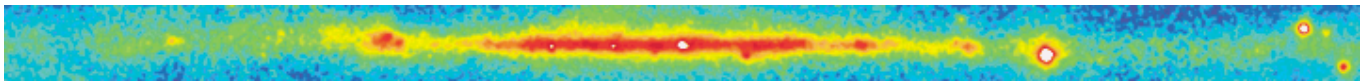
Update on a Search for a Neutrino Flux from the Galactic Plane



John Kelley

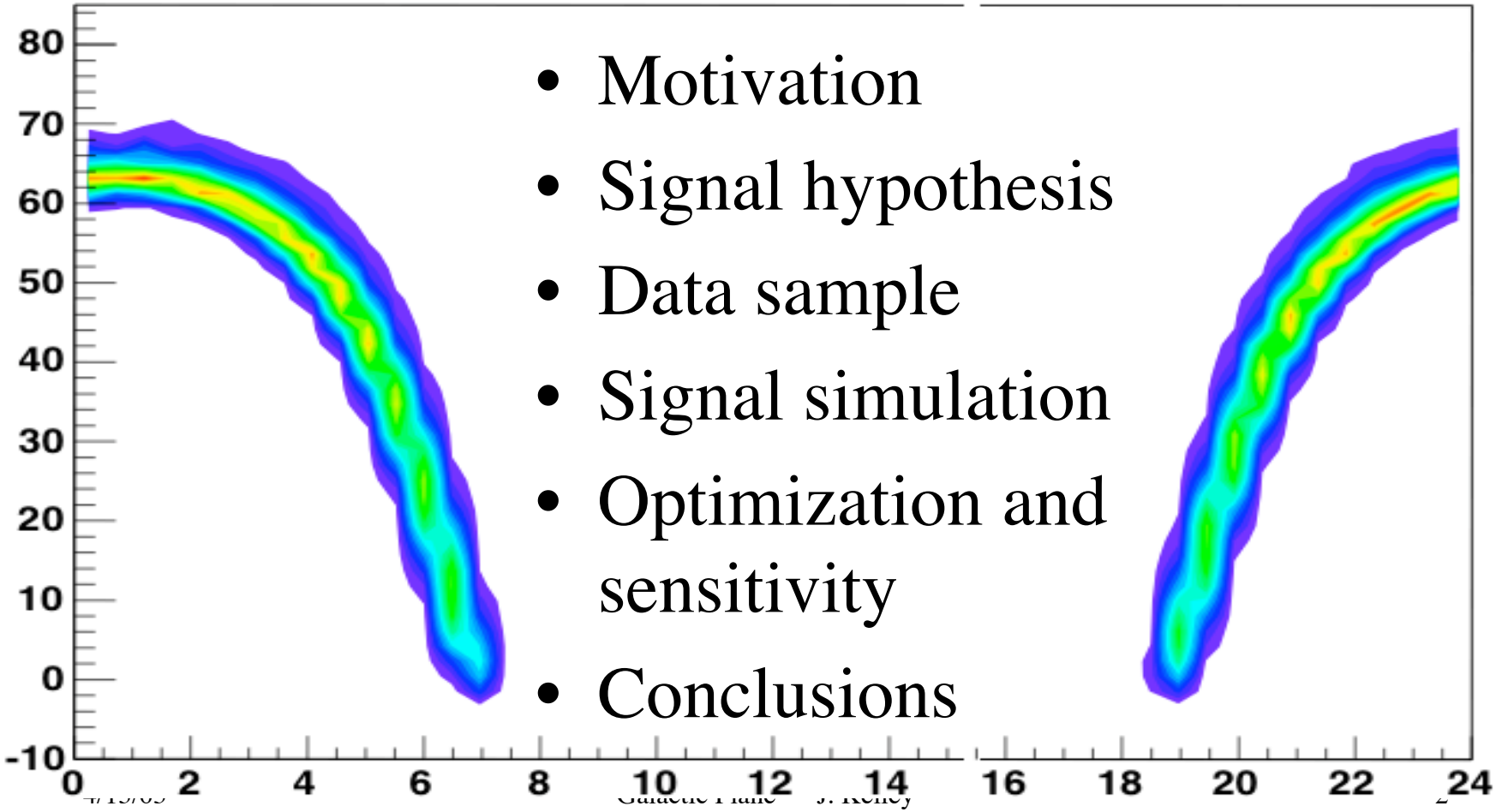
IceCube Collaboration Meeting

Berkeley, CA

March 19, 2005

Outline

- Motivation
- Signal hypothesis
- Data sample
- Signal simulation
- Optimization and sensitivity
- Conclusions



Motivation

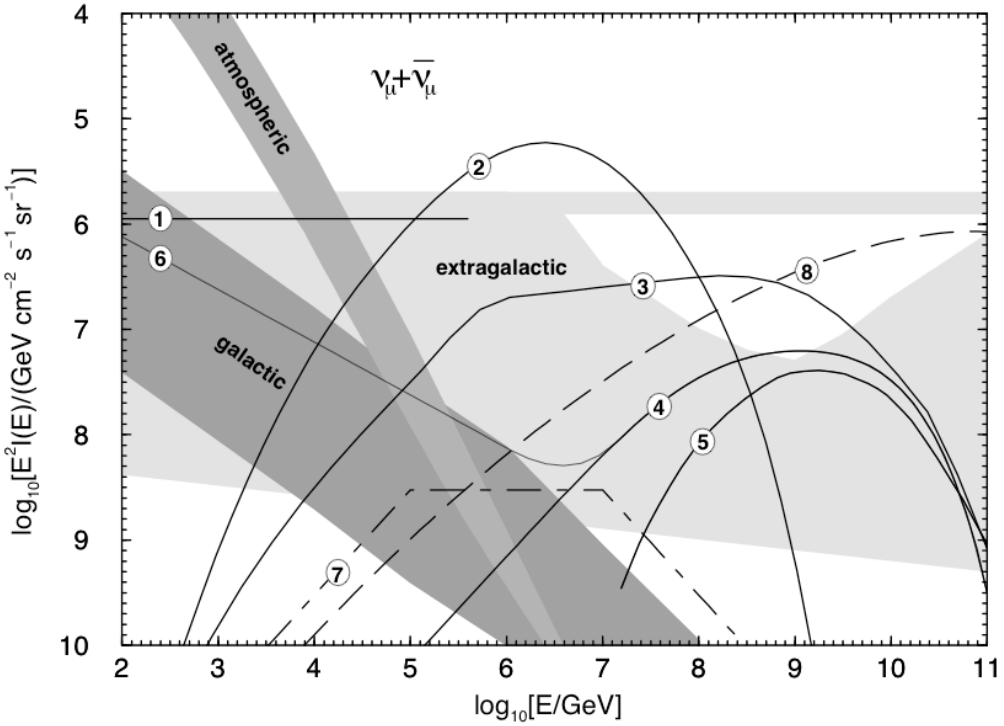
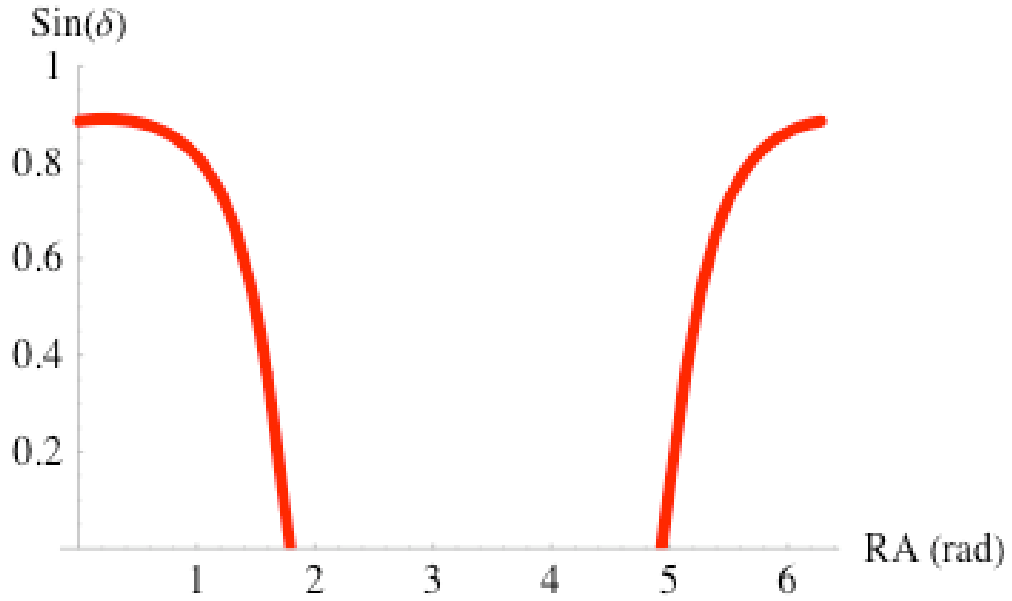


Figure: Learned & Mannheim, Annu. Rev. Nucl. Part.Sci.2000.50

- Cosmic rays interact with galactic ISM, produce γ, ν
- Similar to atmospheric neutrino flux — guaranteed at some level
- Lower density of ISM ⇒ spectrum follows CR primary spectrum, $E^{-2.7}$

Signal Hypothesis

- Line source of neutrinos from galactic equator
- Isotropic in galactic longitude
- Spectrum of $E^{-2.7}$



Why a Line Source?

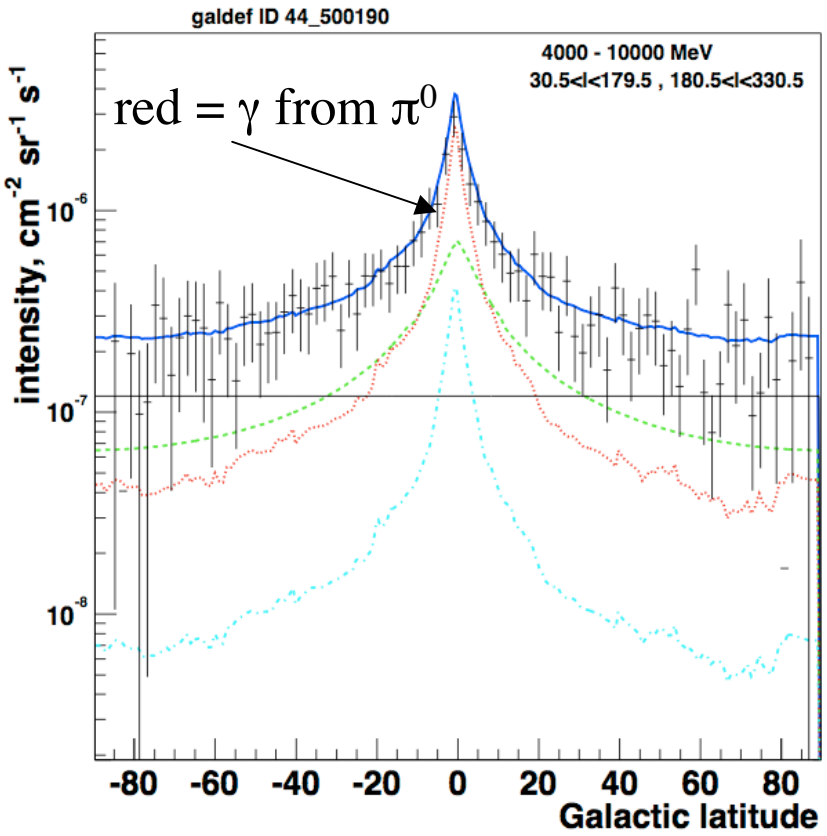
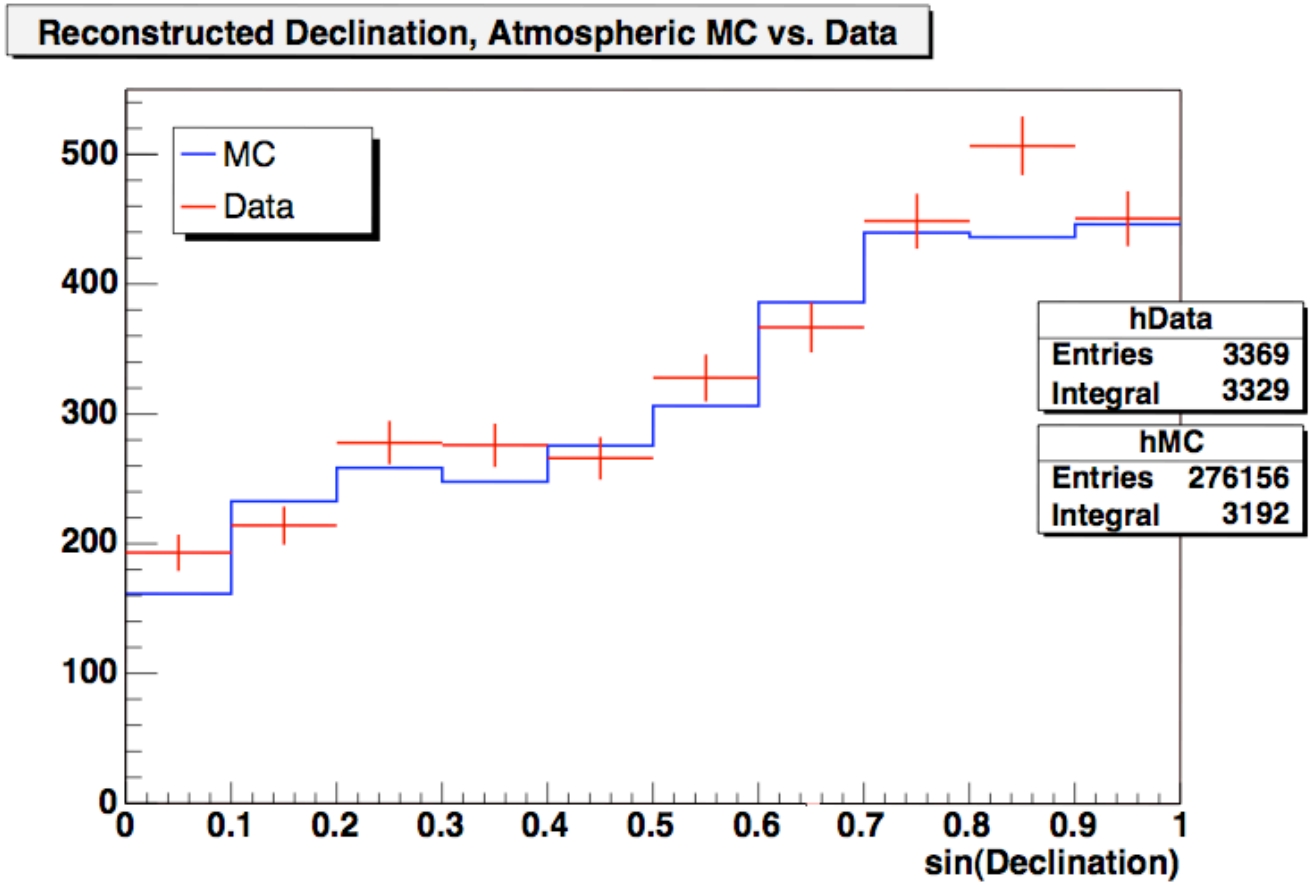


Figure: Strong, Moskalenko, and Reimer, astro-ph/0406254

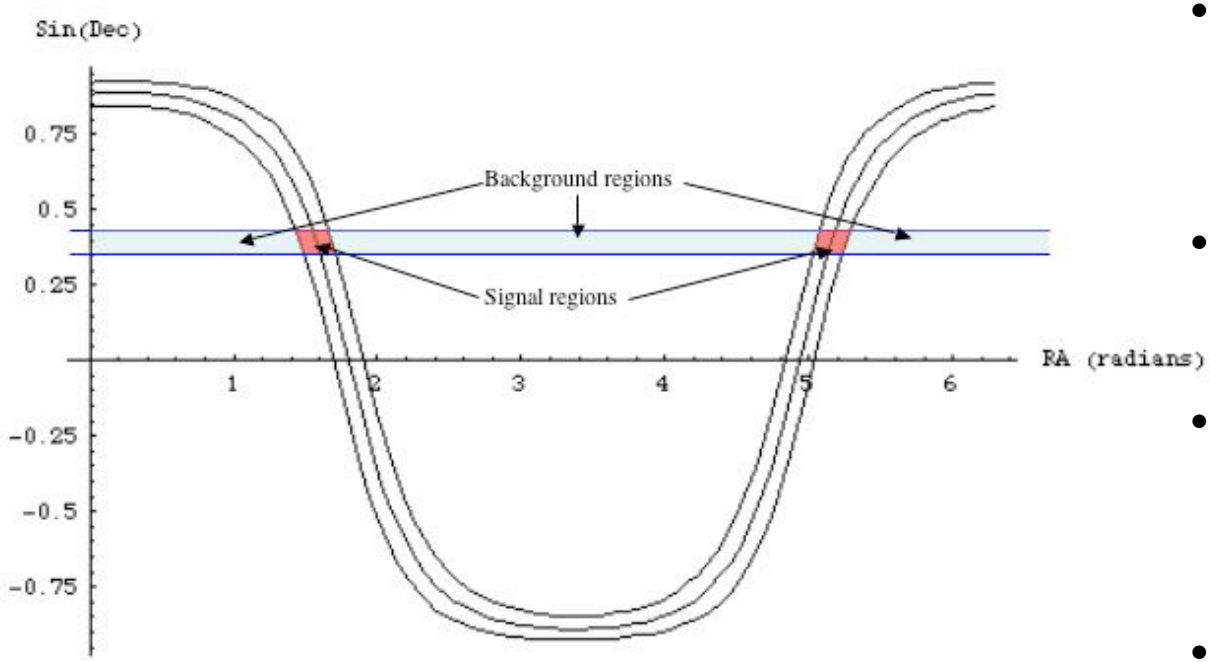
- Width of galactic plane in ν could be less than ~2.5° (FWHM)
- Column density of outer galaxy relatively constant in longitude (to ~30%)

Data Sample: 2000-2003



- Point source optimized cuts (Zeuthen)
- RA scrambled for blindness

Background Estimation

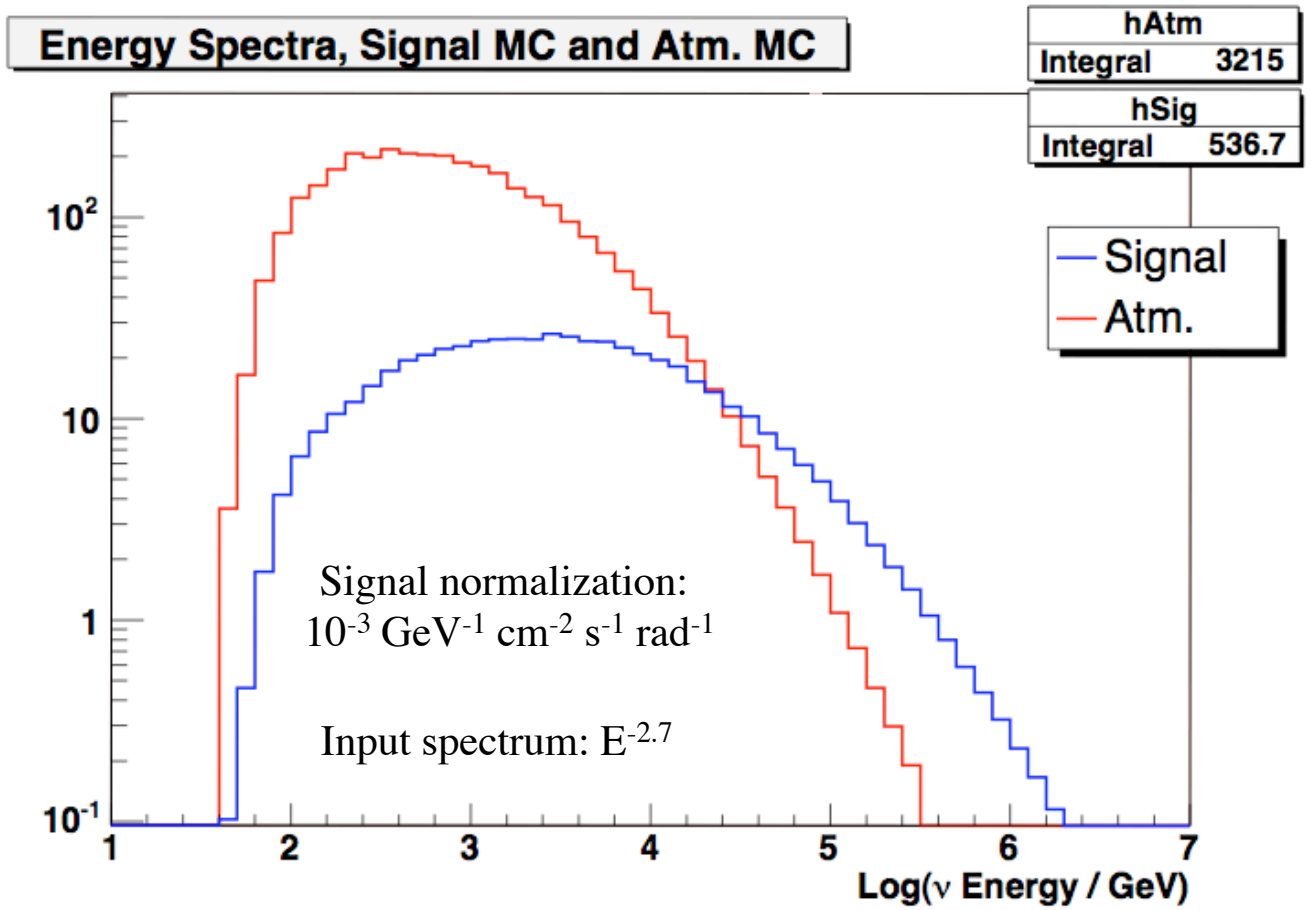


- Source is extended; background is declination-dependent
- Chop plane into 5° slices at a given declination
- On-source region initially $-5° < b < 5°$, will be optimized
- Background estimated from off-source region

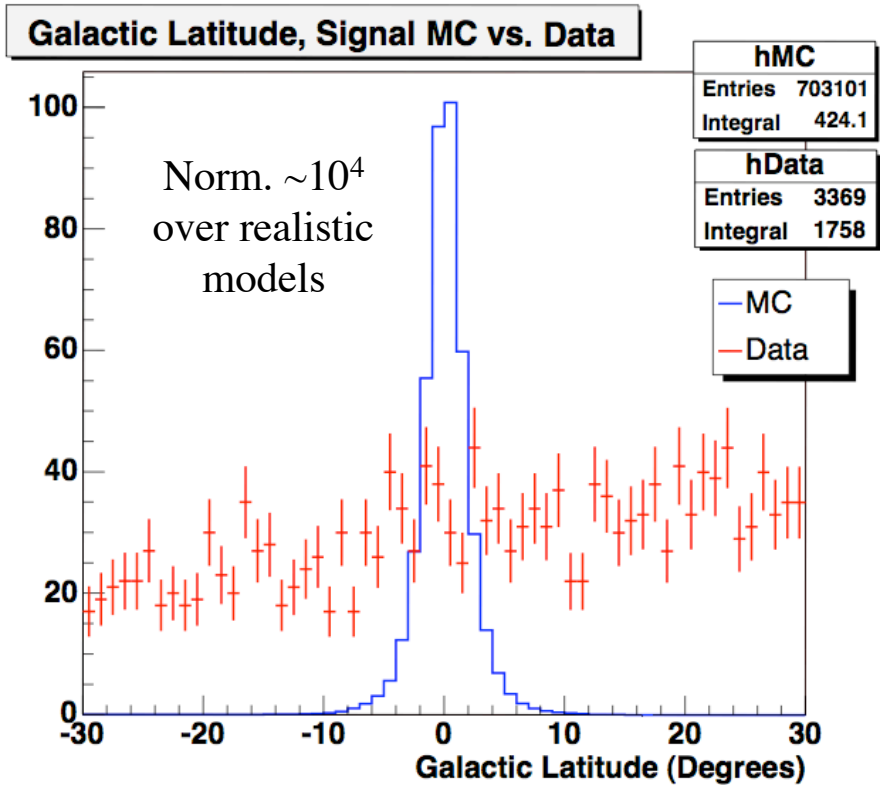
Signal Simulation

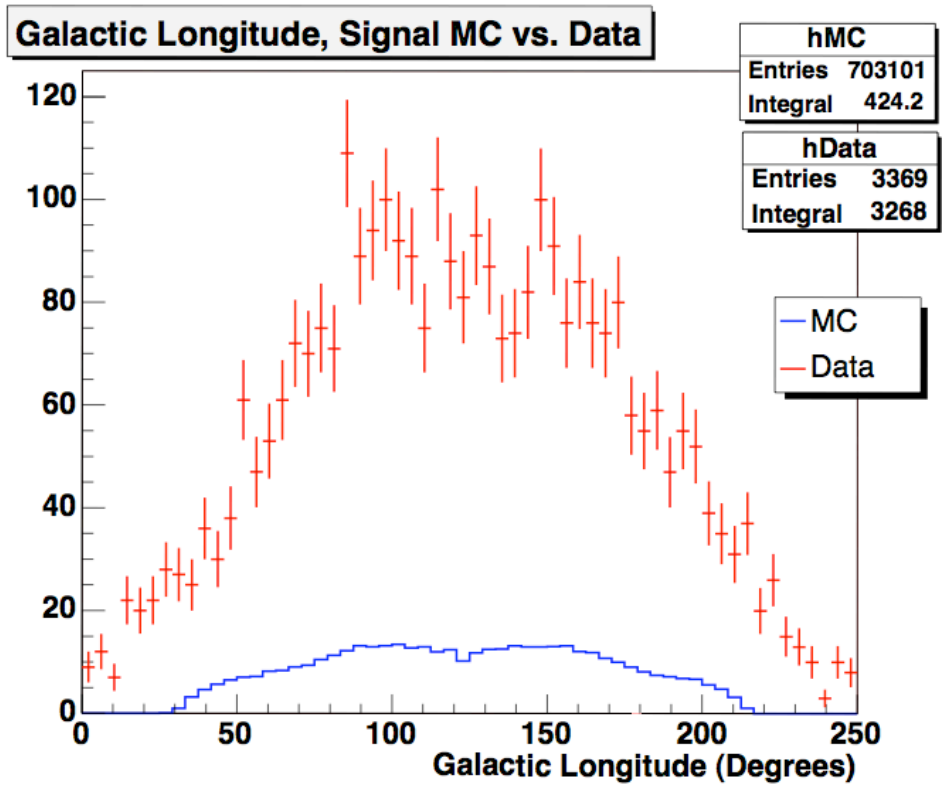
- Modify times and reweight individual nusim MC events to simulate line flux from plane
- Normalize signal to some *linear* flux Φ_{gal} (GeV^{-1} s^{-1} cm^{-2} rad^{-1})
- See Uppsala talk for more details

Simulated Spectra



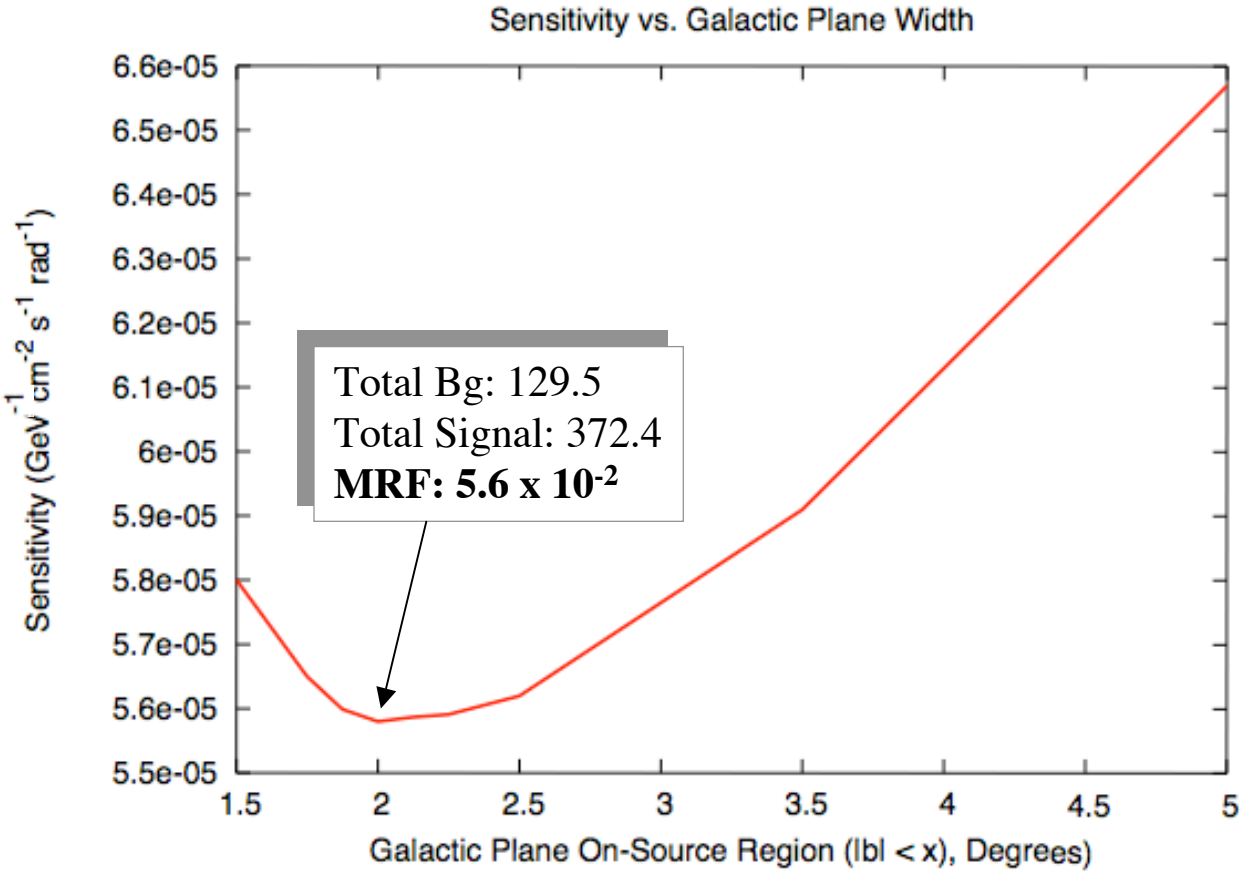
Signal Profile



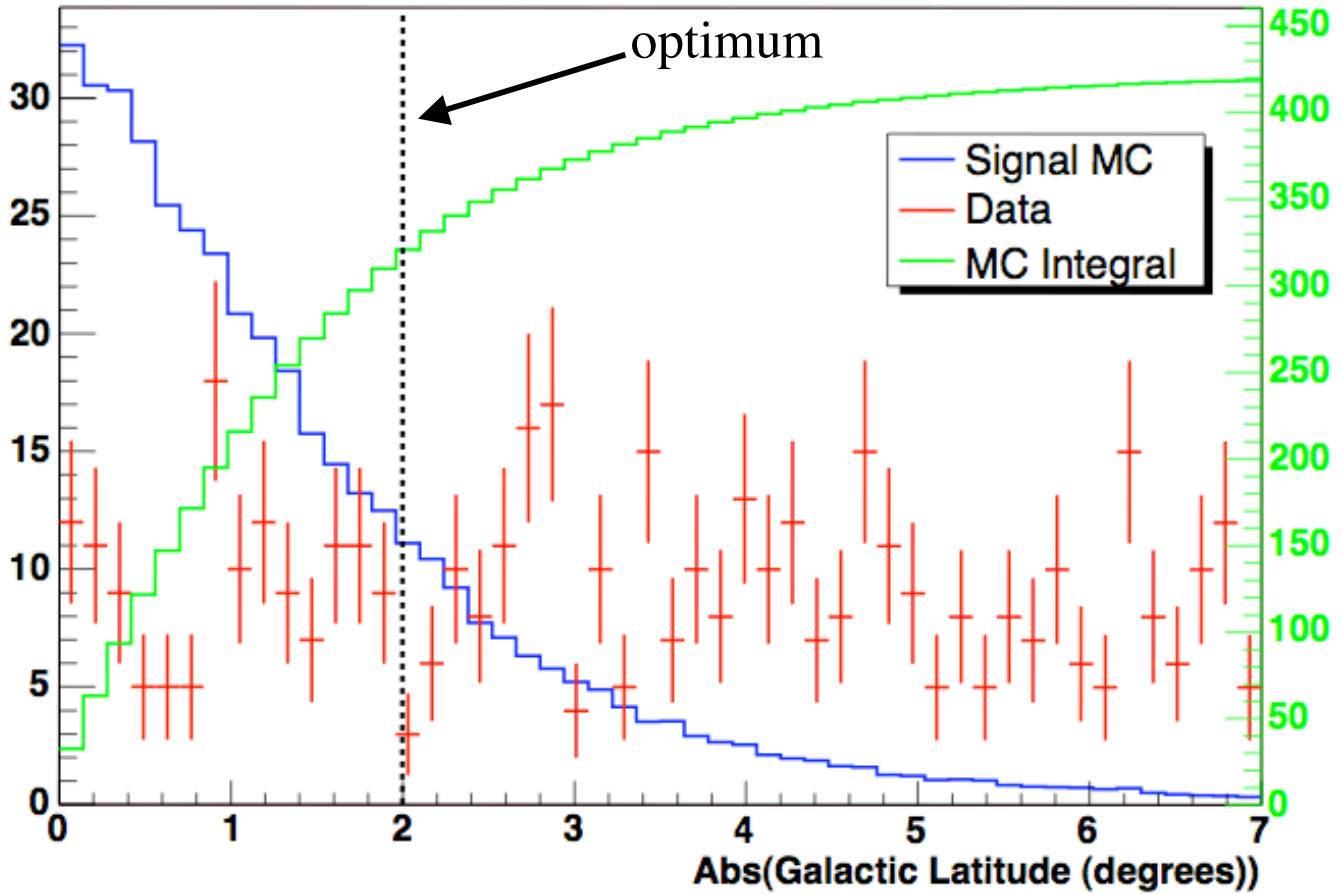


Galactic Latitude (Degrees)

On-Source Region Optimization



Line Spread Function



Reality Check

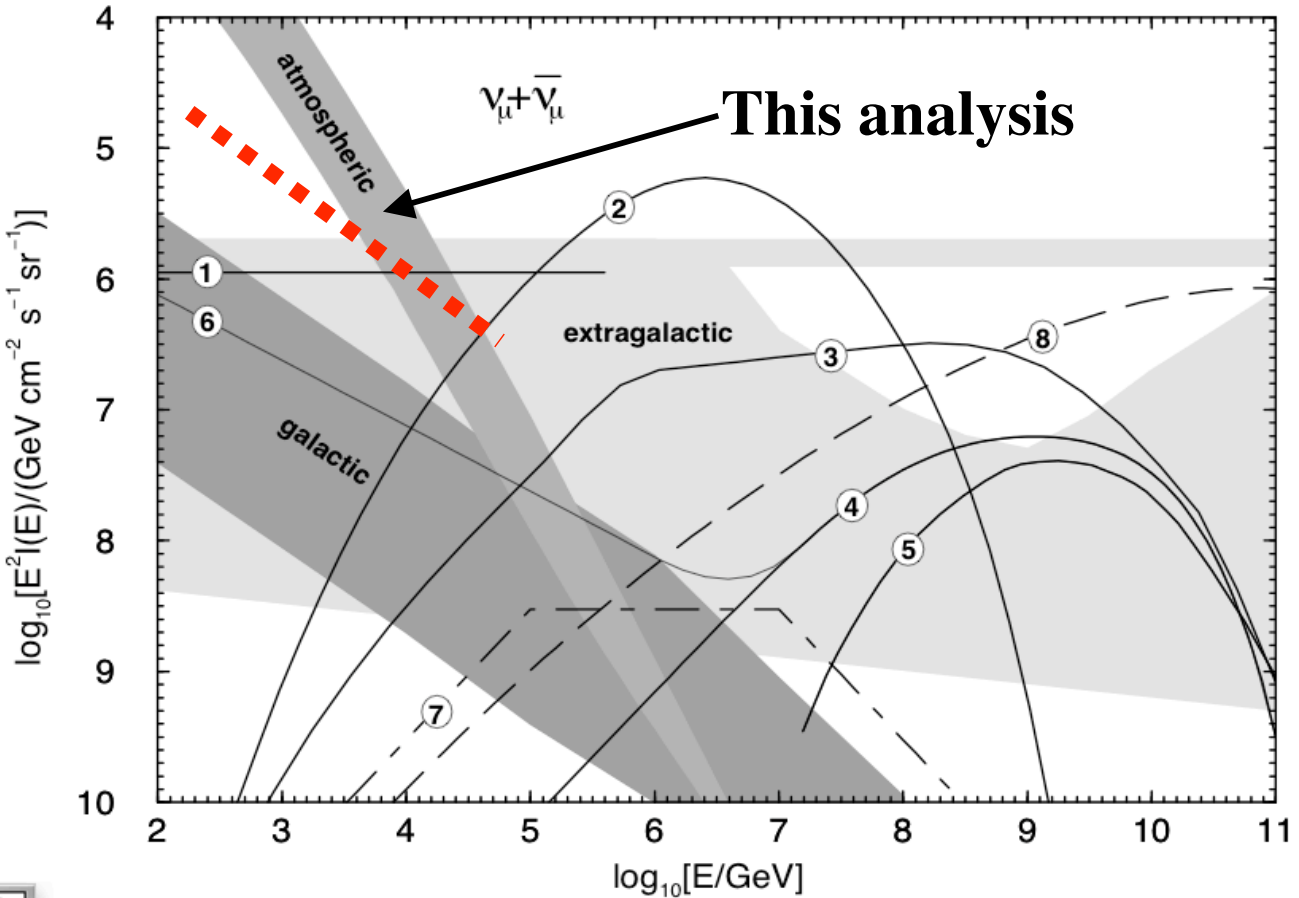
- Optimized sensitivity:
  $\Phi_{gal} = 5.6 \times 10^{-5}$ GeV^{-1} s^{-1} cm^{-2} **rad^{-1}**

- Compute equivalent diffuse flux in on-source region (η = fraction of signal events in region = 74%, Ω_{gal} = solid angle area of on-source region):

$$\Phi_{eff} \approx (\eta\ \Phi_{gal}\ \pi) / \Omega_{gal}$$

- Sensitivity: 7.0×10^{-4} GeV^{-1} s^{-1} cm^{-2} **sr^{-1}**

Sensitivity



Conclusions

- Analysis method is stable and well-defined
- Sensitivity to line flux, $E^{-2.7}$:
  5.6×10^{-5} GeV^{-1} s^{-1} cm^{-2} **rad^{-1}**
- Will be preparing unblinding request soon — we won't find anything unless we look!

Extra Slides

Coordinate Systems

- Note shape of plane in celestial coordinates
- Plane is region around b=0
- 33°< l <213° below horizon from South Pole

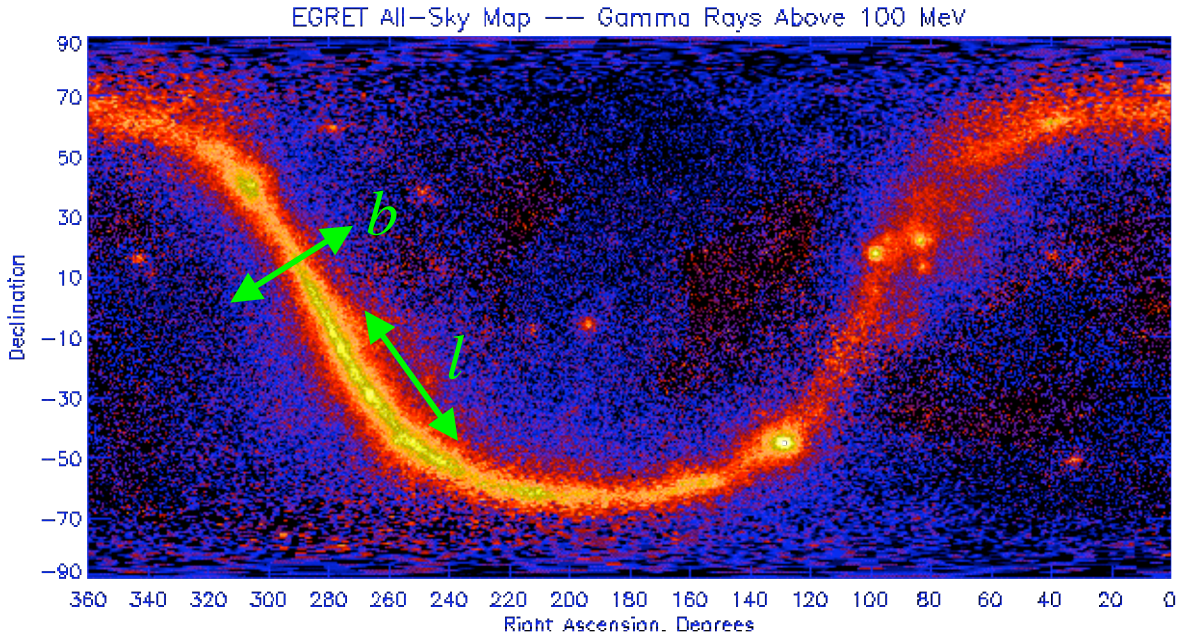
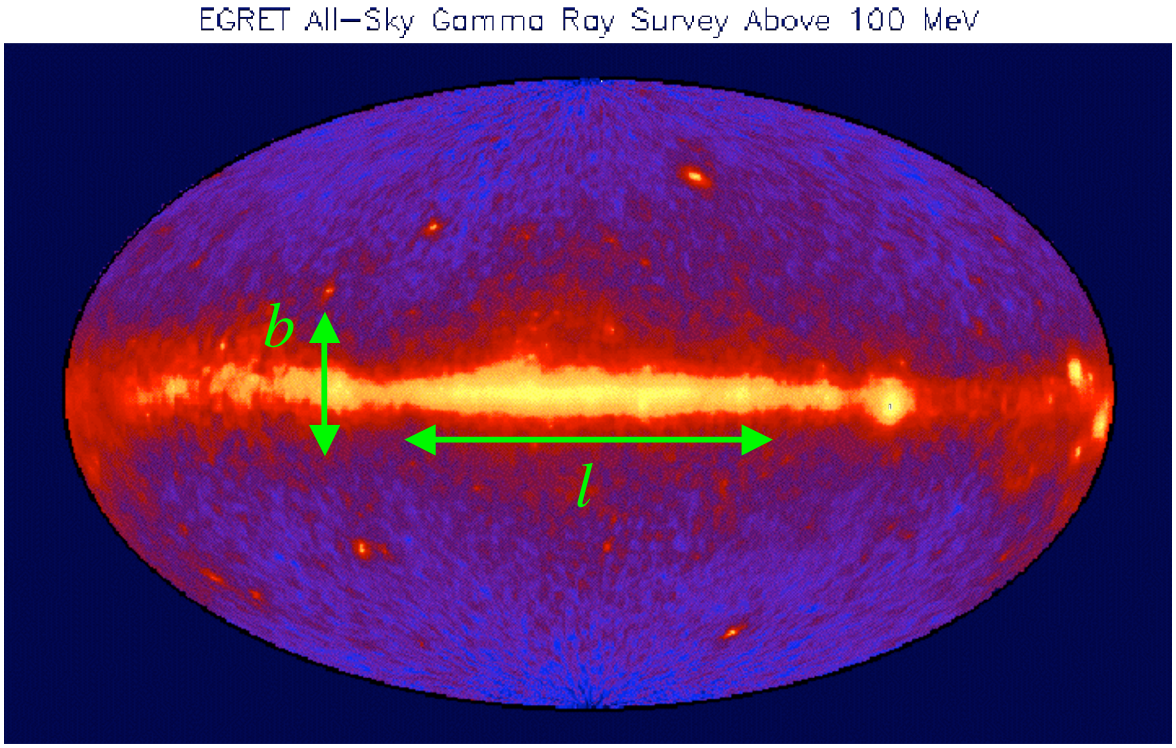


Figure: EGRET collab.

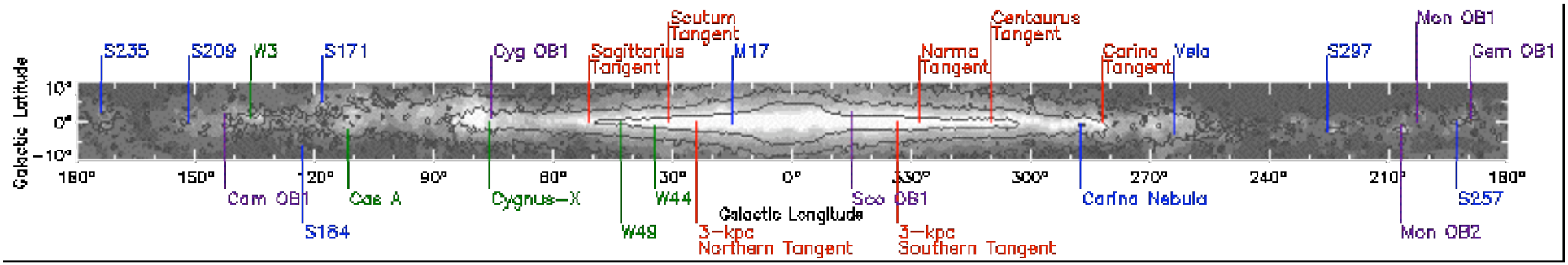
Galactic Coordinates



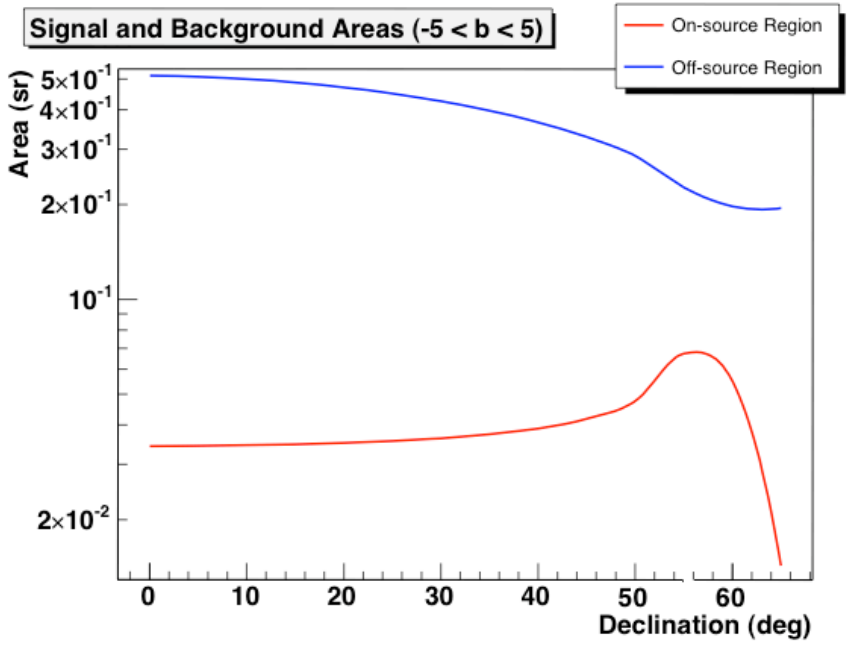
- Galactic equator is $b = 0$
- Galactic center is $l = 0$

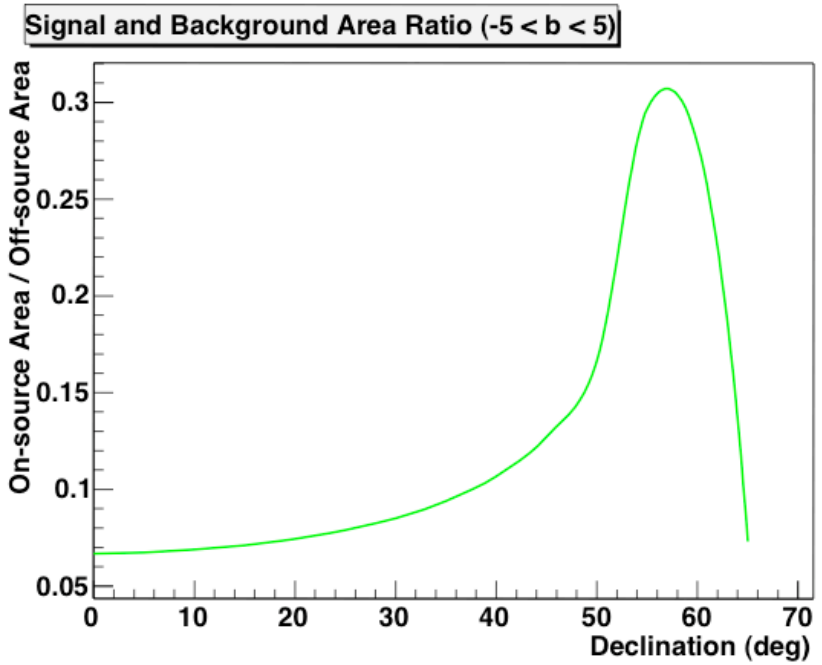
Figure: EGRET collab.

Galactic Map



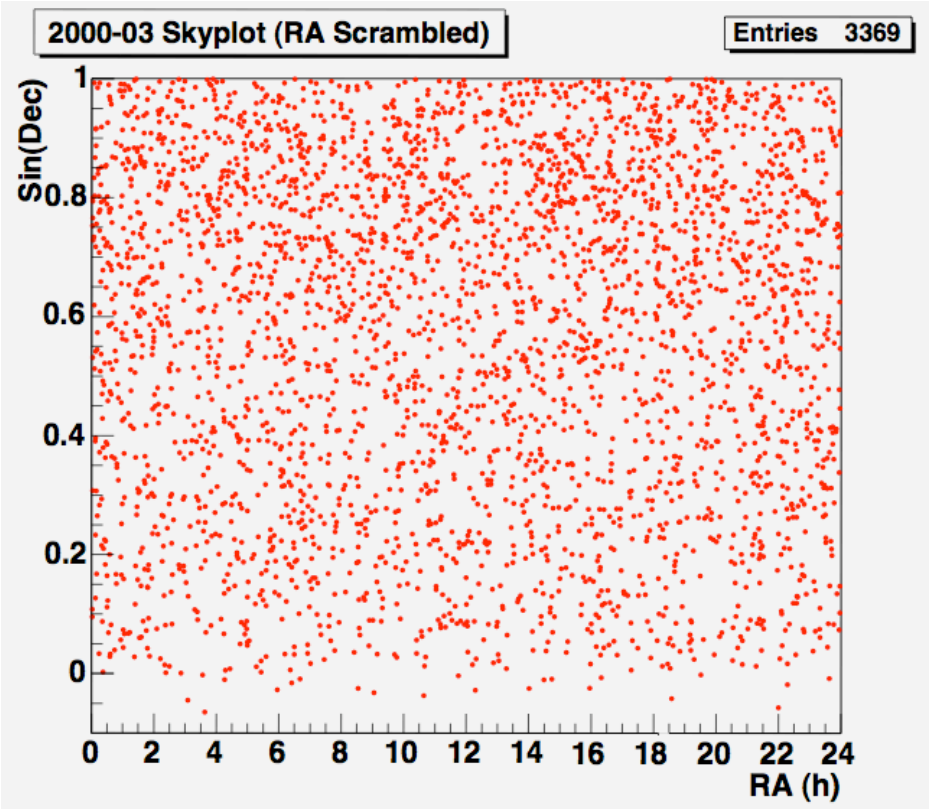
Signal / Background Areas





- Amount of solid angle in signal region is declination-dependent — maximum about 30% on-source, 70% off-source

Event Sample



- High-quality upgoing events, *not* optimized for E^{-2}
- Zeuthen 00-03 combined point source sample replicated in Madison*, RA scrambled for blindness

* Special thanks to M. Ackermann and E. Bernadini

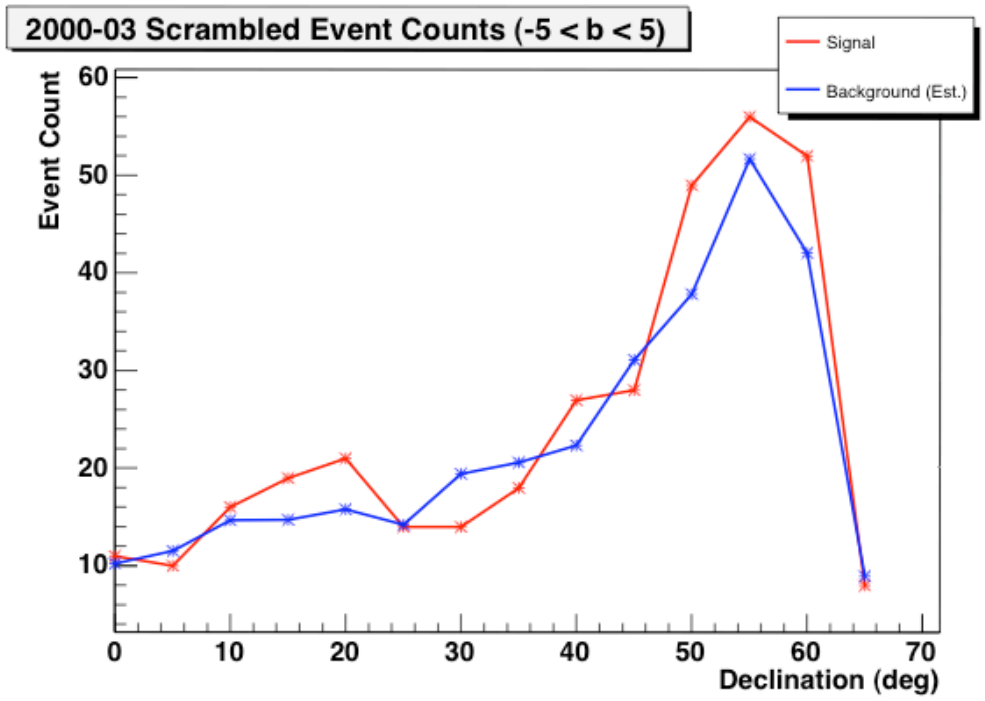
Event Processing

- Start with 2000-03 unified processing level 4

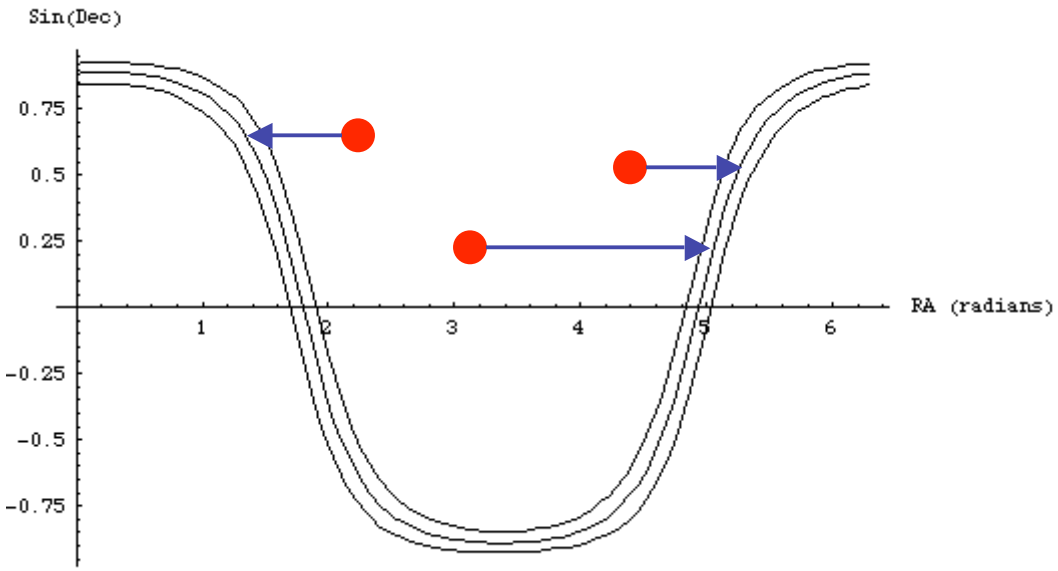
- Optimized cuts (some zenith dependent) from Zeuthen analysis:
  - Smoothness (S_phit[Pandel])
    (also exclude smoothness of exactly 0)
  - Paraboloid fit error (P08err1, P08err2)
    (also exclude negative errors)
  - Likelihood difference (jkchi[Bayes] - jkchi[Pandel])
  - Data only: flare cut and stability period cut

Blind 00-03 “Results”

- Scrambled data still can be used to check methodology
- Total over all declinations: 343 “signal” events on 315.1 background
- As expected, consistent with no signal (fluctuation ~1.6σ)
- Also checked with large downgoing event sample



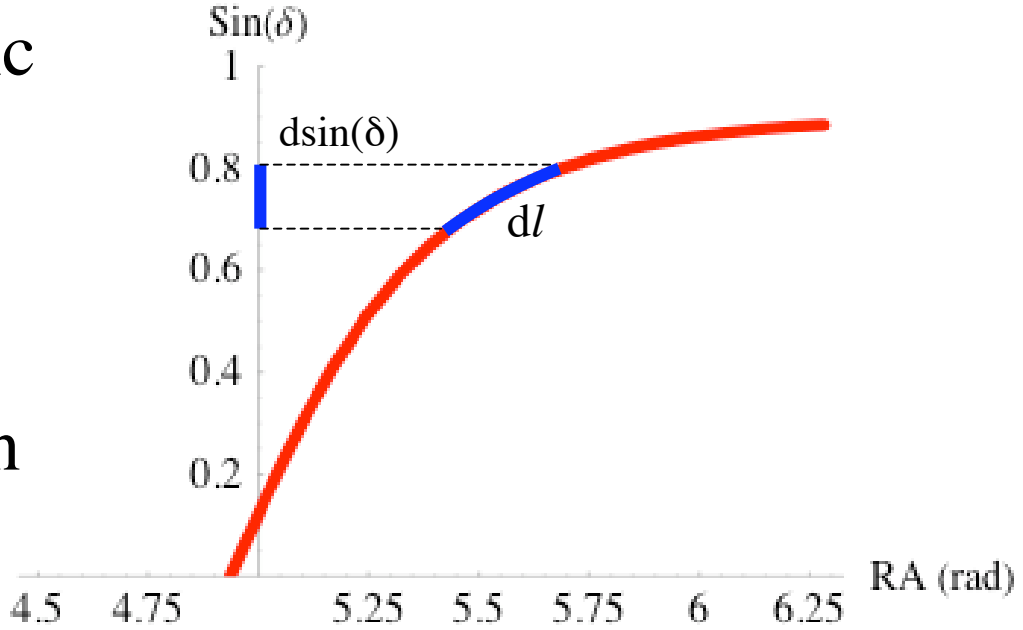
Step 1: Adjust Times



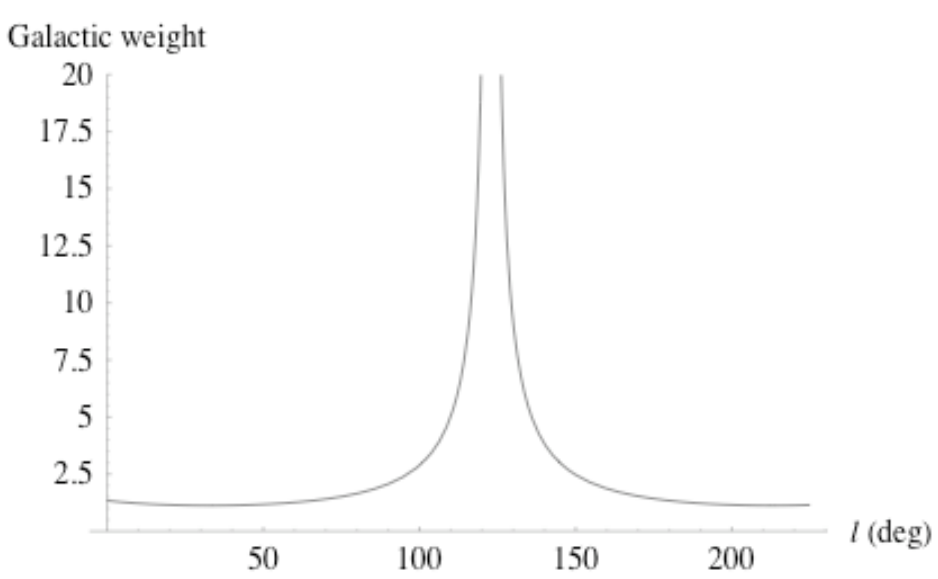
- Time is calculated for each event so that its ϕ lands on galactic equator
- Day of year, segment of plane (two choices) selected randomly

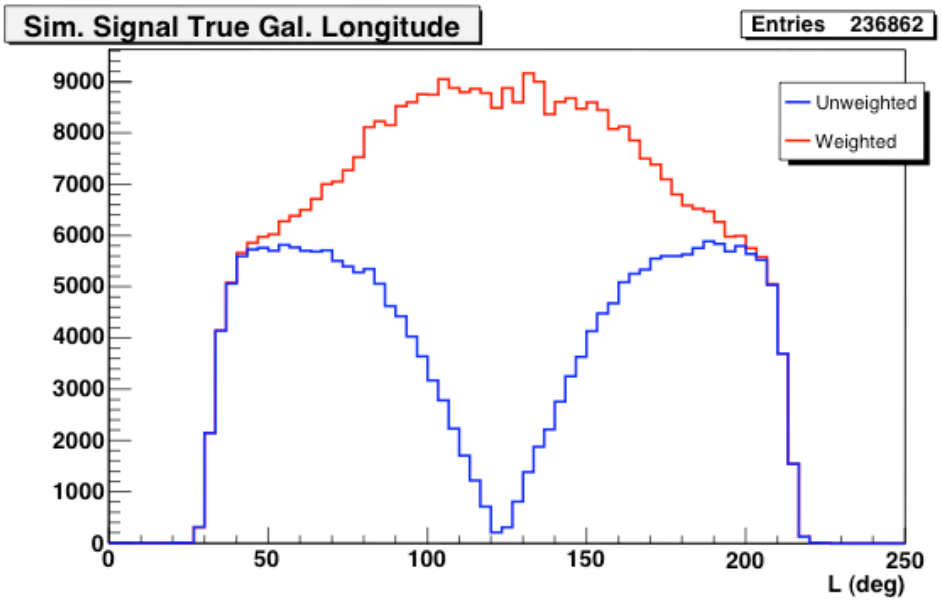
Step 2: Reweight Events

- Must transform distribution from isotropic in sin(δ) to isotropic in *l*
- Weight is Jacobian of coordinate transformation at *b*=0: abs(d*l*/dsin(δ))



Reweighting Results





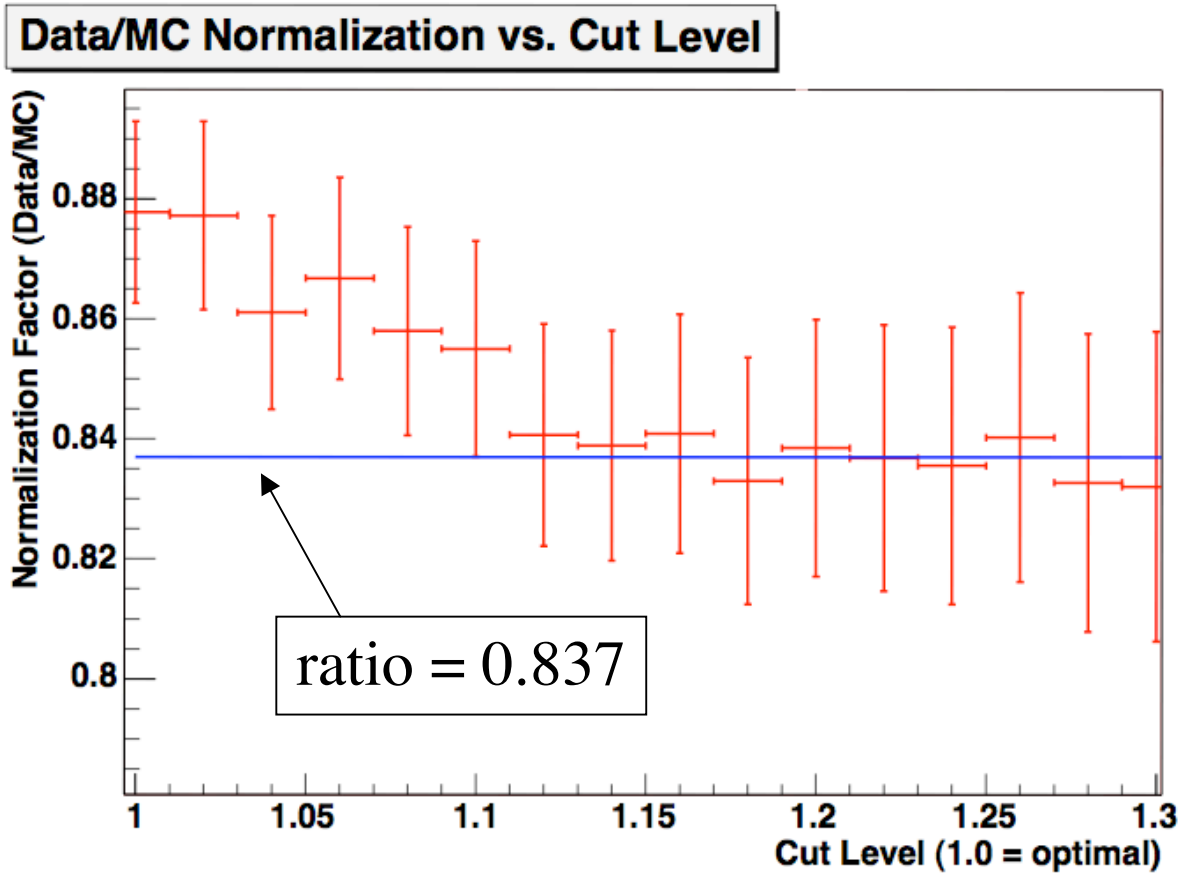
$w(l) = \mathrm{abs}(\cos(\delta_{NGP})\cos(l - l_0))^{-1}$

(2000-03 L4+Opt MC, not normalized)

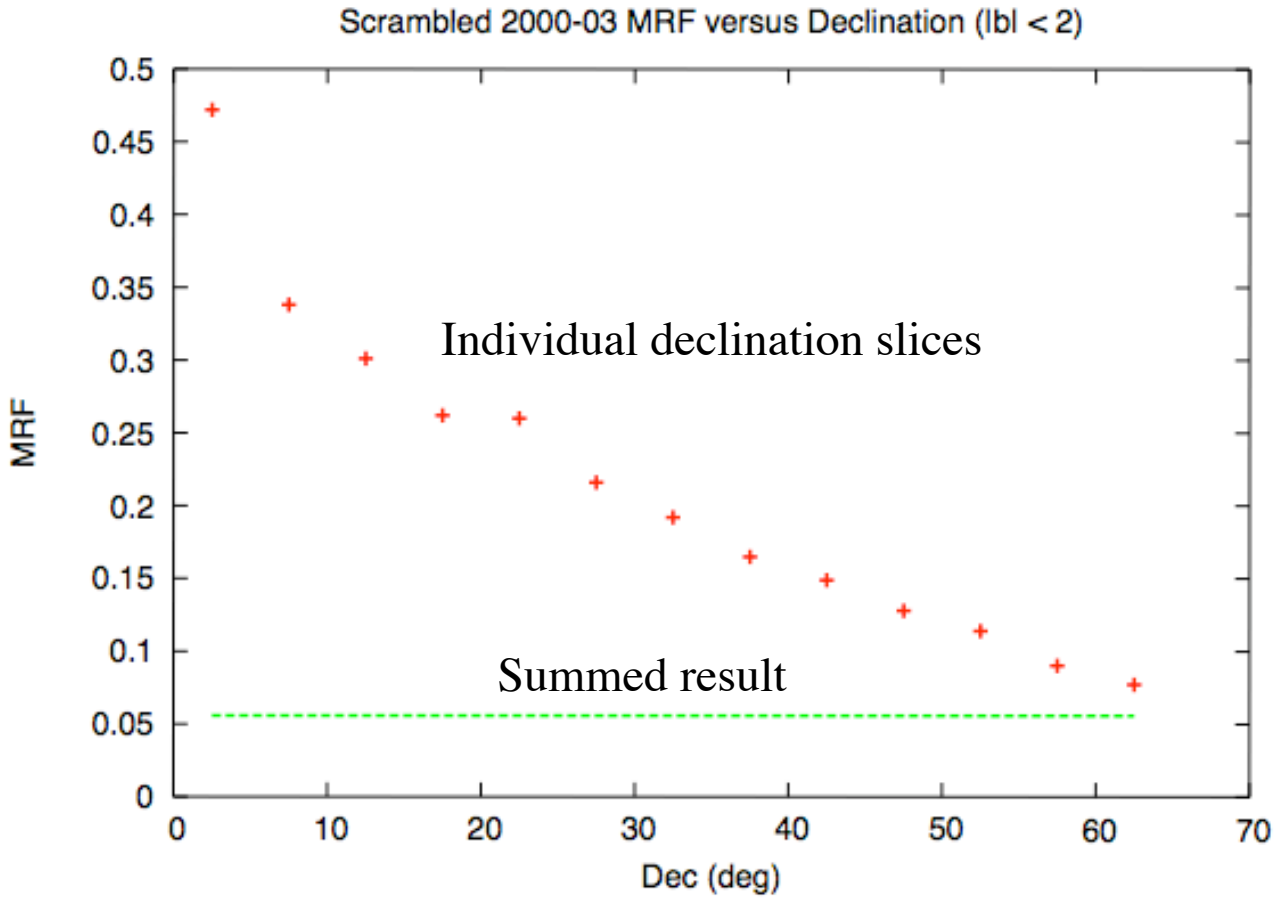
Flux Normalization

- Must normalize signal MC to some *linear* flux Φ_{gal} (GeV^{-1} s^{-1} cm^{-2} rad^{-1})
- Equivalent diffuse flux in normal weighting expression — $\Phi_{eff} = \Phi_{gal} / \pi$
- More details:
  http://amanda.wisc.edu/~jkelley/galactic/weighting.pdf

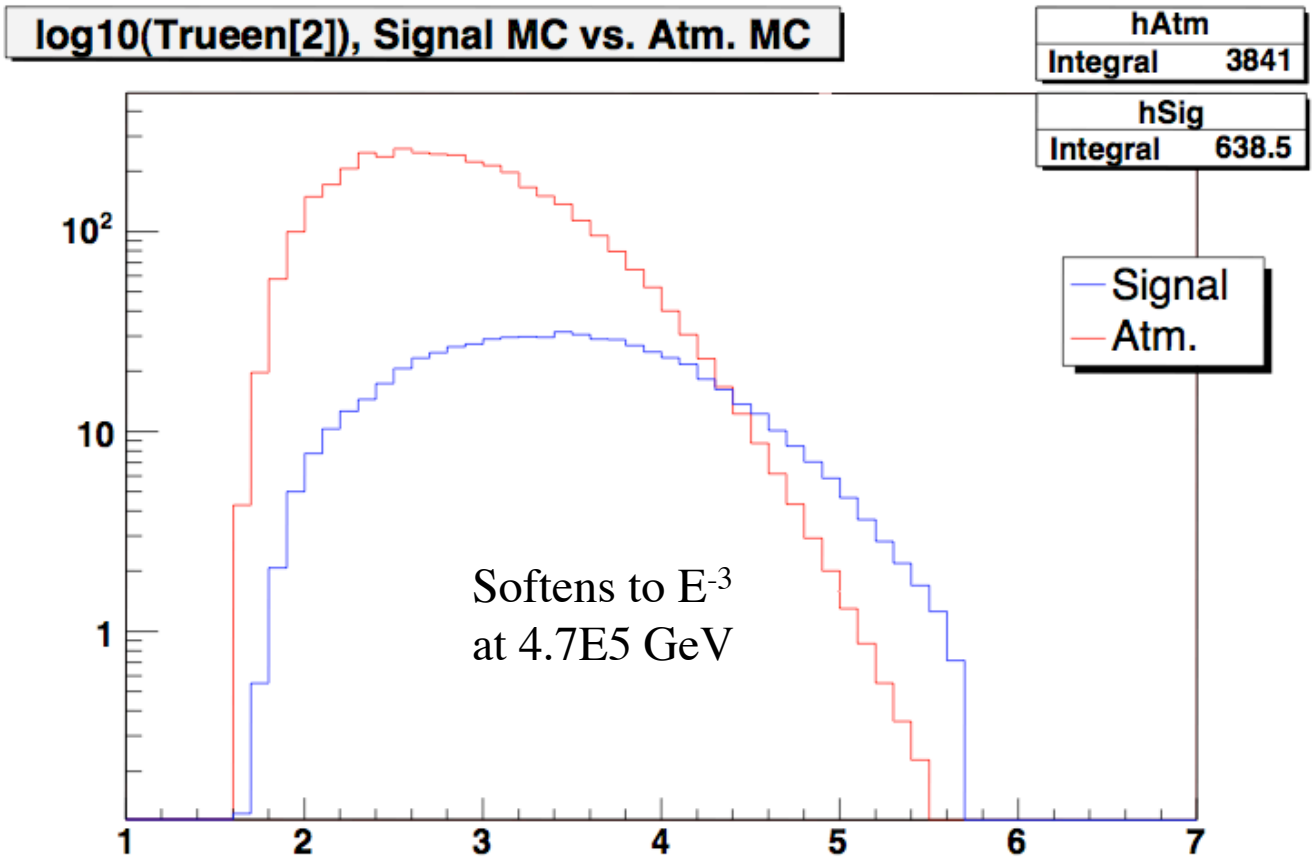
Data/MC Normalization



Model Rejection Factor



Spectrum with Knee



Nch Results (|b| < 2)