RICAP'07 Roma International Conference on Astro-Particle physics

Summary comments

Organization

- Conference
  - Gamma-ray astronomy – June 20
  - Air shower experiments – June 21
  - Neutrino astronomy – June 22
- Themes
  - Multi-messenger astronomy
  - Origin of Cosmic rays
- Organization of this summary talk
  - Detector calibration
  - Galactic sources
  - Extra-galactic sources
  - Cosmology
  - Sociology

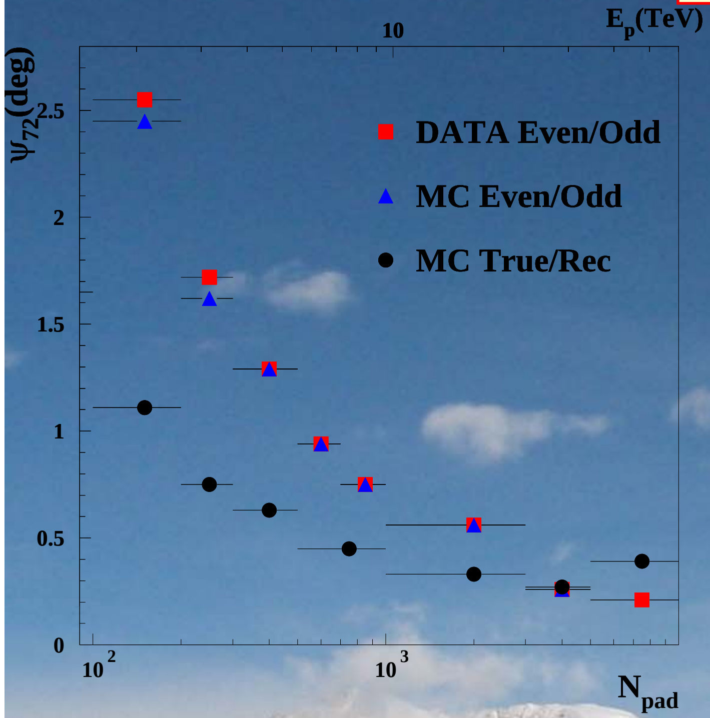
Calibration

LAT calibration approach

- LAT is a complicated instrument, requiring very good calibration to provide the energy, direction and timing reconstruction
- The approach is to avoid a full LAT beam calibration, but rather run the beam tests on the LAT parts and combine the results in the comprehensive whole LAT Monte Carlo simulations (based on Geant 4). This approach requires high confidence in Monte Carlo simulations:
  - Separate parts of LAT have been tested on the different beams (SLAC, CERN, DESY, GSE) several times starting in 1997
  - Single-tower LAT prototype was flown on a balloon in 2001 to verify the design and data analysis approach and to perform background measurements
  - LAT Collaboration ran detailed beam tests at CERN and GSI in the summer of 2006 with 2-tower LAT prototype (Calibration Unit = CU) to verify the simulations. We are still in the process of tuning the MC to agree with the beam test data

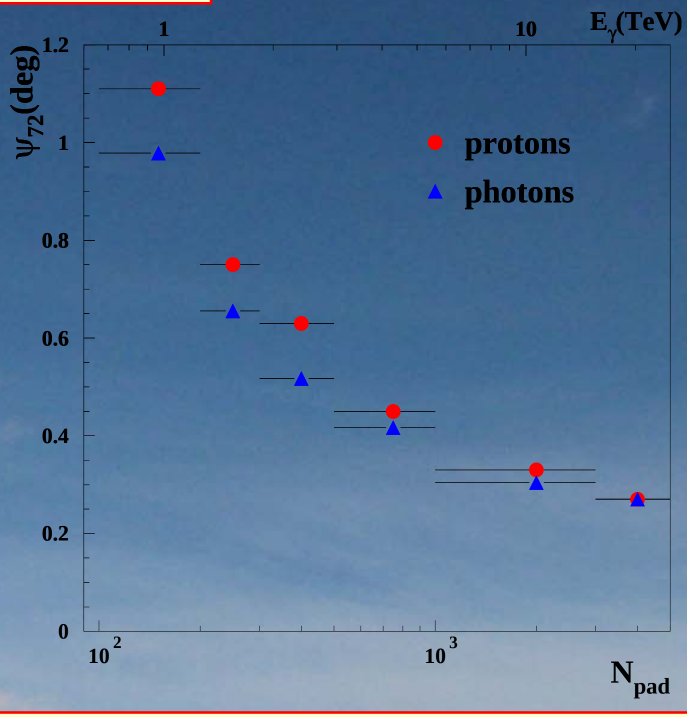
ARGO - d'Ali Staiti

Angular resolution



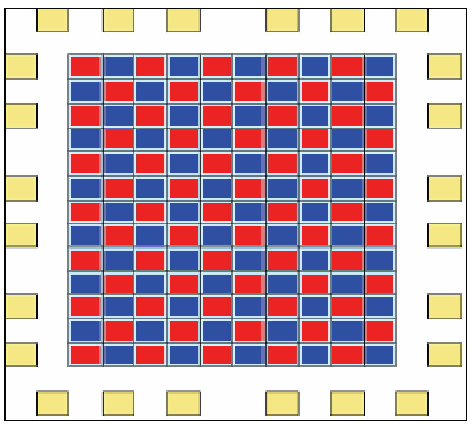
$\sigma_\theta = \Psi_{72}/1.58$

$\sigma_{\theta,mc}$=0,5 $\sigma_{\theta,eo}$
pure statistics

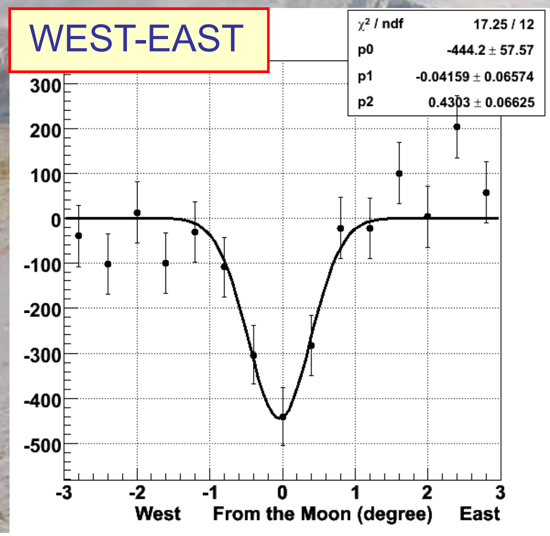


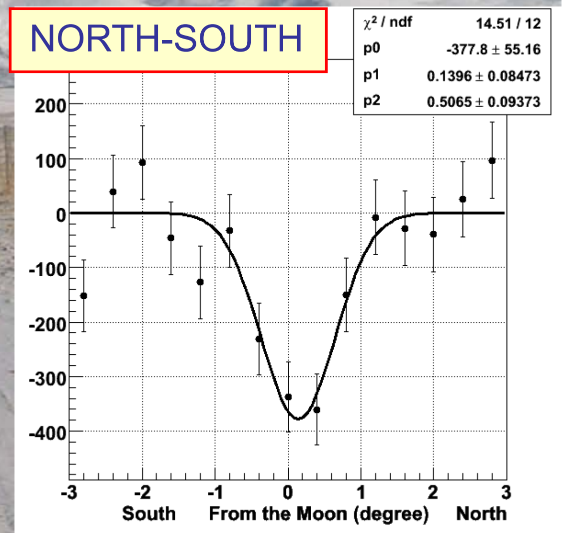
The "size of the Moon", $\sigma_{W\text{-}E}$= 0.43°±0.07°, $\sigma_{S\text{-}N}$= 0.51°±0.09°

The even-odd or "chess-board" method



$$(\psi_{70})_{even/odd} = 2 \cdot (\psi_{70})_{true/rec}$$





Crab Nebula (test pattern)

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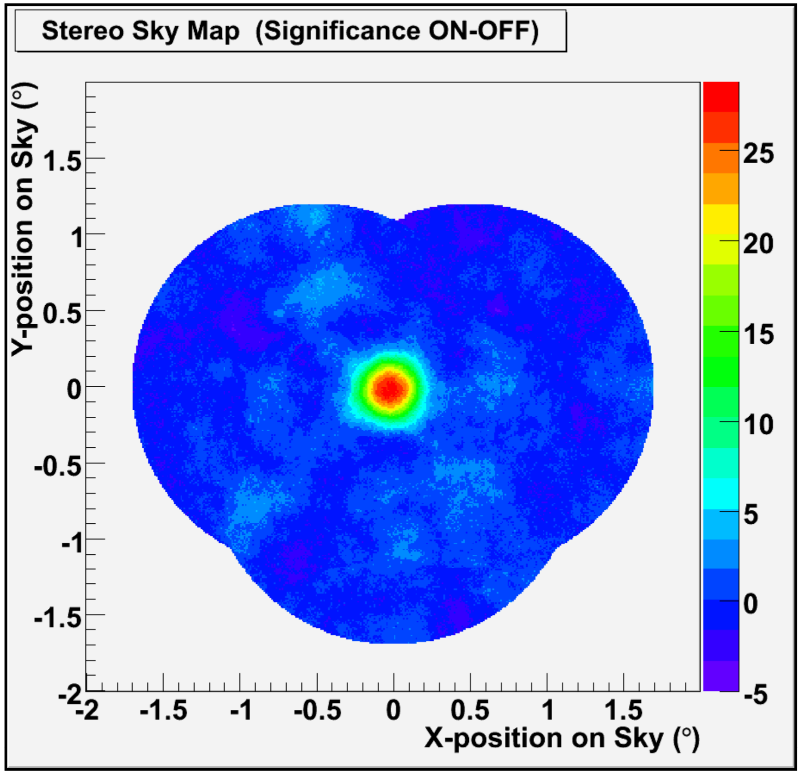
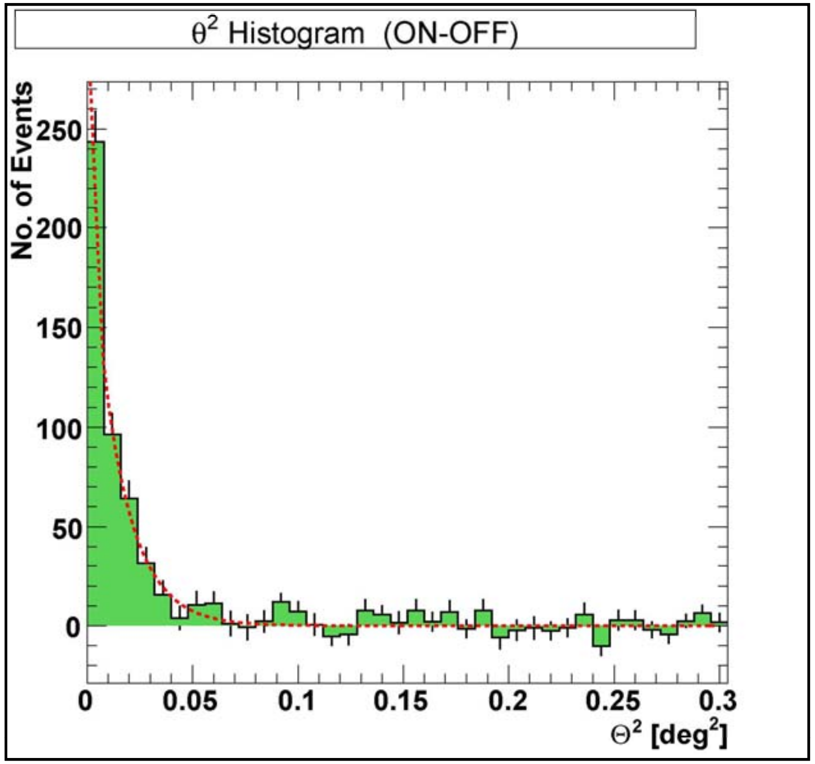
January 2007
three-telescope data
wobble
76^o elevation
28.1 σ

VERITAS - Hanna





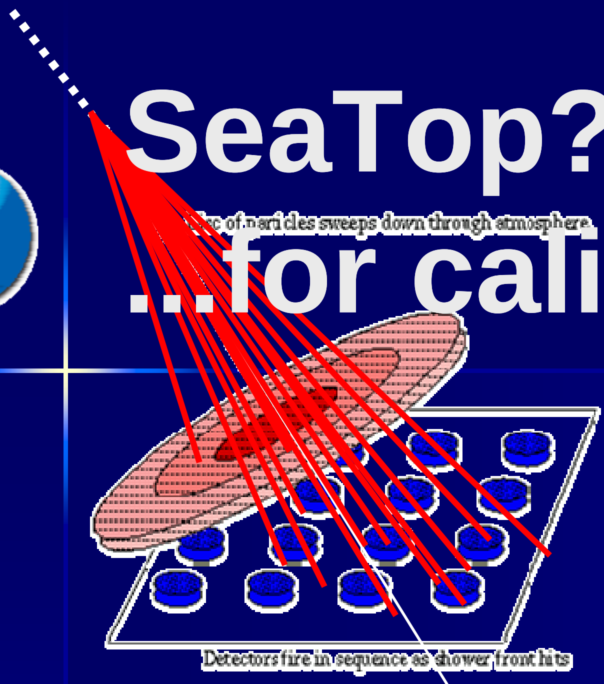
The Contents of the LAT Data Challenge Sky

Bright variable AGN	204
Faint Steady AGN	900
GRB	134 (64 GBM triggers)
GRB Afterglow	9
PBH	1
Galaxy clusters	4
Galaxies	5
Extragalactic diffuse	1

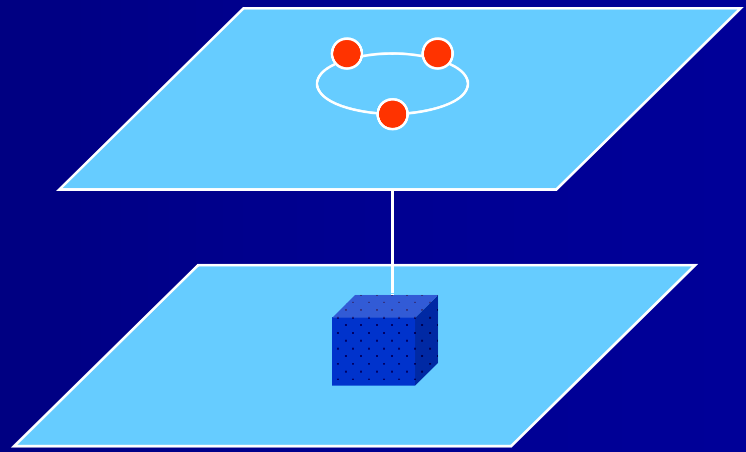
Milky Way itself	1
Pulsars	414
Plerions	7
SNR	11
XRB	5
OB associations	4
Small molecular clouds (40)	40
Dark matter (~2)	~2
‘Other 3EG’ (120)	120
Sun (1 flare)	1 flare
Moon (1)	1

Alexander Moiseev RICAP-07 Rome June 20, 2007 19

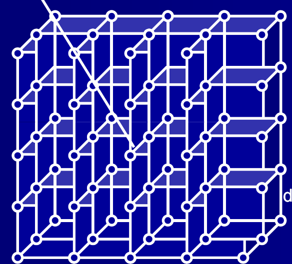
SeaTop?
...for calibration only



Three stations at 20 m distances with 16 m2 scintillators each

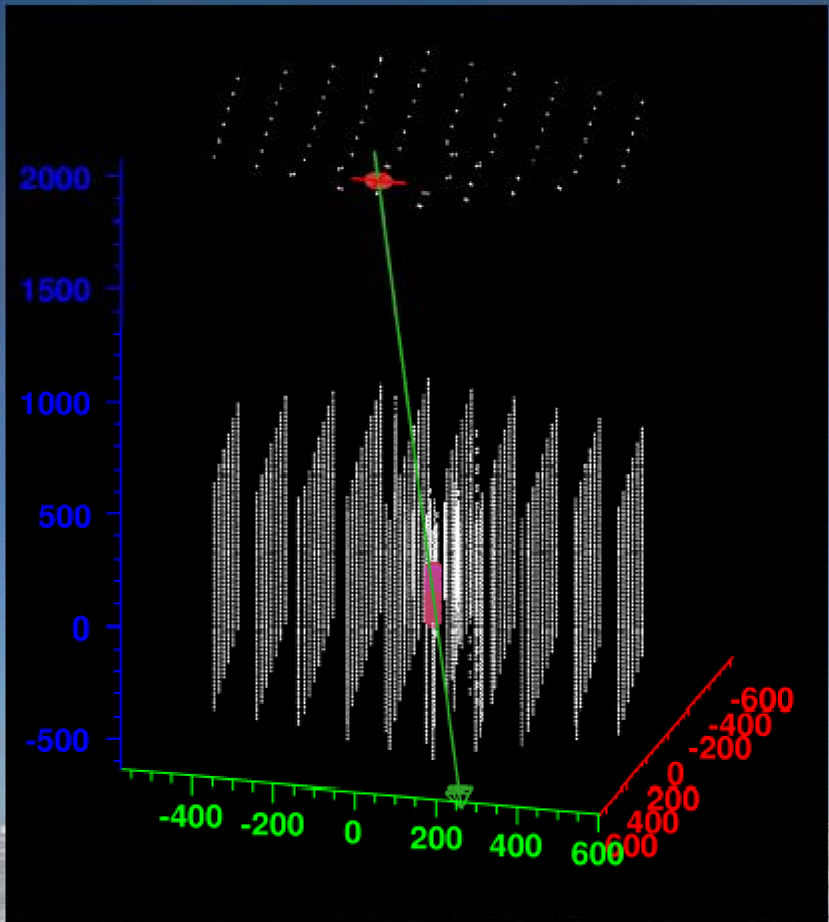


Calibration:
- angular offset
- efficiency
- angular resolution
- absolute position



Calibration of IceCube with tagged single μ

Single Station – InIce Coincidences

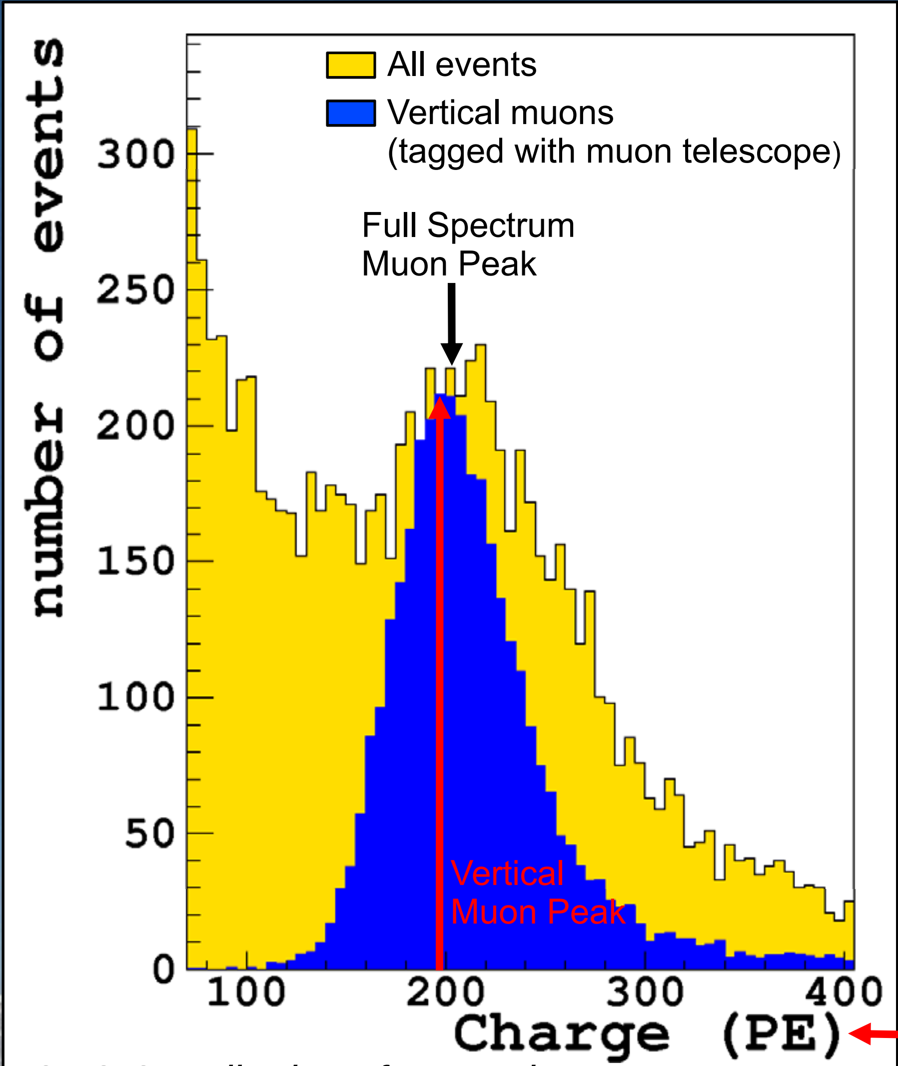


Single station rate for 16 station array: ~ 1.2 Hz

Providing tagged muons to test the detector performance and InIce reconstructions i.e.:

- Detector timing
- InIce direction reconstruction.
- Measurement of muon background.

Tank Calibration (Haverah Park, Auger, IceTop)

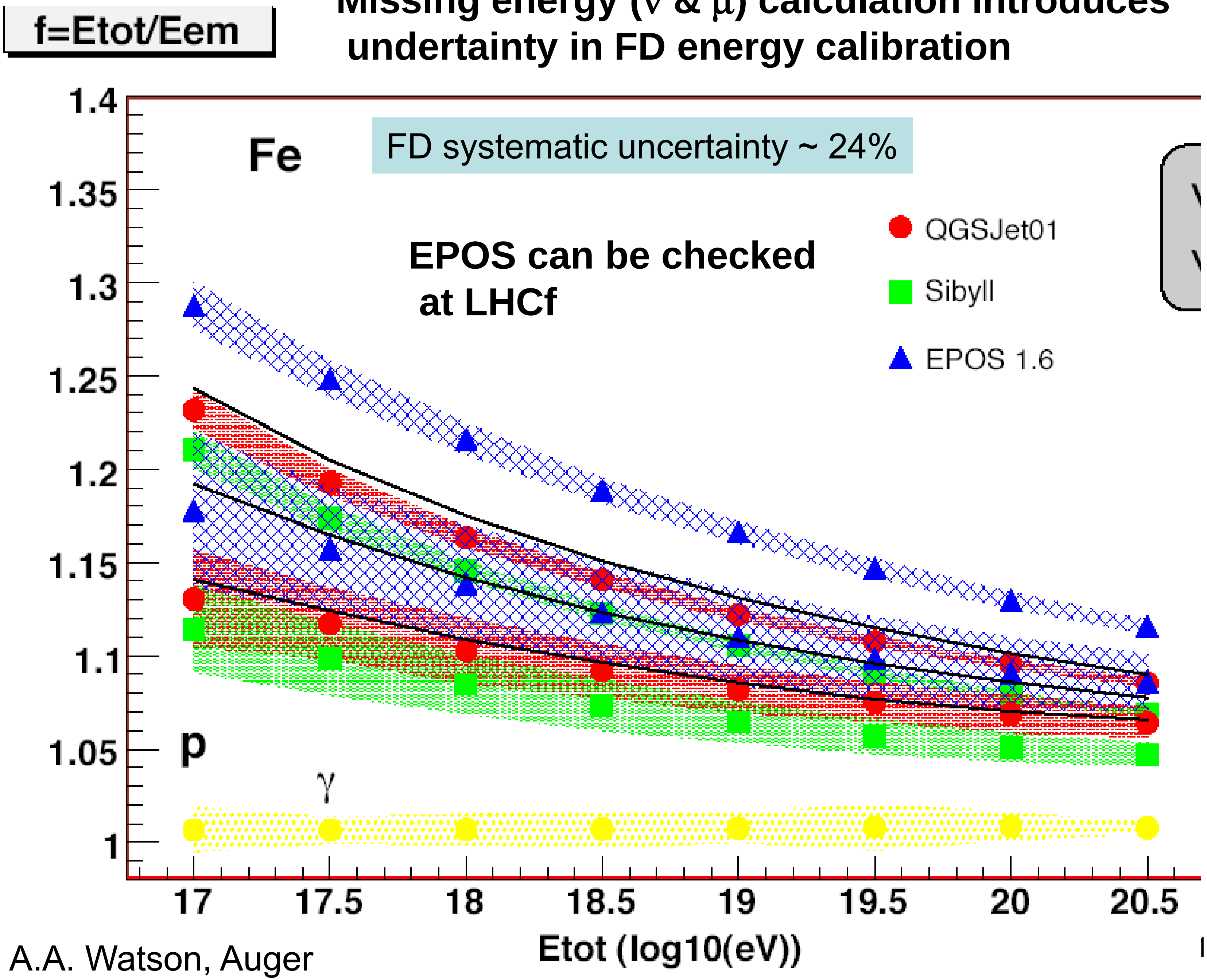


Photoelectrons

ICRC Contribution of L. Demirörs

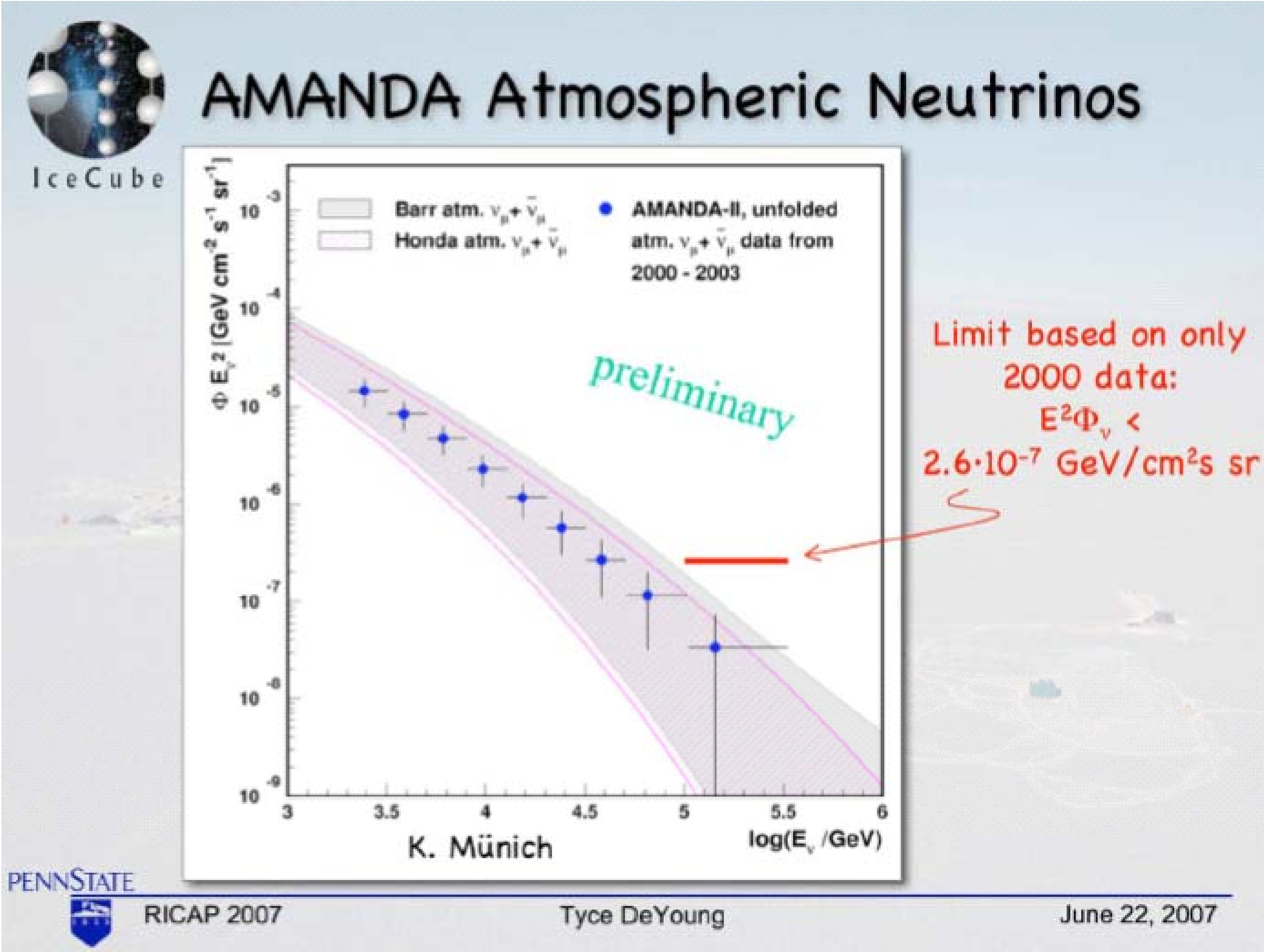
- Vertical muons as "calibration light source" for tanks.
- Measurement of the tank charge spectra with special calibration runs.
- Determination of Full Spectrum Muon Peak.
- 1 Vertical Equivalent Muon (VEM) corresponds to ~ 95% of full spectrum peak charge.

Missing energy (ν & μ) calculation introduces undertainty in FD energy calibration

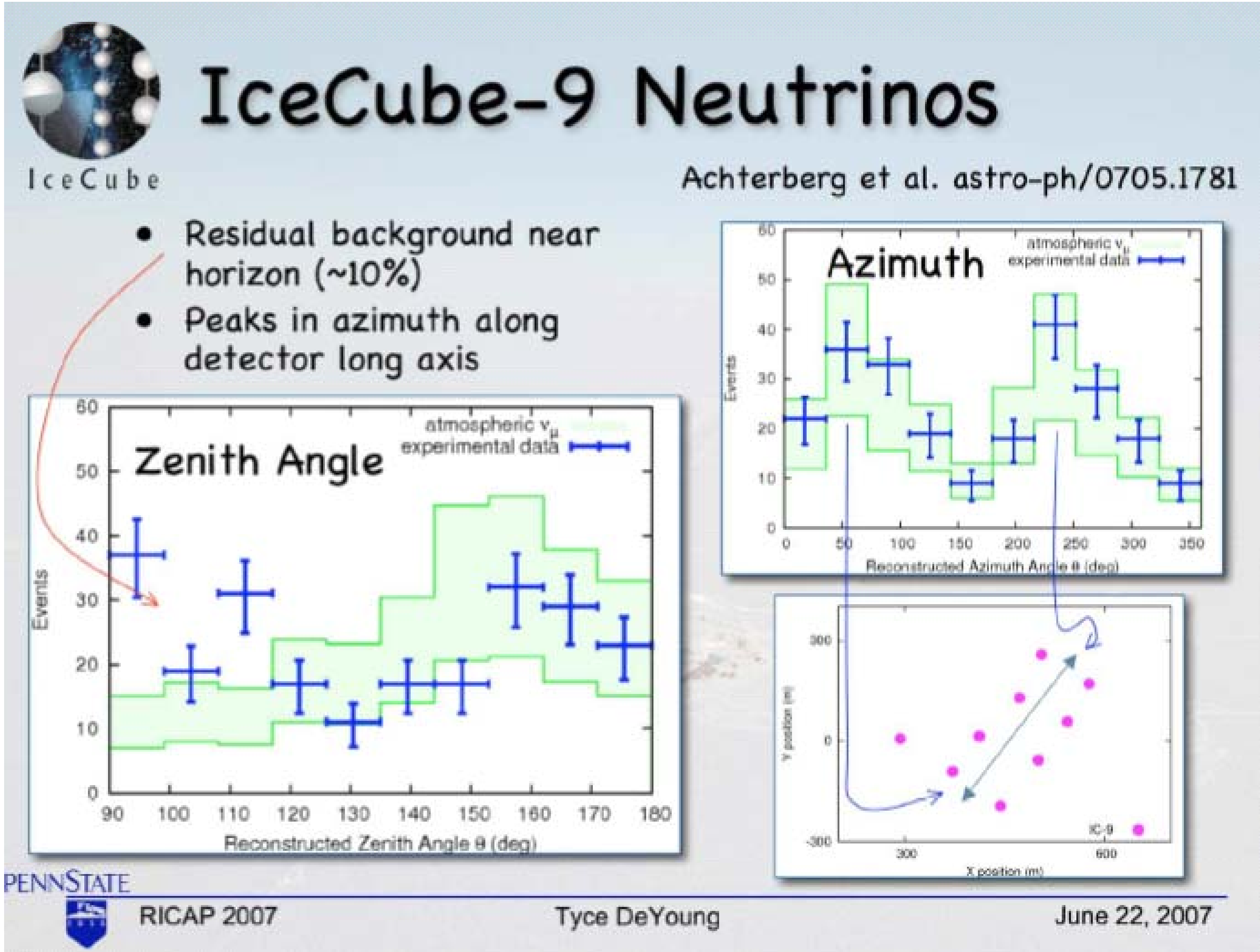


A.A. Watson, Auger

Calibration beam for ν telescopes: Atmospheric neutrinos

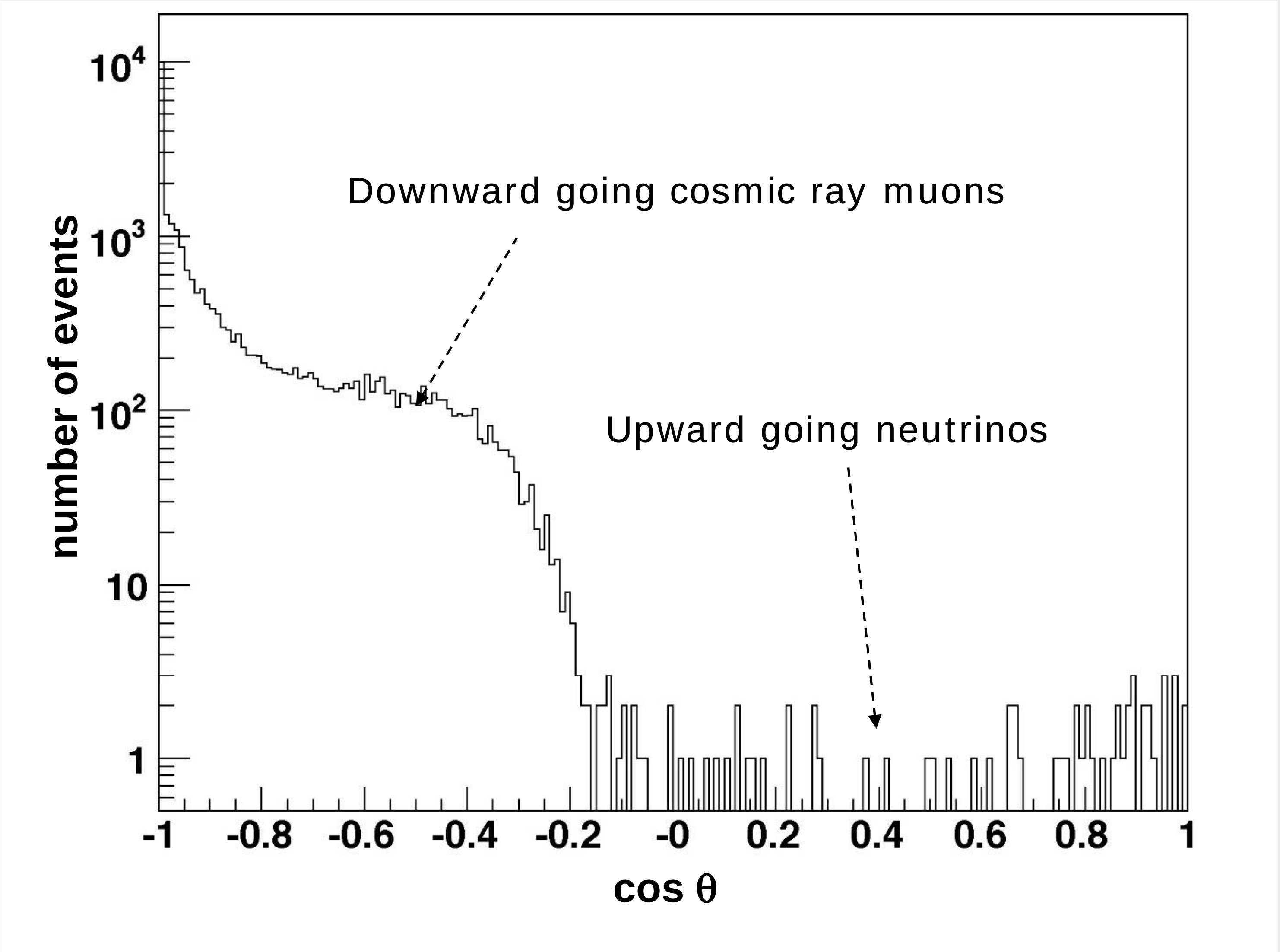


Atmospheric ν in IC-9

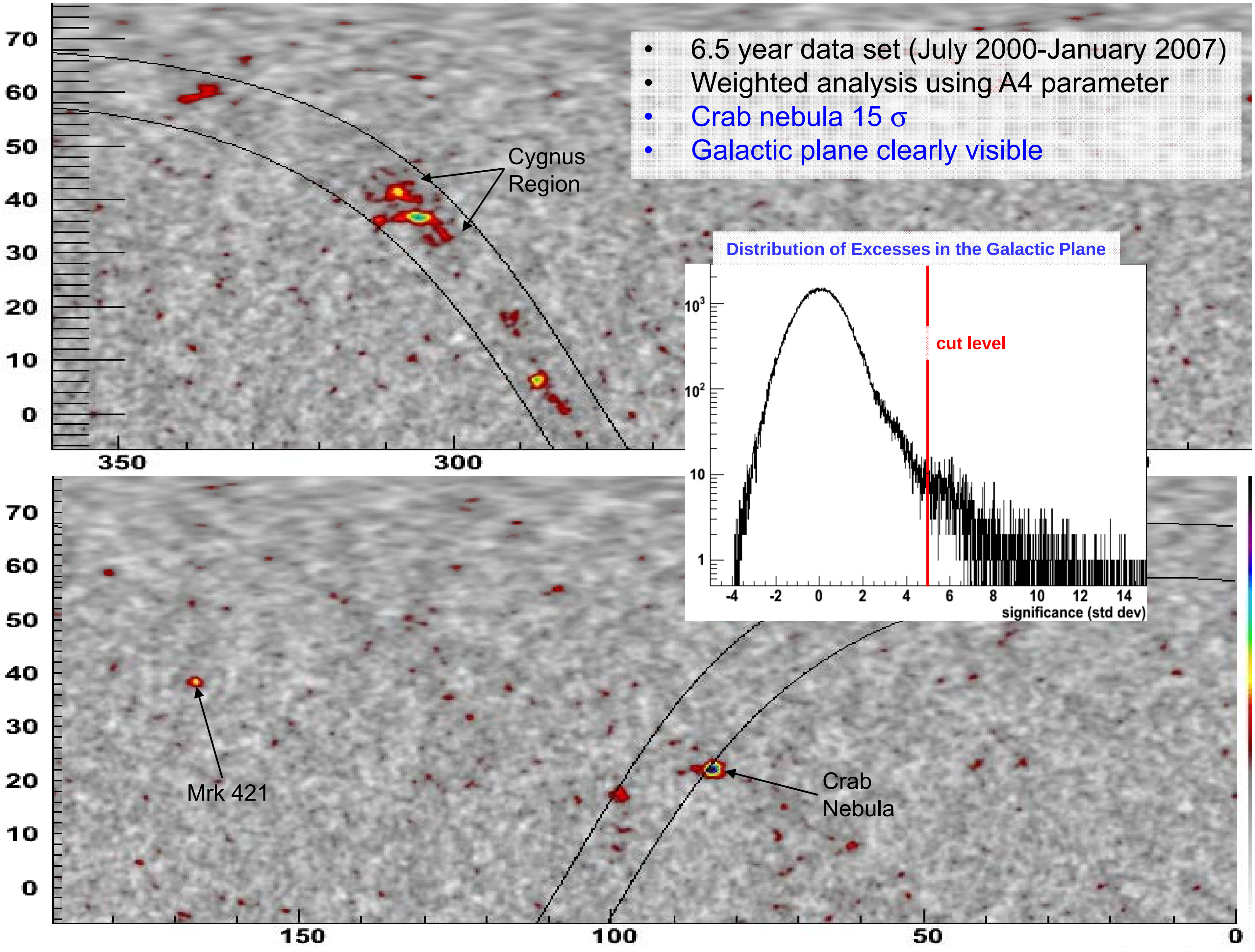


Zenith angle distribution

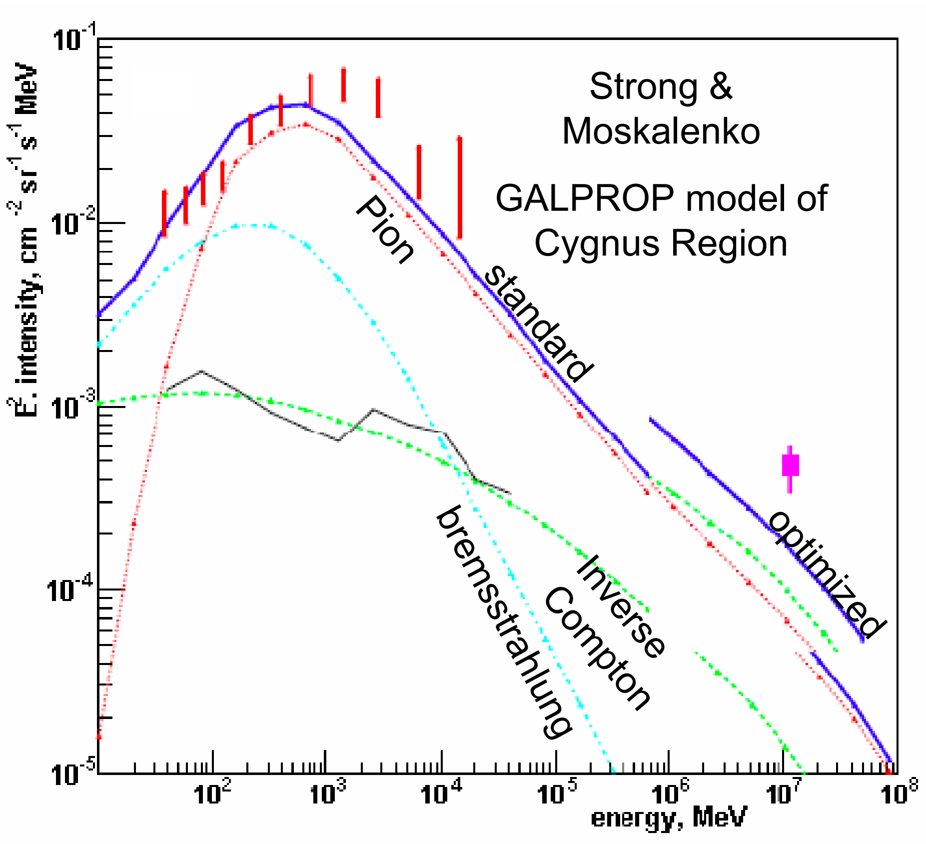
First look at data, no position alignment used



Galactic sources

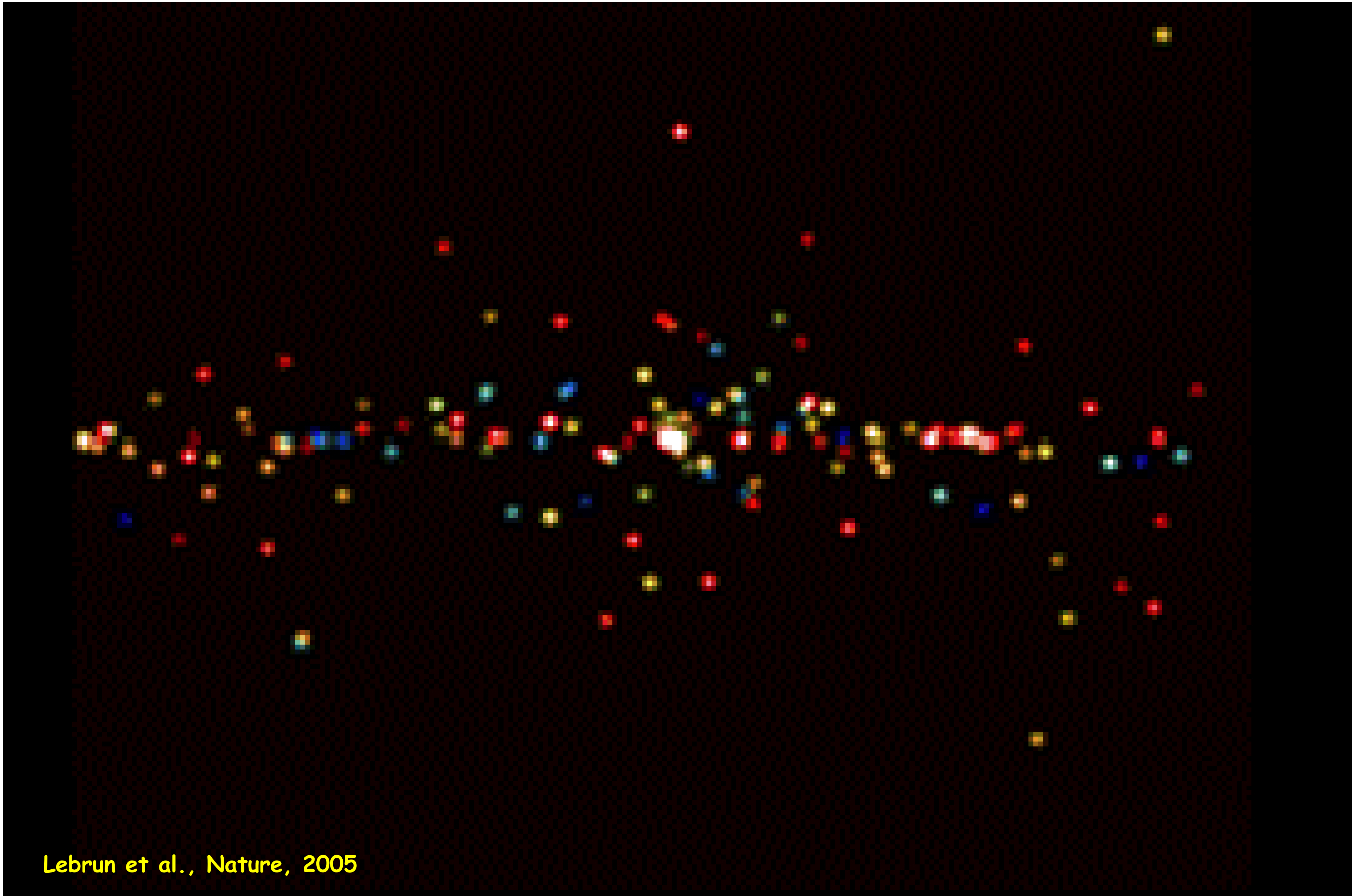

• 6.5 year data set (July 2000-January 2007)
• Weighted analysis using A4 parameter
• Crab nebula 15 σ
• Galactic plane clearly visible
Cygnus Region
Distribution of Excesses in the Galactic Plane
cut level
significance (std dev)
Mrk 421
Crab Nebula
70
60
50
40
30
20
10
0
350
300
150
100
50
0
10^3
10^2
10
1
-4
-2
0
2
4
6
8
10
12
14

The Cygnus Region



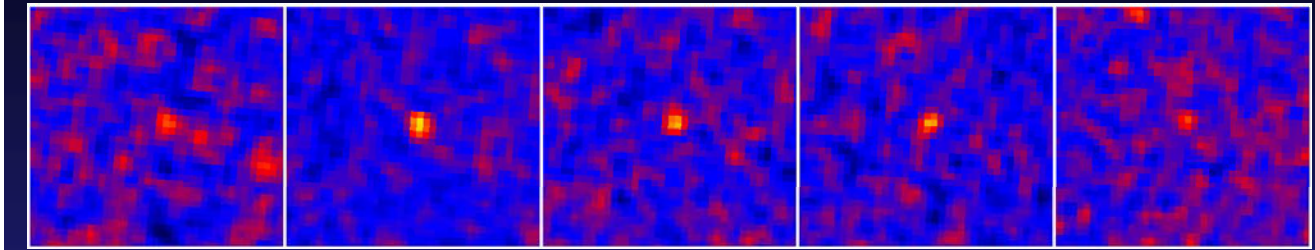
- MGRO J2019+37: 10.9σ (previously reported ApJ Lett v658 L33)
  - Extended source 1.1° ± 0.5° (top hat dia.)
  - Possible Counterparts
    - GeV J2020+3658, PWN G75.2+0.1
- MGRO J2031+41: 6.9σ (5.0σ post-trials)
  - Possible Counterparts:
    - 3EG J2033+4118, GEV J2035+4214
    - TEV J2032+413 (⅓ of Milagro flux)
  - 3.0° ± 0.9° (top hat dia.)
- C1 J2044+36: 5.5σ pre-trials
  - no counterparts
  - < 2.0°
- C2 J2031+33: 5.3σ pre-trials
  - no counterparts
  - possible extension of MGRO J2019+37
  - possible fluctuation of MGRO J2019 tail & diffuse emission & background
- TeV Diffuse emission ~3x predictions
  - Cosmic Ray sources?
  - Unresolved gamma-ray sources?

The IBIS: Central Radiant, no Diffuse Ridge Emission



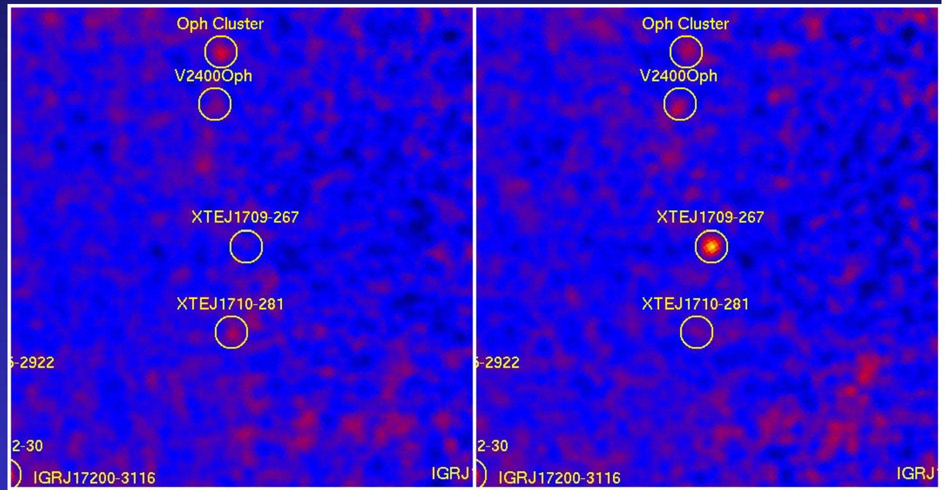
Lebrun et al., Nature, 2005

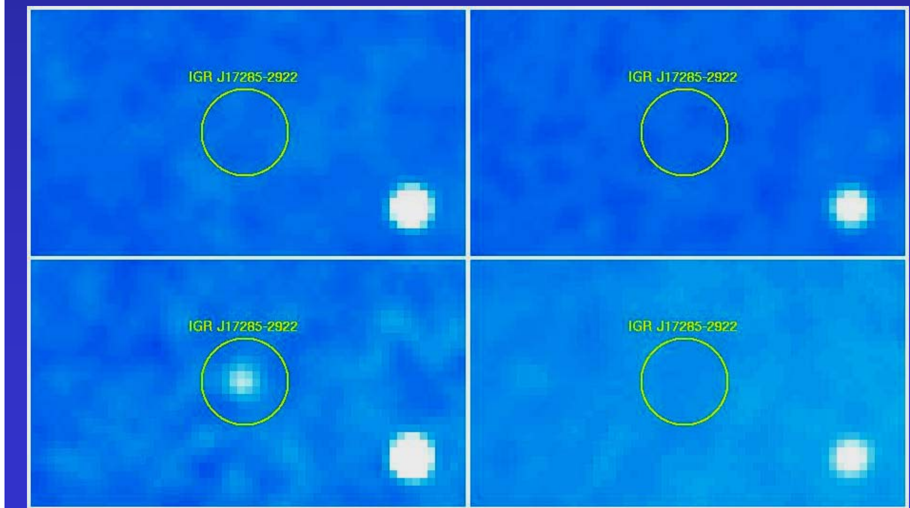
High-energy sources appear on all time-scales



Sources can appear in ~ 1000s

Or in a few days

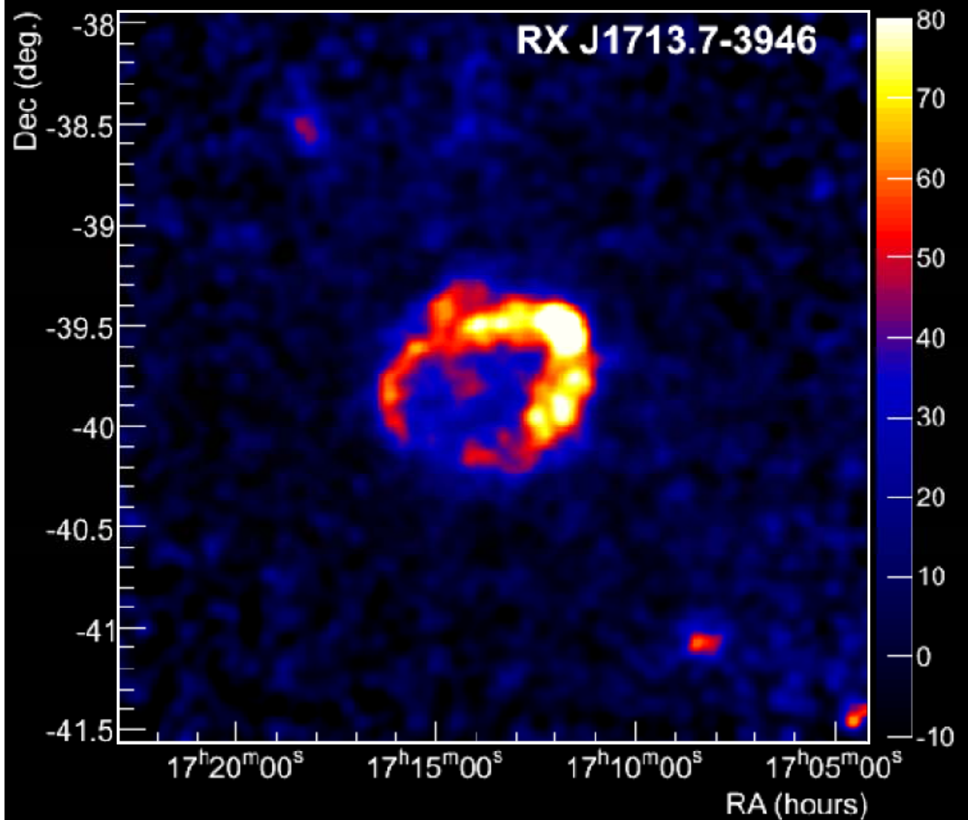


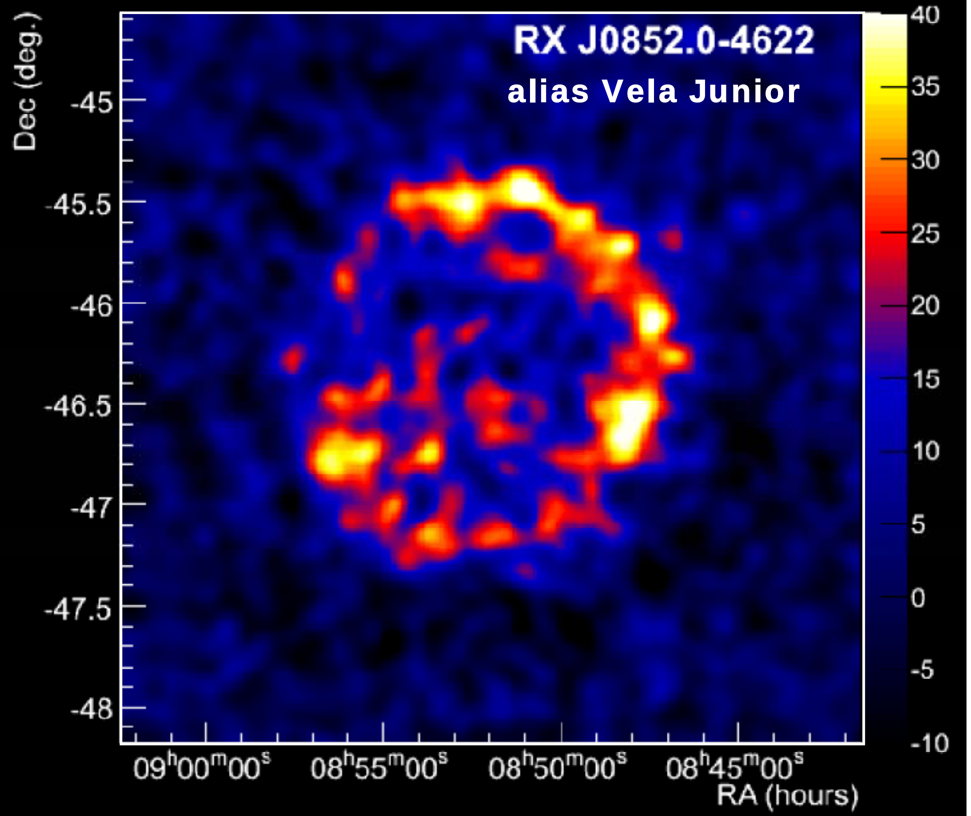


Or in a few weeks

Supernova remnant shells resolved in VHE

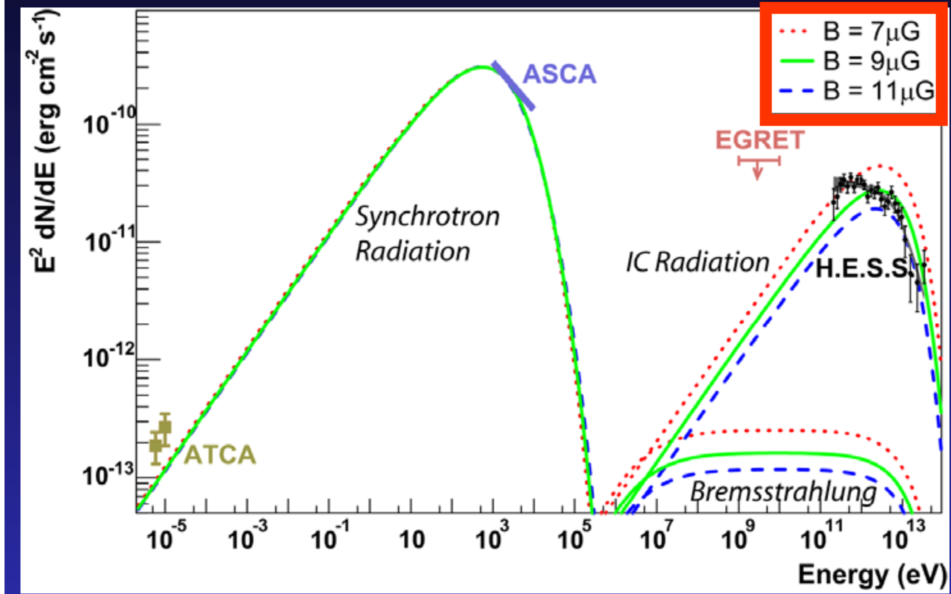
- Unambiguous proof that TeV particle acceleration takes place in SNR shocks
- Young supernova remnants → particles still confined inside sources





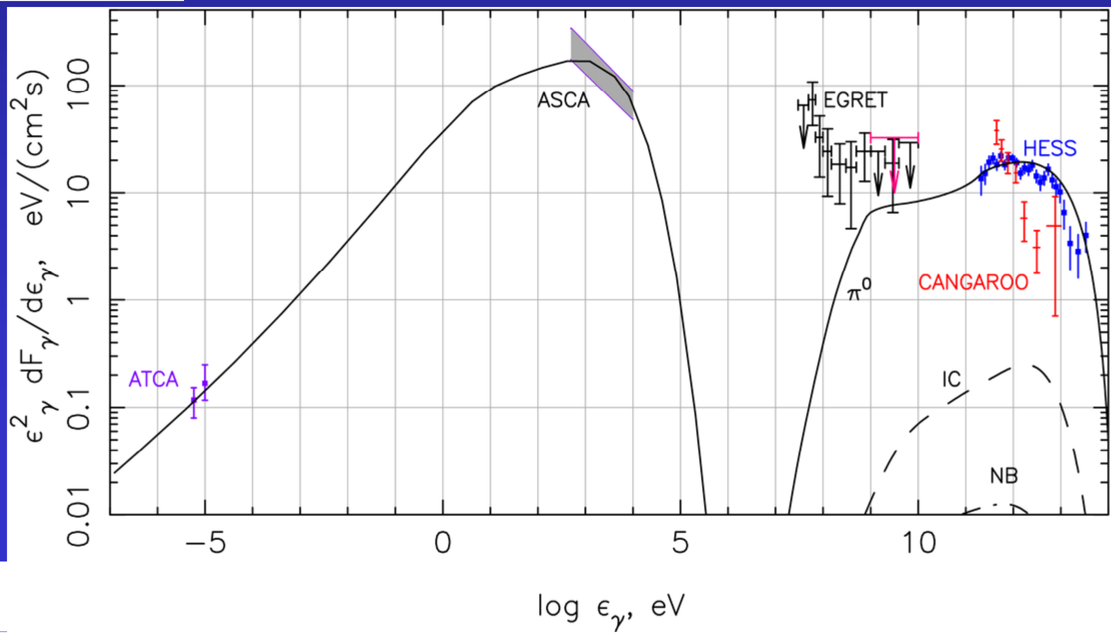
HESS collaboration, Nature 432, 2004 + A&A 449, 2005 HESS collaboration, A&A 437, 2005

Leptonic vs. hadronic (RX J1713-3946)



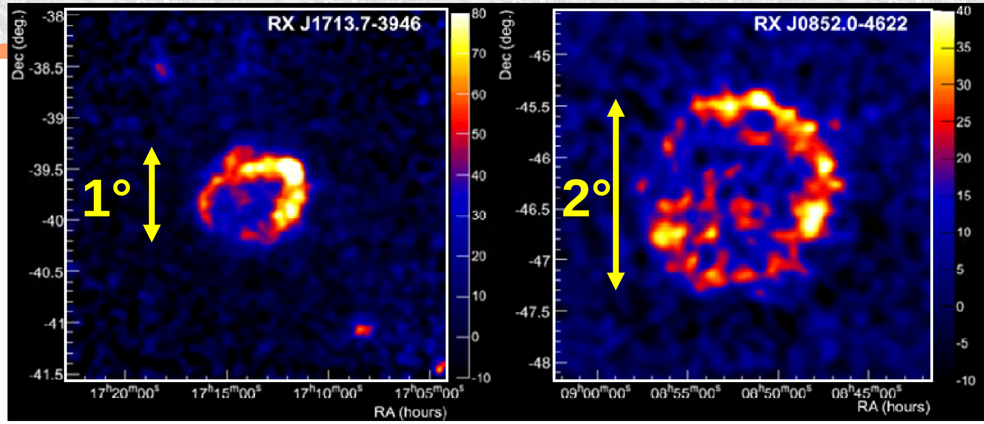
HESS collaboration, A&A 449, 2006

Hadronic broadband model:
Berezkho & Völk, 2006



Critical issue: B-field

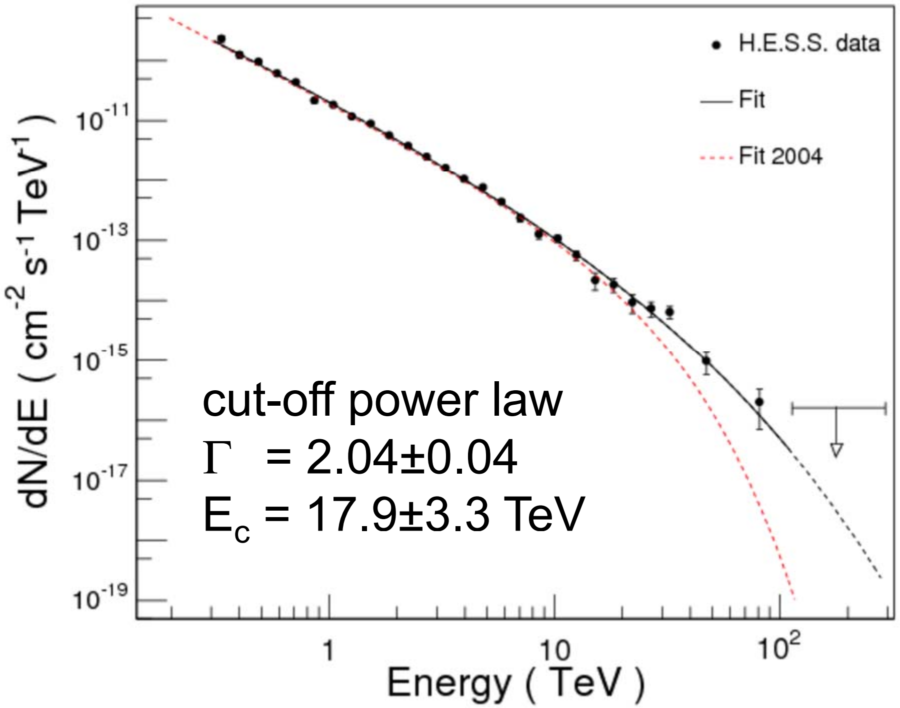
High statistics investigations



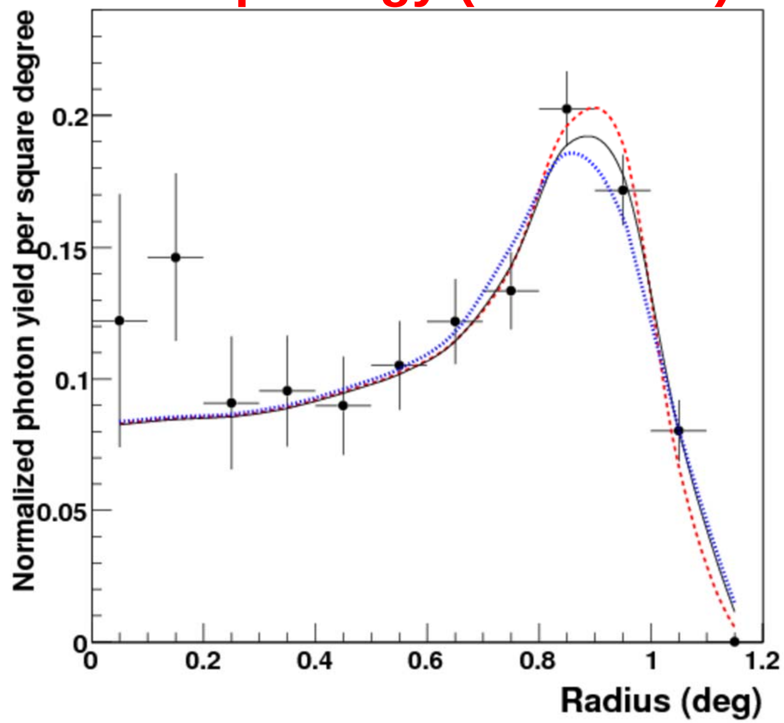
HESS collaboration, A&A 464, 2007

HESS collaboration, ApJ 661, 2007

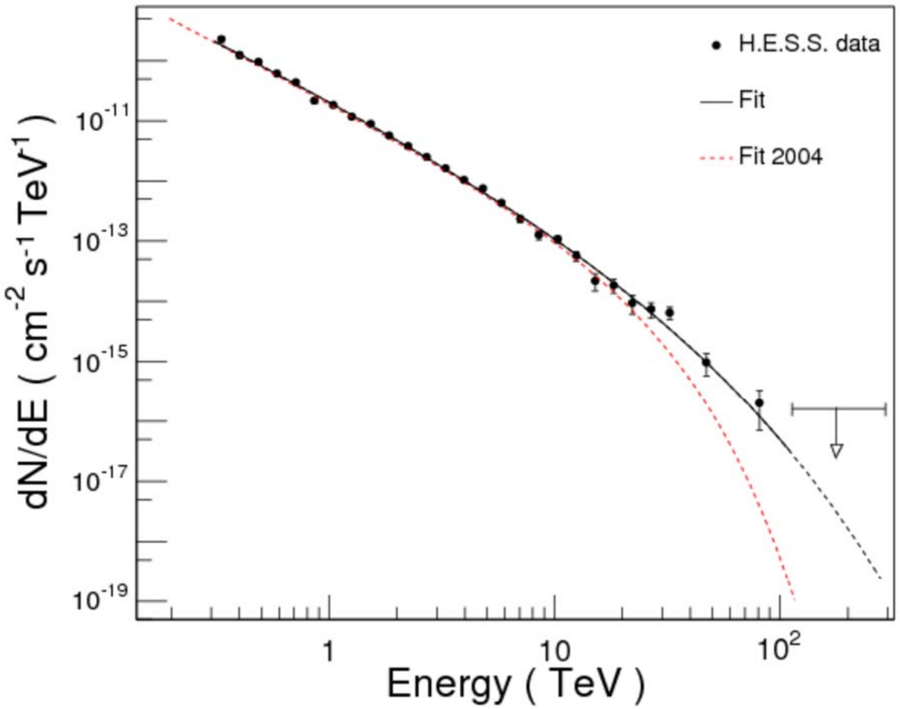
RX J1713-3946: Particle acceleration to beyond 100 TeV



Vela Junior: morphology (and more)



What if RXJ 1713 is hadronic?



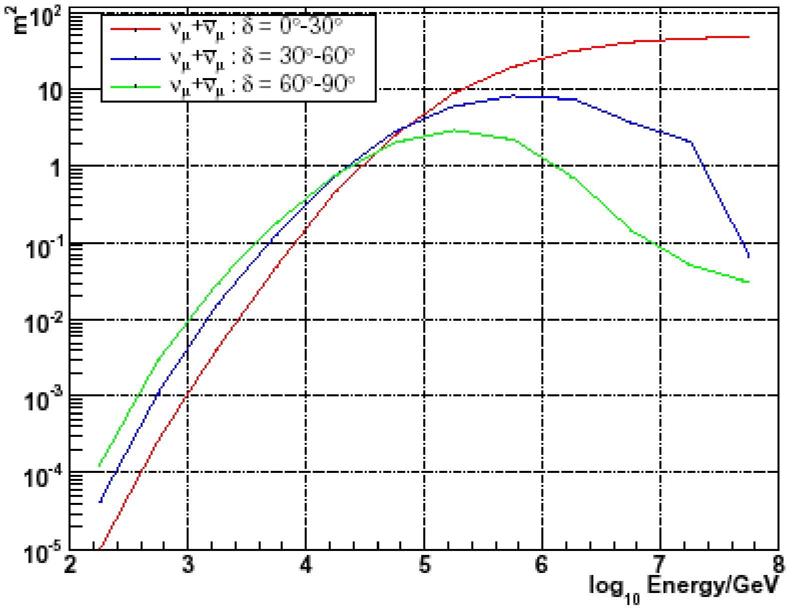
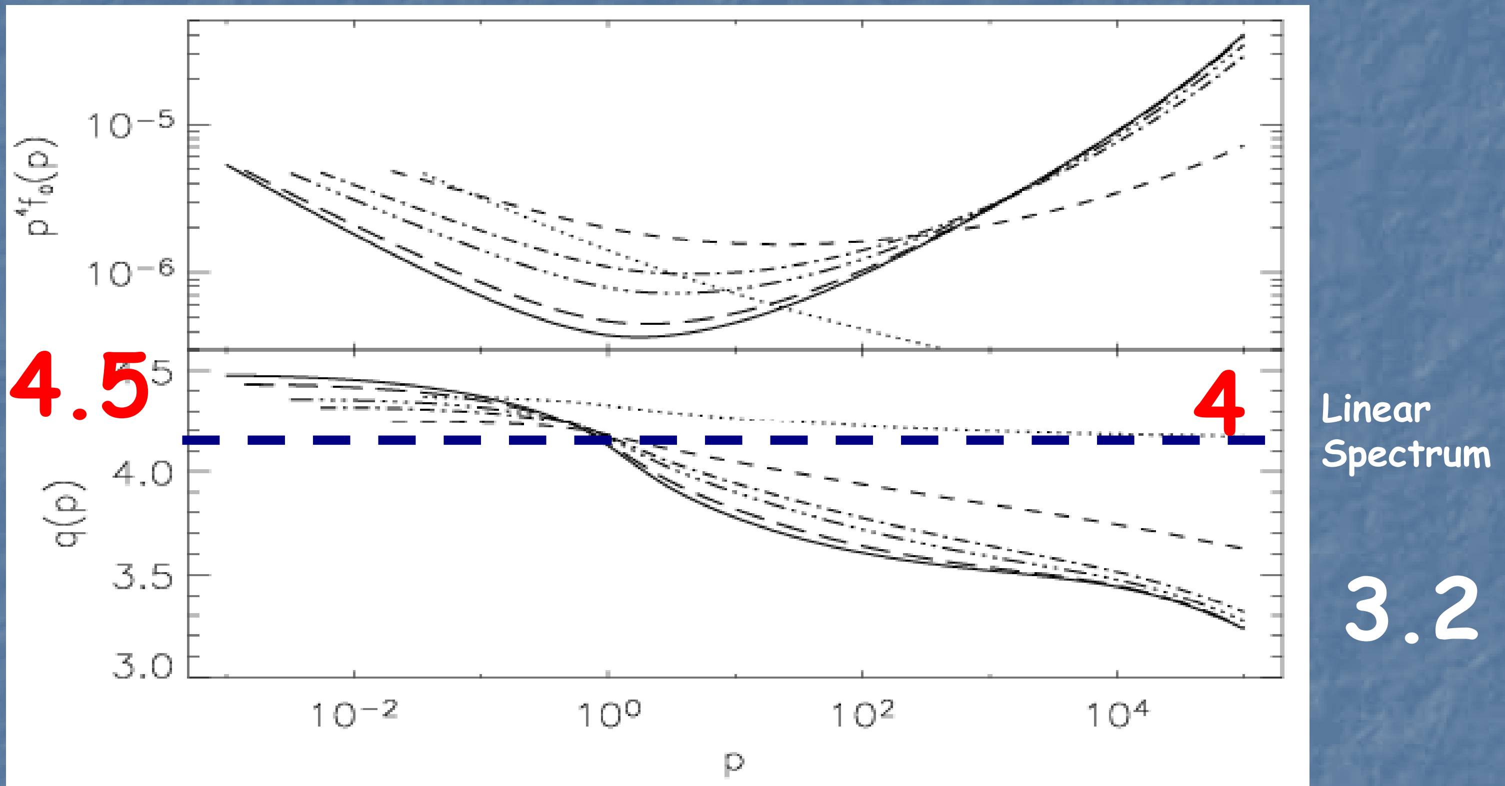


Figure 3: IC-9 effective area to a flux of $\nu_\mu + \bar{\nu}_\mu$, averaged over different declination ranges.

Convolve Flux with effective area for km^3 in the North:

~ 2 ν / year after accounting for kinematics and oscillations

Spectra at Modified Shocks



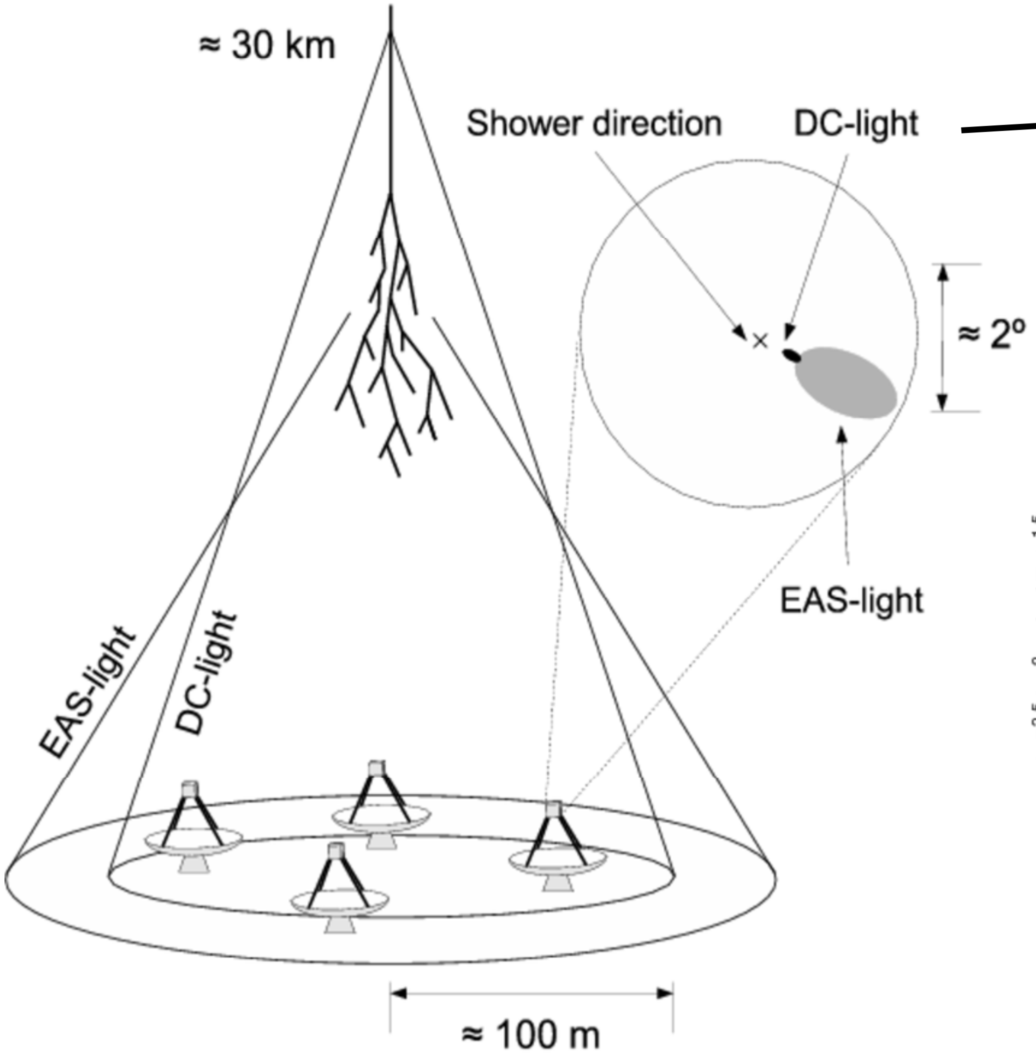
Amato and PB (2005)

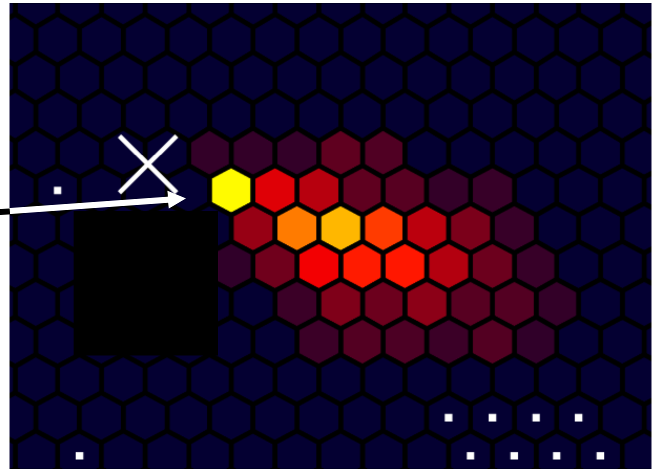
Very Flat Spectra at high energy

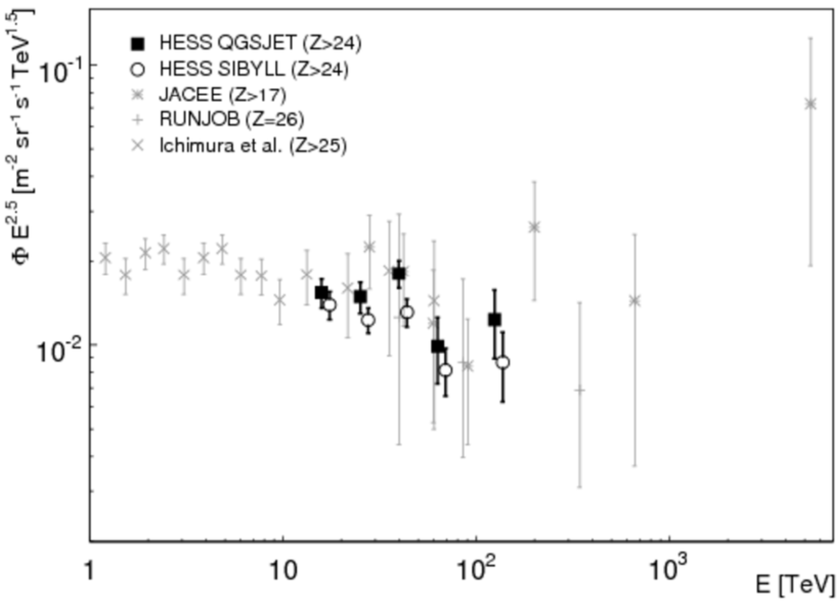
Pasquale Blasi: most energy at Emax
--How to get smooth, power-law spectrum?

CR Iron spectrum from Direct Cherenkov

HESS collaboration, Phys Rev D 27, 2007

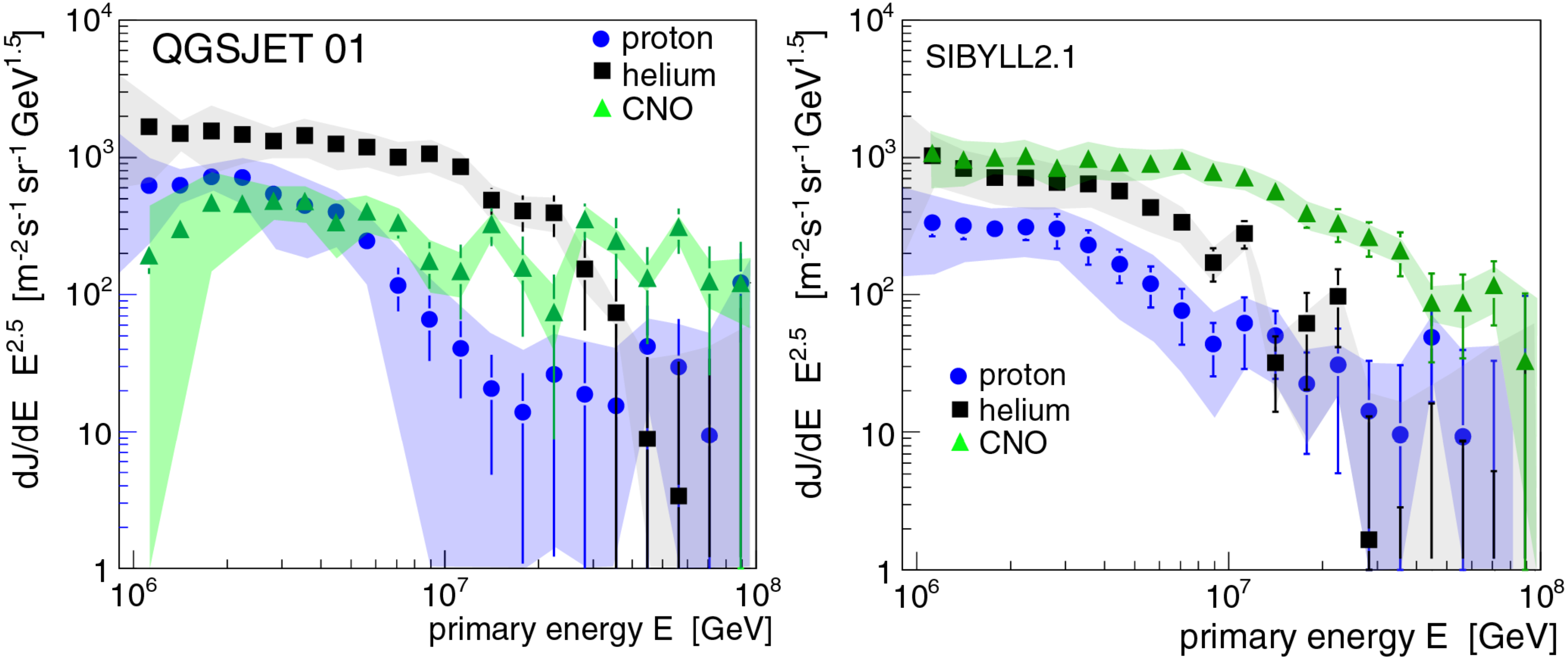






Method proposed by Kieda et al, 2001

KASCADE: Energy spectra for elemental groups

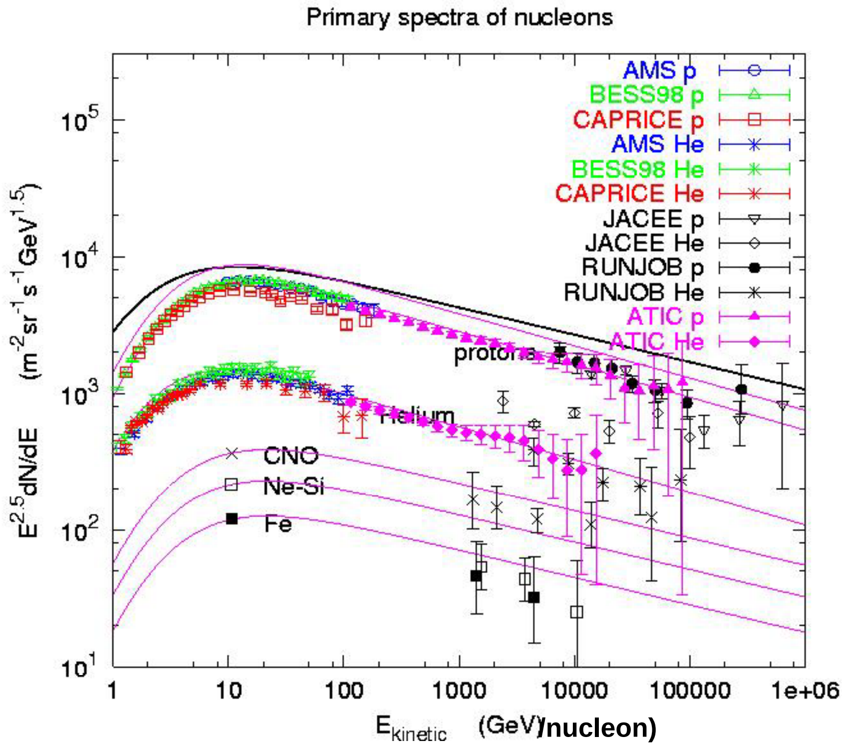


Knee caused by cut-off for light elements

Astrophysical interpretation limited by description of interactions in the atmosphere

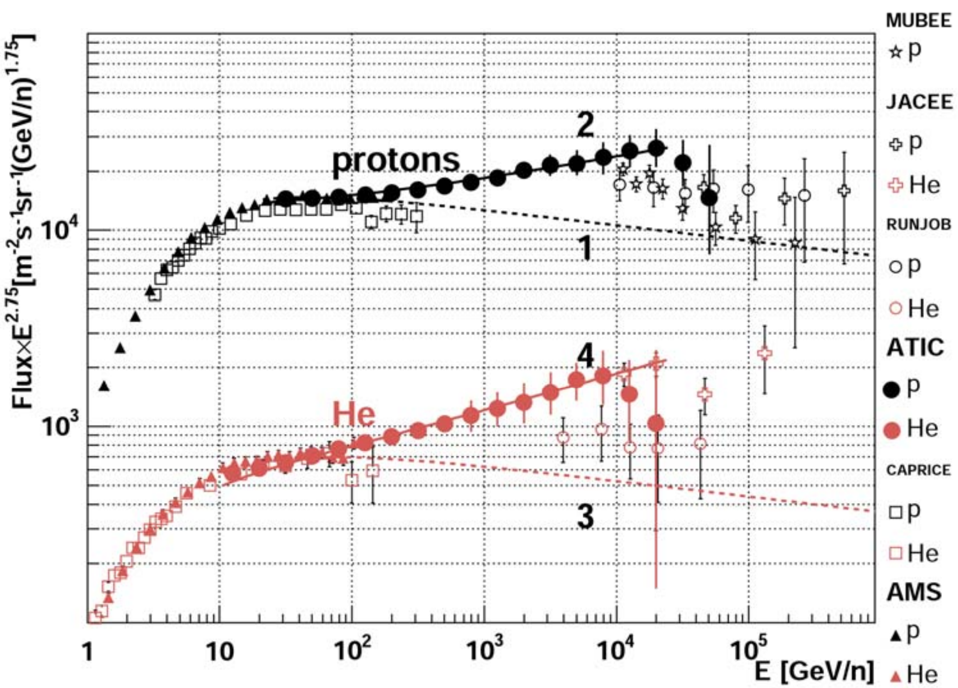
T. Antoni et al., Astropart. Phys. 24 (2005) 1

Hard Helium spectrum ?

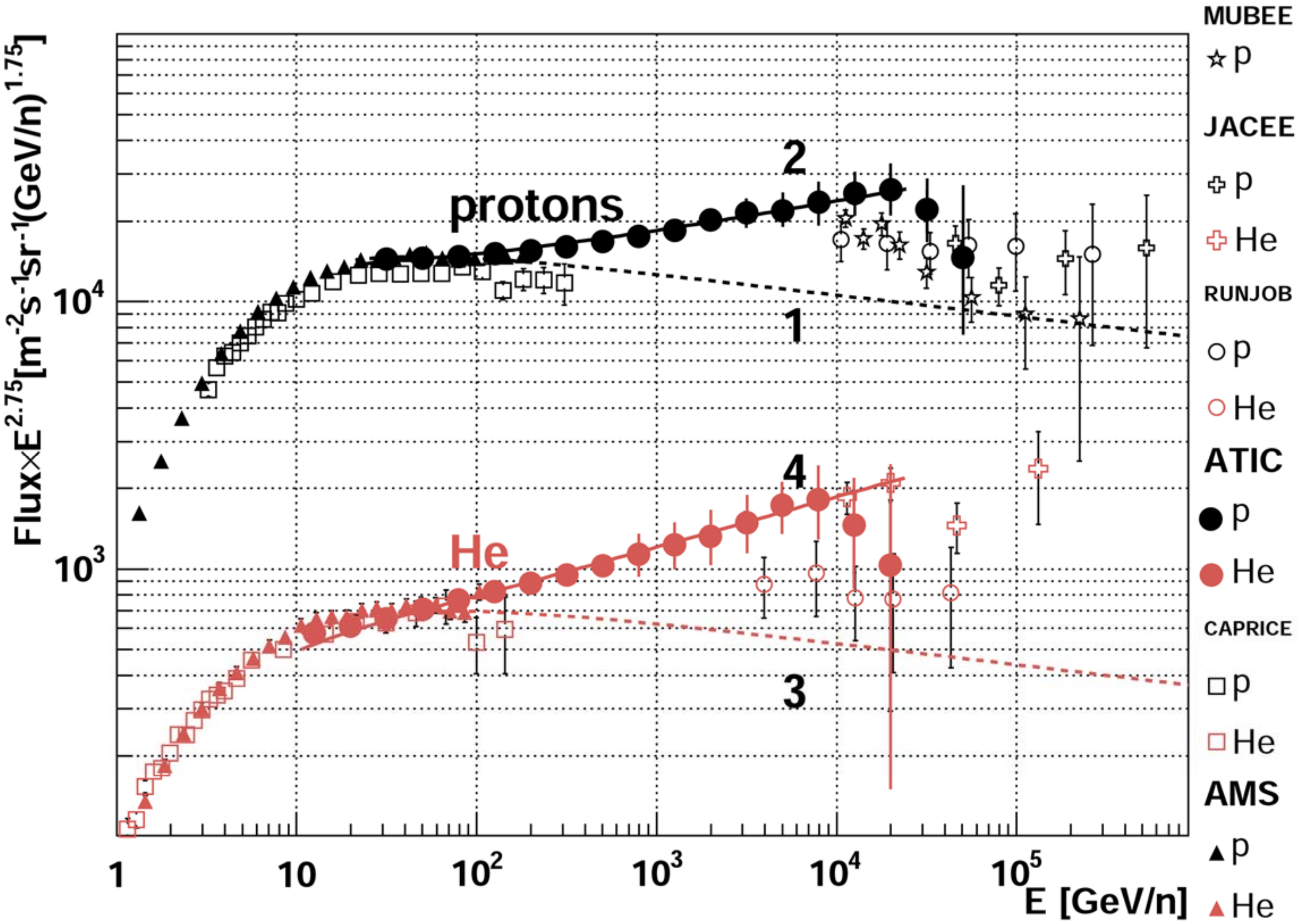


RUNJOB: thanks to T. Shibata
ATIC: thanks to E-S Seo & J. Wefel

ATIC 2, John Wefel et al.

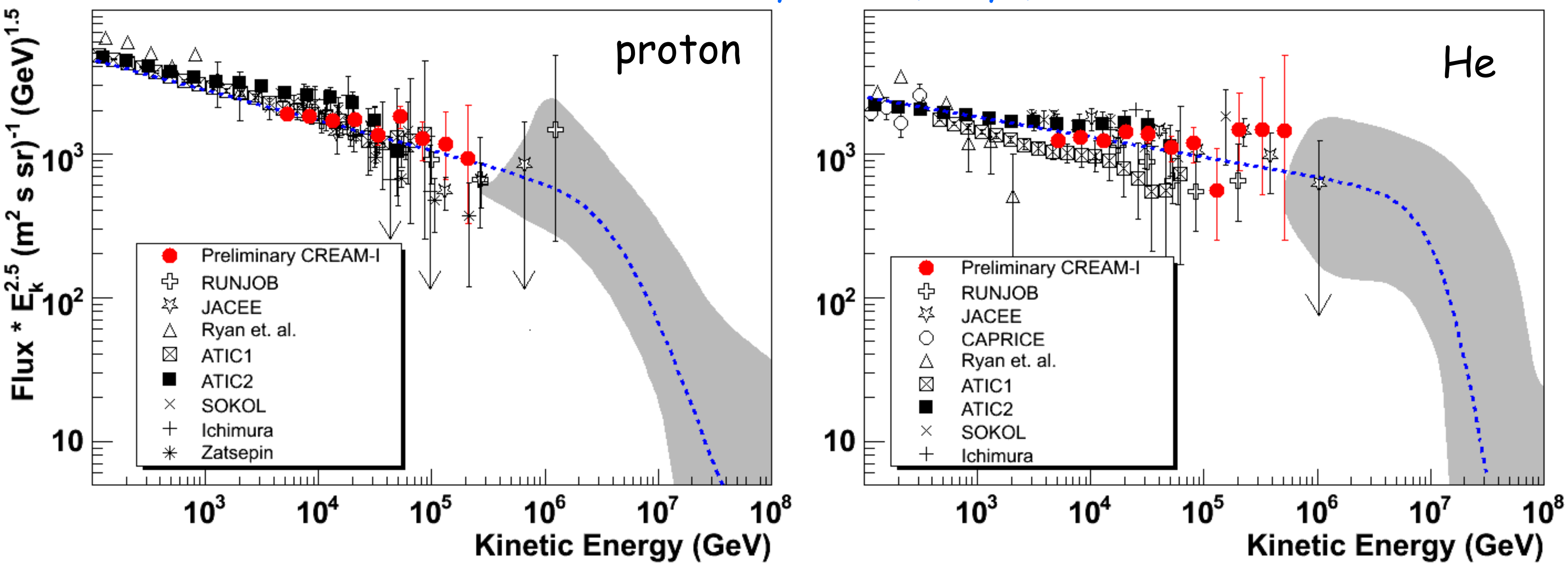


ATIC, John Wefel



Approaching the "knee"

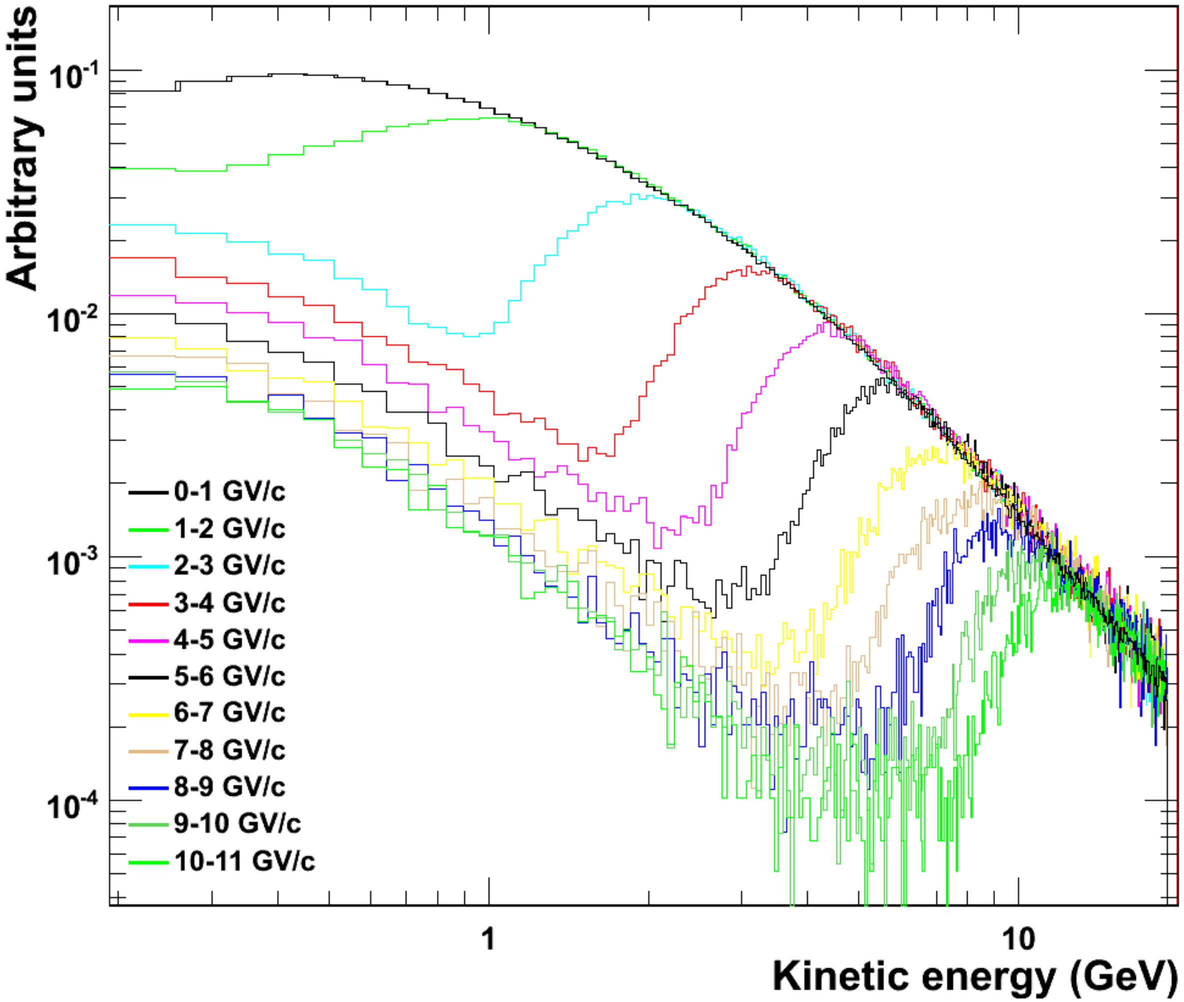
E. S. Seo et al., Proc. Int. Workshop on Cosmic-rays and High Energy Universe, Universal Academy Press (Tokyo), 2007.



- The proton spectrum follows a power law without much change up to ~ 100 TeV.
- He spectrum seems harder than the proton spectrum.
- Compared to lower energy data, there seems to be an increase in the abundance of Helium nuclei relative to protons.
- Future flights will extend the CREAM energy reach to higher energies to distinguish hadronic interaction models such as QGSJET and SIBYLL used for ground based data.

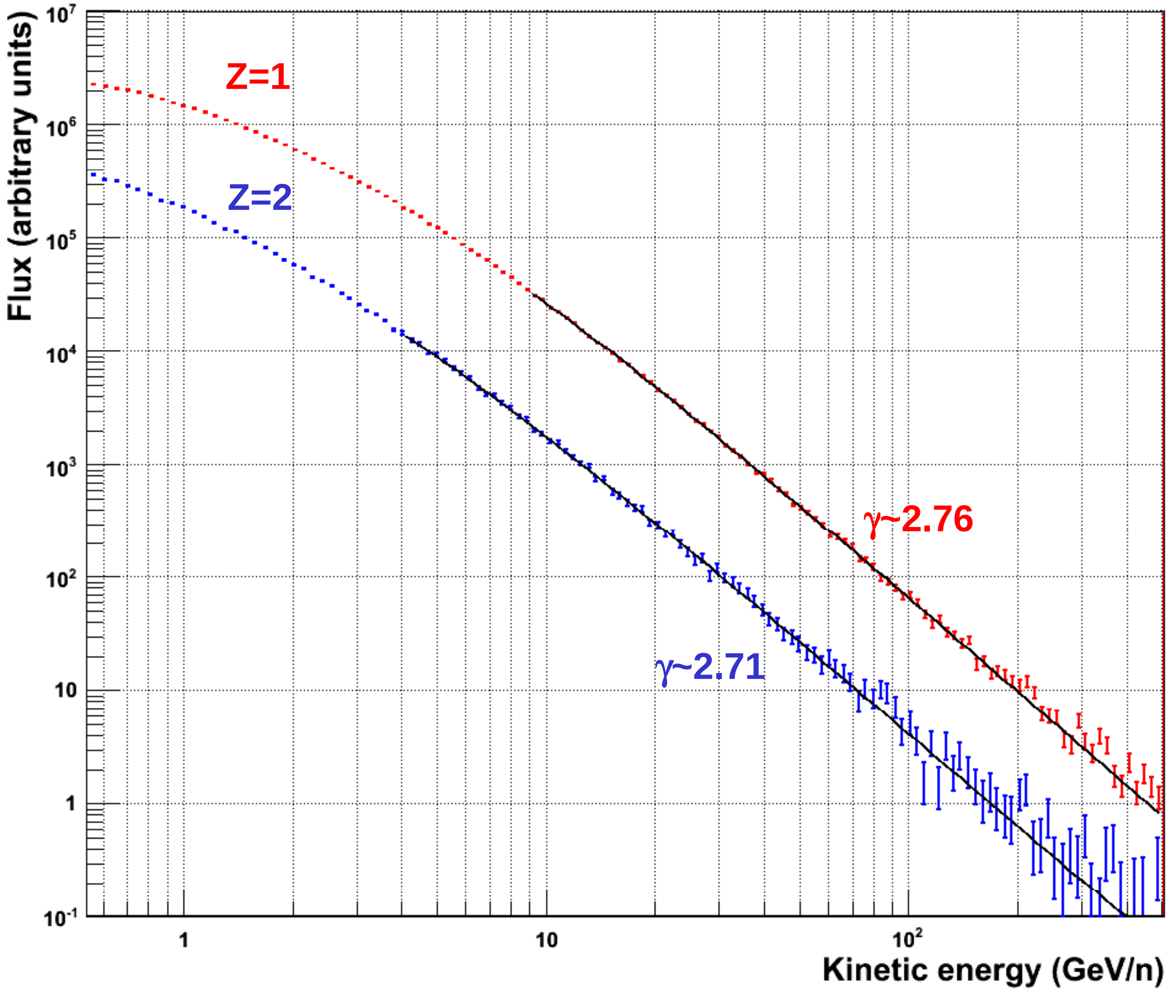
H spectra @ different cutoff rigidities

Preliminary !!!

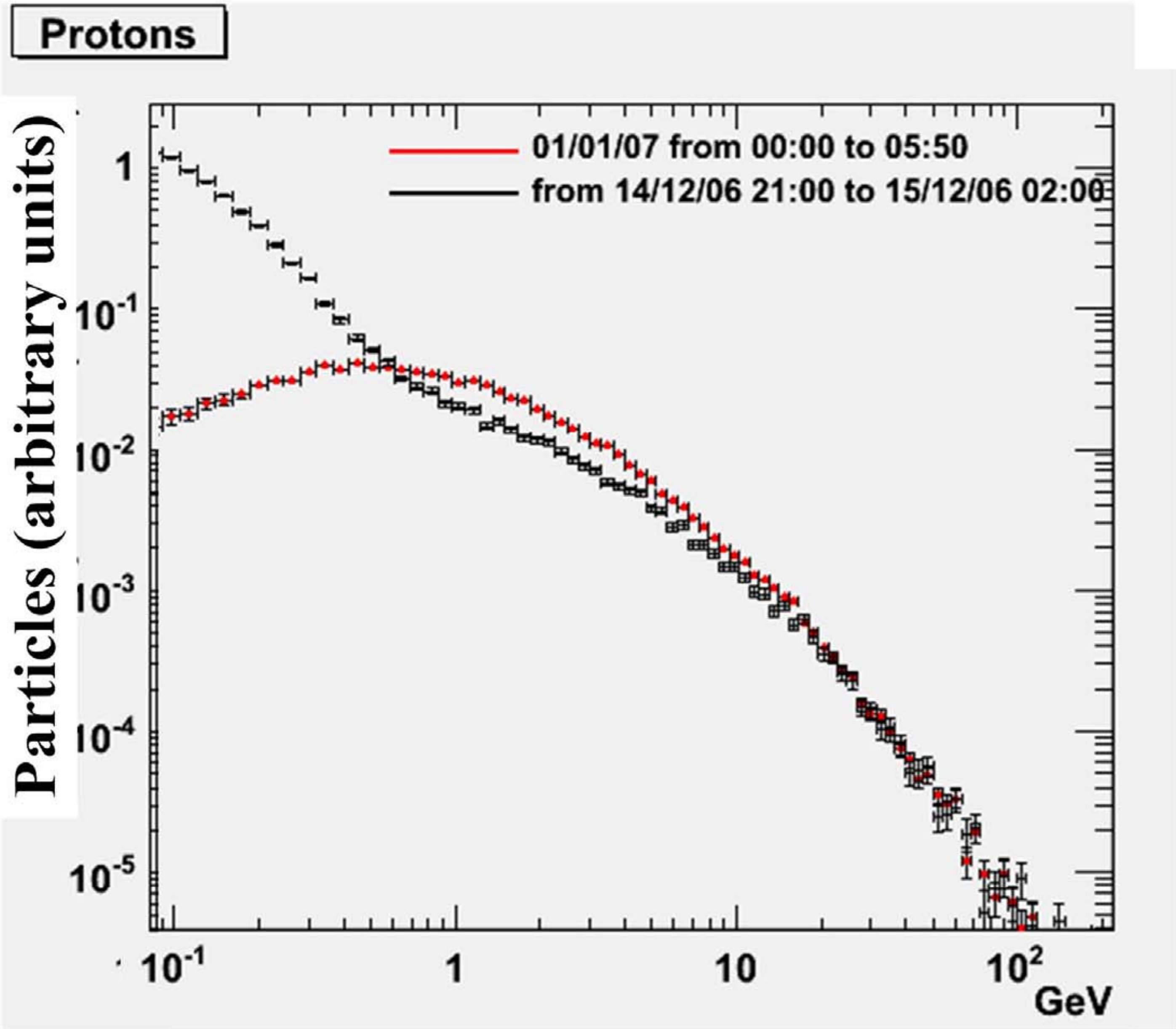


Galactic H and He spectra

Preliminary !!!

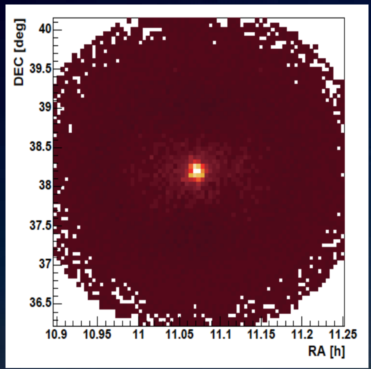


Solar flare

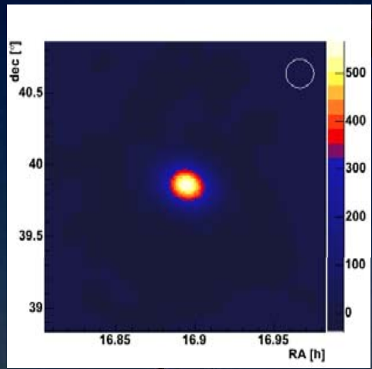

Protons
Particles (arbitrary units)
01/01/07 from 00:00 to 05:50
from 14/12/06 21:00 to 15/12/06 02:00
1
10-1
10-2
10-3
10-4
10-5
10-1
1
10
10²
GeV

Extra-galactic sources

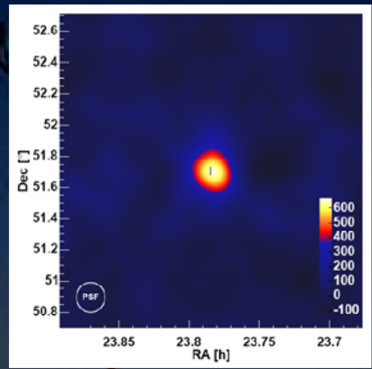
MAGIC: Extragalactic Sources



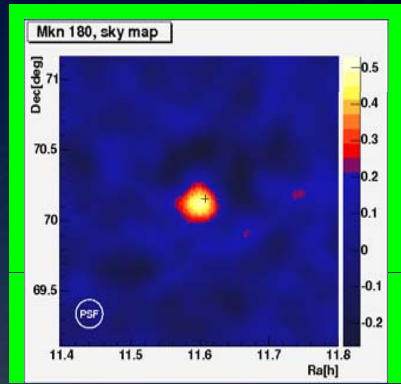
Mrk 421 (0.031)



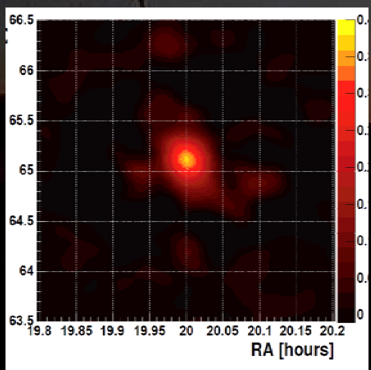
Mrk 501 (0.034)



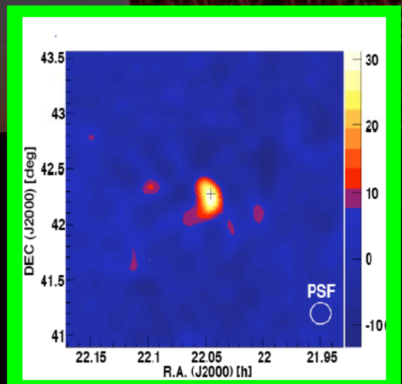
1es2344 (0.044)



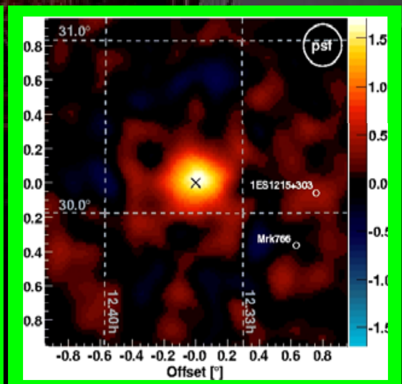
Mrk 180 (0.045)



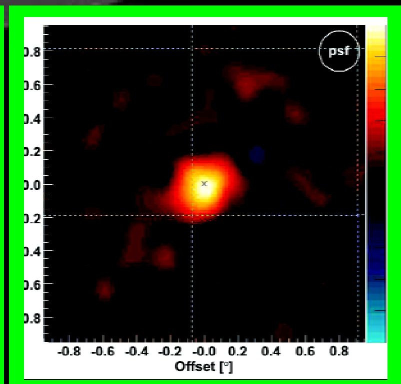
1es1959 (0.047)



BL Lac (0.069)



1es1218 (0.18)



PG1553 (>0.25)

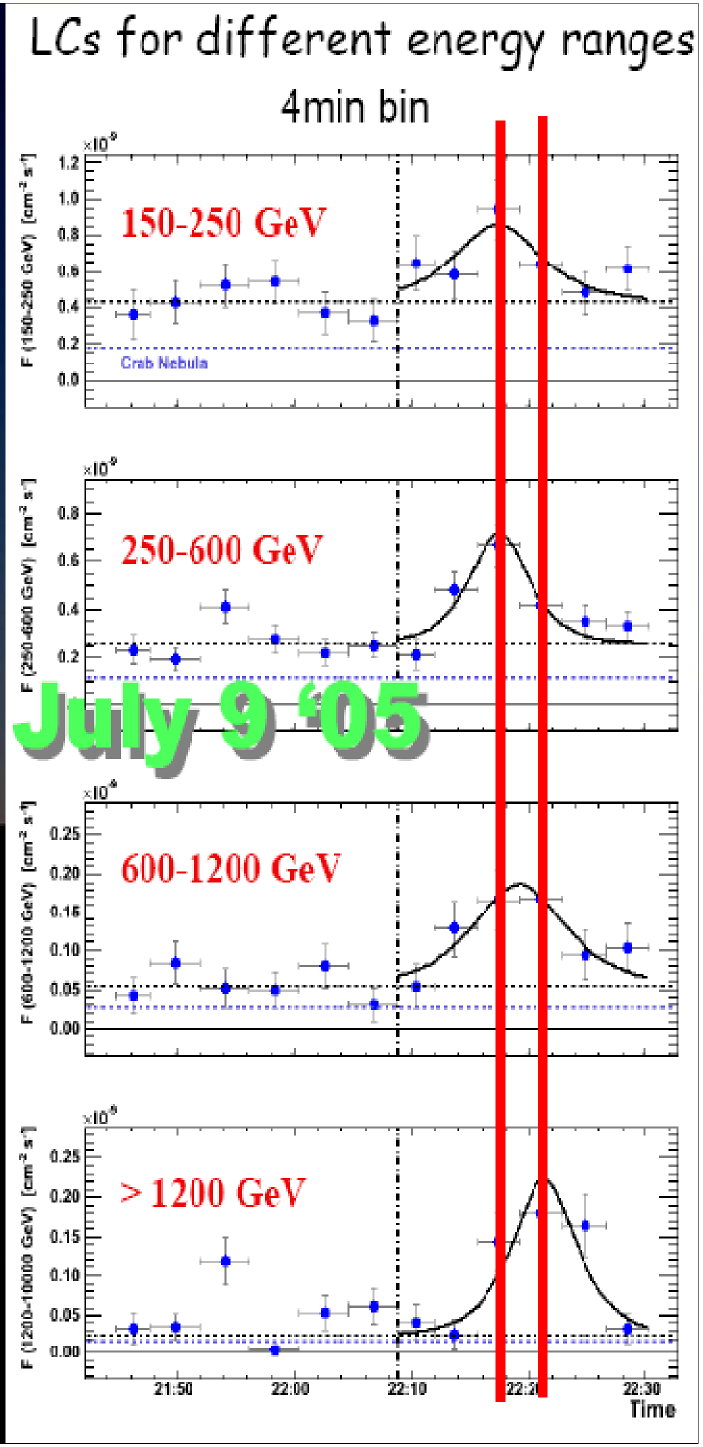
Markarian 501: Time lag

- Evident 4±1 min Time Lag between $\Phi_{<250GeV}$ and $\Phi_{>1.2TeV}$
- May be explained by the particle acceleration process
- BUT, if photons at diff. E emitted simultaneously:

Lorentz invariance violation?

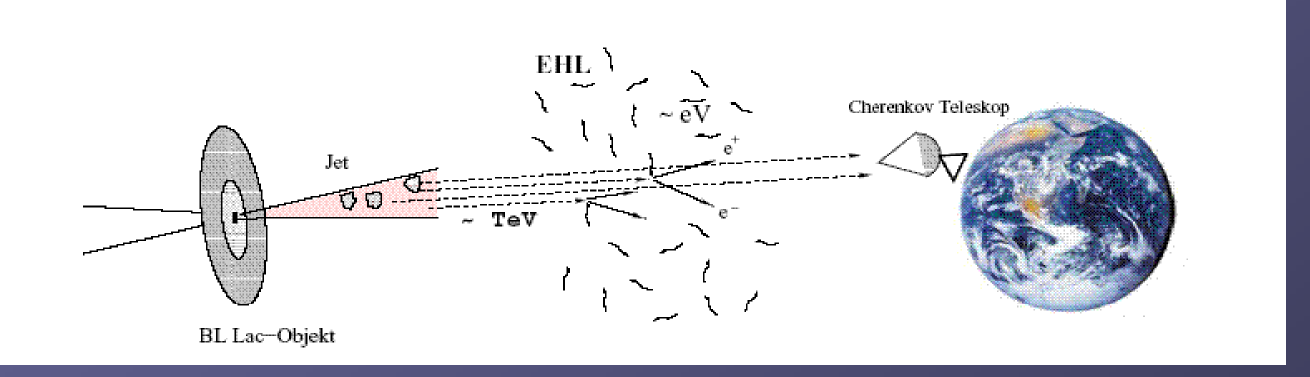
$\Delta T \sim 4$ min, $\Delta E \sim 1$ TeV

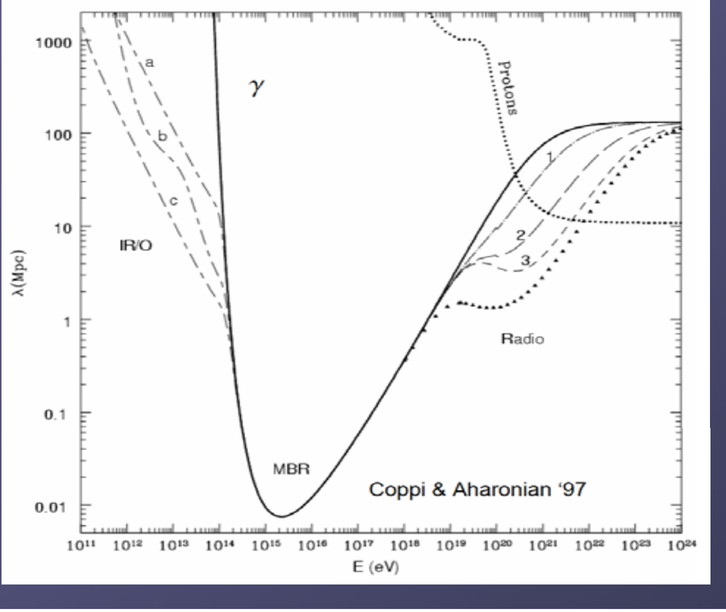
$\Rightarrow E_{scale} \sim 10^{17\div18}$ GeV

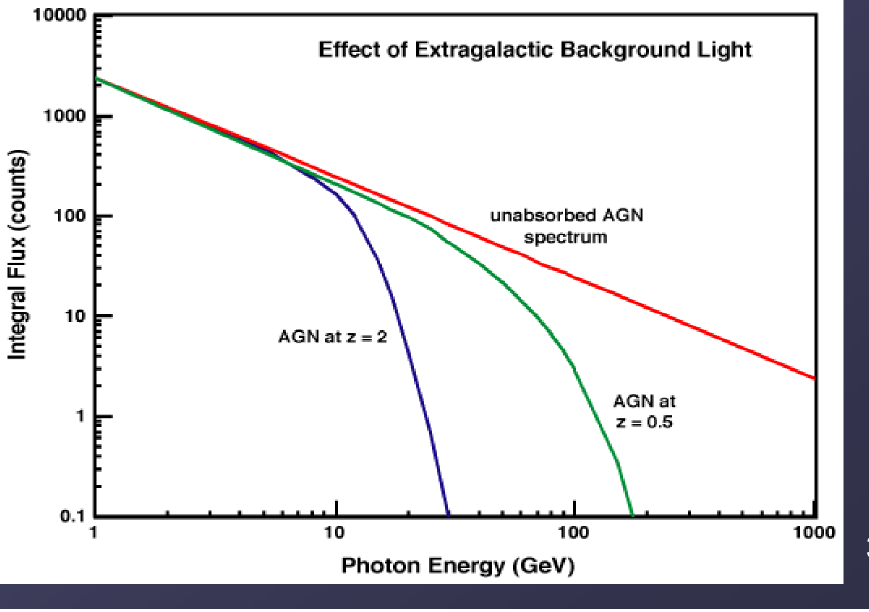


Absorption of gamma rays in the universe

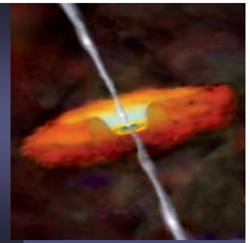
Pair Creation; $\gamma + \gamma \rightarrow e^+ + e^-$

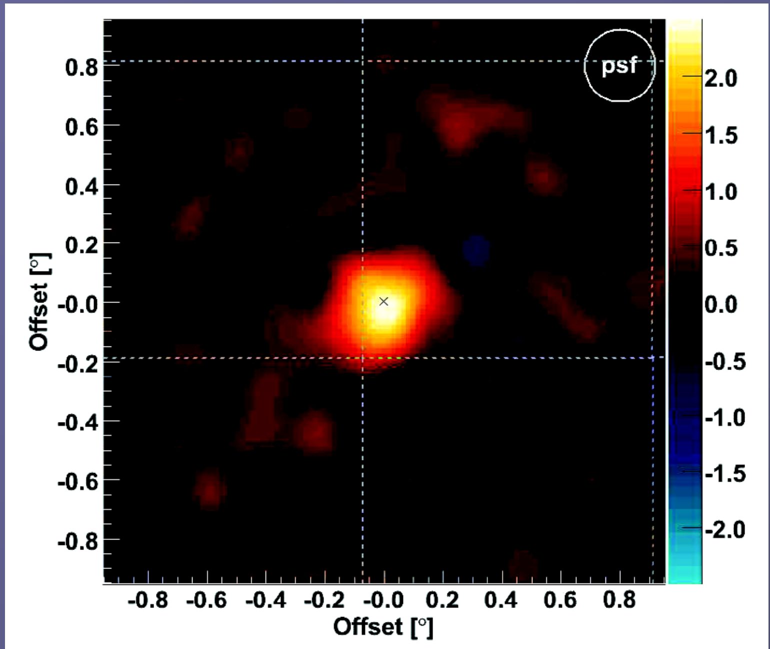


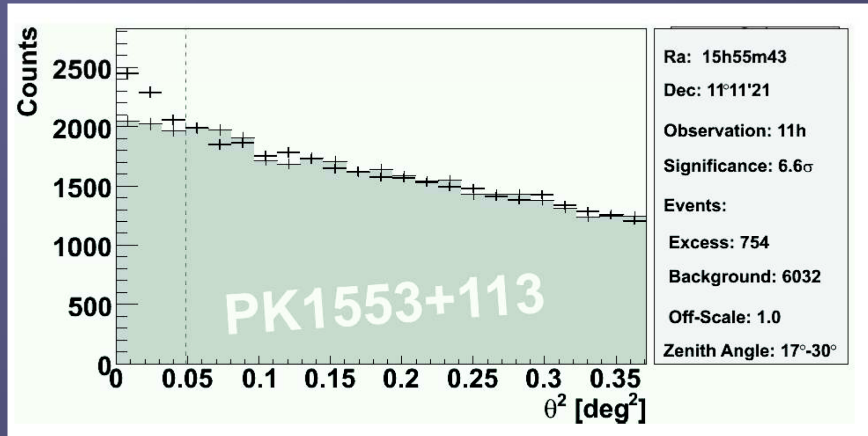


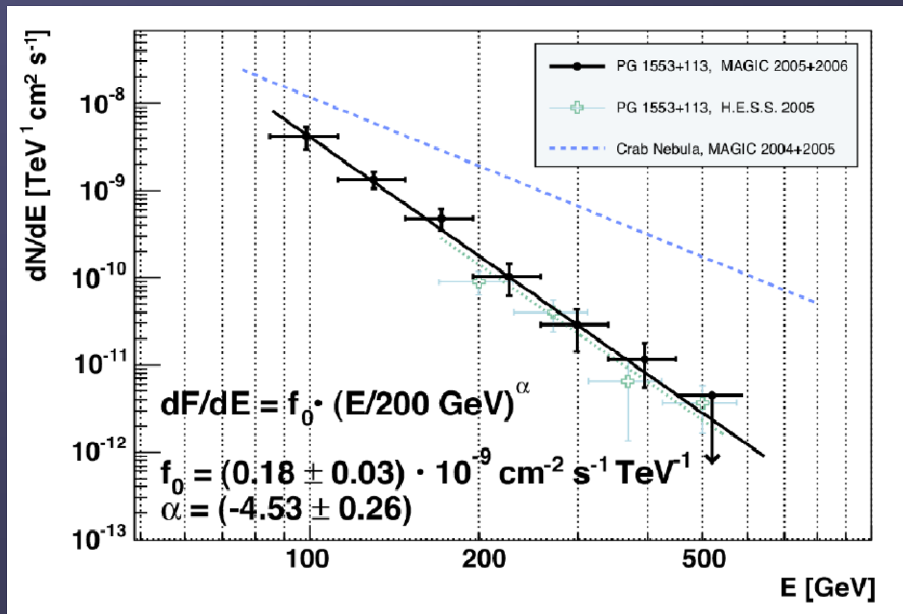


PG 1553 (z>0.25 unknown)









Very Soft energy spectrum

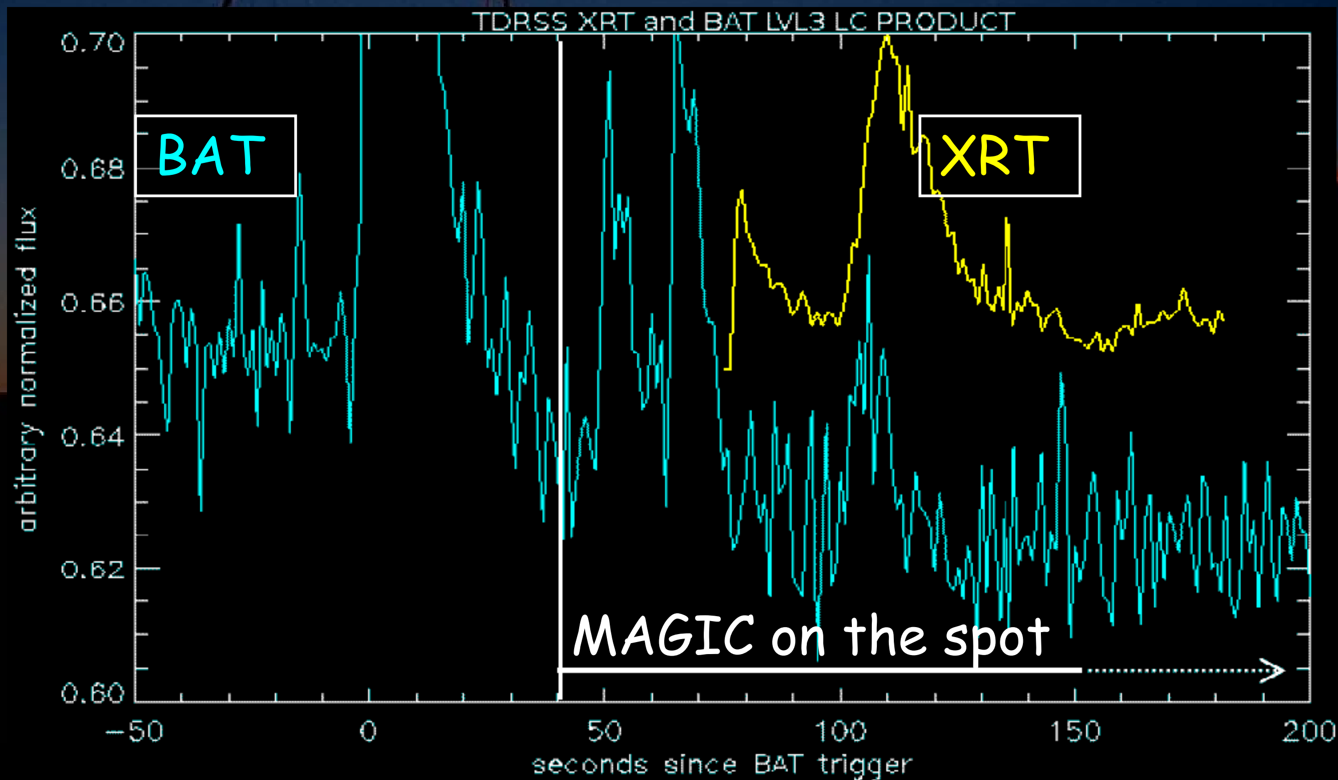
the attenuation by pair creation or nature of SSC mechanism

MAGIC+HESS ➔ Z < 0.42
D.Mazin and F.Goebel

GRB Observations

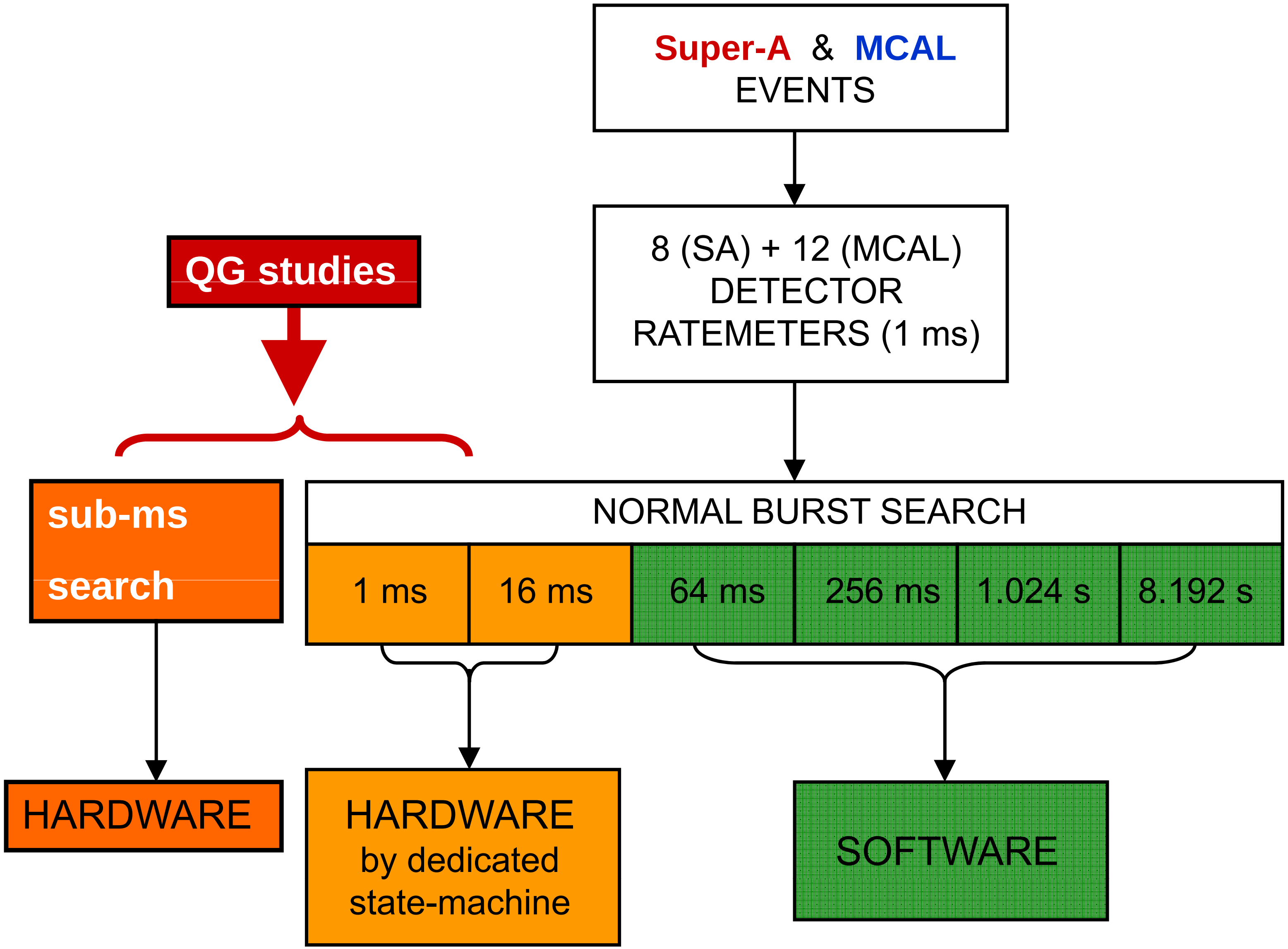
- 22 GRBs follow-up: 2 even while during the prompt emission
- UL ≈ 80 GeV
- Analysis results sent via GCN asap!
- Need a closer GRB

- GRB 050713a ApJ 641 L9 (2006)
- 1st DC: ApJ 667n2



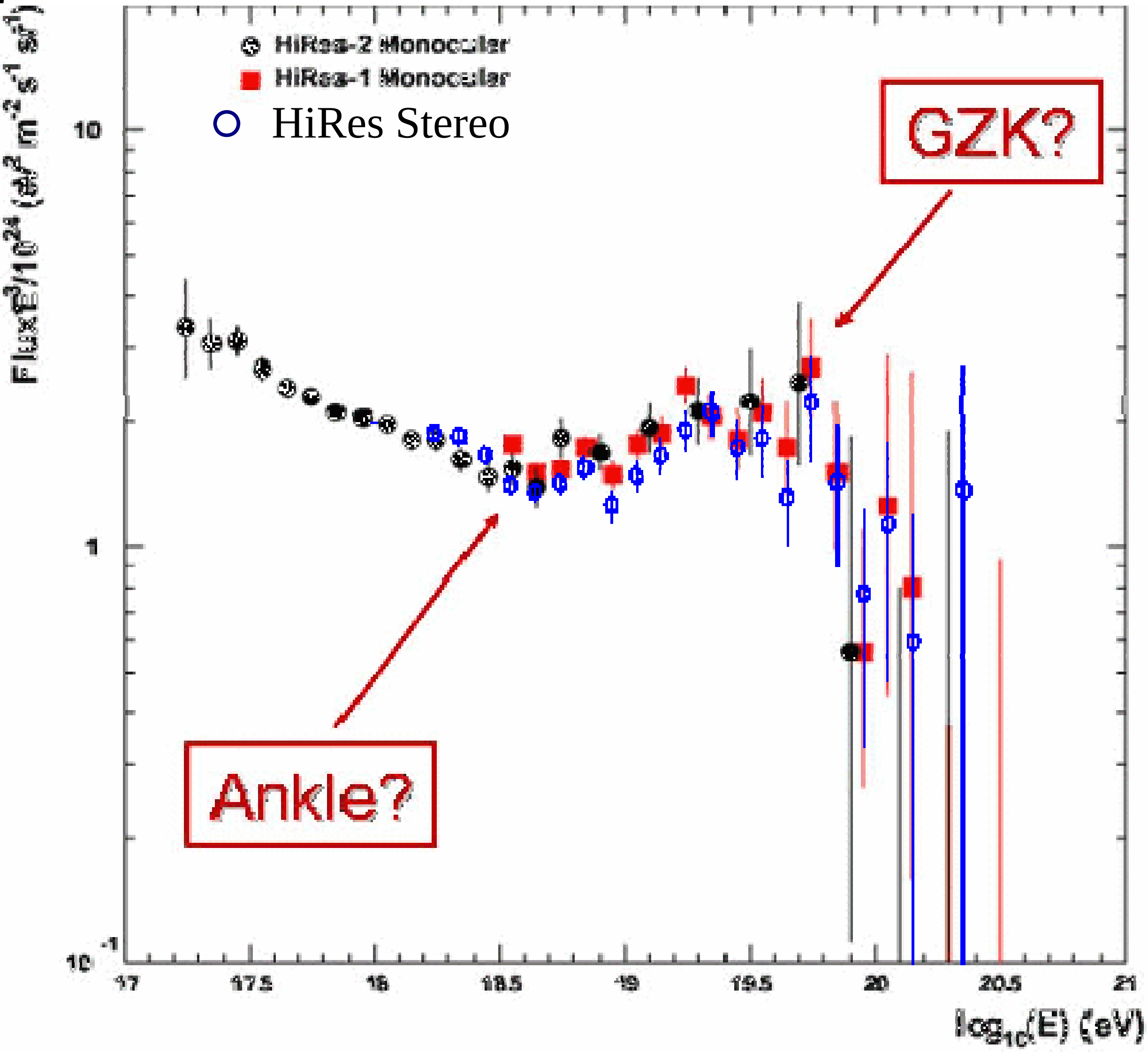
No TeV GRBs yet

AGILE NORMAL GRB SEARCH MODE



Comparing with monocular spectrum:

mono spectrum is confirmed



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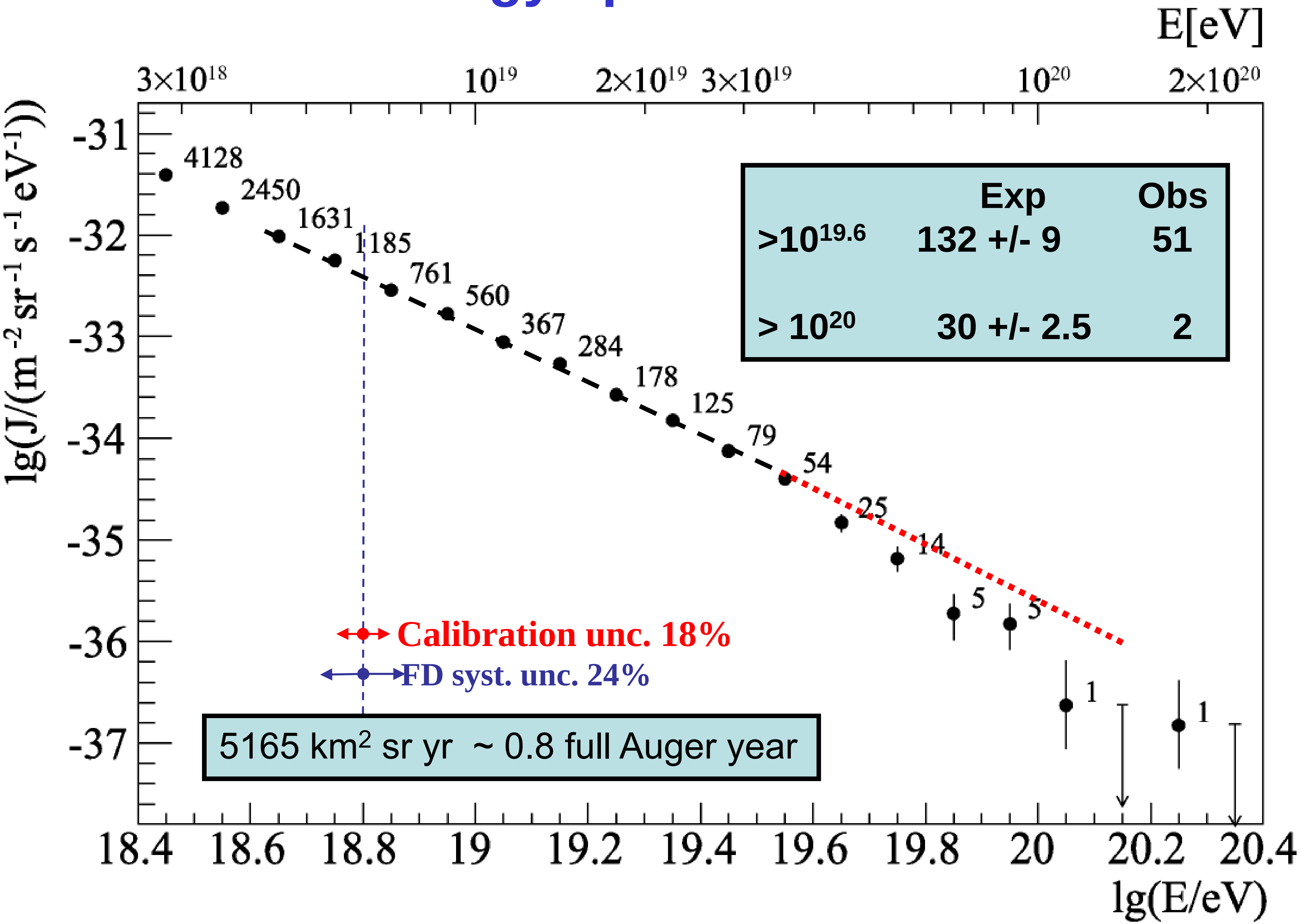
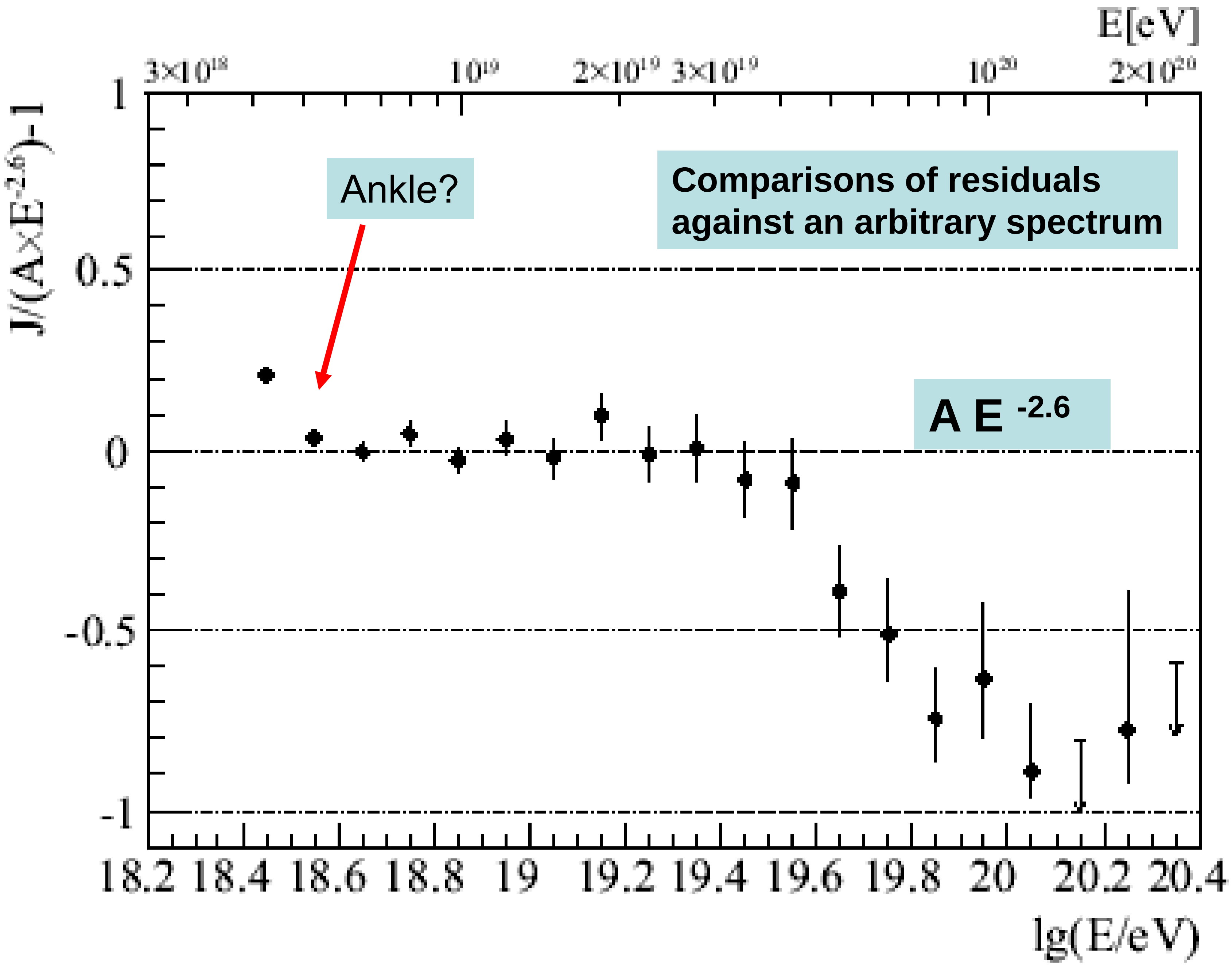
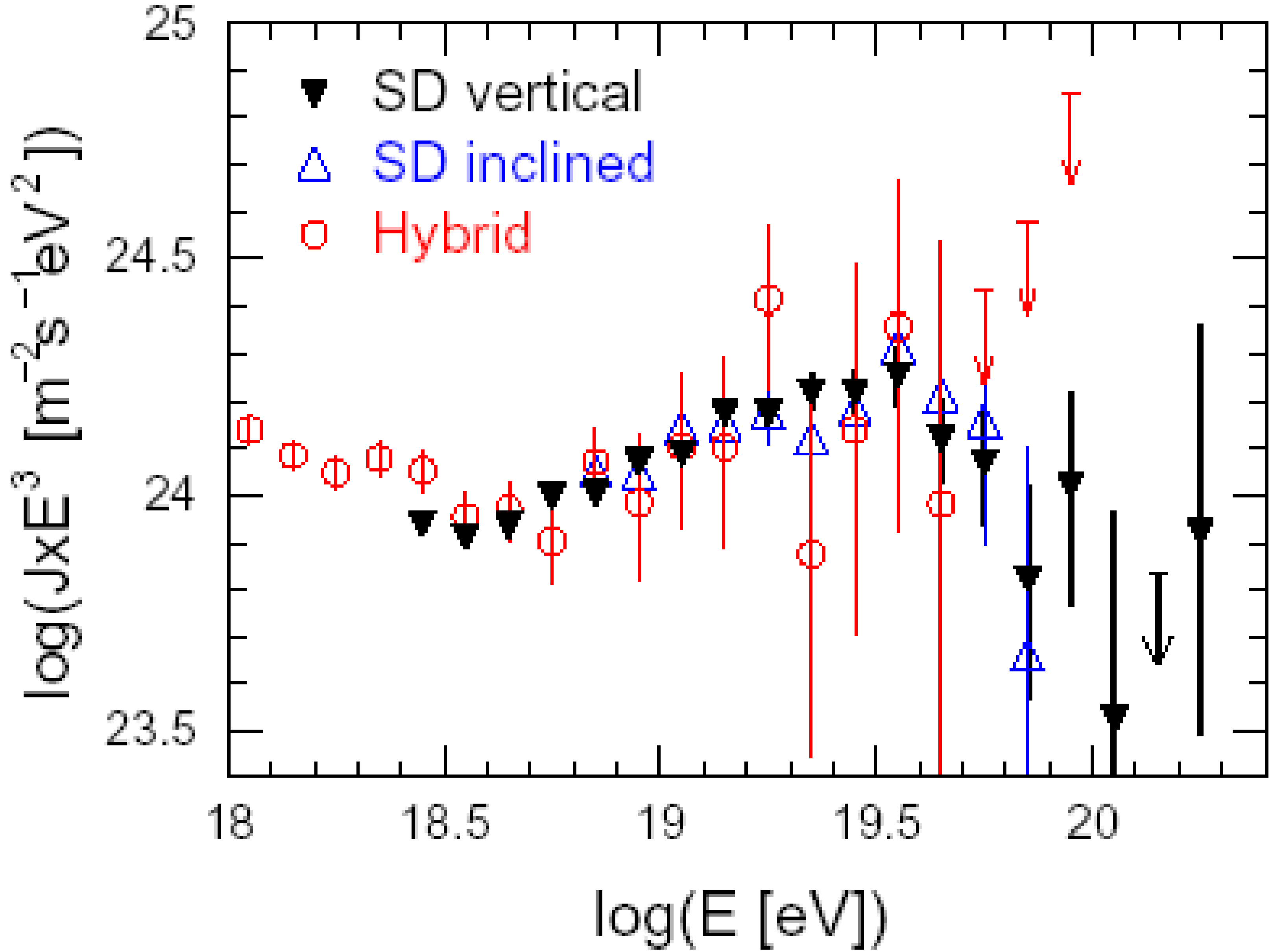
Roma, 22 June 2007

Energy spectrum from SD

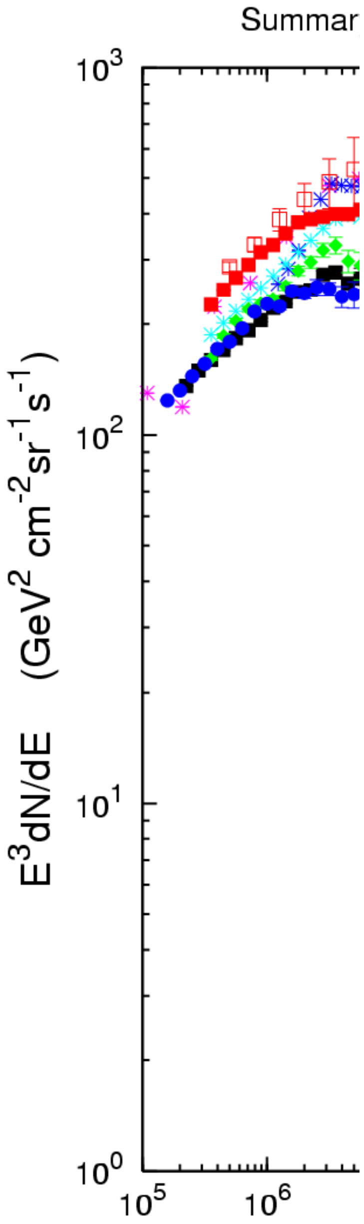


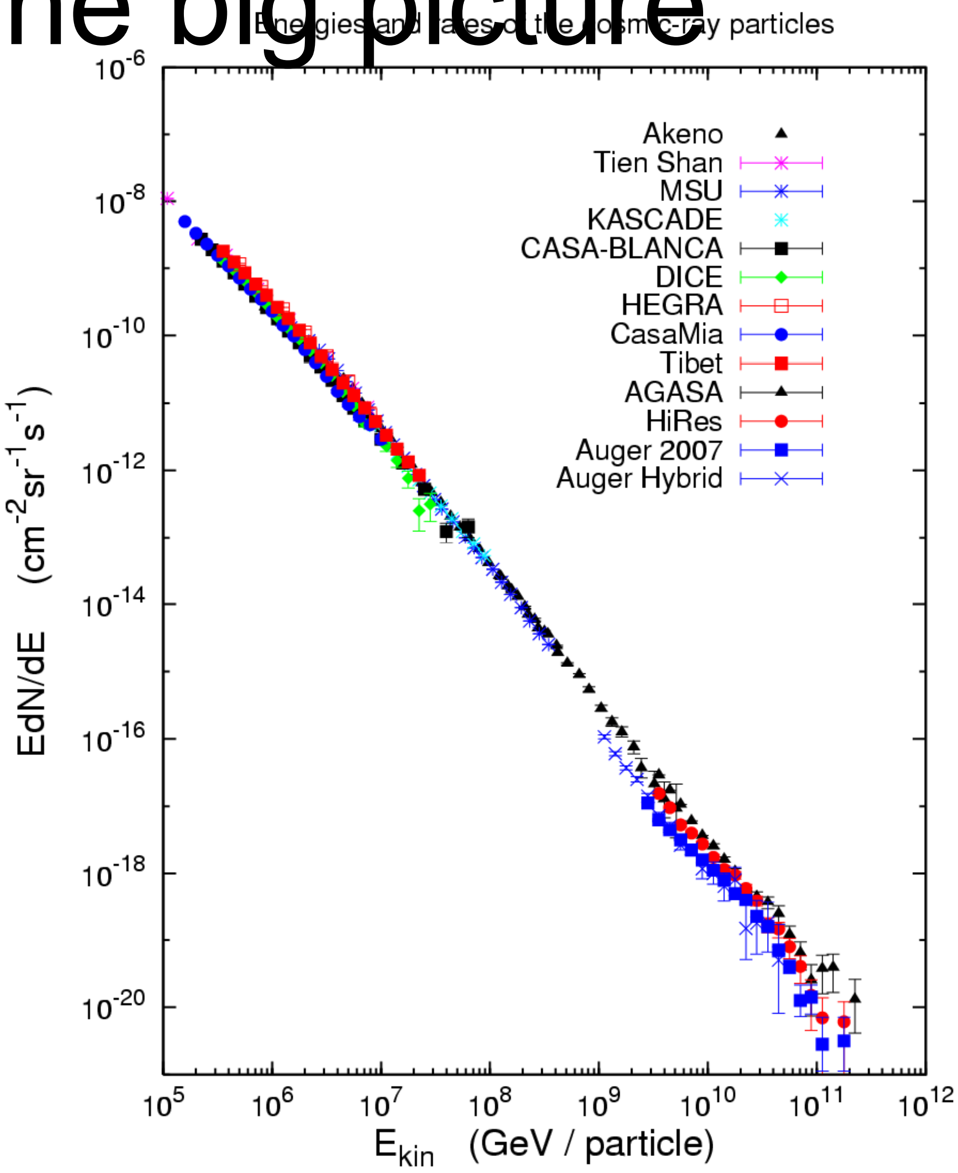


E[eV]
3×10^18
10^19
2×10^19
3×10^19
10^20
2×10^20
J/(A×E^-2.6)-1
1
0.5
0
-0.5
-1
Ankle?
Comparisons of residuals
against an arbitrary spectrum
A E -2.6
18.2
18.4
18.6
18.8
19
19.2
19.4
19.6
19.8
20
20.2
20.4
lg(E/eV)


SD vertical
SD inclined
Hybrid
25
24.5
24
23.5
18
18.5
19
19.5
20
log(JxE^3 [m^{-2}s^{-1}eV^2])
log(E [eV])

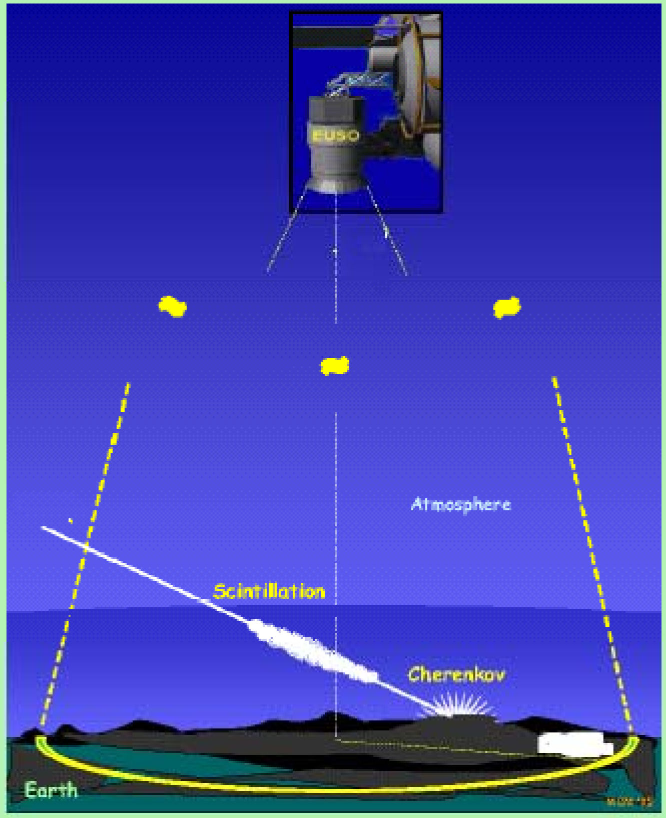
The big picture





~10^6 km^2 sr from space

The apparatus required for space-based UHECP observation

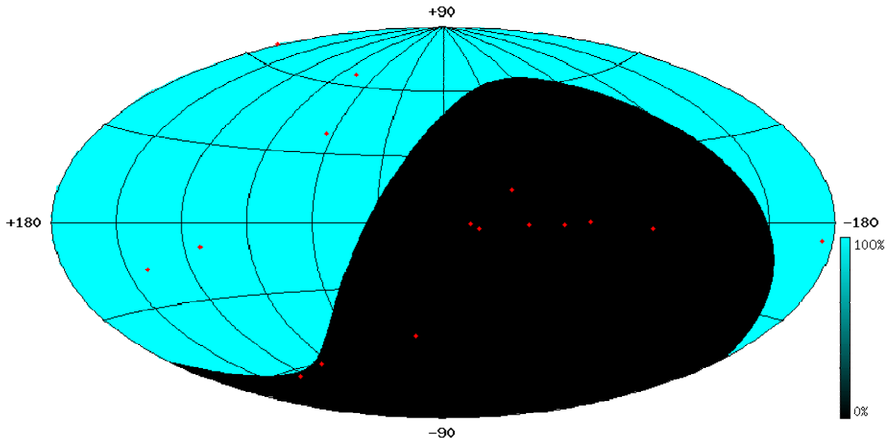


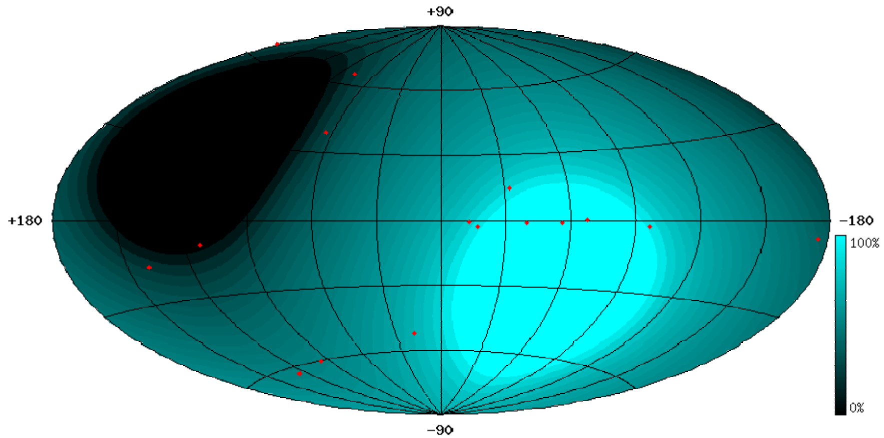
Region of sky observable by Neutrino Telescopes

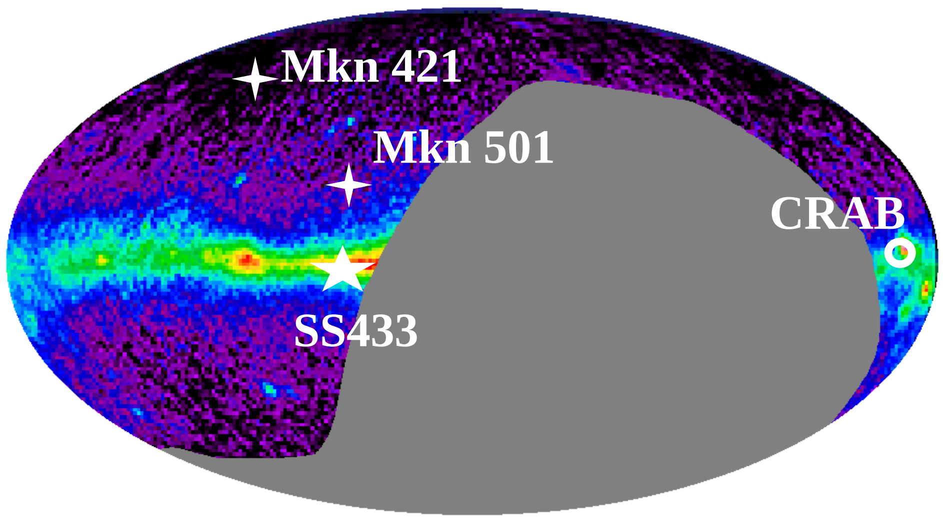
John Carr

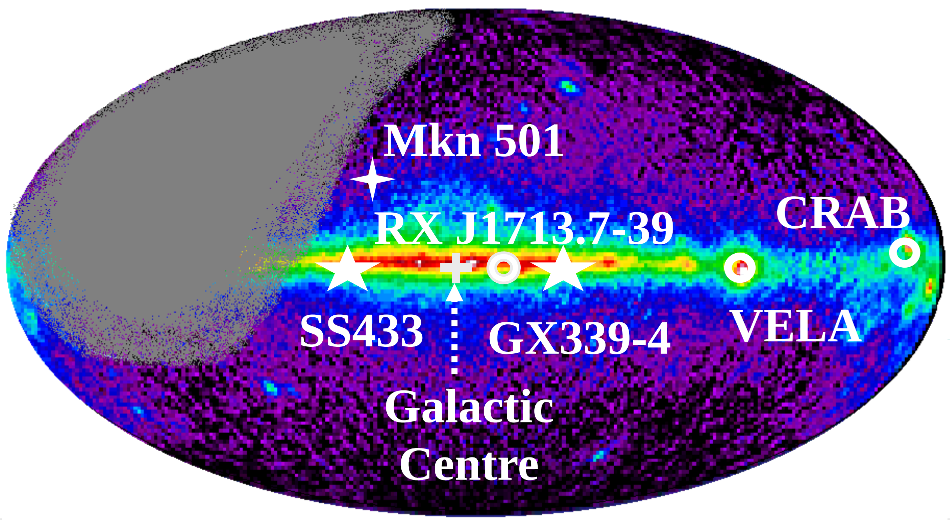
AMANDA (South Pole)

ANTARES (43° North)

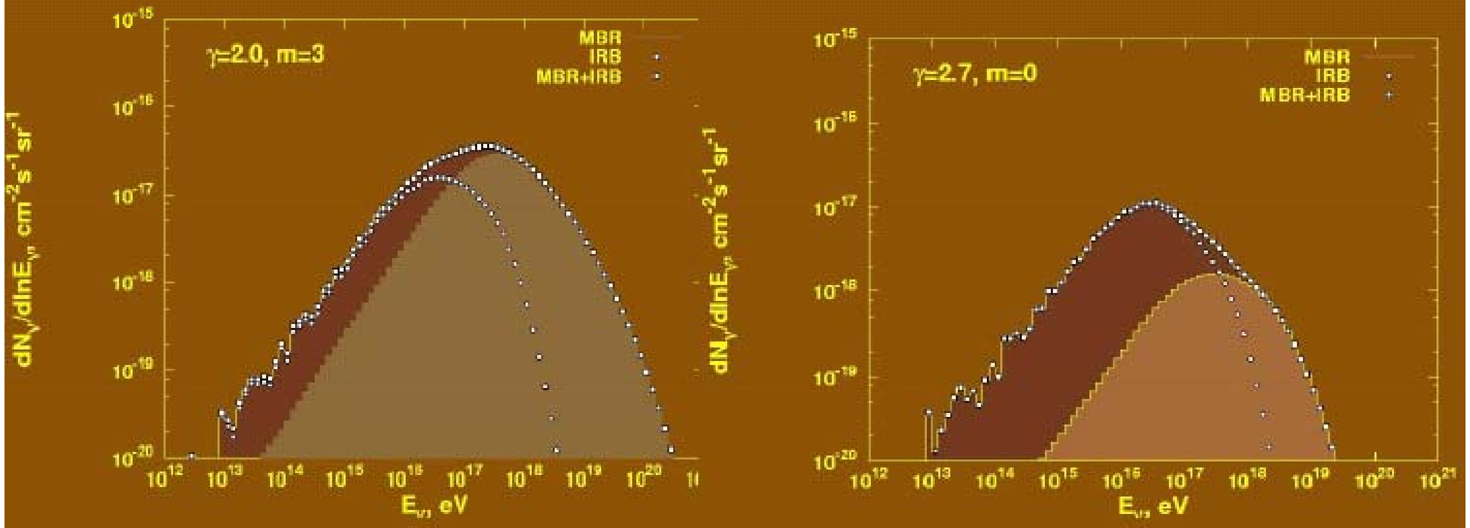








GZK neutrinos as probe of evolution of UHE sources



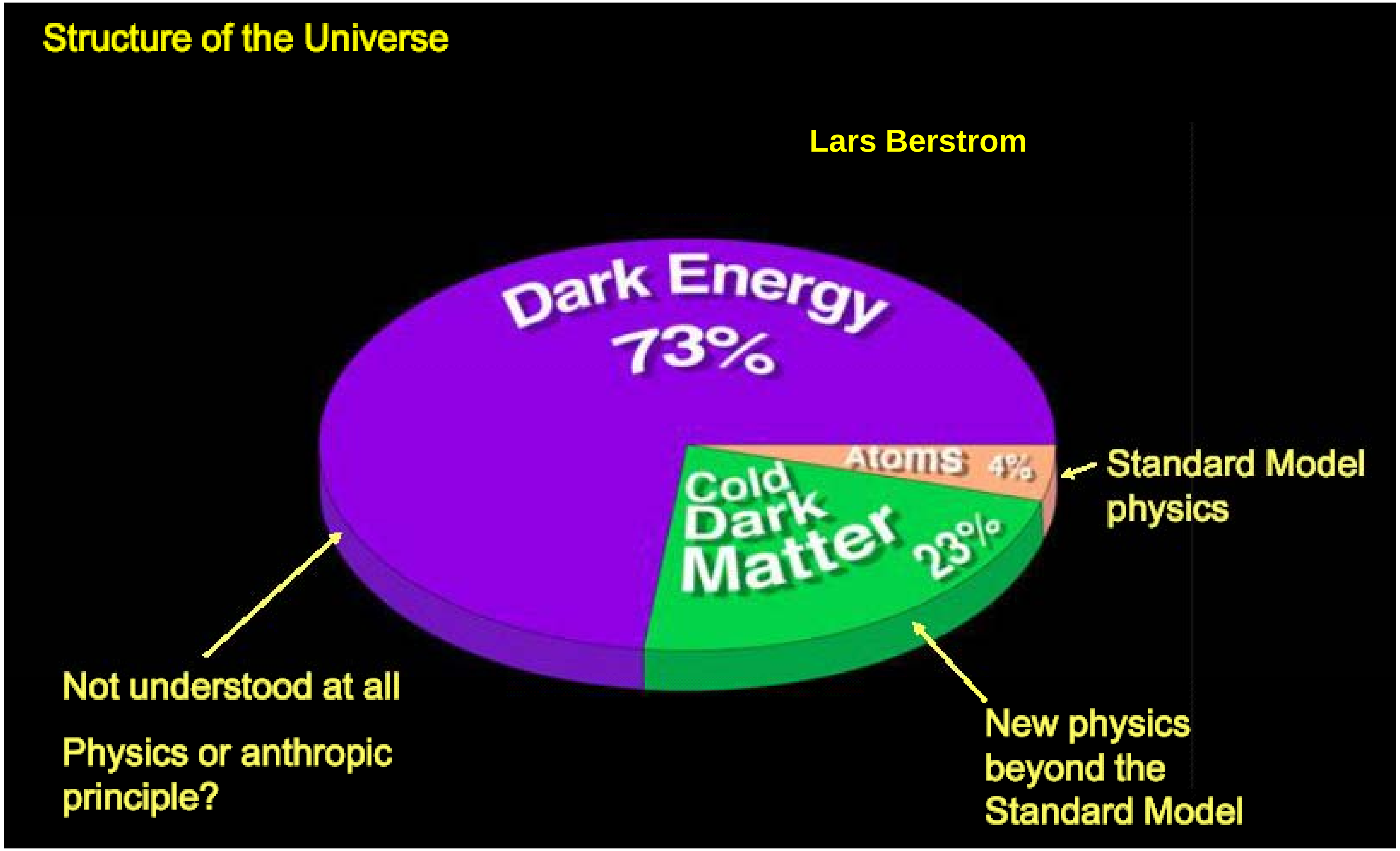
The cosmogenic neutrino spectra generated by the two extreme models of the injection spectra of UHECR protons in case of isotropic homogeneous distribution of the cosmic ray sources. The big difference in case of `MBR only' interactions is due to the flat injection spectrum and the cosmological evolution of the sources. The interaction rate is dominated by IRB generated neutrinos in the case of steep injection spectrum. MBR neutrinos dominate the high energy end, especially in the flat injection spectrum case.

T. Stanev

Radio: In-Progress Efforts (D. Besson)

Expt	Threshold	N(element)	Comment
RICE	100 PeV	20 (dipole)	1999-, small
ANITA	10^4 PeV	36 (dual-pol horn)	06-07 flite, systematix?
nuMoon, GLUE, FORTE, PRO	1000 PeV	1 BIG dish	Livetime?
AURA	100 PeV	2 cluster x 4/cluster	Initial data-analysis
SALSA	100 PeV	14000	Salt props?
ARIANNA (Ross Ice Shelf)	10 PeV	10000 horn	Start-up $ - 12/06 msrmnt
LOPES/LOFAR/ CODALEMA	100 PeV	~10-20	Large RFI backgrounds

Cosmology


Structure of the Universe
Lars Berstrom
Dark Energy
73%
Atoms 4%
Cold Dark Matter 23%
Standard Model physics
Not understood at all
Physics or anthropic principle?
New physics beyond the Standard Model

Lars Bergstrom

Example of more "conventional" dark matter model

Spin-0 Dark Matter Candidate: Inert Higgs Doublet Model

Introduce extra Higgs doublet H_2, impose discrete symmetry $H_2 \to -H_2$ similar to R-parity in SUSY (Deshpande and Ma, 1978; Barbieri, Hall, Rychkov 2006)

$$V = \mu_1^2|H_1|^2 + \mu_2^2|H_2|^2 + \lambda_1|H_1|^4 + \lambda_2|H_2|^4 + \lambda_3|H_1|^2|H_2|^2 + \lambda_4|H_1^\dagger H_2|^2 + \lambda_5 Re\left[(H_1^\dagger H_2)^2\right]$$

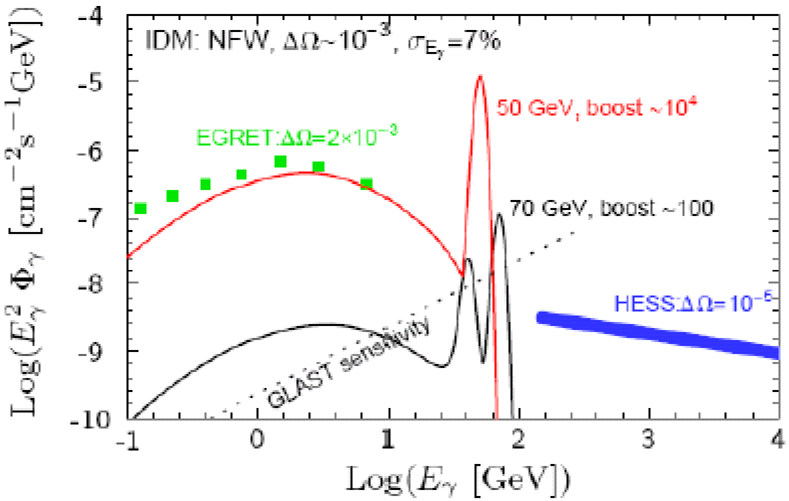
$\Rightarrow$ Ordinary Higgs can be as heavy as 500 GeV without violation of electroweak precision tests

$\Rightarrow$ 40 – 70 GeV inert Higgs gives correct dark matter density

$\Rightarrow$ Coannihilations with pseudoscalar A are important

$\Rightarrow$ Interesting phenomenology: Tree-level annihilations are very weak in the halo; loop-induced $\gamma\gamma$ and $Z\gamma$ processes dominate!

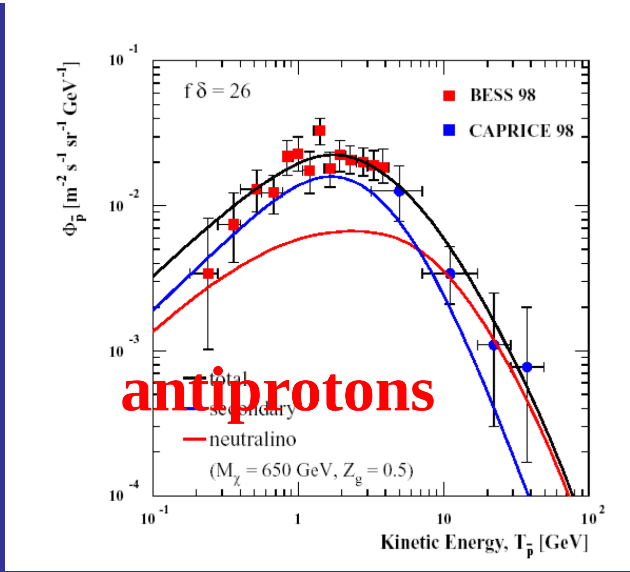
$\Rightarrow$ The perfect candidate for detection in GLAST!



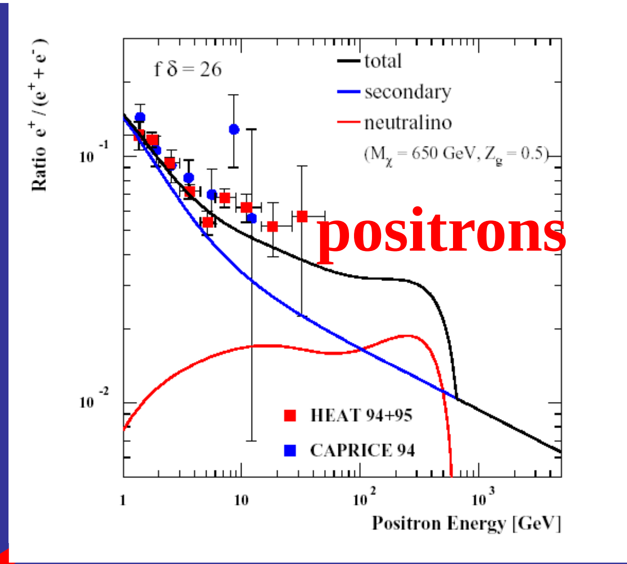
M. Gustafsson , L.B., J. Edsjö, E. Lundström, PRL to appear, 2007

Can be searched for at LHC through

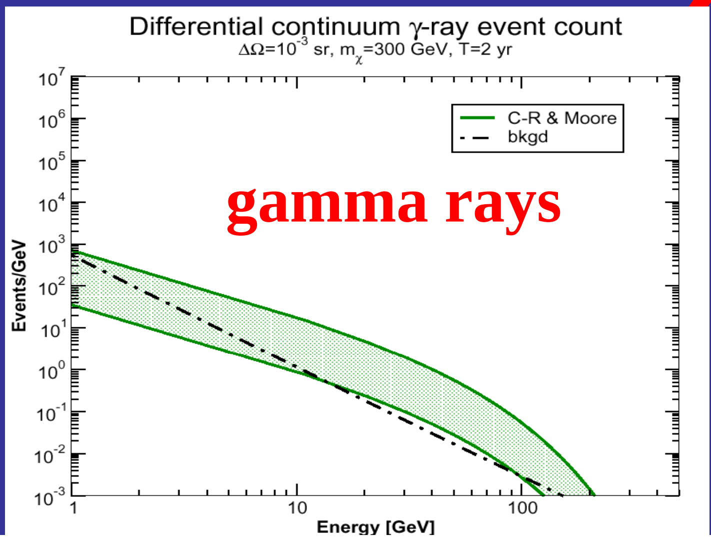
$$pp \to W^* \to HA \text{ or } HS$$
$$pp \to Z^*(\gamma^*) \to SA \text{ or } H^+H^-$$

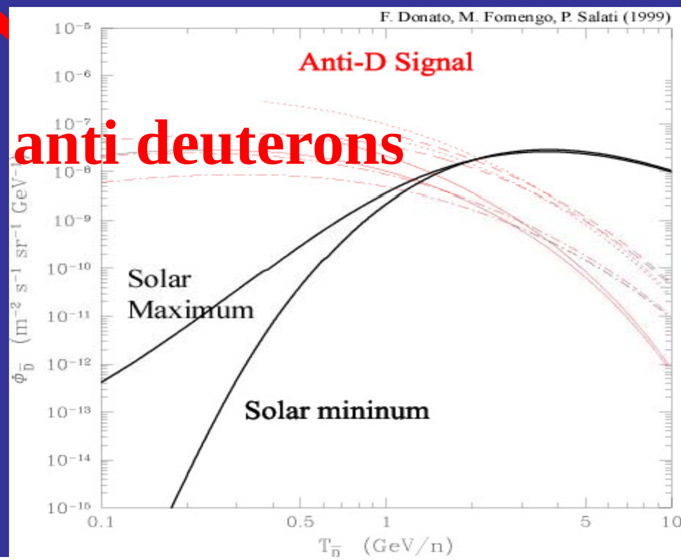


Unique Feature Of AMS



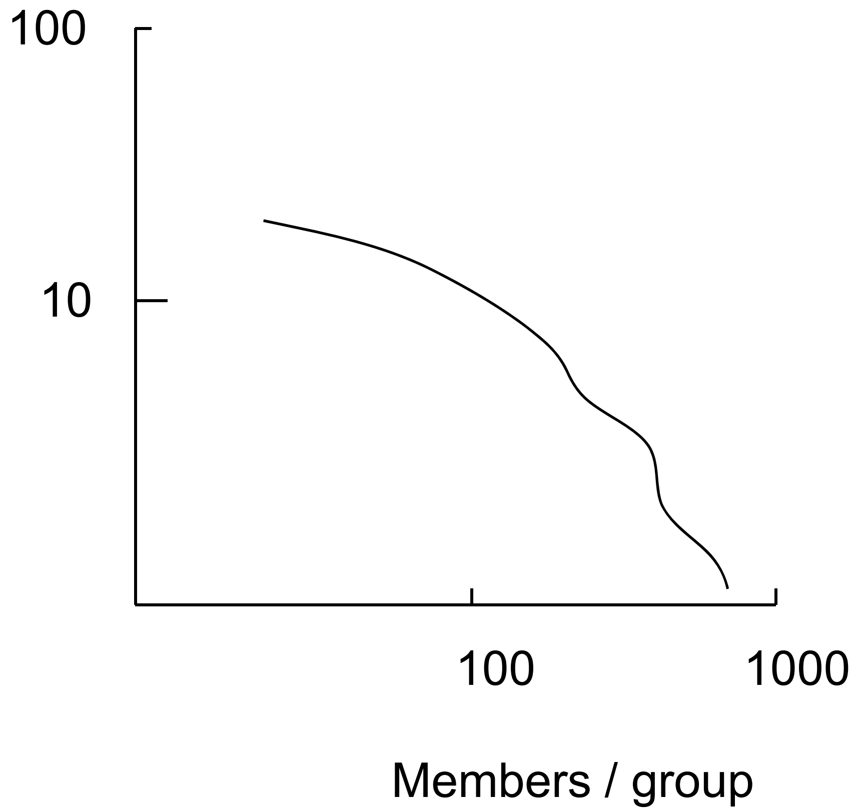
Combining searches in different channels could give (much) higher sensitiviy to SUSY DM signals





Sociology

Number of experimental groups at RICAP07 with > N members

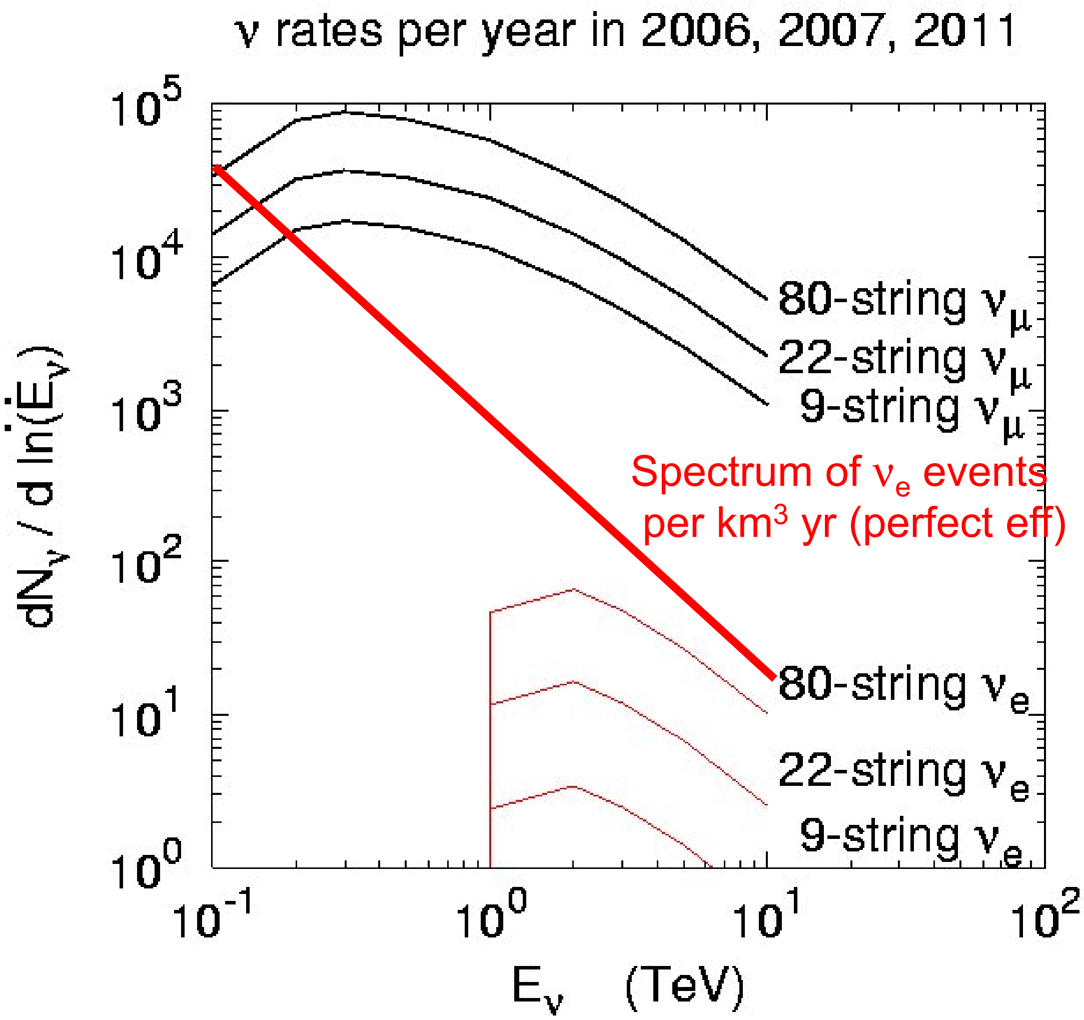


Conclusion

Thanks to Tonino Capone and his colleagues

Expectations for rates of atmospheric ν

- Assumptions:
  - Muon neutrinos: full efficiency for μ range > 0.5 km (E_ν > 150 GeV)
  - Electron neutrinos: Efficiency for ν_e from PDD is 0 for E_ν < TeV
- Note advantage of lowering E_{th} for ν_e
  - ~800 ν_e interactions per km^3 yr



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Roma, 22 June 2007