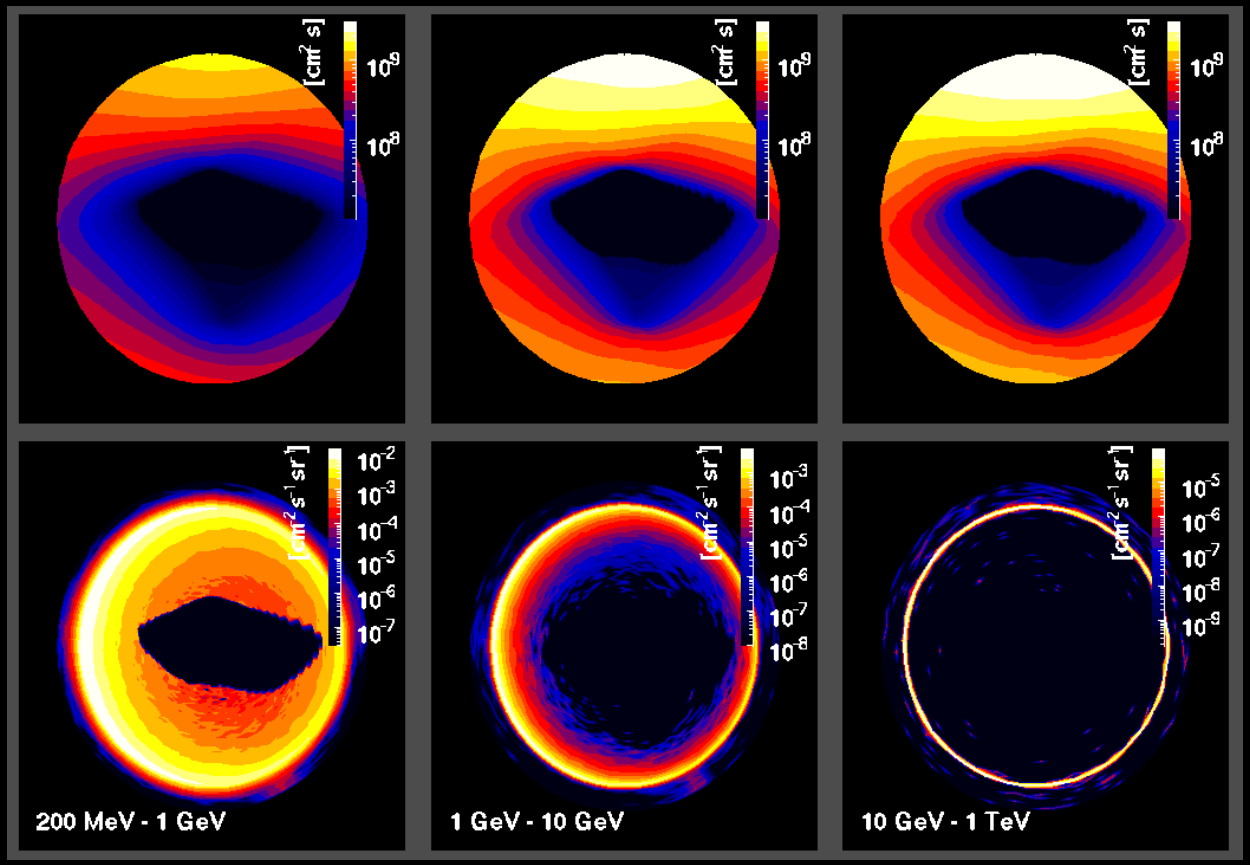
Earth Gamma-Ray Albedo Measurements with the Fermi-LAT



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TeV Particle Astrophysics 2009
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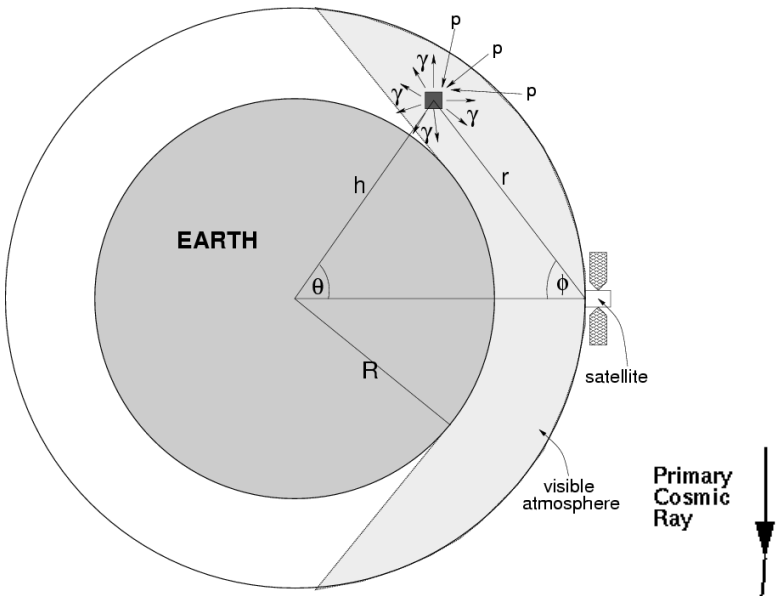
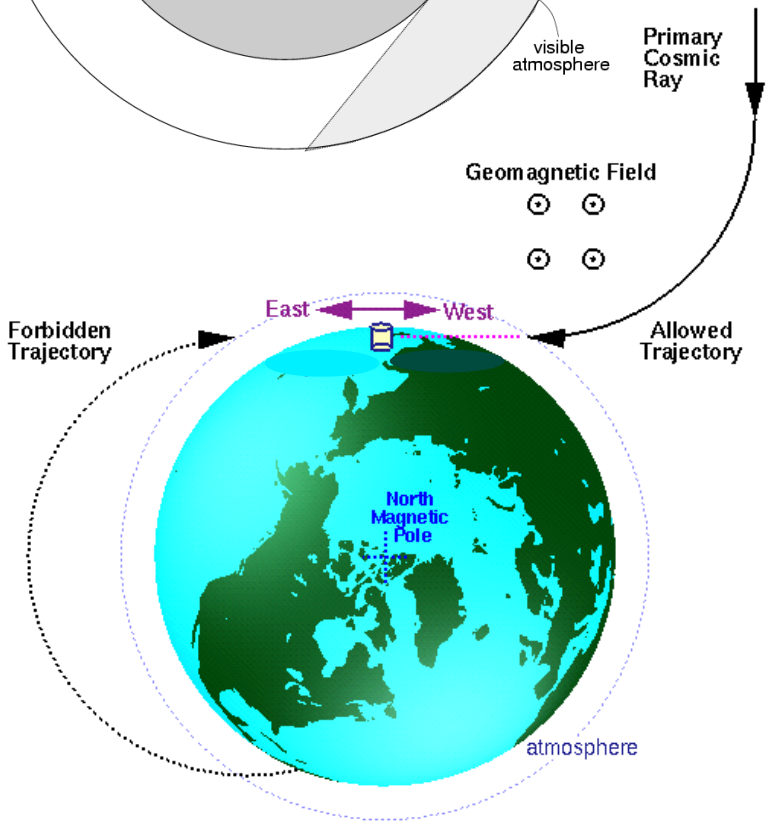
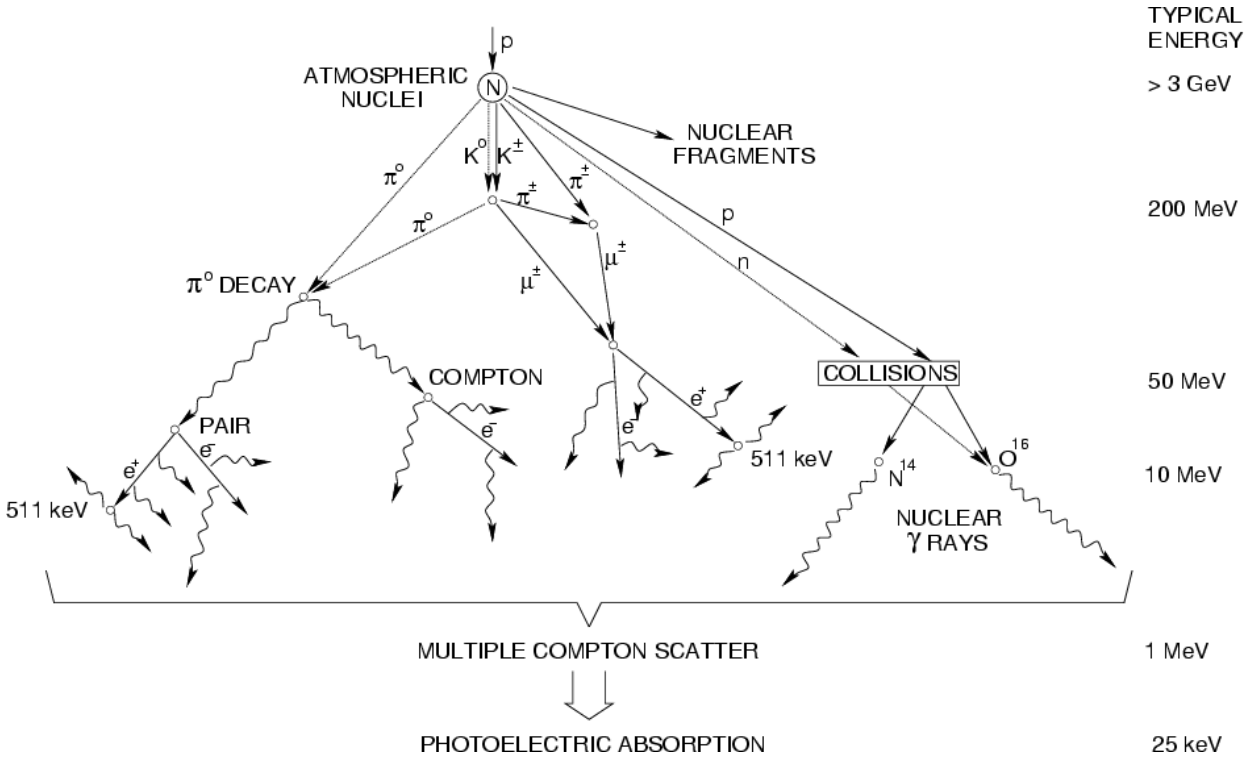
SLAC National Accelerator Laboratory

Production Mechanism







Diagrams taken from:
- Shaw S. E., et al. 2003, A&A, 398, 391-402
- http://hep.bu.edu/~superk/ew-effect.html

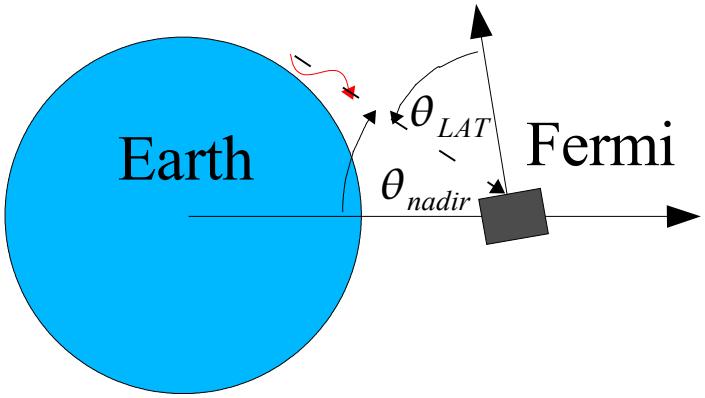
Data and Exposure Selections

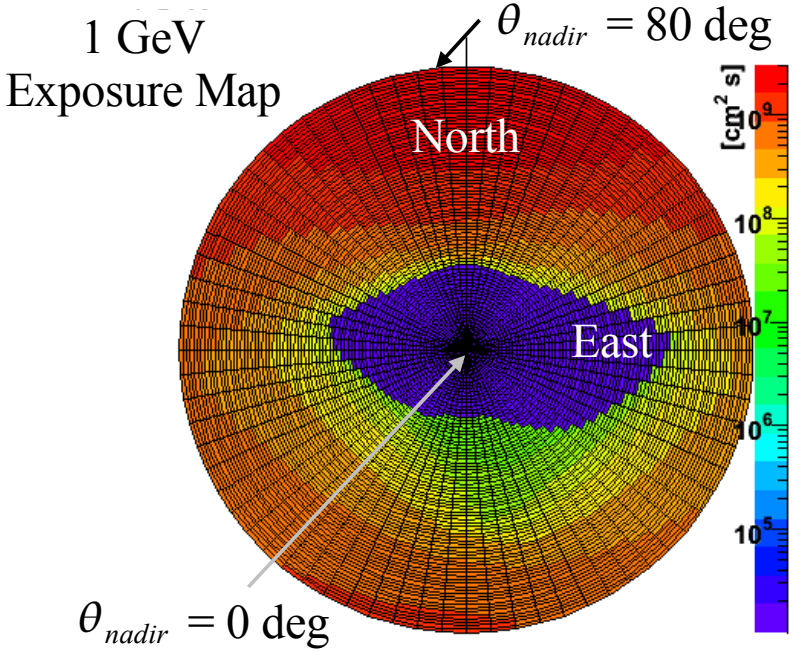
Data

- Standard diffuse photon selection (P6V3)
- $\theta_{LAT} < 65$ deg

Exposure

- Split into 41 energy bins in $\log_{10}$ between 80 MeV and 1 TeV
- Mask out common regions with low exposure





Data Sets

- Launch & Early Orbit (July 15 – 29, 2008) and Limb Observation (September 30, 2008)
- ~10^6 sec of livetime
- ~10^7 earth diffuse albedo photons
- 218 photons with E>100 GeV
- 16 photons with E>500 GeV

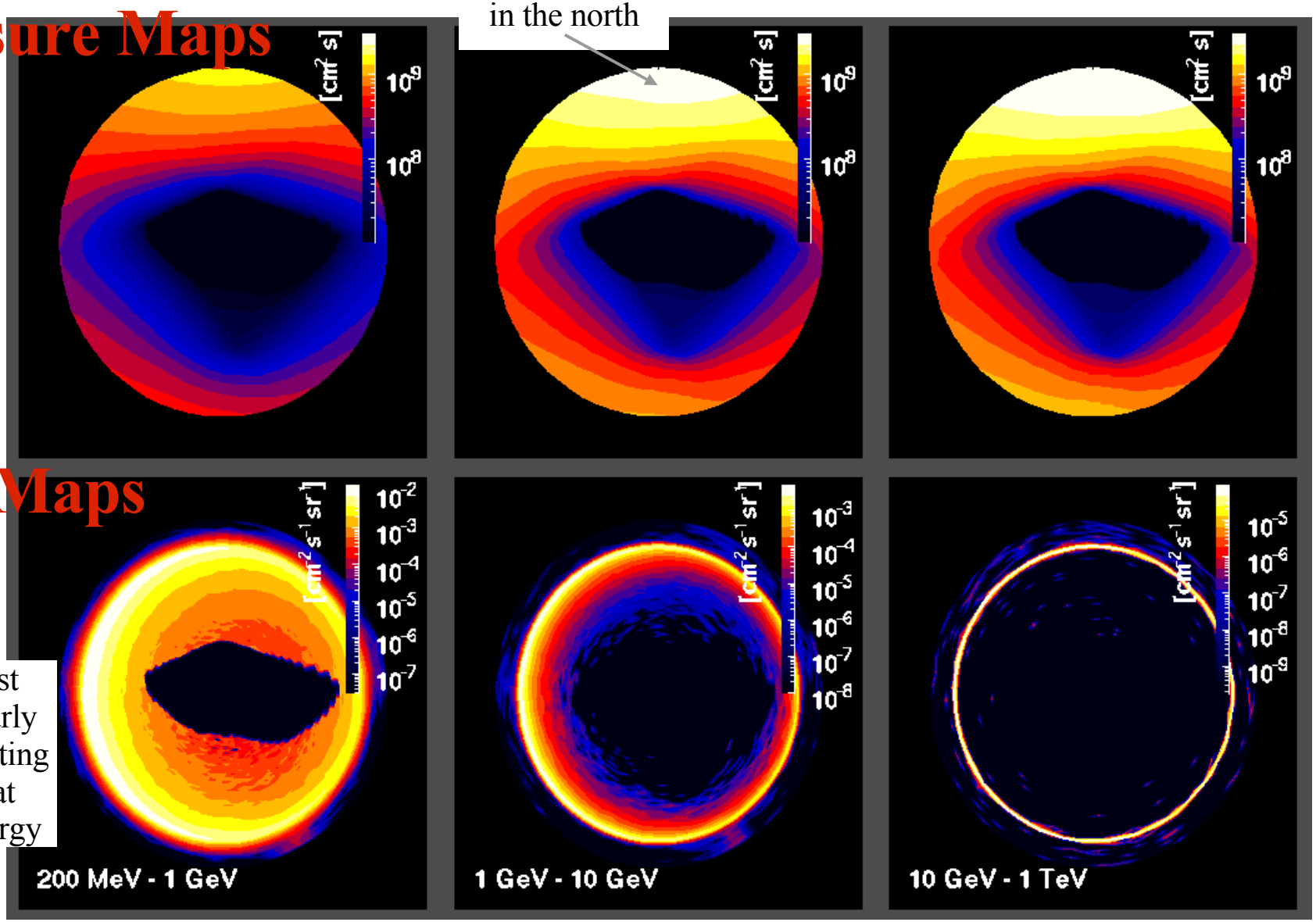
Exposure Maps and Flux Maps

Exposure Maps

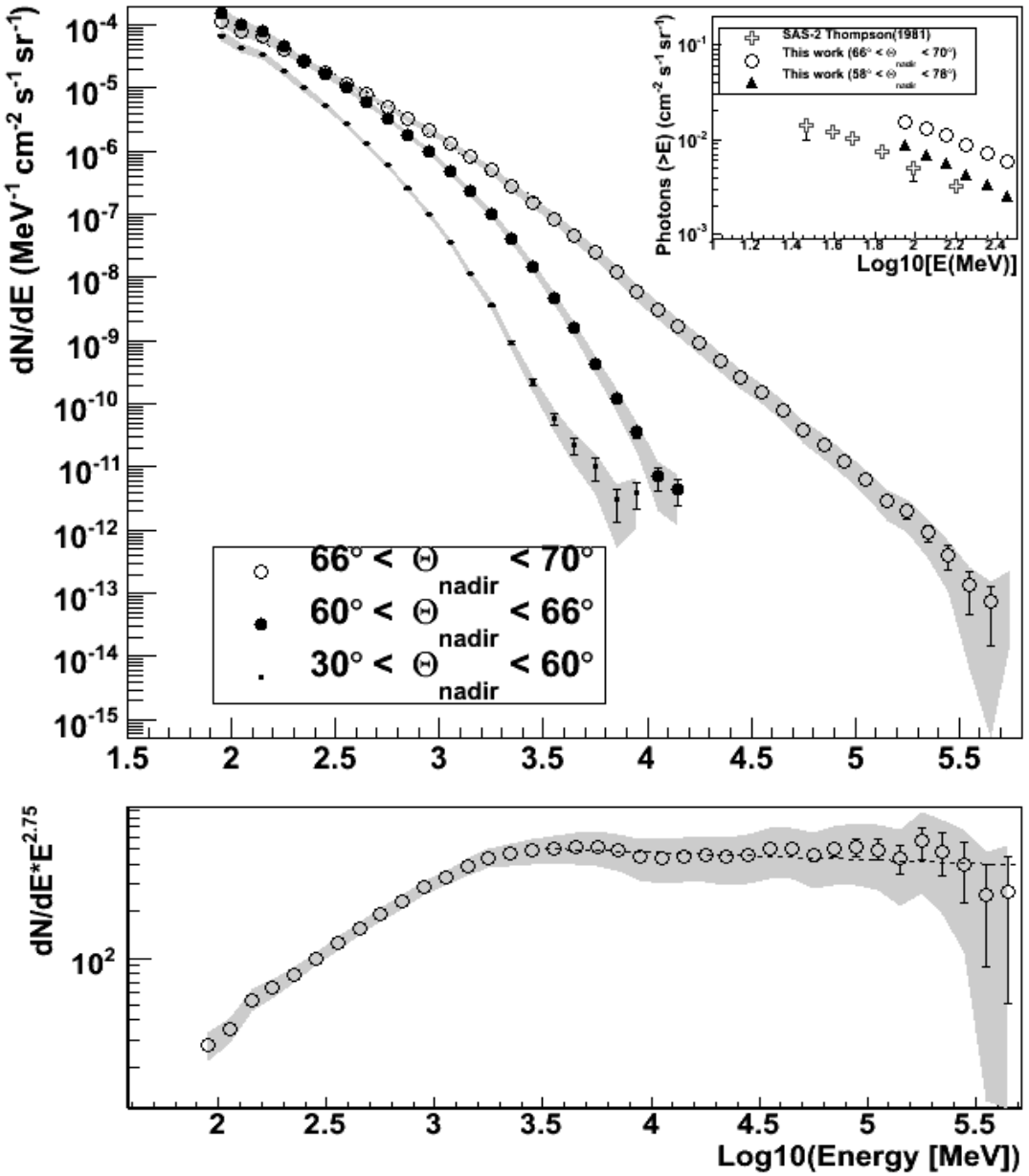
More exposure in the north

Flux Maps

East-West effect clearly visible, getting smaller at higher energy

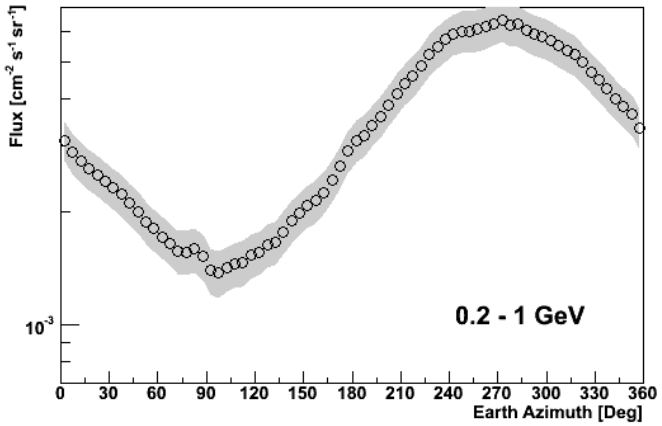


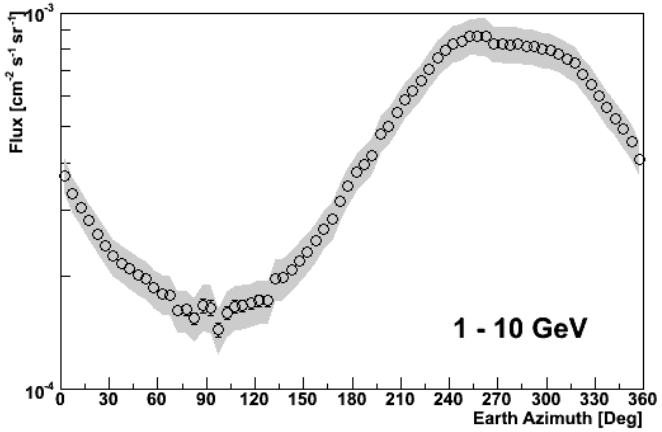
Earth Albedo Gamma Spectrum

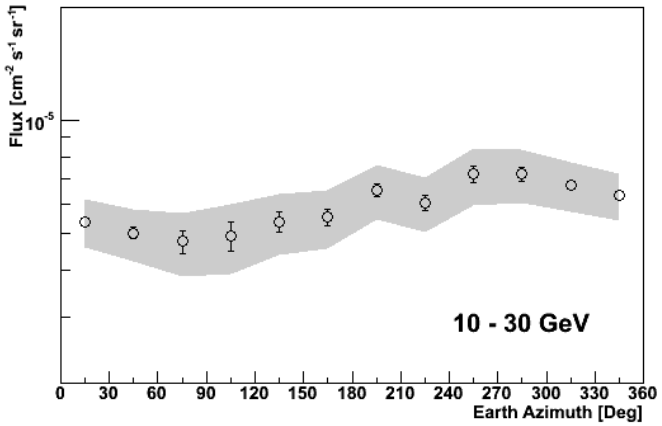


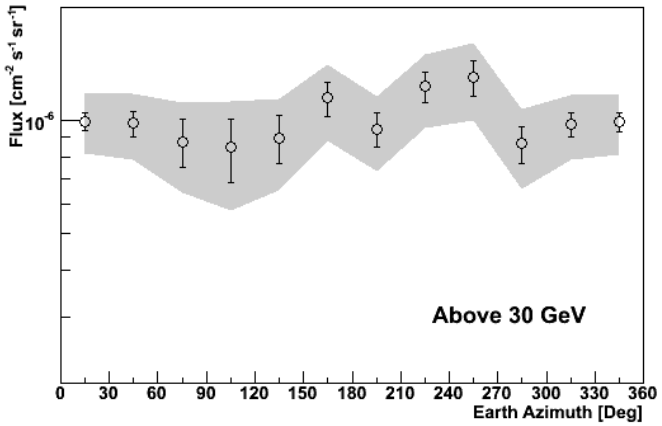
- Spectra from different regions
  - Softer for the inner part of the earth because the forward-scattered secondaries tend to have higher energy than the backward-scattered ones
- Power-law spectrum for the rim at E > 30 GeV with the fitted spectral index of -2.80 +/- 0.06
  - Good agreement with the cosmic ray (CR) spectral index of -2.75
- Reasonable agreement with the previous measurement by SAS-2

East-West Effect from the Earth Magnetic Field



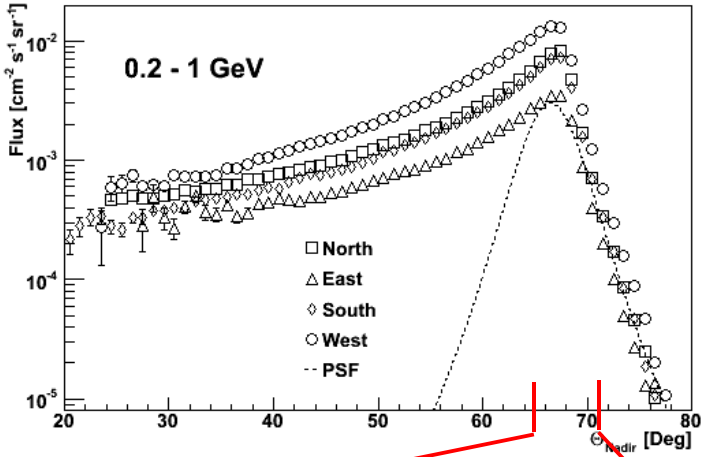


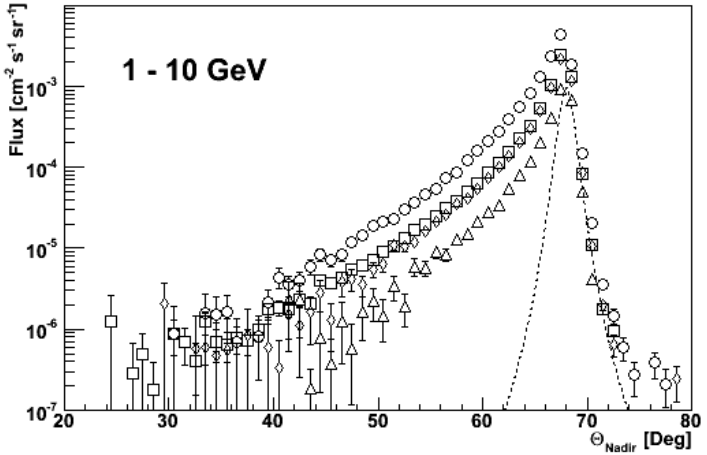


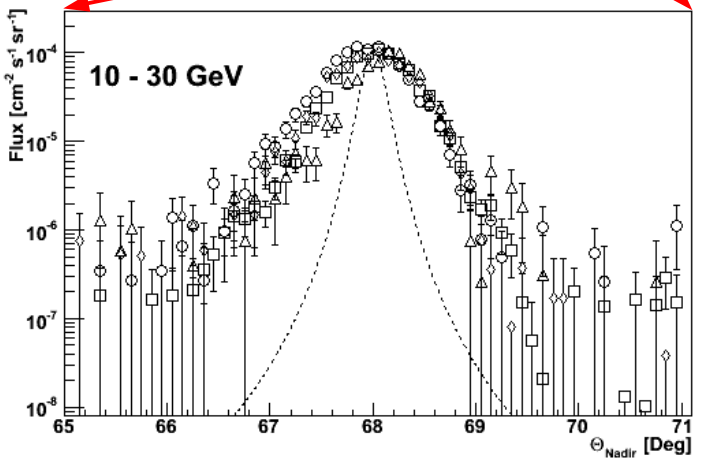


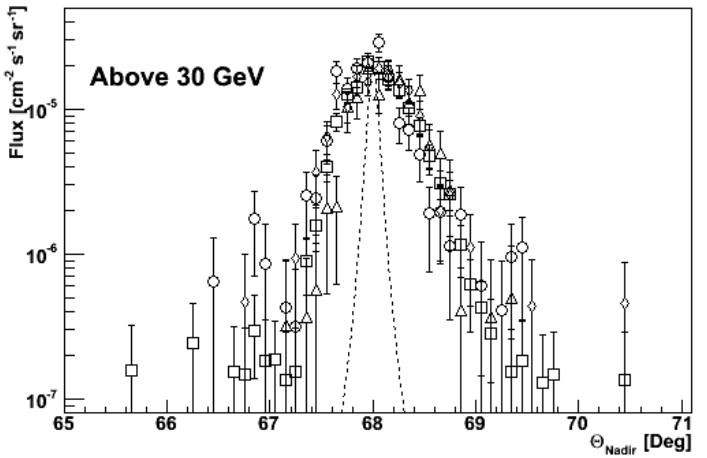
- This plot is for the earth rim ($60 < \theta_{nadir} < 75$)
  - North = 0 deg
  - East = 90 deg
  - South = 180 deg
  - West = 270 deg
- The east-west effect is stronger at low energy as expected
- Above 30 GeV, the profile can be fitted well with a flat line

Radial Flux Profile





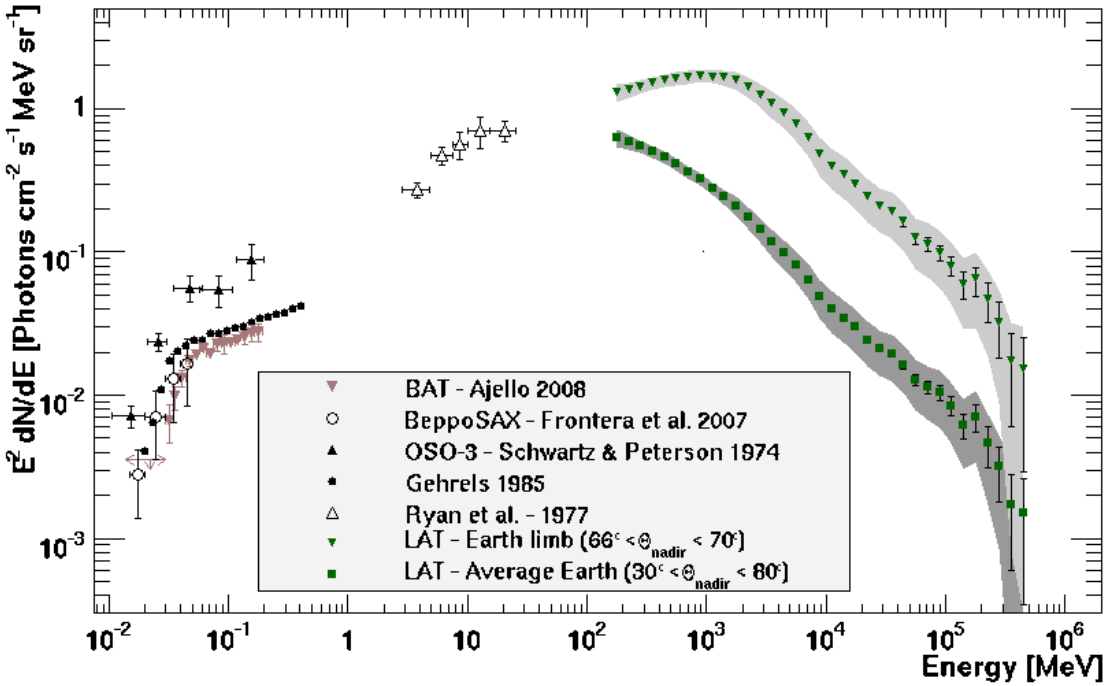




- Earth center is at 0 deg, rim at ~68 deg
- The dash lines are the PSF of each energy bin
- The profiles get narrower for higher energy
- Note the change in x-scale for the two bottom plots

Conclusion

- We have obtained the earth albedo spectral and spatial properties from the early data of the Fermi-LAT
  - Add more than 3 decades of the energy spectrum from 200 MeV to 500 GeV
  - The rim spectral index above 30 GeV follows that of the CR
  - The east-west effect is observed up to 30 GeV



  - The radial profile can be resolved for E > 10 GeV and can be used to study CR-atmosphere interaction