Gammapy “user” Introduction

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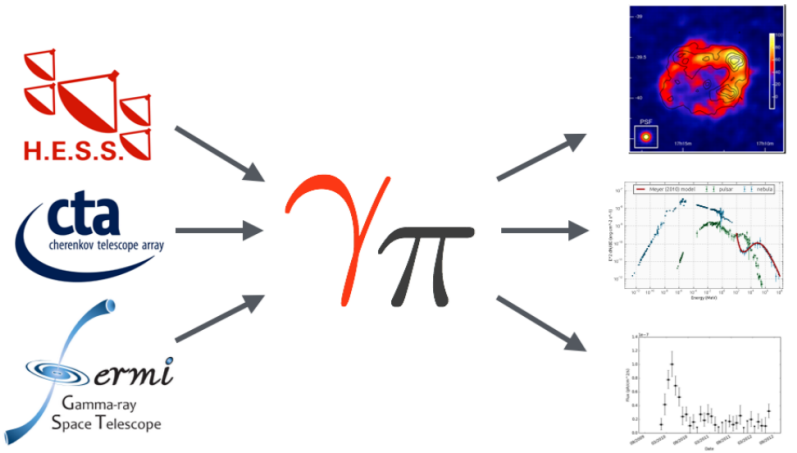
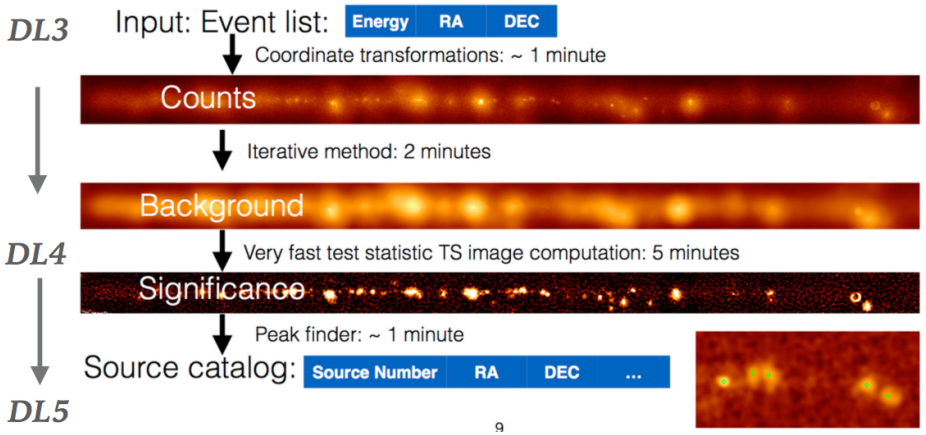
Most of the material from C.Deil and J.Lefaucheur

What is Gammapy?

- Gammapy is a Python package for gamma-ray astronomy
- Open source, open development (on Github)
- Officially proposed as CTA science tool prototype at the Kashiwa meeting in May 2016
- Currently used for H.E.S.S., CTA prototyping and Fermi-LAT
- Used for upcoming H.E.S.S. Galactic plane survey paper





Gammapy references

- Code: https://github.com/gammapy/gammapy
- Docs: http://docs.gammapy.org **To get started, click here!**
- Tutorials: https://nbviewer.jupyter.org/github/gammapy/gammapy-extra/blob/master/index.ipynb

Questions, comments, requests?

- Mailing list: http://groups.google.com/group/gammapy
- Me: Christoph.Deil@mpi-hd.mpg.de

Gammapy references

- ICRC 2015 paper: 2015arXiv150907408D
- Code: https://github.com/gammapy/gammapy
- Docs: http://docs.gammapy.org
- Mailing list: http://groups.google.com/group/gammapy
- License: BSD-3 (same as Numpy, Scipy, Astropy, ...)

Gammapy paper

Astrophysics > Instrumentation and Methods for Astrophysics

Gammapy - A Python package for γ-ray astronomy

Axel Donath, Christoph Deil, Manuel Paz Arribas, Johannes King, Ellis Owen, Régis Terrier, Ignasi Reichardt, Jon Harris, Rolf Bühler, Stefan Klepser

(Submitted on 24 Sep 2015 (v1), last revised 6 Oct 2015 (this version, v2))

In the past decade imaging atmospheric Cherenkov telescope arrays such as H.E.S.S., MAGIC, VERITAS, as well as the Fermi-LAT space telescope have provided us with detailed images and spectra of the gamma-ray universe for the first time. Currently the gamma-ray community is preparing to build the next-generation Cherenkov Telecope Array (CTA), which will be operated as an open observatory. Gammapy (available at this https URL under the open-source BSD license) is a new in-development Astropy affiliated package for high-level analysis and simulation of astronomical gamma-ray data. It is built on the scientific Python stack (Numpy, Scipy, matplotlib and scikit-image) and makes use of other open-source astronomy packages such as Astropy, Sherpa and Naima to provide a flexible set of tools for gamma-ray astronomers. We present an overview of the current Gammapy features and example analyses on real as well as simulated gamma-ray datasets. We would like Gammapy to become a community-developed project and a place of collaboration between scientists interested in gamma-ray astronomy with Python. Contributions welcome!

Comments: For more information about Gammapy visit this https URL, corrected typo in author list, removed latex commands in abstract
Subjects: **Instrumentation and Methods for Astrophysics (astro-ph.IM)**
Cite as: **arXiv:1509.07408 [astro-ph.IM]**
(or **arXiv:1509.07408v2 [astro-ph.IM]** for this version)

Software use in Astronomy — An informal survey

- Not everyone is using FTOOLs!
- Python has replaced IDL as #1 language in Astronomy
- The Astropy project started in 2011 and has become the standard core package for thousands of users (Hubble, JWST, Chandra, ...)
- I have personally met several users that are comfortable using Python functions and classes.
- :-)

2015arXiv150703989M

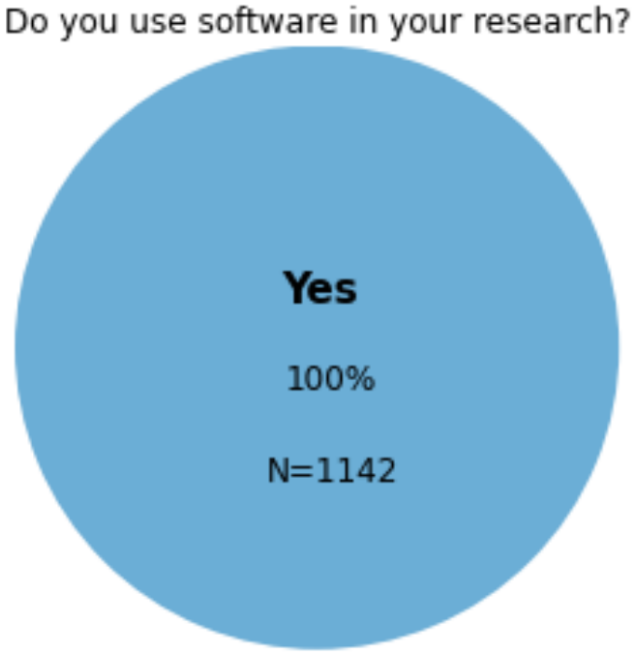
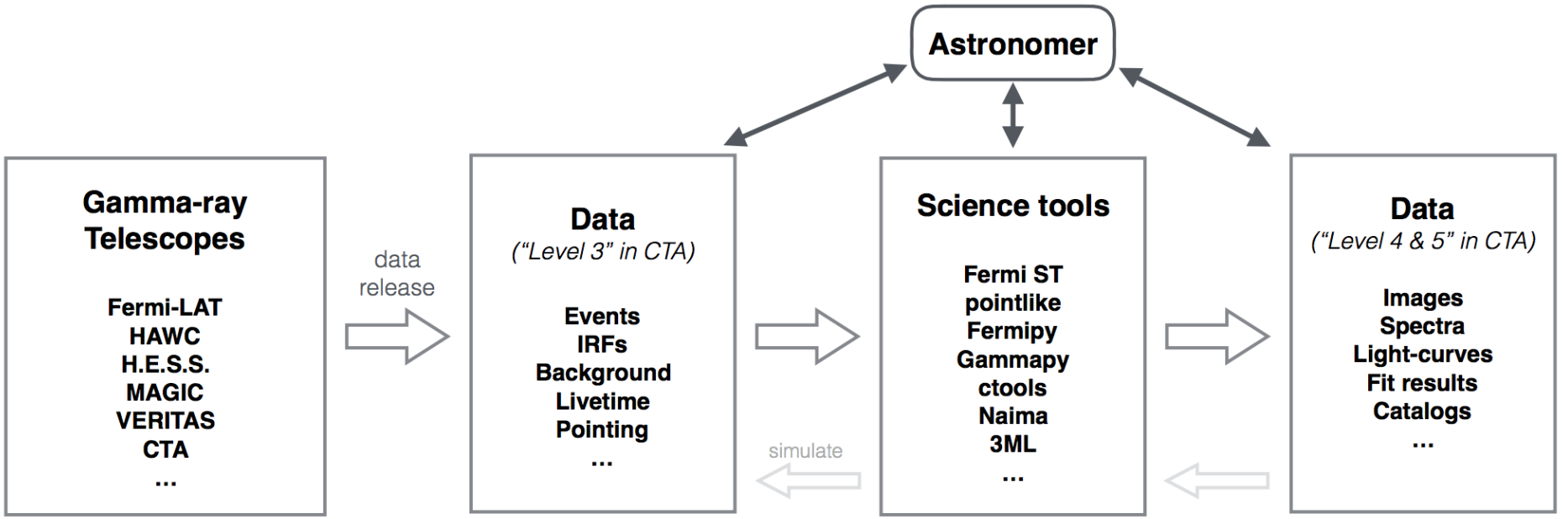


FIG. 2.— Responses to the question "Do you use software in your research?". 100% of survey participants answered in the affirmative.

Gammapy context

Several instruments producing high-level FITS data.
Always very similar, but different in detail.



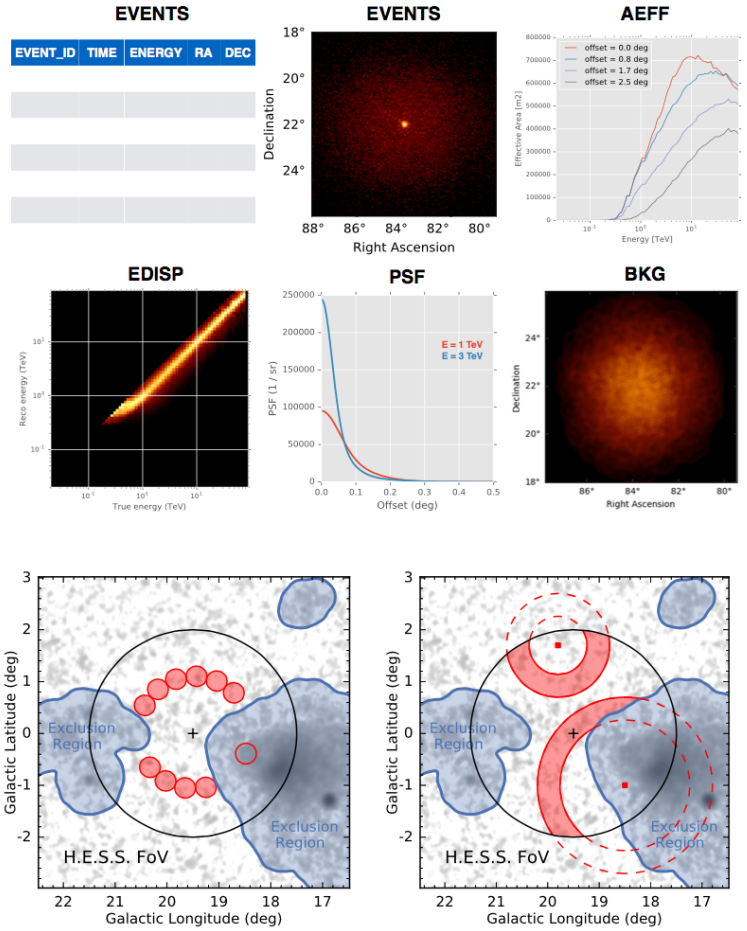
Open and reproducible science a big topic now.
Many projects and people develop their tools as open source.

Gammapy

- A prototype for the CTA science tools (proposed in Kashiwa)
- A Python package for gamma-ray astronomy, built on Python, Numpy, Scipy, Astropy
- 27k lines of code,
  21 contributors
- So far mostly used for H.E.S.S.
  (e.g. Galactic plane survey)
- Now with the first data challenge, focus is moving more to CTA

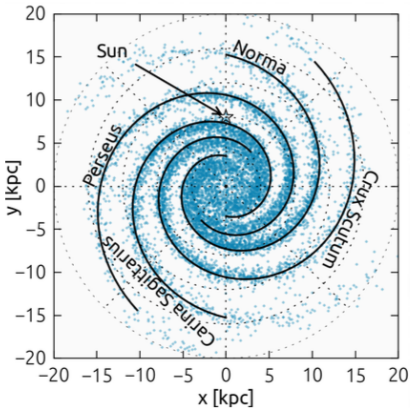
Gammapy features

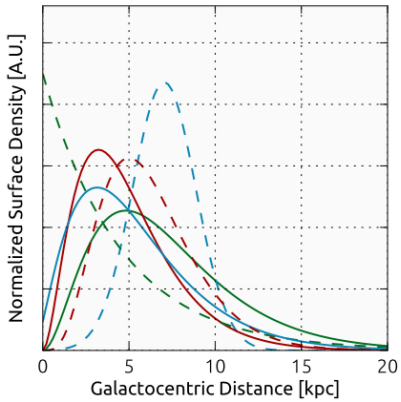
- **gammapy.data & gammapy.irf**
  IACT DL3 data handling
- **gammapy.image**
  2-dim image analysis
- **gammapy.spectrum**
  1-dim region spectral analysis
- **gammapy.background**
  Background modeling methods
  (might merge in image, spectrum cube)
- **gammapy.cube**
  3-dim cube analysis (work in progress)
- **gammapy.detect**
  Source detection (image-based for now)

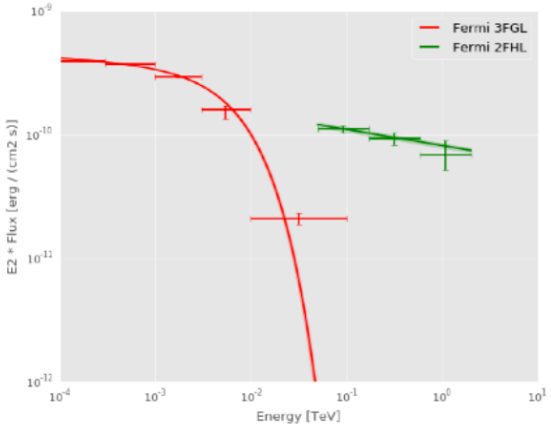


Gammapy features

- **gammapy.stats**
  Statistics methods
- **gammapy.time**
  Time analysis (not much available yet)
- **gammapy.catalog**
  - Fermi-LAT spectra, lightcurves
  - Next: TeV data (gamma-cat)
- **gammapy.astro**
  Some simple models for Galactic sources and source populations
  (could go in separate higher-level science package)
- **gammapy.scripts**
  Command line interface (CLI) tools for common operations
  (not much available yet, see comments on science too user interface in backup slides)

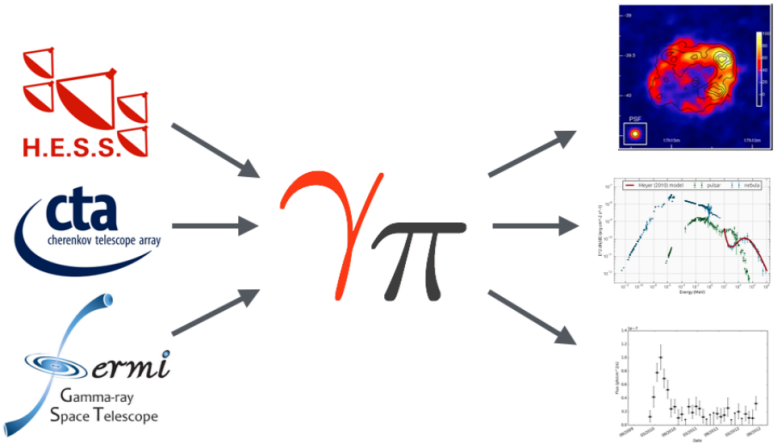


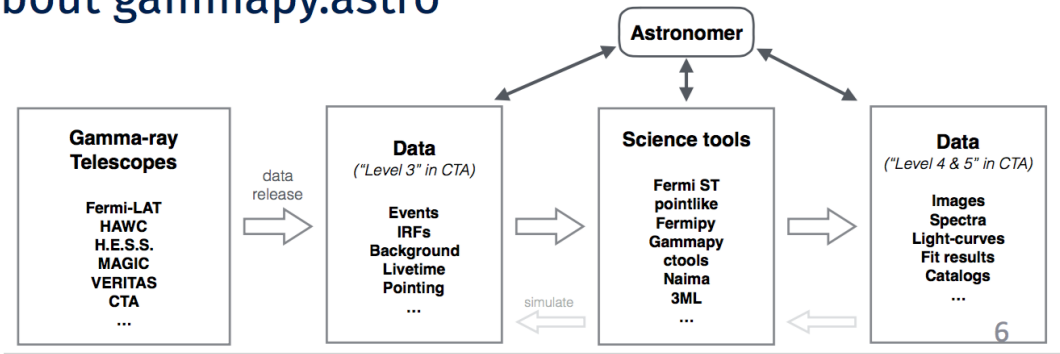




Gammapy scope & other projects

- Gammapy scope not set in stone
  Driven by users and contributions
- So far mostly prototyping of IACT DL3 FITS data formats and “classical TeV analysis” applied to H.E.S.S.
- Now project is expanding
  CTA use cases and data challenge
- Started collaborating with Fermipy
  Gammapy is the base package
  Move HEALPix, SED to Gammapy
- Astro model efforts are currently scattered (Naima, Gamera, …)
  Will have to see what to do about gammapy.astro





Gammapy approach

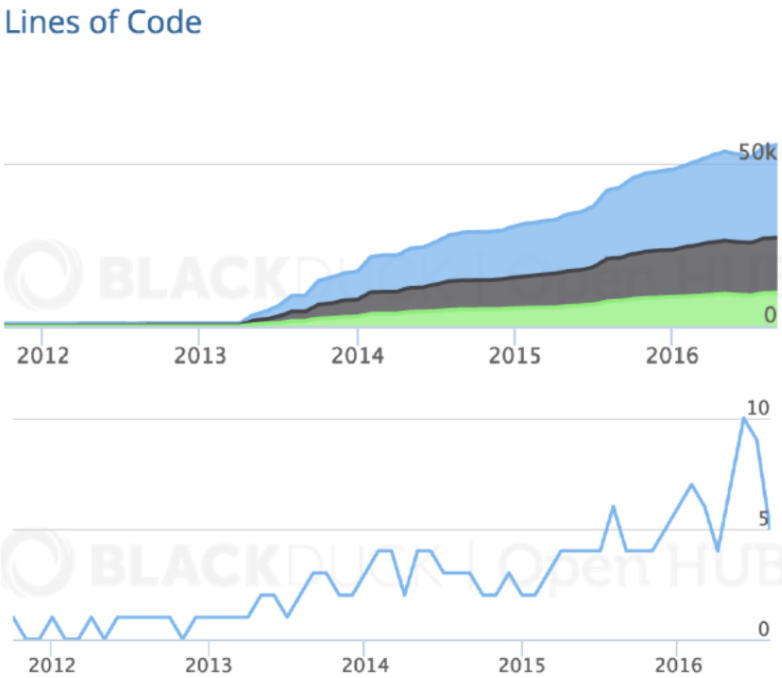
- Gammapy is written in Python, using Numpy, Scipy, Astropy
- For modeling / fitting, we currently use Sherpa
- A few stable, well-maintained, widely used dependencies
- Data in Gammapy objects *(EventList, SkyImage, ...)* or Astropy objects *(Time, SkyCoord, WCS, ...)* is stored as Numpy arrays

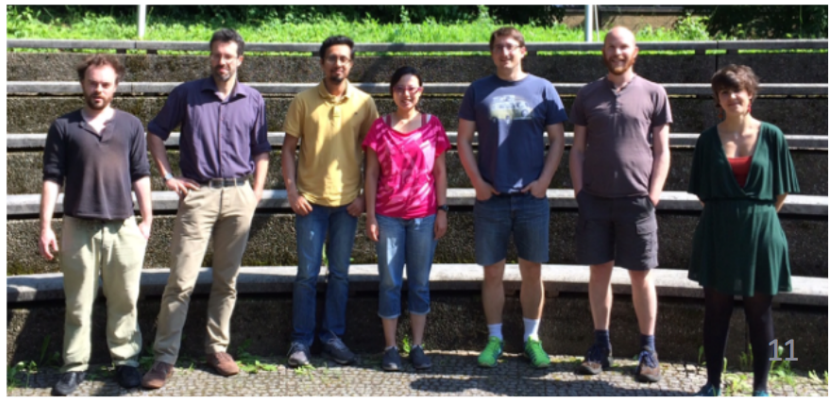
Gammapy approach benefits

- *"Standing on the shoulders of giants ..."*
- Gammapy codebase is small and focused on gamma-ray astronomy
- Single high-level language codebase that's easy to use, read and extend
- Interoperable (Numpy arrays) with larger scientific Python ecosystem: iminuit, emcee, Fermipy, naima, pint, ...
- Connected to the large scientific and specifically astronomy Python community

Gammapy development activity

- Gammapy development started in 2013 and is now accelerating
- 21 contributors (1+ commit)
- 27k lines of code (includes tests, but not docs/comments)
- First Gammapy coding sprint in June 2016 at MPIK, Heidelberg
- Releases ~ every 6 months, see changelog for details



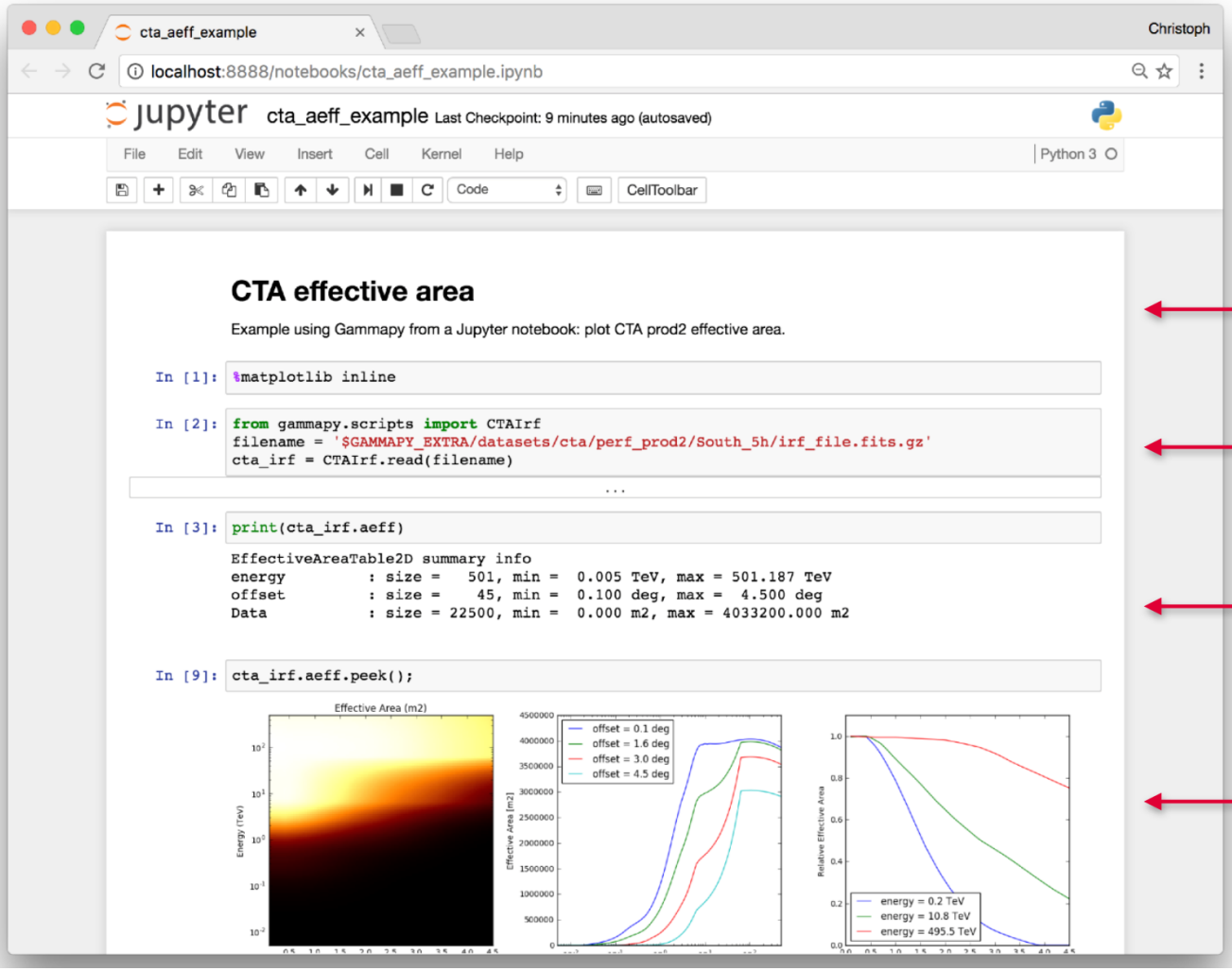


Summary

- Gammapy is a Python package for gamma-ray astronomy
- A prototype / contender for the CTA science tools
- Built on Python, Numpy, Scipy, Astropy
- Young project, many features missing or can be improved.
  Development activity accelerating in the past months.
- Gammapy can do “classical analysis” of TeV data now
  (2-dim for detection / morphology, 1-dim for spectra)
- 3-dim cube analysis prototype exists (using Sherpa).
- Only binned likelihood analysis so far. No concrete plans to add unbinned. Are there any important use cases that can only be done unbinned in an efficient way?
- Almost nothing for timing analysis available yet.
  But should be easy to implement, no? Interested?

Gammapy from Jupyter notebook

Interactive data exploration and analysis from Jupyter notebook.
Notebook is a JSON file that can be shared and executed locally or on server.



Documentation

Code

Output text

Output images

Astropy and Astropy-affiliated packages

- Gammapy is an astropy-affiliated package
- Astropy core package is the base
- Other packages of interest:
  - Fermipy - plan is to import Gammapy from Fermipy, move the SED and HEALPIX cube classes to Gammapy
  - Naima - SED modeling, so far no good integration with Gammapy, but fitting SED models from Naima certainly possible.
  - Astropy regions — split out from Gammapy, now developed as separate package. Idea is to move to Astropy core
  - PINT - a new pulsar timing built on Astropy Time
  - Many more: reproject, photutils, astroquery, ...