

AMS-02 Upgrade Status

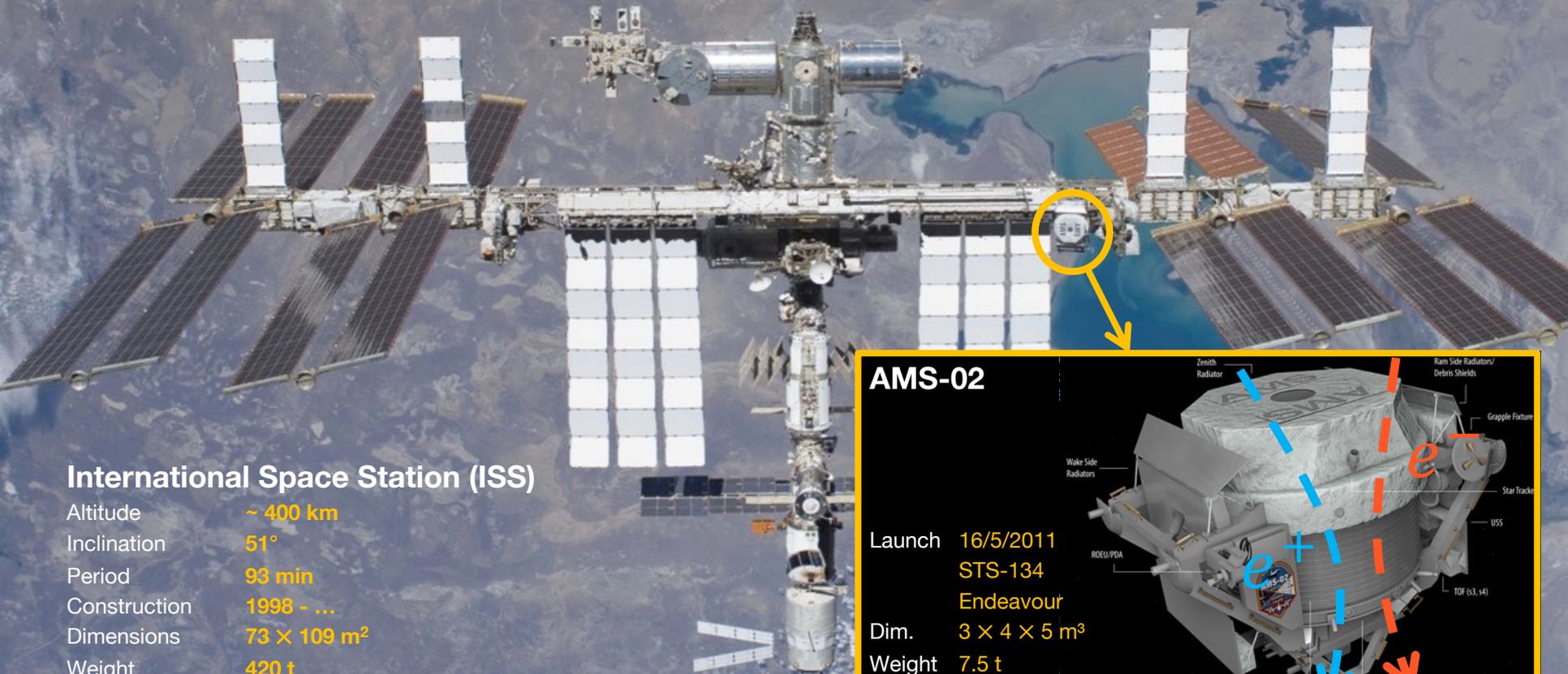
A. Oliva, INFN Bologna

ASI-INFN AMS RT
23rd April 2024



AMS-02: The Alpha Magnetic Spectrometer

The prototype, AMS-01, flown in 1998. AMS-02 has been designed and built in 2000-2011. Installed in 2011 on the ISS. Takes data continuously since then. AMS-02 has collected more than **230 billion cosmic rays** up to now.

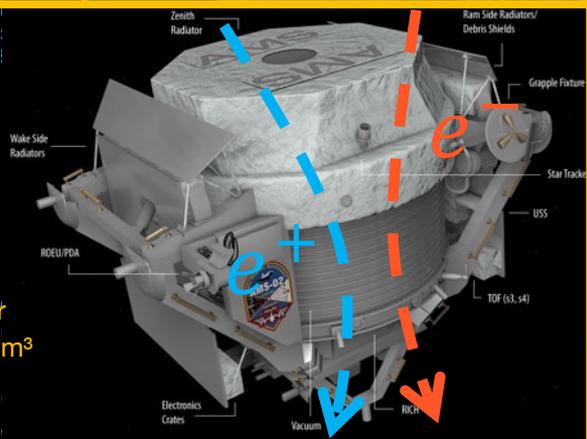


International Space Station (ISS)

Altitude	~ 400 km
Inclination	51°
Period	93 min
Construction	1998 - ...
Dimensions	73 × 109 m ²
Weight	420 t

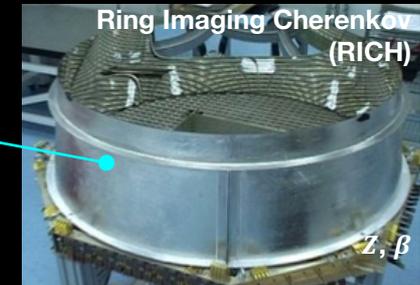
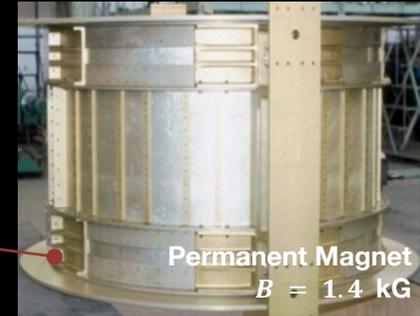
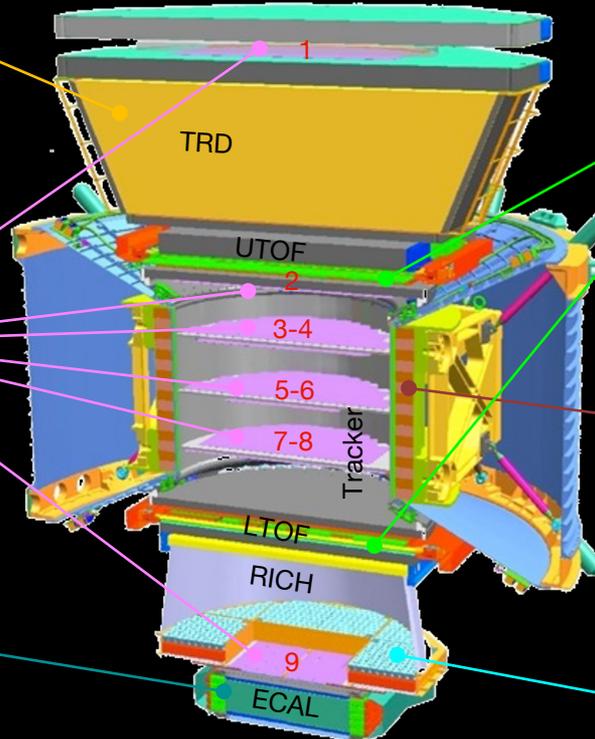
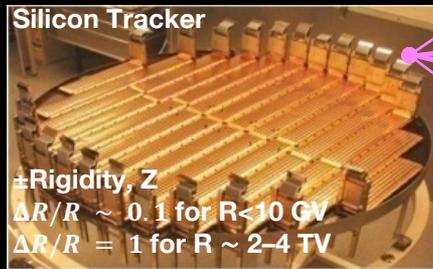
AMS-02

Launch	16/5/2011
	STS-134
	Endeavour
Dim.	3 × 4 × 5 m ³
Weight	7.5 t
Power	2500 W



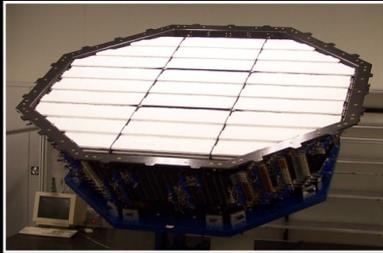
A TeV Multi-Purpose Spectrometer

AMS-02 separates hadrons from leptons, matter from anti-matter, chemical and isotopic composition from fraction of GeV to multi-TeV.

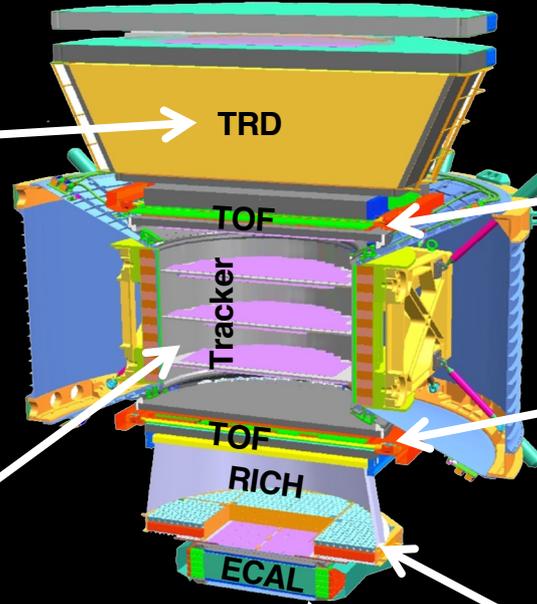


Multiple and/or Independent Measurement of Charge (Z), Energy (β, p, E) and Charge Sign (\pm).

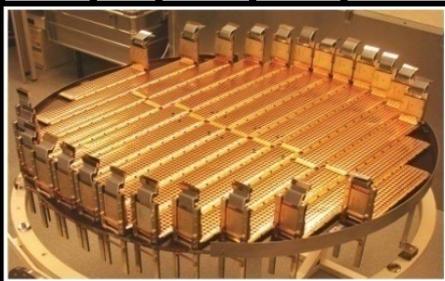
Rome: TRD



Bologna: TOF



Perugia: Tracker



Pisa: ECAL

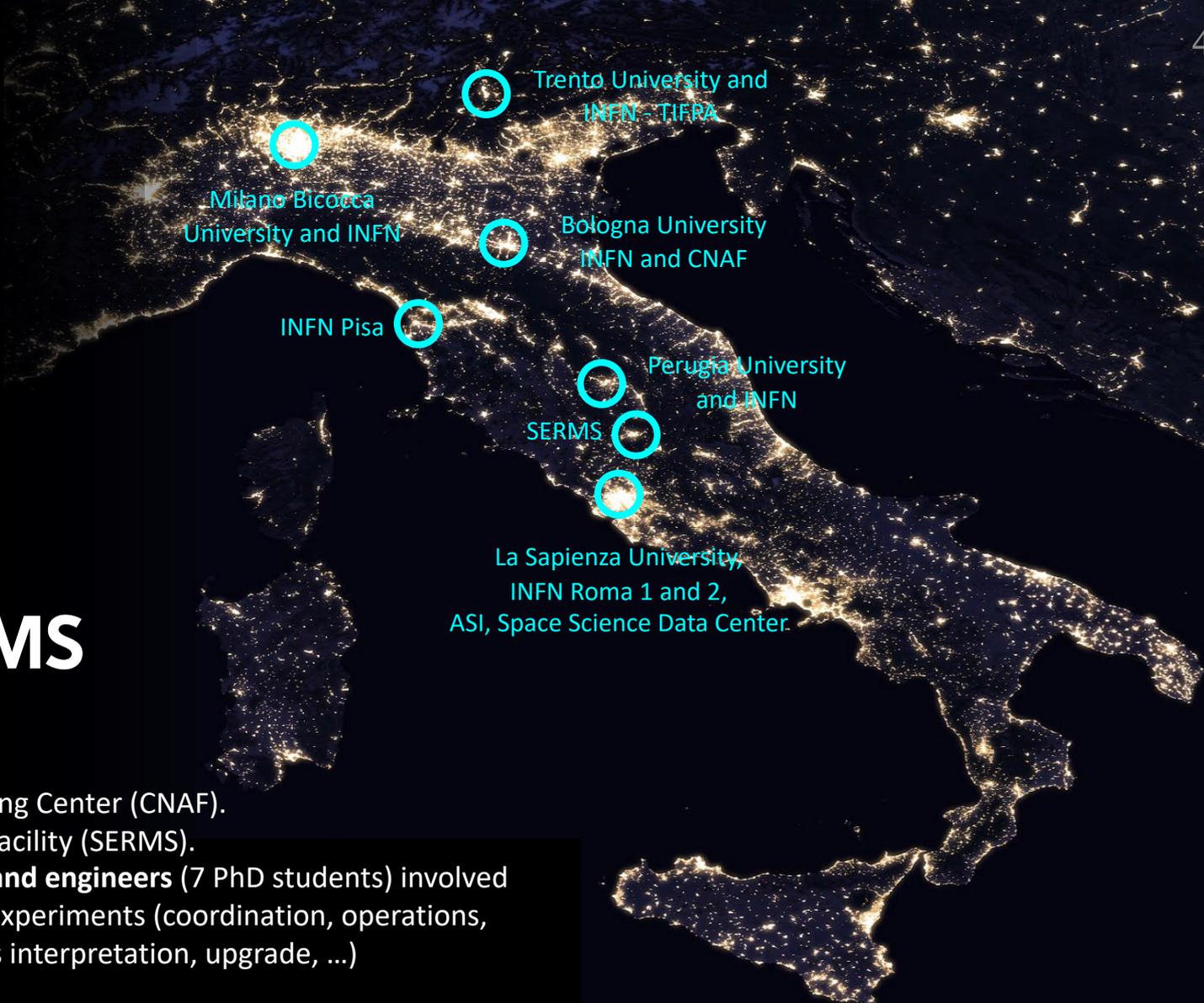


Bologna: RICH



Italy in AMS

- 7 INFN Divisions.
- 6 Universities.
- Italian INFN Computing Center (CNAF).
- Space Qualification Facility (SERMS).
- About **50 physicists and engineers** (7 PhD students) involved in all aspects of the experiments (coordination, operations, data analysis, physics interpretation, upgrade, ...)



Milano Bicocca
University and INFN

Trento University and
INFN - TIFRA

Bologna University
INFN and CNAF

INFN Pisa

Perugia University
and INFN

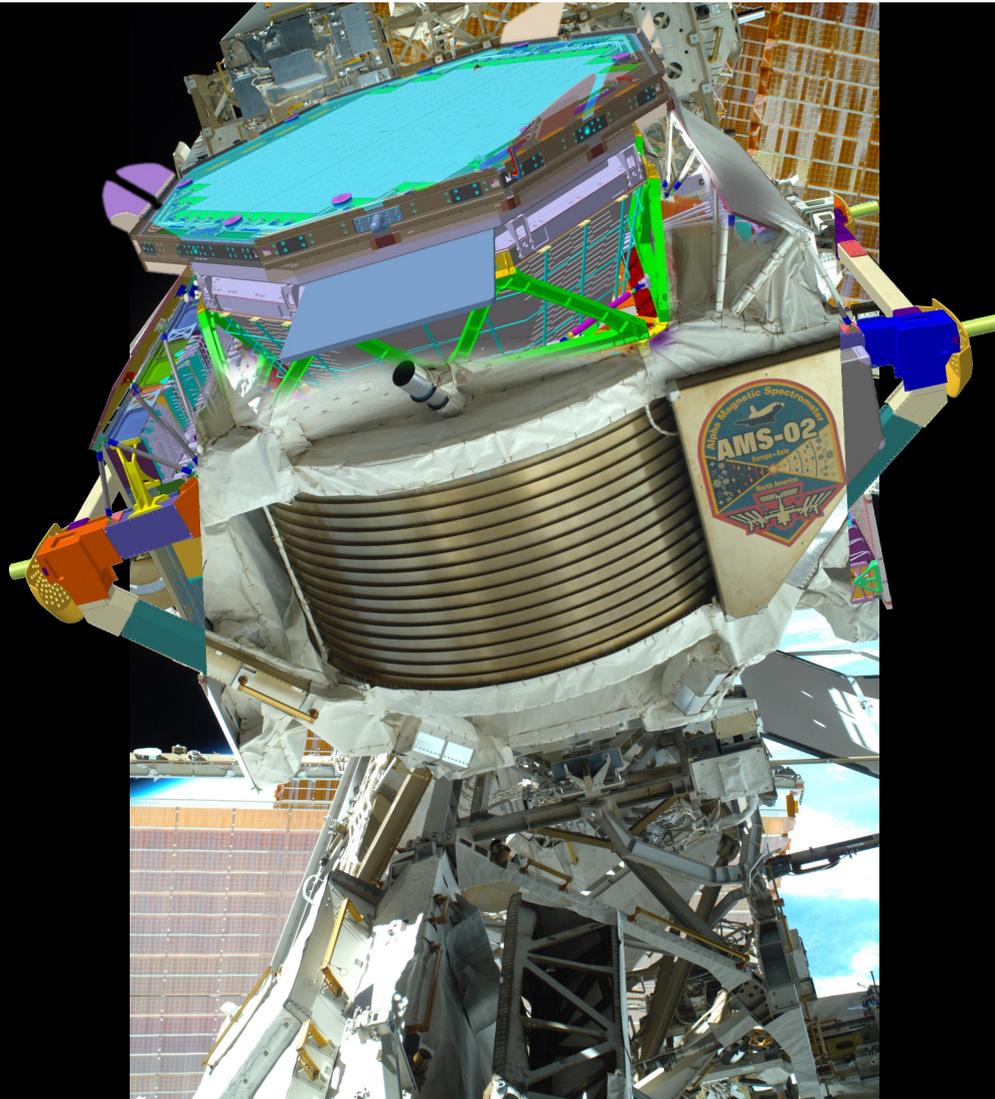
SERMS

La Sapienza University,
INFN Roma 1 and 2,
ASI, Space Science Data Center.

The AMS-02 Upgrade (AMS-02.2)



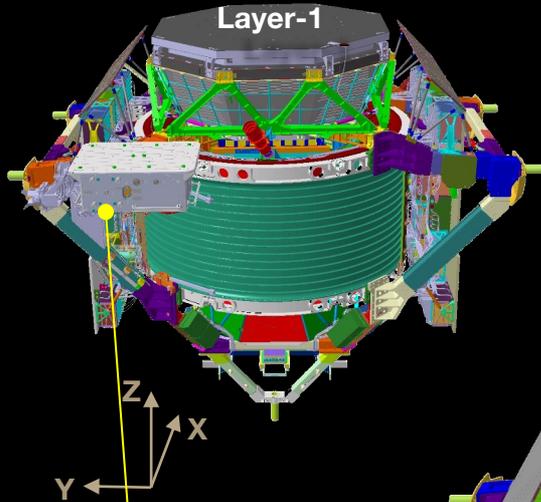
The AMS-02 Upgrade (AMS-02.2)



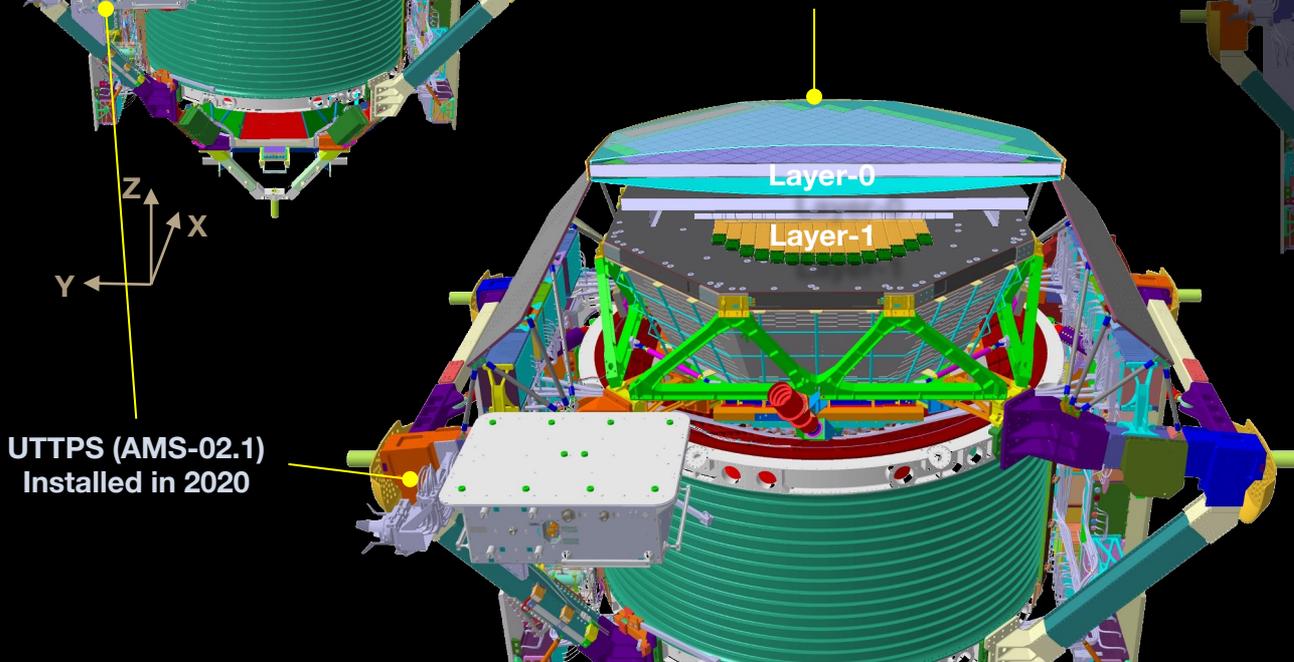
A New Tracking Layer (Layer-0)

The increase of 300% in the acceptance will allow for the best use of the time left on the ISS, allowing higher rate in data collection for many analysis channels (positrons, nuclei, ...).

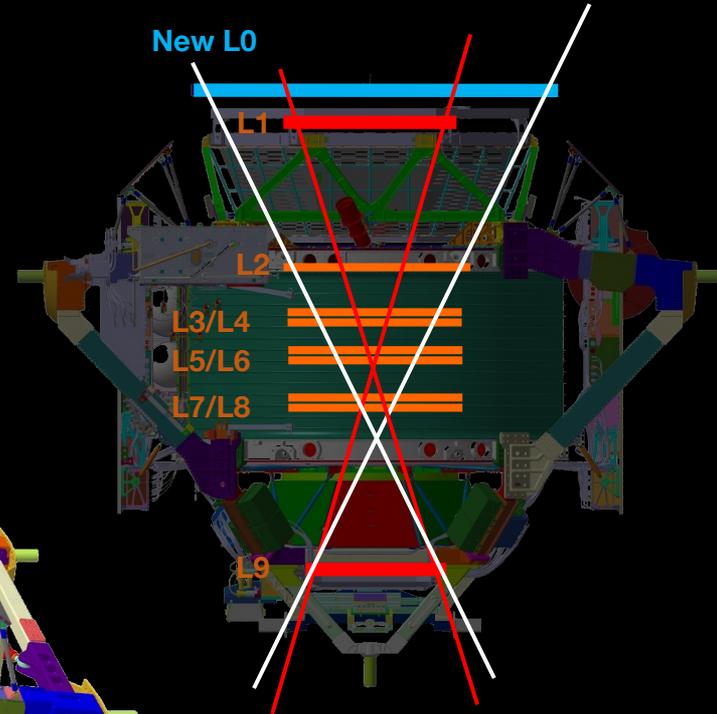
AMS-02 present layout



New Tracker (Layer-0)



New L0

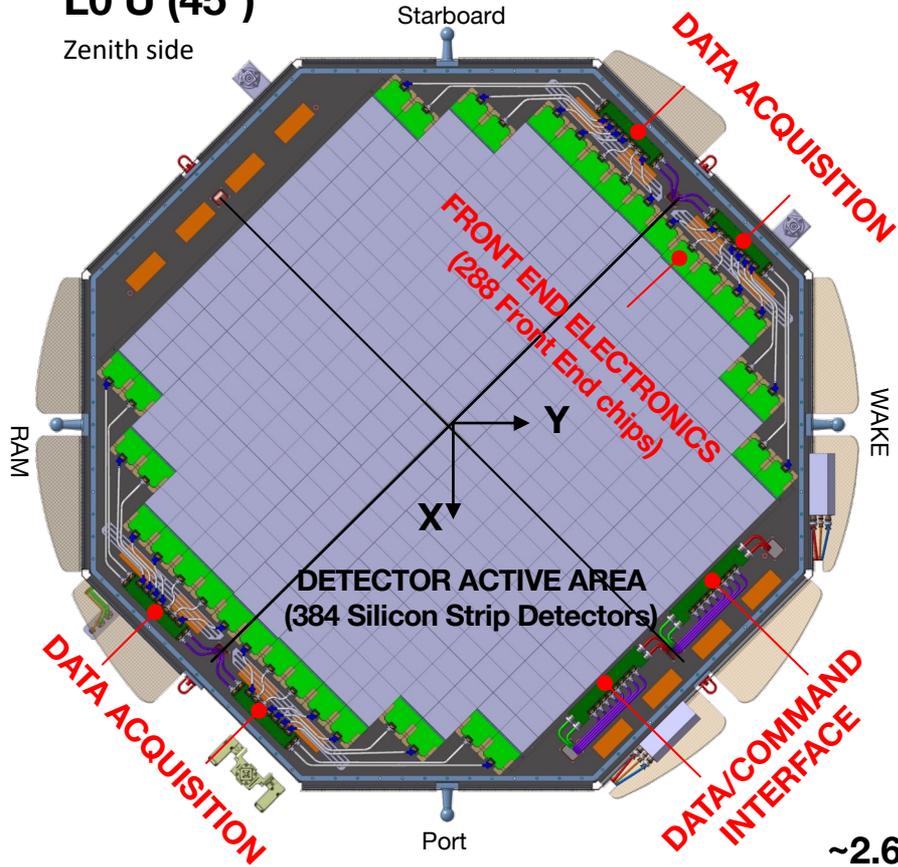


UTTPS (AMS-02.1)
Installed in 2020

Layer-0 Layout

LO U (45°)

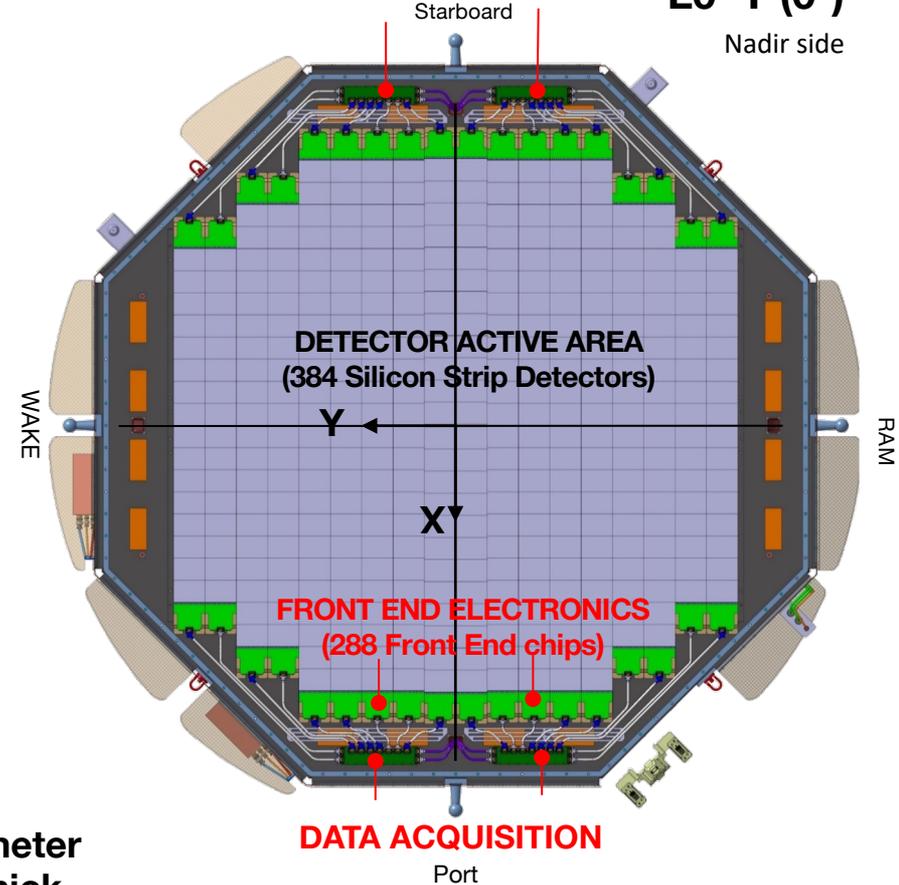
Zenith side



DATA ACQUISITION

LO Y (0°)

Nadir side



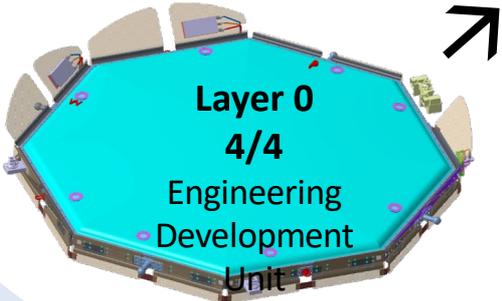
~2.6m diameter
~ 30 cm thick
~ 250 kg

~155W power consumption

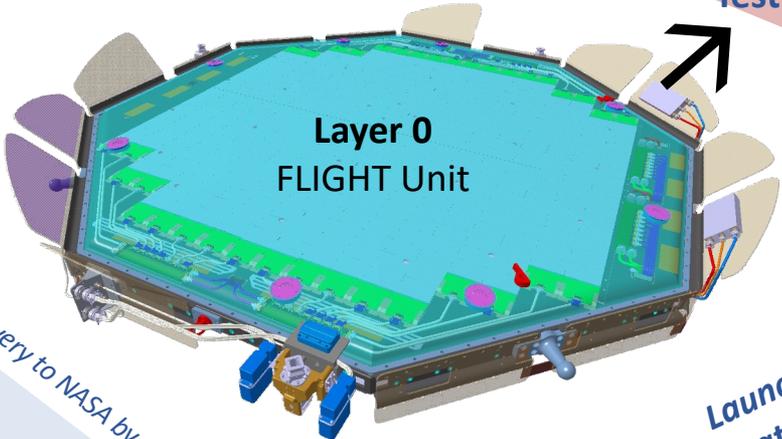
Development, Qualification and Flight Units



¼ QM
Final Grade Carbon Fiber
Vibration
Thermo-vacuum
EMI

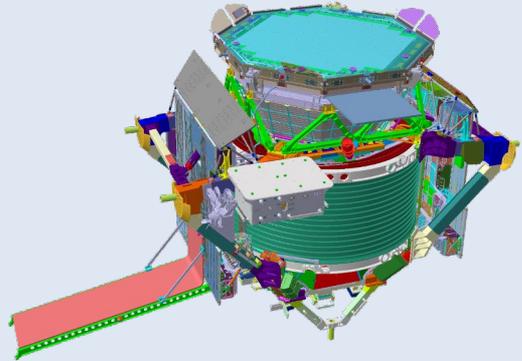


Full scale EDU
Low Grade Carbon Fiber
Vibration



Flight
Low Grade Carbon Fiber
Survey
Vibration
Thermo-vacuum
Vibration
Survey
Test beam

*Flight production of ladders, electronics, cables...
Sensor testing for scientific performances...*



... Delivery to NASA by mid-2025

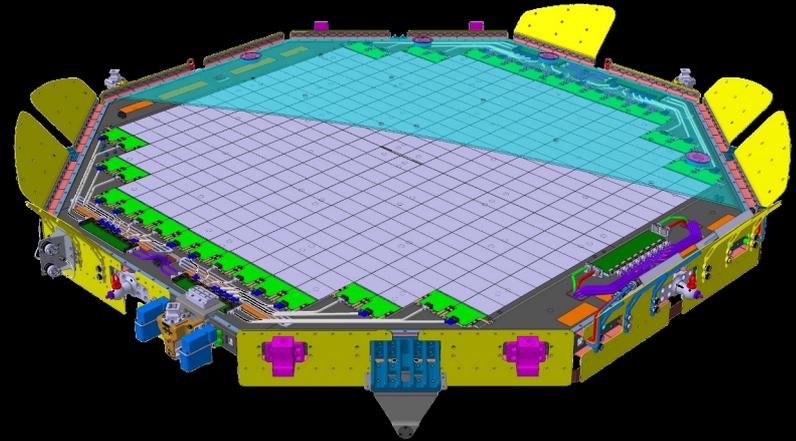
*Launch opportunity
at beginning of
2026 (SpX-33)!*

72 Ladders + Spares:

flight production ongoing @ IHEP

- ✓ 35 SSD mounted
- ✓ 18 fully tested
- ✓ End production by May

Ladders go to Terni for $\frac{1}{4}$ plane assembly
Assembly of $\frac{1}{4}$ plane start end of May



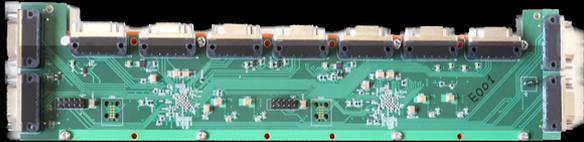
Flight Model: Electronics Production

- ✓ **72/72 Front End Board flight production completed**
Boards at IHEP for ladders integration



LEF

- ✓ **8/8 Intermediate Board flight production ongoing**
4 FM LINF-R at CERN since Dec, 4 FM LINF-L in April



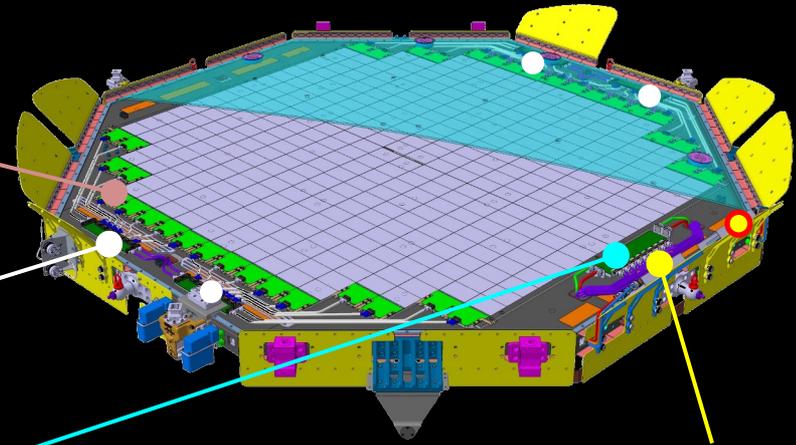
LINF

- ✓ **1 Flight production will start (mid May)**
Version3 design released after radiation test (3 May)

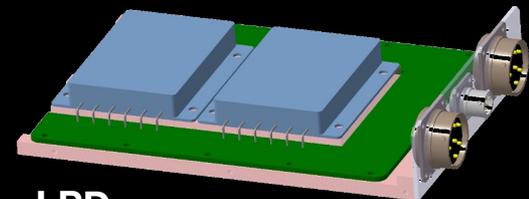


LINJ

Productions @ NCSIST (Taiwan)

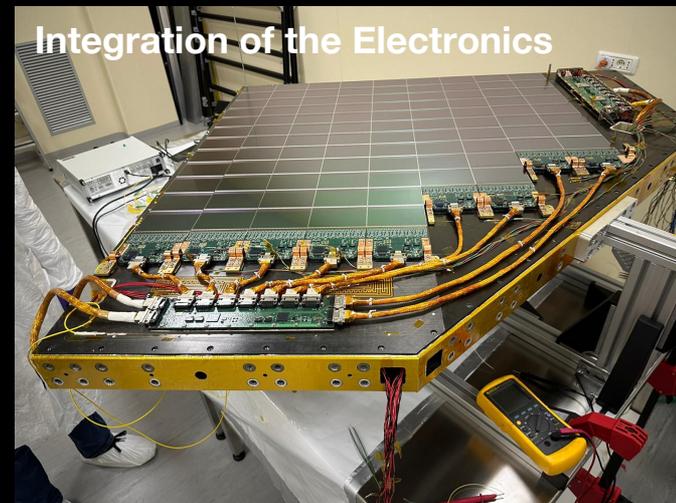
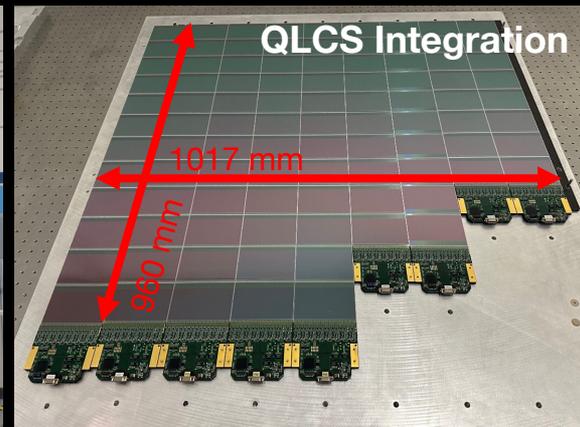


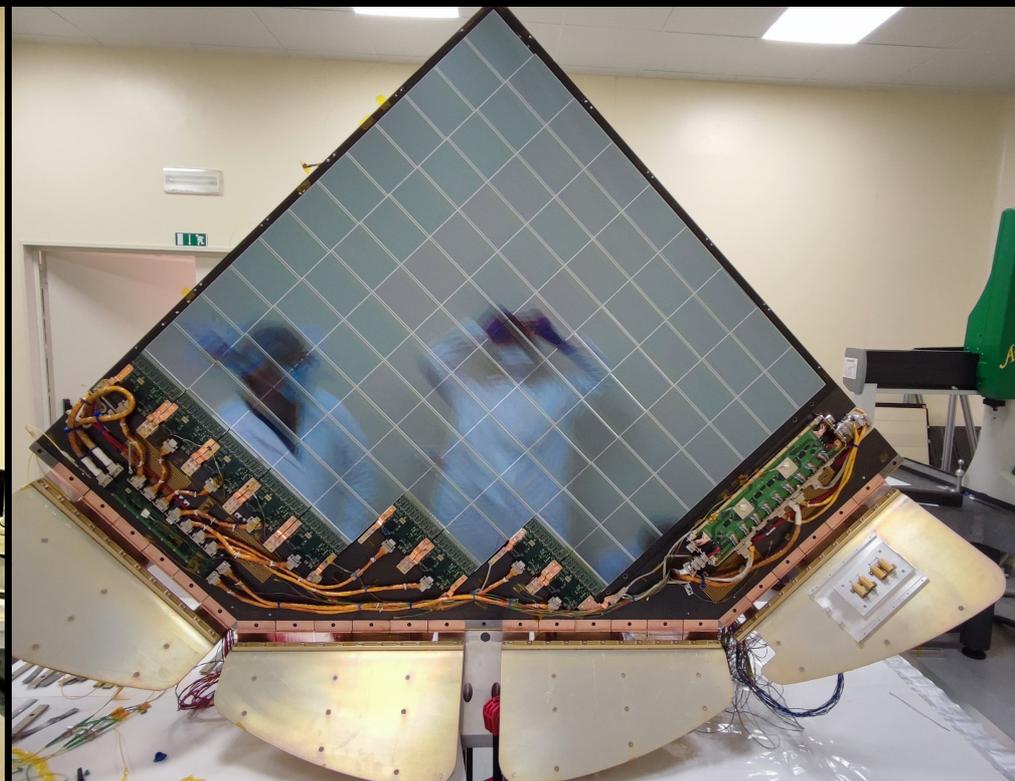
- ✓ **2 Power Board 1st non-flight production April**
-> conductive emission test -> 2 flight production



LPD

1/4 Quality Model: Integration in Terni

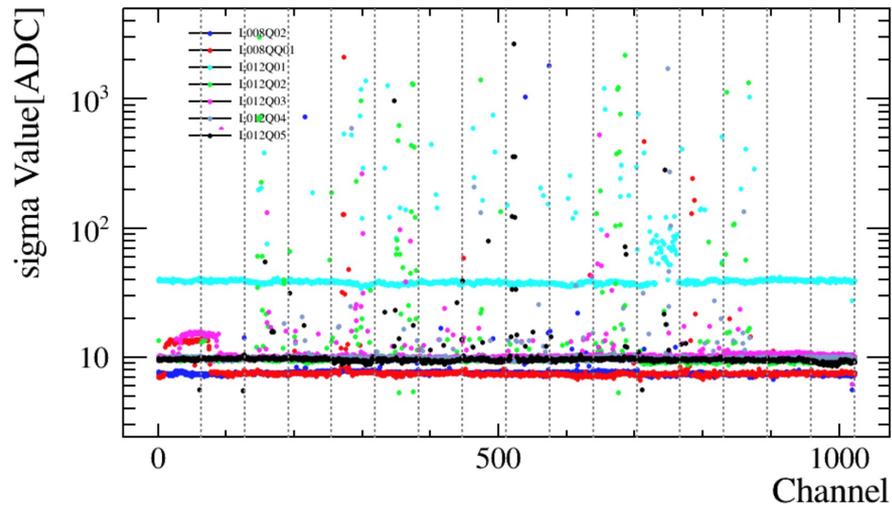
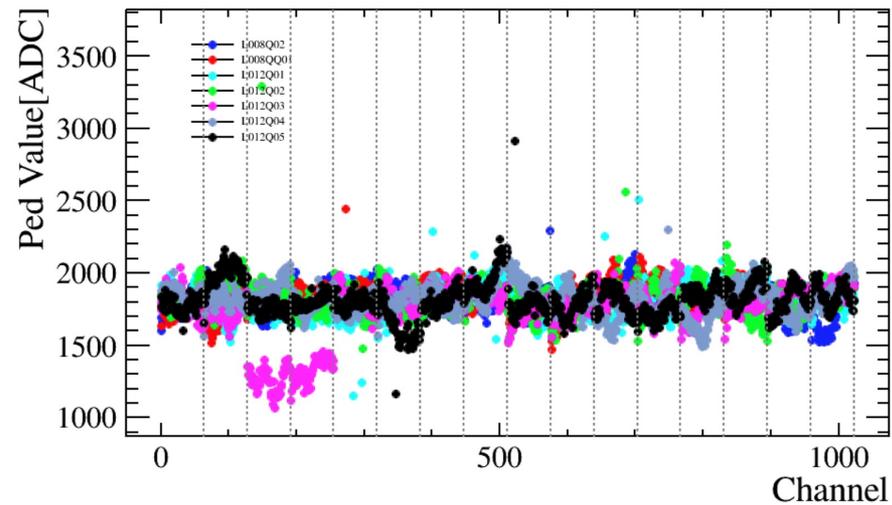
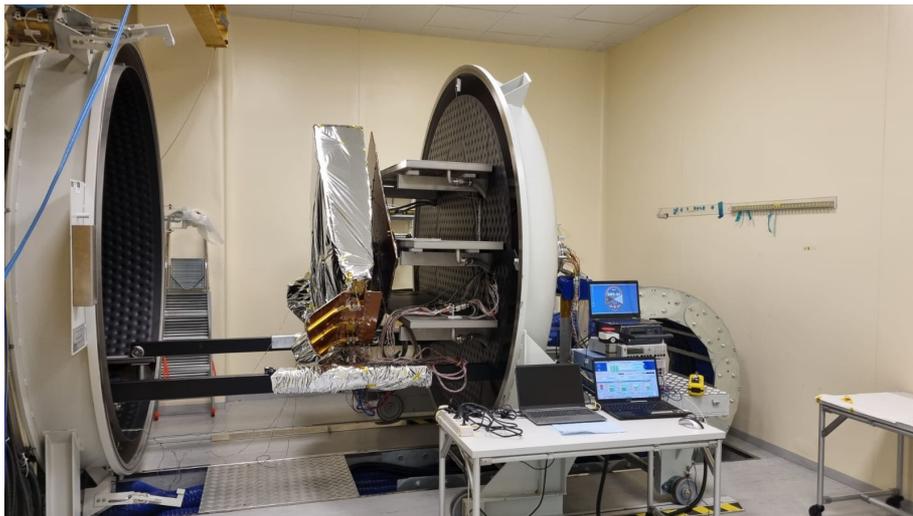




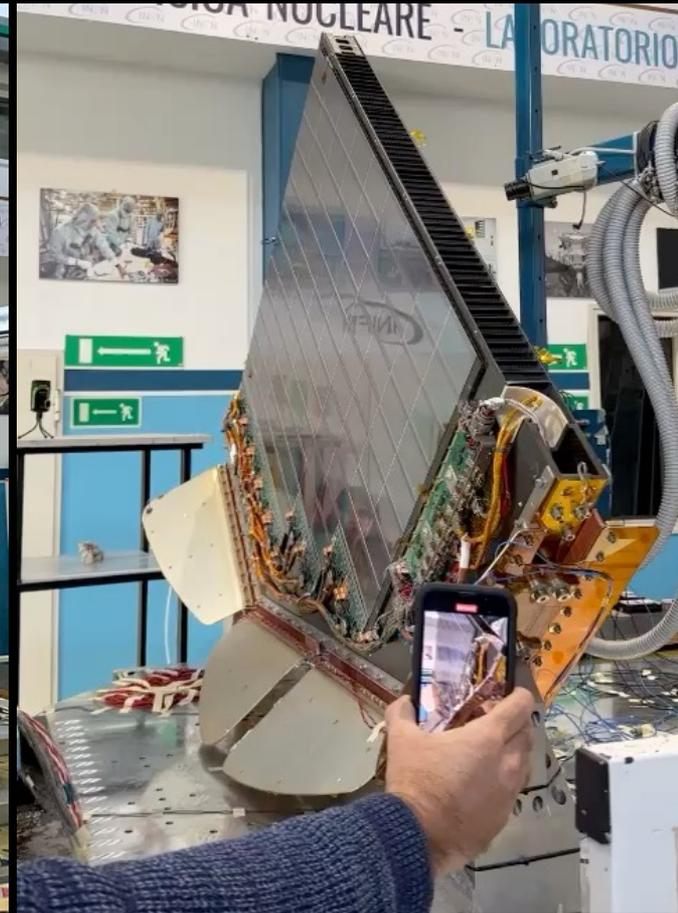
**Dummy ladders (mechanical Si)
bare PCB, and heat load simulator**

**QM ladders with full
electronics and cabling**

1/4 Quality Model: Thermo-Vacuum Test



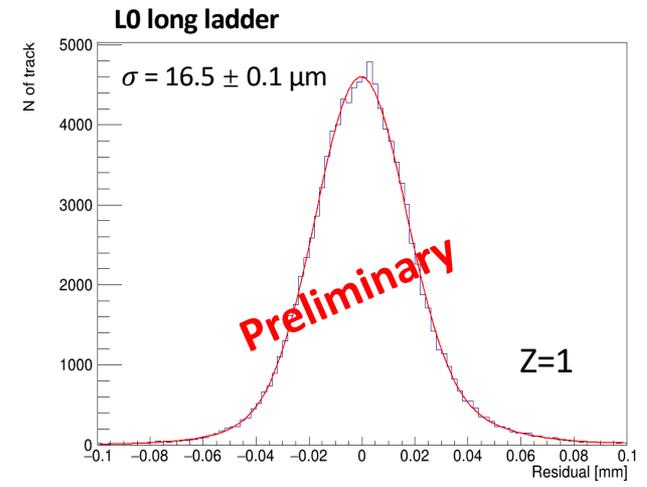
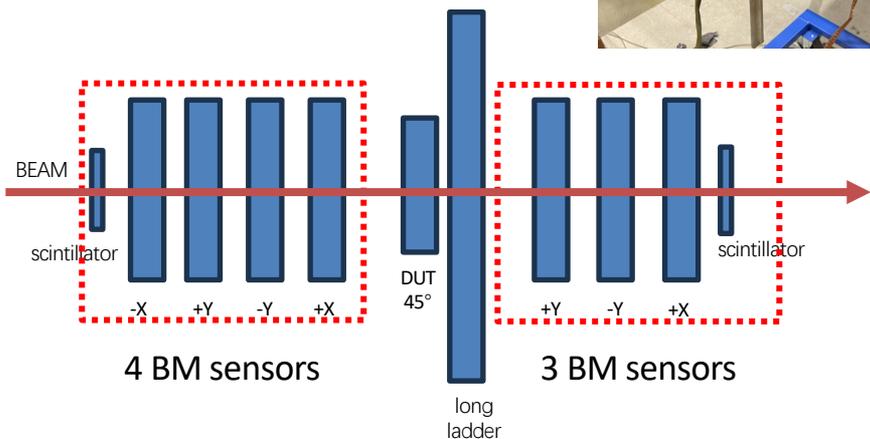
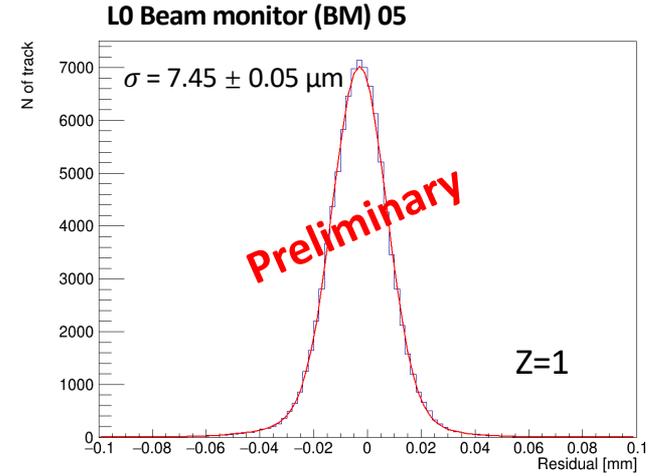
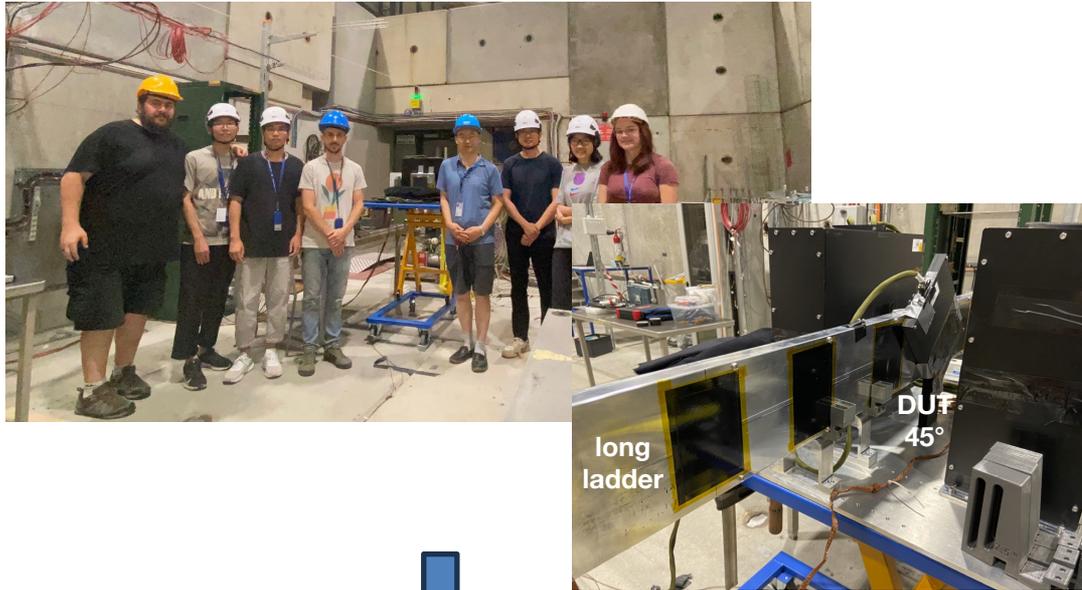
1/4 Quality Model: Vibration Test



- After all the tests, no failure on any of the parts of the system.
- Mechanical and thermal design are good (detailed data analysis in progress).
- Ladders performance did not degrade during the tests.

L0 Sensor Characterisation on Test-Beam

August 2023, Test at SPS with high energy muons and hadrons.

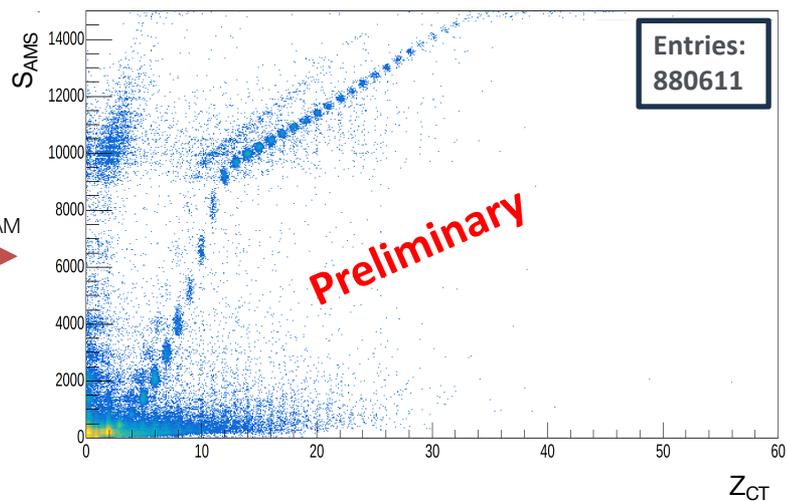
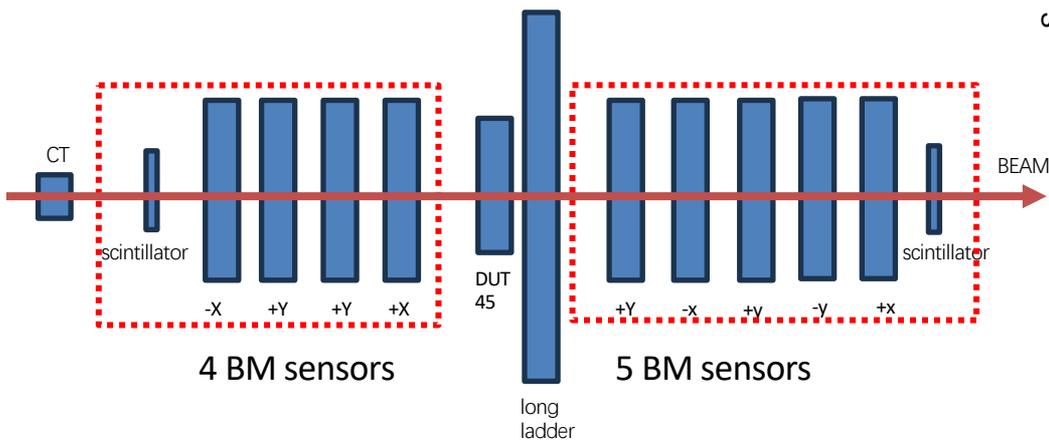
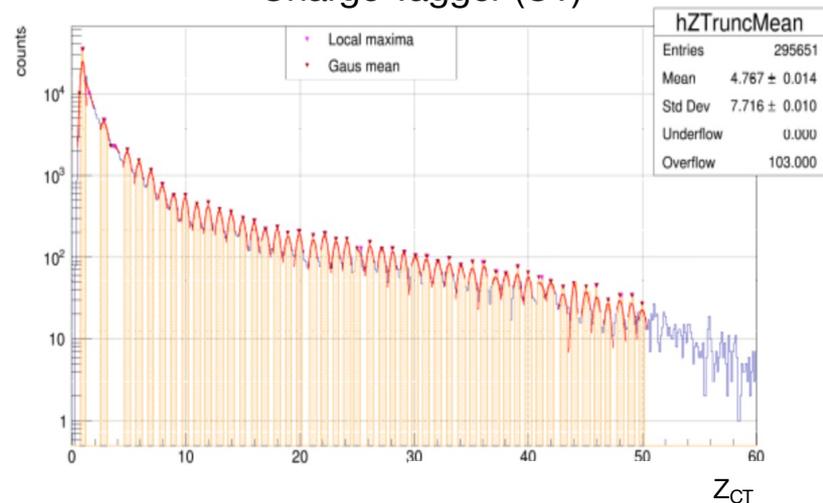


L0 Sensor Characterisation on Test-Beam

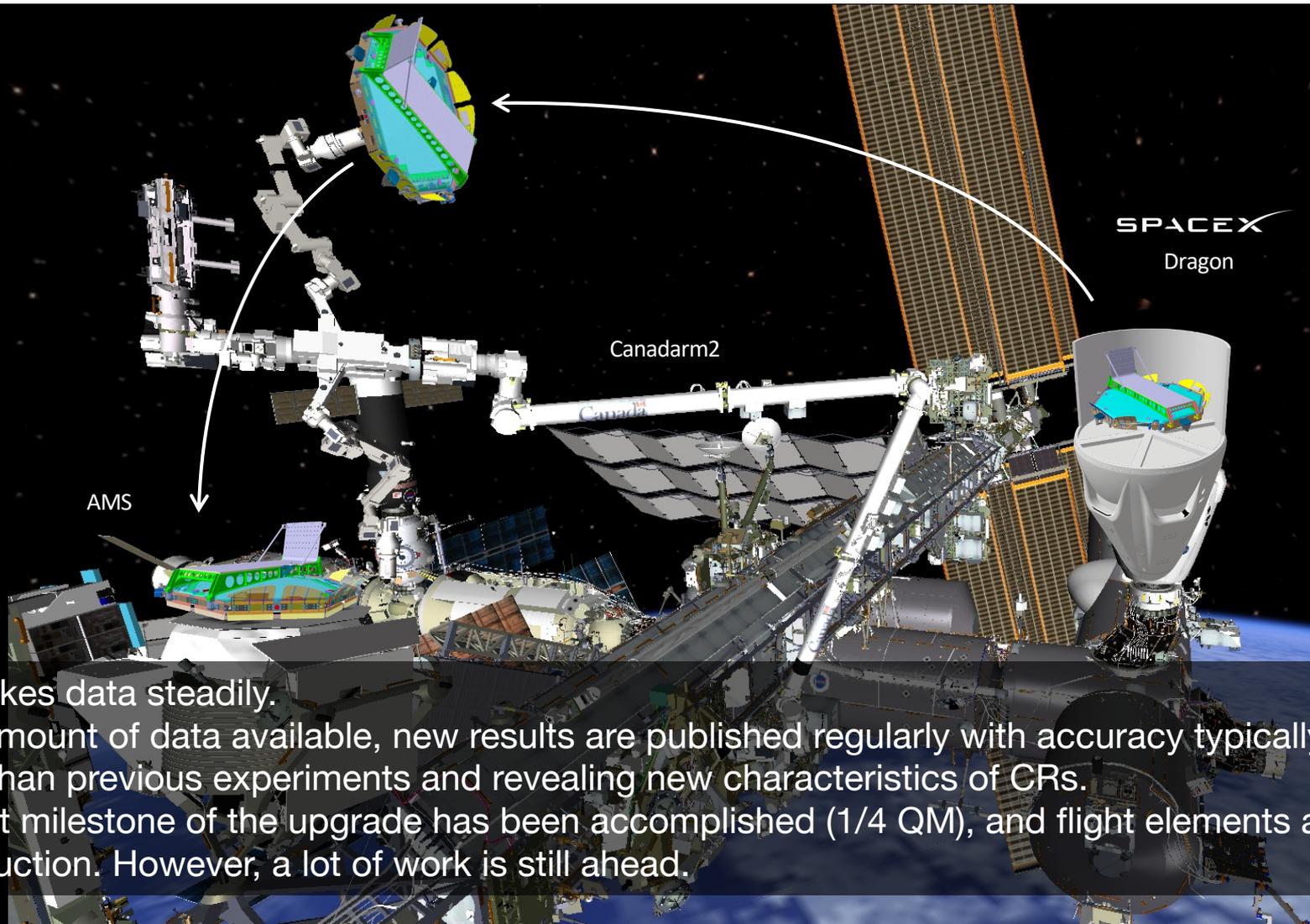
October 2023, Test at SPS with high energy fragmented ion beam.



Charge Tagger (CT)



Conclusions



- AMS takes data steadily.
- Huge amount of data available, new results are published regularly with accuracy typically better than previous experiments and revealing new characteristics of CRs.
- The first milestone of the upgrade has been accomplished (1/4 QM), and flight elements are in production. However, a lot of work is still ahead.