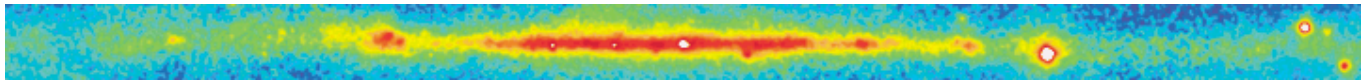
Update on a Search for a Neutrino Flux from the Galactic Plane



John Kelley

February 25, 2005

Motivation

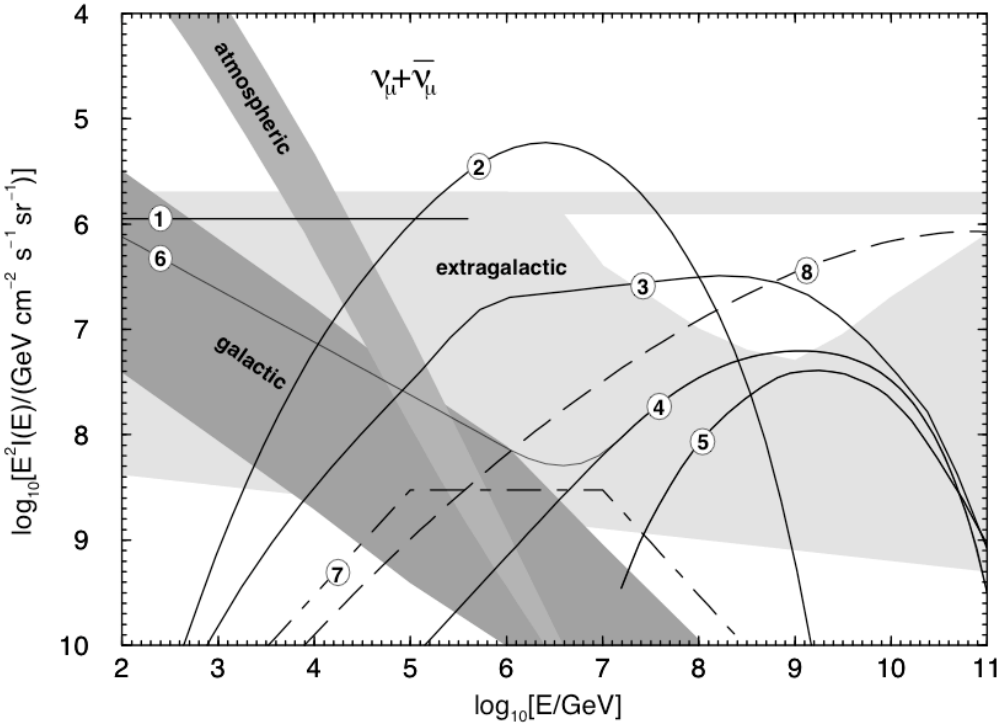
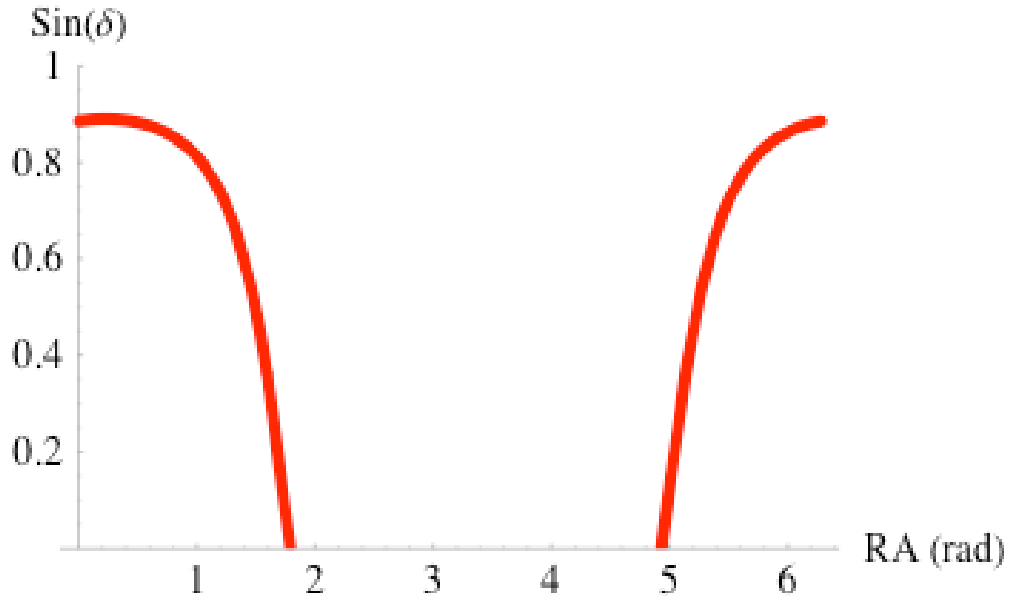


Figure: Learned & Mannheim, Annu. Rev. Nucl. Part.Sci.2000.50

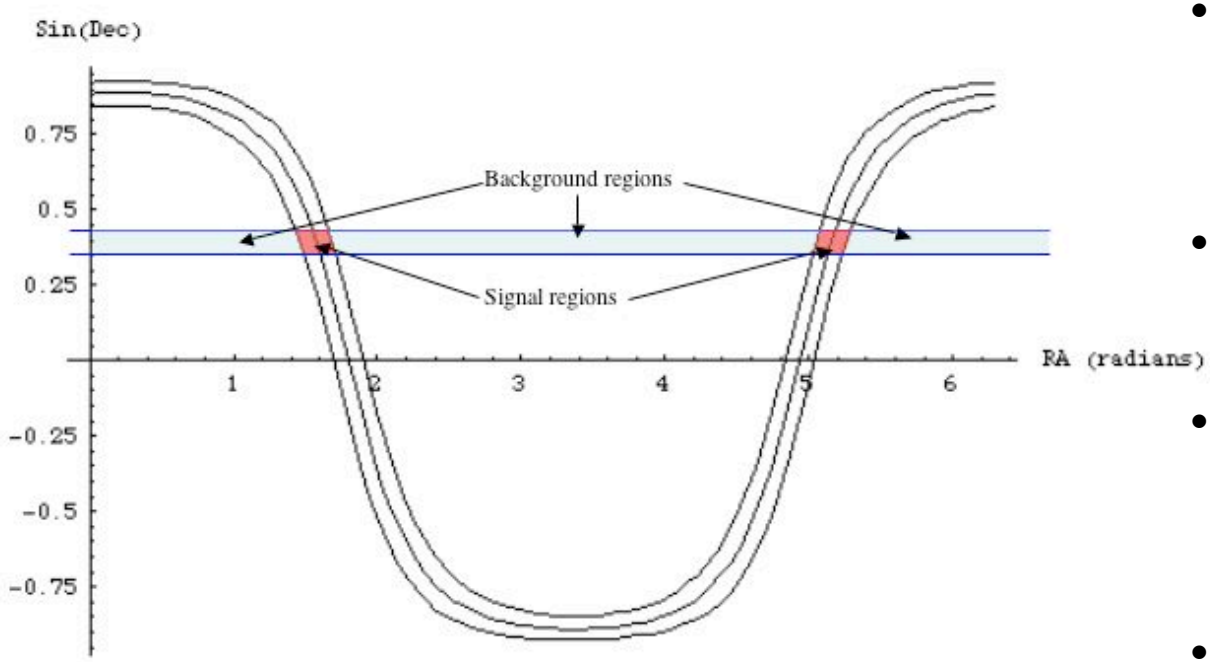
- Cosmic rays interact with galactic ISM, produce γ, ν
- Similar to atmospheric neutrino flux — guaranteed at some level
- Lower density of ISM ⇒ spectrum follows CR primary spectrum, $E^{-2.7}$
- Event rates: 5-15 / yr in AMANDA (Berezinsky *et al.*)

Signal Hypothesis

- Line source of neutrinos from galactic equator
- Isotropic in galactic longitude
- Spectrum $E^{-2.7}$ (+knee more later…)

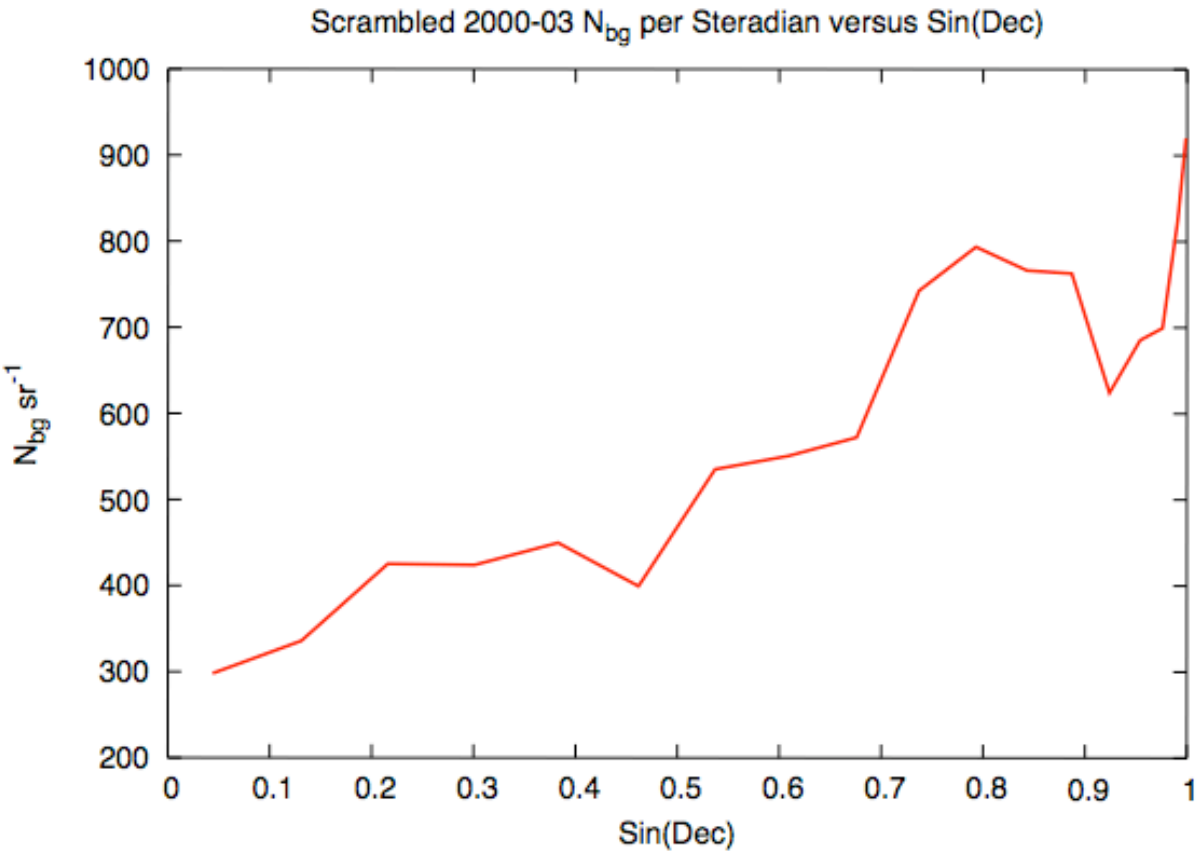


Event Counting



- Source is extended; background is declination-dependent
- Chop plane into 5° slices at a given declination
- Signal region initially $-5° < b < 5°$, will be optimized
- Add signal and background events from each slice

Background Rates, 2000-03 Data

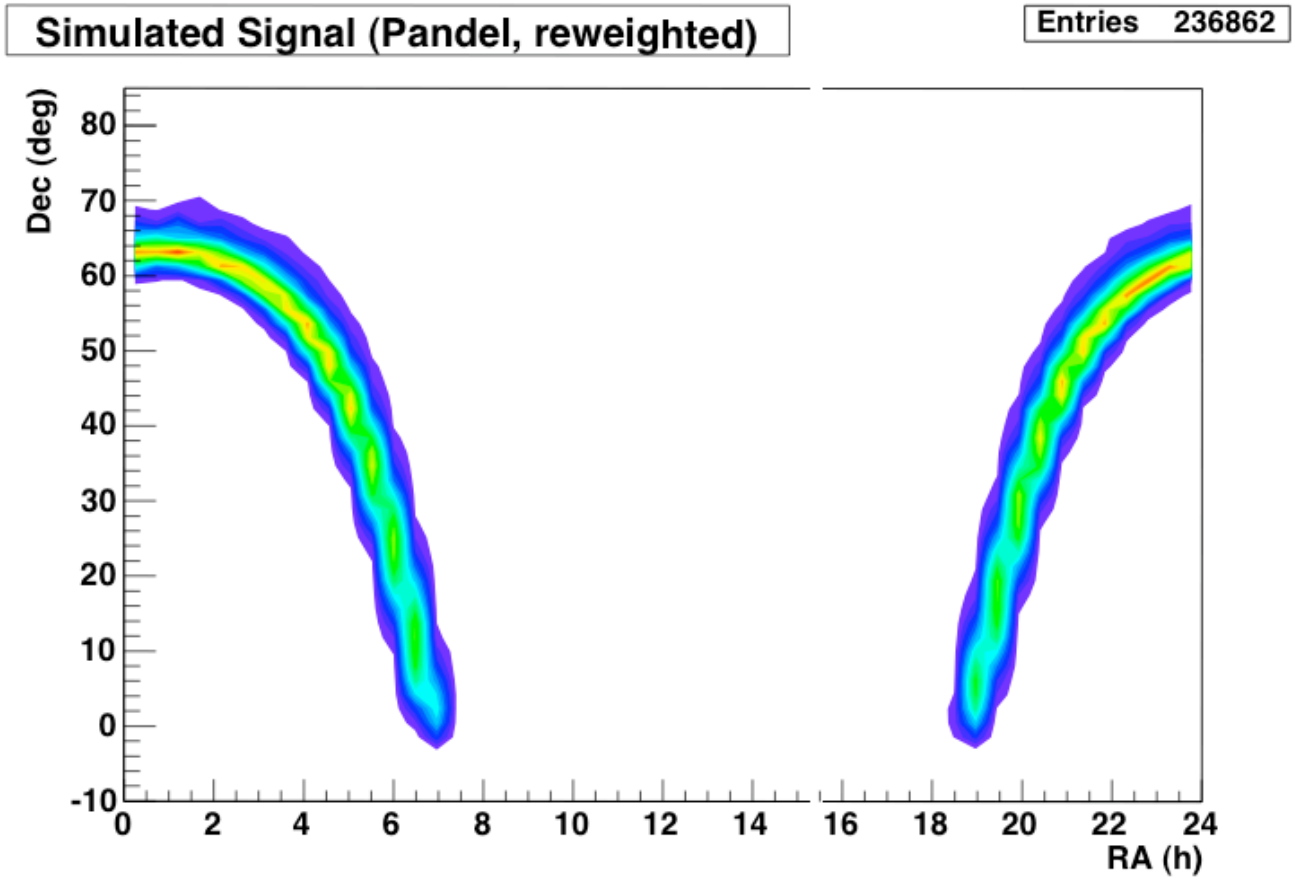


- Point source optimized cuts
- RA scrambled for blindness

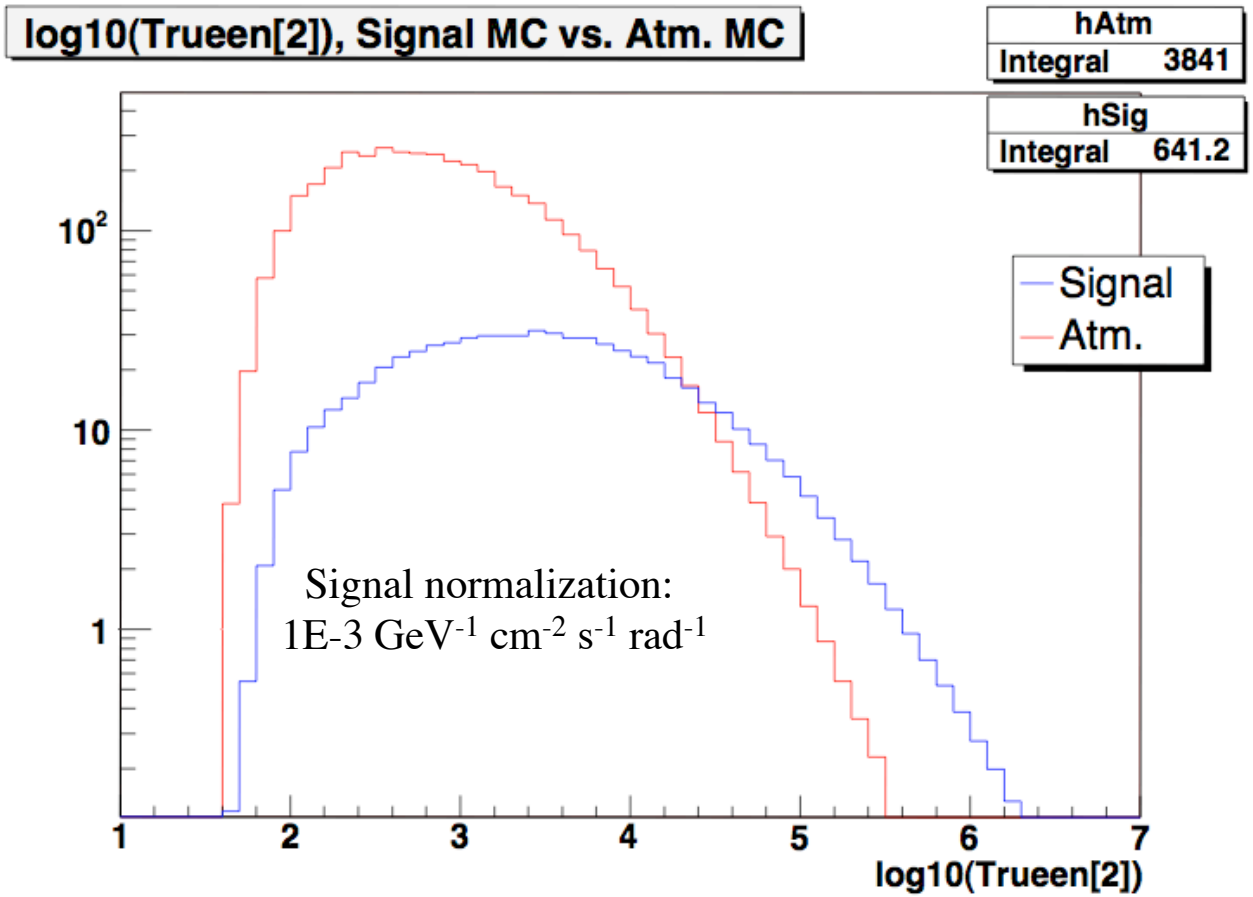
Signal Simulation

- Modify times and reweight individual atmospheric MC output to simulate line flux from plane
- Normalize signal to some *linear* flux Φ_{gal} (GeV^{-1} s^{-1} cm^{-2} rad^{-1})
- Normalize for livetime, number of events

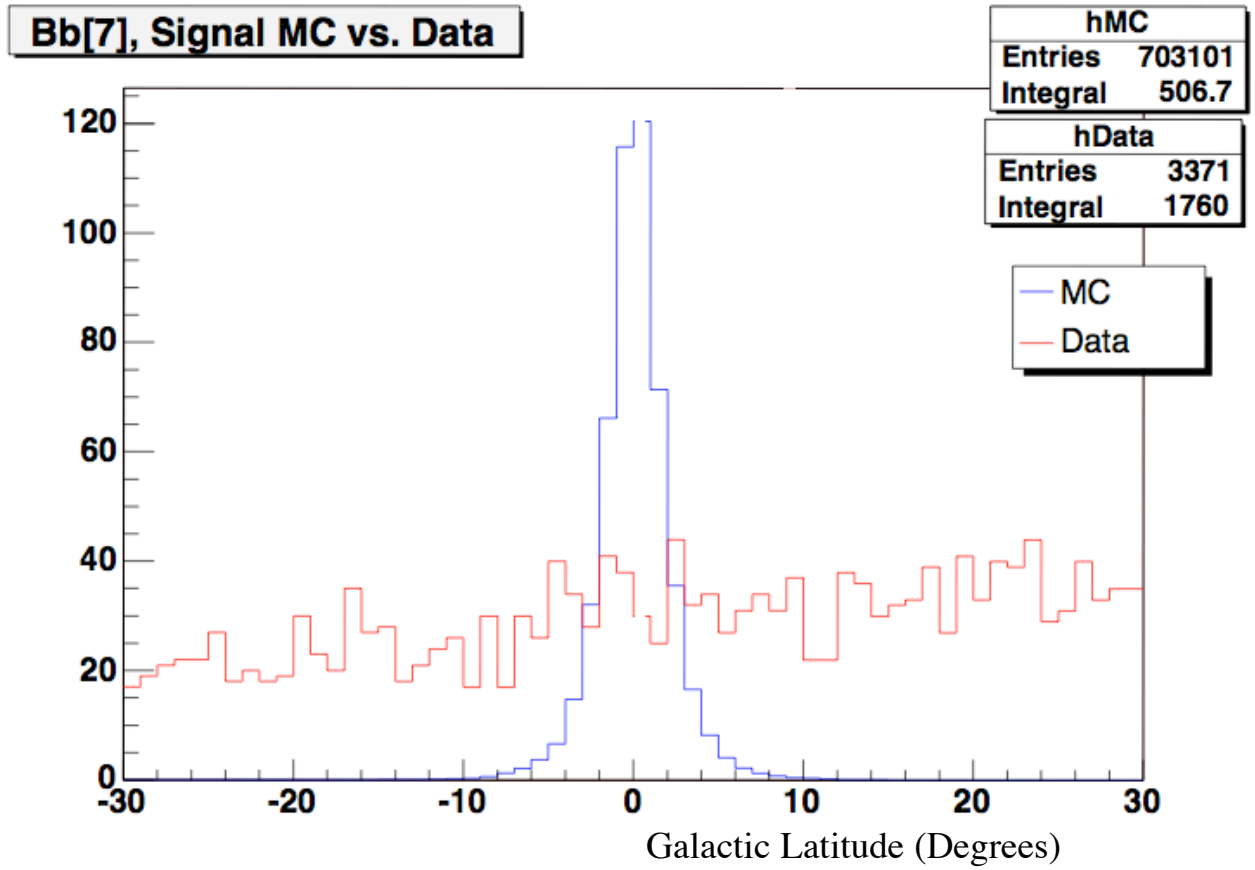
Signal Skyplot



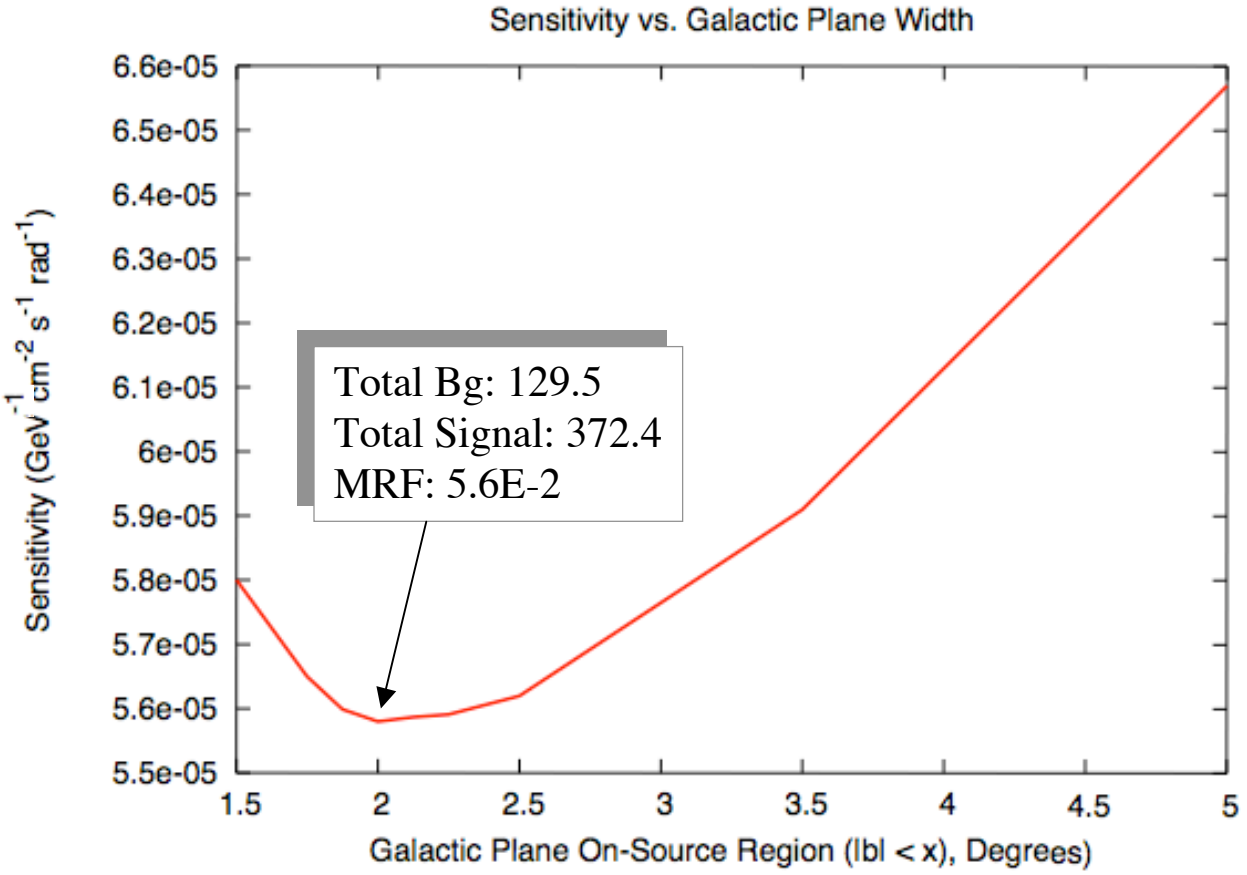
Simulated Spectra



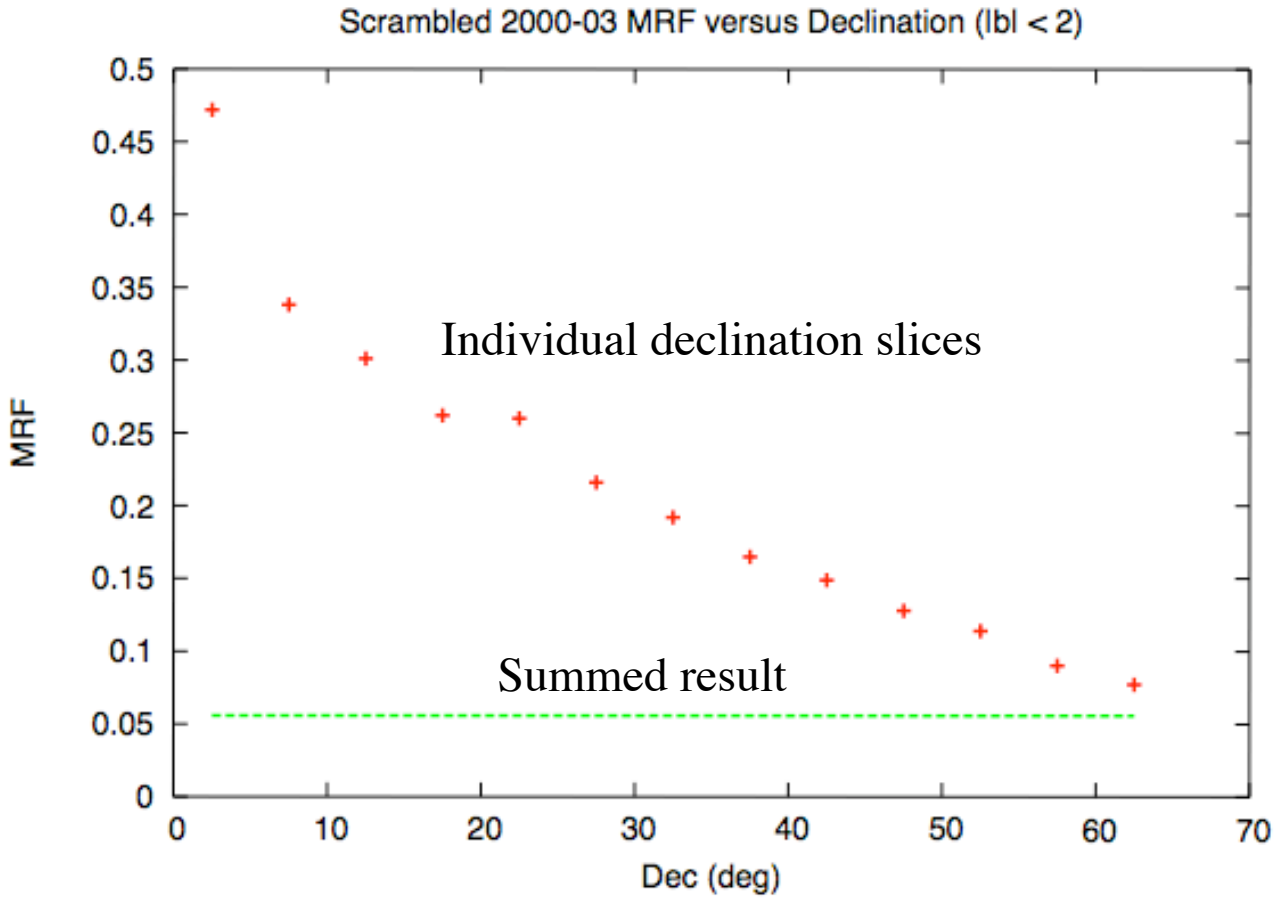
Galactic Latitude



On-Source Region Optimization



Model Rejection Factor



Reality Check

- How to compare to models quoting flux per steradian? Compute equivalent diffuse flux in on-source region:

$$\Phi_{eff} = \eta\, \Phi_{gal}\, \pi / A_{gal} = 14.3\, \Phi_{gal}\, (|b| < 2)$$

- Sensitivity: 8.0E-4 $GeV^{-1}\ s^{-1}\ cm^{-2}\ sr^{-1}$

Even More Reality

- Average column density from Bloemen's map, and parameterization from Ingelman & Thunman:

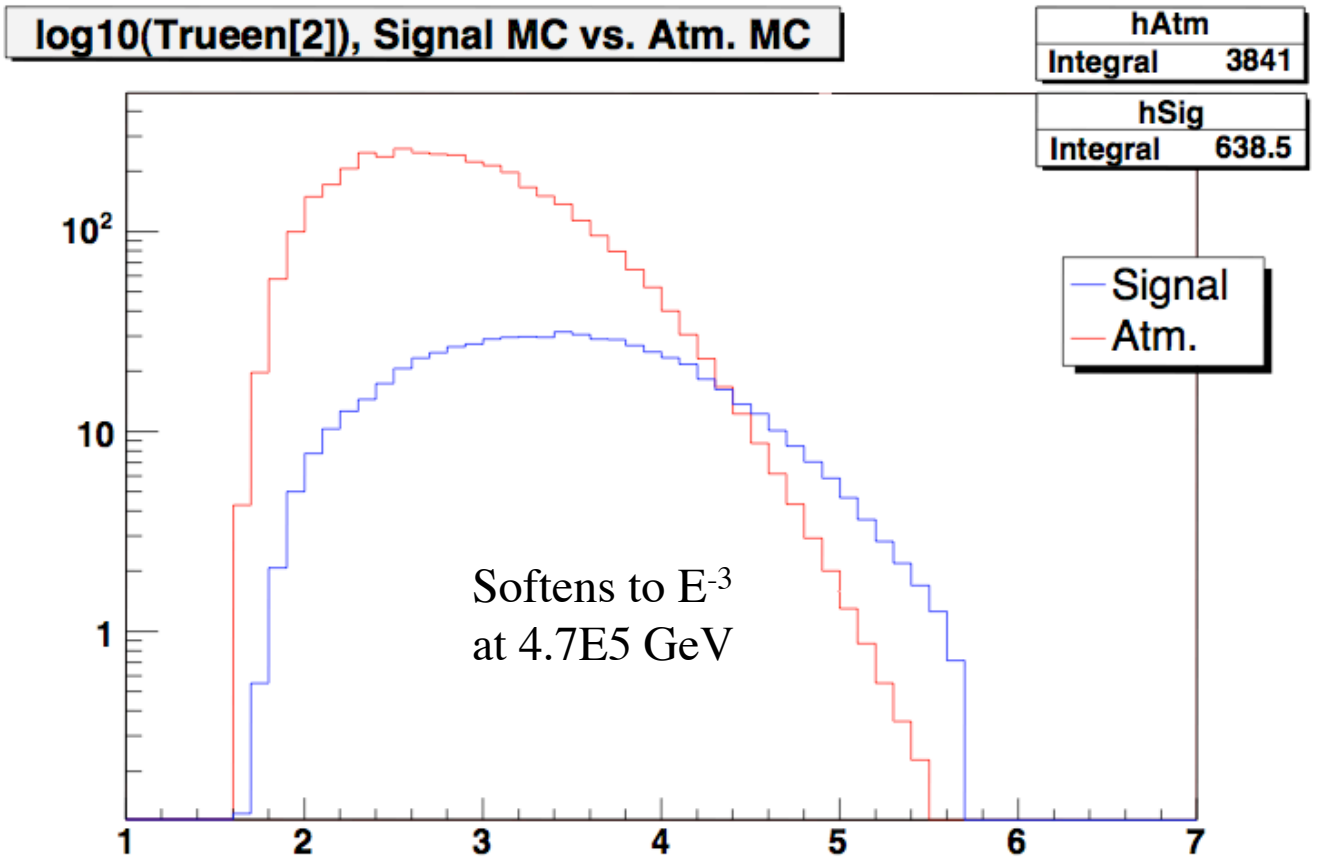
  $\Phi(E)\ E^{2.7} = 7.6E\text{-}6\ GeV^{-1}\ s^{-1}\ cm^{-2}\ sr^{-1}$

- A mere *44,000 years* of AMANDA data necessary to reach that level!

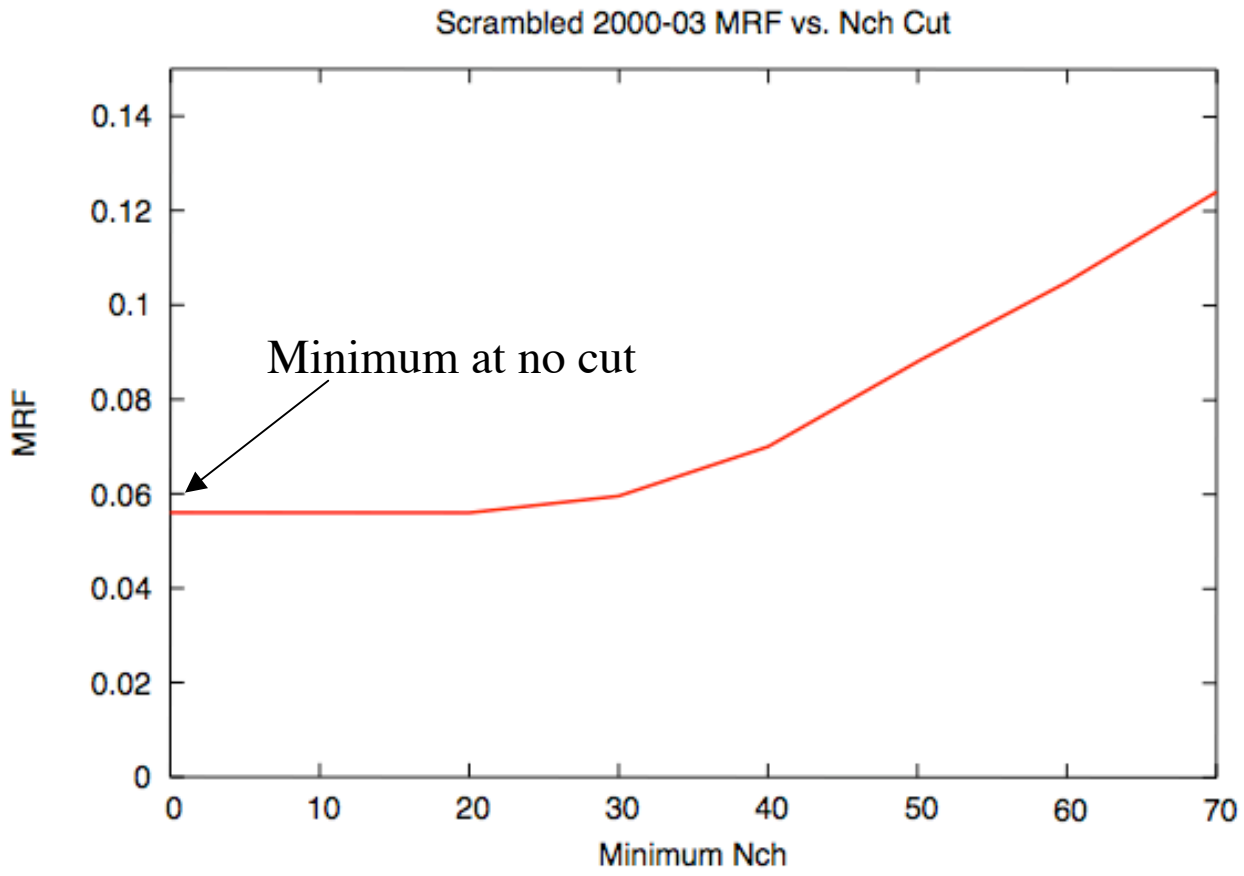
- Compared to central region of galaxy: 1.0E-4 (!)
  Only need 250 years of data

- Will Nch cut help?

Spectrum with Knee



Nch Results (|b| < 2)



Next Steps

- Calculated and apply absolute MC/data normalization (0.83 expected)
- Check signal MC normalization with effective area
- Check signal MC prediction with Francis' numbers (5 events/yr?!) — need flux at 5.0E-5 level for these rates, correcting for signal efficiency
- Check downgoing contamination
- Try harder spectra (optimistic)?
- Request unblinding

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

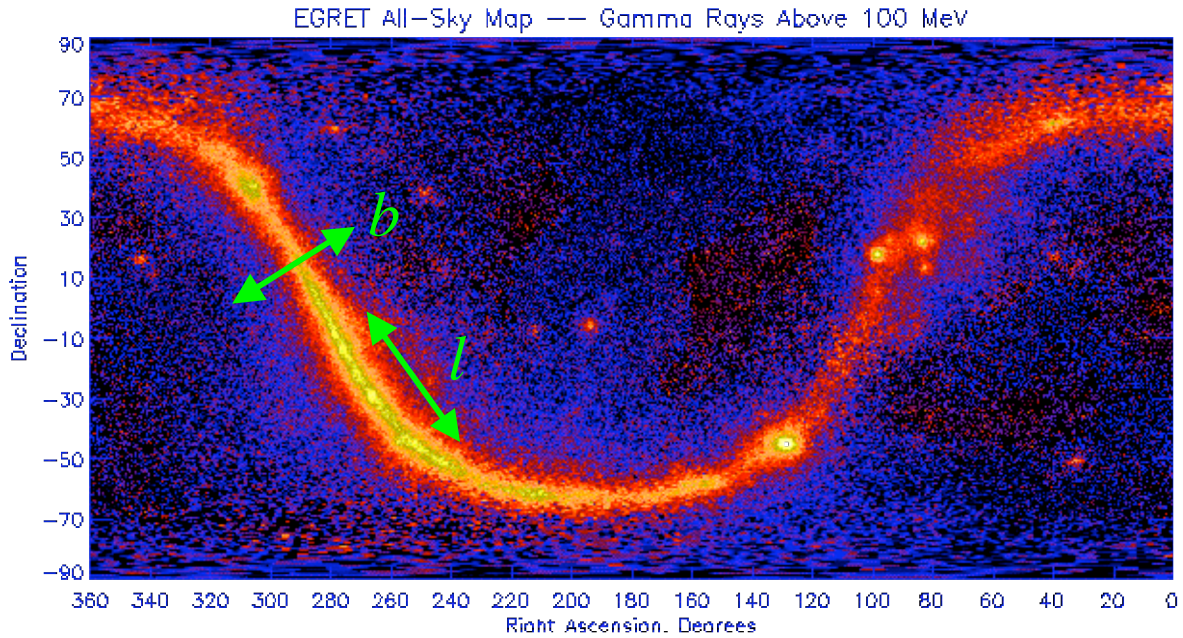
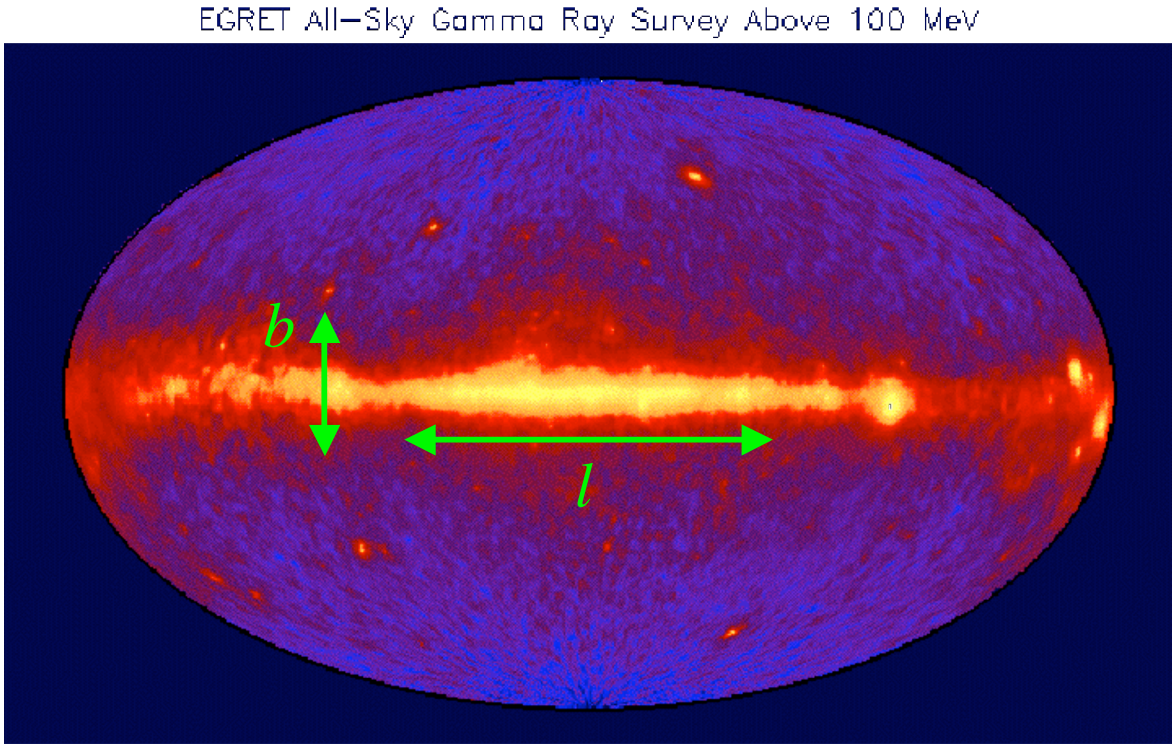


Figure: EGRET collab.

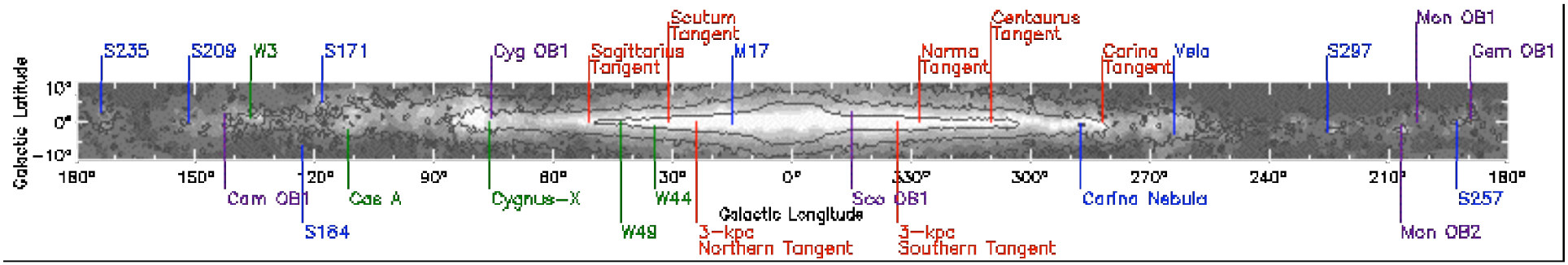
Galactic Coordinates



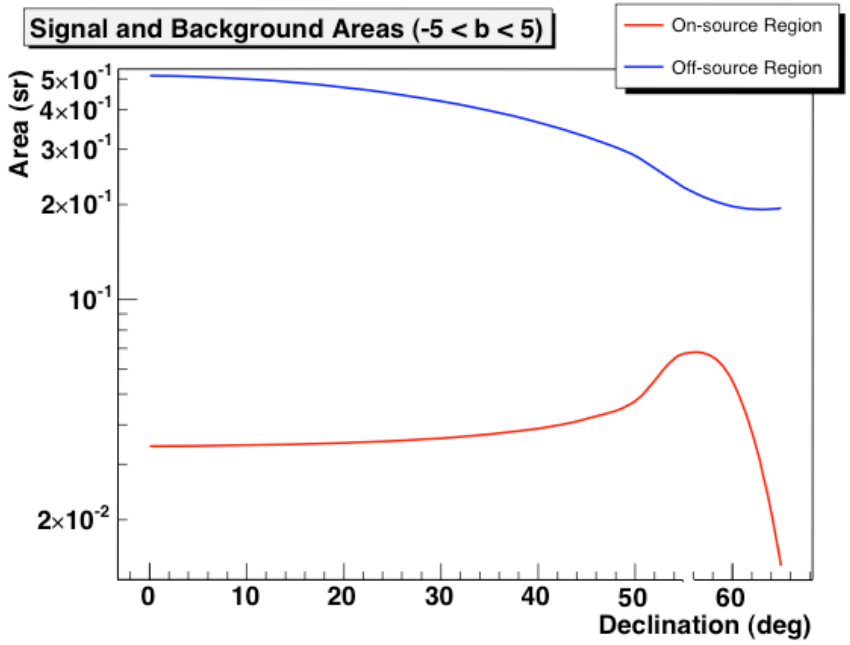
- Galactic equator is $b = 0$
- Galactic center is $l = 0$

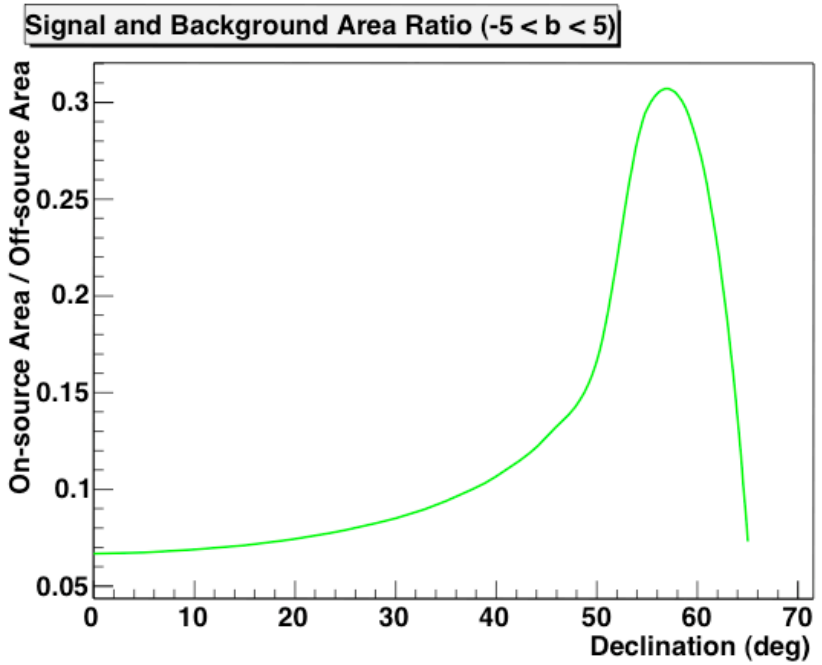
Figure: EGRET collab.

Galactic Map



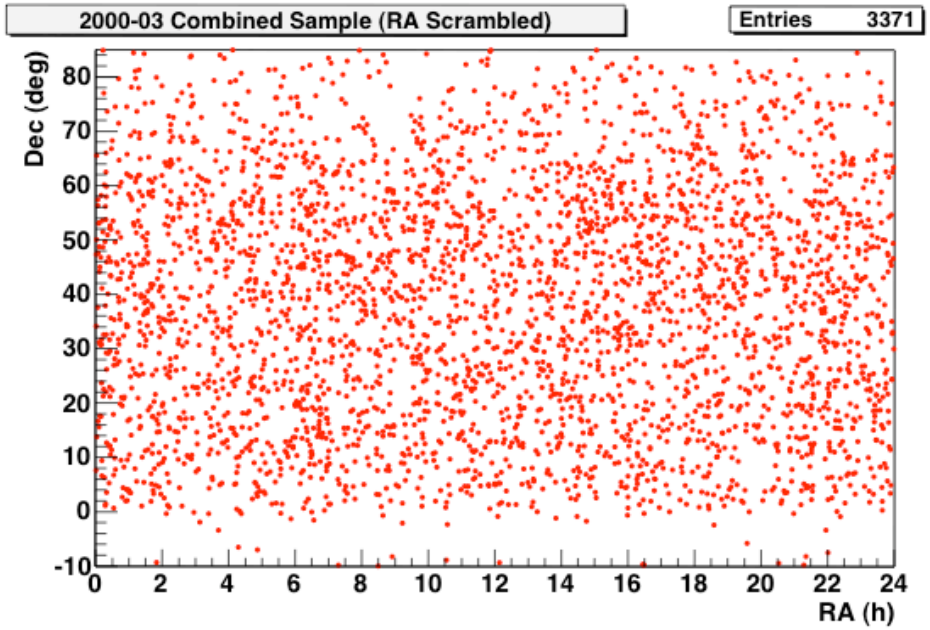
Signal / Background Areas





- 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

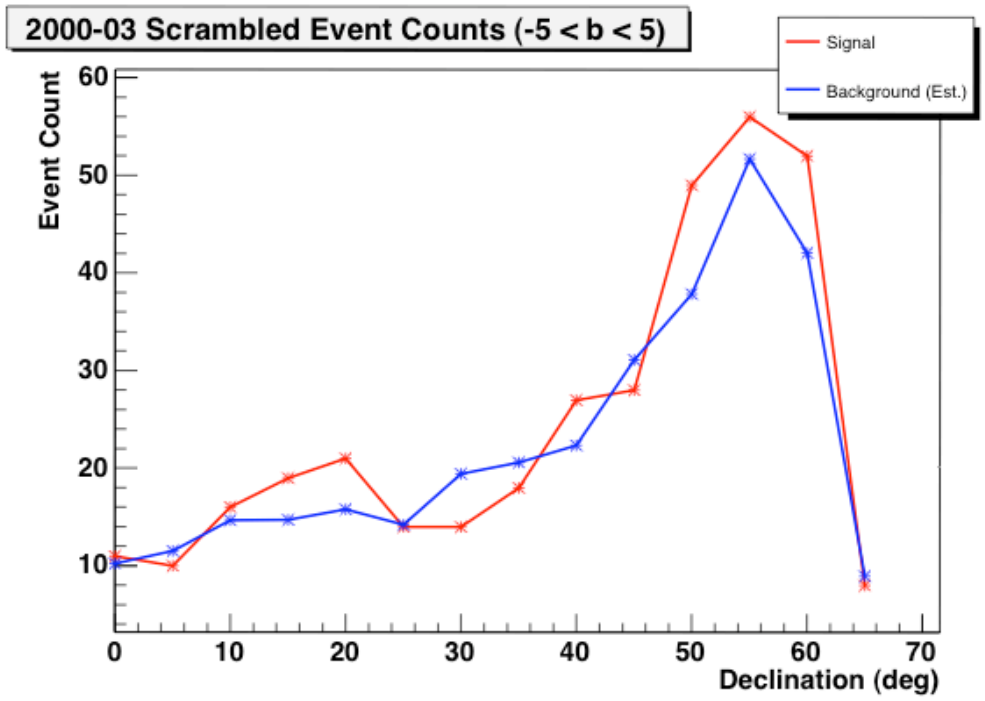
Event Processing

- Start with 2000-03 unified processing level 4

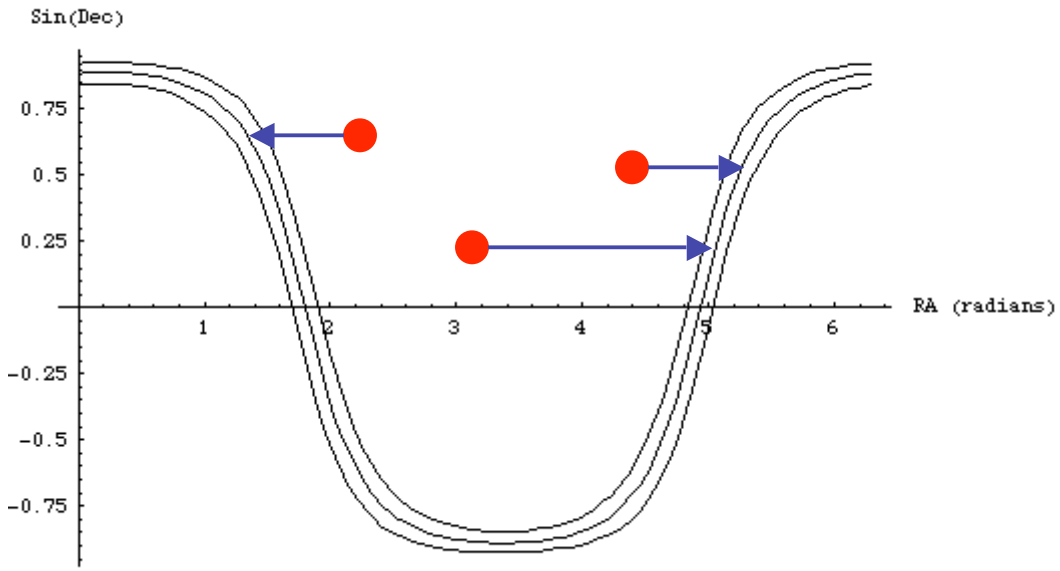
- Optimized cuts (some zenith dependent) from Zeuthen analysis:
  - Smoothness (S_phit[Pandel])
    (also exclude smoothness of exactly 0)
  - Paraboloid fit error (P08err1, P08err2)
    (also exclude negative errors)
  - Likelihood difference (jkchi[Bayes] - jkchi[Pandel])
  - Data only: flare cut and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



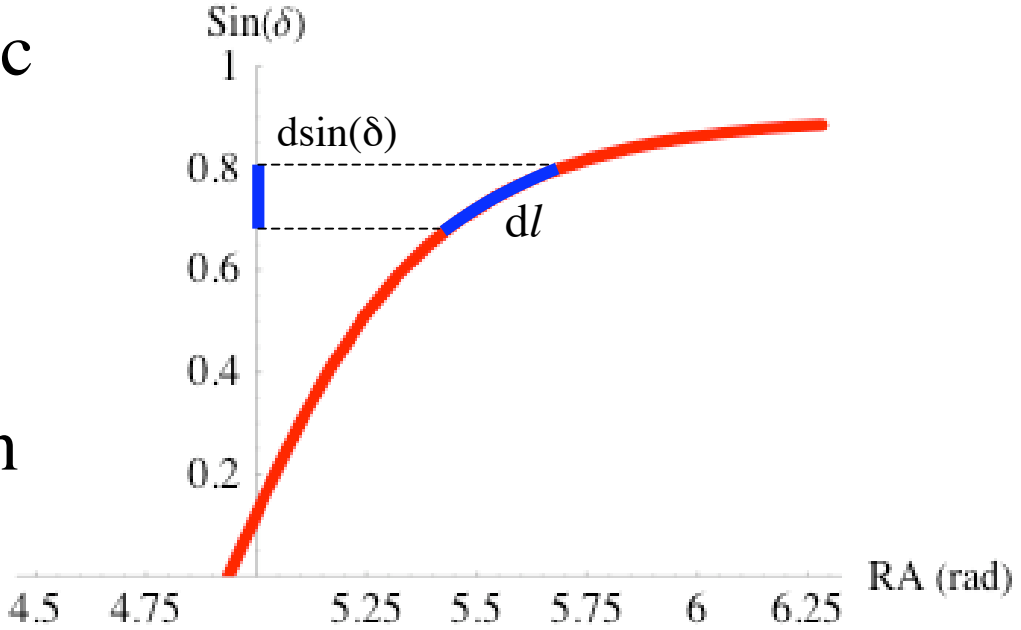
Step 1: Adjust Times



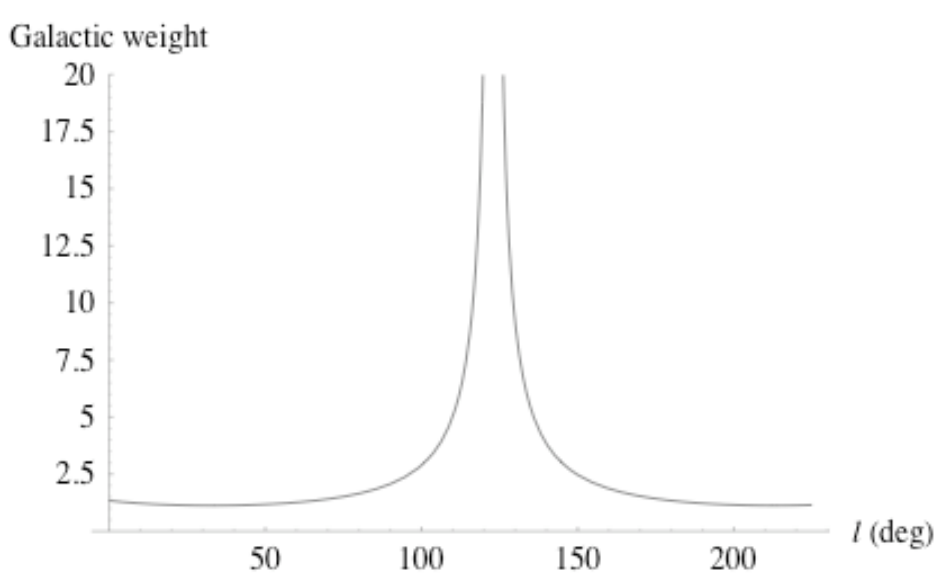
- Time is calculated for each event so that its ϕ lands on galactic equator
- Day of year, segment of plane (two choices) selected randomly

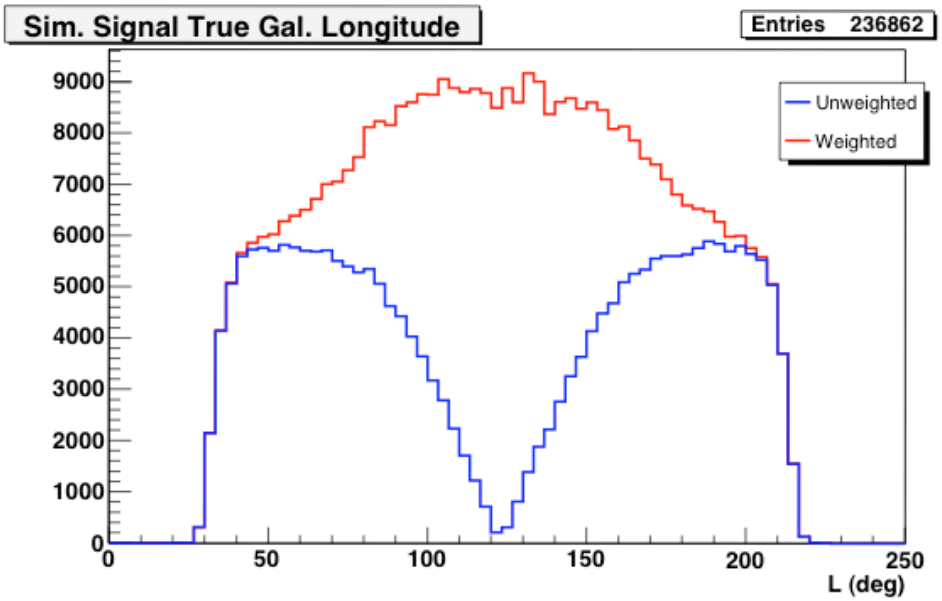
Step 2: Reweight Events

- 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