



AMS02: Overview and Challenges

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On behalf of the AMS02 collaboration

**Nuclear physics for Galactic Cosmic Rays Workshop –
December 3rd 2012 - Grenoble**

Outline

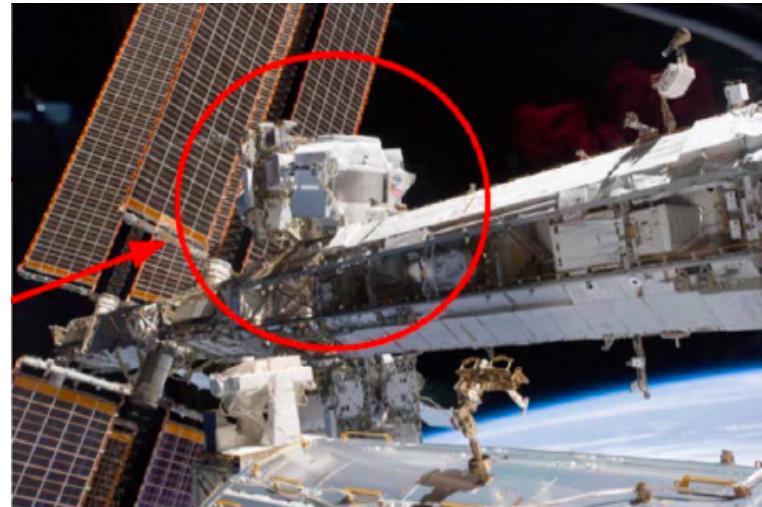
- AMS02 in Space : an overview
- Experimental issues for
 - Positron fraction
 - Electron-Proton-Helium spectra
 - B/C ratio

Results extracted from the presentation of Pr S.Ting SPACE 2012, Nov 6th

AMS02 on board of the ISS

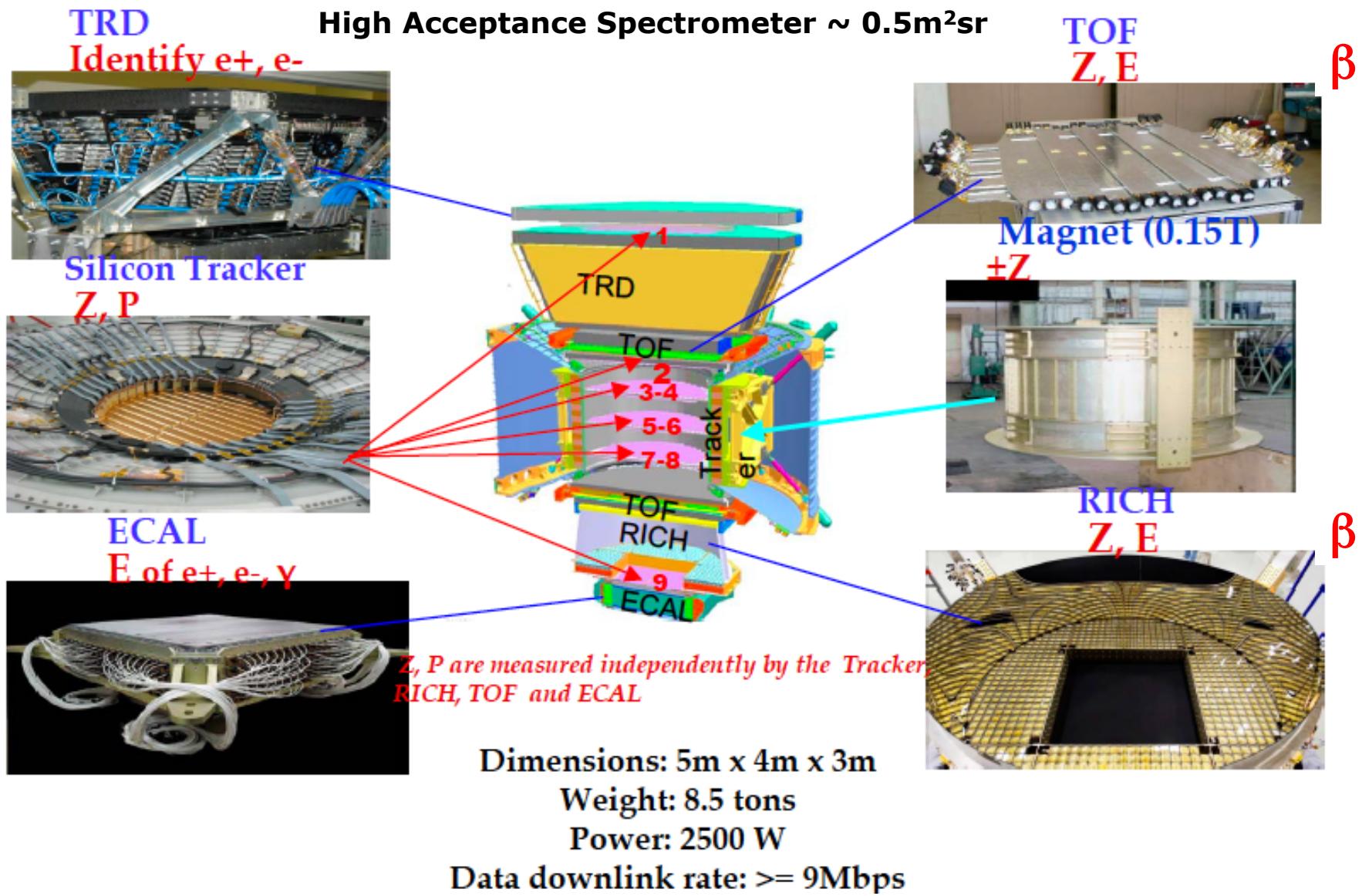


May 19 2011

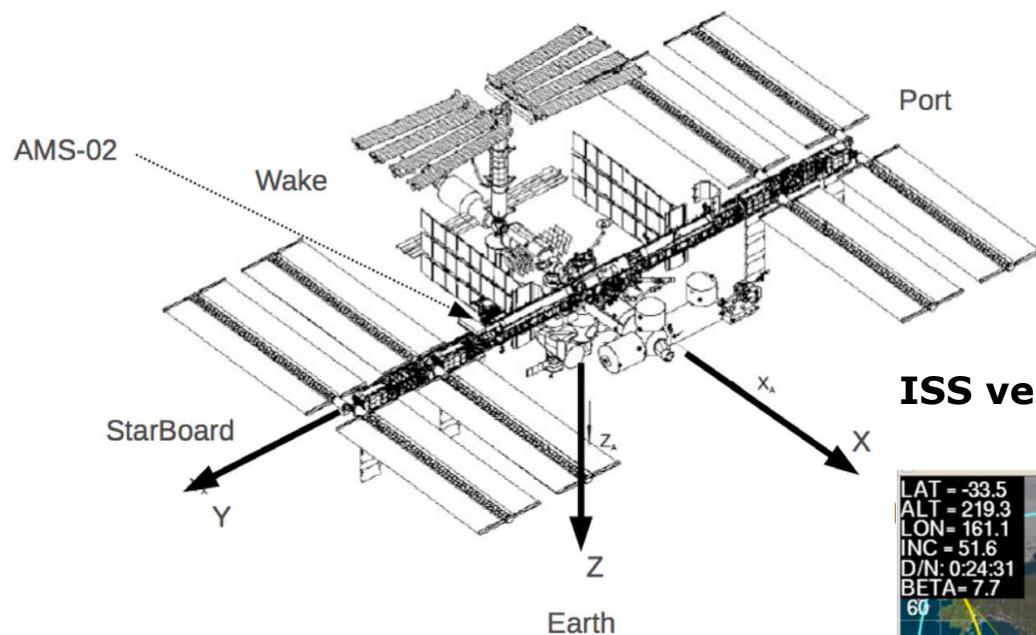


AMS installation completed on ISS at 5:15 CDT, start taking data 9:35 CDT Until 2020+
(CDT Central Daylight Time)

AMS02: A TeV precision, multi purpose Spectrometer

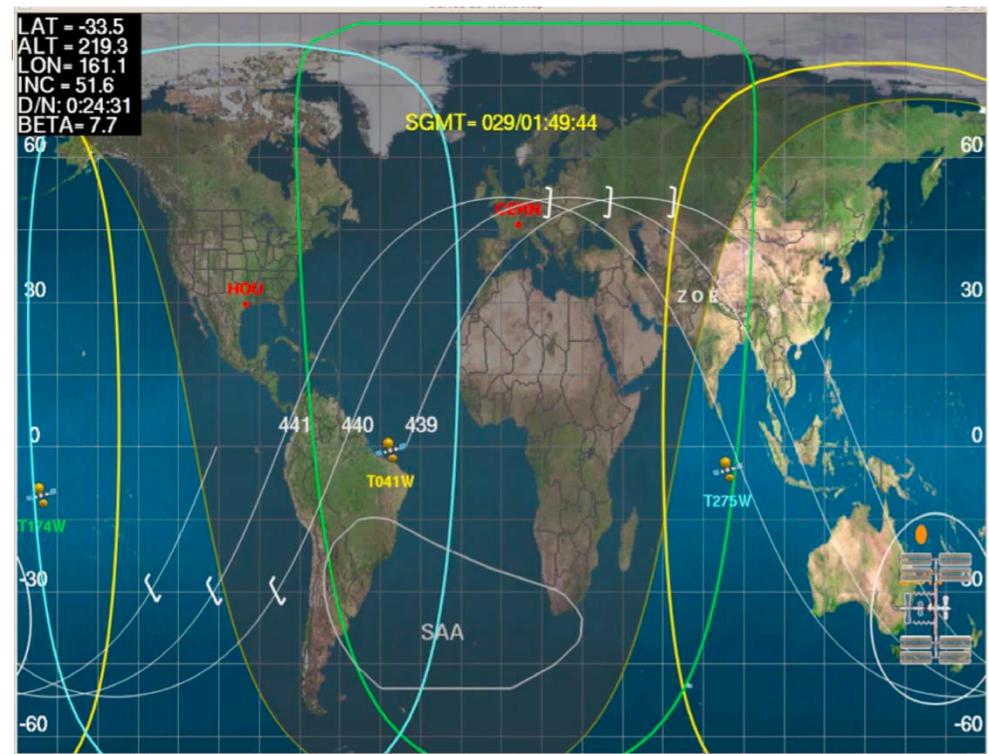


ISS orbit



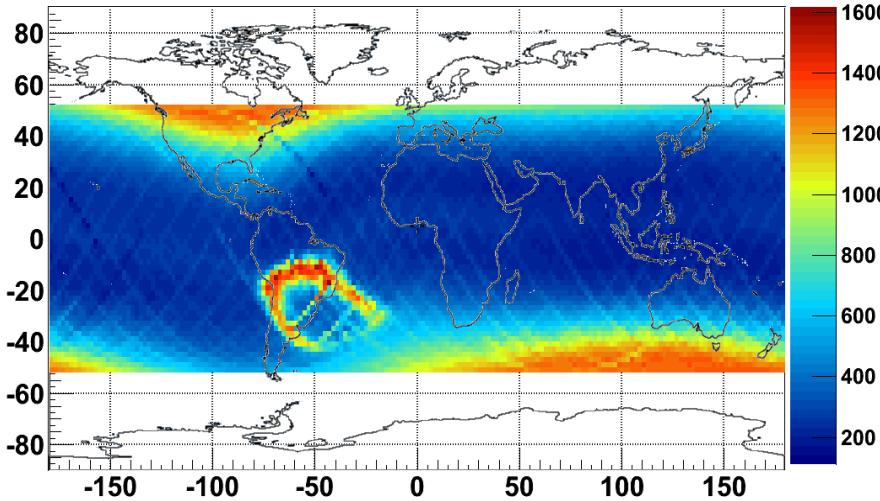
ISS Size: 100 m

ISS velocity: 8km/s 4, one orbit every 90 mn

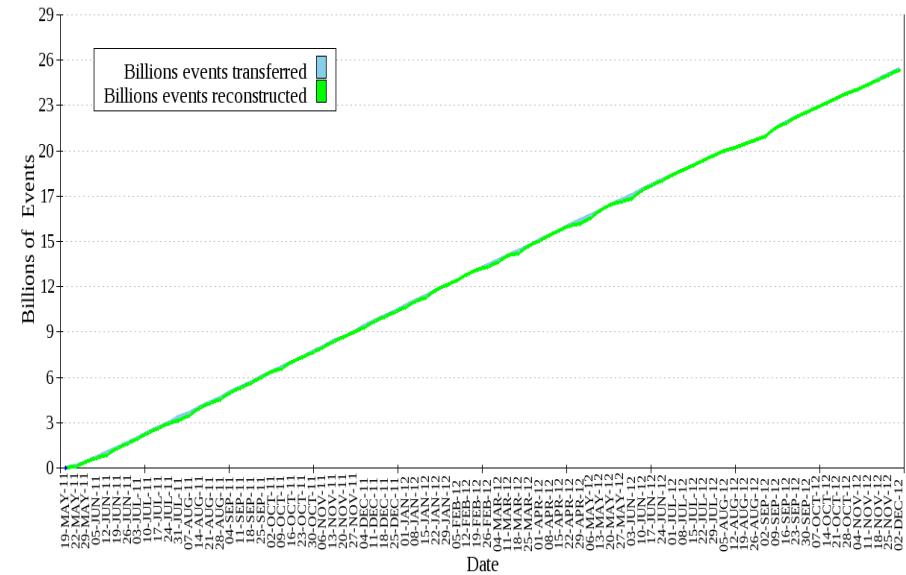
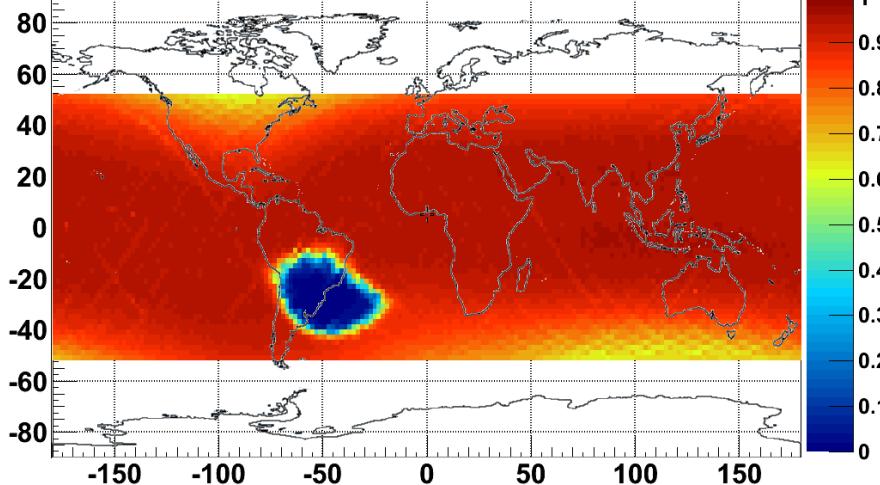


Orbital DAQ parameters

Acquisition rate [Hz]

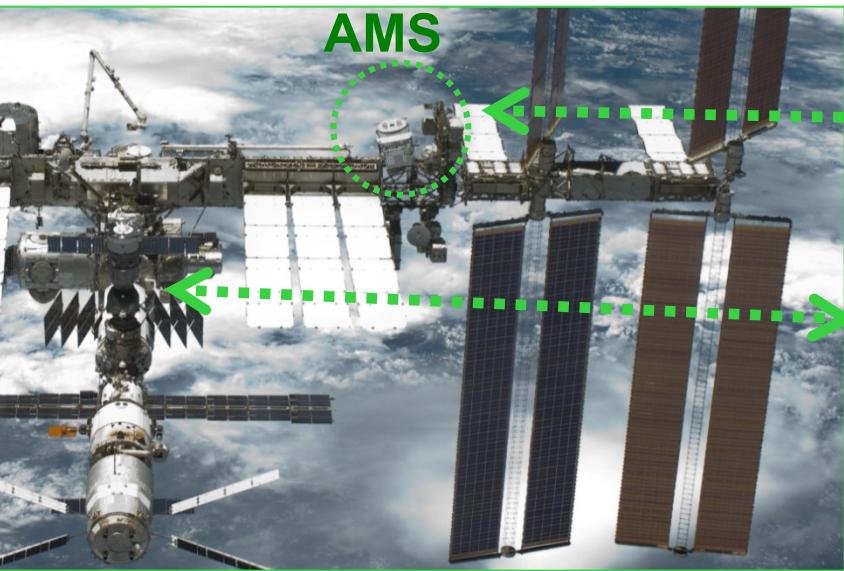


DAQ efficiency



- Particle rates vary from 200 to 2000 Hz per orbit
 - On average:
 - DAQ efficiency 85%
 - DAQ rate ~ 700 Hz
- $\Rightarrow \sim 26$ billions of events up to the 2th of December

AMS Data Flow



Ku-Band
High Rate (down):
Events <10Mbit/s>



Astronaut at ISS AMS Laptop



White Sands Ground Terminal, NM

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

AMS Computers at MSFC, AL

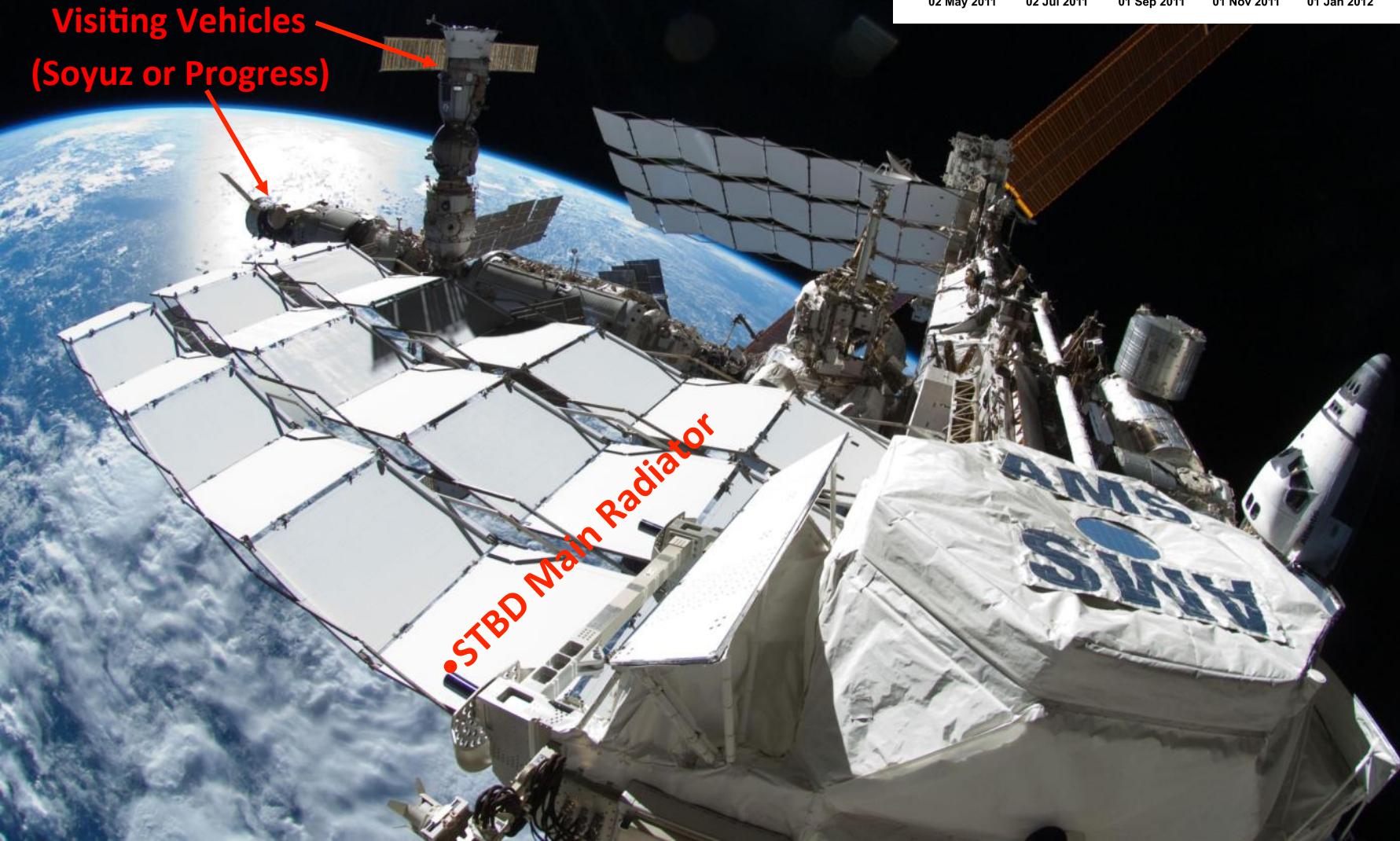
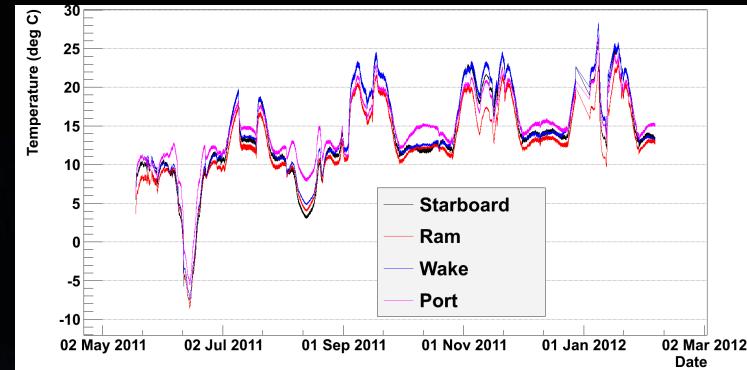
S-Band
Low Rate (up & down):
Commanding: 1 Kbit/s
Monitoring: 30 Kbit/s

AMS Physics Potential

- Searches for primordial antimatter:
 - Anti-nuclei: He, ...
- Dark Matter searches:
 - e^+ , e^\pm , p, γ ...
 - simultaneous observation of several signal channels.
- Searches for new forms of matter:
 - strangelets, ...
- Measuring CR spectra – refining propagation models (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

Thermal Issues:

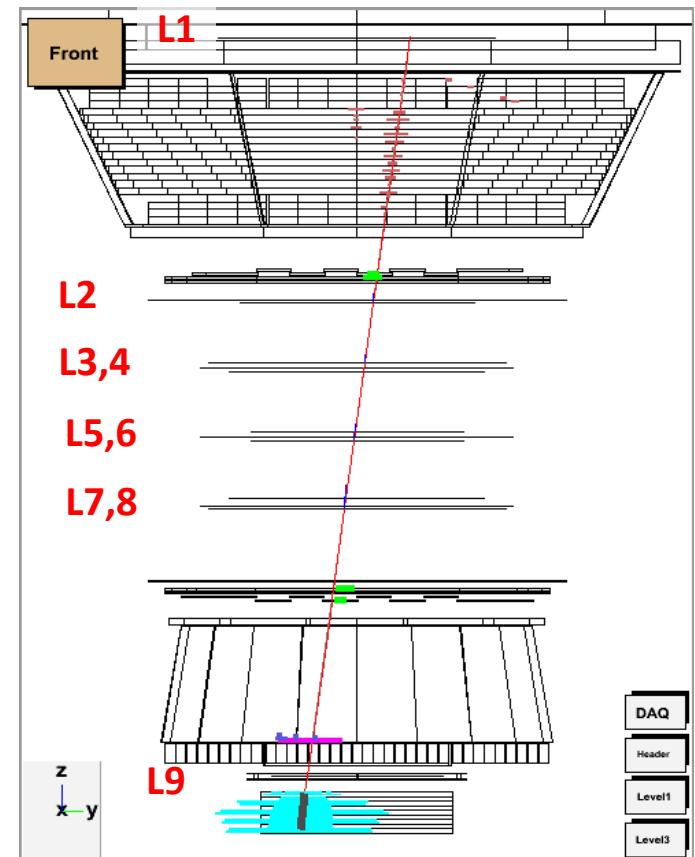
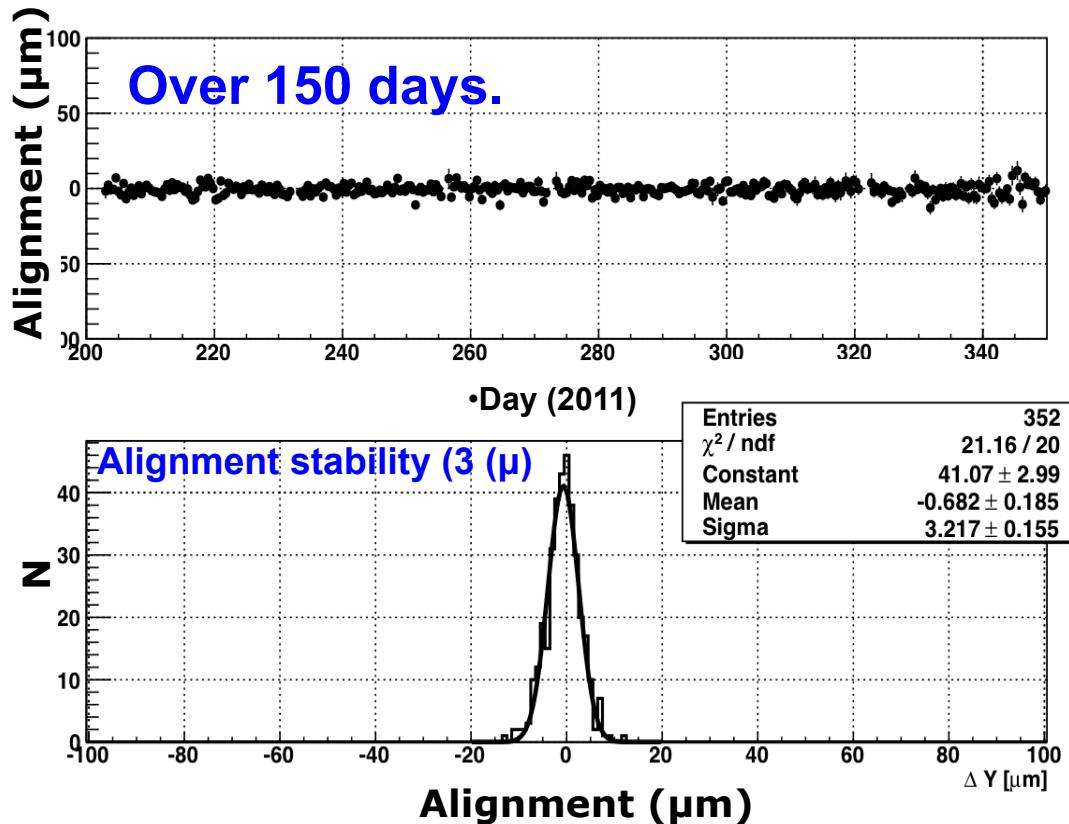
- ISS Radiator positions
- ISS attitude changes (primarily for visiting vehicles)
- Solar Array positions



AMS Tracker on ISS

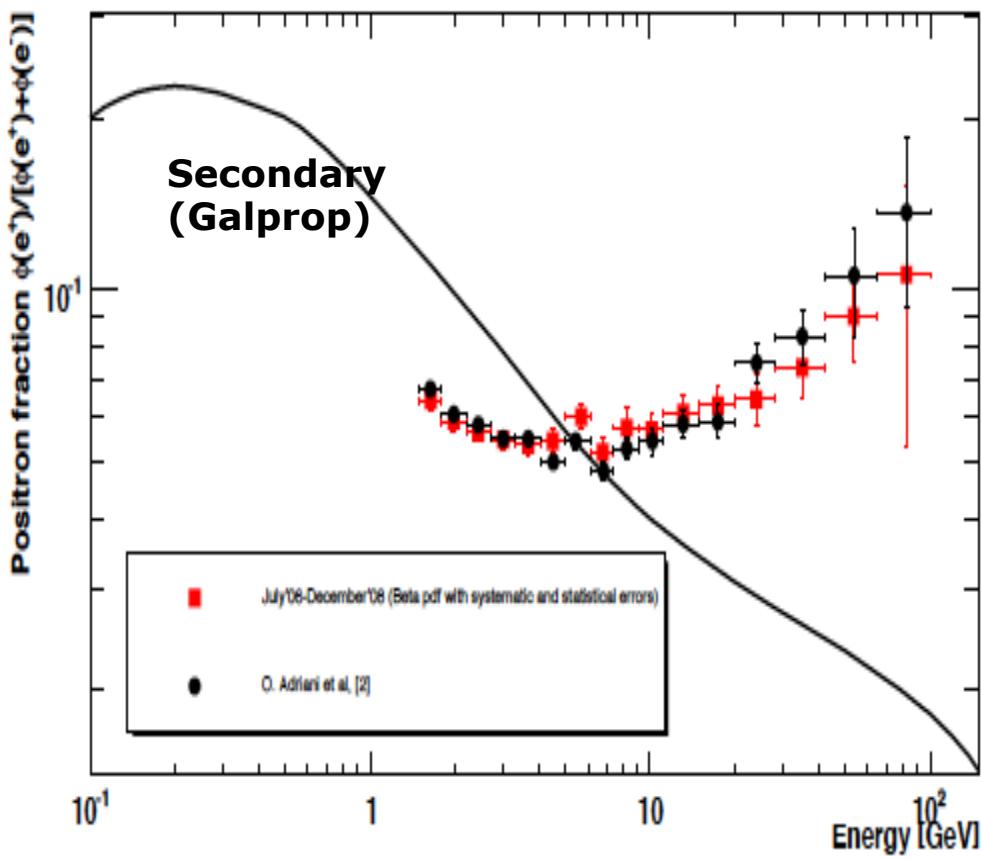
The alignment stability (3 microns) of the uppermost Tracker plane (1).

Over 150 days.



Positron fraction

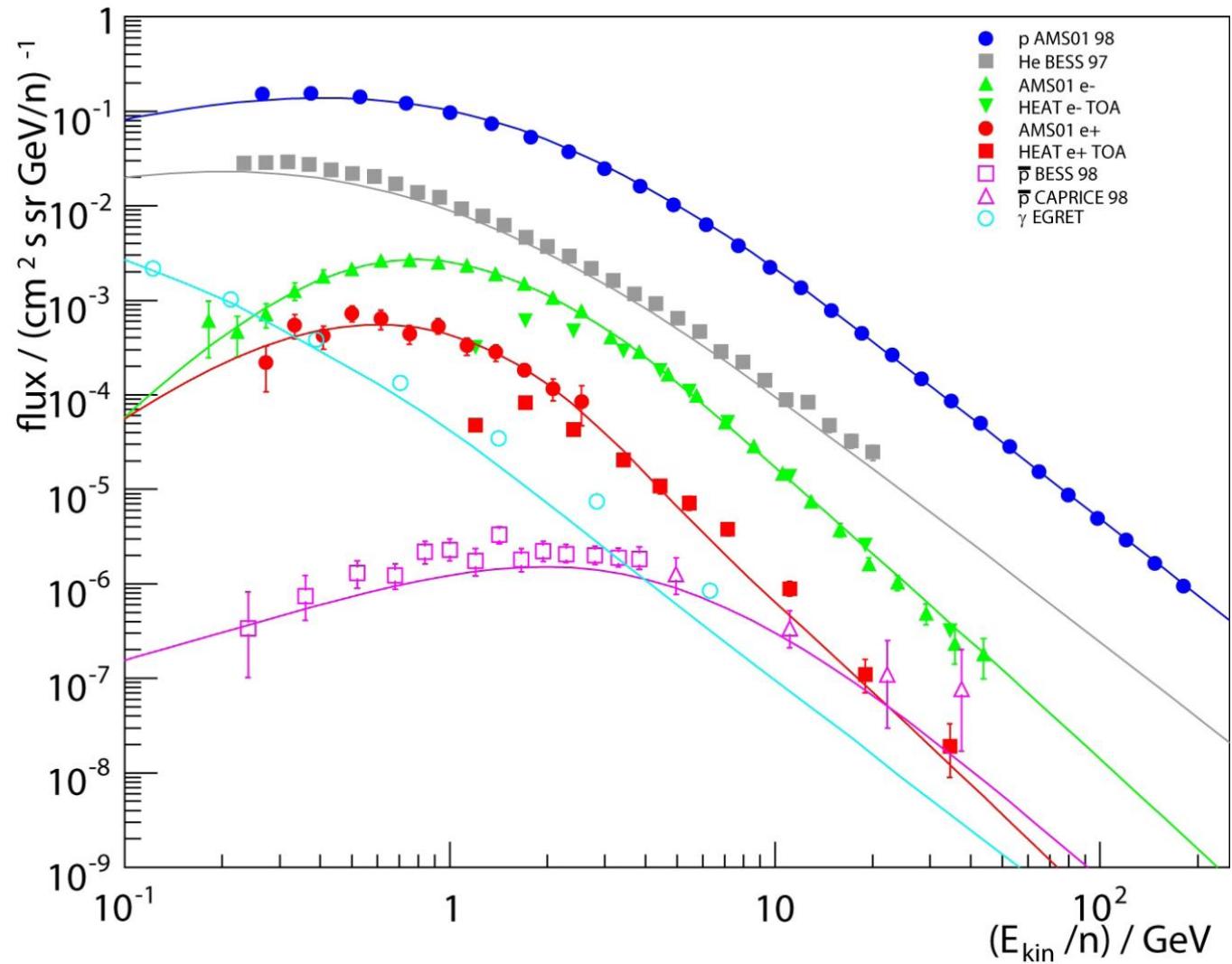
Pamela: O.Adriani et al., Astropart. Phys. 34 (2010)



- **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: 4 detectors in AMS are used:**
 - TRD,
 - tracker (Momentum and Energy matching)
 - and the ECAL
 - Rich (Energy < 10 GeV)

Cosmic rays composition

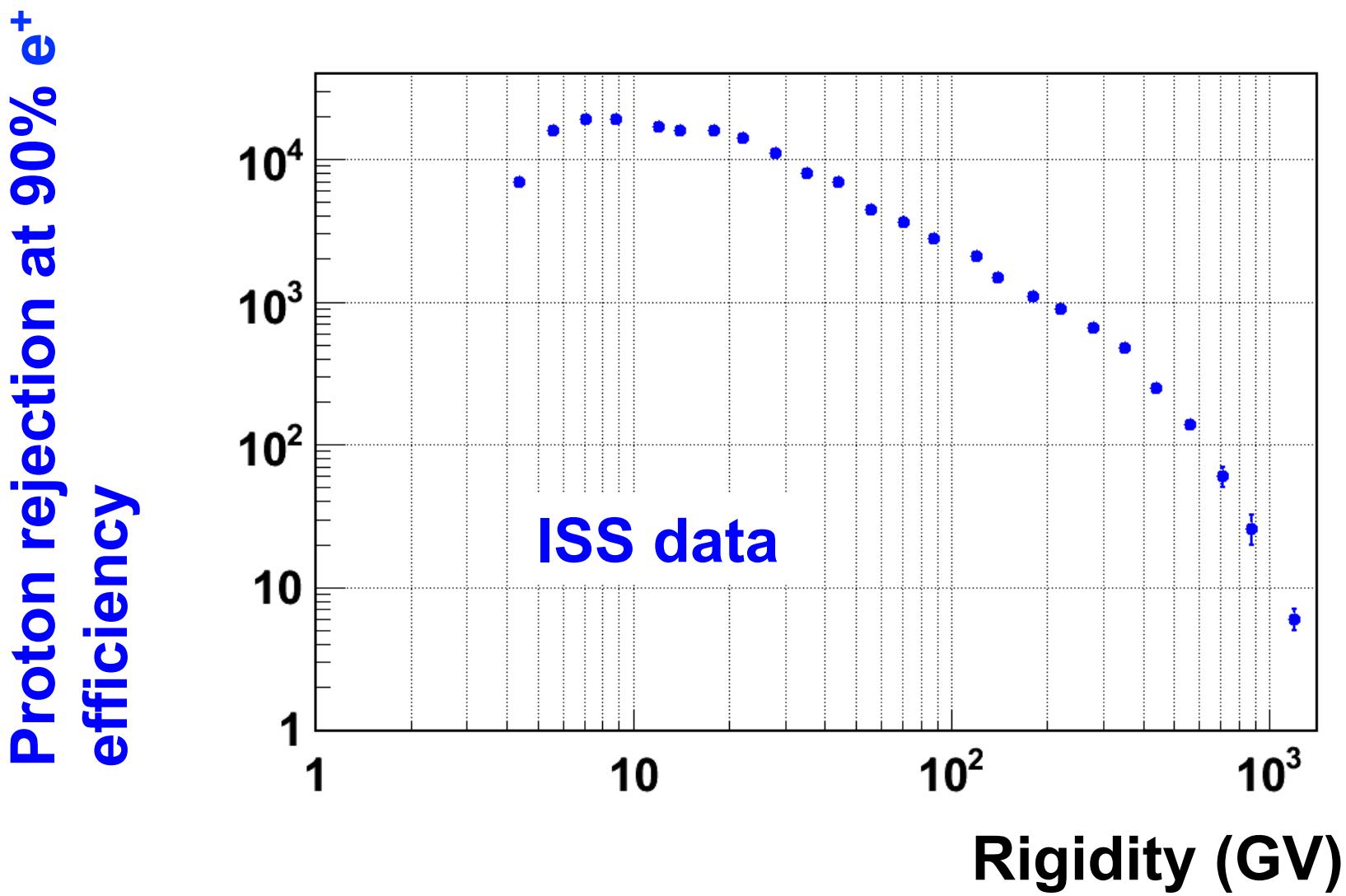
Data before Pamela



@ 10 GeV

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

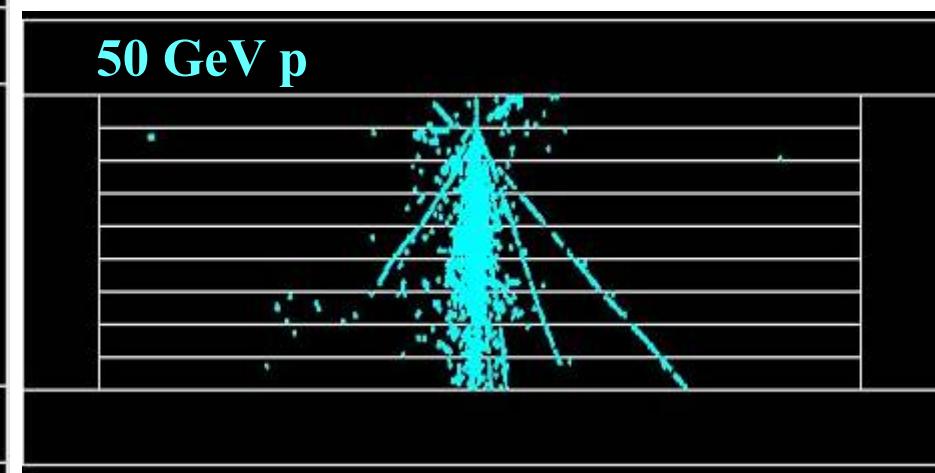
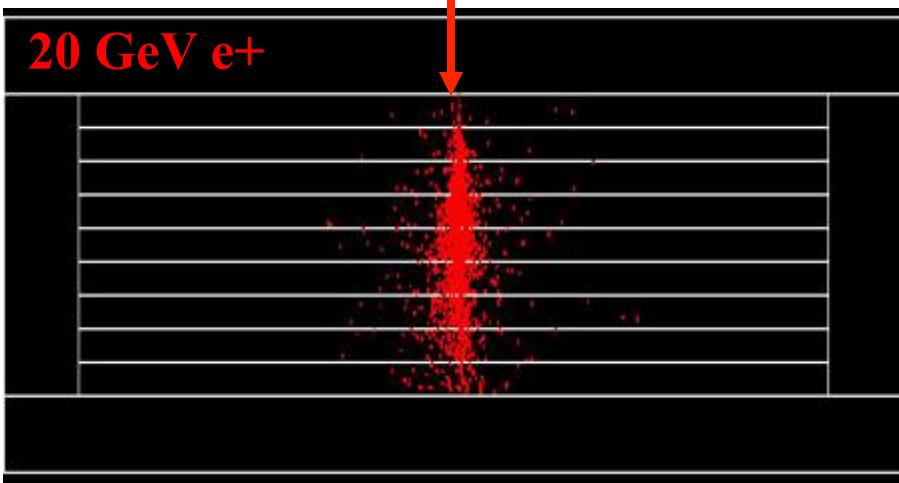
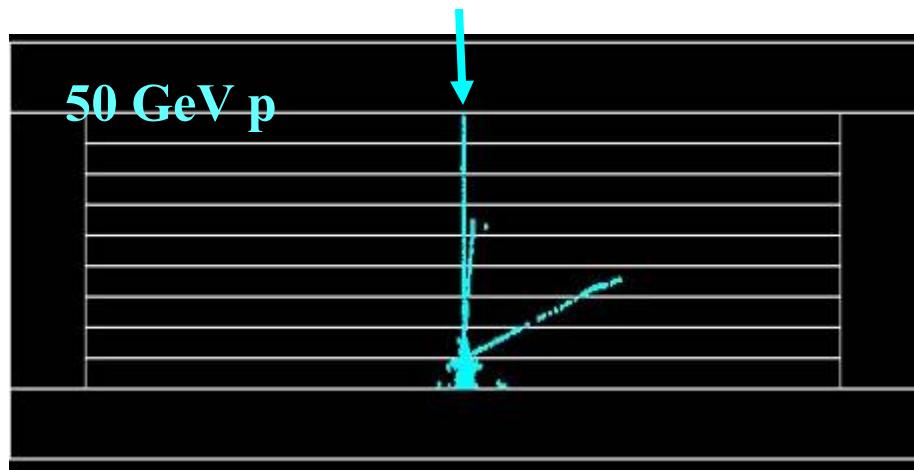
Proton rejection:TRD (1)



Proton rejection: Ecal (2)

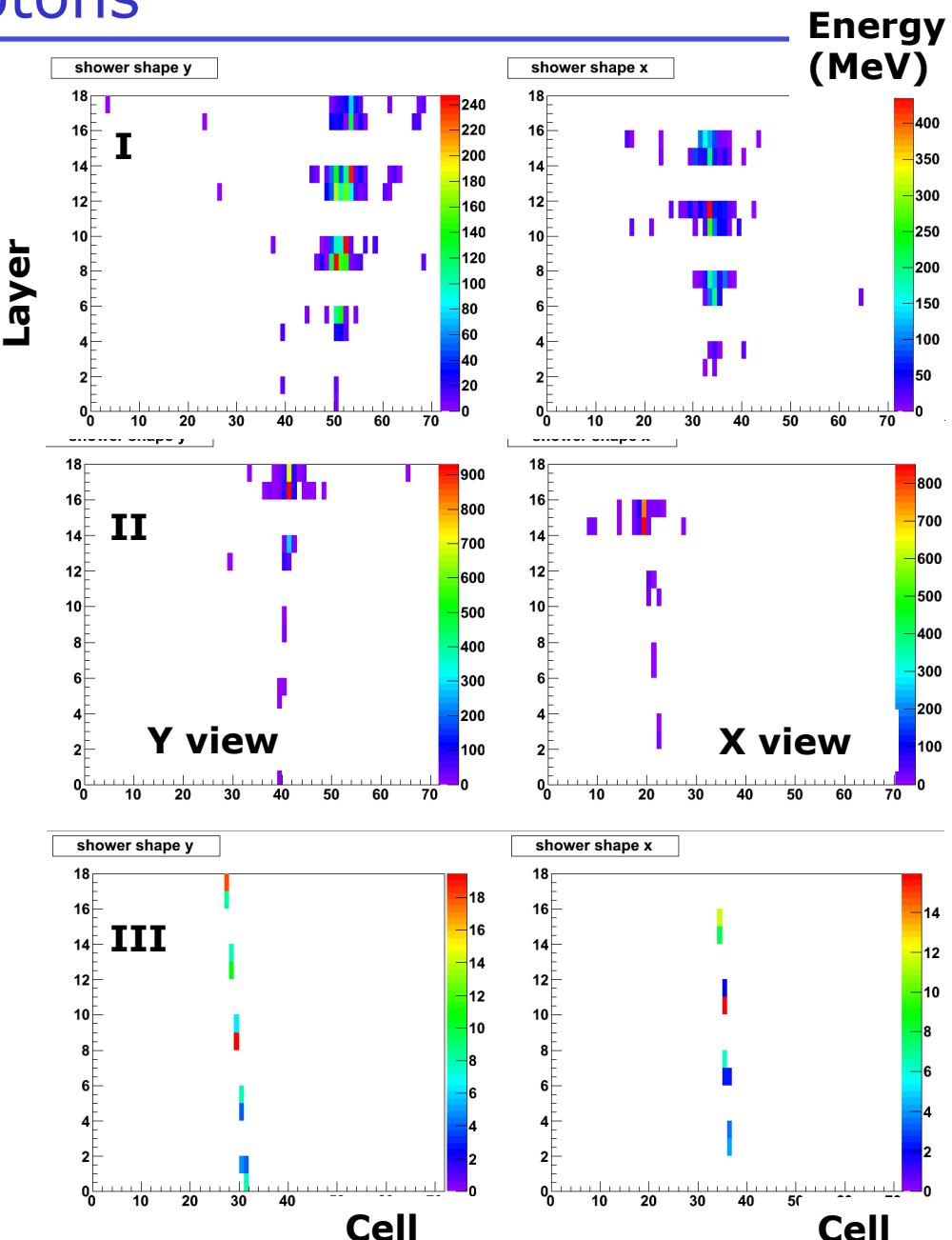
- Identify proton interacting in the first layers
- Exploit the EM shower shape properties in the 3 dimensions (reduced variables and at the layer or cell levels)
- Compare the Deposit Energy with the momentum measured in the tracker
- Use Test beam data and ISS data relying on TRD and tracker.

Simulation in Geant4



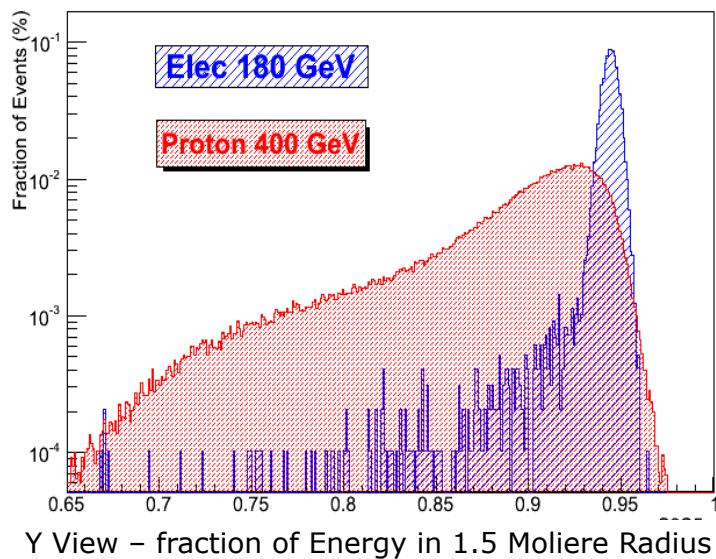
e/P rejection - ISS protons

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

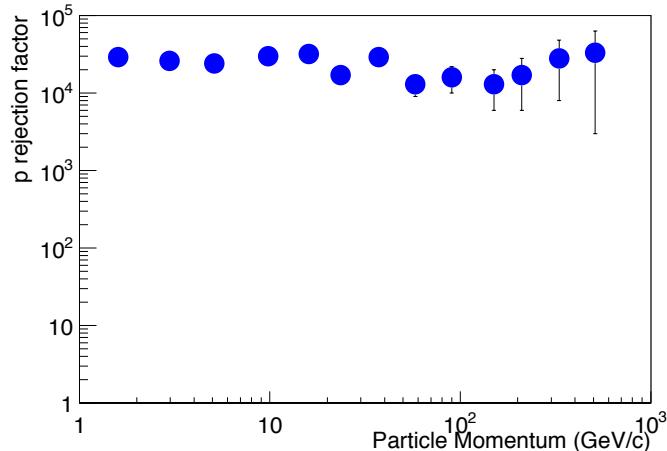


e/P rejection

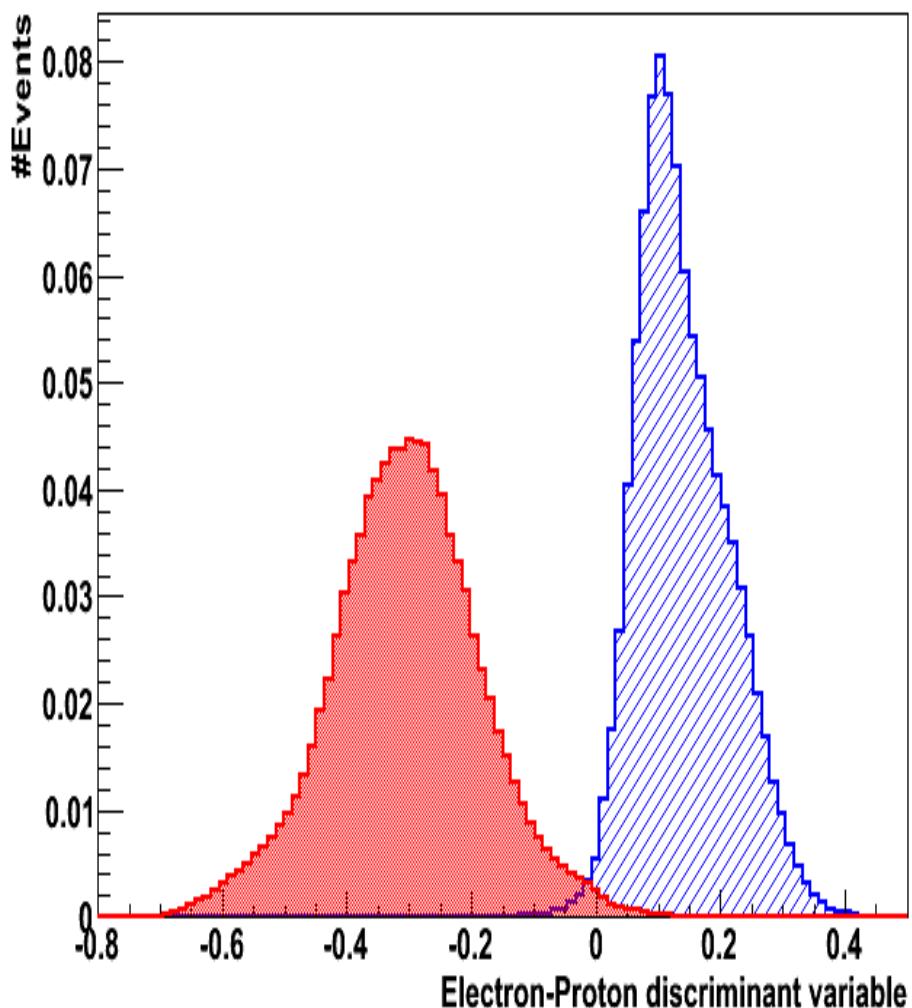
Test Beam @ CERN



Combined ECAL+ Tracker Proton rejection (ISS data)

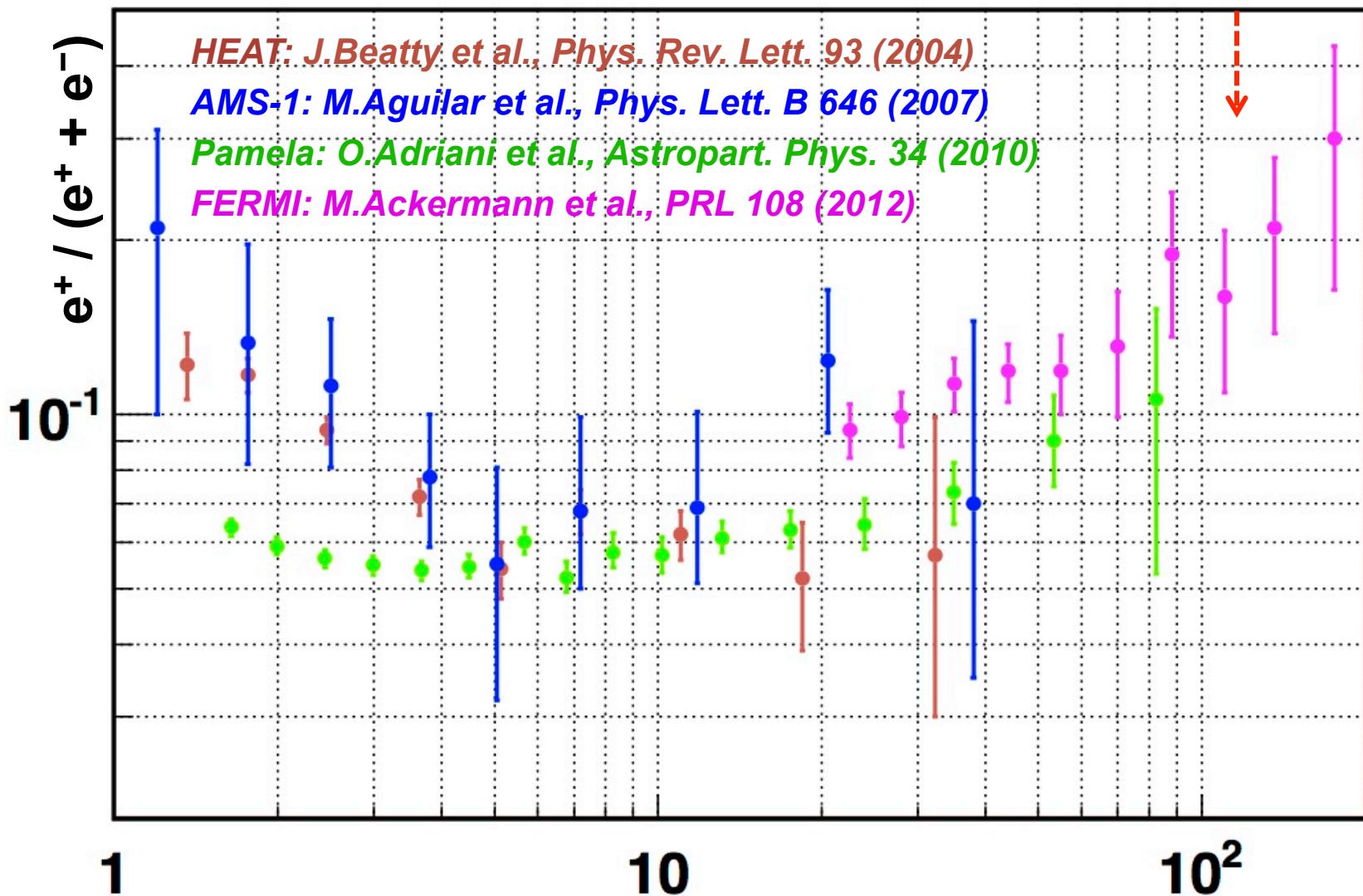


ISS data – Multivariate Analysis-ECAL,
proton fraction can be measure from the
data relying on 2/3 variables



AMS
1600 e+ events (65-100 GeV)

Error size

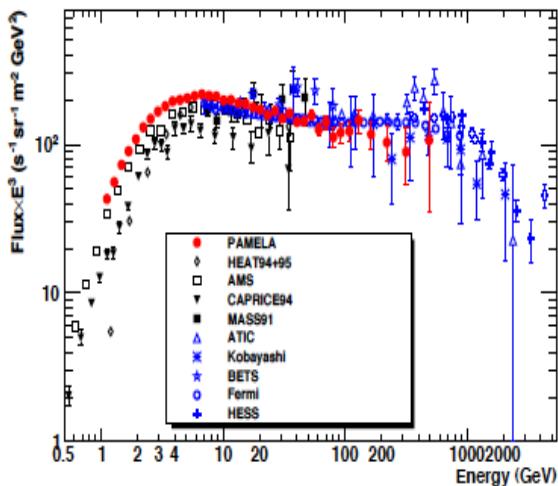


A statistical gain of *8-10 wrt to Pamela

Energy (GeV)

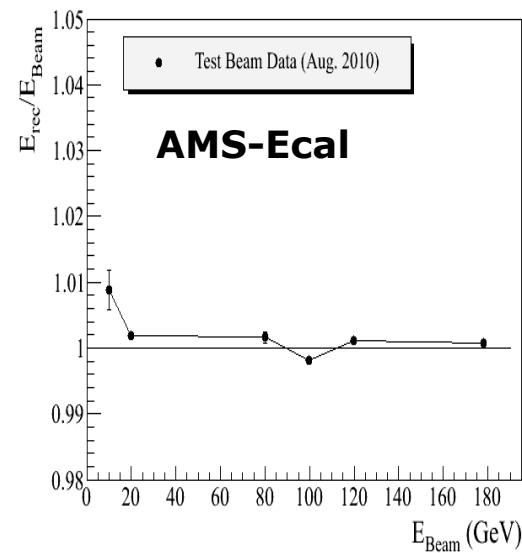
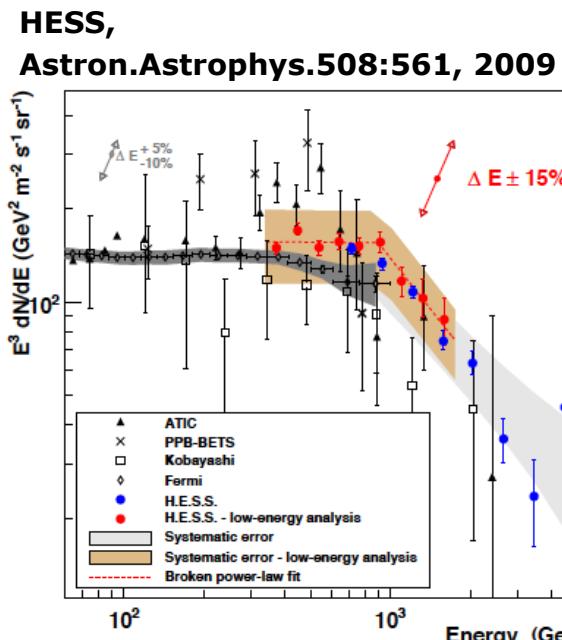
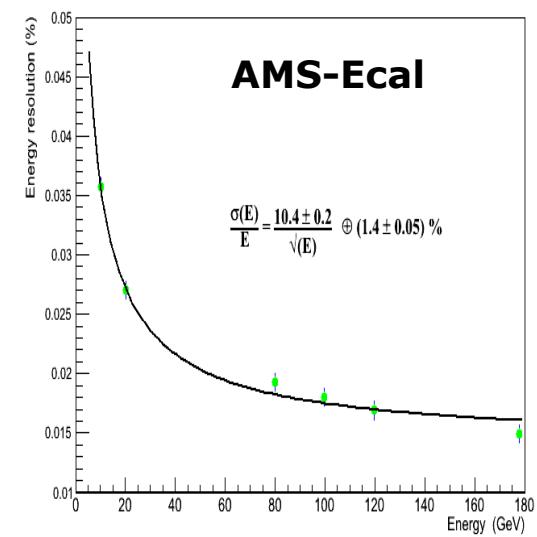
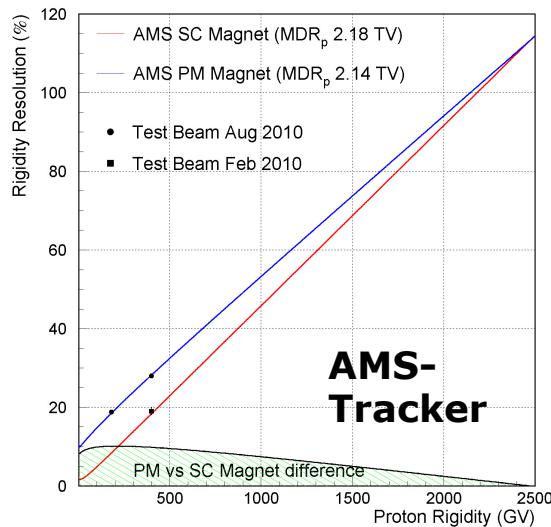
Electron Fluxes

Pamela ,
Phys.Rev.Lett.106:201101,2011



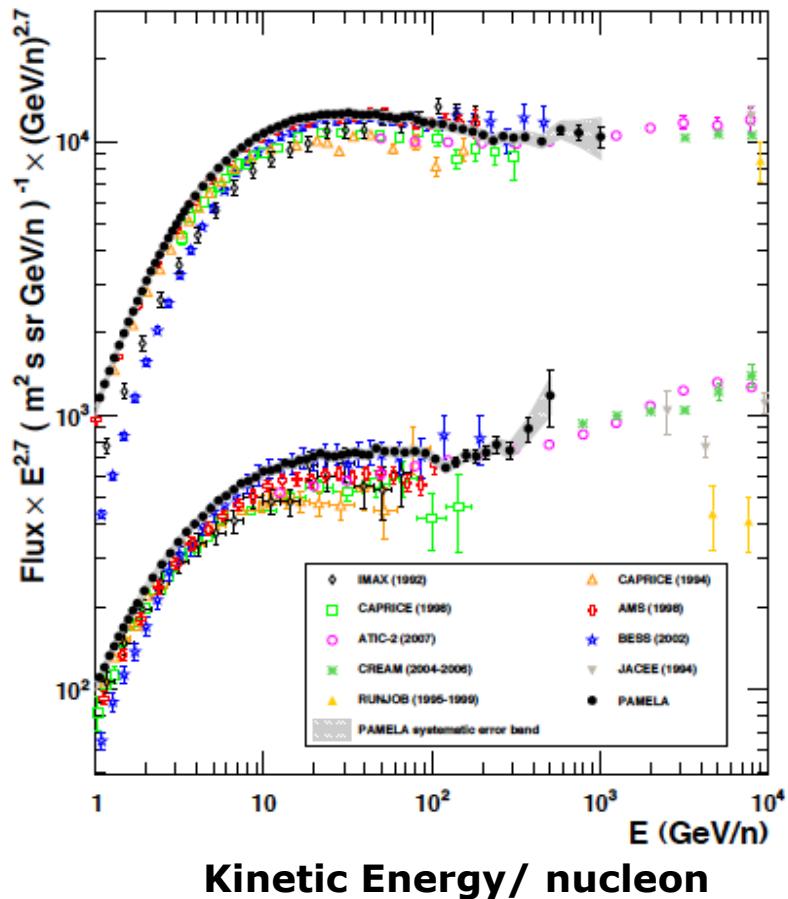
- **Experimental issues**
 - Charge confusion (proton rejection at high energy)
 - Energy measurement (resolution and energy scale, absolute calibration)
 - Acceptance correction (MC model needed)

Test Beam @ CERN



Proton and helium Fluxes measurement

Pamela, Science 1 April 2011, Vol 332



- **Experimental issues**

Nuclei identification i.e charge measurement

Rigidity (at large rigidity , unfolding necessary)

Measured Rigidity-> "True" Rigidity

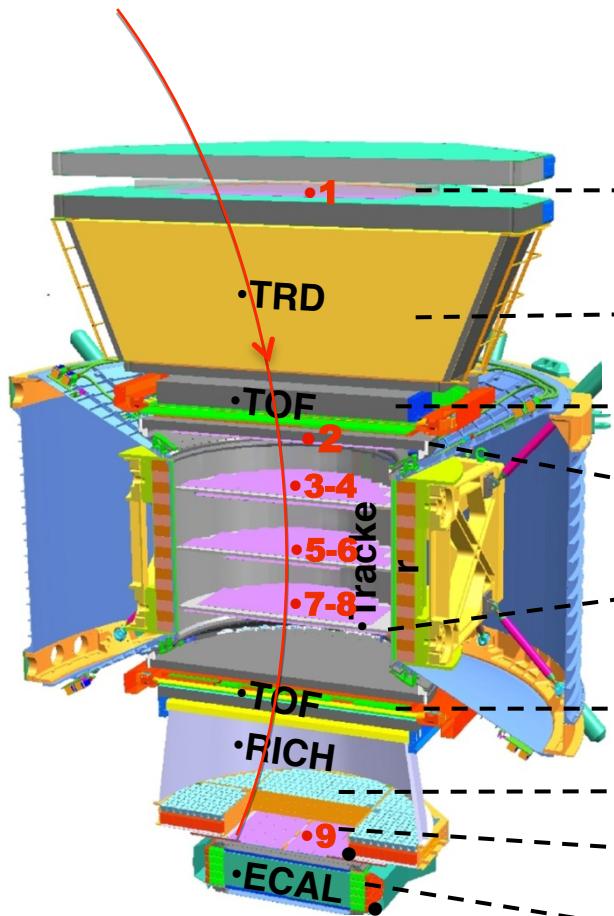
Fragmentation in the detector

Acceptance (Spectrum->fluxes, needs of MC, realistic model)

- **Charge measurement**

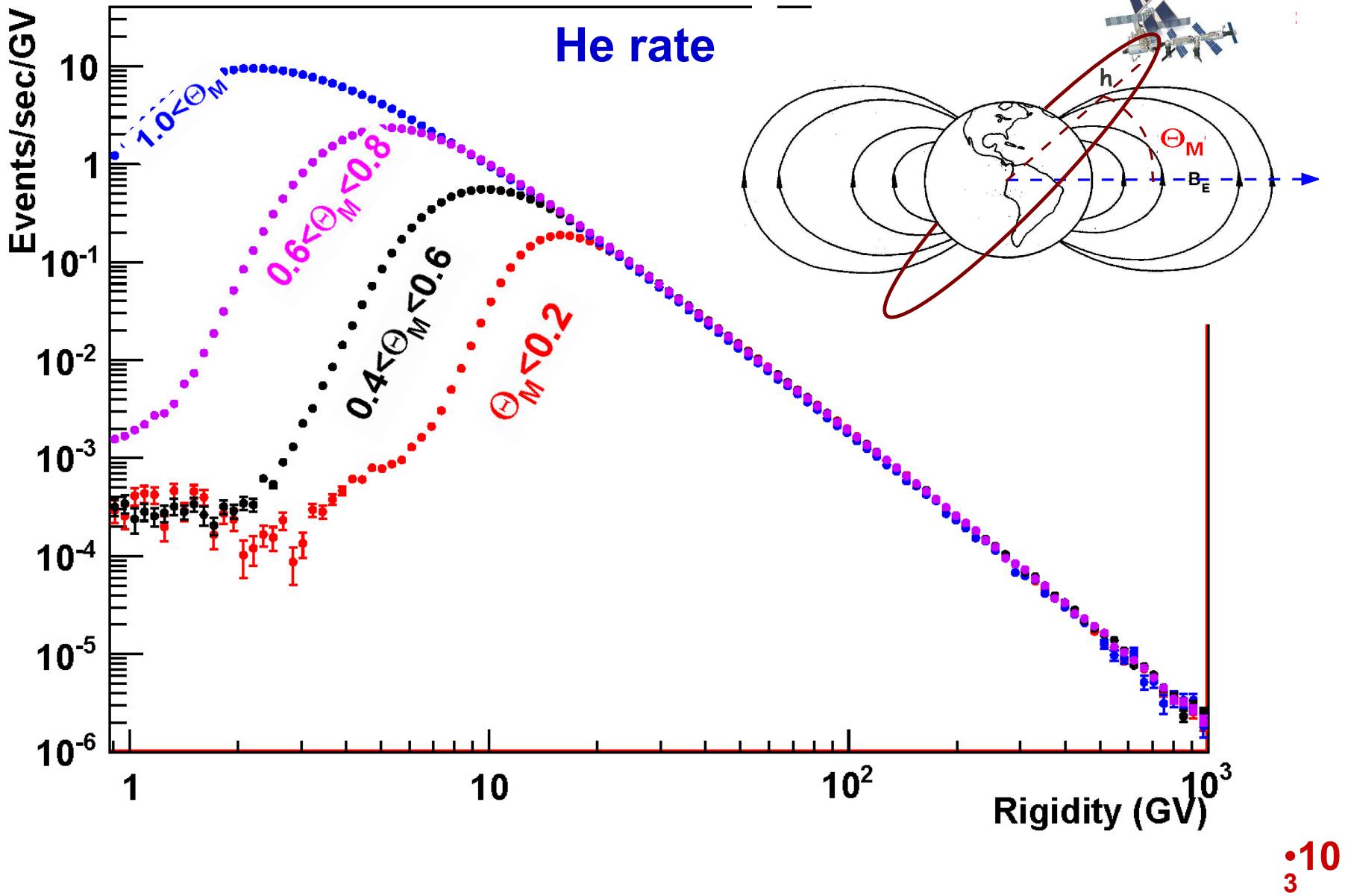
High redundancy, (Tracker, Tof, Rich, TRD)

Multiple Independent Measurements of the Charge ($|Z|$)

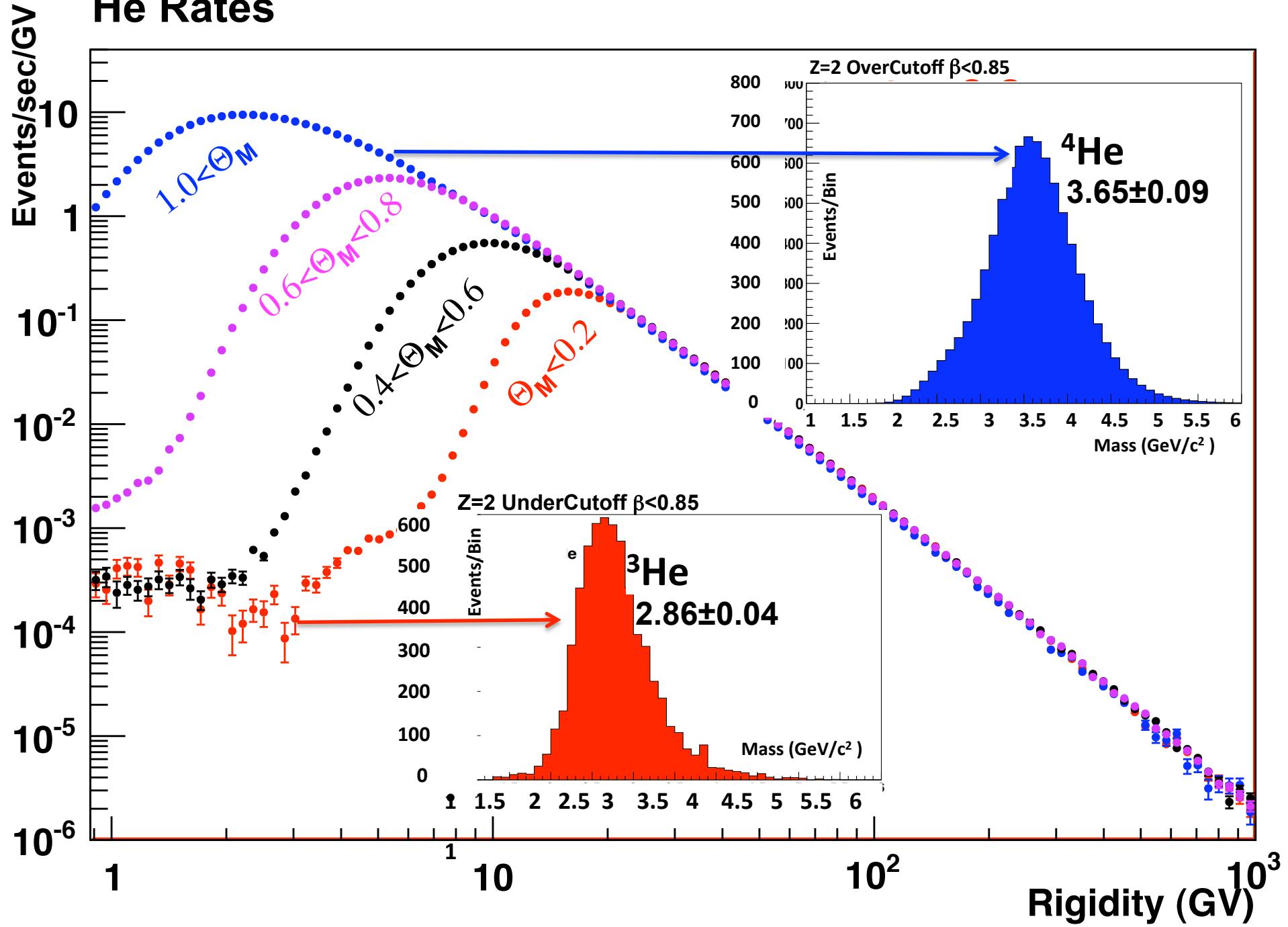


Carbon ($Z=6$)	ΔZ (cu)
1. Tracker Plane 1	0.30
2. TRD	0.33
3. Upper TOF	0.17
4. Tracker Planes 2-8	0.15
5. Lower TOF	0.20
6. RICH	0.32
7. Tracker Plane 9	0.30
8. Ecal MIP>10/18	0.36

Physics Example of AMS: Particle Yield



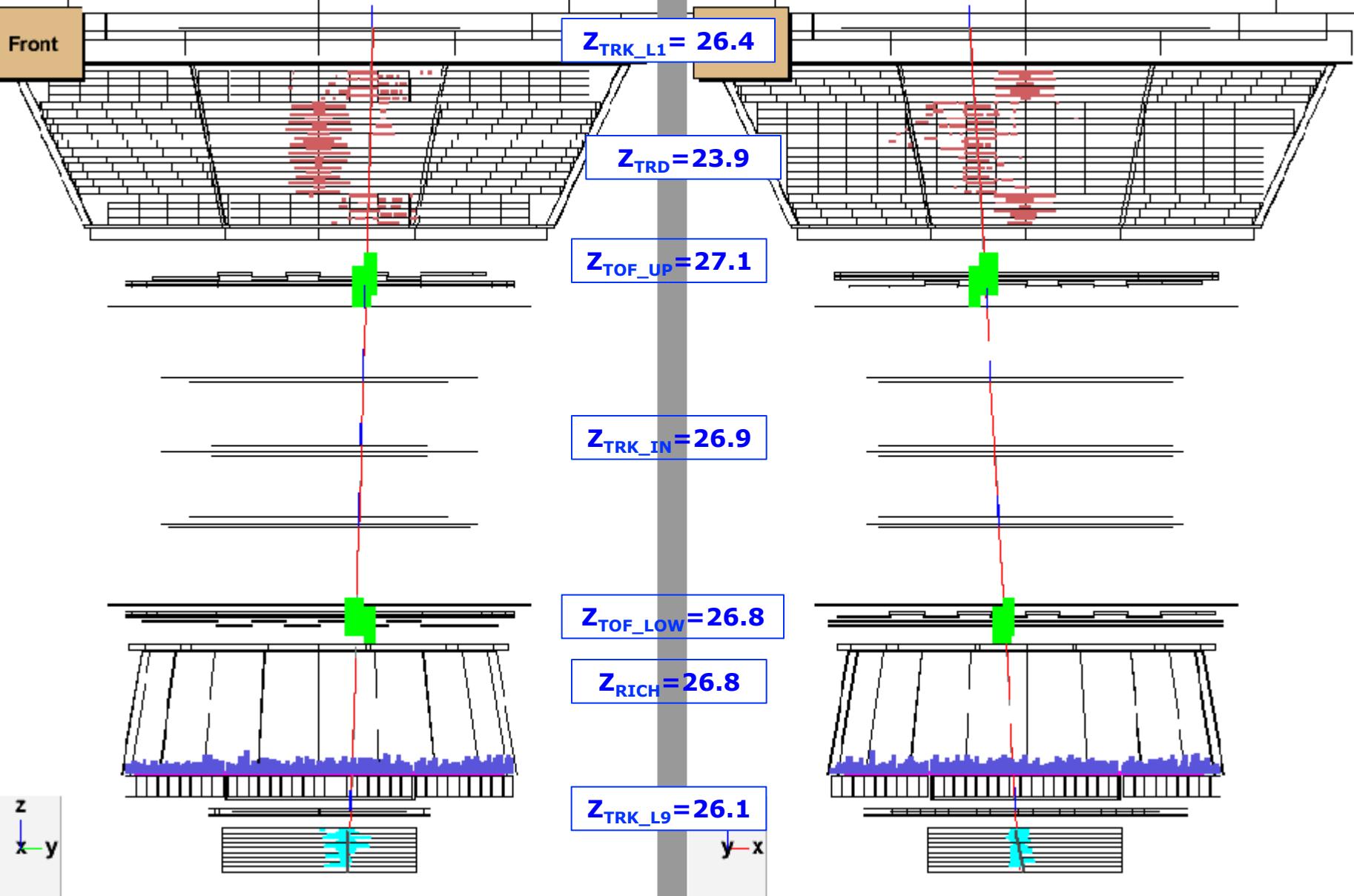
He Rates



Data from ISS

AMS Event Display

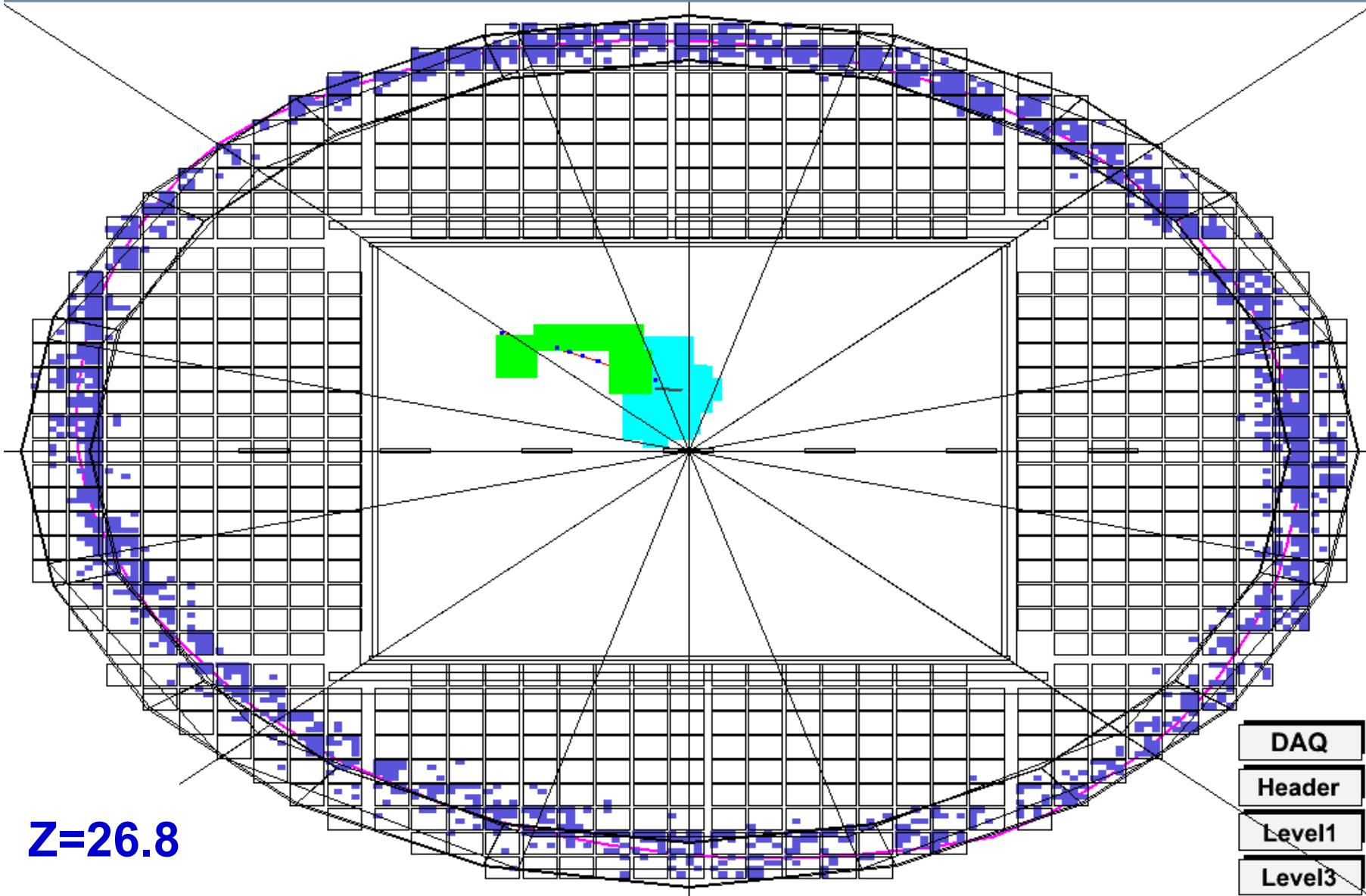
Run/Event 1331498136 / 219985 GMT Time 2012-071.20:50:42



Data from ISS

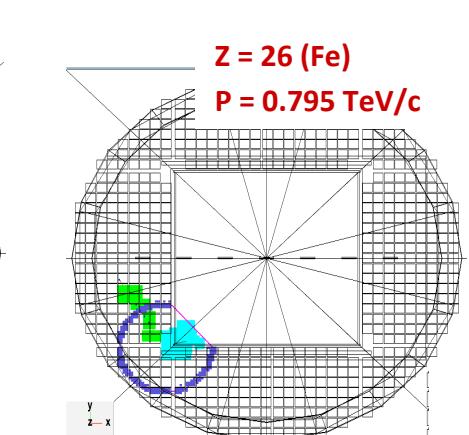
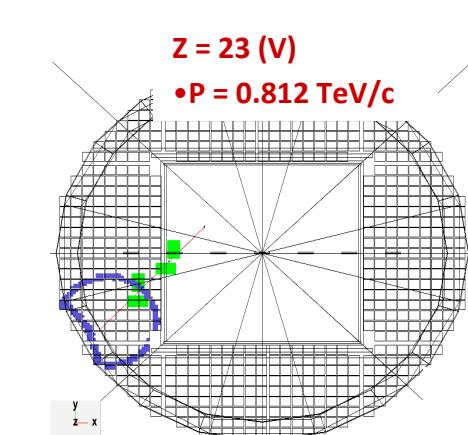
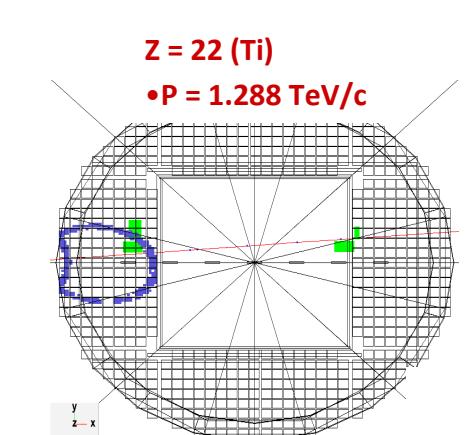
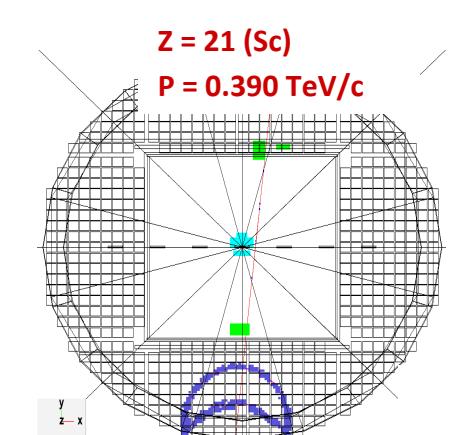
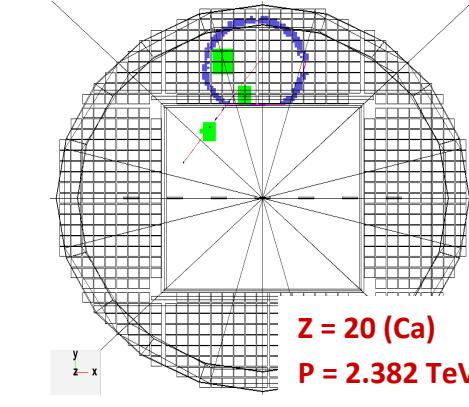
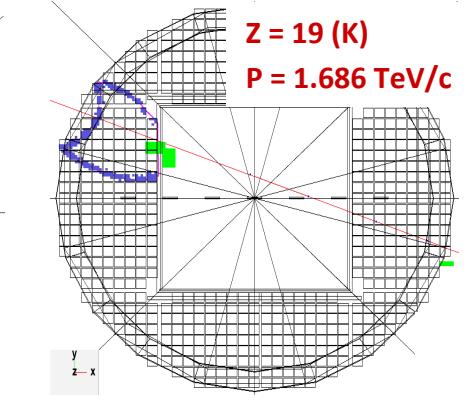
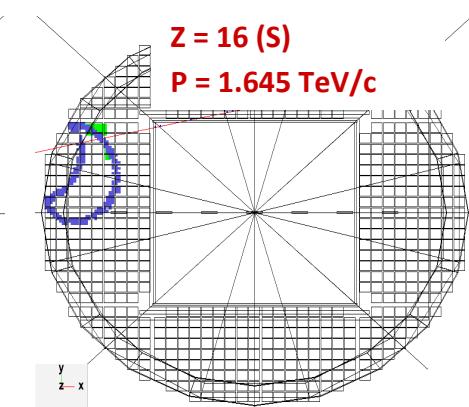
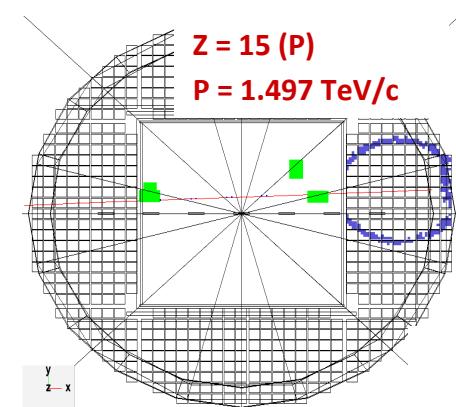
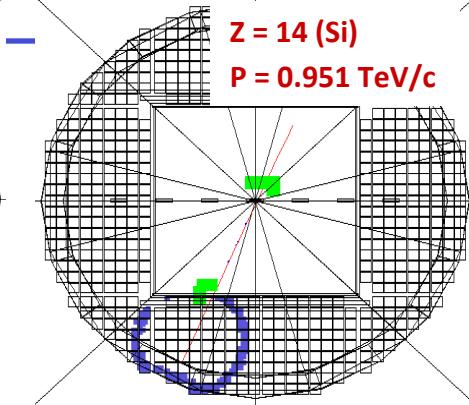
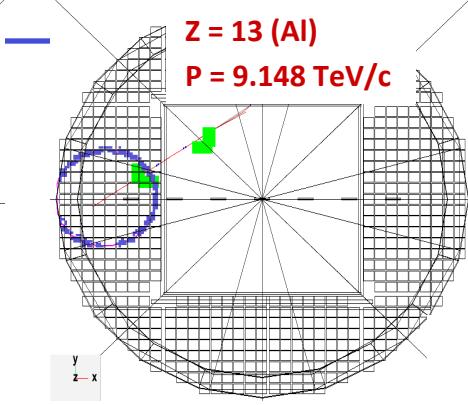
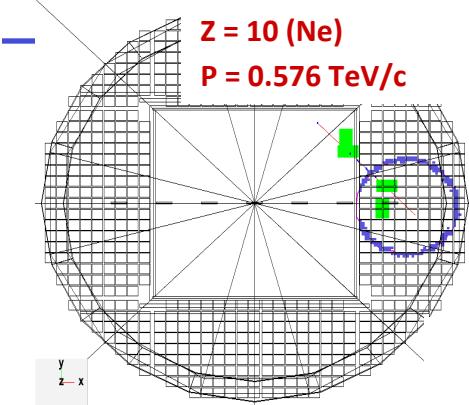
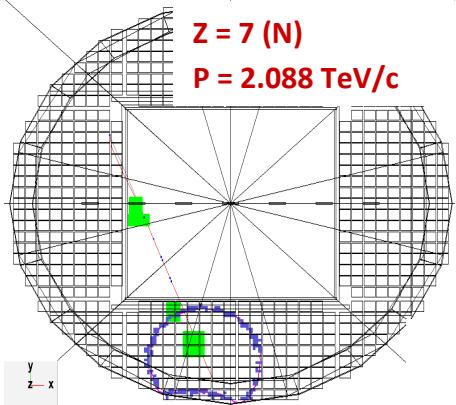
AMS Event Display

Run/Event 1331498136 / 219985 GMT Time 2012-07-12 20:50:42



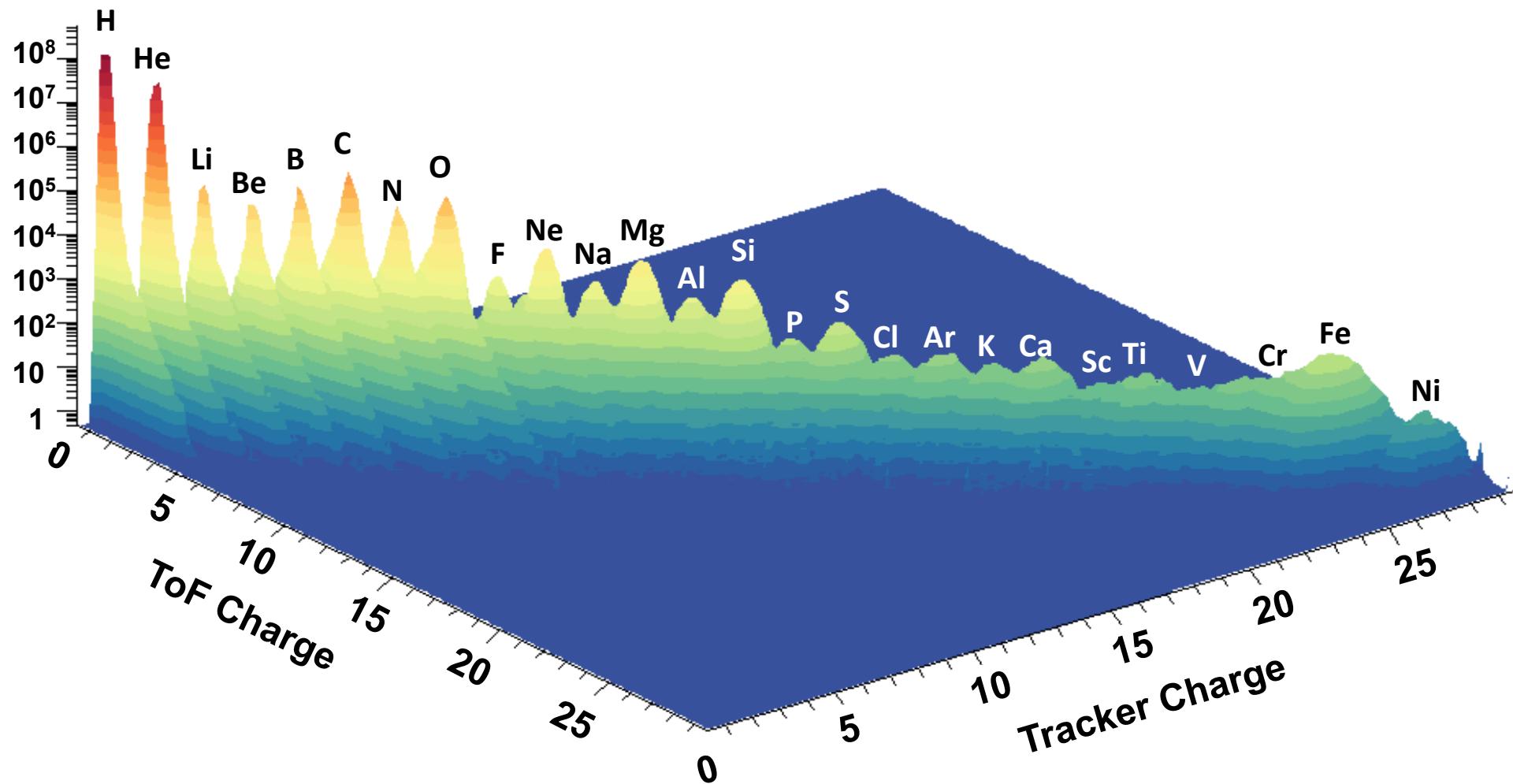
Data from ISS

Nuclei in the TeV range



AMS Nuclei Measurement on ISS

Entries

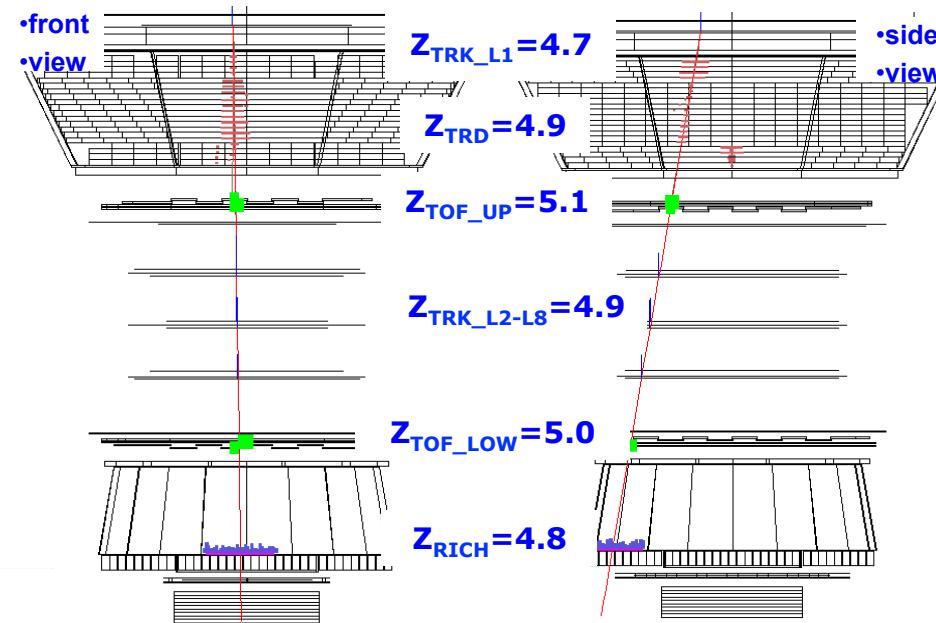


Rigidity ~ 20 GV

Boron

Rigidity=24 GV

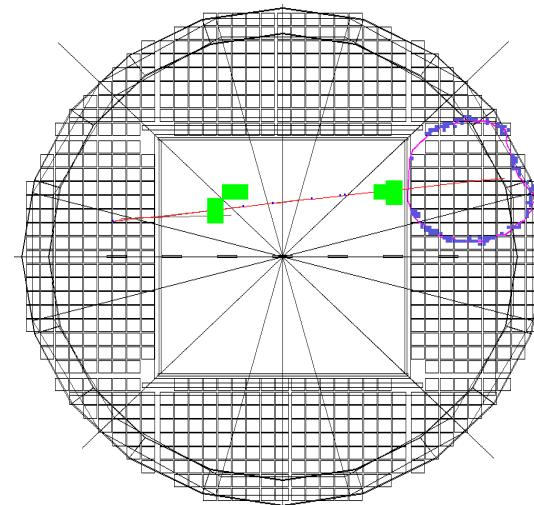
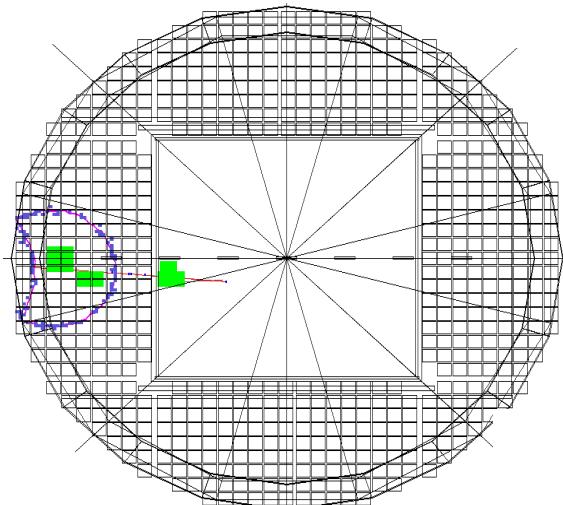
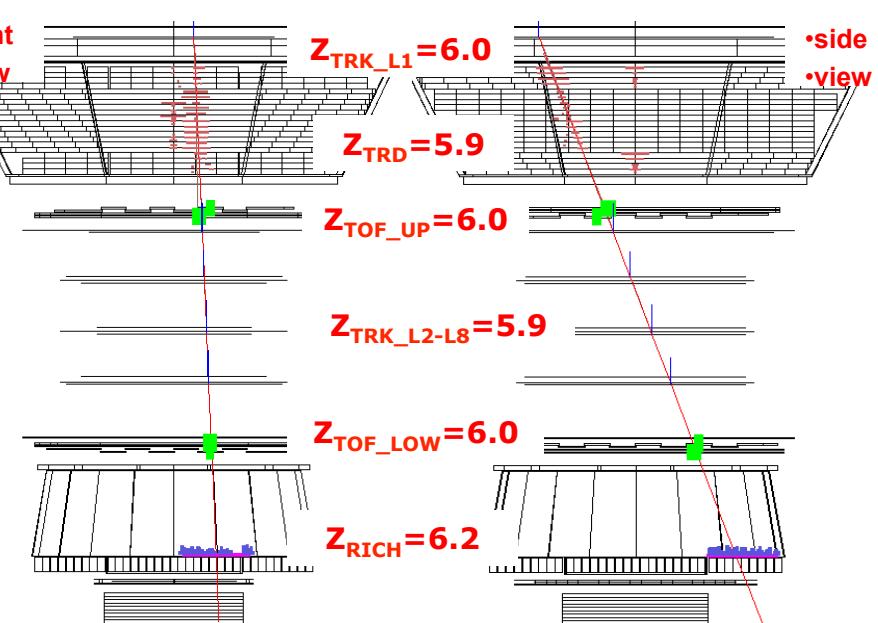
Run/Event 1326201809/ 798775



Carbon

Rigidity=24 GV

Run/Event 1329490720/ 473181

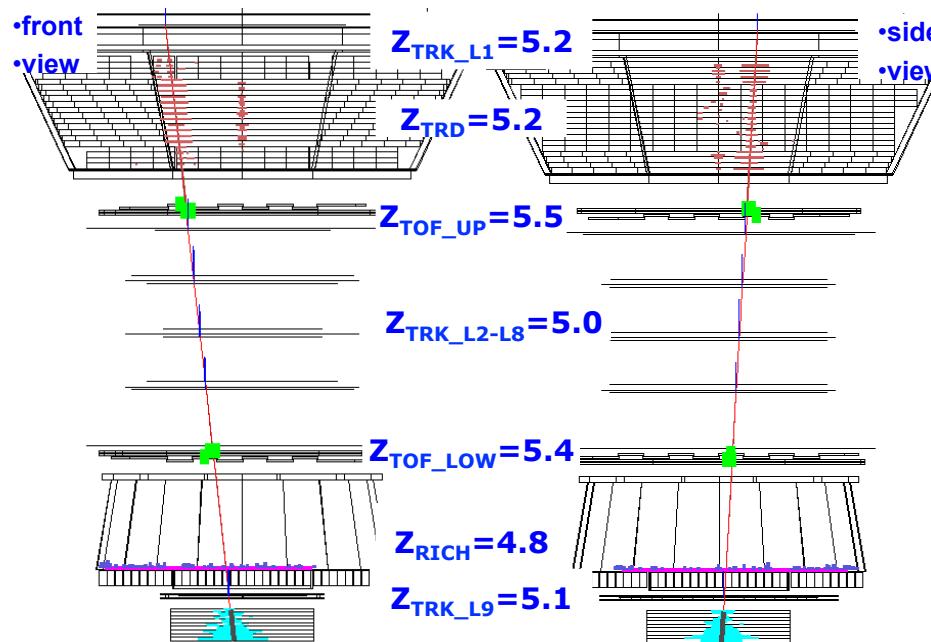


Rigidity ~ 700 GV

Boron

Rigidity=680 GV

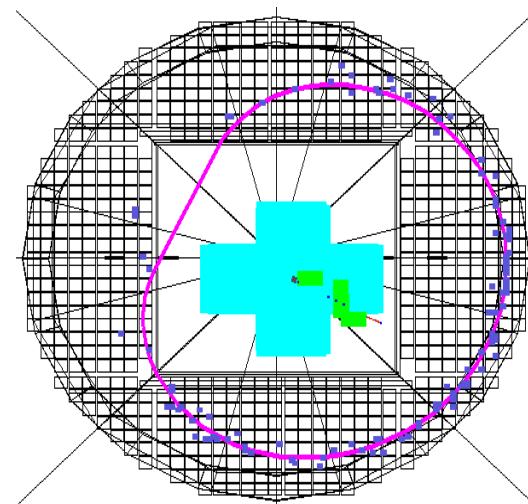
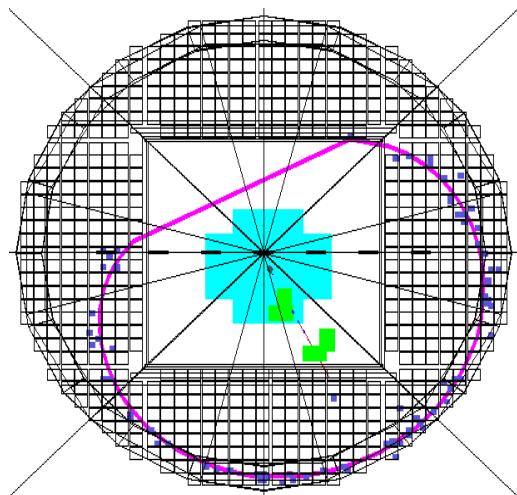
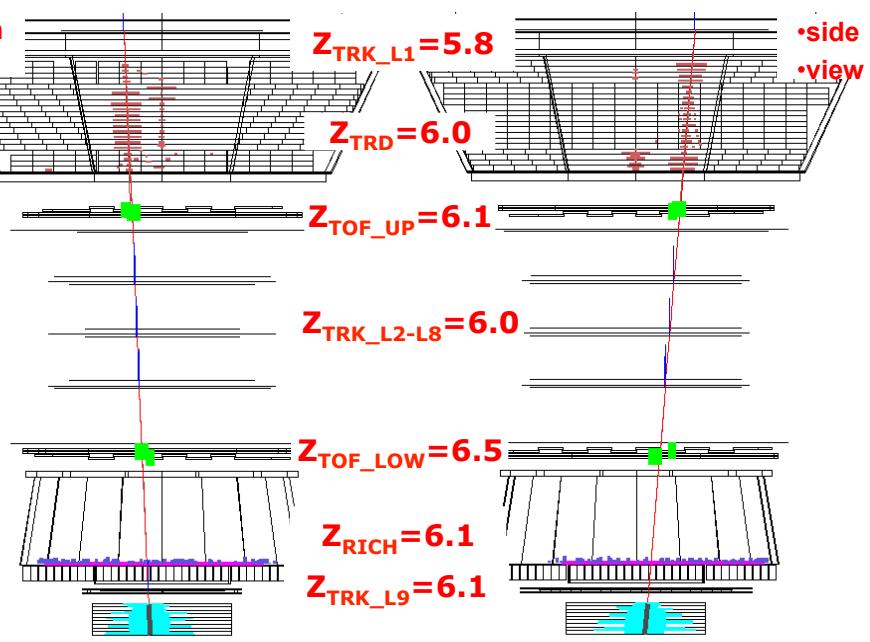
Run/Event 1319990213/ 235892



Carbon

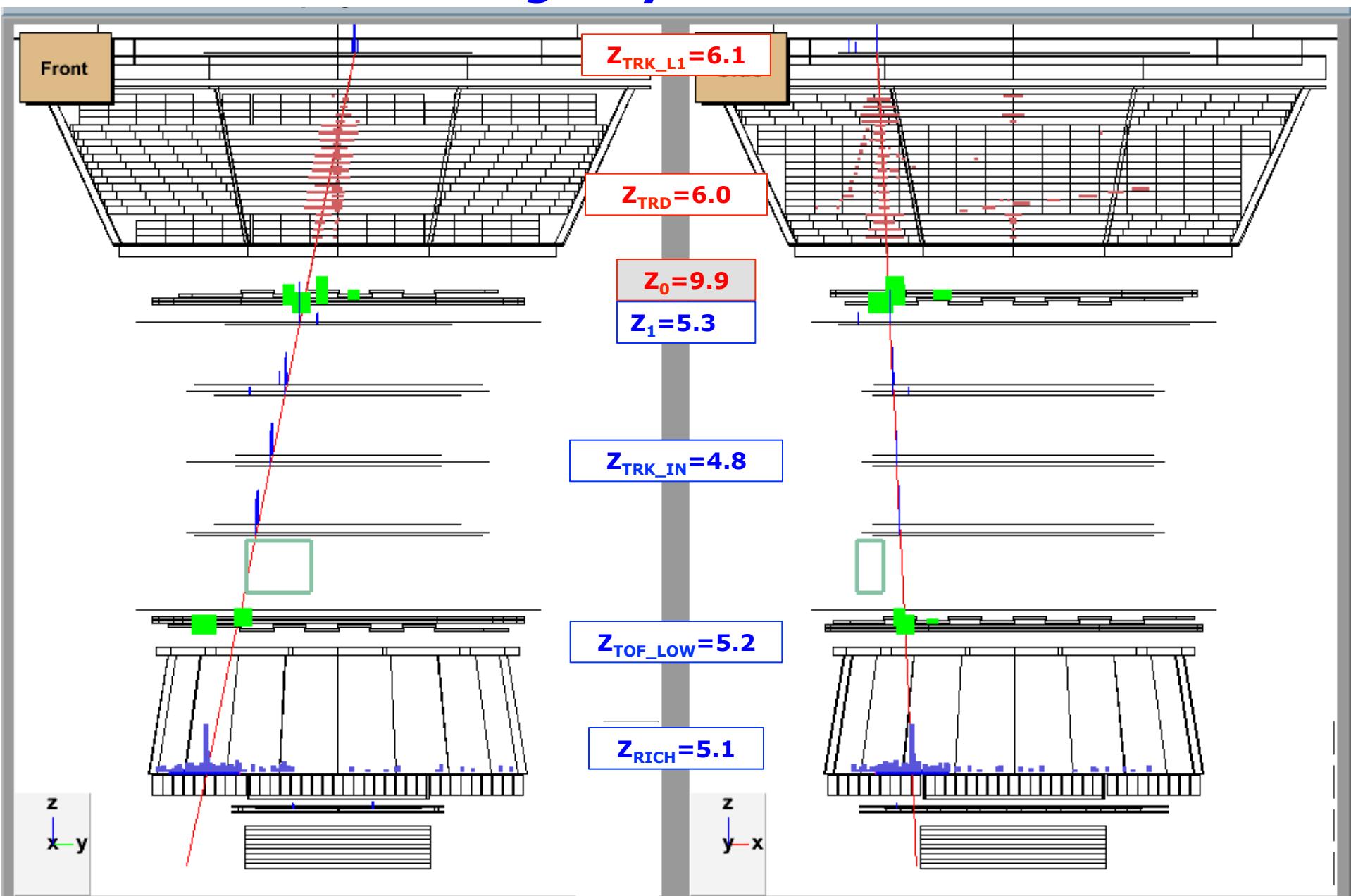
Rigidity=666 GV

Run/Event 1327184805/ 266043



Carbon Fragmentation to Boron in Upper TOF

Rigidity 10.6 GV



Summary

- AMS02 is operating on the ISS since the 19th May 2011 and has collected ~26 billions of events: All AMS subsystems are fully operational with the performance expected from ground measurements.
- e^+ / ($e^+ + e^-$) : significant statistics increased with respect to previous measurements and systematics due to the proton contamination is low.
- Redundancy of the charge measurement allows to identify Nuclei's fragmentation in the detector

=> Analyses are on going.