Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

MAX-PLANCK-GESELLSCHAFT

A spatial likelihood analysis for MAGIC skymaps

DPG Frühjahrestagung 2016, Hamburg

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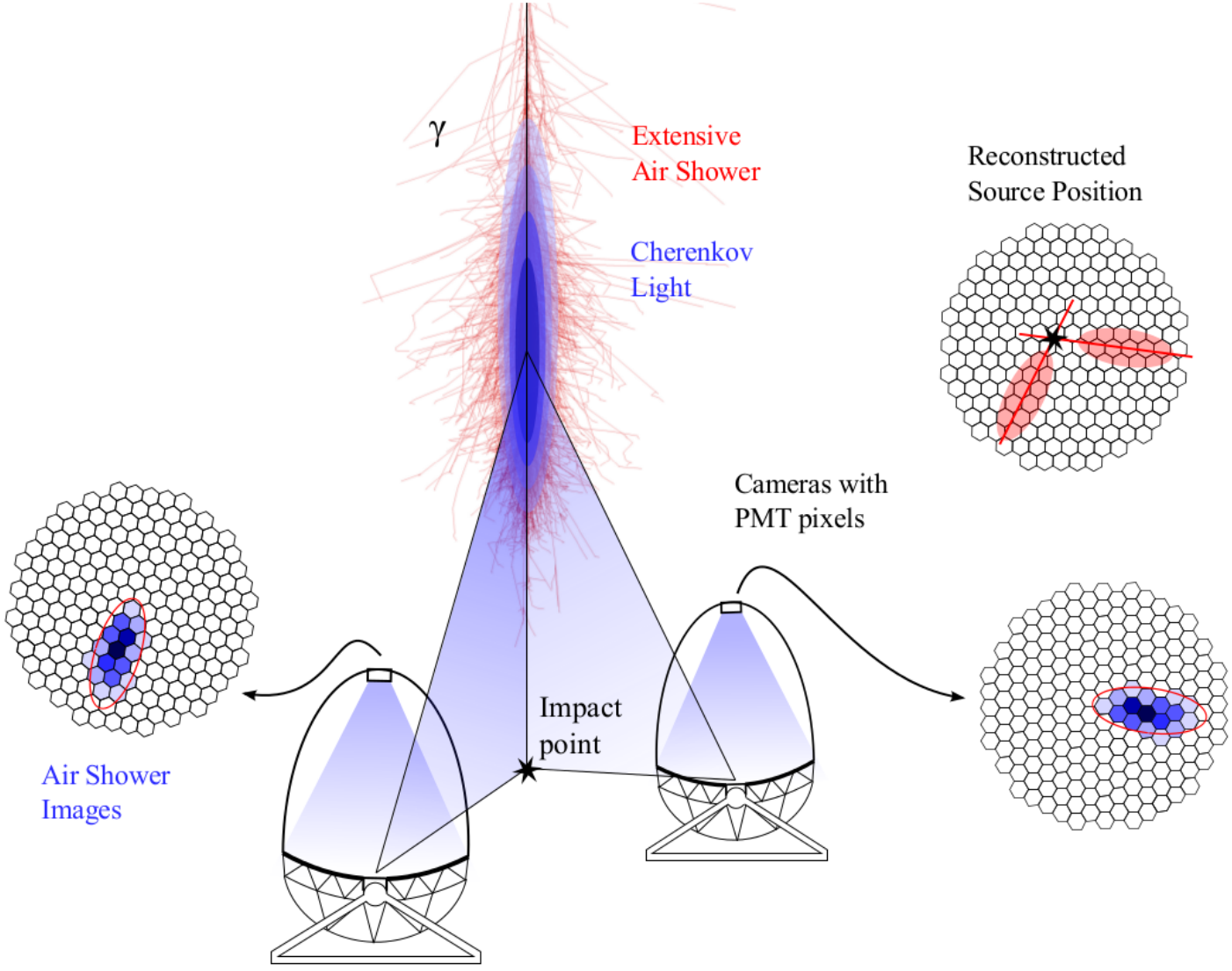
I. Vovk, and C. Fruck for the MAGIC Collaboration

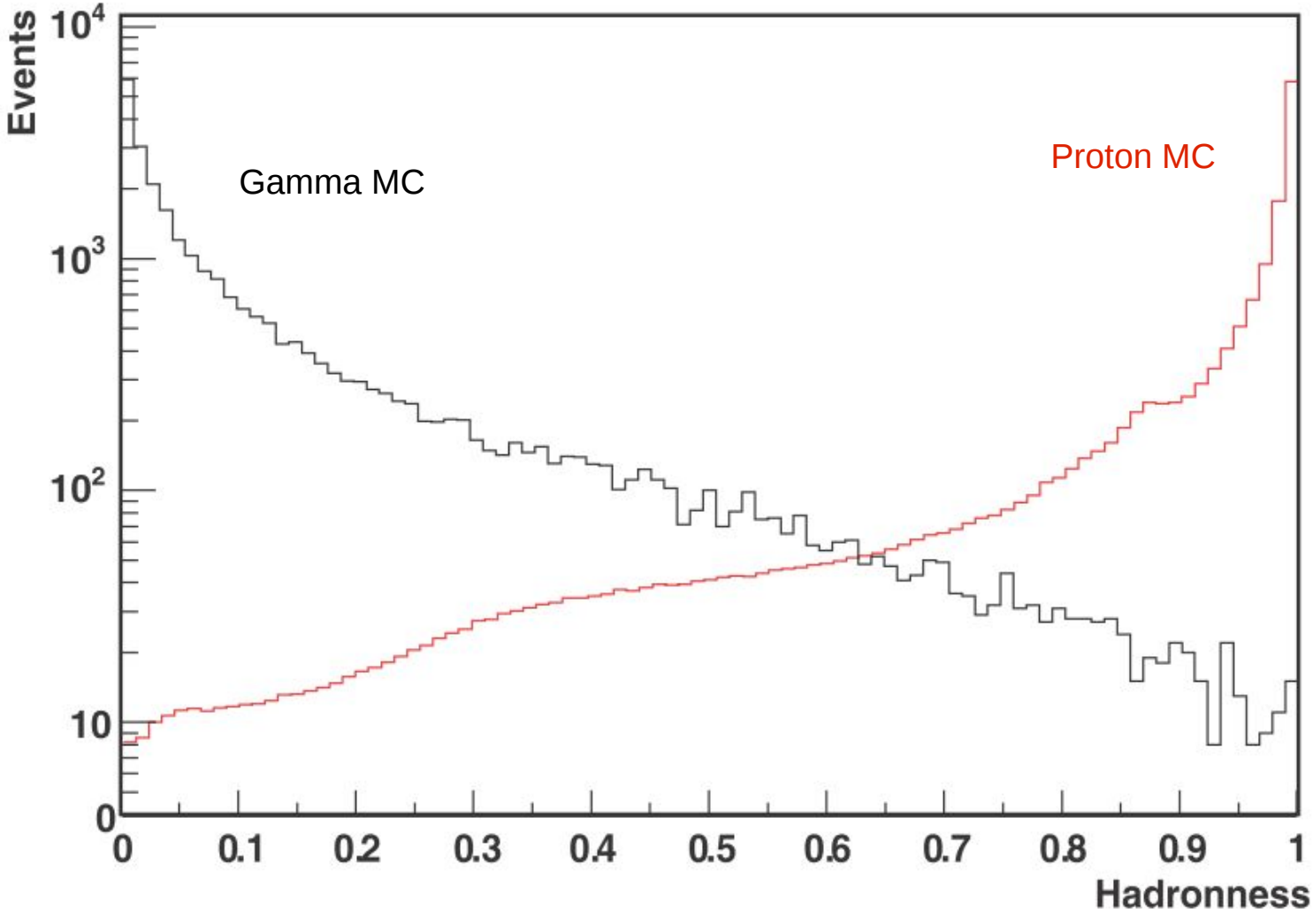
Max-Planck-Institut für Physik

03.02.2016

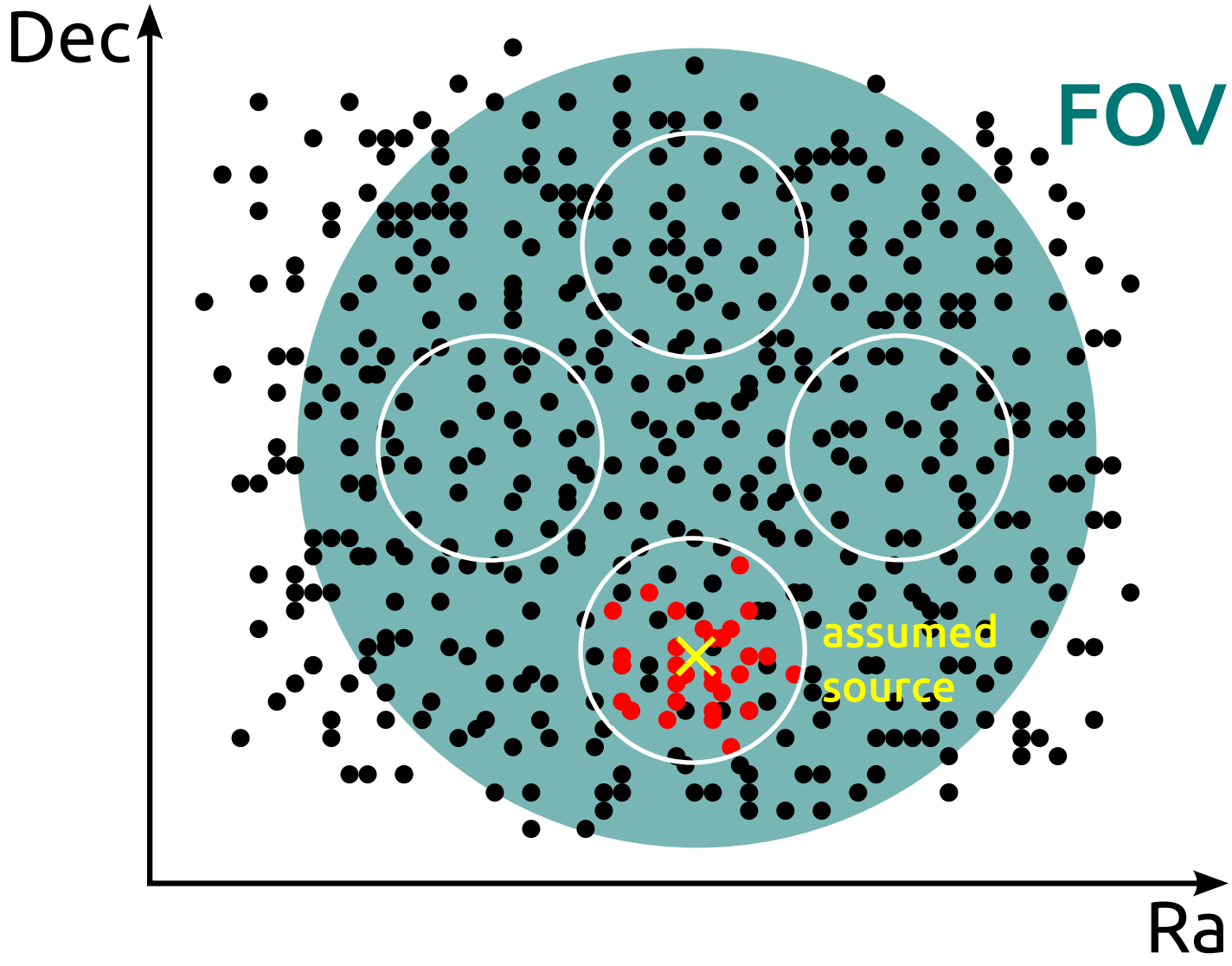
Cherenkov telescope - counting experiments



Background - no escape



Counting events - Signal & Background



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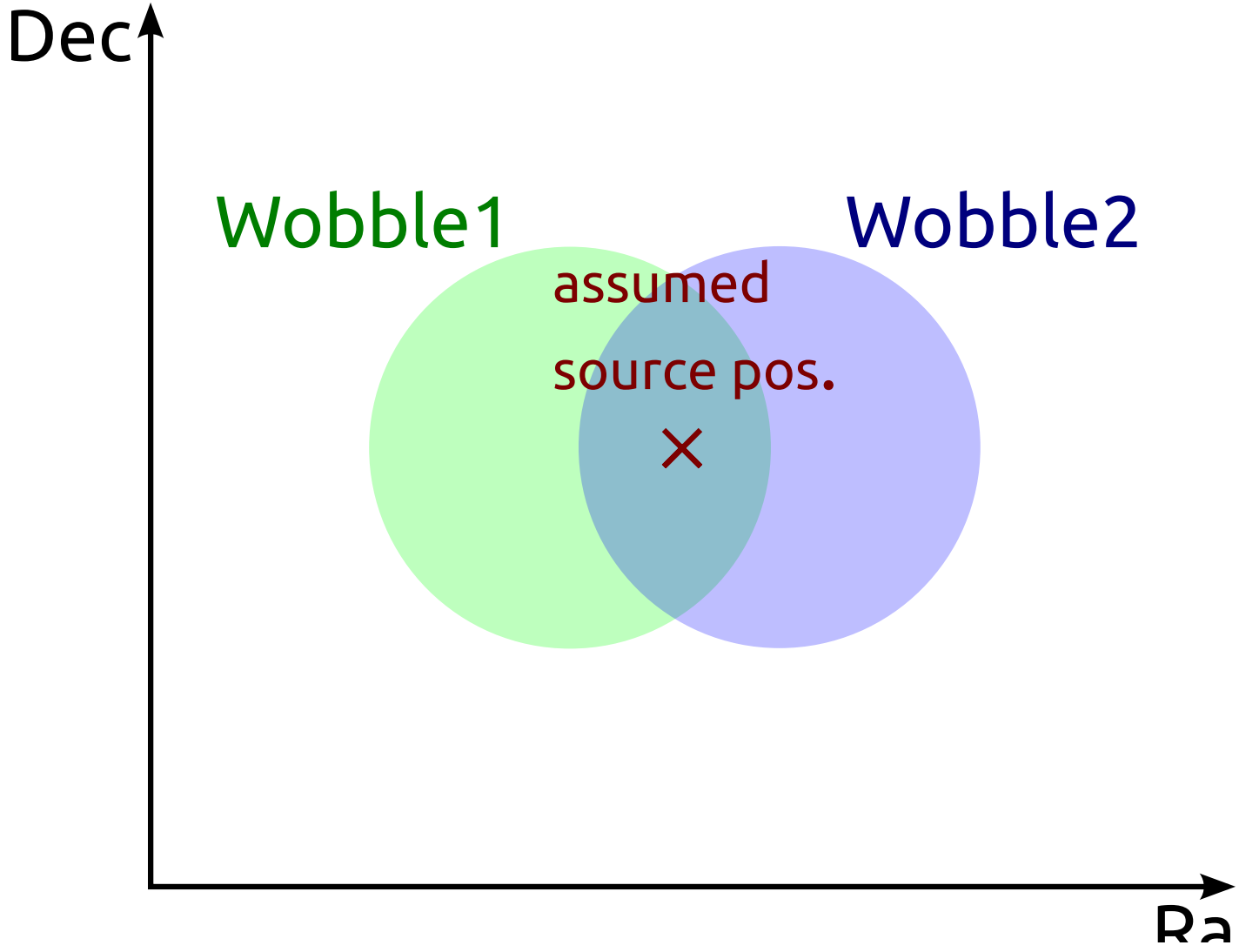
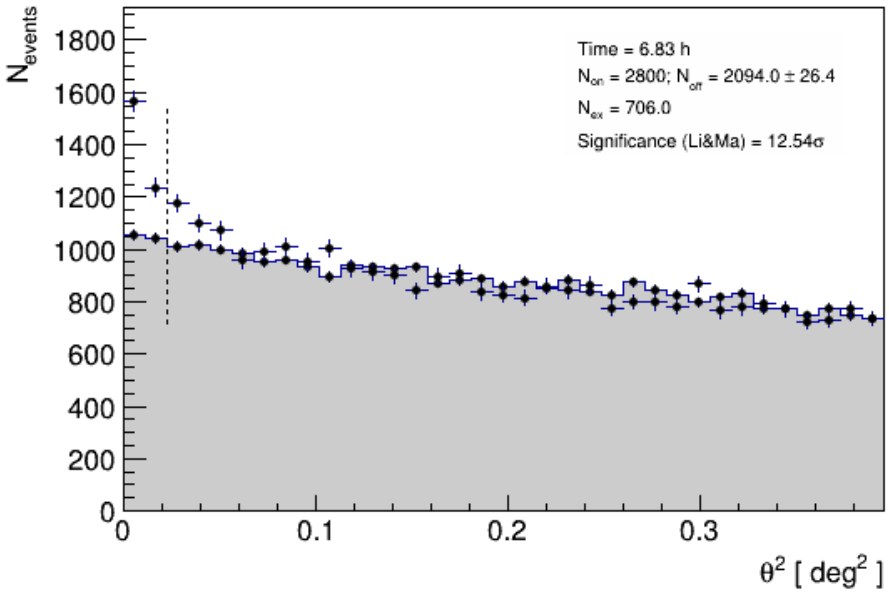


Standard Analysis

- parametrise distance of events to source
- significance based on Gaussian likelihood ratio test
- sky position of excess $\Rightarrow$ skymap
- excess events in each energy bin $\Rightarrow$ spectrum



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$$S_{Li,Ma} = \sqrt{2}\left\{ N_{on} \ln\left[\frac{1+\alpha}{\alpha}\left(\frac{N_{on}}{N_{on}+N_{off}}\right)\right] + N_{off} \ln\left[(1+\alpha)\left(\frac{N_{off}}{N_{on}+N_{off}}\right)\right]\right\}^{\frac{1}{2}}$$

Li,Ma ApJ 1983 272 317

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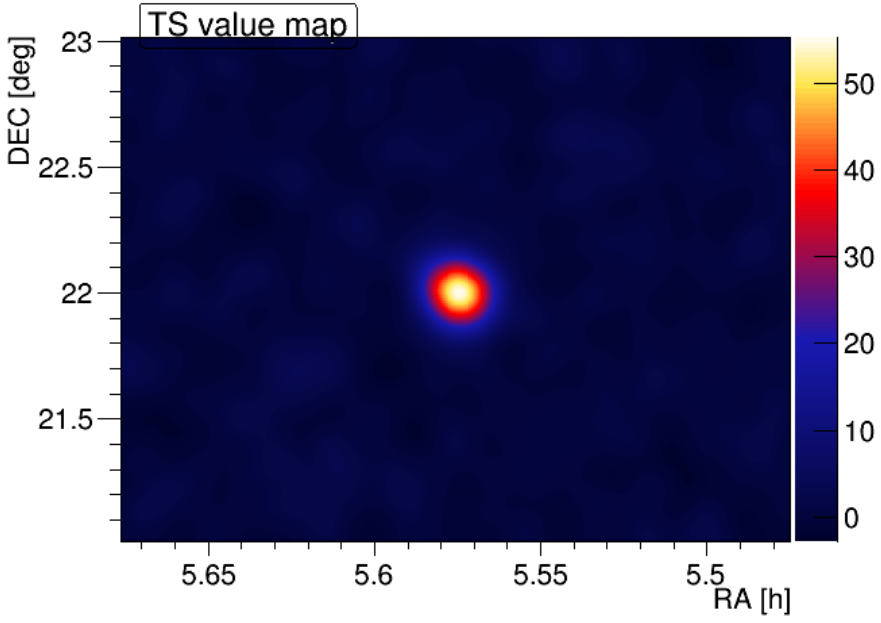

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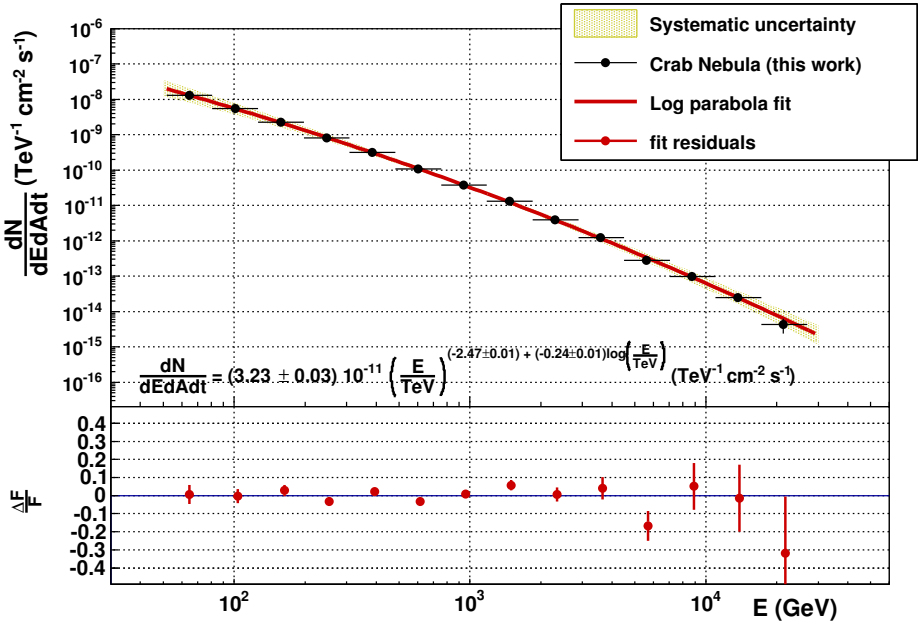
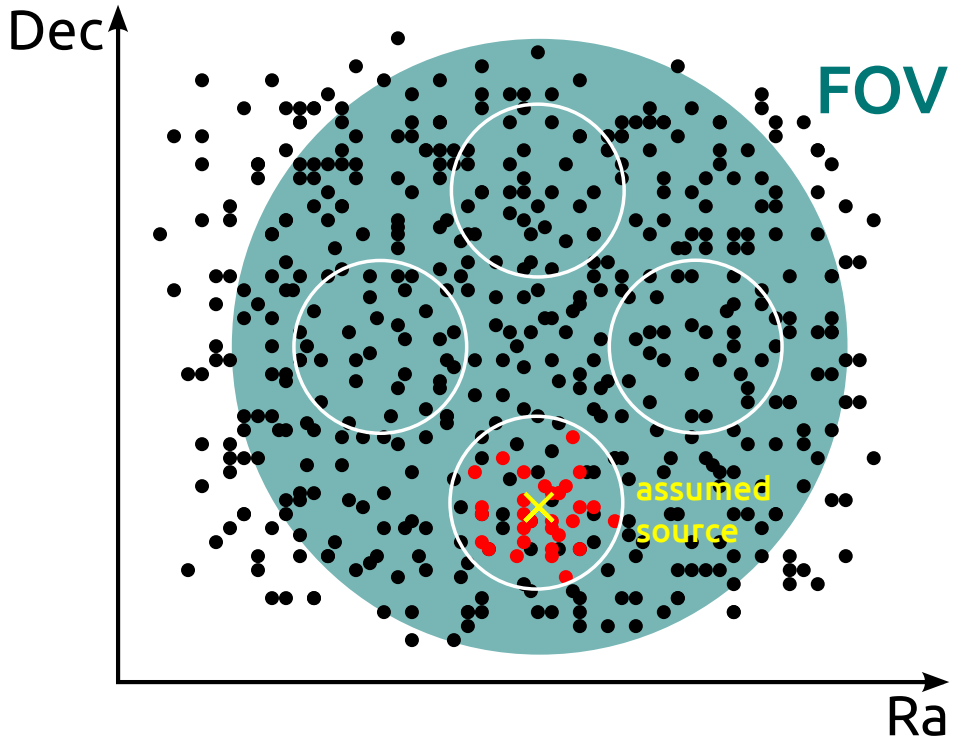


Aleksić et al. JHEAp 2015 5 30A

Issues of the “classical” approach

- θ^2 requires source to be roundish
- source extends beyond wobble distance
- overlapping sources



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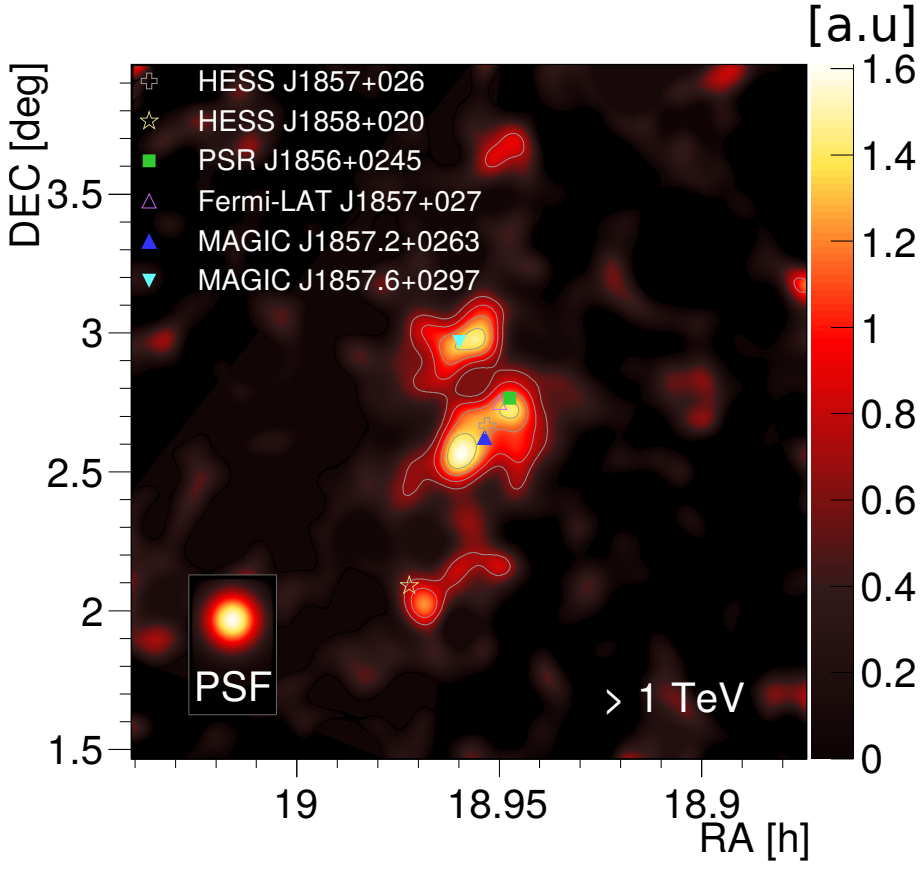
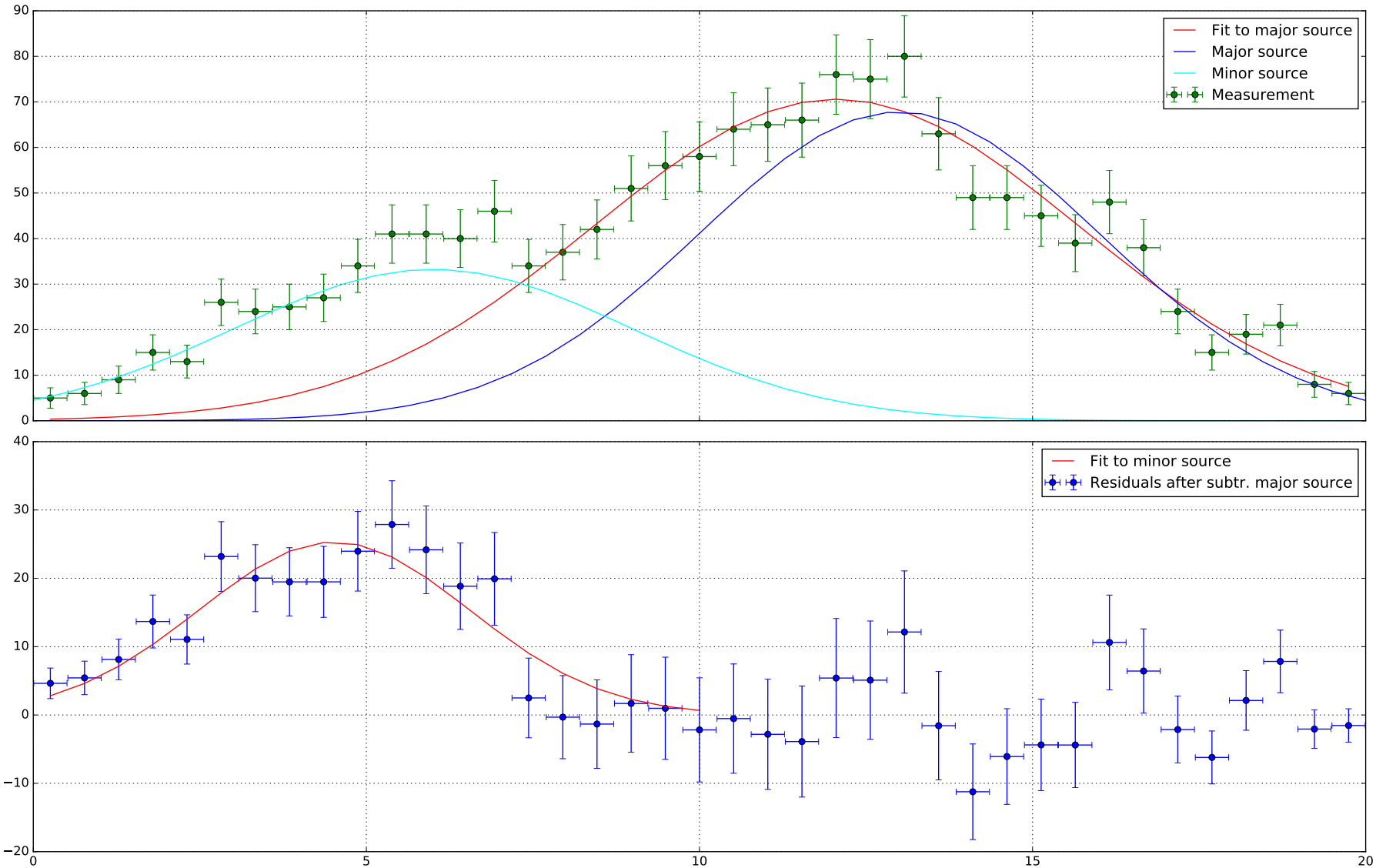


Aleksiċ et al. A&A 571A 96M

Overlapping sources or sub-structures



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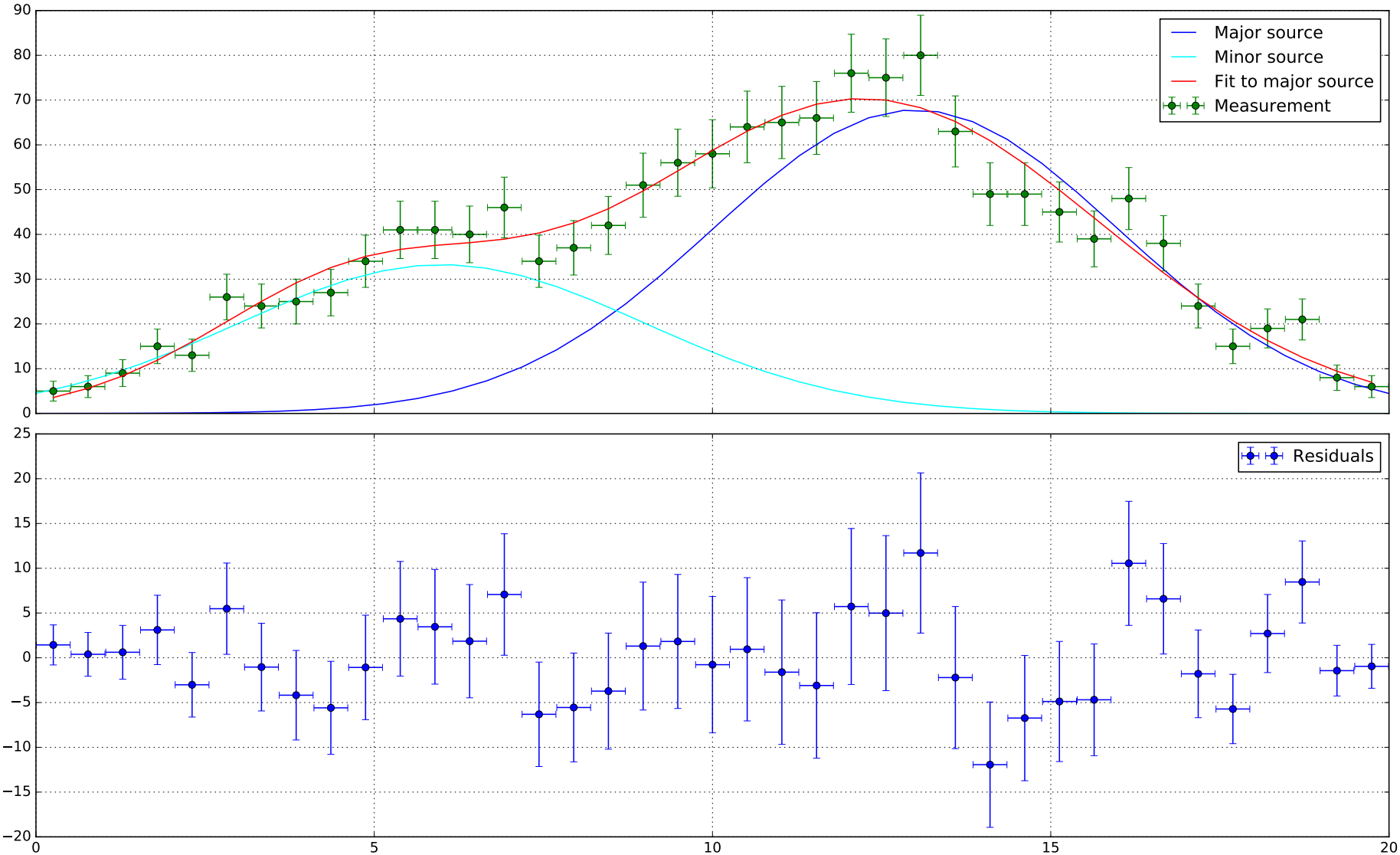


Poisson likelihood

What to fit?

$$\ln L = \sum_{ij} n_{ij} \ln\left(\theta_{ij}\right) - \sum_{ij} \theta_{ij} - \sum \ln(n_{ij}!)$$

with measured counts n in bin (i, j) and expected value of θ_{ij}.

Likelihood ratio test

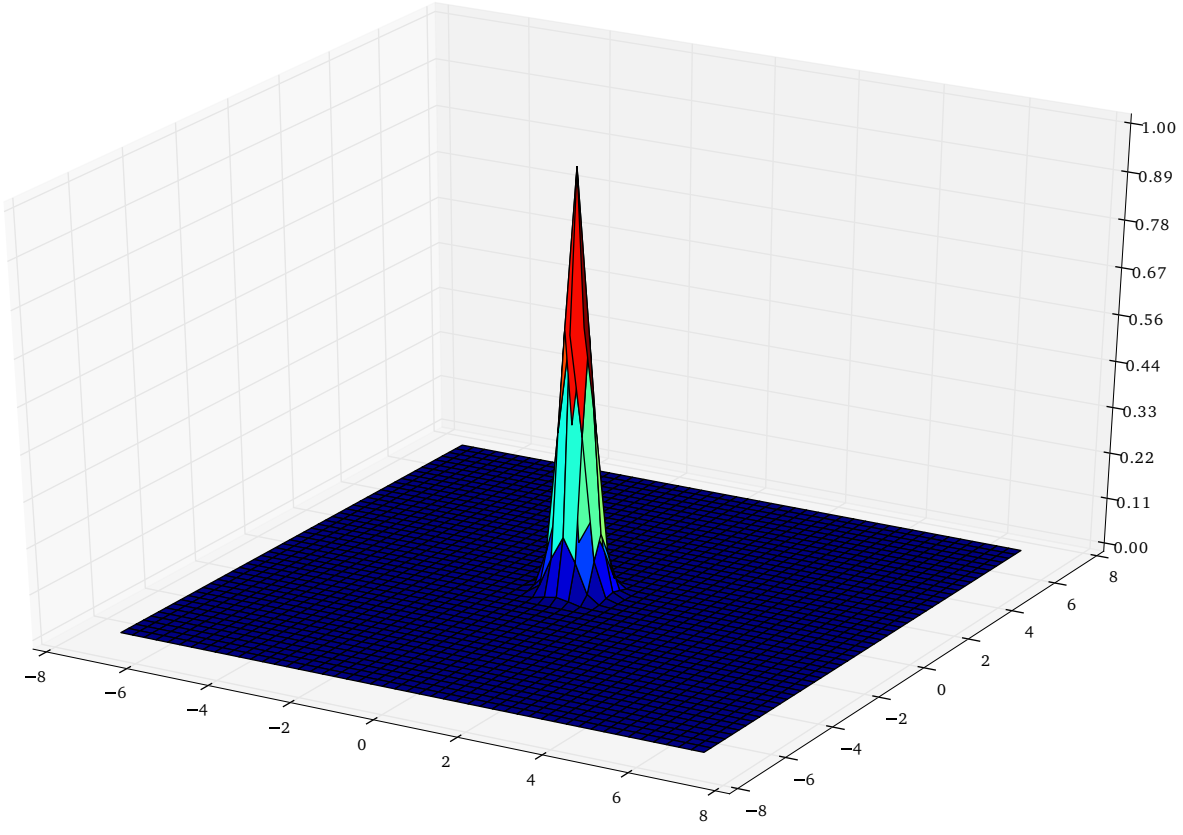
$$T_s = -2\left(\ln L_0 - \ln L_1\right)$$

$\sim \chi^2_n$ distributed (Wilk's theorem)

Fermi-LAT like approach: Mattox et al. ApJ 1996 461 396M

How to construct the model

- source model
- convolve with PSF
- add background
- scale with acceptance



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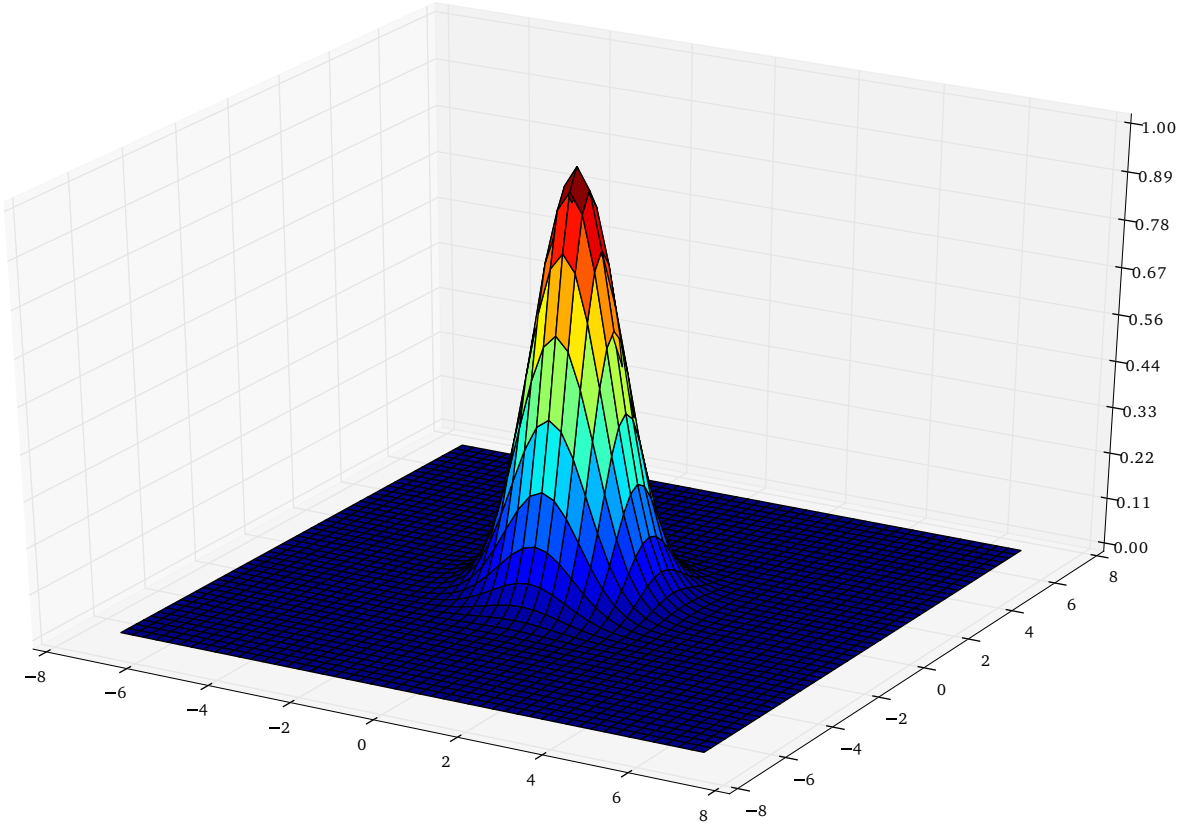

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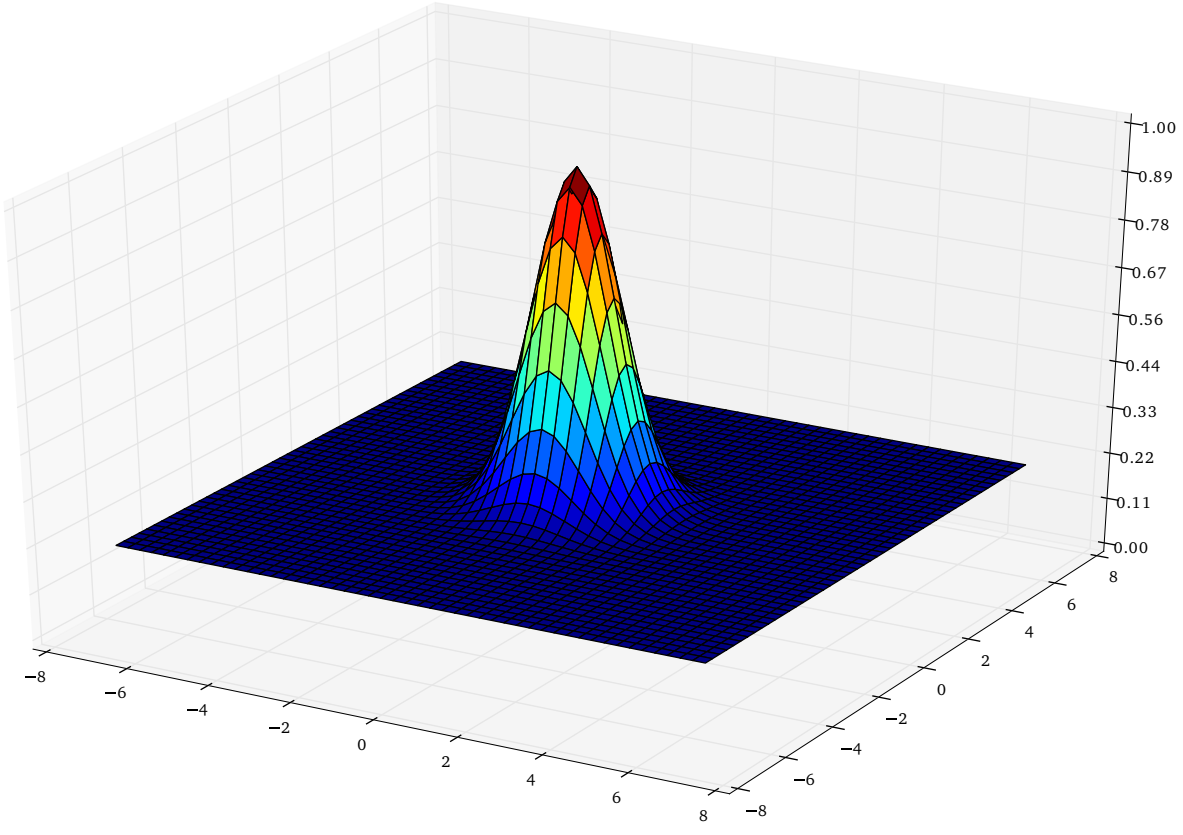

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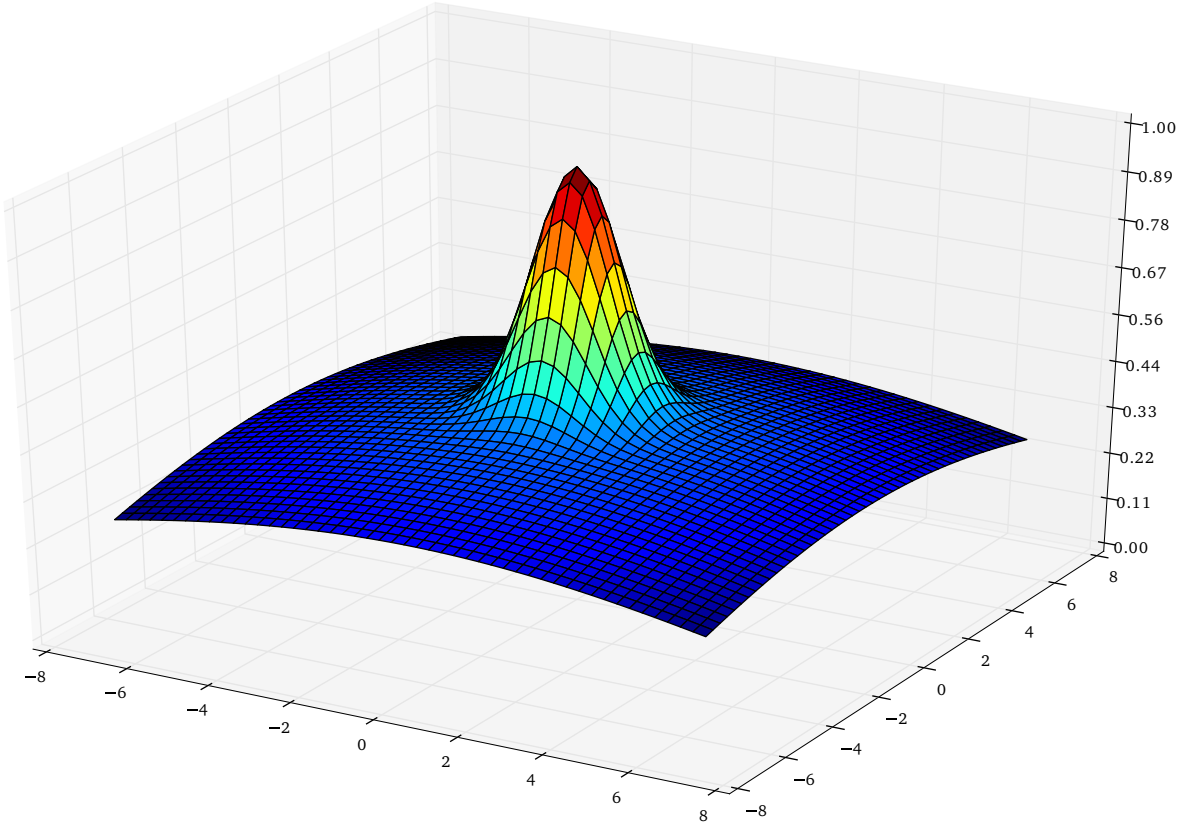
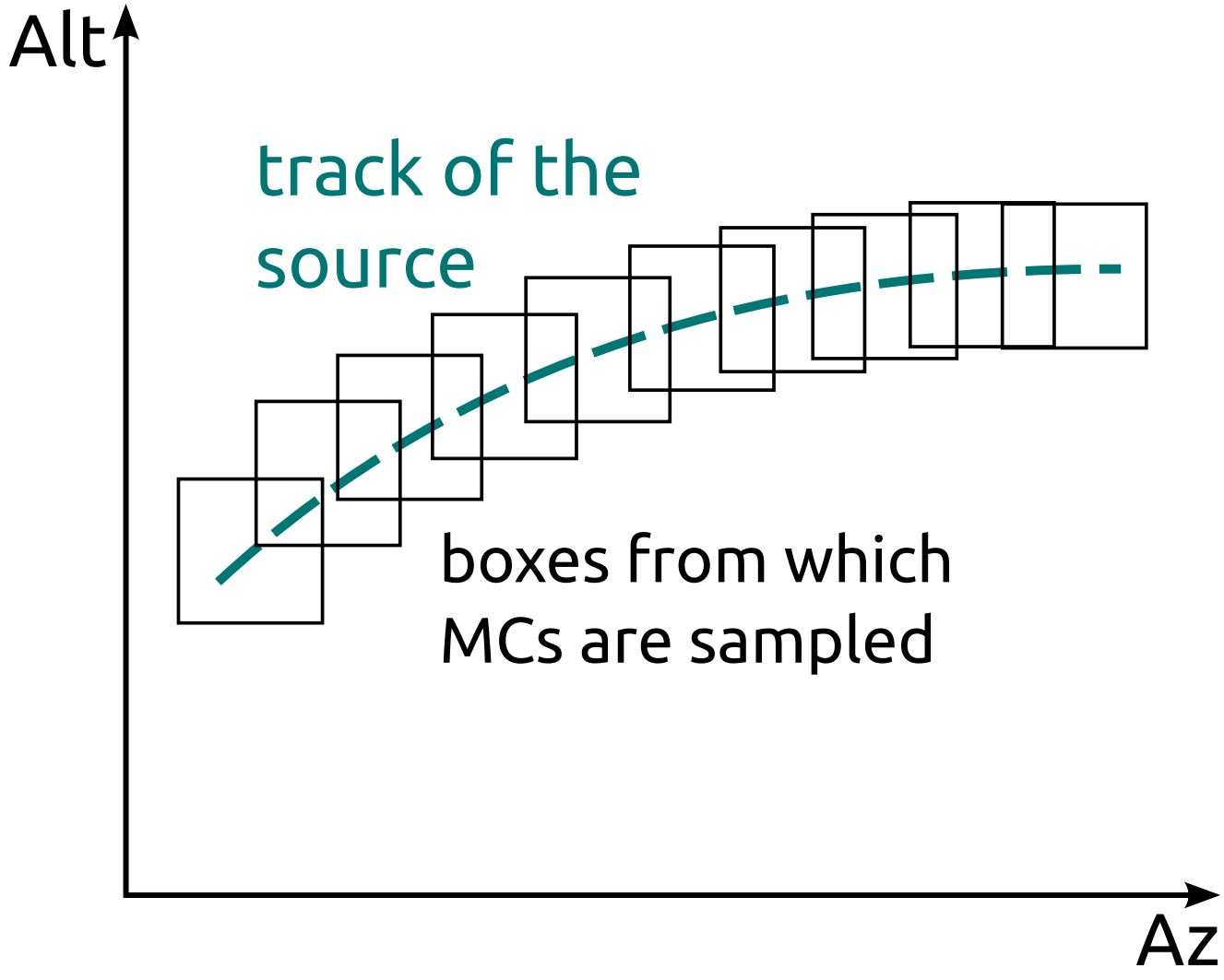
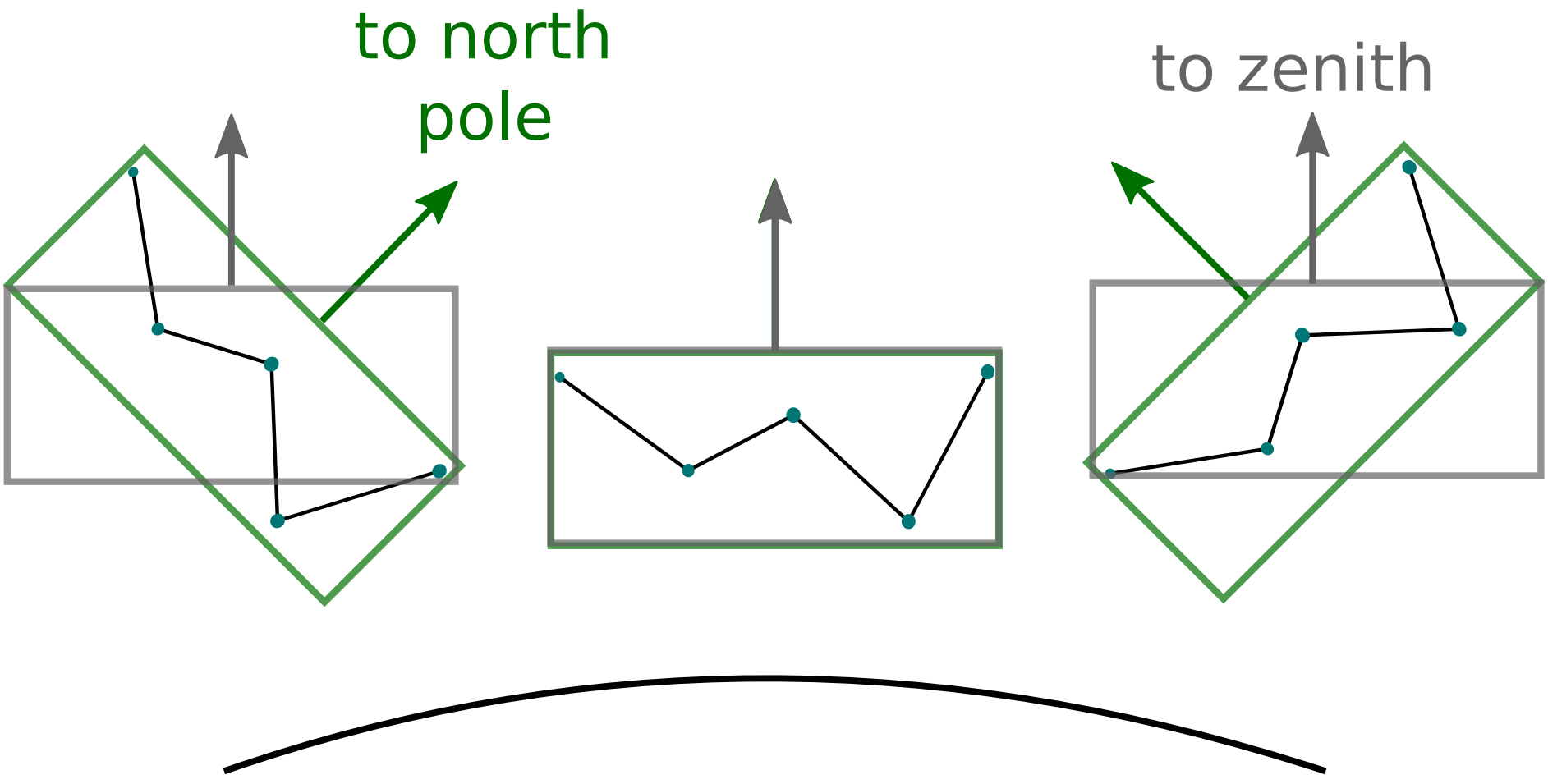


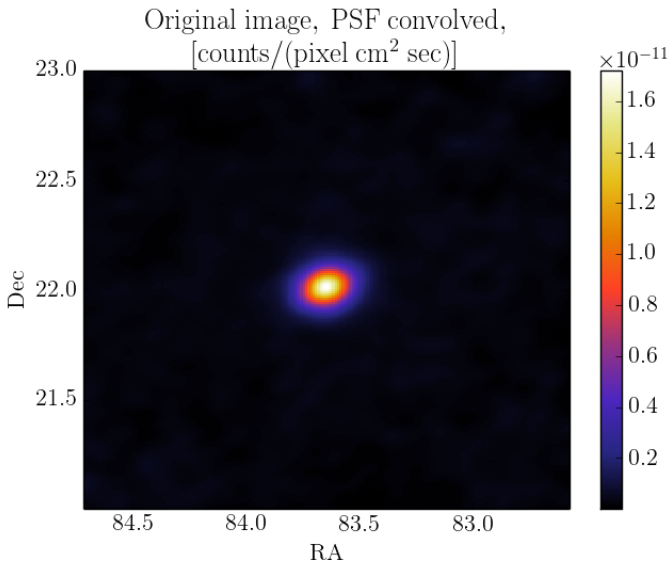
Get the IRF right $\Rightarrow$ Alt/Az dependence

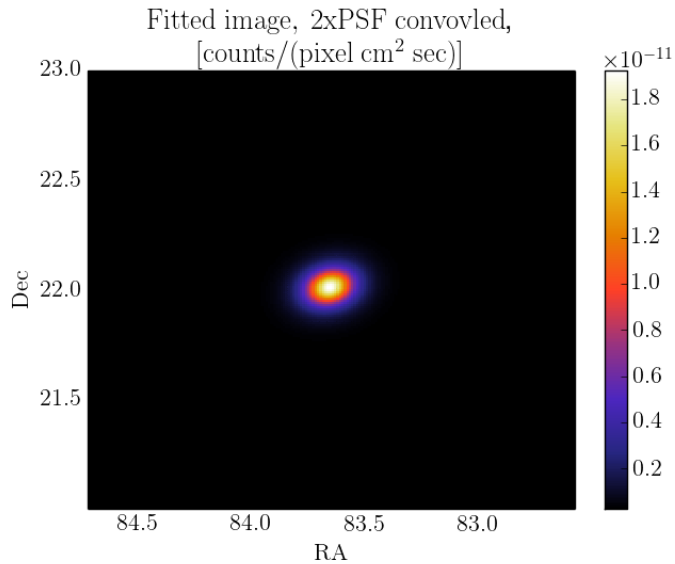


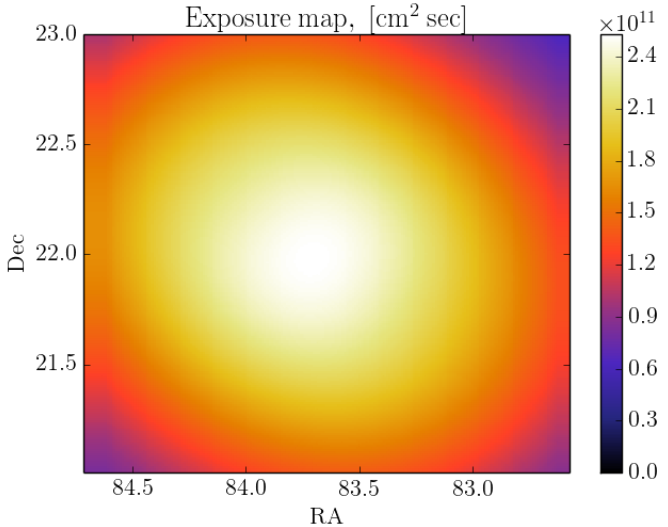
Mind rotational frames - Alt/Az vs. Ra/Dec

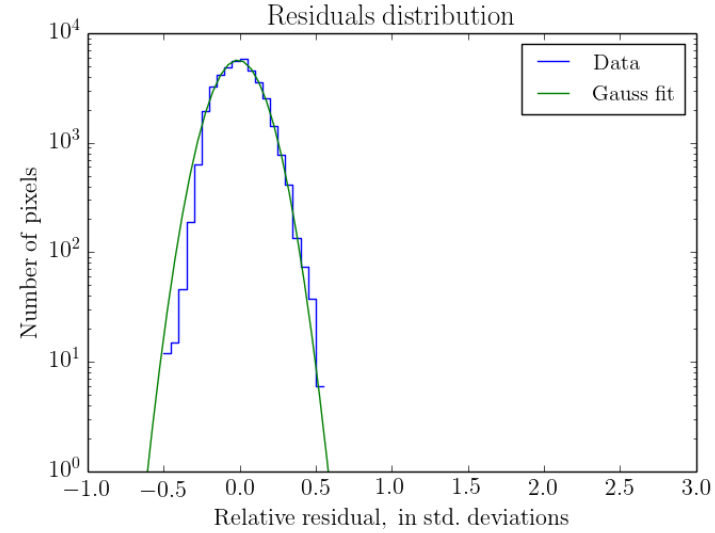


Example on the standard candle - Crab Nebula









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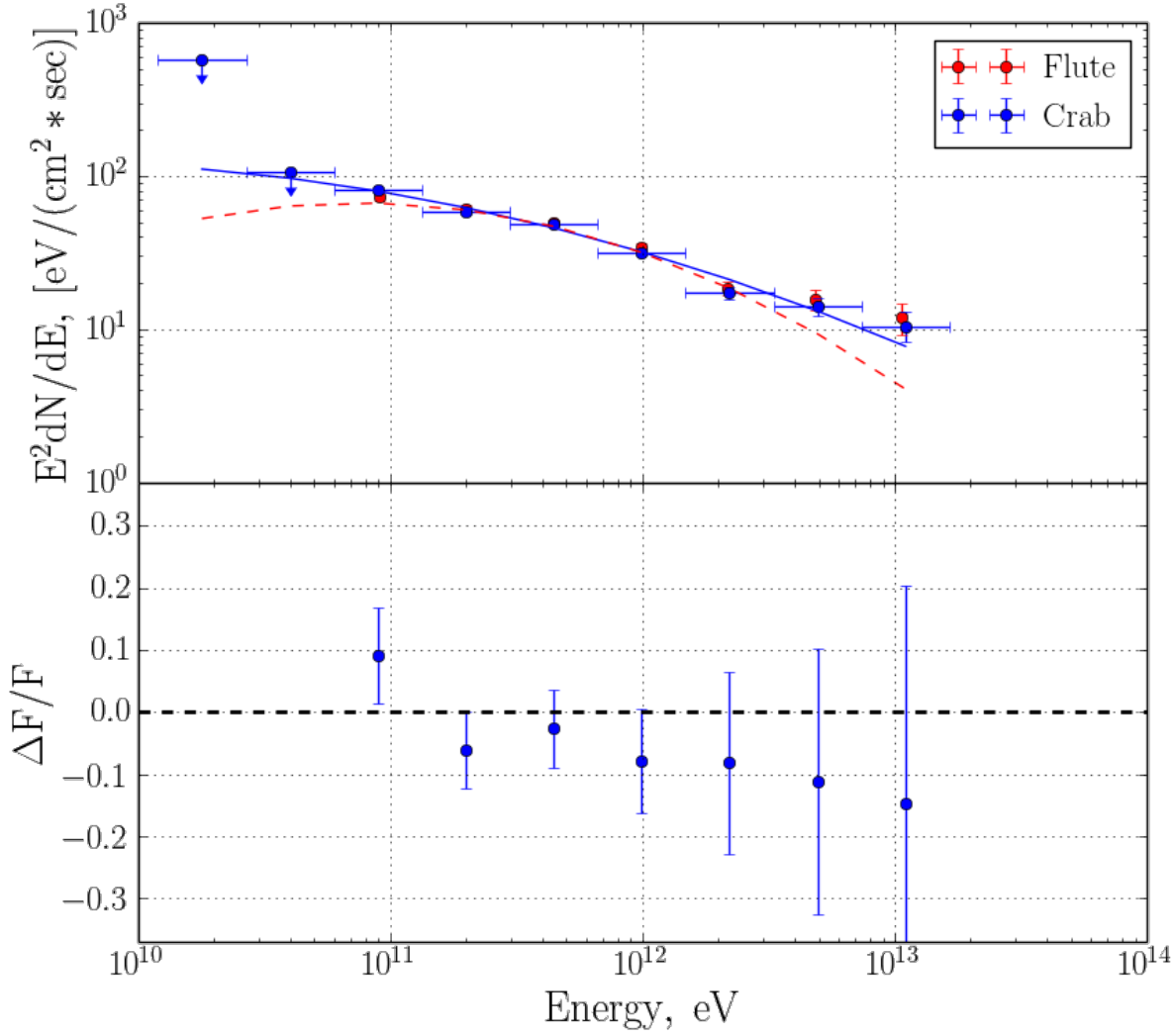

Thank you for your attention and interest!

- “classical” analysis method has weaknesses for non-point sources
- Poisson likelihood offers versatile and consistent approach
- construction of IRF and models non-trivial task