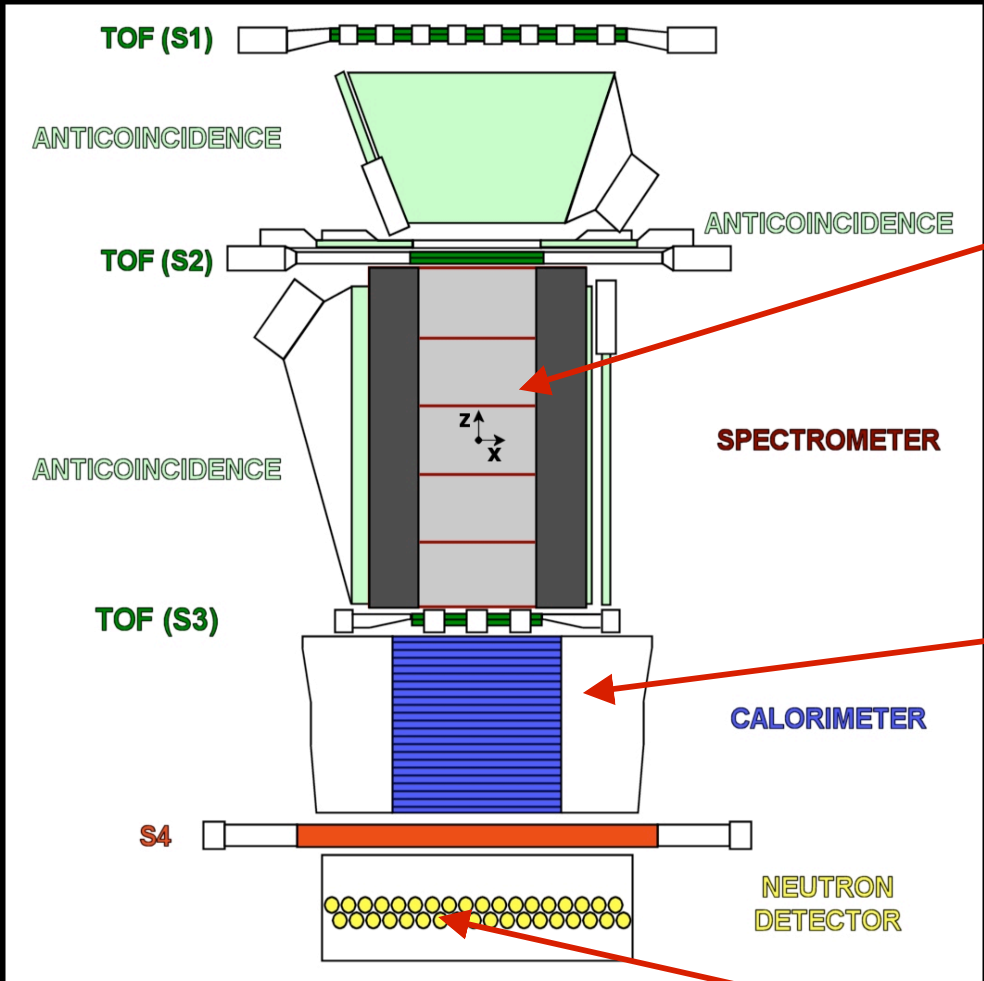
22nd European Cosmic Ray Symposium
3 - 6 August 2010

Pamela observations at minimum of cycle 23 and potential for cycle 24

M. Casolino,
INFN & University of Roma Tor Vergata

on behalf of the PAMELA collaboration



Spatial Resolution

- ≅ 2.8 μm bending view
- ≅ 13.1 μm non-bending view

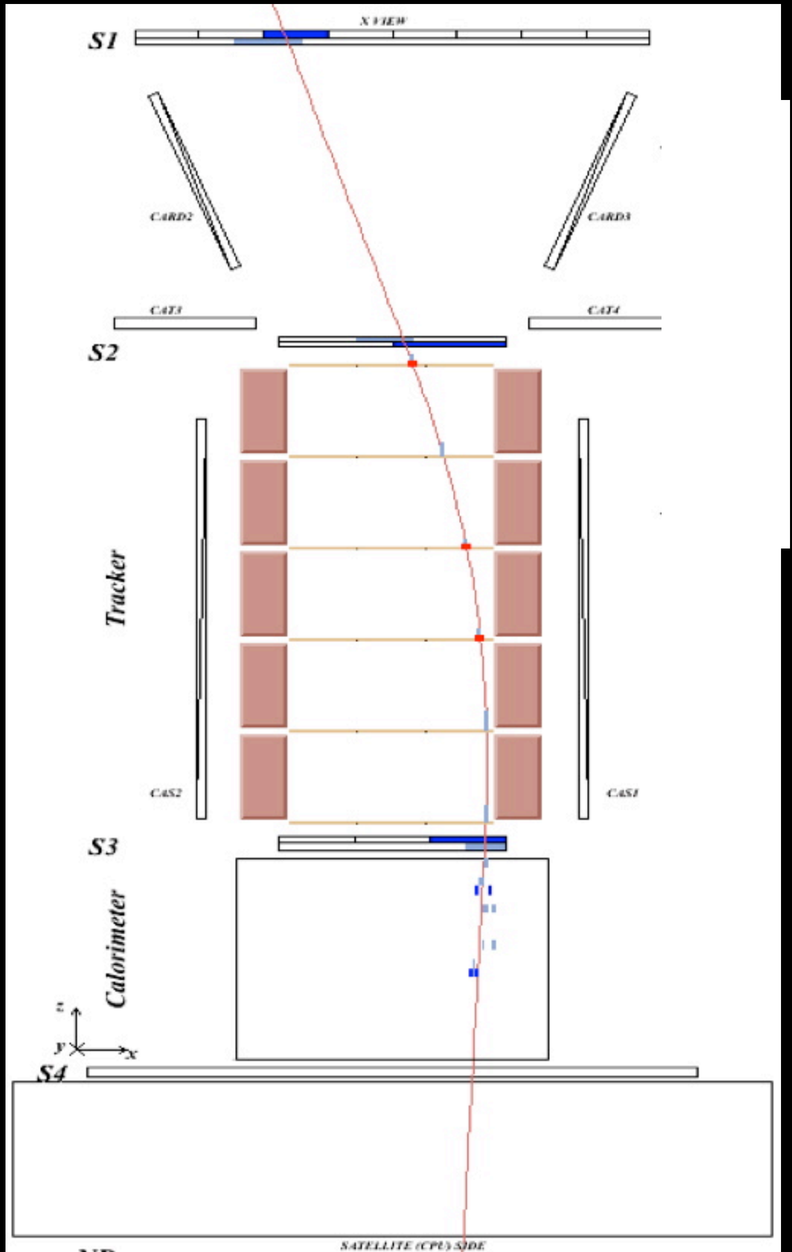
MDR from test beam data ≅ 1 TV

Calorimeter Performances:

- $\bar{p}/e^+$ selection eff. ~ 90%
- p rejection factor ~ 10^5
- e^- rejection factor > 10^4

ND p/e separation capabilities >10 above 10 GeV/c, increasing with energy

GF ~20.5 $cm^2 sr$
Mass: 470 kg
Size: 120x40x45 cm^3
Power Budget: 360 W

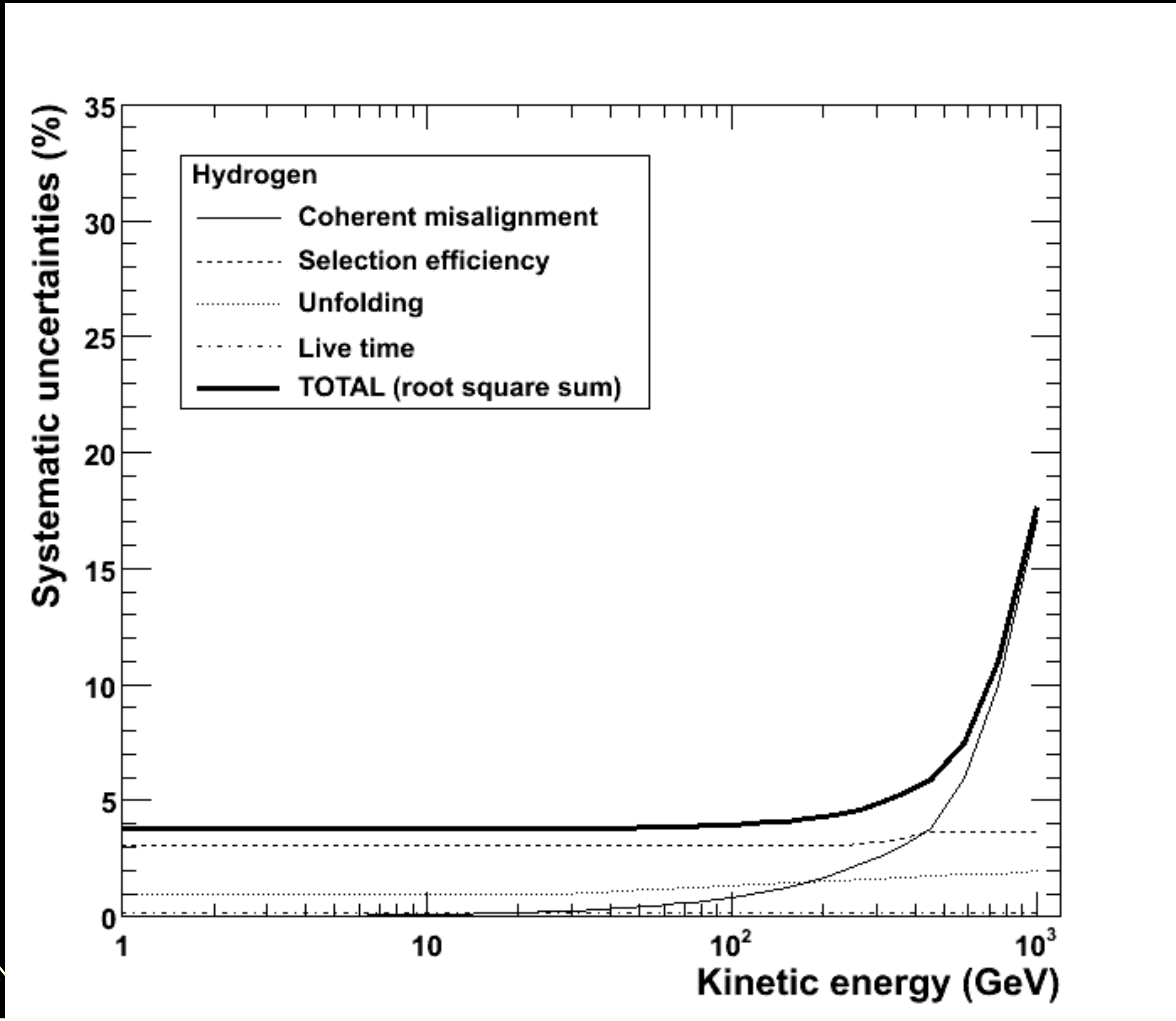


PHYSICAL QUANTITIES MEASURED BY PAMELA

1. DEDX
(scintillators, tracker, calo)
→ Z of the particle
2. DEFLECTION = 1/Rigidity
→ Impulse (4-6 planes)
3. Time of flight = 1/Beta
(12 betas)
4. Shower (No, Hadronic, Electromagnetic)
→ lepton/hadron
5. Number of neutrons
→ lepton/hadron

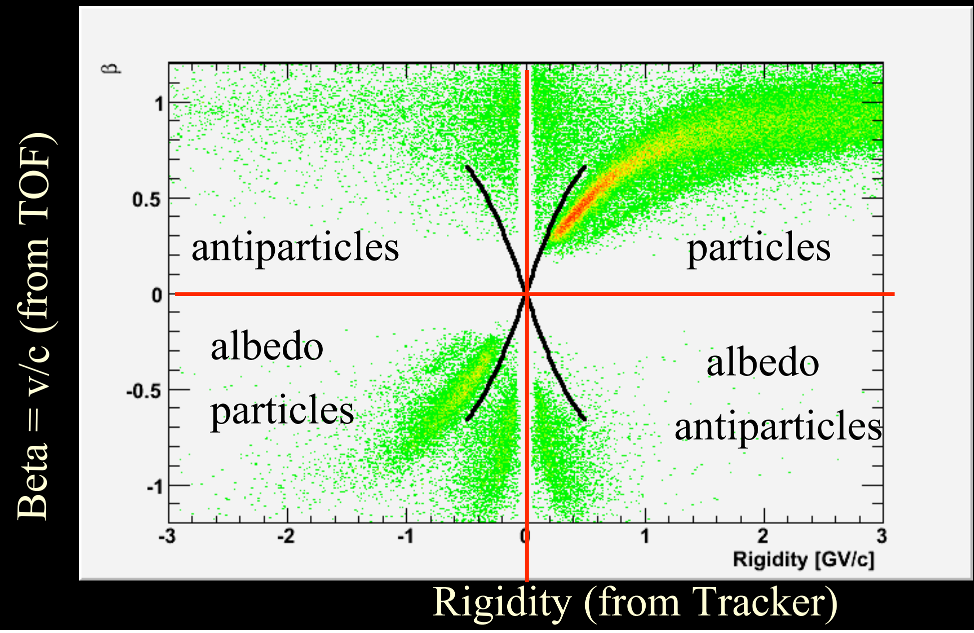
5% to 10% precision

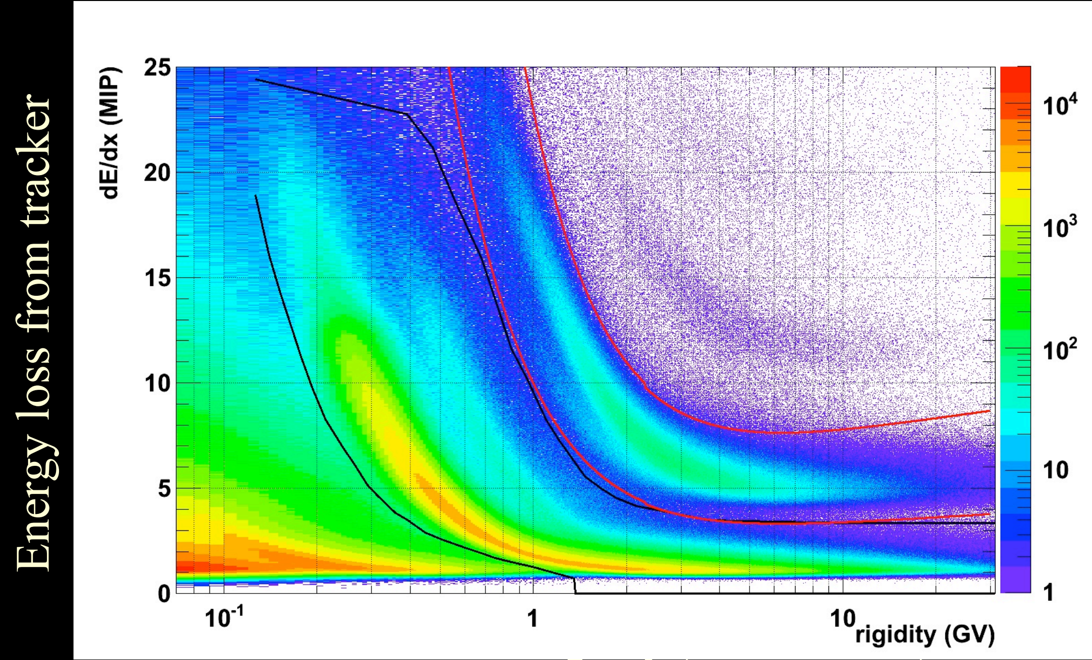
Systematic errors



Proton and Helium Absolute flux

- Montecarlo efficency for cuts
- Trigger efficiency
- Tracking efficiency
- Multiple Scattering
- Correction for energy loss in det
- Back scattering…
- Systematics under close investigation, currently about 1-2% uncertainty on abs flux.





Selection criteria

Fitted, single track

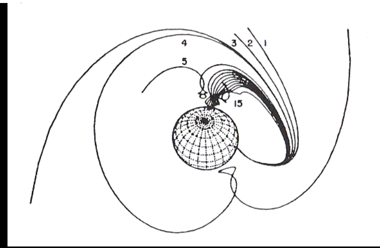
High lever arm, Nx

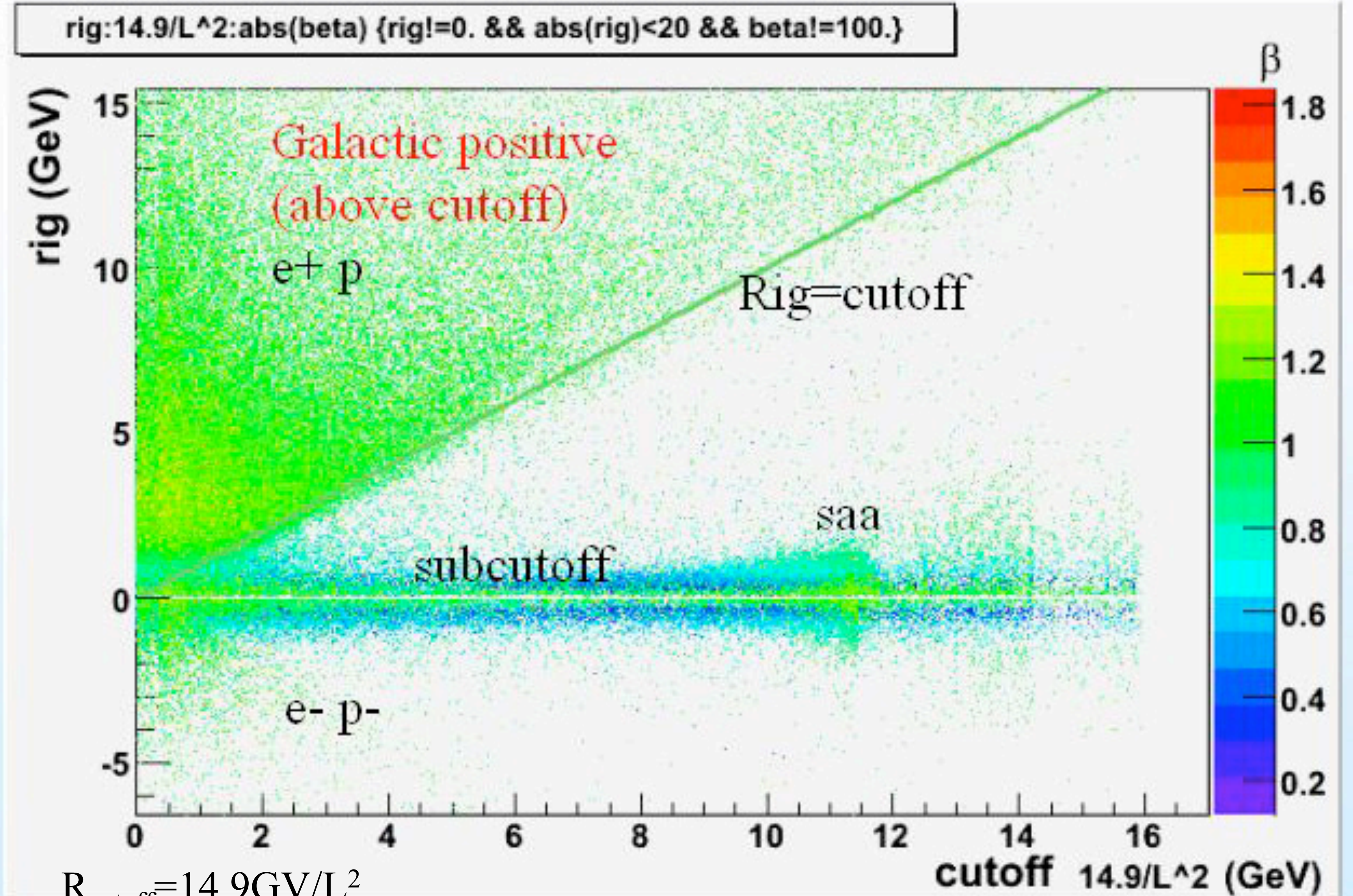
Rigidity R>0

Beta>.2

No anti

Selection of galactic component according to geomagnetic cutoff

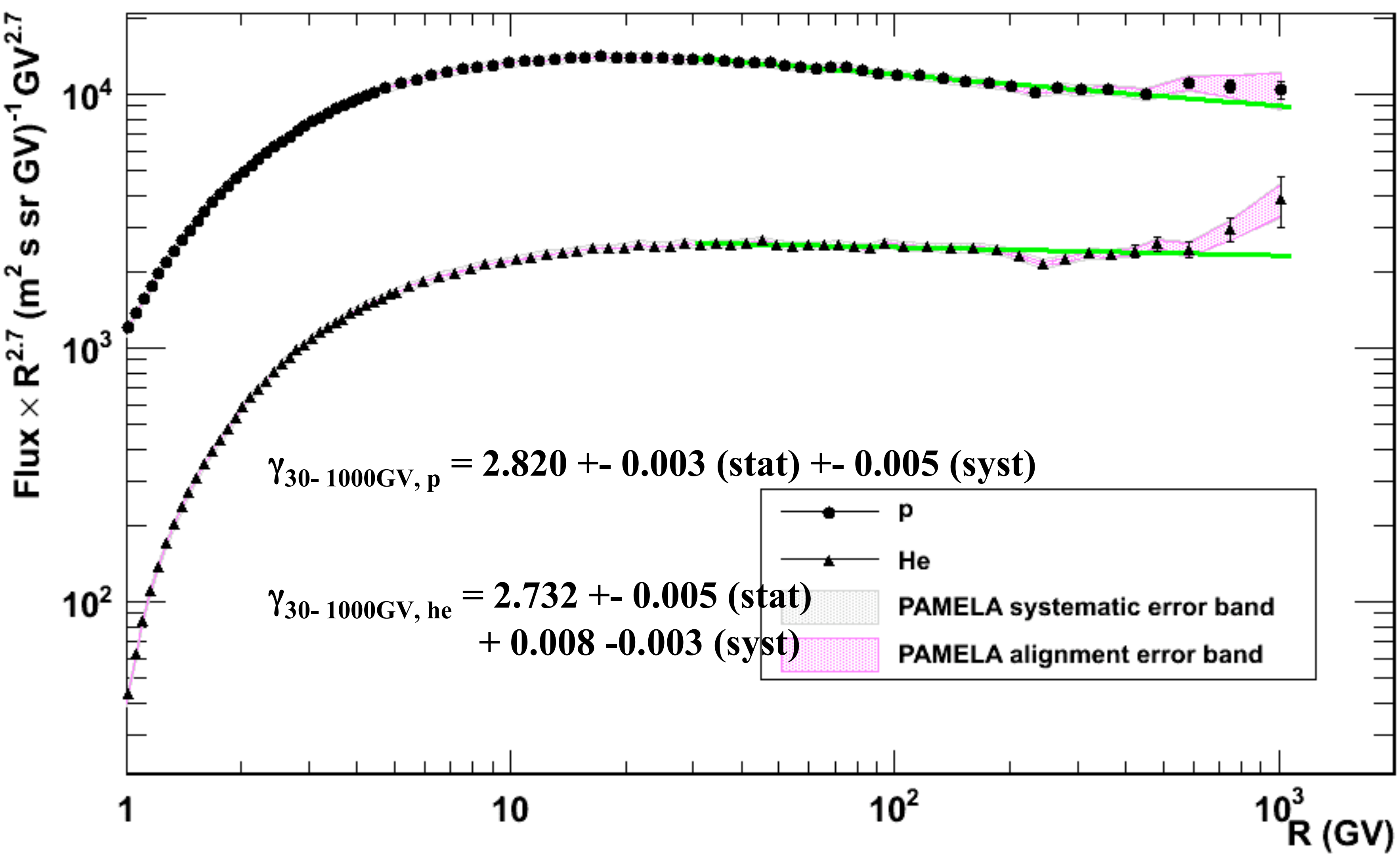




$R_{cutoff}=14.9GV/L^2$

Galactic p and he

2006-2008

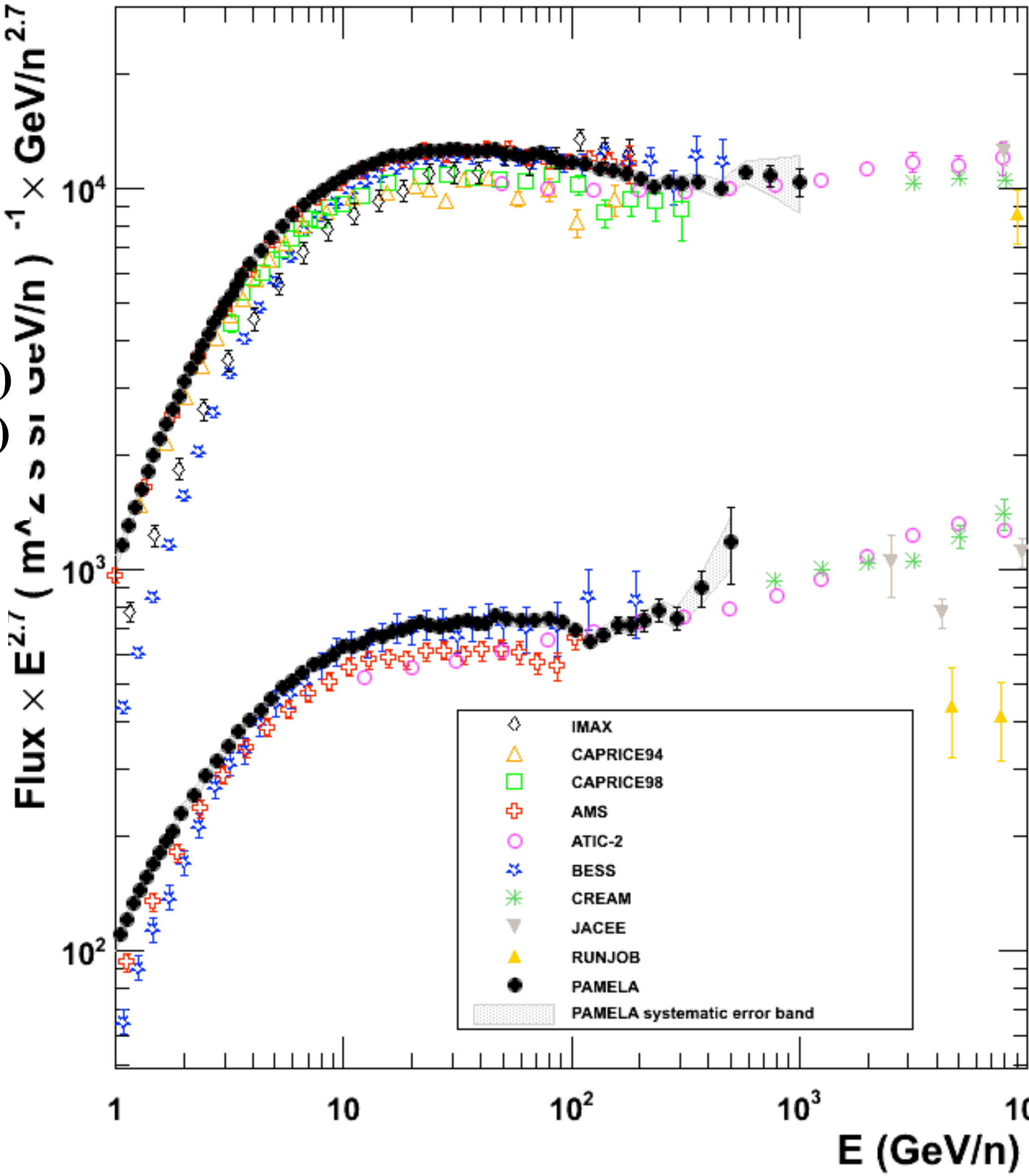


Comparison with previous experiments

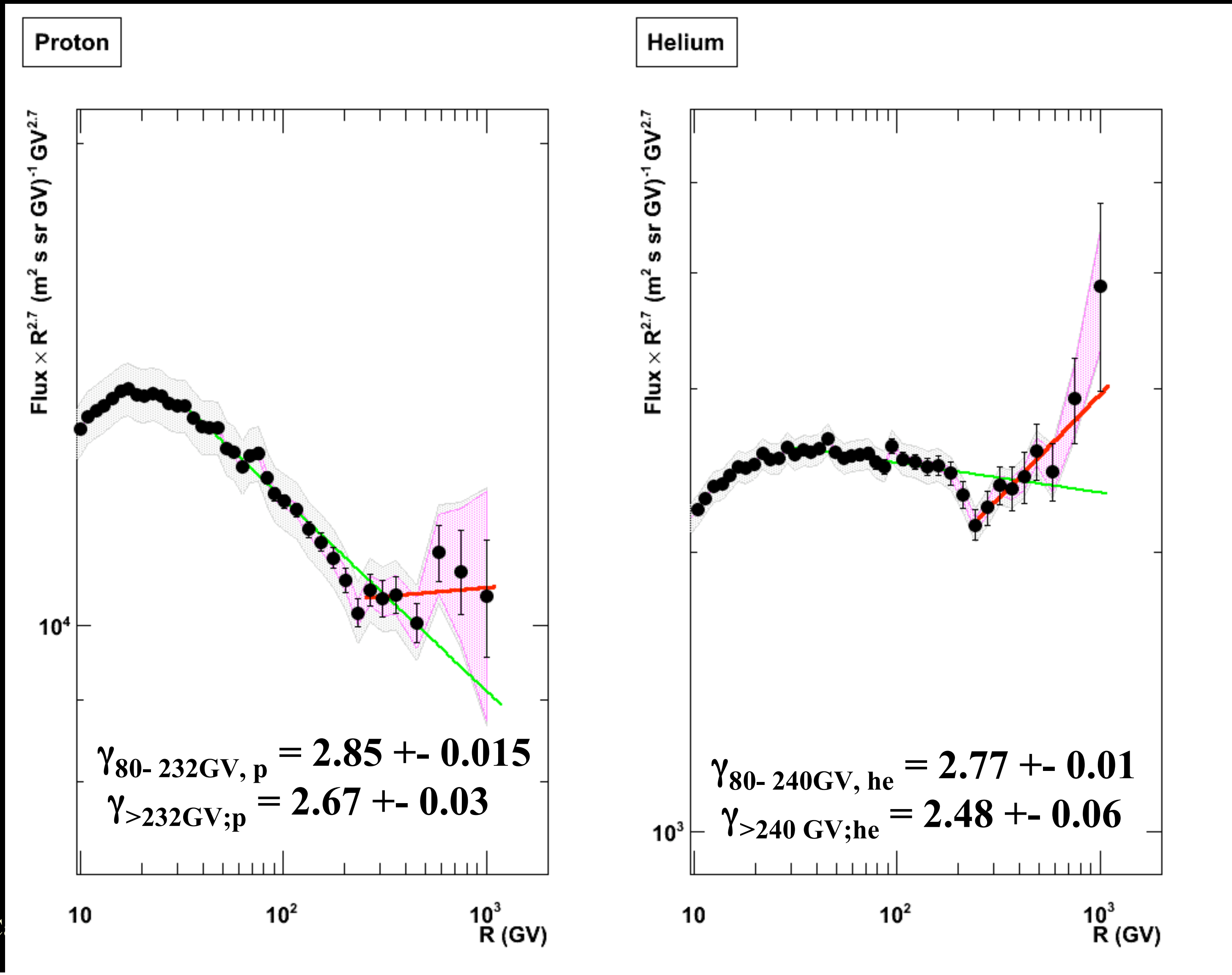
$\gamma_{30\text{-}1000\text{GeV, p}} = 2.782$ +- 0.003 (stat) +- 0.004 (syst)

$\gamma_{15\text{-}600\text{GeV/n, he}} = 2.71$ +- 0.01 (stat) +- 0.007 (syst)

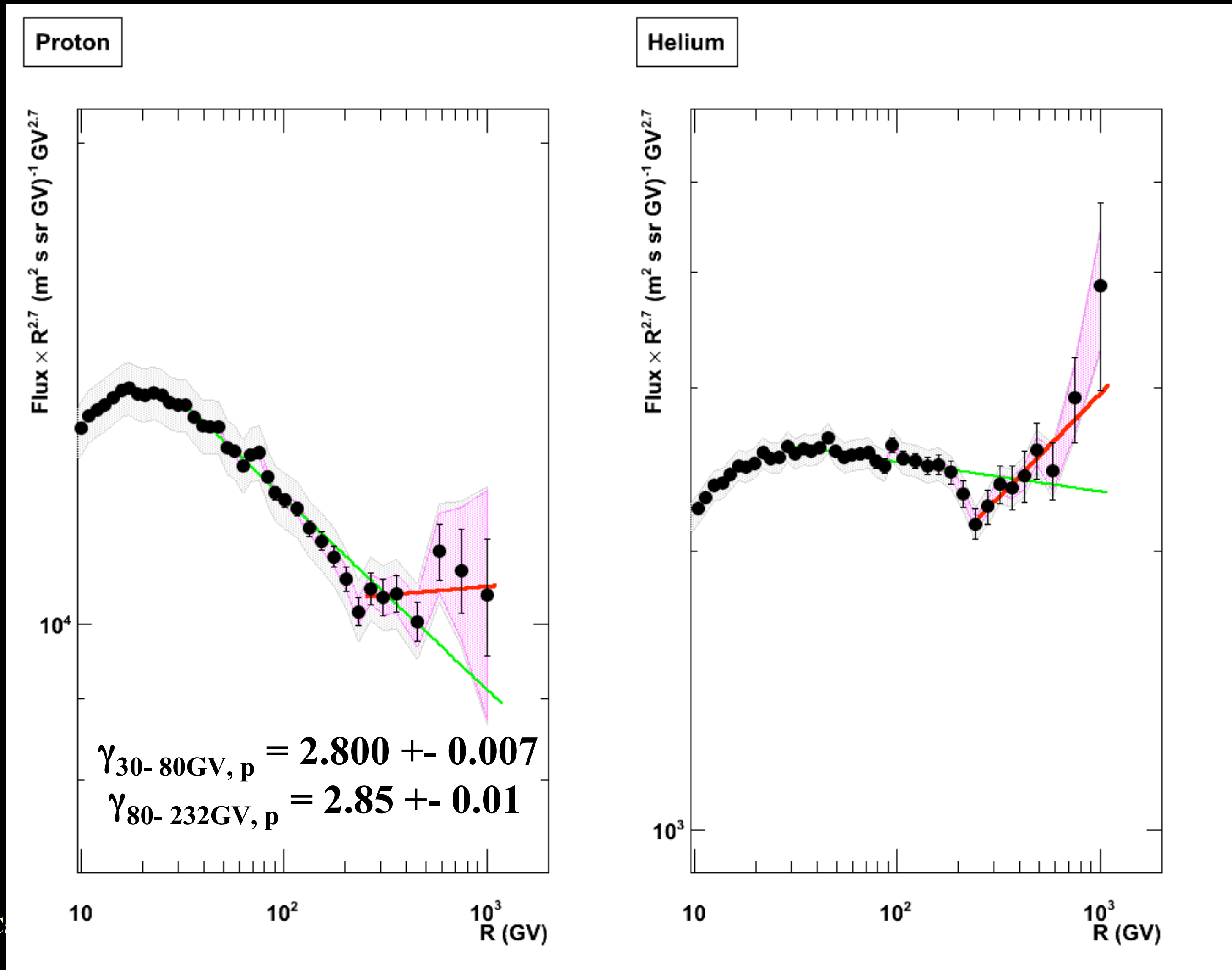
$$\gamma_T = \frac{dlog(\phi_T)}{logT} = (\gamma_R - 1)\frac{T^2 + Tmc^2}{T^2 + 2Tmc^2} + \frac{T}{T + mc^2}$$



Deviations from the power law: >230-240 GV



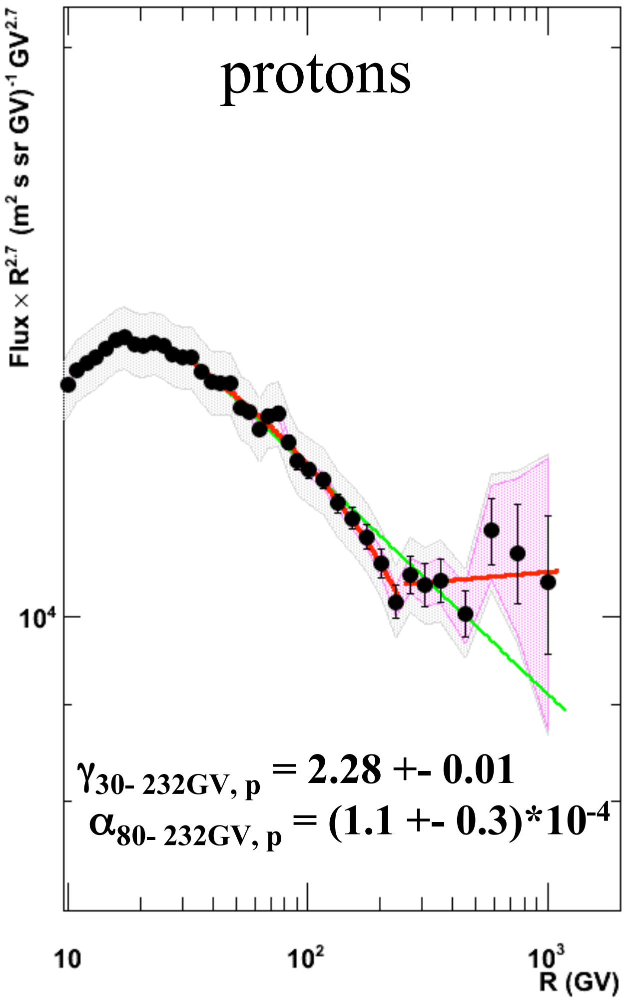
Deviations from the power law: 30-240 GV

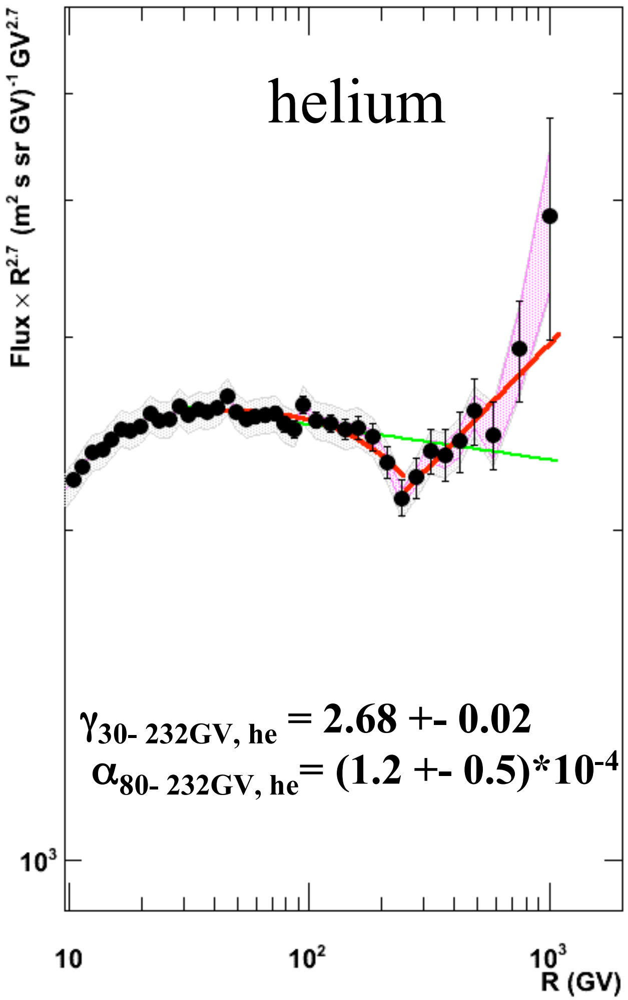


Deviations from the power law 30-240 GV

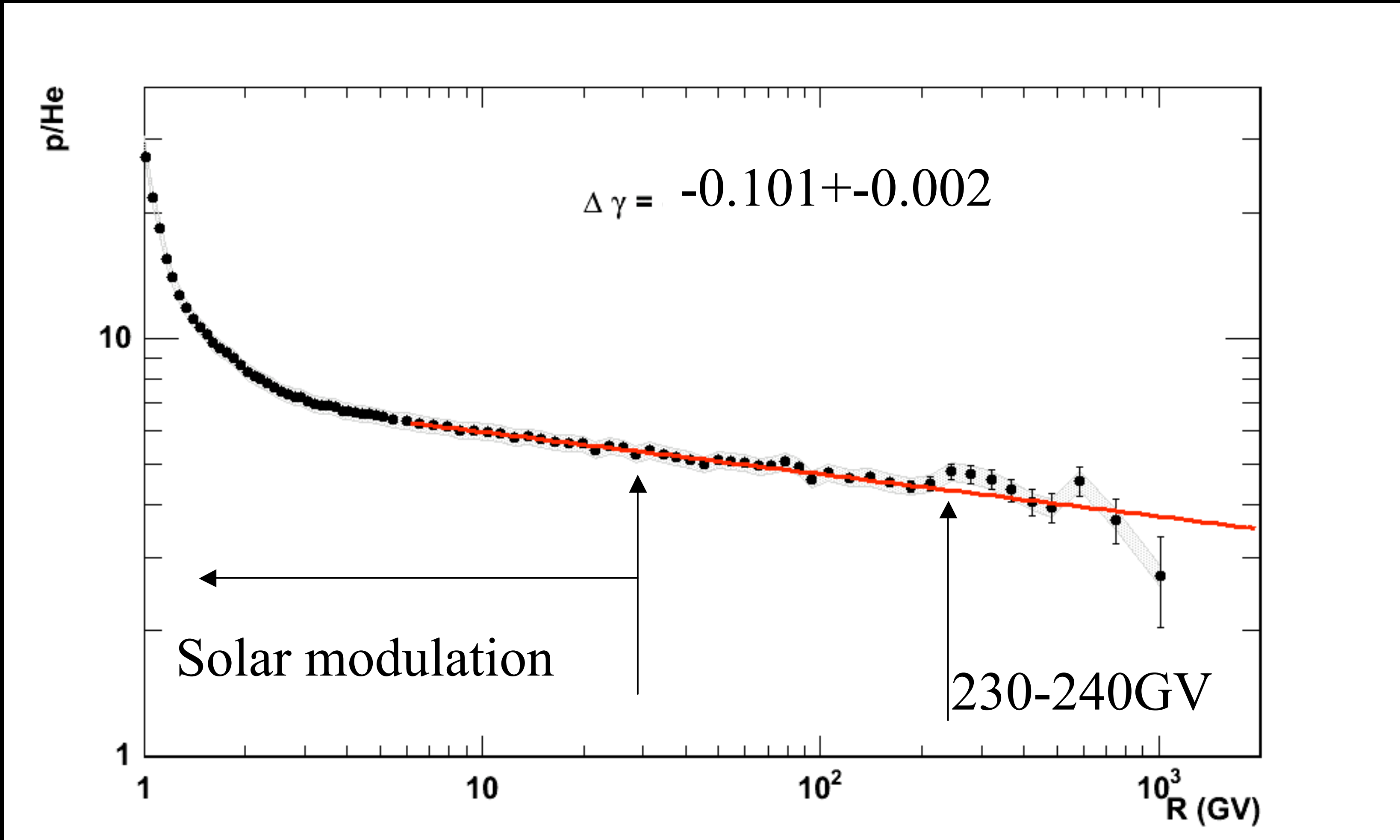
$$\Phi = A * R^{-\Gamma} = A * R^{-\gamma-\alpha\frac{R-R_0}{R_0}}$$

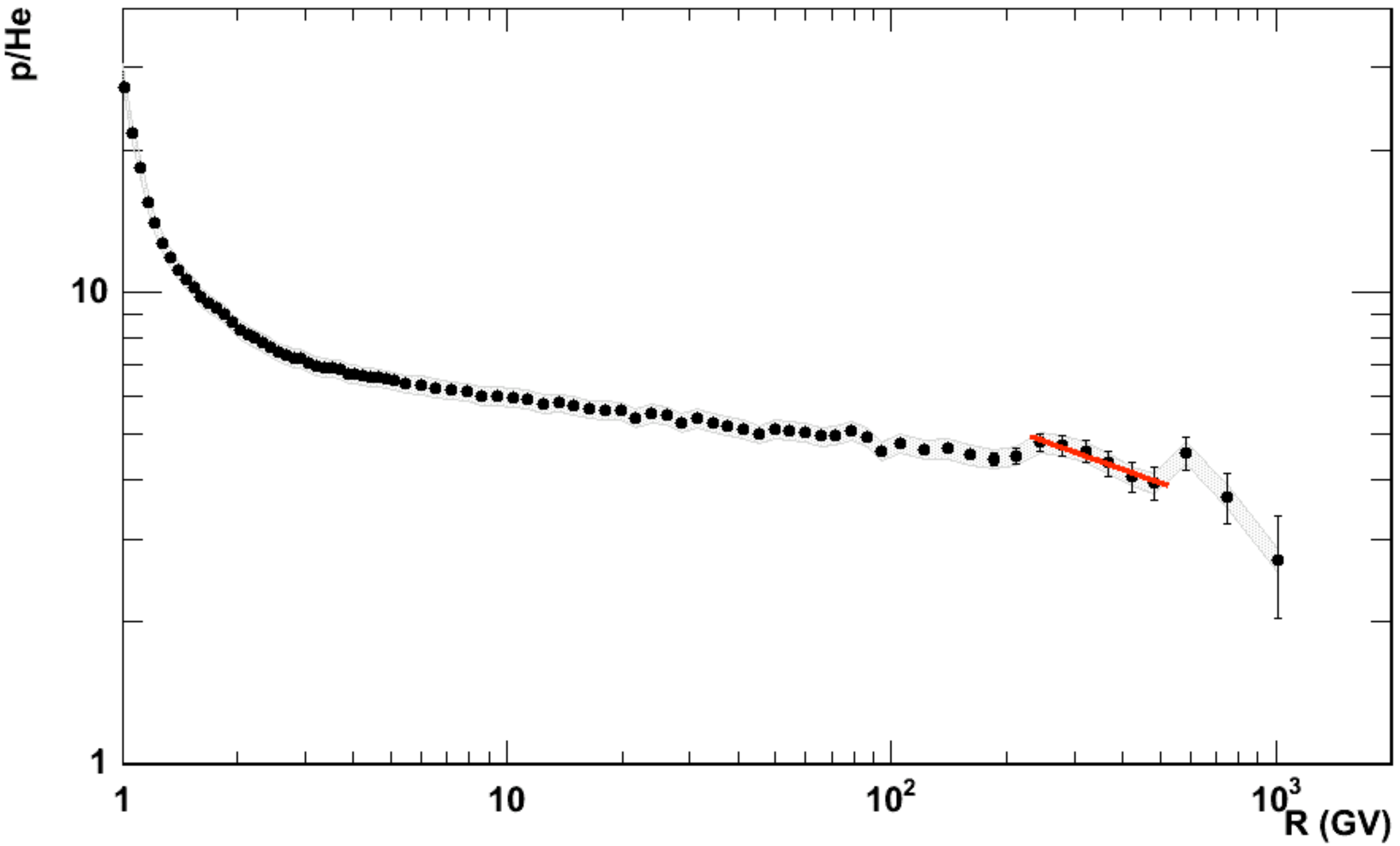
$$\gamma_R(R) = \frac{dlog(\Phi_R)}{dlog(R)} = -\gamma_0 + \alpha(1 - \frac{R}{R_0}(logR + 1))$$



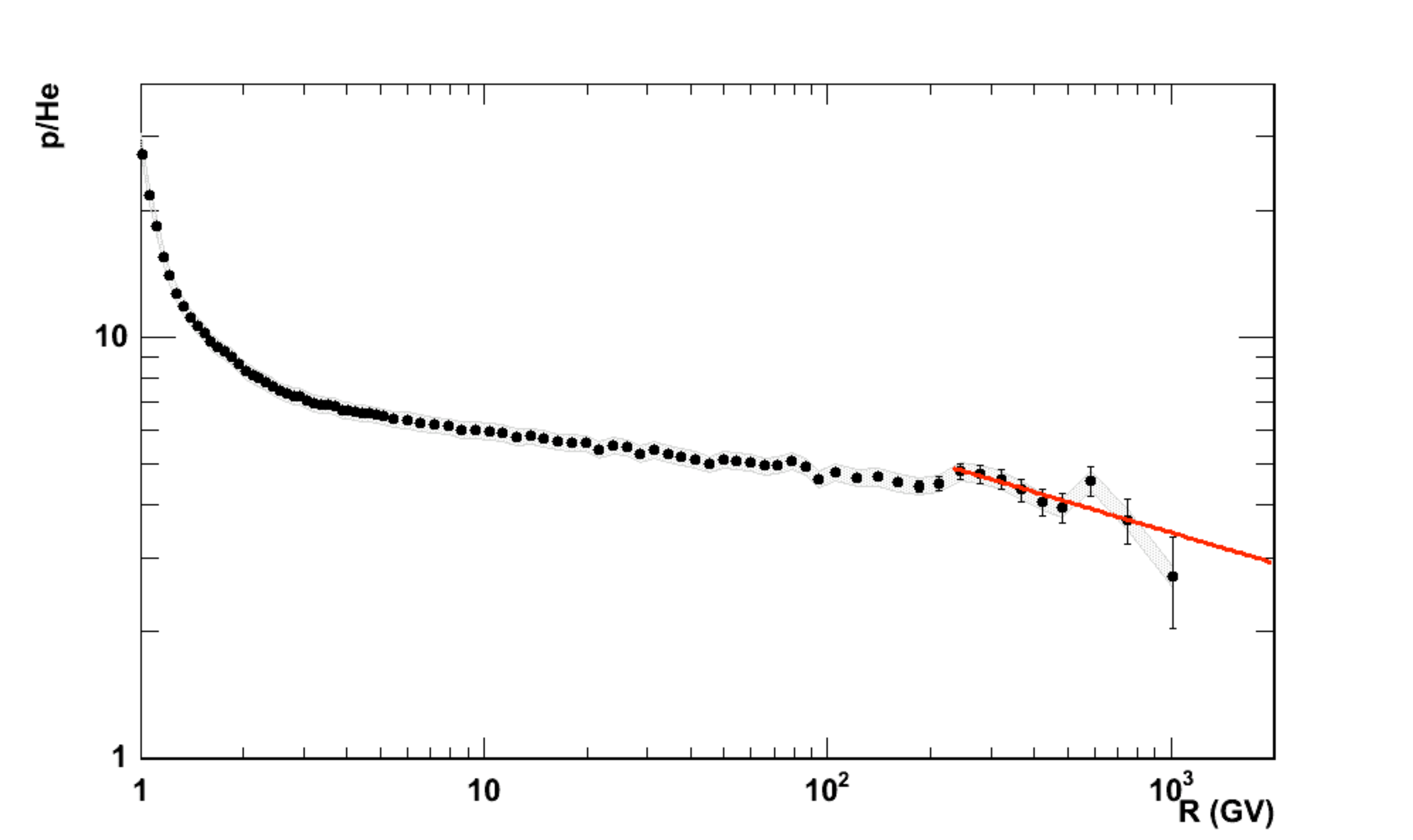


Fitting the proton / helium ratio

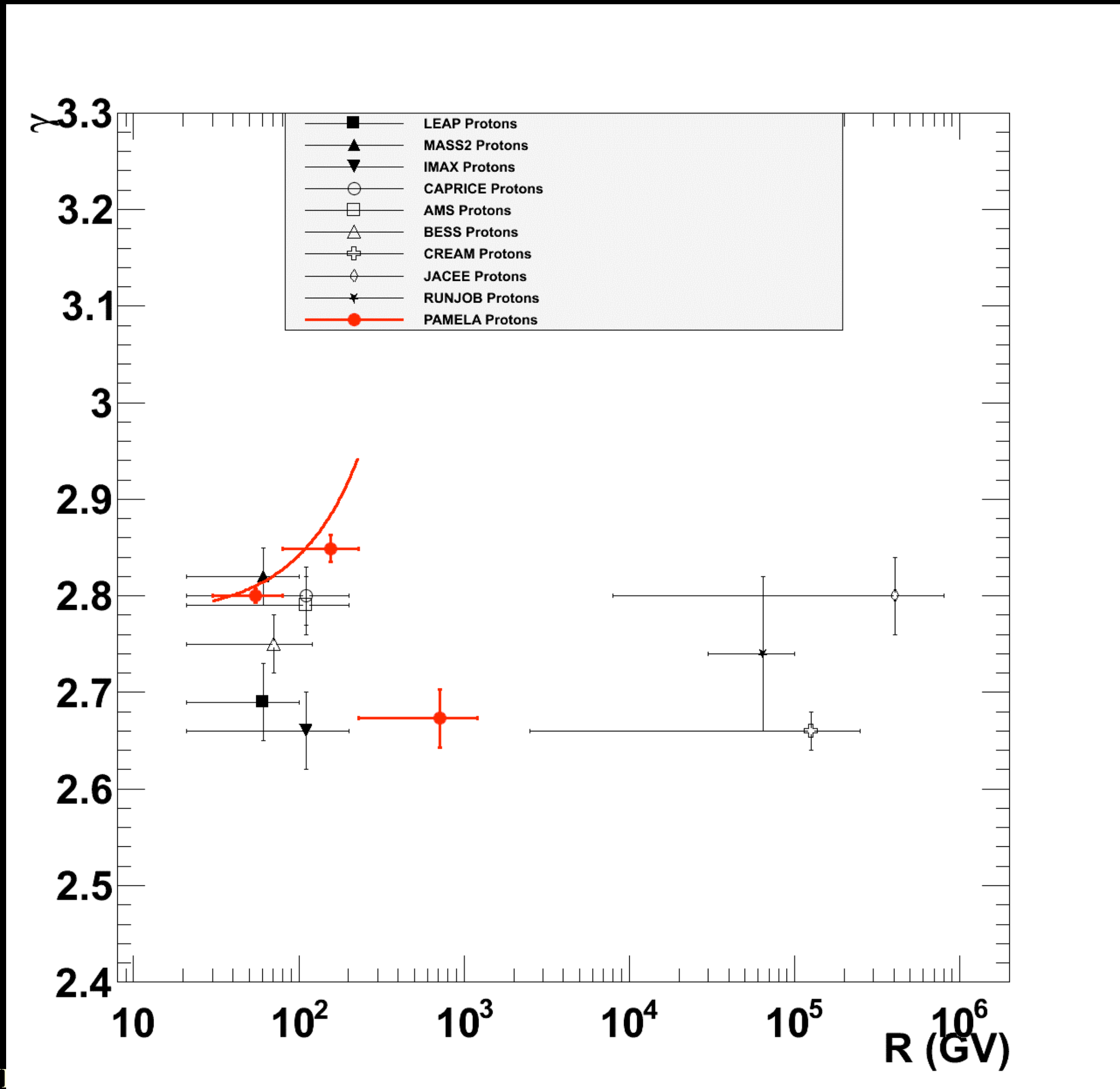




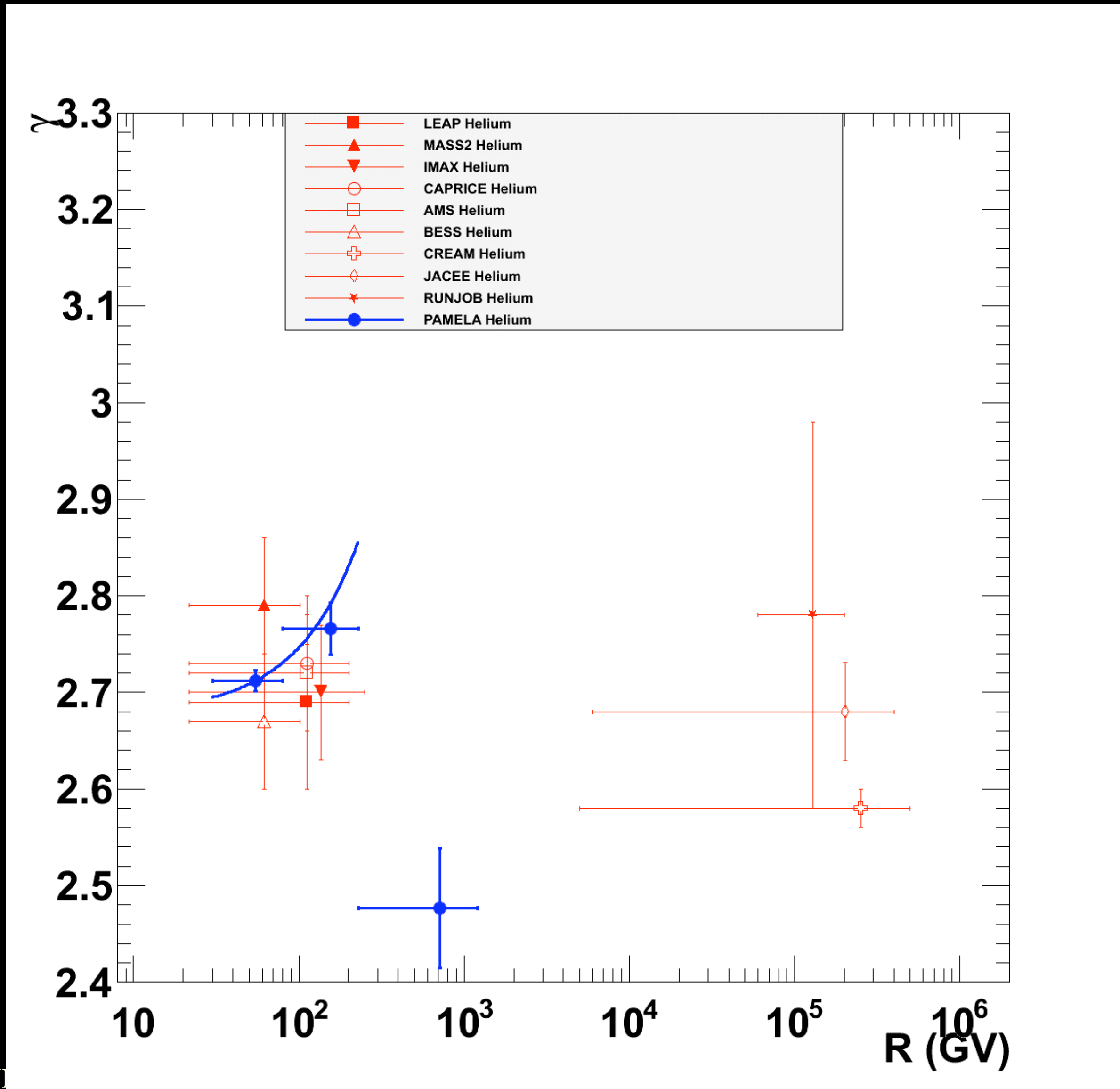
p/He
10
1
1
10
10^2
10^3
R (GV)


p/He
10
1
1
10
10^2
10^3
R (GV)

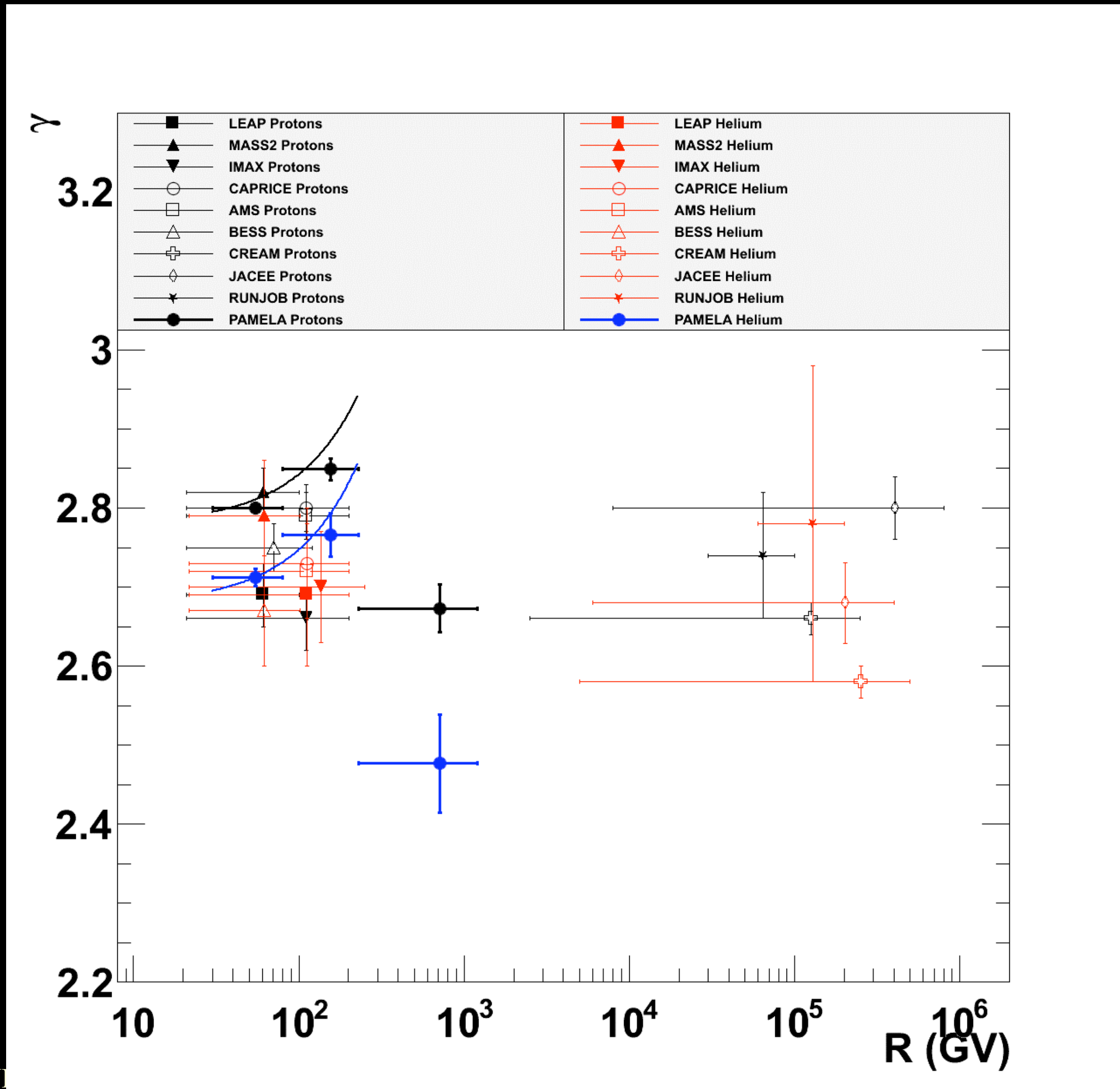
Proton spectral indexes

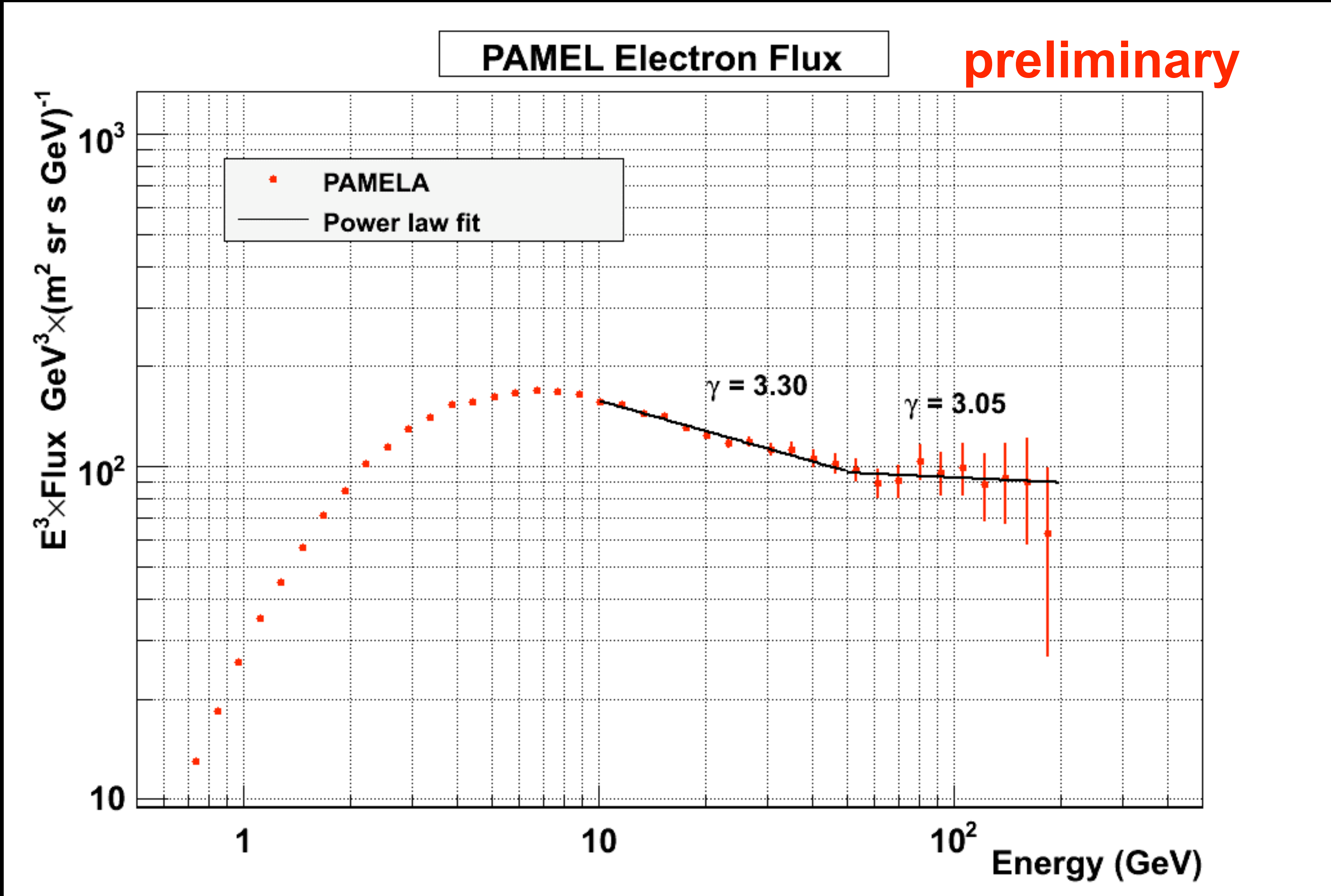


Helium spectral indexes



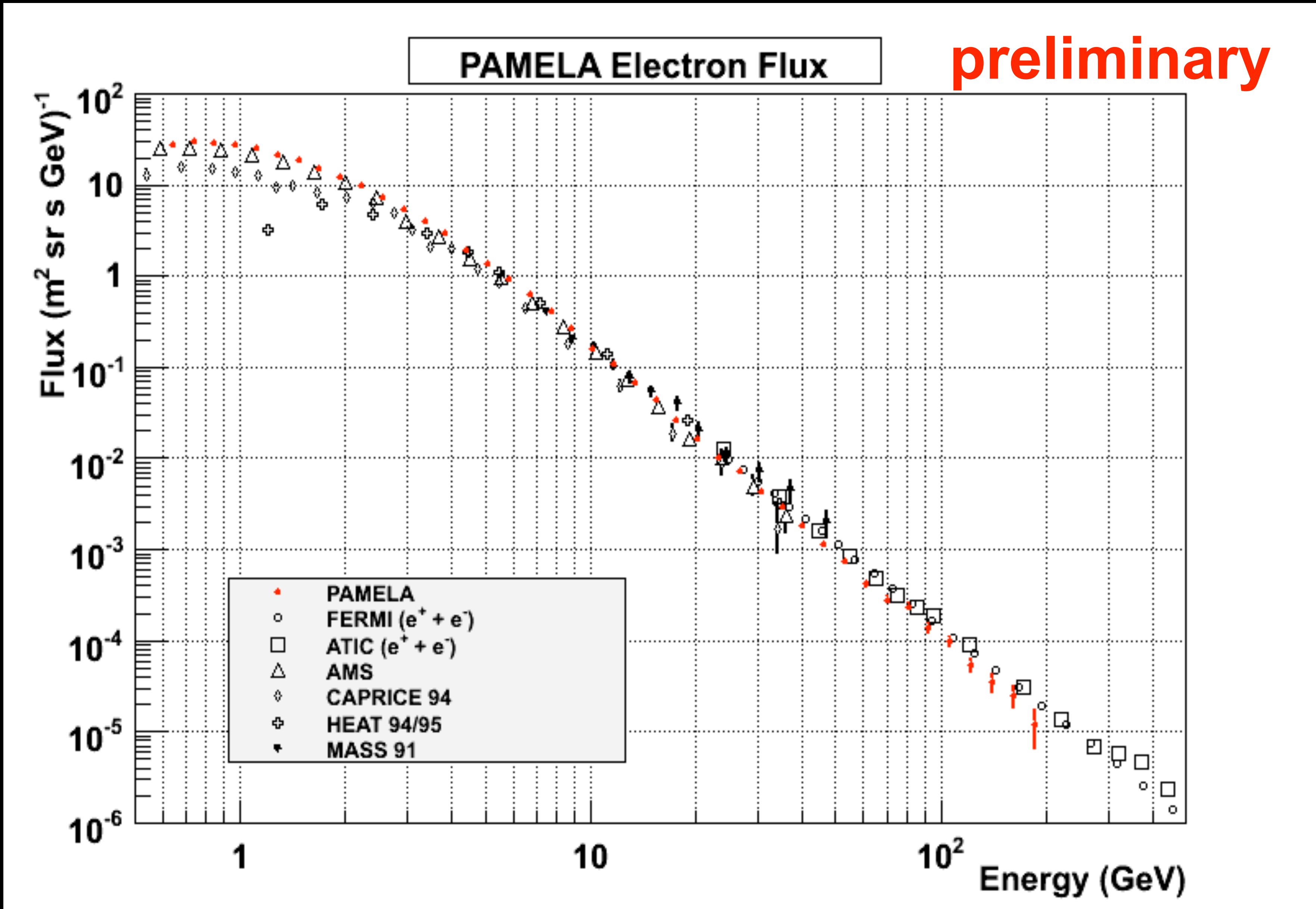
Proton and helium comparison





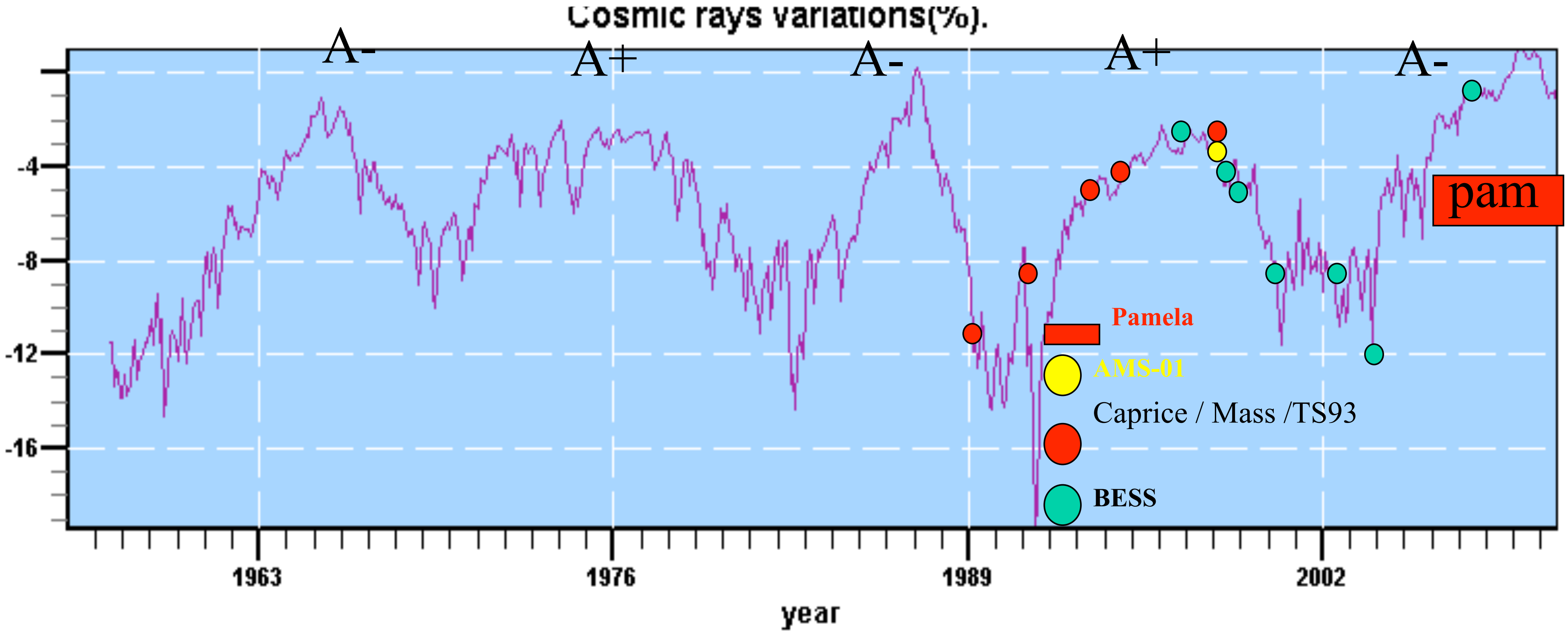
PAMEL Electron Flux
preliminary
PAMELA
Power law fit
γ = 3.30
γ = 3.05
E^3×Flux GeV^3×(m^2 sr s GeV)^-1
10^3
10^2
10
1
10
10^2
Energy (GeV)

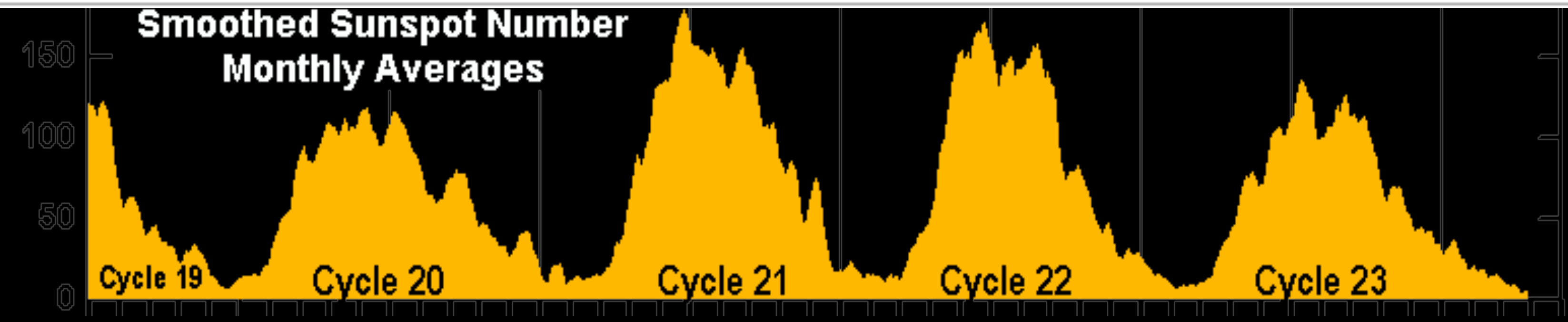
Comparison with other experiments

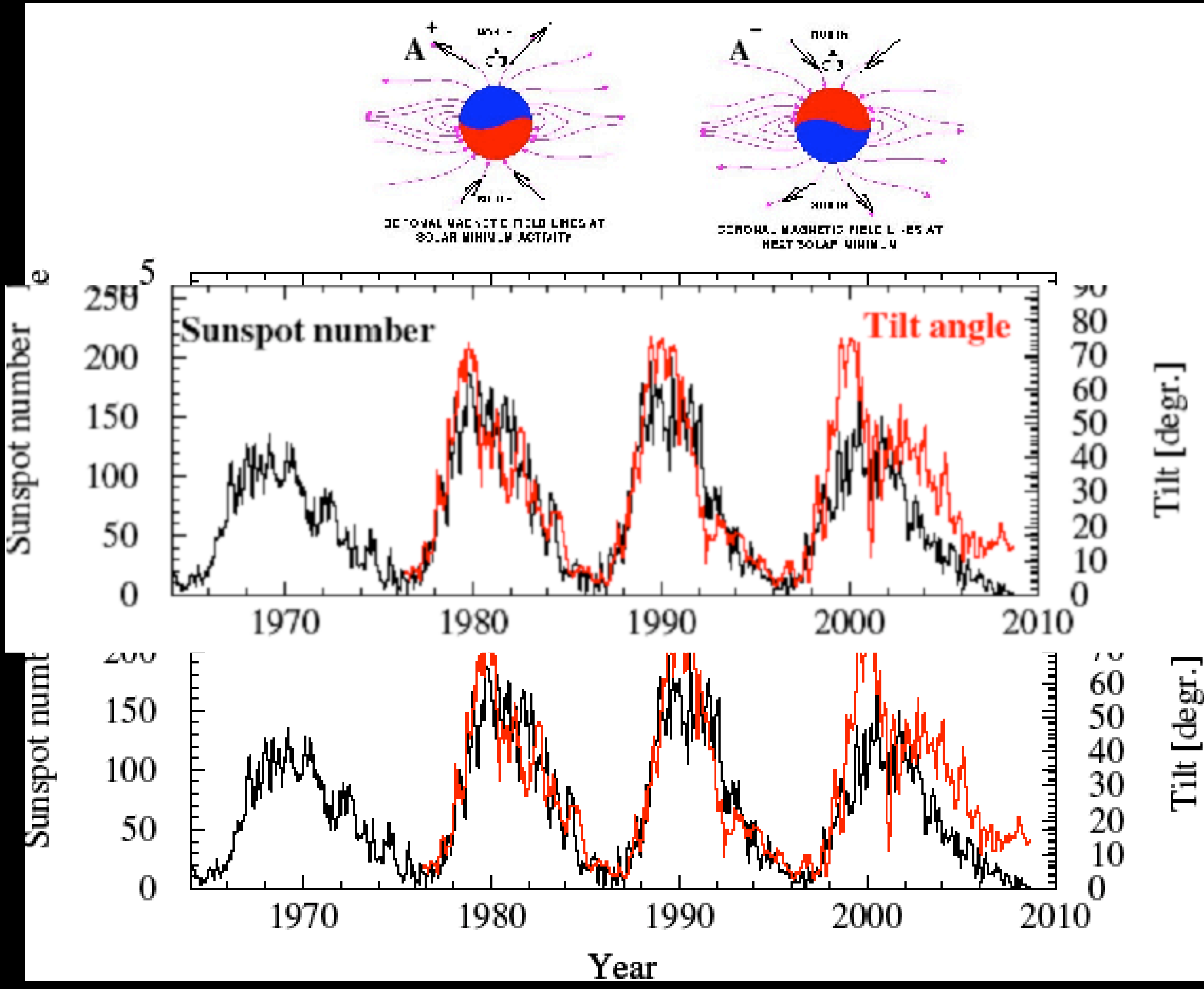


Solar modulation at minimum of solar cycle XXIII years 2006-2008

Rome Monthly neutron monitor

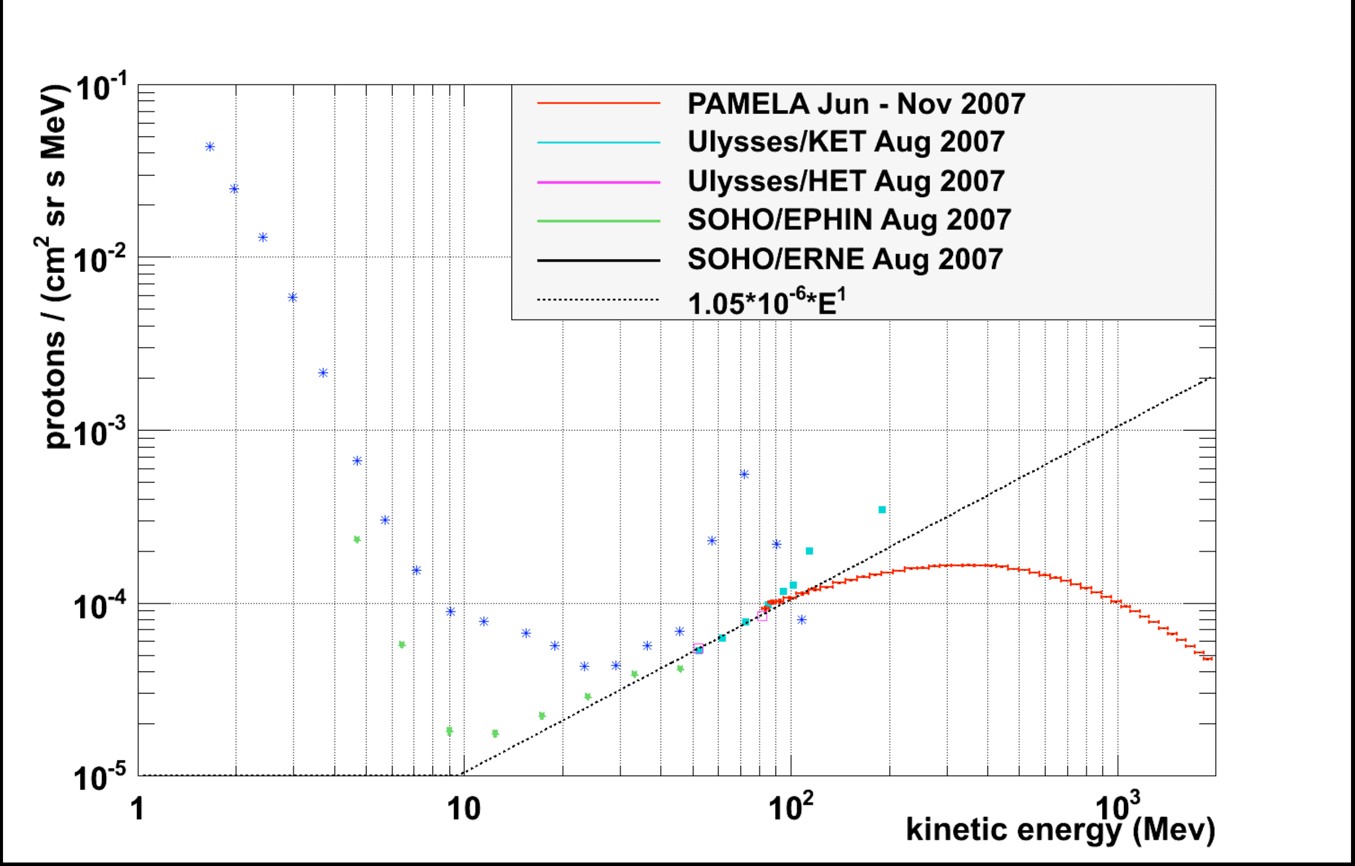






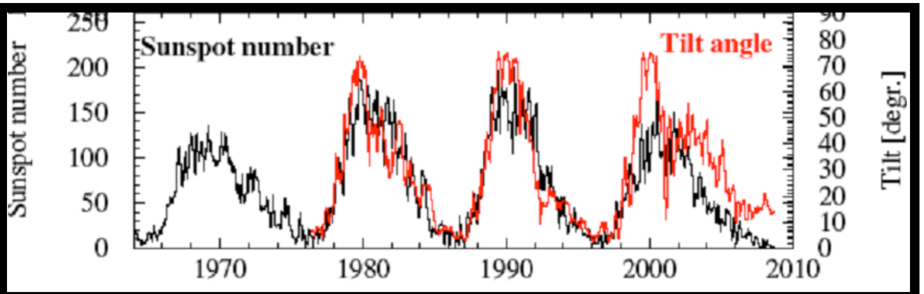
A^+
A^-
Sunspot number
Tilt angle
Tilt [degr.]
Year

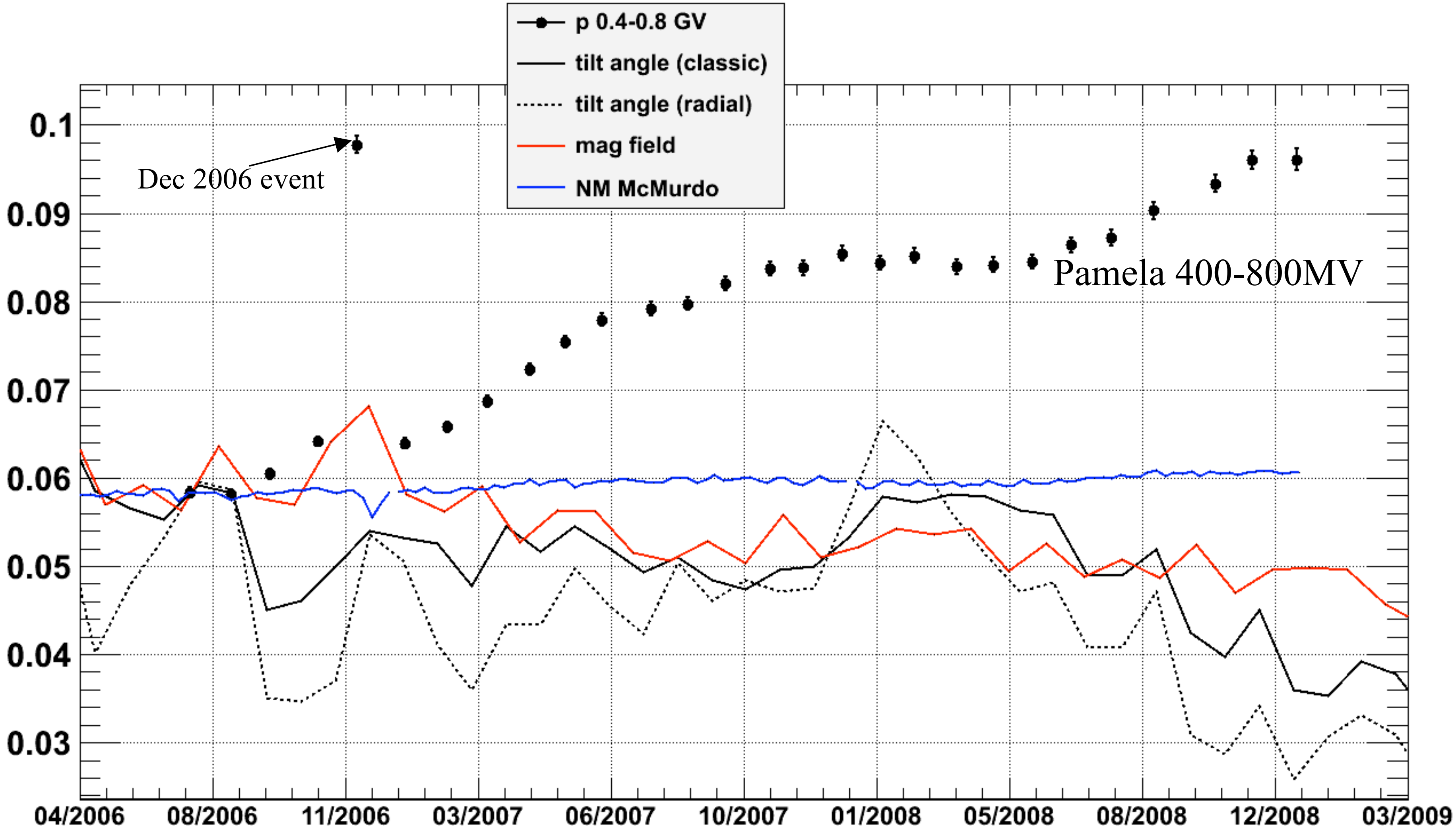
Comparison KET / Pamela / Soho



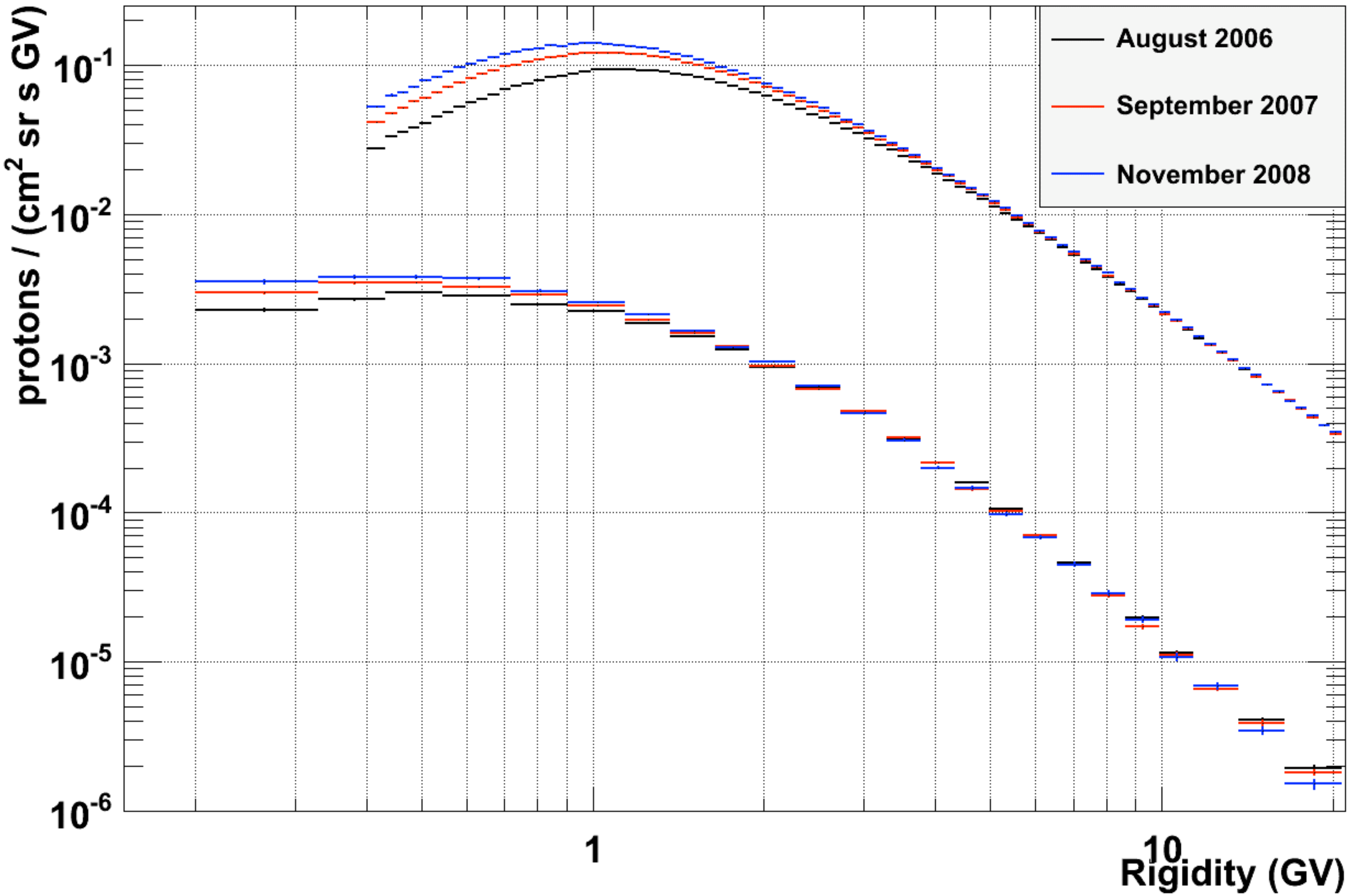
From Jan Gieseler, N. De Simone

Time evolution of Pamela low energy proton flux

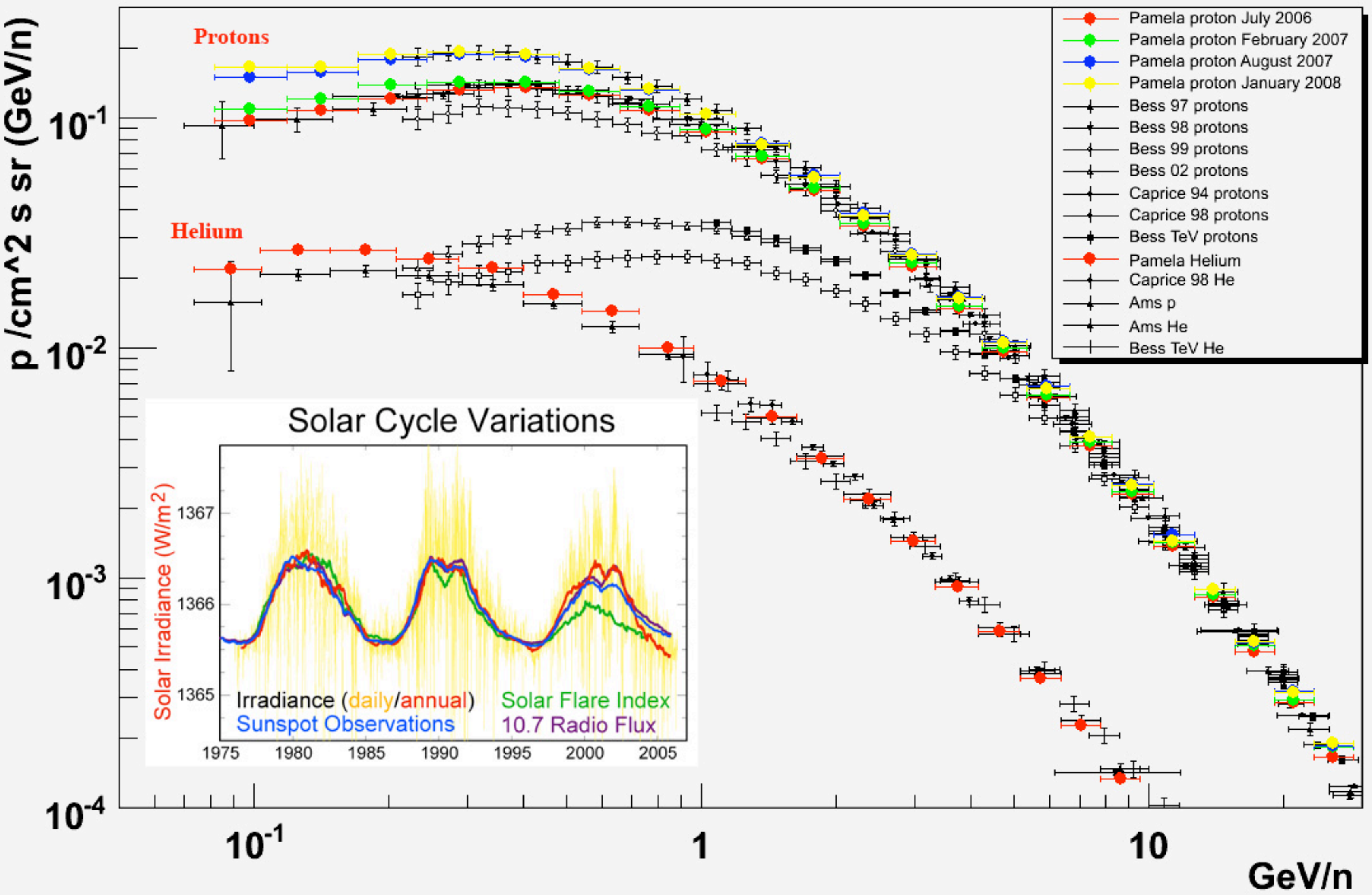




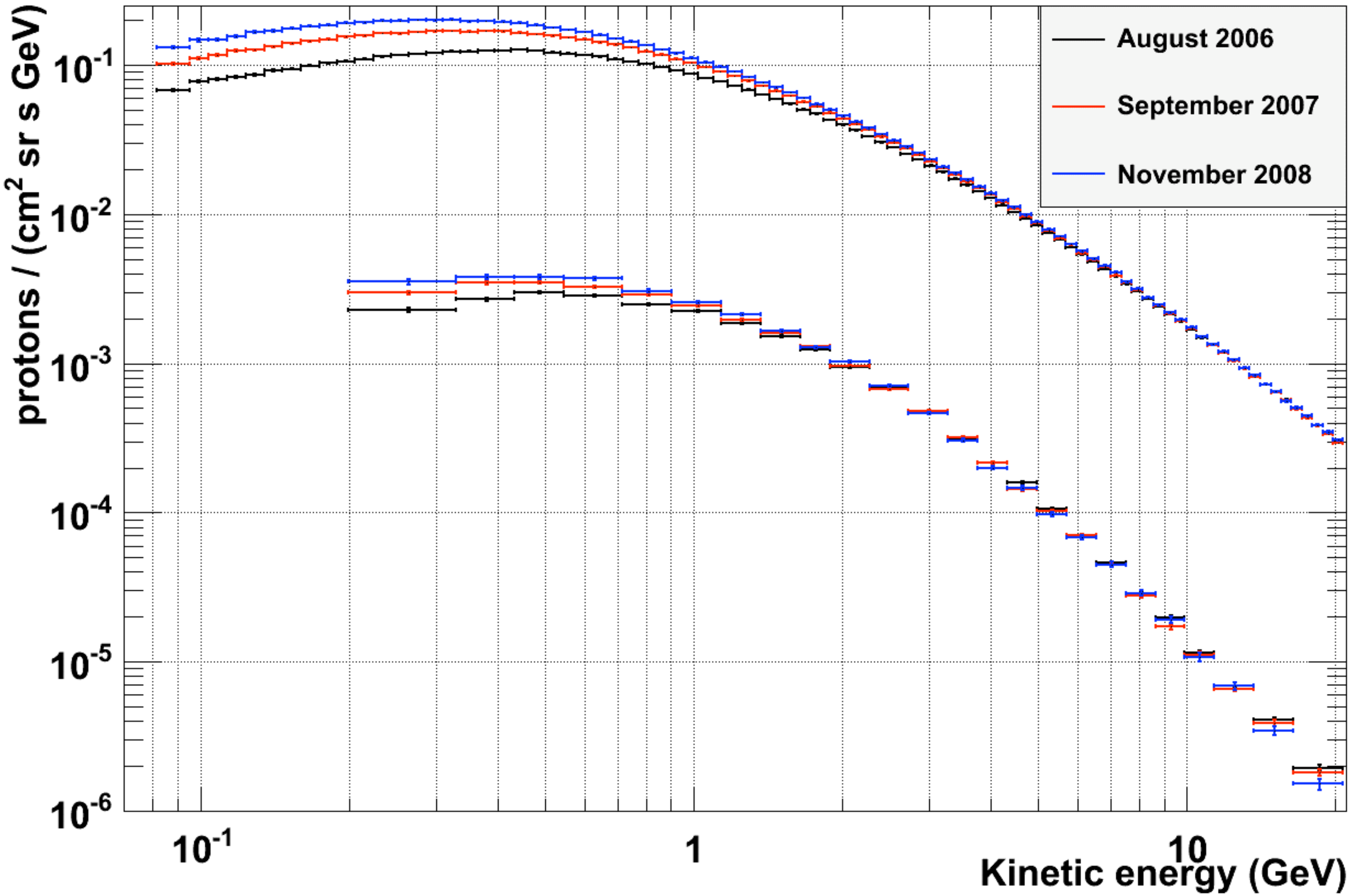
Solar modulation: P and e



Solar modulation: P and He



Solar modulation: P and e



Solar modulation at minimum of solar cycle XXIII years 2006-2008

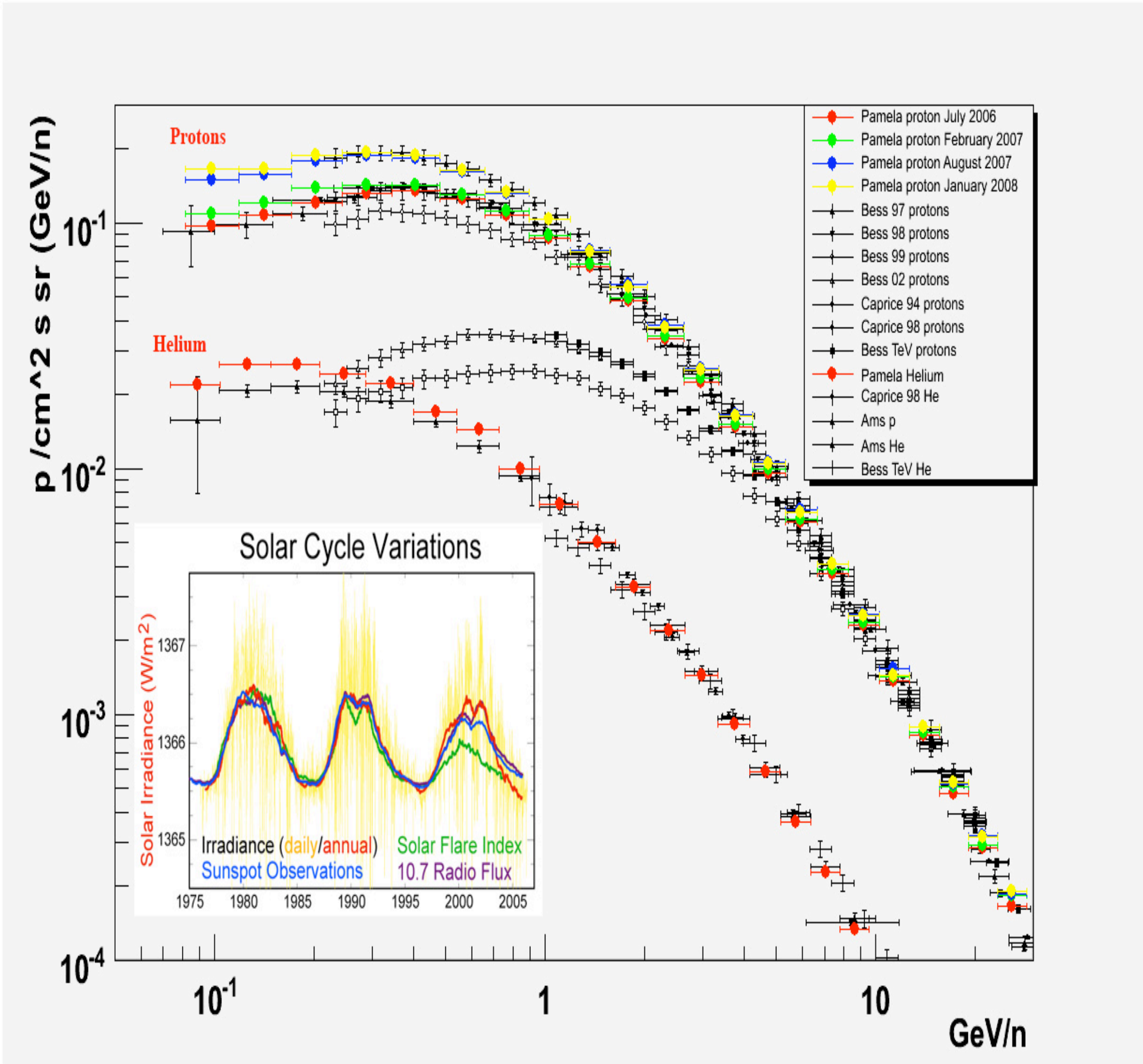
$F_{is} = 1.54\ \beta_{is}^{0.7}\ R_{is}^{-2.76}$

p/(cm² s sr GV)

Spectral index

2.76 ±0.01

$$J(r,E,t) = \frac{E^2 - E_0^{\ 2}}{(E^2 + \Phi(t))^2 - E_0^{\ 2}} J(\infty, E + \Phi(t))$$



Solar modulation parameter

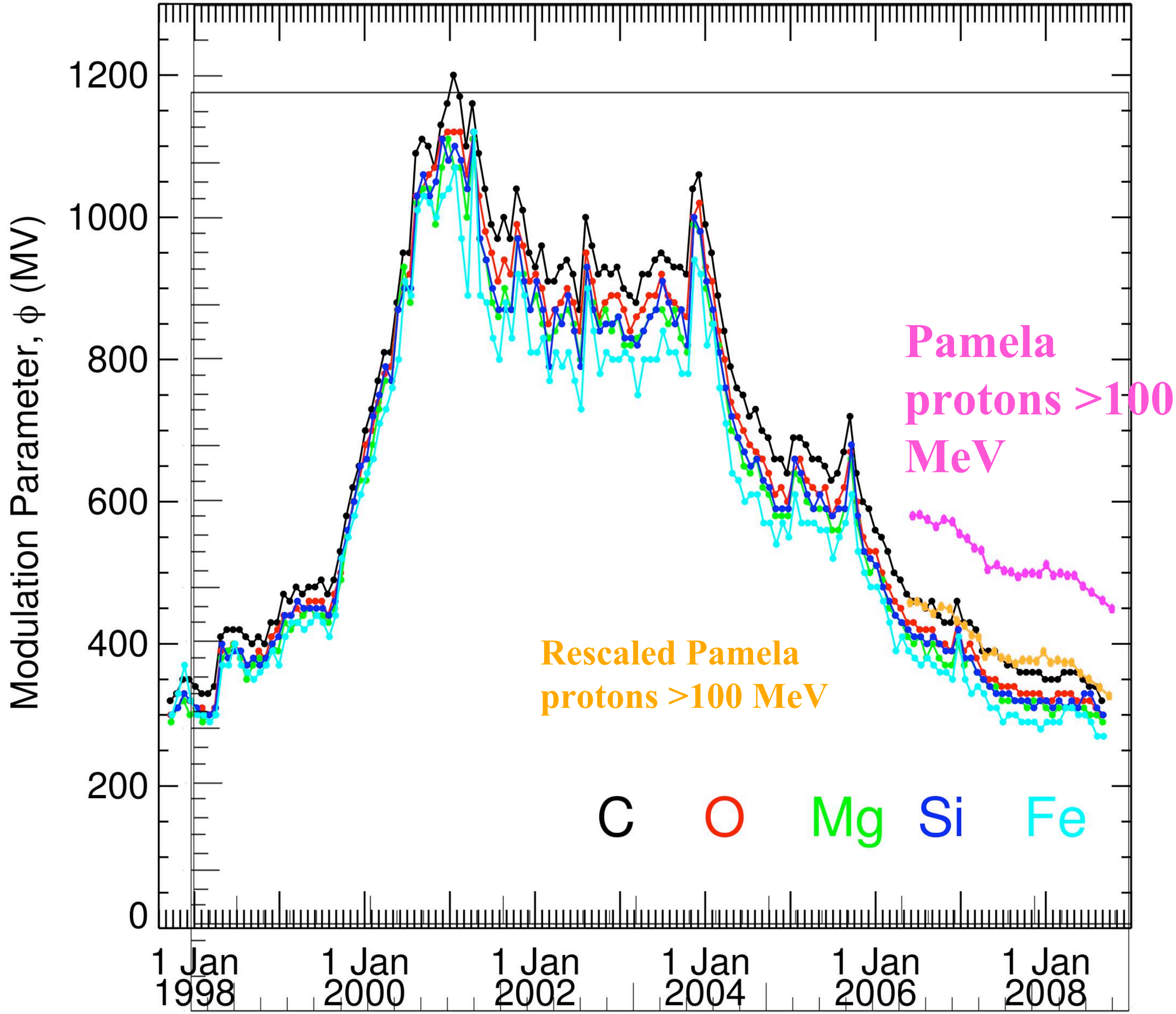
ϕ(GV)

JUL06 5.81-01 ± 2e-03

DEC07 5.00-01 ± 2-03

dec08 4.82-01 ± 3-03

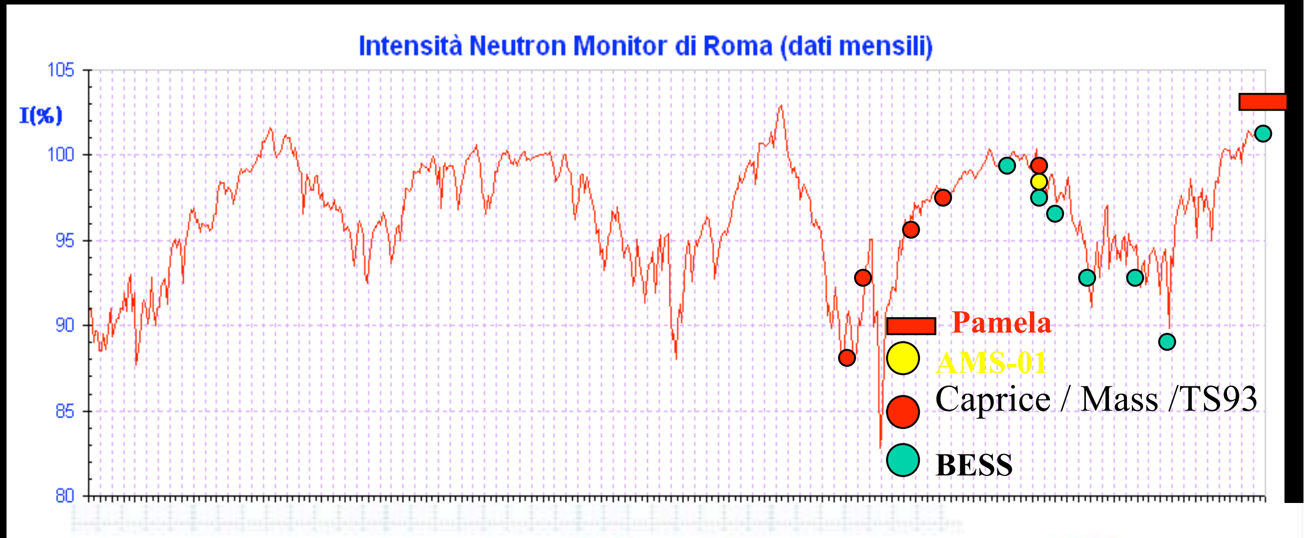
But Spherical approximation is n
sufficient for charge dependent
solar modulation

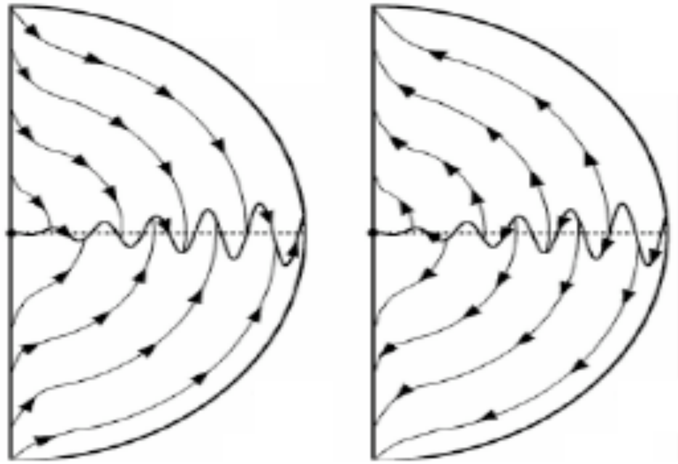

Modulation Parameter, φ (MV)
1200
1000
800
600
400
200
0
1 Jan 1998
1 Jan 2000
1 Jan 2002
1 Jan 2004
1 Jan 2006
1 Jan 2008
Pamela protons >100 MeV
Rescaled Pamela protons >100 MeV
C
O
Mg
Si
Fe


Pamela
Measurement of
the radiation belts
http://www.youtube.com/watch?v=OaoiPw5Pqbg
2008 M. Casolino
Google
Image NASA

Charge dependent solar modulation of low energy positrons

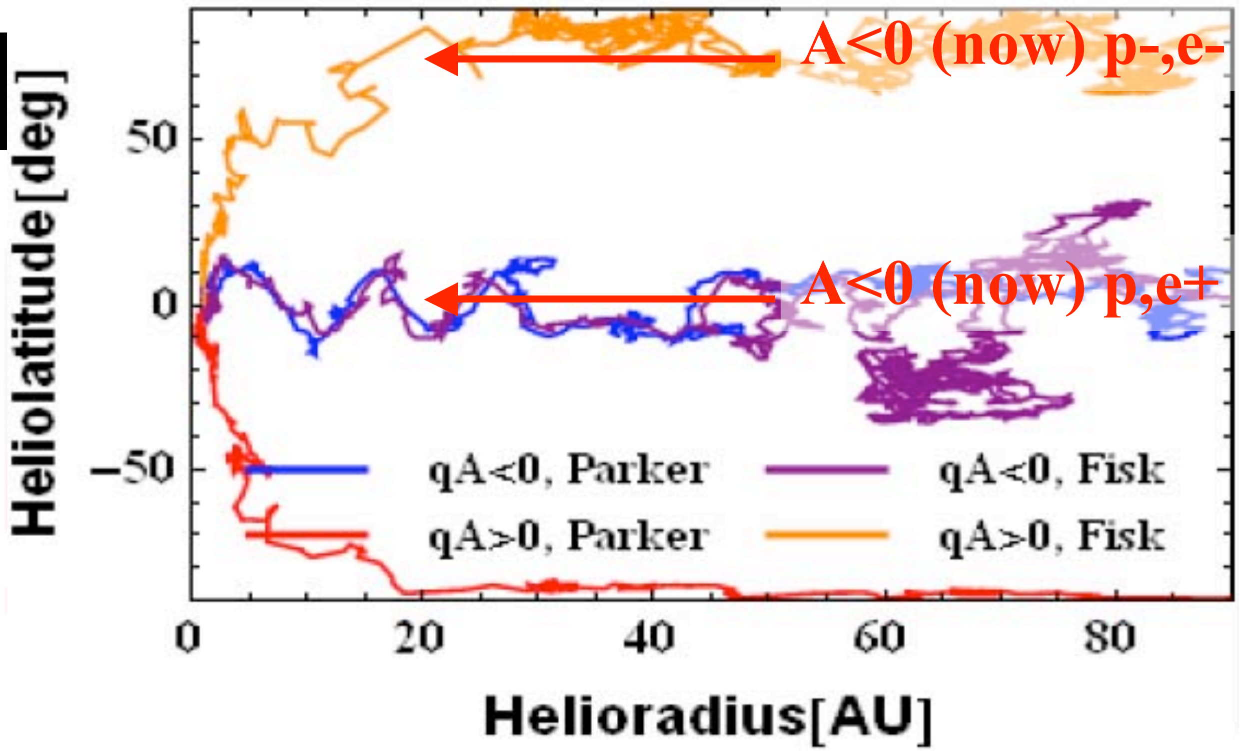
- •Charge dependent solar modulation
- •Separate qA>0 with qA<0 solar cycles
- •Evident in the proton flux
- •Observed in the antiproton channel by BESS
- •Full 3D solution of the Parker equation – drift term depends on sign of the charge





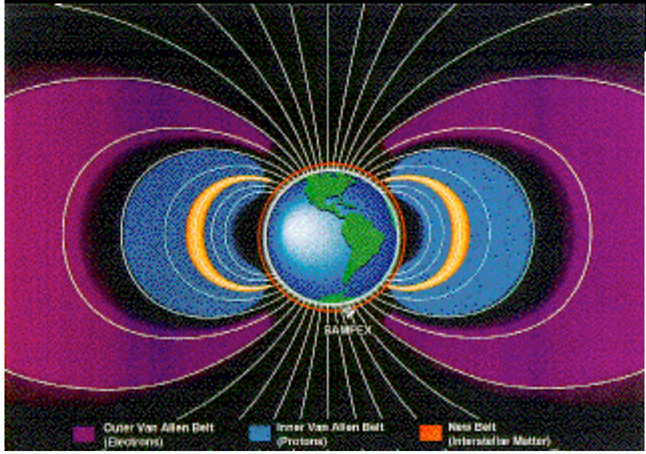
A > 0
Positive particles

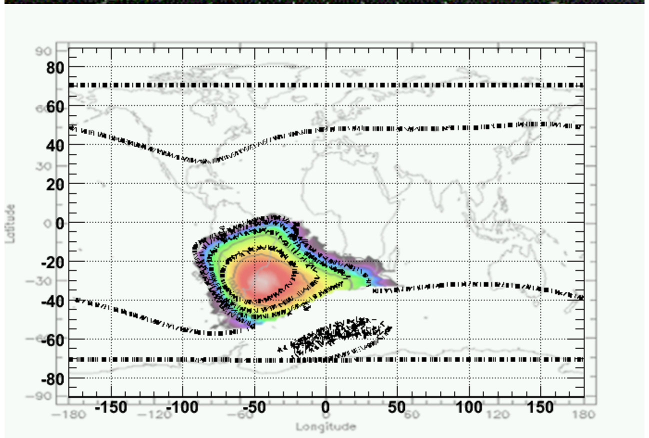
A < 0
Positive particles

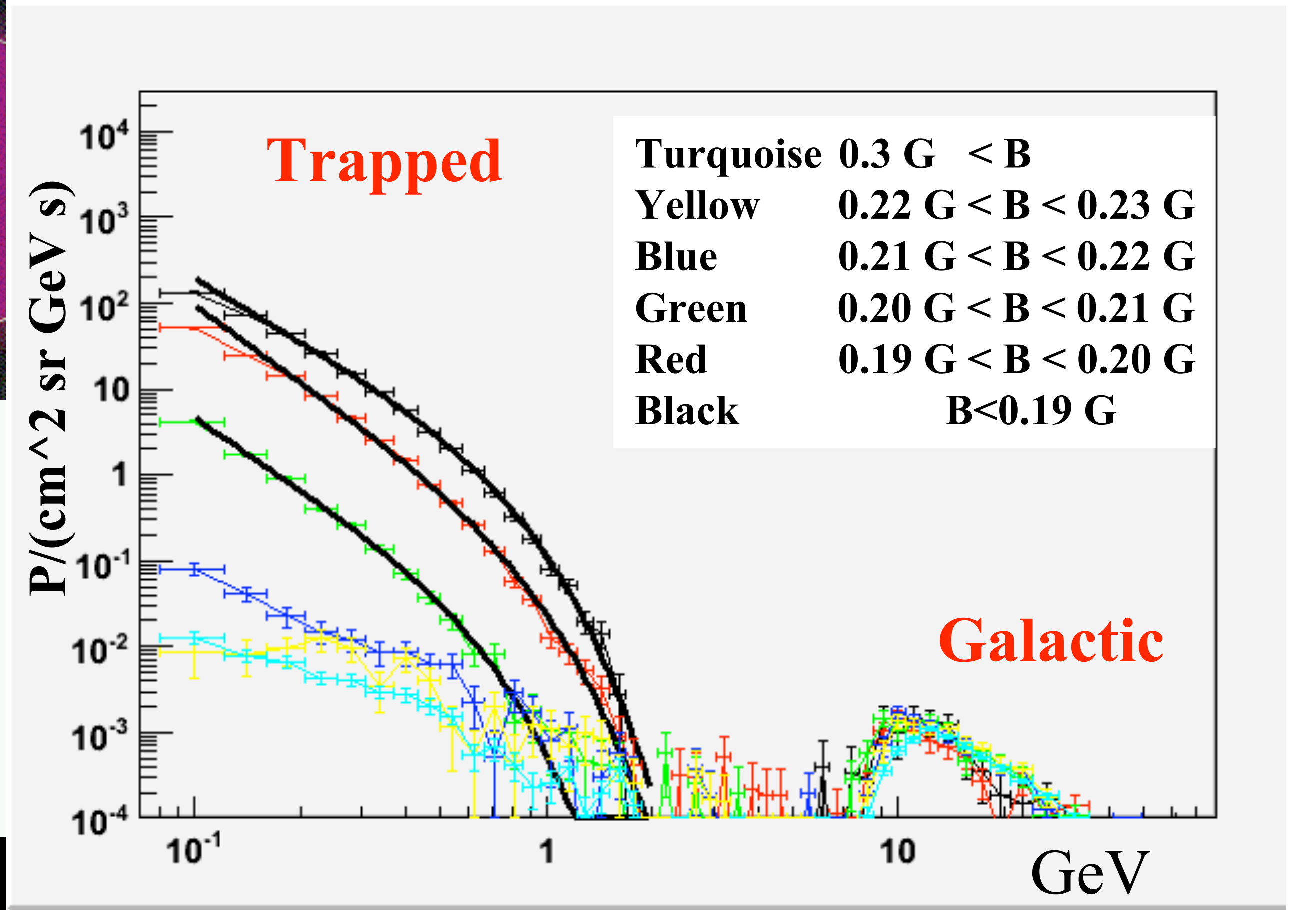


Trapped proton flux in the Van Allen belt
(South Atlantic Anomaly)

Arxiv 0810.4980v1







Integral Pamela flux
(E>35 MeV)
(PSB97 plot by SPENVIS project, model by BIRA-IASB)

	A	γ_0	γ_1	χ^2/ndf
nero	0.11±0.01	6.0±0.4	3.1±0.5	7.1
rosso	(2.3±0.3) 10^{-2}	5.9±0.5	2.6±0.6	6.8
verde	(5±3) 10^{-4}	8.1±1.8	4.7±1.8	10.

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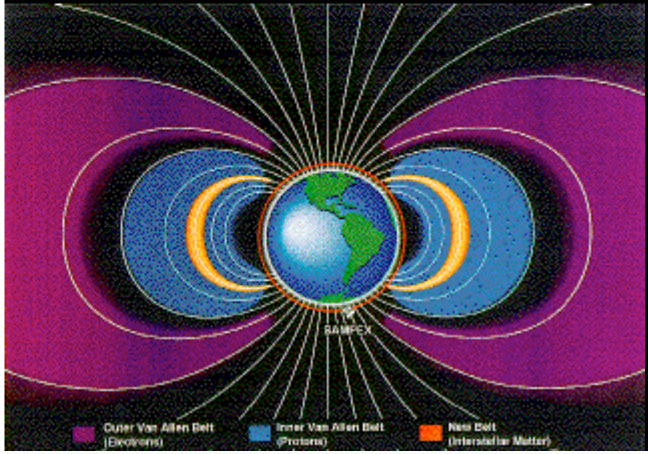
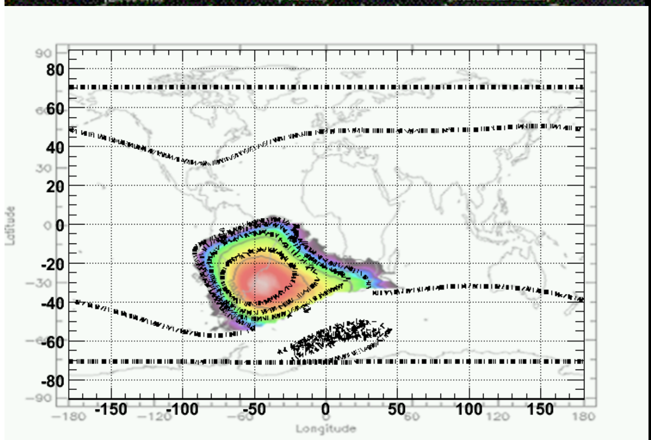
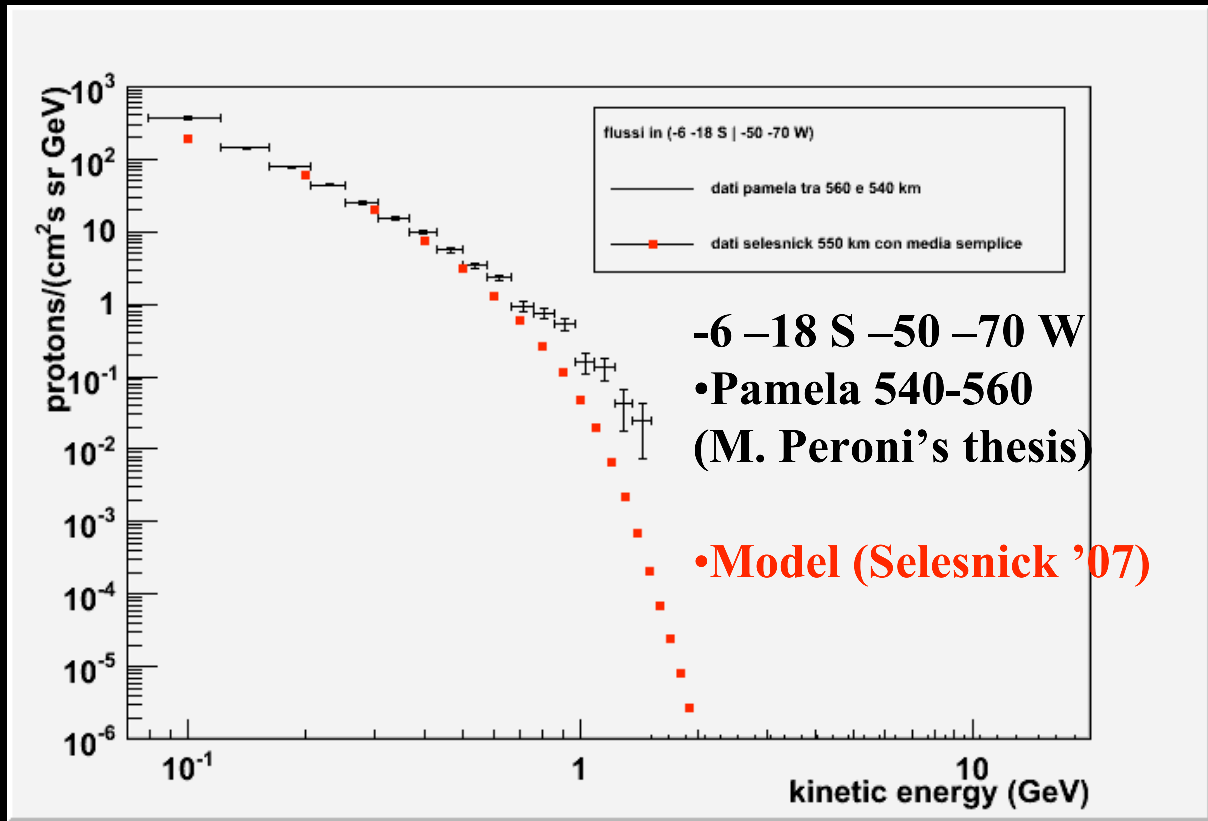
Trapped proton flux in the Van Allen belt
Comparison with models





Integral Pamela flux
(E>35 MeV)
(PSB97 plot by SPENVIS project, model by BIRA-IASB)

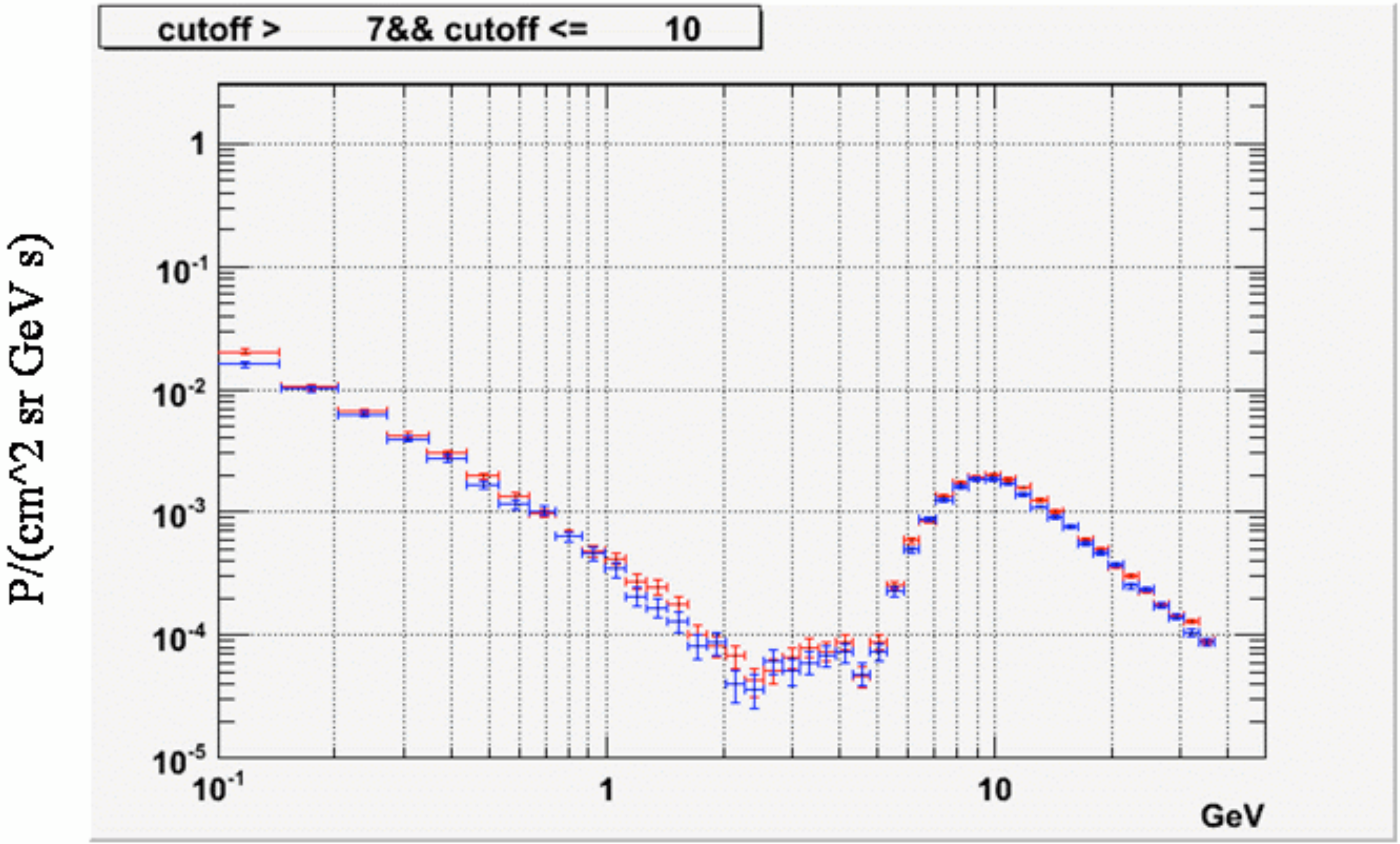


-6 –18 S –50 –70 W

- **Pamela 540-560 (M. Peroni's thesis)**
- **Model (Selesnick '07)**

Selesnick, Looper, Mewaldt, Sp Weath 5, S04003, 2007

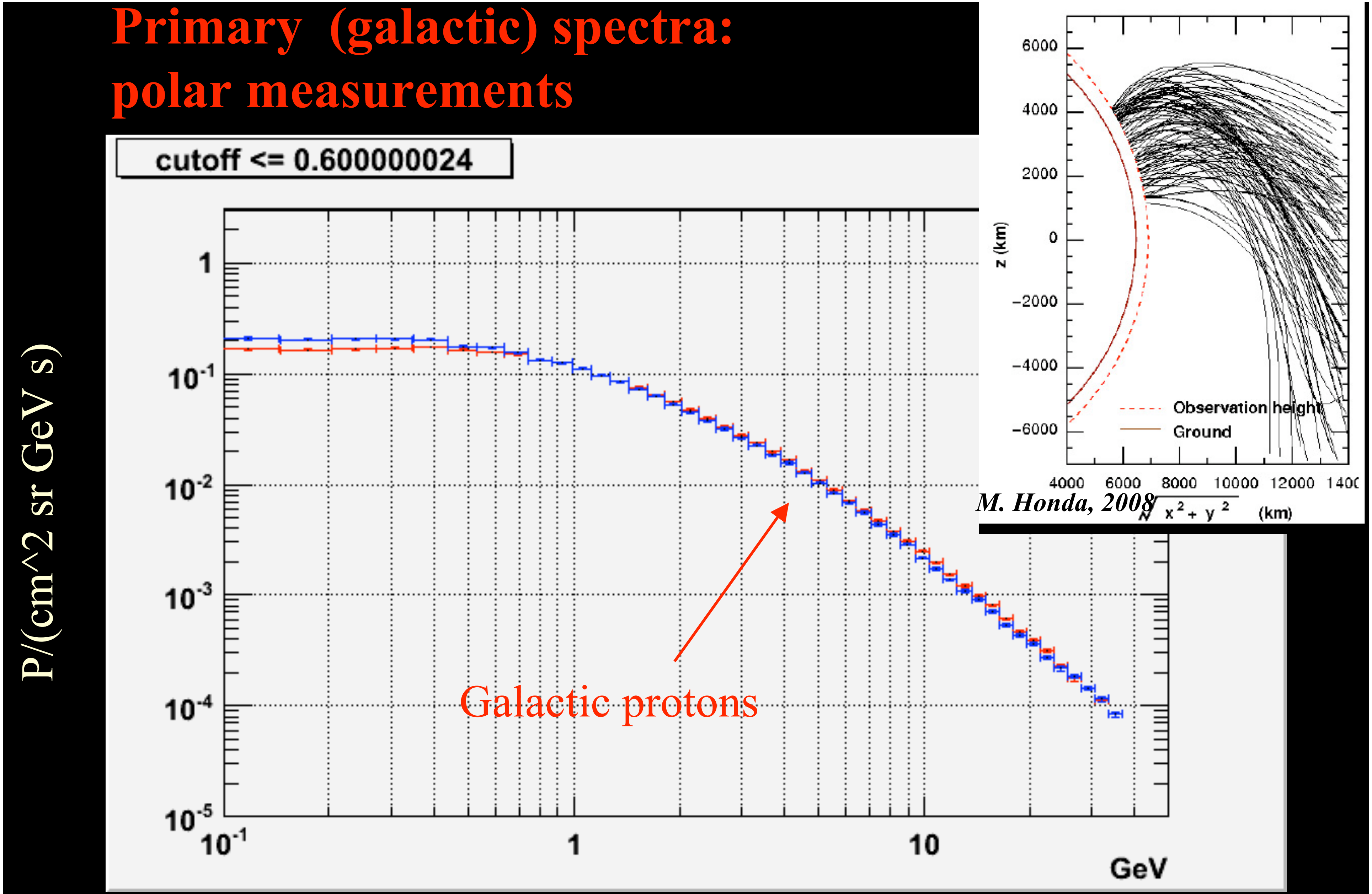
Primary and Secondary spectra



RED: JULY 2006

BLUE: AUGUST 2007

Primary (galactic) spectra: polar measurements

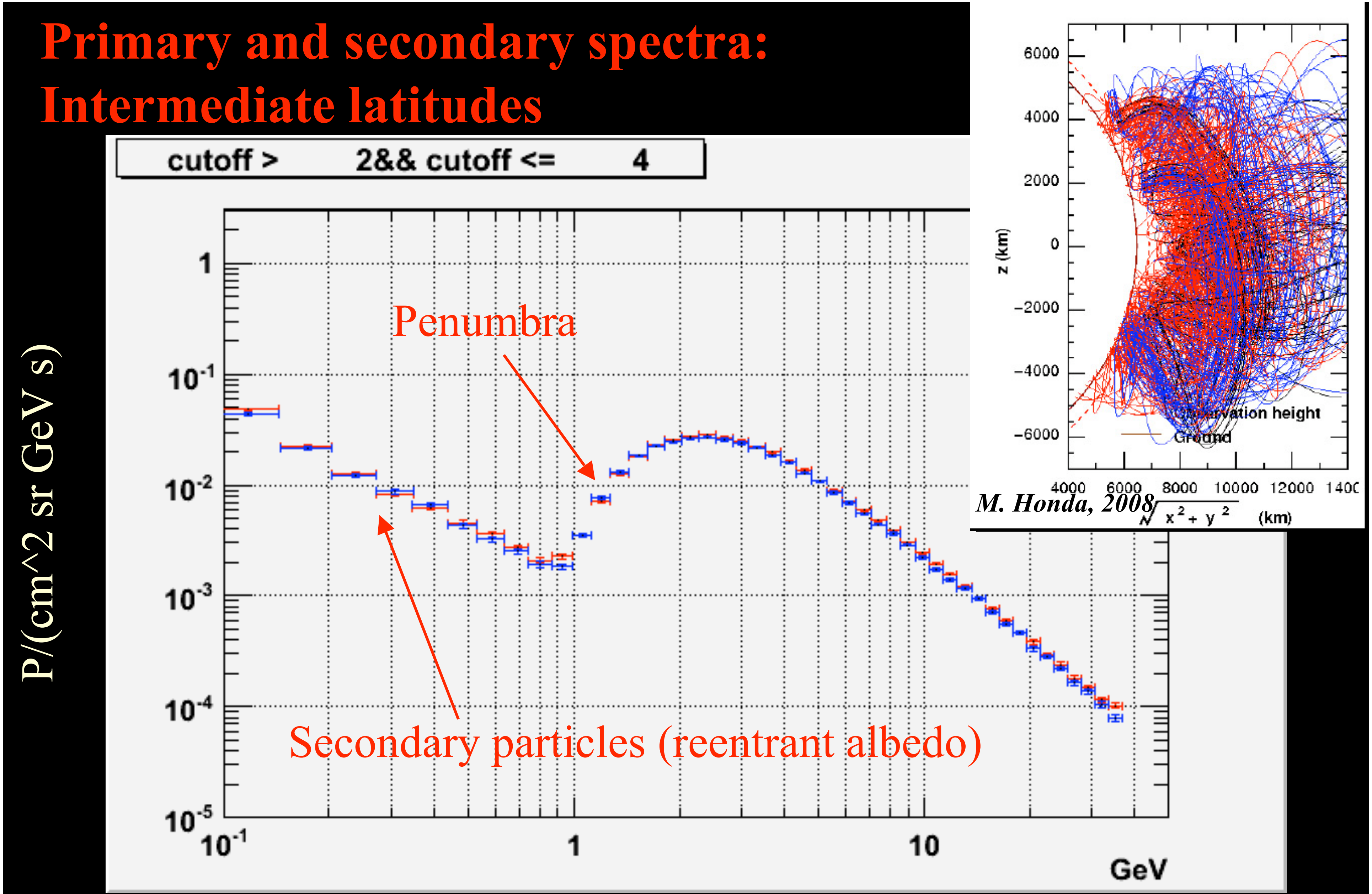


M. Honda, 2008

RED: JULY 2006

BLUE: AUGUST 2007

Primary and secondary spectra: Intermediate latitudes

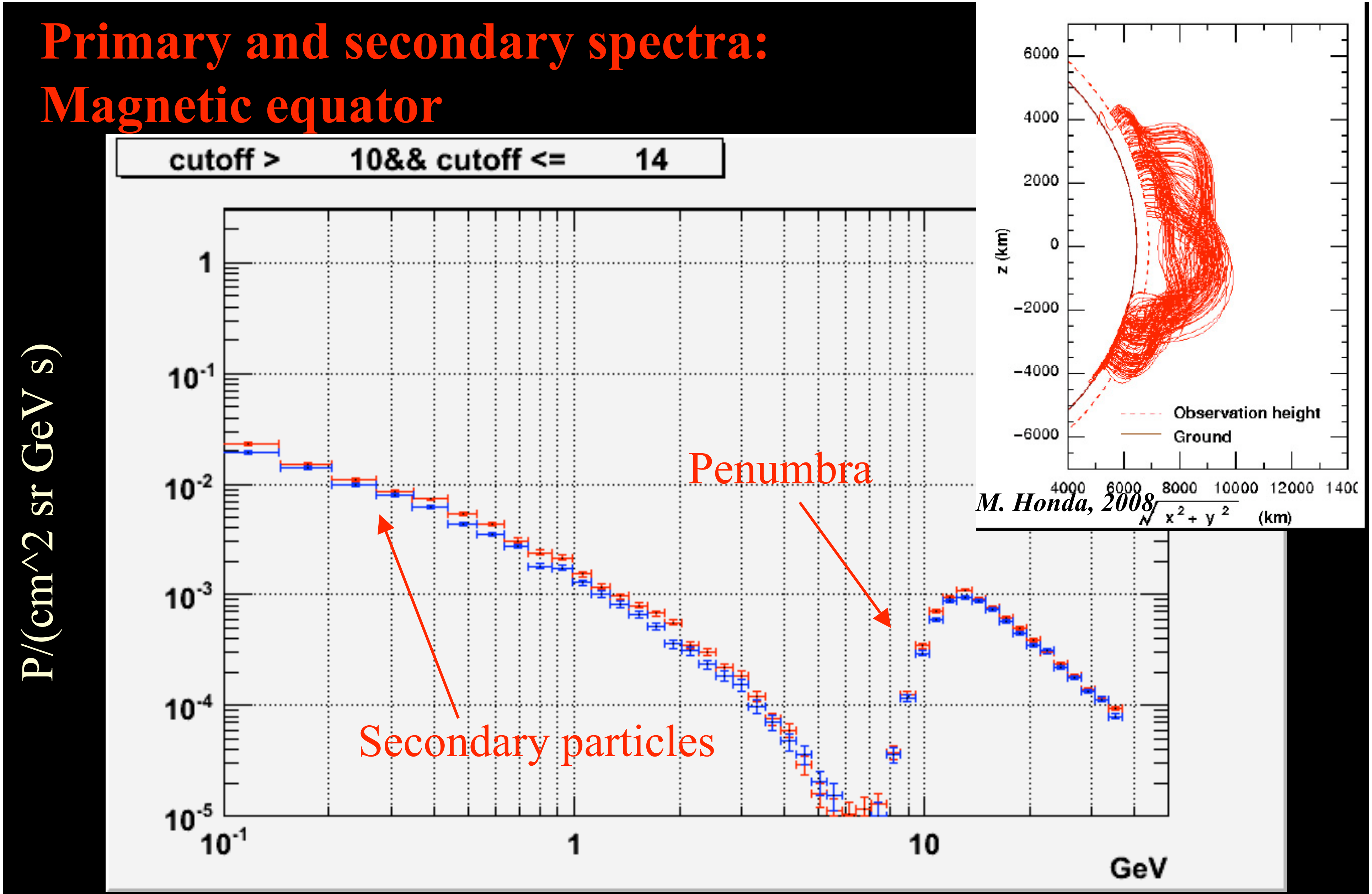


M. Honda, 2008

RED: JULY 2006

BLUE: AUGUST 2007

Primary and secondary spectra: Magnetic equator



RED: JULY 2006

BLUE: AUGUST 2007

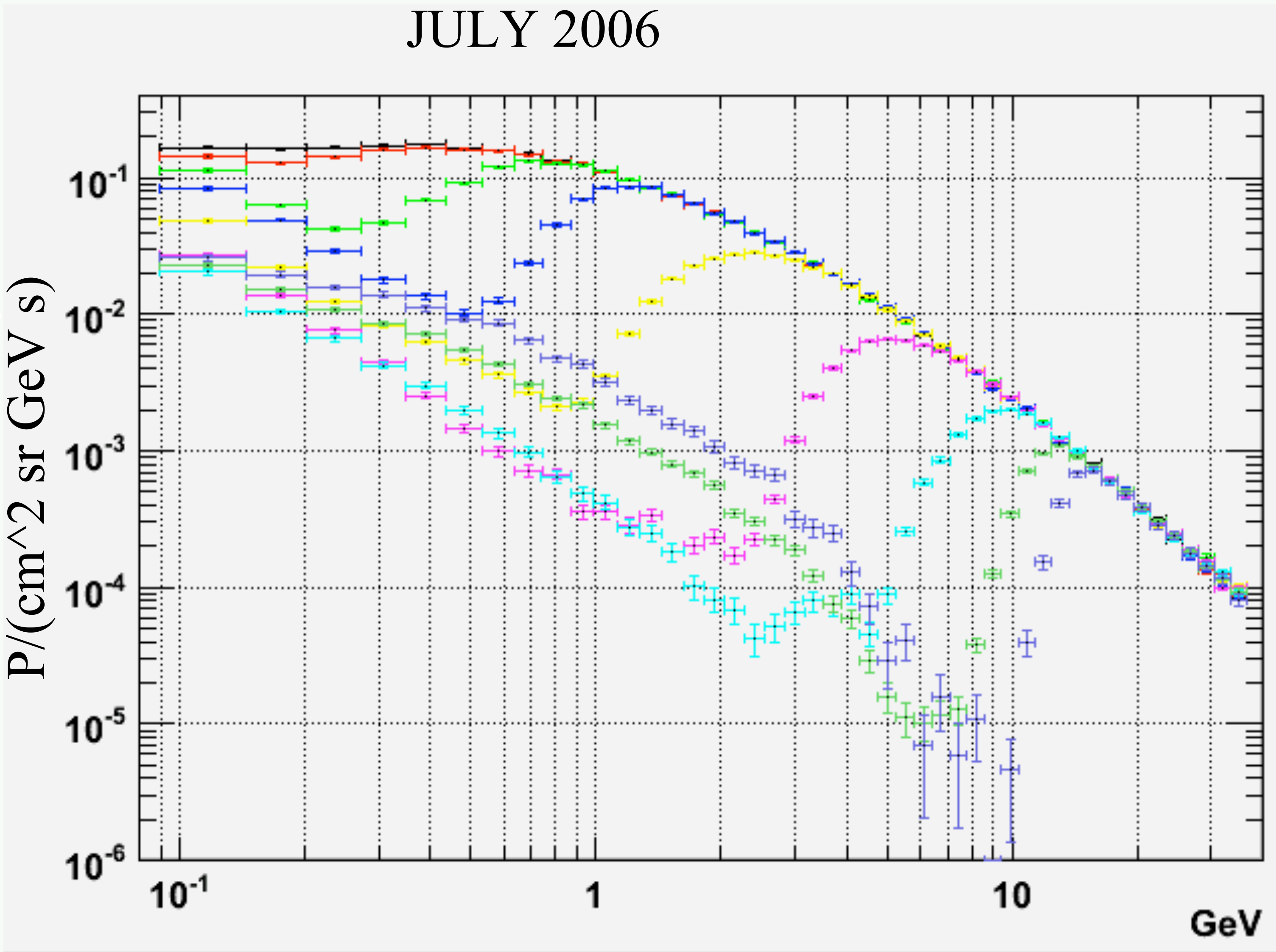
Proton Flux at various cutoff

Subcutoff (secondary albedo) Particles
•P, e-,e+, P-

•Grigorov, Sov. Phys. Dokl. **22**, 305 1977
•NINA results:
  •ApJ Supp.132 365, 2001
•AMS results:
  Phys. Lett. B 472 2000.215,
  Phys. Lett. B 484 2000.10–22
•G. Esposito PhD

•+calculations

•Lipari, Astrop. Ph. 14, 171, 2000
•Huang et al, Pys Rev. D **68**, 053008 2003
•Sanuki et al, Phys Rev D75 043005 2007
•Honda et al, Phys Rev D75 043006 2007

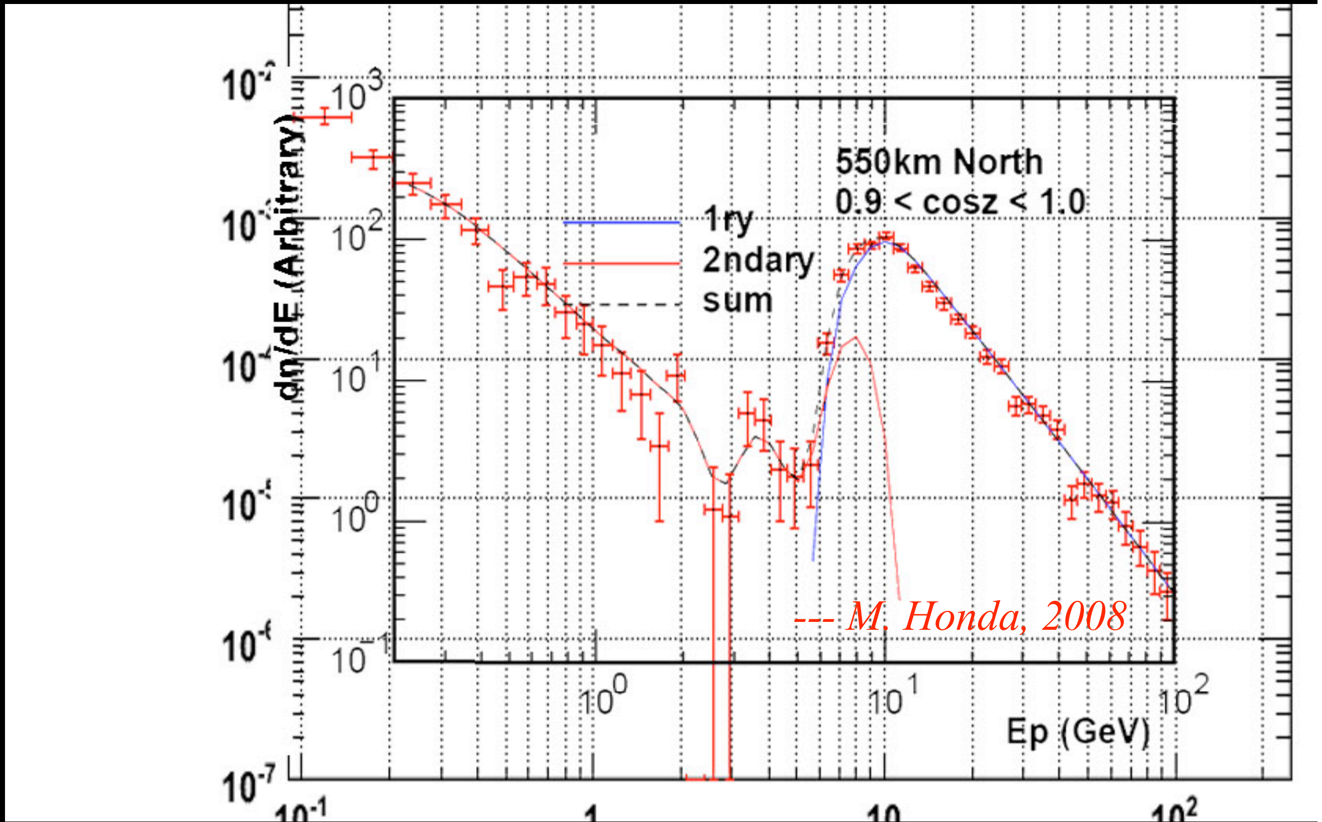


Secondary (reentrant albedo) proton flux at various cutoffs

→Atmospheric neutrino contribution

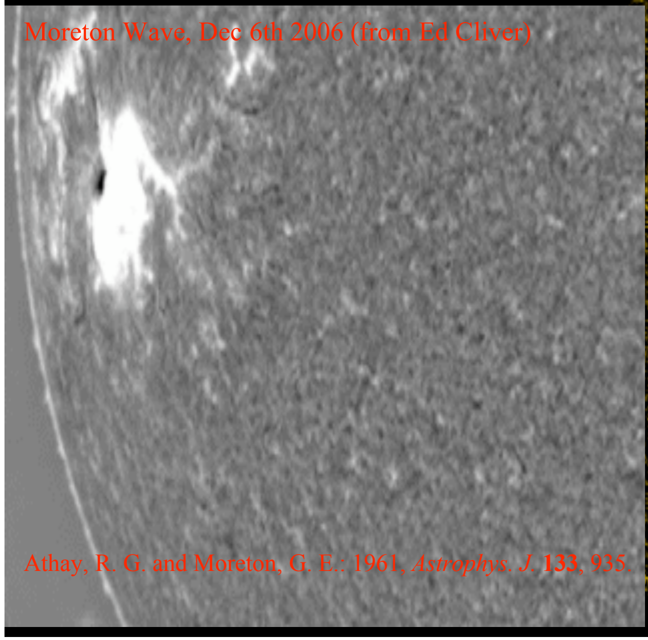
→Astronaut dose on board International Space Station

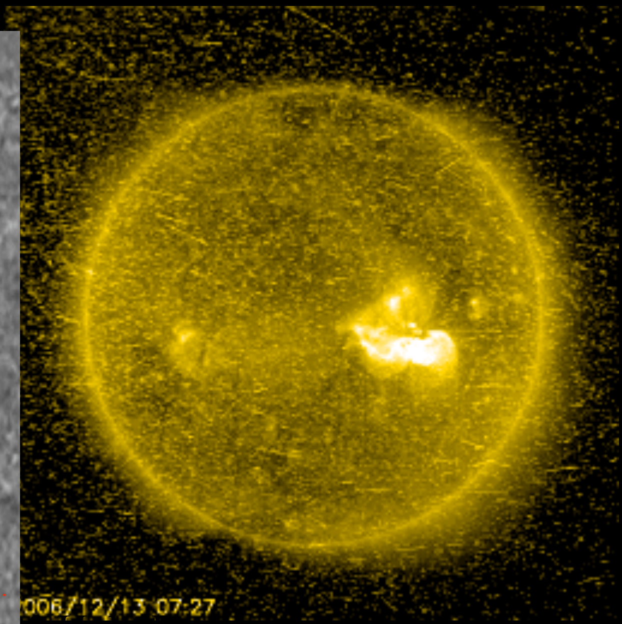
→Indirect measurement of cross section in the atmosphere

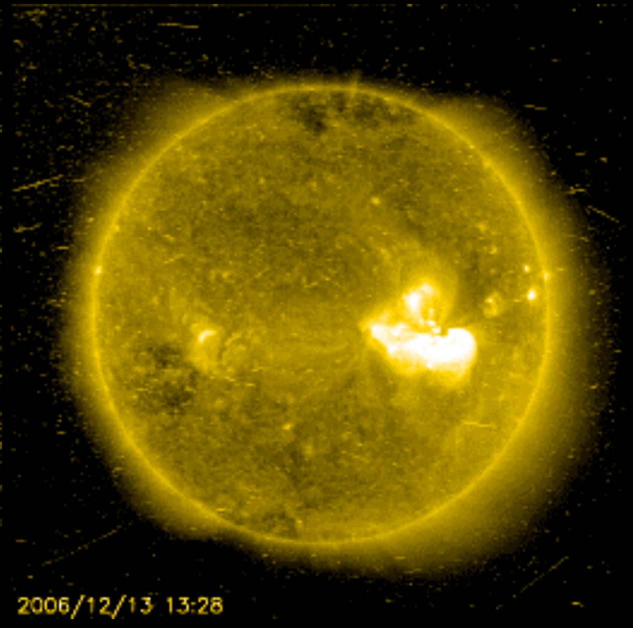


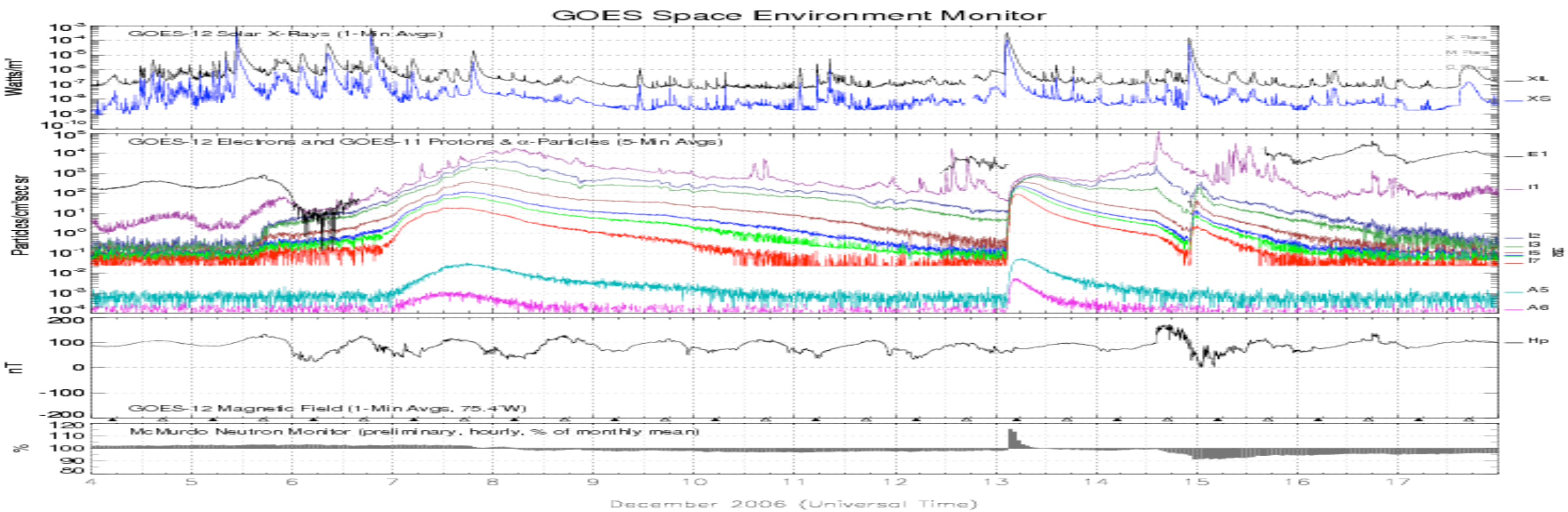
Arxiv 0810.4980v1

December 2006 Solar particle events



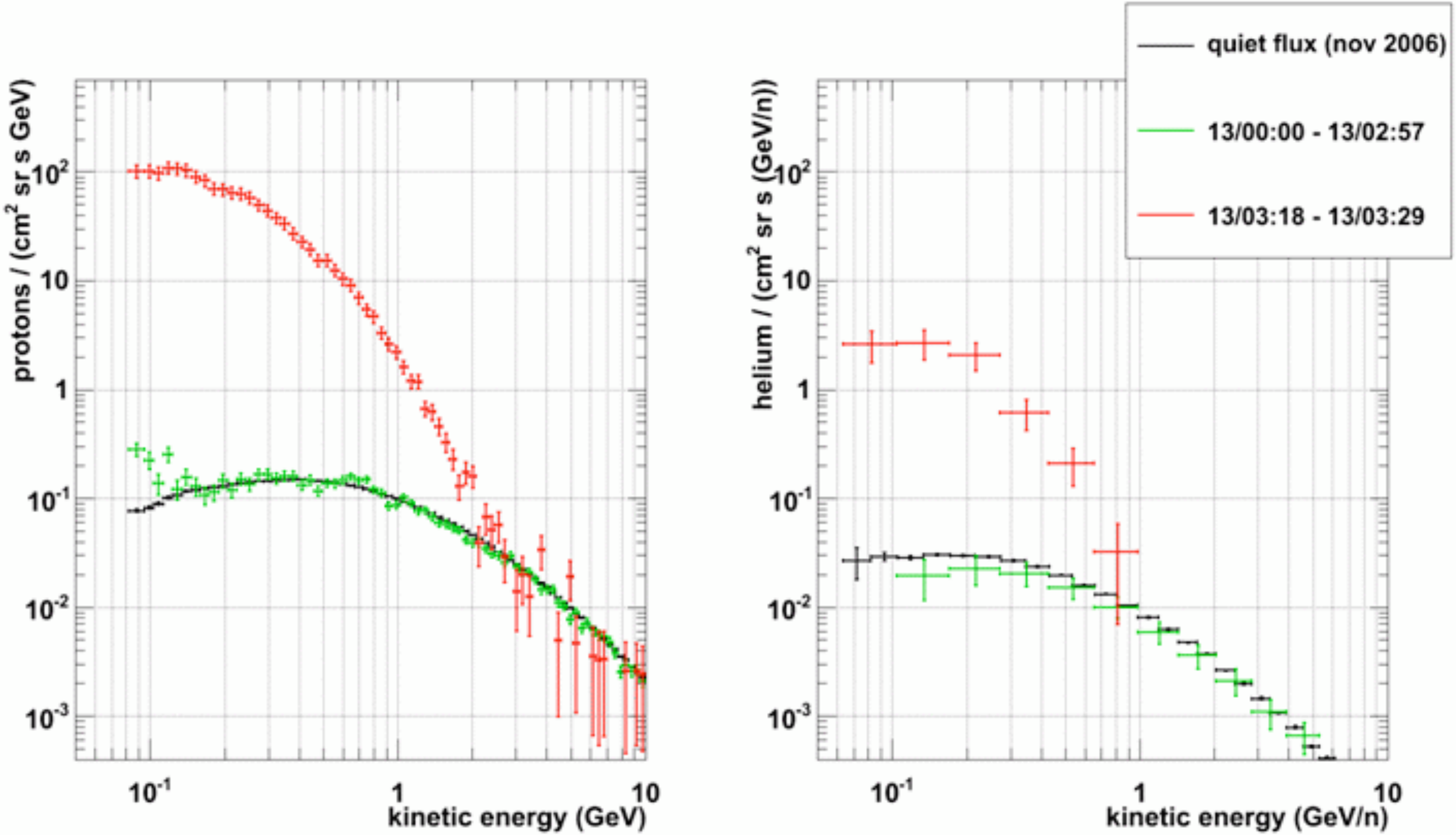


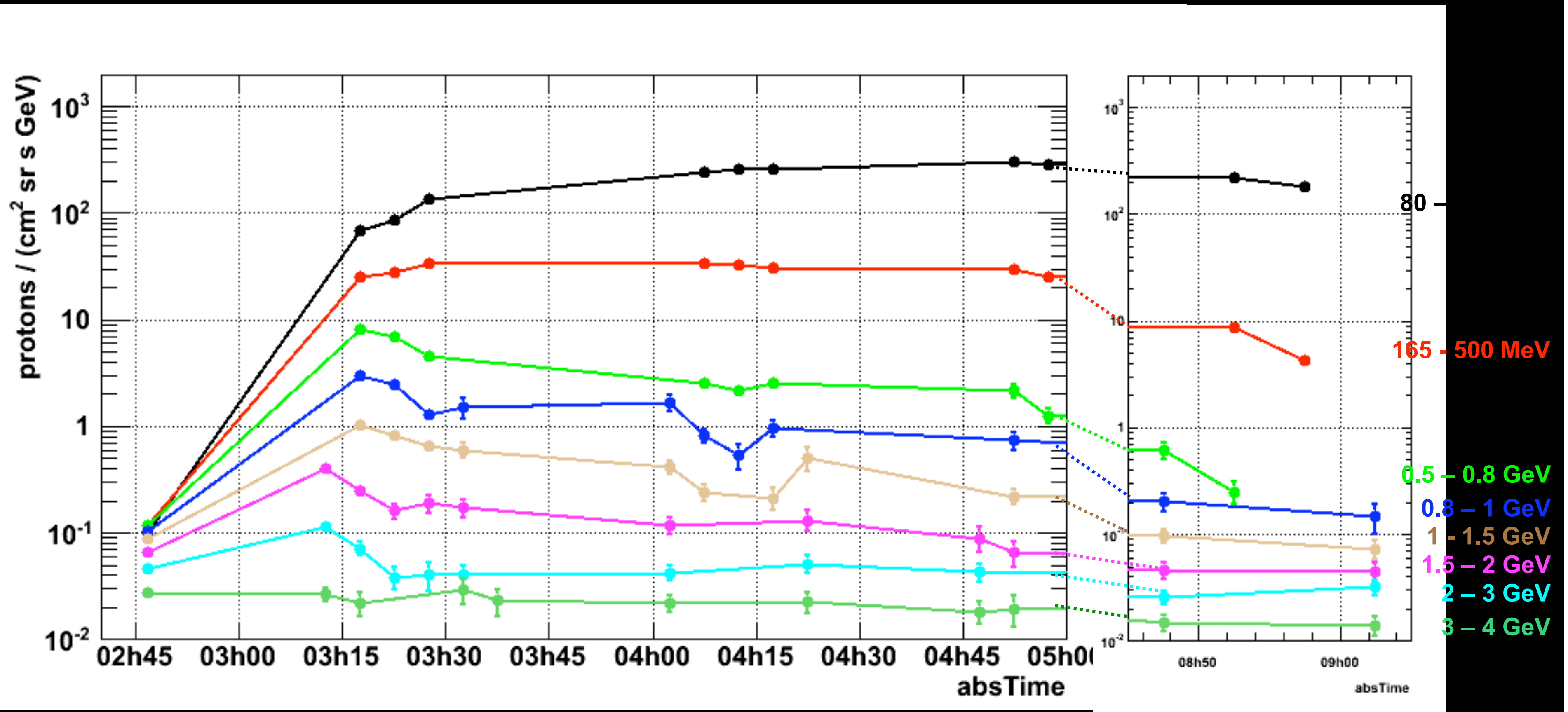




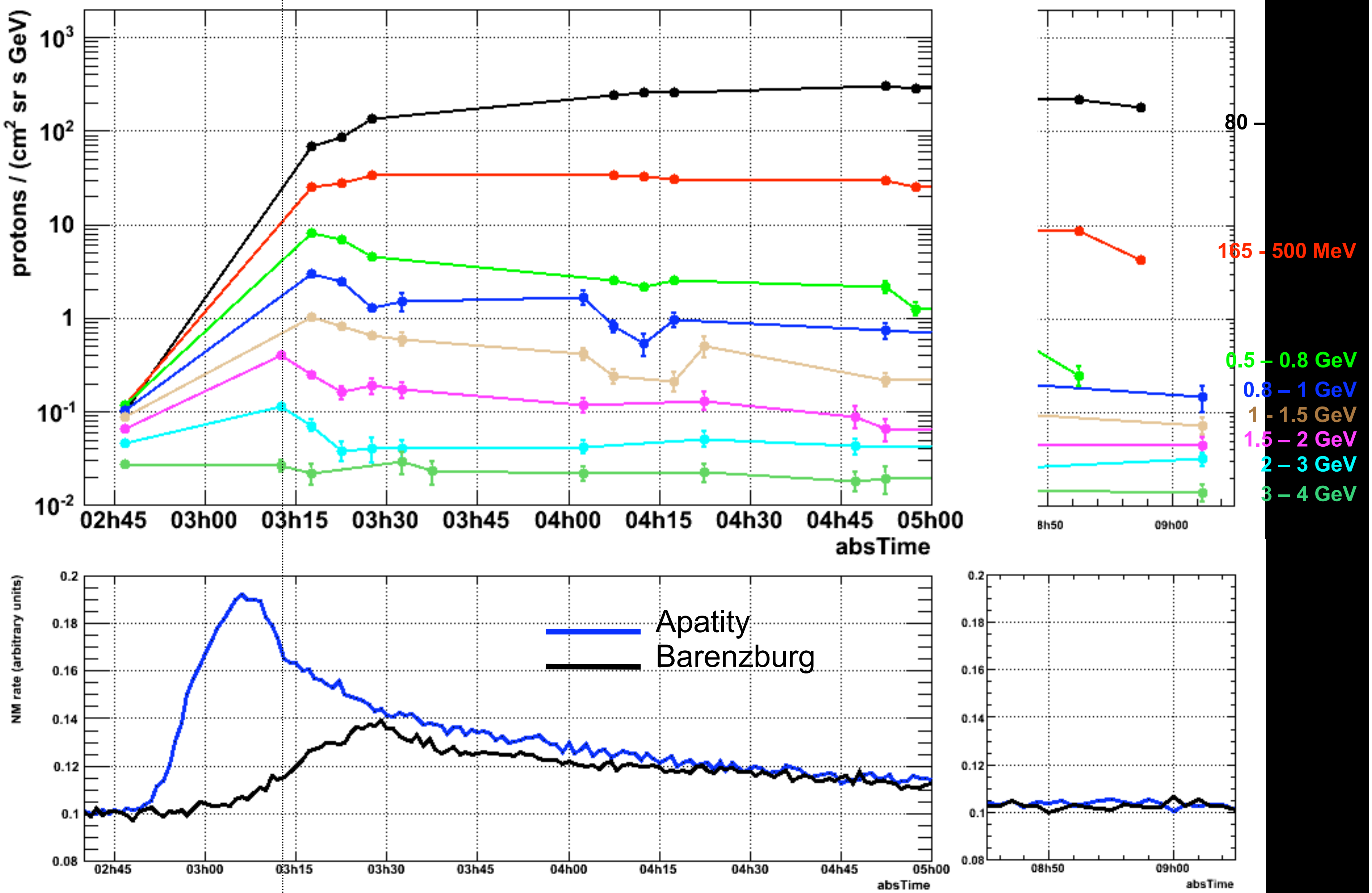
December 13

Proton flux   Helium flux

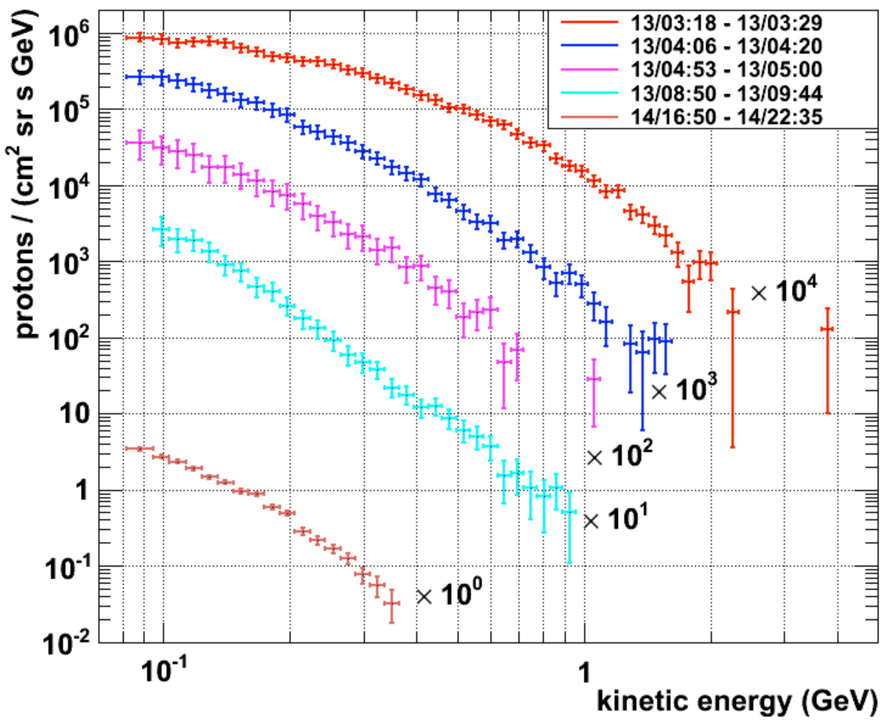




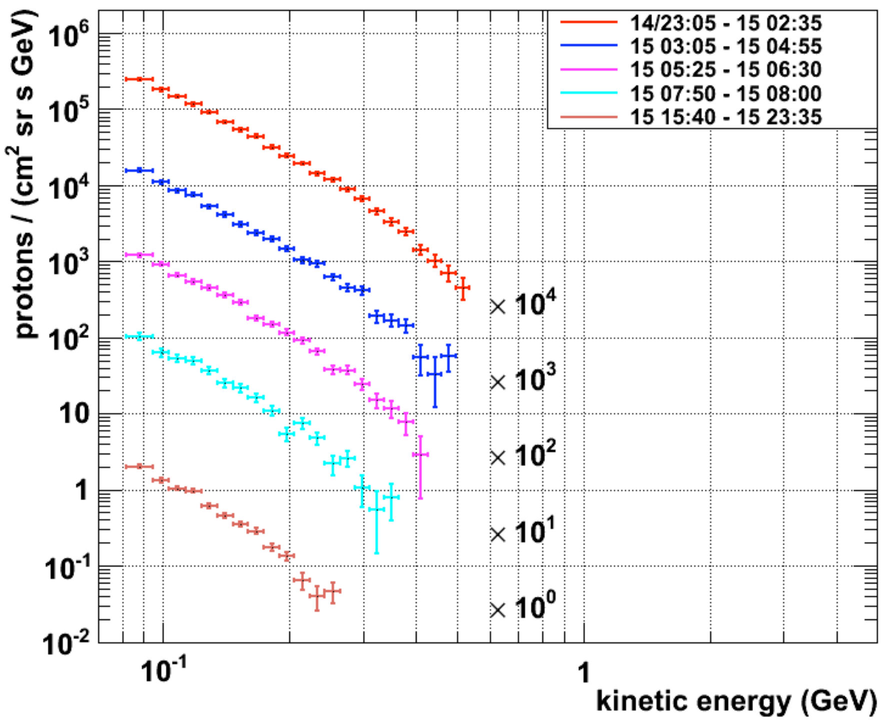
protons / (cm² sr s GeV)
10³
10²
10
1
10⁻¹
10⁻²
02h45
03h00
03h15
03h30
03h45
04h00
04h15
04h30
04h45
05h00
absTime
08h50
09h00
absTime
80 –
165 - 500 MeV
0.5 – 0.8 GeV
0.8 – 1 GeV
1 - 1.5 GeV
1.5 – 2 GeV
2 – 3 GeV
3 – 4 GeV


protons / (cm^2 sr s GeV)
10^3
10^2
10
1
10^{-1}
10^{-2}
02h45 03h00 03h15 03h30 03h45 04h00 04h15 04h30 04h45 05h00
absTime
8h50 09h00
80 –
165 - 500 MeV
0.5 – 0.8 GeV
0.8 – 1 GeV
1 - 1.5 GeV
1.5 – 2 GeV
2 – 3 GeV
3 – 4 GeV
NM rate (arbitrary units)
0.2 0.18 0.16 0.14 0.12 0.1 0.08
Apatity
Barenzburg
02h45 03h00 03h15 03h30 03h45 04h00 04h15 04h30 04h45 05h00
absTime
08h50 09h00
absTime

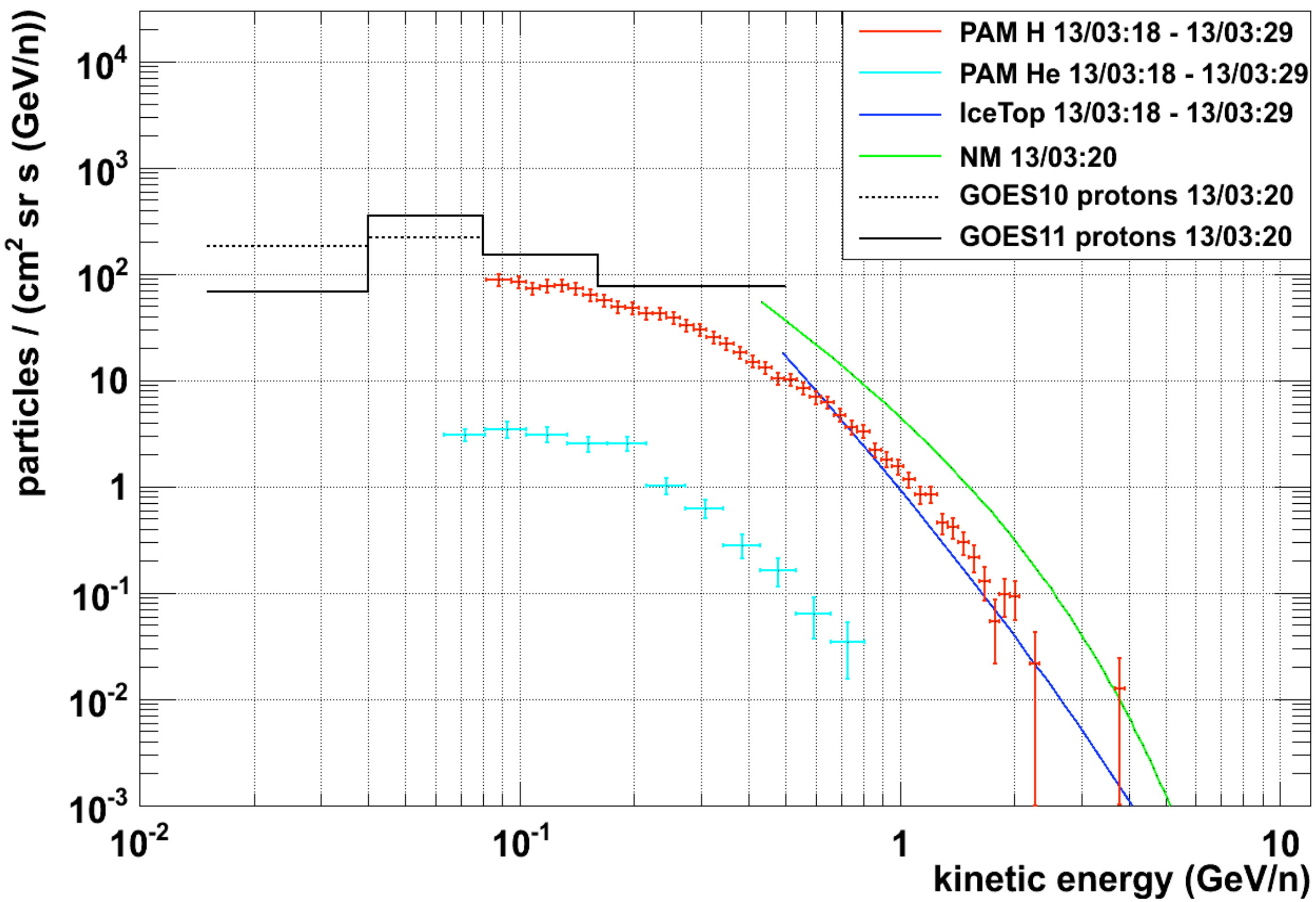
13 December 2006



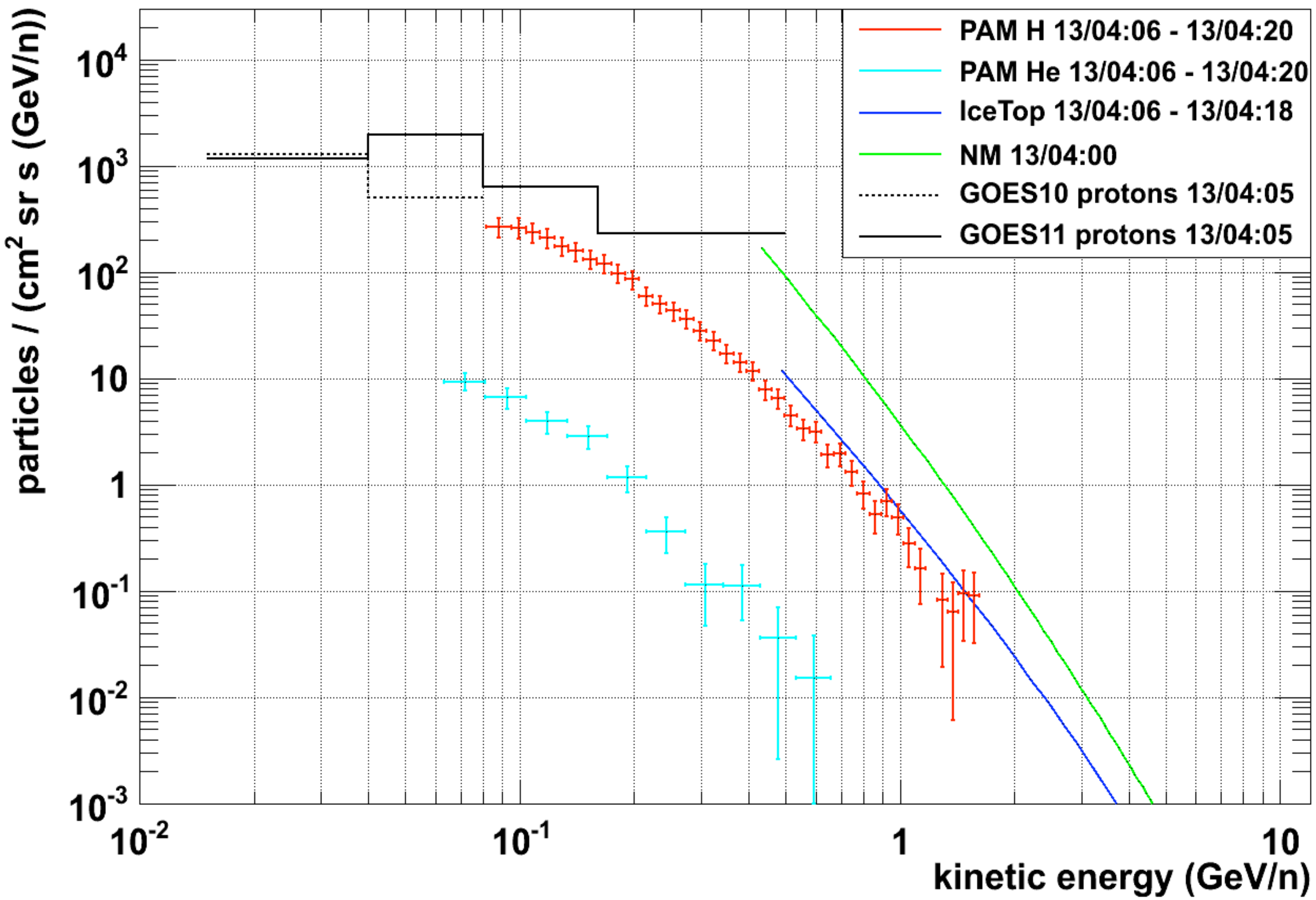
14 December 2006



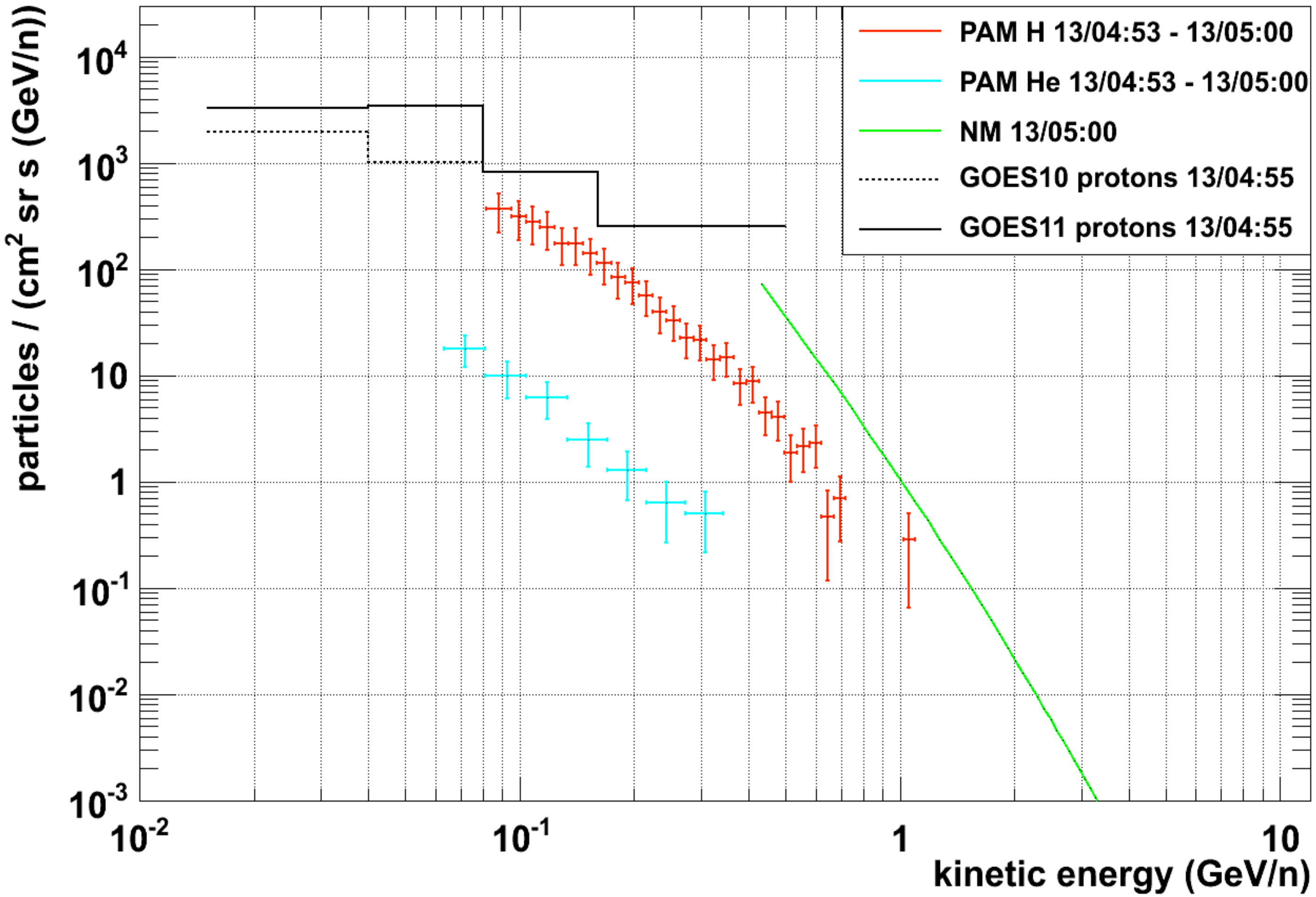
Neutron monitor (Vashenyuk) 03:20 UT
IceTop 03:18 – 03:29 UT
GOES 10 prot. 03:20 UT
GOES 11 prot. 03:20 UT
PAMELA 03:18 – 03:29 UT



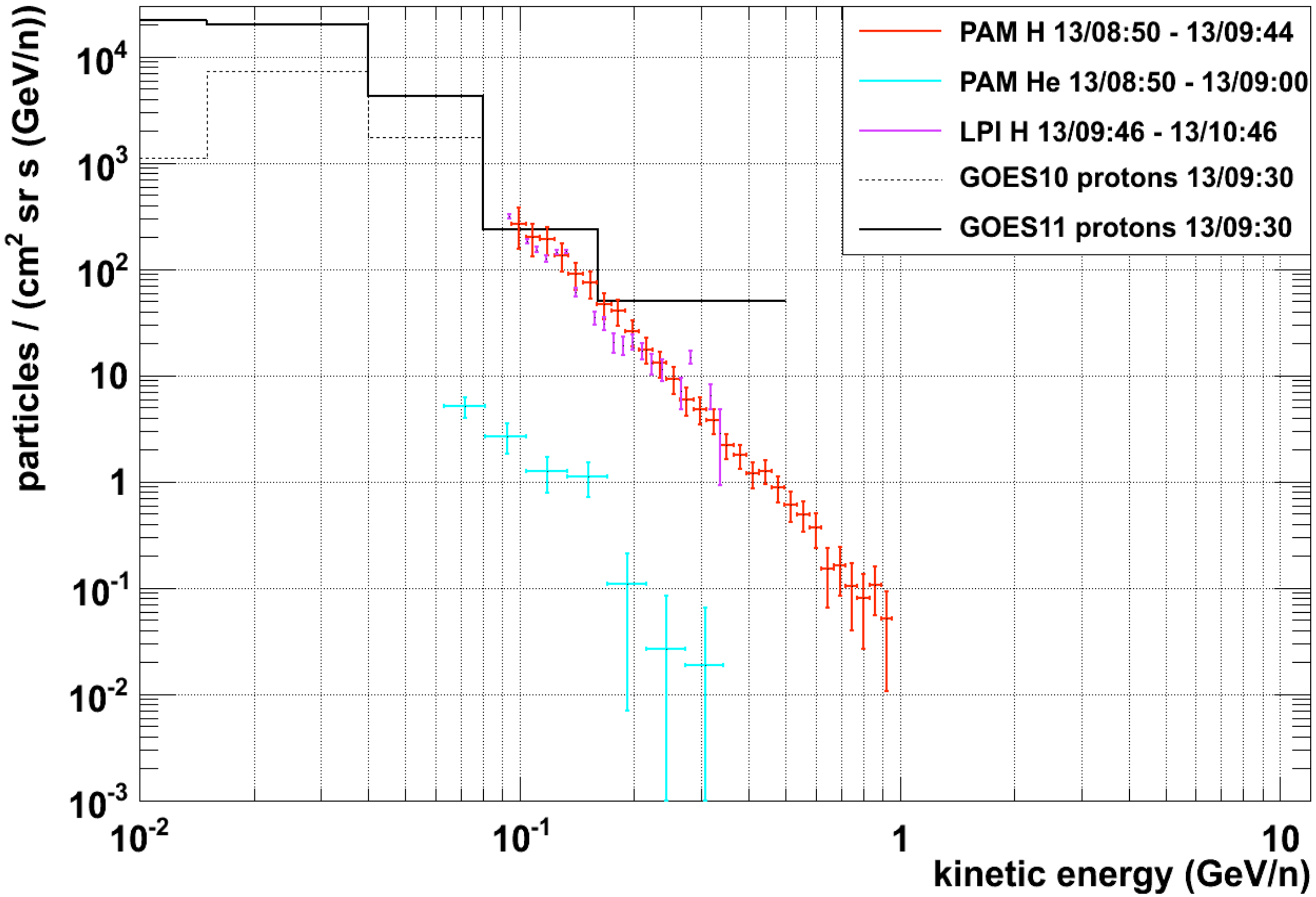
Neutron monitors (Vashenyuk) 04:00 UT
IceTop 04:06 – 04:18 UT
GOES 10 prot. 04:05 UT
GOES 11 prot. 04:05 UT
PAMELA 04:06 – 04:18 UT

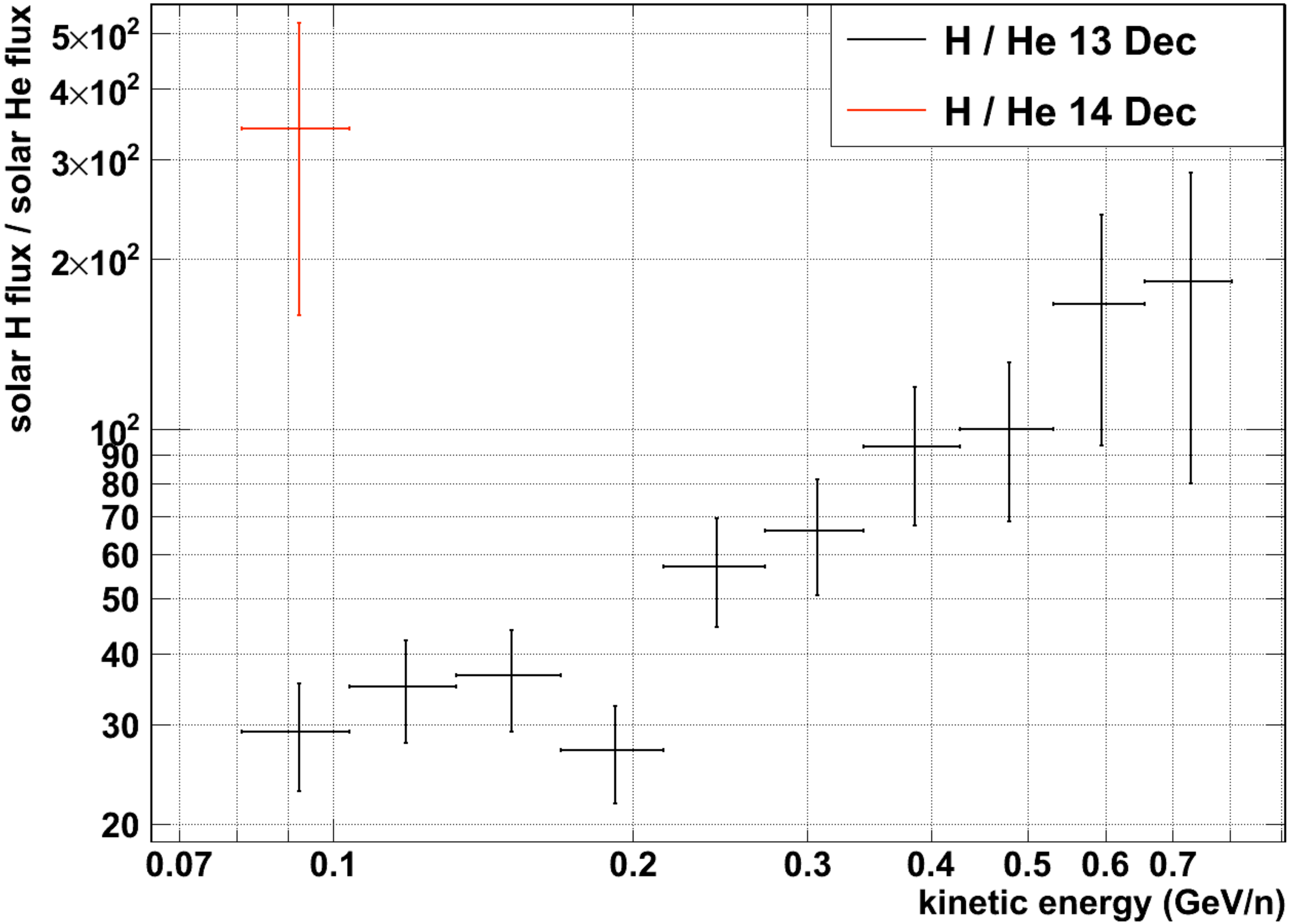


Neutron monitors (Vashenyuk) 05:00 UT
GOES 10 prot. 04:55 UT
GOES 11 prot. 04:55 UT
PAMELA 04:53 – 04:59 UT

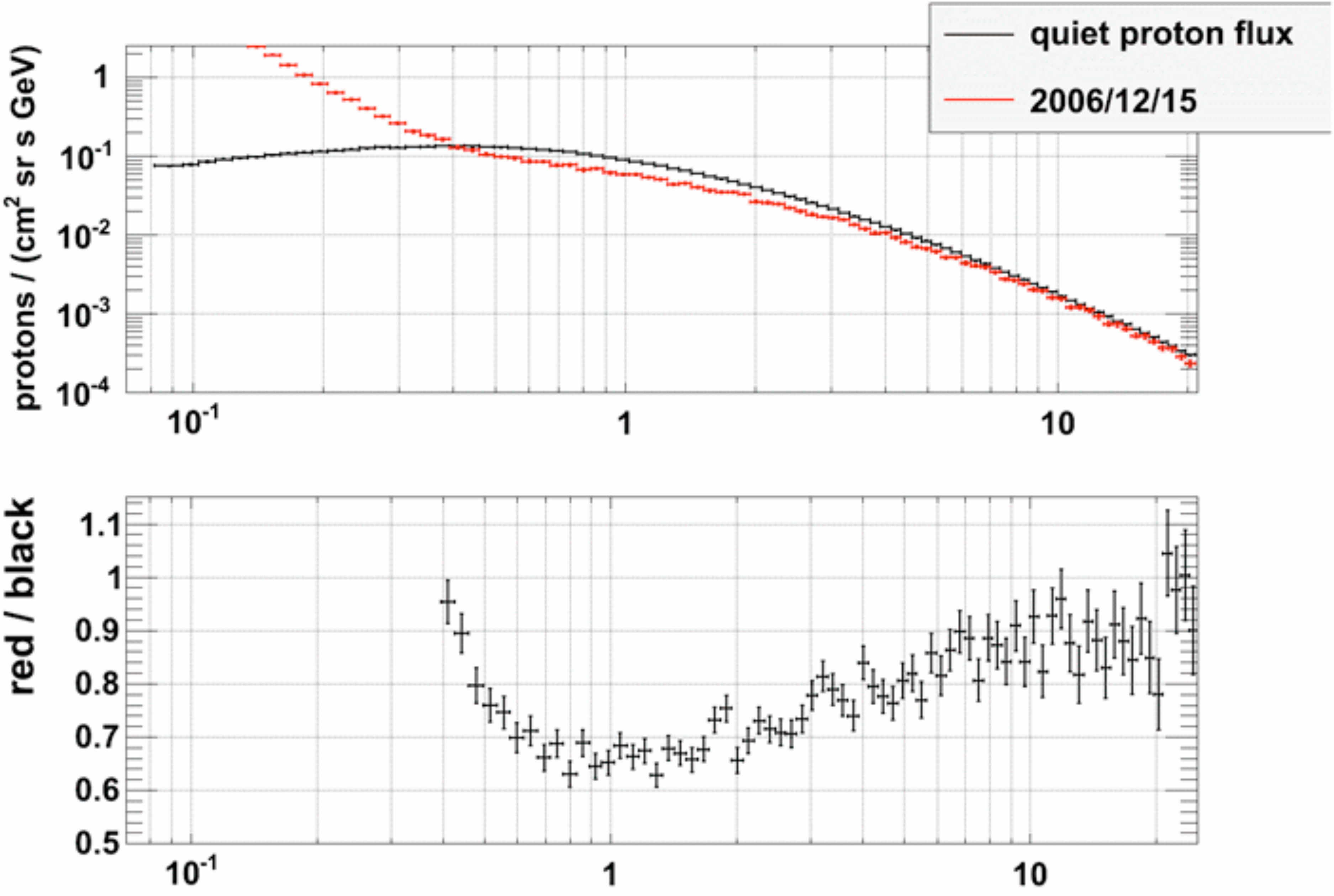


LPI Balloon (Mirny, Antartica)		09:46 – 10:46 UT
GOES 10 prot.		09:30 – 10:45 UT
GOES 11 prot.		09:30 – 10:45 UT
PAMELA		09:32 – 09:34 UT

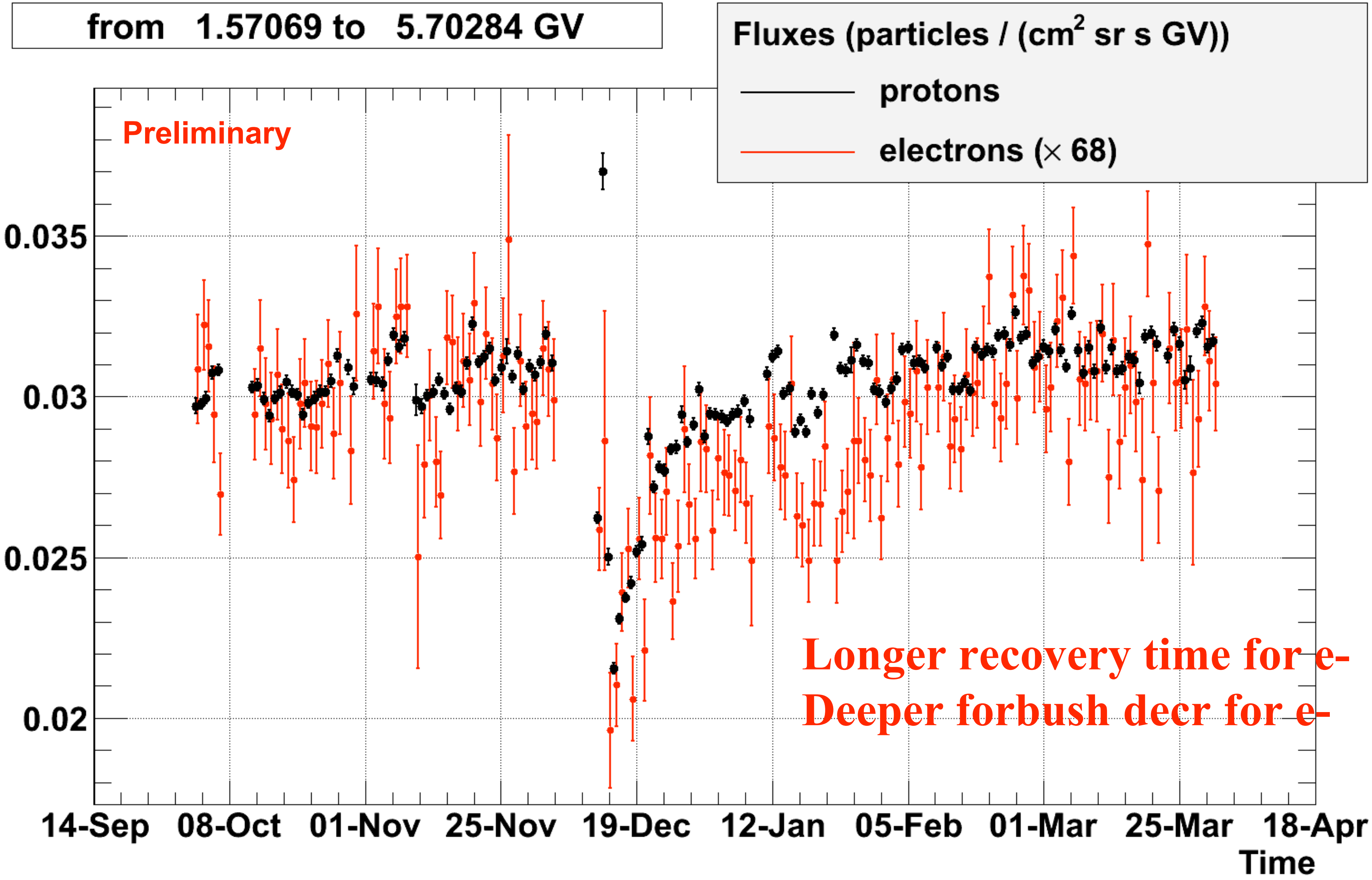



H / He 13 Dec
H / He 14 Dec
solar H flux / solar He flux
5×10²
4×10²
3×10²
2×10²
10²
90
80
70
60
50
40
30
20
0.07
0.1
0.2
0.3
0.4
0.5
0.6
0.7
kinetic energy (GeV/n)

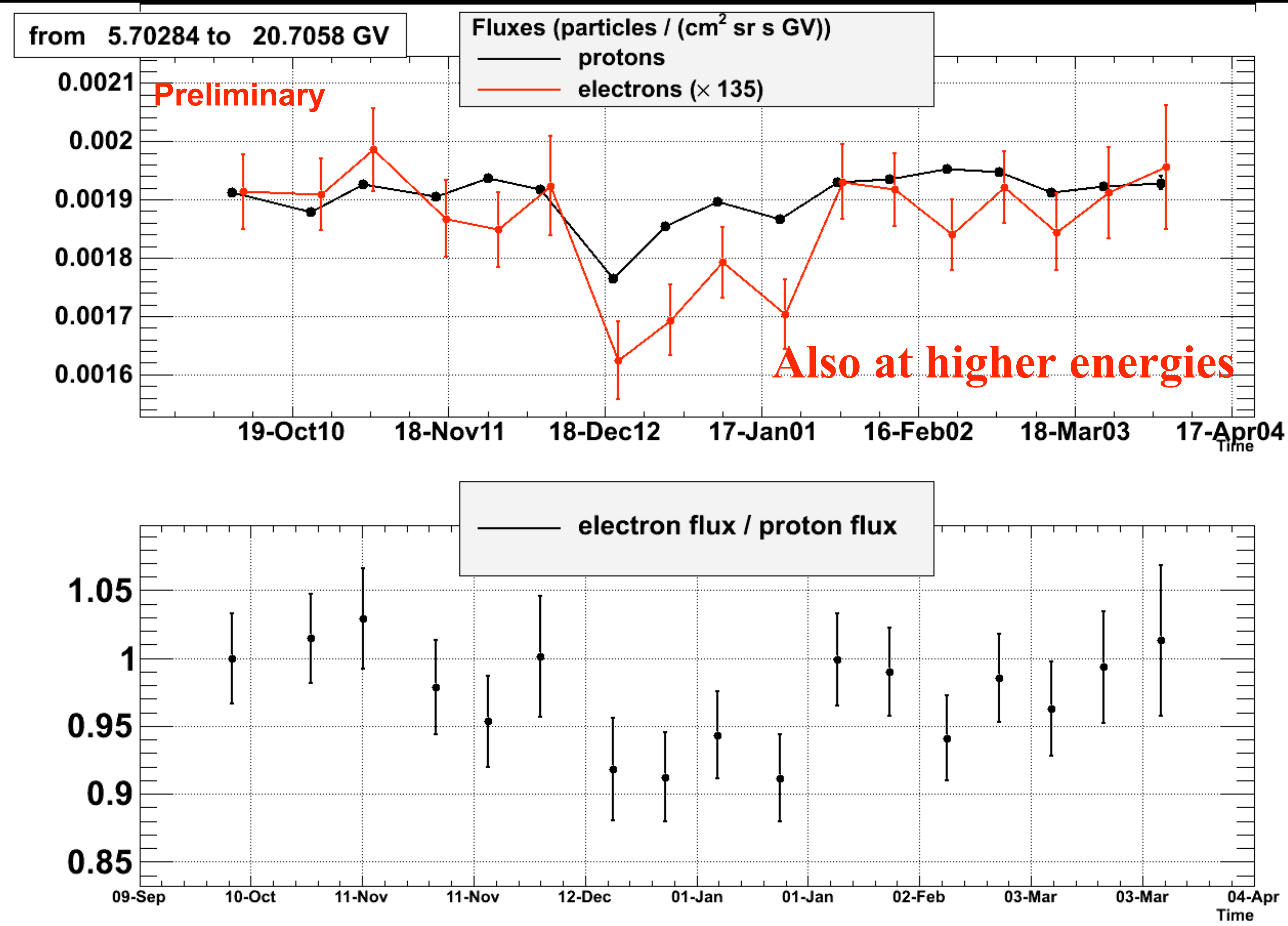
Forbush decrease



Forbush decrease: comparison with e-



Forbush decrease




•Pamela is operating successfully in space
•Expected three years of operations – survived four!
•Mission prolonged 1 more year
•Hope to measure in the 24th solar cycle
http://pamela.roma2.infn.it

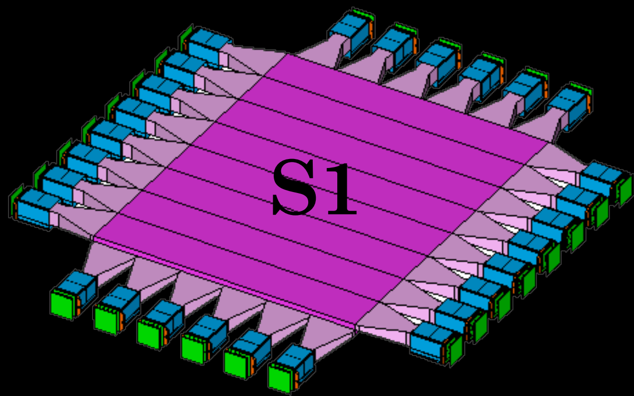
•6 x-y layers arranged on 3 planes;

• 48 channels.

•Albedo rejection

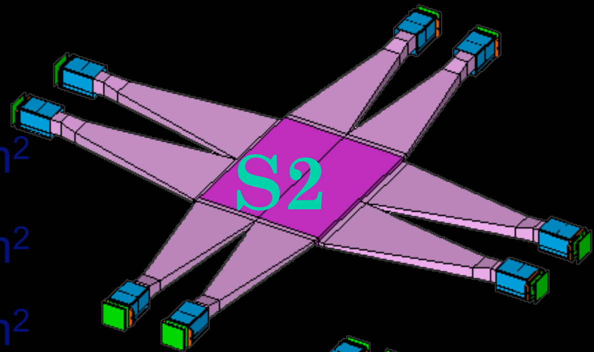
•Part ident. Up to 1 GeV with 150ps resolution

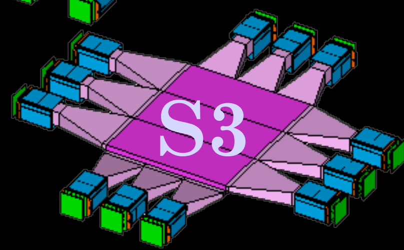
•Nuclear identification up to Oxygen



DIMENSIONS

S11	8	330 x 51 mm^2	7 mm	357 mm^2
S12	6	408 x 55 mm^2	7 mm	385 mm^2
S21	2	180 x 75 mm^2	5 mm	375 mm^2
S22	2	150 x 90 mm^2	5 mm	450 mm^2
S31	3	150 x 60 mm^2	7 mm	420 mm^2
S32	3	180 x 50 mm^2	7 mm	350 mm^2





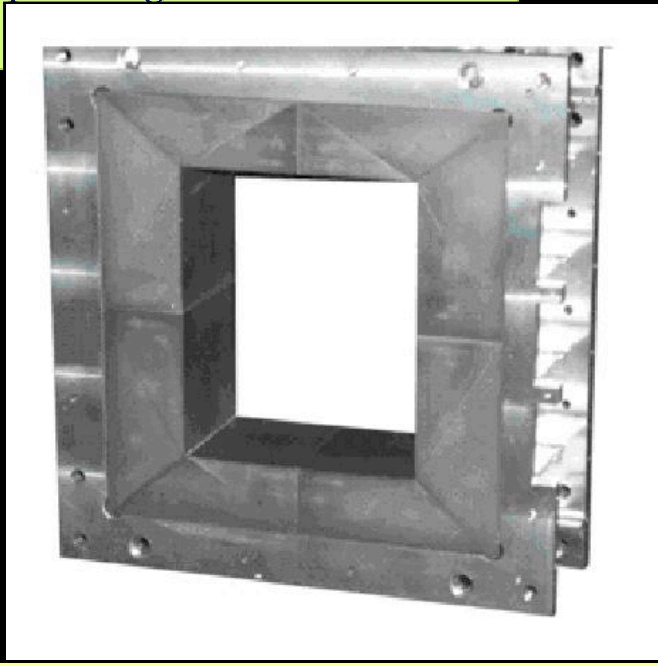
Adapted from W. Menn

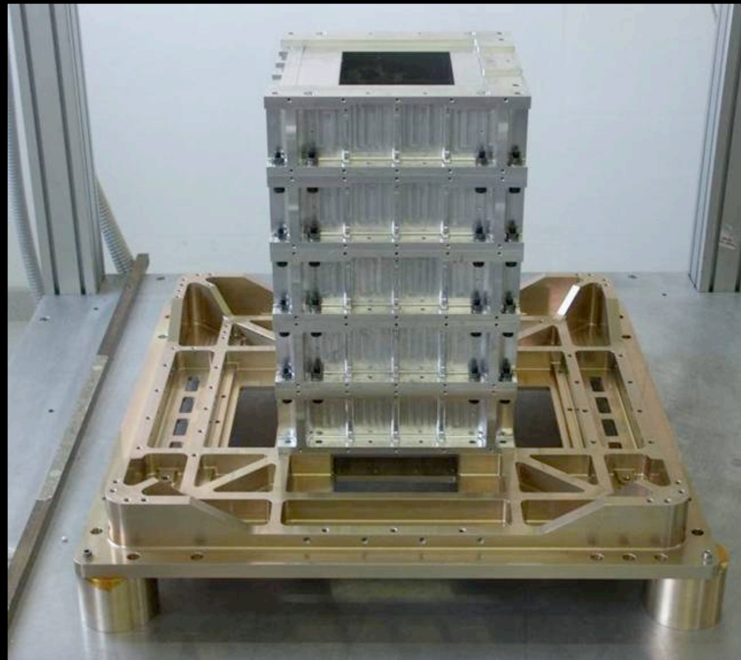
The permanent magnet

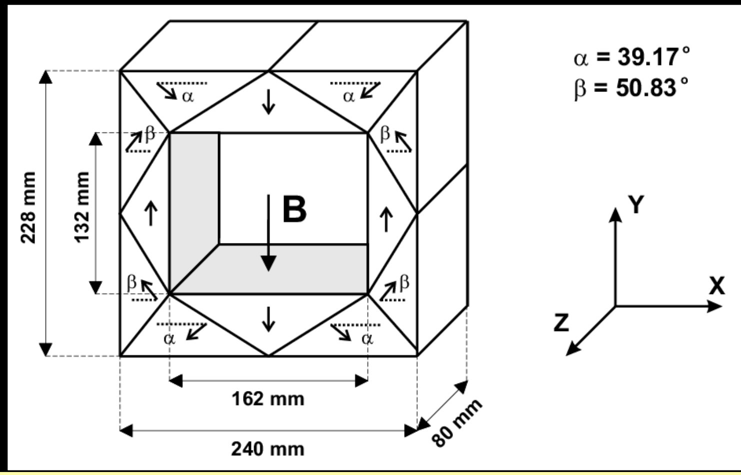
- 5 magnetic modules
- Permanent magnet (Nd-Fe-B alloy) assembled in an aluminum mechanics
- Magnetic cavity sizes (132 x 162) mm^2 x 445 mm
- Field inside the cavity 0.48 T at the center
- Average field along the central axis of the magnetic cavity : **0.43 T**

Geometric Factor: **20.5 cm^2sr**

- Black IR absorbing painting
- Magnetic shields







The permanent magnet

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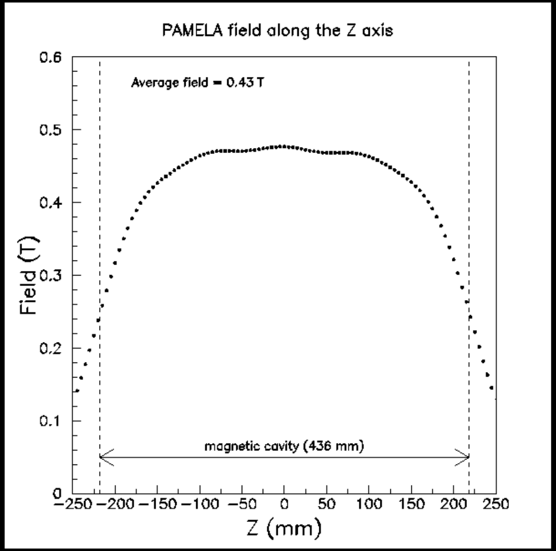
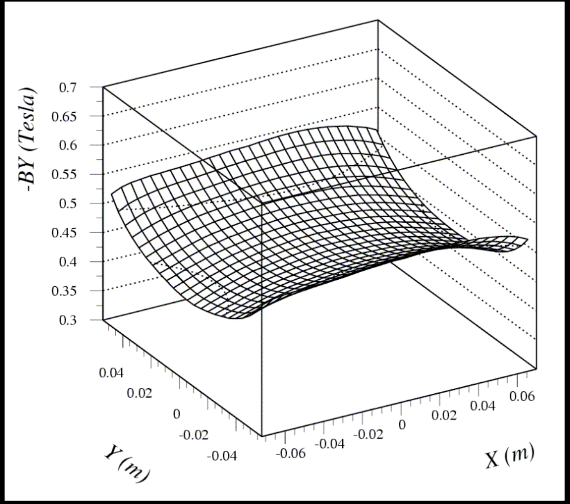
- Magnetic cavity sizes (132 x 162) mm^2 x 445 mm
- Geometric Factor: **20.5 cm^2sr**
- Black IR absorbing painting
- Magnetic shields

MAGNETIC FIELD MEASUREMENTS

- Gaussmeter (F.W. Bell) equipped with 3-axis probe mounted on a motorized positioning device (0.1mm precision)
- Measurement of the three components in 67367 points 5mm apart from each other
- Field inside the cavity 0.48 T at the center
- Average field along the central axis of the magnetic cavity : **0.43 T**
- Good uniformity
- Measurement of external magnetic field – magnetic momentum < 90 Am^2

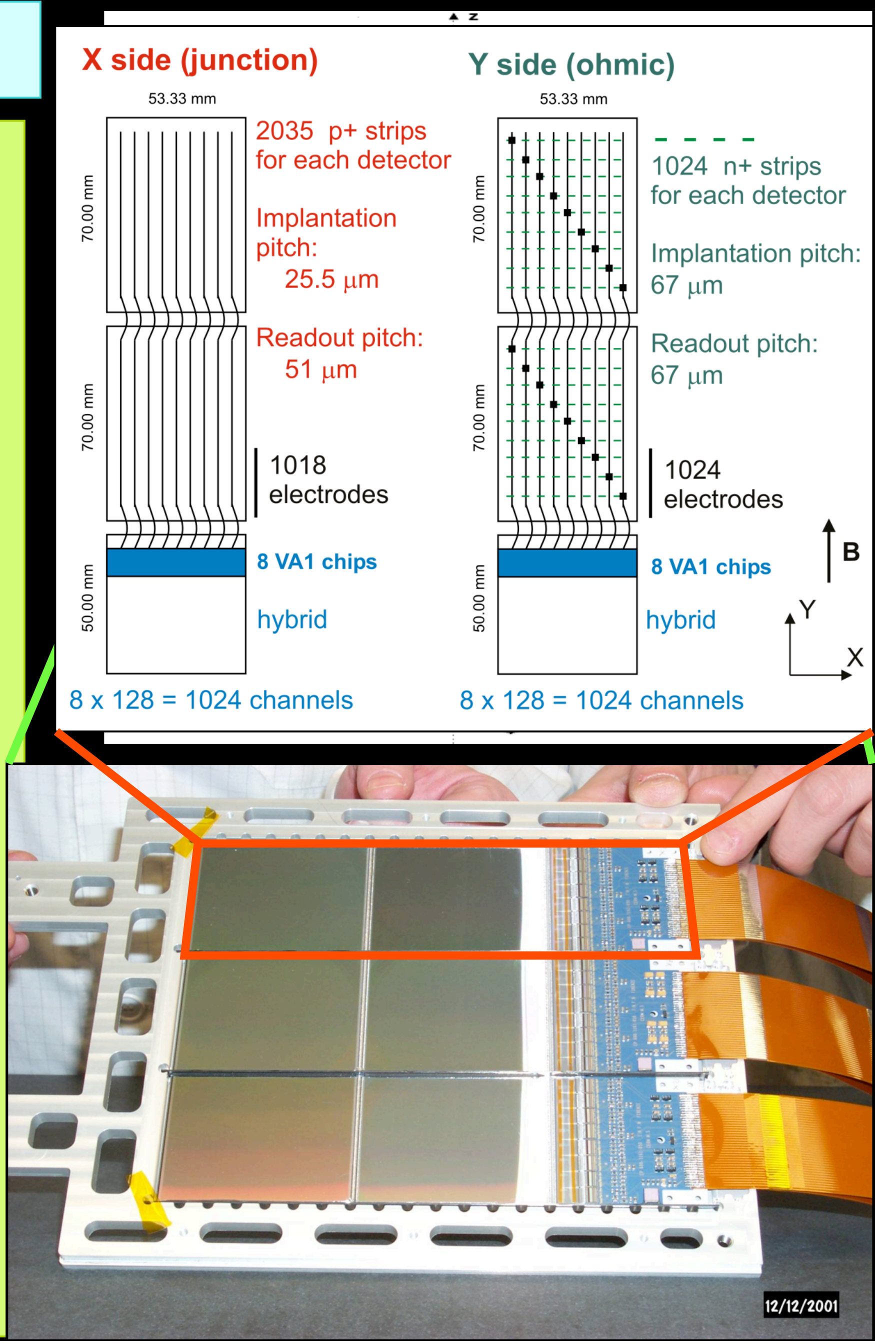




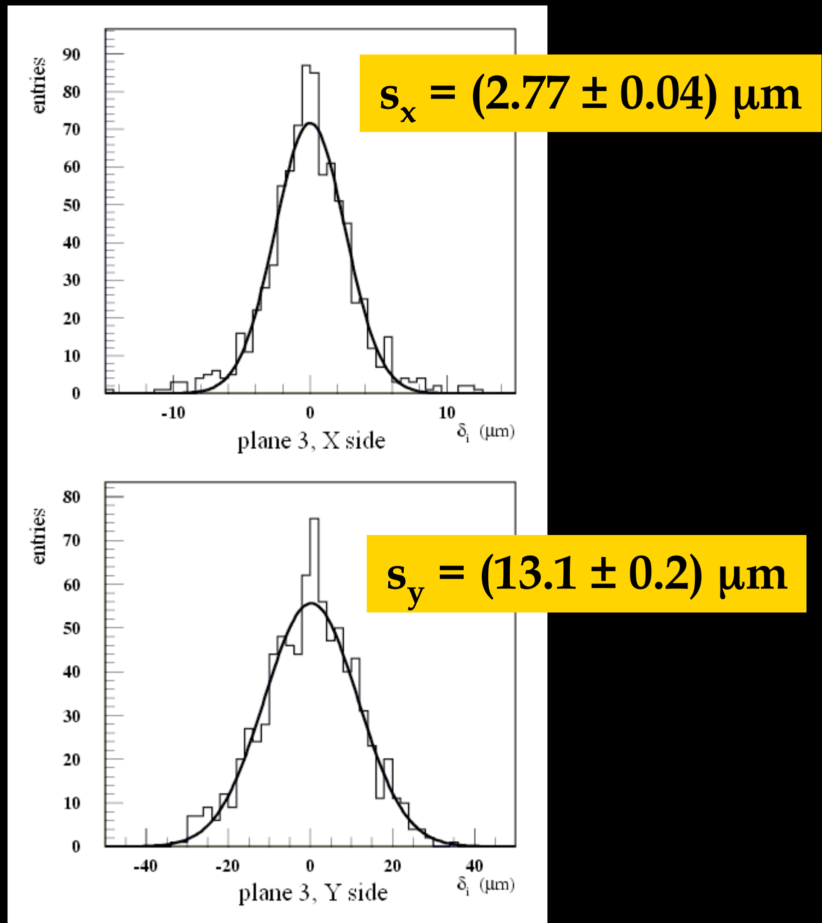
The tracking system

6 detector planes composed by 3 "ladders"

- Mechanical assembly
  - no material above/below the plane (1 plane = 0.3% X_0)
  - carbon fibers stiffeners glued laterally to the ladders
- ladder : - 2 microstrip silicon sensors
  - 1 "hybrid" with front-end electronics
- silicon sensors (Hamamatsu):
  - 300 mm, Double Sided - x & y view
  - Double Metal - No Kapton Fanout
  - AC Coupled - No external chips
- FE electronics: VA1 chip
  - Low noise charge preamplifier -
  - Operating point set for optimal compromise:
    - total FE dissipation: 37 W on 36864 channels
    - Dynamic range up to 10 MIP
- DAQ: 12 DSPs
  - data compression (>95%)
  - on-line calibration (PED,SIG,BAD)

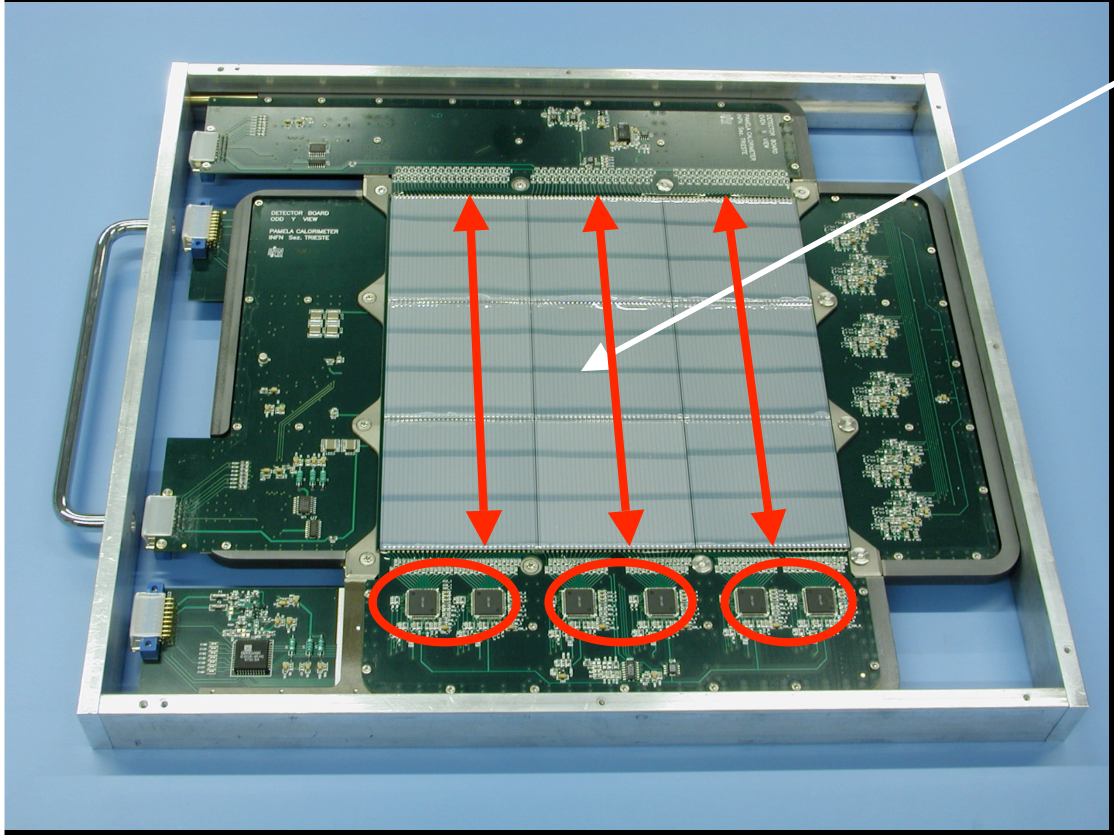


Spatial resolution



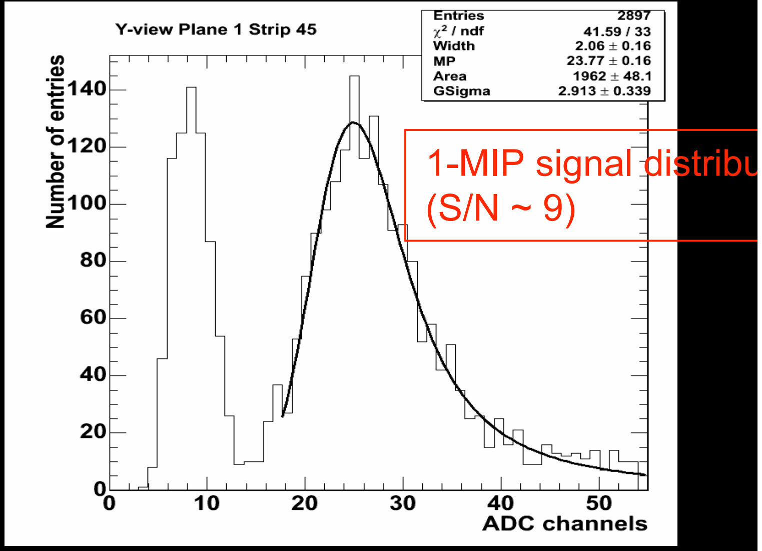
40-100 GeV pions (CERN-SPS 2000) beam-test of a small tracking-system prototype

Imaging Calorimeter



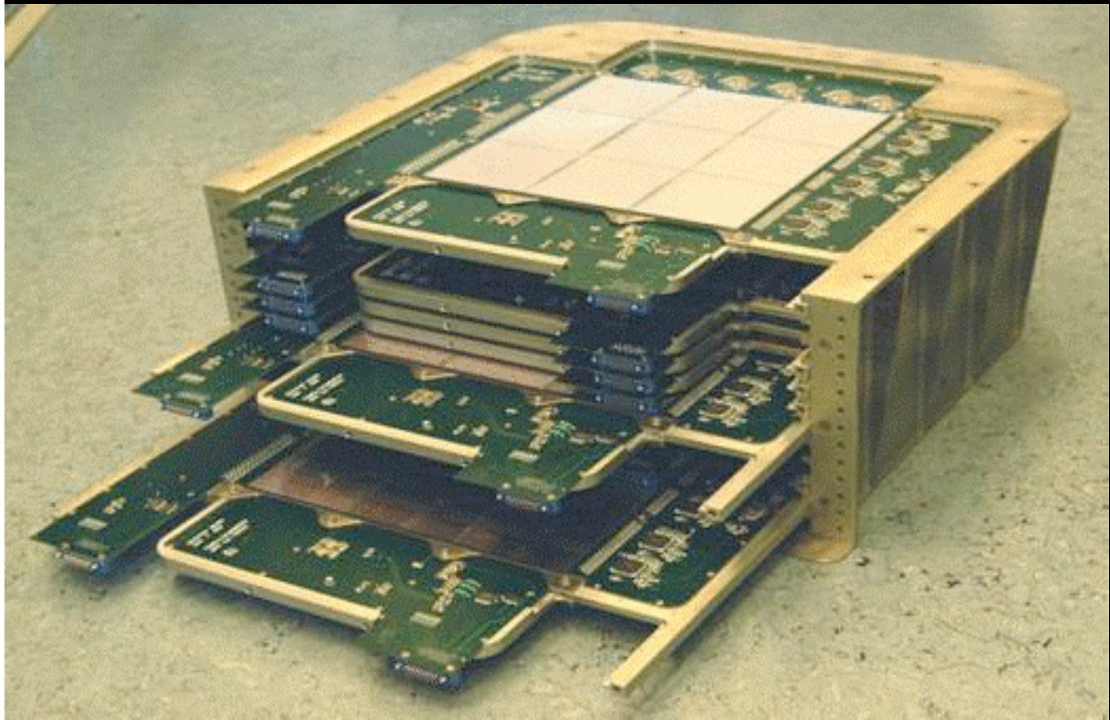
44 Si detector views (22X and 22Y)

- $8x8\ cm^2$ detectors arranged in a 3x3 matrix
- 32 strips/detector, 2.4 mm pitch
- Strips of detectors in the same row (column) are bonded together (ladder) ⇒ 24 cm long strips
- Each ladder (32 channels) is read out by 2 CR1.4P front-end chips ⇒ 6 front-end chips/view
- In total:
  - 396 silicon detectors
  - 264 CR1.4P chips
  - 4224 channels



From V. Bonvicini

Imaging Calorimeter



- **Main tasks:**
- **lepton/hadron discrimination**
- **$e^{+/-}$ energy measurement**

- **Characteristics:**
- **22 W plates (2.6 mm / 0.74 X_0)**
- **44 Si layers (X-Y), 380 μm thick**
- **Total depth: 16.3 X_0 / 0.6 λ_I**
- **4224 channels**
- **Self-triggering mode option (> 300 GeV; GF~600 cm^2 sr)**
- **Mass: 110 kg**
- **Power Consumption: 48 W**

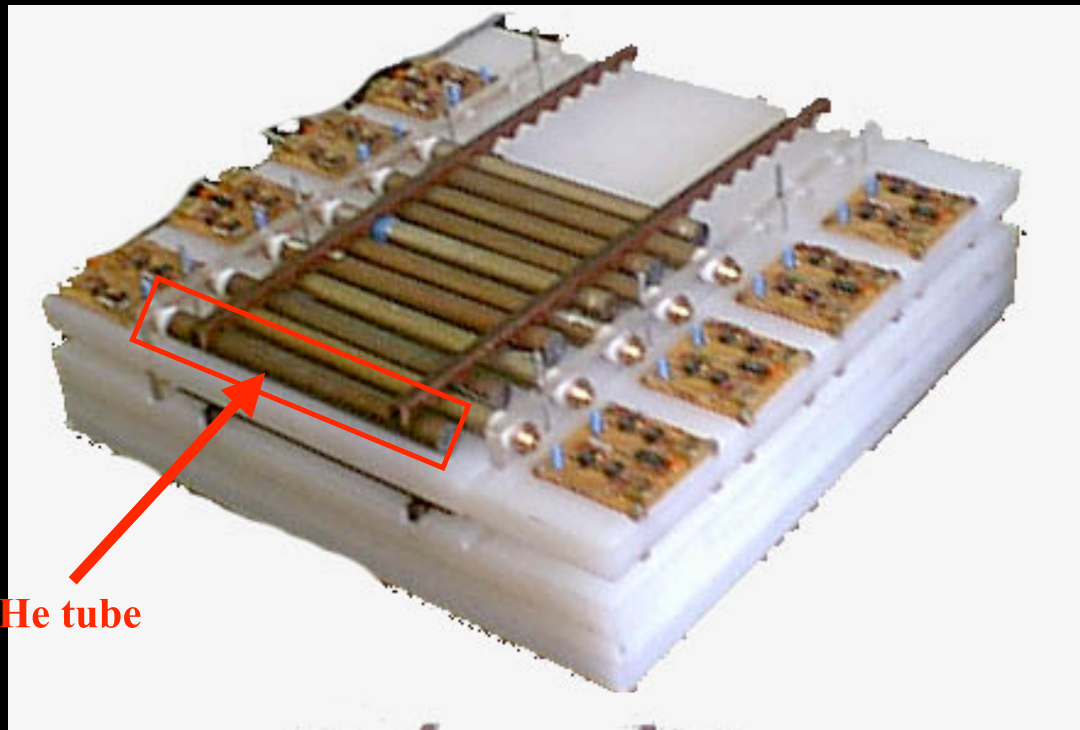
- **Design performance:**
- **$\bar{p}$,e^+ selection efficiency ~ 90%**
- **p rejection factor ~ 10^5**
- **e rejection factor > 10^4**
- **Energy resolution ~ 5% @ 200 GeV**

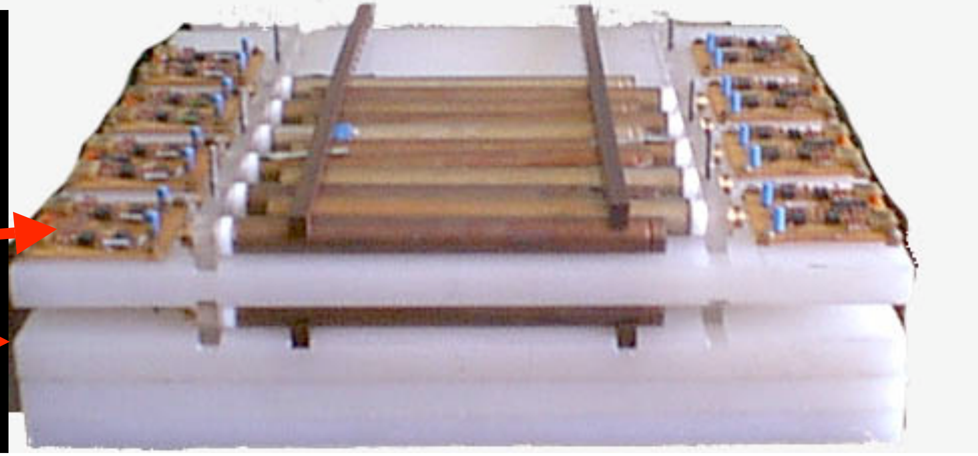
Adapted from V. Bonvicini

Neutron Detector

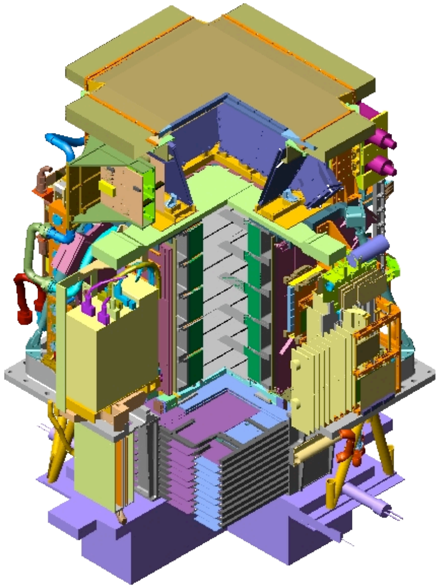
Lebedev Physical Institute Academy of Science, Russia

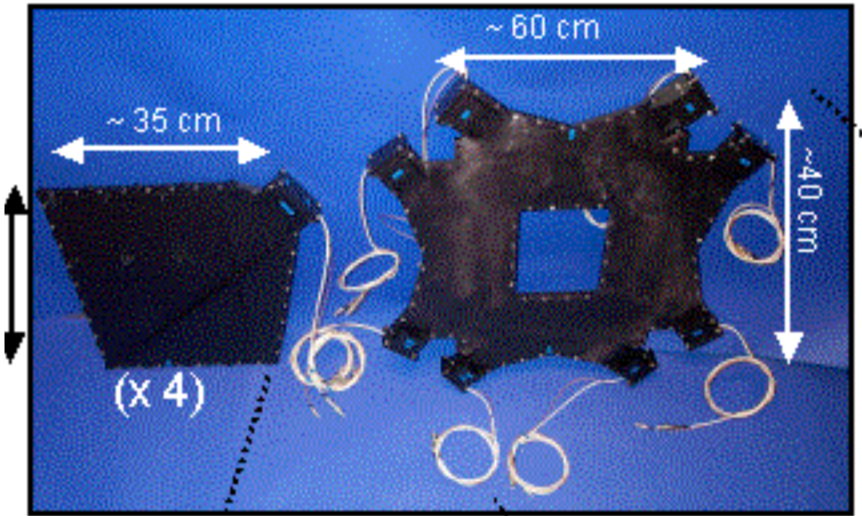
- 36 ^{3}He containers (2 planes)
- 9.5 cm polyethilene moderator enveloped in thin cadmium layer.
- 60x55x15 cm^3,   30 kg, 10 W
- **(10% eff for E<1MeV n)**
- Triggered counts
- Background counting



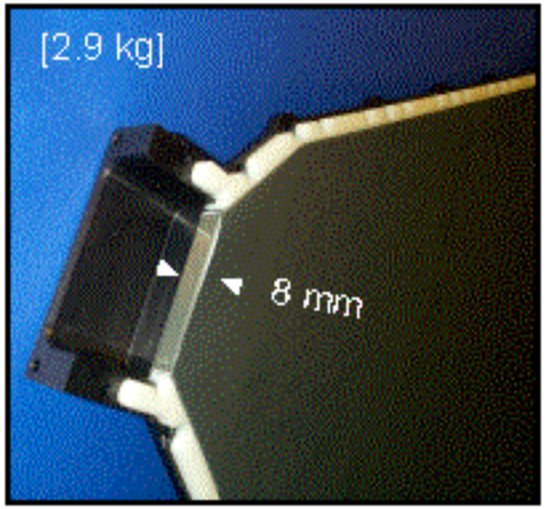


The Anticoincidence Systems



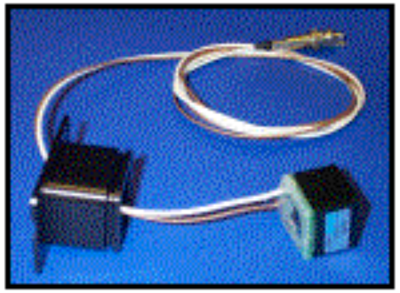


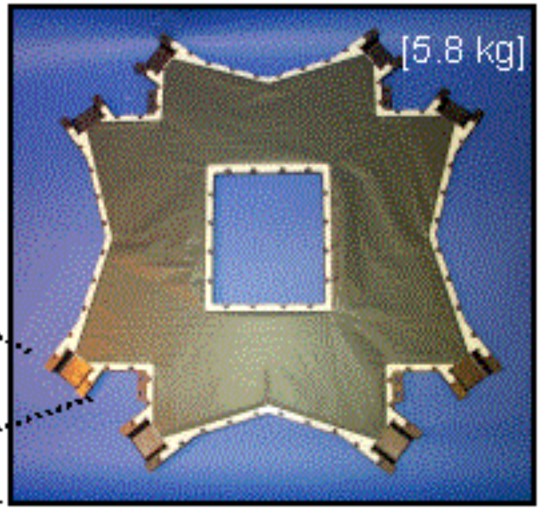
Anticoincidences are mounted on the sides, top and interscintillator area. They are used to reject false triggers coming from the satellite



[Bicron BC-448M]

[Hamamatsu R5900U]



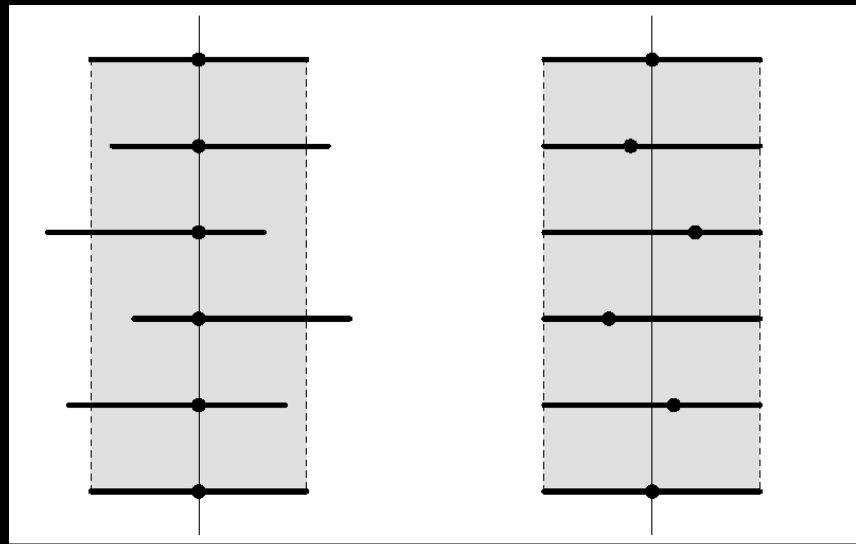


[3M Tedlar / Tyvek]

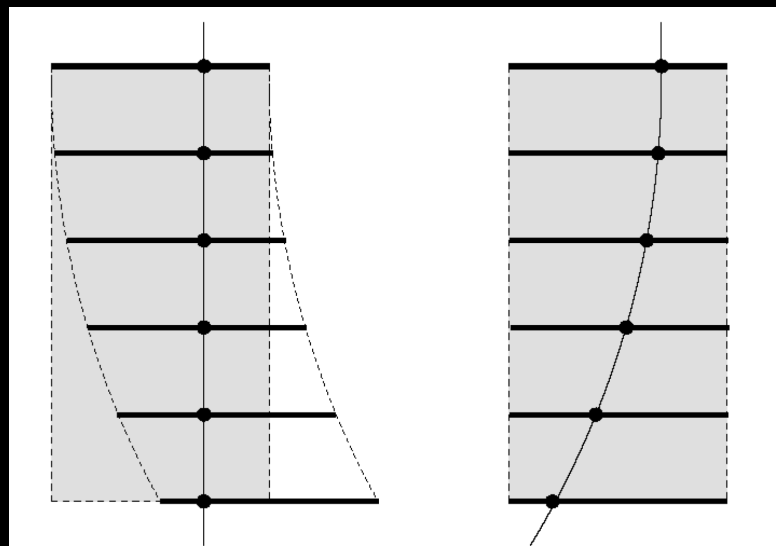
Alignment

Critical Issue: an antiparticle
Can be faked if alignment of the
detector is wrongly considered

Incoherent misalignment
Correction with protons
2 steps: column alignment +
inter-column alignment



Coherent misalignment
Correction with electrons
(or electrons + positrons)
and comparison with
simulation

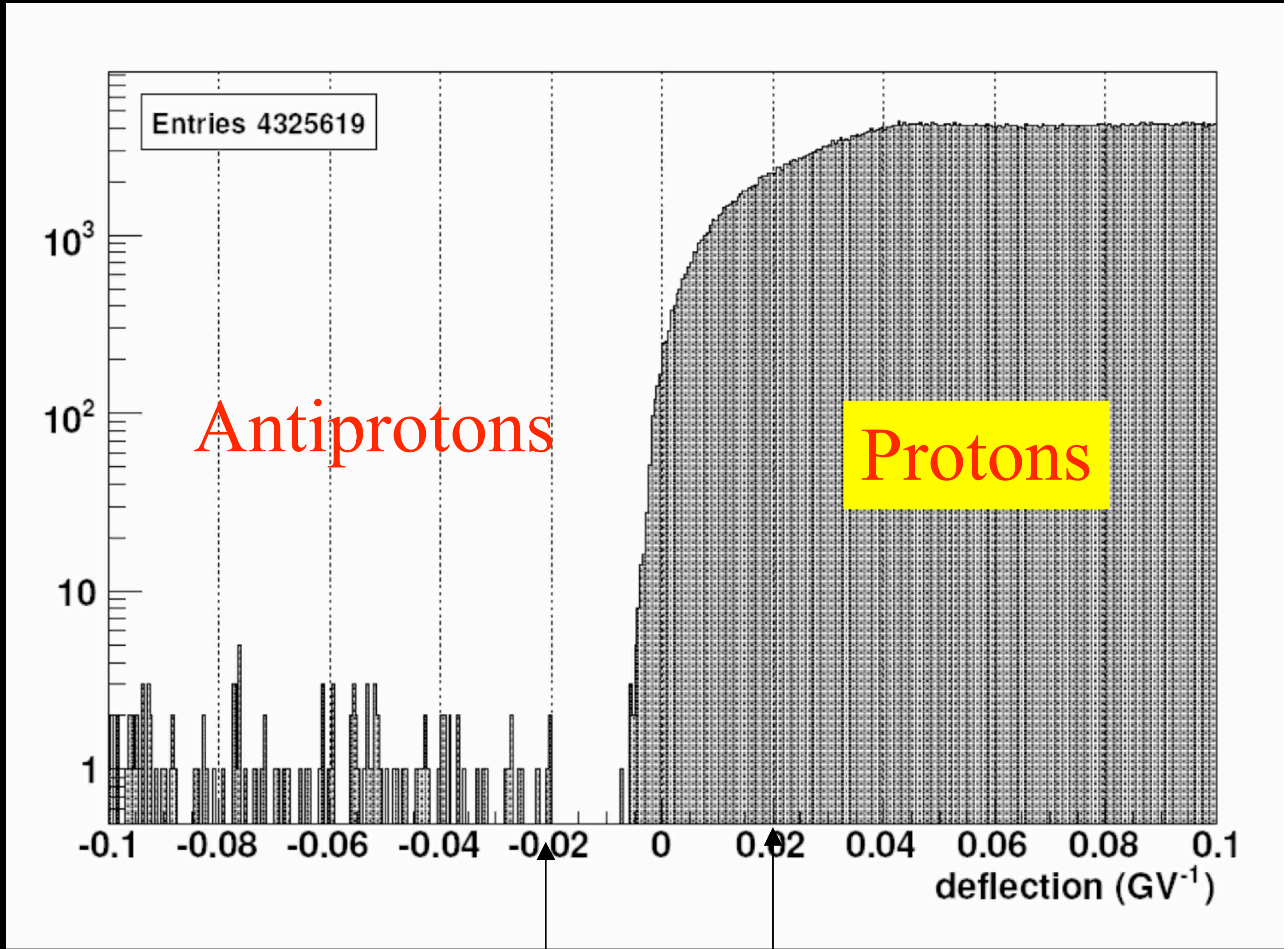


From E. Vannuccini, P. Papini

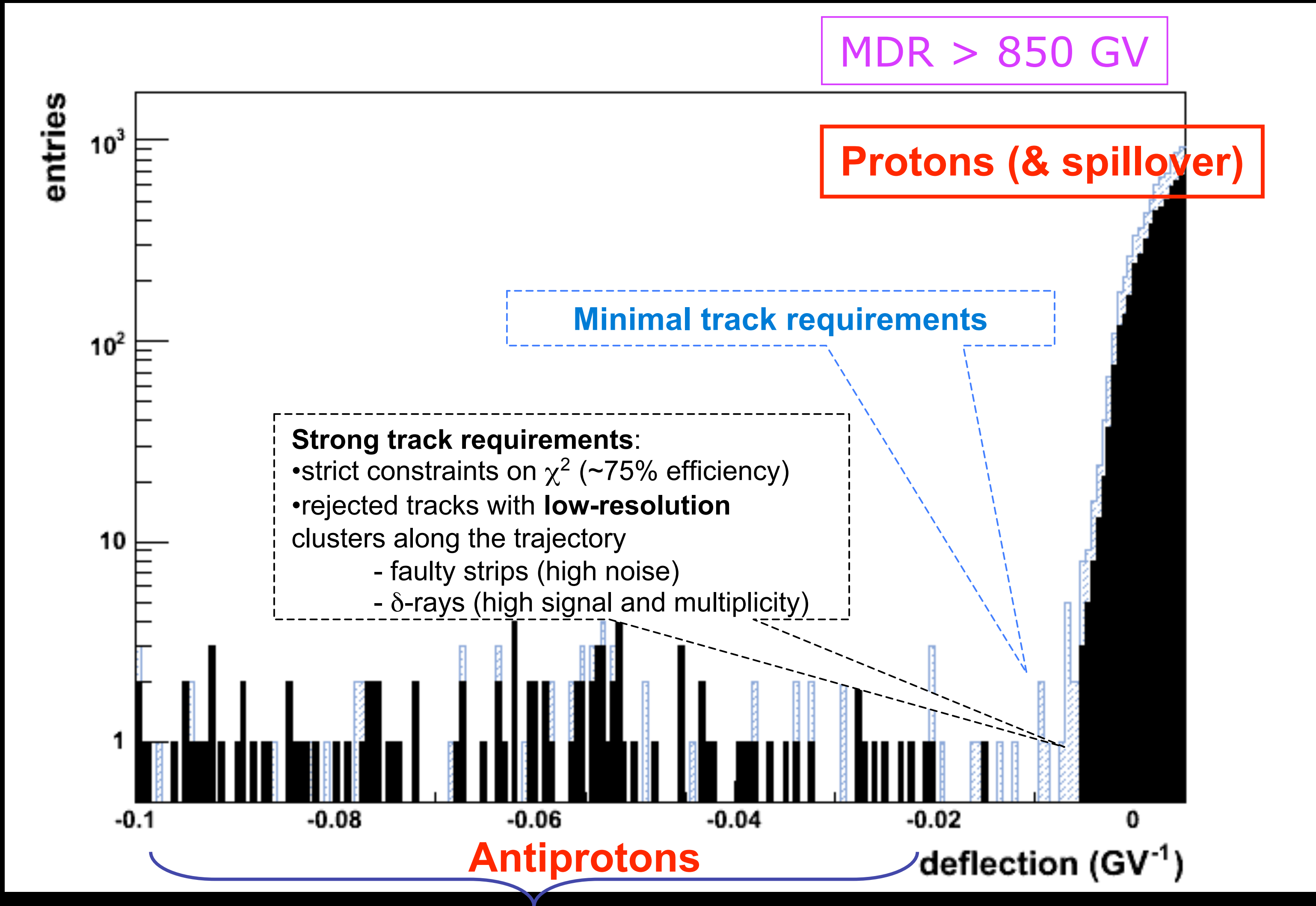
Deflection

D=1/R

Very sharp and conservative cuts
Maximum lever (top and bottom planes of the spectrometer must be hit)
arm in magnet to keep spillover under control
Then release this criterium

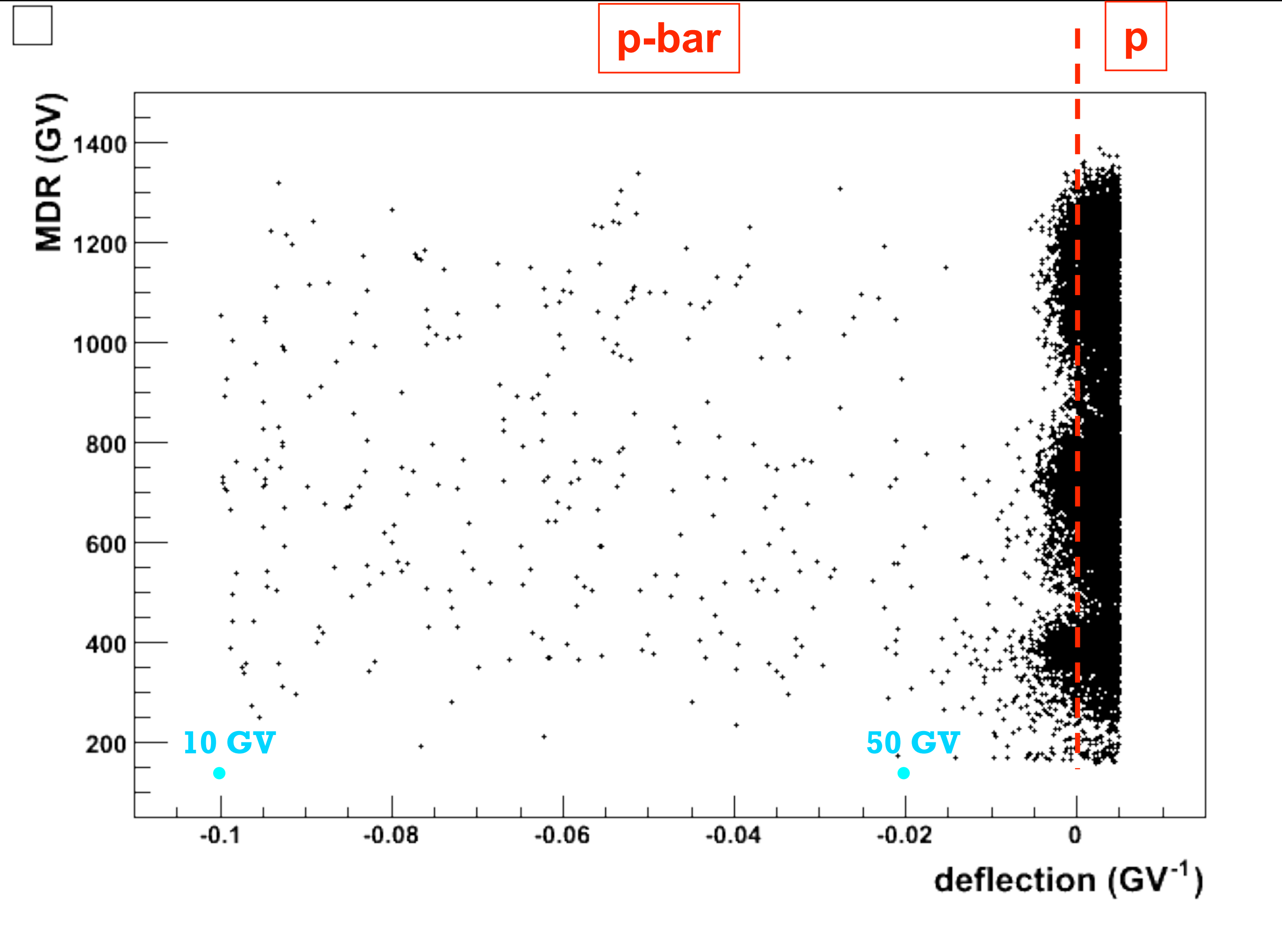


Proton spillover background



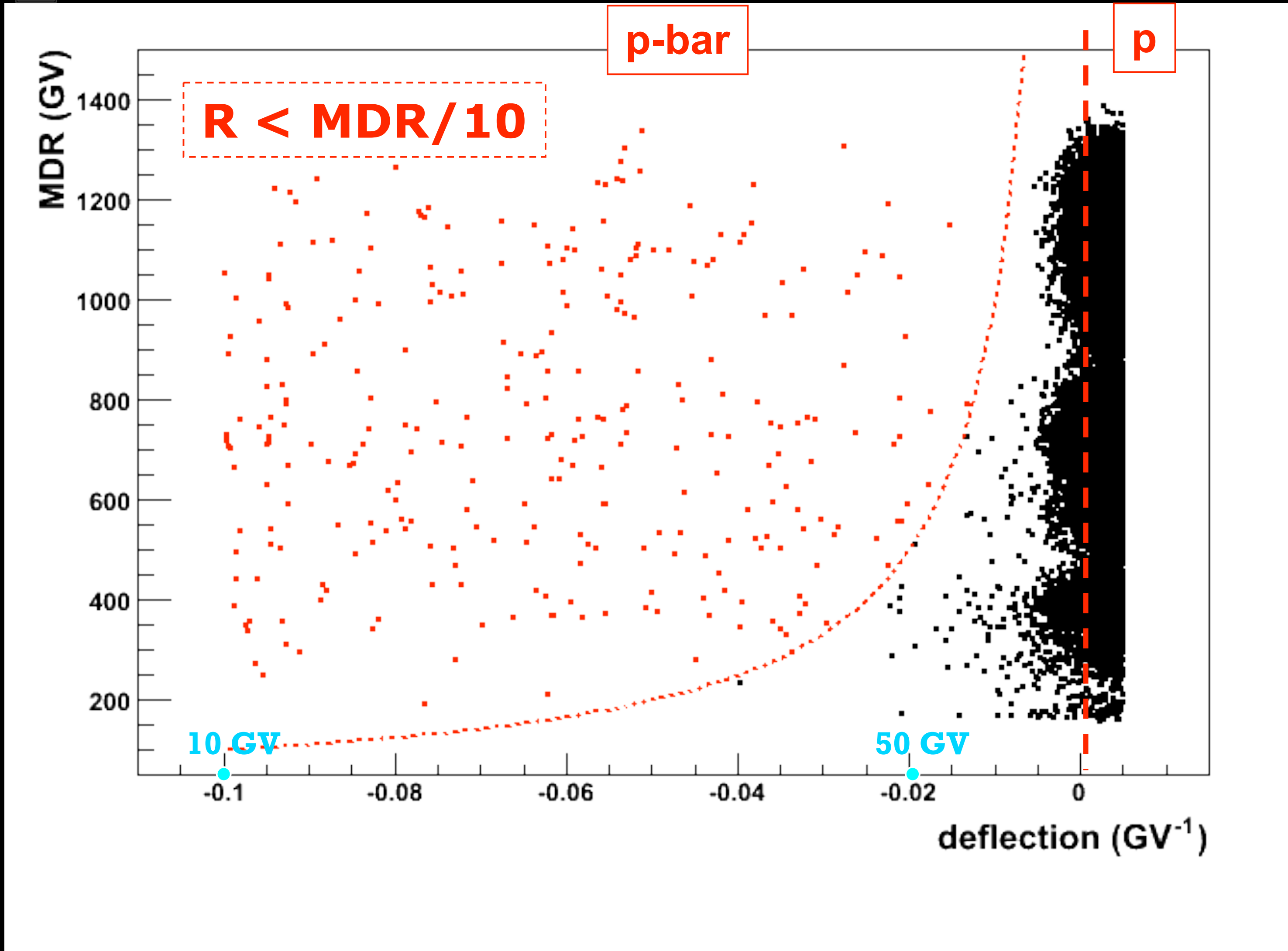
From O. Adriani ata

High-energy antiproton selection



From O. Adriani

High-energy antiproton selection



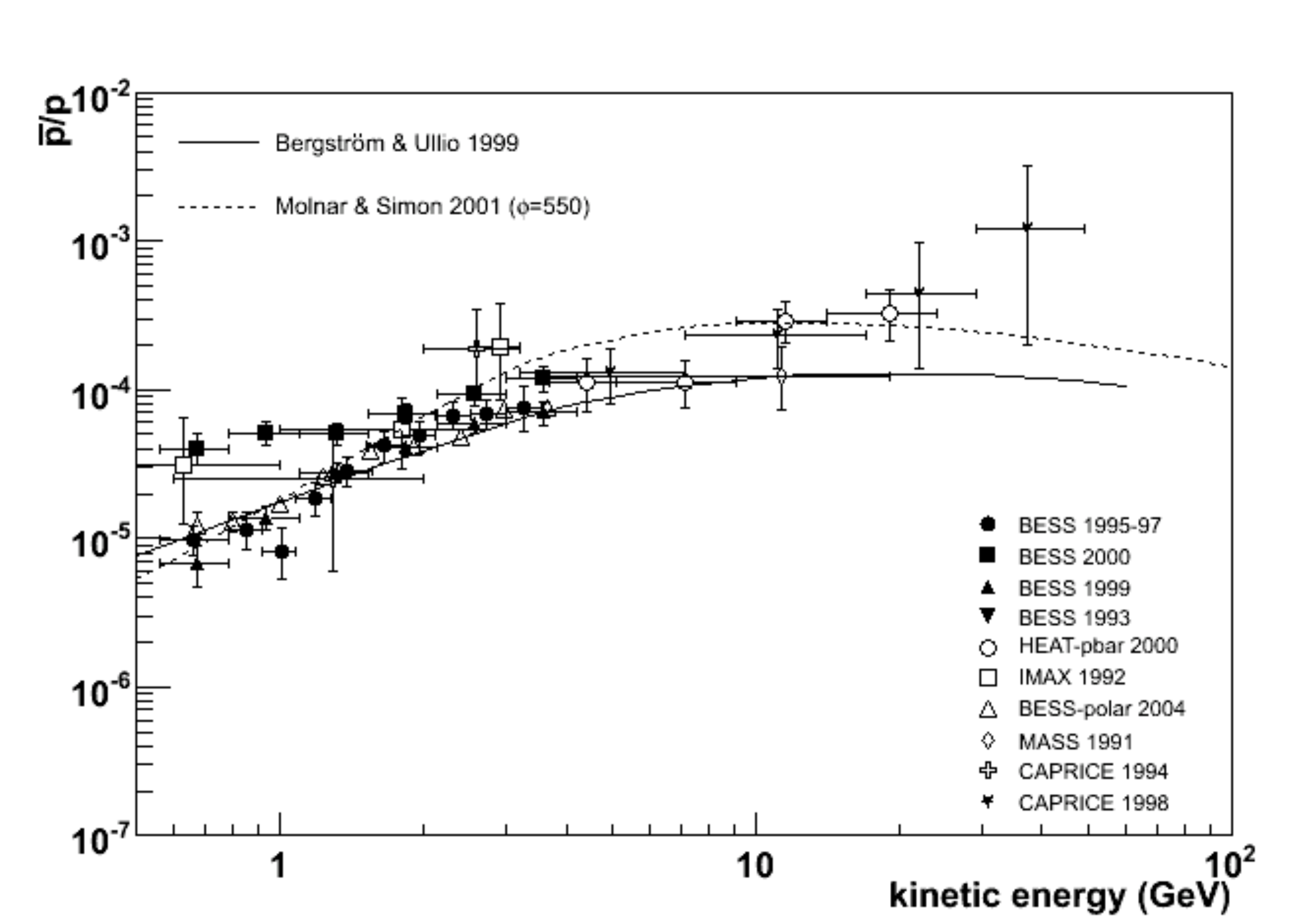
From O. Adriani

Antiproton-Proton Ratio

Why Ratios?

Reduce systematic error
All (most) efficiencies cancel out

Subsequently absolute fluxes



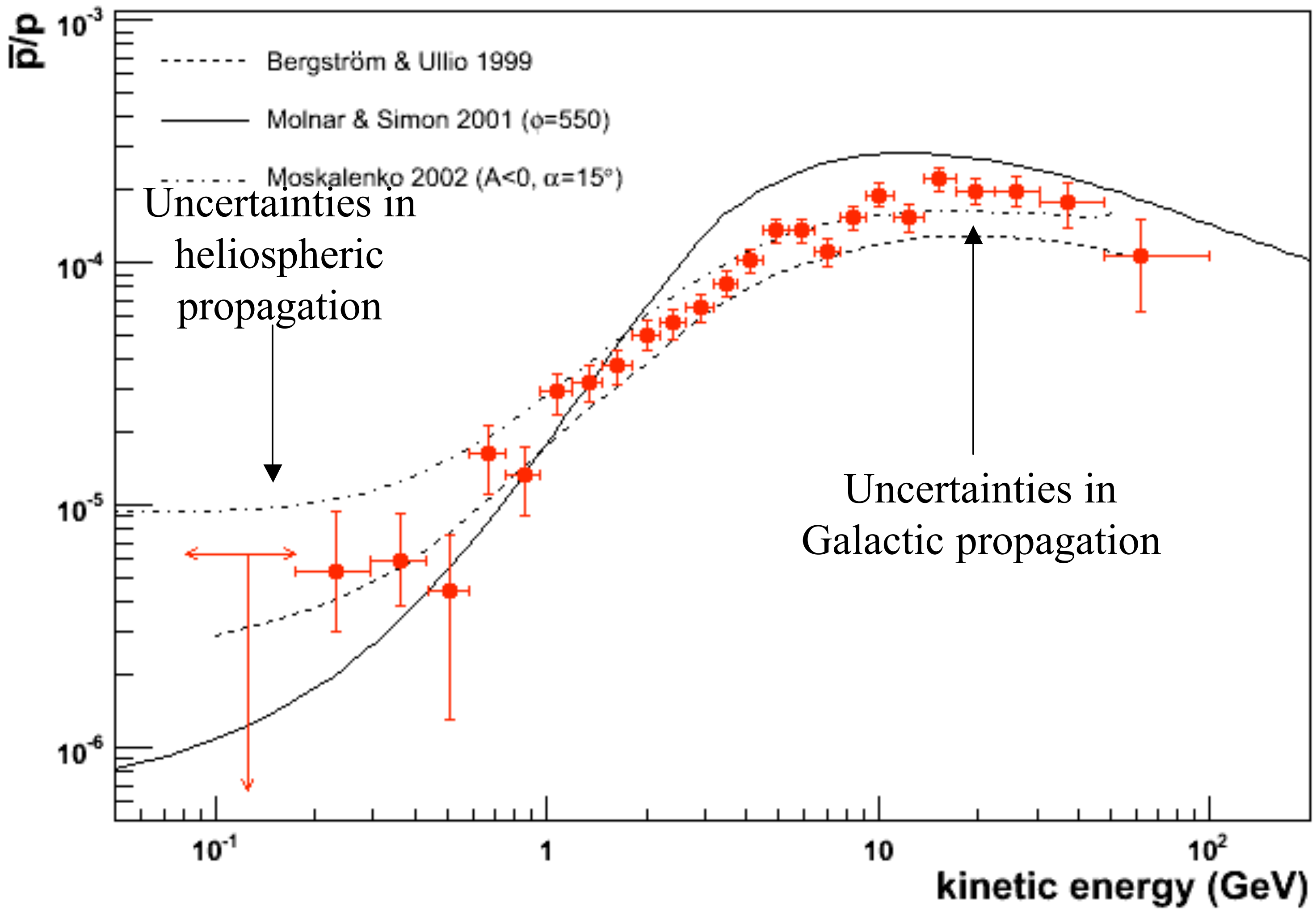
Antiproton ratio measured with Pamela: Comparison with theoretical models

Released data 1-100 GeV

Currently roughly 10 TB of data

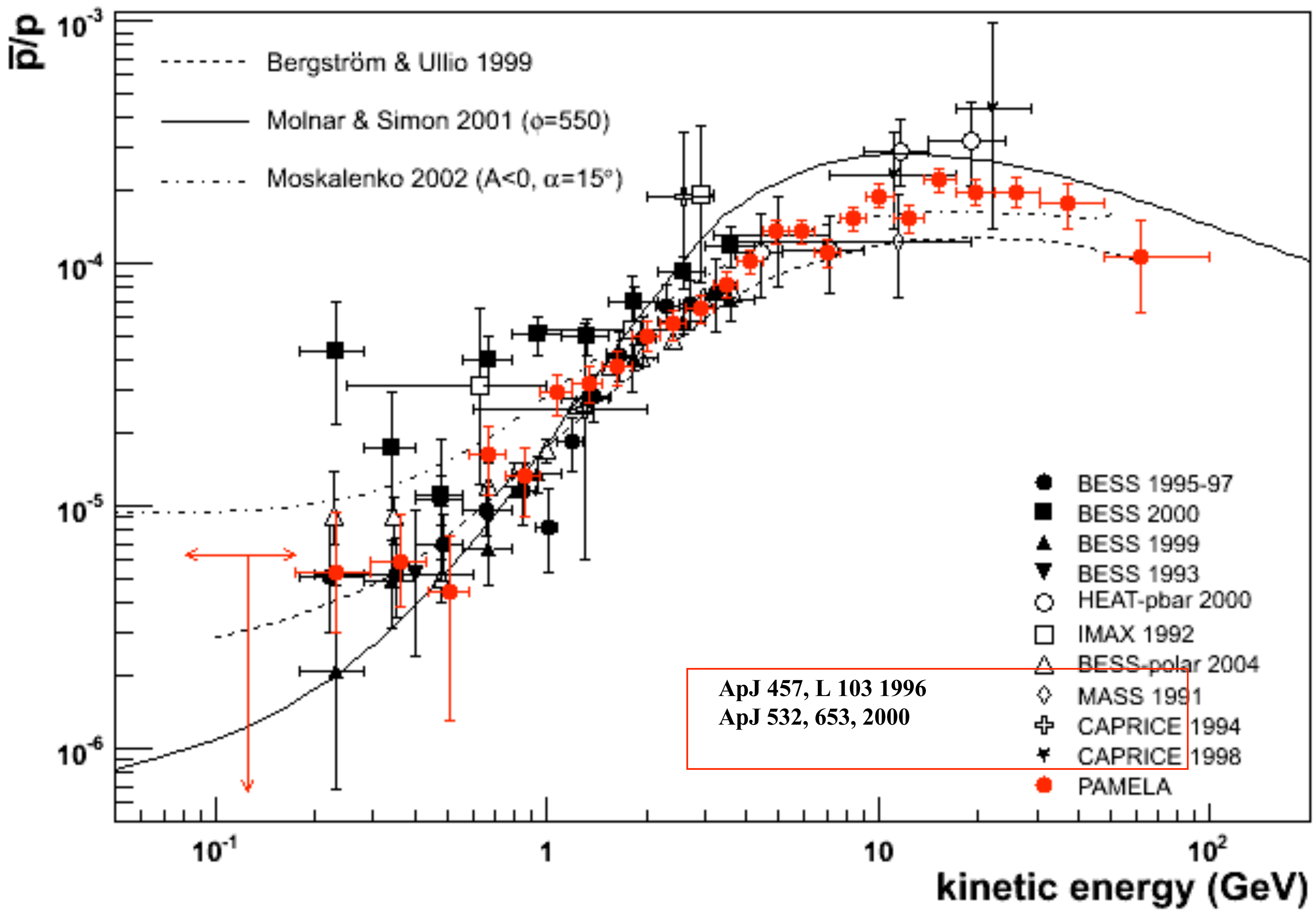
As of March ’08 Out of 8.8 TB

- 10^7 p
- 800 p^-



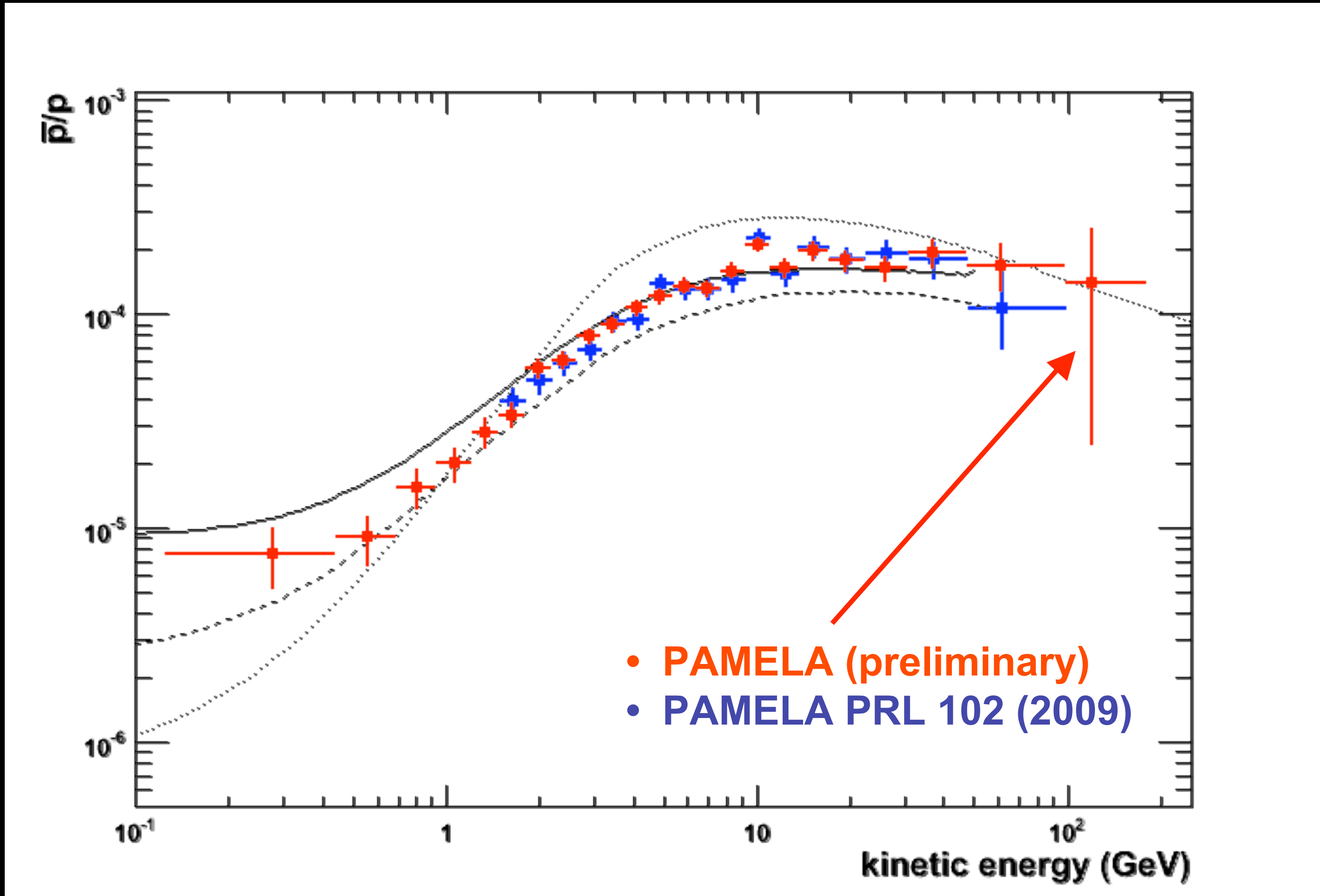
Antiproton ratio measured with Pamela: Comparison with experimental data

•Highest energy up to now
•Coherent with secondary production
•Uncertainties of Galactic Propagation
•Would favour Moskalenko 2002 (except highest energy)



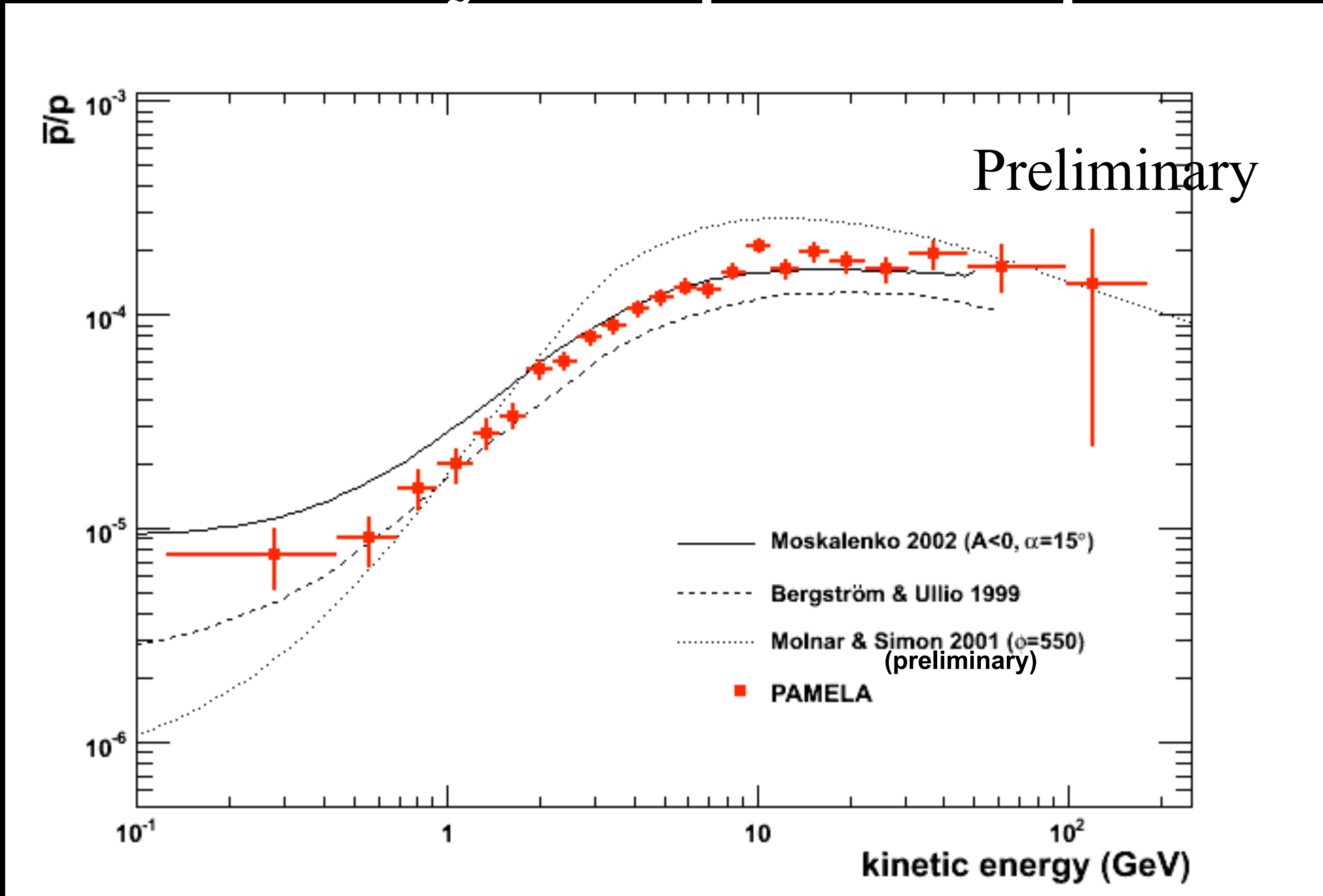
arXiv:0810.4994v1 [astro-ph] 28 Oct 2008 PRL

Antiproton ratio



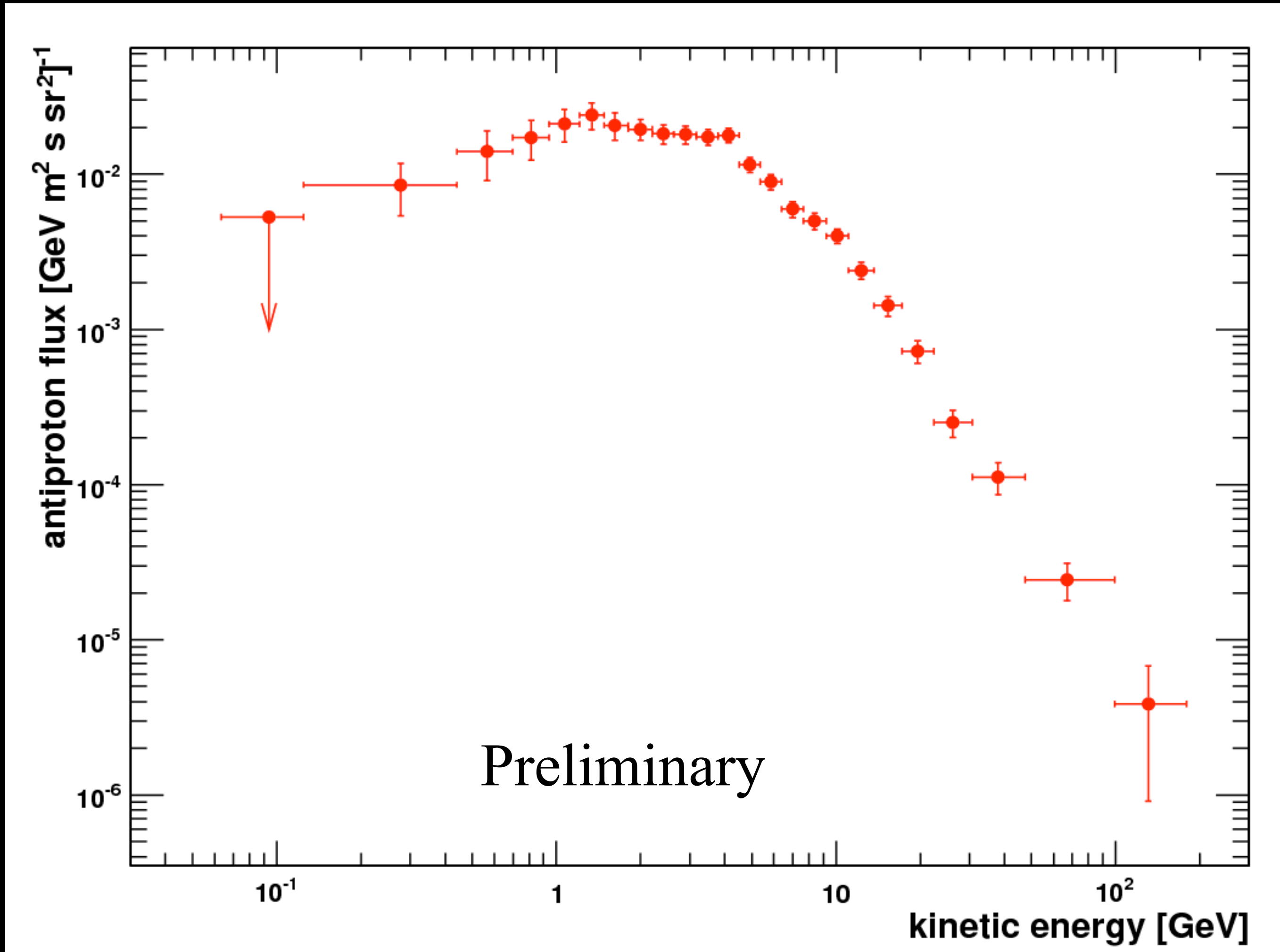
- New points consistent with old ones.

Preliminary antiproton spectrum



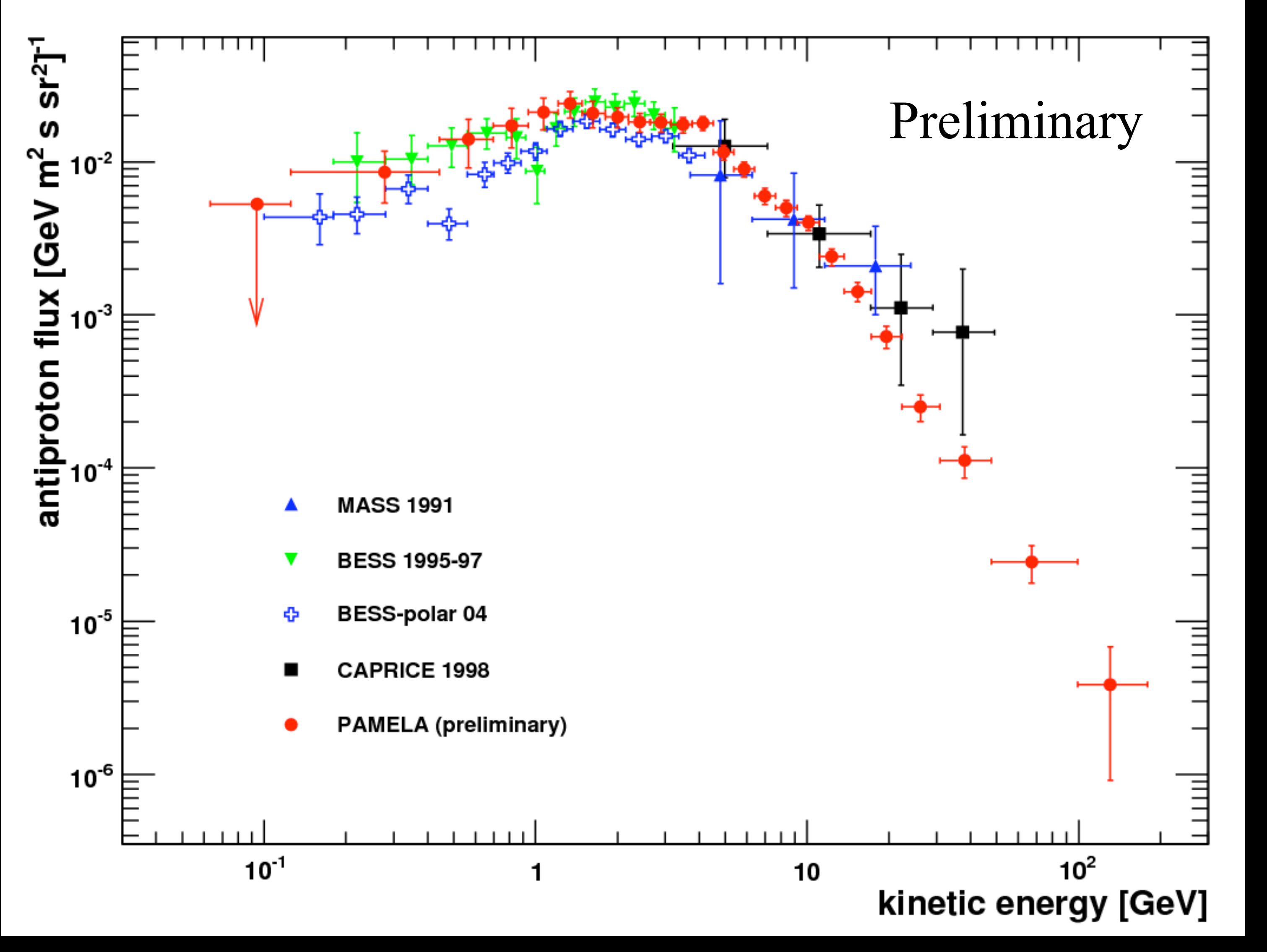
- highest bin: MDR > 6 · |R| is used to increase statistics..

Preliminary antiproton spectrum

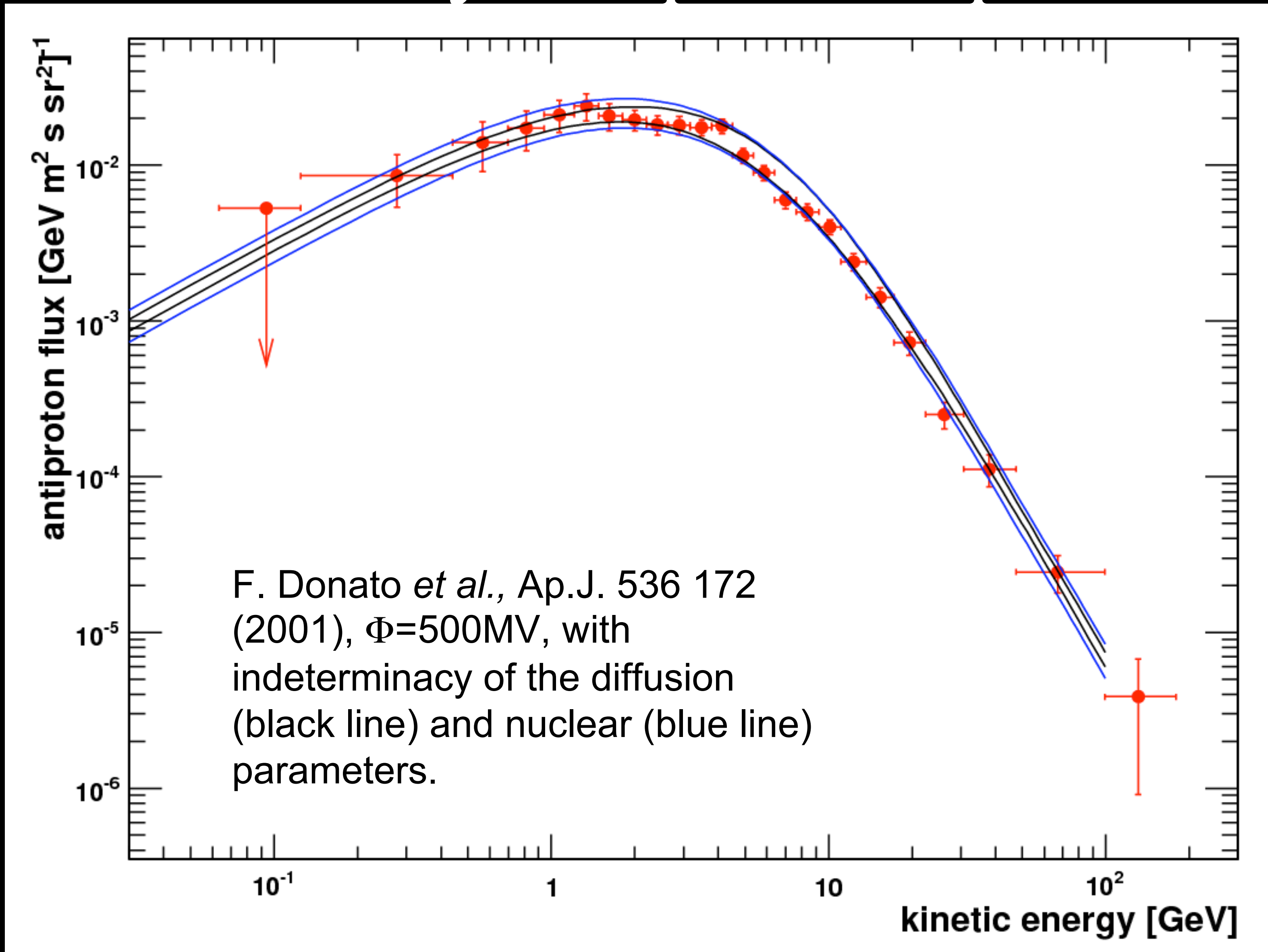


– Accepted on PRL.

Preliminary antiproton spectrum

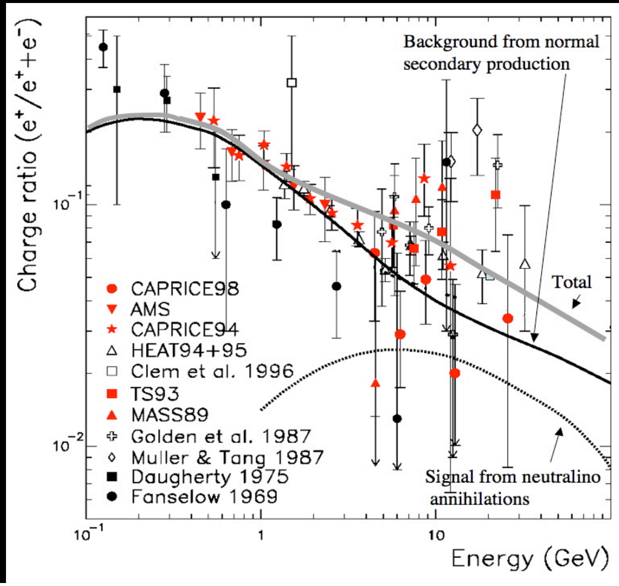


Preliminary antiproton spectrum



Positrons results

- Till August 30th about 20000 positrons from 200 MeV up to 200 GeV have been analyzed
- More than 15000 positrons over 1 GeV
- Other eight months data to be analyzed
- Selection criteria based on calorimeter
- Tuned and tested with
  - Montecarlo
  - Test Beam
  - In flight data
  - Cross-checked with Neutron Detector



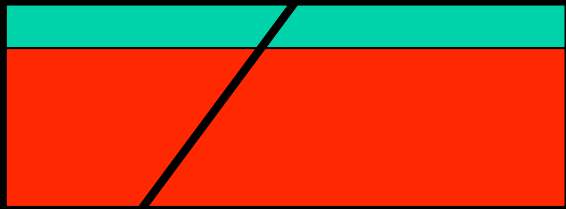
M. Casolino, INFN & University Roma Tor Vergata

Preshower Technique to reduce systematics of proton contamination:

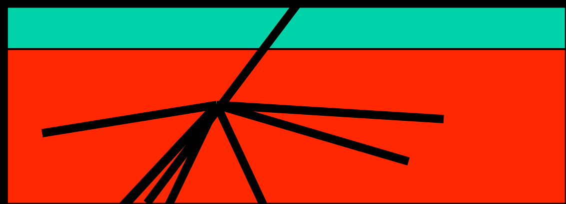
Optimize electromagnetic/hadronic shower discrimination, reduce systematics

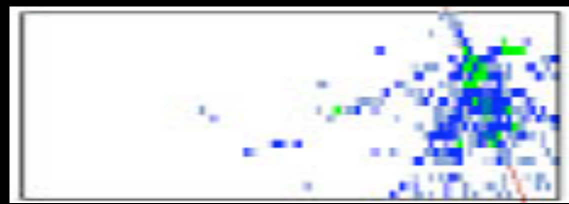
Protons:

- Non Interacting



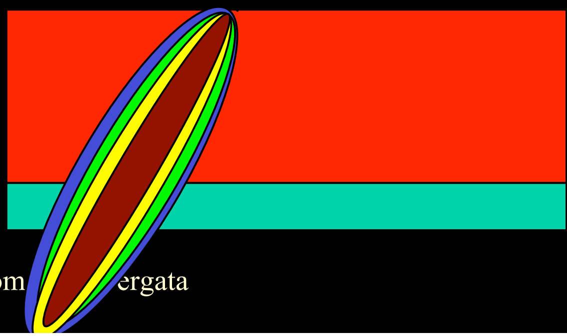
- Interacting

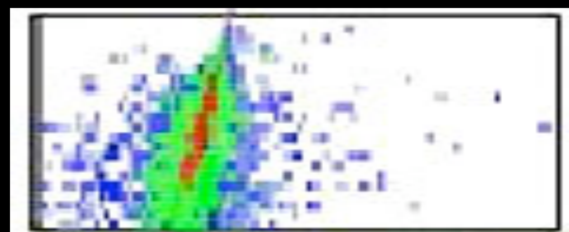




Electrons / Positrons

- Interacting (e.m.)





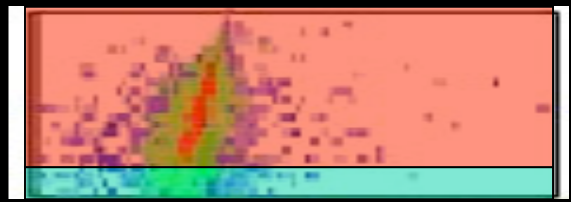
Recipe: M. Boezio, E. Mocchiutti

Preshower Technique to reduce systematics of proton contamination:

1. Take straight track in SmallTop → Select Protons
   Take interacting protons in BigBottom
   (known sample of hadronic shower. No leptons)

P hadronic shower

2. Define cuts (energy/topology) on 40 layers
   Using "BigTop" for e.m. showers (electrons)
   "BigBottom" for hadronic showers (protons)



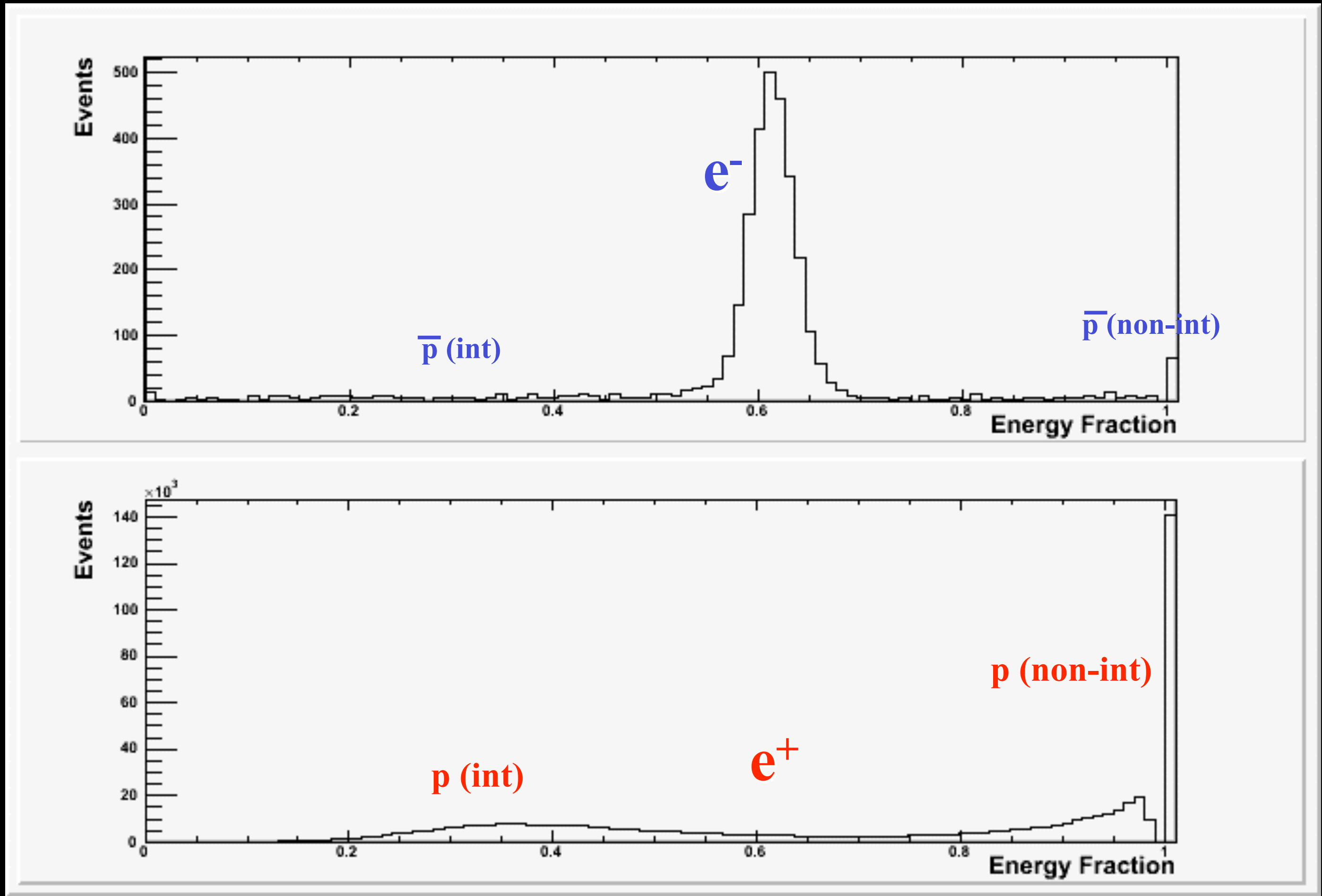
$e^{+/-}$ e.m. shower

3. Apply cuts to the positron sample

4. Apply cuts to electron sample to estimate efficiency

Positron selection with calorimeter (1)

Rigidity: 20-30 GV

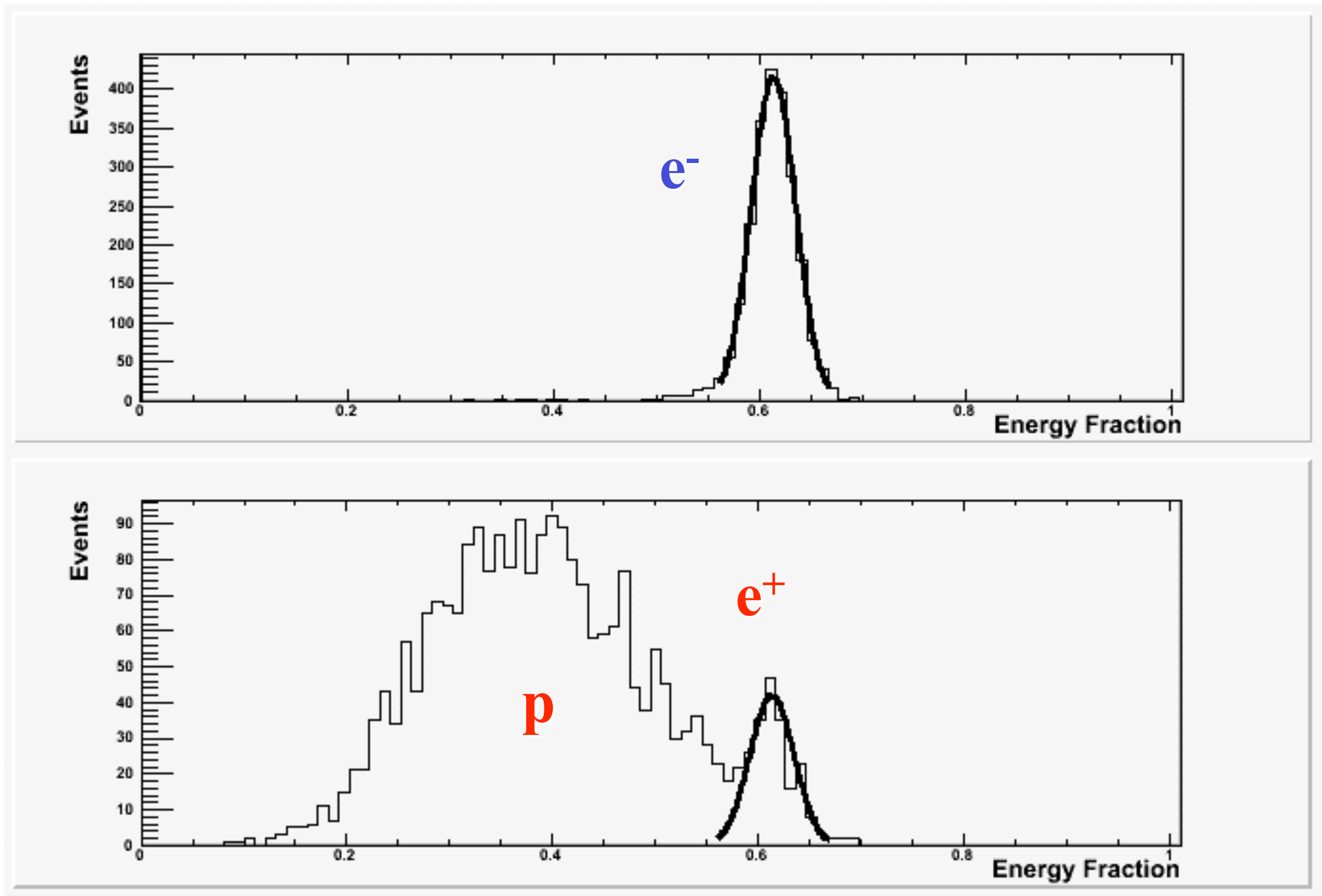


Fraction of charge released along the calorimeter track (left, hit, right)

M. Casolino, INFN & University Roma Tor Vergata

Positron selection with calorimeter (2)

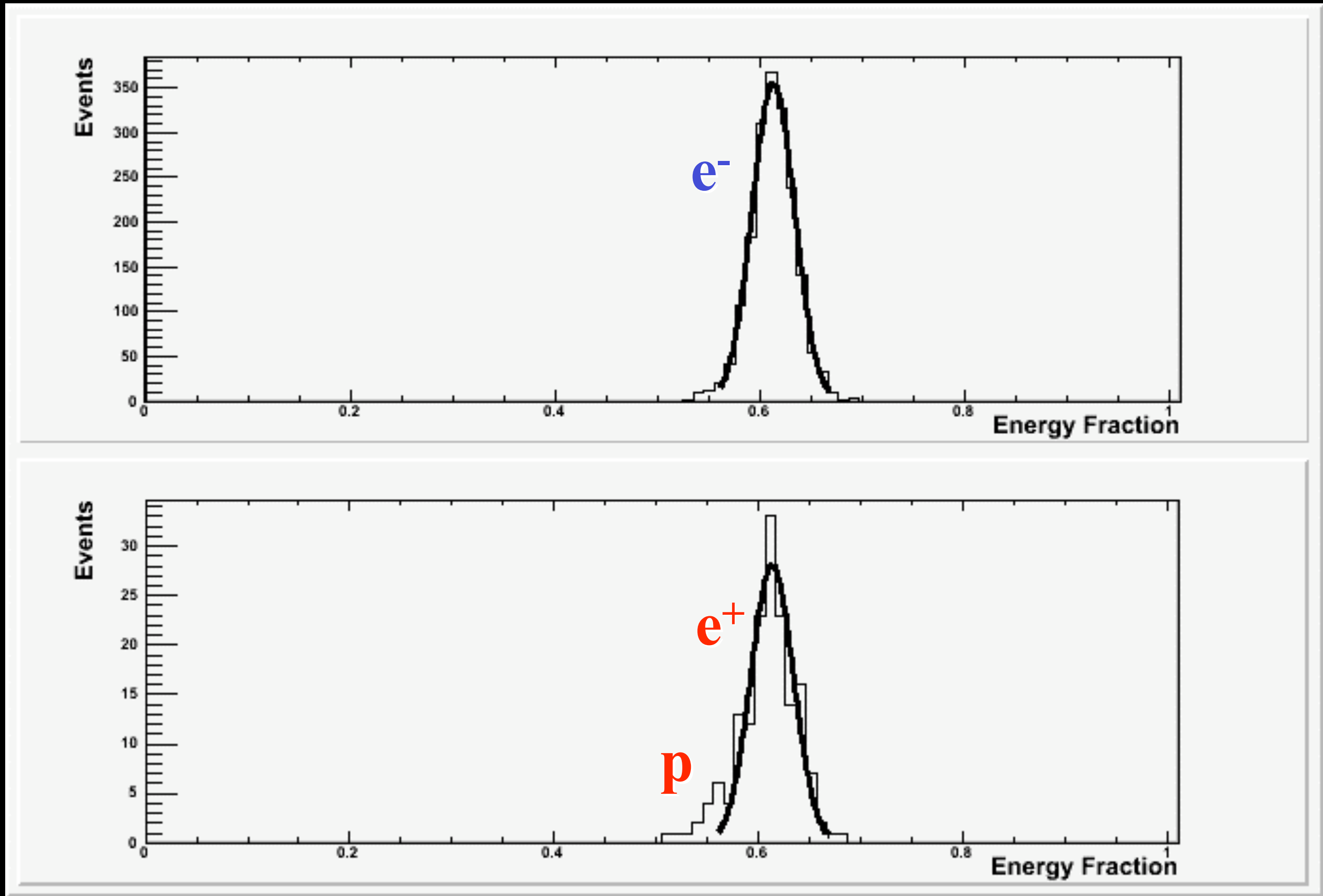
Rigidity: 20-30 GV



Fraction of charge released along the calorimeter track (left, hit, right) **+** **Energy-momentum match**

Positron selection with calorimeter (3)

Rigidity: 20-30 GV

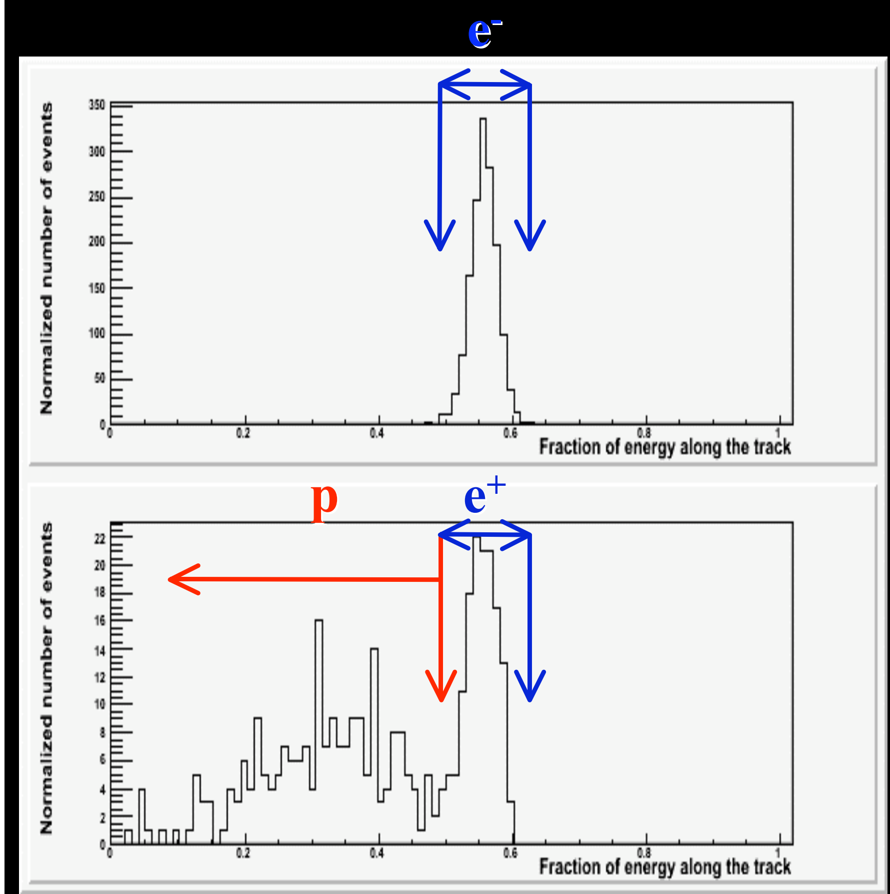


Fraction of charge released along the calorimeter track (left, hit, right) **+** **Energy-momentum match** **+** **.** **Starting point of shower Longitudinal profile**

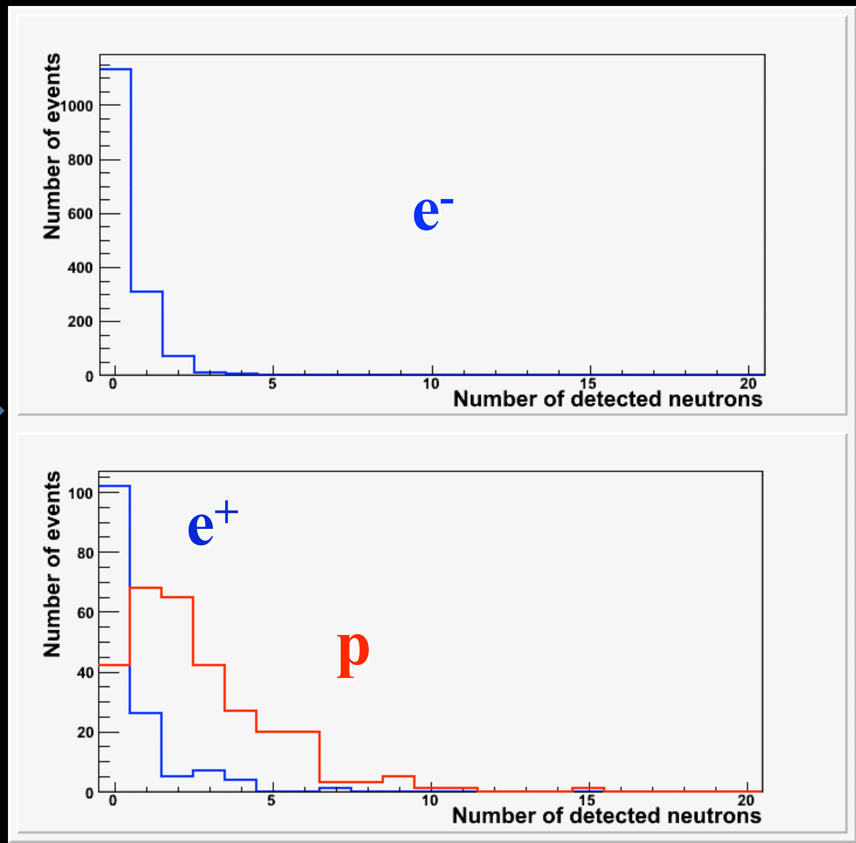
Positron selection (4)
Indipendent selection/check with ND

Rigidity: 20-30 GV

Fraction of charge released along the calorimeter track (left, hit, right)



Neutrons detected by ND

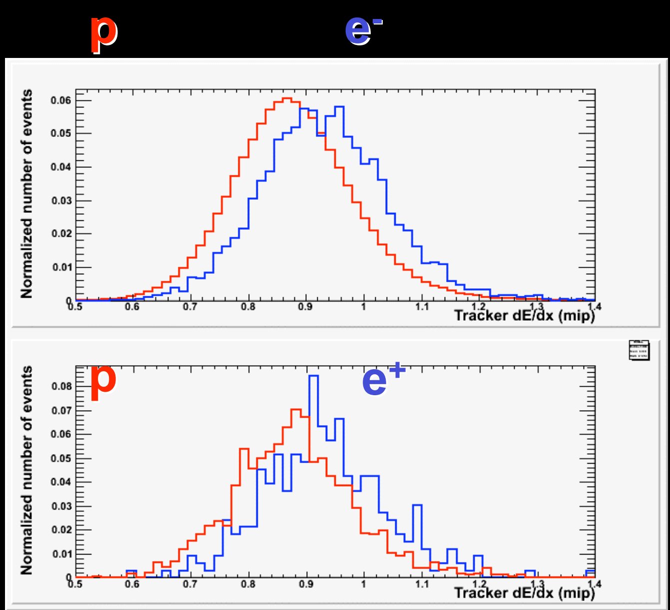


Energy-momentum match
Starting point of shower

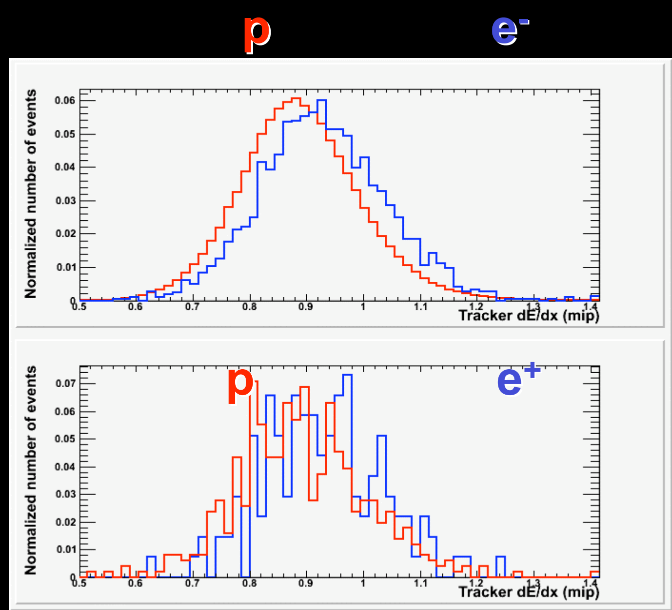
$$-\frac{dE}{dx} = Kz^2 \frac{Z}{A} \frac{1}{\beta^2} \left[\frac{1}{2} \ln \frac{2m_e c^2 \beta^2 \gamma^2 T_{\max}}{I^2} - \beta^2 - \frac{\delta(\beta\gamma)}{2} \right]$$

Top: proton and electron samples, identified with TRK only (charge sign).

Rigidity: 10-15 GV

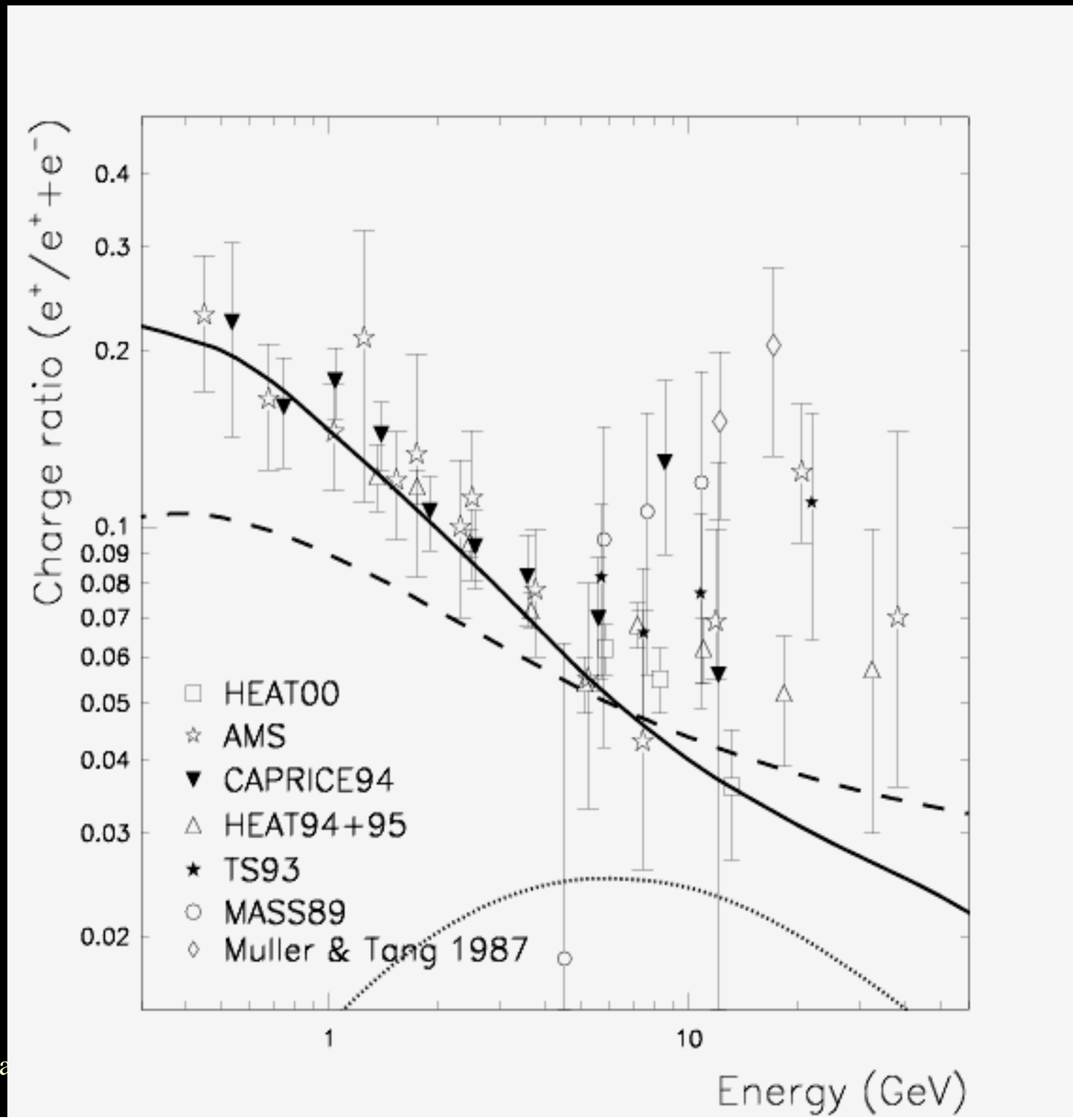


Rigidity: 15-20 GV



- Bottom: proton and positron (+ residual p background) samples, identified with present CALO requirements.

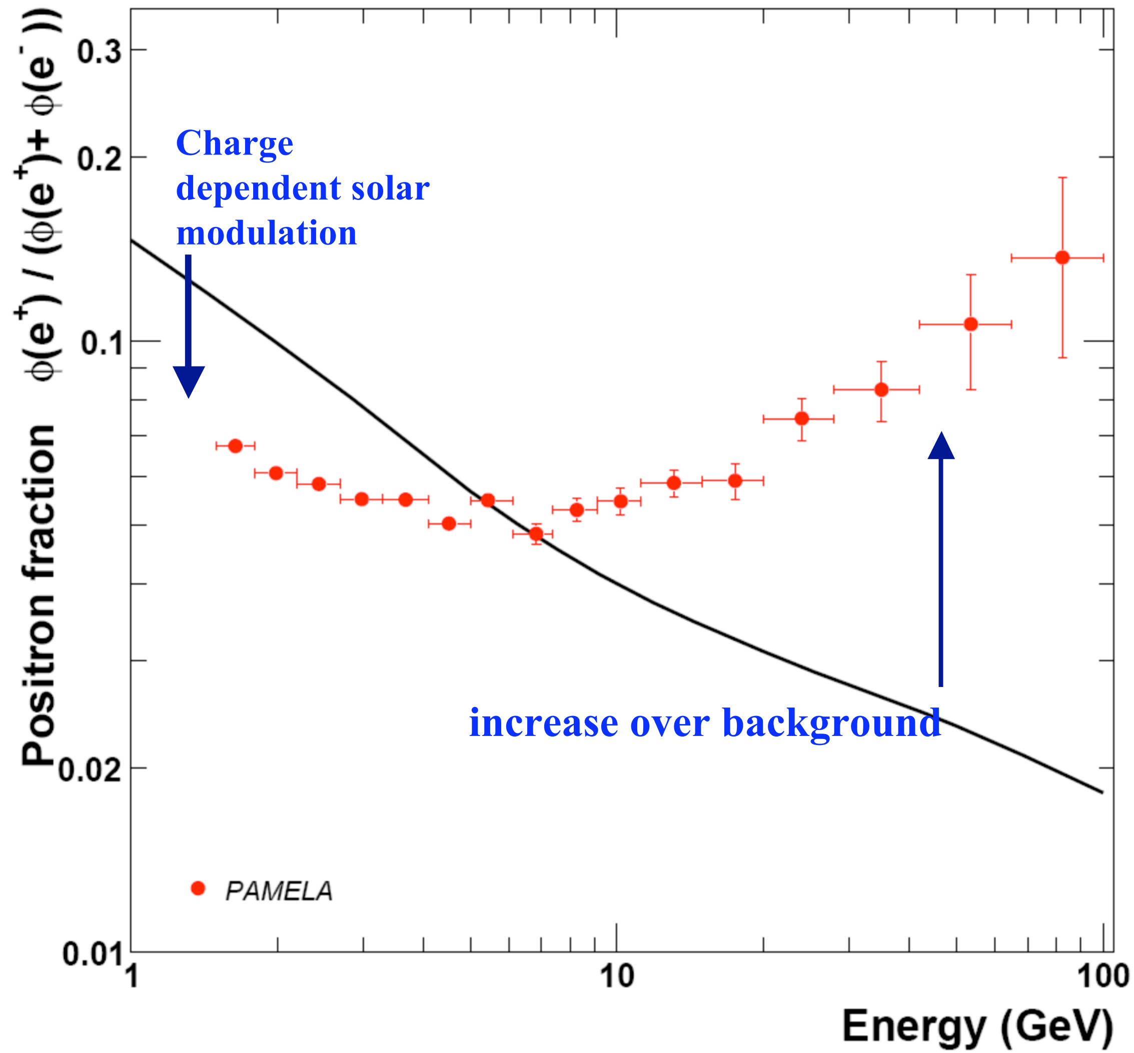
Status of Positron - Electron ratio



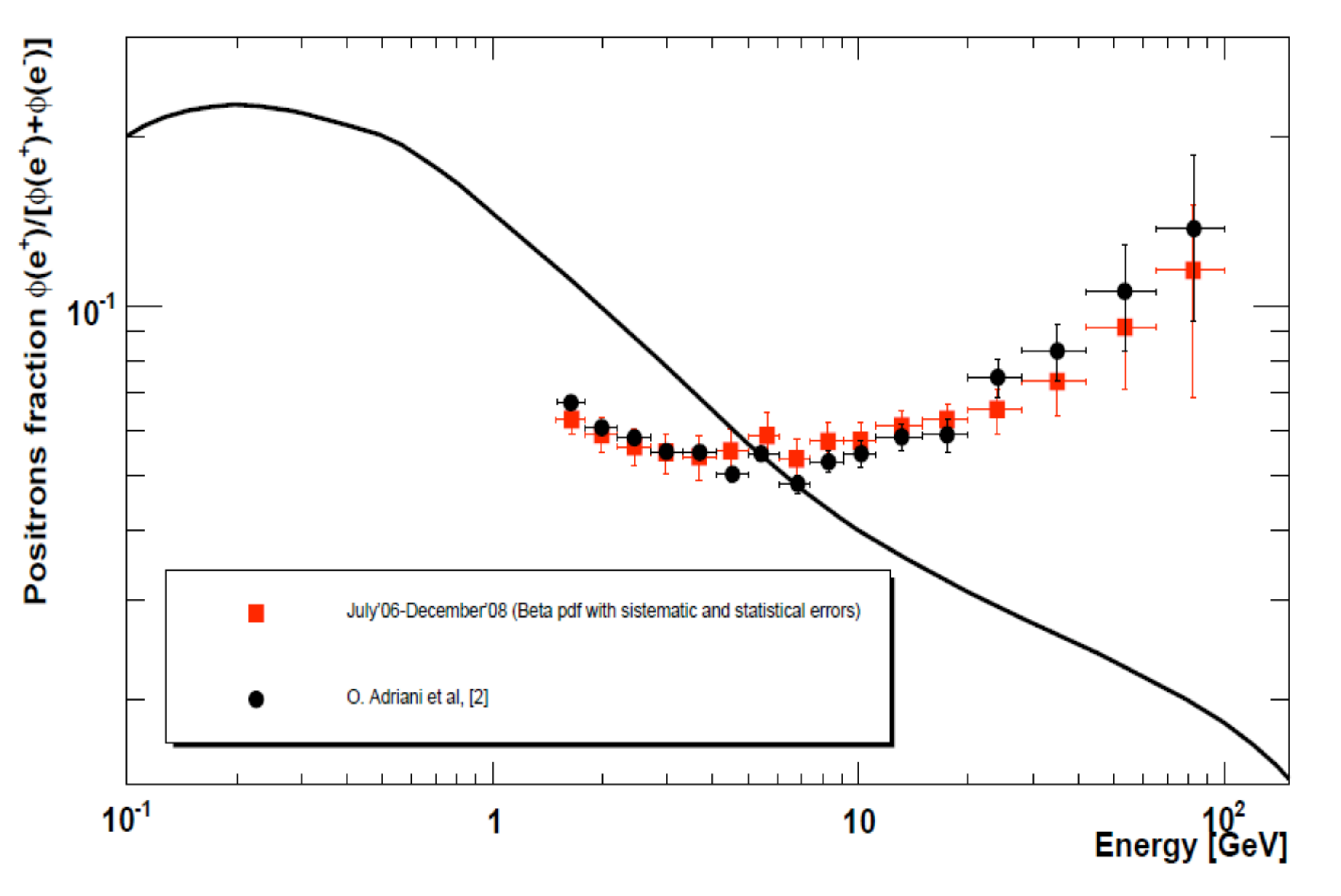
Pamela positron fraction

- July 2006 – February 2008 (~500 days)
- Collected triggers ~10^8
- Identified ~ 150 10^3 electrons and ~ 9 10^3 positrons between 1.5 and 100 GeV (180 positrons above 20 GeV

Nature ***458****, 607-609 (2009)*



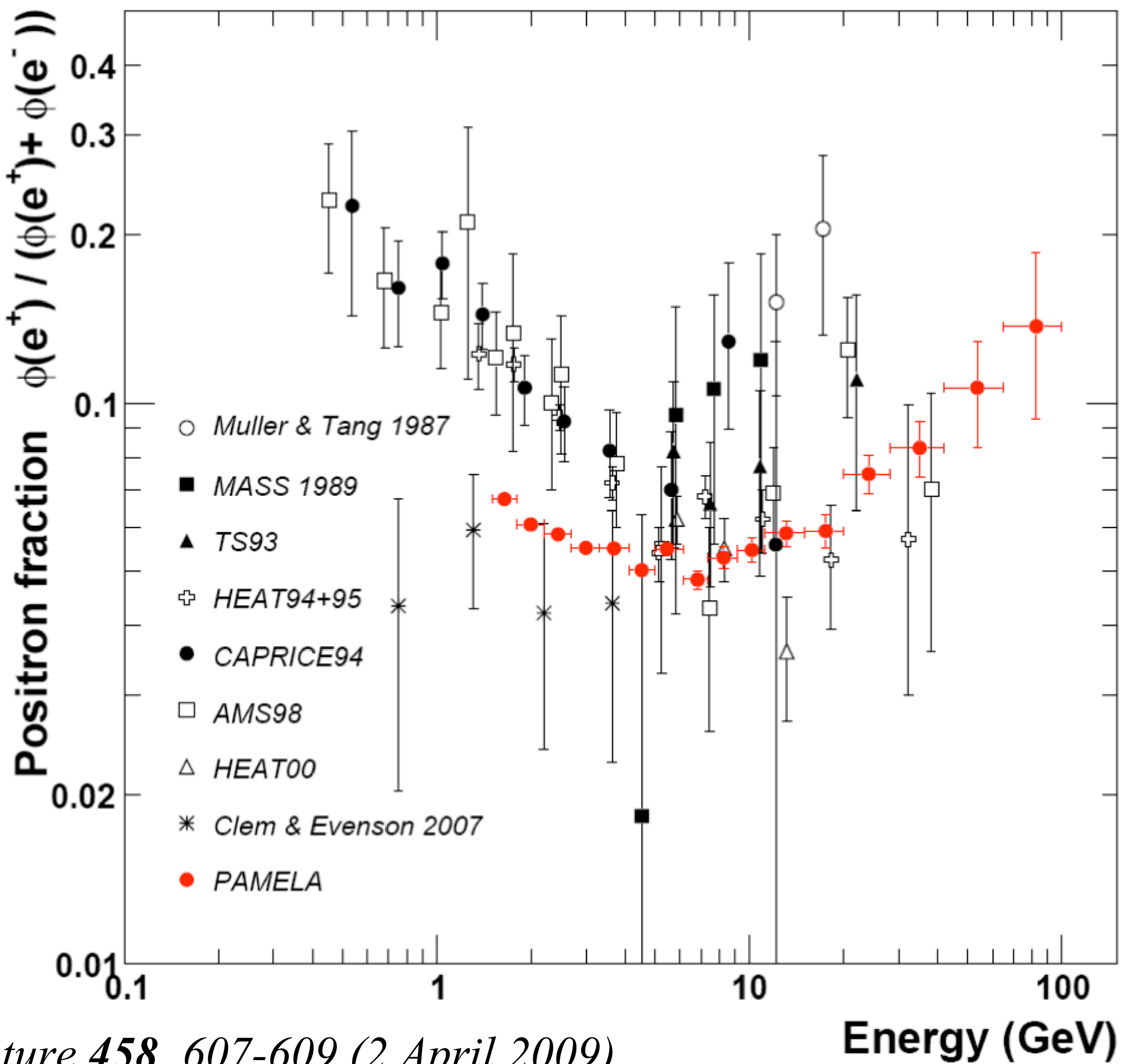
More positrons… data up to December 2008



July 2006 → December 2008

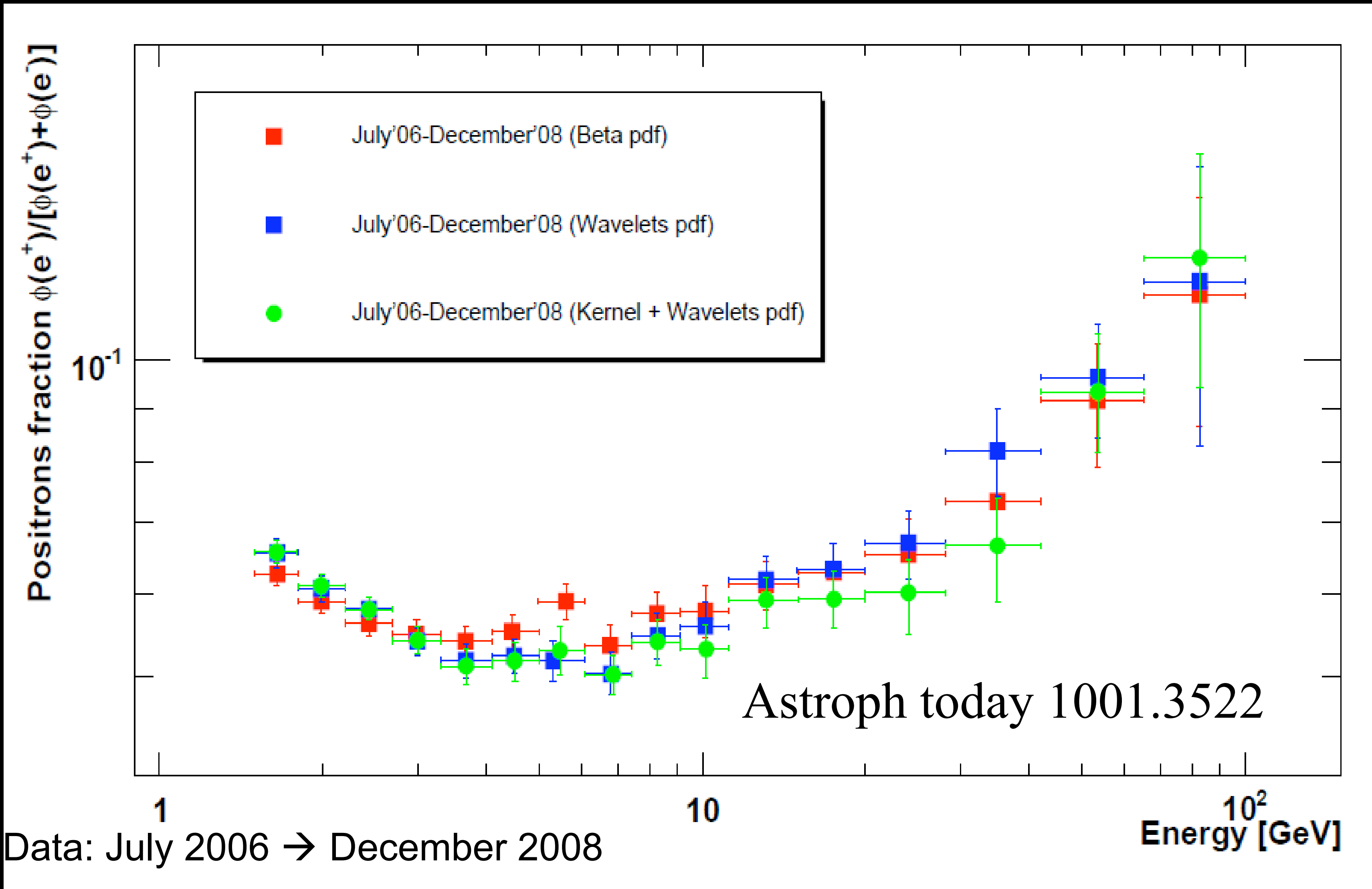
M. Casolino, INFN & University Roma Tor Vergata

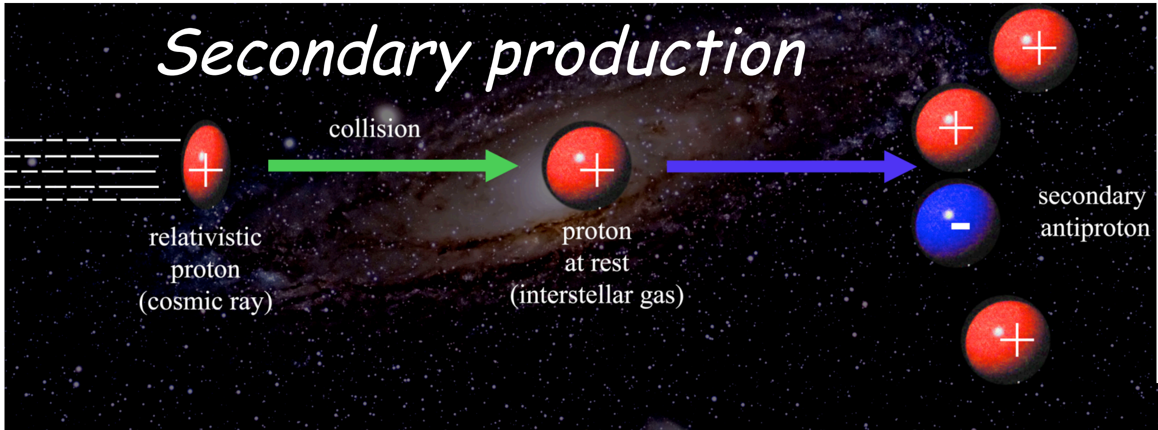
Pamela positron fraction: comparison with other data

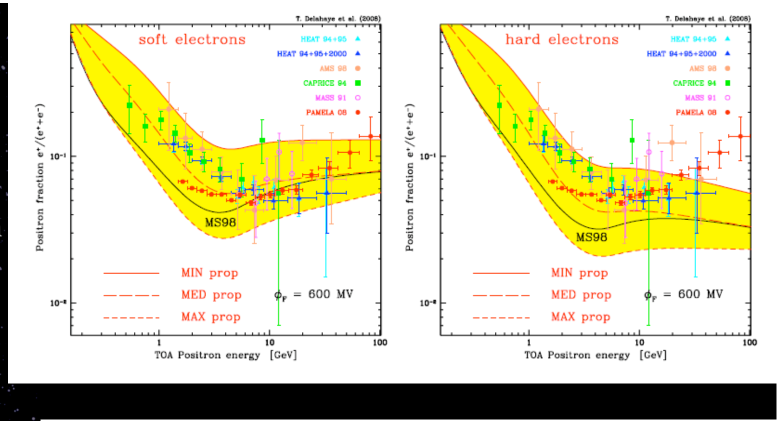


*Nature **458**, 607-609 (2 April 2009)*

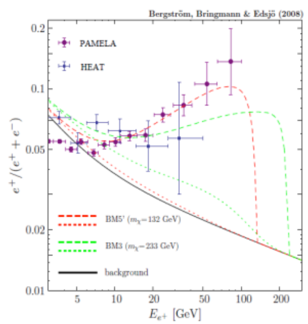
Various approach to background subtraction

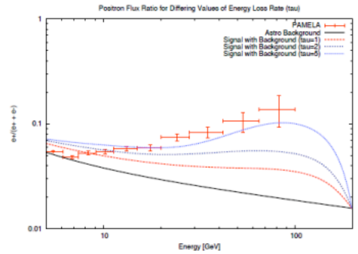






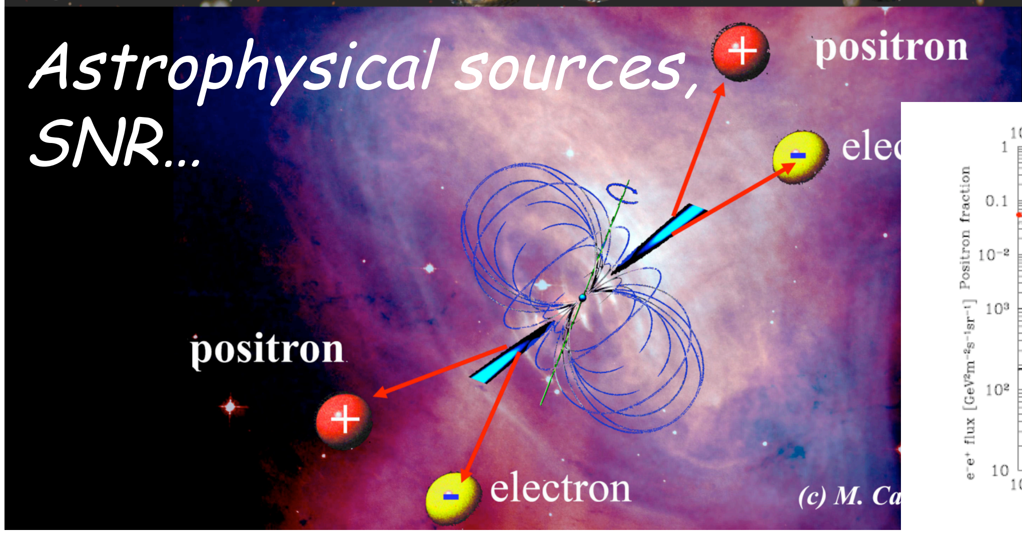
2. Example of DM solution: SUSY with internal bremsstrahlung and large boost factors, or Winos with unusual propagation parameters can give the right spectrum:

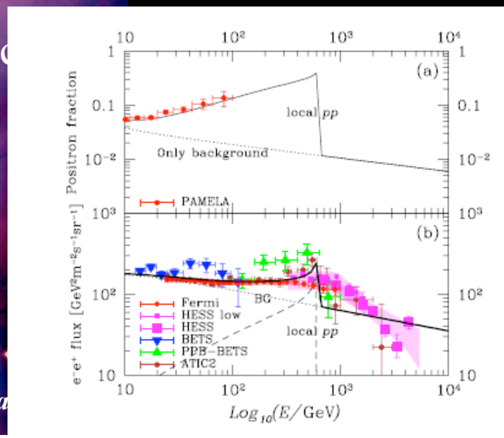


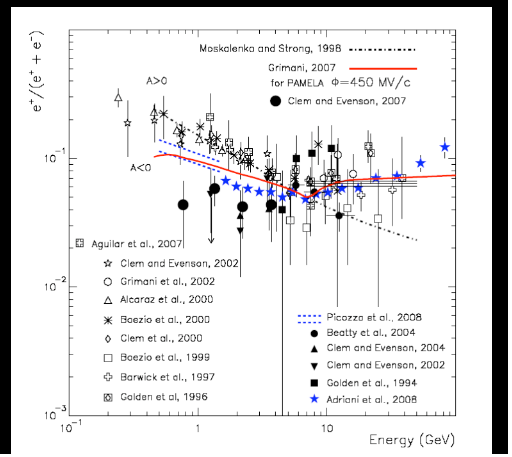


P. Grajek, G.L. Kane, D. Phalen, A. Pierce,and S. Watson. arXiv:0812.4555

However, does not explain new electron plus positron data (see later)







EDSJO 2009

Pulsars	New SNRs mechanisms	Dark matter	?
Uncertainties			
• Acceleration model (polar cap, outer gap, ...) • Injection spectrum $E^{-\alpha}$? • Release into the ISM (when, how much?) • Source locations, ages, ...	• Environmental parameters at SNR (production mechanism) • Distance to closest source • Cut-off energies	• Particle physics model • Particle physics enhancement (Sommerfeld) • Substructure enhancement (halo model)	?
Tests			
• Anisotropy of flux • Fluctuations in spectrum • consistency checks (gamma, X-ray, ...)	• Antiproton fluxes • Secondary nuclei	• FSR & IC photons from galactic centre • Continuing positron rise • CMBR distortions	?

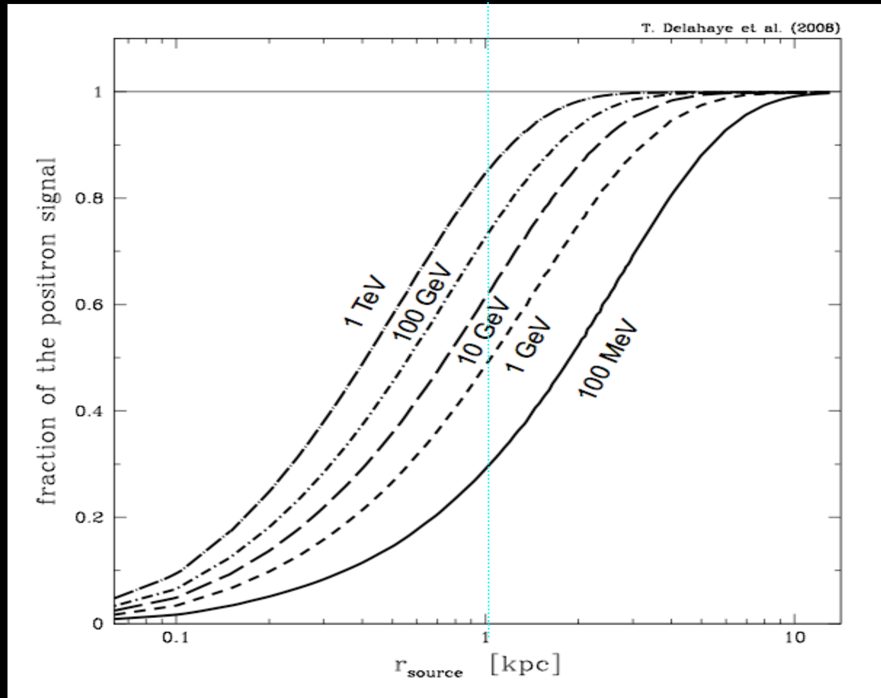
Positron origin

Where do positrons and electrons come from?

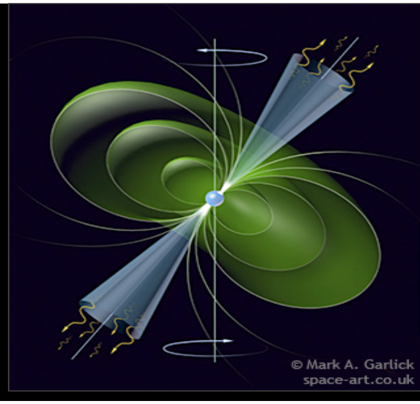
Mostly locally within 1 Kpc, due to the energy losses by Synchrotron Radiation and Inverse Compton
They sample the neighborhood of the galaxy
Protons and antiptotons the whole galaxy

Typical lifetime

$$\tau \simeq 5 \cdot 10^5 \mathrm{yr} \left(\frac{1\,\mathrm{TeV}}{E} \right)$$

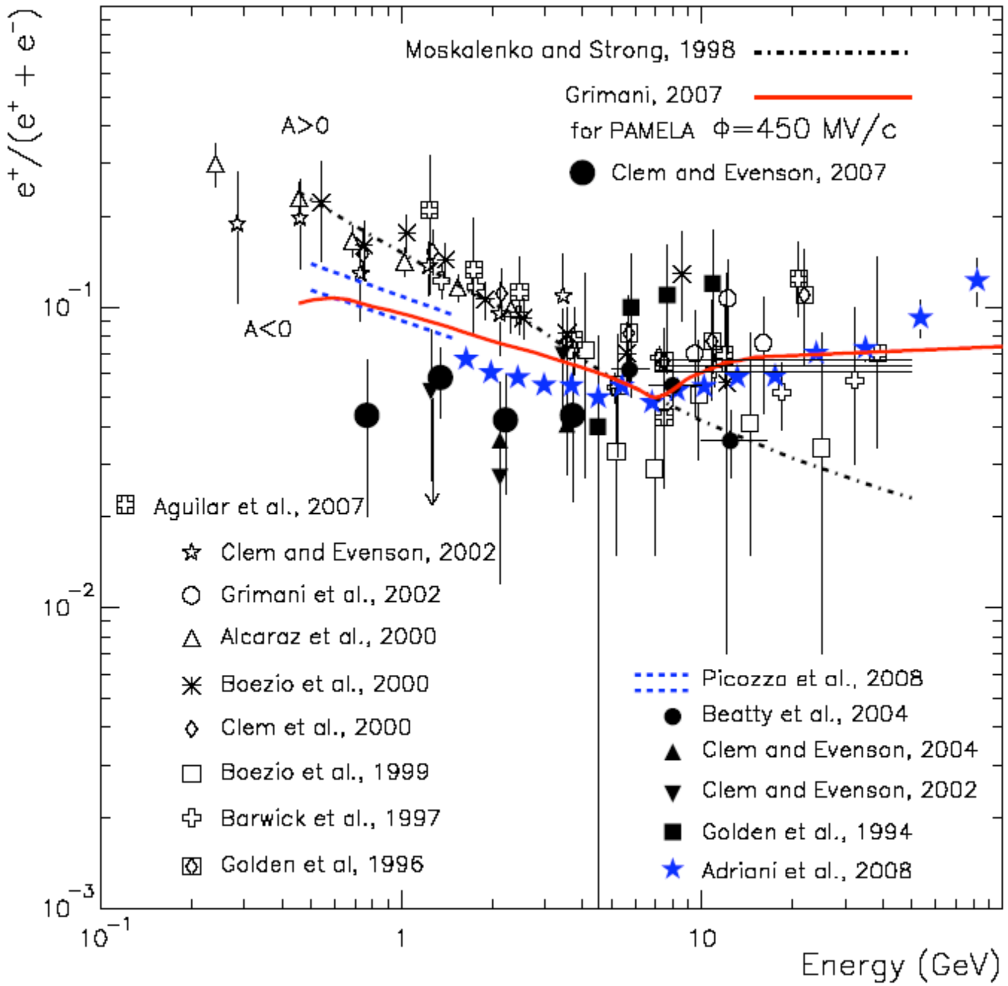


Astrophysical Origin



Pulsars

Must be young (T<10^5 yr) and nearby (<1 kpc). If not: too much diffusion, low energy, too low flux.



Injection flux:

$$\Phi_{e\pm} \simeq E^{-p} \exp(E/E_c)$$

$$p \simeq 2$$

$$E_c \simeq 10 - 10^2 \,\mathrm{TeV}$$

Data fitting

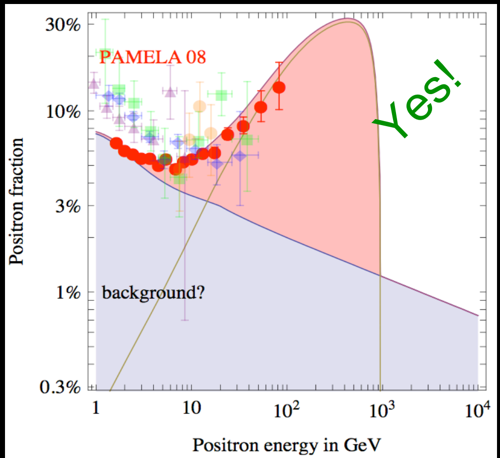
What if we consider ATIC and PPB-BETS data?

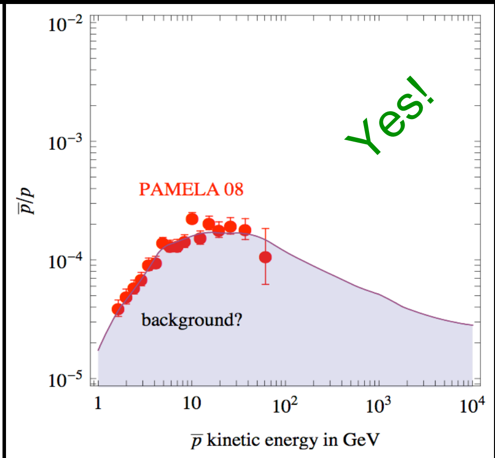
DM with $m_\chi \simeq 1\,\mathrm{TeV}$ and $\mu^+\mu^-$ dominant annihilation channel

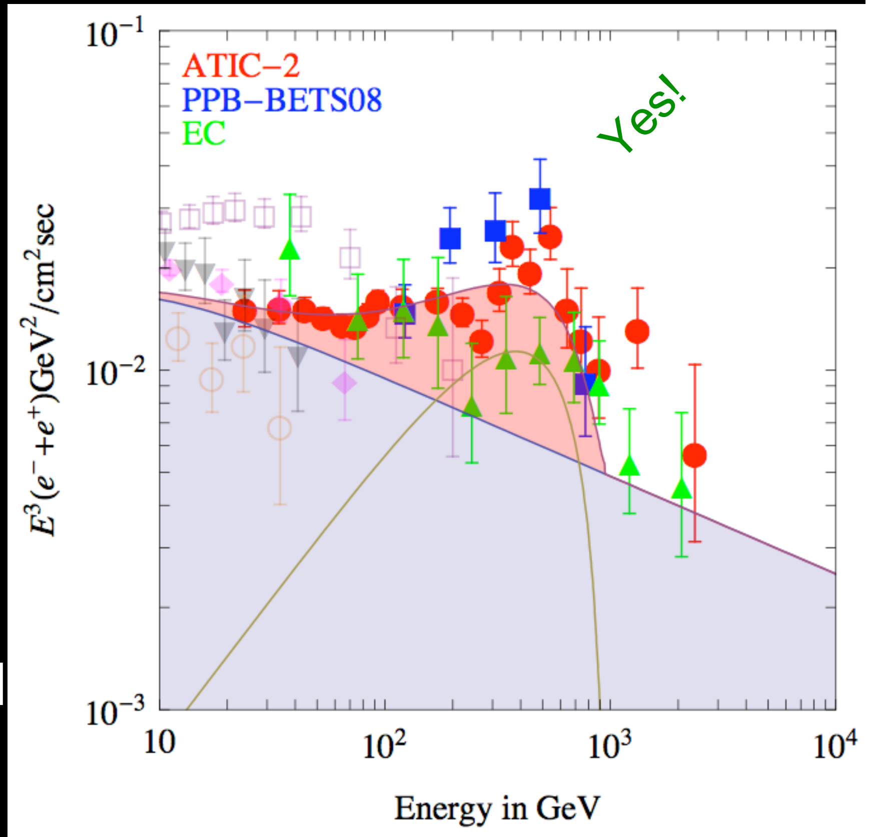
positrons

antiprotons

electron+positrons







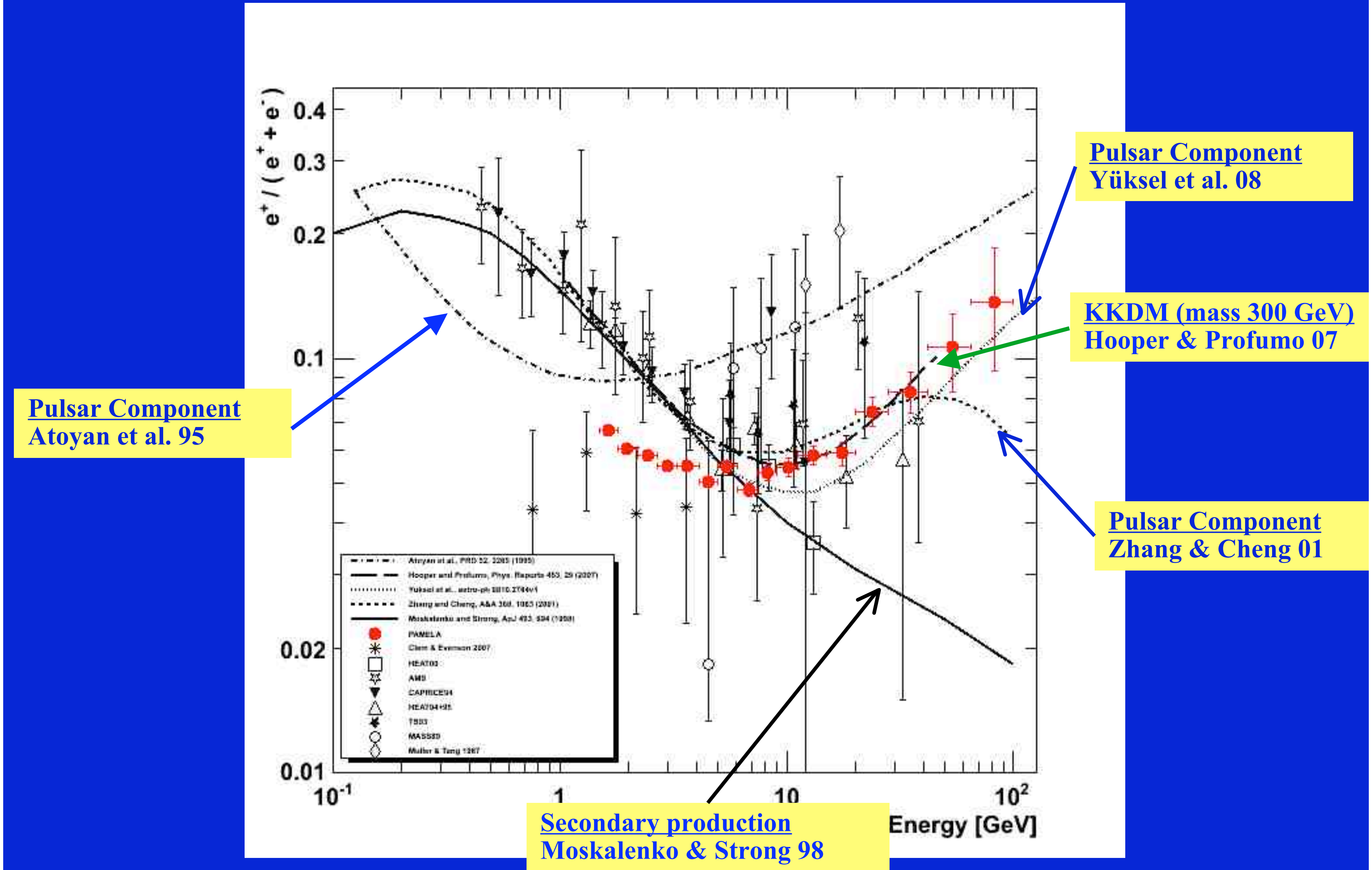
DM identification for the first time!?!?

Yes: Arkani-Hamed et al. arXiv:0810.071

+tons of other

From M. Cirelli, P. Picozza

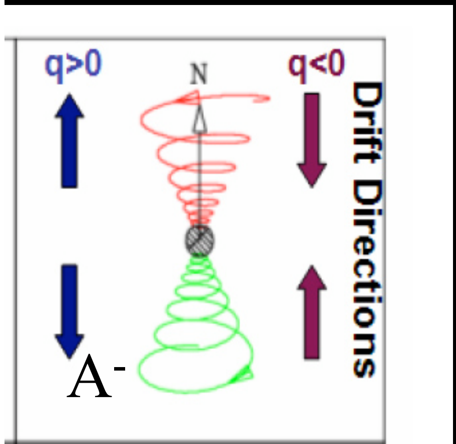
Positron fraction: comparison with models

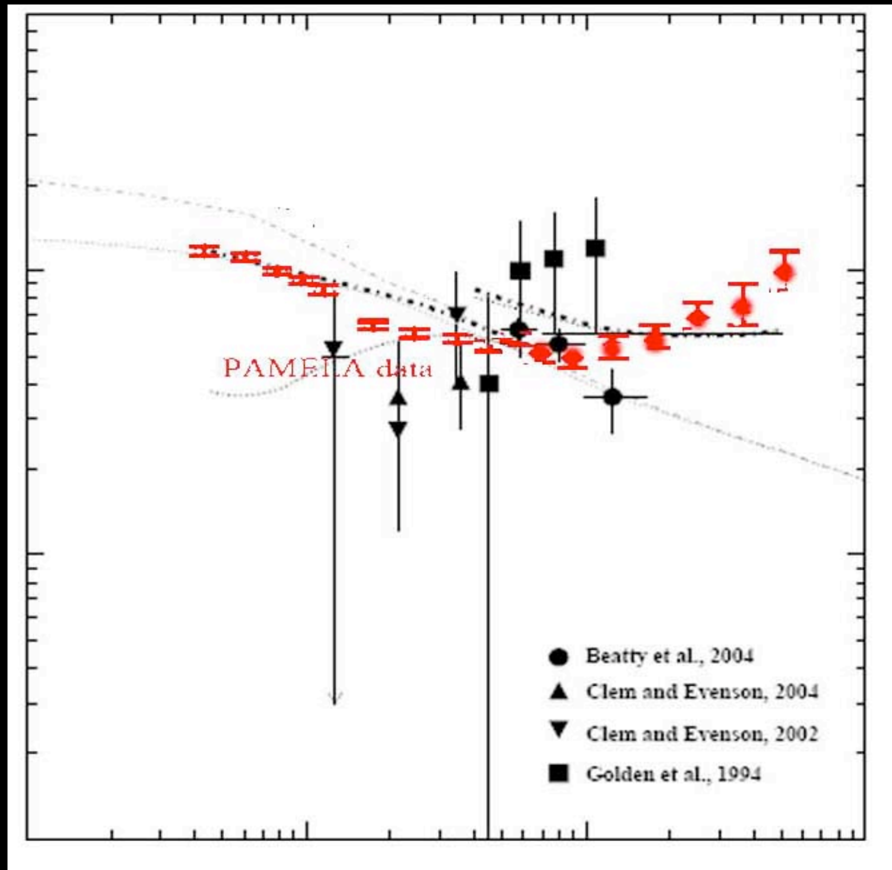


Comparison with solar cycle – low energy

qA<0 measurements (now or 22 years ago)

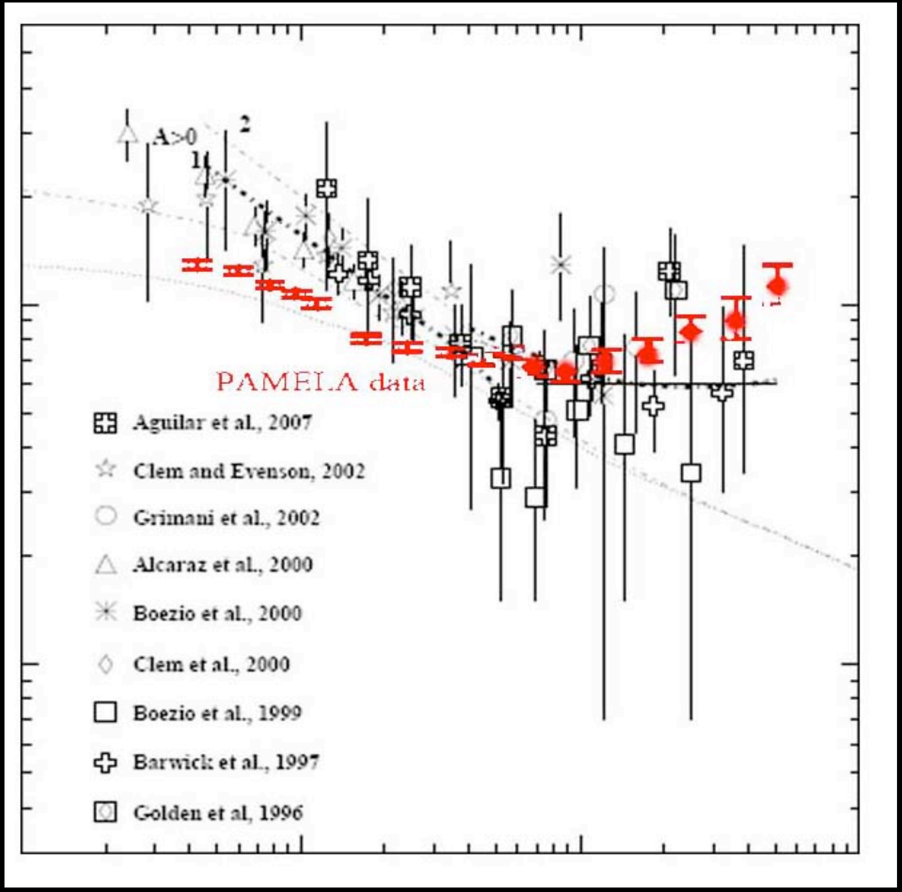
Solar modulation effects up to 10 GeV

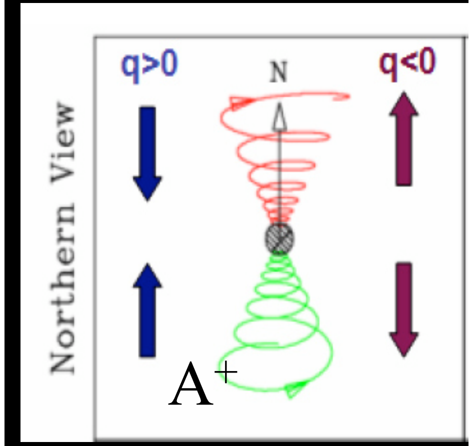




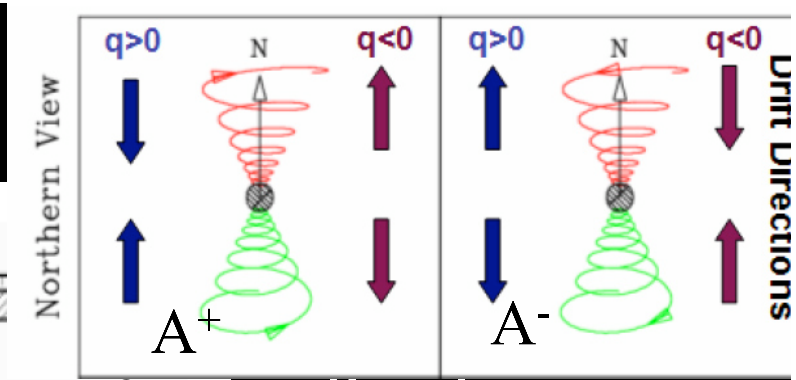
Comparison with solar cycle

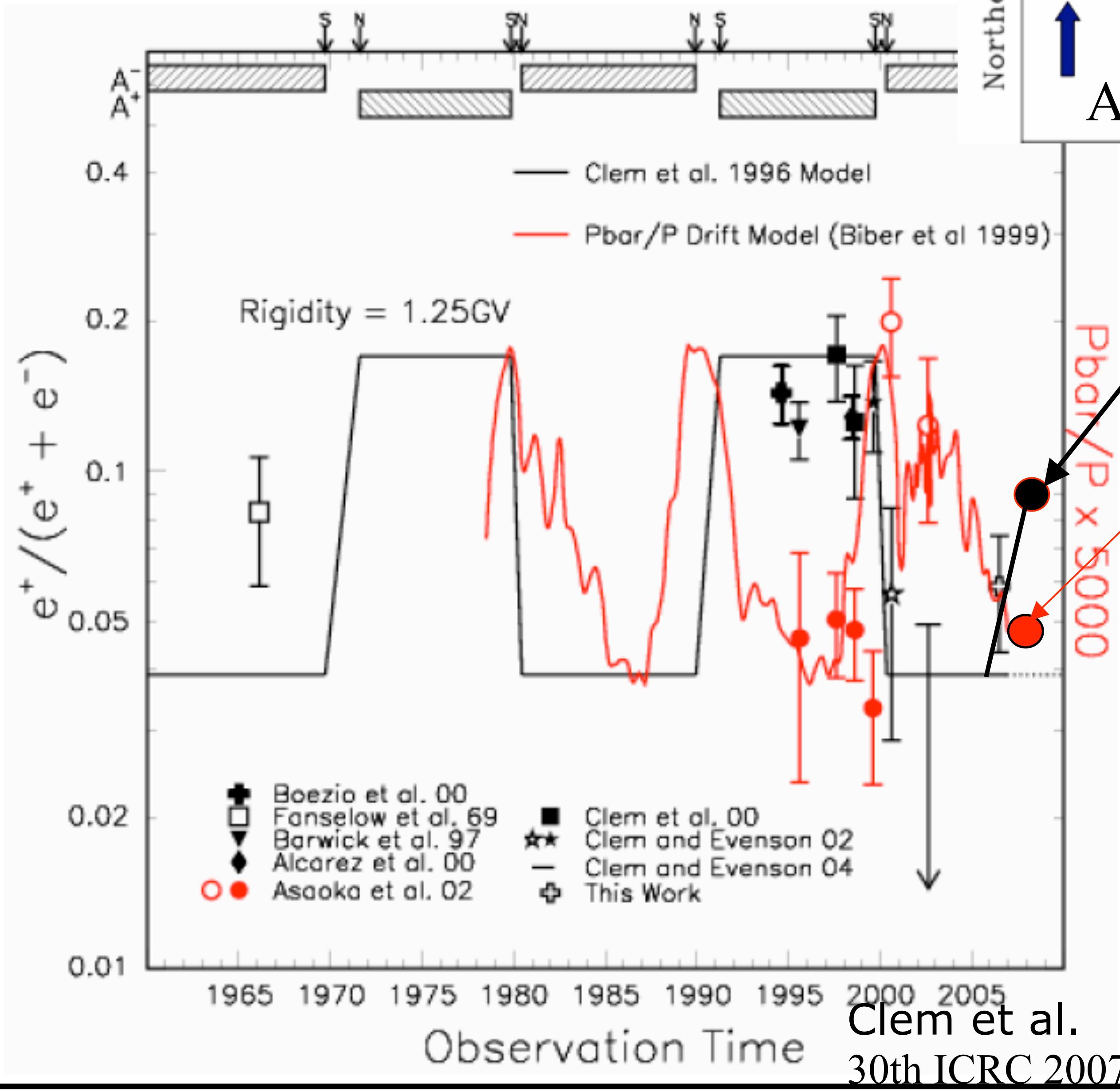
qA>0 measurements
(most data 11 years ago)





Charge dependent solar modulation

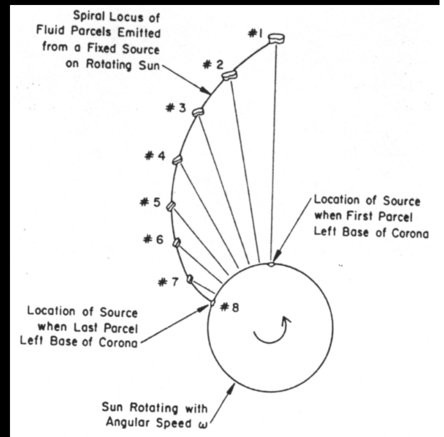




Pamela

Pamela e+

Pamela p-



Clem et al.
30th ICRC 2007

Fermi seems to exclude Egret excess

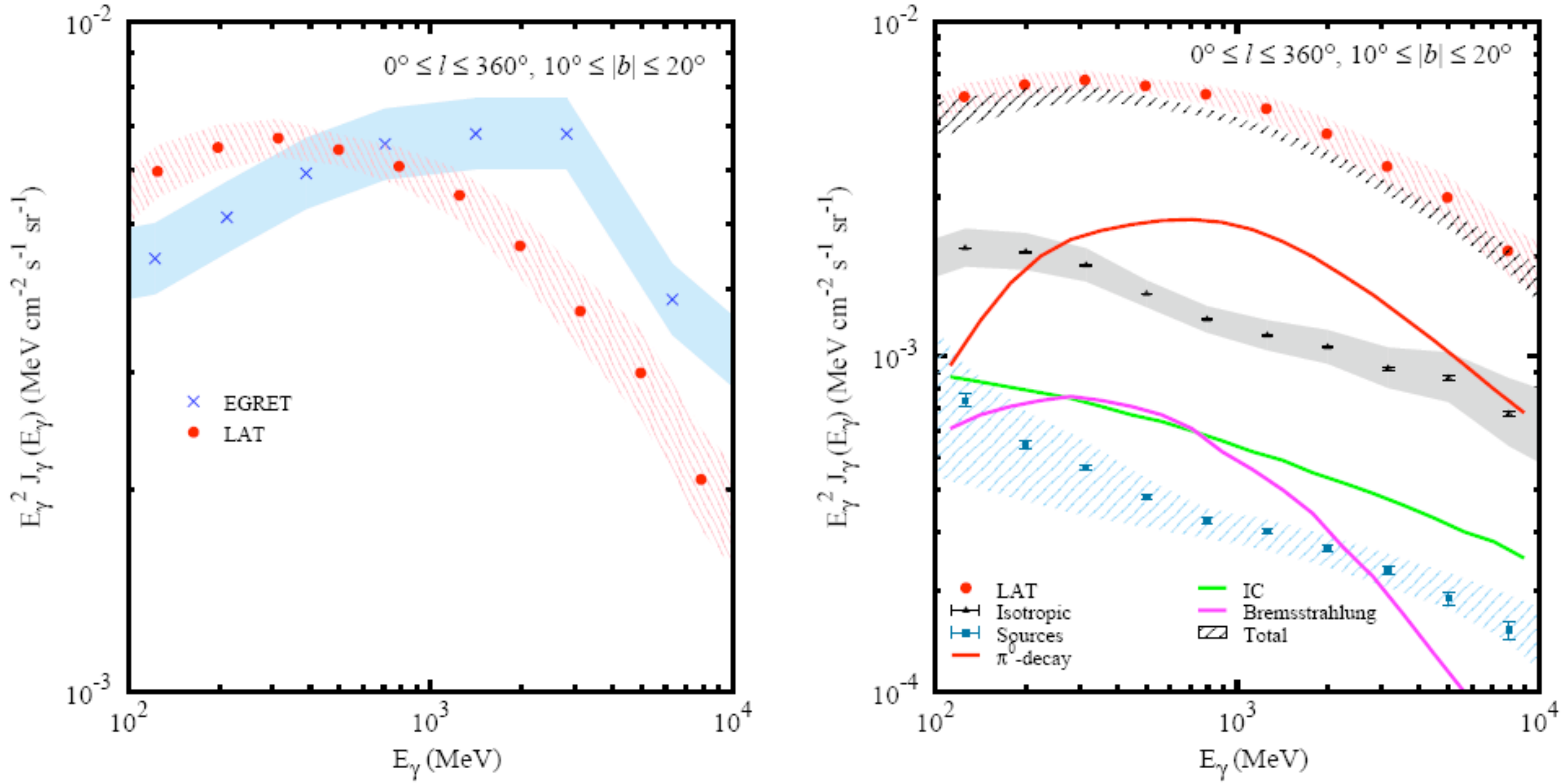


Fig. 1: *Left:* Preliminary diffuse emission intensity averaged over all Galactic longitudes for latitude range $10° \le |b| \le 20°$. Data points: LAT, red dots; EGRET, blue crosses. Systematic uncertainties: LAT, red; EGRET, blue. *Right:* Preliminary LAT data with model, source, and UIB components for same sky region. Model (lines): π^0-decay, red; Bremsstrahlung, magenta; IC, green. Shaded/hatched regions: isotropic, grey/solid; source, blue/hatched; total (model + UIB + source), black/hatched.

Porter, Icrc 2009

Fermi Haze
as IC counterpart of WMAP

Wmap haze in synchroton rad
Toward glactic center

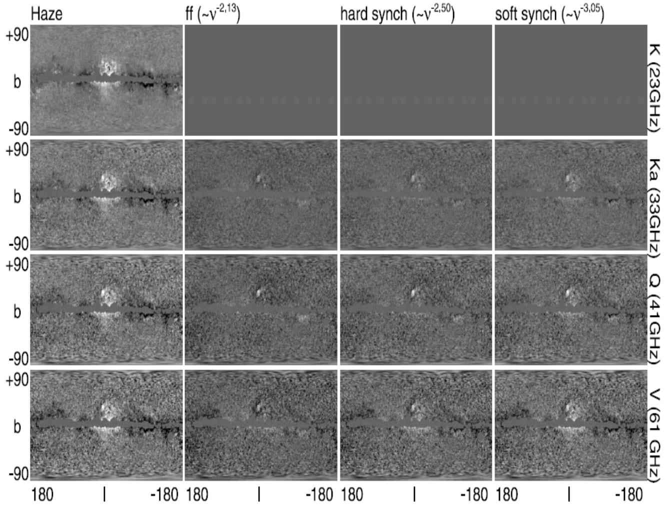


Fig. 5.—Haze is determined in 4 *WMAP* bands by subtracting CMB, soft synchrotron (Haslam et al. [1982] template), free-free (Hα template), and spinning dust. Using the K-band haze as a template, it is then subtracted from Ka, Q, and V bands assuming various power laws. A free-free spectrum fits most of the sky well, apart from the ζ Oph cloud $(l, b) = (5^\circ, 25^\circ)$. See § 3.3.

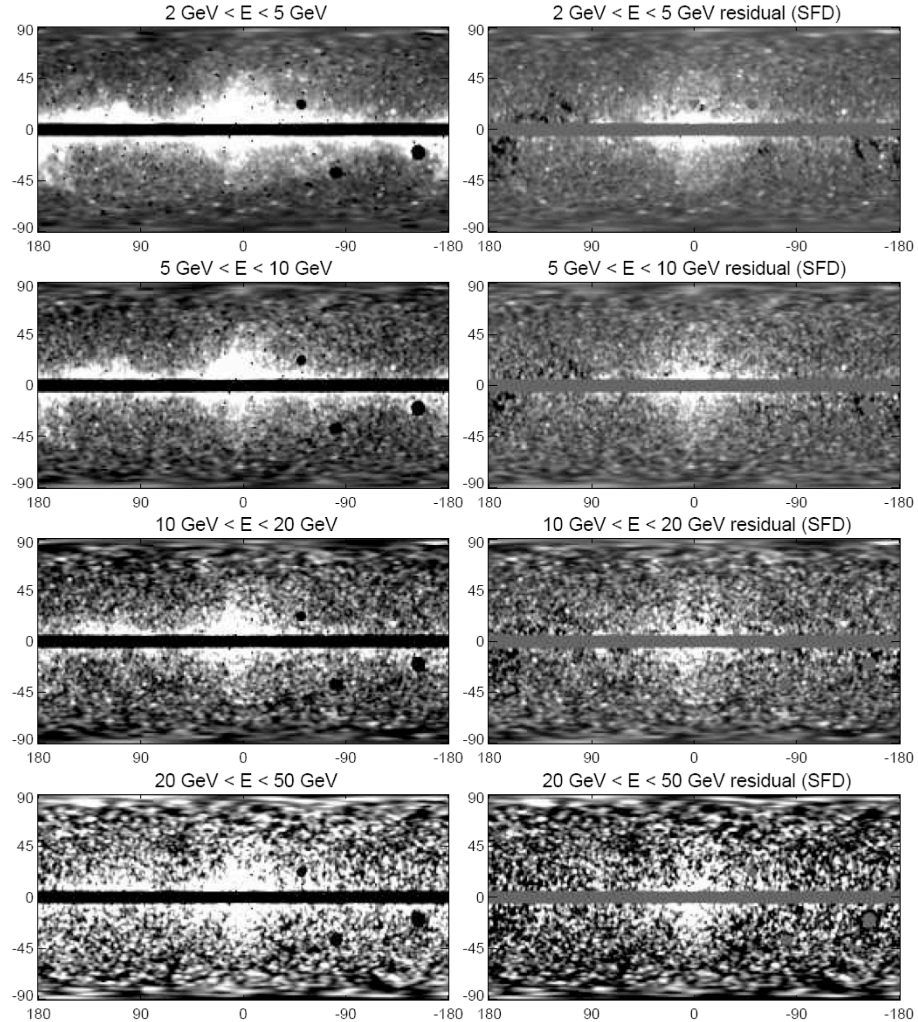


Fig. 3.— Residual maps after cross-correlating *Fermi* maps at various energies with the SFD dust map. The mask is described in §3.2. Cross-correlations are done over unmasked pixels and for $75 \leq \ell \leq 285$. Although the template removes much of the emission, there is a clear excess towards the Galactic center. This excess also includes a disky component which is likely due to ICS and bremsstrahlung from softer electrons (see Figure 5).

ApJ, 614:186–193,
2004 October 10

arXiv:0910.4583v1

Electrons and positrons are fashionable

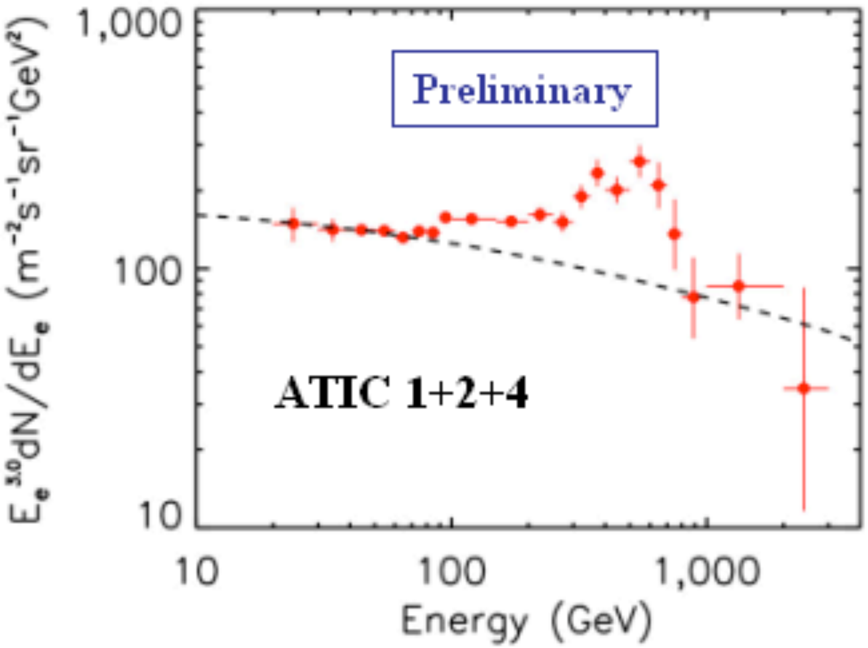
But there is disagreement on the $e^+ + e^-$ spectrum

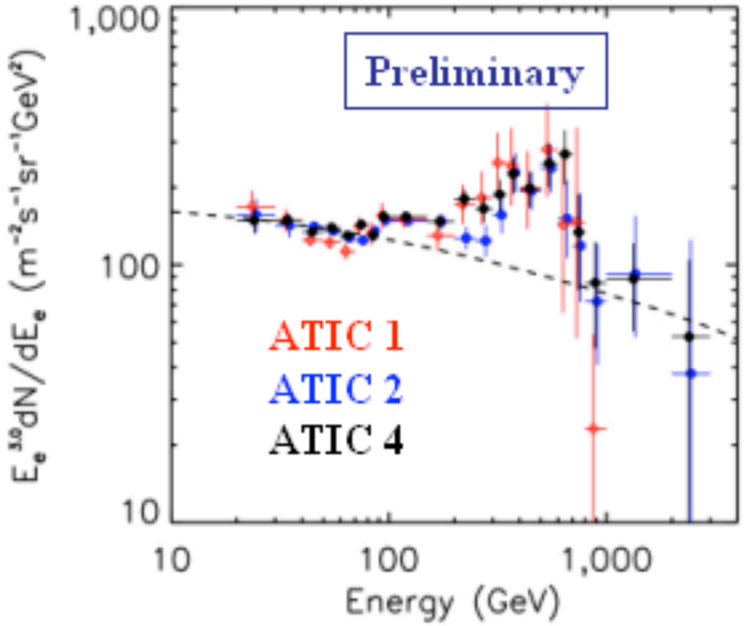
Atic: Balloon but deep detector

BGO calorimeter,
ATIC 1+2, 18.4 rl,
in 4 XY, planes,
ATIC 4, 22.9 rl,
in 5 XY planes,

Fermi: Large statistics (400 events in last bin) but shallow: **12.5 X_0**

All three ATIC flights are consistent



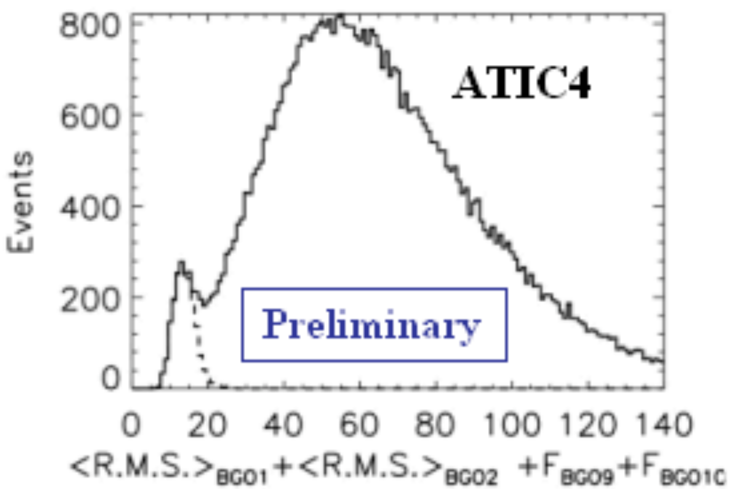


"Source on/source off" significance of bump for ATIC1+2 is about 3.8 sigma

ATIC-4 with 10 BGO layers has improved e , p separation. **(~4x lower background)**

"Bump" is seen in all three flights.

Significance for ATIC1+2+4 is 5.1 sigma

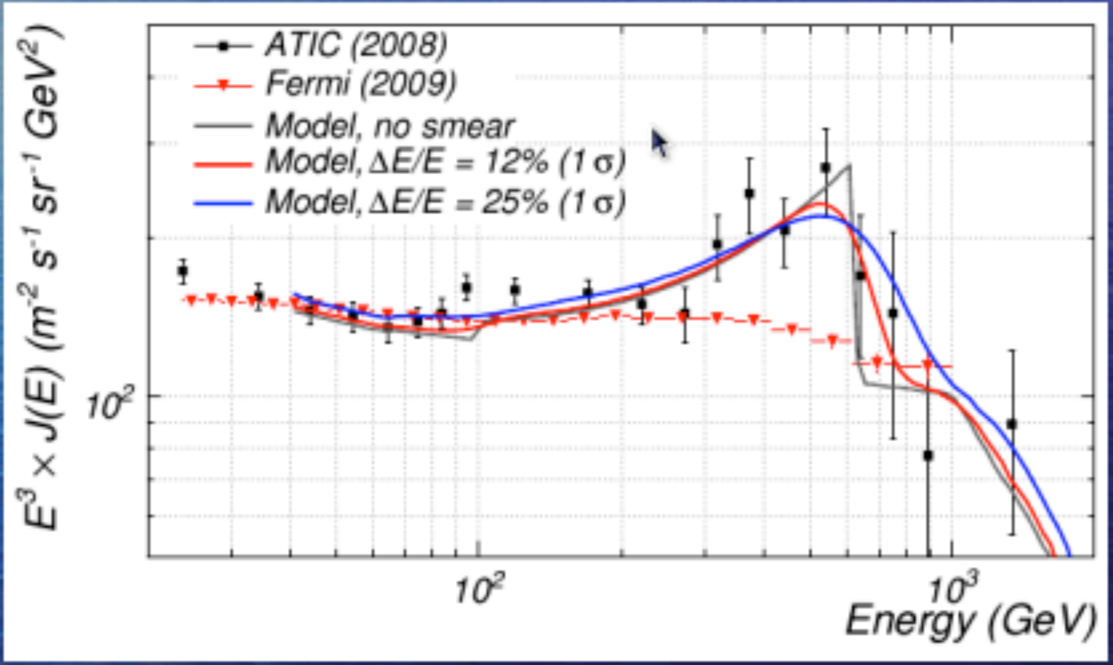


Joachim Isbert PAMELA 2009

And finally we want to check - could we miss "ATIC-like" spectral feature?

We validated the spectrum reconstruction by:

- *comparing the results for different path length subsets*
- *varying the electron selections*
- *simulating the LAT response to a spectrum with an "ATIC-like" feature:*

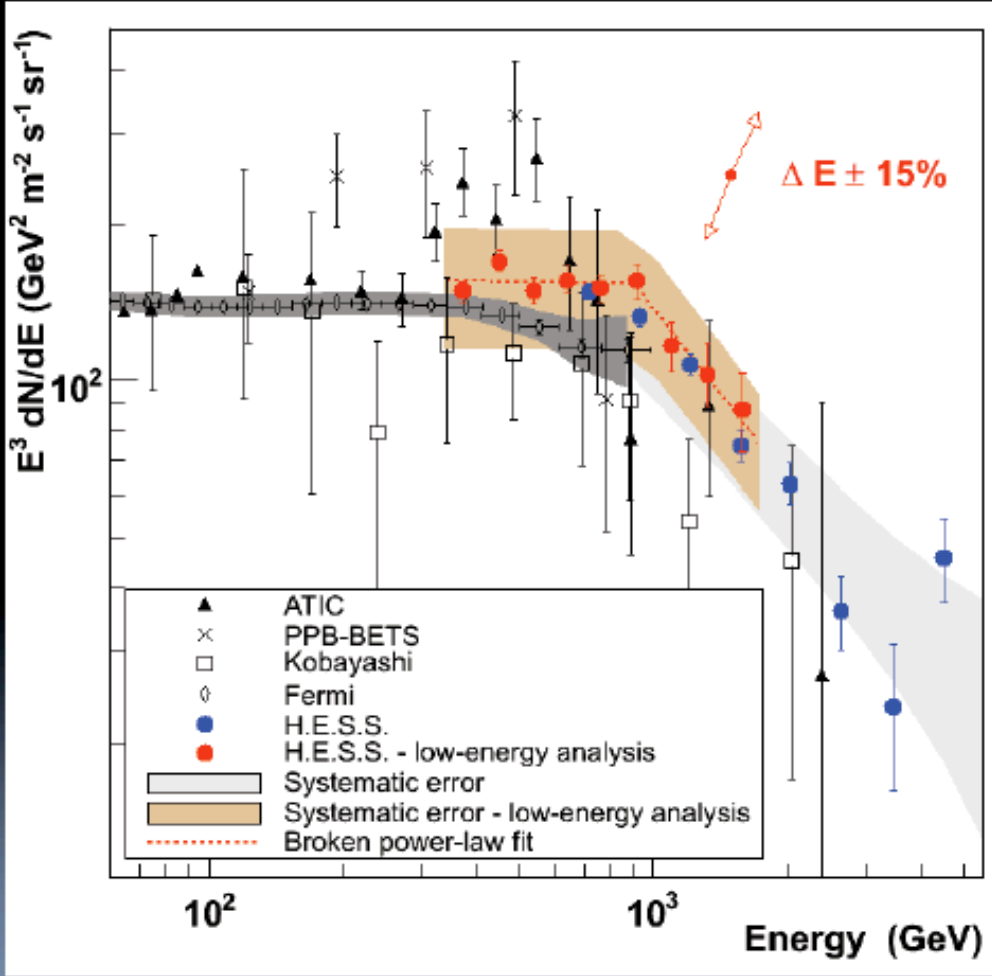


This demonstrates that the Fermi LAT would have been able to reveal "ATIC-like" spectral feature with high confidence if it were there. <u>Energy resolution is not an issue with such a wide feature</u>

Egberts, 2009

HESS electrons

- Cuts:
  - impact distance < 100 m
  - image size in each camera > 80 photo electrons
  - Data set of 2004/2005
- Syst. uncertainty: atmospheric variations + model dependence of proton simulations (SIBYLL vs. QGSJET-II)
- Spectral index:
  $\Gamma_1 = 3.0 \pm 0.1(\text{stat}) \pm 0.3(\text{syst.})$
  $\Gamma_2 = 3.9 \pm 0.1(\text{stat}) \pm 0.3(\text{syst.})$



PAMELA electron flux