Gamma Ray Source Studies Using Muon Tracking

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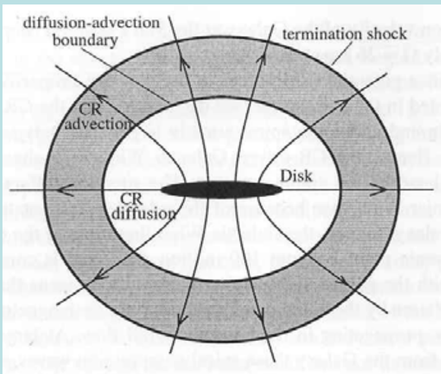
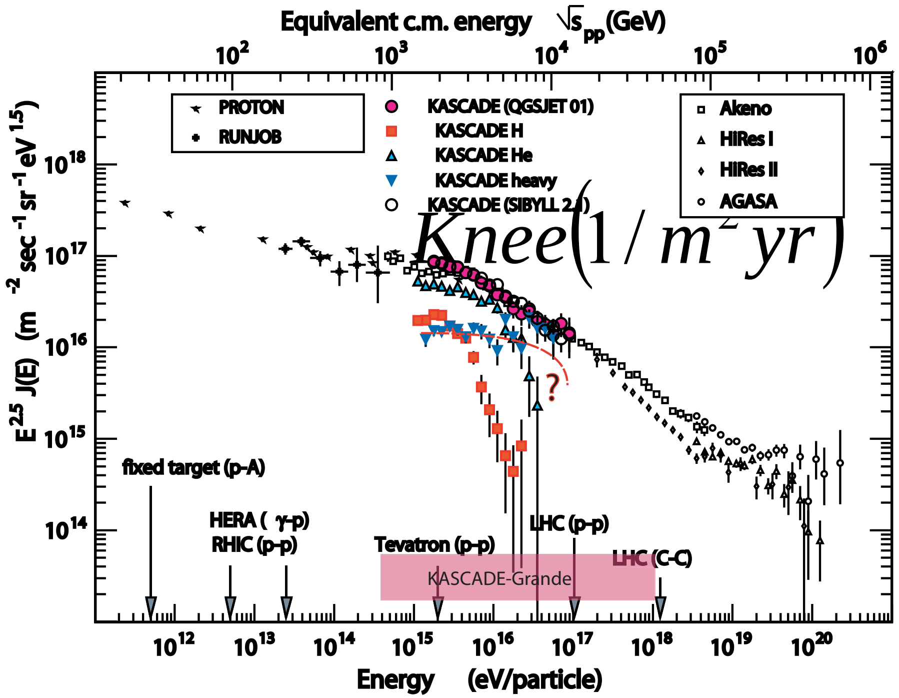
Study of Cosmic Rays (CR)

Cosmic Radiation opens a window to the high energy processes in the Cosmos.
We obtain information from electromagnetic and particle radiation.



H.J.Völk,V.N.Zirakashvili
A&A 417(2004)807



1.Acceleration
2.Propagation
3.Fragmentation

E_p = 10000 TeV or E_e = 10 TeV
boost $E_\gamma=1$ keV to $E_\gamma=10$ GeV

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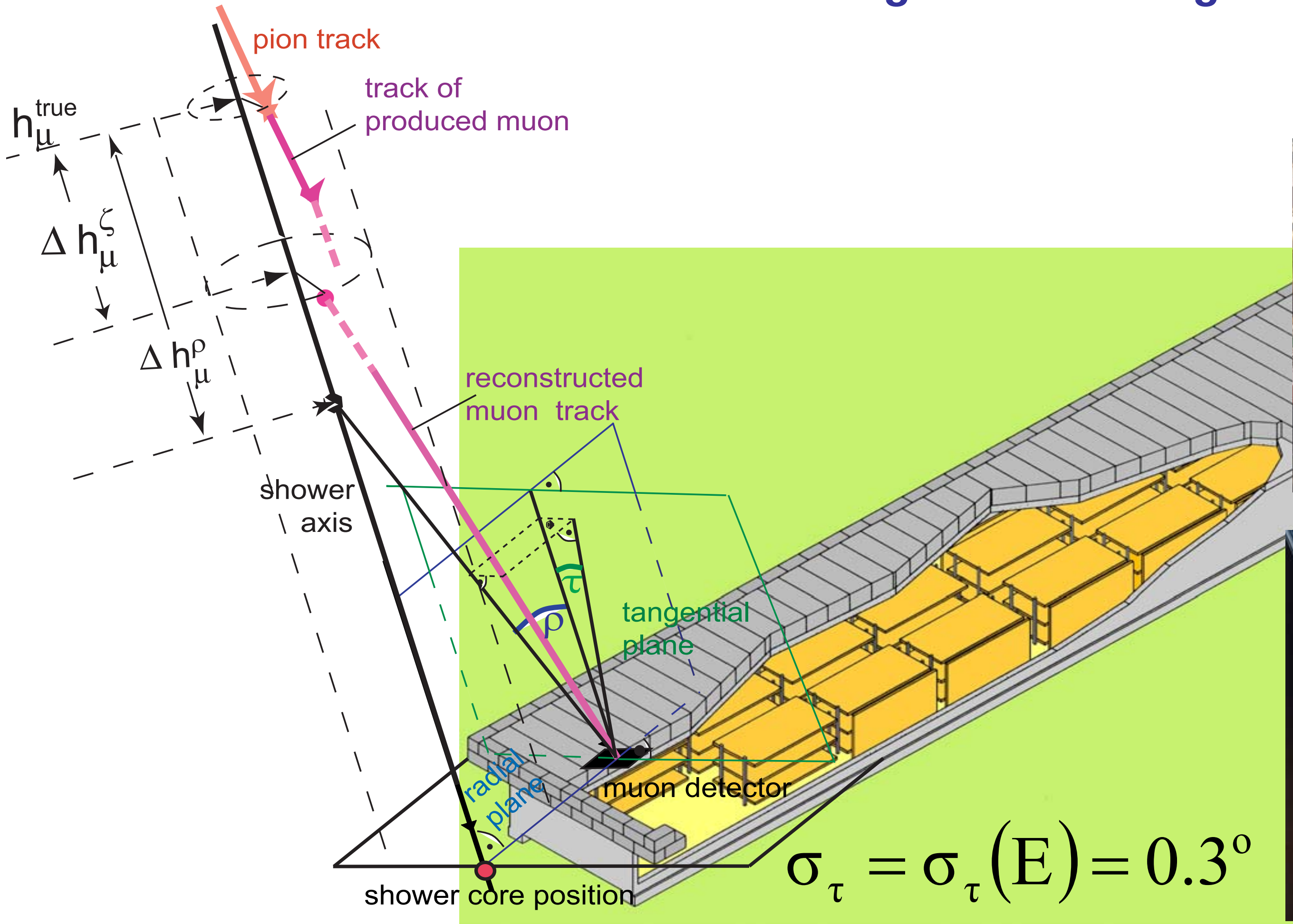
Berezinsky et al., Nucl.Phys.B(Proc.Suppl.)151(2006)497
Wibig et al., J.Phys.G 31(2005)255
de Rujula et al., Nucl.Phys.B (Proc.Suppl.)151(2006)23
R.Engel priv. Communication

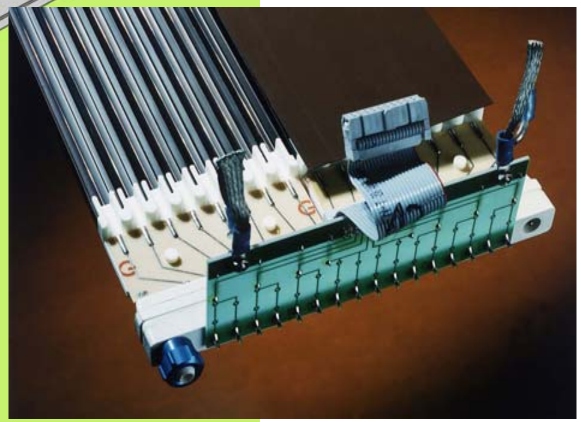
Gamma Source Studies using Muon Tracking Detector

The Muon Tracking Detector (MTD) measures direction of muons with respect to the shower axis. Can a MTD distinguish incoming Gammas from CRs ?



$$\sigma_\tau = \sigma_\tau(E) = 0.3^o$$

128m², Filter:Eμ >0.8GeV



Low mass

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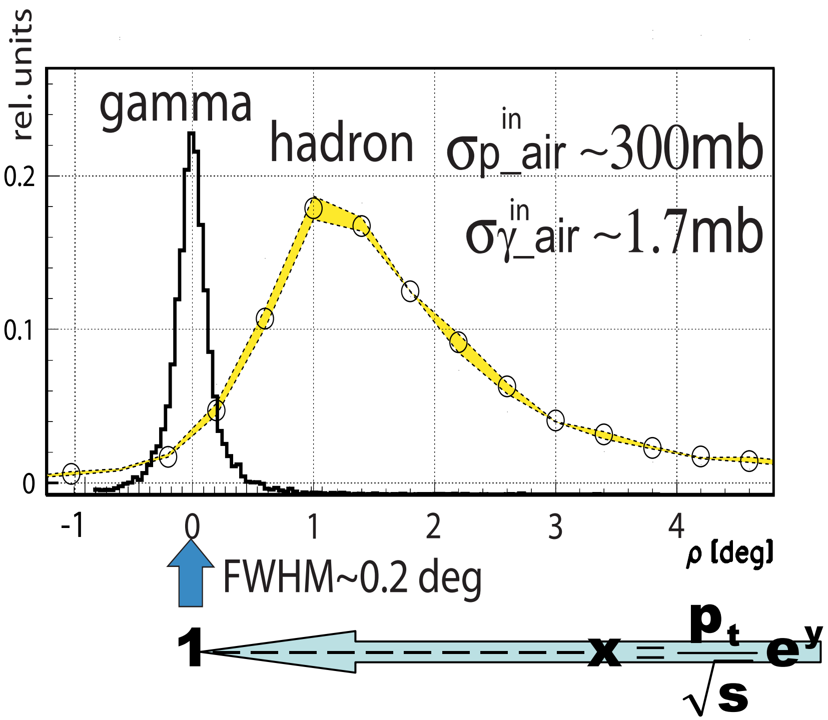
P.Doll et al., Nucl.Instr.and Meth.A488(2002)517.

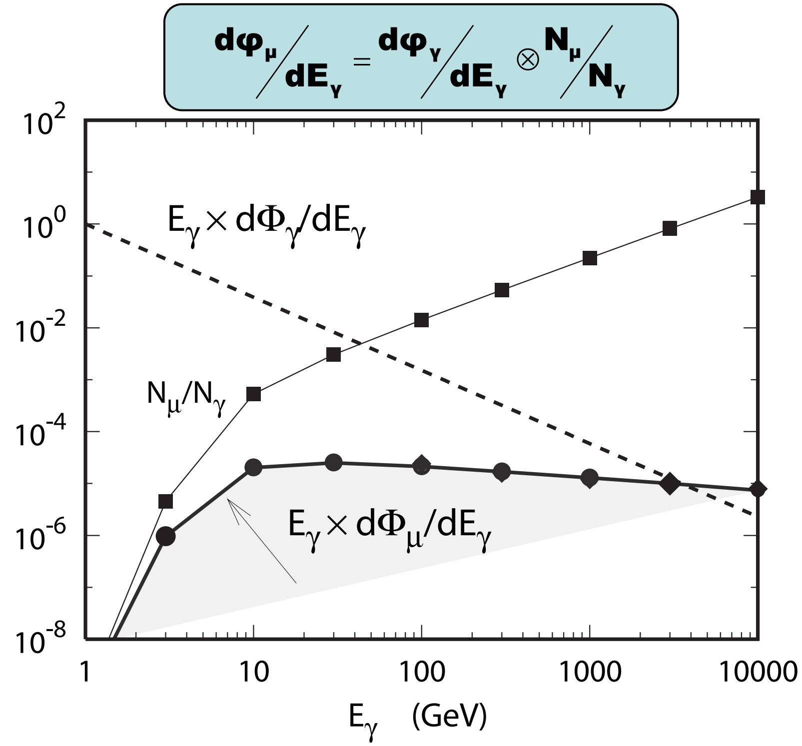
F.Halzen, T.Stanev and G.B.Yodh, Phys.Rev. D55 (1997)4475.

Gamma-Hadron Separation.

Gamma-Hadron Separation: Gammas produce a larger fraction (10^4 times) of high-x πs than protons.



Energy spectrum of primary gamma ray (slope=2.41). Nμ/Nγ at sea level and resulting muon flux spectrum.



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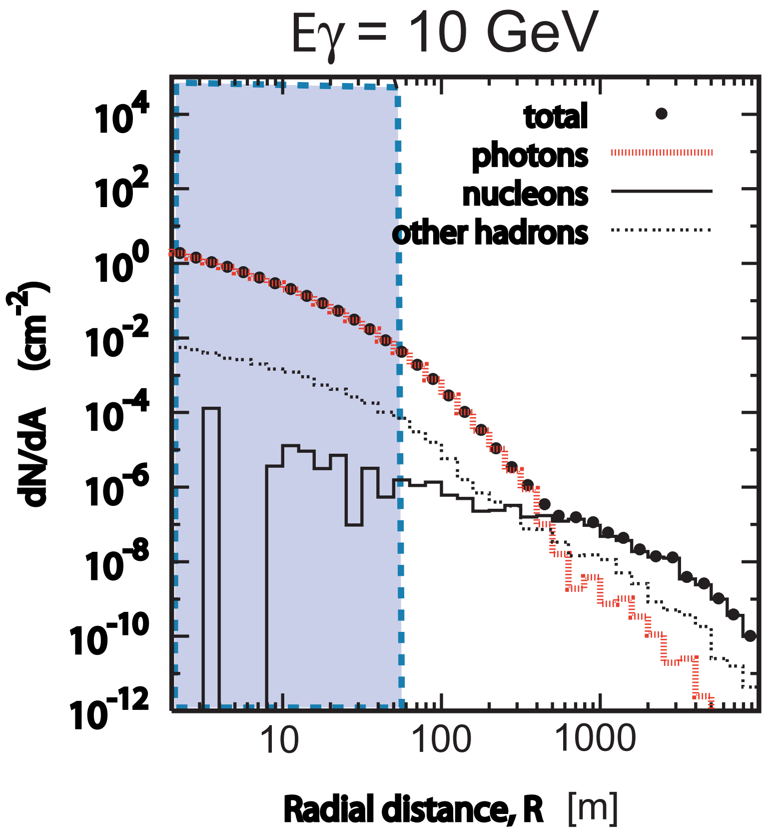
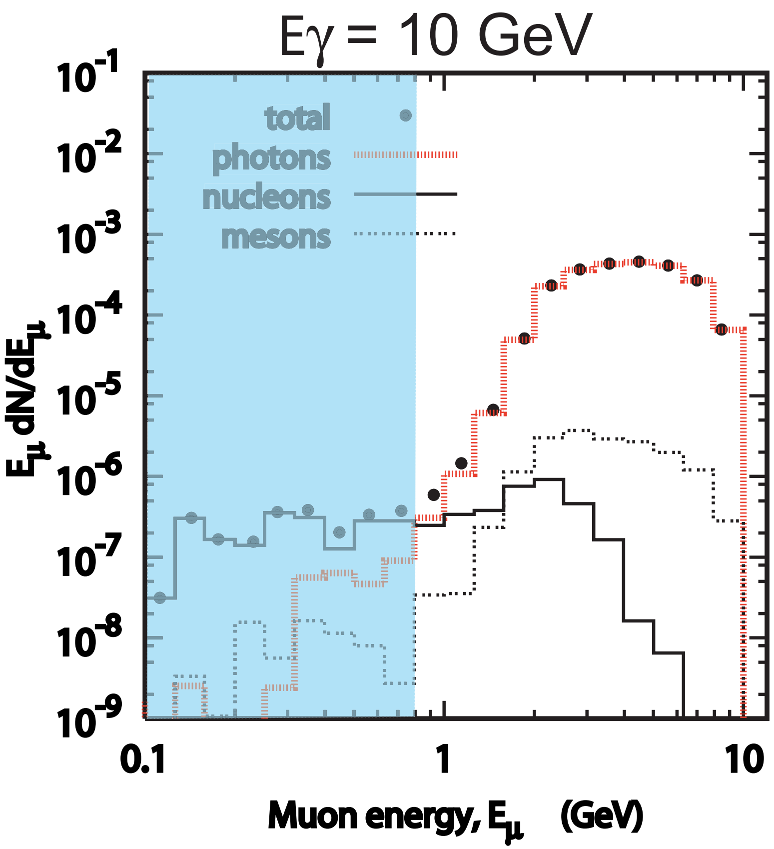
J.Poirier, S.Roesler and A.Fasso, Astropart.Phys. 17(2002)441. J.Poirier, T.Catanach, Proc. 32th ICRC (2011)Beijing,China,Vol.11,p.346.

μ-Production Studies using FLUKA

μ-Production Studies using FLUKA(2000).
For <10m from axis: Eγ>10GeV.



Kin. energy of muons at production vertices and per primary parent photon.
$E_\gamma \sim E_\mu^{1.3}$



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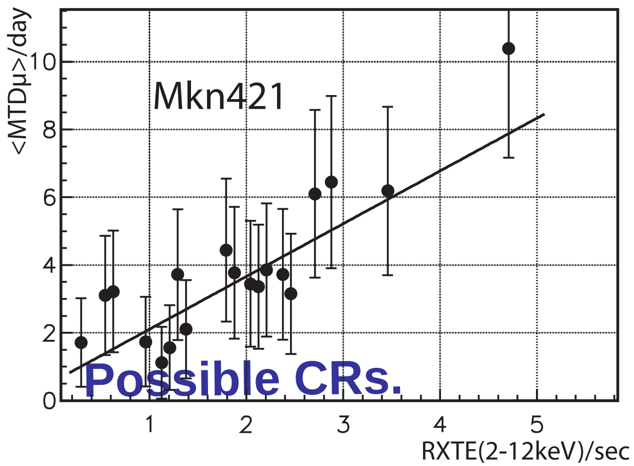
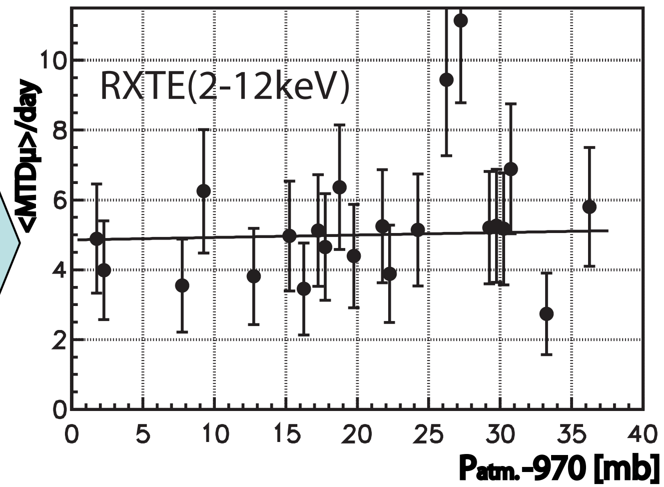
J.Poirier, S.Roesler and A.Fasso, Astropart.Phys. 17(2002)441. J.Poirier, T.Catanach, Proc. 32th ICRC (2011)Beijing,China,Vol.11,p.346.

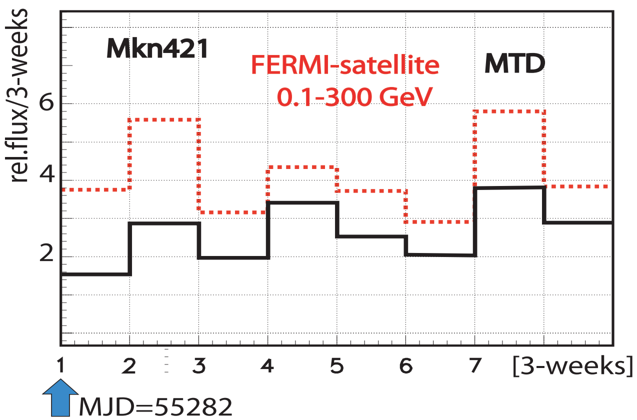
Employing Gamma Flux from Mkn421

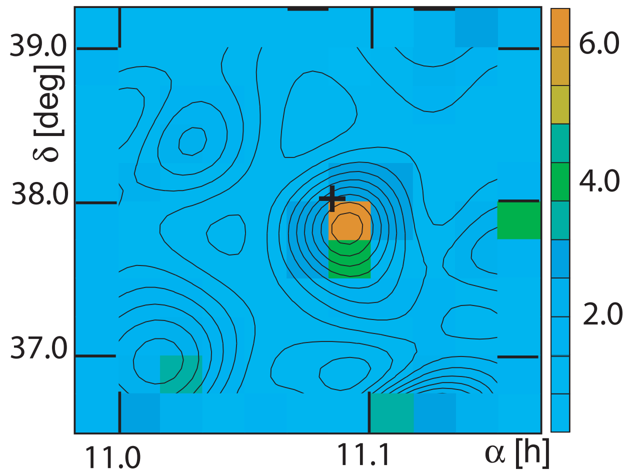
Correlation between satellite RXTE and FERMI fluxes and single muon counts (MTD) - multi wavelength-campaign (February-March 2010).



Increase of single μ production with patm.







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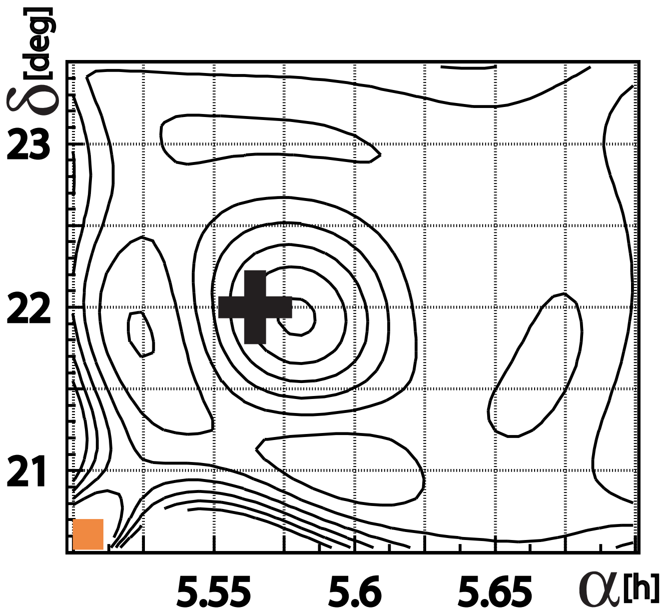
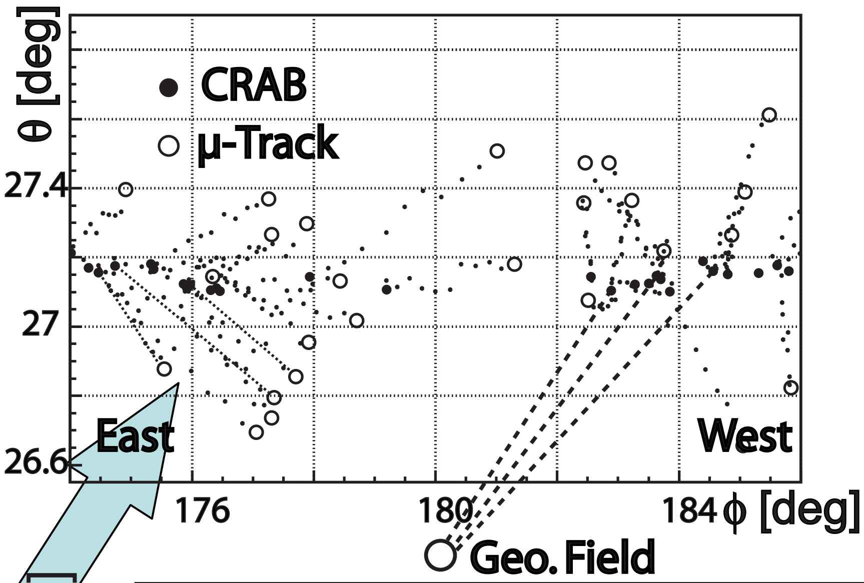
http://xte.mit.edu./ASM
M.H.Grondin et al., FERMI-LAT Coll.,Proc.31th ICRC,(2009
http://fermi.gsfc.nasa.gov/ssc/data

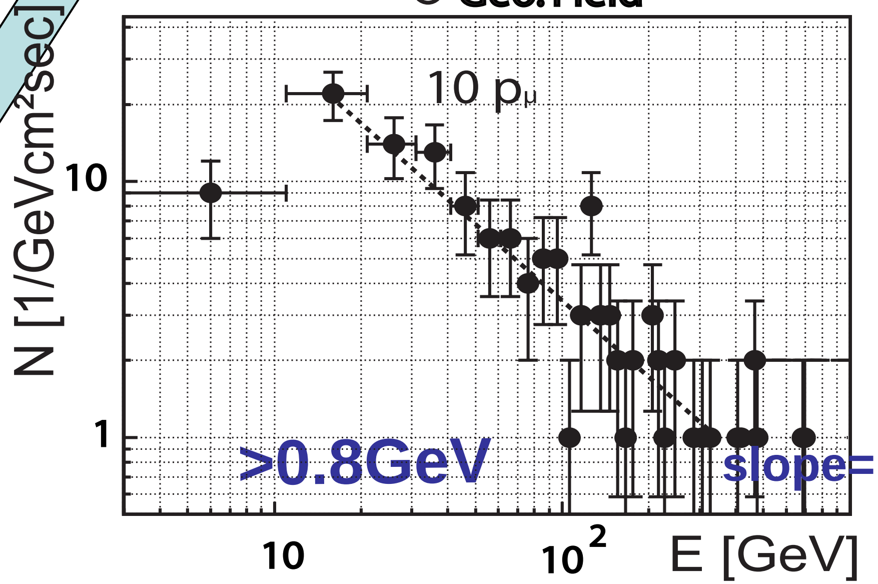
Study of Gamma Source Crab

Improved MTD alignment for single isolated μ-tracks.



Single μ-track with respect to actual Crab position.





Deviation from the source position ($\delta_\mu \sim 1/p_\mu$) provides preliminary Crab flux spectrum.

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Gamma Source Studies using Muon Tracking Detector

Outlook:

1. **Muon tracking provides alternative ground based observation technique.**

2. **Correlation between satellite X-ray fluxes and single muon counts (MTD) allows to study $\gamma + \text{air} \Rightarrow \pi^{\pm}$ production in atmosphere.**

3. **Atmospheric monitoring is needed to improve the sensitivity of the muon tracking technique for gamma source studies.**