Gammapy in H.E.S.S.

& joint Crab paper with MAGIC / Fermi-LAT

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Status

- Gammapy has been used H.E.S.S. internally for years
- But overall not successful. Very few papers use Gammapy (survey, new shells), none that start with FITS events
- The same is true for DL3 FITS data in general and ctools — no H.E.S.S. science paper using it

Why?

- Hard to say, just some points I think are worth mentioning:
  - Let’s be honest: Gammapy quality not very good yet
    Similar to HAP, but we want to do better, right?
  - Everything always work in progress (data formats, exporters, science tools, even methods e.g. for background modeling)
  - PhD/postdocs do something for their study and move on,
    not focused on validation, FITS productions, support
  - No requirement or deadline to ever use open data or tools;
    H.E.S.S. data private - can always do some measurement later
  - Try a simple analysis that is well understood -
    “Why use a new tool? Just use the H.E.S.S. software!”
  - Try a hard analysis that needs new tools / methods -
    “Not clear if results correct. No publication for you!”

We need to forget about science papers, and re-focus on technical work for a while!

Re-focus

- Important technical projects for Gammapy & H.E.S.S.:

  1. H.E.S.S. data level 3 (DL3) test data release 1 (DR1)

  2. H.E.S.S. FITS & Gammapy & ctools validation paper

  3. Joint Crab paper with MAGIC & Fermi-LAT

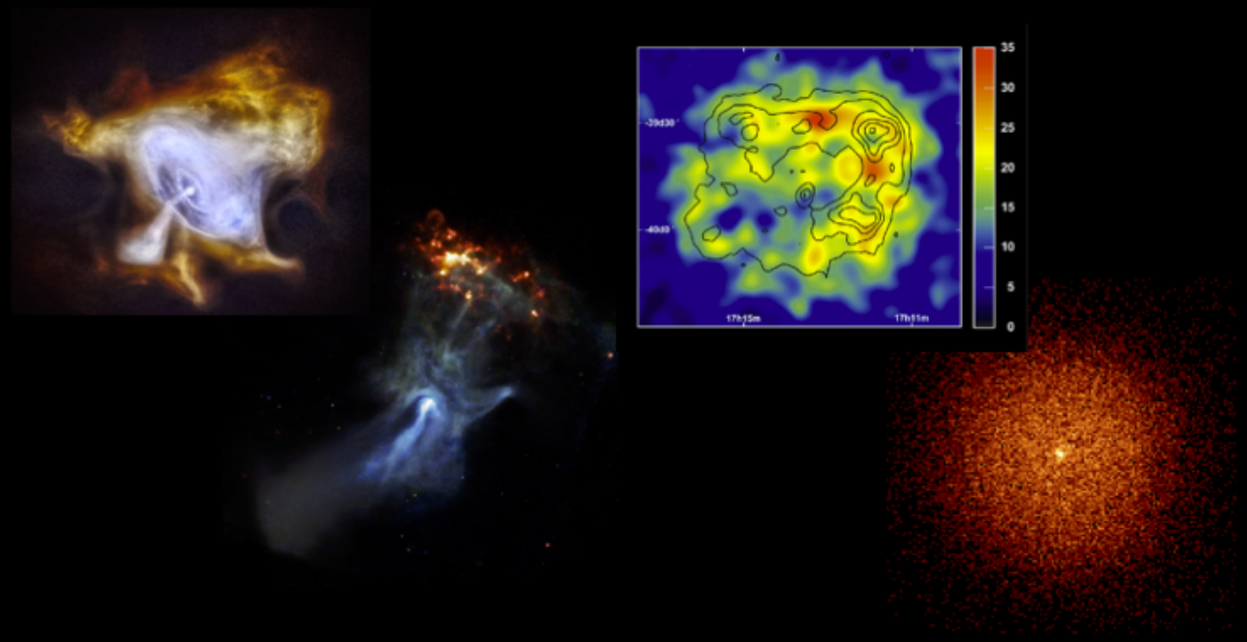
- *Of course several science studies continue in parallel …*

H.E.S.S. test data release

- 28 hours, 33 MB of HESS 1 data, mostly from 2004
- Data level 3 (DL3): event table and IRF per observation
- Two point sources, two extended sources, one variable source; plus 20 hours of “off data”, i.e. background only
- Purpose: help open data & tool development
  Terms of use forbid external science publications!
- H.E.S.S.-internal review Feb 2—23
- FITS data and release notes on H.E.S.S. Confluence
- Data should be 100% compatible with the open spec: http://gamma-astro-data-formats.readthedocs.io/

H.E.S.S. test data release

- Relevance for Gammapy:
  - made this explicitly to have a nice curated public H.E.S.S. reference datasets for Gammapy
  - use for tutorials (see talk by Roberta)
  - use for high-level tests (“science validation”)
- If you’re in H.E.S.S., please review until Feb 23 and let us know what you find (good or bad!) at H.E.S.S. Confluence
- Work on updating Gammapy tutorials to this dataset now most valuable. Help welcome!



H.E.S.S.

FITS data

Data level 3, public test release 1
Feb 2018

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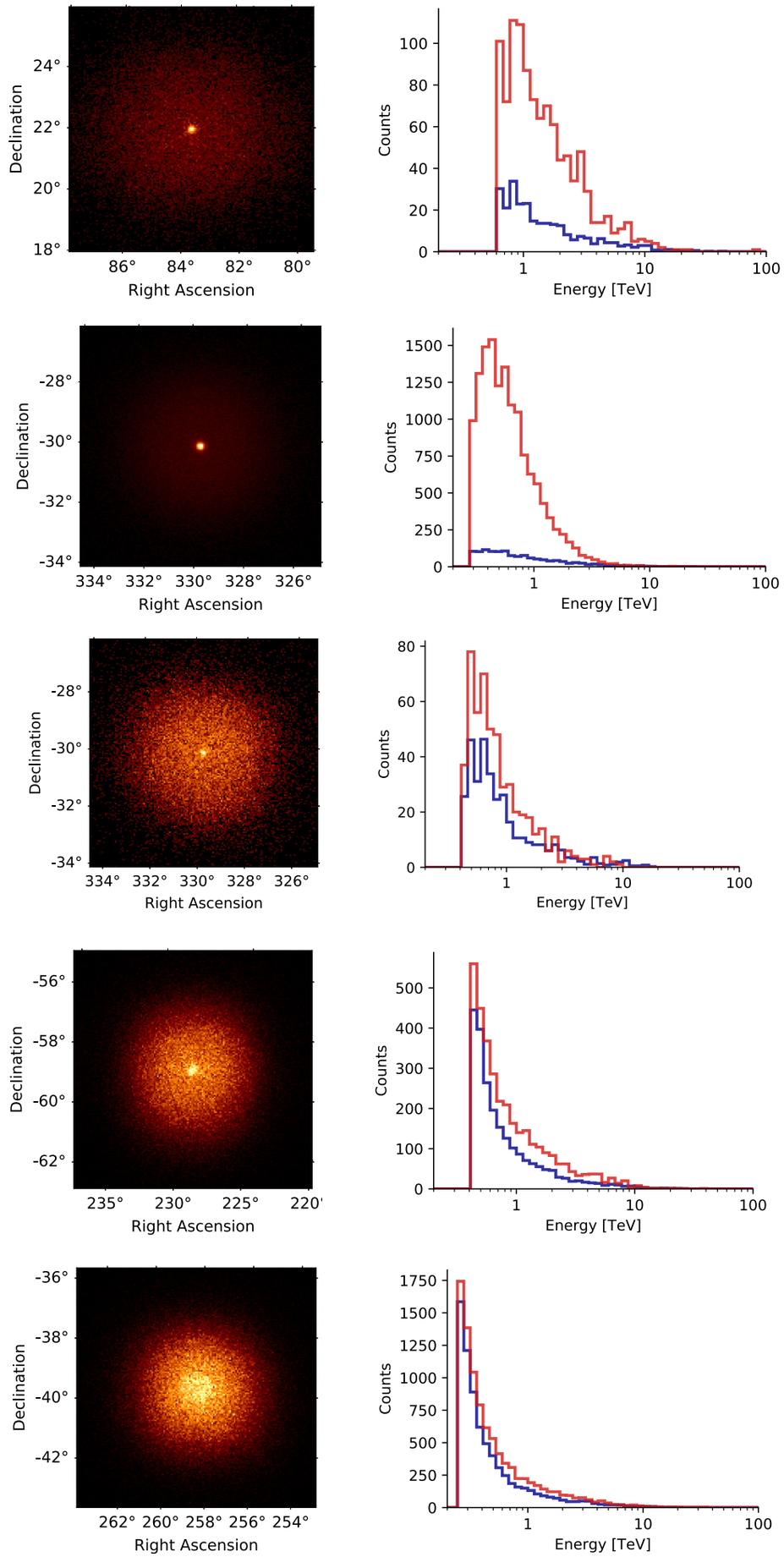
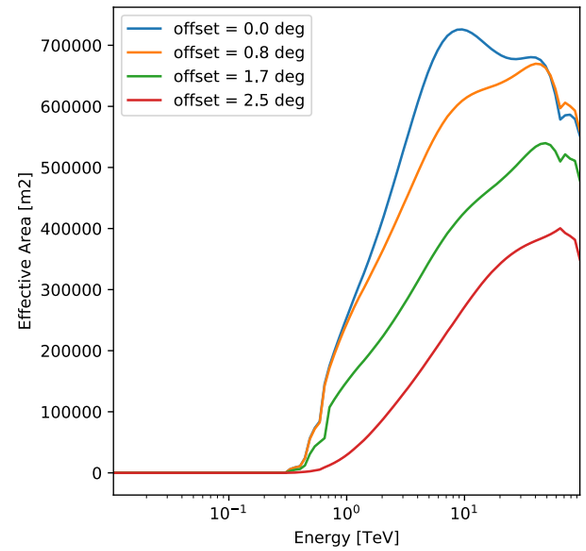
Preliminary

Source Name	N_{obs}	Time (h)	Dates
Crab	4	1.9	2004-12-04 - 2004-12-08
PKS 2155-304 (flare)	15	7.0	2006-07-29 - 2006-07-30
PKS 2155-304 (steady)	6	2.8	2008-08-27 - 2008-08-28
MSH 15-52	20	9.1	2004-03-26 - 2004-04-19
RX J1713.7-3946	15	7.0	2004-04-17 - 2004-05-21
Off data	45	20.7	2004-04-14 - 2005-11-20

```
├─ hess_dl3_dr1_v1.pdf
├─ hess_dl3_dr1_v1.tar.gz
├─ hess_dl3_dr1_v1
│  ├─ README.txt
│  ├─ hdu-index.fits.gz
│  ├─ obs-index.fits.gz
│  └─ data
│     ├─ hess_dl3_dr1_obs_id_NNNNNN.fits.gz
│     ├─ hess_dl3_dr1_obs_id_NNNNNN.fits.gz
│     └─ ...
```

HDU	Description	HDUCLAS4	Rows	Cols	Size (kB)
EVENTS	Event parameters		–	7	350.3
GTI	Good time intervals		2	2	0.0
AEFF	Effective area	AEFF_2D	1	5	3.0
EDISP	Energy dispersion	EDISP_2D	1	7	95.1
PSF	Point spread function	PSF_TABLE	1	7	15.6

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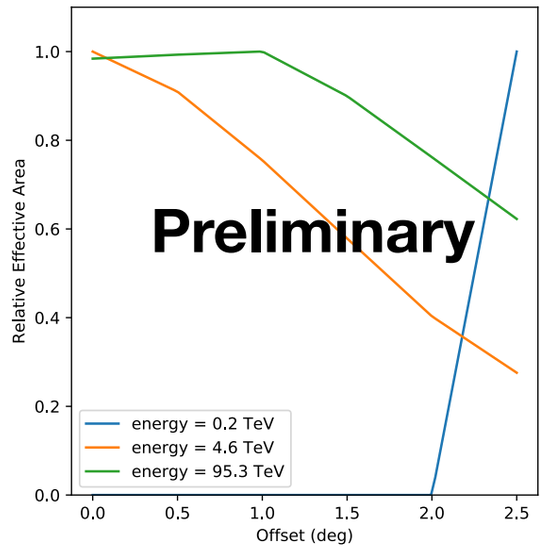
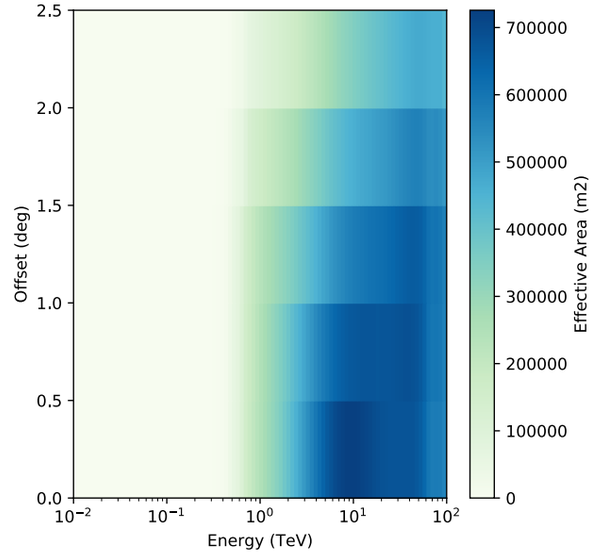
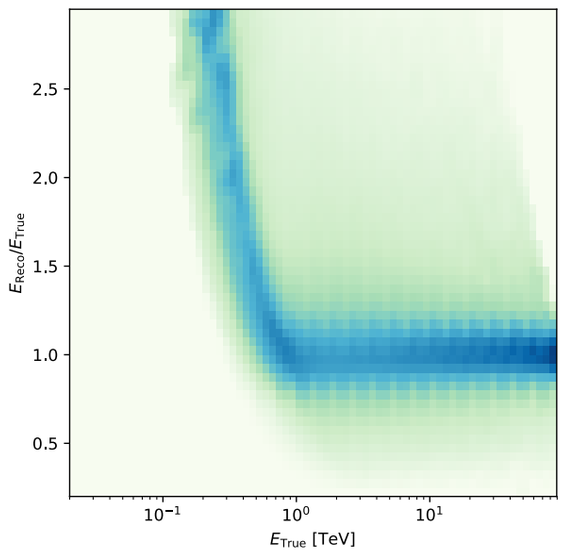
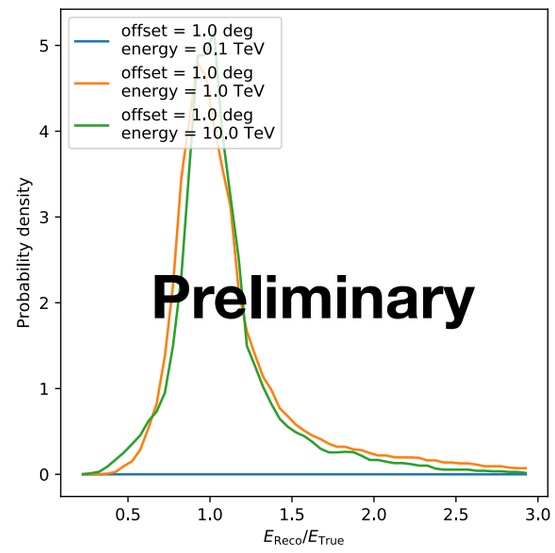
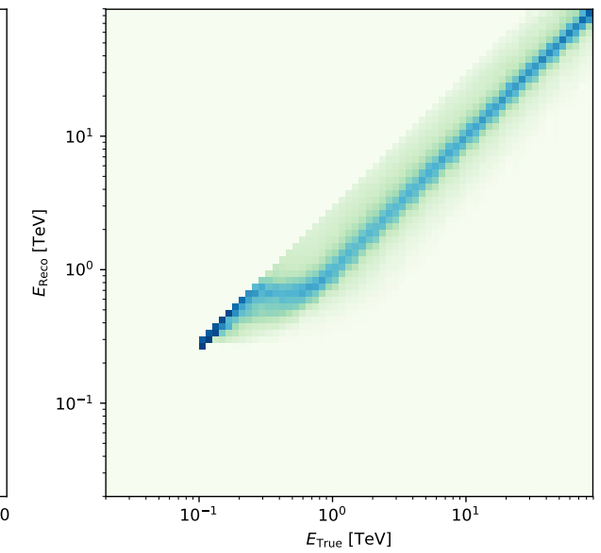
offset = 2.5 deg
Effective Area [m2]
Energy [TeV]

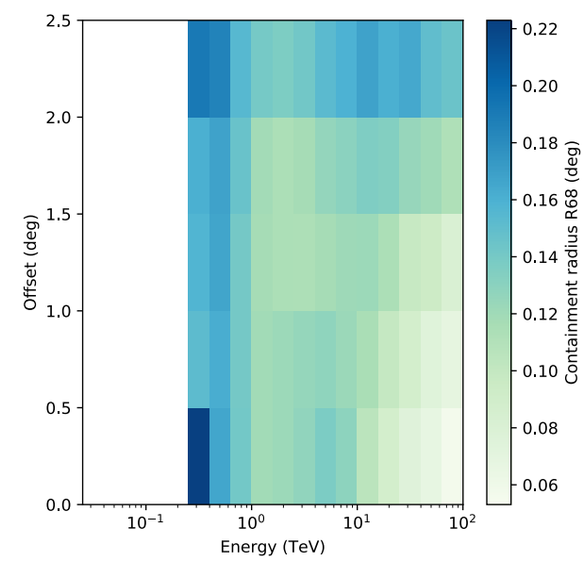

Preliminary
energy = 0.2 TeV
energy = 4.6 TeV
energy = 95.3 TeV
Relative Effective Area
Offset (deg)

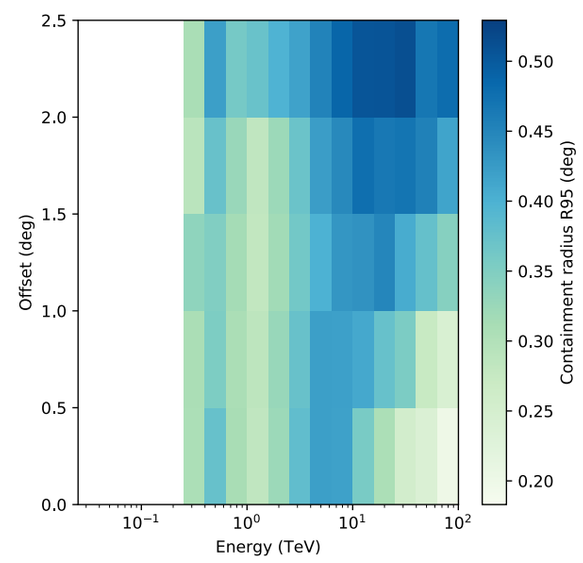

Offset (deg)
Energy (TeV)
Effective Area (m2)

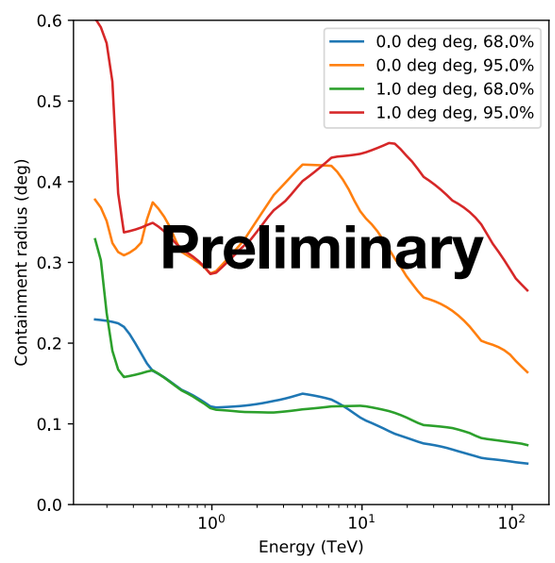

E_{Reco}/E_{True}
E_{True} [TeV]


offset = 1.0 deg
energy = 0.1 TeV
offset = 1.0 deg
energy = 1.0 TeV
offset = 1.0 deg
energy = 10.0 TeV
Preliminary
Probability density
E_{Reco}/E_{True}


E_{Reco} [TeV]
E_{True} [TeV]


Offset (deg)
Energy (TeV)
Containment radius R68 (deg)


Offset (deg)
Energy (TeV)
Containment radius R95 (deg)


0.0 deg deg, 68.0%
0.0 deg deg, 95.0%
1.0 deg deg, 68.0%
1.0 deg deg, 95.0%
Preliminary
Containment radius (deg)
Energy (TeV)

H.E.S.S. validation paper

- The first test data release notes contain no analysis results
- Last year a “validation paper” was requested, even put as a requirement before new tools can be used for H.E.S.S. science papers.
- Lars Mohrmann / Erlangen group have taken the lead and are working on HAP & Gammapy & ctools analyses starting with detailed data release target analyses and building background models

H.E.S.S. validation paper

- Relevance for Gammapy:
  - This study & paper is the key to Gammapy for H.E.S.S.
  - We need to focus on this in 2018, or FITS / Gammapy simply comes too late to have an impact in H.E.S.S.
- The best way to support this is just to improve our 1D / 2D / 3D analysis in Gammapy.
- Or if you think other checks / validations should be added, e.g. checks using MC shower simulations, do them and talk to Lars if they fit in the paper.

H.E.S.S. / MAGIC
Joint Crab paper

- Idea: showcase the power of open and common data formats and open science tools in gamma-ray astronomy; reproducible analysis
- Not a science paper! Not a H.E.S.S. or MAGIC collaboration paper! Something small and technical.
- Release of 2 Crab runs in MAGIC approved, from H.E.S.S. we use the 4 Crab runs from the public test data release
- Open invite in fall 2017; other gamma-ray instruments (VERITAS, HAWC) and science tools (ctools, 3ML) didn’t want to join
- Analysis (1D spectrum) well advanced, not much written yet (but we want it to be short anyways)
- Hope to finish this up soon: Cosimo Nigro (DESY) will visit MPIK Feb 26 - Mar 1. Come join us!

H.E.S.S. / MAGIC
Joint Crab paper

- Relevance for Gammapy:
  - Our first multi-mission joint Poisson likelihood fit! Crab spectrum with Fermi-LAT, MAGIC & H.E.S.S.
  - An open, well-studied, standard reference dataset for further developments in Gammapy. E.g. 3D analysis with Fermi-LAT in joint likelihood with 1D IACT analysis
  - Some code developed to extract 1D spectra for Fermi-LAT, we'll probably add that to Gammapy.

Towards open data and reproducible analyses in VHE gamma-ray astronomy

TBD[1,*], Boisson, C.[a], Deil, C.[b], Donath, A.[b], Hassan, T.[c], Khelifi, B.[a], Jouvin, L.[e], King, J.[b], Nigro, C.[f], Saha, L.[d], Zanin, R.[b]

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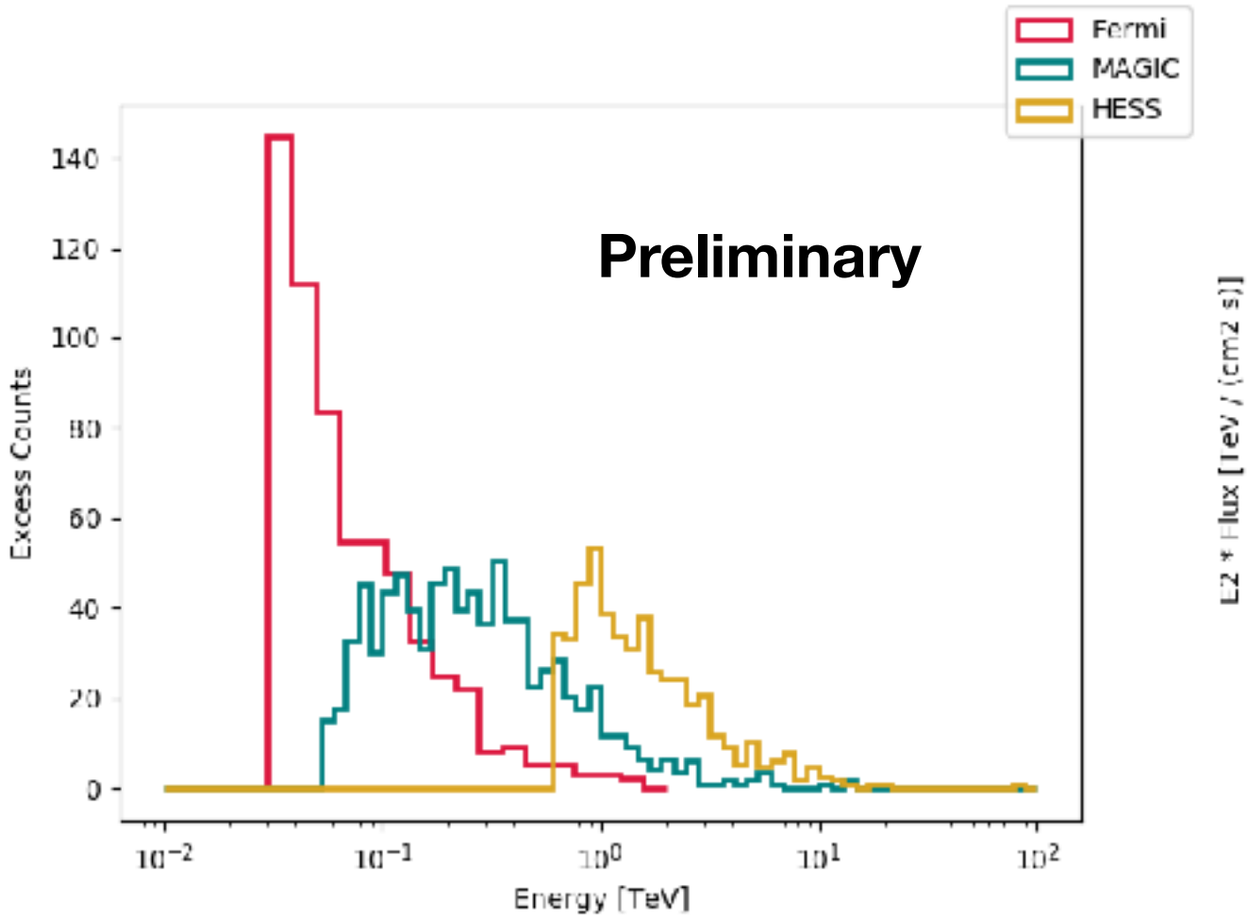
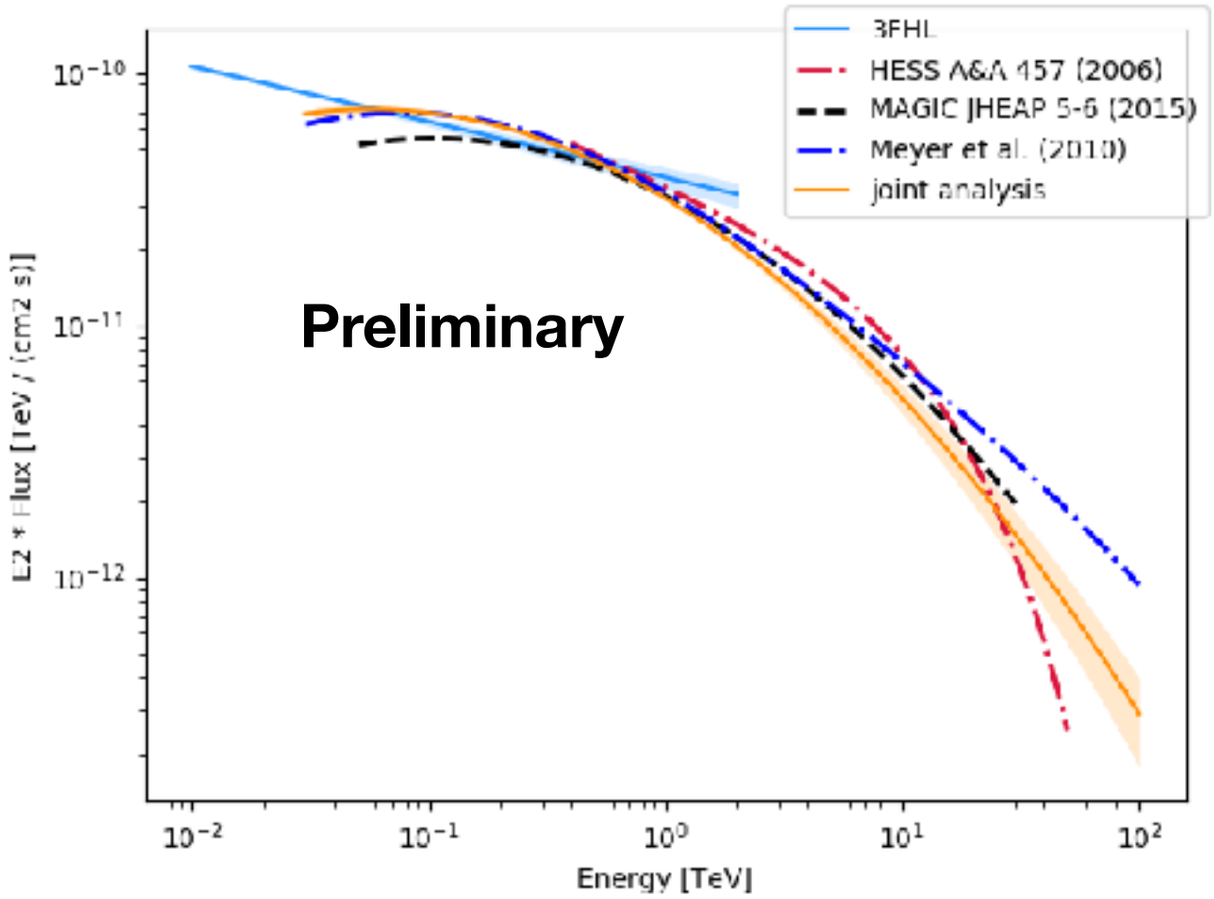
Preliminary

Preliminary

Most work so far done by Cosimo Nigro





Conclusions

- Gammapy in H.E.S.S. not terribly successful so far
- I think our re-focus on the technical projects is good
- We need even more of that in 2018, help welcome!!!
- HESS data release & joint Crab in March
- Then validation paper, then science papers