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# Vector

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# VECTOR

Vector is a Python 3.8+ library (Python 3.6 and 3.7 supported till `v0.9.0` and `v1.0.0`, respectively) for 2D, 3D, and [Lorentz vectors](#), especially *arrays of vectors*, to solve common physics problems in a NumPy-like way.

Main features of Vector:

- Pure Python with NumPy as its only dependency. This makes it easier to install.
- Vectors may be represented in a variety of coordinate systems: Cartesian, cylindrical, pseudorapidity, and any combination of these with time or proper time for Lorentz vectors. In all, there are 12 coordinate systems:  $\{x - y \text{ vs } - \text{ in the azimuthal plane}\} \times \{z \text{ vs } \text{ longitudinally}\} \times \{t \text{ vs } \text{ temporally}\}$ .
- Uses names and conventions set by ROOT's `TLorentzVector` and `Math::LorentzVector`, as well as `scikit-hep/math`, `uproot-methods TLorentzVector`, `henryiii/hepvector`, and `coffea.nanoevents.methods.vector`.
- **Implemented on a variety of backends:**
  - pure Python objects
  - NumPy arrays of vectors (as a `structured array` subclass)
  - `Awkward Arrays` of vectors
  - potential for more: CuPy, TensorFlow, Torch, JAX...
- NumPy/Awkward backends also implemented in `Numba` for JIT-compiled calculations on vectors.
- Distinction between geometrical vectors, which have a minimum of attribute and method names, and vectors representing momentum, which have synonyms like `pt = rho`, `energy = t`, `mass = tau`.



## INSTALLATION

Vector is available on [PyPI](#) as well as on [conda](#). The library can be installed using pip -

```
pip install vector
```

or using conda -

```
conda install -c conda-forge vector
```





## EXAMPLE GALLERY

`Vector` has several examples covering the basics as well as some advanced usage of the library. The example gallery covers almost all the features offered by `vector` and any new additions to the gallery are welcomed.

**Note:** Adding more examples and improving the existing examples for newcomers is still in progress.

### 2.1 Introduction to Vector

`Vector` is a Python 3.8+ library (Python 3.6 and 3.7 supported till `v0.9.0` and `v1.0.0`, respectively) for 2D, 3D, and [Lorentz vectors](#), especially *arrays of vectors*, to solve common physics problems in a NumPy-like way.

Main features of `Vector`:

- Pure Python with NumPy as its only dependency. This makes it easier to install.
- Vectors may be represented in a variety of coordinate systems: Cartesian, cylindrical, spherical, and any combination of these with time or proper time for Lorentz vectors. In all, there are 12 coordinate systems:  $\{x-y \text{ vs } \rho-\phi \text{ in the azimuthal plane}\} \times \{z \text{ vs } \theta \text{ vs } \eta \text{ longitudinally}\} \times \{t \text{ vs } \tau \text{ temporally}\}$ .
- Uses names and conventions set by `ROOT`'s `TLorentzVector` and `Math::LorentzVector`, as well as `scikit-hep/math`, `uproot-methods` `TLorentzVector`, `henryiii/hepvector`, and `coffea.nanoevents.methods.vector`.
- Implemented on a variety of backends:
  - pure Python objects
  - `SymPy` vectors
  - NumPy arrays of vectors (as a `structured array` subclass)
  - `Awkward Arrays` of vectors
  - potential for more: `CuPy`, `TensorFlow`, `Torch`...
- `Awkward` backend also implemented in `Numba` for JIT-compiled calculations on vectors.
- `JAX` and `Dask` support through `Awkward Arrays`.
- Distinction between geometrical vectors, which have a minimum of attribute and method names, and vectors representing momentum, which have synonyms like `pt = rho`, `energy = t`, `mass = tau`.

This notebook requires `Vector`, `NumPy`, `Awkward Array`, `SymPy`, and `Numba` to run.

```
[1]: import awkward as ak # at least version 1.2.0rc5
import numba as nb
import numpy as np
import sympy
```

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```
import vector
```

### 2.1.1 Constructing a vector or an array of vectors

The easiest way to create one or many vectors is with a helper function:

- `vector.obj` to make a pure Python vector object,
- `vector.arr` to make a NumPy array of vectors (lowercase, like `np.array`),
- `vector.awk` to make an Awkward Array of vectors (uppercase, like `ak.Array`),
- `vector.zip` to make an Awkward Array of vectors (similar to `ak.zip`)

#### Pure Python vectors

You can directly use the `VectorObject` classes to construct object type vectors:

```
[2]: vector.VectorObject2D(x=1.1, y=2.2)
```

```
[2]: VectorObject2D(x=1.1, y=2.2)
```

```
[3]: vector.MomentumObject3D(px=1.1, py=2.2, pz=3.3)
```

```
[3]: MomentumObject3D(px=1.1, py=2.2, pz=3.3)
```

```
[4]: vector.VectorObject4D(x=1.1, y=2.2, eta=3.3, tau=4.4)
```

```
[4]: VectorObject4D(x=1.1, y=2.2, eta=3.3, tau=4.4)
```

and so on for every class.

Or, you can use a single wrapper function to construct all possible combinations of object type vectors:

```
[5]: vector.obj(x=3, y=4) # Cartesian 2D vector
```

```
[5]: VectorObject2D(x=3, y=4)
```

```
[6]: vector.obj(rho=5, phi=0.9273) # same in polar coordinates
```

```
[6]: VectorObject2D(rho=5, phi=0.9273)
```

```
[7]: vector.obj(x=3, y=4).isclose(  
    vector.obj(rho=5, phi=0.9273)  
) # use "isclose" unless they are exactly equal
```

```
[7]: True
```

```
[8]: vector.obj(x=3, y=4, z=-2) # Cartesian 3D vector
```

```
[8]: VectorObject3D(x=3, y=4, z=-2)
```

```
[9]: vector.obj(x=3, y=4, z=-2, t=10) # Cartesian 4D vector
```

```
[9]: VectorObject4D(x=3, y=4, z=-2, t=10)
```

```
[10]: vector.obj(
    rho=5, phi=0.9273, eta=-0.39, t=10
) # in rho-phi-eta-t cylindrical coordinates
```

```
[10]: VectorObject4D(rho=5, phi=0.9273, eta=-0.39, t=10)
```

```
[11]: vector.obj(
    pt=5, phi=0.9273, eta=-0.39, E=10
) # use momentum-synonyms to get a momentum vector
```

```
[11]: MomentumObject4D(pt=5, phi=0.9273, eta=-0.39, E=10)
```

```
[12]: vector.obj(rho=5, phi=0.9273, eta=-0.39, t=10) == vector.obj(
    pt=5, phi=0.9273, eta=-0.390035, E=10
)
```

```
[12]: False
```

```
[13]: vector.obj(
    rho=5, phi=0.9273, eta=-0.39, t=10
).tau # geometrical vectors have to use geometrical names ("tau", not "mass")
```

```
[13]: 8.426194916448265
```

```
[14]: vector.obj(
    pt=5, phi=0.9273, eta=-0.39, E=10
).mass # momentum vectors can use momentum names (as well as geometrical ones)
```

```
[14]: 8.426194916448265
```

```
[15]: vector.obj(
    pt=5, phi=0.9273, theta=1.9513, mass=8.4262
) # any combination of azimuthal, longitudinal, and temporal coordinates is allowed
```

```
[15]: MomentumObject4D(pt=5, phi=0.9273, theta=1.9513, mass=8.4262)
```

```
[16]: vector.obj(x=3, y=4, z=-2, t=10).isclose(
    vector.obj(pt=5, phi=0.9273, theta=1.9513, mass=8.4262)
)
```

```
[16]: True
```

```
[17]: # Test instance type for any level of granularity.
(
    isinstance(
        vector.obj(x=1.1, y=2.2), vector.Vector
    ), # is a vector or array of vectors
    isinstance(vector.obj(x=1.1, y=2.2), vector.Vector2D), # is 2D (not 3D or 4D)
    isinstance(
        vector.obj(x=1.1, y=2.2), vector.VectorObject
    ), # is a vector object (not an array)
    isinstance(vector.obj(px=1.1, py=2.2), vector.Momentum), # has momentum synonyms
```

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```

isinstance(
    vector.obj(x=1.1, y=2.2, z=3.3, t=4.4), vector.Planar
), # has transverse plane (2D, 3D, or 4D)
isinstance(
    vector.obj(x=1.1, y=2.2, z=3.3, t=4.4), vector.Spatial
), # has all spatial coordinates (3D or 4D)
isinstance(
    vector.obj(x=1.1, y=2.2, z=3.3, t=4.4), vector.Lorentz
), # has temporal coordinates (4D)
isinstance(
    vector.obj(x=1.1, y=2.2, z=3.3, t=4.4).azimuthal, vector.AzimuthalXY
), # azimuthal coordinate type
isinstance(
    vector.obj(x=1.1, y=2.2, z=3.3, t=4.4).longitudinal, vector.LongitudinalZ
), # longitudinal coordinate type
isinstance(
    vector.obj(x=1.1, y=2.2, z=3.3, t=4.4).temporal, vector.TemporalT
), # temporal coordinate type
)

```

[17]: (True, True, True, True, True, True, True, True, True, True)

The allowed keyword arguments for 2D vectors are:

- `x` and `y` for Cartesian azimuthal coordinates,
- `px` and `py` for momentum,
- `rho` and `phi` for polar azimuthal coordinates,
- `pt` and `phi` for momentum.

For 3D vectors, you need the above and:

- `z` for the Cartesian longitudinal coordinate,
- `pz` for momentum,
- `theta` for the spherical polar angle (from 0 to  $\pi$ , inclusive),
- `eta` for pseudorapidity, which is a kind of spherical polar angle.

For 4D vectors, you need the above and:

- `t` for the Cartesian temporal coordinate,
- `E` or `energy` to get four-momentum,
- `tau` for the “proper time” (temporal coordinate in the vector’s rest coordinate system),
- `M` or `mass` to get four-momentum.

Since momentum vectors have momentum-synonyms *in addition* to the geometrical names, any momentum-synonym will make the whole vector a momentum vector.

If you want to bypass the dimension and coordinate system inference through keyword arguments (e.g. for static typing), you can use specialized constructors:

[18]: `vector.VectorObject2D.from_xy(1.1, 2.2)`

[18]: `VectorObject2D(x=1.1, y=2.2)`

```
[19]: vector.MomentumObject3D.from_rhophiz(1.1, 2.2, 3.3)
```

```
[19]: MomentumObject3D(pt=1.1, phi=2.2, pz=3.3)
```

```
[20]: vector.VectorObject4D.from_xyetatau(1.1, 2.2, 3.3, 4.4)
```

```
[20]: VectorObject4D(x=1.1, y=2.2, eta=3.3, tau=4.4)
```

and so on, for all combinations of azimuthal, longitudinal, and temporal coordinates, geometric and momentum-flavored.

## SymPy vectors

**Note:** Operations on SymPy vectors are only 100% compatible with numeric vectors (Python, NumPy, and Awkward backends) if the vectors are positive time-like, that is, if  $t^{**2} > x^{**2} + y^{**2} + z^{**2}$ . The space-like and negative time-like cases have different sign conventions.

You can directly use the `VectorSympy` and `MomentumSympy` classes to construct object type vectors:

```
[21]: x, y, z, t, px, py, pz, eta, tau = sympy.symbols(
      "x y z t px py pz eta tau",
      real=True, # see sympy assumptions to add more restrictions on the symbols
    )
```

```
[22]: vector.VectorSympy2D(x=x, y=y)
```

```
[22]: VectorSympy2D(x=x, y=y)
```

```
[23]: vector.MomentumSympy3D(px=px, py=py, pz=pz)
```

```
[23]: MomentumSympy3D(px=px, py=py, pz=pz)
```

```
[24]: vector.VectorSympy4D(x=x, y=y, eta=eta, tau=tau)
```

```
[24]: VectorSympy4D(x=x, y=y, eta=eta, tau=tau)
```

and so on for every class.

```
[25]: # Test instance type for any level of granularity.
      (
        # is a vector or array of vectors
        isinstance(vector.VectorSympy2D(x=x, y=y), vector.Vector),
        # is 2D (not 3D or 4D)
        isinstance(vector.VectorSympy2D(x=x, y=y), vector.Vector2D),
        # is a sympy vector (not an array)
        isinstance(vector.VectorSympy2D(x=x, y=y), vector.VectorSympy),
        # has momentum synonyms
        isinstance(vector.MomentumSympy2D(px=px, py=py), vector.Momentum),
        # has transverse plane (2D, 3D, or 4D)
        isinstance(vector.VectorSympy4D(x=x, y=y, z=z, t=t), vector.Planar),
        # has all spatial coordinates (3D or 4D)
        isinstance(vector.VectorSympy4D(x=x, y=y, z=z, t=t), vector.Spatial),
        # has temporal coordinates (4D)
        isinstance(vector.VectorSympy4D(x=x, y=y, z=z, t=t), vector.Lorentz),
      )
```

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```

# azimuthal coordinate type
isinstance(vector.VectorSymPy4D(x=x, y=y, z=z, t=t).azimuthal, vector.AzimuthalXY),
# longitudinal coordinate type
isinstance(
    vector.VectorSymPy4D(x=x, y=y, z=z, t=t).longitudinal, vector.LongitudinalZ
),
# temporal coordinate type
isinstance(vector.VectorSymPy4D(x=x, y=y, z=z, t=t).temporal, vector.TemporalT),
)

```

[25]: (True, True, True, True, True, True, True, True, True, True)

Since VectorSymPy2D, VectorSymPy3D, VectorSymPy4D, and their momentum equivalents operate on SymPy expressions, all of the normal SymPy methods and functions work on the results, coordinates, and the vectors.

[26]: `sympy.init_session()` # latex printing

IPython console for SymPy 1.12 (Python 3.11.5-64-bit) (ground types: python)

These commands were executed:

```

>>> from sympy import *
>>> x, y, z, t = symbols('x y z t')
>>> k, m, n = symbols('k m n', integer=True)
>>> f, g, h = symbols('f g h', cls=Function)
>>> init_printing()

```

Documentation can be found at <https://docs.sympy.org/1.12/>

[27]: `v1 = vector.VectorSymPy2D(x=x, y=y)`  
`sympy.Eq(v1.rho, sympy.sqrt(x**2 + y**2))`

[27]: True

[28]: `v2 = vector.VectorSymPy4D(x=x, y=y, z=z, t=t)`

[29]: `v2.to_rhophithetataau().tau`

[29]:  $\sqrt{-t^2 + x^2 + y^2 + z^2}$

[30]: `values = {x: 3, y: 2, z: 1, t: 10}` # `t**2 > x**2 + y**2 + z**2`

[31]: `v2.is_timelike()`

[31]:  $t^2 - x^2 - y^2 - z^2 > 0$

[32]: `v2.is_timelike().subs(values)`

[32]: True

[33]: `v2.to_rhophithetataau().tau.subs(values).evalf()`

[33]: 9.2736184954957

```
[34]: v2.boost(v2.to_beta3())
```

```
[34]: VectorSympy4D(x=x*(1 + x**2/(t**2*(1 + 1/sqrt(1 - x**2/t**2 - y**2/t**2 - z**2/t**2)))*(1 -
    x**2/t**2 - y**2/t**2 - z**2/t**2)) + x/sqrt(1 - x**2/t**2 - y**2/t**2 - z**2/t**2),
    y=y*(1 + y**2/(t**2*(1 + 1/sqrt(1 - x**2/t**2 - y**2/t**2 - z**2/t**2)))*(1 - x**2/t**2 -
    y**2/t**2 - z**2/t**2)) + y/sqrt(1 - x**2/t**2 - y**2/t**2 - z**2/t**2),
    z=z*(1 + z**2/(t**2*(1 + 1/sqrt(1 - x**2/t**2 - y**2/t**2 - z**2/t**2)))*(1 - x**2/t**2 -
    y**2/t**2 - z**2/t**2)) + z/sqrt(1 - x**2/t**2 - y**2/t**2 - z**2/t**2),
    t=t/sqrt(1 - x**2/t**2 - y**2/t**2 - z**2/t**2))
```

```
[35]: v2.boost(v2.to_beta3()).t
```

```
[35]:
```

$$\frac{t}{\sqrt{1 - \frac{x^2}{t^2} - \frac{y^2}{t^2} - \frac{z^2}{t^2}}} + \frac{x^2}{t\sqrt{1 - \frac{x^2}{t^2} - \frac{y^2}{t^2} - \frac{z^2}{t^2}}} + \frac{y^2}{t\sqrt{1 - \frac{x^2}{t^2} - \frac{y^2}{t^2} - \frac{z^2}{t^2}}} + \frac{z^2}{t\sqrt{1 - \frac{x^2}{t^2} - \frac{y^2}{t^2} - \frac{z^2}{t^2}}}$$

```
[36]: v2.boost(v2.to_beta3()).t.simplify()
```

```
[36]:
```

$$\frac{t\sqrt{\frac{t^2 - x^2 - y^2 - z^2}{t^2}}(t^2 + x^2 + y^2 + z^2)}{t^2 - x^2 - y^2 - z^2}$$

```
[37]: v2.boost(v2.to_beta3()).t.subs(values)
```

```
[37]:
```

$$\frac{57\sqrt{86}}{43}$$

```
[38]: v2.boost(v2.to_beta3()).t.subs(values).evalf()
```

```
[38]: 12.292936145192
```

All of the keyword arguments and rules that apply to `vector.obj` construction apply to `vector.VectorSympyND` and `vector.MomentumObjectND` objects.

## NumPy arrays of vectors

You can directly use the `VectorNumpy` classes to construct object type vectors:

```
[39]: # NumPy-like arguments (literally passed through to NumPy)
vector.VectorNumpy2D(
    [(1.1, 2.1), (1.2, 2.2), (1.3, 2.3), (1.4, 2.4), (1.5, 2.5)],
    dtype=[('x', float), ('y', float)],
)
```

```
[39]: VectorNumpy2D([(1.1, 2.1), (1.2, 2.2), (1.3, 2.3), (1.4, 2.4), (1.5, 2.5)],
    dtype=[('x', '<f8'), ('y', '<f8')])
```

```
[40]: # Pandas-like arguments (dict from names to column arrays)
vector.VectorNumpy2D({"x": [1.1, 1.2, 1.3, 1.4, 1.5], "y": [2.1, 2.2, 2.3, 2.4, 2.5]})

[40]: VectorNumpy2D([(1.1, 2.1), (1.2, 2.2), (1.3, 2.3), (1.4, 2.4), (1.5, 2.5)],
                    dtype=[('x', '<f8'), ('y', '<f8')])
```

```
[41]: # As with objects, the coordinate system and dimension is taken from the names of the
      ↪ fields.
vector.VectorNumpy4D(
    {
        "x": [1.1, 1.2, 1.3, 1.4, 1.5],
        "y": [2.1, 2.2, 2.3, 2.4, 2.5],
        "z": [3.1, 3.2, 3.3, 3.4, 3.5],
        "t": [4.1, 4.2, 4.3, 4.4, 4.5],
    }
)

[41]: VectorNumpy4D([(1.1, 2.1, 3.1, 4.1), (1.2, 2.2, 3.2, 4.2), (1.3, 2.3, 3.3, 4.3),
                    (1.4, 2.4, 3.4, 4.4), (1.5, 2.5, 3.5, 4.5)],
                    dtype=[('x', '<f8'), ('y', '<f8'), ('z', '<f8'), ('t', '<f8')])
```

and so on for every class.

Or, you can use a single wrapper function to construct all possible combinations of NumPy type vectors:

```
[42]: # NumPy-like arguments (literally passed through to NumPy)
vector.array(
    [(1.1, 2.1), (1.2, 2.2), (1.3, 2.3), (1.4, 2.4), (1.5, 2.5)],
    dtype=[("x", float), ("y", float)],
)

[42]: VectorNumpy2D([(1.1, 2.1), (1.2, 2.2), (1.3, 2.3), (1.4, 2.4), (1.5, 2.5)],
                    dtype=[('x', '<f8'), ('y', '<f8')])

[43]: # Pandas-like arguments (dict from names to column arrays)
vector.array({"x": [1.1, 1.2, 1.3, 1.4, 1.5], "y": [2.1, 2.2, 2.3, 2.4, 2.5]})

[43]: VectorNumpy2D([(1.1, 2.1), (1.2, 2.2), (1.3, 2.3), (1.4, 2.4), (1.5, 2.5)],
                    dtype=[('x', '<f8'), ('y', '<f8')])
```

```
[44]: # As with objects, the coordinate system and dimension is taken from the names of the
      ↪ fields.
vector.array(
    {
        "x": [1.1, 1.2, 1.3, 1.4, 1.5],
        "y": [2.1, 2.2, 2.3, 2.4, 2.5],
        "z": [3.1, 3.2, 3.3, 3.4, 3.5],
        "t": [4.1, 4.2, 4.3, 4.4, 4.5],
    }
)

[44]: VectorNumpy4D([(1.1, 2.1, 3.1, 4.1), (1.2, 2.2, 3.2, 4.2), (1.3, 2.3, 3.3, 4.3),
                    (1.4, 2.4, 3.4, 4.4), (1.5, 2.5, 3.5, 4.5)],
                    dtype=[('x', '<f8'), ('y', '<f8'), ('z', '<f8'), ('t', '<f8')])
```



```
[45]: vector.array(
    {
        "pt": [1.1, 1.2, 1.3, 1.4, 1.5],
        "phi": [2.1, 2.2, 2.3, 2.4, 2.5],
        "eta": [3.1, 3.2, 3.3, 3.4, 3.5],
        "M": [4.1, 4.2, 4.3, 4.4, 4.5],
    }
)

[45]: MomentumNumpy4D([(1.1, 2.1, 3.1, 4.1), (1.2, 2.2, 3.2, 4.2), (1.3, 2.3, 3.3, 4.3),
    (1.4, 2.4, 3.4, 4.4), (1.5, 2.5, 3.5, 4.5)],
    dtype=[('rho', '<f8'), ('phi', '<f8'), ('eta', '<f8'), ('tau', '<f8')])
```

Existing NumPy arrays can be viewed as arrays of vectors, but it needs to be a [structured array](#) with recognized field names.

```
[46]: # NumPy array          # interpret groups of four values as named fields          #_
    ↪ give it vector properties and methods
np.arange(0, 24, 0.1).view(
    [("x", float), ("y", float), ("z", float), ("t", float)])
).view(vector.VectorNumpy4D)

[46]: VectorNumpy4D([( 0. ,  0.1,  0.2,  0.3), ( 0.4,  0.5,  0.6,  0.7),
    ( 0.8,  0.9,  1. ,  1.1), ( 1.2,  1.3,  1.4,  1.5),
    ( 1.6,  1.7,  1.8,  1.9), ( 2. ,  2.1,  2.2,  2.3),
    ( 2.4,  2.5,  2.6,  2.7), ( 2.8,  2.9,  3. ,  3.1),
    ( 3.2,  3.3,  3.4,  3.5), ( 3.6,  3.7,  3.8,  3.9),
    ( 4. ,  4.1,  4.2,  4.3), ( 4.4,  4.5,  4.6,  4.7),
    ( 4.8,  4.9,  5. ,  5.1), ( 5.2,  5.3,  5.4,  5.5),
    ( 5.6,  5.7,  5.8,  5.9), ( 6. ,  6.1,  6.2,  6.3),
    ( 6.4,  6.5,  6.6,  6.7), ( 6.8,  6.9,  7. ,  7.1),
    ( 7.2,  7.3,  7.4,  7.5), ( 7.6,  7.7,  7.8,  7.9),
    ( 8. ,  8.1,  8.2,  8.3), ( 8.4,  8.5,  8.6,  8.7),
    ( 8.8,  8.9,  9. ,  9.1), ( 9.2,  9.3,  9.4,  9.5),
    ( 9.6,  9.7,  9.8,  9.9), (10. , 10.1, 10.2, 10.3),
    (10.4, 10.5, 10.6, 10.7), (10.8, 10.9, 11. , 11.1),
    (11.2, 11.3, 11.4, 11.5), (11.6, 11.7, 11.8, 11.9),
    (12. , 12.1, 12.2, 12.3), (12.4, 12.5, 12.6, 12.7),
    (12.8, 12.9, 13. , 13.1), (13.2, 13.3, 13.4, 13.5),
    (13.6, 13.7, 13.8, 13.9), (14. , 14.1, 14.2, 14.3),
    (14.4, 14.5, 14.6, 14.7), (14.8, 14.9, 15. , 15.1),
    (15.2, 15.3, 15.4, 15.5), (15.6, 15.7, 15.8, 15.9),
    (16. , 16.1, 16.2, 16.3), (16.4, 16.5, 16.6, 16.7),
    (16.8, 16.9, 17. , 17.1), (17.2, 17.3, 17.4, 17.5),
    (17.6, 17.7, 17.8, 17.9), (18. , 18.1, 18.2, 18.3),
    (18.4, 18.5, 18.6, 18.7), (18.8, 18.9, 19. , 19.1),
    (19.2, 19.3, 19.4, 19.5), (19.6, 19.7, 19.8, 19.9),
    (20. , 20.1, 20.2, 20.3), (20.4, 20.5, 20.6, 20.7),
    (20.8, 20.9, 21. , 21.1), (21.2, 21.3, 21.4, 21.5),
    (21.6, 21.7, 21.8, 21.9), (22. , 22.1, 22.2, 22.3),
    (22.4, 22.5, 22.6, 22.7), (22.8, 22.9, 23. , 23.1),
    (23.2, 23.3, 23.4, 23.5), (23.6, 23.7, 23.8, 23.9)],
    dtype=[('x', '<f8'), ('y', '<f8'), ('z', '<f8'), ('t', '<f8')])
```

Since VectorNumpy2D, VectorNumpy3D, VectorNumpy4D, and their momentum equivalents are NumPy array sub-

classes, all of the normal NumPy methods and functions work on them.

```
[47]: np.arange(0, 24, 0.1).view(
      [("x", float), ("y", float), ("z", float), ("t", float)])
      ).view(vector.VectorNumpy4D).reshape(6, 5, 2)

[47]: VectorNumpy4D([[ ( 0. ,  0.1,  0.2,  0.3), ( 0.4,  0.5,  0.6,  0.7)],
                    [ ( 0.8,  0.9,  1. ,  1.1), ( 1.2,  1.3,  1.4,  1.5)],
                    [ ( 1.6,  1.7,  1.8,  1.9), ( 2. ,  2.1,  2.2,  2.3)],
                    [ ( 2.4,  2.5,  2.6,  2.7), ( 2.8,  2.9,  3. ,  3.1)],
                    [ ( 3.2,  3.3,  3.4,  3.5), ( 3.6,  3.7,  3.8,  3.9)]],

                    [[ ( 4. ,  4.1,  4.2,  4.3), ( 4.4,  4.5,  4.6,  4.7)],
                    [ ( 4.8,  4.9,  5. ,  5.1), ( 5.2,  5.3,  5.4,  5.5)],
                    [ ( 5.6,  5.7,  5.8,  5.9), ( 6. ,  6.1,  6.2,  6.3)],
                    [ ( 6.4,  6.5,  6.6,  6.7), ( 6.8,  6.9,  7. ,  7.1)],
                    [ ( 7.2,  7.3,  7.4,  7.5), ( 7.6,  7.7,  7.8,  7.9)]],

                    [[ ( 8. ,  8.1,  8.2,  8.3), ( 8.4,  8.5,  8.6,  8.7)],
                    [ ( 8.8,  8.9,  9. ,  9.1), ( 9.2,  9.3,  9.4,  9.5)],
                    [ ( 9.6,  9.7,  9.8,  9.9), (10. , 10.1, 10.2, 10.3)],
                    [ (10.4, 10.5, 10.6, 10.7), (10.8, 10.9, 11. , 11.1)],
                    [ (11.2, 11.3, 11.4, 11.5), (11.6, 11.7, 11.8, 11.9)]],

                    [[ (12. , 12.1, 12.2, 12.3), (12.4, 12.5, 12.6, 12.7)],
                    [ (12.8, 12.9, 13. , 13.1), (13.2, 13.3, 13.4, 13.5)],
                    [ (13.6, 13.7, 13.8, 13.9), (14. , 14.1, 14.2, 14.3)],
                    [ (14.4, 14.5, 14.6, 14.7), (14.8, 14.9, 15. , 15.1)],
                    [ (15.2, 15.3, 15.4, 15.5), (15.6, 15.7, 15.8, 15.9)]],

                    [[ (16. , 16.1, 16.2, 16.3), (16.4, 16.5, 16.6, 16.7)],
                    [ (16.8, 16.9, 17. , 17.1), (17.2, 17.3, 17.4, 17.5)],
                    [ (17.6, 17.7, 17.8, 17.9), (18. , 18.1, 18.2, 18.3)],
                    [ (18.4, 18.5, 18.6, 18.7), (18.8, 18.9, 19. , 19.1)],
                    [ (19.2, 19.3, 19.4, 19.5), (19.6, 19.7, 19.8, 19.9)]],

                    [[ (20. , 20.1, 20.2, 20.3), (20.4, 20.5, 20.6, 20.7)],
                    [ (20.8, 20.9, 21. , 21.1), (21.2, 21.3, 21.4, 21.5)],
                    [ (21.6, 21.7, 21.8, 21.9), (22. , 22.1, 22.2, 22.3)],
                    [ (22.4, 22.5, 22.6, 22.7), (22.8, 22.9, 23. , 23.1)],
                    [ (23.2, 23.3, 23.4, 23.5), (23.6, 23.7, 23.8, 23.9)]]],
      dtype=[('x', '<f8'), ('y', '<f8'), ('z', '<f8'), ('t', '<f8')])
```

All of the keyword arguments and rules that apply to `vector.obj` construction apply to `vector.array` dtypes.

Geometrical names are used in the dtype, even if momentum-synonyms are used in construction.

```
[48]: vector.array(
      {"px": [1, 2, 3, 4], "py": [1.1, 2.2, 3.3, 4.4], "pz": [0.1, 0.2, 0.3, 0.4]}
      )

[48]: MomentumNumpy3D([(1., 1.1, 0.1), (2., 2.2, 0.2), (3., 3.3, 0.3), (4., 4.4, 0.4)],
                      dtype=[('x', '<f8'), ('y', '<f8'), ('z', '<f8')])
```

## Awkward Arrays of vectors

Awkward Arrays are arrays with more complex data structures than NumPy allows, such as variable-length lists, nested records, missing and even heterogeneous data (multiple data types: use sparingly).

The `vector.Array` function behaves exactly like the `ak.Array` constructor, except that it makes arrays of vectors.

```
[49]: vector.Array(
    [
        [{"x": 1, "y": 1.1, "z": 0.1}, {"x": 2, "y": 2.2, "z": 0.2}],
        [],
        [{"x": 3, "y": 3.3, "z": 0.3}],
        [
            {"x": 4, "y": 4.4, "z": 0.4},
            {"x": 5, "y": 5.5, "z": 0.5},
            {"x": 6, "y": 6.6, "z": 0.6},
        ],
    ],
)
```

```
[49]: <VectorArray3D [[{x: 1, y: 1.1, ...}, {...}], ...] type='4 * var * Vector3D... '>
```

If you want *any* records named “Vector2D”, “Vector3D”, “Vector4D”, “Momentum2D”, “Momentum3D”, or “Momentum4D” to be interpreted as vectors, register the behaviors globally.

```
[50]: vector.register_awkward()
```

```
[51]: ak.Array(
    [
        [{"x": 1, "y": 1.1, "z": 0.1}, {"x": 2, "y": 2.2, "z": 0.2}],
        [],
        [{"x": 3, "y": 3.3, "z": 0.3}],
        [
            {"x": 4, "y": 4.4, "z": 0.4},
            {"x": 5, "y": 5.5, "z": 0.5},
            {"x": 6, "y": 6.6, "z": 0.6},
        ],
    ],
    with_name="Vector3D",
)
```

```
[51]: <VectorArray3D [[{x: 1, y: 1.1, ...}, {...}], ...] type='4 * var * Vector3D... '>
```

All of the keyword arguments and rules that apply to `vector.obj` construction apply to `vector.Array` field names.

Finally, the `VectorAwkward` mixins can be subclassed to create custom vector classes. The awkward behavior classes and projections must be named as `*Array`. For example, `coffea` uses the following names - `TwoVectorArray`, `ThreeVectorArray`, `PolarTwoVectorArray`, `SphericalThreeVectorArray`, ...

### 2.1.2 Vector properties

Any geometrical coordinate can be computed from vectors in any coordinate system; they'll be provided or computed as needed.

```
[52]: vector.obj(x=3, y=4).rho
```

```
[52]: 5.0
```

```
[53]: vector.obj(rho=5, phi=0.9273).x
```

```
[53]: 2.99998087197215
```

```
[54]: vector.obj(rho=5, phi=0.9273).y
```

```
[54]: 4.00001434594943
```

```
[55]: vector.obj(x=1, y=2, z=3).theta
```

```
[55]: 0.640522312679424
```

```
[56]: vector.obj(x=1, y=2, z=3).eta
```

```
[56]: 1.10358684156015
```

Some properties are not coordinates, but derived from them.

```
[57]: vector.obj(x=1, y=2, z=3).costheta
```

```
[57]: 0.801783725737273
```

```
[58]: vector.obj(x=1, y=2, z=3).mag # spatial magnitude
```

```
[58]: 3.74165738677394
```

```
[59]: vector.obj(x=1, y=2, z=3).mag2 # spatial magnitude squared
```

```
[59]: 14
```

These properties are provided because they can be computed faster or with more numerical stability in different coordinate systems. For instance, the magnitude ignores phi in polar coordinates.

```
[60]: vector.obj(rho=3, phi=0.123456789, z=4).mag2
```

```
[60]: 25
```

Momentum vectors have geometrical properties as well as their momentum-synonyms.

```
[61]: vector.obj(px=3, py=4).rho
```

```
[61]: 5.0
```

```
[62]: vector.obj(px=3, py=4).pt
```

```
[62]: 5.0
```

```
[63]: vector.obj(x=1, y=2, z=3, E=4).tau
```

```
[63]: 1.4142135623731
```

```
[64]: vector.obj(x=1, y=2, z=3, E=4).mass
```

[64]: 1.4142135623731

Here's the key thing: *arrays of vectors return arrays of coordinates.*

```
[65]: vector.array(
    {
        "x": [1.0, 2.0, 3.0, 4.0, 5.0],
        "y": [1.1, 2.2, 3.3, 4.4, 5.5],
        "z": [0.1, 0.2, 0.3, 0.4, 0.5],
    }
).theta
```

[65]: array([1.50363023, 1.50363023, 1.50363023, 1.50363023, 1.50363023])

```
[66]: vector.Array(
    [
        [{"x": 1, "y": 1.1, "z": 0.1}, {"x": 2, "y": 2.2, "z": 0.2}],
        [],
        [{"x": 3, "y": 3.3, "z": 0.3}],
        [{"x": 4, "y": 4.4, "z": 0.4}, {"x": 5, "y": 5.5, "z": 0.5}],
    ]
).theta
```

[66]: <Array [[1.5, 1.5], [], [1.5], [1.5, 1.5]] type='4 \* var \* float64'>

```
[67]: # Make a large, random NumPy array of 3D momentum vectors.
array = (
    np.random.normal(0, 1, 150)
    .view([(x, float) for x in ("x", "y", "z")])
    .view(vector.MomentumNumpy3D)
    .reshape(5, 5, 2)
)
array
```

```
[67]: MomentumNumpy3D([[[[ 0.55677765, -2.39134767, -1.14009875e+00),
    (-0.4099286 , -1.35111044,  1.22805909e+00)],
    [[ 2.17202778, -0.68150151,  1.67793905e-01),
    (-0.41973476, -1.62000792, -2.62404832e-04)],
    [[-1.51641767, -1.40147683,  2.47076578e+00),
    ( 0.60257785, -1.30590029, -6.77753691e-01)],
    [[ 0.19640056,  0.20738716,  2.04561027e-02),
    (-0.53479171,  0.94471872,  7.09228434e-02)],
    [[ 0.01832378,  1.12336773, -9.97689716e-01),
    (-1.67101189,  0.62237498, -6.39758959e-02)]],

    [[[ 0.87762728, -1.98374752, -2.01469599e+00),
    ( 0.17471933,  0.12161887, -9.42606081e-02)],
    [[-0.5445472 , -0.8928596 , -6.90405216e-01),
    ( 0.29222871, -0.14303945, -7.06930314e-01)],
    [[ 0.11103332, -0.81876775,  2.21759321e-01),
    ( 0.6930197 ,  0.44511978,  3.74892308e-01)],
    [[ 0.47797932, -0.54189062, -1.06199035e+00),
    ( 0.70067255, -0.01567734,  4.51905779e-01)],
    [[-0.98069469, -0.67226787,  1.63755227e+00),
```

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```

( 1.33964903, -1.01568176, 9.33791315e-01)],
[[-0.79781737, 0.8604048, 1.75923001e-01),
 (-1.27055185, 0.28886057, 8.56541197e-01)],
[[-1.05366515, -0.15041122, 7.55757703e-01),
 ( 1.65815748, 1.32132905, -1.46950305e+00)],
[[-0.67879973, -1.95059887, -1.15938843e-01),
 (-1.7877064, -0.69352448, 3.20265686e-01)],
[( 0.28149666, 0.54879607, -7.82537808e-01),
 ( 0.31366026, 0.36907726, 3.36517183e-01)],
[[-1.01885702, -0.66434627, 6.41372208e-01),
 (-0.77216596, 0.08913472, -2.49368534e-01)],

[[-0.75470986, -0.15824692, -2.04355139e-01),
 ( 0.24682491, -0.44316793, -2.55907965e-01)],
[[-1.14906251, 1.08234259, -4.37065854e-01),
 ( 0.39882584, -0.80339686, 8.25692598e-01)],
[[-0.2832258, 1.04610965, 4.32860052e-01),
 (-0.27051201, -1.54016307, -6.61530929e-01)],
[[-0.10674002, 0.14105683, 1.27337139e+00),
 (-0.4728045, 0.22134932, -1.07465967e+00)],
[[-0.10652267, 0.00870547, 1.32620623e+00),
 (-0.96161573, 0.4993631, 5.57284082e-01)],

[[ ( 0.51468134, 0.48772909, -2.59407633e-01),
 ( 0.61031019, 1.25211695, -5.04208824e-01)],
 [(-0.31302188, -0.07605632, -1.93811954e+00),
 ( 1.02092718, 0.26294964, -9.27338521e-01)],
 [( 1.88041867, -0.91344964, -6.85620574e-01),
 (-0.07825839, -0.14948375, -1.52505471e-01)],
 [(-1.71248754, 0.25225344, -1.28889867e+00),
 (-0.96428705, 0.87685202, -4.98042758e-01)],
 [(-0.45582323, 0.40835731, 1.82438535e-01),
 ( 0.58168782, 1.04561222, -7.12156826e-01)]]],
dtype=[('x', '<f8'), ('y', '<f8'), ('z', '<f8')])

```

```

[68]: # Get the transverse momentum of each one.
array.pt

```

```

[68]: array([[2.45530956, 1.41192807],
 [2.27643339, 1.67350021],
 [2.06486316, 1.43821961],
 [0.2856267, 1.08558539],
 [1.12351716, 1.78315208]],

 [2.16921272, 0.21288023],
 [1.04581543, 0.32535812],
 [0.82626208, 0.82365522],
 [0.72257157, 0.70084792],
 [1.18899376, 1.68115108]],

 [[1.17337504, 1.30297446],

```

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```

    [1.06434664, 2.12023506],
    [2.06533412, 1.91751672],
    [0.61677994, 0.48435605],
    [1.21631641, 0.77729356]],

    [[0.77112195, 0.50726753],
     [1.57854684, 0.89694401],
     [1.08377223, 1.56373879],
     [0.1768911 , 0.52205327],
     [0.10687781, 1.08354433]],

    [[0.70906738, 1.39293768],
     [0.32212926, 1.05424609],
     [2.09054171, 0.16872986],
     [1.7309666 , 1.30334914],
     [0.61198898, 1.19652231]]])

```

```
[69]: # The array and its components have the same shape.
      array.shape
```

```
[69]: (5, 5, 2)
```

```
[70]: array.pt.shape
```

```
[70]: (5, 5, 2)
```

```
[71]: # Make a large, random Awkward Array of 3D momentum vectors.
      array = vector.Array(
          [
              [
                  {x: np.random.normal(0, 1) for x in ("px", "py", "pz")}
                  for inner in range(np.random.poisson(1.5))
              ]
              for outer in range(50)
          ]
      )
      array
```

```
[71]: <MomentumArray3D [[], ..., [{x: 0.463, ...}, {...}]] type='50 * var * Momen... '>
```

```
[72]: # Get the transverse momentum of each one, in the same nested structure.
      array.pt
```

```
[72]: <Array [[], [2.32], ..., [0.283], [0.472, 2.39]] type='50 * var * float64'>
```

```
[73]: # The array and its components have the same list lengths (and can therefore be used
      ↪ together in subsequent calculations).
      ak.num(array)
```

```
[73]: <Array [0, 1, 2, 2, 0, 2, 1, 0, ..., 0, 1, 1, 4, 4, 2, 1, 2] type='50 * int64'>
```

```
[74]: ak.num(array.pt)
```

```
[74]: <Array [0, 1, 2, 2, 0, 2, 1, 0, ..., 0, 1, 1, 4, 4, 2, 1, 2] type='50 * int64'>
```

### 2.1.3 Vector methods

Vector methods require arguments (in parentheses), which may be scalars or other vectors, depending on the calculation.

```
[75]: vector.obj(x=3, y=4).rotateZ(0.1)
```

```
[75]: VectorObject2D(x=2.585678829246765, y=4.279516911052588)
```

```
[76]: vector.obj(rho=5, phi=0.4).rotateZ(0.1)
```

```
[76]: VectorObject2D(rho=5, phi=0.5)
```

```
[77]: # Broadcasts a scalar rotation angle of 0.5 to all elements of the NumPy array.
print(
    vector.array({"rho": [1, 2, 3, 4, 5], "phi": [0.1, 0.2, 0.3, 0.4, 0.5]}).rotateZ(
        0.5
    )
)
[(1., 0.6) (2., 0.7) (3., 0.8) (4., 0.9) (5., 1. )]
```

```
[78]: # Matches each rotation angle to an element of the NumPy array.
print(
    vector.array({"rho": [1, 2, 3, 4, 5], "phi": [0.1, 0.2, 0.3, 0.4, 0.5]}).rotateZ(
        np.array([0.1, 0.2, 0.3, 0.4, 0.5])
    )
)
[(1., 0.2) (2., 0.4) (3., 0.6) (4., 0.8) (5., 1. )]
```

```
[79]: # Broadcasts a scalar rotation angle of 0.5 to all elements of the Awkward Array.
print(
    vector.Array(
        [{"rho": 1, "phi": 0.1}, {"rho": 2, "phi": 0.2}], [], [{"rho": 3, "phi": 0.3}])
    ).rotateZ(0.5)
)
[{"rho": 1, "phi": 0.6}, {"rho": 2, "phi": 0.7}], [{"rho": 3, "phi": 0.8}]
```

```
[80]: # Broadcasts a rotation angle of 0.1 to both elements of the first list, 0.2 to the
→ empty list, and 0.3 to the only element of the last list.
print(
    vector.Array(
        [{"rho": 1, "phi": 0.1}, {"rho": 2, "phi": 0.2}], [{"rho": 3, "phi": 0.3}])
    ).rotateZ([0.1, 0.2, 0.3])
)
[{"rho": 1, "phi": 0.2}, {"rho": 2, "phi": 0.3}], [{"rho": 3, "phi": 0.6}]
```

```
[81]: # Matches each rotation angle to an element of the Awkward Array.
print(
```

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```
vector.Array(
  [{"rho": 1, "phi": 0.1}, {"rho": 2, "phi": 0.2}], [], [{"rho": 3, "phi": 0.3}]]
).rotateZ([[0.1, 0.2], [], [0.3]])
)
```

```
[[{"rho": 1, "phi": 0.2}, {"rho": 2, "phi": 0.4}], [], [{"rho": 3, "phi": 0.6}]]
```

Some methods are equivalent to binary operators.

```
[82]: vector.obj(x=3, y=4).scale(10)
```

```
[82]: VectorObject2D(x=30, y=40)
```

```
[83]: vector.obj(x=3, y=4) * 10
```

```
[83]: VectorObject2D(x=30, y=40)
```

```
[84]: 10 * vector.obj(x=3, y=4)
```

```
[84]: VectorObject2D(x=30, y=40)
```

```
[85]: vector.obj(rho=5, phi=0.5) * 10
```

```
[85]: VectorObject2D(rho=50, phi=0.5)
```

Some methods involve more than one vector.

```
[86]: vector.obj(x=1, y=2).add(vector.obj(x=5, y=5))
```

```
[86]: VectorObject2D(x=6, y=7)
```

```
[87]: vector.obj(x=1, y=2) + vector.obj(x=5, y=5)
```

```
[87]: VectorObject2D(x=6, y=7)
```

```
[88]: vector.obj(x=1, y=2).dot(vector.obj(x=5, y=5))
```

```
[88]: 15
```

```
[89]: vector.obj(x=1, y=2) @ vector.obj(x=5, y=5)
```

```
[89]: 15
```

The vectors can use different coordinate systems. Conversions are necessary, but minimized for speed and numeric stability.

```
[90]: vector.obj(x=3, y=4) @ vector.obj(x=6, y=8) # both are Cartesian, dot product is exact
```

```
[90]: 50
```

```
[91]: vector.obj(rho=5, phi=0.9273) @ vector.obj(
      x=6, y=8
    ) # one is polar, dot product is approximate
```

```
[91]: 49.9999999994283
```

```
[92]: vector.obj(x=3, y=4) @ vector.obj(
      rho=10, phi=0.9273
    ) # one is polar, dot product is approximate
```

```
[92]: 49.9999999994283
```

```
[93]: vector.obj(rho=5, phi=0.9273) @ vector.obj(
      rho=10, phi=0.9273
    ) # both are polar, a formula that depends on phi differences is used
```

```
[93]: 50.0
```

In Python, some “operators” are actually built-in functions, such as `abs`.

```
[94]: abs(vector.obj(x=3, y=4))
```

```
[94]: 5.0
```

Note that `abs` returns

- `rho` for 2D vectors
- `mag` for 3D vectors
- `tau (mass)` for 4D vectors

Use the named properties when you want magnitude in a specific number of dimensions; use `abs` when you want the magnitude for any number of dimensions.

The vectors can be from different backends. Normal rules for broadcasting Python numbers, NumPy arrays, and Awkward Arrays apply.

```
[95]: vector.array({"x": [1, 2, 3, 4, 5], "y": [0.1, 0.2, 0.3, 0.4, 0.5]}) + vector.obj(
      x=10, y=5
    )
```

```
[95]: VectorNumpy2D([(11., 5.1), (12., 5.2), (13., 5.3), (14., 5.4), (15., 5.5)],
      dtype=[('x', '<f8'), ('y', '<f8')])
```

```
[96]: (
      vector.Array(
        [ # an Awkward Array of vectors
          [{"x": 1, "y": 1.1}, {"x": 2, "y": 2.2}],
          [],
          [{"x": 3, "y": 3.3}],
          [{"x": 4, "y": 4.4}, {"x": 5, "y": 5.5}],
        ]
      )
      + vector.obj(x=10, y=5) # and a single vector object
    )
```

```
[96]: <VectorArray2D [[{x: 11, y: 6.1}, {...}], ..., [...]] type='4 * var * Vecto... '>
```

```
[97]: (
      vector.Array(
        [ # an Awkward Array of vectors
          [{"x": 1, "y": 1.1}, {"x": 2, "y": 2.2}],
          [],

```

(continues on next page)

(continued from previous page)

```

        [{"x": 3, "y": 3.3}],
        [{"x": 4, "y": 4.4}, {"x": 5, "y": 5.5}],
    ]
)
+ vector.array(
    {"x": [4, 3, 2, 1], "y": [0.1, 0.1, 0.1, 0.1]}
) # and a NumPy array of vectors
)

```

```
[97]: <VectorArray2D [[{x: 5, y: 1.2}, {...}], ..., [...]] type='4 * var * Vector... '>
```

Some operations are defined for 2D or 3D vectors, but are usable on higher-dimensional vectors because the additional components can be ignored or are passed through unaffected.

```
[98]: vector.obj(rho=1, phi=0.5).deltaphi(
    vector.obj(rho=2, phi=0.3)
) # deltaphi is a planar operation (defined on the transverse plane)
```

```
[98]: 0.2
```

```
[99]: vector.obj(rho=1, phi=0.5, z=10).deltaphi(
    vector.obj(rho=2, phi=0.3, theta=1.4)
) # but we can use it on 3D vectors
```

```
[99]: 0.2
```

```
[100]: vector.obj(rho=1, phi=0.5, z=10, t=100).deltaphi(
    vector.obj(rho=2, phi=0.3, theta=1.4, tau=1000)
) # and 4D vectors
```

```
[100]: 0.2
```

```
[101]: vector.obj(rho=1, phi=0.5).deltaphi(
    vector.obj(rho=2, phi=0.3, theta=1.4, tau=1000)
) # and mixed dimensionality
```

```
[101]: 0.2
```

This is especially useful for giving 4D vectors all the capabilities of 3D vectors.

```
[102]: vector.obj(x=1, y=2, z=3).rotateX(np.pi / 4)
```

```
[102]: VectorObject3D(x=1, y=-0.7071067811865472, z=3.5355339059327378)
```

```
[103]: vector.obj(x=1, y=2, z=3, tau=10).rotateX(np.pi / 4)
```

```
[103]: VectorObject4D(x=1, y=-0.7071067811865472, z=3.5355339059327378, tau=10)
```

```
[104]: vector.obj(pt=1, phi=1.3, eta=2).deltaR(vector.obj(pt=2, phi=0.3, eta=1))
```

```
[104]: 1.4142135623731
```

```
[105]: vector.obj(pt=1, phi=1.3, eta=2, mass=5).deltaR(
    vector.obj(pt=2, phi=0.3, eta=1, mass=10)
)
```

```
[105]: 1.4142135623731
```

For a few operations  $+$ ,  $-$ ,  $==$ ,  $!=$ ,  $\dots$  - the dimension of the vectors should be equal. This can be achieved by using the `like` method, `to_{coordinate_name}` methods, `to_Vector*D` methods. The `to_Vector*D` methods provide more flexibility to the users, that is, new coordinate values can be passed into the methods as named arguments.

```
[106]: v1 = vector.obj(x=1, y=2, z=3)
v2 = vector.obj(x=1, y=2)

print(v1 - v2.like(v1))           # transforms v2 to v1's coordinate system (imputes z=0)
print(v1.like(v2) - v2)           # transforms v1 to v2's coordinate system (removes z)
print(v1 - v2.to_xyz())           # transforms v2 to xyz coordinates (imputes z=0)
print(v1.to_xy() - v2)            # transforms v1 to xy coordinates (removes z)
print(v1 - v2.to_Vector3D(z=3))   # transforms v2 to 3D (imputes z=3)
print(v1.to_Vector2D() - v2)      # transforms v1 to 2D (removes z)

VectorObject3D(x=0, y=0, z=3.0)
VectorObject2D(x=0, y=0)
VectorObject3D(x=0, y=0, z=3.0)
VectorObject2D(x=0, y=0)
VectorObject3D(x=0, y=0, z=0)
VectorObject2D(x=0, y=0)
```

Similarly, for a few vector methods, the dimension of the input vectors are type checked strictly.

For instance, a cross-product is only defined for 3D and 7D vectors; hence, running the method on a 4D vector will error out.

```
[107]: vector.obj(x=0.1, y=0.2, z=0.3).cross(vector.obj(x=0.4, y=0.5, z=0.6))

[107]: VectorObject3D(x=-0.03, y=0.06, z=-0.03000000000000000013)
```

The (current) list of properties and methods is:

### Planar (2D, 3D, 4D):

- `x` (px)
- `y` (py)
- `rho` (pt): two-dimensional magnitude
- `rho2` (pt2): two-dimensional magnitude squared
- `phi`
- `deltaphi(vector)`: difference in `phi` (signed and rectified to  $-\pi$  through  $\pi$ )
- `rotateZ(angle)`
- `transform2D(obj)`: the `obj` must supply components through `obj["xx"]`, `obj["xy"]`, `obj["yx"]`, `obj["yy"]`
- `is_parallel(vector, tolerance=1e-5)`: only true if they're pointing in the same direction
- `is_antiparallel(vector, tolerance=1e-5)`: only true if they're pointing in opposite directions
- `is_perpendicular(vector, tolerance=1e-5)`

### Spatial (3D, 4D):

- `z` (pz)
- `theta`
- `eta`

- `costheta`
- `cottheta`
- `mag (p)`: three-dimensional magnitude, does not include temporal component
- `mag2 (p2)`: three-dimensional magnitude squared
- `cross`: cross-product (strictly 3D)
- `deltaangle(vector)`: difference in angle (always non-negative)
- `deltaeta(vector)`: difference in eta (signed)
- `deltaR(vector)`:  $\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$
- `deltaR2(vector)`: the above, squared
- `rotateX(angle)`
- `rotateY(angle)`
- `rotate_axis(axis, angle)`: the magnitude of `axis` is ignored, but it must be at least 3D
- `rotate_euler(phi, theta, psi, order="zxx")`: the arguments are in the same order as `ROOT::Math::EulerAngles`, and `order="zxx"` agrees with ROOT's choice of conventions
- `rotate_nautical(yaw, pitch, roll)`
- `rotate_quaternion(u, i, j, k)`: again, the conventions match `ROOT::Math::Quaternion`.
- `transform3D(obj)`: the `obj` must supply components through `obj["xx"]`, `obj["xy"]`, etc.
- `is_parallel(vector, tolerance=1e-5)`: only true *if they're pointing in the same direction*
- `is_antiparallel(vector, tolerance=1e-5)`: only true *if they're pointing in opposite directions*
- `is_perpendicular(vector, tolerance=1e-5)`

#### Lorentz (4D only):

- `t (E, energy)`: follows the `ROOT::Math::LorentzVector` behavior of treating spacelike vectors as negative `t` and negative `tau` and truncating wrong-direction timelike vectors
- `t2 (E2, energy2)`
- `tau (M, mass)`: see note above
- `tau2 (M2, mass2)`
- `beta`: scalar(s) between 0 (inclusive) and 1 (exclusive, unless the vector components are infinite)
- `deltaRapidityPhi`:  $\Delta R_{\text{rapidity}} = \Delta\phi^2 + \Delta\text{rapidity}^2$
- `deltaRapidityPhi2`: the above, squared
- `gamma`: scalar(s) between 1 (inclusive) and  $\infty$
- `rapidity`: scalar(s) between 0 (inclusive) and  $\infty$
- `boost_p4(four_vector)`: change coordinate system using another 4D vector as the difference
- `boost_beta(three_vector)`: change coordinate system using a 3D beta vector (all components between  $-1$  and  $+1$ )
- `boost(vector)`: uses the dimension of the given vector to determine behavior
- `boostX(beta=None, gamma=None)`: supply `beta` xor `gamma`, but not both
- `boostY(beta=None, gamma=None)`: supply `beta` xor `gamma`, but not both

- `boostZ(beta=None, gamma=None)`: supply beta xor gamma, but not both
- `transform4D(obj)`: the obj must supply components through `obj["xx"]`, `obj["xy"]`, etc.
- `to_beta3()`: turns a `four_vector` (for `boost_p4`) into a `three_vector` (for `boost_beta3`)
- `is_timelike(tolerance=0)`
- `is_spacelike(tolerance=0)`
- `is_lightlike(tolerance=1e-5)`: note the different tolerance

### All numbers of dimensions:

- `unit()`: note the parentheses
- `dot(vector)`: can also use the `@` operator
- `add(vector)`: can also use the `+` operator
- `subtract(vector)`: can also use the `-` operator
- `scale(factor)`: can also use the `*` operator
- `equal(vector)`: can also use the `==` operator, but consider `isclose` instead
- `not_equal(vector)`: can also use the `!=` operator, but consider `isclose` instead
- `sum()`: can also use the `numpy.sum` or `awkward.sum`, only for NumPy and Awkward vectors
- `count_nonzero()`: can also use `numpy.count_nonzero` or `awkward.count_nonzero`, only for NumPy and Awkward vectors
- `count()`: can also use `awkward.count`, only for Awkward vectors
- `isclose(vector, rtol=1e-5, atol=1e-8, equal_nan=False)`: works like `np.isclose`; arrays also have an `allclose` method
- `to_VectorND(coordinates)/to_ND(coordinates)`: replace N with the required vector dimension
- `to_{coordinate-names}`: for example - `to_rhophietatau`
- `like(other)`: projects the vector into the dimensions of `other`, for example - `two_d_vector.like(three_d_vector)`

## 2.1.4 Compiling your Python with Numba

Numba is a just-in-time (JIT) compiler for a mathematically relevant subset of NumPy and Python. It allows you to write fast code without leaving the Python environment. The drawback of Numba is that it can only compile code blocks involving objects and functions that it recognizes.

The Vector library includes extensions to inform Numba about vector objects, vector NumPy arrays, and vector Awkward Arrays. At the time of writing, the implementation of vector NumPy arrays is incomplete due to [numba/numba#6148](#).

For instance, consider the following function:

```
[108]: @nb.njit
def compute_mass(v1, v2):
    return (v1 + v2).mass

[109]: compute_mass(vector.obj(px=1, py=2, pz=3, E=4), vector.obj(px=-1, py=-2, pz=-3, E=4))
```

[109]: 8.0

When the two `MomentumObject4D` objects are passed as arguments, Numba recognizes them and replaces the Python objects with low-level structs. When it compiles the function, it recognizes `+` as the 4D add function and recognizes `.mass` as the tau component of the result.

Although this demonstrates that Numba can manipulate vector objects, there is no performance advantage (and a likely disadvantage) to compiling a calculation on just a few vectors. The advantage comes when many vectors are involved, in arrays.

```
[110]: # This is still not a large number. You want millions.
array = vector.Array(
    [
        [
            dict(
                {x: np.random.normal(0, 1) for x in ("px", "py", "pz")},
                E=np.random.normal(10, 1),
            )
            for inner in range(np.random.poisson(1.5))
        ]
        for outer in range(50)
    ]
)
array
```

[110]: <MomentumArray4D [[{x: 0.315, y: 0.693, ...}], ...] type='50 \* var \* Moment... '>

```
[111]: @nb.njit
def compute_masses(array):
    out = np.empty(len(array), np.float64)
    for i, event in enumerate(array):
        total = vector.obj(px=0.0, py=0.0, pz=0.0, E=0.0)
        for vec in event:
            total = total + vec
        out[i] = total.mass
    return out
```

[112]: compute\_masses(array)

```
[112]: array([ 9.1537046 , 16.76309287,  0.          ,  0.          , 19.91509641,
 10.54846375,  9.50567043, 50.02632217, 29.51323214, 15.98664711,
  9.45752217, 20.20656999, 38.98606898,  0.          ,  9.32749399,
  9.80117359, 10.70486904, 10.92982222, 35.85520701,  0.          ,
 29.04849791, 19.86279222, 10.31575156, 41.42782629, 11.75731099,
  9.81553407, 39.64420462, 20.78386006, 19.88365545,  8.76680915,
  9.54468769, 21.83630629,  8.90974542, 21.75954326, 19.27688599,
 10.06840737,  9.11771604, 10.78960379,  0.          , 10.55577844,
 19.37816397, 48.01216378,  0.          , 31.96752978, 28.30692309,
 28.78329415, 23.09265714,  0.          , 31.48155952,  7.83341747])
```

### 2.1.5 Talks about vector

- 9th October 2023 - What's new with Vector? First major release is out! - PyHEP 2023 (virtual)
- 13th September 2022 - Constructing HEP vectors and analyzing HEP data using Vector - PyHEP 2022 (virtual)
- 20th July 2022 - Analysis Grand Challenge / HEP Scientific Python Ecosystem - DANCE/CoDaS@Snowmass 2022 computational and data science software training
- 25th April 2022 - Foundation libraries (uproot, awkward, hist, mplhep) - IRIS-HEP AGC Tools 2022 Workshop
- 3rd November 2021 - Data handling: uproot, awkward & vector - IRIS-HEP AGC Tools 2021 Workshop

### Status as of November 17, 2023

First major release of vector is out and the package has reached a stable position. The work is spearheaded by bug reports and feature requests created on GitHub. It can only be improved by your feedback!

[ ]:

## 2.2 Structure of Vector



## TALKS ABOUT VECTOR

- 13th September 2022 - Constructing HEP vectors and analyzing HEP data using Vector - PyHEP 2022 (virtual)
- 20th July 2022 - Analysis Grand Challenge / HEP Scientific Python Ecosystem - DANCE/CoDaS@Snowmass 2022 computational and data science software training
- 25th April 2022 - Foundation libraries (uproot, awkward, hist, mplhep) - IRIS-HEP AGC Tools 2022 Workshop
- 3rd November 2021 - Data handling: uproot, awkward & vector - IRIS-HEP AGC Tools 2021 Workshop



## CHANGES IN VECTOR'S API

The `changelog` file describes the changes in `vector`'s API and usage introduced in every new version. These changes can be breaking changes or minor adjustments, hence one should go through this file and their existing codebase while updating `vector`'s version.

### 4.1 Changelog

#### 4.1.1 Version 1.4

##### Version 1.4.0

##### Features

- feat: allow coord values in `to_<coord_names>` methods [#446](#)
- feat: a sympy backend [#442](#)

##### Bug fixes

- fix: call the square implementation for power 2 on object vectors [#444](#)
- fix: use `negfactor` in `negfactor` scale test [#456](#)

##### Maintenance

- chore: test on numpy 2.0 [#451](#)

#### 4.1.2 Version 1.3

##### Version 1.3.1

##### Features

- feat: make momentum-ness infectious [#437](#)

### Bug fixes

- fix: support dask-awkward 2024.3.0 [#436](#)
- fix: momentum coords should not be repeated with generic coords in subclasses [#438](#)

### Version 1.3.0

#### Features

- feat: coordinate transformation functions with momentum names [#424](#)
- feat: allow momentum coords in `to_Vector*D` methods + cleanup [#423](#)
- feat: add a lite nox session + add numba as optional dependency [#431](#)
- feat: `like` method for projecting vector into the coordinate space of another vector + better type errors and hints [#426](#)
- feat: add support for dask-awkward arrays in vector constructors [#429](#)
- feat: short names for `to_VectorND` methods [#432](#)

### 4.1.3 Version 1.2

#### Version 1.2.0

#### Bug fixes

- fix: result of an infix operation should be demoted to the lowest possible dimension [#413](#)
- fix: all infix operations should not depend on the order of arguments [#413](#)
- fix: return the correct awkward record when performing an infix operation [#413](#)
- fix: respect user defined awkward mixin subclasses and projection classes [#413](#)

#### Documentation

- Update README and `intro.ipynb` to include the latest developments [#399](#)
- docs: add docs for `vector.zip` [#390](#)
- Fix `Vector*` mixin's docstring [#404](#)

#### Maintenance

- chore: repo review updates [#408](#)
- black -> ruff format [#414](#)
- chore: migrate to pytest-doctestplus [#416](#)

## 4.1.4 Version 1.1

### Version 1.1.1.post1

#### Maintenance

- chore: support Python 3.12 #388
- Fix CI badge in README and docs #386

### Version 1.1.1

#### Bug fixes

- fix: keepdims in `numpy.sum` should not be None #376

#### Maintenance

- chore: remove license string (not standard) #371
- chore: blackend-docs moved #370
- chore: use 2x faster black mirror #367
- chore: clean up VCS versioning #363
- chore: target-version no longer needed by Black or Ruff #359
- chore: ruff moved to astral-sh #358

### Version 1.1.0

#### Features

- feat: implement `sum`, `count`, and `count_nonzero` reductions #347

#### Maintenance

- chore: remove Python 3.7 support #355
- chore: use trusted publisher deployment #354
- chore: replace custom definition of `np.isclose` with numba's `np.isclose` #348

### 4.1.5 Version 1.0

#### Version 1.0.0

##### Features

- feat: add constructors for `VectorObject3D` and `MomentumObject3D` #231
- feat: add constructors for `VectorObject4D` and `MomentumObject4D` #232
- feat: update `to_Vector3D` to pass new coordinate values #278
- feat: allow passing coordinates to `to_Vector-D` #319

##### Bug fixes

- fix: better elif conditions for obj `__init__` methods #316

##### Documentation

- docs: a readable changelog #320

##### Maintenance

- ci: use `numpy~=1.24.0` in pre-commit #308
- fix: update `discheck` #305
- ci: update number of builds for codecov bot #314
- chore: move to using `Ruff` #315
- chore: update copyright and license for 2022 and 2023 #321

### 4.1.6 Version 0.11

#### Version 0.11.0

##### Features

- Add constructors for `VectorObject2D` and `MomentumObject2D` #89
- Add support for awkward v2 (and keep supporting v1) #284

## Bug fixes

- `vector.arr` should construct NumPy vectors #254
- Development dependency missing #280

## Documentation

- docs: add a section for talks #264
- docs: fix missing backslash in latex for readme #285
- docs: update changelog.md, PR template, and CONTRIBUTING.md #275
- docs: add a developer guide #233

## Maintenance

- chore: add PyLint and additional pre-commit hooks #260
- chore: pull request template-Priyadarshi #271
- chore: add issue templates #267
- chore: better and long term fix for flake8-bugbear #298
- chore: bump mypy and revert python-version #263
- chore: fix the failing mypy hook by pinning python-version #261
- chore: ignore flake8 B905 + improve bug report template #297
- chore: minor cleanups #266
- chore: test on awkward v1.10.0 and add cov to noxfile #256
- chore: use Python 3.11! #282
- chore: zenodo badge sync #269
- ci: test notebooks on PRs #272

## 4.1.7 Version 0.10

### Version 0.10.0

#### Maintenance

- Remove Python 3.6 support #251

## 4.1.8 Version 0.9

### Version 0.9.0

#### Features

- Implements `deltaRapidityPhi` and `deltaRapidityPhi2`. #175
- Remove underscores #192
- feat: add git archive support #244

#### Bug fixes

- fix bad values for high (abs) eta #172
- Add custom reprs to awkward coordinate classes #212
- Explicitly set `posinf` and `neginf` in `nan_to_num` so they stay infinite. #173
- Add type checks in constructors #210

#### Documentation

- Add Conda and Zenodo badges to the README-rodriques [#183][[#183](#)]
- Tests and docs for `deltaRapidityPhi` #187
- docs: fix intro notebook, and submodule and subpackage index #191
- docs: add codecov badge to README #203
- docs: fix warnings #193
- docs: add docstrings in the `backends.numpy` module #195
- docs: add docstrings in the `backends.object` module #201
- docs: improve the landing page and API docs structure #204
- docs: add docstrings in the `backends.awkward` module #207
- Implement doctests in CI #211
- docs: Add CITATION.cff Citation File Format file #243
- docs: update changelog [#248][[#248](#)]

#### Maintenance

- chore: wheel not required for setuptools PEP 517 (all-repos) #176
- fix: bump black to 22.3.0 due to click 8.1 release #181
- ci: fix a test and update CI to catch errors regularly #199
- chore: fix conda badge and update dependabot #213
- docs: render module level docstrings in documentation #218
- chore: pass repo review #219



- chore: migrate to hatchling #223
- chore: add codecov.yml #229
- chore: add pyproject-fmt pre-commit hook #230
- chore: remove redundant tool.check-manifest from pyproject.toml #235
- chore: support awkward v1 and v2 together #226
- chore: build and test on Python 3.10 and 3.11-dev #252

## 4.1.9 Version 0.8

### Version 0.8.5

- Added boostCM\_of to clarify #134, supported by scaled and negD #135
- Let 'eta' be NaN if 'z' is NaN #139
- Defined dot product without absolute value #148
- Fixed numpy array code examples in documentation #151
- Vector components may be NumpyArrayType or IndexedArrayType in Numba #162
- VectorNumpy pickle support to enable multiprocessing #163
- pre-commit and style cleanup #164

### Version 0.8.4

- Allow VectorObject, VectorNumpy, and VectorAwkward to be subclassed by other projects #128

### Version 0.8.3

- Fixed Awkward Arrays of momentum vectors in Numba #112

### Version 0.8.2

- Fixed missing momentum synonyms in CoordinatesAwkward #84
- Added vector.zip #94
- Allowed lowercase e and m for energy and mass #95
- Fixed \_wrap\_result for methods called on an ak.Record #100
- Fixed error in calculation of deltaangle #105
- Fixed Awkward version check #82
- Pinned Python version for dis (in tests) #90
- Using myst-parser (in docs) #91

### Version 0.8.1

- Fix issue importing without Awkward installed [#76](#)

### Version 0.8.0

First release to PyPI. Initial implementation. Initial features:

- 2D, 3D, and Lorentz vectors
- Single, Array, and Awkward forms
- Supports Numba / Awkward + Numba
- Multiple coordinate systems
- Geometric / momentum versions
- Statically typed

You can currently construct vectors using `obj/arr/awk` (or `obj/array/Array`) for single, NumPy, and Awkward vectors, respectively. The next version is likely to improve the vector construction process.

## GETTING HELP

- Vector's code is hosted on [GitHub](#).
- If something is not working the way it should, or if you want to request a new feature, create a new [issue](#) on GitHub.
- To discuss something related to `vector`, use the [discussions](#) tab on GitHub or `vector`'s gitter ([Scikit-HEP/vector](#)) chat room.



## **CONTRIBUTING TO VECTOR**

If you are planning to develop `vector` (thank you!), or if you want to use the latest commit of `vector` on your local machine, you might want to install it from the source. Refer to our [Contributing Guidelines](#) for more information.



## API REFERENCE

The API reference details the functionality of each `class` and `function` present in `vector`'s codebase.

### 7.1 `vector`

#### 7.1.1 `vector` package

##### Subpackages

##### `vector.backends` package

Vector comes loaded with 3 + 2 backends; a pure Python object backend, a NumPy backend, an Awkward Array backend, an Object-Numba, and an Awkward-Numba backend to leverage JIT (Just In Time) compiled calculations on vectors. Other potential future vanilla backends include Tensorflow and JAX, and other possible future Numba-backends include Numba-NumPy.

##### Submodules

##### `vector.backends.object` module

Defines behaviors for Object vectors. New vectors created with the respective classes

```
vector.VectorObject2D(...)  
vector.VectorObject3D(...)
```

will have these behaviors built in (and will pass them to any derived objects).

The class methods can also be used to construct object type vectors -

```
vec = vector.VectorObject2D.from_xy(1, 2)
```

Additionally, object type vectors can also be constructed using -

```
vector.obj(...)
```

function.

**class** `vector.backends.object.AzimuthalObject`

Bases: `CoordinatesObject`, `Azimuthal`

Azimuthal class for the Object backend.

**class** `vector.backends.object.AzimuthalObjectRhoPhi(rho: float, phi: float)`

Bases: `AzimuthalObject`, `AzimuthalRhoPhi`, `TupleRhoPhi`

Class for the rho and phi (azimuthal) coordinates of Object backend. Use the `elements` property to retrieve the coordinates.

**property** `elements: tuple[float, float]`

Azimuthal coordinates (rho and phi) as a tuple. Each coordinate is a scalar and not a vector.

### Examples

```
>>> import vector
>>> v = vector.VectorObject2D(rho=1, phi=2)
>>> az = v.azimuthal
>>> az.elements
(1, 2)
```

**class** `vector.backends.object.AzimuthalObjectXY(x: float, y: float)`

Bases: `AzimuthalObject`, `AzimuthalXY`, `TupleXY`

Class for the x and y (azimuthal) coordinates of Object backend. Use the `elements` property to retrieve the coordinates.

**property** `elements: tuple[float, float]`

Azimuthal coordinates (x and y) as a tuple. Each coordinate is a scalar and not a vector.

### Examples

```
>>> import vector
>>> v = vector.VectorObject2D(x=1, y=2)
>>> az = v.azimuthal
>>> az.elements
(1, 2)
```

**class** `vector.backends.object.CoordinatesObject`

Bases: `object`

Coordinates class for the Object backend.

**class** `vector.backends.object.LongitudinalObject`

Bases: `CoordinatesObject`, `Longitudinal`

Longitudinal class for the Object backend.

**class** `vector.backends.object.LongitudinalObjectEta(eta: float)`

Bases: `LongitudinalObject`, `LongitudinalEta`, `TupleEta`

Class for the eta (longitudinal) coordinate of Object backend. Use the `elements` property to retrieve the coordinates.

**property** `elements: tuple[float]`

Longitudinal coordinates (theta) as a tuple. Each coordinate is a scalar and not a vector.



## Examples

```
>>> import vector
>>> v = vector.obj(rho=1, phi=2, eta=3)
>>> lc = v.longitudinal
>>> lc.elements
(3,)
```

**class** `vector.backends.object.LongitudinalObjectTheta(theta: float)`

Bases: *LongitudinalObject*, *LongitudinalTheta*, *TupleTheta*

Class for the theta (longitudinal) coordinate of Object backend. Use the `elements` property to retrieve the coordinates.

**property** `elements: tuple[float]`

Longitudinal coordinates (theta) as a tuple. Each coordinate is a scalar and not a vector.

## Examples

```
>>> import vector
>>> v = vector.obj(rho=1, phi=2, theta=3)
>>> lc = v.longitudinal
>>> lc.elements
(3,)
```

**class** `vector.backends.object.LongitudinalObjectZ(z: float)`

Bases: *LongitudinalObject*, *LongitudinalZ*, *TupleZ*

Class for the z (longitudinal) coordinate of Object backend. Use the `elements` property to retrieve the coordinates.

**property** `elements: tuple[float]`

Longitudinal coordinates (z) as a tuple. Each coordinate is a scalar and not a vector.

## Examples

```
>>> import vector
>>> v = vector.obj(rho=1, phi=2, z=3)
>>> lc = v.longitudinal
>>> lc.elements
(3,)
```

**class** `vector.backends.object.MomentumObject2D(*, x: float, y: float)`

**class** `vector.backends.object.MomentumObject2D(*, rho: float, phi: float)`

**class** `vector.backends.object.MomentumObject2D(*, x: float, y: float, z: float)`

**class** `vector.backends.object.MomentumObject2D(*, x: float, y: float, eta: float)`

**class** `vector.backends.object.MomentumObject2D(*, x: float, y: float, theta: float)`

**class** `vector.backends.object.MomentumObject2D(*, rho: float, phi: float, z: float)`

**class** `vector.backends.object.MomentumObject2D(*, rho: float, phi: float, eta: float)`

**class** `vector.backends.object.MomentumObject2D(*, rho: float, phi: float, theta: float)`

**class** `vector.backends.object.MomentumObject2D(*, px: float, py: float)`









```
class vector.backends.object.MomentumObject2D(*, pm: float, phi: float, pz: float, m: float)
class vector.backends.object.MomentumObject2D(*, x: float, y: float, theta: float, m: float)
class vector.backends.object.MomentumObject2D(*, x: float, py: float, theta: float, m: float)
class vector.backends.object.MomentumObject2D(*, px: float, y: float, theta: float, m: float)
class vector.backends.object.MomentumObject2D(*, px: float, py: float, theta: float, m: float)
class vector.backends.object.MomentumObject2D(*, rho: float, phi: float, theta: float, m: float)
class vector.backends.object.MomentumObject2D(*, pm: float, phi: float, theta: float, m: float)
class vector.backends.object.MomentumObject2D(*, x: float, y: float, eta: float, m: float)
class vector.backends.object.MomentumObject2D(*, x: float, py: float, eta: float, m: float)
class vector.backends.object.MomentumObject2D(*, px: float, y: float, eta: float, m: float)
class vector.backends.object.MomentumObject2D(*, px: float, py: float, eta: float, m: float)
class vector.backends.object.MomentumObject2D(*, rho: float, phi: float, eta: float, m: float)
class vector.backends.object.MomentumObject2D(*, pm: float, phi: float, eta: float, m: float)
class vector.backends.object.MomentumObject2D(*, x: float, y: float, z: float, mass: float)
class vector.backends.object.MomentumObject2D(*, x: float, y: float, pz: float, mass: float)
class vector.backends.object.MomentumObject2D(*, x: float, py: float, z: float, mass: float)
class vector.backends.object.MomentumObject2D(*, x: float, py: float, pz: float, mass: float)
class vector.backends.object.MomentumObject2D(*, px: float, y: float, z: float, mass: float)
class vector.backends.object.MomentumObject2D(*, px: float, y: float, pz: float, mass: float)
class vector.backends.object.MomentumObject2D(*, px: float, py: float, z: float, mass: float)
class vector.backends.object.MomentumObject2D(*, px: float, py: float, pz: float, mass: float)
class vector.backends.object.MomentumObject2D(*, rho: float, phi: float, z: float, mass: float)
class vector.backends.object.MomentumObject2D(*, rho: float, phi: float, pz: float, mass: float)
class vector.backends.object.MomentumObject2D(*, pt: float, phi: float, z: float, mass: float)
class vector.backends.object.MomentumObject2D(*, pt: float, phi: float, pz: float, mass: float)
class vector.backends.object.MomentumObject2D(*, x: float, y: float, theta: float, mass: float)
class vector.backends.object.MomentumObject2D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.object.MomentumObject2D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.object.MomentumObject2D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.object.MomentumObject2D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.object.MomentumObject2D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.object.MomentumObject2D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.object.MomentumObject2D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.object.MomentumObject2D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.object.MomentumObject2D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.object.MomentumObject2D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.object.MomentumObject2D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.object.MomentumObject2D(__azumthal: Azimuthal)
class vector.backends.object.MomentumObject2D(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.object.MomentumObject2D(__azumthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)
```

Bases: [PlanarMomentum](#), [VectorObject2D](#)

Two dimensional momentum vector class for the object backend.

## Examples

```
>>> import vector
>>> vec = vector.MomentumObject2D(px=1, py=2)
>>> vec.px, vec.py
(1, 2)
>>> vec = vector.MomentumObject2D(pt=1, phi=2)
>>> vec.pt, vec.phi
(1, 2)
>>> vec = vector.MomentumObject2D(azimuthal=vector.backends.object.
↳AzimuthalObjectXY(1, 2))
>>> vec.px, vec.py
(1, 2)
```

The `vector.obj()` function can also be used to construct 2D momentum object type vectors.

For two dimensional vector objects, see [vector.backends.object.VectorObject2D](#).

### GenericClass

alias of [VectorObject2D](#)

### MomentumClass

alias of [MomentumObject2D](#)

### ProjectionClass2D

alias of [MomentumObject2D](#)

### ProjectionClass3D

alias of [MomentumObject3D](#)

### ProjectionClass4D

alias of [MomentumObject4D](#)

**azimuthal:** [AzimuthalObject](#)

**property pt: float**

Momentum-synonym for [vector.\\_methods.VectorProtocolPlanar.rho](#).

**property px: float**

Momentum-synonym for [vector.\\_methods.VectorProtocolPlanar.x](#).

**property py: float**

Momentum-synonym for [vector.\\_methods.VectorProtocolPlanar.y](#).

```
class vector.backends.object.MomentumObject3D(*, x: float, y: float)
class vector.backends.object.MomentumObject3D(*, rho: float, phi: float)
class vector.backends.object.MomentumObject3D(*, x: float, y: float, z: float)
class vector.backends.object.MomentumObject3D(*, x: float, y: float, eta: float)
class vector.backends.object.MomentumObject3D(*, x: float, y: float, theta: float)
class vector.backends.object.MomentumObject3D(*, rho: float, phi: float, z: float)
class vector.backends.object.MomentumObject3D(*, rho: float, phi: float, eta: float)
class vector.backends.object.MomentumObject3D(*, rho: float, phi: float, theta: float)
class vector.backends.object.MomentumObject3D(*, px: float, py: float)
class vector.backends.object.MomentumObject3D(*, x: float, py: float)
class vector.backends.object.MomentumObject3D(*, px: float, y: float)
```





[illegible]





```
class vector.backends.object.MomentumObject3D(*, x: float, py: float, theta: float, m: float)
class vector.backends.object.MomentumObject3D(*, px: float, y: float, theta: float, m: float)
class vector.backends.object.MomentumObject3D(*, px: float, py: float, theta: float, m: float)
class vector.backends.object.MomentumObject3D(*, rho: float, phi: float, theta: float, m: float)
class vector.backends.object.MomentumObject3D(*, pm: float, phi: float, theta: float, m: float)
class vector.backends.object.MomentumObject3D(*, x: float, y: float, eta: float, m: float)
class vector.backends.object.MomentumObject3D(*, x: float, py: float, eta: float, m: float)
class vector.backends.object.MomentumObject3D(*, px: float, y: float, eta: float, m: float)
class vector.backends.object.MomentumObject3D(*, px: float, py: float, eta: float, m: float)
class vector.backends.object.MomentumObject3D(*, rho: float, phi: float, eta: float, m: float)
class vector.backends.object.MomentumObject3D(*, pm: float, phi: float, eta: float, m: float)
class vector.backends.object.MomentumObject3D(*, x: float, y: float, z: float, mass: float)
class vector.backends.object.MomentumObject3D(*, x: float, y: float, pz: float, mass: float)
class vector.backends.object.MomentumObject3D(*, x: float, py: float, z: float, mass: float)
class vector.backends.object.MomentumObject3D(*, x: float, py: float, pz: float, mass: float)
class vector.backends.object.MomentumObject3D(*, px: float, y: float, z: float, mass: float)
class vector.backends.object.MomentumObject3D(*, px: float, y: float, pz: float, mass: float)
class vector.backends.object.MomentumObject3D(*, px: float, py: float, z: float, mass: float)
class vector.backends.object.MomentumObject3D(*, px: float, py: float, pz: float, mass: float)
class vector.backends.object.MomentumObject3D(*, rho: float, phi: float, z: float, mass: float)
class vector.backends.object.MomentumObject3D(*, rho: float, phi: float, pz: float, mass: float)
class vector.backends.object.MomentumObject3D(*, pt: float, phi: float, z: float, mass: float)
class vector.backends.object.MomentumObject3D(*, pt: float, phi: float, pz: float, mass: float)
class vector.backends.object.MomentumObject3D(*, x: float, y: float, theta: float, mass: float)
class vector.backends.object.MomentumObject3D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.object.MomentumObject3D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.object.MomentumObject3D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.object.MomentumObject3D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.object.MomentumObject3D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.object.MomentumObject3D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.object.MomentumObject3D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.object.MomentumObject3D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.object.MomentumObject3D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.object.MomentumObject3D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.object.MomentumObject3D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.object.MomentumObject3D(__azumthal: Azimuthal)
class vector.backends.object.MomentumObject3D(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.object.MomentumObject3D(__azumthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)
```

Bases: [SpatialMomentum](#), [VectorObject3D](#)

Three dimensional momentum vector class for the object backend.

## Examples

```
>>> import vector
>>> vec = vector.MomentumObject3D(px=1, py=2, pz=3)
>>> vec.px, vec.py, vec.pz
(1, 2, 3)
>>> vec = vector.MomentumObject3D(pt=1, phi=2, pz=3)
>>> vec.pt, vec.phi, vec.pz
(1, 2, 3)
>>> vec = vector.MomentumObject3D(
...     azimuthal=vector.backends.object.AzimuthalObjectXY(1, 2),
...     longitudinal=vector.backends.object.LongitudinalObjectTheta(3)
... )
>>> vec.x, vec.y, vec.theta
(1, 2, 3)
```

The `vector.obj()` function can also be used to construct 3D momentum object type vectors.

For three dimensional vector objects, see [`vector.backends.object.VectorObject3D`](#).

### GenericClass

alias of [`VectorObject3D`](#)

### MomentumClass

alias of [`MomentumObject3D`](#)

### ProjectionClass2D

alias of [`MomentumObject2D`](#)

### ProjectionClass3D

alias of [`MomentumObject3D`](#)

### ProjectionClass4D

alias of [`MomentumObject4D`](#)

**azimuthal:** [`AzimuthalObject`](#)

**longitudinal:** [`LongitudinalObject`](#)

**property pt: float**

Momentum-synonym for [`vector.\_methods.VectorProtocolPlanar.rho`](#).

**property px: float**

Momentum-synonym for [`vector.\_methods.VectorProtocolPlanar.x`](#).

**property py: float**

Momentum-synonym for [`vector.\_methods.VectorProtocolPlanar.y`](#).

**property pz: float**

Momentum-synonym for [`vector.\_methods.VectorProtocolSpatial.z`](#).

```
class vector.backends.object.MomentumObject4D(*, x: float, y: float)
```

```
class vector.backends.object.MomentumObject4D(*, rho: float, phi: float)
```

```
class vector.backends.object.MomentumObject4D(*, x: float, y: float, z: float)
```

```
class vector.backends.object.MomentumObject4D(*, x: float, y: float, eta: float)
```

```
class vector.backends.object.MomentumObject4D(*, x: float, y: float, theta: float)
```



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[illegible]



```
class vector.backends.object.MomentumObject4D(__azimuthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)
```

Bases: [LorentzMomentum](#), [VectorObject4D](#)

Four dimensional momentum vector class for the object backend.

## Examples

```
>>> import vector
>>> vec = vector.MomentumObject4D(px=1, py=2, pz=3, t=4)
>>> vec.px, vec.py, vec.pz, vec.t
(1, 2, 3, 4)
>>> vec = vector.MomentumObject4D(pt=1, phi=2, pz=3, M=4)
>>> vec.pt, vec.phi, vec.pz, vec.M
(1, 2, 3, 4)
>>> vec = vector.MomentumObject4D(
...     azimuthal=vector.backends.object.AzimuthalObjectXY(1, 2),
...     longitudinal=vector.backends.object.LongitudinalObjectTheta(3),
...     temporal=vector.backends.object.TemporalObjectTau(4)
... )
>>> vec.x, vec.y, vec.theta, vec.tau
(1, 2, 3, 4)
```

The `vector.obj()` function can also be used to construct 4D momentum object type vectors.

For four dimensional vector objects, see [vector.backends.object.VectorObject4D](#).

### property E: float

Momentum-synonyor [vector.\\_methods.VectorProtocolLorentz.t](#).

### GenericClass

alias of [VectorObject4D](#)

### property M: float

Momentum-synonym for [vector.\\_methods.VectorProtocolLorentz.tau](#).

### MomentumClass

alias of [MomentumObject4D](#)

### ProjectionClass2D

alias of [MomentumObject2D](#)

### ProjectionClass3D

alias of [MomentumObject3D](#)

### ProjectionClass4D

alias of [MomentumObject4D](#)

### azimuthal: [AzimuthalObject](#)

### property e: float

Momentum-synonym for [vector.\\_methods.VectorProtocolLorentz.t](#).

### property energy: float

Momentum-synonym for [vector.\\_methods.VectorProtocolLorentz.t](#).

**longitudinal:** *LongitudinalObject*

**property m:** float

Momentum-synonym for *vector.\_methods.VectorProtocolLorentz.tau*.

**property mass:** float

Momentum-synonym for *vector.\_methods.VectorProtocolLorentz.tau*.

**property pt:** float

Momentum-synonym for *vector.\_methods.VectorProtocolPlanar.rho*.

**property px:** float

Momentum-synonym for *vector.\_methods.VectorProtocolPlanar.x*.

**property py:** float

Momentum-synonym for *vector.\_methods.VectorProtocolPlanar.y*.

**property pz:** float

Momentum-synonym for *vector.\_methods.VectorProtocolSpatial.z*.

**temporal:** *TemporalObject*

**class** *vector.backends.object.TemporalObject*

Bases: *CoordinatesObject*, *Temporal*

Temporal class for the Object backend.

**class** *vector.backends.object.TemporalObjectT(t: float)*

Bases: *TemporalObject*, *TemporalT*, *TupleT*

Class for the t (temporal) coordinate of Object backend. Use the `elements` property to retrieve the coordinates.

**property elements:** tuple[float]

Temporal coordinates (t) as a tuple. Each coordinate is a scalar and not a vector.

### Examples

```
>>> import vector
>>> v = vector.obj(rho=1, phi=2, theta=3, t=4)
>>> tc = v.temporal
>>> tc.elements
(4,)
```

**class** *vector.backends.object.TemporalObjectTau(tau: float)*

Bases: *TemporalObject*, *TemporalTau*, *TupleTau*

Class for the tau (temporal) coordinate of Object backend. Use the `elements` property to retrieve the coordinates.

**property elements:** tuple[float]

Temporal coordinates (tau) as a tuple. Each coordinate is a scalar and not a vector.

## Examples

```
>>> import vector
>>> v = vector.obj(rho=1, phi=2, theta=3, tau=4)
>>> tc = v.temporal
>>> tc.elements
(4,)
```

**class** vector.backends.object.**TupleEta**(eta: float)

Bases: NamedTuple

eta coordinate as a NamedTuple.

**\_asdict**()

Return a new dict which maps field names to their values.

**\_field\_defaults** = {}

**\_fields** = ('eta',)

**classmethod** **\_make**(iterable)

Make a new TupleEta object from a sequence or iterable

**\_replace**(\*\*kws)

Return a new TupleEta object replacing specified fields with new values

**eta**: float

Alias for field number 0

**class** vector.backends.object.**TupleRhoPhi**(rho: float, phi: float)

Bases: NamedTuple

rho and phi coordinates as a NamedTuple.

**\_asdict**()

Return a new dict which maps field names to their values.

**\_field\_defaults** = {}

**\_fields** = ('rho', 'phi')

**classmethod** **\_make**(iterable)

Make a new TupleRhoPhi object from a sequence or iterable

**\_replace**(\*\*kws)

Return a new TupleRhoPhi object replacing specified fields with new values

**phi**: float

Alias for field number 1

**rho**: float

Alias for field number 0

**class** vector.backends.object.**TupleT**(t: float)

Bases: NamedTuple

t coordinate as a NamedTuple.

**\_asdict()**

Return a new dict which maps field names to their values.

**\_field\_defaults = {}**

**\_fields = ('t',)**

**classmethod \_make(*iterable*)**

Make a new TupleT object from a sequence or iterable

**\_replace(\*\**kws*)**

Return a new TupleT object replacing specified fields with new values

**t: float**

Alias for field number 0

**class** vector.backends.object.**TupleTau**(*tau: float*)

Bases: NamedTuple

tau coordinate as a NamedTuple.

**\_asdict()**

Return a new dict which maps field names to their values.

**\_field\_defaults = {}**

**\_fields = ('tau',)**

**classmethod \_make(*iterable*)**

Make a new TupleTau object from a sequence or iterable

**\_replace(\*\**kws*)**

Return a new TupleTau object replacing specified fields with new values

**tau: float**

Alias for field number 0

**class** vector.backends.object.**TupleTheta**(*theta: float*)

Bases: NamedTuple

theta coordinates as a NamedTuple.

**\_asdict()**

Return a new dict which maps field names to their values.

**\_field\_defaults = {}**

**\_fields = ('theta',)**

**classmethod \_make(*iterable*)**

Make a new TupleTheta object from a sequence or iterable

**\_replace(\*\**kws*)**

Return a new TupleTheta object replacing specified fields with new values

**theta: float**

Alias for field number 0

---

```

class vector.backends.object.TupleXY(x: float, y: float)
    Bases: NamedTuple
    x and y coordinates as a NamedTuple.
    _asdict()
        Return a new dict which maps field names to their values.
    _field_defaults = {}
    _fields = ('x', 'y')
    classmethod _make(iterable)
        Make a new TupleXY object from a sequence or iterable
    _replace(**kws)
        Return a new TupleXY object replacing specified fields with new values
    x: float
        Alias for field number 0
    y: float
        Alias for field number 1
class vector.backends.object.TupleZ(z: float)
    Bases: NamedTuple
    z coordinate as a NamedTuple.
    _asdict()
        Return a new dict which maps field names to their values.
    _field_defaults = {}
    _fields = ('z',)
    classmethod _make(iterable)
        Make a new TupleZ object from a sequence or iterable
    _replace(**kws)
        Return a new TupleZ object replacing specified fields with new values
    z: float
        Alias for field number 0
class vector.backends.object.VectorObject(*, x: float, y: float)
class vector.backends.object.VectorObject(*, rho: float, phi: float)
class vector.backends.object.VectorObject(*, x: float, y: float, z: float)
class vector.backends.object.VectorObject(*, x: float, y: float, eta: float)
class vector.backends.object.VectorObject(*, x: float, y: float, theta: float)
class vector.backends.object.VectorObject(*, rho: float, phi: float, z: float)
class vector.backends.object.VectorObject(*, rho: float, phi: float, eta: float)
class vector.backends.object.VectorObject(*, rho: float, phi: float, theta: float)
class vector.backends.object.VectorObject(*, px: float, py: float)
class vector.backends.object.VectorObject(*, x: float, py: float)
class vector.backends.object.VectorObject(*, px: float, y: float)

```











```
class vector.backends.object.VectorObject(*, x: float, py: float, theta: float, m: float)
class vector.backends.object.VectorObject(*, px: float, y: float, theta: float, m: float)
class vector.backends.object.VectorObject(*, px: float, py: float, theta: float, m: float)
class vector.backends.object.VectorObject(*, rho: float, phi: float, theta: float, m: float)
class vector.backends.object.VectorObject(*, pm: float, phi: float, theta: float, m: float)
class vector.backends.object.VectorObject(*, x: float, y: float, eta: float, m: float)
class vector.backends.object.VectorObject(*, x: float, py: float, eta: float, m: float)
class vector.backends.object.VectorObject(*, px: float, y: float, eta: float, m: float)
class vector.backends.object.VectorObject(*, px: float, py: float, eta: float, m: float)
class vector.backends.object.VectorObject(*, rho: float, phi: float, eta: float, m: float)
class vector.backends.object.VectorObject(*, pm: float, phi: float, eta: float, m: float)
class vector.backends.object.VectorObject(*, x: float, y: float, z: float, mass: float)
class vector.backends.object.VectorObject(*, x: float, y: float, pz: float, mass: float)
class vector.backends.object.VectorObject(*, x: float, py: float, z: float, mass: float)
class vector.backends.object.VectorObject(*, x: float, py: float, pz: float, mass: float)
class vector.backends.object.VectorObject(*, px: float, y: float, z: float, mass: float)
class vector.backends.object.VectorObject(*, px: float, y: float, pz: float, mass: float)
class vector.backends.object.VectorObject(*, px: float, py: float, z: float, mass: float)
class vector.backends.object.VectorObject(*, px: float, py: float, pz: float, mass: float)
class vector.backends.object.VectorObject(*, rho: float, phi: float, z: float, mass: float)
class vector.backends.object.VectorObject(*, rho: float, phi: float, pz: float, mass: float)
class vector.backends.object.VectorObject(*, pt: float, phi: float, z: float, mass: float)
class vector.backends.object.VectorObject(*, pt: float, phi: float, pz: float, mass: float)
class vector.backends.object.VectorObject(*, x: float, y: float, theta: float, mass: float)
class vector.backends.object.VectorObject(*, x: float, py: float, theta: float, mass: float)
class vector.backends.object.VectorObject(*, px: float, y: float, theta: float, mass: float)
class vector.backends.object.VectorObject(*, px: float, py: float, theta: float, mass: float)
class vector.backends.object.VectorObject(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.object.VectorObject(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.object.VectorObject(*, x: float, y: float, eta: float, mass: float)
class vector.backends.object.VectorObject(*, x: float, py: float, eta: float, mass: float)
class vector.backends.object.VectorObject(*, px: float, y: float, eta: float, mass: float)
class vector.backends.object.VectorObject(*, px: float, py: float, eta: float, mass: float)
class vector.backends.object.VectorObject(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.object.VectorObject(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.object.VectorObject(__azumthal: Azimuthal)
class vector.backends.object.VectorObject(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.object.VectorObject(__azumthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)
```

Bases: [Vector](#)

Mixin class for Object vectors.

---

```
lib = <module 'numpy' from '/home/docs/checkouts/readthedocs.org/user_builds/vector/
envs/latest/lib/python3.12/site-packages/numpy/__init__.py'>
```

```
class vector.backends.object.VectorObject2D(*, x: float, y: float)
class vector.backends.object.VectorObject2D(*, rho: float, phi: float)
class vector.backends.object.VectorObject2D(*, x: float, y: float, z: float)
class vector.backends.object.VectorObject2D(*, x: float, y: float, eta: float)
class vector.backends.object.VectorObject2D(*, x: float, y: float, theta: float)
class vector.backends.object.VectorObject2D(*, rho: float, phi: float, z: float)
class vector.backends.object.VectorObject2D(*, rho: float, phi: float, eta: float)
class vector.backends.object.VectorObject2D(*, rho: float, phi: float, theta: float)
class vector.backends.object.VectorObject2D(*, px: float, py: float)
class vector.backends.object.VectorObject2D(*, x: float, py: float)
class vector.backends.object.VectorObject2D(*, px: float, y: float)
class vector.backends.object.VectorObject2D(*, pt: float, phi: float)
class vector.backends.object.VectorObject2D(*, x: float, y: float, pz: float)
class vector.backends.object.VectorObject2D(*, x: float, py: float, z: float)
class vector.backends.object.VectorObject2D(*, x: float, py: float, pz: float)
class vector.backends.object.VectorObject2D(*, px: float, y: float, z: float)
class vector.backends.object.VectorObject2D(*, px: float, y: float, pz: float)
class vector.backends.object.VectorObject2D(*, px: float, py: float, z: float)
class vector.backends.object.VectorObject2D(*, px: float, py: float, pz: float)
class vector.backends.object.VectorObject2D(*, rho: float, phi: float, pz: float)
class vector.backends.object.VectorObject2D(*, pt: float, phi: float, z: float)
class vector.backends.object.VectorObject2D(*, pt: float, phi: float, pz: float)
class vector.backends.object.VectorObject2D(*, x: float, py: float, theta: float)
class vector.backends.object.VectorObject2D(*, px: float, y: float, theta: float)
class vector.backends.object.VectorObject2D(*, px: float, py: float, theta: float)
class vector.backends.object.VectorObject2D(*, pt: float, phi: float, theta: float)
class vector.backends.object.VectorObject2D(*, x: float, py: float, eta: float)
class vector.backends.object.VectorObject2D(*, px: float, y: float, eta: float)
class vector.backends.object.VectorObject2D(*, px: float, py: float, eta: float)
class vector.backends.object.VectorObject2D(*, pt: float, phi: float, eta: float)
class vector.backends.object.VectorObject2D(*, x: float, y: float, z: float, t: float)
class vector.backends.object.VectorObject2D(*, x: float, y: float, pz: float, t: float)
class vector.backends.object.VectorObject2D(*, x: float, py: float, z: float, t: float)
class vector.backends.object.VectorObject2D(*, x: float, py: float, pz: float, t: float)
class vector.backends.object.VectorObject2D(*, px: float, y: float, z: float, t: float)
class vector.backends.object.VectorObject2D(*, px: float, y: float, pz: float, t: float)
class vector.backends.object.VectorObject2D(*, px: float, py: float, z: float, t: float)
class vector.backends.object.VectorObject2D(*, px: float, py: float, pz: float, t: float)
class vector.backends.object.VectorObject2D(*, rho: float, phi: float, z: float, t: float)
class vector.backends.object.VectorObject2D(*, rho: float, phi: float, pz: float, t: float)
class vector.backends.object.VectorObject2D(*, pt: float, phi: float, z: float, t: float)
```











```
class vector.backends.object.VectorObject2D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.object.VectorObject2D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.object.VectorObject2D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.object.VectorObject2D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.object.VectorObject2D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.object.VectorObject2D(__azumthal: Azimuthal)
class vector.backends.object.VectorObject2D(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.object.VectorObject2D(__azumthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)
```

Bases: [VectorObject](#), [Planar](#), [Vector2D](#)

Two dimensional vector class for the object backend.

## Examples

```
>>> import vector
>>> vec = vector.VectorObject2D(x=1, y=2)
>>> vec.x, vec.y
(1, 2)
>>> vec = vector.VectorObject2D(rho=1, phi=2)
>>> vec.rho, vec.phi
(1, 2)
>>> vec = vector.VectorObject2D(azimuthal=vector.backends.object.
↪AzimuthalObjectXY(1, 2))
>>> vec.x, vec.y
(1, 2)
```

The following class methods can also be used to construct 2D object type vectors -

- [VectorObject2D.from\\_xy\(\)](#)
- [VectorObject2D.from\\_rhophi\(\)](#)

Additionally, the `vector.obj()` function can also be used to construct 2D object type vectors.

For two dimensional momentum vector objects, see [vector.backends.object.MomentumObject2D](#).

### GenericClass

alias of [VectorObject2D](#)

### MomentumClass

alias of [MomentumObject2D](#)

### ProjectionClass2D

alias of [VectorObject2D](#)

### ProjectionClass3D

alias of [VectorObject3D](#)

### ProjectionClass4D

alias of [VectorObject4D](#)

`_wrap_result(cls: Any, result: Any, returns: Any, num_vecargs: Any) → Any`

Wraps the raw result of a compute function as a scalar or a vector.

### Parameters

- **result** – Value or tuple of values from a compute function.
- **returns** – Signature from a `dispatch_map`.
- **num\_vecargs** (*int*) – Number of vector arguments in the function that would be treated on an equal footing (i.e. `add` has two, but `rotate_axis` has only one: the axis is secondary).

**azimuthal:** *AzimuthalObject*

**classmethod** `from_rhophi` (*rho: float, phi: float*) → *VectorObject2D*

Constructs a *VectorObject2D* from polar coordinates.

Use *vector.backends.object.MomentumObject2D* to construct a vector with momentum properties and methods.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject2D.from_rhophi(1, 2)
>>> vec
VectorObject2D(rho=1, phi=2)
```

**classmethod** `from_xy` (*x: float, y: float*) → *VectorObject2D*

Constructs a *VectorObject2D* from Cartesian coordinates.

Use *vector.backends.object.MomentumObject2D* to construct a vector with momentum properties and methods.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject2D.from_xy(1, 2)
>>> vec
VectorObject2D(x=1, y=2)
```

**property** `phi: float`

The polar  $\phi$  coordinate of the vector or every vector in the array (in radians, always between  $-\pi$  and  $\pi$ ).

**property** `rho: float`

The polar  $\rho$  coordinate of the vector or every vector in the array.

This is also the magnitude of the 2D azimuthal part of the vector (not including any longitudinal or temporal parts).

**property** `x: float`

The Cartesian  $x$  coordinate of the vector or every vector in the array.

**property** `y: float`

The Cartesian  $y$  coordinate of the vector or every vector in the array.

**class** `vector.backends.object.VectorObject3D` (\*, *x: float, y: float*)

**class** `vector.backends.object.VectorObject3D` (\*, *rho: float, phi: float*)

**class** `vector.backends.object.VectorObject3D` (\*, *x: float, y: float, z: float*)

**class** `vector.backends.object.VectorObject3D` (\*, *x: float, y: float, eta: float*)

**class** `vector.backends.object.VectorObject3D` (\*, *x: float, y: float, theta: float*)













```
class vector.backends.object.VectorObject3D(__azimuthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)
```

Bases: *VectorObject*, *Spatial*, *Vector3D*

Three dimensional vector class for the object backend. Use the class methods -

### Examples

```
>>> import vector
>>> vec = vector.VectorObject3D(x=1, y=2, z=3)
>>> vec.x, vec.y, vec.z
(1, 2, 3)
>>> vec = vector.VectorObject3D(rho=1, phi=2, eta=3)
>>> vec.rho, vec.phi, vec.eta
(1, 2, 3)
>>> vec = vector.VectorObject3D(
...     azimuthal=vector.backends.object.AzimuthalObjectXY(1, 2),
...     longitudinal=vector.backends.object.LongitudinalObjectTheta(3)
... )
>>> vec.x, vec.y, vec.theta
(1, 2, 3)
```

The following class methods can also be used to construct 3D object type vectors -

- *VectorObject3D.from\_xyz()*
- *VectorObject3D.from\_xytheta()*
- *VectorObject3D.from\_xyeta()*
- *VectorObject3D.from\_rhophiz()*
- *VectorObject3D.from\_rhophitheta()*
- *VectorObject3D.from\_rhophieta()*

Additionally, the `vector.obj()` function can also be used to construct 3D object type vectors.

For three dimensional momentum vector objects, see *vector.backends.object.MomentumObject3D*.

#### GenericClass

alias of *VectorObject3D*

#### MomentumClass

alias of *MomentumObject3D*

#### ProjectionClass2D

alias of *VectorObject2D*

#### ProjectionClass3D

alias of *VectorObject3D*

#### ProjectionClass4D

alias of *VectorObject4D*

**`_wrap_result`**(cls: Any, result: Any, returns: Any, num\_vecargs: Any) → Any

Wraps the raw result of a compute function as a scalar or a vector.

#### Parameters

- **result** – Value or tuple of values from a compute function.
- **returns** – Signature from a `dispatch_map`.
- **num\_vecargs** (*int*) – Number of vector arguments in the function that would be treated on an equal footing (i.e. `add` has two, but `rotate_axis` has only one: the axis is secondary).

**azimuthal:** [\*AzimuthalObject\*](#)

**property eta:** `float`

The pseudorapidity  $\eta$  coordinate of the vector or every vector in the array (in radians, always between 0 ( $+z$ ) and  $\pi$  ( $-z$ )).

**classmethod** `from_rhophieta`(*rho: float, phi: float, eta: float*)  $\rightarrow$  [\*VectorObject3D\*](#)

Constructs a `VectorObject3D` from polar azimuthal coordinates and a pseudorapidity  $\eta$ .

Use [`vector.backends.object.MomentumObject3D`](#) to construct a vector with momentum properties and methods.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject3D.from_rhophieta(1, 1, 1)
>>> vec
VectorObject3D(rho=1, phi=1, eta=1)
```

**classmethod** `from_rhophitheta`(*rho: float, phi: float, theta: float*)  $\rightarrow$  [\*VectorObject3D\*](#)

Constructs a `VectorObject3D` from polar azimuthal coordinates and a polar angle  $\theta$ .

Use [`vector.backends.object.MomentumObject3D`](#) to construct a vector with momentum properties and methods.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject3D.from_rhophitheta(1, 1, 1)
>>> vec
VectorObject3D(rho=1, phi=1, theta=1)
```

**classmethod** `from_rhophiz`(*rho: float, phi: float, z: float*)  $\rightarrow$  [\*VectorObject3D\*](#)

Constructs a `VectorObject3D` from polar azimuthal coordinates and a Cartesian longitudinal coordinate  $z$ .

Use [`vector.backends.object.MomentumObject3D`](#) to construct a vector with momentum properties and methods.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject3D.from_rhophiz(1, 1, 1)
>>> vec
VectorObject3D(rho=1, phi=1, z=1)
```

**classmethod** `from_xyeta`(*x: float, y: float, eta: float*) → *VectorObject3D*

Constructs a `VectorObject3D` from Cartesian coordinates and a pseudorapidity  $\eta$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject3D.from_xyeta(1, 1, 1)
>>> vec
VectorObject3D(x=1, y=1, eta=1)
```

**classmethod** `from_xytheta`(*x: float, y: float, theta: float*) → *VectorObject3D*

Constructs a `VectorObject3D` from Cartesian azimuthal coordinates and a polar angle  $\theta$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject3D.from_xytheta(1, 1, 1)
>>> vec
VectorObject3D(x=1, y=1, theta=1)
```

**classmethod** `from_xyz`(*x: float, y: float, z: float*) → *VectorObject3D*

Constructs a `VectorObject3D` from Cartesian coordinates.

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject3D.from_xyz(1, 1, 1)
>>> vec
VectorObject3D(x=1, y=1, z=1)
```

**longitudinal:** *LongitudinalObject*

**property** `phi:` float

The polar  $\phi$  coordinate of the vector or every vector in the array (in radians, always between  $-\pi$  and  $\pi$ ).

**property rho: float**

The polar  $\rho$  coordinate of the vector or every vector in the array.

This is also the magnitude of the 2D azimuthal part of the vector (not including any longitudinal or temporal parts).

**property theta: float**

The spherical  $\theta$  coordinate (polar angle) of the vector or every vector in the array (in radians, always between 0 (+z) and  $\pi$  (-z)).

**property x: float**

The Cartesian  $x$  coordinate of the vector or every vector in the array.

**property y: float**

The Cartesian  $y$  coordinate of the vector or every vector in the array.

**property z: float**

The Cartesian  $z$  coordinate of the vector or every vector in the array.

```
class vector.backends.object.VectorObject4D(*, x: float, y: float)
class vector.backends.object.VectorObject4D(*, rho: float, phi: float)
class vector.backends.object.VectorObject4D(*, x: float, y: float, z: float)
class vector.backends.object.VectorObject4D(*, x: float, y: float, eta: float)
class vector.backends.object.VectorObject4D(*, x: float, y: float, theta: float)
class vector.backends.object.VectorObject4D(*, rho: float, phi: float, z: float)
class vector.backends.object.VectorObject4D(*, rho: float, phi: float, eta: float)
class vector.backends.object.VectorObject4D(*, rho: float, phi: float, theta: float)
class vector.backends.object.VectorObject4D(*, px: float, py: float)
class vector.backends.object.VectorObject4D(*, x: float, py: float)
class vector.backends.object.VectorObject4D(*, px: float, y: float)
class vector.backends.object.VectorObject4D(*, pt: float, phi: float)
class vector.backends.object.VectorObject4D(*, x: float, y: float, pz: float)
class vector.backends.object.VectorObject4D(*, x: float, py: float, z: float)
class vector.backends.object.VectorObject4D(*, x: float, py: float, pz: float)
class vector.backends.object.VectorObject4D(*, px: float, y: float, z: float)
class vector.backends.object.VectorObject4D(*, px: float, y: float, pz: float)
class vector.backends.object.VectorObject4D(*, px: float, py: float, z: float)
class vector.backends.object.VectorObject4D(*, px: float, py: float, pz: float)
class vector.backends.object.VectorObject4D(*, rho: float, phi: float, pz: float)
class vector.backends.object.VectorObject4D(*, pt: float, phi: float, z: float)
class vector.backends.object.VectorObject4D(*, pt: float, phi: float, pz: float)
class vector.backends.object.VectorObject4D(*, x: float, py: float, theta: float)
class vector.backends.object.VectorObject4D(*, px: float, y: float, theta: float)
class vector.backends.object.VectorObject4D(*, px: float, py: float, theta: float)
class vector.backends.object.VectorObject4D(*, pt: float, phi: float, theta: float)
class vector.backends.object.VectorObject4D(*, x: float, py: float, eta: float)
class vector.backends.object.VectorObject4D(*, px: float, y: float, eta: float)
class vector.backends.object.VectorObject4D(*, px: float, py: float, eta: float)
class vector.backends.object.VectorObject4D(*, pt: float, phi: float, eta: float)
```











```

class vector.backends.object.VectorObject4D(*, rho: float, phi: float, z: float, mass: float)
class vector.backends.object.VectorObject4D(*, rho: float, phi: float, pz: float, mass: float)
class vector.backends.object.VectorObject4D(*, pt: float, phi: float, z: float, mass: float)
class vector.backends.object.VectorObject4D(*, pt: float, phi: float, pz: float, mass: float)
class vector.backends.object.VectorObject4D(*, x: float, y: float, theta: float, mass: float)
class vector.backends.object.VectorObject4D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.object.VectorObject4D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.object.VectorObject4D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.object.VectorObject4D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.object.VectorObject4D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.object.VectorObject4D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.object.VectorObject4D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.object.VectorObject4D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.object.VectorObject4D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.object.VectorObject4D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.object.VectorObject4D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.object.VectorObject4D(__azimuthal: Azimuthal)
class vector.backends.object.VectorObject4D(__azimuthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.object.VectorObject4D(__azimuthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)

```

Bases: [VectorObject](#), [Lorentz](#), [Vector4D](#)

Four dimensional vector class for the object backend. Use the class methods -

### Examples

```

>>> import vector
>>> vec = vector.VectorObject4D(x=1, y=2, z=3, t=4)
>>> vec.x, vec.y, vec.z, vec.t
(1, 2, 3, 4)
>>> vec = vector.VectorObject4D(rho=1, phi=2, eta=3, tau=4)
>>> vec.rho, vec.phi, vec.eta, vec.tau
(1, 2, 3, 4)
>>> vec = vector.VectorObject4D(
...     azimuthal=vector.backends.object.AzimuthalObjectXY(1, 2),
...     longitudinal=vector.backends.object.LongitudinalObjectTheta(3),
...     temporal=vector.backends.object.TemporalObjectTau(4)
... )
>>> vec.x, vec.y, vec.theta, vec.tau
(1, 2, 3, 4)

```

The following class methods can also be used to construct 4D object type vectors -

- [VectorObject4D.from\\_xyzt\(\)](#)
- [VectorObject4D.from\\_xythetat\(\)](#)
- [VectorObject4D.from\\_xyetat\(\)](#)
- [VectorObject4D.from\\_rhophizt\(\)](#)
- [VectorObject4D.from\\_rhophithetat\(\)](#)

- `VectorObject4D.from_rhophietat()`
- `VectorObject4D.from_xyztau()`
- `VectorObject4D.from_xythetatau()`
- `VectorObject4D.from_xyetatau()`
- `VectorObject4D.from_rhophiztau()`
- `VectorObject4D.from_rhophithetatau()`
- `VectorObject4D.from_rhophietatau()`

Additionally, the `vector.obj()` function can also be used to construct 4D object type vectors.

For four dimensional momentum vector objects, see `vector.backends.object.MomentumObject4D`.

#### **GenericClass**

alias of `VectorObject4D`

#### **MomentumClass**

alias of `MomentumObject4D`

#### **ProjectionClass2D**

alias of `VectorObject2D`

#### **ProjectionClass3D**

alias of `VectorObject3D`

#### **ProjectionClass4D**

alias of `VectorObject4D`

**`_wrap_result`**(*cls: Any, result: Any, returns: Any, num\_vecargs: Any*)  $\rightarrow$  Any

Wraps the raw result of a compute function as a scalar or a vector.

#### **Parameters**

- **result** – Value or tuple of values from a compute function.
- **returns** – Signature from a `dispatch_map`.
- **num\_vecargs** (*int*) – Number of vector arguments in the function that would be treated on an equal footing (i.e. `add` has two, but `rotate_axis` has only one: the `axis` is secondary).

**azimuthal:** `AzimuthalObject`

**property eta:** float

The pseudorapidity  $\eta$  coordinate of the vector or every vector in the array (in radians, always between 0 (+z) and  $\pi$  (−z)).

**classmethod from\_rhophietat**(*rho: float, phi: float, eta: float, t: float*)  $\rightarrow$  `VectorObject4D`

Constructs a `VectorObject3D` from polar azimuthal coordinates, a pseudorapidity  $\eta$ , and a time coordinate  $t$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

## Examples

```
>>> import vector
>>> vec = vector.VectorObject4D.from_rhophietat(1, 1, 1, 1)
>>> vec
VectorObject4D(rho=1, phi=1, eta=1, t=1)
```

**classmethod** `from_rhophietatau(rho: float, phi: float, eta: float, tau: float) → VectorObject4D`

Constructs a `VectorObject3D` from polar azimuthal coordinates, a pseudorapidity  $\eta$ , and a proper time coordinate  $\tau$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

## Examples

```
>>> import vector
>>> vec = vector.VectorObject4D.from_rhophietatau(1, 1, 1, 1)
>>> vec
VectorObject4D(rho=1, phi=1, eta=1, tau=1)
```

**classmethod** `from_rhophithetat(rho: float, phi: float, theta: float, t: float) → VectorObject4D`

Constructs a `VectorObject3D` from polar azimuthal coordinates, a polar angle  $\theta$ , and a time coordinate  $t$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

## Examples

```
>>> import vector
>>> vec = vector.VectorObject4D.from_rhophithetat(1, 1, 1, 1)
>>> vec
VectorObject4D(rho=1, phi=1, theta=1, t=1)
```

**classmethod** `from_rhophithetatau(rho: float, phi: float, theta: float, tau: float) → VectorObject4D`

Constructs a `VectorObject3D` from polar azimuthal coordinates, a polar angle  $\theta$ , and a proper time coordinate  $\tau$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

## Examples

```
>>> import vector
>>> vec = vector.VectorObject4D.from_rhophithetatau(1, 1, 1, 1)
>>> vec
VectorObject4D(rho=1, phi=1, theta=1, tau=1)
```

**classmethod** `from_rhophizt(rho: float, phi: float, z: float, t: float) → VectorObject4D`

Constructs a `VectorObject3D` from polar azimuthal coordinates, a Cartesian longitudinal coordinate  $z$ , and a time coordinate  $t$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject4D.from_rhophizt(1, 1, 1, 1)
>>> vec
VectorObject4D(rho=1, phi=1, z=1, t=1)
```

**classmethod** `from_rhophiztau(rho: float, phi: float, z: float, tau: float) → VectorObject4D`

Constructs a `VectorObject3D` from polar azimuthal coordinates, a Cartesian longitudinal coordinate  $z$ , and a proper time coordinate  $\tau$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject4D.from_rhophiztau(1, 1, 1, 1)
>>> vec
VectorObject4D(rho=1, phi=1, z=1, tau=1)
```

**classmethod** `from_xyetat(x: float, y: float, eta: float, t: float) → VectorObject4D`

Constructs a `VectorObject3D` from Cartesian coordinates, a pseudorapidity  $\eta$ , and a time coordinate  $t$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject4D.from_xyetat(1, 1, 1, 1)
>>> vec
VectorObject4D(x=1, y=1, eta=1, t=1)
```

**classmethod** `from_xyetatau(x: float, y: float, eta: float, tau: float) → VectorObject4D`

Constructs a `VectorObject3D` from Cartesian coordinates, a pseudorapidity  $\eta$ , and a proper time coordinate  $\tau$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

## Examples

```
>>> import vector
>>> vec = vector.VectorObject4D.from_xyetatau(1, 1, 1, 1)
>>> vec
VectorObject4D(x=1, y=1, eta=1, tau=1)
```

**classmethod** `from_xythetat`(*x: float, y: float, theta: float, t: float*) → *VectorObject4D*

Constructs a `VectorObject3D` from Cartesian azimuthal coordinates, a polar angle  $\theta$ , and a time coordinate  $t$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

## Examples

```
>>> import vector
>>> vec = vector.VectorObject4D.from_xythetat(1, 1, 1, 1)
>>> vec
VectorObject4D(x=1, y=1, theta=1, t=1)
```

**classmethod** `from_xythetatau`(*x: float, y: float, theta: float, tau: float*) → *VectorObject4D*

Constructs a `VectorObject3D` from Cartesian azimuthal coordinates, a polar angle  $\theta$ , and a proper time coordinate  $\tau$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

## Examples

```
>>> import vector
>>> vec = vector.VectorObject4D.from_xythetatau(1, 1, 1, 1)
>>> vec
VectorObject4D(x=1, y=1, theta=1, tau=1)
```

**classmethod** `from_xyzt`(*x: float, y: float, z: float, t: float*) → *VectorObject4D*

Constructs a `VectorObject3D` from Cartesian coordinates and a time coordinate  $t$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

## Examples

```
>>> import vector
>>> vec = vector.VectorObject4D.from_xyzt(1, 1, 1, 1)
>>> vec
VectorObject4D(x=1, y=1, z=1, t=1)
```

**classmethod** `from_xyztau`(*x: float, y: float, z: float, tau: float*) → *VectorObject4D*

Constructs a `VectorObject3D` from Cartesian coordinates and a proper time coordinate  $\tau$ .

Use `vector.backends.object.MomentumObject3D` to construct a vector with momentum properties and methods.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject4D.from_xyztau(1, 1, 1, 1)
>>> vec
VectorObject4D(x=1, y=1, z=1, tau=1)
```

**longitudinal:** *LongitudinalObject*

**property phi:** float

The polar  $\phi$  coordinate of the vector or every vector in the array (in radians, always between  $-\pi$  and  $\pi$ ).

**property rho:** float

The polar  $\rho$  coordinate of the vector or every vector in the array.

This is also the magnitude of the 2D azimuthal part of the vector (not including any longitudinal or temporal parts).

**property t:** float

The Cartesian  $t$  (time) coordinate of the vector or every vector in the array.

If  $t$  is derived from  $\tau$ , it is not allowed to be NaN.

```
t = sqrt(max(copysign(tau**2, tau) + mag**2, 0))
```

**property tau:** float

The Lorentz magnitude  $\tau$  (proper time) of the vector or every vector in the array.

If  $\tau$  is derived from  $t$ , spacelike vectors are represented by negative proper times.

```
tau = copysign(sqrt(abs(t**2 - mag**2)), t**2 - mag**2)
```

**temporal:** *TemporalObject*

**property theta:** float

The spherical  $\theta$  coordinate (polar angle) of the vector or every vector in the array (in radians, always between  $0$  ( $+z$ ) and  $\pi$  ( $-z$ )).

**property x:** float

The Cartesian  $x$  coordinate of the vector or every vector in the array.

**property y:** float

The Cartesian  $y$  coordinate of the vector or every vector in the array.

**property z:** float

The Cartesian  $z$  coordinate of the vector or every vector in the array.

`vector.backends.object._gather_coordinates(planar_class: type[VectorObject2D], spatial_class: type[VectorObject3D], lorentz_class: type[VectorObject4D], coordinates: dict[str, Any]) → Any`

Helper function for `vector.backends.object.obj()`.

Constructs and returns a 2D, 3D, or 4D `VectorObject` or `MomentumObject` with the provided coordinates (dictionary), planar (`VectorObject2D` or `MomentumObject2D`), spatial (`VectorObject3D` or `MomentumObject3D`), and lorentz (`VectorObject4D` or `MomentumObject4D`) classes.

`vector.backends.object._is_type_safe(coordinates: dict[str, Any]) → bool`

`vector.backends.object._replace_data(obj: Any, result: Any) → Any`

`vector.backends.object.obj(*, x: float, y: float) → VectorObject2D`

`vector.backends.object.obj(*, x: float, py: float) → MomentumObject2D`

`vector.backends.object.obj(*, px: float, y: float) → MomentumObject2D`

`vector.backends.object.obj(*, px: float, py: float) → MomentumObject2D`

`vector.backends.object.obj(*, rho: float, phi: float) → VectorObject2D`

`vector.backends.object.obj(*, pt: float, phi: float) → MomentumObject2D`

`vector.backends.object.obj(*, x: float, y: float, z: float) → VectorObject3D`

`vector.backends.object.obj(*, x: float, y: float, pz: float) → MomentumObject3D`

`vector.backends.object.obj(*, x: float, py: float, z: float) → MomentumObject3D`

`vector.backends.object.obj(*, x: float, py: float, pz: float) → MomentumObject3D`

`vector.backends.object.obj(*, px: float, y: float, z: float) → MomentumObject3D`

`vector.backends.object.obj(*, px: float, y: float, pz: float) → MomentumObject3D`

`vector.backends.object.obj(*, px: float, py: float, z: float) → MomentumObject3D`

`vector.backends.object.obj(*, px: float, py: float, pz: float) → MomentumObject3D`

`vector.backends.object.obj(*, rho: float, phi: float, z: float) → VectorObject3D`

`vector.backends.object.obj(*, rho: float, phi: float, pz: float) → MomentumObject3D`

`vector.backends.object.obj(*, pt: float, phi: float, z: float) → MomentumObject3D`

`vector.backends.object.obj(*, pt: float, phi: float, pz: float) → MomentumObject3D`

`vector.backends.object.obj(*, x: float, y: float, theta: float) → VectorObject3D`

`vector.backends.object.obj(*, x: float, py: float, theta: float) → MomentumObject3D`

`vector.backends.object.obj(*, px: float, y: float, theta: float) → MomentumObject3D`

`vector.backends.object.obj(*, px: float, py: float, theta: float) → MomentumObject3D`

`vector.backends.object.obj(*, rho: float, phi: float, theta: float) → VectorObject3D`

`vector.backends.object.obj(*, pt: float, phi: float, theta: float) → MomentumObject3D`

`vector.backends.object.obj(*, x: float, y: float, eta: float) → VectorObject3D`

`vector.backends.object.obj(*, x: float, py: float, eta: float) → MomentumObject3D`

`vector.backends.object.obj(*, px: float, y: float, eta: float) → MomentumObject3D`

`vector.backends.object.obj(*, px: float, py: float, eta: float) → MomentumObject3D`

`vector.backends.object.obj(*, rho: float, phi: float, eta: float) → VectorObject3D`

`vector.backends.object.obj(*, pt: float, phi: float, eta: float) → MomentumObject3D`

`vector.backends.object.obj(*, x: float, y: float, z: float, t: float) → VectorObject4D`

`vector.backends.object.obj(*, x: float, y: float, pz: float, t: float) → MomentumObject4D`

`vector.backends.object.obj(*, x: float, py: float, z: float, t: float) → MomentumObject4D`

`vector.backends.object.obj(*, x: float, py: float, pz: float, t: float) → MomentumObject4D`

`vector.backends.object.obj(*, px: float, y: float, z: float, t: float) → MomentumObject4D`

`vector.backends.object.obj(*, px: float, y: float, pz: float, t: float) → MomentumObject4D`

`vector.backends.object.obj(*, px: float, py: float, z: float, t: float) → MomentumObject4D`

`vector.backends.object.obj(*, px: float, py: float, pz: float, t: float) → MomentumObject4D`













`vector.backends.object.obj(*, rho: float, phi: float, theta: float, mass: float) → MomentumObject4D`

`vector.backends.object.obj(*, pt: float, phi: float, theta: float, mass: float) → MomentumObject4D`

`vector.backends.object.obj(*, x: float, y: float, eta: float, mass: float) → MomentumObject4D`

`vector.backends.object.obj(*, x: float, py: float, eta: float, mass: float) → MomentumObject4D`

`vector.backends.object.obj(*, px: float, y: float, eta: float, mass: float) → MomentumObject4D`

`vector.backends.object.obj(*, px: float, py: float, eta: float, mass: float) → MomentumObject4D`

`vector.backends.object.obj(*, rho: float, phi: float, eta: float, mass: float) → MomentumObject4D`

`vector.backends.object.obj(*, pt: float, phi: float, eta: float, mass: float) → MomentumObject4D`

Constructs a single Object type vector, whose type is determined by the keyword-only arguments to this function.

Allowed combinations are:

- (2D) x, y
- (2D) rho, phi
- (3D) x, y, z
- (3D) x, y, theta
- (3D) x, y, eta
- (3D) rho, phi, z
- (3D) rho, phi, theta
- (3D) rho, phi, eta
- (4D) x, y, z, t
- (4D) x, y, z, tau`
- (4D) x, y, theta, t`
- (4D) x, y, theta, tau`
- (4D) x, y, eta, t`
- (4D) x, y, eta, tau`
- (4D) rho, phi, z, t`
- (4D) rho, phi, z, tau`
- (4D) rho, phi, theta, t`
- (4D) rho, phi, theta, tau`
- (4D) rho, phi, eta, t`
- (4D) rho, phi, eta, tau`

in which

- px may be substituted for x
- py may be substituted for y
- pt may be substituted for rho
- pz may be substituted for z
- E may be substituted for t
- e may be substituted for tau`
- energy may be substituted for tau`

- $M$  may be substituted for  $\tau$
- $m$  may be substituted for  $\tau$
- $mass$  may be substituted for  $\tau$

to make the vector a momentum vector.

Alternatively, the `vector.backends.object.VectorObject2D`, `vector.backends.object.VectorObject3D`, and `vector.backends.object.VectorObject4D` classes (with momentum subclasses) have explicit constructors:

- `vector.backends.object.VectorObject2D.from_xy()`
- `vector.backends.object.VectorObject2D.from_rhophi()`
- `vector.backends.object.VectorObject3D.from_xyz()`
- `vector.backends.object.VectorObject3D.from_xytheta()`
- `vector.backends.object.VectorObject3D.from_xyeta()`
- `vector.backends.object.VectorObject3D.from_rhophiz()`
- `vector.backends.object.VectorObject3D.from_rhophitheta()`
- `vector.backends.object.VectorObject3D.from_rhophieta()`
- `vector.backends.object.VectorObject4D.from_xyzt()`
- `vector.backends.object.VectorObject4D.from_xyztau()`
- `vector.backends.object.VectorObject4D.from_xythetat()`
- `vector.backends.object.VectorObject4D.from_xythetatau()`
- `vector.backends.object.VectorObject4D.from_xyetata()`
- `vector.backends.object.VectorObject4D.from_xyetatau()`
- `vector.backends.object.VectorObject4D.from_rhophizt()`
- `vector.backends.object.VectorObject4D.from_rhophiztau()`
- `vector.backends.object.VectorObject4D.from_rhophithetat()`
- `vector.backends.object.VectorObject4D.from_rhophithetatau()`
- `vector.backends.object.VectorObject4D.from_rhophietat()`
- `vector.backends.object.VectorObject4D.from_rhophietatau()`

### vector.backends.numpy module

Defines behaviors for NumPy Array. New arrays created with the

```
vector.array(...)
```

function will have these behaviors built in (and will pass them to any derived arrays).

**class** `vector.backends.numpy.AzimuthalNumpy`

Bases: `CoordinatesNumpy`, `Azimuthal`

Azimuthal class for the NumPy backend.



**ObjectClass:** `type[AzimuthalObject]`

**class** `vector.backends.numpy.AzimuthalNumpyRhoPhi(*args: Any, **kwargs: Any)`

Bases: `AzimuthalNumpy`, `AzimuthalRhoPhi`, `GetItem`, `ndarray`

Class for the rho and phi (azimuthal) coordinates of NumPy backend. Creates a structured NumPy array and returns it as an `AzimuthalNumpyXY` object.

### Examples

```
>>> import vector
>>> vector.backends.numpy.AzimuthalNumpyRhoPhi([(1, 1), (2.1, 3.1)], dtype=[("rho",
↪float), ("phi", float)])
AzimuthalNumpyRhoPhi([(1. , 1. ), (2.1, 3.1)],
                      dtype=[('rho', '<f8'), ('phi', '<f8')])
```

### ObjectClass

alias of `AzimuthalObjectRhoPhi`

**\_IS\_MOMENTUM:** `ClassVar[bool] = False`

**property elements:** `tuple[ndarray, ndarray]`

Azimuthal coordinates (rho and phi) as a tuple.

Each coordinate is a NumPy array of values and not a vector.

### Examples

```
>>> import vector
>>> vec = vector.backends.numpy.AzimuthalNumpyRhoPhi([(1, 1), (2.1, 3.1)],
↪dtype=[("rho", float), ("phi", float)])
>>> vec.elements
(array([1. , 2.1]), array([1. , 3.1]))
```

**property phi:** `ndarray`

The phi coordinates.

**property rho:** `ndarray`

The rho coordinates.

**class** `vector.backends.numpy.AzimuthalNumpyXY(*args: Any, **kwargs: Any)`

Bases: `AzimuthalNumpy`, `AzimuthalXY`, `GetItem`, `ndarray`

Class for the x and y (azimuthal) coordinates of NumPy backend. Creates a structured NumPy array and returns it as an `AzimuthalNumpyXY` object.

## Examples

```
>>> import vector
>>> vector.backends.numpy.AzimuthalNumpyXY([(1, 1), (2.1, 3.1)], dtype=[("x",
↪ float), ("y", float)])
AzimuthalNumpyXY([(1. , 1. ), (2.1, 3.1)],
                  dtype=[('x', '<f8'), ('y', '<f8')])
```

### ObjectClass

alias of *AzimuthalObjectXY*

**\_IS\_MOMENTUM:** ClassVar[bool] = False

**property elements:** tuple[ndarray, ndarray]

Azimuthal coordinates (x and y) as a tuple.

Each coordinate is a NumPy array of values and not a vector.

## Examples

```
>>> import vector
>>> vec = vector.backends.numpy.AzimuthalNumpyXY([(1, 1), (2.1, 3.1)], dtype=[(
↪ "x", float), ("y", float)])
>>> vec.elements
(array([1. , 2.1]), array([1. , 3.1]))
```

**property x:** ndarray

The x coordinates.

**property y:** ndarray

The y coordinates.

**class** vector.backends.numpy.CoordinatesNumpy

Bases: object

Coordinates class for the Numpy backend.

**dtype:** dtype[Any]

lib = <module 'numpy' from '/home/docs/checkouts/readthedocs.org/user\_builds/vector/envs/latest/lib/python3.12/site-packages/numpy/\_\_init\_\_.py'>

**class** vector.backends.numpy.GetItem

Bases: object

**\_IS\_MOMENTUM:** ClassVar[bool]

**class** vector.backends.numpy.LongitudinalNumpy

Bases: *CoordinatesNumpy*, *Longitudinal*

Longitudinal class for the NumPy backend.

**ObjectClass:** type[*LongitudinalObject*]

**class** `vector.backends.numpy.LongitudinalNumpyEta(*args: Any, **kwargs: Any)`

Bases: *LongitudinalNumpy*, *LongitudinalEta*, *GetItem*, *ndarray*

Class for the eta (longitudinal) coordinate of NumPy backend. Creates a structured NumPy array and returns it as a *LongitudinalNumpyEta* object.

### Examples

```
>>> import vector
>>> vector.backends.numpy.LongitudinalNumpyEta([(1), (2.1)], dtype=[("eta", float)])
LongitudinalNumpyEta([(1. ,), (2.1,)], dtype=[('eta', '<f8')])
```

#### ObjectClass

alias of *LongitudinalObjectEta*

`_IS_MOMENTUM: ClassVar[bool] = False`

**property** `elements: tuple[ndarray]`

Longitudinal coordinates (eta) as a tuple.

Each coordinate is a NumPy array of values and not a vector.

### Examples

```
>>> import vector
>>> vec = vector.backends.numpy.LongitudinalNumpyTheta([(1), (2.1)], dtype=[(
    ↪ "theta", float)])
>>> vec.elements
(array([1. , 2.1]),)
```

**property** `eta: ndarray`

The eta coordinates.

**class** `vector.backends.numpy.LongitudinalNumpyTheta(*args: Any, **kwargs: Any)`

Bases: *LongitudinalNumpy*, *LongitudinalTheta*, *GetItem*, *ndarray*

Class for the theta (longitudinal) coordinate of NumPy backend. Creates a structured NumPy array and returns it as a *LongitudinalNumpyTheta* object.

### Examples

```
>>> import vector
>>> vector.backends.numpy.LongitudinalNumpyTheta([(1), (2.1)], dtype=[("theta", ↵
    ↪ float)])
LongitudinalNumpyTheta([(1. ,), (2.1,)], dtype=[('theta', '<f8')])
```

#### ObjectClass

alias of *LongitudinalObjectTheta*

`_IS_MOMENTUM: ClassVar[bool] = False`



**property elements: tuple[ndarray]**

Longitudinal coordinates (theta) as a tuple.

Each coordinate is a NumPy array of values and not a vector.

### Examples

```
>>> import vector
>>> vec = vector.backends.numpy.LongitudinalNumpyTheta([(1), (2.1)], dtype=[(
↳ "theta", float)])
>>> vec.elements
(array([1. , 2.1]),)
```

**property theta: ndarray**

The theta coordinates.

**class** vector.backends.numpy.LongitudinalNumpyZ(\*args: Any, \*\*kwargs: Any)

Bases: *LongitudinalNumpy*, *LongitudinalZ*, *GetItem*, ndarray

Class for the z (longitudinal) coordinate of NumPy backend. Creates a structured NumPy array and returns it as a LongitudinalNumpyZ object.

### Examples

```
>>> import vector
>>> vector.backends.numpy.LongitudinalNumpyZ([(1), (2.1)], dtype=[("z", float)])
LongitudinalNumpyZ([(1. ,), (2.1,)], dtype=[('z', '<f8')])
```

**ObjectClass**

alias of *LongitudinalObjectZ*

**\_IS\_MOMENTUM: ClassVar[bool] = False**

**property elements: tuple[ndarray]**

Longitudinal coordinates (z) as a tuple.

Each coordinate is a NumPy array of values and not a vector.

### Examples

```
>>> import vector
>>> vec = vector.backends.numpy.LongitudinalNumpyZ([(1), (2.1)], dtype=[("z",
↳ float)])
>>> vec.elements
(array([1. , 2.1]),)
```

**property z: ndarray**

The z coordinates.

**class** `vector.backends.numpy.MomentumNumpy2D(*args: Any, **kwargs: Any)`

Bases: *PlanarMomentum*, *VectorNumpy2D*

Two dimensional momentum vector class for the NumPy backend. This class can be directly used to construct two dimensional NumPy momentum vectors. For two dimensional NumPy vectors see [vector.backends.numpy.VectorNumpy2D](#).

### Examples

```
>>> import vector
>>> vec = vector.MomentumNumpy2D([(1.1, 2.1), (1.2, 2.2), (1.3, 2.3), (1.4, 2.4),
↪ (1.5, 2.5)],
...                               dtype=[('px', float), ('py', float)])
>>> vec
MomentumNumpy2D([(1.1, 2.1), (1.2, 2.2), (1.3, 2.3), (1.4, 2.4), (1.5, 2.5)],
                  dtype=[('x', '<f8'), ('y', '<f8')])
```

#### GenericClass

alias of *VectorNumpy2D*

#### MomentumClass

alias of *MomentumNumpy2D*

#### ObjectClass

alias of *MomentumObject2D*

#### ProjectionClass2D

alias of *MomentumNumpy2D*

#### ProjectionClass3D

alias of *MomentumNumpy3D*

#### ProjectionClass4D

alias of *MomentumNumpy4D*

**\_IS\_MOMENTUM:** `ClassVar[bool] = True`

**class** `vector.backends.numpy.MomentumNumpy3D(*args: Any, **kwargs: Any)`

Bases: *SpatialMomentum*, *VectorNumpy3D*

Three dimensional momentum vector class for the NumPy backend. This class can be directly used to construct three dimensional NumPy momentum vectors. For three dimensional NumPy vectors see [vector.backends.numpy.VectorNumpy3D](#).

### Examples

```
>>> import vector
>>> vec = vector.MomentumNumpy3D([(1.1, 2.1, 3.1), (1.2, 2.2, 3.2), (1.3, 2.3, 3.3),
↪ (1.4, 2.4, 3.4), (1.5, 2.5, 3.5)],
...                               dtype=[('px', float), ('py', float), ('pz', float)])
>>> vec
MomentumNumpy3D([(1.1, 2.1, 3.1), (1.2, 2.2, 3.2), (1.3, 2.3, 3.3), (1.4, 2.4, 3.4),
                  (1.5, 2.5, 3.5)], dtype=[('x', '<f8'), ('y', '<f8'), ('z', '<f8')])
```

**GenericClass**alias of *VectorNumpy3D***MomentumClass**alias of *MomentumNumpy3D***ObjectClass**alias of *MomentumObject3D***ProjectionClass2D**alias of *MomentumNumpy2D***ProjectionClass3D**alias of *MomentumNumpy3D***ProjectionClass4D**alias of *MomentumNumpy4D***\_IS\_MOMENTUM:** ClassVar[bool] = True**class** vector.backends.numpy.**MomentumNumpy4D**(\*args: Any, \*\*kwargs: Any)Bases: *LorentzMomentum*, *VectorNumpy4D*

Four dimensional momentum vector class for the NumPy backend. This class can be directly used to construct four dimensional NumPy momentum vectors. For three dimensional NumPy vectors see *vector.backends.numpy.VectorNumpy4D*.

**Examples**

```
>>> import vector
>>> vec = vector.MomentumNumpy4D([(1.1, 2.1, 3.1, 4.1), (1.2, 2.2, 3.2, 4.2), (1.3, 2.3, 3.3, 4.3), (1.4, 2.4, 3.4, 4.4), (1.5, 2.5, 3.5, 4.5)],
...                               dtype=[('px', float), ('py', float), ('pz', float), ('t', float)])
>>> vec
MomentumNumpy4D([(1.1, 2.1, 3.1, 4.1), (1.2, 2.2, 3.2, 4.2), (1.3, 2.3, 3.3, 4.3), (1.4, 2.4, 3.4, 4.4), (1.5, 2.5, 3.5, 4.5)],
                  dtype=[('x', '<f8'), ('y', '<f8'), ('z', '<f8'), ('t', '<f8')])
```

**GenericClass**alias of *VectorNumpy4D***MomentumClass**alias of *MomentumNumpy4D***ObjectClass**alias of *MomentumObject4D***ProjectionClass2D**alias of *MomentumNumpy2D***ProjectionClass3D**alias of *MomentumNumpy3D***ProjectionClass4D**alias of *MomentumNumpy4D*

```
_IS_MOMENTUM: ClassVar[bool] = True
```

```
class vector.backends.numpy.TemporalNumpy
```

```
Bases: CoordinatesNumpy, Temporal
```

Temporal class for the NumPy backend.

```
ObjectClass: type[TemporalObject]
```

```
class vector.backends.numpy.TemporalNumpyT(*args: Any, **kwargs: Any)
```

```
Bases: TemporalNumpy, TemporalT, GetItem, ndarray
```

Class for the t (temporal) coordinate of NumPy backend. Creates a structured NumPy array and returns it as a TemporalNumpyT object.

### Examples

```
>>> import vector
>>> vector.backends.numpy.TemporalNumpyT([(1), (2.1)], dtype=[("t", float)])
TemporalNumpyT([(1. ,), (2.1,)], dtype=[('t', '<f8')])
```

**ObjectClass**

alias of *TemporalObjectT*

```
_IS_MOMENTUM: ClassVar[bool] = False
```

```
property elements: tuple[ndarray]
```

Temporal coordinates (t) as a tuple.

Each coordinate is a NumPy array of values and not a vector.

### Examples

```
>>> import vector
>>> vec = vector.backends.numpy.TemporalNumpyT([(1), (2.1)], dtype=[("t",
↳ float)])
>>> vec.elements
(array([1. , 2.1]),)
```

**property t: ndarray**

The t coordinates.

```
class vector.backends.numpy.TemporalNumpyTau(*args: Any, **kwargs: Any)
```

```
Bases: TemporalNumpy, TemporalTau, GetItem, ndarray
```

Class for the tau (temporal) coordinate of NumPy backend.

**ObjectClass**

alias of *TemporalObjectTau*

```
_IS_MOMENTUM: ClassVar[bool] = False
```

```
property elements: tuple[ndarray]
```

Temporal coordinates (tau) as a tuple.

Each coordinate is a NumPy array of values and not a vector.

## Examples

```
>>> import vector
>>> vec = vector.backends.numpy.TemporalNumpyTau([(1), (2.1)], dtype=[("tau",
↪float)])
>>> vec.elements
(array([1. , 2.1]),)
```

**property tau: ndarray**

The tau coordinates.

```
class vector.backends.numpy.VectorNumpy(*, x: float, y: float)
class vector.backends.numpy.VectorNumpy(*, rho: float, phi: float)
class vector.backends.numpy.VectorNumpy(*, x: float, y: float, z: float)
class vector.backends.numpy.VectorNumpy(*, x: float, y: float, eta: float)
class vector.backends.numpy.VectorNumpy(*, x: float, y: float, theta: float)
class vector.backends.numpy.VectorNumpy(*, rho: float, phi: float, z: float)
class vector.backends.numpy.VectorNumpy(*, rho: float, phi: float, eta: float)
class vector.backends.numpy.VectorNumpy(*, rho: float, phi: float, theta: float)
class vector.backends.numpy.VectorNumpy(*, px: float, py: float)
class vector.backends.numpy.VectorNumpy(*, x: float, py: float)
class vector.backends.numpy.VectorNumpy(*, px: float, y: float)
class vector.backends.numpy.VectorNumpy(*, pt: float, phi: float)
class vector.backends.numpy.VectorNumpy(*, x: float, y: float, pz: float)
class vector.backends.numpy.VectorNumpy(*, x: float, py: float, z: float)
class vector.backends.numpy.VectorNumpy(*, x: float, py: float, pz: float)
class vector.backends.numpy.VectorNumpy(*, px: float, y: float, z: float)
class vector.backends.numpy.VectorNumpy(*, px: float, y: float, pz: float)
class vector.backends.numpy.VectorNumpy(*, px: float, py: float, z: float)
class vector.backends.numpy.VectorNumpy(*, px: float, py: float, pz: float)
class vector.backends.numpy.VectorNumpy(*, rho: float, phi: float, pz: float)
class vector.backends.numpy.VectorNumpy(*, pt: float, phi: float, z: float)
class vector.backends.numpy.VectorNumpy(*, pt: float, phi: float, pz: float)
class vector.backends.numpy.VectorNumpy(*, x: float, py: float, theta: float)
class vector.backends.numpy.VectorNumpy(*, px: float, y: float, theta: float)
class vector.backends.numpy.VectorNumpy(*, px: float, py: float, theta: float)
class vector.backends.numpy.VectorNumpy(*, pt: float, phi: float, theta: float)
class vector.backends.numpy.VectorNumpy(*, x: float, py: float, eta: float)
class vector.backends.numpy.VectorNumpy(*, px: float, y: float, eta: float)
class vector.backends.numpy.VectorNumpy(*, px: float, py: float, eta: float)
class vector.backends.numpy.VectorNumpy(*, pt: float, phi: float, eta: float)
class vector.backends.numpy.VectorNumpy(*, x: float, y: float, z: float, t: float)
class vector.backends.numpy.VectorNumpy(*, x: float, y: float, pz: float, t: float)
class vector.backends.numpy.VectorNumpy(*, x: float, py: float, z: float, t: float)
class vector.backends.numpy.VectorNumpy(*, x: float, py: float, pz: float, t: float)
class vector.backends.numpy.VectorNumpy(*, px: float, y: float, z: float, t: float)
```











```

class vector.backends.numpy.VectorNumpy(*, x: float, py: float, theta: float, mass: float)
class vector.backends.numpy.VectorNumpy(*, px: float, y: float, theta: float, mass: float)
class vector.backends.numpy.VectorNumpy(*, px: float, py: float, theta: float, mass: float)
class vector.backends.numpy.VectorNumpy(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.numpy.VectorNumpy(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.numpy.VectorNumpy(*, x: float, y: float, eta: float, mass: float)
class vector.backends.numpy.VectorNumpy(*, x: float, py: float, eta: float, mass: float)
class vector.backends.numpy.VectorNumpy(*, px: float, y: float, eta: float, mass: float)
class vector.backends.numpy.VectorNumpy(*, px: float, py: float, eta: float, mass: float)
class vector.backends.numpy.VectorNumpy(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.numpy.VectorNumpy(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.numpy.VectorNumpy(__azimuthal: Azimuthal)
class vector.backends.numpy.VectorNumpy(__azimuthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.numpy.VectorNumpy(__azimuthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)

```

Bases: [Vector](#), [GetItem](#)

Mixin class for NumPy vectors.

**allclose**(*other*: [VectorProtocol](#), *rtol*: float | ndarray = 1e-05, *atol*: float | ndarray = 1e-08, *equal\_nan*: bool | ndarray = False) → Any

Like np.ndarray.allclose, but for VectorNumpy.

**dtype**: numpy.dtype[Any]

**lib** = <module 'numpy' from '/home/docs/checkouts/readthedocs.org/user\_builds/vector/envs/latest/lib/python3.12/site-packages/numpy/\_\_init\_\_.py'>

**sum**(*axis*: int | None = None, *dtype*: dtype[Any] | str | None = None, *out*: Any | None = None, *keepdims*: bool = False, *initial*: Any = None, *where*: Any = None) → SameVectorNumpyType

**class** vector.backends.numpy.VectorNumpy2D(\*args: Any, \*\*kwargs: Any)

Bases: [VectorNumpy](#), [Planar](#), [Vector2D](#), ndarray

Two dimensional vector class for the NumPy backend. This class can be directly used to construct two dimensional NumPy vectors. For two dimensional Momentum NumPy vectors see [vector.backends.numpy.MomentumNumpy2D](#).

## Examples

```

>>> import vector
>>> vec = vector.VectorNumpy2D([(1.1, 2.1), (1.2, 2.2), (1.3, 2.3), (1.4, 2.4), (1.
→ 5, 2.5)],
...                             dtype=[('x', float), ('y', float)])
>>> vec
VectorNumpy2D([(1.1, 2.1), (1.2, 2.2), (1.3, 2.3), (1.4, 2.4), (1.5, 2.5)],
               dtype=[('x', '<f8'), ('y', '<f8')])

```

## GenericClass

alias of [VectorNumpy2D](#)

**MomentumClass**alias of *MomentumNumpy2D***ObjectClass**alias of *VectorObject2D***ProjectionClass2D**alias of *VectorNumpy2D***ProjectionClass3D**alias of *VectorNumpy3D***ProjectionClass4D**alias of *VectorNumpy4D***\_IS\_MOMENTUM:** ClassVar[bool] = False**\_azimuthal\_type:** type[*AzimuthalNumpyXY*] | type[*AzimuthalNumpyRhoPhi*]**\_wrap\_result**(cls: Any, result: Any, returns: Any, num\_vecargs: Any) → Any

Wraps the raw result of a compute function as an array of scalars or an array of vectors.

**Parameters**

- **result** – Value or tuple of values from a compute function.
- **returns** – Signature from a dispatch\_map.
- **num\_vecargs** (int) – Number of vector arguments in the function that would be treated on an equal footing (i.e. add has two, but rotate\_axis has only one: the axis is secondary).

**property azimuthal:** *AzimuthalNumpy*

Returns the azimuthal type class for the given VectorNumpy2D object.

**Examples**

```
>>> import vector
>>> vec = vector.array([
...     (1.1, 2.1), (1.2, 2.2), (1.3, 2.3), (1.4, 2.4), (1.5, 2.5)
... ], dtype=[("x", float), ("y", float)])
>>> vec.azimuthal
AzimuthalNumpyXY([(1.1, 2.1), (1.2, 2.2), (1.3, 2.3), (1.4, 2.4),
                    (1.5, 2.5)], dtype=[('x', '<f8'), ('y', '<f8')])
```

**class** vector.backends.numpy.**VectorNumpy3D**(\*args: Any, \*\*kwargs: Any)Bases: *VectorNumpy*, *Spatial*, *Vector3D*, ndarray

Three dimensional vector class for the NumPy backend. This class can be directly used to construct three dimensional NumPy vectors. For three dimensional Momentum NumPy vectors see *vector.backends.numpy.MomentumNumpy3D*.

## Examples

```
>>> import vector
>>> vec = vector.VectorNumpy3D([(1.1, 2.1, 3.1), (1.2, 2.2, 3.2), (1.3, 2.3, 3.3),
→ (1.4, 2.4, 3.4), (1.5, 2.5, 3.5)],
...                             dtype=[('x', float), ('y', float), ('z', float)])
>>> vec
VectorNumpy3D([(1.1, 2.1, 3.1), (1.2, 2.2, 3.2), (1.3, 2.3, 3.3), (1.4, 2.4, 3.4),
                (1.5, 2.5, 3.5)], dtype=[('x', '<f8'), ('y', '<f8'), ('z', '<f8')])
```

**GenericClass**alias of *VectorNumpy3D***MomentumClass**alias of *MomentumNumpy3D***ObjectClass**alias of *VectorObject3D***ProjectionClass2D**alias of *VectorNumpy2D***ProjectionClass3D**alias of *VectorNumpy3D***ProjectionClass4D**alias of *VectorNumpy4D***\_IS\_MOMENTUM:** ClassVar[bool] = False**\_azimuthal\_type:** type[*AzimuthalNumpyXY*] | type[*AzimuthalNumpyRhoPhi*]**\_longitudinal\_type:** type[*LongitudinalNumpyZ*] | type[*LongitudinalNumpyTheta*] |  
type[*LongitudinalNumpyEta*]**\_wrap\_result**(cls: Any, result: Any, returns: Any, num\_vecargs: Any) → Any

Wraps the raw result of a compute function as an array of scalars or an array of vectors.

**Parameters**

- **result** – Value or tuple of values from a compute function.
- **returns** – Signature from a `dispatch_map`.
- **num\_vecargs** (*int*) – Number of vector arguments in the function that would be treated on an equal footing (i.e. `add` has two, but `rotate_axis` has only one: the axis is secondary).

**property azimuthal:** *AzimuthalNumpy*Returns the azimuthal type class for the given *VectorNumpy3D* object.**property longitudinal:** *LongitudinalNumpy*Returns the longitudinal type class for the given *VectorNumpy3D* object.**class** `vector.backends.numpy.VectorNumpy4D`(\*args: Any, \*\*kwargs: Any)Bases: *VectorNumpy*, *Lorentz*, *Vector4D*, *ndarray*

Four dimensional vector class for the NumPy backend. This class can be directly used to construct four dimensional NumPy vectors. For four dimensional Momentum NumPy vectors see *vector.backends.numpy.MomentumNumpy4D*.

## Examples

```
>>> import vector
>>> vec = vector.VectorNumpy4D([(1.1, 2.1, 3.1, 4.1), (1.2, 2.2, 3.2, 4.2), (1.3, 2.
→ 3, 3.3, 4.3), (1.4, 2.4, 3.4, 4.4), (1.5, 2.5, 3.5, 4.5)],
...                             dtype=[('x', float), ('y', float), ('z', float), ('t', float)])
>>> vec
VectorNumpy4D([(1.1, 2.1, 3.1, 4.1), (1.2, 2.2, 3.2, 4.2), (1.3, 2.3, 3.3, 4.3),
               (1.4, 2.4, 3.4, 4.4), (1.5, 2.5, 3.5, 4.5)],
               dtype=[('x', '<f8'), ('y', '<f8'), ('z', '<f8'), ('t', '<f8')])
```

### GenericClass

alias of *VectorNumpy4D*

### MomentumClass

alias of *MomentumNumpy4D*

### ObjectClass

alias of *VectorObject4D*

### ProjectionClass2D

alias of *VectorNumpy2D*

### ProjectionClass3D

alias of *VectorNumpy3D*

### ProjectionClass4D

alias of *VectorNumpy4D*

**\_IS\_MOMENTUM:** ClassVar[bool] = False

**\_azimuthal\_type:** type[*AzimuthalNumpyXY*] | type[*AzimuthalNumpyRhoPhi*]

**\_longitudinal\_type:** type[*LongitudinalNumpyZ*] | type[*LongitudinalNumpyTheta*] |  
type[*LongitudinalNumpyEta*]

**\_temporal\_type:** type[*TemporalNumpyT*] | type[*TemporalNumpyTau*]

**\_wrap\_result**(cls: Any, result: Any, returns: Any, num\_vecargs: Any) → Any

Wraps the raw result of a compute function as an array of scalars or an array of vectors.

#### Parameters

- **result** – Value or tuple of values from a compute function.
- **returns** – Signature from a dispatch\_map.
- **num\_vecargs** (int) – Number of vector arguments in the function that would be treated on an equal footing (i.e. add has two, but rotate\_axis has only one: the axis is secondary).

**property azimuthal:** *AzimuthalNumpy*

Returns the azimuthal type class for the given VectorNumpy4D object.

**property longitudinal:** *LongitudinalNumpy*

Returns the longitudinal type class for the given VectorNumpy4D object.

**property temporal:** *TemporalNumpy*

Returns the azimuthal type class for the given VectorNumpy4D object.

`vector.backends.numpy._array_from_columns(columns: dict[str, Any]) → Any`

Converts a dictionary (or columns) of coordinates to an array.

**Parameters**

**columns** (*dict*) – The dictionary of coordinates to be converted.

**Returns**

A structured array of coordinates.

**Return type**

`np.ndarray`

## Examples

```
>>> import vector
>>> vector.backends.numpy._array_from_columns({"x": [1, 2, 3], "y": [1, 2, 4]})
array([(1., 1.), (2., 2.), (3., 4.)], dtype=[('x', '<f8'), ('y', '<f8')])
```

`vector.backends.numpy._array_repr(array: VectorNumpy2D | VectorNumpy3D | VectorNumpy4D, is_momentum: bool) → str`

Constructs the value for `__repr__` function of the provided `VectorNumpy` class.

`vector.backends.numpy._getitem(array: VectorNumpy2D | VectorNumpy3D | VectorNumpy4D, where: Any, is_momentum: bool) → float | ndarray`

Implementation for the `__getitem__` method. See [GetItem](#) for more details.

`vector.backends.numpy._has(array: VectorNumpy2D | VectorNumpy3D | VectorNumpy4D | MomentumNumpy2D | MomentumNumpy3D | MomentumNumpy4D | CoordinatesNumpy, names: tuple[str, ...]) → bool`

Checks if a NumPy vector has the provided coordinate attributes.

**Parameters**

- **array** (*NumPy vector*) – A NumPy Vector whose coordinate attributes have to be checked.
- **names** (*tuple*) – Names of the attributes.

**Returns**

If the attribute exists or not.

**Return type**

`bool`

## Examples

```
>>> from vector.backends.numpy import _has
>>> from vector._methods import _coordinate_class_to_names
>>> vec = vector.array([
...     (1.1, 2.1), (1.2, 2.2), (1.3, 2.3), (1.4, 2.4), (1.5, 2.5)
... ], dtype=[("x", float), ("y", float)])
>>> _has(vec, ("x", "y"))
True
>>> _has(vec, _coordinate_class_to_names[vector._methods.AzimuthalXY])
True
>>> _has(vec, _coordinate_class_to_names[vector._methods.AzimuthalRhoPhi])
False
```

```
vector.backends.numpy._is_type_safe(array: VectorNumpy2D | VectorNumpy3D | VectorNumpy4D |
                                     MomentumNumpy2D | MomentumNumpy3D | MomentumNumpy4D
                                     | CoordinatesNumpy) → bool
```

```
vector.backends.numpy._reduce_count_nonzero(a: T, axis: int | None = None, *, keepdims: bool = False)
→ Any
```

```
vector.backends.numpy._reduce_sum(a: T, axis: int | None = None, dtype: Any = None, out: Any = None,
                                   keepdims: bool = False, initial: Any = None, where: Any = None) → T
```

```
vector.backends.numpy._setitem(array: VectorNumpy2D | VectorNumpy3D | VectorNumpy4D, where: Any,
                                what: Any, is_momentum: bool) → None
```

```
vector.backends.numpy._shape_of(result: tuple[ndarray, ...] | Any) → tuple[int, ...]
```

Calculates the shape of a tuple of ``numpy.array``'s. The shape returned is the highest (numerical) value of the shapes present in the tuple.

#### Parameters

**result** (*tuple*) – A tuple of ``numpy.array``'s.

#### Returns

The calculated shape.

#### Return type

*tuple*

### Examples

```
>>> from vector.backends.numpy import _shape_of
>>> import numpy as np
>>> _shape_of((np.array([1]), np.array([2])))
(1,)
>>> _shape_of((np.array([1]), np.array([2, 8]), np.array([0])))
(2,)
>>> _shape_of((np.array([1]), np.array([2, 8])))
(2,)
```

```
vector.backends.numpy._toarrays(result: tuple[Any, ...] | Any) → tuple[ndarray, ...]
```

Converts a tuple of values to a tuple of ``numpy.array``'s.

#### Parameters

**result** (*tuple*) – A tuple of values to be converted.

#### Returns

A tuple of `numpy.array`.

#### Return type

*tuple*

### Examples

```
>>> from vector.backends.numpy import _toarrays
>>> _toarrays((1, 2, 3, 4))
(array([1.]), array([2.]), array([3.]), array([4.]))
>>> _toarrays((1, 2, (1, 2, 3)))
(array([1.]), array([2.]), array([[1., 2., 3.]])
```

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```
>>> _toarrays((1, 2, (1, 2, False)))
(array([1.]), array([2.]), array([[1., 2., 0.])))
```

`vector.backends.numpy.array(*args: Any, **kwargs: Any) → VectorNumpy`

Constructs a NumPy array of vectors, whose type is determined by the dtype of the structured array or Pandas-style “columns” argument.

All allowed signatures for `np.array` can be used in this function, plus one more:

```
vector.array({"x": x_column, "y": y_column})
```

to make an array with `dtype=[("x", x_column.dtype), ("y", y_column.dtype)]`.

The array must have structured dtype (i.e. `dtype.names` is not `None`) and the following combinations of names are allowed:

- (2D) x, y
- (2D) rho, phi
- (3D) x, y, z
- (3D) x, y, theta
- (3D) x, y, eta
- (3D) rho, phi, z
- (3D) rho, phi, theta
- (3D) rho, phi, eta
- (4D) x, y, z, t
- (4D) x, y, z, tau`
- (4D) x, y, theta, t`
- (4D) x, y, theta, tau`
- (4D) x, y, eta, t`
- (4D) x, y, eta, tau`
- (4D) rho, phi, z, t`
- (4D) rho, phi, z, tau`
- (4D) rho, phi, theta, t`
- (4D) rho, phi, theta, tau`
- (4D) rho, phi, eta, t`
- (4D) rho, phi, eta, tau`

in which

- `px` may be substituted for `x`
- `py` may be substituted for `y`
- `pt` may be substituted for `rho`
- `pz` may be substituted for `z`



- E may be substituted for  $t$
- e may be substituted for  $t$
- energy may be substituted for  $t$
- M may be substituted for  $\tau$
- m may be substituted for  $\tau$
- mass may be substituted for  $\tau$

to make the vector a momentum vector.

### vector.backends.awkward module

Defines behaviors for Awkward Array. New arrays created with the

```
vector.Array(...)
vector.awk(...)
vector.zip(...)
```

function will have these behaviors built in (and will pass them to any derived arrays).

Alternatively, you can

```
vector.register_awkward()
```

to install the behaviors globally, so that any record named `Vector2D`, `Vector3D`, `Vector4D`, `Momentum2D`, `Momentum3D`, or `Momentum4D` will have these properties and methods.

The Awkward-Vectors-in-Numba extension is also implemented here, since it requires two non-strict dependencies of Vector: Awkward and Numba. Awkward's `ak.behavior` manages this non-strictness well.

```
class vector.backends.awkward.AwkwardProtocol(*args, **kwargs)
```

Bases: *Protocol*

```
_abc_impl = <_abc._abc_data object>
```

```
_is_protocol = True
```

```
class vector.backends.awkward.AzimuthalAwkward
```

Bases: *CoordinatesAwkward*, *Azimuthal*

Azimuthal class for the Awkward backend. See -

- *AzimuthalAwkward.from\_fields()*
- *AzimuthalAwkward.from\_momentum\_fields()*

to construct azimuthal type objects.

```
classmethod from_fields(array: Array) → AzimuthalAwkward
```

Create a *vector.backends.awkward.AzimuthalAwkwardXY* or a *vector.backends.awkward.AzimuthalAwkwardRhoPhi*, depending on the fields in array.

## Examples

```
>>> import vector
>>> import awkward as ak
>>> a = ak.Array([{"x": [1, 2]}, {"y": [1]}])
>>> az = vector.backends.awkward.AzimuthalAwkward.from_fields(a)
>>> az
AzimuthalAwkwardXY(<Array [[1, 2], None] type='2 * option[var * int64]'",
↳<Array [None, [1]] type='2 * option[var * int64]'">)
>>> az.elements
(<Array [[1, 2], None] type='2 * option[var * int64]'", <Array [None, [1]] type=
↳'2 * option[var * int64]'">)
```

**classmethod** `from_momentum_fields(array: Array) → AzimuthalAwkward`

Create a `vector.backends.awkward.AzimuthalAwkwardXY` or a `vector.backends.awkward.AzimuthalAwkwardRhoPhi`, depending on the fields in `array`, allowing momentum synonyms.

## Examples

```
>>> import vector
>>> import awkward as ak
>>> a = ak.Array([{"px": [1, 2]}, {"py": [1]}])
>>> az = vector.backends.awkward.AzimuthalAwkward.from_momentum_fields(a)
>>> az
AzimuthalAwkwardXY(<Array [[1, 2], None] type='2 * option[var * int64]'",
↳<Array [None, [1]] type='2 * option[var * int64]'">)
>>> az.elements
(<Array [[1, 2], None] type='2 * option[var * int64]'", <Array [None, [1]] type=
↳'2 * option[var * int64]'">)
```

**class** `vector.backends.awkward.AzimuthalAwkwardRhoPhi(rho: Any, phi: Any)`

Bases: `AzimuthalAwkward`, `AzimuthalRhoPhi`

Class for the rho and phi (azimuthal) coordinates of Awkward backend.

## Examples

```
>>> import vector
>>> import awkward as ak
>>> a = ak.Array([{"rho": [1, 2]}, {"phi": [1]}])
>>> az = vector.backends.awkward.AzimuthalAwkwardRhoPhi(a["rho"], a["phi"])
>>> az
AzimuthalAwkwardRhoPhi(<Array [[1, 2], None] type='2 * option[var * int64]'",
↳<Array [None, [1]] type='2 * option[var * int64]'">)
>>> az.elements
(<Array [[1, 2], None] type='2 * option[var * int64]'", <Array [None, [1]] type='2 *
↳option[var * int64]'">)
```

**property** `elements: tuple[ArrayOrRecord, ArrayOrRecord]`

Azimuthal coordinates (rho and phi) as a tuple.

## Examples

```
>>> import vector
>>> az = vector.backends.awkward.AzimuthalAwkwardRhoPhi([1, 2, 3], [1, 2])
>>> az.elements
([1, 2, 3], [1, 2])
```

**phi:** Any

**rho:** Any

**class** vector.backends.awkward.AzimuthalAwkwardXY(x: Any, y: Any)

Bases: [AzimuthalAwkward](#), [AzimuthalXY](#)

Class for the x and y (azimuthal) coordinates of Awkward backend.

## Examples

```
>>> import vector
>>> import awkward as ak
>>> a = ak.Array([{"x": [1, 2]}, {"y": [1]}])
>>> az = vector.backends.awkward.AzimuthalAwkwardXY(a["x"], a["y"])
>>> az
AzimuthalAwkwardXY(<Array [[1, 2], None] type='2 * option[var * int64]'\>, <Array [
  ↳ [None, [1]] type='2 * option[var * int64]'\>)>
>>> az.elements
(<Array [[1, 2], None] type='2 * option[var * int64]'\>, <Array [None, [1]] type='2 *
  ↳ * option[var * int64]'\>)>
```

**property elements:** tuple[ArrayOrRecord, ArrayOrRecord]

Azimuthal coordinates (x and y) as a tuple.

## Examples

```
>>> import vector
>>> az = vector.backends.awkward.AzimuthalAwkwardXY([1, 2, 3], [1, 2])
>>> az.elements
([1, 2, 3], [1, 2])
```

**x:** Any

**y:** Any

**class** vector.backends.awkward.CoordinatesAwkward

Bases: object

**lib:** ModuleType = <module 'numpy' from '/home/docs/checkouts/readthedocs.org/user\_builds/vector/envs/latest/lib/python3.12/site-packages/numpy/\_\_init\_\_.py'>

**class** vector.backends.awkward.LongitudinalAwkward

Bases: [CoordinatesAwkward](#), [Longitudinal](#)

Longitudinal class for the Awkward backend. See -

- `LongitudinalAwkward.from_fields()`
- `LongitudinalAwkward.from_momentum_fields()`

to construct longitudinal type objects.

**classmethod** `from_fields(array: Array) → LongitudinalAwkward`

Create a `vector.backends.awkward.LongitudinalAwkwardZ`, a `vector.backends.awkward.LongitudinalAwkwardTheta`, or a `vector.backends.awkward.LongitudinalAwkwardEta`, depending on the fields in array.

### Examples

```
>>> import vector
>>> import awkward as ak
>>> a = ak.Array([{"theta": [1, 0]}])
>>> l = vector.backends.awkward.LongitudinalAwkward.from_fields(a)
>>> l
LongitudinalAwkwardTheta(<Array [[1, 0]] type='1 * var * int64'>,)
>>> l.elements
(<Array [[1, 0]] type='1 * var * int64'>,)

```

**classmethod** `from_momentum_fields(array: Array) → LongitudinalAwkward`

Create a `vector.backends.awkward.LongitudinalAwkwardZ`, a `vector.backends.awkward.LongitudinalAwkwardTheta`, or a `vector.backends.awkward.LongitudinalAwkwardEta`, depending on the fields in array, allowing momentum synonyms.

### Examples

```
>>> import vector
>>> import awkward as ak
>>> a = ak.Array([{"theta": [1, 0]}])
>>> l = vector.backends.awkward.LongitudinalAwkward.from_momentum_fields(a)
>>> l
LongitudinalAwkwardTheta(<Array [[1, 0]] type='1 * var * int64'>,)
>>> l.elements
(<Array [[1, 0]] type='1 * var * int64'>,)

```

**class** `vector.backends.awkward.LongitudinalAwkwardEta(eta: Any)`

Bases: `LongitudinalAwkward`, `LongitudinalEta`

Class for the eta (longitudinal) coordinate of Awkward backend.

### Examples

```
>>> import vector
>>> import awkward as ak
>>> a = ak.Array([{"eta": [1, 2]}])
>>> l = vector.backends.awkward.LongitudinalAwkwardEta(a["eta"])
>>> l
LongitudinalAwkwardEta(<Array [[1, 2]] type='1 * var * int64'>,)

```

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(continued from previous page)

```
>>> l.elements
(<Array [[1, 2]] type='1 * var * int64'>,)
```

**property elements:** tuple[ArrayOrRecord]

Longitudinal coordinates (eta) as a tuple.

### Examples

```
>>> import vector
>>> l = vector.backends.awkward.LongitudinalAwkwardEta(5)
>>> l.elements
(5,)
```

**eta:** Any

**class** vector.backends.awkward.LongitudinalAwkwardTheta(theta: Any)

Bases: [LongitudinalAwkward](#), [LongitudinalTheta](#)

Class for the theta (longitudinal) coordinate of Awkward backend.

### Examples

```
>>> import vector
>>> import awkward as ak
>>> a = ak.Array([{"theta": [1, 2]}])
>>> l = vector.backends.awkward.LongitudinalAwkwardTheta(a["theta"])
>>> l
LongitudinalAwkwardTheta(<Array [[1, 2]] type='1 * var * int64'>,)
>>> l.elements
(<Array [[1, 2]] type='1 * var * int64'>,)
>>>
```

**property elements:** tuple[ArrayOrRecord]

Longitudinal coordinates (theta) as a tuple.

### Examples

```
>>> import vector
>>> l = vector.backends.awkward.LongitudinalAwkwardTheta(5)
>>> l.elements
(5,)
```

**theta:** Any

**class** vector.backends.awkward.LongitudinalAwkwardZ(z: Any)

Bases: [LongitudinalAwkward](#), [LongitudinalZ](#)

Class for the z (longitudinal) coordinate of Awkward backend.

## Examples

```
>>> import vector
>>> import awkward as ak
>>> a = ak.Array([{"z": [1, 2]}])
>>> l = vector.backends.awkward.LongitudinalAwkwardZ(a["z"])
>>> l
LongitudinalAwkwardZ(<Array [[1, 2]] type='1 * var * int64'>,)
>>> l.elements
(<Array [[1, 2]] type='1 * var * int64'>,)

```

**property elements:** tuple[ArrayOrRecord]

Longitudinal coordinates (z) as a tuple.

## Examples

```
>>> import vector
>>> l = vector.backends.awkward.LongitudinalAwkwardZ(5)
>>> l.elements
(5,)

```

**z:** Any

```
class vector.backends.awkward.MomentumArray2D(*, x: float, y: float)
class vector.backends.awkward.MomentumArray2D(*, rho: float, phi: float)
class vector.backends.awkward.MomentumArray2D(*, x: float, y: float, z: float)
class vector.backends.awkward.MomentumArray2D(*, x: float, y: float, eta: float)
class vector.backends.awkward.MomentumArray2D(*, x: float, y: float, theta: float)
class vector.backends.awkward.MomentumArray2D(*, rho: float, phi: float, z: float)
class vector.backends.awkward.MomentumArray2D(*, rho: float, phi: float, eta: float)
class vector.backends.awkward.MomentumArray2D(*, rho: float, phi: float, theta: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, py: float)
class vector.backends.awkward.MomentumArray2D(*, x: float, py: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, y: float)
class vector.backends.awkward.MomentumArray2D(*, pt: float, phi: float)
class vector.backends.awkward.MomentumArray2D(*, x: float, y: float, pz: float)
class vector.backends.awkward.MomentumArray2D(*, x: float, py: float, z: float)
class vector.backends.awkward.MomentumArray2D(*, x: float, py: float, pz: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, y: float, z: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, y: float, pz: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, py: float, z: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, py: float, pz: float)
class vector.backends.awkward.MomentumArray2D(*, rho: float, phi: float, pz: float)
class vector.backends.awkward.MomentumArray2D(*, pt: float, phi: float, z: float)
class vector.backends.awkward.MomentumArray2D(*, pt: float, phi: float, pz: float)
class vector.backends.awkward.MomentumArray2D(*, x: float, py: float, theta: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, y: float, theta: float)

```

[illegible]

[illegible]







```

class vector.backends.awkward.MomentumArray2D(*, x: float, py: float, z: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, x: float, py: float, pz: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, y: float, z: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, y: float, pz: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, py: float, z: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, py: float, pz: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, rho: float, phi: float, z: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, rho: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, pt: float, phi: float, z: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, pt: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, x: float, y: float, theta: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray2D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray2D(__azimuthal: Azimuthal)
class vector.backends.awkward.MomentumArray2D(__azimuthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.awkward.MomentumArray2D(__azimuthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)

```

Bases: [MomentumAwkward2D](#), Array

Defines awkward behavior for a 2 dimensional momentum vector.

See [MomentumRecord2D](#) and [VectorArray2D](#) for the corresponding Record and Vector classes.

#### GenericClass

alias of [VectorArray2D](#)

#### MomentumClass

alias of [MomentumArray2D](#)

#### ProjectionClass2D

alias of [MomentumArray2D](#)

#### ProjectionClass3D

alias of [MomentumArray3D](#)

#### ProjectionClass4D

alias of [MomentumArray4D](#)

`_abc_impl = <_abc._abc_data object>`

**allclose**(*other*: [VectorProtocol](#), *rtol*: Any = 1e-05, *atol*: Any = 1e-08, *equal\_nan*: Any = False) → Any

Like `np.ndarray.allclose`, but for `MomentumArray4D`.

```
class vector.backends.awkward.MomentumArray3D(*, x: float, y: float)
class vector.backends.awkward.MomentumArray3D(*, rho: float, phi: float)
class vector.backends.awkward.MomentumArray3D(*, x: float, y: float, z: float)
class vector.backends.awkward.MomentumArray3D(*, x: float, y: float, eta: float)
class vector.backends.awkward.MomentumArray3D(*, x: float, y: float, theta: float)
class vector.backends.awkward.MomentumArray3D(*, rho: float, phi: float, z: float)
class vector.backends.awkward.MomentumArray3D(*, rho: float, phi: float, eta: float)
class vector.backends.awkward.MomentumArray3D(*, rho: float, phi: float, theta: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, py: float)
class vector.backends.awkward.MomentumArray3D(*, x: float, py: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, y: float)
class vector.backends.awkward.MomentumArray3D(*, pt: float, phi: float)
class vector.backends.awkward.MomentumArray3D(*, x: float, y: float, pz: float)
class vector.backends.awkward.MomentumArray3D(*, x: float, py: float, z: float)
class vector.backends.awkward.MomentumArray3D(*, x: float, py: float, pz: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, y: float, z: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, y: float, pz: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, py: float, z: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, py: float, pz: float)
class vector.backends.awkward.MomentumArray3D(*, rho: float, phi: float, pz: float)
class vector.backends.awkward.MomentumArray3D(*, pt: float, phi: float, z: float)
class vector.backends.awkward.MomentumArray3D(*, pt: float, phi: float, pz: float)
class vector.backends.awkward.MomentumArray3D(*, x: float, py: float, theta: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, y: float, theta: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, py: float, theta: float)
class vector.backends.awkward.MomentumArray3D(*, pt: float, phi: float, theta: float)
class vector.backends.awkward.MomentumArray3D(*, x: float, py: float, eta: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, y: float, eta: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, py: float, eta: float)
class vector.backends.awkward.MomentumArray3D(*, pt: float, phi: float, eta: float)
class vector.backends.awkward.MomentumArray3D(*, x: float, y: float, z: float, t: float)
class vector.backends.awkward.MomentumArray3D(*, x: float, y: float, pz: float, t: float)
class vector.backends.awkward.MomentumArray3D(*, x: float, py: float, z: float, t: float)
class vector.backends.awkward.MomentumArray3D(*, x: float, py: float, pz: float, t: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, y: float, z: float, t: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, y: float, pz: float, t: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, py: float, z: float, t: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, py: float, pz: float, t: float)
class vector.backends.awkward.MomentumArray3D(*, rho: float, phi: float, z: float, t: float)
class vector.backends.awkward.MomentumArray3D(*, rho: float, phi: float, pz: float, t: float)
class vector.backends.awkward.MomentumArray3D(*, pt: float, phi: float, z: float, t: float)
class vector.backends.awkward.MomentumArray3D(*, pt: float, phi: float, pz: float, t: float)
```







[illegible]



```

class vector.backends.awkward.MomentumArray3D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray3D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray3D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray3D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray3D(__azimuthal: Azimuthal)
class vector.backends.awkward.MomentumArray3D(__azimuthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.awkward.MomentumArray3D(__azimuthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)

```

Bases: [MomentumAwkward3D](#), [Array](#)

Defines awkward behavior for a 3 dimensional momentum vector.

See [MomentumRecord3D](#) and [VectorArray3D](#) for the corresponding Record and Vector classes.

#### GenericClass

alias of [VectorArray3D](#)

#### MomentumClass

alias of [MomentumArray3D](#)

#### ProjectionClass2D

alias of [MomentumArray2D](#)

#### ProjectionClass3D

alias of [MomentumArray3D](#)

#### ProjectionClass4D

alias of [MomentumArray4D](#)

`_abc_impl = <_abc._abc_data object>`

`allclose(other: VectorProtocol, rtol: Any = 1e-05, atol: Any = 1e-08, equal_nan: Any = False) → Any`

```

class vector.backends.awkward.MomentumArray4D(*, x: float, y: float)
class vector.backends.awkward.MomentumArray4D(*, rho: float, phi: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, y: float, z: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, y: float, eta: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, y: float, theta: float)
class vector.backends.awkward.MomentumArray4D(*, rho: float, phi: float, z: float)
class vector.backends.awkward.MomentumArray4D(*, rho: float, phi: float, eta: float)
class vector.backends.awkward.MomentumArray4D(*, rho: float, phi: float, theta: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, py: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, py: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, y: float)
class vector.backends.awkward.MomentumArray4D(*, pt: float, phi: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, y: float, pz: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, py: float, z: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, py: float, pz: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, y: float, z: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, y: float, pz: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, py: float, z: float)

```

[illegible]







```
class vector.backends.awkward.MomentumArray4D(*, px: float, y: float, eta: float, m: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, py: float, eta: float, m: float)
class vector.backends.awkward.MomentumArray4D(*, rho: float, phi: float, eta: float, m: float)
class vector.backends.awkward.MomentumArray4D(*, pm: float, phi: float, eta: float, m: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, y: float, z: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, y: float, pz: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, py: float, z: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, py: float, pz: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, y: float, z: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, y: float, pz: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, py: float, z: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, py: float, pz: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, rho: float, phi: float, z: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, rho: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, pt: float, phi: float, z: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, pt: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, y: float, theta: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray4D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumArray4D(__azumthal: Azimuthal)
class vector.backends.awkward.MomentumArray4D(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.awkward.MomentumArray4D(__azumthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)
```

Bases: [MomentumAwkward4D](#), [Array](#)

Defines awkward behavior for a 4 dimensional momentum vector.

See [MomentumRecord4D](#) and [VectorArray4D](#) for the corresponding Record and Vector classes.

#### GenericClass

alias of [VectorArray4D](#)

#### MomentumClass

alias of [MomentumArray4D](#)

#### ProjectionClass2D

alias of [MomentumArray2D](#)

#### ProjectionClass3D

alias of [MomentumArray3D](#)

**ProjectionClass4D**alias of *MomentumArray4D***\_abc\_impl** = <\_abc.\_abc\_data object>**allclose**(*other*: *VectorProtocol*, *rtol*: *Any* = 1e-05, *atol*: *Any* = 1e-08, *equal\_nan*: *Any* = False) → *Any*

```

class vector.backends.awkward.MomentumAwkward2D(*, x: float, y: float)
class vector.backends.awkward.MomentumAwkward2D(*, rho: float, phi: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, y: float, z: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, y: float, eta: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, y: float, theta: float)
class vector.backends.awkward.MomentumAwkward2D(*, rho: float, phi: float, z: float)
class vector.backends.awkward.MomentumAwkward2D(*, rho: float, phi: float, eta: float)
class vector.backends.awkward.MomentumAwkward2D(*, rho: float, phi: float, theta: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, py: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, py: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, y: float)
class vector.backends.awkward.MomentumAwkward2D(*, pt: float, phi: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, y: float, pz: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, py: float, z: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, py: float, pz: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, y: float, z: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, y: float, pz: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, py: float, z: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, py: float, pz: float)
class vector.backends.awkward.MomentumAwkward2D(*, rho: float, phi: float, pz: float)
class vector.backends.awkward.MomentumAwkward2D(*, pt: float, phi: float, z: float)
class vector.backends.awkward.MomentumAwkward2D(*, pt: float, phi: float, pz: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, py: float, theta: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, y: float, theta: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, py: float, theta: float)
class vector.backends.awkward.MomentumAwkward2D(*, pt: float, phi: float, theta: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, py: float, eta: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, y: float, eta: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, py: float, eta: float)
class vector.backends.awkward.MomentumAwkward2D(*, pt: float, phi: float, eta: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, y: float, z: float, t: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, y: float, pz: float, t: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, py: float, z: float, t: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, py: float, pz: float, t: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, y: float, z: float, t: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, y: float, pz: float, t: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, py: float, z: float, t: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, py: float, pz: float, t: float)
class vector.backends.awkward.MomentumAwkward2D(*, rho: float, phi: float, z: float, t: float)

```













```
class vector.backends.awkward.MomentumAwkward2D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward2D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward2D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward2D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward2D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward2D(__azimuthal: Azimuthal)
class vector.backends.awkward.MomentumAwkward2D(__azimuthal: Azimuthal, __longitudinal:
Longitudinal)
class vector.backends.awkward.MomentumAwkward2D(__azimuthal: Azimuthal, __longitudinal:
Longitudinal, __temporal: Temporal)
```

Bases: [PlanarMomentum](#), [VectorAwkward2D](#)

Two dimensional momentum vector class for the Awkward backend. Two dimensional momentum vectors for the users are defined using the [MomentumArray2D](#) class.

See [VectorAwkward2D](#) for momentum vectors.

**property azimuthal:** [AzimuthalAwkward](#)

Returns an Azimuthal type object containing the azimuthal coordinates.

Use the elements property of the created object to access the coordinates.

## Examples

```
>>> import vector
>>> a = vector.Array(
...     [{"px": 1, "py": 1.1}, {"px": 2, "py": 2.2}],
... )
>>> a.azimuthal
AzimuthalAwkwardXY(<Array [1, 2] type='2 * int64'>, <Array [1.1, 2.2] type='2 *
↳float64'>)
>>> a.azimuthal.elements
(<Array [1, 2] type='2 * int64'>, <Array [1.1, 2.2] type='2 * float64'>)
```

```
class vector.backends.awkward.MomentumAwkward3D(*, x: float, y: float)
class vector.backends.awkward.MomentumAwkward3D(*, rho: float, phi: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, y: float, z: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, y: float, eta: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, y: float, theta: float)
class vector.backends.awkward.MomentumAwkward3D(*, rho: float, phi: float, z: float)
class vector.backends.awkward.MomentumAwkward3D(*, rho: float, phi: float, eta: float)
class vector.backends.awkward.MomentumAwkward3D(*, rho: float, phi: float, theta: float)
class vector.backends.awkward.MomentumAwkward3D(*, px: float, py: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, py: float)
class vector.backends.awkward.MomentumAwkward3D(*, px: float, y: float)
class vector.backends.awkward.MomentumAwkward3D(*, pt: float, phi: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, y: float, pz: float)
```











```

class vector.backends.awkward.MomentumAwkward3D(*, px: float, py: float, theta: float, m: float)
class vector.backends.awkward.MomentumAwkward3D(*, rho: float, phi: float, theta: float, m: float)
class vector.backends.awkward.MomentumAwkward3D(*, pm: float, phi: float, theta: float, m: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, y: float, eta: float, m: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, py: float, eta: float, m: float)
class vector.backends.awkward.MomentumAwkward3D(*, px: float, y: float, eta: float, m: float)
class vector.backends.awkward.MomentumAwkward3D(*, px: float, py: float, eta: float, m: float)
class vector.backends.awkward.MomentumAwkward3D(*, rho: float, phi: float, eta: float, m: float)
class vector.backends.awkward.MomentumAwkward3D(*, pm: float, phi: float, eta: float, m: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, y: float, z: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, y: float, pz: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, py: float, z: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, py: float, pz: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, px: float, y: float, z: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, px: float, y: float, pz: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, px: float, py: float, z: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, px: float, py: float, pz: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, rho: float, phi: float, z: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, rho: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, pt: float, phi: float, z: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, pt: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, y: float, theta: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward3D(__azimuthal: Azimuthal)
class vector.backends.awkward.MomentumAwkward3D(__azimuthal: Azimuthal, __longitudinal:
Longitudinal)
class vector.backends.awkward.MomentumAwkward3D(__azimuthal: Azimuthal, __longitudinal:
Longitudinal, __temporal: Temporal)

```

Bases: [SpatialMomentum](#), [VectorAwkward3D](#)

Three dimensional momentum vector class for the Awkward backend. Three dimensional momentum vectors for the users are defined using the [MomentumArray3D](#) class.

See [VectorAwkward3D](#) for momentum vectors.

**property azimuthal:** [AzimuthalAwkward](#)

Returns an Azimuthal type object containing the azimuthal coordinates.

Use the `elements` property of the created object to access the coordinates.

## Examples

```
>>> import vector
>>> a = vector.Array(
...     [{"px": 1, "py": 1.1, "z": 0.1}, {"px": 2, "py": 2.2, "z": 0.2}],
... )
>>> a.azimuthal
AzimuthalAwkwardXY(<Array [1, 2] type='2 * int64'>, <Array [1.1, 2.2] type='2 *
↳float64'>
>>> a.azimuthal.elements
(<Array [1, 2] type='2 * int64'>, <Array [1.1, 2.2] type='2 * float64'>)
```

**property longitudinal:** *LongitudinalAwkward*

Returns a Longitudinal type object containing the longitudinal coordinates.

Use the elements property of the created object to access the coordinates.

## Examples

```
>>> import vector
>>> a = vector.Array(
...     [{"px": 1, "py": 1.1, "z": 0.1}, {"px": 2, "py": 2.2, "z": 0.2}],
... )
>>> a.longitudinal
LongitudinalAwkwardZ(<Array [0.1, 0.2] type='2 * float64'>,)
>>> a.longitudinal.elements
(<Array [0.1, 0.2] type='2 * float64'>,)
```

```
class vector.backends.awkward.MomentumAwkward4D(*, x: float, y: float)
class vector.backends.awkward.MomentumAwkward4D(*, rho: float, phi: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, y: float, z: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, y: float, eta: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, y: float, theta: float)
class vector.backends.awkward.MomentumAwkward4D(*, rho: float, phi: float, z: float)
class vector.backends.awkward.MomentumAwkward4D(*, rho: float, phi: float, eta: float)
class vector.backends.awkward.MomentumAwkward4D(*, rho: float, phi: float, theta: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, py: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, py: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, y: float)
class vector.backends.awkward.MomentumAwkward4D(*, pt: float, phi: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, y: float, pz: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, py: float, z: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, py: float, pz: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, y: float, z: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, y: float, pz: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, py: float, z: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, py: float, pz: float)
class vector.backends.awkward.MomentumAwkward4D(*, rho: float, phi: float, pz: float)
```









```

class vector.backends.awkward.MomentumAwkward4D(*, rho: float, phi: float, eta: float, m: float)
class vector.backends.awkward.MomentumAwkward4D(*, pm: float, phi: float, eta: float, m: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, y: float, z: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, y: float, pz: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, py: float, z: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, py: float, pz: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, y: float, z: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, y: float, pz: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, py: float, z: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, py: float, pz: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, rho: float, phi: float, z: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, rho: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, pt: float, phi: float, z: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, pt: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, y: float, theta: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumAwkward4D(__azimuthal: Azimuthal)
class vector.backends.awkward.MomentumAwkward4D(__azimuthal: Azimuthal, __longitudinal:
Longitudinal)
class vector.backends.awkward.MomentumAwkward4D(__azimuthal: Azimuthal, __longitudinal:
Longitudinal, __temporal: Temporal)

```

Bases: [LorentzMomentum](#), [VectorAwkward4D](#)

Four dimensional momentum vector class for the Awkward backend. Four dimensional momentum vectors for the users are defined using the [MomentumArray4D](#) class.

See [VectorAwkward4D](#) for momentum vectors.

**property azimuthal:** [AzimuthalAwkward](#)

Returns an Azimuthal type object containing the azimuthal coordinates.

Use the `elements` property of the created object to access the coordinates.



## Examples

```
>>> import vector
>>> a = vector.Array(
...     [{"px": 1, "py": 1.1, "z": 0.1, "m": 1}, {"px": 2, "py": 2.2, "z": 0.
↪2, "m": 3}],
... )
>>> a.azimuthal
AzimuthalAwkwardXY(<Array [1, 2] type='2 * int64'>, <Array [1.1, 2.2] type='2 *
↪float64'>)
>>> a.azimuthal.elements
(<Array [1, 2] type='2 * int64'>, <Array [1.1, 2.2] type='2 * float64'>)
```

**property longitudinal:** *LongitudinalAwkward*

Returns a Longitudinal type object containing the longitudinal coordinates.

Use the elements property of the created object to access the coordinates.

## Examples

```
>>> import vector
>>> a = vector.Array(
...     [{"px": 1, "py": 1.1, "z": 0.1, "m": 1}, {"px": 2, "py": 2.2, "z": 0.
↪2, "m": 3}],
... )
>>> a.longitudinal
LongitudinalAwkwardZ(<Array [0.1, 0.2] type='2 * float64'>,)
>>> a.longitudinal.elements
(<Array [0.1, 0.2] type='2 * float64'>,)
>>>
```

**property temporal:** *TemporalAwkward*

Returns a Temporal type object containing the temporal coordinates.

Use the elements property of the created object to access the coordinates. .. rubric:: Examples

```
>>> import vector
>>> a = vector.Array(
...     [{"px": 1, "py": 1.1, "z": 0.1, "m": 1}, {"px": 2, "py": 2.2, "z": 0.
↪2, "m": 3}],
... )
>>> a.temporal
TemporalAwkwardTau(<Array [1, 3] type='2 * int64'>,)
>>> a.temporal.elements
(<Array [1, 3] type='2 * int64'>,)
>>>
```

```
class vector.backends.awkward.MomentumRecord2D(*, x: float, y: float)
```

```
class vector.backends.awkward.MomentumRecord2D(*, rho: float, phi: float)
```

```
class vector.backends.awkward.MomentumRecord2D(*, x: float, y: float, z: float)
```

```
class vector.backends.awkward.MomentumRecord2D(*, x: float, y: float, eta: float)
```

```
class vector.backends.awkward.MomentumRecord2D(*, x: float, y: float, theta: float)
```

```
class vector.backends.awkward.MomentumRecord2D(*, rho: float, phi: float, z: float)
```

```
class vector.backends.awkward.MomentumRecord2D(*, rho: float, phi: float, eta: float)
```









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```
class vector.backends.awkward.MomentumRecord2D(__azumthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)
```

Bases: [MomentumAwkward2D](#), [Record](#)

Defines awkward behavior for a 2 dimensional momentum record.

See [MomentumArray2D](#) and [VectorArray2D](#) for the corresponding Momentum and Vector classes.

#### GenericClass

alias of [VectorRecord2D](#)

#### MomentumClass

alias of [MomentumRecord2D](#)

#### ProjectionClass2D

alias of [MomentumRecord2D](#)

#### ProjectionClass3D

alias of [MomentumRecord3D](#)

#### ProjectionClass4D

alias of [MomentumRecord4D](#)

```
class vector.backends.awkward.MomentumRecord3D(*, x: float, y: float)
class vector.backends.awkward.MomentumRecord3D(*, rho: float, phi: float)
class vector.backends.awkward.MomentumRecord3D(*, x: float, y: float, z: float)
class vector.backends.awkward.MomentumRecord3D(*, x: float, y: float, eta: float)
class vector.backends.awkward.MomentumRecord3D(*, x: float, y: float, theta: float)
class vector.backends.awkward.MomentumRecord3D(*, rho: float, phi: float, z: float)
class vector.backends.awkward.MomentumRecord3D(*, rho: float, phi: float, eta: float)
class vector.backends.awkward.MomentumRecord3D(*, rho: float, phi: float, theta: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, py: float)
class vector.backends.awkward.MomentumRecord3D(*, x: float, py: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, y: float)
class vector.backends.awkward.MomentumRecord3D(*, pt: float, phi: float)
class vector.backends.awkward.MomentumRecord3D(*, x: float, y: float, pz: float)
class vector.backends.awkward.MomentumRecord3D(*, x: float, py: float, z: float)
class vector.backends.awkward.MomentumRecord3D(*, x: float, py: float, pz: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, y: float, z: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, y: float, pz: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, py: float, z: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, py: float, pz: float)
class vector.backends.awkward.MomentumRecord3D(*, rho: float, phi: float, pz: float)
class vector.backends.awkward.MomentumRecord3D(*, pt: float, phi: float, z: float)
class vector.backends.awkward.MomentumRecord3D(*, pt: float, phi: float, pz: float)
class vector.backends.awkward.MomentumRecord3D(*, x: float, py: float, theta: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, y: float, theta: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, py: float, theta: float)
class vector.backends.awkward.MomentumRecord3D(*, pt: float, phi: float, theta: float)
class vector.backends.awkward.MomentumRecord3D(*, x: float, py: float, eta: float)
```











```

class vector.backends.awkward.MomentumRecord3D(*, px: float, y: float, pz: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, py: float, z: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, py: float, pz: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, rho: float, phi: float, z: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, rho: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, pt: float, phi: float, z: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, pt: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, x: float, y: float, theta: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.MomentumRecord3D(__azumthal: Azimuthal)
class vector.backends.awkward.MomentumRecord3D(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.awkward.MomentumRecord3D(__azumthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)

```

Bases: [MomentumAwkward3D](#), [Record](#)

Defines awkward behavior for a 3 dimensional momentum record.

See [MomentumArray3D](#) and [VectorArray3D](#) for the corresponding Momentum and Vector classes.

#### GenericClass

alias of [VectorRecord3D](#)

#### MomentumClass

alias of [MomentumRecord3D](#)

#### ProjectionClass2D

alias of [MomentumRecord2D](#)

#### ProjectionClass3D

alias of [MomentumRecord3D](#)

#### ProjectionClass4D

alias of [MomentumRecord4D](#)

```

class vector.backends.awkward.MomentumRecord4D(*, x: float, y: float)
class vector.backends.awkward.MomentumRecord4D(*, rho: float, phi: float)
class vector.backends.awkward.MomentumRecord4D(*, x: float, y: float, z: float)
class vector.backends.awkward.MomentumRecord4D(*, x: float, y: float, eta: float)
class vector.backends.awkward.MomentumRecord4D(*, x: float, y: float, theta: float)
class vector.backends.awkward.MomentumRecord4D(*, rho: float, phi: float, z: float)

```















---

```
class vector.backends.awkward.MomentumRecord4D(__azimuthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)
```

Bases: *MomentumAwkward4D*, *Record*

Defines awkward behavior for a 4 dimensional momentum record.

See *MomentumArray4D* and *VectorArray4D* for the corresponding Momentum and Vector classes.

**GenericClass**

alias of *VectorRecord4D*

**MomentumClass**

alias of *MomentumRecord4D*

**ProjectionClass2D**

alias of *MomentumRecord2D*

**ProjectionClass3D**

alias of *MomentumRecord3D*

**ProjectionClass4D**

alias of *MomentumRecord4D*

```
class vector.backends.awkward.TemporalAwkward
```

Bases: *CoordinatesAwkward*, *Temporal*

Temporal class for the Awkward backend. See -

- *TemporalAwkward.from\_fields()*
- *TemporalAwkward.from\_momentum\_fields()*

to construct longitudinal type objects.

**classmethod** *from\_fields*(array: Array) → *TemporalAwkward*

Create a *vector.backends.awkward.TemporalT* or a *vector.backends.awkward.TemporalTau*, depending on the fields in array.

## Examples

```
>>> import vector
>>> import awkward as ak
>>> a = ak.Array([{"tau": [1, 0]}])
>>> t = vector.backends.awkward.TemporalAwkward.from_fields(a)
>>> t
TemporalAwkwardTau(<Array [[1, 0]] type='1 * var * int64'>,)
>>> t.elements
(<Array [[1, 0]] type='1 * var * int64'>,)

```

**classmethod** *from\_momentum\_fields*(array: Array) → *TemporalAwkward*

Create a *vector.backends.awkward.TemporalT* or a *vector.backends.awkward.TemporalTau*, depending on the fields in array, allowing momentum synonyms.

### Examples

```
>>> import vector
>>> import awkward as ak
>>> a = ak.Array([{"mass": [1, 0]}])
>>> t = vector.backends.awkward.TemporalAwkward.from_momentum_fields(a)
>>> t
TemporalAwkwardTau(<Array [[1, 0]] type='1 * var * int64'>,)
>>> t.elements
(<Array [[1, 0]] type='1 * var * int64'>,,)
```

**class** `vector.backends.awkward.TemporalAwkwardT`(*t: Any*)

Bases: [`TemporalAwkward`](#), [`TemporalT`](#)

Class for the t (temporal) coordinate of Awkward backend.

### Examples

```
>>> import vector
>>> import awkward as ak
>>> a = ak.Array([{"t": [1, 2]}])
>>> t = vector.backends.awkward.TemporalAwkwardT(a["t"])
>>> t
TemporalAwkwardT(<Array [[1, 2]] type='1 * var * int64'>,)
>>> t.elements
(<Array [[1, 2]] type='1 * var * int64'>,,)
```

**property** `elements: tuple[ArrayOrRecord]`

Temporal coordinates (t) as a tuple.

### Examples

```
>>> import vector
>>> t = vector.backends.awkward.TemporalAwkwardT(5)
>>> t.elements
(5,,)
```

**t:** `Any`

**class** `vector.backends.awkward.TemporalAwkwardTau`(*tau: Any*)

Bases: [`TemporalAwkward`](#), [`TemporalTau`](#)

Class for the tau (temporal) coordinate of Awkward backend.

## Examples

```
>>> import vector
>>> import awkward as ak
>>> a = ak.Array([{"tau": [1, 2]}])
>>> t = vector.backends.awkward.TemporalAwkwardTau(a["tau"])
>>> t
TemporalAwkwardTau(<Array [[1, 2]] type='1 * var * int64'>,)
>>> t.elements
(<Array [[1, 2]] type='1 * var * int64'>,)

```

**property elements:** tuple[ArrayOrRecord]

Temporal coordinates (tau) as a tuple.

## Examples

```
>>> import vector
>>> t = vector.backends.awkward.TemporalAwkwardTau(5)
>>> t.elements
(5,)

```

**tau:** Any

```
class vector.backends.awkward.VectorArray2D(*, x: float, y: float)
class vector.backends.awkward.VectorArray2D(*, rho: float, phi: float)
class vector.backends.awkward.VectorArray2D(*, x: float, y: float, z: float)
class vector.backends.awkward.VectorArray2D(*, x: float, y: float, eta: float)
class vector.backends.awkward.VectorArray2D(*, x: float, y: float, theta: float)
class vector.backends.awkward.VectorArray2D(*, rho: float, phi: float, z: float)
class vector.backends.awkward.VectorArray2D(*, rho: float, phi: float, eta: float)
class vector.backends.awkward.VectorArray2D(*, rho: float, phi: float, theta: float)
class vector.backends.awkward.VectorArray2D(*, px: float, py: float)
class vector.backends.awkward.VectorArray2D(*, x: float, py: float)
class vector.backends.awkward.VectorArray2D(*, px: float, y: float)
class vector.backends.awkward.VectorArray2D(*, pt: float, phi: float)
class vector.backends.awkward.VectorArray2D(*, x: float, y: float, pz: float)
class vector.backends.awkward.VectorArray2D(*, x: float, py: float, z: float)
class vector.backends.awkward.VectorArray2D(*, x: float, py: float, pz: float)
class vector.backends.awkward.VectorArray2D(*, px: float, y: float, z: float)
class vector.backends.awkward.VectorArray2D(*, px: float, y: float, pz: float)
class vector.backends.awkward.VectorArray2D(*, px: float, py: float, z: float)
class vector.backends.awkward.VectorArray2D(*, px: float, py: float, pz: float)
class vector.backends.awkward.VectorArray2D(*, rho: float, phi: float, pz: float)
class vector.backends.awkward.VectorArray2D(*, pt: float, phi: float, z: float)
class vector.backends.awkward.VectorArray2D(*, pt: float, phi: float, pz: float)
class vector.backends.awkward.VectorArray2D(*, x: float, py: float, theta: float)
class vector.backends.awkward.VectorArray2D(*, px: float, y: float, theta: float)

```









```
class vector.backends.awkward.VectorArray2D(*, x: float, py: float, z: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, x: float, py: float, pz: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, px: float, y: float, z: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, px: float, y: float, pz: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, px: float, py: float, z: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, px: float, py: float, pz: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, rho: float, phi: float, z: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, rho: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, pt: float, phi: float, z: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, pt: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, x: float, y: float, theta: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray2D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray2D(__azimuthal: Azimuthal)
class vector.backends.awkward.VectorArray2D(__azimuthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.awkward.VectorArray2D(__azimuthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)
```

Bases: [VectorAwkward2D](#), Array

Defines awkward behavior for a 2 dimensional vector.

See [VectorRecord2D](#) and [MomentumArray2D](#) for the corresponding Record and Momentum classes.

#### GenericClass

alias of [VectorArray2D](#)

#### MomentumClass

alias of [MomentumArray2D](#)

#### ProjectionClass2D

alias of [VectorArray2D](#)

#### ProjectionClass3D

alias of [VectorArray3D](#)

#### ProjectionClass4D

alias of [VectorArray4D](#)

`_abc_impl = <_abc._abc_data object>`



**allclose**(*other*: [VectorProtocol](#), *rtol*: Any = 1e-05, *atol*: Any = 1e-08, *equal\_nan*: Any = False) → Any

Like `np.ndarray.allclose`, but for `VectorArray2D`.

```

class vector.backends.awkward.VectorArray3D(*, x: float, y: float)
class vector.backends.awkward.VectorArray3D(*, rho: float, phi: float)
class vector.backends.awkward.VectorArray3D(*, x: float, y: float, z: float)
class vector.backends.awkward.VectorArray3D(*, x: float, y: float, eta: float)
class vector.backends.awkward.VectorArray3D(*, x: float, y: float, theta: float)
class vector.backends.awkward.VectorArray3D(*, rho: float, phi: float, z: float)
class vector.backends.awkward.VectorArray3D(*, rho: float, phi: float, eta: float)
class vector.backends.awkward.VectorArray3D(*, rho: float, phi: float, theta: float)
class vector.backends.awkward.VectorArray3D(*, px: float, py: float)
class vector.backends.awkward.VectorArray3D(*, x: float, py: float)
class vector.backends.awkward.VectorArray3D(*, px: float, y: float)
class vector.backends.awkward.VectorArray3D(*, pt: float, phi: float)
class vector.backends.awkward.VectorArray3D(*, x: float, y: float, pz: float)
class vector.backends.awkward.VectorArray3D(*, x: float, py: float, z: float)
class vector.backends.awkward.VectorArray3D(*, x: float, py: float, pz: float)
class vector.backends.awkward.VectorArray3D(*, px: float, y: float, z: float)
class vector.backends.awkward.VectorArray3D(*, px: float, y: float, pz: float)
class vector.backends.awkward.VectorArray3D(*, px: float, py: float, z: float)
class vector.backends.awkward.VectorArray3D(*, px: float, py: float, pz: float)
class vector.backends.awkward.VectorArray3D(*, rho: float, phi: float, pz: float)
class vector.backends.awkward.VectorArray3D(*, pt: float, phi: float, z: float)
class vector.backends.awkward.VectorArray3D(*, pt: float, phi: float, pz: float)
class vector.backends.awkward.VectorArray3D(*, x: float, py: float, theta: float)
class vector.backends.awkward.VectorArray3D(*, px: float, y: float, theta: float)
class vector.backends.awkward.VectorArray3D(*, px: float, py: float, theta: float)
class vector.backends.awkward.VectorArray3D(*, pt: float, phi: float, theta: float)
class vector.backends.awkward.VectorArray3D(*, x: float, py: float, eta: float)
class vector.backends.awkward.VectorArray3D(*, px: float, y: float, eta: float)
class vector.backends.awkward.VectorArray3D(*, px: float, py: float, eta: float)
class vector.backends.awkward.VectorArray3D(*, pt: float, phi: float, eta: float)
class vector.backends.awkward.VectorArray3D(*, x: float, y: float, z: float, t: float)
class vector.backends.awkward.VectorArray3D(*, x: float, y: float, pz: float, t: float)
class vector.backends.awkward.VectorArray3D(*, x: float, py: float, z: float, t: float)
class vector.backends.awkward.VectorArray3D(*, x: float, py: float, pz: float, t: float)
class vector.backends.awkward.VectorArray3D(*, px: float, y: float, z: float, t: float)
class vector.backends.awkward.VectorArray3D(*, px: float, y: float, pz: float, t: float)
class vector.backends.awkward.VectorArray3D(*, px: float, py: float, z: float, t: float)
class vector.backends.awkward.VectorArray3D(*, px: float, py: float, pz: float, t: float)
class vector.backends.awkward.VectorArray3D(*, rho: float, phi: float, z: float, t: float)
class vector.backends.awkward.VectorArray3D(*, rho: float, phi: float, pz: float, t: float)
class vector.backends.awkward.VectorArray3D(*, pt: float, phi: float, z: float, t: float)
class vector.backends.awkward.VectorArray3D(*, pt: float, phi: float, pz: float, t: float)

```









```
class vector.backends.awkward.VectorArray3D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray3D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray3D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray3D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray3D(__azumthal: Azimuthal)
class vector.backends.awkward.VectorArray3D(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.awkward.VectorArray3D(__azumthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)
```

Bases: [VectorAwkward3D](#), [Array](#)

Defines awkward behavior for a 3 dimensional vector.

See [VectorRecord3D](#) and [MomentumArray3D](#) for the corresponding Record and Momentum classes.

#### GenericClass

alias of [VectorArray3D](#)

#### MomentumClass

alias of [MomentumArray3D](#)

#### ProjectionClass2D

alias of [VectorArray2D](#)

#### ProjectionClass3D

alias of [VectorArray3D](#)

#### ProjectionClass4D

alias of [VectorArray4D](#)

`_abc_impl = <_abc._abc_data object>`

`allclose(other: VectorProtocol, rtol: Any = 1e-05, atol: Any = 1e-08, equal_nan: Any = False) → Any`

Like `np.ndarray.allclose`, but for [VectorArray3D](#).

```
class vector.backends.awkward.VectorArray4D(*, x: float, y: float)
class vector.backends.awkward.VectorArray4D(*, rho: float, phi: float)
class vector.backends.awkward.VectorArray4D(*, x: float, y: float, z: float)
class vector.backends.awkward.VectorArray4D(*, x: float, y: float, eta: float)
class vector.backends.awkward.VectorArray4D(*, x: float, y: float, theta: float)
class vector.backends.awkward.VectorArray4D(*, rho: float, phi: float, z: float)
class vector.backends.awkward.VectorArray4D(*, rho: float, phi: float, eta: float)
class vector.backends.awkward.VectorArray4D(*, rho: float, phi: float, theta: float)
class vector.backends.awkward.VectorArray4D(*, px: float, py: float)
class vector.backends.awkward.VectorArray4D(*, x: float, py: float)
class vector.backends.awkward.VectorArray4D(*, px: float, y: float)
class vector.backends.awkward.VectorArray4D(*, pt: float, phi: float)
class vector.backends.awkward.VectorArray4D(*, x: float, y: float, pz: float)
class vector.backends.awkward.VectorArray4D(*, x: float, py: float, z: float)
class vector.backends.awkward.VectorArray4D(*, x: float, py: float, pz: float)
class vector.backends.awkward.VectorArray4D(*, px: float, y: float, z: float)
class vector.backends.awkward.VectorArray4D(*, px: float, y: float, pz: float)
class vector.backends.awkward.VectorArray4D(*, px: float, py: float, z: float)
```











```

class vector.backends.awkward.VectorArray4D(*, px: float, y: float, eta: float, m: float)
class vector.backends.awkward.VectorArray4D(*, px: float, py: float, eta: float, m: float)
class vector.backends.awkward.VectorArray4D(*, rho: float, phi: float, eta: float, m: float)
class vector.backends.awkward.VectorArray4D(*, pm: float, phi: float, eta: float, m: float)
class vector.backends.awkward.VectorArray4D(*, x: float, y: float, z: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, x: float, y: float, pz: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, x: float, py: float, z: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, x: float, py: float, pz: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, px: float, y: float, z: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, px: float, y: float, pz: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, px: float, py: float, z: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, px: float, py: float, pz: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, rho: float, phi: float, z: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, rho: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, pt: float, phi: float, z: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, pt: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, x: float, y: float, theta: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray4D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorArray4D(__azumthal: Azimuthal)
class vector.backends.awkward.VectorArray4D(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.awkward.VectorArray4D(__azumthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)

```

Bases: [VectorAwkward4D](#), [Array](#)

Defines awkward behavior for a 4 dimensional vector.

See [VectorRecord4D](#) and [MomentumArray4D](#) for the corresponding Record and Momentum classes.

#### GenericClass

alias of [VectorArray4D](#)

#### MomentumClass

alias of [MomentumArray4D](#)

#### ProjectionClass2D

alias of [VectorArray2D](#)

#### ProjectionClass3D

alias of [VectorArray3D](#)

**ProjectionClass4D**alias of *VectorArray4D***\_abc\_impl** = <\_abc.\_abc\_data object>**allclose**(*other*: *VectorProtocol*, *rtol*: *Any* = 1e-05, *atol*: *Any* = 1e-08, *equal\_nan*: *Any* = False) → *Any*Like `np.ndarray.allclose`, but for *VectorArray4D*.**class** `vector.backends.awkward.VectorAwkward`Bases: `object`

Mixin class for Awkward vectors.

**\_wrap\_result**(*cls*: *Any*, *result*: *Any*, *returns*: *Any*, *num\_vecargs*: *Any*) → *Any*

Wraps the raw result of a compute function as an array of scalars or an array of vectors.

**Parameters**

- **result** – Value or tuple of values from a compute function.
- **returns** – Signature from a `dispatch_map`.
- **num\_vecargs** (*int*) – Number of vector arguments in the function that would be treated on an equal footing (i.e. `add` has two, but `rotate_axis` has only one: the axis is secondary).

**lib**: `ModuleType` = <module 'numpy' from '/home/docs/checkouts/readthedocs.org/user\_builds/vector/envs/latest/lib/python3.12/site-packages/numpy/\_\_init\_\_.py'>**class** `vector.backends.awkward.VectorAwkward2D`(\**x*: *float*, *y*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**rho*: *float*, *phi*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**x*: *float*, *y*: *float*, *z*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**x*: *float*, *y*: *float*, *eta*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**x*: *float*, *y*: *float*, *theta*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**rho*: *float*, *phi*: *float*, *z*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**rho*: *float*, *phi*: *float*, *eta*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**rho*: *float*, *phi*: *float*, *theta*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**px*: *float*, *py*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**x*: *float*, *py*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**px*: *float*, *y*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**pt*: *float*, *phi*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**x*: *float*, *y*: *float*, *pz*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**x*: *float*, *py*: *float*, *z*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**x*: *float*, *py*: *float*, *pz*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**px*: *float*, *y*: *float*, *z*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**px*: *float*, *y*: *float*, *pz*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**px*: *float*, *py*: *float*, *z*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**px*: *float*, *py*: *float*, *pz*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**rho*: *float*, *phi*: *float*, *pz*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**pt*: *float*, *phi*: *float*, *z*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**pt*: *float*, *phi*: *float*, *pz*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**x*: *float*, *py*: *float*, *theta*: *float*)**class** `vector.backends.awkward.VectorAwkward2D`(\**px*: *float*, *y*: *float*, *theta*: *float*)











```

class vector.backends.awkward.VectorAwkward2D(*, x: float, py: float, z: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, x: float, py: float, pz: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, px: float, y: float, z: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, px: float, y: float, pz: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, px: float, py: float, z: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, px: float, py: float, pz: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, rho: float, phi: float, z: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, rho: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, pt: float, phi: float, z: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, pt: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, x: float, y: float, theta: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorAwkward2D(__azimuthal: Azimuthal)
class vector.backends.awkward.VectorAwkward2D(__azimuthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.awkward.VectorAwkward2D(__azimuthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)

```

Bases: [VectorAwkward](#), [Planar](#), [Vector2D](#)

Two dimensional vector class for the Awkward backend. Two dimensional awkward vectors for the users are defined using the [VectorArray2D](#) class.

See [MomentumAwkward2D](#) for momentum vectors.

**property azimuthal:** [AzimuthalAwkward](#)

Returns an Azimuthal type object.

Use the elements property of the created object to access the coordinates.

## Examples

```

>>> import vector
>>> a = vector.Array(
...     [{"x": 1, "y": 1.1}, {"x": 2, "y": 2.2}],
... )
>>> a.azimuthal
AzimuthalAwkwardXY(<Array [1, 2] type='2 * int64'>, <Array [1.1, 2.2] type='2 * float64'>)
>>> a.azimuthal.elements
(<Array [1, 2] type='2 * int64'>, <Array [1.1, 2.2] type='2 * float64'>)

```











```

class vector.backends.awkward.VectorAwkward3D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorAwkward3D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorAwkward3D(__azimuthal: Azimuthal)
class vector.backends.awkward.VectorAwkward3D(__azimuthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.awkward.VectorAwkward3D(__azimuthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)

```

Bases: [VectorAwkward](#), [Spatial](#), [Vector3D](#)

Three dimensional vector class for the Awkward backend. Three dimensional awkward vectors for the users are defined using the [VectorArray3D](#) class.

See [MomentumAwkward3D](#) for momentum vectors.

**property azimuthal:** [AzimuthalAwkward](#)

Returns an Azimuthal type object containing the azimuthal coordinates.

Use the `elements` property of the created object to access the coordinates.

### Examples

```

>>> import vector
>>> a = vector.Array(
...     [{"x": 1, "y": 1.1, "z": 0.1}, {"x": 2, "y": 2.2, "z": 0.2}],
... )
>>> a.azimuthal
AzimuthalAwkwardXY(<Array [1, 2] type='2 * int64'>, <Array [1.1, 2.2] type='2 * float64'>)
>>> a.azimuthal.elements
(<Array [1, 2] type='2 * int64'>, <Array [1.1, 2.2] type='2 * float64'>)

```

**property longitudinal:** [LongitudinalAwkward](#)

Returns a Longitudinal type object containing the longitudinal coordinates.

Use the `elements` property of the created object to access the coordinates.

### Examples

```

>>> import vector
>>> a = vector.Array(
...     [{"x": 1, "y": 1.1, "z": 0.1}, {"x": 2, "y": 2.2, "z": 0.2}],
... )
>>> a.longitudinal
LongitudinalAwkwardZ(<Array [0.1, 0.2] type='2 * float64'>,)
>>> a.longitudinal.elements
(<Array [0.1, 0.2] type='2 * float64'>,)

```

```

class vector.backends.awkward.VectorAwkward4D(*, x: float, y: float)
class vector.backends.awkward.VectorAwkward4D(*, rho: float, phi: float)
class vector.backends.awkward.VectorAwkward4D(*, x: float, y: float, z: float)
class vector.backends.awkward.VectorAwkward4D(*, x: float, y: float, eta: float)
class vector.backends.awkward.VectorAwkward4D(*, x: float, y: float, theta: float)
class vector.backends.awkward.VectorAwkward4D(*, rho: float, phi: float, z: float)

```













---

```
class vector.backends.awkward.VectorAwkward4D(__azimuthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)
```

Bases: *VectorAwkward*, *Lorentz*, *Vector4D*

Four dimensional momentum vector class for the Awkward backend. Four dimensional momentum vectors for the users are defined using the *MomentumArray4D* class.

See *VectorAwkward4D* for momentum vectors.

**property azimuthal:** *AzimuthalAwkward*

Returns an Azimuthal type object containing the azimuthal coordinates.

Use the `elements` property of the created object to access the coordinates.

### Examples

```
>>> import vector
>>> a = vector.Array(
...     [{"x": 1, "y": 1.1, "z": 0.1, "tau": 1}, {"x": 2, "y": 2.2, "z": 0.2,
...     ↪ "tau": 3}],
... )
>>> a.azimuthal
AzimuthalAwkwardXY(<Array [1, 2] type='2 * int64'>, <Array [1.1, 2.2] type='2 *
... ↪ float64'>)
>>> a.azimuthal.elements
(<Array [1, 2] type='2 * int64'>, <Array [1.1, 2.2] type='2 * float64'>)
```

**property longitudinal:** *LongitudinalAwkward*

Returns a Longitudinal type object containing the longitudinal coordinates.

Use the `elements` property of the created object to access the coordinates.

### Examples

```
>>> import vector
>>> a = vector.Array(
...     [{"x": 1, "y": 1.1, "z": 0.1, "tau": 1}, {"x": 2, "y": 2.2, "z": 0.2,
...     ↪ "tau": 3}],
... )
>>> a.longitudinal
LongitudinalAwkwardZ(<Array [0.1, 0.2] type='2 * float64'>,)
>>> a.longitudinal.elements
(<Array [0.1, 0.2] type='2 * float64'>,,)
```

**property temporal:** *TemporalAwkward*

Returns a Temporal type object containing the temporal coordinates.

Use the `elements` property of the created object to access the coordinates.

## Examples

```

>>> import vector
>>> a = vector.Array(
...     [{"x": 1, "y": 1.1, "z": 0.1, "tau": 1}, {"x": 2, "y": 2.2, "z": 0.2,
...     ↪ "tau": 3}],
... )
>>> a.temporal
TemporalAwkwardTau(<Array [1, 3] type='2 * int64'>,)
>>> a.temporal.elements
(<Array [1, 3] type='2 * int64'>,)

```

```

class vector.backends.awkward.VectorRecord2D(*, x: float, y: float)
class vector.backends.awkward.VectorRecord2D(*, rho: float, phi: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, y: float, z: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, y: float, eta: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, y: float, theta: float)
class vector.backends.awkward.VectorRecord2D(*, rho: float, phi: float, z: float)
class vector.backends.awkward.VectorRecord2D(*, rho: float, phi: float, eta: float)
class vector.backends.awkward.VectorRecord2D(*, rho: float, phi: float, theta: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, py: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, py: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, y: float)
class vector.backends.awkward.VectorRecord2D(*, pt: float, phi: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, y: float, pz: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, py: float, z: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, py: float, pz: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, y: float, z: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, y: float, pz: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, py: float, z: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, py: float, pz: float)
class vector.backends.awkward.VectorRecord2D(*, rho: float, phi: float, pz: float)
class vector.backends.awkward.VectorRecord2D(*, pt: float, phi: float, z: float)
class vector.backends.awkward.VectorRecord2D(*, pt: float, phi: float, pz: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, py: float, theta: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, y: float, theta: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, py: float, theta: float)
class vector.backends.awkward.VectorRecord2D(*, pt: float, phi: float, theta: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, py: float, eta: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, y: float, eta: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, py: float, eta: float)
class vector.backends.awkward.VectorRecord2D(*, pt: float, phi: float, eta: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, y: float, z: float, t: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, y: float, pz: float, t: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, py: float, z: float, t: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, py: float, pz: float, t: float)

```











```

class vector.backends.awkward.VectorRecord2D(*, x: float, y: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord2D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord2D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord2D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord2D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord2D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord2D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord2D(__azumthal: Azimuthal)
class vector.backends.awkward.VectorRecord2D(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.awkward.VectorRecord2D(__azumthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)

```

Bases: [VectorAwkward2D](#), Record

Defines awkward behavior for a 2 dimensional vector record.

See [VectorArray2D](#) and [MomentumArray2D](#) for the corresponding Vector and Momentum classes.

#### GenericClass

alias of [VectorRecord2D](#)

#### MomentumClass

alias of [MomentumRecord2D](#)

#### ProjectionClass2D

alias of [VectorRecord2D](#)

#### ProjectionClass3D

alias of [VectorRecord3D](#)

#### ProjectionClass4D

alias of [VectorRecord4D](#)

```

class vector.backends.awkward.VectorRecord3D(*, x: float, y: float)
class vector.backends.awkward.VectorRecord3D(*, rho: float, phi: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, y: float, z: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, y: float, eta: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, y: float, theta: float)
class vector.backends.awkward.VectorRecord3D(*, rho: float, phi: float, z: float)
class vector.backends.awkward.VectorRecord3D(*, rho: float, phi: float, eta: float)
class vector.backends.awkward.VectorRecord3D(*, rho: float, phi: float, theta: float)
class vector.backends.awkward.VectorRecord3D(*, px: float, py: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, py: float)
class vector.backends.awkward.VectorRecord3D(*, px: float, y: float)
class vector.backends.awkward.VectorRecord3D(*, pt: float, phi: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, y: float, pz: float)

```









```
class vector.backends.awkward.VectorRecord3D(*, px: float, py: float, theta: float, m: float)
class vector.backends.awkward.VectorRecord3D(*, rho: float, phi: float, theta: float, m: float)
class vector.backends.awkward.VectorRecord3D(*, pm: float, phi: float, theta: float, m: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, y: float, eta: float, m: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, py: float, eta: float, m: float)
class vector.backends.awkward.VectorRecord3D(*, px: float, y: float, eta: float, m: float)
class vector.backends.awkward.VectorRecord3D(*, px: float, py: float, eta: float, m: float)
class vector.backends.awkward.VectorRecord3D(*, rho: float, phi: float, eta: float, m: float)
class vector.backends.awkward.VectorRecord3D(*, pm: float, phi: float, eta: float, m: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, y: float, z: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, y: float, pz: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, py: float, z: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, py: float, pz: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, px: float, y: float, z: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, px: float, y: float, pz: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, px: float, py: float, z: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, px: float, py: float, pz: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, rho: float, phi: float, z: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, rho: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, pt: float, phi: float, z: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, pt: float, phi: float, pz: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, y: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord3D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord3D(__azumthal: Azimuthal)
class vector.backends.awkward.VectorRecord3D(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.awkward.VectorRecord3D(__azumthal: Azimuthal, __longitudinal: Longitudinal,
__temporal: Temporal)
```

Bases: [VectorAwkward3D](#), [Record](#)

Defines awkward behavior for a 3 dimensional vector record.

See [VectorArray3D](#) and [MomentumArray3D](#) for the corresponding Vector and Momentum classes.

#### GenericClass

alias of [VectorRecord3D](#)



**MomentumClass**alias of *MomentumRecord3D***ProjectionClass2D**alias of *VectorRecord2D***ProjectionClass3D**alias of *VectorRecord3D***ProjectionClass4D**alias of *VectorRecord4D*

```

class vector.backends.awkward.VectorRecord4D(*, x: float, y: float)
class vector.backends.awkward.VectorRecord4D(*, rho: float, phi: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, y: float, z: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, y: float, eta: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, y: float, theta: float)
class vector.backends.awkward.VectorRecord4D(*, rho: float, phi: float, z: float)
class vector.backends.awkward.VectorRecord4D(*, rho: float, phi: float, eta: float)
class vector.backends.awkward.VectorRecord4D(*, rho: float, phi: float, theta: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, py: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, py: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, y: float)
class vector.backends.awkward.VectorRecord4D(*, pt: float, phi: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, y: float, pz: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, py: float, z: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, py: float, pz: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, y: float, z: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, y: float, pz: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, py: float, z: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, py: float, pz: float)
class vector.backends.awkward.VectorRecord4D(*, rho: float, phi: float, pz: float)
class vector.backends.awkward.VectorRecord4D(*, pt: float, phi: float, z: float)
class vector.backends.awkward.VectorRecord4D(*, pt: float, phi: float, pz: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, py: float, theta: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, y: float, theta: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, py: float, theta: float)
class vector.backends.awkward.VectorRecord4D(*, pt: float, phi: float, theta: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, py: float, eta: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, y: float, eta: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, py: float, eta: float)
class vector.backends.awkward.VectorRecord4D(*, pt: float, phi: float, eta: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, y: float, z: float, t: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, y: float, pz: float, t: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, py: float, z: float, t: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, py: float, pz: float, t: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, y: float, z: float, t: float)

```









```
class vector.backends.awkward.VectorRecord4D(*, x: float, py: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, y: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, py: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord4D(*, rho: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord4D(*, pt: float, phi: float, theta: float, mass: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, y: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord4D(*, x: float, py: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, y: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord4D(*, px: float, py: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord4D(*, rho: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord4D(*, pt: float, phi: float, eta: float, mass: float)
class vector.backends.awkward.VectorRecord4D(__azimuthal: Azimuthal)
class vector.backends.awkward.VectorRecord4D(__azimuthal: Azimuthal, __longitudinal: Longitudinal)
class vector.backends.awkward.VectorRecord4D(__azimuthal: Azimuthal, __longitudinal: Longitudinal,
                                              __temporal: Temporal)
```

Bases: [VectorAwkward4D](#), [Record](#)

Defines awkward behavior for a 4 dimensional vector record.

See [VectorArray4D](#) and [MomentumArray4D](#) for the corresponding Vector and Momentum classes.

#### GenericClass

alias of [VectorRecord4D](#)

#### MomentumClass

alias of [MomentumRecord4D](#)

#### ProjectionClass2D

alias of [VectorRecord2D](#)

#### ProjectionClass3D

alias of [VectorRecord3D](#)

#### ProjectionClass4D

alias of [VectorRecord4D](#)

`vector.backends.awkward._arraytype_of(awkwardtype: Any, component: str) → Any`

`vector.backends.awkward._aztype_of(recordarraytype: Any, is_momentum: bool) → Any`

`vector.backends.awkward._class_to_name(cls: type[VectorProtocol]) → str`

`vector.backends.awkward._lookup_field(record_type: Any, name: str) → int`

`vector.backends.awkward._ltype_of(recordarraytype: Any, is_momentum: bool) → Any`

`vector.backends.awkward._no_record(x: Array) → Array | None`

`vector.backends.awkward._numba_lower(context: Any, builder: Any, sig: Any, args: Any) → Any`

`vector.backends.awkward._numba typer_Momentum2D(viewtype: Any) → Any`

`vector.backends.awkward._numba typer_Momentum3D(viewtype: Any) → Any`

`vector.backends.awkward._numba typer_Momentum4D(viewtype: Any) → Any`

```

vector.backends.awkward._numba_typer_Vector2D(viewtype: Any) → Any
vector.backends.awkward._numba_typer_Vector3D(viewtype: Any) → Any
vector.backends.awkward._numba_typer_Vector4D(viewtype: Any) → Any
vector.backends.awkward._reduce_count(array: VectorArray2D | VectorArray3D | VectorArray4D |
                                      MomentumArray2D | MomentumArray3D | MomentumArray4D,
                                      mask_identity: bool) → VectorProtocol
vector.backends.awkward._reduce_count_nonzero(array: VectorArray2D | VectorArray3D | VectorArray4D |
                                              MomentumArray2D | MomentumArray3D |
                                              MomentumArray4D, mask_identity: bool) → Any
vector.backends.awkward._reduce_sum(array: VectorArray2D | VectorArray3D | VectorArray4D |
                                    MomentumArray2D | MomentumArray3D | MomentumArray4D,
                                    mask_identity: bool) → VectorProtocol
vector.backends.awkward._ttype_of(recordarraytype: Any, is_momentum: bool) → Any
vector.backends.awkward._yes_record(x: Array) → float | Record | None
vector.backends.awkward.impl(array: VectorArray2D | VectorArray3D | VectorArray4D | MomentumArray2D
                             | MomentumArray3D | MomentumArray4D, mask_identity: bool) → Any

```

### vector.backends.awkward\_constructors module

```
vector.backends.awkward_constructors.Array(*args: Any, **kwargs: Any) → Any
```

Constructs an Awkward Array of vectors, whose type is determined by the fields of the record array (which may be nested within lists or other non-record structures).

All allowed signatures for `ak.Array` can be used in this function.

The array must contain records with the following combinations of field names:

- (2D) x, y
- (2D) rho, phi
- (3D) x, y, z
- (3D) x, y, theta
- (3D) x, y, eta
- (3D) rho, phi, z
- (3D) rho, phi, theta
- (3D) rho, phi, eta
- (4D) x, y, z, t
- (4D) x, y, z, tau`
- (4D) x, y, theta, t`
- (4D) x, y, theta, tau`
- (4D) x, y, eta, t`
- (4D) x, y, eta, tau`

- (4D) rho, phi, z, t`
- (4D) rho, phi, z, tau`
- (4D) rho, phi, theta, t`
- (4D) rho, phi, theta, tau`
- (4D) rho, phi, eta, t`
- (4D) rho, phi, eta, tau`

in which

- px may be substituted for x
- py may be substituted for y
- pt may be substituted for rho
- pz may be substituted for z
- E may be substituted for t
- e may be substituted for t
- energy may be substituted for t
- M may be substituted for tau
- m may be substituted for tau
- mass may be substituted for tau

to make the vector a momentum vector.

No constraints are placed on the types of the vector fields, though if they are not numbers, mathematical operations will fail. Usually, you want them to be integers or floating-point numbers.

```
vector.backends.awkward_constructors._check_names(projectable: Any, fieldnames: list[str]) →  
tuple[bool, int, list[str], Any]
```

```
vector.backends.awkward_constructors._is_type_safe(array_type: Any) → bool
```

```
vector.backends.awkward_constructors._recname(is_momentum: bool, dimension: int) → str
```

```
vector.backends.awkward_constructors.zip(arrays: dict[str, Any], depth_limit: int | None = None) → Any
```

Constructs an Awkward Array of vectors, whose type is determined by the fields of the record array (which may be nested within lists or other non-record structures).

This function accepts a subset of `ak.zip`'s arguments.

#### Parameters

- **arrays** (*dict of str to array-like*) – Arrays, lists, etc. to zip together. Unlike `ak.zip`, this must be a dict with string keys to determine the coordinate system of the arrays; it may not be a tuple.
- **depth\_limit** (*None or int*) – If `None`, attempt to fully broadcast the array to all levels. If an `int`, limit the number of dimensions that get broadcasted. The minimum value is 1, for no broadcasting.

The array must contain records with the following combinations of field names:

- (2D) x, y
- (2D) rho, phi



- (3D)  $x, y, z$
- (3D)  $x, y, \theta$
- (3D)  $x, y, \eta$
- (3D)  $\rho, \phi, z$
- (3D)  $\rho, \phi, \theta$
- (3D)  $\rho, \phi, \eta$
- (4D)  $x, y, z, t$
- (4D)  $x, y, z, \tau$
- (4D)  $x, y, \theta, t$
- (4D)  $x, y, \theta, \tau$
- (4D)  $x, y, \eta, t$
- (4D)  $x, y, \eta, \tau$
- (4D)  $\rho, \phi, z, t$
- (4D)  $\rho, \phi, z, \tau$
- (4D)  $\rho, \phi, \theta, t$
- (4D)  $\rho, \phi, \theta, \tau$
- (4D)  $\rho, \phi, \eta, t$
- (4D)  $\rho, \phi, \eta, \tau$

in which

- $p_x$  may be substituted for  $x$
- $p_y$  may be substituted for  $y$
- $p_t$  may be substituted for  $\rho$
- $p_z$  may be substituted for  $z$
- $E$  may be substituted for  $t$
- $e$  may be substituted for  $\tau$
- $\text{energy}$  may be substituted for  $t$
- $M$  may be substituted for  $\tau$
- $m$  may be substituted for  $\tau$
- $\text{mass}$  may be substituted for  $\tau$

to make the vector a momentum vector.

**vector.backends.\_numba module****vector.backends.numba\_numpy module**

Implements VectorNumpys in Numba. Only `__getitem__` should be overloaded to return lowered VectorObjects, and maybe the `vector.array` constructor should also be handled.

As mentioned in [scikit-hep/vector#43](#), this capability is blocked by [numba/numba#6148](#).

**vector.backends.\_numba\_object module**

Implements VectorObjects in Numba. Every function should be made usable in Numba.

```
class vector.backends._numba_object.MomentumObject2DType(*args: Any, **kwargs: Any)
```

Bases: *VectorObject2DType*

```
instance_class
```

alias of *MomentumObject2D*

```
vector.backends._numba_object.MomentumObject2D_constructor_typer(context)
```

```
class vector.backends._numba_object.MomentumObject3DType(*args: Any, **kwargs: Any)
```

Bases: *VectorObject3DType*

```
instance_class
```

alias of *MomentumObject3D*

```
vector.backends._numba_object.MomentumObject3D_constructor_typer(context)
```

```
class vector.backends._numba_object.MomentumObject4DType(*args: Any, **kwargs: Any)
```

Bases: *VectorObject4DType*

```
instance_class
```

alias of *MomentumObject4D*

```
vector.backends._numba_object.MomentumObject4DType_E(v)
```

```
vector.backends._numba_object.MomentumObject4DType_E2(v)
```

```
vector.backends._numba_object.MomentumObject4DType_M(v)
```

```
vector.backends._numba_object.MomentumObject4DType_M2(v)
```

```
vector.backends._numba_object.MomentumObject4DType_energy(v)
```

```
vector.backends._numba_object.MomentumObject4DType_energy2(v)
```

```
vector.backends._numba_object.MomentumObject4DType_mass(v)
```

```
vector.backends._numba_object.MomentumObject4DType_mass2(v)
```

```
vector.backends._numba_object.MomentumObject4DType_transverse_energy(v)
```

```
vector.backends._numba_object.MomentumObject4DType_transverse_energy2(v)
```

```
vector.backends._numba_object.MomentumObject4DType_transverse_mass(v)
```

```

vector.backends._numba_object.MomentumObject4DType_transverse_mass2(v)
vector.backends._numba_object.MomentumObject4D_constructor_typer(context)
class vector.backends._numba_object.VectorObject2DType(*args: Any, **kwargs: Any)
    Bases: Type
    instance_class
        alias of VectorObject2D
vector.backends._numba_object.VectorObject2DType_unit(v)
vector.backends._numba_object.VectorObject2D_box(typ, val, c)
vector.backends._numba_object.VectorObject2D_constructor_typer(context)
vector.backends._numba_object.VectorObject2D_to_Vector2D(v)
vector.backends._numba_object.VectorObject2D_to_Vector3D(v)
vector.backends._numba_object.VectorObject2D_to_Vector4D(v)
vector.backends._numba_object.VectorObject2D_typeof(val, c)
vector.backends._numba_object.VectorObject2D_unbox(typ, obj, c)
class vector.backends._numba_object.VectorObject3DType(*args: Any, **kwargs: Any)
    Bases: Type
    instance_class
        alias of VectorObject3D
vector.backends._numba_object.VectorObject3DType_unit(v)
vector.backends._numba_object.VectorObject3D_box(typ, val, c)
vector.backends._numba_object.VectorObject3D_constructor_typer(context)
vector.backends._numba_object.VectorObject3D_to_Vector2D(v)
vector.backends._numba_object.VectorObject3D_to_Vector3D(v)
vector.backends._numba_object.VectorObject3D_to_Vector4D(v)
vector.backends._numba_object.VectorObject3D_typeof(val, c)
vector.backends._numba_object.VectorObject3D_unbox(typ, obj, c)
class vector.backends._numba_object.VectorObject4DType(*args: Any, **kwargs: Any)
    Bases: Type
    instance_class
        alias of VectorObject4D
vector.backends._numba_object.VectorObject4DType_boost(v, booster)
vector.backends._numba_object.VectorObject4DType_boostCM_of(v, booster)
vector.backends._numba_object.VectorObject4DType_boostCM_of_beta3(v, beta3)

```

```
vector.backends._numba_object.VectorObject4DType_boostCM_of_p4(v, p4)
vector.backends._numba_object.VectorObject4DType_boost_beta3(v, beta3)
vector.backends._numba_object.VectorObject4DType_boost_p4(v, p4)
vector.backends._numba_object.VectorObject4DType_is_lightlike(v, tolerance=1e-05)
vector.backends._numba_object.VectorObject4DType_is_spacelike(v, tolerance=0)
vector.backends._numba_object.VectorObject4DType_is_timelike(v, tolerance=0)
vector.backends._numba_object.VectorObject4DType_neg4D(v)
vector.backends._numba_object.VectorObject4DType_scale3D(v, factor)
vector.backends._numba_object.VectorObject4DType_to_beta3(v)
vector.backends._numba_object.VectorObject4DType_transform4D(v, obj)
vector.backends._numba_object.VectorObject4DType_unit(v)
vector.backends._numba_object.VectorObject4D_box(typ, val, c)
vector.backends._numba_object.VectorObject4D_constructor_typer(context)
vector.backends._numba_object.VectorObject4D_to_Vector2D(v)
vector.backends._numba_object.VectorObject4D_to_Vector3D(v)
vector.backends._numba_object.VectorObject4D_to_Vector4D(v)
vector.backends._numba_object.VectorObject4D_typeof(val, c)
vector.backends._numba_object.VectorObject4D_unbox(typ, obj, c)
vector.backends._numba_object._awkward_numba_E(record)
vector.backends._numba_object._awkward_numba_M(record)
vector.backends._numba_object._awkward_numba_e(record)
vector.backends._numba_object._awkward_numba_energy(record)
vector.backends._numba_object._awkward_numba_eta(record)
vector.backends._numba_object._awkward_numba_m(record)
vector.backends._numba_object._awkward_numba_mass(record)
vector.backends._numba_object._awkward_numba_ptphi(record)
vector.backends._numba_object._awkward_numba_pxpy(record)
vector.backends._numba_object._awkward_numba_pxy(record)
vector.backends._numba_object._awkward_numba_pz(record)
vector.backends._numba_object._awkward_numba_rhophi(record)
vector.backends._numba_object._awkward_numba_t(record)
```

---

```

vector.backends._numba_object._awkward_numba_tau(record)
vector.backends._numba_object._awkward_numba_theta(record)
vector.backends._numba_object._awkward_numba_xpy(record)
vector.backends._numba_object._awkward_numba_xy(record)
vector.backends._numba_object._awkward_numba_z(record)
vector.backends._numba_object.add_binary_method(vectortype, gn, methodname)
vector.backends._numba_object.add_boostXYZ(methodname)
vector.backends._numba_object.add_coordinate_change(vectortype, azcoordtype, lcoordtype, tcoordtype)
vector.backends._numba_object.add_isclose_method(vectortype)
vector.backends._numba_object.add_lorentz_property(vectortype, propertyname)
vector.backends._numba_object.add_planar_property(vectortype, propertyname)
vector.backends._numba_object.add_rotateZ(vectortype)
vector.backends._numba_object.add_spatial_property(vectortype, propertyname)
vector.backends._numba_object.add_tolerance_method(vectortype, methodname)
vector.backends._numba_object.add_transform2D(vectortype)
vector.backends._numba_object.azimuthalrho_phi_coord1(v)
vector.backends._numba_object.azimuthalrho_phi_coord2(v)
vector.backends._numba_object.azimuthalxy_coord1(v)
vector.backends._numba_object.azimuthalxy_coord2(v)
vector.backends._numba_object.dimension_of(v)
vector.backends._numba_object.flavor_of(v1, v2)
vector.backends._numba_object.is_azimuthaltype(typ)
vector.backends._numba_object.is_longitudinaltype(typ)
vector.backends._numba_object.is_temporaltype(typ)
vector.backends._numba_object.longitudinaleta_coord1(v)
vector.backends._numba_object.longitudinaltheta_coord1(v)
vector.backends._numba_object.longitudinalz_coord1(v)
vector.backends._numba_object.make_AzimuthalObjectRhoPhi(v)
vector.backends._numba_object.make_AzimuthalObjectXY(v)
vector.backends._numba_object.make_LongitudinalObjectEta(v)
vector.backends._numba_object.make_LongitudinalObjectEta_zero(v)

```

```
vector.backends._numba_object.make_LongitudinalObjectTheta(v)
vector.backends._numba_object.make_LongitudinalObjectTheta_zero(v)
vector.backends._numba_object.make_LongitudinalObjectZ(v)
vector.backends._numba_object.make_LongitudinalObjectZ_zero(v)
vector.backends._numba_object.make_TemporalObjectT(v)
vector.backends._numba_object.make_TemporalObjectT_zero(v)
vector.backends._numba_object.make_TemporalObjectTau(v)
vector.backends._numba_object.make_TemporalObjectTau_zero(v)
vector.backends._numba_object.nan_to_num(x, copy=True, nan=0.0, posinf=None, neginf=None)
vector.backends._numba_object.numba_aztype(typ)
vector.backends._numba_object.numba_ltype(typ)
vector.backends._numba_object.numba_ttype(typ)
vector.backends._numba_object.numpy_absolute(v)
vector.backends._numba_object.numpy_add(v1, v2)
vector.backends._numba_object.numpy_cbrt(v)
vector.backends._numba_object.numpy_matmul(v1, v2)
vector.backends._numba_object.numpy_multiply(a, b)
vector.backends._numba_object.numpy_negative(v)
vector.backends._numba_object.numpy_positive(v)
vector.backends._numba_object.numpy_power(v, expo)
vector.backends._numba_object.numpy_sqrt(v)
vector.backends._numba_object.numpy_square(v)
vector.backends._numba_object.numpy_subtract(v1, v2)
vector.backends._numba_object.numpy_true_divide(a, b)
vector.backends._numba_object.operator_abs(v)
vector.backends._numba_object.operator_add(v1, v2)
vector.backends._numba_object.operator_eq(v1, v2)
vector.backends._numba_object.operator_matmul(v1, v2)
vector.backends._numba_object.operator_mul(a, b)
vector.backends._numba_object.operator_ne(v1, v2)
vector.backends._numba_object.operator_neg(v)
```

---

```

vector.backends._numba_object.operator_pos(v)
vector.backends._numba_object.operator_pow(a, b)
vector.backends._numba_object.operator_sub(v1, v2)
vector.backends._numba_object.operator_truediv(a, b)
vector.backends._numba_object.operator_truth(v)
vector.backends._numba_object.temporalt_coord1(v)
vector.backends._numba_object.temporaltau_coord1(v)
vector.backends._numba_object.vector_obj(unrecognized_argument=None, x=None, px=None, y=None,
py=None, rho=None, pt=None, phi=None, z=None, pz=None,
theta=None, eta=None, t=None, E=None, e=None,
energy=None, tau=None, M=None, m=None, mass=None)

vector.backends._numba_object.vector_obj_Azimuthal_ptphi(x, px, y, py, rho, pt, phi)
vector.backends._numba_object.vector_obj_Azimuthal_pxpyp(x, px, y, py, rho, pt, phi)
vector.backends._numba_object.vector_obj_Azimuthal_pxy(x, px, y, py, rho, pt, phi)
vector.backends._numba_object.vector_obj_Azimuthal_rhophi(x, px, y, py, rho, pt, phi)
vector.backends._numba_object.vector_obj_Azimuthal_xpy(x, px, y, py, rho, pt, phi)
vector.backends._numba_object.vector_obj_Azimuthal_xy(x, px, y, py, rho, pt, phi)
vector.backends._numba_object.vector_obj_Longitudinal_eta(z, pz, theta, eta)
vector.backends._numba_object.vector_obj_Longitudinal_pz(z, pz, theta, eta)
vector.backends._numba_object.vector_obj_Longitudinal_theta(z, pz, theta, eta)
vector.backends._numba_object.vector_obj_Longitudinal_z(z, pz, theta, eta)
vector.backends._numba_object.vector_obj_Temporal_E(t, E, e, energy, tau, M, m, mass)
vector.backends._numba_object.vector_obj_Temporal_M(t, E, e, energy, tau, M, m, mass)
vector.backends._numba_object.vector_obj_Temporal_e(t, E, e, energy, tau, M, m, mass)
vector.backends._numba_object.vector_obj_Temporal_energy(t, E, e, energy, tau, M, m, mass)
vector.backends._numba_object.vector_obj_Temporal_m(t, E, e, energy, tau, M, m, mass)
vector.backends._numba_object.vector_obj_Temporal_mass(t, E, e, energy, tau, M, m, mass)
vector.backends._numba_object.vector_obj_Temporal_t(t, E, e, energy, tau, M, m, mass)
vector.backends._numba_object.vector_obj_Temporal_tau(t, E, e, energy, tau, M, m, mass)
vector.backends._numba_object.vectortype
    alias of VectorObject4DType

```

## **vector.\_compute package**

### **Subpackages**

#### **vector.\_compute.lorentz package**

Compute functions for lorentz vectors, which is to say 4D.

Each function is a module with variants for each coordinate system (or combination of coordinate systems) as functions within the module.

Each module has a `dispatch_map` (dict) that maps coordinate types to the appropriate function and its return type(s), and a `dispatch` (function) uses this information to call the right function and return the right type.

The compute functions themselves are restricted to a minimum of Python features: no statements other than assignments and one return, no assumptions about data types. In particular, if statements and loops are not allowed. The `tests/test_compute_features.py` suite ensures that these rules are followed (though that set of allowed features can be expanded if it doesn't prevent the addition of new backends).

### **Submodules**

#### **vector.\_compute.lorentz.add module**

```
Lorentz.add(self, other)
```

```
vector._compute.lorentz.add.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.lorentz.add.make_conversion(azimuthal1, longitudinal1, temporal1, azimuthal2,  
                                             longitudinal2, temporal2)
```

#### **vector.\_compute.lorentz.beta module**

```
@property  
Lorentz.beta(self)
```

```
vector._compute.lorentz.beta.dispatch(v: Any) → Any
```

```
vector._compute.lorentz.beta.rhophi_eta_t(lib, rho, phi, eta, t)
```

```
vector._compute.lorentz.beta.rhophi_eta_tau(lib, rho, phi, eta, tau)
```

```
vector._compute.lorentz.beta.rhophi_theta_t(lib, rho, phi, theta, t)
```

```
vector._compute.lorentz.beta.rhophi_theta_tau(lib, rho, phi, theta, tau)
```

```
vector._compute.lorentz.beta.rhophi_z_t(lib, rho, phi, z, t)
```

```
vector._compute.lorentz.beta.rhophi_z_tau(lib, rho, phi, z, tau)
```

```
vector._compute.lorentz.beta.xy_eta_t(lib, x, y, eta, t)
```

```
vector._compute.lorentz.beta.xy_eta_tau(lib, x, y, eta, tau)
```



```
vector._compute.lorentz.beta.xy_theta_t(lib, x, y, theta, t)
vector._compute.lorentz.beta.xy_theta_tau(lib, x, y, theta, tau)
vector._compute.lorentz.beta.xy_z_t(lib, x, y, z, t)
vector._compute.lorentz.beta.xy_z_tau(lib, x, y, z, tau)
```

### **vector.\_compute.lorentz.boost\_beta3 module**

```
Lorentz.boost_beta3(self, beta3)
```

or

```
Lorentz.boost(self, beta3=...)
```

```
vector._compute.lorentz.boost_beta3.cartesian_t(lib, x1, y1, z1, t1, betax, betay, betaz)
vector._compute.lorentz.boost_beta3.cartesian_t_rhophi_eta(lib, x1, y1, z1, t1, rho2, phi2, eta2)
vector._compute.lorentz.boost_beta3.cartesian_t_rhophi_theta(lib, x1, y1, z1, t1, rho2, phi2, theta2)
vector._compute.lorentz.boost_beta3.cartesian_t_rhophi_z(lib, x1, y1, z1, t1, rho2, phi2, z2)
vector._compute.lorentz.boost_beta3.cartesian_t_xy_eta(lib, x1, y1, z1, t1, x2, y2, eta2)
vector._compute.lorentz.boost_beta3.cartesian_t_xy_theta(lib, x1, y1, z1, t1, x2, y2, theta2)
vector._compute.lorentz.boost_beta3.cartesian_t_xy_z(lib, x1, y1, z1, t1, x2, y2, z2)
vector._compute.lorentz.boost_beta3.cartesian_tau(lib, x1, y1, z1, tau1, betax, betay, betaz)
vector._compute.lorentz.boost_beta3.cartesian_tau_rhophi_eta(lib, x1, y1, z1, tau1, rho2, phi2, eta2)
vector._compute.lorentz.boost_beta3.cartesian_tau_rhophi_theta(lib, x1, y1, z1, tau1, rho2, phi2,
                                                                theta2)
vector._compute.lorentz.boost_beta3.cartesian_tau_rhophi_z(lib, x1, y1, z1, tau1, rho2, phi2, z2)
vector._compute.lorentz.boost_beta3.cartesian_tau_xy_eta(lib, x1, y1, z1, tau1, x2, y2, eta2)
vector._compute.lorentz.boost_beta3.cartesian_tau_xy_theta(lib, x1, y1, z1, tau1, x2, y2, theta2)
vector._compute.lorentz.boost_beta3.cartesian_tau_xy_z(lib, x1, y1, z1, tau1, x2, y2, z2)
vector._compute.lorentz.boost_beta3.dispatch(v1: Any, v2: Any) → Any
vector._compute.lorentz.boost_beta3.make_conversion(azimuthal1, longitudinal1, temporal1,
                                                    azimuthal2, longitudinal2)
```

**vector.\_compute.lorentz.boost\_p4 module**

```
Lorentz.boost_p4(self, p4)
```

or

```
Lorentz.boost(self, p4=...)
```

```
vector._compute.lorentz.boost_p4.cartesian_t(lib, x1, y1, z1, t1, energy, mass, mass2, x2, y2, z2)
```

```
vector._compute.lorentz.boost_p4.cartesian_t_rhophi_eta_t(lib, x1, y1, z1, t1, rho2, phi2, eta2, t2)
```

```
vector._compute.lorentz.boost_p4.cartesian_t_rhophi_eta_tau(lib, x1, y1, z1, t1, rho2, phi2, eta2,  
                                                             tau2)
```

```
vector._compute.lorentz.boost_p4.cartesian_t_rhophi_theta_t(lib, x1, y1, z1, t1, rho2, phi2, theta2,  
                                                             t2)
```

```
vector._compute.lorentz.boost_p4.cartesian_t_rhophi_theta_tau(lib, x1, y1, z1, t1, rho2, phi2, theta2,  
                                                             tau2)
```

```
vector._compute.lorentz.boost_p4.cartesian_t_rhophi_z_t(lib, x1, y1, z1, t1, rho2, phi2, z2, t2)
```

```
vector._compute.lorentz.boost_p4.cartesian_t_rhophi_z_tau(lib, x1, y1, z1, t1, rho2, phi2, z2, tau2)
```

```
vector._compute.lorentz.boost_p4.cartesian_t_xy_eta_t(lib, x1, y1, z1, t1, x2, y2, eta2, t2)
```

```
vector._compute.lorentz.boost_p4.cartesian_t_xy_eta_tau(lib, x1, y1, z1, t1, x2, y2, eta2, tau2)
```

```
vector._compute.lorentz.boost_p4.cartesian_t_xy_theta_t(lib, x1, y1, z1, t1, x2, y2, theta2, t2)
```

```
vector._compute.lorentz.boost_p4.cartesian_t_xy_theta_tau(lib, x1, y1, z1, t1, x2, y2, theta2, tau2)
```

```
vector._compute.lorentz.boost_p4.cartesian_t_xy_z_t(lib, x1, y1, z1, t1, x2, y2, z2, t2)
```

```
vector._compute.lorentz.boost_p4.cartesian_t_xy_z_tau(lib, x1, y1, z1, t1, x2, y2, z2, tau2)
```

```
vector._compute.lorentz.boost_p4.cartesian_tau(lib, x1, y1, z1, tau1, energy, mass, mass2, x2, y2, z2)
```

```
vector._compute.lorentz.boost_p4.cartesian_tau_rhophi_eta_t(lib, x1, y1, z1, tau1, rho2, phi2, eta2,  
                                                             t2)
```

```
vector._compute.lorentz.boost_p4.cartesian_tau_rhophi_eta_tau(lib, x1, y1, z1, tau1, rho2, phi2,  
                                                             eta2, tau2)
```

```
vector._compute.lorentz.boost_p4.cartesian_tau_rhophi_theta_t(lib, x1, y1, z1, tau1, rho2, phi2,  
                                                             theta2, t2)
```

```
vector._compute.lorentz.boost_p4.cartesian_tau_rhophi_theta_tau(lib, x1, y1, z1, tau1, rho2, phi2,  
                                                             theta2, tau2)
```

```
vector._compute.lorentz.boost_p4.cartesian_tau_rhophi_z_t(lib, x1, y1, z1, tau1, rho2, phi2, z2, t2)
```

```
vector._compute.lorentz.boost_p4.cartesian_tau_rhophi_z_tau(lib, x1, y1, z1, tau1, rho2, phi2, z2,  
                                                             tau2)
```

```
vector._compute.lorentz.boost_p4.cartesian_tau_xy_eta_t(lib, x1, y1, z1, tau1, x2, y2, eta2, t2)
```

```

vector._compute.lorentz.boost_p4.cartesian_tau_xy_eta_tau(lib, x1, y1, z1, tau1, x2, y2, eta2, tau2)
vector._compute.lorentz.boost_p4.cartesian_tau_xy_theta_t(lib, x1, y1, z1, tau1, x2, y2, theta2, t2)
vector._compute.lorentz.boost_p4.cartesian_tau_xy_theta_tau(lib, x1, y1, z1, tau1, x2, y2, theta2,
                                                             tau2)

vector._compute.lorentz.boost_p4.cartesian_tau_xy_z_t(lib, x1, y1, z1, tau1, x2, y2, z2, t2)
vector._compute.lorentz.boost_p4.cartesian_tau_xy_z_tau(lib, x1, y1, z1, tau1, x2, y2, z2, tau2)
vector._compute.lorentz.boost_p4.dispatch(v1: Any, v2: Any) → Any
vector._compute.lorentz.boost_p4.make_conversion(azimuthal1, longitudinal1, temporal1, azimuthal2,
                                                  longitudinal2, temporal2)

```

### vector.\_compute.lorentz.boostX\_beta module

```
Lorentz.boostX(self, beta=...)
```

```

vector._compute.lorentz.boostX_beta.dispatch(beta: Any, v: Any) → Any
vector._compute.lorentz.boostX_beta.rhophi_eta_t(lib, beta, rho, phi, eta, t)
vector._compute.lorentz.boostX_beta.rhophi_eta_tau(lib, beta, rho, phi, eta, tau)
vector._compute.lorentz.boostX_beta.rhophi_theta_t(lib, beta, rho, phi, theta, t)
vector._compute.lorentz.boostX_beta.rhophi_theta_tau(lib, beta, rho, phi, theta, tau)
vector._compute.lorentz.boostX_beta.rhophi_z_t(lib, beta, rho, phi, z, t)
vector._compute.lorentz.boostX_beta.rhophi_z_tau(lib, beta, rho, phi, z, tau)
vector._compute.lorentz.boostX_beta.xy_eta_t(lib, beta, x, y, eta, t)
vector._compute.lorentz.boostX_beta.xy_eta_tau(lib, beta, x, y, eta, tau)
vector._compute.lorentz.boostX_beta.xy_theta_t(lib, beta, x, y, theta, t)
vector._compute.lorentz.boostX_beta.xy_theta_tau(lib, beta, x, y, theta, tau)
vector._compute.lorentz.boostX_beta.xy_z_t(lib, beta, x, y, z, t)
vector._compute.lorentz.boostX_beta.xy_z_tau(lib, beta, x, y, z, tau)

```

### vector.\_compute.lorentz.boostX\_gamma module

```
Lorentz.boostX(self, gamma=)
```

```

vector._compute.lorentz.boostX_gamma.dispatch(gamma: Any, v: Any) → Any
vector._compute.lorentz.boostX_gamma.rhophi_eta_t(lib, gamma, rho, phi, eta, t)
vector._compute.lorentz.boostX_gamma.rhophi_eta_tau(lib, gamma, rho, phi, eta, tau)

```

```
vector._compute.lorentz.boostX_gamma.rhophi_theta_t(lib, gamma, rho, phi, theta, t)
vector._compute.lorentz.boostX_gamma.rhophi_theta_tau(lib, gamma, rho, phi, theta, tau)
vector._compute.lorentz.boostX_gamma.rhophi_z_t(lib, gamma, rho, phi, z, t)
vector._compute.lorentz.boostX_gamma.rhophi_z_tau(lib, gamma, rho, phi, z, tau)
vector._compute.lorentz.boostX_gamma.xy_eta_t(lib, gamma, x, y, eta, t)
vector._compute.lorentz.boostX_gamma.xy_eta_tau(lib, gamma, x, y, eta, tau)
vector._compute.lorentz.boostX_gamma.xy_theta_t(lib, gamma, x, y, theta, t)
vector._compute.lorentz.boostX_gamma.xy_theta_tau(lib, gamma, x, y, theta, tau)
vector._compute.lorentz.boostX_gamma.xy_z_t(lib, gamma, x, y, z, t)
vector._compute.lorentz.boostX_gamma.xy_z_tau(lib, gamma, x, y, z, tau)
```

### **vector.\_compute.lorentz.boostY\_beta module**

```
Lorentz.boostY(self, beta=...)
```

```
vector._compute.lorentz.boostY_beta.dispatch(beta: Any, v: Any) → Any
vector._compute.lorentz.boostY_beta.rhophi_eta_t(lib, beta, rho, phi, eta, t)
vector._compute.lorentz.boostY_beta.rhophi_eta_tau(lib, beta, rho, phi, eta, tau)
vector._compute.lorentz.boostY_beta.rhophi_theta_t(lib, beta, rho, phi, theta, t)
vector._compute.lorentz.boostY_beta.rhophi_theta_tau(lib, beta, rho, phi, theta, tau)
vector._compute.lorentz.boostY_beta.rhophi_z_t(lib, beta, rho, phi, z, t)
vector._compute.lorentz.boostY_beta.rhophi_z_tau(lib, beta, rho, phi, z, tau)
vector._compute.lorentz.boostY_beta.xy_eta_t(lib, beta, x, y, eta, t)
vector._compute.lorentz.boostY_beta.xy_eta_tau(lib, beta, x, y, eta, tau)
vector._compute.lorentz.boostY_beta.xy_theta_t(lib, beta, x, y, theta, t)
vector._compute.lorentz.boostY_beta.xy_theta_tau(lib, beta, x, y, theta, tau)
vector._compute.lorentz.boostY_beta.xy_z_t(lib, beta, x, y, z, t)
vector._compute.lorentz.boostY_beta.xy_z_tau(lib, beta, x, y, z, tau)
```

**vector.\_compute.lorentz.boostY\_gamma module**

```
Lorentz.boostY(self, gamma=...)
```

```
vector._compute.lorentz.boostY_gamma.dispatch(gamma: Any, v: Any) → Any
```

```
vector._compute.lorentz.boostY_gamma.rhophi_eta_t(lib, gamma, rho, phi, eta, t)
```

```
vector._compute.lorentz.boostY_gamma.rhophi_eta_tau(lib, gamma, rho, phi, eta, tau)
```

```
vector._compute.lorentz.boostY_gamma.rhophi_theta_t(lib, gamma, rho, phi, theta, t)
```

```
vector._compute.lorentz.boostY_gamma.rhophi_theta_tau(lib, gamma, rho, phi, theta, tau)
```

```
vector._compute.lorentz.boostY_gamma.rhophi_z_t(lib, gamma, rho, phi, z, t)
```

```
vector._compute.lorentz.boostY_gamma.rhophi_z_tau(lib, gamma, rho, phi, z, tau)
```

```
vector._compute.lorentz.boostY_gamma.xy_eta_t(lib, gamma, x, y, eta, t)
```

```
vector._compute.lorentz.boostY_gamma.xy_eta_tau(lib, gamma, x, y, eta, tau)
```

```
vector._compute.lorentz.boostY_gamma.xy_theta_t(lib, gamma, x, y, theta, t)
```

```
vector._compute.lorentz.boostY_gamma.xy_theta_tau(lib, gamma, x, y, theta, tau)
```

```
vector._compute.lorentz.boostY_gamma.xy_z_t(lib, gamma, x, y, z, t)
```

```
vector._compute.lorentz.boostY_gamma.xy_z_tau(lib, gamma, x, y, z, tau)
```

**vector.\_compute.lorentz.boostZ\_beta module**

```
Lorentz.boostZ(self, beta=...)
```

```
vector._compute.lorentz.boostZ_beta.dispatch(beta: Any, v: Any) → Any
```

```
vector._compute.lorentz.boostZ_beta.rhophi_eta_t(lib, beta, rho, phi, eta, t)
```

```
vector._compute.lorentz.boostZ_beta.rhophi_eta_tau(lib, beta, rho, phi, eta, tau)
```

```
vector._compute.lorentz.boostZ_beta.rhophi_theta_t(lib, beta, rho, phi, theta, t)
```

```
vector._compute.lorentz.boostZ_beta.rhophi_theta_tau(lib, beta, rho, phi, theta, tau)
```

```
vector._compute.lorentz.boostZ_beta.rhophi_z_t(lib, beta, rho, phi, z, t)
```

```
vector._compute.lorentz.boostZ_beta.rhophi_z_tau(lib, beta, rho, phi, z, tau)
```

```
vector._compute.lorentz.boostZ_beta.xy_eta_t(lib, beta, x, y, eta, t)
```

```
vector._compute.lorentz.boostZ_beta.xy_eta_tau(lib, beta, x, y, eta, tau)
```

```
vector._compute.lorentz.boostZ_beta.xy_theta_t(lib, beta, x, y, theta, t)
```

```
vector._compute.lorentz.boostZ_beta.xy_theta_tau(lib, beta, x, y, theta, tau)
```

```
vector._compute.lorentz.boostZ_beta.xy_z_t(lib, beta, x, y, z, t)
```

```
vector._compute.lorentz.boostZ_beta.xy_z_tau(lib, beta, x, y, z, tau)
```

**vector.\_compute.lorentz.boostZ\_gamma module**

```
Lorentz.boostZ(self, gamma=...)
```

```
vector._compute.lorentz.boostZ_gamma.dispatch(gamma: Any, v: Any) → Any
```

```
vector._compute.lorentz.boostZ_gamma.rhophi_eta_t(lib, gamma, rho, phi, eta, t)
```

```
vector._compute.lorentz.boostZ_gamma.rhophi_eta_tau(lib, gamma, rho, phi, eta, tau)
```

```
vector._compute.lorentz.boostZ_gamma.rhophi_theta_t(lib, gamma, rho, phi, theta, t)
```

```
vector._compute.lorentz.boostZ_gamma.rhophi_theta_tau(lib, gamma, rho, phi, theta, tau)
```

```
vector._compute.lorentz.boostZ_gamma.rhophi_z_t(lib, gamma, rho, phi, z, t)
```

```
vector._compute.lorentz.boostZ_gamma.rhophi_z_tau(lib, gamma, rho, phi, z, tau)
```

```
vector._compute.lorentz.boostZ_gamma.xy_eta_t(lib, gamma, x, y, eta, t)
```

```
vector._compute.lorentz.boostZ_gamma.xy_eta_tau(lib, gamma, x, y, eta, tau)
```

```
vector._compute.lorentz.boostZ_gamma.xy_theta_t(lib, gamma, x, y, theta, t)
```

```
vector._compute.lorentz.boostZ_gamma.xy_theta_tau(lib, gamma, x, y, theta, tau)
```

```
vector._compute.lorentz.boostZ_gamma.xy_z_t(lib, gamma, x, y, z, t)
```

```
vector._compute.lorentz.boostZ_gamma.xy_z_tau(lib, gamma, x, y, z, tau)
```

**vector.\_compute.lorentz.deltaRapidityPhi module**

```
Spatial.deltaRapidityPhi(self, other)
```

```
vector._compute.lorentz.deltaRapidityPhi.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.lorentz.deltaRapidityPhi.make_conversion(azimuthal1, longitudinal1, temporal1,  
                                                         azimuthal2, longitudinal2, temporal2)
```

**vector.\_compute.lorentz.deltaRapidityPhi2 module**

```
Spatial.deltaRapidityPhi2(self, other)
```

```
vector._compute.lorentz.deltaRapidityPhi2.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.lorentz.deltaRapidityPhi2.make_conversion(azimuthal1, longitudinal1, temporal1,  
                                                         azimuthal2, longitudinal2, temporal2)
```

**vector.\_compute.lorentz.dot module**

```
Lorentz.dot(self, other)
```

```
vector._compute.lorentz.dot.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.lorentz.dot.make_conversion(azimuthal1, longitudinal1, temporal1, azimuthal2,  
longitudinal2, temporal2)
```

**vector.\_compute.lorentz.equal module**

```
Lorentz.equal(self, other)
```

```
vector._compute.lorentz.equal.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.lorentz.equal.make_conversion(azimuthal1, longitudinal1, temporal1, azimuthal2,  
longitudinal2, temporal2)
```

**vector.\_compute.lorentz.Et module**

```
@property  
Lorentz.Et(self)
```

```
vector._compute.lorentz.Et.dispatch(v: Any) → Any
```

```
vector._compute.lorentz.Et.rhophi_eta_t(lib, rho, phi, eta, t)
```

```
vector._compute.lorentz.Et.rhophi_eta_tau(lib, rho, phi, eta, tau)
```

```
vector._compute.lorentz.Et.rhophi_theta_t(lib, rho, phi, theta, t)
```

```
vector._compute.lorentz.Et.rhophi_theta_tau(lib, rho, phi, theta, tau)
```

```
vector._compute.lorentz.Et.rhophi_z_t(lib, rho, phi, z, t)
```

```
vector._compute.lorentz.Et.rhophi_z_tau(lib, rho, phi, z, tau)
```

```
vector._compute.lorentz.Et.xy_eta_t(lib, x, y, eta, t)
```

```
vector._compute.lorentz.Et.xy_eta_tau(lib, x, y, eta, tau)
```

```
vector._compute.lorentz.Et.xy_theta_t(lib, x, y, theta, t)
```

```
vector._compute.lorentz.Et.xy_theta_tau(lib, x, y, theta, tau)
```

```
vector._compute.lorentz.Et.xy_z_t(lib, x, y, z, t)
```

```
vector._compute.lorentz.Et.xy_z_tau(lib, x, y, z, tau)
```

### vector.\_compute.lorentz.Et2 module

```
@property
Lorentz.Et2(self)
```

```
vector._compute.lorentz.Et2.dispatch(v: Any) → Any
vector._compute.lorentz.Et2.rhophi_eta_t(lib, rho, phi, eta, t)
vector._compute.lorentz.Et2.rhophi_eta_tau(lib, rho, phi, eta, tau)
vector._compute.lorentz.Et2.rhophi_theta_t(lib, rho, phi, theta, t)
vector._compute.lorentz.Et2.rhophi_theta_tau(lib, rho, phi, theta, tau)
vector._compute.lorentz.Et2.rhophi_z_t(lib, rho, phi, z, t)
vector._compute.lorentz.Et2.rhophi_z_tau(lib, rho, phi, z, tau)
vector._compute.lorentz.Et2.xy_eta_t(lib, x, y, eta, t)
vector._compute.lorentz.Et2.xy_eta_tau(lib, x, y, eta, tau)
vector._compute.lorentz.Et2.xy_theta_t(lib, x, y, theta, t)
vector._compute.lorentz.Et2.xy_theta_tau(lib, x, y, theta, tau)
vector._compute.lorentz.Et2.xy_z_t(lib, x, y, z, t)
vector._compute.lorentz.Et2.xy_z_tau(lib, x, y, z, tau)
```

### vector.\_compute.lorentz.gamma module

```
@property
Lorentz.gamma(self)
```

```
vector._compute.lorentz.gamma.dispatch(v: Any) → Any
vector._compute.lorentz.gamma.rhophi_eta_t(lib, rho, phi, eta, t)
vector._compute.lorentz.gamma.rhophi_eta_tau(lib, rho, phi, eta, tau)
vector._compute.lorentz.gamma.rhophi_theta_t(lib, rho, phi, theta, t)
vector._compute.lorentz.gamma.rhophi_theta_tau(lib, rho, phi, theta, tau)
vector._compute.lorentz.gamma.rhophi_z_t(lib, rho, phi, z, t)
vector._compute.lorentz.gamma.rhophi_z_tau(lib, rho, phi, z, tau)
vector._compute.lorentz.gamma.xy_eta_t(lib, x, y, eta, t)
vector._compute.lorentz.gamma.xy_eta_tau(lib, x, y, eta, tau)
vector._compute.lorentz.gamma.xy_theta_t(lib, x, y, theta, t)
vector._compute.lorentz.gamma.xy_theta_tau(lib, x, y, theta, tau)
```



```
vector._compute.lorentz.gamma.xy_z_t(lib, x, y, z, t)
```

```
vector._compute.lorentz.gamma.xy_z_tau(lib, x, y, z, tau)
```

### vector.\_compute.lorentz.is\_lightlike module

```
Lorentz.is_lightlike(self, tolerance=...)
```

```
vector._compute.lorentz.is_lightlike.dispatch(tolerance: Any, v: Any) → Any
```

```
vector._compute.lorentz.is_lightlike.make_function(azimuthal, longitudinal, temporal)
```

### vector.\_compute.lorentz.is\_spacelike module

```
Lorentz.is_spacelike(self, tolerance=...)
```

```
vector._compute.lorentz.is_spacelike.dispatch(tolerance: Any, v: Any) → Any
```

```
vector._compute.lorentz.is_spacelike.make_function(azimuthal, longitudinal, temporal)
```

### vector.\_compute.lorentz.is\_timelike module

```
Lorentz.is_timelike(self, tolerance=...)
```

```
vector._compute.lorentz.is_timelike.dispatch(tolerance: Any, v: Any) → Any
```

```
vector._compute.lorentz.is_timelike.make_function(azimuthal, longitudinal, temporal)
```

### vector.\_compute.lorentz.isclose module

```
Lorentz.isclose(self, rtol=..., atol=..., equal_nan=...)
```

```
vector._compute.lorentz.isclose.dispatch(rtol: Any, atol: Any, equal_nan: Any, v1: Any, v2: Any) →  
Any
```

```
vector._compute.lorentz.isclose.make_conversion(azimuthal1, longitudinal1, temporal1, azimuthal2,  
longitudinal2, temporal2)
```

### vector.\_compute.lorentz.Mt module

```
@property  
Lorentz.Mt(self)
```

```
vector._compute.lorentz.Mt.dispatch(v: Any) → Any
```

```
vector._compute.lorentz.Mt.rhophi_eta_t(lib, rho, phi, eta, t)
```

```
vector._compute.lorentz.Mt.rhophi_eta_tau(lib, rho, phi, eta, tau)
vector._compute.lorentz.Mt.rhophi_theta_t(lib, rho, phi, theta, t)
vector._compute.lorentz.Mt.rhophi_theta_tau(lib, rho, phi, theta, tau)
vector._compute.lorentz.Mt.rhophi_z_t(lib, rho, phi, z, t)
vector._compute.lorentz.Mt.rhophi_z_tau(lib, rho, phi, z, tau)
vector._compute.lorentz.Mt.xy_eta_t(lib, x, y, eta, t)
vector._compute.lorentz.Mt.xy_eta_tau(lib, x, y, eta, tau)
vector._compute.lorentz.Mt.xy_theta_t(lib, x, y, theta, t)
vector._compute.lorentz.Mt.xy_theta_tau(lib, x, y, theta, tau)
vector._compute.lorentz.Mt.xy_z_t(lib, x, y, z, t)
vector._compute.lorentz.Mt.xy_z_tau(lib, x, y, z, tau)
```

### **vector.\_compute.lorentz.Mt2 module**

```
@property
Lorentz.Mt2(self)
```

```
vector._compute.lorentz.Mt2.dispatch(v: Any) → Any
vector._compute.lorentz.Mt2.rhophi_eta_t(lib, rho, phi, eta, t)
vector._compute.lorentz.Mt2.rhophi_eta_tau(lib, rho, phi, eta, tau)
vector._compute.lorentz.Mt2.rhophi_theta_t(lib, rho, phi, theta, t)
vector._compute.lorentz.Mt2.rhophi_theta_tau(lib, rho, phi, theta, tau)
vector._compute.lorentz.Mt2.rhophi_z_t(lib, rho, phi, z, t)
vector._compute.lorentz.Mt2.rhophi_z_tau(lib, rho, phi, z, tau)
vector._compute.lorentz.Mt2.xy_eta_t(lib, x, y, eta, t)
vector._compute.lorentz.Mt2.xy_eta_tau(lib, x, y, eta, tau)
vector._compute.lorentz.Mt2.xy_theta_t(lib, x, y, theta, t)
vector._compute.lorentz.Mt2.xy_theta_tau(lib, x, y, theta, tau)
vector._compute.lorentz.Mt2.xy_z_t(lib, x, y, z, t)
vector._compute.lorentz.Mt2.xy_z_tau(lib, x, y, z, tau)
```

**vector.\_compute.lorentz.not\_equal module**

```
Lorentz.not_equal(self, other)
```

```
vector._compute.lorentz.not_equal.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.lorentz.not_equal.make_conversion(azimuthal1, longitudinal1, temporal1, azimuthal2,
longitudinal2, temporal2)
```

**vector.\_compute.lorentz.rapidity module**

```
@property
Lorentz.rapidity(self)
```

```
vector._compute.lorentz.rapidity.dispatch(v: Any) → Any
```

```
vector._compute.lorentz.rapidity.rhophi_eta_t(lib, rho, phi, eta, t)
```

```
vector._compute.lorentz.rapidity.rhophi_eta_tau(lib, rho, phi, eta, tau)
```

```
vector._compute.lorentz.rapidity.rhophi_theta_t(lib, rho, phi, theta, t)
```

```
vector._compute.lorentz.rapidity.rhophi_theta_tau(lib, rho, phi, theta, tau)
```

```
vector._compute.lorentz.rapidity.rhophi_z_t(lib, rho, phi, z, t)
```

```
vector._compute.lorentz.rapidity.rhophi_z_tau(lib, rho, phi, z, tau)
```

```
vector._compute.lorentz.rapidity.xy_eta_t(lib, x, y, eta, t)
```

```
vector._compute.lorentz.rapidity.xy_eta_tau(lib, x, y, eta, tau)
```

```
vector._compute.lorentz.rapidity.xy_theta_t(lib, x, y, theta, t)
```

```
vector._compute.lorentz.rapidity.xy_theta_tau(lib, x, y, theta, tau)
```

```
vector._compute.lorentz.rapidity.xy_z_t(lib, x, y, z, t)
```

```
vector._compute.lorentz.rapidity.xy_z_tau(lib, x, y, z, tau)
```

**vector.\_compute.lorentz.scale module**

```
Lorentz.scale(self, factor)
```

```
vector._compute.lorentz.scale.dispatch(factor: Any, v: Any) → Any
```

```
vector._compute.lorentz.scale.rhophi_eta_t(lib, factor, rho, phi, eta, t)
```

```
vector._compute.lorentz.scale.rhophi_eta_tau(lib, factor, rho, phi, eta, tau)
```

```
vector._compute.lorentz.scale.rhophi_theta_t(lib, factor, rho, phi, theta, t)
```

```
vector._compute.lorentz.scale.rhophi_theta_tau(lib, factor, rho, phi, theta, tau)
```

```
vector._compute.lorentz.scale.rhophi_z_t(lib, factor, rho, phi, z, t)
vector._compute.lorentz.scale.rhophi_z_tau(lib, factor, rho, phi, z, tau)
vector._compute.lorentz.scale.xy_eta_t(lib, factor, x, y, eta, t)
vector._compute.lorentz.scale.xy_eta_tau(lib, factor, x, y, eta, tau)
vector._compute.lorentz.scale.xy_theta_t(lib, factor, x, y, theta, t)
vector._compute.lorentz.scale.xy_theta_tau(lib, factor, x, y, theta, tau)
vector._compute.lorentz.scale.xy_z_t(lib, factor, x, y, z, t)
vector._compute.lorentz.scale.xy_z_tau(lib, factor, x, y, z, tau)
```

### vector.\_compute.lorentz.subtract module

```
Lorentz.subtract(self, other)
```

```
vector._compute.lorentz.subtract.dispatch(v1: Any, v2: Any) → Any
vector._compute.lorentz.subtract.make_conversion(azimuthal1, longitudinal1, temporal1, azimuthal2,
                                                    longitudinal2, temporal2)
```

### vector.\_compute.lorentz.t module

```
@property
Lorentz.t(self)
```

```
vector._compute.lorentz.t.dispatch(v: Any) → Any
vector._compute.lorentz.t.rhophi_eta_t(lib, rho, phi, eta, t)
vector._compute.lorentz.t.rhophi_eta_tau(lib, rho, phi, eta, tau)
vector._compute.lorentz.t.rhophi_theta_t(lib, rho, phi, theta, t)
vector._compute.lorentz.t.rhophi_theta_tau(lib, rho, phi, theta, tau)
vector._compute.lorentz.t.rhophi_z_t(lib, rho, phi, z, t)
vector._compute.lorentz.t.rhophi_z_tau(lib, rho, phi, z, tau)
vector._compute.lorentz.t.xy_eta_t(lib, x, y, eta, t)
vector._compute.lorentz.t.xy_eta_tau(lib, x, y, eta, tau)
vector._compute.lorentz.t.xy_theta_t(lib, x, y, theta, t)
vector._compute.lorentz.t.xy_theta_tau(lib, x, y, theta, tau)
vector._compute.lorentz.t.xy_z_t(lib, x, y, z, t)
vector._compute.lorentz.t.xy_z_tau(lib, x, y, z, tau)
```

**vector.\_compute.lorentz.t2 module**

```
@property
Lorentz.t2(self)
```

```
vector._compute.lorentz.t2.dispatch(v: Any) → Any
vector._compute.lorentz.t2.rhopi_eta_t(lib, rho, phi, eta, t)
vector._compute.lorentz.t2.rhopi_eta_tau(lib, rho, phi, eta, tau)
vector._compute.lorentz.t2.rhopi_theta_t(lib, rho, phi, theta, t)
vector._compute.lorentz.t2.rhopi_theta_tau(lib, rho, phi, theta, tau)
vector._compute.lorentz.t2.rhopi_z_t(lib, rho, phi, z, t)
vector._compute.lorentz.t2.rhopi_z_tau(lib, rho, phi, z, tau)
vector._compute.lorentz.t2.xy_eta_t(lib, x, y, eta, t)
vector._compute.lorentz.t2.xy_eta_tau(lib, x, y, eta, tau)
vector._compute.lorentz.t2.xy_theta_t(lib, x, y, theta, t)
vector._compute.lorentz.t2.xy_theta_tau(lib, x, y, theta, tau)
vector._compute.lorentz.t2.xy_z_t(lib, x, y, z, t)
vector._compute.lorentz.t2.xy_z_tau(lib, x, y, z, tau)
```

**vector.\_compute.lorentz.tau module**

```
@property
Lorentz.tau(self)
```

```
vector._compute.lorentz.tau.dispatch(v: Any) → Any
vector._compute.lorentz.tau.rhopi_eta_t(lib, rho, phi, eta, t)
vector._compute.lorentz.tau.rhopi_eta_tau(lib, rho, phi, eta, tau)
vector._compute.lorentz.tau.rhopi_theta_t(lib, rho, phi, theta, t)
vector._compute.lorentz.tau.rhopi_theta_tau(lib, rho, phi, theta, tau)
vector._compute.lorentz.tau.rhopi_z_t(lib, rho, phi, z, t)
vector._compute.lorentz.tau.rhopi_z_tau(lib, rho, phi, z, tau)
vector._compute.lorentz.tau.xy_eta_t(lib, x, y, eta, t)
vector._compute.lorentz.tau.xy_eta_tau(lib, x, y, eta, tau)
vector._compute.lorentz.tau.xy_theta_t(lib, x, y, theta, t)
vector._compute.lorentz.tau.xy_theta_tau(lib, x, y, theta, tau)
```

```
vector._compute.lorentz.tau.xy_z_t(lib, x, y, z, t)
```

```
vector._compute.lorentz.tau.xy_z_tau(lib, x, y, z, tau)
```

### vector.\_compute.lorentz.tau2 module

```
@property  
Lorentz.tau2(self)
```

```
vector._compute.lorentz.tau2.dispatch(v: Any) → Any
```

```
vector._compute.lorentz.tau2.rhophi_eta_t(lib, rho, phi, eta, t)
```

```
vector._compute.lorentz.tau2.rhophi_eta_tau(lib, rho, phi, eta, tau)
```

```
vector._compute.lorentz.tau2.rhophi_theta_t(lib, rho, phi, theta, t)
```

```
vector._compute.lorentz.tau2.rhophi_theta_tau(lib, rho, phi, theta, tau)
```

```
vector._compute.lorentz.tau2.rhophi_z_t(lib, rho, phi, z, t)
```

```
vector._compute.lorentz.tau2.rhophi_z_tau(lib, rho, phi, z, tau)
```

```
vector._compute.lorentz.tau2.xy_eta_t(lib, x, y, eta, t)
```

```
vector._compute.lorentz.tau2.xy_eta_tau(lib, x, y, eta, tau)
```

```
vector._compute.lorentz.tau2.xy_theta_t(lib, x, y, theta, t)
```

```
vector._compute.lorentz.tau2.xy_theta_tau(lib, x, y, theta, tau)
```

```
vector._compute.lorentz.tau2.xy_z_t(lib, x, y, z, t)
```

```
vector._compute.lorentz.tau2.xy_z_tau(lib, x, y, z, tau)
```

### vector.\_compute.lorentz.to\_beta3 module

```
Lorentz.to_beta3(self)
```

```
vector._compute.lorentz.to_beta3.dispatch(v: Any) → Any
```

```
vector._compute.lorentz.to_beta3.rhophi_eta_t(lib, rho, phi, eta, t)
```

```
vector._compute.lorentz.to_beta3.rhophi_eta_tau(lib, rho, phi, eta, tau)
```

```
vector._compute.lorentz.to_beta3.rhophi_theta_t(lib, rho, phi, theta, t)
```

```
vector._compute.lorentz.to_beta3.rhophi_theta_tau(lib, rho, phi, theta, tau)
```

```
vector._compute.lorentz.to_beta3.rhophi_z_t(lib, rho, phi, z, t)
```

```
vector._compute.lorentz.to_beta3.rhophi_z_tau(lib, rho, phi, z, tau)
```

```
vector._compute.lorentz.to_beta3.xy_eta_t(lib, x, y, eta, t)
```

```

vector._compute.lorentz.to_beta3.xy_eta_tau(lib, x, y, eta, tau)
vector._compute.lorentz.to_beta3.xy_theta_t(lib, x, y, theta, t)
vector._compute.lorentz.to_beta3.xy_theta_tau(lib, x, y, theta, tau)
vector._compute.lorentz.to_beta3.xy_z_t(lib, x, y, z, t)
vector._compute.lorentz.to_beta3.xy_z_tau(lib, x, y, z, tau)

```

### vector.\_compute.lorentz.transform4D module

```

Lorentz.transform4D(self, obj)

```

where obj has obj["xx"], obj["xy"], etc.

```

vector._compute.lorentz.transform4D.cartesian_t(lib, xx, xy, xz, xt, yx, yy, yz, yt, zx, zy, zz, zt, tx, ty, tz,
                                                tt, x, y, z, t)
vector._compute.lorentz.transform4D.cartesian_tau(lib, xx, xy, xz, xt, yx, yy, yz, yt, zx, zy, zz, zt, x, y, z,
                                                  tau)
vector._compute.lorentz.transform4D.dispatch(obj: Any, v: Any) → Any
vector._compute.lorentz.transform4D.make_conversion(azimuthal, longitudinal, temporal)

```

### vector.\_compute.lorentz.unit module

```

Lorentz.unit(self)

```

```

vector._compute.lorentz.unit.dispatch(v: Any) → Any
vector._compute.lorentz.unit.rhophi_eta_t(lib, rho, phi, eta, t)
vector._compute.lorentz.unit.rhophi_eta_tau(lib, rho, phi, eta, tau)
vector._compute.lorentz.unit.rhophi_theta_t(lib, rho, phi, theta, t)
vector._compute.lorentz.unit.rhophi_theta_tau(lib, rho, phi, theta, tau)
vector._compute.lorentz.unit.rhophi_z_t(lib, rho, phi, z, t)
vector._compute.lorentz.unit.rhophi_z_tau(lib, rho, phi, z, tau)
vector._compute.lorentz.unit.xy_eta_t(lib, x, y, eta, t)
vector._compute.lorentz.unit.xy_eta_tau(lib, x, y, eta, tau)
vector._compute.lorentz.unit.xy_theta_t(lib, x, y, theta, t)
vector._compute.lorentz.unit.xy_theta_tau(lib, x, y, theta, tau)
vector._compute.lorentz.unit.xy_z_t(lib, x, y, z, t)
vector._compute.lorentz.unit.xy_z_tau(lib, x, y, z, tau)

```

### vector.\_compute.planar package

Compute functions for planar vectors, which is to say 2D, 3D, and 4D.

Each function is a module with variants for each coordinate system (or combination of coordinate systems) as functions within the module.

Each module has a `dispatch_map` (dict) that maps coordinate types to the appropriate function and its return type(s), and a `dispatch` (function) uses this information to call the right function and return the right type.

The compute functions themselves are restricted to a minimum of Python features: no statements other than assignments and one return, no assumptions about data types. In particular, if statements and loops are not allowed. The tests/test\_compute\_features.py suite ensures that these rules are followed (though that set of allowed features can be expanded if it doesn't prevent the addition of new backends).

### Submodules

#### vector.\_compute.planar.add module

```
Planar.add(self, other)
```

```
vector._compute.planar.add.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.planar.add.rectify(lib, phi)
```

```
vector._compute.planar.add.rhophi_rhophi(lib, rho1, phi1, rho2, phi2)
```

```
vector._compute.planar.add.rhophi_xy(lib, rho1, phi1, x2, y2)
```

```
vector._compute.planar.add.xy_rhophi(lib, x1, y1, rho2, phi2)
```

```
vector._compute.planar.add.xy_xy(lib, x1, y1, x2, y2)
```

#### vector.\_compute.planar.deltaphi module

```
Planar.deltaphi(self, other)
```

```
vector._compute.planar.deltaphi.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.planar.deltaphi.rectify(lib, phi)
```

```
vector._compute.planar.deltaphi.rhophi_rhophi(lib, rho1, phi1, rho2, phi2)
```

```
vector._compute.planar.deltaphi.rhophi_xy(lib, rho1, phi1, x2, y2)
```

```
vector._compute.planar.deltaphi.xy_rhophi(lib, x1, y1, rho2, phi2)
```

```
vector._compute.planar.deltaphi.xy_xy(lib, x1, y1, x2, y2)
```



**vector.\_compute.planar.dot module**

```
Planar.dot(self, other)
```

```
vector._compute.planar.dot.dispatch(v1: Any, v2: Any) → Any
vector._compute.planar.dot.rhophi_rhophi(lib, rho1, phi1, rho2, phi2)
vector._compute.planar.dot.rhophi_xy(lib, rho1, phi1, x2, y2)
vector._compute.planar.dot.xy_rhophi(lib, x1, y1, rho2, phi2)
vector._compute.planar.dot.xy_xy(lib, x1, y1, x2, y2)
```

**vector.\_compute.planar.equal module**

```
Planar.equal(self, other)
```

```
vector._compute.planar.equal.dispatch(v1: Any, v2: Any) → Any
vector._compute.planar.equal.rhophi_rhophi(lib, rho1, phi1, rho2, phi2)
vector._compute.planar.equal.rhophi_xy(lib, rho1, phi1, x2, y2)
vector._compute.planar.equal.xy_rhophi(lib, x1, y1, rho2, phi2)
vector._compute.planar.equal.xy_xy(lib, x1, y1, x2, y2)
```

**vector.\_compute.planar.is\_antiparallel module**

```
Planar.is_antiparallel(self, other, tolerance=...)
```

```
vector._compute.planar.is_antiparallel.dispatch(tolerance: Any, v1: Any, v2: Any) → Any
vector._compute.planar.is_antiparallel.make_function(azimuthal1, azimuthal2)
```

**vector.\_compute.planar.is\_parallel module**

```
Planar.is_parallel(self, other, tolerance=...)
```

```
vector._compute.planar.is_parallel.dispatch(tolerance: Any, v1: Any, v2: Any) → Any
vector._compute.planar.is_parallel.make_function(azimuthal1, azimuthal2)
```

### vector.\_compute.planar.is\_perpendicular module

```
Planar.is_perpendicular(self, other, tolerance=...)
```

vector.\_compute.planar.is\_perpendicular.**dispatch**(*tolerance: Any, v1: Any, v2: Any*) → Any

vector.\_compute.planar.is\_perpendicular.**make\_function**(*azimuthal1, azimuthal2*)

### vector.\_compute.planar.isclose module

```
Planar.isclose(self, other, rtol=..., atol=..., equal_nan=...)
```

vector.\_compute.planar.isclose.**dispatch**(*rtol: Any, atol: Any, equal\_nan: Any, v1: Any, v2: Any*) → Any

vector.\_compute.planar.isclose.**rhophi\_rhophi**(*lib, rtol, atol, equal\_nan, rho1, phi1, rho2, phi2*)

vector.\_compute.planar.isclose.**rhophi\_xy**(*lib, rtol, atol, equal\_nan, rho1, phi1, x2, y2*)

vector.\_compute.planar.isclose.**xy\_rhophi**(*lib, rtol, atol, equal\_nan, x1, y1, rho2, phi2*)

vector.\_compute.planar.isclose.**xy\_xy**(*lib, rtol, atol, equal\_nan, x1, y1, x2, y2*)

### vector.\_compute.planar.not\_equal module

```
Planar.not_equal(self, other)
```

vector.\_compute.planar.not\_equal.**dispatch**(*v1: Any, v2: Any*) → Any

vector.\_compute.planar.not\_equal.**rhophi\_rhophi**(*lib, rho1, phi1, rho2, phi2*)

vector.\_compute.planar.not\_equal.**rhophi\_xy**(*lib, rho1, phi1, x2, y2*)

vector.\_compute.planar.not\_equal.**xy\_rhophi**(*lib, x1, y1, rho2, phi2*)

vector.\_compute.planar.not\_equal.**xy\_xy**(*lib, x1, y1, x2, y2*)

### vector.\_compute.planar.phi module

```
@property  
Planar.phi(self)
```

vector.\_compute.planar.phi.**dispatch**(*v: Any*) → Any

vector.\_compute.planar.phi.**rhophi**(*lib, rho, phi*)

vector.\_compute.planar.phi.**xy**(*lib, x, y*)

**vector.\_compute.planar.rho module**

```
@property
Planar.rho(self)
```

```
vector._compute.planar.rho.dispatch(v: Any) → Any
```

```
vector._compute.planar.rho.rhophi(lib, rho, phi)
```

```
vector._compute.planar.rho.xy(lib, x, y)
```

**vector.\_compute.planar.rho2 module**

```
@property
Planar.rho2(self)
```

```
vector._compute.planar.rho2.dispatch(v: Any) → Any
```

```
vector._compute.planar.rho2.rhophi(lib, rho, phi)
```

```
vector._compute.planar.rho2.xy(lib, x, y)
```

**vector.\_compute.planar.rotateZ module**

```
Planar.rotateZ(self, angle)
```

```
vector._compute.planar.rotateZ.dispatch(angle: Any, v: Any) → Any
```

```
vector._compute.planar.rotateZ.rectify(lib, phi)
```

```
vector._compute.planar.rotateZ.rhophi(lib, angle, rho, phi)
```

```
vector._compute.planar.rotateZ.xy(lib, angle, x, y)
```

**vector.\_compute.planar.scale module**

```
Planar.scale(self, factor)
```

```
vector._compute.planar.scale.dispatch(factor: Any, v: Any) → Any
```

```
vector._compute.planar.scale.rectify(lib, phi)
```

```
vector._compute.planar.scale.rhophi(lib, factor, rho, phi)
```

```
vector._compute.planar.scale.xy(lib, factor, x, y)
```

### vector.\_compute.planar.subtract module

```
Planar.subtract(self, other)
```

```
vector._compute.planar.subtract.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.planar.subtract.rectify(lib, phi)
```

```
vector._compute.planar.subtract.rhophi_rhophi(lib, rho1, phi1, rho2, phi2)
```

```
vector._compute.planar.subtract.rhophi_xy(lib, rho1, phi1, x2, y2)
```

```
vector._compute.planar.subtract.xy_rhophi(lib, x1, y1, rho2, phi2)
```

```
vector._compute.planar.subtract.xy_xy(lib, x1, y1, x2, y2)
```

### vector.\_compute.planar.transform2D module

```
Planar.transform2D(self, obj)
```

where obj has obj["xx"], obj["xy"], etc.

```
vector._compute.planar.transform2D.cartesian(lib, xx, xy, yx, yy, x, y)
```

```
vector._compute.planar.transform2D.dispatch(obj: Any, v: Any) → Any
```

```
vector._compute.planar.transform2D.rhophi(lib, xx, xy, yx, yy, rho, phi)
```

### vector.\_compute.planar.unit module

```
Planar.unit(self)
```

```
vector._compute.planar.unit.dispatch(v: Any) → Any
```

```
vector._compute.planar.unit.rhophi(lib, rho, phi)
```

```
vector._compute.planar.unit.xy(lib, x, y)
```

### vector.\_compute.planar.x module

```
@property  
Planar.x(self)
```

```
vector._compute.planar.x.dispatch(v: Any) → Any
```

```
vector._compute.planar.x.rhophi(lib, rho, phi)
```

```
vector._compute.planar.x.xy(lib, x, y)
```

## vector.\_compute.planar.y module

```
@property
Planar.y(self)
```

```
vector._compute.planar.y.dispatch(v: Any) → Any
```

```
vector._compute.planar.y.rhophi(lib, rho, phi)
```

```
vector._compute.planar.y.xy(lib, x, y)
```

## vector.\_compute.spatial package

Compute functions for spatial vectors, which is to say 3D and 4D.

Each function is a module with variants for each coordinate system (or combination of coordinate systems) as functions within the module.

Each module has a `dispatch_map` (dict) that maps coordinate types to the appropriate function and its return type(s), and a `dispatch` (function) uses this information to call the right function and return the right type.

The compute functions themselves are restricted to a minimum of Python features: no statements other than assignments and one return, no assumptions about data types. In particular, if statements and loops are not allowed. The tests/test\_compute\_features.py suite ensures that these rules are followed (though that set of allowed features can be expanded if it doesn't prevent the addition of new backends).

## Submodules

### vector.\_compute.spatial.add module

```
Spatial.add(self, other)
```

```
vector._compute.spatial.add.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.spatial.add.rhophi_eta_rhophi_eta(lib, rho1, phi1, eta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.add.rhophi_eta_rhophi_theta(lib, rho1, phi1, eta1, rho2, phi2, theta2)
```

```
vector._compute.spatial.add.rhophi_eta_rhophi_z(lib, rho1, phi1, eta1, rho2, phi2, z2)
```

```
vector._compute.spatial.add.rhophi_eta_xy_eta(lib, rho1, phi1, eta1, x2, y2, eta2)
```

```
vector._compute.spatial.add.rhophi_eta_xy_theta(lib, rho1, phi1, eta1, x2, y2, theta2)
```

```
vector._compute.spatial.add.rhophi_eta_xy_z(lib, rho1, phi1, eta1, x2, y2, z2)
```

```
vector._compute.spatial.add.rhophi_theta_rhophi_eta(lib, rho1, phi1, theta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.add.rhophi_theta_rhophi_theta(lib, rho1, phi1, theta1, rho2, phi2, theta2)
```

```
vector._compute.spatial.add.rhophi_theta_rhophi_z(lib, rho1, phi1, theta1, rho2, phi2, z2)
```

```
vector._compute.spatial.add.rhophi_theta_xy_eta(lib, rho1, phi1, theta1, x2, y2, eta2)
```

```
vector._compute.spatial.add.rhophi_theta_xy_theta(lib, rho1, phi1, theta1, x2, y2, theta2)
vector._compute.spatial.add.rhophi_theta_xy_z(lib, rho1, phi1, theta1, x2, y2, z2)
vector._compute.spatial.add.rhophi_z_rhophi_eta(lib, rho1, phi1, z1, rho2, phi2, eta2)
vector._compute.spatial.add.rhophi_z_rhophi_theta(lib, rho1, phi1, z1, rho2, phi2, theta2)
vector._compute.spatial.add.rhophi_z_rhophi_z(lib, rho1, phi1, z1, rho2, phi2, z2)
vector._compute.spatial.add.rhophi_z_xy_eta(lib, rho1, phi1, z1, x2, y2, eta2)
vector._compute.spatial.add.rhophi_z_xy_theta(lib, rho1, phi1, z1, x2, y2, theta2)
vector._compute.spatial.add.rhophi_z_xy_z(lib, rho1, phi1, z1, x2, y2, z2)
vector._compute.spatial.add.xy_eta_rhophi_eta(lib, x1, y1, eta1, rho2, phi2, eta2)
vector._compute.spatial.add.xy_eta_rhophi_theta(lib, x1, y1, eta1, rho2, phi2, theta2)
vector._compute.spatial.add.xy_eta_rhophi_z(lib, x1, y1, eta1, rho2, phi2, z2)
vector._compute.spatial.add.xy_eta_xy_eta(lib, x1, y1, eta1, x2, y2, eta2)
vector._compute.spatial.add.xy_eta_xy_theta(lib, x1, y1, eta1, x2, y2, theta2)
vector._compute.spatial.add.xy_eta_xy_z(lib, x1, y1, eta1, x2, y2, z2)
vector._compute.spatial.add.xy_theta_rhophi_eta(lib, x1, y1, theta1, rho2, phi2, eta2)
vector._compute.spatial.add.xy_theta_rhophi_theta(lib, x1, y1, theta1, rho2, phi2, theta2)
vector._compute.spatial.add.xy_theta_rhophi_z(lib, x1, y1, theta1, rho2, phi2, z2)
vector._compute.spatial.add.xy_theta_xy_eta(lib, x1, y1, theta1, x2, y2, eta2)
vector._compute.spatial.add.xy_theta_xy_theta(lib, x1, y1, theta1, x2, y2, theta2)
vector._compute.spatial.add.xy_theta_xy_z(lib, x1, y1, theta1, x2, y2, z2)
vector._compute.spatial.add.xy_z_rhophi_eta(lib, x1, y1, z1, rho2, phi2, eta2)
vector._compute.spatial.add.xy_z_rhophi_theta(lib, x1, y1, z1, rho2, phi2, theta2)
vector._compute.spatial.add.xy_z_rhophi_z(lib, x1, y1, z1, rho2, phi2, z2)
vector._compute.spatial.add.xy_z_xy_eta(lib, x1, y1, z1, x2, y2, eta2)
vector._compute.spatial.add.xy_z_xy_theta(lib, x1, y1, z1, x2, y2, theta2)
vector._compute.spatial.add.xy_z_xy_z(lib, x1, y1, z1, x2, y2, z2)
```

**vector.\_compute.spatial.costheta module**

```
@property
Spatial.costheta(self)
```

```
vector._compute.spatial.costheta.dispatch(v: Any) → Any
vector._compute.spatial.costheta.rhophi_eta(lib, rho, phi, eta)
vector._compute.spatial.costheta.rhophi_theta(lib, rho, phi, theta)
vector._compute.spatial.costheta.rhophi_z(lib, rho, phi, z)
vector._compute.spatial.costheta.xy_eta(lib, x, y, eta)
vector._compute.spatial.costheta.xy_theta(lib, x, y, theta)
vector._compute.spatial.costheta.xy_z(lib, x, y, z)
```

**vector.\_compute.spatial.cottheta module**

```
@property
Spatial.cottheta(self)
```

```
vector._compute.spatial.cottheta.dispatch(v: Any) → Any
vector._compute.spatial.cottheta.rhophi_eta(lib, rho, phi, eta)
vector._compute.spatial.cottheta.rhophi_theta(lib, rho, phi, theta)
vector._compute.spatial.cottheta.rhophi_z(lib, rho, phi, z)
vector._compute.spatial.cottheta.xy_eta(lib, x, y, eta)
vector._compute.spatial.cottheta.xy_theta(lib, x, y, theta)
vector._compute.spatial.cottheta.xy_z(lib, x, y, z)
```

**vector.\_compute.spatial.cross module**

```
Spatial.cross(self, other)
```

Note that this returns a 3D vector even for 4D inputs. The None at the end of the return signature indicates termination.

```
vector._compute.spatial.cross.dispatch(v1: Any, v2: Any) → Any
vector._compute.spatial.cross.make_conversion(azimuthal1, longitudinal1, azimuthal2, longitudinal2)
vector._compute.spatial.cross.xy_z_xy_z(lib, x1, y1, z1, x2, y2, z2)
```

**vector.\_compute.spatial.deltaangle module**

```
Spatial.deltaangle(self, other)
```

```
vector._compute.spatial.deltaangle.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.spatial.deltaangle.rhopi_eta_rhopi_eta(lib, rho1, phi1, eta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.deltaangle.rhopi_eta_rhopi_theta(lib, rho1, phi1, eta1, rho2, phi2, theta2)
```

```
vector._compute.spatial.deltaangle.rhopi_eta_rhopi_z(lib, rho1, phi1, eta1, rho2, phi2, z2)
```

```
vector._compute.spatial.deltaangle.rhopi_eta_xy_eta(lib, rho1, phi1, eta1, x2, y2, eta2)
```

```
vector._compute.spatial.deltaangle.rhopi_eta_xy_theta(lib, rho1, phi1, eta1, x2, y2, theta2)
```

```
vector._compute.spatial.deltaangle.rhopi_eta_xy_z(lib, rho1, phi1, eta1, x2, y2, z2)
```

```
vector._compute.spatial.deltaangle.rhopi_theta_rhopi_eta(lib, rho1, phi1, theta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.deltaangle.rhopi_theta_rhopi_theta(lib, rho1, phi1, theta1, rho2, phi2,  
theta2)
```

```
vector._compute.spatial.deltaangle.rhopi_theta_rhopi_z(lib, rho1, phi1, theta1, rho2, phi2, z2)
```

```
vector._compute.spatial.deltaangle.rhopi_theta_xy_eta(lib, rho1, phi1, theta1, x2, y2, eta2)
```

```
vector._compute.spatial.deltaangle.rhopi_theta_xy_theta(lib, rho1, phi1, theta1, x2, y2, theta2)
```

```
vector._compute.spatial.deltaangle.rhopi_theta_xy_z(lib, rho1, phi1, theta1, x2, y2, z2)
```

```
vector._compute.spatial.deltaangle.rhopi_z_rhopi_eta(lib, rho1, phi1, z1, rho2, phi2, eta2)
```

```
vector._compute.spatial.deltaangle.rhopi_z_rhopi_theta(lib, rho1, phi1, z1, rho2, phi2, theta2)
```

```
vector._compute.spatial.deltaangle.rhopi_z_rhopi_z(lib, rho1, phi1, z1, rho2, phi2, z2)
```

```
vector._compute.spatial.deltaangle.rhopi_z_xy_eta(lib, rho1, phi1, z1, x2, y2, eta2)
```

```
vector._compute.spatial.deltaangle.rhopi_z_xy_theta(lib, rho1, phi1, z1, x2, y2, theta2)
```

```
vector._compute.spatial.deltaangle.rhopi_z_xy_z(lib, rho1, phi1, z1, x2, y2, z2)
```

```
vector._compute.spatial.deltaangle.xy_eta_rhopi_eta(lib, x1, y1, eta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.deltaangle.xy_eta_rhopi_theta(lib, x1, y1, eta1, rho2, phi2, theta2)
```

```
vector._compute.spatial.deltaangle.xy_eta_rhopi_z(lib, x1, y1, eta1, rho2, phi2, z2)
```

```
vector._compute.spatial.deltaangle.xy_eta_xy_eta(lib, x1, y1, eta1, x2, y2, eta2)
```

```
vector._compute.spatial.deltaangle.xy_eta_xy_theta(lib, x1, y1, eta1, x2, y2, theta2)
```

```
vector._compute.spatial.deltaangle.xy_eta_xy_z(lib, x1, y1, eta1, x2, y2, z2)
```

```
vector._compute.spatial.deltaangle.xy_theta_rhopi_eta(lib, x1, y1, theta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.deltaangle.xy_theta_rhopi_theta(lib, x1, y1, theta1, rho2, phi2, theta2)
```



```

vector._compute.spatial.deltaangle.xy_theta_rho_phi_z(lib, x1, y1, theta1, rho2, phi2, z2)
vector._compute.spatial.deltaangle.xy_theta_xy_eta(lib, x1, y1, theta1, x2, y2, eta2)
vector._compute.spatial.deltaangle.xy_theta_xy_theta(lib, x1, y1, theta1, x2, y2, theta2)
vector._compute.spatial.deltaangle.xy_theta_xy_z(lib, x1, y1, theta1, x2, y2, z2)
vector._compute.spatial.deltaangle.xy_z_rho_phi_eta(lib, x1, y1, z1, rho2, phi2, eta2)
vector._compute.spatial.deltaangle.xy_z_rho_phi_theta(lib, x1, y1, z1, rho2, phi2, theta2)
vector._compute.spatial.deltaangle.xy_z_rho_phi_z(lib, x1, y1, z1, rho2, phi2, z2)
vector._compute.spatial.deltaangle.xy_z_xy_eta(lib, x1, y1, z1, x2, y2, eta2)
vector._compute.spatial.deltaangle.xy_z_xy_theta(lib, x1, y1, z1, x2, y2, theta2)
vector._compute.spatial.deltaangle.xy_z_xy_z(lib, x1, y1, z1, x2, y2, z2)

```

### vector.\_compute.spatial.deltaeta module

```
Spatial.deltaeta(self, other)
```

```

vector._compute.spatial.deltaeta.dispatch(v1: Any, v2: Any) → Any
vector._compute.spatial.deltaeta.rhophi_eta_rhophi_eta(lib, rho1, phi1, eta1, rho2, phi2, eta2)
vector._compute.spatial.deltaeta.rhophi_eta_rhophi_theta(lib, rho1, phi1, eta1, rho2, phi2, theta2)
vector._compute.spatial.deltaeta.rhophi_eta_rhophi_z(lib, rho1, phi1, eta1, rho2, phi2, z2)
vector._compute.spatial.deltaeta.rhophi_eta_xy_eta(lib, rho1, phi1, eta1, x2, y2, eta2)
vector._compute.spatial.deltaeta.rhophi_eta_xy_theta(lib, rho1, phi1, eta1, x2, y2, theta2)
vector._compute.spatial.deltaeta.rhophi_eta_xy_z(lib, rho1, phi1, eta1, x2, y2, z2)
vector._compute.spatial.deltaeta.rhophi_theta_rhophi_eta(lib, rho1, phi1, theta1, rho2, phi2, eta2)
vector._compute.spatial.deltaeta.rhophi_theta_rhophi_theta(lib, rho1, phi1, theta1, rho2, phi2,
    theta2)
vector._compute.spatial.deltaeta.rhophi_theta_rhophi_z(lib, rho1, phi1, theta1, rho2, phi2, z2)
vector._compute.spatial.deltaeta.rhophi_theta_xy_eta(lib, rho1, phi1, theta1, x2, y2, eta2)
vector._compute.spatial.deltaeta.rhophi_theta_xy_theta(lib, rho1, phi1, theta1, x2, y2, theta2)
vector._compute.spatial.deltaeta.rhophi_theta_xy_z(lib, rho1, phi1, theta1, x2, y2, z2)
vector._compute.spatial.deltaeta.rhophi_z_rhophi_eta(lib, rho1, phi1, z1, rho2, phi2, eta2)
vector._compute.spatial.deltaeta.rhophi_z_rhophi_theta(lib, rho1, phi1, z1, rho2, phi2, theta2)
vector._compute.spatial.deltaeta.rhophi_z_rhophi_z(lib, rho1, phi1, z1, rho2, phi2, z2)
vector._compute.spatial.deltaeta.rhophi_z_xy_eta(lib, rho1, phi1, z1, x2, y2, eta2)

```

```
vector._compute.spatial.deltaeta.rhophi_z_xy_theta(lib, rho1, phi1, z1, x2, y2, theta2)
vector._compute.spatial.deltaeta.rhophi_z_xy_z(lib, rho1, phi1, z1, x2, y2, z2)
vector._compute.spatial.deltaeta.xy_eta_rhophi_eta(lib, x1, y1, eta1, rho2, phi2, eta2)
vector._compute.spatial.deltaeta.xy_eta_rhophi_theta(lib, x1, y1, eta1, rho2, phi2, theta2)
vector._compute.spatial.deltaeta.xy_eta_rhophi_z(lib, x1, y1, eta1, rho2, phi2, z2)
vector._compute.spatial.deltaeta.xy_eta_xy_eta(lib, x1, y1, eta1, x2, y2, eta2)
vector._compute.spatial.deltaeta.xy_eta_xy_theta(lib, x1, y1, eta1, x2, y2, theta2)
vector._compute.spatial.deltaeta.xy_eta_xy_z(lib, x1, y1, eta1, x2, y2, z2)
vector._compute.spatial.deltaeta.xy_theta_rhophi_eta(lib, x1, y1, theta1, rho2, phi2, eta2)
vector._compute.spatial.deltaeta.xy_theta_rhophi_theta(lib, x1, y1, theta1, rho2, phi2, theta2)
vector._compute.spatial.deltaeta.xy_theta_rhophi_z(lib, x1, y1, theta1, rho2, phi2, z2)
vector._compute.spatial.deltaeta.xy_theta_xy_eta(lib, x1, y1, theta1, x2, y2, eta2)
vector._compute.spatial.deltaeta.xy_theta_xy_theta(lib, x1, y1, theta1, x2, y2, theta2)
vector._compute.spatial.deltaeta.xy_theta_xy_z(lib, x1, y1, theta1, x2, y2, z2)
vector._compute.spatial.deltaeta.xy_z_rhophi_eta(lib, x1, y1, z1, rho2, phi2, eta2)
vector._compute.spatial.deltaeta.xy_z_rhophi_theta(lib, x1, y1, z1, rho2, phi2, theta2)
vector._compute.spatial.deltaeta.xy_z_rhophi_z(lib, x1, y1, z1, rho2, phi2, z2)
vector._compute.spatial.deltaeta.xy_z_xy_eta(lib, x1, y1, z1, x2, y2, eta2)
vector._compute.spatial.deltaeta.xy_z_xy_theta(lib, x1, y1, z1, x2, y2, theta2)
vector._compute.spatial.deltaeta.xy_z_xy_z(lib, x1, y1, z1, x2, y2, z2)
```

### **vector.\_compute.spatial.deltaR module**

```
Spatial.deltaR(self, other)
```

```
vector._compute.spatial.deltaR.dispatch(v1: Any, v2: Any) → Any
vector._compute.spatial.deltaR.rhophi_eta_rhophi_eta(lib, rho1, phi1, eta1, rho2, phi2, eta2)
vector._compute.spatial.deltaR.rhophi_eta_rhophi_theta(lib, rho1, phi1, eta1, rho2, phi2, theta2)
vector._compute.spatial.deltaR.rhophi_eta_rhophi_z(lib, rho1, phi1, eta1, rho2, phi2, z2)
vector._compute.spatial.deltaR.rhophi_eta_xy_eta(lib, rho1, phi1, eta1, x2, y2, eta2)
vector._compute.spatial.deltaR.rhophi_eta_xy_theta(lib, rho1, phi1, eta1, x2, y2, theta2)
vector._compute.spatial.deltaR.rhophi_eta_xy_z(lib, rho1, phi1, eta1, x2, y2, z2)
```

```

vector._compute.spatial.deltaR.rhophi_theta_rhophi_eta(lib, rho1, phi1, theta1, rho2, phi2, eta2)
vector._compute.spatial.deltaR.rhophi_theta_rhophi_theta(lib, rho1, phi1, theta1, rho2, phi2, theta2)
vector._compute.spatial.deltaR.rhophi_theta_rhophi_z(lib, rho1, phi1, theta1, rho2, phi2, z2)
vector._compute.spatial.deltaR.rhophi_theta_xy_eta(lib, rho1, phi1, theta1, x2, y2, eta2)
vector._compute.spatial.deltaR.rhophi_theta_xy_theta(lib, rho1, phi1, theta1, x2, y2, theta2)
vector._compute.spatial.deltaR.rhophi_theta_xy_z(lib, rho1, phi1, theta1, x2, y2, z2)
vector._compute.spatial.deltaR.rhophi_z_rhophi_eta(lib, rho1, phi1, z1, rho2, phi2, eta2)
vector._compute.spatial.deltaR.rhophi_z_rhophi_theta(lib, rho1, phi1, z1, rho2, phi2, theta2)
vector._compute.spatial.deltaR.rhophi_z_rhophi_z(lib, rho1, phi1, z1, rho2, phi2, z2)
vector._compute.spatial.deltaR.rhophi_z_xy_eta(lib, rho1, phi1, z1, x2, y2, eta2)
vector._compute.spatial.deltaR.rhophi_z_xy_theta(lib, rho1, phi1, z1, x2, y2, theta2)
vector._compute.spatial.deltaR.rhophi_z_xy_z(lib, rho1, phi1, z1, x2, y2, z2)
vector._compute.spatial.deltaR.xy_eta_rhophi_eta(lib, x1, y1, eta1, rho2, phi2, eta2)
vector._compute.spatial.deltaR.xy_eta_rhophi_theta(lib, x1, y1, eta1, rho2, phi2, theta2)
vector._compute.spatial.deltaR.xy_eta_rhophi_z(lib, x1, y1, eta1, rho2, phi2, z2)
vector._compute.spatial.deltaR.xy_eta_xy_eta(lib, x1, y1, eta1, x2, y2, eta2)
vector._compute.spatial.deltaR.xy_eta_xy_theta(lib, x1, y1, eta1, x2, y2, theta2)
vector._compute.spatial.deltaR.xy_eta_xy_z(lib, x1, y1, eta1, x2, y2, z2)
vector._compute.spatial.deltaR.xy_theta_rhophi_eta(lib, x1, y1, theta1, rho2, phi2, eta2)
vector._compute.spatial.deltaR.xy_theta_rhophi_theta(lib, x1, y1, theta1, rho2, phi2, theta2)
vector._compute.spatial.deltaR.xy_theta_rhophi_z(lib, x1, y1, theta1, rho2, phi2, z2)
vector._compute.spatial.deltaR.xy_theta_xy_eta(lib, x1, y1, theta1, x2, y2, eta2)
vector._compute.spatial.deltaR.xy_theta_xy_theta(lib, x1, y1, theta1, x2, y2, theta2)
vector._compute.spatial.deltaR.xy_theta_xy_z(lib, x1, y1, theta1, x2, y2, z2)
vector._compute.spatial.deltaR.xy_z_rhophi_eta(lib, x1, y1, z1, rho2, phi2, eta2)
vector._compute.spatial.deltaR.xy_z_rhophi_theta(lib, x1, y1, z1, rho2, phi2, theta2)
vector._compute.spatial.deltaR.xy_z_rhophi_z(lib, x1, y1, z1, rho2, phi2, z2)
vector._compute.spatial.deltaR.xy_z_xy_eta(lib, x1, y1, z1, x2, y2, eta2)
vector._compute.spatial.deltaR.xy_z_xy_theta(lib, x1, y1, z1, x2, y2, theta2)
vector._compute.spatial.deltaR.xy_z_xy_z(lib, x1, y1, z1, x2, y2, z2)

```

**vector.\_compute.spatial.deltaR2 module**

```
Spatial.deltaR2(self, other)
```

```
vector._compute.spatial.deltaR2.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.spatial.deltaR2.rhophi_eta_rhophi_eta(lib, rho1, phi1, eta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.deltaR2.rhophi_eta_rhophi_theta(lib, rho1, phi1, eta1, rho2, phi2, theta2)
```

```
vector._compute.spatial.deltaR2.rhophi_eta_rhophi_z(lib, rho1, phi1, eta1, rho2, phi2, z2)
```

```
vector._compute.spatial.deltaR2.rhophi_eta_xy_eta(lib, rho1, phi1, eta1, x2, y2, eta2)
```

```
vector._compute.spatial.deltaR2.rhophi_eta_xy_theta(lib, rho1, phi1, eta1, x2, y2, theta2)
```

```
vector._compute.spatial.deltaR2.rhophi_eta_xy_z(lib, rho1, phi1, eta1, x2, y2, z2)
```

```
vector._compute.spatial.deltaR2.rhophi_theta_rhophi_eta(lib, rho1, phi1, theta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.deltaR2.rhophi_theta_rhophi_theta(lib, rho1, phi1, theta1, rho2, phi2,
                                                         theta2)
```

```
vector._compute.spatial.deltaR2.rhophi_theta_rhophi_z(lib, rho1, phi1, theta1, rho2, phi2, z2)
```

```
vector._compute.spatial.deltaR2.rhophi_theta_xy_eta(lib, rho1, phi1, theta1, x2, y2, eta2)
```

```
vector._compute.spatial.deltaR2.rhophi_theta_xy_theta(lib, rho1, phi1, theta1, x2, y2, theta2)
```

```
vector._compute.spatial.deltaR2.rhophi_theta_xy_z(lib, rho1, phi1, theta1, x2, y2, z2)
```

```
vector._compute.spatial.deltaR2.rhophi_z_rhophi_eta(lib, rho1, phi1, z1, rho2, phi2, eta2)
```

```
vector._compute.spatial.deltaR2.rhophi_z_rhophi_theta(lib, rho1, phi1, z1, rho2, phi2, theta2)
```

```
vector._compute.spatial.deltaR2.rhophi_z_rhophi_z(lib, rho1, phi1, z1, rho2, phi2, z2)
```

```
vector._compute.spatial.deltaR2.rhophi_z_xy_eta(lib, rho1, phi1, z1, x2, y2, eta2)
```

```
vector._compute.spatial.deltaR2.rhophi_z_xy_theta(lib, rho1, phi1, z1, x2, y2, theta2)
```

```
vector._compute.spatial.deltaR2.rhophi_z_xy_z(lib, rho1, phi1, z1, x2, y2, z2)
```

```
vector._compute.spatial.deltaR2.xy_eta_rhophi_eta(lib, x1, y1, eta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.deltaR2.xy_eta_rhophi_theta(lib, x1, y1, eta1, rho2, phi2, theta2)
```

```
vector._compute.spatial.deltaR2.xy_eta_rhophi_z(lib, x1, y1, eta1, rho2, phi2, z2)
```

```
vector._compute.spatial.deltaR2.xy_eta_xy_eta(lib, x1, y1, eta1, x2, y2, eta2)
```

```
vector._compute.spatial.deltaR2.xy_eta_xy_theta(lib, x1, y1, eta1, x2, y2, theta2)
```

```
vector._compute.spatial.deltaR2.xy_eta_xy_z(lib, x1, y1, eta1, x2, y2, z2)
```

```
vector._compute.spatial.deltaR2.xy_theta_rhophi_eta(lib, x1, y1, theta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.deltaR2.xy_theta_rhophi_theta(lib, x1, y1, theta1, rho2, phi2, theta2)
```

```

vector._compute.spatial.deltaR2.xy_theta_rho_phi_z(lib, x1, y1, theta1, rho2, phi2, z2)
vector._compute.spatial.deltaR2.xy_theta_xy_eta(lib, x1, y1, theta1, x2, y2, eta2)
vector._compute.spatial.deltaR2.xy_theta_xy_theta(lib, x1, y1, theta1, x2, y2, theta2)
vector._compute.spatial.deltaR2.xy_theta_xy_z(lib, x1, y1, theta1, x2, y2, z2)
vector._compute.spatial.deltaR2.xy_z_rho_phi_eta(lib, x1, y1, z1, rho2, phi2, eta2)
vector._compute.spatial.deltaR2.xy_z_rho_phi_theta(lib, x1, y1, z1, rho2, phi2, theta2)
vector._compute.spatial.deltaR2.xy_z_rho_phi_z(lib, x1, y1, z1, rho2, phi2, z2)
vector._compute.spatial.deltaR2.xy_z_xy_eta(lib, x1, y1, z1, x2, y2, eta2)
vector._compute.spatial.deltaR2.xy_z_xy_theta(lib, x1, y1, z1, x2, y2, theta2)
vector._compute.spatial.deltaR2.xy_z_xy_z(lib, x1, y1, z1, x2, y2, z2)

```

### vector.\_compute.spatial.dot module

```
Spatial.dot(self, other)
```

```

vector._compute.spatial.dot.dispatch(v1: Any, v2: Any) → Any
vector._compute.spatial.dot.rhopi_eta_rho_phi_eta(lib, rho1, phi1, eta1, rho2, phi2, eta2)
vector._compute.spatial.dot.rhopi_eta_rho_phi_theta(lib, rho1, phi1, eta1, rho2, phi2, theta2)
vector._compute.spatial.dot.rhopi_eta_rho_phi_z(lib, rho1, phi1, eta1, rho2, phi2, z2)
vector._compute.spatial.dot.rhopi_eta_xy_eta(lib, rho1, phi1, eta1, x2, y2, eta2)
vector._compute.spatial.dot.rhopi_eta_xy_theta(lib, rho1, phi1, eta1, x2, y2, theta2)
vector._compute.spatial.dot.rhopi_eta_xy_z(lib, rho1, phi1, eta1, x2, y2, z2)
vector._compute.spatial.dot.rhopi_theta_rho_phi_eta(lib, rho1, phi1, theta1, rho2, phi2, eta2)
vector._compute.spatial.dot.rhopi_theta_rho_phi_theta(lib, rho1, phi1, theta1, rho2, phi2, theta2)
vector._compute.spatial.dot.rhopi_theta_rho_phi_z(lib, rho1, phi1, theta1, rho2, phi2, z2)
vector._compute.spatial.dot.rhopi_theta_xy_eta(lib, rho1, phi1, theta1, x2, y2, eta2)
vector._compute.spatial.dot.rhopi_theta_xy_theta(lib, rho1, phi1, theta1, x2, y2, theta2)
vector._compute.spatial.dot.rhopi_theta_xy_z(lib, rho1, phi1, theta1, x2, y2, z2)
vector._compute.spatial.dot.rhopi_z_rho_phi_eta(lib, rho1, phi1, z1, rho2, phi2, eta2)
vector._compute.spatial.dot.rhopi_z_rho_phi_theta(lib, rho1, phi1, z1, rho2, phi2, theta2)
vector._compute.spatial.dot.rhopi_z_rho_phi_z(lib, rho1, phi1, z1, rho2, phi2, z2)
vector._compute.spatial.dot.rhopi_z_xy_eta(lib, rho1, phi1, z1, x2, y2, eta2)

```

```
vector._compute.spatial.dot.rhophi_z_xy_theta(lib, rho1, phi1, z1, x2, y2, theta2)
vector._compute.spatial.dot.rhophi_z_xy_z(lib, rho1, phi1, z1, x2, y2, z2)
vector._compute.spatial.dot.xy_eta_rhophi_eta(lib, x1, y1, eta1, rho2, phi2, eta2)
vector._compute.spatial.dot.xy_eta_rhophi_theta(lib, x1, y1, eta1, rho2, phi2, theta2)
vector._compute.spatial.dot.xy_eta_rhophi_z(lib, x1, y1, eta1, rho2, phi2, z2)
vector._compute.spatial.dot.xy_eta_xy_eta(lib, x1, y1, eta1, x2, y2, eta2)
vector._compute.spatial.dot.xy_eta_xy_theta(lib, x1, y1, eta1, x2, y2, theta2)
vector._compute.spatial.dot.xy_eta_xy_z(lib, x1, y1, eta1, x2, y2, z2)
vector._compute.spatial.dot.xy_theta_rhophi_eta(lib, x1, y1, theta1, rho2, phi2, eta2)
vector._compute.spatial.dot.xy_theta_rhophi_theta(lib, x1, y1, theta1, rho2, phi2, theta2)
vector._compute.spatial.dot.xy_theta_rhophi_z(lib, x1, y1, theta1, rho2, phi2, z2)
vector._compute.spatial.dot.xy_theta_xy_eta(lib, x1, y1, theta1, x2, y2, eta2)
vector._compute.spatial.dot.xy_theta_xy_theta(lib, x1, y1, theta1, x2, y2, theta2)
vector._compute.spatial.dot.xy_theta_xy_z(lib, x1, y1, theta1, x2, y2, z2)
vector._compute.spatial.dot.xy_z_rhophi_eta(lib, x1, y1, z1, rho2, phi2, eta2)
vector._compute.spatial.dot.xy_z_rhophi_theta(lib, x1, y1, z1, rho2, phi2, theta2)
vector._compute.spatial.dot.xy_z_rhophi_z(lib, x1, y1, z1, rho2, phi2, z2)
vector._compute.spatial.dot.xy_z_xy_eta(lib, x1, y1, z1, x2, y2, eta2)
vector._compute.spatial.dot.xy_z_xy_theta(lib, x1, y1, z1, x2, y2, theta2)
vector._compute.spatial.dot.xy_z_xy_z(lib, x1, y1, z1, x2, y2, z2)
```

### **vector.\_compute.spatial.equal module**

```
Spatial.equal(self, other)
```

```
vector._compute.spatial.equal.dispatch(v1: Any, v2: Any) → Any
vector._compute.spatial.equal.rhophi_eta_rhophi_eta(lib, rho1, phi1, eta1, rho2, phi2, eta2)
vector._compute.spatial.equal.rhophi_eta_rhophi_theta(lib, rho1, phi1, eta1, rho2, phi2, theta2)
vector._compute.spatial.equal.rhophi_eta_rhophi_z(lib, rho1, phi1, eta1, rho2, phi2, z2)
vector._compute.spatial.equal.rhophi_eta_xy_eta(lib, rho1, phi1, eta1, x2, y2, eta2)
vector._compute.spatial.equal.rhophi_eta_xy_theta(lib, rho1, phi1, eta1, x2, y2, theta2)
vector._compute.spatial.equal.rhophi_eta_xy_z(lib, rho1, phi1, eta1, x2, y2, z2)
```

```

vector._compute.spatial.equal.rhophi_theta_rhophi_eta(lib, rho1, phi1, theta1, rho2, phi2, eta2)
vector._compute.spatial.equal.rhophi_theta_rhophi_theta(lib, rho1, phi1, theta1, rho2, phi2, theta2)
vector._compute.spatial.equal.rhophi_theta_rhophi_z(lib, rho1, phi1, theta1, rho2, phi2, z2)
vector._compute.spatial.equal.rhophi_theta_xy_eta(lib, rho1, phi1, theta1, x2, y2, eta2)
vector._compute.spatial.equal.rhophi_theta_xy_theta(lib, rho1, phi1, theta1, x2, y2, theta2)
vector._compute.spatial.equal.rhophi_theta_xy_z(lib, rho1, phi1, theta1, x2, y2, z2)
vector._compute.spatial.equal.rhophi_z_rhophi_eta(lib, rho1, phi1, z1, rho2, phi2, eta2)
vector._compute.spatial.equal.rhophi_z_rhophi_theta(lib, rho1, phi1, z1, rho2, phi2, theta2)
vector._compute.spatial.equal.rhophi_z_rhophi_z(lib, rho1, phi1, z1, rho2, phi2, z2)
vector._compute.spatial.equal.rhophi_z_xy_eta(lib, rho1, phi1, z1, x2, y2, eta2)
vector._compute.spatial.equal.rhophi_z_xy_theta(lib, rho1, phi1, z1, x2, y2, theta2)
vector._compute.spatial.equal.rhophi_z_xy_z(lib, rho1, phi1, z1, x2, y2, z2)
vector._compute.spatial.equal.xy_eta_rhophi_eta(lib, x1, y1, eta1, rho2, phi2, eta2)
vector._compute.spatial.equal.xy_eta_rhophi_theta(lib, x1, y1, eta1, rho2, phi2, theta2)
vector._compute.spatial.equal.xy_eta_rhophi_z(lib, x1, y1, eta1, rho2, phi2, z2)
vector._compute.spatial.equal.xy_eta_xy_eta(lib, x1, y1, eta1, x2, y2, eta2)
vector._compute.spatial.equal.xy_eta_xy_theta(lib, x1, y1, eta1, x2, y2, theta2)
vector._compute.spatial.equal.xy_eta_xy_z(lib, x1, y1, eta1, x2, y2, z2)
vector._compute.spatial.equal.xy_theta_rhophi_eta(lib, x1, y1, theta1, rho2, phi2, eta2)
vector._compute.spatial.equal.xy_theta_rhophi_theta(lib, x1, y1, theta1, rho2, phi2, theta2)
vector._compute.spatial.equal.xy_theta_rhophi_z(lib, x1, y1, theta1, rho2, phi2, z2)
vector._compute.spatial.equal.xy_theta_xy_eta(lib, x1, y1, theta1, x2, y2, eta2)
vector._compute.spatial.equal.xy_theta_xy_theta(lib, x1, y1, theta1, x2, y2, theta2)
vector._compute.spatial.equal.xy_theta_xy_z(lib, x1, y1, theta1, x2, y2, z2)
vector._compute.spatial.equal.xy_z_rhophi_eta(lib, x1, y1, z1, rho2, phi2, eta2)
vector._compute.spatial.equal.xy_z_rhophi_theta(lib, x1, y1, z1, rho2, phi2, theta2)
vector._compute.spatial.equal.xy_z_rhophi_z(lib, x1, y1, z1, rho2, phi2, z2)
vector._compute.spatial.equal.xy_z_xy_eta(lib, x1, y1, z1, x2, y2, eta2)
vector._compute.spatial.equal.xy_z_xy_theta(lib, x1, y1, z1, x2, y2, theta2)
vector._compute.spatial.equal.xy_z_xy_z(lib, x1, y1, z1, x2, y2, z2)

```

### vector.\_compute.spatial.eta module

```
@property  
Spatial.eta(self)
```

```
vector._compute.spatial.eta.dispatch(v: Any) → Any  
vector._compute.spatial.eta.rhophi_eta(lib, rho, phi, eta)  
vector._compute.spatial.eta.rhophi_theta(lib, rho, phi, theta)  
vector._compute.spatial.eta.rhophi_z(lib, rho, phi, z)  
vector._compute.spatial.eta.xy_eta(lib, x, y, eta)  
vector._compute.spatial.eta.xy_theta(lib, x, y, theta)  
vector._compute.spatial.eta.xy_z(lib, x, y, z)
```

### vector.\_compute.spatial.is\_antiparallel module

```
Spatial.is_antiparallel(self, other, tolerance=...)
```

```
vector._compute.spatial.is_antiparallel.dispatch(tolerance: Any, v1: Any, v2: Any) → Any  
vector._compute.spatial.is_antiparallel.make_function(azimuthal1, longitudinal1, azimuthal2,  
                                                    longitudinal2)
```

### vector.\_compute.spatial.is\_parallel module

```
Spatial.is_parallel(self, other, tolerance=...)
```

```
vector._compute.spatial.is_parallel.dispatch(tolerance: Any, v1: Any, v2: Any) → Any  
vector._compute.spatial.is_parallel.make_function(azimuthal1, longitudinal1, azimuthal2,  
                                                    longitudinal2)
```

### vector.\_compute.spatial.is\_perpendicular module

```
Spatial.is_perpendicular(self, other, tolerance=...)
```

```
vector._compute.spatial.is_perpendicular.dispatch(tolerance: Any, v1: Any, v2: Any) → Any  
vector._compute.spatial.is_perpendicular.make_function(azimuthal1, longitudinal1, azimuthal2,  
                                                    longitudinal2)
```



**vector.\_compute.spatial.isclose module**

```
Spatial.isclose(self, other, rtol=..., atol=..., equal_nan=...)
```

```
vector._compute.spatial.isclose.dispatch(rtol: Any, atol: Any, equal_nan: Any, v1: Any, v2: Any) → Any
```

```
vector._compute.spatial.isclose.rhophi_eta_rhophi_eta(lib, rtol, atol, equal_nan, rho1, phi1, eta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.isclose.rhophi_eta_rhophi_theta(lib, rtol, atol, equal_nan, rho1, phi1, eta1, rho2, phi2, theta2)
```

```
vector._compute.spatial.isclose.rhophi_eta_rhophi_z(lib, rtol, atol, equal_nan, rho1, phi1, eta1, rho2, phi2, z2)
```

```
vector._compute.spatial.isclose.rhophi_eta_xy_eta(lib, rtol, atol, equal_nan, rho1, phi1, eta1, x2, y2, eta2)
```

```
vector._compute.spatial.isclose.rhophi_eta_xy_theta(lib, rtol, atol, equal_nan, rho1, phi1, eta1, x2, y2, theta2)
```

```
vector._compute.spatial.isclose.rhophi_eta_xy_z(lib, rtol, atol, equal_nan, rho1, phi1, eta1, x2, y2, z2)
```

```
vector._compute.spatial.isclose.rhophi_theta_rhophi_eta(lib, rtol, atol, equal_nan, rho1, phi1, theta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.isclose.rhophi_theta_rhophi_theta(lib, rtol, atol, equal_nan, rho1, phi1, theta1, rho2, phi2, theta2)
```

```
vector._compute.spatial.isclose.rhophi_theta_rhophi_z(lib, rtol, atol, equal_nan, rho1, phi1, theta1, rho2, phi2, z2)
```

```
vector._compute.spatial.isclose.rhophi_theta_xy_eta(lib, rtol, atol, equal_nan, rho1, phi1, theta1, x2, y2, eta2)
```

```
vector._compute.spatial.isclose.rhophi_theta_xy_theta(lib, rtol, atol, equal_nan, rho1, phi1, theta1, x2, y2, theta2)
```

```
vector._compute.spatial.isclose.rhophi_theta_xy_z(lib, rtol, atol, equal_nan, rho1, phi1, theta1, x2, y2, z2)
```

```
vector._compute.spatial.isclose.rhophi_z_rhophi_eta(lib, rtol, atol, equal_nan, rho1, phi1, z1, rho2, phi2, eta2)
```

```
vector._compute.spatial.isclose.rhophi_z_rhophi_theta(lib, rtol, atol, equal_nan, rho1, phi1, z1, rho2, phi2, theta2)
```

```
vector._compute.spatial.isclose.rhophi_z_rhophi_z(lib, rtol, atol, equal_nan, rho1, phi1, z1, rho2, phi2, z2)
```

```
vector._compute.spatial.isclose.rhophi_z_xy_eta(lib, rtol, atol, equal_nan, rho1, phi1, z1, x2, y2, eta2)
```

```
vector._compute.spatial.isclose.rhophi_z_xy_theta(lib, rtol, atol, equal_nan, rho1, phi1, z1, x2, y2, theta2)
```

```
vector._compute.spatial.isclose.rhophi_z_xy_z(lib, rtol, atol, equal_nan, rho1, phi1, z1, x2, y2, z2)
vector._compute.spatial.isclose.xy_eta_rhophi_eta(lib, rtol, atol, equal_nan, x1, y1, eta1, rho2, phi2,
                                                    eta2)
vector._compute.spatial.isclose.xy_eta_rhophi_theta(lib, rtol, atol, equal_nan, x1, y1, eta1, rho2,
                                                    phi2, theta2)
vector._compute.spatial.isclose.xy_eta_rhophi_z(lib, rtol, atol, equal_nan, x1, y1, eta1, rho2, phi2, z2)
vector._compute.spatial.isclose.xy_eta_xy_eta(lib, rtol, atol, equal_nan, x1, y1, eta1, x2, y2, eta2)
vector._compute.spatial.isclose.xy_eta_xy_theta(lib, rtol, atol, equal_nan, x1, y1, eta1, x2, y2, theta2)
vector._compute.spatial.isclose.xy_eta_xy_z(lib, rtol, atol, equal_nan, x1, y1, eta1, x2, y2, z2)
vector._compute.spatial.isclose.xy_theta_rhophi_eta(lib, rtol, atol, equal_nan, x1, y1, theta1, rho2,
                                                    phi2, eta2)
vector._compute.spatial.isclose.xy_theta_rhophi_theta(lib, rtol, atol, equal_nan, x1, y1, theta1, rho2,
                                                    phi2, theta2)
vector._compute.spatial.isclose.xy_theta_rhophi_z(lib, rtol, atol, equal_nan, x1, y1, theta1, rho2, phi2,
                                                    z2)
vector._compute.spatial.isclose.xy_theta_xy_eta(lib, rtol, atol, equal_nan, x1, y1, theta1, x2, y2, eta2)
vector._compute.spatial.isclose.xy_theta_xy_theta(lib, rtol, atol, equal_nan, x1, y1, theta1, x2, y2,
                                                    theta2)
vector._compute.spatial.isclose.xy_theta_xy_z(lib, rtol, atol, equal_nan, x1, y1, theta1, x2, y2, z2)
vector._compute.spatial.isclose.xy_z_rhophi_eta(lib, rtol, atol, equal_nan, x1, y1, z1, rho2, phi2, eta2)
vector._compute.spatial.isclose.xy_z_rhophi_theta(lib, rtol, atol, equal_nan, x1, y1, z1, rho2, phi2,
                                                    theta2)
vector._compute.spatial.isclose.xy_z_rhophi_z(lib, rtol, atol, equal_nan, x1, y1, z1, rho2, phi2, z2)
vector._compute.spatial.isclose.xy_z_xy_eta(lib, rtol, atol, equal_nan, x1, y1, z1, x2, y2, eta2)
vector._compute.spatial.isclose.xy_z_xy_theta(lib, rtol, atol, equal_nan, x1, y1, z1, x2, y2, theta2)
vector._compute.spatial.isclose.xy_z_xy_z(lib, rtol, atol, equal_nan, x1, y1, z1, x2, y2, z2)
```

**vector.\_compute.spatial.mag module**

```
@property
Spatial.mag(self)
```

```
vector._compute.spatial.mag.dispatch(v: Any) → Any
vector._compute.spatial.mag.rhophi_eta(lib, rho, phi, eta)
vector._compute.spatial.mag.rhophi_theta(lib, rho, phi, theta)
```

```
vector._compute.spatial.mag.rhophi_z(lib, rho, phi, z)
```

```
vector._compute.spatial.mag.xy_eta(lib, x, y, eta)
```

```
vector._compute.spatial.mag.xy_theta(lib, x, y, theta)
```

```
vector._compute.spatial.mag.xy_z(lib, x, y, z)
```

### vector.\_compute.spatial.mag2 module

```
@property
Spatial.mag2(self)
```

```
vector._compute.spatial.mag2.dispatch(v: Any) → Any
```

```
vector._compute.spatial.mag2.rhophi_eta(lib, rho, phi, eta)
```

```
vector._compute.spatial.mag2.rhophi_theta(lib, rho, phi, theta)
```

```
vector._compute.spatial.mag2.rhophi_z(lib, rho, phi, z)
```

```
vector._compute.spatial.mag2.xy_eta(lib, x, y, eta)
```

```
vector._compute.spatial.mag2.xy_theta(lib, x, y, theta)
```

```
vector._compute.spatial.mag2.xy_z(lib, x, y, z)
```

### vector.\_compute.spatial.not\_equal module

```
Spatial.not_equal(self, other)
```

```
vector._compute.spatial.not_equal.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.spatial.not_equal.rhophi_eta_rhophi_eta(lib, rho1, phi1, eta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.not_equal.rhophi_eta_rhophi_theta(lib, rho1, phi1, eta1, rho2, phi2, theta2)
```

```
vector._compute.spatial.not_equal.rhophi_eta_rhophi_z(lib, rho1, phi1, eta1, rho2, phi2, z2)
```

```
vector._compute.spatial.not_equal.rhophi_eta_xy_eta(lib, rho1, phi1, eta1, x2, y2, eta2)
```

```
vector._compute.spatial.not_equal.rhophi_eta_xy_theta(lib, rho1, phi1, eta1, x2, y2, theta2)
```

```
vector._compute.spatial.not_equal.rhophi_eta_xy_z(lib, rho1, phi1, eta1, x2, y2, z2)
```

```
vector._compute.spatial.not_equal.rhophi_theta_rhophi_eta(lib, rho1, phi1, theta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.not_equal.rhophi_theta_rhophi_theta(lib, rho1, phi1, theta1, rho2, phi2,
                                                             theta2)
```

```
vector._compute.spatial.not_equal.rhophi_theta_rhophi_z(lib, rho1, phi1, theta1, rho2, phi2, z2)
```

```
vector._compute.spatial.not_equal.rhophi_theta_xy_eta(lib, rho1, phi1, theta1, x2, y2, eta2)
```

```
vector._compute.spatial.not_equal.rhophi_theta_xy_theta(lib, rho1, phi1, theta1, x2, y2, theta2)
```

```
vector._compute.spatial.not_equal.rhophi_theta_xy_z(lib, rho1, phi1, theta1, x2, y2, z2)
vector._compute.spatial.not_equal.rhophi_z_rhophi_eta(lib, rho1, phi1, z1, rho2, phi2, eta2)
vector._compute.spatial.not_equal.rhophi_z_rhophi_theta(lib, rho1, phi1, z1, rho2, phi2, theta2)
vector._compute.spatial.not_equal.rhophi_z_rhophi_z(lib, rho1, phi1, z1, rho2, phi2, z2)
vector._compute.spatial.not_equal.rhophi_z_xy_eta(lib, rho1, phi1, z1, x2, y2, eta2)
vector._compute.spatial.not_equal.rhophi_z_xy_theta(lib, rho1, phi1, z1, x2, y2, theta2)
vector._compute.spatial.not_equal.rhophi_z_xy_z(lib, rho1, phi1, z1, x2, y2, z2)
vector._compute.spatial.not_equal.xy_eta_rhophi_eta(lib, x1, y1, eta1, rho2, phi2, eta2)
vector._compute.spatial.not_equal.xy_eta_rhophi_theta(lib, x1, y1, eta1, rho2, phi2, theta2)
vector._compute.spatial.not_equal.xy_eta_rhophi_z(lib, x1, y1, eta1, rho2, phi2, z2)
vector._compute.spatial.not_equal.xy_eta_xy_eta(lib, x1, y1, eta1, x2, y2, eta2)
vector._compute.spatial.not_equal.xy_eta_xy_theta(lib, x1, y1, eta1, x2, y2, theta2)
vector._compute.spatial.not_equal.xy_eta_xy_z(lib, x1, y1, eta1, x2, y2, z2)
vector._compute.spatial.not_equal.xy_theta_rhophi_eta(lib, x1, y1, theta1, rho2, phi2, eta2)
vector._compute.spatial.not_equal.xy_theta_rhophi_theta(lib, x1, y1, theta1, rho2, phi2, theta2)
vector._compute.spatial.not_equal.xy_theta_rhophi_z(lib, x1, y1, theta1, rho2, phi2, z2)
vector._compute.spatial.not_equal.xy_theta_xy_eta(lib, x1, y1, theta1, x2, y2, eta2)
vector._compute.spatial.not_equal.xy_theta_xy_theta(lib, x1, y1, theta1, x2, y2, theta2)
vector._compute.spatial.not_equal.xy_theta_xy_z(lib, x1, y1, theta1, x2, y2, z2)
vector._compute.spatial.not_equal.xy_z_rhophi_eta(lib, x1, y1, z1, rho2, phi2, eta2)
vector._compute.spatial.not_equal.xy_z_rhophi_theta(lib, x1, y1, z1, rho2, phi2, theta2)
vector._compute.spatial.not_equal.xy_z_rhophi_z(lib, x1, y1, z1, rho2, phi2, z2)
vector._compute.spatial.not_equal.xy_z_xy_eta(lib, x1, y1, z1, x2, y2, eta2)
vector._compute.spatial.not_equal.xy_z_xy_theta(lib, x1, y1, z1, x2, y2, theta2)
vector._compute.spatial.not_equal.xy_z_xy_z(lib, x1, y1, z1, x2, y2, z2)
```

### **vector.\_compute.spatial.rotate\_axis module**

```
Spatial.rotate_axis(self, axis, angle)
```

```
vector._compute.spatial.rotate_axis.cartesian(lib, angle, x1, y1, z1, x2, y2, z2)
vector._compute.spatial.rotate_axis.dispatch(angle: Any, v1: Any, v2: Any) → Any
vector._compute.spatial.rotate_axis.make_conversion(azimuthal1, longitudinal1, azimuthal2,
                                                    longitudinal2)
```

**vector.\_compute.spatial.rotate\_euler module**

```
Spatial.rotate_euler(self, phi, theta, psi, order=...)
```

```
vector._compute.spatial.rotate_euler.cartesian_xyx(lib, phi, theta, psi, x, y, z)
```

```
vector._compute.spatial.rotate_euler.cartesian_xyz(lib, phi, theta, psi, x, y, z)
```

```
vector._compute.spatial.rotate_euler.cartesian_zxx(lib, phi, theta, psi, x, y, z)
```

```
vector._compute.spatial.rotate_euler.cartesian_xzy(lib, phi, theta, psi, x, y, z)
```

```
vector._compute.spatial.rotate_euler.cartesian_yxy(lib, phi, theta, psi, x, y, z)
```

```
vector._compute.spatial.rotate_euler.cartesian_yxz(lib, phi, theta, psi, x, y, z)
```

```
vector._compute.spatial.rotate_euler.cartesian_yzx(lib, phi, theta, psi, x, y, z)
```

```
vector._compute.spatial.rotate_euler.cartesian_zyy(lib, phi, theta, psi, x, y, z)
```

```
vector._compute.spatial.rotate_euler.cartesian_zxy(lib, phi, theta, psi, x, y, z)
```

```
vector._compute.spatial.rotate_euler.cartesian_zxz(lib, phi, theta, psi, x, y, z)
```

```
vector._compute.spatial.rotate_euler.cartesian_zyx(lib, phi, theta, psi, x, y, z)
```

```
vector._compute.spatial.rotate_euler.cartesian_zyz(lib, phi, theta, psi, x, y, z)
```

```
vector._compute.spatial.rotate_euler.dispatch(phi: Any, theta: Any, psi: Any, order: Any, v: Any) → Any
```

```
vector._compute.spatial.rotate_euler.make_conversion(azimuthal, longitudinal, order)
```

**vector.\_compute.spatial.rotate\_quaternion module**

```
Spatial.rotate_quaternion(self, u, i, j, k)
```

```
vector._compute.spatial.rotate_quaternion.cartesian(lib, u, i, j, k, x, y, z)
```

```
vector._compute.spatial.rotate_quaternion.dispatch(u: Any, i: Any, j: Any, k: Any, vec: Any) → Any
```

```
vector._compute.spatial.rotate_quaternion.make_conversion(azimuthal, longitudinal)
```

**vector.\_compute.spatial.rotateX module**

```
Spatial.rotateX(self, angle)
```

```
vector._compute.spatial.rotateX.dispatch(angle: Any, v: Any) → Any
```

```
vector._compute.spatial.rotateX.rhophi_eta(lib, angle, rho, phi, eta)
```

```
vector._compute.spatial.rotateX.rhophi_theta(lib, angle, rho, phi, theta)
```

```
vector._compute.spatial.rotateX.rhophi_z(lib, angle, rho, phi, z)
```

```
vector._compute.spatial.rotateX.xy_eta(lib, angle, x, y, eta)
```

```
vector._compute.spatial.rotateX.xy_theta(lib, angle, x, y, theta)
```

```
vector._compute.spatial.rotateX.xy_z(lib, angle, x, y, z)
```

### **vector.\_compute.spatial.rotateY module**

```
Spatial.rotateY(self, angle)
```

```
vector._compute.spatial.rotateY.dispatch(angle: Any, v: Any) → Any
```

```
vector._compute.spatial.rotateY.rhophi_eta(lib, angle, rho, phi, eta)
```

```
vector._compute.spatial.rotateY.rhophi_theta(lib, angle, rho, phi, theta)
```

```
vector._compute.spatial.rotateY.rhophi_z(lib, angle, rho, phi, z)
```

```
vector._compute.spatial.rotateY.xy_eta(lib, angle, x, y, eta)
```

```
vector._compute.spatial.rotateY.xy_theta(lib, angle, x, y, theta)
```

```
vector._compute.spatial.rotateY.xy_z(lib, angle, x, y, z)
```

### **vector.\_compute.spatial.scale module**

```
Spatial.scale(self, factor)
```

```
vector._compute.spatial.scale.dispatch(factor: Any, v: Any) → Any
```

```
vector._compute.spatial.scale.rectify(lib, phi)
```

```
vector._compute.spatial.scale.rhophi_eta(lib, factor, rho, phi, eta)
```

```
vector._compute.spatial.scale.rhophi_theta(lib, factor, rho, phi, theta)
```

```
vector._compute.spatial.scale.rhophi_z(lib, factor, rho, phi, z)
```

```
vector._compute.spatial.scale.xy_eta(lib, factor, x, y, eta)
```

```
vector._compute.spatial.scale.xy_theta(lib, factor, x, y, theta)
```

```
vector._compute.spatial.scale.xy_z(lib, factor, x, y, z)
```

### **vector.\_compute.spatial.subtract module**

```
Spatial.subtract(self, angle)
```

```
vector._compute.spatial.subtract.dispatch(v1: Any, v2: Any) → Any
```

```
vector._compute.spatial.subtract.rhophi_eta_rhophi_eta(lib, rho1, phi1, eta1, rho2, phi2, eta2)
```

```
vector._compute.spatial.subtract.rhophi_eta_rhophi_theta(lib, rho1, phi1, eta1, rho2, phi2, theta2)
```

```

vector._compute.spatial.subtract.rhophi_eta_rhophi_z(lib, rho1, phi1, eta1, rho2, phi2, z2)
vector._compute.spatial.subtract.rhophi_eta_xy_eta(lib, rho1, phi1, eta1, x2, y2, eta2)
vector._compute.spatial.subtract.rhophi_eta_xy_theta(lib, rho1, phi1, eta1, x2, y2, theta2)
vector._compute.spatial.subtract.rhophi_eta_xy_z(lib, rho1, phi1, eta1, x2, y2, z2)
vector._compute.spatial.subtract.rhophi_theta_rhophi_eta(lib, rho1, phi1, theta1, rho2, phi2, eta2)
vector._compute.spatial.subtract.rhophi_theta_rhophi_theta(lib, rho1, phi1, theta1, rho2, phi2,
    theta2)
vector._compute.spatial.subtract.rhophi_theta_rhophi_z(lib, rho1, phi1, theta1, rho2, phi2, z2)
vector._compute.spatial.subtract.rhophi_theta_xy_eta(lib, rho1, phi1, theta1, x2, y2, eta2)
vector._compute.spatial.subtract.rhophi_theta_xy_theta(lib, rho1, phi1, theta1, x2, y2, theta2)
vector._compute.spatial.subtract.rhophi_theta_xy_z(lib, rho1, phi1, theta1, x2, y2, z2)
vector._compute.spatial.subtract.rhophi_z_rhophi_eta(lib, rho1, phi1, z1, rho2, phi2, eta2)
vector._compute.spatial.subtract.rhophi_z_rhophi_theta(lib, rho1, phi1, z1, rho2, phi2, theta2)
vector._compute.spatial.subtract.rhophi_z_rhophi_z(lib, rho1, phi1, z1, rho2, phi2, z2)
vector._compute.spatial.subtract.rhophi_z_xy_eta(lib, rho1, phi1, z1, x2, y2, eta2)
vector._compute.spatial.subtract.rhophi_z_xy_theta(lib, rho1, phi1, z1, x2, y2, theta2)
vector._compute.spatial.subtract.rhophi_z_xy_z(lib, rho1, phi1, z1, x2, y2, z2)
vector._compute.spatial.subtract.xy_eta_rhophi_eta(lib, x1, y1, eta1, rho2, phi2, eta2)
vector._compute.spatial.subtract.xy_eta_rhophi_theta(lib, x1, y1, eta1, rho2, phi2, theta2)
vector._compute.spatial.subtract.xy_eta_rhophi_z(lib, x1, y1, eta1, rho2, phi2, z2)
vector._compute.spatial.subtract.xy_eta_xy_eta(lib, x1, y1, eta1, x2, y2, eta2)
vector._compute.spatial.subtract.xy_eta_xy_theta(lib, x1, y1, eta1, x2, y2, theta2)
vector._compute.spatial.subtract.xy_eta_xy_z(lib, x1, y1, eta1, x2, y2, z2)
vector._compute.spatial.subtract.xy_theta_rhophi_eta(lib, x1, y1, theta1, rho2, phi2, eta2)
vector._compute.spatial.subtract.xy_theta_rhophi_theta(lib, x1, y1, theta1, rho2, phi2, theta2)
vector._compute.spatial.subtract.xy_theta_rhophi_z(lib, x1, y1, theta1, rho2, phi2, z2)
vector._compute.spatial.subtract.xy_theta_xy_eta(lib, x1, y1, theta1, x2, y2, eta2)
vector._compute.spatial.subtract.xy_theta_xy_theta(lib, x1, y1, theta1, x2, y2, theta2)
vector._compute.spatial.subtract.xy_theta_xy_z(lib, x1, y1, theta1, x2, y2, z2)
vector._compute.spatial.subtract.xy_z_rhophi_eta(lib, x1, y1, z1, rho2, phi2, eta2)
vector._compute.spatial.subtract.xy_z_rhophi_theta(lib, x1, y1, z1, rho2, phi2, theta2)

```

```
vector._compute.spatial.subtract.xy_z_rhophi_z(lib, x1, y1, z1, rho2, phi2, z2)
```

```
vector._compute.spatial.subtract.xy_z_xy_eta(lib, x1, y1, z1, x2, y2, eta2)
```

```
vector._compute.spatial.subtract.xy_z_xy_theta(lib, x1, y1, z1, x2, y2, theta2)
```

```
vector._compute.spatial.subtract.xy_z_xy_z(lib, x1, y1, z1, x2, y2, z2)
```

### **vector.\_compute.spatial.theta** module

```
@property  
Spatial.theta(self)
```

```
vector._compute.spatial.theta.dispatch(v: Any) → Any
```

```
vector._compute.spatial.theta.rhophi_eta(lib, rho, phi, eta)
```

```
vector._compute.spatial.theta.rhophi_theta(lib, rho, phi, theta)
```

```
vector._compute.spatial.theta.rhophi_z(lib, rho, phi, z)
```

```
vector._compute.spatial.theta.xy_eta(lib, x, y, eta)
```

```
vector._compute.spatial.theta.xy_theta(lib, x, y, theta)
```

```
vector._compute.spatial.theta.xy_z(lib, x, y, z)
```

### **vector.\_compute.spatial.transform3D** module

```
Spatial.transform3D(self, obj)
```

where obj` has ``obj["xx"], obj["xy"], etc.

```
vector._compute.spatial.transform3D.cartesian(lib, xx, xy, xz, yx, yy, yz, zx, zy, zz, x, y, z)
```

```
vector._compute.spatial.transform3D.dispatch(obj: Any, v: Any) → Any
```

```
vector._compute.spatial.transform3D.rhophi_eta(lib, xx, xy, xz, yx, yy, yz, zx, zy, zz, rho, phi, eta)
```

```
vector._compute.spatial.transform3D.rhophi_theta(lib, xx, xy, xz, yx, yy, yz, zx, zy, zz, rho, phi, theta)
```

```
vector._compute.spatial.transform3D.rhophi_z(lib, xx, xy, xz, yx, yy, yz, zx, zy, zz, rho, phi, z)
```

```
vector._compute.spatial.transform3D.xy_eta(lib, xx, xy, xz, yx, yy, yz, zx, zy, zz, x, y, eta)
```

```
vector._compute.spatial.transform3D.xy_theta(lib, xx, xy, xz, yx, yy, yz, zx, zy, zz, x, y, theta)
```



**vector.\_compute.spatial.unit module**

```
Spatial.unit(self)
```

```
vector._compute.spatial.unit.dispatch(v: Any) → Any
```

```
vector._compute.spatial.unit.rhophi_eta(lib, rho, phi, eta)
```

```
vector._compute.spatial.unit.rhophi_theta(lib, rho, phi, theta)
```

```
vector._compute.spatial.unit.rhophi_z(lib, rho, phi, z)
```

```
vector._compute.spatial.unit.xy_eta(lib, x, y, eta)
```

```
vector._compute.spatial.unit.xy_theta(lib, x, y, theta)
```

```
vector._compute.spatial.unit.xy_z(lib, x, y, z)
```

**vector.\_compute.spatial.z module**

```
@property
Spatial.z(self)
```

```
vector._compute.spatial.z.dispatch(v: Any) → Any
```

```
vector._compute.spatial.z.rhophi_eta(lib, rho, phi, eta)
```

```
vector._compute.spatial.z.rhophi_theta(lib, rho, phi, theta)
```

```
vector._compute.spatial.z.rhophi_z(lib, rho, phi, z)
```

```
vector._compute.spatial.z.xy_eta(lib, x, y, eta)
```

```
vector._compute.spatial.z.xy_theta(lib, x, y, theta)
```

```
vector._compute.spatial.z.xy_z(lib, x, y, z)
```

**Submodules****vector.\_methods module**

```
class vector._methods.Azimuthal
```

Bases: *Coordinates*

```
property elements: tuple[Any, Any]
```

Azimuthal coordinates as a tuple.

Each coordinate may be a scalar, a NumPy array, an Awkward Array, etc., but they are not vectors.

```
class vector._methods.AzimuthalRhoPhi
```

Bases: *Azimuthal*

**rho**The  $\rho$  coordinate(s).**Type**scalar, `np.ndarray`, `ak.Array`, etc.**phi**The  $\phi$  coordinate(s).**Type**scalar, `np.ndarray`, `ak.Array`, etc.**phi: Any****rho: Any****class** `vector._methods.AzimuthalXY`Bases: [\*Azimuthal\*](#)**x**The  $x$  coordinate(s).**Type**scalar, `np.ndarray`, `ak.Array`, etc.**y**The  $y$  coordinate(s).**Type**scalar, `np.ndarray`, `ak.Array`, etc.**x: Any****y: Any****class** `vector._methods.Coordinates`Bases: `object`**class** `vector._methods.Longitudinal`Bases: [\*Coordinates\*](#)**property** `elements: tuple[Any]`

Longitudinal coordinates as a tuple.

Each coordinate may be a scalar, a NumPy array, an Awkward Array, etc., but they are not vectors.

**class** `vector._methods.LongitudinalEta`Bases: [\*Longitudinal\*](#)**eta**The  $\eta$  coordinate(s).**Type**scalar, `np.ndarray`, `ak.Array`, etc.**eta: Any****class** `vector._methods.LongitudinalTheta`Bases: [\*Longitudinal\*](#)

**theta**

The  $\theta$  coordinate(s).

**Type**

scalar, `np.ndarray`, `ak.Array`, etc.

**theta:** Any

**class** `vector._methods.LongitudinalZ`

Bases: *Longitudinal*

**z**

The  $z$  coordinate(s).

**Type**

scalar, `np.ndarray`, `ak.Array`, etc.

**z:** Any

**class** `vector._methods.Lorentz`

Bases: *Spatial*, *VectorProtocolLorentz*

**add**(*other*: *VectorProtocol*)  $\rightarrow$  *VectorProtocol*

Sum of `self` and `other`.

This method is equivalent to the `+` operator.

**property beta:** Any

The speed(s) of the Lorentz vector or array of vectors, in which lightlike vectors have `beta == 1`.

**boost**(*booster*: *VectorProtocolSpatial* | *VectorProtocolLorentz*)  $\rightarrow$  SameVectorType

Boosts the vector or array of vectors using the 3D or 4D booster.

If `booster` is 3D, it is interpreted as a velocity (in which lightlike velocities have `mag == 1`) and `vector._methods.VectorProtocolLorentz.boost_beta3()` is called.

If `booster` is 4D, it is interpreted as a Lorentz vector and `vector._methods.VectorProtocolLorentz.boost_p4()` is called.

Note that `v.boost(v)` does not boost into the center-of-mass (CM) frame of `v`; it boosts *away* from its CM frame. Neither does `v.boost(-v)`, since that negates the time component of `v` as well.

To boost to the center-of-mass frame of a vector `v`, use `vector._methods.VectorProtocolLorentz.boostCM_of()`. For instance, `v.boostCM_of(v)` is guaranteed to have spatial components close to zero and a temporal component close to `v.tau`.

**boostCM\_of**(*booster*: *VectorProtocolSpatial* | *VectorProtocolLorentz*)  $\rightarrow$  SameVectorType

Boosts the vector or array of vectors to the center-of-mass (CM) frame of the 3D or 4D booster.

If `booster` is 3D, it is interpreted as a velocity (in which lightlike velocities have `mag == 1`) and `vector._methods.VectorProtocolLorentz.boostCM_of_beta3()` is called.

If `booster` is 4D, it is interpreted as a Lorentz vector and `vector._methods.VectorProtocolLorentz.boostCM_of_p4()` is called.

Note that `v.boostCM_of(v)` is guaranteed to have spatial components close to zero and a temporal component close to `v.tau`.

**boostCM\_of\_beta3**(*beta3*: [VectorProtocolSpatial](#)) → SameVectorType

Boosts the vector or array of vectors to the center-of-mass (CM) frame of the 3D velocity or array of velocity vectors *beta3*.

Note that `v.boostCM_of_beta3(v.to_beta3())` is guaranteed to have spatial components close to zero and a temporal component close to `v.tau`.

**boostCM\_of\_p4**(*p4*: [VectorProtocolLorentz](#)) → SameVectorType

Boosts the vector or array of vectors to the center-of-mass (CM) frame of the 4D vector or array of vectors *p4*.

This function is equivalent to but more numerically stable than

```
boostCM_of_beta3(p4.to_beta3())
```

Note that `v.boostCM_of_p4(v)` is guaranteed to have spatial components close to zero and a temporal component close to `v.tau`.

**boostX**(*beta*: Any | None = None, *gamma*: Any | None = None) → SameVectorType

Boosts the vector or array of vectors in the *x* direction by a speed *beta* (in which lightlike boosts have *beta* == 1) or time dilation/length contraction factor *gamma*.

Either *beta* xor *gamma* must be specified, not both or neither.

If *beta* or *gamma* is negative, it is taken as a boost in the  $-x$  direction.

**boostY**(*beta*: Any | None = None, *gamma*: Any | None = None) → SameVectorType

Boosts the vector or array of vectors in the *y* direction by a speed *beta* (in which lightlike boosts have *beta* == 1) or time dilation/length contraction factor *gamma*.

Either *beta* xor *gamma* must be specified, not both or neither.

If *beta* or *gamma* is negative, it is taken as a boost in the  $-y$  direction.

**boostZ**(*beta*: Any | None = None, *gamma*: Any | None = None) → SameVectorType

Boosts the vector or array of vectors in the *z* direction by a speed *beta* (in which lightlike boosts have *beta* == 1) or time dilation/length contraction factor *gamma*.

Either *beta* xor *gamma* must be specified, not both or neither.

If *beta* or *gamma* is negative, it is taken as a boost in the  $-z$  direction.

**boost\_beta3**(*beta3*: [VectorProtocolSpatial](#)) → SameVectorType

Boosts the vector or array of vectors in a direction and magnitude given by the 3D velocity or array of velocity vectors *beta3*.

Note that `v.boost_beta3(v.to_beta3())` does not boost into the center-of-mass (CM) frame of *v*; it boosts *away* from its CM frame. Neither does `v.boost_beta3((-v).to_beta3())`, since that negates the time component of *v* as well. On the other hand, `v.boost_beta3(-(v.to_beta3()))` *would* boost to the center-of-mass frame.

However, there's a function for that: [vector.\\_methods.VectorProtocolLorentz.boostCM\\_of\\_beta3\(\)](#) is explicit about boosting to a center-of-mass (CM) frame and it handles the negative sign for you: `v.boostCM_of_beta3(v.to_beta3())` is guaranteed to have spatial components close to zero and a temporal component close to `v.tau`.

**boost\_p4**(*p4*: [VectorProtocolLorentz](#)) → SameVectorType

Boosts the vector or array of vectors in a direction and magnitude given by the 4D vector or array of vectors *p4*.

This function is equivalent to but more numerically stable than

```
boost_beta3(p4.to_beta3())
```

where `vector._methods.VectorProtocolLorentz.to_beta3()` converts a 4D Lorentz vector into a 3D velocity (in which lightlike velocities have `mag == 1`).

Note that `v.boost_p4(v)` does not boost into the center-of-mass (CM) frame of `v`; it boosts *away* from its CM frame. Neither does `v.boost_p4(-v)`, since that negates the time component of `v` as well.

To boost to the center-of-mass frame of a vector `v`, use `vector._methods.VectorProtocolLorentz.boostCM_of_p4()`. For instance, `v.boostCM_of_p4(v)` is guaranteed to have spatial components close to zero and a temporal component close to `v.tau`.

**deltaRapidityPhi**(*other*: `VectorProtocolLorentz`) → Any

Sum in quadrature of `vector._methods.VectorProtocolPlanar.deltaphi()` and the difference in `vector._methods.VectorProtocolLorentz.rapidity` of the two vectors:

$$\Delta R_{\text{rapidity}} = \sqrt{\Delta\phi^2 + \Delta\text{rapidity}^2}$$

**deltaRapidityPhi2**(*other*: `VectorProtocolLorentz`) → Any

Square of the sum in quadrature of `vector._methods.VectorProtocolPlanar.deltaphi()` and the difference in `vector._methods.VectorProtocolLorentz.rapidity` of the two vectors:

$$\Delta R_{\text{rapidity}} = \Delta\phi^2 + \Delta\text{rapidity}^2$$

**dot**(*other*: `VectorProtocol`) → Any

Vector dot product of `self` with `other`.

This method is equivalent to the `@` operator.

**equal**(*other*: `VectorProtocol`) → Any

Returns True if `self` is exactly equal to `other` (possibly for arrays of vectors), False otherwise.

This method is equivalent to the `==` operator.

Typically, you'll want to check `vector._methods.VectorProtocol.isclose()` to allow for numerical errors.

**property gamma**: Any

The time dilation/length contraction factor(s) of the Lorentz vector or array of vectors:  $t/\tau$ .

**is\_lightlike**(*tolerance*: Any =  $1e-05$ ) → Any

Returns True if the vector or a vector in the array is pointing in a lightlike direction, `t**2 == mag**2`, False otherwise.

The tolerance is in units of `t` and `mag`. Note that

- the default tolerance for `vector._methods.VectorProtocolLorentz.is_timelike()` is 0
- the default tolerance for `vector._methods.VectorProtocolLorentz.is_spacelike()` is 0
- the default tolerance for `vector._methods.VectorProtocolLorentz.is_lightlike()` is  $1e-5$

If you want to use these methods to divide space-time into non-overlapping regions (the light-cone), use the same tolerance for each.

**is\_spacelike**(*tolerance: Any = 0*) → Any

Returns True if the vector or a vector in the array is pointing in a spacelike direction,  $t^{**2} < mag^{**2}$ , False otherwise.

The tolerance is in units of *t* and *mag*. Note that

- the default tolerance for `vector._methods.VectorProtocolLorentz.is_timelike()` is 0
- the default tolerance for `vector._methods.VectorProtocolLorentz.is_spacelike()` is 0
- the default tolerance for `vector._methods.VectorProtocolLorentz.is_lightlike()` is  $1e-5$

If you want to use these methods to divide space-time into non-overlapping regions (the light-cone), use the same tolerance for each.

**is\_timelike**(*tolerance: Any = 0*) → Any

Returns True if the vector or a vector in the array is pointing in a timelike direction,  $t^{**2} > mag^{**2}$ , False otherwise.

The tolerance is in units of *t* and *mag*. Note that

- the default tolerance for `vector._methods.VectorProtocolLorentz.is_timelike()` is 0
- the default tolerance for `vector._methods.VectorProtocolLorentz.is_spacelike()` is 0
- the default tolerance for `vector._methods.VectorProtocolLorentz.is_lightlike()` is  $1e-5$

If you want to use these methods to divide space-time into non-overlapping regions (the light-cone), use the same tolerance for each.

**isclose**(*other: VectorProtocol, rtol: Any = 1e-05, atol: Any = 1e-08, equal\_nan: Any = False*) → Any

Returns True if *self* is approximately equal to *other* (possibly for arrays of vectors), False otherwise.

The relative tolerance (*rtol*) and absolute tolerance (*atol*) are interpreted as in `np.isclose`:

```
close_enough = abs(self - other) <= atol + rtol * abs(other)
```

**property neg2D: SameVectorType**

Returns vector(s) with the 2D part negated, not affecting any longitudinal or temporal parts.

**property neg3D: SameVectorType**

Returns vector(s) with the 3D part negated, not affecting any longitudinal or temporal parts.

**property neg4D: SameVectorType**

Same as multiplying by -1.

**not\_equal**(*other: VectorProtocol*) → Any

Returns False if *self* is exactly equal to *other* (possibly for arrays of vectors), True otherwise.

This method is equivalent to the `!=` operator.

Typically, you'll want to check `vector._methods.VectorProtocol.isclose()` to allow for numerical errors.

**property rapidity: Any**

The rapidity relative to the longitudinal axis of the Lorentz vector or array of vectors.

```
0.5 * log((t + z) / (t - z))
```

**scale**(*factor*: Any) → SameVectorType

Returns vector(s) scaled by a **factor**, changing the length(s) but not the direction(s).

This method is equivalent to the `*` operator.

**scale2D**(*factor*: Any) → SameVectorType

Returns vector(s) with the 2D part scaled by a **factor**, not affecting any longitudinal or temporal parts.

**scale3D**(*factor*: Any) → SameVectorType

Returns vector(s) with the 3D part scaled by a **factor**, not affecting any longitudinal or temporal parts.

**scale4D**(*factor*: Any) → SameVectorType

Same as **scale**.

**subtract**(*other*: VectorProtocol) → VectorProtocol

Difference of **self** minus **other**.

This method is equivalent to the `-` operator.

**property t**: Any

The Cartesian  $t$  (time) coordinate of the vector or every vector in the array.

If  $t$  is derived from  $\tau$ , it is not allowed to be NaN.

```
t = sqrt(max(copysign(tau**2, tau) + mag**2, 0))
```

**property t2**: Any

The Cartesian  $t$  (time) coordinate squared of the vector or every vector in the array.

If  $t^2$  is derived from  $\tau$ , it is not allowed to be negative.

```
t2 = max(copysign(tau**2, tau) + mag**2, 0)
```

**property tau**: Any

The Lorentz magnitude  $\tau$  (proper time) of the vector or every vector in the array.

If  $\tau$  is derived from  $t$ , spacelike vectors are represented by negative proper times.

```
tau = copysign(sqrt(abs(t**2 - mag**2)), t**2 - mag**2)
```

**property tau2**: Any

The Lorentz magnitude  $\tau$  (proper time) squared of the vector or every vector in the array.

```
tau2 = t**2 - mag**2
```

**to\_beta3**() → VectorProtocolSpatial

Converts the 4D Lorentz vector or array of vectors into a 3D velocity vector or array of vectors, in which lightlike velocities have `mag == 1`.

**transform4D**(*obj*: TransformProtocol4D) → SameVectorType

Arbitrarily transforms the vector(s) by

```
obj["xx"] obj["xy"] obj["xz"] obj["xt"]
obj["yx"] obj["yy"] obj["yz"] obj["yt"]
obj["zx"] obj["zy"] obj["zz"] obj["zt"]
obj["tx"] obj["ty"] obj["tz"] obj["tt"]
```

There is no restriction on the type of `obj`; it just has to provide those components (which can be arrays if the vectors are in an array).

**unit()** → SameVectorType

Returns vector(s) normalized to unit length, which is  $\rho == 1$  for 2D vectors,  $\text{mag} == 1$  for 3D vectors, and  $\text{tau} == 1$  for 4D vectors.

**class** `vector._methods.LorentzMomentum`

Bases: `SpatialMomentum`, `MomentumProtocolLorentz`

**property** `E`: Any

Momentum-synonyor `vector._methods.VectorProtocolLorentz.t`.

**property** `E2`: Any

Momentum-synonym for `vector._methods.VectorProtocolLorentz2`.

**property** `Et`: Any

Transverse energy of the four-momentum vector or array of vectors:  $E_T = E \sin \theta$ .

**property** `Et2`: Any

Transverse energy squared of the four-momentum vector or array of vectors:  $E_T^2 = E^2 \sin^2 \theta$ .

**property** `M`: Any

Momentum-synonym for `vector._methods.VectorProtocolLorentz.tau`.

**property** `M2`: Any

Momentum-synonym for `vector._methods.VectorProtocolLorentz.tau2`.

**property** `Mt`: Any

Transverse mass of the four-momentum vector or array of vectors:  $M_T = \sqrt{t^2 - z^2}$ .

**property** `Mt2`: Any

Transverse mass squared of the four-momentum vector or array of vectors:  $M_T^2 = t^2 - z^2$ .

**property** `e`: Any

Momentum-synonym for `vector._methods.VectorProtocolLorentz.t`.

**property** `e2`: Any

Momentum-synonym for `vector._methods.VectorProtocolLorentz.t2`.

**property** `energy`: Any

Momentum-synonym for `vector._methods.VectorProtocolLorentz.t`.

**property** `energy2`: Any

Momentum-synonym for `vector._methods.VectorProtocolLorentz.t2`.

**property** `et`: Any

Transverse energy of the four-momentum vector or array of vectors:  $E_T = E \sin \theta$ .

**property** `et2`: Any

Transverse energy squared of the four-momentum vector or array of vectors:  $E_T^2 = E^2 \sin^2 \theta$ .

**property** `m`: Any

Momentum-synonym for `vector._methods.VectorProtocolLorentz.tau`.

**property** `m2`: Any

Momentum-synonym for `vector._methods.VectorProtocolLorentz.tau2`.



**property mass: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz.tau`.

**property mass2: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz.tau2`.

**property mt: Any**

Transverse mass of the four-momentum vector or array of vectors:  $M_T = \sqrt{t^2 - z^2}$ .

**property mt2: Any**

Transverse mass squared of the four-momentum vector or array of vectors:  $M_T^2 = t^2 - z^2$ .

**property transverse\_energy: Any**

Synonym for `vector._methods.MomentumProtocolLorentz.Et`.

**property transverse\_energy2: Any**

Synonym for `vector._methods.MomentumProtocolLorentz.Et2`.

**property transverse\_mass: Any**

Synonym for `vector._methods.MomentumProtocolLorentz.Mt`.

**property transverse\_mass2: Any**

Synonym for `vector._methods.MomentumProtocolLorentz.Mt2`.

**class vector.\_methods.Momentum**

Bases: object

**class vector.\_methods.MomentumProtocolLorentz**

Bases: `VectorProtocolLorentz`, `MomentumProtocolSpatial`

**property E: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz.t`.

**property E2: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz2`.

**property Et: Any**

Transverse energy of the four-momentum vector or array of vectors:  $E_T = E \sin \theta$ .

**property Et2: Any**

Transverse energy squared of the four-momentum vector or array of vectors:  $E_T^2 = E^2 \sin^2 \theta$ .

**property M: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz.tau`.

**property M2: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz.tau2`.

**property Mt: Any**

Transverse mass of the four-momentum vector or array of vectors:  $M_T = \sqrt{t^2 - z^2}$ .

**property Mt2: Any**

Transverse mass squared of the four-momentum vector or array of vectors:  $M_T^2 = t^2 - z^2$ .

**property e: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz.t`.

**property e2: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz.t2`.

**property energy: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz.t`.

**property energy2: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz.t2`.

**property et: Any**

Transverse energy of the four-momentum vector or array of vectors:  $E_T = E \sin \theta$ .

**property et2: Any**

Transverse energy squared of the four-momentum vector or array of vectors:  $E_T^2 = E^2 \sin^2 \theta$ .

**property m: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz.tau`.

**property m2: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz.tau2`.

**property mass: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz.tau`.

**property mass2: Any**

Momentum-synonym for `vector._methods.VectorProtocolLorentz.tau2`.

**property mt: Any**

Transverse mass of the four-momentum vector or array of vectors:  $M_T = \sqrt{t^2 - z^2}$ .

**property mt2: Any**

Transverse mass squared of the four-momentum vector or array of vectors:  $M_T^2 = t^2 - z^2$ .

**property transverse\_energy: Any**

Synonym for `vector._methods.MomentumProtocolLorentz.Et`.

**property transverse\_energy2: Any**

Synonym for `vector._methods.MomentumProtocolLorentz.Et2`.

**property transverse\_mass: Any**

Synonym for `vector._methods.MomentumProtocolLorentz.Mt`.

**property transverse\_mass2: Any**

Synonym for `vector._methods.MomentumProtocolLorentz.Mt2`.

**class vector.\_methods.MomentumProtocolPlanar**

Bases: `VectorProtocolPlanar`

**property pt: Any**

Momentum-synonym for `vector._methods.VectorProtocolPlanar.rho`.

**property pt2: Any**

Momentum-synonym for `vector._methods.VectorProtocolPlanar.rho2`.

**property px: Any**

Momentum-synonym for `vector._methods.VectorProtocolPlanar.x`.

**property py: Any**

Momentum-synonym for `vector._methods.VectorProtocolPlanar.y`.

**class vector.\_methods.MomentumProtocolSpatial**

Bases: `VectorProtocolSpatial`, `MomentumProtocolPlanar`

**property p: Any**

Momentum-synonym for `vector._methods.VectorProtocolSpatial.mag`.

**property p2: Any**

Momentum-synonym for `vector._methods.VectorProtocolSpatial.mag2`.

**property pseudorapidity: Any**

Momentum-synonym for `vector._methods.VectorProtocolSpatial.eta`.

**property pz: Any**

Momentum-synonym for `vector._methods.VectorProtocolSpatial.z`.

**class vector.\_methods.Planar**

Bases: `VectorProtocolPlanar`

**add(other: VectorProtocol) → VectorProtocol**

Sum of `self` and `other`.

This method is equivalent to the `+` operator.

**deltaphi(other: VectorProtocol) → Any**

Signed difference in  $\phi$  of `self` minus `other` (in radians).

**dot(other: VectorProtocol) → Any**

Vector dot product of `self` with `other`.

This method is equivalent to the `@` operator.

**equal(other: VectorProtocol) → Any**

Returns True if `self` is exactly equal to `other` (possibly for arrays of vectors), False otherwise.

This method is equivalent to the `==` operator.

Typically, you'll want to check `vector._methods.VectorProtocol.isclose()` to allow for numerical errors.

**is\_antiparallel(other: VectorProtocol, tolerance: Any = 1e-05) → Any**

Returns True if `self` and `other` are pointing in opposite directions (i.e. dot product is nearly  $-\text{abs}(\text{self}) * \text{abs}(\text{other})$ ).

The tolerance is measured in units of  $\cos(\Delta\alpha)$  where  $\Delta\alpha$  is `self.deltaangle(other)`.

**is\_parallel(other: VectorProtocol, tolerance: Any = 1e-05) → Any**

Returns True if `self` and `other` are pointing in the same direction (i.e. not “antiparallel”; dot product is nearly  $\text{abs}(\text{self}) * \text{abs}(\text{other})$ ).

The tolerance is measured in units of  $\cos(\Delta\alpha)$  where  $\Delta\alpha$  is `self.deltaangle(other)`.

**is\_perpendicular(other: VectorProtocol, tolerance: Any = 1e-05) → Any**

Returns True if `self` and `other` are pointing in perpendicular directions (i.e. dot product is nearly 0).

The tolerance is measured in units of  $\cos(\Delta\alpha)$  where  $\Delta\alpha$  is `self.deltaangle(other)`.

**isclose**(*other*: [VectorProtocol](#), *rtol*: *Any* = 1e-05, *atol*: *Any* = 1e-08, *equal\_nan*: *Any* = False) → *Any*  
 Returns True if **self** is approximately equal to **other** (possibly for arrays of vectors), False otherwise.  
 The relative tolerance (*rtol*) and absolute tolerance (*atol*) are interpreted as in `np.isclose`:

```
close_enough = abs(self - other) <= atol + rtol * abs(other)
```

**property neg2D**: [SameVectorType](#)

Returns vector(s) with the 2D part negated, not affecting any longitudinal or temporal parts.

**not\_equal**(*other*: [VectorProtocol](#)) → *Any*

Returns False if **self** is exactly equal to **other** (possibly for arrays of vectors), True otherwise.

This method is equivalent to the `!=` operator.

Typically, you'll want to check `vector._methods.VectorProtocol.isclose()` to allow for numerical errors.

**property phi**: *Any*

The polar  $\phi$  coordinate of the vector or every vector in the array (in radians, always between  $-\pi$  and  $\pi$ ).

**property rho**: *Any*

The polar  $\rho$  coordinate of the vector or every vector in the array.

This is also the magnitude of the 2D azimuthal part of the vector (not including any longitudinal or temporal parts).

**property rho2**: *Any*

The polar  $\rho$  coordinate squared of the vector or every vector in the array.

**rotateZ**(*angle*: *Any*) → [SameVectorType](#)

Rotates the vector(s) by a given *angle* (in radians) around the longitudinal axis.

Note that the *angle* can be an array with the same length as the vectors, if the vectors are in an array.

**scale**(*factor*: *Any*) → [SameVectorType](#)

Returns vector(s) scaled by a *factor*, changing the length(s) but not the direction(s).

This method is equivalent to the `*` operator.

**scale2D**(*factor*: *Any*) → [SameVectorType](#)

Returns vector(s) with the 2D part scaled by a *factor*, not affecting any longitudinal or temporal parts.

**subtract**(*other*: [VectorProtocol](#)) → [VectorProtocol](#)

Difference of **self** minus **other**.

This method is equivalent to the `-` operator.

**transform2D**(*obj*: [TransformProtocol2D](#)) → [SameVectorType](#)

Arbitrarily transforms the vector(s) by

```
obj["xx"]  obj["xy"]
obj["yx"]  obj["yy"]
```

leaving any longitudinal or temporal coordinates unchanged. There is no restriction on the type of *obj*; it just has to provide those components (which can be arrays if the vectors are in an array).

**unit**() → [SameVectorType](#)

Returns vector(s) normalized to unit length, which is *rho* == 1 for 2D vectors, *mag* == 1 for 3D vectors, and *tau* == 1 for 4D vectors.

**property x: Any**

The Cartesian  $x$  coordinate of the vector or every vector in the array.

**property y: Any**

The Cartesian  $y$  coordinate of the vector or every vector in the array.

**class** `vector._methods.PlanarMomentum`

Bases: `Momentum`, `MomentumProtocolPlanar`

**property pt: Any**

Momentum-synonym for `vector._methods.VectorProtocolPlanar.rho`.

**property pt2: Any**

Momentum-synonym for `vector._methods.VectorProtocolPlanar.rho2`.

**property px: Any**

Momentum-synonym for `vector._methods.VectorProtocolPlanar.x`.

**property py: Any**

Momentum-synonym for `vector._methods.VectorProtocolPlanar.y`.

**class** `vector._methods.Spatial`

Bases: `Planar`, `VectorProtocolSpatial`

**add**(*other*: `VectorProtocol`)  $\rightarrow$  `VectorProtocol`

Sum of `self` and `other`.

This method is equivalent to the `+` operator.

**property costheta: Any**

The  $\cos \theta$  coordinate of the vector or every vector in the array (has the same sign as  $z$ ).

**property cottheta: Any**

The  $\cot \theta$  coordinate of the vector or every vector in the array (has the same sign as  $z$ ).

**cross**(*other*: `VectorProtocolSpatial`)  $\rightarrow$  `VectorProtocolSpatial`

The 3D cross-product of `self` with `other`.

Even if `self` or `other` is 4D, the resulting vector(s) is/are 3D.

**deltaR**(*other*: `VectorProtocolSpatial` | `VectorProtocolLorentz`)  $\rightarrow$  Any

Sum in quadrature of `vector._methods.VectorProtocolPlanar.deltaphi()` and `vector._methods.VectorProtocolSpatial.deltaeta()`:

$$\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$$

**deltaR2**(*other*: `VectorProtocolSpatial` | `VectorProtocolLorentz`)  $\rightarrow$  Any

Square of the sum in quadrature of `vector._methods.VectorProtocolPlanar.deltaphi()` and `vector._methods.VectorProtocolSpatial.deltaeta()`:

$$\Delta R^2 = \Delta\phi^2 + \Delta\eta^2$$

**deltaangle**(*other*: `VectorProtocolSpatial` | `VectorProtocolLorentz`)  $\rightarrow$  Any

Angle in 3D space between `self` and `other`, which is always positive, between 0 and  $\pi$ .

**deltaeta**(*other*: [VectorProtocolSpatial](#) | [VectorProtocolLorentz](#)) → Any

Signed difference in  $\eta$  of **self** minus **other**.

**dot**(*other*: [VectorProtocol](#)) → Any

Vector dot product of **self** with **other**.

This method is equivalent to the @ operator.

**equal**(*other*: [VectorProtocol](#)) → Any

Returns True if **self** is exactly equal to **other** (possibly for arrays of vectors), False otherwise.

This method is equivalent to the == operator.

Typically, you'll want to check [vector.\\_methods.VectorProtocol.isclose\(\)](#) to allow for numerical errors.

**property eta**: Any

The pseudorapidity  $\eta$  coordinate of the vector or every vector in the array (in radians, always between 0 (+z) and  $\pi$  (-z)).

**is\_antiparallel**(*other*: [VectorProtocol](#), *tolerance*: Any = 1e-05) → Any

Returns True if **self** and **other** are pointing in opposite directions (i.e. dot product is nearly  $-\text{abs}(\text{self}) * \text{abs}(\text{other})$ ).

The tolerance is measured in units of  $\cos(\Delta\alpha)$  where  $\Delta\alpha$  is **self.deltaangle(other)**.

**is\_parallel**(*other*: [VectorProtocol](#), *tolerance*: Any = 1e-05) → Any

Returns True if **self** and **other** are pointing in the same direction (i.e. not “antiparallel”; dot product is nearly  $\text{abs}(\text{self}) * \text{abs}(\text{other})$ ).

The tolerance is measured in units of  $\cos(\Delta\alpha)$  where  $\Delta\alpha$  is **self.deltaangle(other)**.

**is\_perpendicular**(*other*: [VectorProtocol](#), *tolerance*: Any = 1e-05) → Any

Returns True if **self** and **other** are pointing in perpendicular directions (i.e. dot product is nearly 0).

The tolerance is measured in units of  $\cos(\Delta\alpha)$  where  $\Delta\alpha$  is **self.deltaangle(other)**.

**isclose**(*other*: [VectorProtocol](#), *rtol*: Any = 1e-05, *atol*: Any = 1e-08, *equal\_nan*: Any = False) → Any

Returns True if **self** is approximately equal to **other** (possibly for arrays of vectors), False otherwise.

The relative tolerance (*rtol*) and absolute tolerance (*atol*) are interpreted as in [np.isclose](#):

```
close_enough = abs(self - other) <= atol + rtol * abs(other)
```

**property mag**: Any

The magnitude of the vector(s) in 3D (not including any temporal parts).

**property mag2**: Any

The magnitude-squared of the vector(s) in 3D (not including any temporal parts).

**property neg2D**: SameVectorType

Returns vector(s) with the 2D part negated, not affecting any longitudinal or temporal parts.

**property neg3D**: SameVectorType

Returns vector(s) with the 3D part negated, not affecting any longitudinal or temporal parts.

**not\_equal**(*other*: [VectorProtocol](#)) → Any

Returns False if **self** is exactly equal to **other** (possibly for arrays of vectors), True otherwise.

This method is equivalent to the != operator.

Typically, you'll want to check `vector._methods.VectorProtocol.isclose()` to allow for numerical errors.

**rotateX**(*angle: Any*) → SameVectorType

Rotates the vector(s) by a given **angle** (in radians) around the *x* axis.

Note that the **angle** can be an array with the same length as the vectors, if the vectors are in an array.

**rotateY**(*angle: Any*) → SameVectorType

Rotates the vector(s) by a given **angle** (in radians) around the *y* axis.

Note that the **angle** can be an array with the same length as the vectors, if the vectors are in an array.

**rotate\_axis**(*axis: VectorProtocolSpatial, angle: Any*) → SameVectorType

Rotates the vector(s) by a given **angle** (in radians) around the axis indicated by another vector, **axis**. The magnitude of **axis** is ignored.

Note that the **axis** and **angle** can be arrays with the same length as the vectors, if the vectors are in an array.

**rotate\_euler**(*phi: Any, theta: Any, psi: Any, order: str = 'zxz'*) → SameVectorType

Rotates the vector(s) by three given angles: **phi**, **theta**, and **psi** (in radians). The order string determines which axis each rotation is applied around:

- "zxz", "xyx", "yzy", "zyz", "xzx", and "yxy" are proper Euler angles
- "zxz", "xyx", "yzy", "zyz", "xzx", and "yxy" are Tait-Bryan angles (see `vector._methods.VectorProtocolSpatial.rotate_nautical()`)

The names **phi**, **theta**, and **psi** agree with Wikipedia's terminology, and both the names and order agree with ROOT's `Math::EulerAngles`. The default order = "zxz" is also ROOT's convention.

Note that the angles can be arrays with the same lengths as the vectors, if the vectors are in an array.

**rotate\_nautical**(*yaw: Any, pitch: Any, roll: Any*) → SameVectorType

Rotates the vector(s) by three given angles: **yaw**, **pitch**, and **roll** (in radians). These are Tait-Bryan angles often used for boats and planes (see [this lesson](#) and [this lesson](#)).

This function is entirely equivalent to

```
rotate_euler(roll, pitch, yaw, order="zyx")
```

Note that the angles can be arrays with the same lengths as the vectors, if the vectors are in an array.

**rotate\_quaternion**(*u: Any, i: Any, j: Any, k: Any*) → SameVectorType

Rotates the vector(s) by four angles as quaternion coefficients (in radians). Four angles are sometimes preferred over three because the latter has a pathology known as "gimbal lock."

This function follows the same conventions as ROOT's `Math::Quaternion`.

Note that the angles can be arrays with the same lengths as the vectors, if the vectors are in an array.

**scale**(*factor: Any*) → SameVectorType

Returns vector(s) scaled by a **factor**, changing the length(s) but not the direction(s).

This method is equivalent to the `*` operator.

**scale2D**(*factor: Any*) → SameVectorType

Returns vector(s) with the 2D part scaled by a **factor**, not affecting any longitudinal or temporal parts.

**scale3D**(*factor: Any*) → SameVectorType

Returns vector(s) with the 3D part scaled by a **factor**, not affecting any longitudinal or temporal parts.

**subtract**(*other*: [VectorProtocol](#)) → [VectorProtocol](#)

Difference of `self` minus `other`.

This method is equivalent to the `-` operator.

**property theta**: Any

The spherical  $\theta$  coordinate (polar angle) of the vector or every vector in the array (in radians, always between 0 (+ $z$ ) and  $\pi$  ( $-z$ )).

**transform3D**(*obj*: [TransformProtocol3D](#)) → SameVectorType

Arbitrarily transforms the vector(s) by

```
obj["xx"]  obj["xy"]  obj["xz"]
obj["yx"]  obj["yy"]  obj["yz"]
obj["zx"]  obj["zy"]  obj["zz"]
```

leaving any temporal coordinate unchanged. There is no restriction on the type of `obj`; it just has to provide those components (which can be arrays if the vectors are in an array).

**unit**() → SameVectorType

Returns vector(s) normalized to unit length, which is  $\rho == 1$  for 2D vectors,  $\text{mag} == 1$  for 3D vectors, and  $\text{tau} == 1$  for 4D vectors.

**property z**: Any

The Cartesian  $z$  coordinate of the vector or every vector in the array.

**class** `vector._methods.SpatialMomentum`

Bases: [PlanarMomentum](#), [MomentumProtocolSpatial](#)

**property p**: Any

Momentum-synonym for `vector._methods.VectorProtocolSpatial.mag`.

**property p2**: Any

Momentum-synonym for `vector._methods.VectorProtocolSpatial.mag2`.

**property pseudorapidity**: Any

Momentum-synonym for `vector._methods.VectorProtocolSpatial.eta`.

**property pz**: Any

Momentum-synonym for `vector._methods.VectorProtocolSpatial.z`.

**class** `vector._methods.Temporal`

Bases: [Coordinates](#)

**property elements**: tuple[Any]

Temporal coordinates as a tuple.

Each coordinate may be a scalar, a NumPy array, an Awkward Array, etc., but they are not vectors.

**class** `vector._methods.TemporalT`

Bases: [Temporal](#)

**t**

The  $t$  coordinate(s).

**Type**

scalar, `np.ndarray`, `ak.Array`, etc.



**t: Any**

**class** vector.\_methods.TemporalTau

Bases: *Temporal*

**tau**

The  $\tau$  coordinate(s).

**Type**

scalar, np.ndarray, ak.Array, etc.

**tau: Any**

```

class vector._methods.Vector(*, x: float, y: float)
class vector._methods.Vector(*, rho: float, phi: float)
class vector._methods.Vector(*, x: float, y: float, z: float)
class vector._methods.Vector(*, x: float, y: float, eta: float)
class vector._methods.Vector(*, x: float, y: float, theta: float)
class vector._methods.Vector(*, rho: float, phi: float, z: float)
class vector._methods.Vector(*, rho: float, phi: float, eta: float)
class vector._methods.Vector(*, rho: float, phi: float, theta: float)
class vector._methods.Vector(*, px: float, py: float)
class vector._methods.Vector(*, x: float, py: float)
class vector._methods.Vector(*, px: float, y: float)
class vector._methods.Vector(*, pt: float, phi: float)
class vector._methods.Vector(*, x: float, y: float, pz: float)
class vector._methods.Vector(*, x: float, py: float, z: float)
class vector._methods.Vector(*, x: float, py: float, pz: float)
class vector._methods.Vector(*, px: float, y: float, z: float)
class vector._methods.Vector(*, px: float, y: float, pz: float)
class vector._methods.Vector(*, px: float, py: float, z: float)
class vector._methods.Vector(*, px: float, py: float, pz: float)
class vector._methods.Vector(*, rho: float, phi: float, pz: float)
class vector._methods.Vector(*, pt: float, phi: float, z: float)
class vector._methods.Vector(*, pt: float, phi: float, pz: float)
class vector._methods.Vector(*, x: float, py: float, theta: float)
class vector._methods.Vector(*, px: float, y: float, theta: float)
class vector._methods.Vector(*, px: float, py: float, theta: float)
class vector._methods.Vector(*, pt: float, phi: float, theta: float)
class vector._methods.Vector(*, x: float, py: float, eta: float)
class vector._methods.Vector(*, px: float, y: float, eta: float)
class vector._methods.Vector(*, px: float, py: float, eta: float)
class vector._methods.Vector(*, pt: float, phi: float, eta: float)
class vector._methods.Vector(*, x: float, y: float, z: float, t: float)
class vector._methods.Vector(*, x: float, y: float, pz: float, t: float)
class vector._methods.Vector(*, x: float, py: float, z: float, t: float)
class vector._methods.Vector(*, x: float, py: float, pz: float, t: float)

```









```

class vector._methods.Vector(*, x: float, y: float, theta: float, mass: float)
class vector._methods.Vector(*, x: float, py: float, theta: float, mass: float)
class vector._methods.Vector(*, px: float, y: float, theta: float, mass: float)
class vector._methods.Vector(*, px: float, py: float, theta: float, mass: float)
class vector._methods.Vector(*, rho: float, phi: float, theta: float, mass: float)
class vector._methods.Vector(*, pt: float, phi: float, theta: float, mass: float)
class vector._methods.Vector(*, x: float, y: float, eta: float, mass: float)
class vector._methods.Vector(*, x: float, py: float, eta: float, mass: float)
class vector._methods.Vector(*, px: float, y: float, eta: float, mass: float)
class vector._methods.Vector(*, px: float, py: float, eta: float, mass: float)
class vector._methods.Vector(*, rho: float, phi: float, eta: float, mass: float)
class vector._methods.Vector(*, pt: float, phi: float, eta: float, mass: float)
class vector._methods.Vector(__azumthal: Azimuthal)
class vector._methods.Vector(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector._methods.Vector(__azumthal: Azimuthal, __longitudinal: Longitudinal, __temporal: Temporal)

```

Bases: [VectorProtocol](#)

**like**(*other*: [VectorProtocol](#)) → [VectorProtocol](#)

Projects the vector into the geometric coordinates of the *other* vector.

Value(s) of 0 is/are imputed while transforming vector from a lower geometric dimension to a higher geometric dimension.

```
vec_4d + vec_3d.like(vec_4d)
```

For more flexibility (passing new coordinate values), see [vector.\\_methods.Vector2D.to\\_Vector3D\(\)](#), [vector.\\_methods.Vector2D.to\\_Vector4D\(\)](#), and [vector.\\_methods.Vector3D.to\\_Vector4D\(\)](#), which can be used as:

```

vec_2d.to_Vector3D(z=3.0)
vec_2d.to_Vector4D(z=3.0, t=4.0)
vec_3d.to_Vector4D(t=4.0)

```

**to\_ptphi**() → [VectorProtocolPlanar](#)

Converts to  $pt$ - $\phi$  coordinates, possibly eliminating dimensions with a projection.

**to\_ptphieta**(\*, *eta*: float | ndarray = 0.0) → [VectorProtocolSpatial](#)

Converts to  $pt$ - $\phi$ - $\eta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *eta* coordinate can be passed as a named argument.

**to\_ptphietaenergy**(\*, *eta*: float | ndarray = 0.0, *energy*: float | ndarray = 0.0) → [VectorProtocolLorentz](#)

Converts to  $pt$ - $\phi$ - $\eta$ -*energy* coordinates, possibly imputing dimensions with a projection.

The *eta* and *energy* coordinates can be passed as a named argument.

**to\_ptphietamass**(\*, *eta*: float | ndarray = 0.0, *mass*: float | ndarray = 0.0) → [VectorProtocolLorentz](#)

Converts to  $pt$ - $\phi$ - $\theta$ -*mass* coordinates, possibly imputing dimensions with a projection.

The *eta* and *mass* coordinates can be passed as a named argument.

**to\_ptphipz**(\*, *pz*: float | ndarray = 0.0) → [VectorProtocolSpatial](#)

Converts to  $pt$ - $\phi$ -*pz* coordinates, possibly eliminating or imputing dimensions with a projection.

The *pz* coordinate can be passed as a named argument.

**to\_ptphipzenergy**(\* , pz: float | ndarray = 0.0, energy: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $pt$ - $\phi$ - $pz$ -*energy* coordinates, possibly imputing dimensions with a projection.

The *pz* and *energy* coordinates can be passed as a named argument.

**to\_ptphipzmass**(\* , pz: float | ndarray = 0.0, mass: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $pt$ - $\phi$ - $pz$ -*mass* coordinates, possibly imputing dimensions with a projection.

The *pz* and *mass* coordinates can be passed as a named argument.

**to\_ptphiitheta**(\* , theta: float | ndarray = 0.0) → *VectorProtocolSpatial*

Converts to  $pt$ - $\phi$ - $\theta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *theta* coordinate can be passed as a named argument.

**to\_ptphiithetaenergy**(\* , theta: float | ndarray = 0.0, energy: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $pt$ - $\phi$ - $\theta$ -*energy* coordinates, possibly imputing dimensions with a projection.

The *theta* and *energy* coordinates can be passed as a named argument.

**to\_ptphiithetamass**(\* , theta: float | ndarray = 0.0, mass: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $pt$ - $\phi$ - $\theta$ -*mass* coordinates, possibly imputing dimensions with a projection.

The *theta* and *mass* coordinates can be passed as a named argument.

**to\_pxpy**() → *VectorProtocolPlanar*

Converts to  $px$ - $py$  coordinates, possibly eliminating dimensions with a projection.

**to\_pxpyeta**(\* , eta: float | ndarray = 0.0) → *VectorProtocolSpatial*

Converts to  $px$ - $py$ - $\eta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *eta* coordinate can be passed as a named argument.

**to\_pxpyetaenergy**(\* , eta: float | ndarray = 0.0, energy: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $px$ - $py$ - $\eta$ -*energy* coordinates, possibly imputing dimensions with a projection.

The *eta* and *energy* coordinates can be passed as a named argument.

**to\_pxpyetamass**(\* , eta: float | ndarray = 0.0, mass: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $px$ - $py$ - $\eta$ -*mass* coordinates, possibly imputing dimensions with a projection.

The *eta* and *mass* coordinates can be passed as a named argument.

**to\_pxpypz**(\* , pz: float | ndarray = 0.0) → *VectorProtocolSpatial*

Converts to  $px$ - $py$ - $pz$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *pz* coordinate can be passed as a named argument.

**to\_pxpypzenergy**(\* , pz: float | ndarray = 0.0, energy: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $px$ - $py$ - $pz$ -*energy* coordinates, possibly imputing dimensions with a projection.

The *pz* and *energy* coordinates can be passed as a named argument.

**to\_pxpypzmass**(\* , pz: float | ndarray = 0.0, mass: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $px$ - $py$ - $pz$ -*mass* coordinates, possibly imputing dimensions with a projection.

The *pz* and *mass* coordinates can be passed as a named argument.

**to\_pxpytheta**(\* , theta: float | ndarray = 0.0) → *VectorProtocolSpatial*

Converts to  $px$ - $py$ - $\theta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *theta* coordinate can be passed as a named argument.

**to\_pxpythetaenergy**(\* , *theta*: float | ndarray = 0.0, *energy*: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $px$ - $py$ - $\theta$ - $energy$  coordinates, possibly imputing dimensions with a projection.

The *theta* and *energy* coordinates can be passed as a named argument.

**to\_pxpythetamass**(\* , *theta*: float | ndarray = 0.0, *mass*: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $px$ - $py$ - $\theta$ - $energy$  coordinates, possibly imputing dimensions with a projection.

The *theta* and *mass* coordinates can be passed as a named argument.

**to\_rhophi**() → *VectorProtocolPlanar*

Converts to  $\rho$ - $\phi$  coordinates, possibly eliminating dimensions with a projection.

**to\_rhophieta**(\* , *eta*: float | ndarray = 0.0) → *VectorProtocolSpatial*

Converts to  $\rho$ - $\phi$ - $\eta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *eta* coordinate can be passed as a named argument.

**to\_rhophieta\_t**(\* , *eta*: float | ndarray = 0.0, *t*: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $\rho$ - $\phi$ - $\eta$ - $t$  coordinates, possibly imputing dimensions with a projection.

The *eta* and *t* coordinates can be passed as a named argument.

**to\_rhophieta\_tau**(\* , *eta*: float | ndarray = 0.0, *tau*: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $\rho$ - $\phi$ - $\eta$ - $\tau$  coordinates, possibly imputing dimensions with a projection.

The *eta* and *tau* coordinates can be passed as a named argument.

**to\_rhophi\_theta**(\* , *theta*: float | ndarray = 0.0) → *VectorProtocolSpatial*

Converts to  $\rho$ - $\phi$ - $\theta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *theta* coordinate can be passed as a named argument.

**to\_rhophi\_theta\_t**(\* , *theta*: float | ndarray = 0.0, *t*: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $\rho$ - $\phi$ - $\theta$ - $t$  coordinates, possibly imputing dimensions with a projection.

The *theta* and *t* coordinates can be passed as a named argument.

**to\_rhophi\_theta\_tau**(\* , *theta*: float | ndarray = 0.0, *tau*: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $\rho$ - $\phi$ - $\theta$ - $\tau$  coordinates, possibly imputing dimensions with a projection.

The *theta* and *tau* coordinates can be passed as a named argument.

**to\_rhophi\_z**(\* , *z*: float | ndarray = 0.0) → *VectorProtocolSpatial*

Converts to  $\rho$ - $\phi$ - $z$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *z* coordinate can be passed as a named argument.

**to\_rhophi\_z\_t**(\* , *z*: float | ndarray = 0.0, *t*: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $\rho$ - $\phi$ - $z$ - $t$  coordinates, possibly imputing dimensions with a projection.

The *z* and *t* coordinates can be passed as a named argument.

**to\_rhophi\_z\_tau**(\* , *z*: float | ndarray = 0.0, *tau*: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $\rho$ - $\phi$ - $z$ - $\tau$  coordinates, possibly imputing dimensions with a projection.

The *z* and *tau* coordinates can be passed as a named argument.

**to\_xy**() → *VectorProtocolPlanar*

Converts to  $x$ - $y$  coordinates, possibly eliminating dimensions with a projection.



**to\_xyeta**(\* , eta: float | ndarray = 0.0) → *VectorProtocolSpatial*

Converts to  $x$ - $y$ - $\eta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *eta* coordinate can be passed as a named argument.

**to\_xyetat**(\* , eta: float | ndarray = 0.0, t: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $x$ - $y$ - $\eta$ - $t$  coordinates, possibly imputing dimensions with a projection.

The *eta* and *t* coordinates can be passed as a named argument.

**to\_xyetatau**(\* , eta: float | ndarray = 0.0, tau: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $x$ - $y$ - $\eta$ - $\tau$  coordinates, possibly imputing dimensions with a projection.

The *eta* and *tau* coordinates can be passed as a named argument.

**to\_xytheta**(\* , theta: float | ndarray = 0.0) → *VectorProtocolSpatial*

Converts to  $x$ - $y$ - $\theta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *theta* coordinate can be passed as a named argument.

**to\_xythetat**(\* , theta: float | ndarray = 0.0, t: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $x$ - $y$ - $\theta$ - $t$  coordinates, possibly imputing dimensions with a projection.

The *theta* and *t* coordinates can be passed as a named argument.

**to\_xythetatau**(\* , theta: float | ndarray = 0.0, tau: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $x$ - $y$ - $\theta$ - $\tau$  coordinates, possibly imputing dimensions with a projection.

The *theta* and *tau* coordinates can be passed as a named argument.

**to\_xyz**(\* , z: float | ndarray = 0.0) → *VectorProtocolSpatial*

Converts to  $x$ - $y$ - $z$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *z* coordinate can be passed as a named argument.

**to\_xyzt**(\* , z: float | ndarray = 0.0, t: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $x$ - $y$ - $z$ - $t$  coordinates, possibly imputing dimensions with a projection.

The *z* and *t* coordinates can be passed as a named argument.

**to\_xyztau**(\* , z: float | ndarray = 0.0, tau: float | ndarray = 0.0) → *VectorProtocolLorentz*

Converts to  $x$ - $y$ - $z$ - $\tau$  coordinates, possibly imputing dimensions with a projection.

The *z* and *tau* coordinates can be passed as a named argument.

**class** vector.\_methods.**Vector2D**(\* , x: float, y: float)

**class** vector.\_methods.**Vector2D**(\* , rho: float, phi: float)

**class** vector.\_methods.**Vector2D**(\* , x: float, y: float, z: float)

**class** vector.\_methods.**Vector2D**(\* , x: float, y: float, eta: float)

**class** vector.\_methods.**Vector2D**(\* , x: float, y: float, theta: float)

**class** vector.\_methods.**Vector2D**(\* , rho: float, phi: float, z: float)

**class** vector.\_methods.**Vector2D**(\* , rho: float, phi: float, eta: float)

**class** vector.\_methods.**Vector2D**(\* , rho: float, phi: float, theta: float)

**class** vector.\_methods.**Vector2D**(\* , px: float, py: float)

**class** vector.\_methods.**Vector2D**(\* , x: float, py: float)

**class** vector.\_methods.**Vector2D**(\* , px: float, y: float)

**class** vector.\_methods.**Vector2D**(\* , pt: float, phi: float)

**class** vector.\_methods.**Vector2D**(\* , x: float, y: float, pz: float)









```
class vector._methods.Vector2D(*, px: float, py: float, theta: float, m: float)
class vector._methods.Vector2D(*, rho: float, phi: float, theta: float, m: float)
class vector._methods.Vector2D(*, pm: float, phi: float, theta: float, m: float)
class vector._methods.Vector2D(*, x: float, y: float, eta: float, m: float)
class vector._methods.Vector2D(*, x: float, py: float, eta: float, m: float)
class vector._methods.Vector2D(*, px: float, y: float, eta: float, m: float)
class vector._methods.Vector2D(*, px: float, py: float, eta: float, m: float)
class vector._methods.Vector2D(*, rho: float, phi: float, eta: float, m: float)
class vector._methods.Vector2D(*, pm: float, phi: float, eta: float, m: float)
class vector._methods.Vector2D(*, x: float, y: float, z: float, mass: float)
class vector._methods.Vector2D(*, x: float, y: float, pz: float, mass: float)
class vector._methods.Vector2D(*, x: float, py: float, z: float, mass: float)
class vector._methods.Vector2D(*, x: float, py: float, pz: float, mass: float)
class vector._methods.Vector2D(*, px: float, y: float, z: float, mass: float)
class vector._methods.Vector2D(*, px: float, y: float, pz: float, mass: float)
class vector._methods.Vector2D(*, px: float, py: float, z: float, mass: float)
class vector._methods.Vector2D(*, px: float, py: float, pz: float, mass: float)
class vector._methods.Vector2D(*, rho: float, phi: float, z: float, mass: float)
class vector._methods.Vector2D(*, rho: float, phi: float, pz: float, mass: float)
class vector._methods.Vector2D(*, pt: float, phi: float, z: float, mass: float)
class vector._methods.Vector2D(*, pt: float, phi: float, pz: float, mass: float)
class vector._methods.Vector2D(*, x: float, y: float, theta: float, mass: float)
class vector._methods.Vector2D(*, x: float, py: float, theta: float, mass: float)
class vector._methods.Vector2D(*, px: float, y: float, theta: float, mass: float)
class vector._methods.Vector2D(*, px: float, py: float, theta: float, mass: float)
class vector._methods.Vector2D(*, rho: float, phi: float, theta: float, mass: float)
class vector._methods.Vector2D(*, pt: float, phi: float, theta: float, mass: float)
class vector._methods.Vector2D(*, x: float, y: float, eta: float, mass: float)
class vector._methods.Vector2D(*, x: float, py: float, eta: float, mass: float)
class vector._methods.Vector2D(*, px: float, y: float, eta: float, mass: float)
class vector._methods.Vector2D(*, px: float, py: float, eta: float, mass: float)
class vector._methods.Vector2D(*, rho: float, phi: float, eta: float, mass: float)
class vector._methods.Vector2D(*, pt: float, phi: float, eta: float, mass: float)
class vector._methods.Vector2D(__azumthal: Azimuthal)
class vector._methods.Vector2D(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector._methods.Vector2D(__azumthal: Azimuthal, __longitudinal: Longitudinal, __temporal:
    Temporal)
```

Bases: [Vector](#), [VectorProtocolPlanar](#)

[to\\_2D\(\)](#) → [VectorProtocolPlanar](#)

Alias for [vector.\\_methods.Vector2D.to\\_Vector2D\(\)](#).

[to\\_3D\(\\*\\*kwargs: float | None\)](#) → [VectorProtocolSpatial](#)

Alias for [vector.\\_methods.Vector2D.to\\_Vector3D\(\)](#).

**to\_4D**(\*\*kwargs: float | None) → *VectorProtocolLorentz*  
 Alias for `vector._methods.Vector2D.to_Vector4D()`.

**to\_Vector2D**() → *VectorProtocolPlanar*  
 Projects this vector/these vectors onto azimuthal coordinates only.

**to\_Vector3D**(\*, z: float | ndarray | None = None, pz: float | ndarray | None = None, theta: float | ndarray | None = None, eta: float | ndarray | None = None) → *VectorProtocolSpatial*  
 Converts a 2D vector to 3D vector.

The scalar longitudinal coordinate is broadcasted for NumPy and Awkward vectors. Only a single longitudinal coordinate should be provided.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject2D(x=1, y=2)
>>> vec.to_Vector3D(z=1)
VectorObject3D(x=1, y=2, z=1)
>>> vec = vector.MomentumObject2D(px=1, py=2)
>>> vec.to_Vector3D(pz=4)
MomentumObject3D(px=1, py=2, pz=4)
```

**to\_Vector4D**(\*, z: float | ndarray | None = None, pz: float | ndarray | None = None, theta: float | ndarray | None = None, eta: float | ndarray | None = None, t: float | ndarray | None = None, e: float | ndarray | None = None, E: float | ndarray | None = None, energy: float | ndarray | None = None, tau: float | ndarray | None = None, m: float | ndarray | None = None, M: float | ndarray | None = None, mass: float | ndarray | None = None) → *VectorProtocolLorentz*

Converts a 2D vector to 4D vector.

The scalar longitudinal and temporal coordinates are broadcasted for NumPy and Awkward vectors. Only a single longitudinal and temporal coordinate should be provided.

### Examples

```
>>> import vector
>>> vec = vector.VectorObject2D(x=1, y=2)
>>> vec.to_Vector4D(z=3, t=4)
VectorObject4D(x=1, y=2, z=3, t=4)
>>> vec = vector.MomentumObject2D(px=1, py=2)
>>> vec.to_Vector4D(pz=4, energy=4)
MomentumObject4D(px=1, py=2, pz=4, E=4)
```

```
class vector._methods.Vector3D(*, x: float, y: float)
class vector._methods.Vector3D(*, rho: float, phi: float)
class vector._methods.Vector3D(*, x: float, y: float, z: float)
class vector._methods.Vector3D(*, x: float, y: float, eta: float)
class vector._methods.Vector3D(*, x: float, y: float, theta: float)
class vector._methods.Vector3D(*, rho: float, phi: float, z: float)
class vector._methods.Vector3D(*, rho: float, phi: float, eta: float)
class vector._methods.Vector3D(*, rho: float, phi: float, theta: float)
```

```
class vector._methods.Vector3D(*, px: float, py: float)
class vector._methods.Vector3D(*, x: float, py: float)
class vector._methods.Vector3D(*, px: float, y: float)
class vector._methods.Vector3D(*, pt: float, phi: float)
class vector._methods.Vector3D(*, x: float, y: float, pz: float)
class vector._methods.Vector3D(*, x: float, py: float, z: float)
class vector._methods.Vector3D(*, x: float, py: float, pz: float)
class vector._methods.Vector3D(*, px: float, y: float, z: float)
class vector._methods.Vector3D(*, px: float, y: float, pz: float)
class vector._methods.Vector3D(*, px: float, py: float, z: float)
class vector._methods.Vector3D(*, px: float, py: float, pz: float)
class vector._methods.Vector3D(*, rho: float, phi: float, pz: float)
class vector._methods.Vector3D(*, pt: float, phi: float, z: float)
class vector._methods.Vector3D(*, pt: float, phi: float, pz: float)
class vector._methods.Vector3D(*, x: float, py: float, theta: float)
class vector._methods.Vector3D(*, px: float, y: float, theta: float)
class vector._methods.Vector3D(*, px: float, py: float, theta: float)
class vector._methods.Vector3D(*, pt: float, phi: float, theta: float)
class vector._methods.Vector3D(*, x: float, py: float, eta: float)
class vector._methods.Vector3D(*, px: float, y: float, eta: float)
class vector._methods.Vector3D(*, px: float, py: float, eta: float)
class vector._methods.Vector3D(*, pt: float, phi: float, eta: float)
class vector._methods.Vector3D(*, x: float, y: float, z: float, t: float)
class vector._methods.Vector3D(*, x: float, y: float, pz: float, t: float)
class vector._methods.Vector3D(*, x: float, py: float, z: float, t: float)
class vector._methods.Vector3D(*, x: float, py: float, pz: float, t: float)
class vector._methods.Vector3D(*, px: float, y: float, z: float, t: float)
class vector._methods.Vector3D(*, px: float, y: float, pz: float, t: float)
class vector._methods.Vector3D(*, px: float, py: float, z: float, t: float)
class vector._methods.Vector3D(*, px: float, py: float, pz: float, t: float)
class vector._methods.Vector3D(*, rho: float, phi: float, z: float, t: float)
class vector._methods.Vector3D(*, rho: float, phi: float, pz: float, t: float)
class vector._methods.Vector3D(*, pt: float, phi: float, z: float, t: float)
class vector._methods.Vector3D(*, pt: float, phi: float, pz: float, t: float)
class vector._methods.Vector3D(*, x: float, y: float, theta: float, t: float)
class vector._methods.Vector3D(*, x: float, py: float, theta: float, t: float)
class vector._methods.Vector3D(*, px: float, y: float, theta: float, t: float)
class vector._methods.Vector3D(*, px: float, py: float, theta: float, t: float)
class vector._methods.Vector3D(*, rho: float, phi: float, theta: float, t: float)
class vector._methods.Vector3D(*, pt: float, phi: float, theta: float, t: float)
class vector._methods.Vector3D(*, x: float, y: float, eta: float, t: float)
class vector._methods.Vector3D(*, x: float, py: float, eta: float, t: float)
class vector._methods.Vector3D(*, px: float, y: float, eta: float, t: float)
class vector._methods.Vector3D(*, px: float, py: float, eta: float, t: float)
```









```
class vector._methods.Vector3D(*, pm: float, phi: float, z: float, m: float)
class vector._methods.Vector3D(*, pm: float, phi: float, pz: float, m: float)
class vector._methods.Vector3D(*, x: float, y: float, theta: float, m: float)
class vector._methods.Vector3D(*, x: float, py: float, theta: float, m: float)
class vector._methods.Vector3D(*, px: float, y: float, theta: float, m: float)
class vector._methods.Vector3D(*, px: float, py: float, theta: float, m: float)
class vector._methods.Vector3D(*, rho: float, phi: float, theta: float, m: float)
class vector._methods.Vector3D(*, pm: float, phi: float, theta: float, m: float)
class vector._methods.Vector3D(*, x: float, y: float, eta: float, m: float)
class vector._methods.Vector3D(*, x: float, py: float, eta: float, m: float)
class vector._methods.Vector3D(*, px: float, y: float, eta: float, m: float)
class vector._methods.Vector3D(*, px: float, py: float, eta: float, m: float)
class vector._methods.Vector3D(*, rho: float, phi: float, eta: float, m: float)
class vector._methods.Vector3D(*, pm: float, phi: float, eta: float, m: float)
class vector._methods.Vector3D(*, x: float, y: float, z: float, mass: float)
class vector._methods.Vector3D(*, x: float, y: float, pz: float, mass: float)
class vector._methods.Vector3D(*, x: float, py: float, z: float, mass: float)
class vector._methods.Vector3D(*, x: float, py: float, pz: float, mass: float)
class vector._methods.Vector3D(*, px: float, y: float, z: float, mass: float)
class vector._methods.Vector3D(*, px: float, y: float, pz: float, mass: float)
class vector._methods.Vector3D(*, px: float, py: float, z: float, mass: float)
class vector._methods.Vector3D(*, px: float, py: float, pz: float, mass: float)
class vector._methods.Vector3D(*, rho: float, phi: float, z: float, mass: float)
class vector._methods.Vector3D(*, rho: float, phi: float, pz: float, mass: float)
class vector._methods.Vector3D(*, pt: float, phi: float, z: float, mass: float)
class vector._methods.Vector3D(*, pt: float, phi: float, pz: float, mass: float)
class vector._methods.Vector3D(*, x: float, y: float, theta: float, mass: float)
class vector._methods.Vector3D(*, x: float, py: float, theta: float, mass: float)
class vector._methods.Vector3D(*, px: float, y: float, theta: float, mass: float)
class vector._methods.Vector3D(*, px: float, py: float, theta: float, mass: float)
class vector._methods.Vector3D(*, rho: float, phi: float, theta: float, mass: float)
class vector._methods.Vector3D(*, pt: float, phi: float, theta: float, mass: float)
class vector._methods.Vector3D(*, x: float, y: float, eta: float, mass: float)
class vector._methods.Vector3D(*, x: float, py: float, eta: float, mass: float)
class vector._methods.Vector3D(*, px: float, y: float, eta: float, mass: float)
class vector._methods.Vector3D(*, px: float, py: float, eta: float, mass: float)
class vector._methods.Vector3D(*, rho: float, phi: float, eta: float, mass: float)
class vector._methods.Vector3D(*, pt: float, phi: float, eta: float, mass: float)
class vector._methods.Vector3D(__azumthal: Azimuthal)
class vector._methods.Vector3D(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector._methods.Vector3D(__azumthal: Azimuthal, __longitudinal: Longitudinal, __temporal:
    Temporal)
```

Bases: [Vector](#), [VectorProtocolSpatial](#)

**to\_2D()** → *VectorProtocolPlanar*

Alias for `vector._methods.Vector3D.to_Vector2D()`.

**to\_3D()** → *VectorProtocolSpatial*

Alias for `vector._methods.Vector3D.to_Vector3D()`.

**to\_4D(\*\*kwargs: float | None)** → *VectorProtocolLorentz*

Alias for `vector._methods.Vector3D.to_Vector4D()`.

**to\_Vector2D()** → *VectorProtocolPlanar*

Projects this vector/these vectors onto azimuthal coordinates only.

**to\_Vector3D()** → *VectorProtocolSpatial*

Projects this vector/these vectors onto azimuthal and longitudinal coordinates only.

If 2D, a default  $z$  component of 0 is imputed.

The longitudinal coordinate can be passed as a named argument.

**to\_Vector4D(\*, t: float | ndarray | None = None, e: float | ndarray | None = None, E: float | ndarray | None = None, energy: float | ndarray | None = None, tau: float | ndarray | None = None, m: float | ndarray | None = None, M: float | ndarray | None = None, mass: float | ndarray | None = None)** → *VectorProtocolLorentz*

Converts a 3D vector to 4D vector.

The scalar temporal coordinate are broadcasted for NumPy and Awkward vectors. Only a single temporal coordinate should be provided.

## Examples

```
>>> import vector
>>> vec = vector.VectorObject3D(x=1, y=2, z=3)
>>> vec.to_Vector4D(t=4)
VectorObject4D(x=1, y=2, z=3, t=4)
>>> vec = vector.MomentumObject3D(px=1, py=2, pz=3)
>>> vec.to_Vector4D(M=4)
MomentumObject4D(px=1, py=2, pz=3, mass=4)
```

```
class vector._methods.Vector4D(*, x: float, y: float)
class vector._methods.Vector4D(*, rho: float, phi: float)
class vector._methods.Vector4D(*, x: float, y: float, z: float)
class vector._methods.Vector4D(*, x: float, y: float, eta: float)
class vector._methods.Vector4D(*, x: float, y: float, theta: float)
class vector._methods.Vector4D(*, rho: float, phi: float, z: float)
class vector._methods.Vector4D(*, rho: float, phi: float, eta: float)
class vector._methods.Vector4D(*, rho: float, phi: float, theta: float)
class vector._methods.Vector4D(*, px: float, py: float)
class vector._methods.Vector4D(*, x: float, py: float)
class vector._methods.Vector4D(*, px: float, y: float)
class vector._methods.Vector4D(*, pt: float, phi: float)
class vector._methods.Vector4D(*, x: float, y: float, pz: float)
class vector._methods.Vector4D(*, x: float, py: float, z: float)
```











```
class vector._methods.Vector4D(*, rho: float, phi: float, theta: float, m: float)
class vector._methods.Vector4D(*, pm: float, phi: float, theta: float, m: float)
class vector._methods.Vector4D(*, x: float, y: float, eta: float, m: float)
class vector._methods.Vector4D(*, x: float, py: float, eta: float, m: float)
class vector._methods.Vector4D(*, px: float, y: float, eta: float, m: float)
class vector._methods.Vector4D(*, px: float, py: float, eta: float, m: float)
class vector._methods.Vector4D(*, rho: float, phi: float, eta: float, m: float)
class vector._methods.Vector4D(*, pm: float, phi: float, eta: float, m: float)
class vector._methods.Vector4D(*, x: float, y: float, z: float, mass: float)
class vector._methods.Vector4D(*, x: float, y: float, pz: float, mass: float)
class vector._methods.Vector4D(*, x: float, py: float, z: float, mass: float)
class vector._methods.Vector4D(*, x: float, py: float, pz: float, mass: float)
class vector._methods.Vector4D(*, px: float, y: float, z: float, mass: float)
class vector._methods.Vector4D(*, px: float, y: float, pz: float, mass: float)
class vector._methods.Vector4D(*, px: float, py: float, z: float, mass: float)
class vector._methods.Vector4D(*, px: float, py: float, pz: float, mass: float)
class vector._methods.Vector4D(*, rho: float, phi: float, z: float, mass: float)
class vector._methods.Vector4D(*, rho: float, phi: float, pz: float, mass: float)
class vector._methods.Vector4D(*, pt: float, phi: float, z: float, mass: float)
class vector._methods.Vector4D(*, pt: float, phi: float, pz: float, mass: float)
class vector._methods.Vector4D(*, x: float, y: float, theta: float, mass: float)
class vector._methods.Vector4D(*, x: float, py: float, theta: float, mass: float)
class vector._methods.Vector4D(*, px: float, y: float, theta: float, mass: float)
class vector._methods.Vector4D(*, px: float, py: float, theta: float, mass: float)
class vector._methods.Vector4D(*, rho: float, phi: float, theta: float, mass: float)
class vector._methods.Vector4D(*, pt: float, phi: float, theta: float, mass: float)
class vector._methods.Vector4D(*, x: float, y: float, eta: float, mass: float)
class vector._methods.Vector4D(*, x: float, py: float, eta: float, mass: float)
class vector._methods.Vector4D(*, px: float, y: float, eta: float, mass: float)
class vector._methods.Vector4D(*, px: float, py: float, eta: float, mass: float)
class vector._methods.Vector4D(*, rho: float, phi: float, eta: float, mass: float)
class vector._methods.Vector4D(*, pt: float, phi: float, eta: float, mass: float)
class vector._methods.Vector4D(__azumthal: Azimuthal)
class vector._methods.Vector4D(__azumthal: Azimuthal, __longitudinal: Longitudinal)
class vector._methods.Vector4D(__azumthal: Azimuthal, __longitudinal: Longitudinal, __temporal:
    Temporal)
```

Bases: [Vector](#), [VectorProtocolLorentz](#)

[to\\_2D\(\)](#) → [VectorProtocolPlanar](#)

Alias for [vector.\\_methods.Vector4D.to\\_Vector2D\(\)](#).

[to\\_3D\(\)](#) → [VectorProtocolSpatial](#)

Alias for [vector.\\_methods.Vector4D.to\\_Vector3D\(\)](#).

[to\\_4D\(\)](#) → [VectorProtocolLorentz](#)

Alias for [vector.\\_methods.Vector4D.to\\_Vector4D\(\)](#).

**to\_Vector2D()** → *VectorProtocolPlanar*

Projects this vector/these vectors onto azimuthal coordinates only.

**to\_Vector3D()** → *VectorProtocolSpatial*

Projects this vector/these vectors onto azimuthal and longitudinal coordinates only.

If 2D, a default  $z$  component of 0 is imputed.

The longitudinal coordinate can be passed as a named argument.

**to\_Vector4D()** → *VectorProtocolLorentz*

Projects this vector/these vectors onto azimuthal, longitudinal, and temporal coordinates.

If 3D, a default  $t$  component of 0 is imputed.

If 2D, a  $z$  component of 0 is imputed along with a default  $t$  component of 0.

The longitudinal and temporal coordinates can be passed as named arguments.

**class** vector.\_methods.**VectorProtocol**

Bases: object

**lib**

The module used for functions used in compute functions (such as `sqrt`, `sin`, `cos`). Usually `numpy`.

**Type**

module

**ProjectionClass2D**

The class that would result from projecting this vector onto azimuthal coordinates only.

**Type**

type

**ProjectionClass3D**

The class that would result from projecting this vector onto azimuthal and longitudinal coordinates only.

**Type**

type

**ProjectionClass4D**

The class that would result from projecting this vector onto azimuthal, longitudinal, and temporal coordinates.

**Type**

type

**GenericClass**

The most generic concrete class for this type, for vectors without momentum-synonyms.

**Type**

type

**MomentumClass**

The momentum class for this type, for vectors with momentum-synonyms.

**Type**

type

**GenericClass:** type[*VectorProtocol*]

**MomentumClass:** `type[VectorProtocol]`

**ProjectionClass2D:** `type[VectorProtocolPlanar]`

**ProjectionClass3D:** `type[VectorProtocolSpatial]`

**ProjectionClass4D:** `type[VectorProtocolLorentz]`

**\_wrap\_result**(*cls: Any, result: Any, returns: Any, num\_vecargs: Any*)  $\rightarrow$  Any

#### Parameters

- **result** – Value or tuple of values from a compute function.
- **returns** – Signature from a `dispatch_map`.
- **num\_vecargs** (*int*) – Number of vector arguments in the function that would be treated on an equal footing (i.e. `add` has two, but `rotate_axis` has only one: the axis is secondary).

Wraps the raw result of a compute function as a scalar, an array of scalars, a vector, or an array of vectors.

**add**(*other: VectorProtocol*)  $\rightarrow$  *VectorProtocol*

Sum of `self` and `other`.

This method is equivalent to the `+` operator.

**dot**(*other: VectorProtocol*)  $\rightarrow$  Any

Vector dot product of `self` with `other`.

This method is equivalent to the `@` operator.

**equal**(*other: VectorProtocol*)  $\rightarrow$  Any

Returns True if `self` is exactly equal to `other` (possibly for arrays of vectors), False otherwise.

This method is equivalent to the `==` operator.

Typically, you'll want to check `vector._methods.VectorProtocol.isclose()` to allow for numerical errors.

**isclose**(*other: VectorProtocol, rtol: Any = 1e-05, atol: Any = 1e-08, equal\_nan: Any = False*)  $\rightarrow$  Any

Returns True if `self` is approximately equal to `other` (possibly for arrays of vectors), False otherwise.

The relative tolerance (`rtol`) and absolute tolerance (`atol`) are interpreted as in `np.isclose`:

```
close_enough = abs(self - other) <= atol + rtol * abs(other)
```

**property lib:** Any

**like**(*other: VectorProtocol*)  $\rightarrow$  *VectorProtocol*

Projects the vector into the geometric coordinates of the *other* vector.

Value(s) of 0 is/are imputed while transforming vector from a lower geometric dimension to a higher geometric dimension.

```
vec_4d + vec_3d.like(vec_4d)
```

For more flexibility (passing new coordinate values), see `vector._methods.Vector2D.to_Vector3D()`, `vector._methods.Vector2D.to_Vector4D()`, and `vector._methods.Vector3D.to_Vector4D()`, which can be used as:

```
vec_2d.to_Vector3D(z=3.0)
vec_2d.to_Vector4D(z=3.0, t=4.0)
vec_3d.to_Vector4D(t=4.0)
```

**not\_equal**(*other*: [VectorProtocol](#)) → Any

Returns False if **self** is exactly equal to **other** (possibly for arrays of vectors), True otherwise.

This method is equivalent to the `!=` operator.

Typically, you'll want to check [vector.\\_methods.VectorProtocol.isclose\(\)](#) to allow for numerical errors.

**scale**(*factor*: Any) → SameVectorType

Returns vector(s) scaled by a **factor**, changing the length(s) but not the direction(s).

This method is equivalent to the `*` operator.

**subtract**(*other*: [VectorProtocol](#)) → [VectorProtocol](#)

Difference of **self** minus **other**.

This method is equivalent to the `-` operator.

**to\_2D**() → [VectorProtocolPlanar](#)

Projects this vector/these vectors onto azimuthal coordinates only.

Alias for [vector.\\_methods.VectorProtocol.to\\_Vector2D\(\)](#).

**to\_3D**() → [VectorProtocolSpatial](#)

Projects this vector/these vectors onto azimuthal and longitudinal coordinates only.

If 2D, a default  $z$  component of 0 is imputed.

The longitudinal coordinate can be passed as a named argument.

Alias for [vector.\\_methods.VectorProtocol.to\\_Vector3D\(\)](#).

**to\_4D**() → [VectorProtocolLorentz](#)

Projects this vector/these vectors onto azimuthal, longitudinal, and temporal coordinates.

If 3D, a default  $t$  component of 0 is imputed.

If 2D, a  $z$  component of 0 is imputed along with a default  $t$  component of 0.

The longitudinal and temporal coordinates can be passed as named arguments.

Alias for [vector.\\_methods.VectorProtocol.to\\_Vector4D\(\)](#).

**to\_Vector2D**() → [VectorProtocolPlanar](#)

Projects this vector/these vectors onto azimuthal coordinates only.

**to\_Vector3D**() → [VectorProtocolSpatial](#)

Projects this vector/these vectors onto azimuthal and longitudinal coordinates only.

If 2D, a default  $z$  component of 0 is imputed.

The longitudinal coordinate can be passed as a named argument.

**to\_Vector4D**() → [VectorProtocolLorentz](#)

Projects this vector/these vectors onto azimuthal, longitudinal, and temporal coordinates.

If 3D, a default  $t$  component of 0 is imputed.

If 2D, a  $z$  component of 0 is imputed along with a default  $t$  component of 0.

The longitudinal and temporal coordinates can be passed as named arguments.

**to\_ptphi()** → *VectorProtocolPlanar*

Converts to  $pt$ - $\phi$  coordinates, possibly eliminating dimensions with a projection.

**to\_ptphieta()** → *VectorProtocolSpatial*

Converts to  $pt$ - $\phi$ - $\eta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *eta* coordinate can be passed as a named argument.

**to\_ptphietaenergy()** → *VectorProtocolLorentz*

Converts to  $pt$ - $\phi$ - $\eta$ -*energy* coordinates, possibly imputing dimensions with a projection.

The *eta* and *energy* coordinates can be passed as a named argument.

**to\_ptphietamass()** → *VectorProtocolLorentz*

Converts to  $pt$ - $\phi$ - $\theta$ -*mass* coordinates, possibly imputing dimensions with a projection.

The *eta* and *mass* coordinates can be passed as a named argument.

**to\_ptphipz()** → *VectorProtocolSpatial*

Converts to  $pt$ - $\phi$ - $pz$  coordinates, possibly eliminating or imputing dimensions with a projection.

The  $pz$  coordinate can be passed as a named argument.

**to\_ptphipzenergy()** → *VectorProtocolLorentz*

Converts to  $pt$ - $\phi$ - $pz$ -*energy* coordinates, possibly imputing dimensions with a projection.

The  $pz$  and *energy* coordinates can be passed as a named argument.

**to\_ptphipzmass()** → *VectorProtocolLorentz*

Converts to  $pt$ - $\phi$ - $pz$ -*mass* coordinates, possibly imputing dimensions with a projection.

The  $pz$  and *mass* coordinates can be passed as a named argument.

**to\_ptphiitheta()** → *VectorProtocolSpatial*

Converts to  $pt$ - $\phi$ - $\theta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *theta* coordinate can be passed as a named argument.

**to\_ptphiithetaenergy()** → *VectorProtocolLorentz*

Converts to  $pt$ - $\phi$ - $\theta$ -*energy* coordinates, possibly imputing dimensions with a projection.

The *theta* and *energy* coordinates can be passed as a named argument.

**to\_ptphiithetamass()** → *VectorProtocolLorentz*

Converts to  $pt$ - $\phi$ - $\theta$ -*mass* coordinates, possibly imputing dimensions with a projection.

The *theta* and *mass* coordinates can be passed as a named argument.

**to\_pxpy()** → *VectorProtocolPlanar*

Converts to  $px$ - $py$  coordinates, possibly eliminating dimensions with a projection.

**to\_pxpyeta()** → *VectorProtocolSpatial*

Converts to  $px$ - $py$ - $\eta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *eta* coordinate can be passed as a named argument.

**to\_pxpyetaenergy()** → *VectorProtocolLorentz*

Converts to  $px$ - $py$ - $\eta$ -*energy* coordinates, possibly imputing dimensions with a projection.

The *eta* and *energy* coordinates can be passed as a named argument.

**to\_pxpyetamass()** → *VectorProtocolLorentz*

Converts to  $px$ - $py$ - $\eta$ - $mass$  coordinates, possibly imputing dimensions with a projection.

The  $\eta$  and  $mass$  coordinates can be passed as a named argument.

**to\_pxpypz()** → *VectorProtocolSpatial*

Converts to  $px$ - $py$ - $pz$  coordinates, possibly eliminating or imputing dimensions with a projection.

The  $pz$  coordinate can be passed as a named argument.

**to\_pxpypzenergy()** → *VectorProtocolLorentz*

Converts to  $px$ - $py$ - $pz$ - $energy$  coordinates, possibly imputing dimensions with a projection.

The  $pz$  and  $energy$  coordinates can be passed as a named argument.

**to\_pxpypzmass()** → *VectorProtocolLorentz*

Converts to  $px$ - $py$ - $pz$ - $mass$  coordinates, possibly imputing dimensions with a projection.

The  $pz$  and  $mass$  coordinates can be passed as a named argument.

**to\_pxpytheta()** → *VectorProtocolSpatial*

Converts to  $px$ - $py$ - $\theta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The  $\theta$  coordinate can be passed as a named argument.

**to\_pxpythetaenergy()** → *VectorProtocolLorentz*

Converts to  $px$ - $py$ - $\theta$ - $energy$  coordinates, possibly imputing dimensions with a projection.

The  $\theta$  and  $energy$  coordinates can be passed as a named argument.

**to\_pxpythetamass()** → *VectorProtocolLorentz*

Converts to  $px$ - $py$ - $\theta$ - $energy$  coordinates, possibly imputing dimensions with a projection.

The  $\theta$  and  $mass$  coordinates can be passed as a named argument.

**to\_rhophi()** → *VectorProtocolPlanar*

Converts to  $\rho$ - $\phi$  coordinates, possibly eliminating dimensions with a projection.

**to\_rhophieta()** → *VectorProtocolSpatial*

Converts to  $\rho$ - $\phi$ - $\eta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The  $\eta$  coordinate can be passed as a named argument.

**to\_rhophietat()** → *VectorProtocolLorentz*

Converts to  $\rho$ - $\phi$ - $\eta$ - $t$  coordinates, possibly imputing dimensions with a projection.

The  $\eta$  and  $t$  coordinates can be passed as a named argument.

**to\_rhophietau()** → *VectorProtocolLorentz*

Converts to  $\rho$ - $\phi$ - $\eta$ - $\tau$  coordinates, possibly imputing dimensions with a projection.

The  $\eta$  and  $\tau$  coordinates can be passed as a named argument.

**to\_rhophihtheta()** → *VectorProtocolSpatial*

Converts to  $\rho$ - $\phi$ - $\theta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The  $\theta$  coordinate can be passed as a named argument.

**to\_rhophihetat()** → *VectorProtocolLorentz*

Converts to  $\rho$ - $\phi$ - $\theta$ - $t$  coordinates, possibly imputing dimensions with a projection.

The  $\theta$  and  $t$  coordinates can be passed as a named argument.

**to\_rhophithetatau()** → *VectorProtocolLorentz*

Converts to  $\rho$ - $\phi$ - $\theta$ - $\tau$  coordinates, possibly imputing dimensions with a projection.

The *theta* and *tau* coordinates can be passed as a named argument.

**to\_rhophiz()** → *VectorProtocolSpatial*

Converts to  $\rho$ - $\phi$ - $z$  coordinates, possibly eliminating or imputing dimensions with a projection.

The  $z$  coordinate can be passed as a named argument.

**to\_rhophizt()** → *VectorProtocolLorentz*

Converts to  $\rho$ - $\phi$ - $z$ - $t$  coordinates, possibly imputing dimensions with a projection.

The  $z$  and  $t$  coordinates can be passed as a named argument.

**to\_rhophiztau()** → *VectorProtocolLorentz*

Converts to  $\rho$ - $\phi$ - $z$ - $\tau$  coordinates, possibly imputing dimensions with a projection.

The  $z$  and *tau* coordinates can be passed as a named argument.

**to\_xy()** → *VectorProtocolPlanar*

Converts to  $x$ - $y$  coordinates, possibly eliminating dimensions with a projection.

**to\_xyeta()** → *VectorProtocolSpatial*

Converts to  $x$ - $y$ - $\eta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *eta* coordinate can be passed as a named argument.

**to\_xyetat()** → *VectorProtocolLorentz*

Converts to  $x$ - $y$ - $\eta$ - $t$  coordinates, possibly imputing dimensions with a projection.

The *eta* and  $t$  coordinates can be passed as a named argument.

**to\_xyetatau()** → *VectorProtocolLorentz*

Converts to  $x$ - $y$ - $\eta$ - $\tau$  coordinates, possibly imputing dimensions with a projection.

The *eta* and *tau* coordinates can be passed as a named argument.

**to\_xytheta()** → *VectorProtocolSpatial*

Converts to  $x$ - $y$ - $\theta$  coordinates, possibly eliminating or imputing dimensions with a projection.

The *theta* coordinate can be passed as a named argument.

**to\_xythetat()** → *VectorProtocolLorentz*

Converts to  $x$ - $y$ - $\theta$ - $t$  coordinates, possibly imputing dimensions with a projection.

The *theta* and  $t$  coordinates can be passed as a named argument.

**to\_xythetatau()** → *VectorProtocolLorentz*

Converts to  $x$ - $y$ - $\theta$ - $\tau$  coordinates, possibly imputing dimensions with a projection.

The *theta* and *tau* coordinates can be passed as a named argument.

**to\_xyz()** → *VectorProtocolSpatial*

Converts to  $x$ - $y$ - $z$  coordinates, possibly eliminating or imputing dimensions with a projection.

The  $z$  coordinate can be passed as a named argument.

**to\_xyzt()** → *VectorProtocolLorentz*

Converts to  $x$ - $y$ - $z$ - $t$  coordinates, possibly imputing dimensions with a projection.

The  $z$  and  $t$  coordinates can be passed as a named argument.



**to\_xyztau()** → *VectorProtocolLorentz*

Converts to  $x$ - $y$ - $z$ - $\tau$  coordinates, possibly imputing dimensions with a projection.

The  $z$  and  $\tau$  coordinates can be passed as a named argument.

**unit()** → SameVectorType

Returns vector(s) normalized to unit length, which is  $\rho == 1$  for 2D vectors,  $\text{mag} == 1$  for 3D vectors, and  $\tau == 1$  for 4D vectors.

**class** `vector._methods.VectorProtocolLorentz`

Bases: *VectorProtocolSpatial*

**property** `beta`: Any

The speed(s) of the Lorentz vector or array of vectors, in which lightlike vectors have `beta == 1`.

**boost**(*booster*: *VectorProtocolSpatial* | *VectorProtocolLorentz*) → SameVectorType

Boosts the vector or array of vectors using the 3D or 4D booster.

If `booster` is 3D, it is interpreted as a velocity (in which lightlike velocities have `mag == 1`) and `vector._methods.VectorProtocolLorentz.boost_beta3()` is called.

If `booster` is 4D, it is interpreted as a Lorentz vector and `vector._methods.VectorProtocolLorentz.boost_p4()` is called.

Note that `v.boost(v)` does not boost into the center-of-mass (CM) frame of `v`; it boosts *away* from its CM frame. Neither does `v.boost(-v)`, since that negates the time component of `v` as well.

To boost to the center-of-mass frame of a vector `v`, use `vector._methods.VectorProtocolLorentz.boostCM_of()`. For instance, `v.boostCM_of(v)` is guaranteed to have spatial components close to zero and a temporal component close to `v.tau`.

**boostCM\_of**(*booster*: *VectorProtocolSpatial* | *VectorProtocolLorentz*) → SameVectorType

Boosts the vector or array of vectors to the center-of-mass (CM) frame of the 3D or 4D booster.

If `booster` is 3D, it is interpreted as a velocity (in which lightlike velocities have `mag == 1`) and `vector._methods.VectorProtocolLorentz.boostCM_of_beta3()` is called.

If `booster` is 4D, it is interpreted as a Lorentz vector and `vector._methods.VectorProtocolLorentz.boostCM_of_p4()` is called.

Note that `v.boostCM_of(v)` is guaranteed to have spatial components close to zero and a temporal component close to `v.tau`.

**boostCM\_of\_beta3**(*beta3*: *VectorProtocolSpatial*) → SameVectorType

Boosts the vector or array of vectors to the center-of-mass (CM) frame of the 3D velocity or array of velocity vectors `beta3`.

Note that `v.boostCM_of_beta3(v.to_beta3())` is guaranteed to have spatial components close to zero and a temporal component close to `v.tau`.

**boostCM\_of\_p4**(*p4*: *VectorProtocolLorentz*) → SameVectorType

Boosts the vector or array of vectors to the center-of-mass (CM) frame of the 4D vector or array of vectors `p4`.

This function is equivalent to but more numerically stable than

```
boostCM_of_beta3(p4.to_beta3())
```

Note that `v.boostCM_of_p4(v)` is guaranteed to have spatial components close to zero and a temporal component close to `v.tau`.

**boostX**(*beta*: Any | None = None, *gamma*: Any | None = None) → SameVectorType

Boosts the vector or array of vectors in the  $x$  direction by a speed *beta* (in which lightlike boosts have *beta* == 1) or time dilation/length contraction factor *gamma*.

Either *beta* xor *gamma* must be specified, not both or neither.

If *beta* or *gamma* is negative, it is taken as a boost in the  $-x$  direction.

**boostY**(*beta*: Any | None = None, *gamma*: Any | None = None) → SameVectorType

Boosts the vector or array of vectors in the  $y$  direction by a speed *beta* (in which lightlike boosts have *beta* == 1) or time dilation/length contraction factor *gamma*.

Either *beta* xor *gamma* must be specified, not both or neither.

If *beta* or *gamma* is negative, it is taken as a boost in the  $-y$  direction.

**boostZ**(*beta*: Any | None = None, *gamma*: Any | None = None) → SameVectorType

Boosts the vector or array of vectors in the  $z$  direction by a speed *beta* (in which lightlike boosts have *beta* == 1) or time dilation/length contraction factor *gamma*.

Either *beta* xor *gamma* must be specified, not both or neither.

If *beta* or *gamma* is negative, it is taken as a boost in the  $-z$  direction.

**boost\_beta3**(*beta3*: VectorProtocolSpatial) → SameVectorType

Boosts the vector or array of vectors in a direction and magnitude given by the 3D velocity or array of velocity vectors *beta3*.

Note that *v*.boost\_beta3(*v*.to\_beta3()) does not boost into the center-of-mass (CM) frame of *v*; it boosts *away* from its CM frame. Neither does *v*.boost\_beta3((-*v*).to\_beta3()), since that negates the time component of *v* as well. On the other hand, *v*.boost\_beta3(-(v.to\_beta3())) *would* boost to the center-of-mass frame.

However, there's a function for that: [vector.\\_methods.VectorProtocolLorentz.boostCM\\_of\\_beta3\(\)](#) is explicit about boosting to a center-of-mass (CM) frame and it handles the negative sign for you: *v*.boostCM\_of\_beta3(*v*.to\_beta3()) is guaranteed to have spatial components close to zero and a temporal component close to *v*.tau.

**boost\_p4**(*p4*: VectorProtocolLorentz) → SameVectorType

Boosts the vector or array of vectors in a direction and magnitude given by the 4D vector or array of vectors *p4*.

This function is equivalent to but more numerically stable than

```
boost_beta3(p4.to_beta3())
```

where [vector.\\_methods.VectorProtocolLorentz.to\\_beta3\(\)](#) converts a 4D Lorentz vector into a 3D velocity (in which lightlike velocities have mag == 1).

Note that *v*.boost\_p4(*v*) does not boost into the center-of-mass (CM) frame of *v*; it boosts *away* from its CM frame. Neither does *v*.boost\_p4(-*v*), since that negates the time component of *v* as well.

To boost to the center-of-mass frame of a vector *v*, use [vector.\\_methods.VectorProtocolLorentz.boostCM\\_of\\_p4\(\)](#). For instance, *v*.boostCM\_of\_p4(*v*) is guaranteed to have spatial components close to zero and a temporal component close to *v*.tau.

**deltaRapidityPhi**(*other*: VectorProtocolLorentz) → Any

Sum in quadrature of [vector.\\_methods.VectorProtocolPlanar.deltaphi\(\)](#) and the difference in [vector.\\_methods.VectorProtocolLorentz.rapidity](#) of the two vectors:

$$\Delta R_{\text{rapidity}} = \sqrt{\Delta\phi^2 + \Delta\text{rapidity}^2}$$

**deltaRapidityPhi2**(*other*: `VectorProtocolLorentz`) → Any

Square of the sum in quadrature of `vector._methods.VectorProtocolPlanar.deltaphi()` and the difference in `vector._methods.VectorProtocolLorentz.rapidity` of the two vectors:

$$\Delta R_{\text{rapidity}} = \Delta\phi^2 + \Delta\text{rapidity}^2$$

**property gamma**: Any

The time dilation/length contraction factor(s) of the Lorentz vector or array of vectors:  $t/\tau$ .

**is\_lightlike**(*tolerance*: Any = 1e-05) → Any

Returns True if the vector or a vector in the array is pointing in a lightlike direction,  $t^2 == \text{mag}^2$ , False otherwise.

The tolerance is in units of  $t$  and  $\text{mag}$ . Note that

- the default tolerance for `vector._methods.VectorProtocolLorentz.is_timelike()` is 0
- the default tolerance for `vector._methods.VectorProtocolLorentz.is_spacelike()` is 0
- the default tolerance for `vector._methods.VectorProtocolLorentz.is_lightlike()` is 1e-5

If you want to use these methods to divide space-time into non-overlapping regions (the light-cone), use the same tolerance for each.

**is\_spacelike**(*tolerance*: Any = 0) → Any

Returns True if the vector or a vector in the array is pointing in a spacelike direction,  $t^2 < \text{mag}^2$ , False otherwise.

The tolerance is in units of  $t$  and  $\text{mag}$ . Note that

- the default tolerance for `vector._methods.VectorProtocolLorentz.is_timelike()` is 0
- the default tolerance for `vector._methods.VectorProtocolLorentz.is_spacelike()` is 0
- the default tolerance for `vector._methods.VectorProtocolLorentz.is_lightlike()` is 1e-5

If you want to use these methods to divide space-time into non-overlapping regions (the light-cone), use the same tolerance for each.

**is\_timelike**(*tolerance*: Any = 0) → Any

Returns True if the vector or a vector in the array is pointing in a timelike direction,  $t^2 > \text{mag}^2$ , False otherwise.

The tolerance is in units of  $t$  and  $\text{mag}$ . Note that

- the default tolerance for `vector._methods.VectorProtocolLorentz.is_timelike()` is 0
- the default tolerance for `vector._methods.VectorProtocolLorentz.is_spacelike()` is 0
- the default tolerance for `vector._methods.VectorProtocolLorentz.is_lightlike()` is 1e-5

If you want to use these methods to divide space-time into non-overlapping regions (the light-cone), use the same tolerance for each.

**property neg4D: SameVectorType**

Same as multiplying by -1.

**property rapidity: Any**

The rapidity relative to the longitudinal axis of the Lorentz vector or array of vectors.

```
0.5 * log((t + z) / (t - z))
```

**scale4D**(factor: Any) → SameVectorType

Same as scale.

**property t: Any**

The Cartesian  $t$  (time) coordinate of the vector or every vector in the array.

If  $t$  is derived from  $\tau$ , it is not allowed to be NaN.

```
t = sqrt(max(copysign(tau**2, tau) + mag**2, 0))
```

**property t2: Any**

The Cartesian  $t$  (time) coordinate squared of the vector or every vector in the array.

If  $t^2$  is derived from  $\tau$ , it is not allowed to be negative.

```
t2 = max(copysign(tau**2, tau) + mag**2, 0)
```

**property tau: Any**

The Lorentz magnitude  $\tau$  (proper time) of the vector or every vector in the array.

If  $\tau$  is derived from  $t$ , spacelike vectors are represented by negative proper times.

```
tau = copysign(sqrt(abs(t**2 - mag**2)), t**2 - mag**2)
```

**property tau2: Any**

The Lorentz magnitude  $\tau$  (proper time) squared of the vector or every vector in the array.

```
tau2 = t**2 - mag**2
```

**property temporal: Temporal**

Container of temporal coordinates, for use in dispatching to compute functions or to identify coordinate system with `isinstance`.

**to\_beta3()** → *VectorProtocolSpatial*

Converts the 4D Lorentz vector or array of vectors into a 3D velocity vector or array of vectors, in which lightlike velocities have `mag == 1`.

**transform4D**(obj: TransformProtocol4D) → SameVectorType

Arbitrarily transforms the vector(s) by

```
obj["xx"] obj["xy"] obj["xz"] obj["xt"]
obj["yx"] obj["yy"] obj["yz"] obj["yt"]
obj["zx"] obj["zy"] obj["zz"] obj["zt"]
obj["tx"] obj["ty"] obj["tz"] obj["tt"]
```

There is no restriction on the type of `obj`; it just has to provide those components (which can be arrays if the vectors are in an array).

**class** `vector._methods.VectorProtocolPlanar`

Bases: `VectorProtocol`

**property** `azimuthal`: `Azimuthal`

Container of azimuthal coordinates, for use in dispatching to compute functions or to identify coordinate system with `isinstance`.

**deltaphi**(*other*: `VectorProtocol`)  $\rightarrow$  Any

Signed difference in  $\phi$  of `self` minus `other` (in radians).

**is\_antiparallel**(*other*: `VectorProtocol`, *tolerance*: Any =  $1e-05$ )  $\rightarrow$  Any

Returns True if `self` and `other` are pointing in opposite directions (i.e. dot product is nearly  $-\text{abs}(\text{self}) * \text{abs}(\text{other})$ ).

The tolerance is measured in units of  $\cos(\Delta\alpha)$  where  $\Delta\alpha$  is `self.deltaangle(other)`.

**is\_parallel**(*other*: `VectorProtocol`, *tolerance*: Any =  $1e-05$ )  $\rightarrow$  Any

Returns True if `self` and `other` are pointing in the same direction (i.e. not “antiparallel”; dot product is nearly  $\text{abs}(\text{self}) * \text{abs}(\text{other})$ ).

The tolerance is measured in units of  $\cos(\Delta\alpha)$  where  $\Delta\alpha$  is `self.deltaangle(other)`.

**is\_perpendicular**(*other*: `VectorProtocol`, *tolerance*: Any =  $1e-05$ )  $\rightarrow$  Any

Returns True if `self` and `other` are pointing in perpendicular directions (i.e. dot product is nearly 0).

The tolerance is measured in units of  $\cos(\Delta\alpha)$  where  $\Delta\alpha$  is `self.deltaangle(other)`.

**property** `neg2D`: `SameVectorType`

Returns vector(s) with the 2D part negated, not affecting any longitudinal or temporal parts.

**property** `phi`: Any

The polar  $\phi$  coordinate of the vector or every vector in the array (in radians, always between  $-\pi$  and  $\pi$ ).

**property** `rho`: Any

The polar  $\rho$  coordinate of the vector or every vector in the array.

This is also the magnitude of the 2D azimuthal part of the vector (not including any longitudinal or temporal parts).

**property** `rho2`: Any

The polar  $\rho$  coordinate squared of the vector or every vector in the array.

**rotateZ**(*angle*: Any)  $\rightarrow$  `SameVectorType`

Rotates the vector(s) by a given `angle` (in radians) around the longitudinal axis.

Note that the `angle` can be an array with the same length as the vectors, if the vectors are in an array.

**scale2D**(*factor*: Any)  $\rightarrow$  `SameVectorType`

Returns vector(s) with the 2D part scaled by a `factor`, not affecting any longitudinal or temporal parts.

**transform2D**(*obj*: `TransformProtocol2D`)  $\rightarrow$  `SameVectorType`

Arbitrarily transforms the vector(s) by

```
obj["xx"]  obj["xy"]
obj["yx"]  obj["yy"]
```

leaving any longitudinal or temporal coordinates unchanged. There is no restriction on the type of `obj`; it just has to provide those components (which can be arrays if the vectors are in an array).

**property x: Any**

The Cartesian  $x$  coordinate of the vector or every vector in the array.

**property y: Any**

The Cartesian  $y$  coordinate of the vector or every vector in the array.

**class vector.\_methods.VectorProtocolSpatial**

Bases: [\*VectorProtocolPlanar\*](#)

**property costheta: Any**

The  $\cos \theta$  coordinate of the vector or every vector in the array (has the same sign as  $z$ ).

**property cottheta: Any**

The  $\cot \theta$  coordinate of the vector or every vector in the array (has the same sign as  $z$ ).

**cross(other: VectorProtocolSpatial) → VectorProtocolSpatial**

The 3D cross-product of `self` with `other`.

Even if `self` or `other` is 4D, the resulting vector(s) is/are 3D.

**deltaR(other: VectorProtocolSpatial | VectorProtocolLorentz) → Any**

Sum in quadrature of [`vector.\_methods.VectorProtocolPlanar.deltaphi\(\)`](#) and [`vector.\_methods.VectorProtocolSpatial.deltaeta\(\)`](#):

$$\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$$

**deltaR2(other: VectorProtocolSpatial | VectorProtocolLorentz) → Any**

Square of the sum in quadrature of [`vector.\_methods.VectorProtocolPlanar.deltaphi\(\)`](#) and [`vector.\_methods.VectorProtocolSpatial.deltaeta\(\)`](#):

$$\Delta R^2 = \Delta\phi^2 + \Delta\eta^2$$

**deltaangle(other: VectorProtocolSpatial | VectorProtocolLorentz) → Any**

Angle in 3D space between `self` and `other`, which is always positive, between 0 and  $\pi$ .

**deltaeta(other: VectorProtocolSpatial | VectorProtocolLorentz) → Any**

Signed difference in  $\eta$  of `self` minus `other`.

**property eta: Any**

The pseudorapidity  $\eta$  coordinate of the vector or every vector in the array (in radians, always between 0 ( $+z$ ) and  $\pi$  ( $-z$ )).

**is\_antiparallel(other: VectorProtocol, tolerance: Any = 1e-05) → Any**

Returns True if `self` and `other` are pointing in opposite directions (i.e. dot product is nearly  $-\text{abs}(\text{self}) * \text{abs}(\text{other})$ ).

The tolerance is measured in units of  $\cos(\Delta\alpha)$  where  $\Delta\alpha$  is `self.deltaangle(other)`.

**is\_parallel(other: VectorProtocol, tolerance: Any = 1e-05) → Any**

Returns True if `self` and `other` are pointing in the same direction (i.e. not “antiparallel”; dot product is nearly  $\text{abs}(\text{self}) * \text{abs}(\text{other})$ ).

The tolerance is measured in units of  $\cos(\Delta\alpha)$  where  $\Delta\alpha$  is `self.deltaangle(other)`.

**is\_perpendicular**(*other*: [VectorProtocol](#), *tolerance*: *Any* = *1e-05*) → *Any*

Returns True if *self* and *other* are pointing in perpendicular directions (i.e. dot product is nearly 0).

The tolerance is measured in units of  $\cos(\Delta\alpha)$  where  $\Delta\alpha$  is *self.deltaangle*(*other*).

**property longitudinal**: [Longitudinal](#)

Container of longitudinal coordinates, for use in dispatching to compute functions or to identify coordinate system with *isinstance*.

**property mag**: *Any*

The magnitude of the vector(s) in 3D (not including any temporal parts).

**property mag2**: *Any*

The magnitude-squared of the vector(s) in 3D (not including any temporal parts).

**property neg3D**: *SameVectorType*

Returns vector(s) with the 3D part negated, not affecting any longitudinal or temporal parts.

**rotateX**(*angle*: *Any*) → *SameVectorType*

Rotates the vector(s) by a given *angle* (in radians) around the *x* axis.

Note that the *angle* can be an array with the same length as the vectors, if the vectors are in an array.

**rotateY**(*angle*: *Any*) → *SameVectorType*

Rotates the vector(s) by a given *angle* (in radians) around the *y* axis.

Note that the *angle* can be an array with the same length as the vectors, if the vectors are in an array.

**rotate\_axis**(*axis*: [VectorProtocolSpatial](#), *angle*: *Any*) → *SameVectorType*

Rotates the vector(s) by a given *angle* (in radians) around the axis indicated by another vector, *axis*. The magnitude of *axis* is ignored.

Note that the *axis* and *angle* can be arrays with the same length as the vectors, if the vectors are in an array.

**rotate\_euler**(*phi*: *Any*, *theta*: *Any*, *psi*: *Any*, *order*: *str* = 'zxz') → *SameVectorType*

Rotates the vector(s) by three given angles: *phi*, *theta*, and *psi* (in radians). The *order* string determines which axis each rotation is applied around:

- "zxz", "xyx", "yzy", "zyz", "xzx", and "yxy" are proper Euler angles
- "zxz", "xyx", "yzy", "zyz", "xzx", and "yxy" are Tait-Bryan angles (see [vector.\\_methods.VectorProtocolSpatial.rotate\\_nautical\(\)](#))

The names *phi*, *theta*, and *psi* agree with Wikipedia's terminology, and both the names and order agree with ROOT's [Math::EulerAngles](#). The default *order* = "zxz" is also ROOT's convention.

Note that the angles can be arrays with the same lengths as the vectors, if the vectors are in an array.

**rotate\_nautical**(*yaw*: *Any*, *pitch*: *Any*, *roll*: *Any*) → *SameVectorType*

Rotates the vector(s) by three given angles: *yaw*, *pitch*, and *roll* (in radians). These are Tait-Bryan angles often used for boats and planes (see [this lesson](#) and [this lesson](#)).

This function is entirely equivalent to

```
rotate_euler(roll, pitch, yaw, order="zyx")
```

Note that the angles can be arrays with the same lengths as the vectors, if the vectors are in an array.

**rotate\_quaternion**(*u: Any, i: Any, j: Any, k: Any*) → SameVectorType

Rotates the vector(s) by four angles as quaternion coefficients (in radians). Four angles are sometimes preferred over three because the latter has a pathology known as “gimbal lock.”

This function follows the same conventions as ROOT’s `Math::Quaternion`.

Note that the angles can be arrays with the same lengths as the vectors, if the vectors are in an array.

**scale3D**(*factor: Any*) → SameVectorType

Returns vector(s) with the 3D part scaled by a `factor`, not affecting any longitudinal or temporal parts.

**property theta: Any**

The spherical  $\theta$  coordinate (polar angle) of the vector or every vector in the array (in radians, always between 0 (+ $z$ ) and  $\pi$  (− $z$ )).

**transform3D**(*obj: TransformProtocol3D*) → SameVectorType

Arbitrarily transforms the vector(s) by

```
obj["xx"] obj["xy"] obj["xz"]
obj["yx"] obj["yy"] obj["yz"]
obj["zx"] obj["zy"] obj["zz"]
```

leaving any temporal coordinate unchanged. There is no restriction on the type of `obj`; it just has to provide those components (which can be arrays if the vectors are in an array).

**property z: Any**

The Cartesian  $z$  coordinate of the vector or every vector in the array.

**vector.\_methods.\_aztype**(*obj: VectorProtocolPlanar*) → type[*Coordinates*]

Determines the Azimuthal type of a vector for use in looking up a dispatched function.

**vector.\_methods.\_check\_instance**(*any\_or\_all: Callable[[Iterable[bool]], bool], objects: tuple[VectorProtocol, ...], clas: type[VectorProtocol]*) → bool

**vector.\_methods.\_compute\_module\_of**(*one: VectorProtocol, two: VectorProtocol, nontemporal: bool = False*) → Any

Determines which compute module to use for functions of two vectors (the one with minimum dimension).

If `nontemporal`, use a spatial module even if both vectors are 4D.

**vector.\_methods.\_flavor\_of**(*\*objects: VectorProtocol*) → type[*VectorProtocol*]

Determines the flavor of the output of a dispatched function, where “flavor” is generic vs momentum.

**vector.\_methods.\_from\_signature**(*name: str, dispatch\_map: dict[Any, Any], signature: tuple[Any, ...]*) → tuple[Any, ...]

Gets a function and its return type from a `dispatch_map` and the `signature` to search for (complaining if none is found).

**vector.\_methods.\_get\_handler\_index**(*obj: VectorProtocol*) → int

Returns the index of the first valid handler checking the list of parent classes

**vector.\_methods.\_handler\_of**(*\*objects: VectorProtocol*) → *VectorProtocol*

Determines which vector should wrap the output of a dispatched function.

Awkward Arrays have higher priority than NumPy arrays, which have higher priority than Python objects, which has the effect of “promoting” Python objects to NumPy arrays to Awkward Arrays whenever two are used in the same formula.



`vector._methods._lib_of(*objects: VectorProtocol) → Any`

Determines the lib of a vector or set of vectors, complaining if they're incompatible.

`vector._methods._ltype(obj: VectorProtocolSpatial) → type[Coordinates]`

Determines the Longitudinal type of a vector for use in looking up a dispatched function.

`vector._methods._maybe_same_dimension_error(v1: VectorProtocol, v2: VectorProtocol, operation: str) → None`

Raises an error if the vectors are not of the same dimension.

`vector._methods._ttype(obj: VectorProtocolLorentz) → type[Coordinates]`

Determines the Temporal type of a vector for use in looking up a dispatched function.

`vector._methods._dim(v: VectorProtocol) → int`

Returns the number of dimensions in a vector: 2, 3, or 4.

## vector.\_typeutils module

`vector._typeutils.BoolCollection`

alias of Any

`vector._typeutils.FloatArray`

alias of ndarray

**class** `vector._typeutils.Protocol`

Bases: Generic

Base class for protocol classes.

Protocol classes are defined as:

```
class Proto(Protocol):
    def meth(self) -> int:
        ...
```

Such classes are primarily used with static type checkers that recognize structural subtyping (static duck-typing).

For example:

```
class C:
    def meth(self) -> int:
        return 0

def func(x: Proto) -> int:
    return x.meth()

func(C()) # Passes static type check
```

See PEP 544 for details. Protocol classes decorated with `@typing.runtime_checkable` act as simple-minded runtime protocols that check only the presence of given attributes, ignoring their type signatures. Protocol classes can be generic, they are defined as:

```
class GenProto[T](Protocol):
    def meth(self) -> T:
        ...
```

```
    _abc_impl = <_abc._abc_data object>
    _is_protocol = True
    _is_runtime_protocol = False
vector._typeutils.ScalarCollection
    alias of Any
class vector._typeutils.TransformProtocol2D
    Bases: TypedDict
    xx: Any
    xy: Any
    yx: Any
    yy: Any
class vector._typeutils.TransformProtocol3D
    Bases: TypedDict
    xx: Any
    xy: Any
    xz: Any
    yx: Any
    yy: Any
    yz: Any
    zx: Any
    zy: Any
    zz: Any
class vector._typeutils.TransformProtocol4D
    Bases: TypedDict
    tt: Any
    tx: Any
    ty: Any
    tz: Any
    xt: Any
    xx: Any
    xy: Any
    xz: Any
```

**yt: Any**

**yx: Any**

**yy: Any**

**yz: Any**

**zt: Any**

**zx: Any**

**zy: Any**

**zz: Any**



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