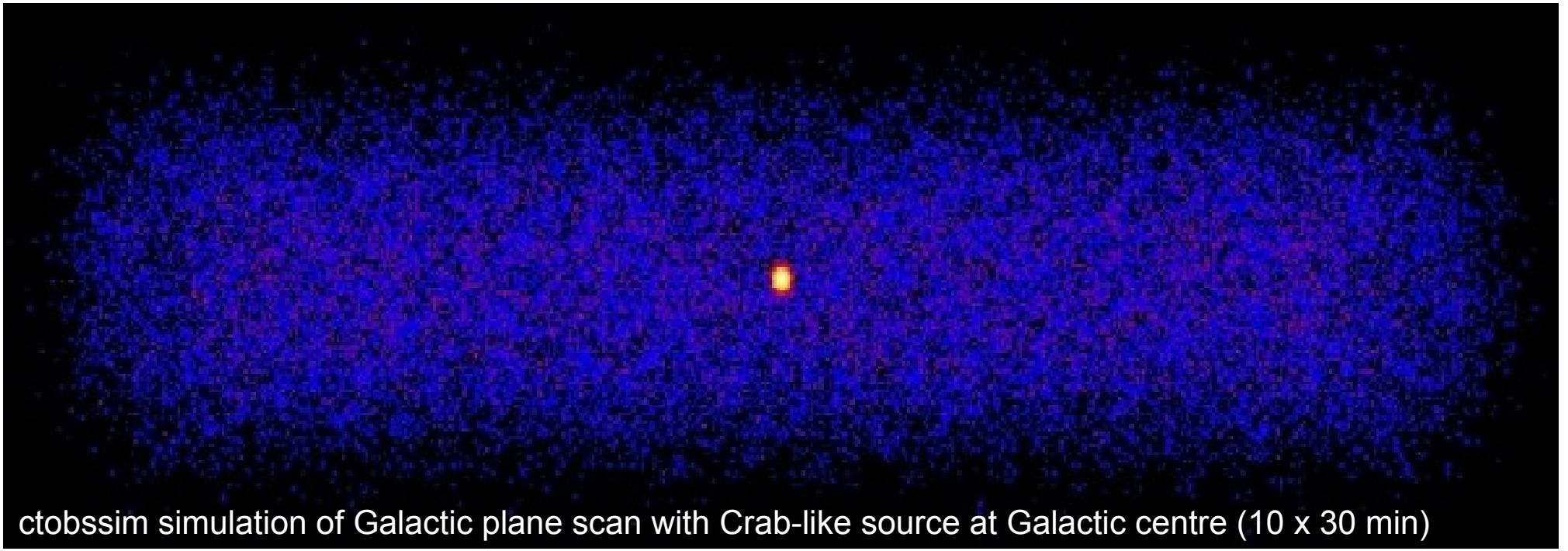
cta tools - recent developments

cherenkov telescope array



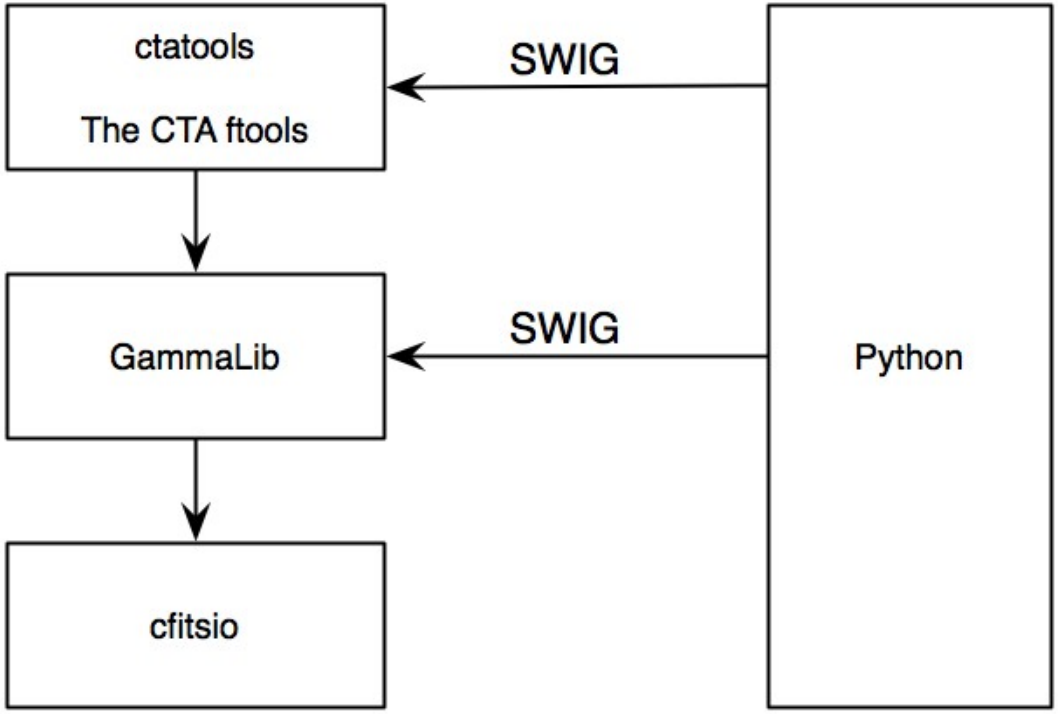
ctobssim simulation of Galactic plane scan with Crab-like source at Galactic centre (10 x 30 min)

Jürgen Knödlseder

irap
astrophysique & planétologie

CTA high-level data analysis

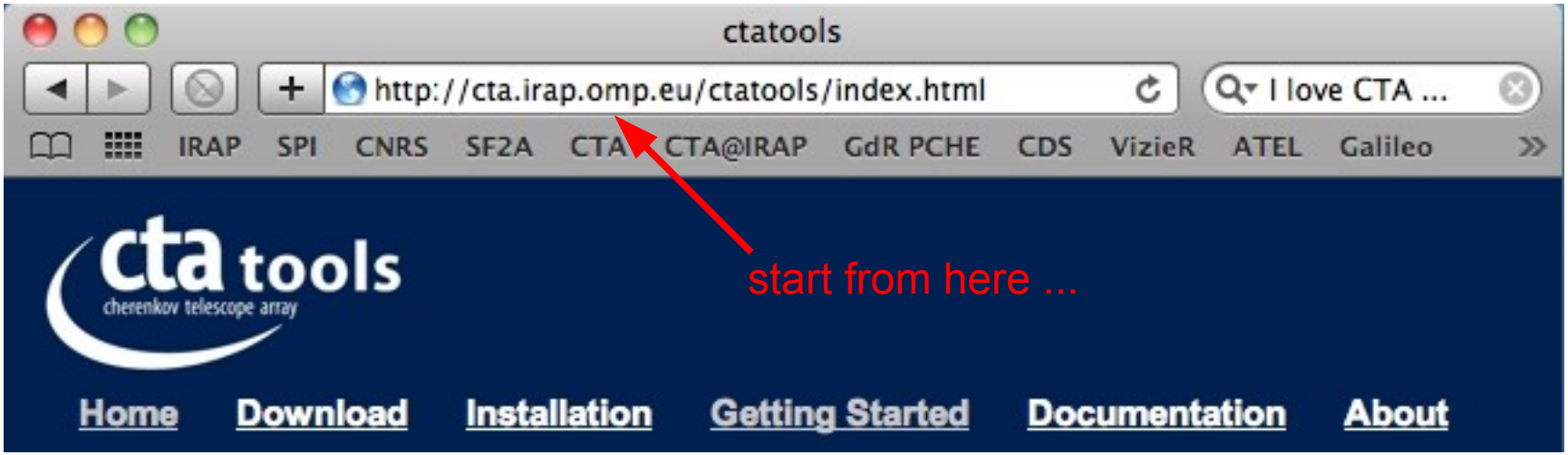
Science analysis "à la Fermi/LAT" - starting from Karl's event list FITS files ...



ctatools = ftools for CTA data analysis

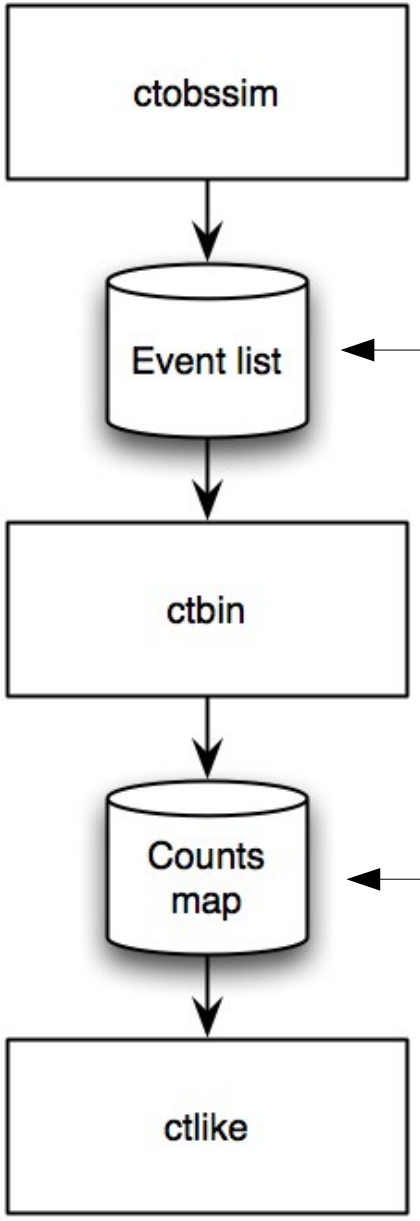
Based on open source versatile gamma-ray astronomy GammaLib toolbox
(instrument independent analysis tools)

Versatile usage:
- command line ftools
- put ftools in script (e.g. shell)
- use ctatools directly from Python
- use CTA interface in GammaLib directly from Python



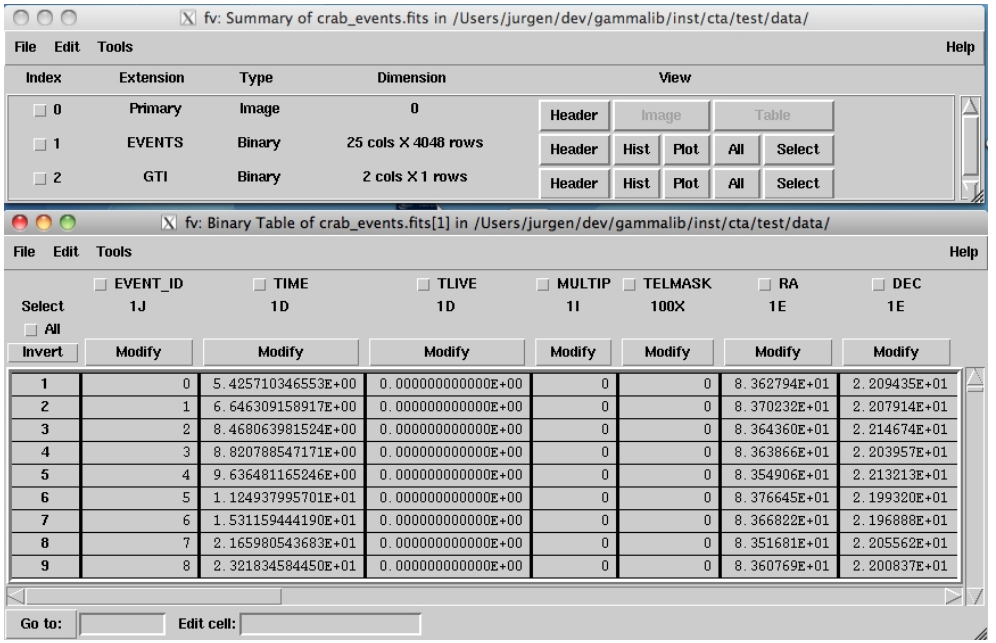
Binned analysis flow

CTA event list simulator for single array pointings

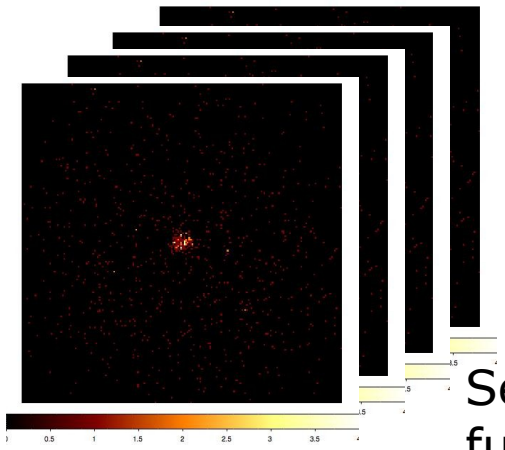


Binning of events in direction (RA,DEC or GLON,GLAT) and logarithmic energy

Maximum likelihood fitting of source model (spatial & spectral)



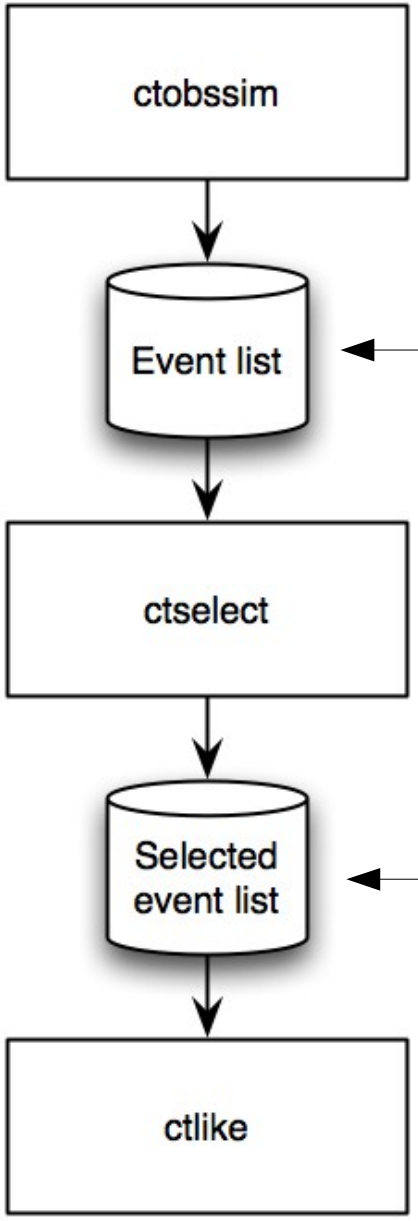
Event list



Set of counts maps as function of energy (3D data cube)

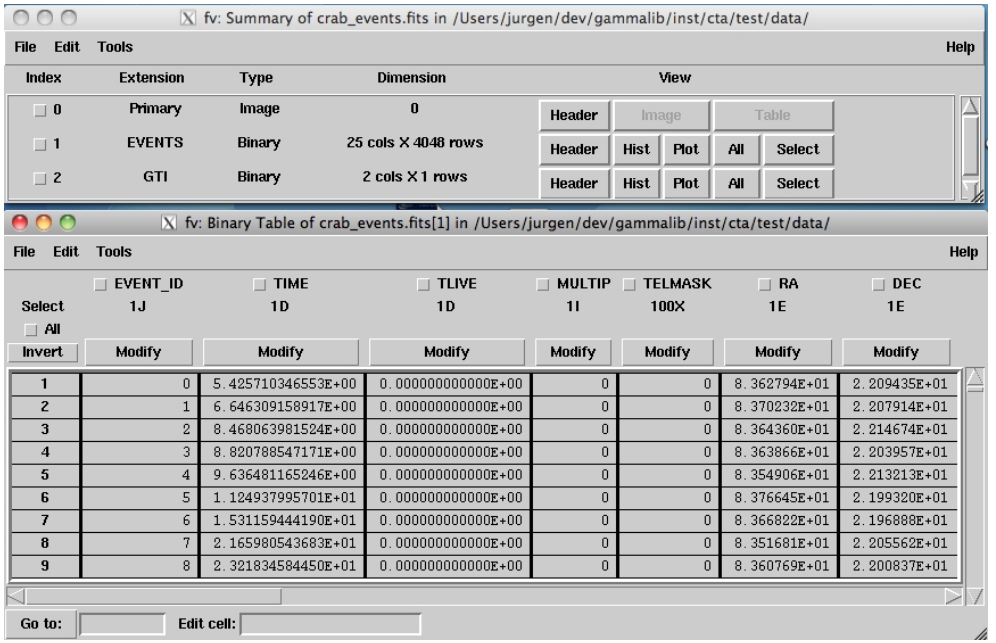
Unbinned analysis flow

CTA event list simulator for single array pointings

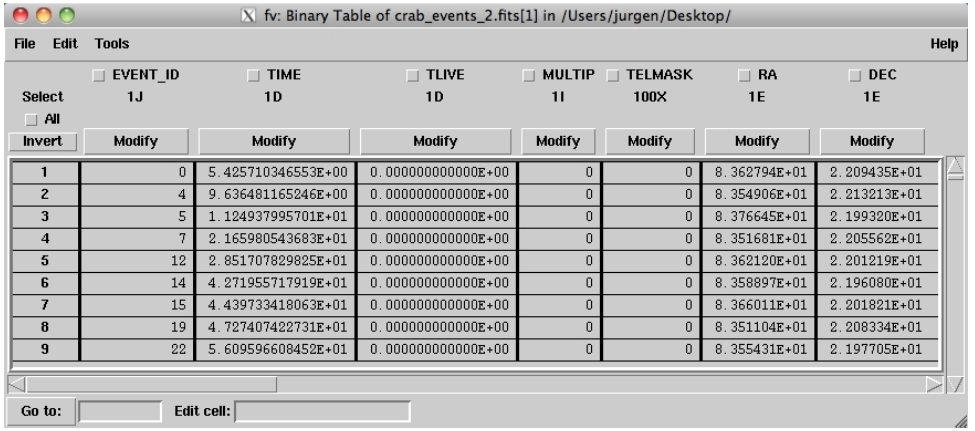


Selection of region of interest (acceptance cone, time interval, energy range)

Maximum likelihood fitting of source model (spatial & spectral)

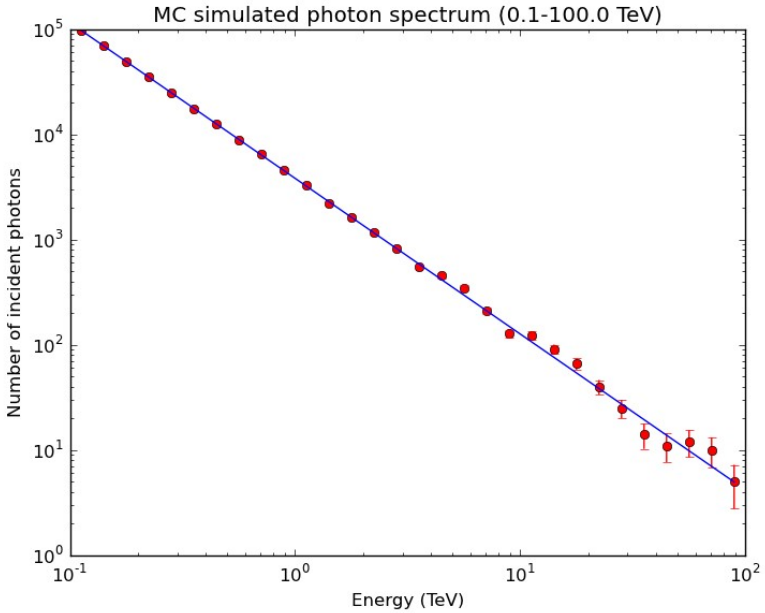


Event list

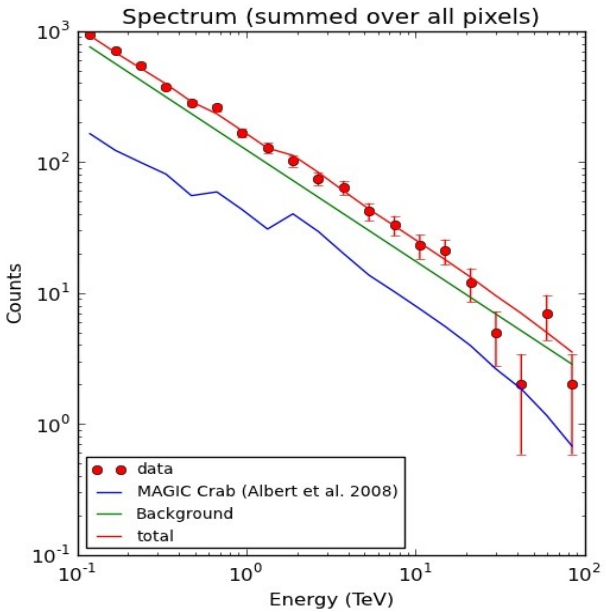


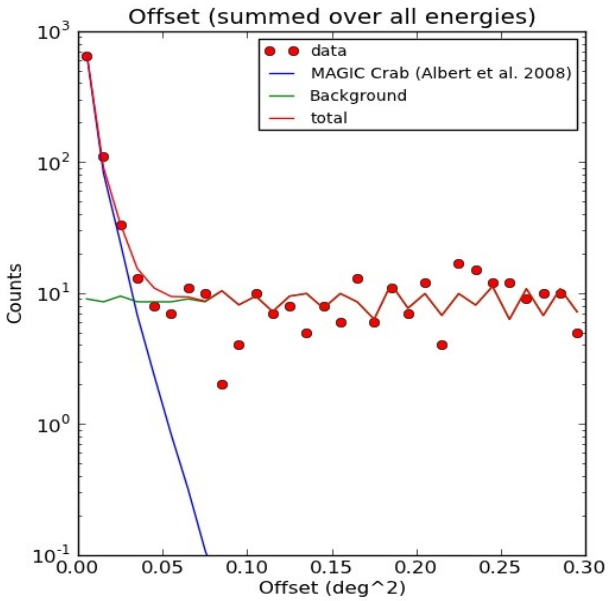
Selected event list

ctobssim - principle

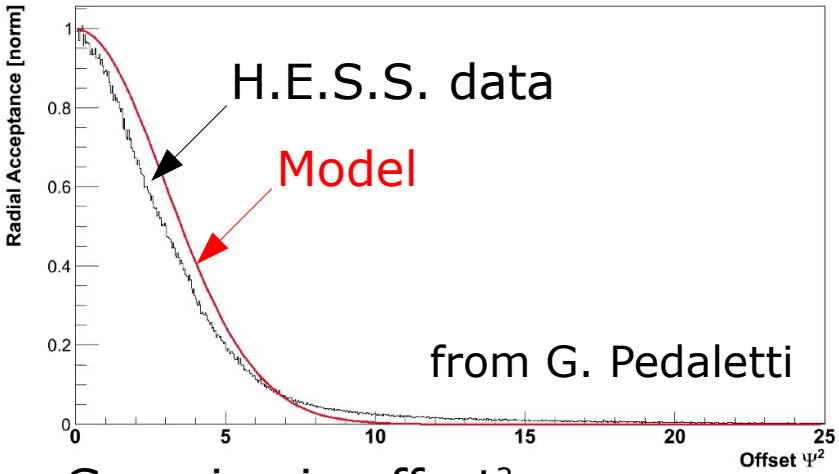


Step 1: Throw photons accordingly to a spectral law and spatial distribution





Radial acceptance model



Gaussian in offset^2

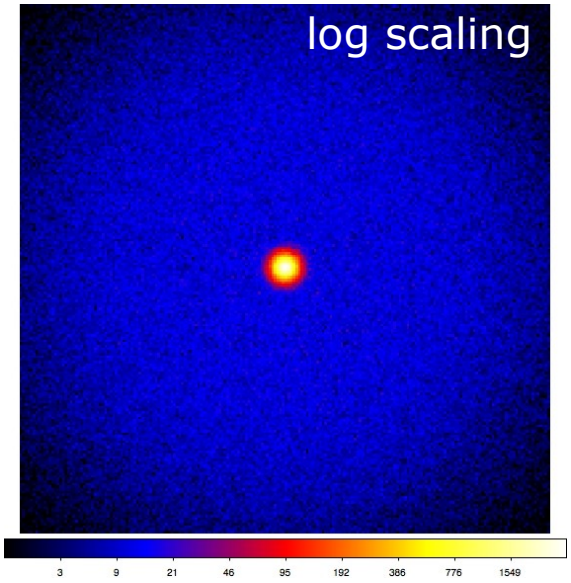
Step 2: Accept photons (using MC decision) depending on energy dependent effective area and point spread function (based on Konrad's performance files)

Step 3: Add background counts based on MC sampling of radial acceptance model

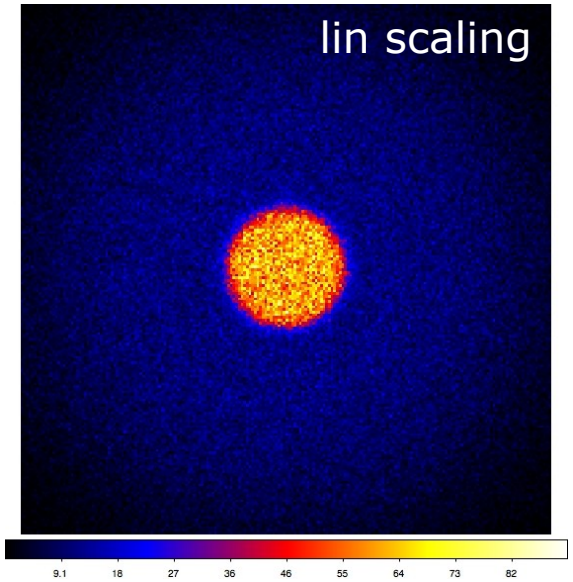
ctobssim - models

50 h, source with Crab flux, background from configuration E

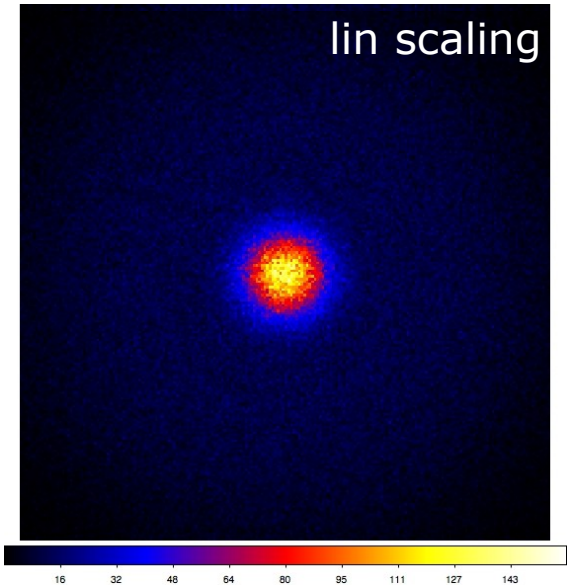
Point source



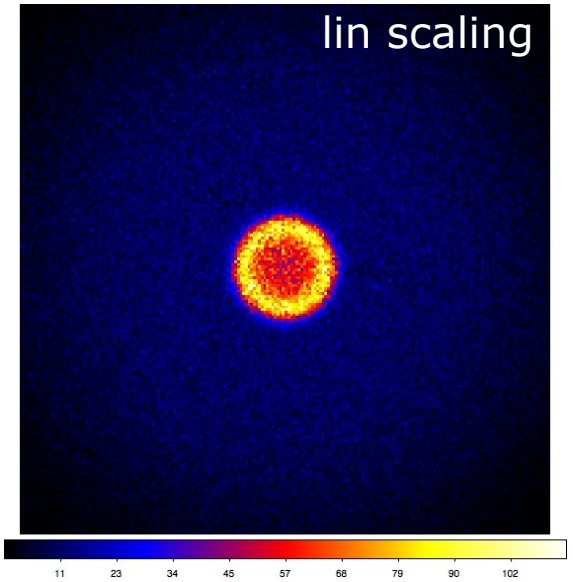
Disk source



Gaussian source



Shell source



Spatial models
Choice of 4 axisymmetric parametric models

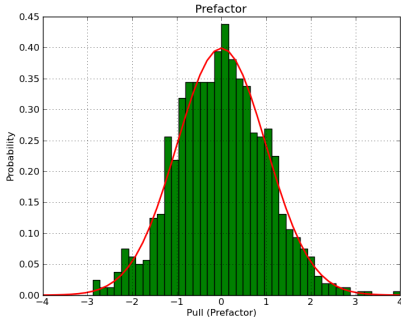
Spectral models
Two flavours of single power law
(intensity or flux normalised – PowerLaw and PowerLaw2 for Fermi/LAT users)

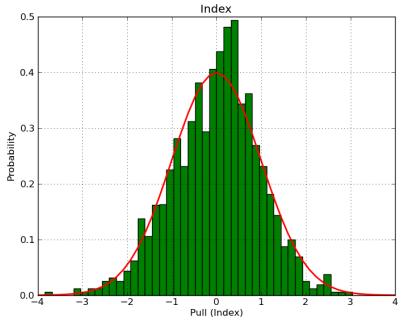
ctlike - validation

Pull distributions: (fitted-expected)/error

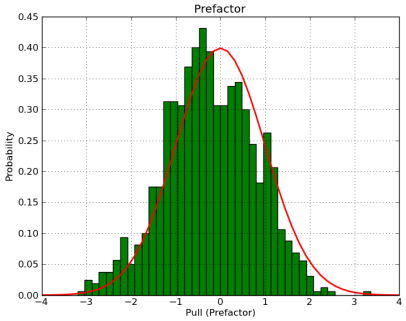
30 min, Crab on-axis, background from configuration E

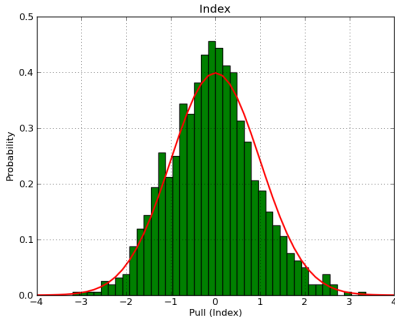
Binned ctlike (20 logarithmically spaced energy bins; 0.1-100 TeV)

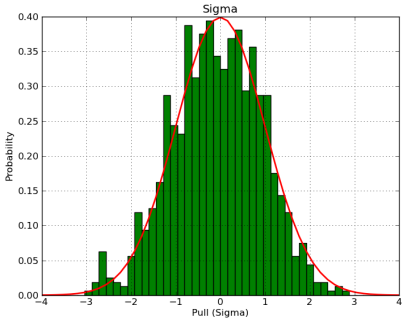




Source

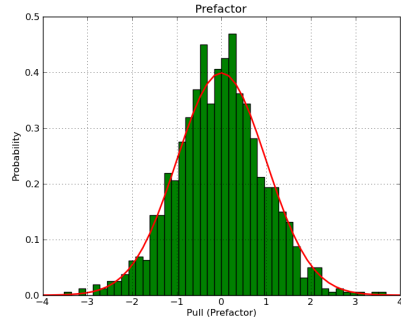


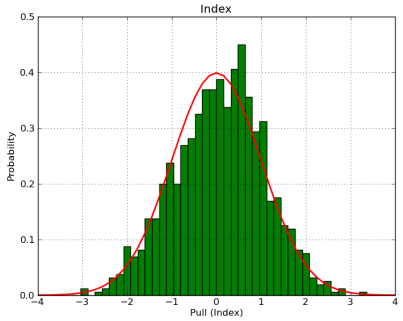




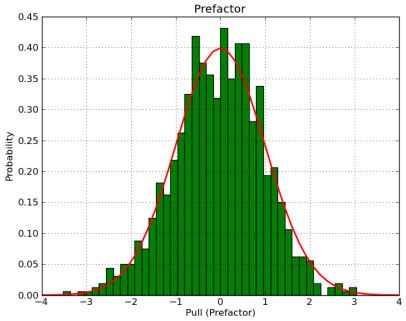
Background

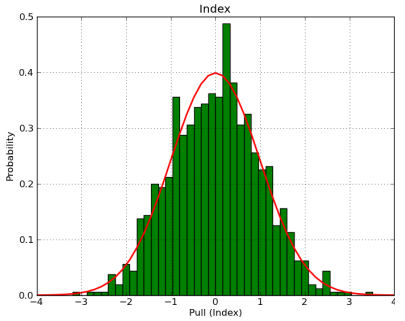
Unbinned ctlike (3° ROI)

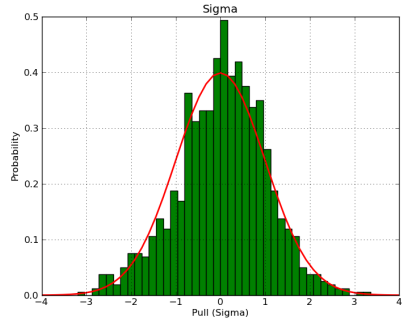




Source







Background

Pull distribution script from Christoph Deil

ctlike - validation

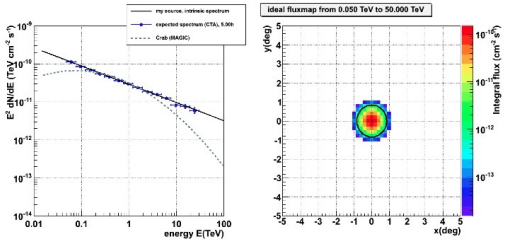
5 hour, Crab spectrum

$$\frac{dN}{dE} = 5.7\times10^{-10}\left(\frac{E}{0.3\ \mathrm{TeV}}\right)^{-2.48}\ \frac{1}{\mathrm{TeV\ cm^2\ s}}$$

← INPUT

Extension 0.25

Configuration E-IFAE-OFFSET



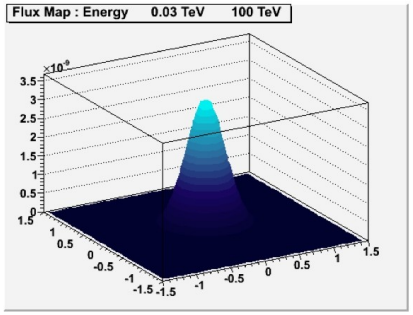
Daniel's tool v6.3 (extended)

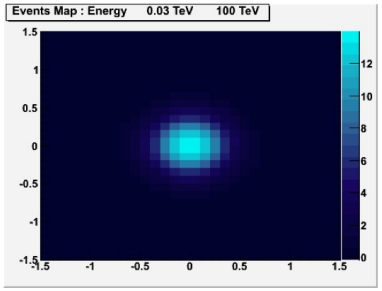
OUTPUT

$$\frac{dN}{dE} = (5.66\pm0.07)\times10^{-10}\left(\frac{E}{0.3\ \mathrm{TeV}}\right)^{-2.48\pm0.01}\ \frac{1}{\mathrm{TeV\ cm^2\ s}}$$

Significance: 75 σ

From Emma's tool v1.0





Results of the Fit

Sigma :0.25+/-0.01
SigmaPSF :0.093

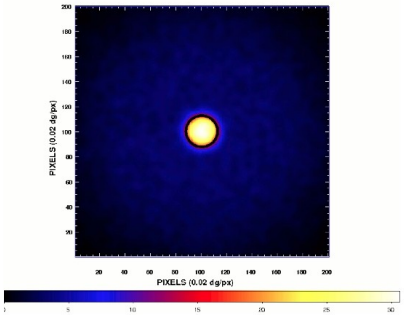
5 hour, Crab spectrum

$$\frac{dN}{dE} = 5.7\times10^{-10}\left(\frac{E}{0.3\ \mathrm{TeV}}\right)^{-2.48}\ \frac{1}{\mathrm{TeV\ cm^2\ s}}$$

← INPUT

Extension 0.25

OUTPUT



$$\frac{dN}{dE} = (5.69\pm0.06)\times10^{-10}\left(\frac{E}{0.3\ \mathrm{TeV}}\right)^{-2.49\pm0.01}\ \frac{1}{\mathrm{TeV\ cm^2\ s}}$$

Extension 0.248 ± 0.001

Maximum log likelihood, source -708419

Maximum log likelihood, no source -725513

Spectral fitting using PHYS scripts developed by D. Mazin provides same results as ctlike spectral fits

Spatial fitting using PHYS tool developed by E. de Ona Wilhelmi provides same extension as ctlike

Work done by G. Pedaletti, E. de Ona Wilhelmi, D. Mazin and D. Torres

Current limitations

Response functions
- no offset angle dependence
- no zenith angle dependence
- PSF represented by single Gaussian

Background
- radial acceptance represented by single Gaussian in offset^2
- no energy dependence
- no zenith angle dependence

Models
- only axisymmetric parametric spatial models
- no FITS maps supported
- no mapcubes supported
- Event simulator only supports power law spectral shapes (ctlike supports more …)

Tools
- no significance maps yet

Next steps

Response functions
- add offset angle dependence

Background
...

Models
- add FITS map support (for extended source analysis)
- add event simulator support for more spectral shapes

Tools
...

... more testing by CTA consortium members required
... more physics validation required

Special thanks to:
Christoph Deil for extensive help on sorting out installation problems on various platforms and for the implementation of the shell model
Giovanna Pedaletti for doing the comparisons with the PHYS tools
... and all the others that provided useful feedback