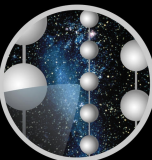




UPPSALA
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ICECUBE

Fermi Bubble Analysis with Low Energy Cascades IC86

Point Source Call
2016-02-22

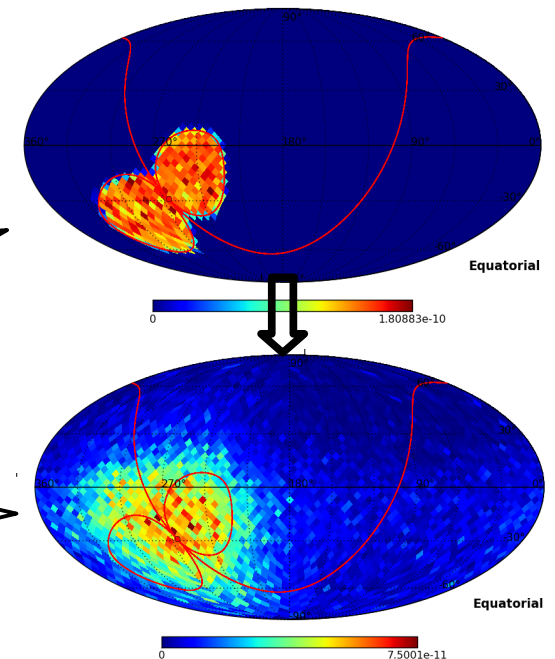
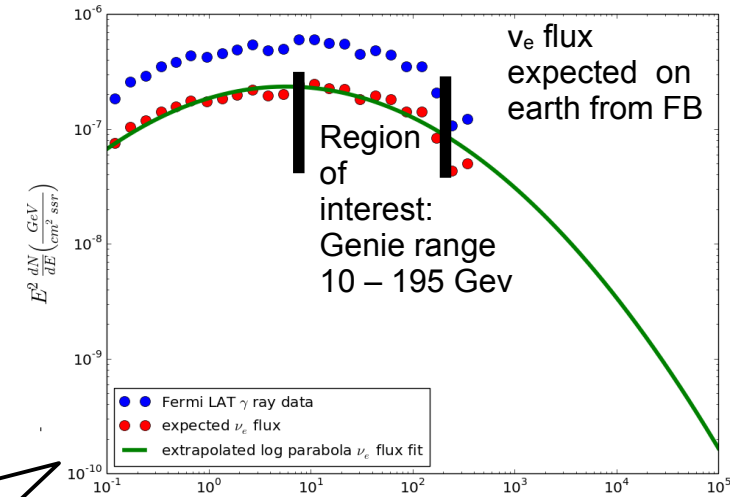
Lisa Unger
Uppsala University

[FB analysis wiki page](#)

Reminder

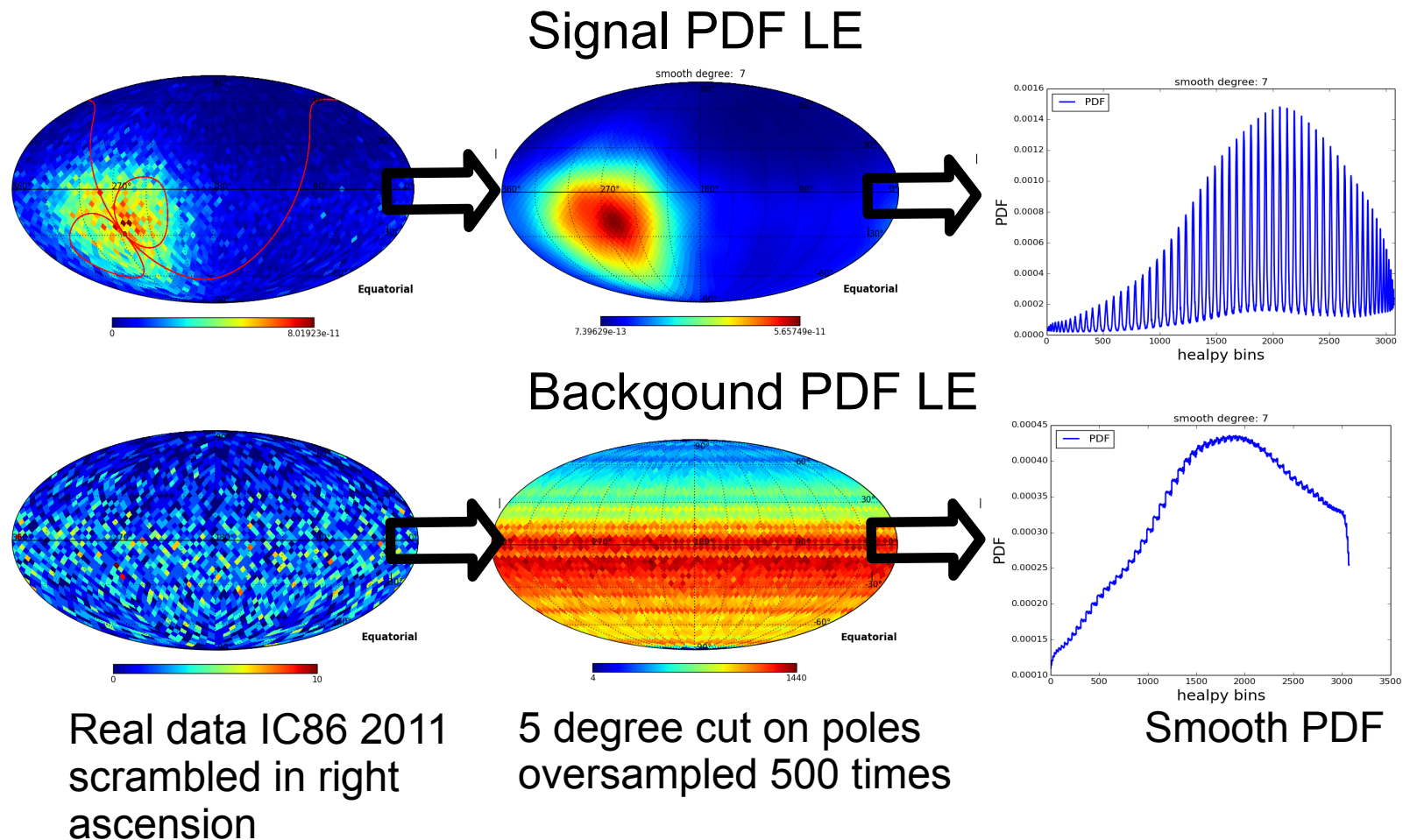
Reviewer:
internal: Mike Richman
external: Spencer Klein

- Used data: IC86 2011
- Samples from Galactic Center WIMP Analysis with Cascades by Henric Taavola ([wiki page](#))
- Low- and High Energy Data Stream (LE / HE)
- All ν - flavors genie simulation
- Events weighted with expected ν - flux from FB per flavor
- Events moved within Zenith bands into the FB area
- Reconstructed with Monopod



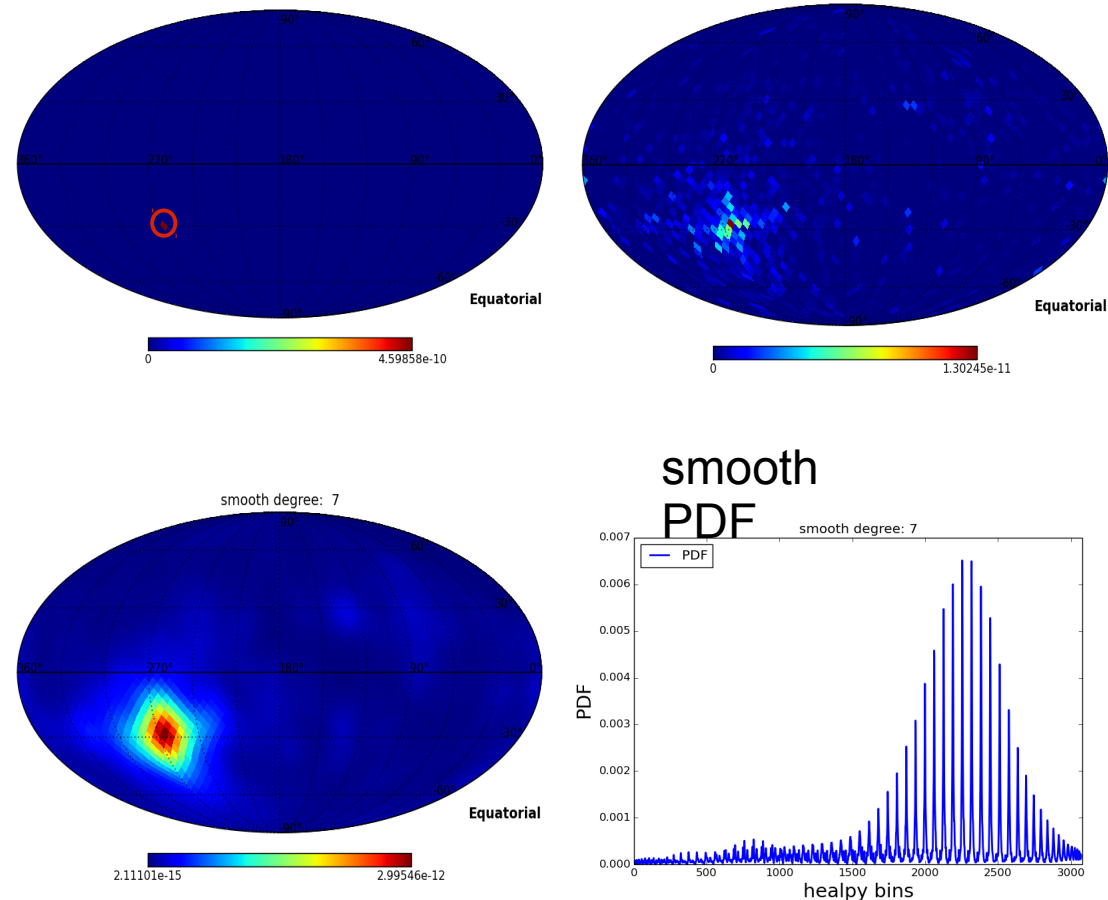
Fermi Bubbles

Shaped maximum likelihood analysis



- Events distributed within 0.5 degrees radius around the Galactic Center
- Same procedure as for FB
- HE plots are on the wiki page
- GC PDFs differ significantly from the FB PDFs
- **Comments from Spencer:**
 - GC analysis could be more sensitive to correctly knowing the cascade point spread function (PSF).
 - The PSF is convoluted in the analysis. Due to the large angular resolution it is not possible to know it more correctly.
 - Analysis might not be as optimal for GC (point source) as for FB (extended)
 - It is a likelihood analysis based on position on the sky (healpy bins), therefore it is more general. It can be applied to all shapes, even a point source.

LE Plots



Question from Spencer

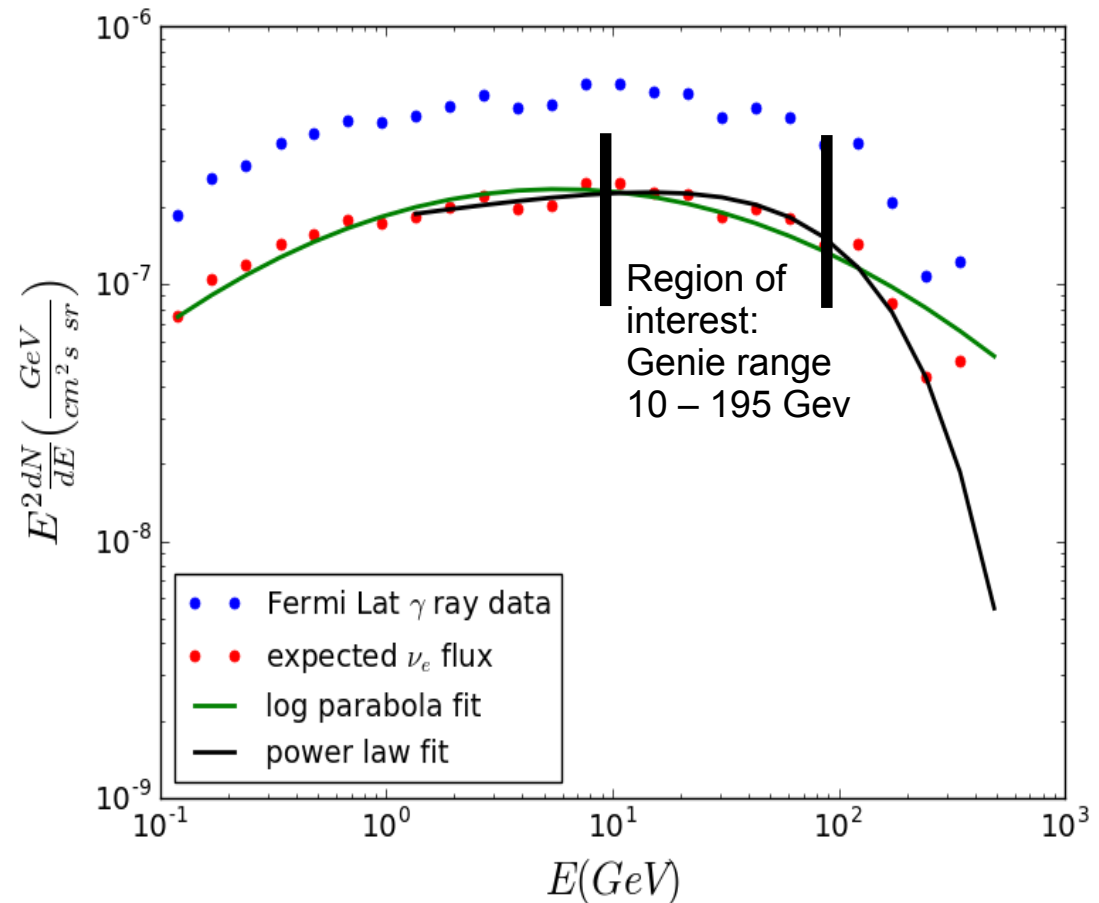
- Neutrino flux has been derived from gamma-ray flux by assumption of a power law.

How much does the assumption of a log parabola affect the result?

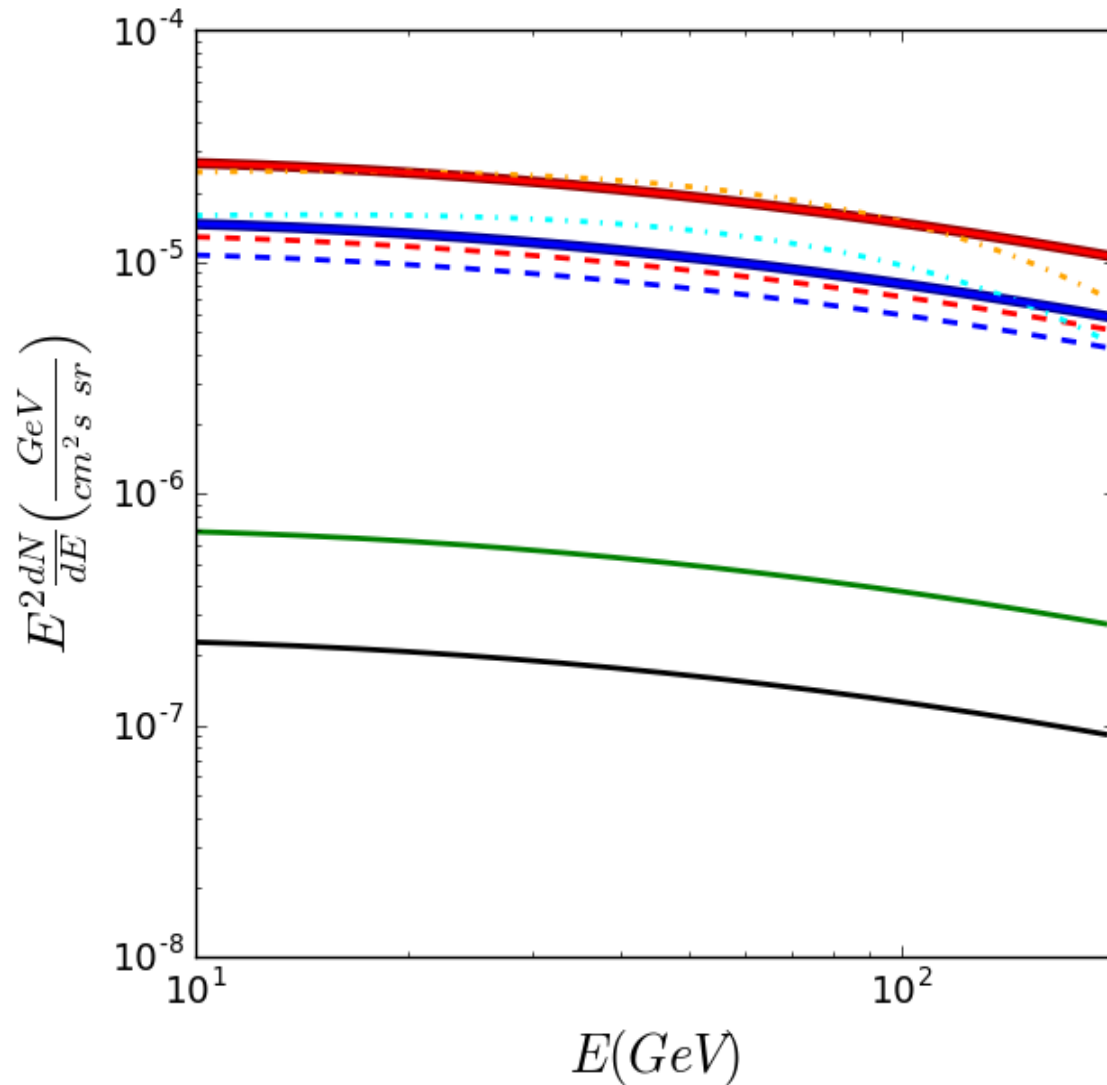
→ The used likelihood takes only the position of the events into account, therefore it is model independent

→ The sensitivity is affected because the expected events are derived using a flux expectation (see slide below)

→ In the region of interest the difference is insignificant



Sensitivity comparison

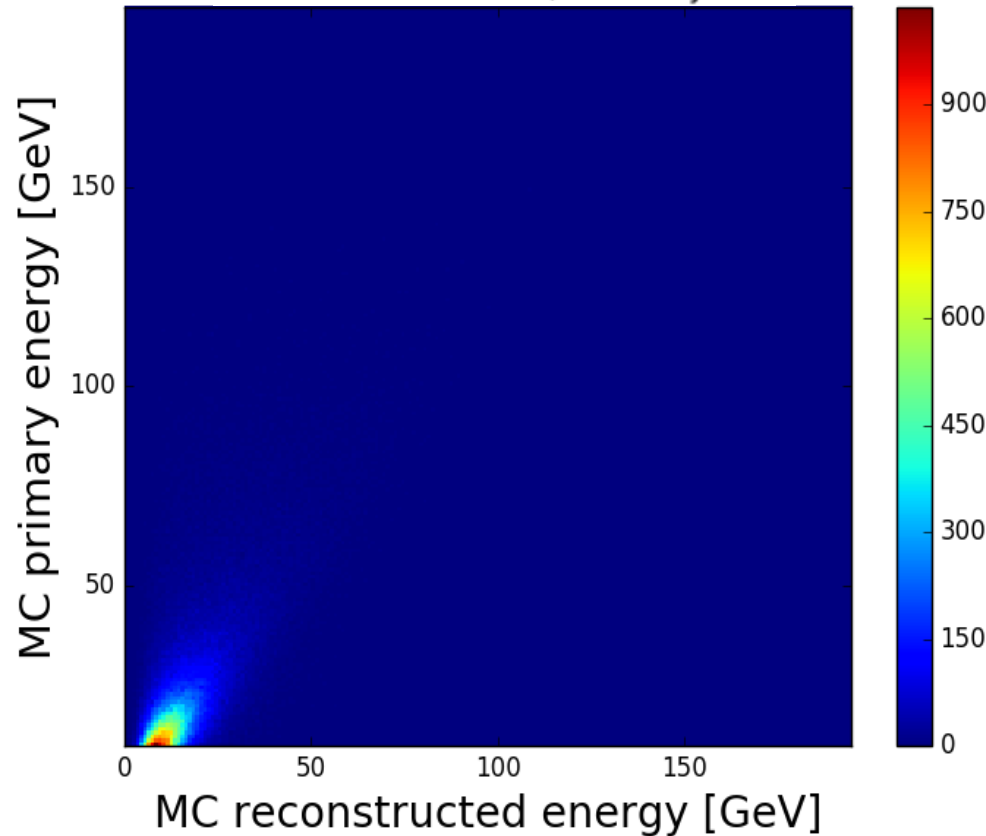


- exp nu_e: expected electron neutrino flux
- Exp nu: expected neutrino flux for all flavors
- LE: low energy sample
- HE: high energy sample
- GC: Galactic Center
- LP: log parabola fit
- PL: power law fit

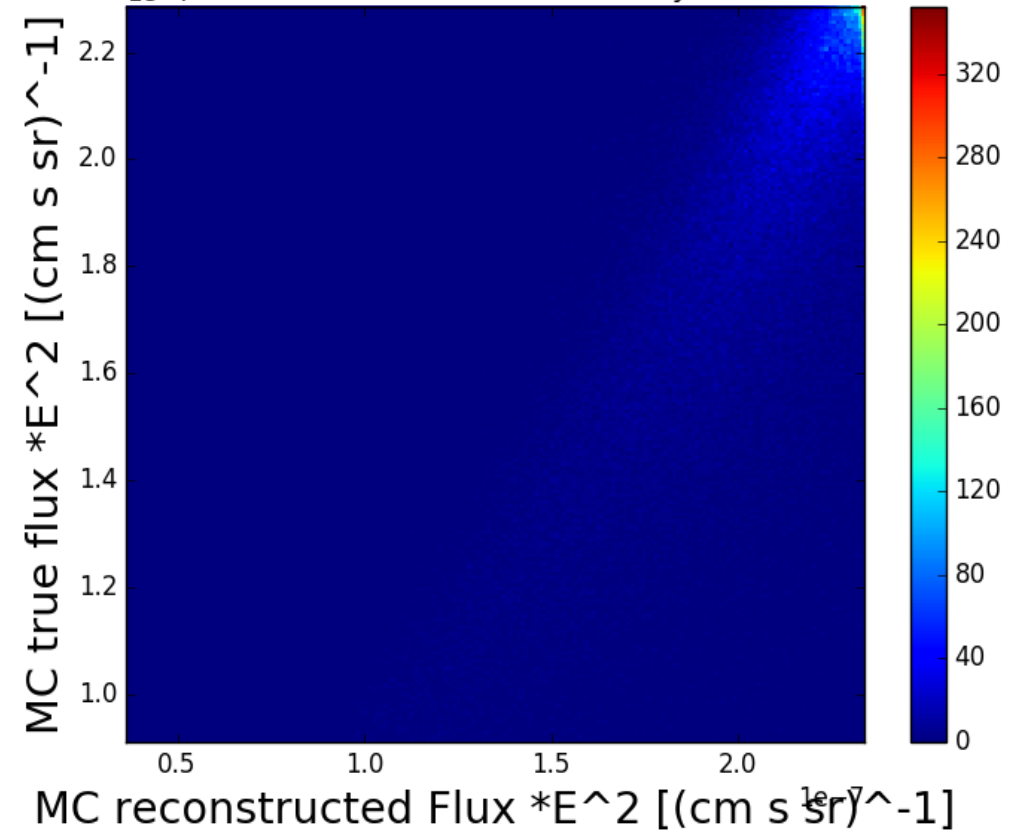
Question from Allan: improvement of sensitivity with energy cut?

Low energy sample GENIE

total Events: 87405, cut away: 73



1e-7 total Events: 87405, cut away: 73

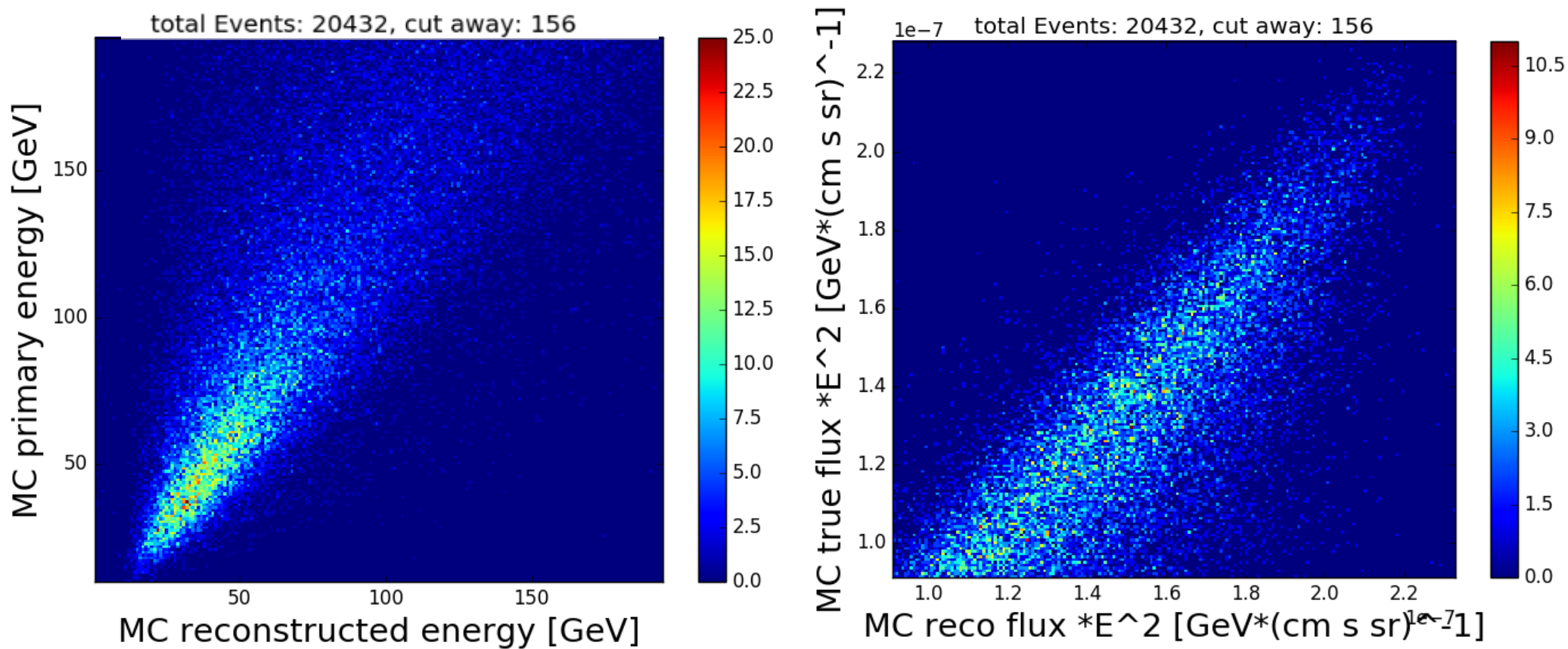


Correlation plots for LE with cut at 195 GeV

Some events have been reconstructed to very high energies > 2TeV.

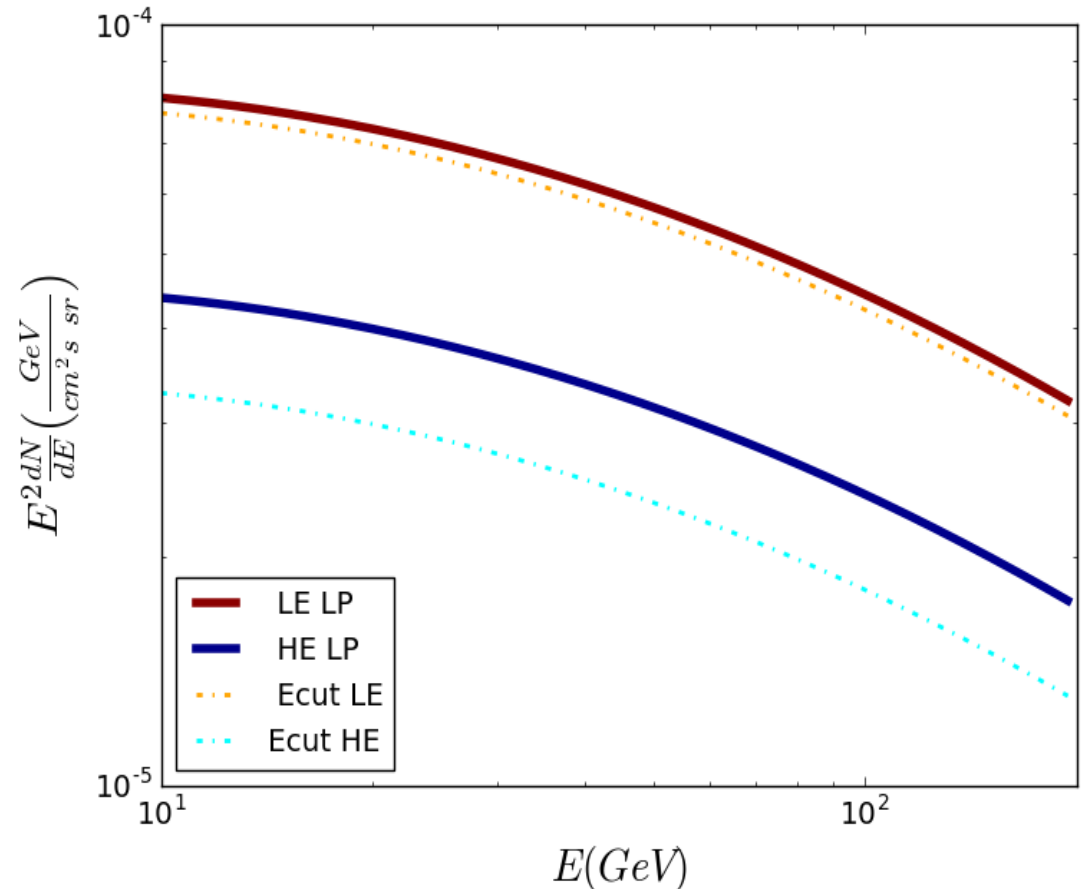
Question from Allan: improvement of sensitivity with energy cut?

High energy sample GENIE



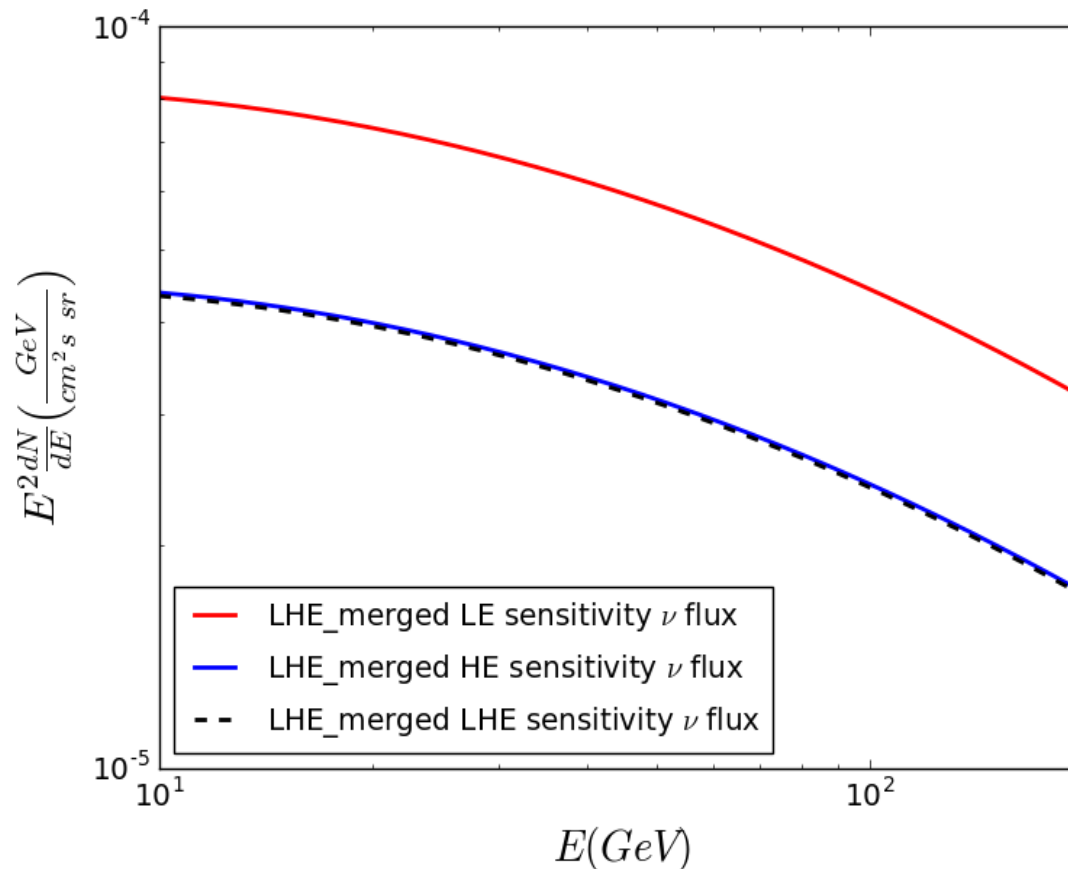
Correlation plots for HE with cut at 195 GeV

- Assuming the same PDFs events with energy > 195 GeV have been cut away
- Lost events
 - LE: 143 of 5905 $\sim 0.02\%$
 - HE: 1058 of 2184 $\sim 48\%$
- **For HE this procedure can not be applied without according PDFs**



Question from Mike: Behavior of sensitivity for a merged sample

Sensitivity for the Fermi Bubbles



- Total amount of events (without double counting): 7426
- Overlapping events: 663



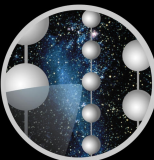
Unblinding request



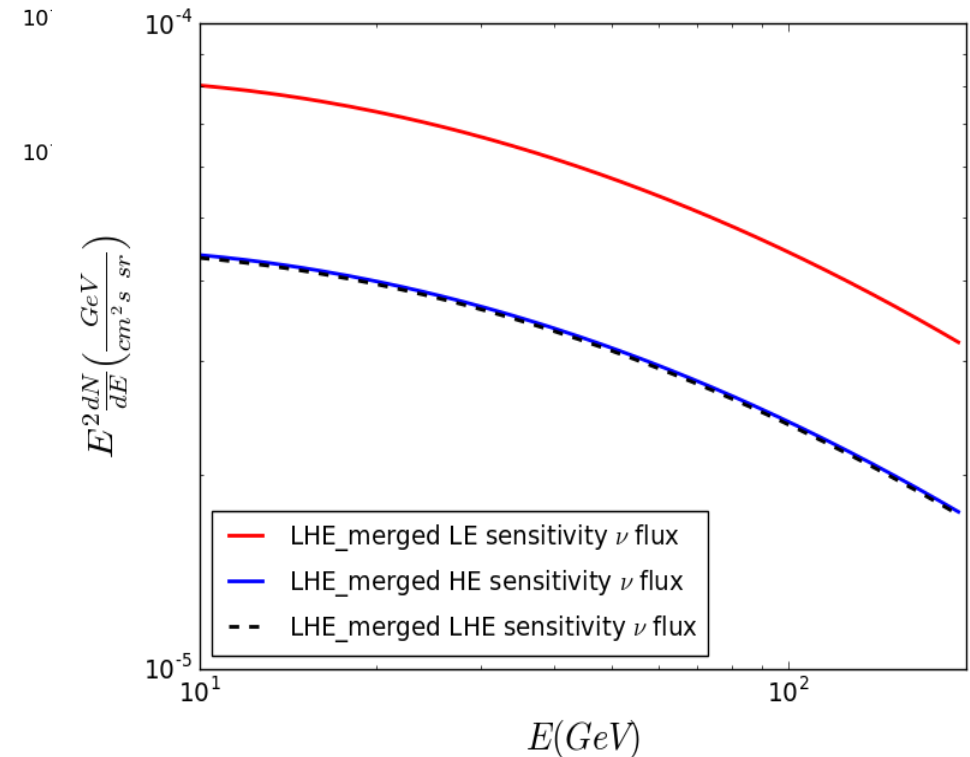
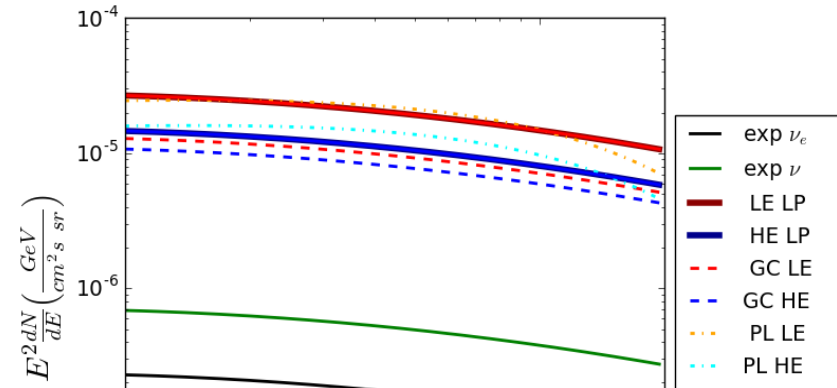
We wish to unblind this analysis for the Fermi Bubbles and the Galactic center and to view the un-scrambled reconstructed directions for the IC86-2011 dataset for the merged low- and high-energy cascade event selection.

After unblinding, the best fit and median upper limits for the number of signal events at 90% Confidence level will be calculated using the maximum likelihood method.

Summary

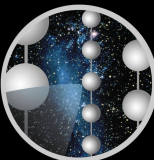


- Comparison of results with
GC signal
Power law flux assumption
energy cut of 195 GeV
combination of LE & HE
- TODO:
GC analysis with merged
samples
Correct application of the
energy cut for merged sample





Back up



More information can be found on my
FB analysis wiki page

- Shaped Maximum Likelihood Analysis
- Similar to the IC79 Low Energy Galactic Center Analysis (Samuel Flis, Martin Wolf)
- Likelihood will be calculated using ML Sandbox (Samuel Flis)

$$\mathcal{L}(b) = \prod_{i=1}^{n_{obs}} f(b_i | \mu)$$

↑ healpy bins ↑ signal events

$$f(b|\mu) = \frac{\mu}{n_{obs}} f_S(b) + \left(1 - \frac{\mu}{n_{obs}}\right) f_B(b|\mu)$$

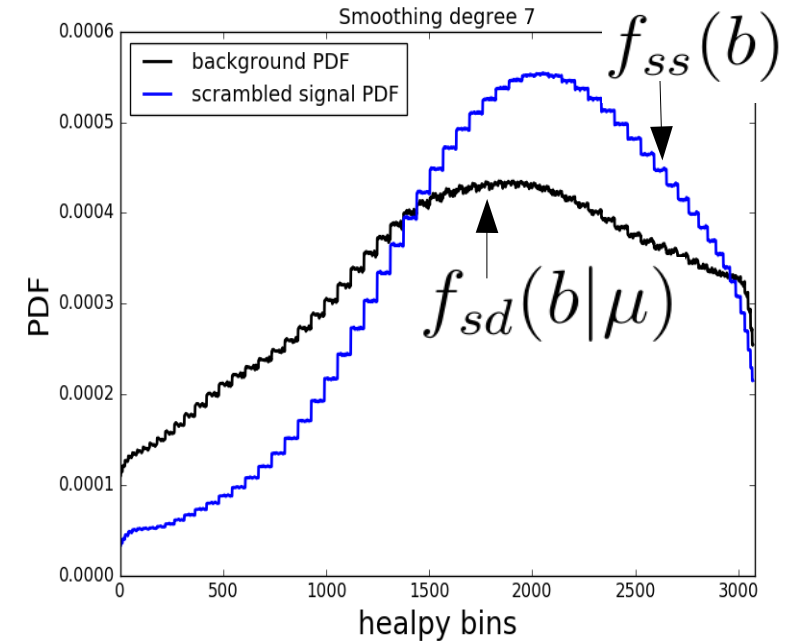
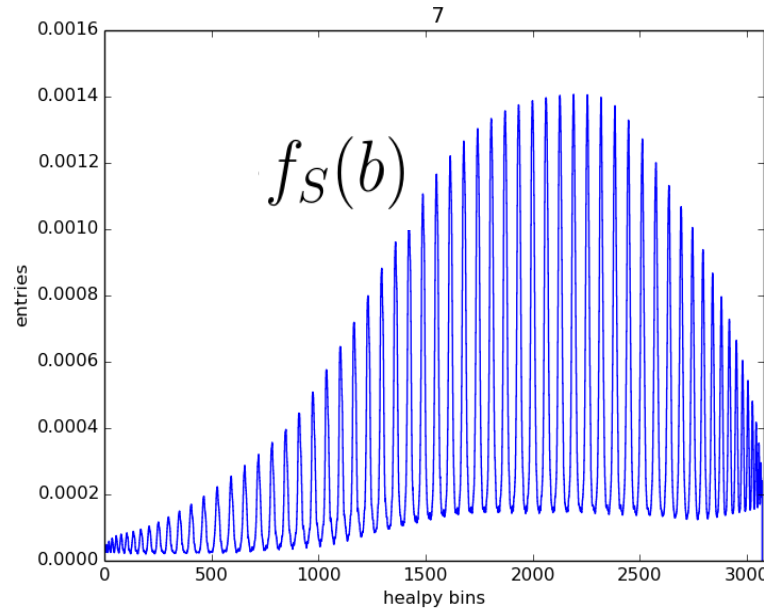
↑ signal PDF ↑ background PDF

$$f_B(b|\mu) = \frac{\mu}{n_{obs}} f_{ss}(b) + \left(1 - \frac{\mu}{n_{obs}}\right) f_{sd}(b|\mu)$$

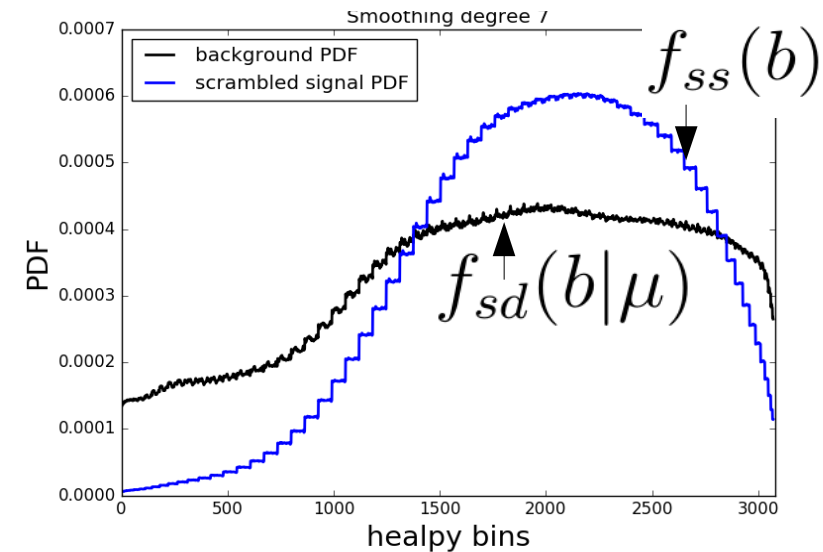
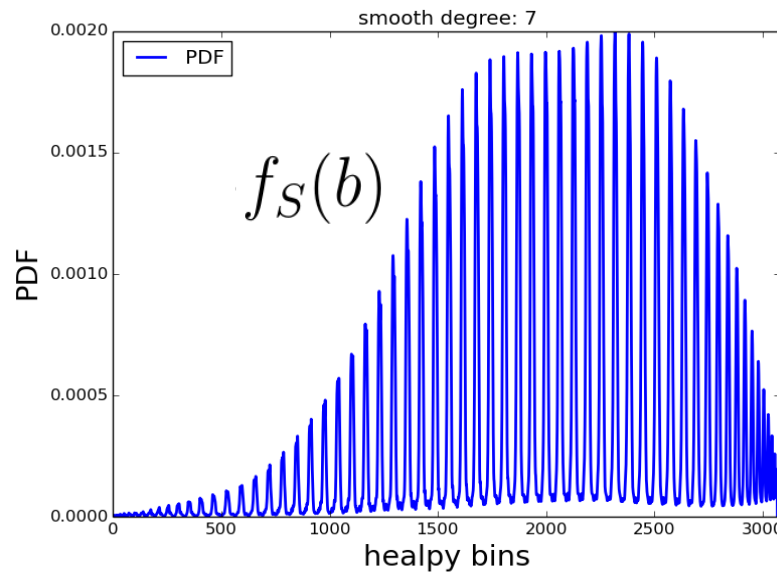
↑ scrambled signal PDF ↑ scrambled data PDF

Probability Density Functions

LE sample:



HE sample:



Expected events - genie

$$N_{Events} = T_{live} \cdot \sum \frac{OneWeight}{nFiles \cdot nEvents} \cdot \frac{\Phi_{\nu}(E, \Omega)}{dE d\Omega}$$

livetime: 329.1 days

LE stream

HE stream

Nue : ~ 0.6 events / livetime

~ 0.5 events / livetime

Numu: ~ 0.3 events / livetime

~ 0.1 events / livetime

Nutau: ~ 0.3 events / livetime

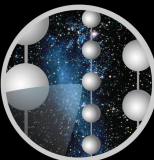
~ 0.2 events / livetime

Nu: ~ 1.2 events / livetime

~ 0.8 events / livetime



Units



$$[\Phi_\nu] = \frac{1}{\text{GeV cm}^2 \text{ s sr}}$$

$$[\text{OneWeight}] = \text{GeV cm}^2 \text{ sr}$$