

# Charge Resolution Study on AMS-02 Silicon Layer 0 Prototype

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## 1) AMS-02

**TRD, Transition Radiation Detector**  
Separation between  $e^\pm$  and  $p$ .



### Silicon Tracker

- 9 Layers of double-sided silicon micro-strips sensors;
- Measurements of **trajectory** and **rigidity** ( $p/q$ );
- Measurements of the charge sign: detection of **anti-matter**.



**ACC, Anti Coincidence Counters**  
Veto for traversing particles sideways.

**ECAL, Electromagnetic calorimeter**

- Measurements of  $e^\pm$  and  $\gamma$  energy;
- Separation between  $e^\pm$ ,  $\gamma$  and hadrons.

**TOF, Time of Flight**

- Main trigger;
- Measurements of  $\beta$  ( $\Delta t \sim 180$  ps);
- Particle incoming direction.

**Permanent Magnet**

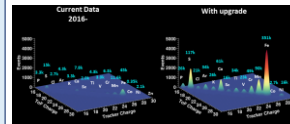
- Magnetic field strength: 0.15 T;
- Discrimination of  $\pm Z$ .

**RICH, Ring Imaging Cherenkov**  
Measurements of  $\beta$  ( $\sigma_\beta/\beta \sim 0.1$  %).

## 2) Layer 0 (L0) Upgrade

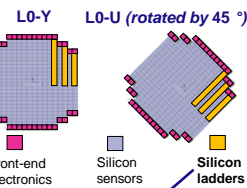
**Two new tracking layers on top of AMS-02**

- $\times 3$  Geometric acceptance;
- Unique new measurements of **high-Z elements** at  $O(\text{TeV})$ :



- New Z measurements to evaluate the **nuclei fragmentations** along the detector.

10  
Sensors  
L0 Ladder  
Prototype



## 3) The Ladder Prototype

**Single sided silicon sensors**

- Strip **pitch**: 27.25  $\mu\text{m}$ ;
- Silicon **thickness**: 320  $\mu\text{m}$ ;
- Silicon **size**: 113  $\times$  80 mm;
- Strip **width**: 10  $\mu\text{m}$ .

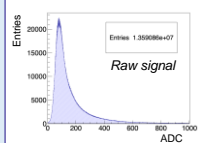
**L0 Ladder Prototype**

- 10 Silicon sensors;
- 16 IDE1140 chips (VA);
- Each VA  $\rightarrow$  64 readout channels;
- Total  $\rightarrow$  1024 readout strips.

## 4) From ADC to Charge

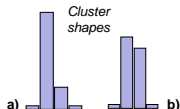
**Raw Signal**

- Analyzed data: **relativistic ions** around 300 GV/c from SPS@CERN;
- Raw signal (in ADC) = measurements of energy loss ( $dE/dx$ ) by ions in silicon sensors;
- Each ion gives  $\text{ADC}(dE/dx) \propto Z^2$  (from Bethe-Bloch formula).



**Cluster center of gravity: Eta ( $\eta$ )**

$$\eta = \frac{S_R}{S_R + S_L}$$



**Charge**

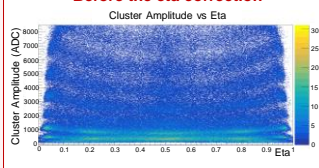
After calibration process:

- Find collecting strips (build the **cluster**) with the clusterization algorithm;
- Select the most energetic cluster per event;
- VA **equalization** and **eta correction**;
- Evaluation of the **charge resolution**.

- $\eta$  defines the **center of gravity** of the two most energetic strips of the cluster;
- The raw signal is  $\eta$  dependent;
- The  $\eta$  dependency has been studied and removed.

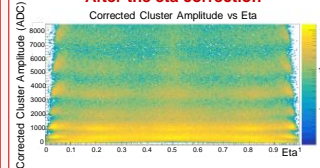
## 5) Charge resolution

**Before the eta correction**



- Distribution of the total cluster amplitude as a function of eta;
- Is visible a clear **energy loss** as a function of eta (and ADC).

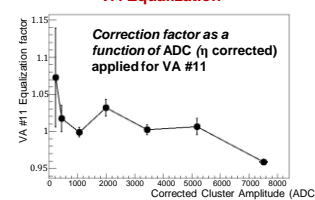
**After the eta correction**



- The dependence on eta has been assumed to be **parabolic and constant** w.r.t. ADC:

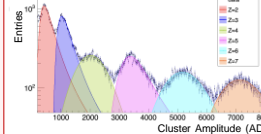
$$f(\eta) = a\eta^2 + b\eta + c$$

**VA Equalization**

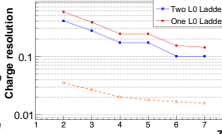


- The VA responses have been equalized w.r.t. VA #10 signal, arbitrarily chosen as a reference.

**Resolution**



- The resolution will be standard deviation/mean ( $\Delta z/Z$ );
- Monte Carlo method to generate samples using LanGauss parameters;
- Central Limit Theorem links the parameters of the sample mean distribution (Gaussian) with  $\Delta z$  and  $Z$ .



- Eta corrected and VA equalized distribution fitted with LanGauss function.

- Resolution from single silicon ladder (red line), from two ladders (blue line) and from AMS-02 Inner Tracker (yellow dotted line).

**Conclusions**

- Obtained resolution is comparable with the AMS-02 Inner Tracker (6 layers);
- Is possible to identify nuclei up to  $Z=7$  with 10 % resolution;
- A complete characterization need a detailed study for  $Z=1$  and  $Z > 7$ ;
- The eta correction can be improved by considering its dependence on ADC.