

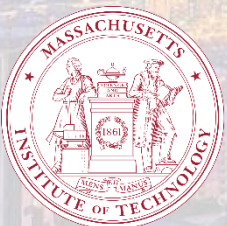
中国科学院高能物理研究所
Institute of High Energy Physics, CAS

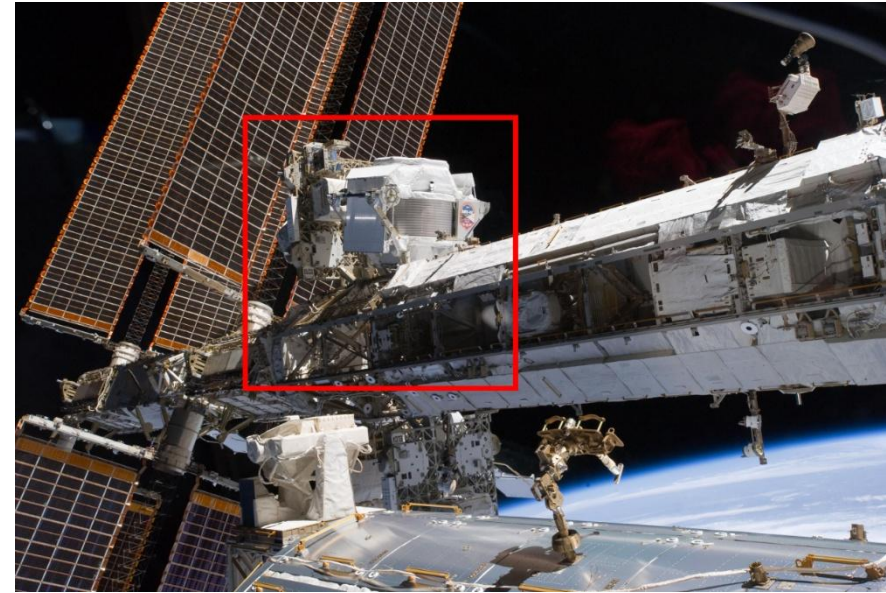
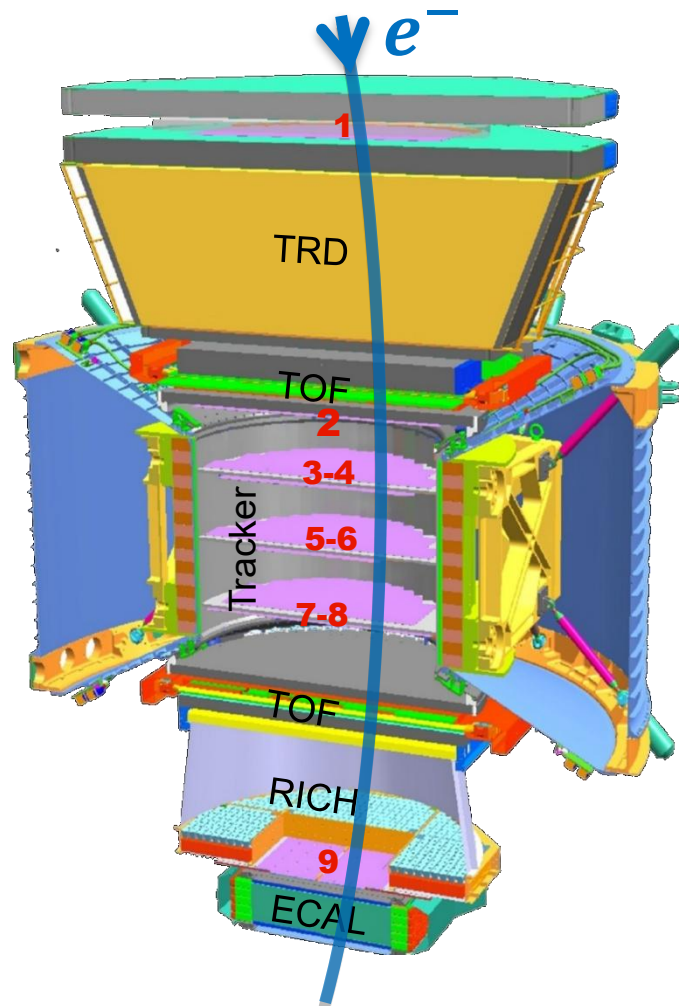
Design and Testbeam of AMS-02 Layer-0 Silicon Strip Detector

Dexing Miao (繆德星), Institute of High Energy Physics, CAS
on behalf of AMSL0 Team

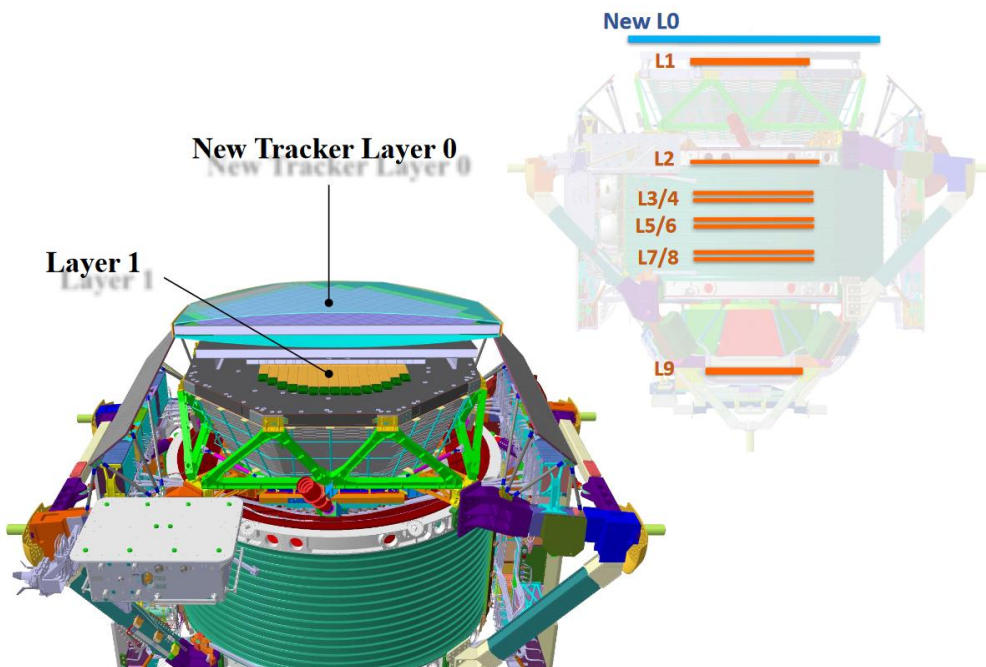
18/11/2025

HSTD14@Taipei

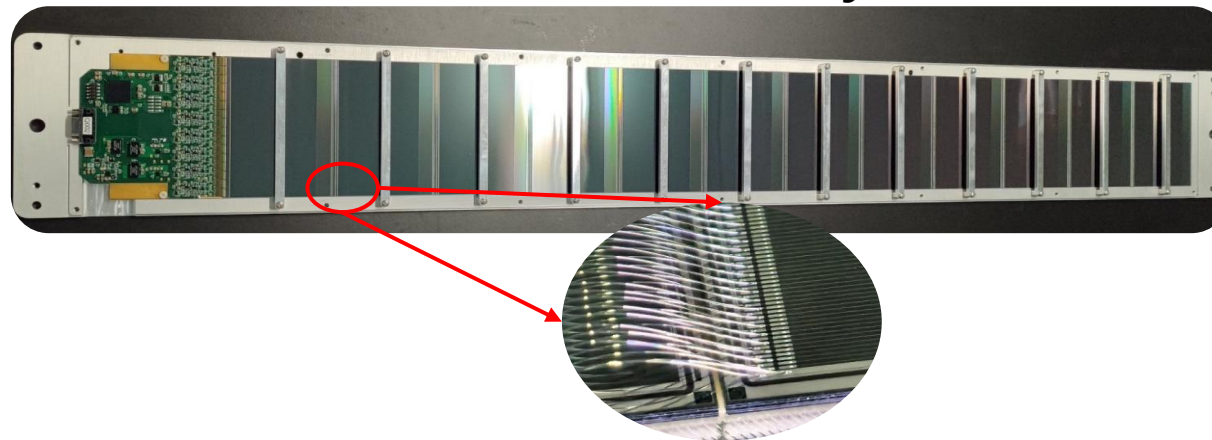


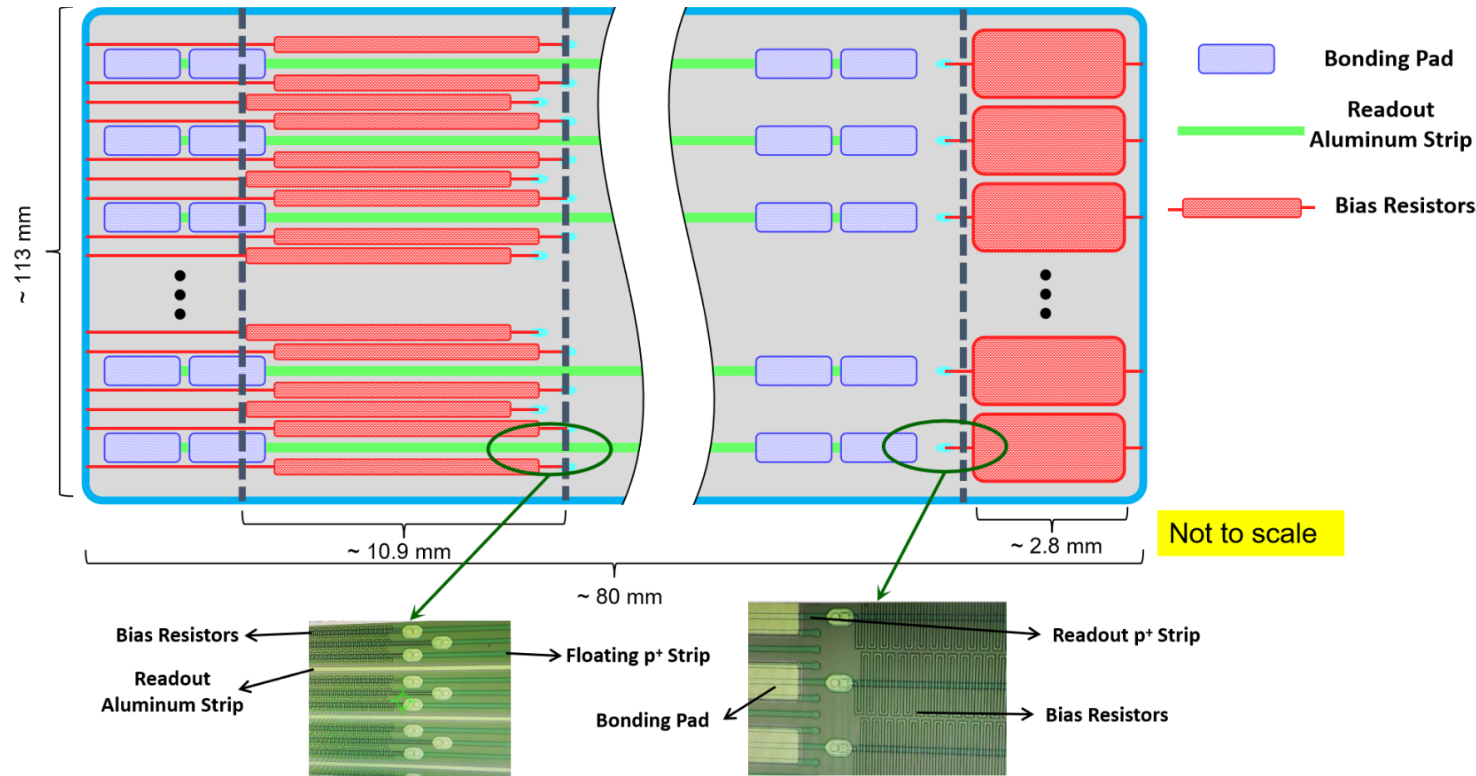


- The only magnetic spectrometer operating in space
- Antimatter, dark matter, and the origin of universe
- Launched to the ISS and installed on May 19, 2011
 - Operating aboard the ISS until ~ 2030

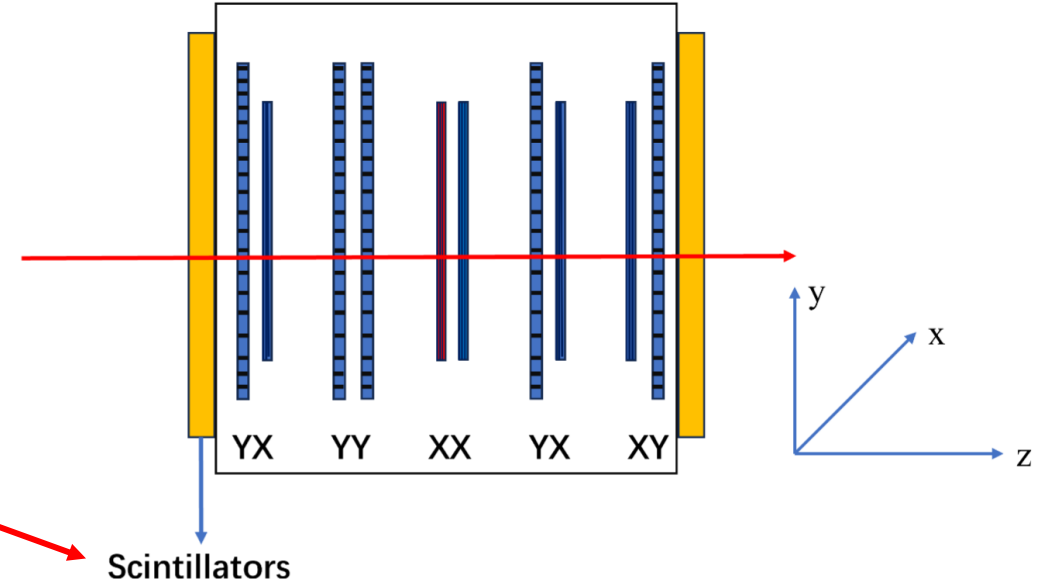
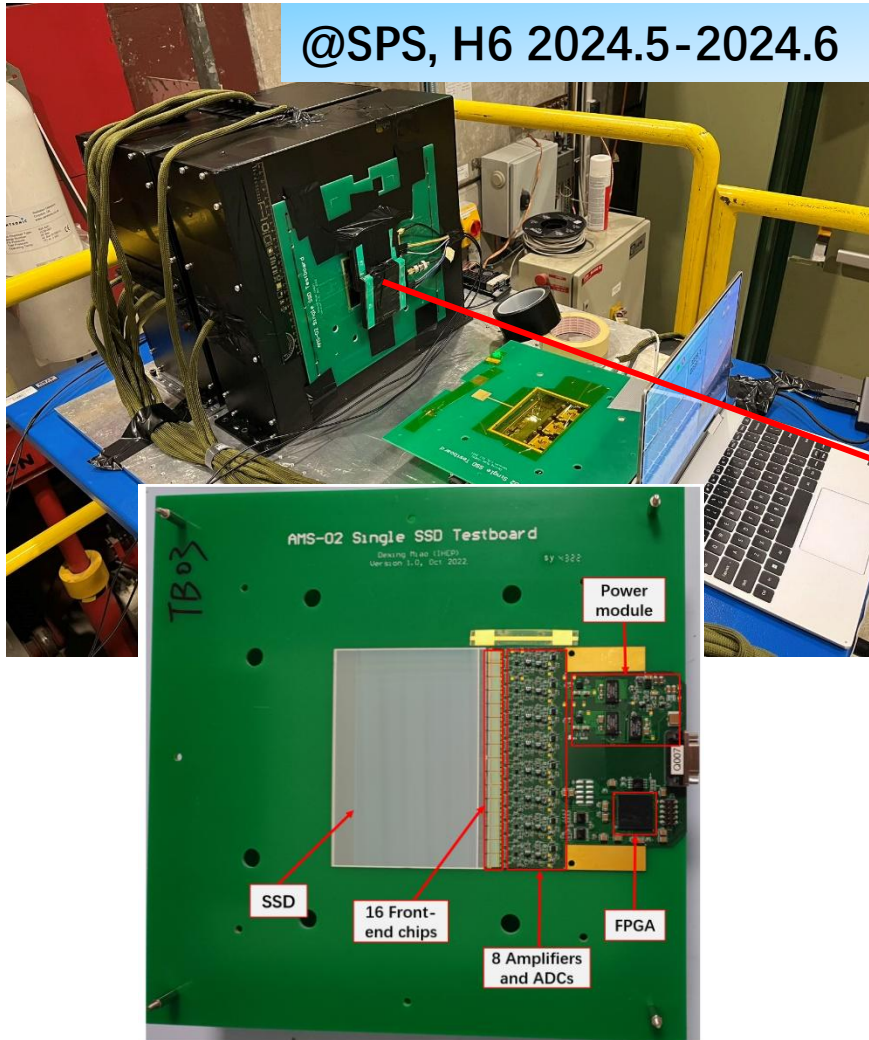


- A new tracker(Layer0) on the top of AMS-02
 - Larger sensitive area ($\sim 7\text{m}^2$) $\Rightarrow$ acceptance to 300%
 - Better charge measurement for cosmic ray nuclei
- 8/10/12 SSDs are connected in series to form a ladder
 - Assembly precision is crucial
 - Large detection area with small power consumption
- **SSD designed by IHEP+Perugia+HPK**
- **All Electronics are produced by IPAS + NCSIST**
- **All FM ladders are constructed by IHEP + SDIAT**

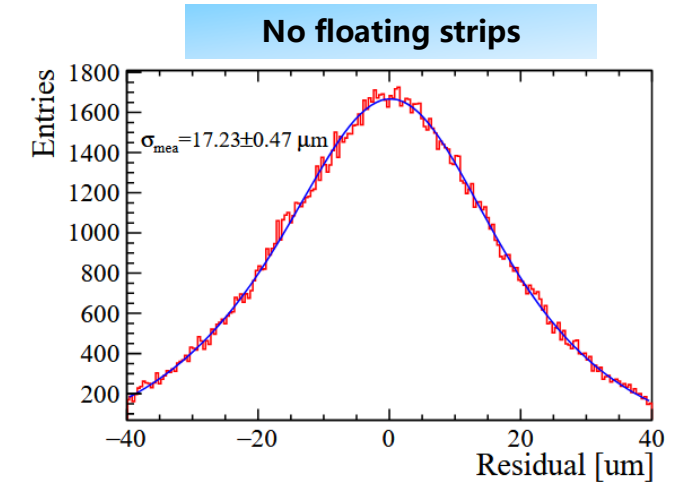
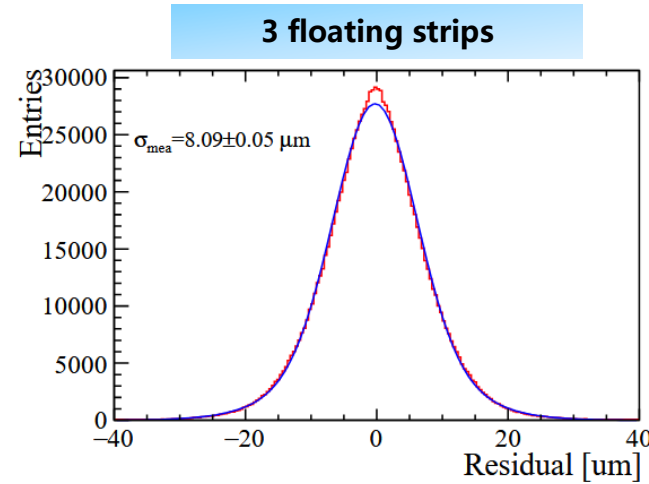
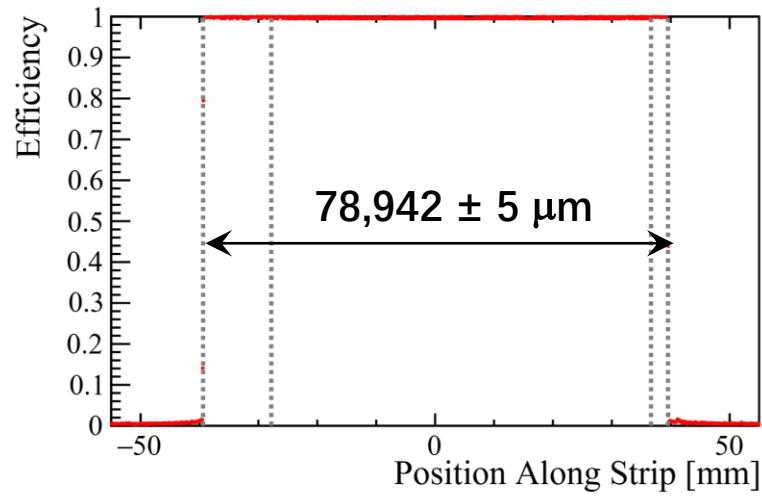
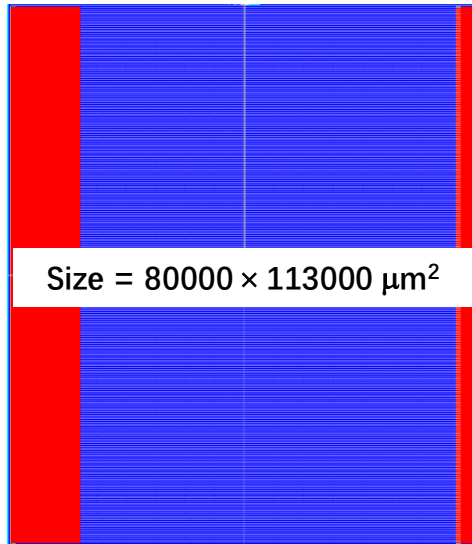




- Series connection of the SSDs leads to a large capacitance, requiring large bias resistor for RC matching
 - Occupy large space
 - Insert between 2 adjacent aluminum strips $\Rightarrow$ affect efficiency ?
- Maintain the spatial resolution while minimizing the number of electronic channels
 - Readout pitch $109\mu\text{m}$ with 3 floating strips

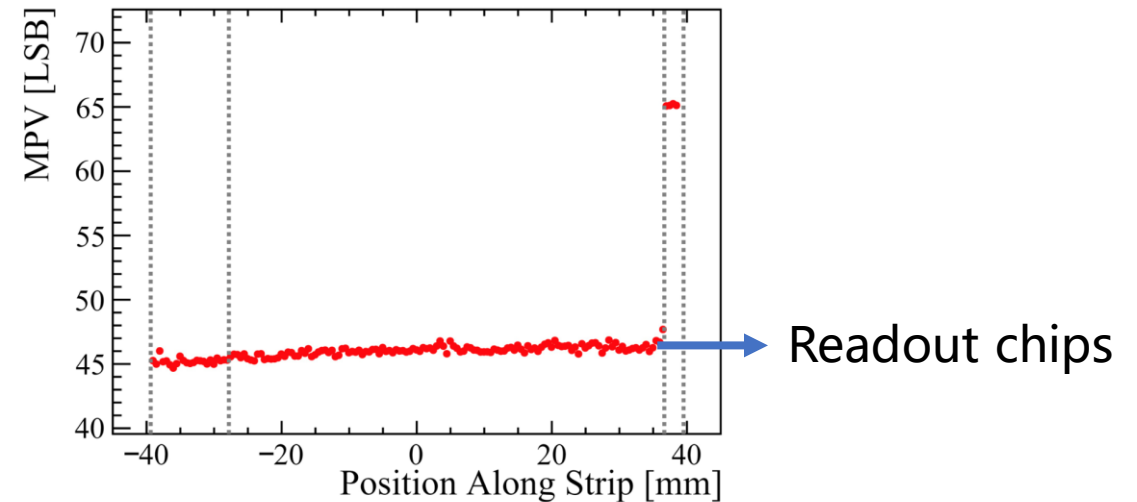
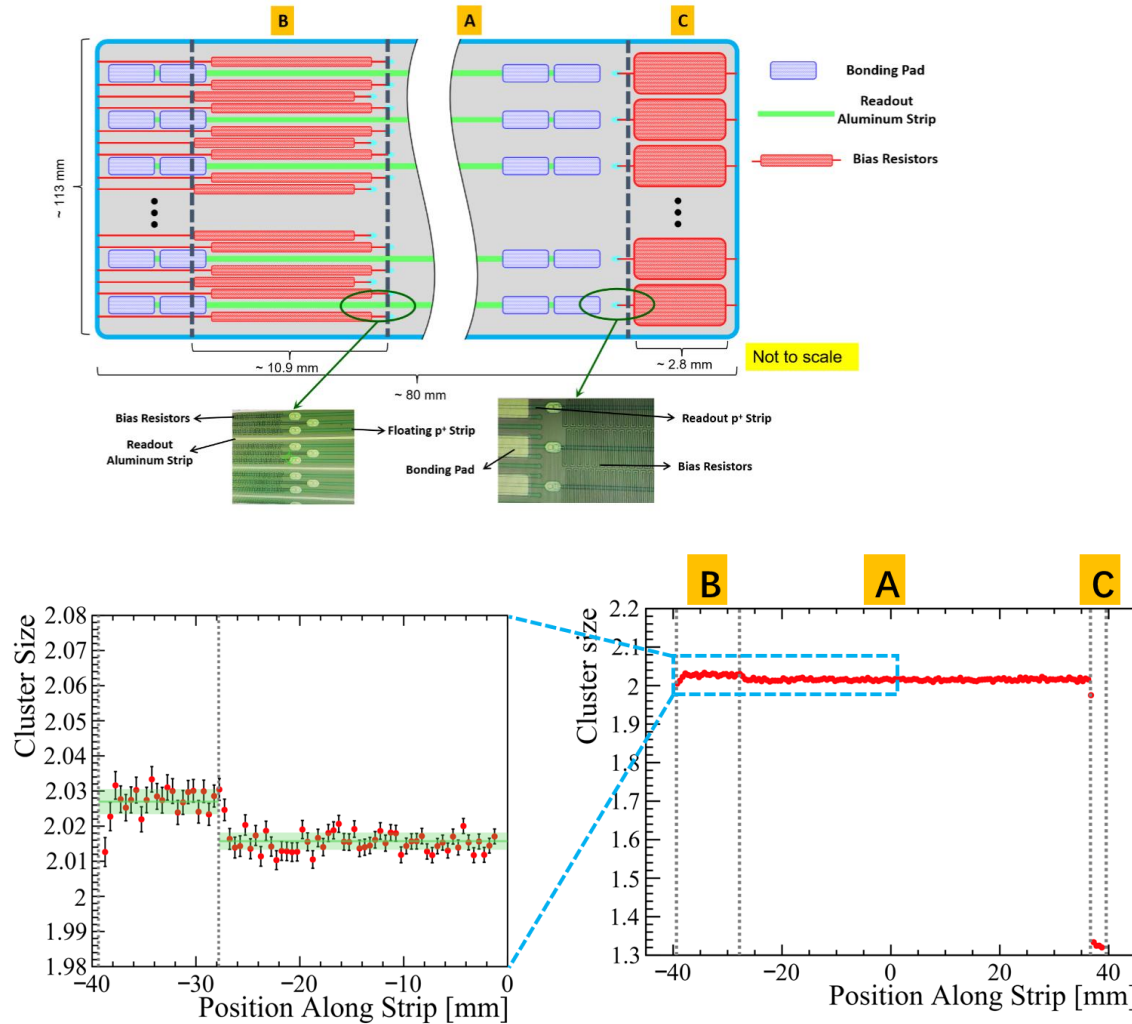


- Muon beam of ~ 30 GeV
- Trigger with coincidence of 2 plastic scintillator + SiPM, cover the full sensor along strip direction

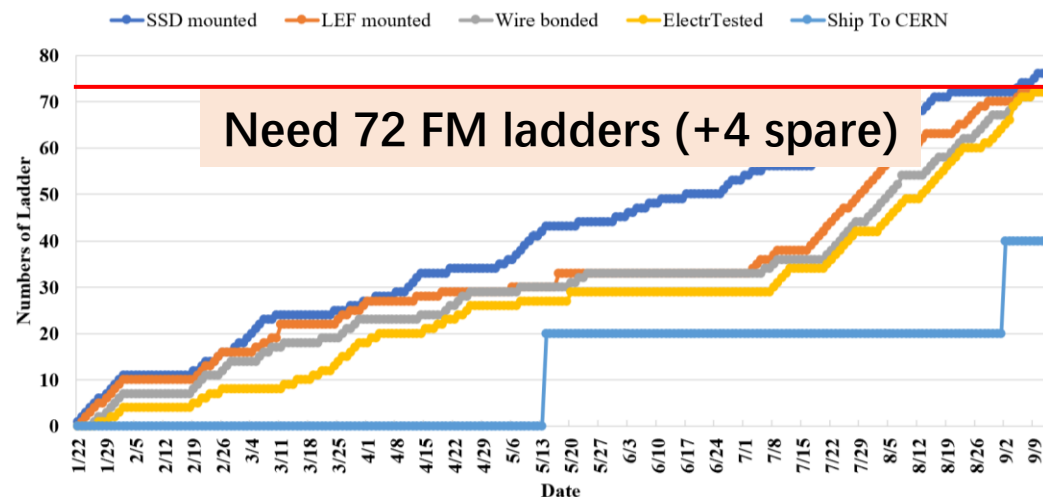
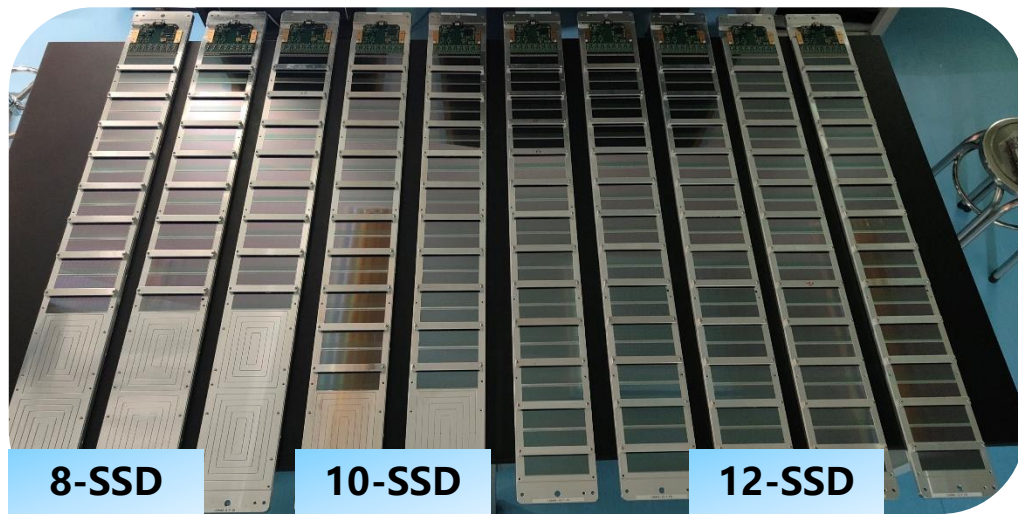


- The presence of the bias resistor does not lead to a decrease in detection efficiency
- Adding 3 floating strips improves the spatial resolution from $17 \mu\text{m}$ to $8 \mu\text{m}$
 - Enhance charge sharing

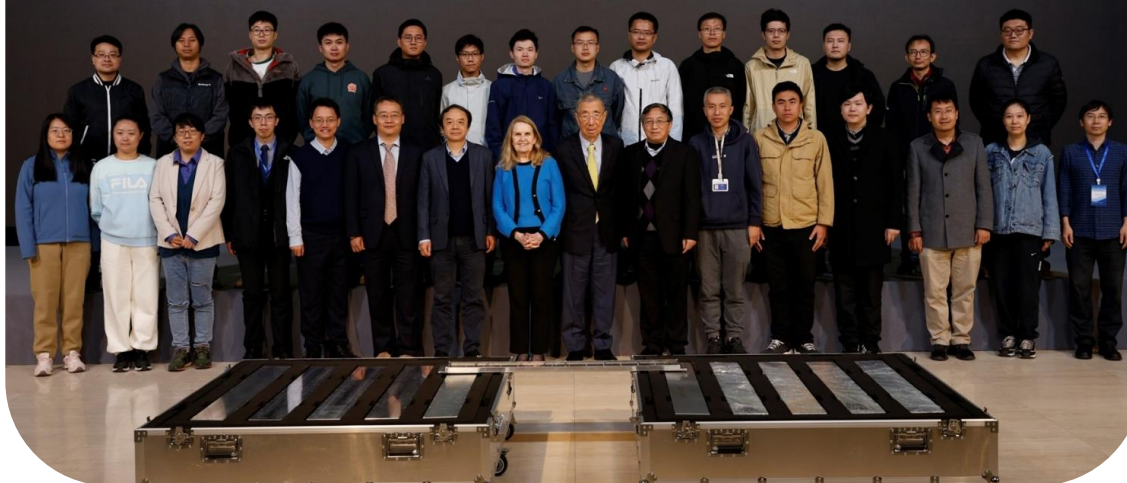
Performance along strip direction



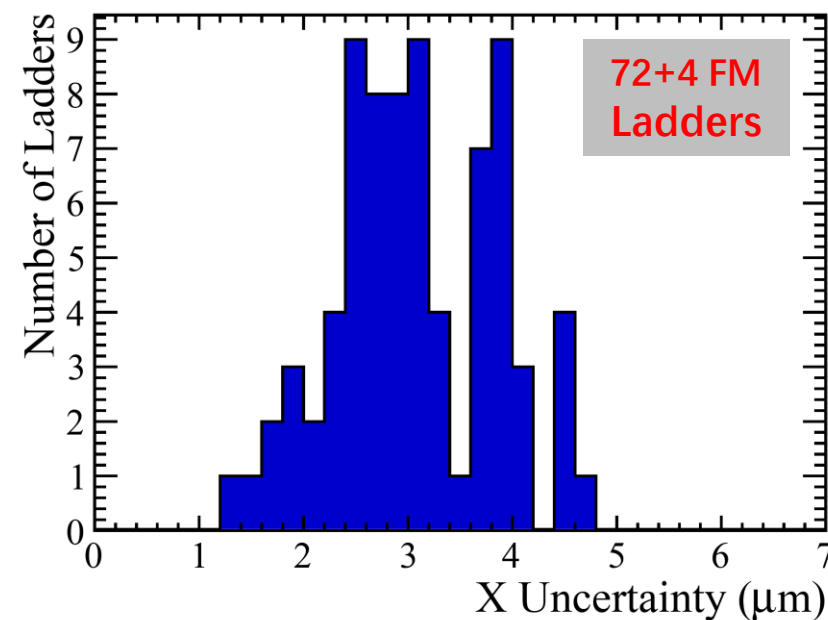
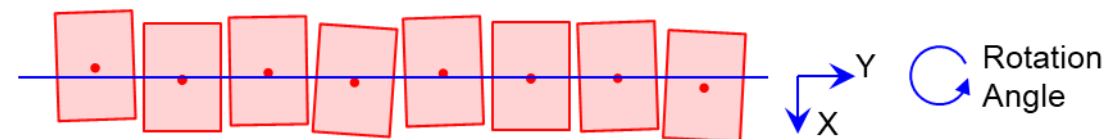
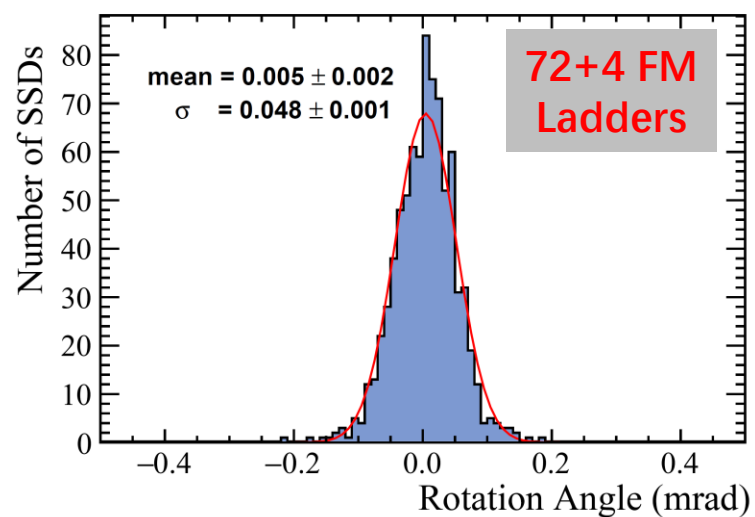
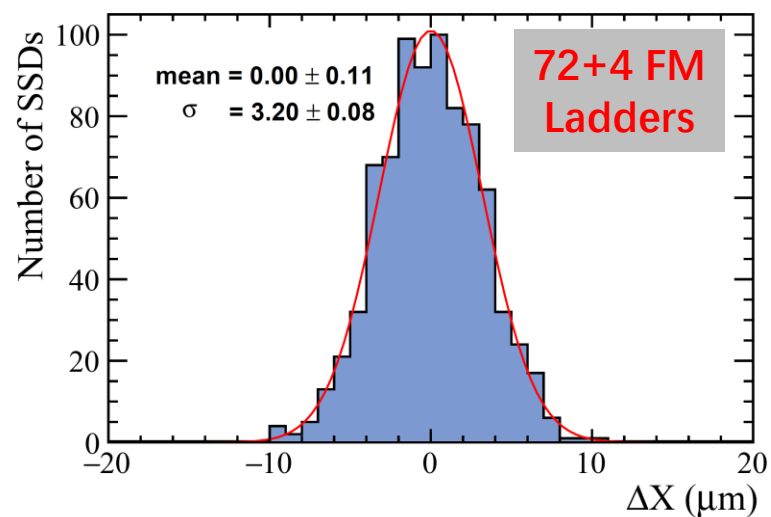
- In the region with the bias resistor, charge sharing enhanced
- The MPV decreases by ~2% from the readout electronics to the opposite end of the strip
 - Concern about the long ladder?
- More information: [arXiv2505.23050](https://arxiv.org/abs/2505.23050)



AMS L0 Upgrade Module Production Successfully Completed

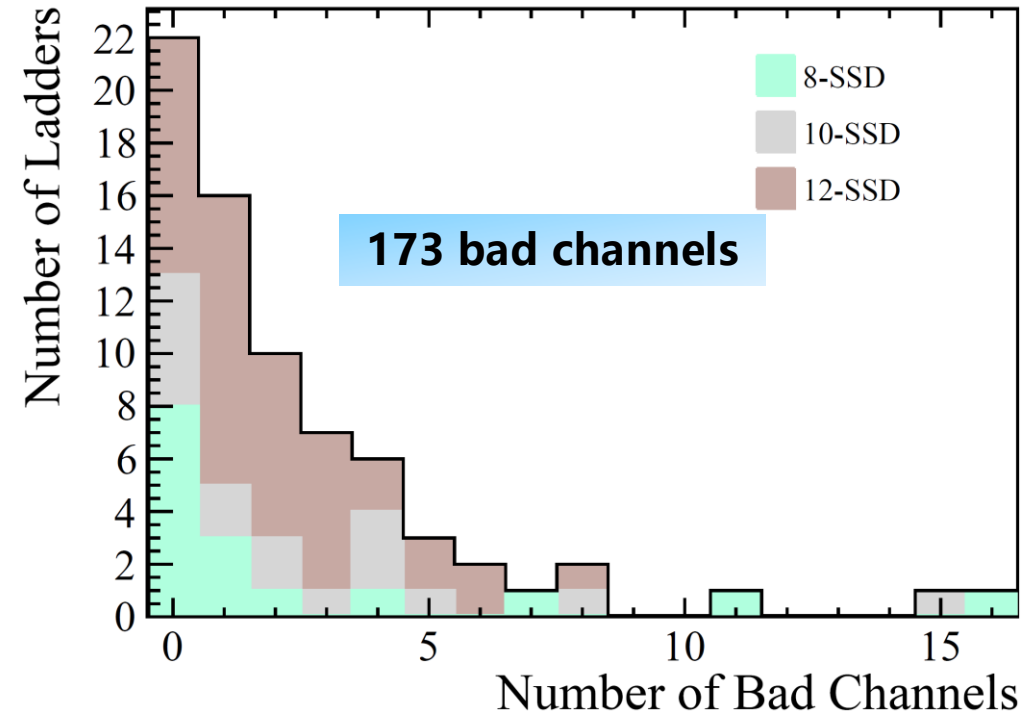
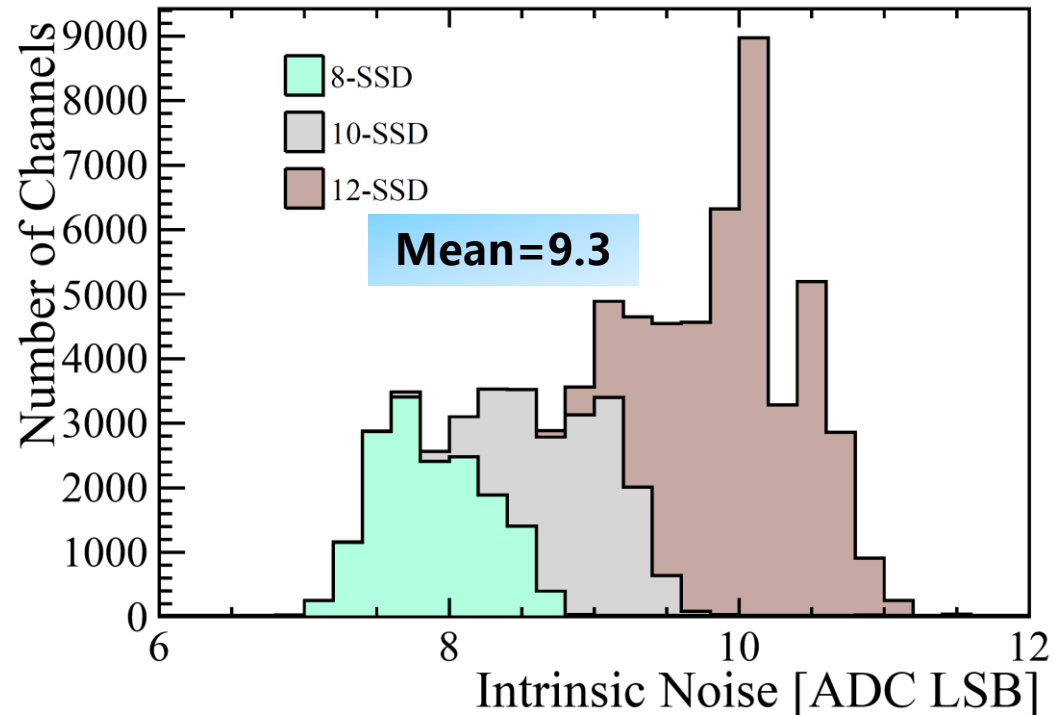


- Three types of ladders: 8-SSD, 10-SSD, 12-SSD
- 72 ladders installed on two planes
- Production finished in 2024 Sept.



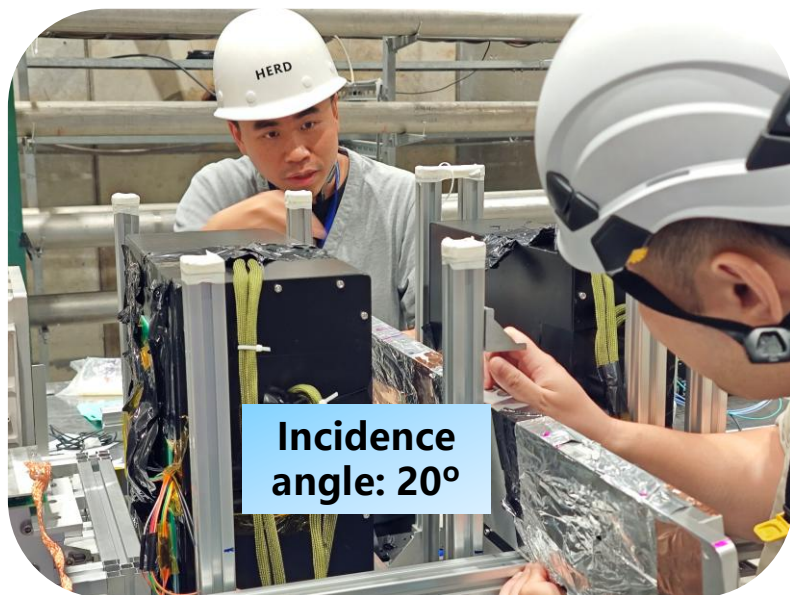
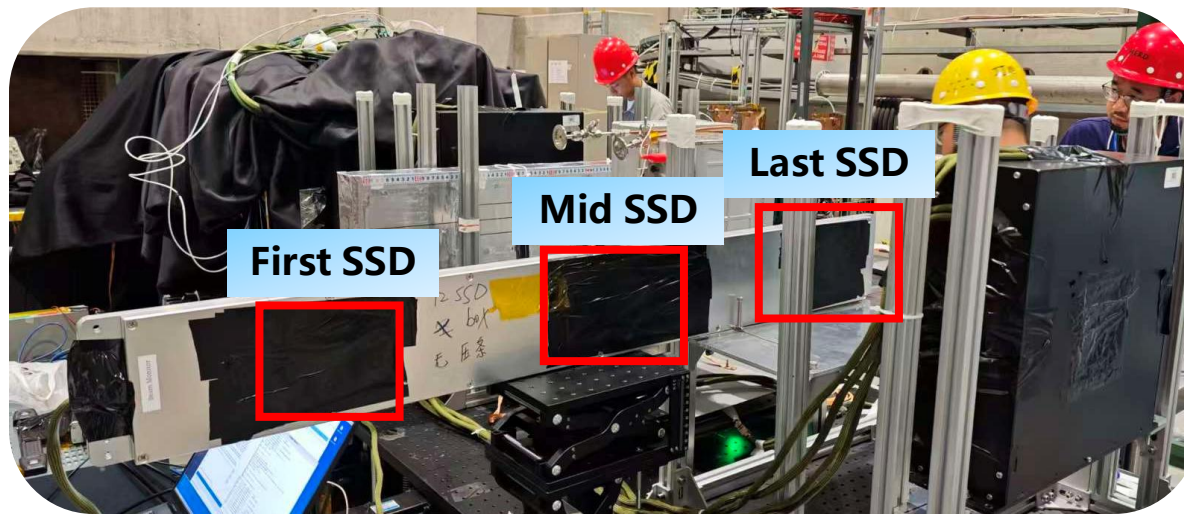
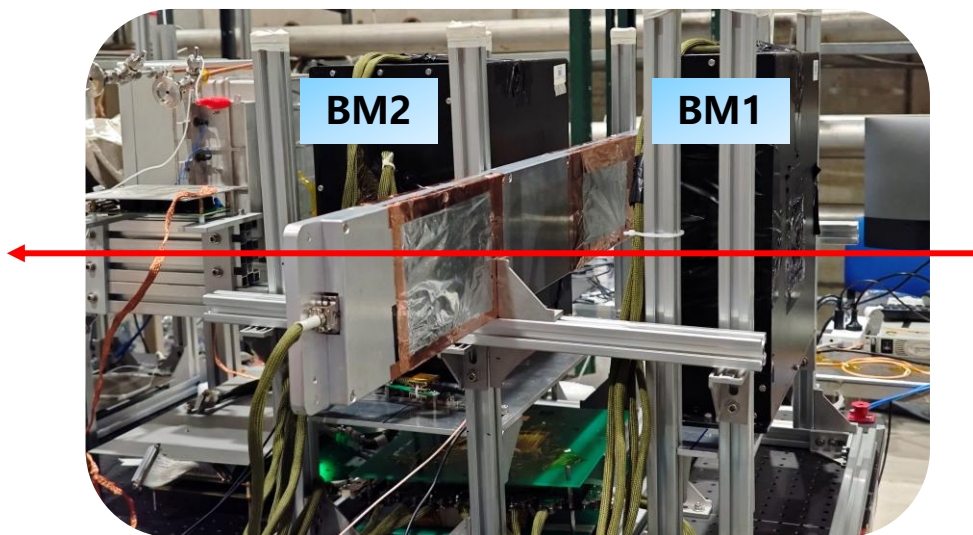
Overall contribution to the X precision
if no correction is applied

$$\sigma_x = 3.4 \mu\text{m}$$



- Dark current of all 72 FM ladders are < 2 mA, measured at 50 V and 80 V bias voltages
- The average common mode suppressed noise level is 9.3 ADC LSBs. In comparison, a MIP signal is about 75 ADC LSBs
- The total number of bad channels is 173, about 0.23% of all channels ($\sim 80K$)

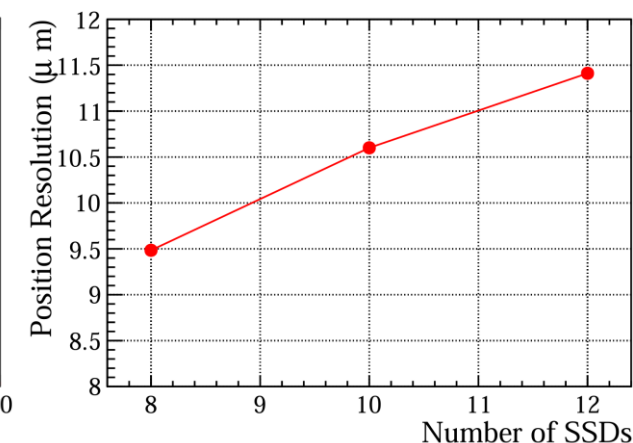
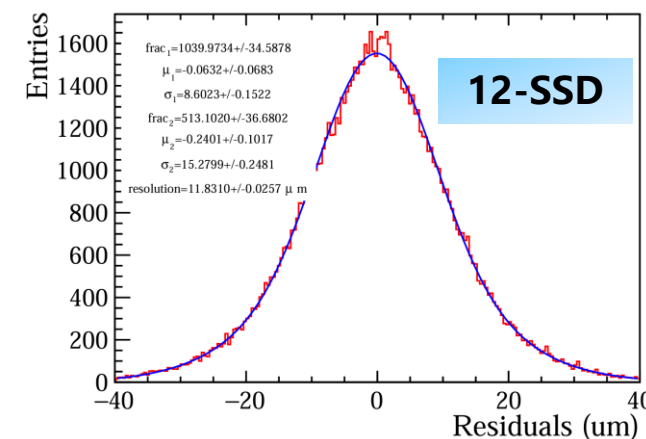
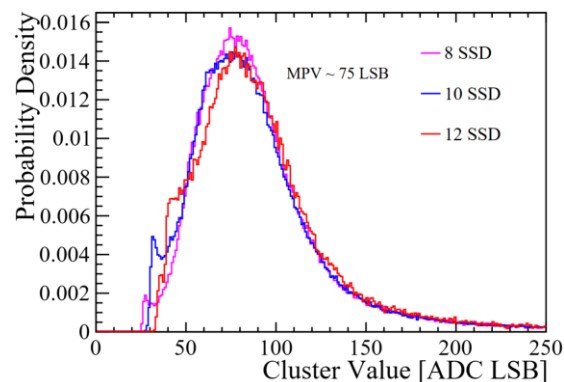
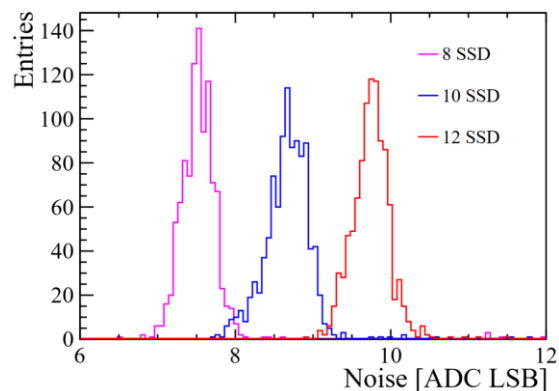
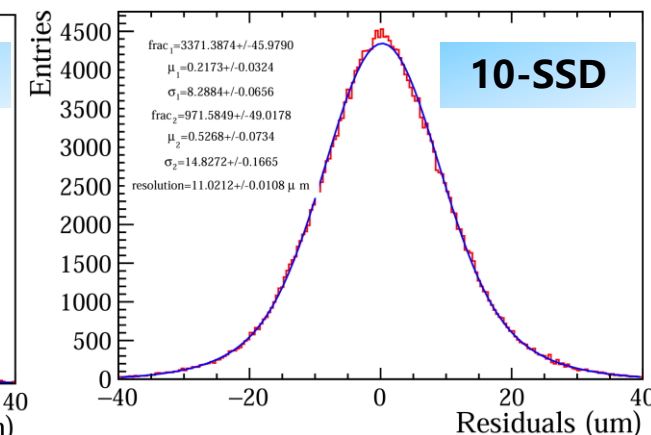
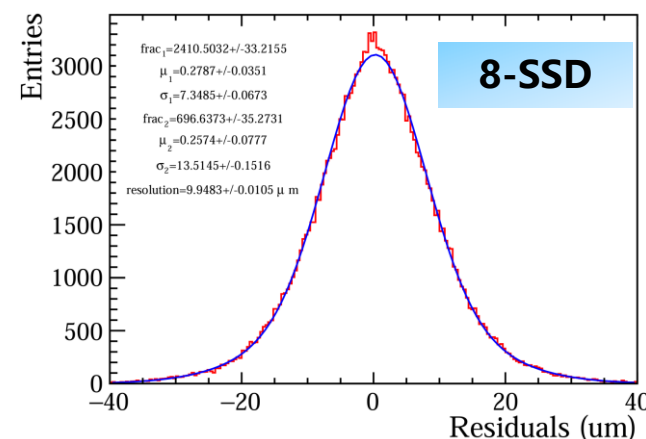
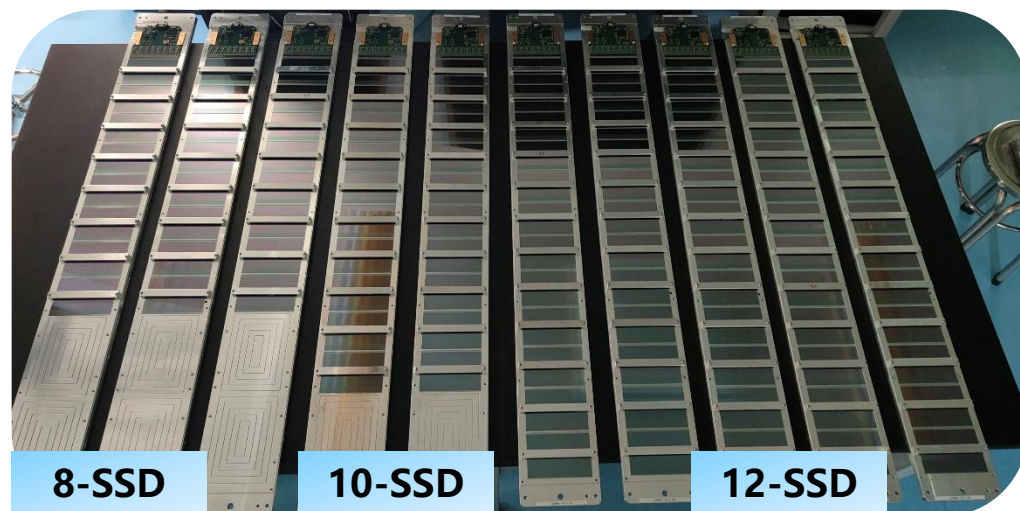
Beam test for Ladder performance



- Signal distribution(MPV) and spatial resolution of ladders
 - Different type of ladder: 8-SSD, 10-SSD, 12-SSD
 - Different incident SSD: first, mid, last
 - Different incident angle: 0°, 10°, 20°, 25°, 30°

@SPS, H6 2025.7, 350GeV Proton

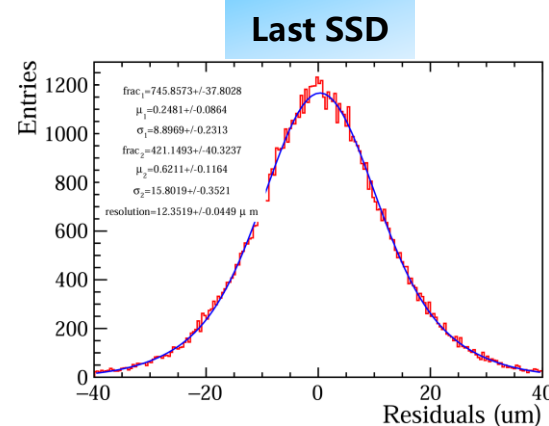
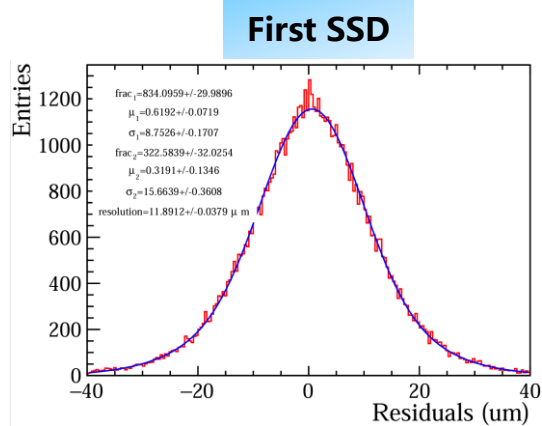
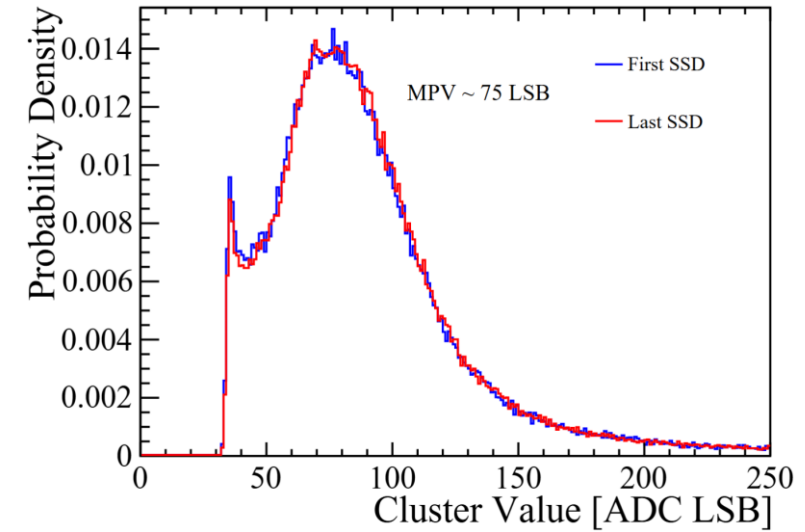
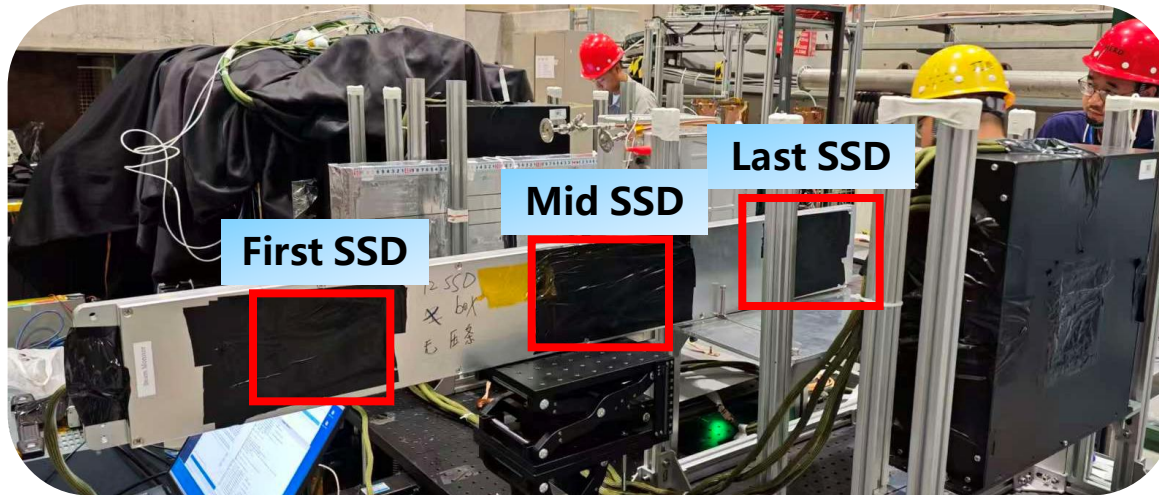
Performance of different type of ladders



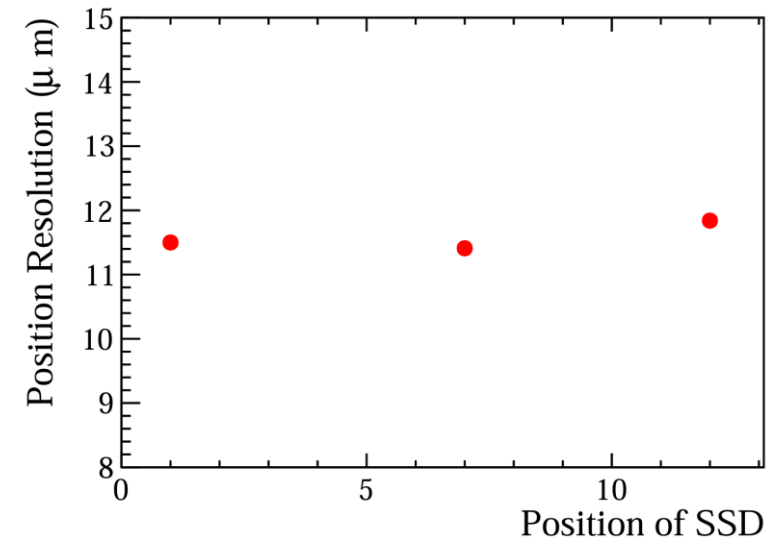
- Tuning trigger delay with maximum signal value
- S/N for MIP: 9.9, 8.7, 7.5 for 8-SSD, 10-SSD, 12-SSD

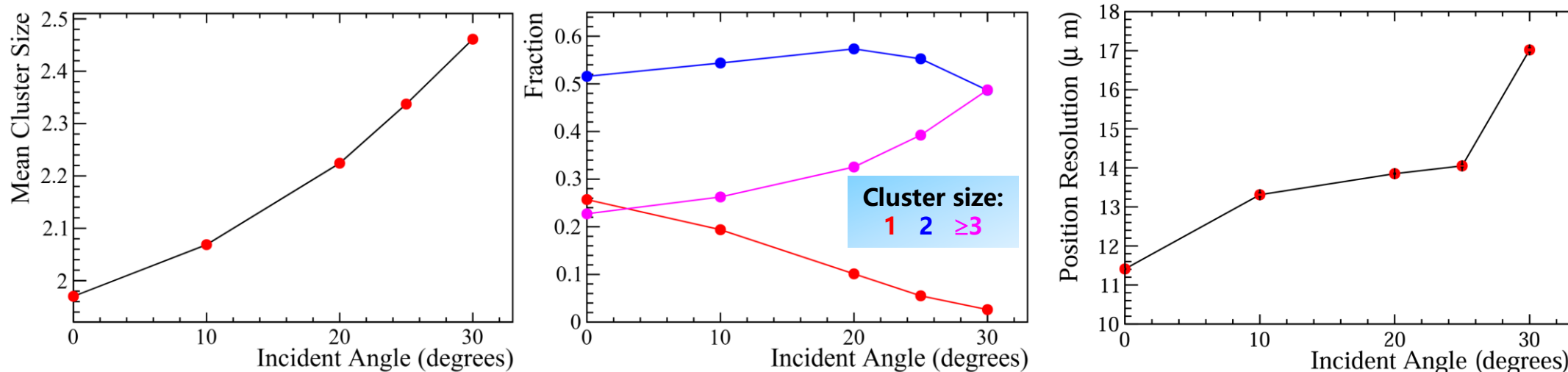
- After subtract uncertainty from the telescope, intrinsic spatial resolutions: $9.5\mu\text{m}$, $10.6\mu\text{m}$, $11.4\mu\text{m}$

Performance of different SSD on a ladder

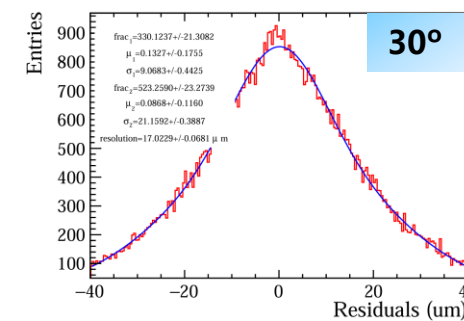
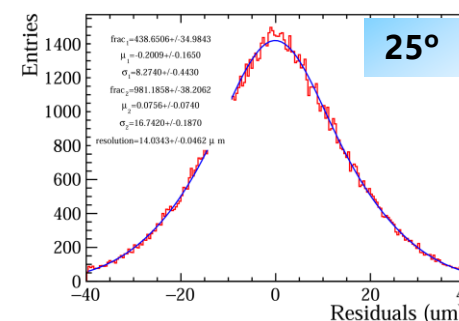
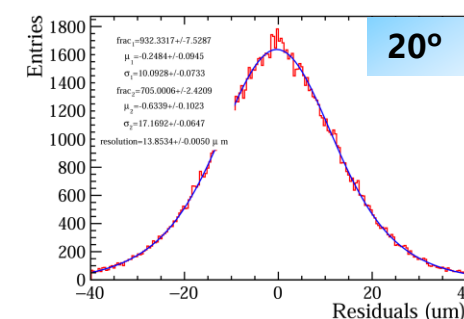
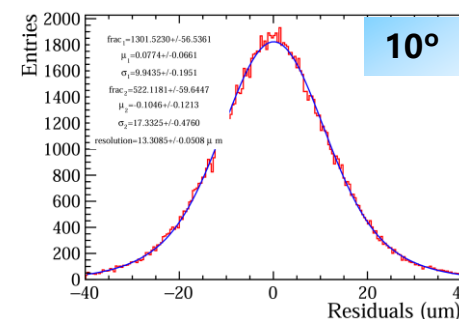


- Test the 1st, 6th, 12th SSD on a 12-SSD ladder
- No significant variation in performance along the ladder





- For the 12-SSD ladder, tests different incident angles: 0°, 10°, 20°, 25°, 30°
- Study the dependence of cluster size on the incident angle
- Spatial resolution degrades as angle increases
 - 109μm readout pitch with 3 floating strips, enough charge sharing for Normal incidence





Integration finished in 2025 Aug.



**Upgrade launching
is expected ~2026-27**

- AMS will add a new silicon strip tracker L0, with a total sensitive area of $7\text{m}^2 \Rightarrow$ Integration Finished !
- The AMS-L0 adopts a design in which multiple sensors are connected in series to form ladders
 - Specially designed SSD and validated through beam test
- Thoroughly characterized the performance of AMS-L0 ladders by beam test
 - Meet the operational requirements

Thanks for your attention!

Backup

NCSIST clean room team



AMS-02
Layer-0 Tracker Electronics
N.C.S.I.S.T, TAIWAN, R.O.C
國家中山科學研究院



