

H.E.S.S. data analysis with open-source tools

Lars Mohrmann

(for the Erlangen FITS group)

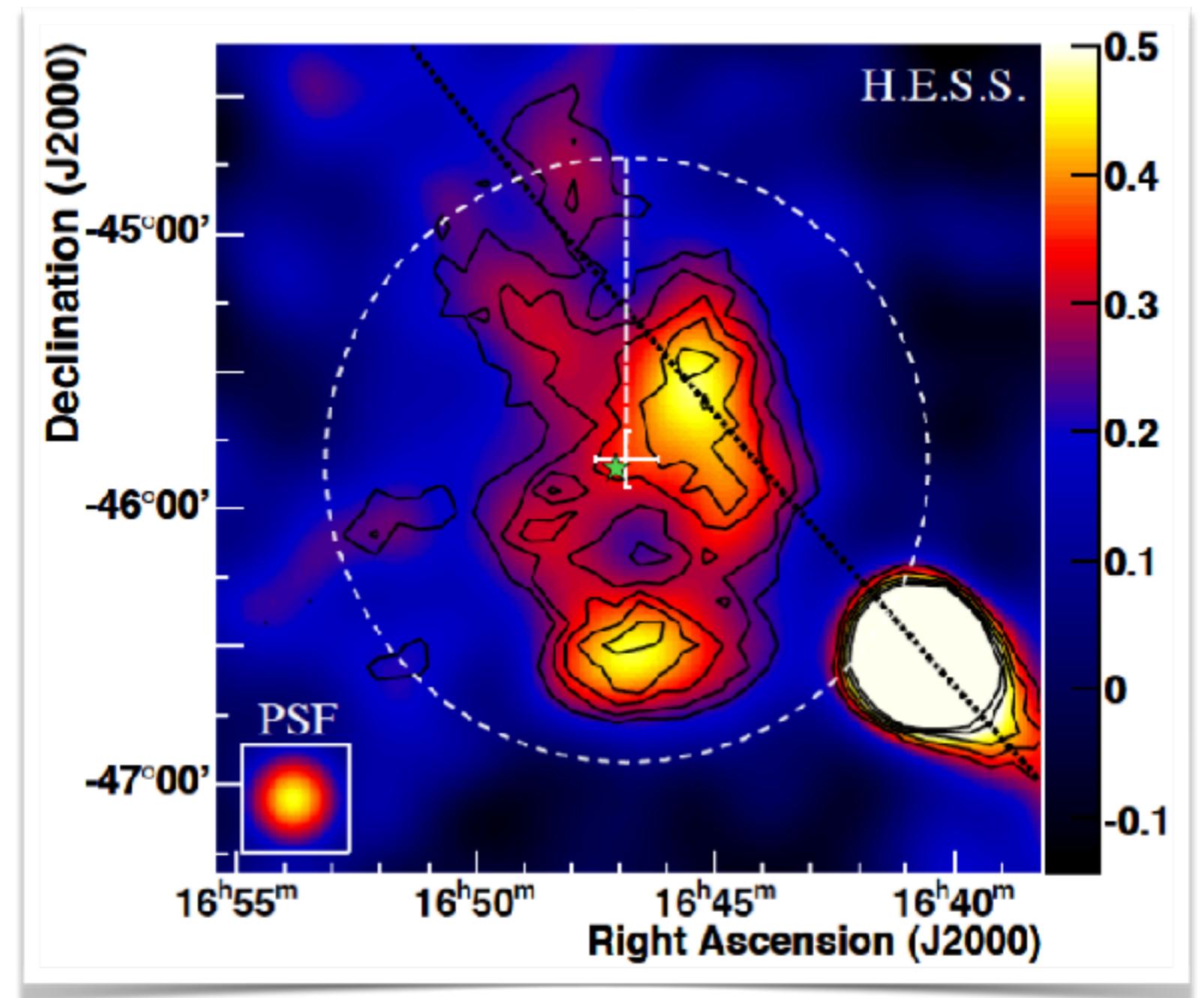
Gammapy coding sprint
Heidelberg, July 9, 2018



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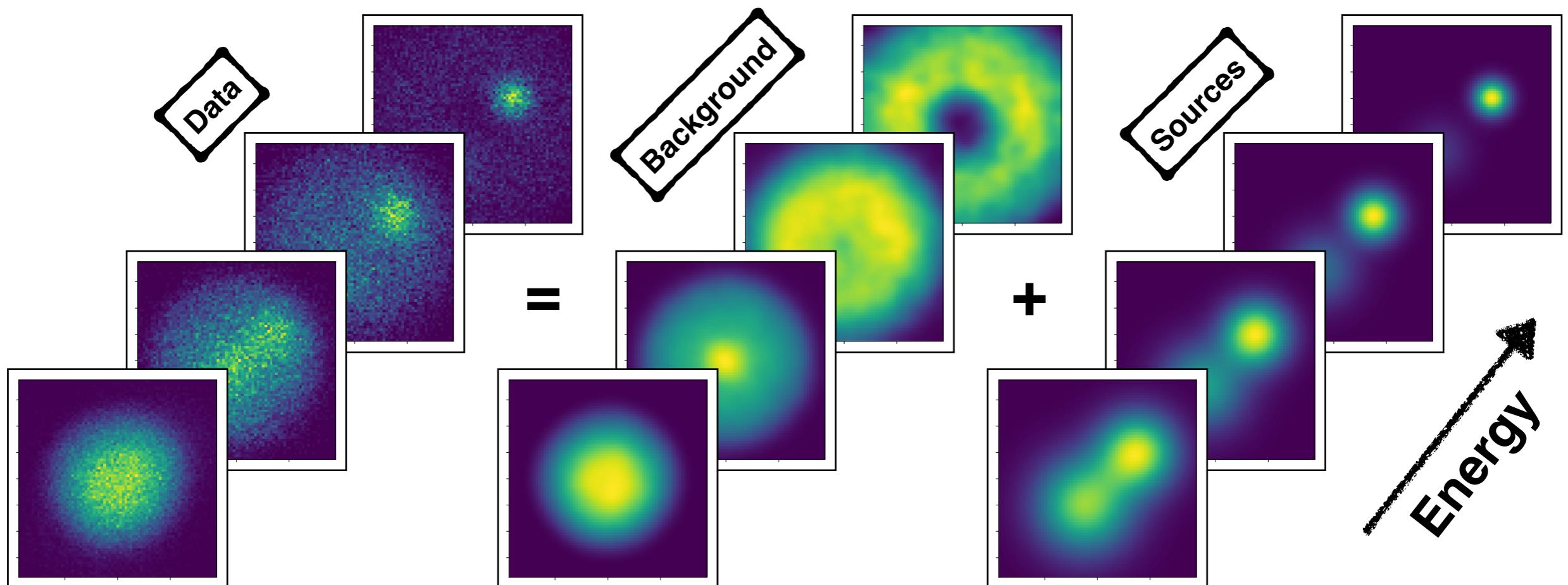
Motivation I



→ “Complex” field-of-views are difficult to analyze with standard methods

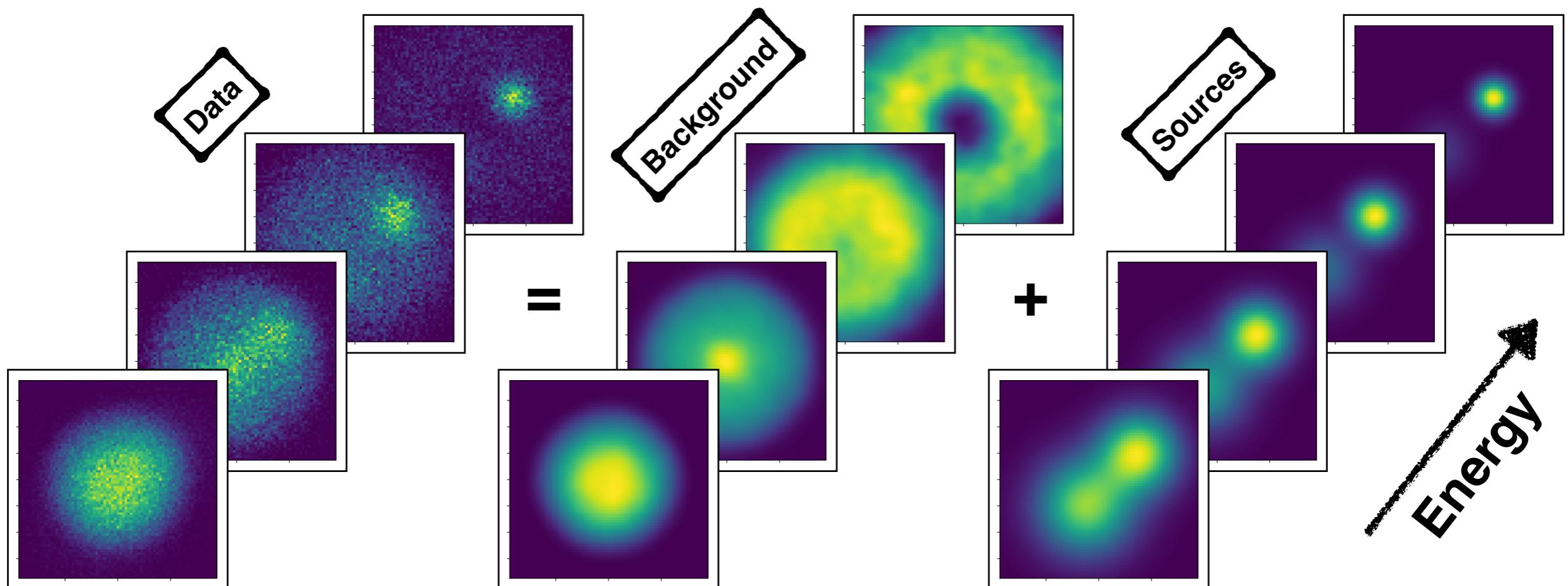
Motivation I

- One solution: perform a **template analysis in 3D**:
 - Model **spectrum & morphology** of multiple components **simultaneously**



Motivation I

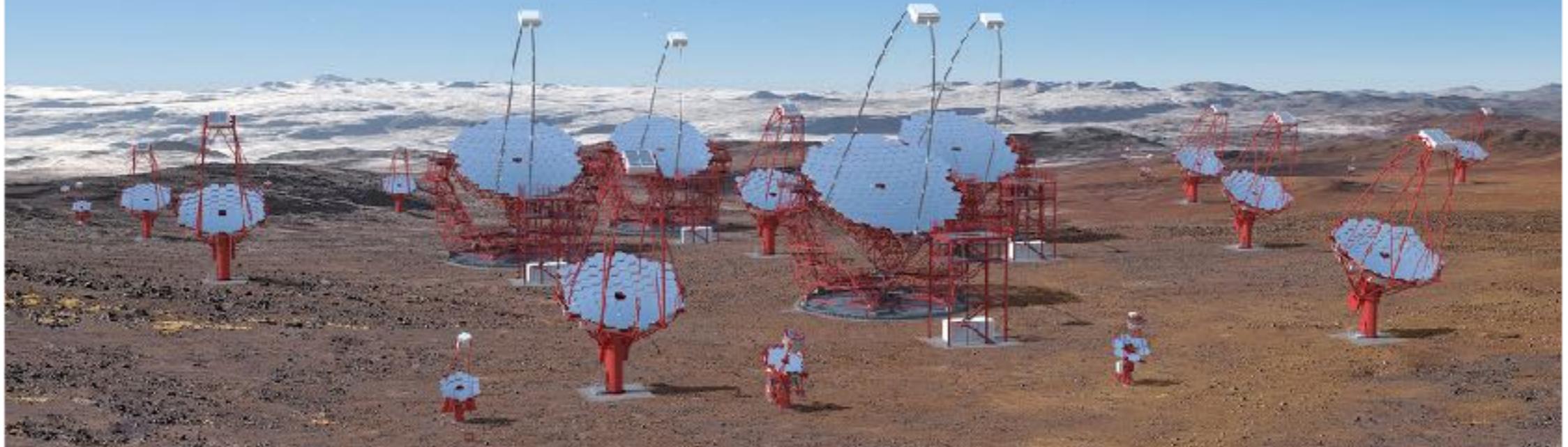
- One solution: perform a **template analysis in 3D**:
 - Model **spectrum & morphology** of multiple components **simultaneously**



- Requires **model template for hadronic background** in field of view
- Most easily carried out in the framework of **open-source analysis tools**
- Template analysis is **performed regularly e.g. in Fermi-LAT**

Motivation II

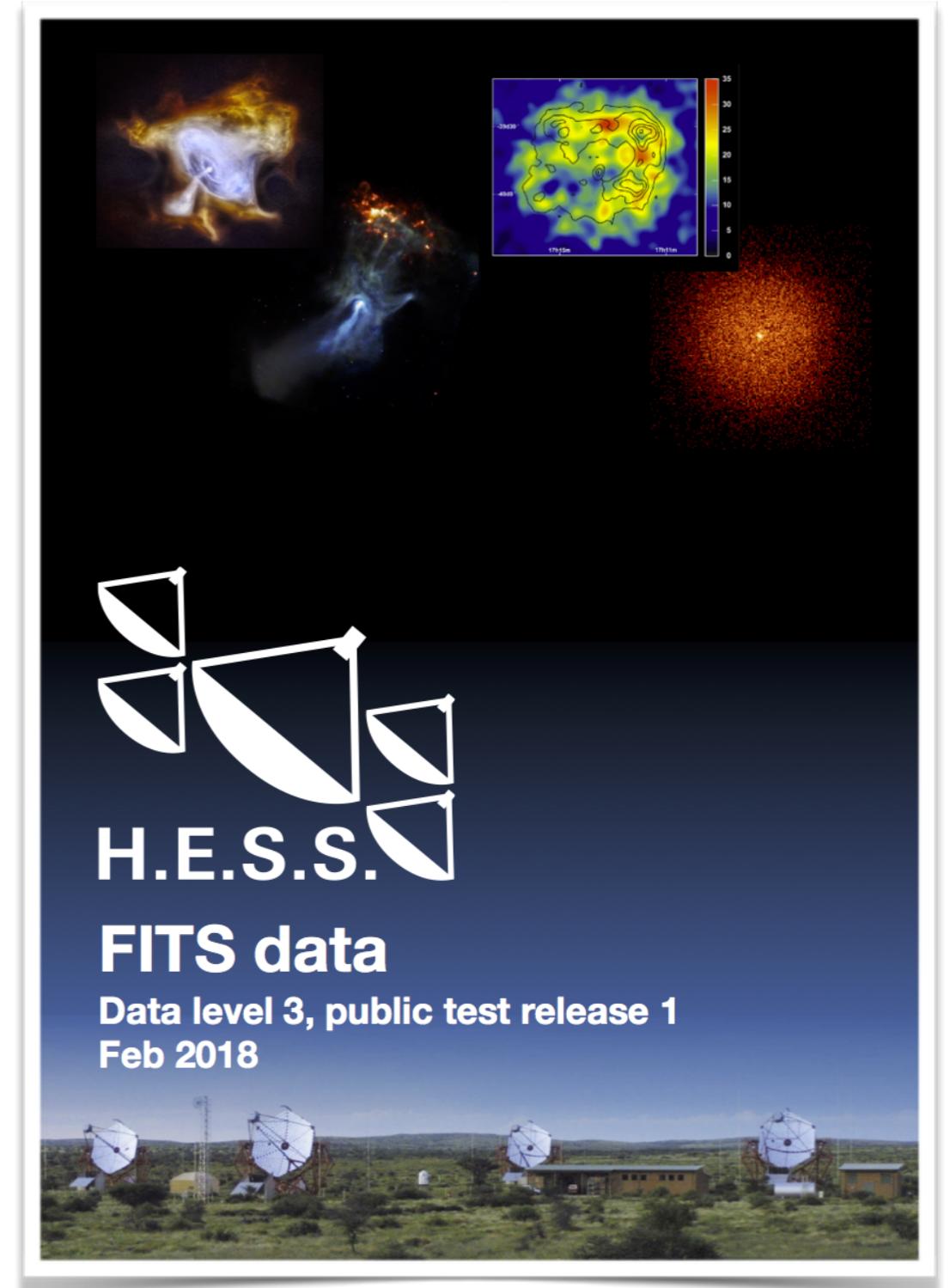
CTA



- CTA will be an observatory —> Open data, *open science tools*
- Proposed as high-level analysis tools: *Gammapy*, *ctools*
 - currently developed + tested in 1st CTA data challenge
 - should be tested on “real” data as well!

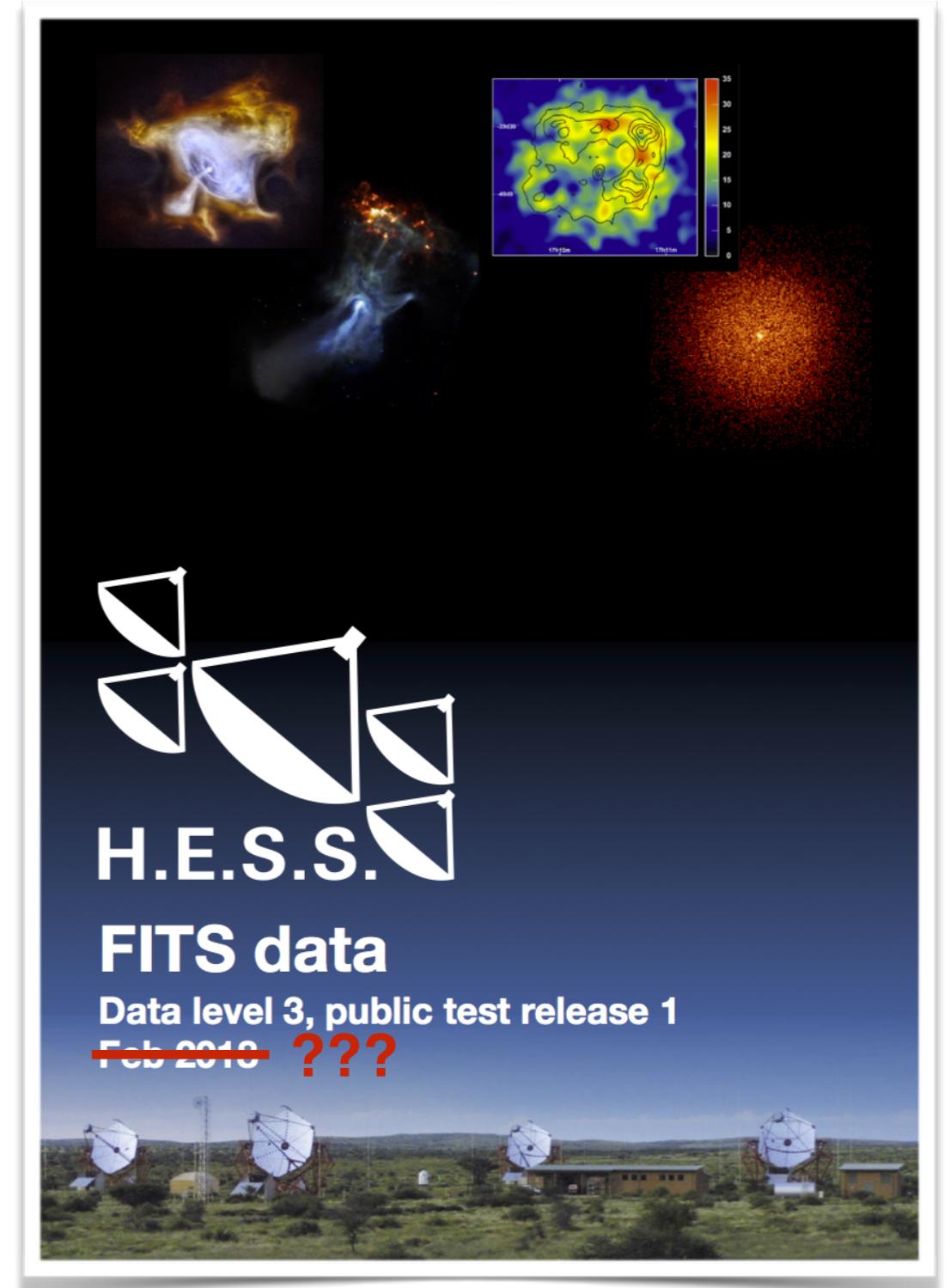
H.E.S.S. public test data release

- Idea:
 - provide “real” IACT data in open FITS format for the first time
 - support development of open-source science tools
- Data:
 - Level 3
 - event lists
 - instrument response functions
 - Well-studied sources
 - Crab nebula (1.9h)
 - PKS 2155-304 (9.8h)
 - RX J1713.7-3946 (7h)
 - MSH 15-52 (9.1h)
 - “Off” data
 - for background modeling
 - 20.7h



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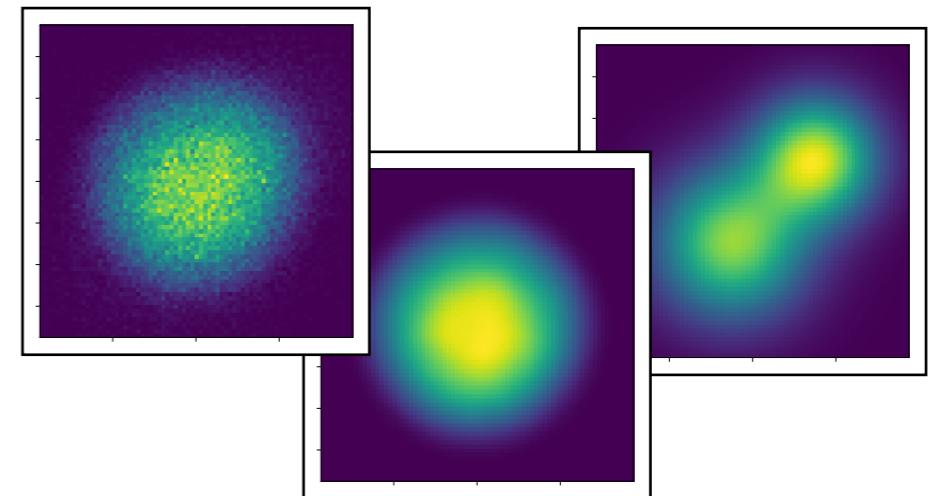
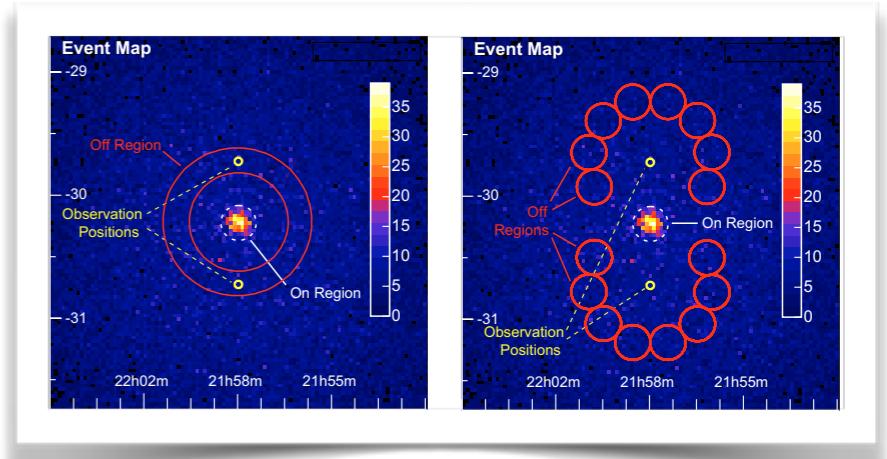


H.E.S.S. FITS paper

- Aims:
 - Establish the use of open-source analysis tools in H.E.S.S.
 - Explore template analysis based on field-of-view background model

H.E.S.S. FITS paper

- Aims:
 - Establish the use of open-source analysis tools in H.E.S.S.
 - Explore template analysis based on field-of-view background model
- Strategy:
 - Utilise public H.E.S.S. FITS test data set
 - Perform “classic” IACT high-level analyses
 - ring & reflected background
 - compare results to standard tools
 - validates the open-source tools
 - Perform template analysis
 - construct background model from archival H.E.S.S. data
 - characterize background model
 - compare results between ctools & Gammapy and to standard tools

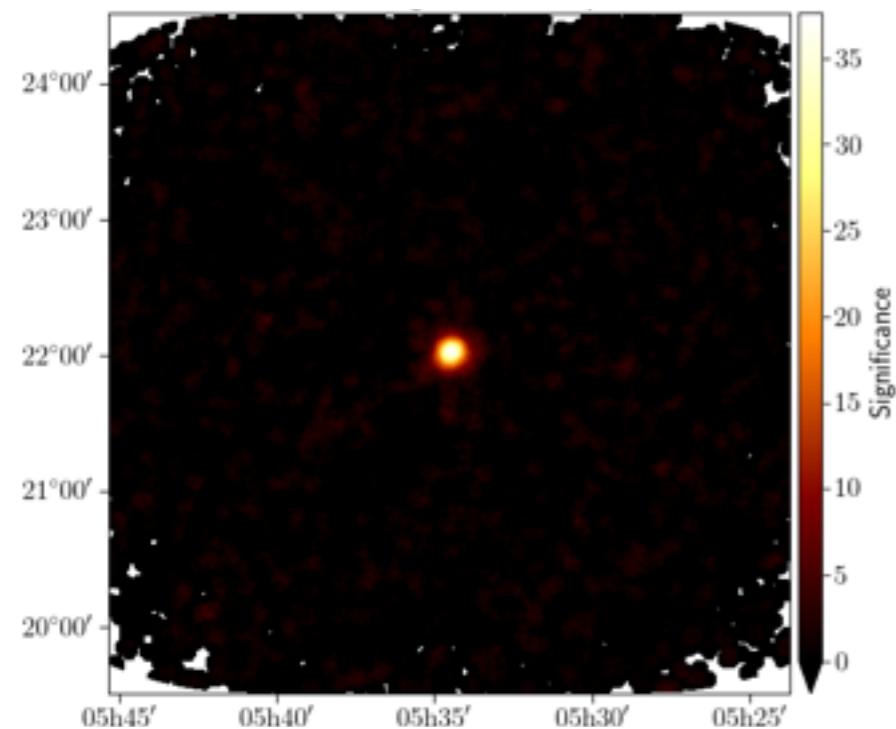


Crab

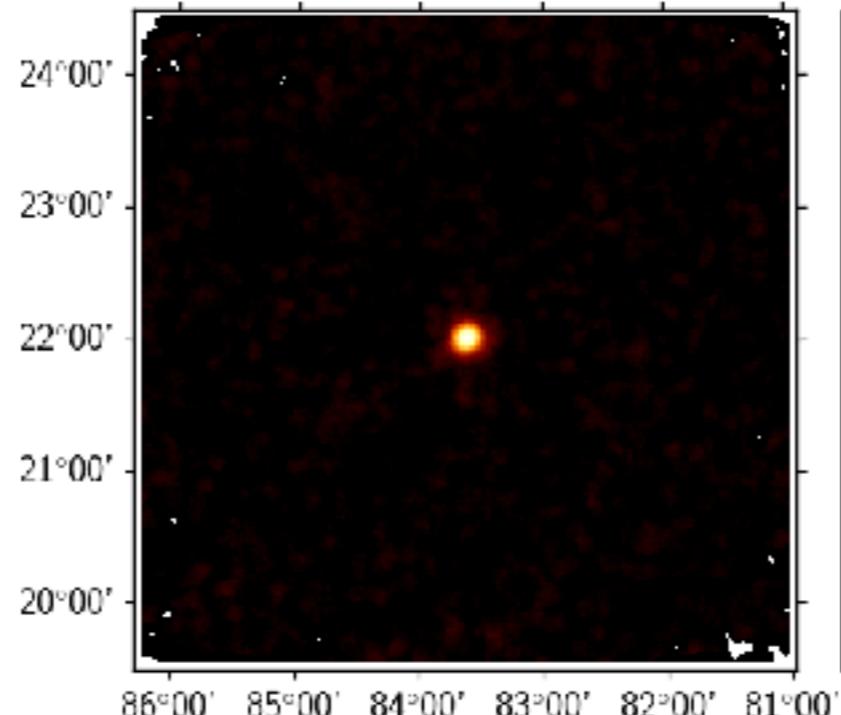
Sky Maps

(ring background)

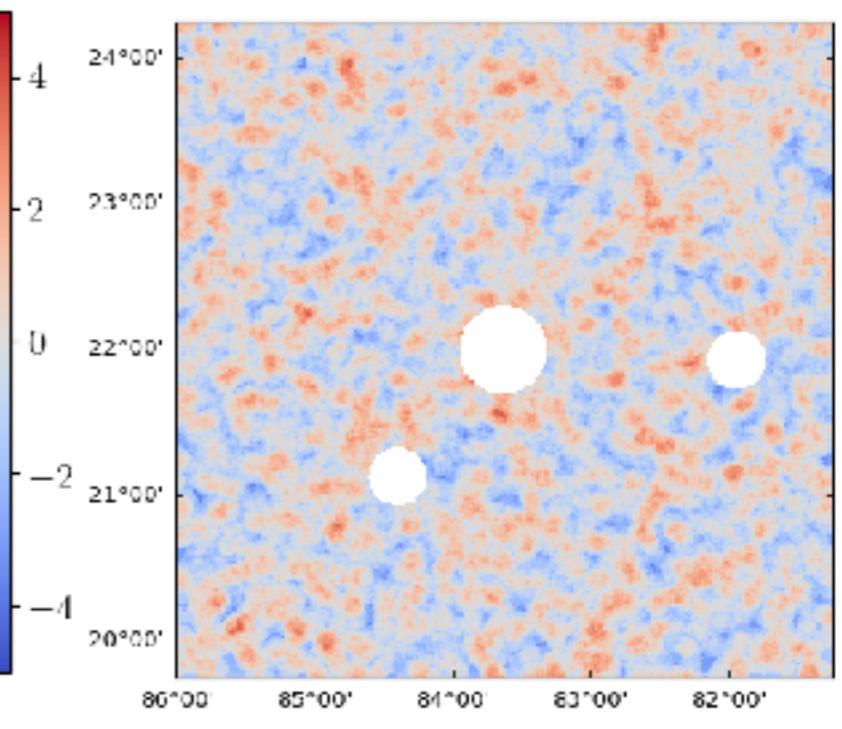
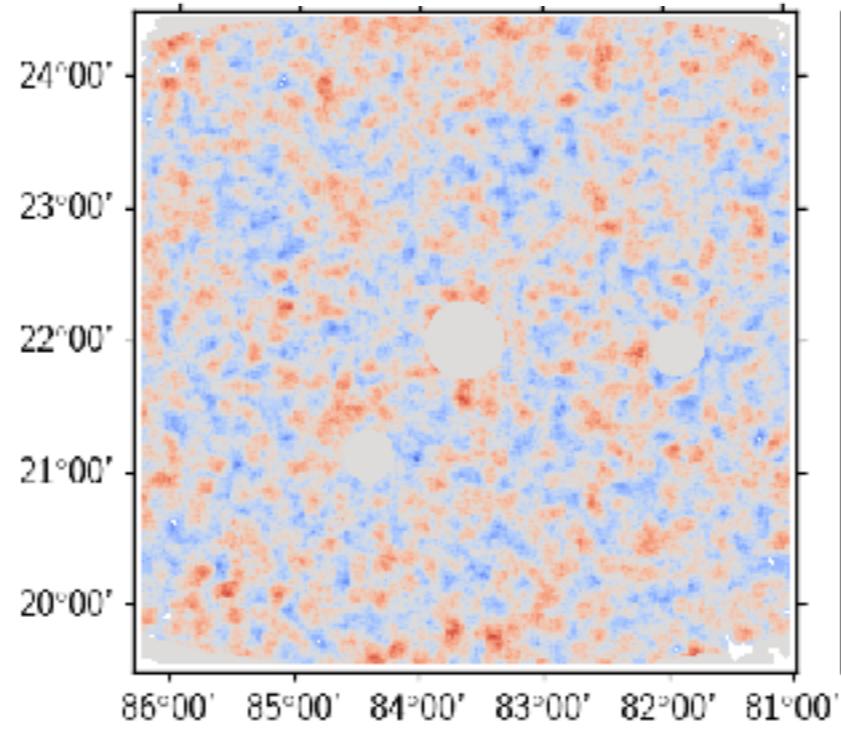
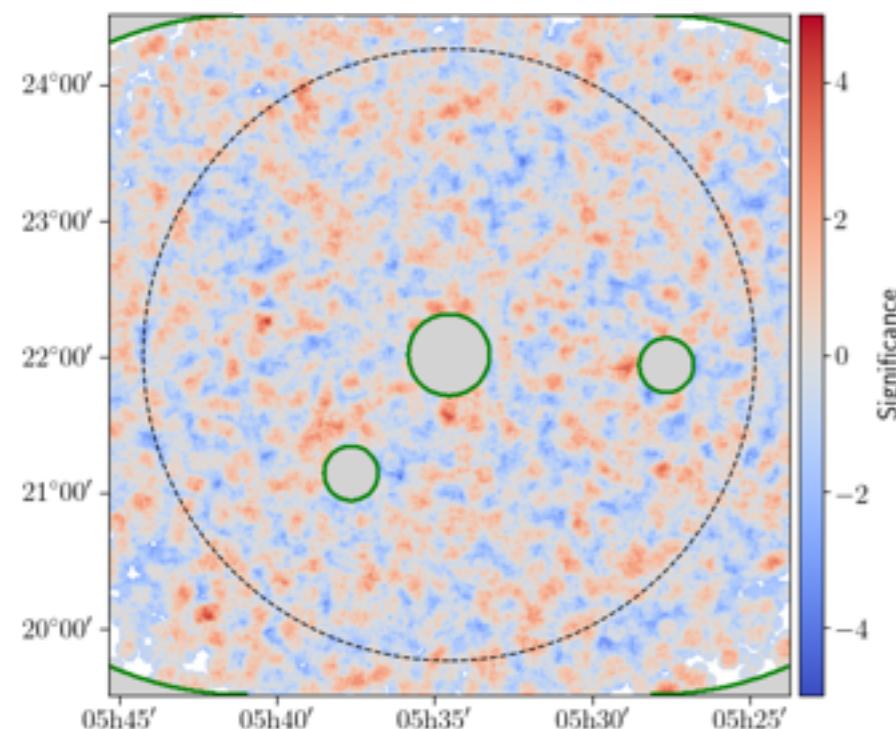
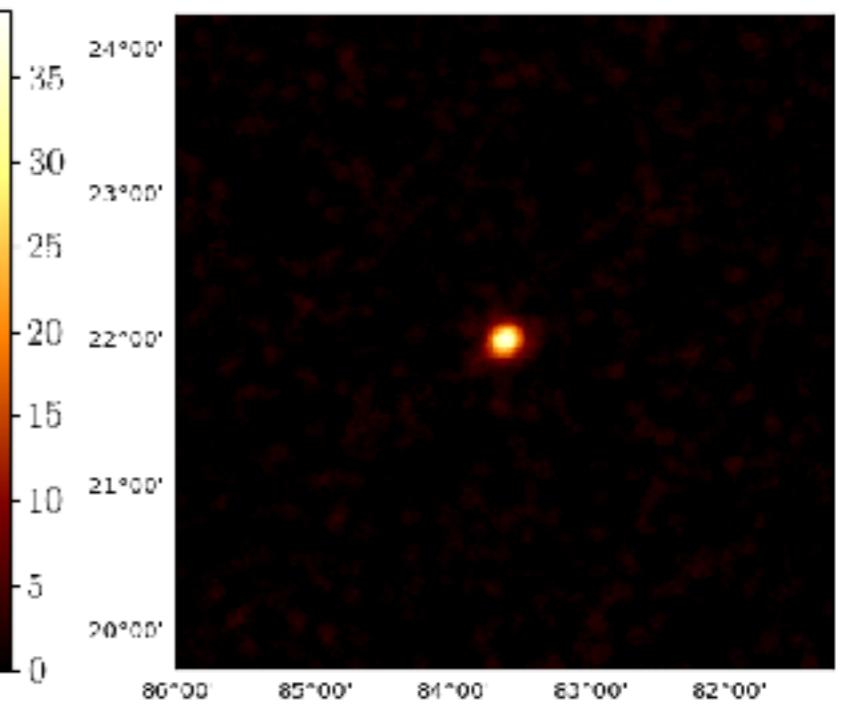
HAP



Gammapy



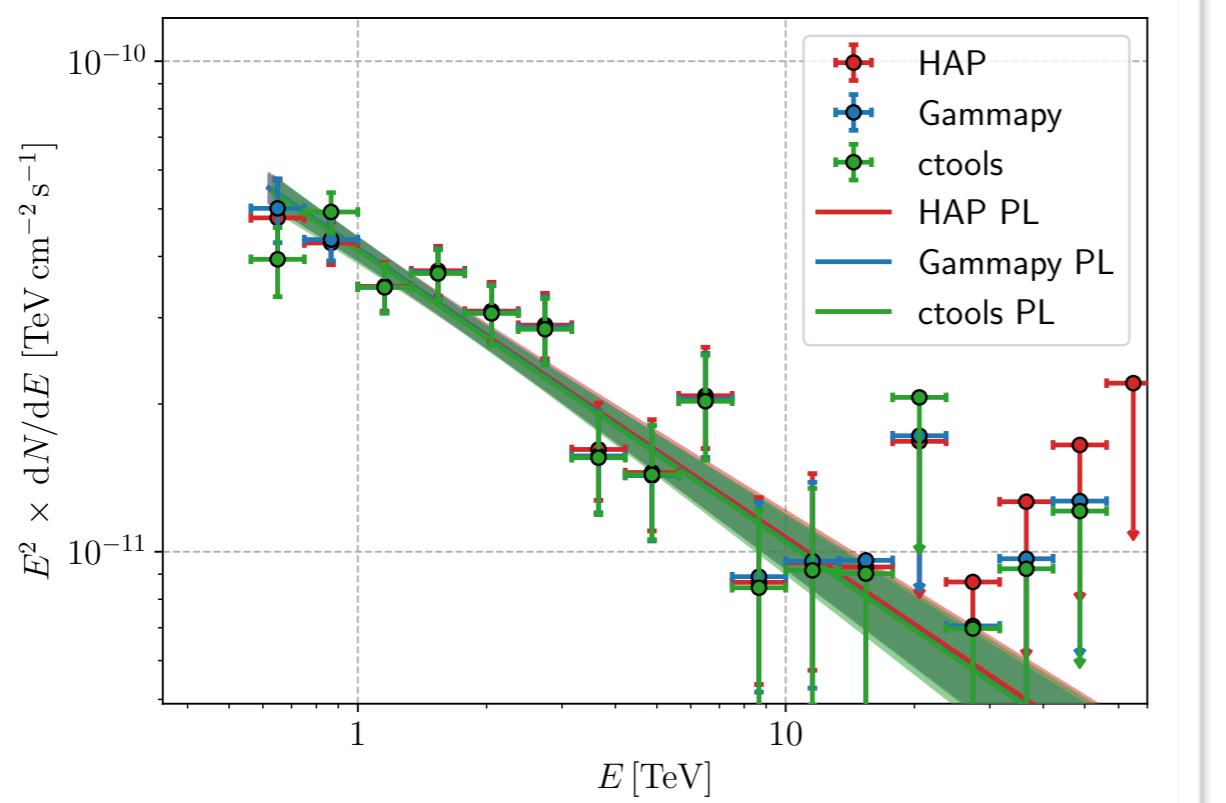
ctools



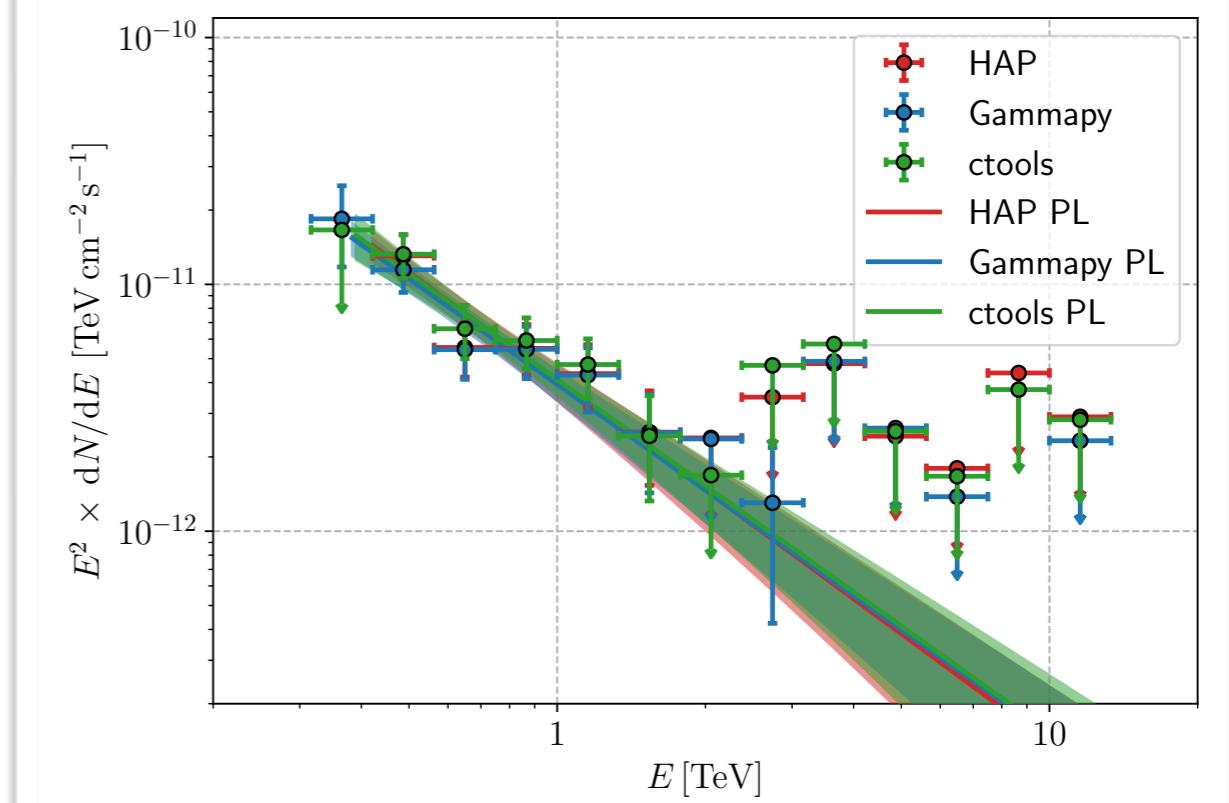
Spectra

(reflected background)

Crab



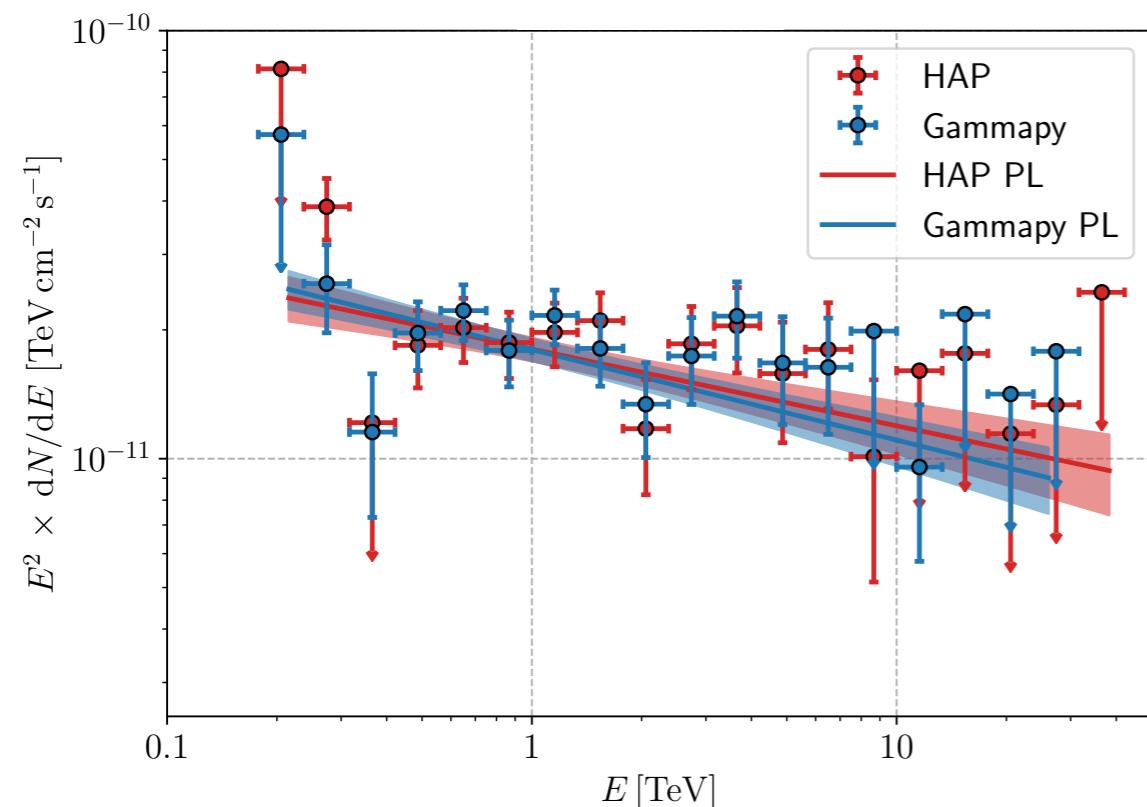
PKS 2155-304



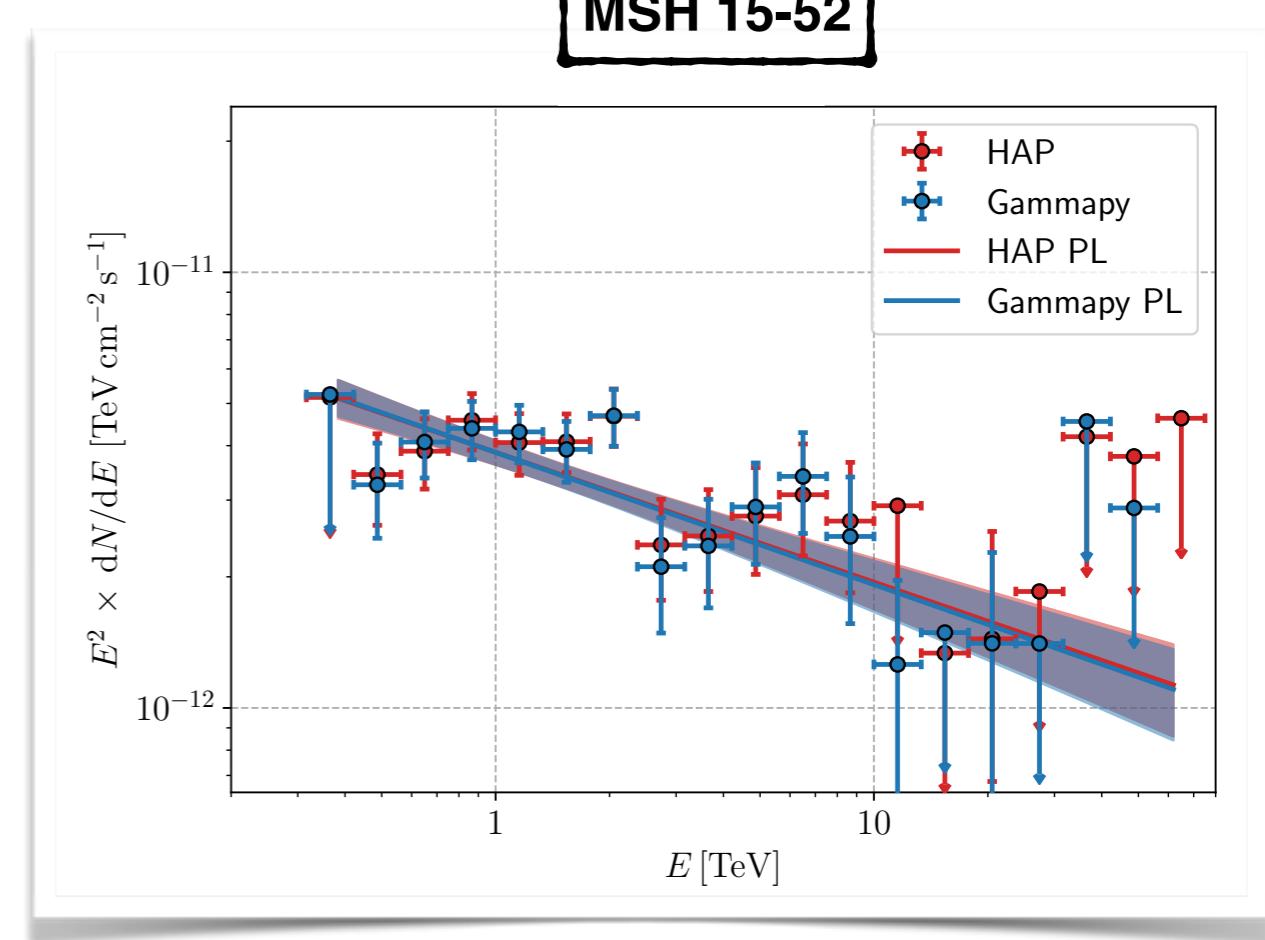
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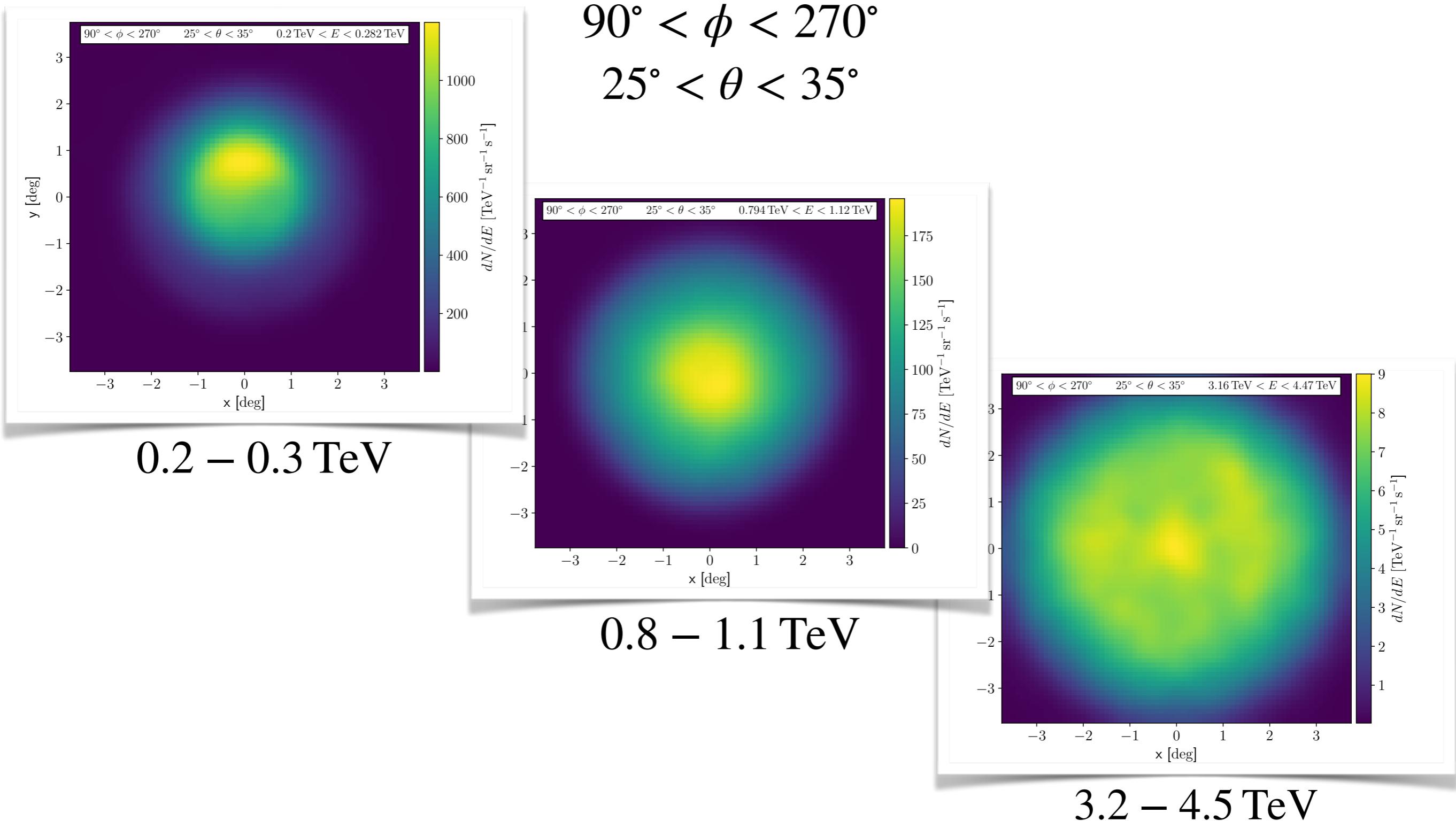
RX J1713.7-3946



MSH 15-52

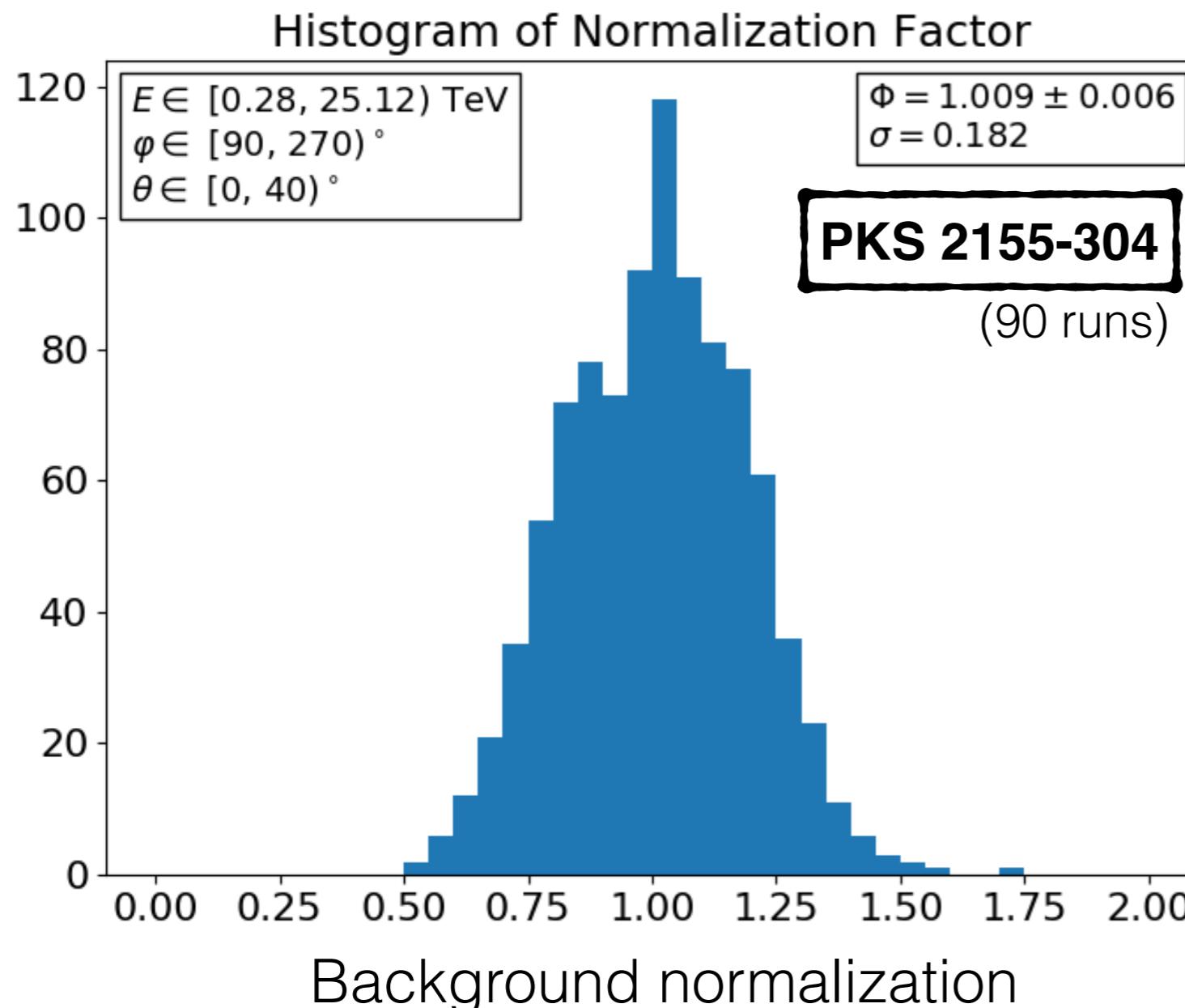


Background Model



Background Model

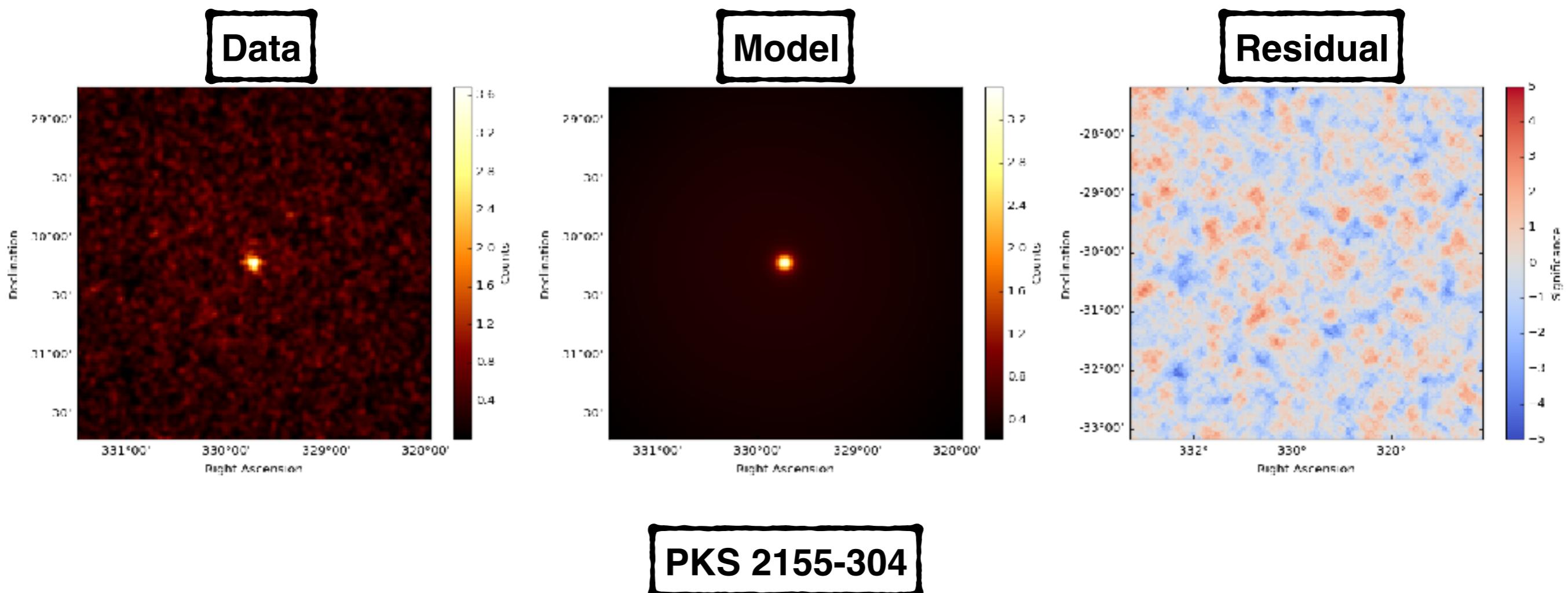
- Fit normalization of model to a set of observation runs:



- Good agreement on average
- Fairly large spread
 - zenith angle binning too coarse?
 - telescope optical efficiency?
 - atmospheric conditions?

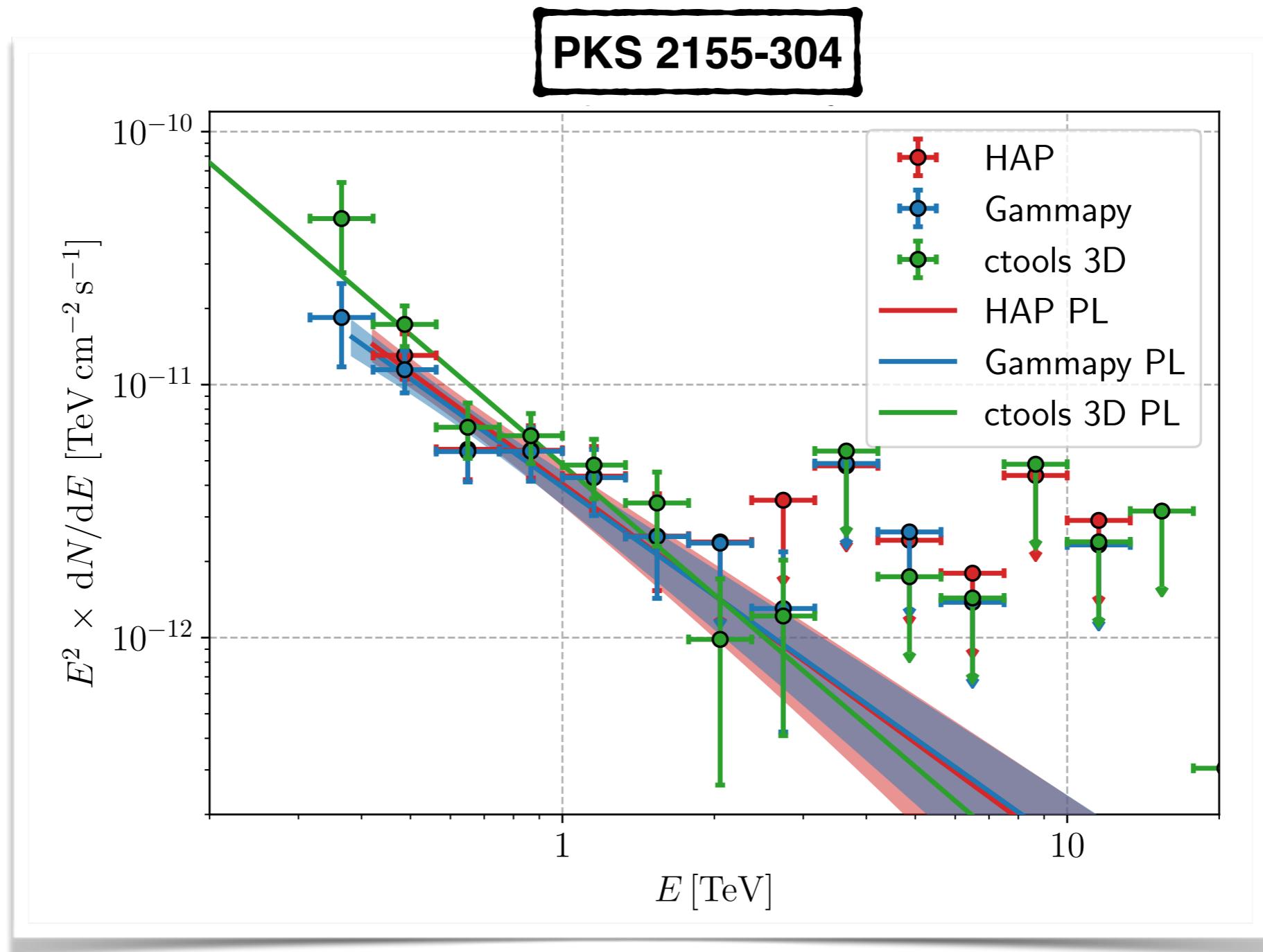
Template Analysis

- Performed first analyses with *ctools*:



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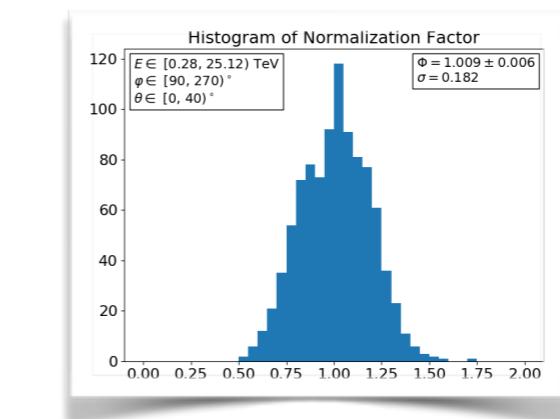
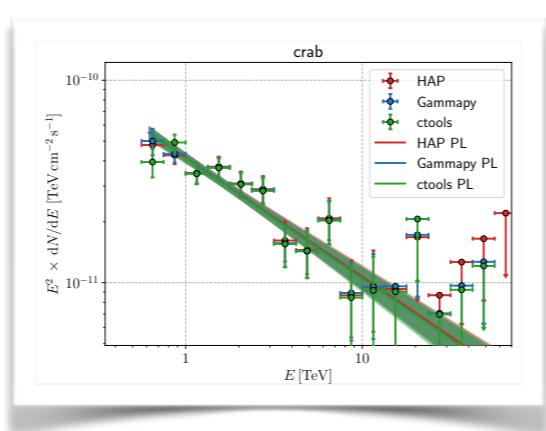
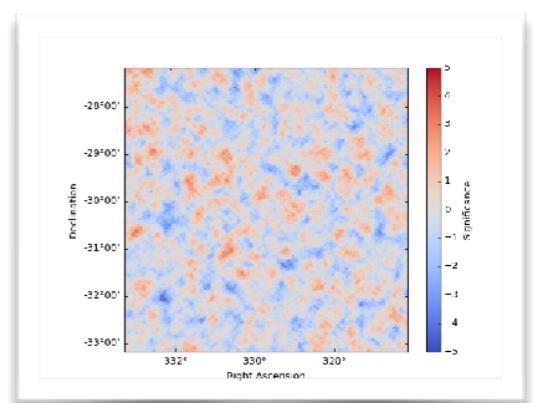
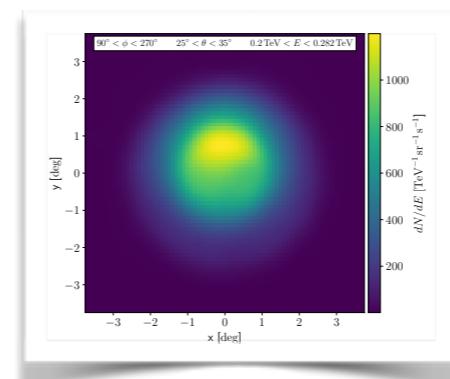
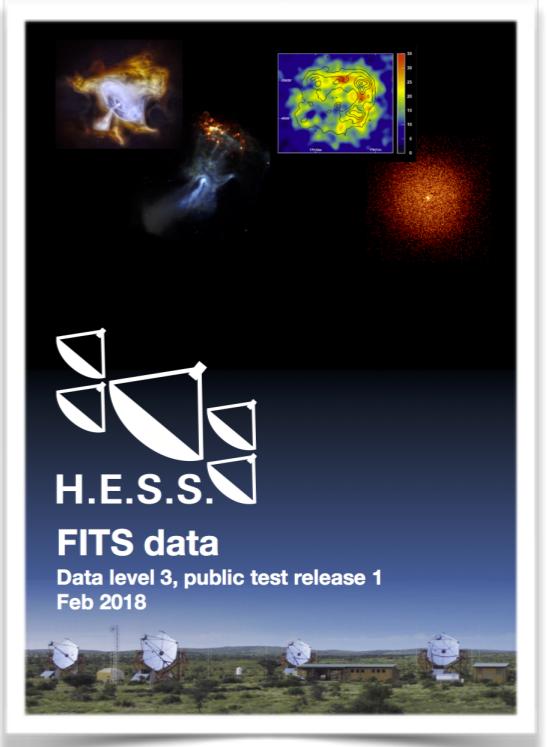


Summary

- H.E.S.S. data analysis with open-source science tools

—> Public test data release

—> Open-source analysis demonstration paper



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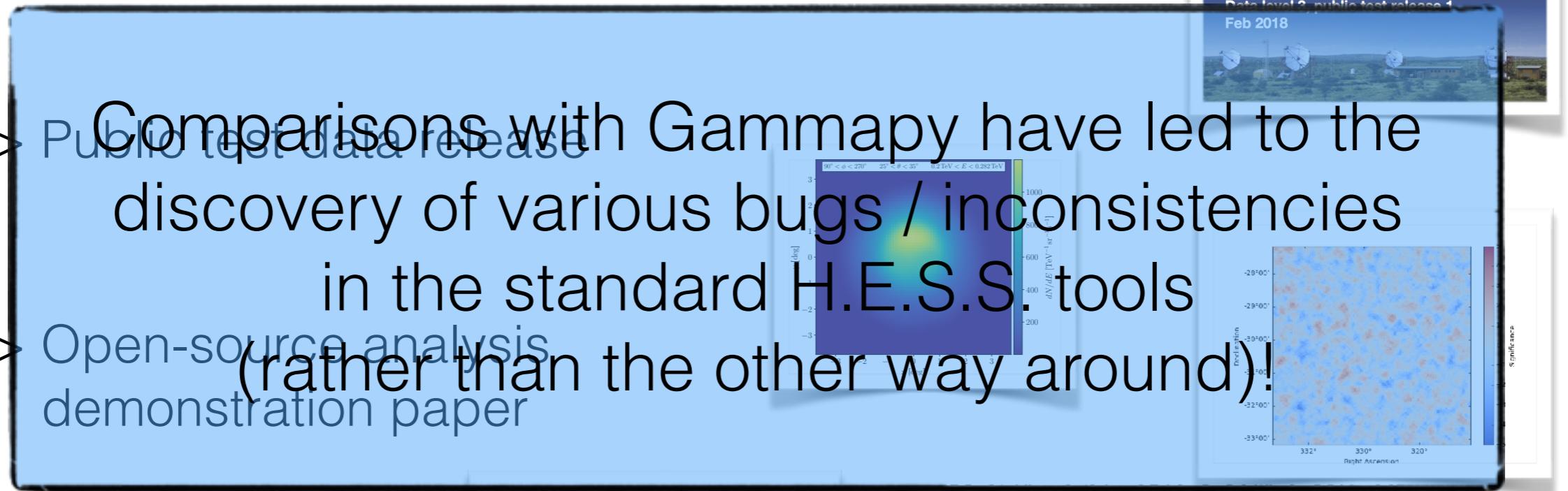


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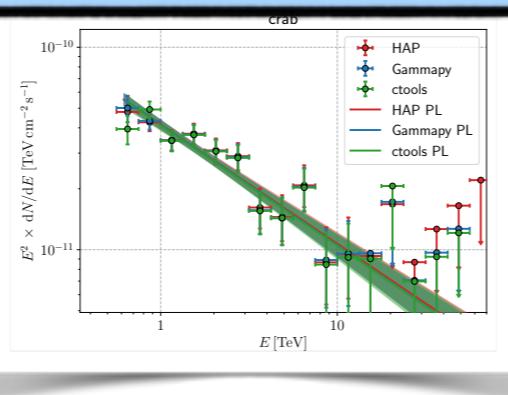
- H.E.S.S. data analysis with open-source science tools

→ Comparisons with Gammapy have led to the discovery of various bugs / inconsistencies in the standard H.E.S.S. tools

→ Open-source analysis (rather than the other way around)!



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