Performance, Operational Aspects and Impact on Physics Results of the AMS Tracker

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On behalf of the AMS Tracker Collaboration

Vertex
19 Sep 2013
Lake Stanberg

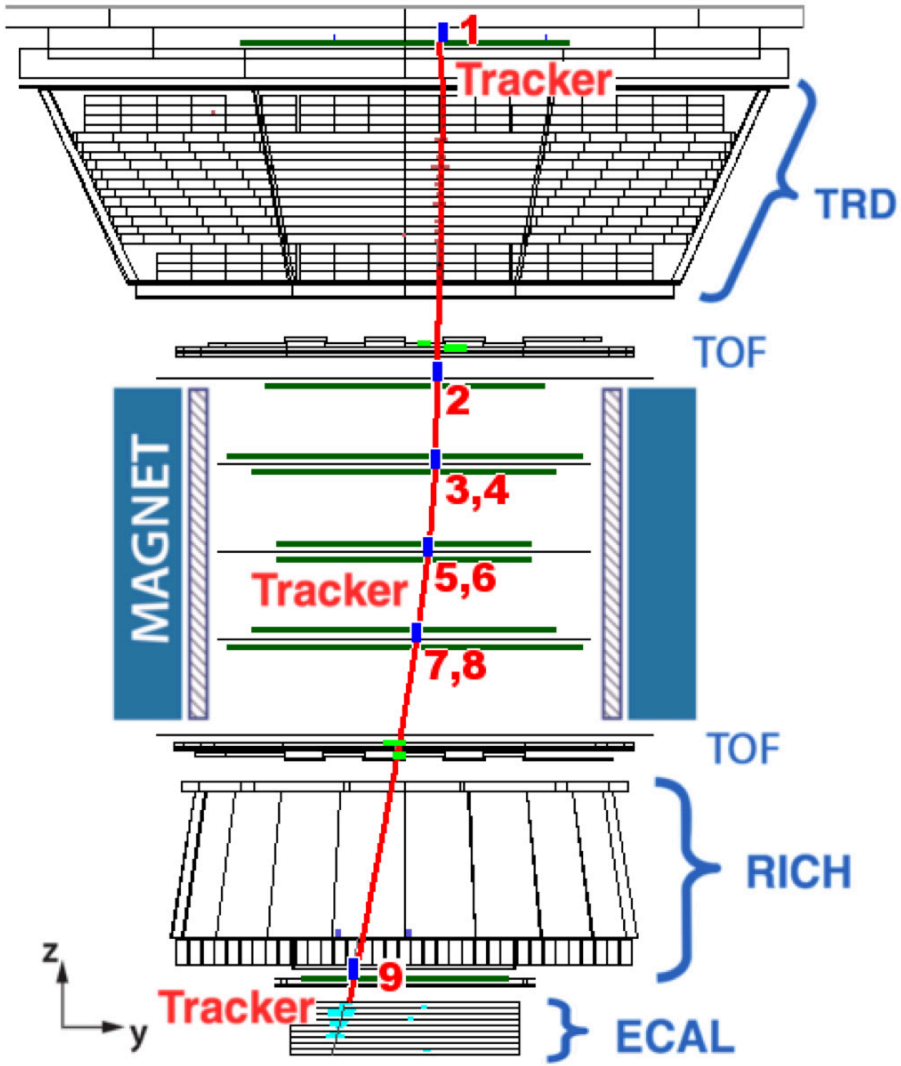
Outline

(a) AMS and its Tracker

(b) Tracker on-orbit

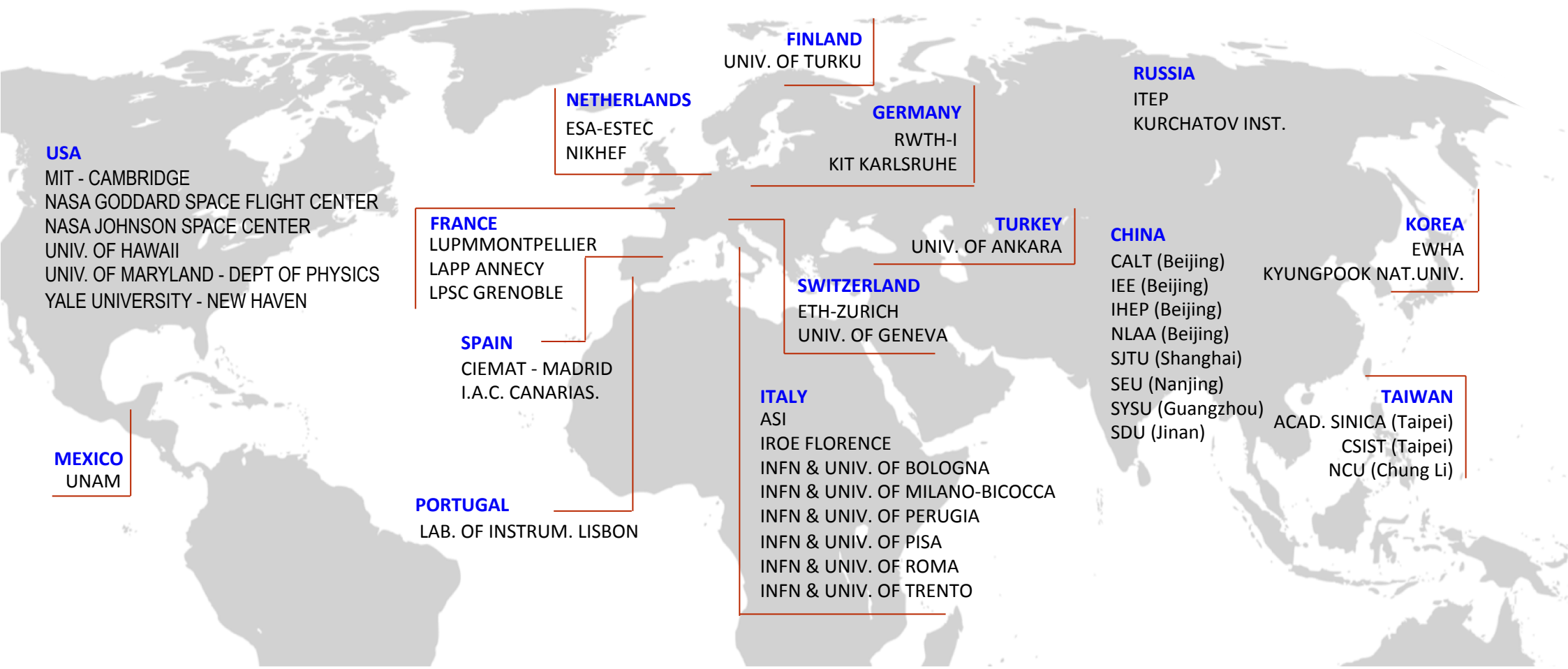
(c) Tracker performances

(d) Tracker in analysis



AMS-02 Collaboration

15 Countries, 44 Institutes and 600 Physicists, 20 years



AMS Tracker Collaboration: Perugia, Geneva, RTWH, SYSU, CSIST

AMS-02 on Orbit

From May 19th 2011 active on ISS.

Acquired more than 38 billion events.

ISS environment

Radiation (Single Event Effect)

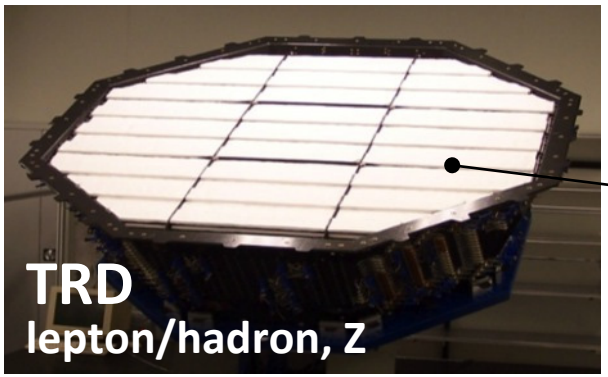
Vacuum (10^{-10} Torr)

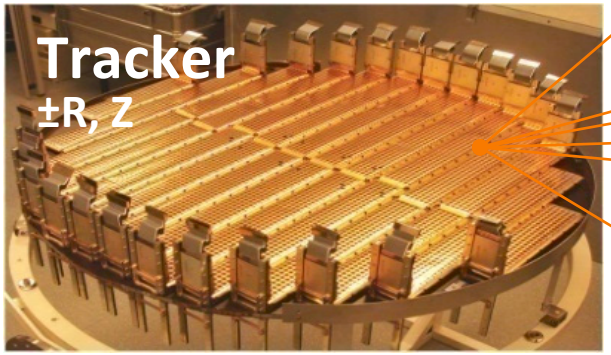
Temperature variation (day/night $\Delta T = 100^{o}C$)

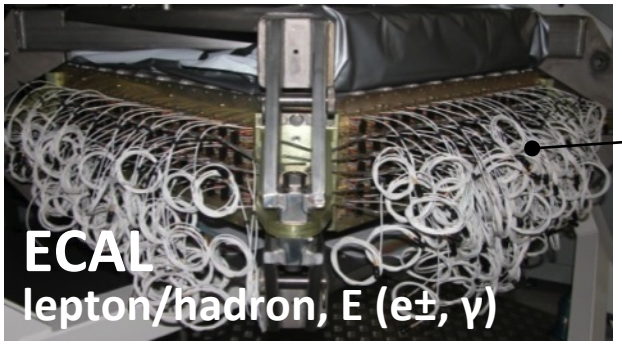
Orbital debris and micrometeorites (v = 7 km/s)

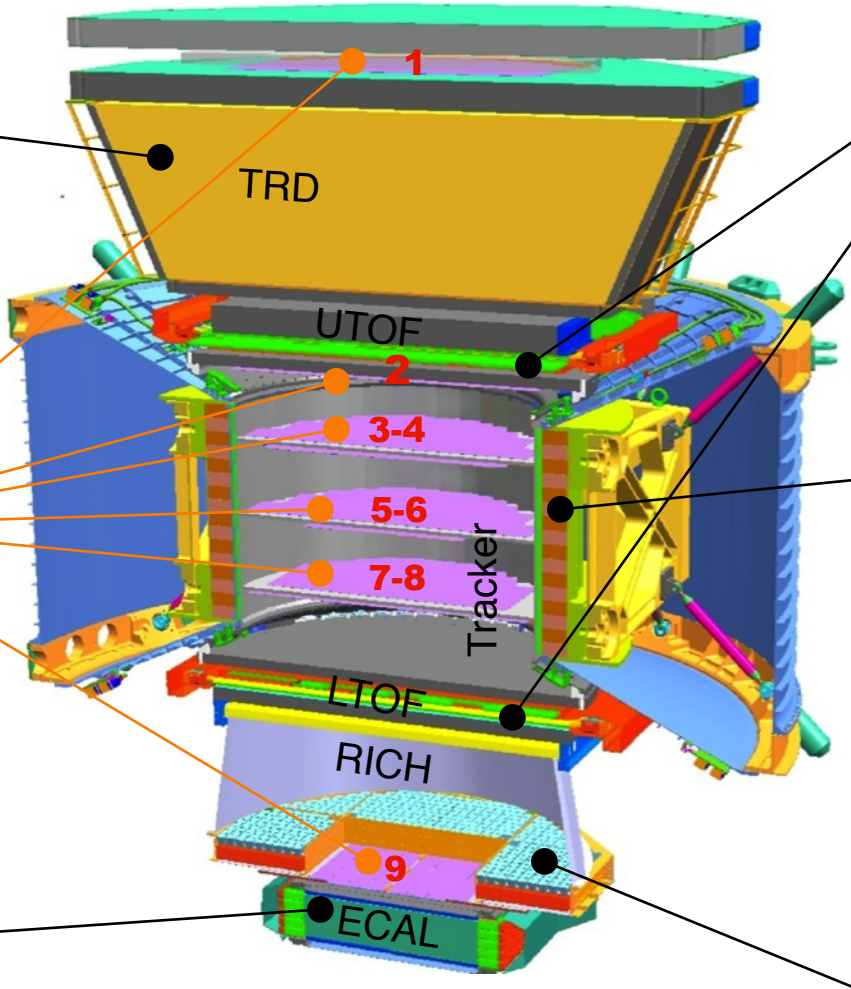
Limitation in power (max. 2kW), bandwidth (max. 20 Mb/s) and maintenance

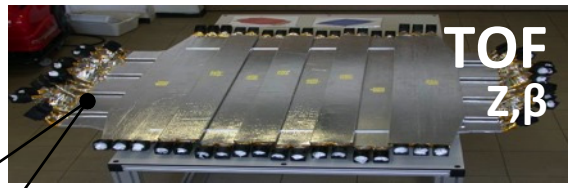
AMS-02 Detector

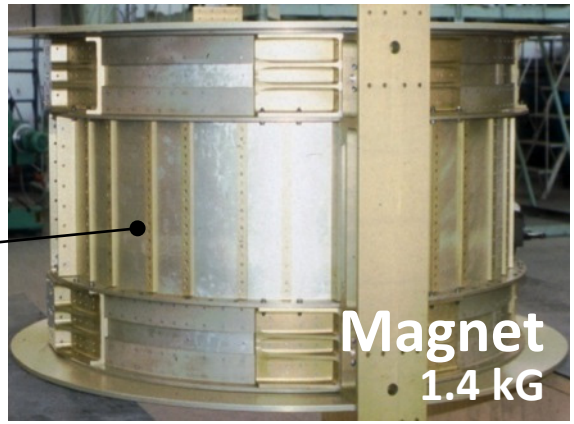


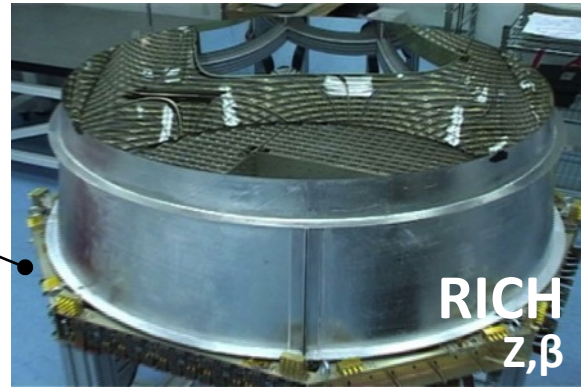




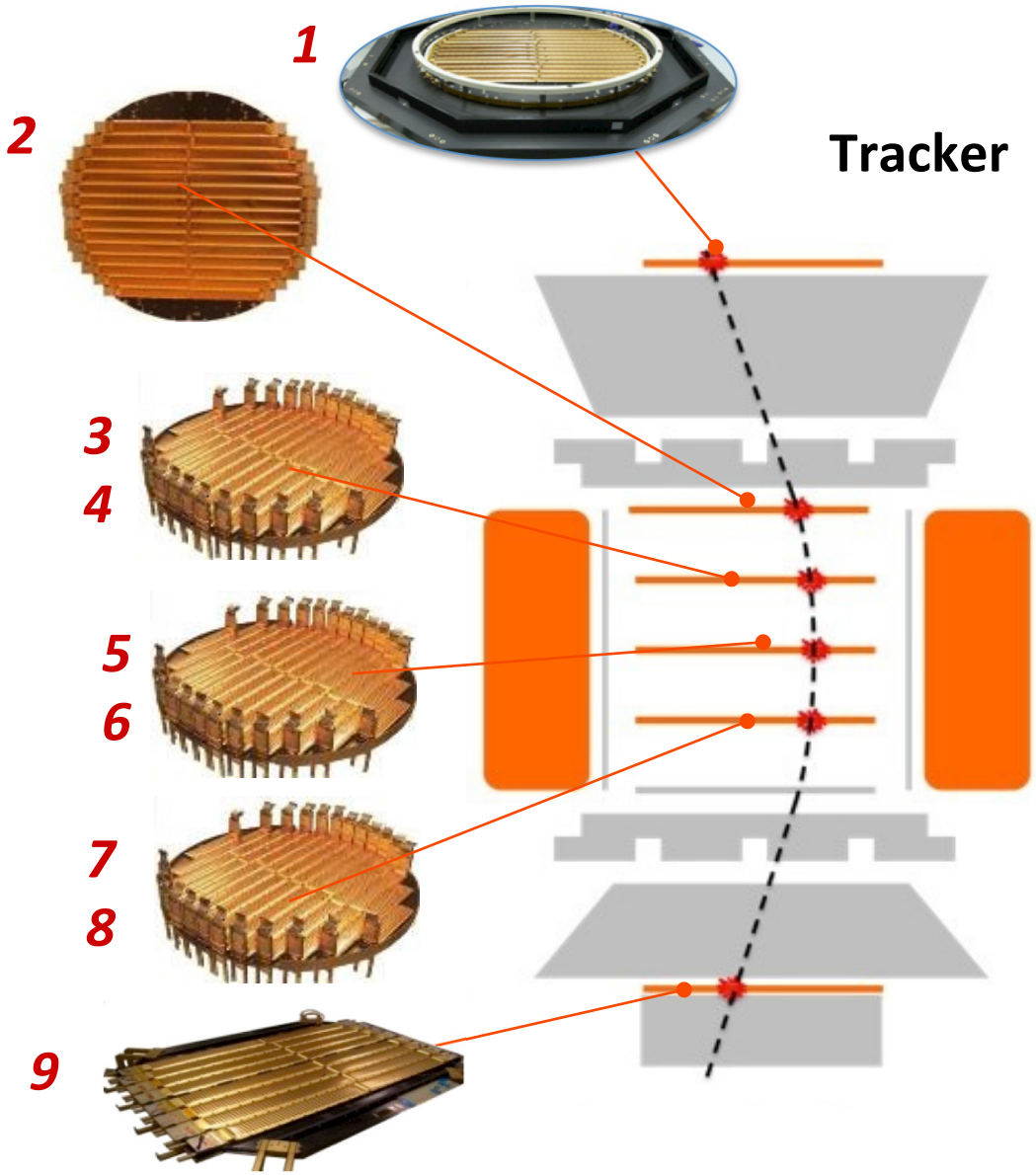




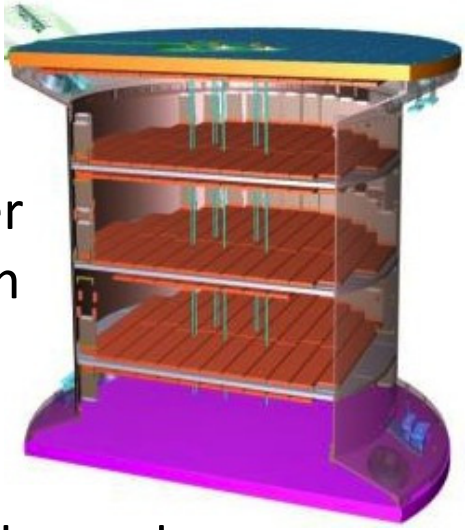




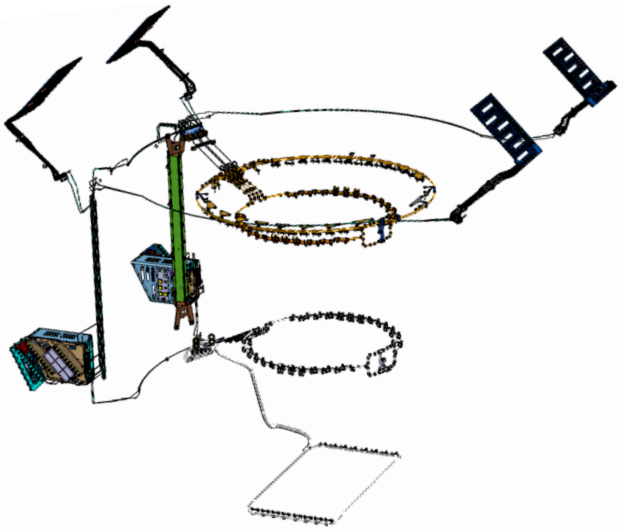
AMS-02 Silicon Tracker System



TAS, Tracker Laser Alignment System

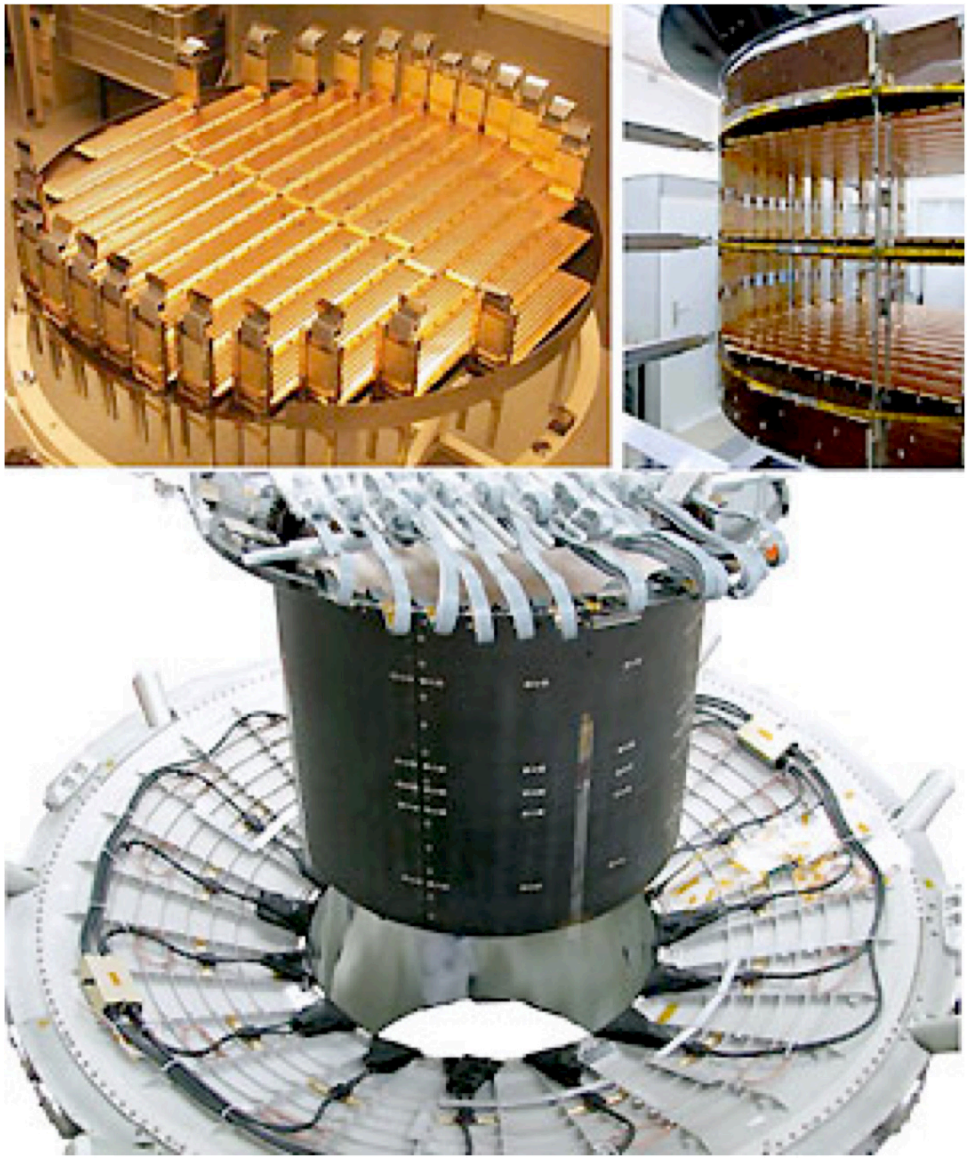


TTCS, Tracker Thermal Control System



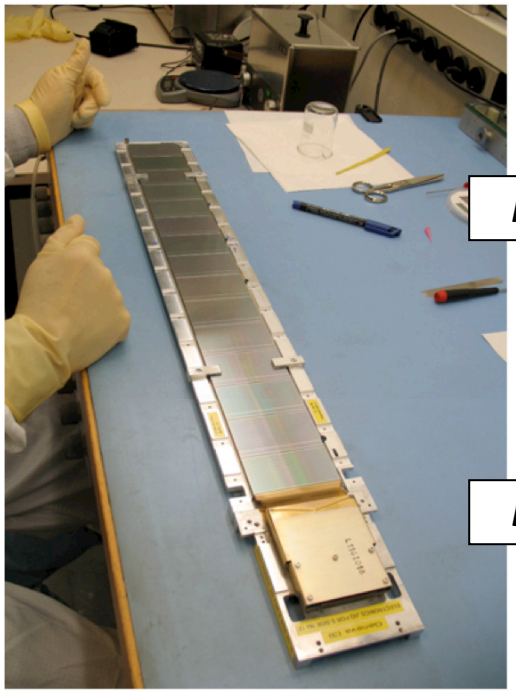
The AMS-02 Silicon Tracker Detector

- 9 layers of **300 μm** thickness **double-sided** silicon detectors arranged in 192 ladders
- 6 honeycomb carbon fiber planes. Overall detector material **~ 0.04 X_0**
- total of **196k channels** for **192 watt** dissipated on the front-end electronics
- **126 W** cooled by TTCS
- **10 μm** (30 μm) spatial resolution in bending (non bending) coordinate
- high dynamic range front end for charge measurement (Z measurement up to Iron)
- wide temperature range:
  - -20/+40 °C survival
  - -10/+25 °C operational

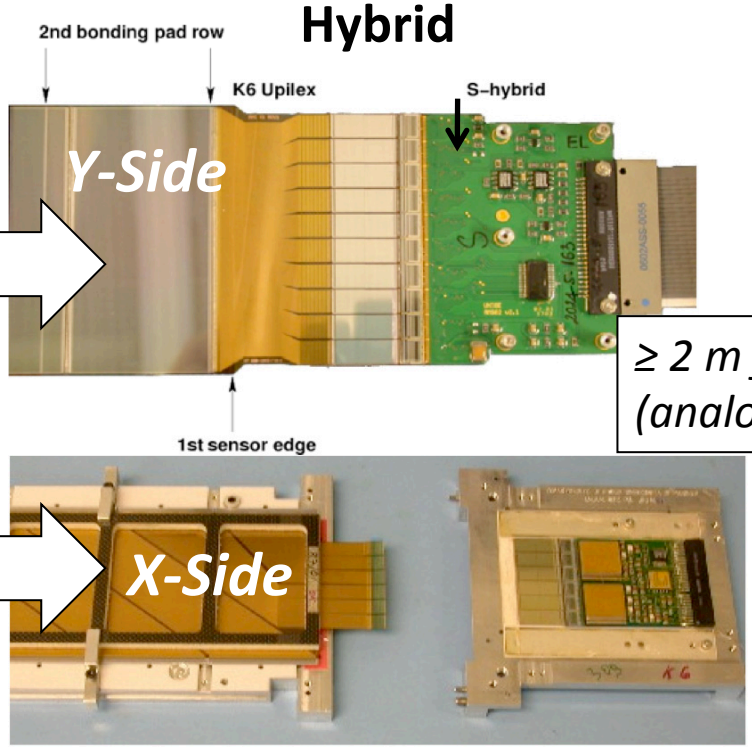


Silicon Tracker Readout Chain

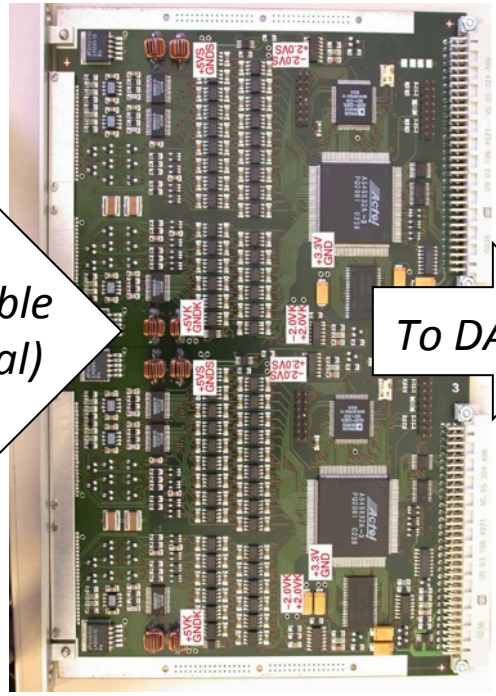
Sensor



Hybrid



Data Reduction



≥ 2 m flat cable (analog signal)

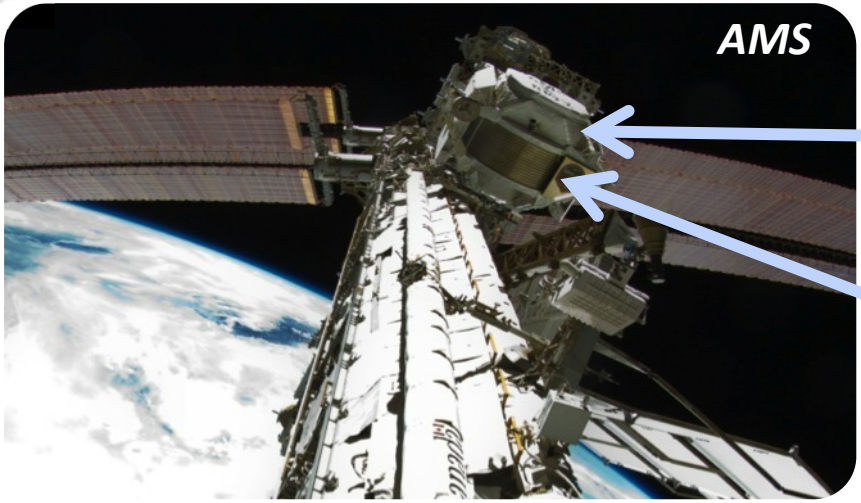
To DAQ

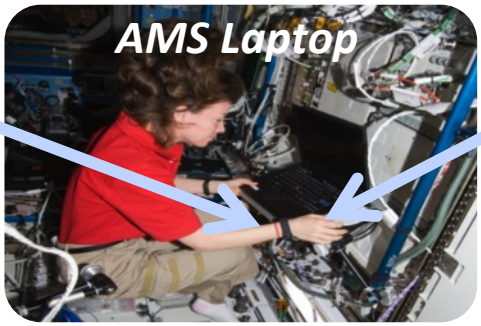
- 300 μm, 7 × 4 cm²
- 27.5(104) μm strip impl. pitch
- 110(208) μm readout pitch
- 81 keV ionization for 1 MIP
- Charge sharing
- Capacitive coupling (1 pF/cm)

- 640(384) readout channels
- Amplification (100 MIP range)
- Shaping (4 μs)
- Sample-and-Hold
- Each channel 0.7 mW power
- 10(6) VA_hdr64a

- 3 ADC
- Pedestal/Noise eval.
- Common noise sub.
- Cluster search
- Comp. factor of ~ 1000

AMS-02 Data Flow





Average data rate
~ 10Mbit/s
→ 70 TB of raw data
→ 30 billion triggers

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

AMS Computers at MSFC, AL

White Sands Ground Terminal, NM

The Thermal Environment

AMS is in shadow

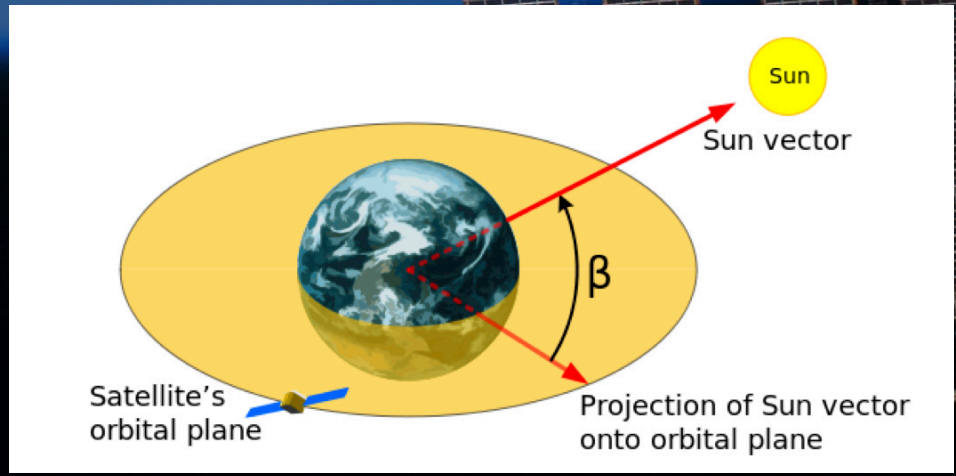
Thermal environment variation factors

Sun position along the orbit (day/night)

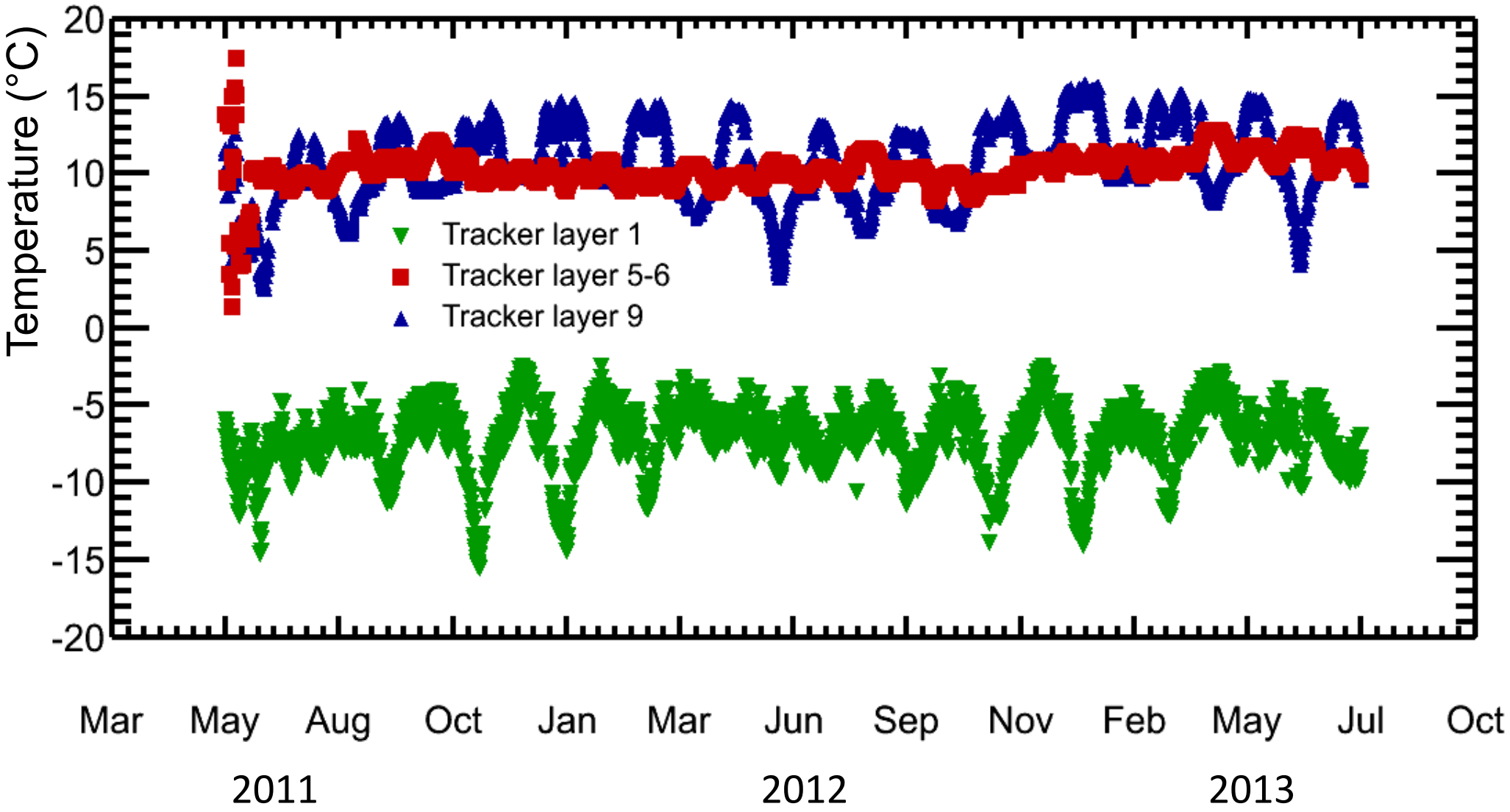
Seasonal variation

Solar arrays and radiator position (shadow)

ISS attitude and visiting vehicles

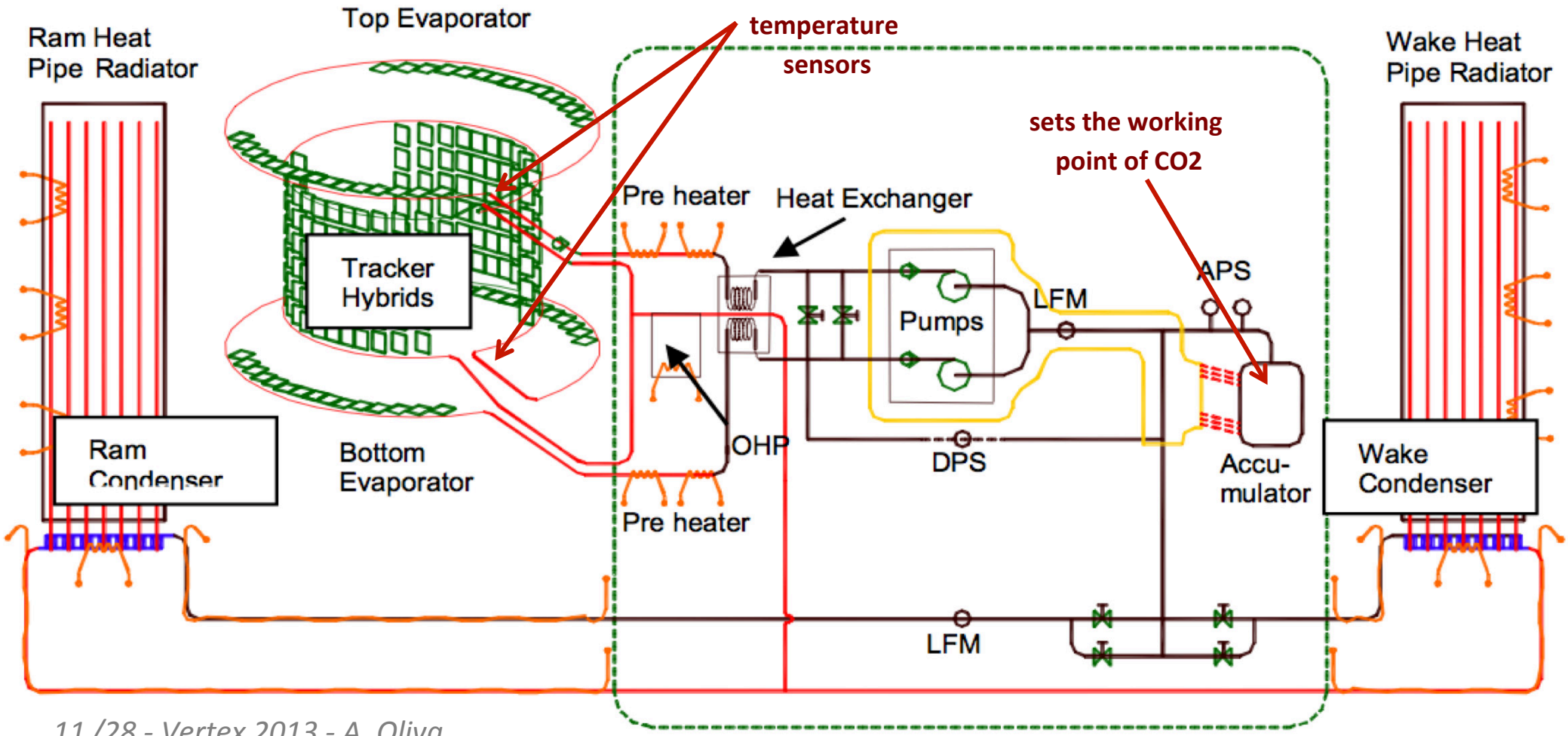


Tracker Temperature Stability



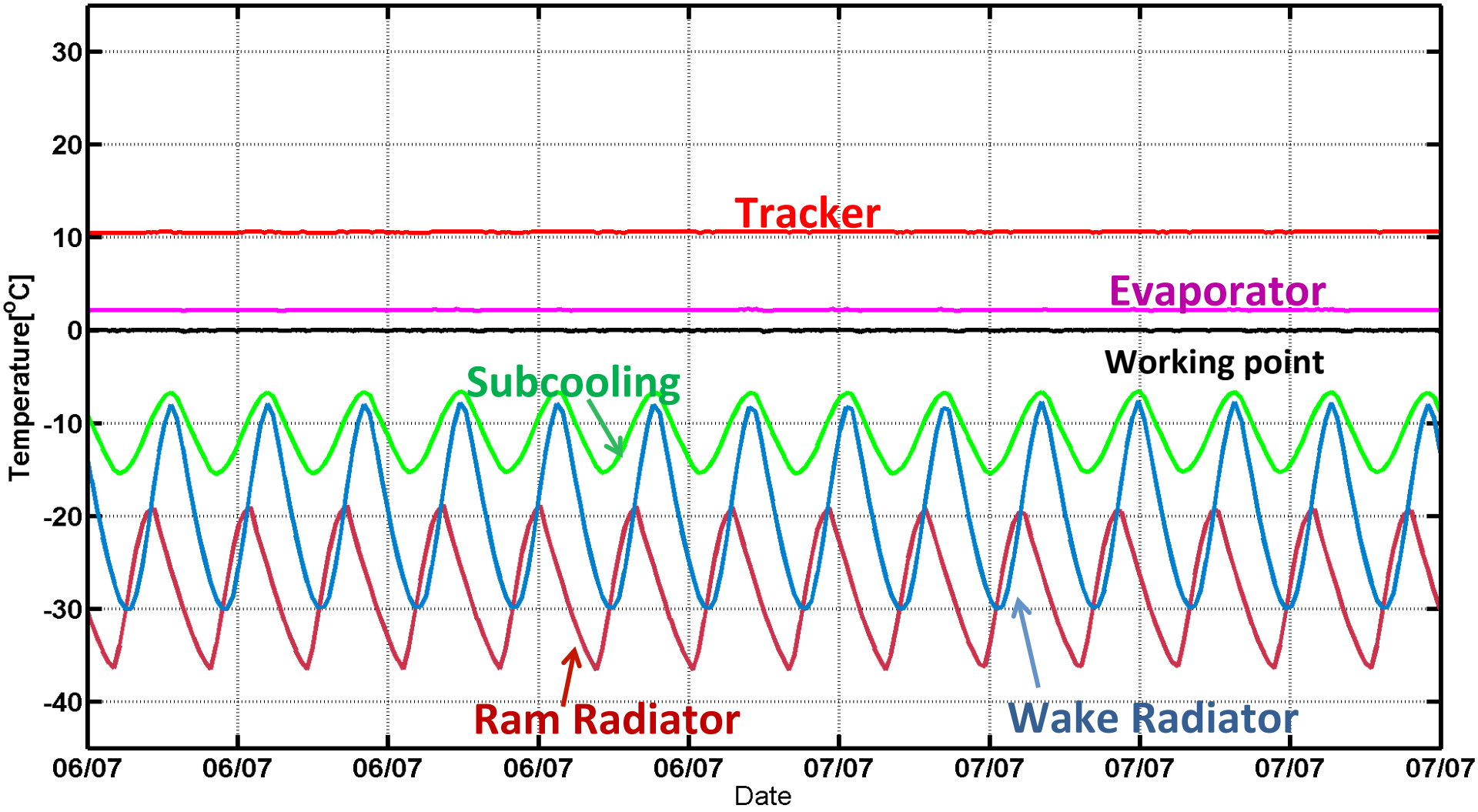
Tracker Thermal Control System

- TTCS is a 2 phases CO_2 pumped loop (first pumped CO_2 system in space)
- TTCS serves to AMS-02 Tracker from layer 2 to layer 9 removing a total power of 125W
- Tracker layer 1, facing deep space, needs only a system of heaters

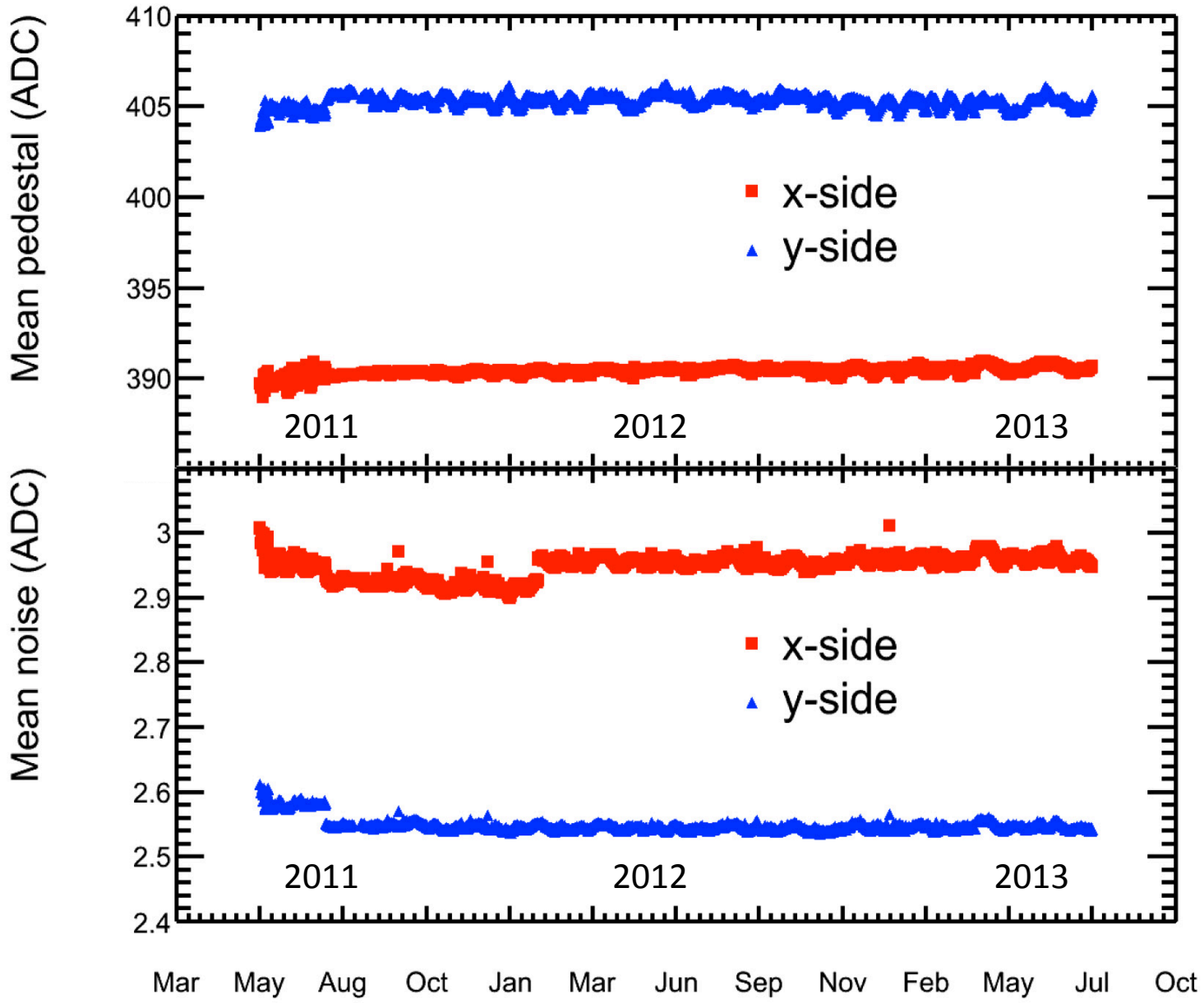


A TTCS Day

- The tracker temperature is stable within 1°C during normal running
- Radiator temperatures vary at the range of 20 °C in every earth orbit

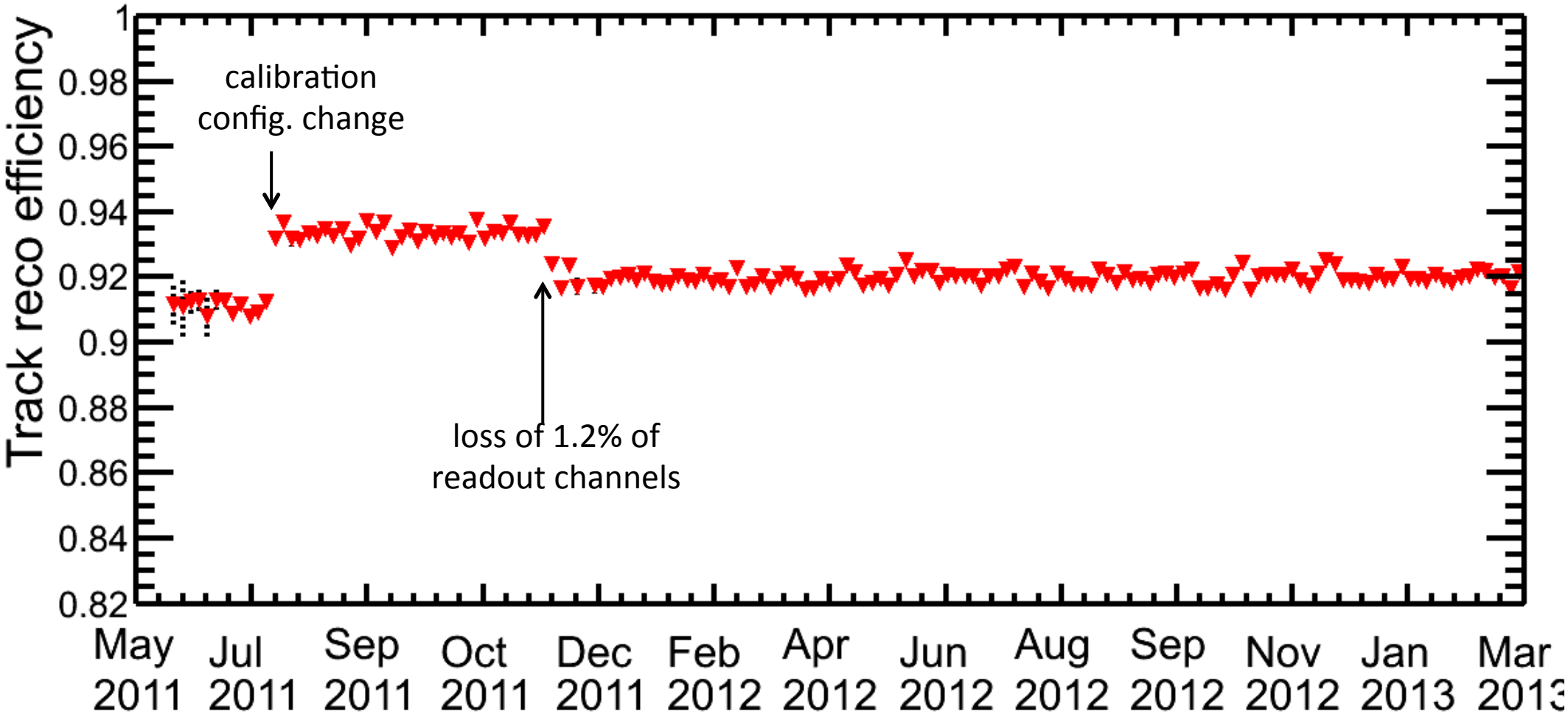


Tracker Calibration Stability



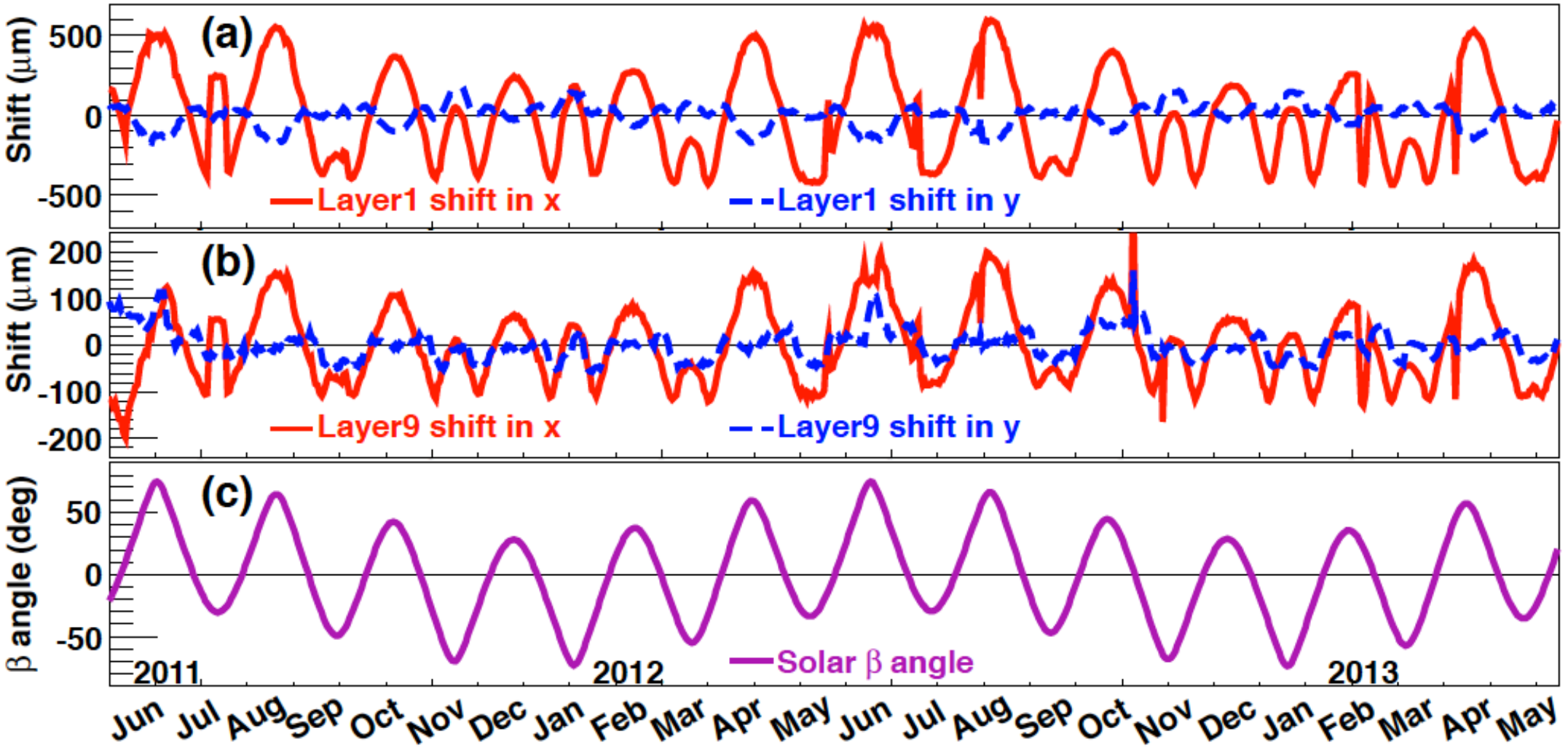
Tracker Efficiency Stability

- Efficiency is estimated using TOF as reference detector

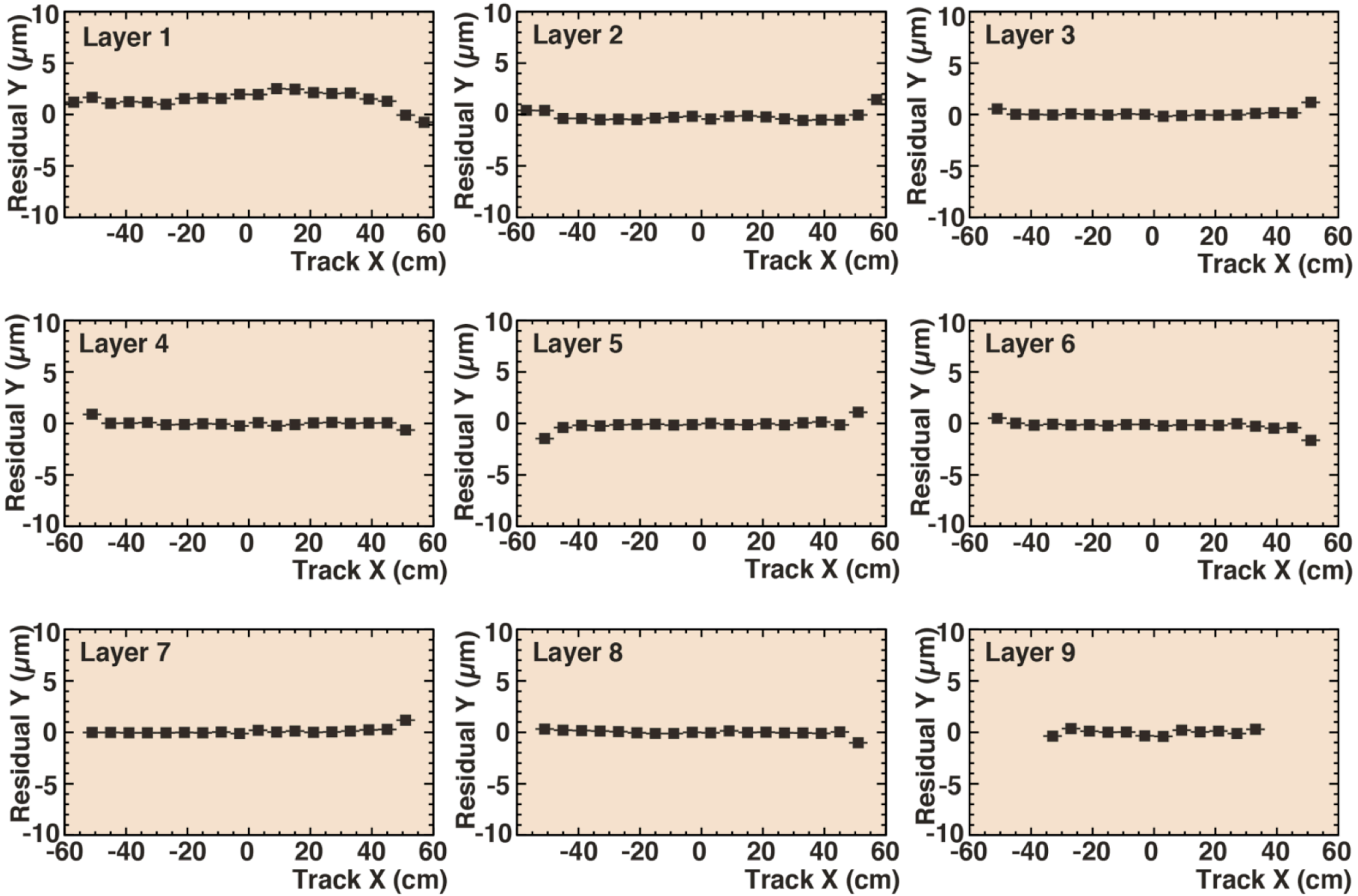


Tracker Alignment Stability

- Large movements due to temperature variation on external layers.
- Procedure to dynamically external planes developed

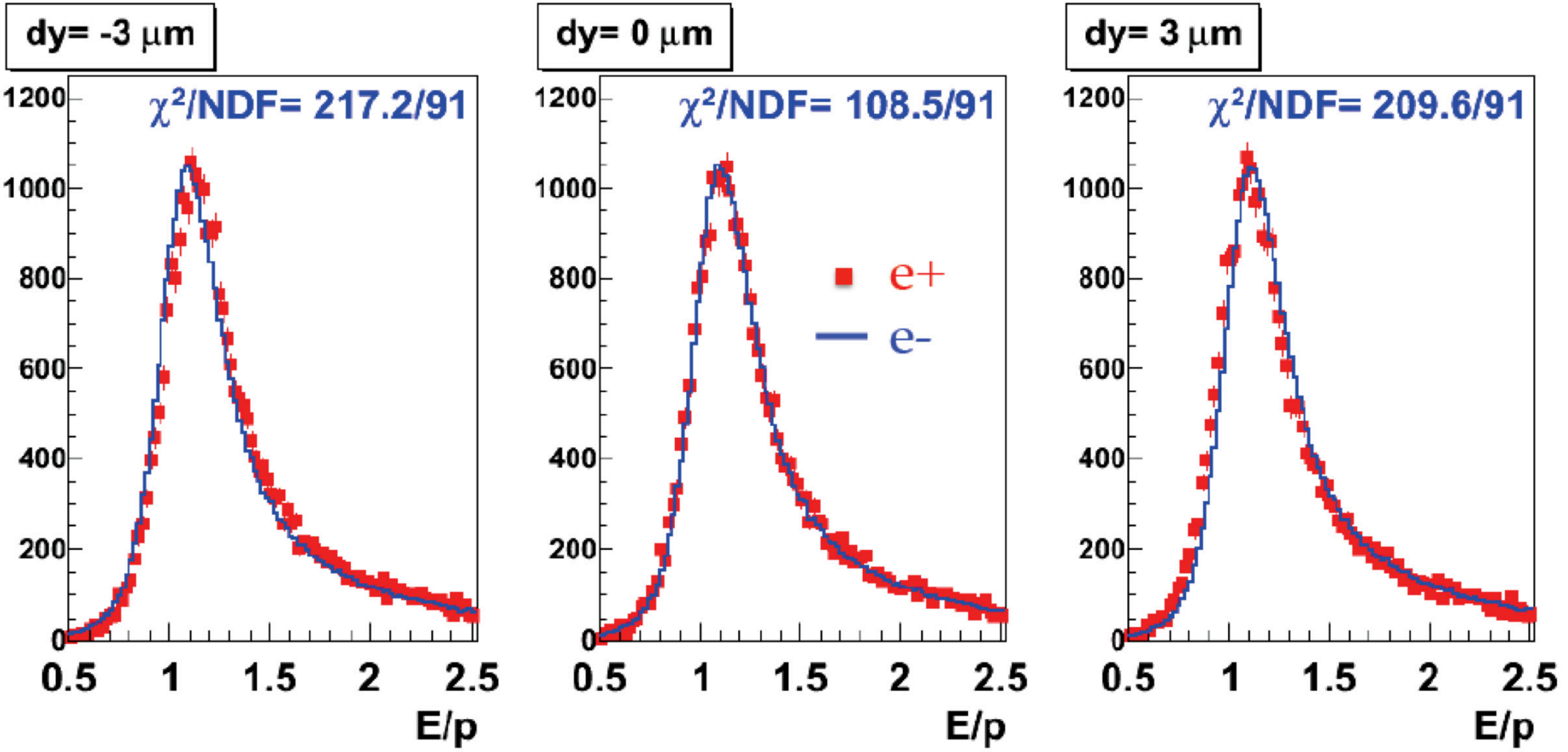


Tracker Alignment Accuracy over 18 Months



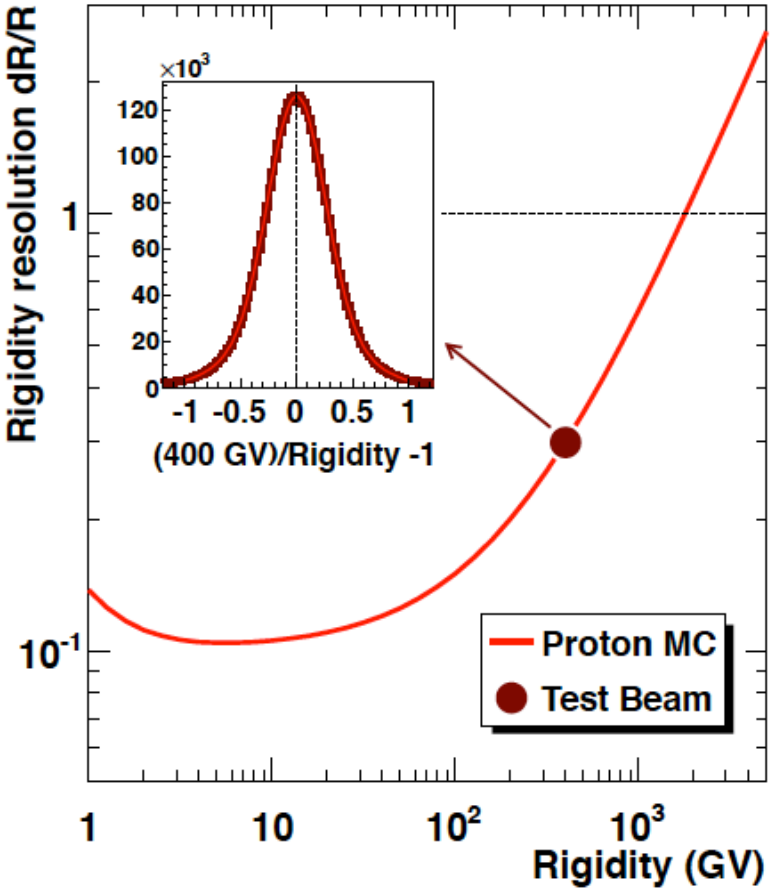
Tracker Alignment Check

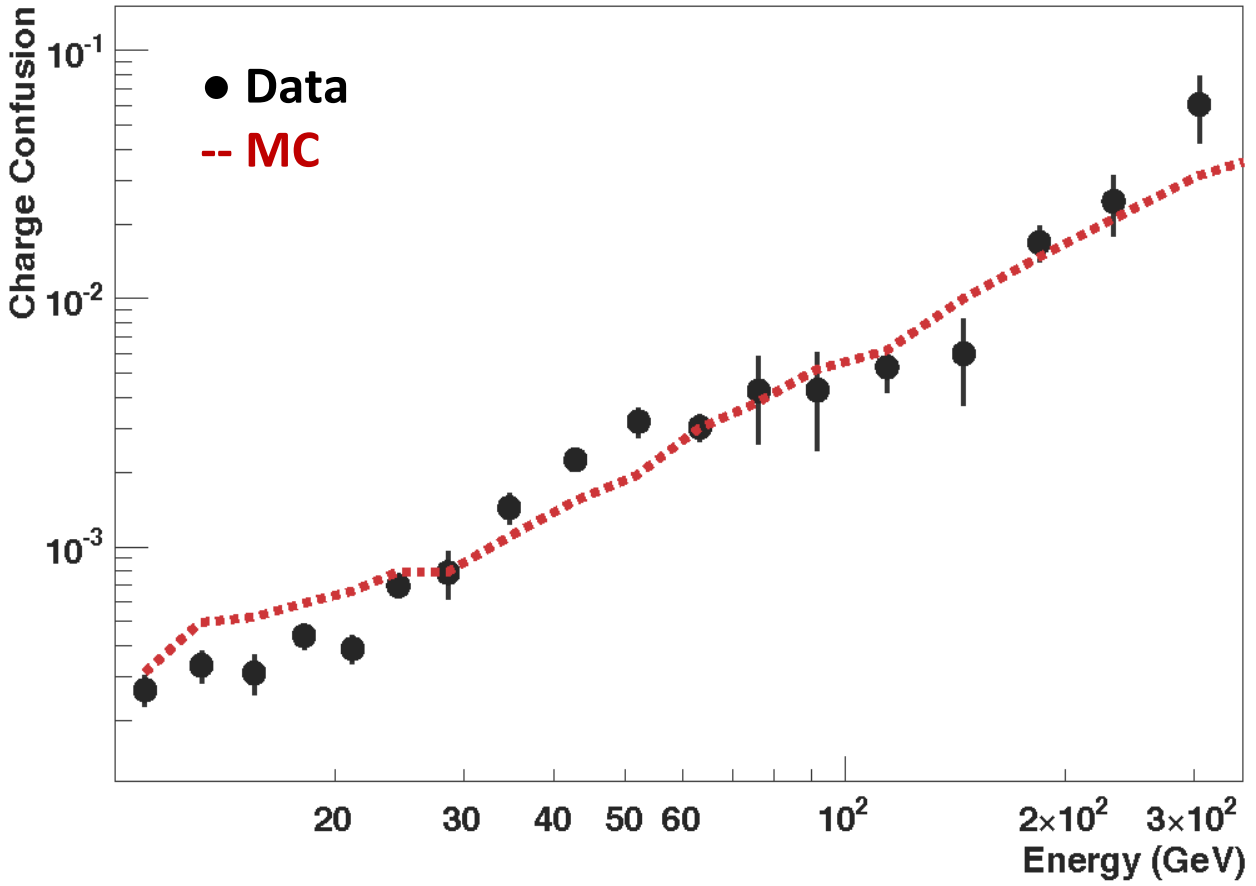
- Alignment checked with the independent ECAL energy measurement
- Check for possible residual “coherent misalignment”



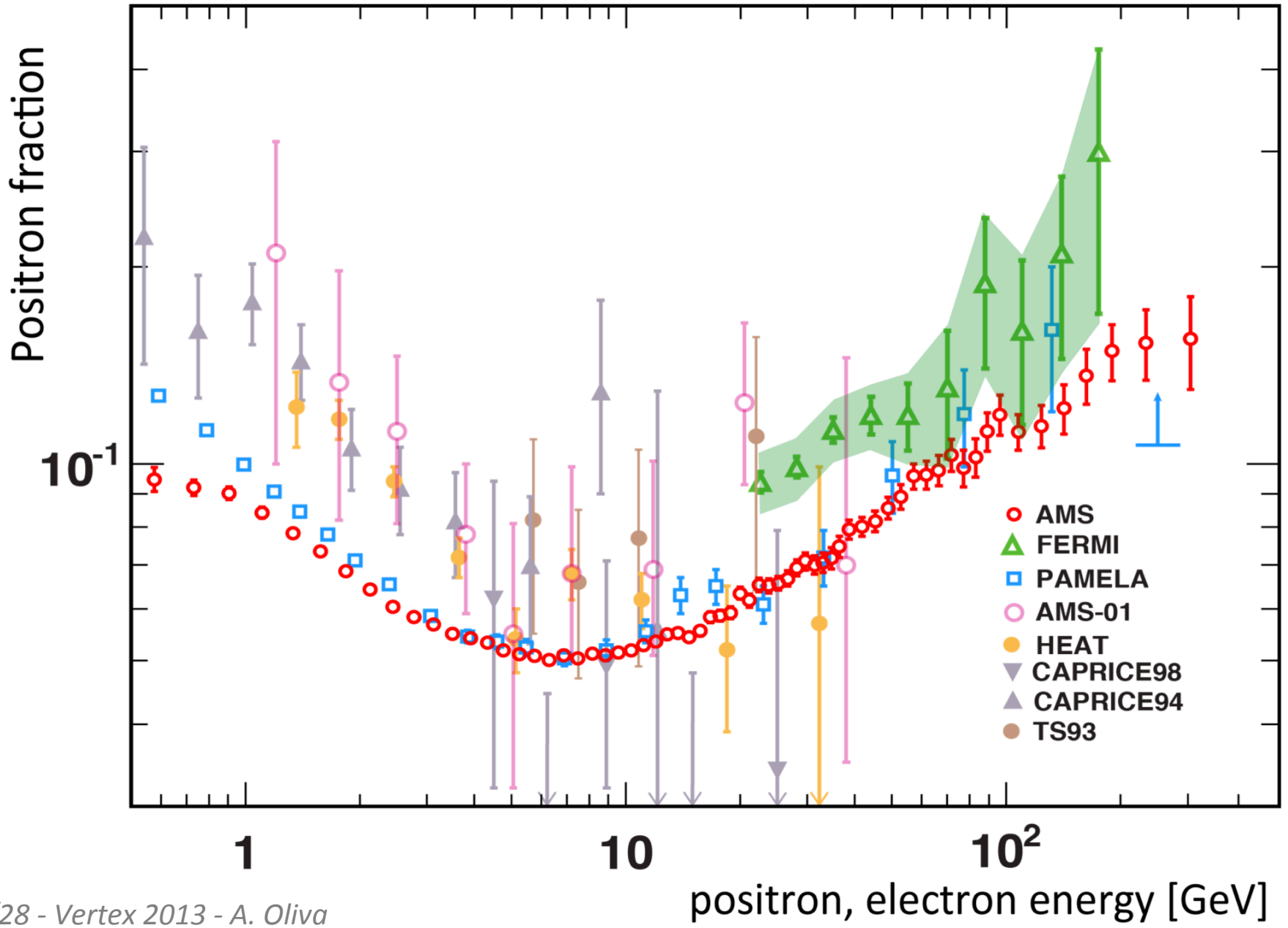
Tracker Momentum Resolution

- Rigidity resolution is 10% at 10 GV. MDR for Z=1 is ~ 2 TV.
- Charge confusion from momentum resolution is < % up to 100 GeV.
- C.c. is dominated at low energies by secondaries production.



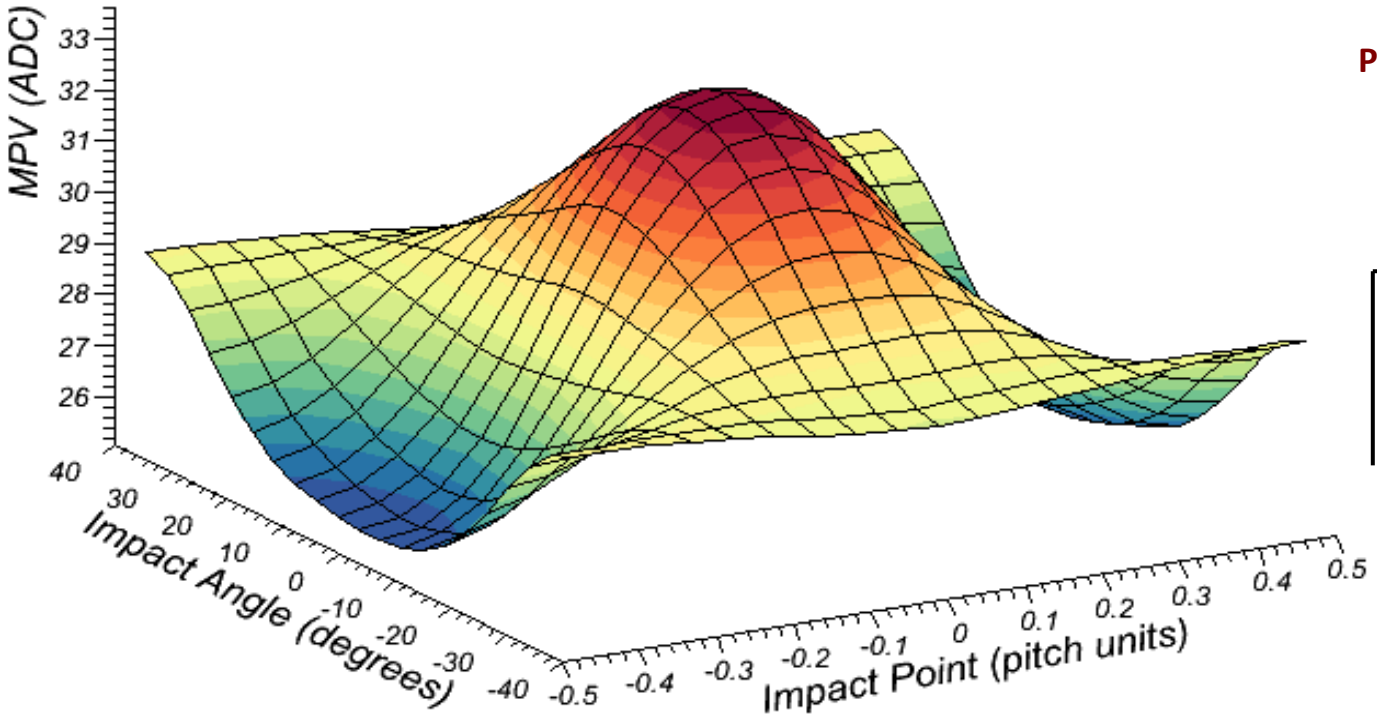


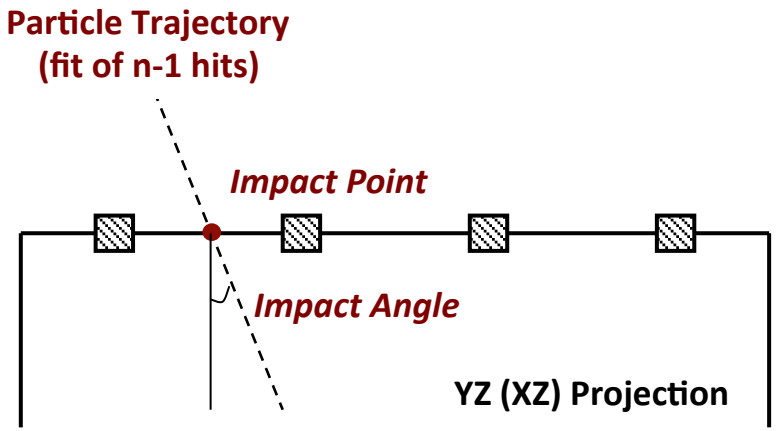
Positron Fraction (PRL 110, 141102, [2013])



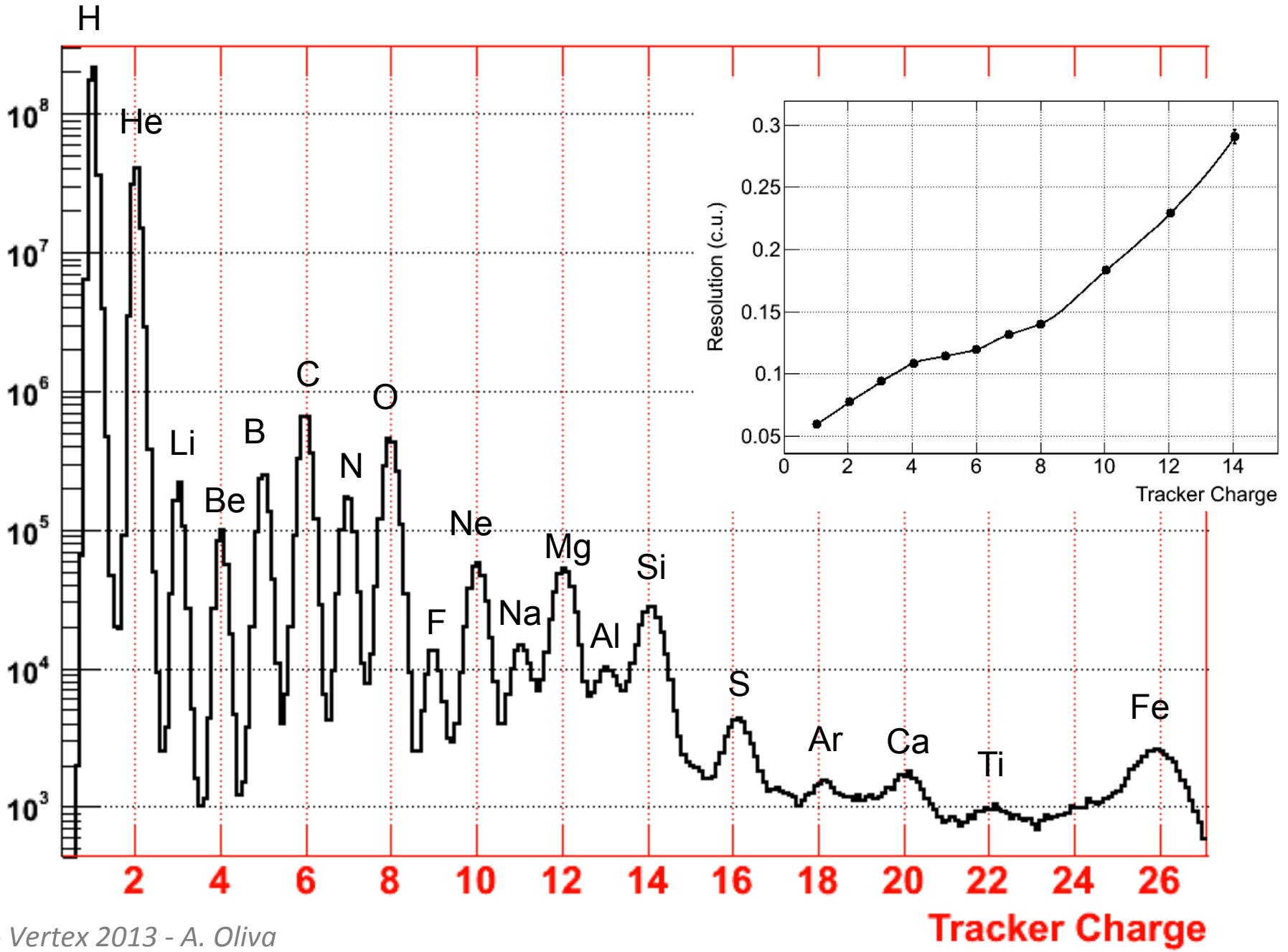
Tracker Charge Calibration

- Equalization of 3072 VAs (gain, from H, He, C)
- Correction of charge-collection effects
- Individual linearization of the VA response up to Iron (~ 700 MIPs)
- Description of the dependence with energy ($1/\beta^2$, $\log\gamma$)



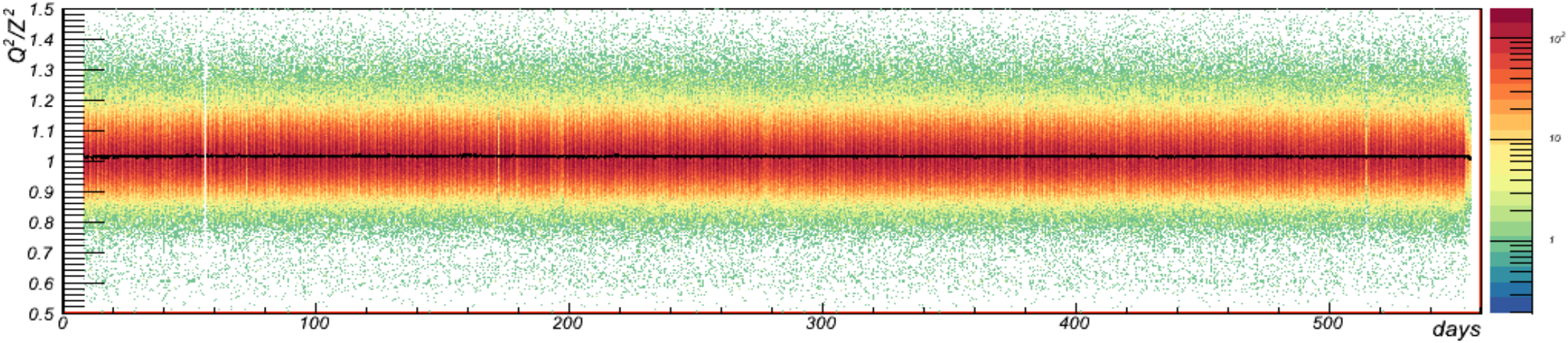


Tracker Charge Resolution

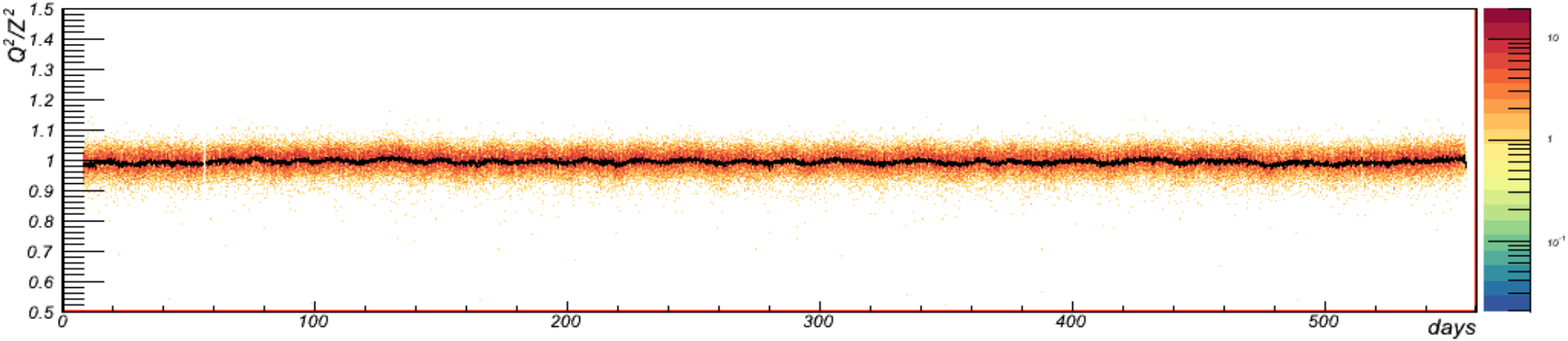


Tracker Charge Measurement Stability

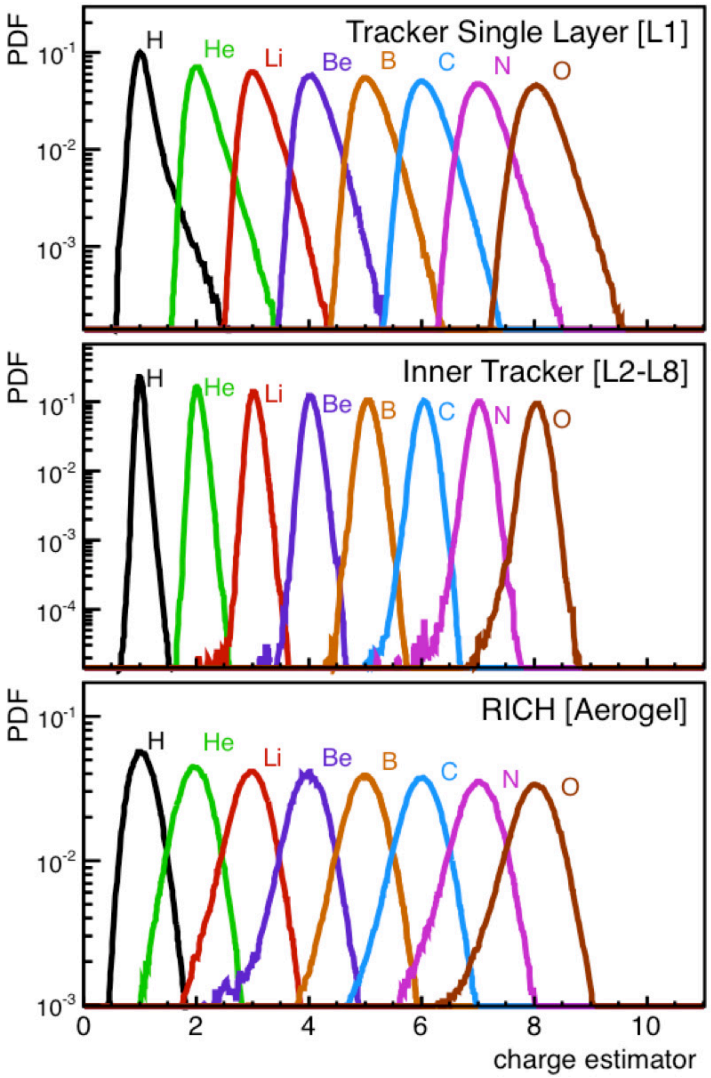
X-Side Z=1

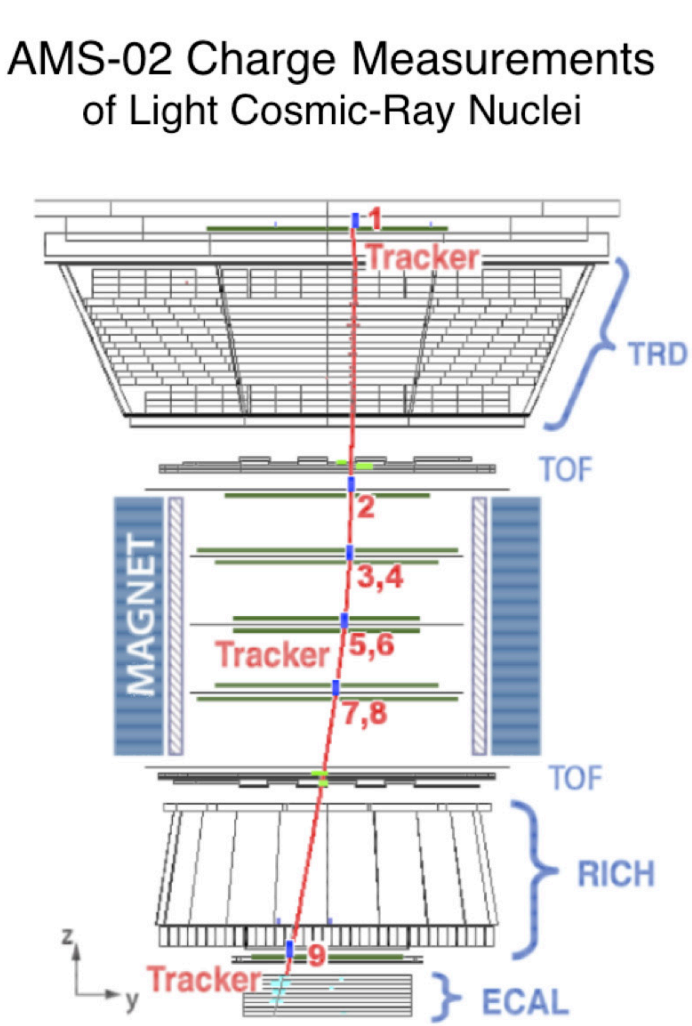


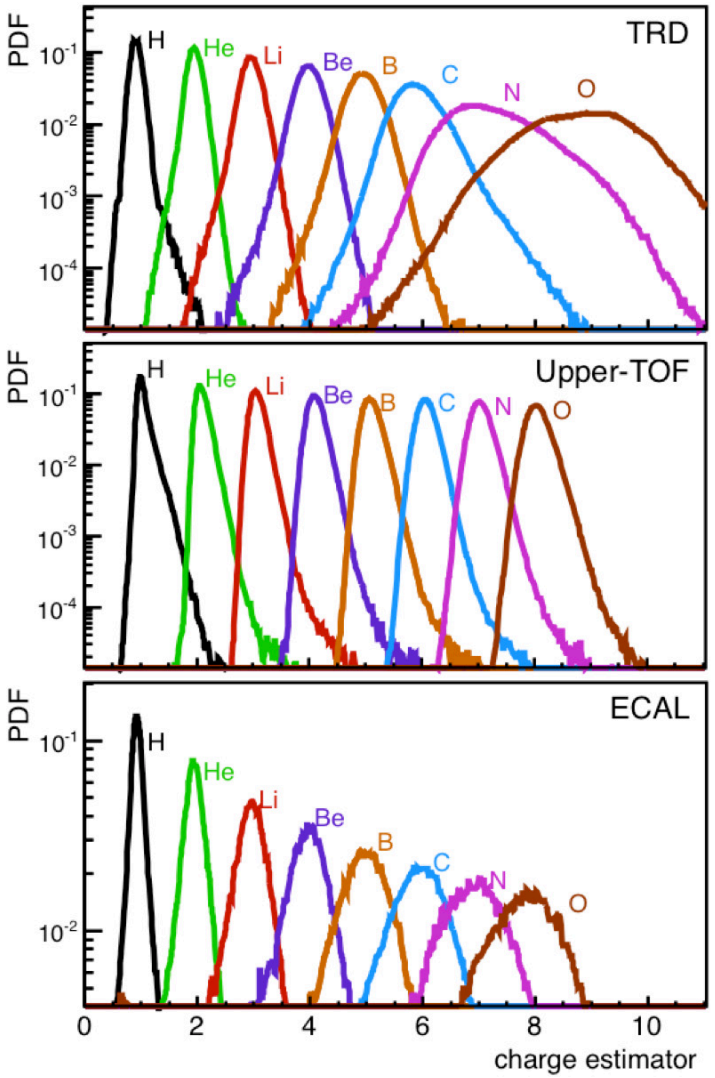
Y-Side Z=26



Multiple Charge Measurement

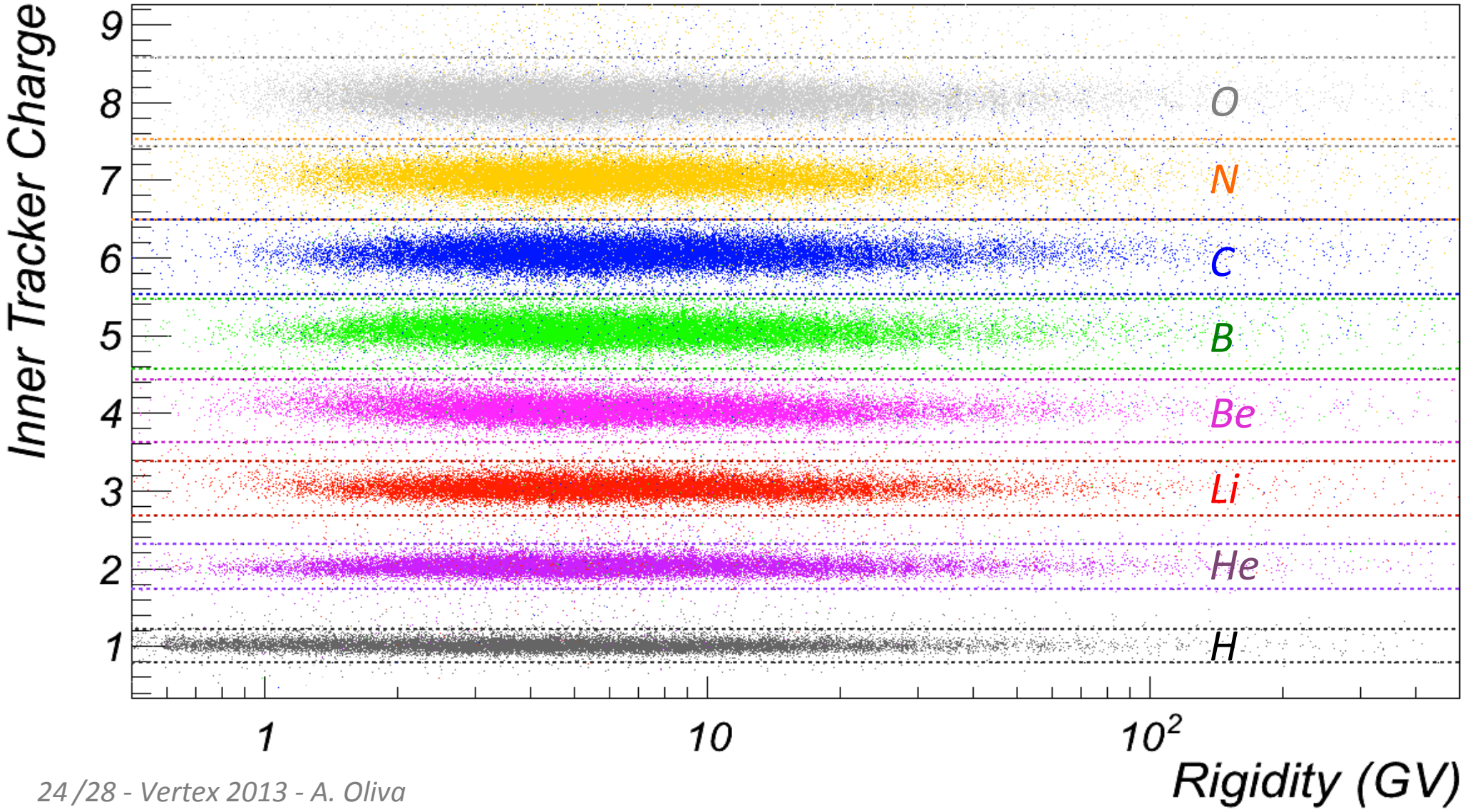




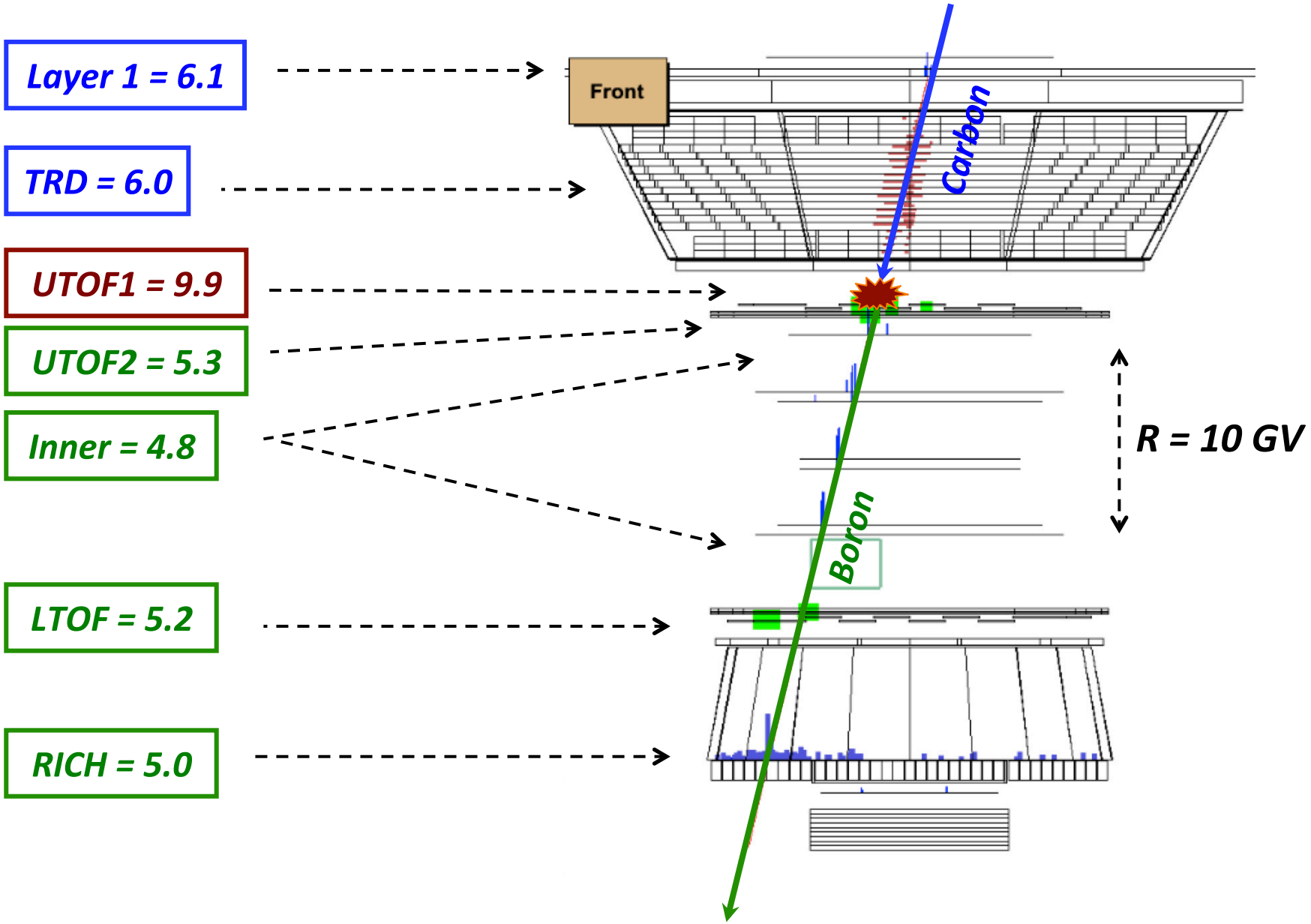


Nuclei Identification Using Inner Tracker

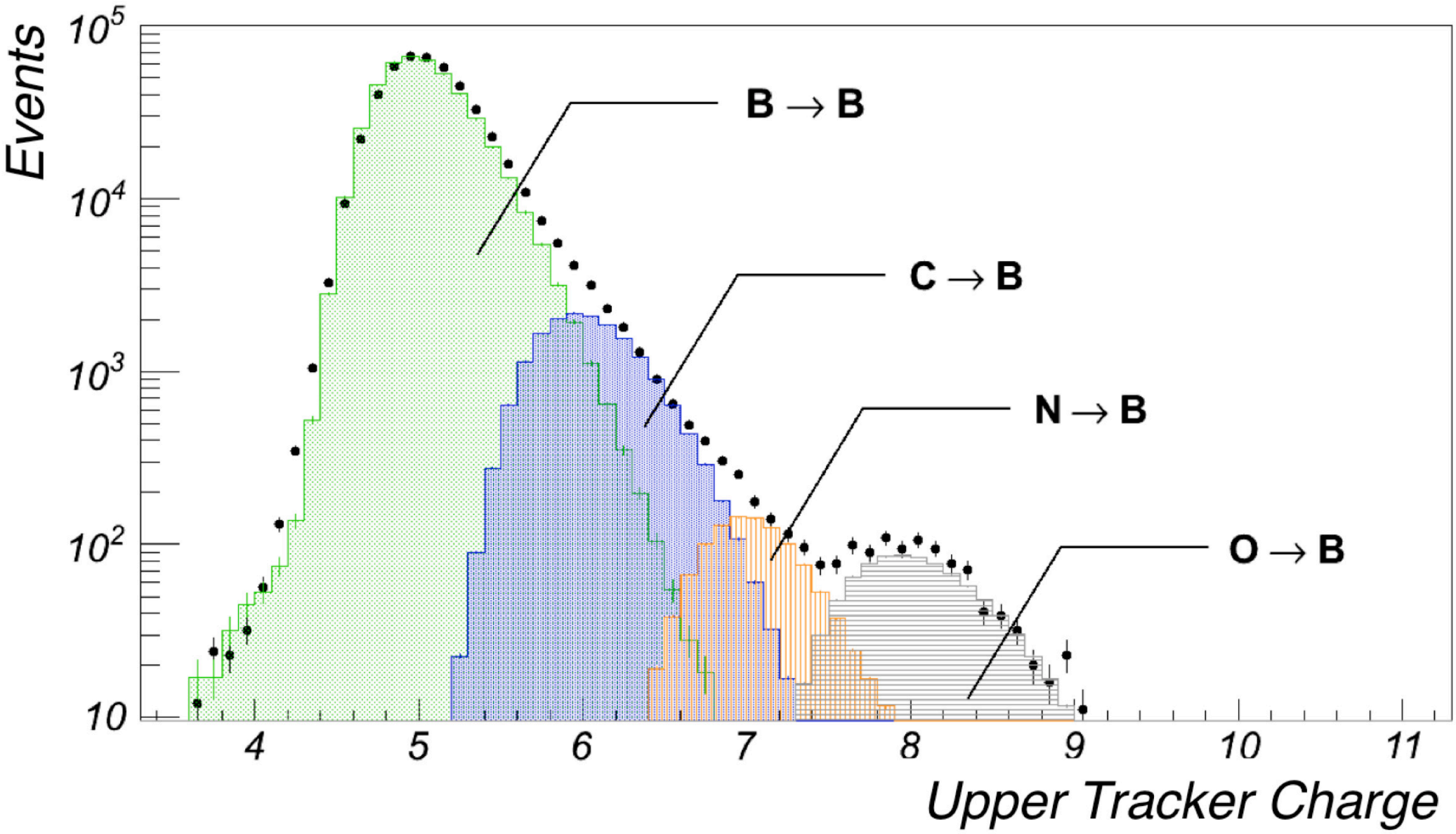
Contamination from neightboring charges < 10^{-4}, identification efficiency is > 98%.



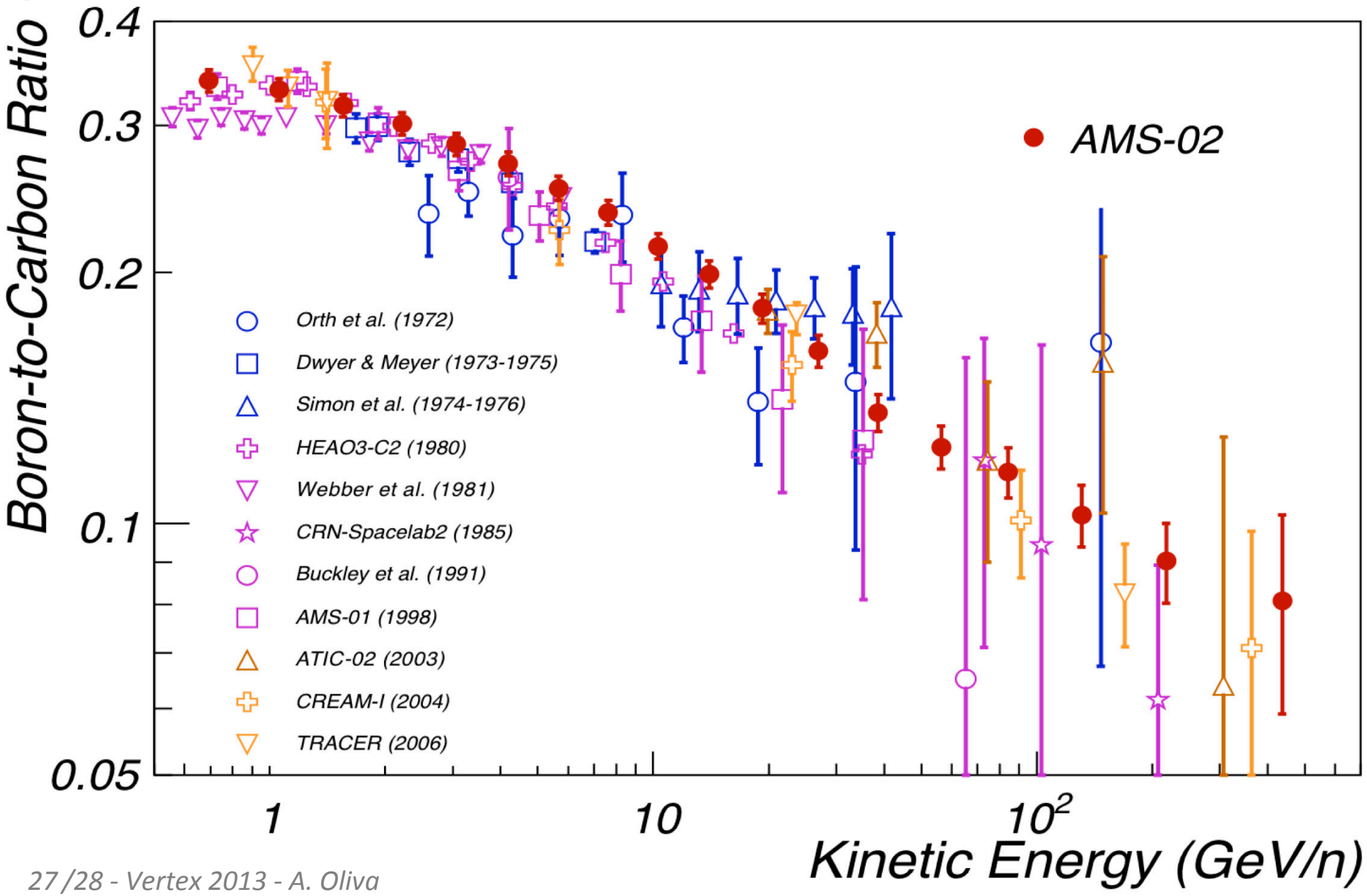
Identification of Fragmentation Events



Estimation of Background



B/C Ratio (ICRC 2013)



Conclusions

AMS operates since a couple of years 24/7/365 smoothly, no major issues, collecting over 38 billion events.

All AMS physics results depend critically on Tracker behavior (even when we use ECAL for energy measurement).

AMS Tracker has a very high and stable efficiency.

Alignment is known better than spatial resolution.

Momentum and charge measurements performances are as expected.

First AMS-02 results published and preliminary results for many CRs species already presented. Soon more news!