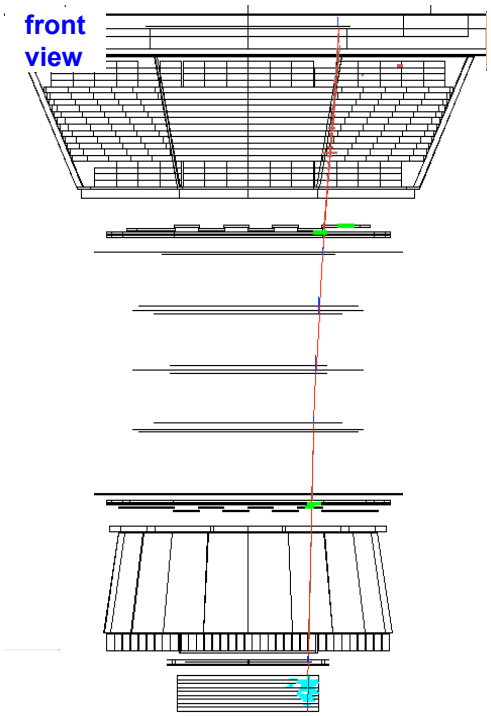
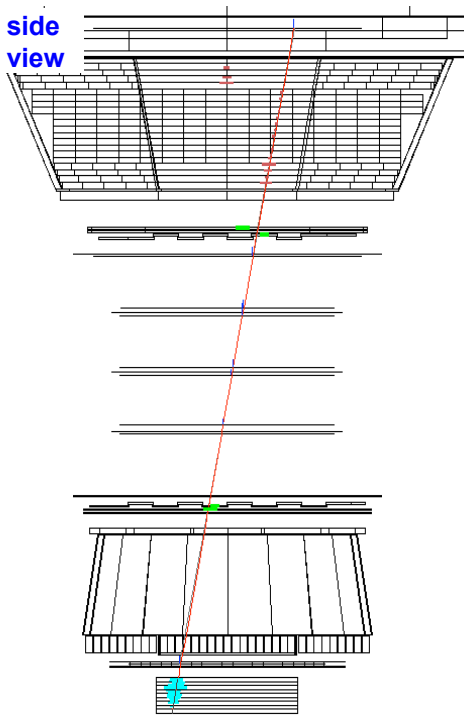
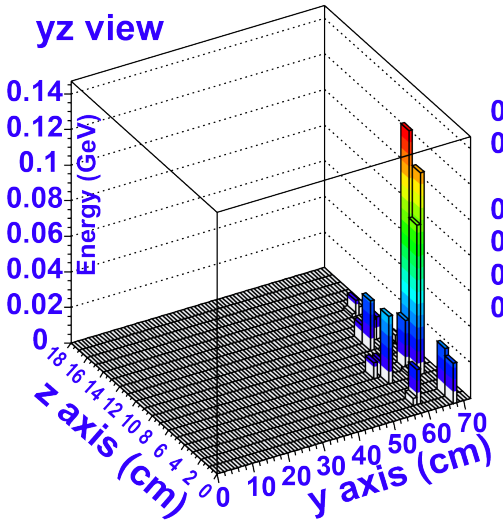
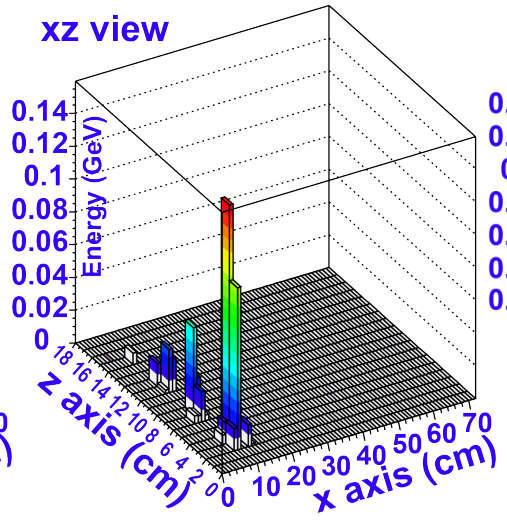
Electron E=1.1 GeV

Run/Event 1315150703/ 667540



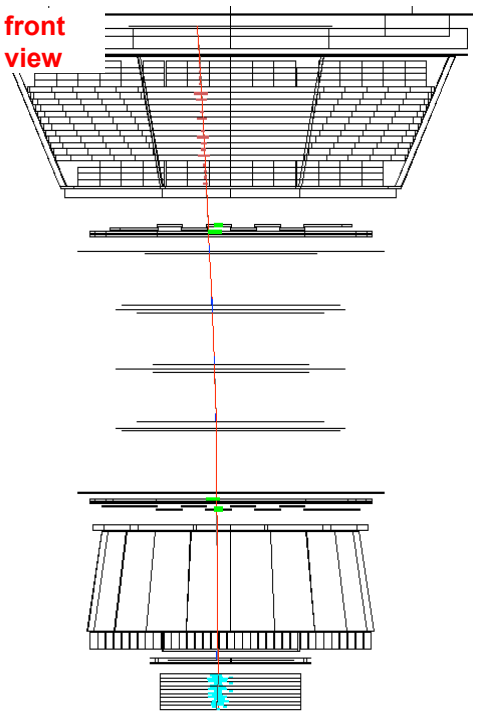


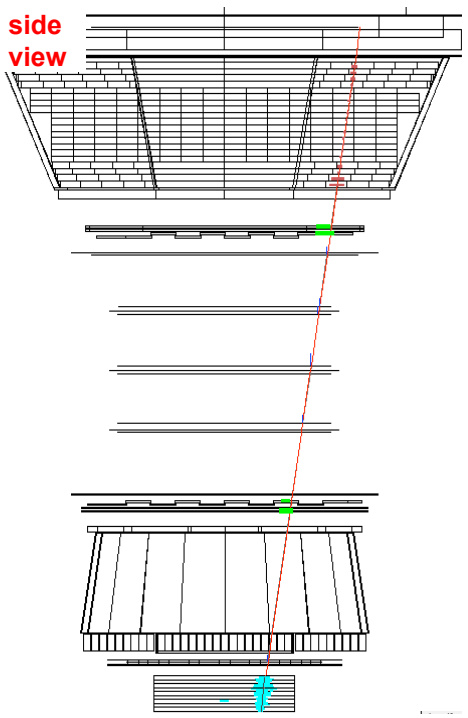


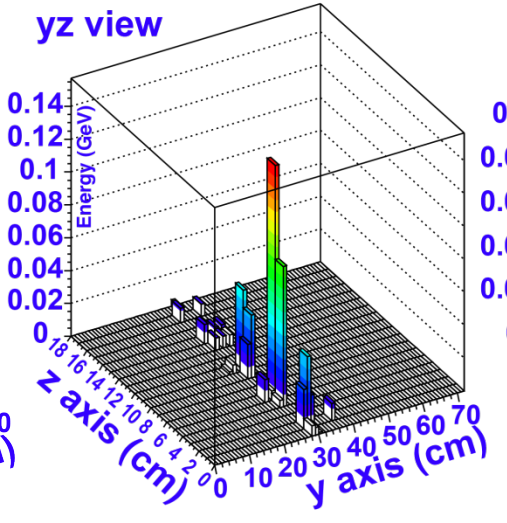


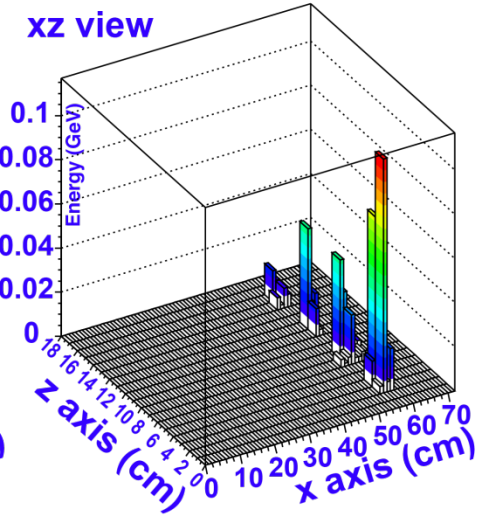
Positron E=1.1 GeV

Run/Event 1316182344/ 919896







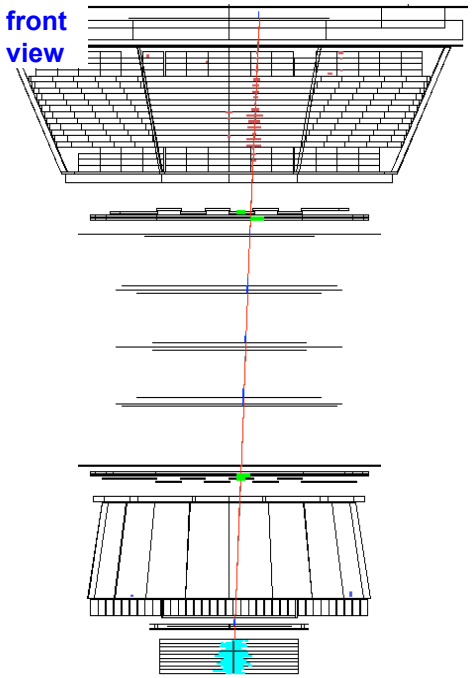


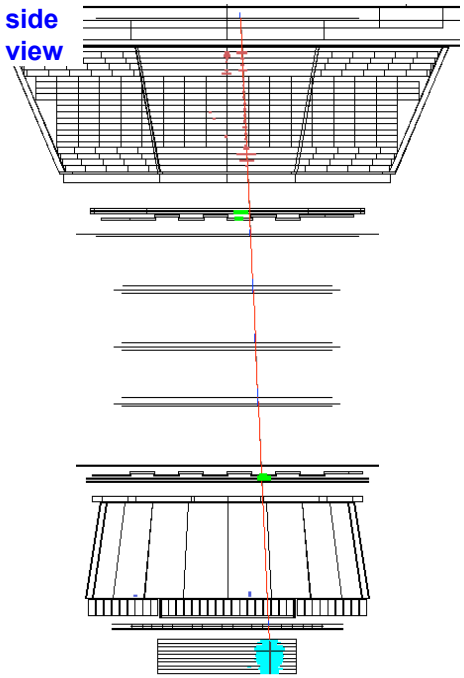
Electron E=10.1 GeV

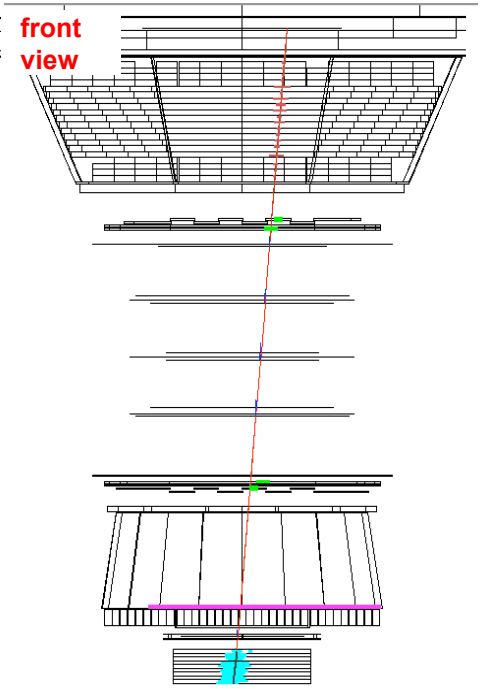
Run/Event 1314950197/ 296945

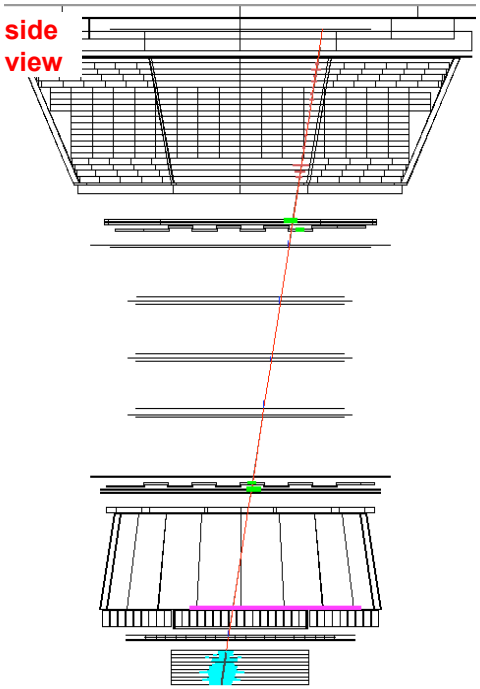
Positron E=9.5 GeV

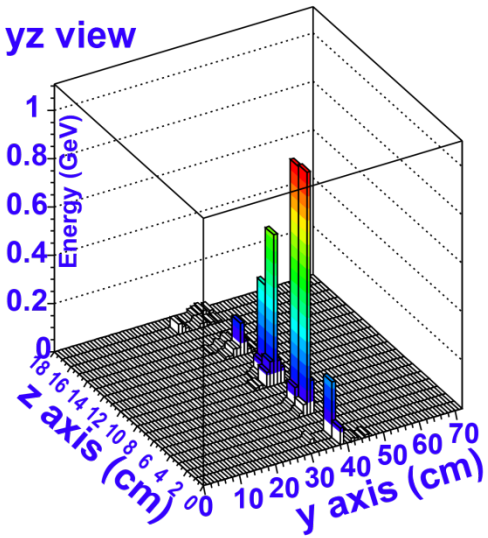
Run/Event 1316692684/ 283617

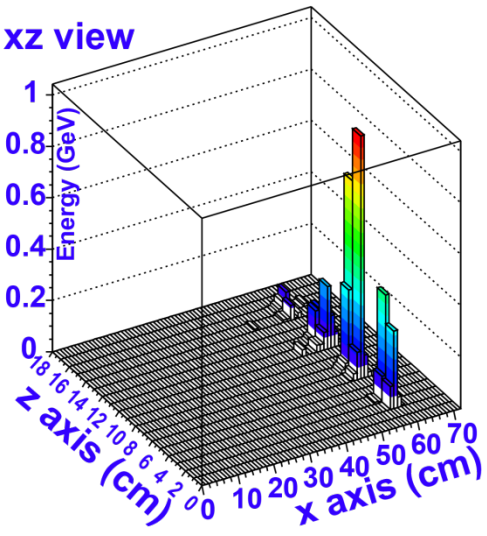


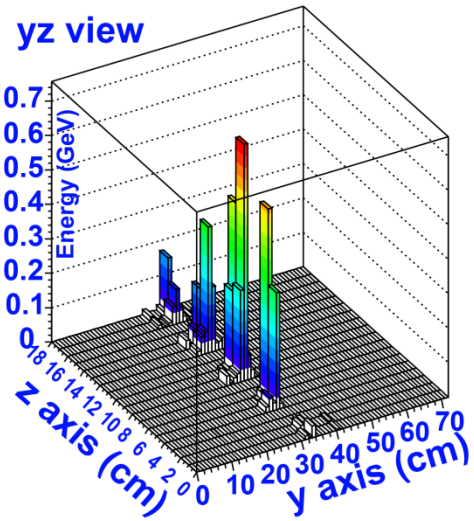


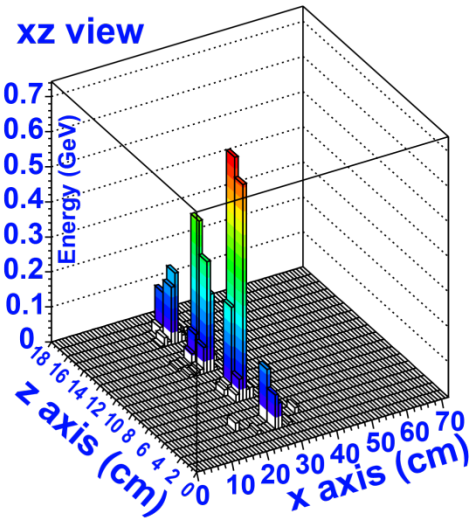






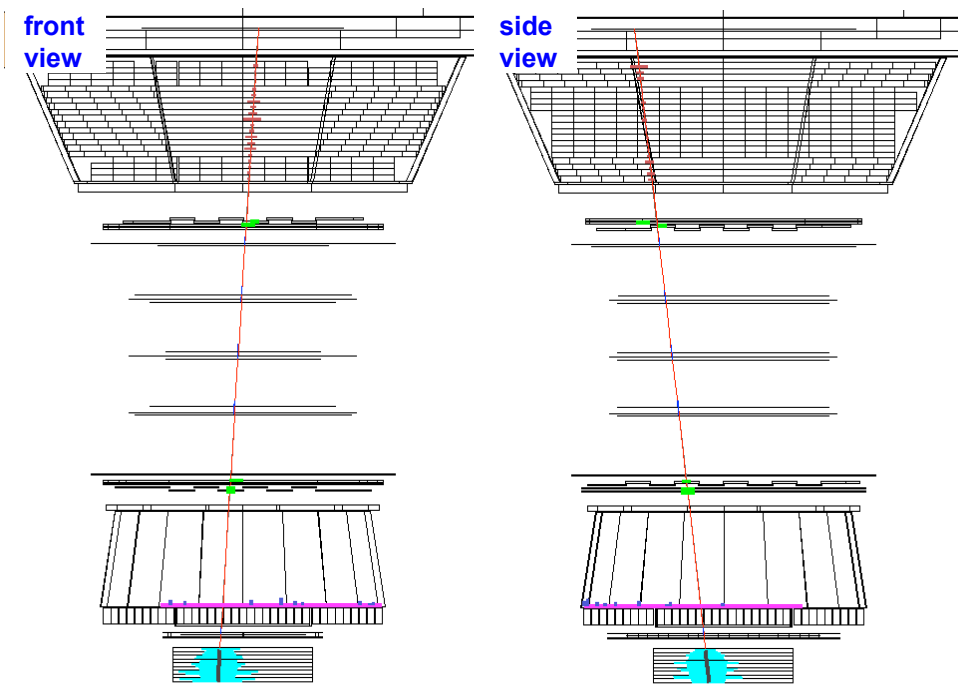


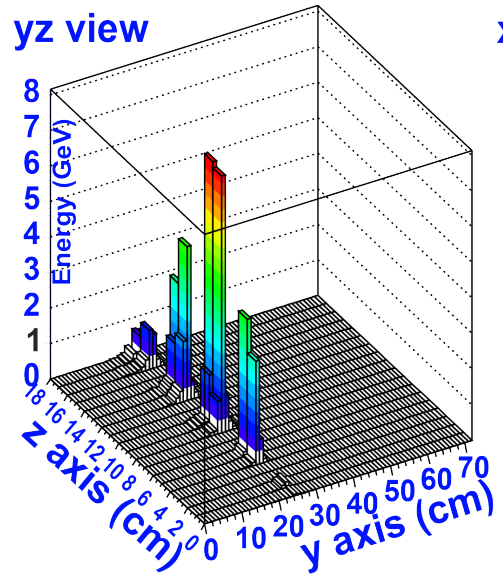


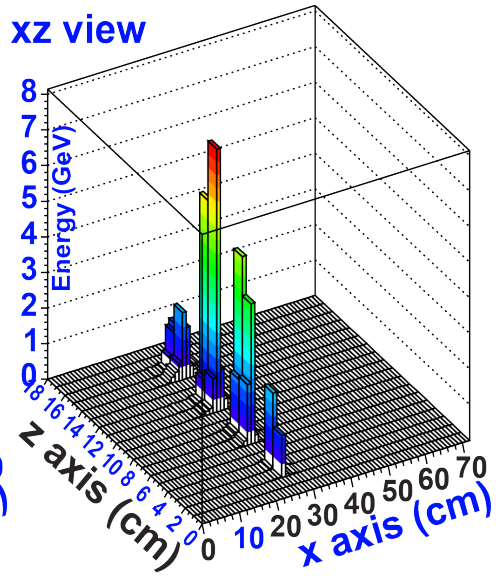


Electron E=99 GeV

Run/Event 1318944028/ 505503

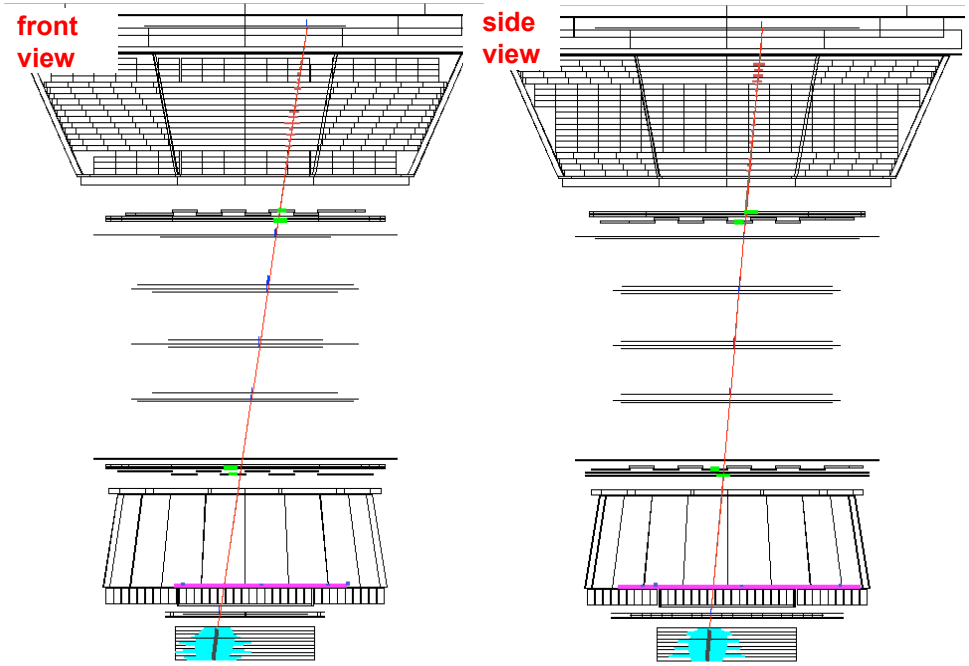


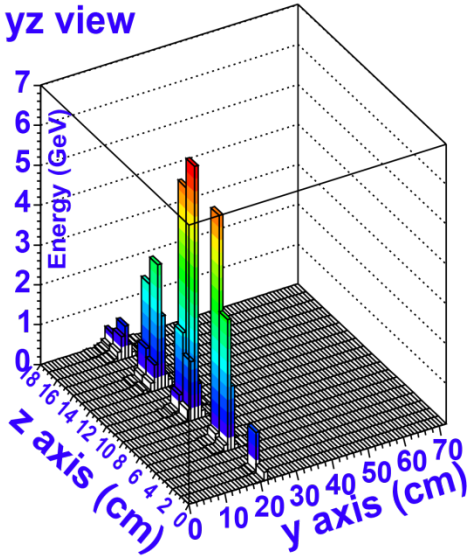


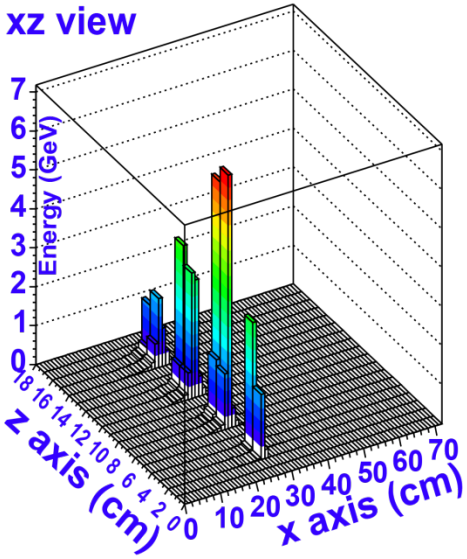


Positron E=100 GeV

Run/Event 1334274023/ 338433

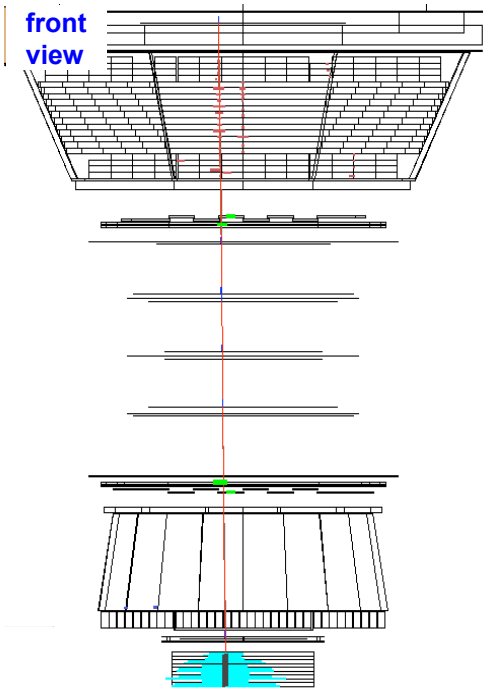


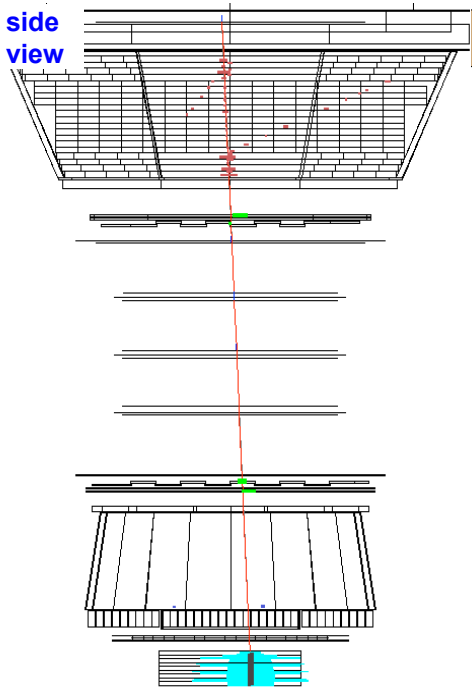


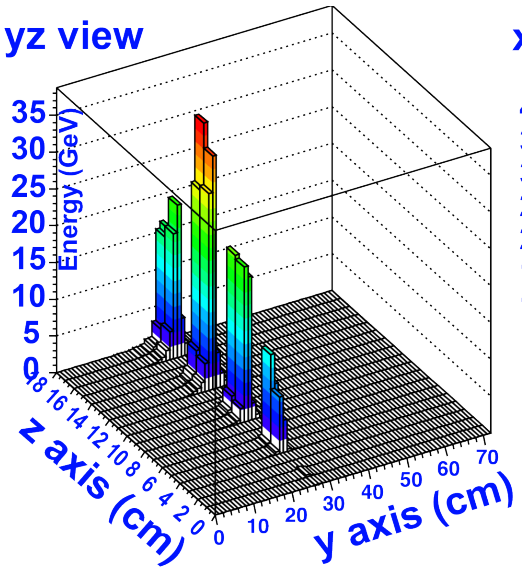


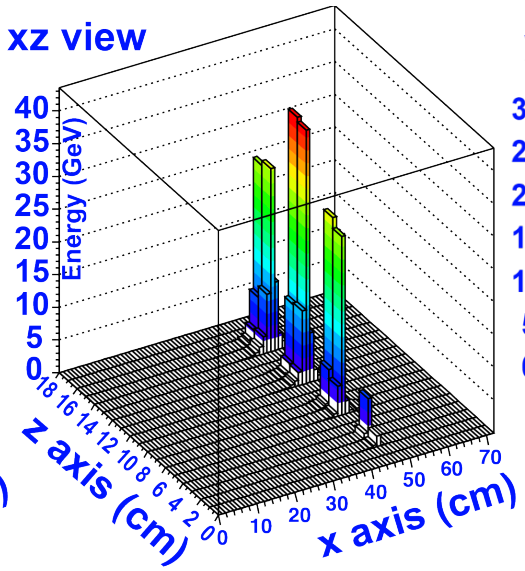
Electron E=982 GeV

Run/Event 1329775818/ 60709



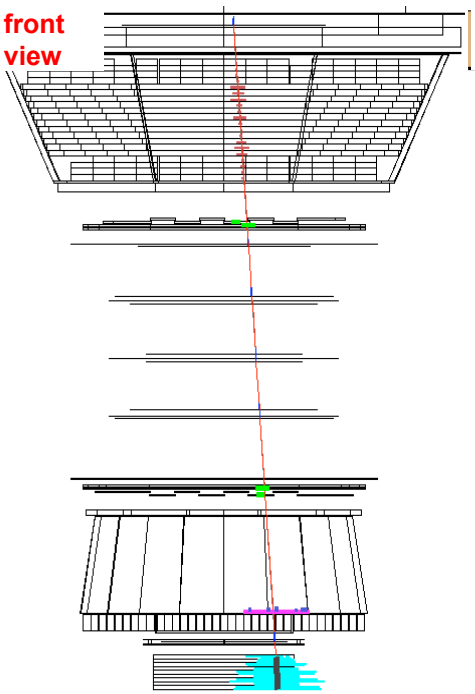


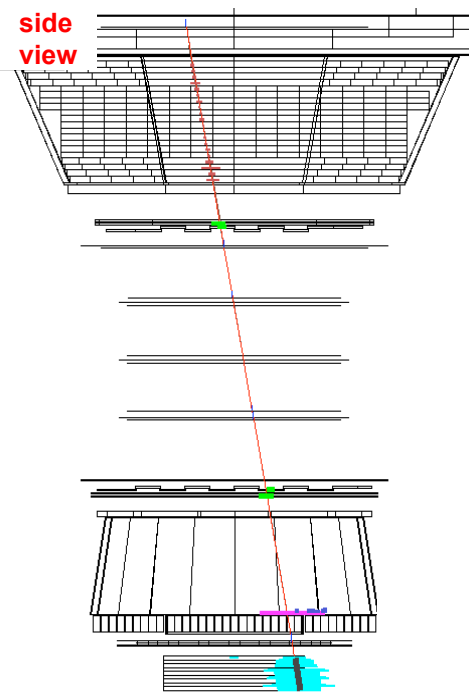


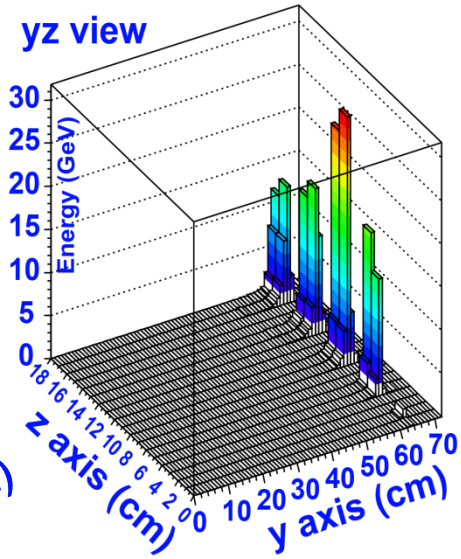


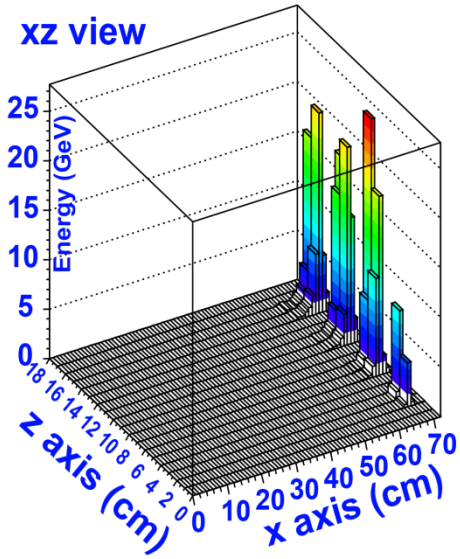
Positron E=636 GeV

Run/Event 133119-743/ 56950







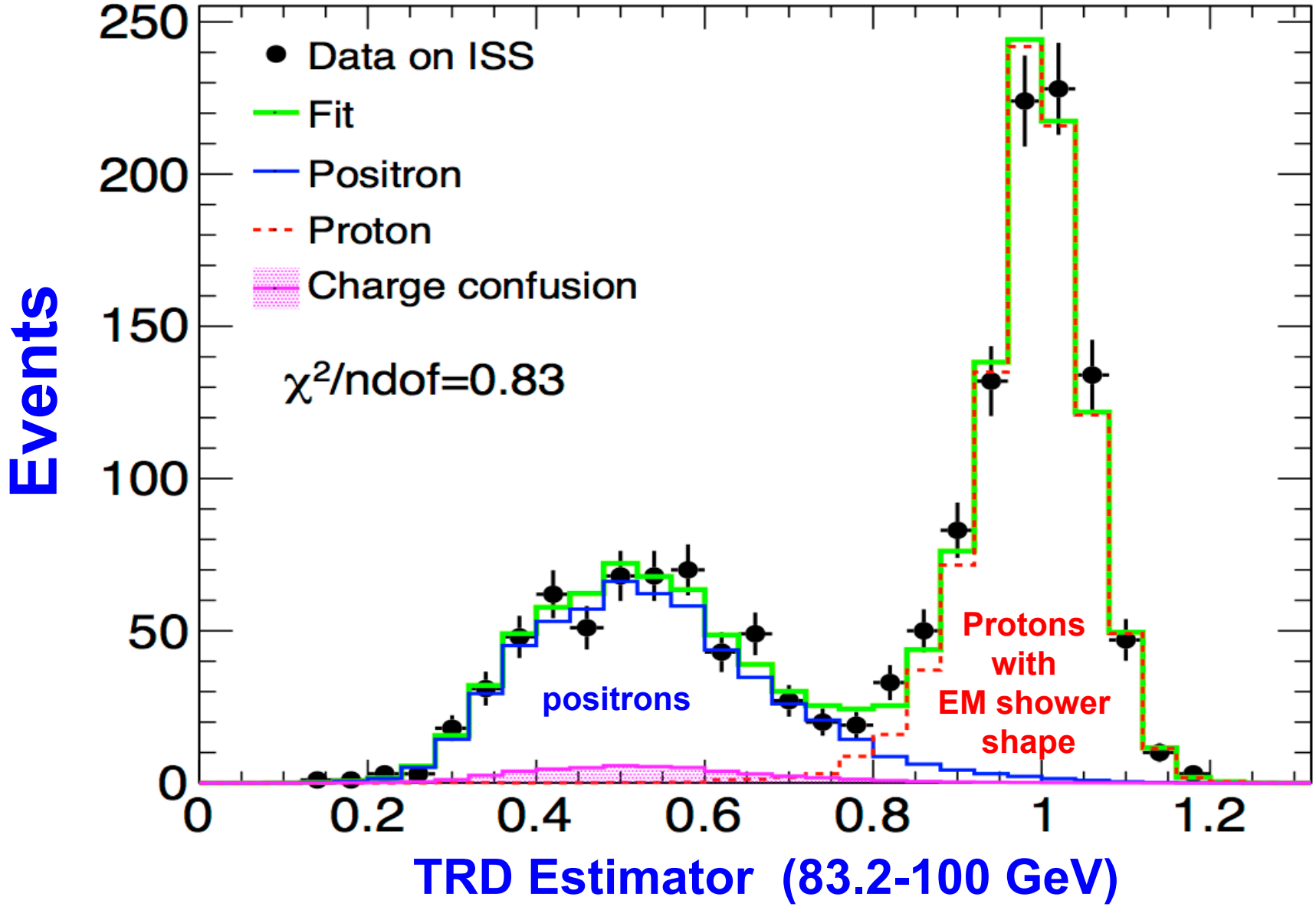


Principle of the measurement:

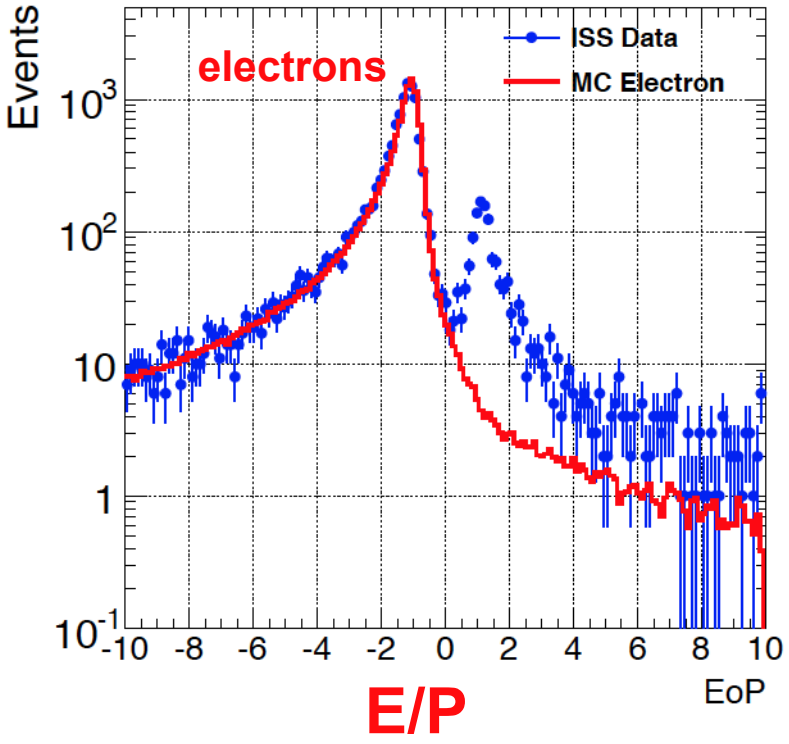
1. Measure the electron spectrum by selecting charge -1 particles with EM shower.
2. Measure the positron spectrum by selecting charge +1 particles with EM shower.
3. Main issue: Huge proton background: $e^+/p \sim 10^{-4}$. Require the further separation power of TRD.
4. Main issue: Charge confusion due to scattering or secondary production are estimated by MC
5. Efficiency, acceptance, and most of the systematics are cancelled by taking the ratio of e^+/e^-.

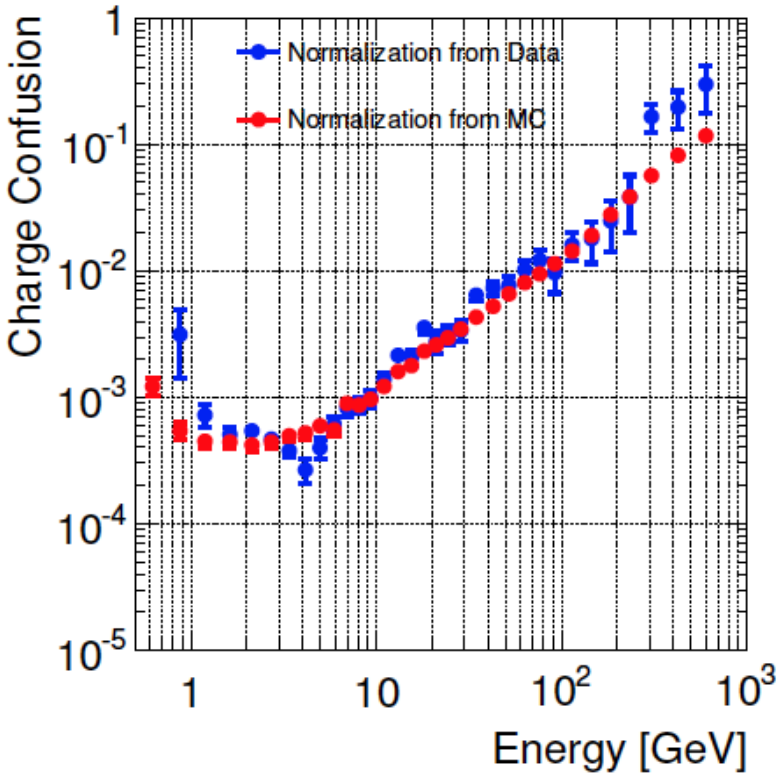
Example of Positron Selection:

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



Charge confusion is estimated based on MC





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.

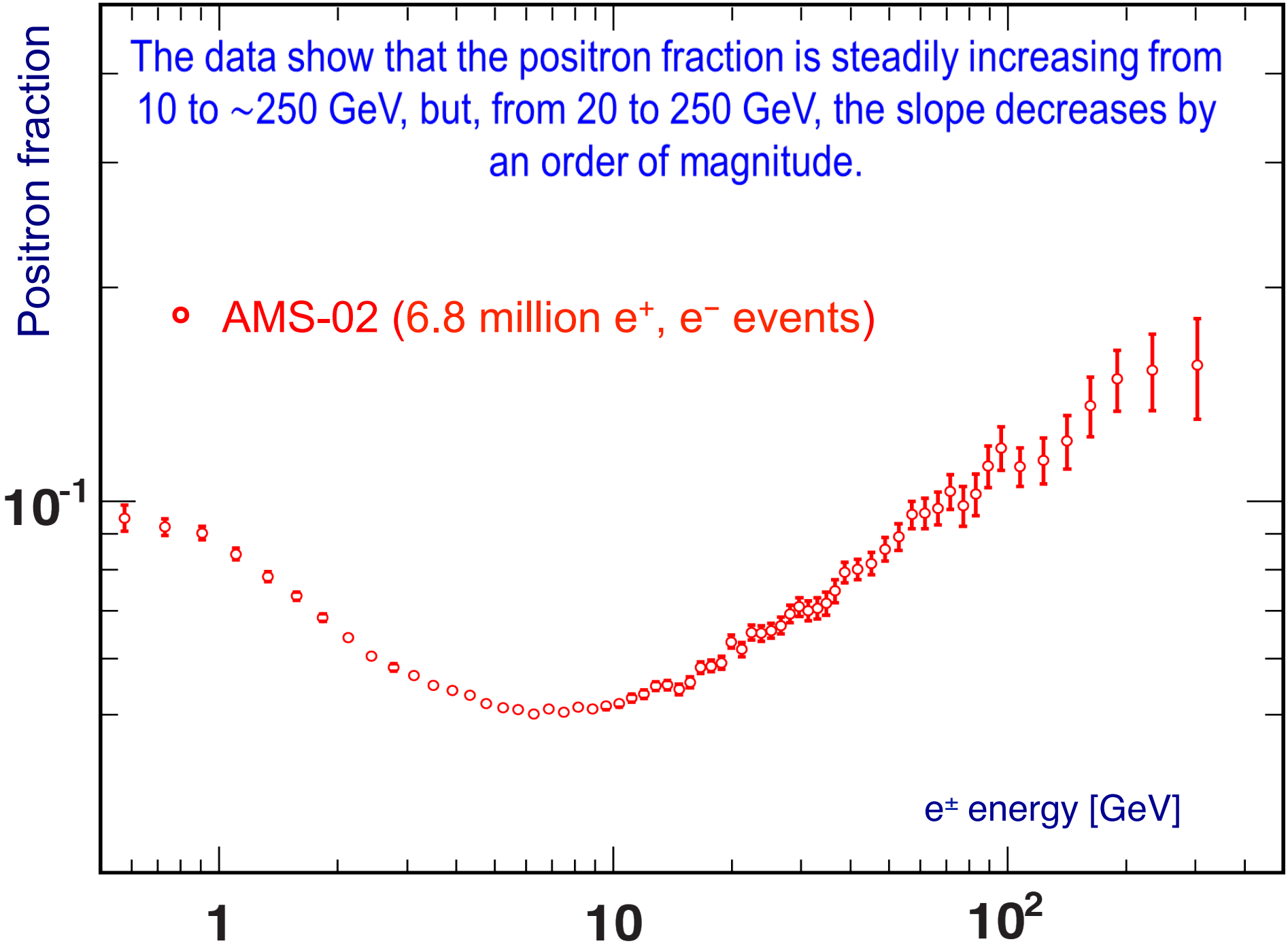
Systematic errors to positron fraction

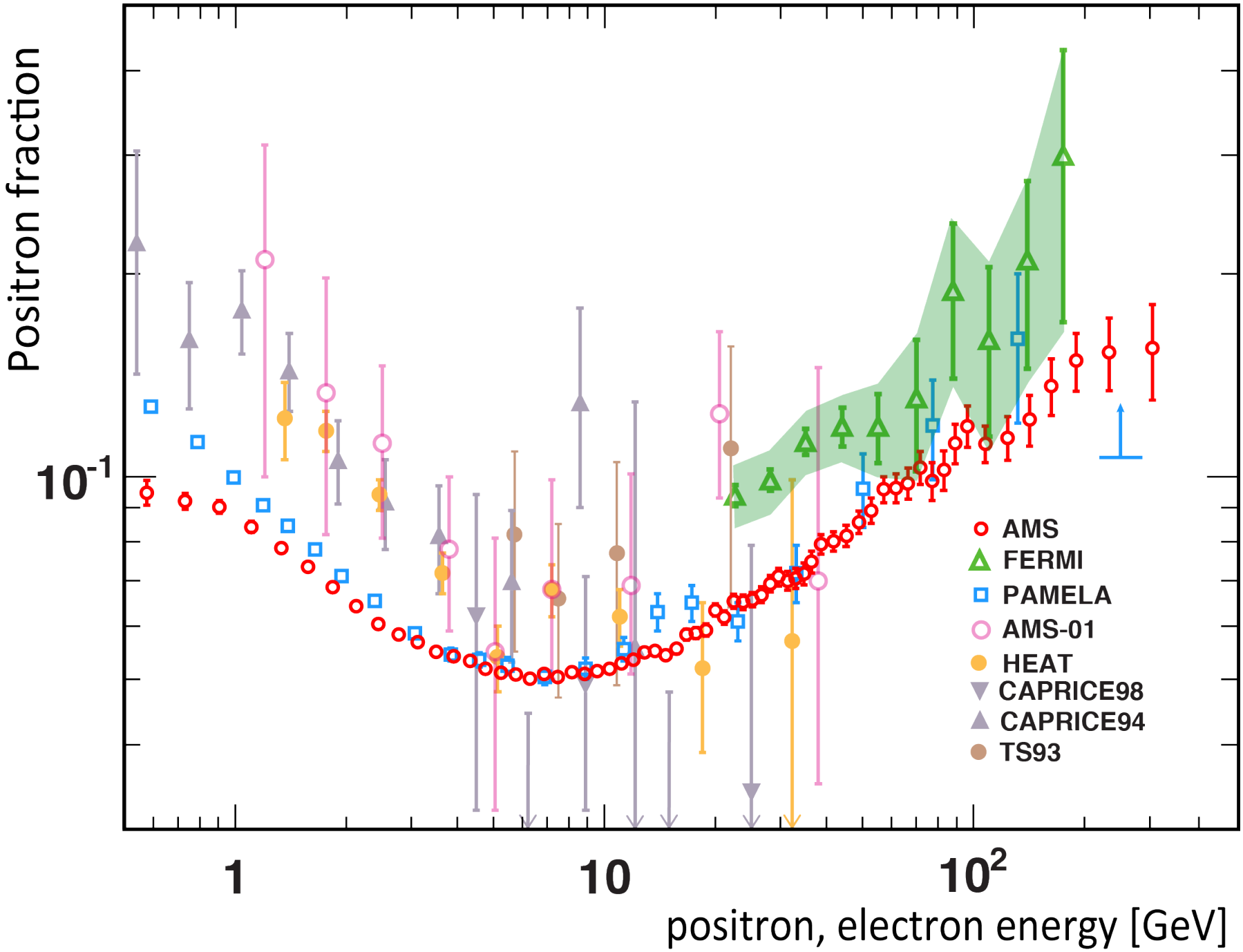
1. **Acceptance asymmetry**
   - Difference between positron and electron acceptance due to known minute tracker asymmetry
2. **Selection dependence**
   - Dependence of the result on the cut values
3. **Migration bin-to bin**
   - Migration of electron and positron events from the neighboring bins affects the measured fraction
4. **Reference spectrum**
   - Definition of the reference spectra is based on pure samples of electrons and protons of finite statistics
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.

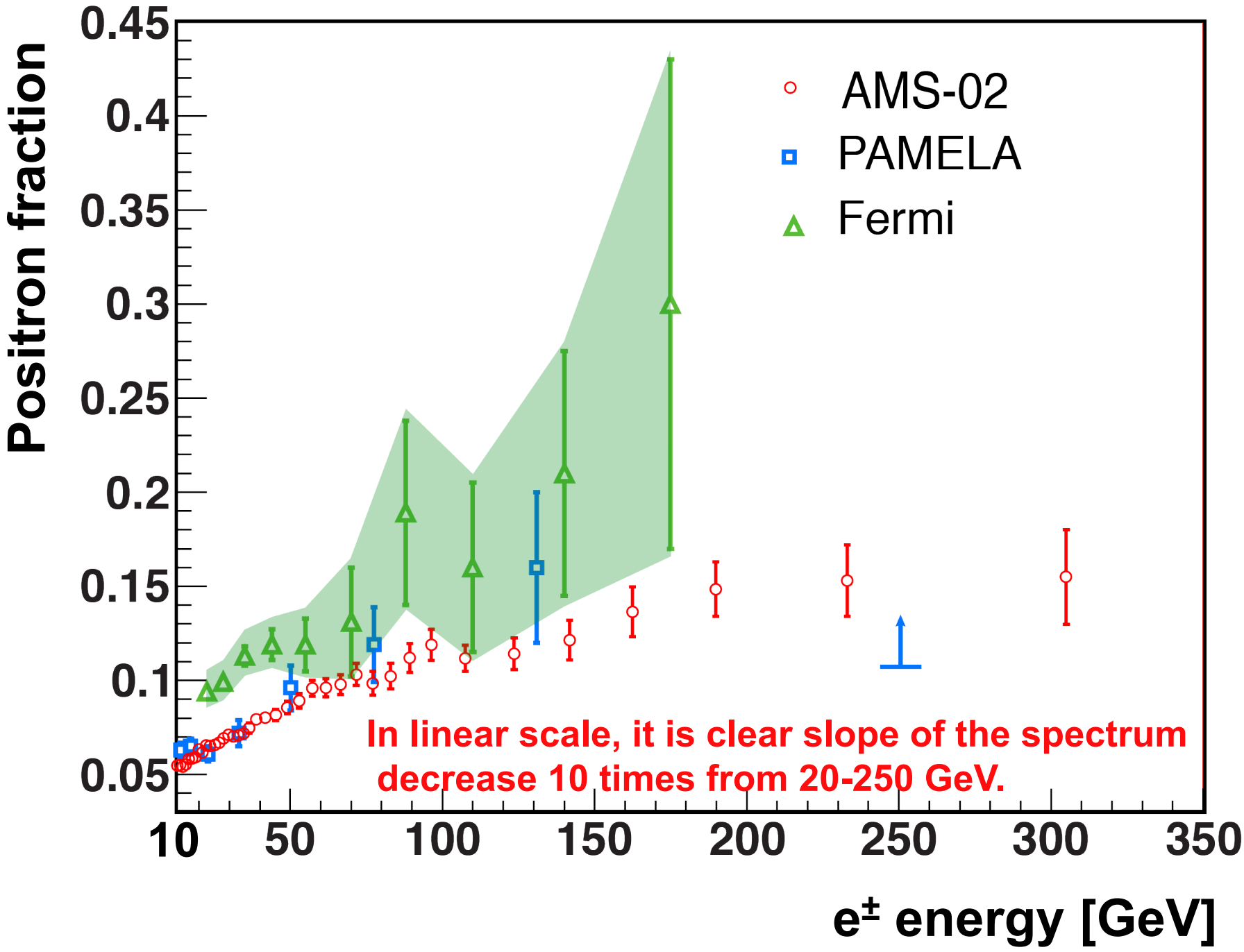
Positron events, positron fraction in each energy bin				Systematic Errors					
Energy [GeV]	N_{e+}	Fraction	statistical error	acceptance asymmetry	event selection	bin-to-bin migration	reference spectra	charge confusion	total systematic uncertainty
Energy[GeV]	N_{e+}	Fraction	$\sigma_{stat.}$	$\sigma_{acc.}$	$\sigma_{sel.}$	$\sigma_{mig.}$	$\sigma_{ref.}$	$\sigma_{c.c.}$	$\sigma_{syst.}$
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

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

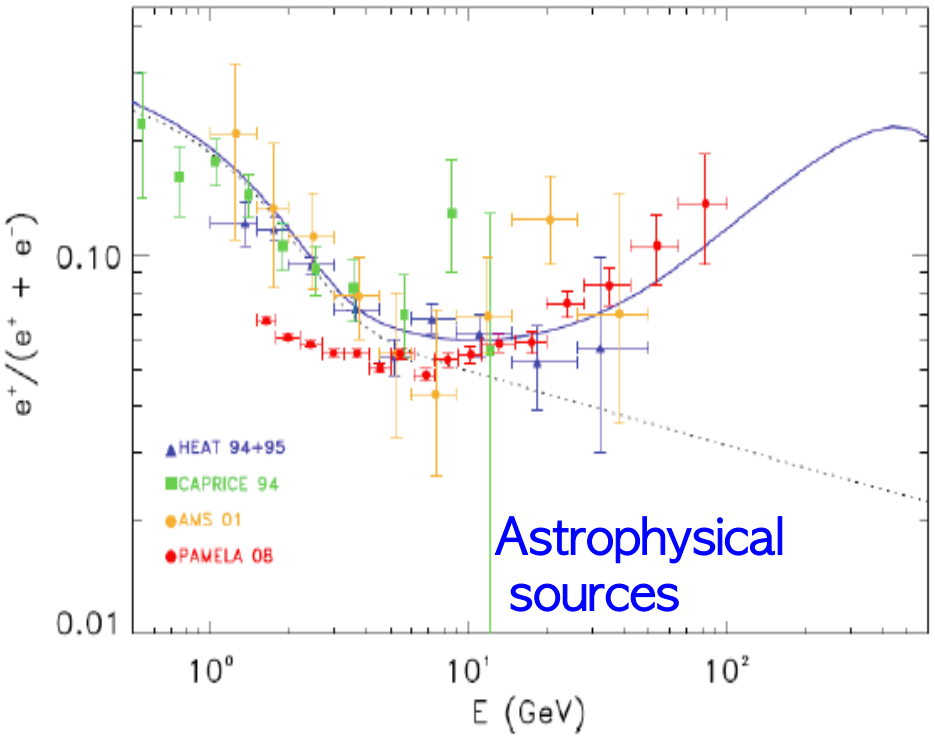

The data show that the positron fraction is steadily increasing from 10 to ~250 GeV, but, from 20 to 250 GeV, the slope decreases by an order of magnitude.
Positron fraction
AMS-02 (6.8 million e+, e− events)
10-1
1
10
10²
e± energy [GeV]


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

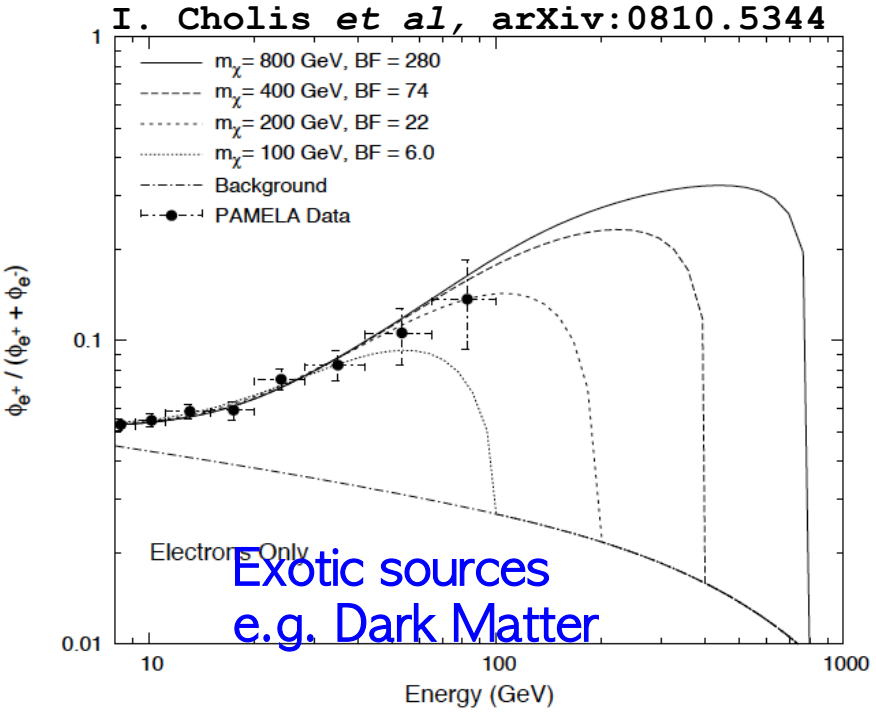

Positron fraction
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
10
50
100
150
200
250
300
350
e± energy [GeV]
AMS-02
PAMELA
Fermi
In linear scale, it is clear slope of the spectrum
decrease 10 times from 20-250 GeV.

Are we seeing the onset of the threshold behavior?

D. Grasso *et al*, arXiv:0905.0636



I. Cholis *et al*, arXiv:0810.5344



Further measurement to higher energy will decide

On the origin of excess positrons

- Fitting the spectrum with a simple model.
- If the excess has a particle physics origin, there should be no anisotropy.

An 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 $e^{\pm}$:

$$\Phi_{e^+} = C_{e^+} E^{-\gamma_{e^+}} + C_s E^{-\gamma_s} e^{-E/E_s} \qquad \textbf{Eq(1)}$$

$$\Phi_{e^-} = C_{e^-} E^{-\gamma_{e^-}} + C_s E^{-\gamma_s} e^{-E/E_s} \quad (E \text{ in GeV}) \qquad \textbf{Eq(2)}$$

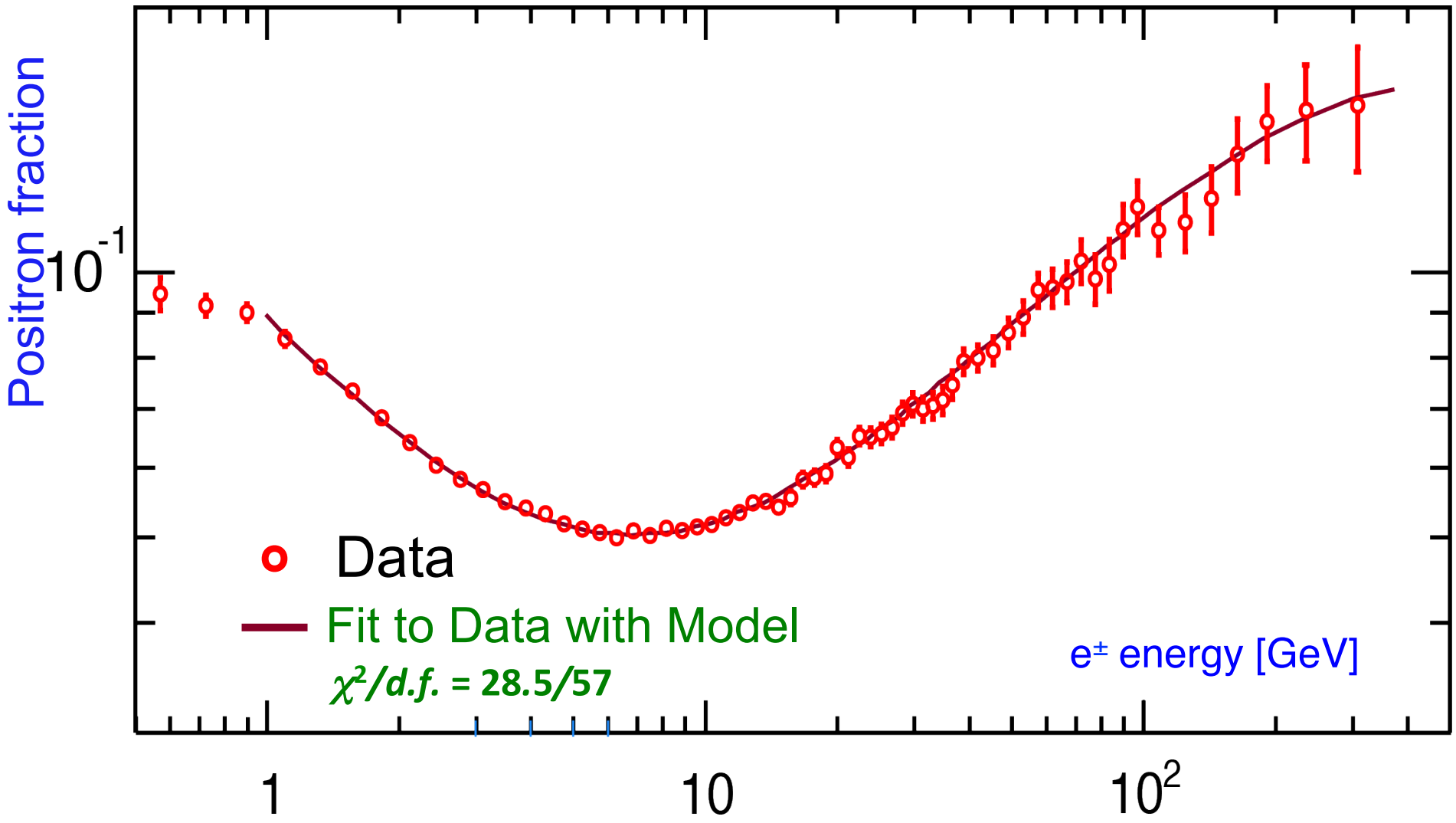
Coefficients C_{e+} and C_{e-} correspond to relative weights of diffuse spectra for positrons and electrons.

C_s is the weight of the source spectrum.

γ_{e+}, γ_{e-} and γ_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 agreement between the data and the model shows that the positron fraction spectrum is consistent with $e^{\pm}$ fluxes each of which is the sum of its 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:

$\gamma_{e-} - \gamma_{e+}$ = **−0.63 ± 0.03**, *i.e.*, the diffuse positron spectrum is less energetic than the diffuse electron spectrum;

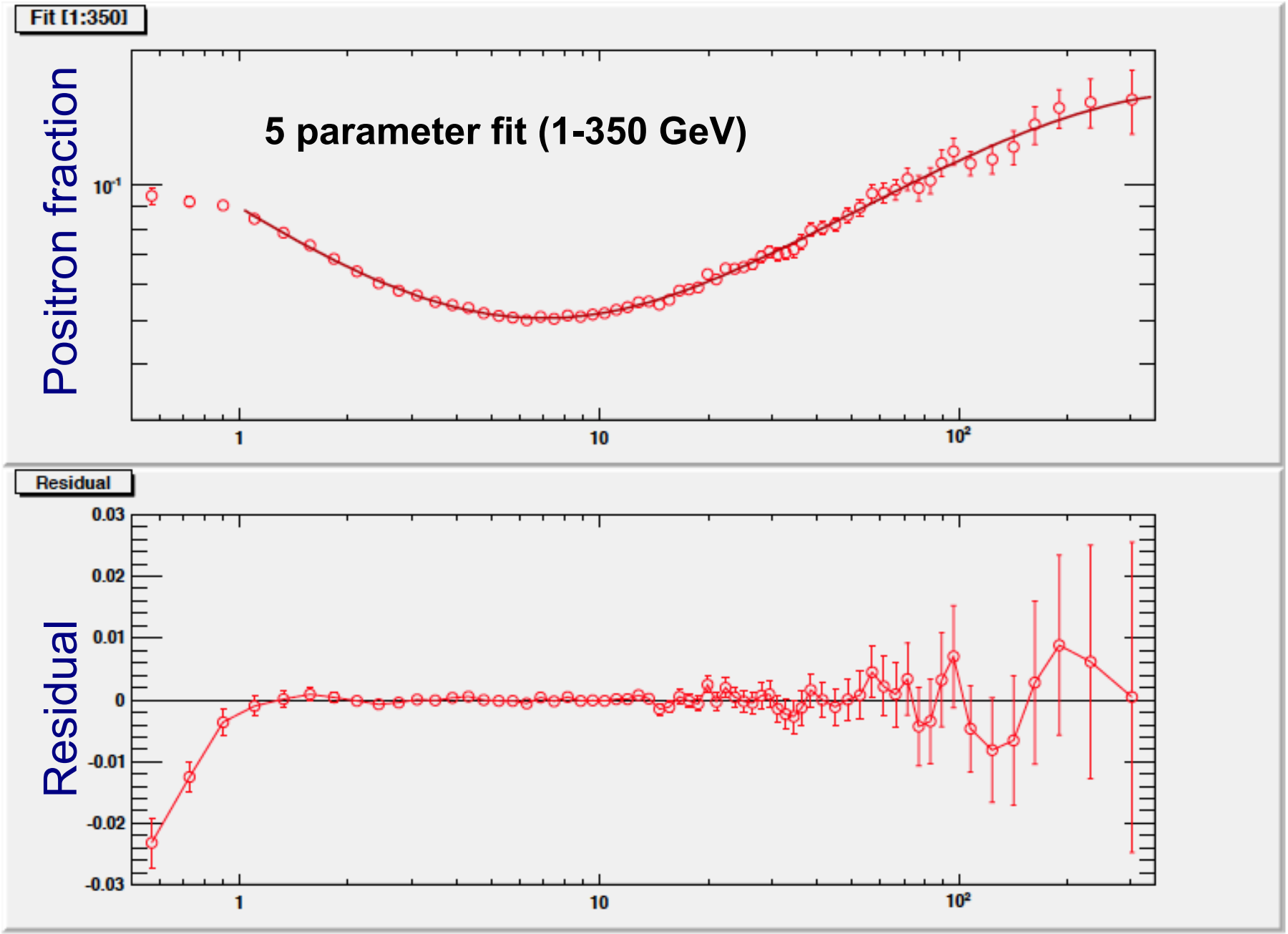
$\gamma_{e-} - \gamma_{S}$ = **0.66±0.05**, *i.e.*, the source spectrum is more energetic than the diffuse electron spectrum;

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;

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;

$1/E_s$ = **0.0013 ± 0.0007 GeV^{-1}**,
corresponding to a cutoff energy of **760^{+1000}_{-280} GeV**.

No structure in the spectrum



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

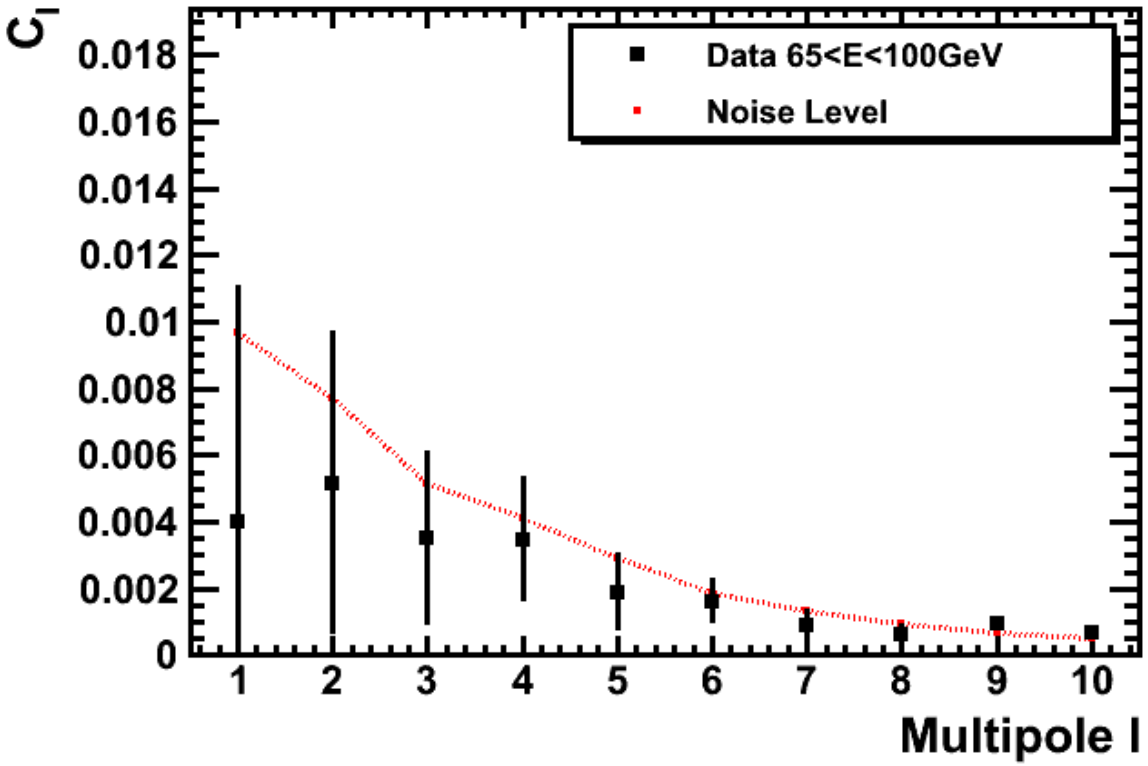
$$C_\ell = \frac{1}{2\ell + 1} \sum_{m=-\ell}^{\ell} |a_{\ell m}|^2.$$

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

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

Limits on the amplitude of a dipole anisotropy in any axis in galactic coordinates on the positron to electron ratio

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



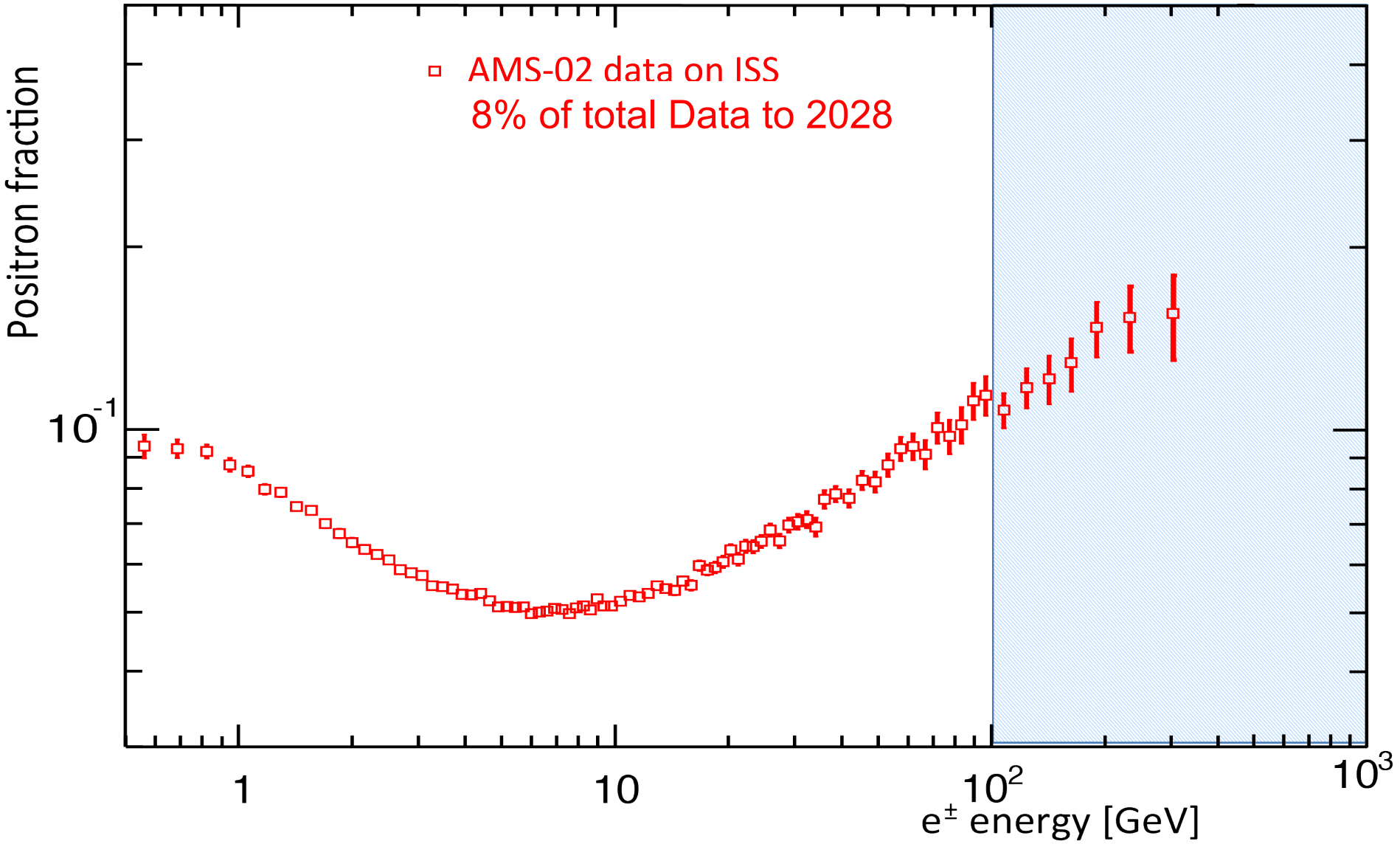
$$C_l = \frac{1}{2l+1} \sum_{m=-l}^{l} |a_{lm}|^2$$

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

δ ≤ 0.036 at the 95% confidence level

AMS will be on ISS for 20 years.

The data to ~1 TeV will be presented when there are sufficient events.



In conclusion, 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.

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 agreement between the data and the model shows that the positron fraction spectrum is consistent with $e^{\pm}$ fluxes each of which is the sum of its 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.