Recent Results from AMS02

S.Rosier-Lees

On behalf of the AMS02 collaboration

KEK seminar - April 5th 2013 – Tsukuba

Outline

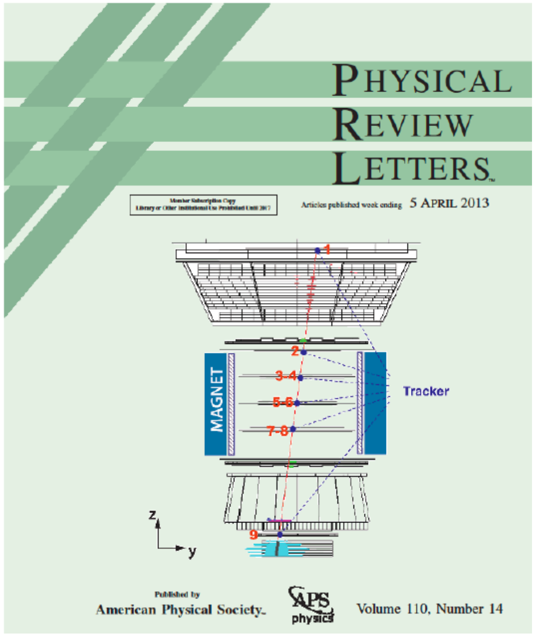
- AMS02 in Space
  - Detector overview and performance in space

- (Charge measurement)

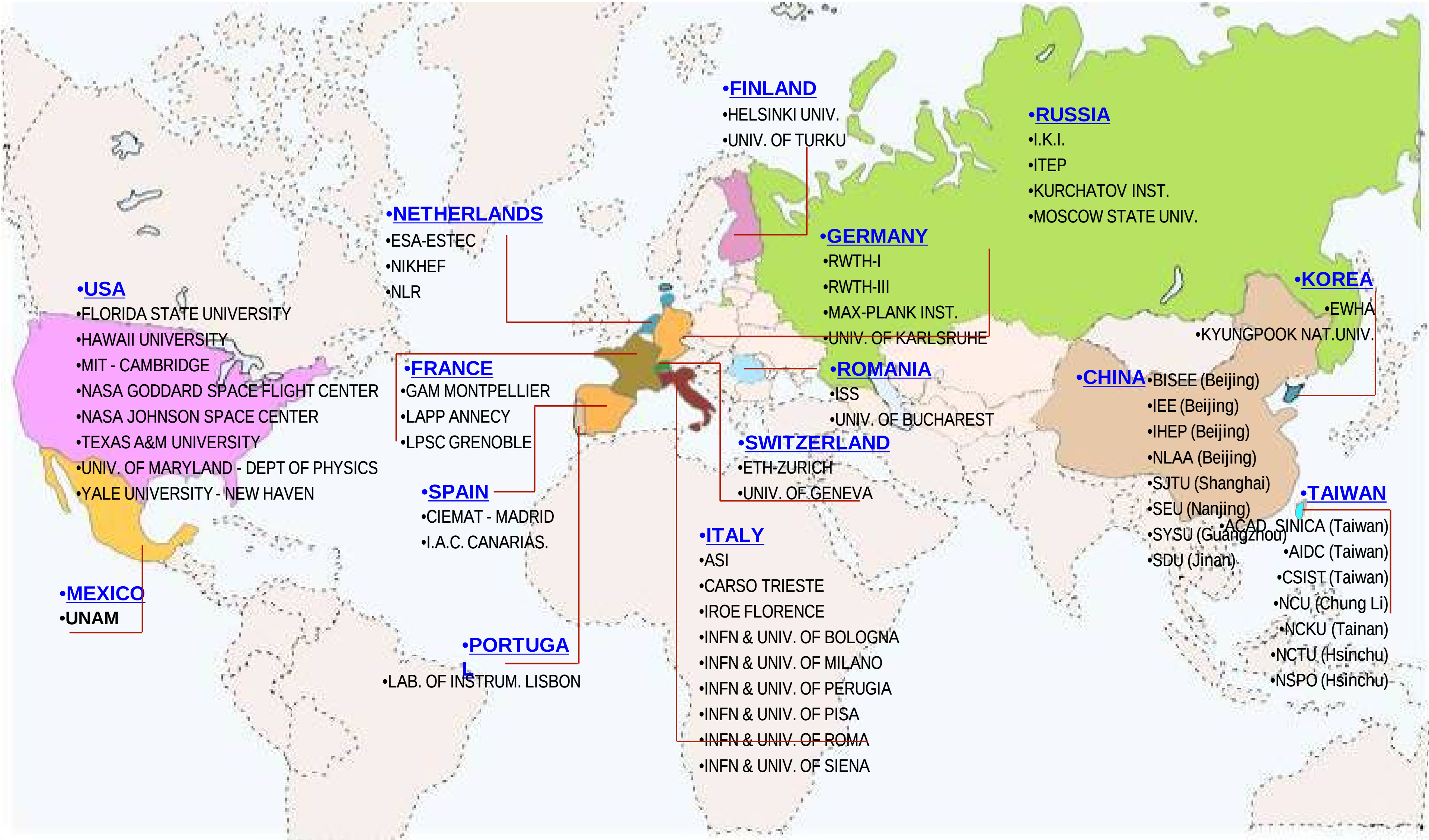
- Positron Fraction measurement

Results extracted from the presentation of

Pr S.Ting CERN, April 5th



The AMS Collaboration

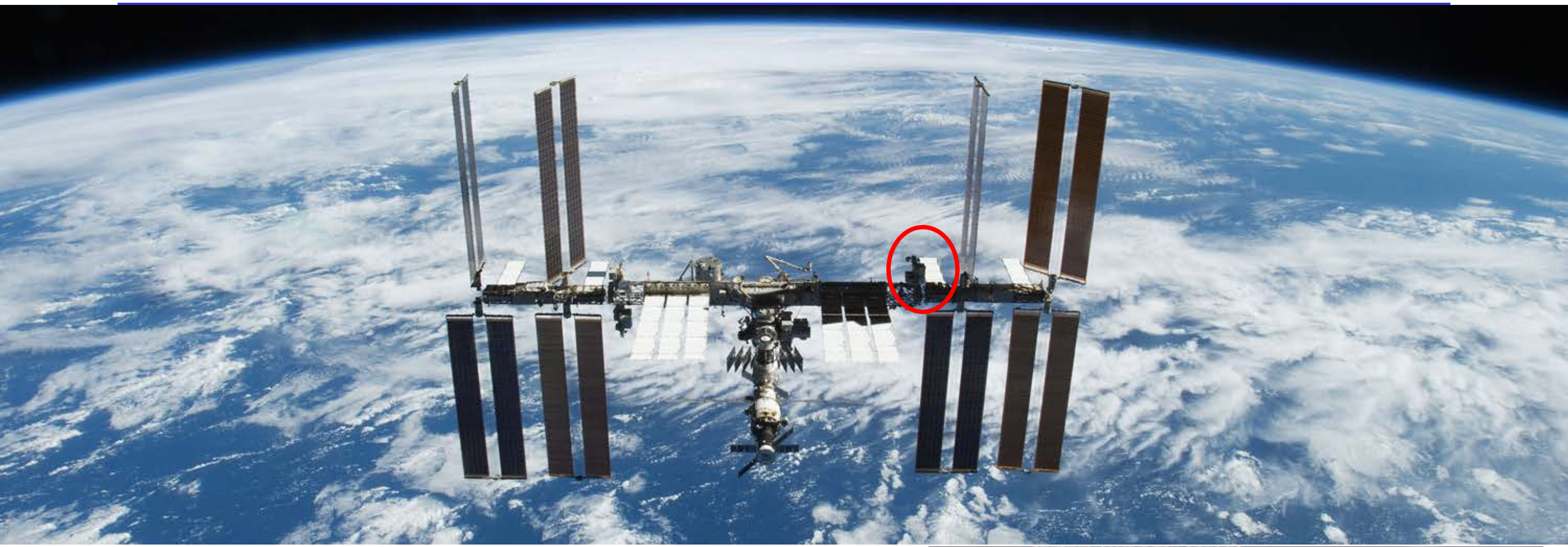


16 Countries, 60 Institutes, 600 Physicists

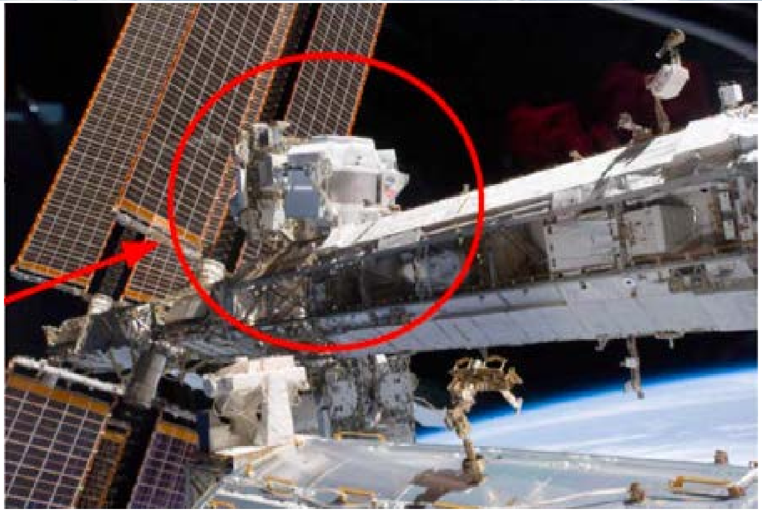
AMS Physics goals

- **Searches for ~~p~~rimordial antimatter:**
  - Anti-nuclei: anti He, …
- **Dark Matter searches**:
  - **e^+ , $e^\pm$, anti-**p , γ…
  - simultaneous observation of several signal channels.
- **Searches for new forms of matter:**
  - strangelets, …
- **Measuring CR spectra – refining propagation model**
  - (B/C, Be Isotopes);
- **Study of local sources of high energy photons in the GeV-TeV**
- **Study effects of solar modulation on CR spectra over 11 year solar cycle**

AMS02 on board of the ISS



May 19 2011

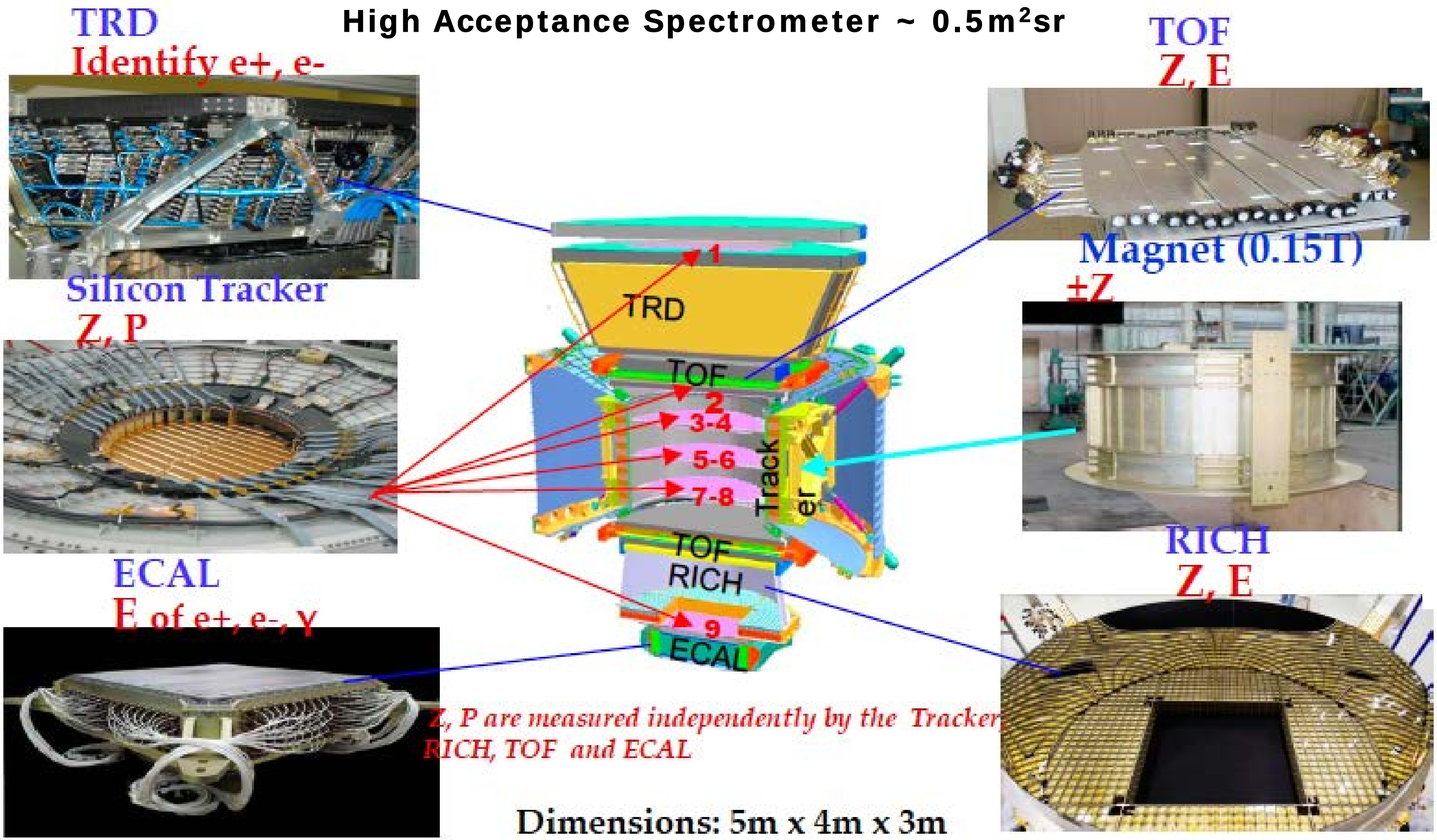


AMS installation completed on ISS at 5:15 CDT, start taking data 9:35 CDT Until 2020+ ….

(CDT Central Daylight Time)

AMS02: A TeV precision, multi purpose Spectrometer

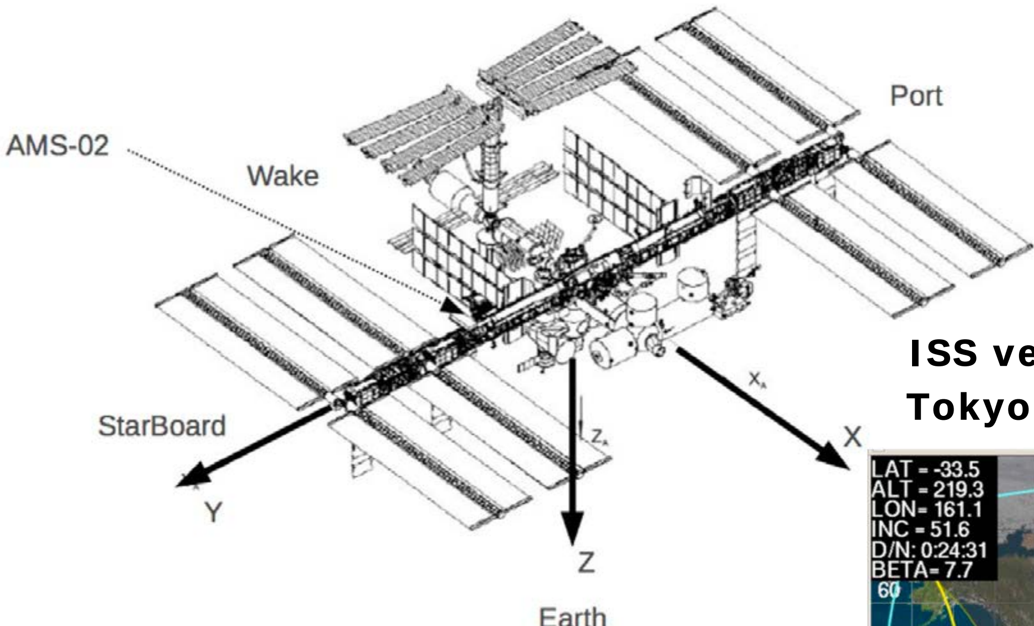
High Acceptance Spectrometer ~ 0.5m^{2}sr



Z, P are measured independently by the Tracker, RICH, TOF and ECAL

Dimensions: 5m x 4m x 3m
Weight: 8.5 tons
Power: 2500 W
Data downlink rate: >= 9Mbps

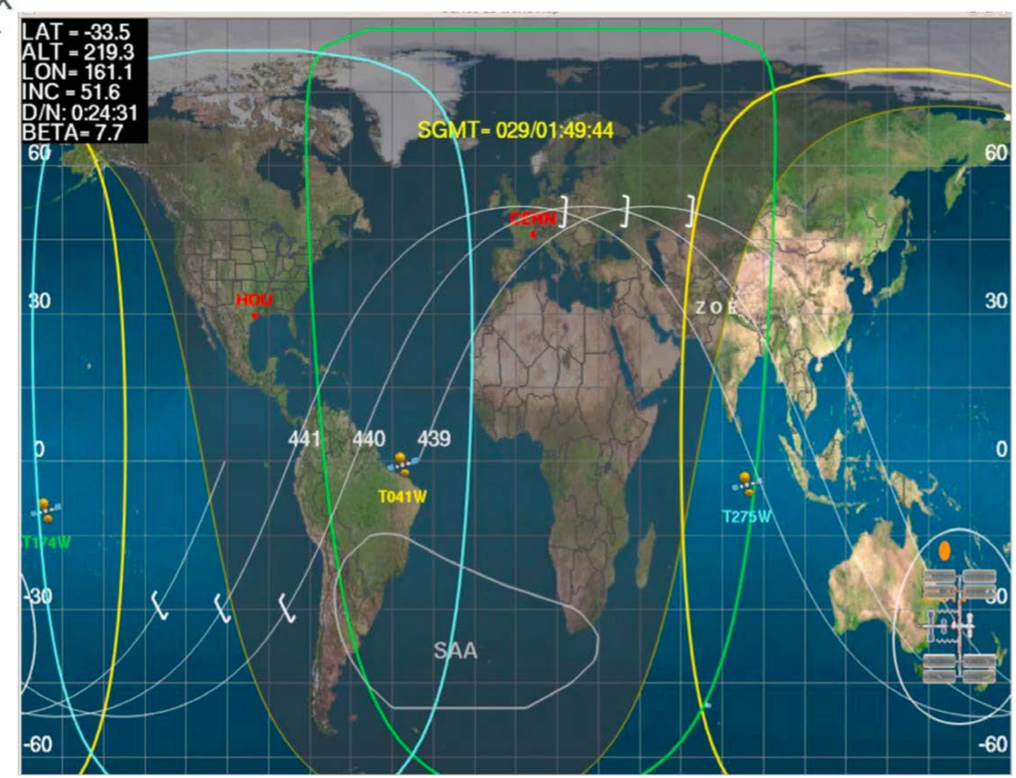
International Space Station orbit



ISS Size: 108.5m x 72.8m
(larger than a soccer field)

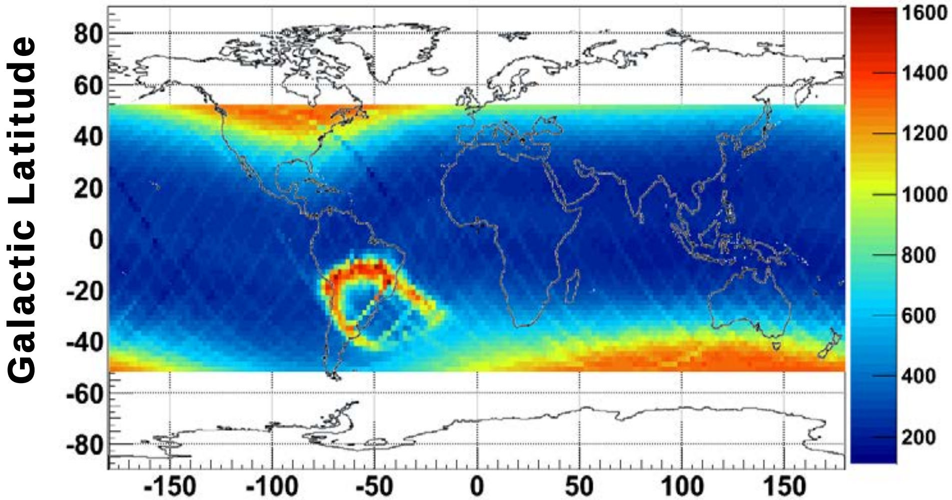
ISS weight: 450 tons
(equivalent to 450 small Passenger cars)

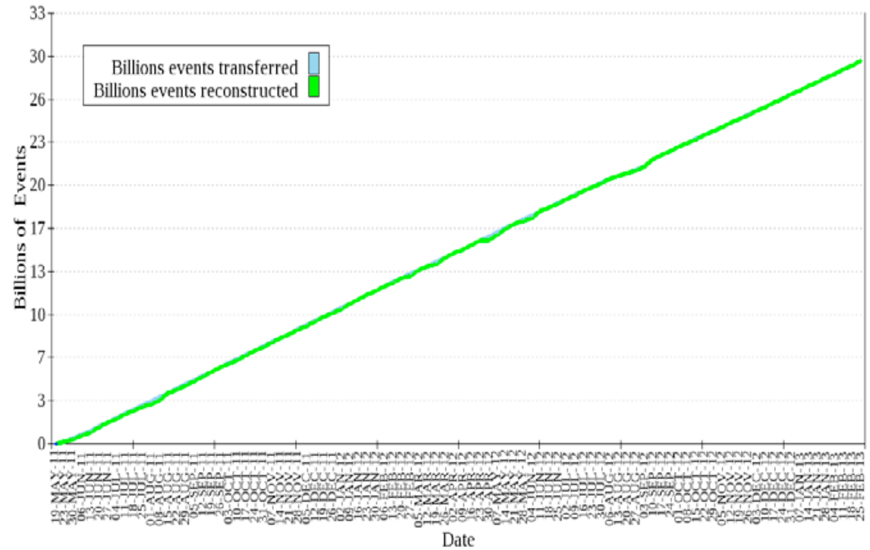
ISS velocity: 8km/s 4, one orbit every 90 mn
Tokyo-Kyoto in less than 1 minute



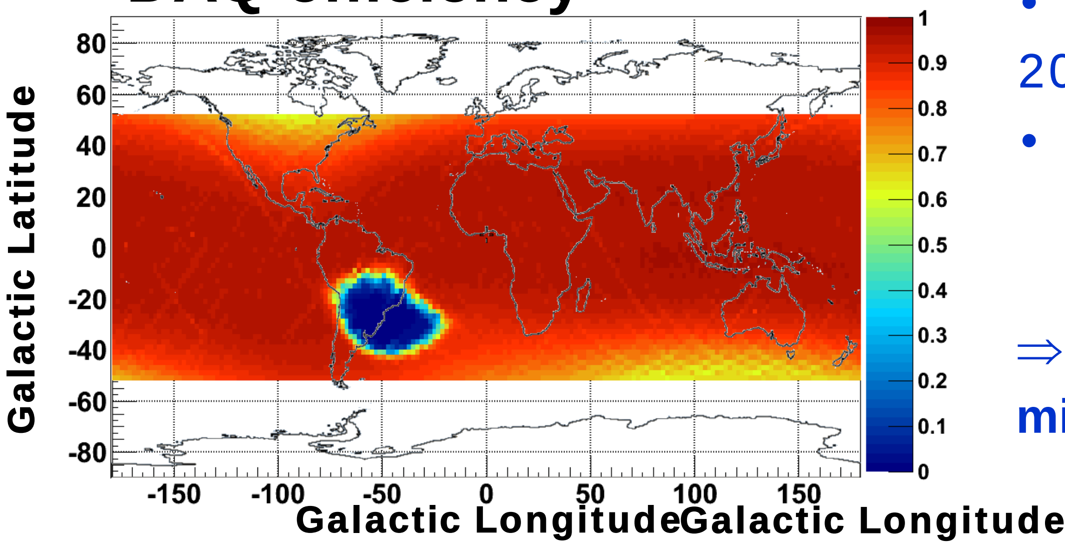
Orbital DAQ parameters

Acquisition rate [Hz]





DAQ efficiency



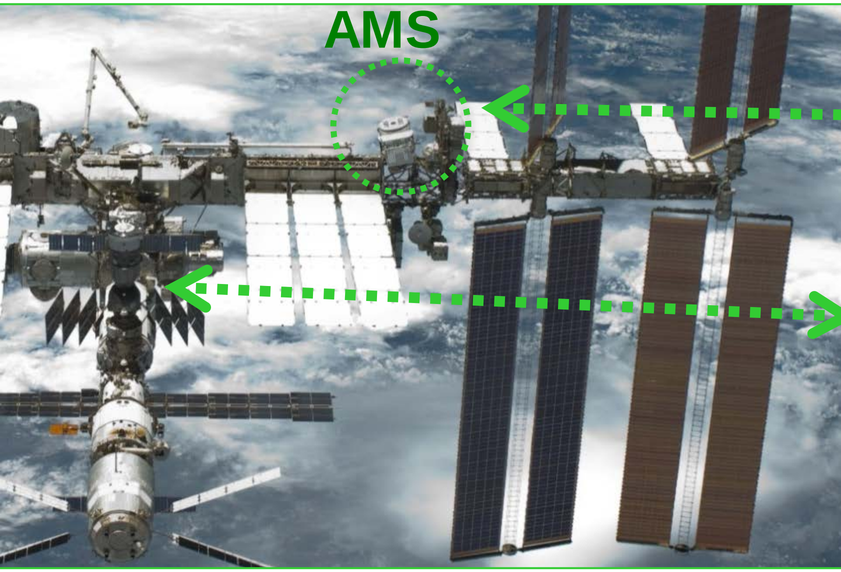
- Particle rates vary from 200 to 2000 Hz per orbit
- On average:

  DAQ efficiency 85%

  DAQ rate ~700Hz

⇒ <~ 30 billions of events up to mid of March

AMS Data Flow



Ku-Band

High Rate (down):

Events <10Mbit/s>

Astronaut at ISS AMS Laptop

S-Band

Low Rate (up & down):

Commanding: 1 Kbit/s

Monitoring: 30 Kbit/s

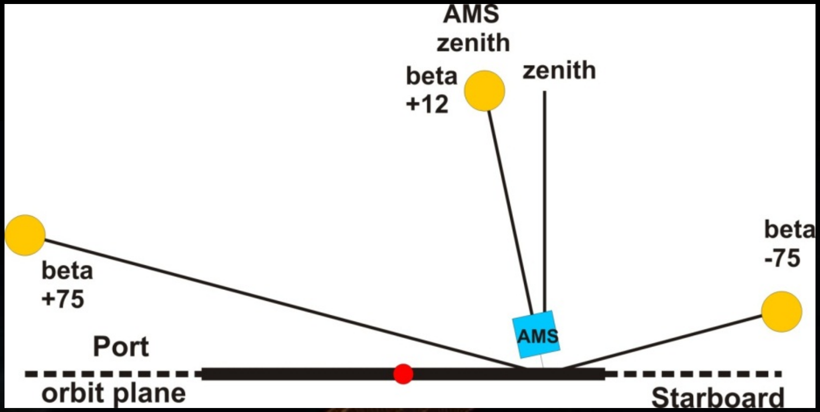
AMS Payload Operations Control and Science Operations Centers (POCC, SOC) at CERN

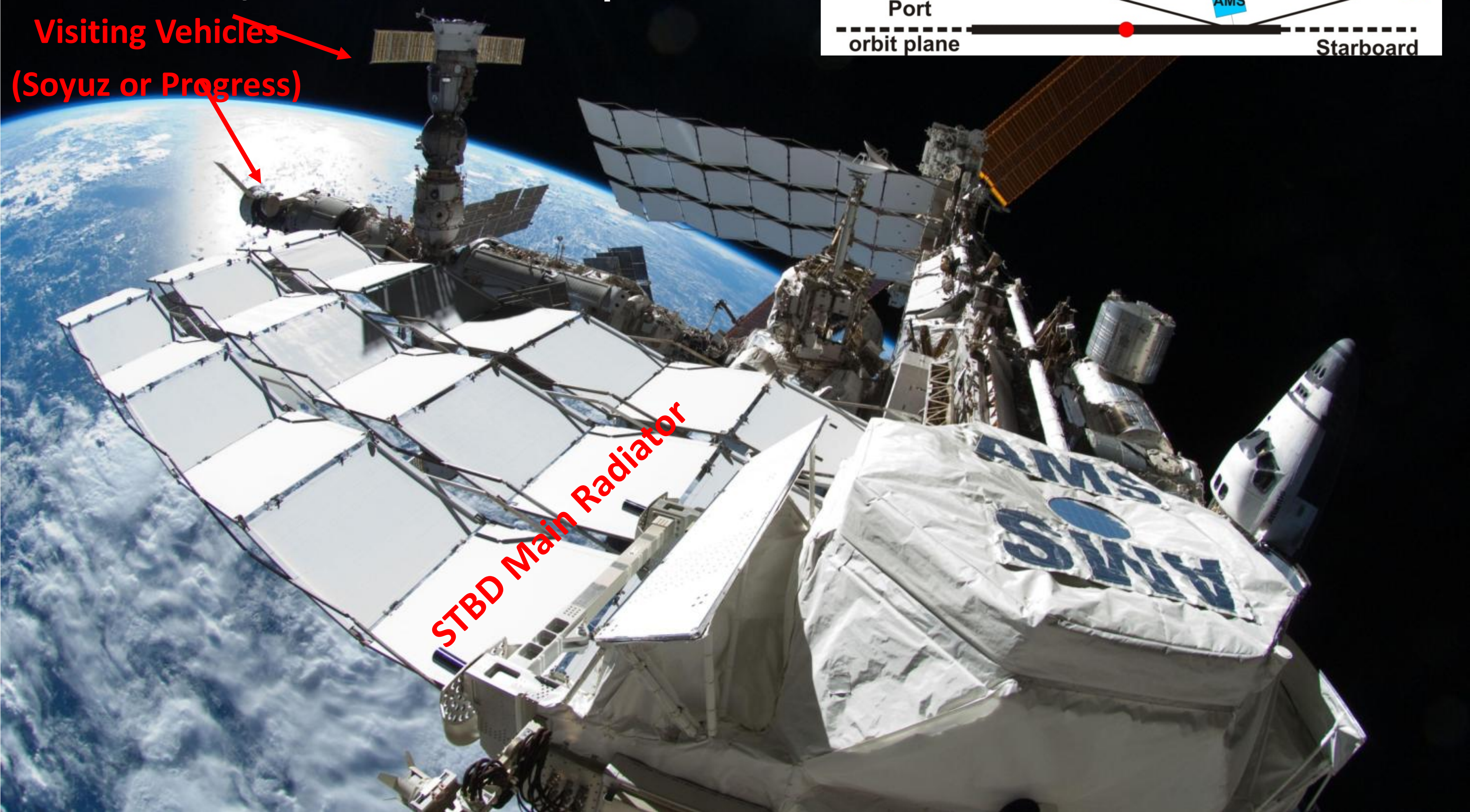
AMS Computers at MSFC, AL

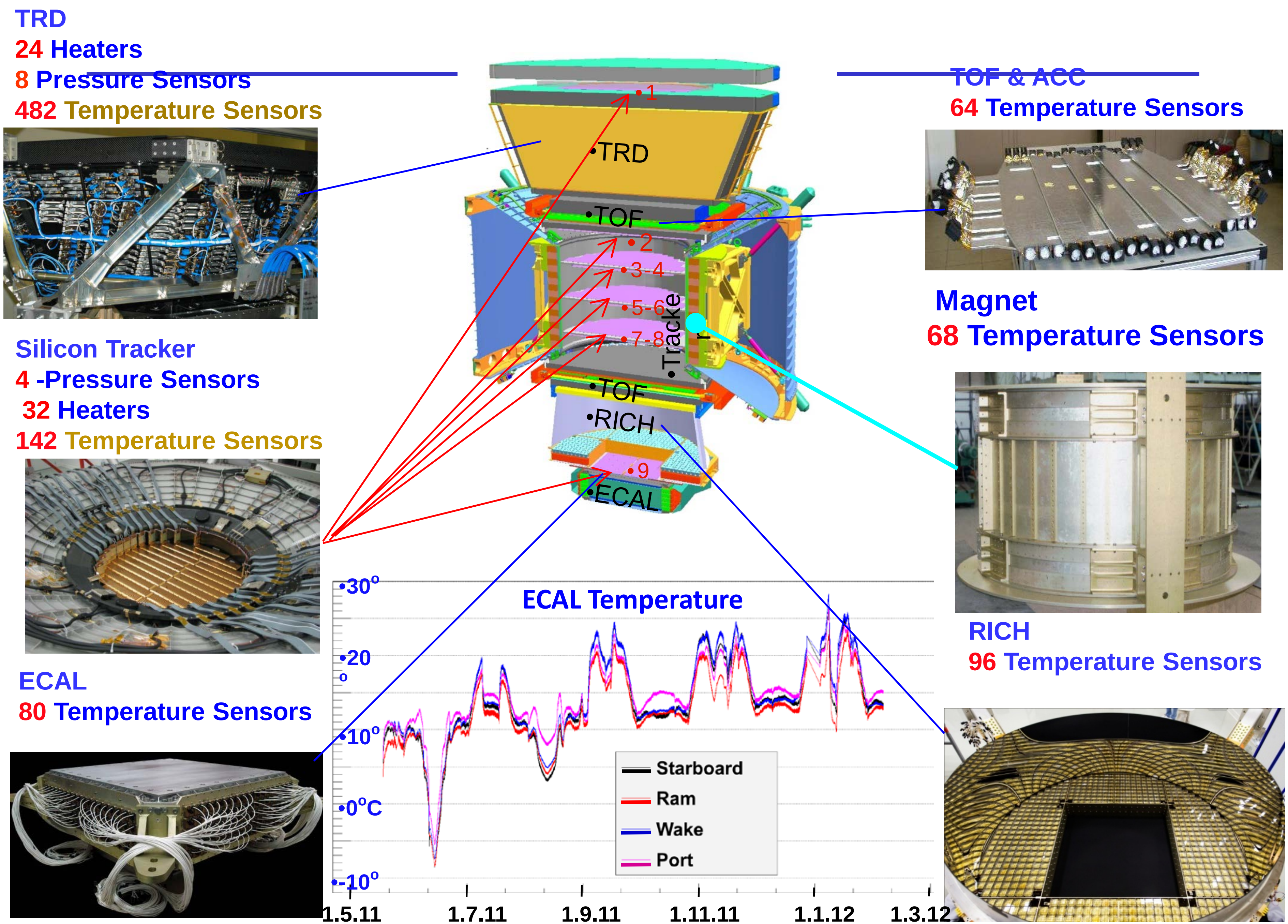
White Sands Ground Terminal, NM

Thermal Issues:

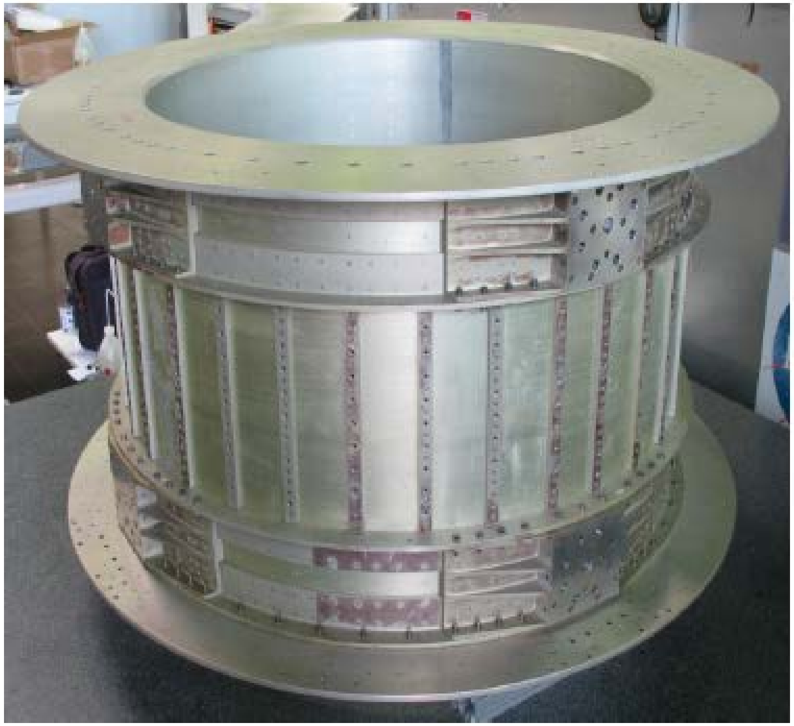
- Sun position: along the orbit + seasonal variation
- ISS attitude changes (primarily for visiting vehicles)
- Solar Array and ISS radiator psoitions

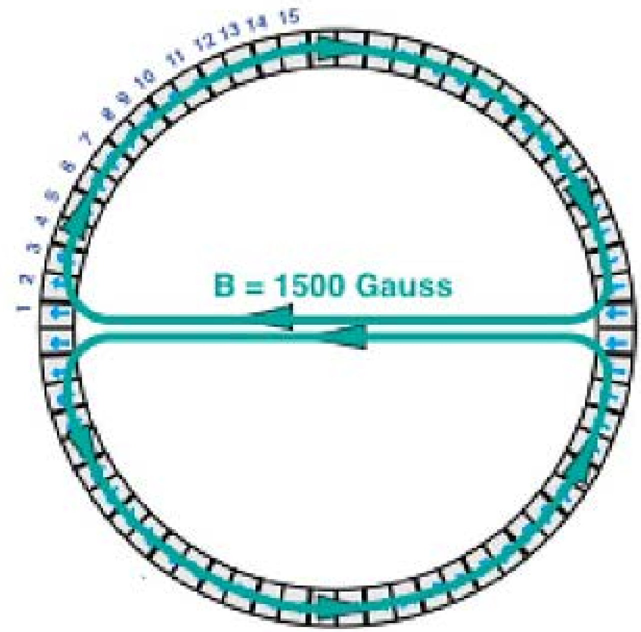





TRD
24 Heaters
8 Pressure Sensors
482 Temperature Sensors
TOF & ACC
64 Temperature Sensors
Magnet
68 Temperature Sensors
Silicon Tracker
4 -Pressure Sensors
32 Heaters
142 Temperature Sensors
ECAL
80 Temperature Sensors
RICH
96 Temperature Sensors
•TRD
•TOF
•Tracker
•TOF
•RICH
•ECAL
•1
•2
•3-4
•5-6
•7-8
•9
ECAL Temperature
•30°
•20°
•10°
•0°C
•-10°
Starboard
Ram
Wake
Port
1.5.11
1.7.11
1.9.11
1.11.11
1.1.12
1.3.12

The Magnet





1. Stable: no torque
2. Safety : no field leak out of the magnet
3 . Low weight: no iron

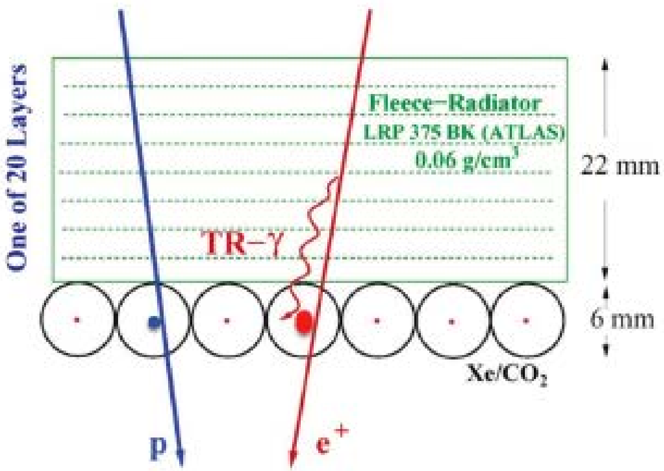
The detailed 3D field map (120k locations) was measured in May 2010

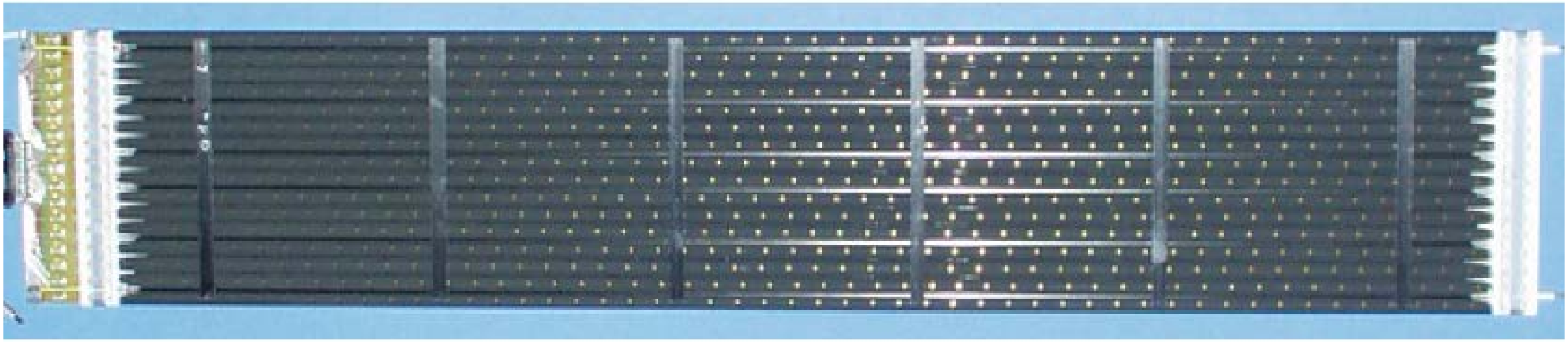
It was found that the deviation from the 1997 measurement had remained the same to <1%

Transition Radiation Detector (TRD) Identifies Positrons, Electrons by transition radiation and Nuclei by dE/dX

20 Layers each consisting of:

- **22 mm fibre fleece**
- **Ø 6 mm straw tubes filled with Xe/CO_2 80%/20%**



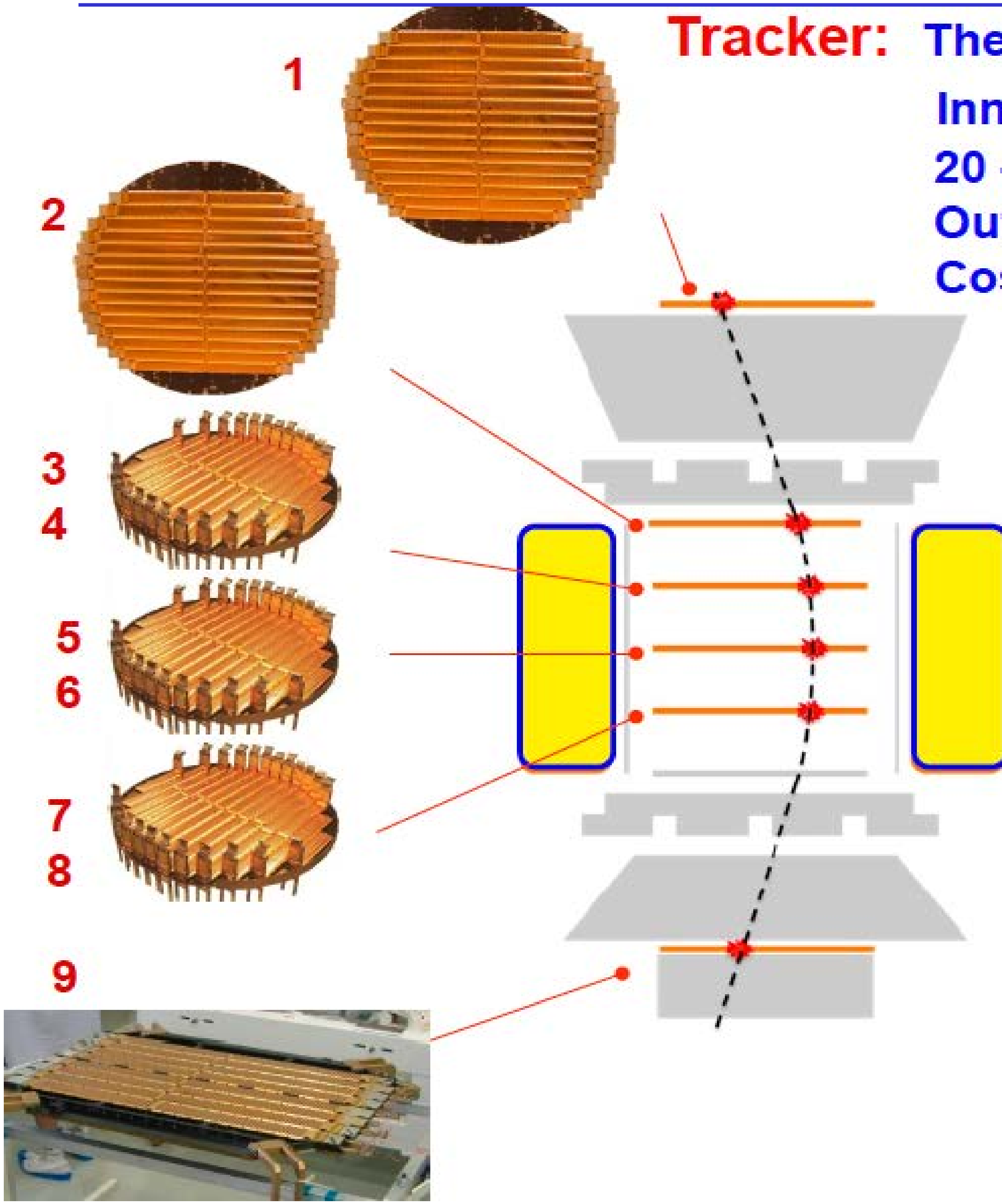


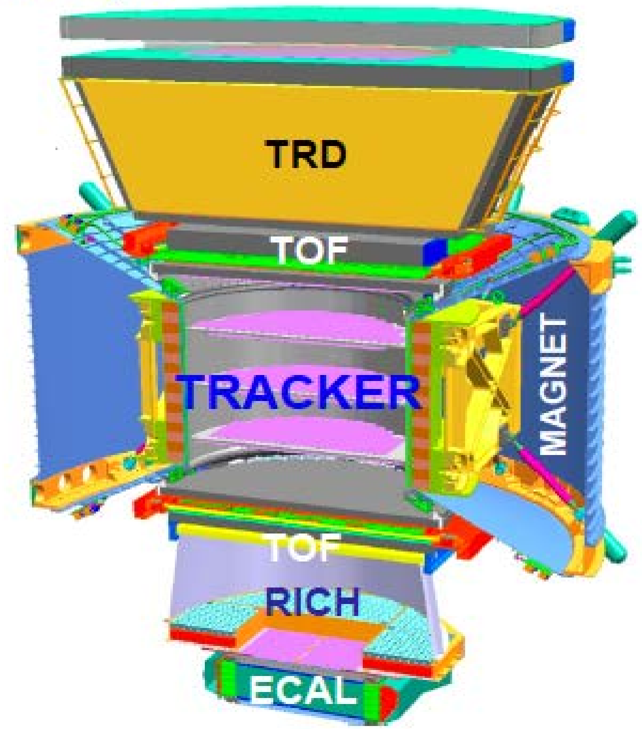
5,248 tubes selected from 9,000, 2 m length centered to 100μm, verified by CAT scanner

AMS Tracker

Tracker: The coordinate resolution is 10 μ

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





AMS Tracker on ISS

The alignment stability (3 microns) of the external Tracker planes

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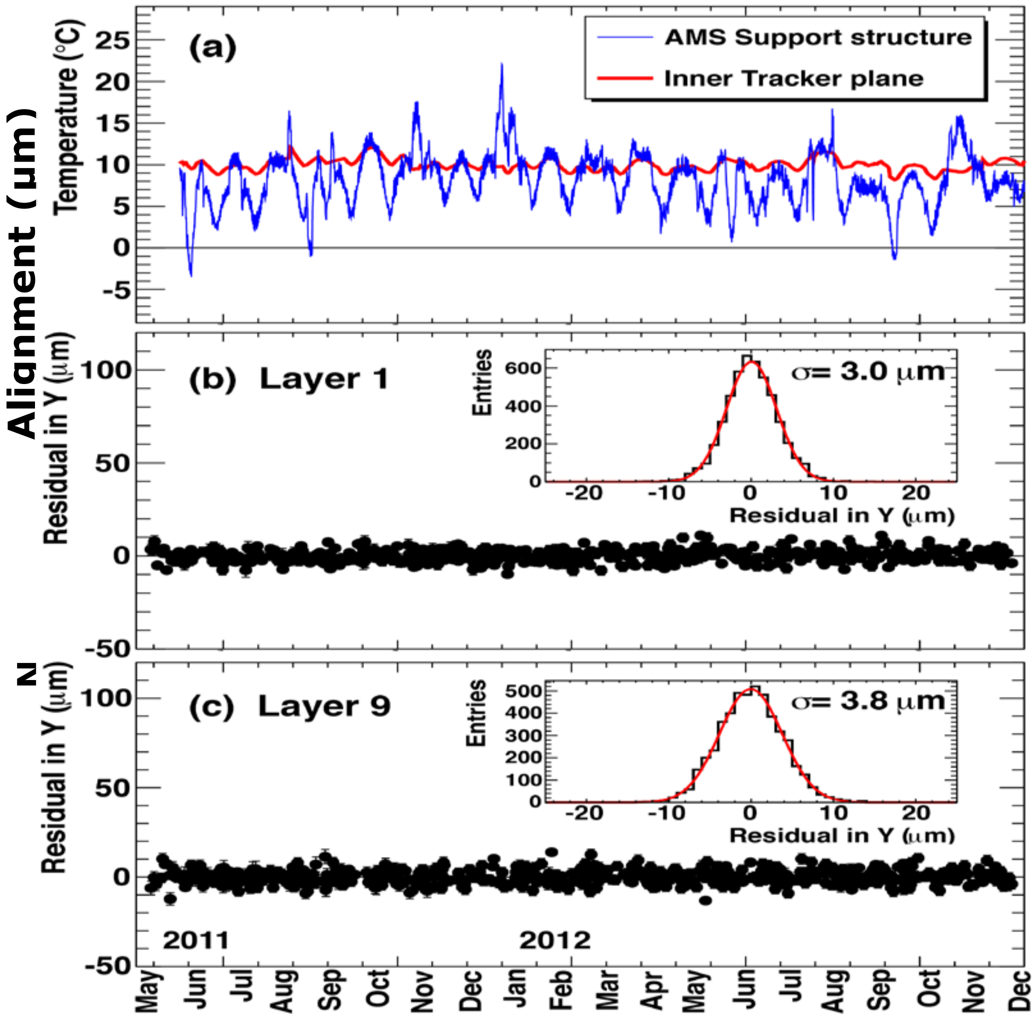
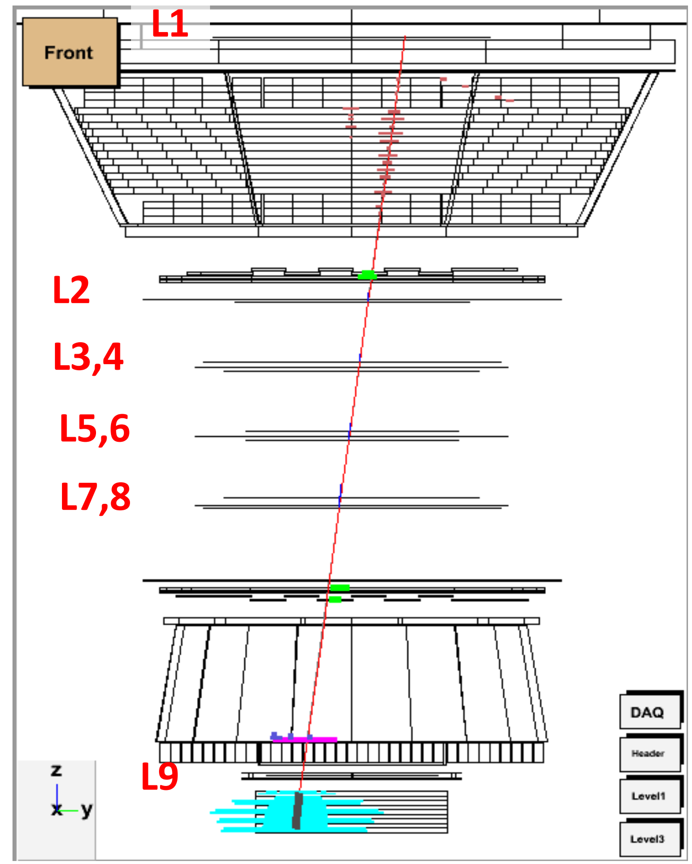
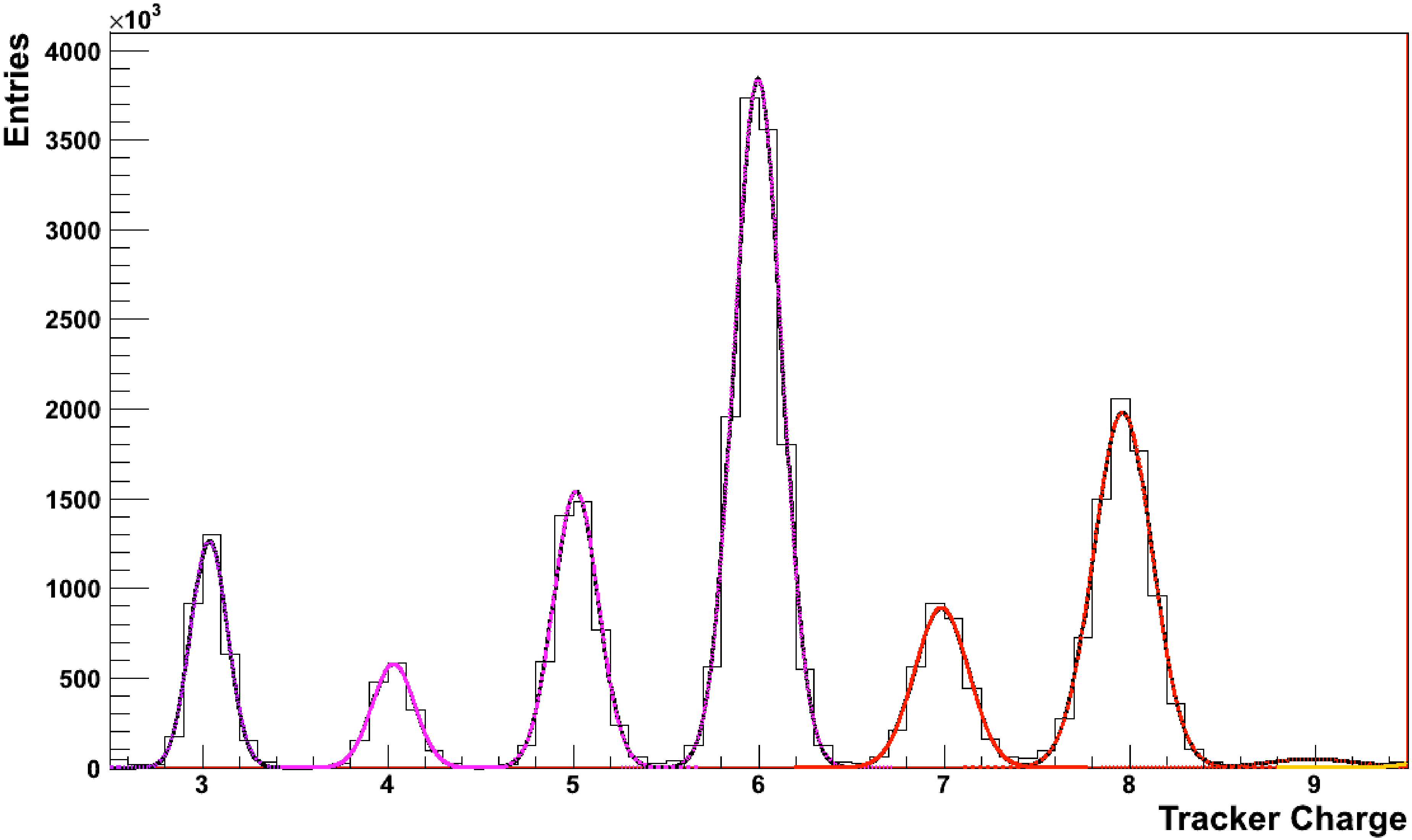




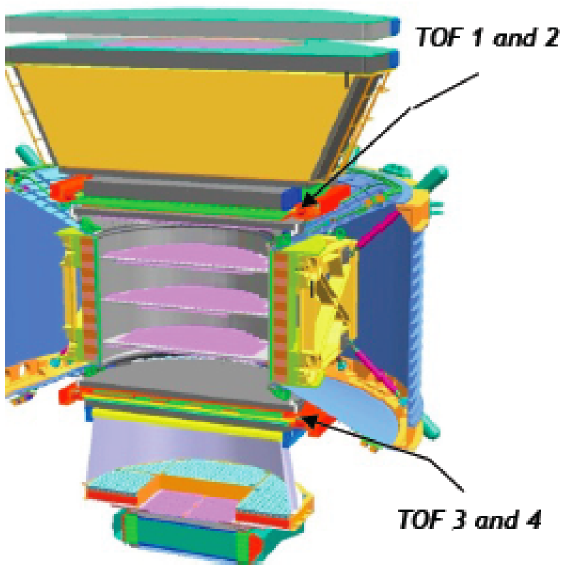
Alignment stability 3-4 (μm)

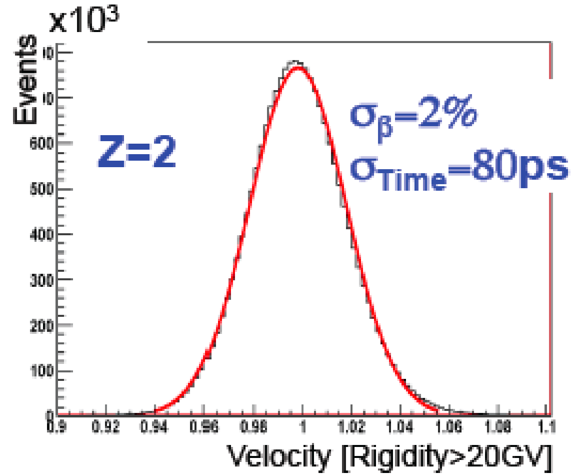
Tracker Charge

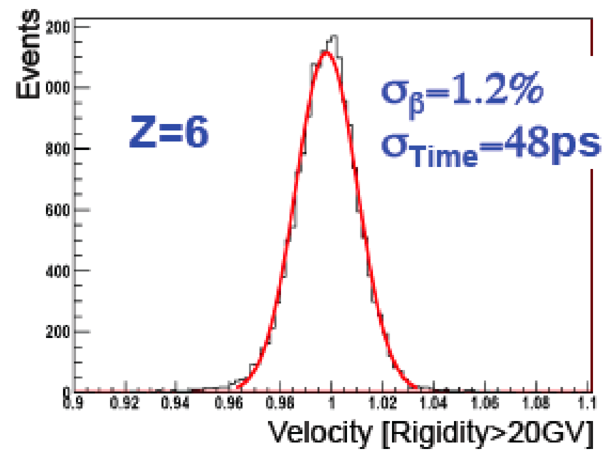


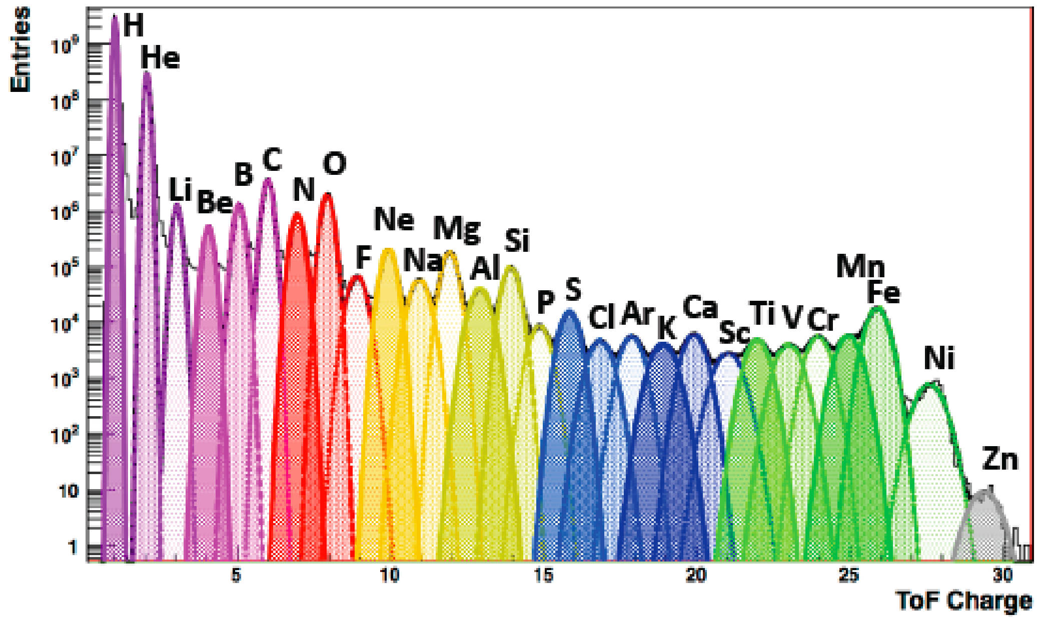
Time of Flight in Space

Measures Velocity and Charge of particles



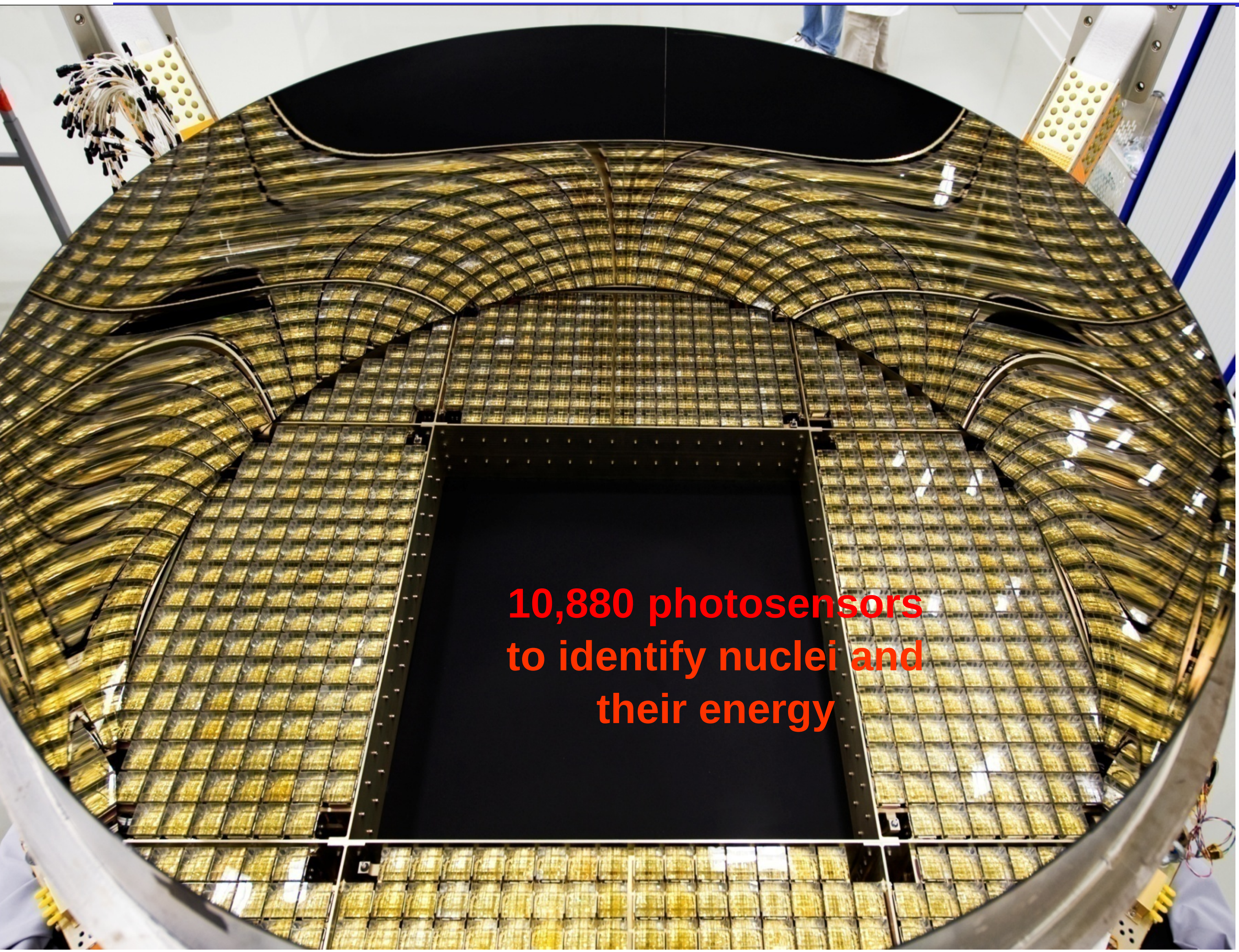




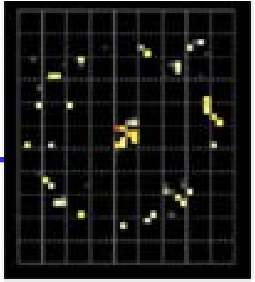


Rich

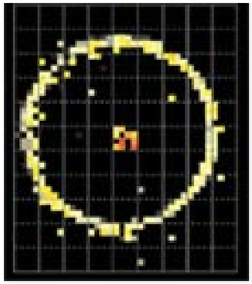
160 Gv



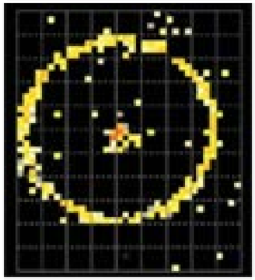
He



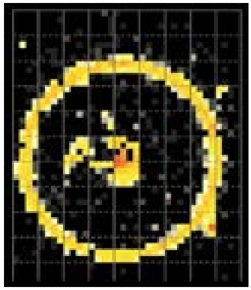
Li



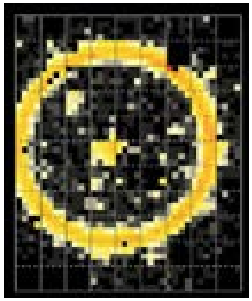
C



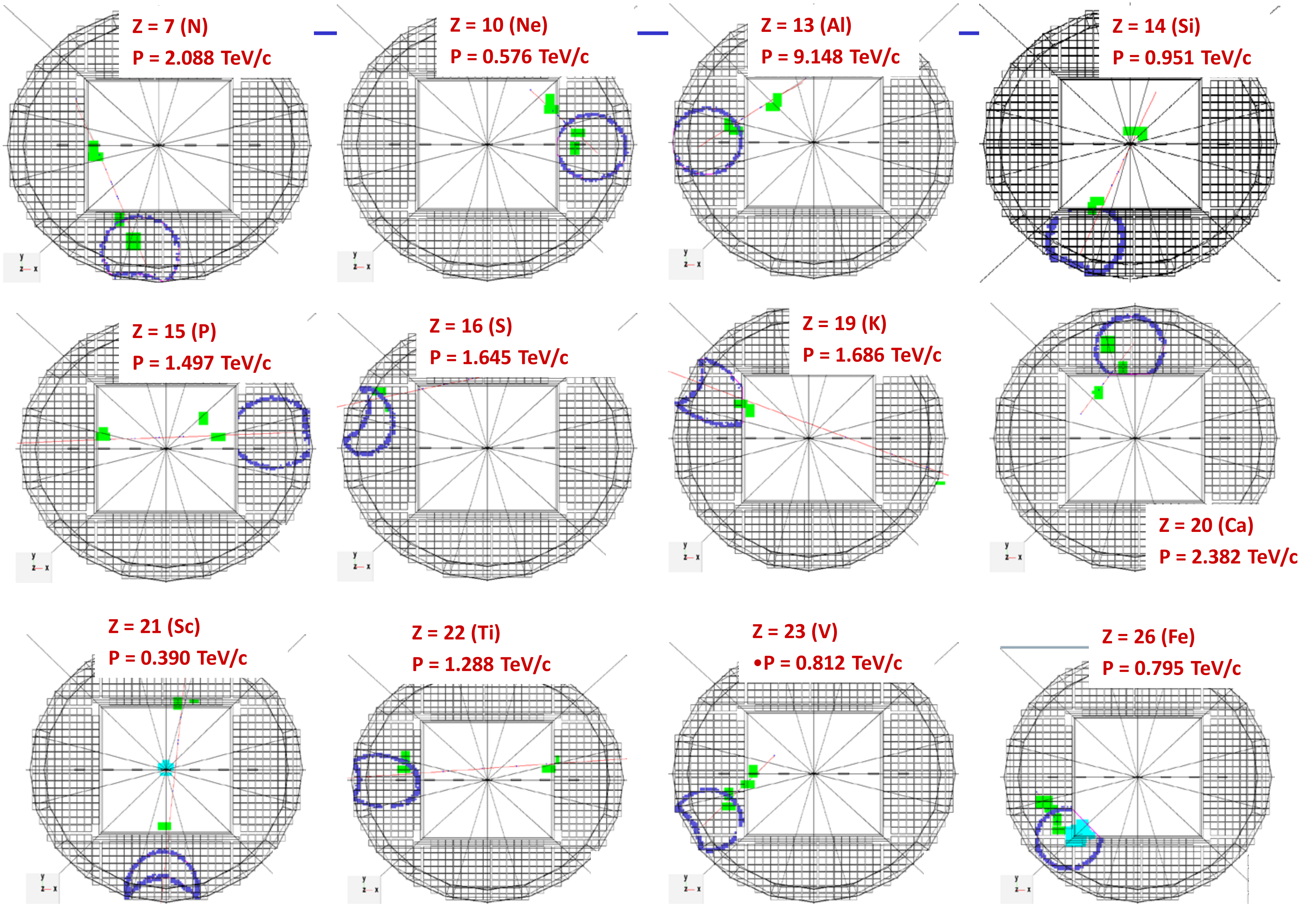
O



Ca



Data from ISS   Nuclei in the TeV range



Ecal: Physics Requirements for AMS02

The Ecal is required:

- To provide a separation factor e/p **10^{3}-10^{4}**

  – λ_I (Interaction length) / X_0 (radiation length) ~ 22

  -3D imaging electromagnetic shower reconstruction with a high granularity in the longitudinal and lateral views.

- to measure the energy for electrons, positrons and photons, with an efficiency ≥ 90%, up to ~ **1 TeV**

  -nX_0 ~ 17 is needed

- To trigger on non converted photons

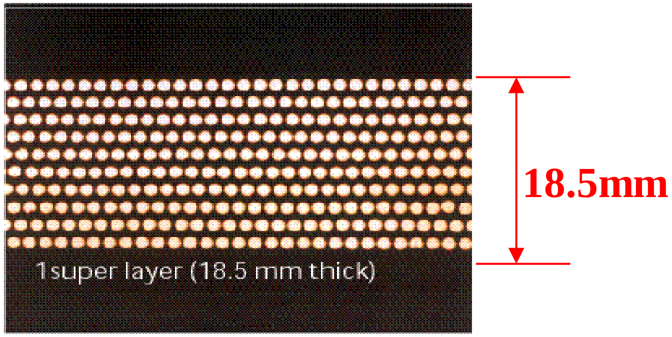
The calorimeter has been designed, realized and tested by the

INFN-Pisa (Italy), IHEP Beijing (China) and the LAPP-IN2P3 (France) groups

ECAL : Description

A 3-D sampling calorimeter made of lead foils and scintillating fibers

One Super Layer

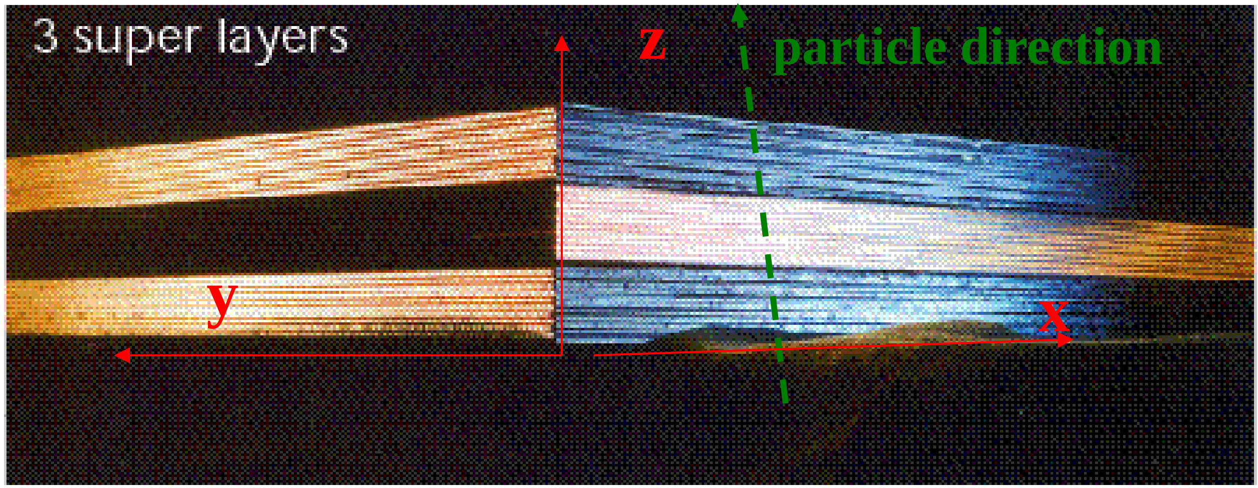


- Lead (58%), Scintillating fibers (33%), Optical glue (9%), Density ~ 6.8 g/cm3
- Dimensions 648x648x167 mm
- 9 super layers : 4 in The X view and 5 in the Y views
- Weight: 661 kg ("pancake" 512 kg)
- Acceptance : 0.06 $m^2 sr$

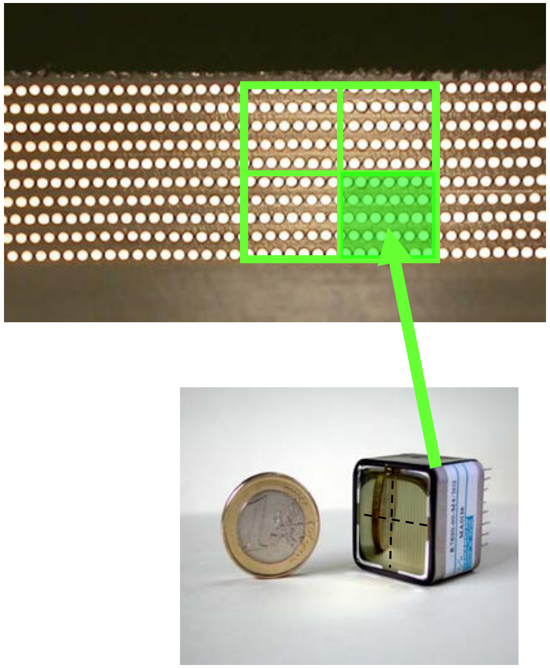
3D Imaging Calorimeter

17 X_0

λ_I / X_0 ~22



Ecal front end and light collection



•Fibers read ,on one side, by 324 4-pixels pmt's (324 PMTs Hamamatzu R7600-00-M4 (4 anodes).

=>**High granularity: ~ 0.9 x 0.9 cm^2**

Readout cells: ~ 1 X0(Z) 0.5 R_M (X,Y)

18 Longitudinal samplings

• From the MIP (10 MeV) ≥ 10*Ped_{RMS} to the TeV

=> **a dynamic range of 60000** implying 2 dynamic ranges for each pixel (ADC 12 bits) and the dynode for redundancy

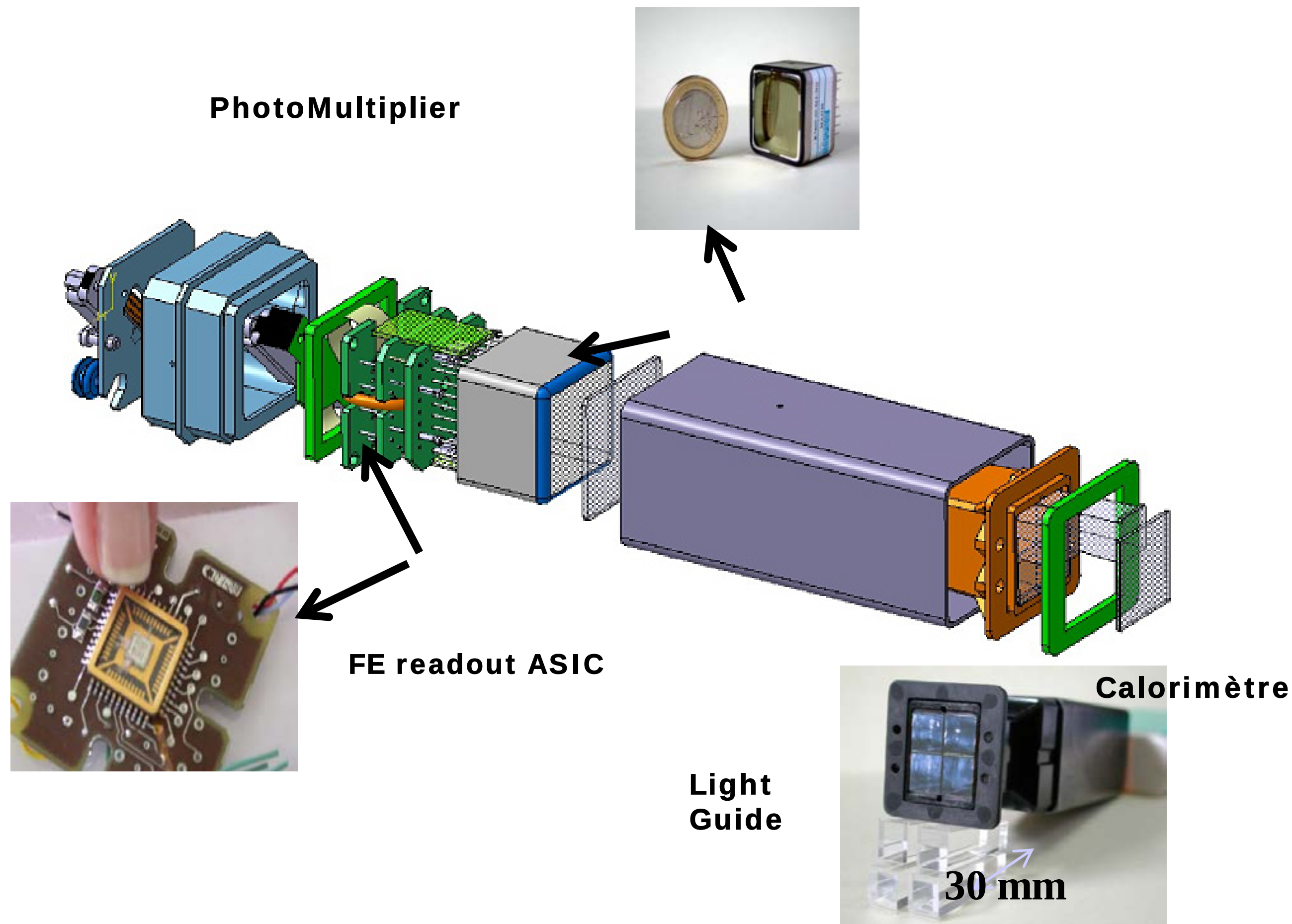
- **High Gain(HG): 0.4 MeV- 1.6 GeV**
- **Low Gain(LG): 150 MeV -55 GeV**

1296 HG, 1296 LG, 324 dynodes

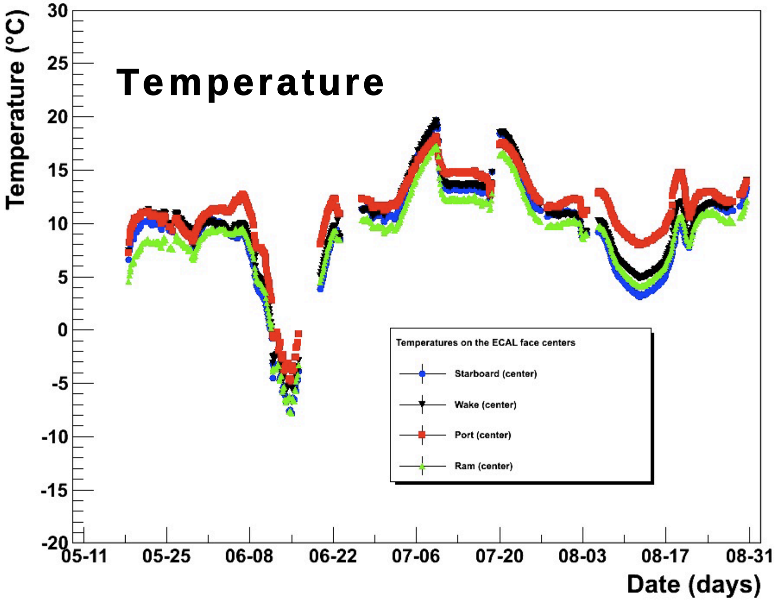
• Stand alone gamma trigger: use of the dynode, amplified by a factor 10, for 6 central super layers. 216 channels

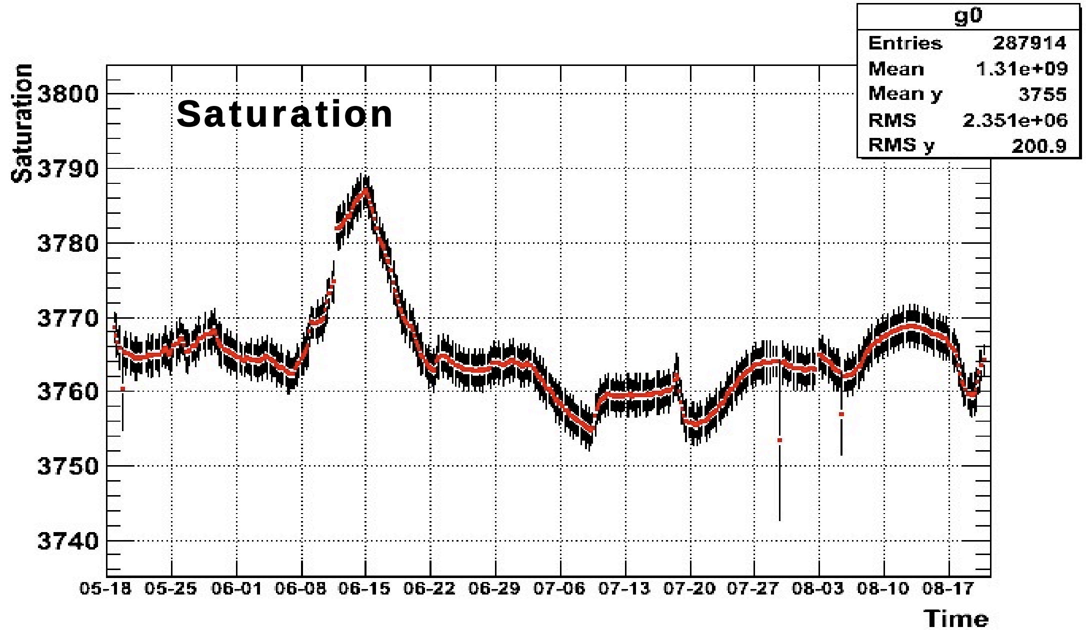
Front End and light collection system

- Robust (fulfill space constraints)
- Compact (70 mm long)
- Light (67 kg)
- Low Power consumption (12W)

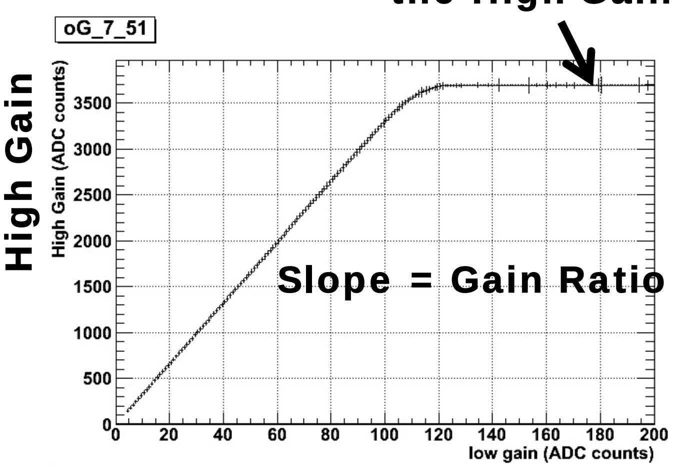


Space Environments: temperature issues

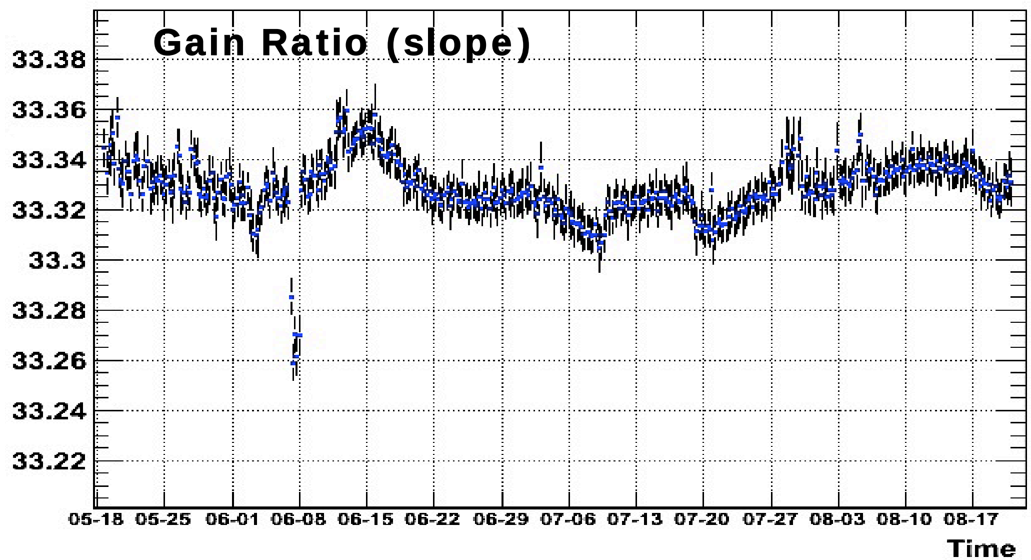




Saturation on the High Gain

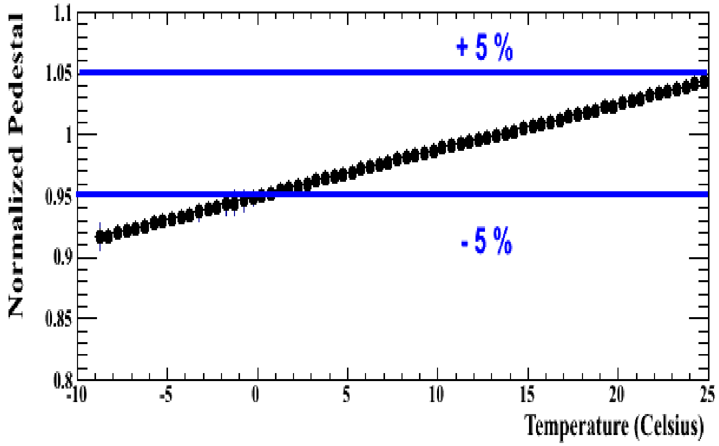


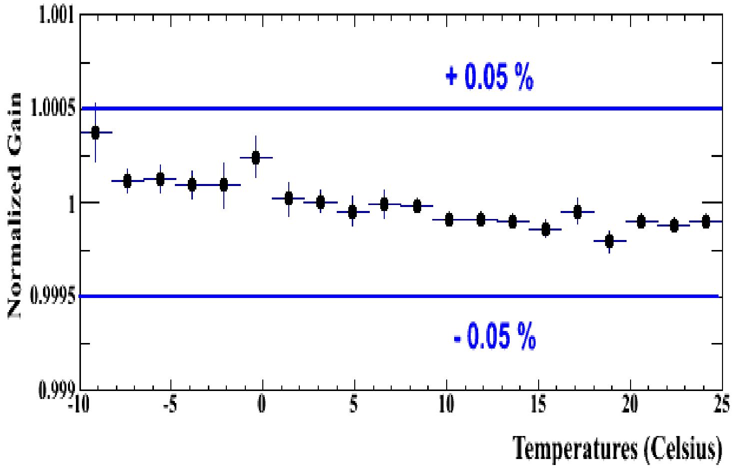
Low Gain



Space Environments: temperature issues

Front end performance: pedestal, gain ratio and saturation





$$\Delta\mathrm{Ped/Ped} = +5\,10^{-3} \text{ per } {}^{0}\mathrm{C}$$

$$\Delta\mathrm{Gain/Gain} = -3 \times 10^{-5} \text{ per } {}^{0}\mathrm{C}$$

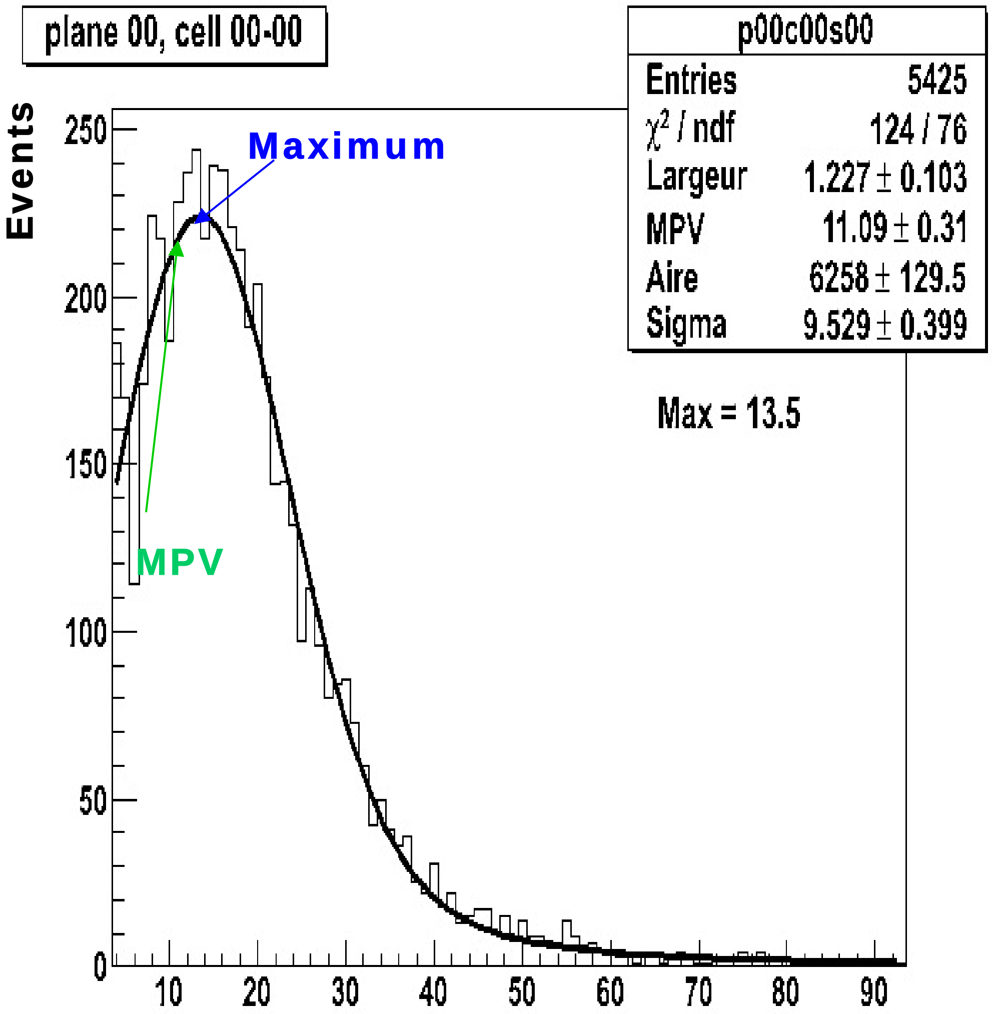
$$\Delta\mathrm{Sat/Sat} = -6 \times 10^{-4} \text{ per } {}^{0}\mathrm{C}$$

Precisely Monitored.

In very good agreement with previous measurements on ground

Calibration in Space : Minimum ionizing Particle

- Performed on the 1296 pixels
- Using both Hydrogen and Helium nuclei
- a fit of a landau convoluted to a Gaussian is performed to measure the Most Probable Value or the Maximum
- The detector response is then equalized accordingly (one HV supply for 4 pixels)



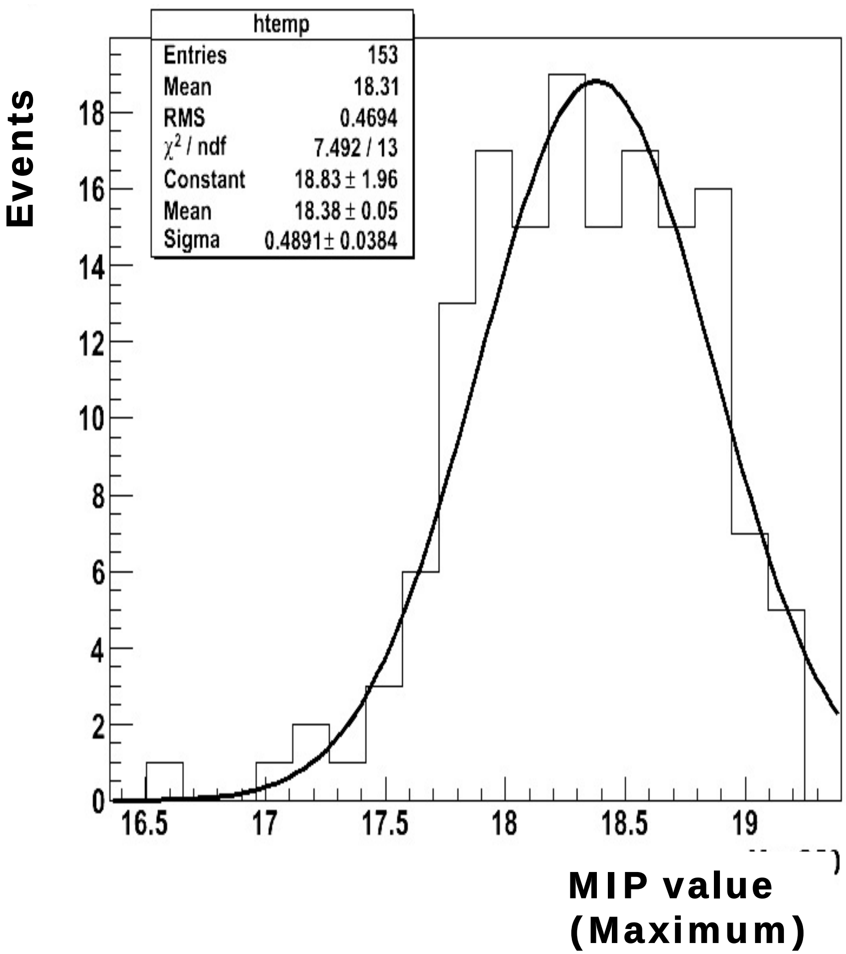
Stability of the MIP signal - ISS data

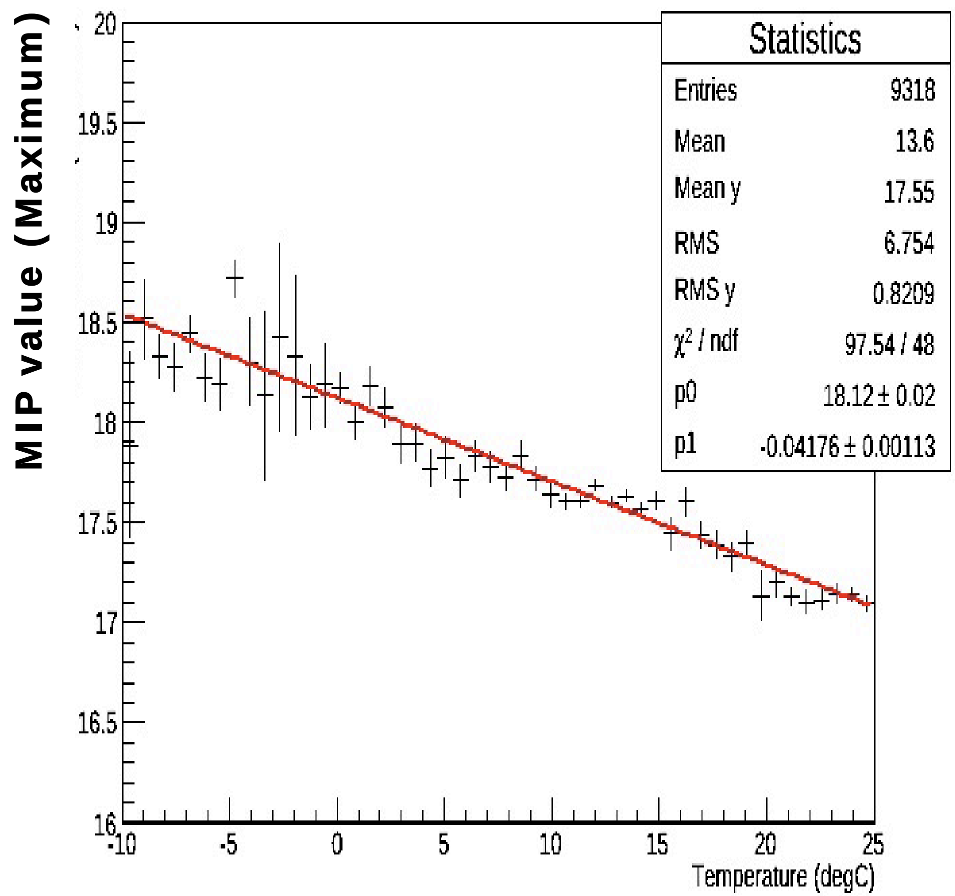
150 days, for one cell,

Relative spread of 3%

Anti-correlated with temperature

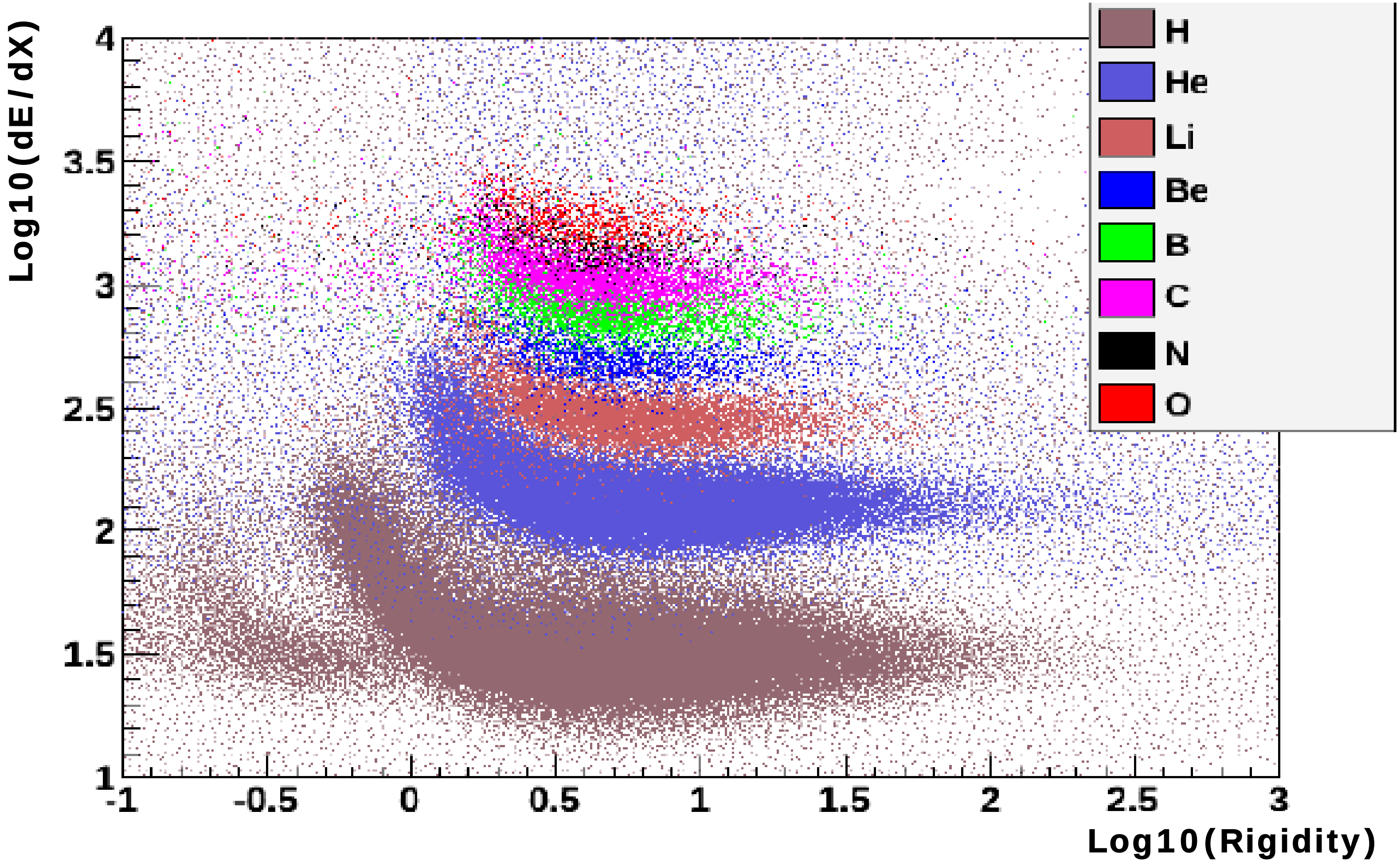
ΔMIP/MIP = -2.5×10^{-3} per ^{0}C



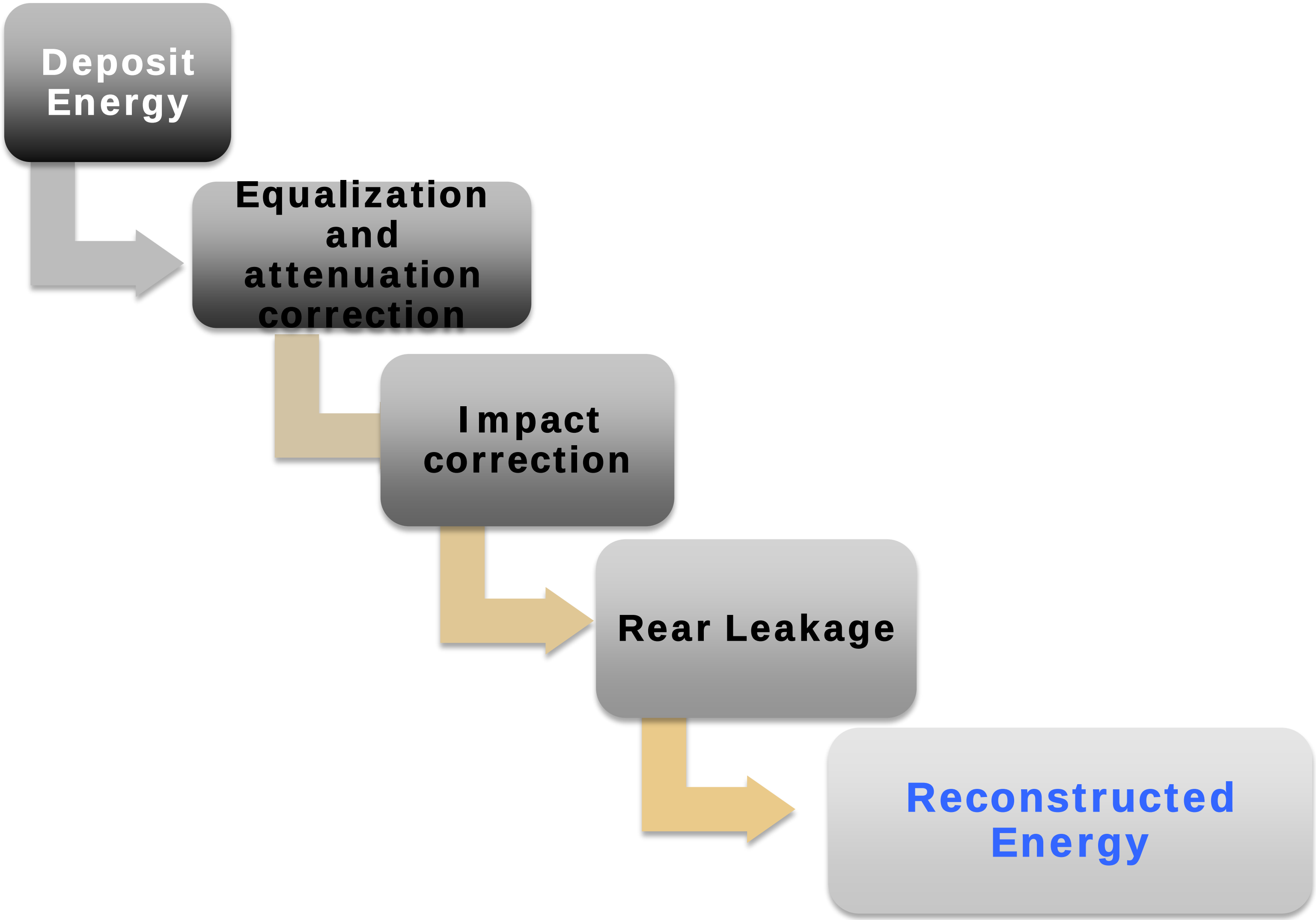


dE/dX measurements with ISS data

- Selecting Nuclei using the Charge measurements in the tracker and the ToF, and the Rigidity of the tracker
- Include in the dE/dX measurement only layers at the MIP

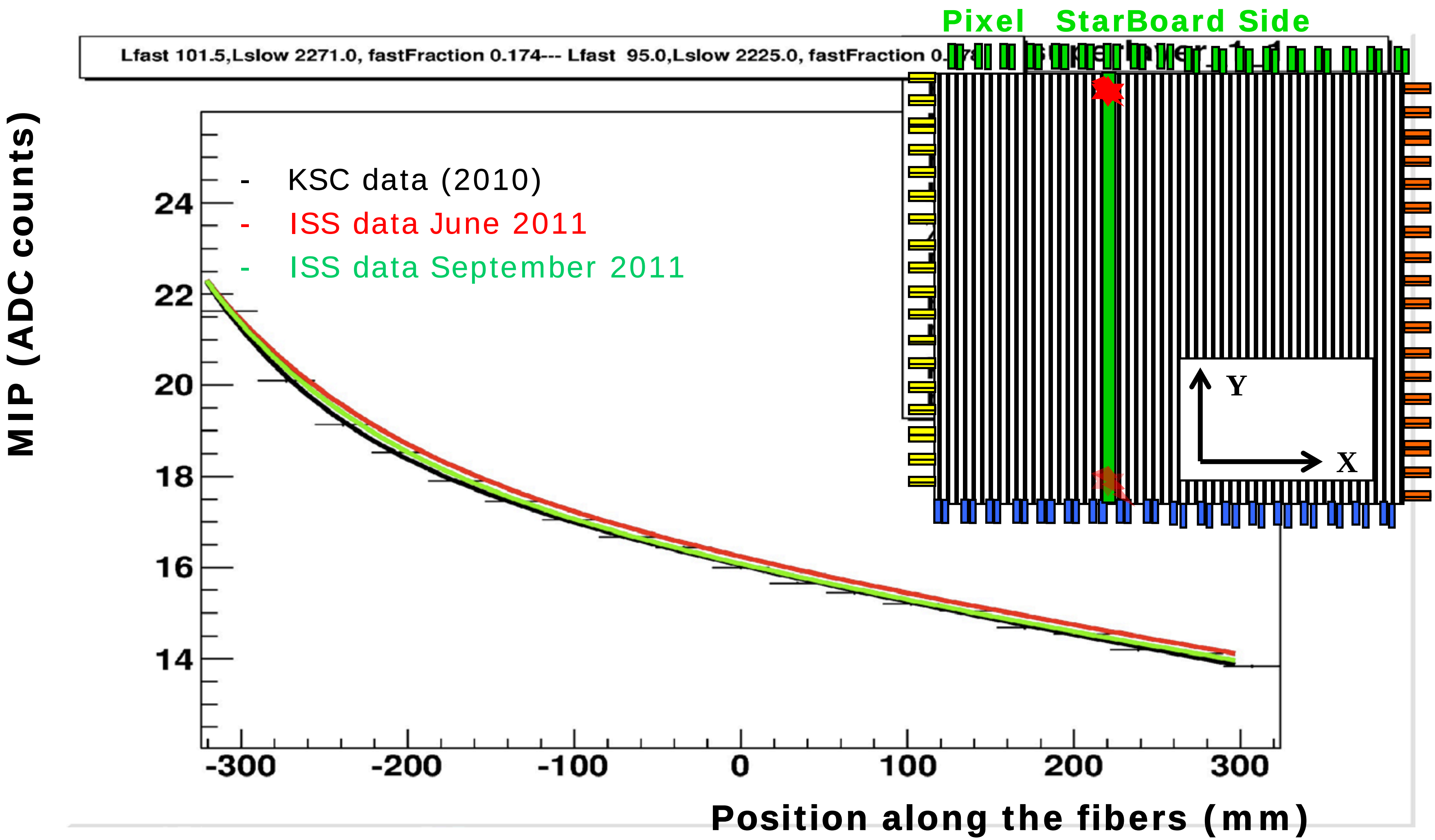


Energy Measurement



Light attenuation Correction – KSC and ISS data

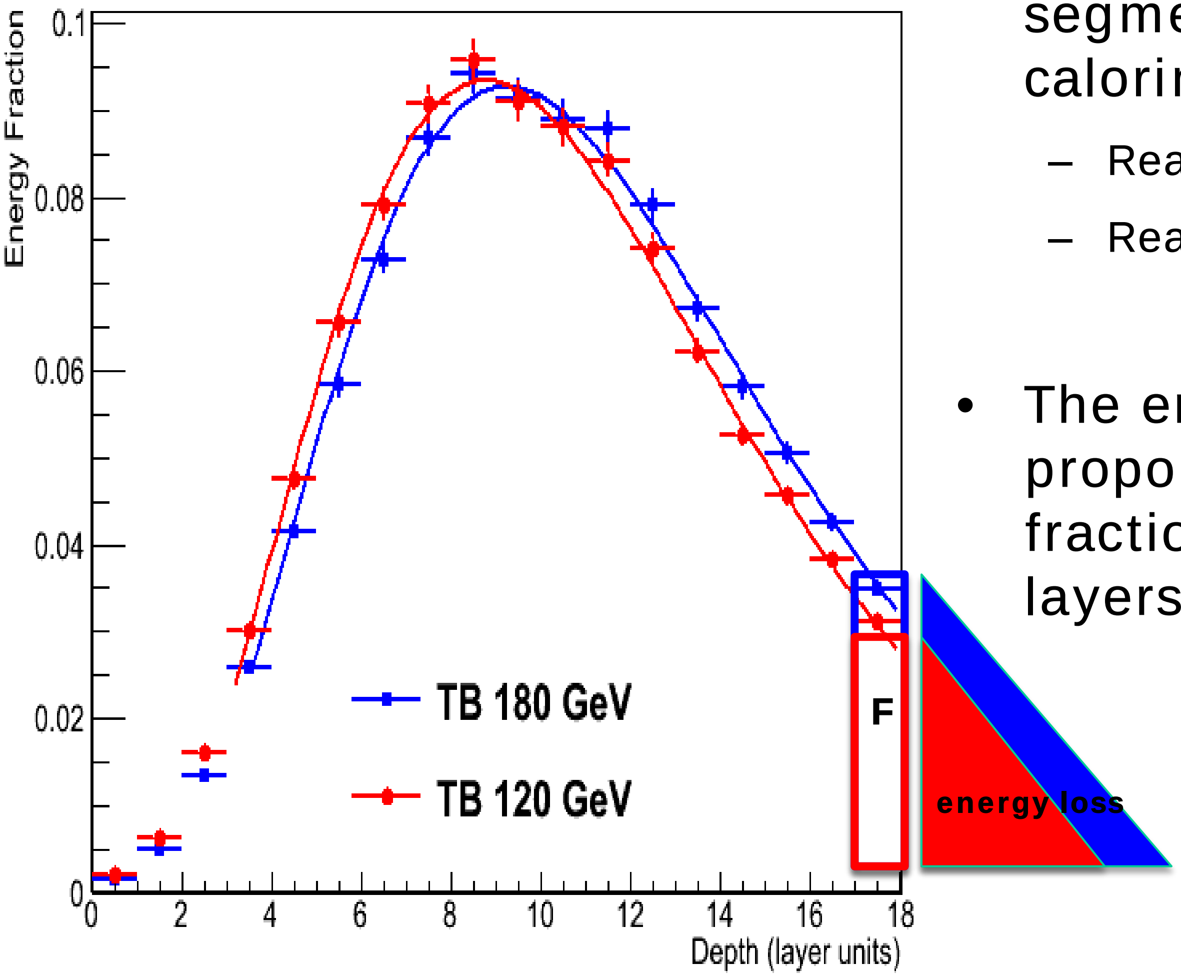
Stable within 1% between Ground and Space data



3 parameters (f, λ_{fast} and λ_{slow}) have been measured for the 18 layers

Rear Leakage Correction - Principle

Test beam Data (Aug 2010)



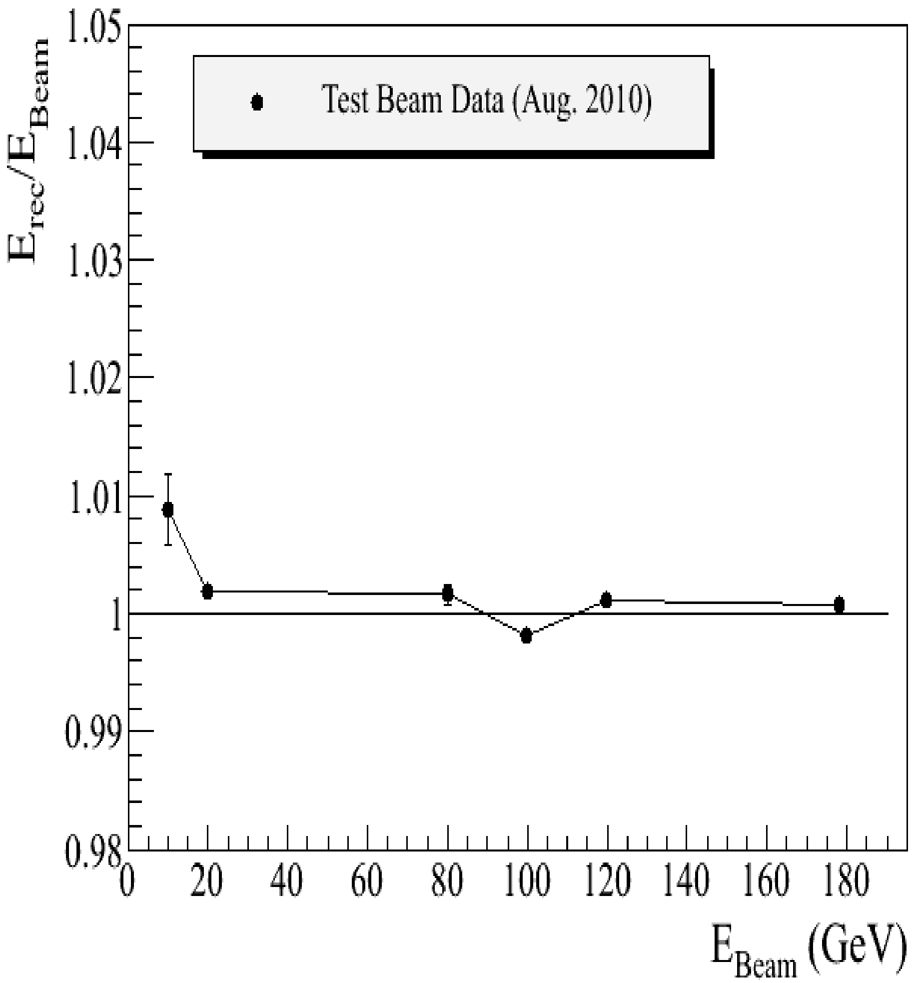
- Using the longitudinal segmentation of the calorimeter, with 17 X0
  - Rear leakage~7 % @ 100 GeV
  - Rear leakage ~ 16 % @ 1000 GeV

- The energy loss (triangle) is proportional to the energy fraction deposited in the 2 last layers : F

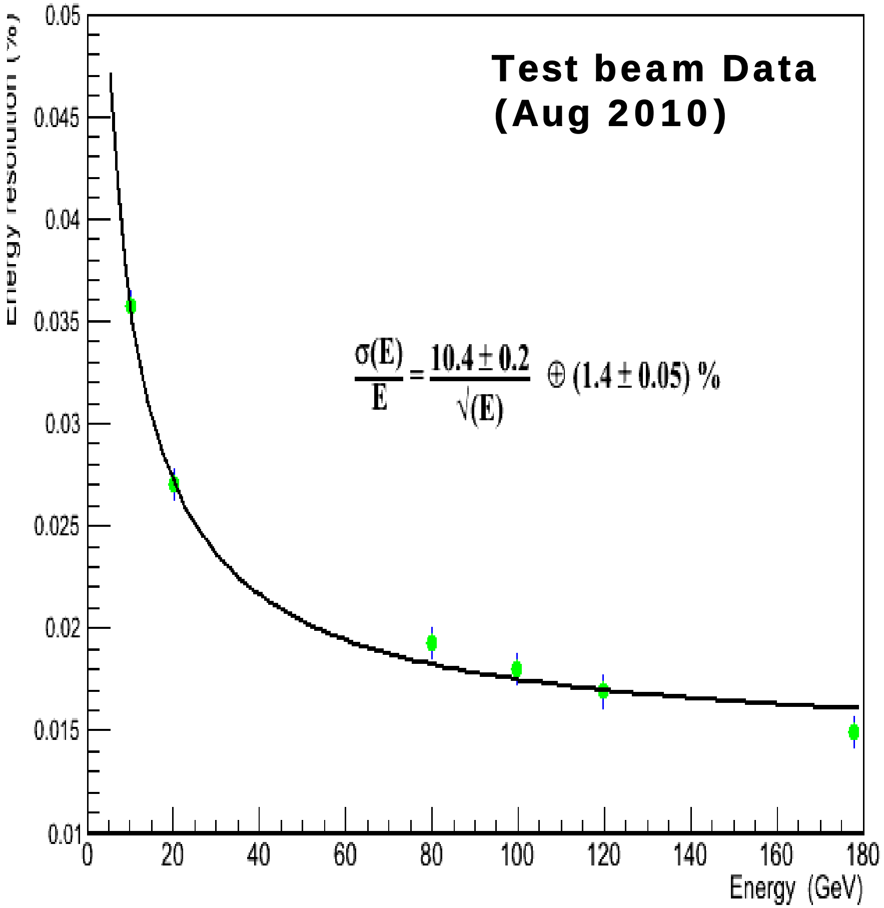
$$F = (E_{16} + E_{17}) / \sum_{l=0}^{l=17} E_l$$

Energy Linearity and Energy resolution

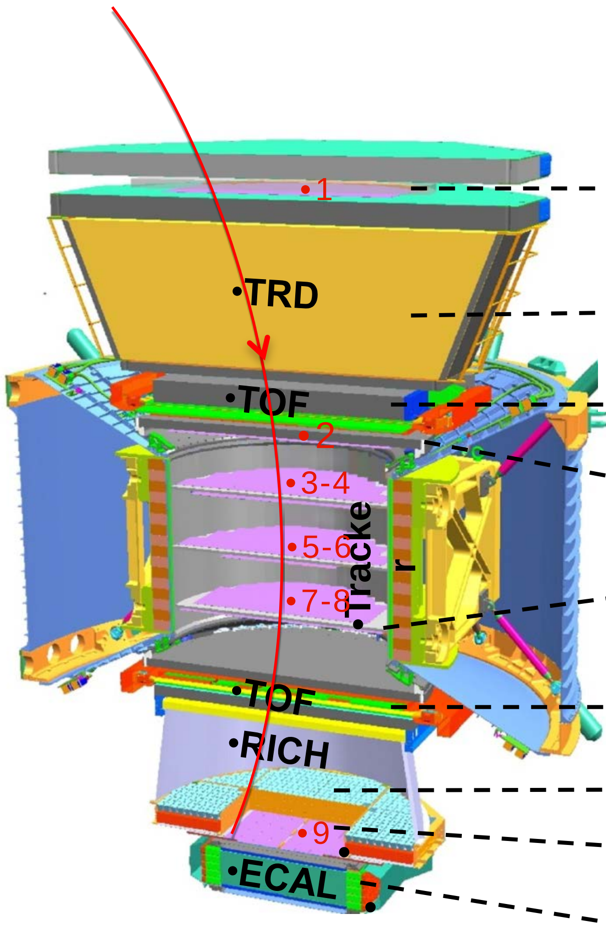
Linearity better than 1%



Energy resolution better than 2 % for Energy>80 GeV



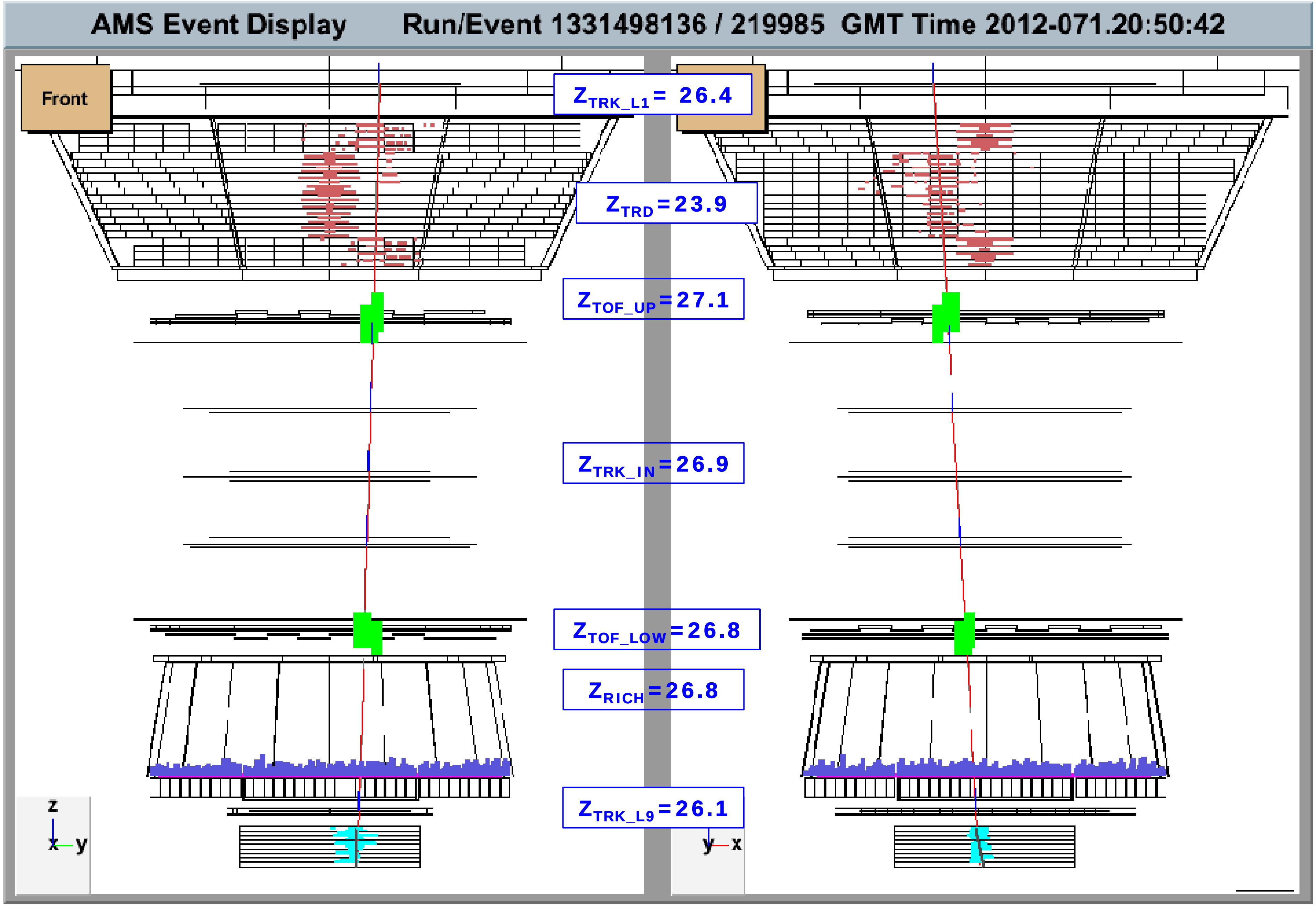
Multiple Independent Measurements of the Charge (|Z|)



	Carbon (Z=6) ΔZ (cu)
1. Tracker Plane 1	0.30
2. TRD	0.33
3. Upper TOF	0.17
4. Tracker Planes 2-8	0.15
5. Lower TOF	0.20
6. RICH	0.32
7. Tracker Plane 9	0.30
8. Ecal MIP>10/18	0.36

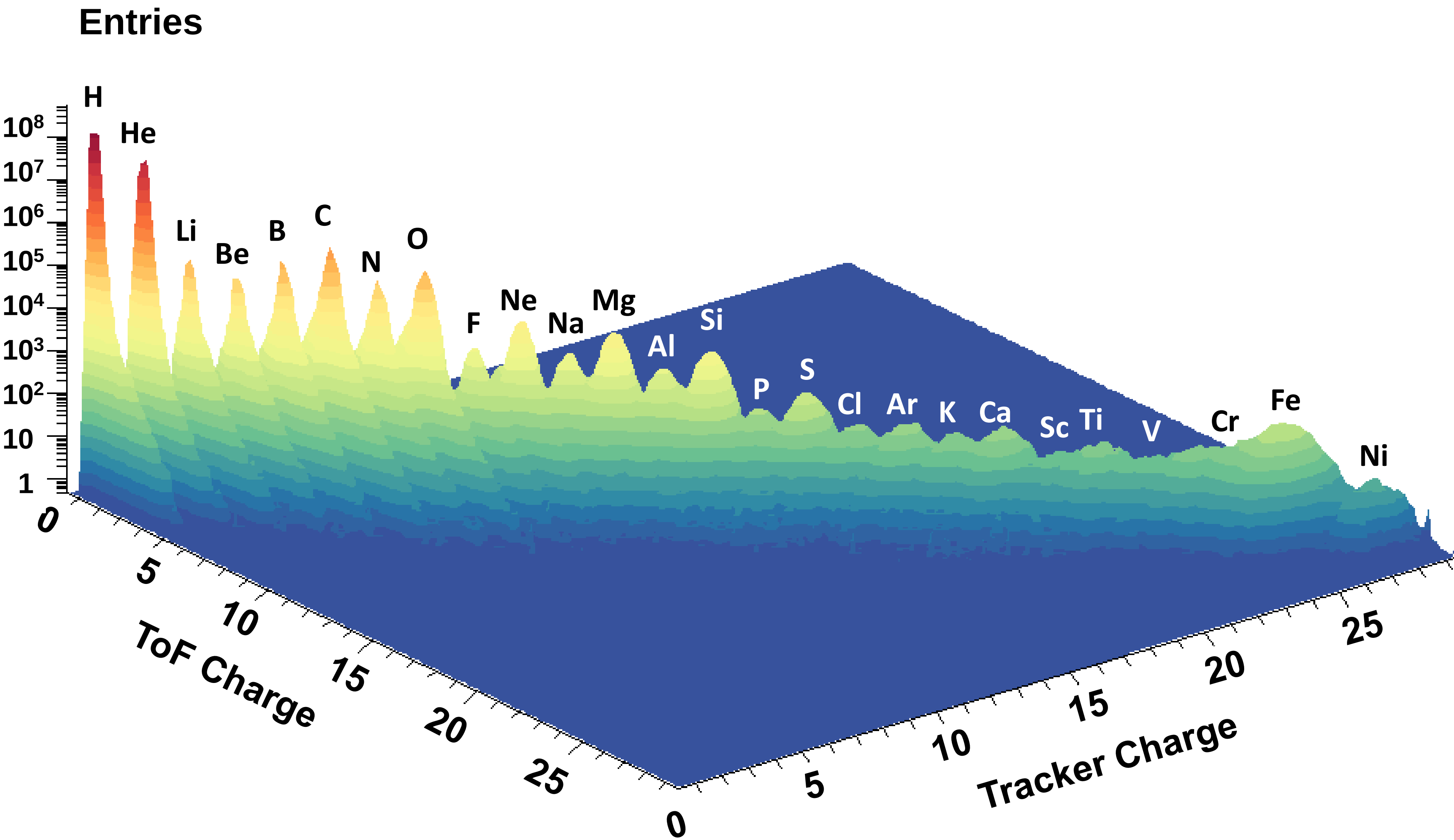
Important for the fragmentation issues

Iron Nuclei



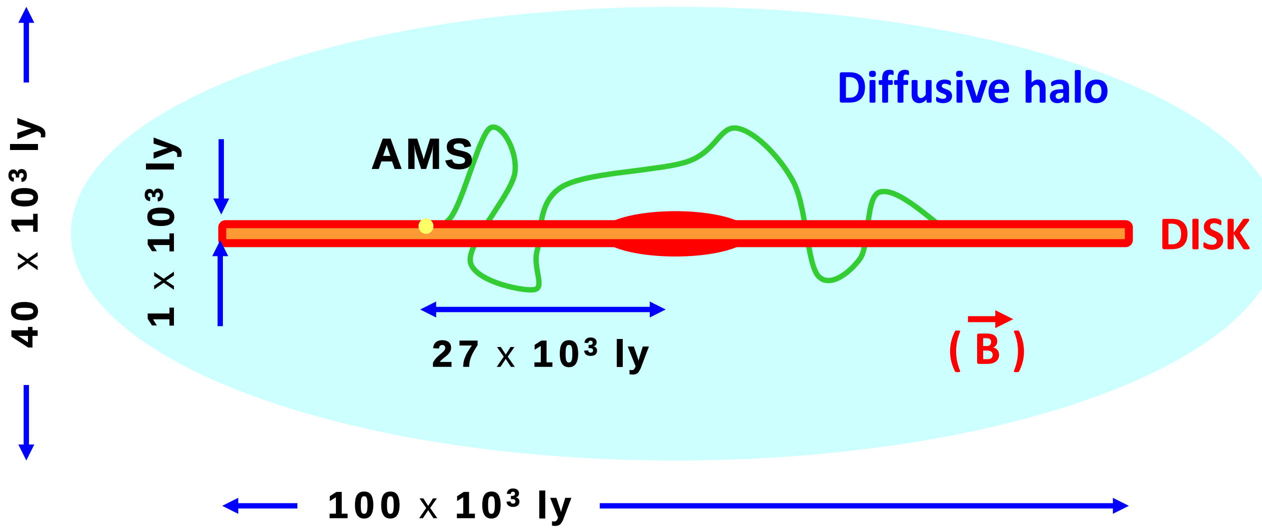
AMS Event Display
Run/Event 1331498136 / 219985 GMT Time 2012-071.20:50:42
Front
Z_{TRK_L1} = 26.4
Z_{TRD}=23.9
Z_{TOF_UP}=27.1
Z_{TRK_IN}=26.9
Z_{TOF_LOW}=26.8
Z_{RICH}=26.8
Z_{TRK_L9}=26.1
z
x
y
y
x

AMS Nuclei Measurement on ISS



Boron-to-Carbon ratio up 1 TV

Precise measurement of the energy spectra of B/C provides information on Propagation parameter



secondary /primary
Diffusion dominating at
E/n> 100 GeV

▷$N_B = \sigma_{spall} N_C / E^{\delta}$

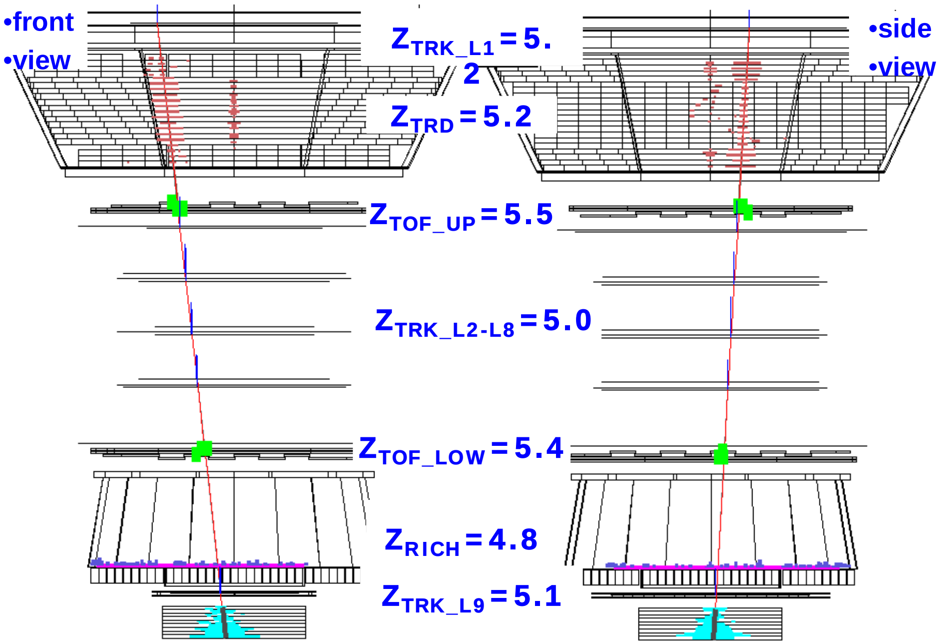
▷$N_{Sec}/N_{Prim} \sim E^{-\delta}$

Rigidity ~ 700 GV

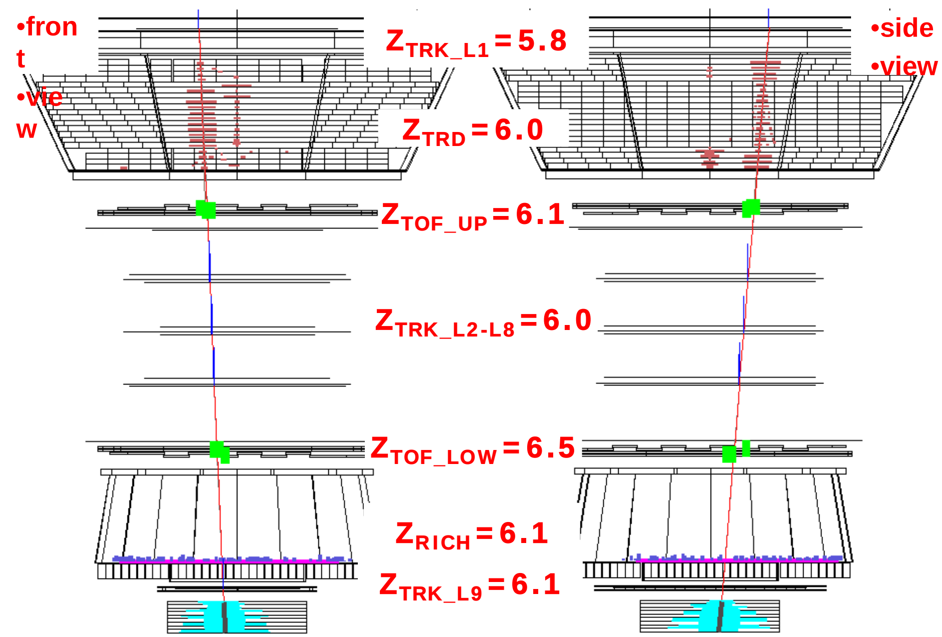
Boron
Rigidity=680 GV

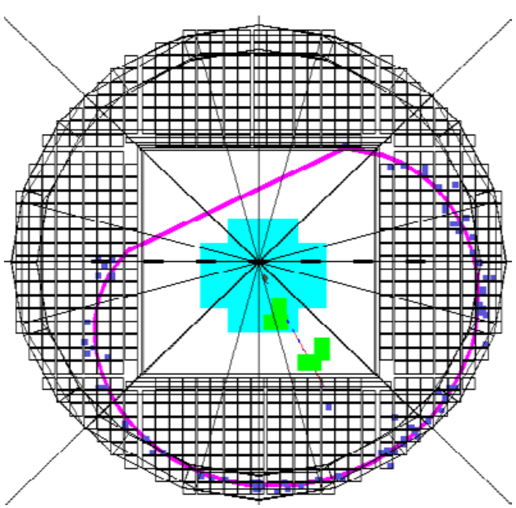
Carbon
Rigidity=666 GV

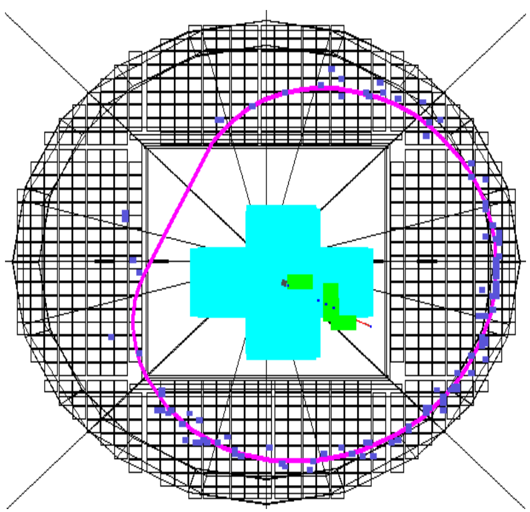
Run/Event 1319990213/ 235892



Run/Event 1327184805/ 266043

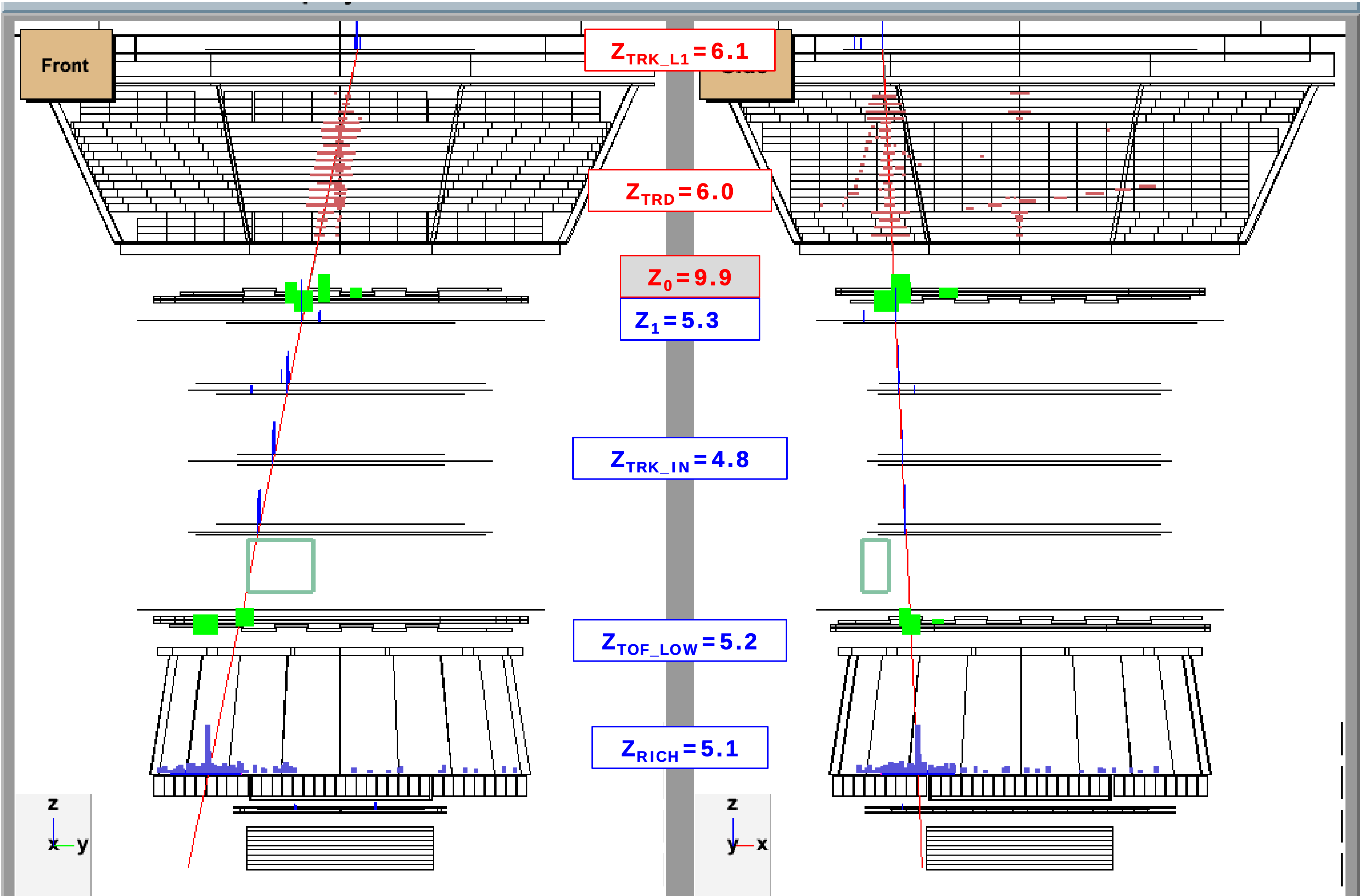




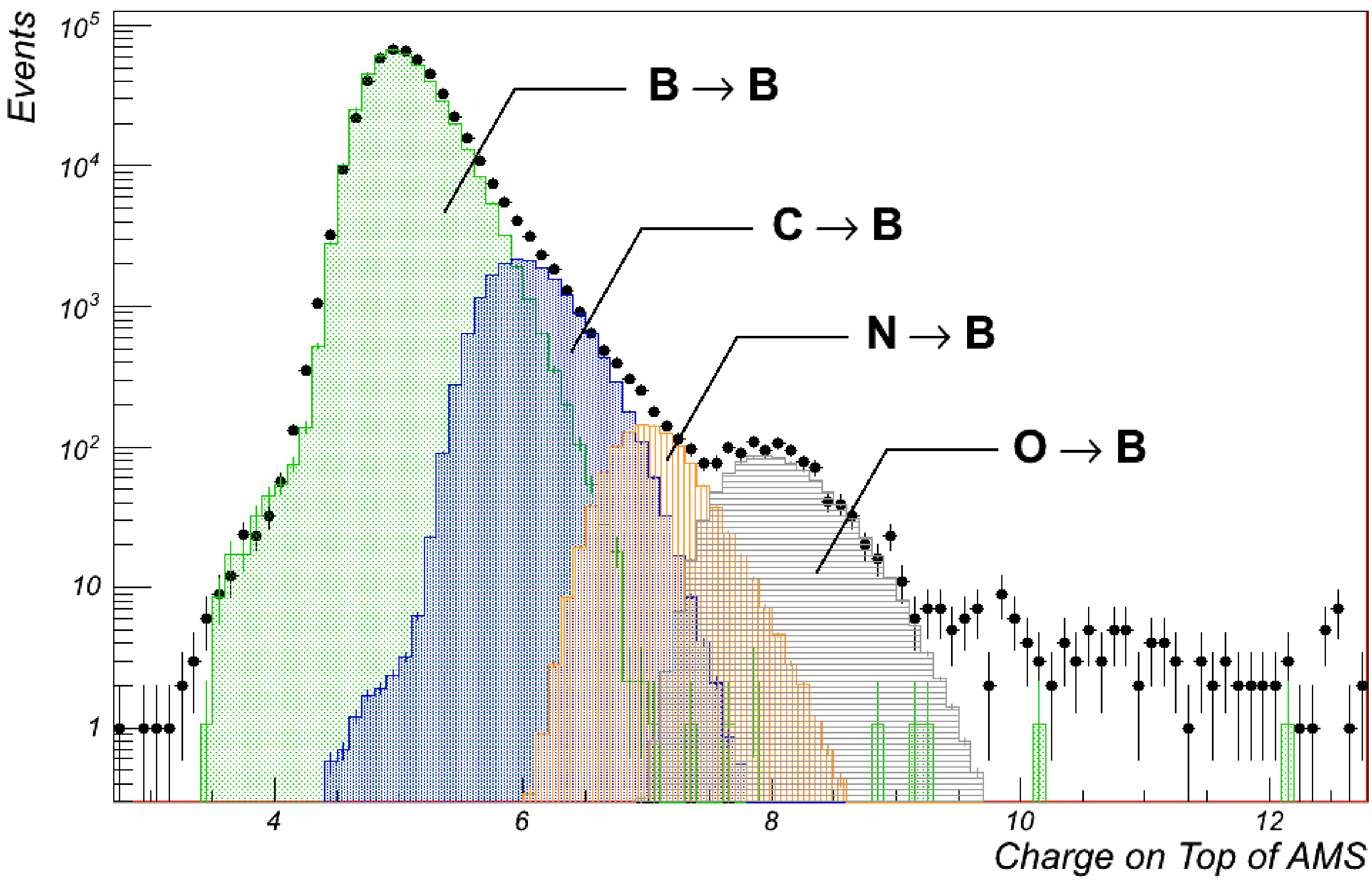


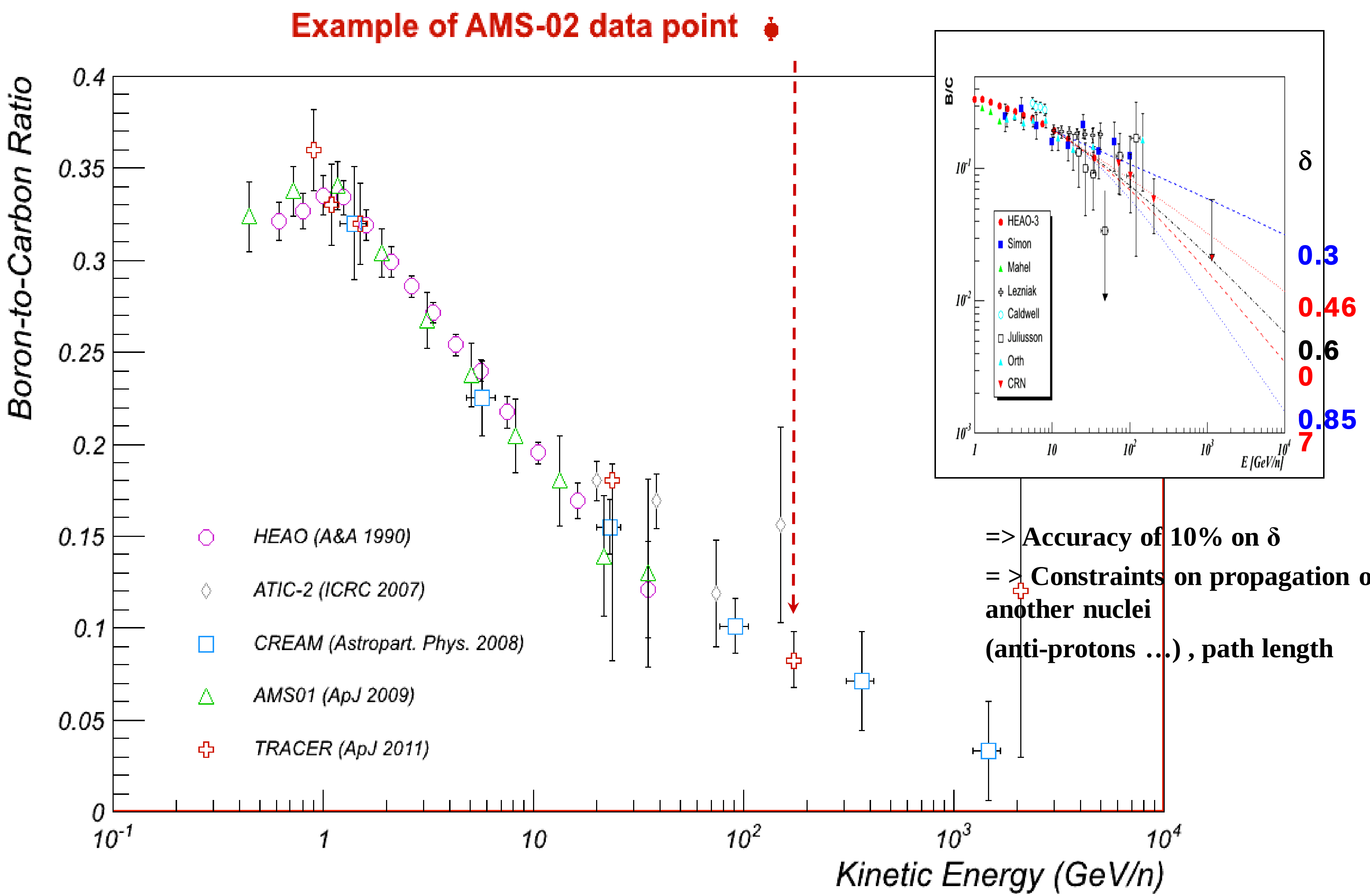
Carbon Fragmentation to Boron in Upper TOF

Rigidity 10.6 GV



Boron measured by AMS



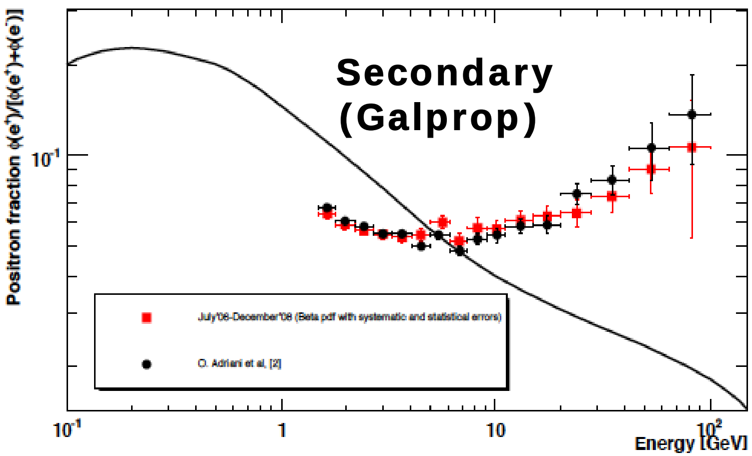


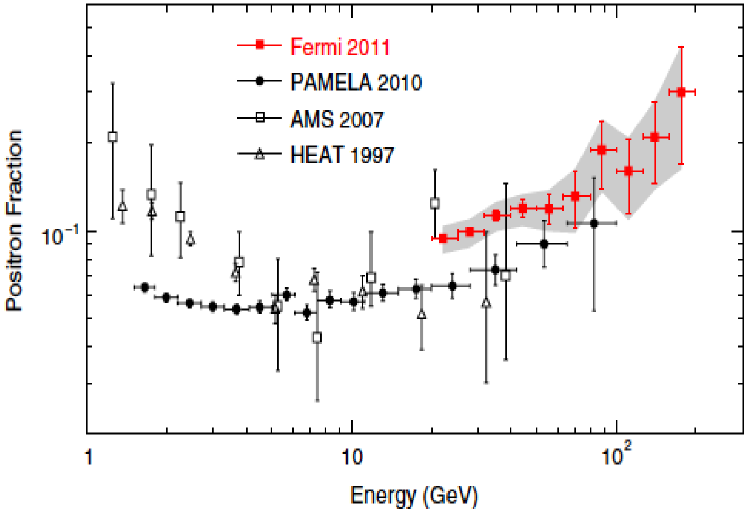
=> Accuracy of 10% on δ

= > Constraints on propagation of another nuclei (anti-protons …) , path length

Positron fraction

Pamela: O.Adriani et al., Astropart. Phys. 34 (2010





- **Experimental issues**

  Proton rejection and High Statistics

  Charge confusion(electron)

  Energy measurement

  Dependence with time ? Effect of the Solar modulation

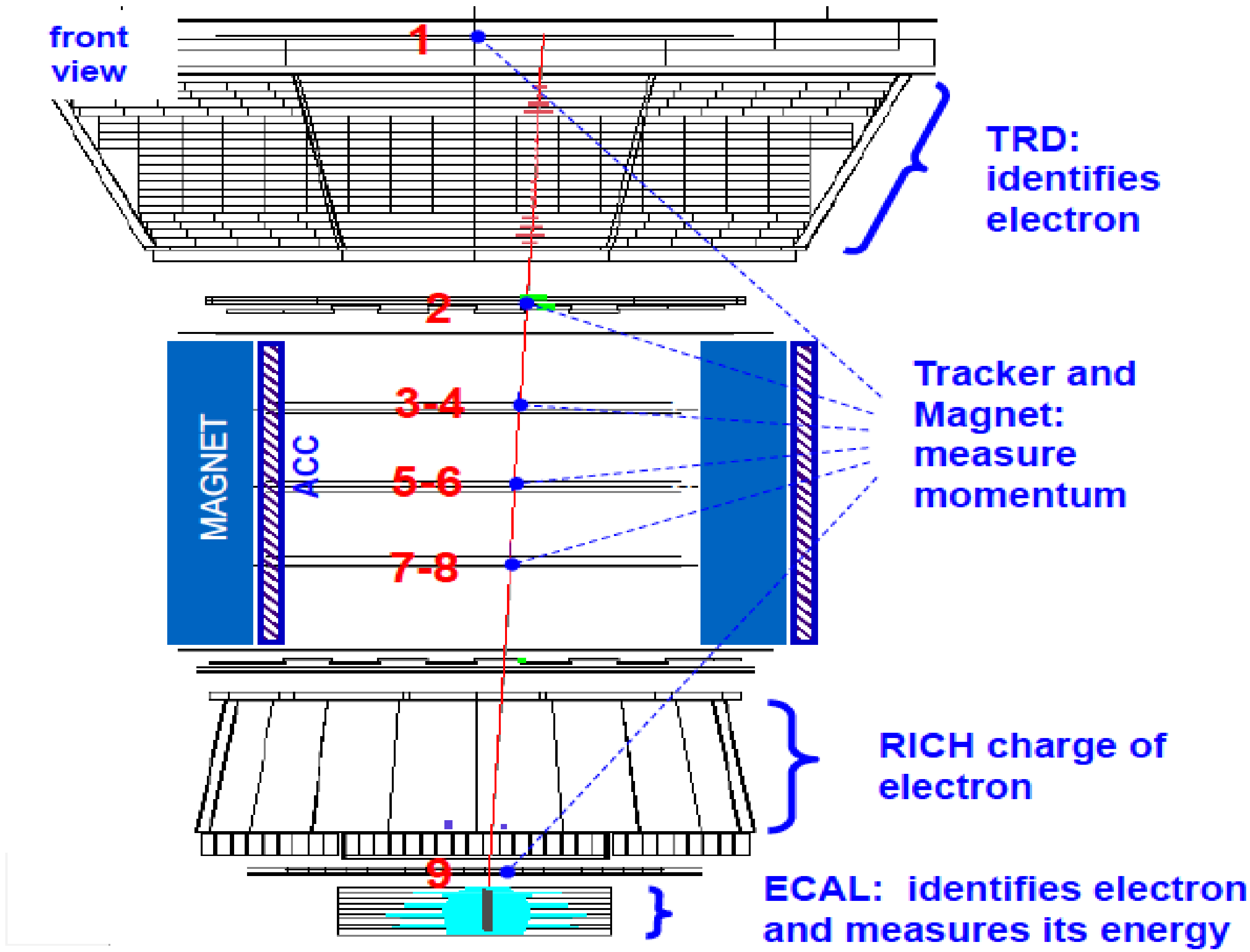
  Acceptance correction (second order)

- **Proton Rejection:**
  - TRD,
  - tracker (Momentum and Energy matching)
  - ECAL

Positron fraction

Over the first eighteen months of operations in space, AMS has collected over 25 billion events.

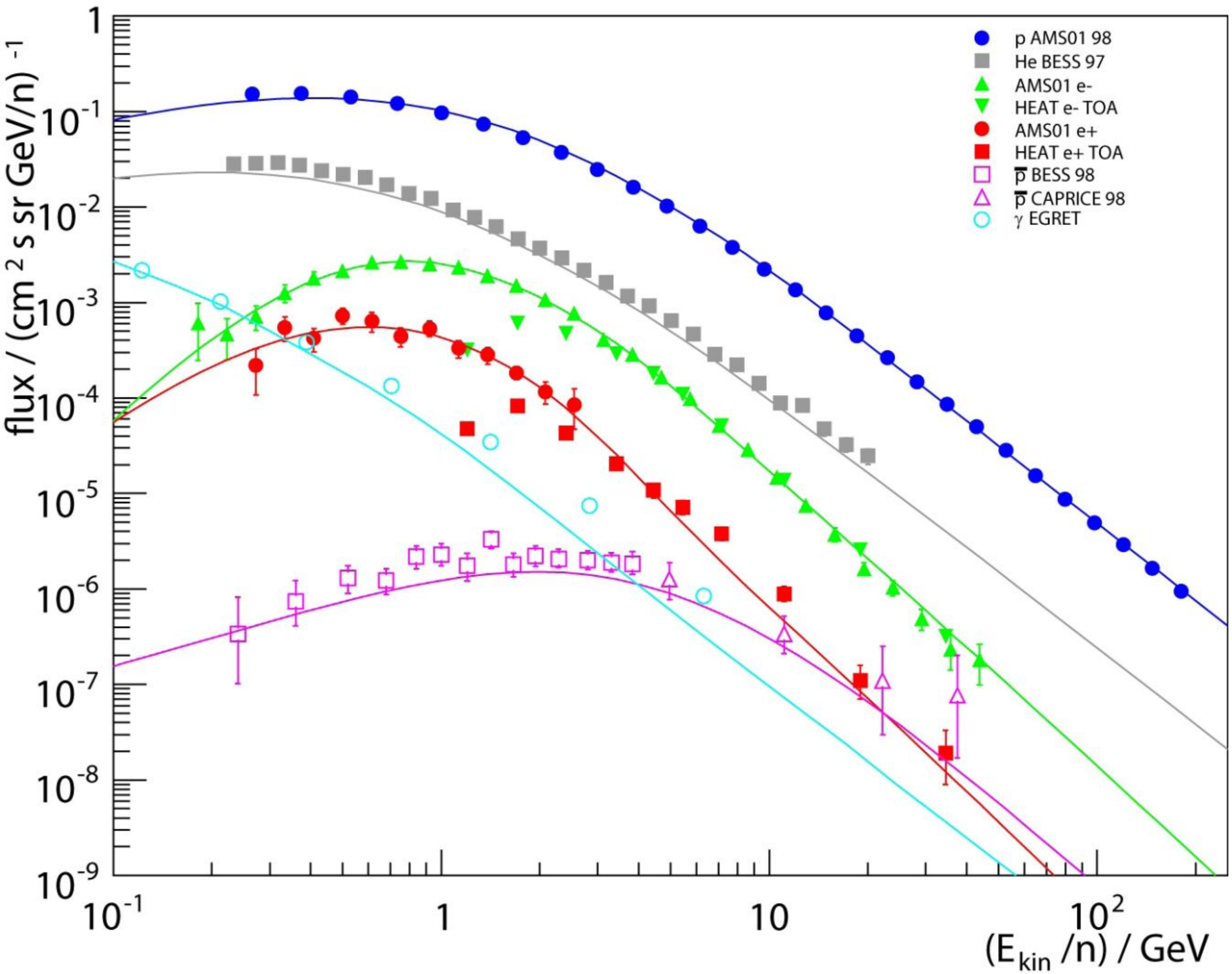
6.8 million are electrons or positrons



AMS data on ISS: 424 GeV positron

Cosmic rays composition

Data before Pamela

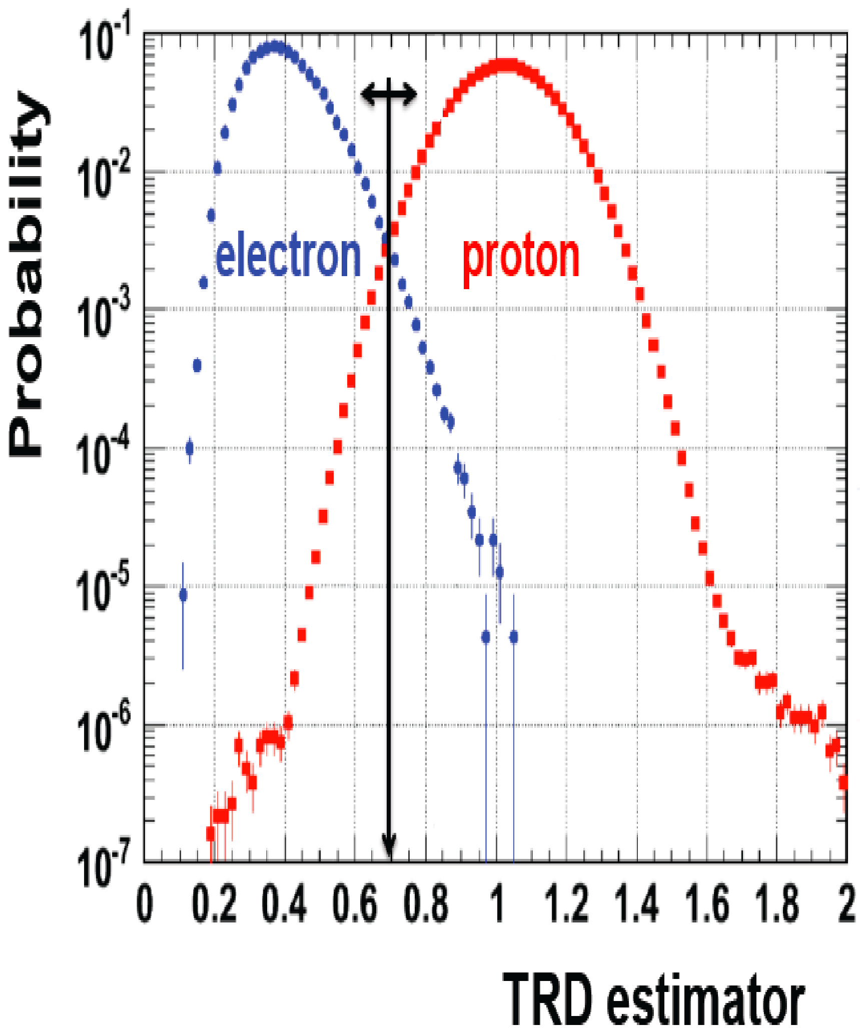


@ 10 GeV

88%	**Protons**
10%	**Helium**
++1%	**Electrons**
++0.1%	**Positrons**
++0.01%	**Gamma rays**
0.001%	**Antiprotons**

Proton rejection:TRD (1)

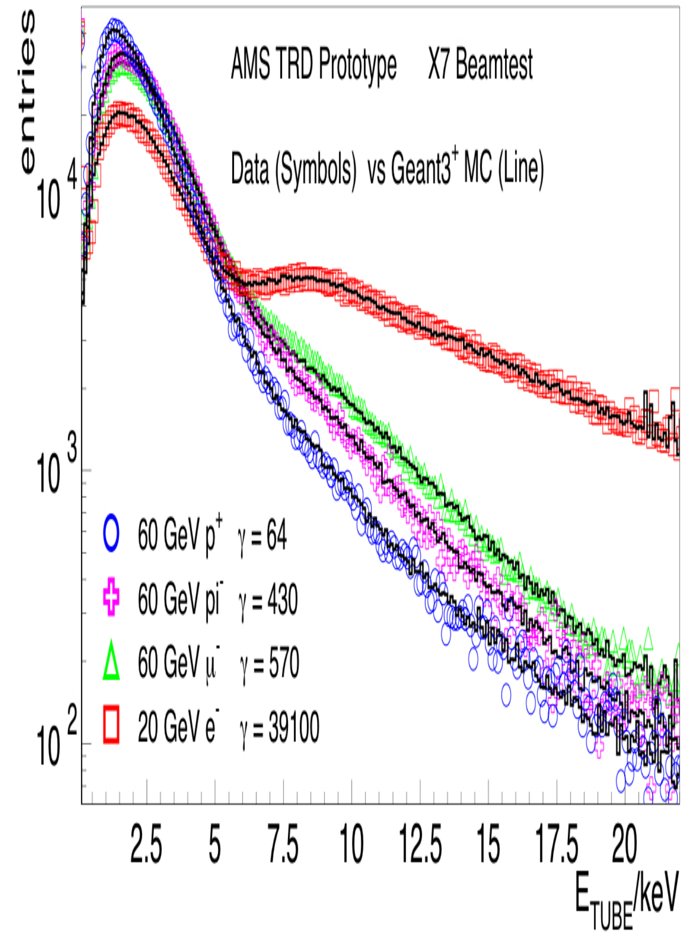
TRD estimator = $-\ln(P_e/(P_e+P_p))$



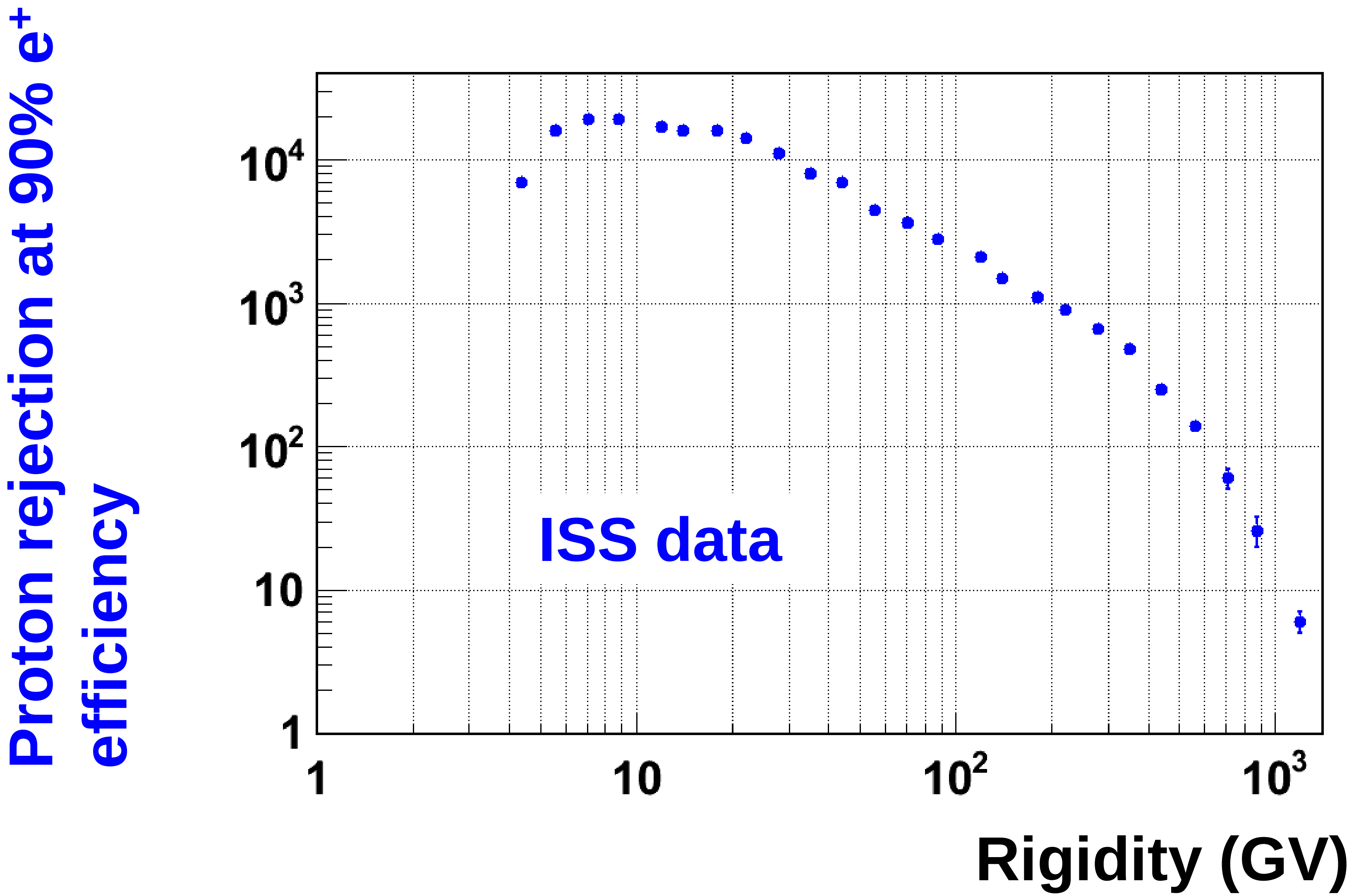
Normalized probabilities P_e and P_p

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

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



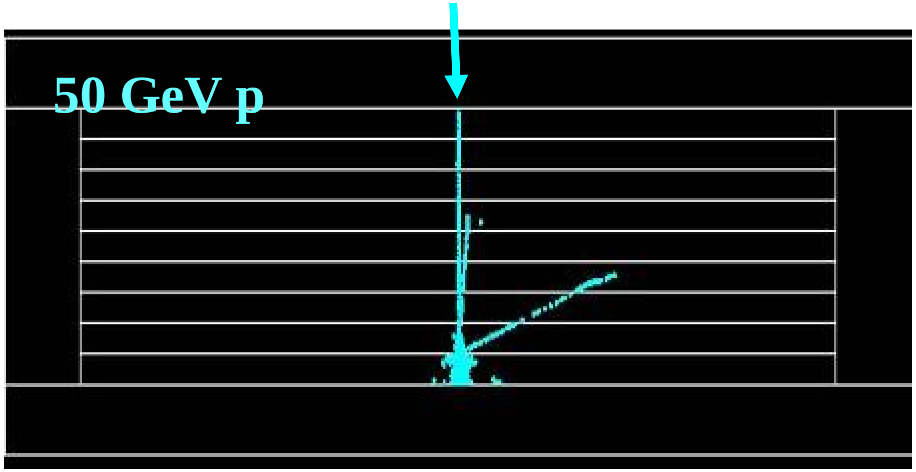
Proton rejection:TRD (1)

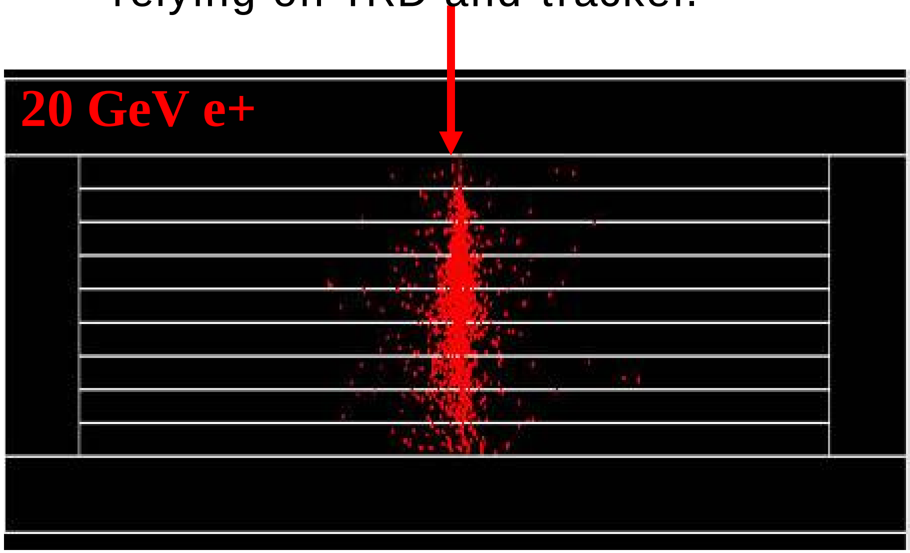


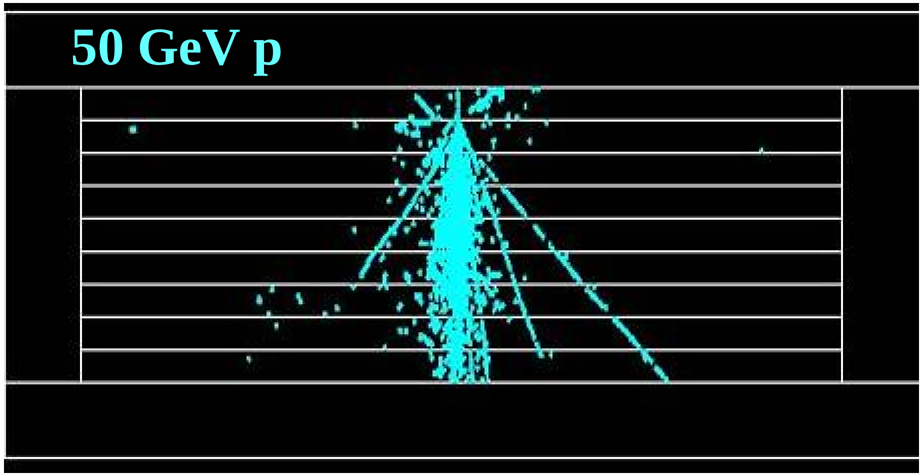
Proton rejection: Ecal (2)

- Identify proton interacting in the first layers
- Exploit the EM shower shape properties in the 3 dimensions (reduced variables and at the layer or cell levels)
- Compare the Deposit Energy with the momentum measured in the tracker
- Use Test beam data and ISS data relying on TRD and tracker.

Simulation in Geant4

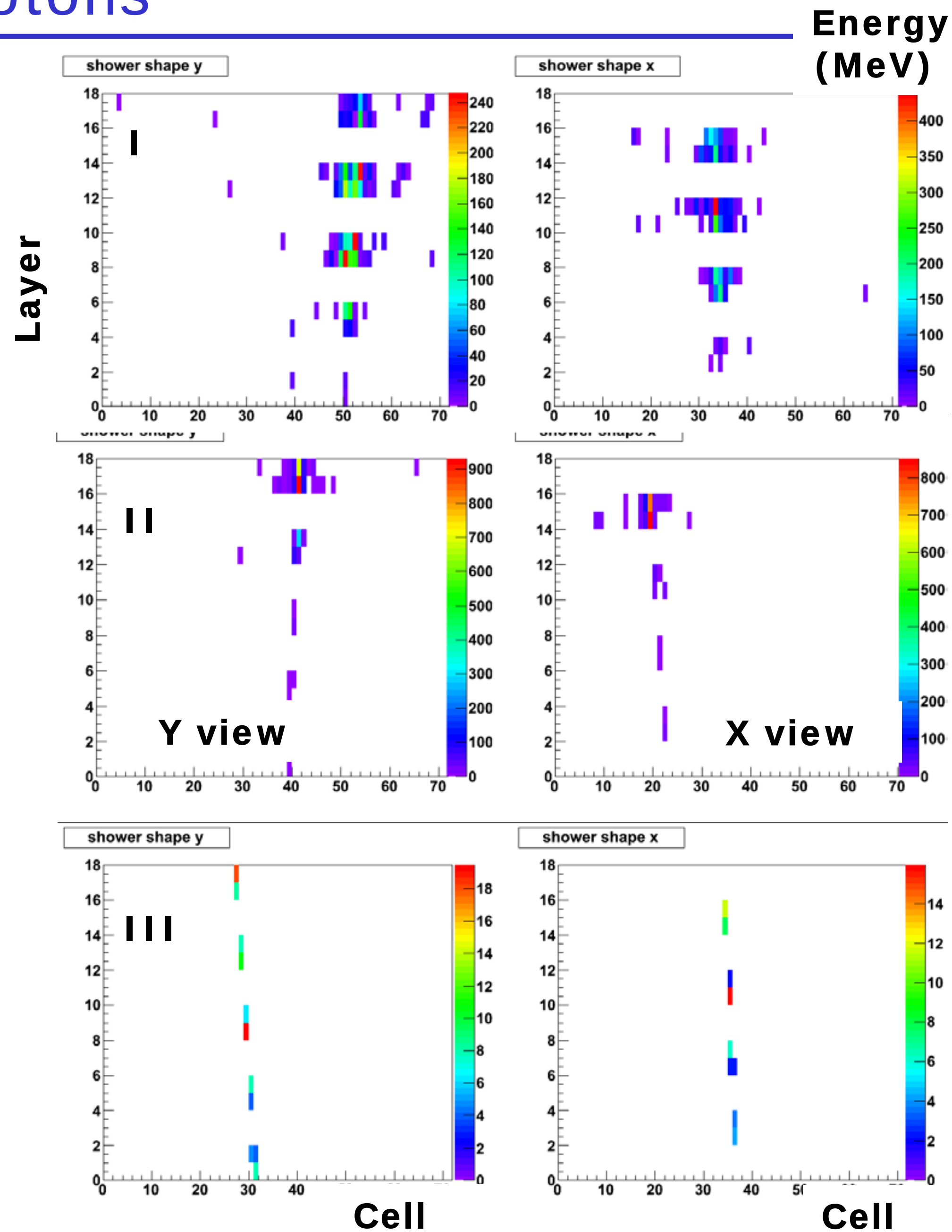






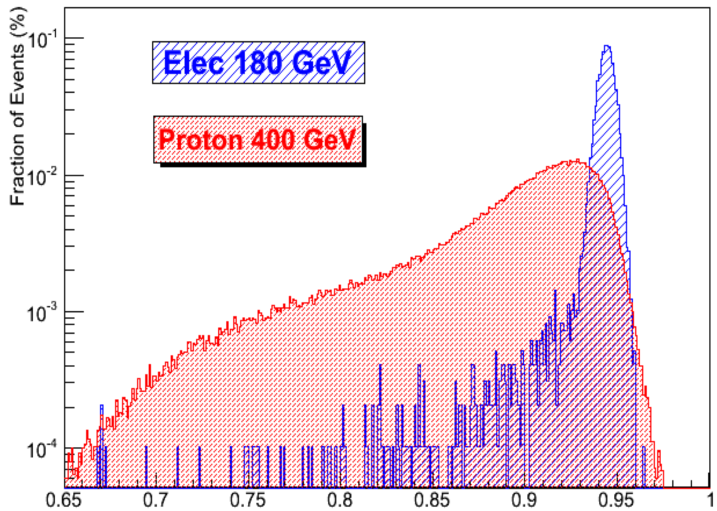
e/P rejection - ISS protons

- 3 regimes
  - I: Nuclear Interaction occurs before the 3 first layers (~ 10-15 %)
  - II: Nuclear interaction in the intermediate zone (3:17) layers
  - III: MIP up to the last layer, 47-53 % of the proton events



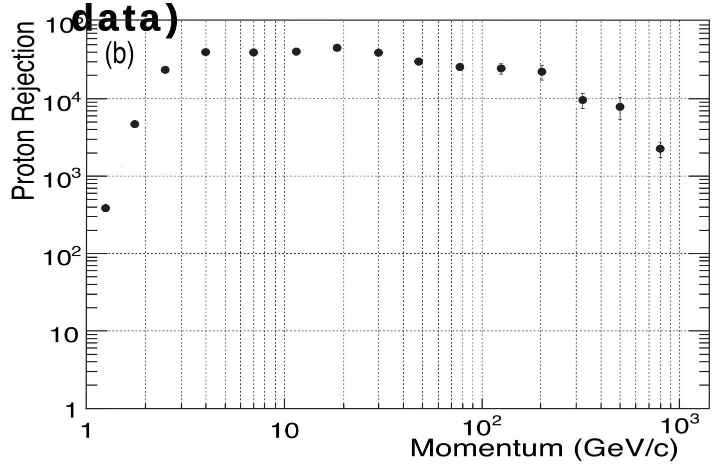
e/P rejection

Test Beam @ CERN

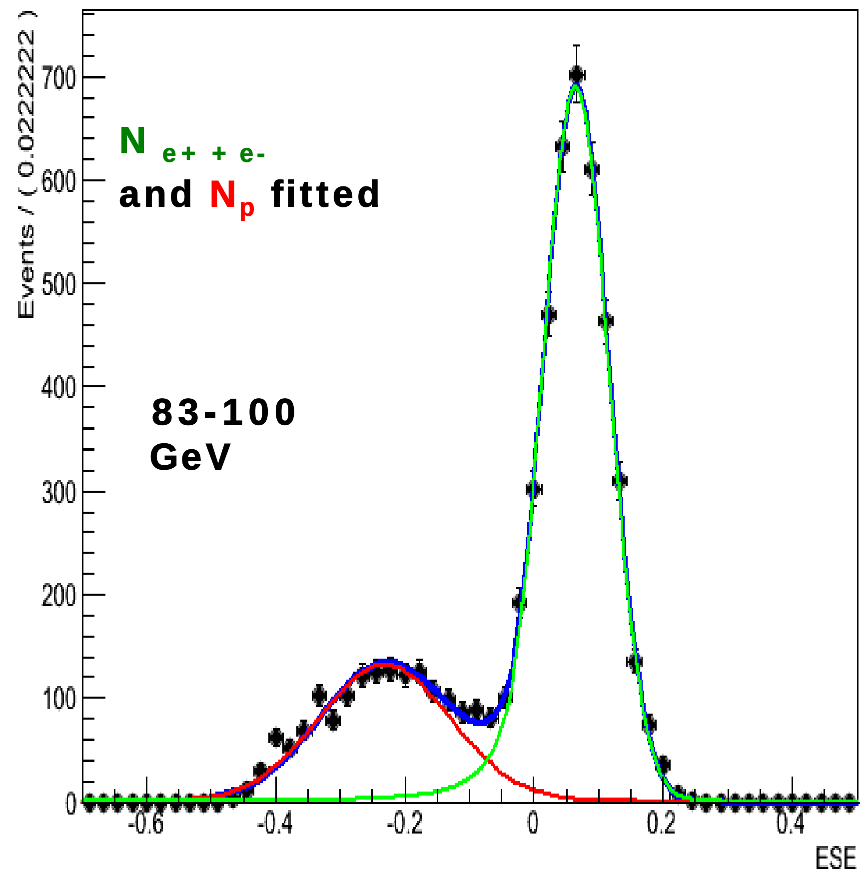


Y View – fraction of Energy in 1.5 Moliere Radius

Combined ECAL+ Tracker (E/P) Proton rejection (ISS data)

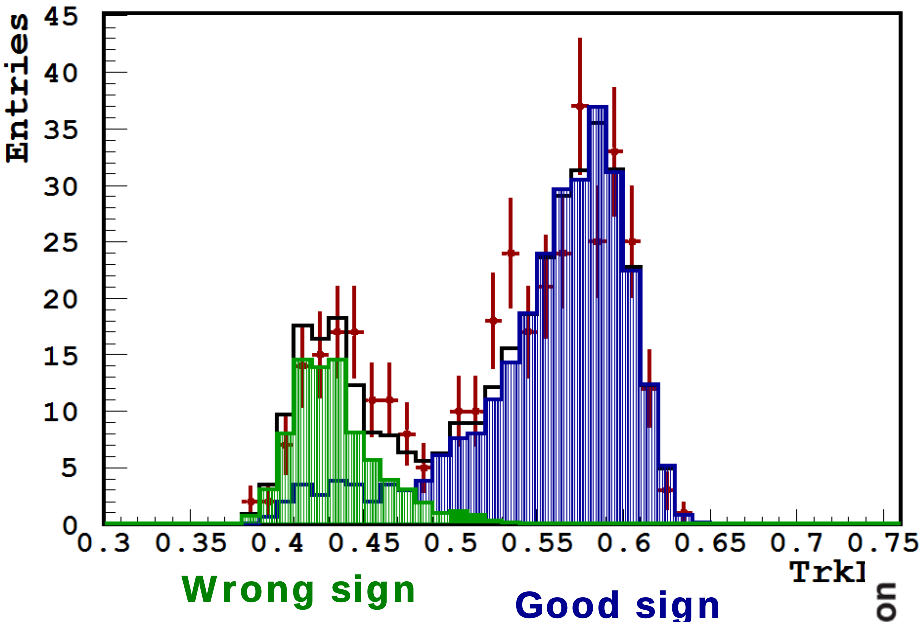


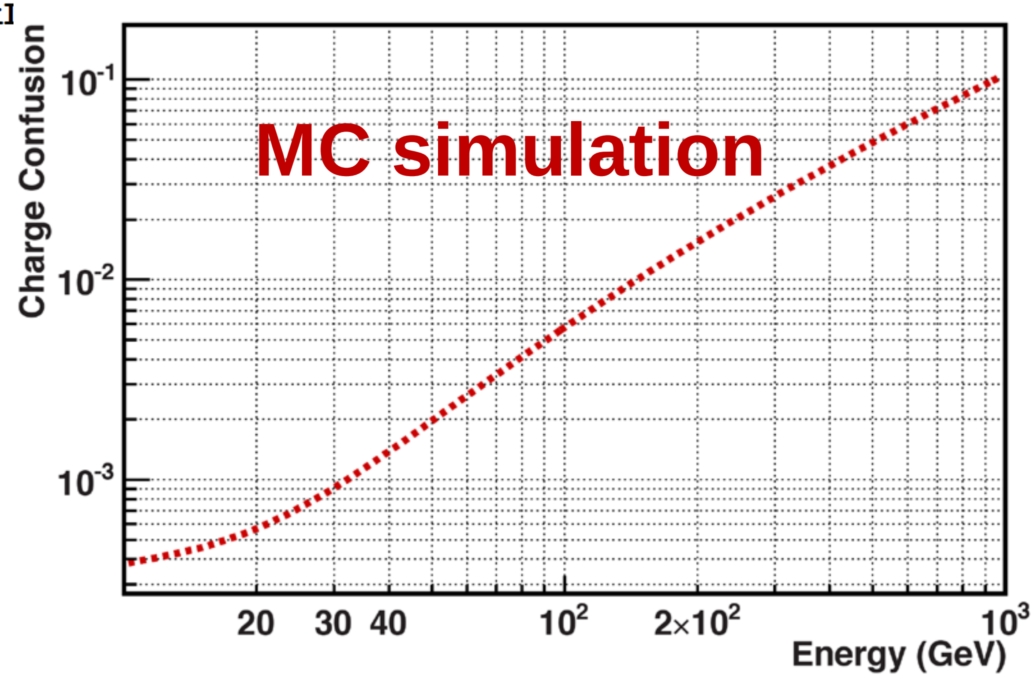
ISS data – Multivariate Analysis-ECAL,



ECAL Estimator (83.2-100 GeV)

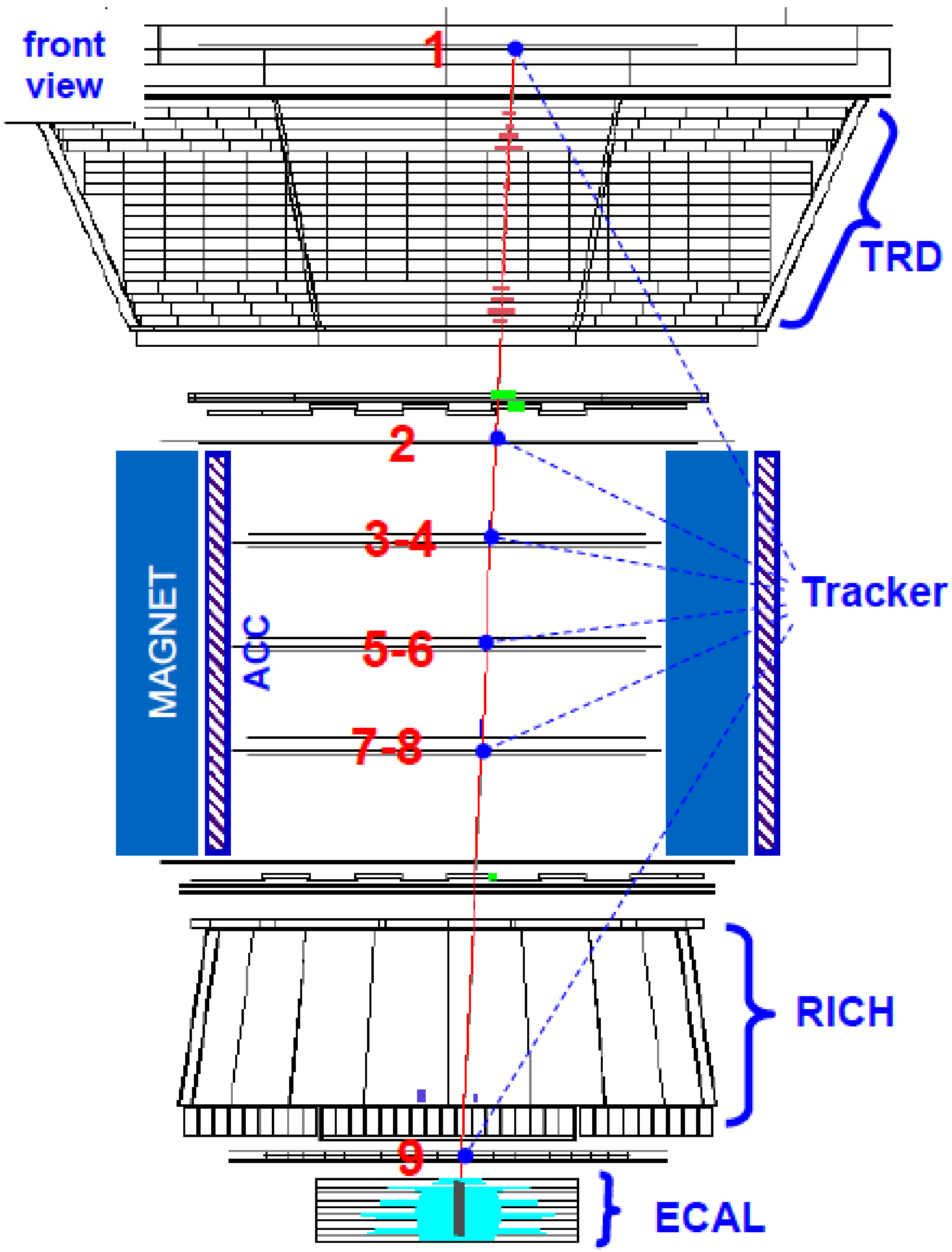
Electron Charge Identification in the tracker

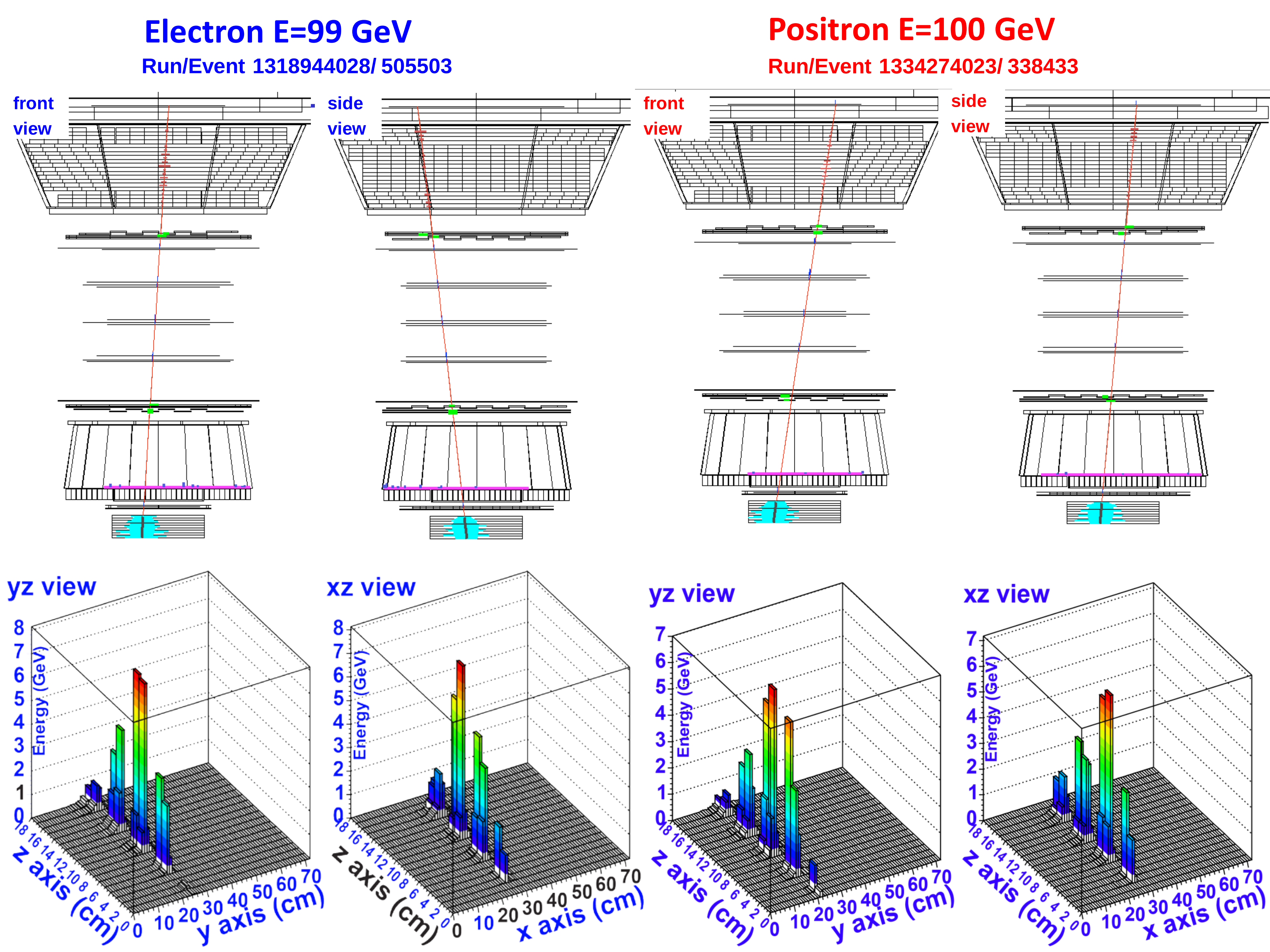




Tracker
A track in the Tracker containing at least one hit in planes 1 or 2 or 9 and hits in planes (3 or 4), (5 or 6) and (7 or 8). In addition, the projected track must pass within 3 cm in x and 10 cm in y of the center of gravity of the ECAL shower.
The relative error on the curvature (inverse of 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 $\beta > 0.8$.
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

Event selection.





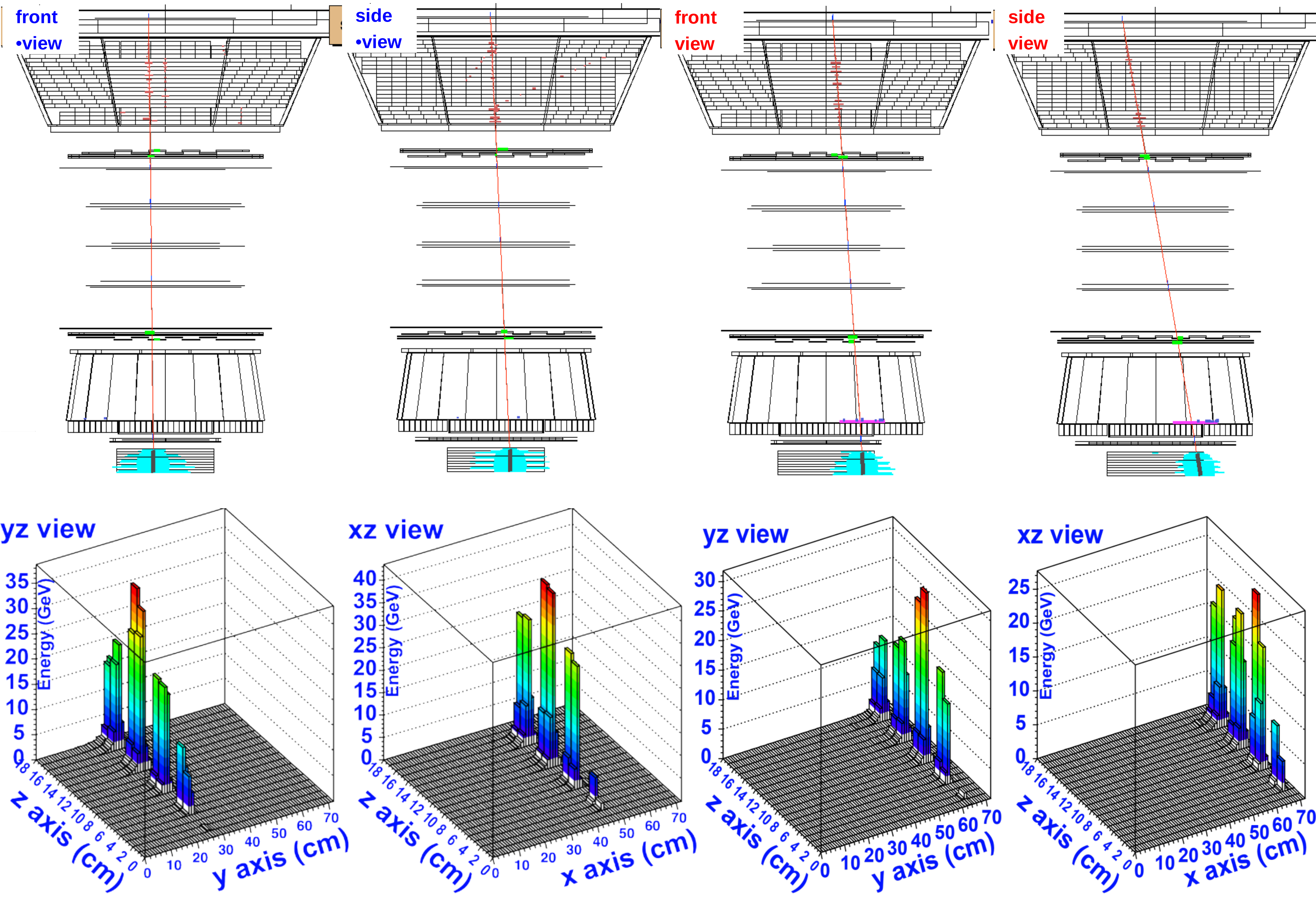
Electron E=99 GeV
Run/Event 1318944028/ 505503
Positron E=100 GeV
Run/Event 1334274023/ 338433
front view
side view
front view
side view
yz view
xz view
yz view
xz view
Energy (GeV)
z axis (cm)
y axis (cm)
x axis (cm)

Electron E=982 GeV

Run/Event 1329775818/ 60709

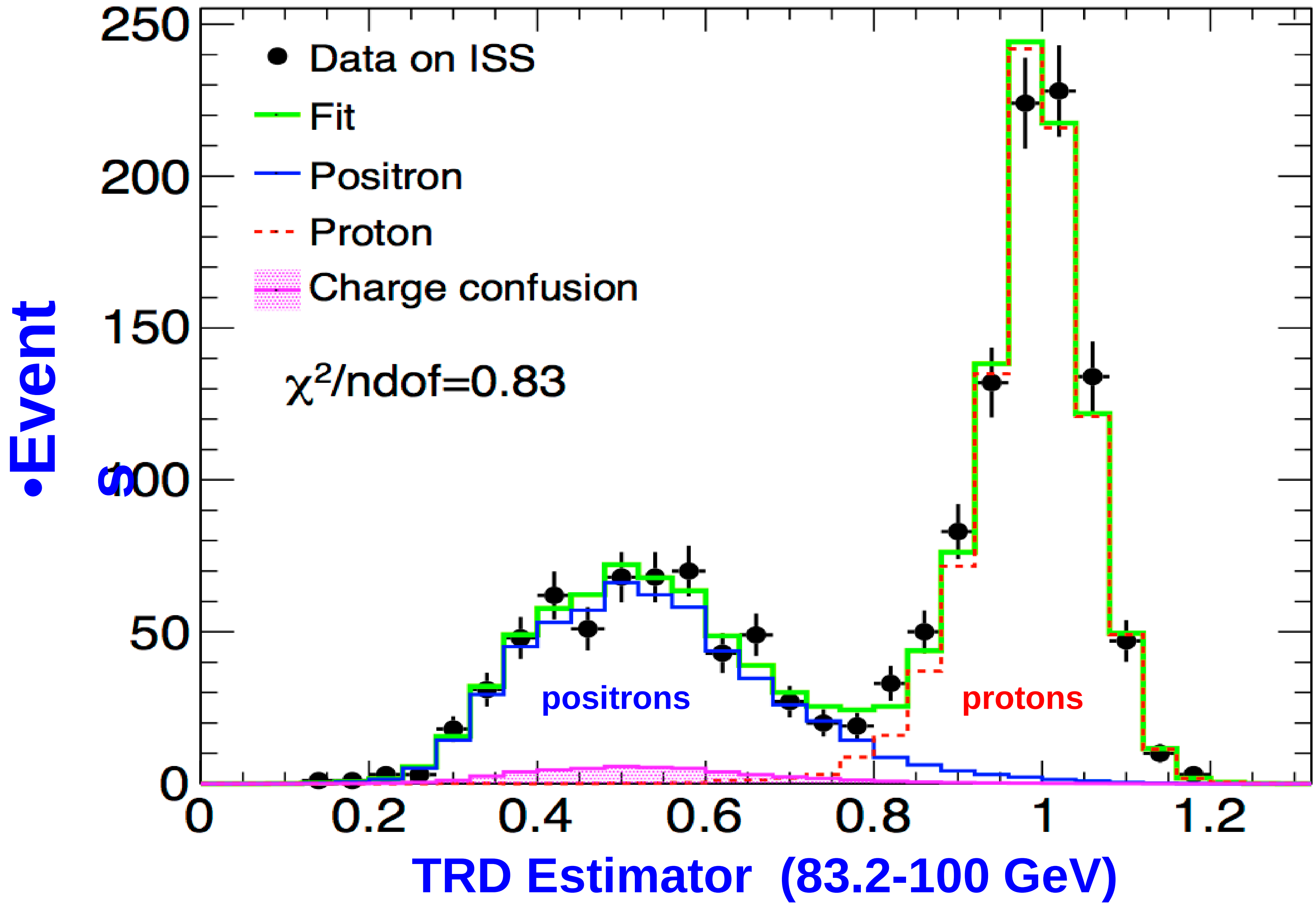
Positron E=636 GeV

Run/Event 133119-743/ 56950



Example of Positron Selection:

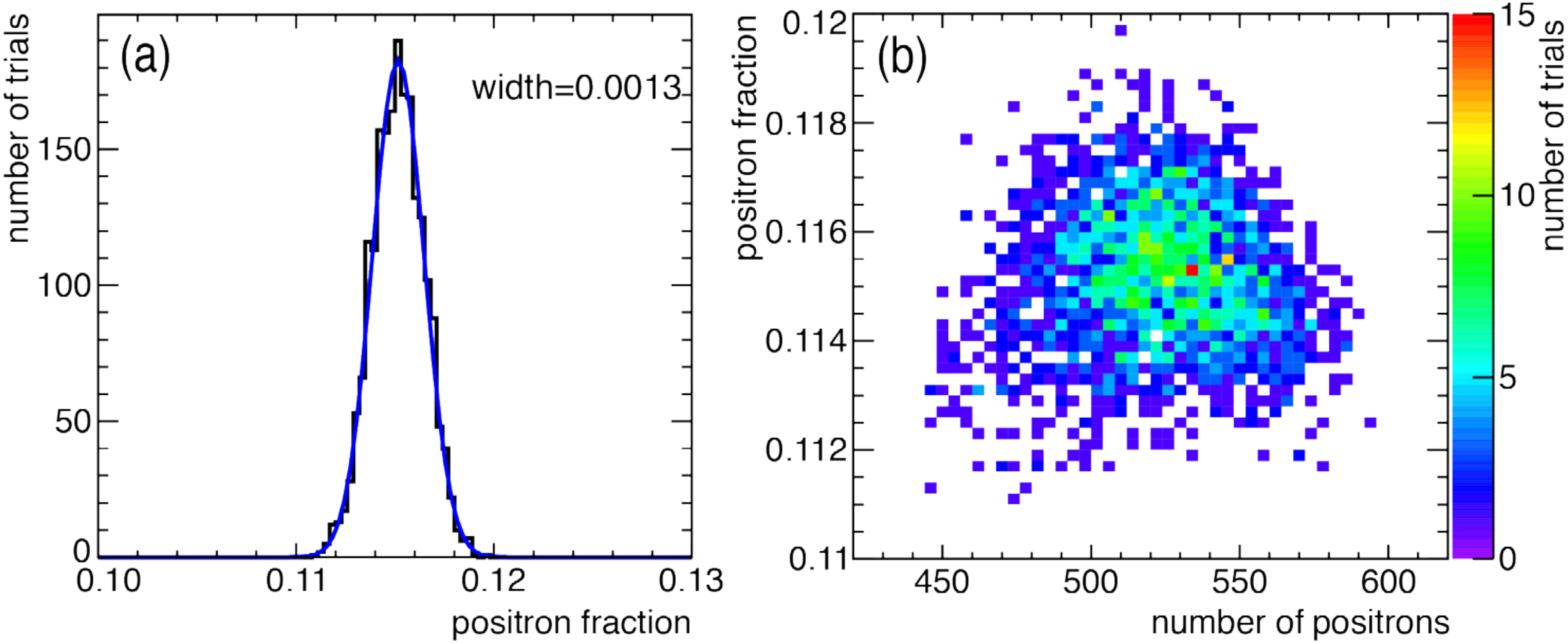
The TRD Estimator shows clear separation between protons and positrons with a small charge confusion background



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.**

Systematic error on the positron fraction: 2. Selection dependence

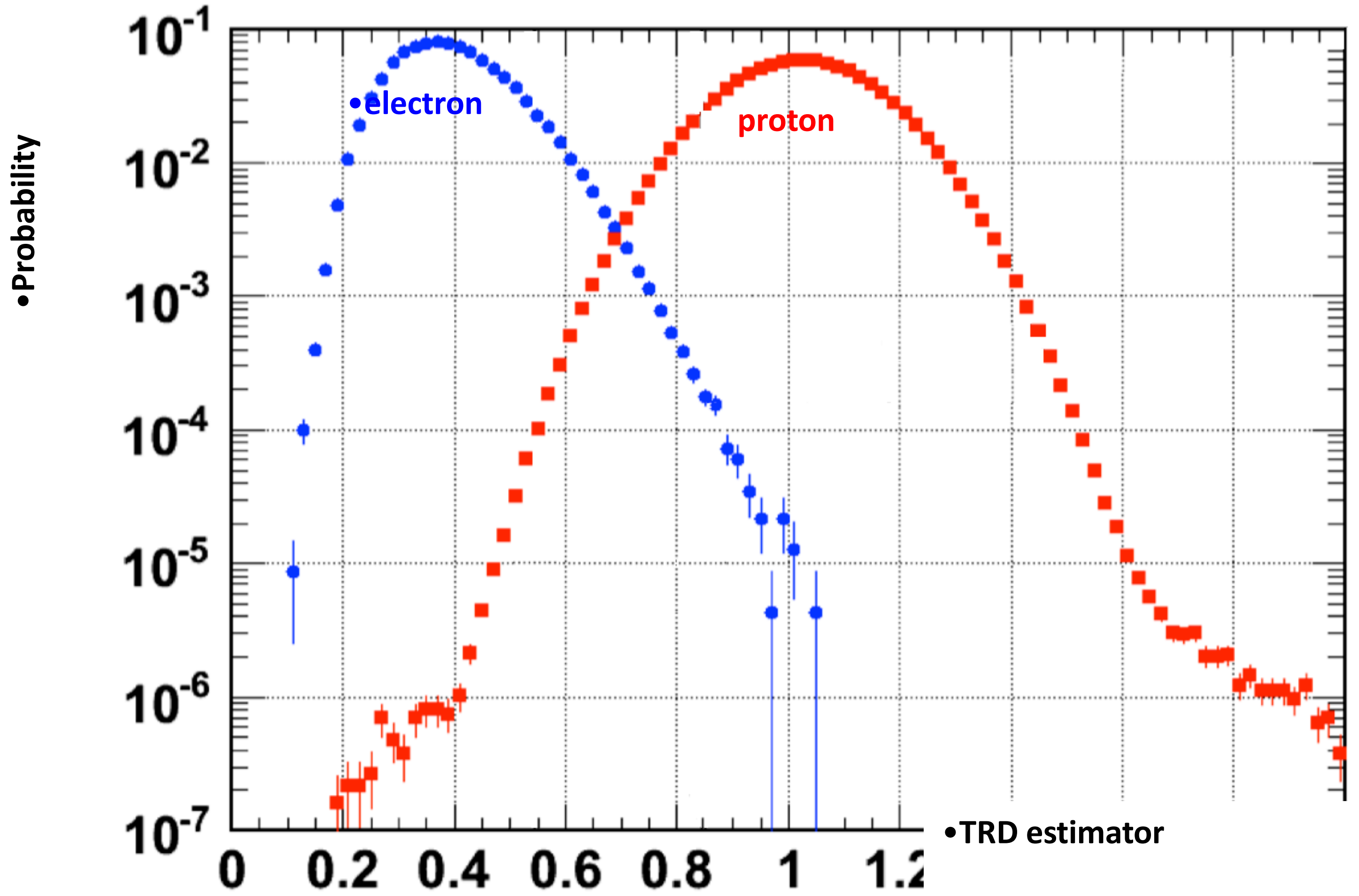


The measurement is stable over wide variations of the cuts in the TRD identification, ECAL Shower Shape, E (from ECAL) matched to |P| (from the Tracker), …

For each energy bin, over 1,000 sets of cuts were analyzed.

Systematic error on the positron fraction:

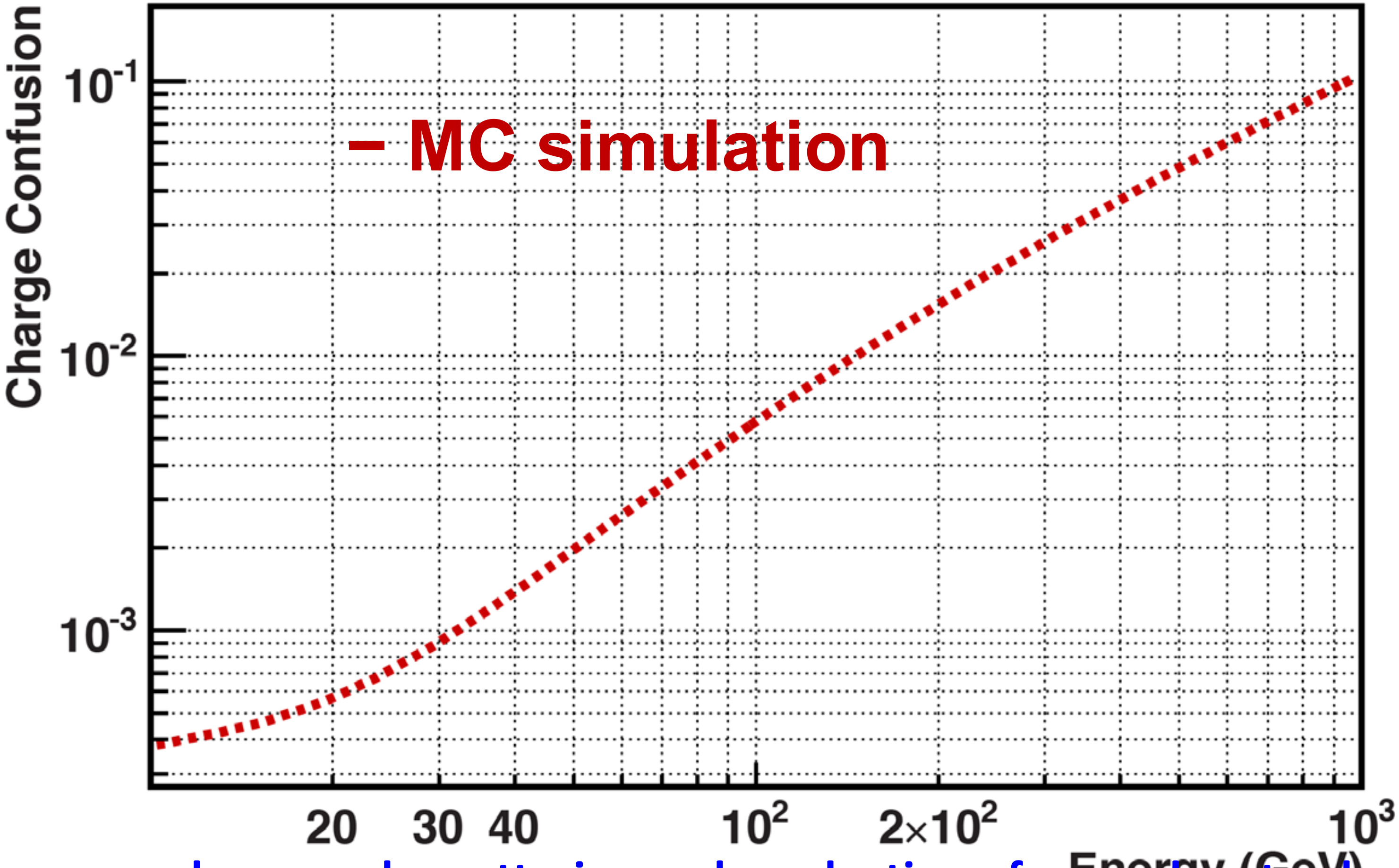
4. Reference spectra



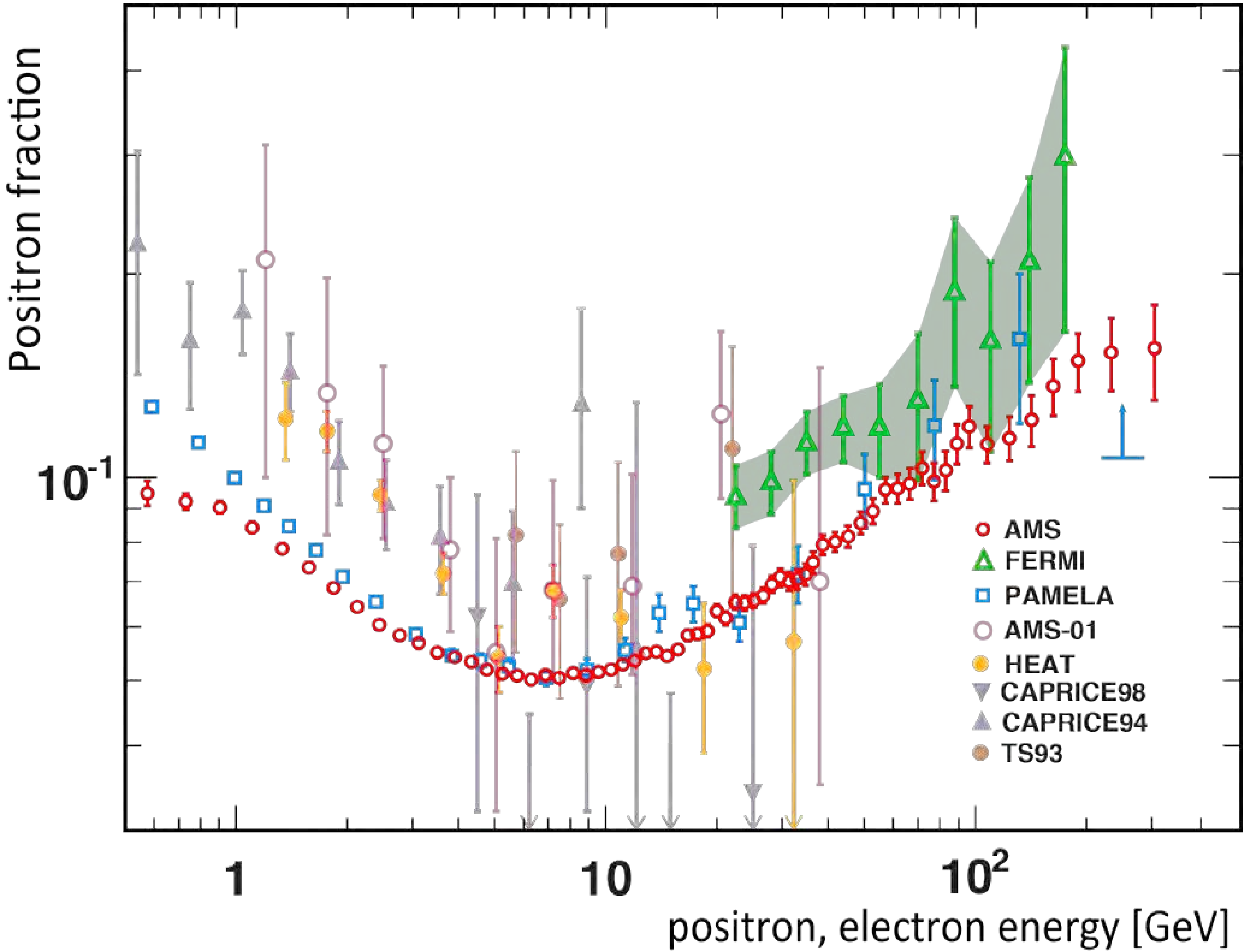
Definition of the reference spectra (PDF templates) is based on pure samples of electrons and protons of finite statistics.

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

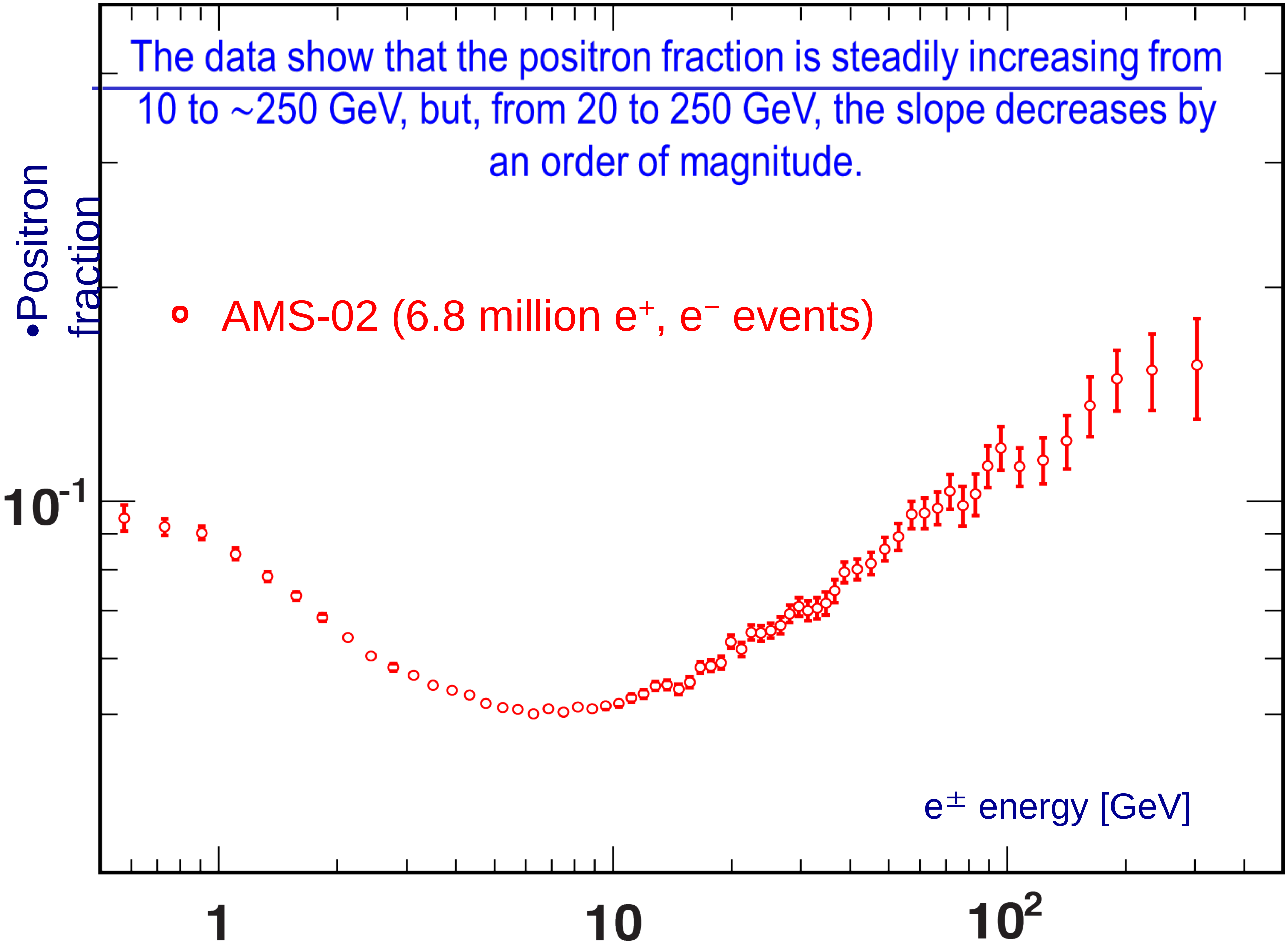
Positron events, positron fraction in each energy bin

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

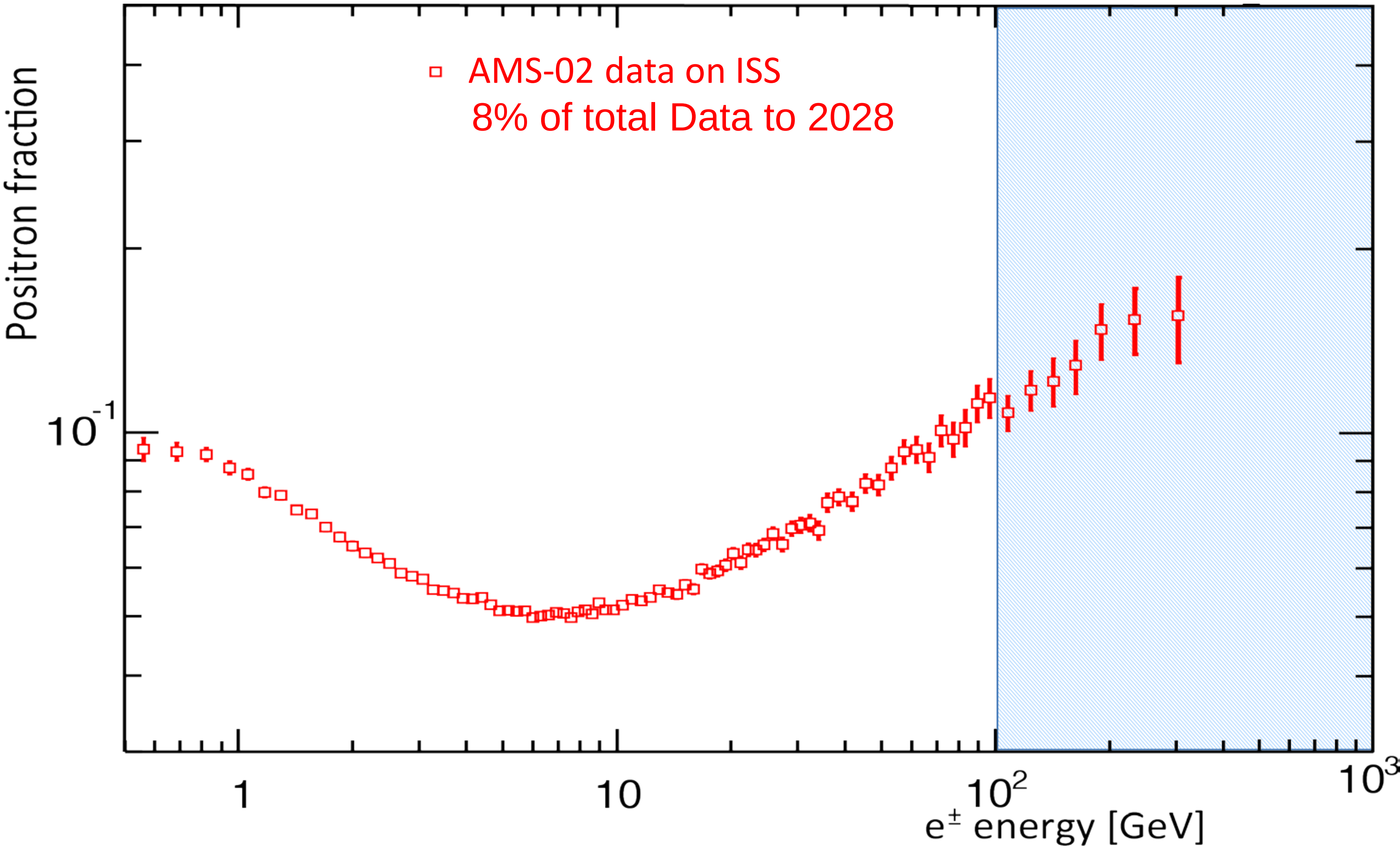


The data show that the positron fraction is steadily increasing from 10 to ~250 GeV, but, from 20 to 250 GeV, the slope decreases by an order of magnitude.
•Positron fraction
AMS-02 (6.8 million e+, e− events)
10-1
e± energy [GeV]
1
10
102

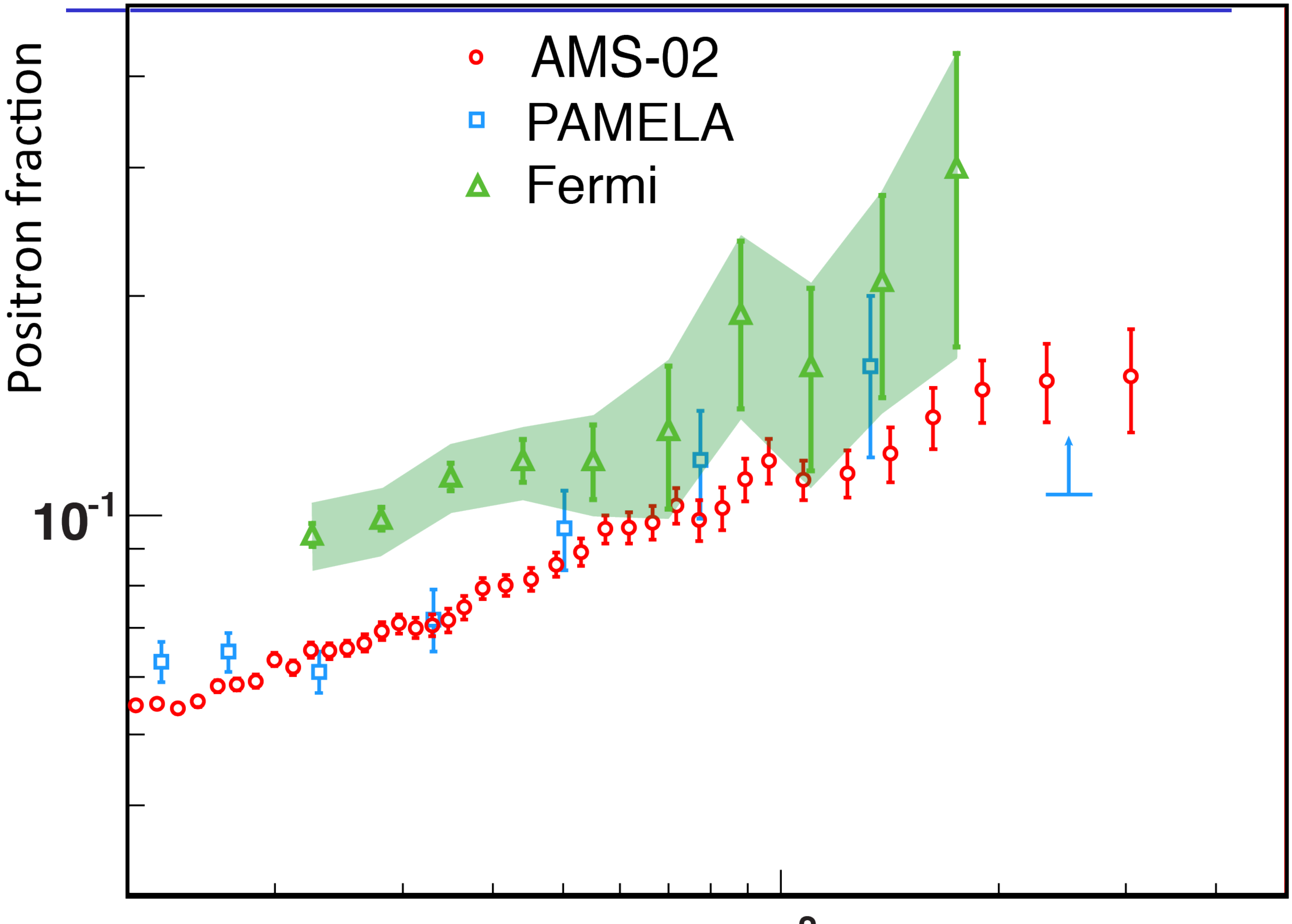
AMS will be on ISS for 20 years.

`

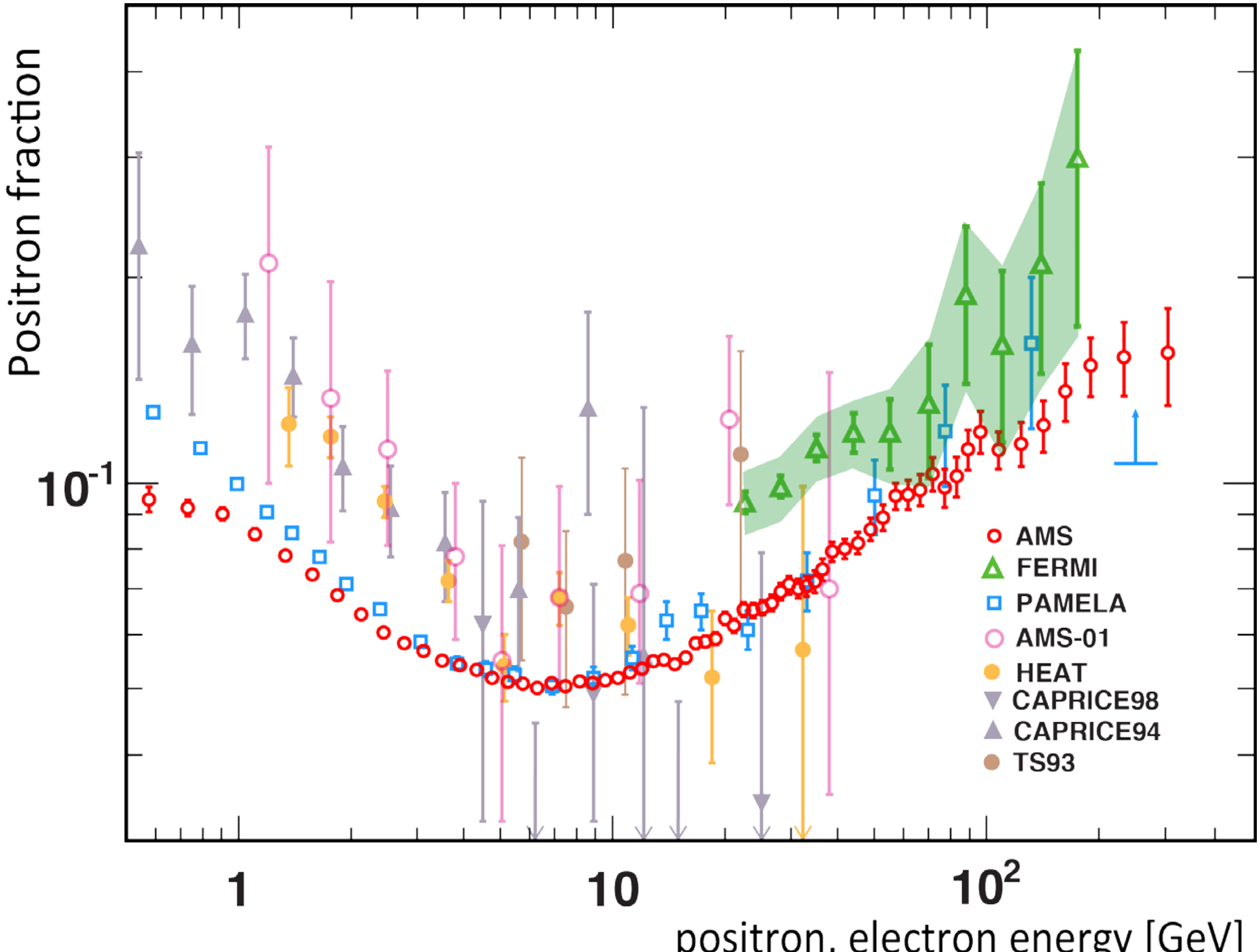
The data to ~1 TeV will be presented when there are enough events.



Comparison at high energies



Comparison at all energies



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 $e^{\pm}$:

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

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

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.

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

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

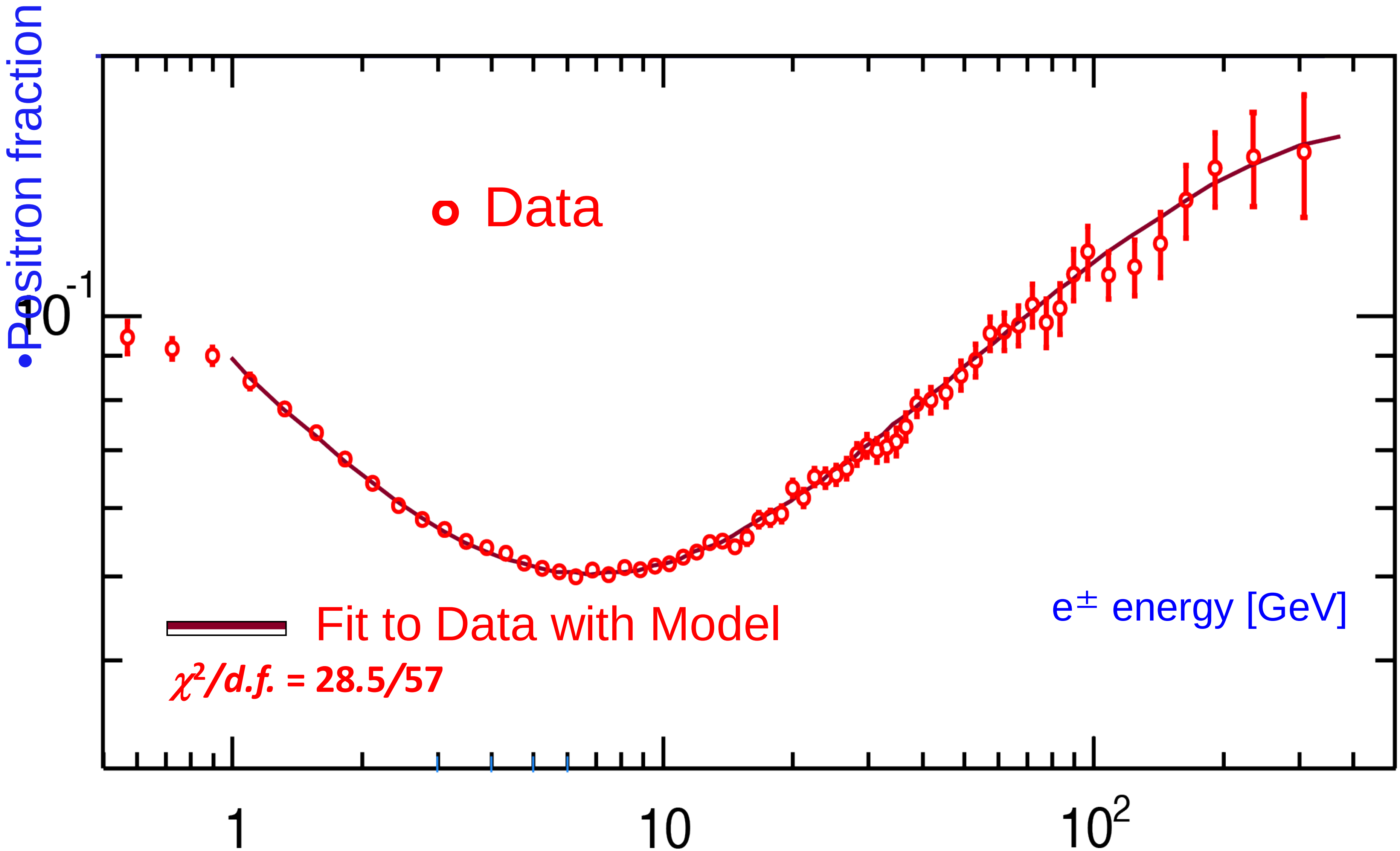
•**$\gamma_{e-} - \gamma_{s} = 0.66 \pm 0.05$**, *i.e.*, the source spectrum is more energetic than the diffuse electron spectrum;

•**$C_{e+}/C_{e-} = 0.091 \pm 0.001$**, *i.e.*, the weight of the diffuse positron flux amounts to ~10% of that of the diffuse electron flux;

•**$C_{S}/C_{e-} = 0.0078 \pm 0.0012$**, *i.e.*, the weight of the common source constitutes only ~1% of that of the diffuse electron flux;

•**$1/E_s = 0.0013 \pm 0.0007\ \mathrm{GeV}^{-1}$**,

corresponding to a cutoff energy of **760^{+1000}_{-280} GeV.**



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.

Summary Positron Fraction

In conclusion, the first 6.8 million primary positron and electron events collected with

AMS on the ISS show:

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

- A steady increase in the positron fraction from 10 to ~250 GeV.
- The determination of the behavior of the positron fraction from 250 to 350 GeV and beyond requires more statistics.
- 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.
- 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 new physics or an astrophysical origin.

Conclusion

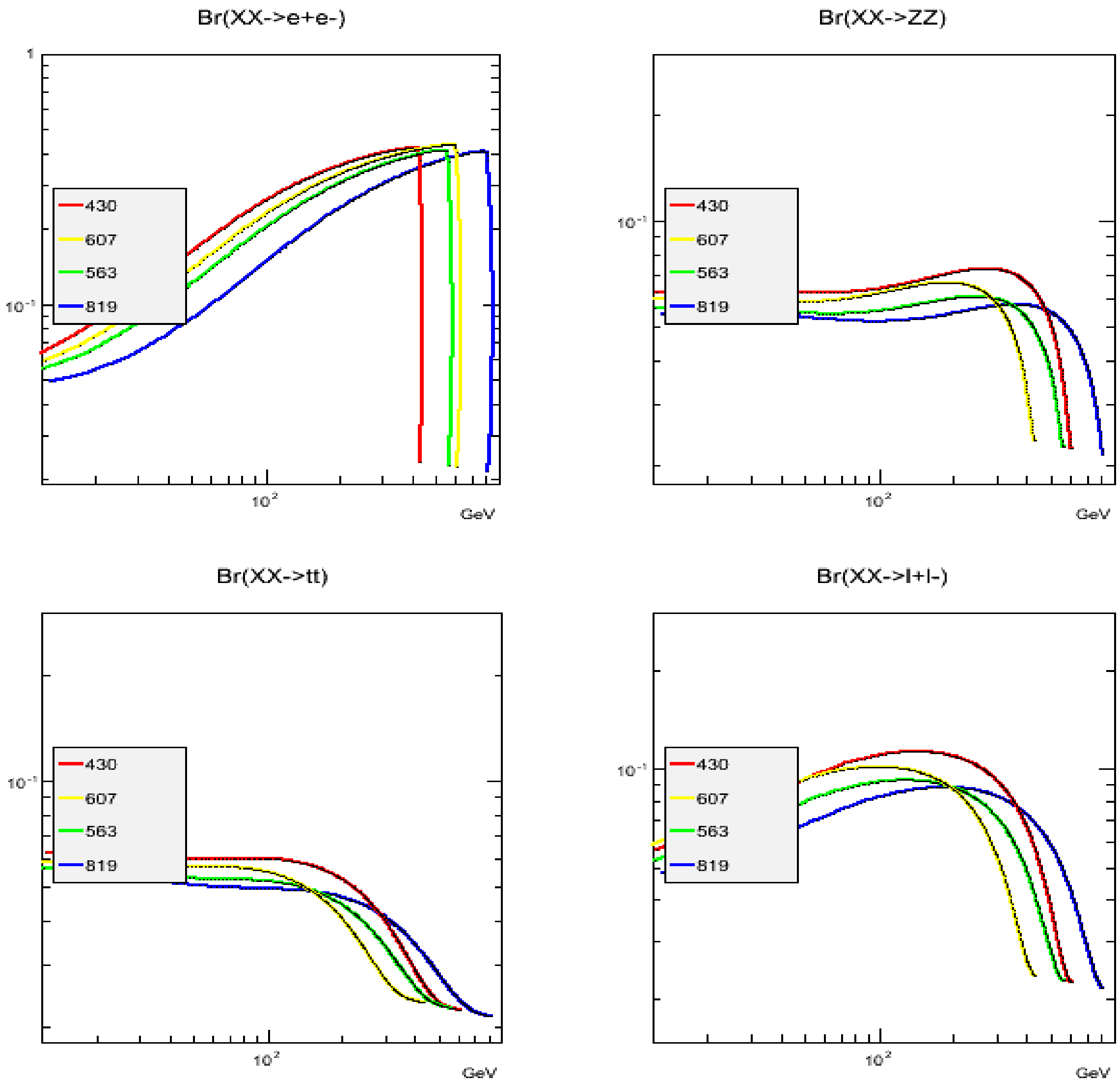
The excess of antimatter (positrons) has been observed for more than twenty years and has aroused much interest.

AMS is the first experiment to probe in detail the nature of this excess with its high sensitivity and precision.

We have observed many new phenomena in this positron spectrum. Soon, the origin of this excess will be understood.

It is very difficult in accelerators to do a 1% accuracy experiment. To do so in space is extremely challenging. It is the effort of the entire AMS collaboration with the support of NASA and CERN which is making this possible.

Positron fractions for different DM annihilation modes



Micromegas,

G. Belanger et al.

-Location Energy Cut off

- spectrum shape

On the origin of excess positrons

If the excess has a particle physics origin, there should be no anisotropy.

•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

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

where $r_\mathrm{e}(b,l)$ denotes the positron ratio at (b,l); $< r_\mathrm{e} >$ 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

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

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

$\delta \leq 0.036$ at the 95% confidence level