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Beam Test For The AMS-02 Layer0 Tracker Upgrade

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1. Introduction

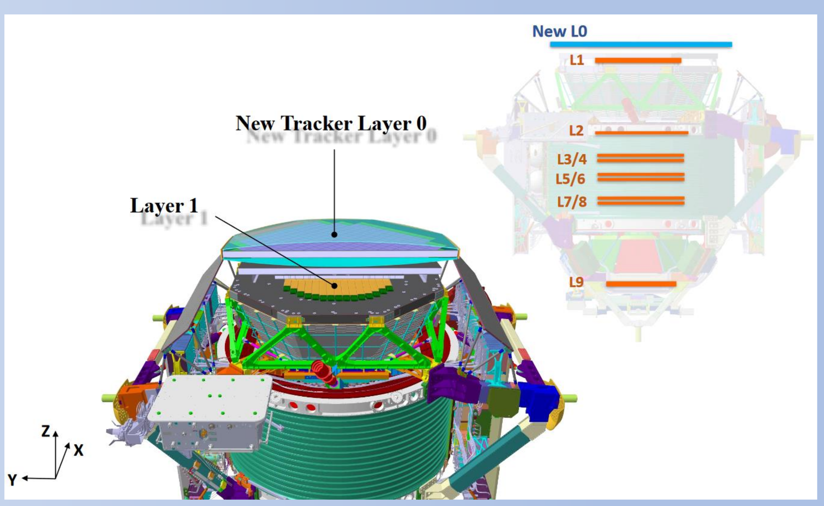


Fig. 1:AMS-02 and new Tracker Layer0

AMSL0 Project:

- Increase the acceptance of cosmic rays by 300%
- Significantly improves the ability of heavy ion particle ID
- The largest single detection Si detector Unit (100cm*11cm)
- The first large Si Detector for major international experiment that the **Chinese team play a leading role**

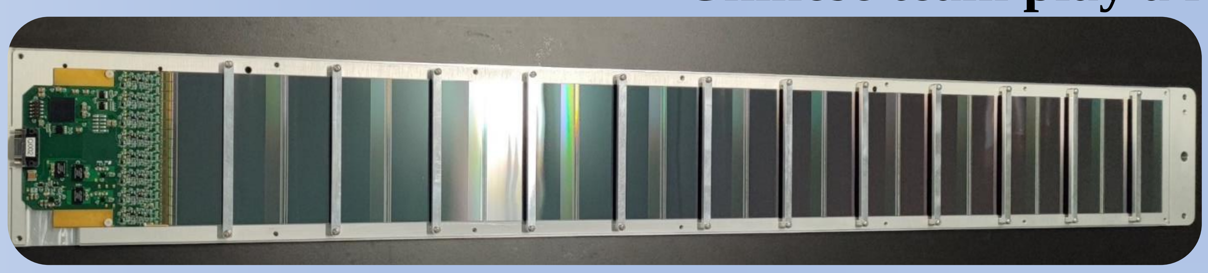


Fig. 2: Detector unit(ladder) of AMSL0

Ladder is formed by 8/10/12 SSDs are connected in series

- Large detection area with small electrical power budget
- Each readout channel corresponds to a very long (~1m) strip
- Requires high precision placement of the SSDs on each ladder, and precise SSD position measurements after assembly with optics and **beam tests**

2. Beam test setup

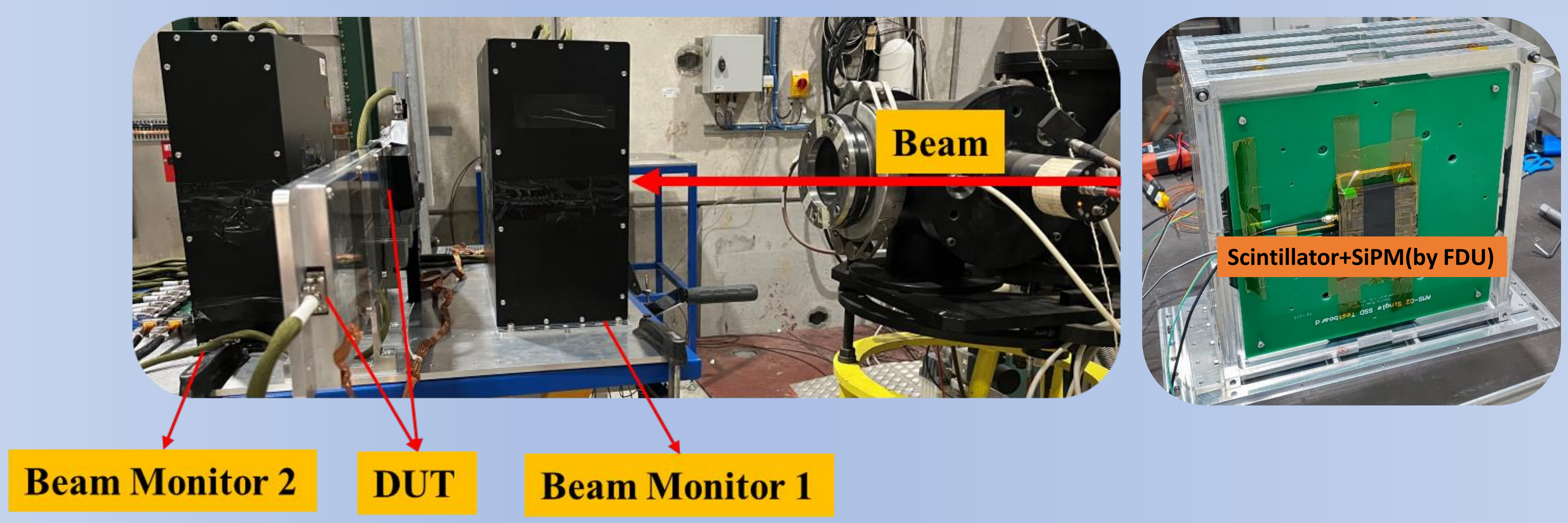


Fig. 3: Photo of beam test setup

- Performed several beam tests at SPS, BSRF with muon, proton, electron and mix heavy ion beams
- Study the spatial resolution, efficiency, heavy ion PID …
- With 12 beam telescope boards using the same SSD and electronics

3. Sensor efficiency

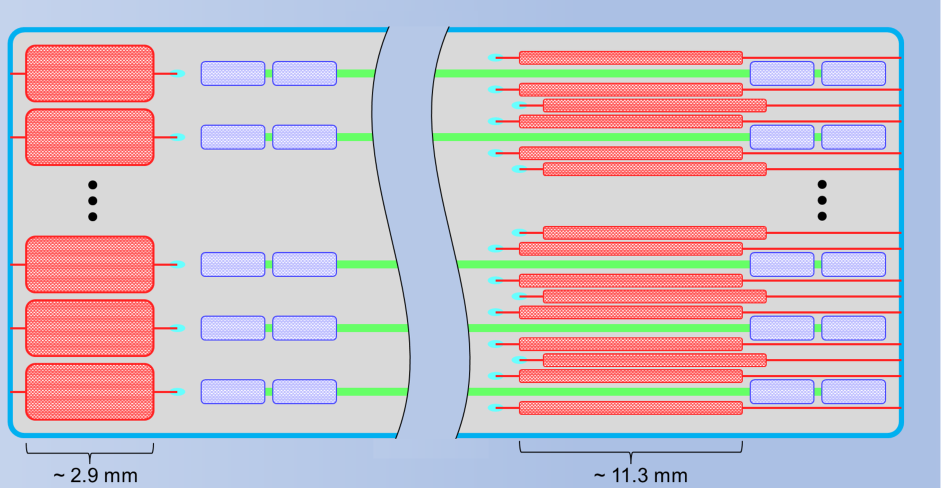


Fig. 4 Schematic of one SSD Unit: 3 bias strip + 1 readout strip(green), 4 bias resistors(red), 4 bonding pads(purple) on the readout strip only

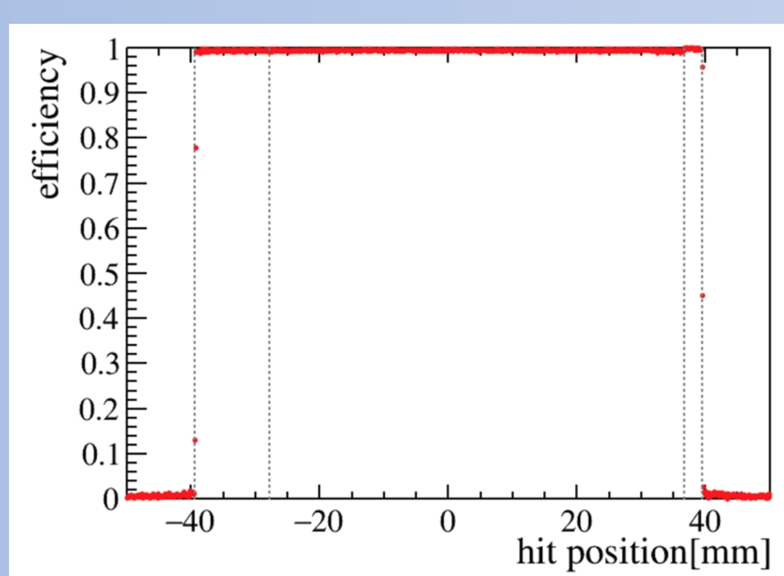


Fig. 5 The detection efficiency of MIP along strip direction

Special design of the SSD

- A large resistance (~100MΩ) is needed to achieve impedance matching
- The bias resistor and strip located on different layers
- The detection efficiency, especially in region of the bias resistors, was studied at test beam
- Fig.5 shows the entire sensor exhibits high detection efficiency(>99.9%)

4. Spatial resolution

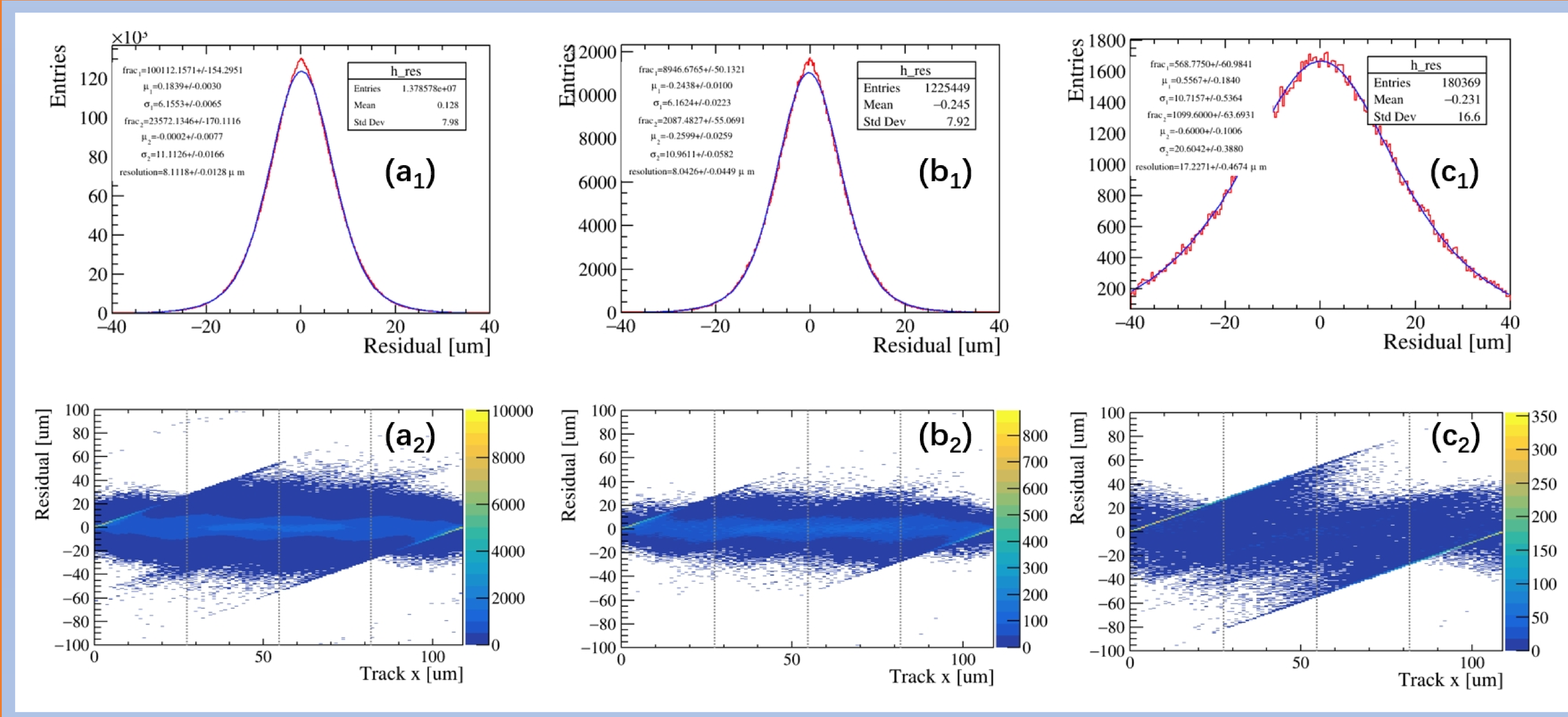


Fig. 6: Residual distribution and residual of in-strip hit position distribution of different regions: $(a_1)(a_2)$ normal region; $(b_1)(b_2)$ bias resistor region; $(c_1)(c_2)$ no intermediate strip region.

- A new position finding algorithm(PFA) is developed to eliminate the channel switching caused by noise
- Get spatial resolution of the SSD of MIP is 7.5um, the bias resistor did not affect the spatial resolution
  - Readout pitch=109um, strip pitch=27.25um
- The design of 3-intermedia strips significantly improve spatial resolution

5. PID and tracking for heavy ions

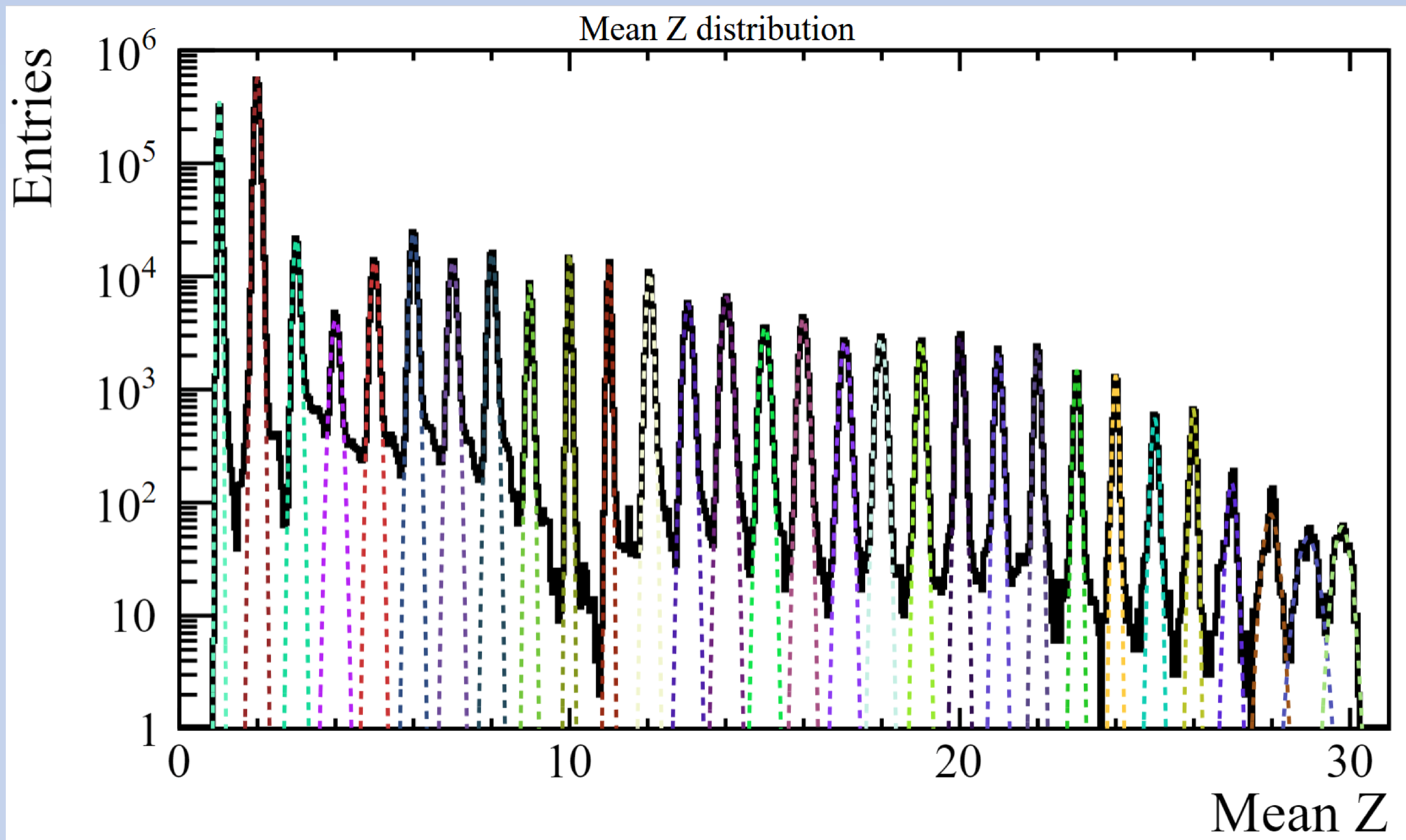


Fig.7 The mean Z-values predicted by the 9-layer telescope

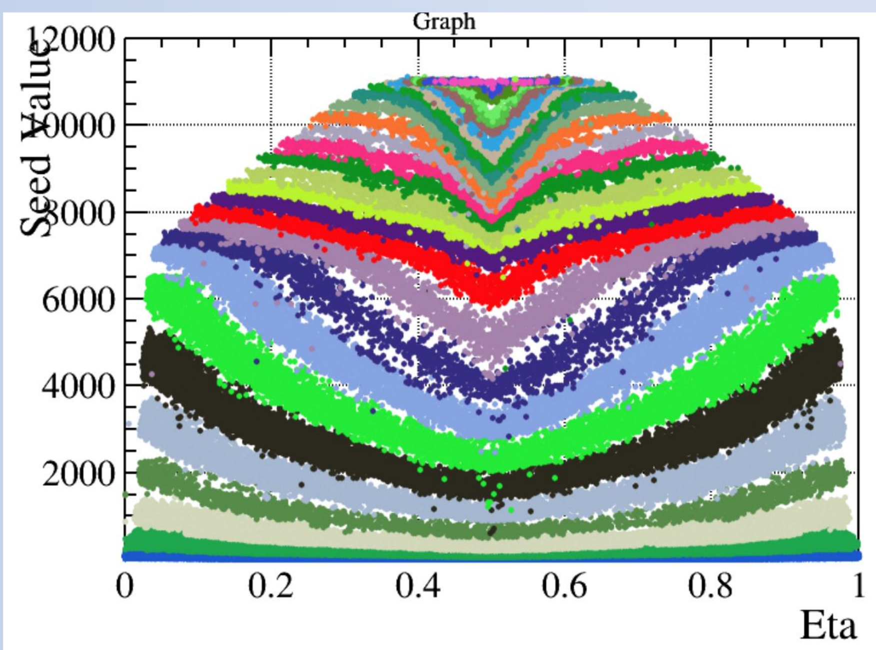
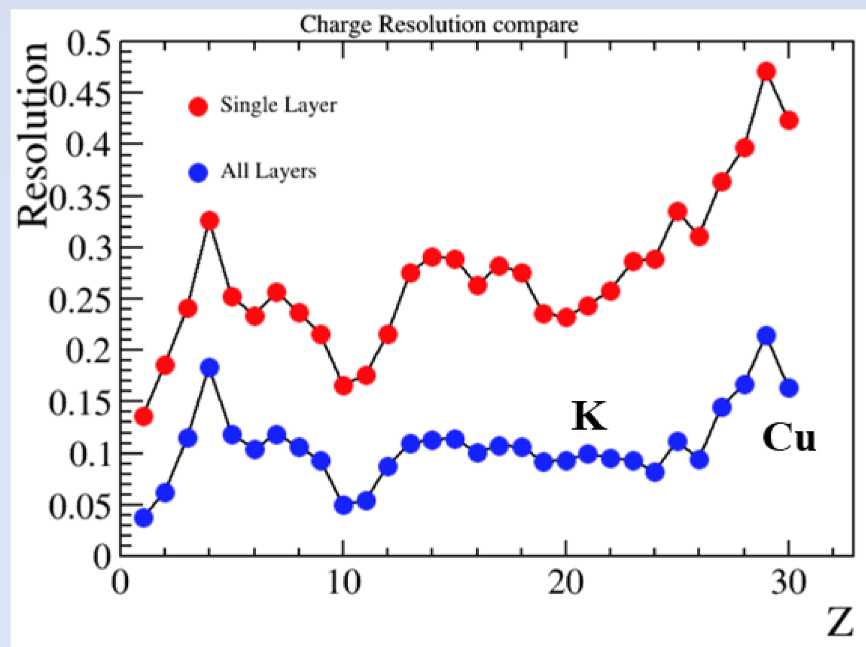


Fig.8 BDT Z-tag display of one layer



Charge resolution of single layer and telescope

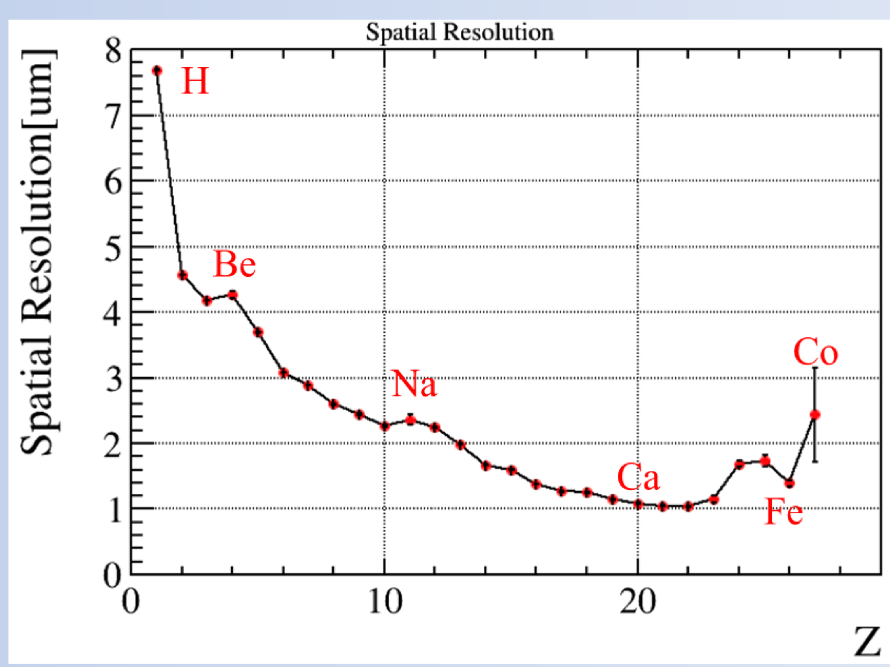


Fig.9 The spatial resolution of the nucleic up to Z=27

- Use BDT to get z-tag of every event, calculate mean Z of 9 layers of each track
- Get ~0.1 charge unit resolution of the telescope up to Cu(Z=30) nuclei
- Obtained the spatial resolution of single layer for heavy nuclei up to Co(Z = 27)
  - Best resolution ~1um

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The 2024 International Workshop on the High Energy Circular Electron Positron Collider, October 23-27, 2024, Hangzhou

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