Nuclei Charge measurement with the AMS-02 Silicon Tracker

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AMS-02 Tracker Collaboration
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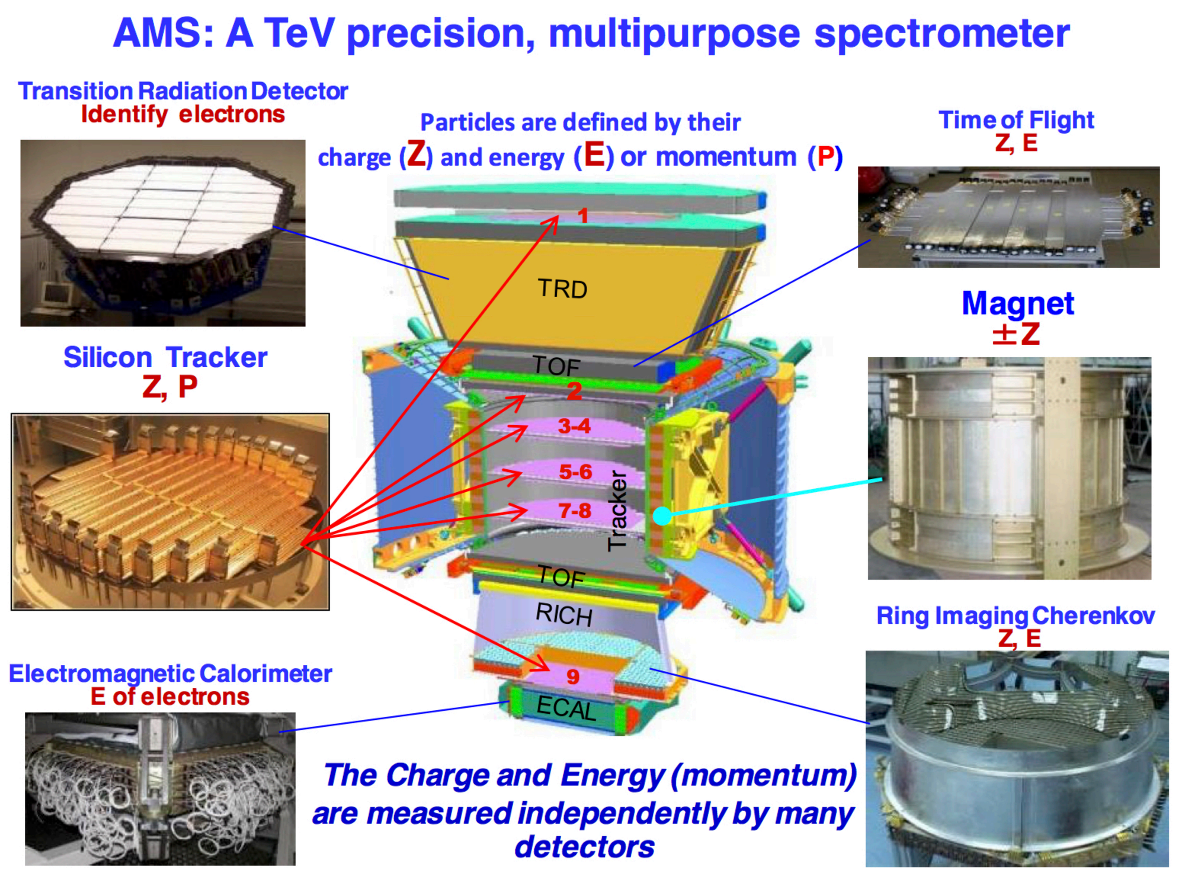
The Alpha Magnetic Spectrometer AMS-02

The **Alpha Magnetic Spectrometer** is an astroparticle detector operating as an external module on the International Space Station since May 2011.

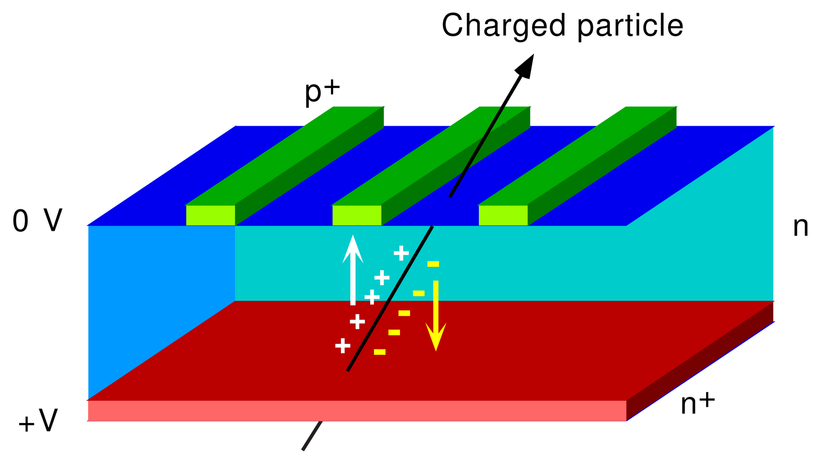
AMS-02 can perform accurate measurements of the spectra of charged cosmic rays from 0.5 GeV to few TeV.

- **Indirect Dark Matter search.** Pairs of γ's, e^+, e^- or p, $\bar{p}$, could originate from dark matter annihilation. Measuring an excess in the fluxes of these particles might give an hint to indirect dark matter detection.
- **Antimatter search.** The detection of anti-nuclei in the cosmic radiation, like a nucleus of anti-He, is a strong evidence of the existence of antimatter domains in the Universe.
- **Cosmic ray physics.** AMS-02 can provide precise measurements of various nuclei fluxes to better understand the origin and the acceleration of Cosmic rays.



The Silicon Tracker

The AMS-02 Tracker is composed of 2284 **double-sided silicon micro-strip sensors**, with dimensions $\sim 72 \times 41 \times 0.3$ mm^3, assembled in basic functional elements called **ladders**. Each ladder is composed of 9 to 15 sensors, for a total of 192 ladders and a sensitive area of 6.75 m^2. Each face of a sensor is implanted with strips running in orthogonal directions, providing a bidimensional measurement of the particle's position.



When a particle traverses a silicon sensor, e^--hole pairs are created along its path. Due to the E-field in the depleted area, e^- and holes flew to opposite sides.

The junction side (p-side) is composed of 14 µm wide p^+ doped strips (implantation pitch of 27.5 µm, readout 110 µm); the opposite ohmic side (n-side) has 40 µm wide strips, (implantation pitch of 104 µm, readout 208 µm).

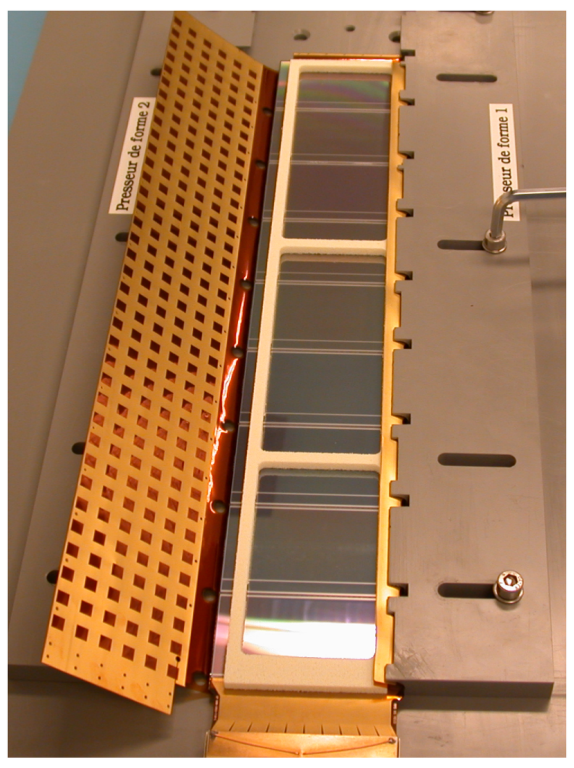
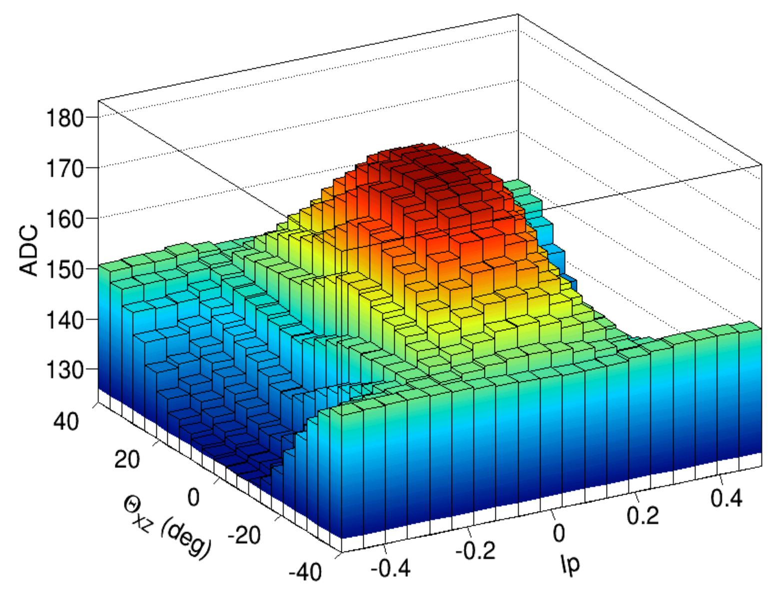


Photo of one ladder.

The opposite sign of the collected signals has an impact on the readout chips (VA) performances which are therefore different on the two sides ⇒ separated calibrations.

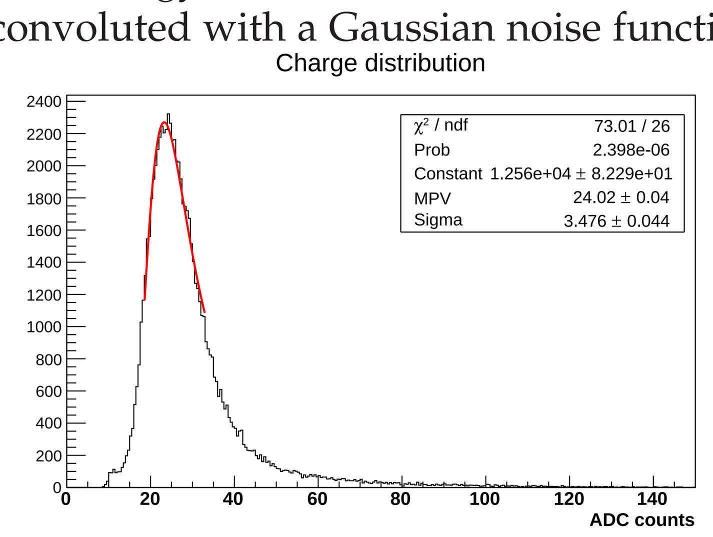
Charge Measurement

The signal of a cosmic particle depends on the impact point and impact angle of the particle. The maximum of collection efficiency appears when the particle traverses at vertical incidence a readout strip.

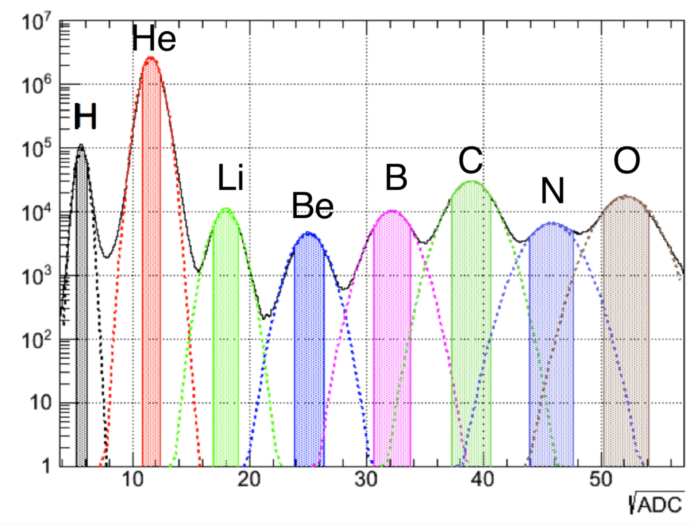


This dependence is a consequence of a loss of collection efficiency when a particle traverses the sensor surface in between two readout strips, while the maximum charge collection efficiency appears when the particle impacts vertically on a readout strip.

The energy loss distribution is a Landau convoluted with a Gaussian noise function.



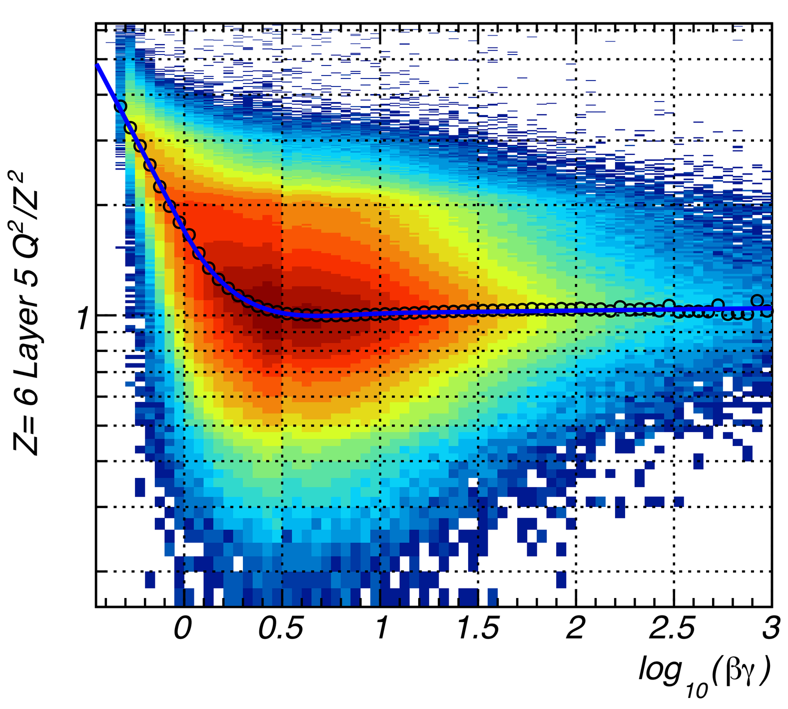
The n-side truncated mean distribution. The peaks of nuclei up to oxygen are visible.



(Sample with H prescaled).

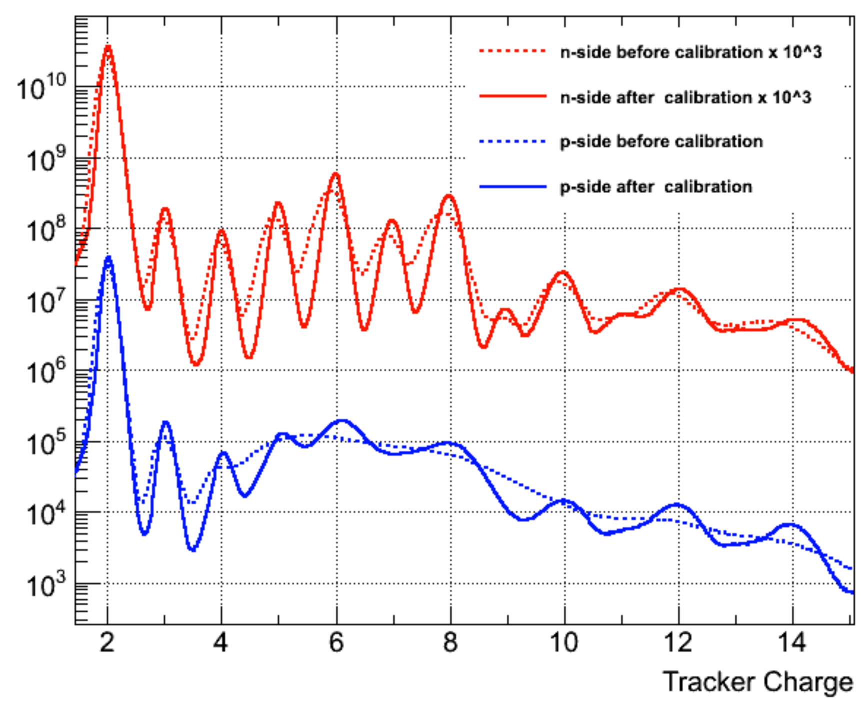
Charge Calibration steps and results

Energy loss



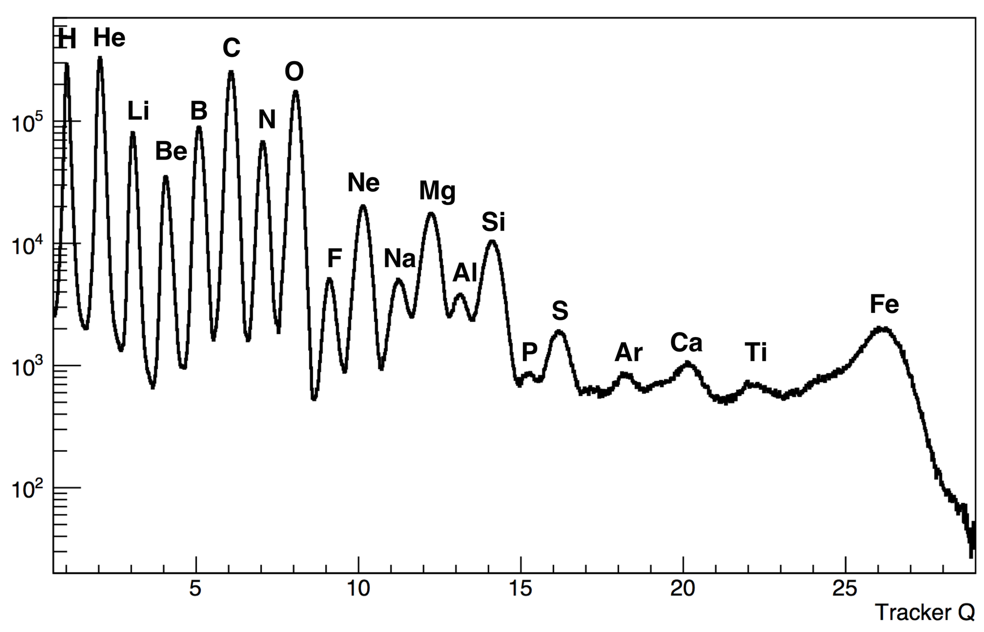
1. **VA Equalization:** We first corrected for differences in the response of the VA chips.
2. **Charge Loss Correction:** we produce 3-dimensional plots that describe the charge measurement as a function of impact angle and position for the different nuclei and for each sensor side.
3. β **Correction:**
   ⇐ The deposited energy presents a dependence with the energy of the particle, following the Bethe-Bloch formula. To account for the additional energy lost by the particle while traversing the AMS detector material, the correction is implemented for each layer.

Calibration results on both sides



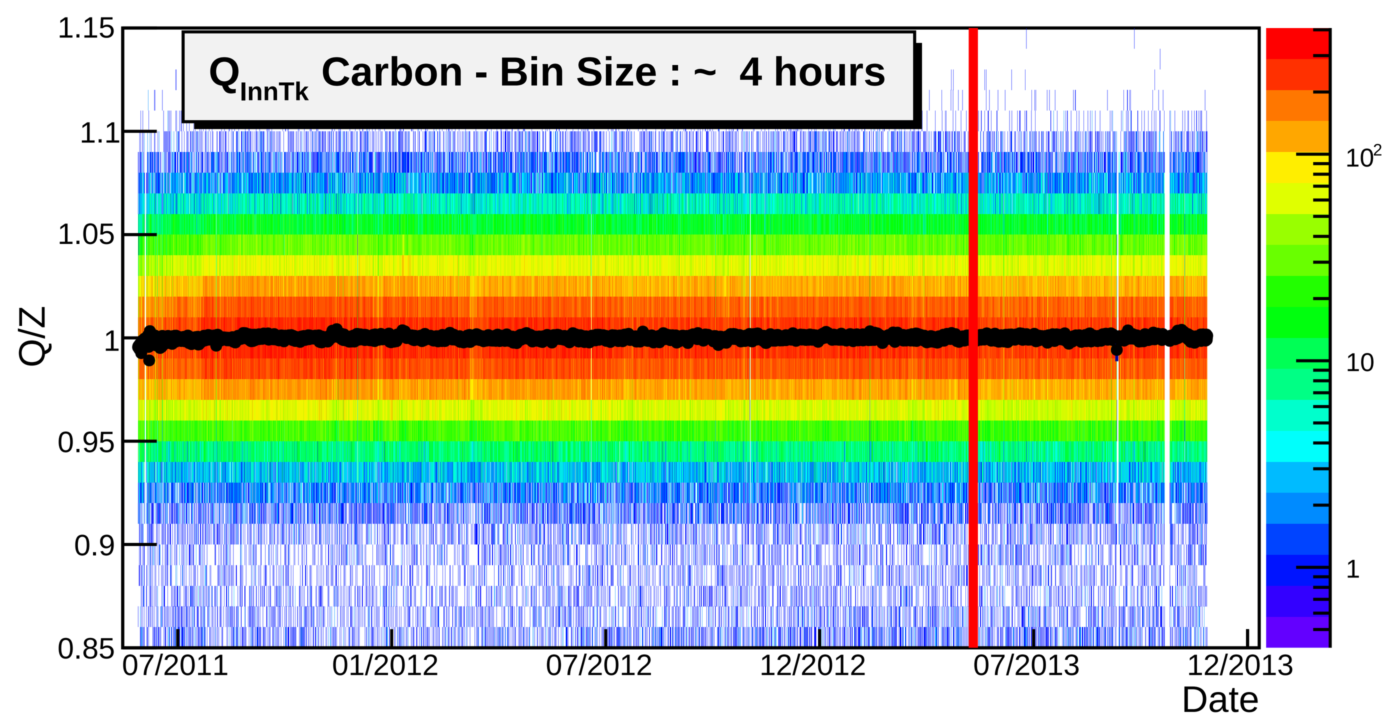
Charge Identification Performance and Time Dependence

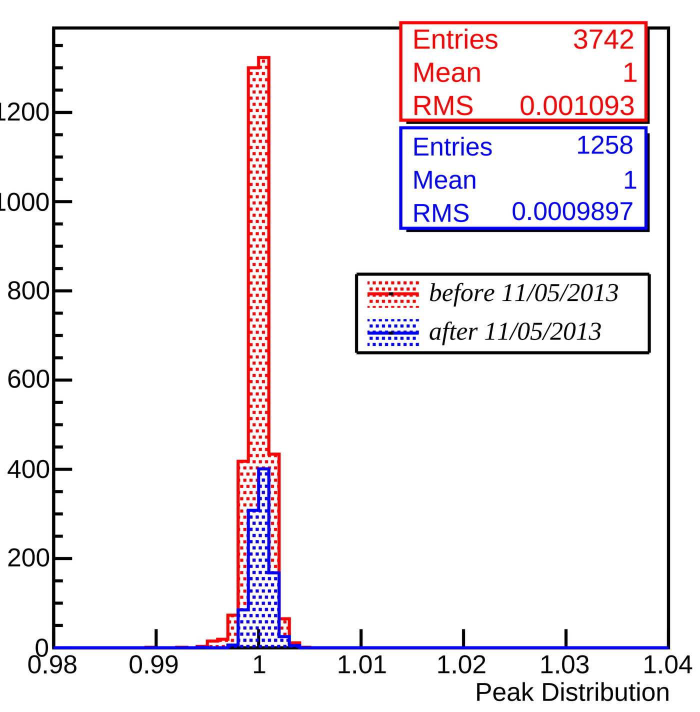
Combined Calibration result



We reach an excellent overall charge separation power with a misidentification probability for carbon lower than 10^{-3}. (Sample with H and He prescaled.)

We studied the dependence of the calibration procedure with time for two separate time periods: one included in the calibration sample and one not.





Left: normalized tracker charge estimator as a function of time for carbon nuclei. Right: distribution of average Q/Z values for the two detecting periods before and after 11/05/2013. No significant time dependences are found for both samples.