Fermi Bubble Analysis with Low Energy Cascades IC86

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ICECUBE

Point Source Call
2016-02-22

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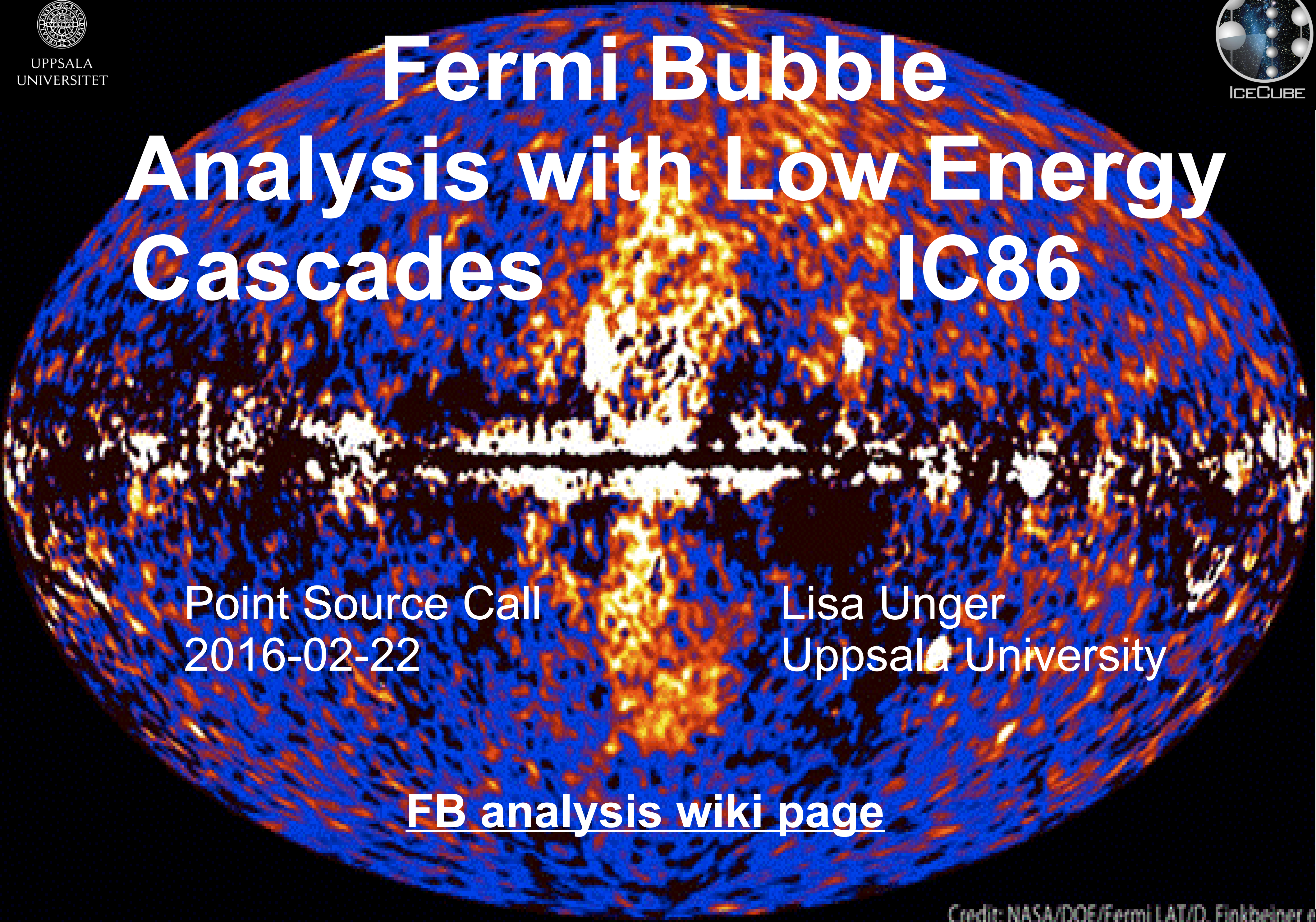
FB analysis wiki page

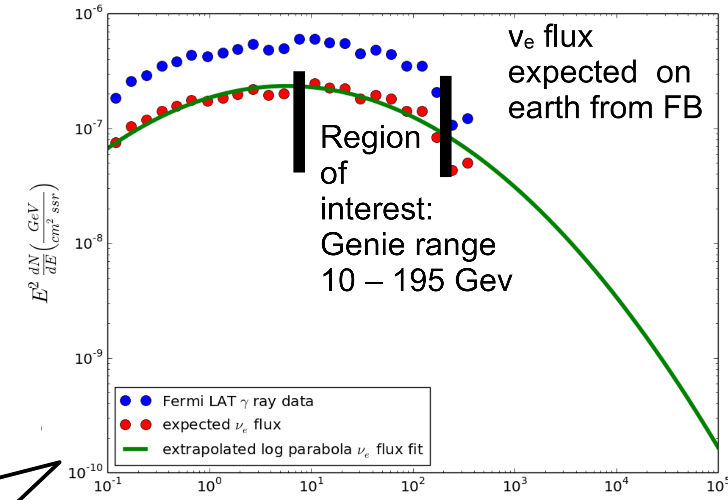


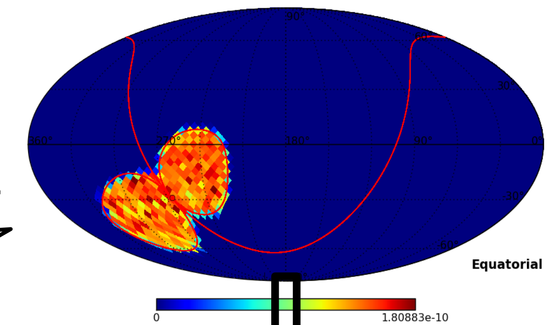
Credit: NASA/DOE/Fermi LAT/D. Finkbeiner e

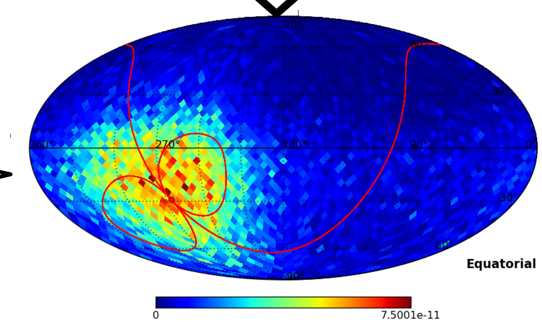
Reminder

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



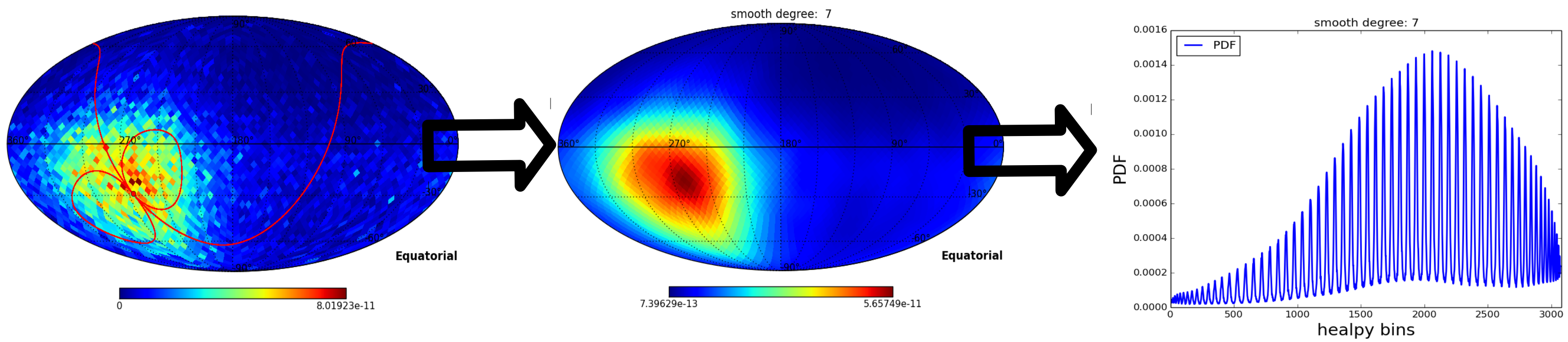




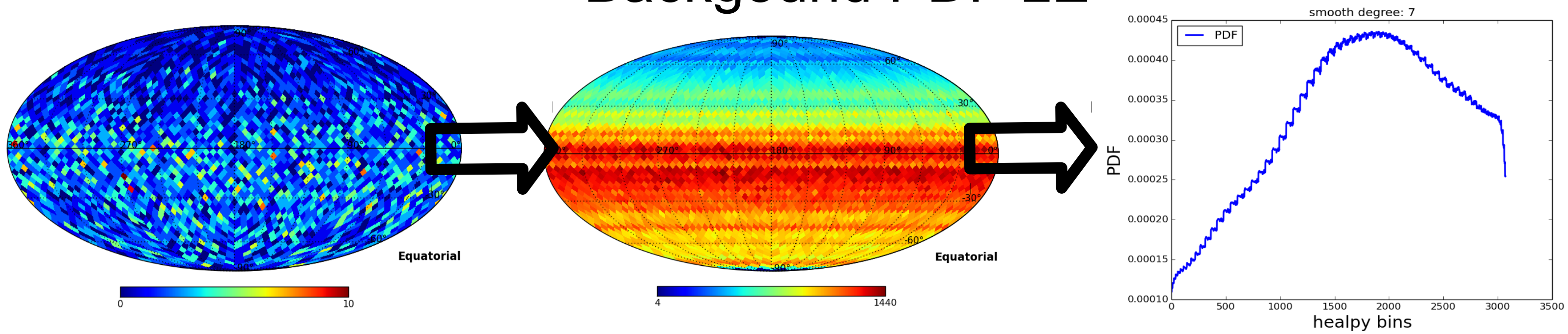
Fermi Bubbles

Shaped maximum likelihood analysis

Signal PDF LE



Backgound PDF LE



Real data IC86 2011 scrambled in right ascension

5 degree cut on poles oversampled 500 times

Smooth PDF

Galactic Center

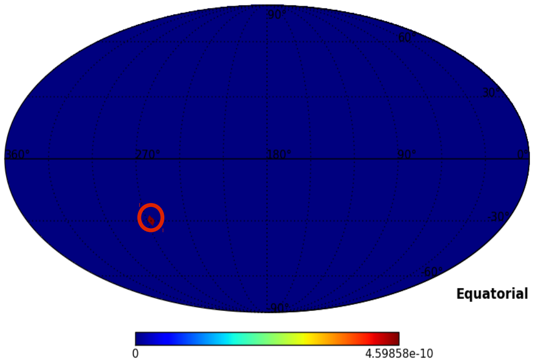
- Events distributed within 0.5 degrees radius around the Galactic Center
- Same procedure as for FB
- HE plots are on the wiki page
- GC PDFs differ significantly from the FB PDFs
- **Comments from Spencer:**
  - GC analysis could be more sensitive to correctly knowing the cascade point spread function (PSF).

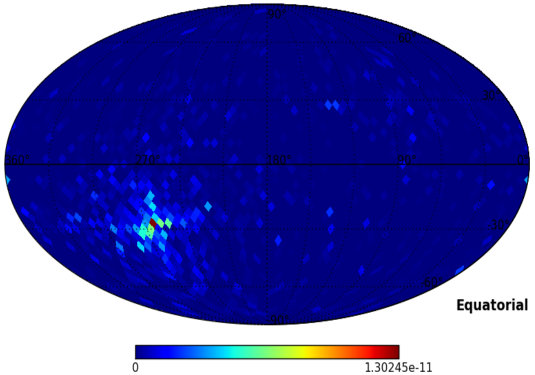
  → The PSF is convoluted in the analysis. Due to the large angular resolution it is not possible to know it more correctly.

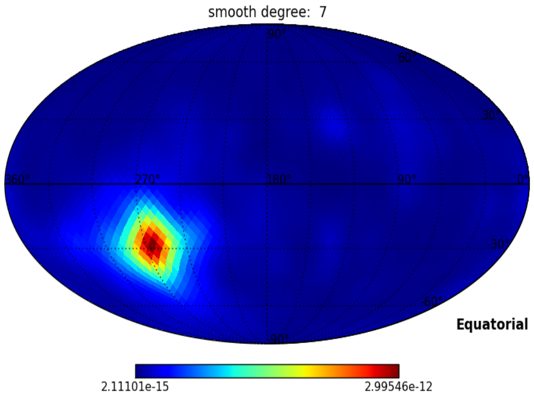
  - Analysis might not be as optimal for GC (point soure) as for FB (extended)

  → 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.

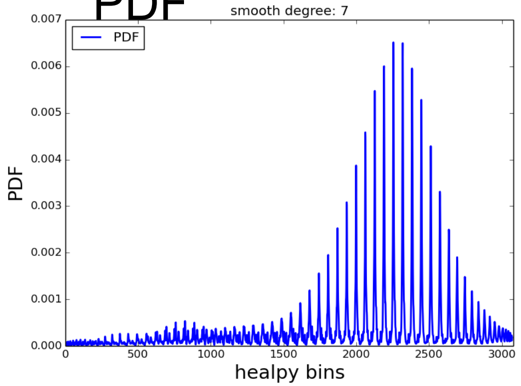
LE Plots







smooth PDF



Question from Spencer

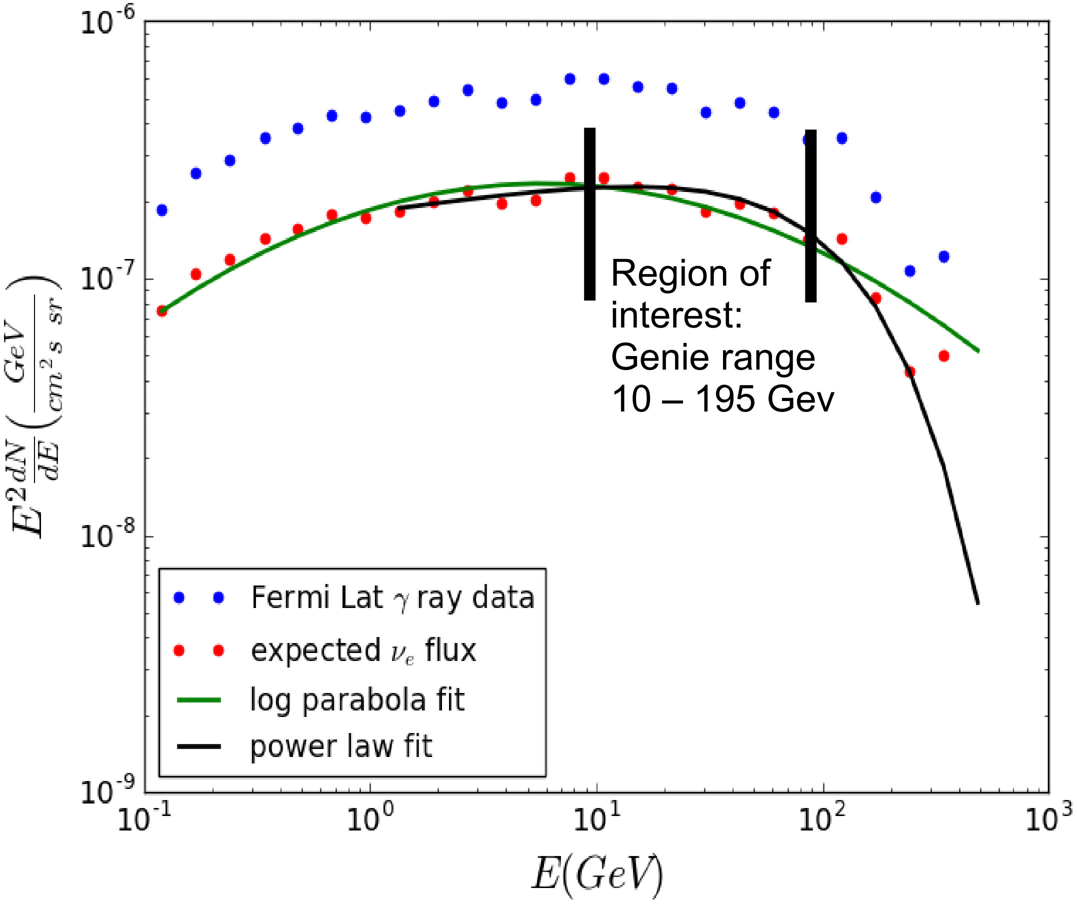
- Neutrino flux has been derived from gamma-ray flux by assumption of a power law.

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

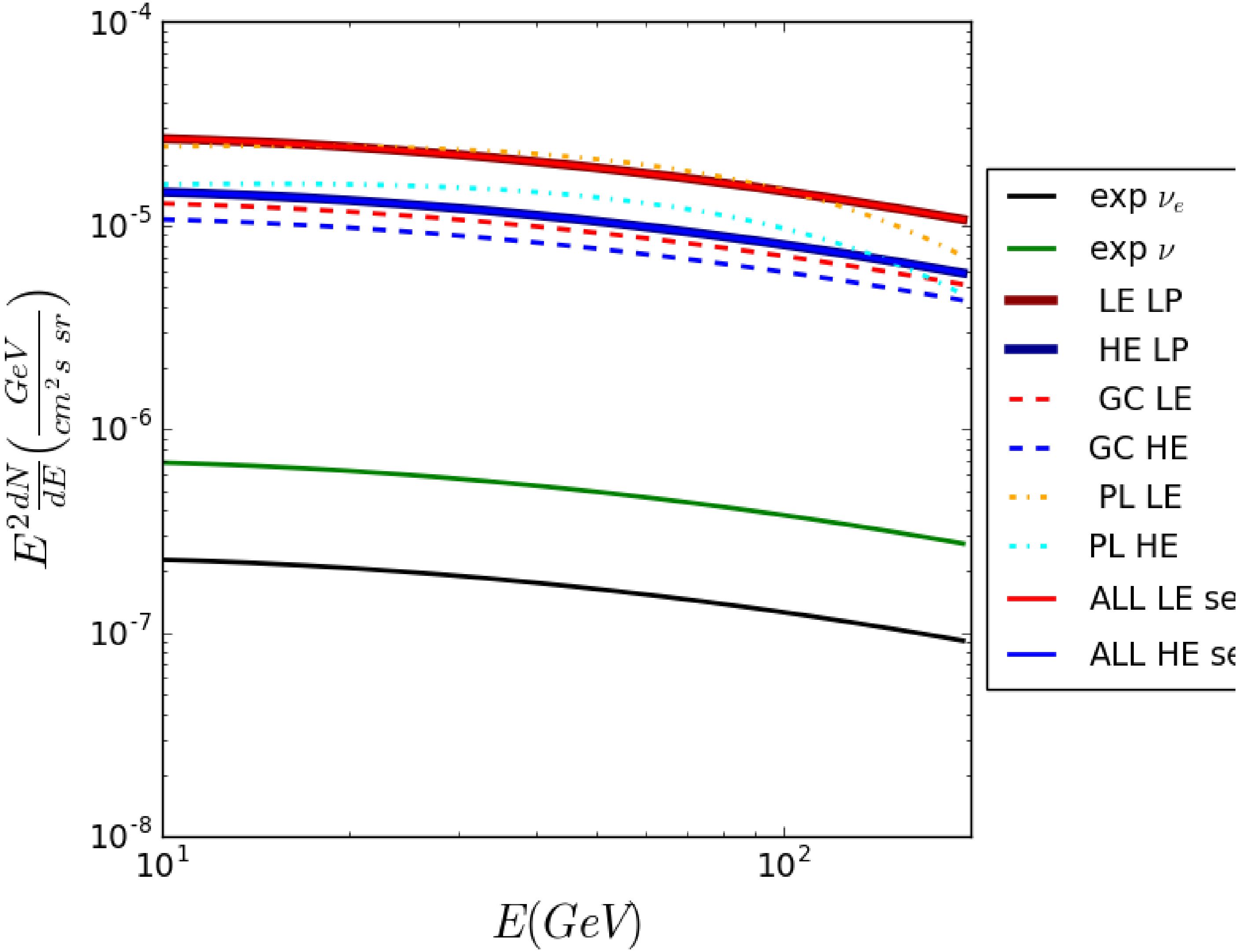
  → The used likelihood takes only the position of the events into account, therefore it is model independent

  → 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



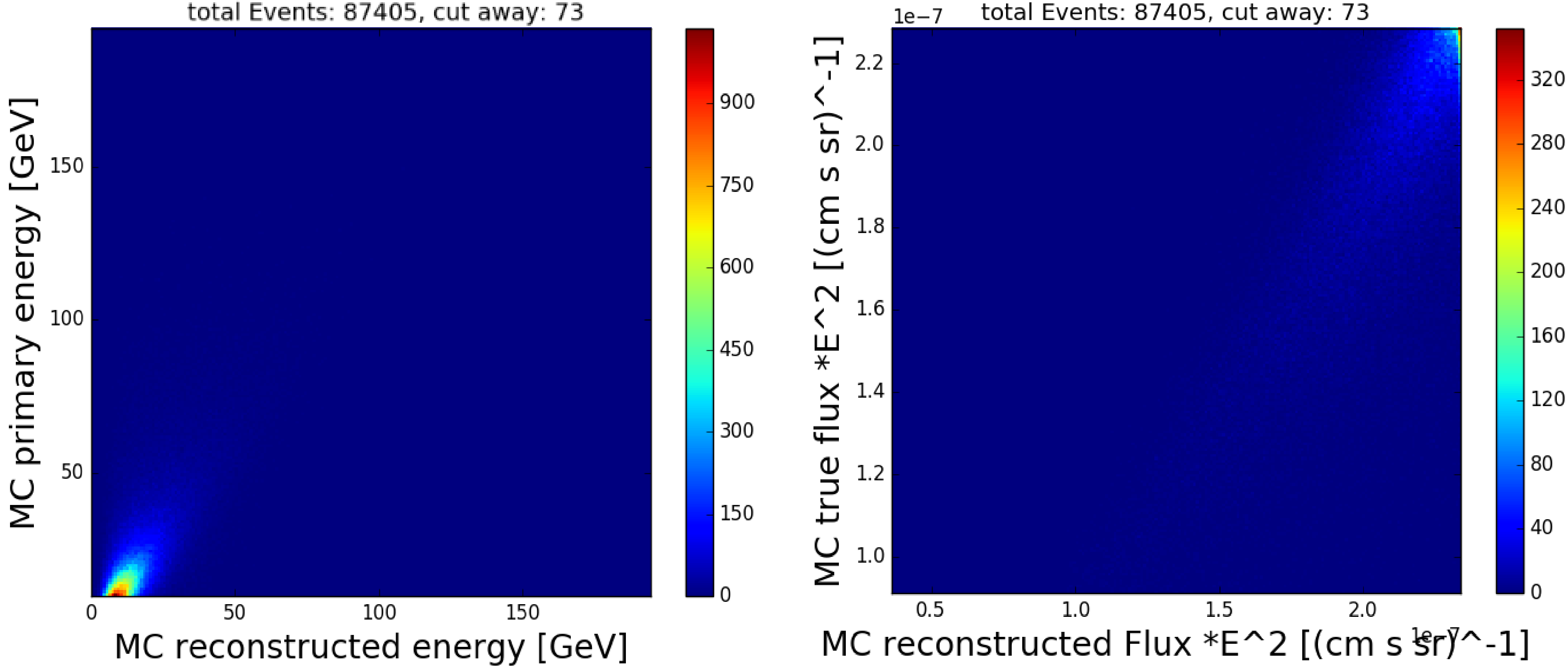
Sensitivity comparison



- 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

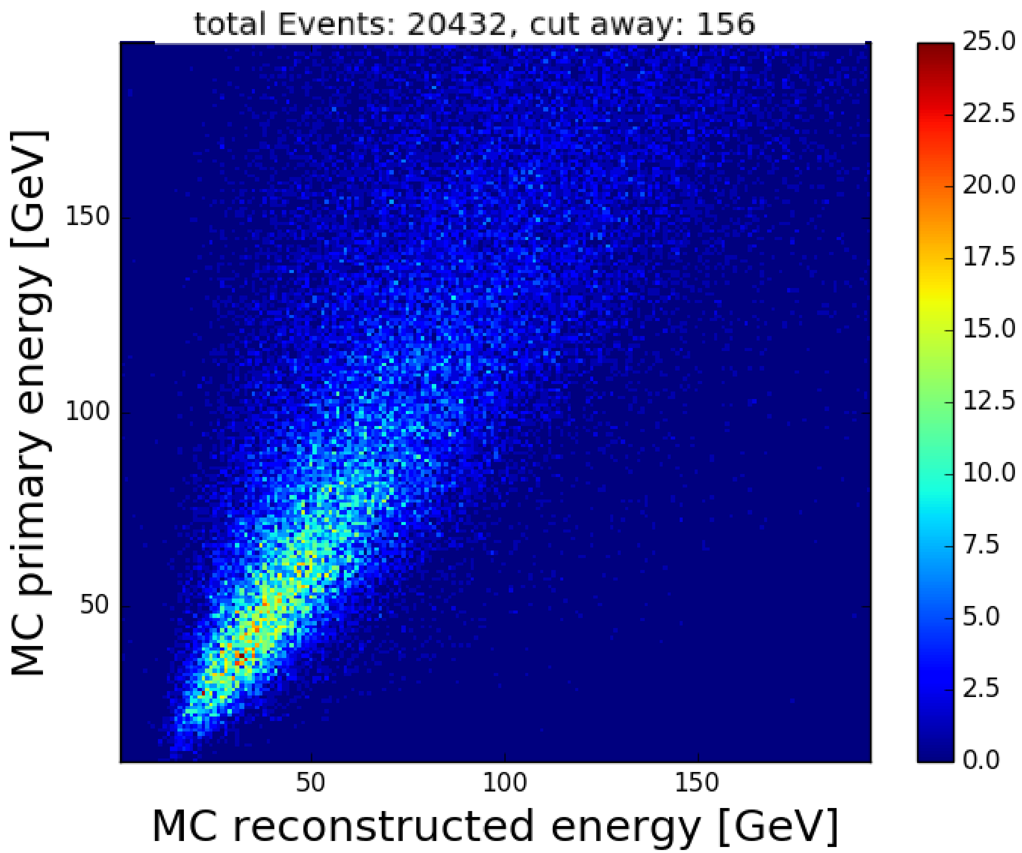


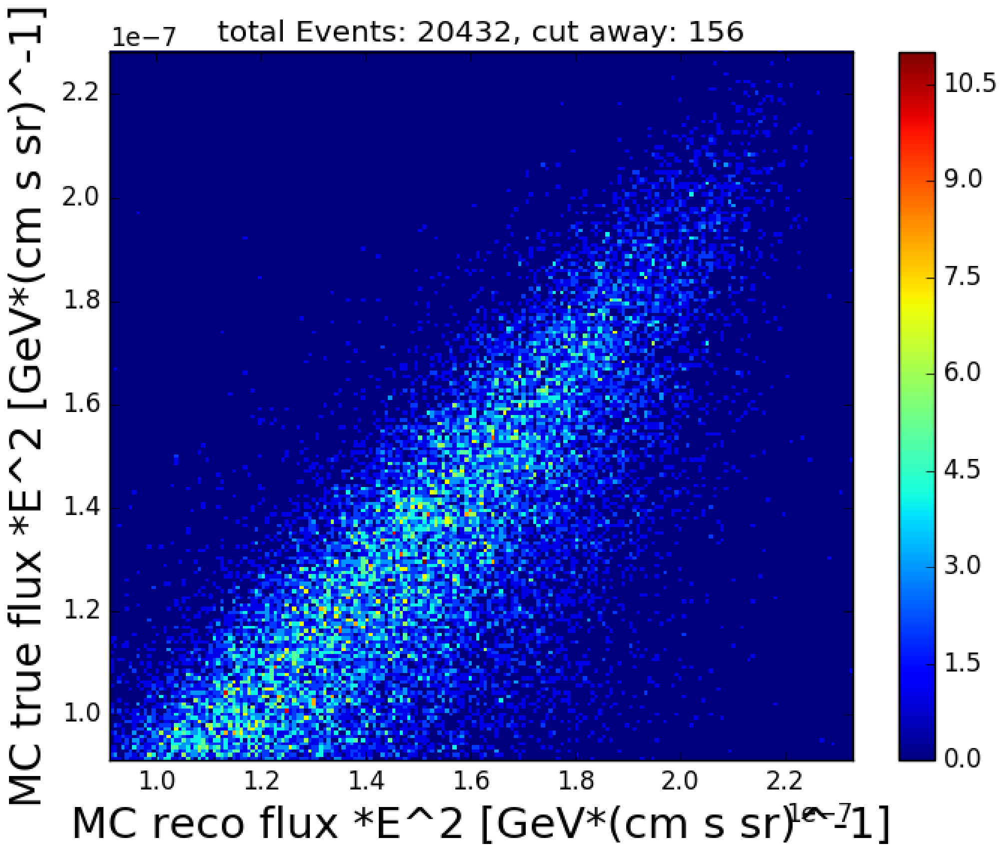
Correlation plots for LE with cut at 195 GeV

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

Sensitivity

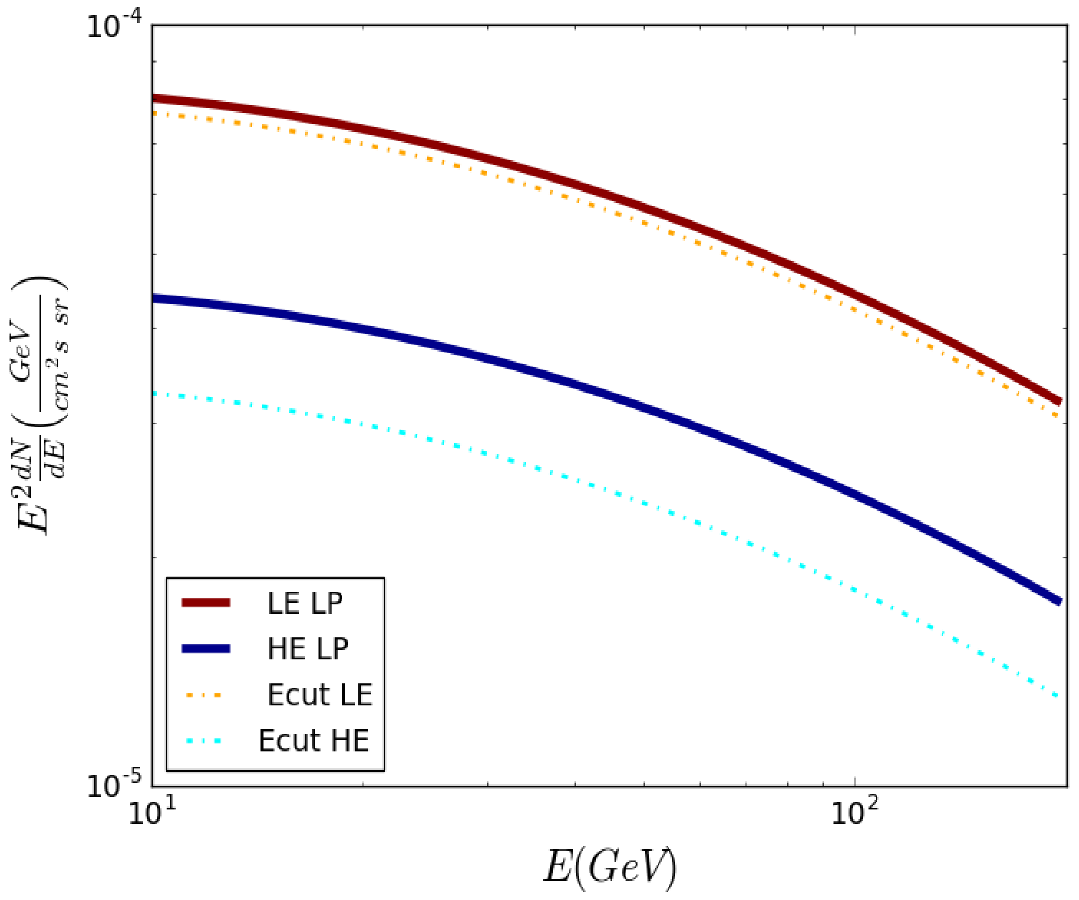
- Assuming the same PDFs events with energy > 195 GeV have been cut away

- Lost events

  LE: 143 of 5905 ~ 0.02%

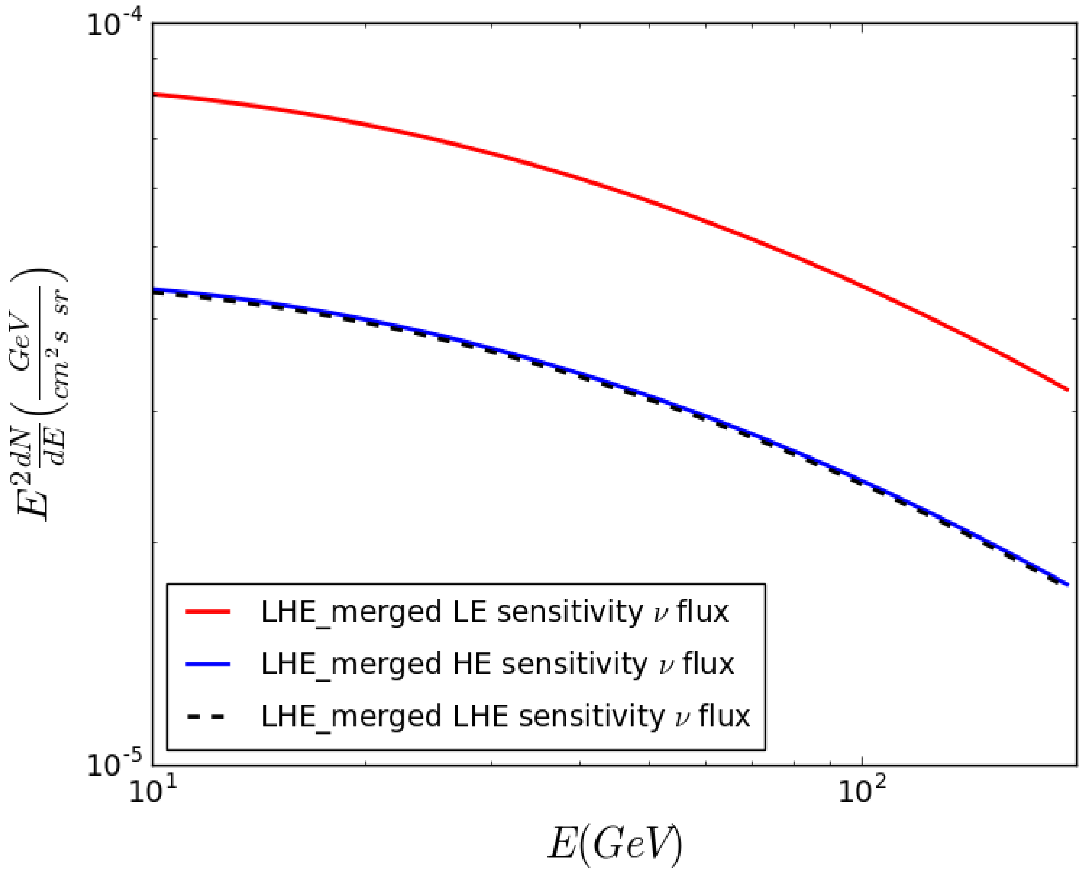
  HE: 1058 of 2184 ~ 48%

- **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

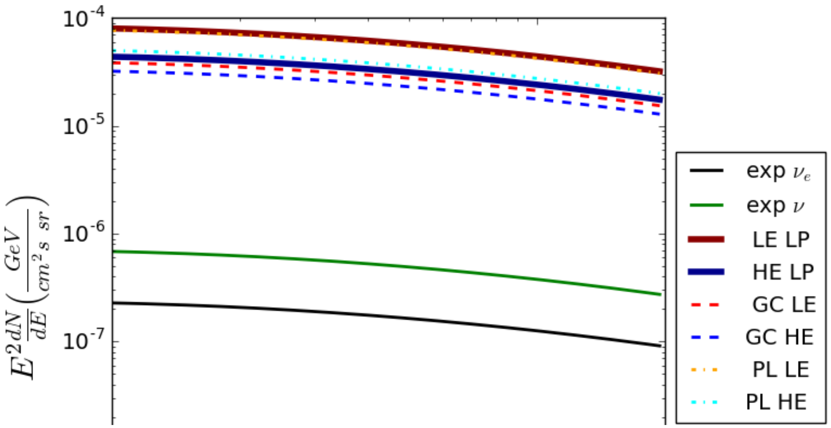
Unblinding request

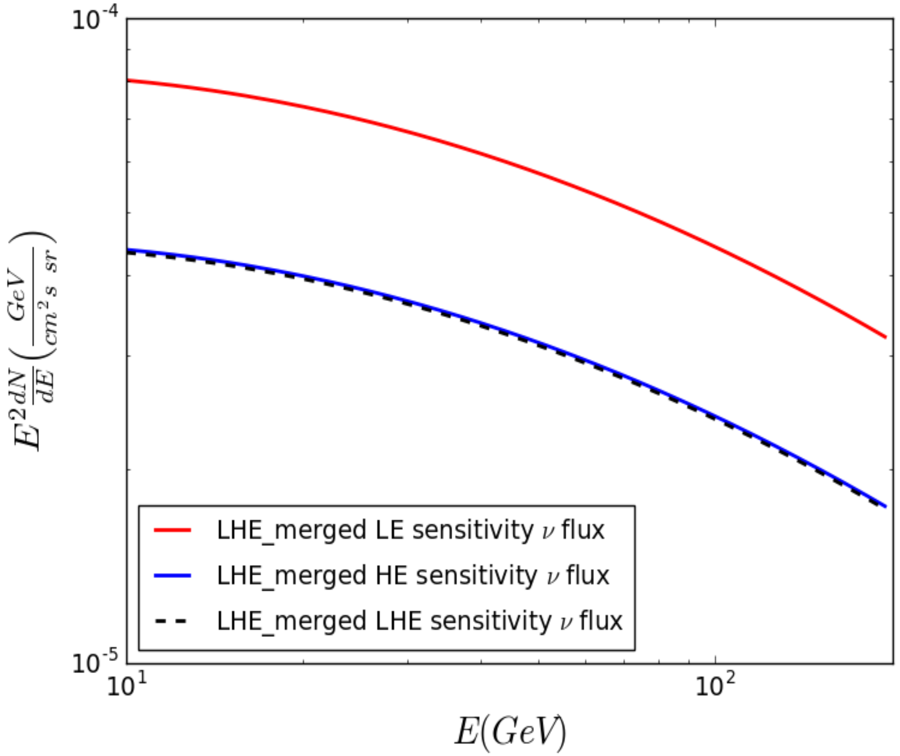
We wish to unblind this analysis for the Fermi Bubbles and the Galactic center and to view the un-scrambled reconstructed directions for the IC86-2011 dataset for the merged low- and high-energy cascade event selection.

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**

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Analysis Method

- 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

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

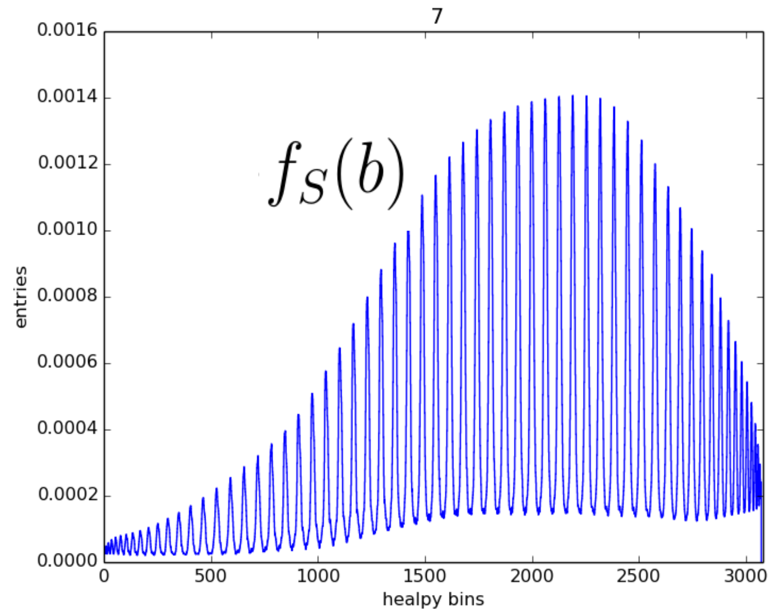
signal PDF — background PDF

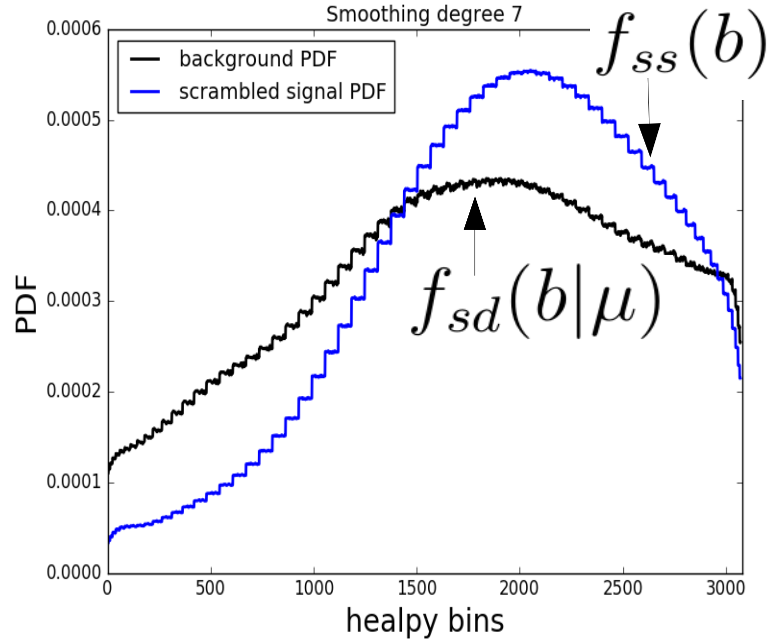
$$f_B(b|\mu) = \frac{\mu}{n_{obs}} f_{ss}(b) + \left(1 - \frac{\mu}{n_{obs}}\right) f_{sd}(b|\mu)$$

scrambled signal PDF — scrambled data PDF

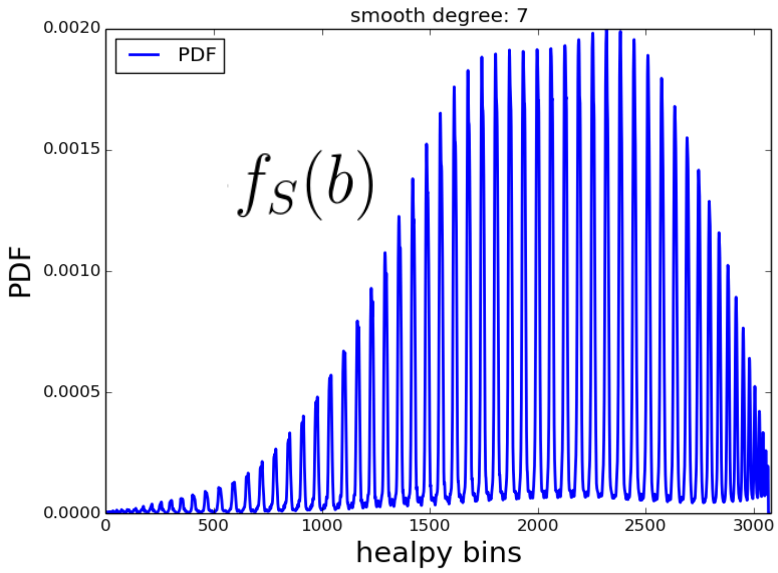
Probability Density Functions

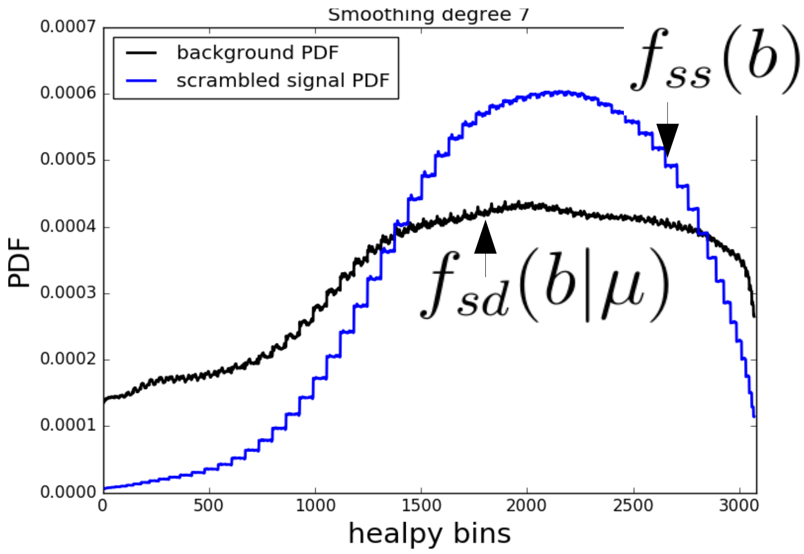
LE sample:





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

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

$$[OneWeight] = GeV\ \ cm^2\ \ sr$$