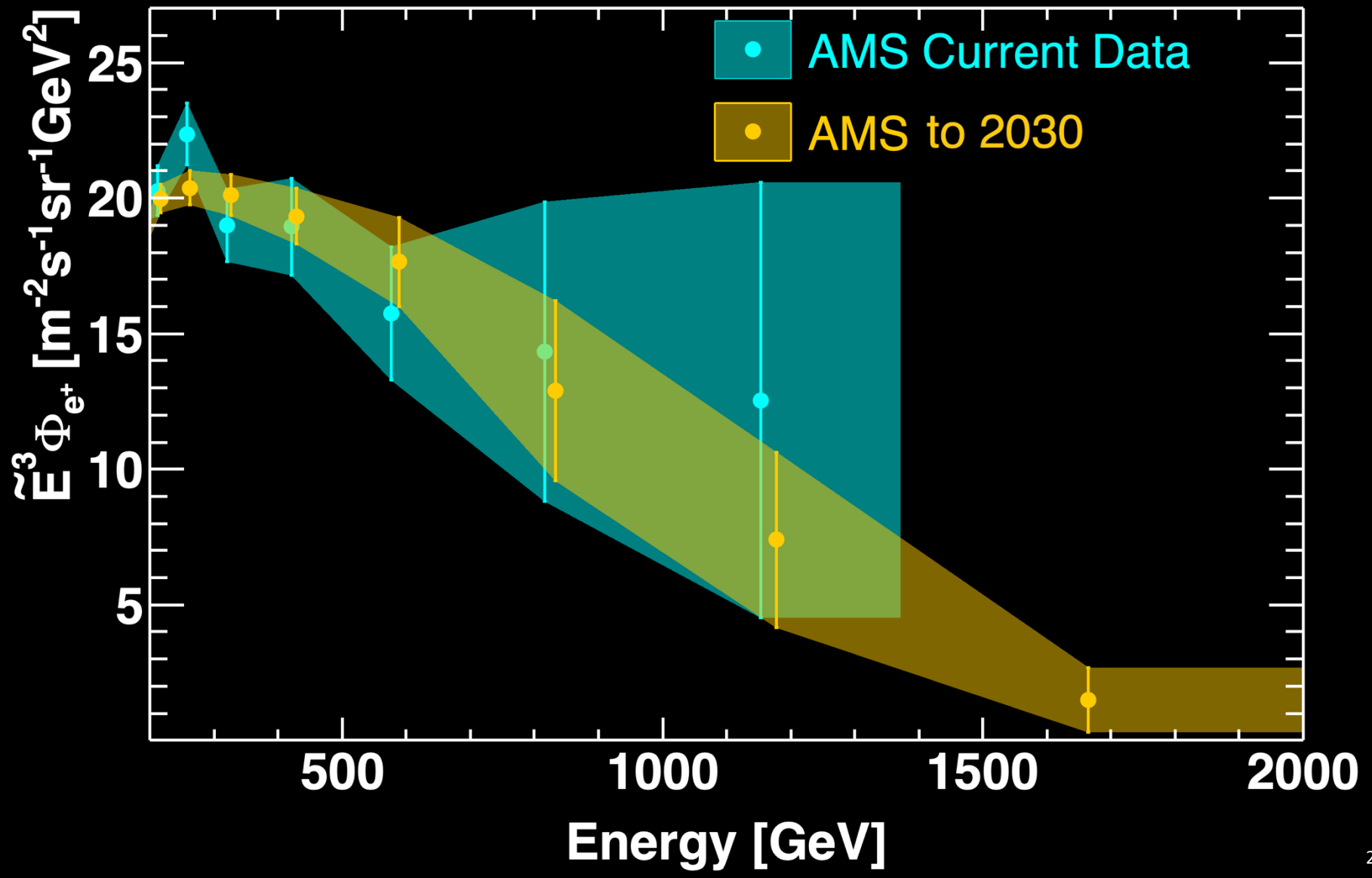
AMS-L0: upgrade status and prospects

G. Ambrosi

INFN Perugia

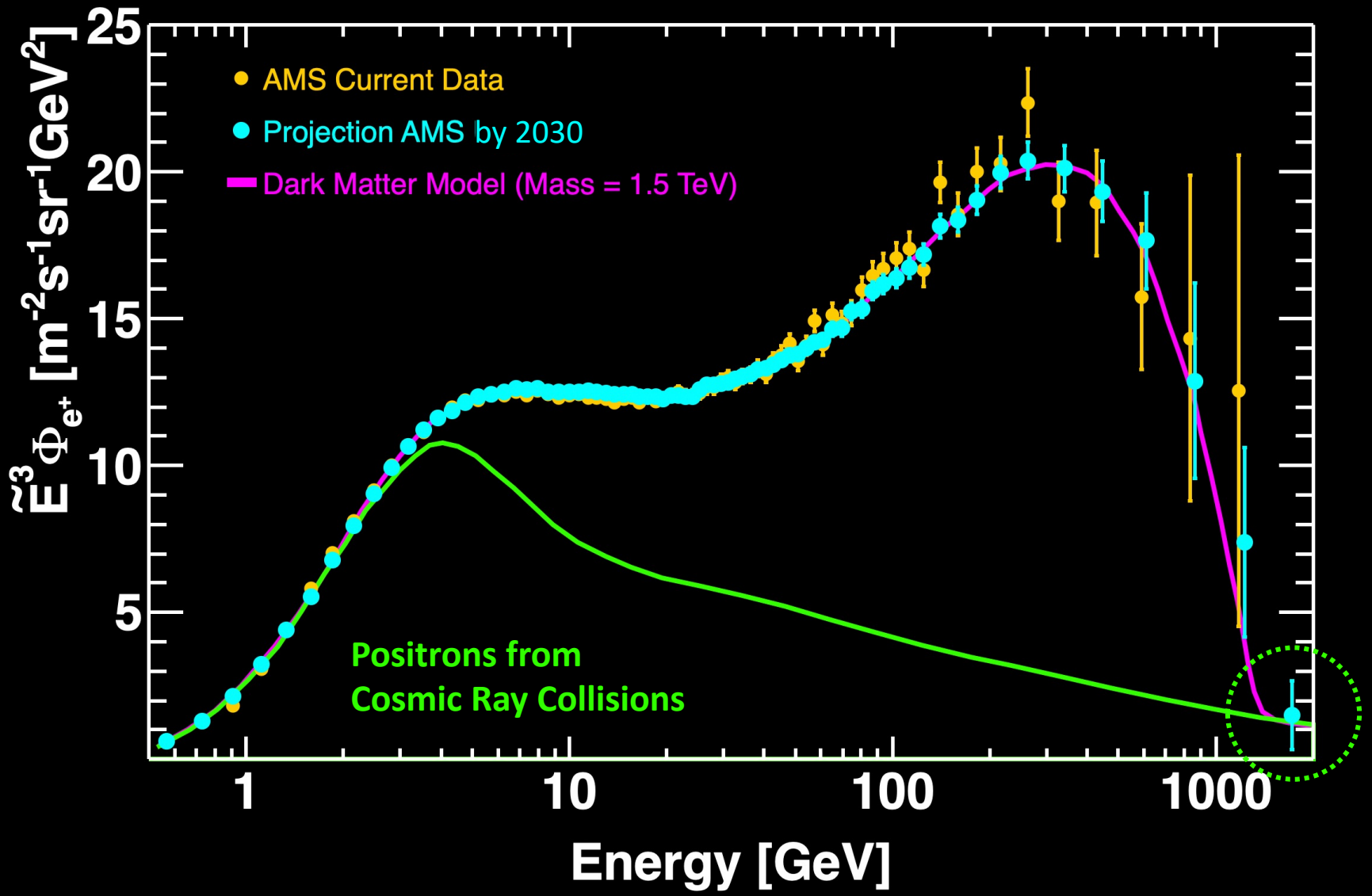
ASAP 2023, June 20th 2023

By 2030, AMS will extend the energy range of the positron flux measurement from 1.4 to 2 TeV and reduce the error by a factor of two compared to current data



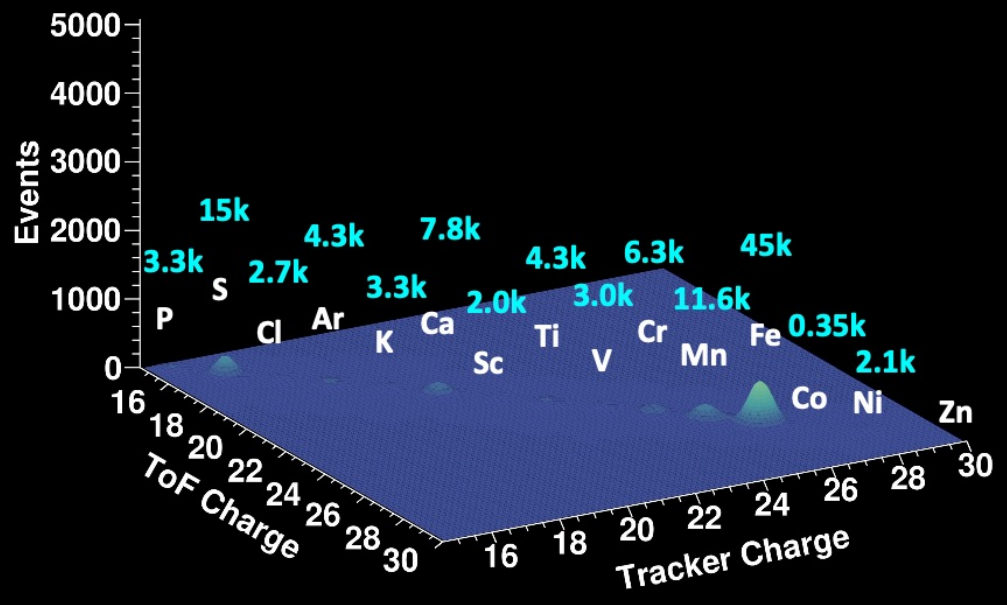
Determination of the Origin of Cosmic Positrons by 2030

AMS will ensure that the measured high energy positron spectrum indeed drops off quickly and, at the highest energies, the positrons only come from cosmic ray collisions as predicted by dark matter models

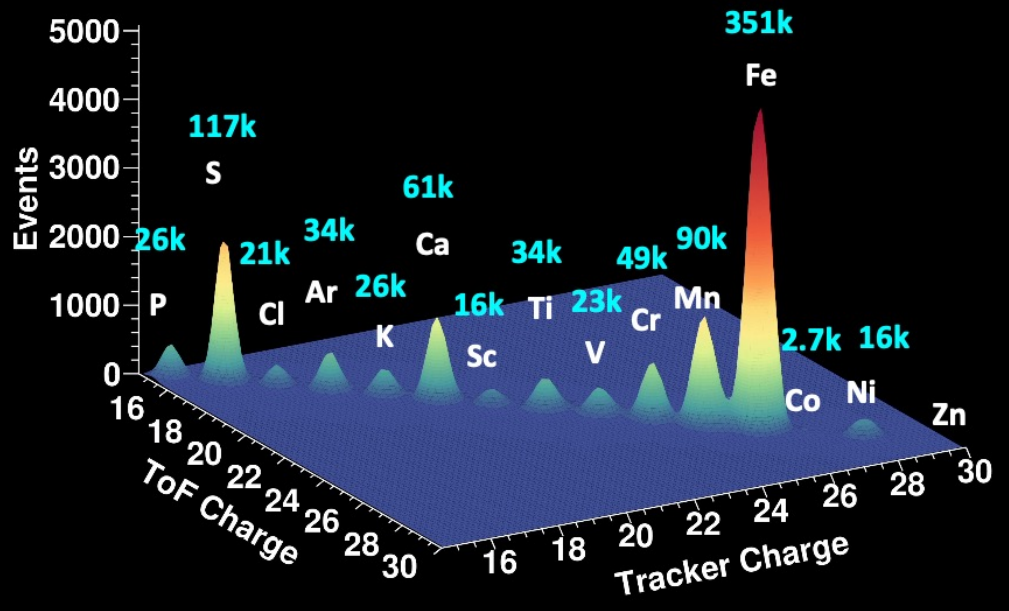


Cosmic Ray Nuclei by 2030

Current Data
2016-

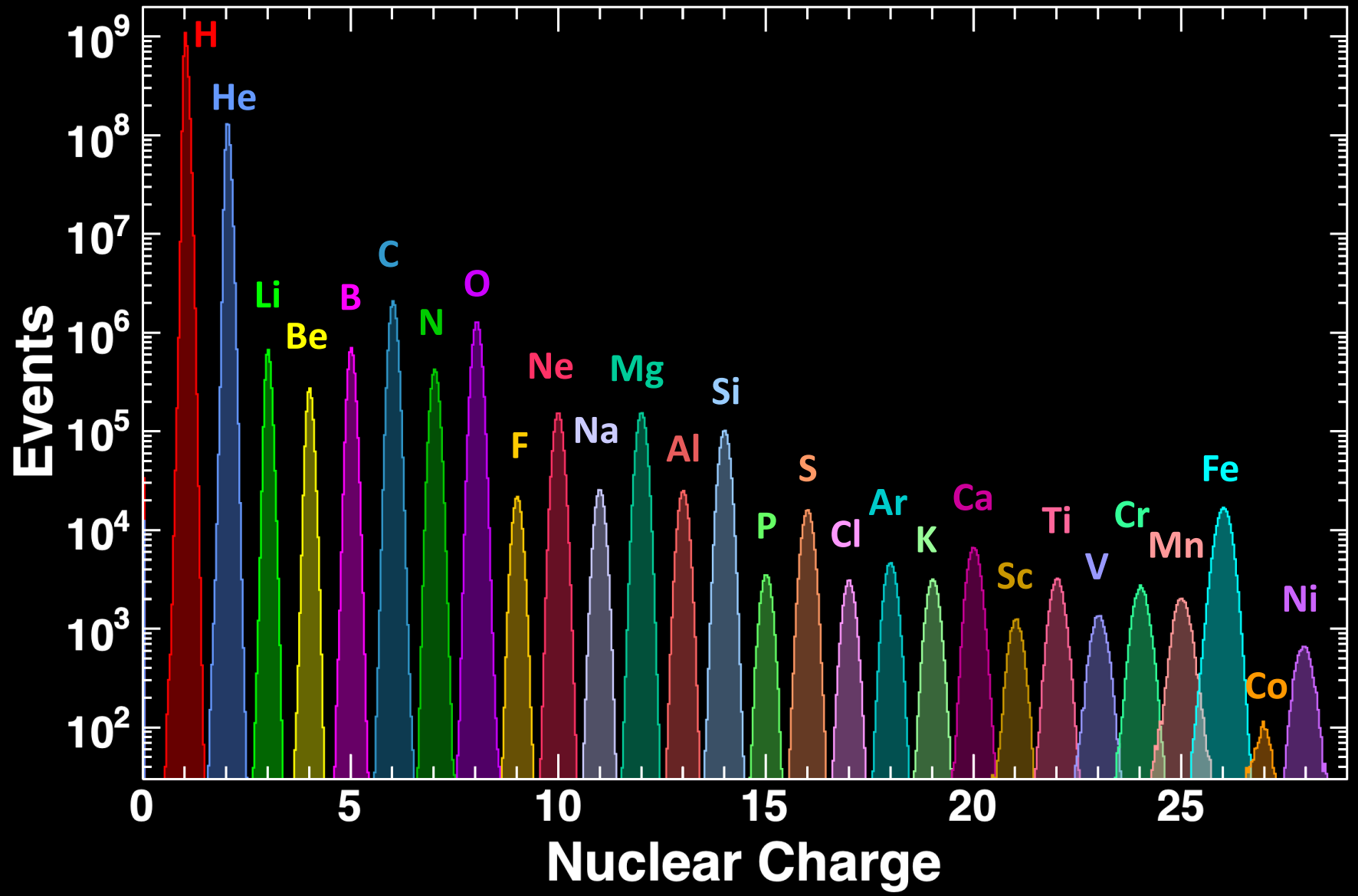


With upgrade

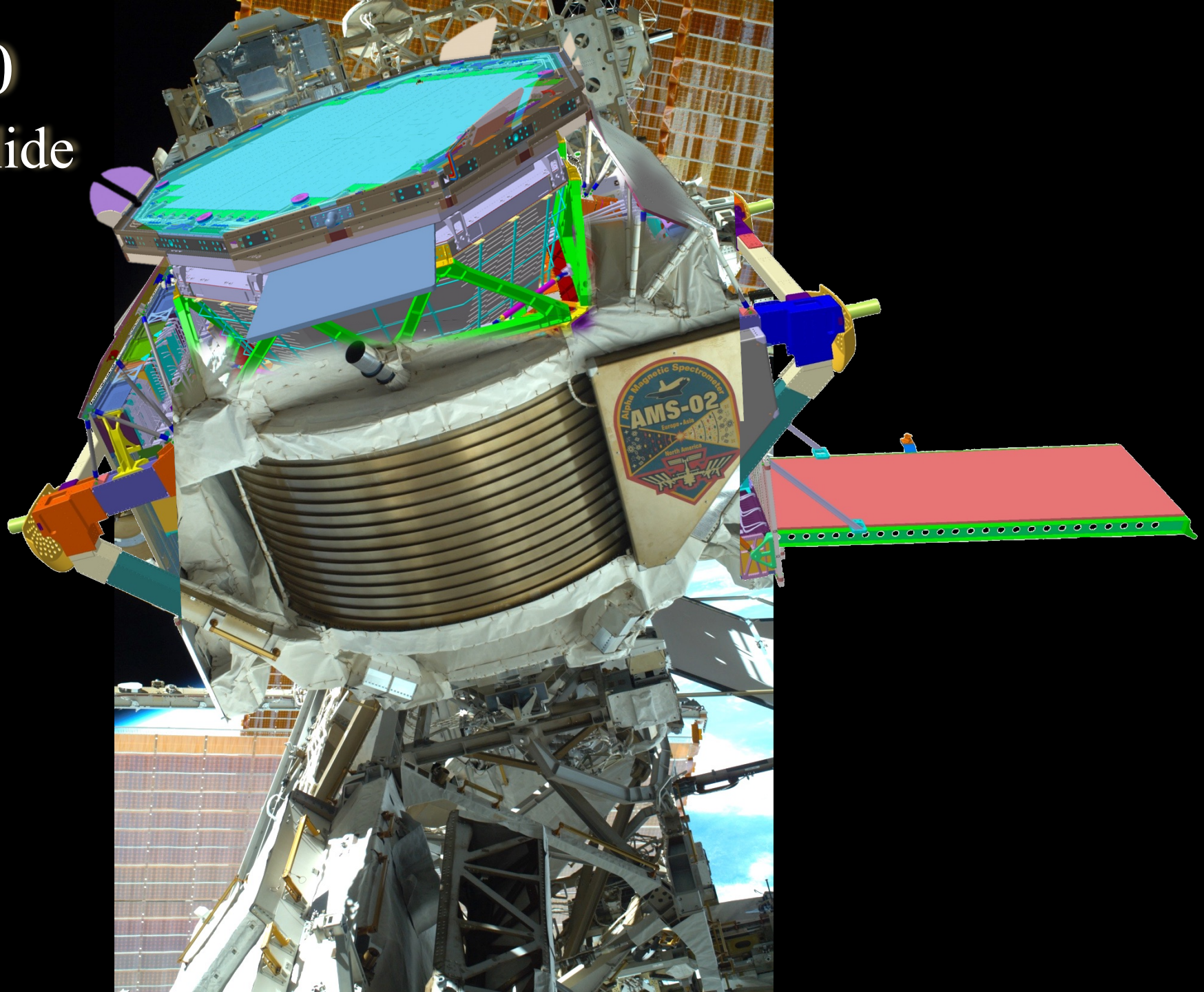


The upgrade of AMS will provide accurate measurements of high-Z (Z≥15) nuclei, particularly with R>35 GV (where no data exists)

Cosmic Ray Nuclei by 2030



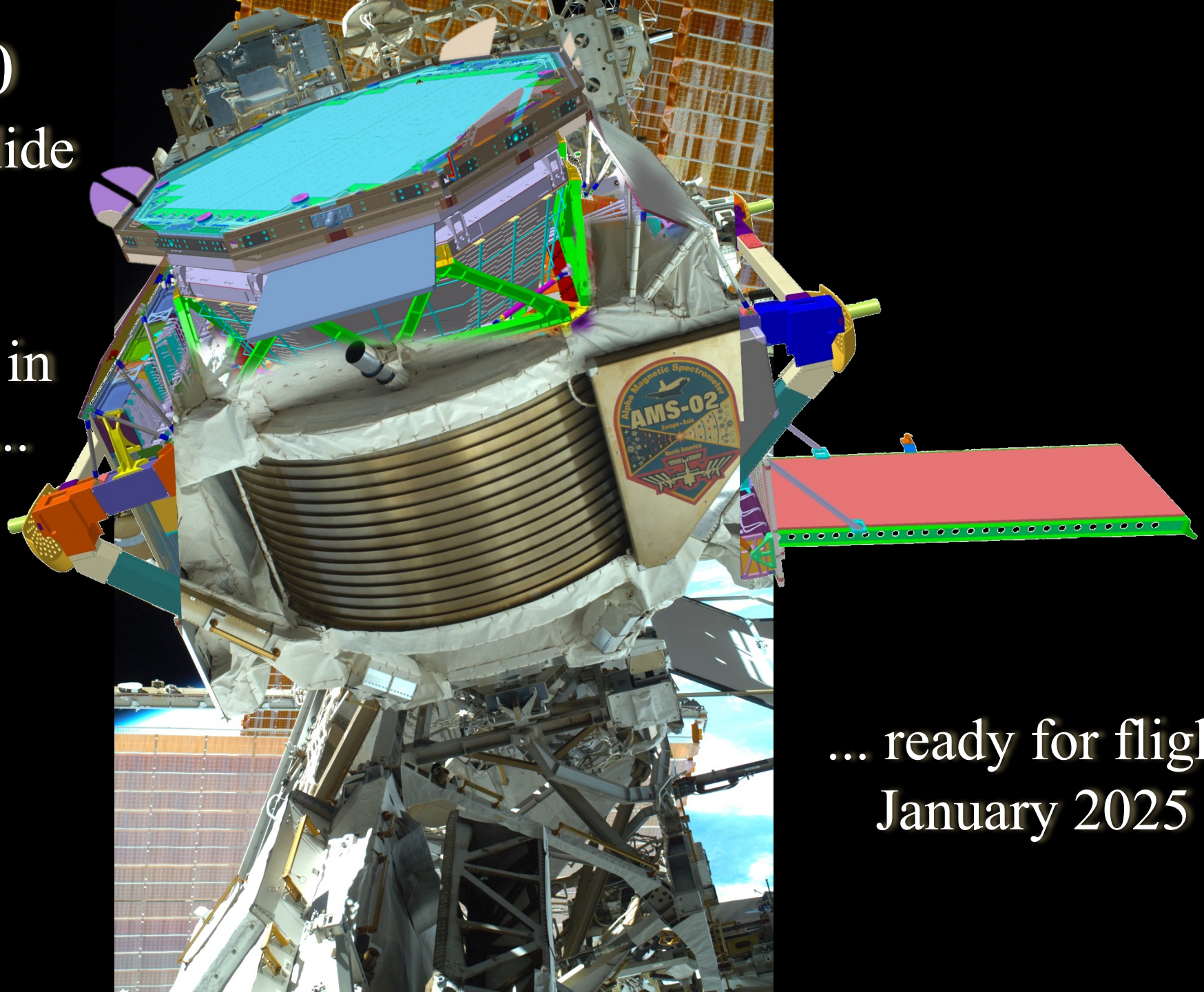
AMS-02 L0
upgrade ... in 1 slide



C. Gargiulo

AMS-02 L0
upgrade ... in 1 slide

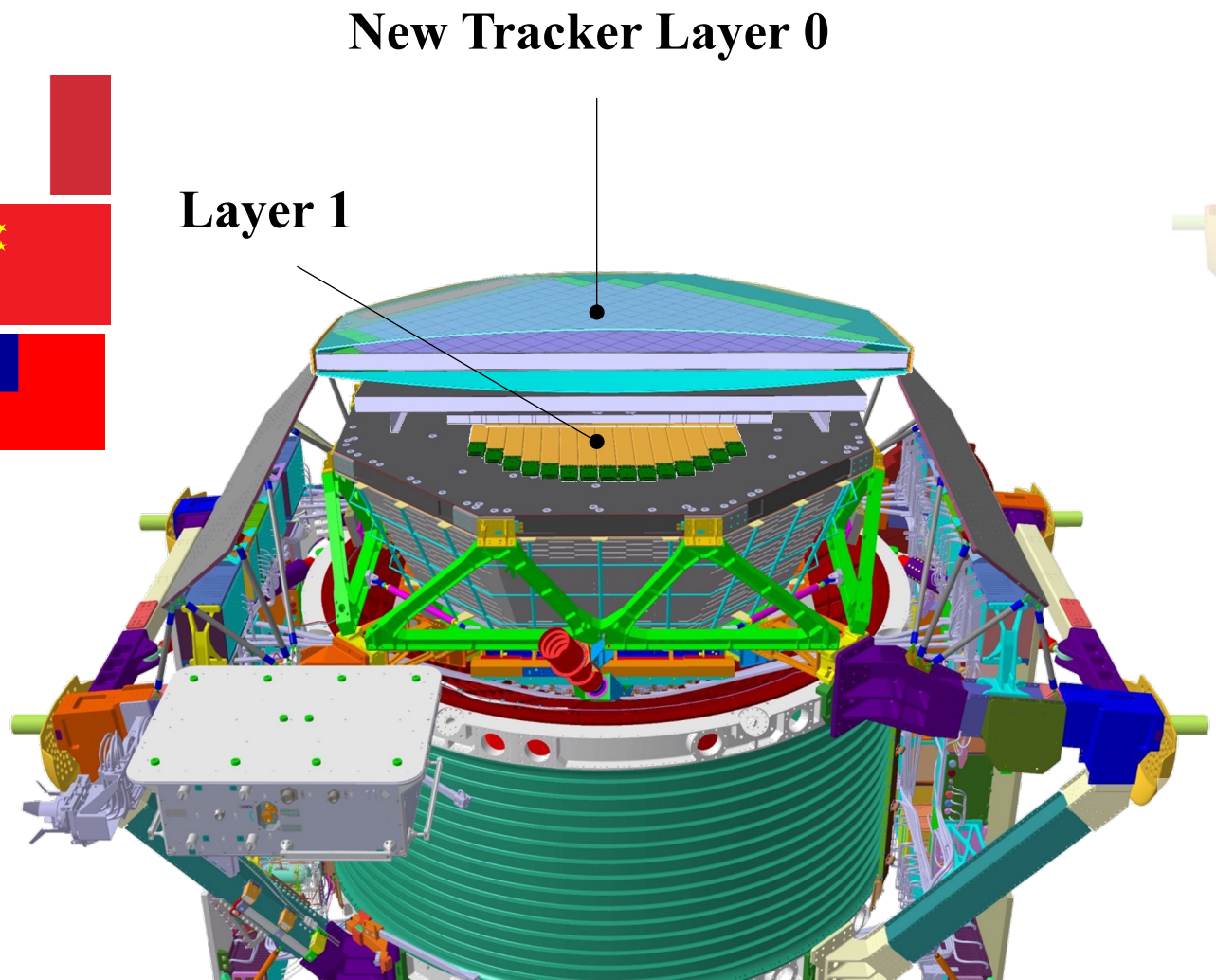
AMS-02 decision in
December 2021 ...

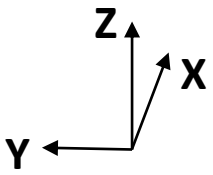


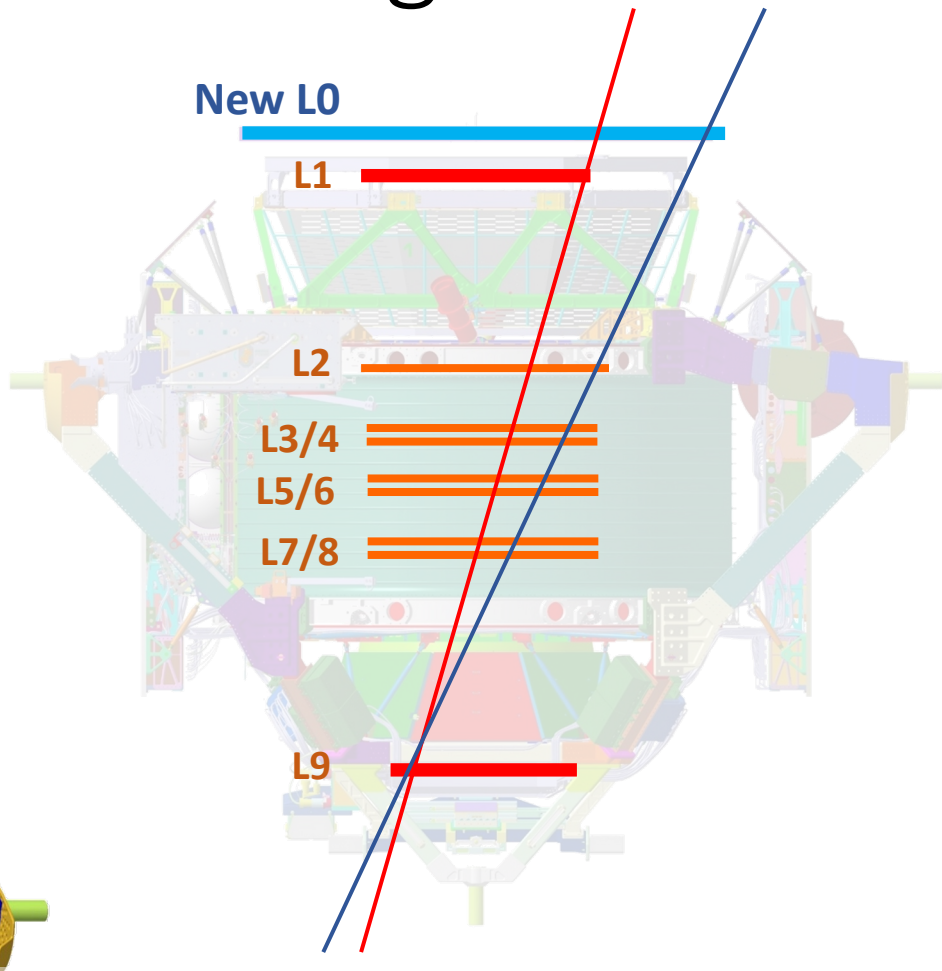
... ready for flight
January 2025

C. Gargiulo

L0 tracking layer added to the existing ones

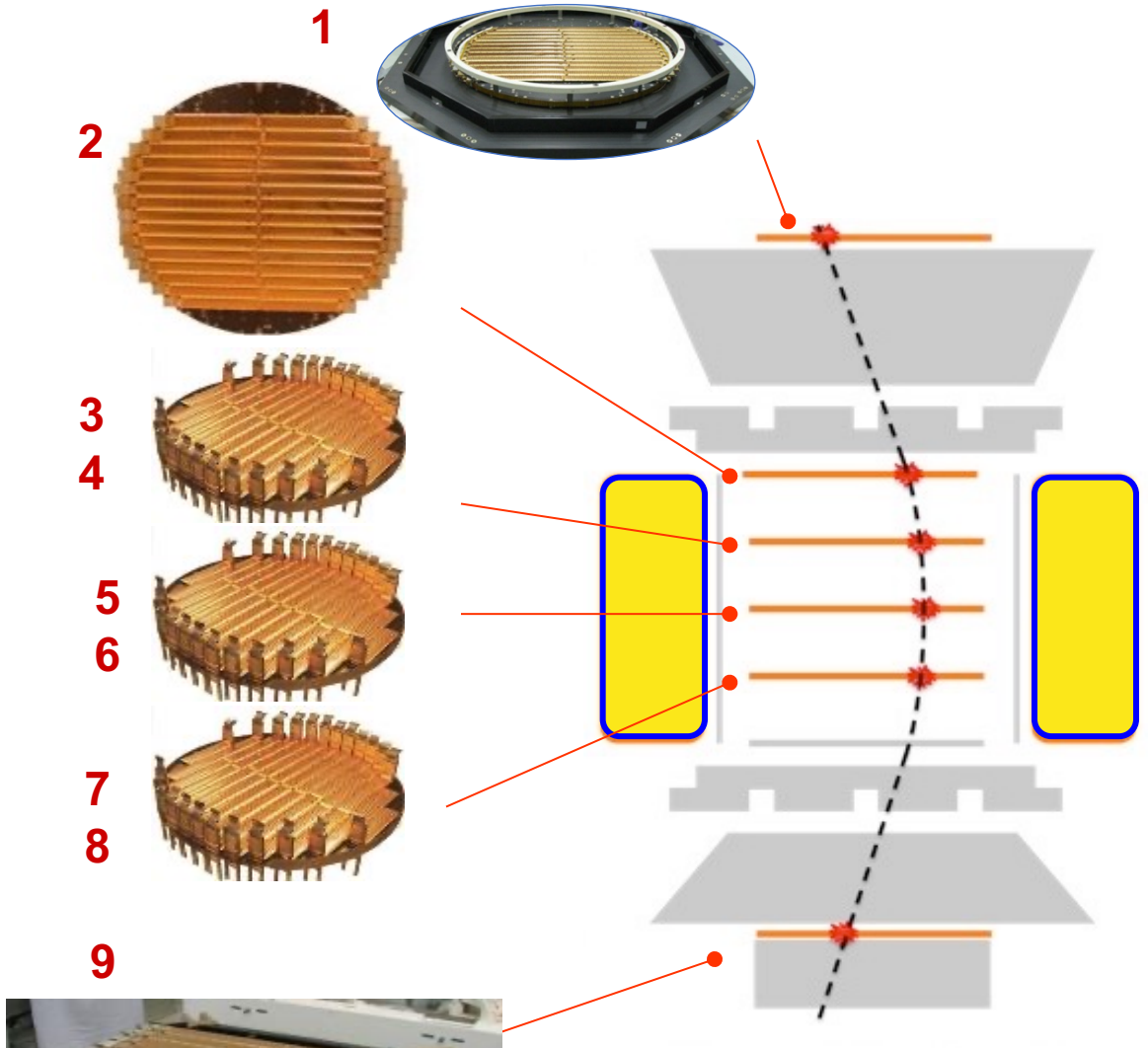


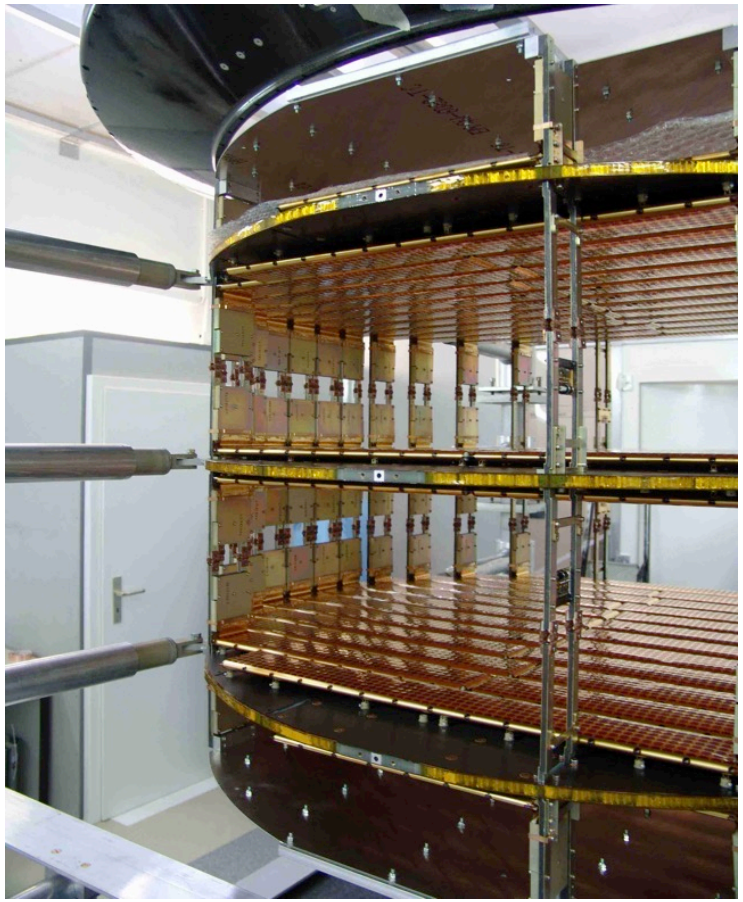




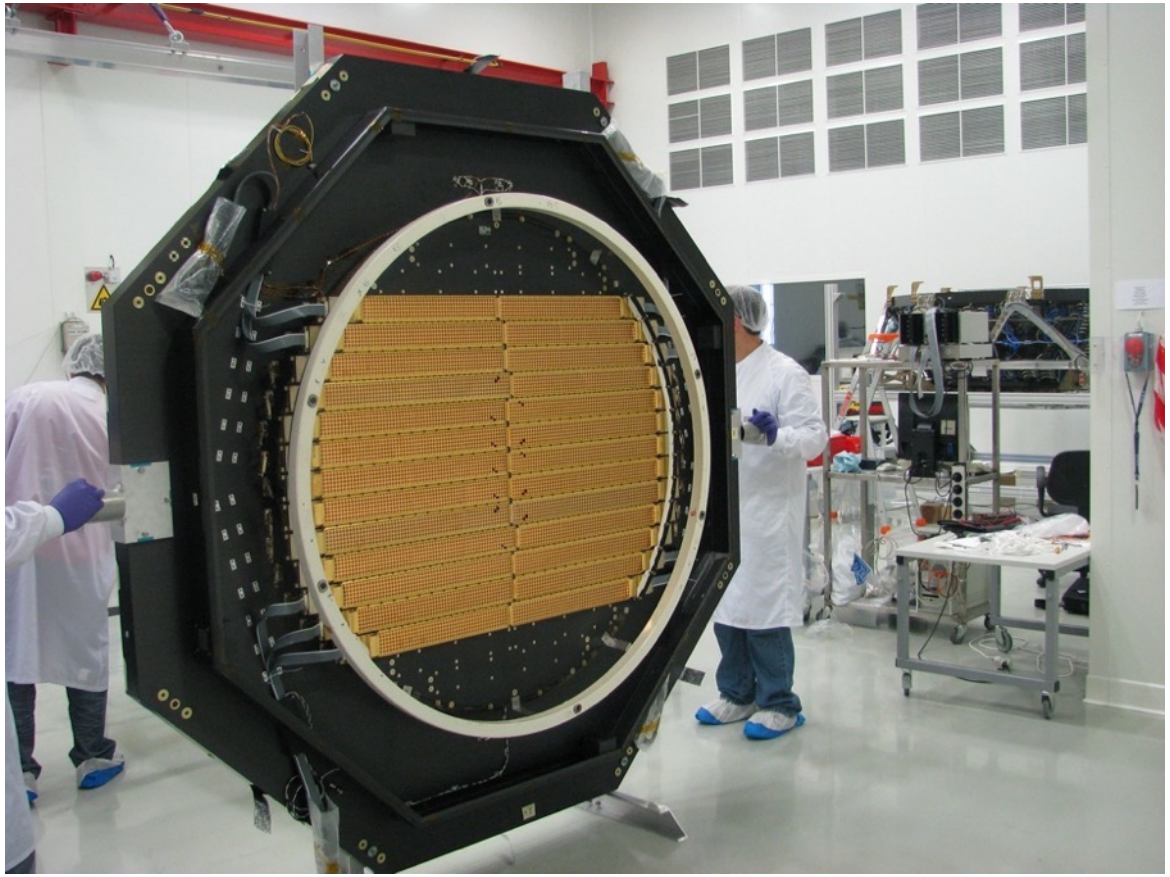
Increase of the detector acceptance by 300%

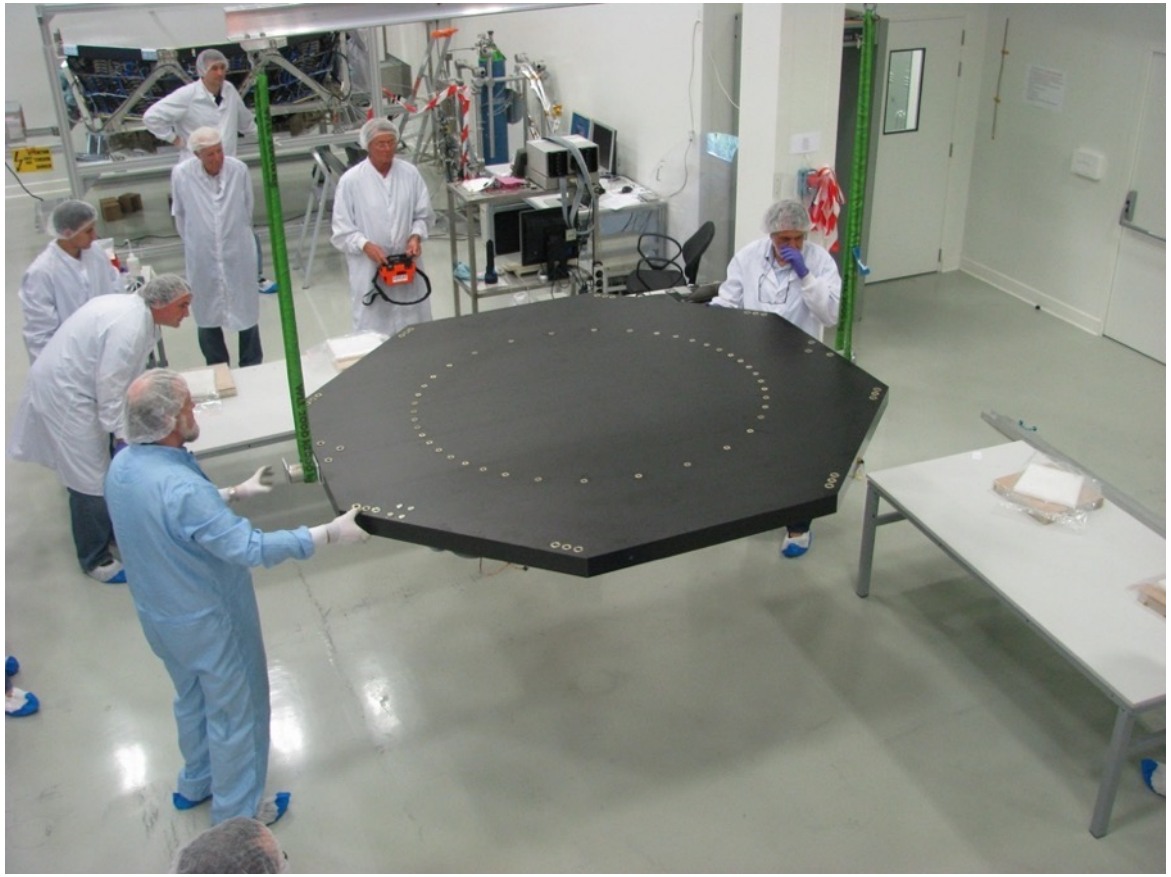
The layout of the AMS-02 Tracker





Layer 1



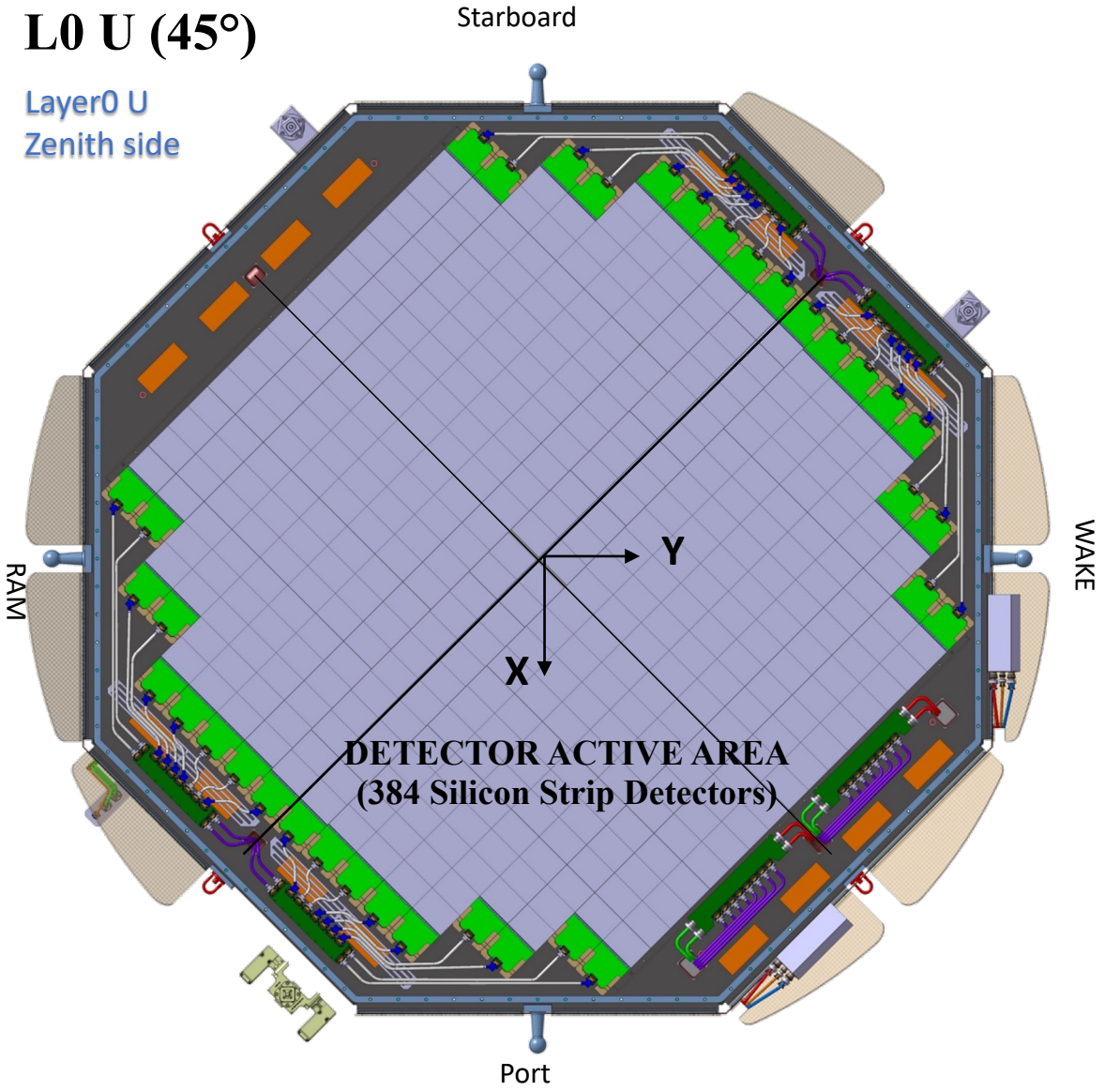


AMS-02 integration activities, 2010

Plane layout

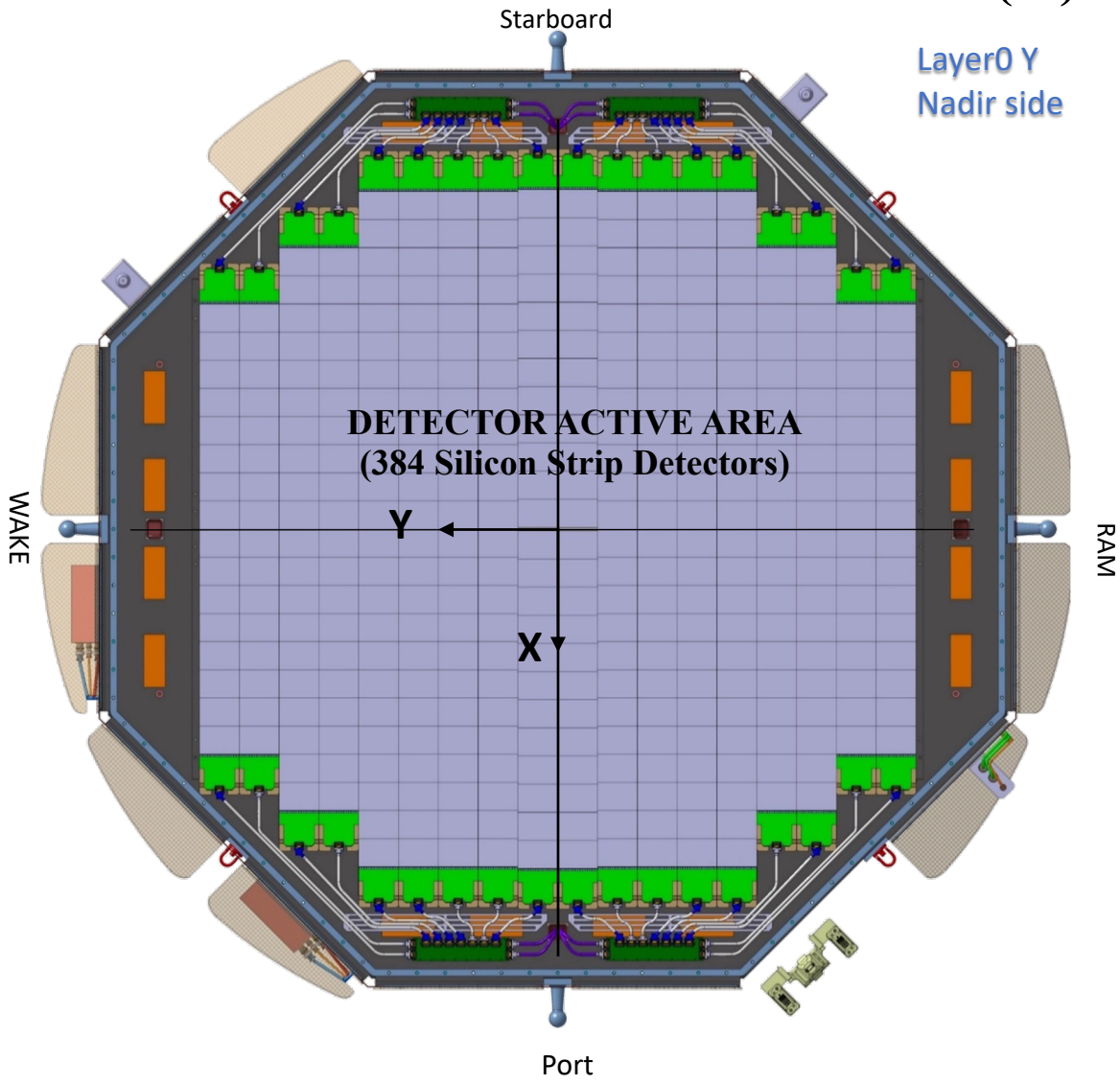
L0 U (45°)

Layer0 U
Zenith side



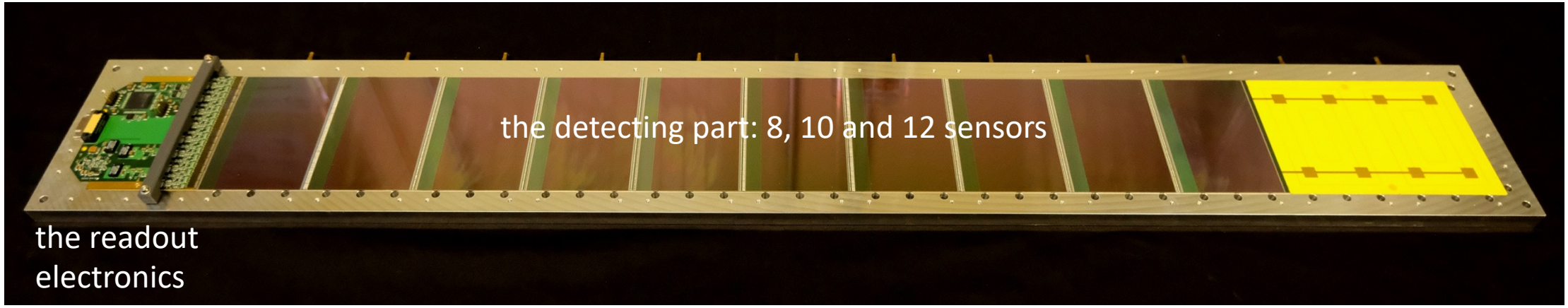
L0 Y (0°)

Layer0 Y
Nadir side

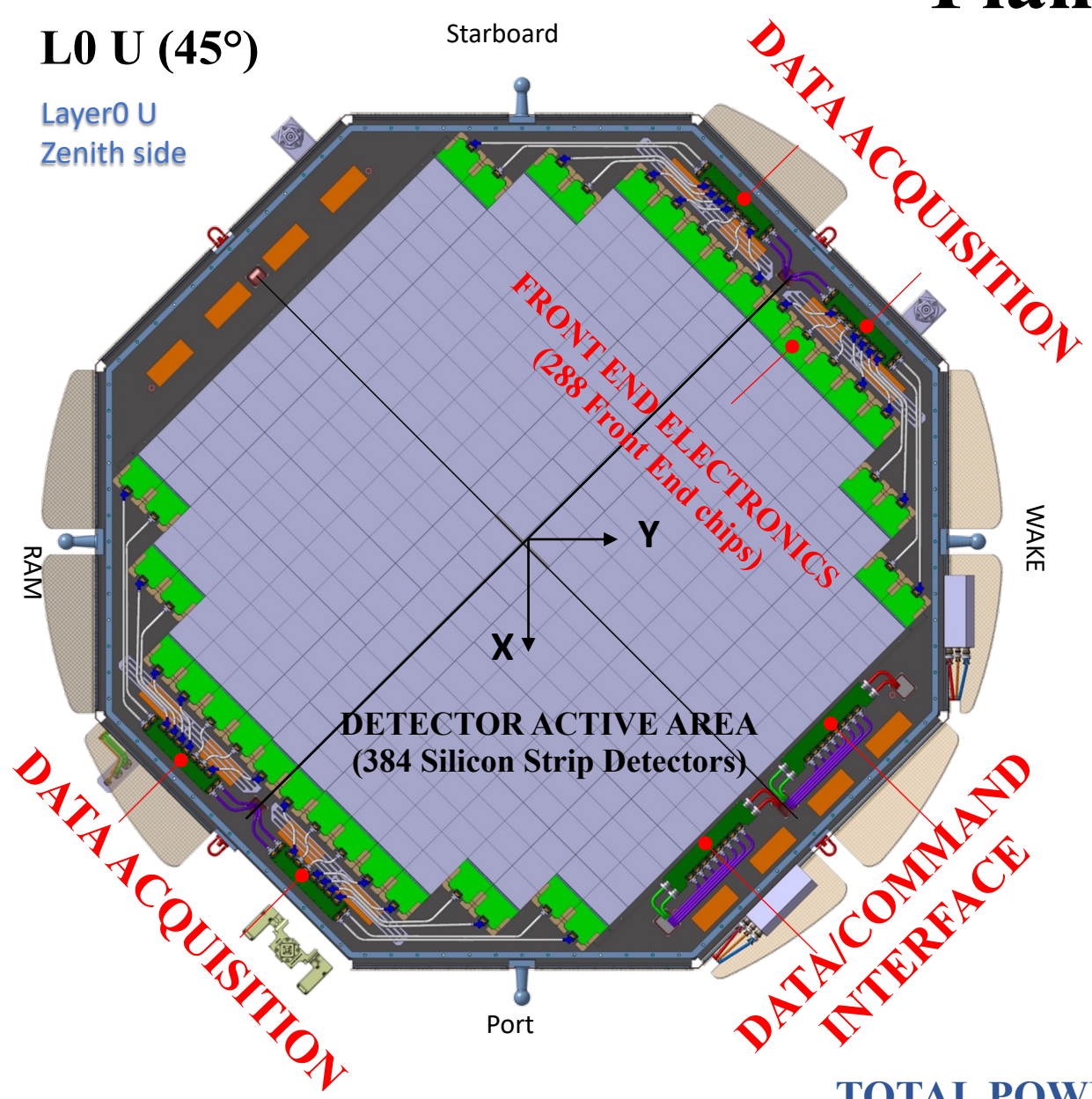


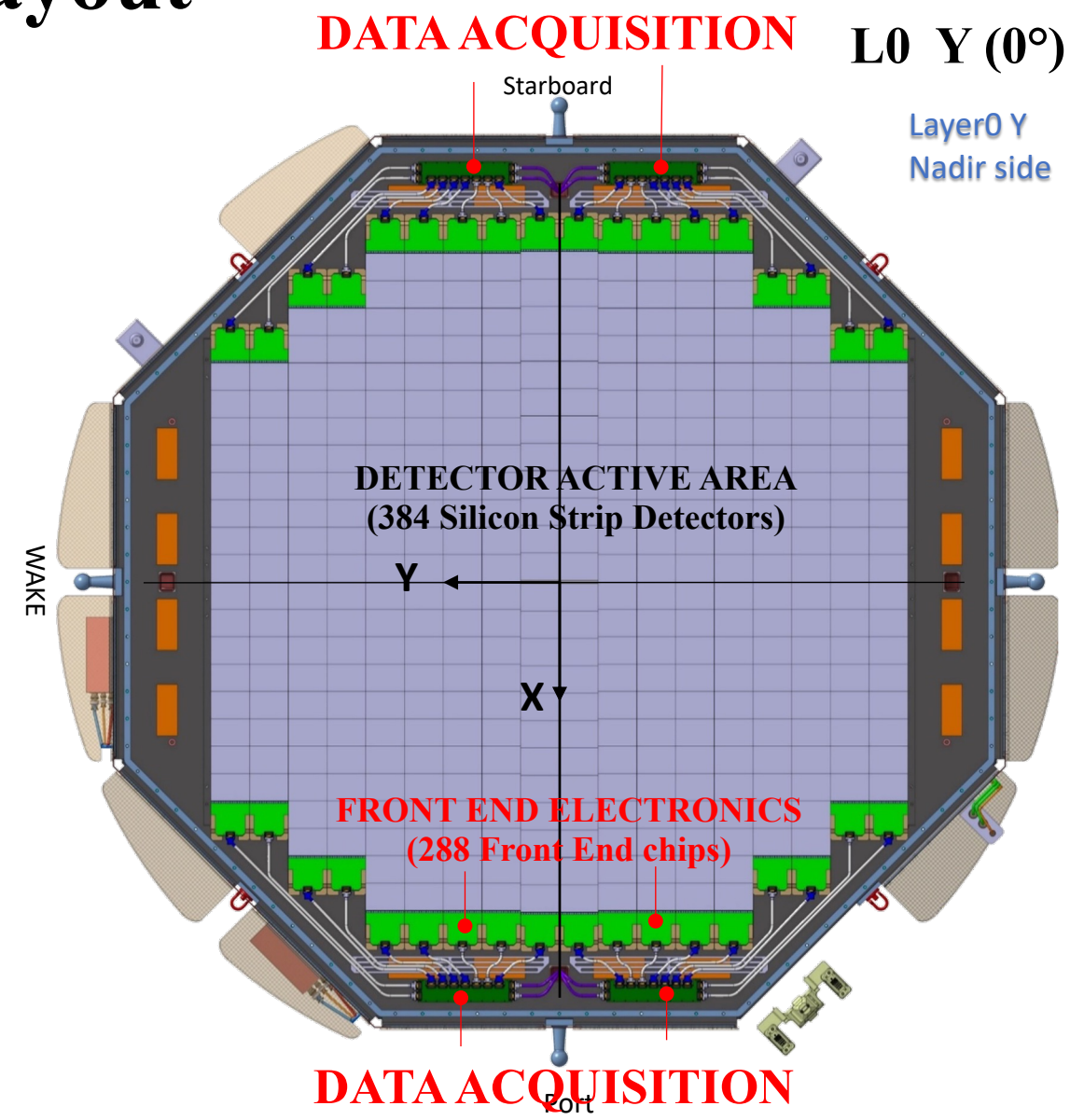
The Ladder

- the basic element of the detector



Plane layout





TOTAL POWER CONSUMPTION 155W

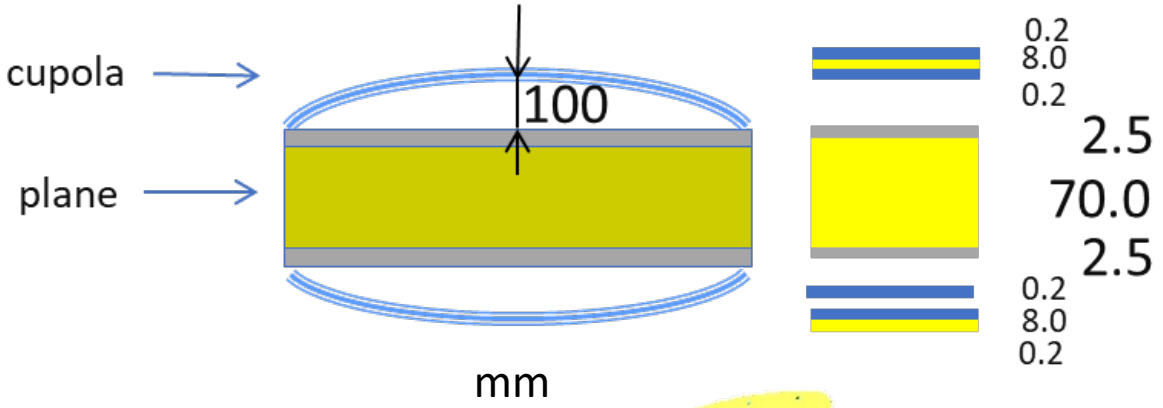
Layer0 overall layout

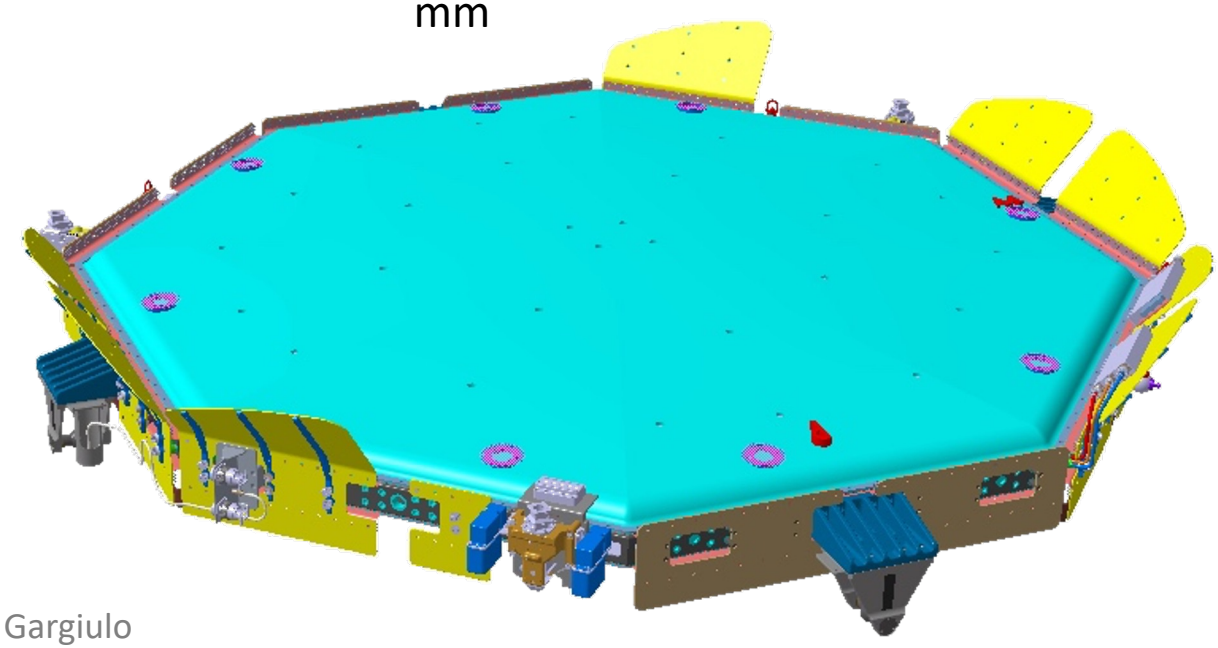
Dimensions

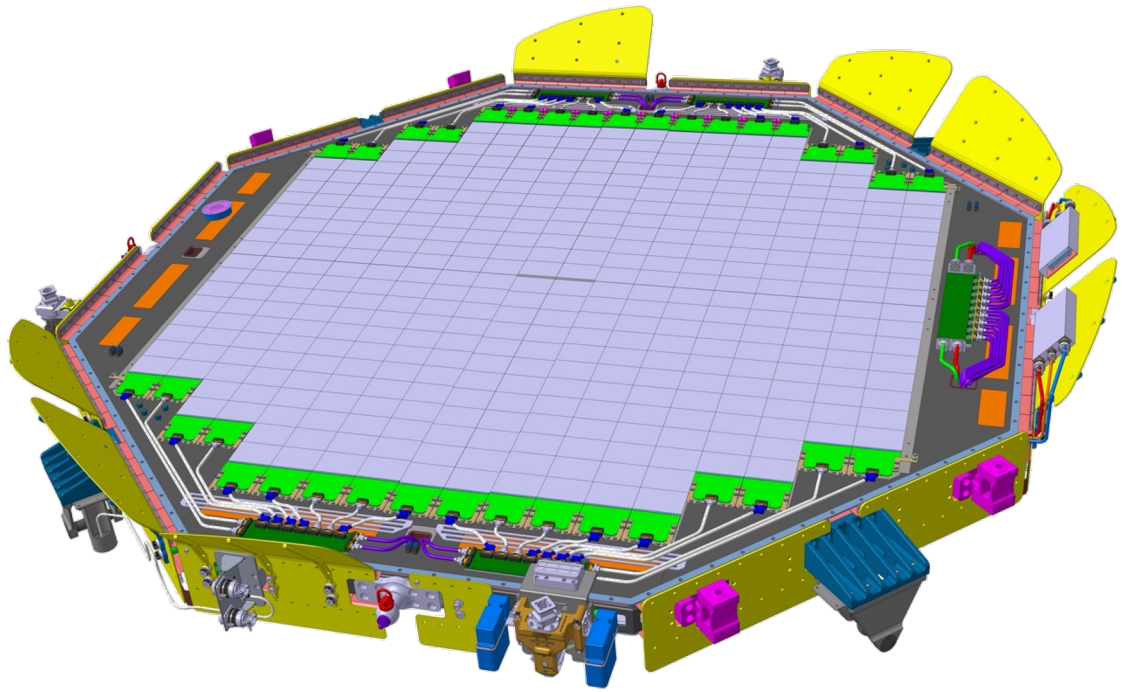
~2.6m diameter

~ 30 cm thick

~ 250 kg







Cupola Top & Bottom

EMI Shielding

Thermal radiator

Light shielding

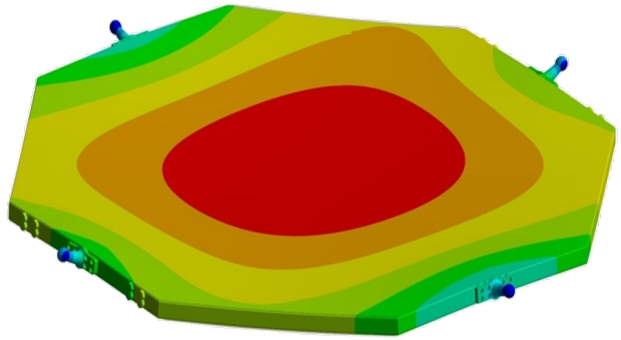
in addition, Cupola Top

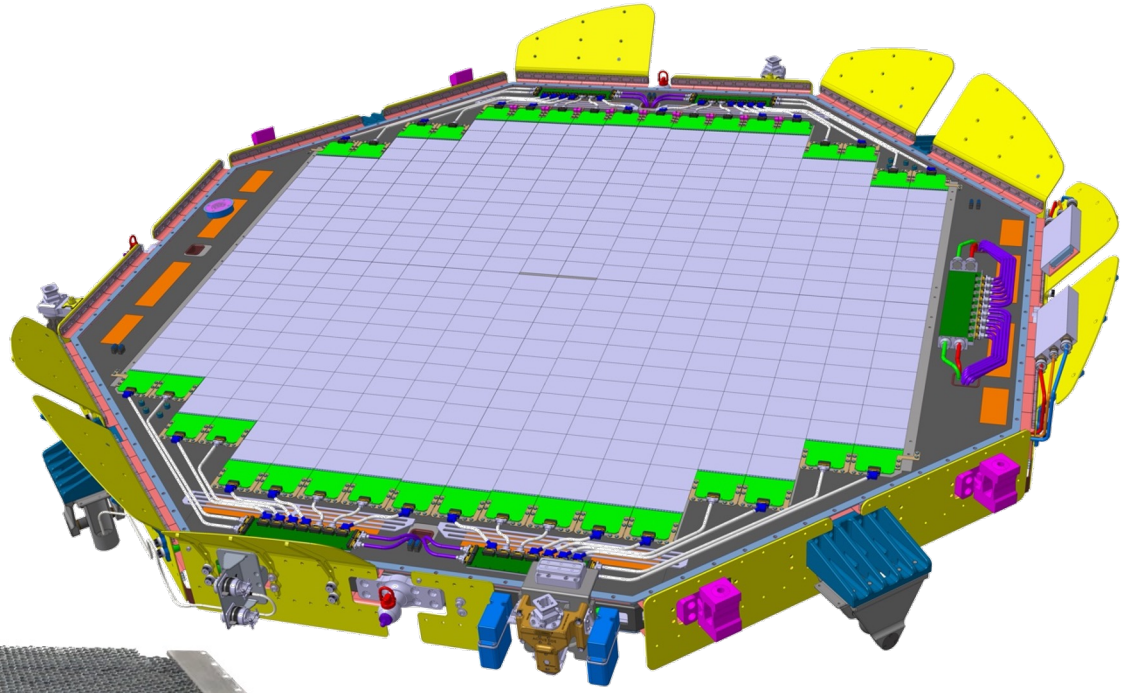
Minimum Material Budget

Micrometeorite shielding

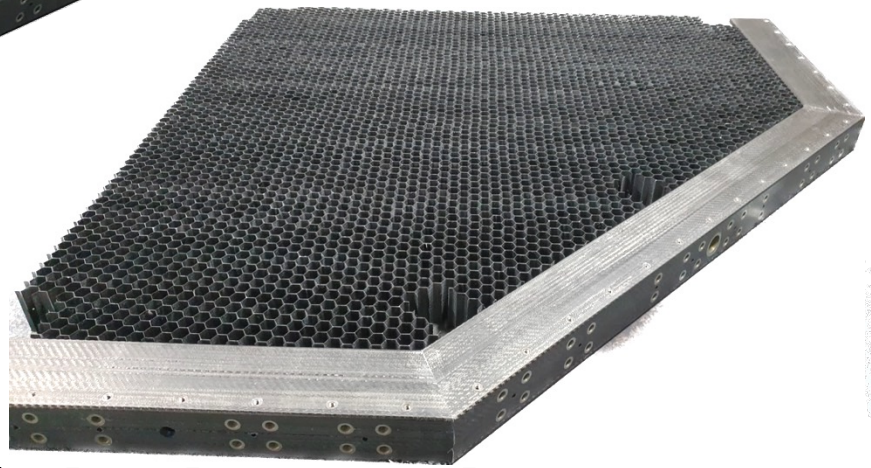
Mechanics

Carbon-plane and carbon-frame realize a thick stiff plane





Carbon skin

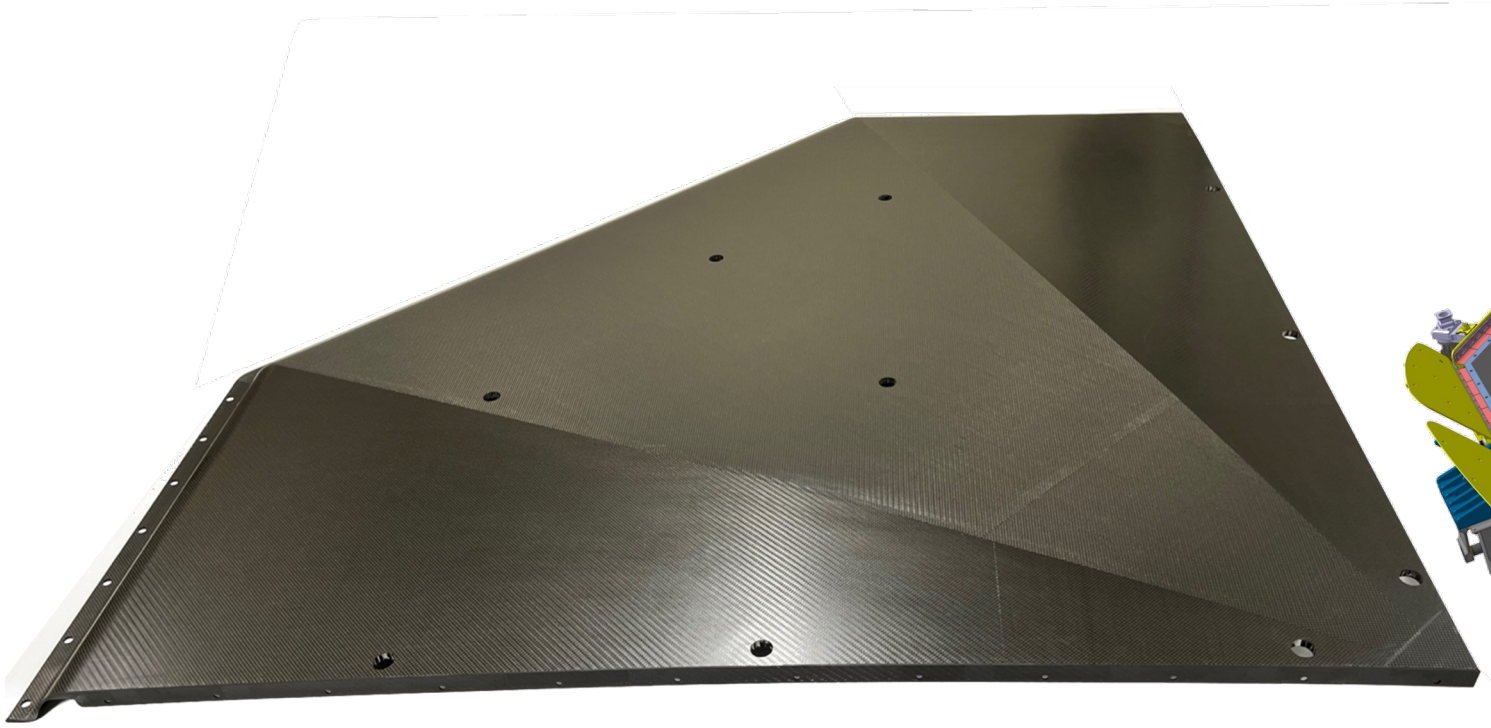


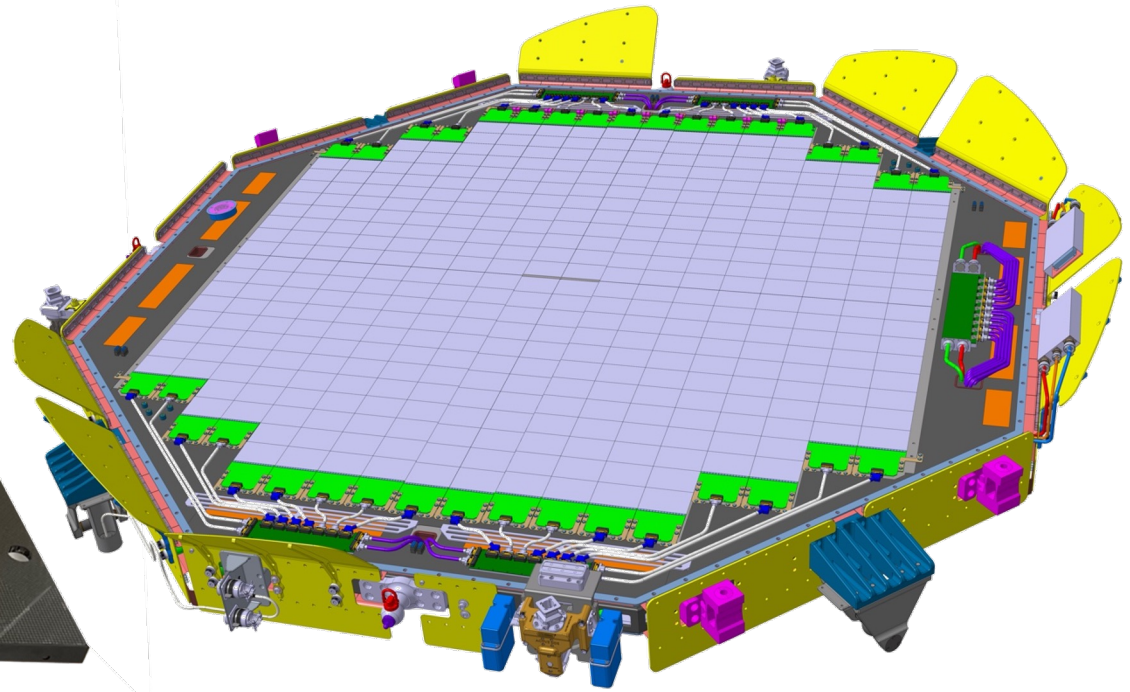
Carbon honeycomb

Carbon OCTO frame

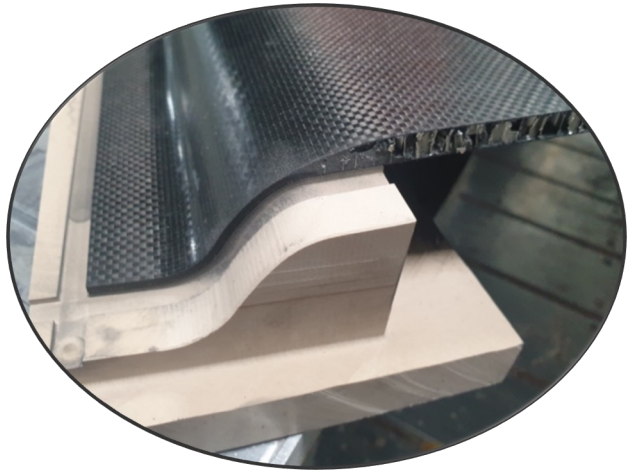
Mechanics

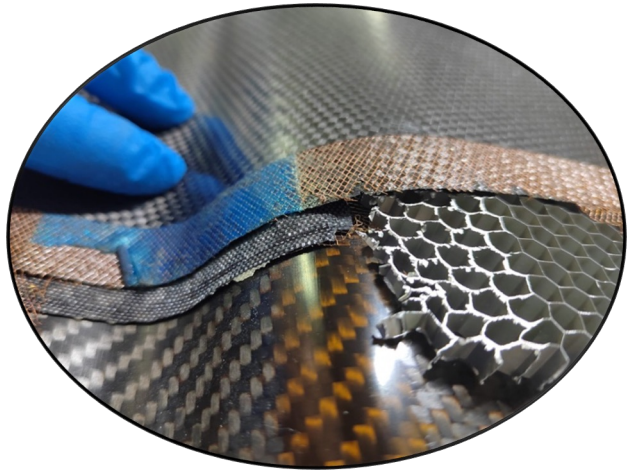
Light carbon cupola





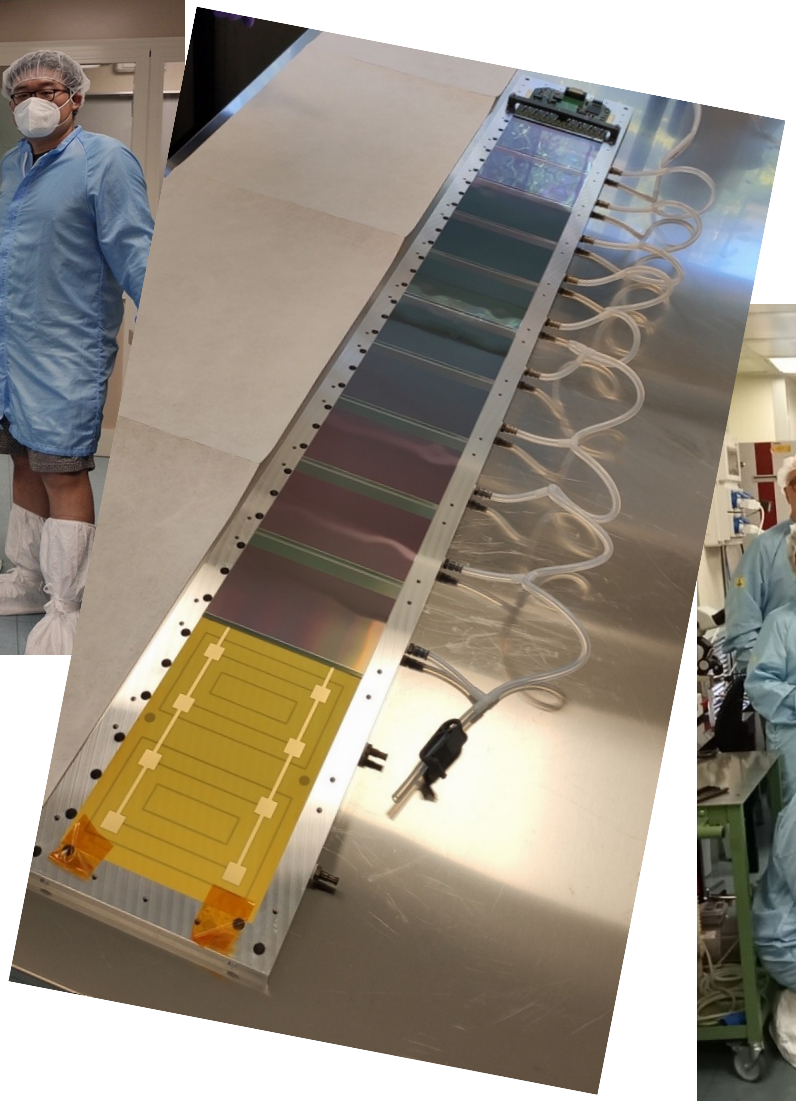
Transition from sandwich to bolted interface





Aluminum honeycomb
Carbon skin
Copper net for EMI

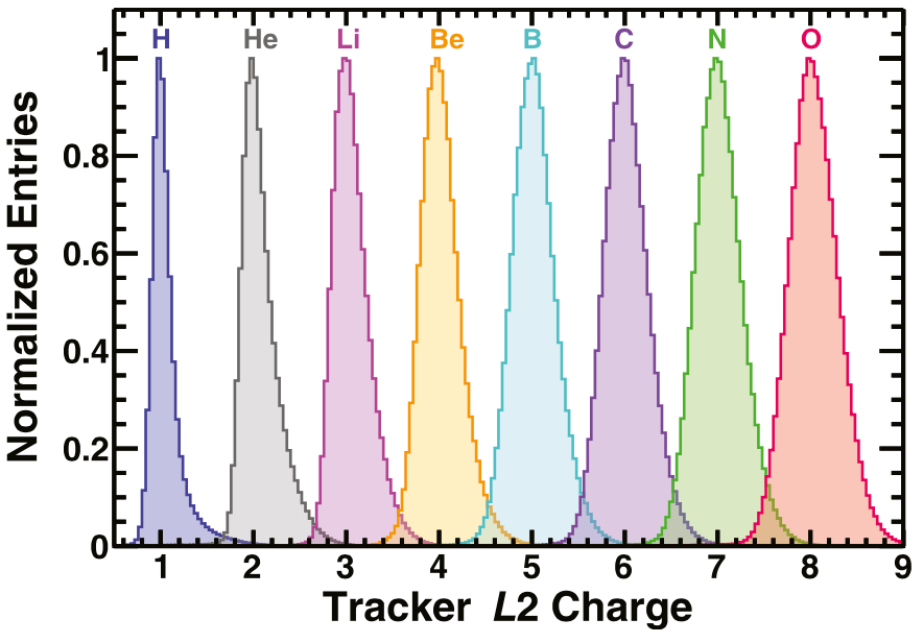
Joint INFN-IHEP-SDIAT team in Perugia, July 2022



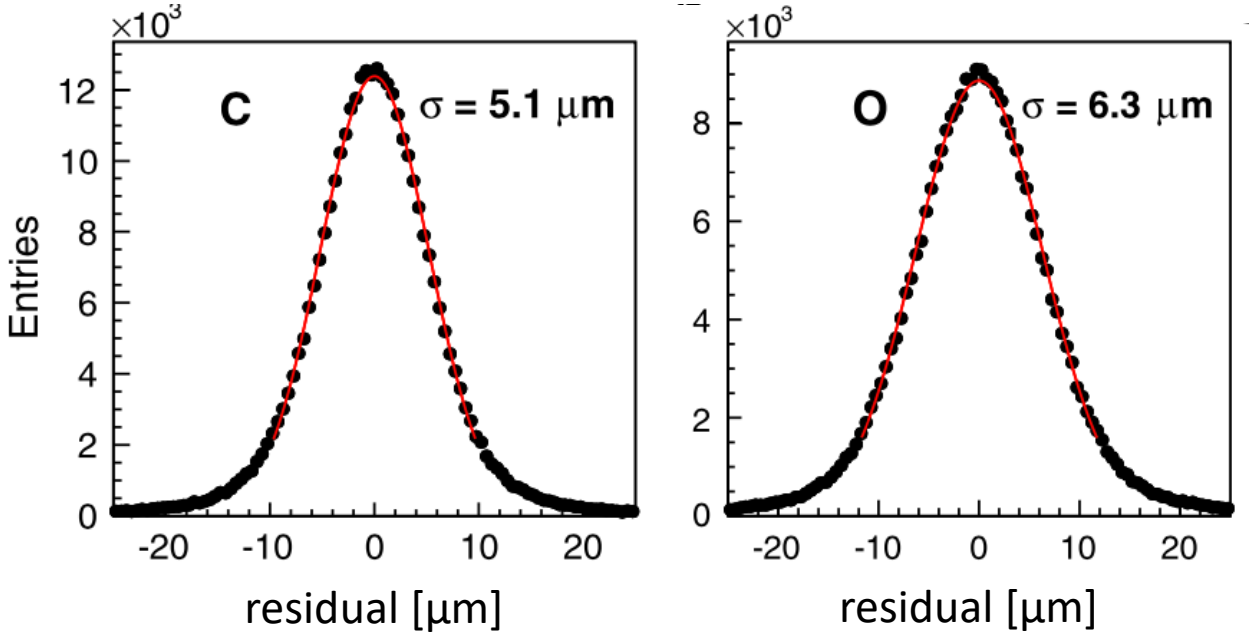
first full-size prototype
(IHEP, Beijing)

current Tracker performance

charge measurement

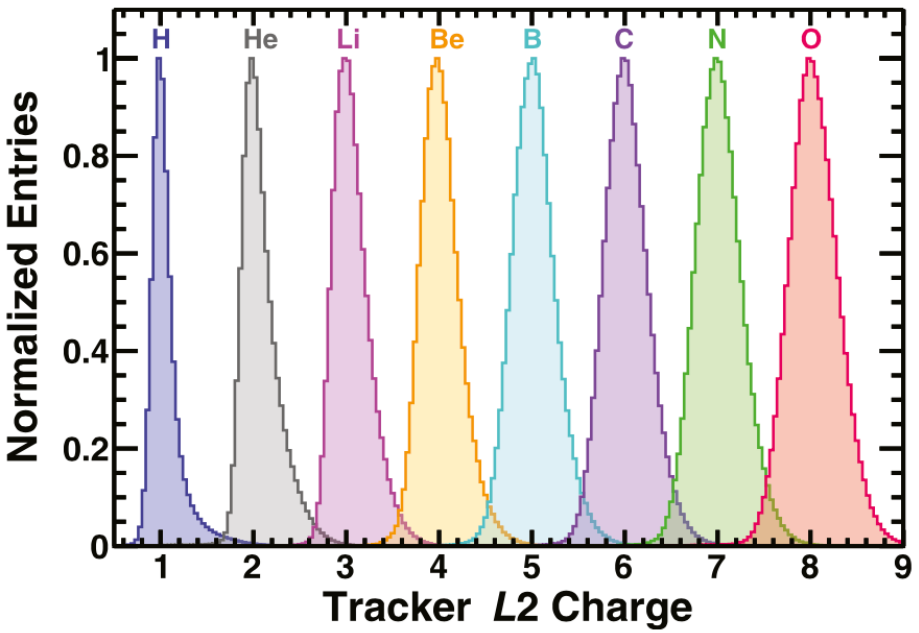


position resolution



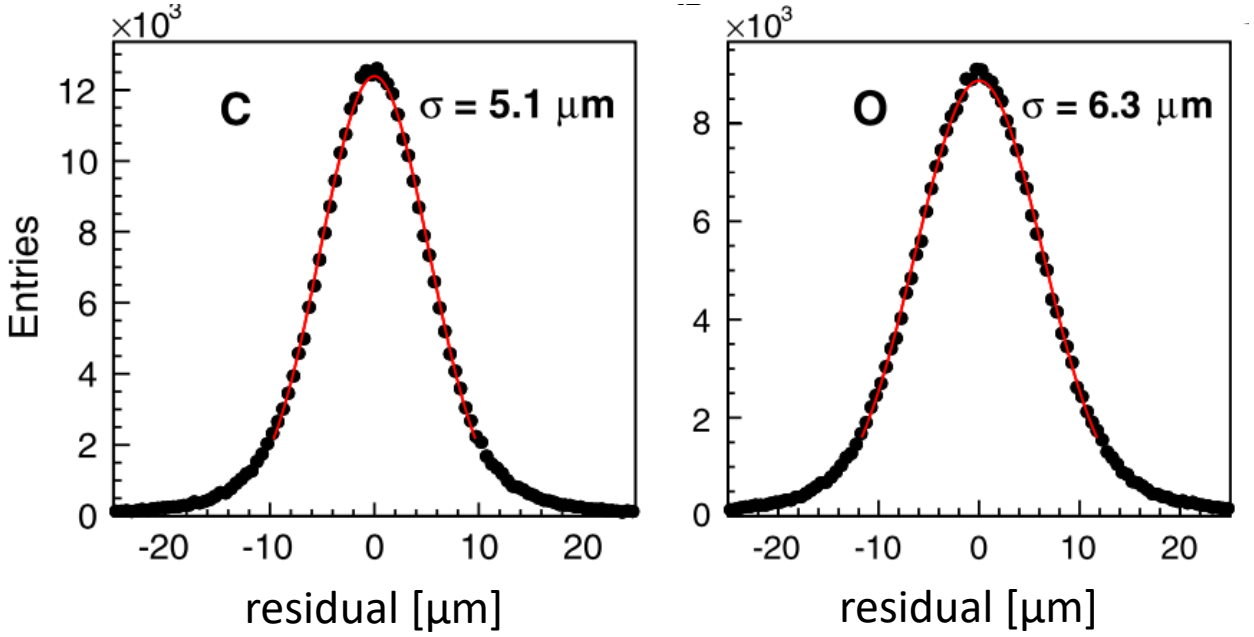
current Tracker performance

charge measurement



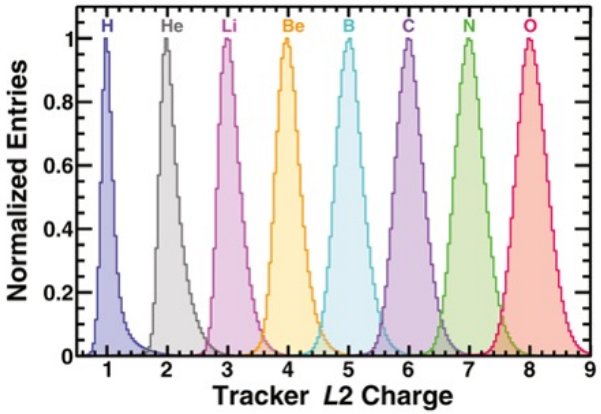
electronics specs

position resolution

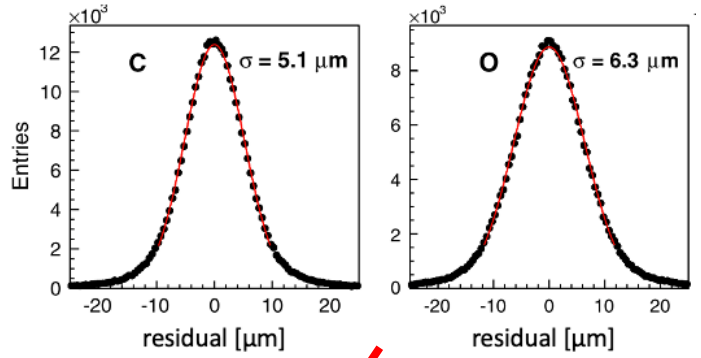


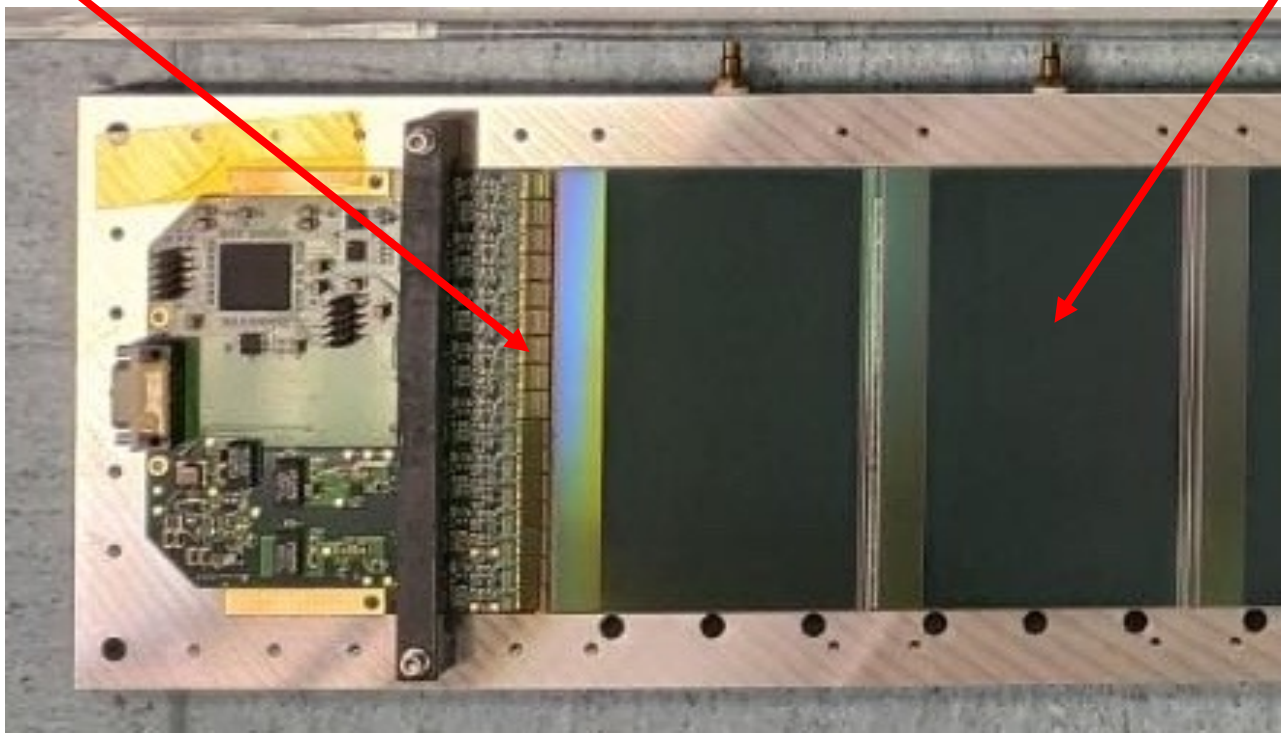
silicon detector specs

charge measurement

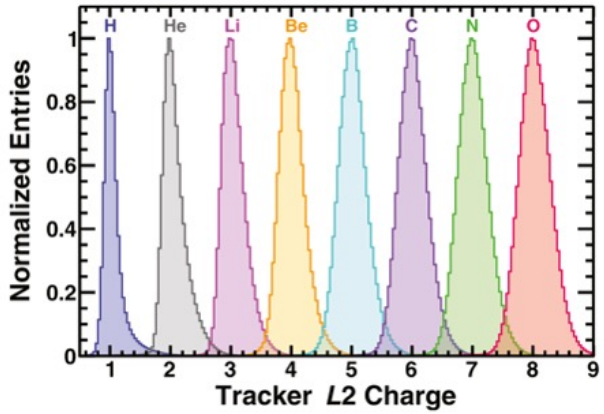


position resolution

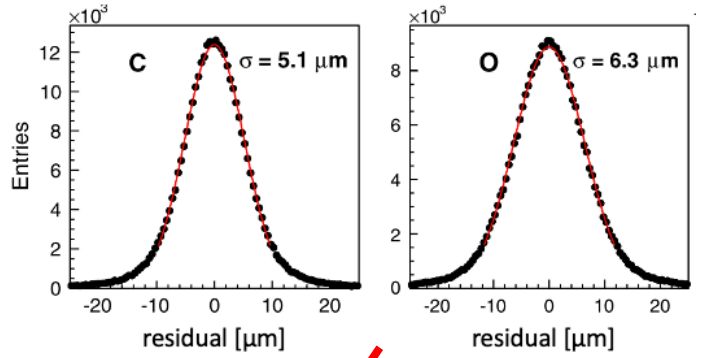


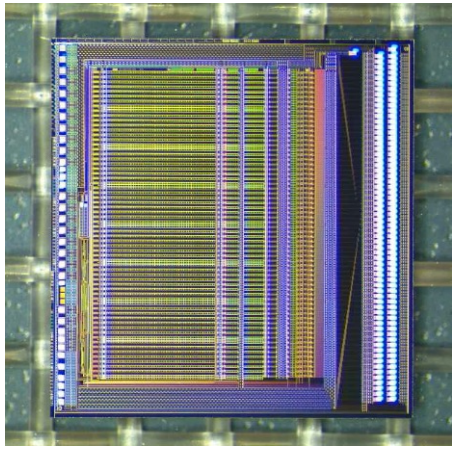


charge measurement

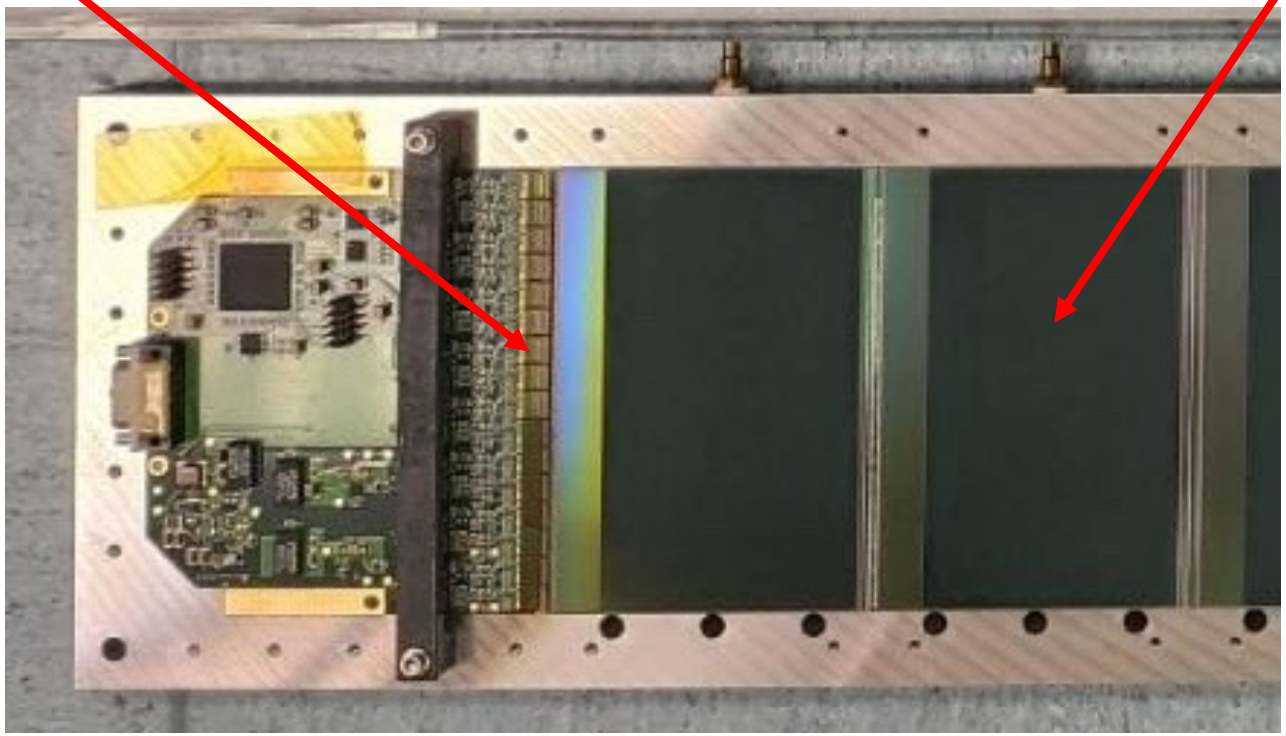


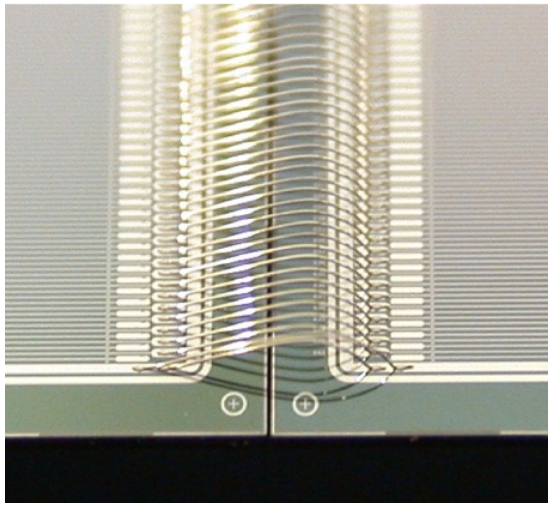
position resolution





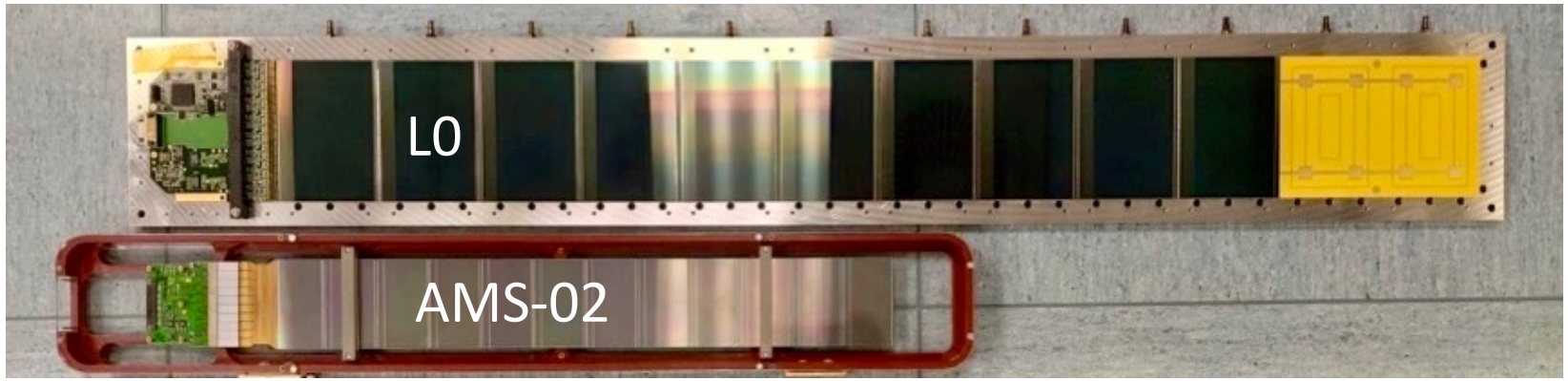
VA1140
high dynamic range

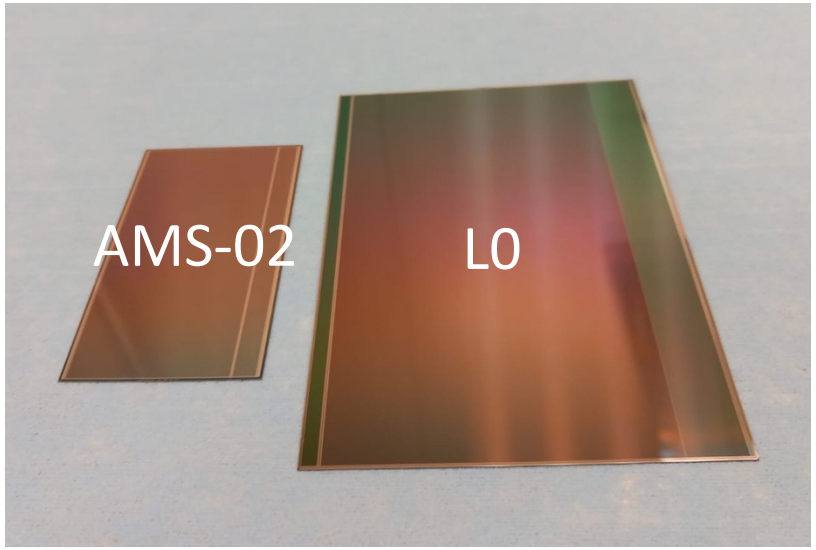




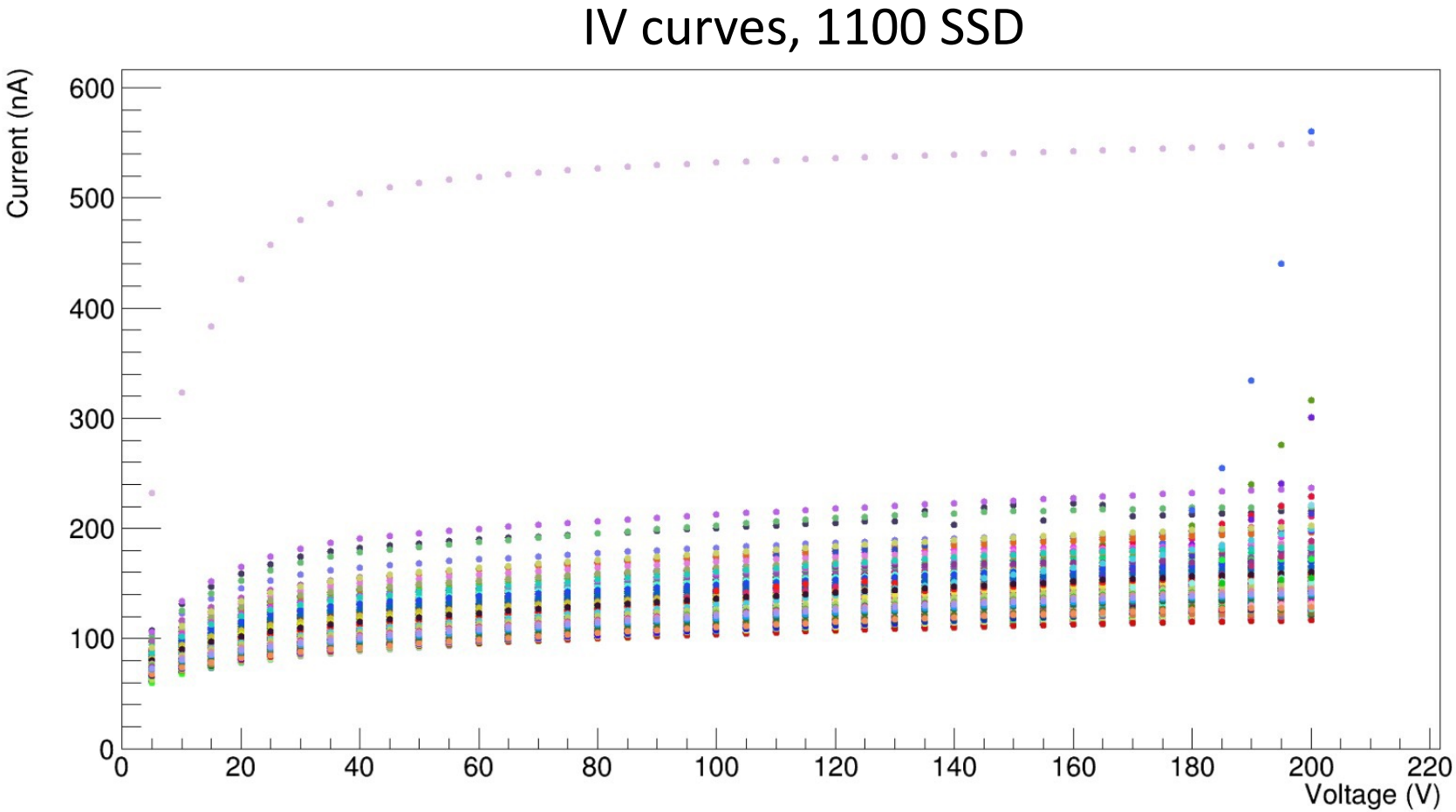
strip pitch 27.25 μm
readout pitch 109 μm

AMS-02 vs L0 ladders

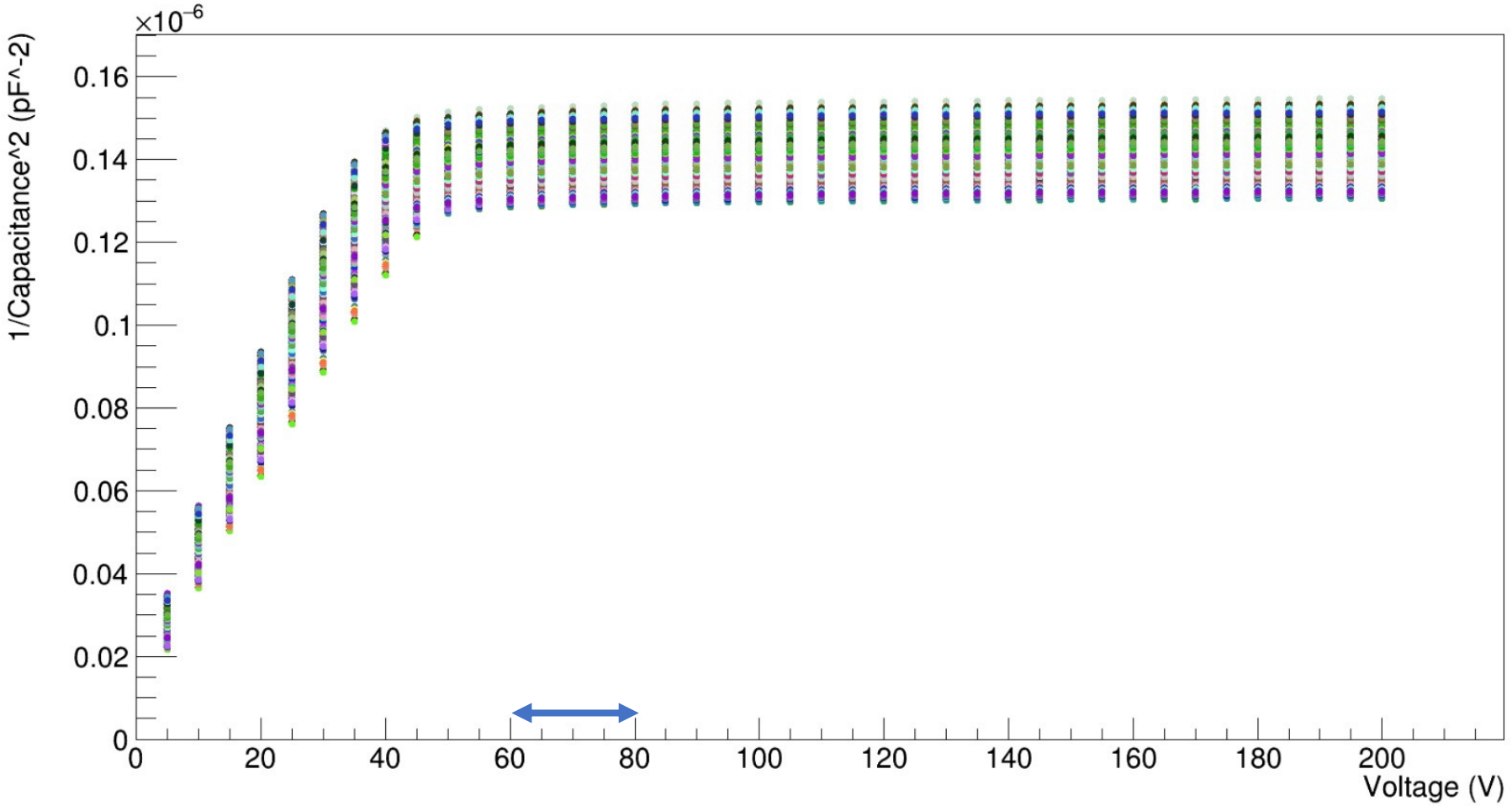




SSD quality ... is excellent

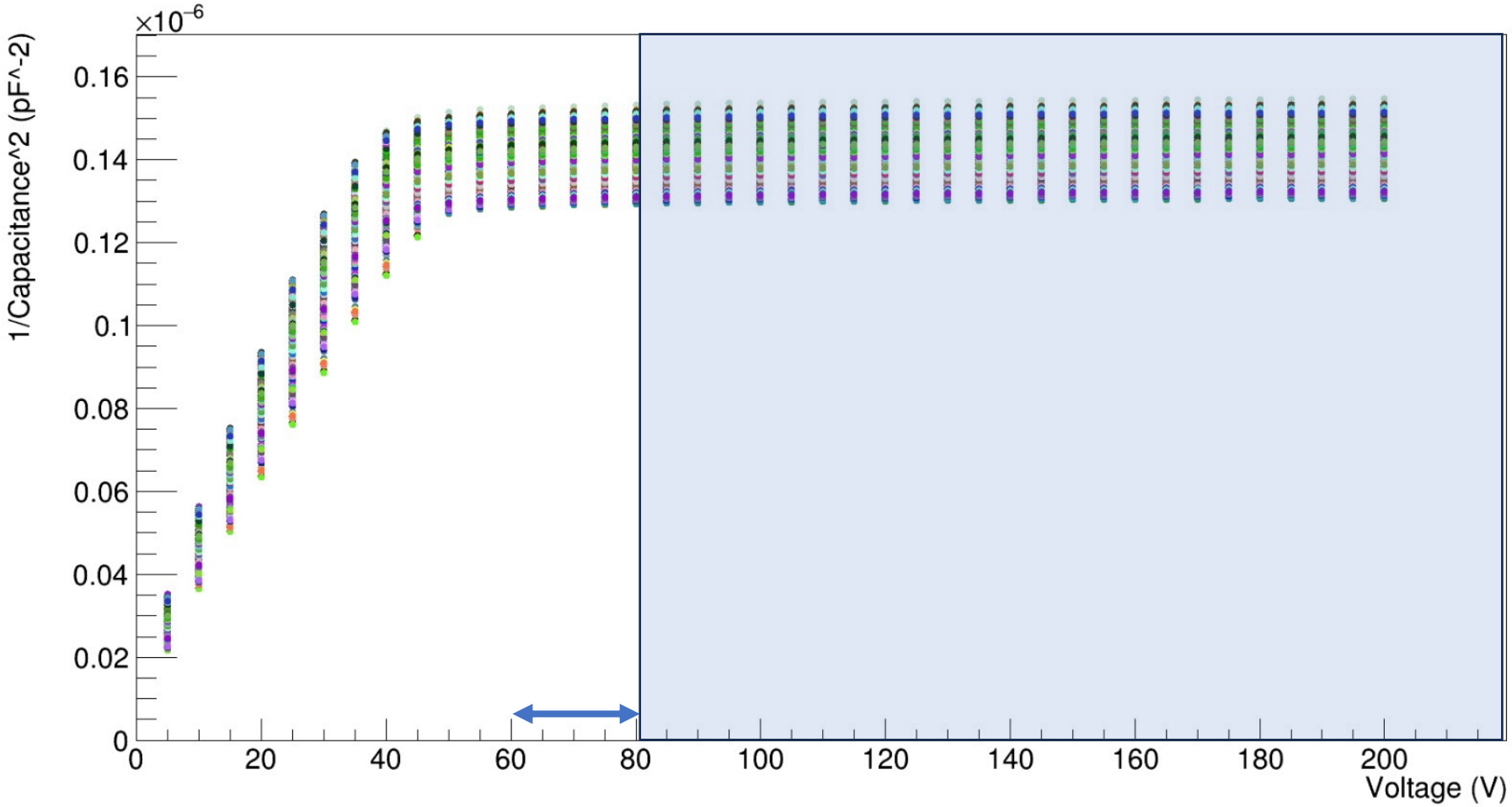


SSD quality … is excellent



total capacitance define the bias voltage to operate the detector

SSD quality … is excellent



total capacitance define the bias voltage to operate the detector

L0 Electronic Front End (LEF)

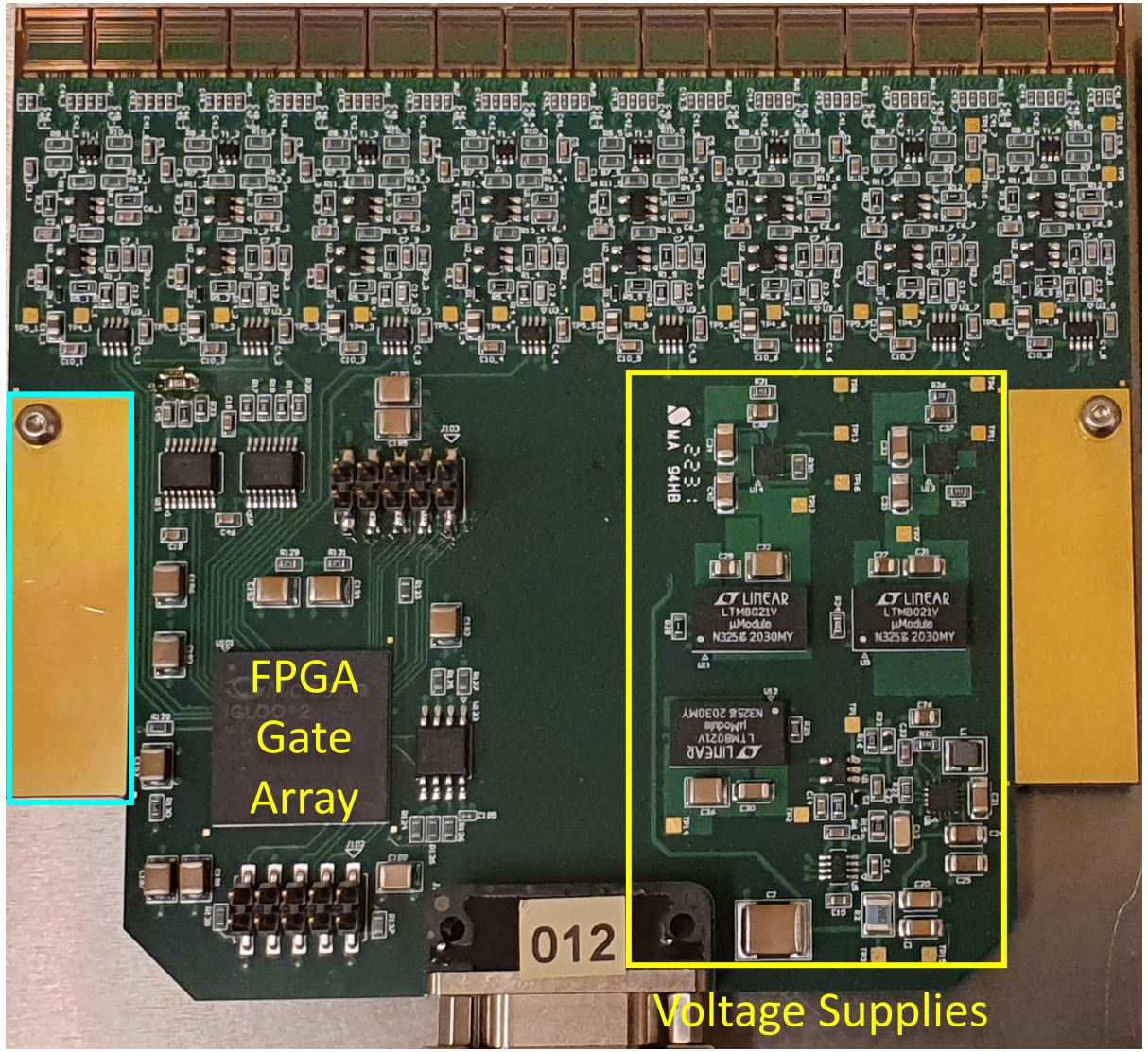
8 Amplifiers

8 14-Bit, 2.5Msps, Serial Sampling ADCs, 4096mV

Thermal Strips

1. Heat path to radiators.

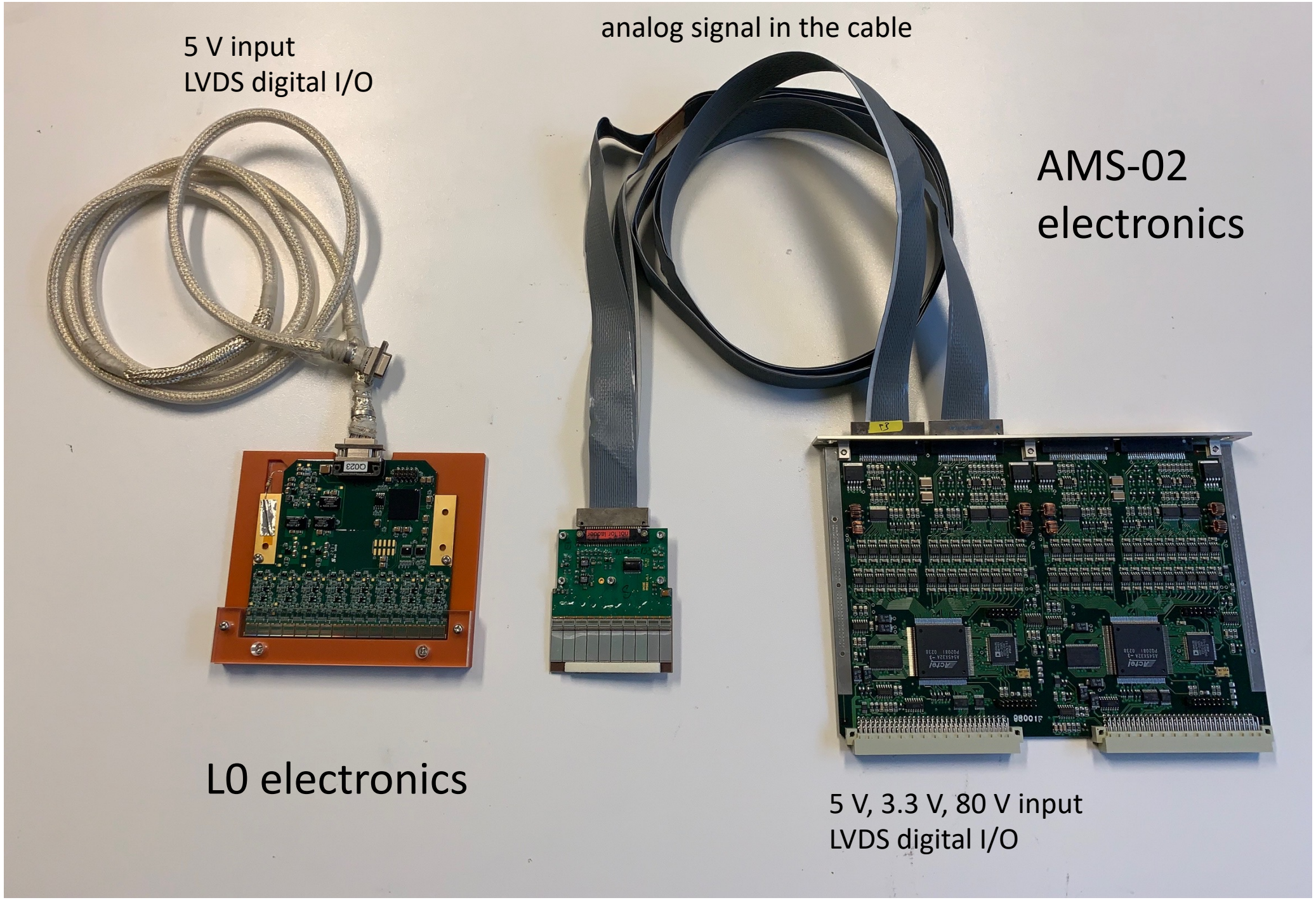
2. Ground path to chassis

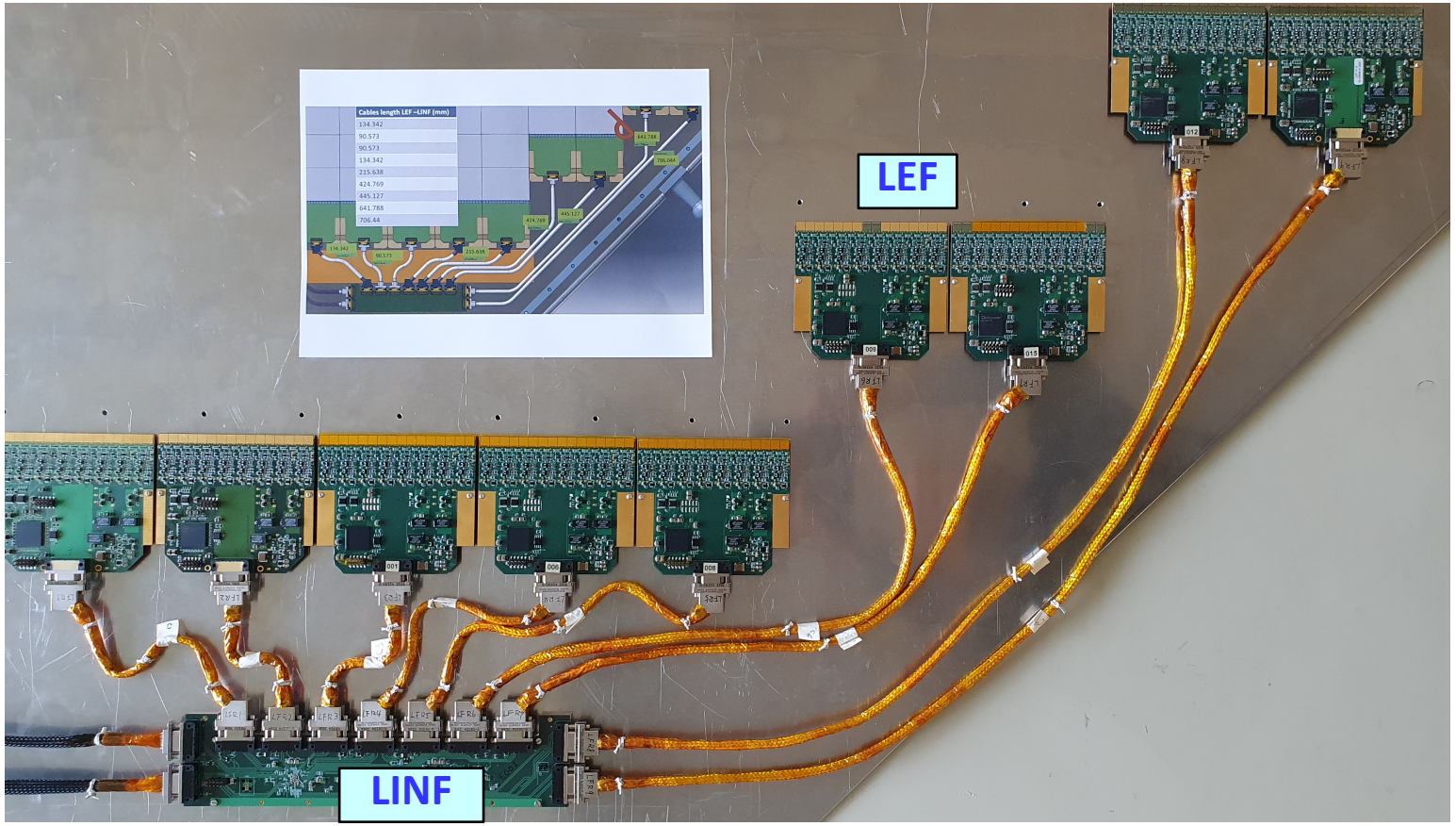


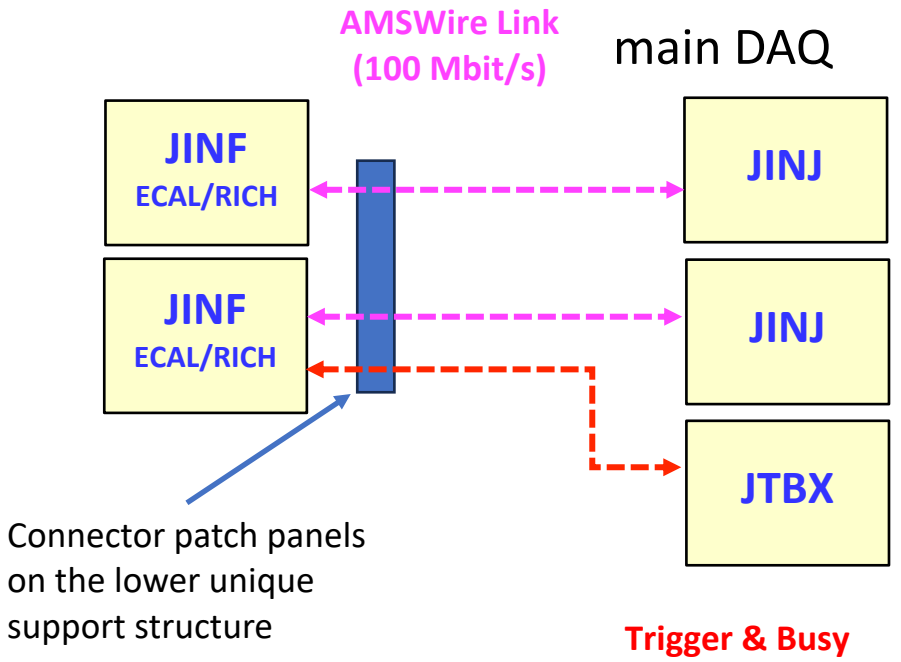
16 IDE1140, 1024 strips

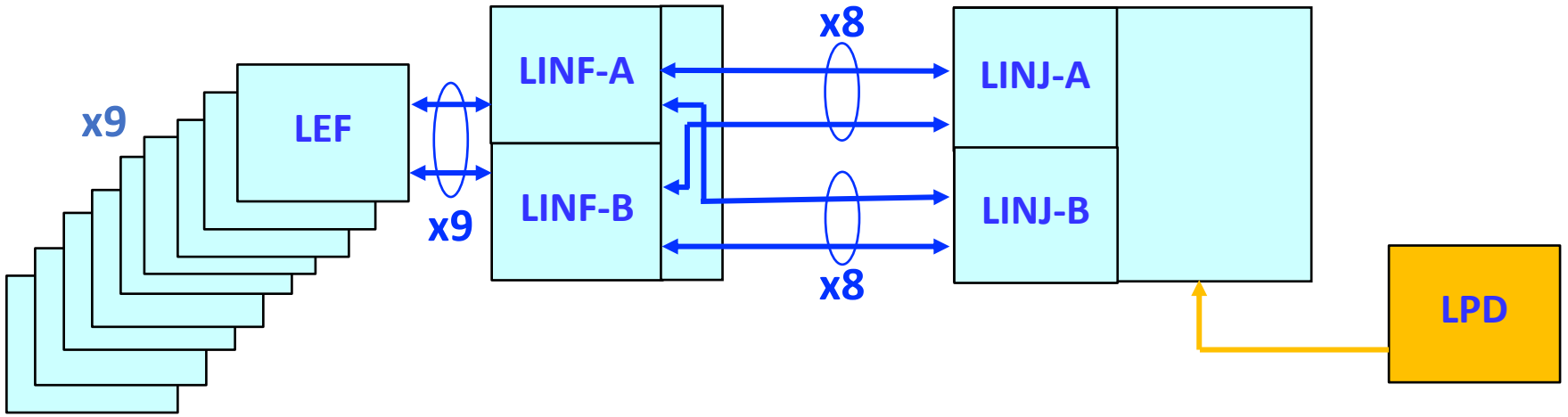
Each IDE1140 (“VA”)

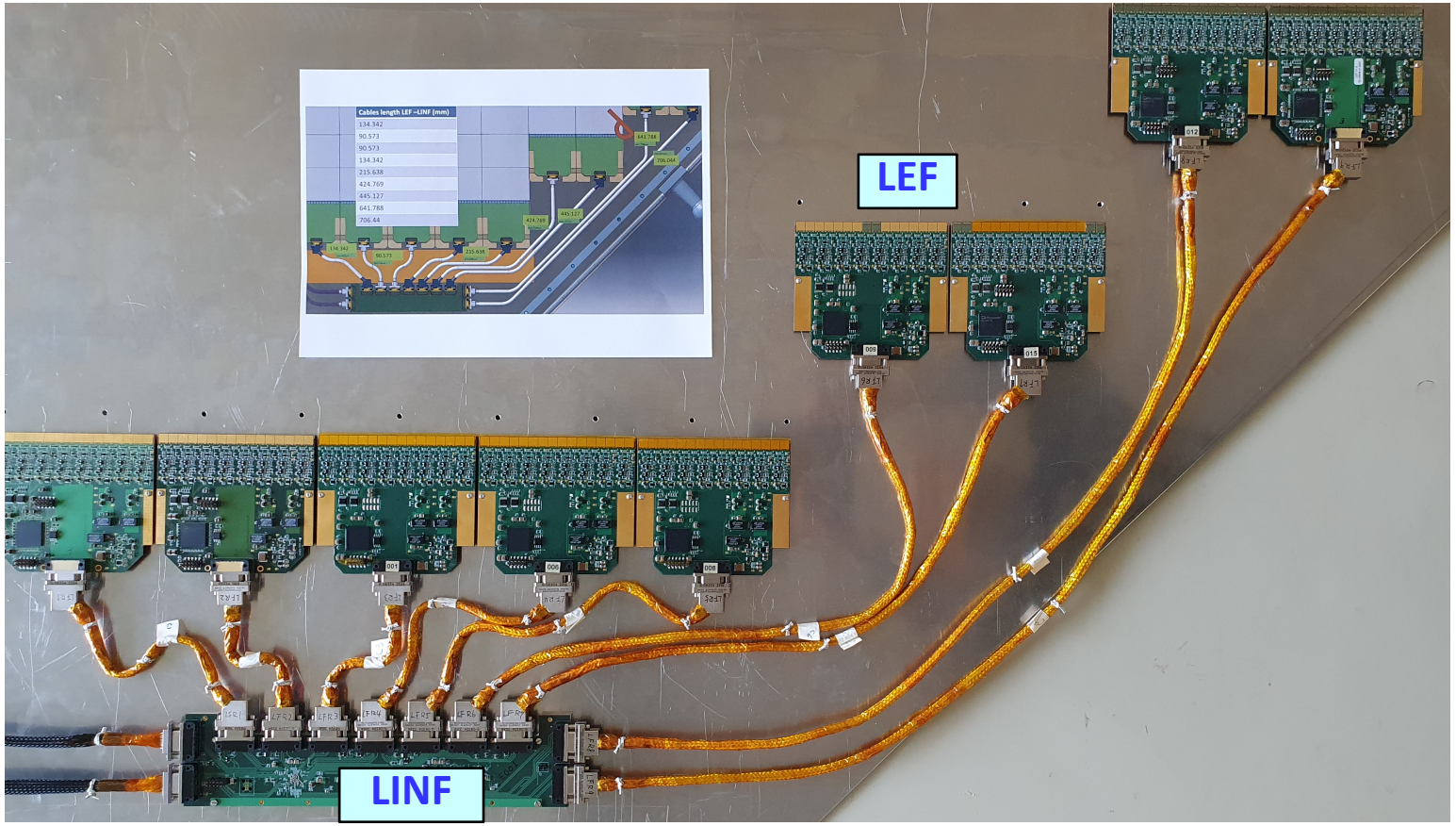
- 64 channels charge amplifier/ shaper.
- Sample and hold.
- 64 channels analog multiplexor.
- 2.6 uA per 1 fC differential current output


5 V input
LVDS digital I/O
analog signal in the cable
AMS-02
electronics
L0 electronics
5 V, 3.3 V, 80 V input
LVDS digital I/O


LEF
LINF


AMSWire Link
(100 Mbit/s)
main DAQ
JINF
ECAL/RICH
JINF
ECAL/RICH
JINJ
JINJ
JTBX
Connector patch panels
on the lower unique
support structure
Trigger & Busy


x9
LEF
x9
LINF-A
LINF-B
x8
x8
LINJ-A
LINJ-B
LPD



AMSWire Link
(100 Mbit/s)

main DAQ

JINF
ECAL/RICH

JINF
ECAL/RICH

JINJ

JINJ

JTBX

Trigger & Busy

Connector patch panels
on the lower unique
support structure

x9

LEF

x9

LINF-A

LINF-B

x8

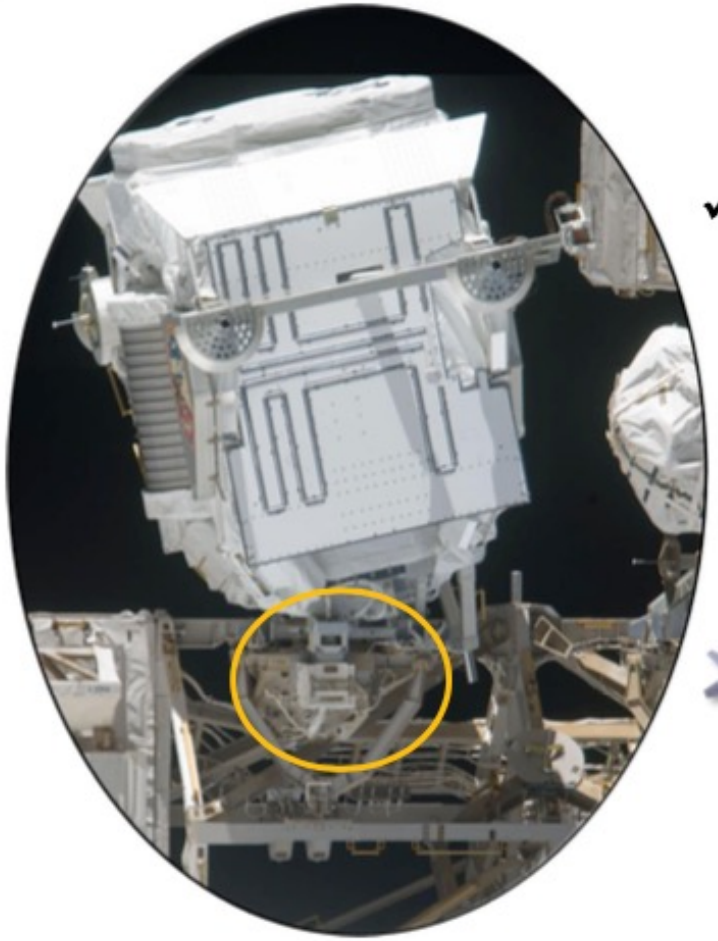
x8

LINJ-A

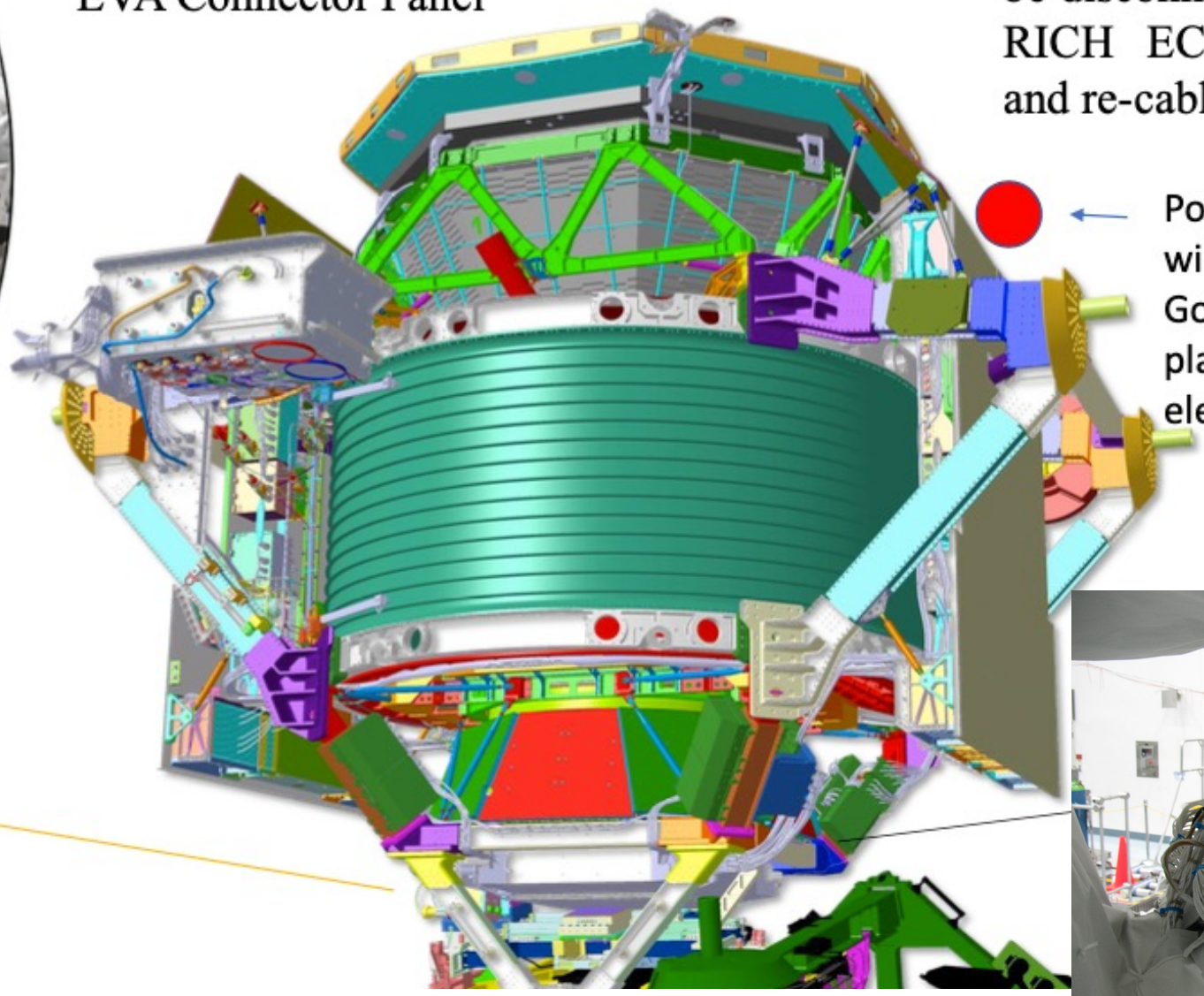
LINJ-B

LPD

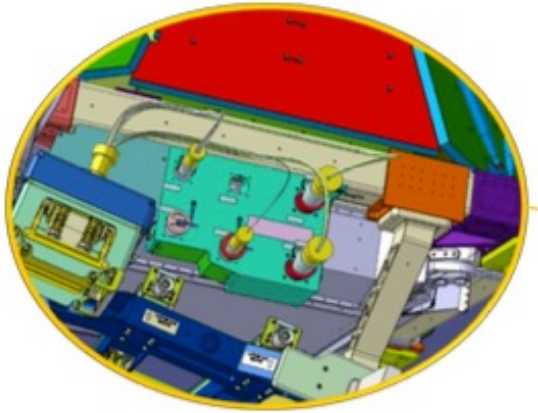
Power & Data from AMS and ISS

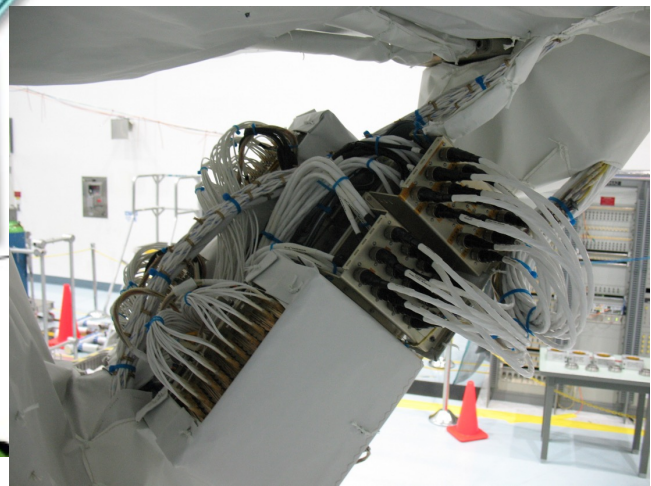


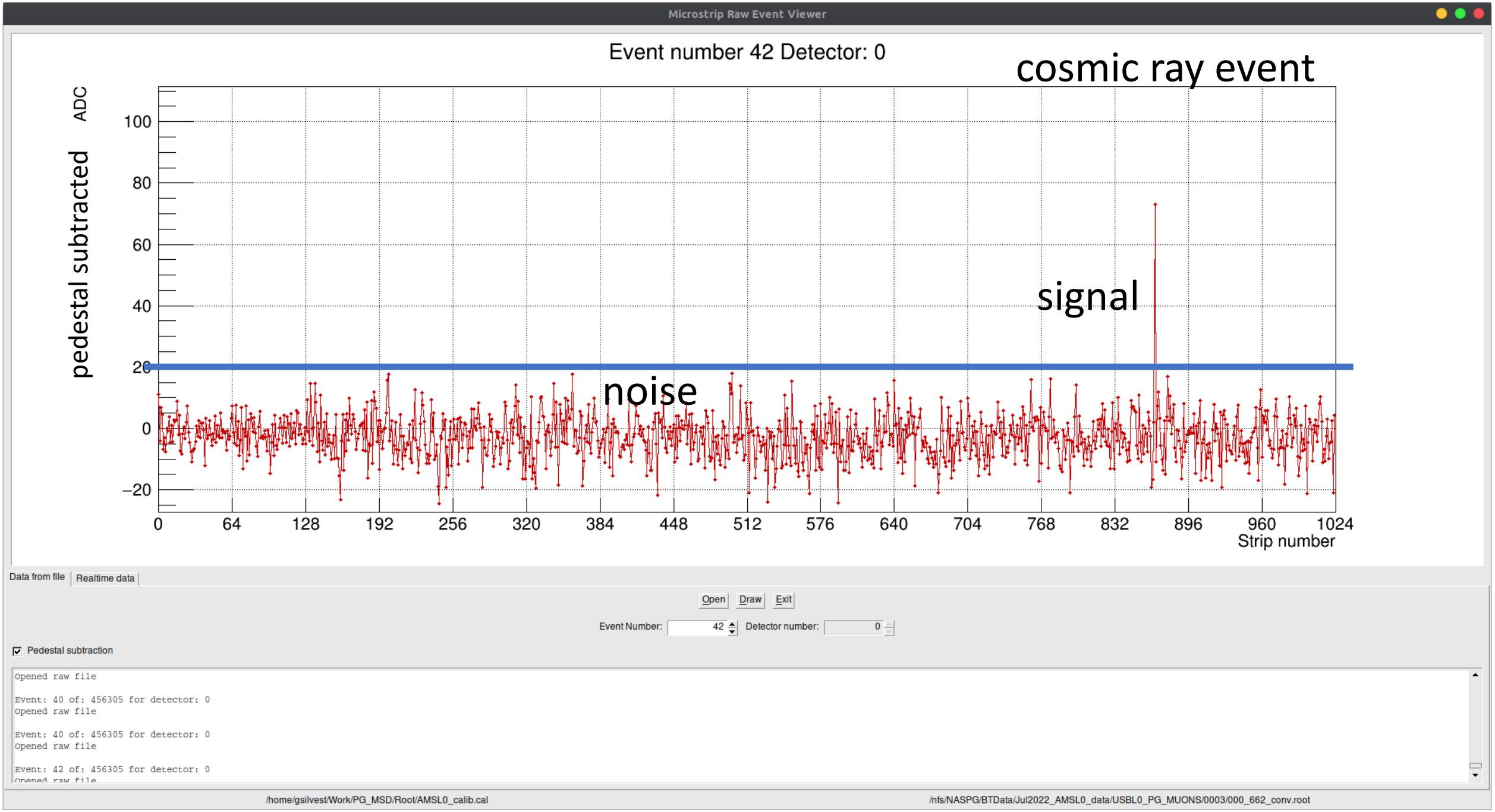
- ✓ Power from main ISS EVA Connector Panel
- ✓ n.3 data connectors need to be disconnected at LUSS, i.e. RICH ECAL Patch Panels and re-cabled for Layer0



Power and Data cables will be routed up to Gold2, where the plane will be electrically connected






Microstrip Raw Event Viewer
Event number 42 Detector: 0
cosmic ray event
pedestal subtracted ADC
100
80
60
40
20
0
−20
signal
noise
0
64
128
192
256
320
384
448
512
576
640
704
768
832
896
960
1024
Strip number
Data from file
Realtime data
Open
Draw
Exit
Event Number:
42
Detector number:
0
Pedestal subtraction
Opened raw file
Event: 40 of: 456305 for detector: 0
Opened raw file
Event: 40 of: 456305 for detector: 0
Opened raw file
Event: 42 of: 456305 for detector: 0
/home/gsilvest/Work/PG_MSD/Root/AMSL0_calib.cal
/nfs/NASPG/BTData/Jul2022_AMSL0_data/USBL0_PG_MUONS/0003/000_662_conv.root

Microstrip Raw Event Viewer

Event number 42 Detector: 0

cosmic ray event

pedestal subtracted ADC

100
80
60
40
20
0
−20

0
64

896
960
1024
Strip number

Charge distribution fit to Landau ⊕ Gaussian

Number of Hits

1800
1600
1400
1200
1000
800
600
400
200
0

0
50
100
150
200
250

Cluster Charge [LSB]

• Measurement

— Fit to function

MP ~ 58 LSB

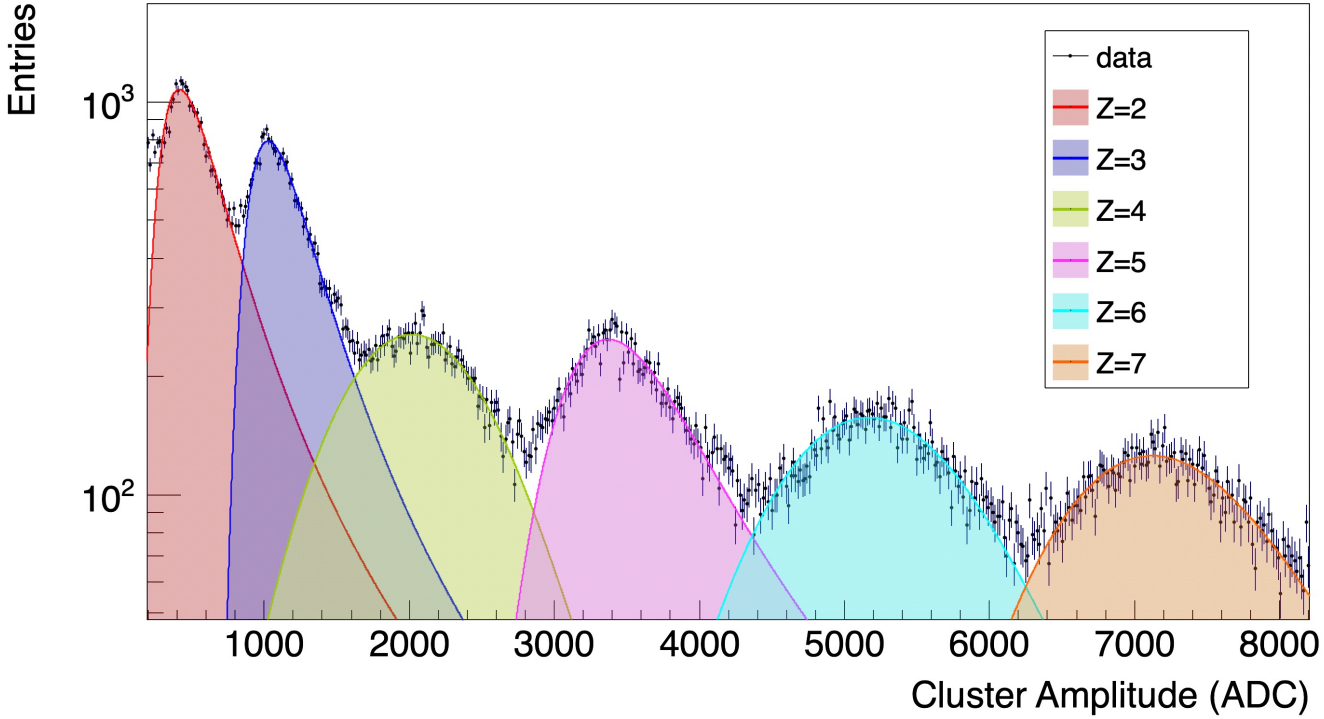
Data from file | Realtime data

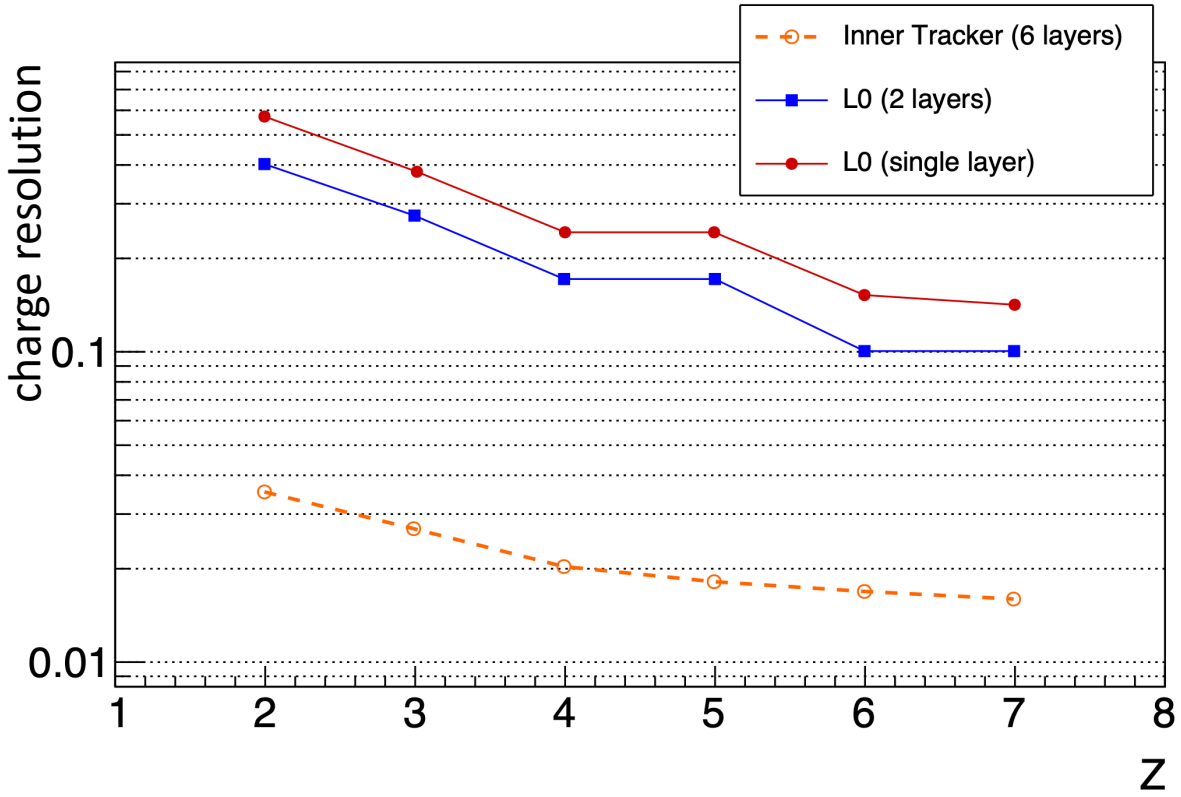
Pedestal subtraction

```
Opened raw file

Event: 40 of: 456305 for detector: 0
Opened raw file

Event: 40 of: 456305 for detector: 0
Opened raw file

Event: 42 of: 456305 for detector: 0
Opened raw file
```

G_MUONS/0003/000_662_conv.root

detector performance (ion beam test)



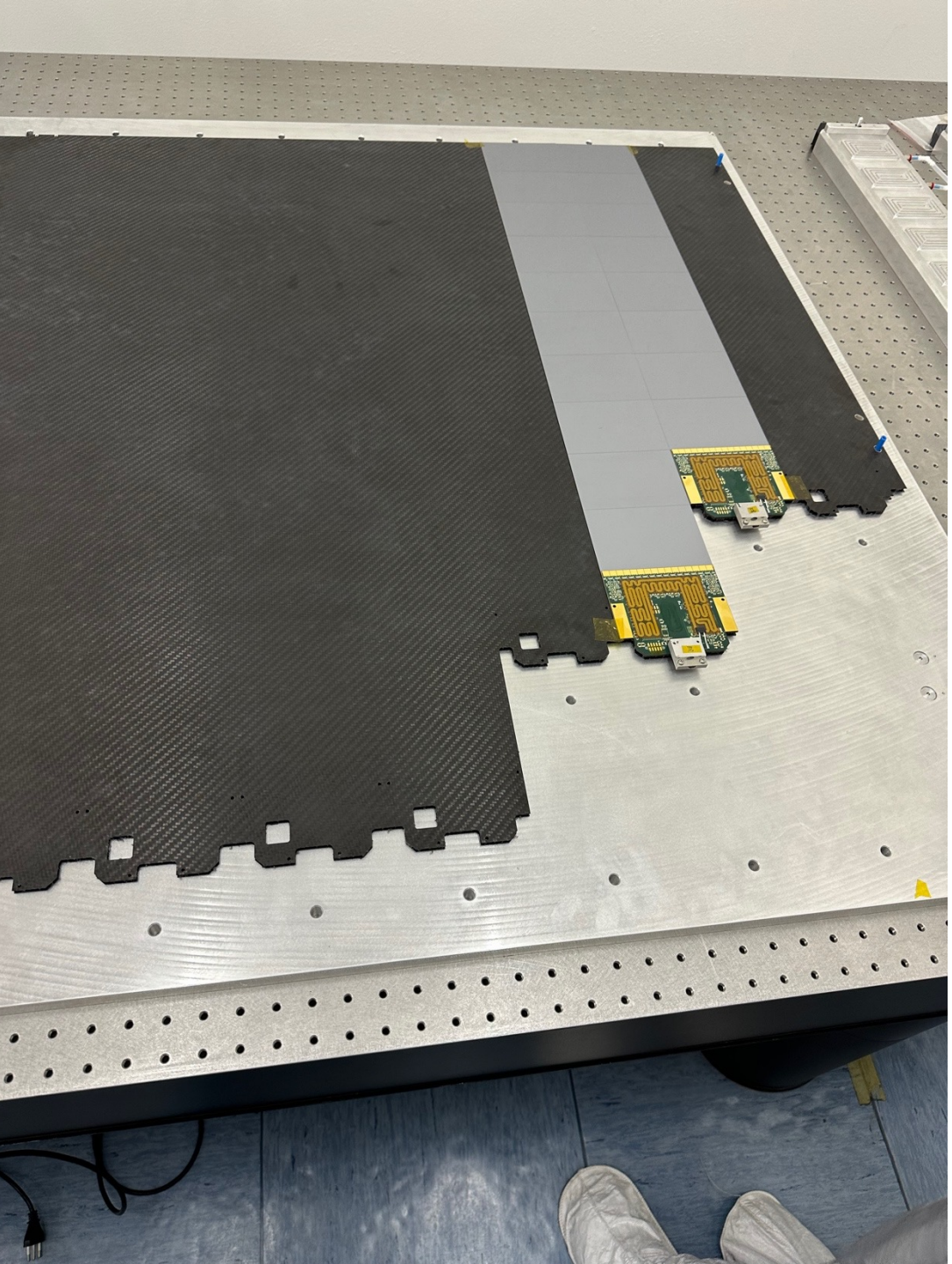


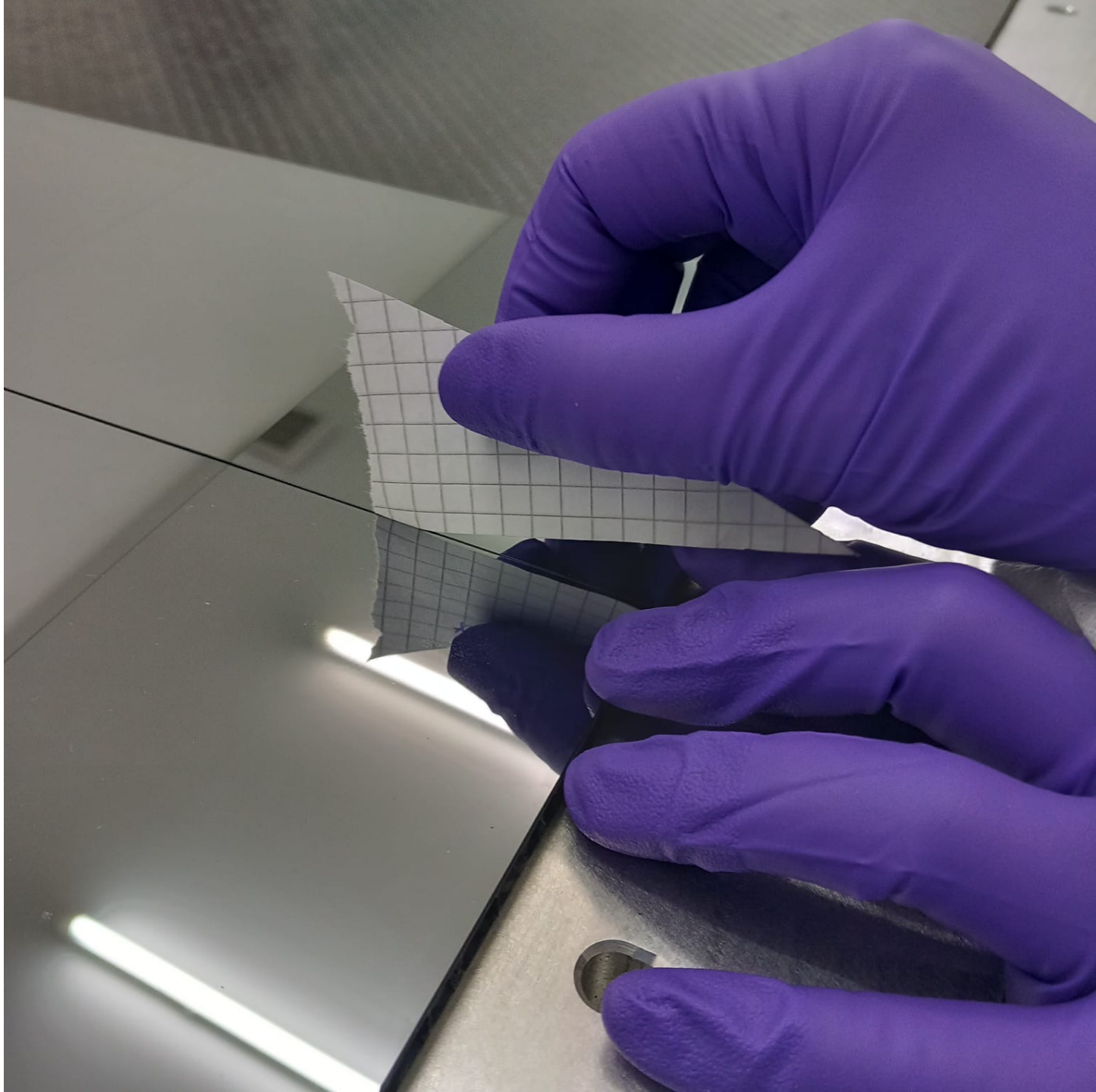
the measured signal can properly identify the ions

Where are we?

- detector components are all available
- first ladder assembly is done
- performance are being evaluated (preliminary results are according to specifications)

space qualified activity



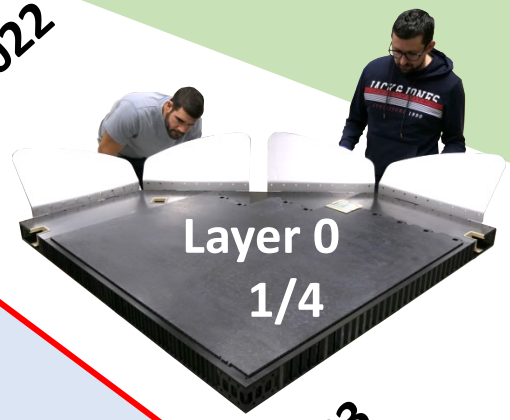


Where are we?

- detector components are all available
- first ladder assembly is done
- performance are being evaluated (preliminary results are according to specifications)
- first integration test is successful
- beam test next August (proton) and October (ions)
- Qualification Model production is started
- Flight Model production is on schedule, start in November 2023

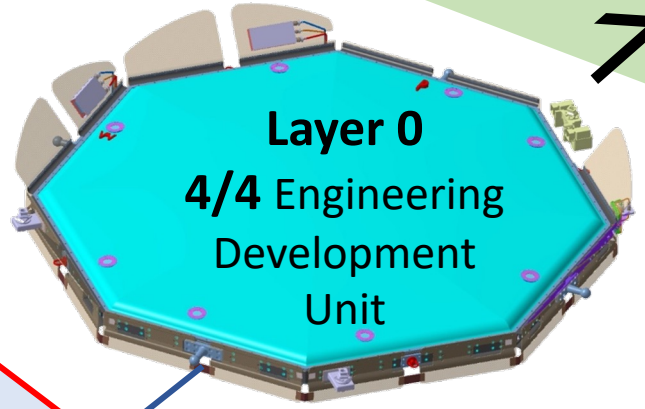
Development, Qualification and Flight units

2022



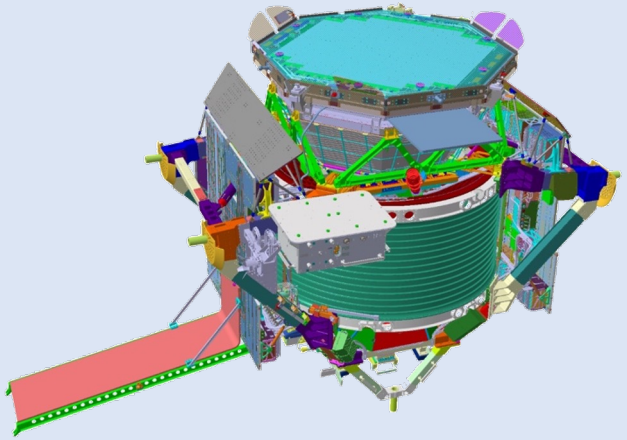
¼ QM
Final Grade Carbon Fiber
Vibration
Thermo-vacuum
EMI

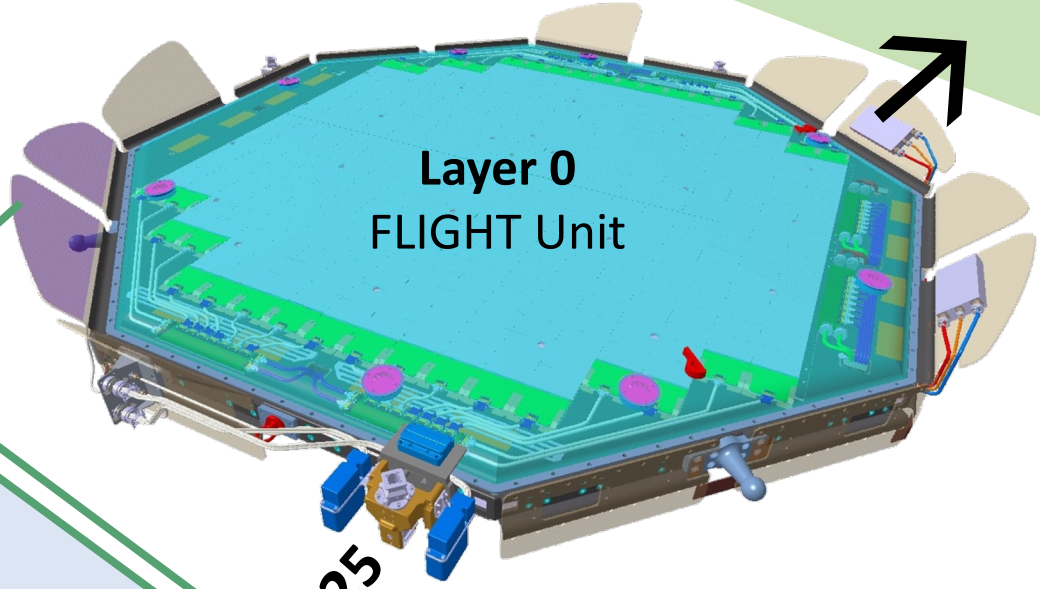
2023



Full scale EDU
Low Grade Carbon Fiber
Vibration

2024





Flight
Survey
Vibration
Thermo-vacuum
Vibration
Survey
Test beam

2025

Ready to deliver to NASA

INFN/UniPG laboratory for space qual Terni, Italy