highlights from the AMS cosmic ray observatory on the ISS

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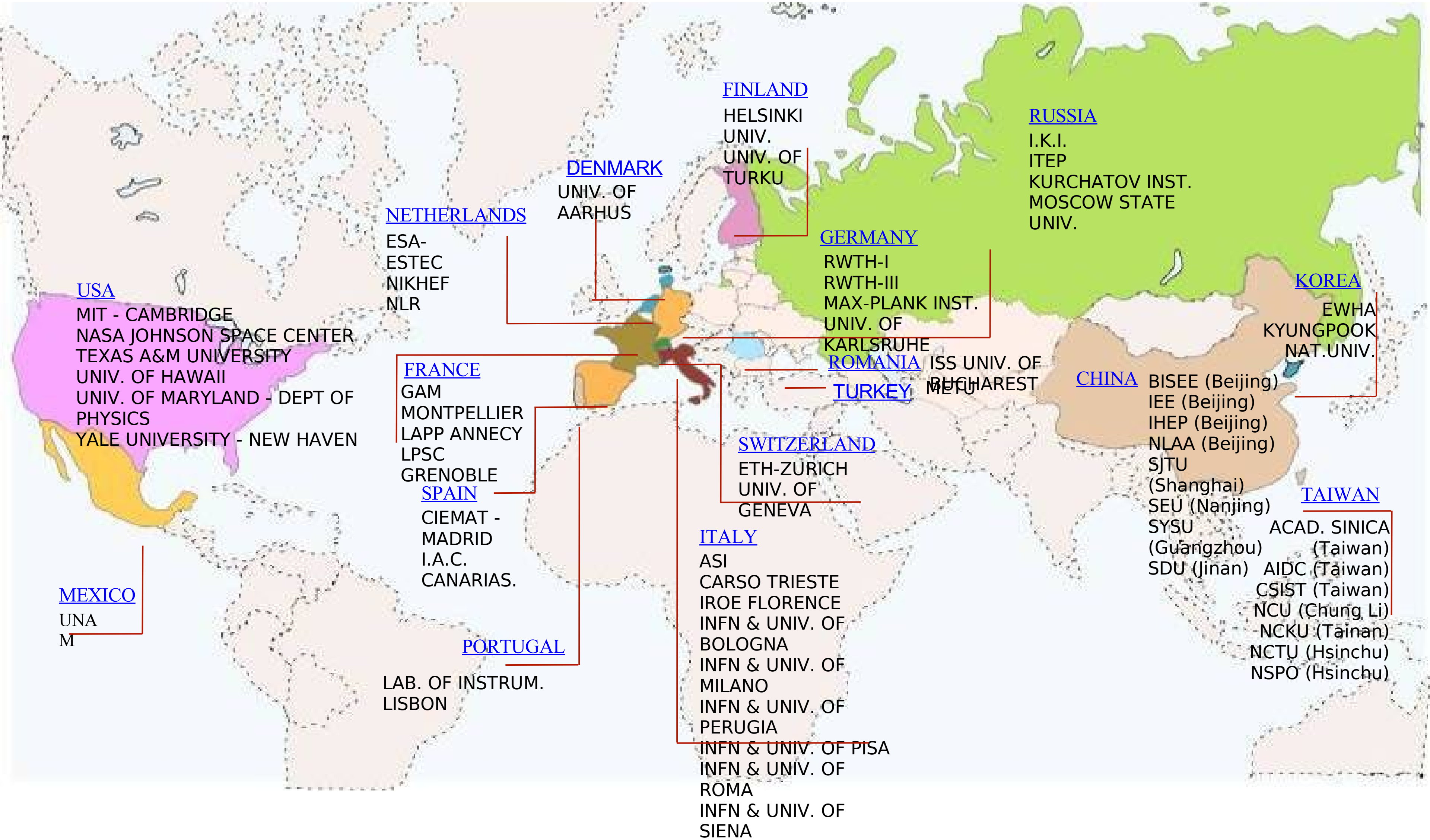
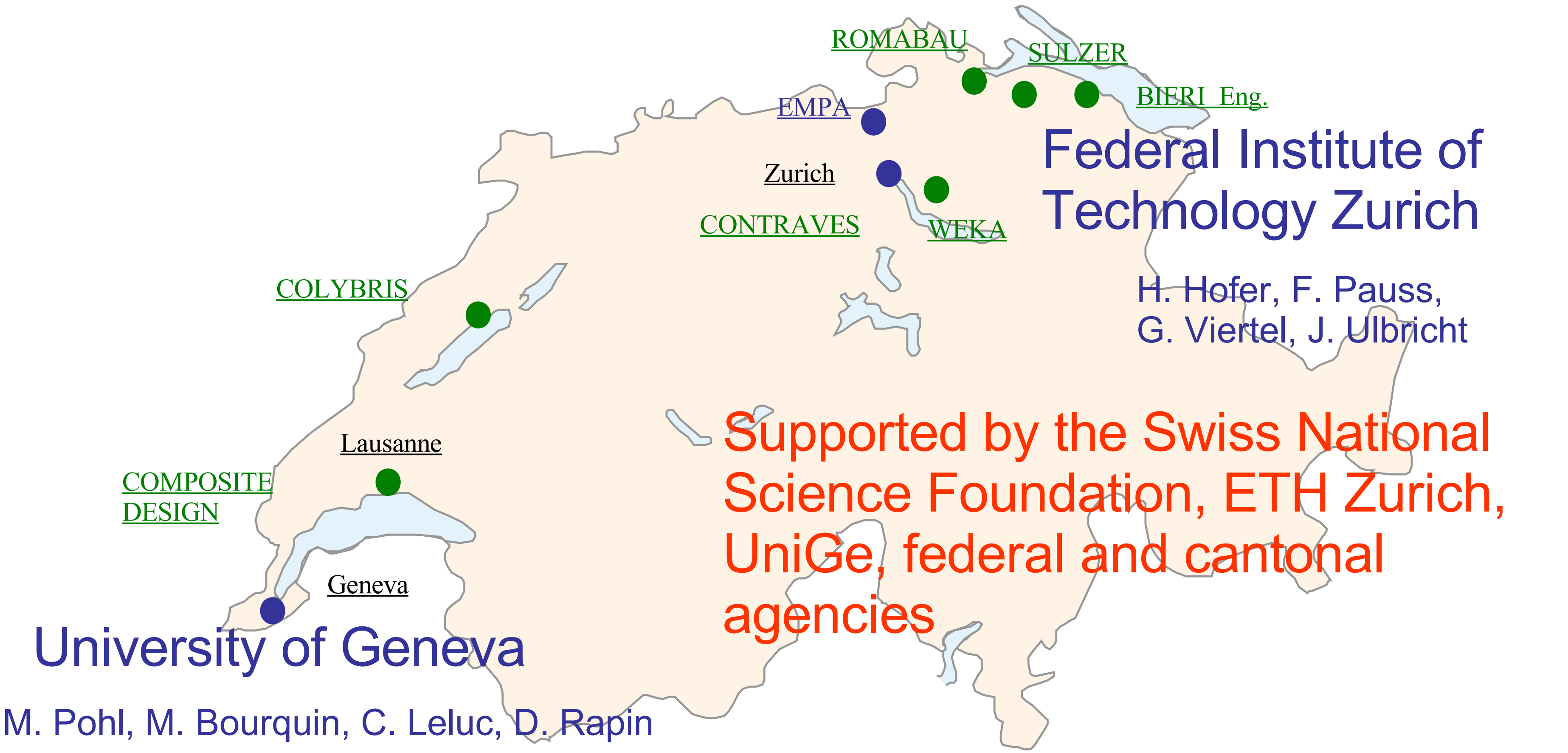
AMS Scientific Mission

- Complete inventory of Cosmic Rays near Earth, composition and spectra, GeV to TeV
- Search for residual antimatter
- Search for non-standard sources of Cosmic Rays, like dark matter self-annihilation or decay
- Search for unusual components, new stable particles

AMS collaboration
16 Countries, 60 Institutes and 600 Physicists

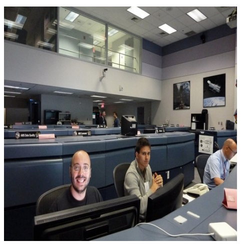


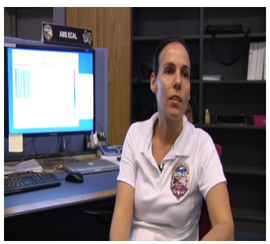
Swiss Participation in AMS



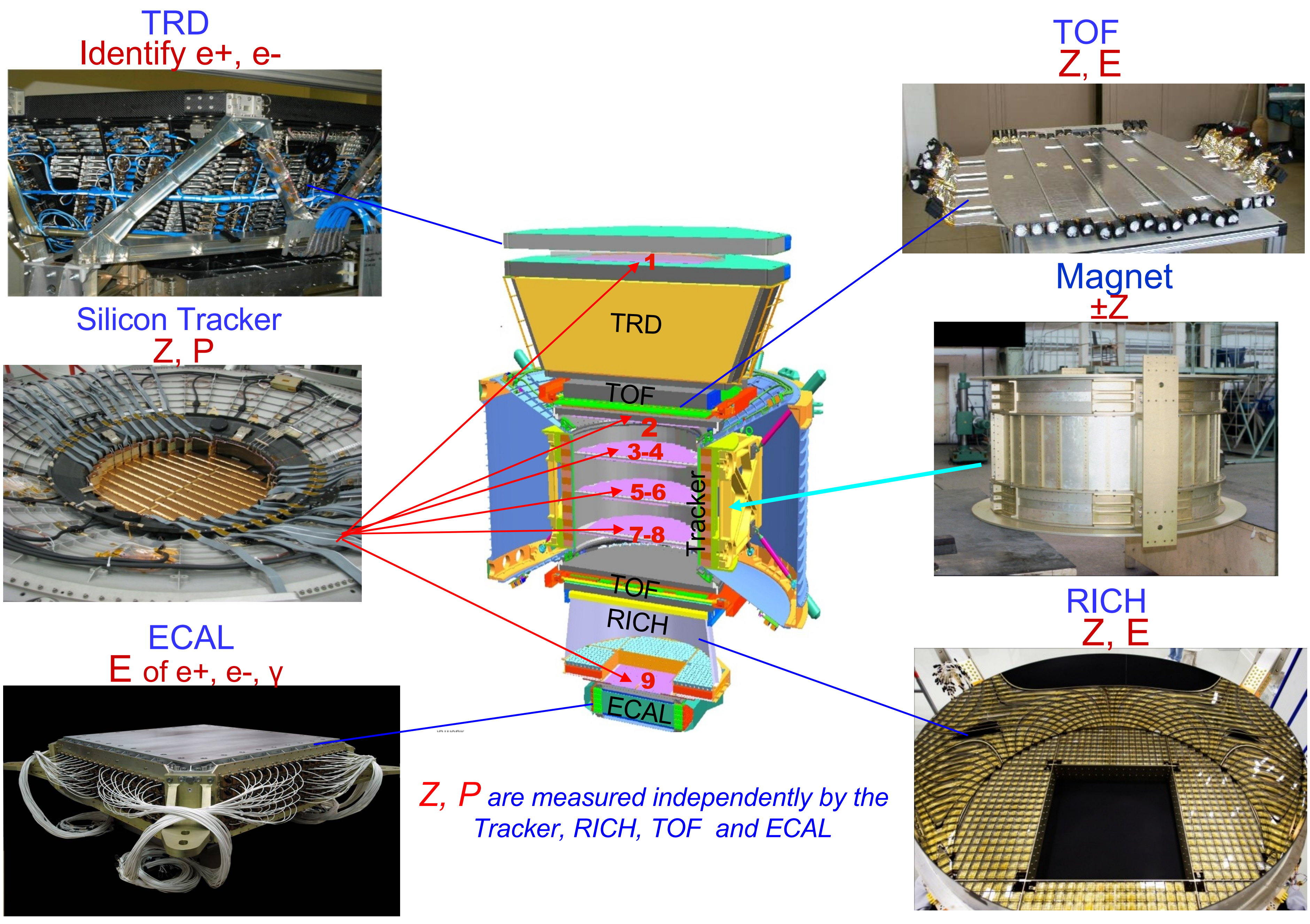
University of Geneva in AMS: A long term commitment

- Two generations of professors
- Two generations of engineers
- Three generations of post-docs and PhD students



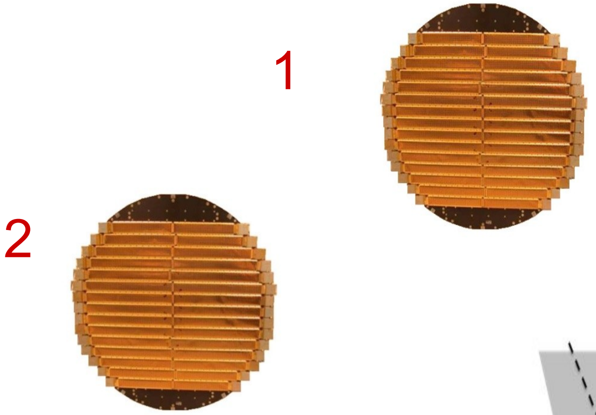


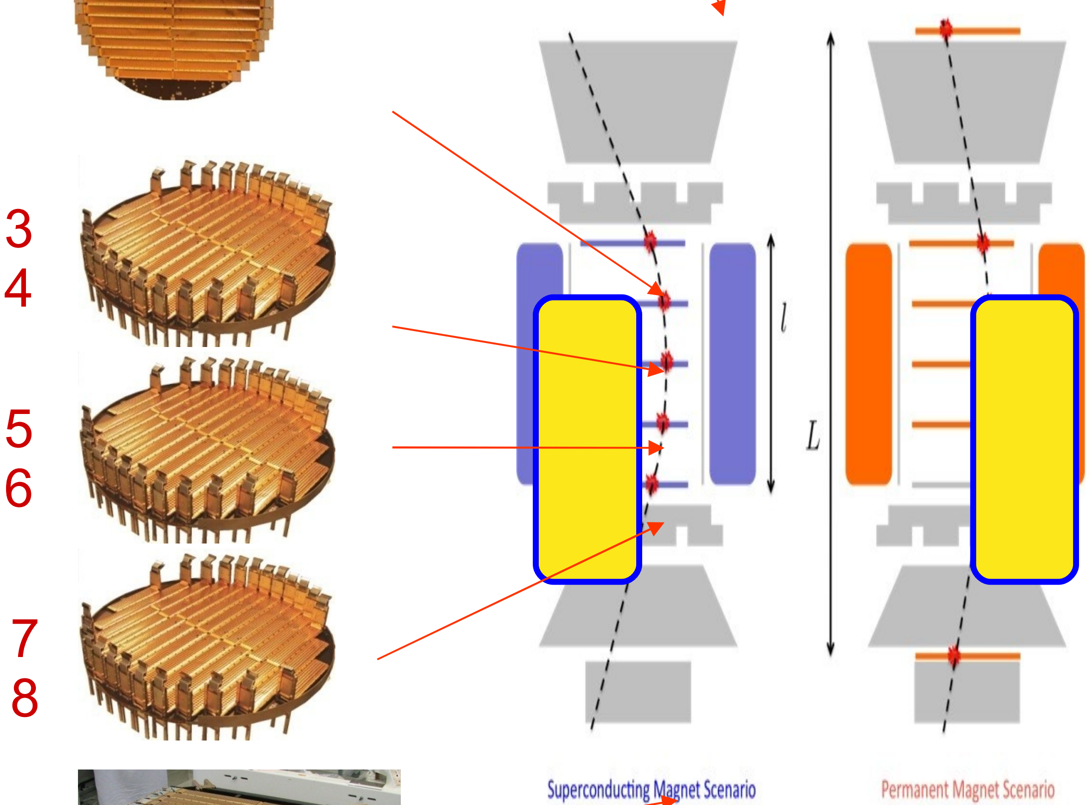
AMS: A TeV precision, multipurpose spectrometer



Tracker: Coordinate resolution 10 μm

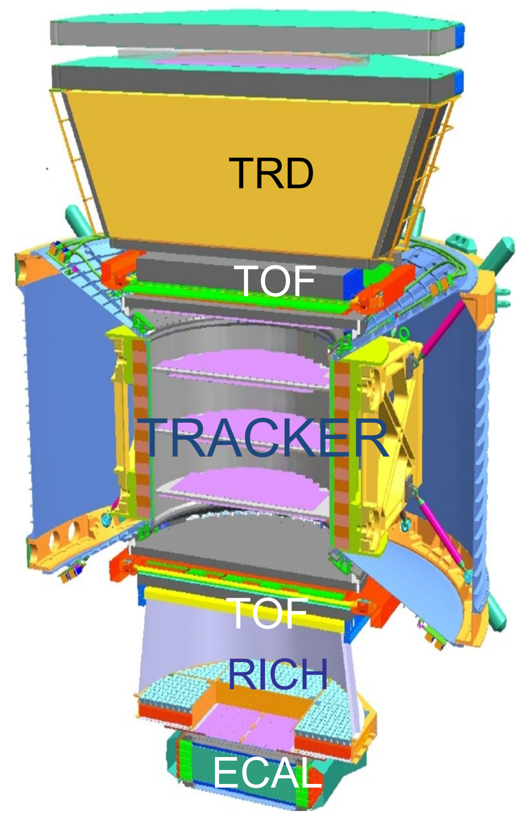
Inner Tracker Alignment via
20 UV Lasers
Outer Tracker Alignment via
Cosmic rays





$$\frac{\Delta R}{R} \propto \frac{1}{B_{scm} l^2}$$

$$\frac{\Delta R}{R} \propto \frac{1}{B_{pm} l L}$$



AMS-02 Launch

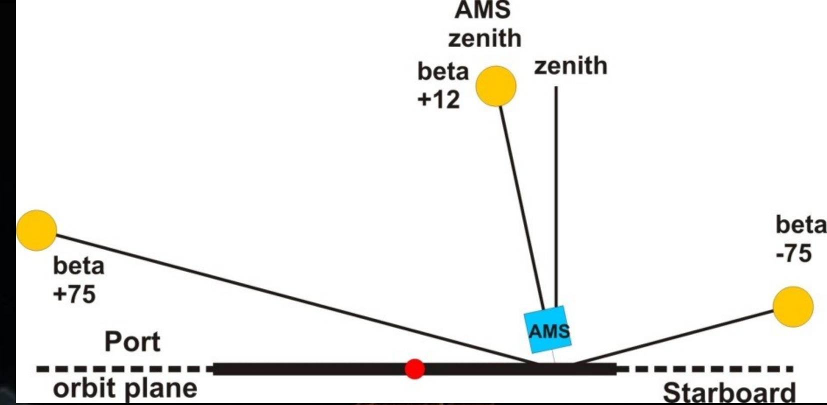
After 12 years of construction, integration, test…

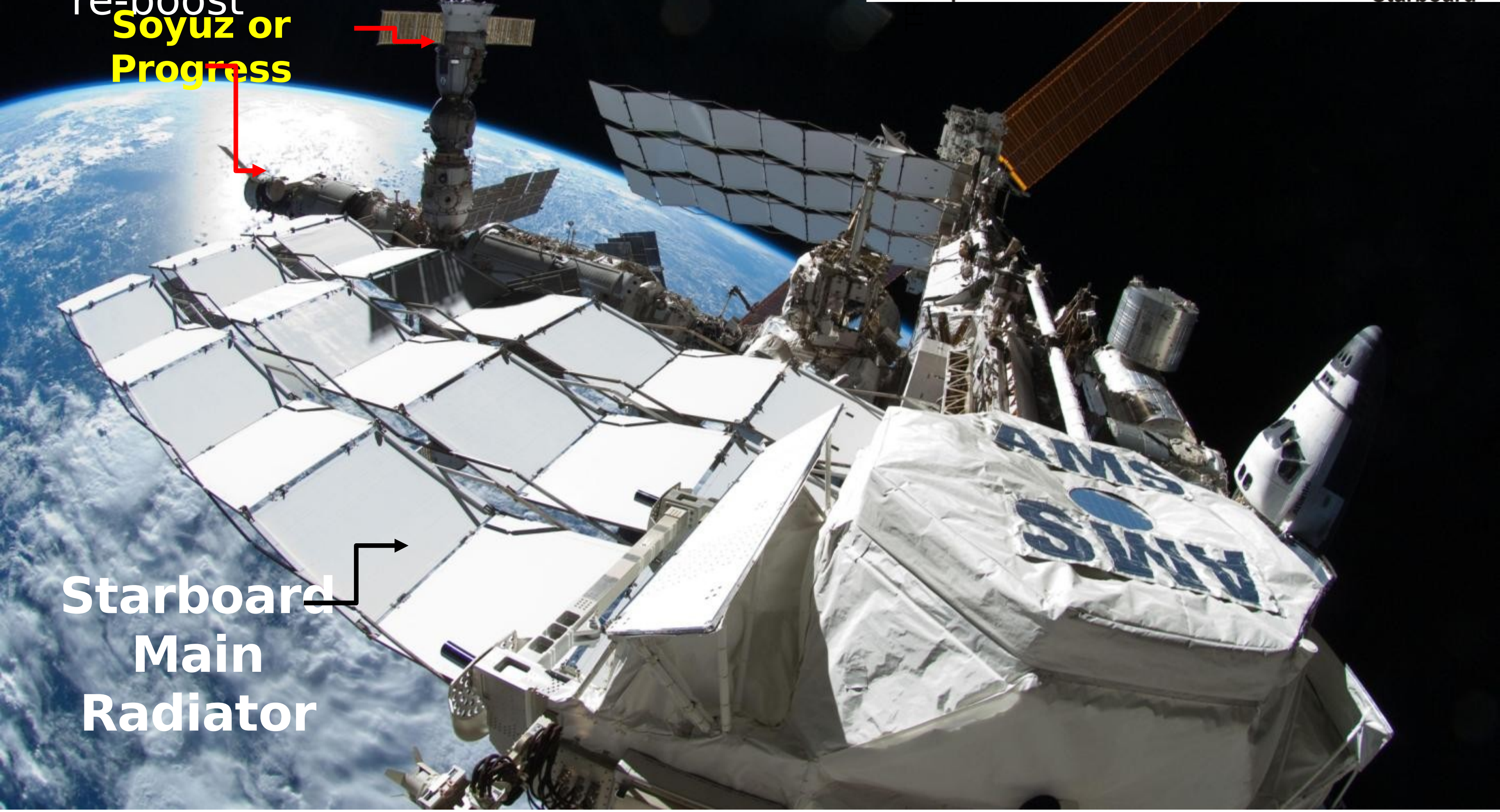
STS-134 Endeavour:

- Successful launch: May 16, 2011, 14:56
- Docking with ISS: May 17, 17:59
- AMS installation complete: May 19, 11:46
- AMS up and running: May 19, 16:38
- First He nucleus: May 19, 16:42

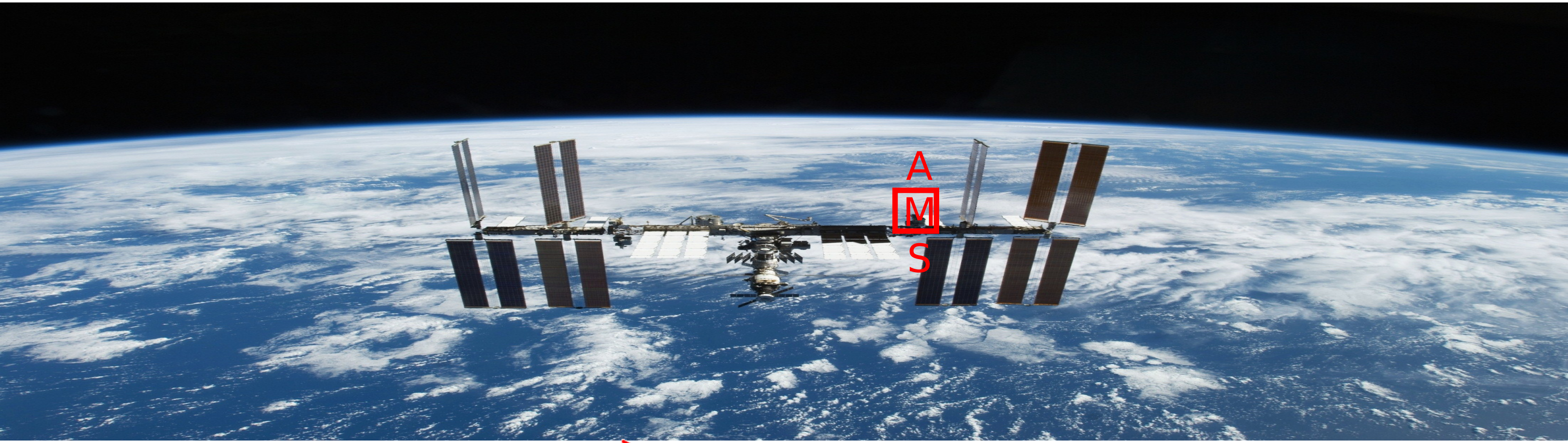
Thermal environment variables:

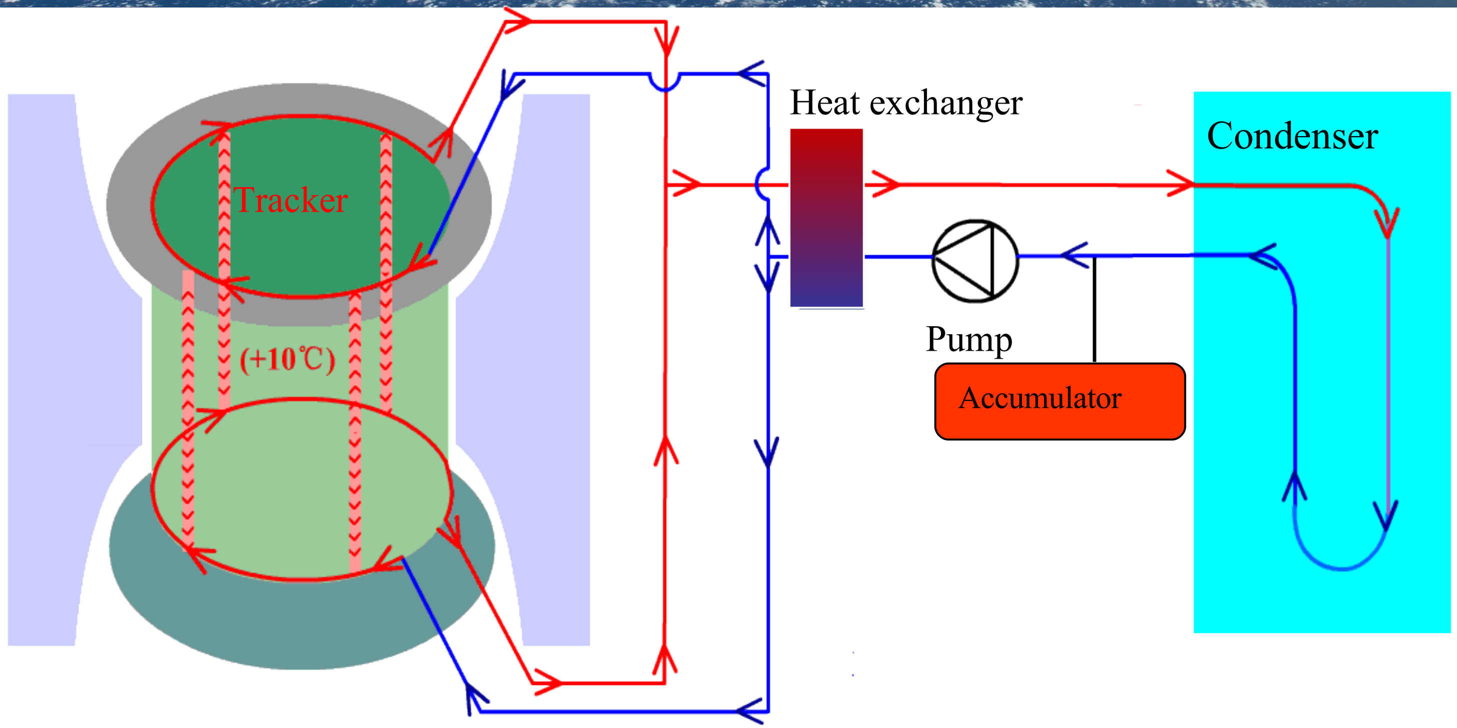
- Solar beta angle
- **ISS main radiator and solar panel positions**
- **ISS attitude, visiting vehicles,** re-boost





Tracker Thermal Control System



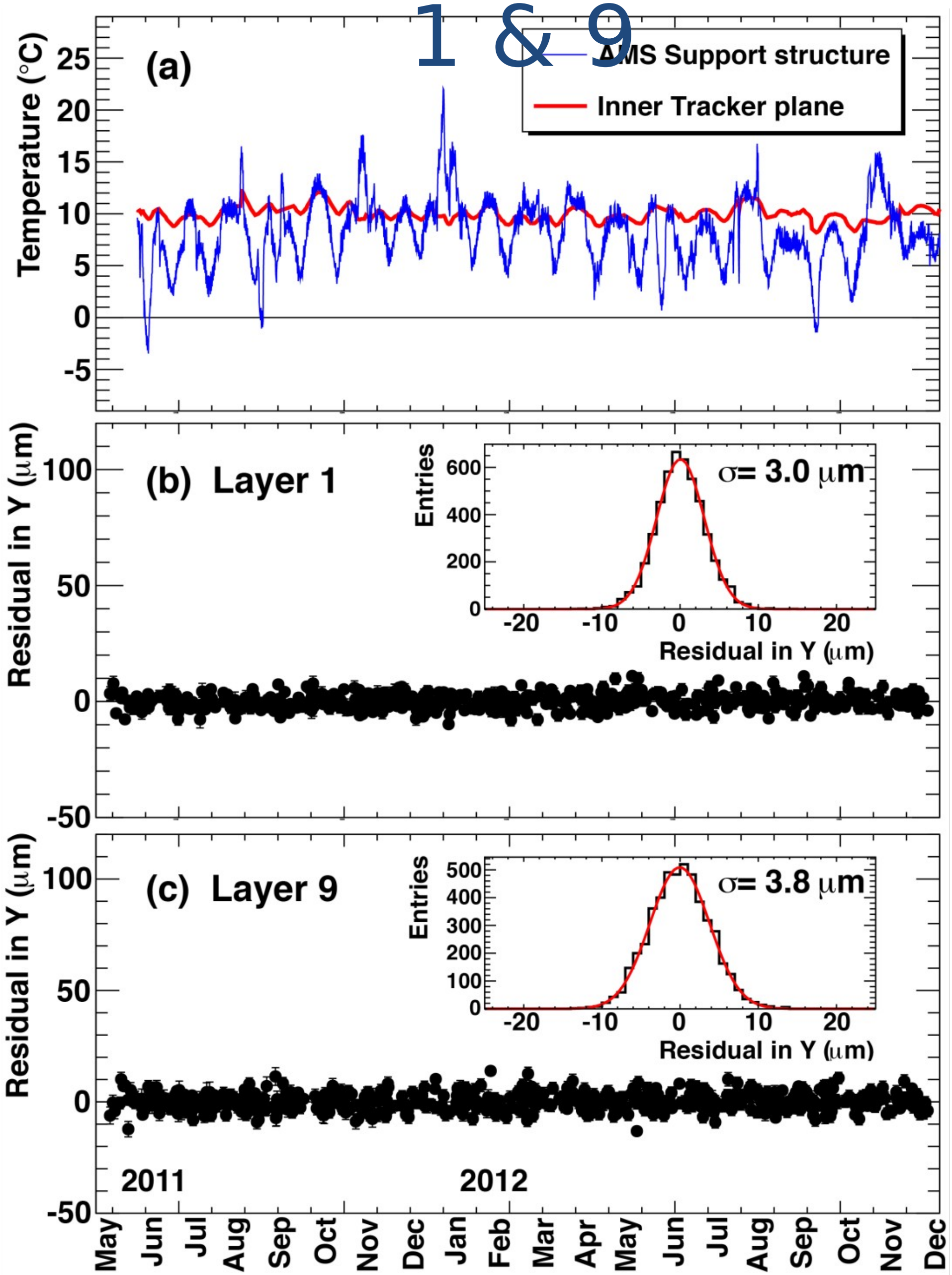


Red line: CO_2 gas/liquid two phase

Blue line: CO_2 liquid phase

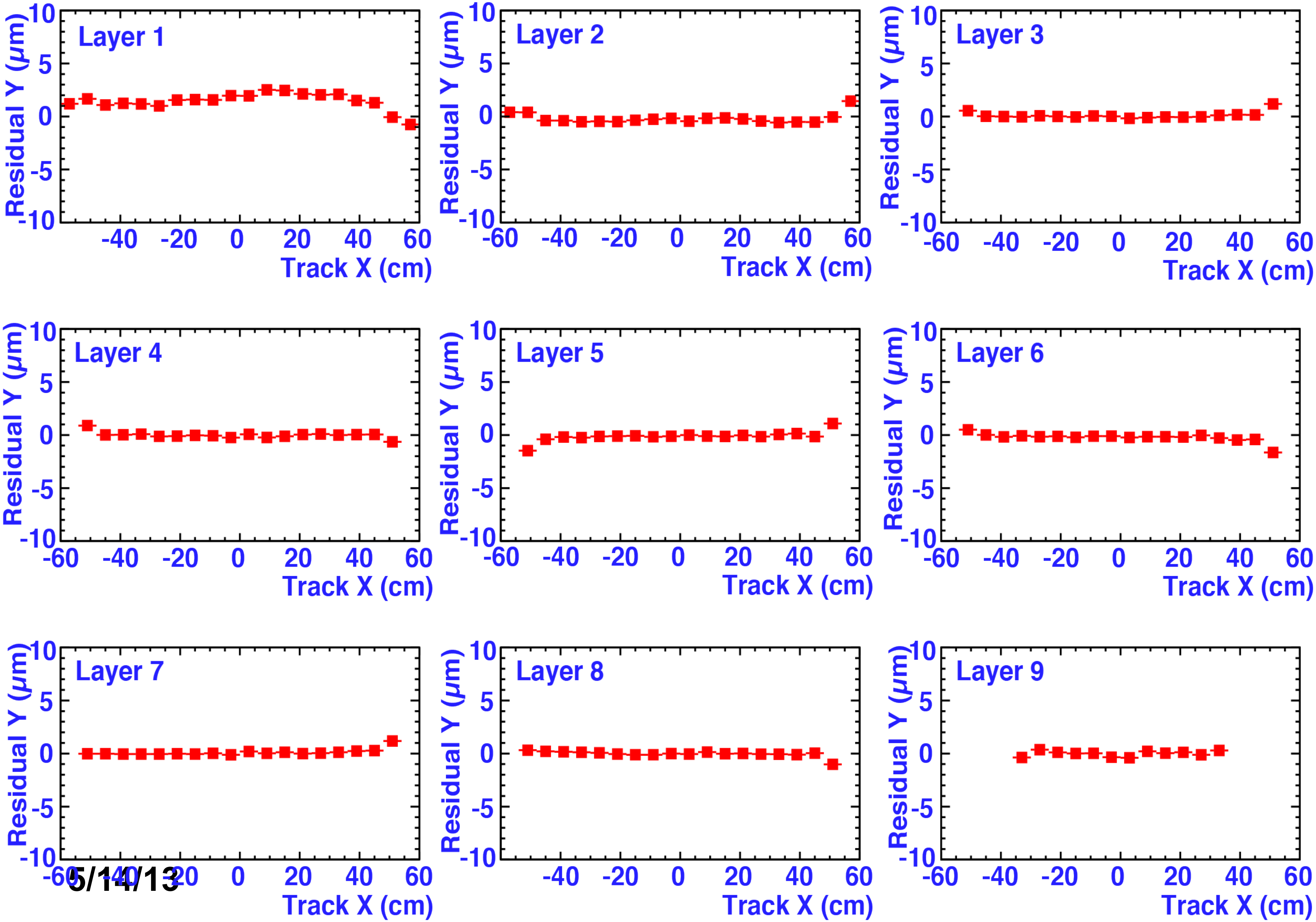
Movements of the external tracker planes with time
before alignment

Stability of the alignment on Tracker plane 1 & 9

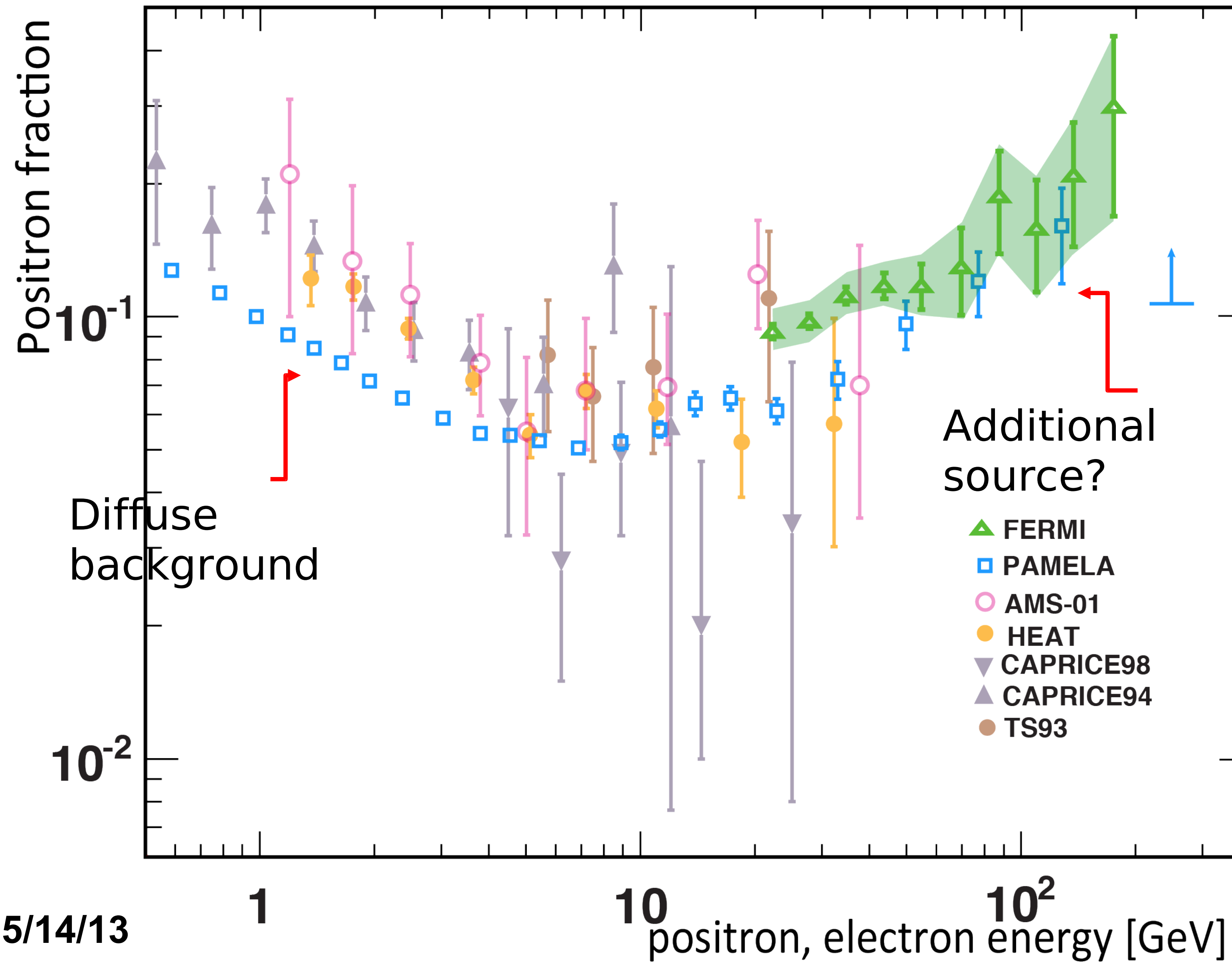


Click

Alignment accuracy of the 9 Tracker layers over 18 months



Positron Fraction = Φ(e+) / [Φ(e+) + Φ(e-)]



Physics of Positron Fraction

M. Turner and F. Wilczek, Phys. Rev. D42 (1990) 1001;
J. Ellis, 26th ICRC Salt Lake City (1999) astro-ph/9911440;
H. Cheng, J. Feng and K. Matchev, Phys. Rev. Lett. 89 (2002) 211301;
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D. Hooper and J. Silk, Phys. Rev. D 71 (2005) 083503;
E. Ponton and L. Randall, JHEP 0904 (2009) 080;
G. Kane, R. Lu and S. Watson, Phys. Lett. B681 (2009) 151;
D. Hooper, P. Blasi and P. D. Serpico, JCAP 0901 025 (2009) 0810.1527; B2
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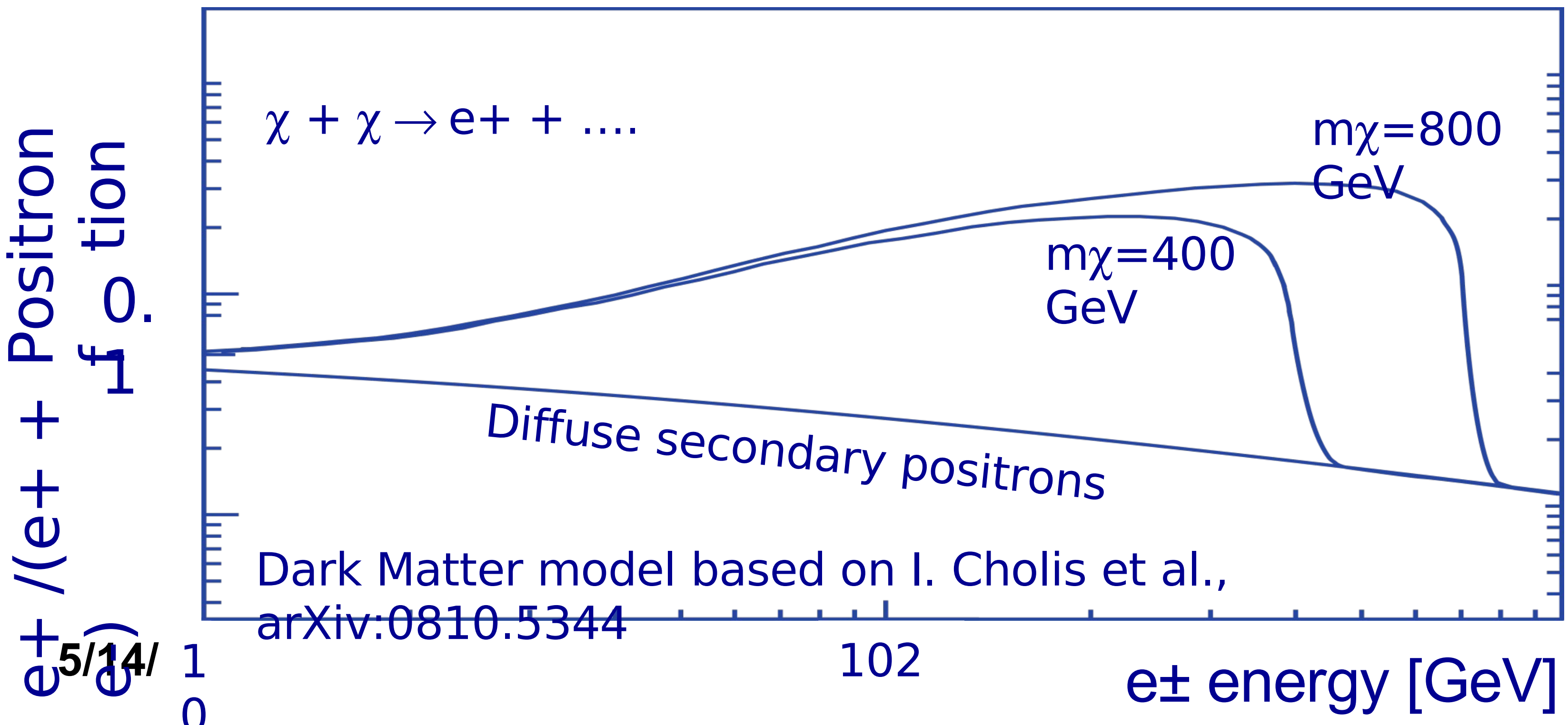
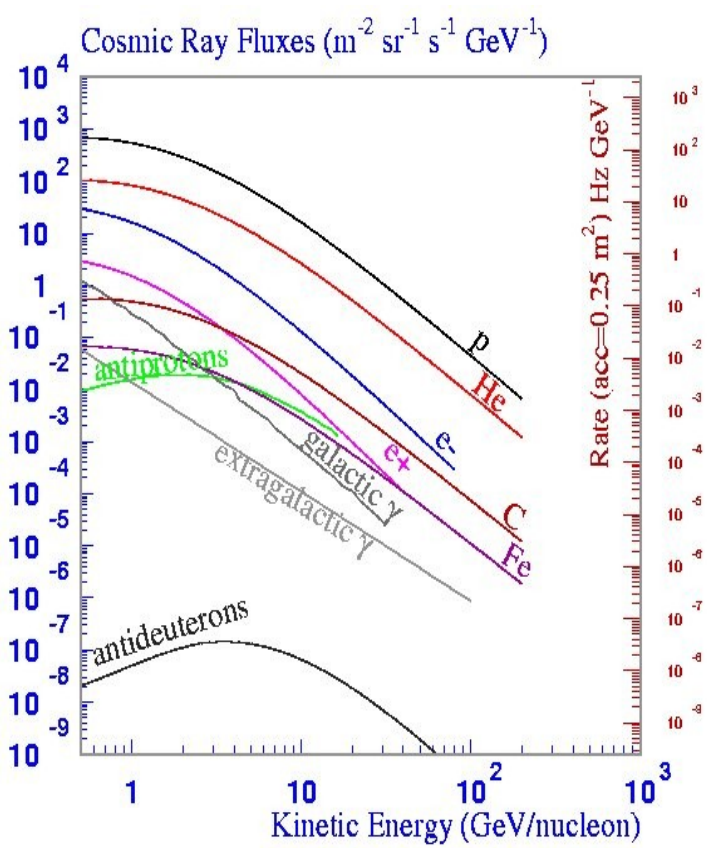
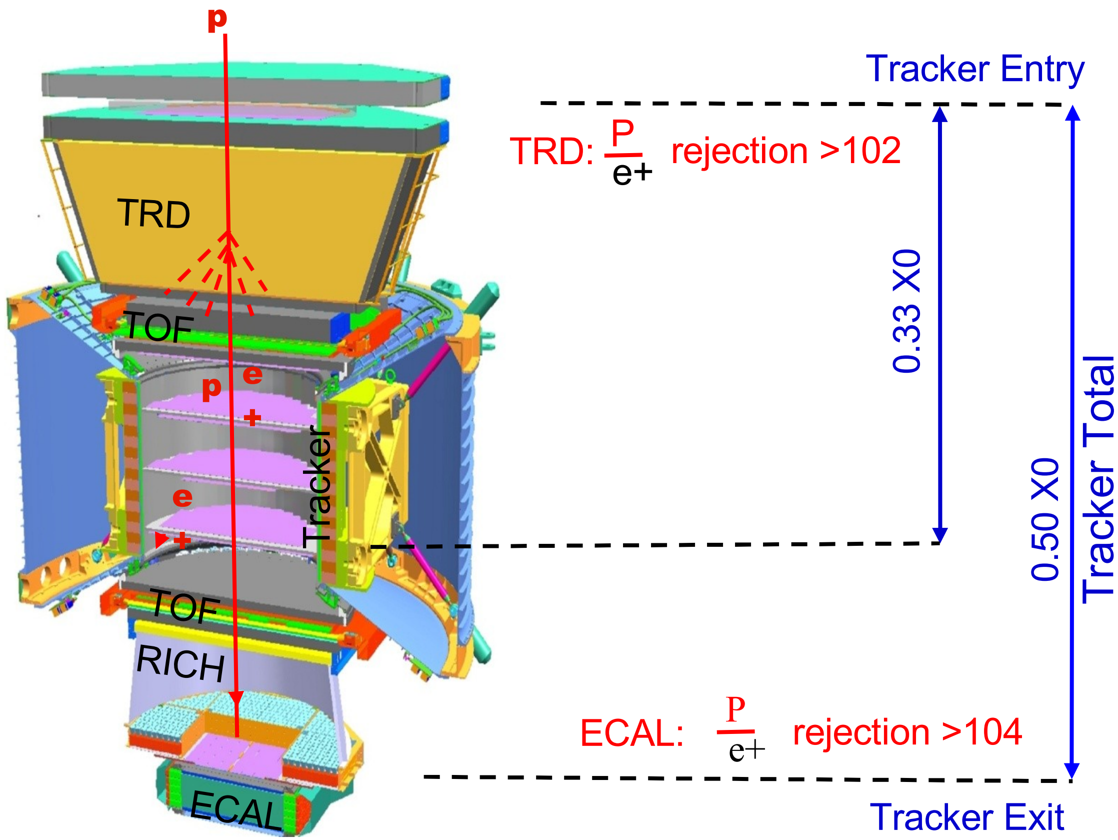


Separation Power for p/e+ >106





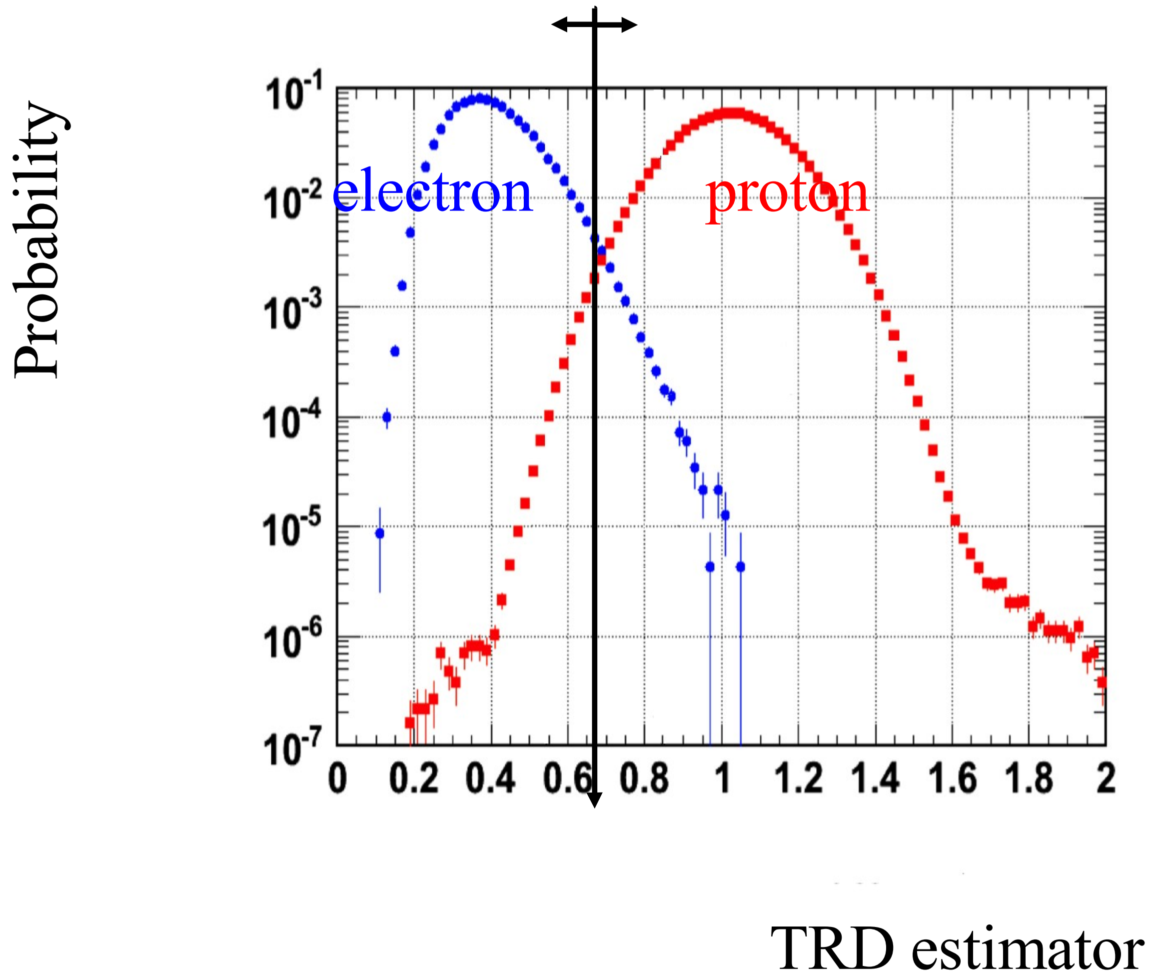
a) Minimal material in the TRD and TOF
So that the detector does not become a source of e+.

b) A magnet separates TRD and ECAL so that e+ produced in TRD will be swept away and not enter ECAL
In this way the rejection power of TRD and ECAL are independent

c) Matching momentum of 9 tracker planes with ECAL energy measurements

TRD performance on ISS

TRD estimator = -ln(*P*e/(*P*e+*P*p))

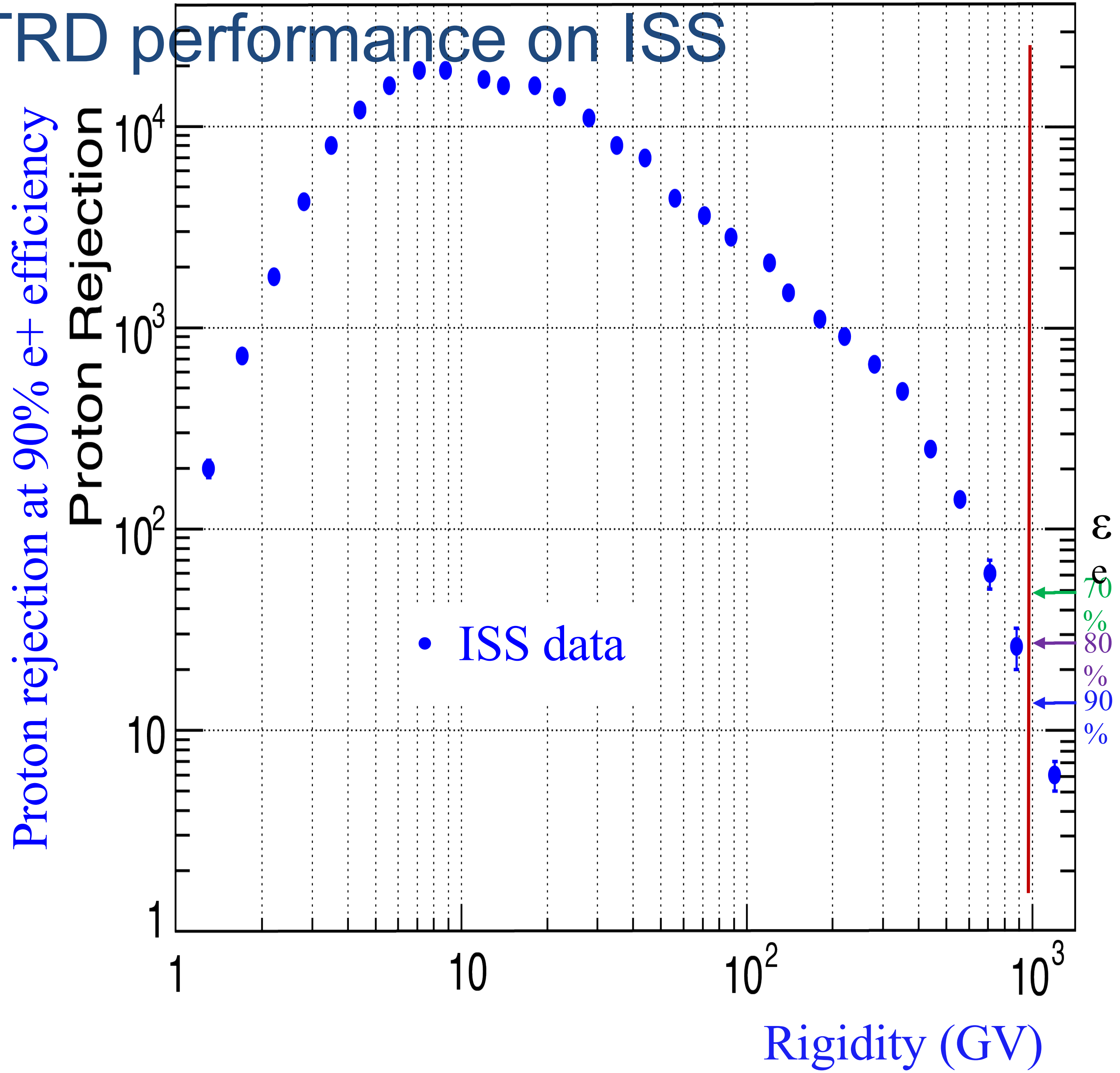


Normalized likelihoods *P*e and *P*p

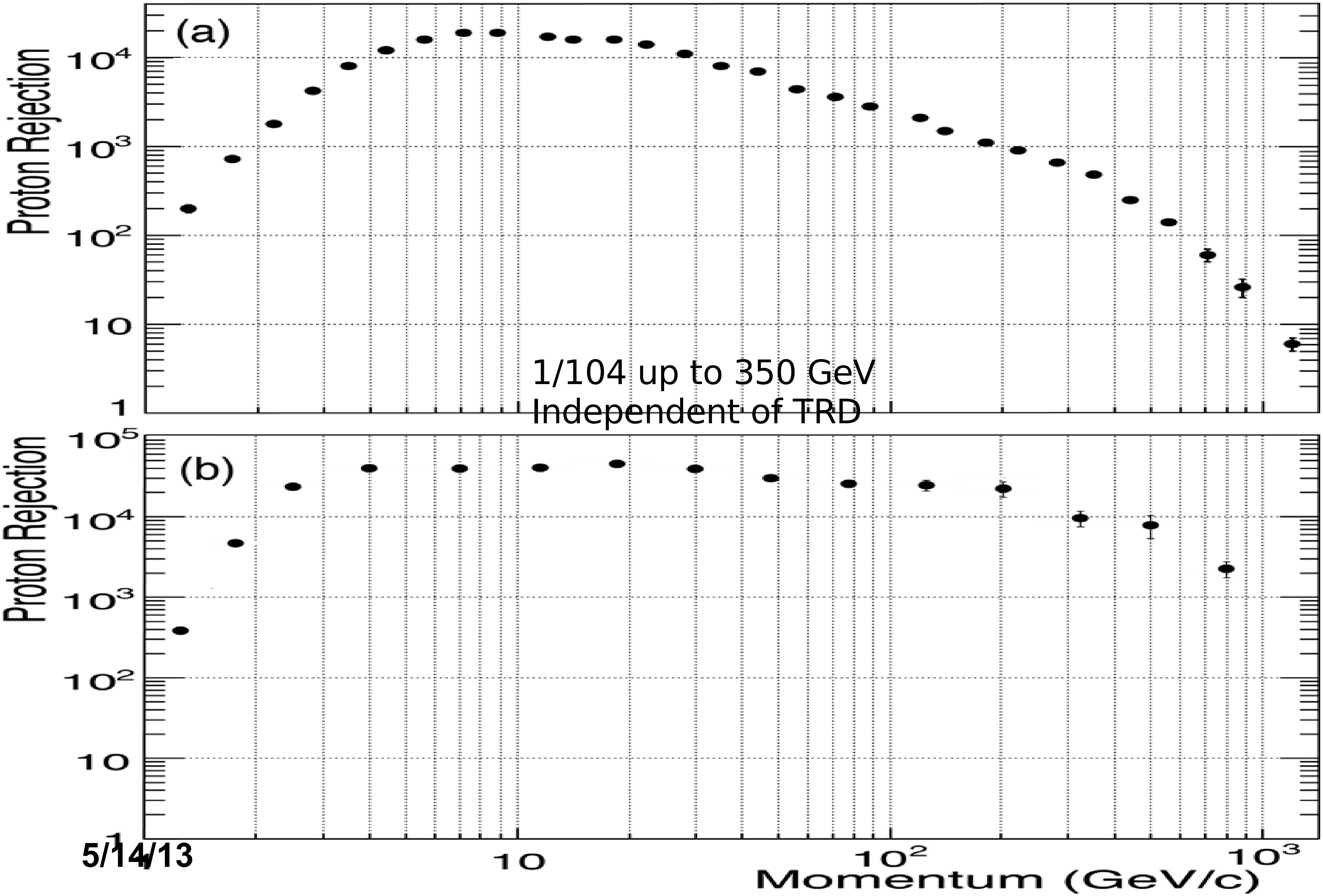
$$P_e = \sqrt[n]{\prod_i^n P_e^{(i)}(A)}$$

$$P_p = \sqrt[n]{\prod_i^n P_p^{(i)}(A)}$$

TRD performance on ISS



Data from ISS: Proton rejection using the ECAL



Over 18 months of operations, AMS has collected over 25 billion events.

6.8 million are electrons or positrons.

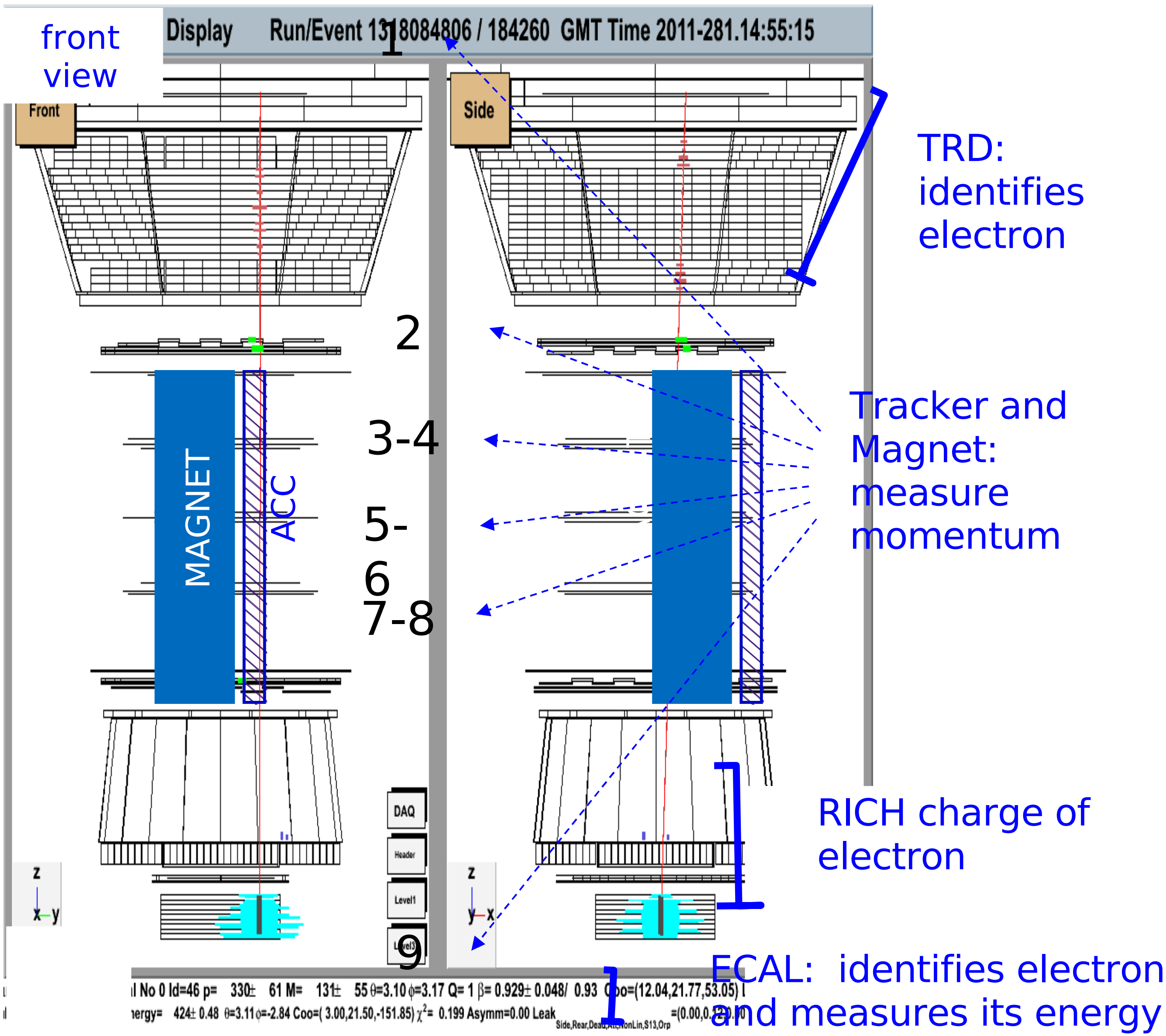
“First Result from the AMS on the ISS: Precision Measurement of the Positron Fraction in Primary Cosmic Rays of 0.5-350 GeV”

Selected for a Viewpoint in Physics and an Editors’ Suggestion

Aguilar,M. et al (AMS Collaboration) Phys. Rev. Lett. 110, 141102 (2013)

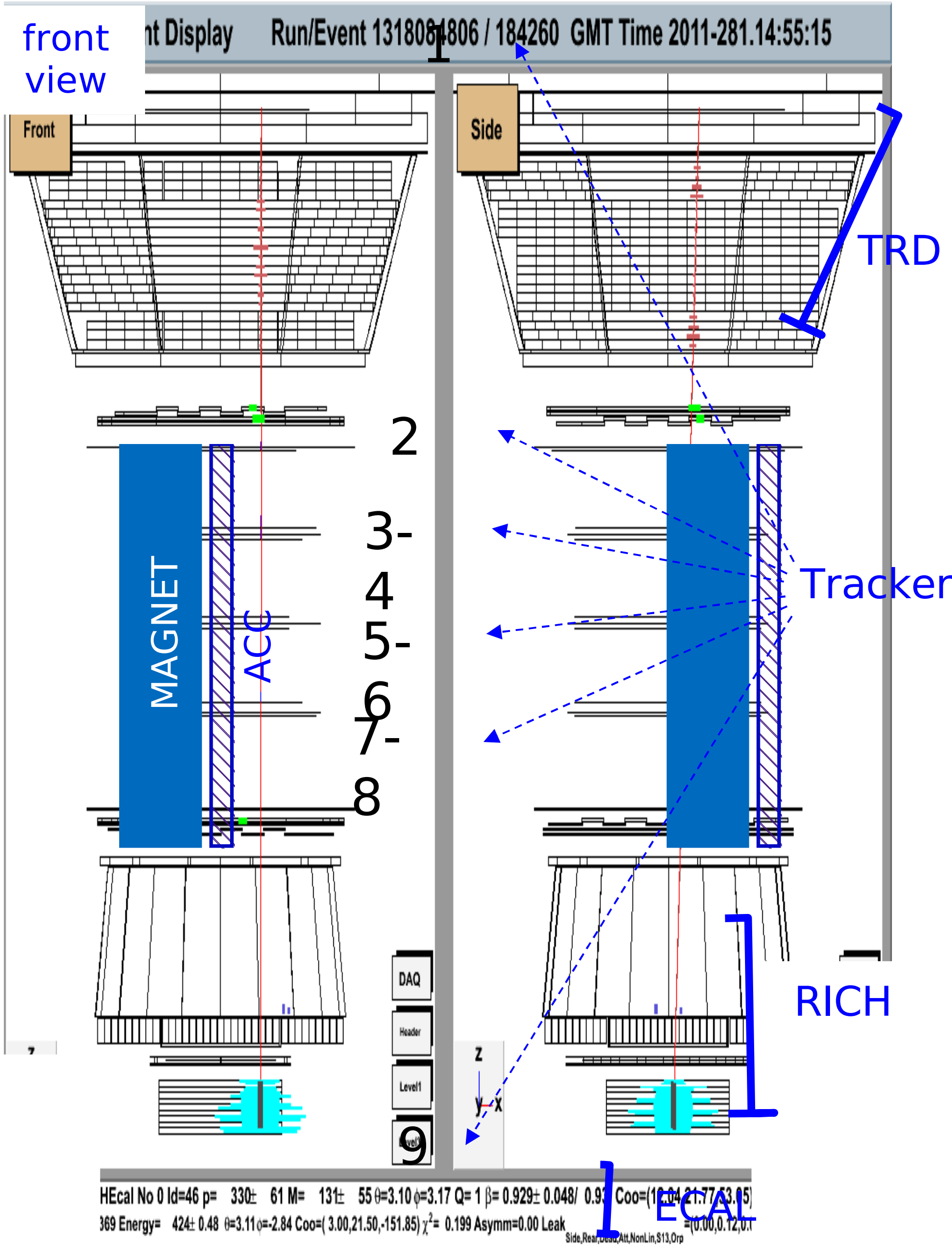
5/14/13

AMS data on ISS: 424 GeV positron



Event selection

Tracker
A track in the Tracker containing at least one hit in planes 1 or 2 or 9 and hits in planes (3 or 4), (5 or 6) and (7 or 8). In addition, the projected track must pass within 3 cm in x and 10 cm in y of the center of gravity of the ECAL shower.
The relative error on the curvature (inverse of the rigidity) value from the track fit is less than 50 %, which ensures that tracks have rigidities well below their Maximum Detectable Rigidity.
The detector livetime exceeded 50 %, which excludes, for example, the South Atlantic Anomaly.
TOF
The particle velocity measured by TOF β >0.8.
The value of the absolute charge is required to be between 0.8 and 1.4.
TRD
At least 15 TRD hits on the Tracker track traced through the TRD.
ECAL
A shower axis within the ECAL fiducial volume.
The ECAL shower has electromagnetic shape

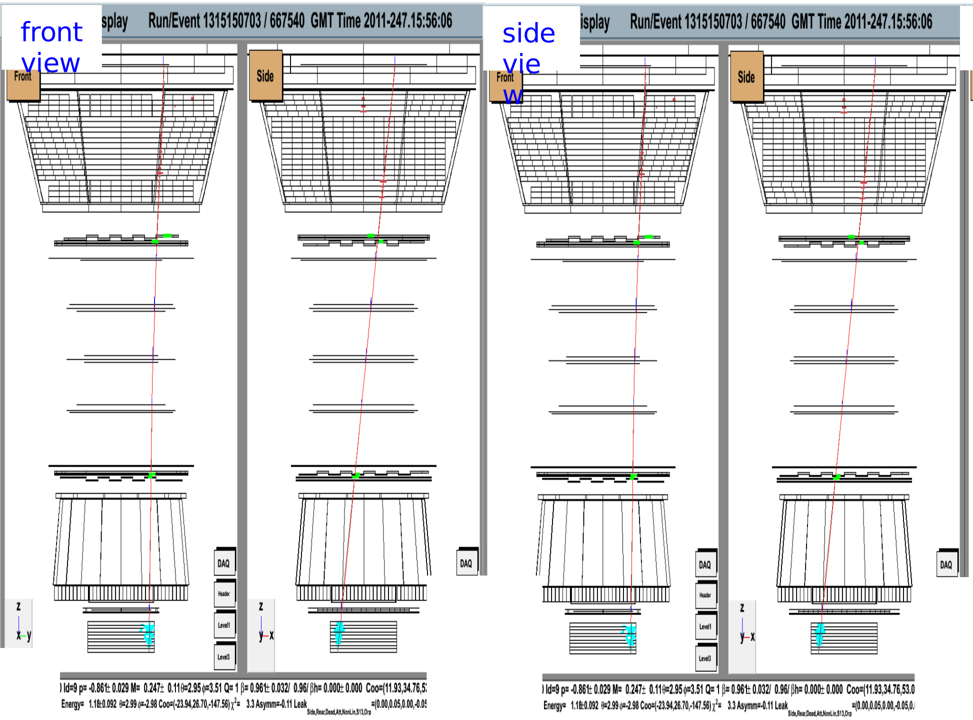


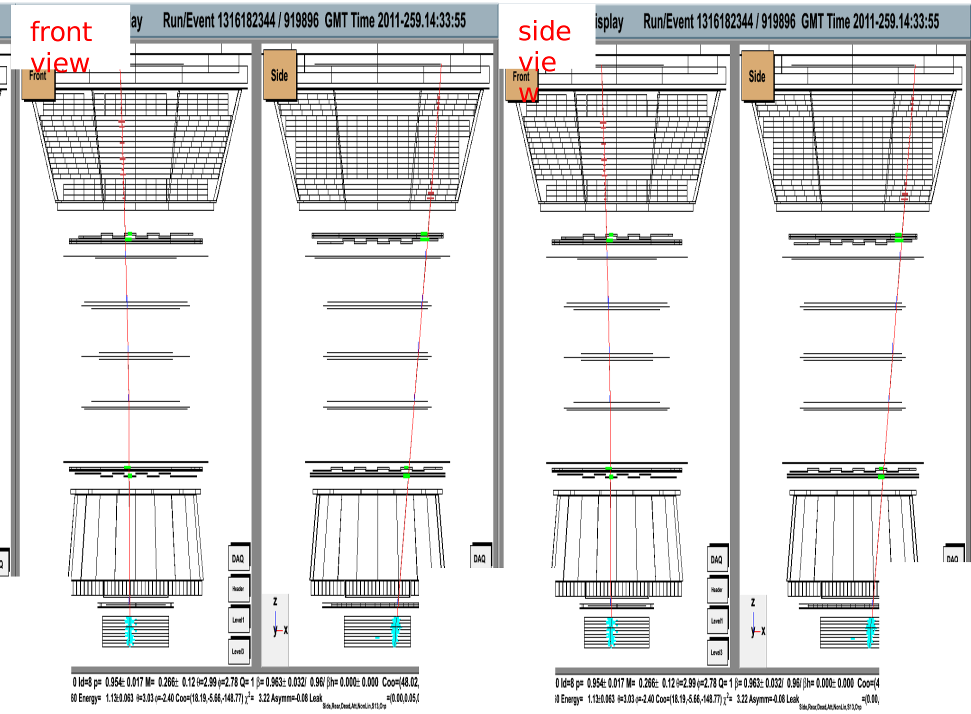
Electron E=1.1 GeV

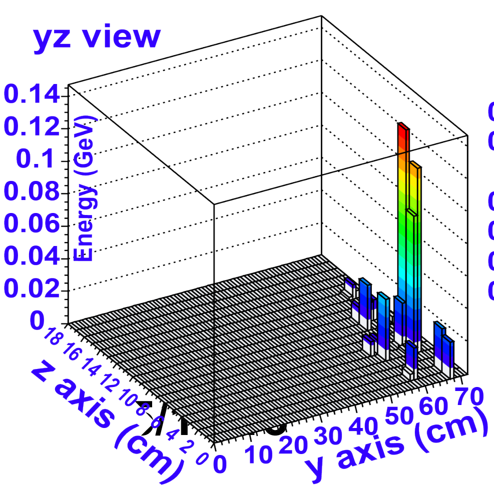
Run/Event 1315150703/
667540

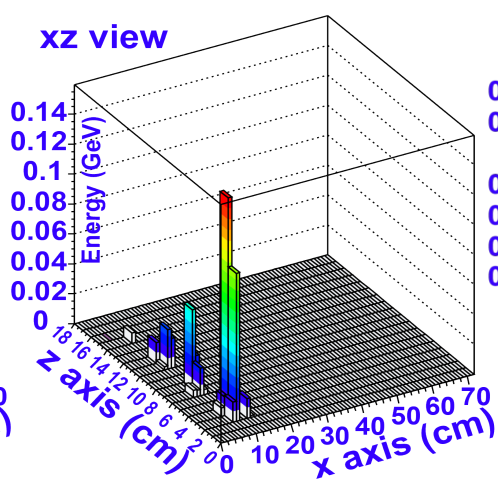
Positron E=1.1 GeV

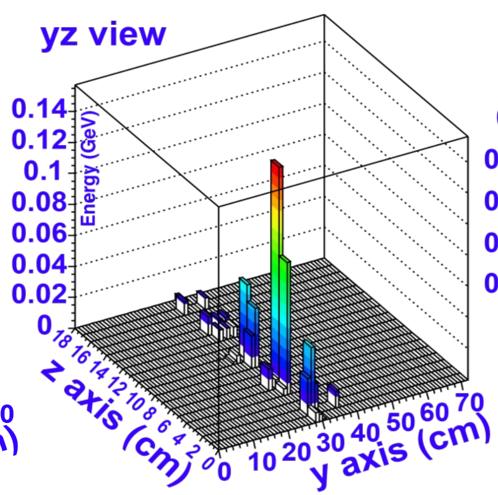
Run/Event 1316182344/
919896

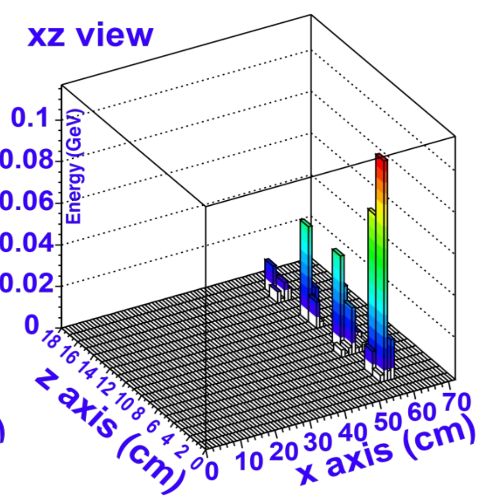






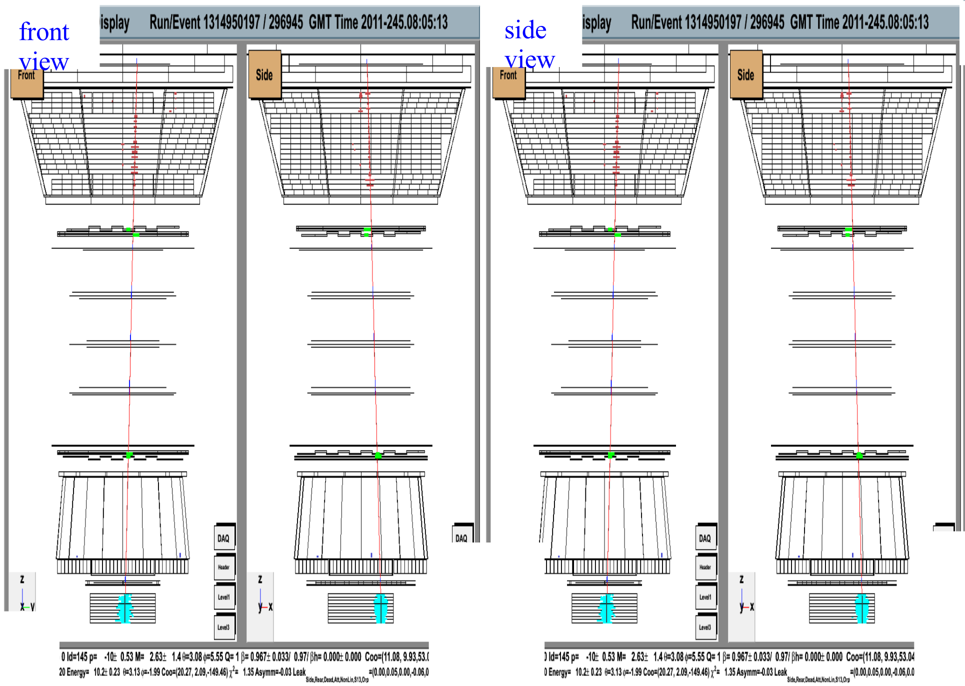






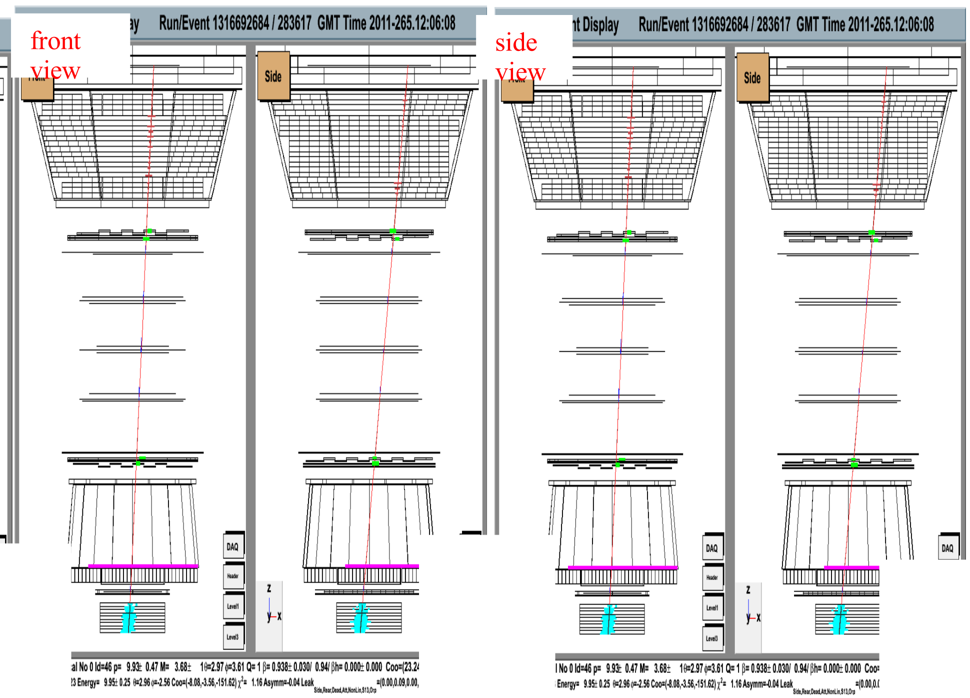
Electron E=10.1 GeV

Run/Event 1314950197/ 296945



Positron E=9.5 GeV

Run/Event 1316692684/ 283617



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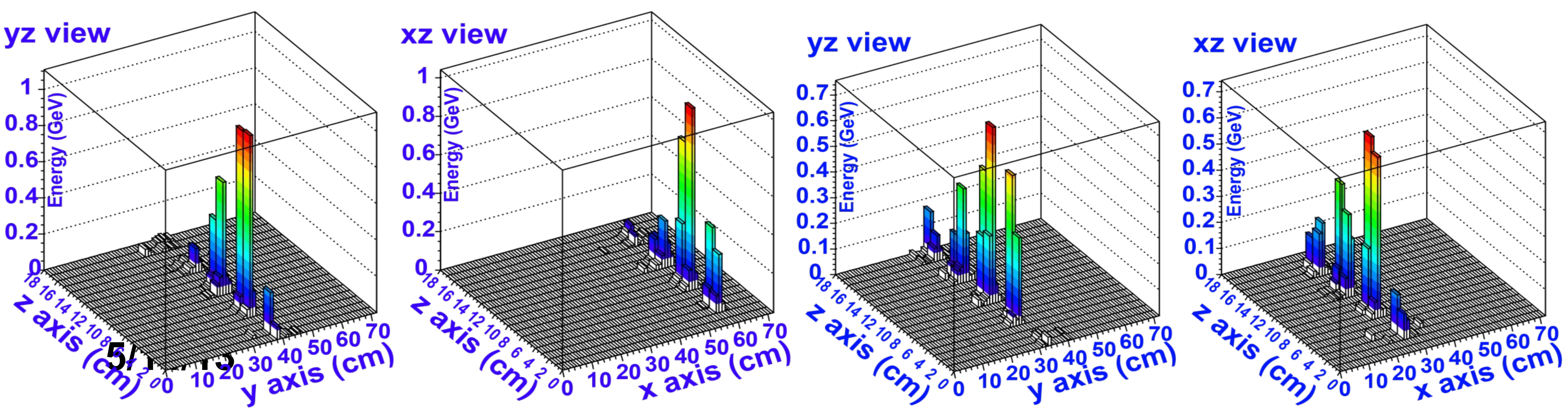
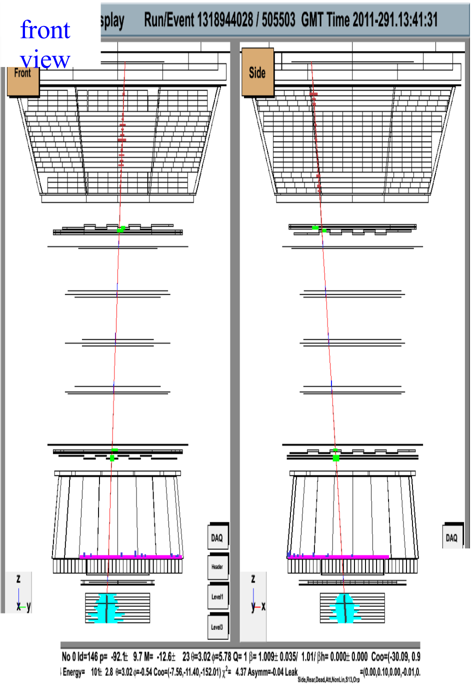


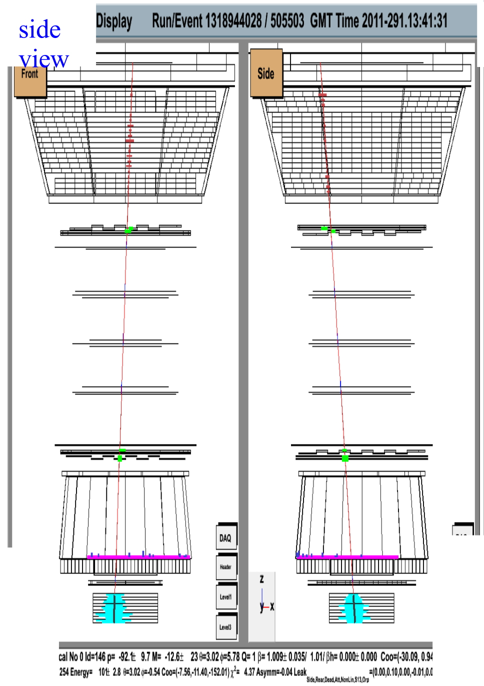
Electron E=99 GeV

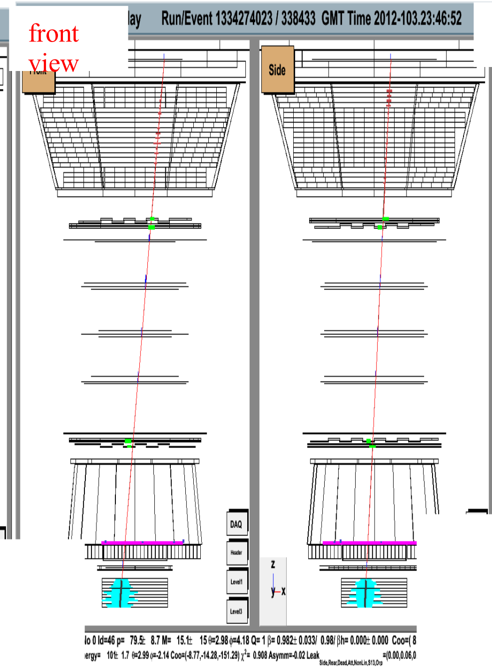
Run/Event 1318944028/ 505503

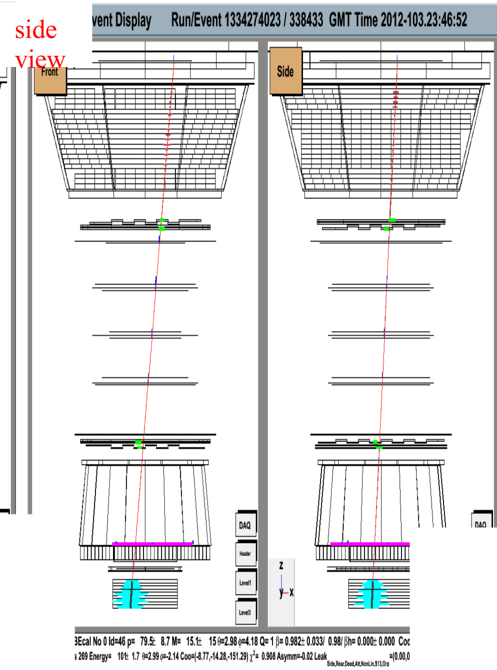
Positron E=100 GeV

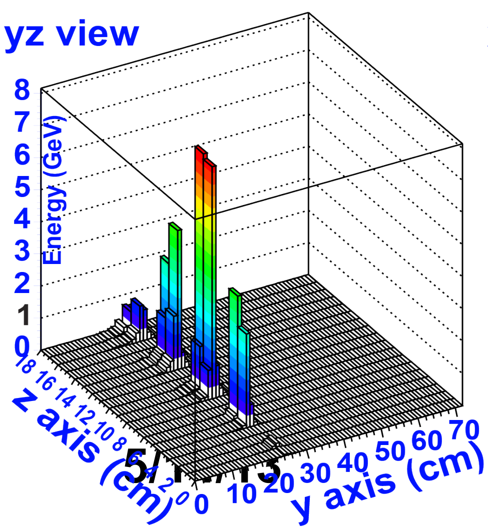
Run/Event 1334274023/ 338433

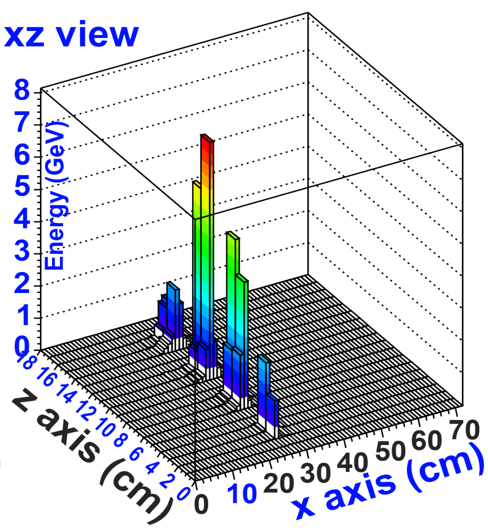


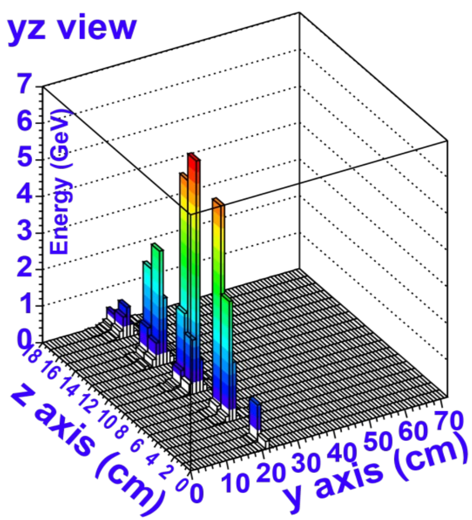


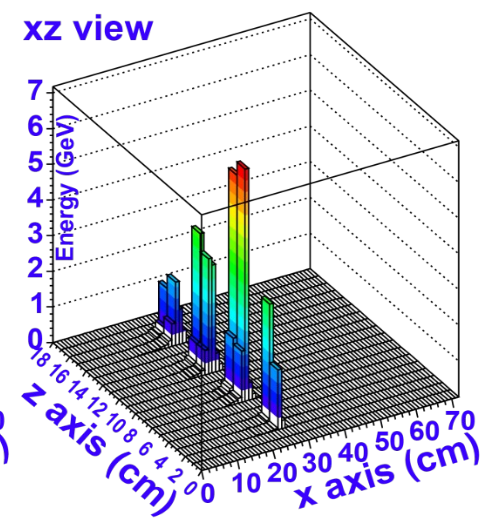










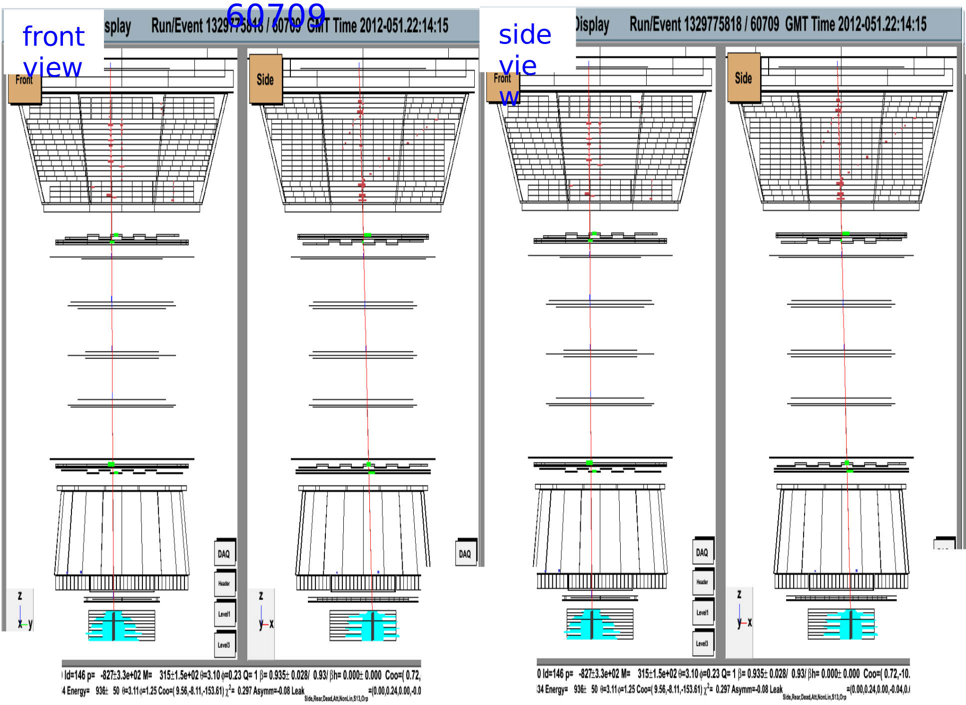


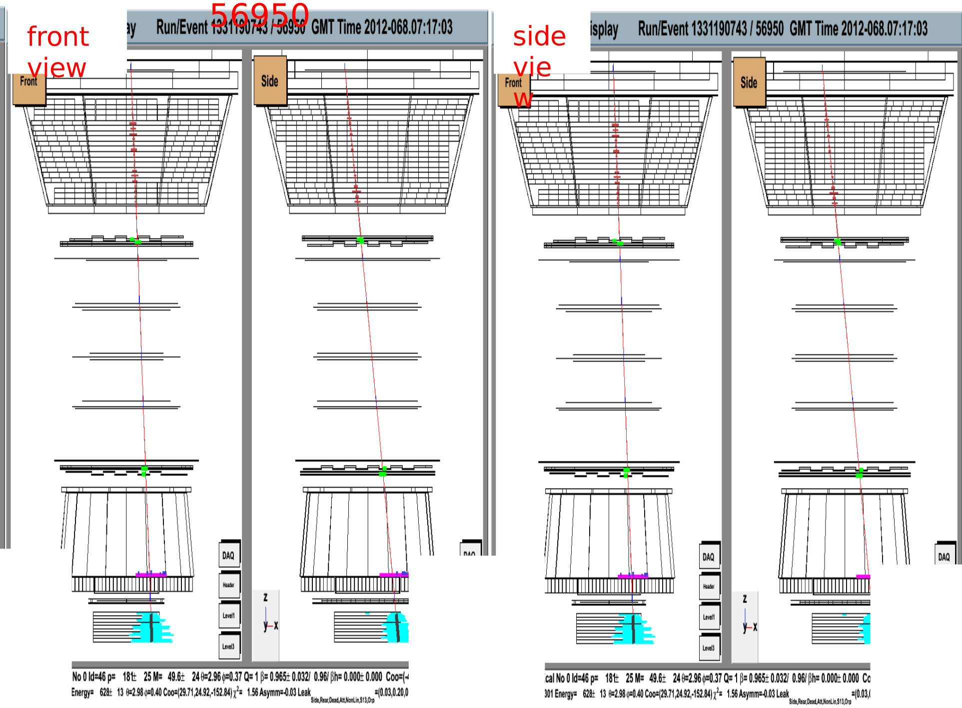
Electron E=982 GeV

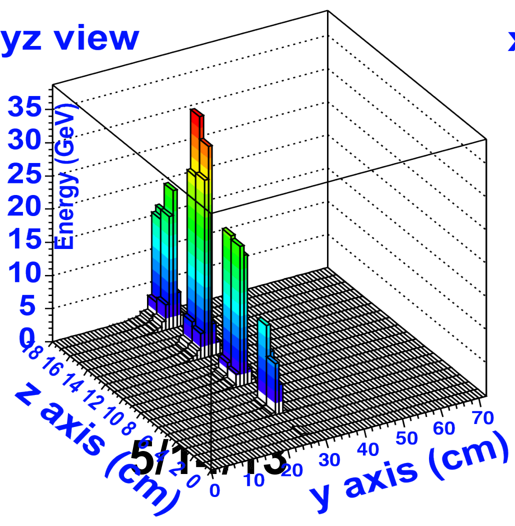
Run/Event 1329775818/ 60709

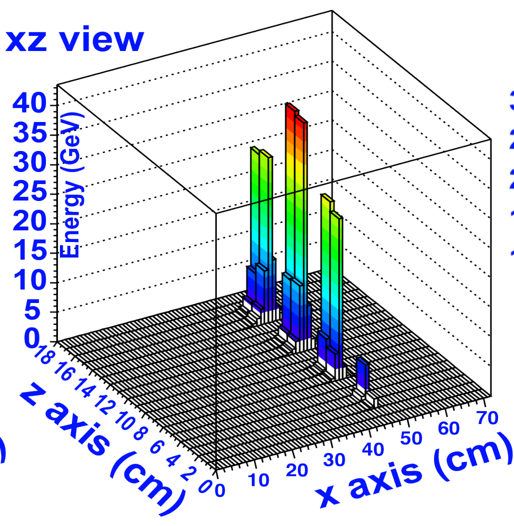
Positron E=636 GeV

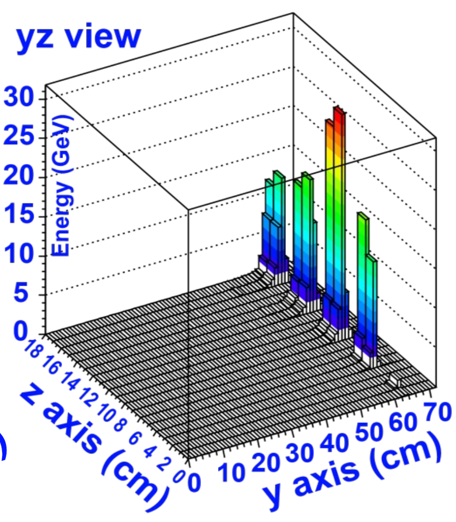
Run/Event 133119-743/ 56950

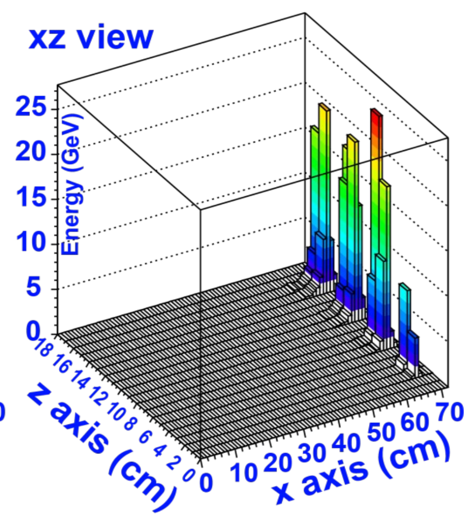




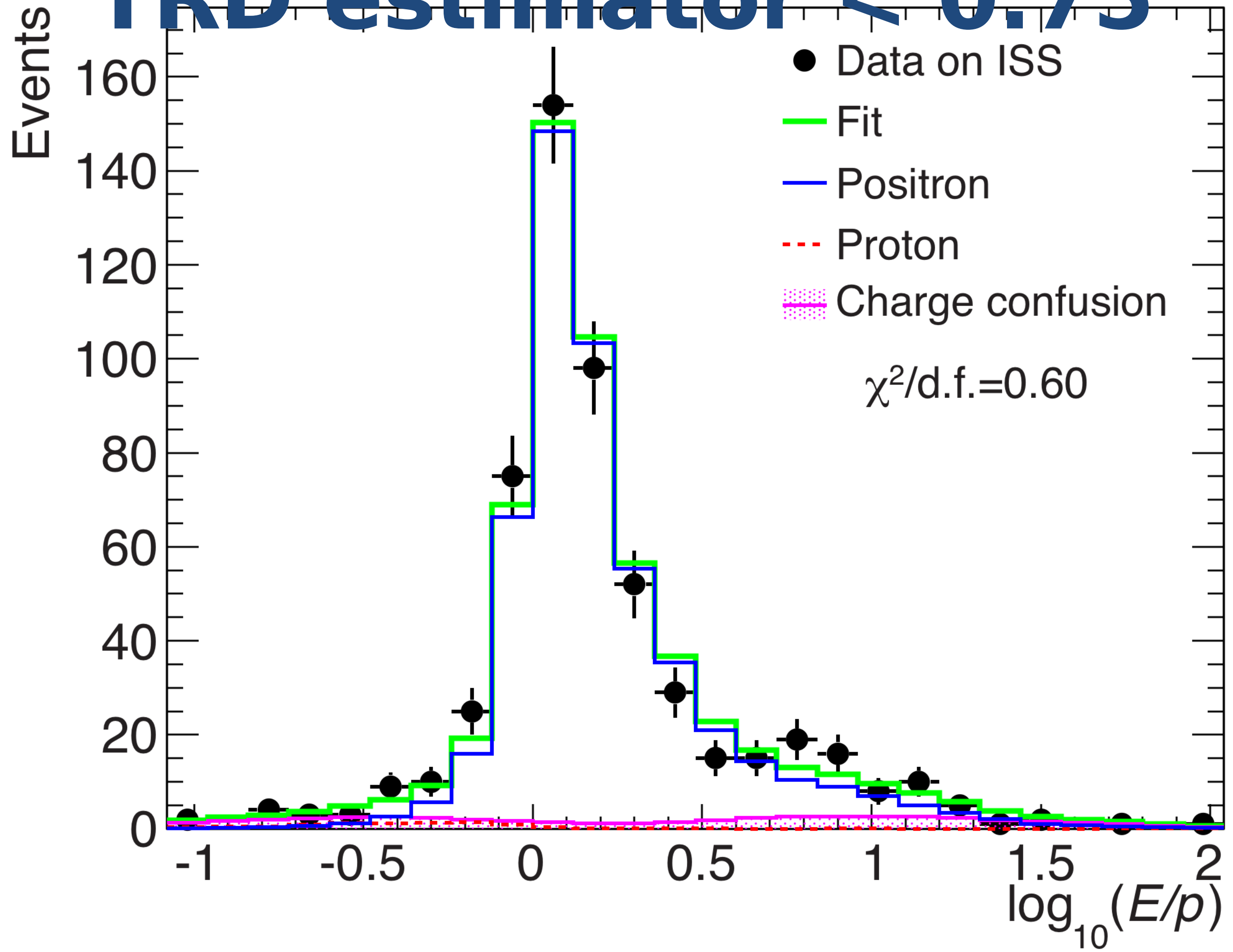






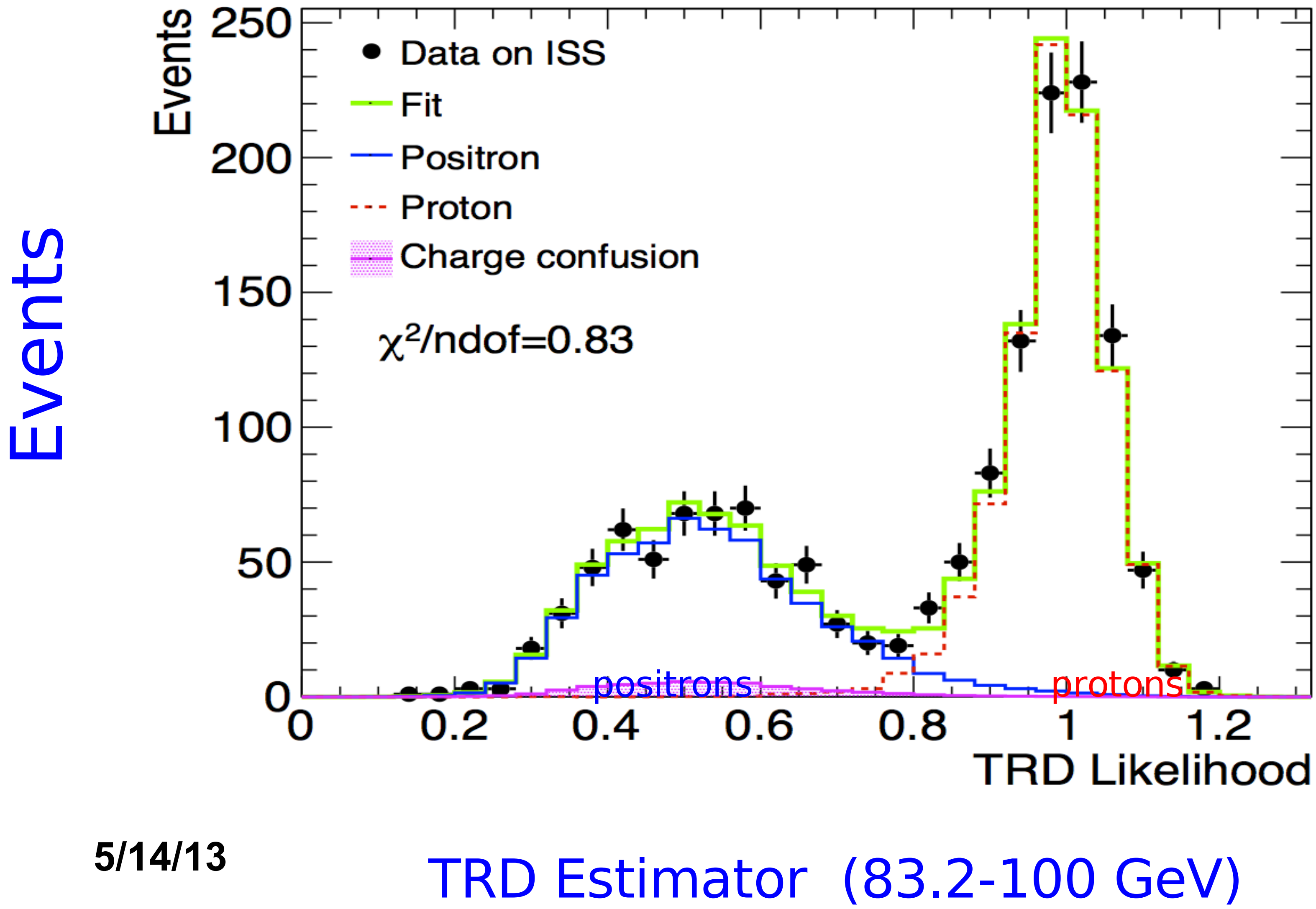


Example of Positron Selection: E/p Ratio for 83.2 < E < 100 GeV, TRD estimator < 0.75



Example of Positron Selection:

TRD Estimator shows clear separation between protons and positrons with a small charge confusion background



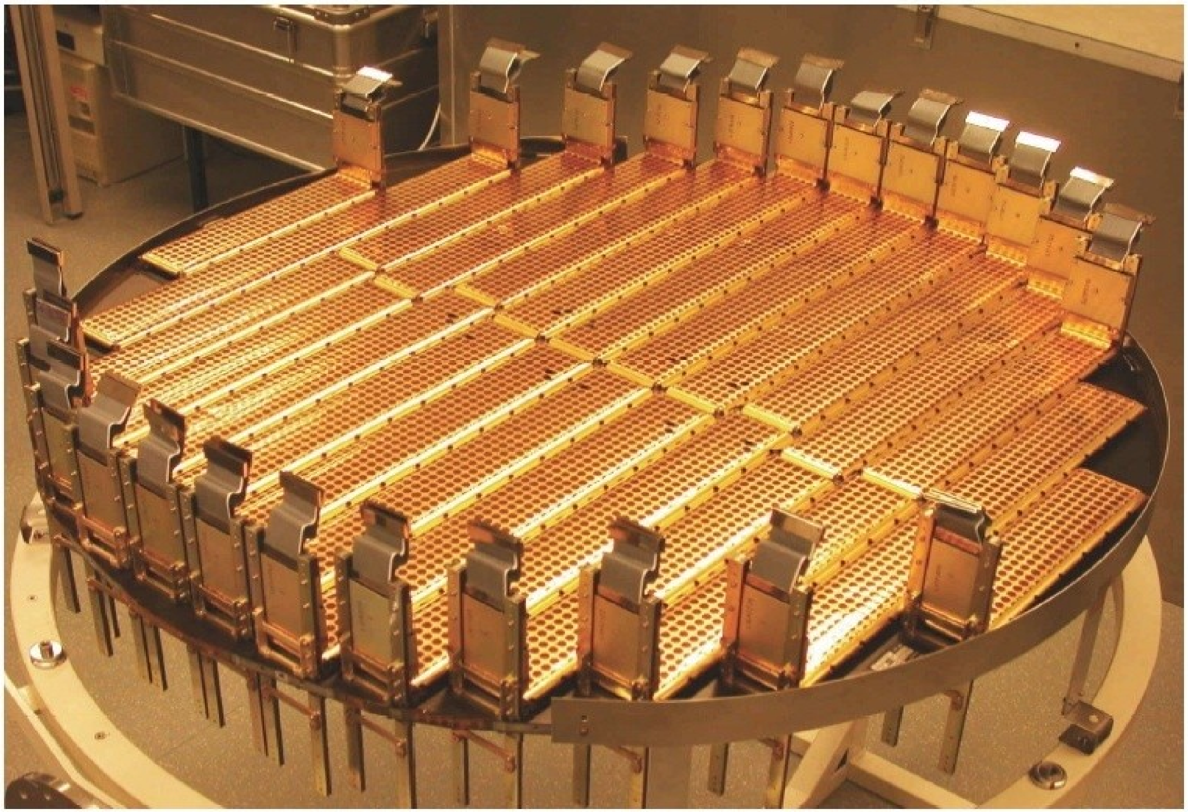
Systematic errors of positron fraction

1. Acceptance asymmetry
   - Difference between positron and electron acceptance due to known minute tracker asymmetry
1. Selection dependence
   - Dependence of the result on the cut values
1. Migration bin-to bin
   - Migration of electron and positron events from the neighboring bins affects the measured fraction
1. Reference spectrum
   - Definition of the reference spectra is based on pure samples of electrons and protons of finite statistics
1. Charge confusion
   - Two sources: large angle scattering and production of secondary tracks along the path of the primary track. Both are well reproduced by MC. Systematic errors correspond to variations of these effects within their statistical limits.

Systematic error of positron fraction: 1. Acceptance asymmetry

AMS TIM CERN- *11 April 2005*

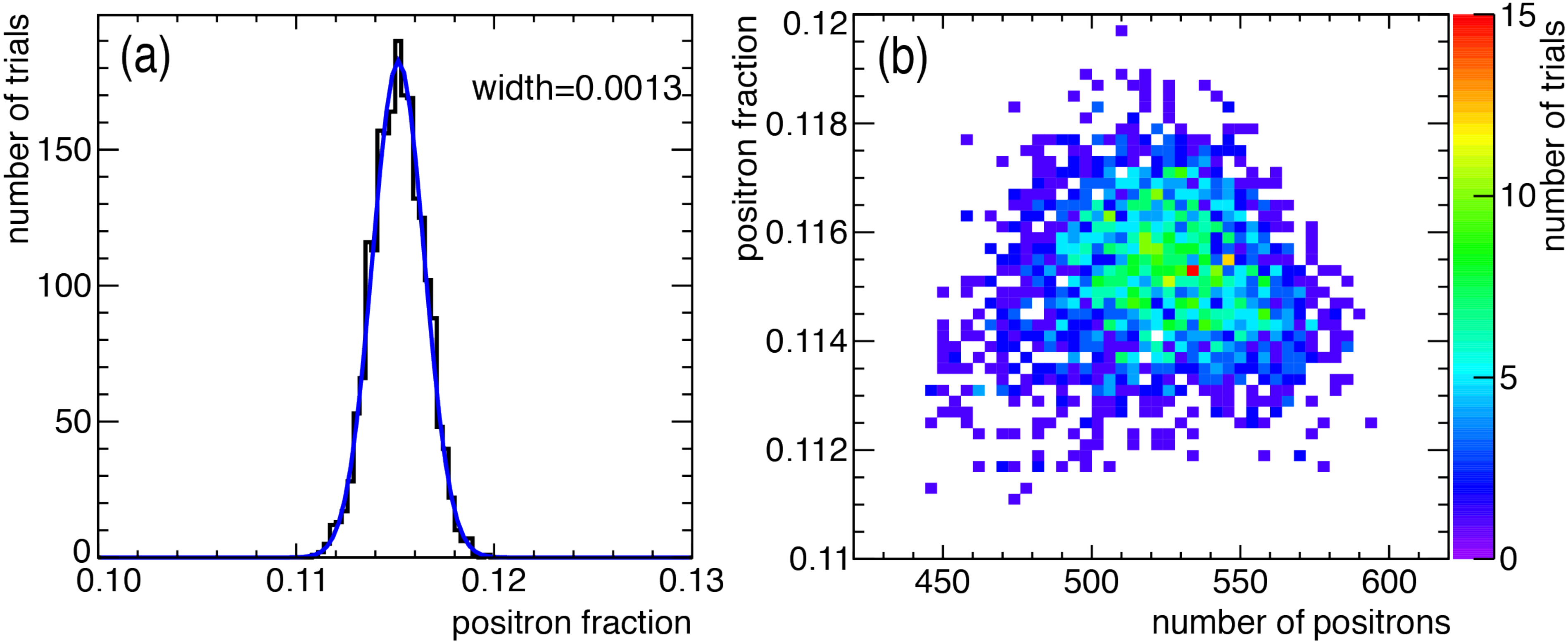
Plane 4 – Layer L7



Mercedes Paniccia *University of Geneva*

Difference between positron and electron acceptance due to known minute tracker asymmetry

Systematic error on the positron fraction: 2. Selection dependence



The measurement is stable over wide variations of the cuts
in the TRD identification, ECAL Shower Shape,
E (from ECAL) matched to |P| (from the Tracker), ...
For each energy bin, over 1,000 sets of cuts were

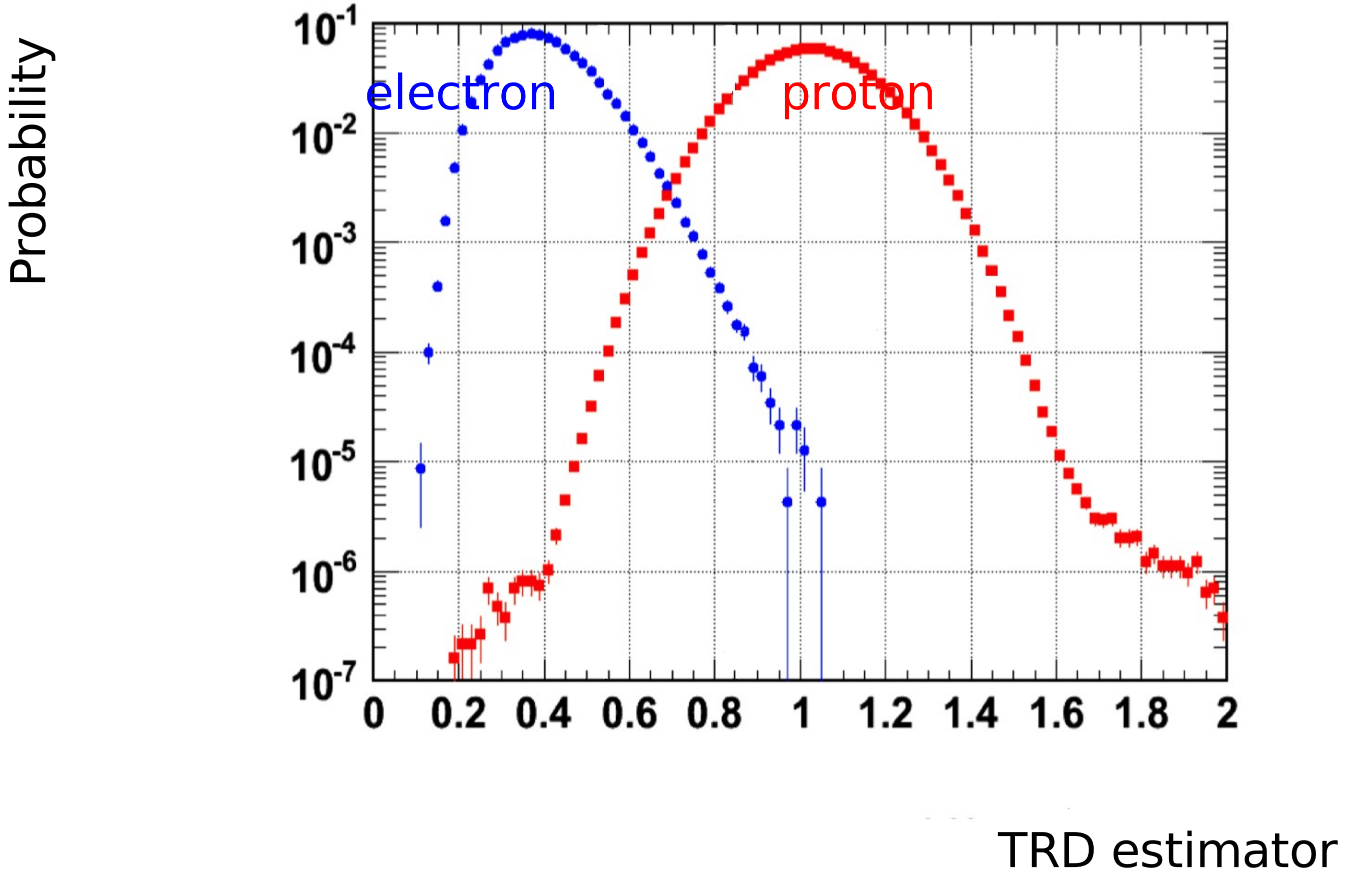
Systematic error on the positron fraction: 3. Bin-to-bin migration

$10.4/\sqrt{E} + 1.4$

Event migration effects are obtained by folding the measured spectra of positrons and electrons with the ECAL energy resolution.

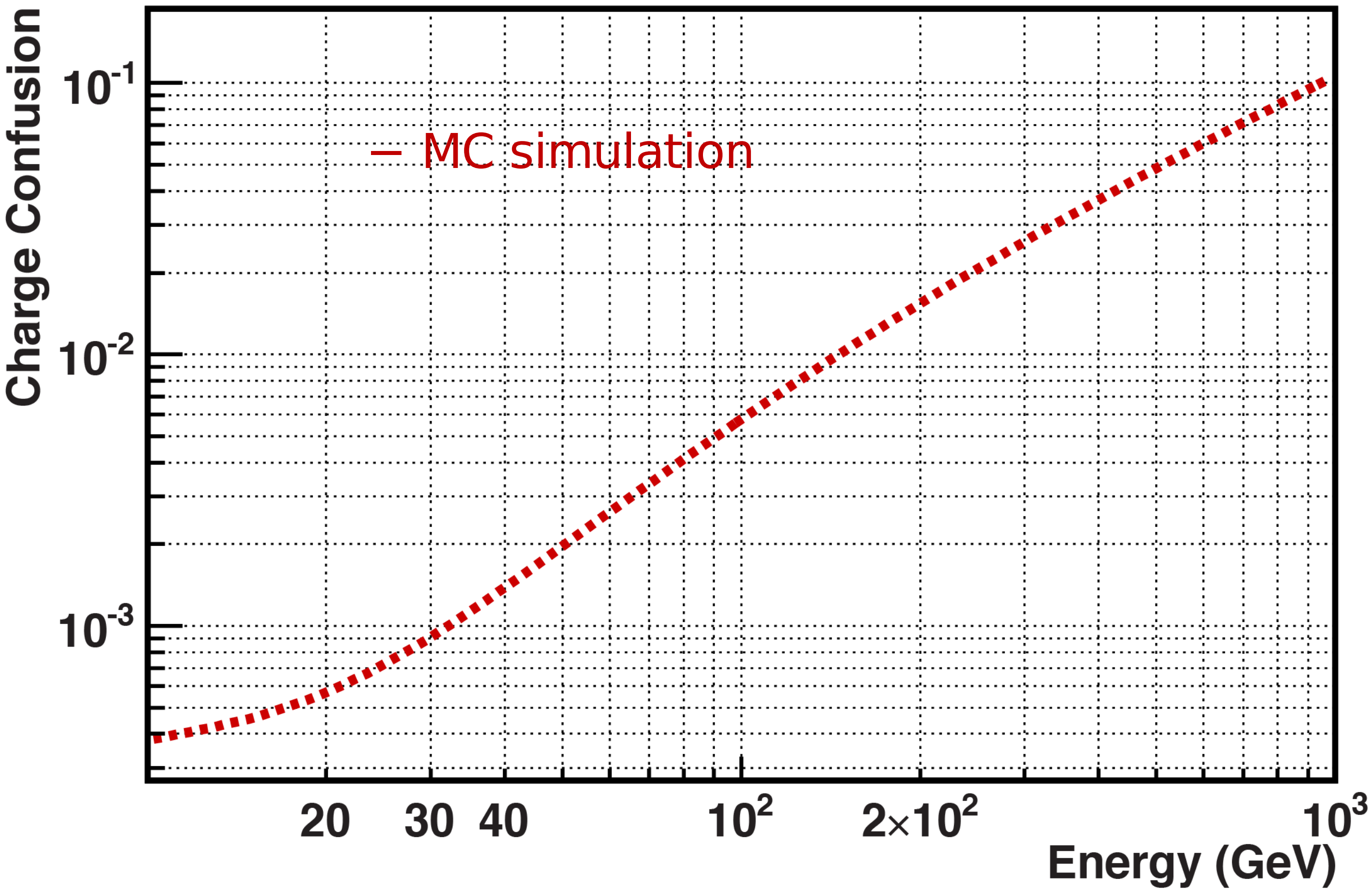
Bin width: 2σ at 5 GeV; 4σ at 50 GeV; 8σ at 100 GeV; 19σ

Systematic error on the positron fraction: 4. Reference spectra



Definition of the reference spectra is based on pure samples of electrons and protons of finite statistics.

Systematic error on the positron fraction: 5. Charge confusion



Two sources: large angle scattering and production of secondary tracks along the path of the primary track. Both are well reproduced by MC. Systematic errors correspond to variations of these effects within their statistical limits.

Positron events, positron fraction in each energy bin

				Systematic Errors					
Energy [GeV]	N_{e+}	Fraction	statistical error	acceptance asymmetry	event selection	bin-to-bin migration	reference spectra	charge confusion	total systematic uncertainty
Energy[GeV]	N_{e+}	Fraction	$\sigma_{stat.}$	$\sigma_{acc.}$	$\sigma_{sel.}$	$\sigma_{mig.}$	$\sigma_{ref.}$	$\sigma_{c.c.}$	$\sigma_{syst.}$
0.50 - 0.65	822	0.0947	0.0034	0.001	0.0016	0.0005	0.0002	0.001	0.0022
0.65 - 0.81	3,045	0.0919	0.0016	0.0007	0.0014	0.0007	0.0002	0.0008	0.0019
0.81 - 1.00	6,504	0.0902	0.0011	0.0006	0.0012	0.0009	0.0002	0.0006	0.0017
1.00 - 1.21	9,335	0.0842	0.0008	0.0005	0.0009	0.0008	0.0001	0.0005	0.0014
1.21 - 1.45	12,621	0.0783	0.0007	0.0004	0.0007	0.0006	0.0001	0.0005	0.0011
1.45 - 1.70	15,189	0.0735	0.0006	0.0003	0.0005	0.0004	0.0001	0.0003	0.0008
1.70 - 1.97	18,400	0.0685	0.0005	0.0003	0.0005	0.0003	0.0001	0.0003	0.0007
1.97 - 2.28	23,893	0.0642	0.0004	0.0002	0.0005	0.0002	0.0001	0.0002	0.0006
2.28 - 2.60	22,455	0.0605	0.0004	0.0002	0.0005	0.0001	0.0001	0.0002	0.0006
2.60 - 2.94	21,587	0.0583	0.0004	0.0001	0.0005	0.0001	0.0001	0.0002	0.0006
2.94 - 3.30	21,158	0.0568	0.0004	0.0001	0.0004	0.0000	0.0001	0.0002	0.0005
3.30 - 3.70	20,707	0.0550	0.0004	0.0001	0.0003	0.0000	0.0001	0.0002	0.0004
3.70 - 4.11	19,429	0.0541	0.0004	0.0001	0.0002	0.0000	0.0001	0.0002	0.0003
4.11 - 4.54	18,370	0.0533	0.0004	0.0001	0.0001	0.0000	0.0001	0.0002	0.0003
4.54 - 5.00	17,064	0.0519	0.0004	0.0001	0.0001	0.0000	0.0001	0.0002	0.0003
5.00 - 5.50	16,385	0.0512	0.0004	0.0001	0.0001	0.0000	0.0001	0.0002	0.0003
5.50 - 6.00	14,244	0.0508	0.0004	0.0001	0.0000	0.0000	0.0001	0.0002	0.0002
6.00 - 6.56	13,880	0.0501	0.0004	0.0001	0.0000	0.0000	0.0001	0.0002	0.0002
6.56 - 7.16	13,153	0.0510	0.0004	0.0001	0.0000	0.0000	0.0001	0.0002	0.0002

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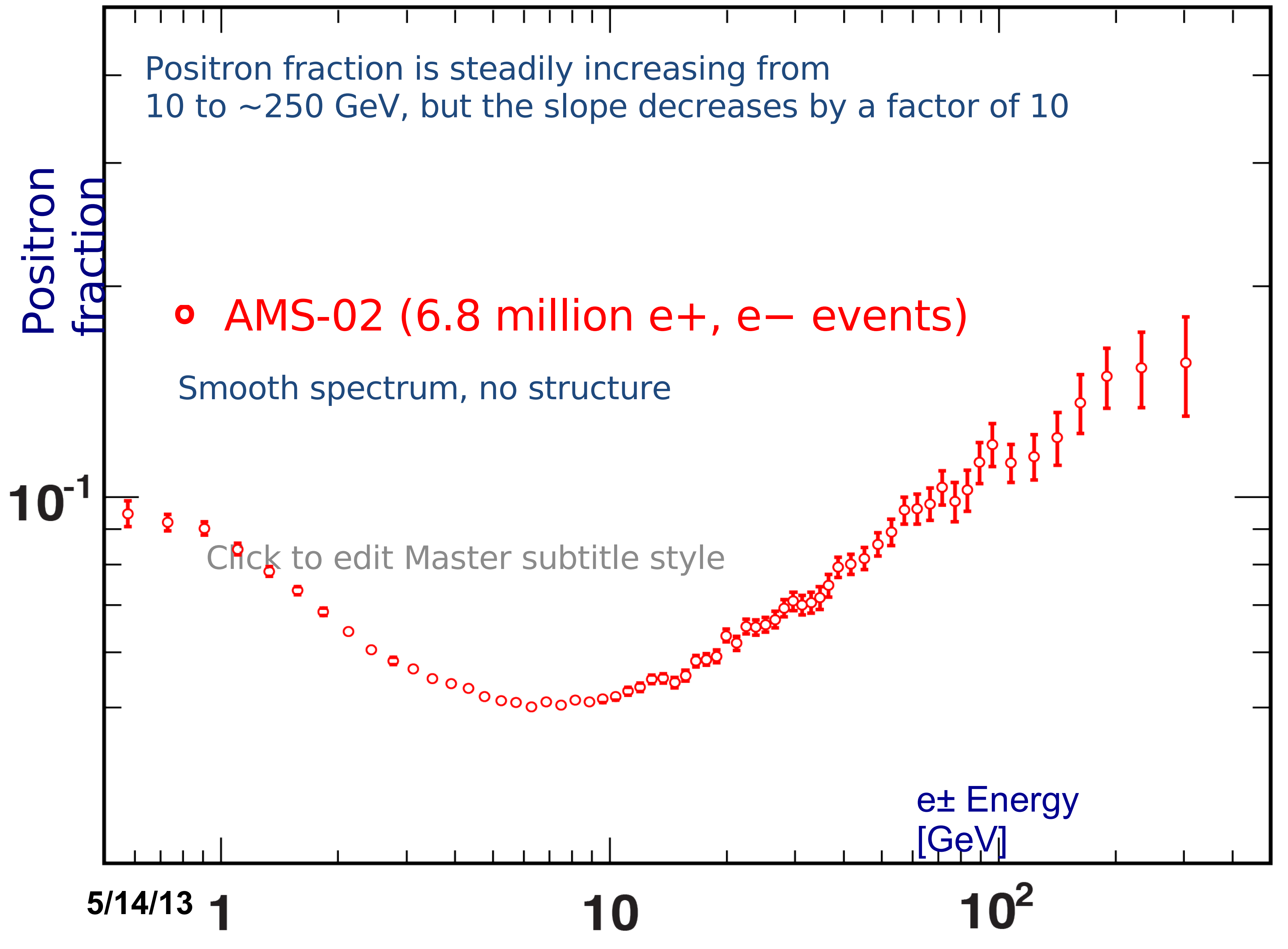
Positron events, positron fraction in each energy bin

				Systematic Errors					
Energy [GeV]	N_{e+}	Fraction	statistical error	acceptance asymmetry	event selection	bin-to-bin migration	reference spectra	charge confusion	total systematic uncertainty
Energy[GeV]	N_{e+}	Fraction	$\sigma_{stat.}$	$\sigma_{acc.}$	$\sigma_{sel.}$	$\sigma_{mig.}$	$\sigma_{ref.}$	$\sigma_{c.c.}$	$\sigma_{syst.}$
7.16 - 7.80	11,747	0.0504	0.0005	0.0001	0.0000	0.0000	0.0001	0.0002	0.0002
7.80 - 8.50	10,910	0.0513	0.0005	0.0001	0.0000	0.0000	0.0001	0.0002	0.0002
8.50 - 9.21	9,110	0.0510	0.0005	0.0001	0.0000	0.0000	0.0001	0.0002	0.0002
9.21 - 9.95	7,501	0.0515	0.0006	0.0001	0.0000	0.0000	0.0001	0.0002	0.0002
9.95 - 10.73	7,161	0.0519	0.0006	0.0001	0.0000	0.0000	0.0001	0.0002	0.0002
10.73 - 11.54	6,047	0.0528	0.0007	0.0001	0.0000	0.0000	0.0001	0.0001	0.0002
11.54 - 12.39	5,246	0.0535	0.0007	0.0001	0.0000	0.0000	0.0001	0.0001	0.0002
12.39 - 13.27	4,787	0.0549	0.0008	0.0001	0.0000	0.0000	0.0001	0.0001	0.0002
13.27 - 14.19	4,166	0.0551	0.0008	0.0001	0.0000	0.0000	0.0001	0.0001	0.0002
14.19 - 15.15	3,698	0.0543	0.0009	0.0001	0.0001	0.0000	0.0001	0.0001	0.0002
15.15 - 16.15	3,326	0.0556	0.0010	0.0001	0.0001	0.0000	0.0001	0.0001	0.0002
16.15 - 17.18	3,007	0.0583	0.0011	0.0001	0.0001	0.0000	0.0001	0.0002	0.0003
17.18 - 18.25	2,663	0.0586	0.0011	0.0001	0.0001	0.0000	0.0001	0.0002	0.0003
18.25 - 19.37	2,410	0.0592	0.0012	0.0001	0.0001	0.0000	0.0001	0.0002	0.0003
19.37 - 20.54	2,322	0.0634	0.0013	0.0001	0.0001	0.0000	0.0001	0.0002	0.0003
20.54 - 21.76	2,052	0.0618	0.0014	0.0001	0.0001	0.0000	0.0001	0.0002	0.0003
21.76 - 23.07	1,992	0.0653	0.0015	0.0001	0.0001	0.0000	0.0001	0.0002	0.0003
23.07 - 24.45	1,788	0.0651	0.0016	0.0001	0.0001	0.0000	0.0001	0.0002	0.0003
24.45 - 25.87	1,642	0.0657	0.0016	0.0001	0.0001	0.0000	0.0001	0.0002	0.0003
25.87 - 27.34	1,447	0.0668	0.0018	0.0001	0.0001	0.0000	0.0001	0.0003	0.0003
27.34 - 28.87	1,260	0.0694	0.0020	0.0001	0.0001	0.0000	0.0001	0.0003	0.0003
28.87 - 30.45	1,137	0.0710	0.0021	0.0001	0.0002	0.0000	0.0001	0.0003	0.0004
30.45 - 32.10	1,094	0.0701	0.0022	0.0001	0.0002	0.0000	0.0001	0.0003	0.0004
32.10 - 33.80	888	0.0707	0.0024	0.0001	0.0002	0.0000	0.0001	0.0004	0.0005

Positron events, positron fraction in each energy bin

				Systematic Errors					
Energy [GeV]	N_{e+}	Fraction	statistical error	acceptance asymmetry	event selection	bin-to-bin migration	reference spectra	charge confusion	total systematic uncertainty
Energy[GeV]	N_{e+}	Fraction	$\sigma_{stat.}$	$\sigma_{acc.}$	$\sigma_{sel.}$	$\sigma_{mig.}$	$\sigma_{ref.}$	$\sigma_{c.c.}$	$\sigma_{syst.}$
33.80 - 35.57	807	0.0718	0.0026	0.0001	0.0003	0.0000	0.0001	0.0004	0.0005
35.57 - 37.40	787	0.0747	0.0027	0.0001	0.0003	0.0000	0.0001	0.0004	0.0005
37.40 - 40.00	982	0.0794	0.0026	0.0002	0.0004	0.0000	0.0001	0.0004	0.0006
40.00 - 43.39	976	0.0802	0.0026	0.0002	0.0005	0.0000	0.0001	0.0004	0.0007
43.39 - 47.01	856	0.0817	0.0029	0.0002	0.0005	0.0000	0.0001	0.0004	0.0007
47.01 - 50.87	739	0.0856	0.0032	0.0002	0.0006	0.0000	0.0001	0.0004	0.0008
50.87 - 54.98	605	0.0891	0.0038	0.0002	0.0006	0.0000	0.0001	0.0004	0.0008
54.98 - 59.36	558	0.0957	0.0041	0.0002	0.0008	0.0000	0.0001	0.0005	0.0010
59.36 - 64.03	448	0.0962	0.0047	0.0002	0.0009	0.0000	0.0002	0.0006	0.0011
64.03 - 69.00	392	0.0978	0.0050	0.0002	0.0010	0.0000	0.0002	0.0007	0.0013
69.00 - 74.30	324	0.1032	0.0057	0.0002	0.0010	0.0000	0.0002	0.0009	0.0014
74.30 - 80.00	276	0.0985	0.0062	0.0002	0.0010	0.0000	0.0002	0.0010	0.0014
80.00 - 86.00	232	0.1023	0.0067	0.0002	0.0010	0.0000	0.0002	0.0010	0.0014
86.00 - 92.50	240	0.1120	0.0075	0.0002	0.0010	0.0000	0.0003	0.0011	0.0015
92.50 - 100.0	226	0.1189	0.0081	0.0002	0.0011	0.0000	0.0003	0.0012	0.0017
100.0 - 115.1	304	0.1118	0.0066	0.0002	0.0015	0.0000	0.0003	0.0015	0.0022
115.1 - 132.1	223	0.1142	0.0080	0.0002	0.0019	0.0000	0.0004	0.0019	0.0027
132.1 - 151.5	156	0.1215	0.0100	0.0002	0.0021	0.0000	0.0005	0.0024	0.0032
151.5 - 173.5	144	0.1364	0.0121	0.0002	0.0026	0.0000	0.0006	0.0045	0.0052
173.5 - 206.0	134	0.1485	0.0133	0.0002	0.0031	0.0000	0.0009	0.0050	0.0060
206.0 - 260.0	101	0.1530	0.0160	0.0003	0.0031	0.0000	0.0013	0.0095	0.0101
260.0 - 350.0	72	0.1550	0.0200	0.0003	0.0056	0.0000	0.0018	0.0140	0.0152



Positron fraction is steadily increasing from
10 to ~250 GeV, but the slope decreases by a factor of 10
Positron fraction
AMS-02 (6.8 million e+, e− events)
Smooth spectrum, no structure
10^{-1}
Click to edit Master subtitle style
e± Energy [GeV]
1
10
10^2
5/14/13

Anisotropy

Primary sources of cosmic ray positrons and electrons may induce some degree of anisotropy of the measured positron to electron ratio, that is, the ratio of the positron flux to the electron flux. Therefore, a systematic search for anisotropies using the selected sample is performed from 16 to 350 GeV.

Arrival directions of electrons and positrons are used to build a sky map in galactic coordinates, (b, l), containing the number of observed positrons and electrons. The fluctuations of the observed positron ratio are described using a spherical harmonic expansion

$$\frac{r_e(b,l)}{< r_e >} - 1 = \sum_{\ell=0}^{\infty} \sum_{m=-\ell}^{\ell} a_{\ell m} \, Y_{\ell m}(\pi/2 - b, l),$$

where $r_e(b,l)$ denotes the positron ratio at (b,l); $< r_e >$ is the average ratio over the sky map; $Y_{\ell m}$ are spherical harmonic functions and $a_{\ell m}$ are the corresponding weights. The coefficients of the angular power spectrum of the fluctuations are defined as

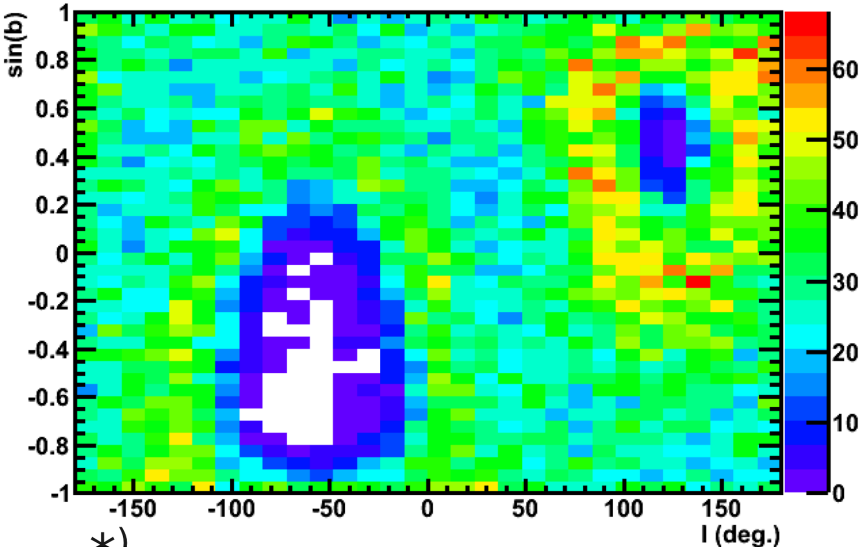
$$C_\ell = \frac{1}{2\ell+1} \sum_{m=-\ell}^{\ell} |a_{\ell m}|^2.$$

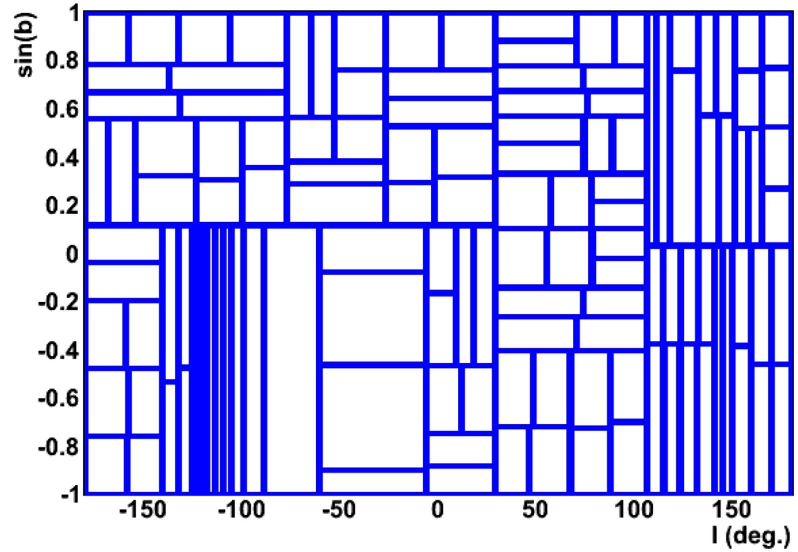
They are found to be consistent with the expectations for isotropy at all energies and upper limits to multipole contributions are obtained. We obtain a limit for any axis in galactic coordinates on the amplitude of dipole anisotropy on the positron to electron ratio of

$$\delta = 3\sqrt{C_1/4\pi} \leq 0.036 \quad (95\% \; C.L.)$$

5

Example of sky map with adaptive binning (256 e-/bin)





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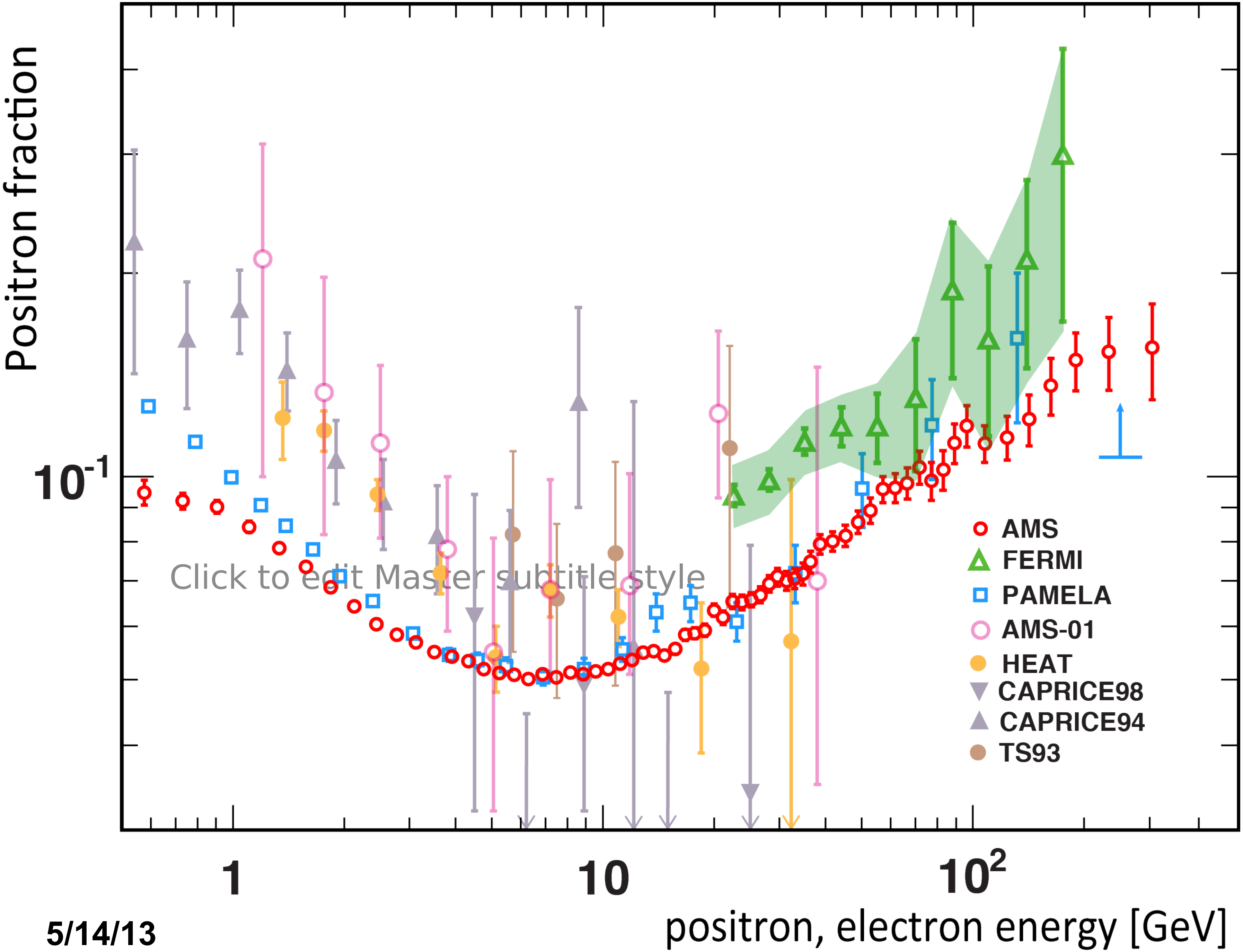
Limit on the amplitude of a dipole anisotropy

$$\frac{r_e(b,l)}{< r_e >} = 1 + \delta \cdot \cos(\theta)$$

along any axis in galactic coordinates on the positron to electron ratio:

$\delta \leq 0.036$ at the 95%CL


Positron fraction
10^{-1}
1
10
10^{2}
positron, electron energy [GeV]
AMS
FERMI
PAMELA
AMS-01
HEAT
CAPRICE98
CAPRICE94
TS93
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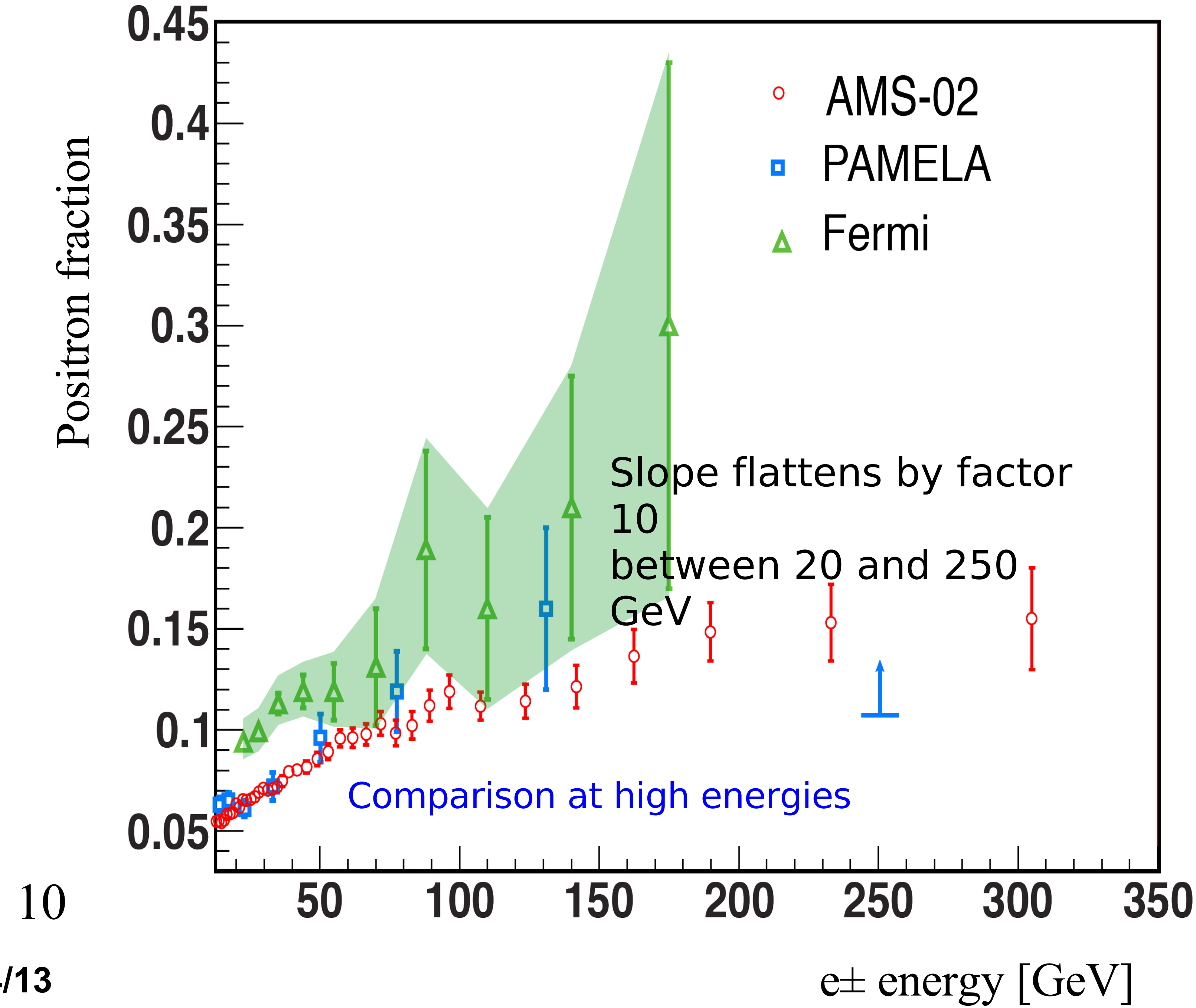
5/14/13



Positron fraction
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
AMS-02
PAMELA
Fermi
Slope flattens by factor 10 between 20 and 250 GeV
Comparison at high energies
10
50
100
150
200
250
300
350
e± energy [GeV]

Example:
Comparing AMS data with a minimal model

In this model the e+ and e- fluxes, Φ_{e+} and Φ_{e-} , are parameterized as the sum of individual diffuse power law spectra and the contribution of a single common source of e±:

$$\Phi_{e+} = C_{e+} E^{-\square_{e+}} + C_s E^{-\square_s} e^{-E/E_s}$$

$$\square_{e-} = C_{e-} E^{-\square_{e-}} + C_s E^{-\square_s} e^{-E/E_s} \quad (E \text{ in GeV})$$

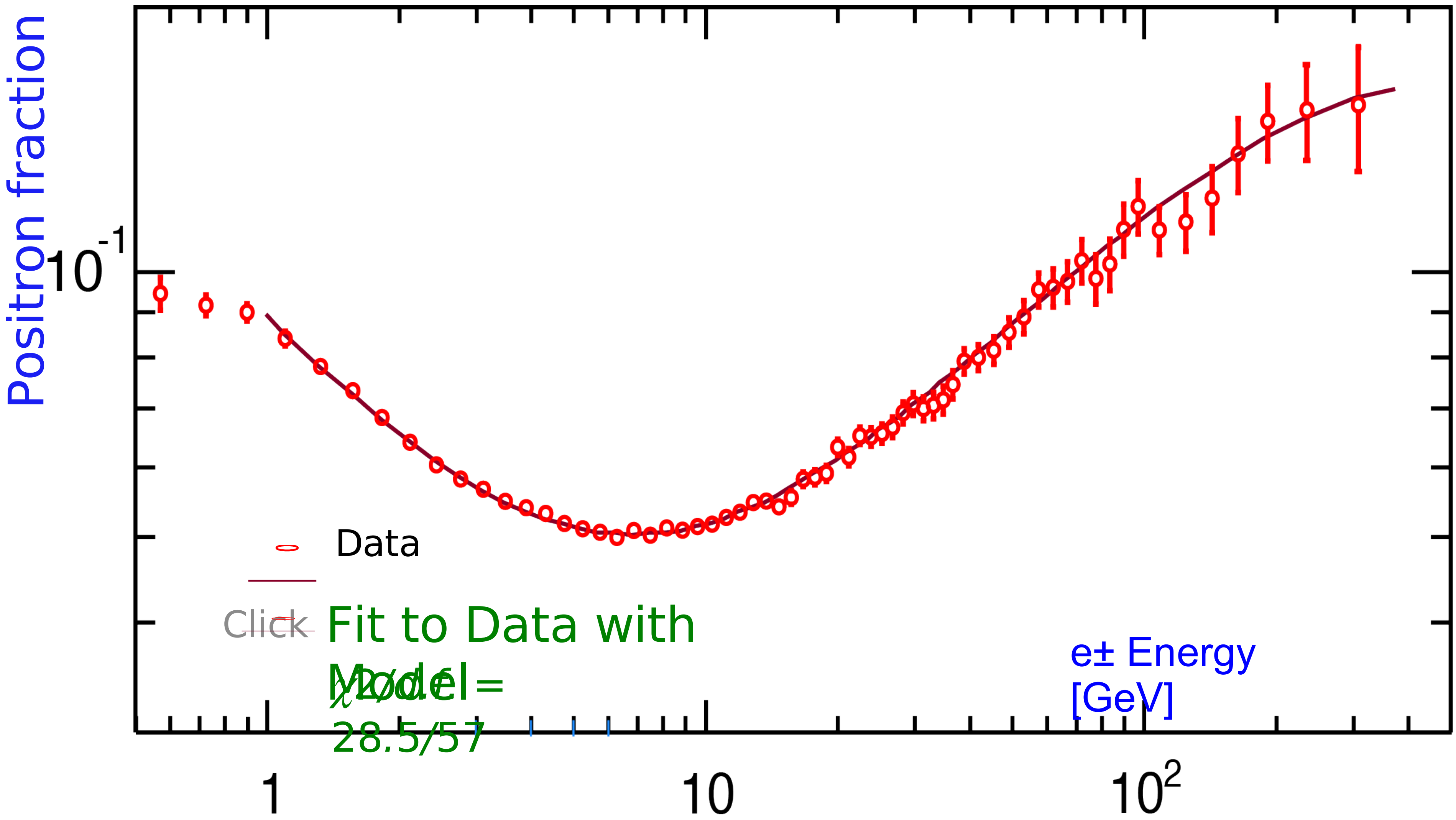
Coefficients C_{e+} and C_{e-} correspond to relative weights of diffuse spectra for positrons and electrons.

C_s is the weight of the source spectrum.

$\square_{e+}$, $\square_{e-}$ and $\square_s$ are the corresponding spectral indexes.

E_s is a characteristic cutoff energy for the source spectrum.

With this parametrization the positron fraction depends on 5 parameters.



The positron fraction is consistent with e± fluxes each of which is the sum of its own diffuse spectrum and a single common power law source.

A fit to the data in the energy range 1 to 350 GeV yields a $\chi^2/d.f. = 28.5/57$ and:

□e- − □e+ = −0.63 ± 0.03, *i.e.*, the diffuse positron spectrum is less
energetic than the diffuse electron spectrum;

□ e- − □ S = 0.66±0.05, *i.e.*, the source spectrum is more energetic than the diffuse electron spectrum;

*C*e+ /*C*e- = 0.091 ± 0.001, *i.e.*, the weight of the diffuse positron flux amounts to ~10% of that of the diffuse electron flux;

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*C*S /*C*e- = 0.0078 ± 0.0012, *i.e.*, the weight of the common source constitutes only ~1% of that of the diffuse electron flux;

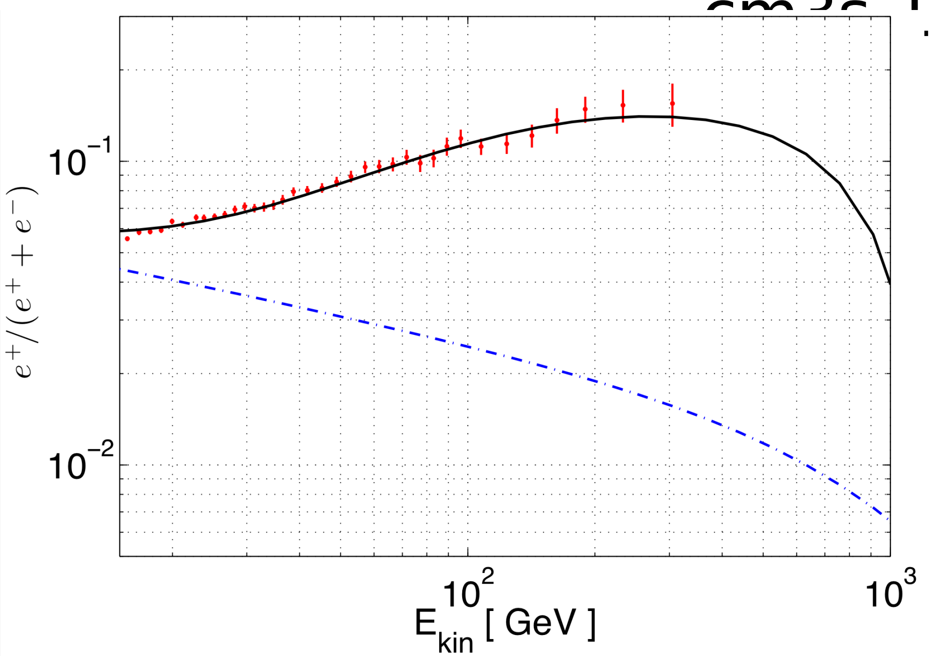
−28
0

1/*Es* = 0.0013 ± 0.0007 GeV−1

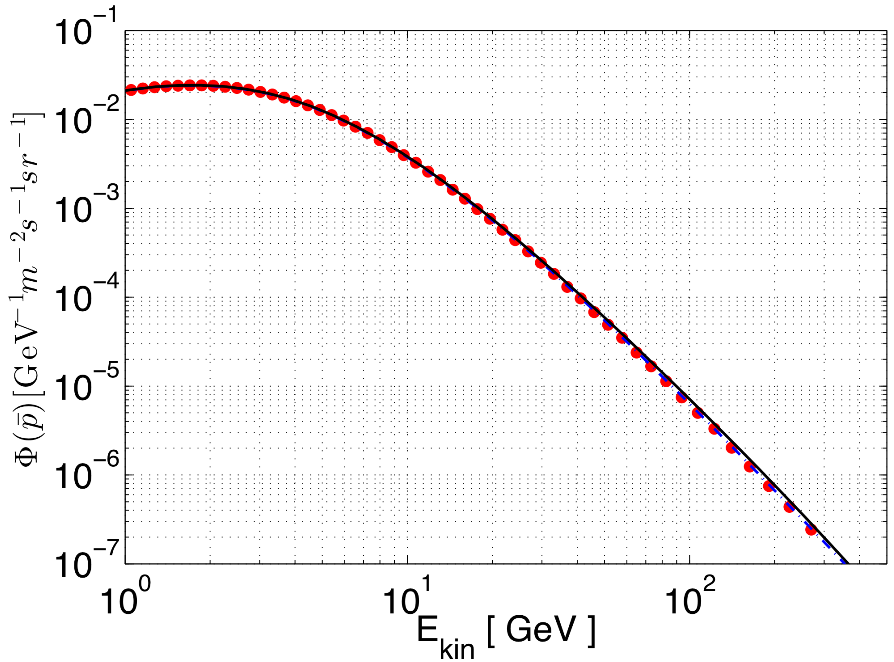
Example: DM DM τ+τ-

Andrea De Simone, Antonio Riotto, Wei Xuec
CERN-PH-TH/2013-054 (April 3, 2013)

mDM = 900 GeV
σv = 5x10-23
cm3s-1



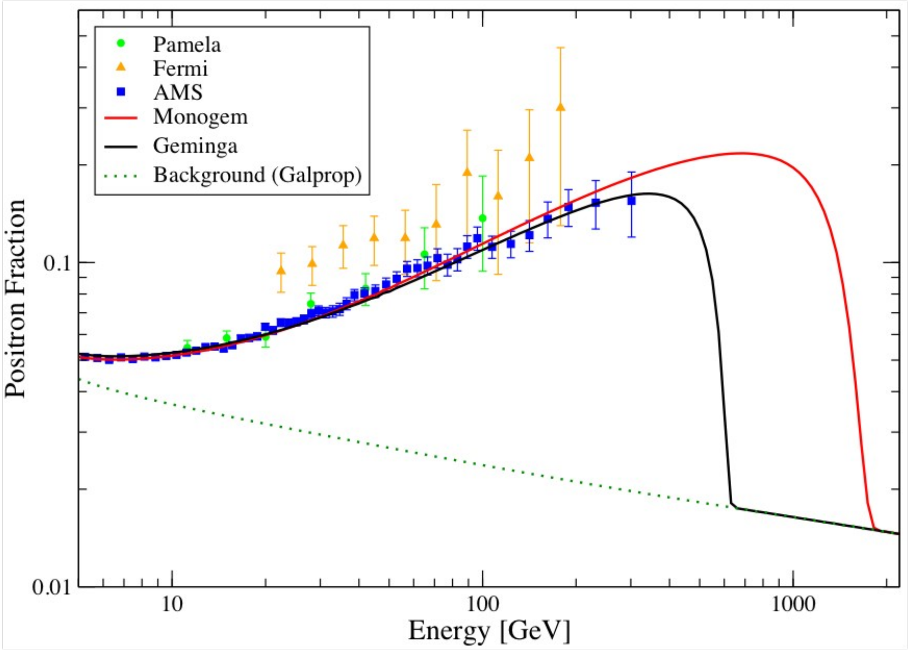
AMS Data: e+ fraction

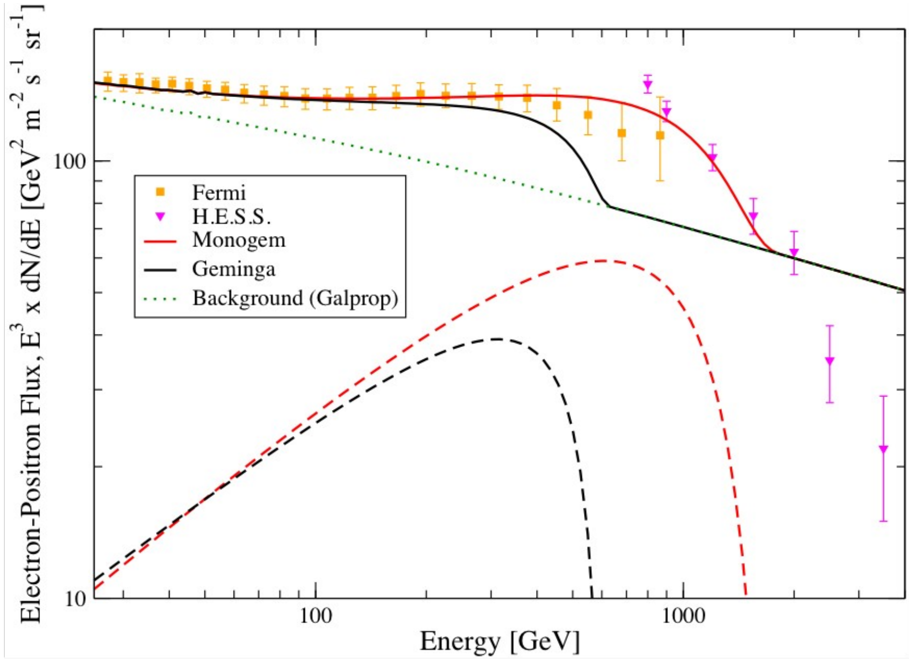


AMS expectation: Φ(p)

Example: Pulsars

Tim Linden and Stefano Profumo
arXiv:1304.1791v1 [astro-ph.HE] 5 Apr 2013





AMS Data: e+ fraction

Fermi/HESS: e-+e+

See also: Cholis and Hooper, arXiv:1304.840v1 [astro-ph.HE] 6 Apr 2013

Example: Pulsars (+ DM?)

Peng-Fei Yin, Zhao-Huan Yu, Qiang Yuan and Xiao-Jun Bi
arXiv:1304.4128v1 [astro-ph.HE] 15 Apr 2013

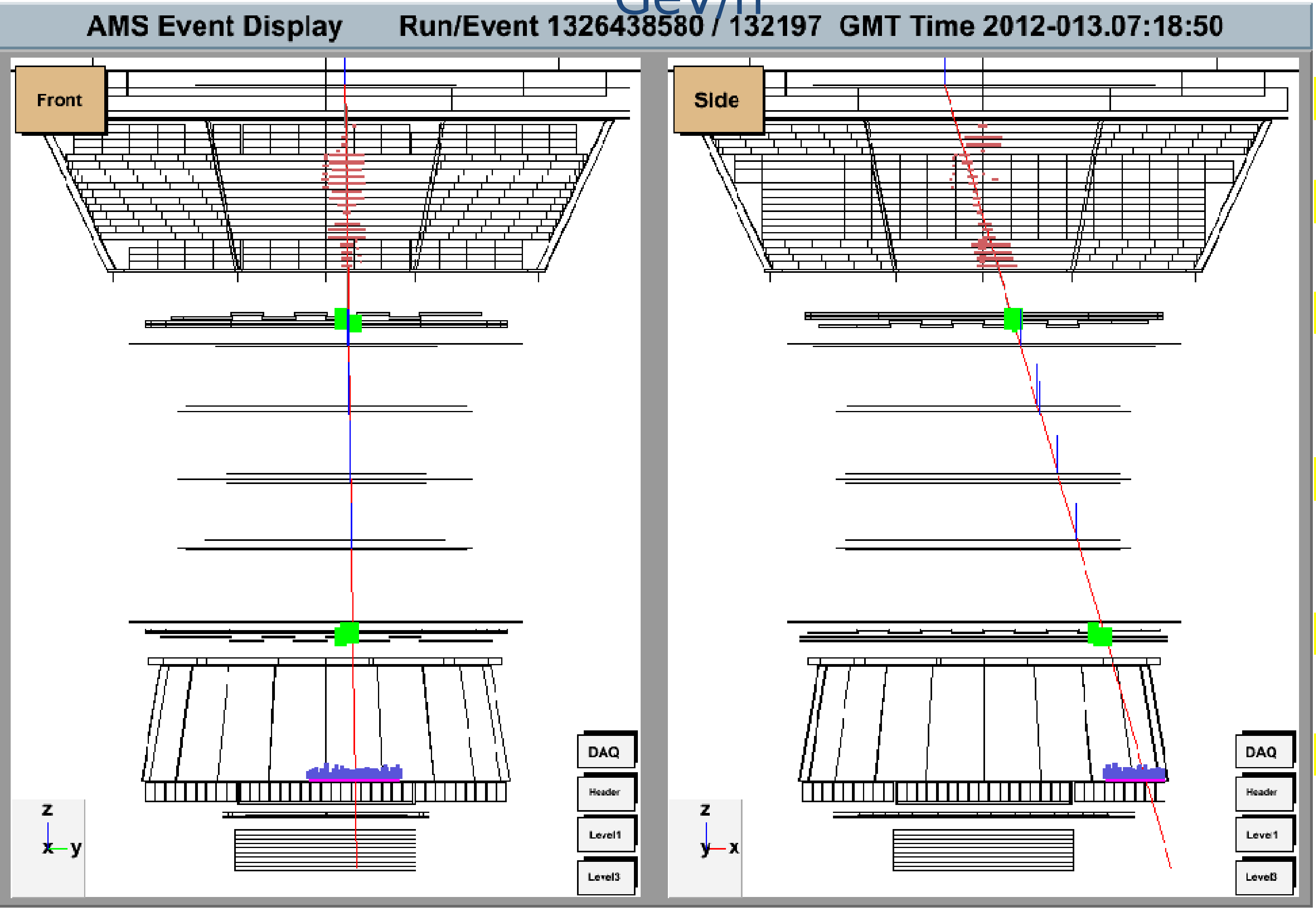
AMS data: e+ fraction

Pamela data
DAMPE expectation: e-

Accurate data on shape of cut-off are badly needed

Redundant charge measurement

C: Rigidity=215 GV, P=1288 GeV, Ekin/A=106 GeV/n



ZTRK_L1=6.1

ZTRD=5.9

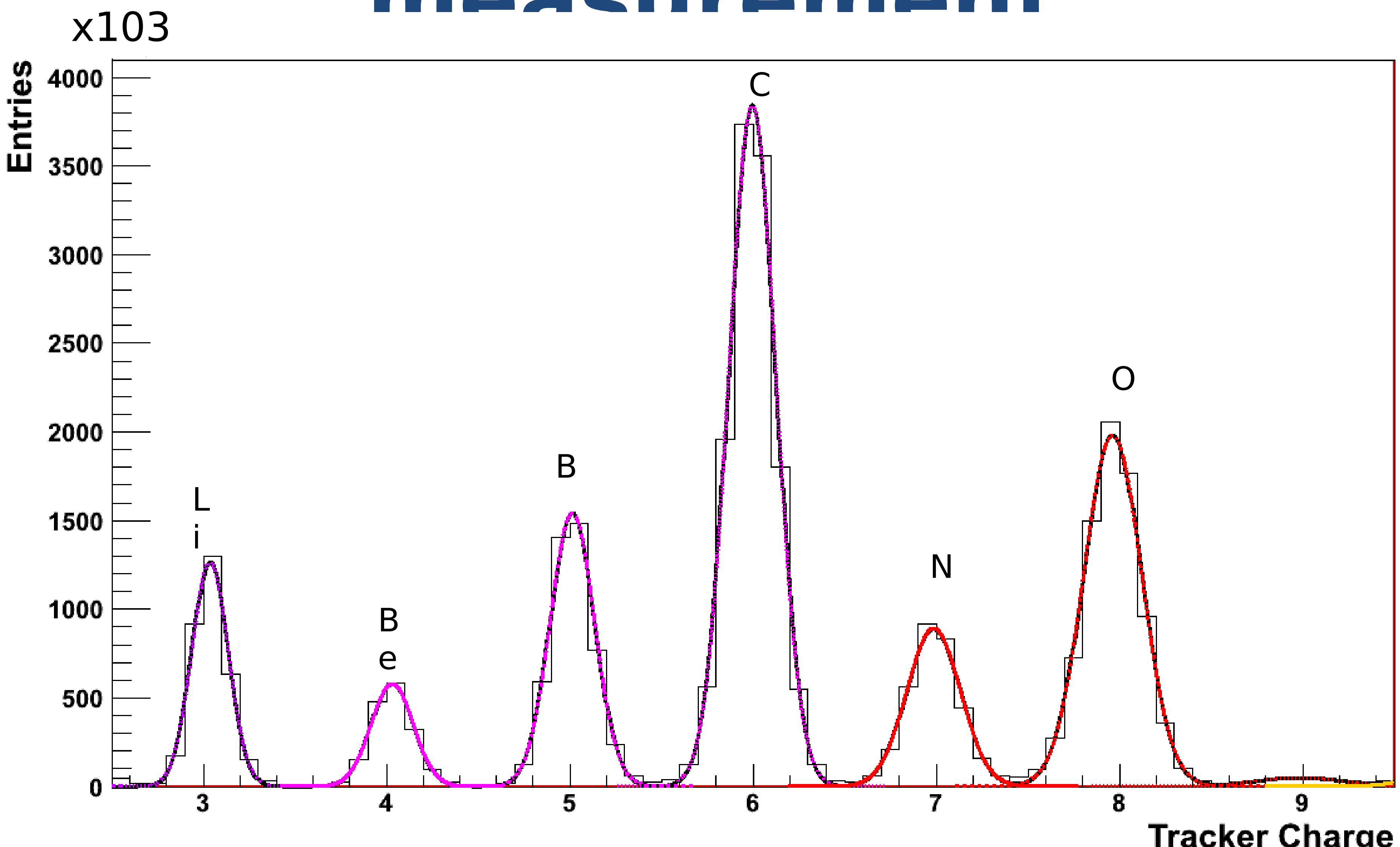
ZTOF_UP=5.9

ZTRK_IN=5.8

ZTOF_LOW=5.8

ZRICH=6.1

Tracker charge measurement



Conclusions:

The first 6.8 million primary positron and electron events collected with AMS on the ISS show:

i. At energies < 10 GeV, a decrease in the positron fraction with increasing energy.

ii. A steady increase in the positron fraction from 10 to ~250 GeV.

iii. The determination of the behavior of the positron fraction from 250 to 350 GeV and beyond requires more statistics and more study.

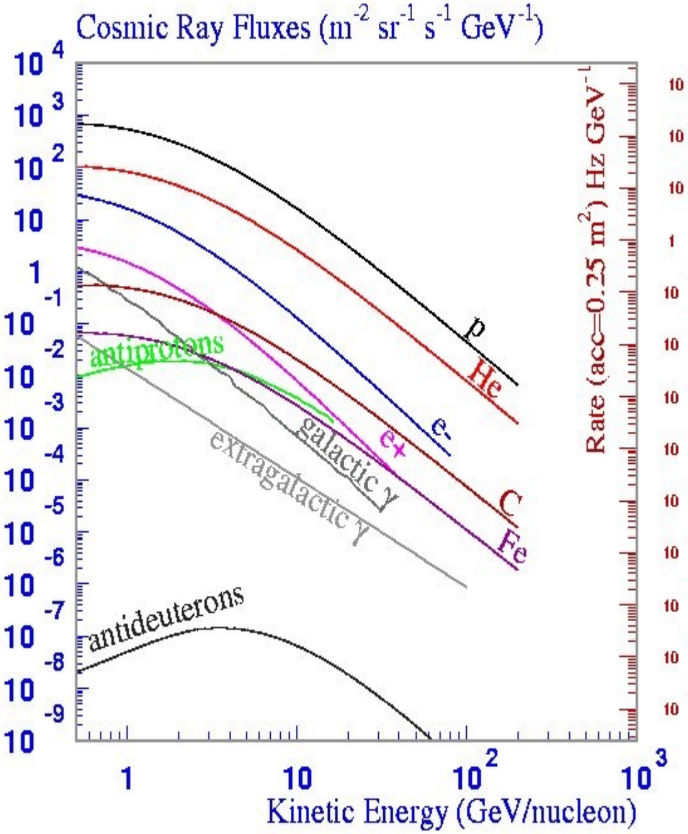
iv. The slope of the positron fraction versus energy decreases by an order of magnitude from 20 to 250GeV and no fine structure is observed. The positron fraction is consistent with e± fluxes each of which is the sum of its own diffuse spectrum and a single common power law source.

v. The positron to electron ratio is consistent with isotropy; $\delta \leq 0.036$ at the 95% *C.L.*

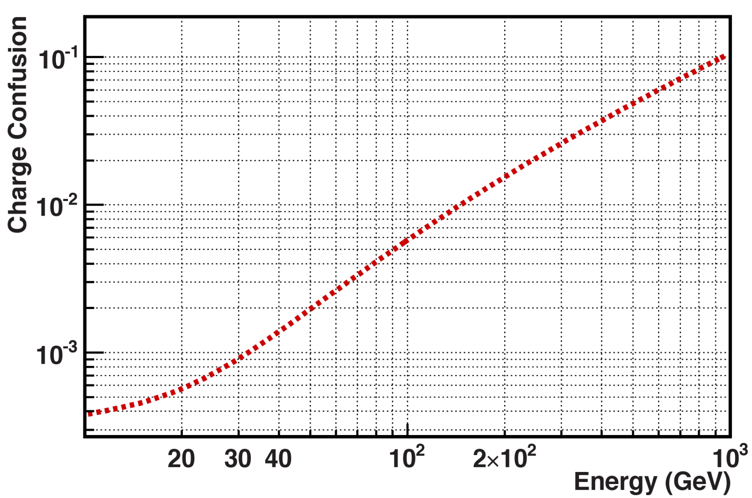
These observations show the existence of new physical phenomena, whether from a particle physics or an astrophysical origin.

Further measurements, including electron and positron spectra, proton and antiproton spectra, the chemical composition of cosmic rays etc., are progressing rapidly.

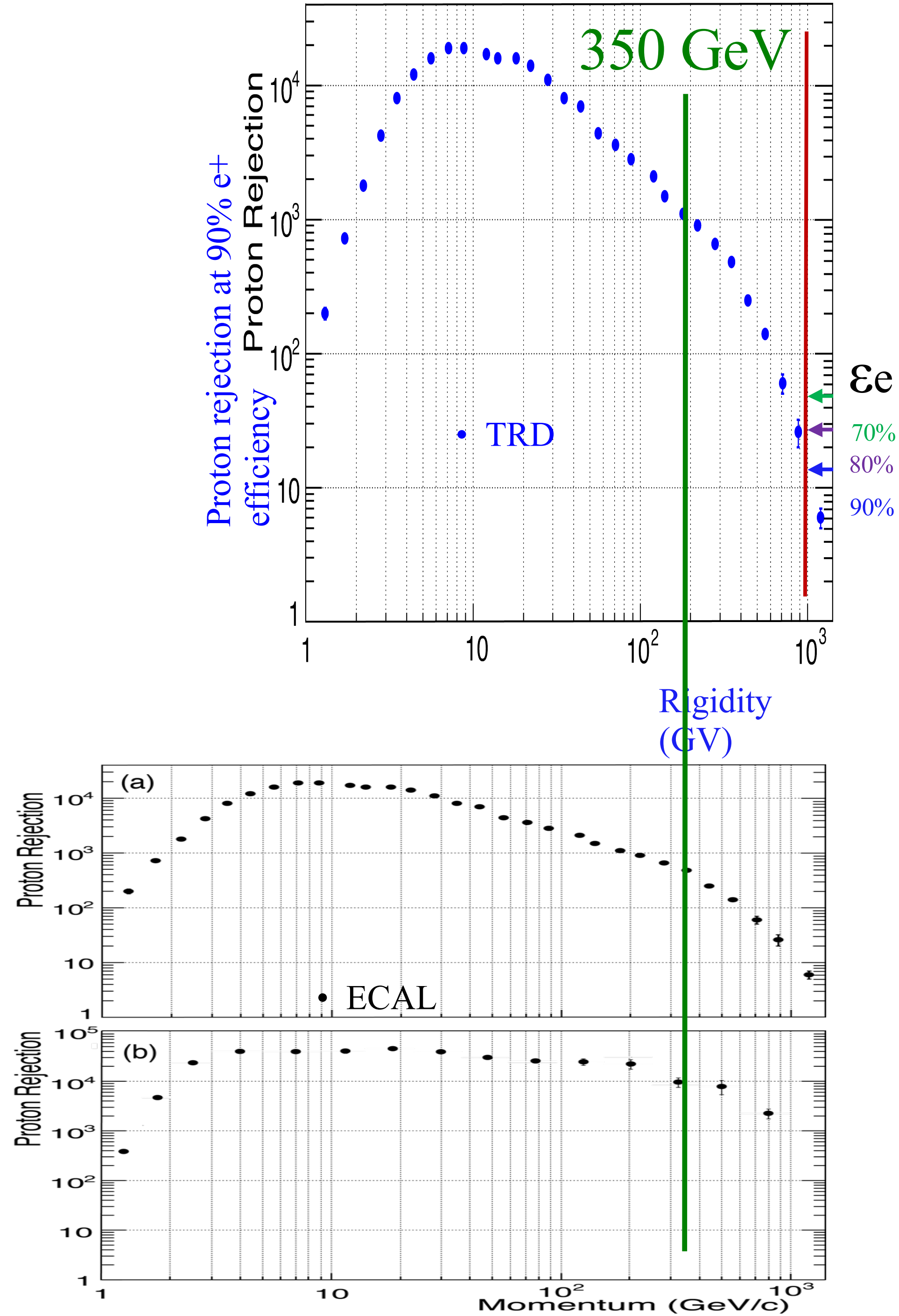
5/14/13



Cosmic Ray Fluxes (m-2 sr-1 s-1 GeV-1)
Rate (acc=0.25 m2) Hz GeV-1
p
He
e-
e+
C
Fe
antiprotons
galactic γ
extragalactic γ
antideuterons
Kinetic Energy (GeV/nucleon)



Charge Confusion
Energy (GeV)



350 GeV
Proton Rejection
Proton rejection at 90% e+ efficiency
TRD
Rigidity (GV)
εe
70%
80%
90%
(a)
ECAL
(b)
Proton Rejection
Momentum (GeV/c)