Matteo Duranti
Perugia University and INFN
on behalf of the AMS02-Tracker group

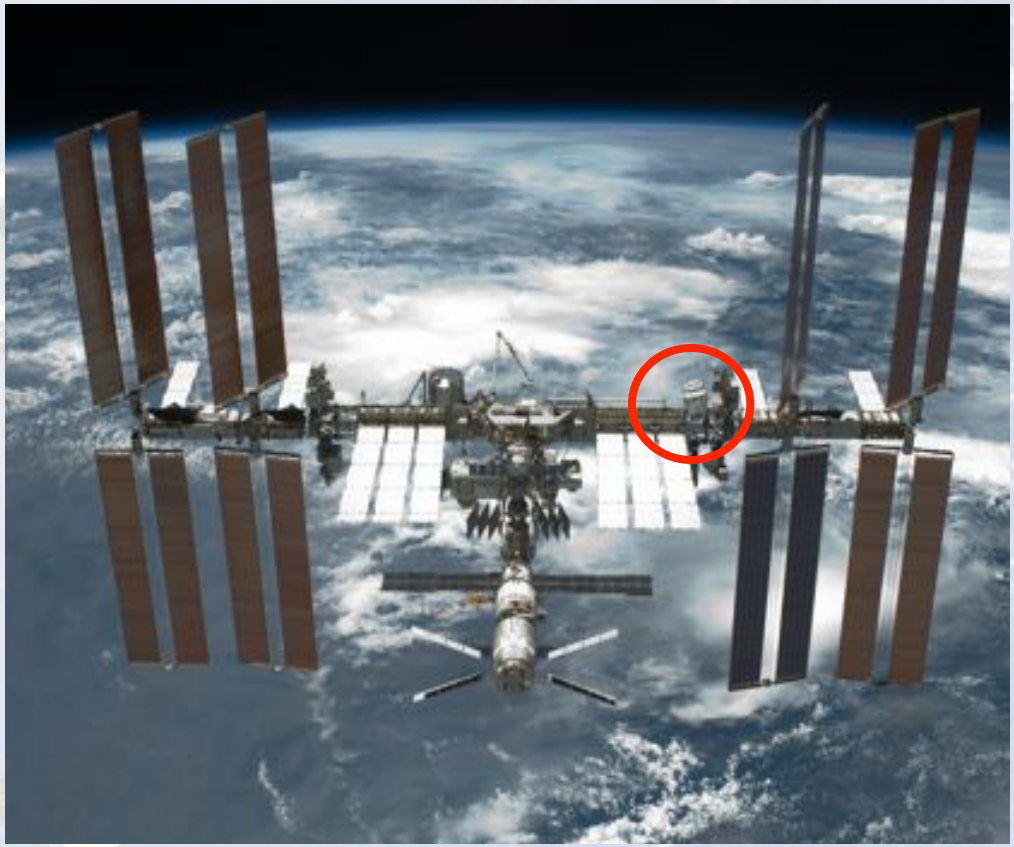
The AMS02 Silicon Tracker: the detector and a first look to the on orbit data

RD11

06/07/2011 - Firenze, Italy

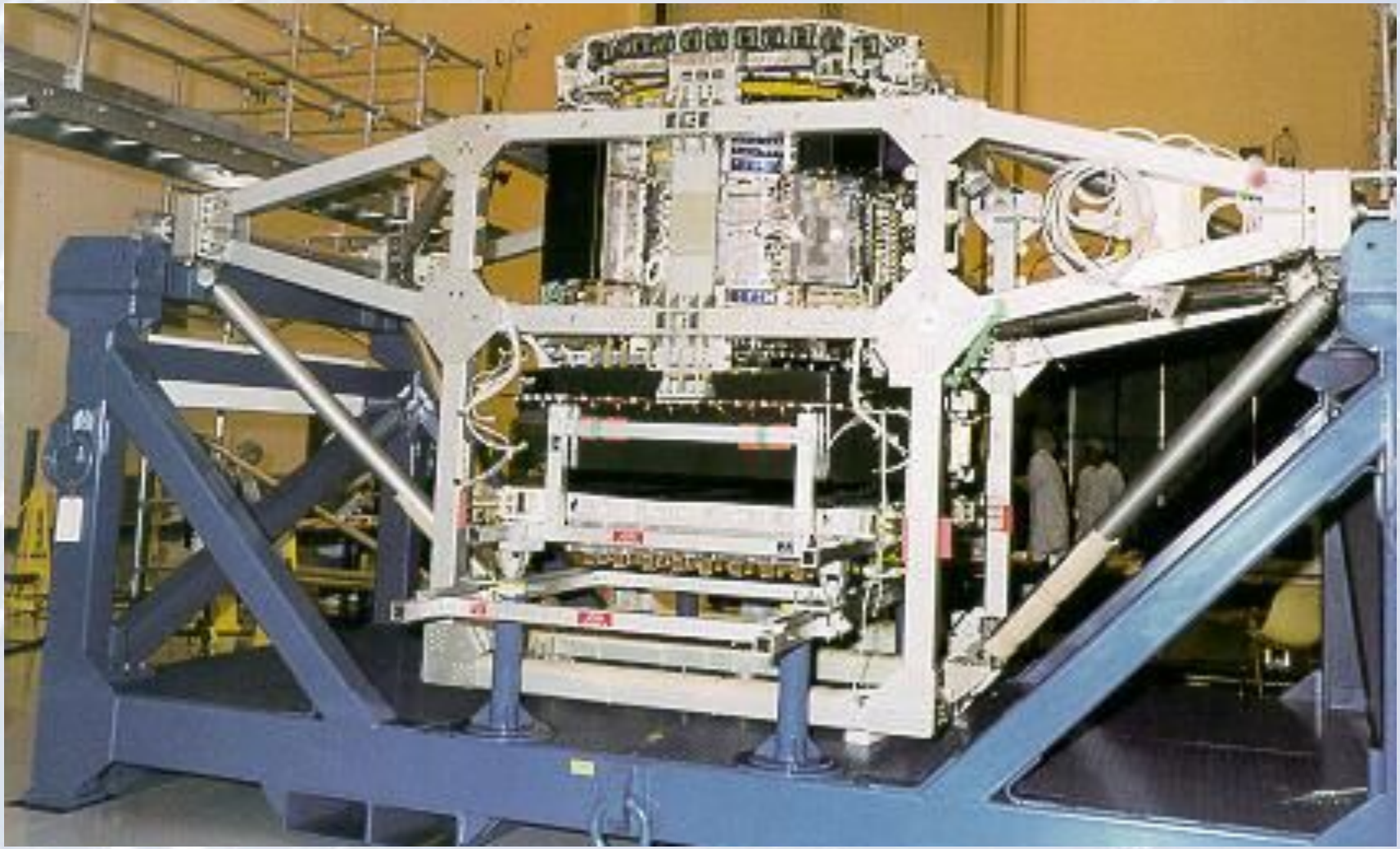
AMS on the International Space Station

- Primordial Antimatter search with 10^{-9} sensitivity
- Indirect Dark Matter search $(e^+, \bar{p}, \gamma)$
- Relative abundance of nuclei and isotopes in primary cosmic rays
- γ ray astrophysics



The purpose of the AMS experiment is to perform accurate, high statistics, long measurements of charged cosmic rays (0.5 GV - 1 TV) and γ rays (E>1GeV)

AMS01 at KSC (Florida) in 1998



AMS-01 pilot experiment: STS91, June 2nd - 12th 1998

- 10 days of data taking in orbit:
  - 400 Km altitude
  - latitudes <51.7°
  - all longitudes
- 10^8 events recorded
- Physics results
- (Phys. Rep. 366 (2002) 331)
  - precise measurements of primary fluxes
  - detection of secondary fluxes (quasi trapped)
  - antimatter limit at 10^{-6}

The instrument we need has …

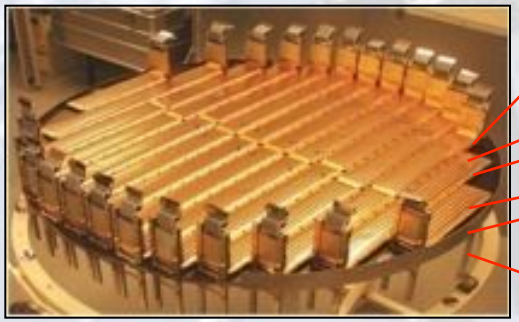
- performance a la 'particle physics':
  - high resolution measurements of momentum, velocity, charge and energy
- characteristics to properly work in the space environment:
  - Vibration (6.8 G rms) and acceleration (17 G)
  - Temperature variation (day/night $\Delta T = 100^{o}C$)
  - Vacuum (10^{-10} Torr)
  - Orbital debris and micrometeorites
  - Radiation (Single Event Effect)
- limitation in weight (15000 lb), power (~2KW), bandwidth and maintenance
- compliant with Electromagnetic Interference and Electromagnetic Compatibility specs


AMS

AMS: A TeV precision, multipurpose particle physics spectrometer in space

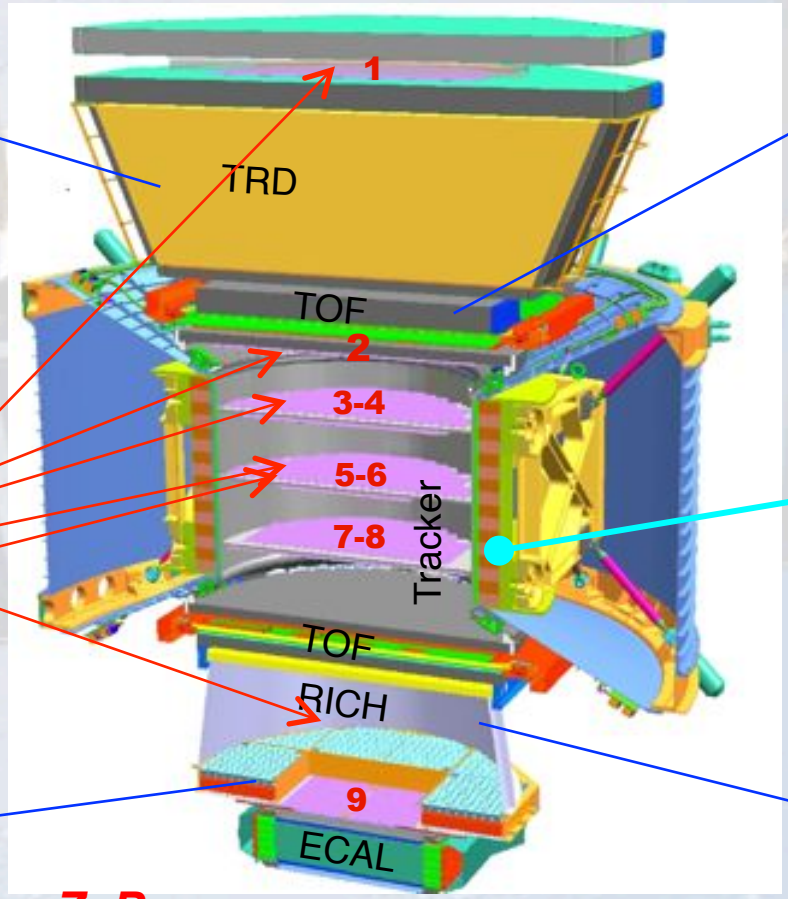
TRD Identify e+, e-

Silicon Tracker Z, P



ECAL E of e+, e-, γ

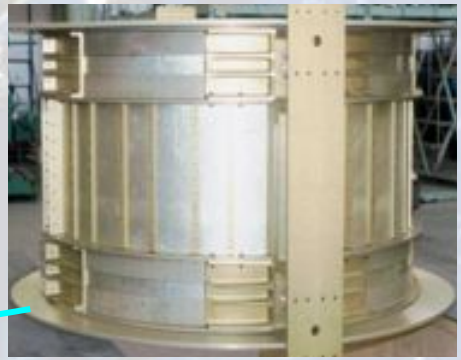
Particles and nuclei are defined by their charge (Z) and energy (E ~ P)



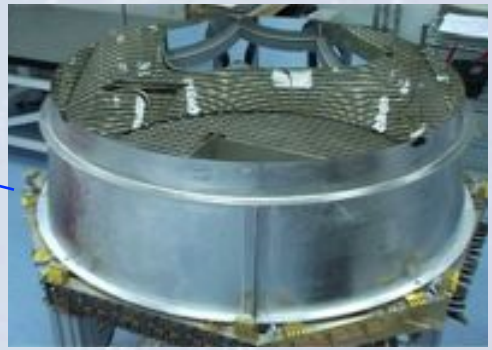
Z, P are measured independently by the Tracker, RICH, TOF and ECAL

TOF Z, E

Magnet ±Z



RICH Z, E

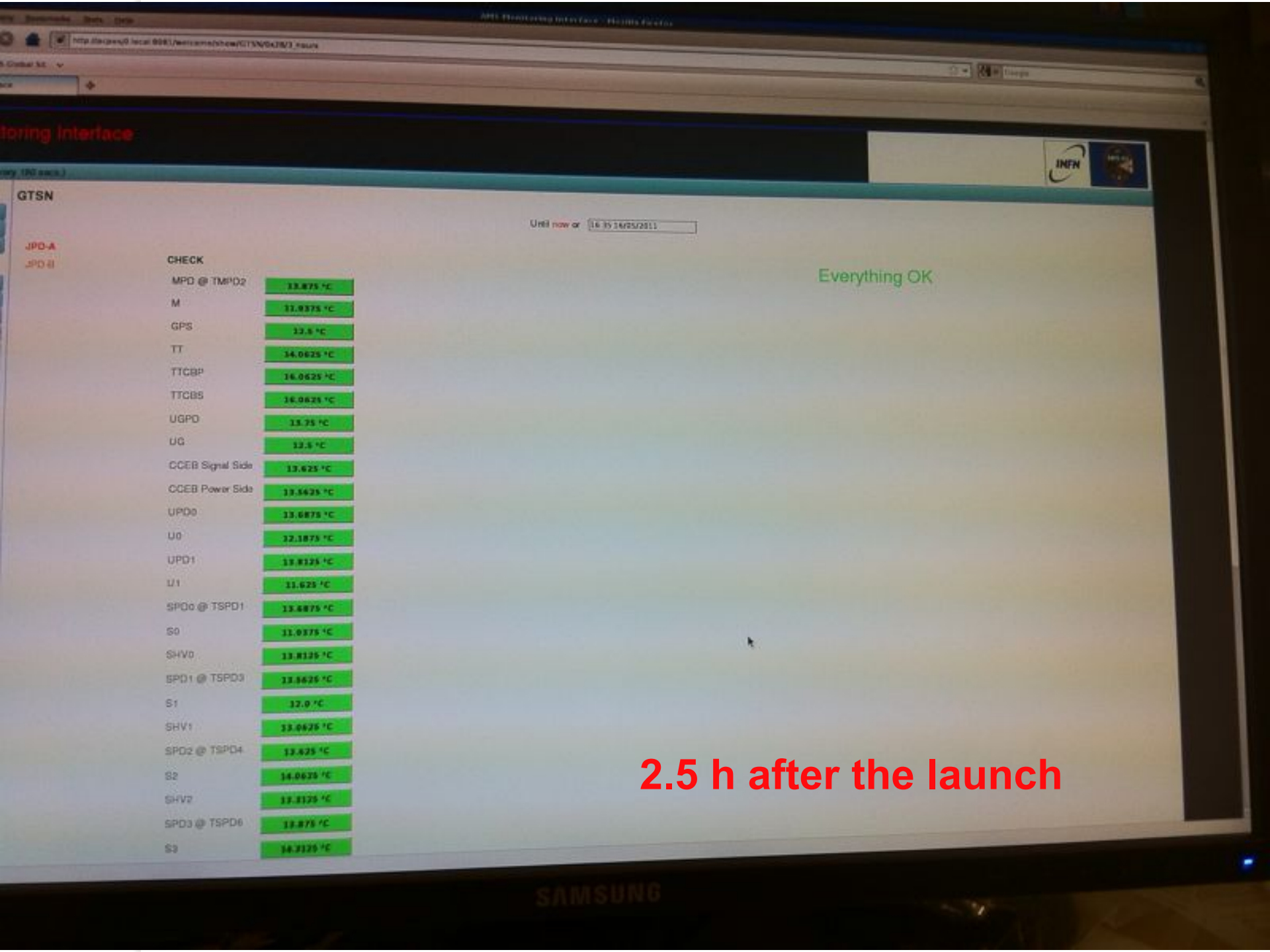


Recent AMS02 history in short

- 2000: started the activity of design and building
- fall 2009: integration at CERN
- February 2010: test beam at CERN
- spring 2010: EMI and TV test at ESTEC (ESA)
- late spring 2010: magnet replacement at CERN
- August 2010: test beam at CERN
- fall/winter 2010-2011 integration at KSC (Florida)
- May 16th 2011: launch!
- May 19th 2011: first activation in space: everything is working!!

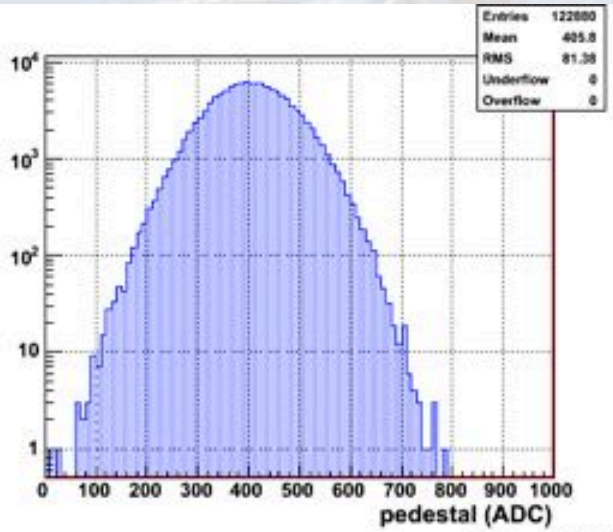
Houston, JSC - May 16, 2011@ 07:56 AM

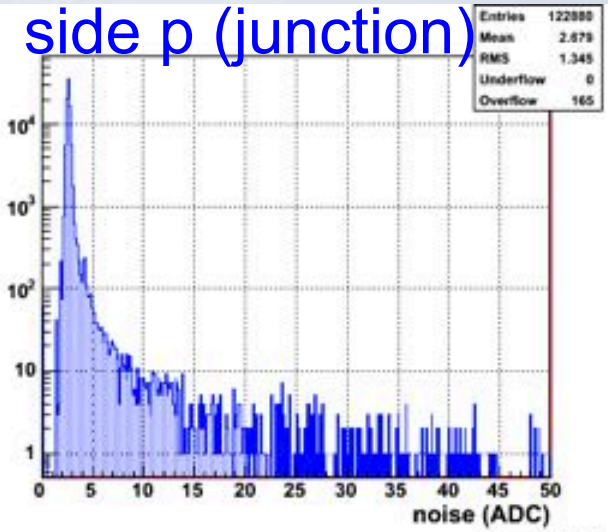

Cape Canveral, KSC - May 16, 2011 @ 08:56 AM

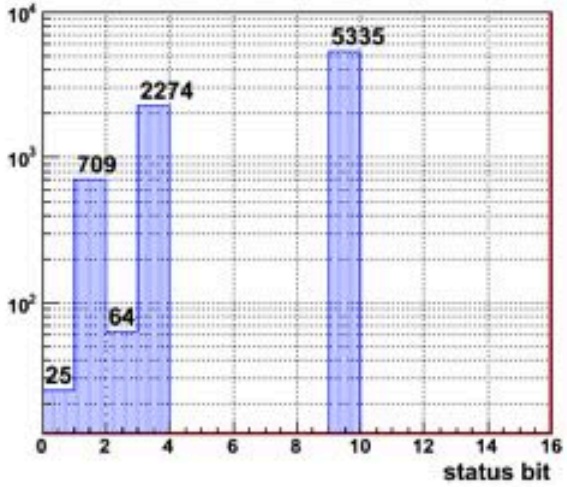

toring interface
GTSN
Until now or
JPD-A
JPD-B
CHECK
MPD @ TMPD2
M
GPS
TT
TTCBP
TTCBS
UGPD
UG
CCEB Signal Side
CCEB Power Side
UPD0
U0
UPD1
U1
SPDo @ TSPD1
S0
SHV0
SPD1 @ TSPD3
S1
SHV1
SPD2 @ TSPD4
S2
SHV2
SPD3 @ TSPD6
S3
Everything OK
2.5 h after the launch
SAMSUNG

First Tracker calibration in space

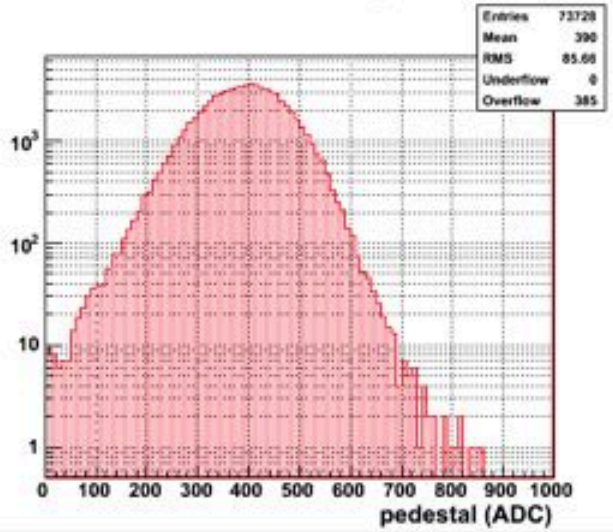
side p (junction)

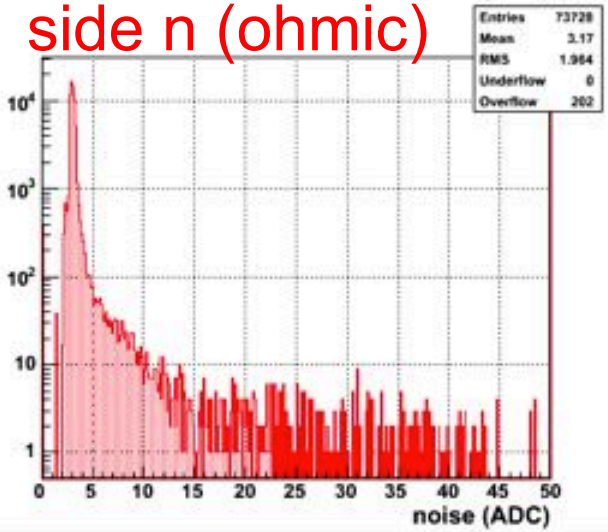


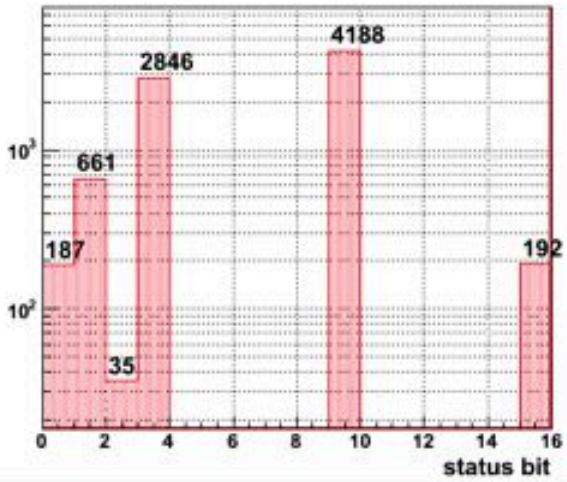




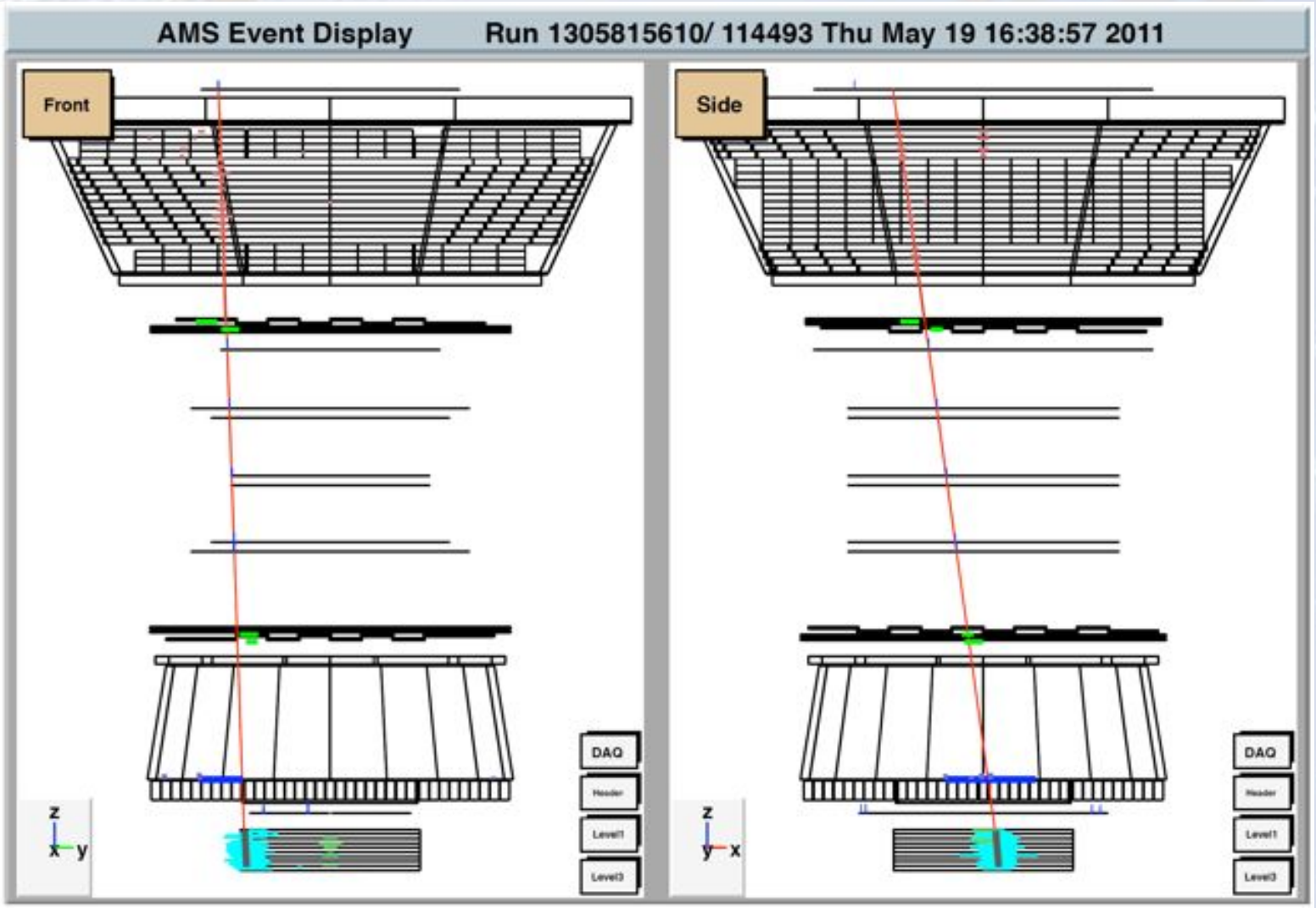
side n (ohmic)



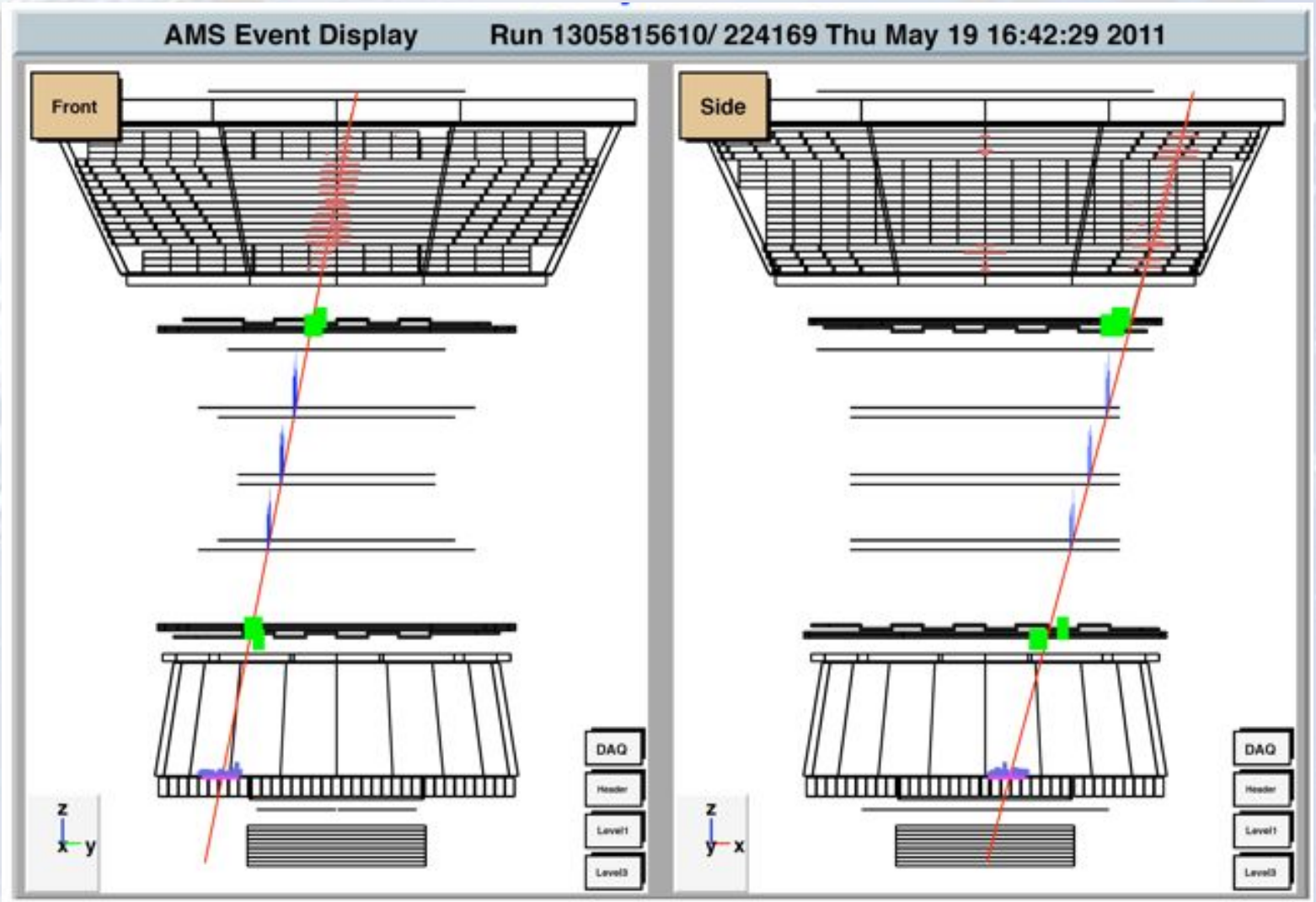




Data from the 1st few minutes – 20 GV/c Electron, 19 May 2011

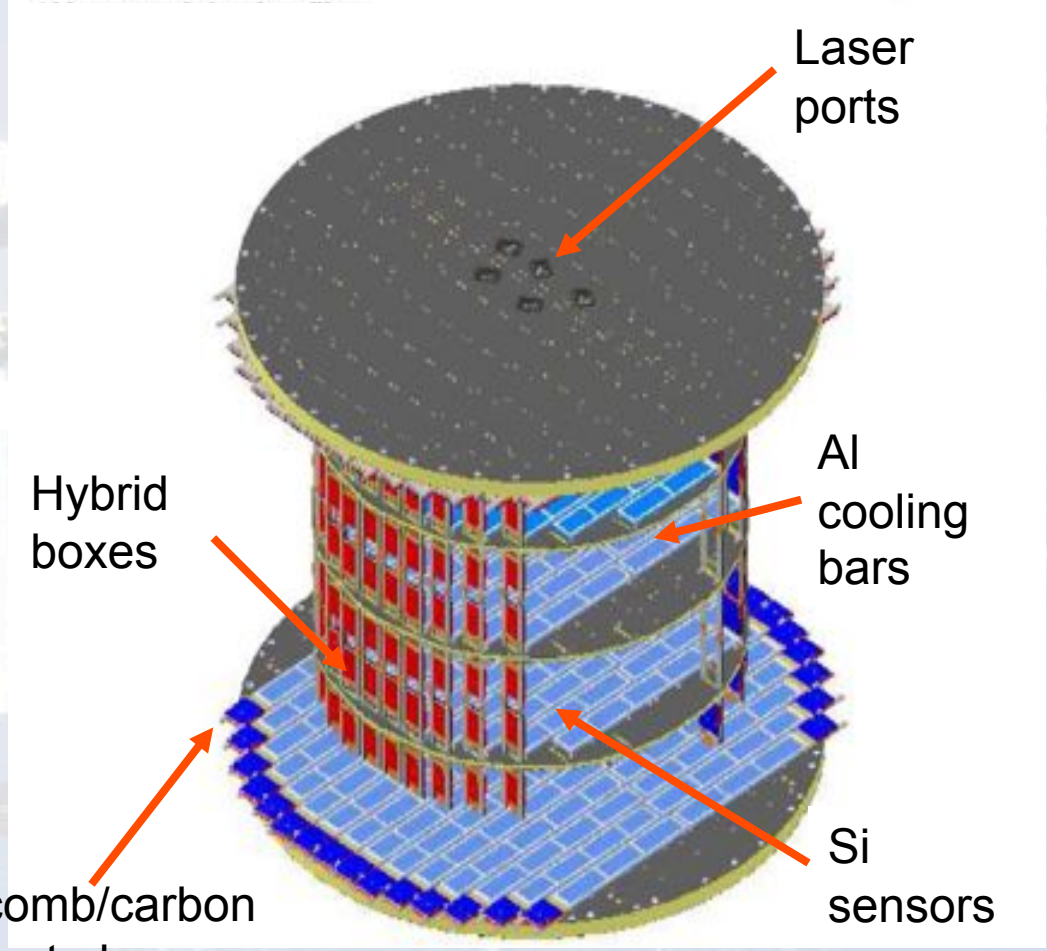


Data from the 1st few minutes – 42 GV/c Carbon, 19 May 2011



Silicon Tracker

- 9 layers of double sided silicon detectors arranged in 192 ladders
- 6 honeycomb carbon fiber plane
- detector material ~ 0.04 Xo
- total of 200 kchannels for 192 watt dissipated inside the magnet volume
- 10 μm (30 μm) spatial resolution in bending (non bending) plane
- momentum resol ~10% at 10 GeV
- high dynamic range front end for charge measurement
- wide temperature range (-20/+40 survival, -10/+25 oper.)



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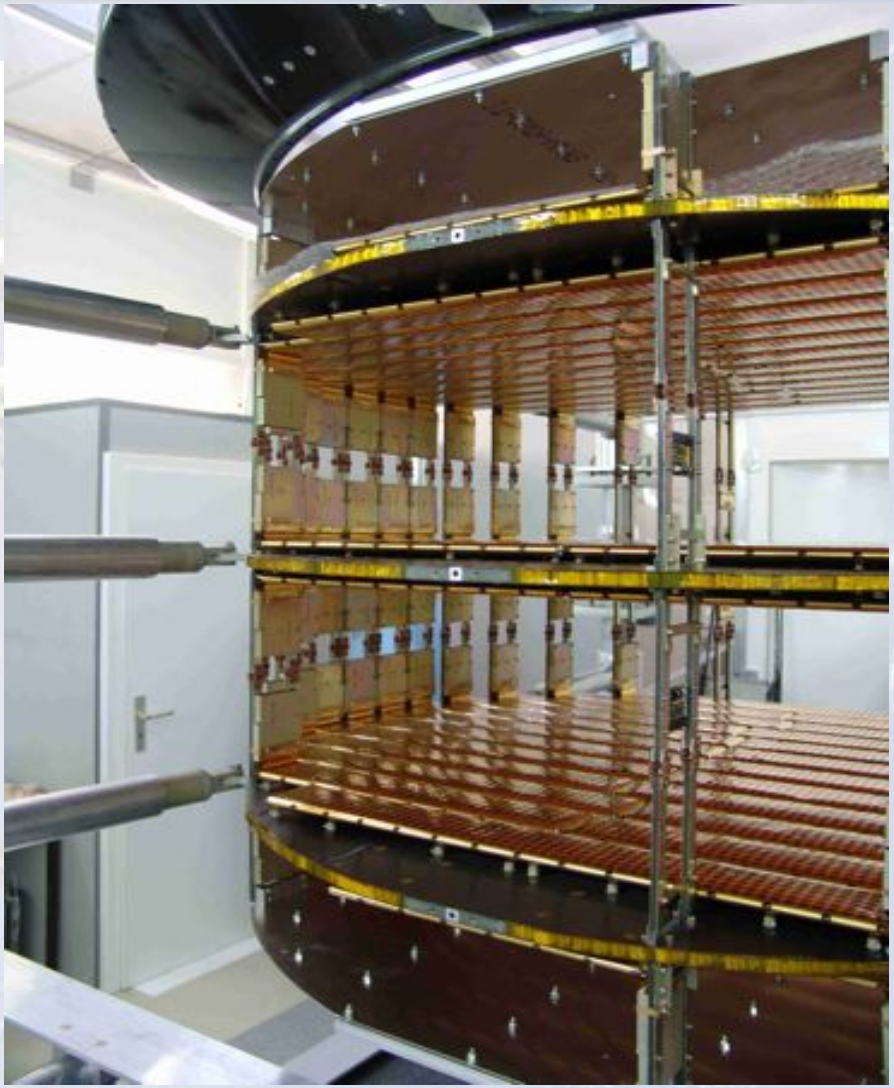
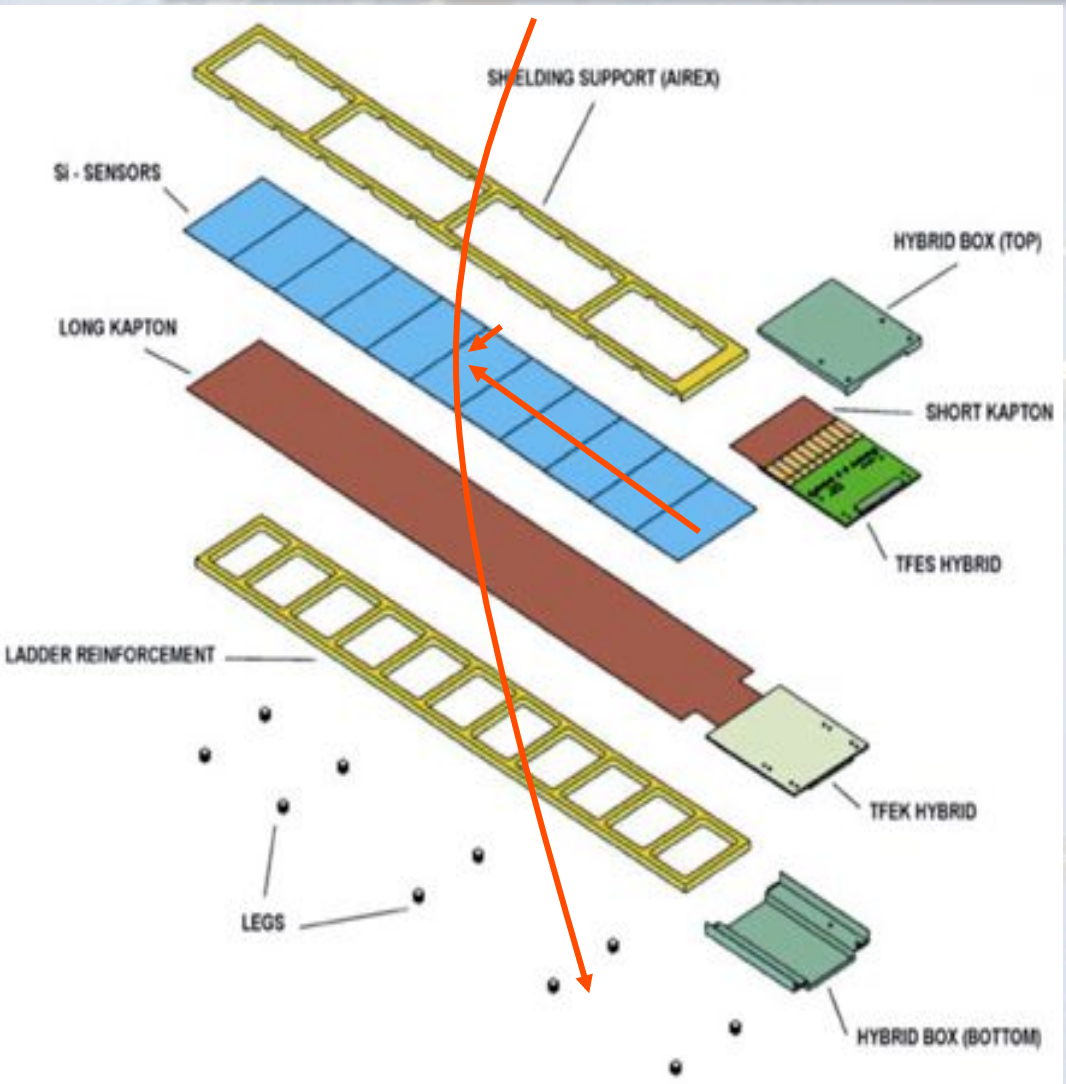


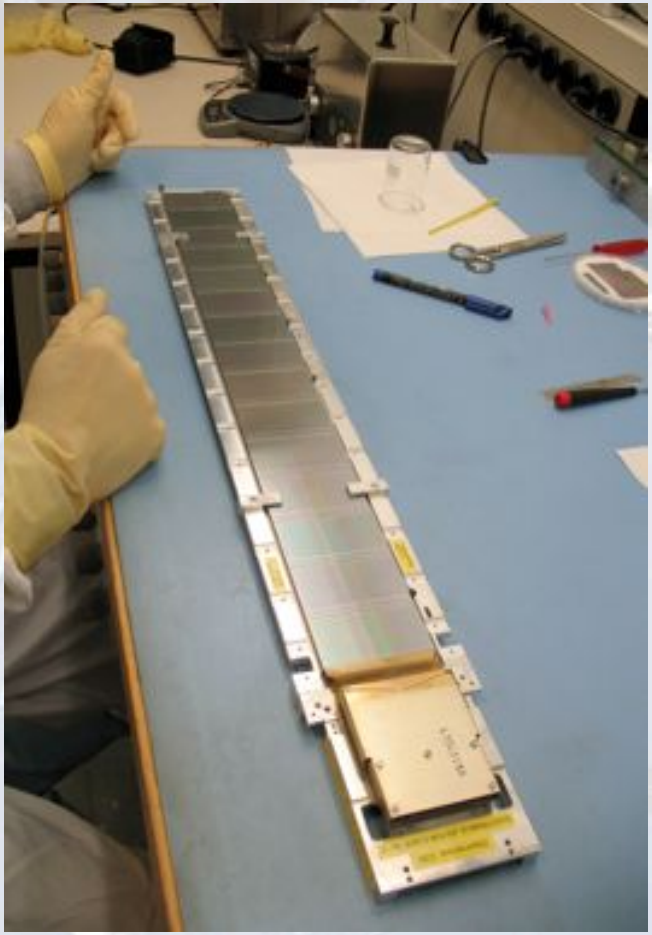
AMS silicon ladders



- 1024 high dynamic range, AC coupled readout channels:
  - 640 on junction (S) side
  - 384 on ohmic (K) side
- Impl/readout pitch:
  - 27.5/110 μm (S side)
  - 104/208 μm (K side)
- 7 – 15 wafers (28 – 60 cm)

192 flight units, 210 assembled in 3 lines:
Perugia (I), Geneva-ETHZ (CH), G&A (Carsoli, I)

AMS silicon ladders



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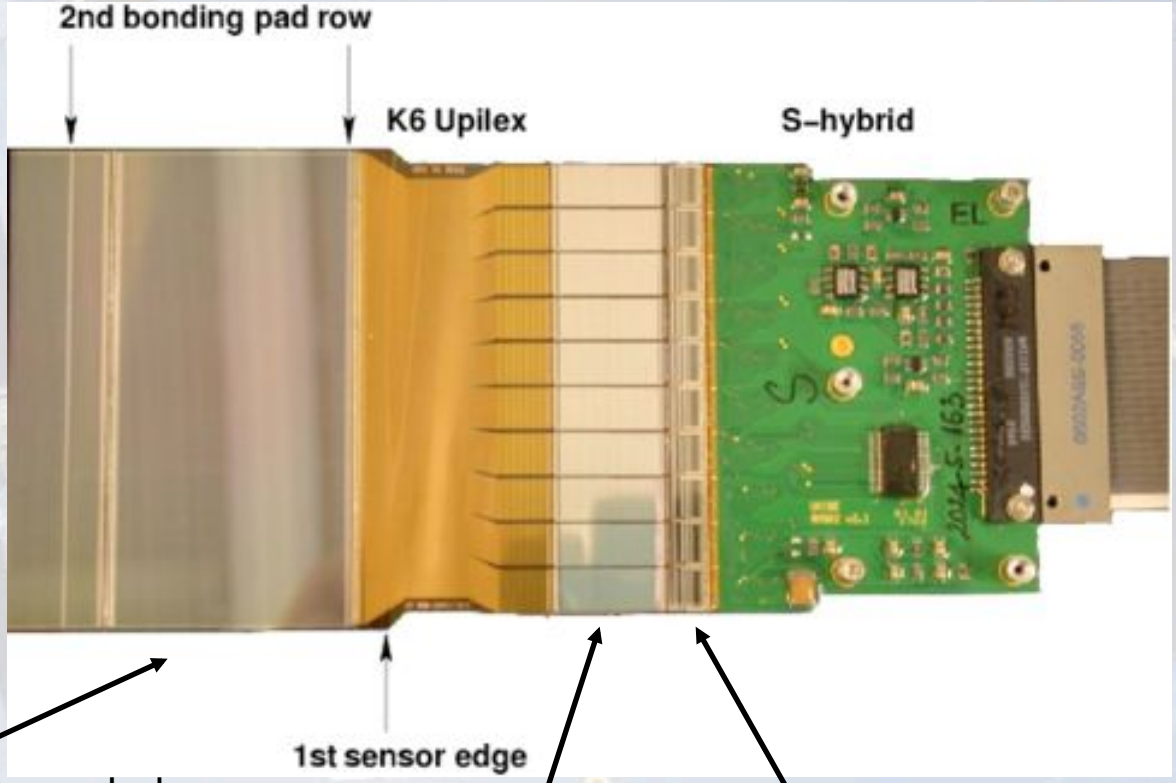
Ladder components (junction/S side)

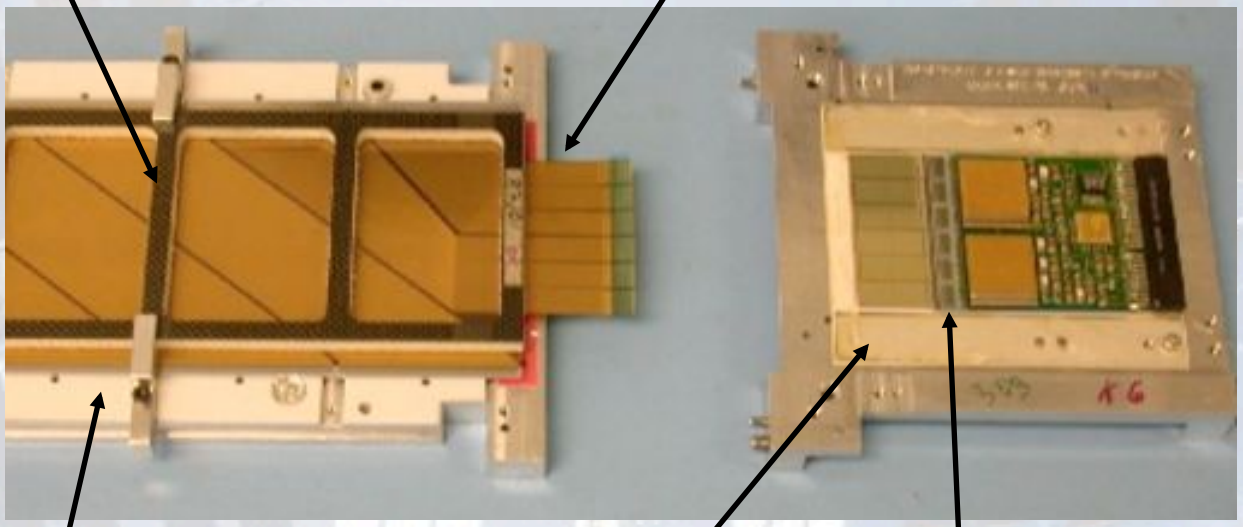


double sided, DC coupled
300 μm thickness
7 - 15 sensors in a ladder
produced at:
- Colybris (CH)
- IRST (IT)

700 pF coupling capacitances

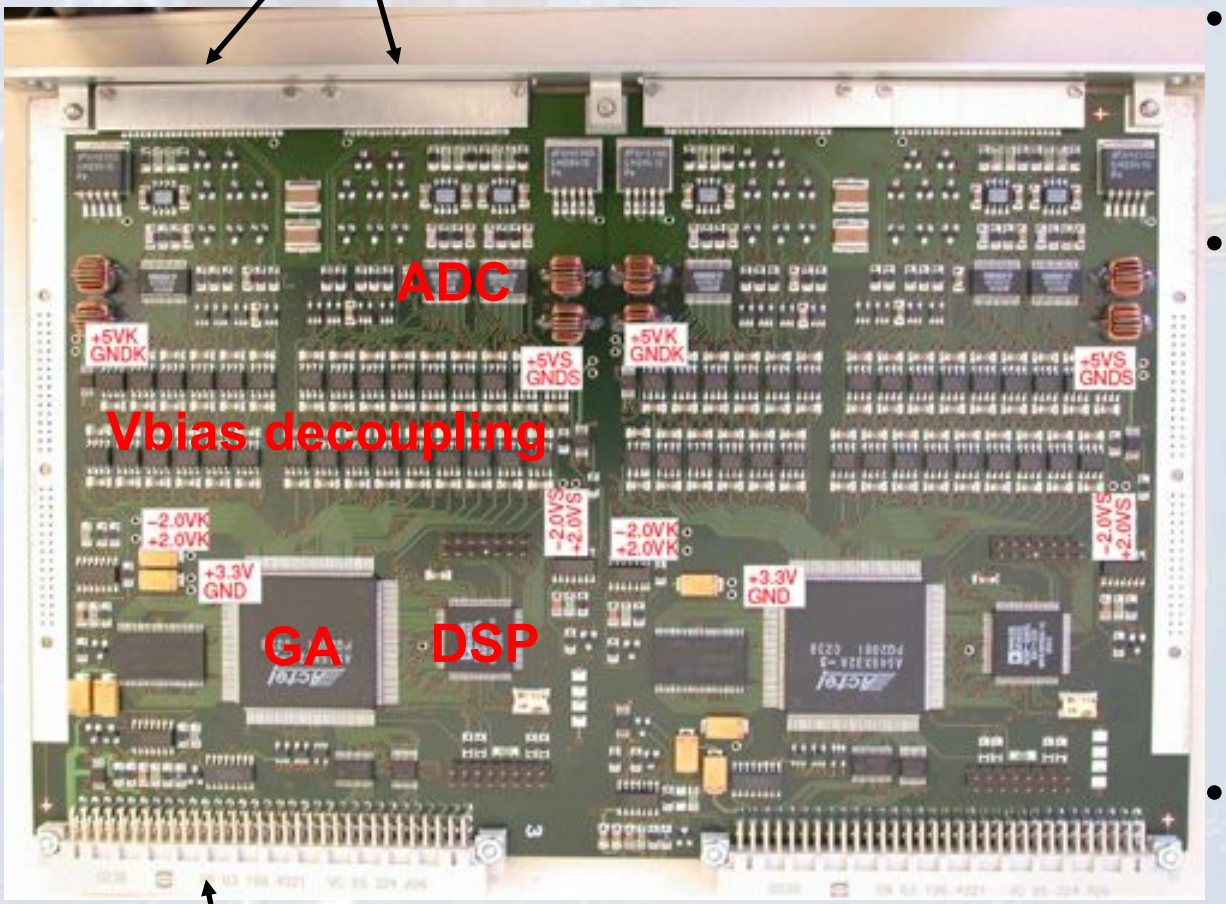
10 VA_hdr64a (IDEas, NO)
640 channels, 0.7 mW power each
CR-RC shaper and S&H
4 μs shaping time
100 MIP dynamic range

Ladder components (ohmic/K side)



Data Reduction Board (TDR2)

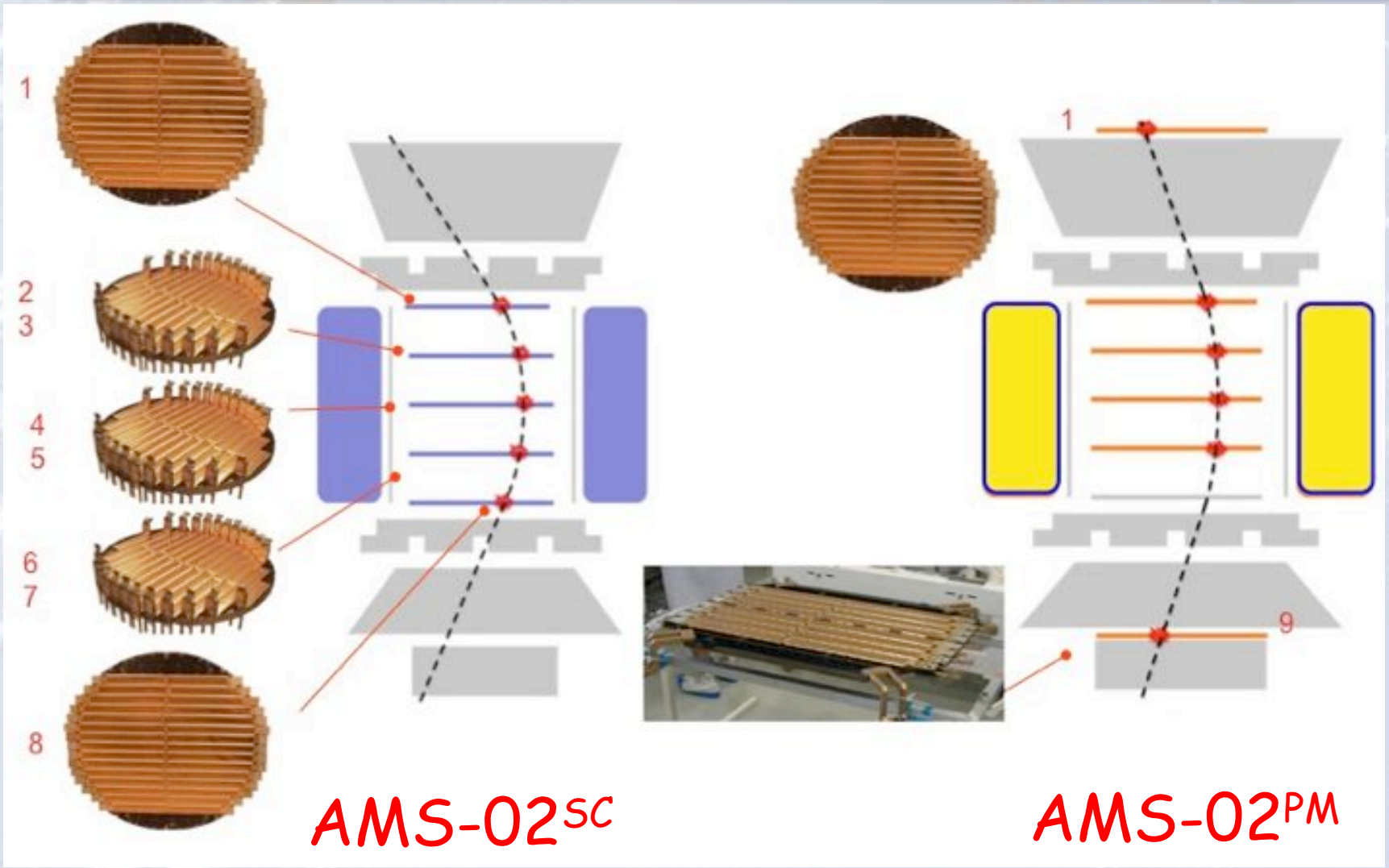
analog signal in from a ladder



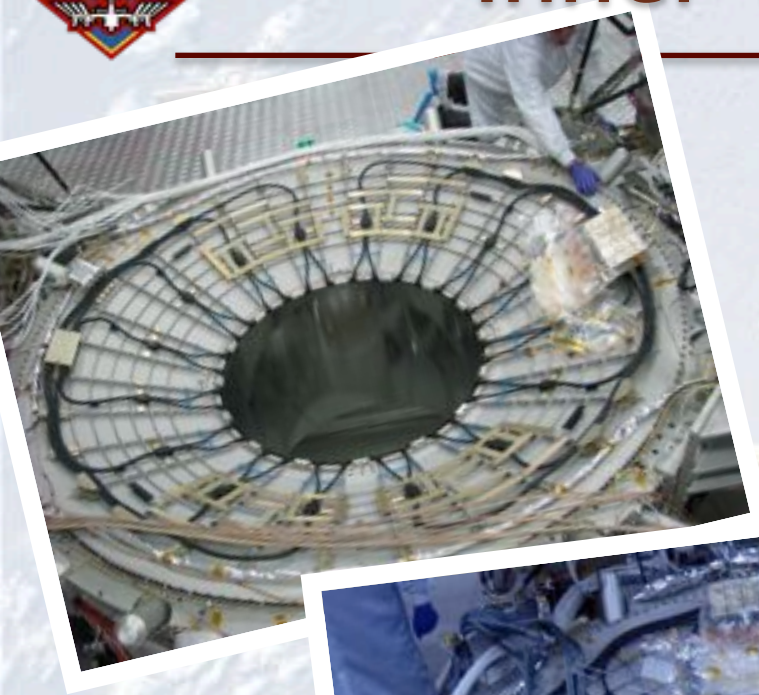
compressed digital out to crate backplane

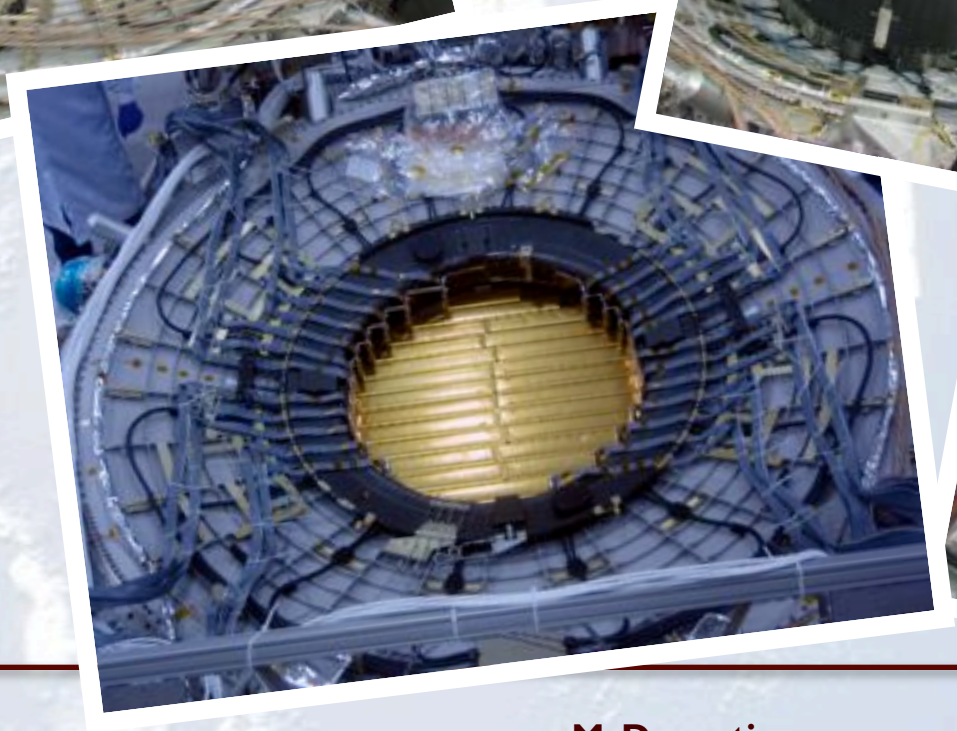
- Collect analog data and digitize it (90 μs irred. dead time)
- Perform online data compression
  - Remove Pedestals
  - Calculate and Remove Common Noise
  - Search Clusters
- Up to 5 KHz trigger rate in compressed mode

Layout modification to use the permanent magnet



Inner Tracker integration

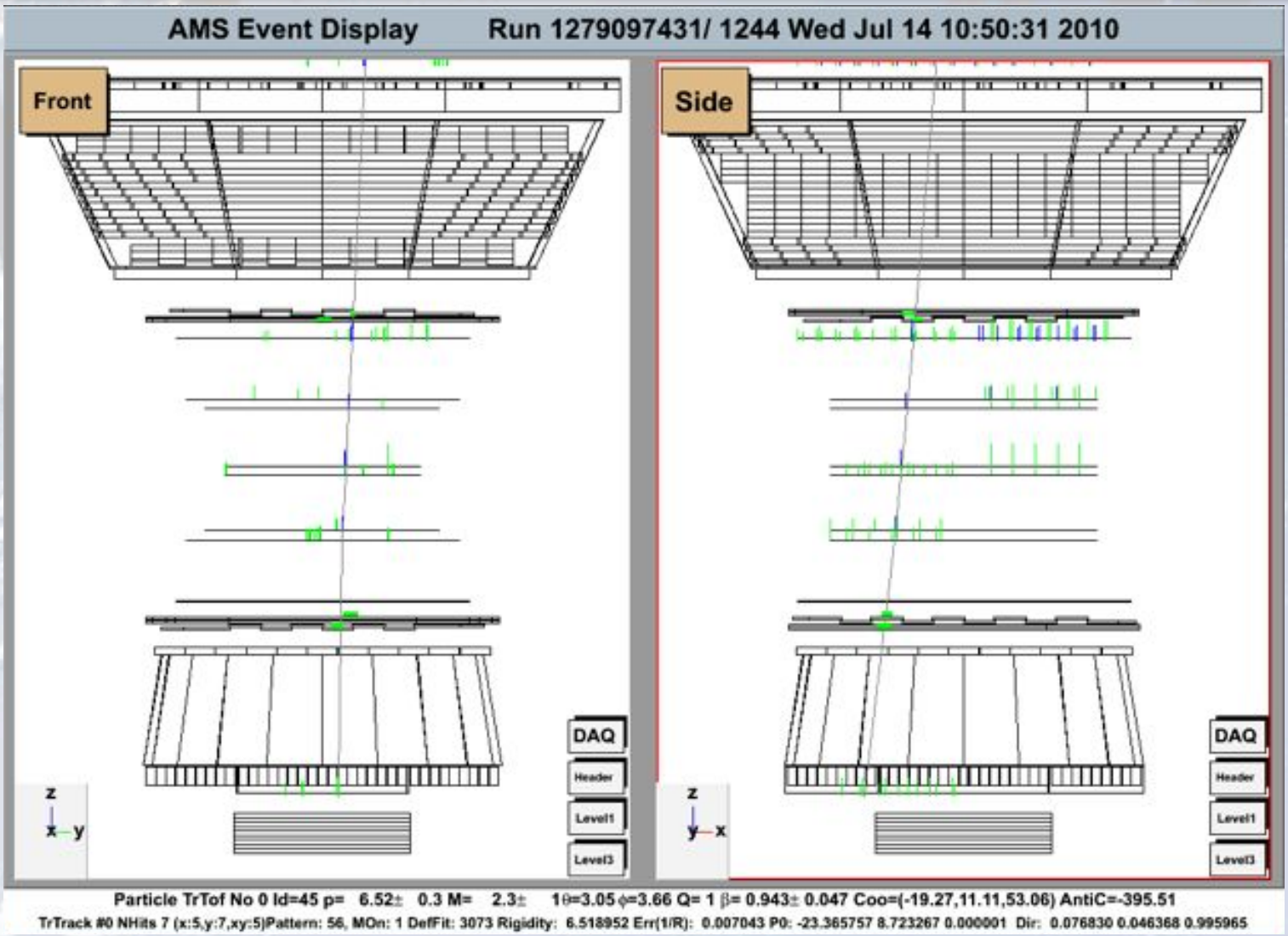




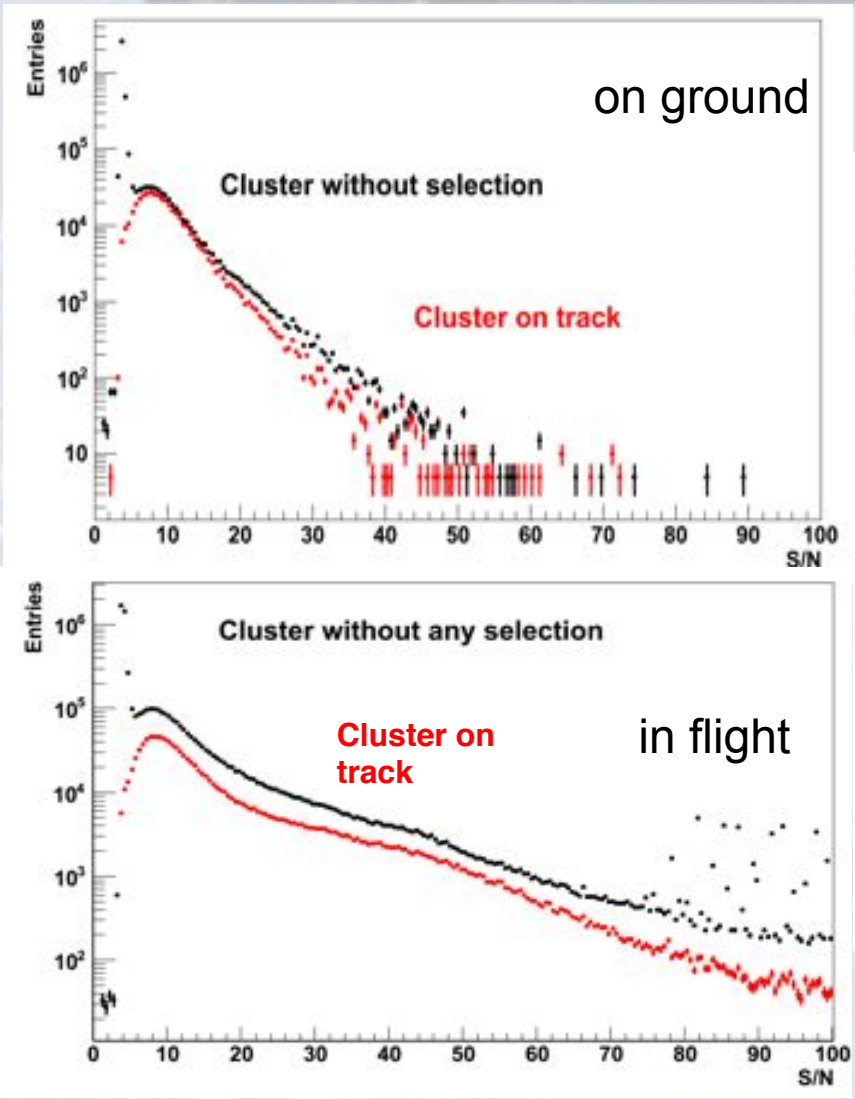
Outer plane integration

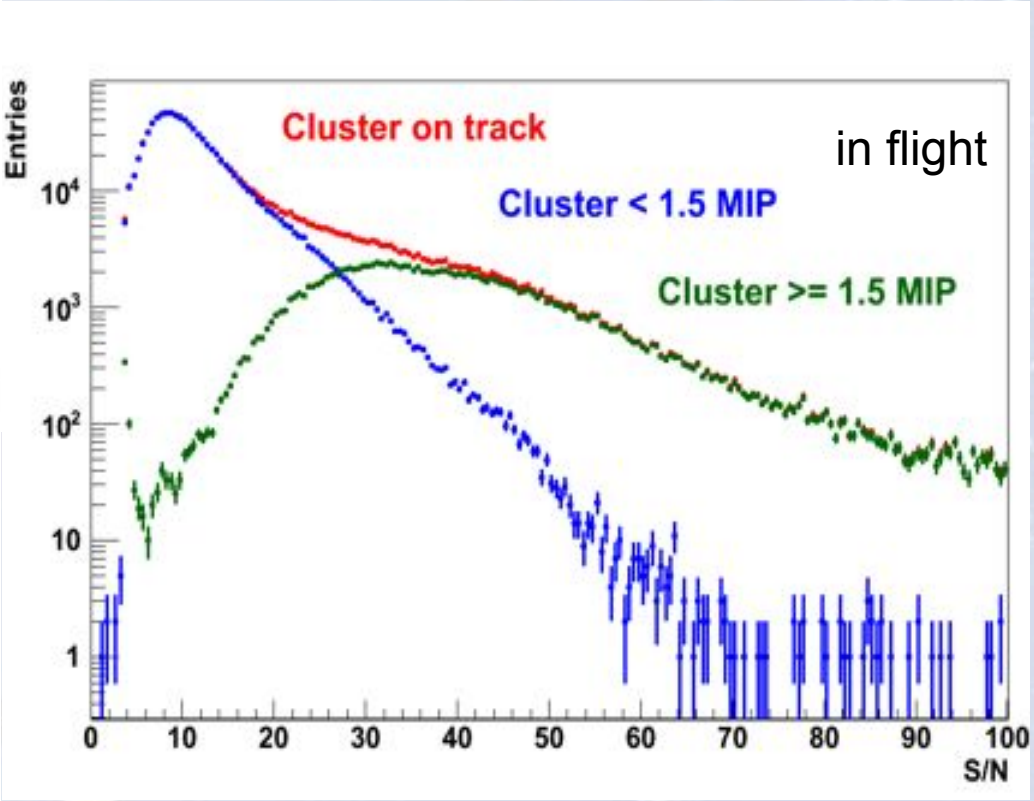
External planes integration

First muon with the "new" Tracker



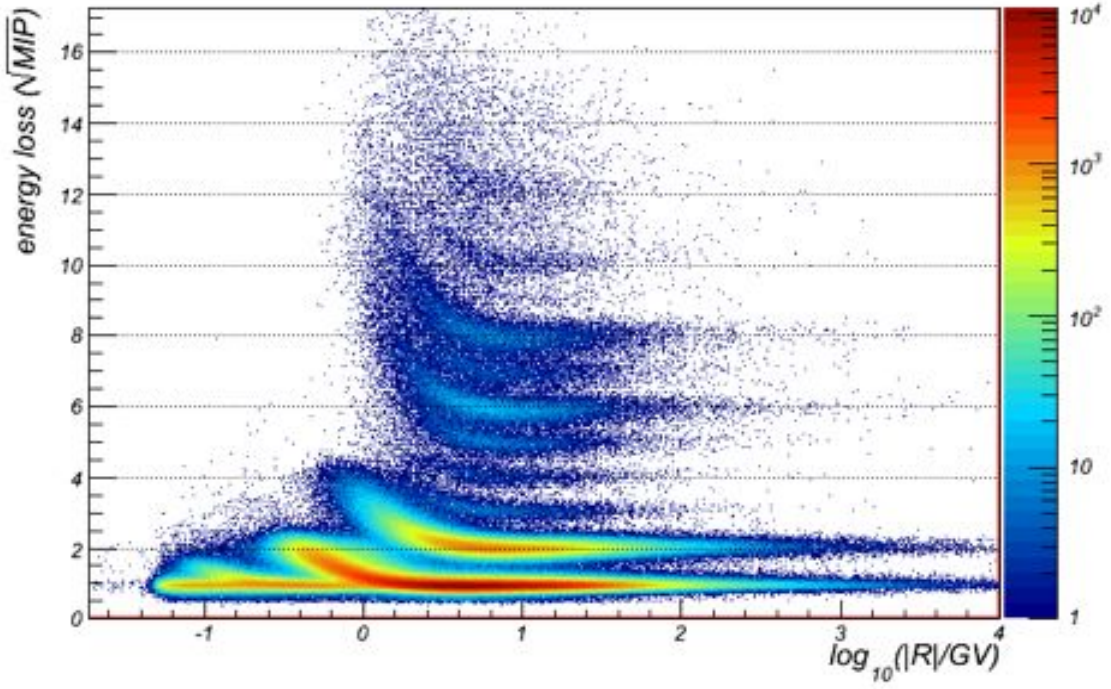
Tracker signals

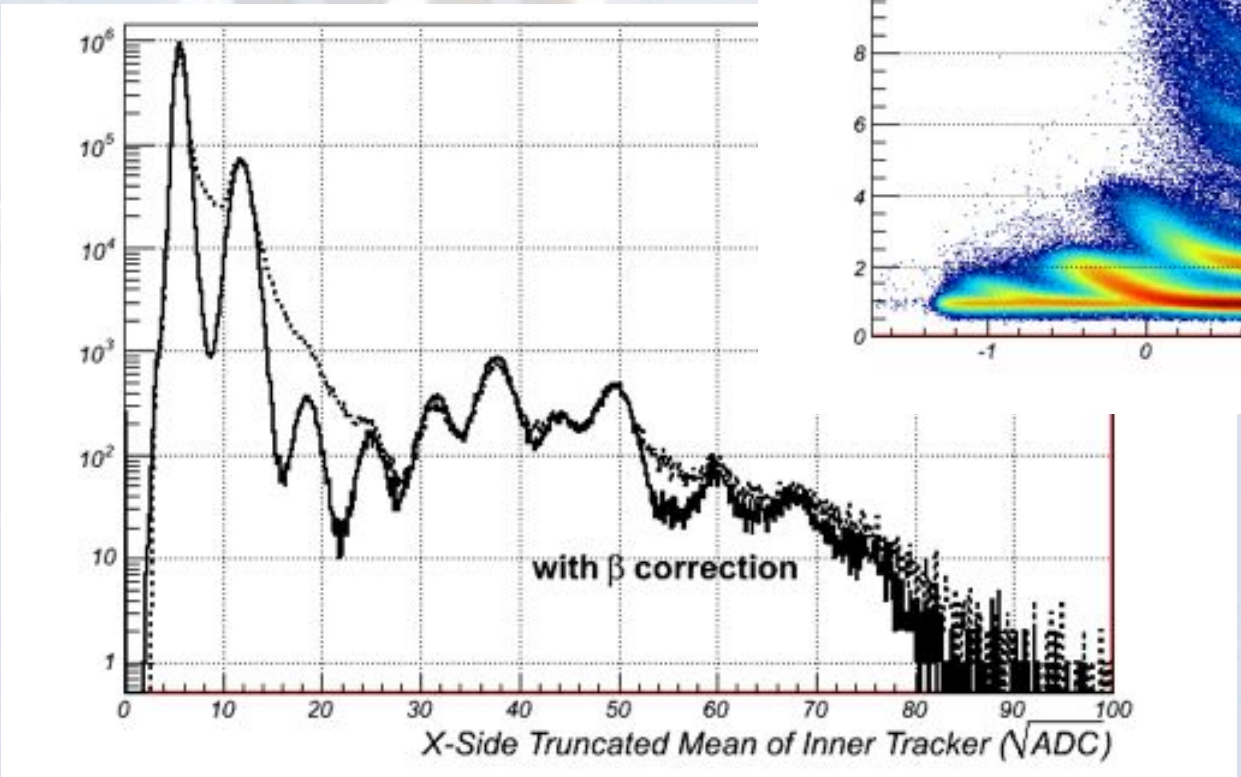




The particles we see

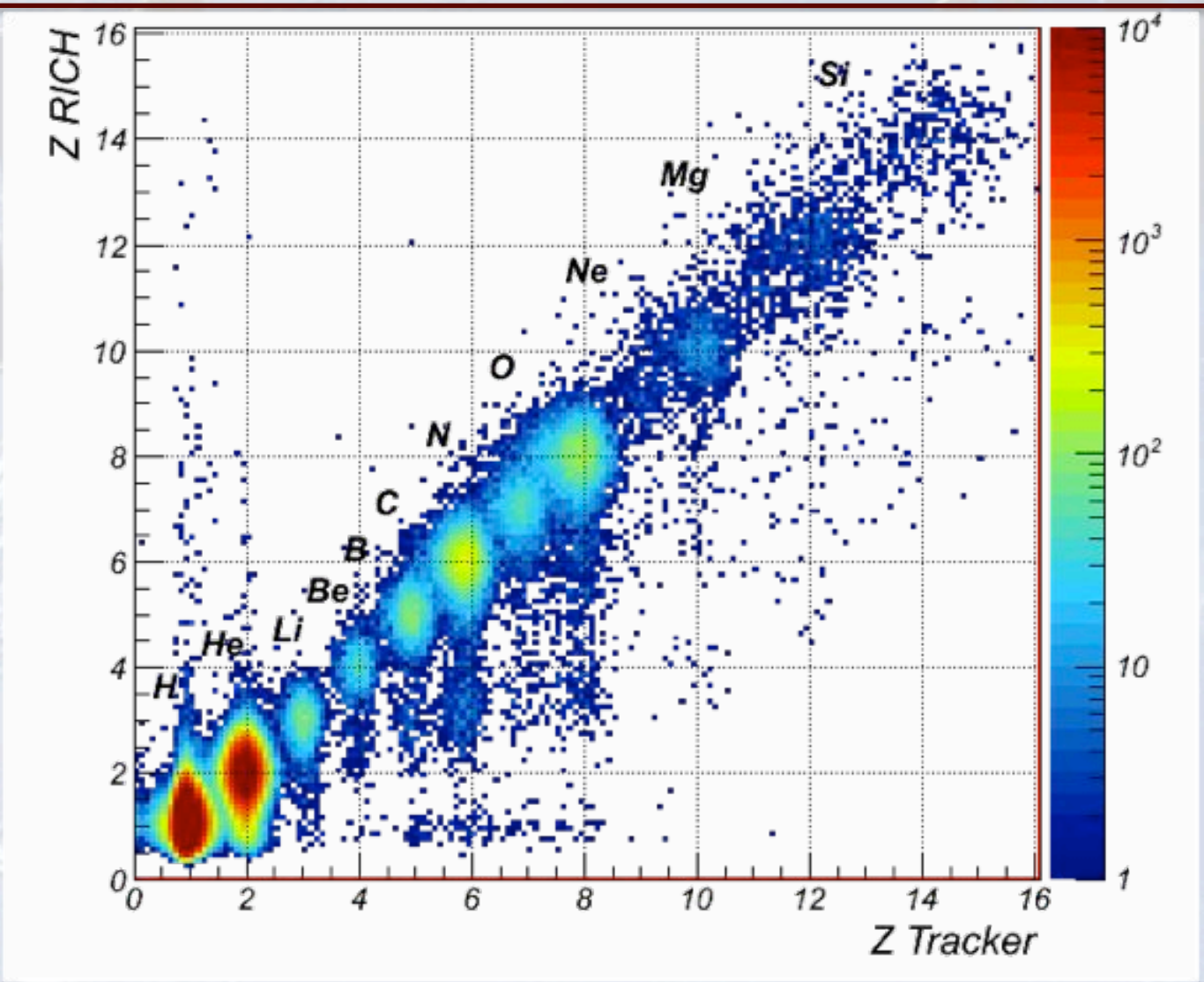
dE/dx vs Rigidity



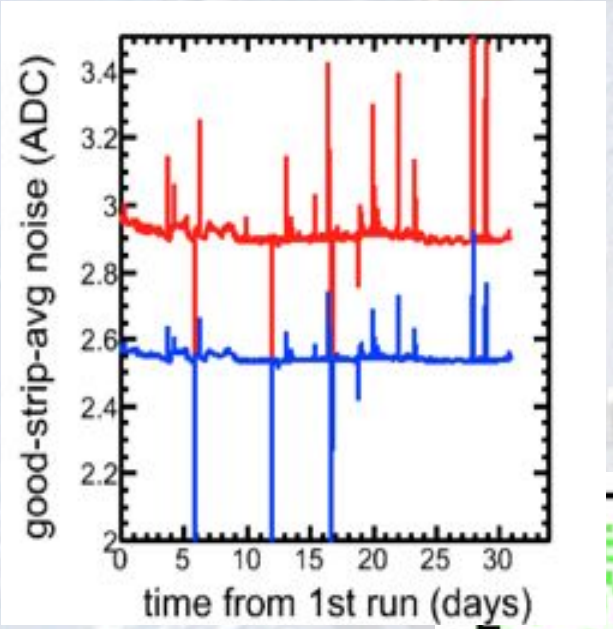


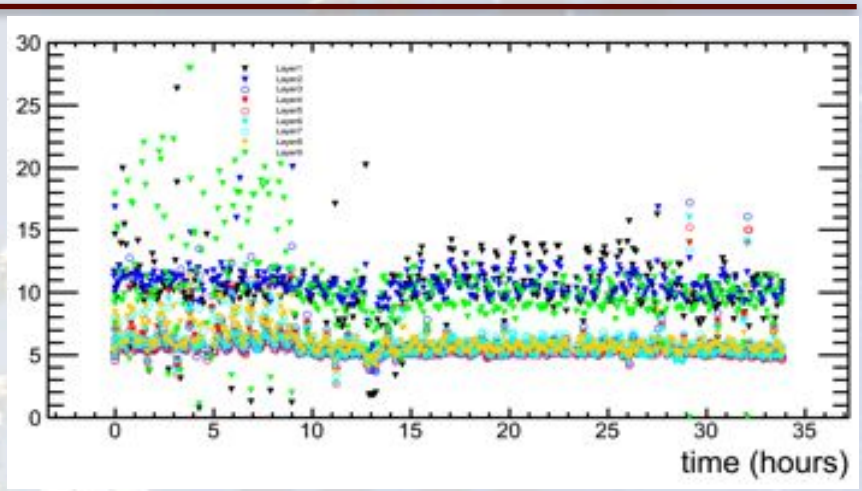
Truncated mean of the dE/dx in the Tracker

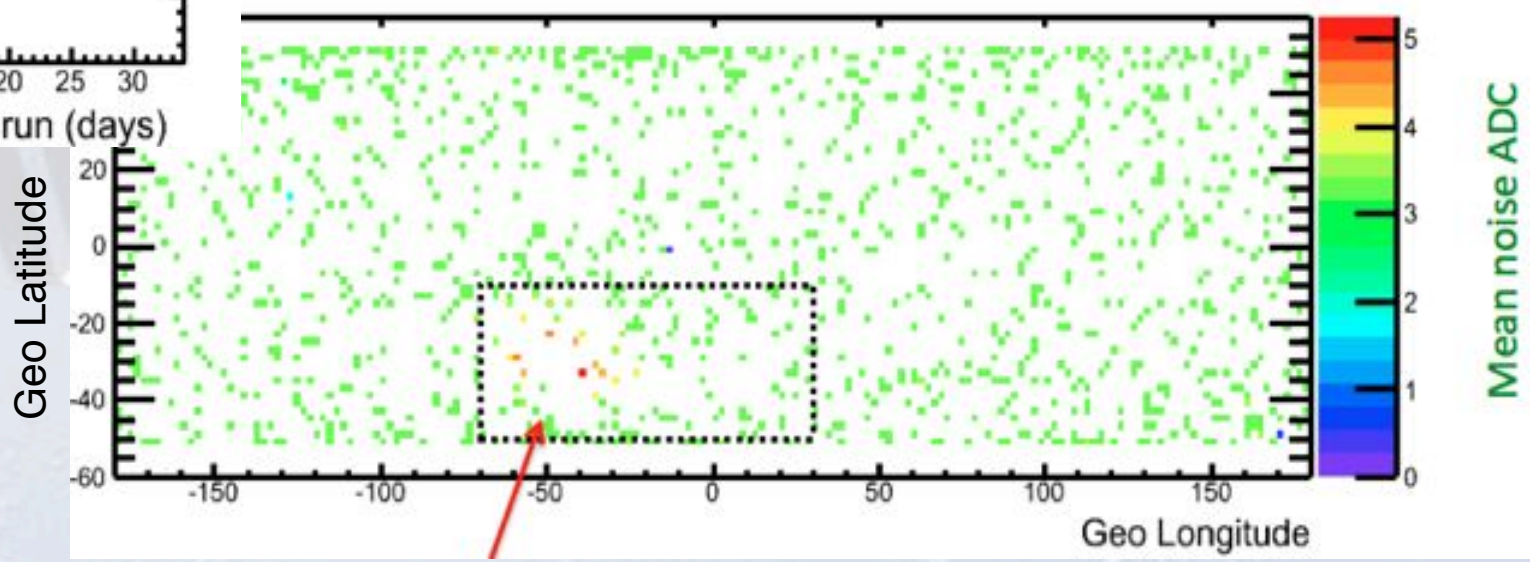
The particles we see



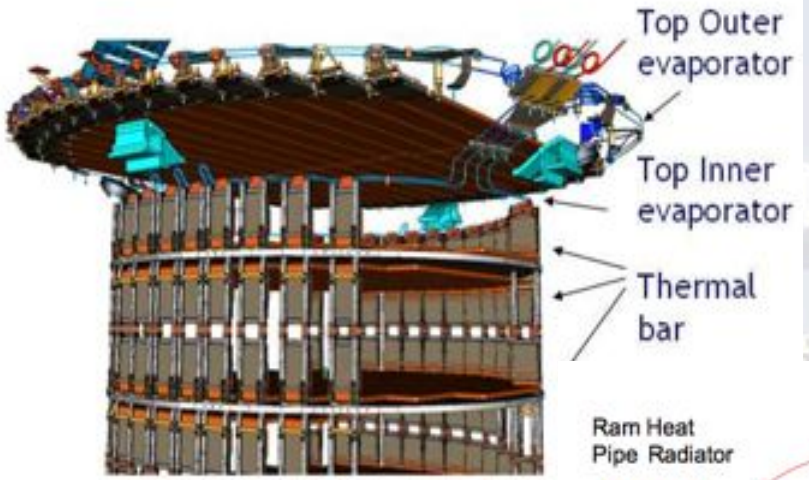
In flight experience



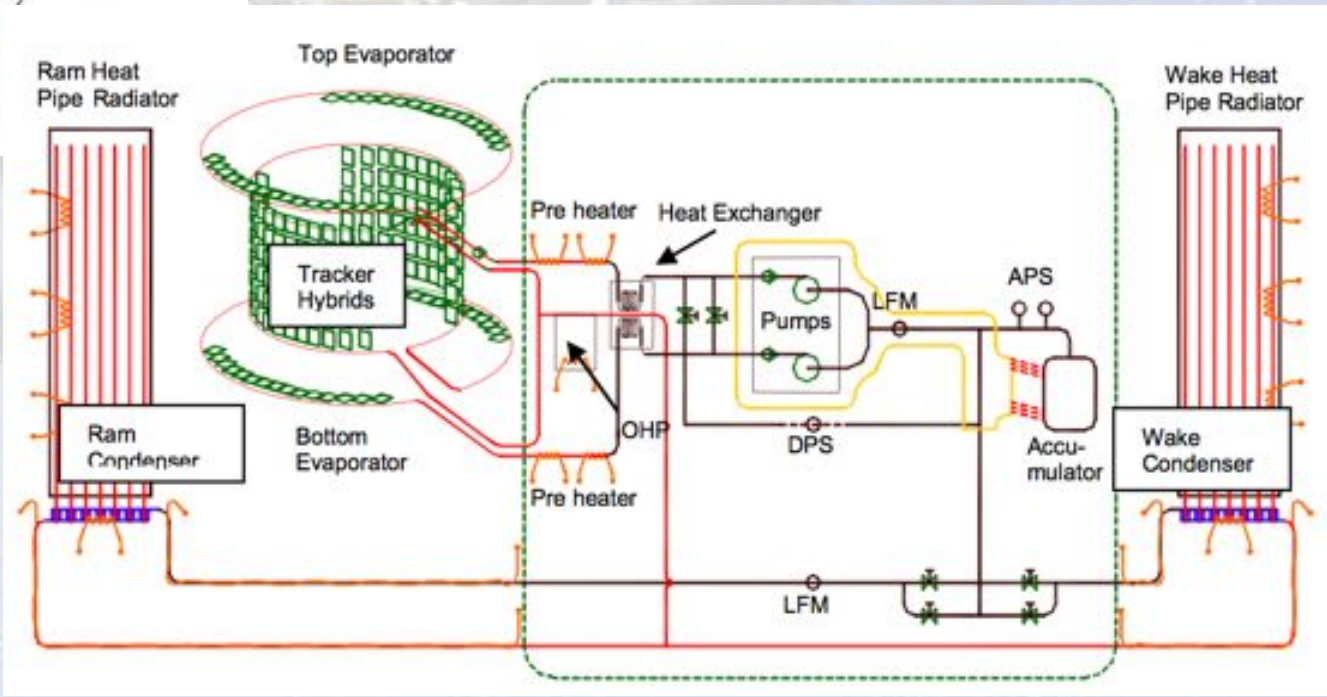




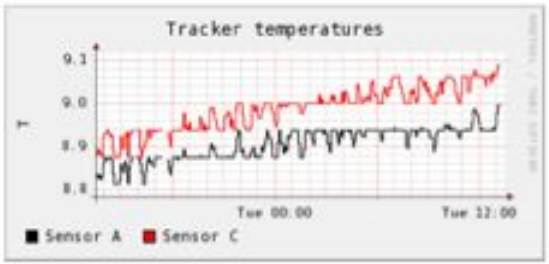
Cooling: 2 phases CO_2 pumped loop

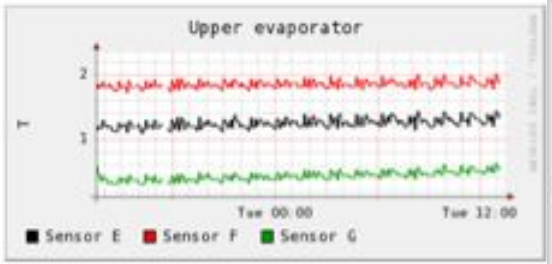


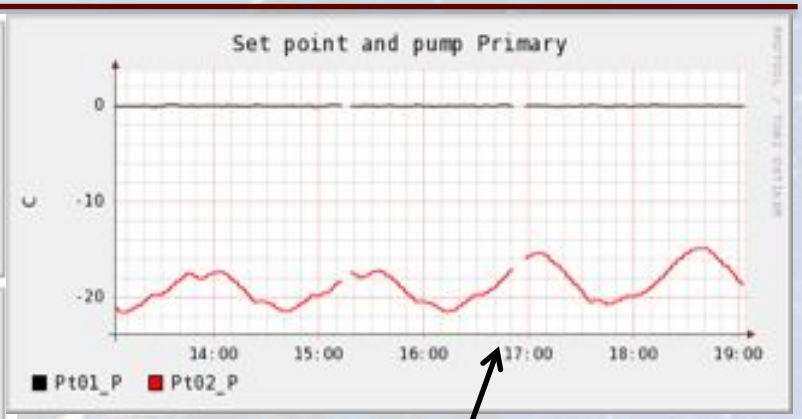
Tracker Thermal Cooling System (TTCS)

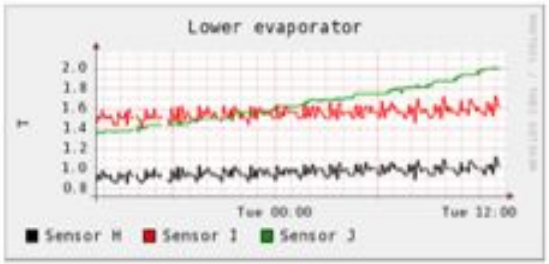


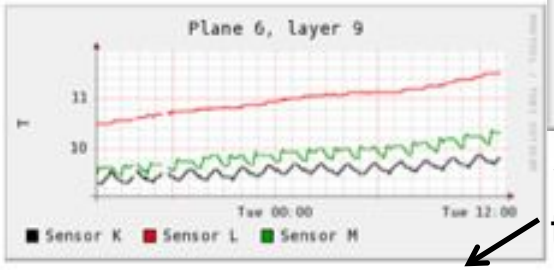
In flight experience: cooling and currents



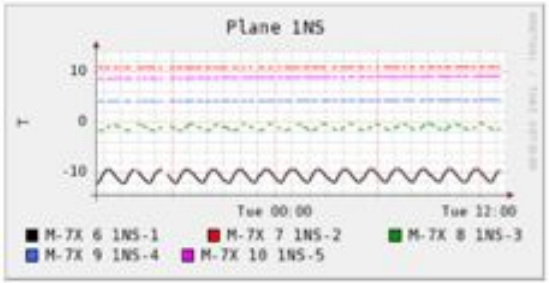


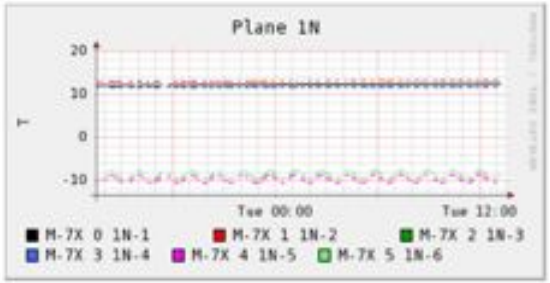


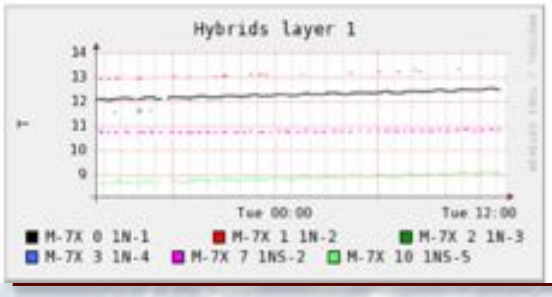


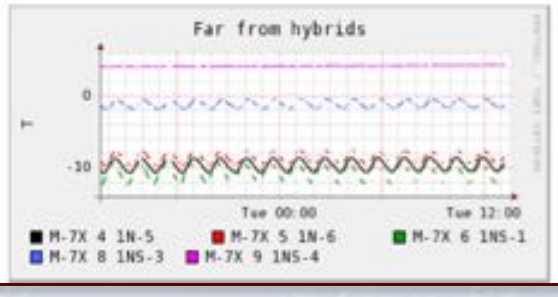


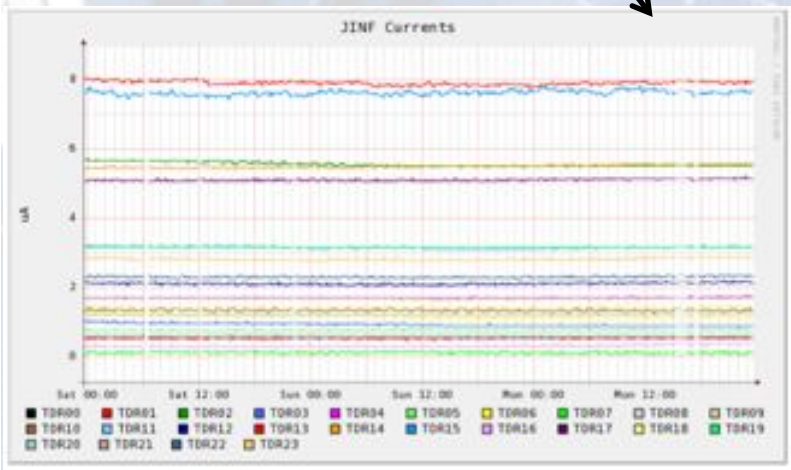
- ✓Tracker and TTCS temperatures
- ✓Crates and ladders currents



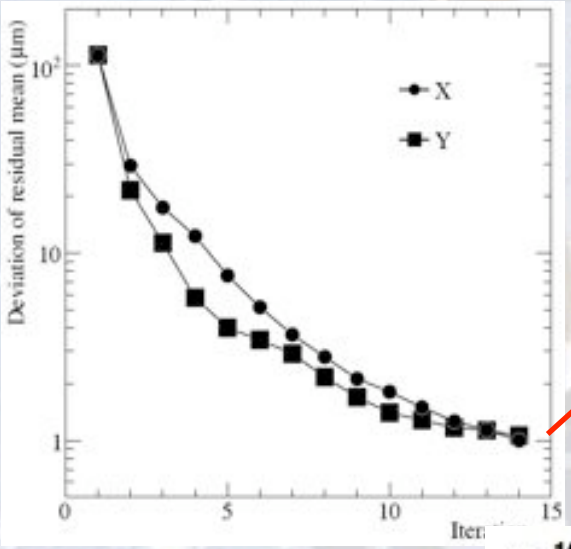


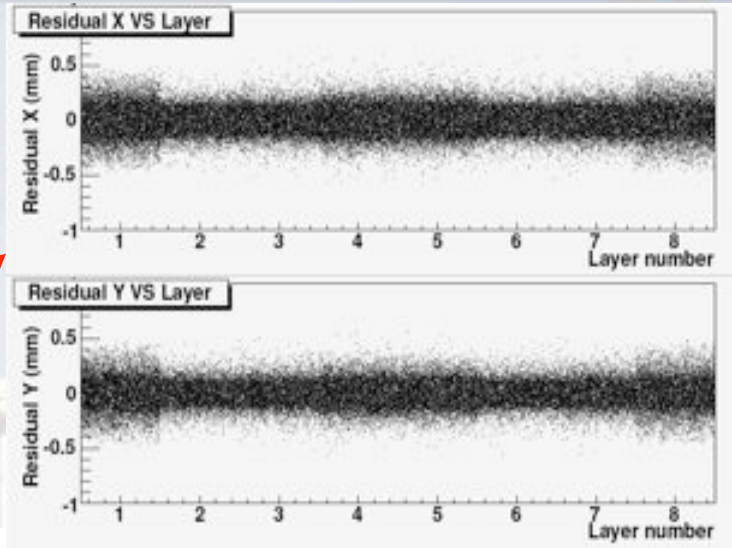




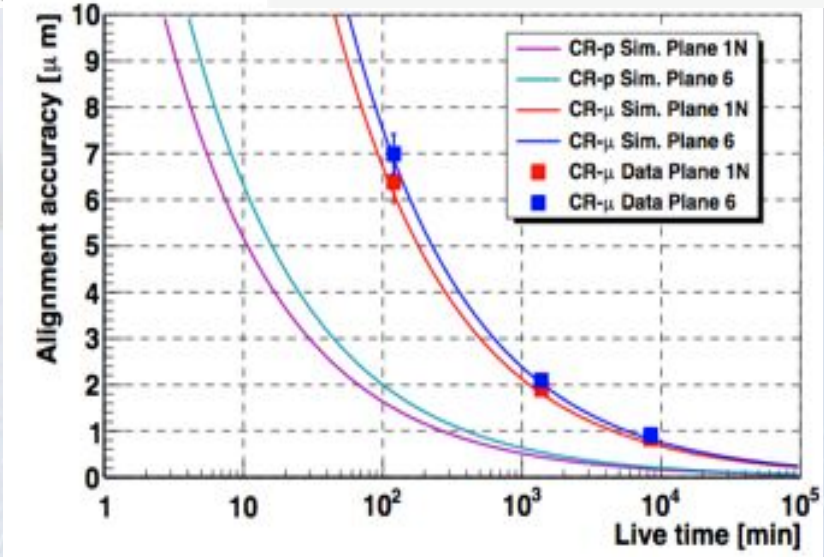


Experience to come: alignment



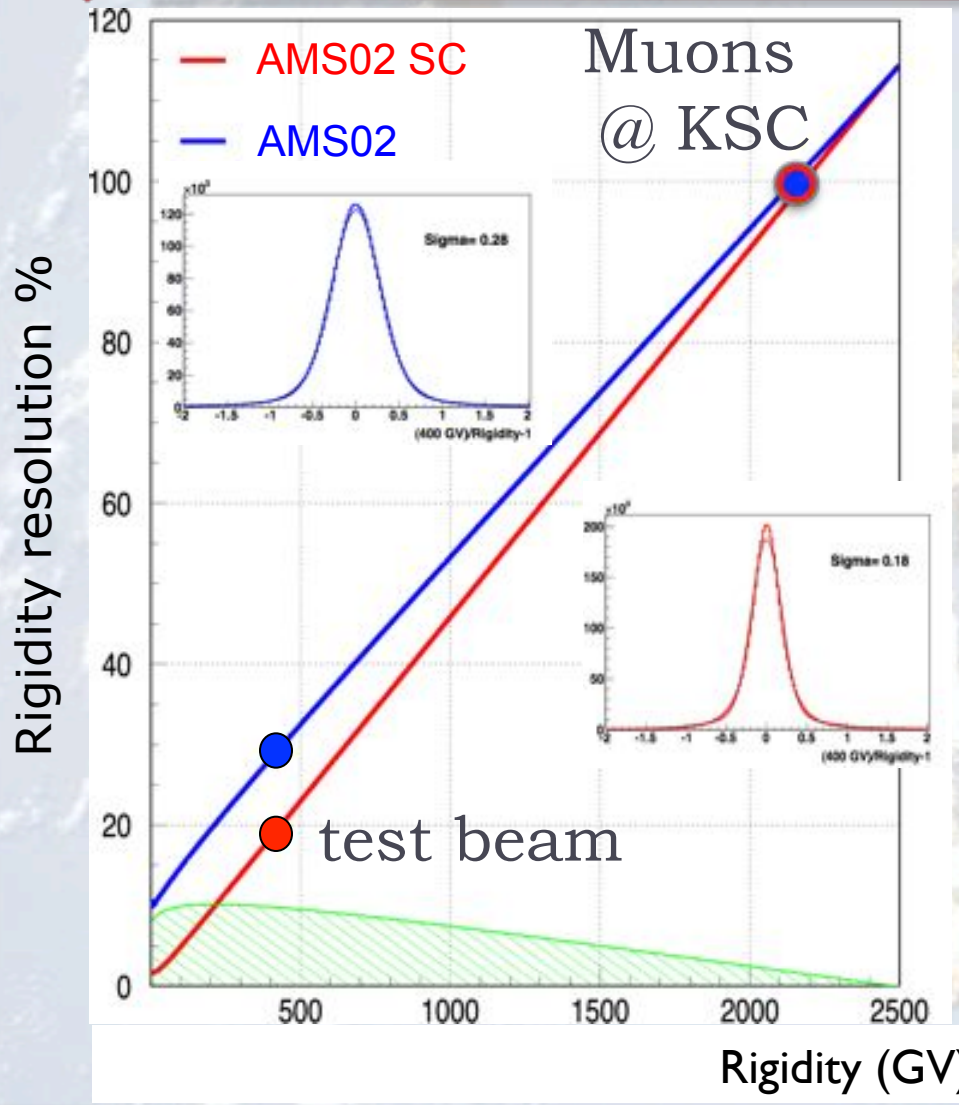


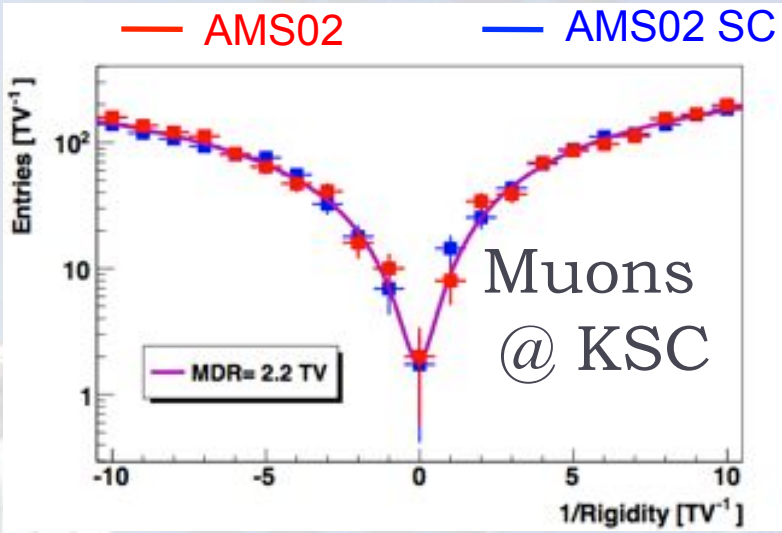
on ground results
inner planes

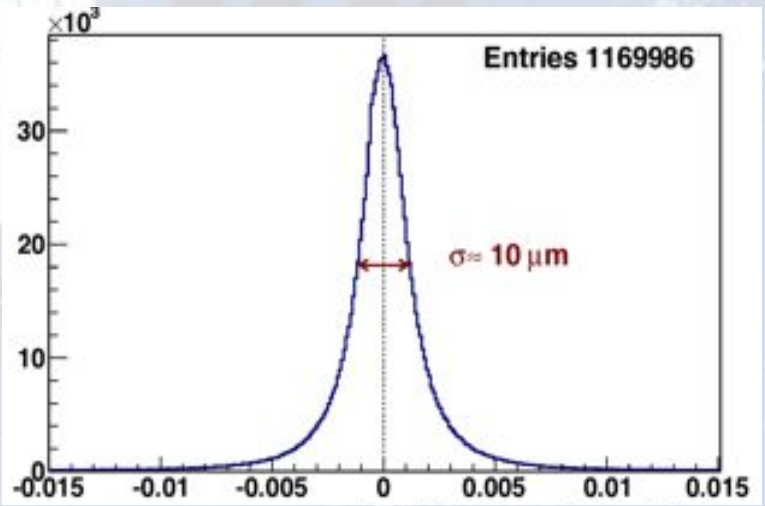


external planes
expected results

The performance we do expect







Conclusions

- AMS02 is in orbit since May 16th 2011
- No damage due to the launch stress or to the space environment, all the system are working in both the primary and redundant part
- All the detectors are properly functioning with DAQ in nominal conditions since May 19th 2011 (> 2 billions triggers)
- Tracker behavior is as expected in term of signal and noise levels
- 10+ years on board the ISS: great discovery potential, lot of work ongoing (alignment!)

Stay tuned for new physics!

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Radiation 'hard' electronics

The problems are the SEE (Single Event Effect)

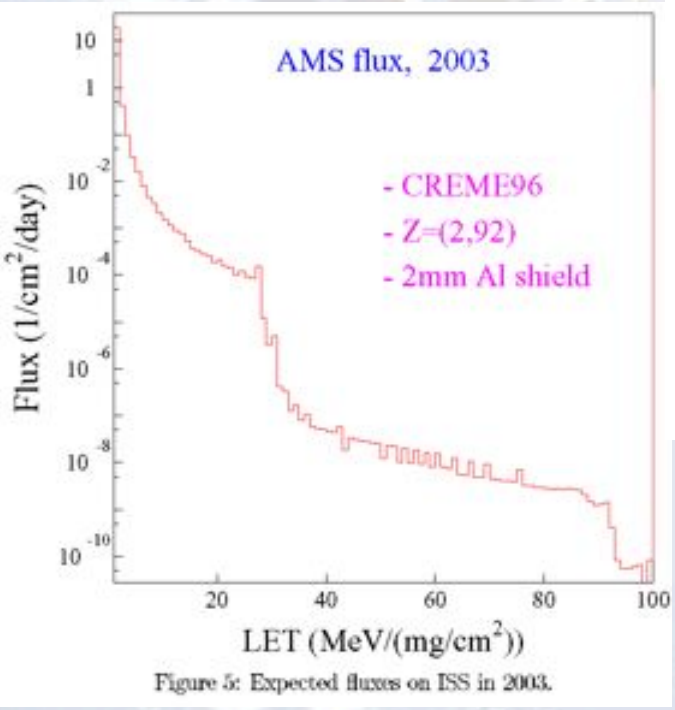
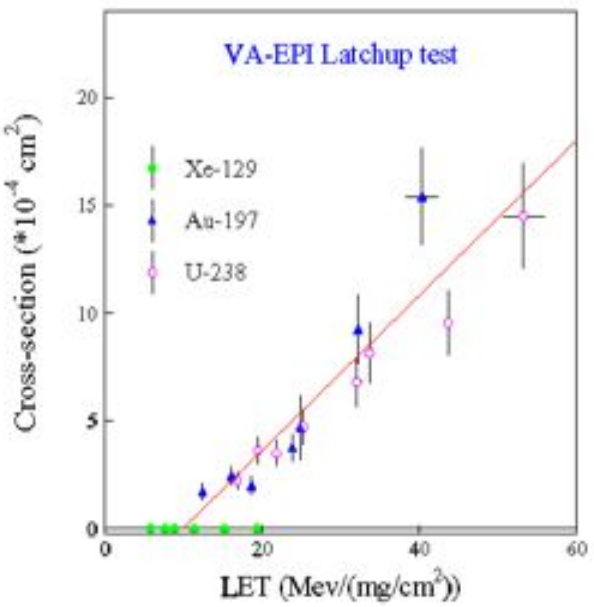


Figure 5: Expected fluxes on ISS in 2003.



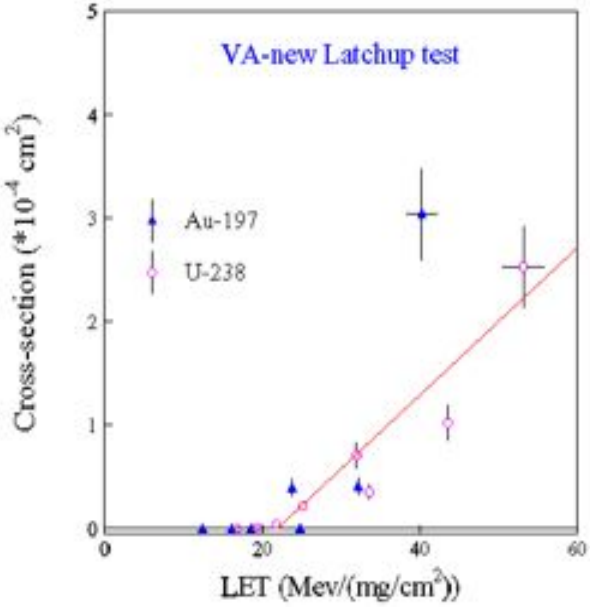


Figure 12: The new VA – SEL rates as measured in GSI

current limit protection is present for all active components