A Python Package for Gamma-Ray Astronomy

“Multi-Messenger Data Analysis in the Era of CTA”, Sexten, June 24th 2019

Axel Donath for the Gammapy team

INTRODUCTION

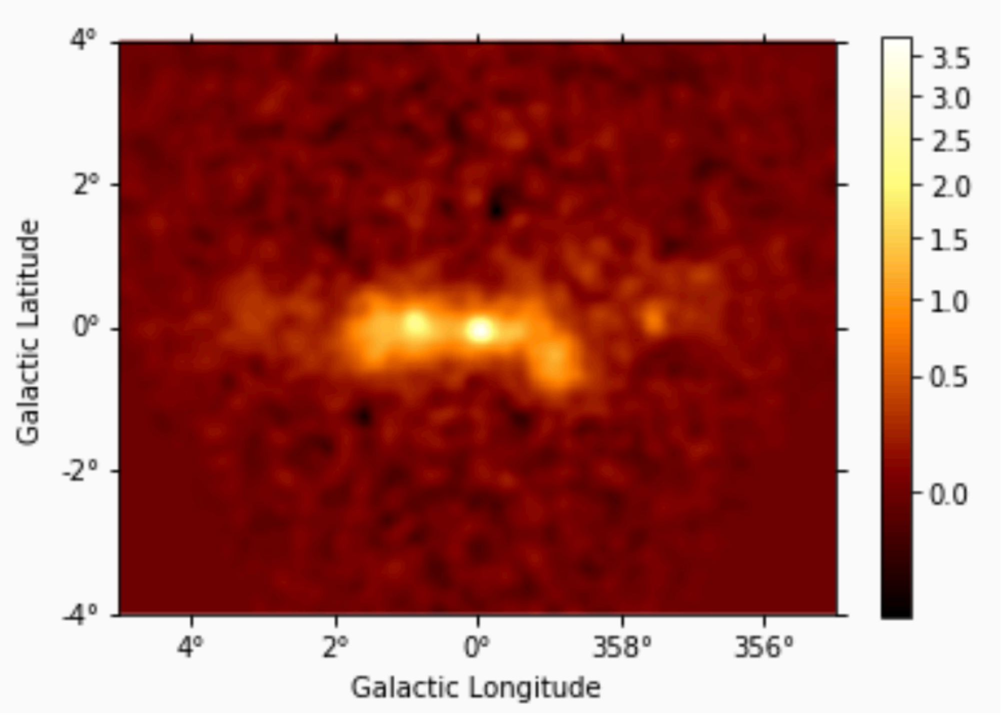
WHAT IS GAMMAPY?

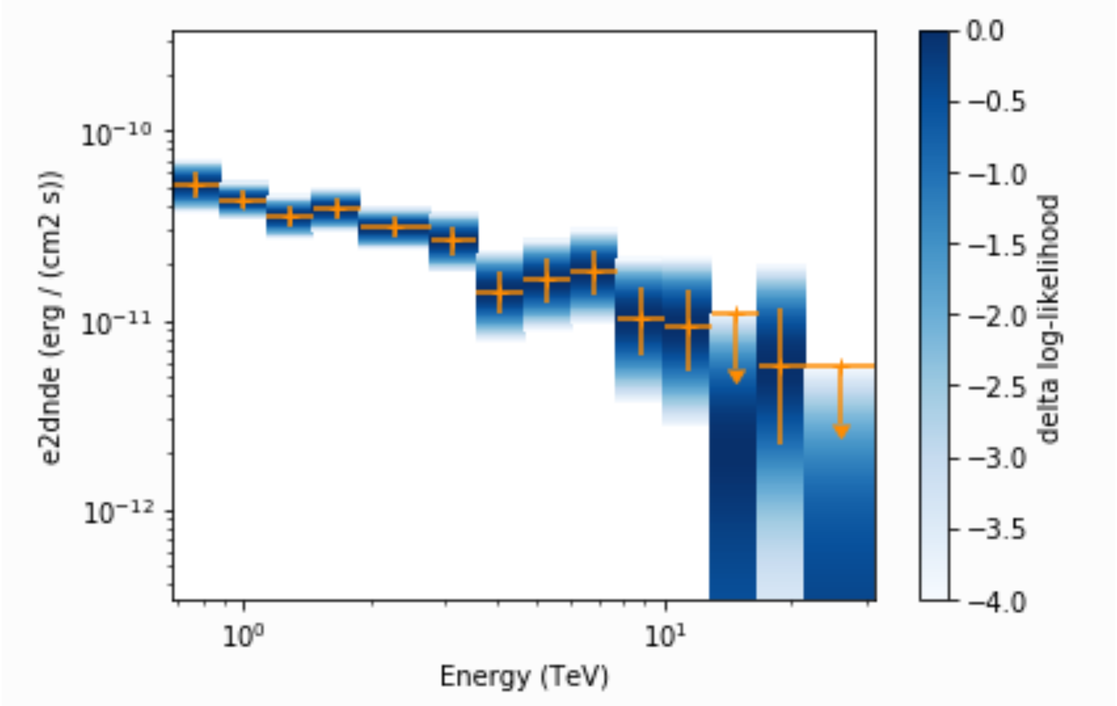
WHAT IS GAMMAPY?

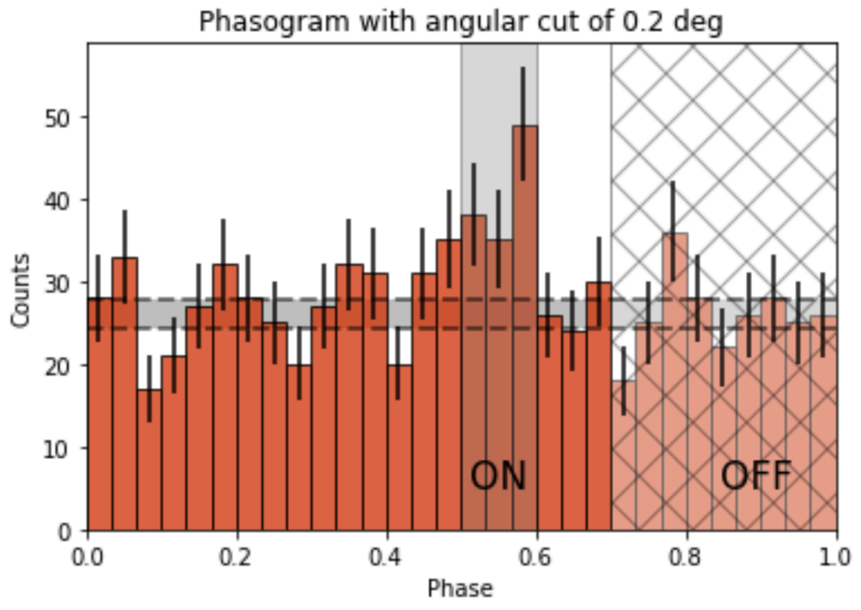
cta DL3

cherenkov telescope array

?







WHAT IS GAMMAPY?

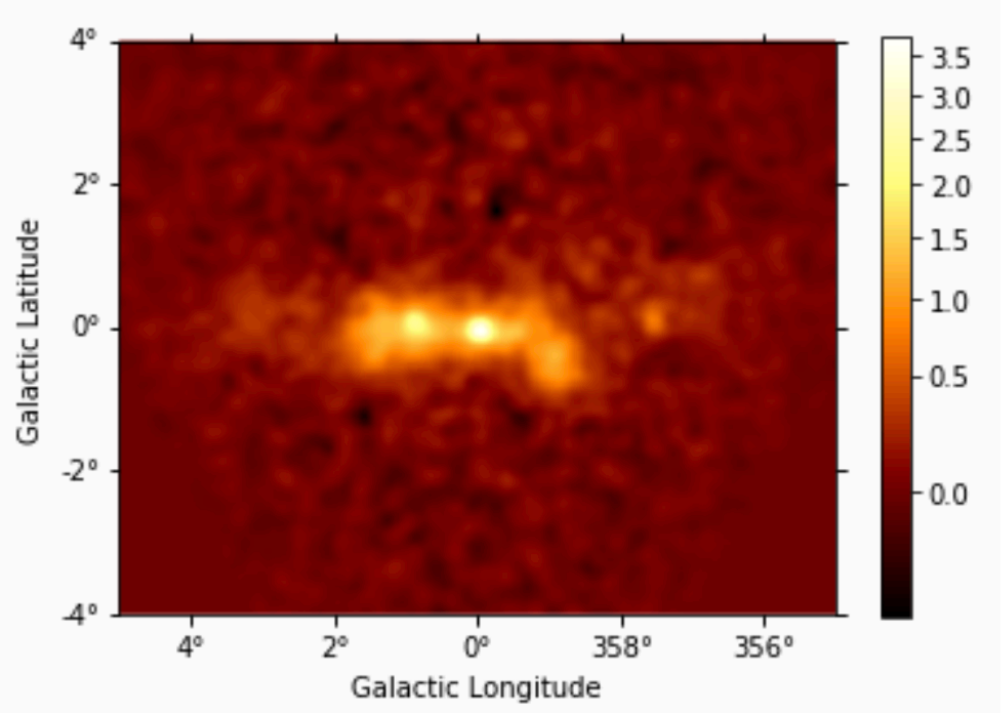
H.E.S.S.

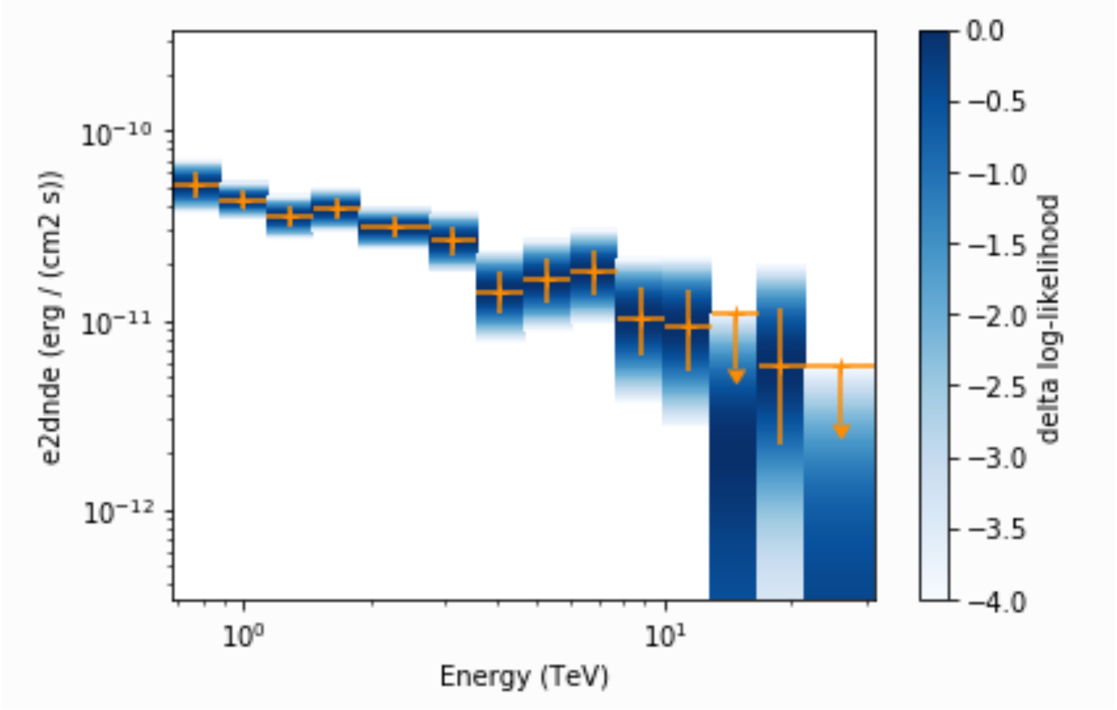
cta DL3

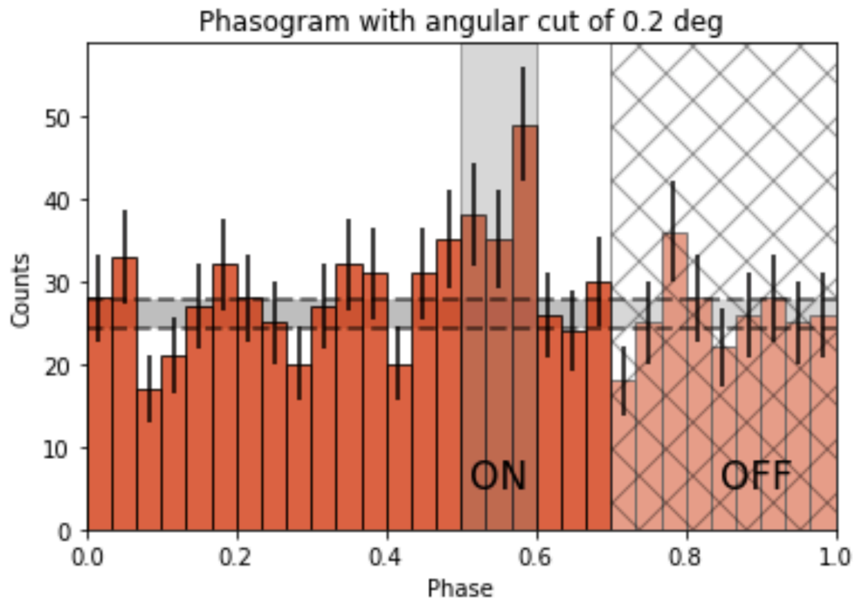
cherenkov telescope array

Fermi

Gamma-ray Space Telescope






Phasogram with angular cut of 0.2 deg

WHAT IS GAMMAPY?

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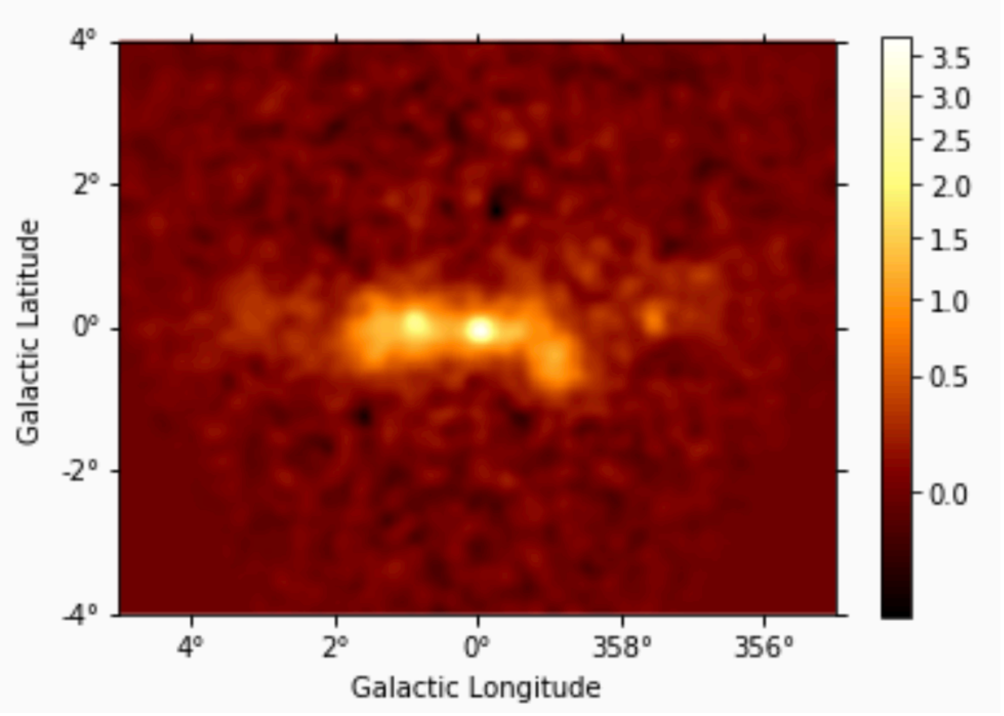
Fermi

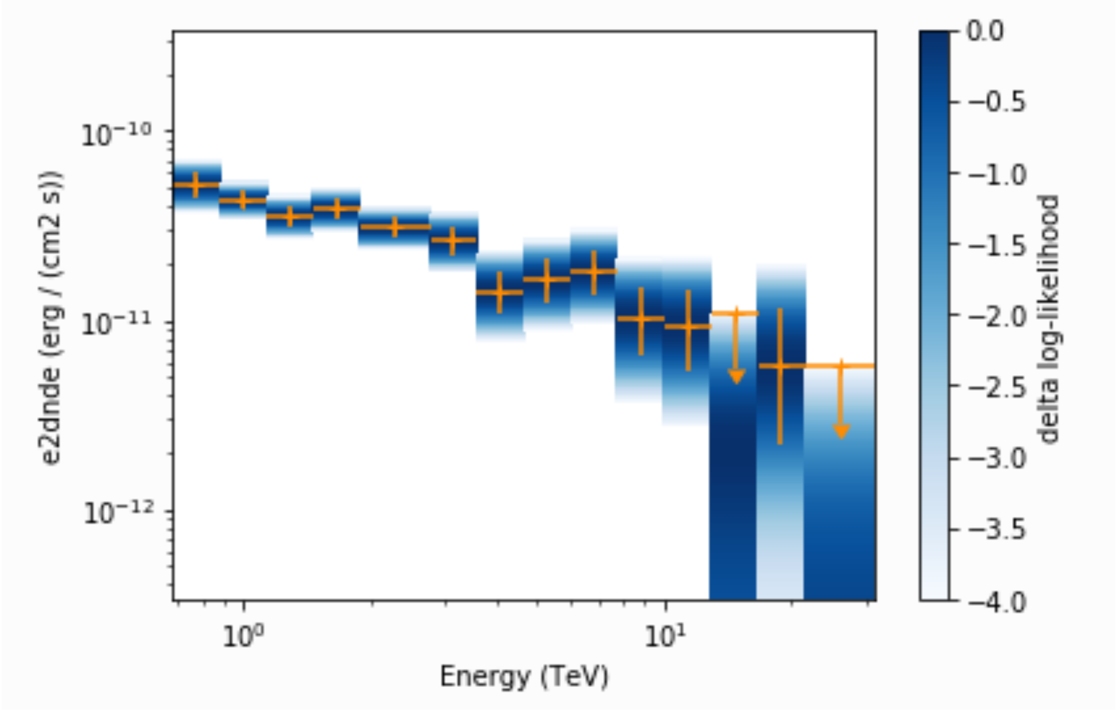
Gamma-ray Space Telescope

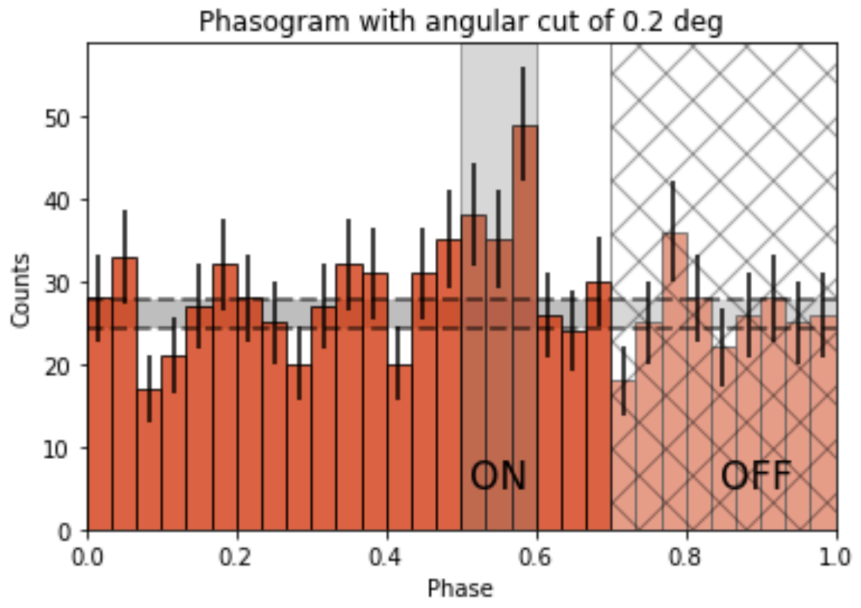
astropy

NumPy

SciPy







WHAT IS GAMMAPY?

H.E.S.S.

cta DL3
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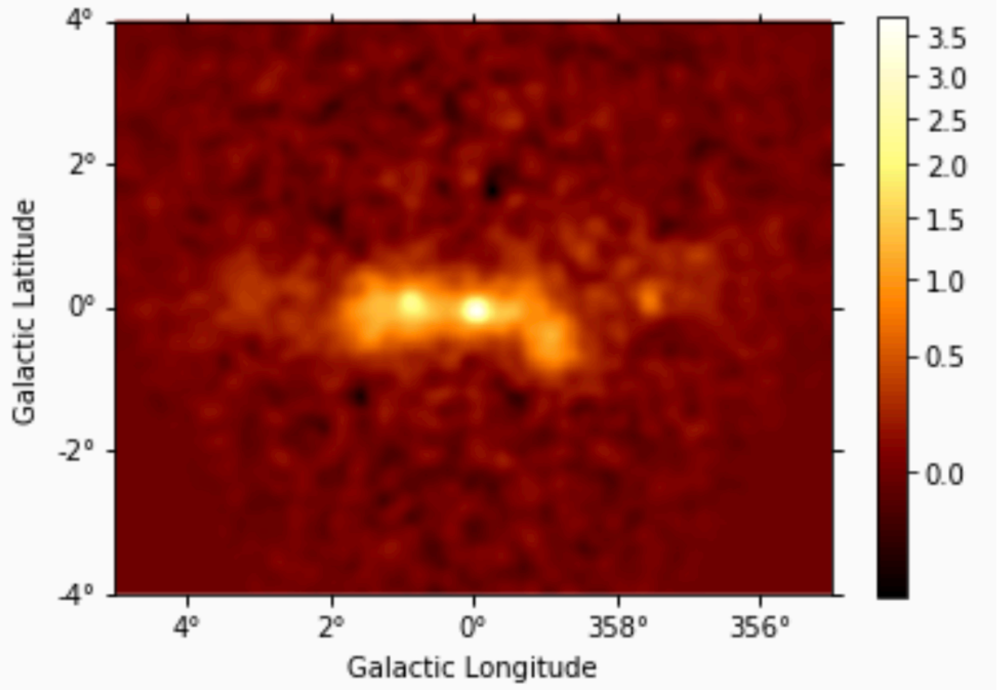
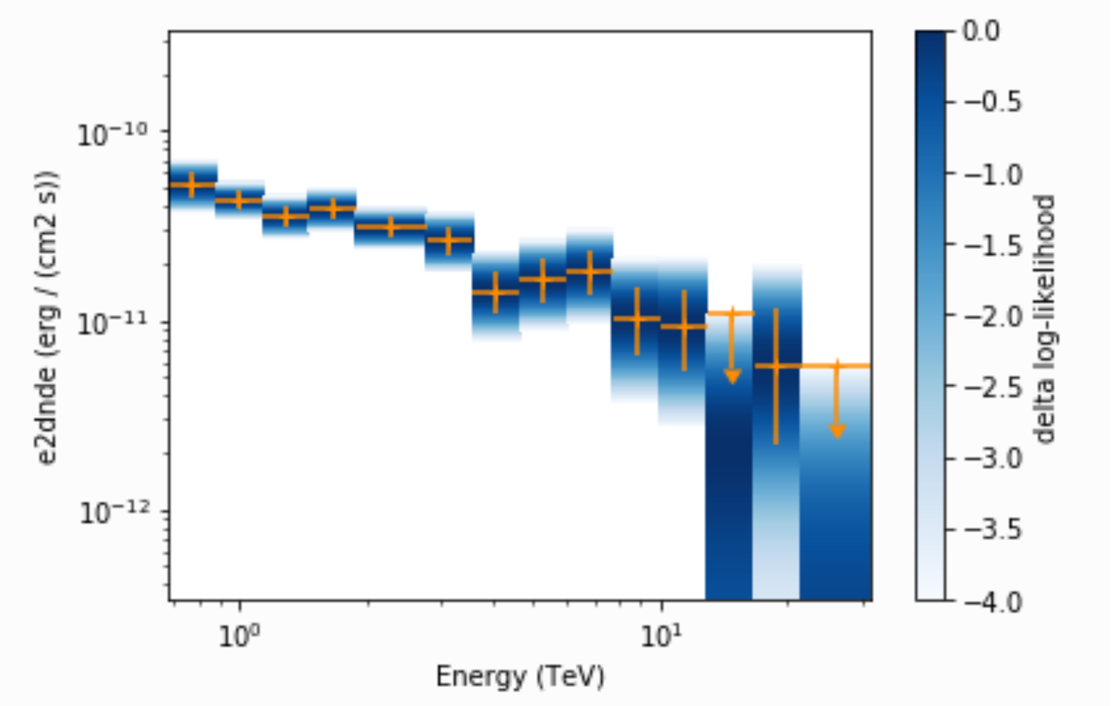
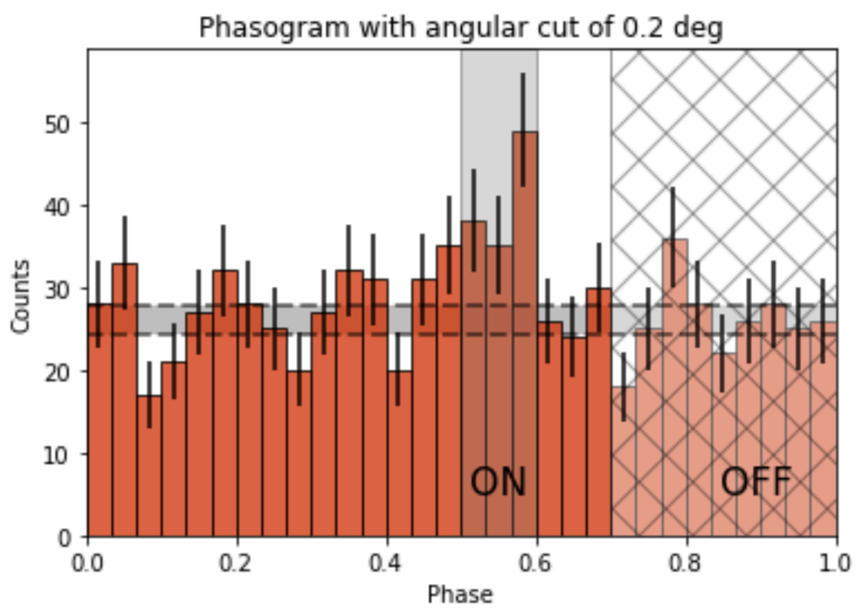
Fermi
Gamma-ray
Space Telescope







A Python package for Gamma-Ray Astronomy
& prototype for the CTA science tools:

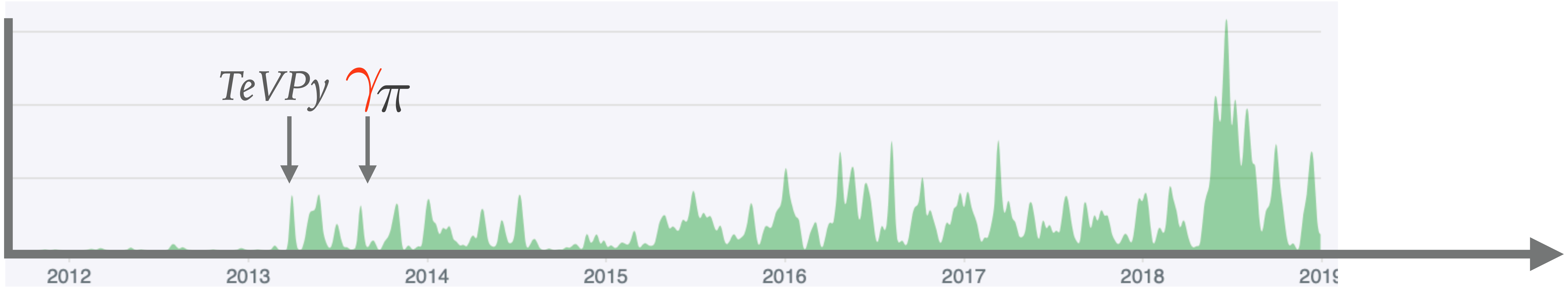
- Based on common data formats

- Transparent to users

- Embedded in the large astronomical Python community

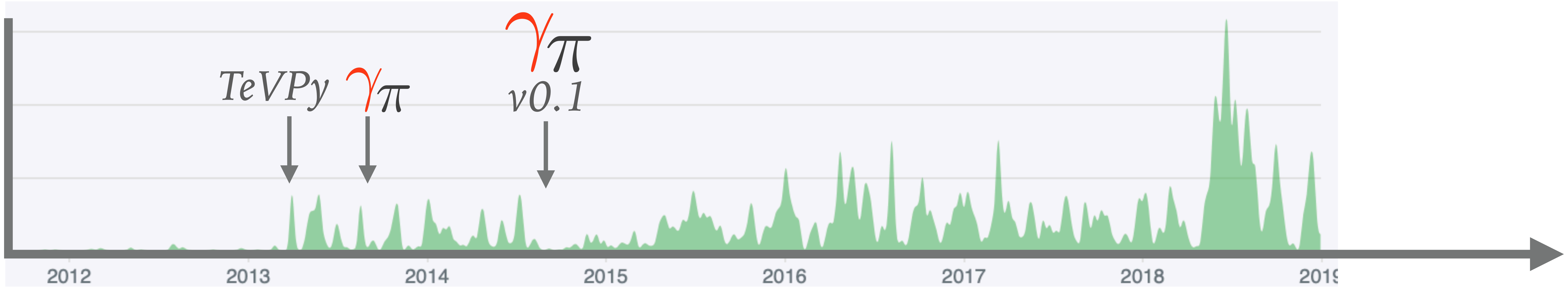
WHAT IS GAMMAPY?

Activitity



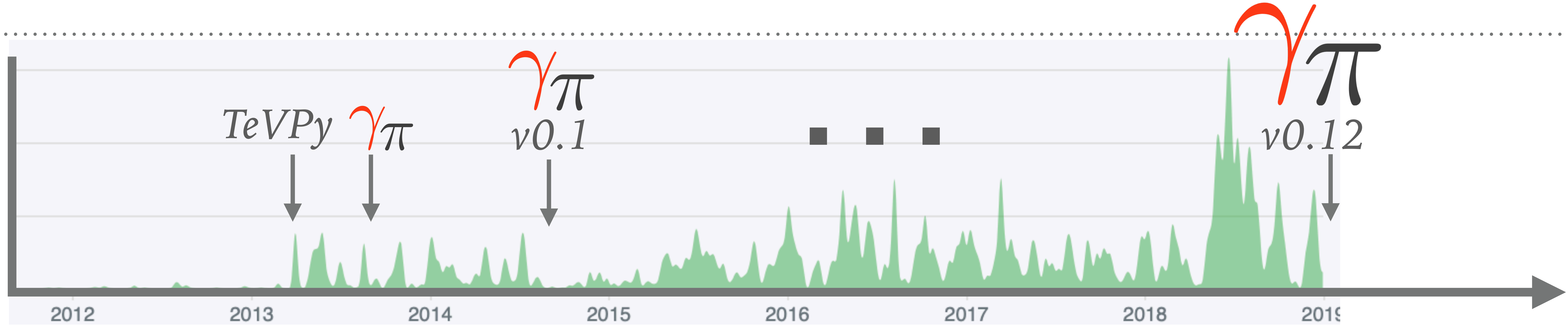
WHAT IS GAMMAPY?

Activitity



WHAT IS GAMMAPY?

Activitity

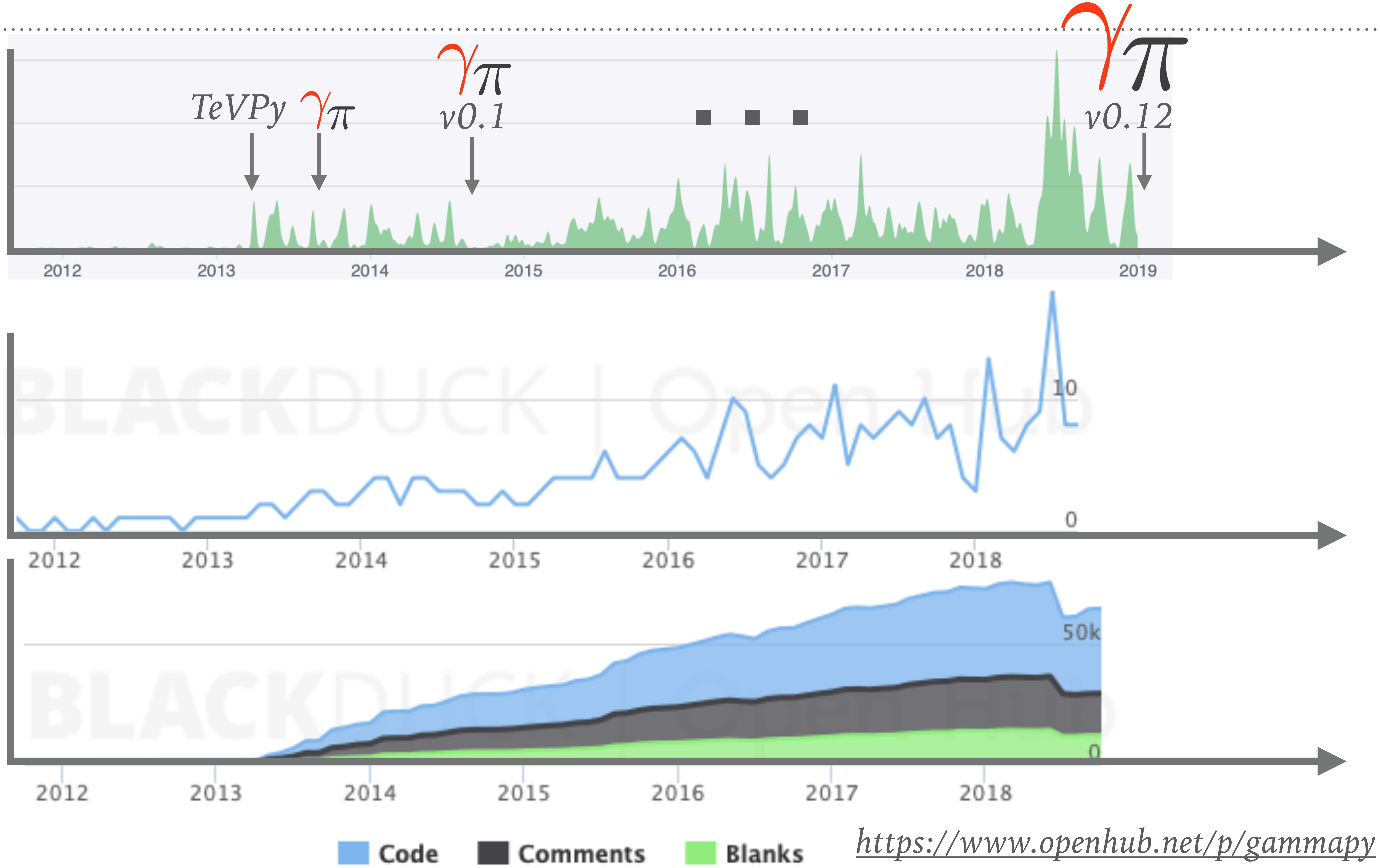


WHAT IS GAMMAPY?

Activitity

Contributors

Lines of code



https://www.openhub.net/p/gammapy

GAMMAPY ORGANISATION / TEAM

Project manager

Bruno Khelifi

https://gammapy.org/team.html

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Project manager

Bruno Khelifi

Lead developers

Christoph Deil

Régis Terrier

Axel Donath

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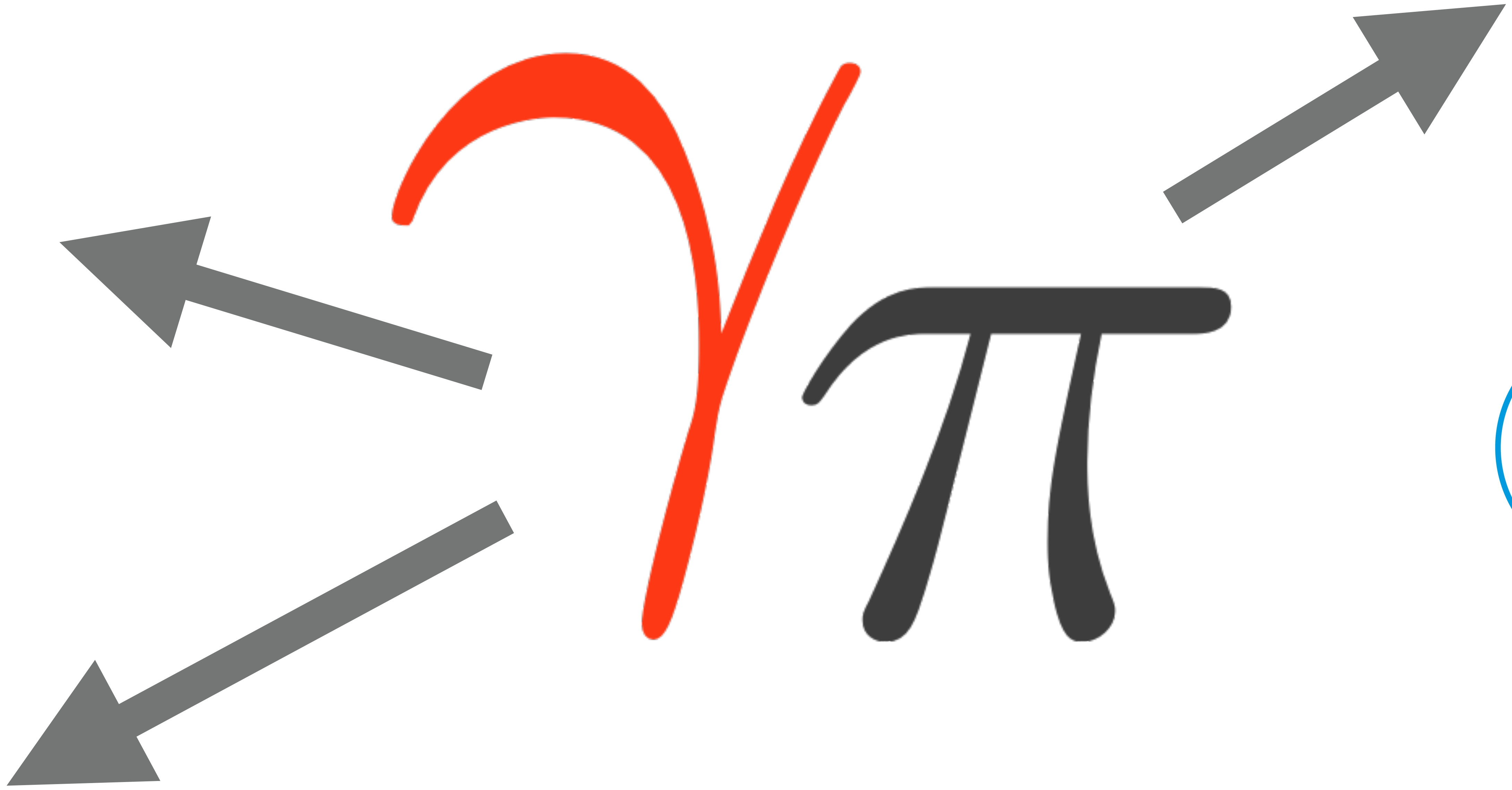


Coordination committee

MAX-PLANCK-INSTITUT FÜR KERNPHYSIK HEIDELBERG

DESY.

UNIVERSIDAD COMPLUTENSE MADRID

APC, CNRS, FRANCE

irfu

l'Observatoire de Paris

cea saclay

Fabio Acero, Catherine Boisson, José-Luis Contreras, Emma de Ońa-Wilhelmi, project managers and lead developers

Lead developers

Christoph Deil

Régis Terrier

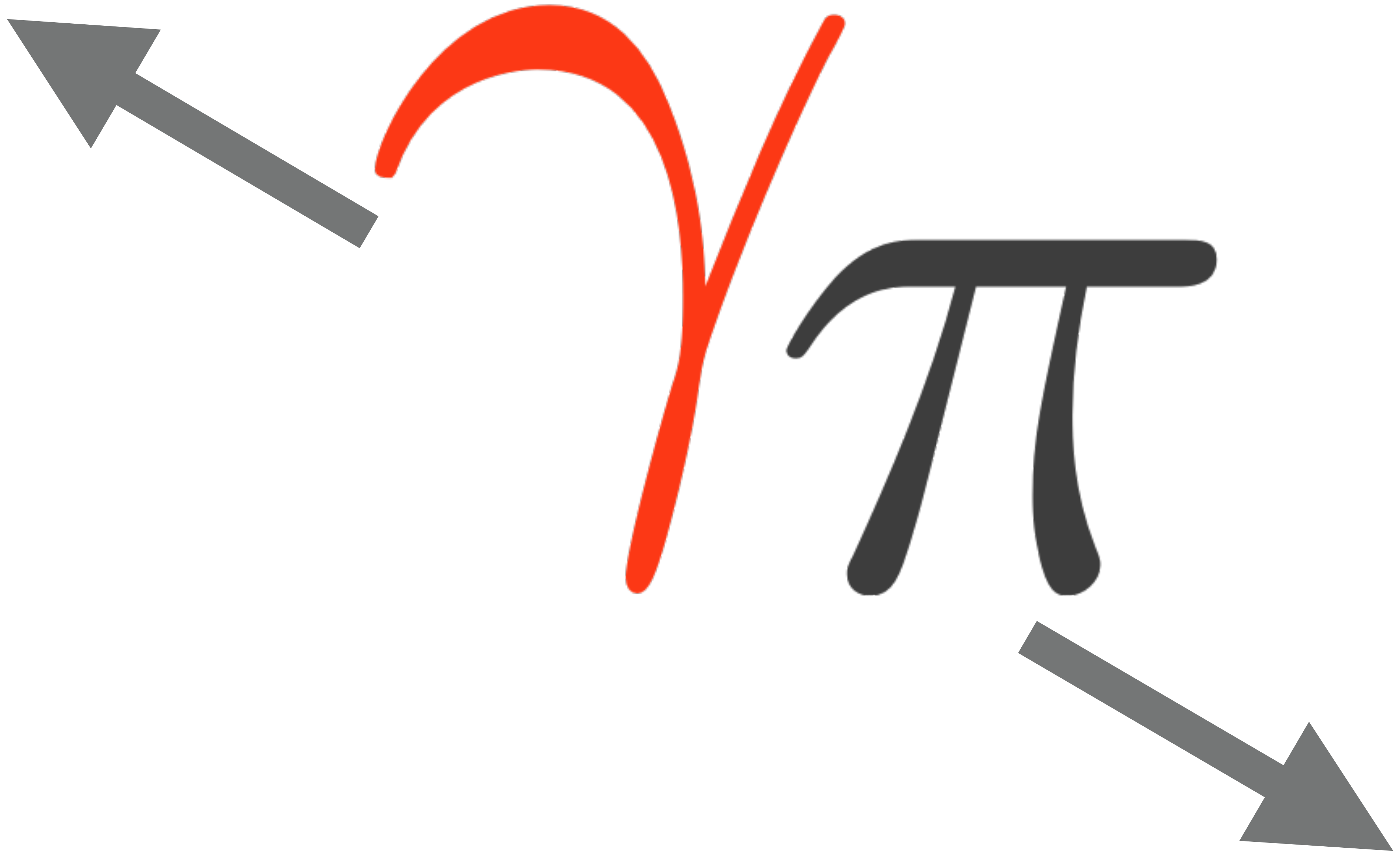
Axel Donath

https://gammapy.org/team.html

GAMMAPY ORGANISATION / TEAM

Core developers

“Regular contributors”

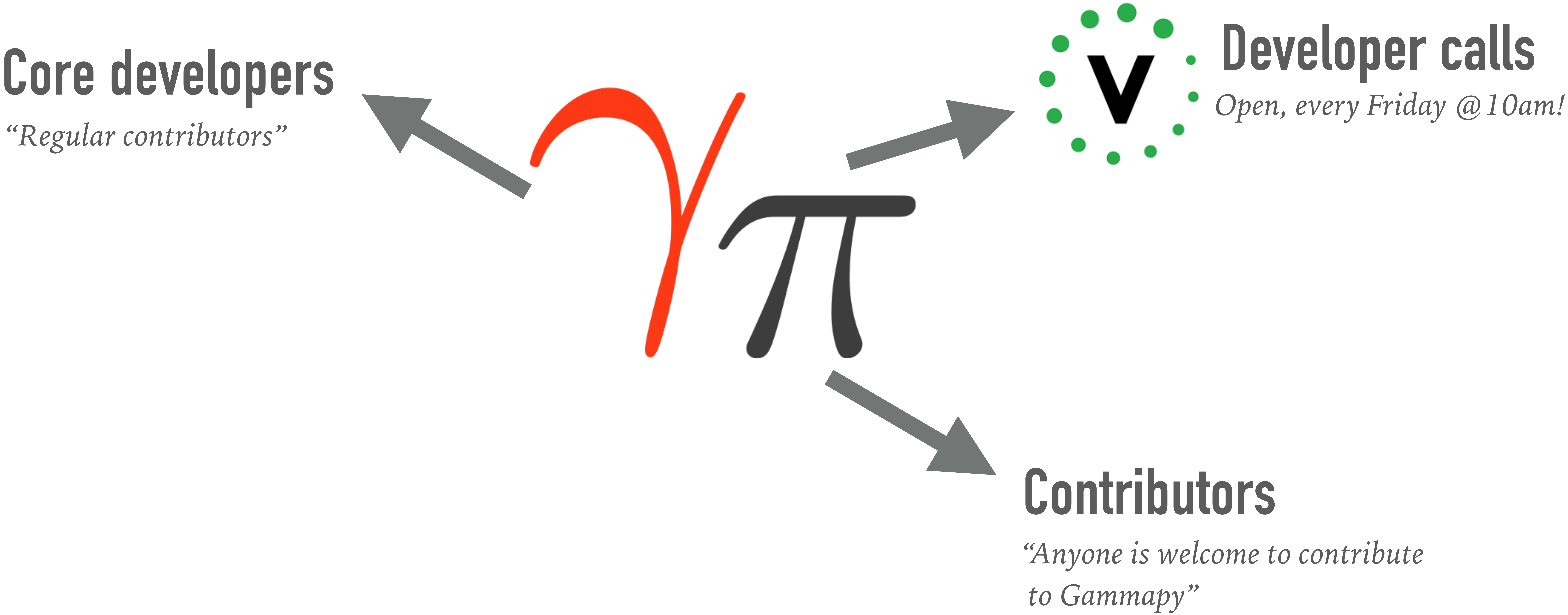


Contributors

“Anyone is welcome to contribute to Gammapy”

https://github.com/gammapy/gammapy/graphs/contributors

GAMMAPY ORGANISATION / TEAM



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Developer calls

Open, every Friday @10am!

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https://github.com/gammapy/gammapy-meetings

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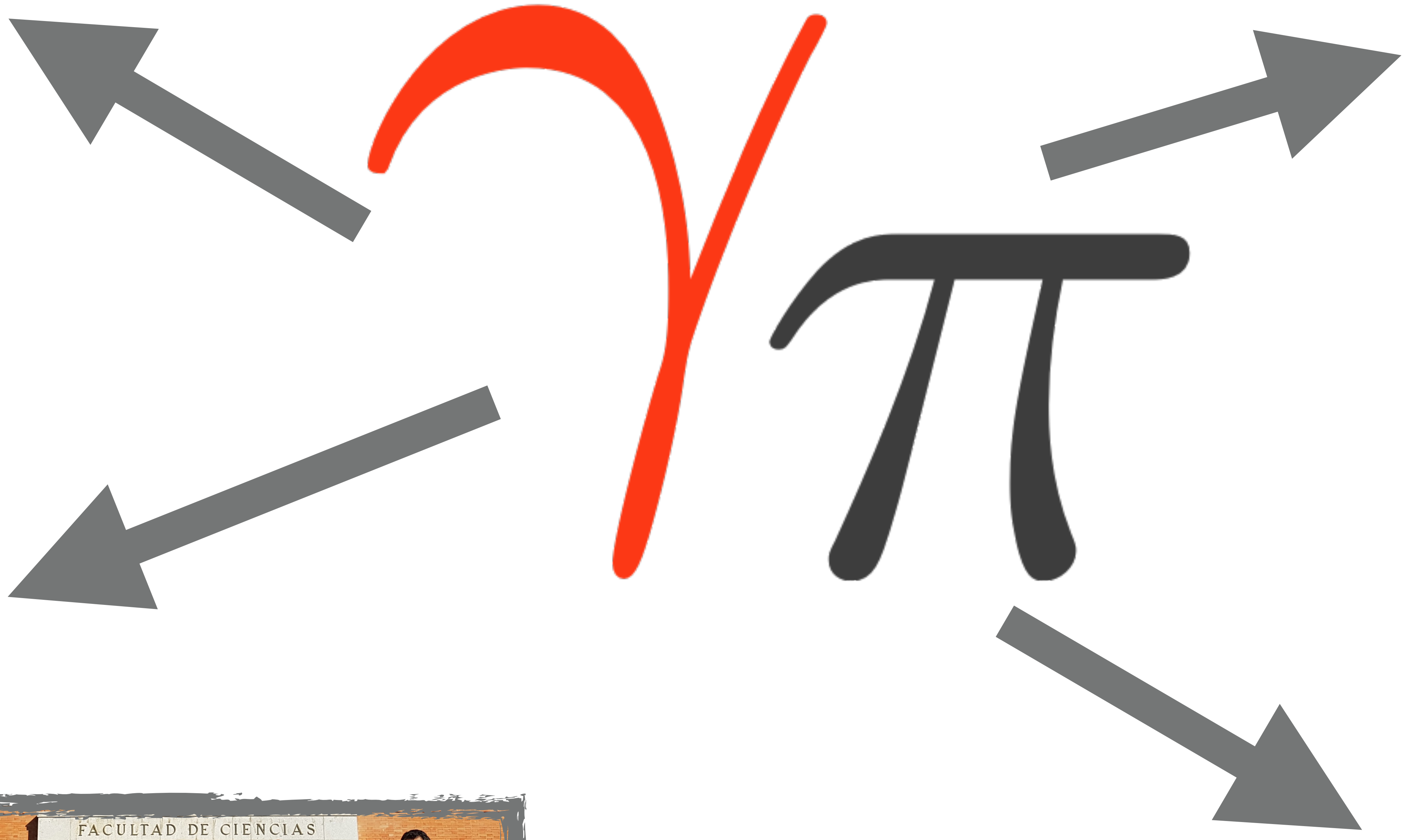

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Coding sprints

Paris in February 2019

Madrid in October 2018

Contributors

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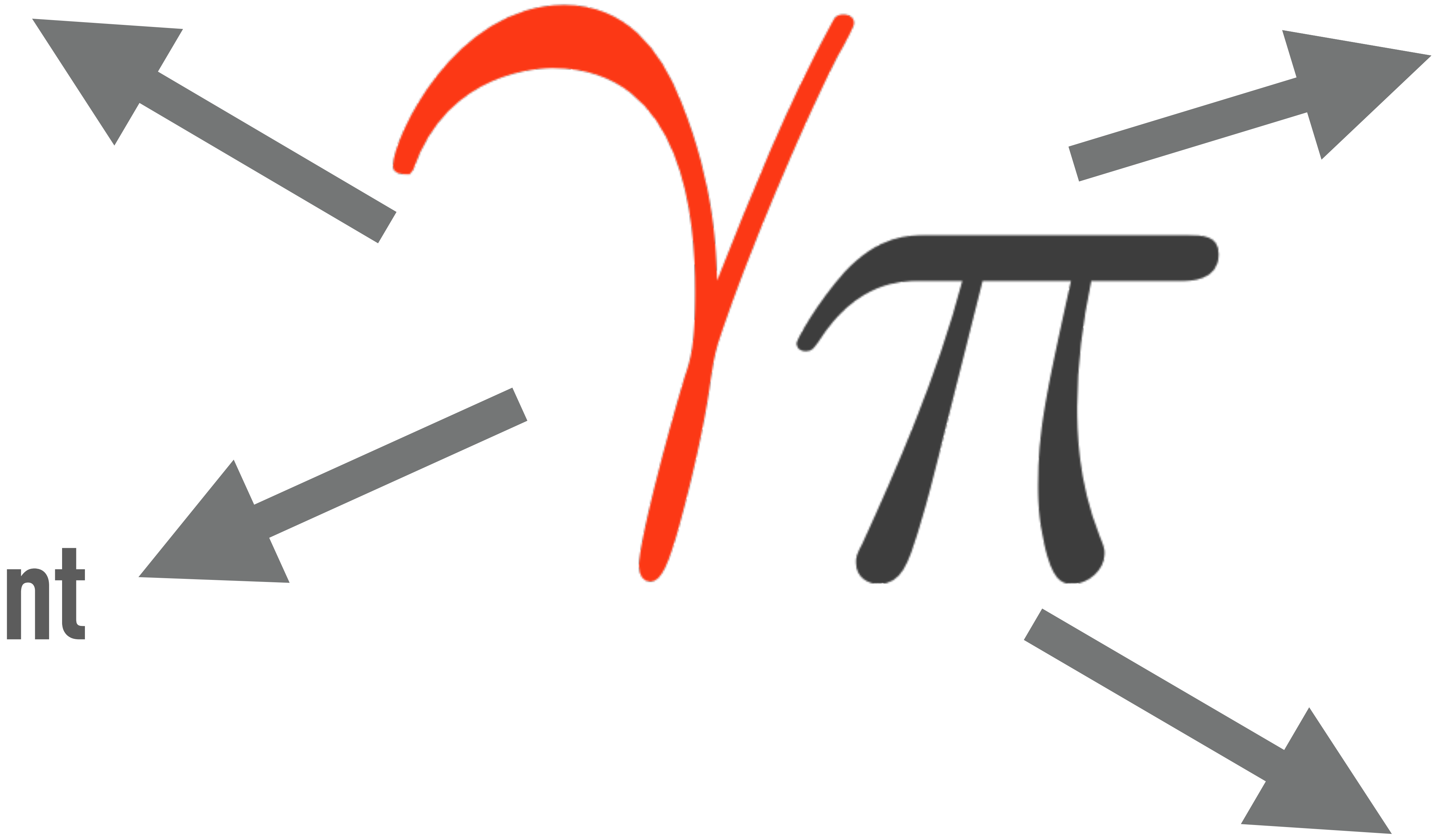
GAMMAPY ORGANISATION / TEAM



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Next coding sprint

ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS

Erlangen July 15th - 19th, 2019

Contributors

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https://github.com/gammapy/gammapy-meetings

RELATED PROJECTS

gamma-cat

“An open data collection and source catalog for VHE gamma-ray astronomy”

https://github.com/gammapy/gamma-cat

PyGamma19

“Python and open data for Gamma-Ray Astronomy Workshop”, March 18th - 22nd

https://indico.cern.ch/event/783425/

gammasky.net

“A portal to the gamma-ray sky”

https://github.com/gammapy/gamma-sky

FITS

Gamma-astro-data-formats

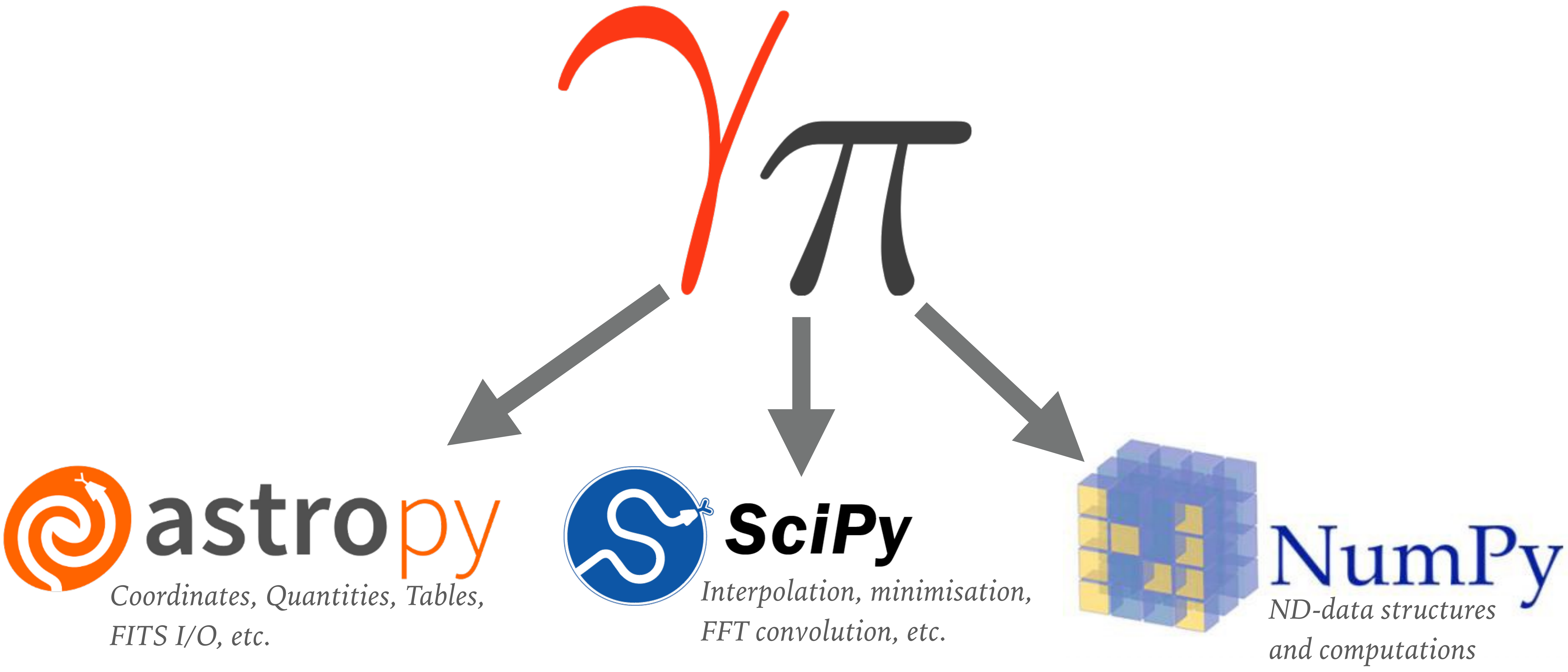
“A place to propose and share data format descriptions for gamma-ray astronomy.”

https://github.com/open-gamma-ray-astro

DEVELOPMENT & SETUP

DEPENDENCIES

Required dependencies



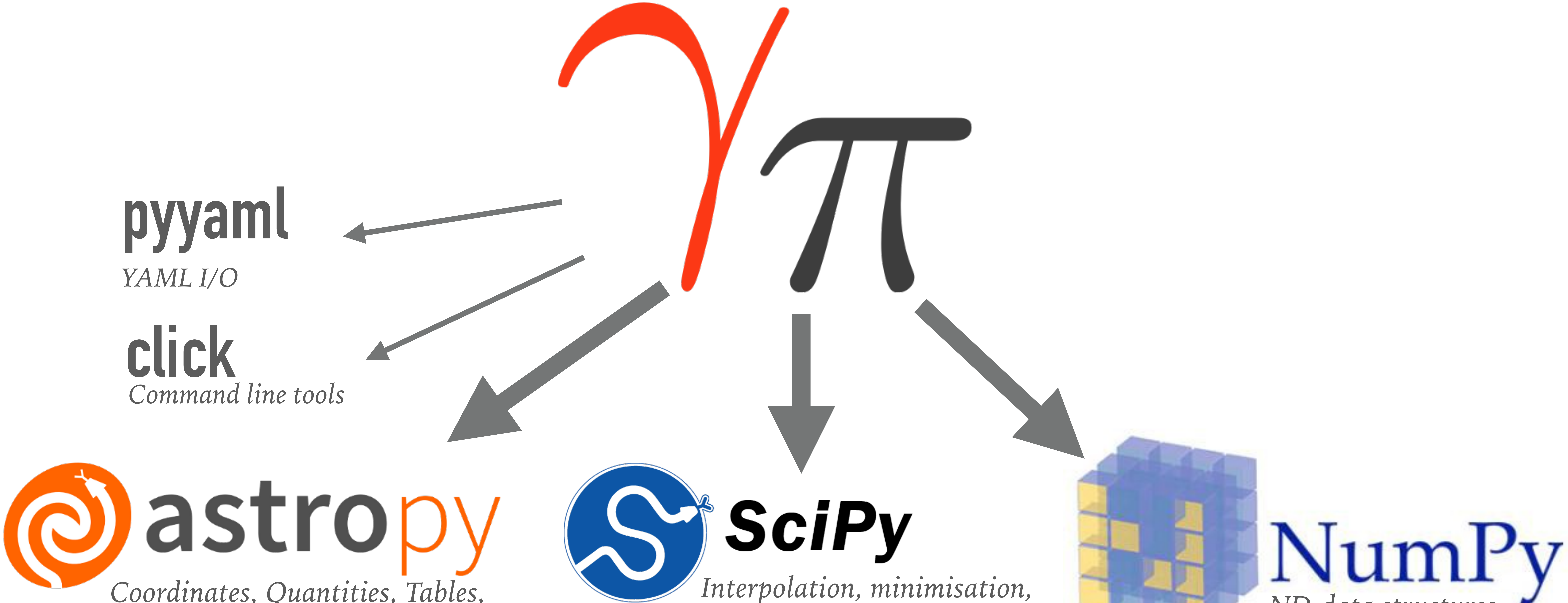
Coordinates, Quantities, Tables, FITS I/O, etc.

Interpolation, minimisation, FFT convolution, etc.

ND-data structures and computations

DEPENDENCIES

Required dependencies →



pyyaml

YAML I/O

click

Command line tools

astropy

Coordinates, Quantities, Tables, FITS I/O, etc.

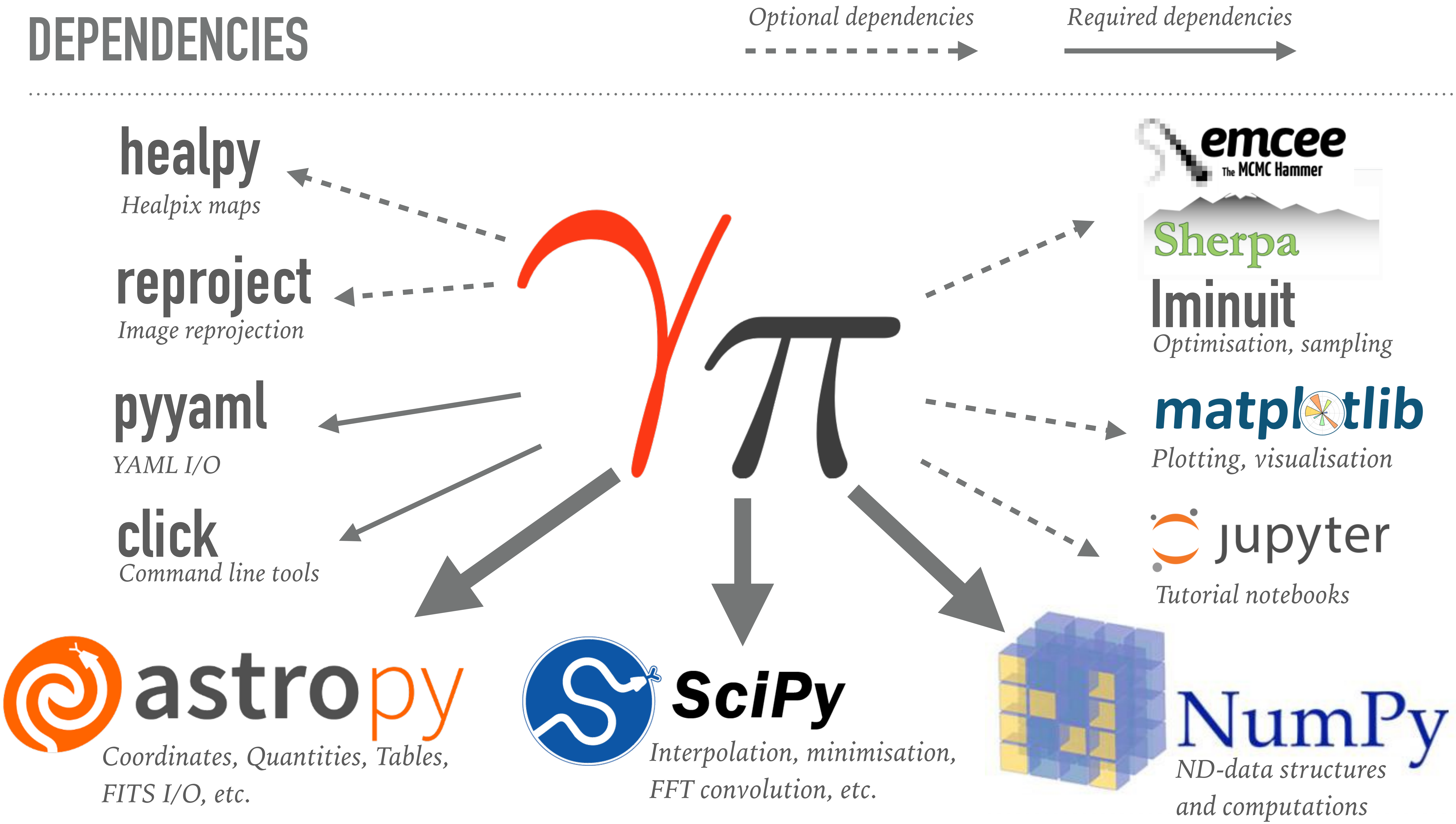
SciPy

Interpolation, minimisation, FFT convolution, etc.

NumPy

ND-data structures and computations

DEPENDENCIES



Optional dependencies

Required dependencies

healpy

Healpix maps

reproject

Image reprojection

pyyaml

YAML I/O

click

Command line tools

emcee

The MCMC Hammer

Sherpa

Iminuit

Optimisation, sampling

matplotlib

Plotting, visualisation

jupyter

Tutorial notebooks

astropy

Coordinates, Quantities, Tables, FITS I/O, etc.

SciPy

Interpolation, minimisation, FFT convolution, etc.

NumPy

ND-data structures and computations

DEVELOPMENT AND CI SETUP

Hosted and openly developed on Github:
https://github.com/gammapy/gammapy

Azure Pipelines

Travis-CI and Azure Pipelines used for continuous integration

COVERALLS

Coveralls used for monitoring of code test coverage

~~Read the Docs~~

Docs are build and deployed manually: https://docs.gammapy.org/

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Docs are build and deployed manually: https://docs.gammapy.org/

Black code formatting used for a consistent code format.

Sphinx used to build the documentation

Pytest used for testing

INSTALLATION & SETUP

Install Gammapy:

https://docs.gammapy.org/0.12/getting-started.html#install

1.
```
$ curl -O https://gammapy.org/download/install/gammapy-0.12-environment.yml
```

2.
```
$ conda env create -f gammapy-0.12-environment.yml
```

3.
```
$ conda activate gammapy-0.12
```

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```
3.
```
$ conda activate gammapy-0.12
```

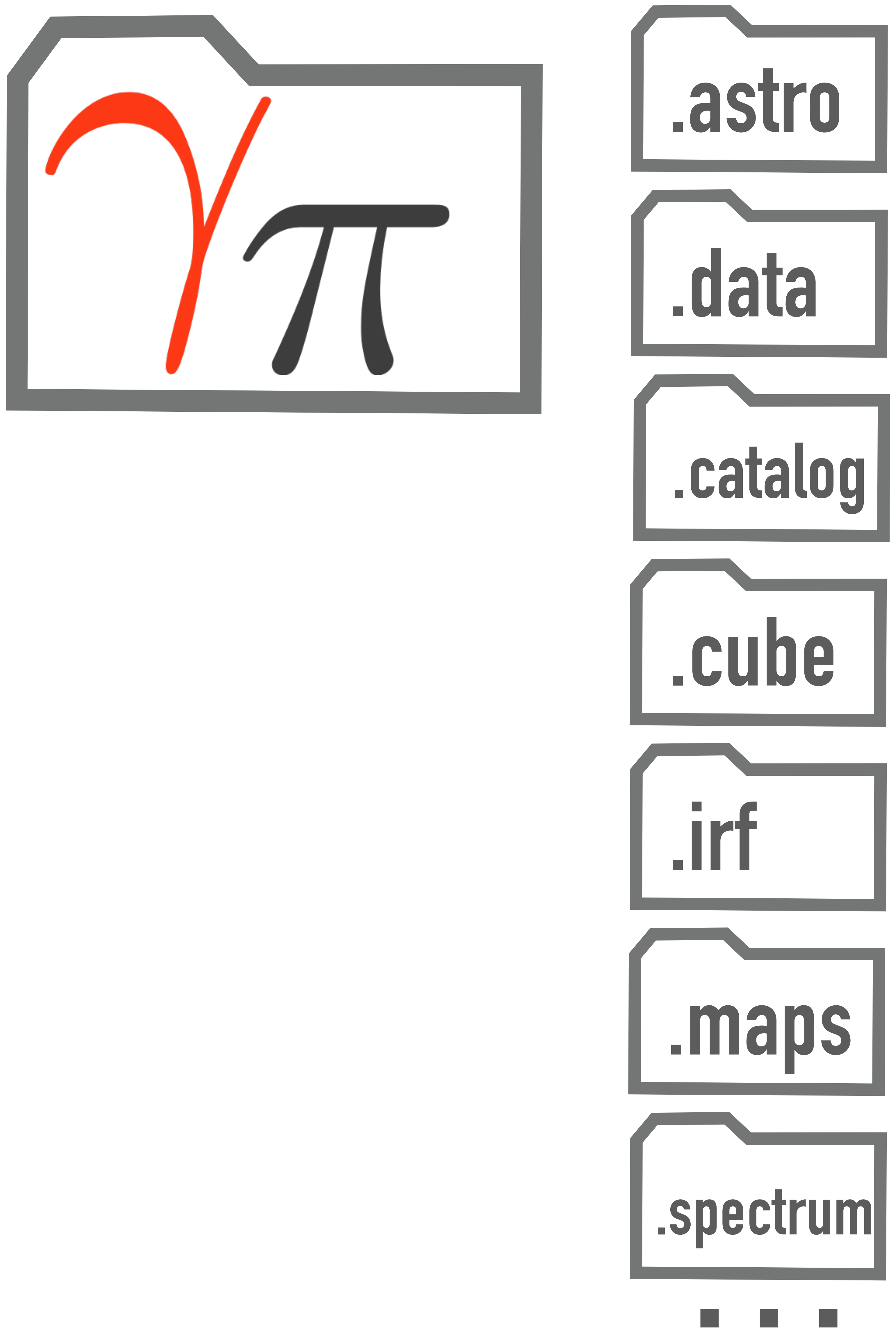
Download tutorials:

1.
```
$ gammapy download tutorials
```
2.
```
$ cd gammapy-tutorials
```
3.
```
$ export GAMMAPY_DATA=$PWD/datasets
```

FEATURES

FEATURES OVERVIEW

FEATURES OVERVIEW



.astro

.data

.catalog

.cube

.irf

.maps

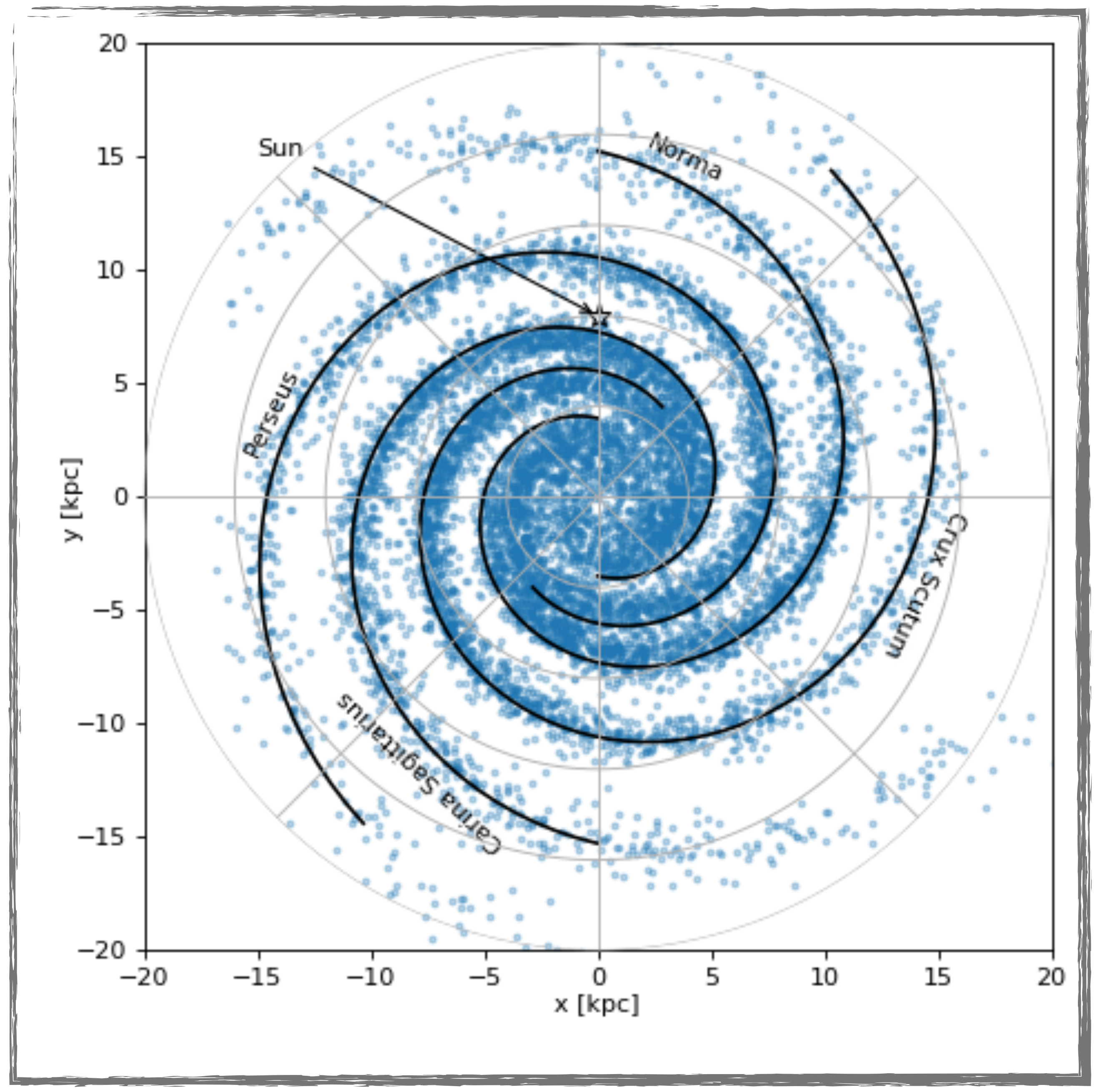
.spectrum

...

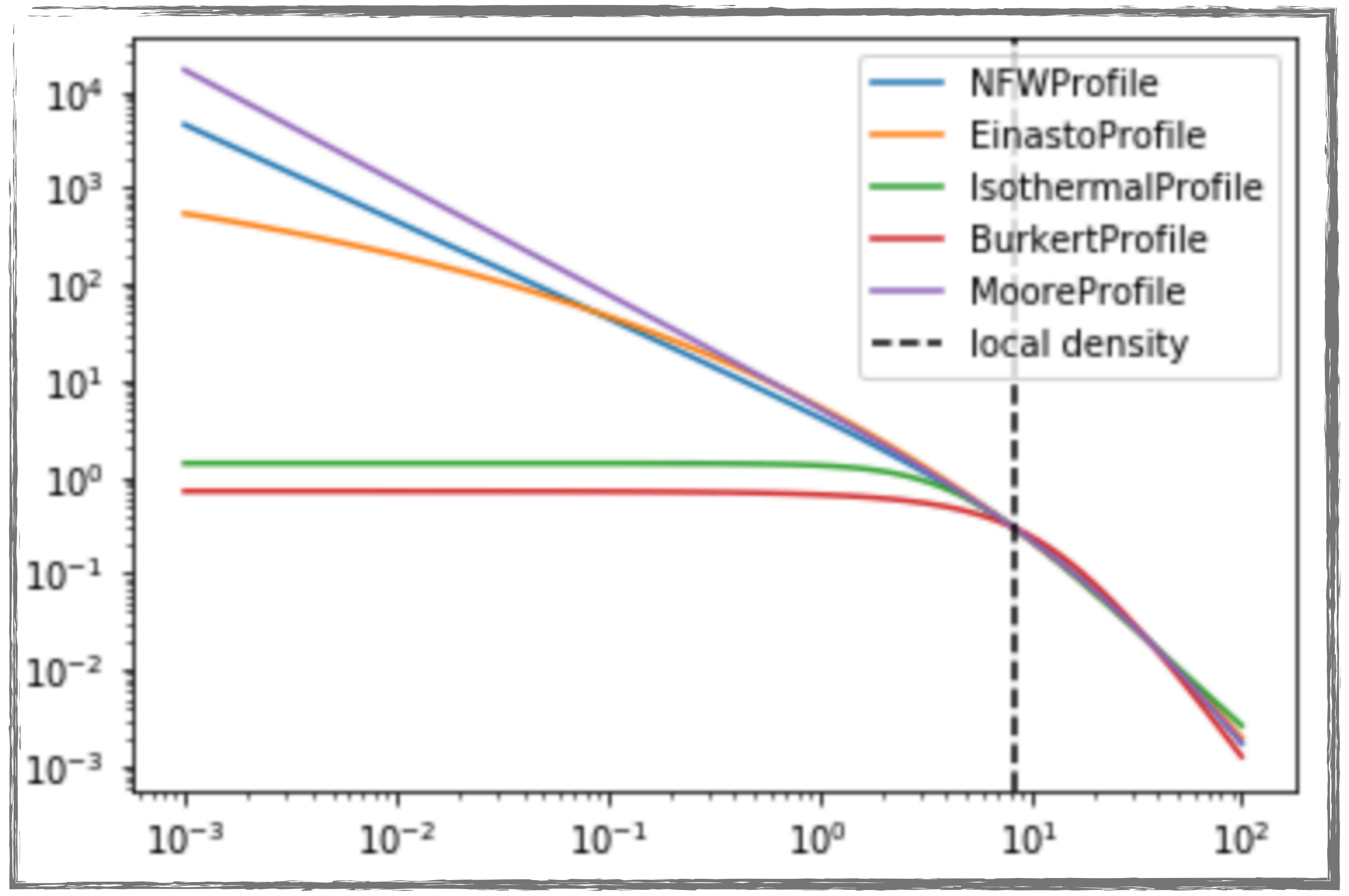
[*https://docs.gammapy.org/0.12/index.html#gammapy-package*](https://docs.gammapy.org/0.12/index.html#gammapy-package)

FEATURES OVERVIEW

- .astro
- .data
- .catalog
- .cube
- .irf
- .maps
- .spectrum
- ...

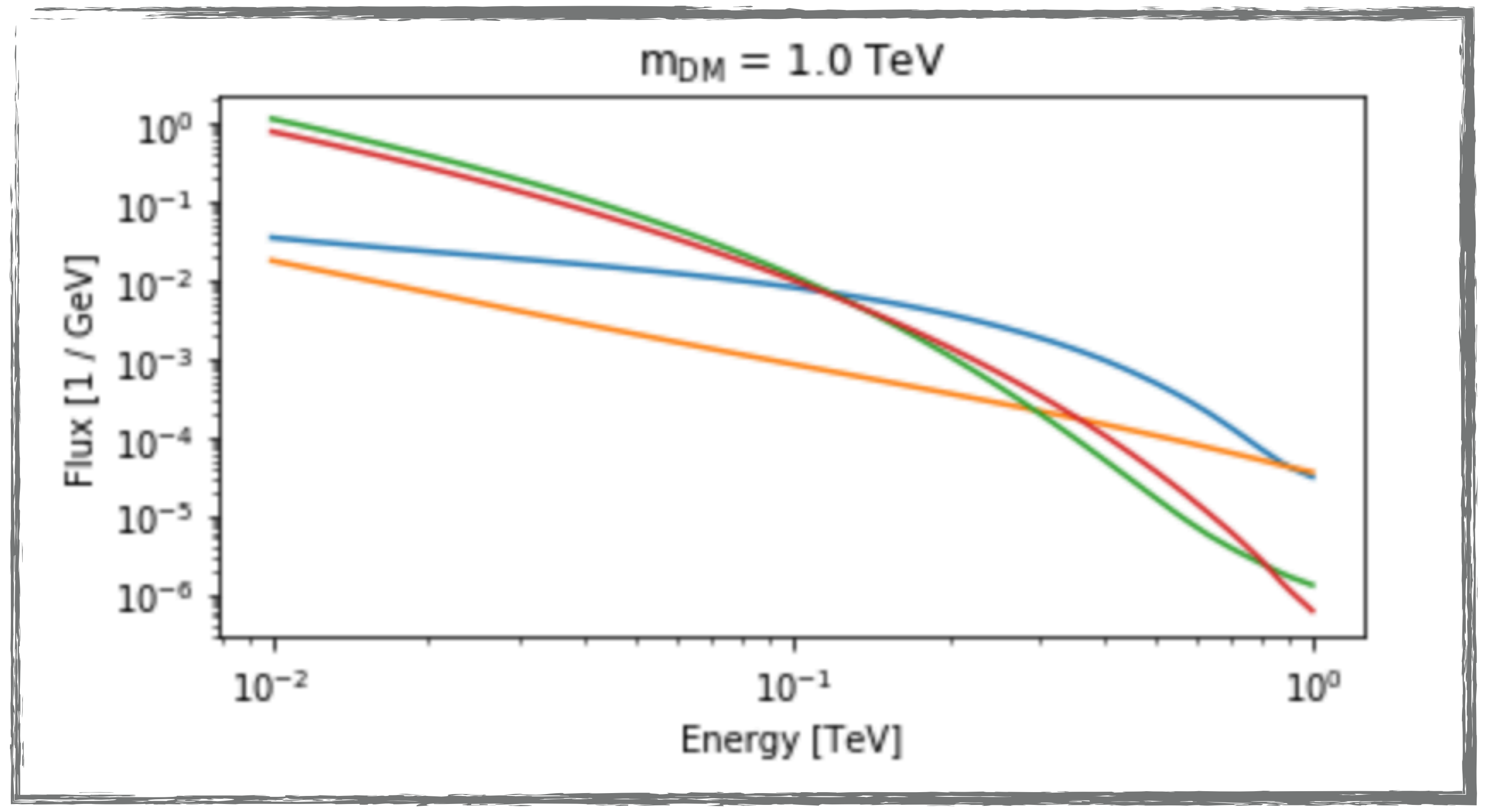


Source population models



DM profiles

DM spectral models



https://docs.gammapy.org/0.12/astro/index.html

FEATURES OVERVIEW

.astro

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.catalog

.cube

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.maps

.spectrum

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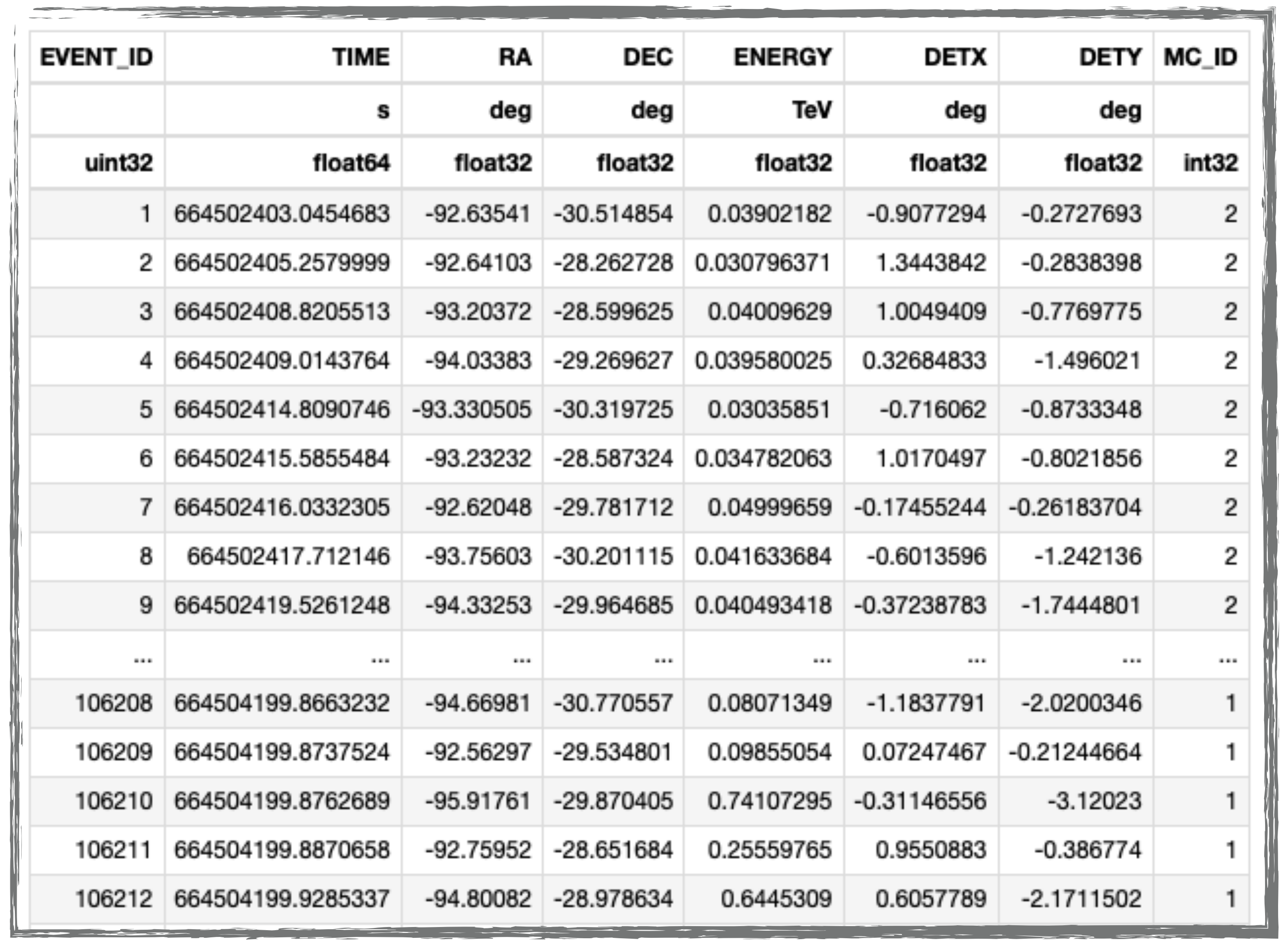
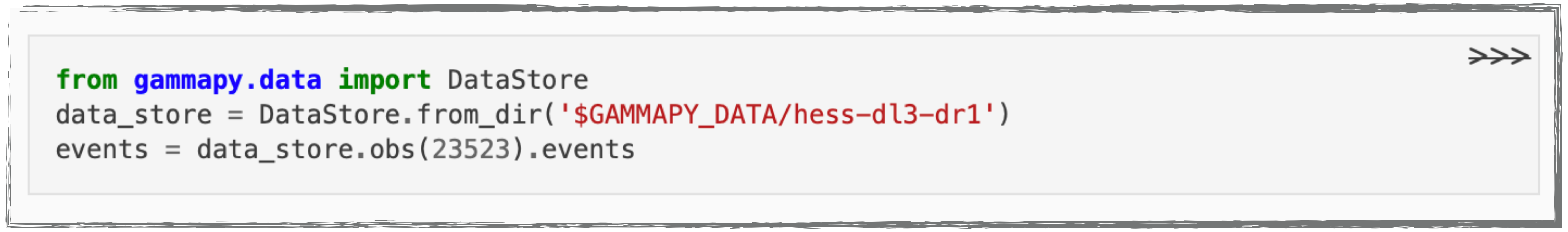
DL3 data access

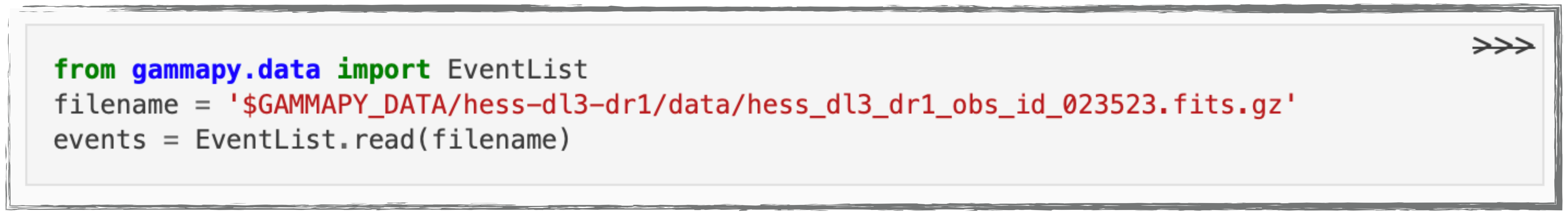
Handling of event lists / GTI tables



EVENT_ID	TIME	RA	DEC	ENERGY	DETX	DETY	MC_ID
	s	deg	deg	TeV	deg	deg	
uint32	float64	float32	float32	float32	float32	float32	int32
1	664502403.0454683	-92.63541	-30.514854	0.03902182	-0.9077294	-0.2727693	2
2	664502405.2579999	-92.64103	-28.262728	0.030796371	1.3443842	-0.2838398	2
3	664502408.8205513	-93.20372	-28.599625	0.04009629	1.0049409	-0.7769775	2
4	664502409.0143764	-94.03383	-29.269627	0.039580025	0.32684833	-1.496021	2
5	664502414.8090746	-93.330505	-30.319725	0.03035851	-0.716062	-0.8733348	2
6	664502415.5855484	-93.23232	-28.587324	0.034782063	1.0170497	-0.8021856	2
7	664502416.0332305	-92.62048	-29.781712	0.04999659	-0.17455244	-0.26183704	2
8	664502417.712146	-93.75603	-30.201115	0.041633684	-0.6013596	-1.242136	2
9	664502419.5261248	-94.33253	-29.964685	0.040493418	-0.37238783	-1.7444801	2
...	...	...	...	...	...	...	...
106208	664504199.8663232	-94.66981	-30.770557	0.08071349	-1.1837791	-2.0200346	1
106209	664504199.8737524	-92.56297	-29.534801	0.09855054	0.07247467	-0.21244664	1
106210	664504199.8762689	-95.91761	-29.870405	0.74107295	-0.31146556	-3.12023	1
106211	664504199.8870658	-92.75952	-28.651684	0.25559765	0.9550883	-0.386774	1
106212	664504199.9285337	-94.80082	-28.978634	0.6445309	0.6057789	-2.1711502	1



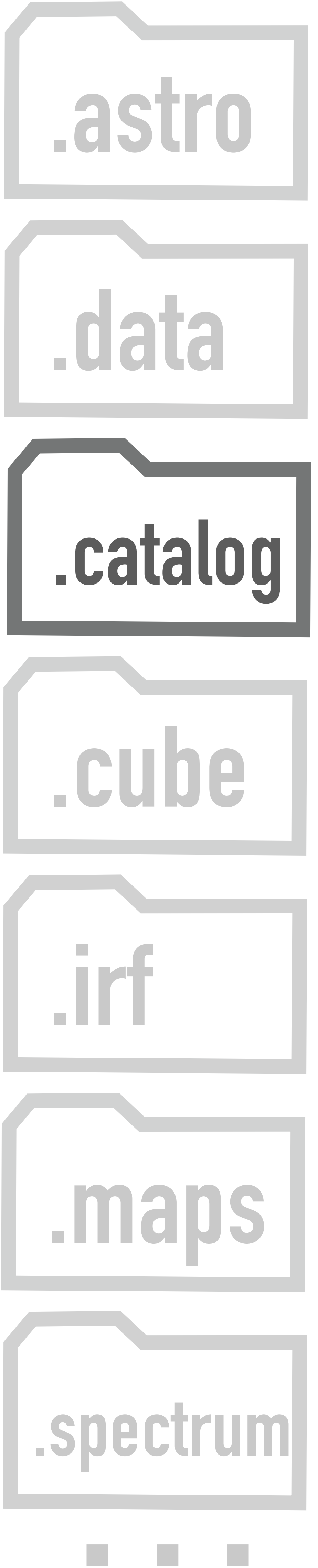
```
>>>
from gammapy.data import DataStore
data_store = DataStore.from_dir('$GAMMAPY_DATA/hess-dl3-dr1')
events = data_store.obs(23523).events
```



```
>>>
from gammapy.data import EventList
filename = '$GAMMAPY_DATA/hess-dl3-dr1/data/hess_dl3_dr1_obs_id_023523.fits.gz'
events = EventList.read(filename)
```

https://docs.gammapy.org/0.12/data/index.html

FEATURES OVERVIEW



.astro

.data

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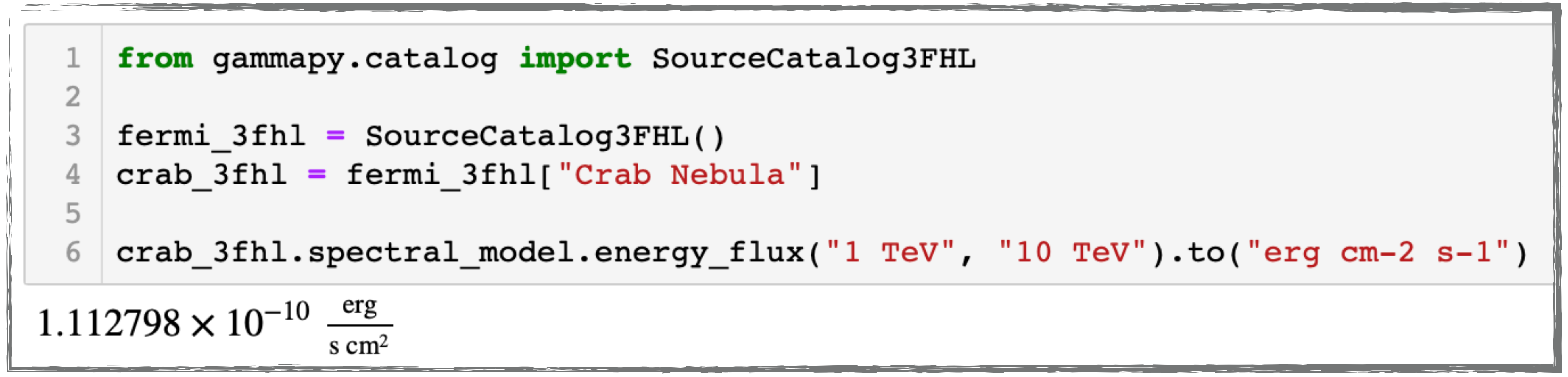
...

Gamma-ray source catalogs access

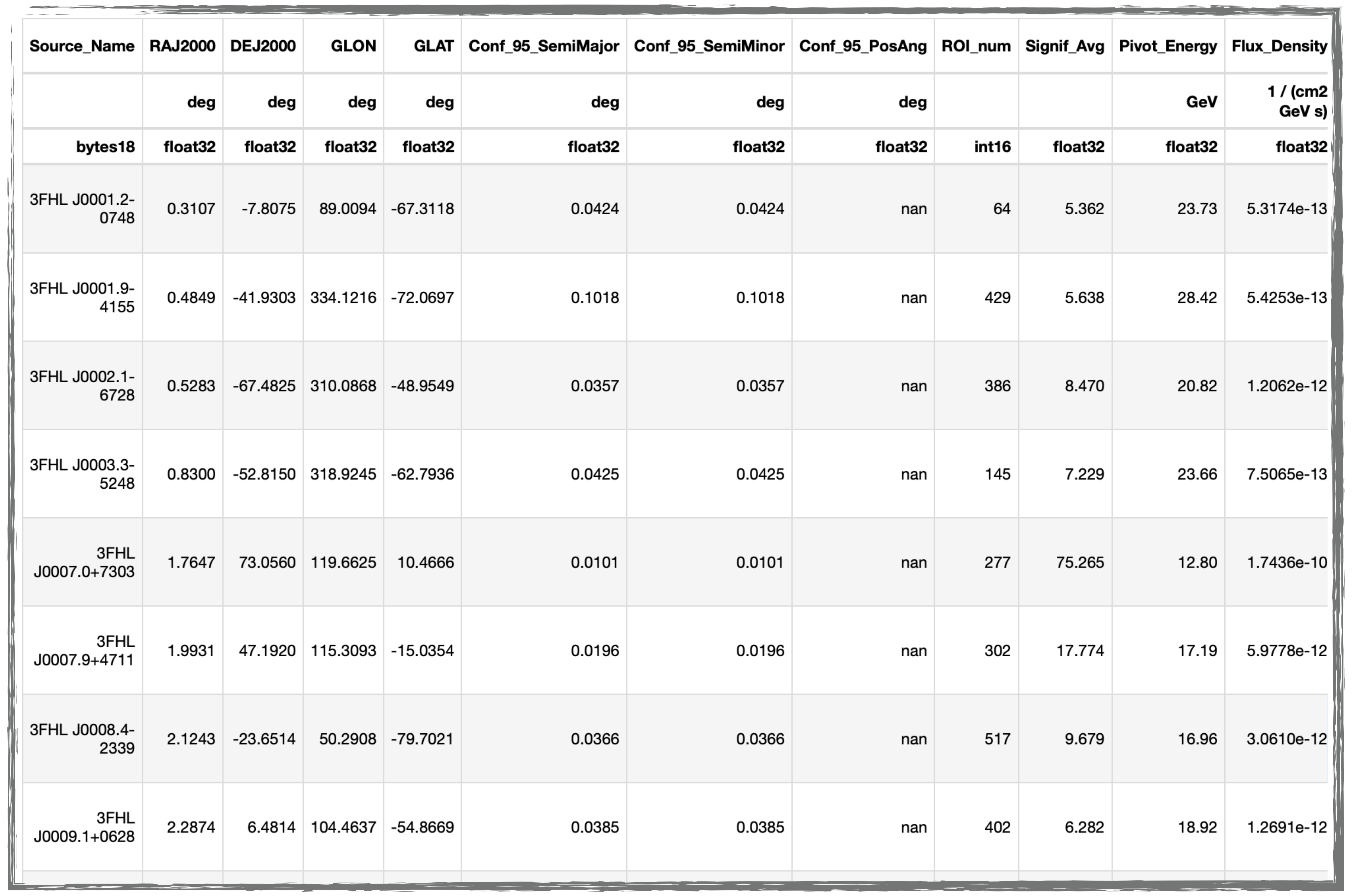


```python
from gammapy.catalog import SourceCatalog3FHL

fermi_3fhl = SourceCatalog3FHL()
crab_3fhl = fermi_3fhl["Crab Nebula"]

crab_3fhl.spectral_model.energy_flux("1 TeV", "10 TeV").to("erg cm-2 s-1")
```

$$1.112798 \times 10^{-10}\ \frac{\mathrm{erg}}{\mathrm{s\ cm^2}}$$



Source_Name	RAJ2000	DEJ2000	GLON	GLAT	Conf_95_SemiMajor	Conf_95_SemiMinor	Conf_95_PosAng	ROI_num	Signif_Avg	Pivot_Energy	Flux_Density
	deg	deg	deg	deg	deg	deg	deg			GeV	1 / (cm2 GeV s)
bytes18	float32	float32	float32	float32	float32	float32	float32	int16	float32	float32	float32
3FHL J0001.2-0748	0.3107	-7.8075	89.0094	-67.3118	0.0424	0.0424	nan	64	5.362	23.73	5.3174e-13
3FHL J0001.9-4155	0.4849	-41.9303	334.1216	-72.0697	0.1018	0.1018	nan	429	5.638	28.42	5.4253e-13
3FHL J0002.1-6728	0.5283	-67.4825	310.0868	-48.9549	0.0357	0.0357	nan	386	8.470	20.82	1.2062e-12
3FHL J0003.3-5248	0.8300	-52.8150	318.9245	-62.7936	0.0425	0.0425	nan	145	7.229	23.66	7.5065e-13
3FHL J0007.0+7303	1.7647	73.0560	119.6625	10.4666	0.0101	0.0101	nan	277	75.265	12.80	1.7436e-10
3FHL J0007.9+4711	1.9931	47.1920	115.3093	-15.0354	0.0196	0.0196	nan	302	17.774	17.19	5.9778e-12
3FHL J0008.4-2339	2.1243	-23.6514	50.2908	-79.7021	0.0366	0.0366	nan	517	9.679	16.96	3.0610e-12
3FHL J0009.1+0628	2.2874	6.4814	104.4637	-54.8669	0.0385	0.0385	nan	402	6.282	18.92	1.2691e-12

H.E.S.S. HGPS

Fermi Gamma-ray Space Telescope

1FHL
2FHL
3FHL
3FGL

HAWC High Altitude Water Cherenkov Gamma-Ray Observatory 2HWC

https://docs.gammapy.org/0.12/catalog/index.html

FEATURES OVERVIEW

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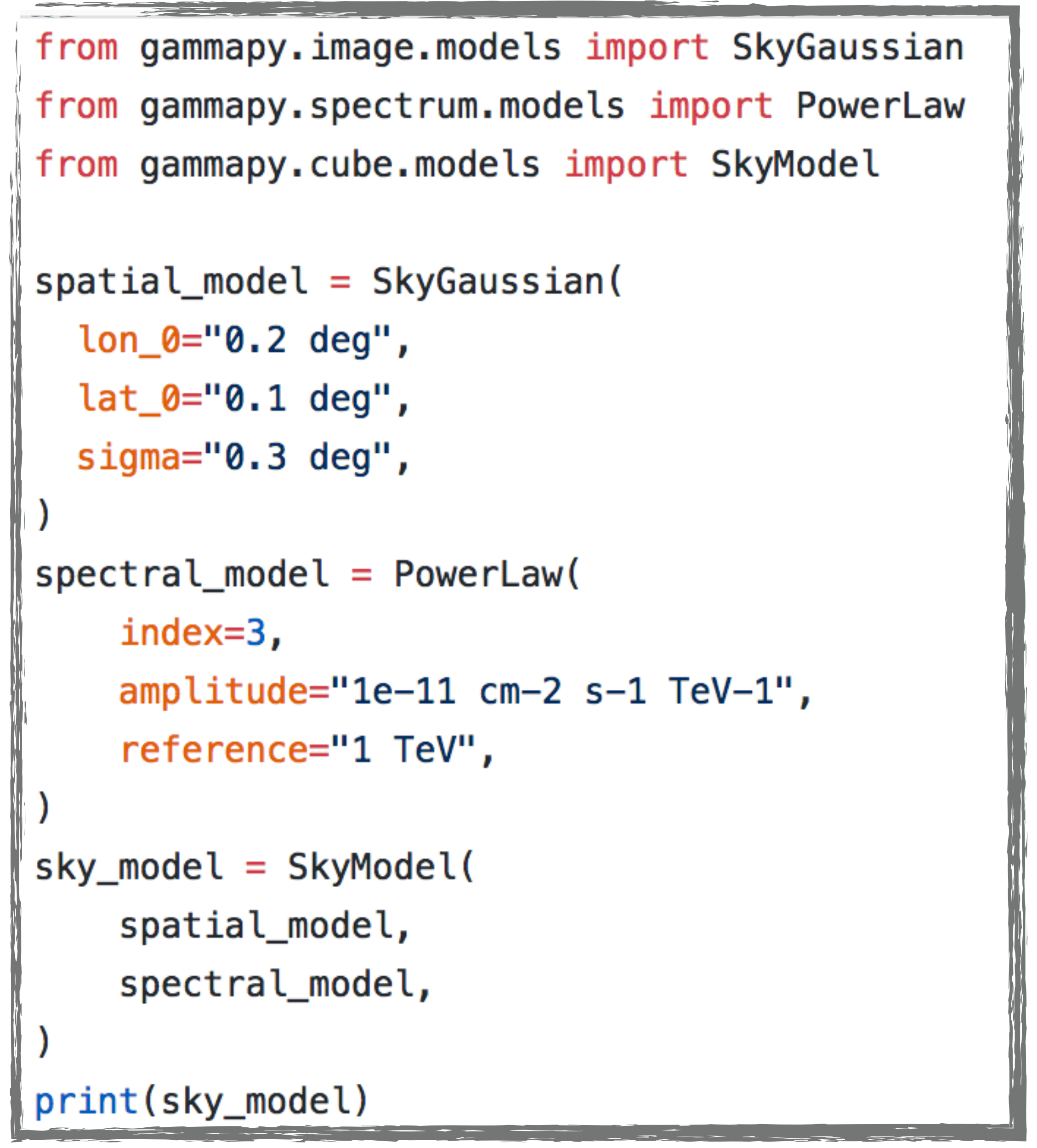
...

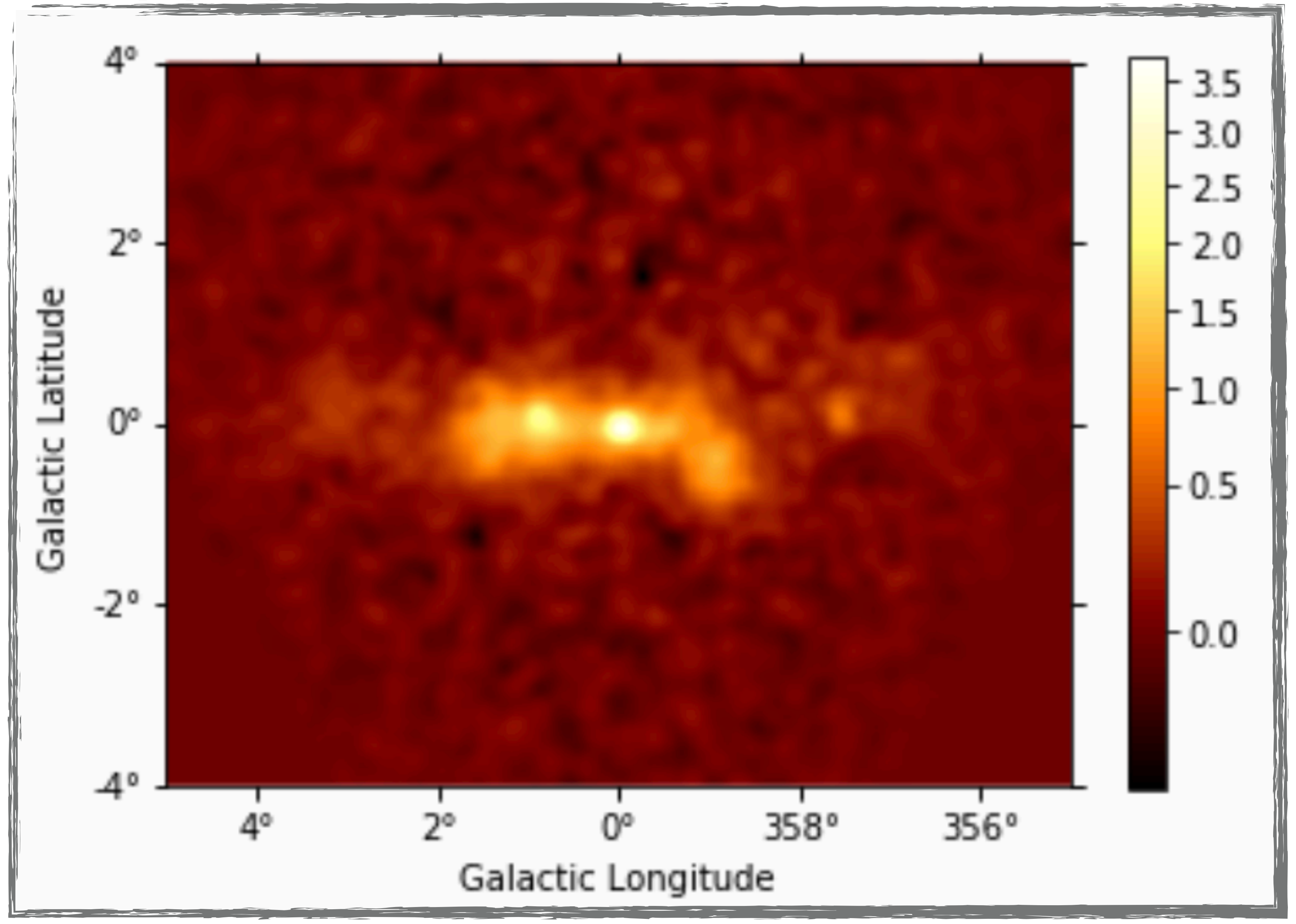
Sky models



```
from gammapy.image.models import SkyGaussian
from gammapy.spectrum.models import PowerLaw
from gammapy.cube.models import SkyModel

spatial_model = SkyGaussian(
  lon_0="0.2 deg",
  lat_0="0.1 deg",
  sigma="0.3 deg",
)
spectral_model = PowerLaw(
    index=3,
    amplitude="1e-11 cm-2 s-1 TeV-1",
    reference="1 TeV",
)
sky_model = SkyModel(
    spatial_model,
    spectral_model,
)
print(sky_model)
```

Map preparation



https://docs.gammapy.org/0.12/cube/index.html

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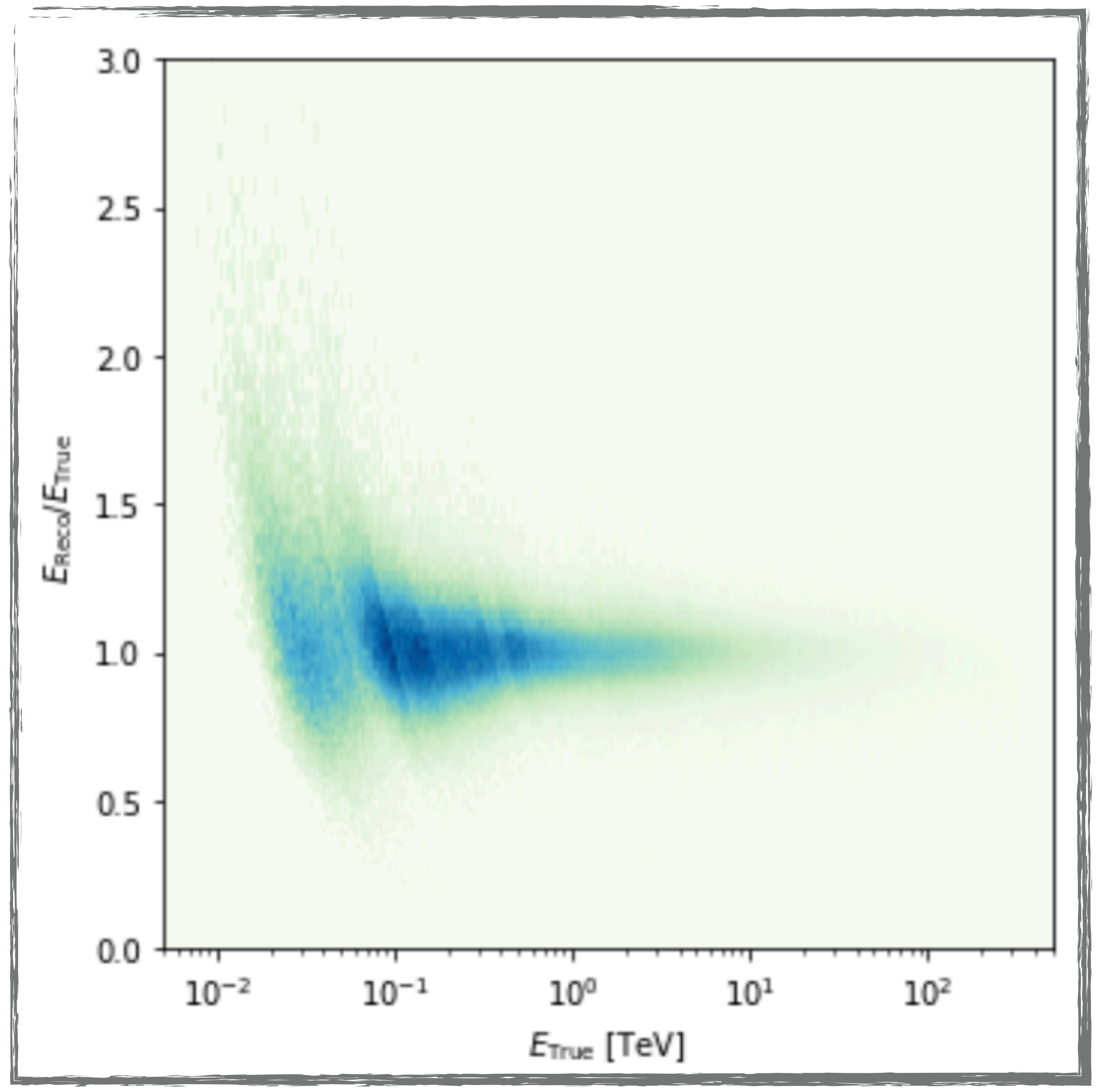
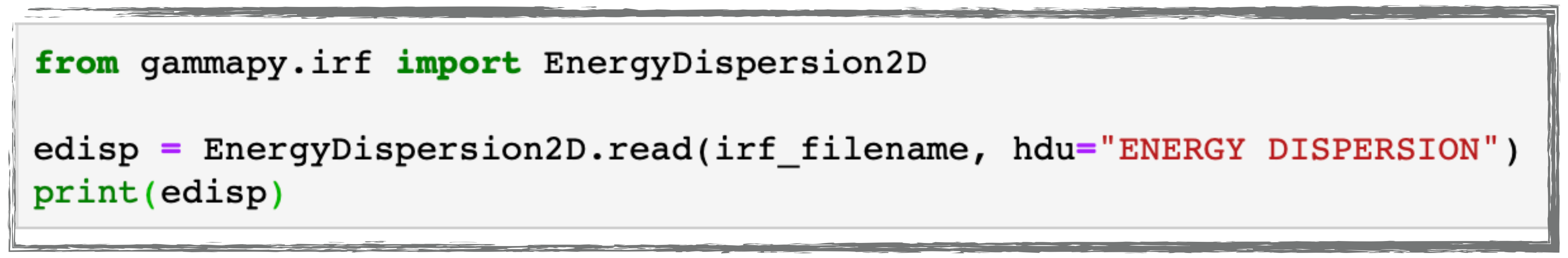
...

Energy dispersion handling

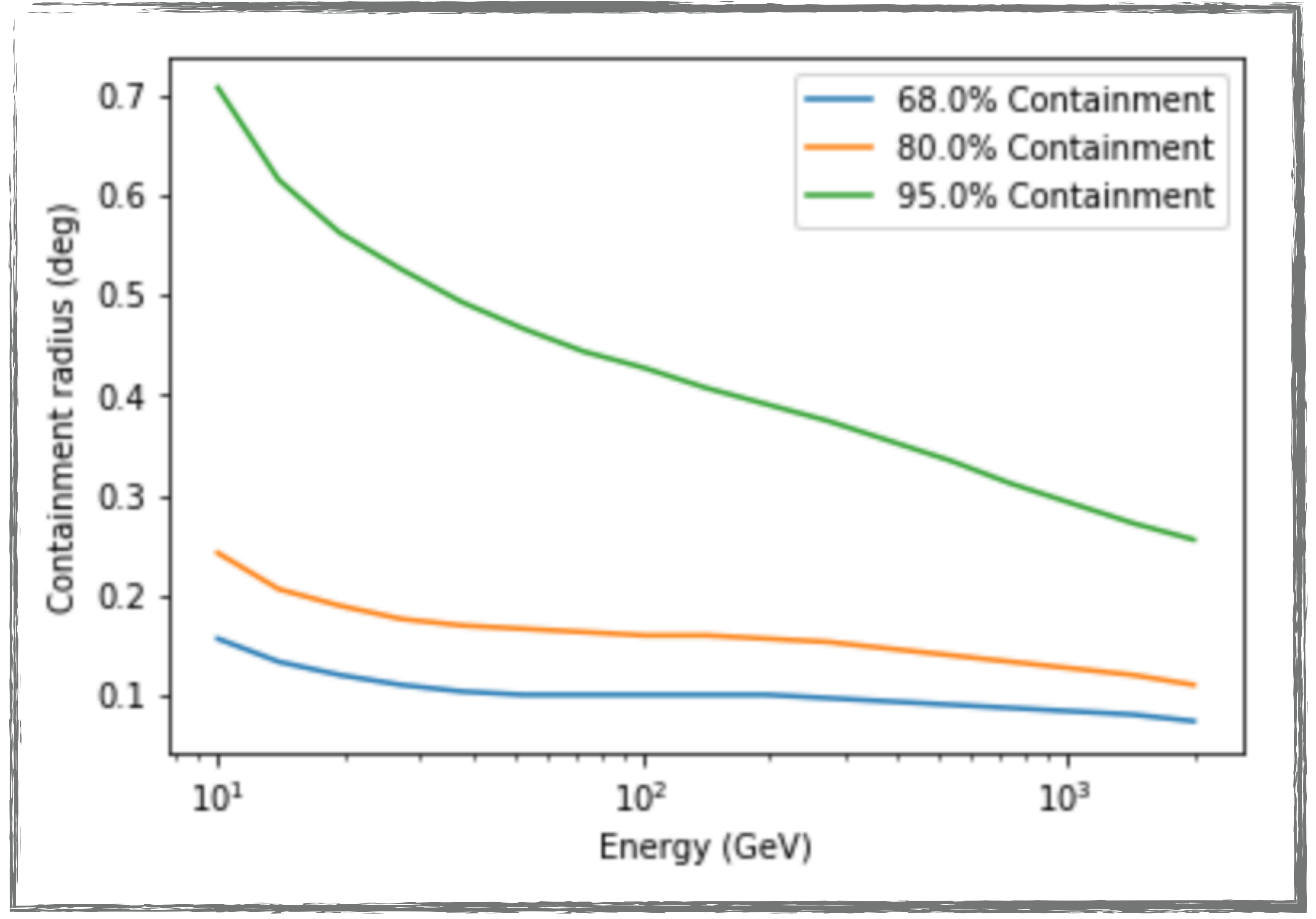


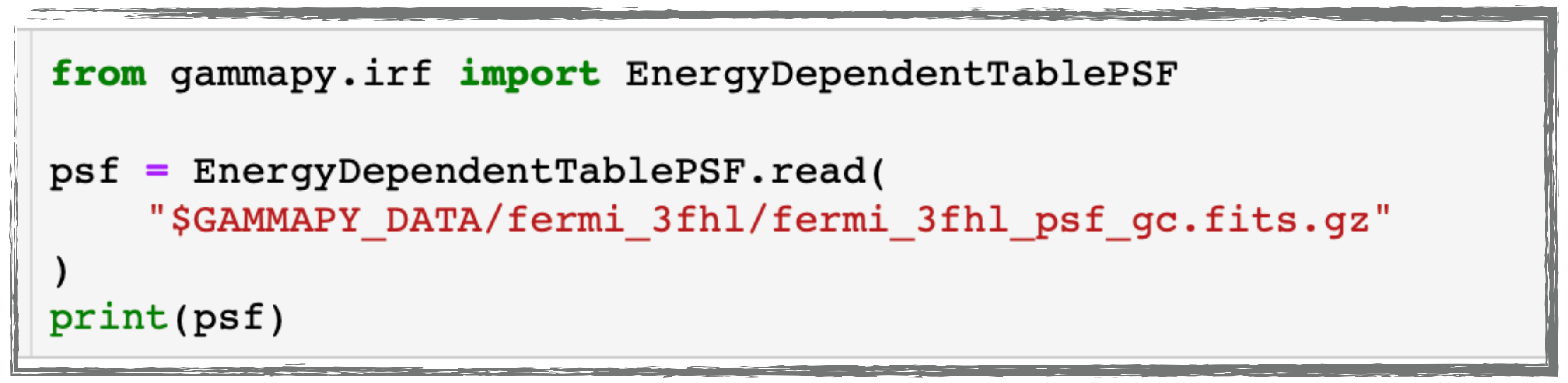


```
from gammapy.irf import EnergyDispersion2D

edisp = EnergyDispersion2D.read(irf_filename, hdu="ENERGY DISPERSION")
print(edisp)
```

PSF handling





```
from gammapy.irf import EnergyDependentTablePSF

psf = EnergyDependentTablePSF.read(
    "$GAMMAPY_DATA/fermi_3fhl/fermi_3fhl_psf_gc.fits.gz"
)
print(psf)
```

https://docs.gammapy.org/0.12/irf/index.html

FEATURES OVERVIEW

.astro

.data

.catalog

.cube

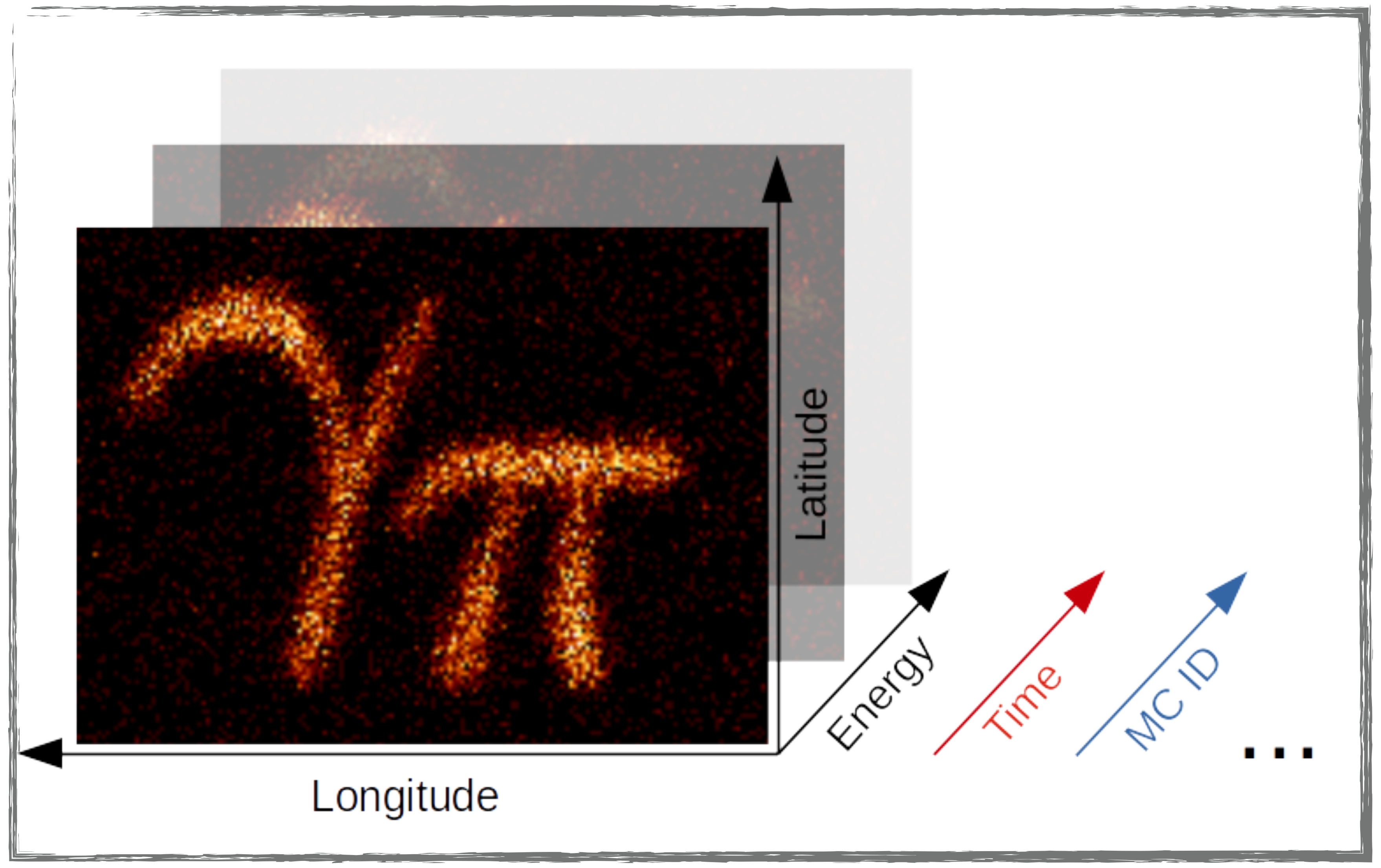
.irf

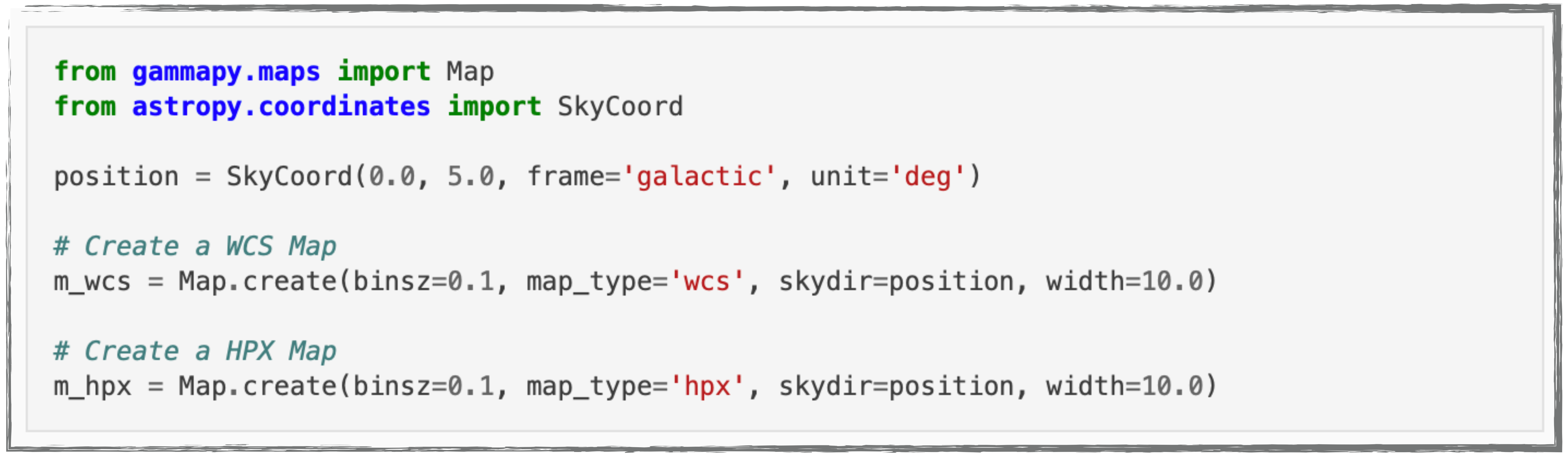
.maps

.spectrum

...

N-dimensional WCS and HEALPix based sky maps





```
from gammapy.maps import Map
from astropy.coordinates import SkyCoord

position = SkyCoord(0.0, 5.0, frame='galactic', unit='deg')

# Create a WCS Map
m_wcs = Map.create(binsz=0.1, map_type='wcs', skydir=position, width=10.0)

# Create a HPX Map
m_hpx = Map.create(binsz=0.1, map_type='hpx', skydir=position, width=10.0)
```

https://docs.gammapy.org/0.12/maps/index.html

FEATURES OVERVIEW

.astro

.data

.catalog

.cube

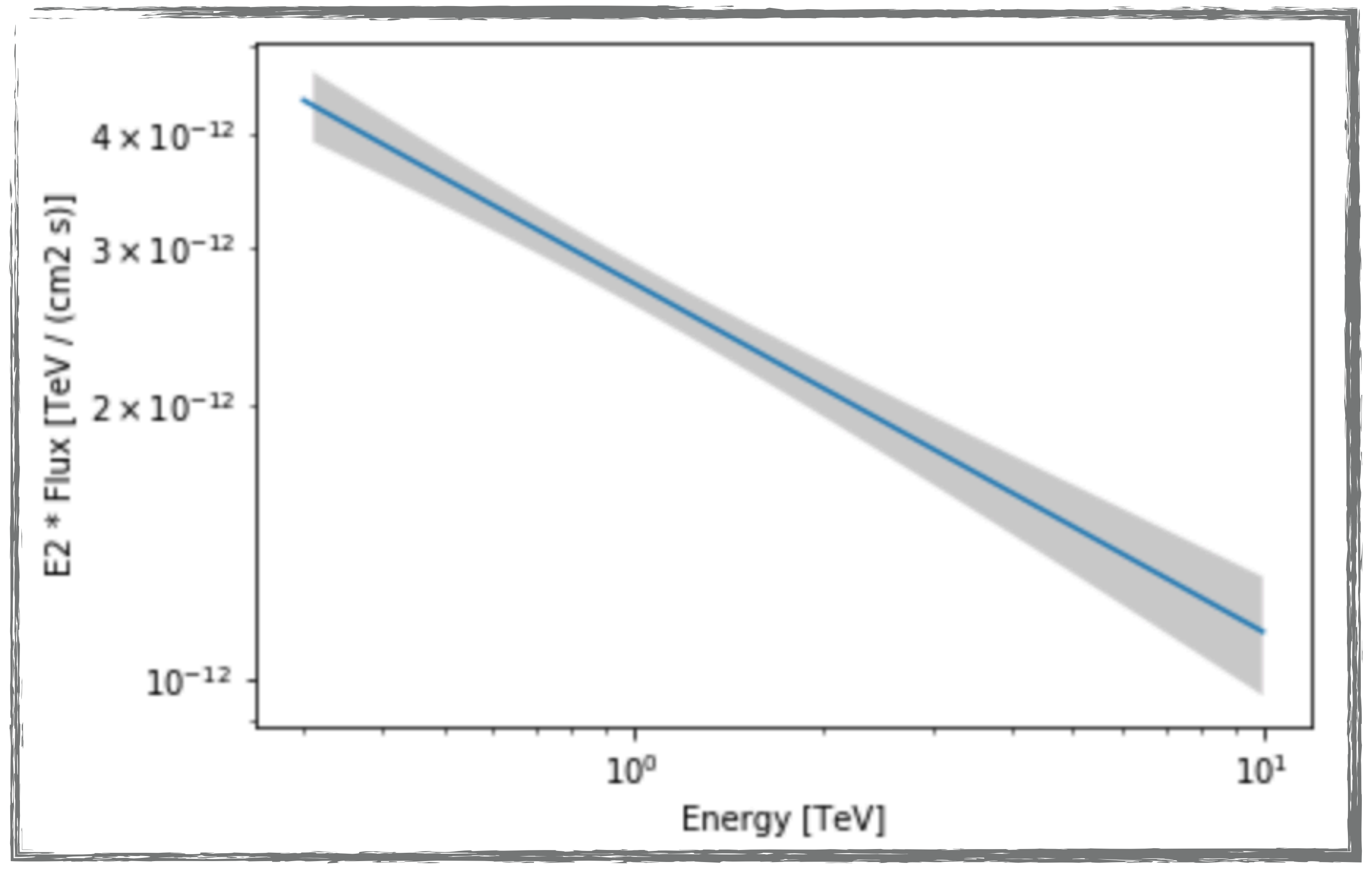
.irf

.maps

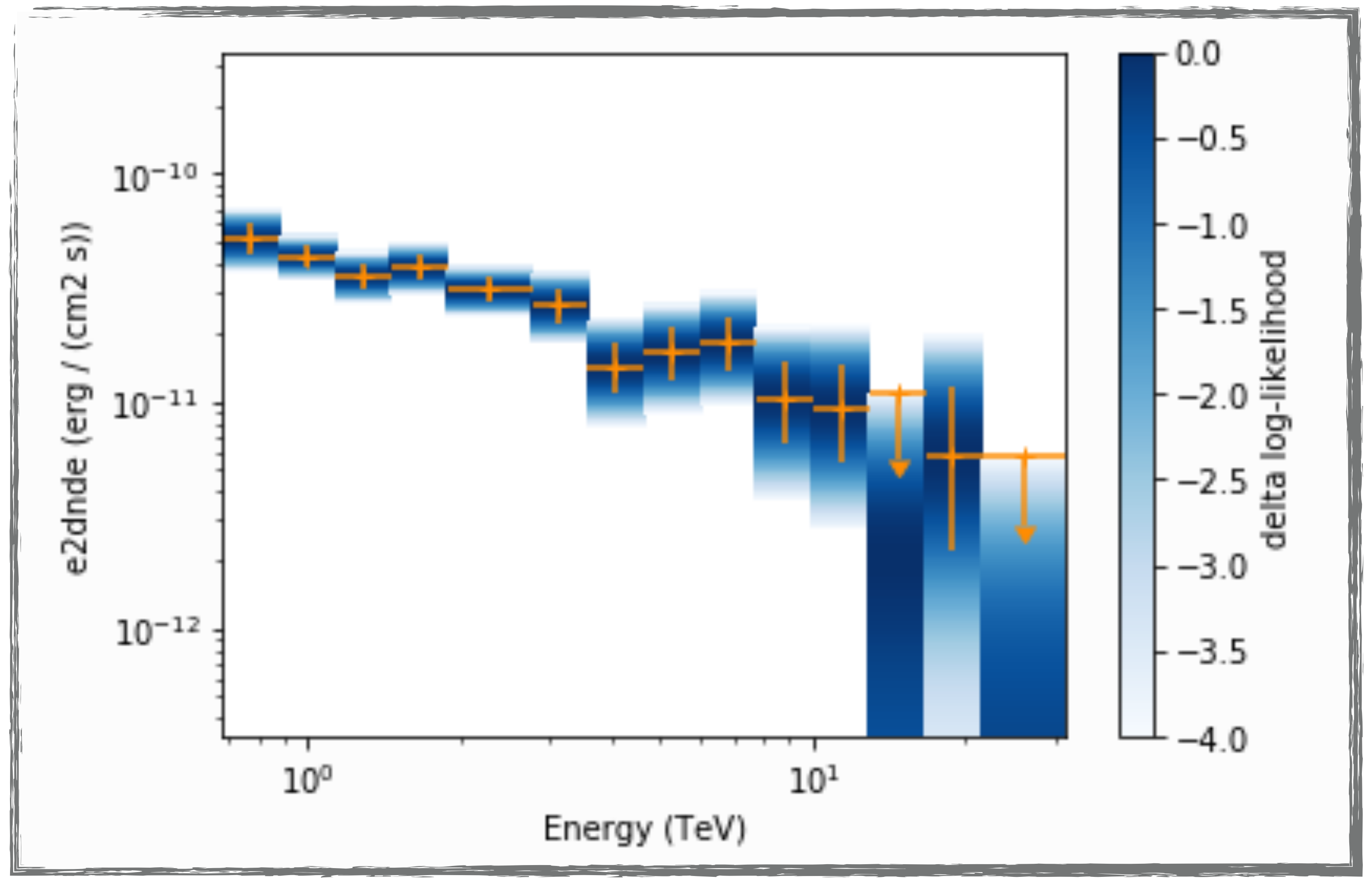
.spectrum

...

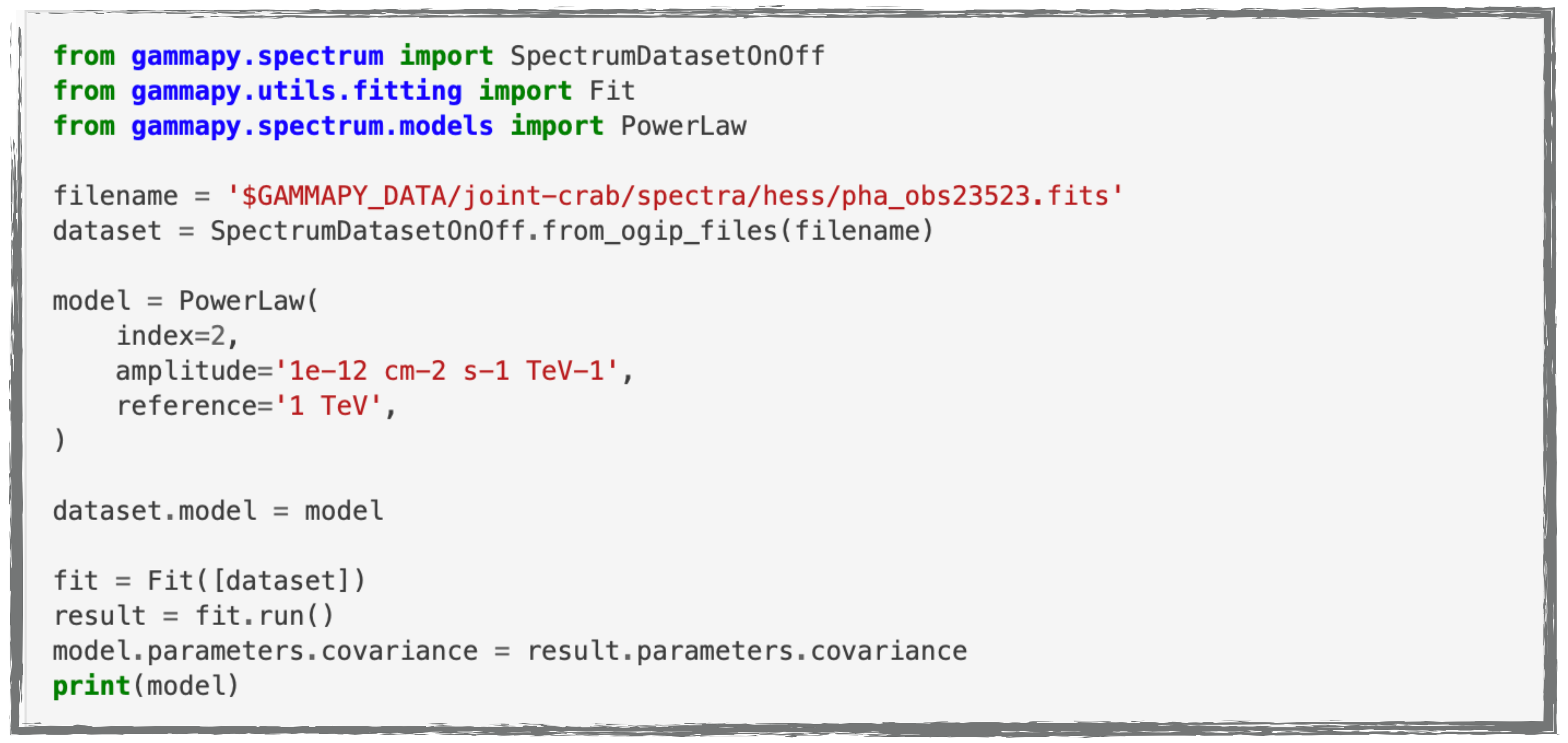
Spectral models



SED computation and handling



Spectral analysis



```python
from gammapy.spectrum import SpectrumDatasetOnOff
from gammapy.utils.fitting import Fit
from gammapy.spectrum.models import PowerLaw

filename = '$GAMMAPY_DATA/joint-crab/spectra/hess/pha_obs23523.fits'
dataset = SpectrumDatasetOnOff.from_ogip_files(filename)

model = PowerLaw(
    index=2,
    amplitude='1e-12 cm-2 s-1 TeV-1',
    reference='1 TeV',
)

dataset.model = model

fit = Fit([dataset])
result = fit.run()
model.parameters.covariance = result.parameters.covariance
print(model)
```

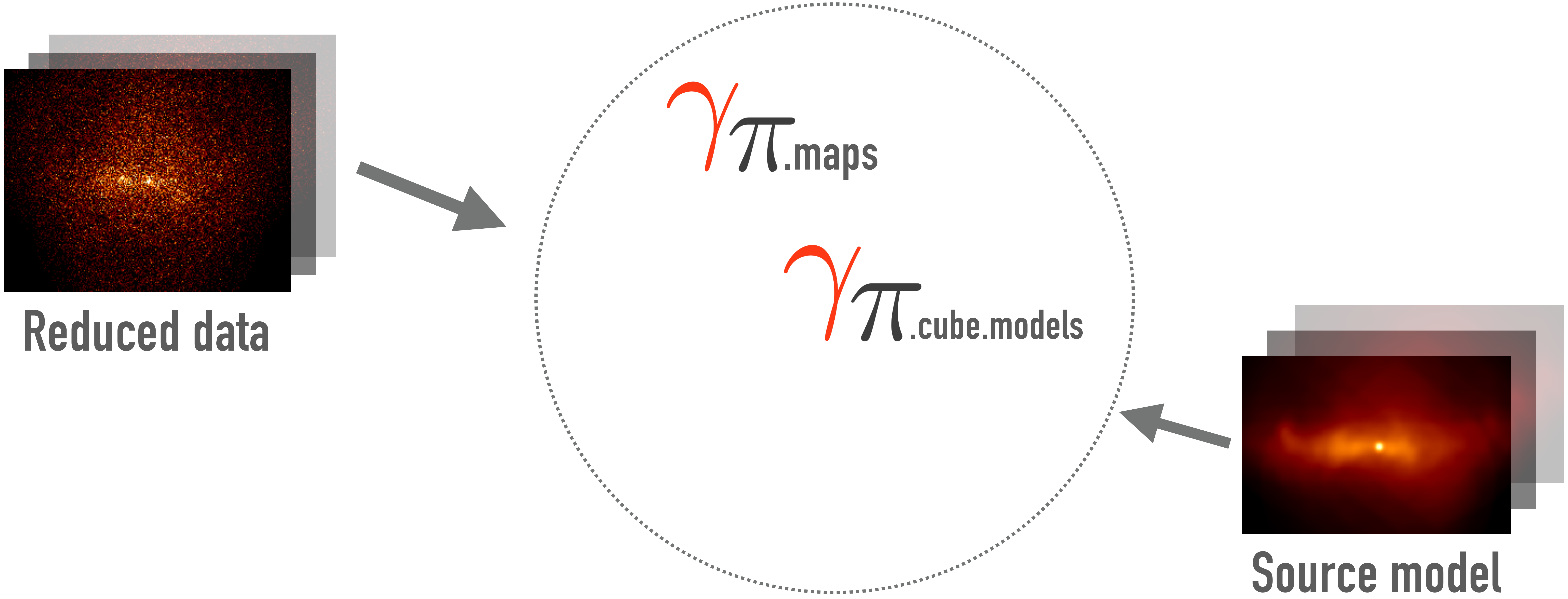
https://docs.gammapy.org/0.12/spectrum/index.html

DEMO

https://docs.gammapy.org/0.12/tutorials.html

RECENT DEVELOPMENTS

DATASETS



γπ.maps

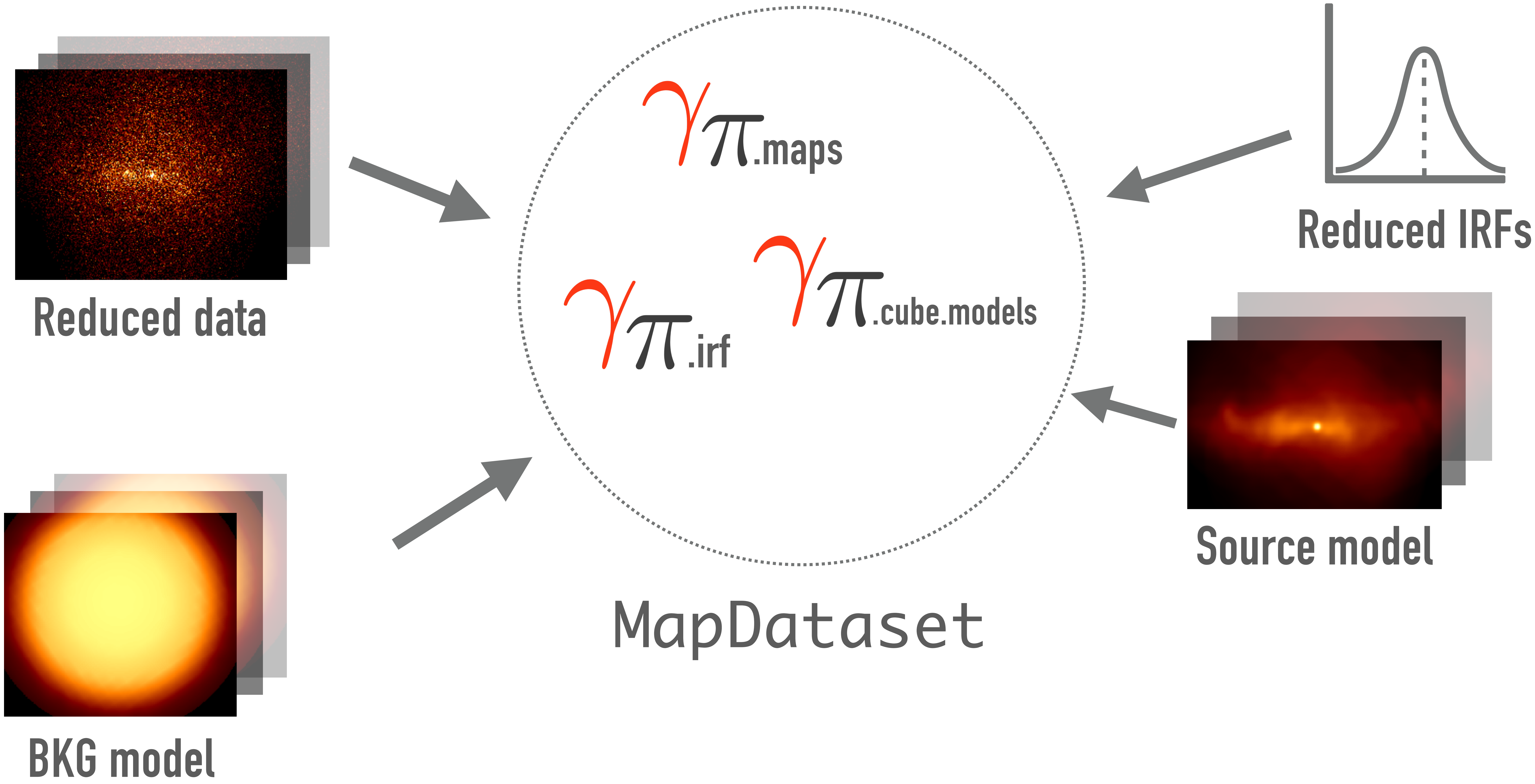
γπ.cube.models

Reduced data

Source model

MapDataset

DATASETS



Reduced data

BKG model

γπ.maps

γπ.irf

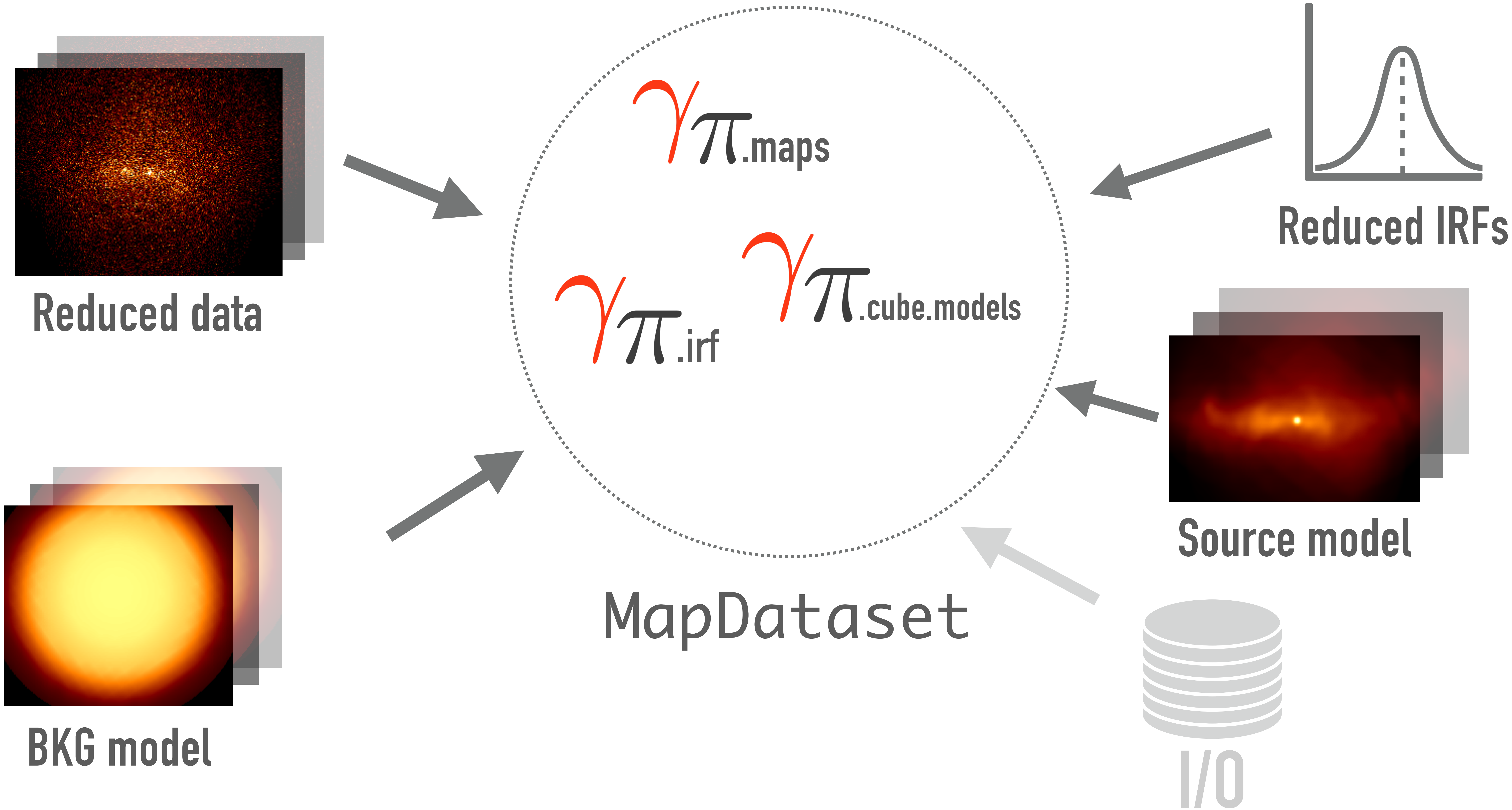
γπ.cube.models

MapDataset

Reduced IRFs

Source model

DATASETS



Reduced data

BKG model

γπ.maps

γπ.irf

γπ.cube.models

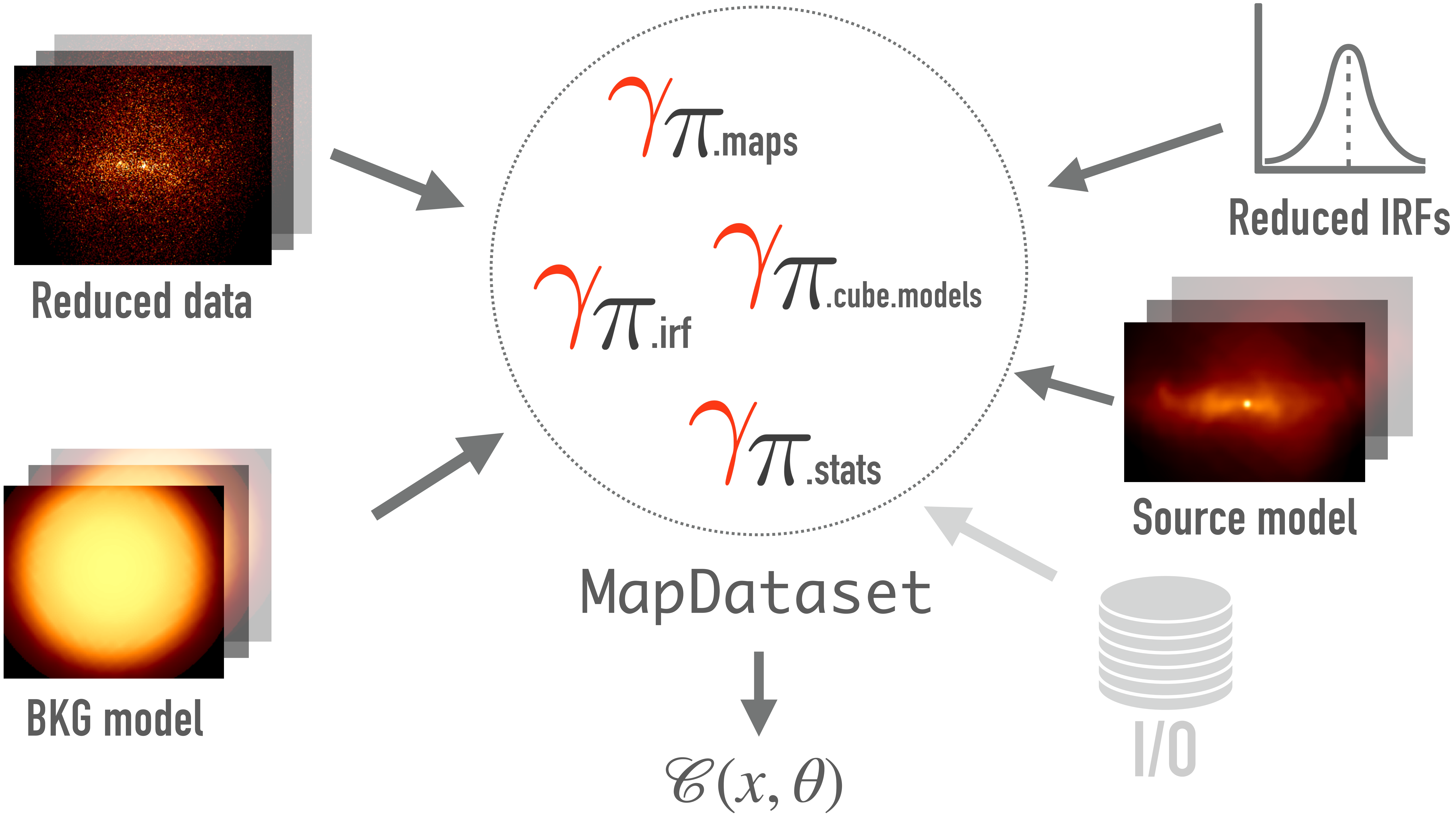
MapDataset

Reduced IRFs

Source model

I/O

DATASETS



Reduced data

BKG model

γπ.maps

γπ.irf

γπ.cube.models

γπ.stats

MapDataset

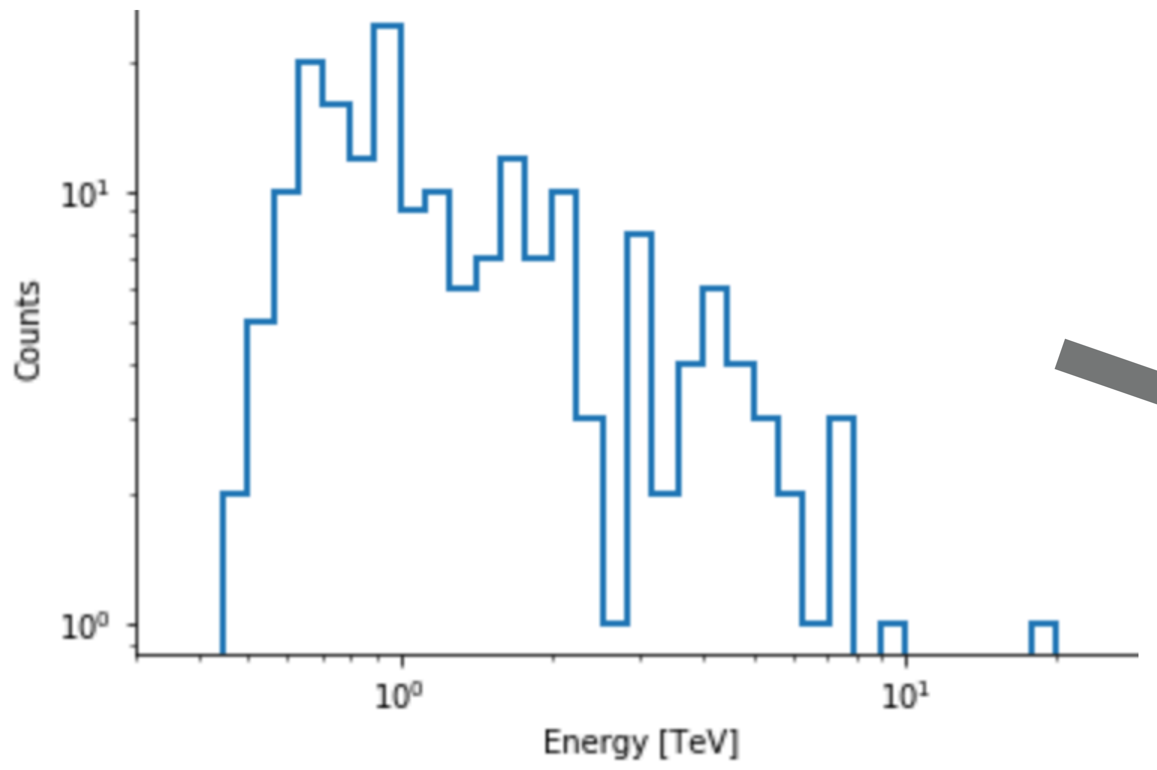
$\mathscr{C}(x, \theta)$

Reduced IRFs

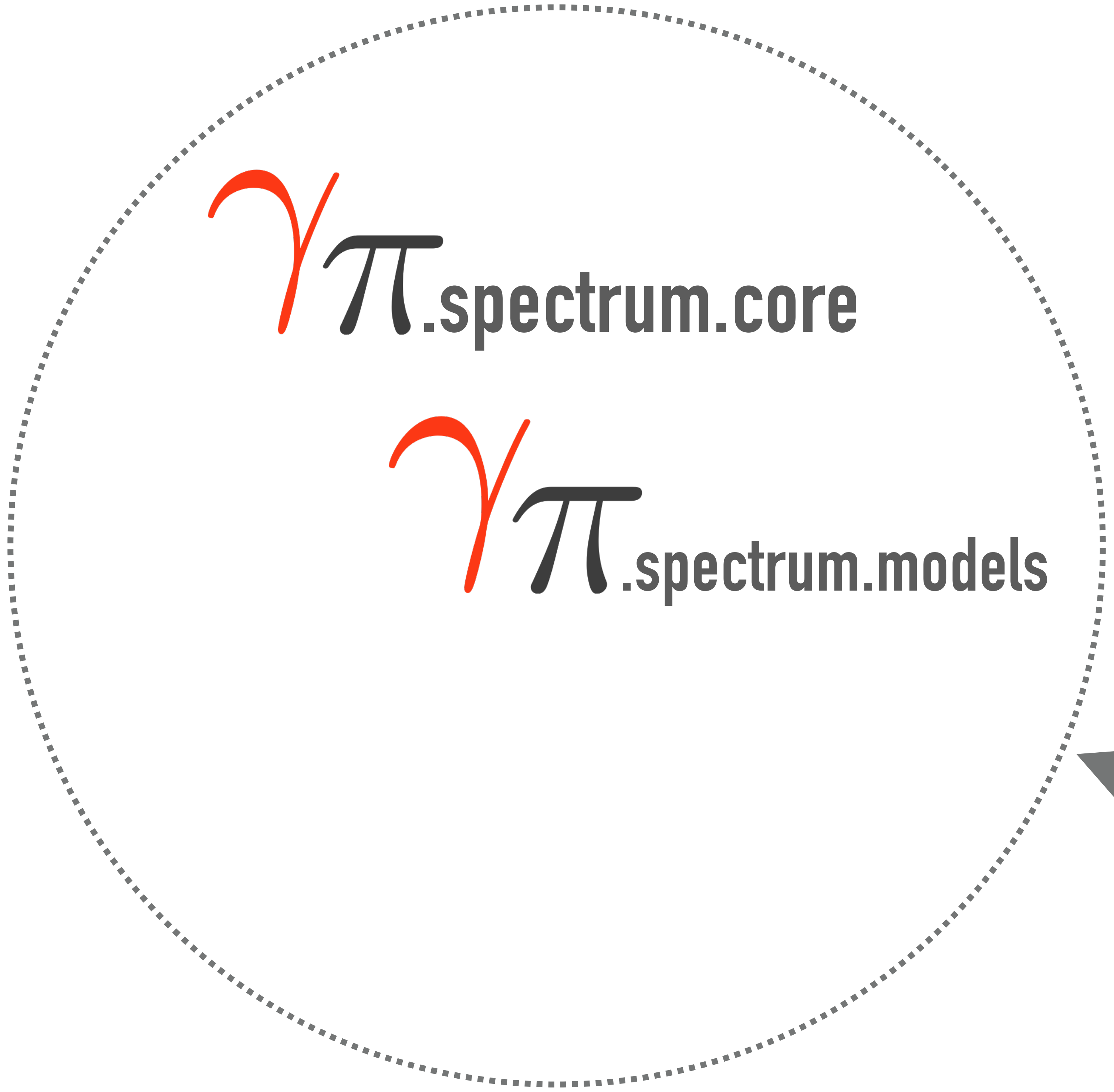
Source model

I/O

DATASETS



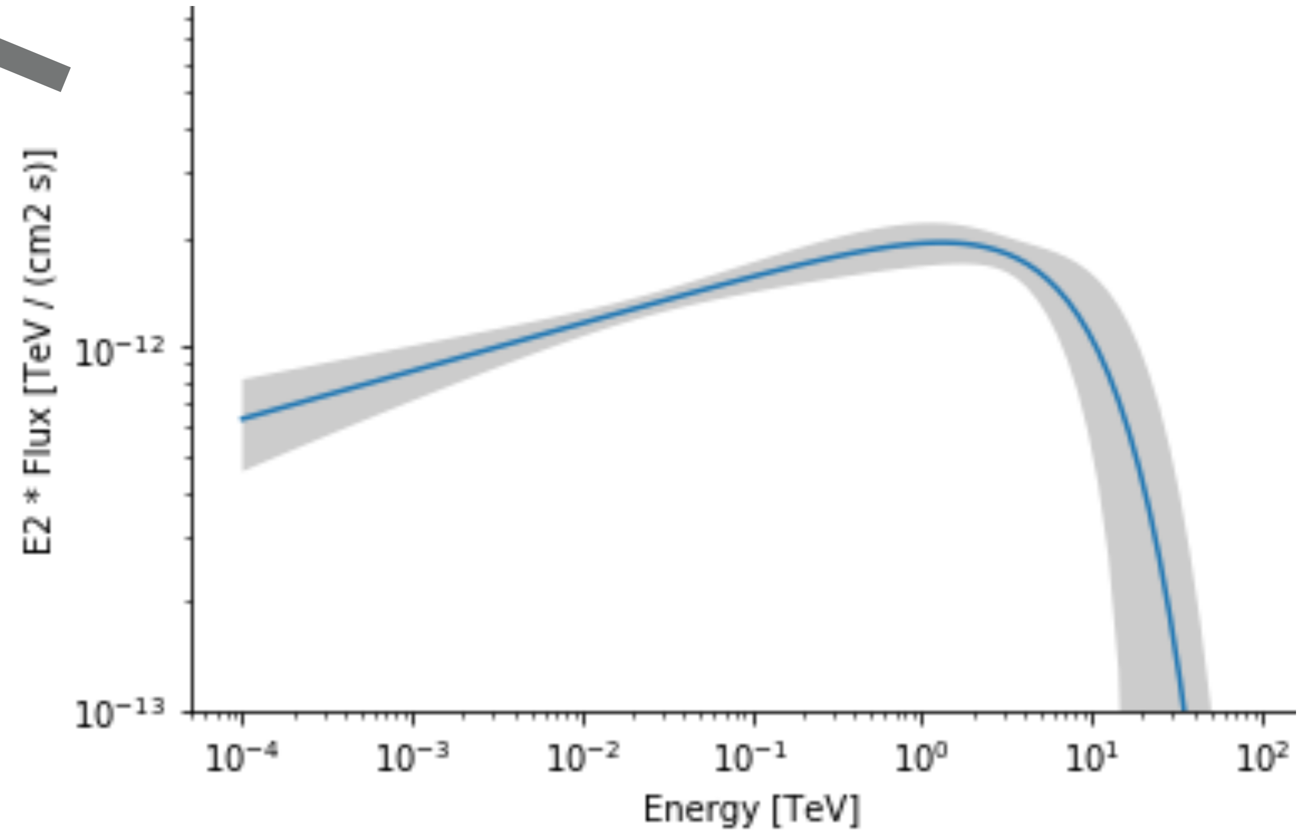
Reduced data



γπ.spectrum.core

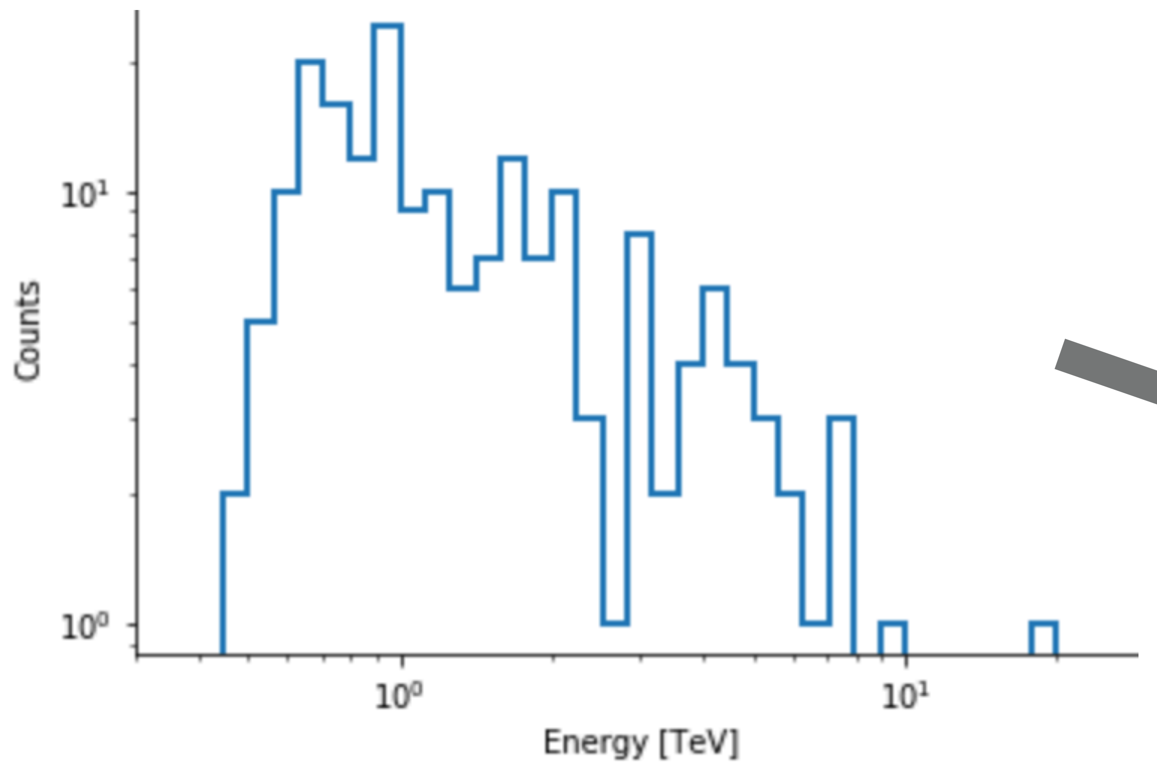
γπ.spectrum.models

SpectrumDatasetOnOff

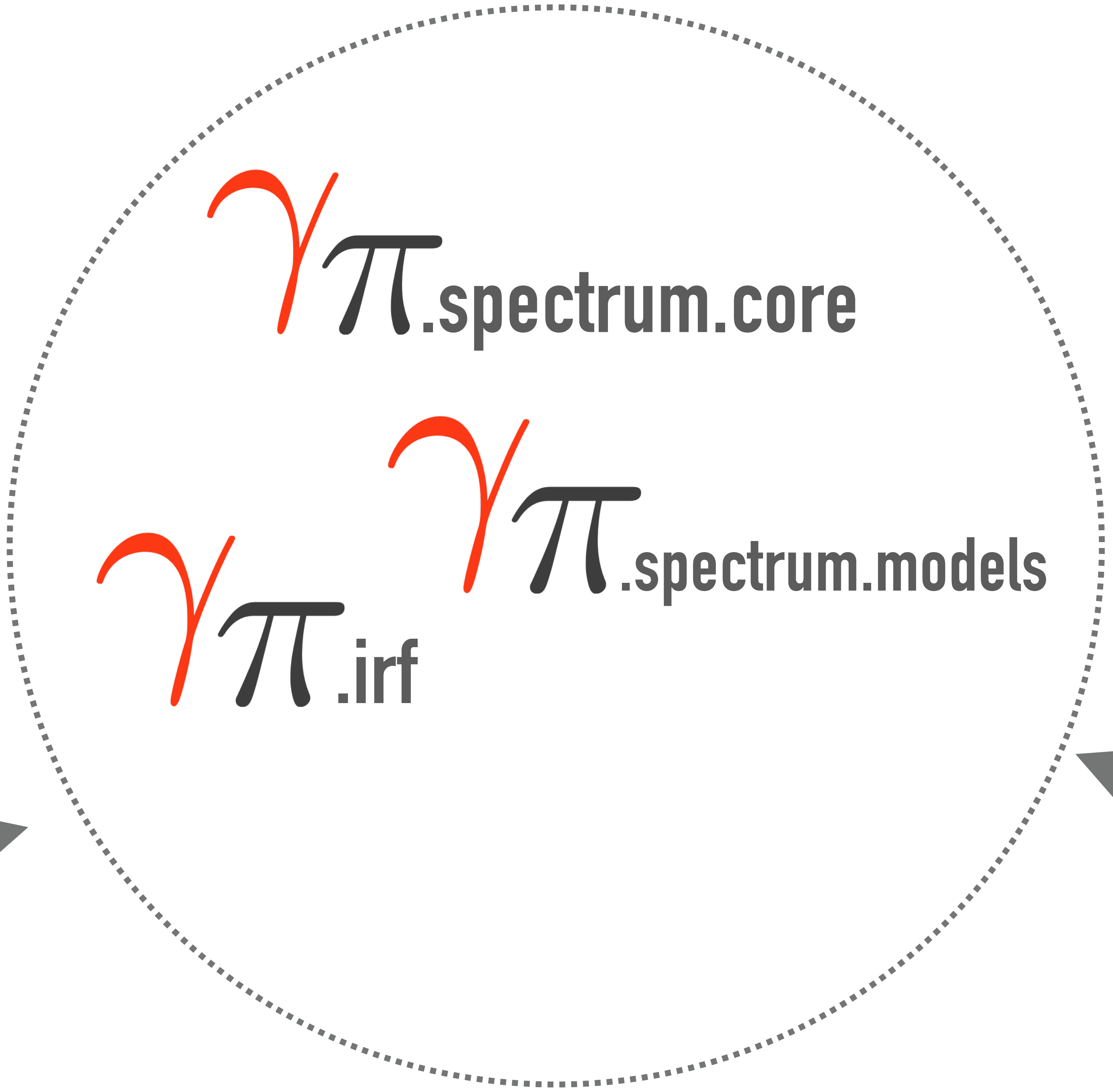


Spectral model

DATASETS



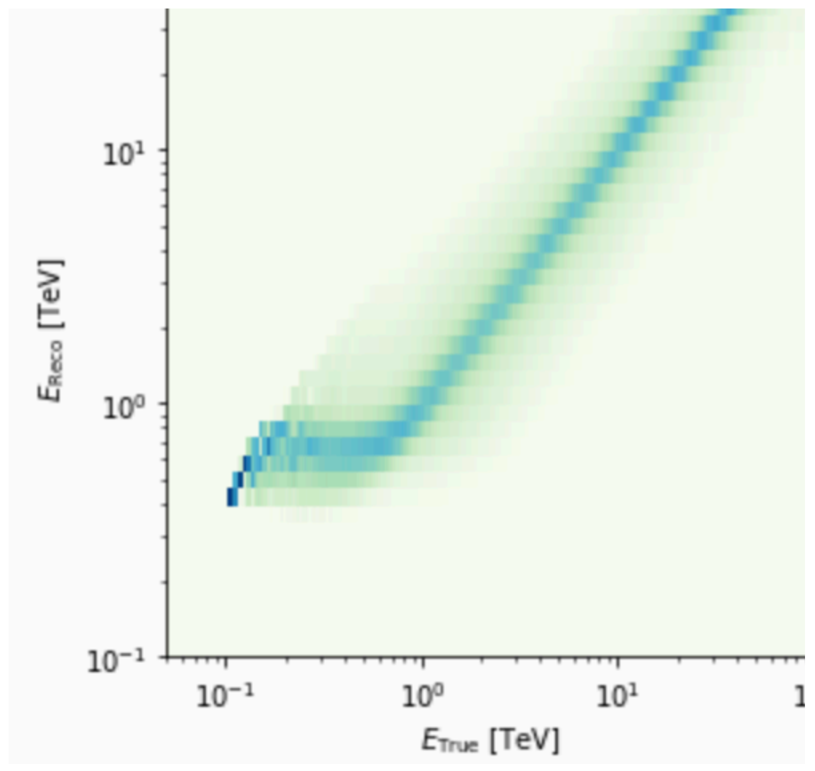
Reduced data



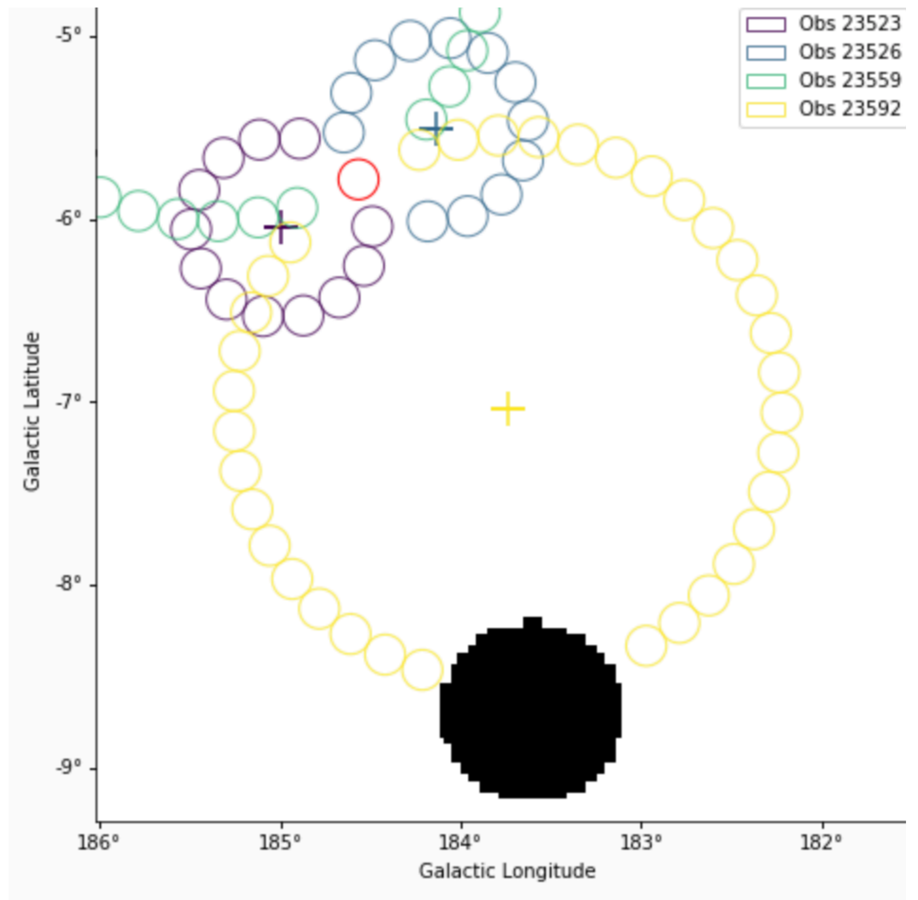
γπ.spectrum.core

γπ.spectrum.models

γπ.irf

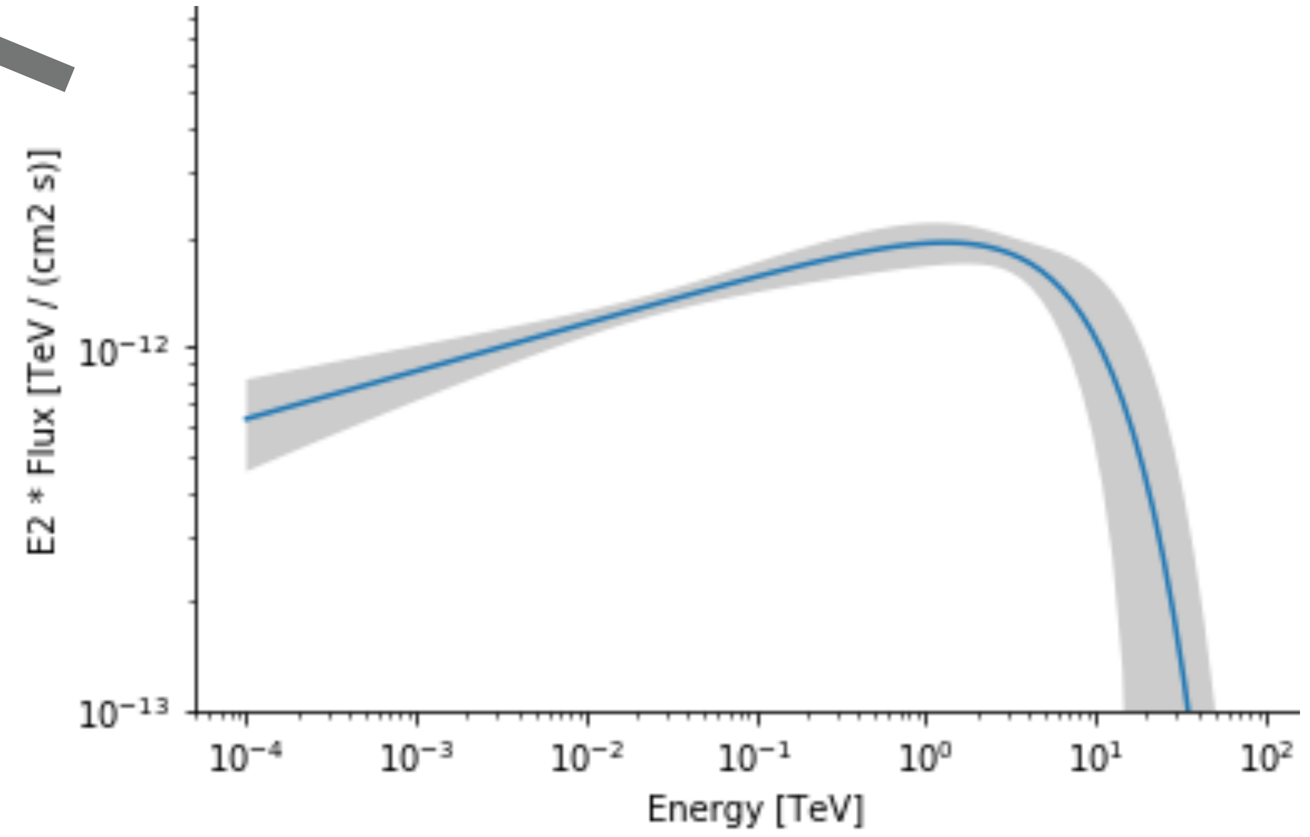


Reduced IRFs



BKG data / model

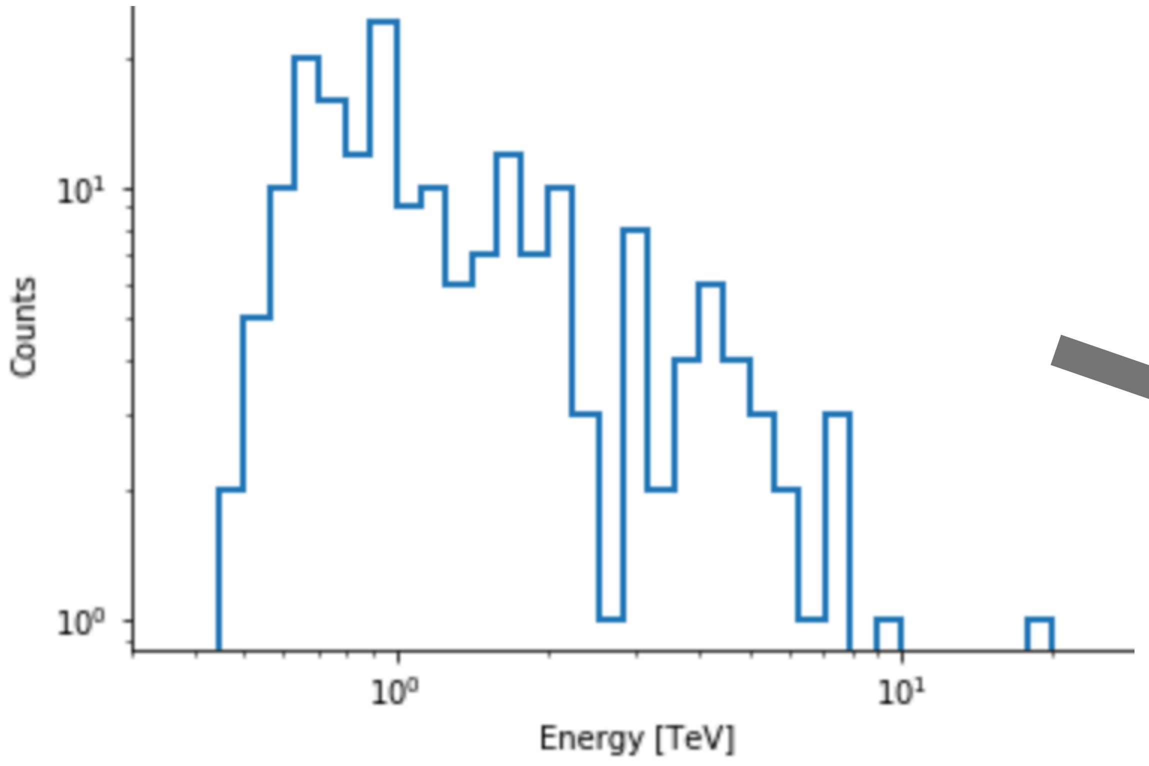
SpectrumDatasetOnOff



Spectral model

DATASETS

OGIP Format

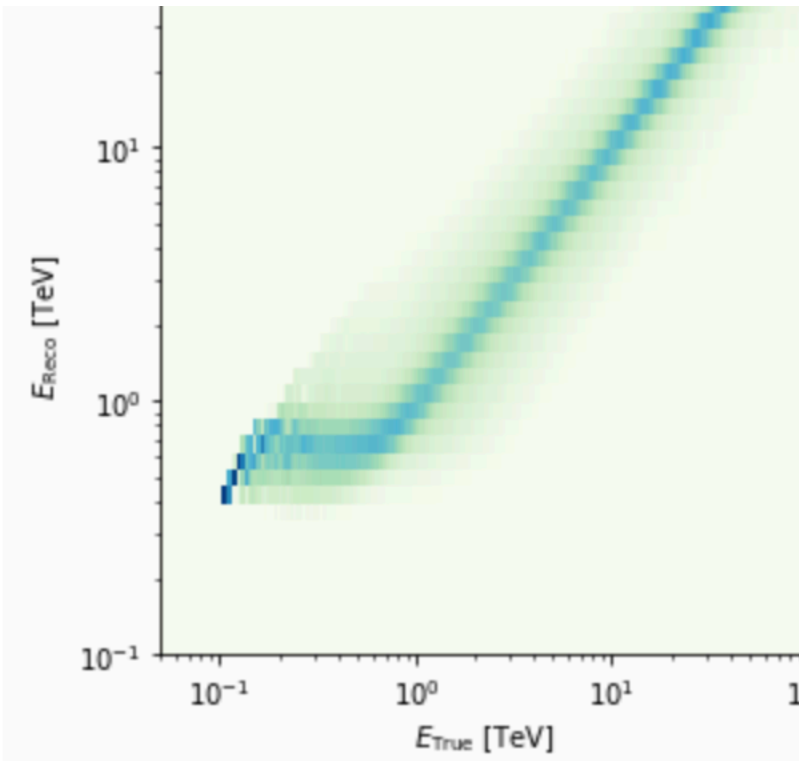


Reduced data

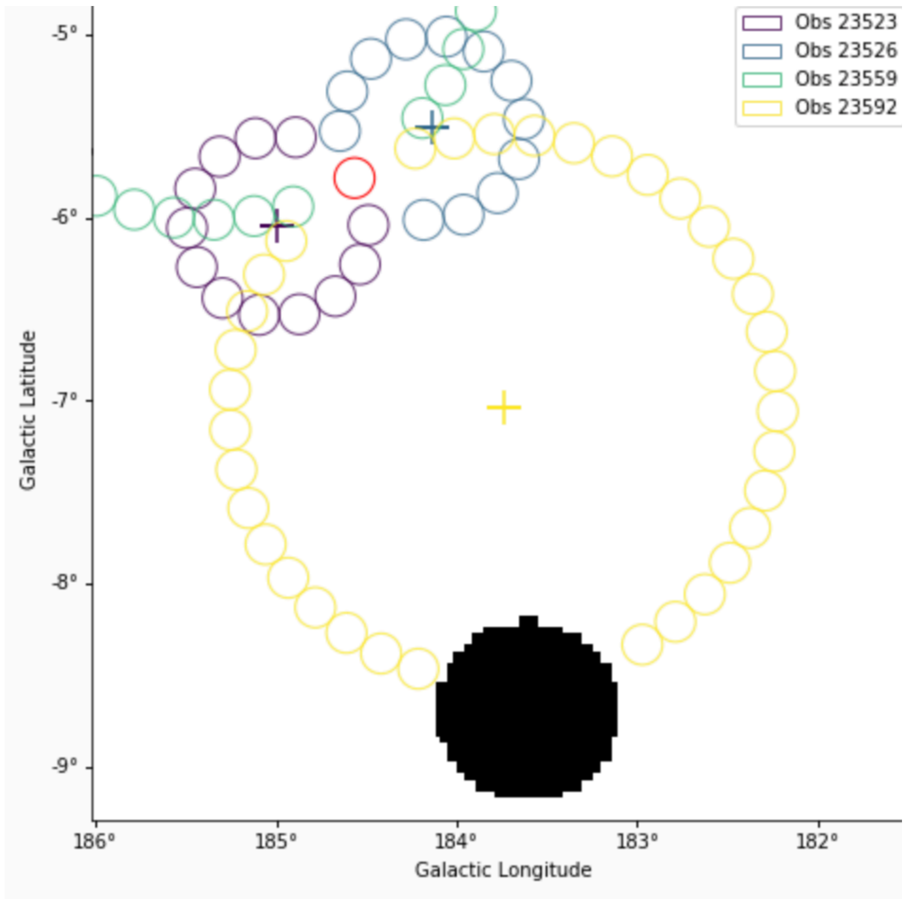
γπ.spectrum.core

γπ.spectrum.models

γπ.irf

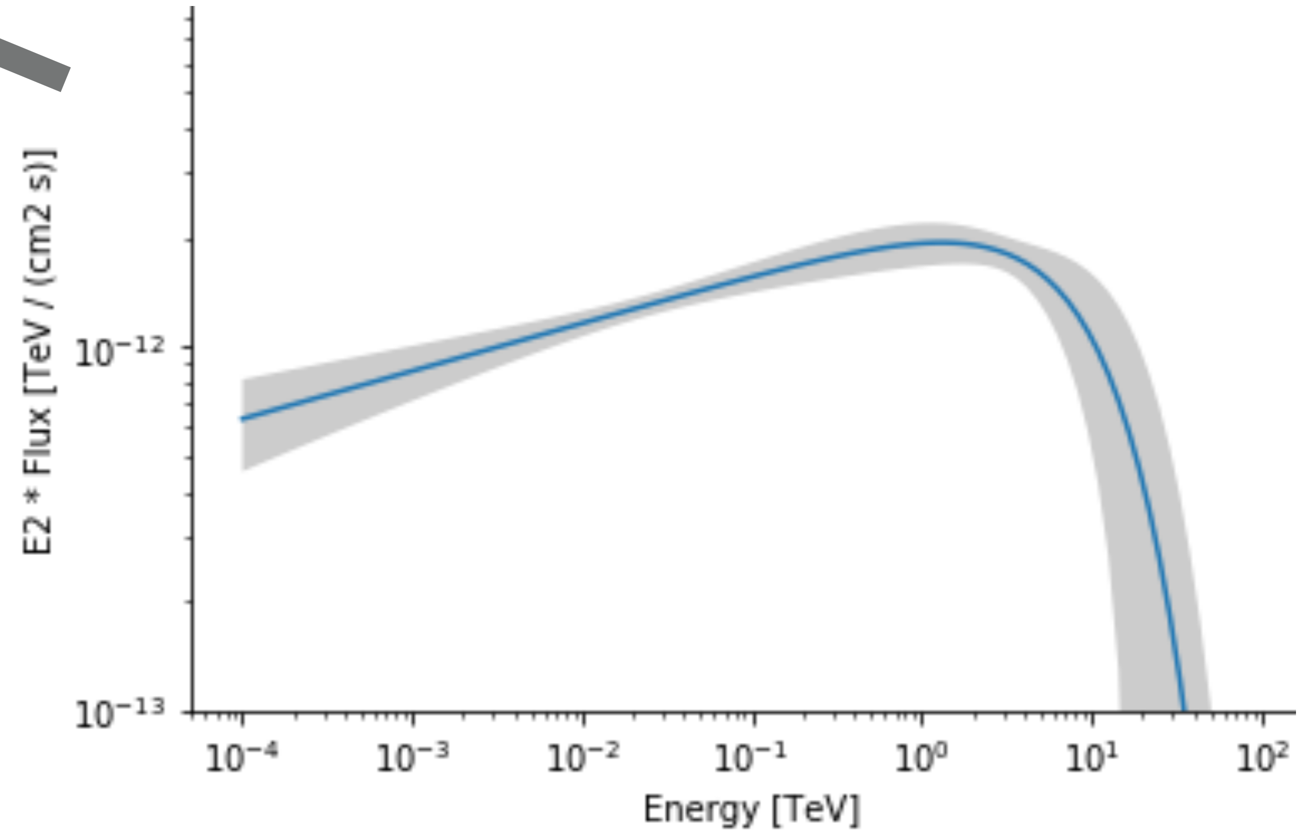


Reduced IRFs



BKG data / model

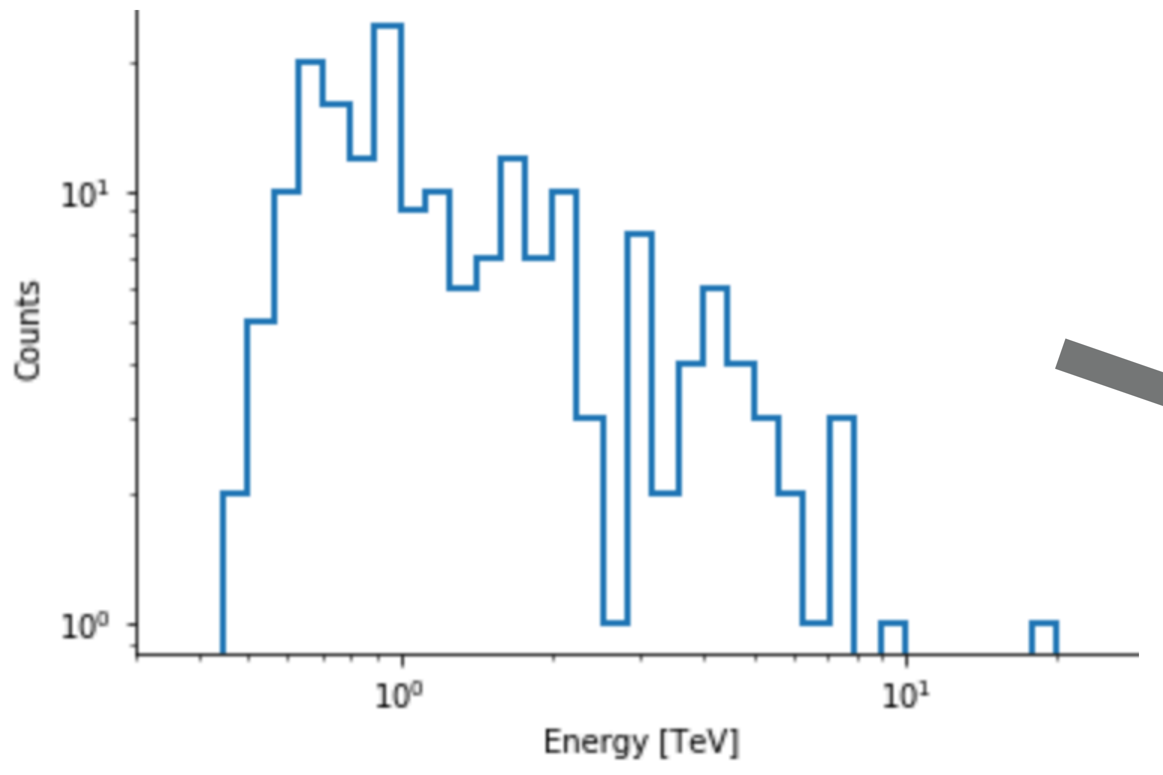
SpectrumDatasetOnOff



Spectral model

DATASETS

OGIP Format



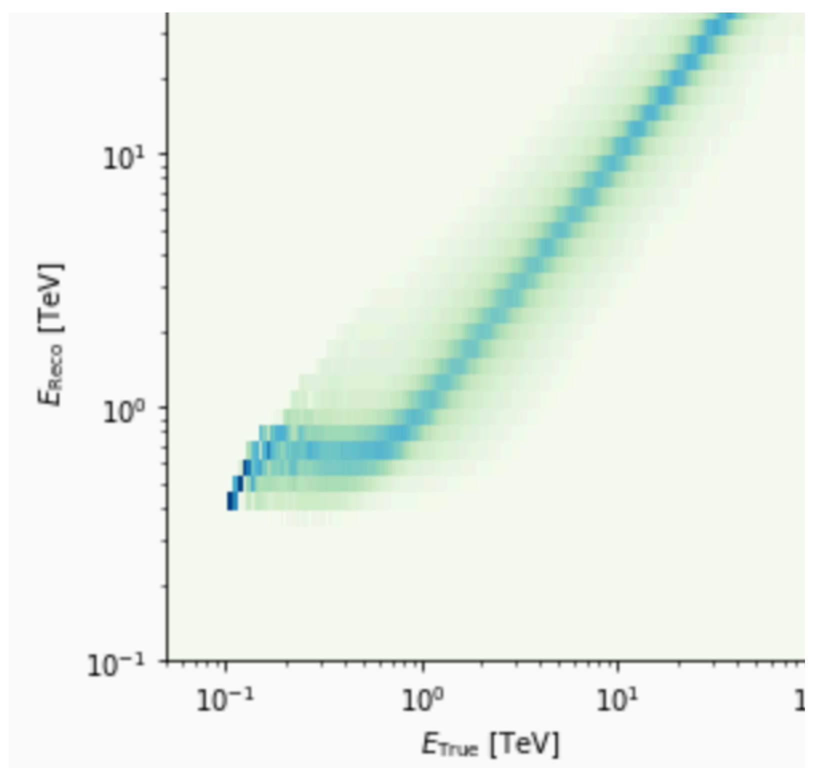
Reduced data

γπ.spectrum.core

γπ.spectrum.models

γπ.irf

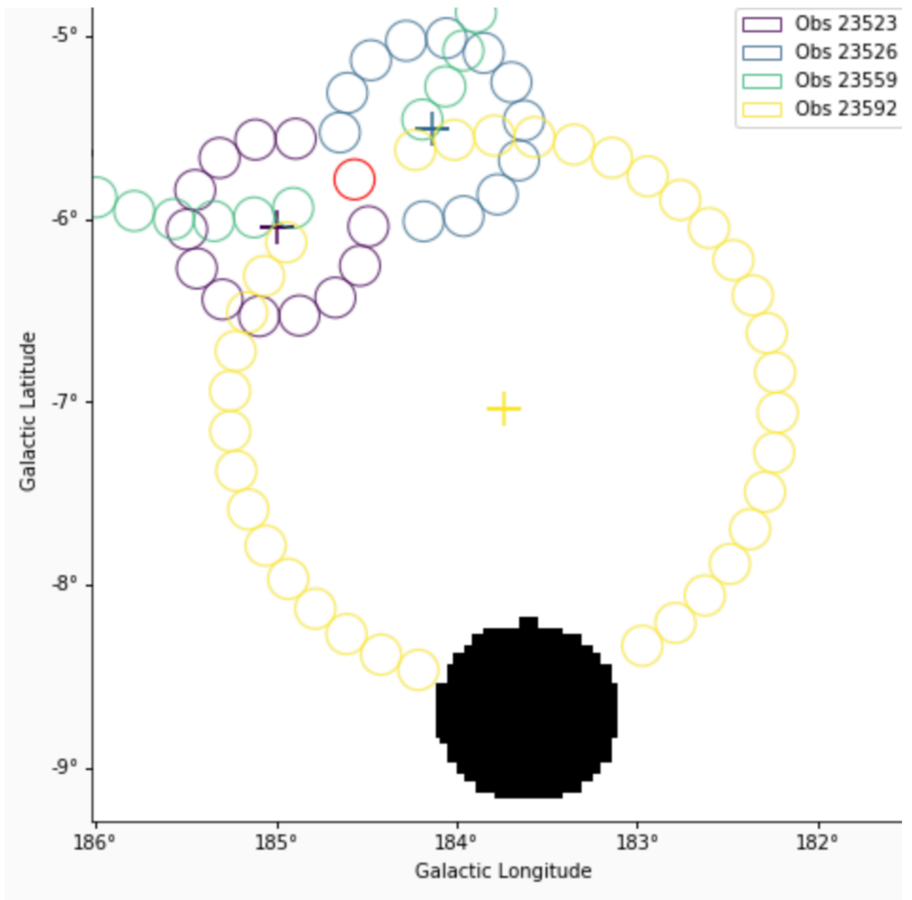
γπ.stats



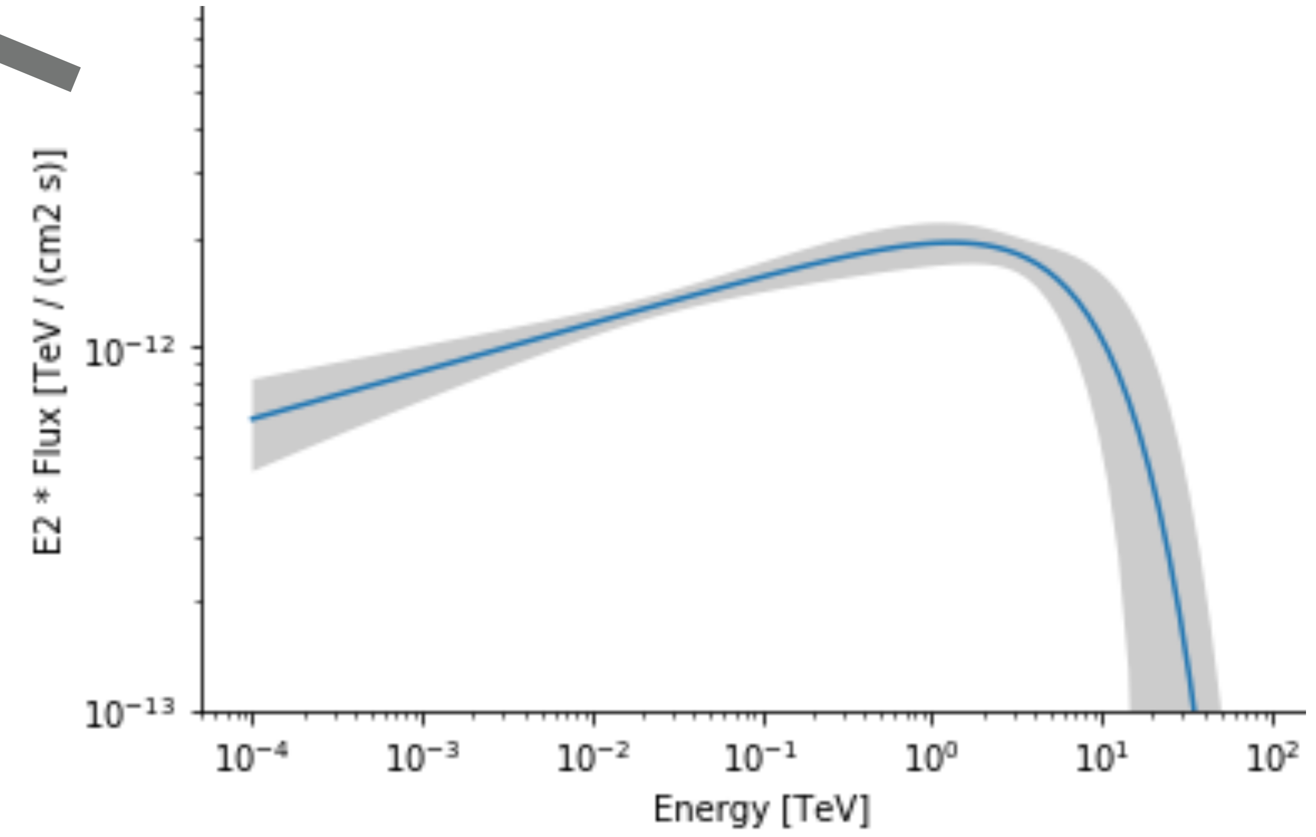
Reduced IRFs

`SpectrumDatasetOnOff`

$$\mathscr{W}(x, \theta)$$

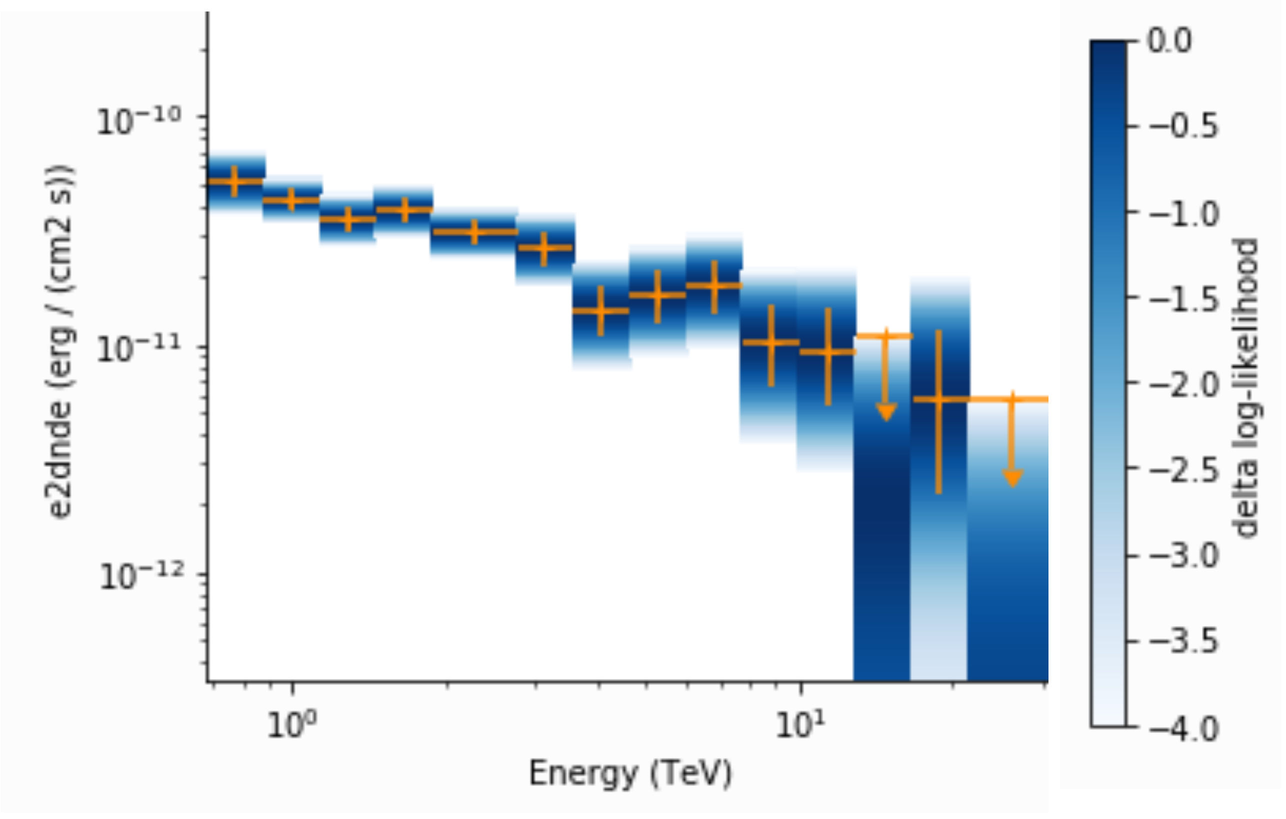


BKG data / model



Spectral model

DATASETS



Reduced data

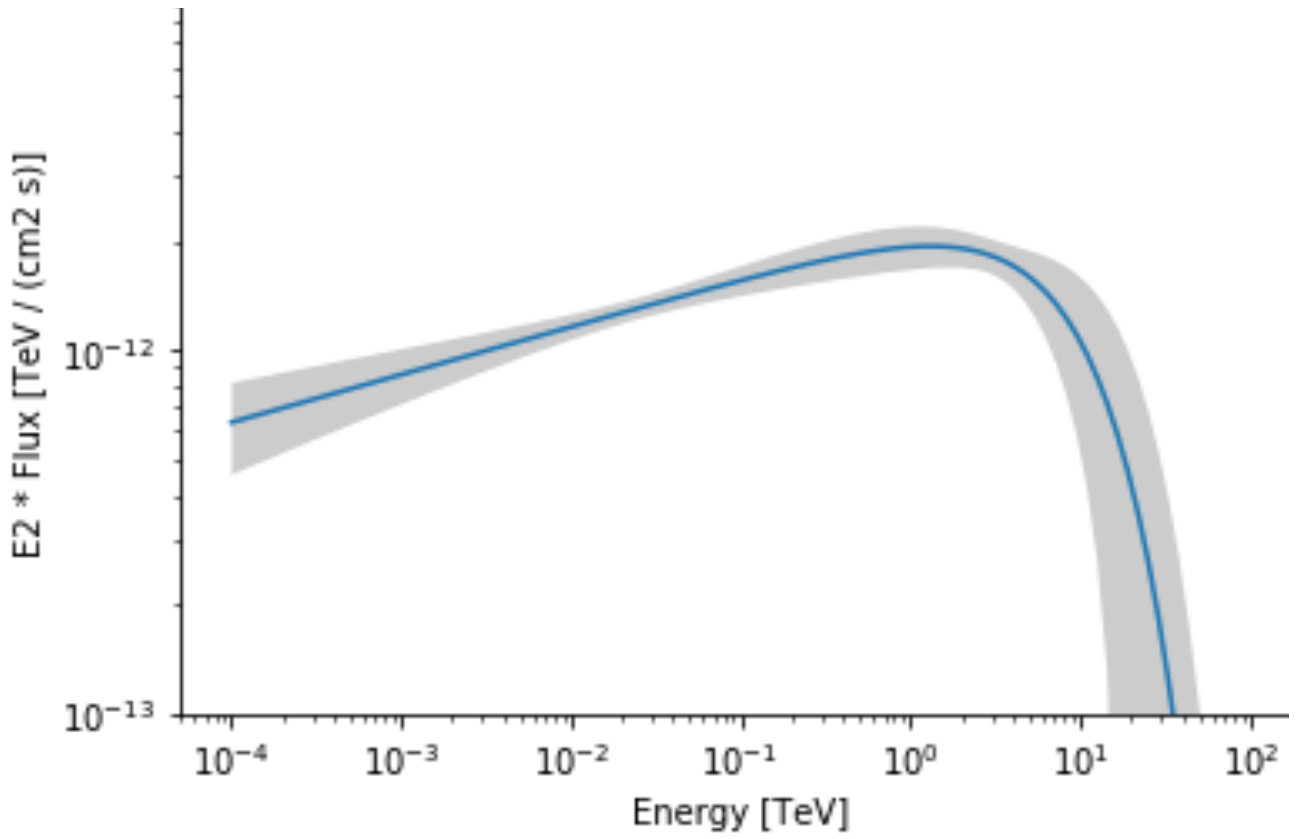
γπ.spectrum.flux_points

γπ.spectrum.models

γπ.stats

FluxPointsDataset

$$\chi^2(x, \theta)$$



Spectral model

JOINT LIKELIHOOD FITTING

$$\mathscr{L}(x_1, \theta)$$

$$*$$

$$\mathscr{L}(x_2, \theta)$$

$$\cdots$$

$$\mathscr{L}(x_{n-2}, \theta)$$

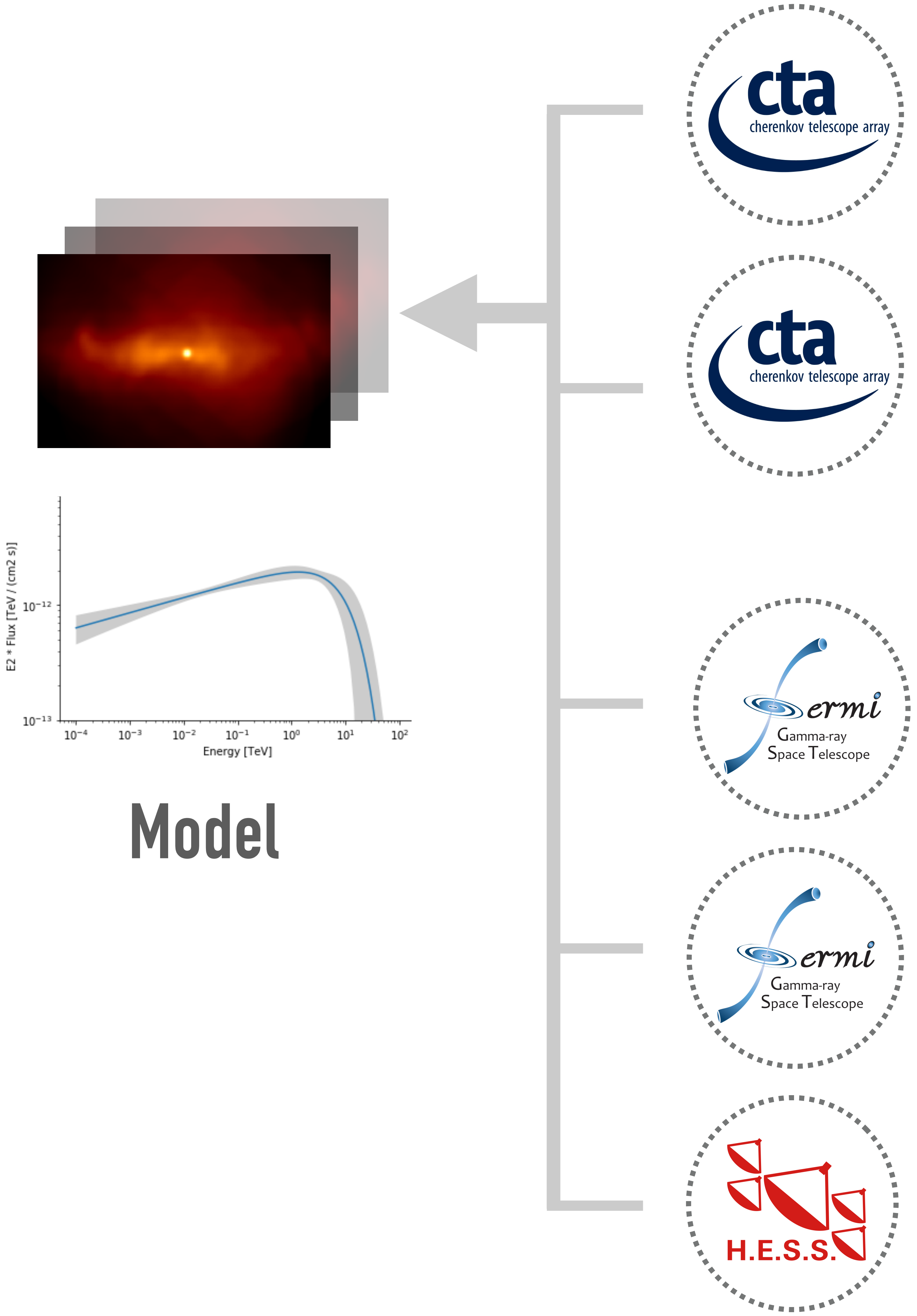
$$*$$

$$\mathscr{L}(x_{n-1}, \theta)$$

$$*$$

$$\mathscr{L}(x_n, \theta)$$

JOINT LIKELIHOOD FITTING



Model

$$\mathscr{L}(x_1, \theta)$$

$$*$$

$$\mathscr{L}(x_2, \theta)$$

$$\cdots$$

$$\mathscr{L}(x_{n-2}, \theta)$$

$$*$$

$$\mathscr{L}(x_{n-1}, \theta)$$

$$*$$

$$\mathscr{L}(x_n, \theta)$$

JOINT LIKELIHOOD FITTING

E2 * Flux [TeV / (cm2 s)]
10^{-12}
10^{-13}
10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2}
Energy [TeV]
cta cherenkov telescope array
Fermi Gamma-ray Space Telescope
H.E.S.S.

Model

$$\mathscr{L}(x_1, \theta)$$

$$*$$

$$\mathscr{L}(x_2, \theta)$$

$$\cdots$$

$$\mathscr{L}(x_{n-2}, \theta)$$

$$*$$

$$\mathscr{L}(x_{n-1}, \theta)$$

$$*$$

$$\mathscr{L}(x_n, \theta)$$

$\gamma\pi$.utils.fitting

.optimize

Sherpa .optmethods

Iminuit

JOINT LIKELIHOOD FITTING

cta
cherenkov telescope array
$\mathscr{L}(x_1, \theta)$
*
cta
cherenkov telescope array
$\mathscr{L}(x_2, \theta)$
...
Fermi
Gamma-ray Space Telescope
$\mathscr{L}(x_{n-2}, \theta)$
*
Fermi
Gamma-ray Space Telescope
$\mathscr{L}(x_{n-1}, \theta)$
*
H.E.S.S.
$\mathscr{L}(x_n, \theta)$
E2 * Flux [TeV / (cm2 s)]
10^{-12}
10^{-13}
10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2}
Energy [TeV]
Model
$\gamma\pi$.utils.fitting
.optimize
Sherpa .optmethods
Iminuit

```
fit = Fit([dataset])
fit = Fit([dataset_1, dataset_2, …])

fit.optimize(backend="sherpa")
fit.optimize(backend="scipy")

fit.covariance(backend="minuit")
fit.confidence(parameter="amplitude")

fit.likelihood_profile(parameter="amplitude")
```

JOINT LIKELIHOOD FITTING

cta cherenkov telescope array
Fermi Gamma-ray Space Telescope
H.E.S.S.
E2 * Flux [TeV / (cm2 s)]
Energy [TeV]
The MCMC Hammer

Model

$\mathscr{L}(x_1, \theta)$

$*$

$\mathscr{L}(x_2, \theta)$

...

$\mathscr{L}(x_{n-2}, \theta)$

$*$

$\mathscr{L}(x_{n-1}, \theta)$

$*$

$\mathscr{L}(x_n, \theta)$

$\gamma\pi$.utils.fitting

.optimize

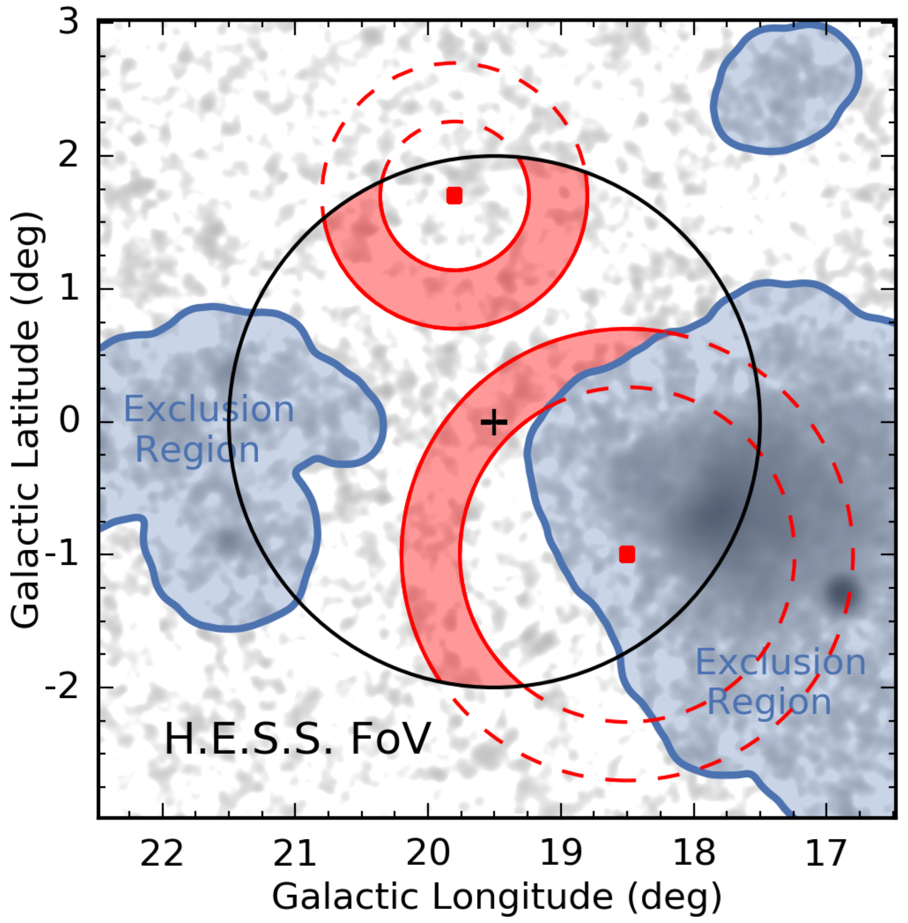
Sherpa .optmethods

Iminuit

emcee

...

MORE CHANGES IN GAMMAPY 0.11 AND 0.12

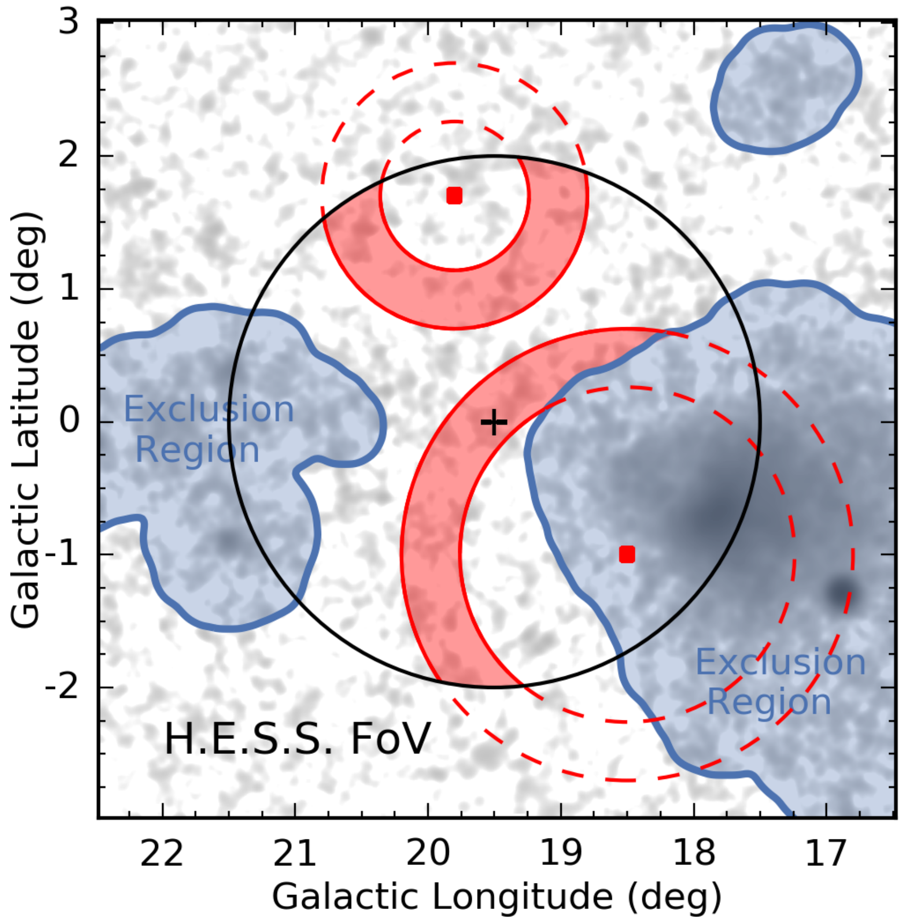


`MapMakerRing()`

https://docs.gammapy.org/0.11/changelog.html#mar-29-2019

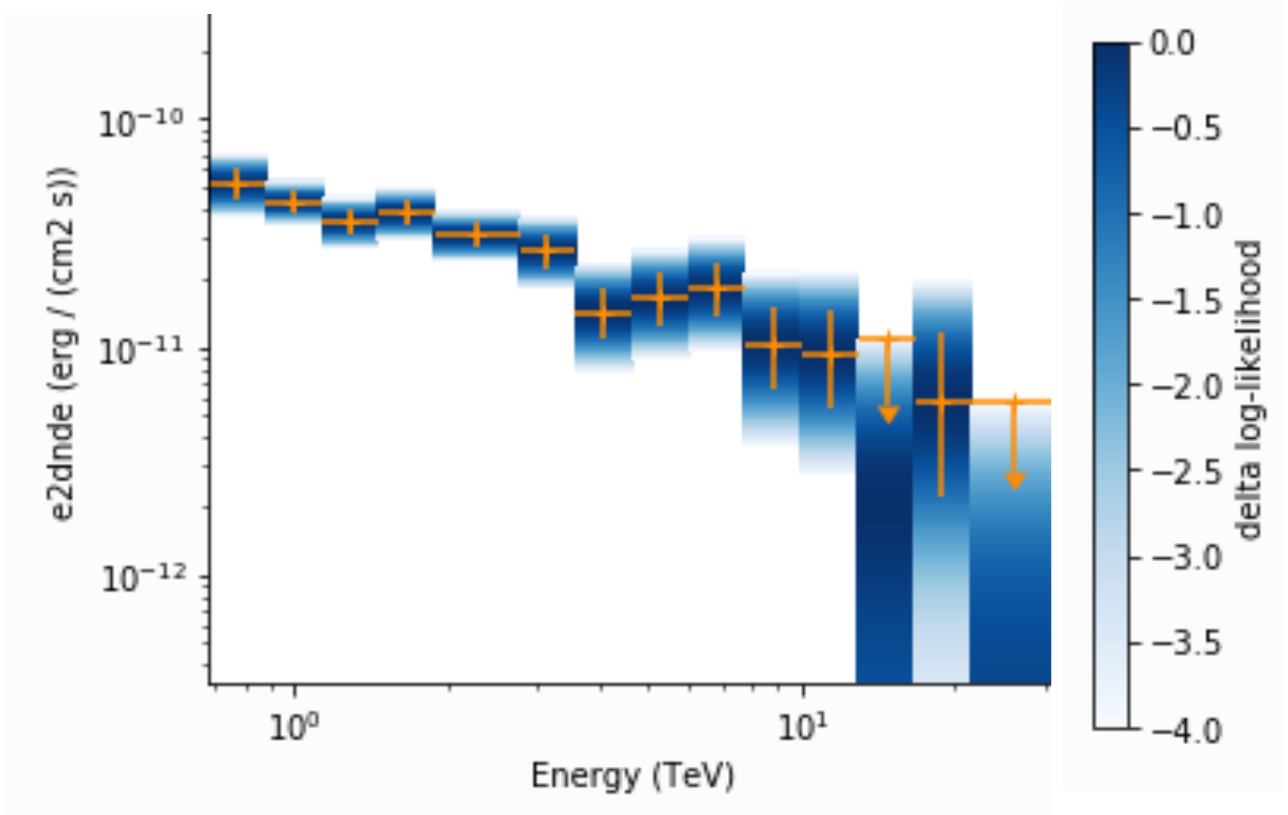
https://docs.gammapy.org/0.12/changelog.html#may-30-2019

MORE CHANGES IN GAMMAPY 0.11 AND 0.12



MapMakerRing()

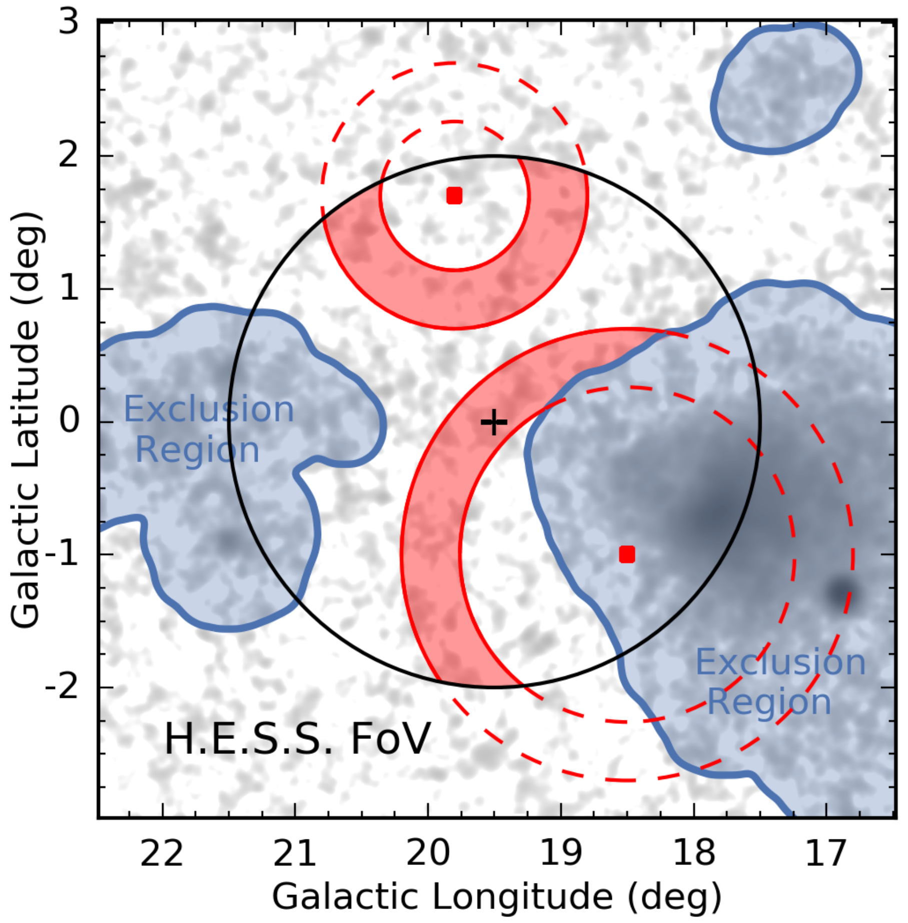
FluxPointsEstimator(datasets=[])



https://docs.gammapy.org/0.11/changelog.html#mar-29-2019

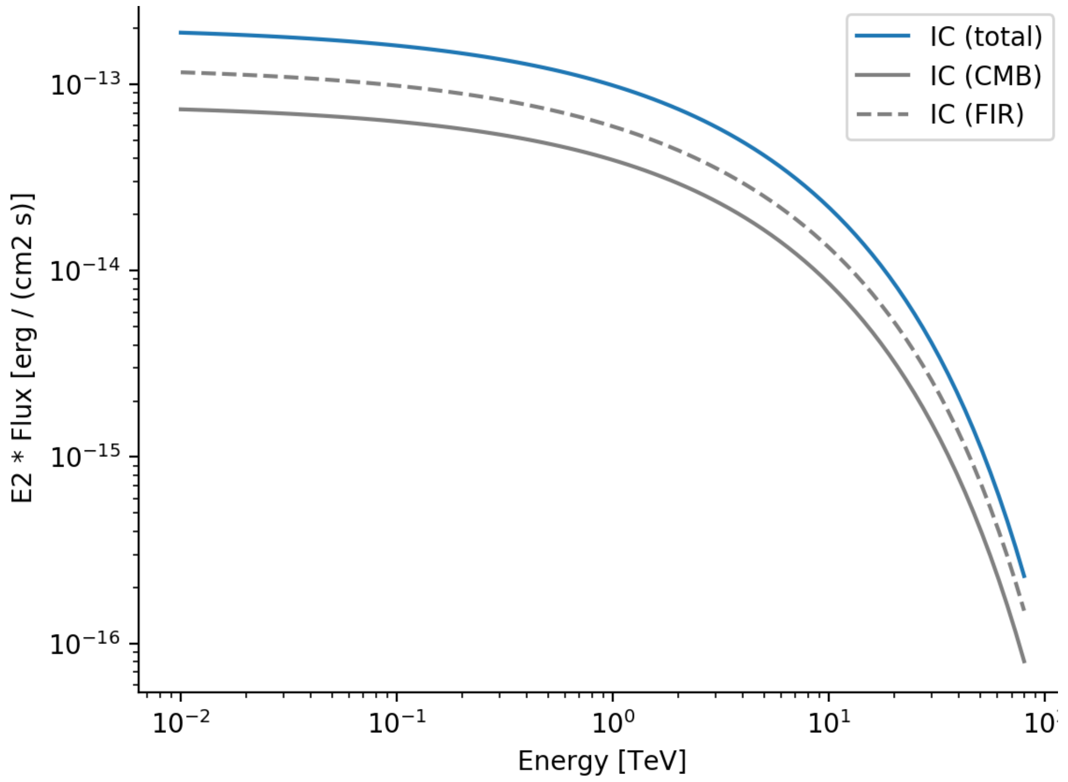
https://docs.gammapy.org/0.12/changelog.html#may-30-2019

MORE CHANGES IN GAMMAPY 0.11 AND 0.12

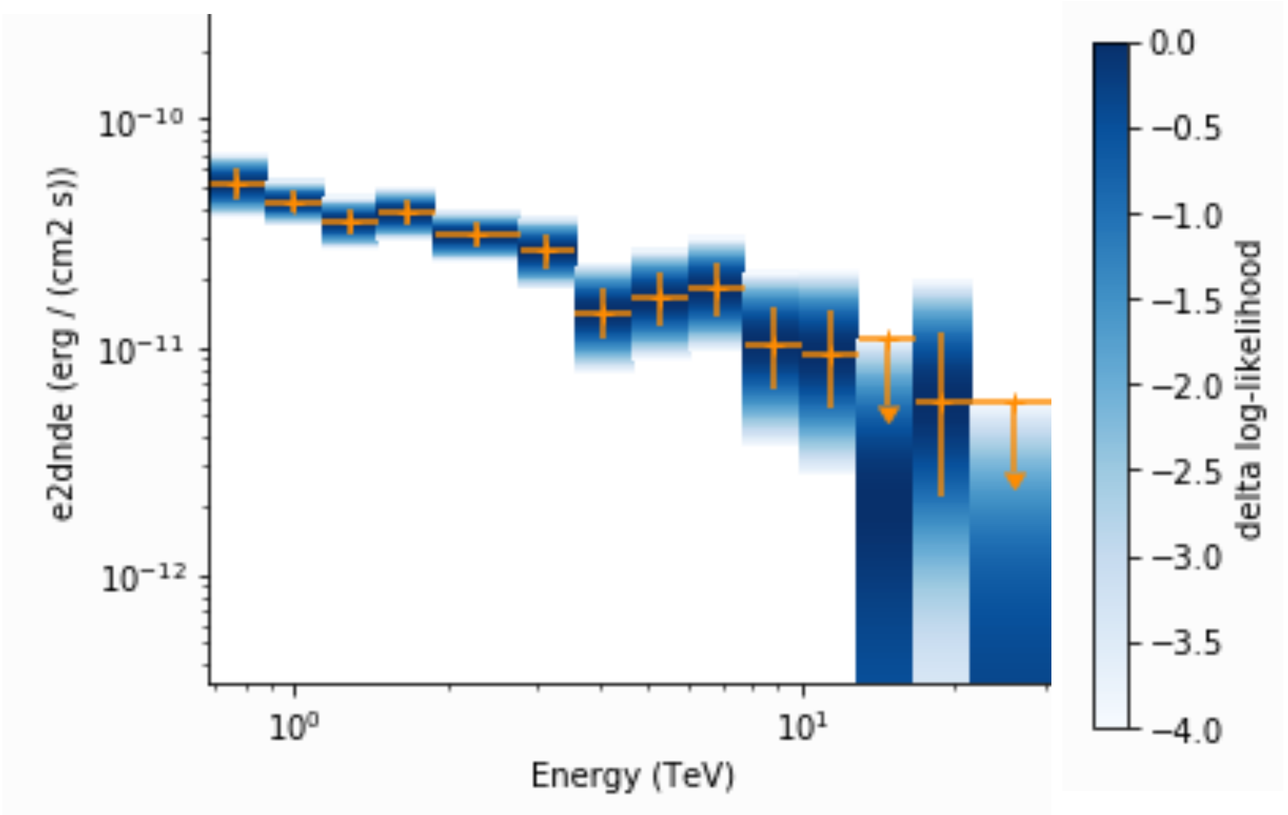


MapMakerRing()

NaimaModel(radiative_model, distance, seed="CMB")



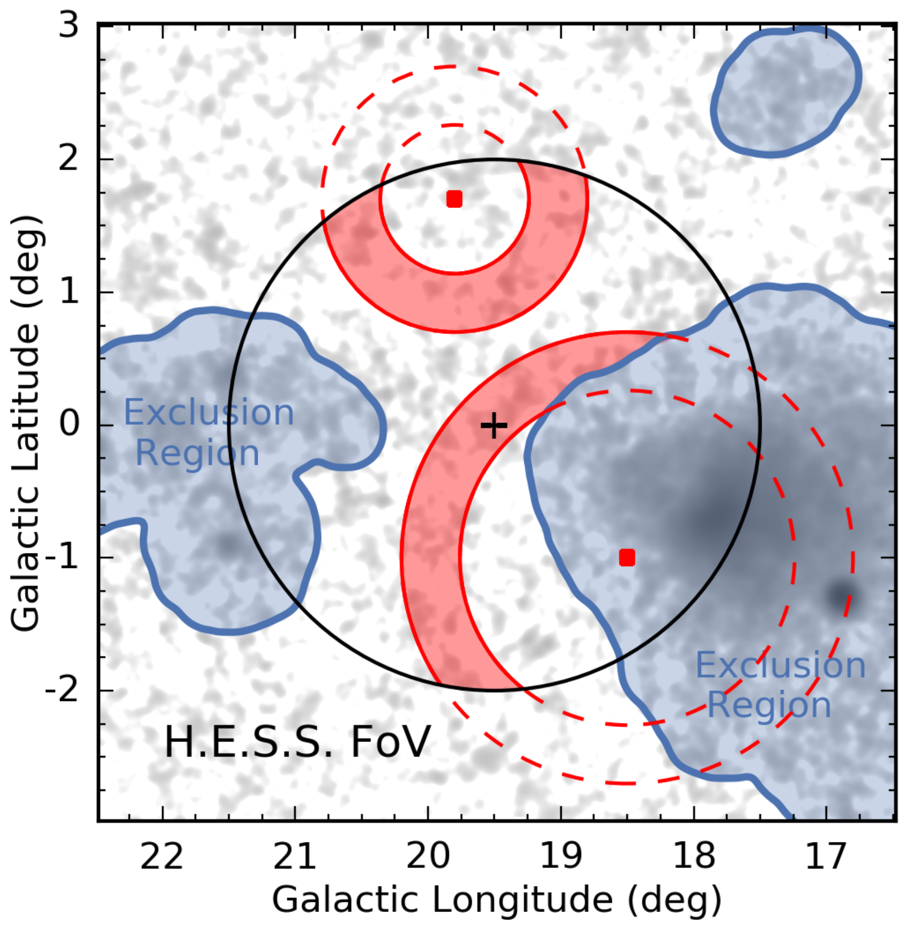
FluxPointsEstimator(datasets=[])



https://docs.gammapy.org/0.11/changelog.html#mar-29-2019

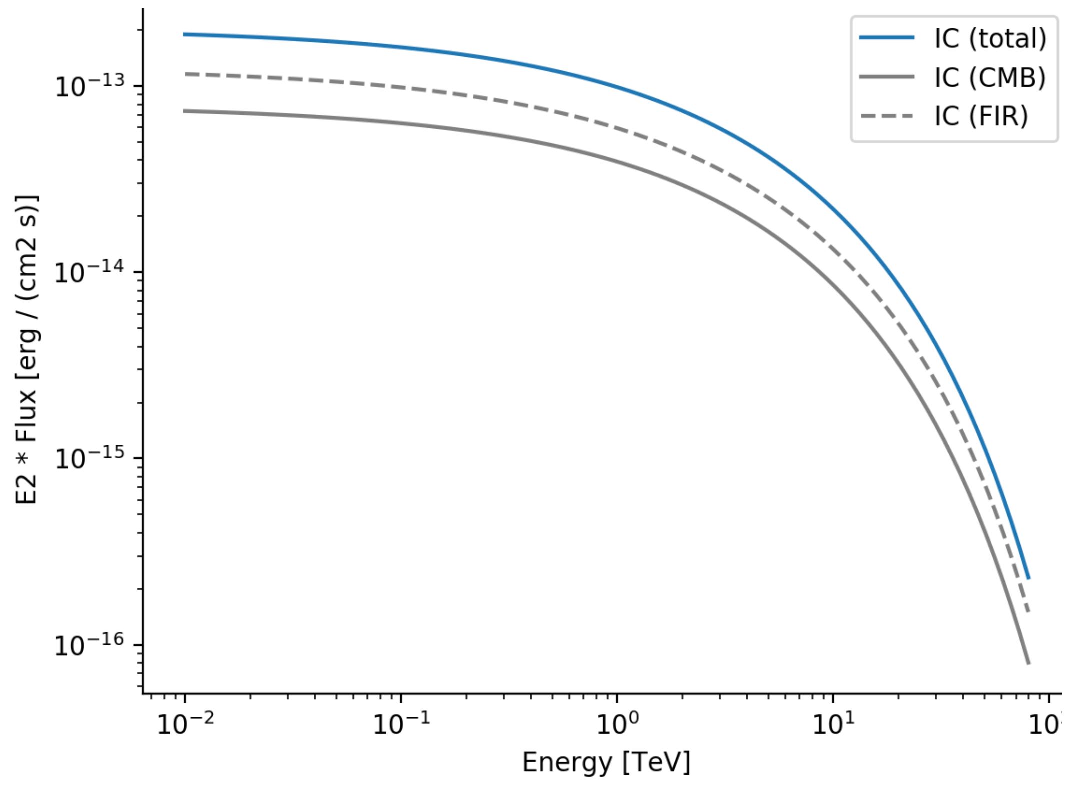
https://docs.gammapy.org/0.12/changelog.html#may-30-2019

MORE CHANGES IN GAMMAPY 0.11 AND 0.12

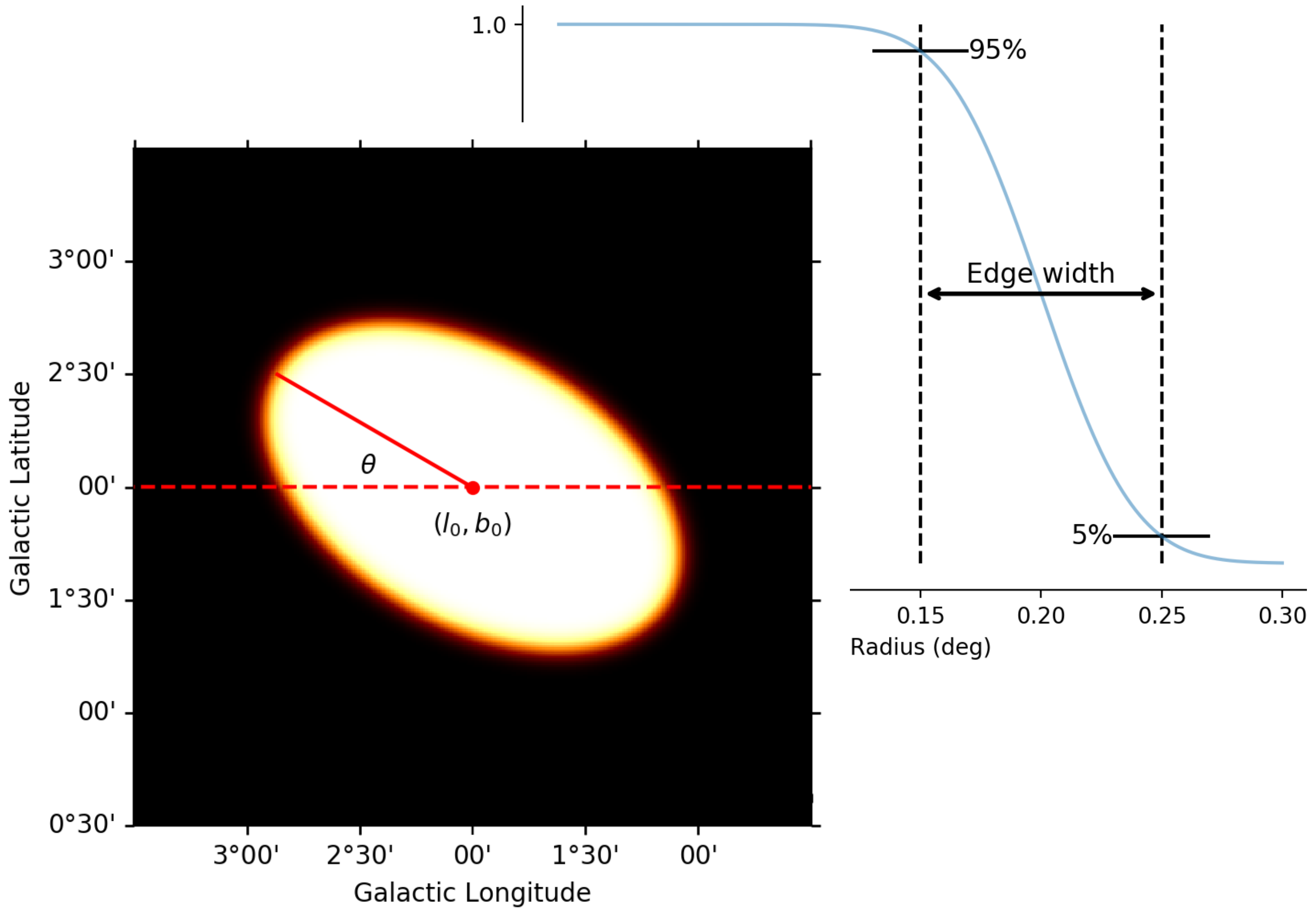


`MapMakerRing()`

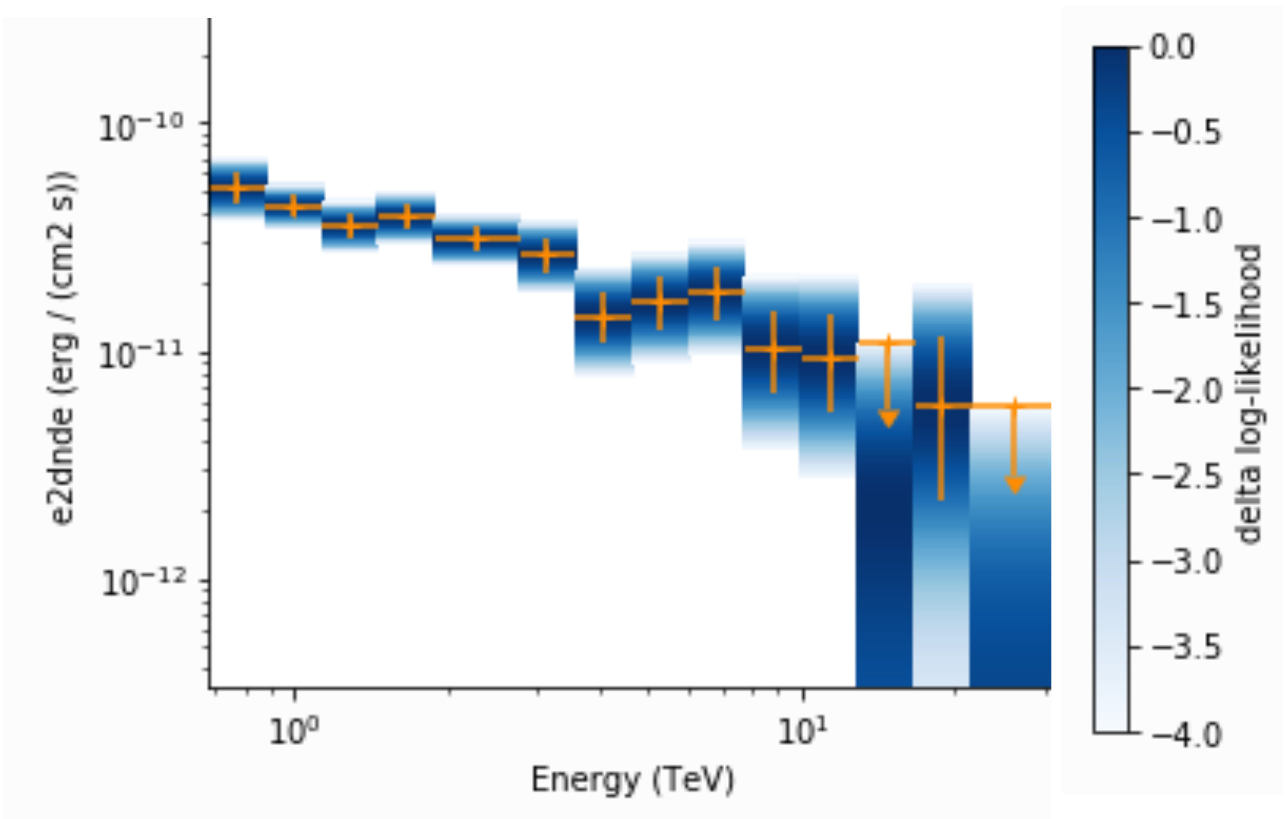
`NaimaModel(radiative_model, distance, seed="CMB")`



`SkyDisk(frame="icrs") & SkyEllipse()`



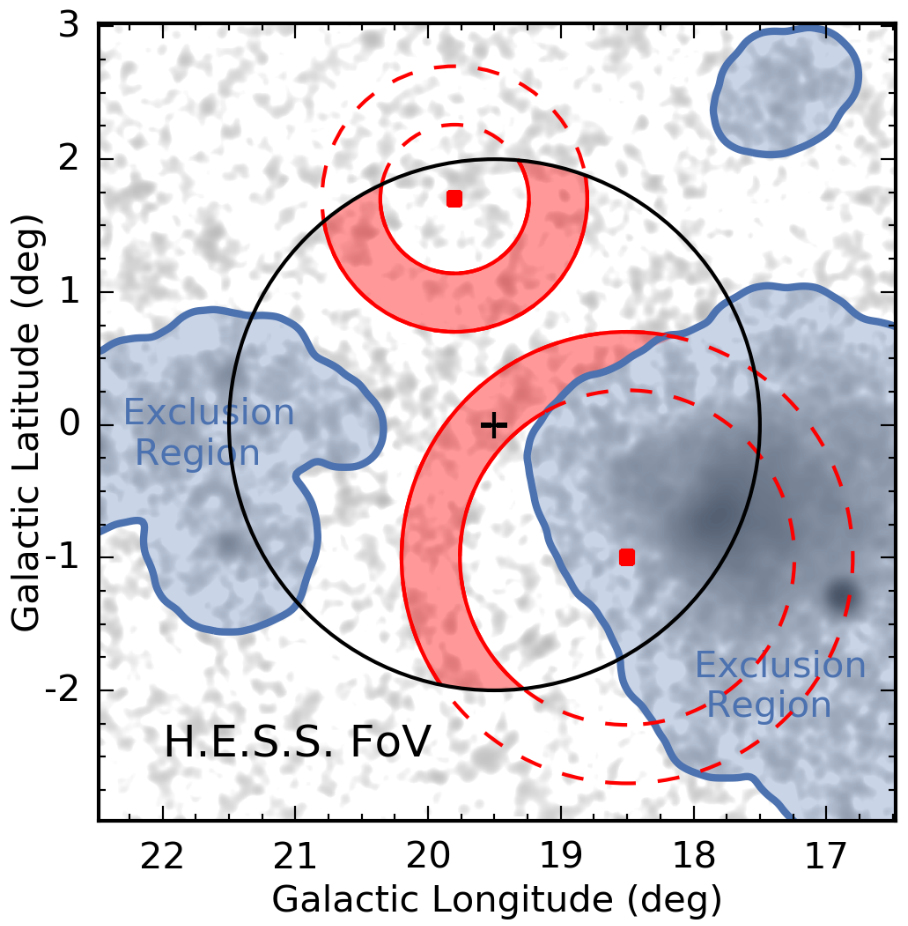
`FluxPointsEstimator(datasets=[])`



https://docs.gammapy.org/0.11/changelog.html#mar-29-2019

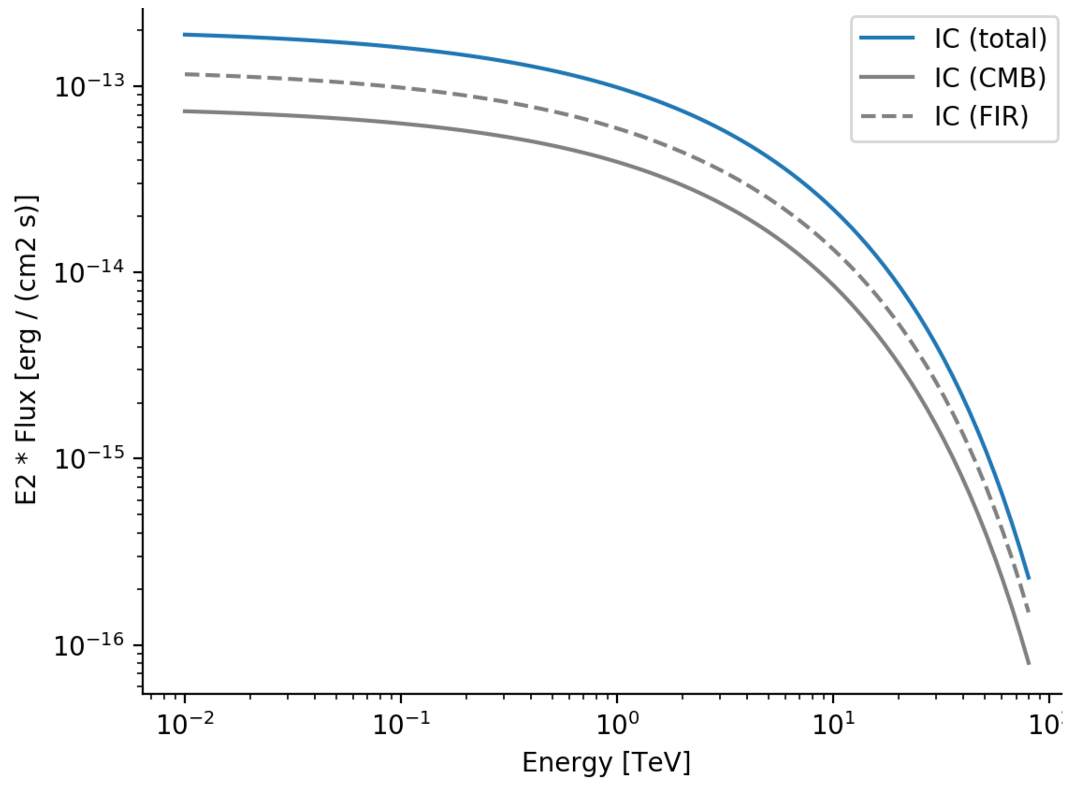
https://docs.gammapy.org/0.12/changelog.html#may-30-2019

MORE CHANGES IN GAMMAPY 0.11 AND 0.12



MapMakerRing()

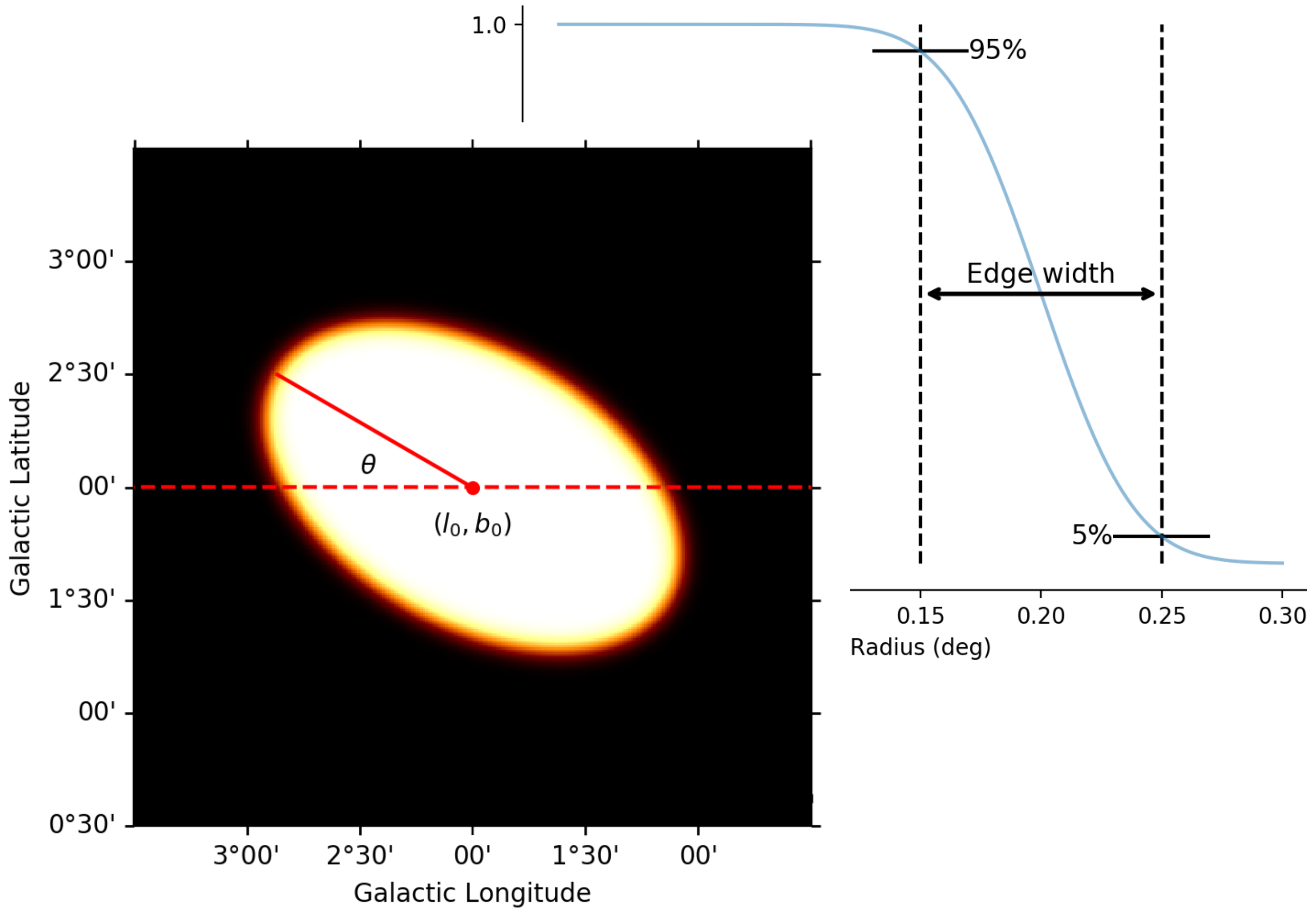
NaimaModel(radiative_model, distance, seed="CMB")



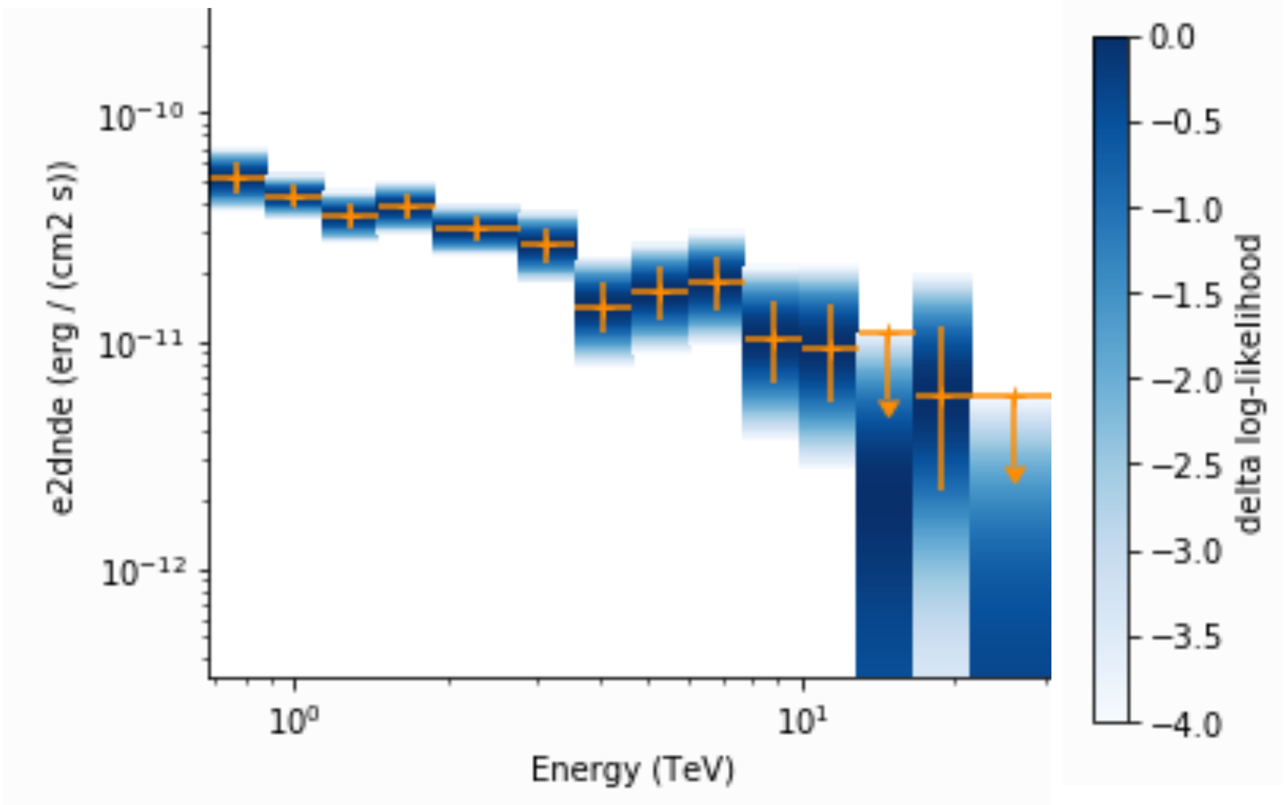
~~SpectrumObservation~~
~~SpectrumObservationList~~

~~MapFit~~
~~SpectrumFit~~
~~FluxPointFit~~

SkyDisk(frame="icrs")
& SkyEllipse()



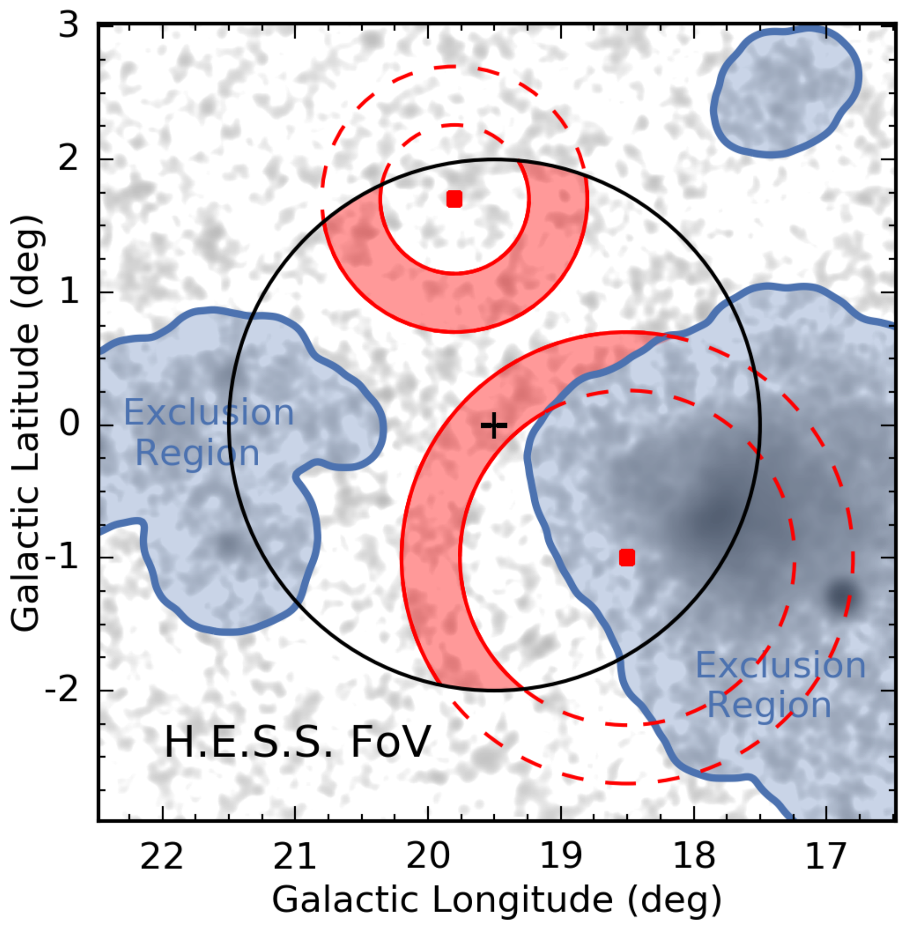
FluxPointsEstimator(datasets=[])



https://docs.gammapy.org/0.11/changelog.html#mar-29-2019

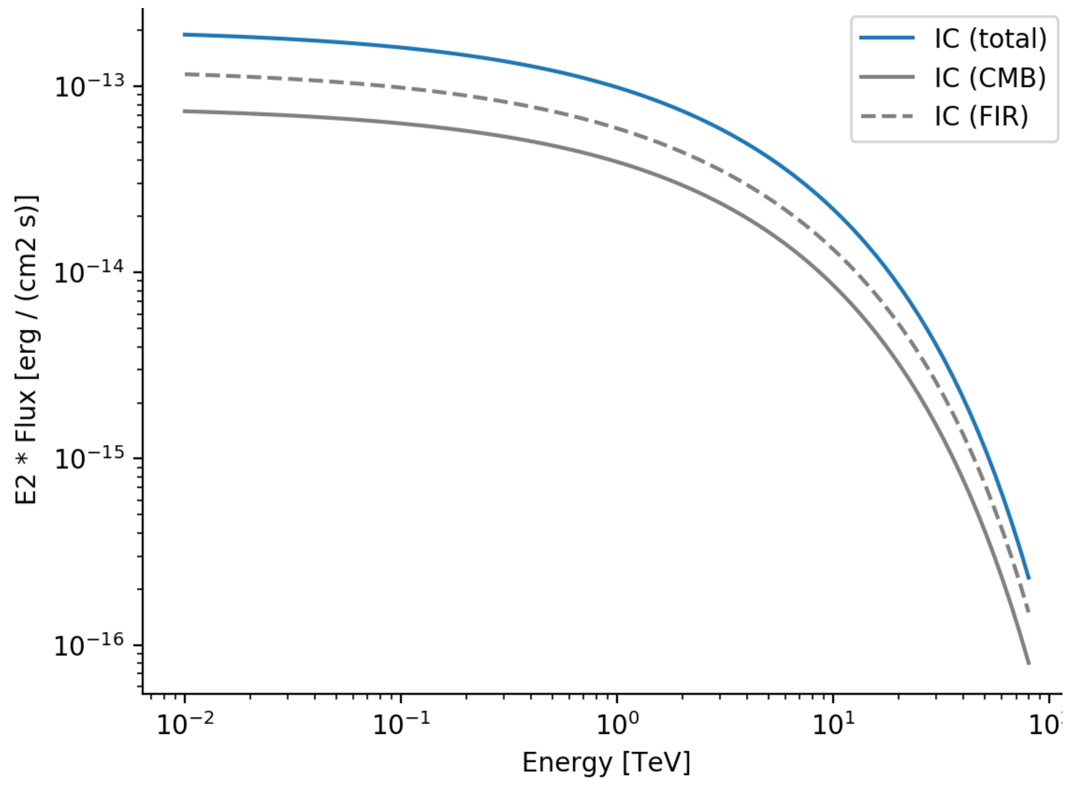
https://docs.gammapy.org/0.12/changelog.html#may-30-2019

MORE CHANGES IN GAMMAPY 0.11 AND 0.12



MapMakerRing()

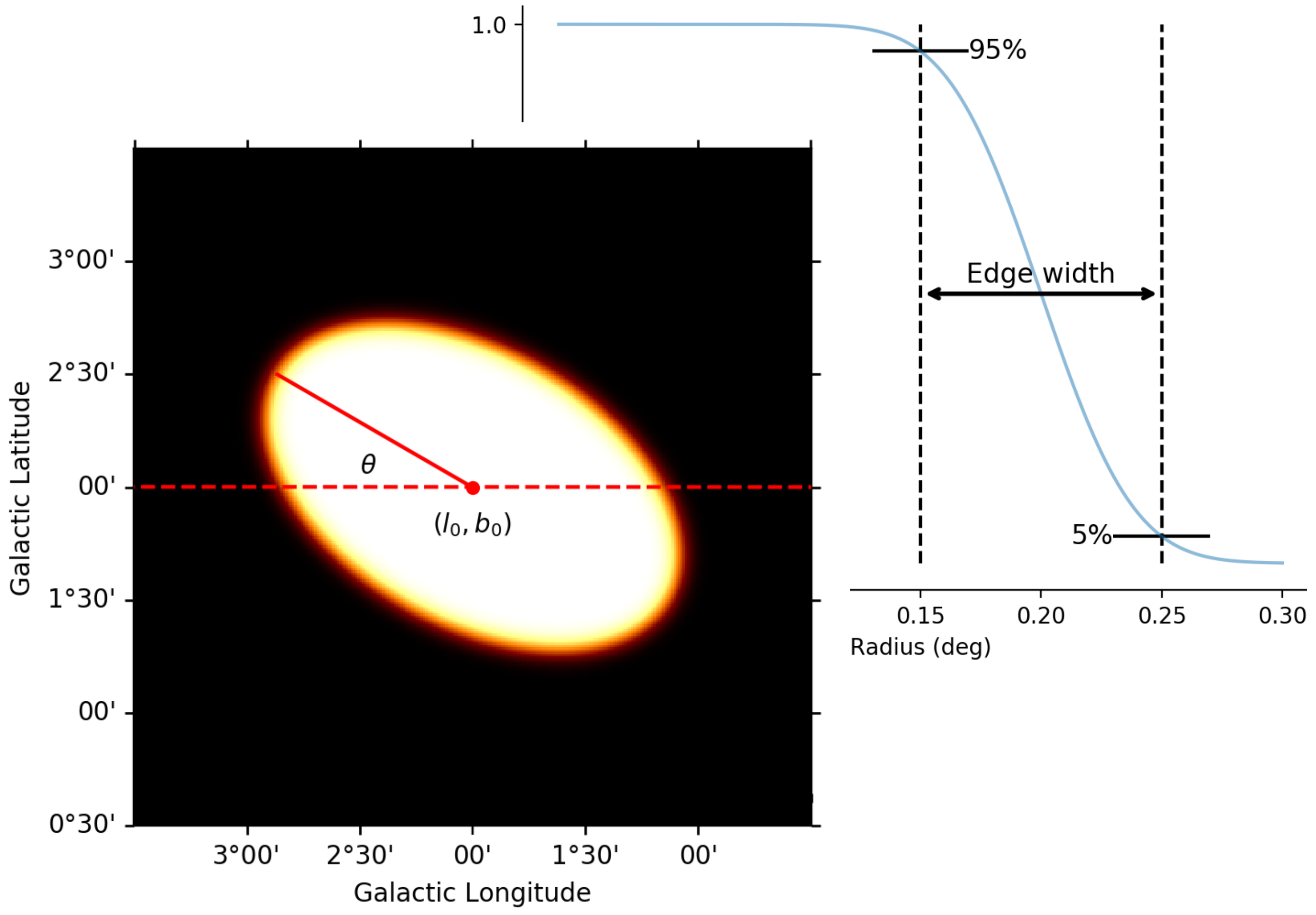
NaimaModel(radiative_model, distance, seed="CMB")



~~SpectrumObservation~~
~~SpectrumObservationList~~

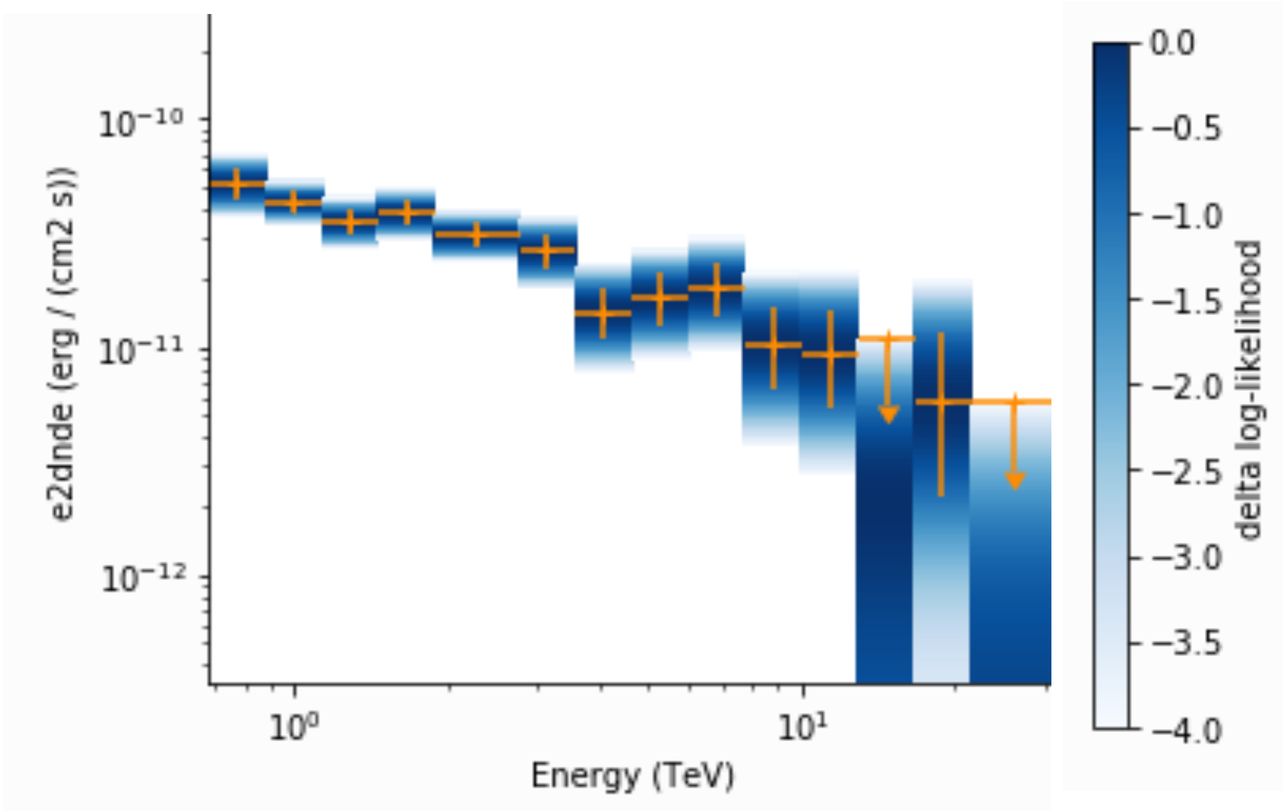
~~MapFit~~
~~SpectrumFit~~
~~FluxPointFit~~

SkyDisk(frame="icrs")
& SkyEllipse()



~~Python 2~~

FluxPointsEstimator(datasets=[])



https://docs.gammapy.org/0.11/changelog.html#mar-29-2019

https://docs.gammapy.org/0.12/changelog.html#may-30-2019

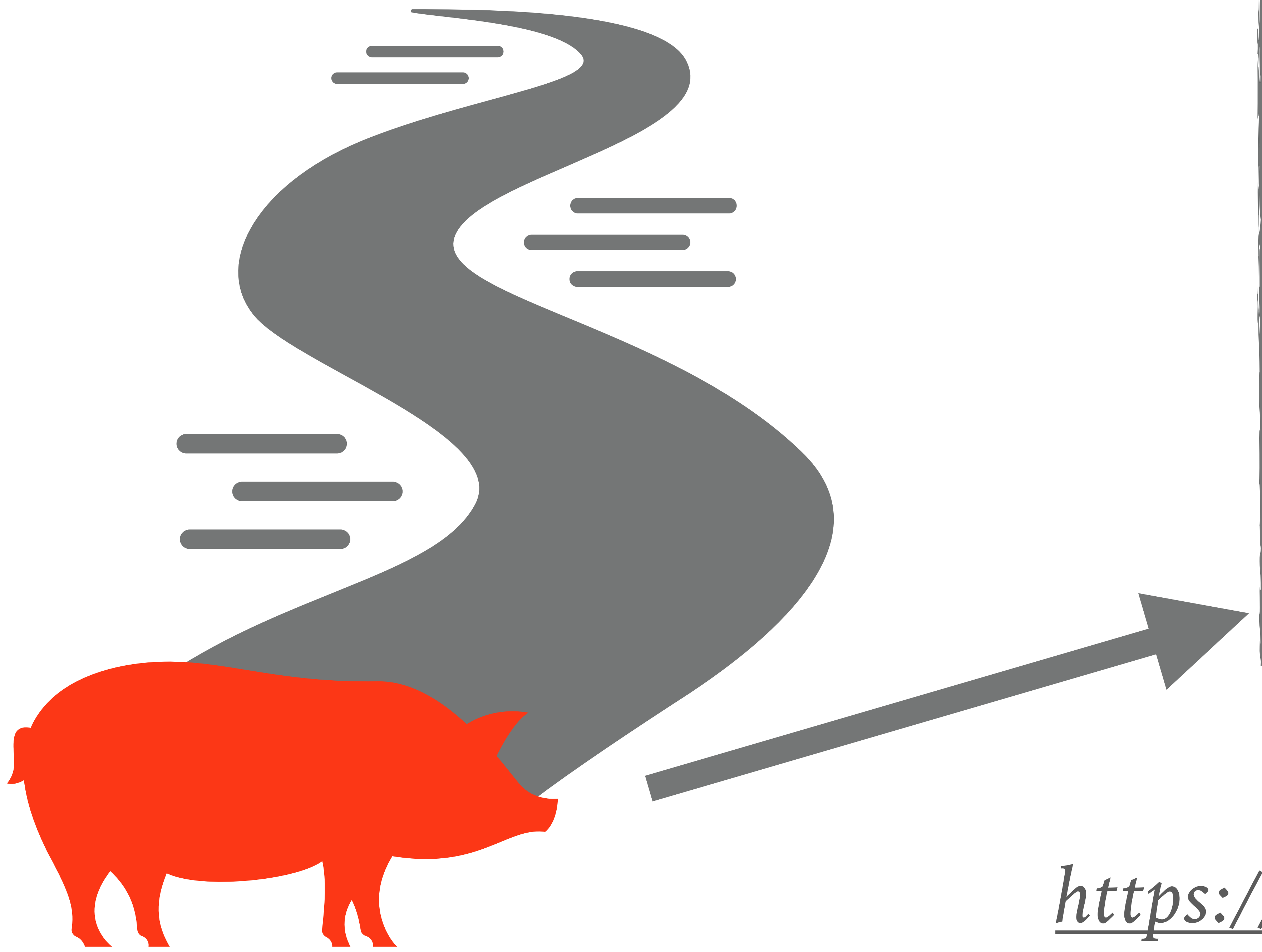
TOWARDS GAMMAPY V1.0

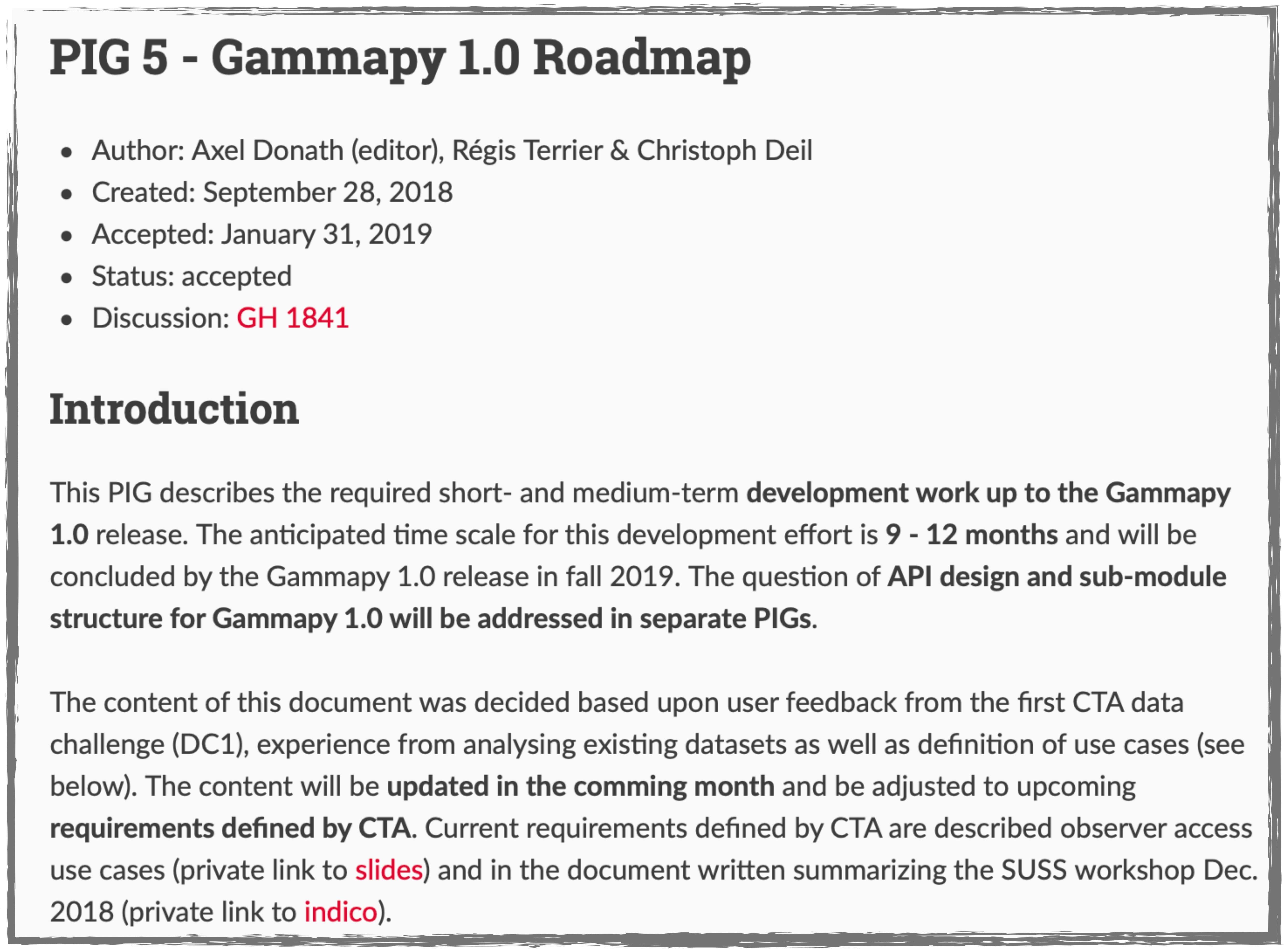
GAMMAPY ROADMAP 2019

v1.0 (late 2019)

GAMMAPY ROADMAP 2019

γπ v1.0 (late 2019)





PIG 5 - Gammapy 1.0 Roadmap

- Author: Axel Donath (editor), Régis Terrier & Christoph Deil
- Created: September 28, 2018
- Accepted: January 31, 2019
- Status: accepted
- Discussion: GH 1841

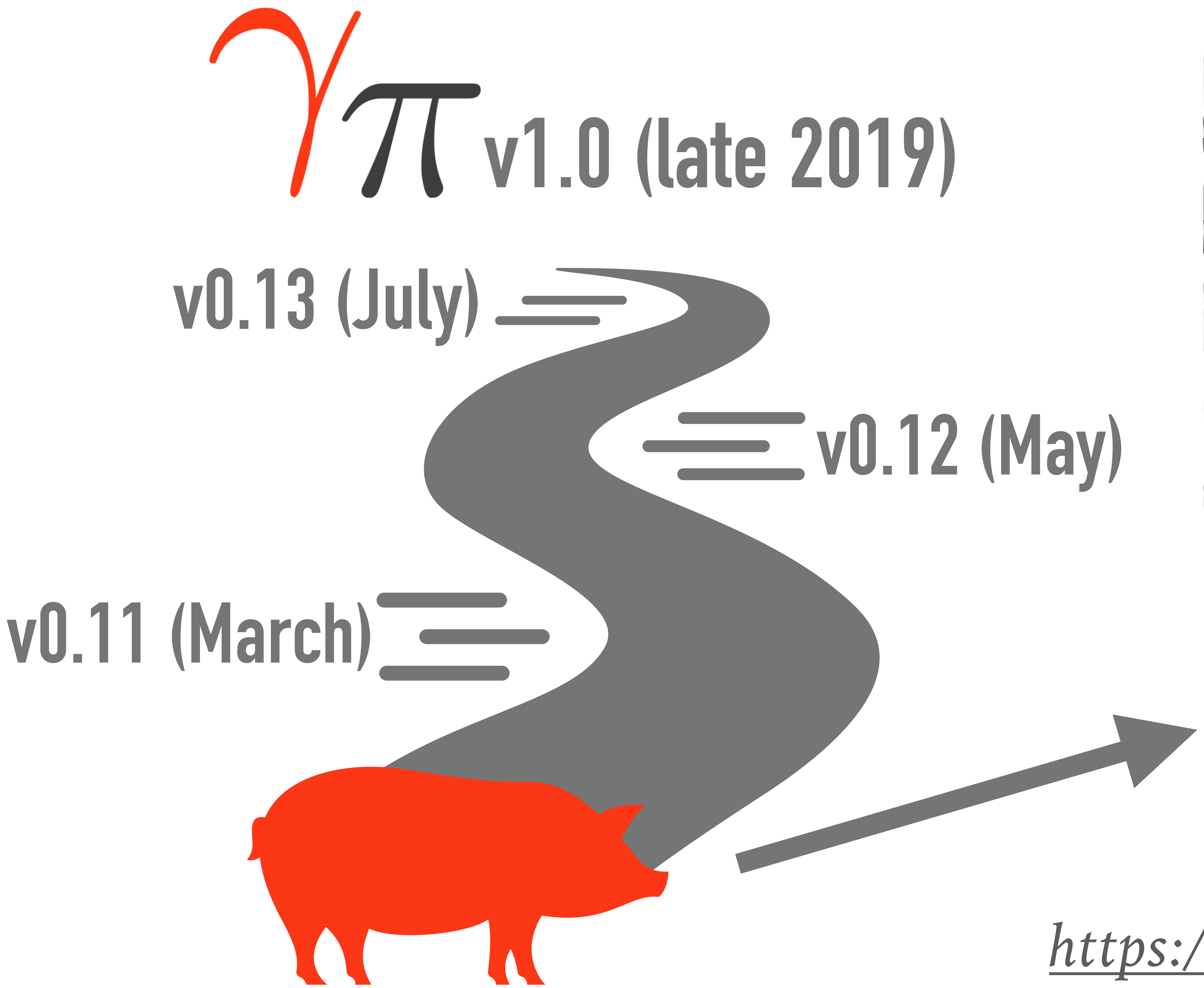
Introduction

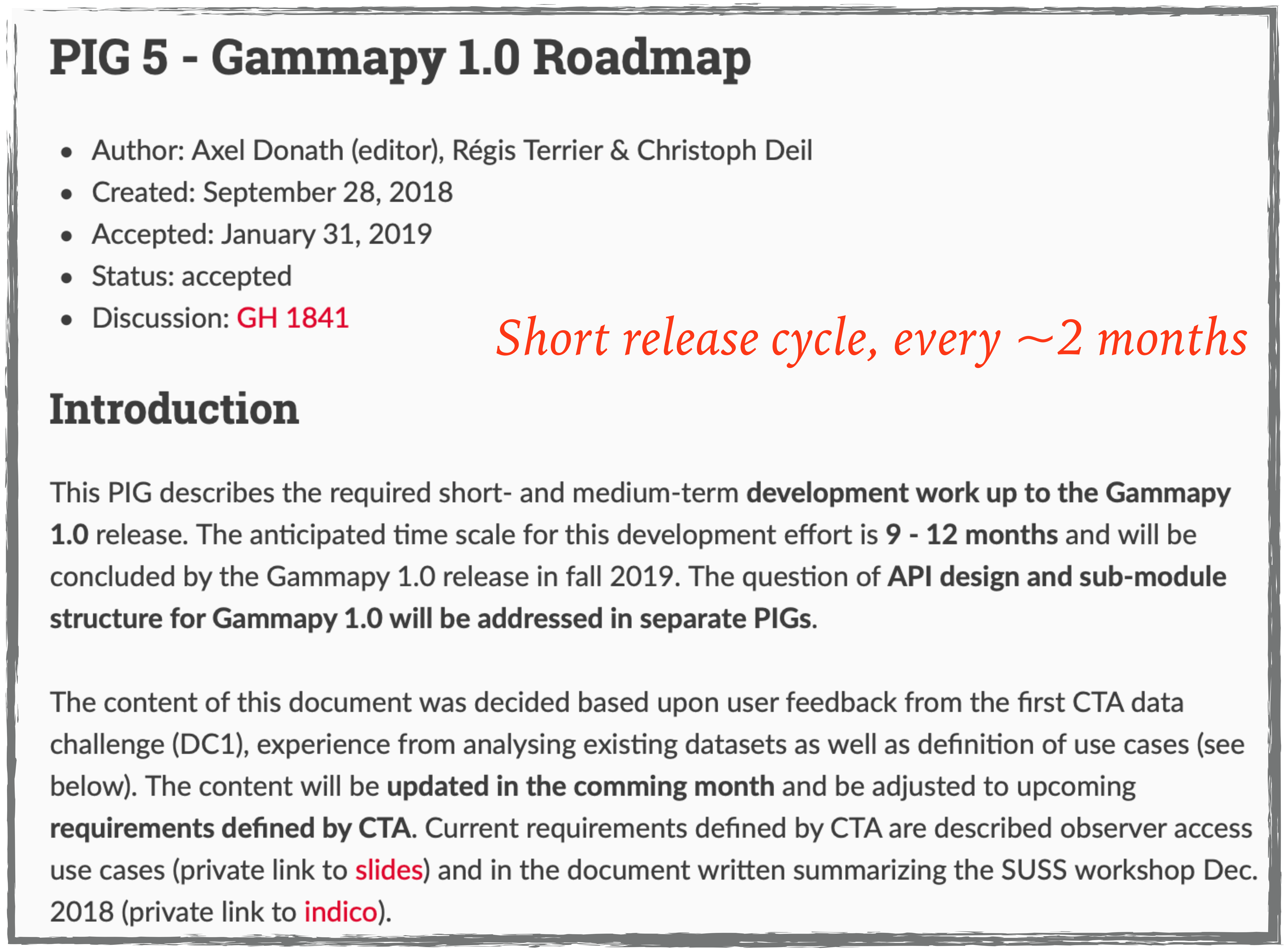
This PIG describes the required short- and medium-term **development work up to the Gammapy 1.0** release. The anticipated time scale for this development effort is **9 - 12 months** and will be concluded by the Gammapy 1.0 release in fall 2019. The question of **API design and sub-module structure for Gammapy 1.0 will be addressed in separate PIGs**.

The content of this document was decided based upon user feedback from the first CTA data challenge (DC1), experience from analysing existing datasets as well as definition of use cases (see below). The content will be **updated in the comming month** and be adjusted to upcoming **requirements defined by CTA**. Current requirements defined by CTA are described observer access use cases (private link to slides) and in the document written summarizing the SUSS workshop Dec. 2018 (private link to indico).

https://docs.gammapy.org/0.12/development/pigs/pig-005.html

GAMMAPY ROADMAP 2019





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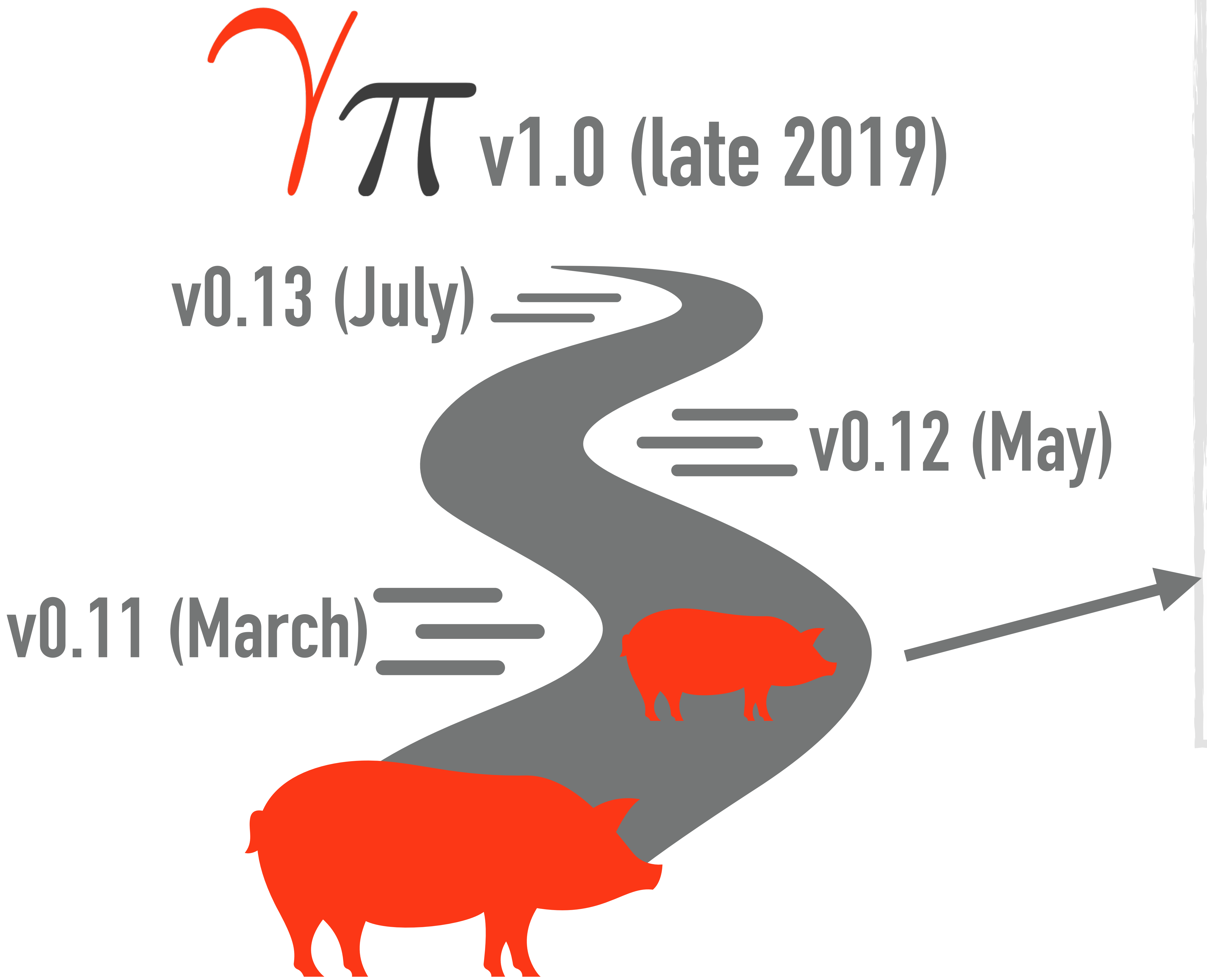
Short release cycle, every $\sim$2 months

https://docs.gammapy.org/0.12/development/pigs/pig-005.html

GAMMAPY ROADMAP 2019

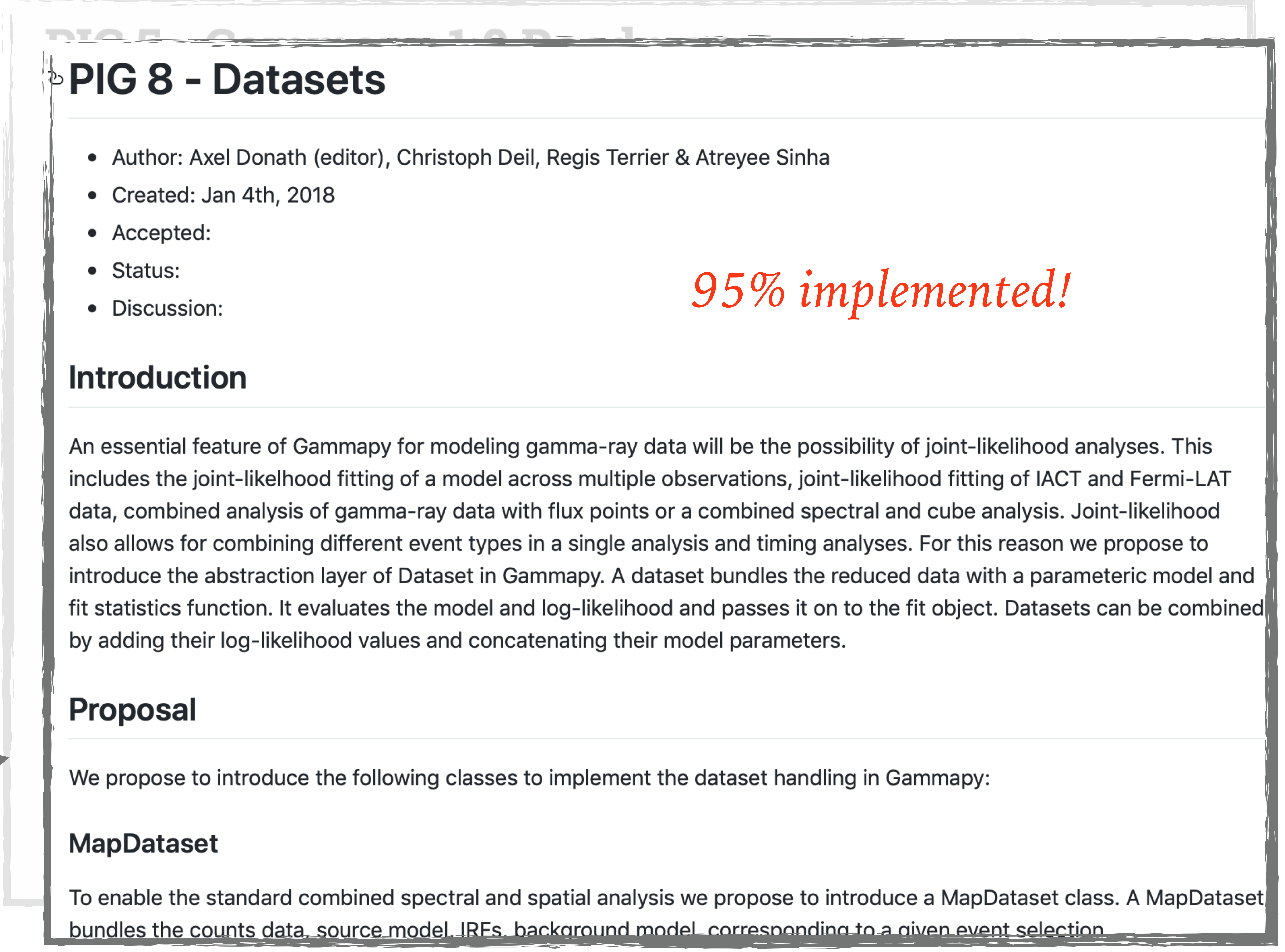


γπ v1.0 (late 2019)

v0.13 (July)

v0.12 (May)

v0.11 (March)



PIG 8 - Datasets

- Author: Axel Donath (editor), Christoph Deil, Regis Terrier & Atreyee Sinha
- Created: Jan 4th, 2018
- Accepted:
- Status:
- Discussion:

95% implemented!

Introduction

An essential feature of Gammapy for modeling gamma-ray data will be the possibility of joint-likelihood analyses. This includes the joint-likelihood fitting of a model across multiple observations, joint-likelihood fitting of IACT and Fermi-LAT data, combined analysis of gamma-ray data with flux points or a combined spectral and cube analysis. Joint-likelihood also allows for combining different event types in a single analysis and timing analyses. For this reason we propose to introduce the abstraction layer of Dataset in Gammapy. A dataset bundles the reduced data with a parametric model and fit statistics function. It evaluates the model and log-likelihood and passes it on to the fit object. Datasets can be combined by adding their log-likelihood values and concatenating their model parameters.

Proposal

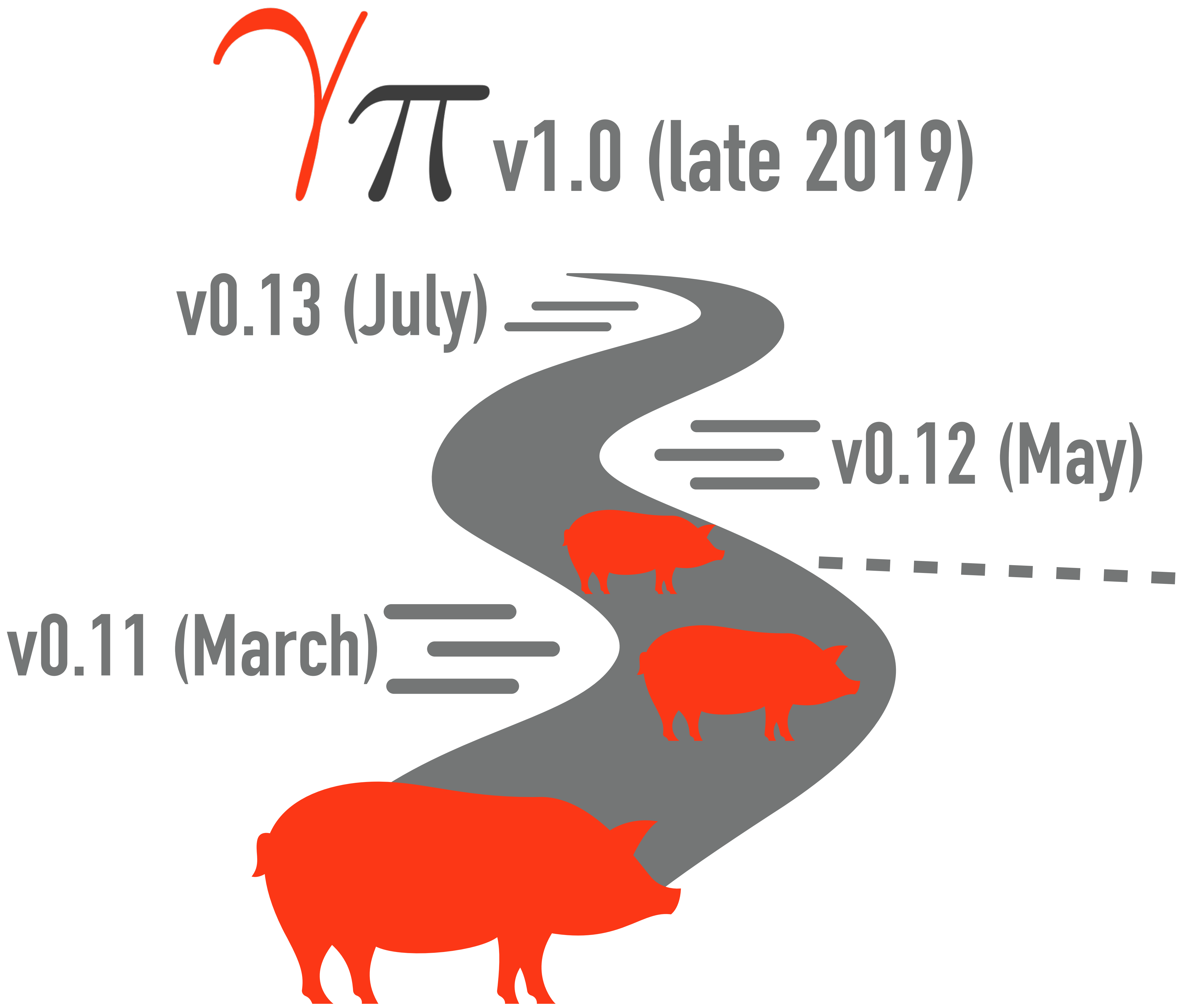
We propose to introduce the following classes to implement the dataset handling in Gammapy:

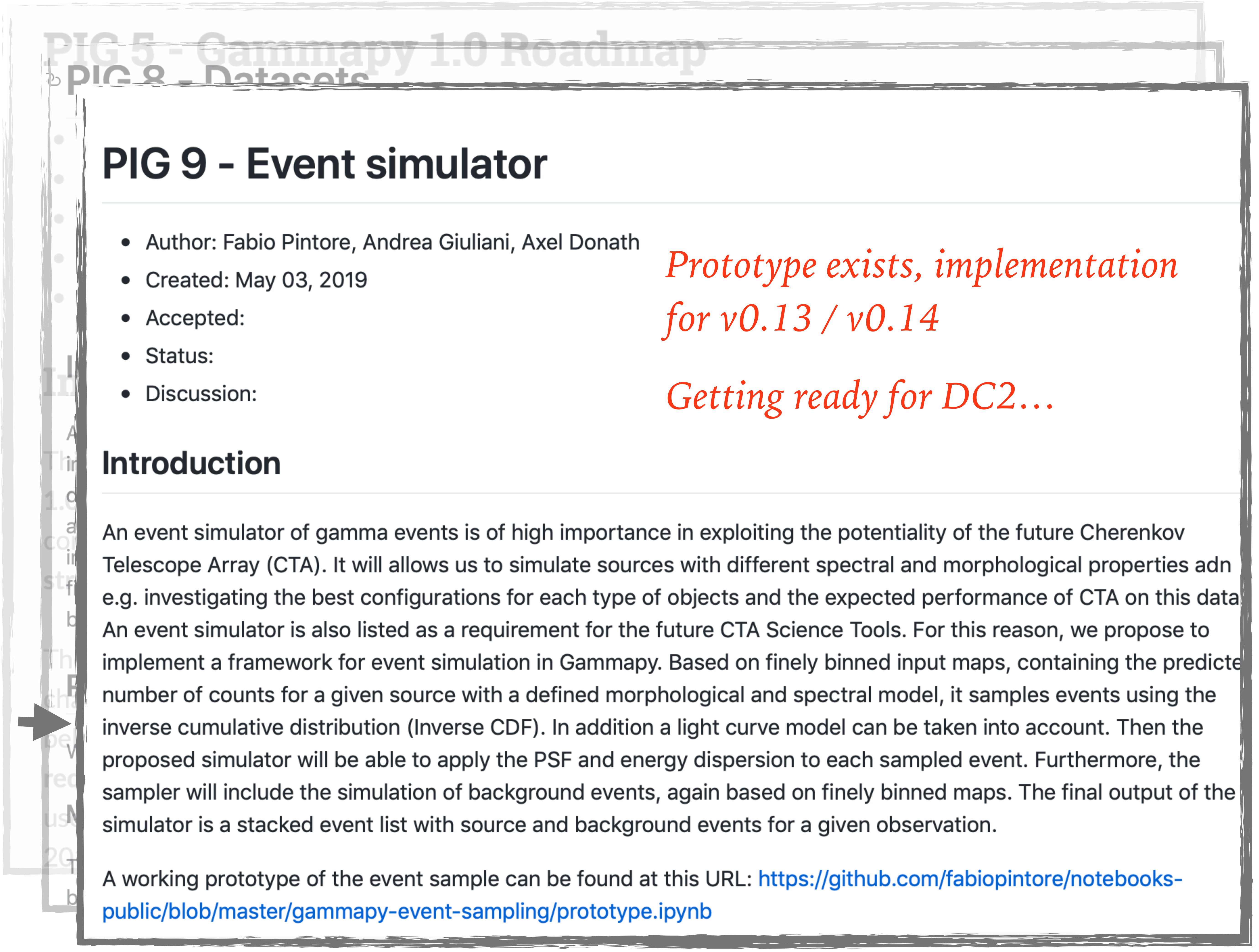
MapDataset

To enable the standard combined spectral and spatial analysis we propose to introduce a MapDataset class. A MapDataset bundles the counts data, source model, IRFs, background model, corresponding to a given event selection.

https://github.com/gammapy/gammapy/pull/1971

GAMMAPY ROADMAP 2019





PIG 5 - Gammapy 1.0 Roadmap

PIG 8 - Datasets

PIG 9 - Event simulator

- Author: Fabio Pintore, Andrea Giuliani, Axel Donath
- Created: May 03, 2019
- Accepted:
- Status:
- Discussion:

Introduction

An event simulator of gamma events is of high importance in exploiting the potentiality of the future Cherenkov Telescope Array (CTA). It will allows us to simulate sources with different spectral and morphological properties adn e.g. investigating the best configurations for each type of objects and the expected performance of CTA on this data An event simulator is also listed as a requirement for the future CTA Science Tools. For this reason, we propose to implement a framework for event simulation in Gammapy. Based on finely binned input maps, containing the predicte number of counts for a given source with a defined morphological and spectral model, it samples events using the inverse cumulative distribution (Inverse CDF). In addition a light curve model can be taken into account. Then the proposed simulator will be able to apply the PSF and energy dispersion to each sampled event. Furthermore, the sampler will include the simulation of background events, again based on finely binned maps. The final output of the simulator is a stacked event list with source and background events for a given observation.

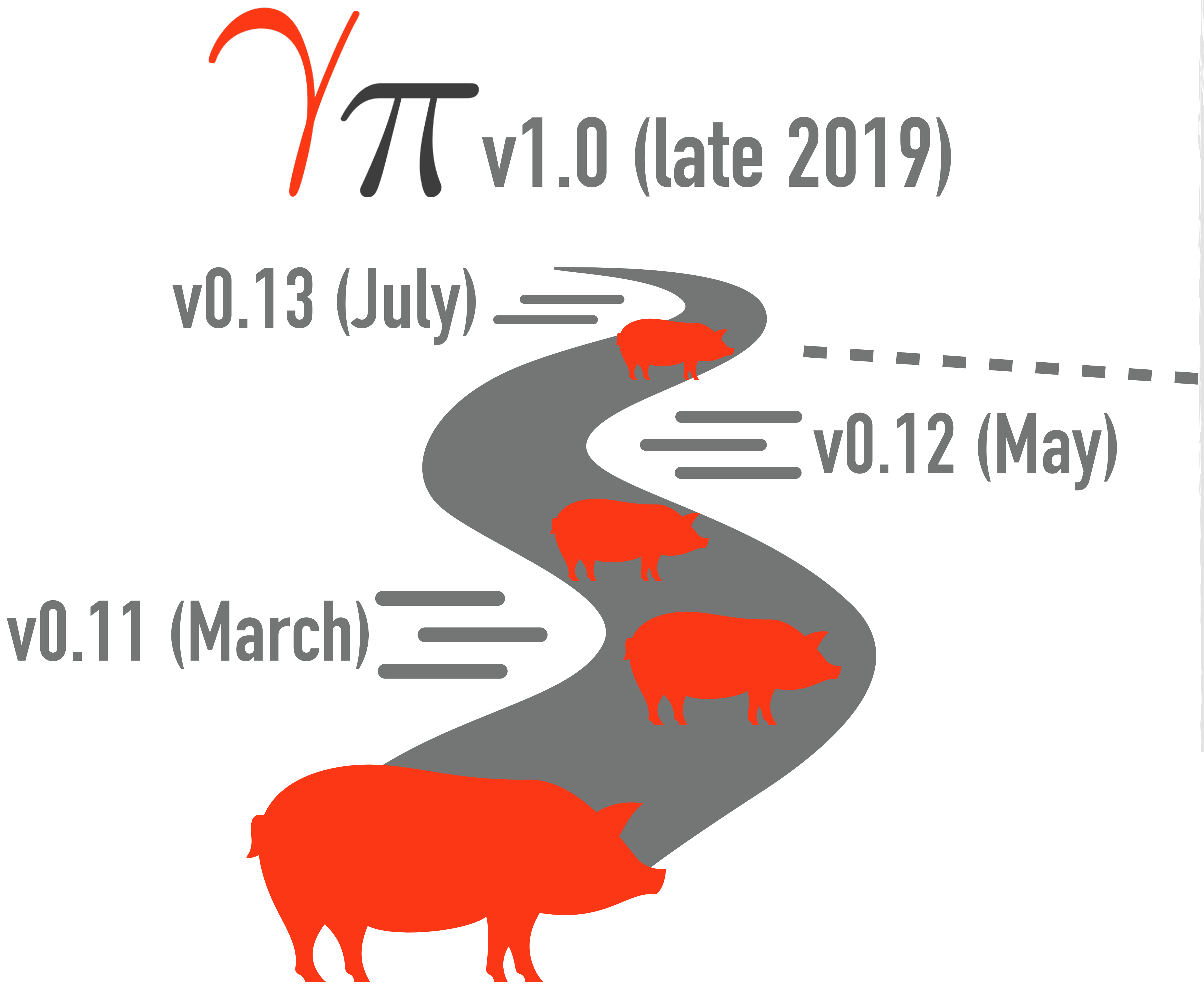
A working prototype of the event sample can be found at this URL: https://github.com/fabiopintore/notebooks-public/blob/master/gammapy-event-sampling/prototype.ipynb

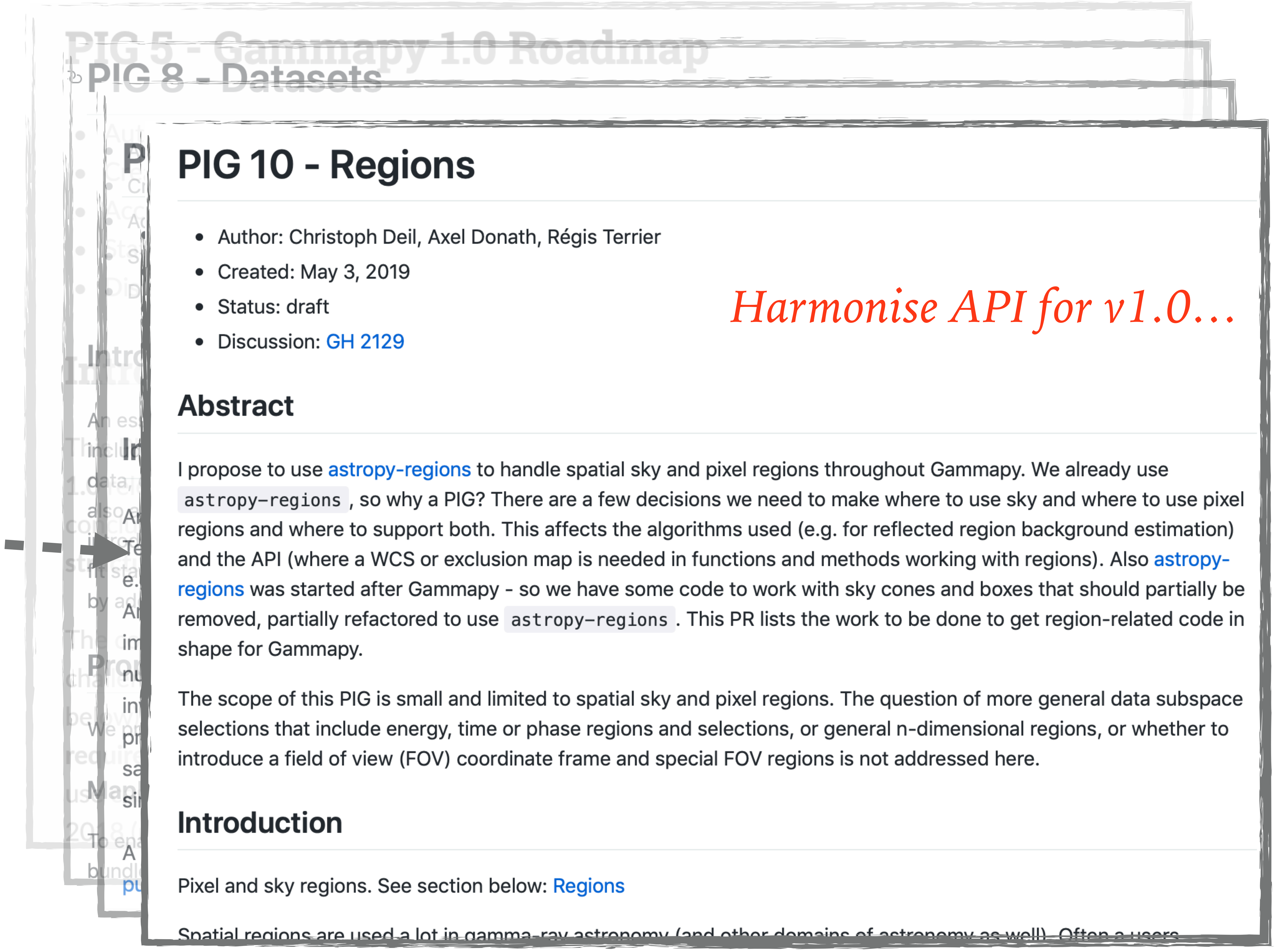
Prototype exists, implementation for v0.13 / v0.14

Getting ready for DC2…

https://github.com/gammapy/gammapy/pull/2136

GAMMAPY ROADMAP 2019





PIG 10 - Regions

- Author: Christoph Deil, Axel Donath, Régis Terrier
- Created: May 3, 2019
- Status: draft
- Discussion: GH 2129

Harmonise API for v1.0...

Abstract

I propose to use astropy-regions to handle spatial sky and pixel regions throughout Gammapy. We already use `astropy-regions`, so why a PIG? There are a few decisions we need to make where to use sky and where to use pixel regions and where to support both. This affects the algorithms used (e.g. for reflected region background estimation) and the API (where a WCS or exclusion map is needed in functions and methods working with regions). Also astropy-regions was started after Gammapy - so we have some code to work with sky cones and boxes that should partially be removed, partially refactored to use `astropy-regions`. This PR lists the work to be done to get region-related code in shape for Gammapy.

The scope of this PIG is small and limited to spatial sky and pixel regions. The question of more general data subspace selections that include energy, time or phase regions and selections, or general n-dimensional regions, or whether to introduce a field of view (FOV) coordinate frame and special FOV regions is not addressed here.

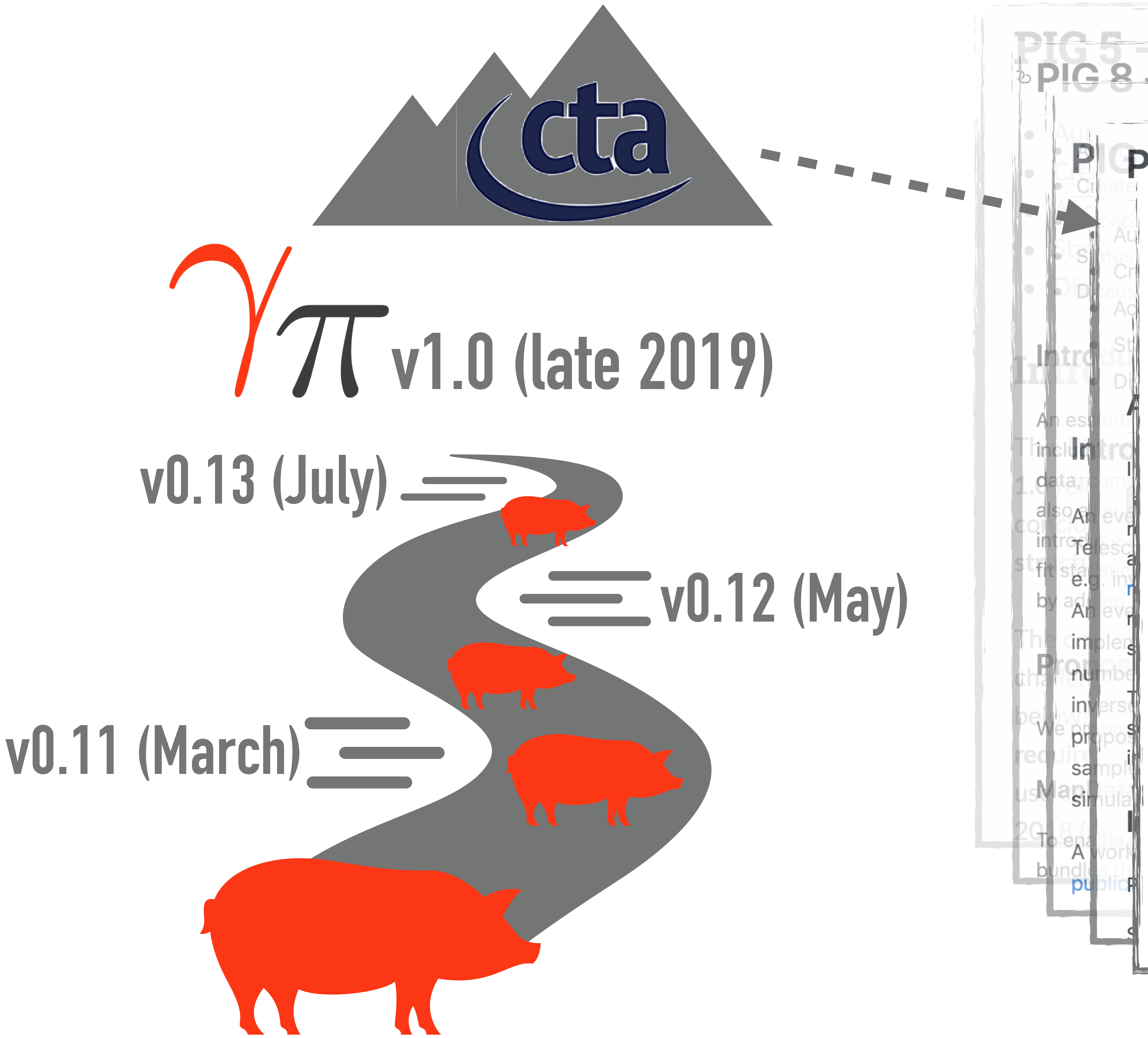
Introduction

Pixel and sky regions. See section below: Regions

Spatial regions are used a lot in gamma-ray astronomy (and other domains of astronomy as well). Often a users

https://github.com/gammapy/gammapy/pull/2129

GAMMAPY ROADMAP 2019



Further topics on the roadmap:

- ➤ Develop command-line interface
- ➤ Harmonise and stabilise API
- ➤ Add support for IRFs per model component
- ➤ Improve GTI handling
- ➤ Add support for event types/classes
- ➤ Improve documentation
- ➤ Set up science verification CI system
- ➤ Support for distributed computing

SUMMARY

SUMMARY

- Gammapy is a Python package for gamma-ray astronomy, built on Numpy, Scipy and Astropy as core dependencies and uses open, FITS based data formats.
- It has grown in both features and contributors significantly over the past ~5 years.
- Development and CI setup are in a very good shape.

- Recently a lot of effort put into improving code quality and harmonising the concepts / API.
- Next releases: v0.13 in July and v0.14 in September with focus on API, data reduction and event sampling
- Science verification on H.E.S.S. DL3 data is in progress, paper expected soon.
- Gammapy v1.0 release and paper are planned for late 2019.

THANKS FOR LISTENING!

```
from gammapy import song; song(karaoke=True)
```