Fermi Summer School 2019:
Testing IACT background model

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Lewes-DE, June 4th 2019

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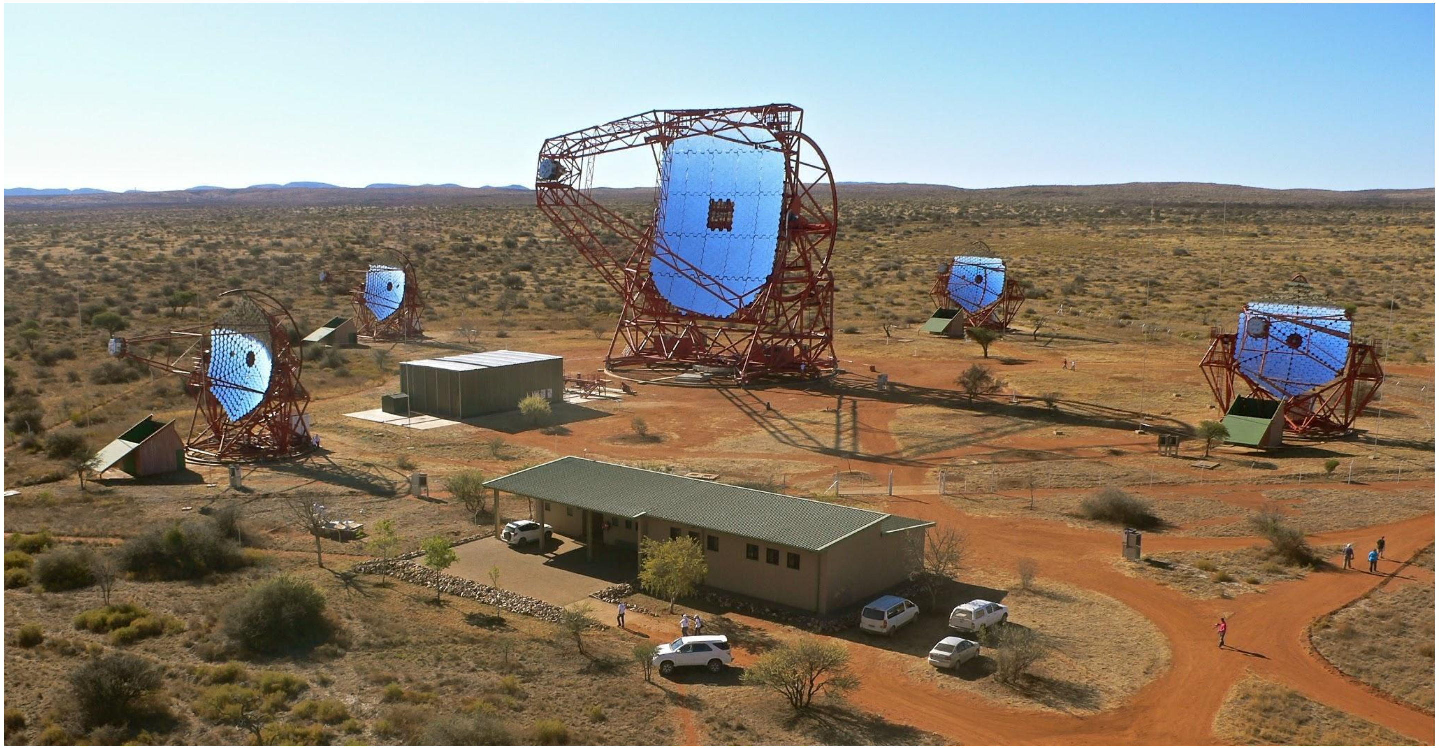
ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS
FAU FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

Introduction

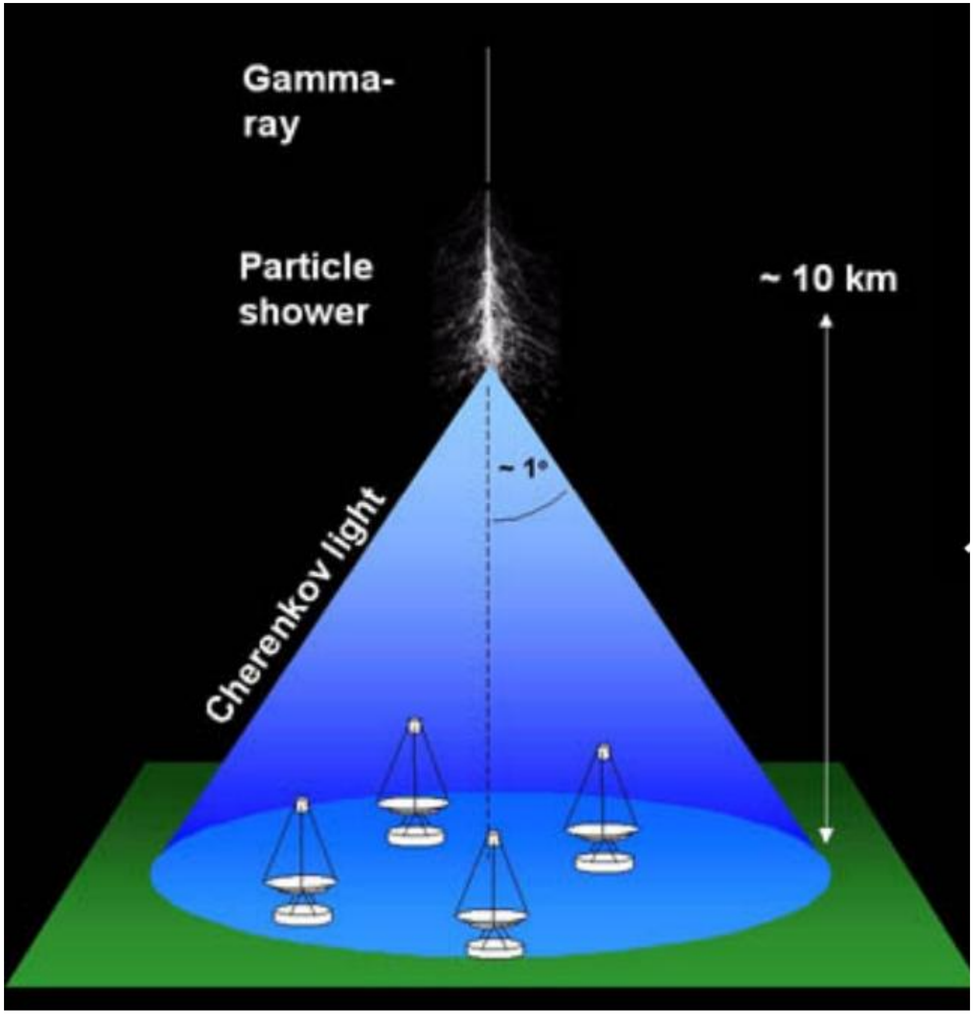
The IACT experiment: HESS



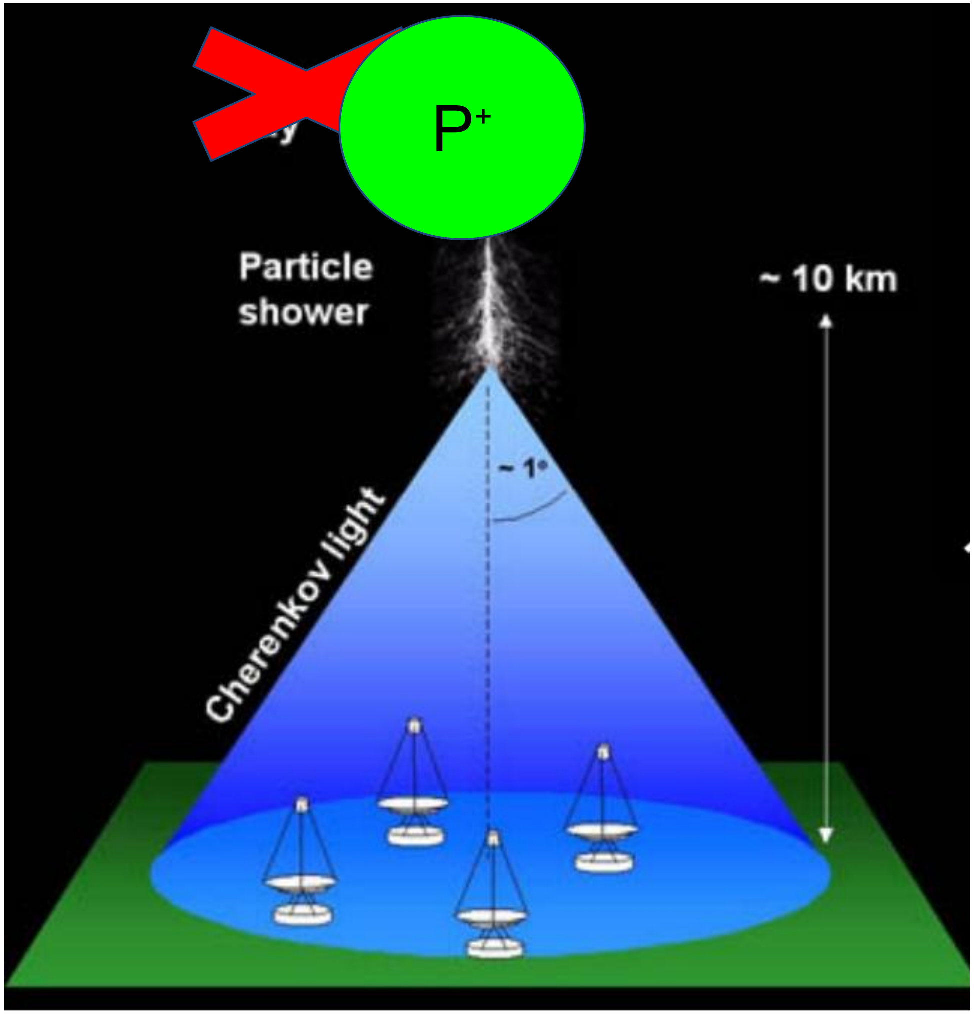
The IACT experiment: HESS

Southern hemisphere!
Galactic center is visible!

Air shower method for detecting gamma-rays



High CR background



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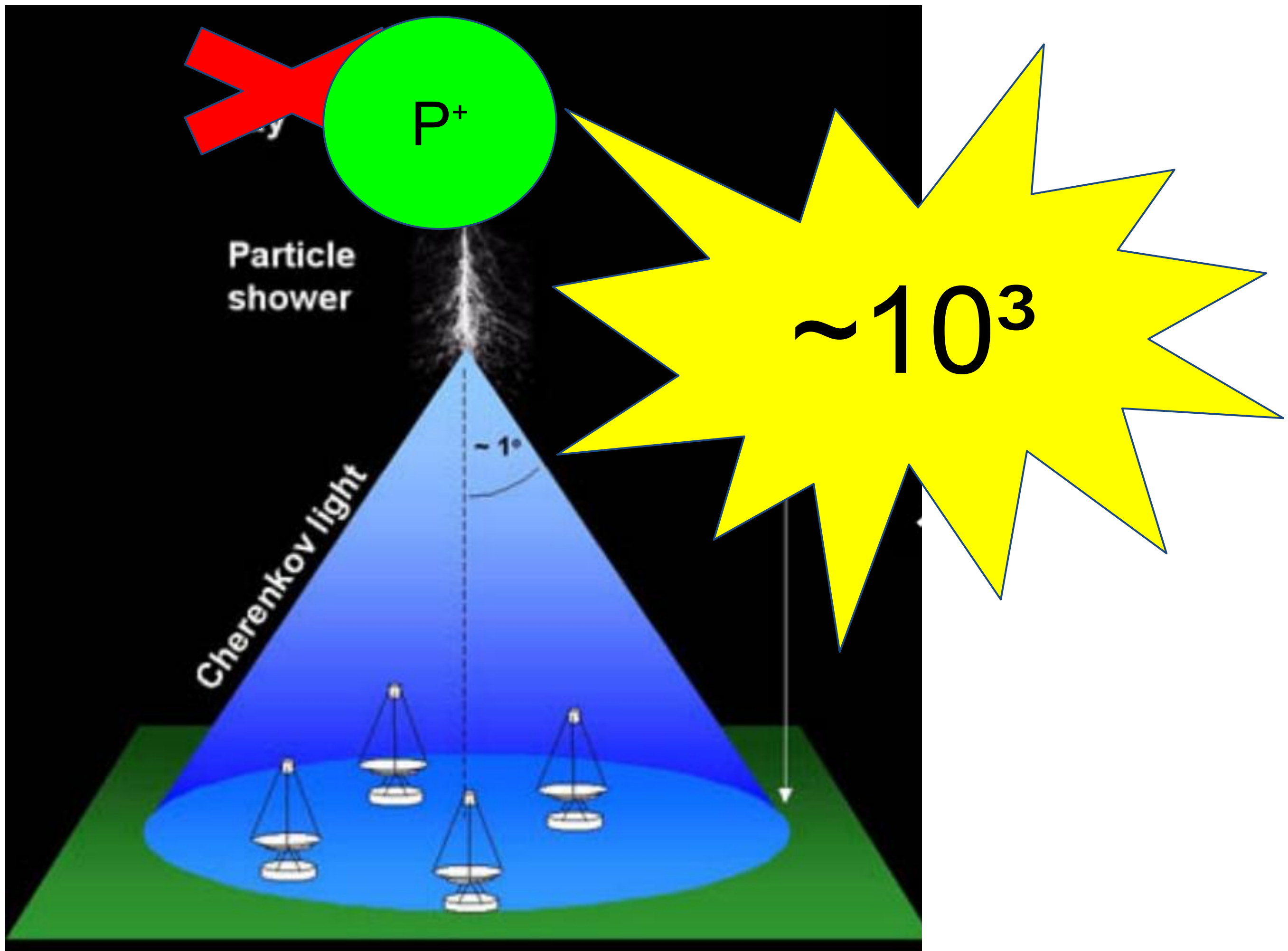
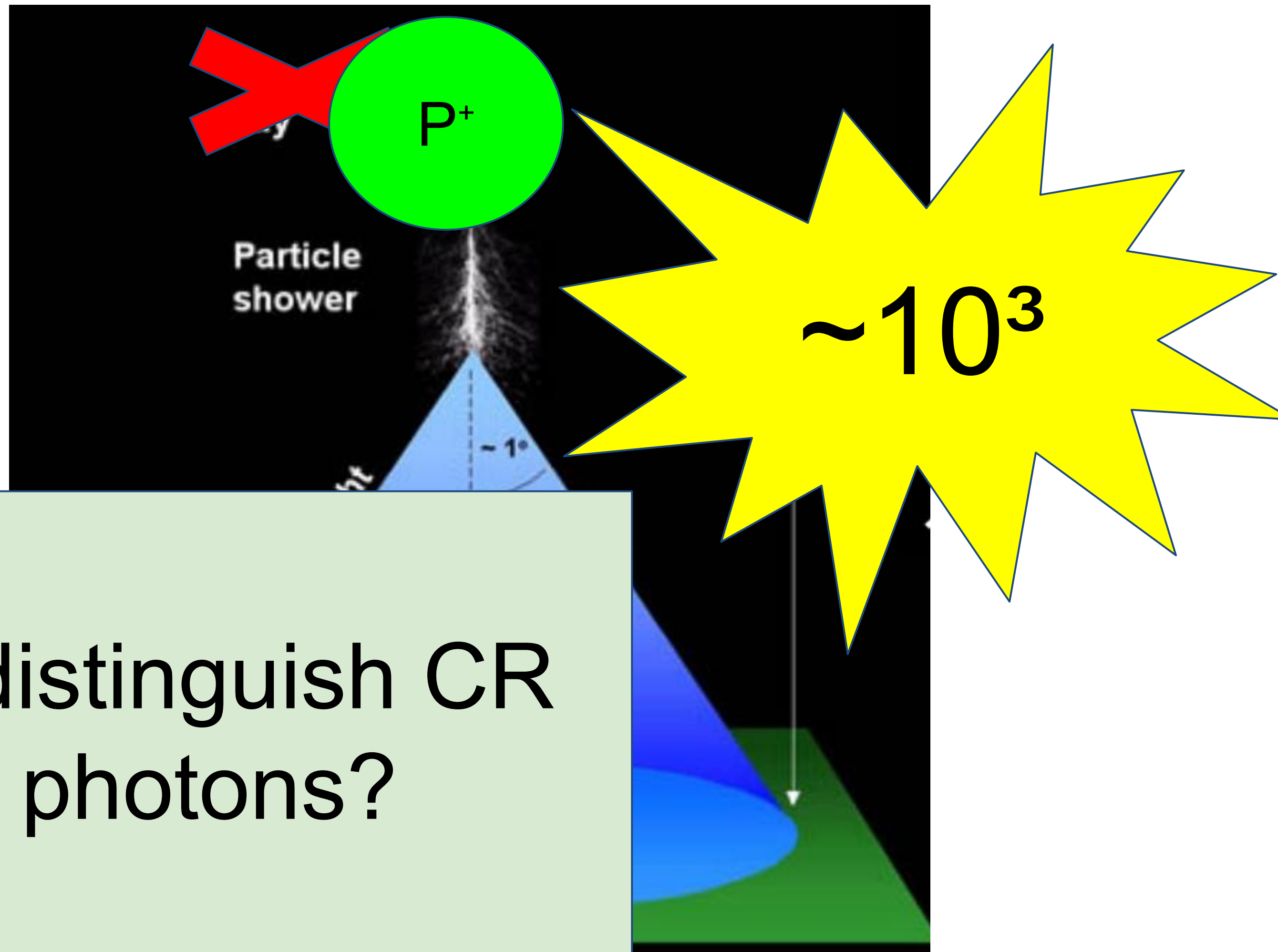
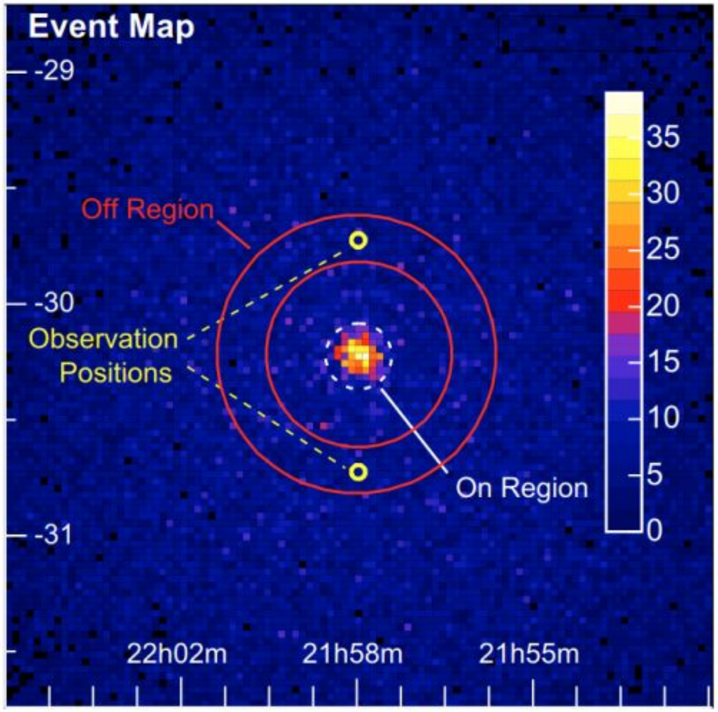


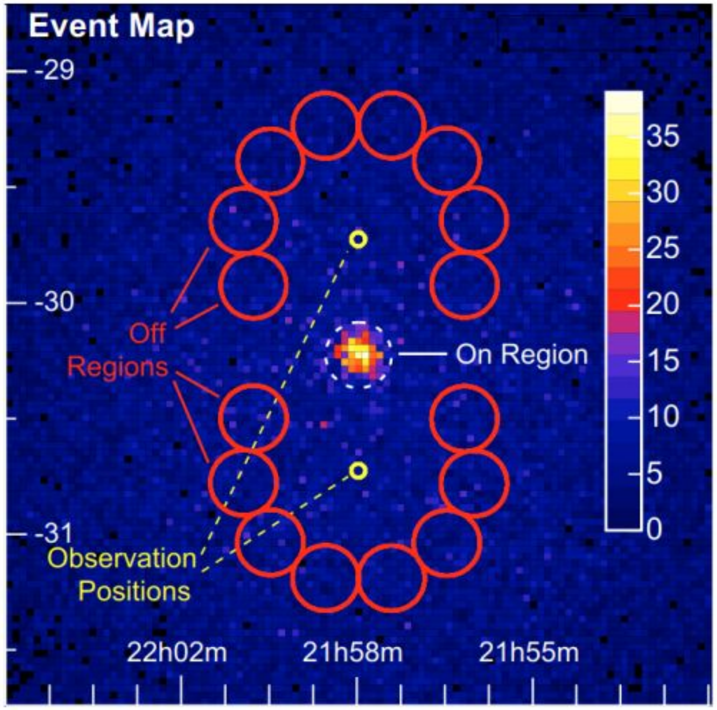
High CR background



How to distinguish CR from photons?

Common analysis for IACT



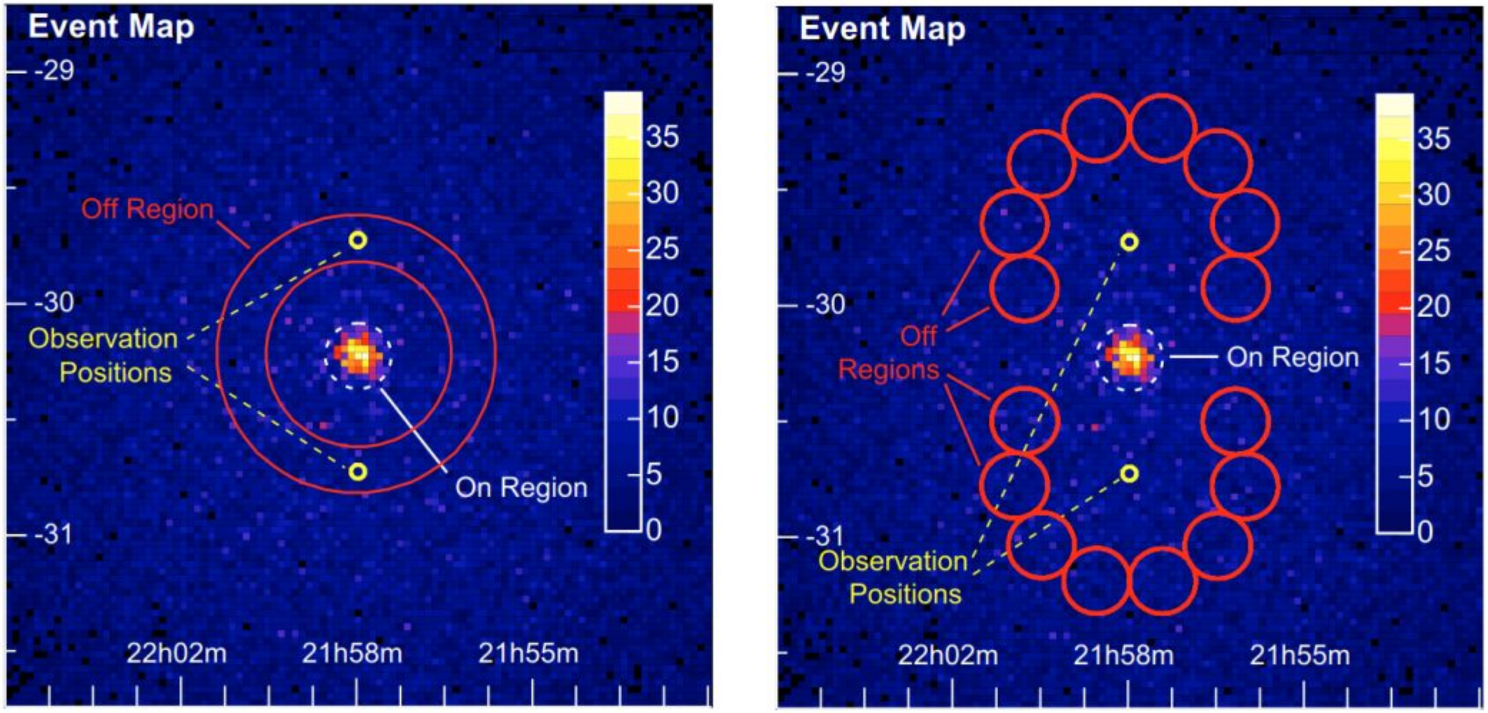


Ring mode

Reflected mode

Berge et al. 2007

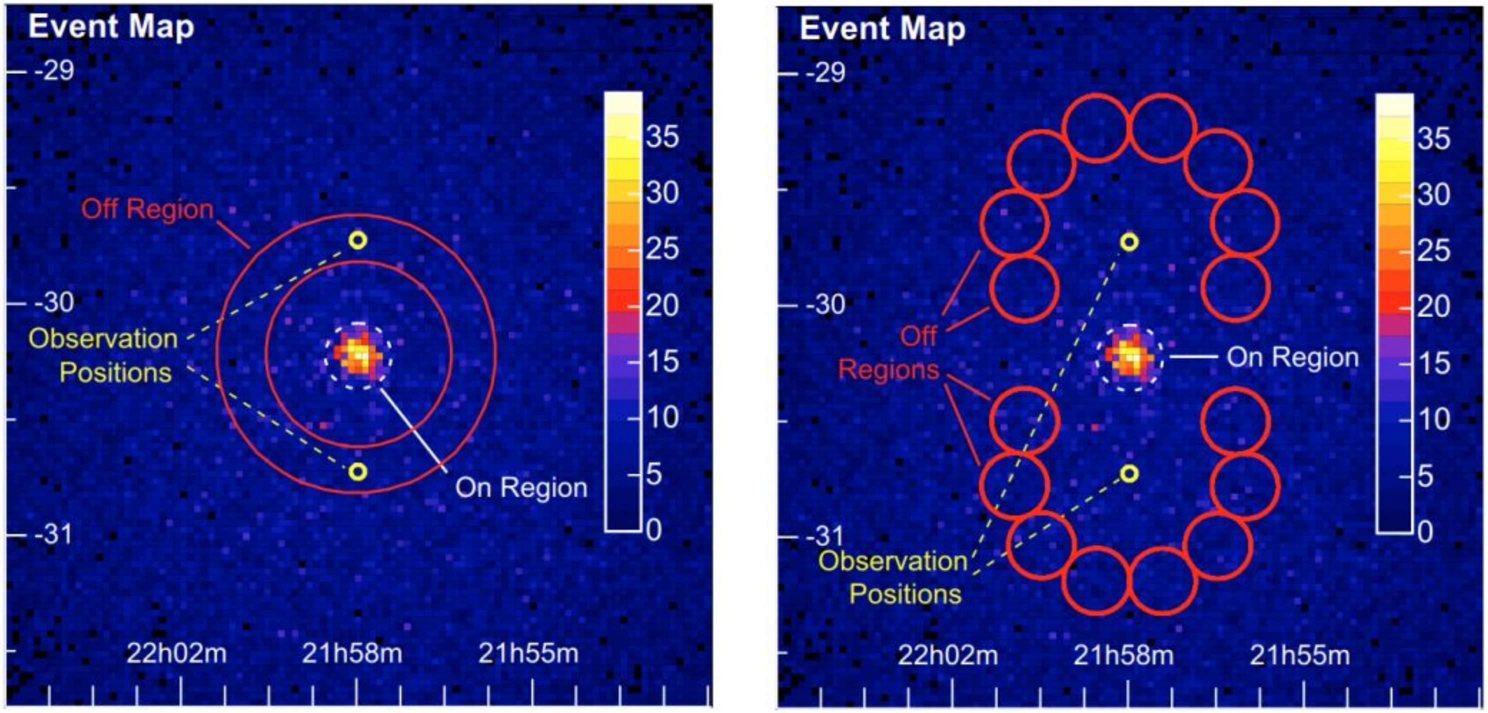
Common analysis for IACT



Signal = counts (on region - off region)

Berge et al. 2007

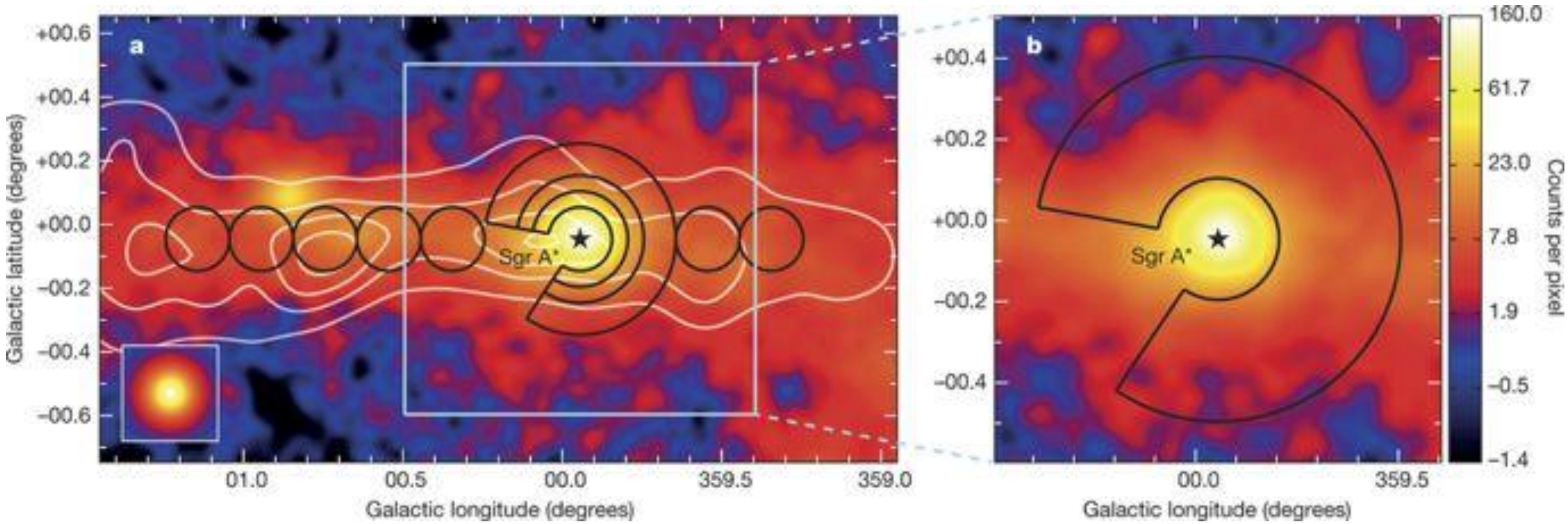
Common analysis for IACT



What about extended sources?

Berge et al. 2007

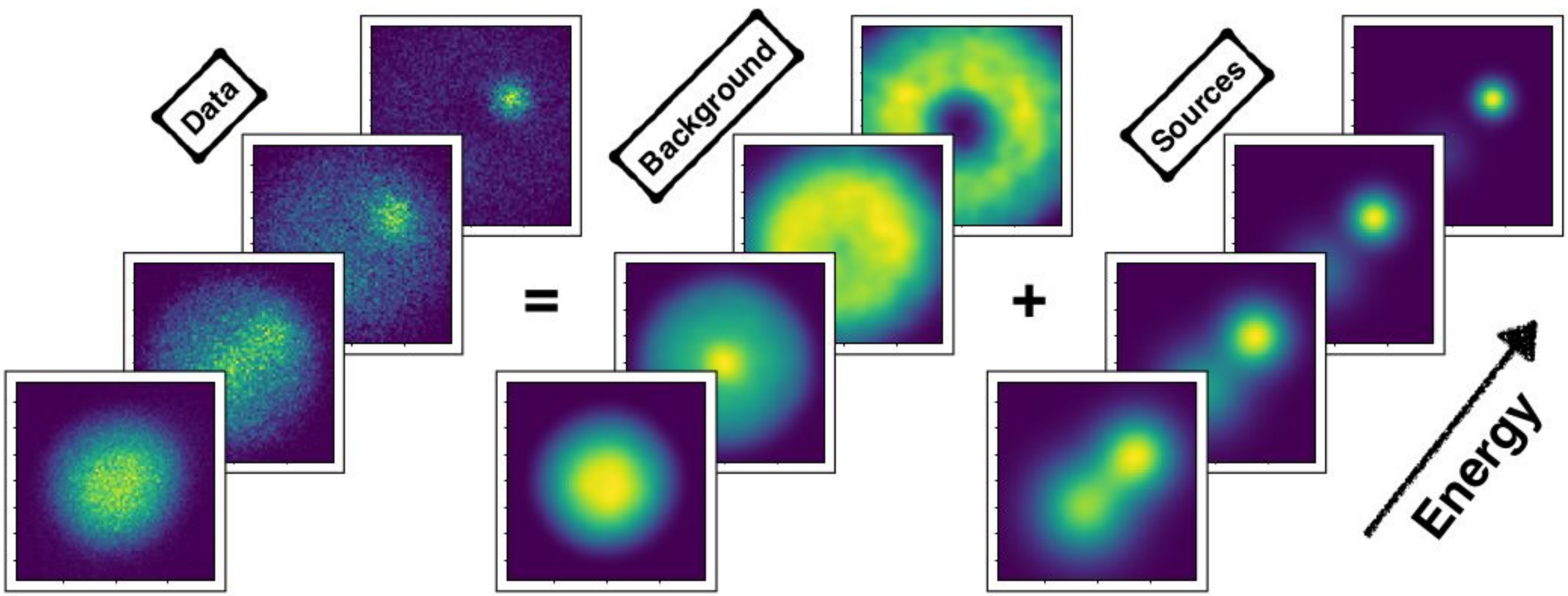
Requires different analysis methods



H.E.S.S. Collaboration. 2016

3D method analysis

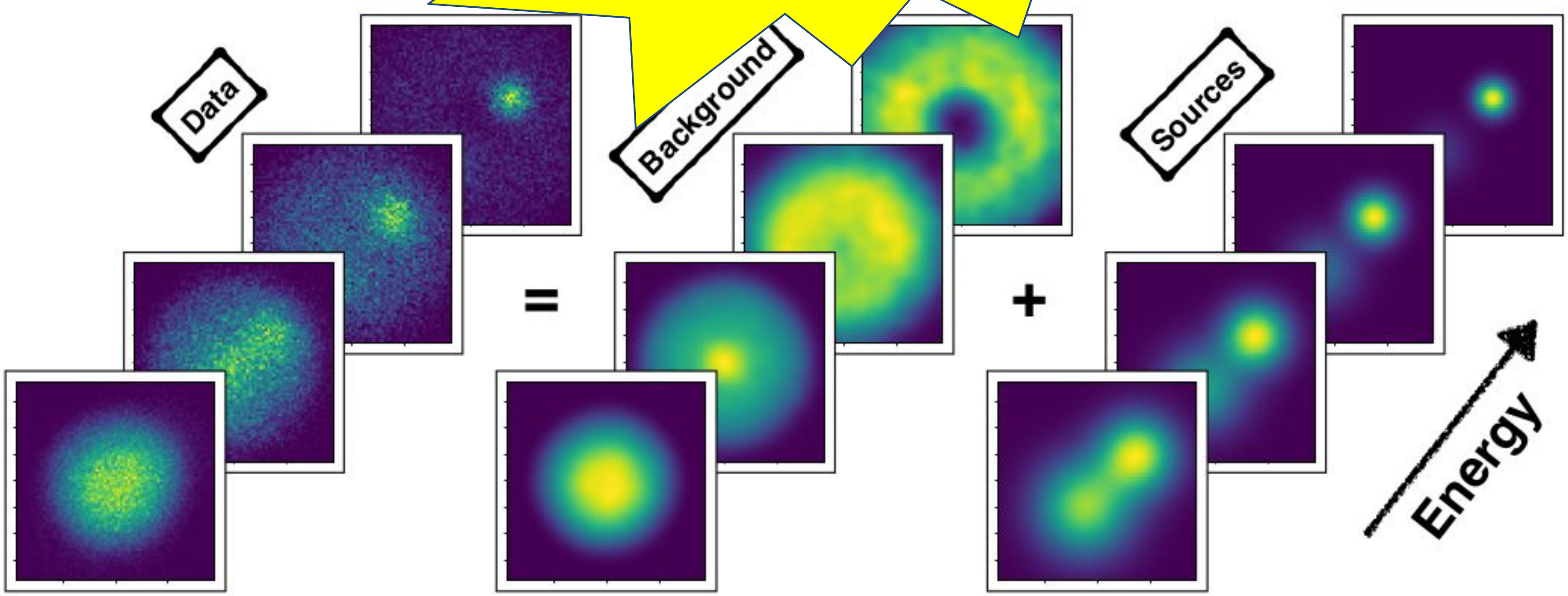
Like it is in Fermi analysis!



3D method analysis

Like it is in Fermi analysis!

Big advantage:
overlapping
sources
(not possible in classical
analysis)



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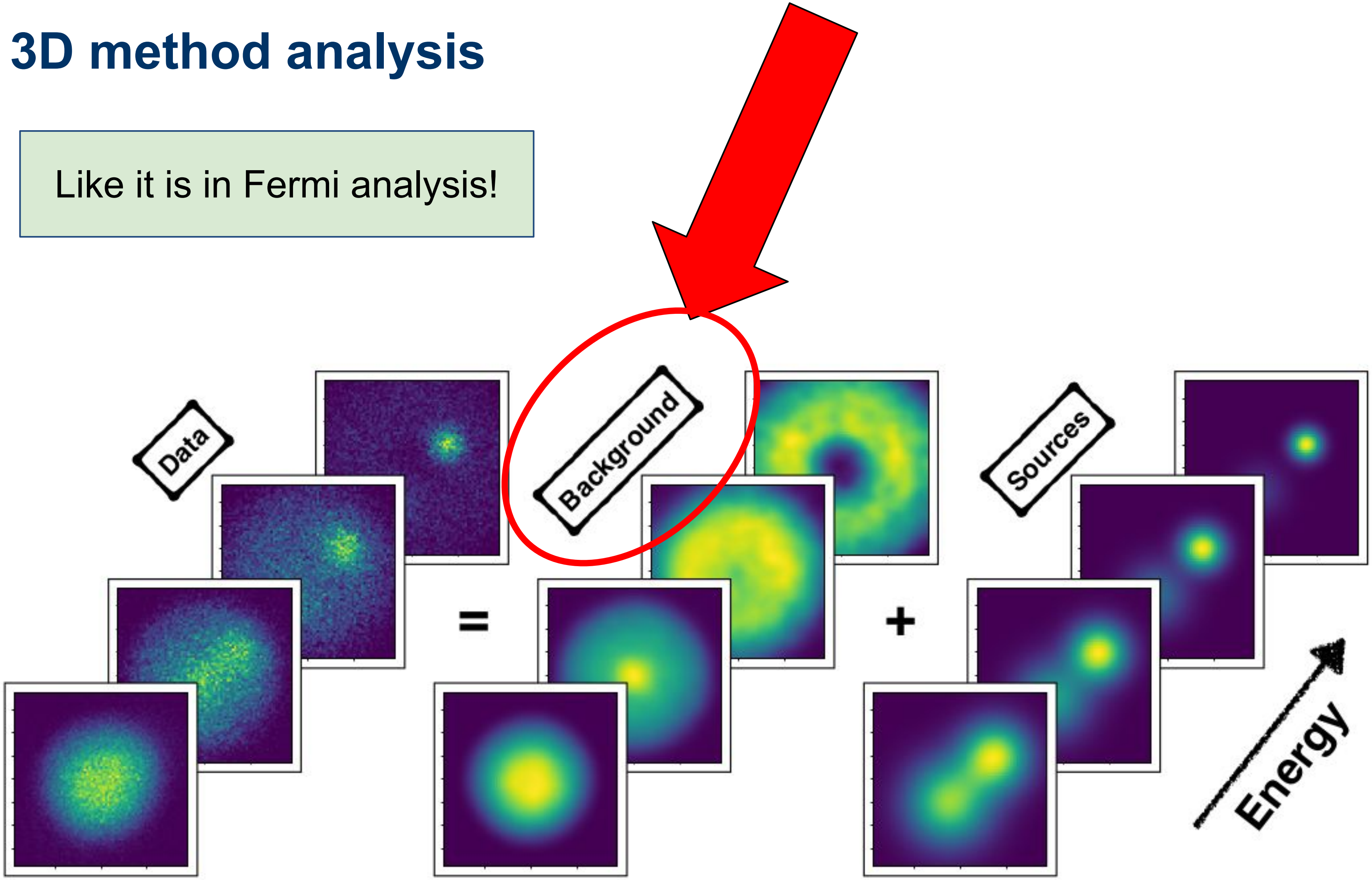
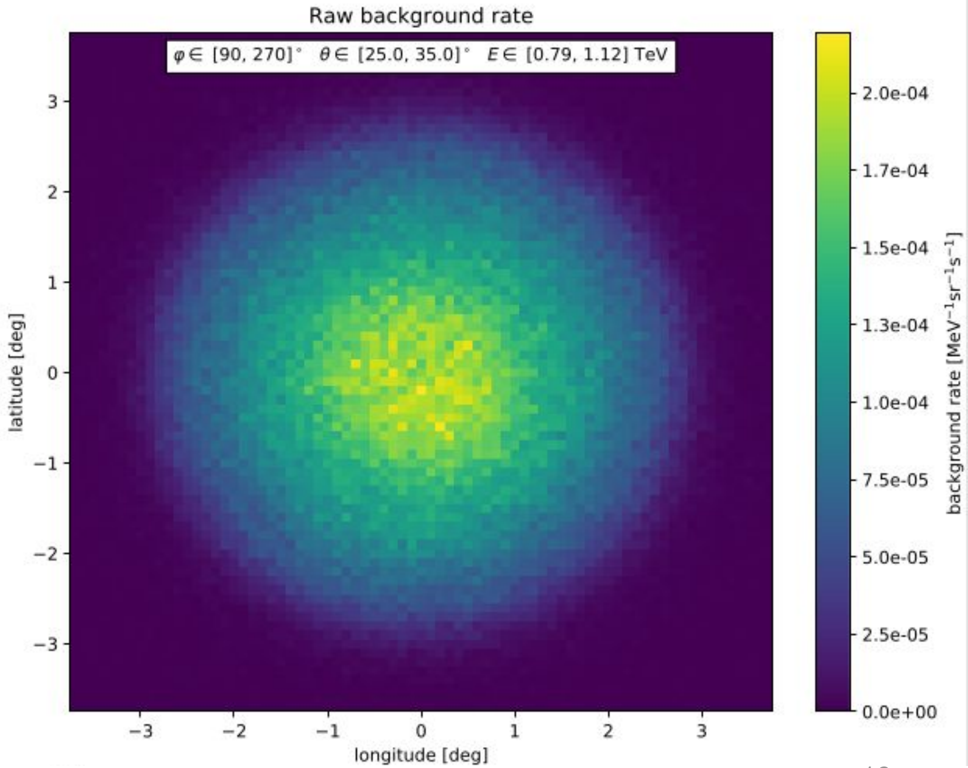


Strategy:

- Select all observations off the Galactic plane
- Group observations in bins of zenith and azimuth angle (but so far not: optical efficiency, telescope multiplicity, ...)
- Stack observations in Alt/Az-aligned field-of-view coordinate system, excluding source regions
- Compute pixel-wise exposure time over all runs in a bin
- Compute background rate
- Apply smoothing algorithm



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telescope m
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field-of-view c
excluding sou
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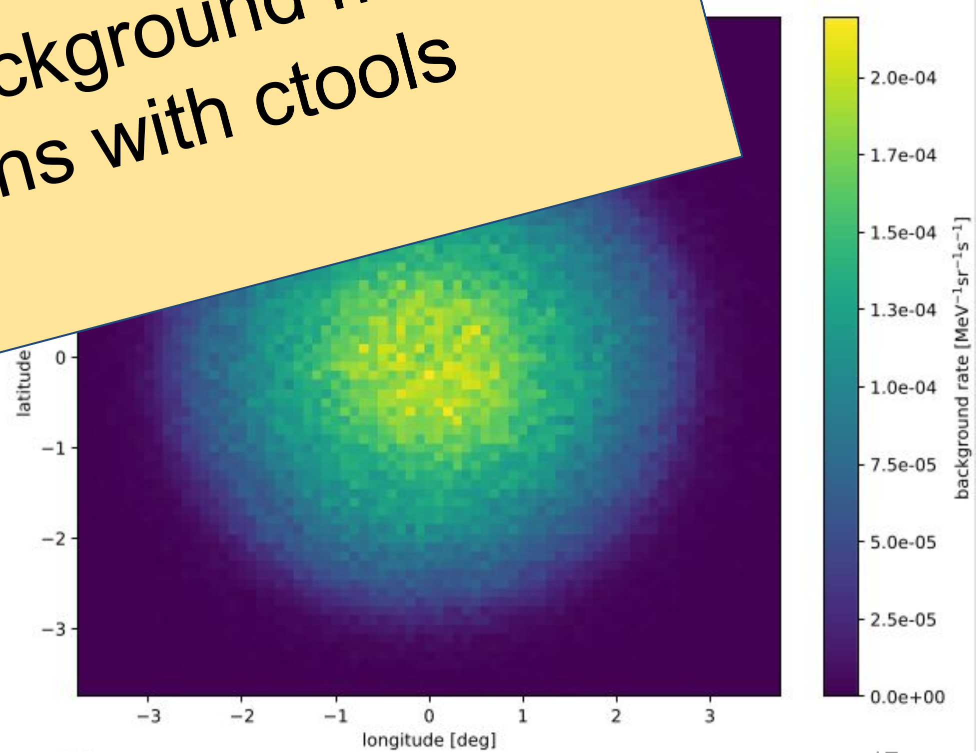
Test of the background model:
Simulations with ctools



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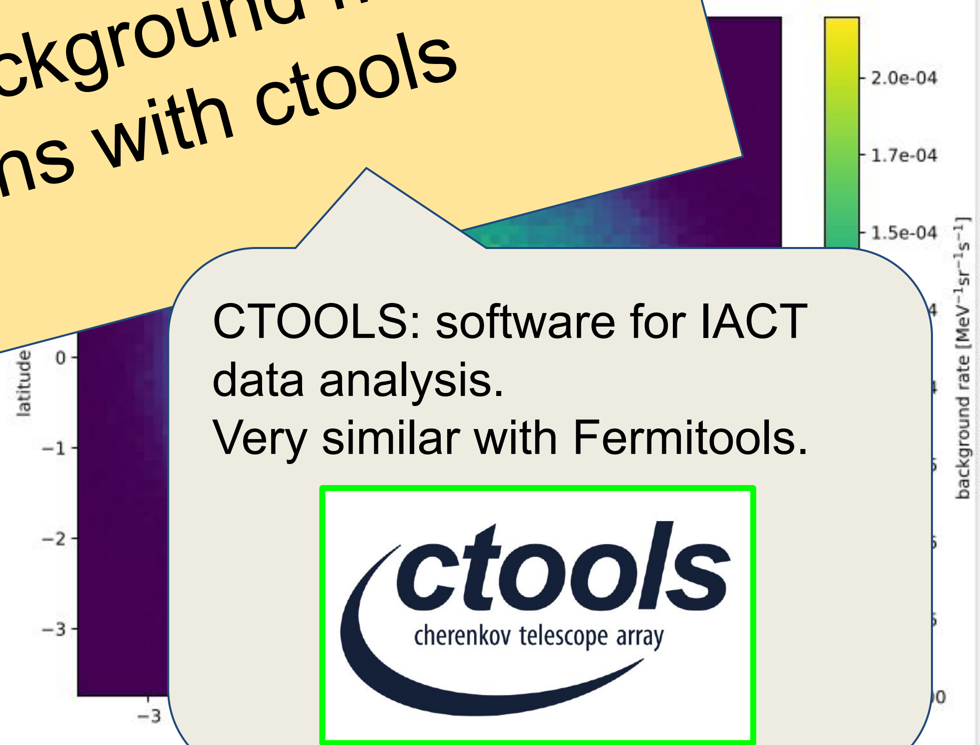


CTOOLS: software for IACT data analysis.
Very similar with Fermitools.

Methods & Results:
Testing the background model using simulation and ctools

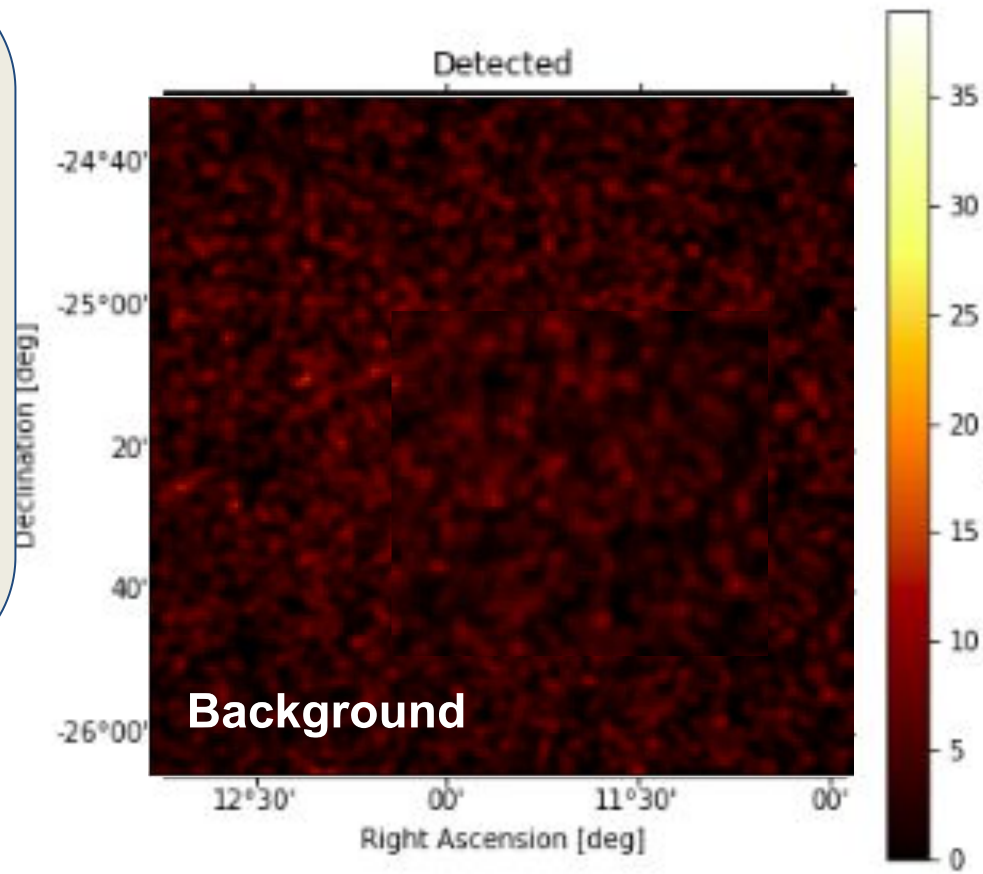
The initial idea

Using off observations, we simulate sources and put on top of it.

Perform the 3D analysis.

Extract the parameters of the input model and check if it is the same as the simulation.

If the fitted values are very close to used in the simulation, then the background test is done and approved.

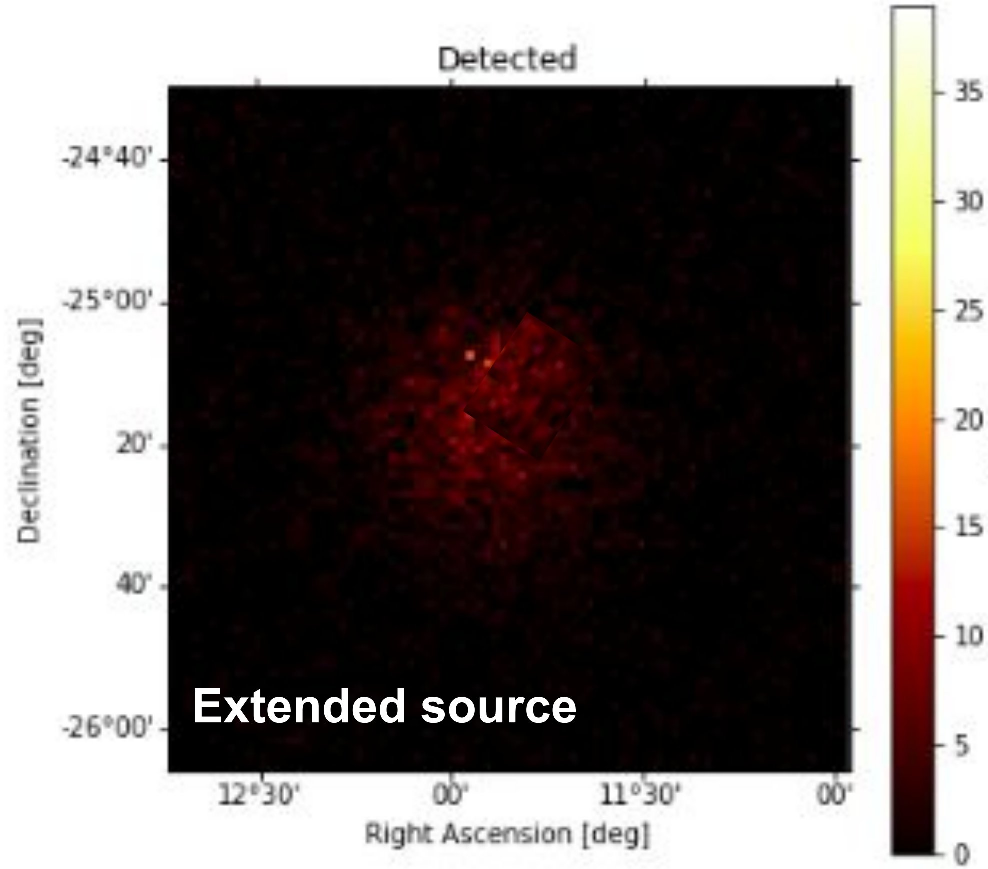


The simulated sources:

Extended source:

<u>Spatial model:</u>
Radial Gaussian:
RA, DEC, Sigma

<u>Spectral Model:</u>
Power Law:
Normalization, Index



The simulated sources:

Extended source:

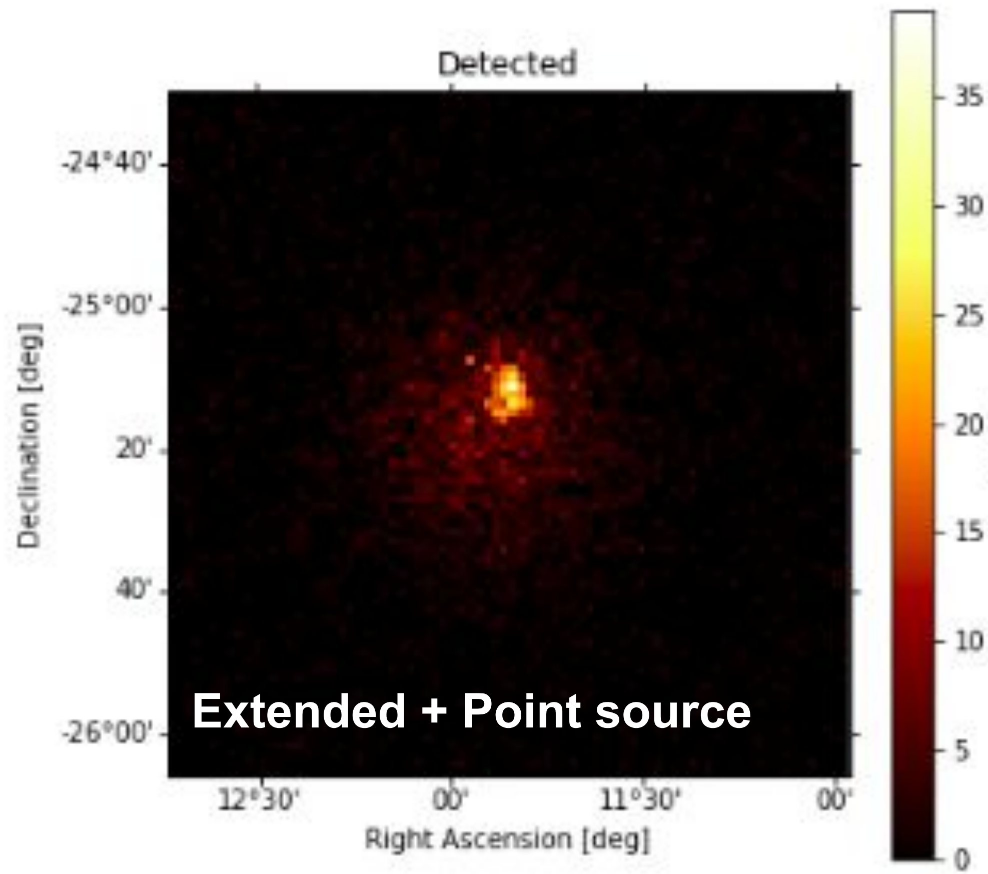
Spatial model:
Radial Gaussian:
RA, DEC, Sigma

Spectral Model:
Power Law:
Normalization, Index

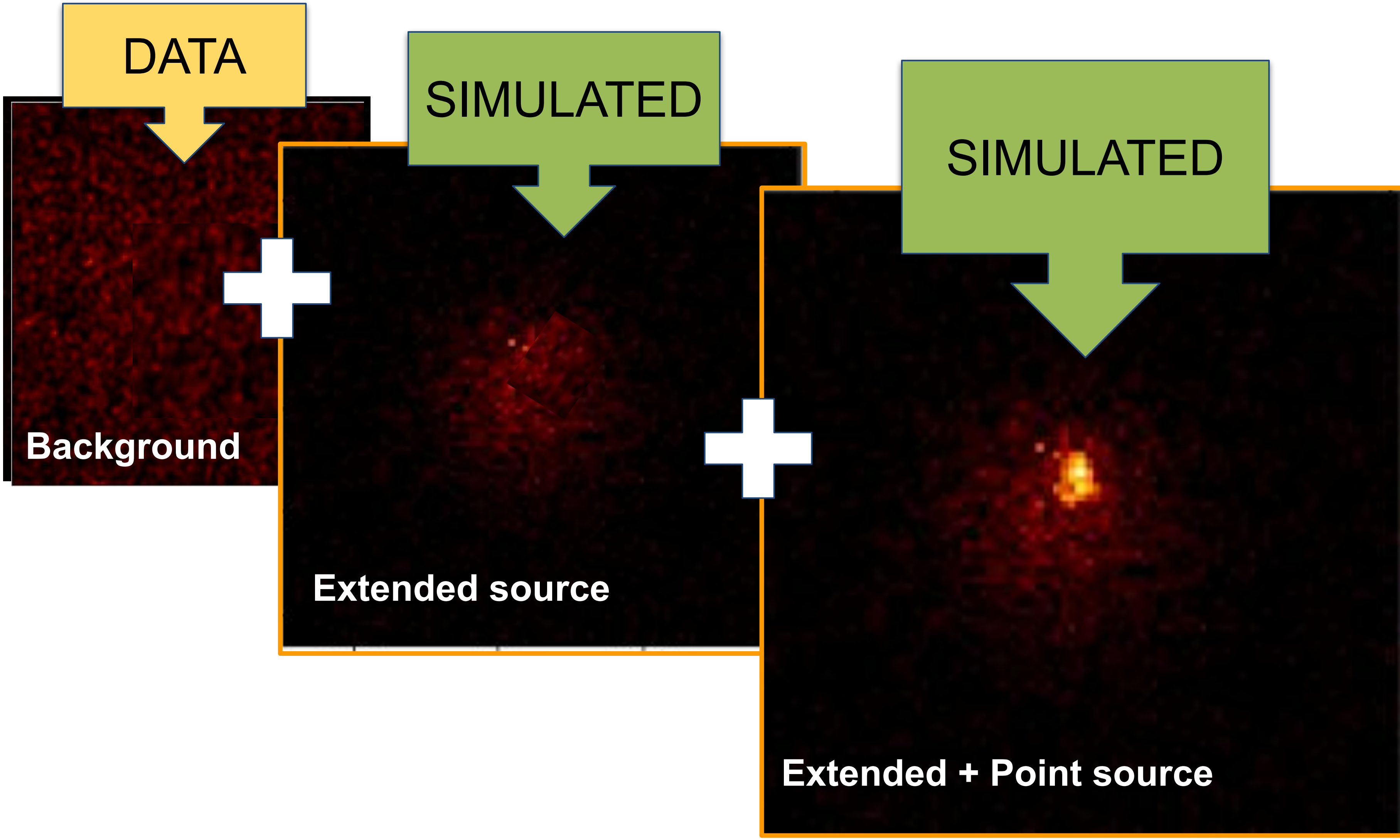
Point source:

Spatial model:
Radial Gaussian:
RA, DEC

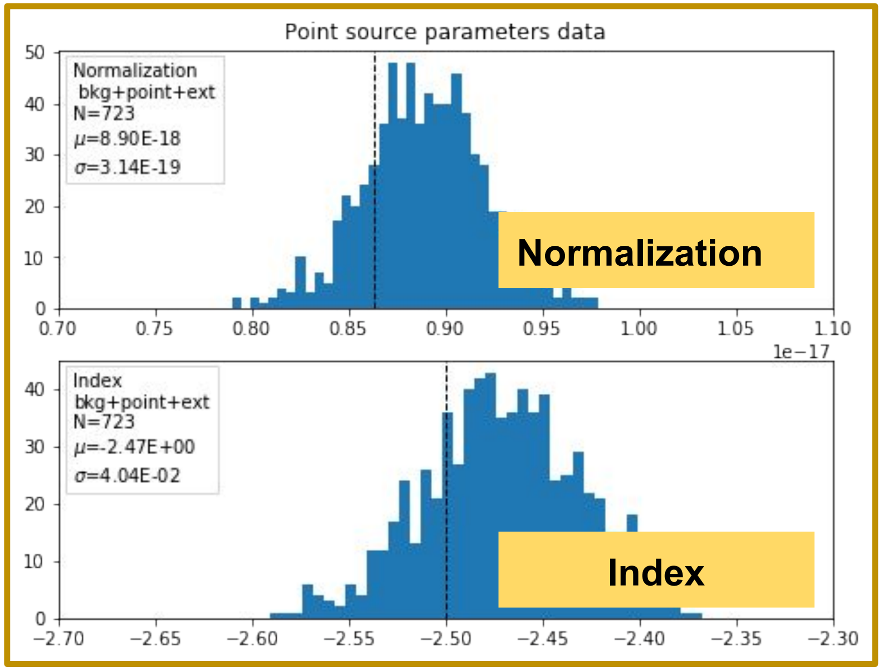
Spectral Model:
Power Law:
Normalization, Index

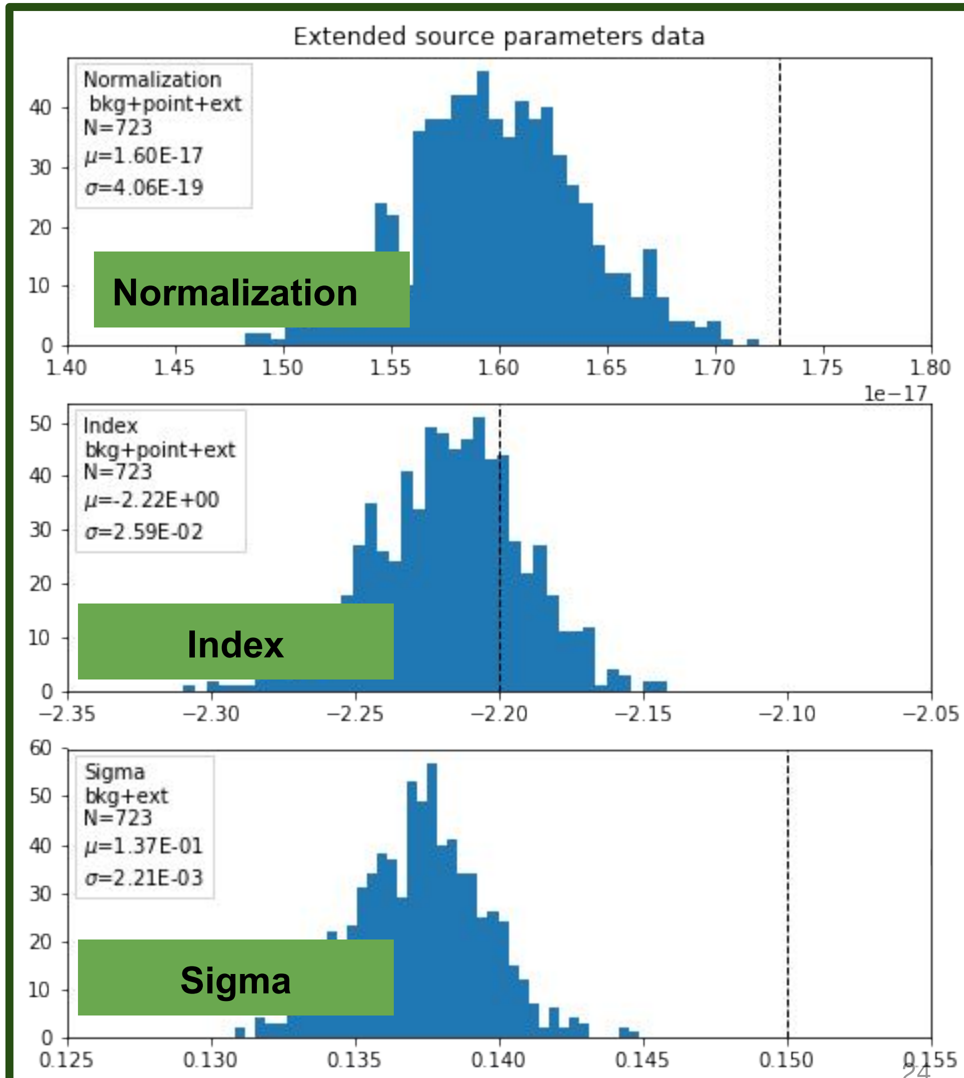


1st round:


DATA
SIMULATED
SIMULATED
Background
Extended source
Extended + Point source

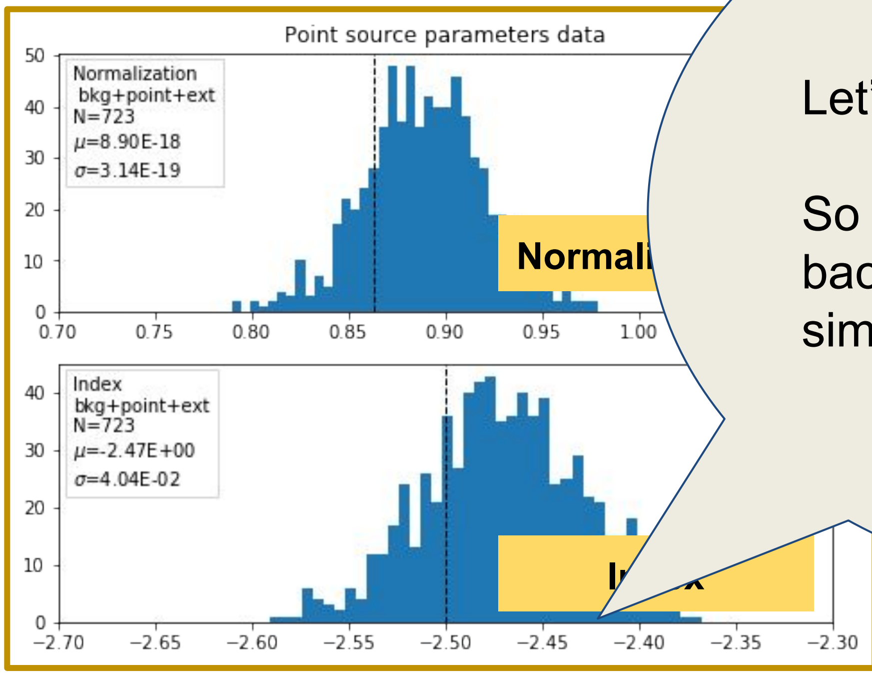
1st round: Results

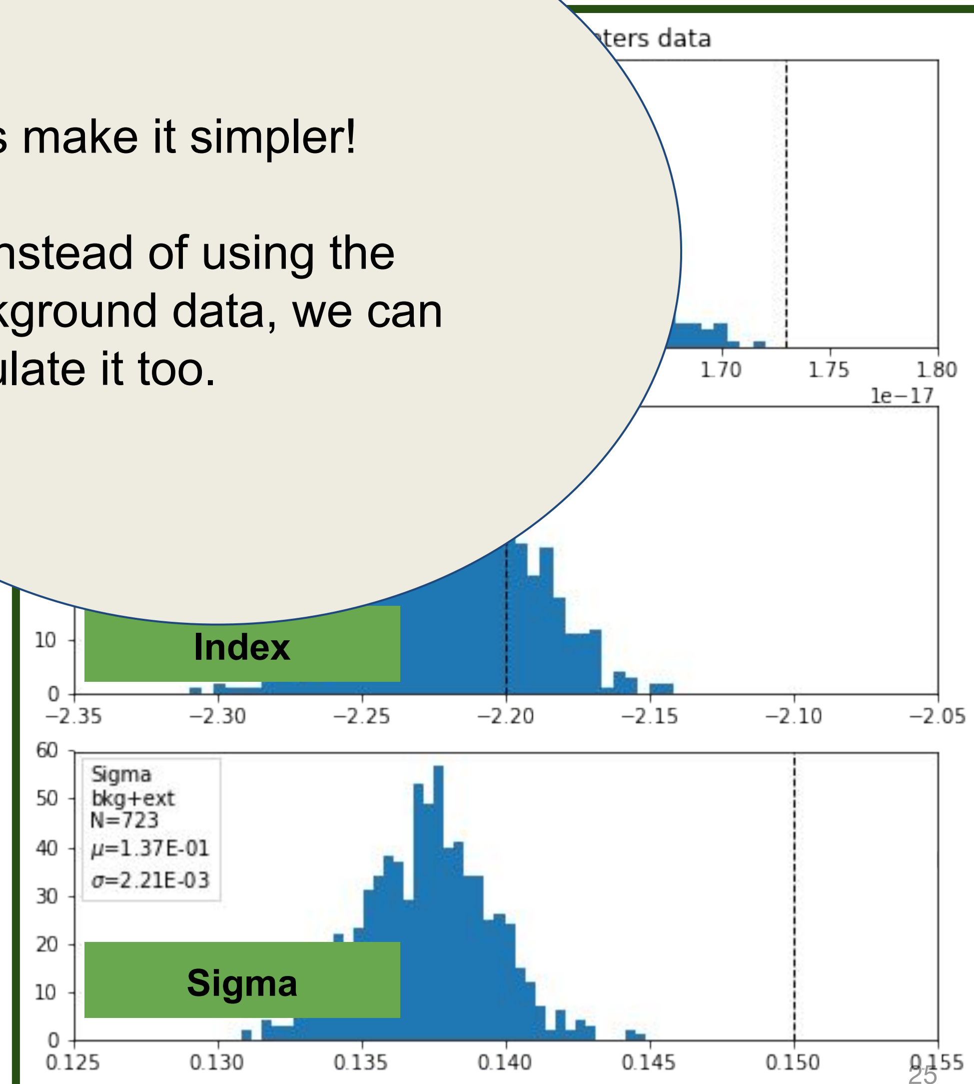




Fitted values different from the expected value.
Correlation between sigma, normalization and point source.

1st round: Results



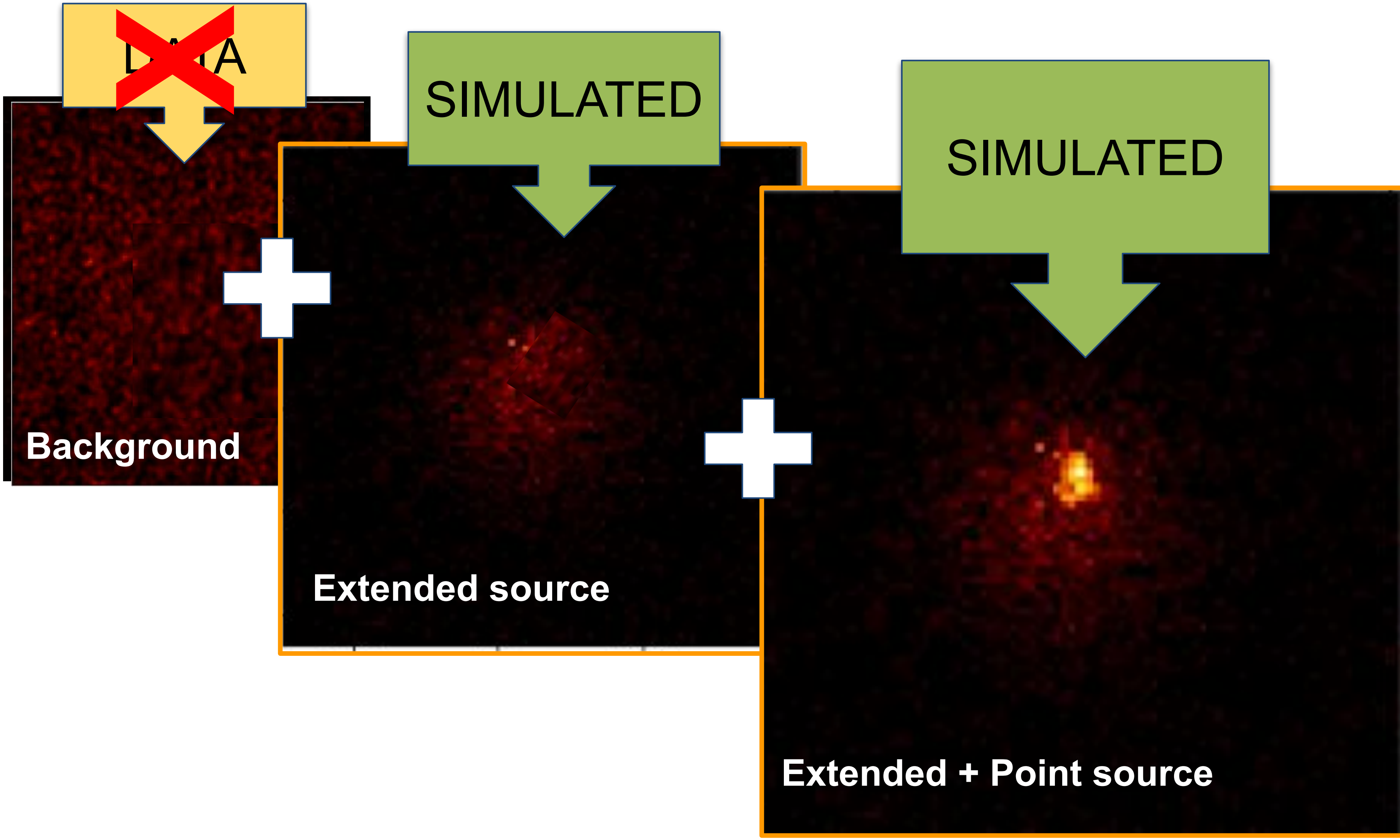


Let's make it simpler!

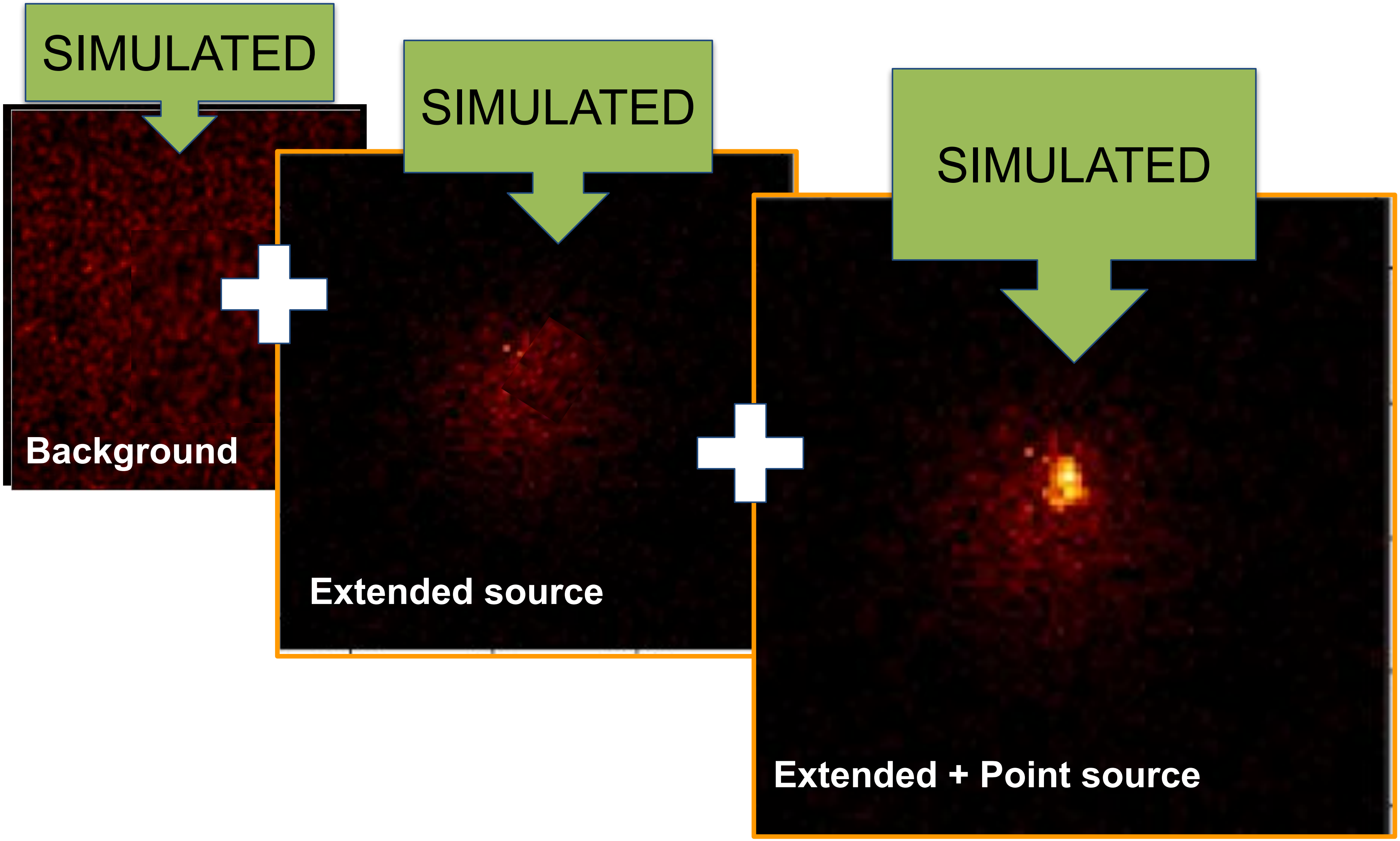
So instead of using the background data, we can simulate it too.

Fitted values different from the expected value.
Correlation between sigma, normalization and point source.

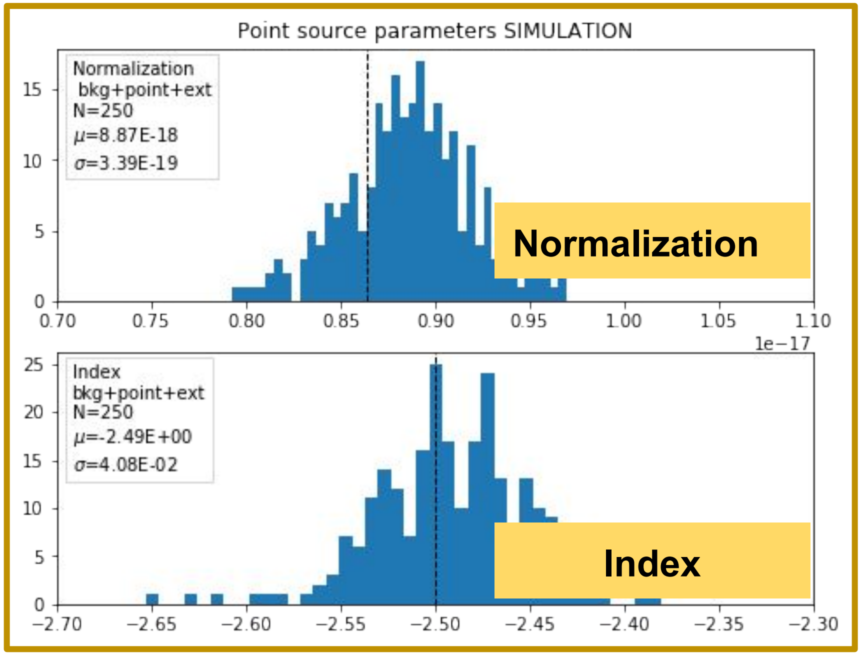
2st round:

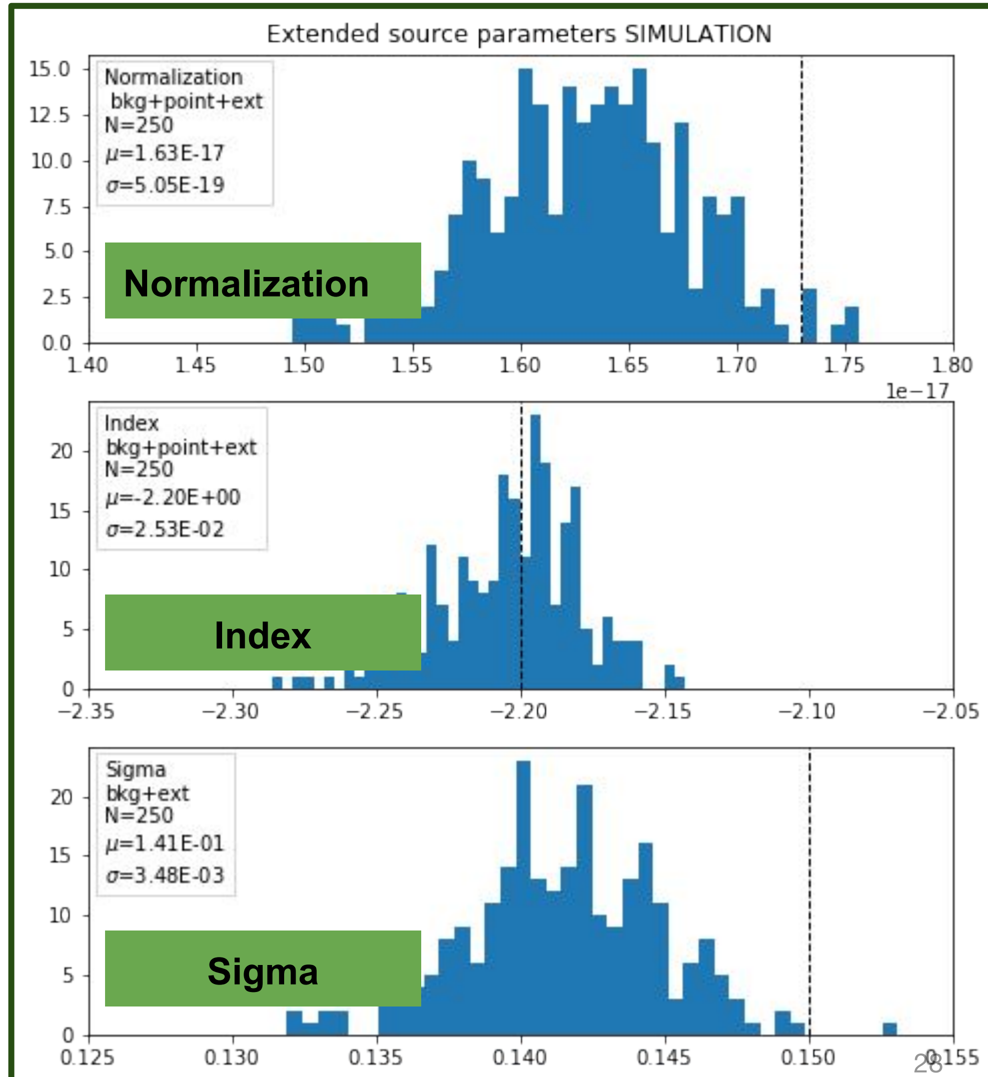

SIMULATED
SIMULATED
Background
Extended source
Extended + Point source

2st round:

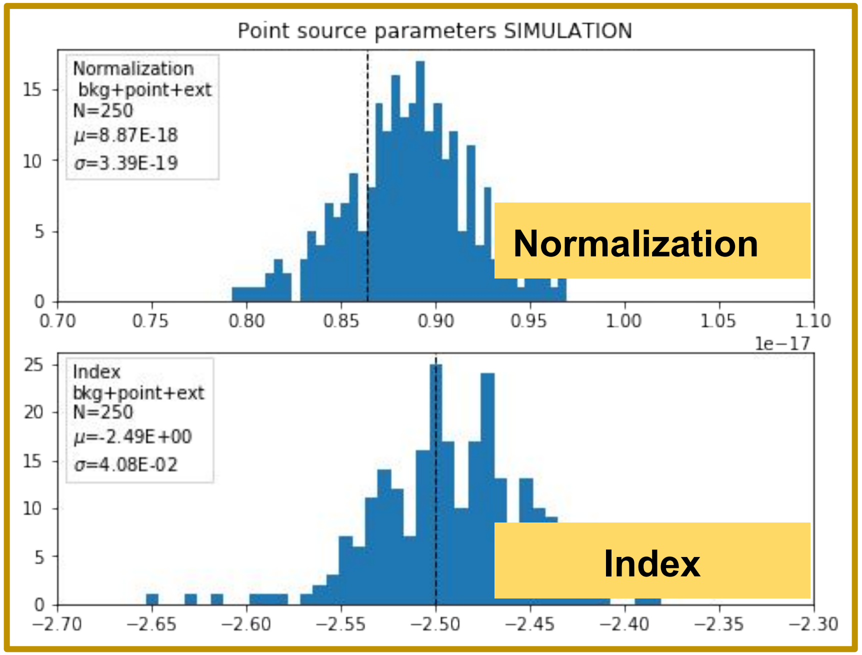

SIMULATED
SIMULATED
SIMULATED
Background
Extended source
Extended + Point source

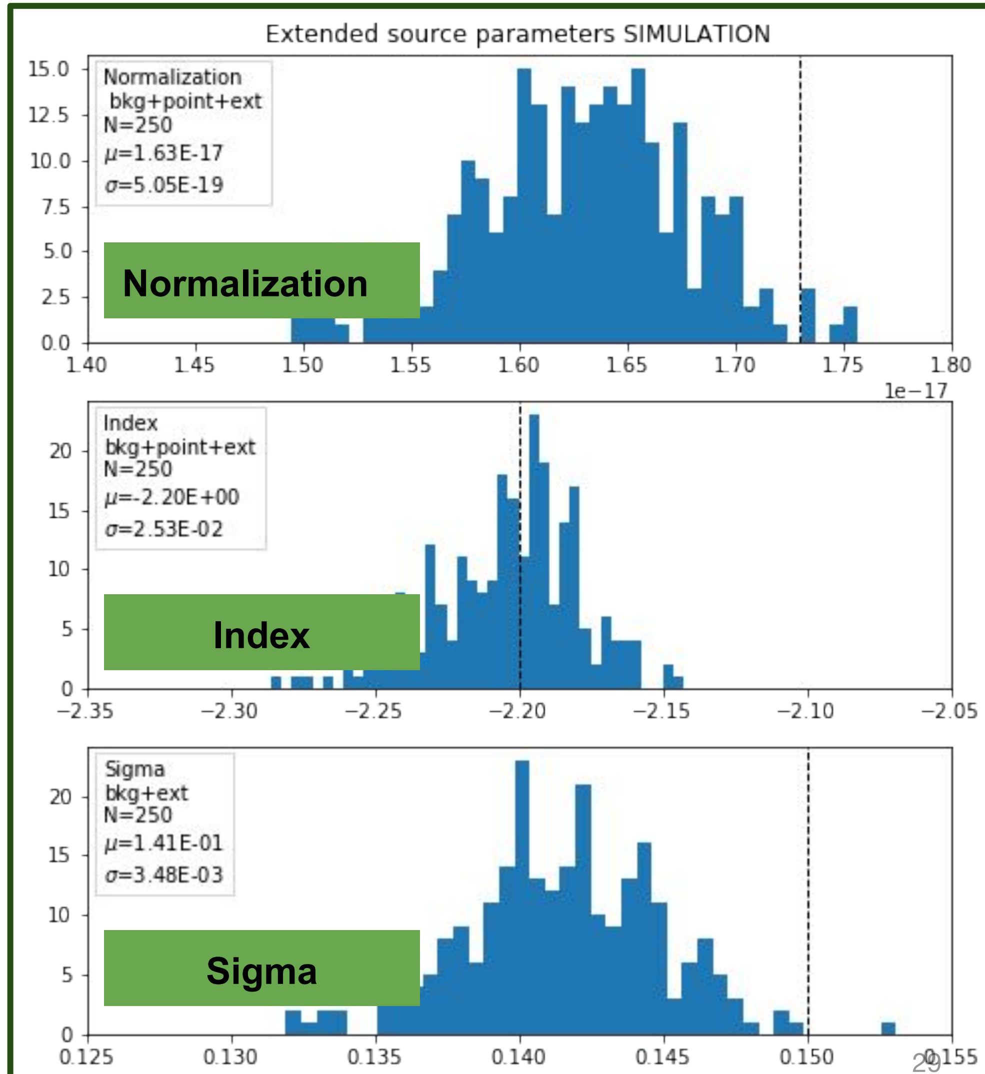
2nd round: Results





2nd round: Results





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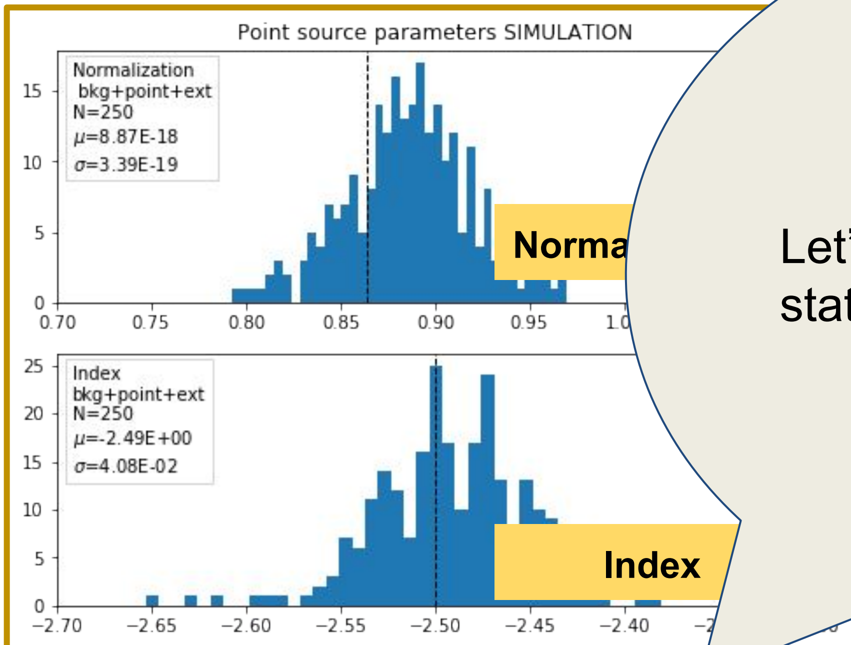
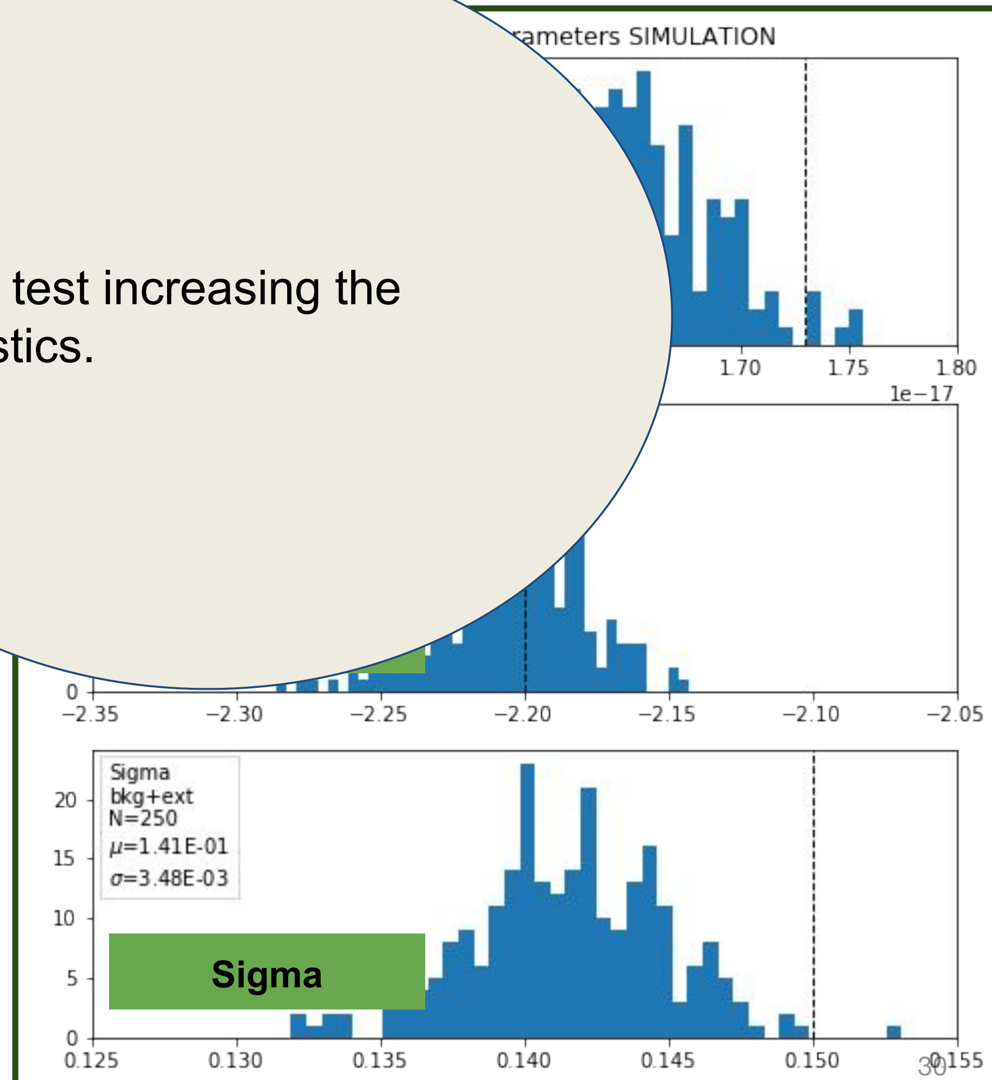
Correlation between sigma, normalization and point source.

2nd round: Results



Let’s test increasing the statistics.



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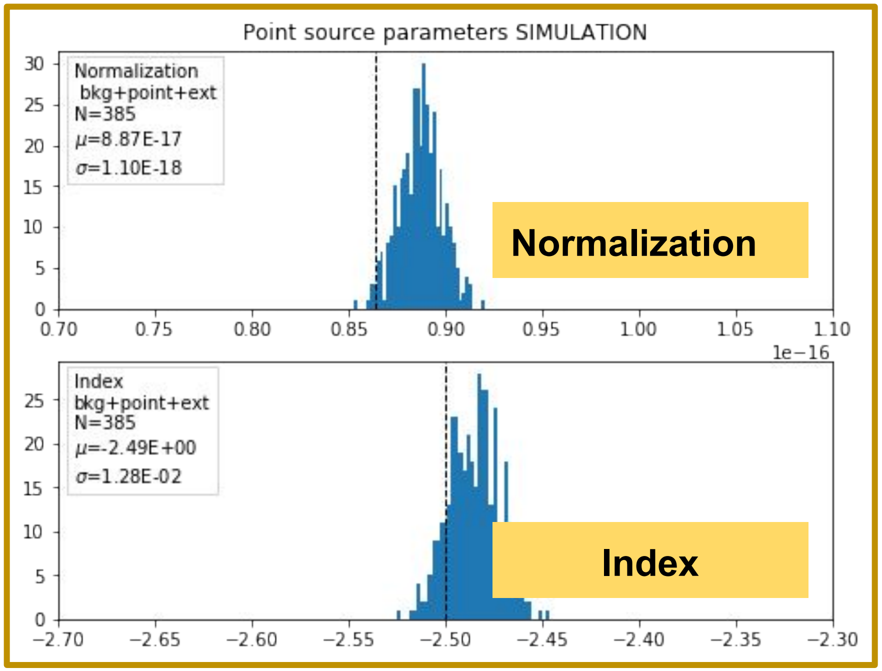
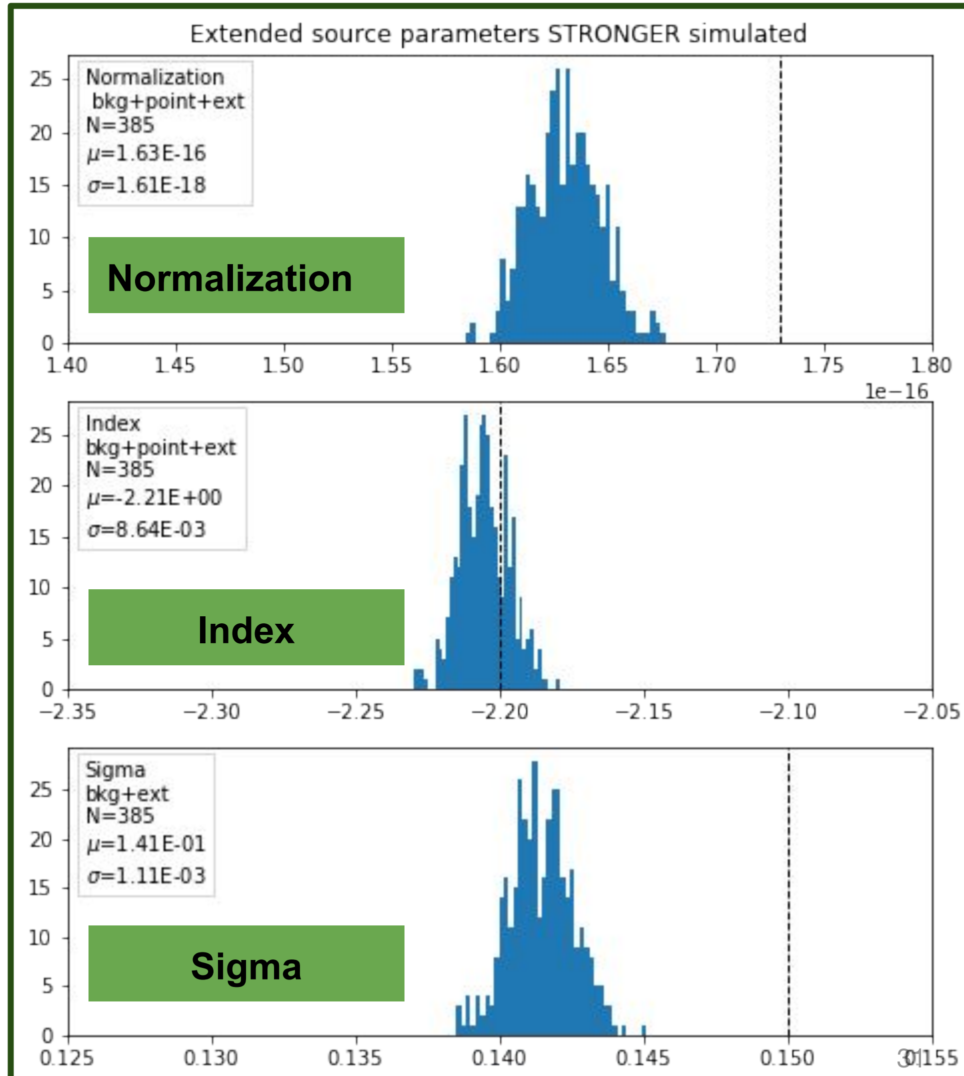
Correlation between sigma, normalization and point source.

2nd round: Results





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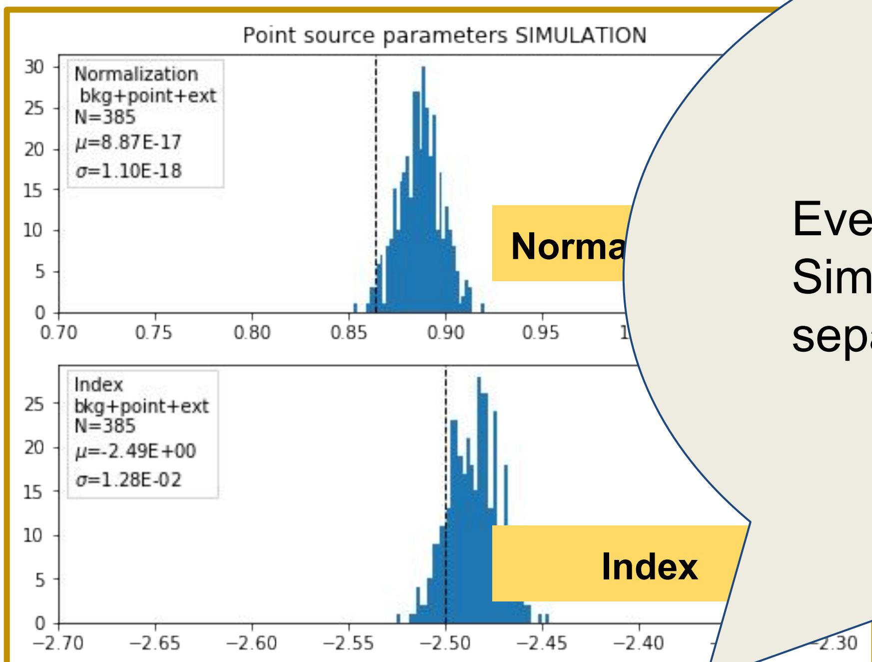
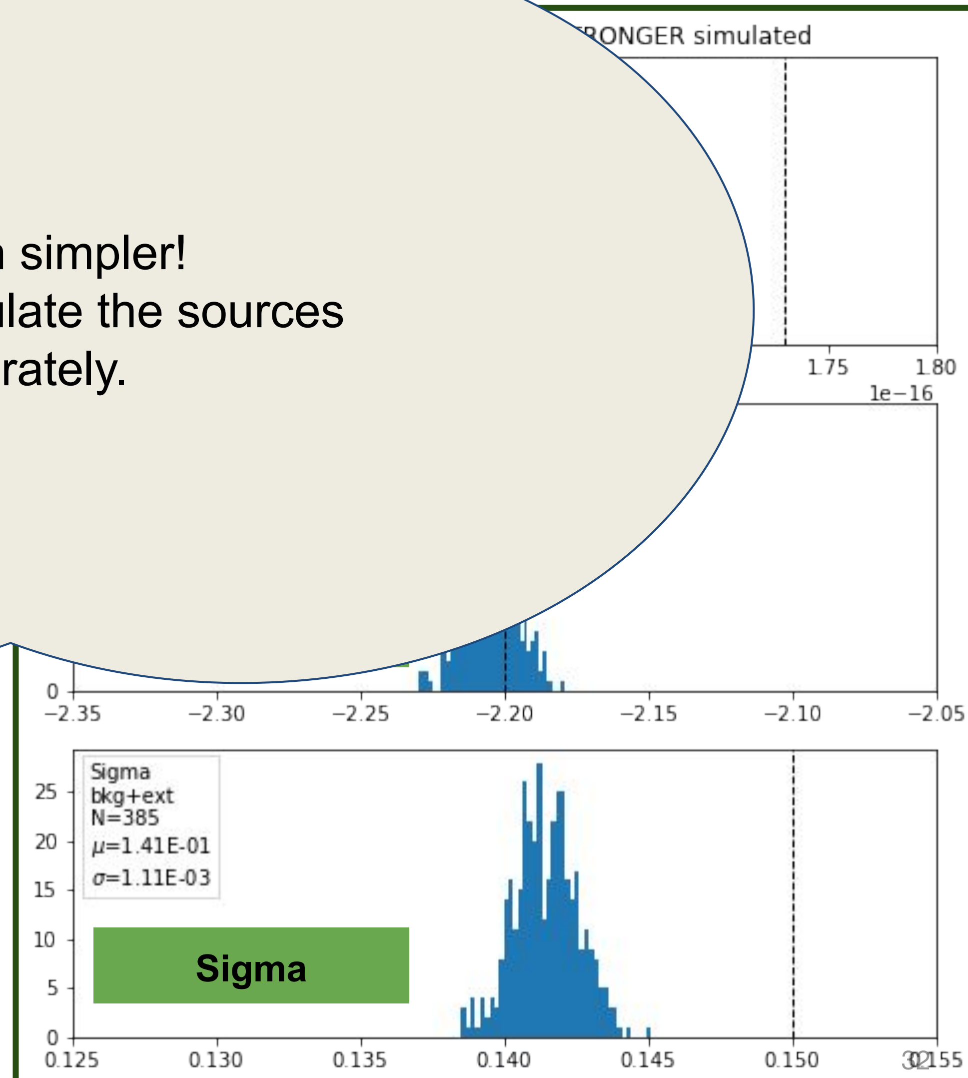
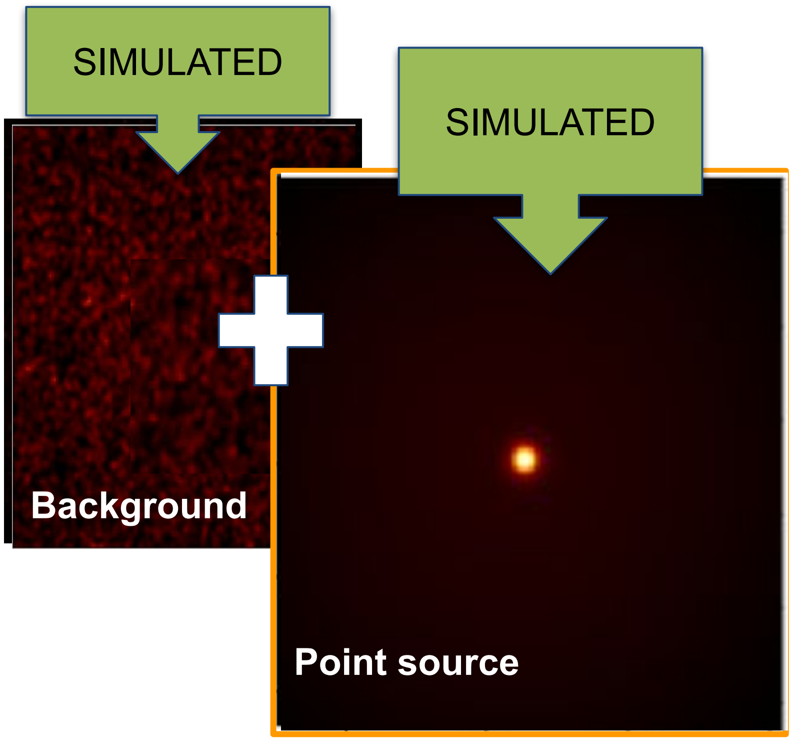




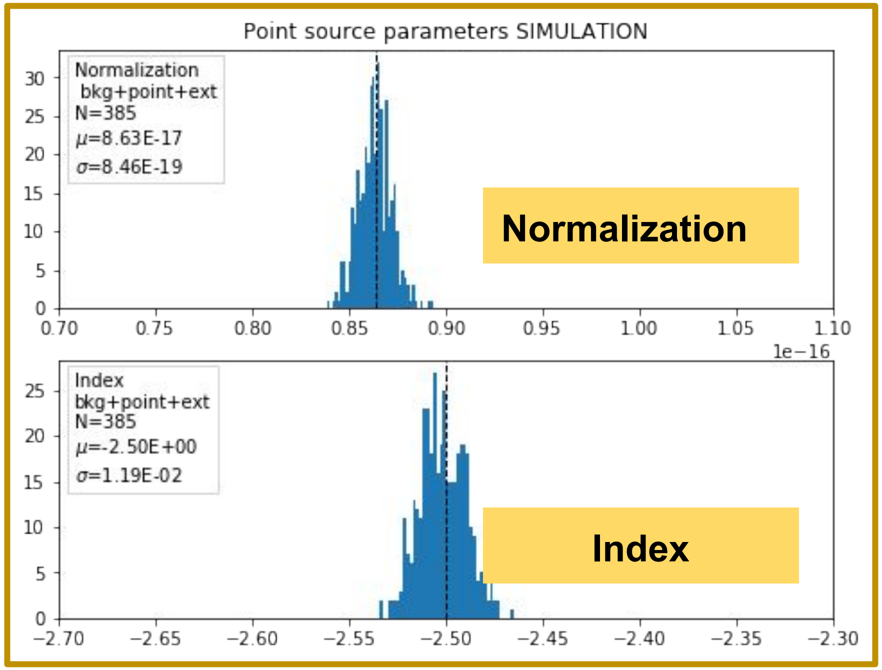
Even simpler!
Simulate the sources separately.

Fitted values different from the expected value.
Correlation between sigma, normalization and point source.

3rd round:



3rd round: Results



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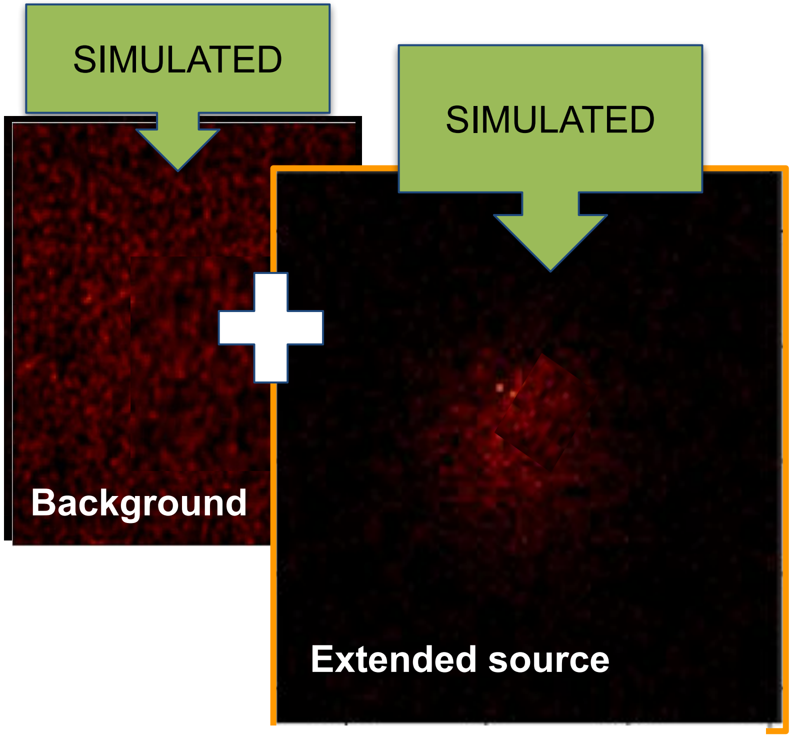
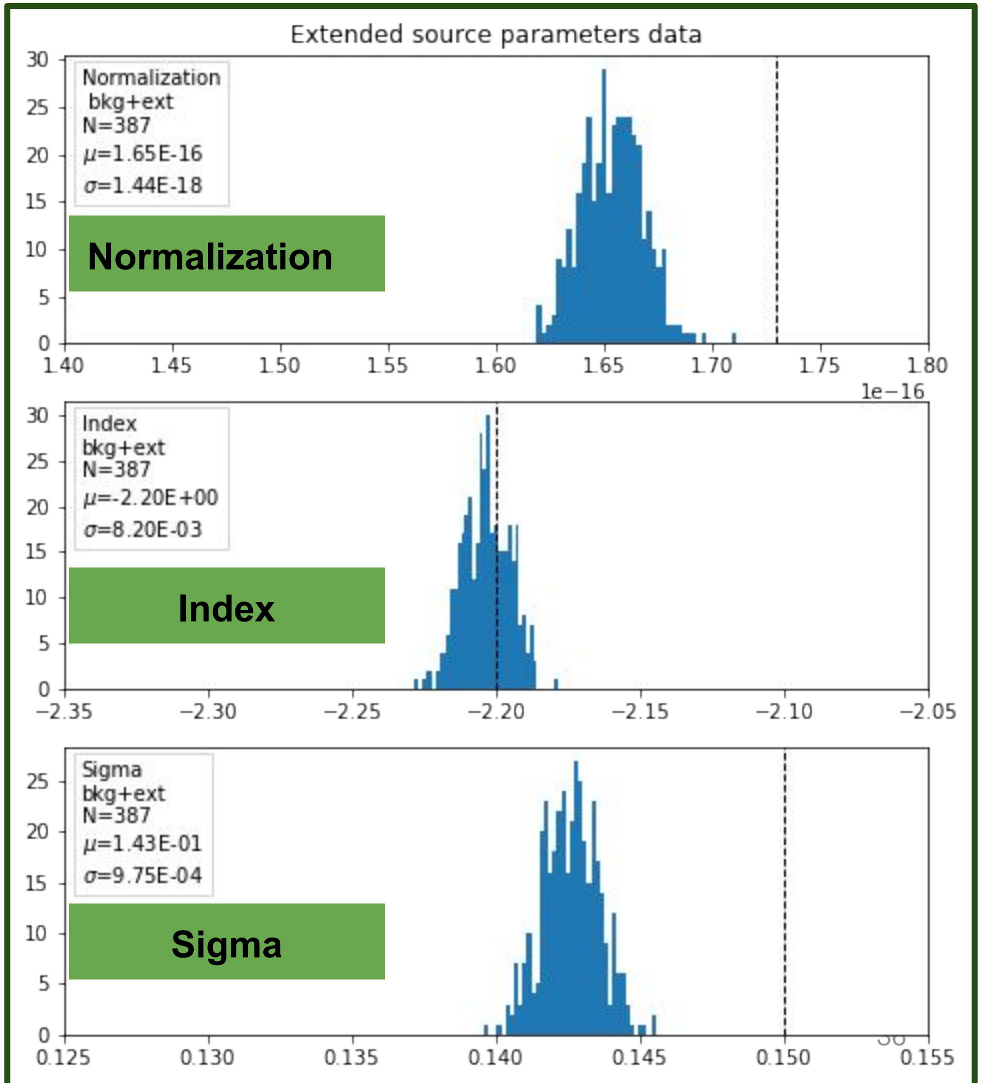
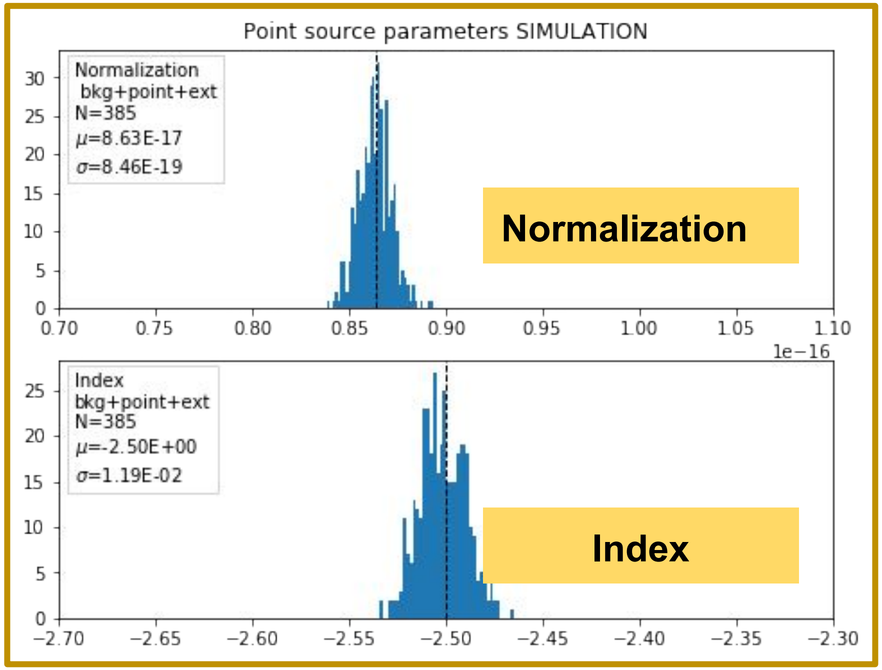
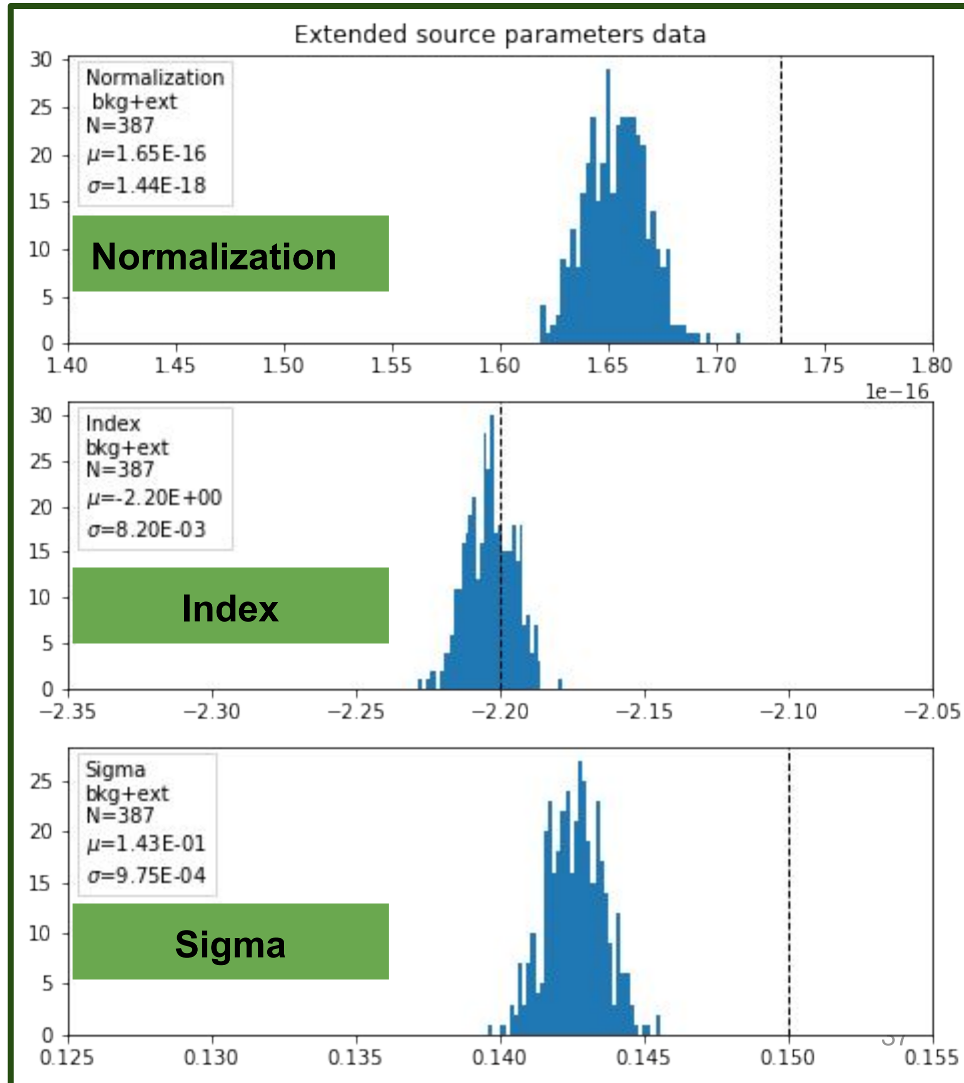


3rd round: Results



3rd round: Results

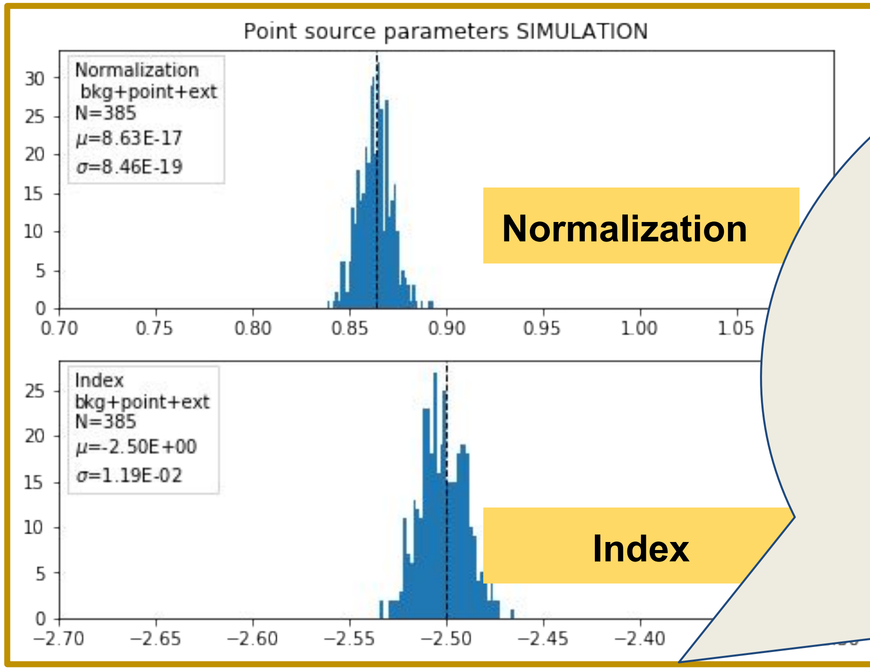


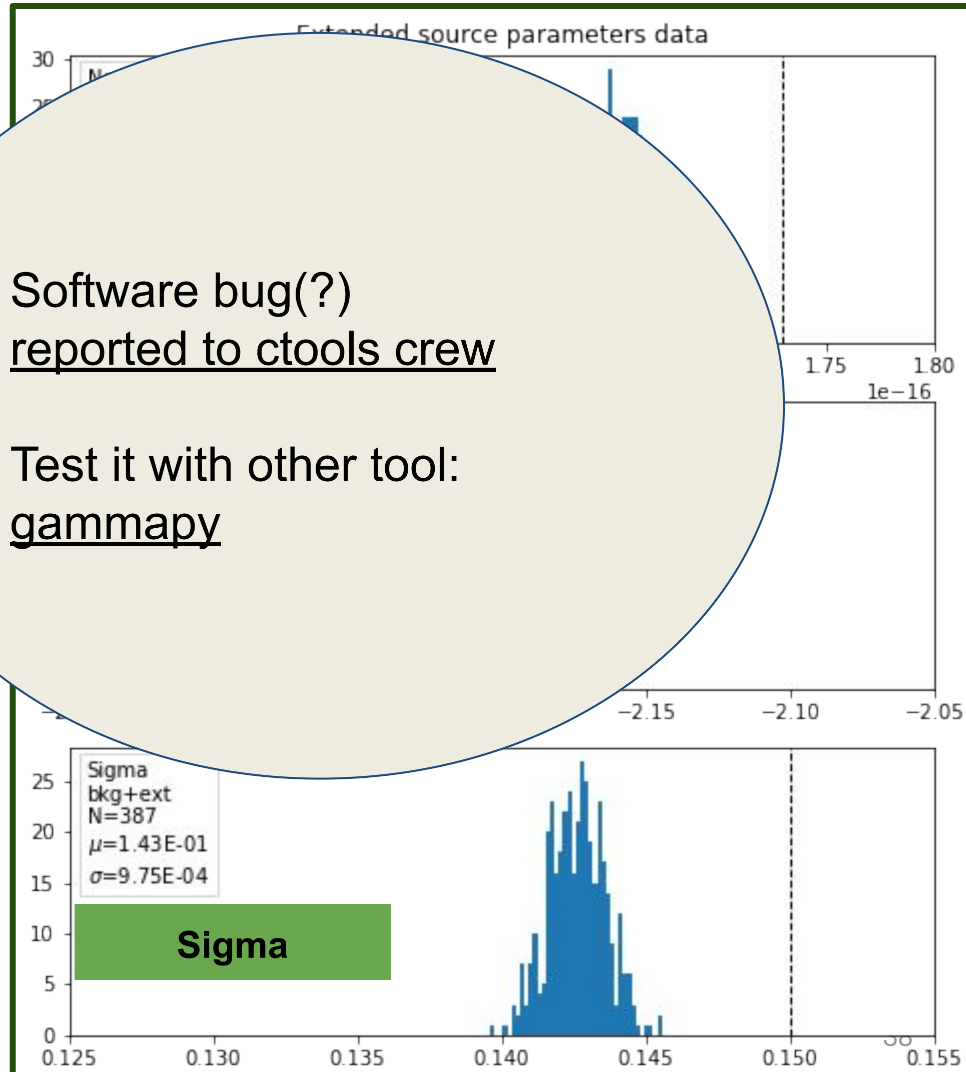


Fitted values different from the expected value for **EXTENDED SOURCE**.
Correlation between sigma,

GOOD FITTING VALUES FOR
POINT SOURCE!

3rd round: Results





Software bug(?)
reported to ctools crew

Test it with other tool:
gammapy

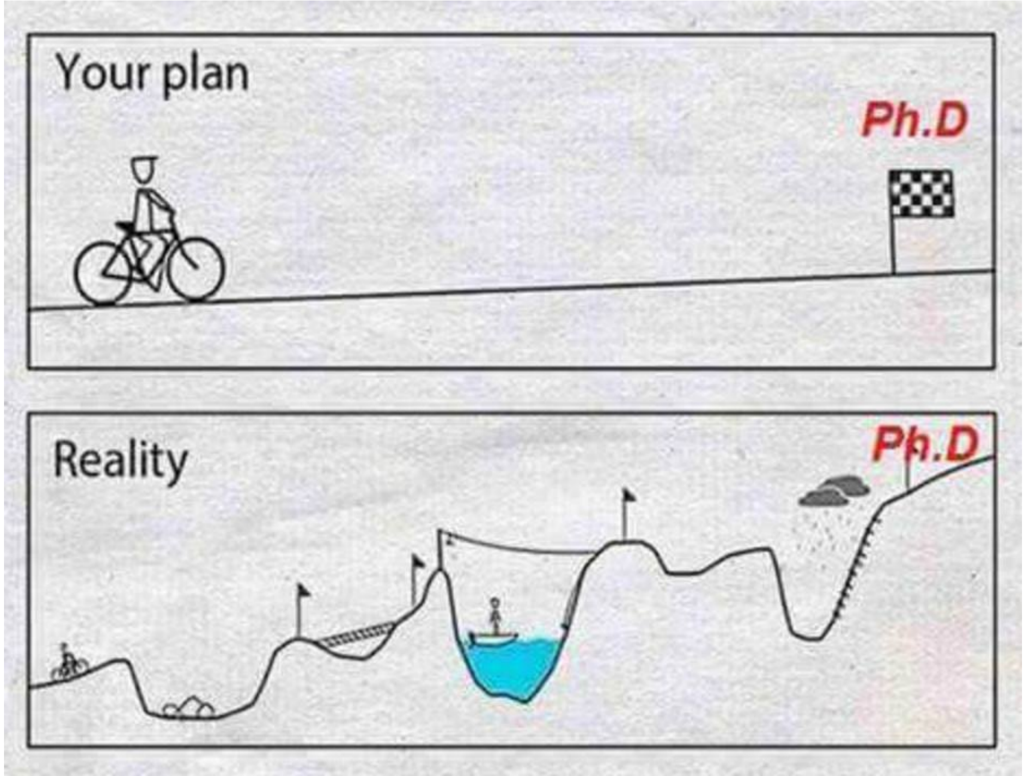
Fitted values different from the expected value for **EXTENDED SOURCE**.
Correlation between sigma,

GOOD FITTING VALUES FOR
POINT SOURCE!

Conclusions

Conclusions

- We developed a background model and it needed to be tested.
- We performed different analysis to understand what is happening.
- Going to simpler and simpler cases.
- We ended up with a possible software bug.



Conclusions

- We developed a background model and it needed to be tested.
- We performed different analysis to understand what is happening.
- Going to simpler and simpler cases.
- We ended up with a possible software bug.

Future prospectives

- Finish testing the background model.
- Apply the 3D analysis for the Galactic Center
- Perform a joint analysis of Fermi high energy data with HESS

Thanks for your attention!

Questions?

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What does it have to do with Fermi?

- It is the same analysis method, 3D analysis.
- The problem is always the background: while in the IACT it is mainly because of the CR, in Fermi, it is due to diffuse emission

- Besides, it could be part of a joint analysis
- Since all the tools work in similar ways.

Outlook

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So, my interest

- Learn how to treat Fermi data, specially highest energy
- Leran how to treat HESS data, specially lowest energy
- Do a joint analysis of the Galactic center.
- I‘m open to suggestion and advices.

Outlook

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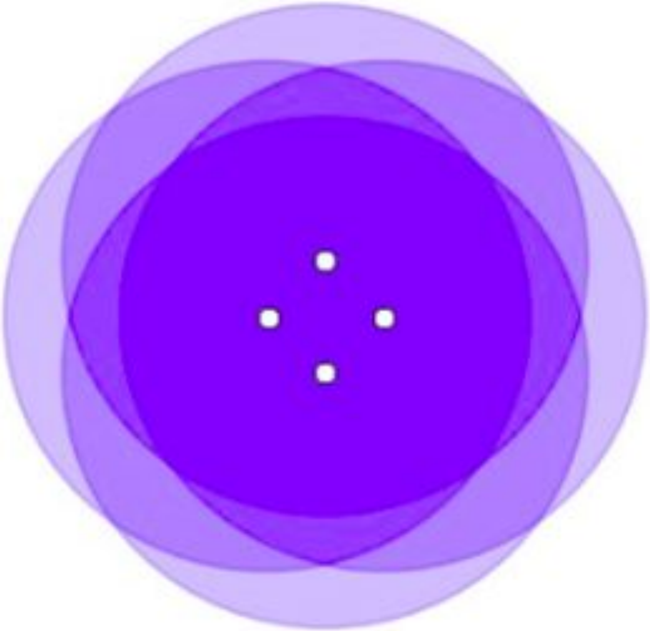
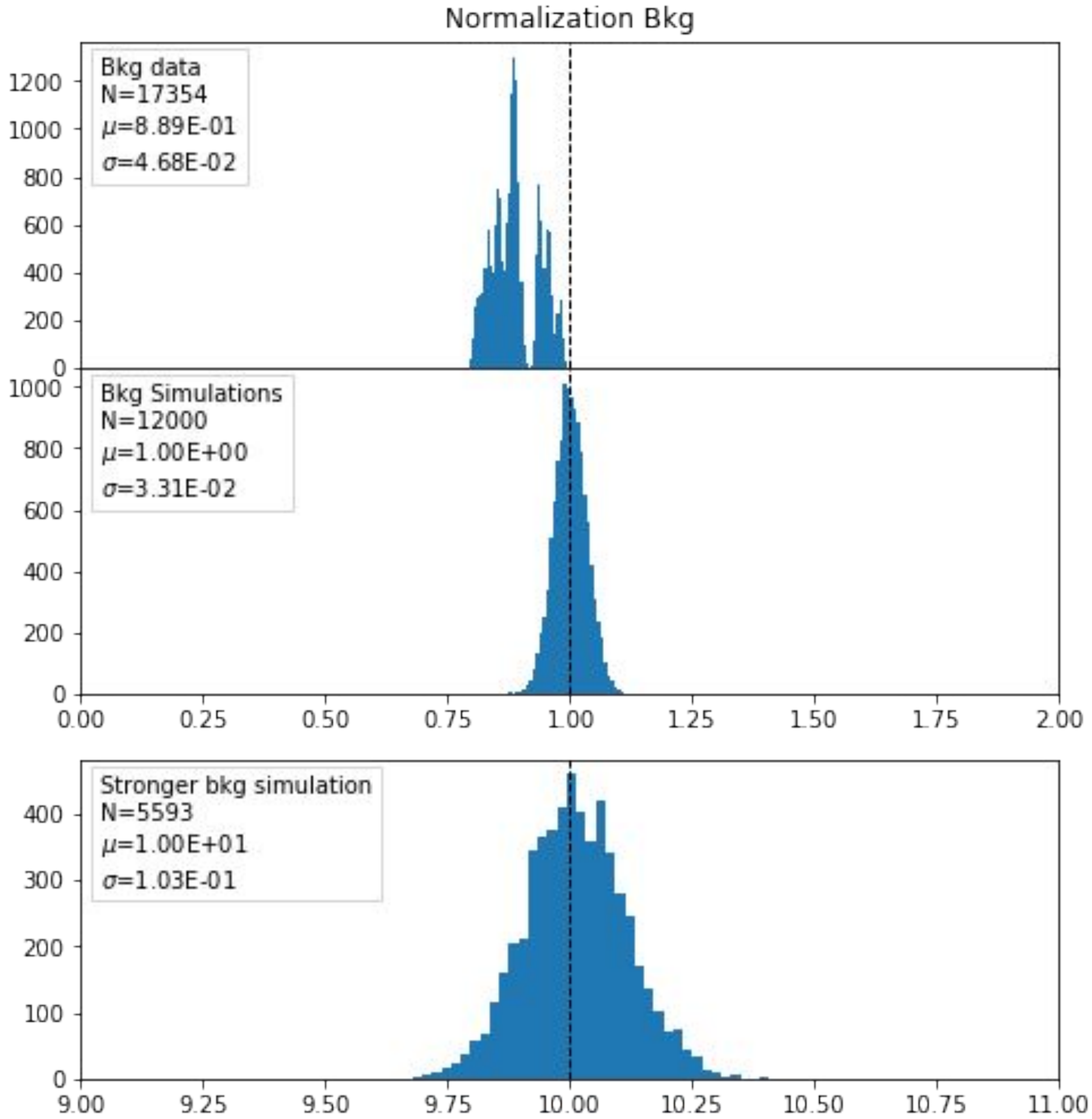
wobble positions
what is it important for?

What are my data set?!!?!?!?





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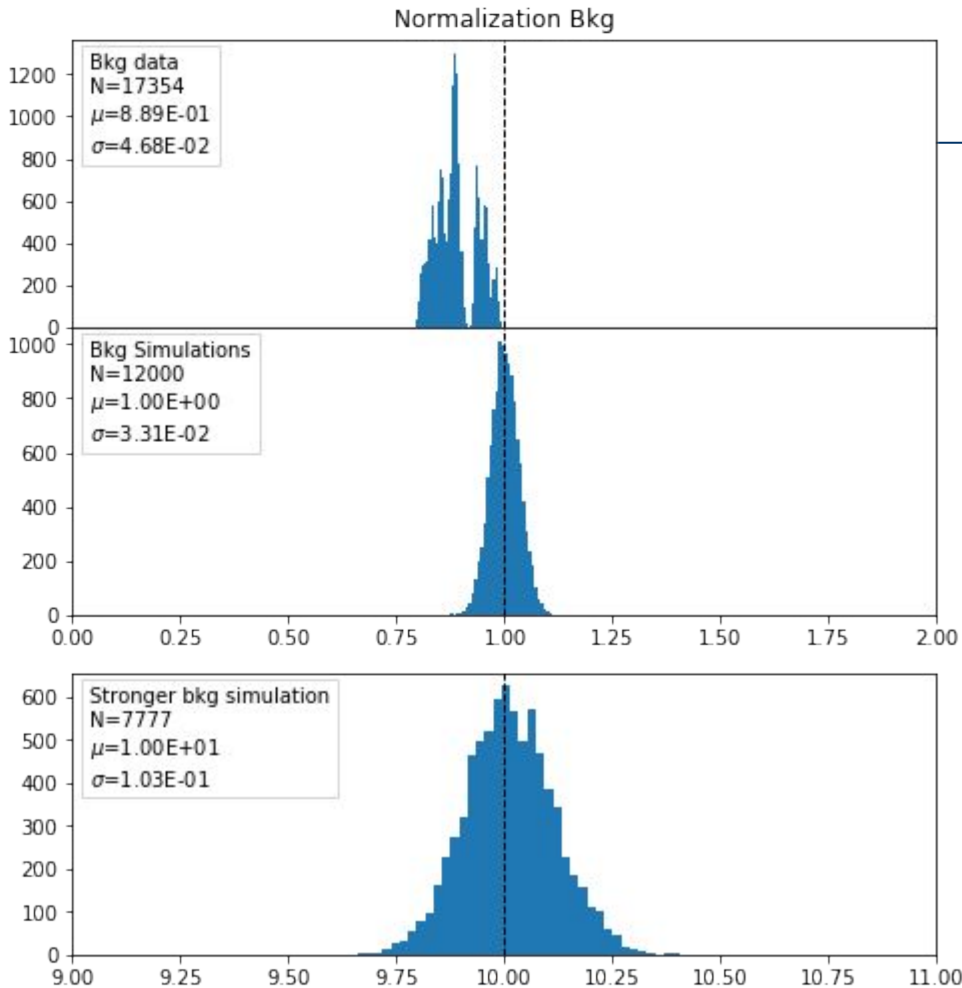

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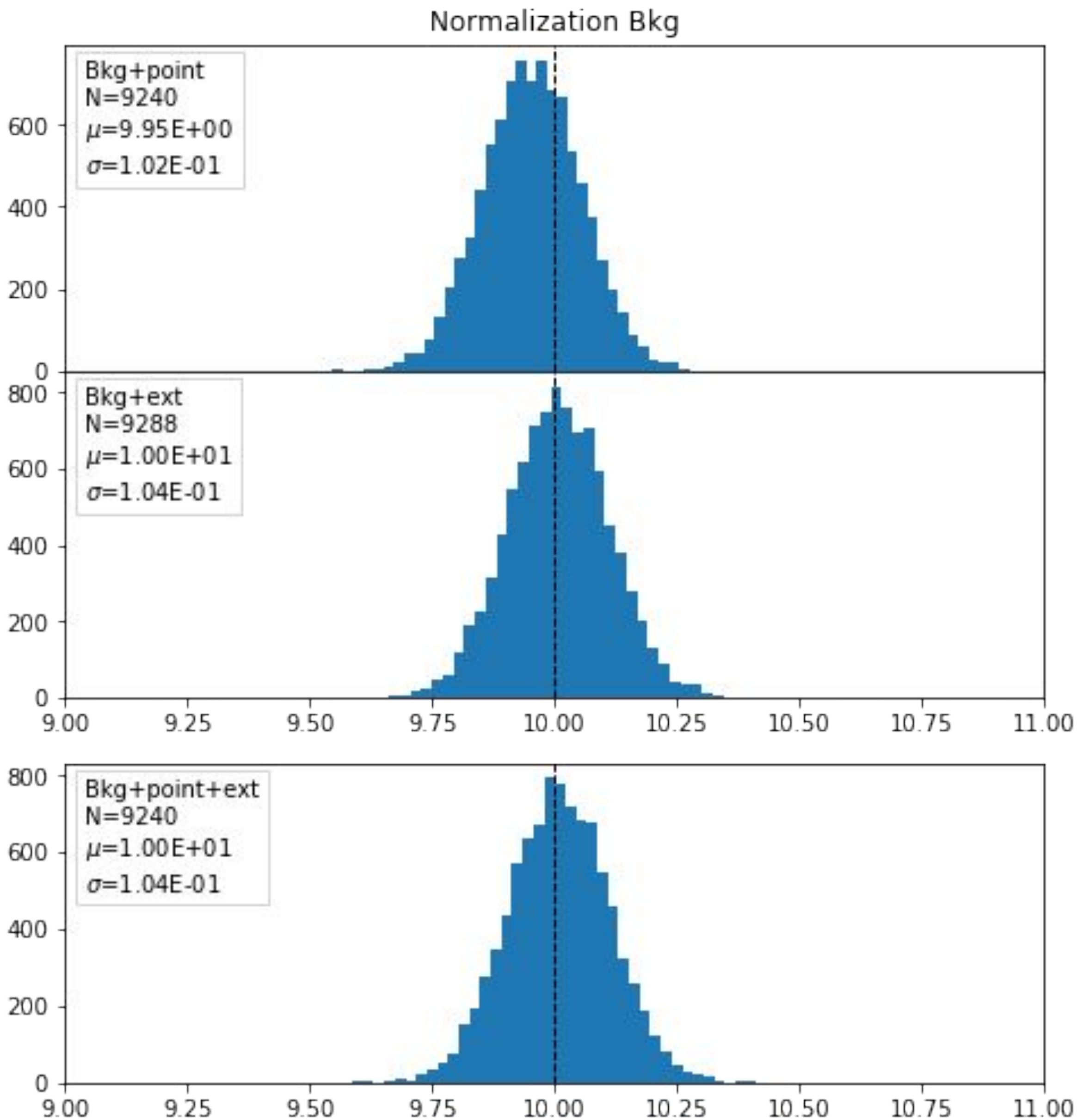

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Backup slides

- Put how the IACT do the measurements
- Remember to point out that among the IACTs HESS is the only one that can observe the GC