Updates on AMS-02

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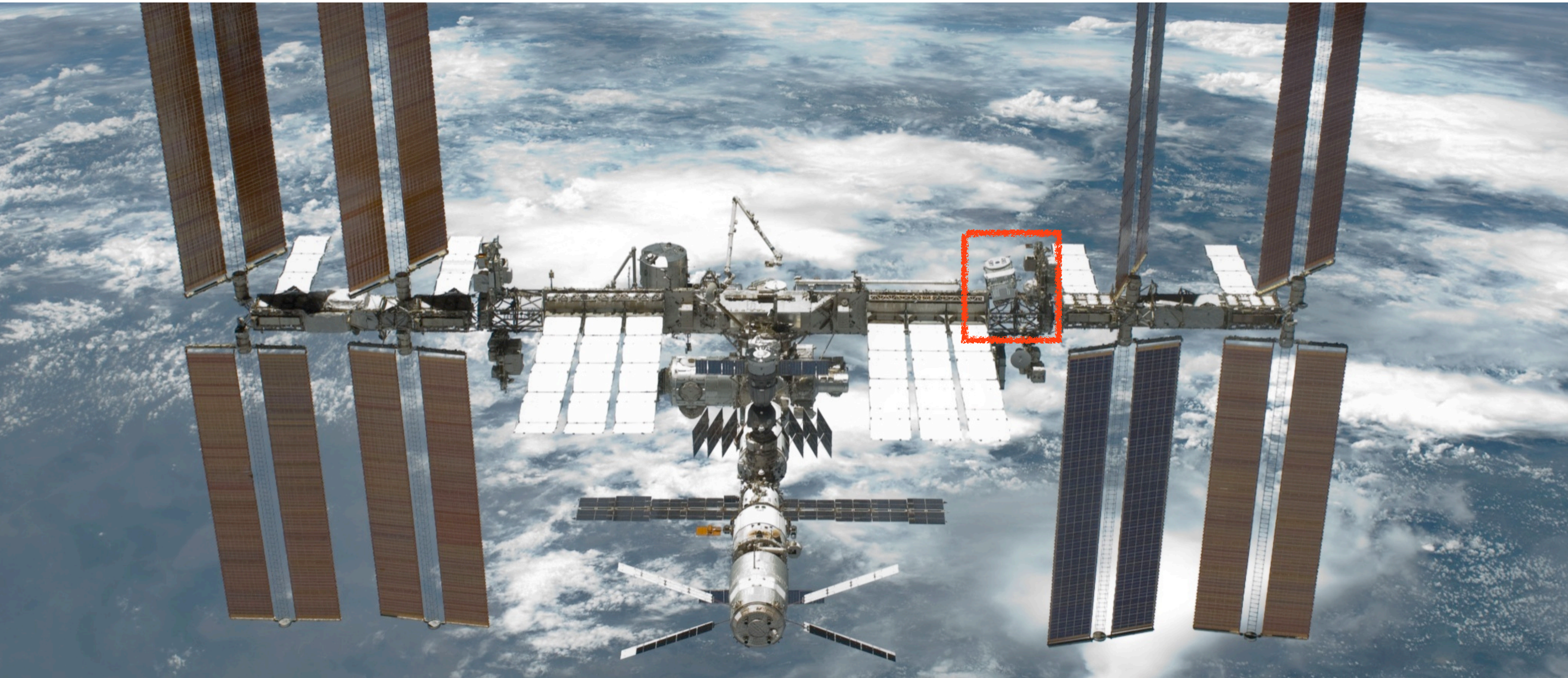
AMS is a US DOE led International Collaboration

Spokesperson: Nobel laureate Prof. Dr. S. Ting from MIT



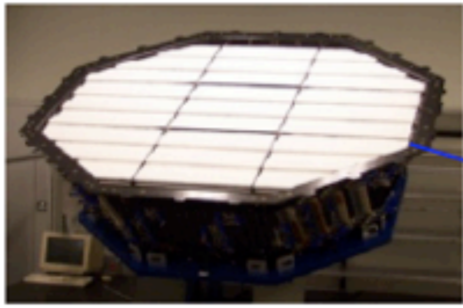
AMS-02 has been installed on the International Space Station on May 19th 2011

5 m x 4 m x 3 m

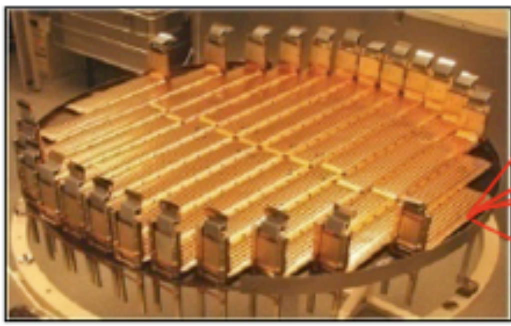
7.5 tons

AMS consists of 5 sub-detectors which provide redundant information for particle identification

Identify e+, e-

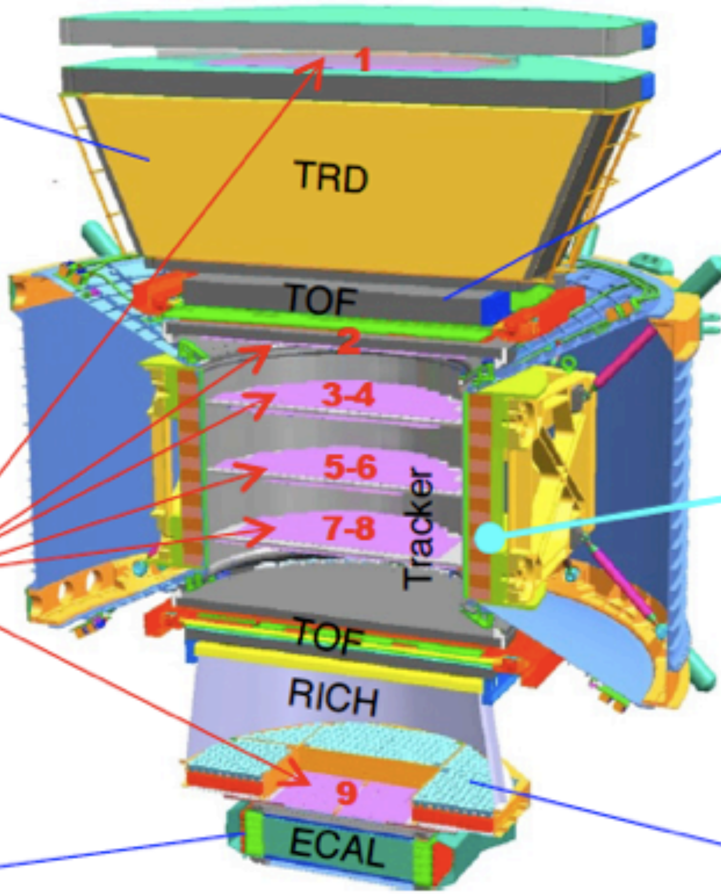


Silicon Tracker
Z, P



ECAL
E of e+, e-, γ

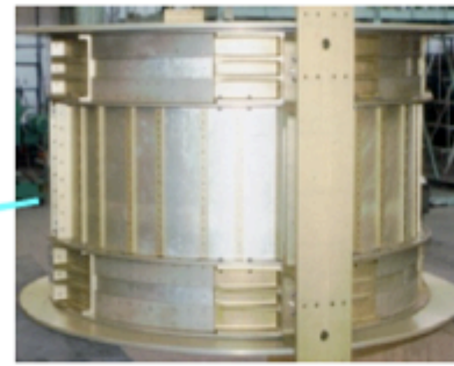
Particles and nuclei are defined by their charge (Z) and energy (E ~ P)



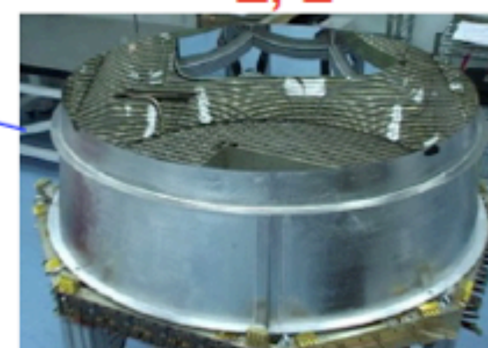
Z, P are measured independently by the Tracker, RICH, TOF and ECAL

TOF
Z, E

Magnet
±Z



RICH
Z, E



Scientific goals of AMS on the International Space Station

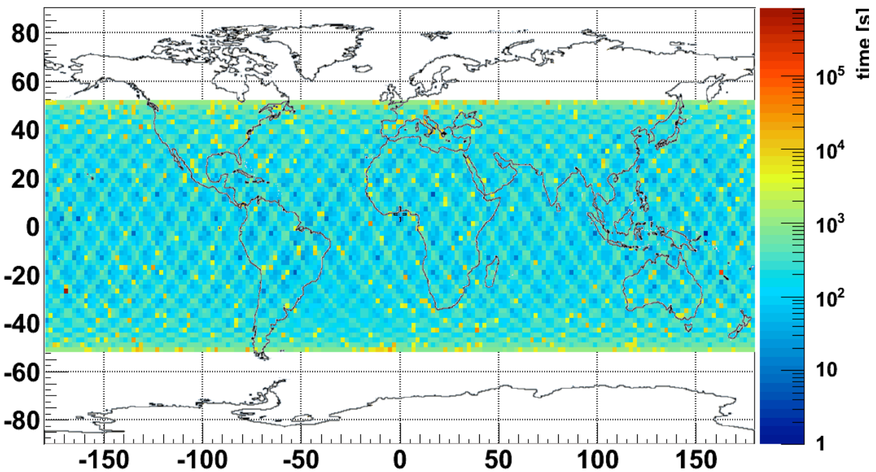
- Indirect search of Dark Matter: simultaneous observation in several signal channels... e+ , antiprotons, γ, antideuterons
- Measuring CR spectra up to the iron – refining propagation models;
- Solar modulation on CR spectra over 11 year solar cycle
- Solar activity
- Direct search of primordial antimatter: Anti He, Anti C ...
- New forms of matter: strangelets
- Identification of local sources of high energy photons: SNR, Pulsars, ...

Main analysis currently on going:

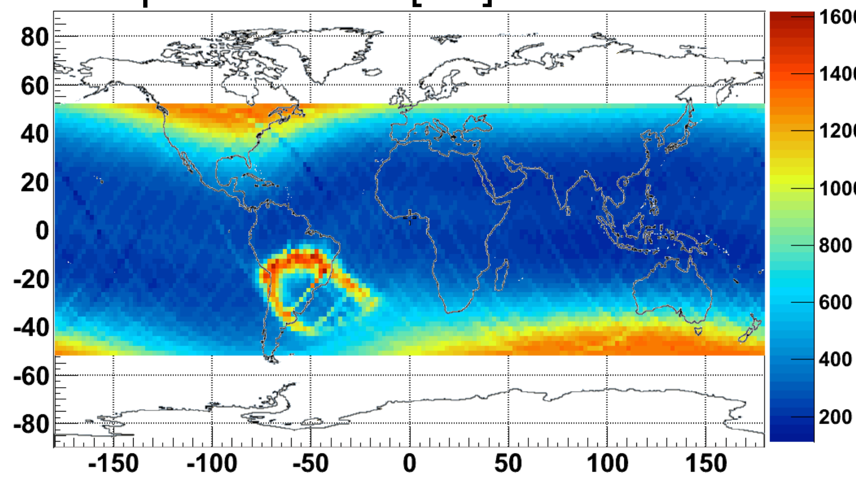
- Positron fraction
- B/C
- P, He, electron ... fluxes
- Monitor of the solar activity

AMS-02 Orbital parameters

Time at location [s]

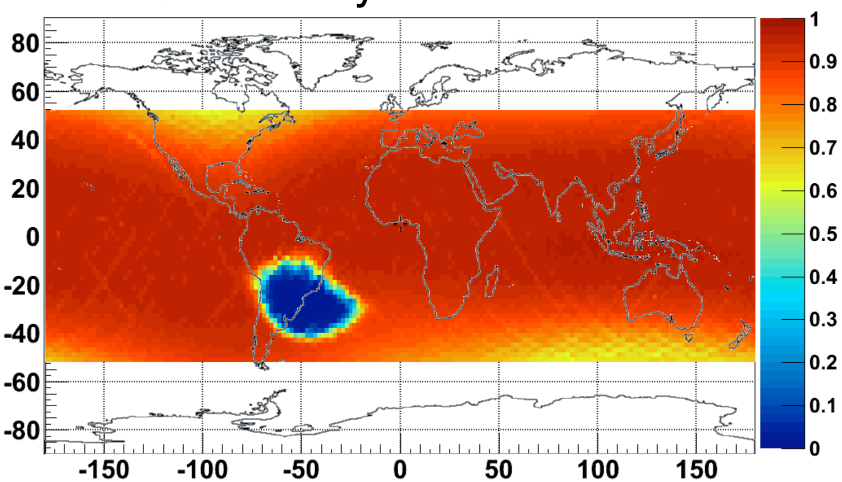


Acquisition rate [Hz]

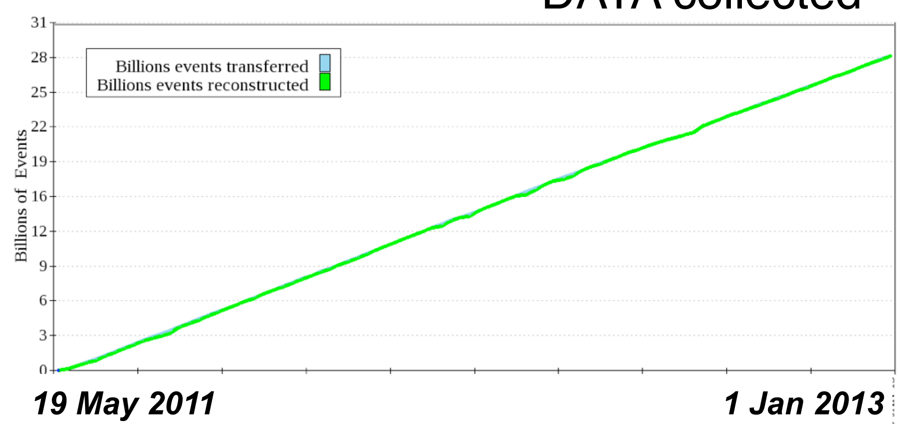


Particle rates vary from 200 to 2000 Hz per orbit

DAQ efficiency



DATA collected



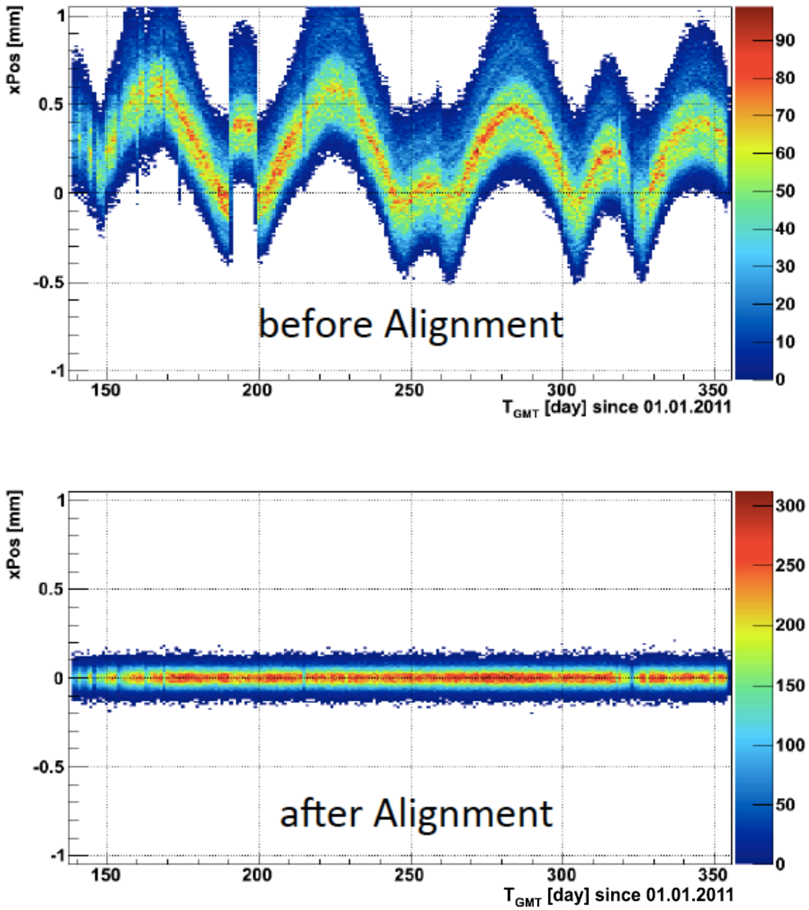
Average DAQ efficiency 85%
Average DAQ rate ~800Hz

28 billion events collected in 18 moths

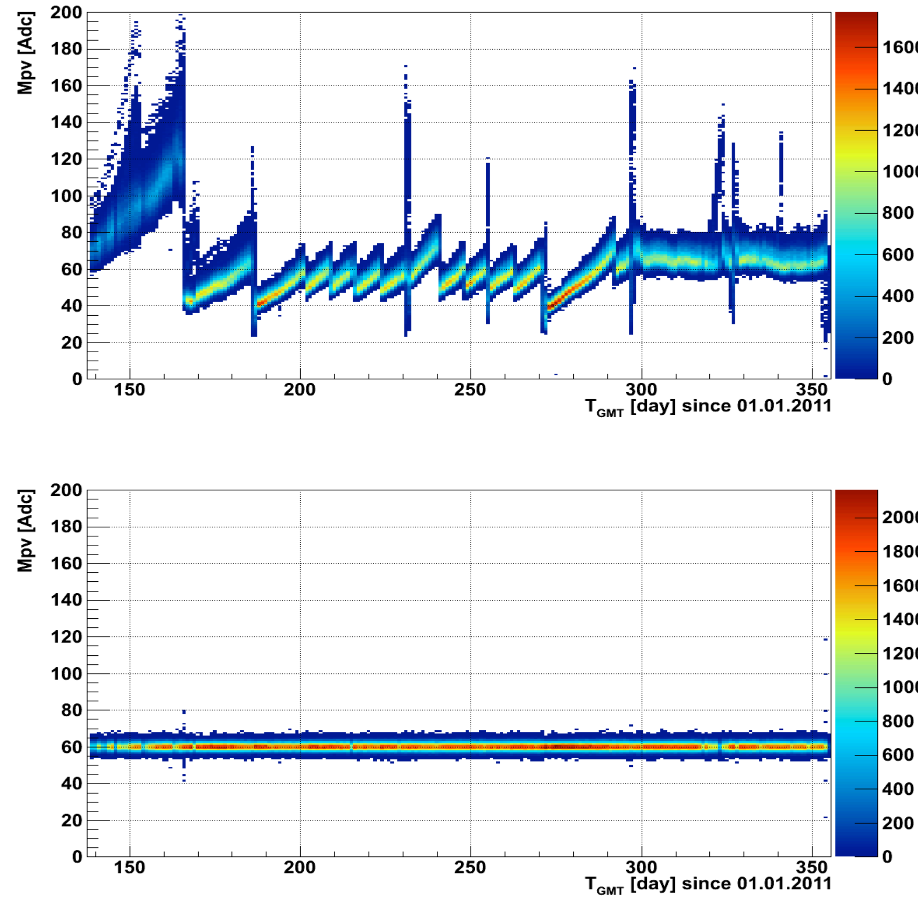
60 TB raw events (Downlink 10 Mbit/s)

TRD offline calibration

TRD alignment

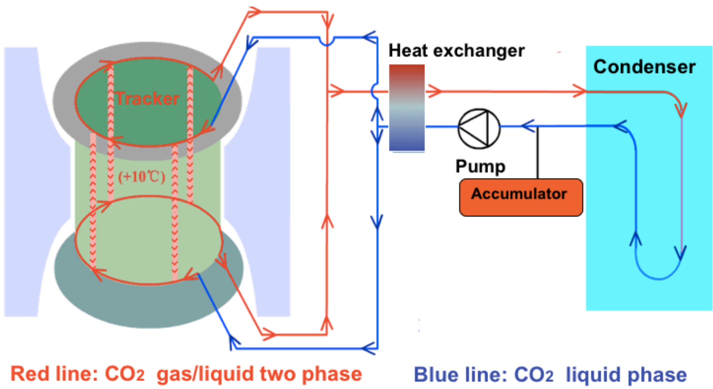


TRD gain calibration



Cosmic protons are used for alignment to an accuracy of 0.04 mm for each straw module and used to calibrate the detector response to 3% accuracy.

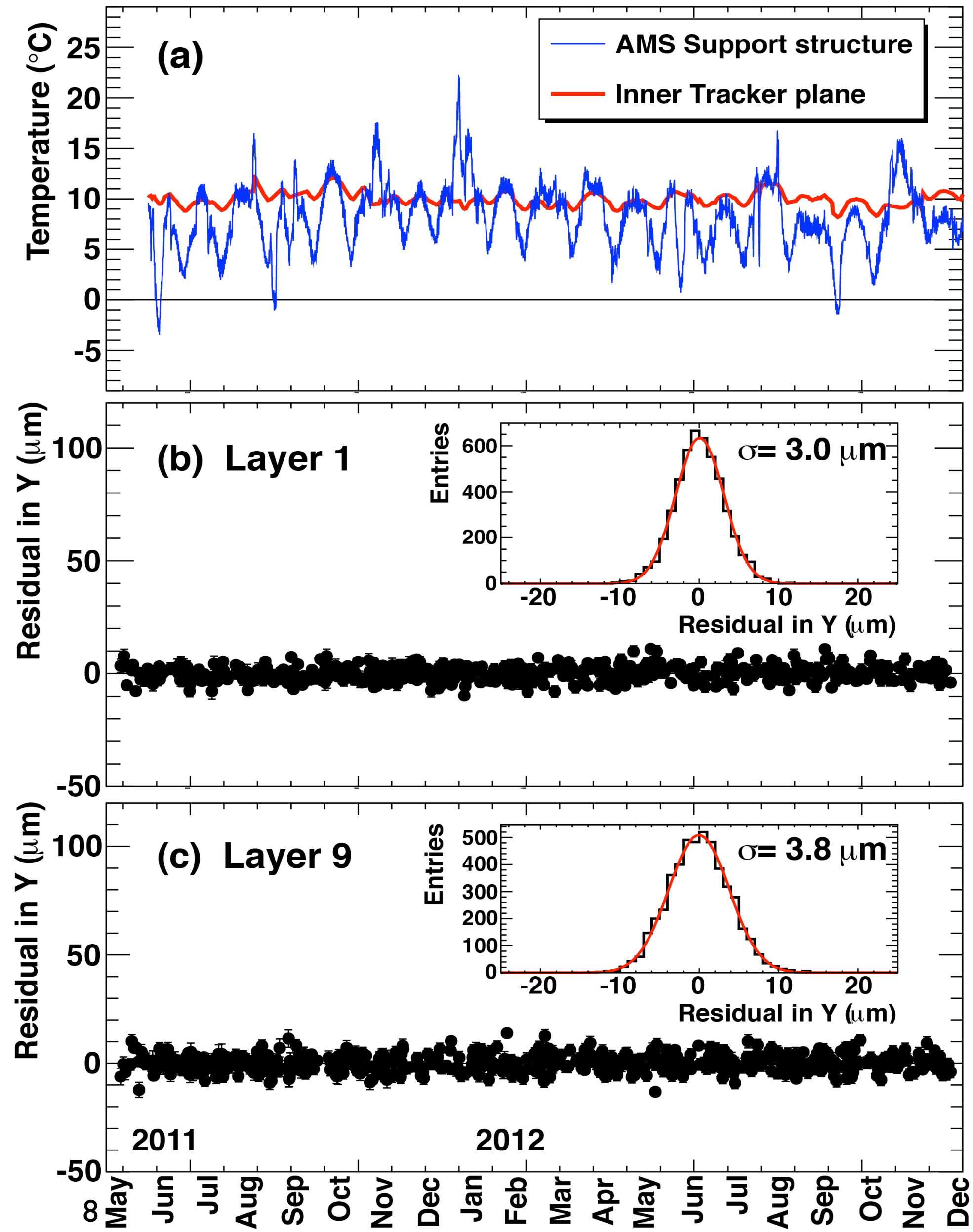
Tracker layers thermal stability



Tracker Thermal Control System

Coordinate resolution on each plane is measured with 10 μm in the bending direction.

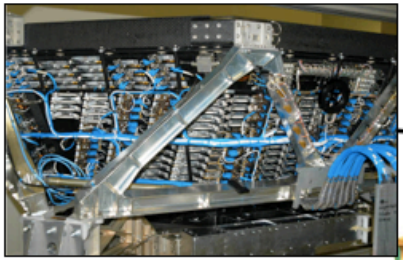
Position of ladders in the external layers are dynamically aligned to an accuracy of 3 μm.



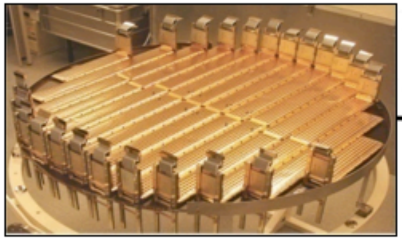
Positron identification and Proton rejection

e^+ low signal and high P background: P ~ ($10^3 \div 10^4$) e^+
P rejection factor: $10^5 \div 10^6$ to identify e^+ with an error at % level

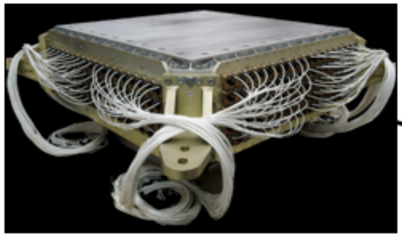
TRD
Distinguish between electrons and protons

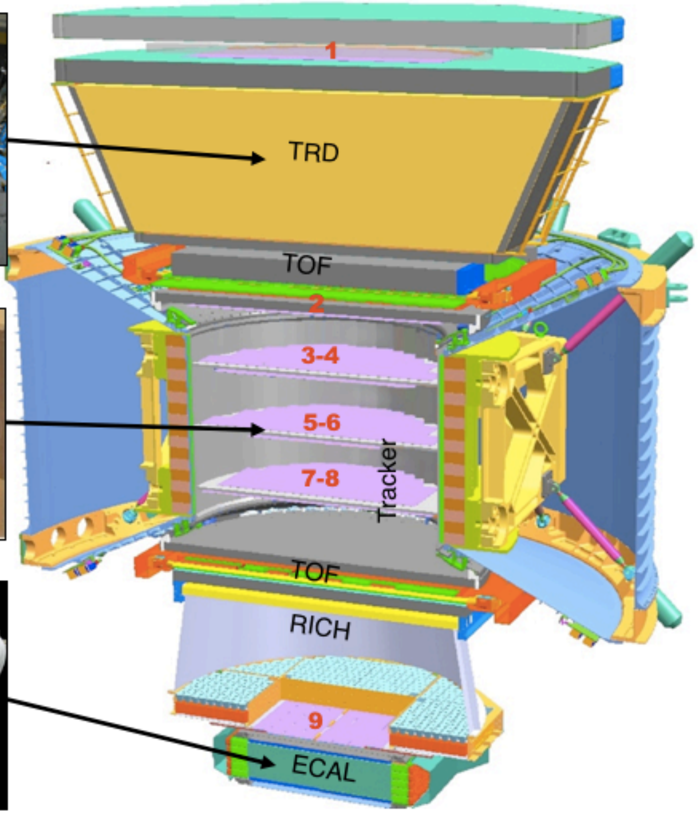


SILICON TRACKER and MAGNET measure the sign and the rigidity



ECAL
measures the energy,
Identifies 3D characteristic positron shower and rejects hadronic showers

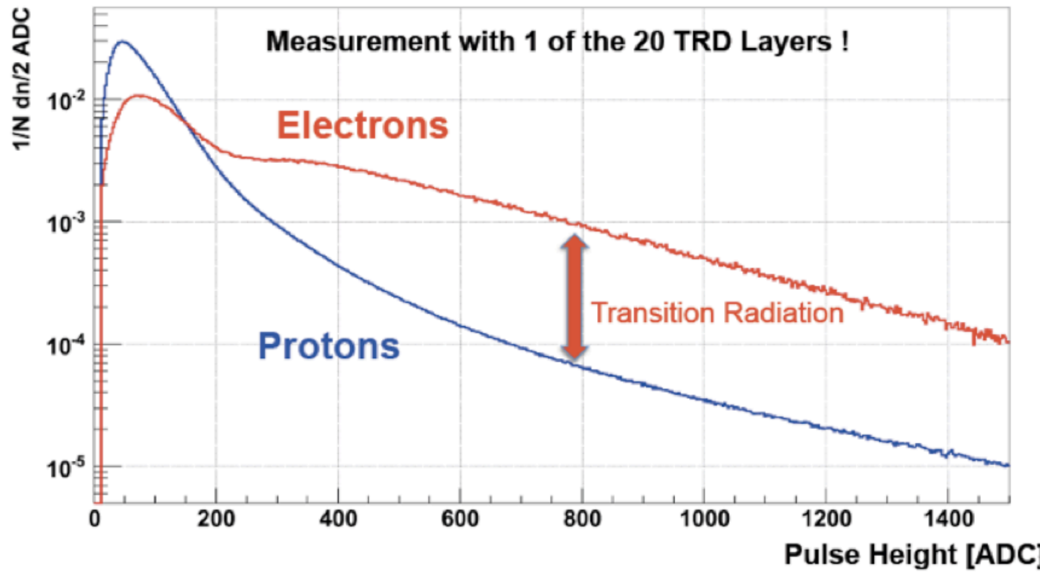


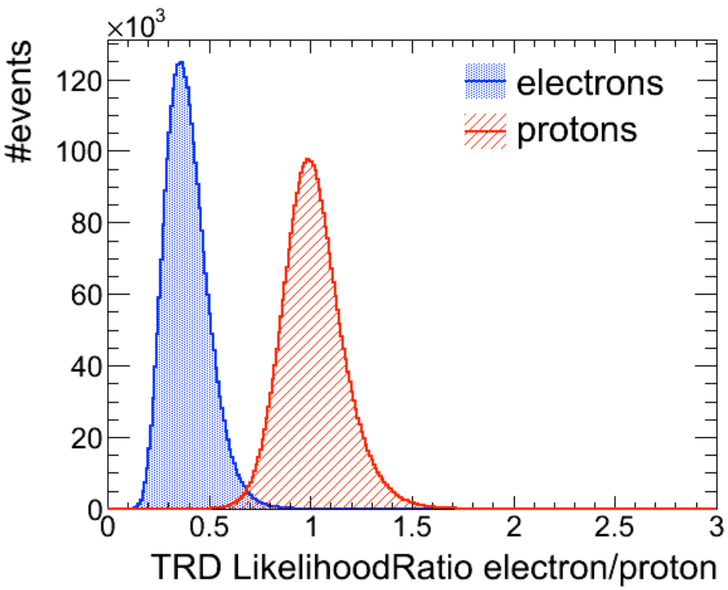


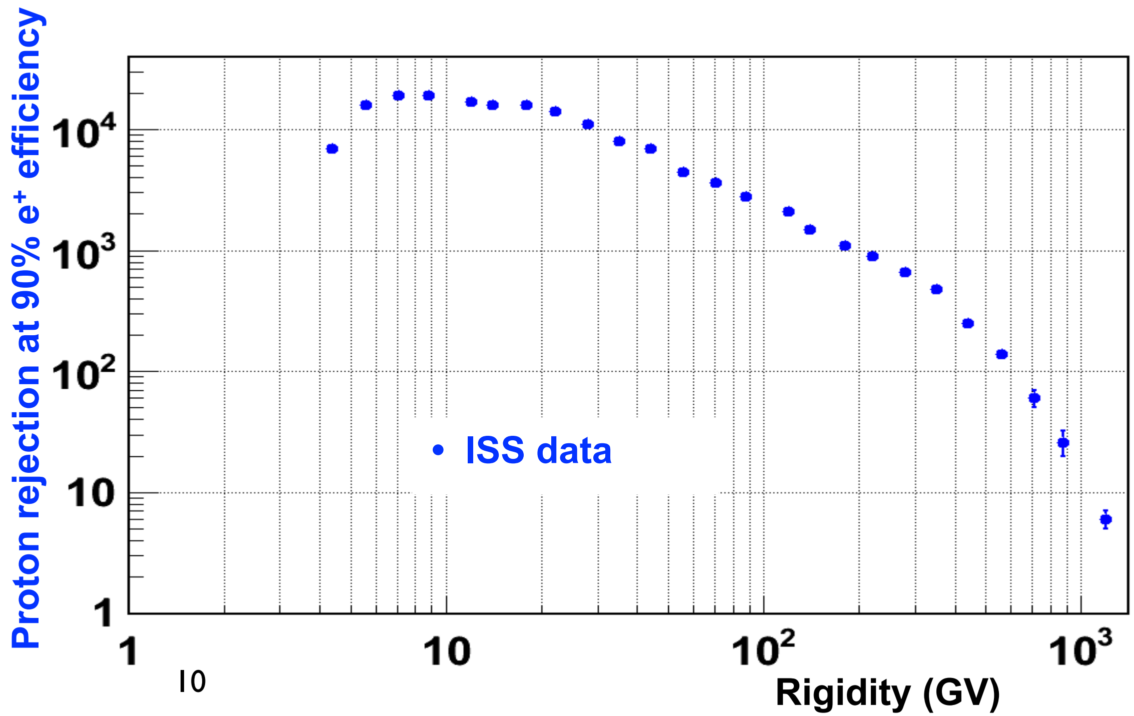
Total rejection of proton 1,000,000
Verified at test beam at CERN

TRD Proton rejection

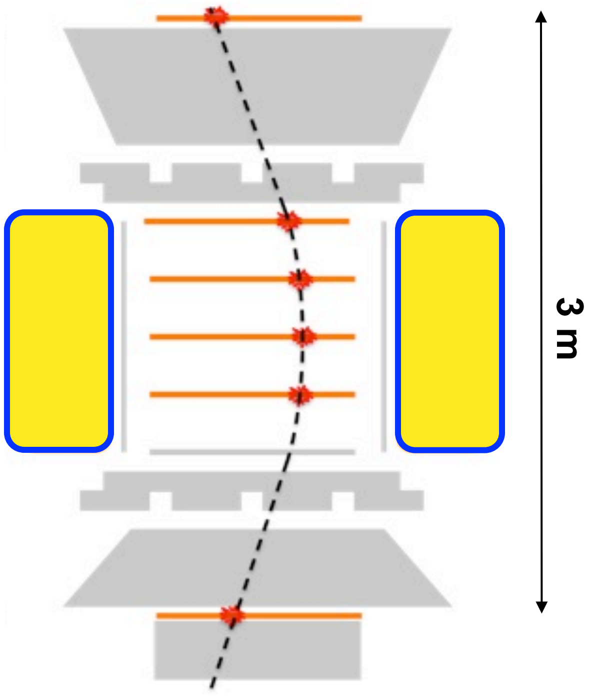
Signals from 20 layers are combined in a likelihood estimator which allows an efficient discrimination of proton background

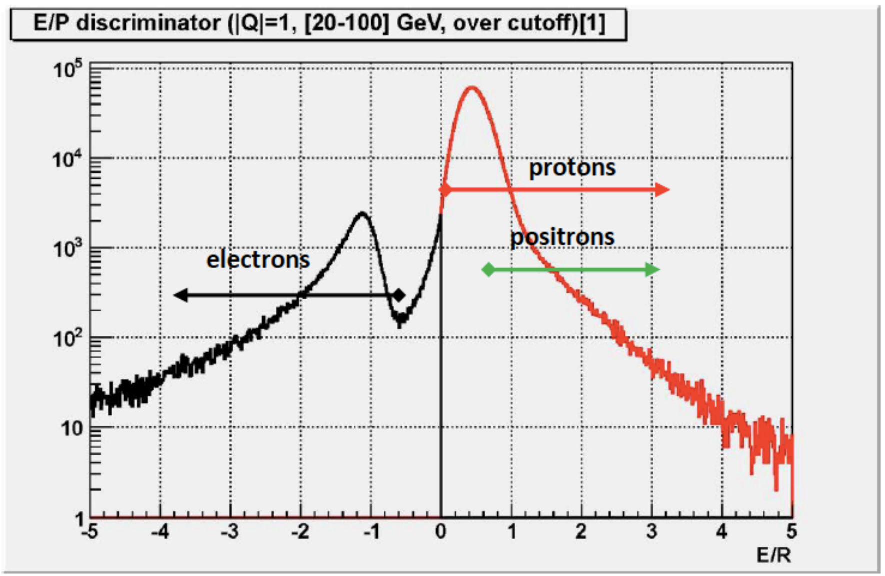






Tracker e+ and e- identification and P rejection





A fit of particle trajectory is used to measure the sign of the particle and its rigidity:

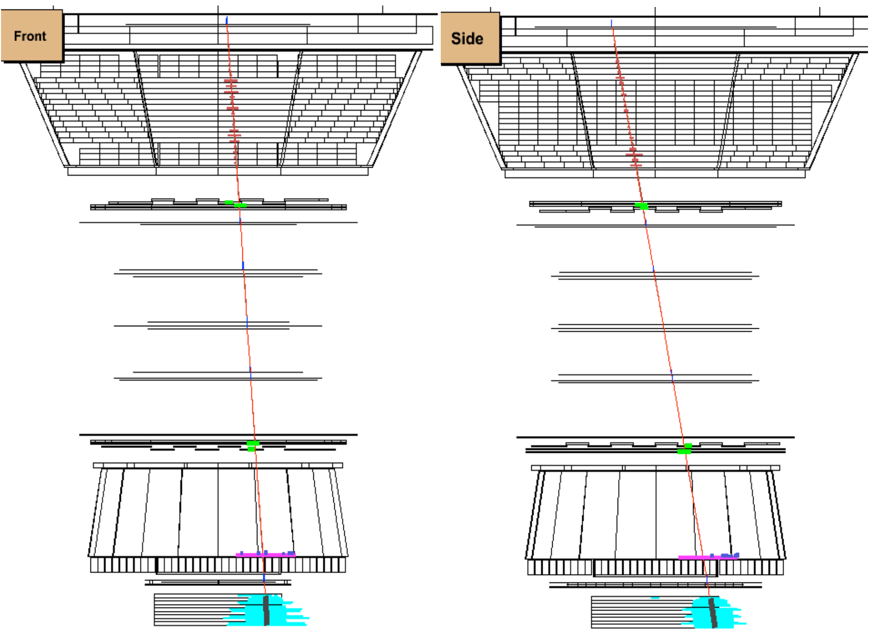
1) Used to suppress e-

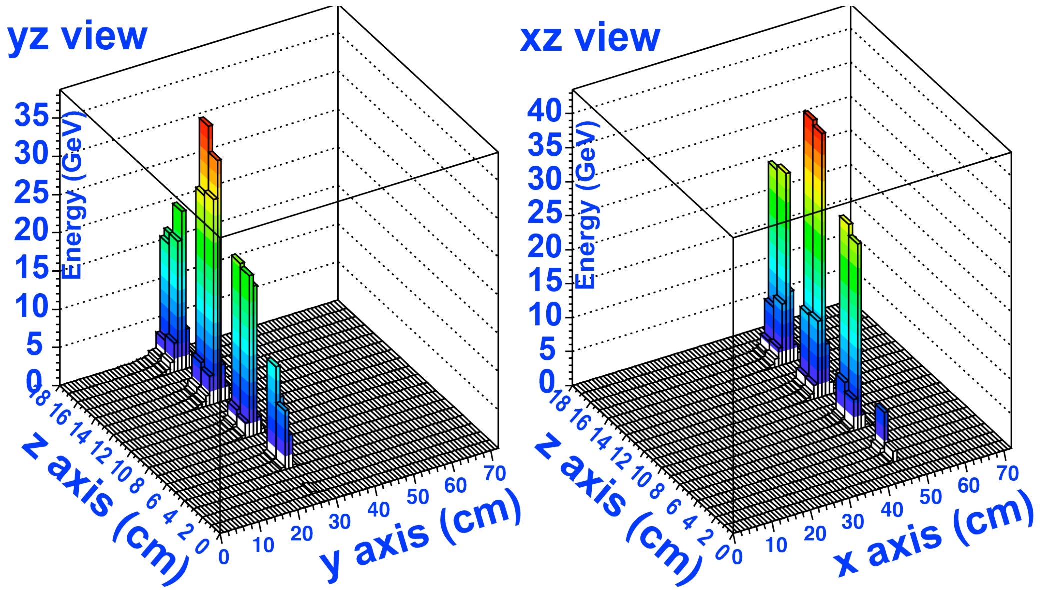
2) compared to the energy E measured by ECAL to suppress P.

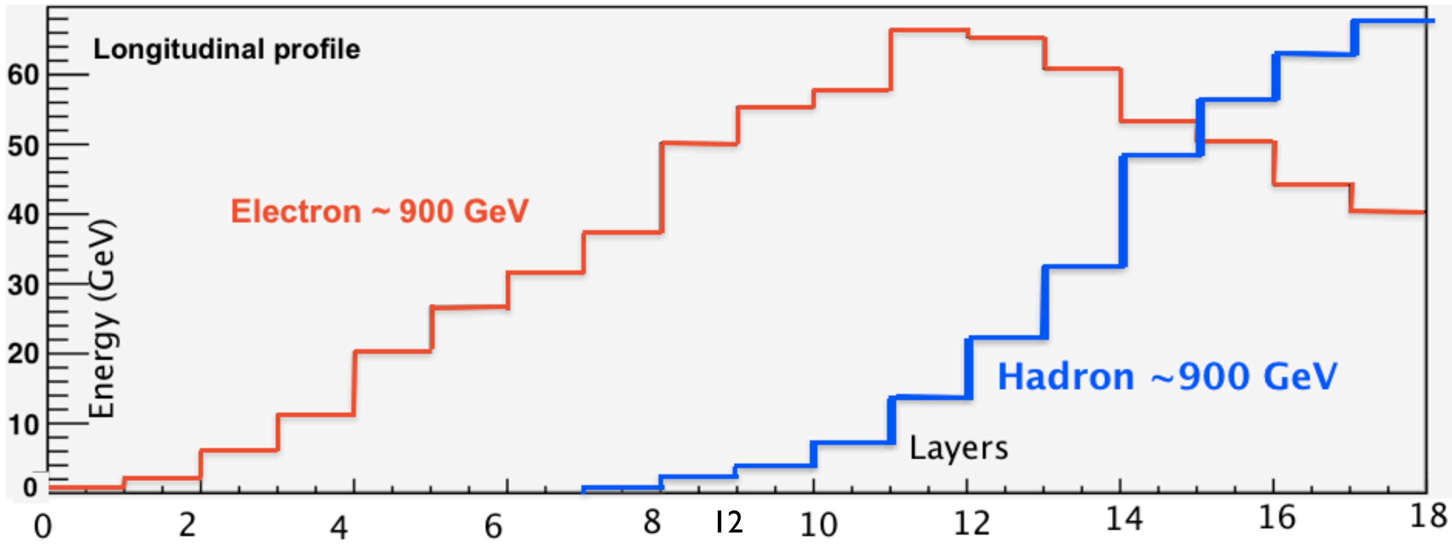
The Electromagnetic Calorimeter

Positron E=636 GeV

17 radiation length



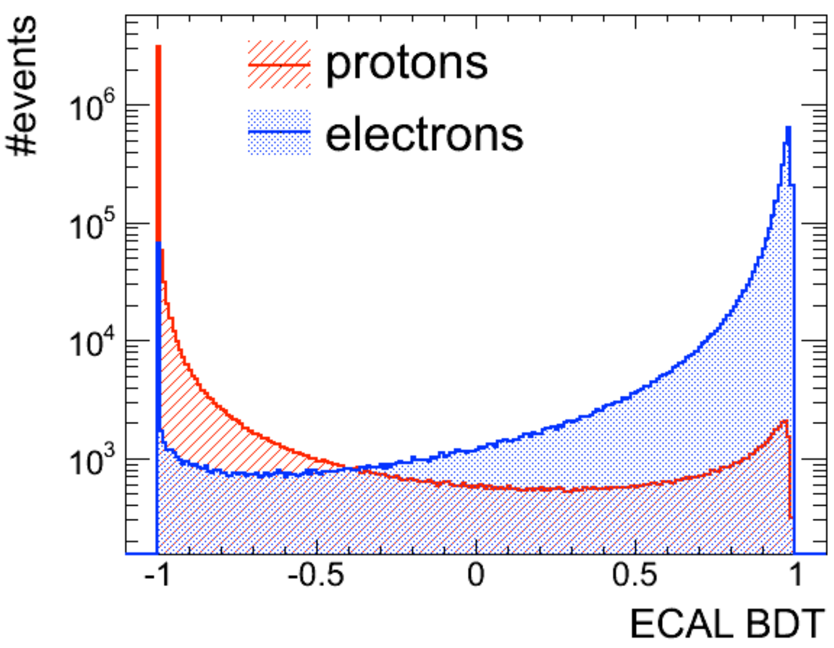


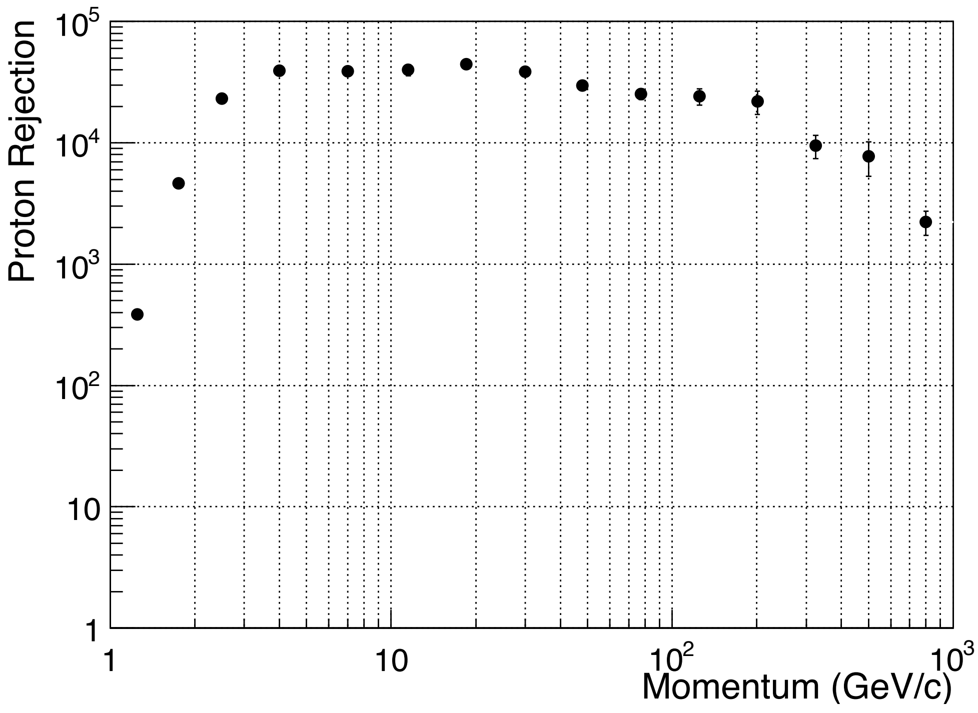


ECAL performance on ISS

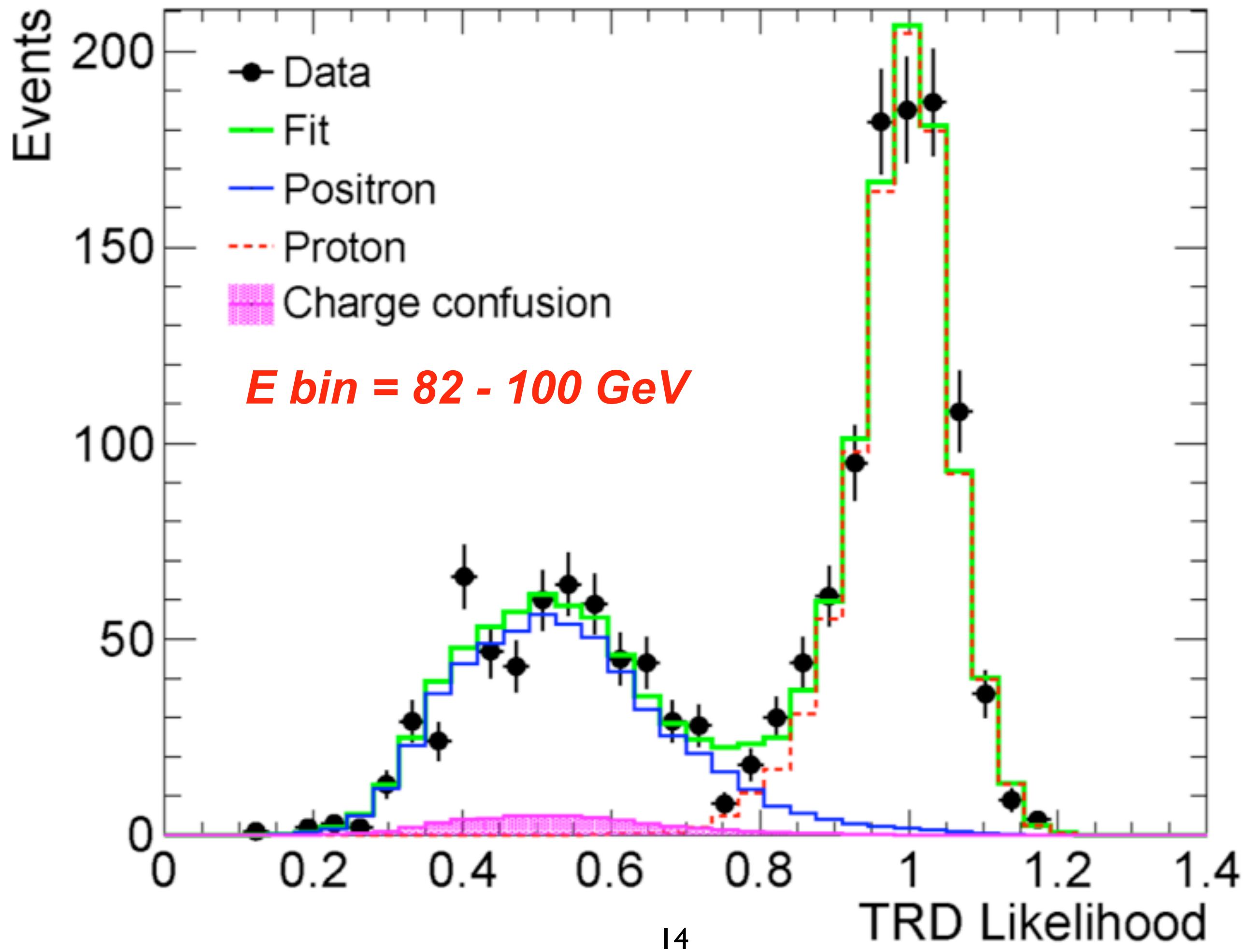
A Boosted Decision Tree (BDT) is constructed on the basis of the shower shape in the ECAL to distinguish protons and electrons.

BDT and E/p matching combined give a Proton Rejection of 10^4

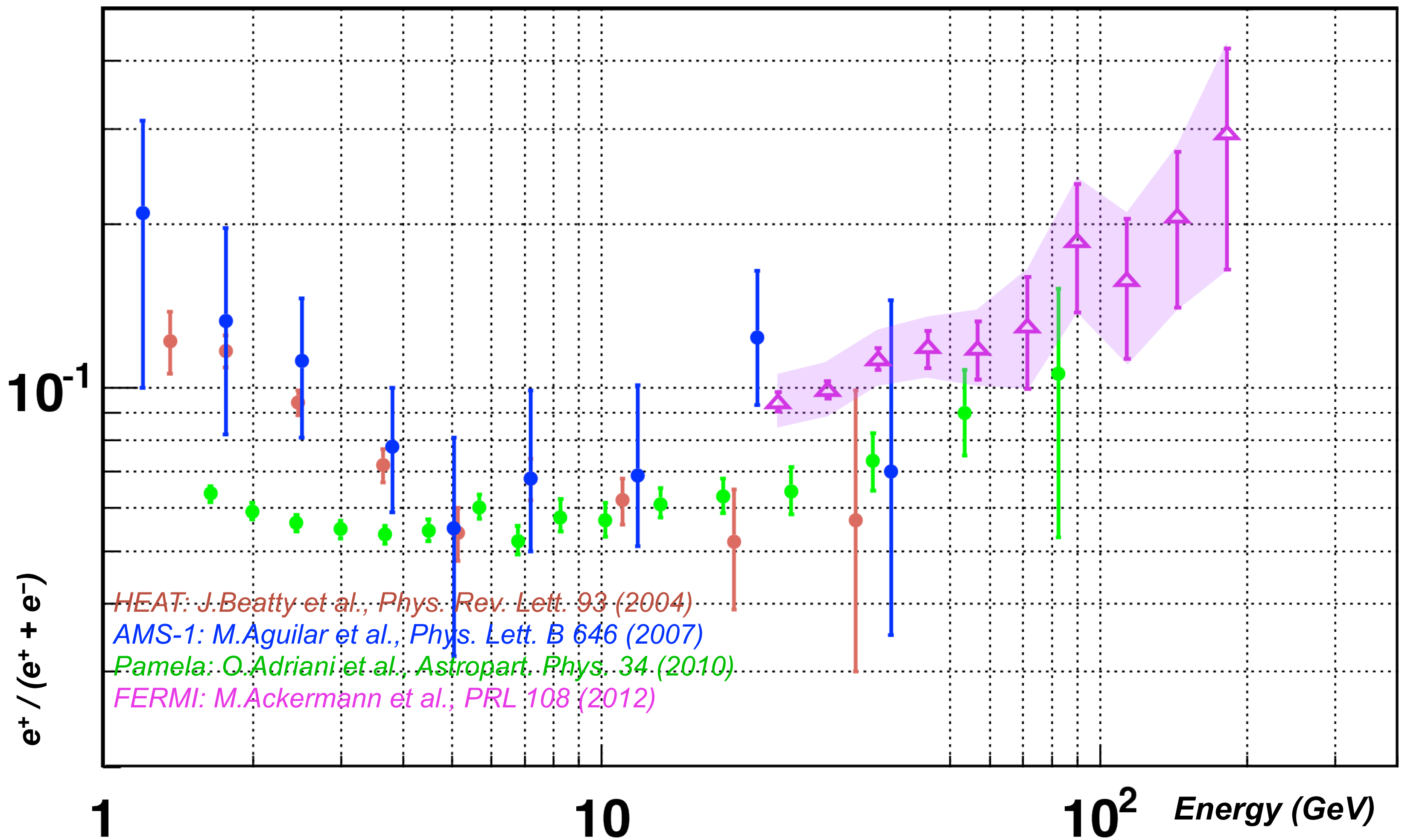




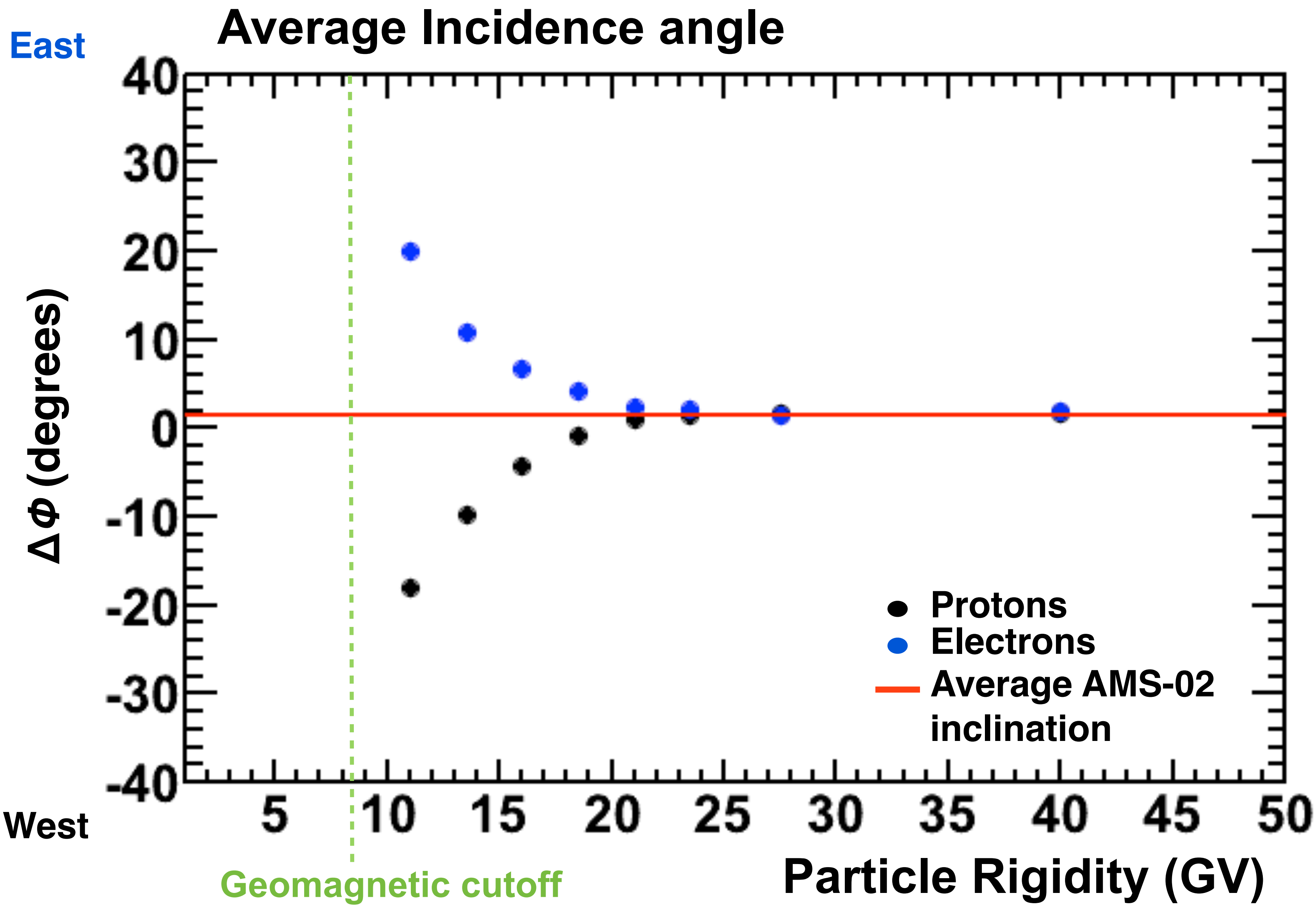
The TRD Likelihood shows clear separation between protons and positrons with a small charge confusion background



AMS-02 Positron Fraction will be published soon



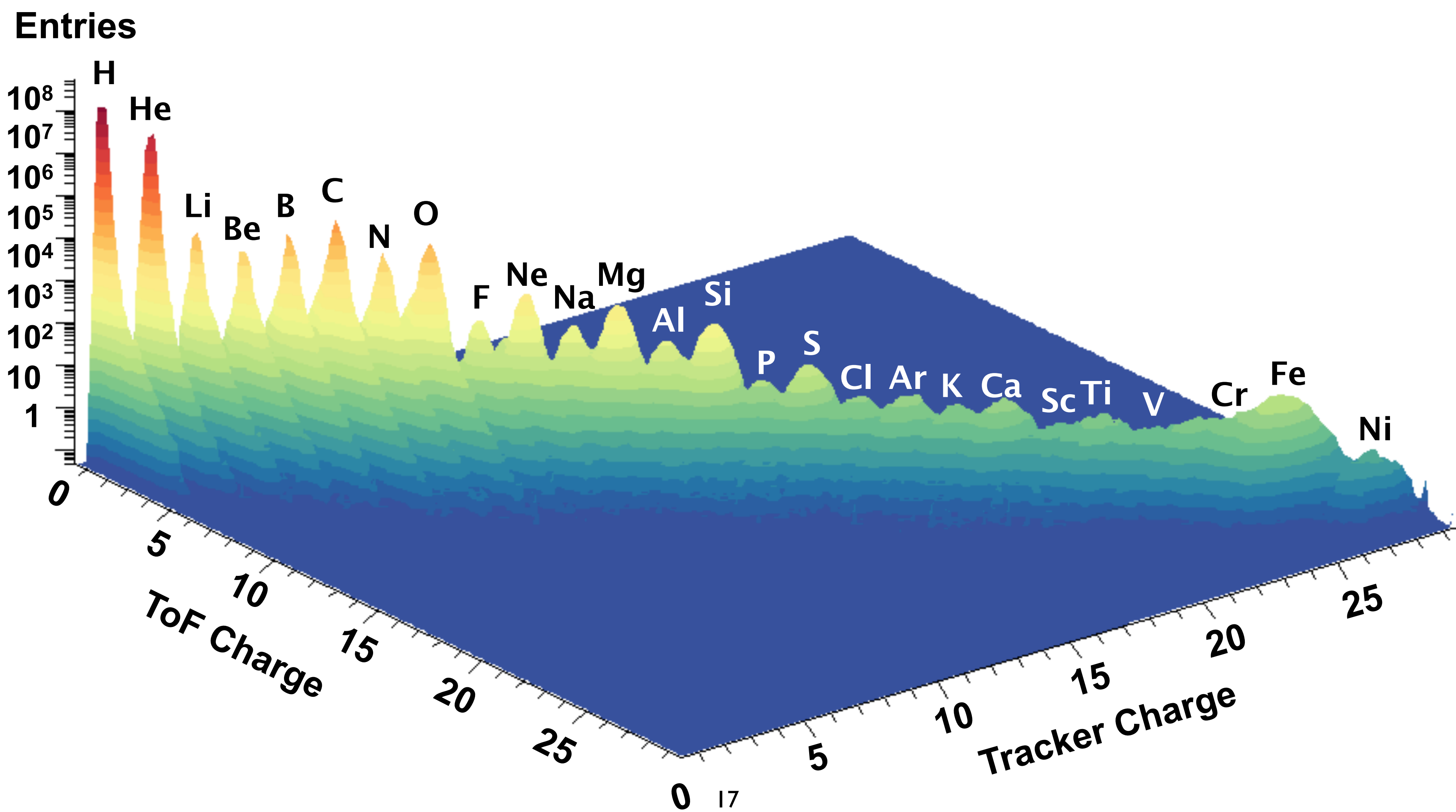
East - West effect



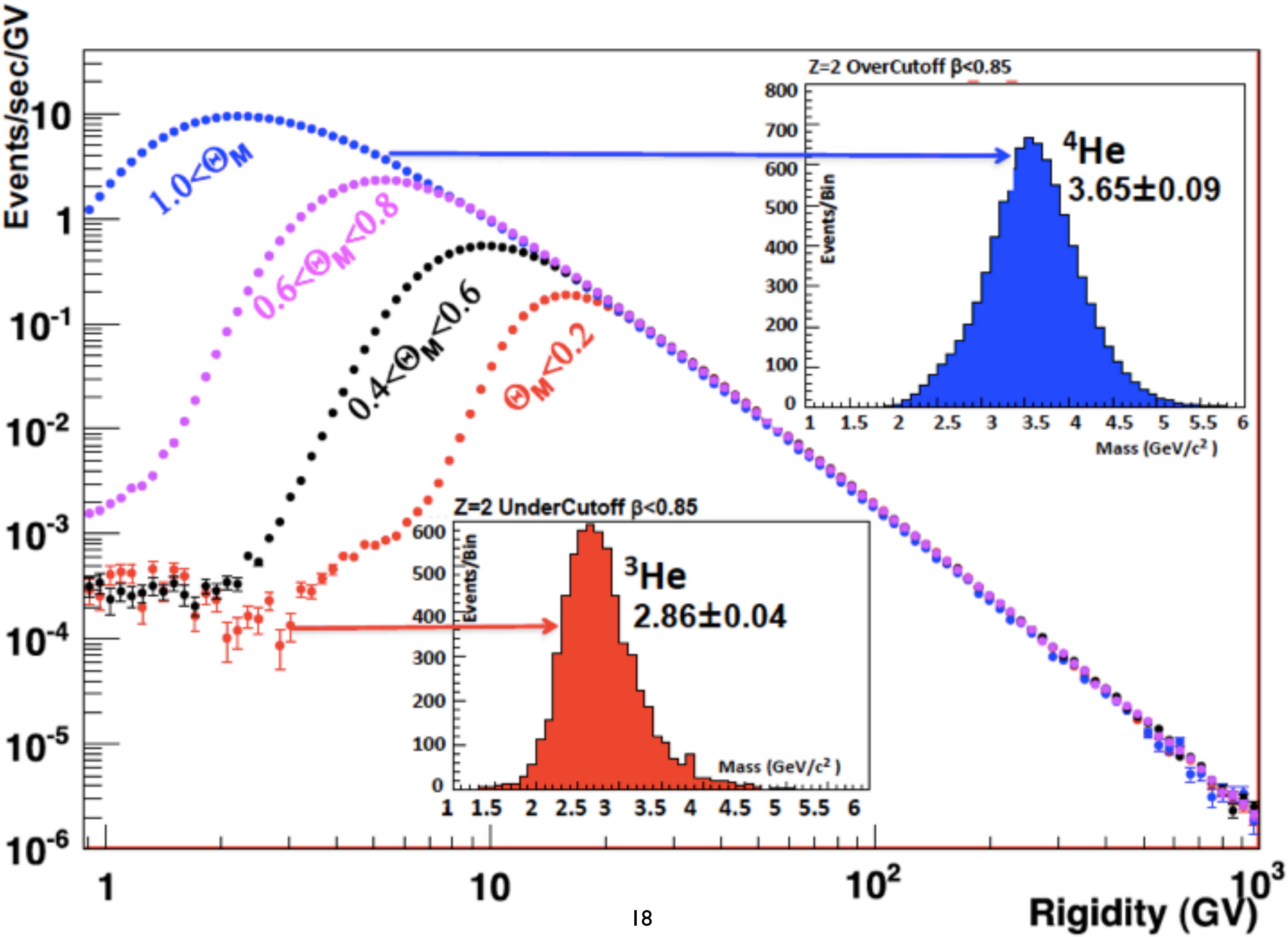
AMS Nuclei Measurement on ISS

Accurate Study of the composition of the cosmic rays

Multiple Independent Measurements of the Charge (|Z|)



Helium rate

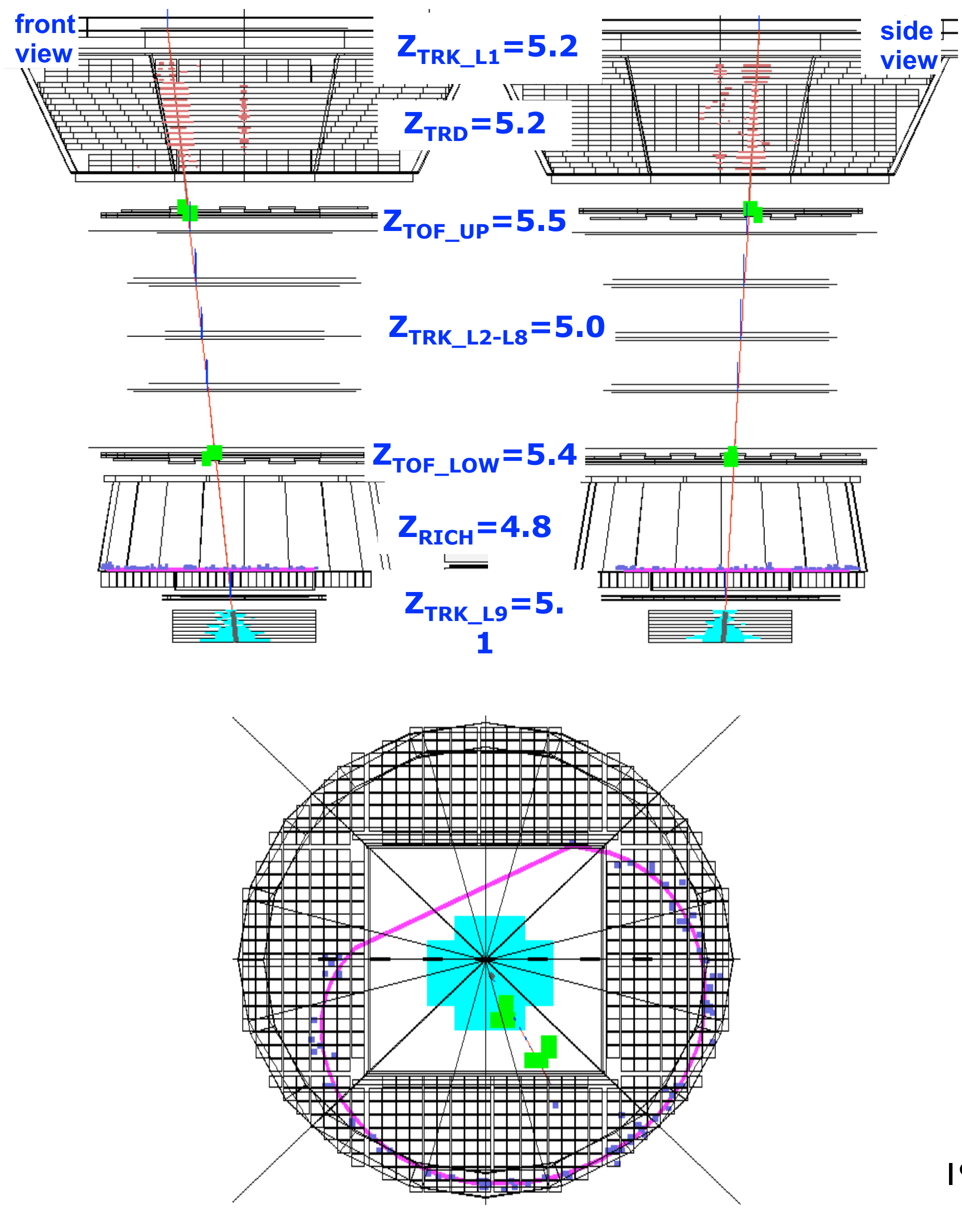


Events/sec/GV
10
1
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
1.0<Θ_M
0.6<Θ_M<0.8
0.4<Θ_M<0.6
Θ_M<0.2
Z=2 OverCutoff β<0.85
Events/Bin
Mass (GeV/c²)
⁴He
3.65±0.09
Z=2 UnderCutoff β<0.85
³He
2.86±0.04
1
10
10^2
10^3
Rigidity (GV)

Boron and Carbon

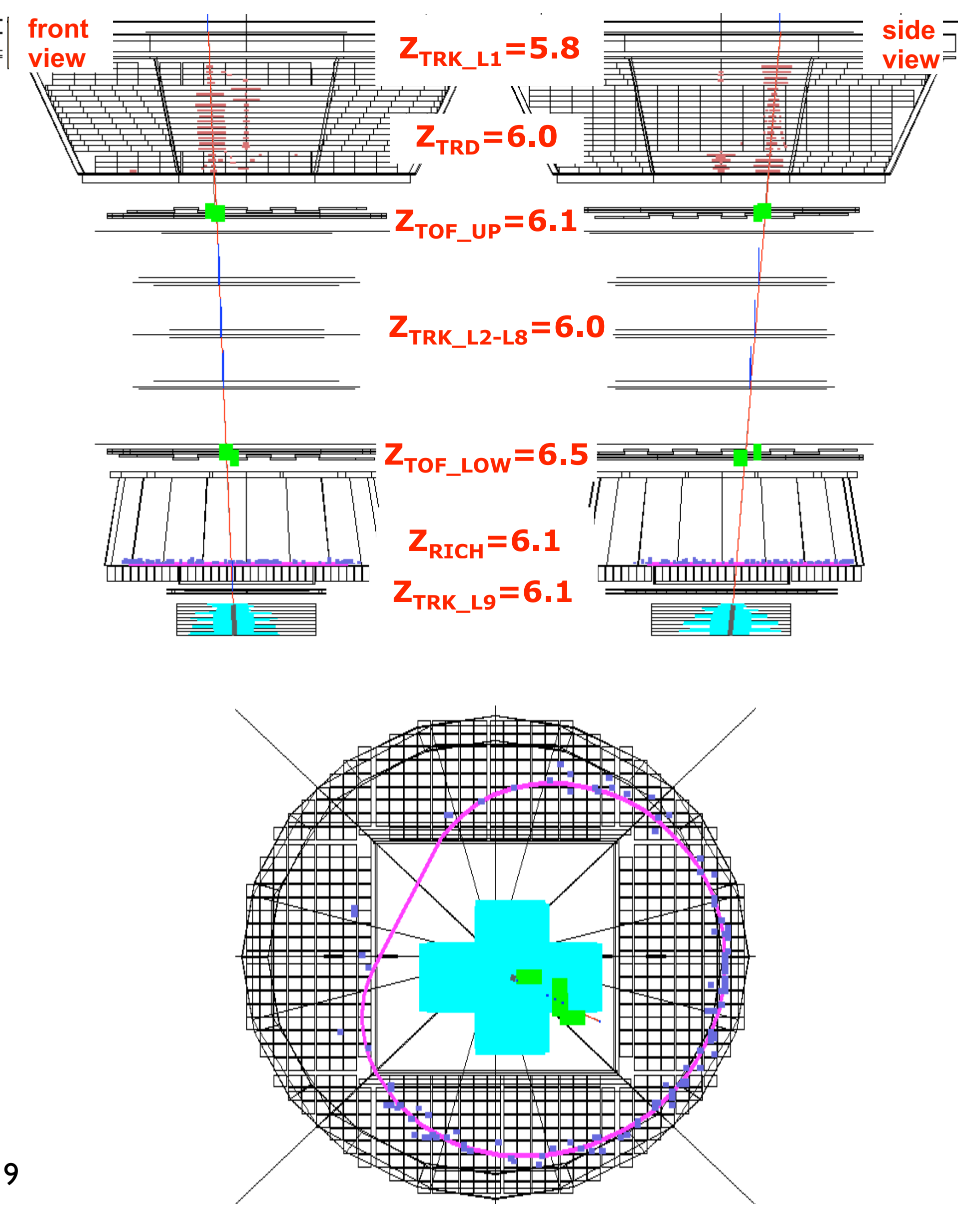
Boron

Rigidity=680 GV



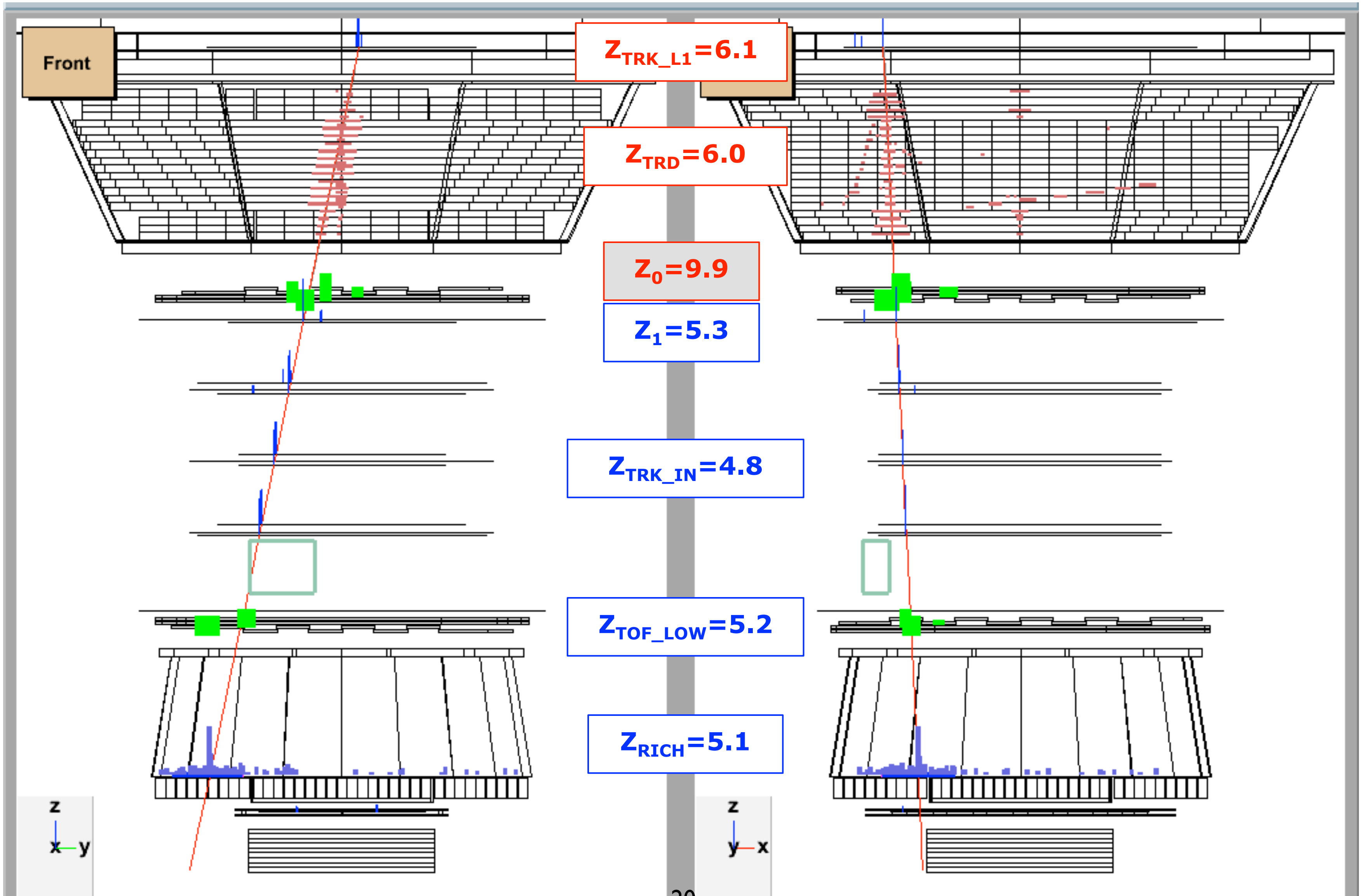
Carbon

Rigidity=666 GV

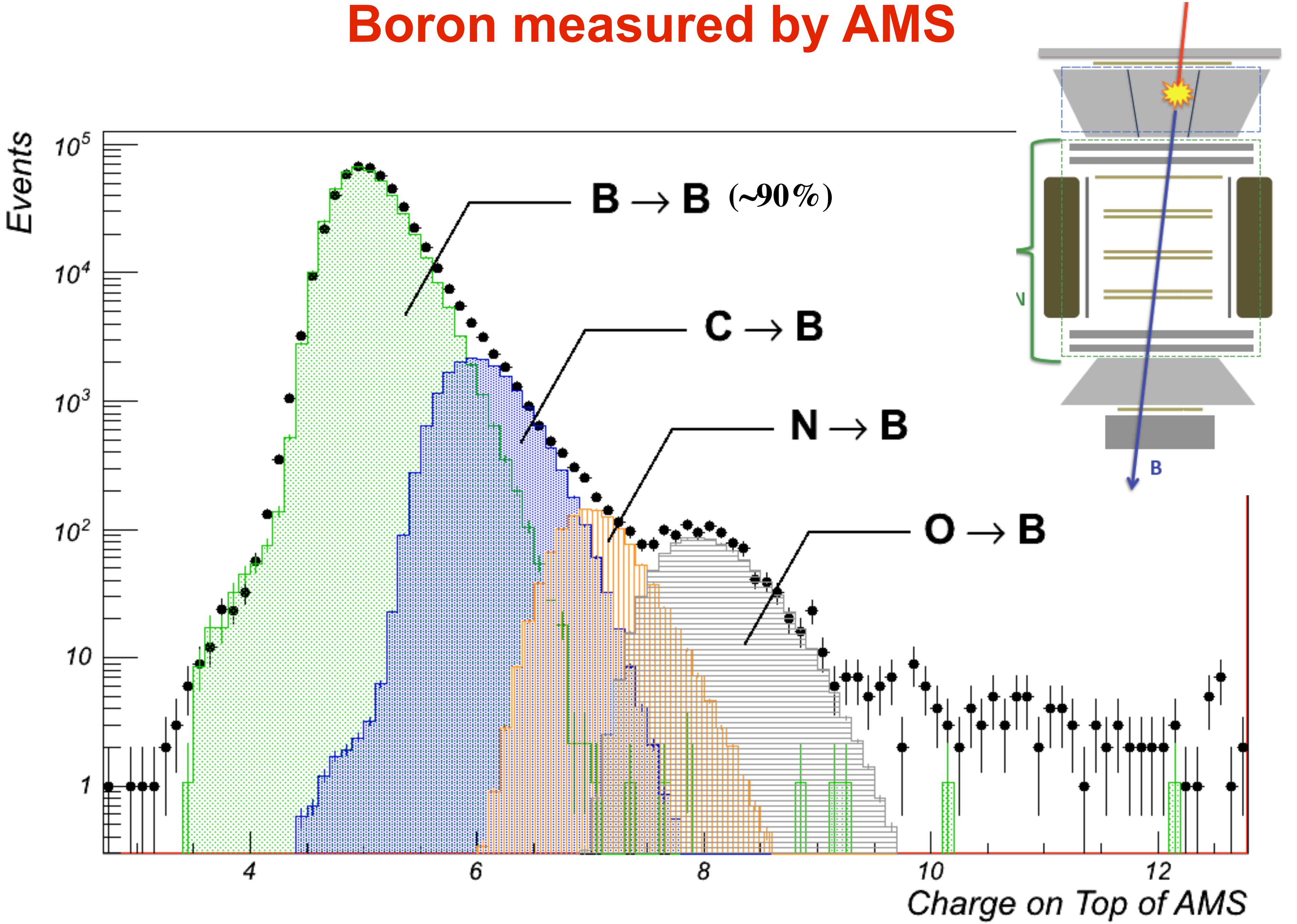


Carbon Fragmentation to Boron in Upper TOF

Rigidity 10.6 GV



Boron measured by AMS



Conclusions

• AMS02 is in on the ISS since May 19th 2011 and all the detectors are properly functioning

• Detector calibration (alignment, e/p rejection, charge id, etc.) are well advanced

• Data analysis is in progress (positron fraction, P and He fluxes, B/C ratio, gamma)

• 10+ years on board the ISS at 10^9 events/year will provide enormous sensitivity and statistic: great physics potential

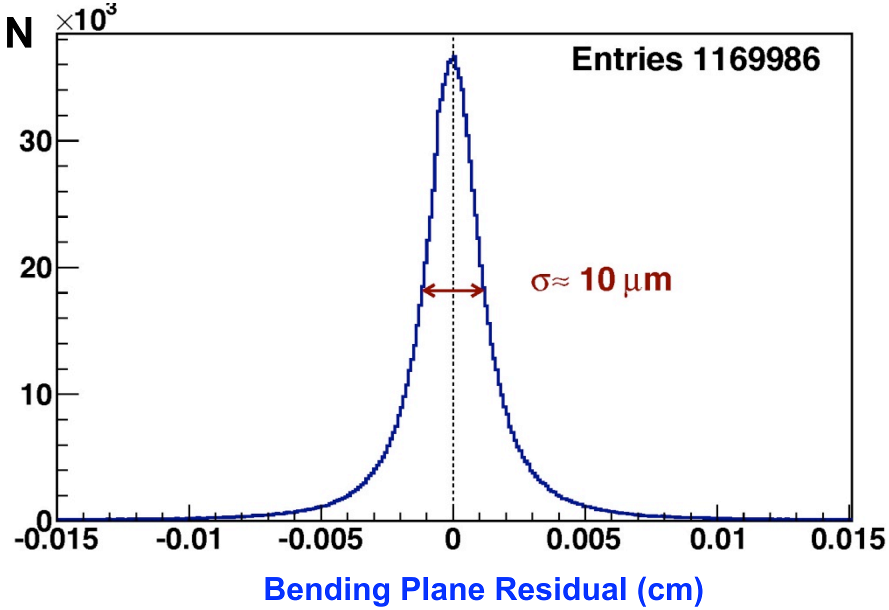
We want to thank NASA and DOE for making AMS possible!

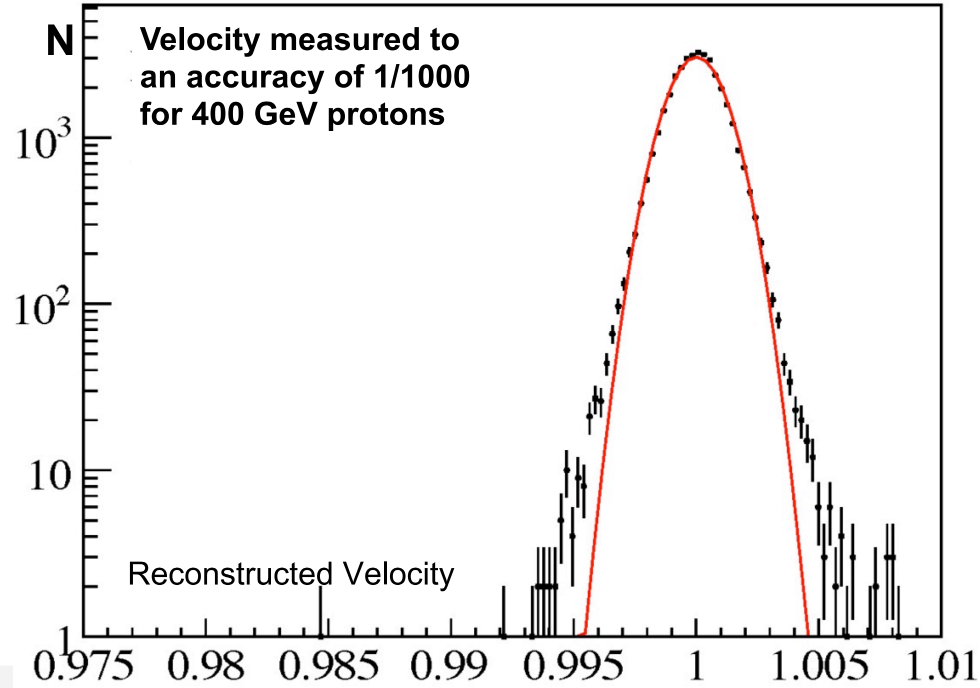
Thank you

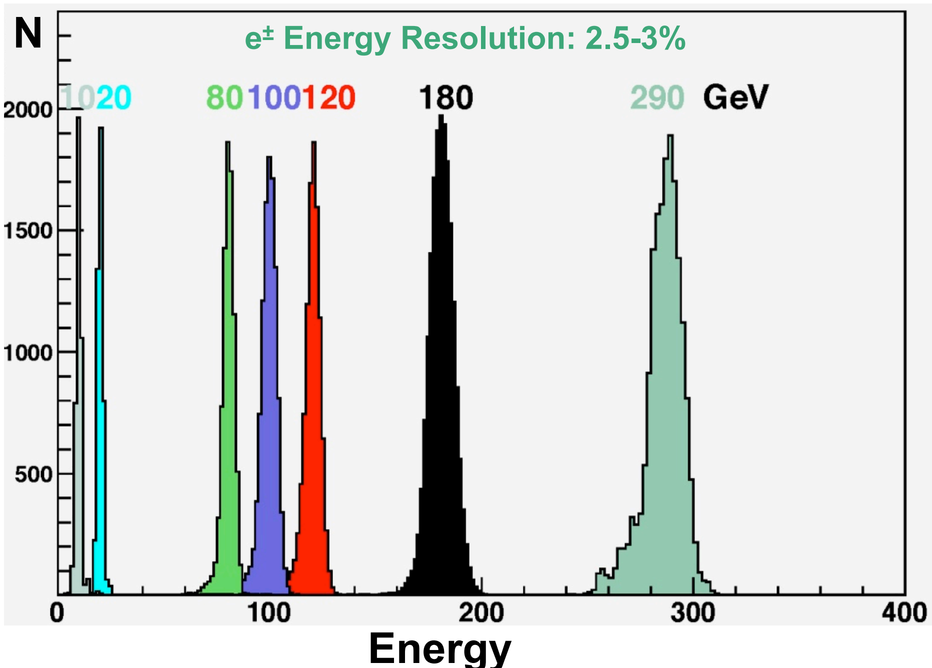
Science coming soon!!! Stay tuned!!!

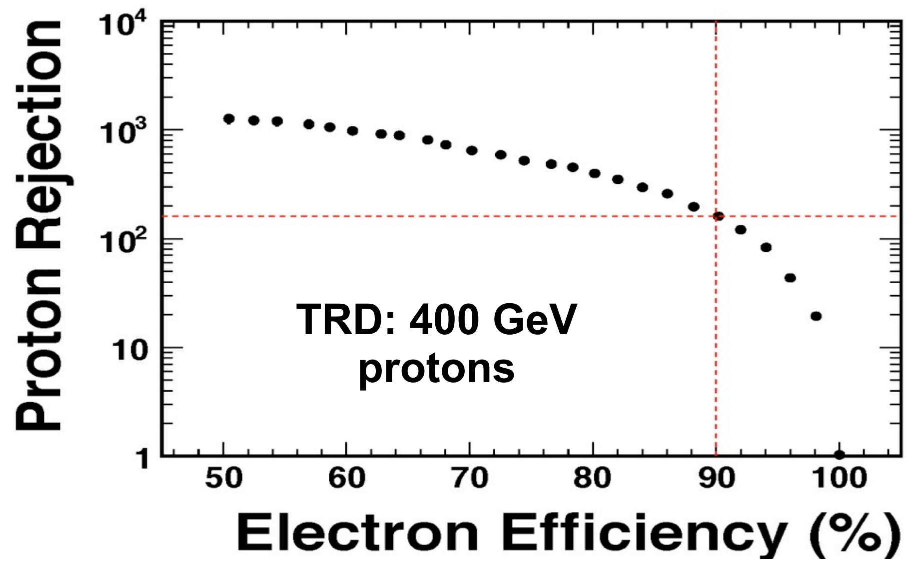
Back-ups

Test Beam Results used as reference points



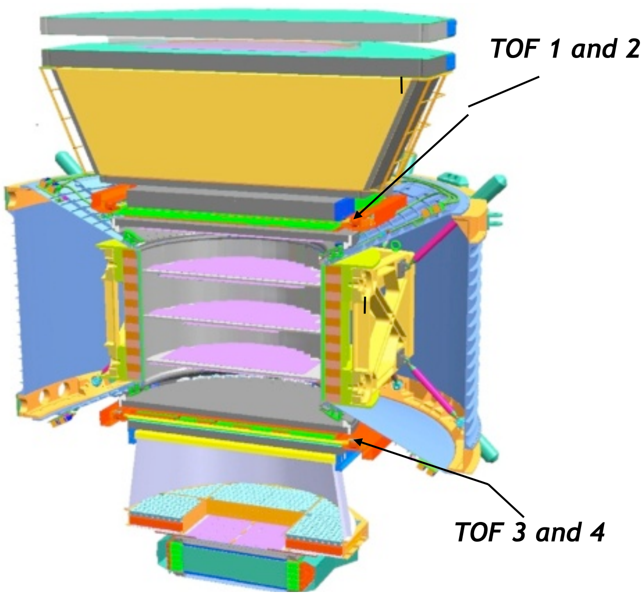


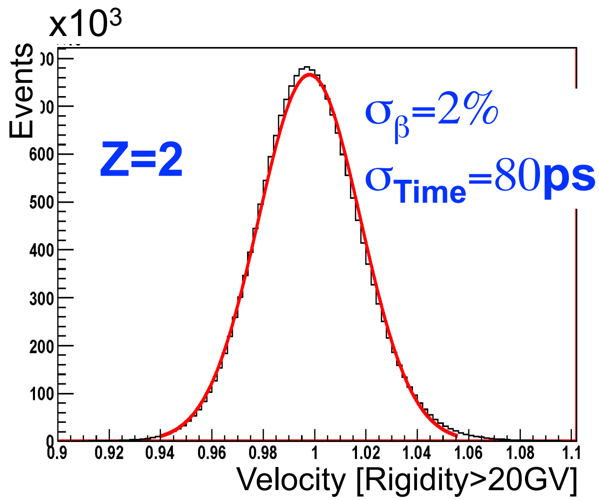


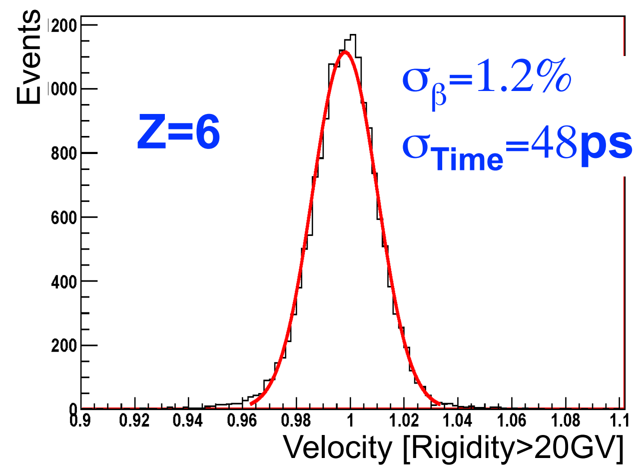


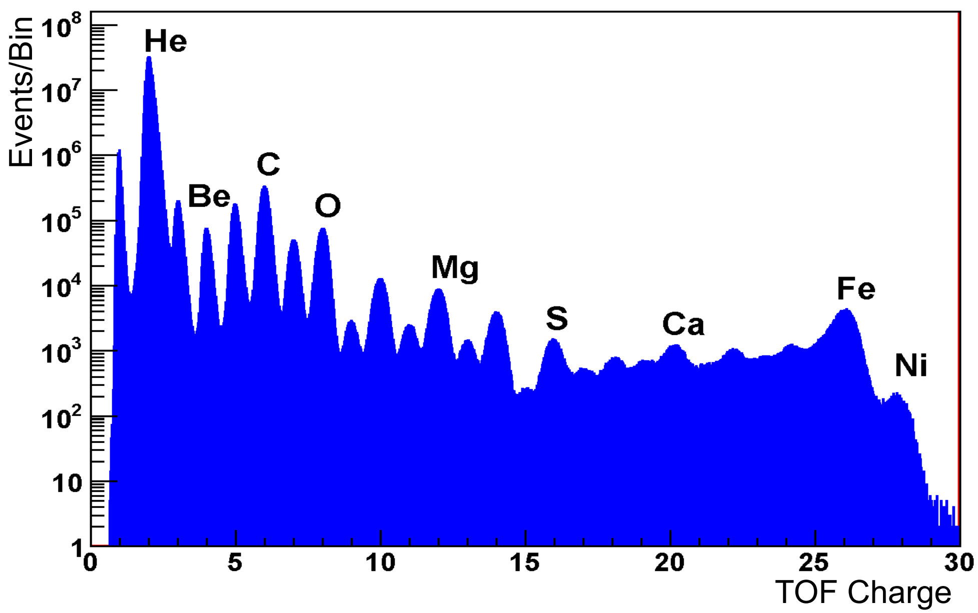
The Time of Flight System - Data from ISS

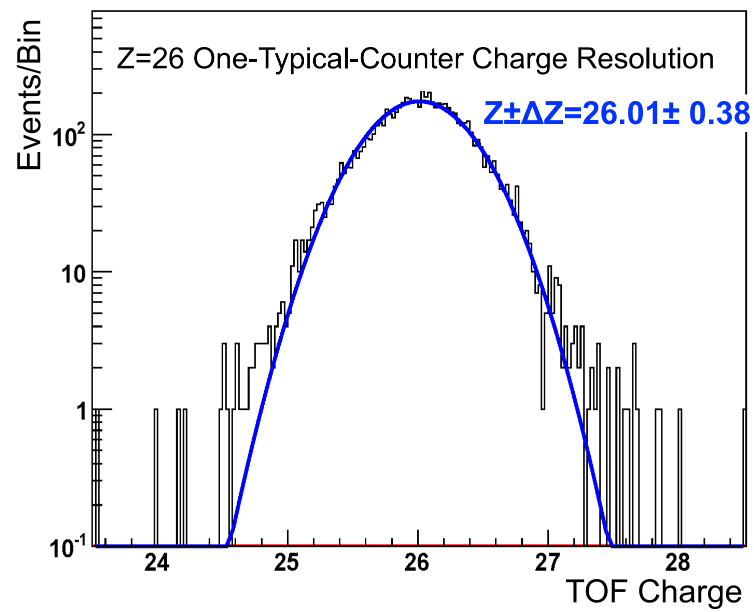
Measures Velocity and Charge of particles





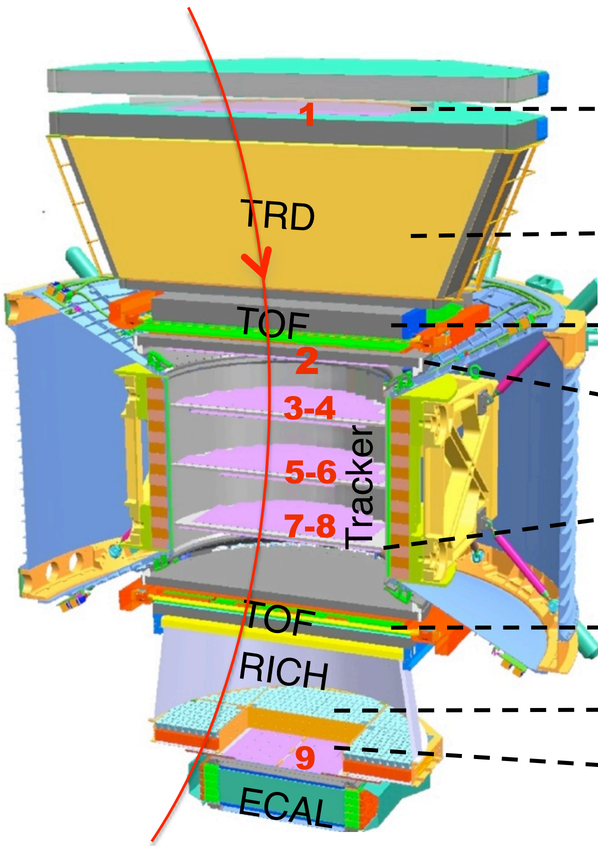






Accurate Study of the composition of the cosmic rays

Multiple Independent Measurements of the Charge (|Z|)



1. Tracker Plane 1
2. TRD
3. Upper TOF
4. Tracker Planes 2-8
5. Lower TOF
6. RICH
7. Tracker Plane 9

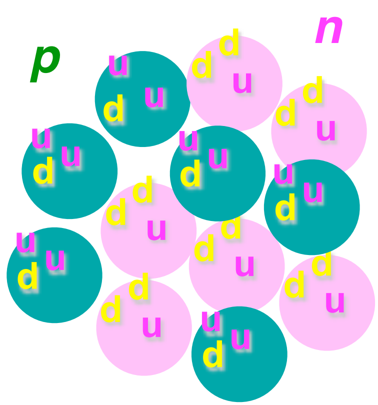
Search for New Matter in the Universe

After many years, the question of the existence of strange quark matter still remains without a definitive answer.

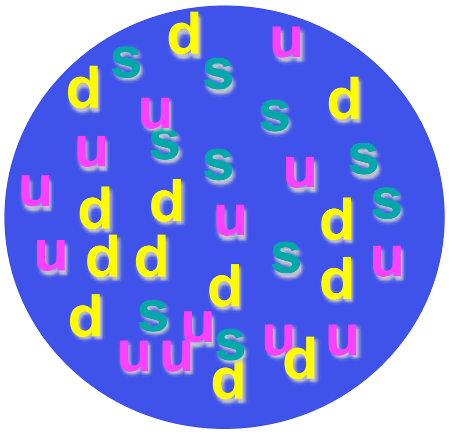
There are six types of Quarks found in accelerators (u, d, s, c, b, t).

All matter on Earth is made out of only two types (u, d) of quarks. "Strangelets" are new types of matter composed of three types of quarks (u, d, s) which should exist in the cosmos.

Carbon Nucleus
Z/A ~ 0.5



Strangelet
Z/A ~ 0.1

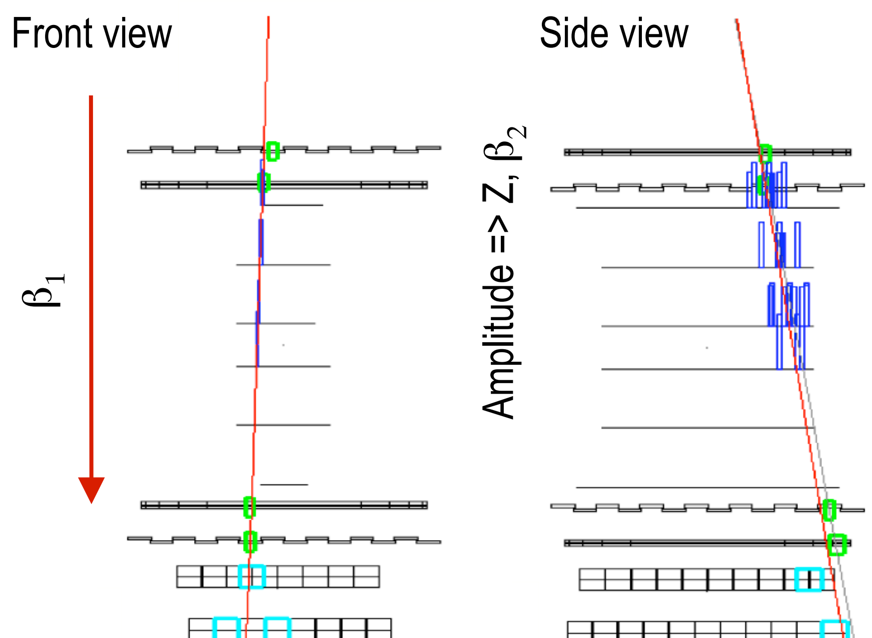


E. Witten, Phys. Rev. D,272-285 (1984)

Strangelets

Jack Sandweiss (Yale) is leading the AMS search.

Candidate observed with AMS-01 5 June 1998 11:13:16 UTC

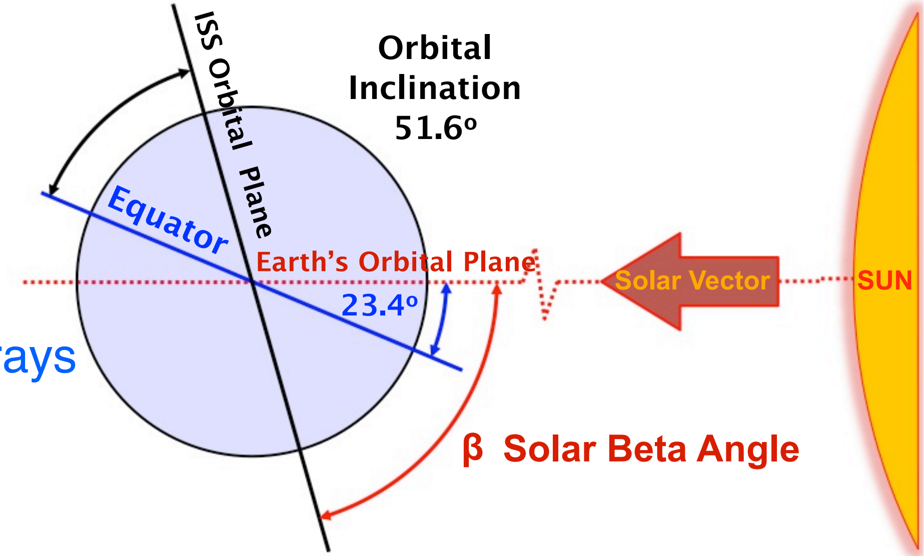


Rigidity = 4.31 ± 0.38 GV
Charge Z = 2
$\beta_1 = \beta_2$ = 0.462 ± 0.005
Mass = 16.45±0.15 GeV/c^2
Z/A = 0.114 ± 0.01
Flux (1.5 < E_K < 10 GeV) = 5×10^{-5} (m^2 sr sec)$^{-1}$

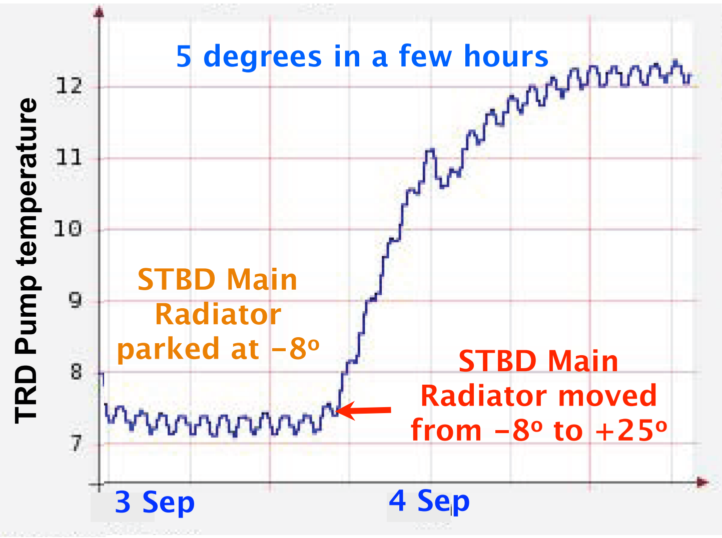
Z/A~0.1

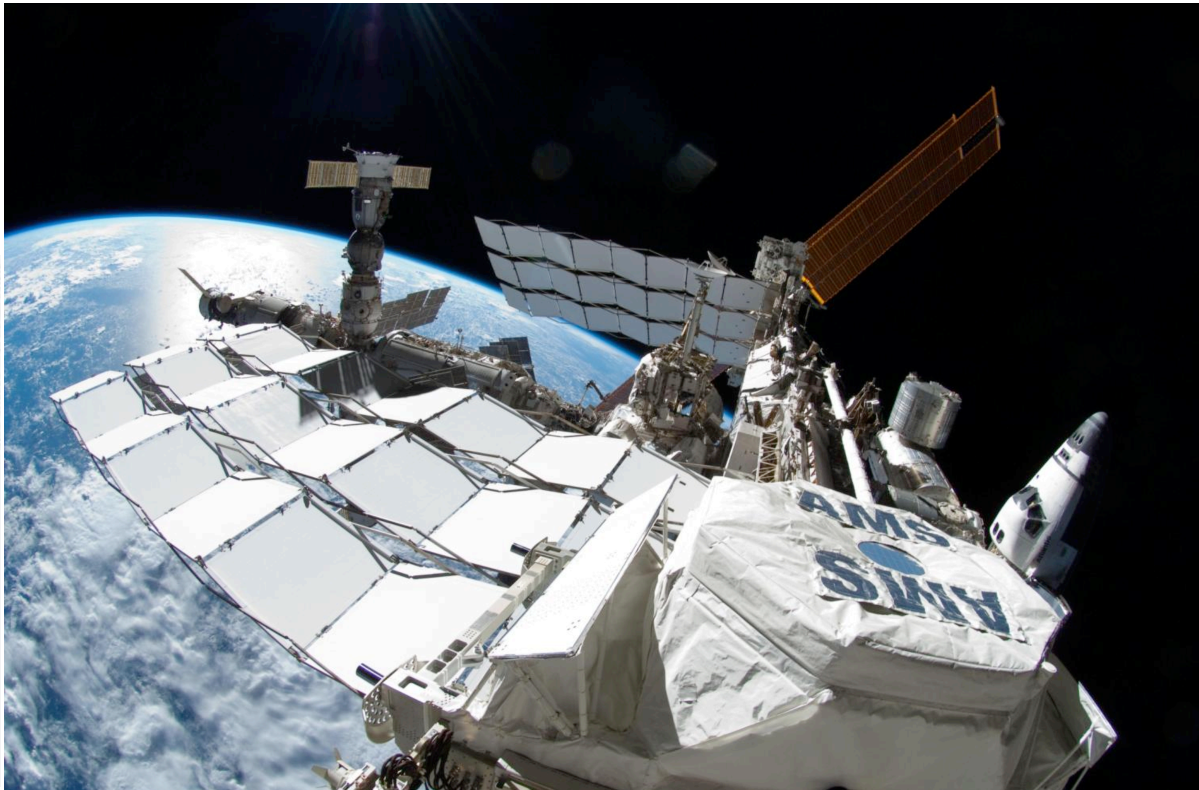
On-orbit thermal control

The thermal environment on ISS is constantly changing due to:
- Solar Beta Angle (beta)
- Position of the ISS Radiators and Solar Arrays
- ISS Attitude



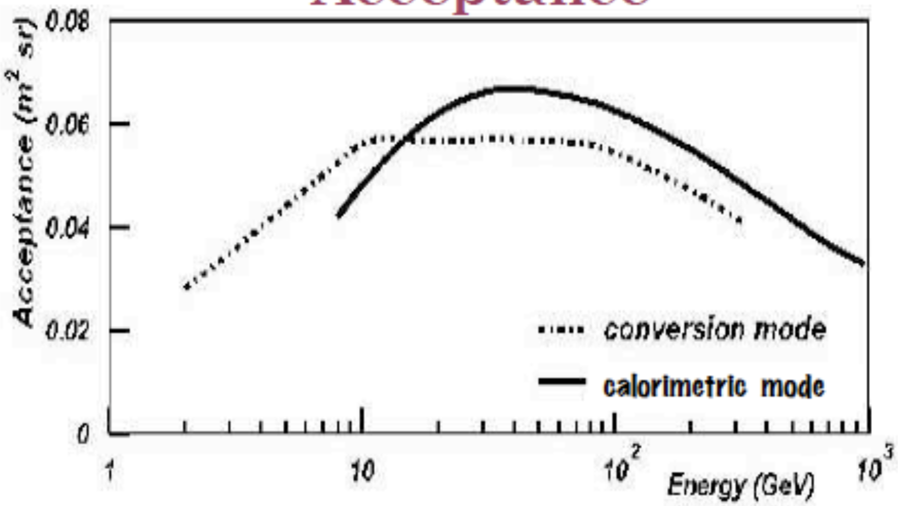
Over 1,100 temperature sensors and 298 heaters are monitored to assure components stay within thermal limits and avoid permanent damage.



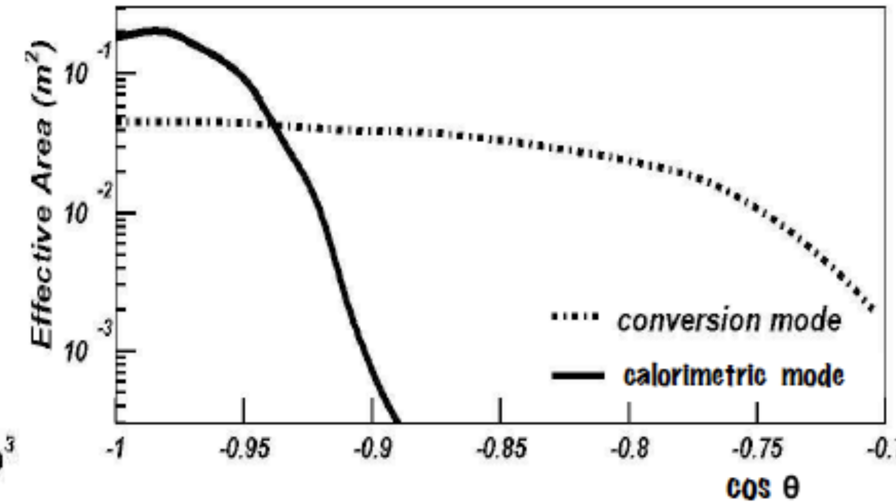


Tracker and Ecal Performances

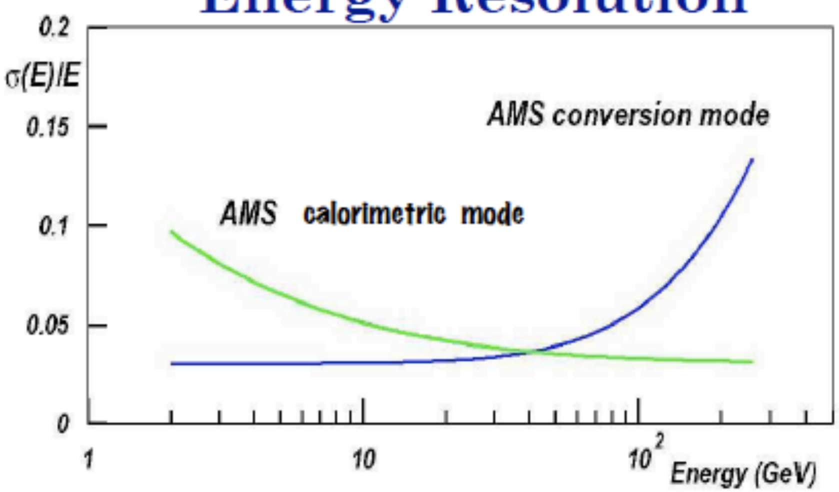
Acceptance



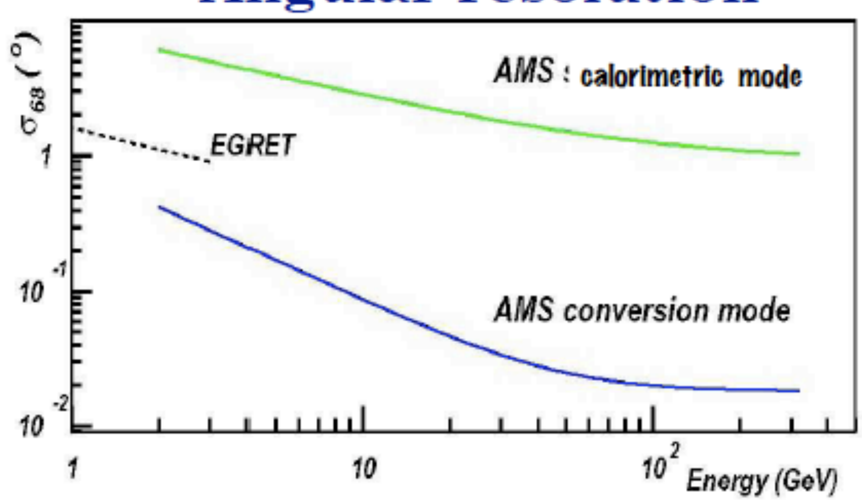
Effective Area



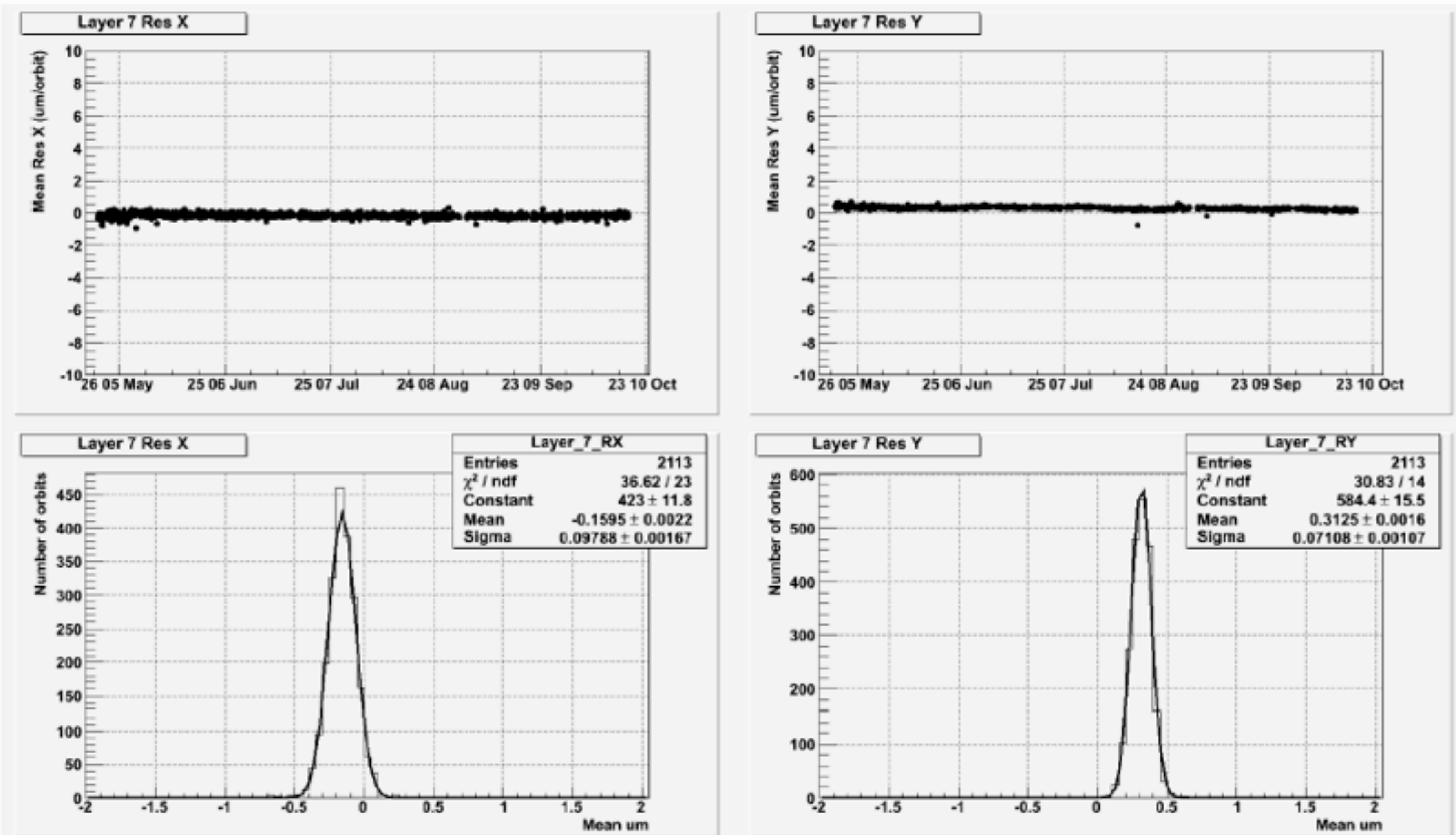
Energy Resolution



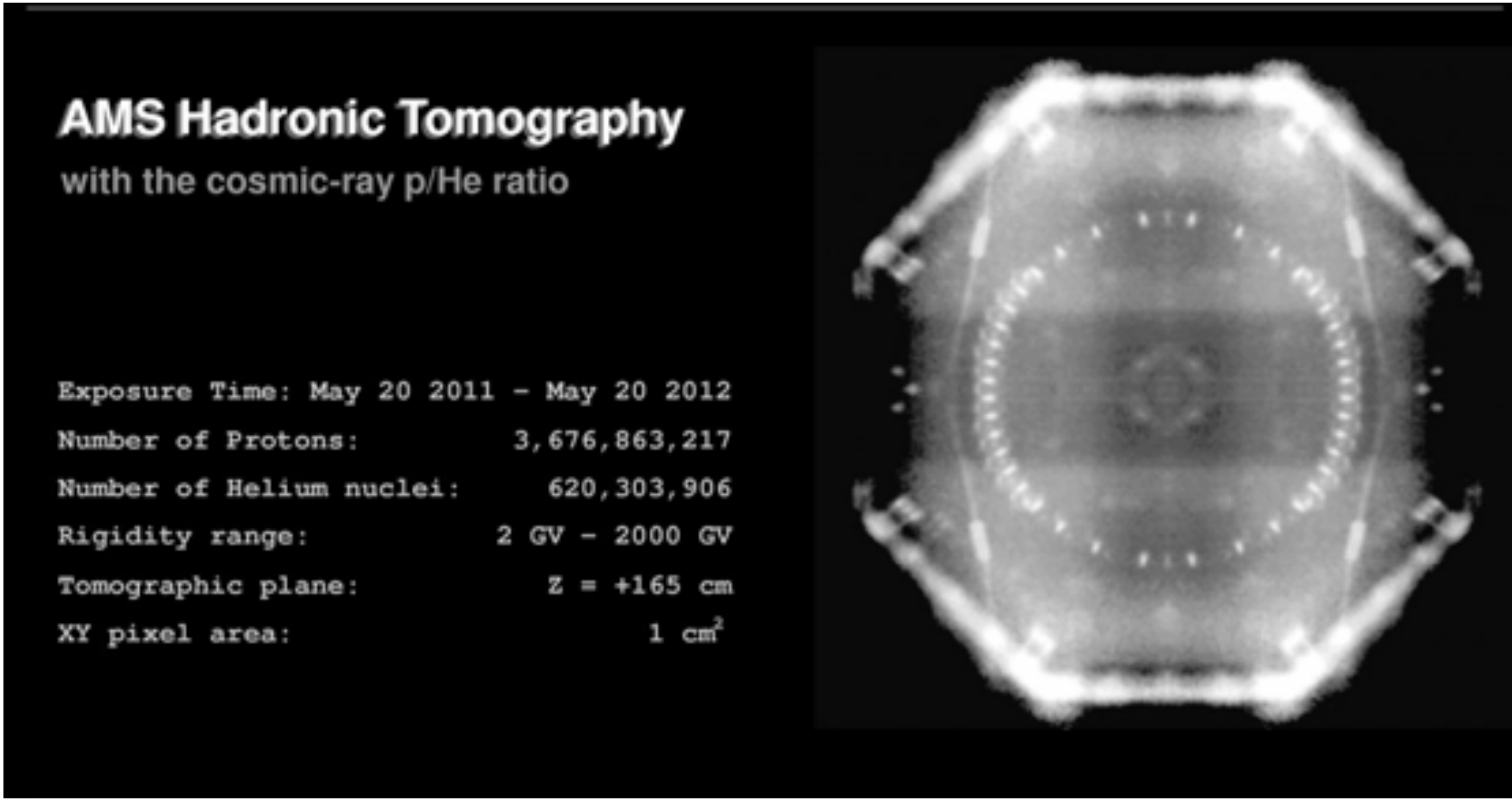
Angular resolution



Typical stability of an inner tracker plane is 0.1 μm as measured with Protons on the ISS



Material on AMS-02



As estimations:
3 g/cm^2 in the TRD
2 g/cm^2 in the TOF

AMS Data/MC Volumes Projected

DATA

Per Year Of Operation:

- 1.6×10^{10} Events
- 35 TB Raw Events
- 130 TB Reconstructed Ev.

MC

Per Year Of Operation:

- ~2 X 10^{10} Simulated Events
- ~ 200 TB Simulated Data Volume