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

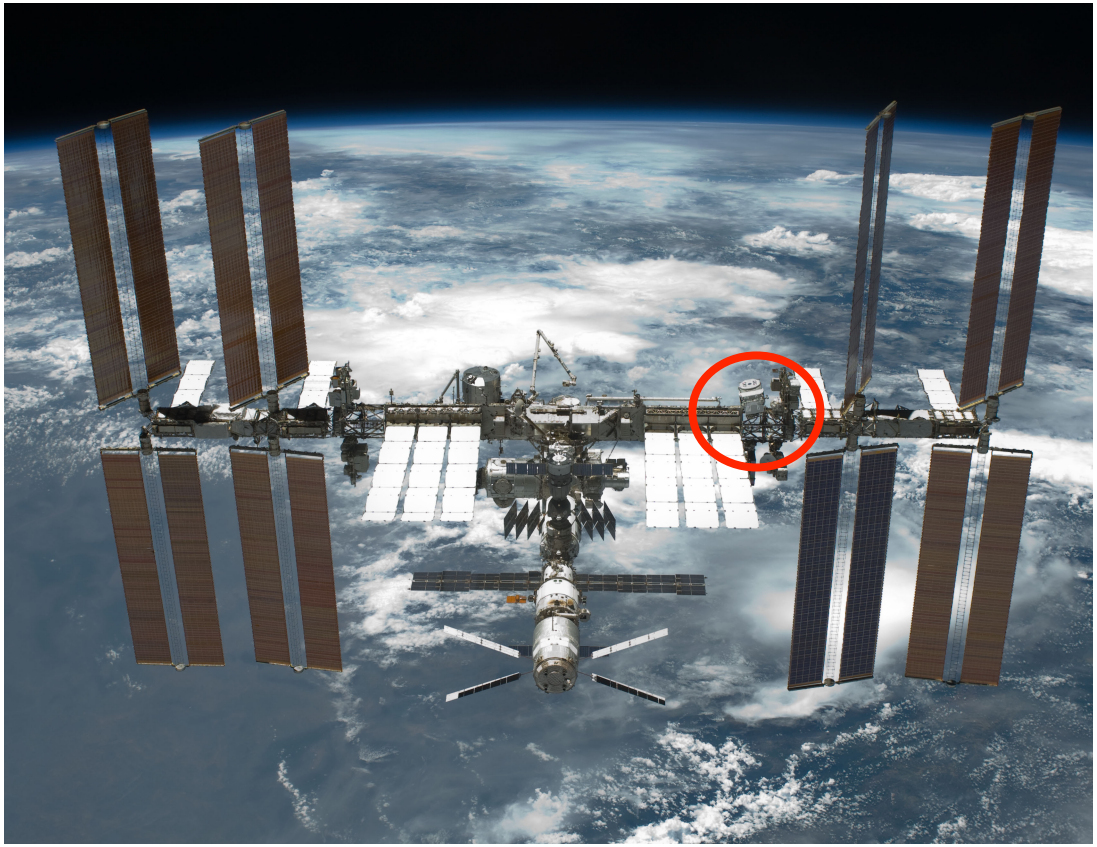
G. Ambrosi

on behalf of the Tracker group

(Perugia INFN and University, Geneva University)

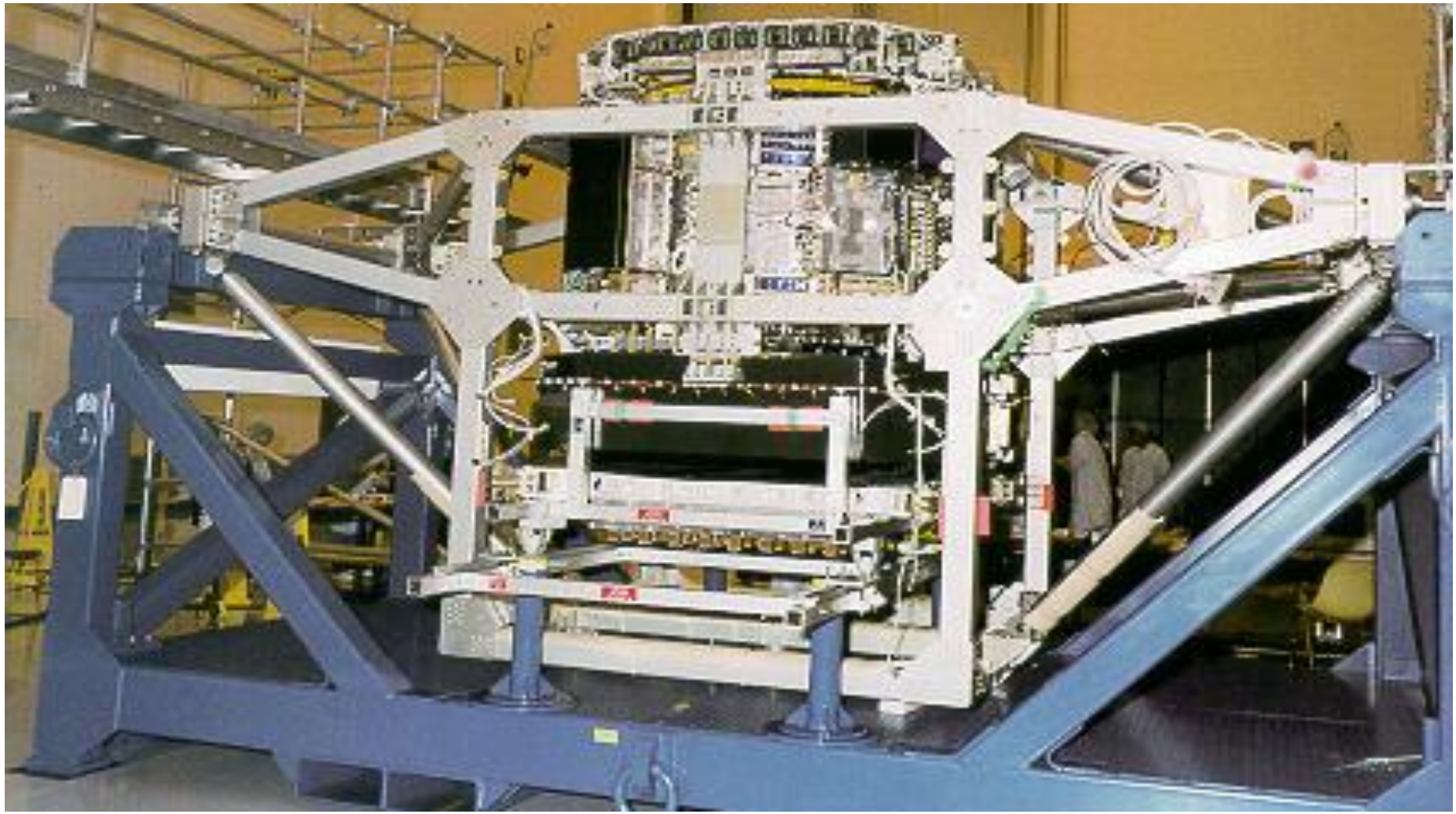
AMS on the International Space Station

- Cosmic 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



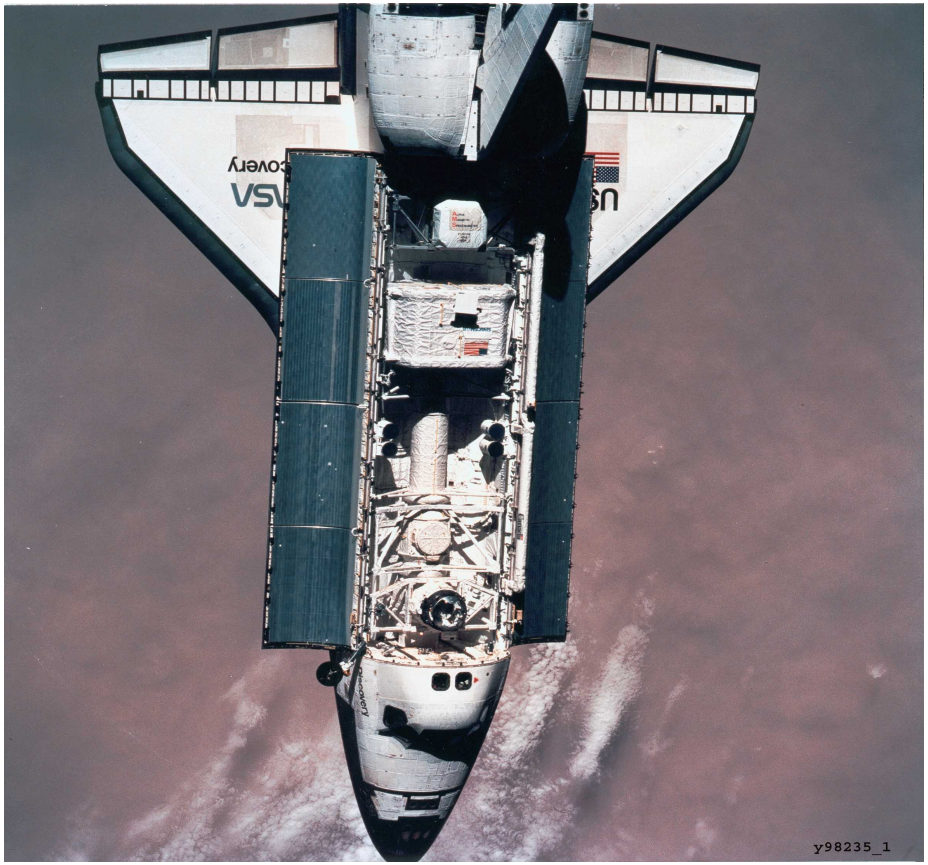
The purpose of the AMS experiment is to perform accurate, high statistics, long measurements of charged cosmic rays (0.5 GV - 1 TV) and γ rays (E>1GeV)

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}



Tracker performance presented at Vertex 1998, Santorini

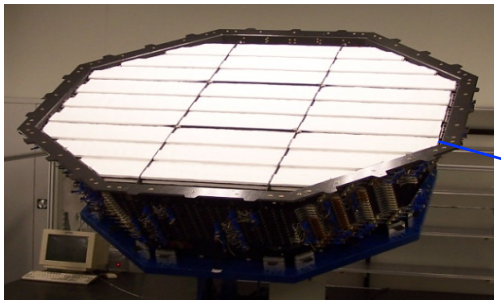
The instrument we need has …

- 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

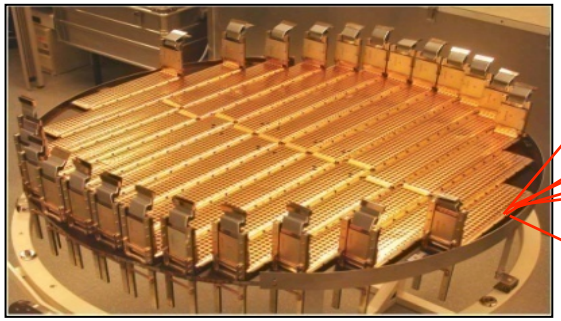

AMS

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

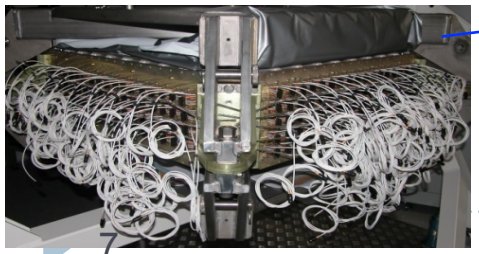
TRD
Identify e+, e-



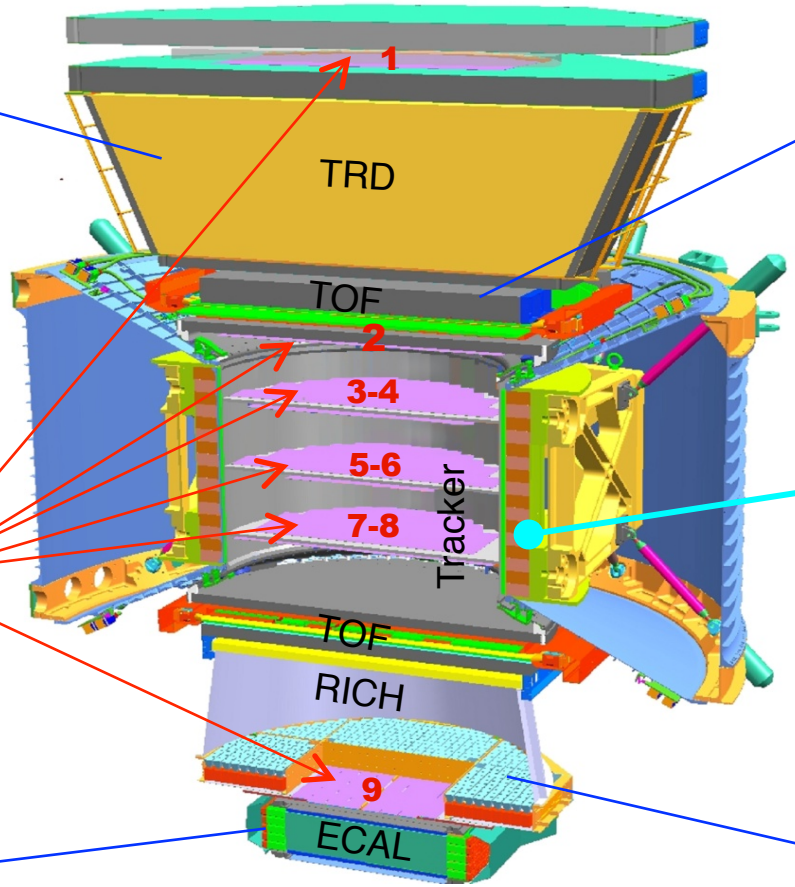
Silicon Tracker
Z, P



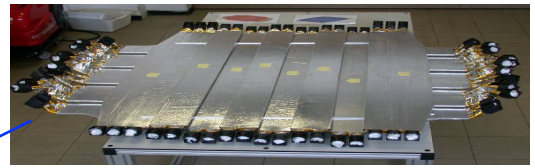
ECAL
E of e+, e-, γ



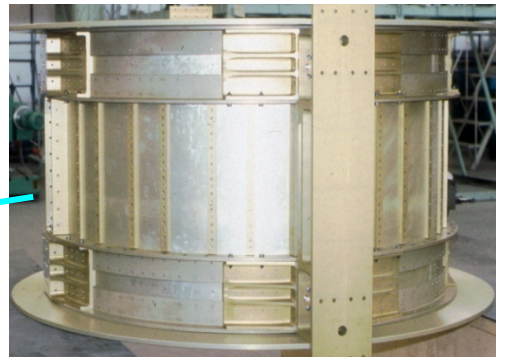
Particles and nuclei are defined by their charge (**Z**) and energy (**E ~ P**)



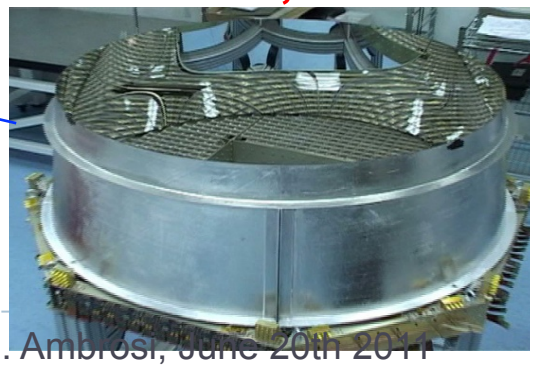
TOF
Z, E



Magnet
±Z



RICH
Z, E



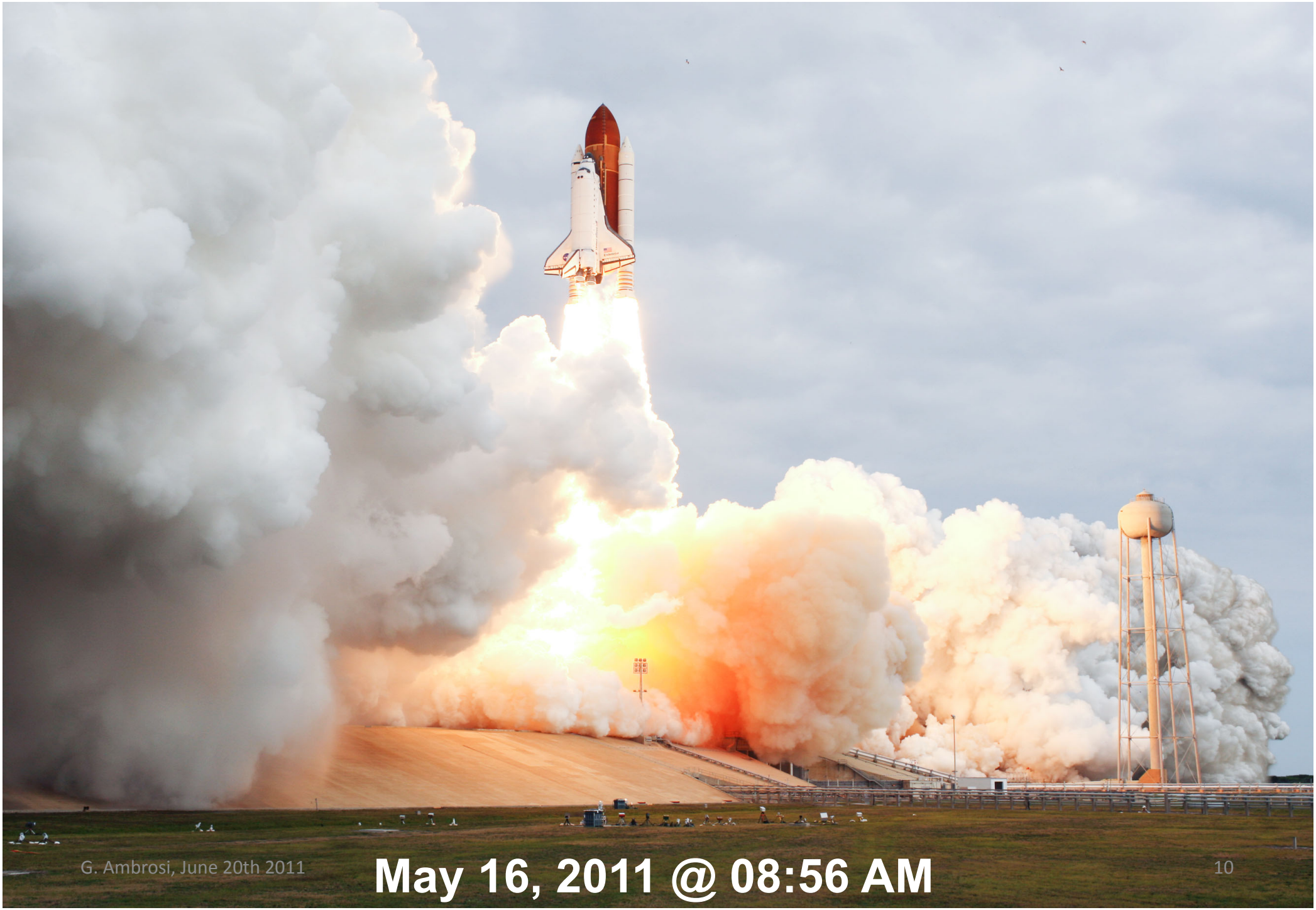
***Z, P** are measured independently by the Tracker, RICH, TOF and ECAL*

recent AMS02 history in short

- 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!!

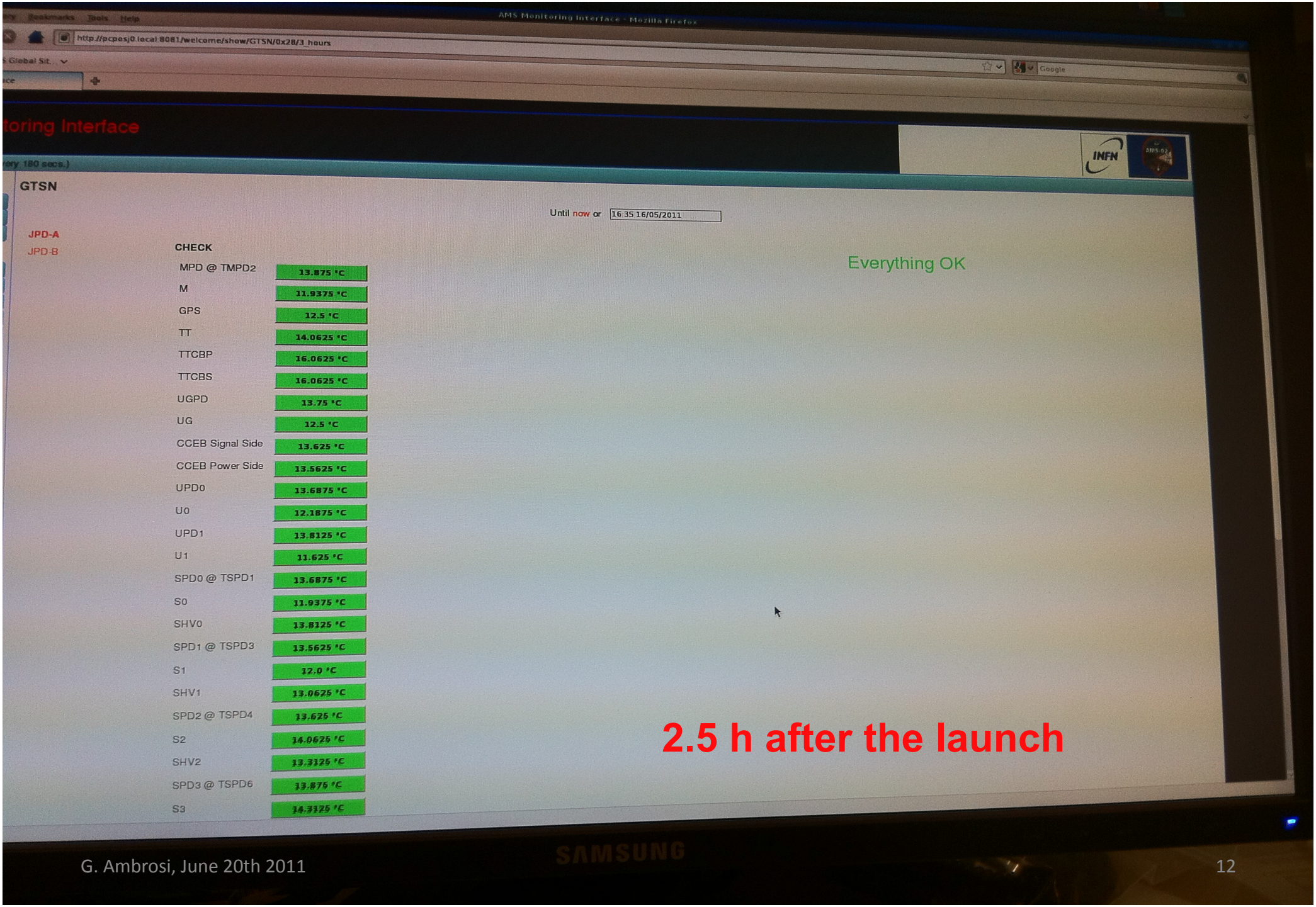

MET
000:00:00:01+
SBND MILA->PDL
SBND PDL ->MILA
SBND MILA->TDRS
00:00:59-
00:02:29-
00:07:29-
JAXA
POCKOCMOC
MCC
AMS RICH

Launching

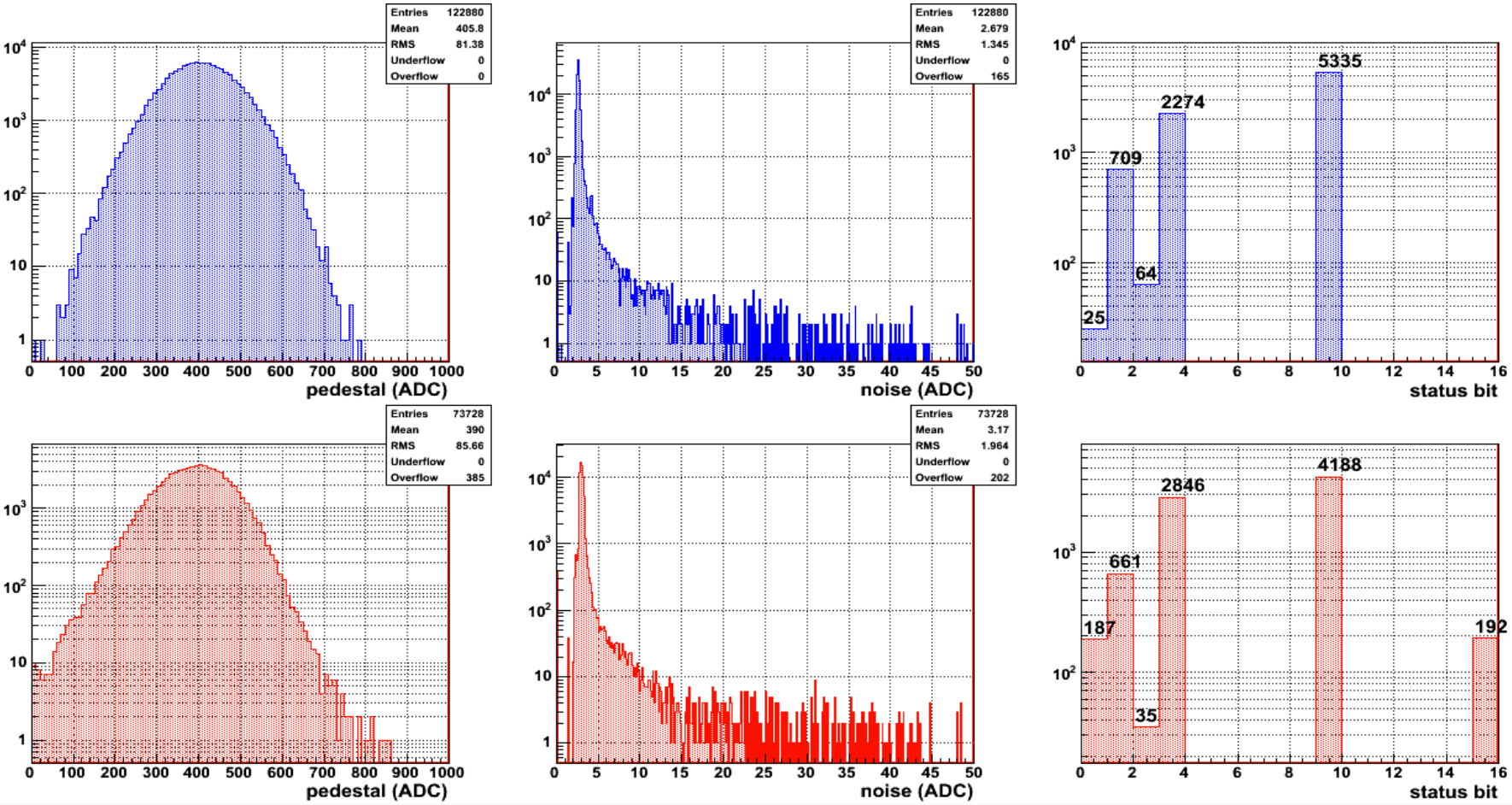


May 16, 2011 @ 08:56 AM

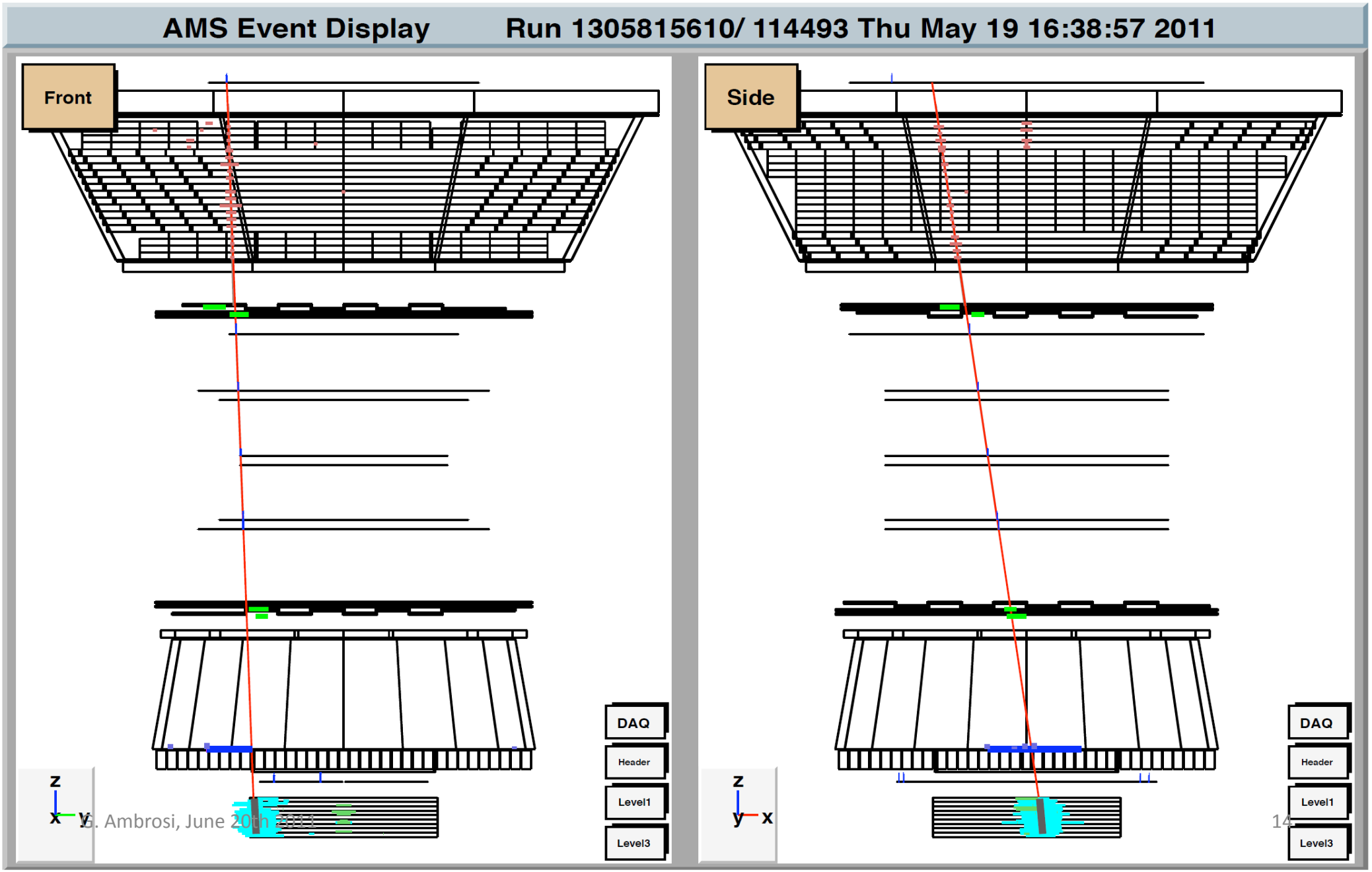

AMS Tracker
AMS TTCS


AMS Monitoring Interface - Mozilla Firefox
http://pcpasj0.local:8081/welcome/show/GTSN/0x28/3_hours
toring Interface
INFN
GTSN
Until now or 16:35 16/05/2011
JPD-A
JPD-B
CHECK
MPD @ TMPD2 13.875 °C
M 11.9375 °C
GPS 12.5 °C
TT 14.0625 °C
TTCBP 16.0625 °C
TTCBS 16.0625 °C
UGPD 13.75 °C
UG 12.5 °C
CCEB Signal Side 13.625 °C
CCEB Power Side 13.5625 °C
UPD0 13.6875 °C
U0 12.1875 °C
UPD1 13.8125 °C
U1 11.625 °C
SPD0 @ TSPD1 13.6875 °C
S0 11.9375 °C
SHV0 13.8125 °C
SPD1 @ TSPD3 13.5625 °C
S1 12.0 °C
SHV1 13.0625 °C
SPD2 @ TSPD4 13.625 °C
S2 14.0625 °C
SHV2 13.3125 °C
SPD3 @ TSPD6 13.875 °C
S3 14.3125 °C
Everything OK
2.5 h after the launch
SAMSUNG

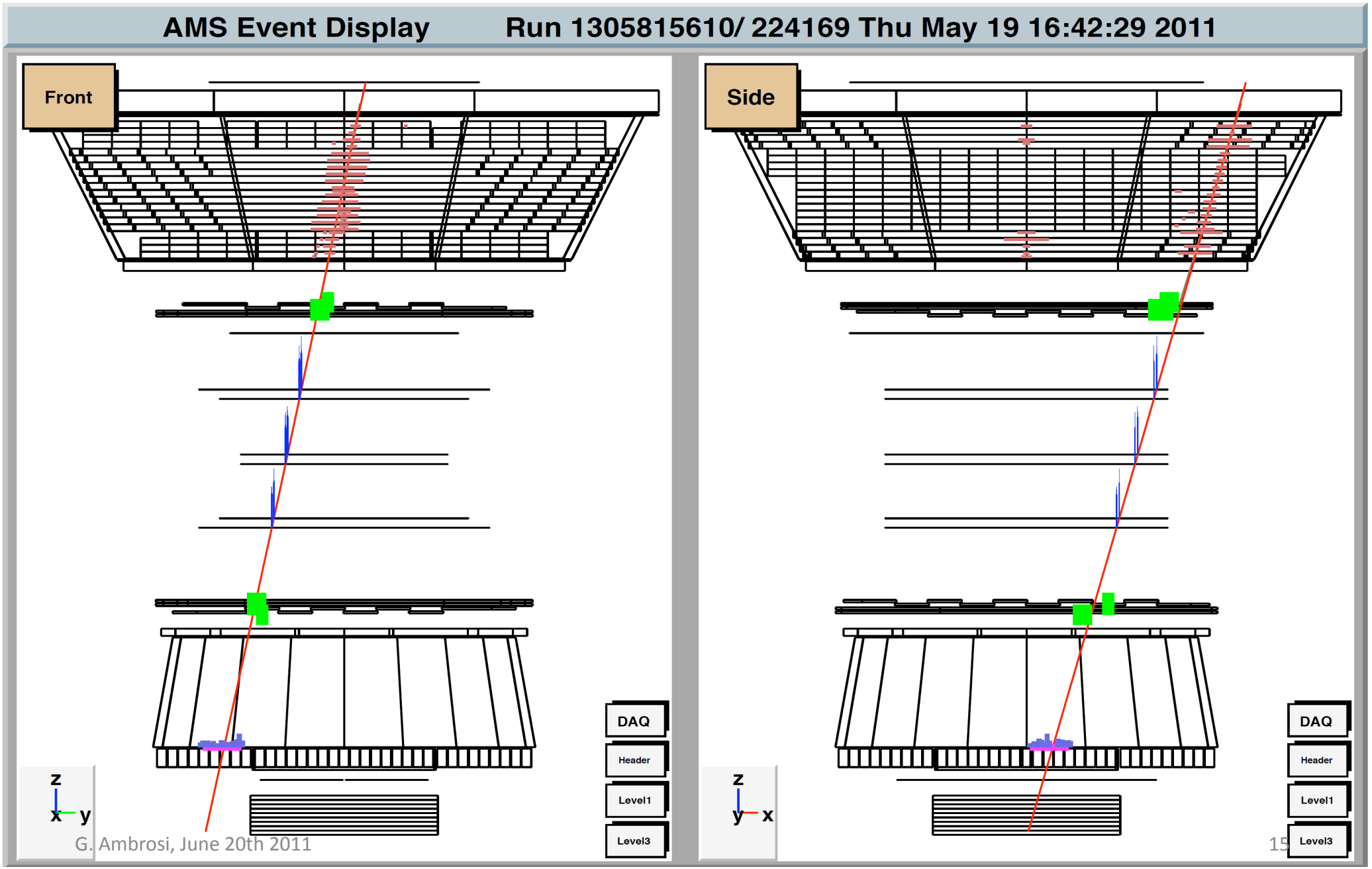
First Tracker calibration in space



Data from the 1st few minutes – 20 GeV Electron, 19 May 2011

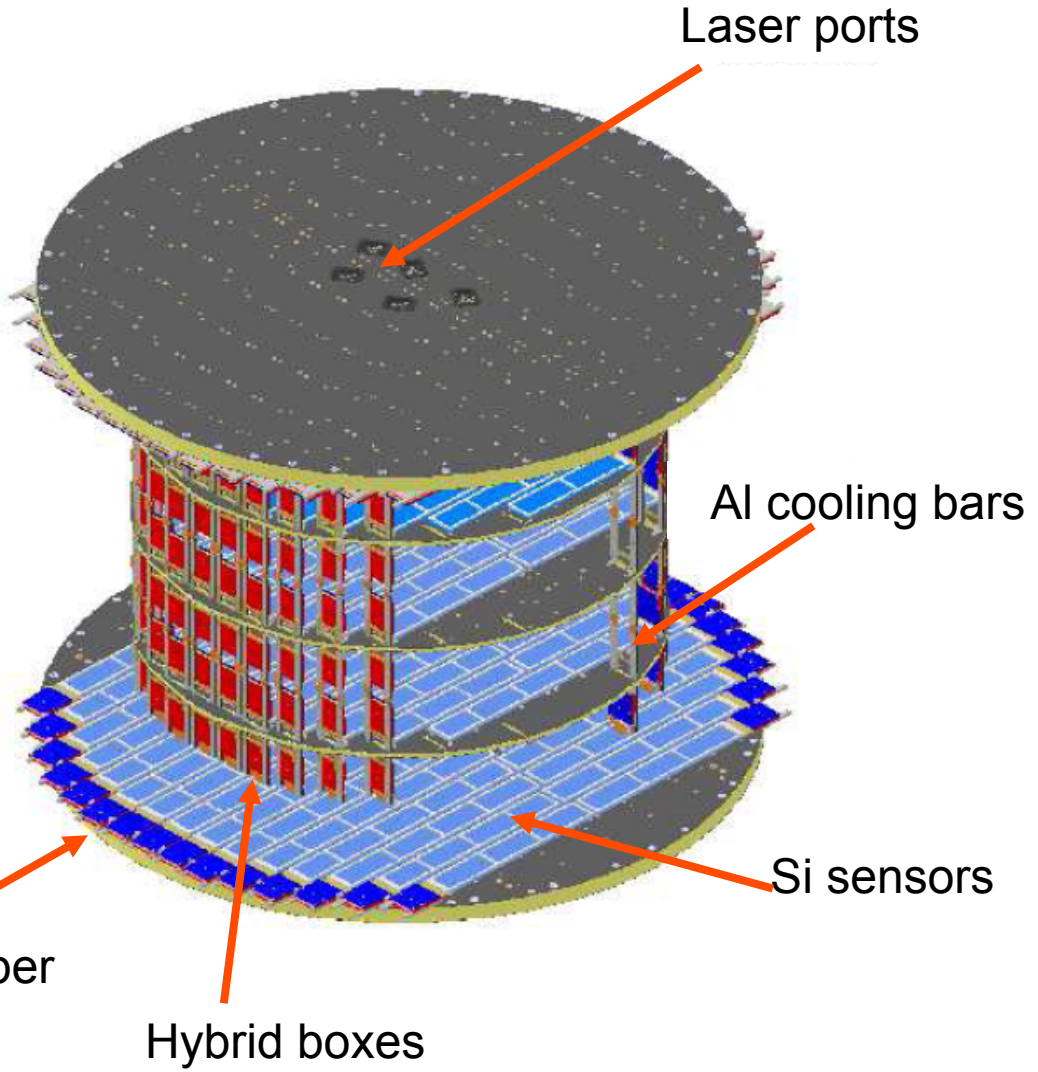


Data from the 1st few minutes – 42 GeV/c Carbon, 19 May 2011



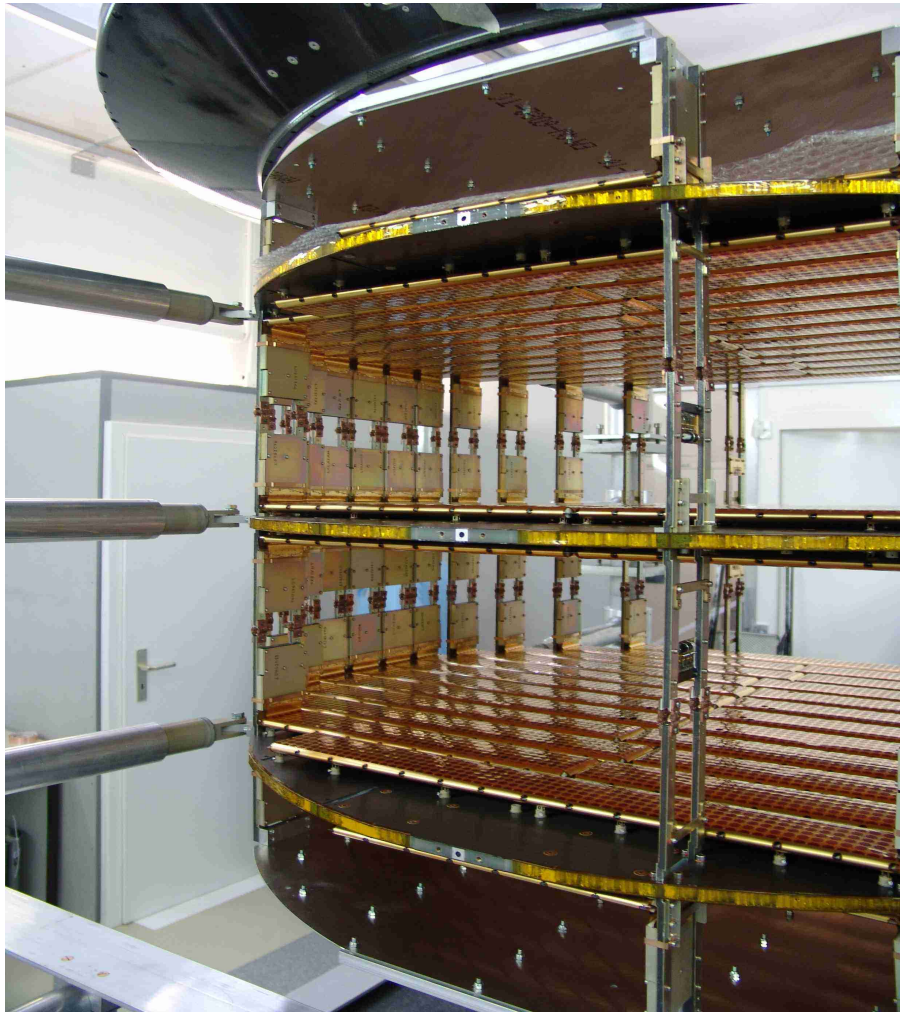
Silicon Tracker

- 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.)

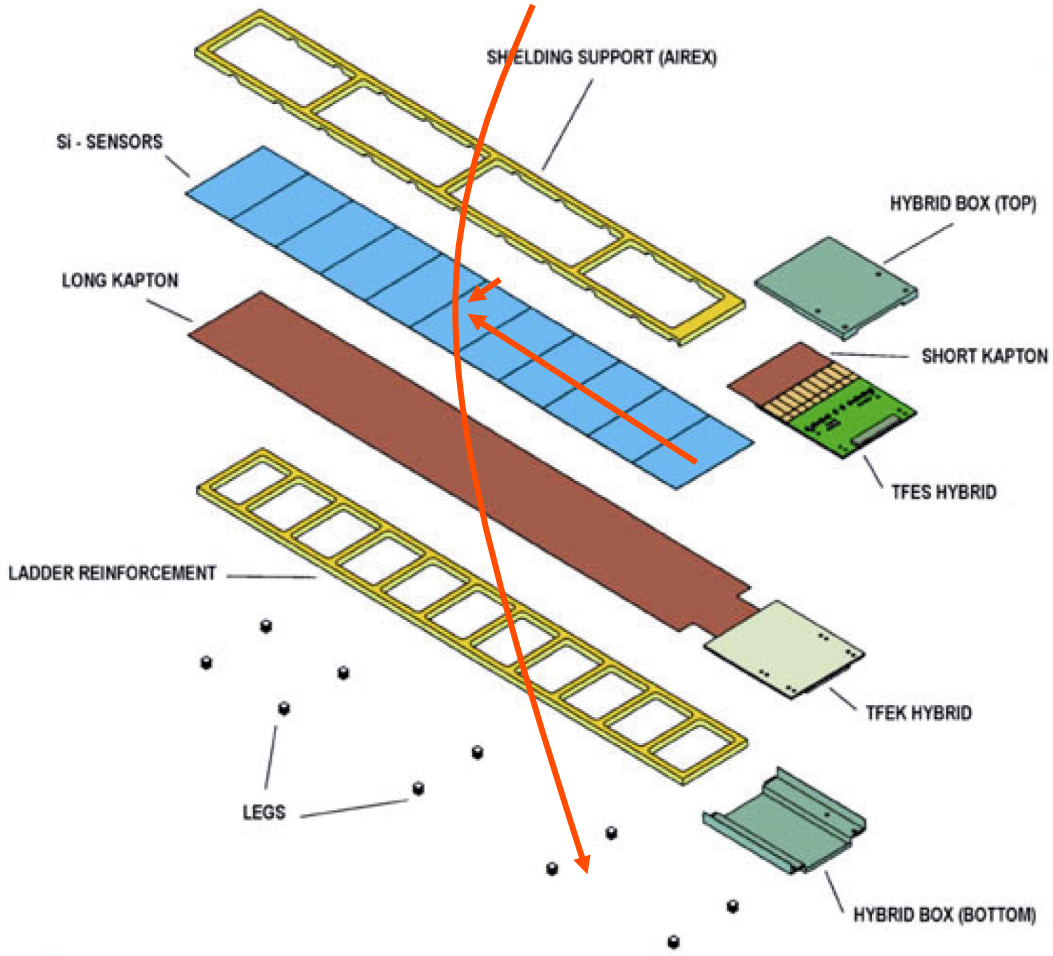


Silicon Tracker

- 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.)



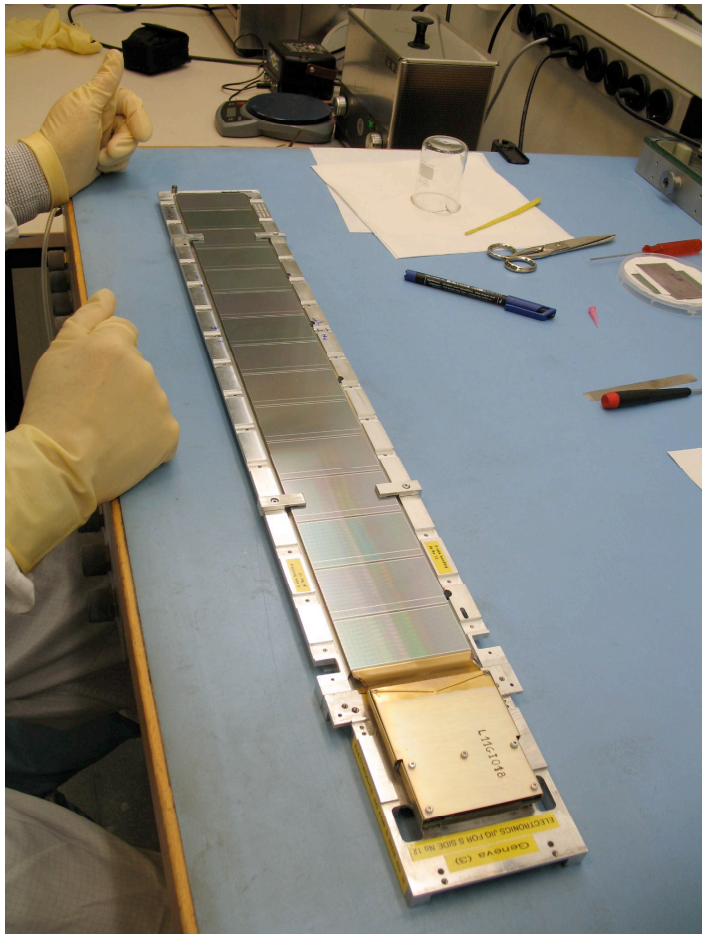
AMS silicon ladders



- 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)

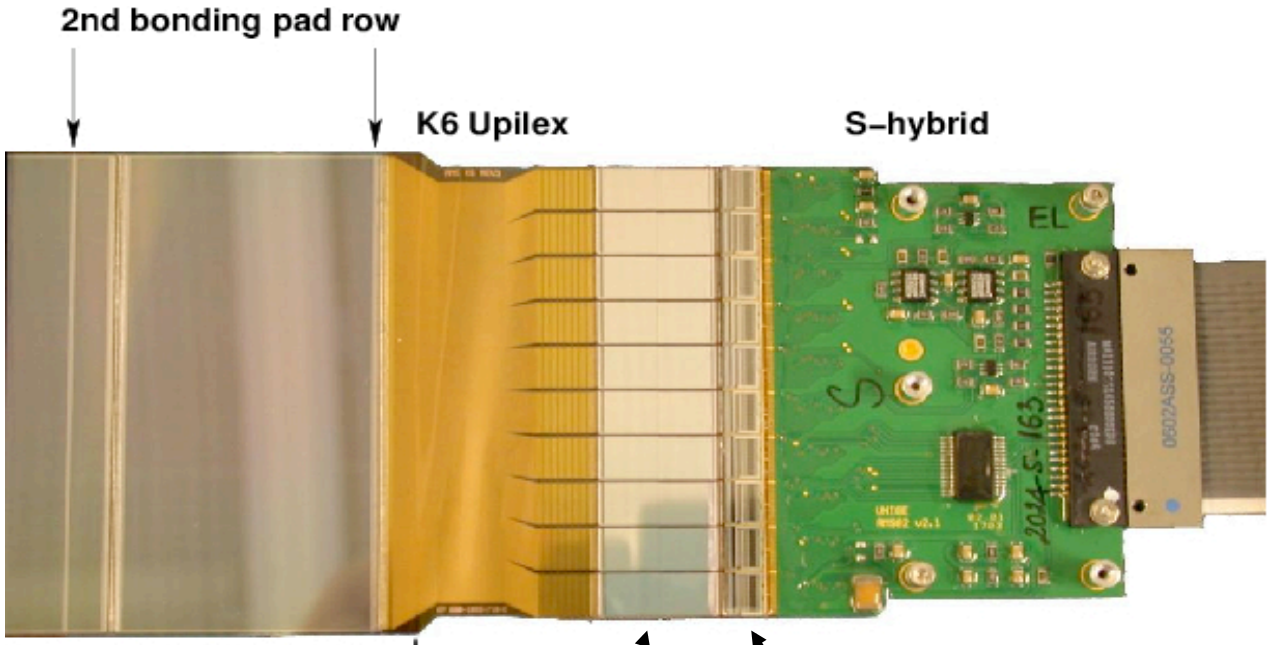
AMS silicon ladders



- 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)

Ladder components (p side)

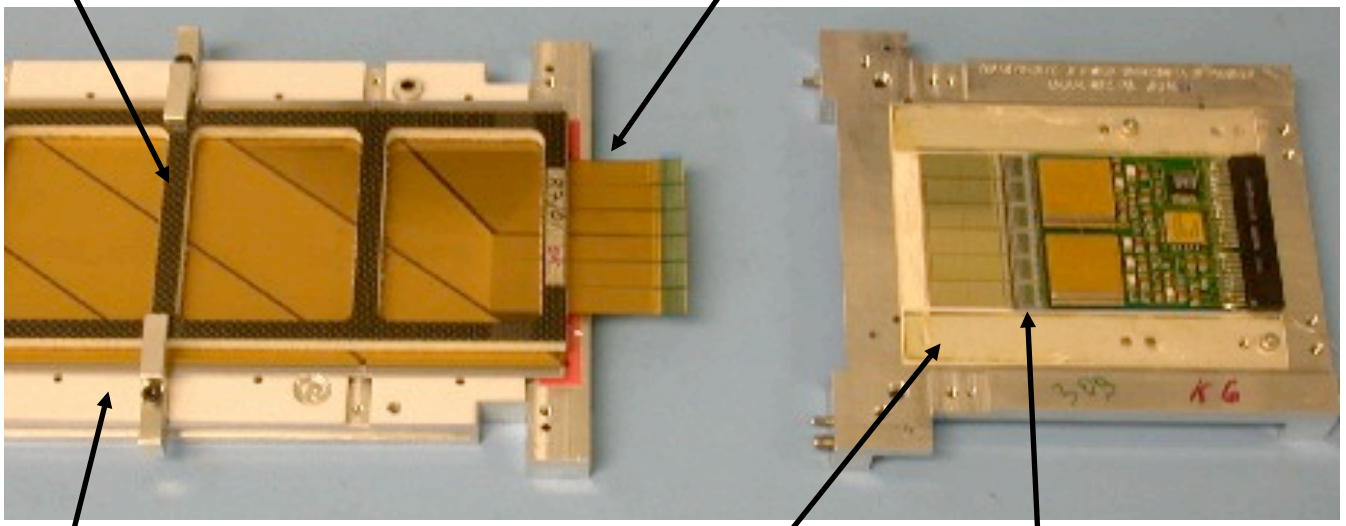


double sided, DC coupled
300 μm thickness
7 - 15 sensors in a ladder
produced at:
- Colybris (CH)
- IRST (IT)

700 pF coupling capa

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 (n side)



Radiation 'hard' electronics

The problem are the SEE (Single Event Effect)

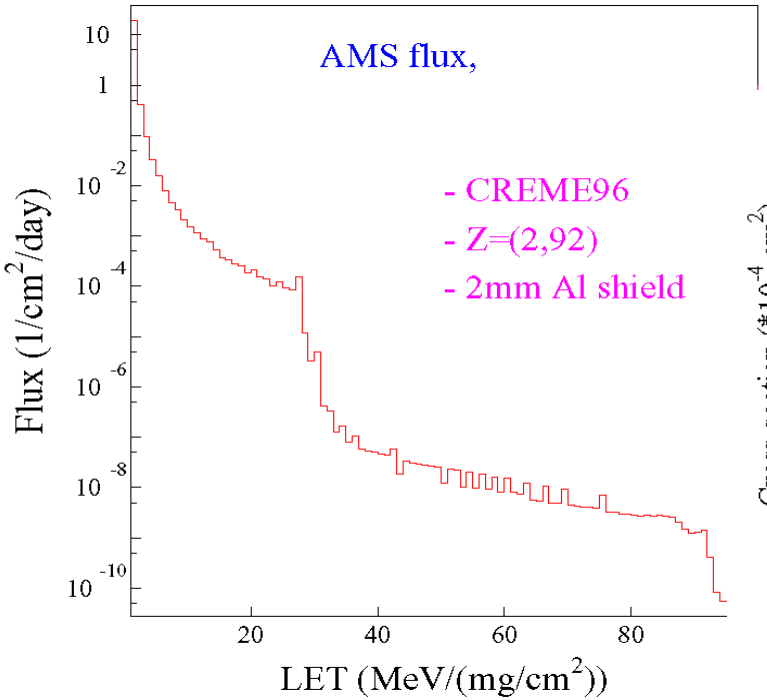
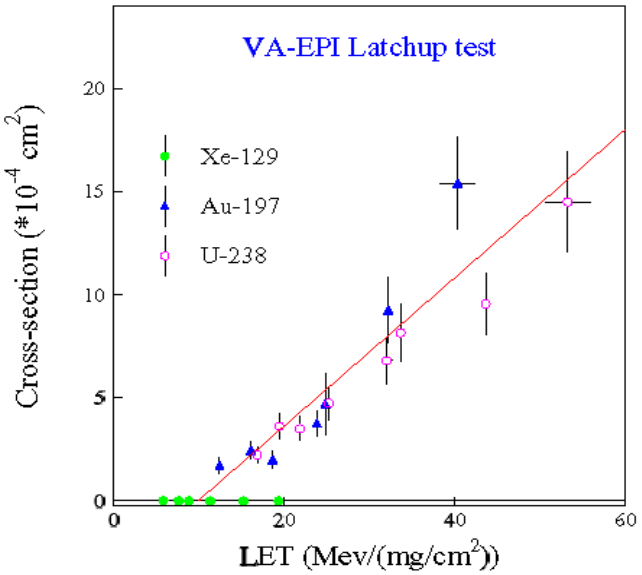


Figure 5: Expected fluxes on ISS in 2003.



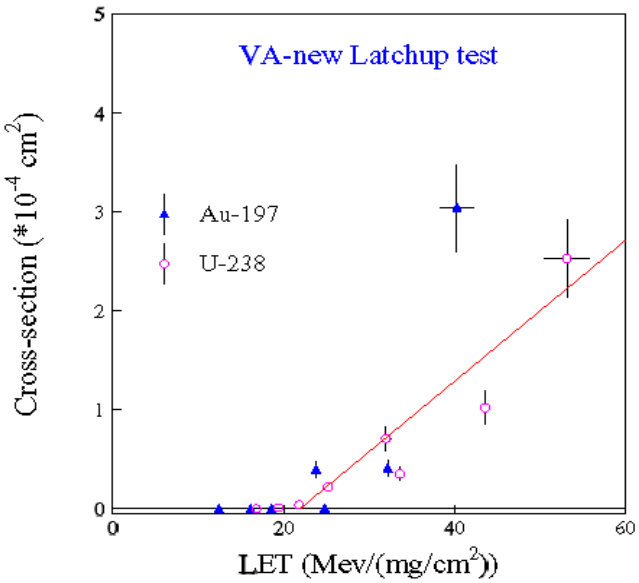
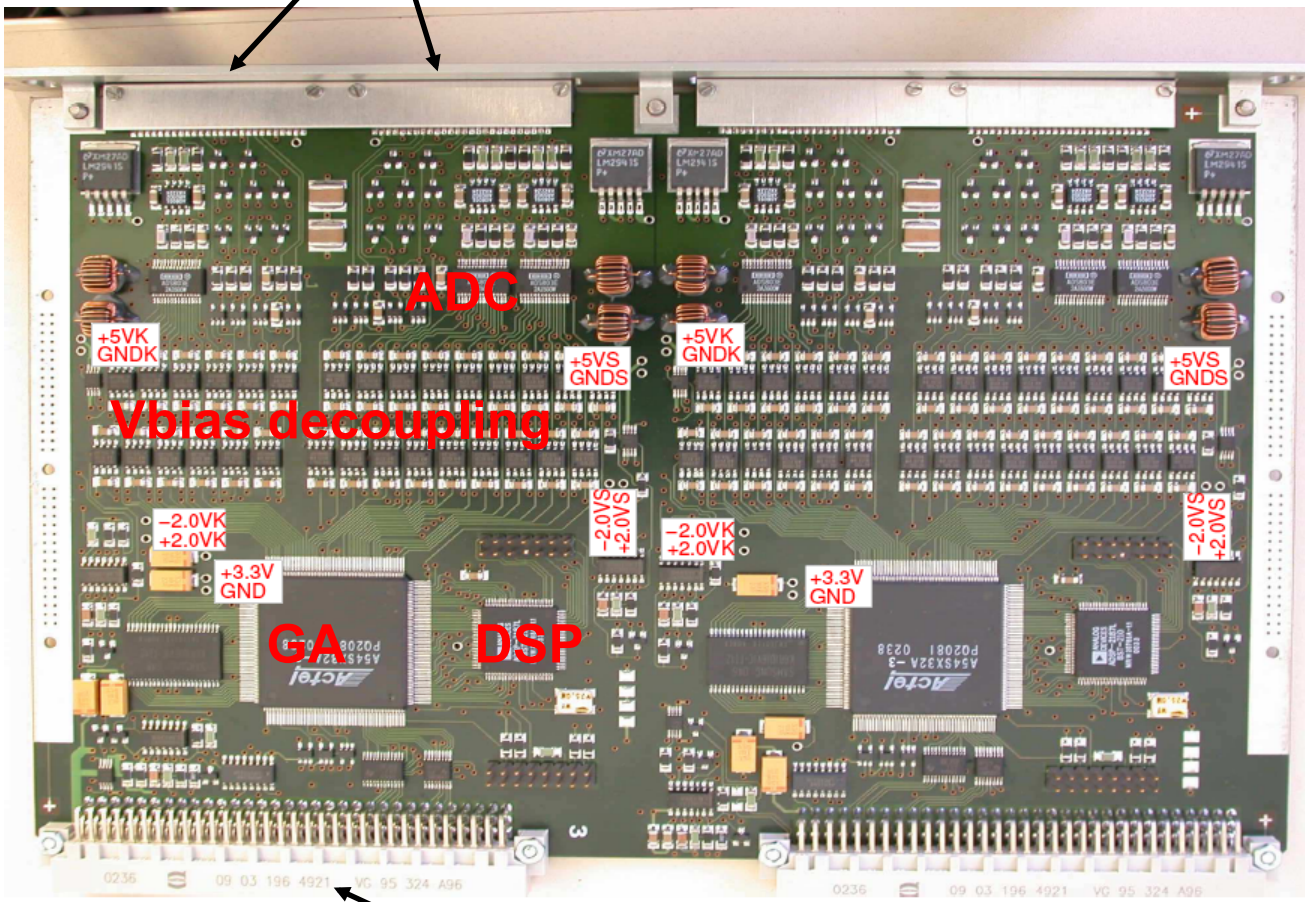


Figure 12: The new VA – SEL rates as measured in GSI

current limit protection is present for all active components

Data Reduction Board (TDR2)

analog signal in



compressed digital out

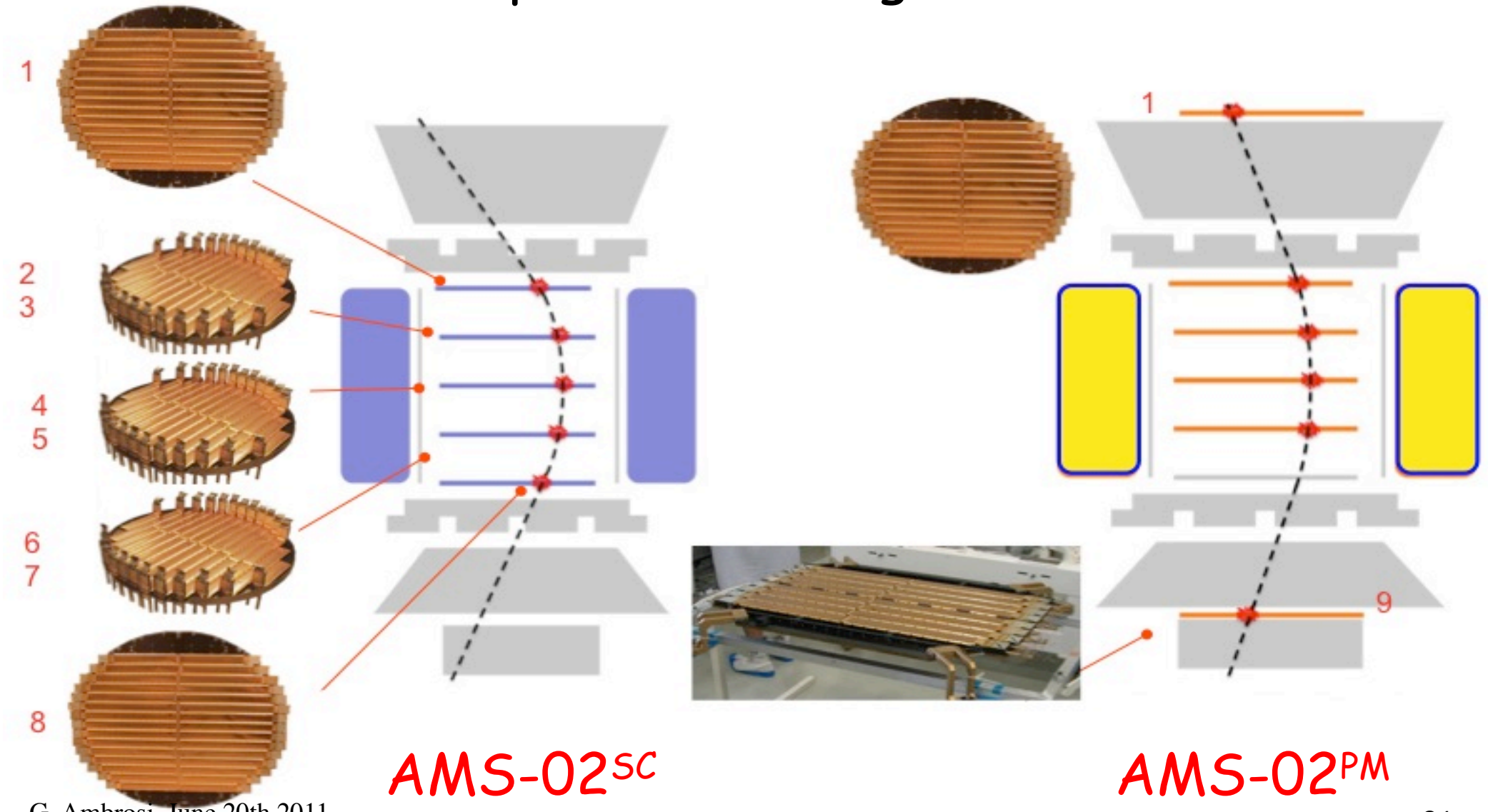
Collect analog data and digitize it (100 μs irred. dead time)

Perform online data compression

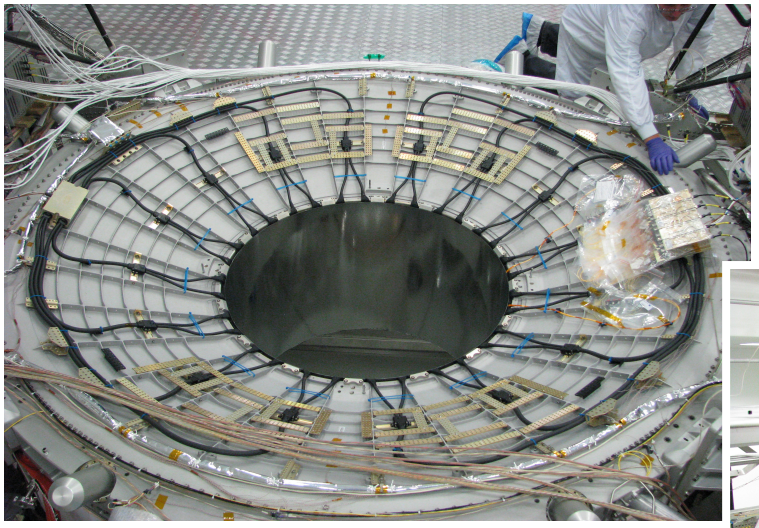
- Remove Pedestals
- Calculate and Remove Common Noise
- Search Clusters

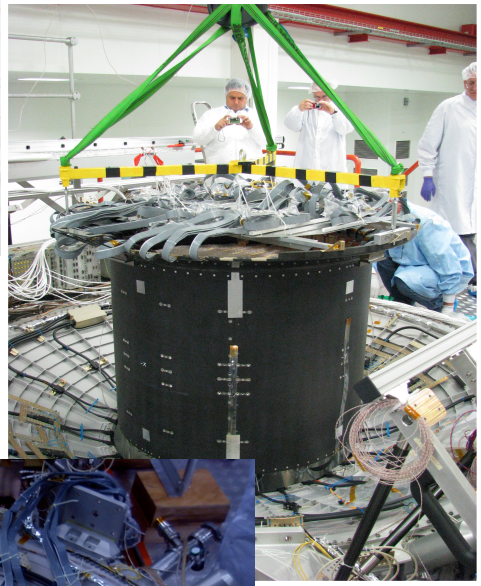
Up to 5 KHz trigger rate in compressed mode

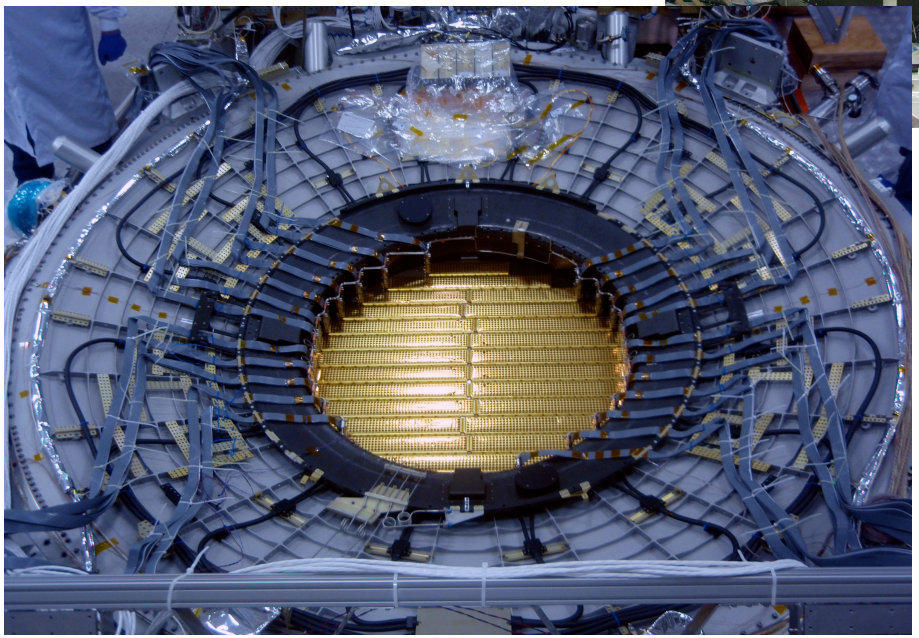
Layout modification to use the permanent magnet

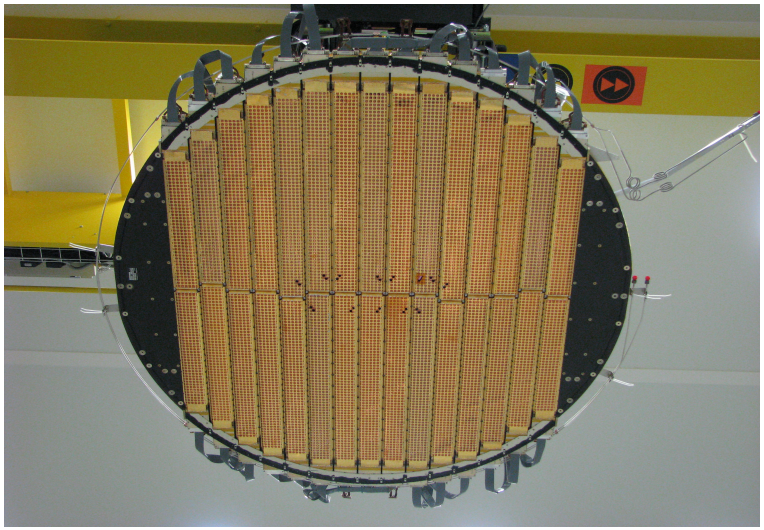


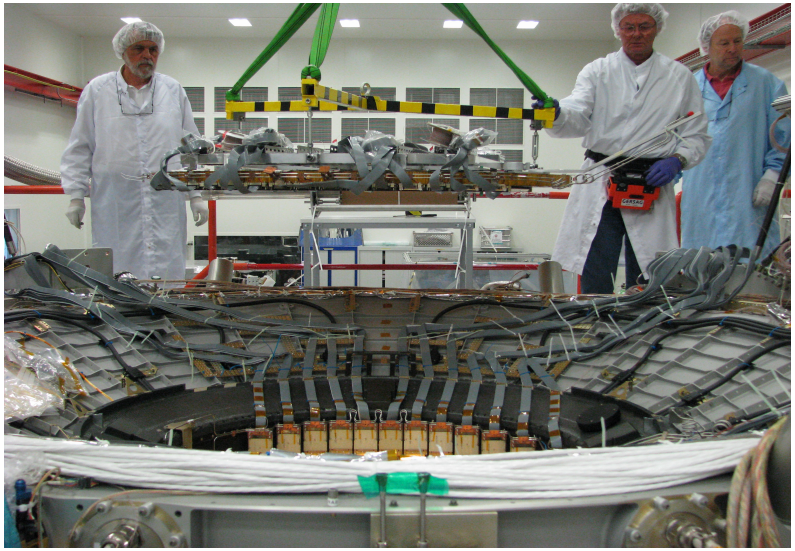
inner Tracker integration



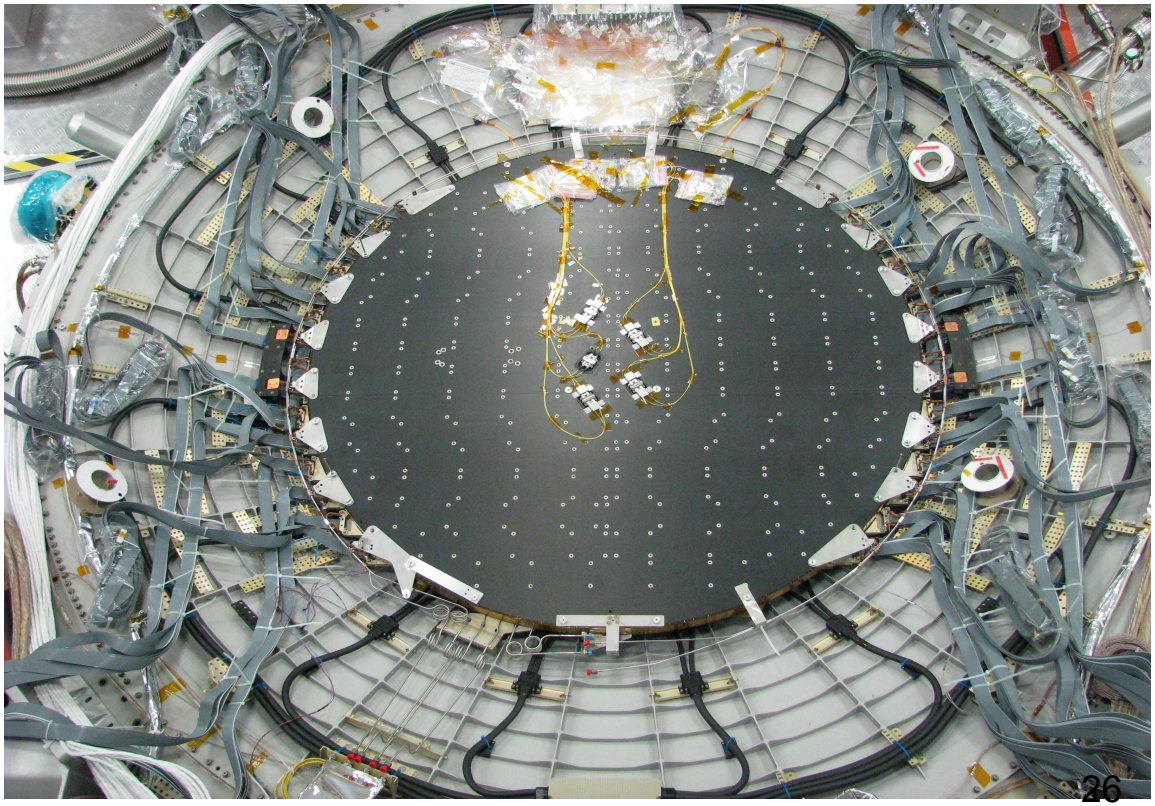




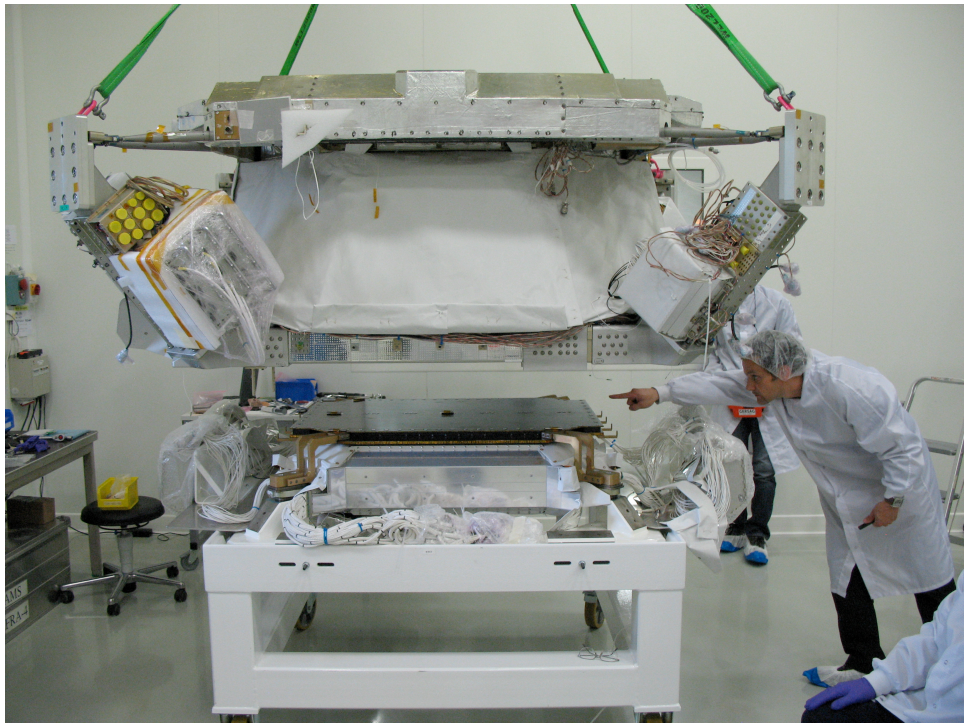




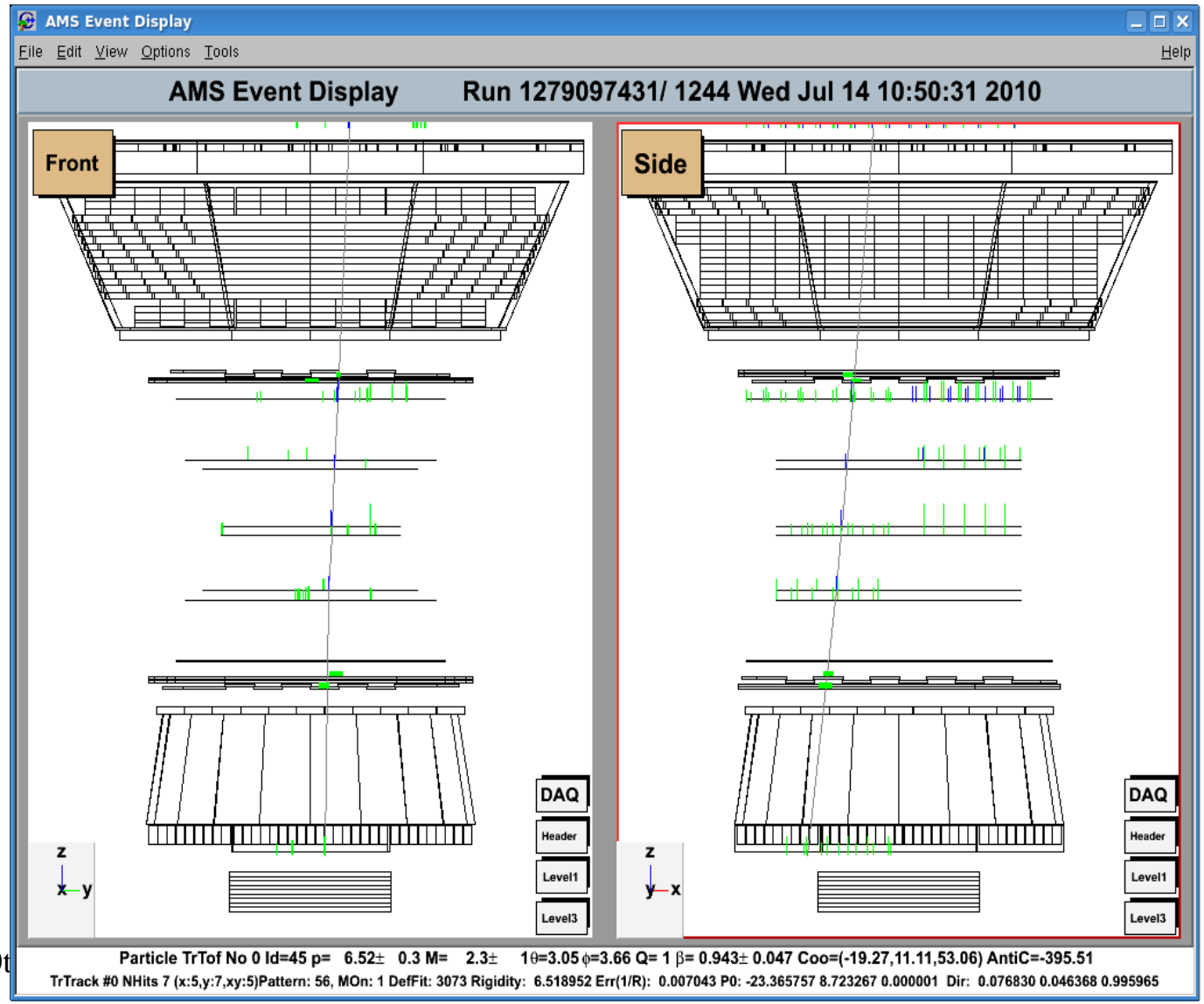
Perugia
INFN
Istituto Nazionale di Fisica Nucleare



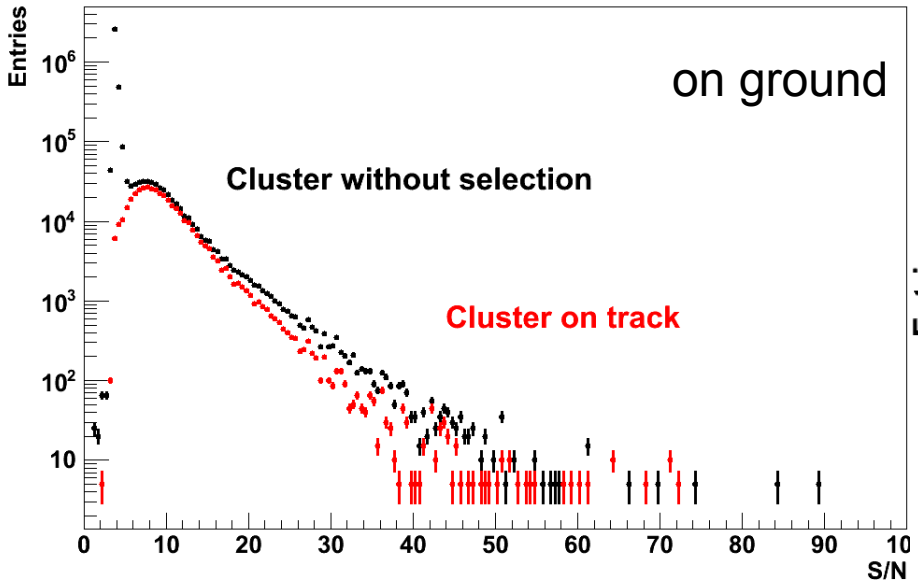
Tracker integration (2)

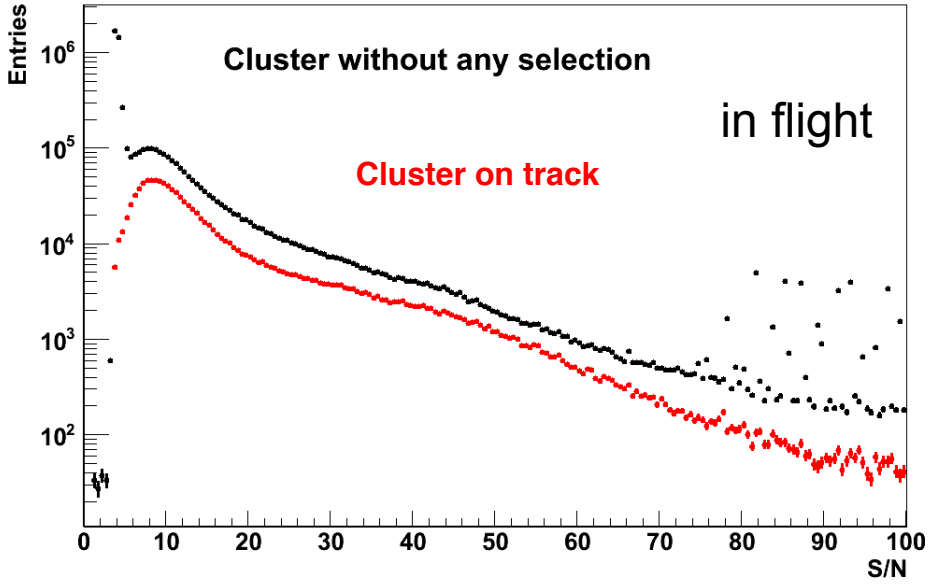


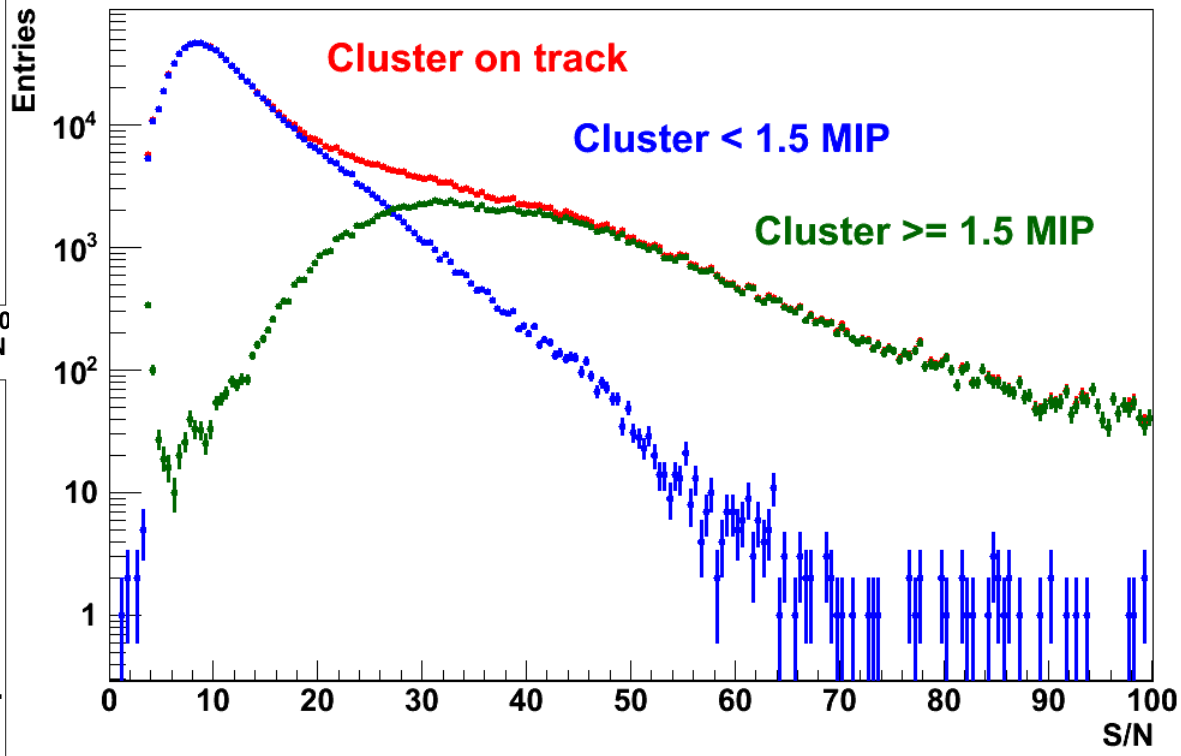
the first muon with the new Tracker



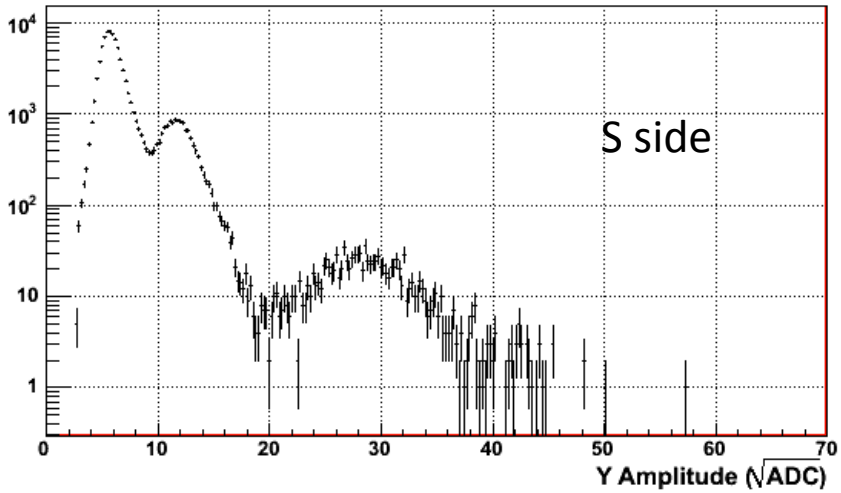
the Tracker signals

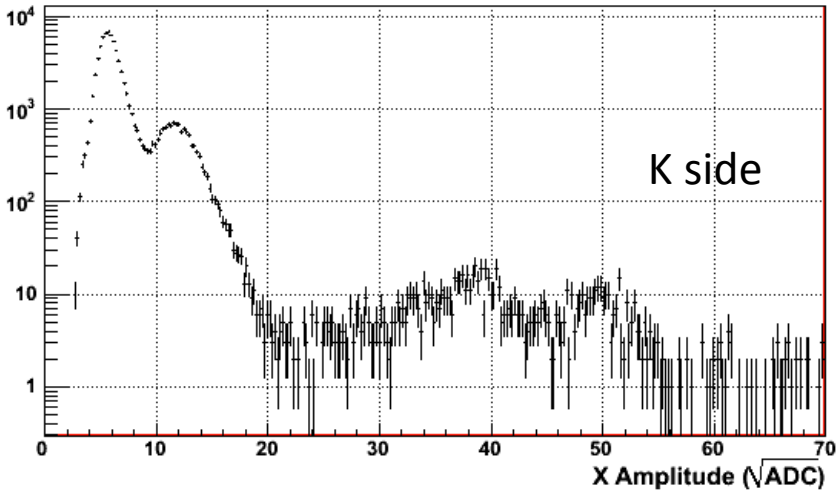


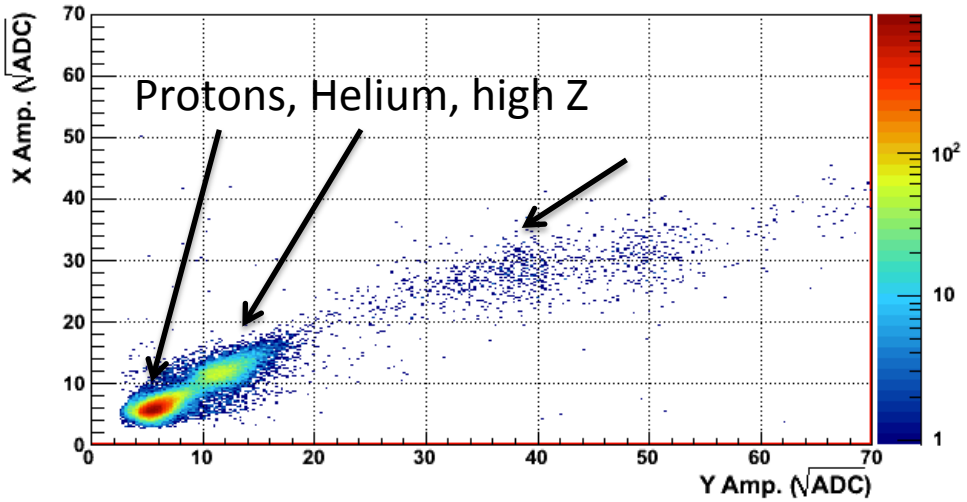


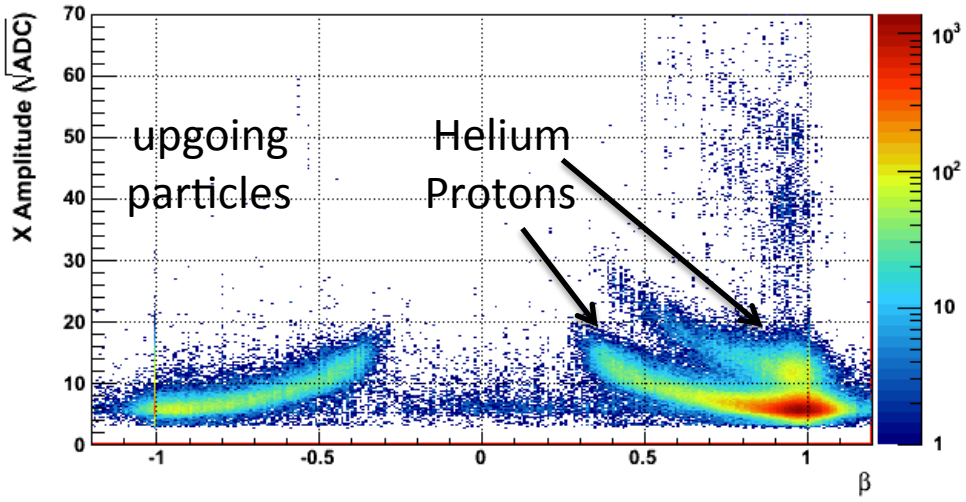


the particles we see

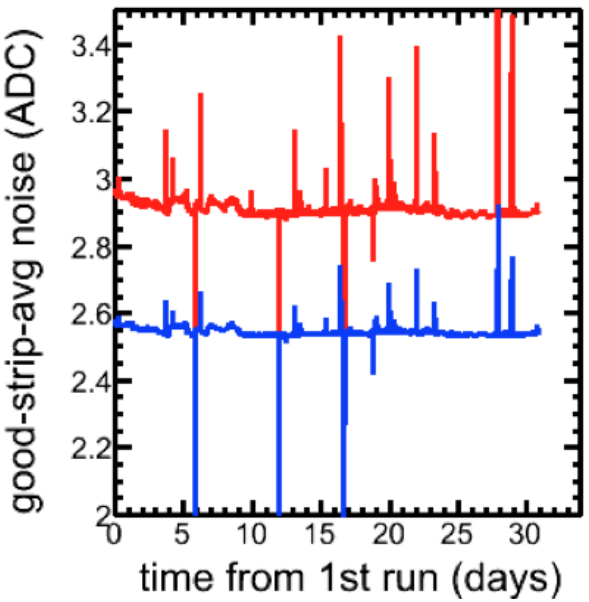


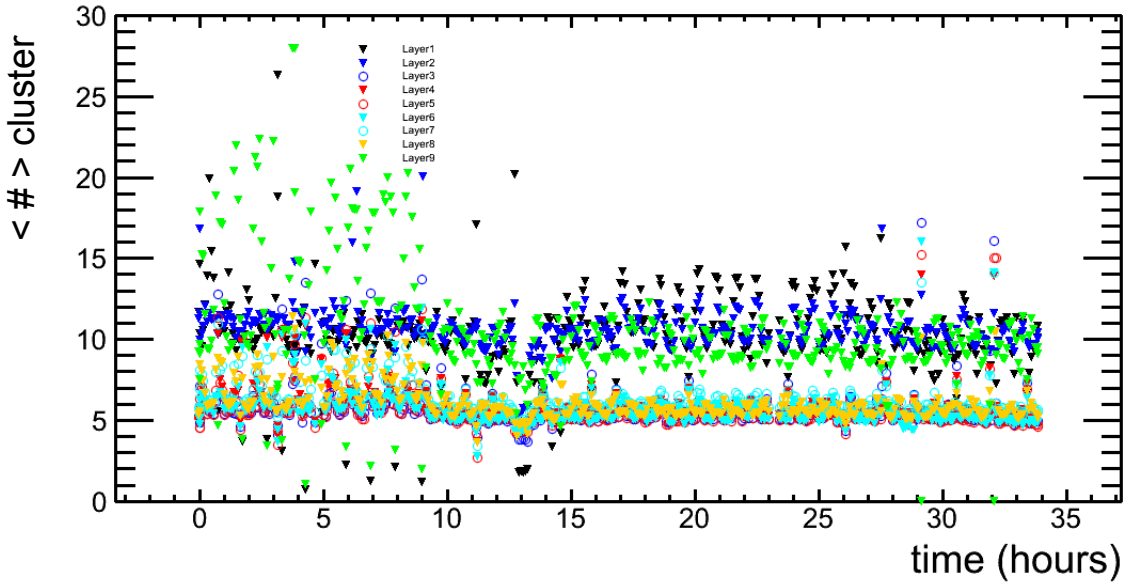


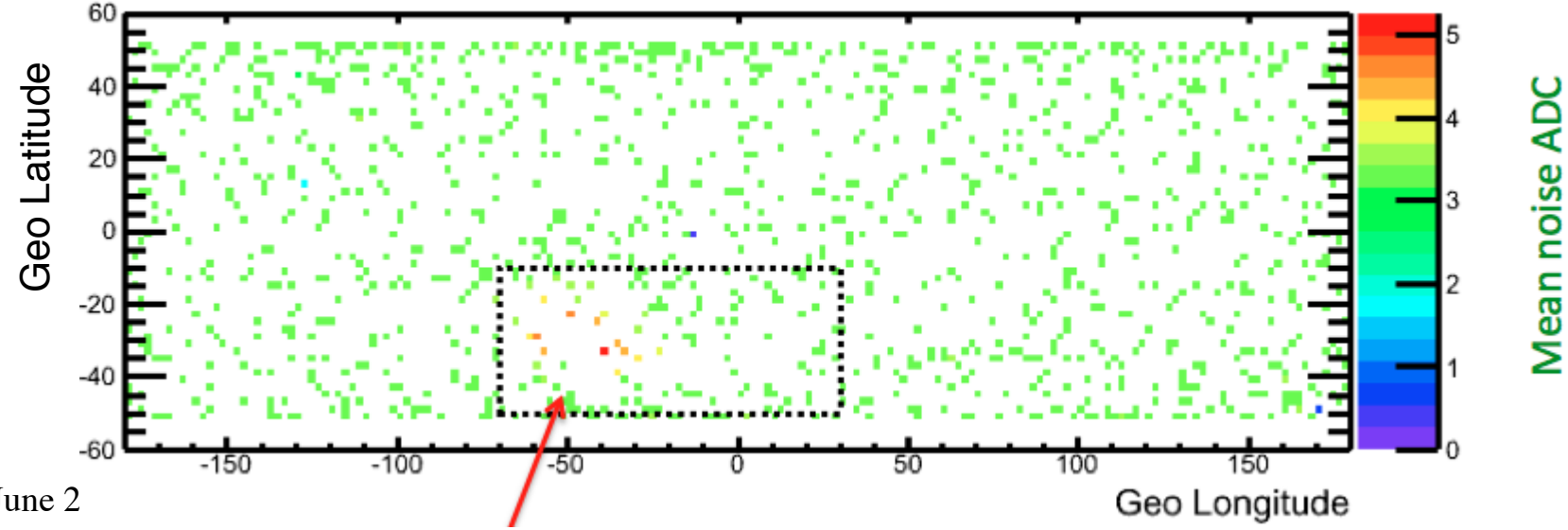




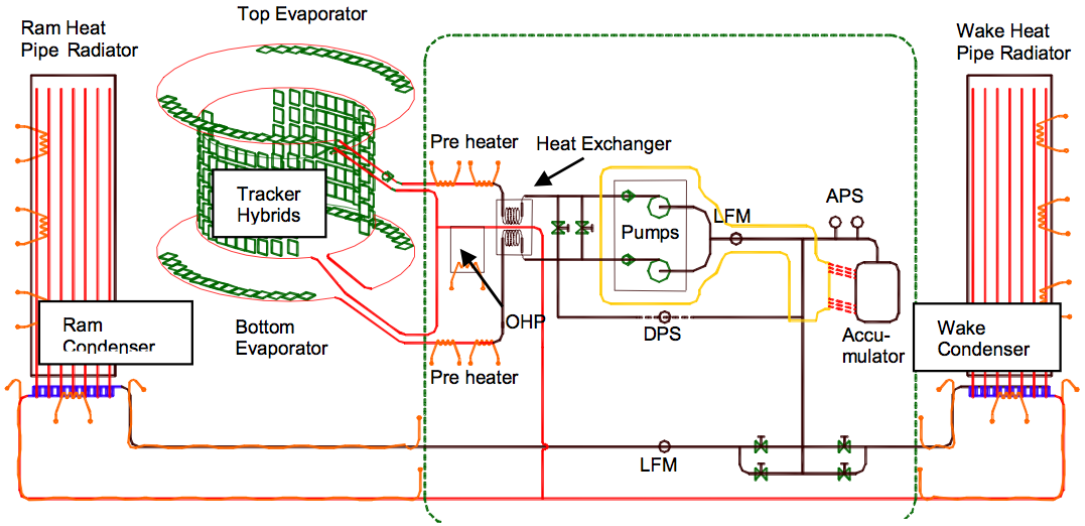
in flight experience

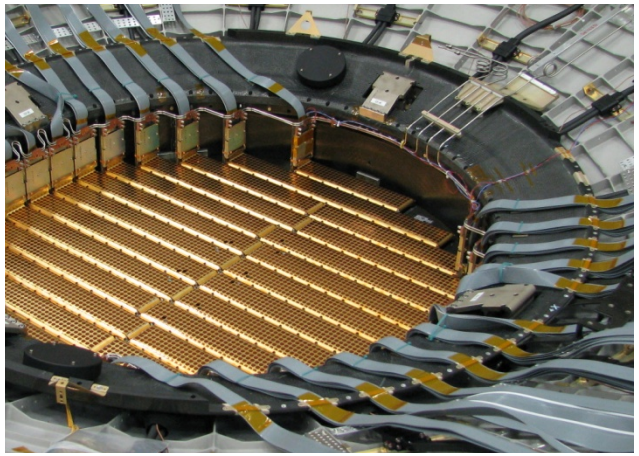


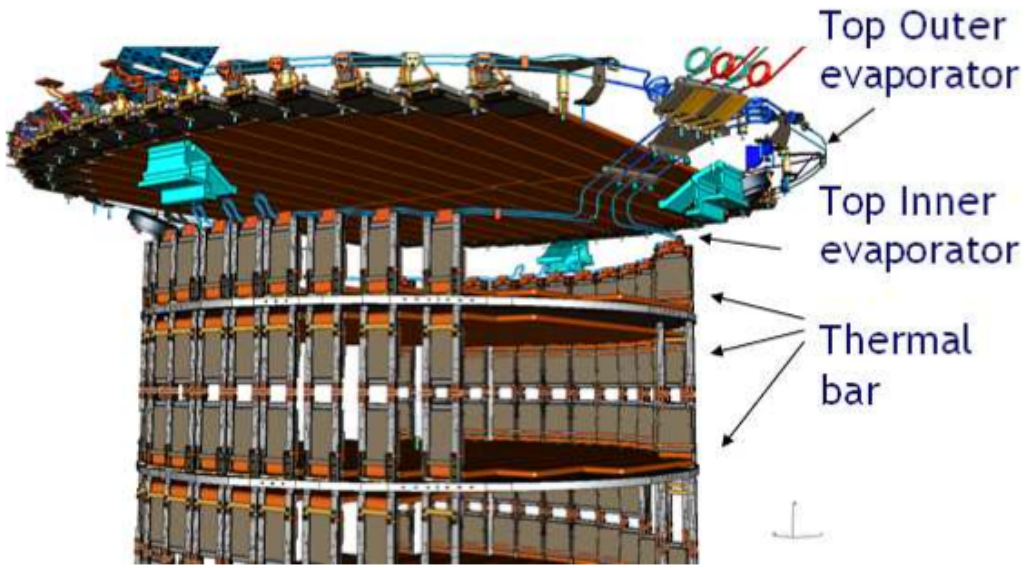




cooling: 2 phases CO2 pumped loop



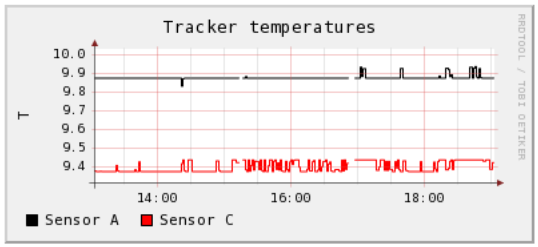


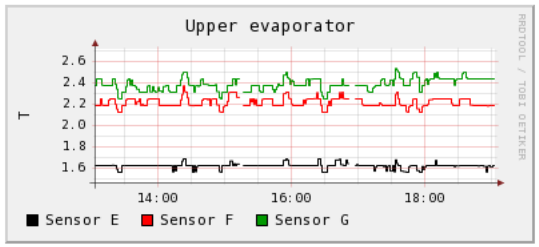


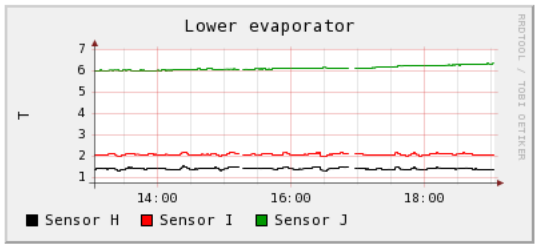
in flight experience: cooling and currents

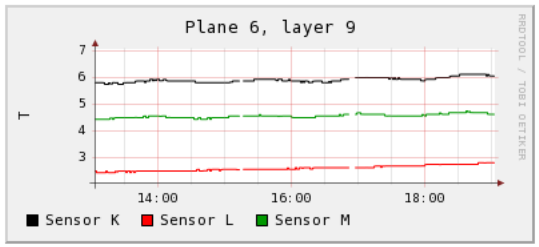
Showing last hour 3_hours **6_hours** day 3_days week

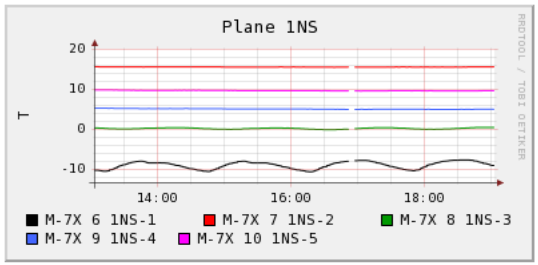
Until now or 19:03 18/06/2011

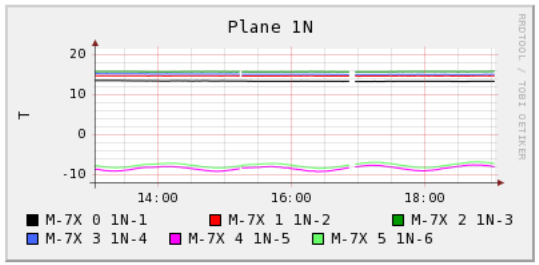


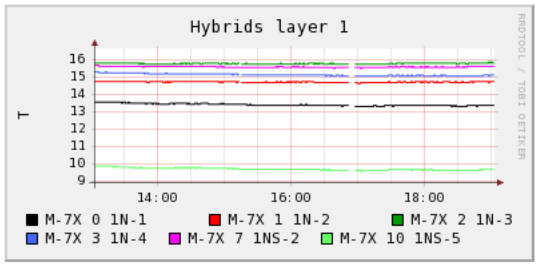


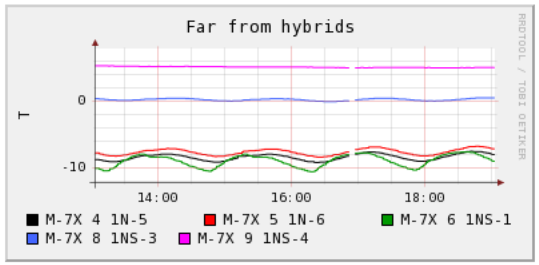


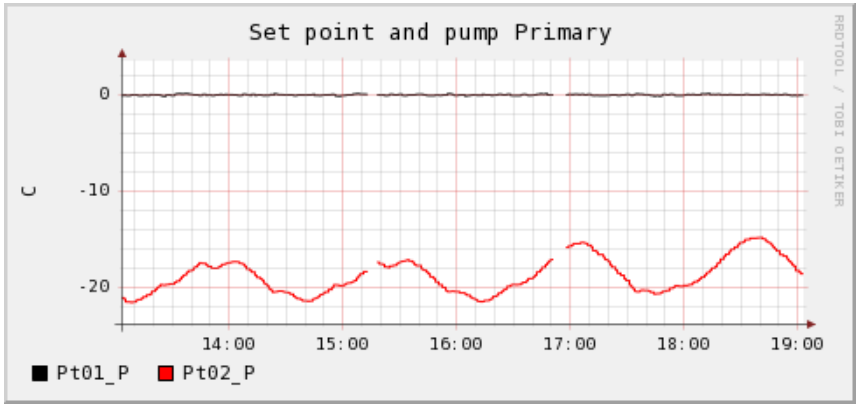


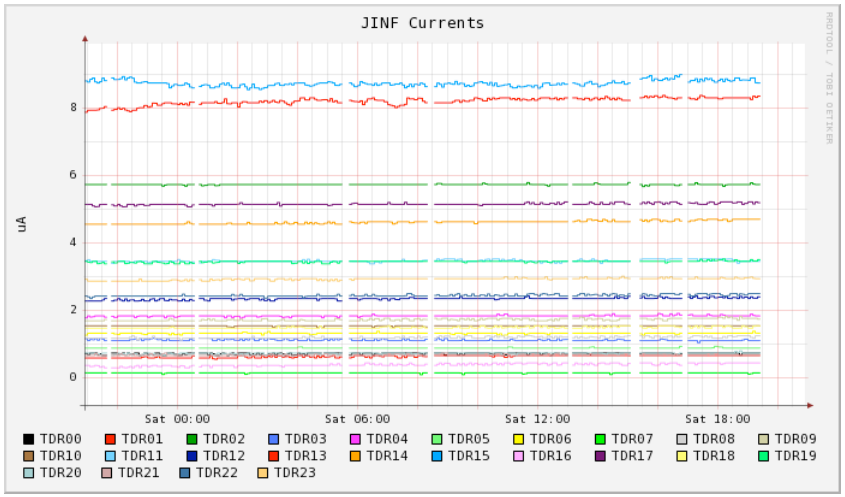




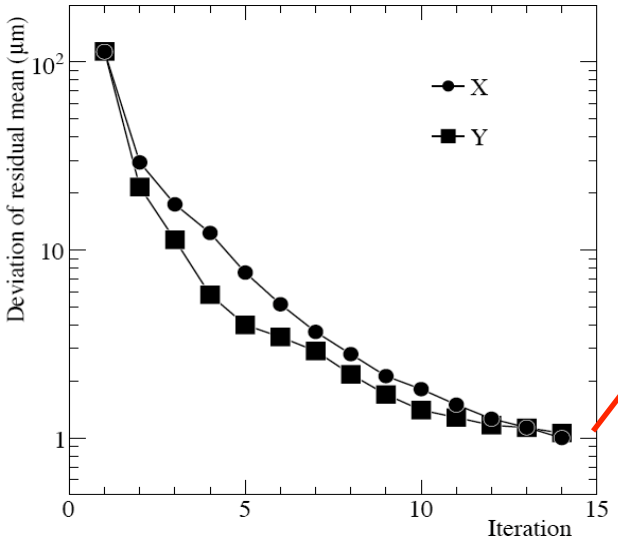


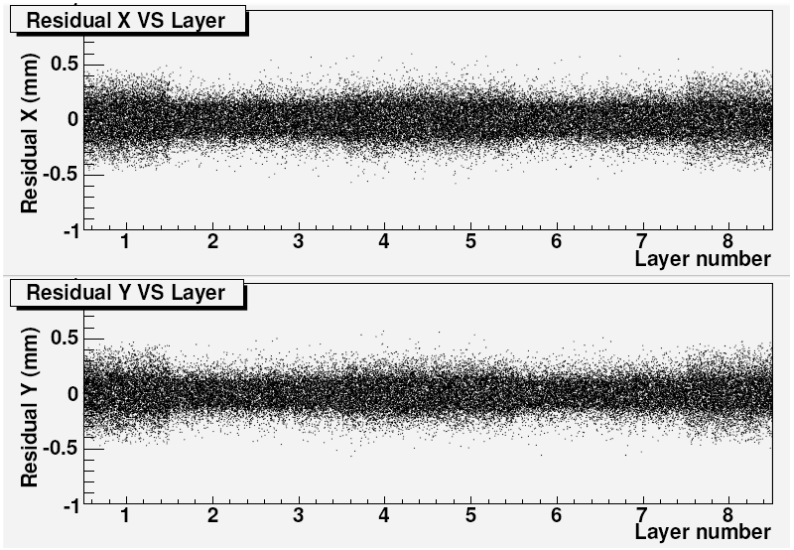




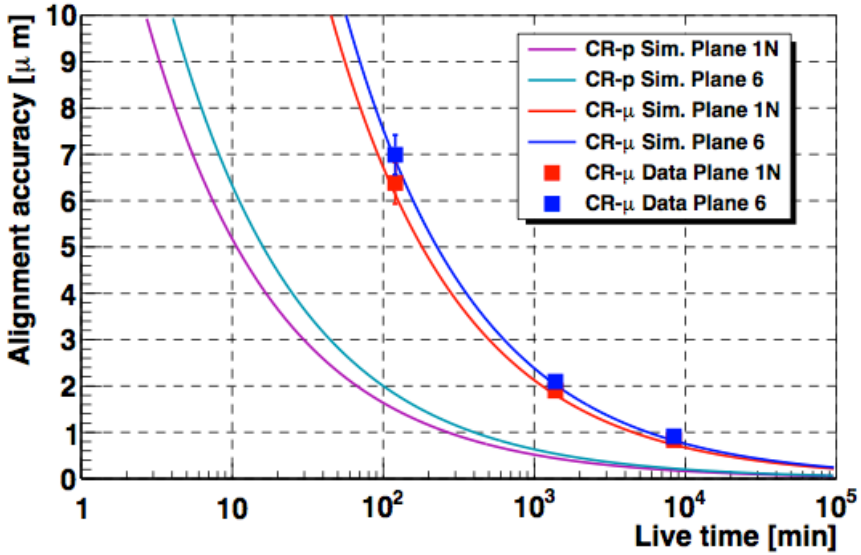


experience to come: alignment



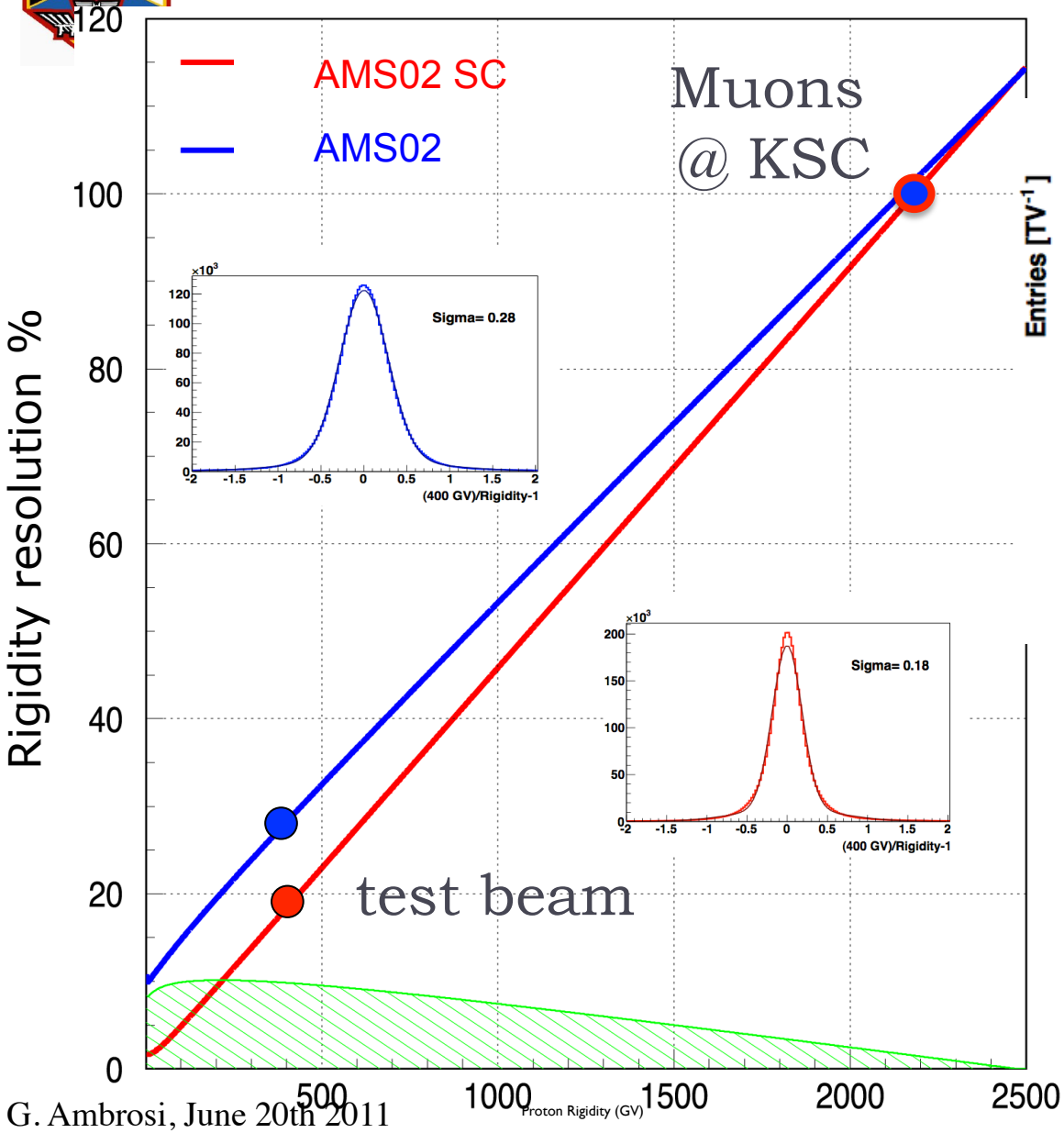


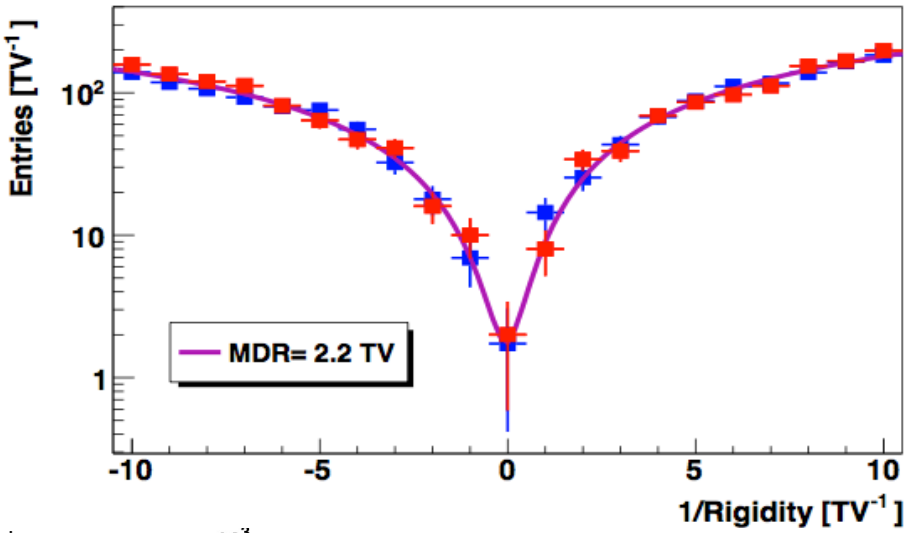
on ground results
inner planes

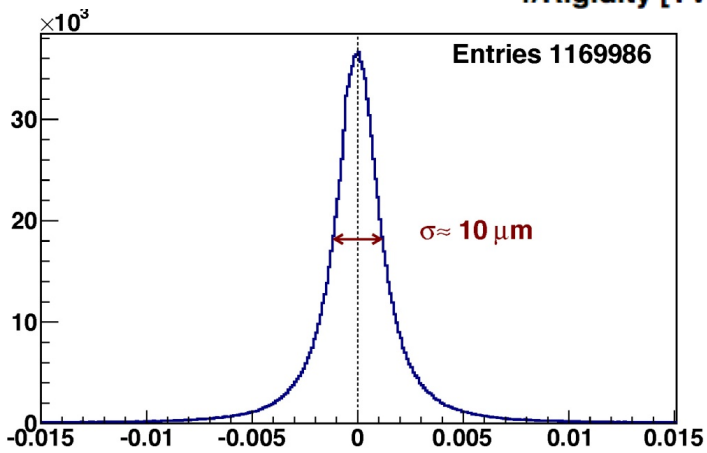


external planes
expected results

the performance we do expect







Bending coord residual (cm)

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 (1.3 billions events)
- 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!)

Science will come soon!