The Alpha Magnetic Spectrometer (AMS) Experiment

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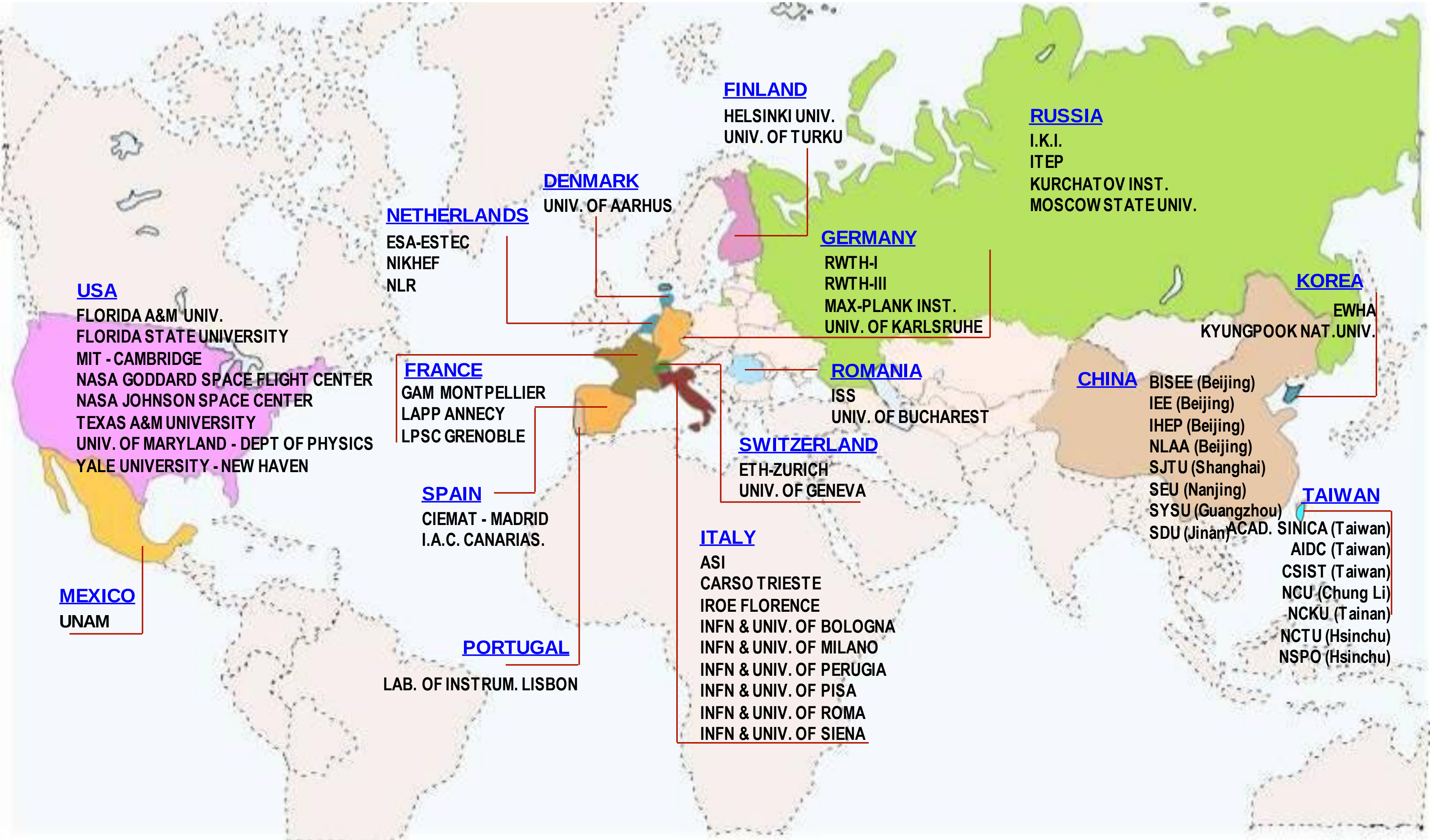
IN2P3 – LAPP

Dark Matter Underground and in the Heavens **CERN July 26, 2011**

AMS is US Dept of Energy (DOE) led International Collaboration

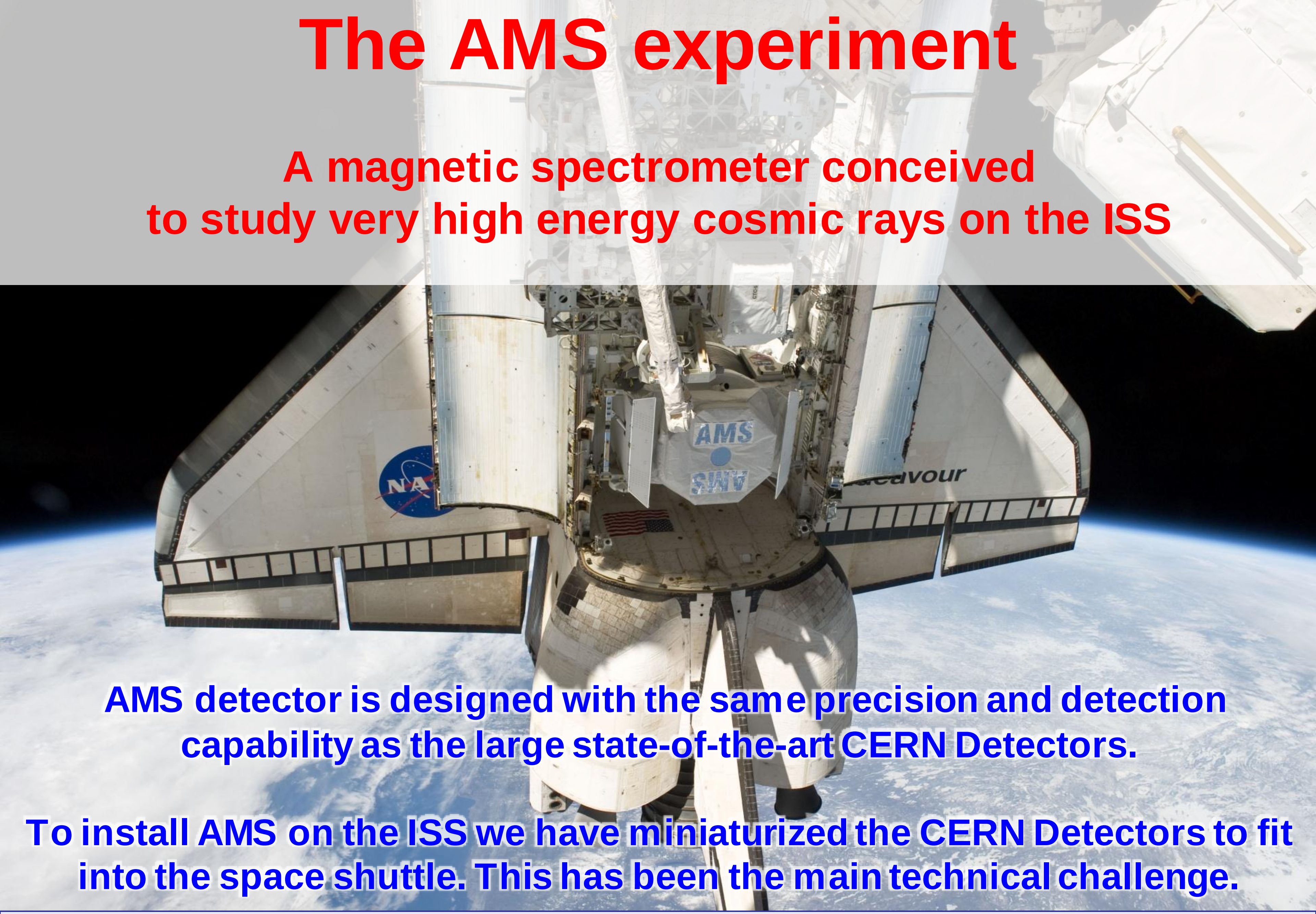
16 Countries, 60 Institutes and 600 Physicists, 17 years



The detectors were built all over the world and assembled at CERN, near Geneva, Switzerland

The AMS experiment

A magnetic spectrometer conceived to study very high energy cosmic rays on the ISS



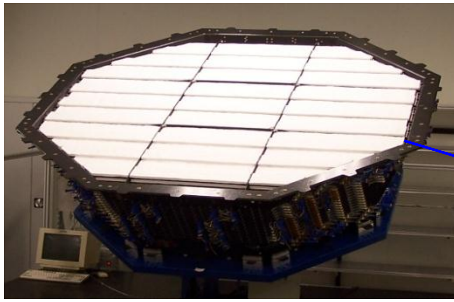
AMS detector is designed with the same precision and detection capability as the large state-of-the-art CERN Detectors.

To install AMS on the ISS we have miniaturized the CERN Detectors to fit into the space shuttle. This has been the main technical challenge.

Steadily taking data on the ISS since May 19 2011

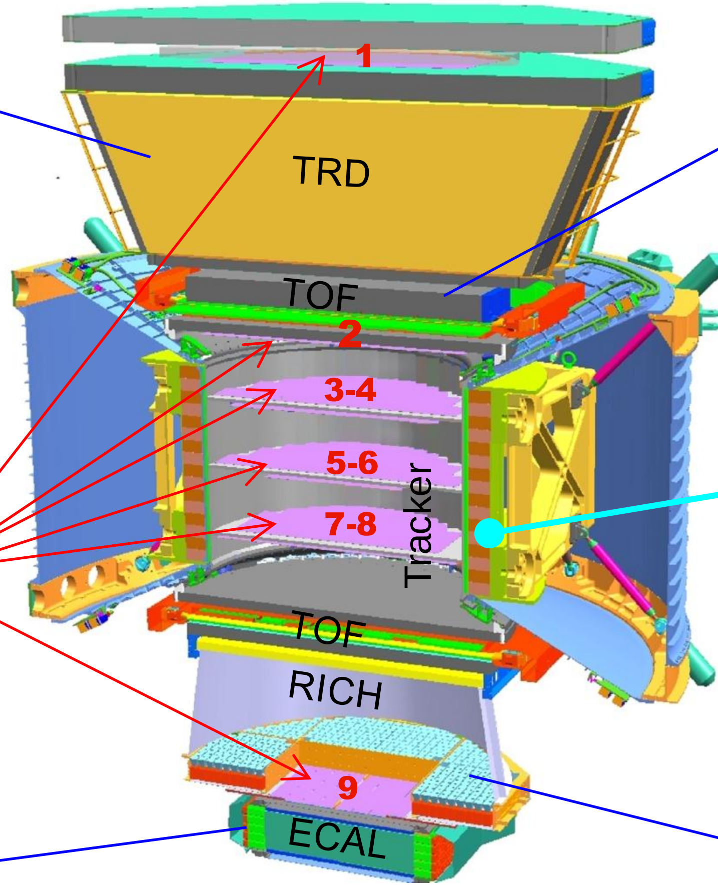
AMS: A TeV precision, multipurpose particle physics spectrometer in space.

TRD
Identify e+, e-

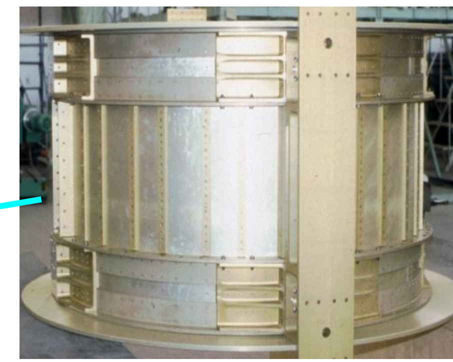


Particles and nuclei are defined by their charge (Z) and energy (E ~ P)

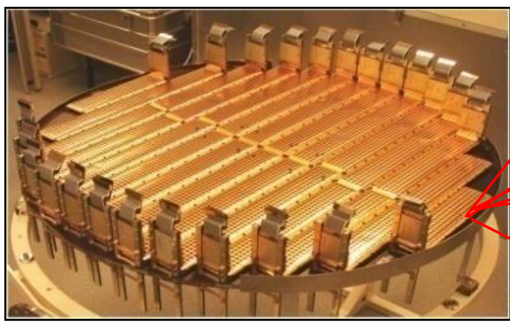
TOF
Z, E



Magnet
±Z



Silicon Tracker
Z, P



ECAL
E of e+, e-, γ

RICH
Z, E

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

AMS Physics highlights: High-precision and simultaneous measurement of cosmic-ray fluxes in the GV to TV rigidity region

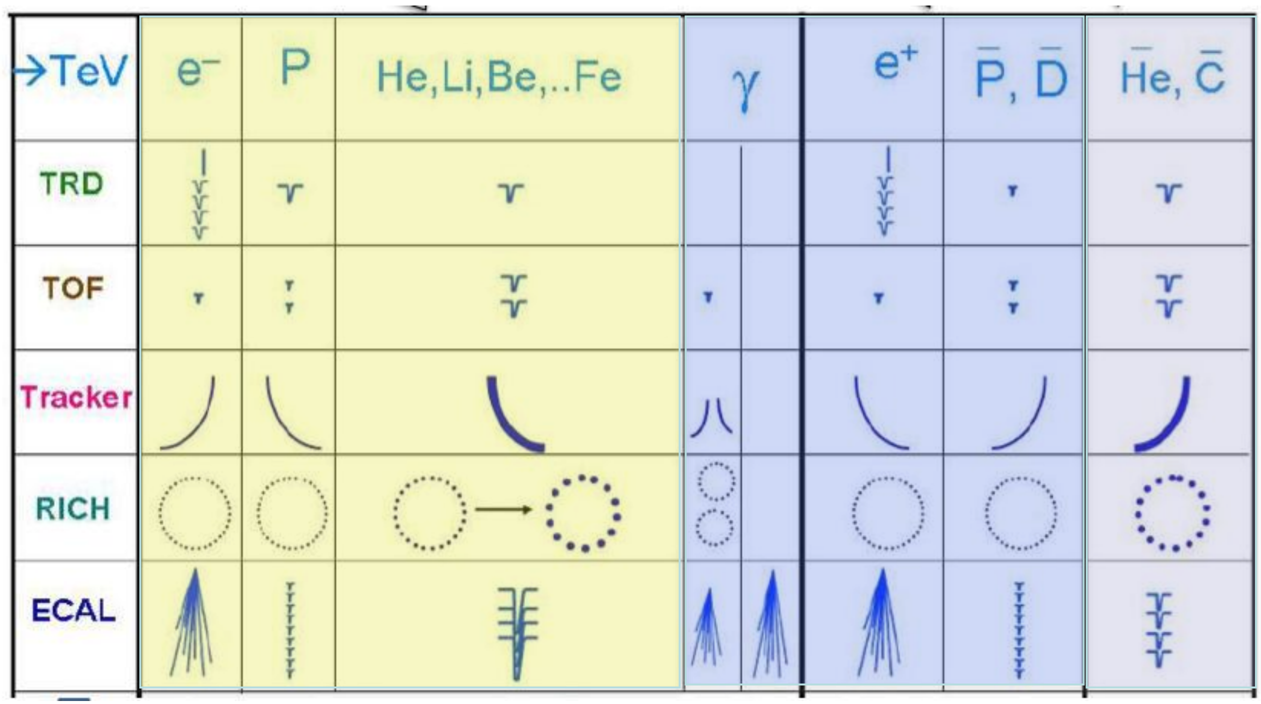
e/hadrons rejection

Trigger,
Particle direction, β, Z^2

Charge sign, P, Z^2, E

β, Z^2

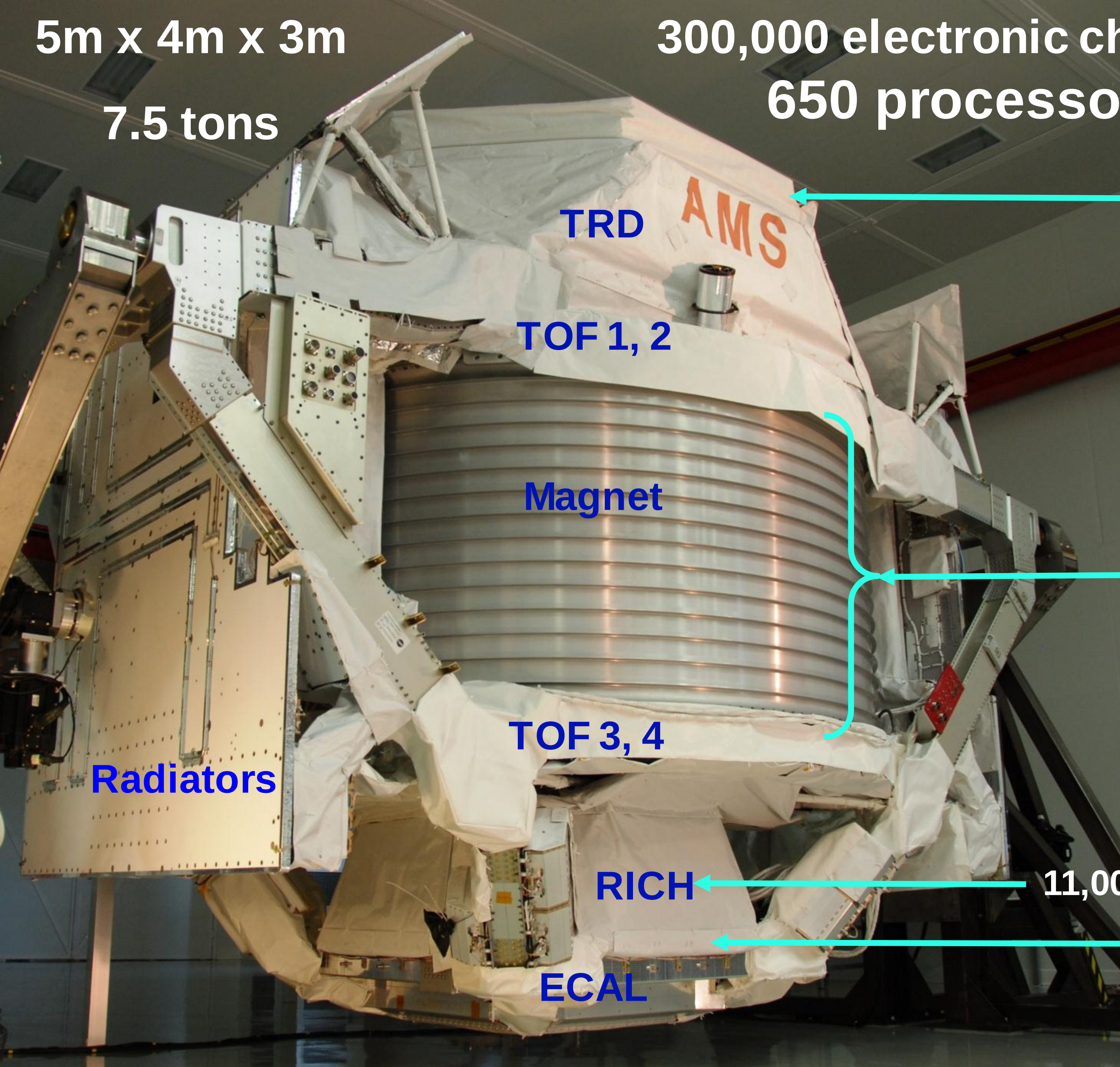
Trigger,
E, e/hadrons rejection,
photon detection



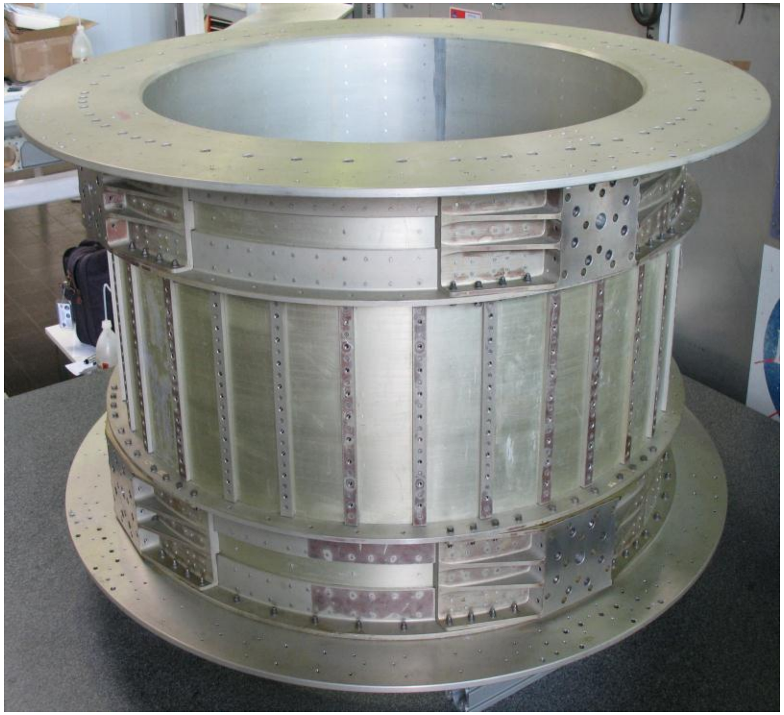
Chemical composition and energy spectra of cosmic rays

Indirect search for Dark Matter

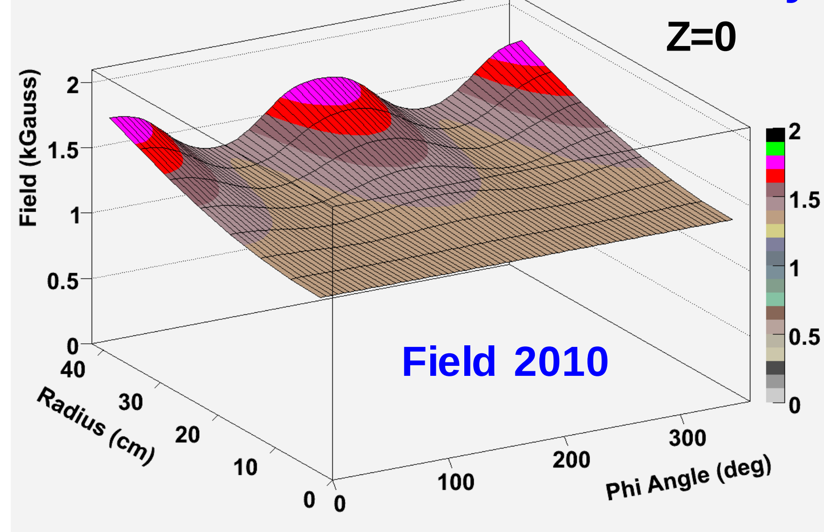
Primordial antimatter

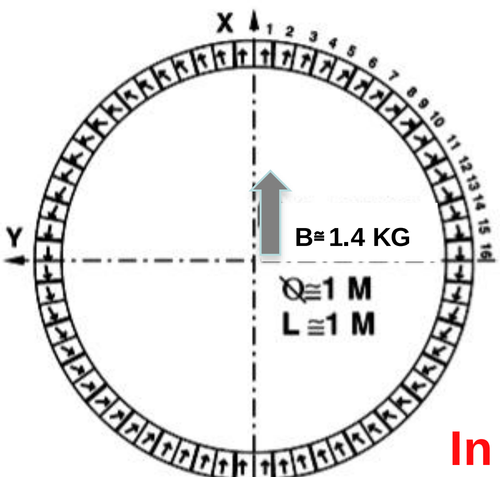

5m x 4m x 3m
7.5 tons
300,000 electronic channels
650 processors
Silicon layer
TRD
AMS
TOF 1, 2
Magnet
7 Silicon layers
TOF 3, 4
Radiators
RICH
11,000 Photo Sensors
Silicon layer
ECAL

The Magnet



The detailed 3D field map (120k locations) was measured at CERN on 25-27 May 2010



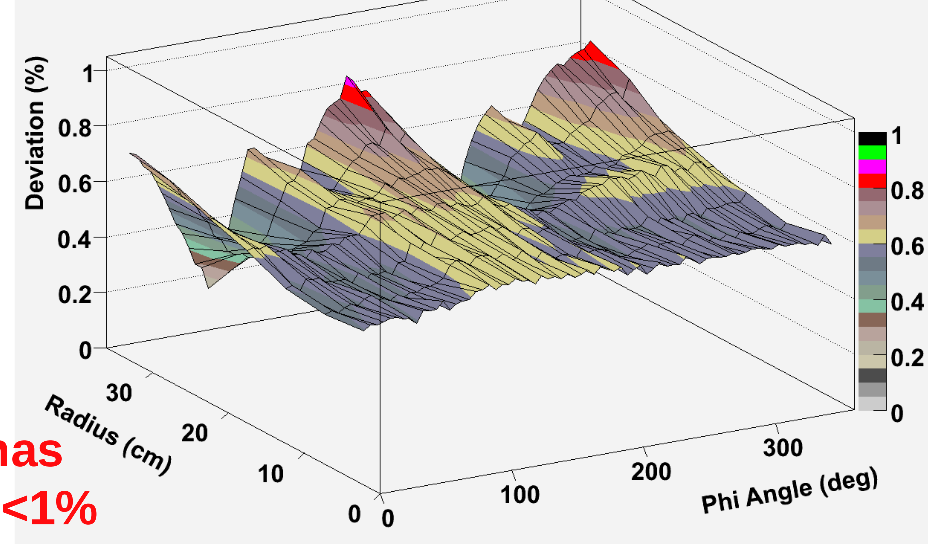


Permanent Magnet

$B_{max} \cong 0.14$ T

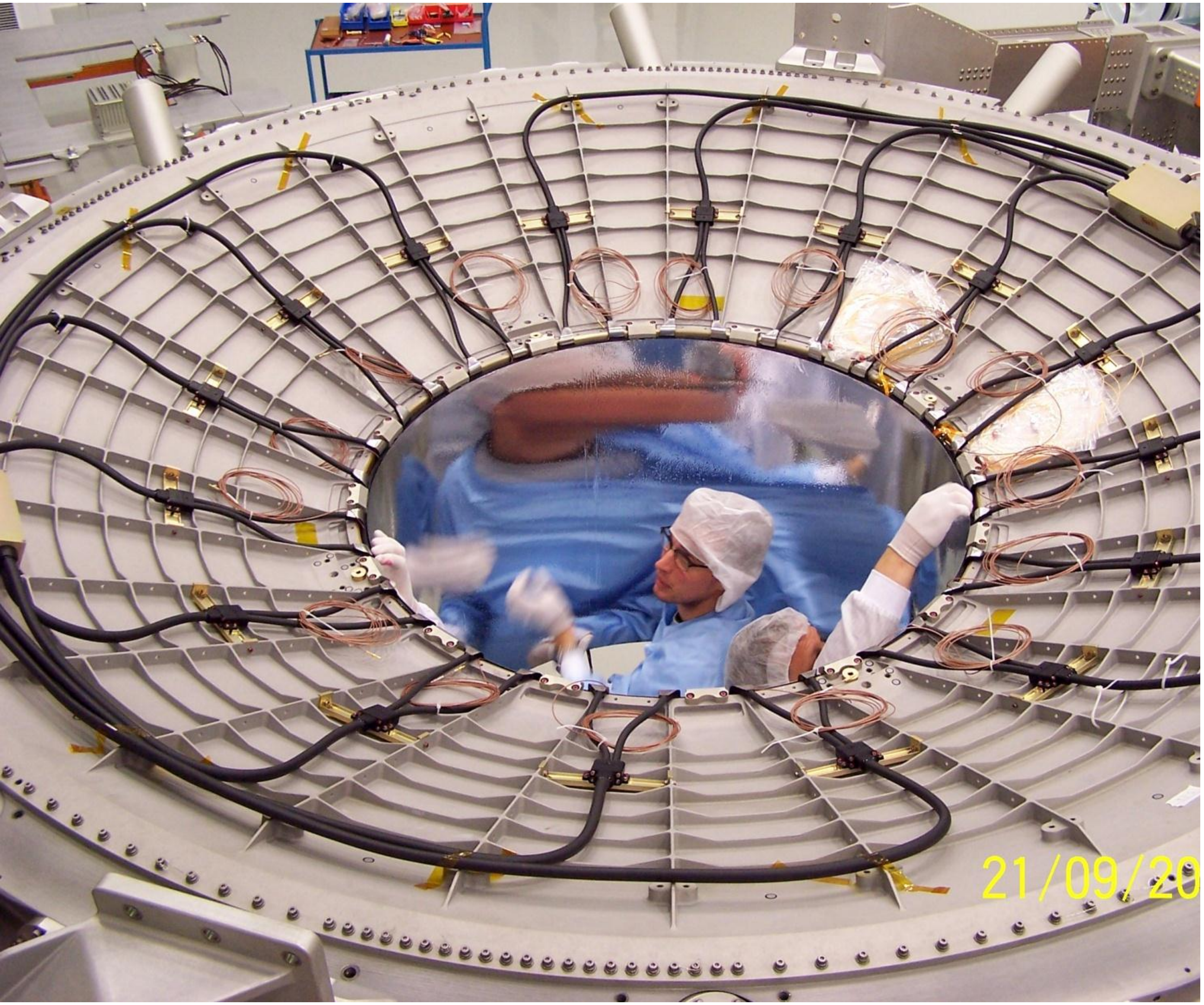
$BL^2 = 0.15\ Tm^2$

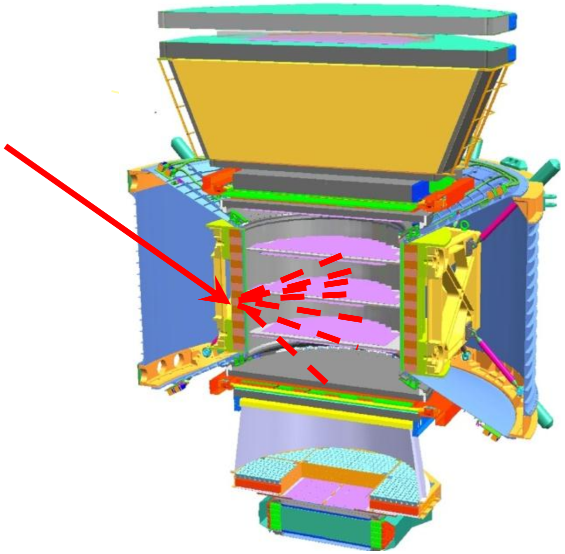
Deviation from 1997 measurement



In 12 years the field has remained the same to <1%

Veto System rejects random cosmic rays





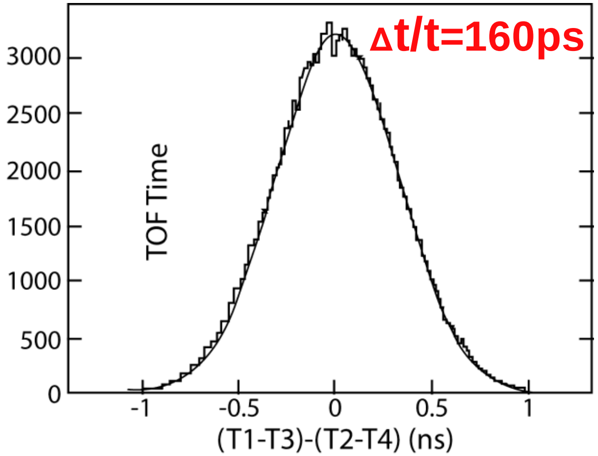
Measured veto efficiency better than 0.99999

Time of Flight (TOF)

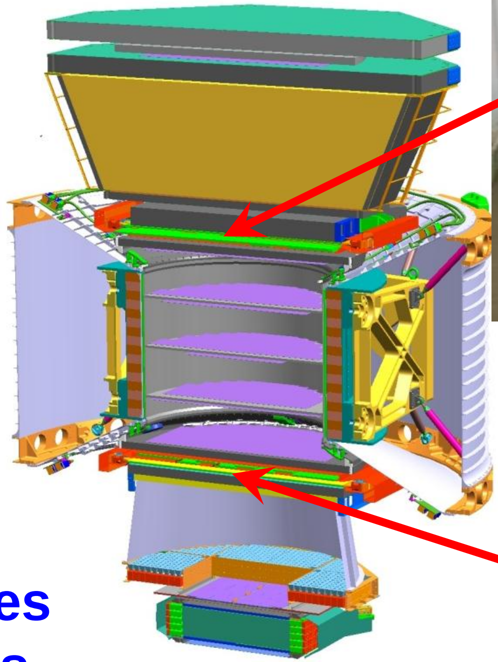
Provides trigger for charged particles

Trigger time is synchronized to UTC time to 1μs

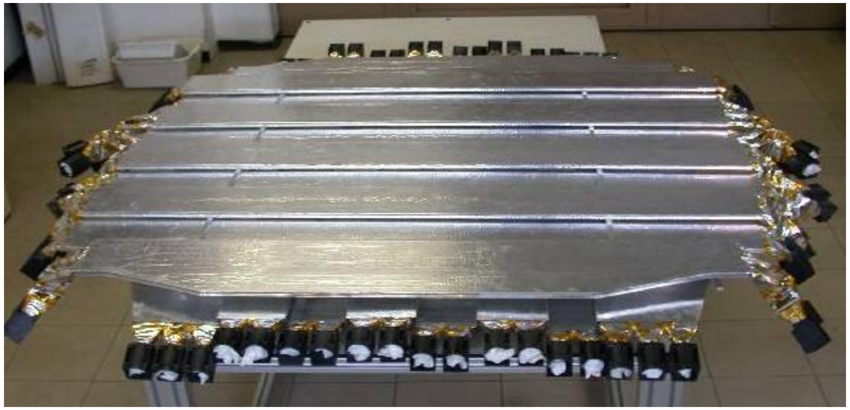
Measures the time of relativistic particles to 160 picoseconds



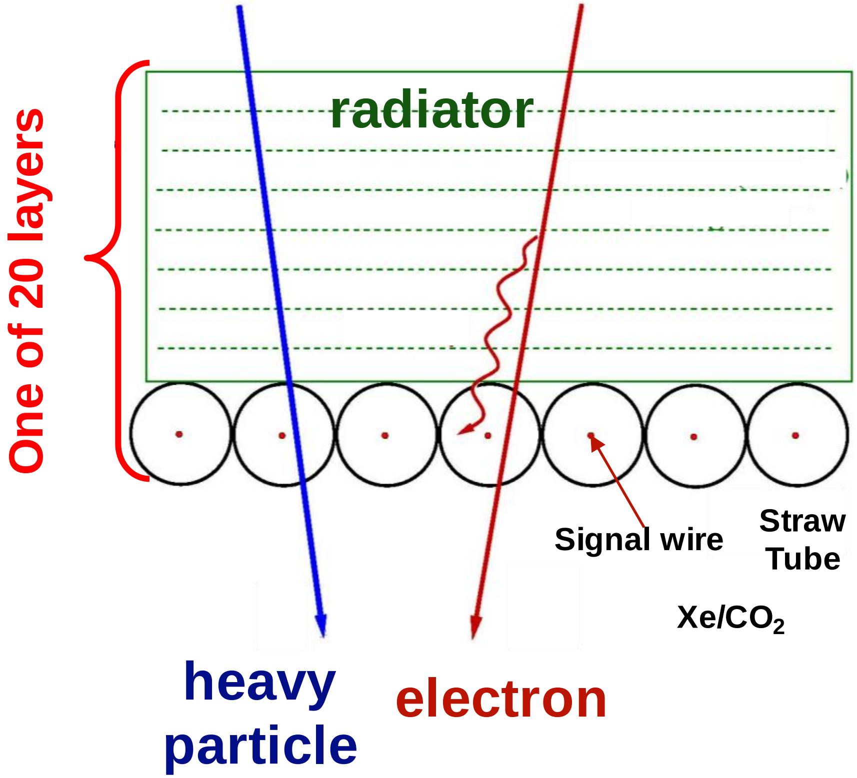
TOF

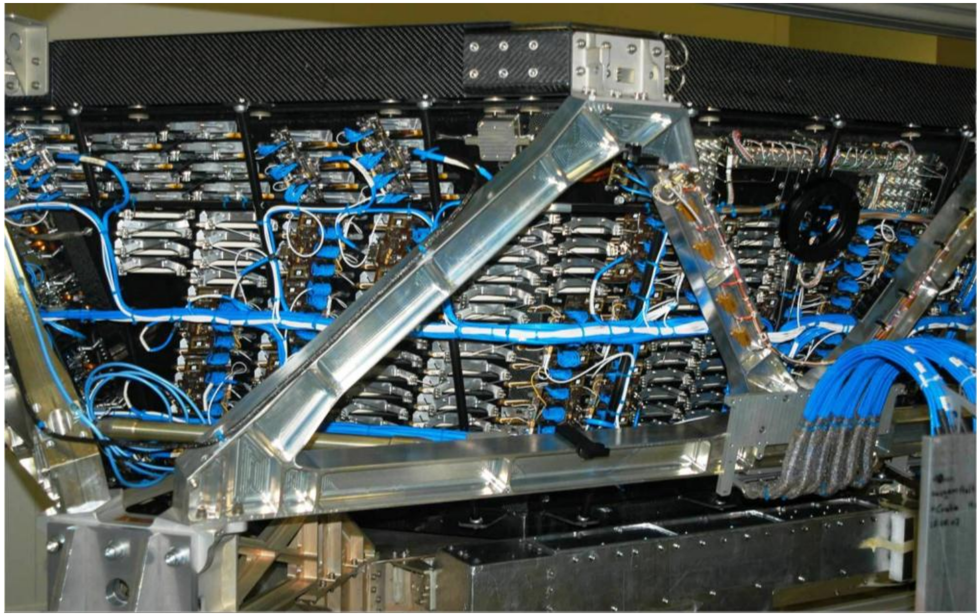


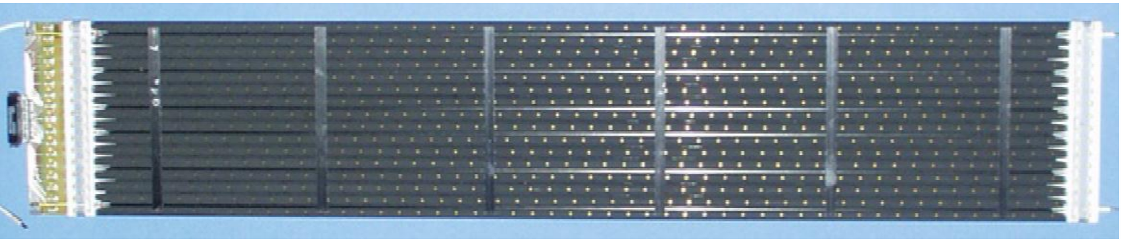
TOF

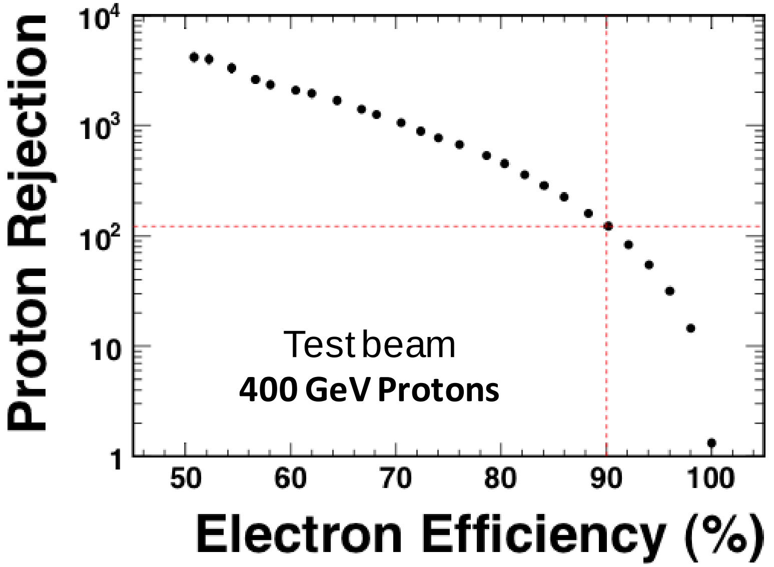


Transition Radiation Detector (TRD): identifies Positron and Electron

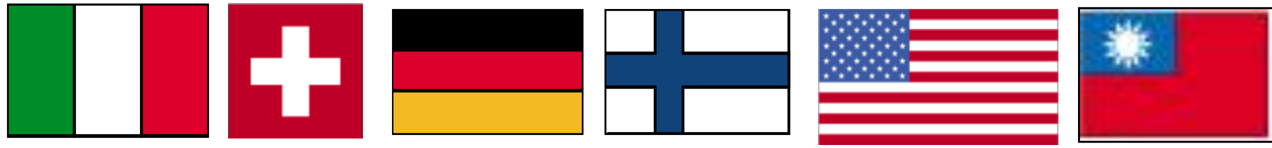


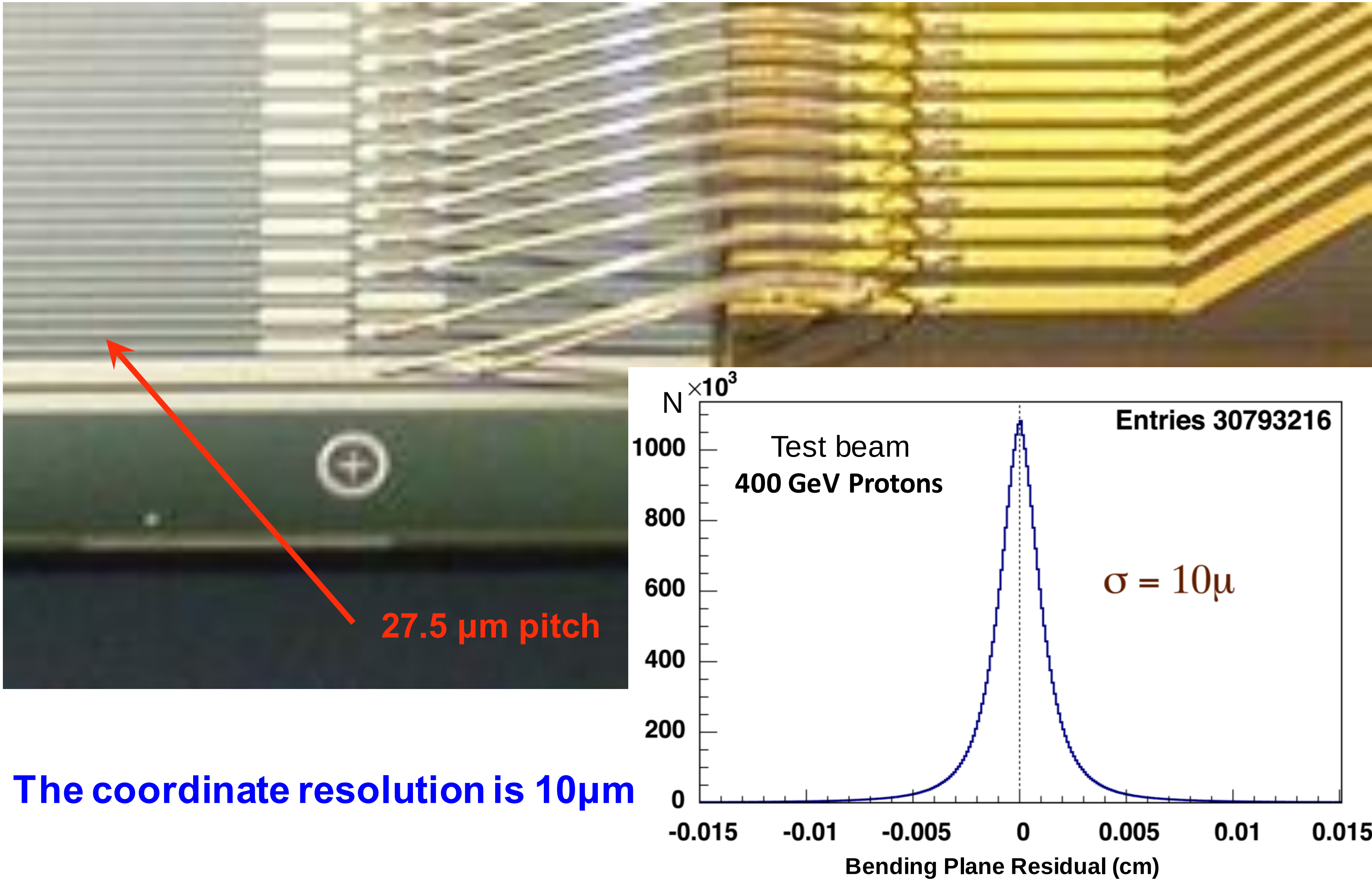






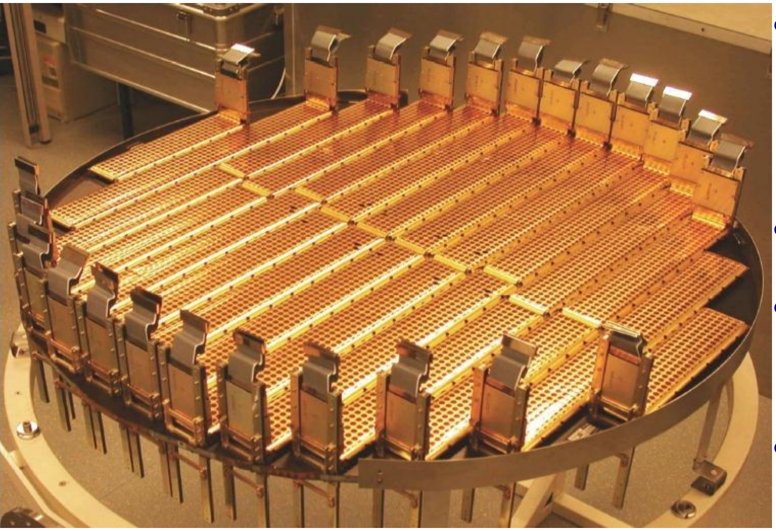
Silicon Tracker



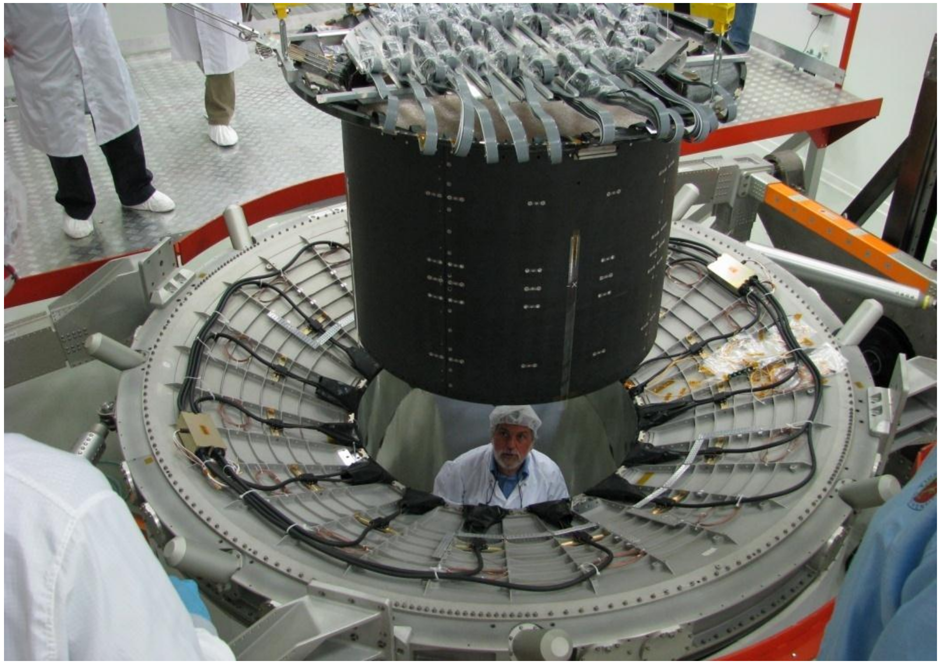


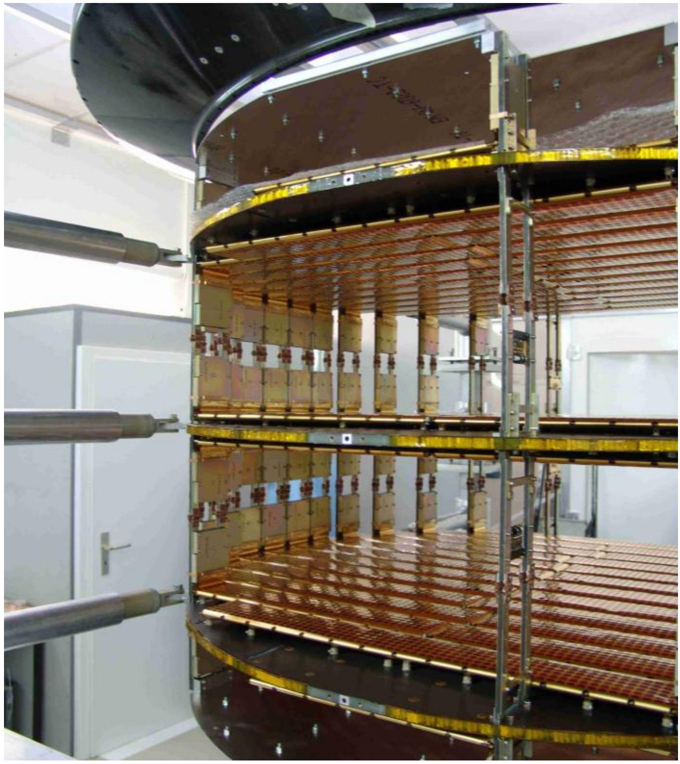
The coordinate resolution is 10µm

Silicon Tracker



- 9 Layers of silicon microstrip detectors for an active area of 6.4m^2, 3 μm mechanical alignment.
- 200k channels for 129 W of power
- high dynamic range front end for charge measurement up to Z=28
- wide temperature range (-20/+40 °C)

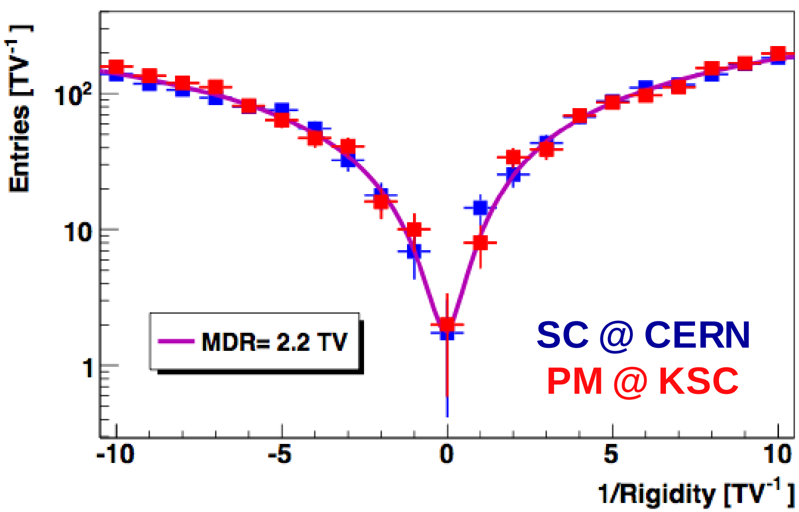


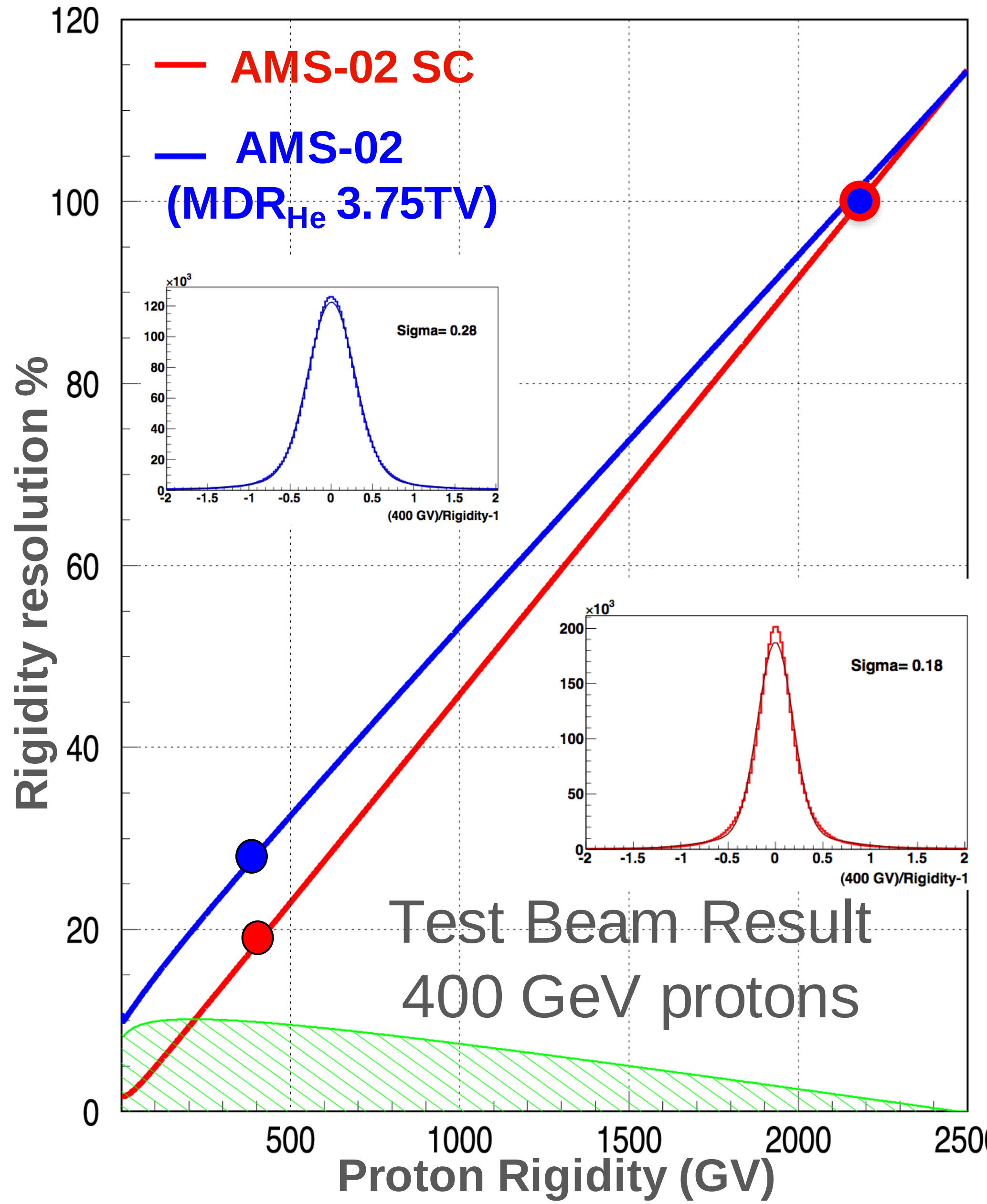


Tracker : Rigidity resolution

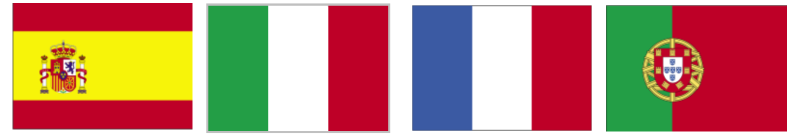
Maximum detectable Rigidity:
- 2.14 TV for protons
- 3.75 TV for He

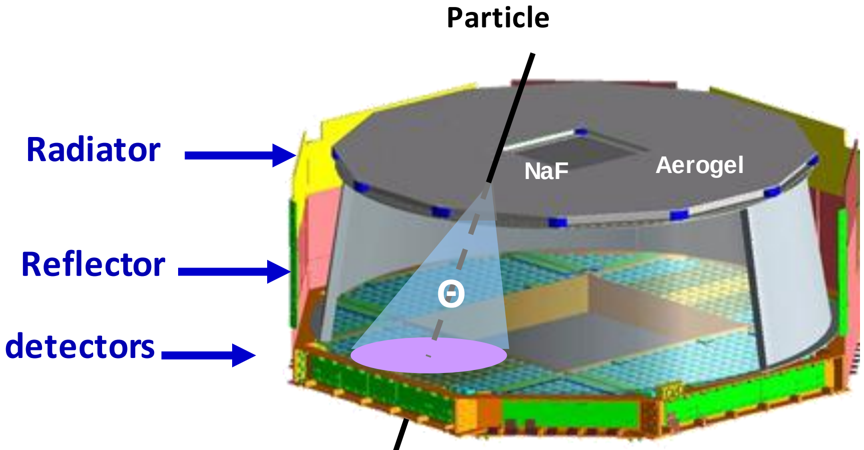
Calibration with muons



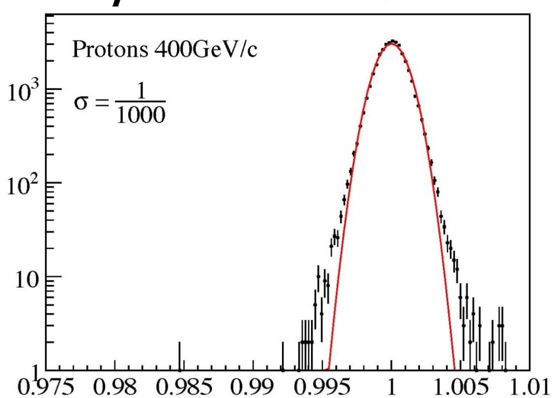


Ring Imaging CHerenkov (RICH)

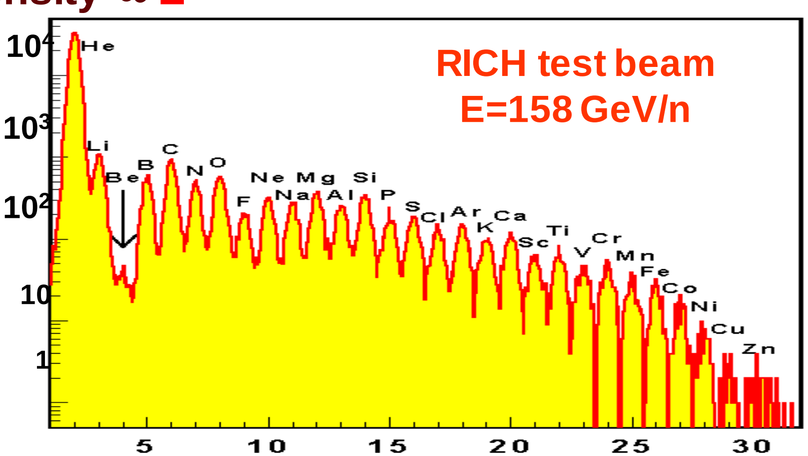


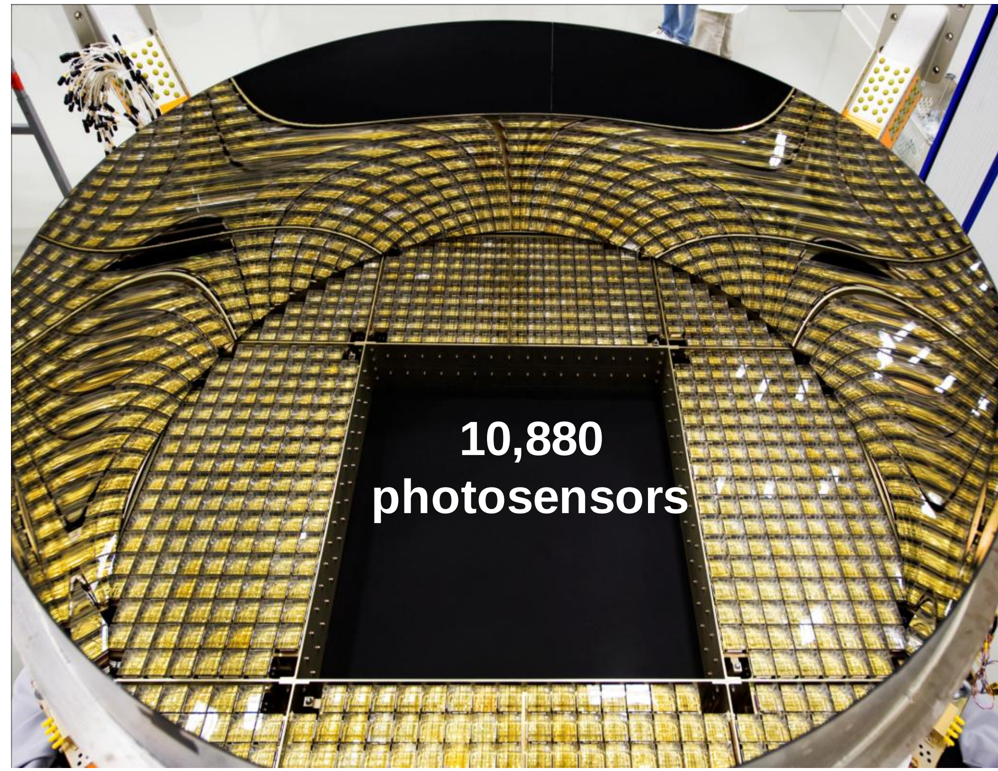


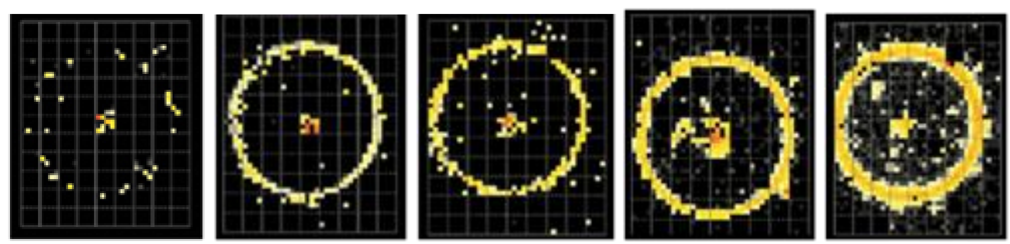
$\Theta \propto \beta$



Intensity $\propto Z^2$







He Li C O Ca

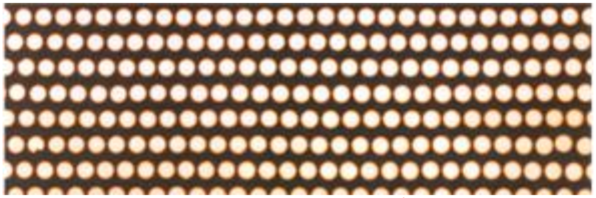
Single Event Displays

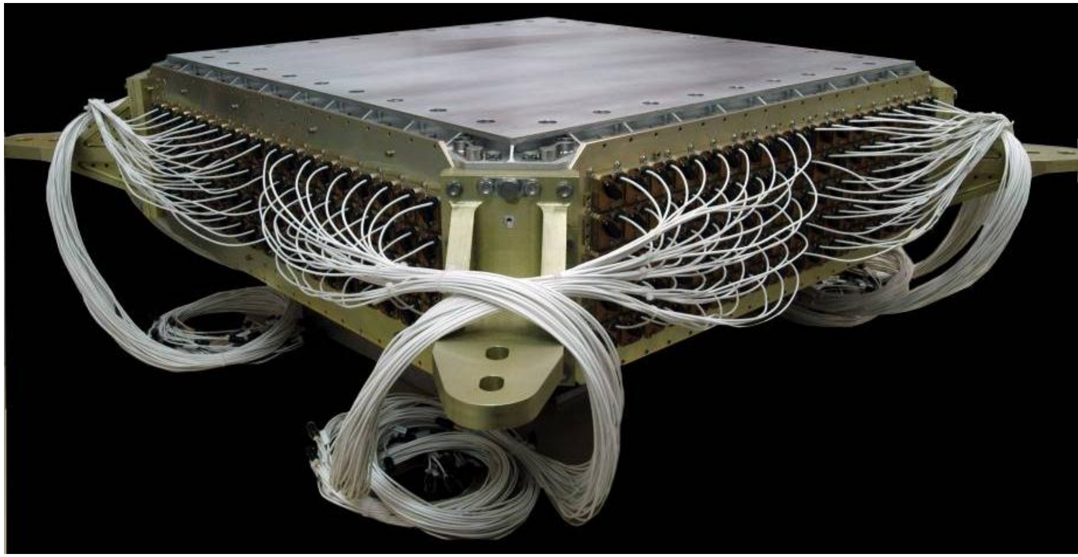
RICH test beam E=158 GeV/n

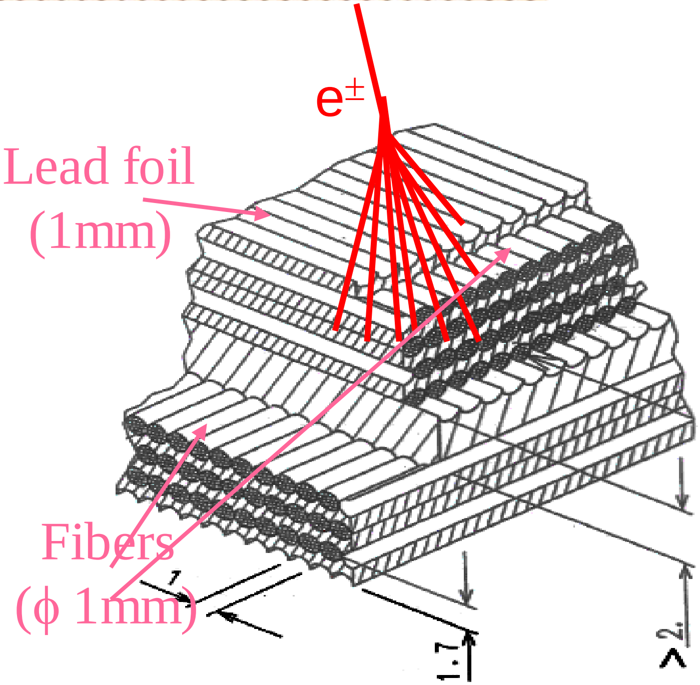
Calorimeter (ECAL)

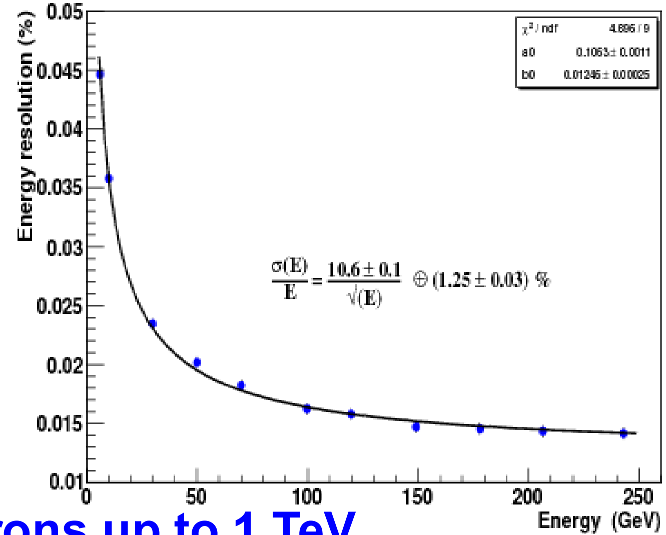
3D Sampling

50,000 fibers, $\phi = 1$mm, distributed uniformly inside 1,200 lb of lead

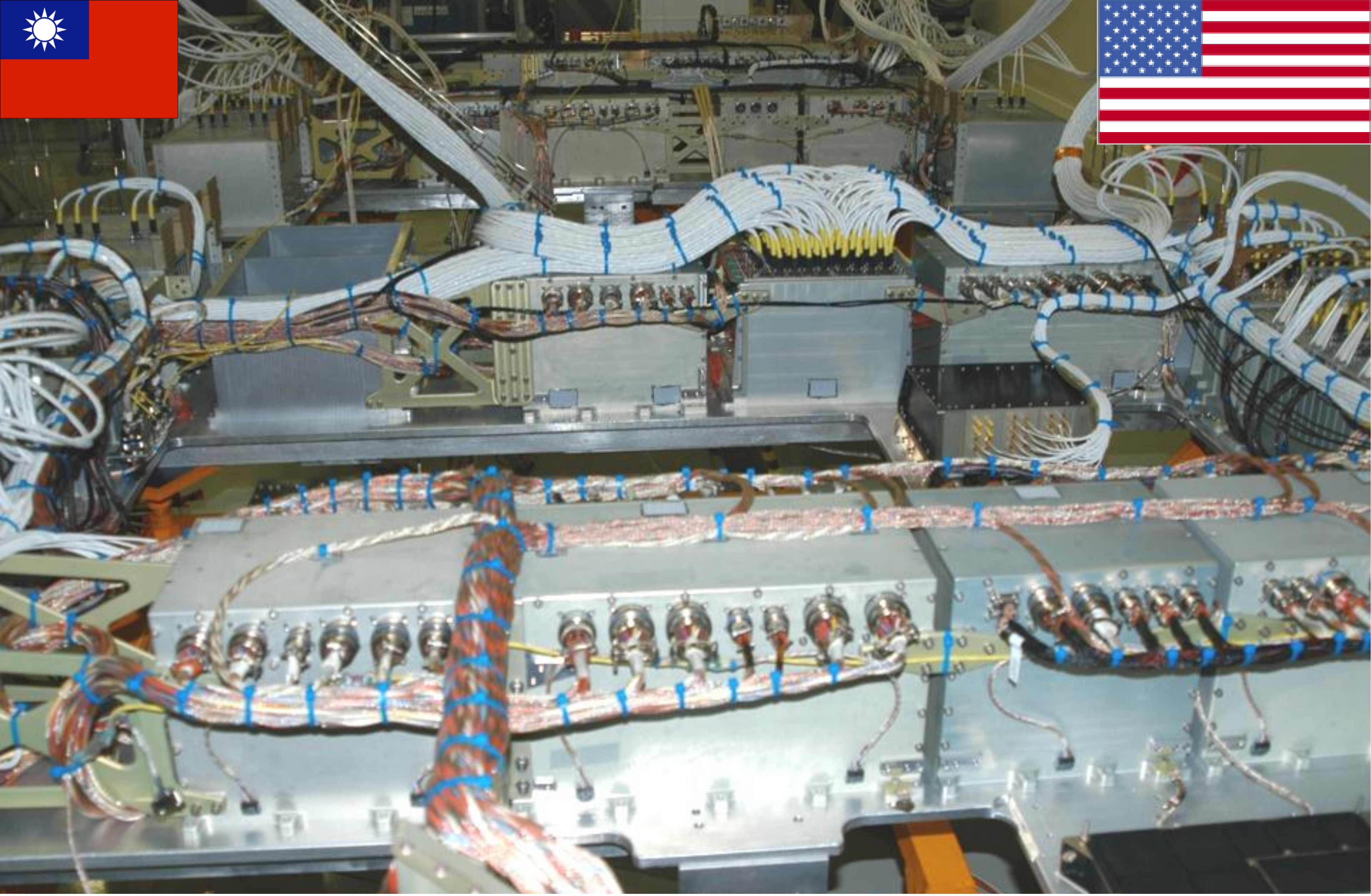






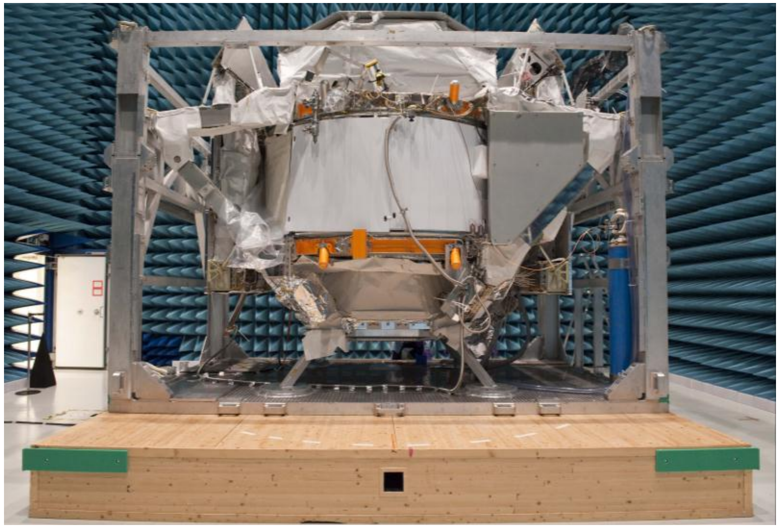


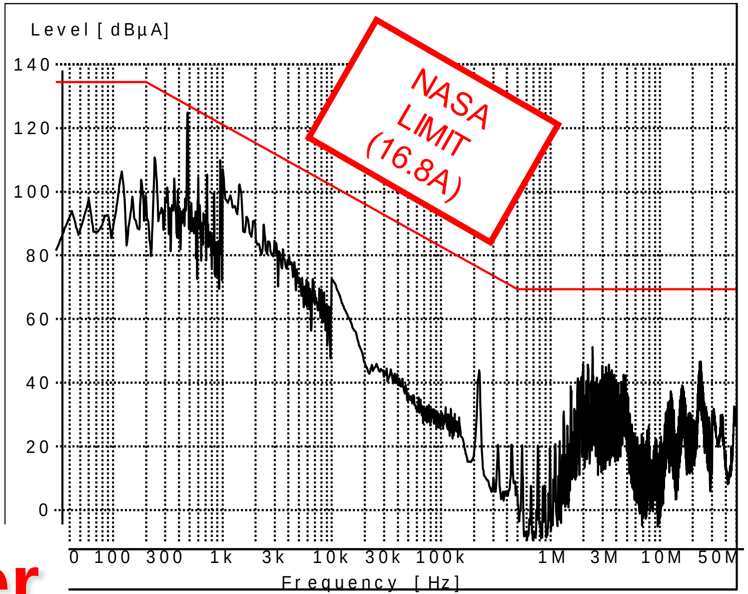
precision, 3-dimensional, $17X_0$ measurement of the directions and energies of γ rays and electrons up to 1 TeV, e^+/p rejection power at 400 GeV of 10^{-3} with 70% electron efficiency



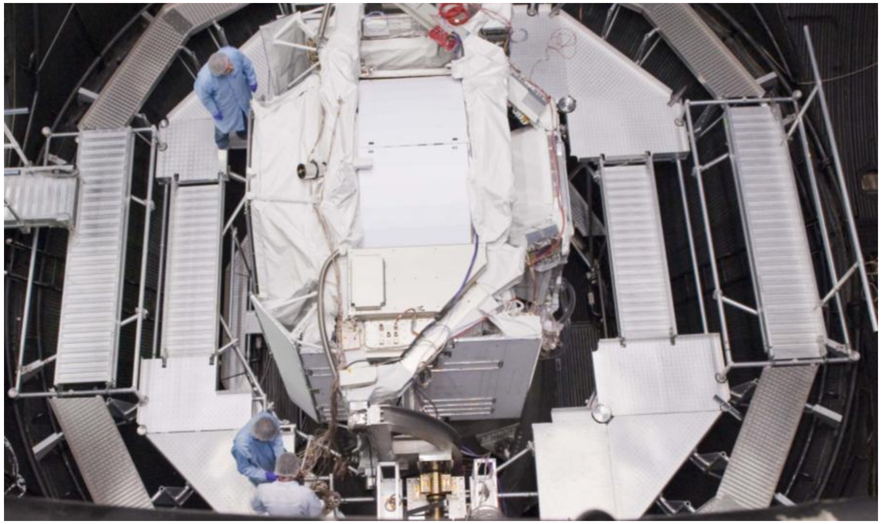
The completed flight electronics
(650 microprocessors, 300,000 channels)

AMS in the Maxwell EMI chamber at ESTEC



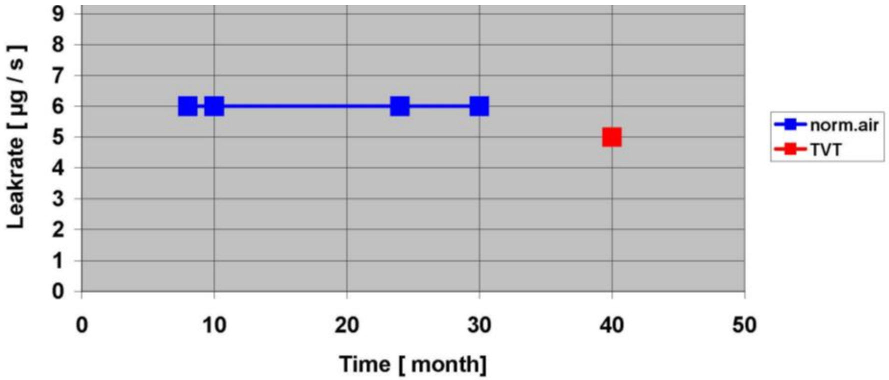


AMS in the ESA TVT Chamber



Consumables lifetime – TRD Leak rate

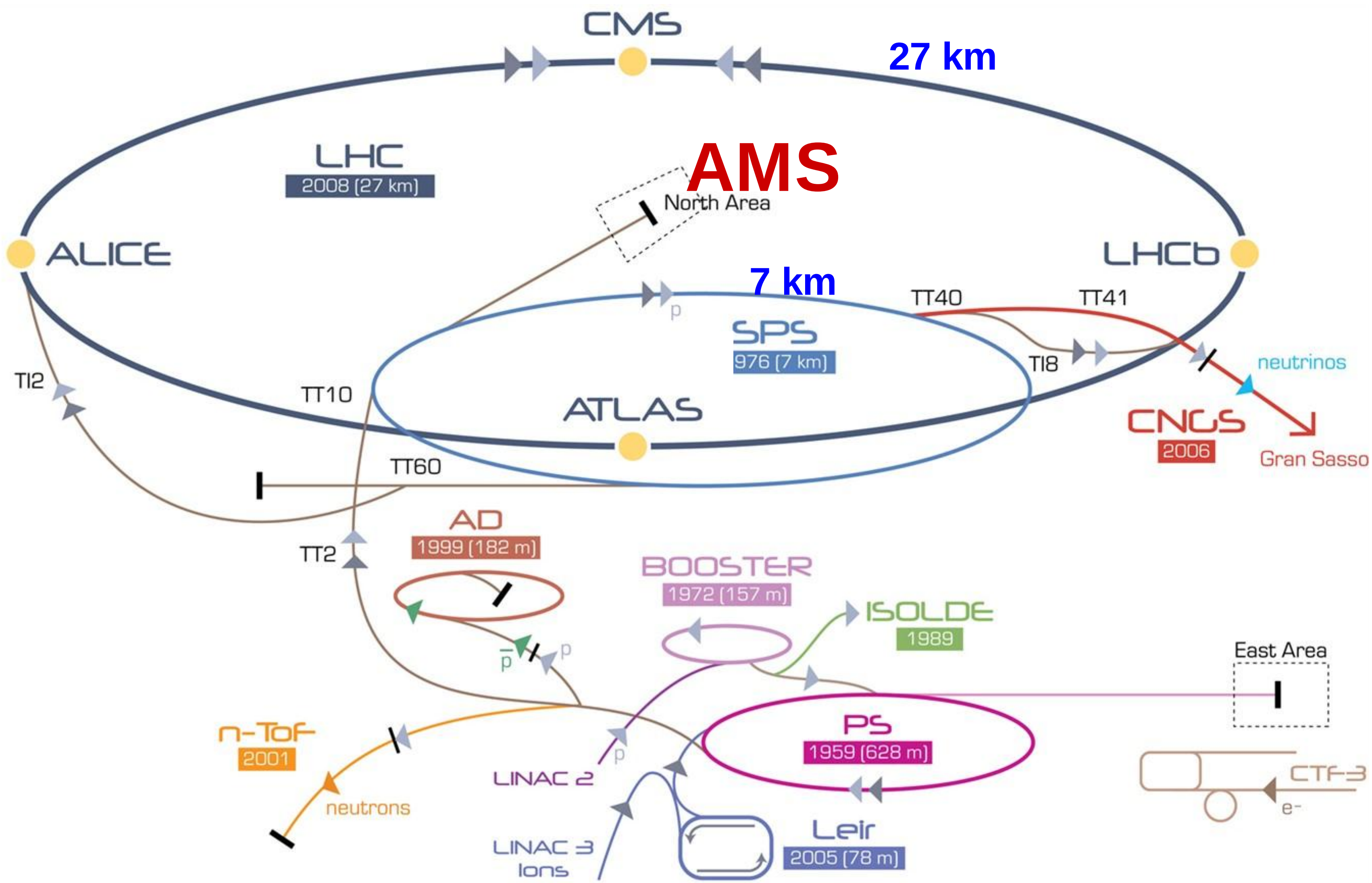
Caused by CO_2 diffusion



CO_2 Storage at Launch: 5 kg

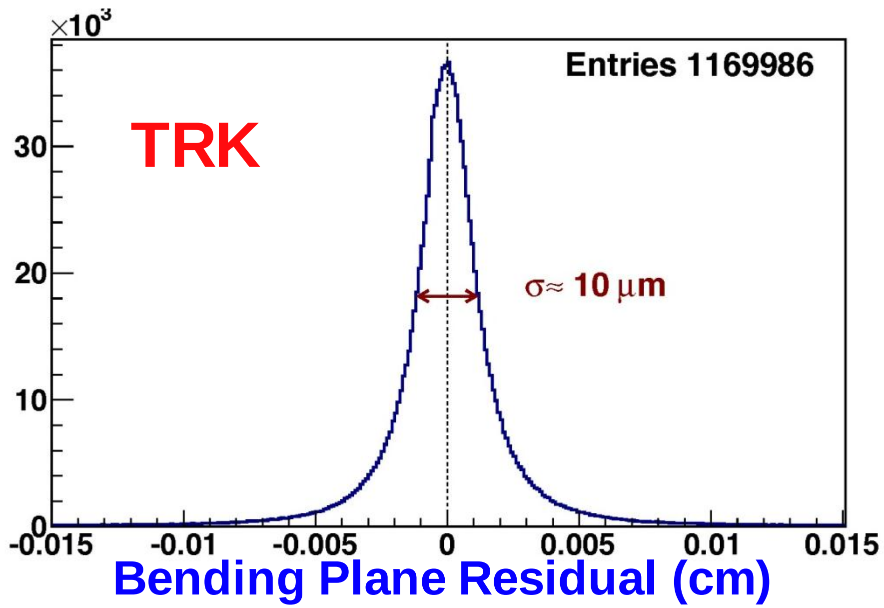
TRD Lifetime of 30 Years

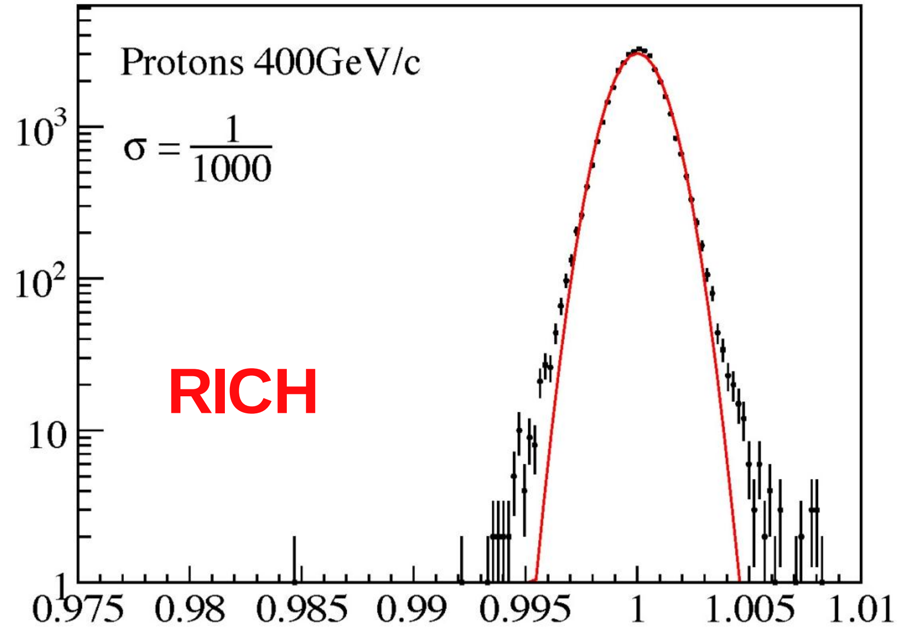
Test at CERN
AMS in accelerator test beam Feb 4-8 and Aug 8-20, 2010

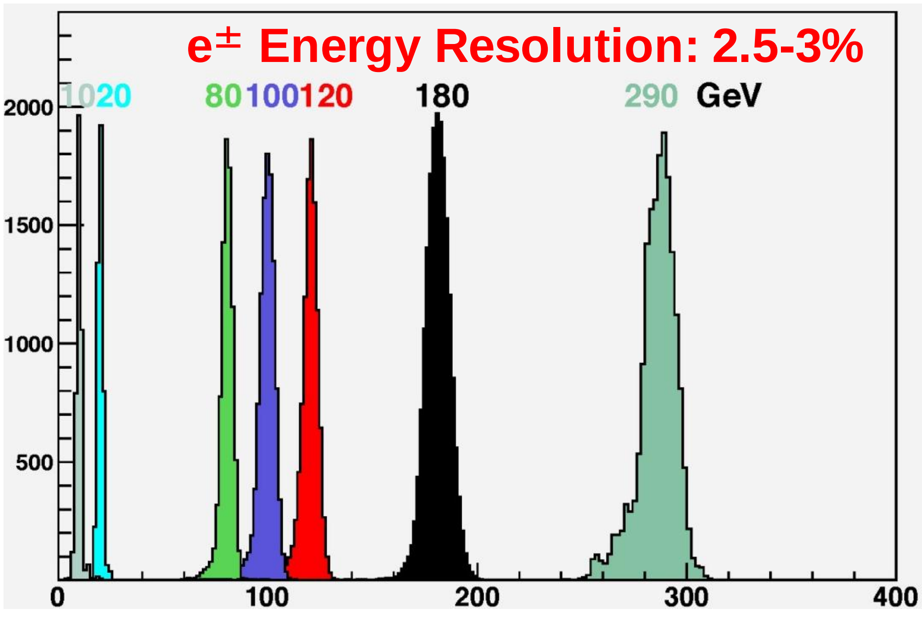


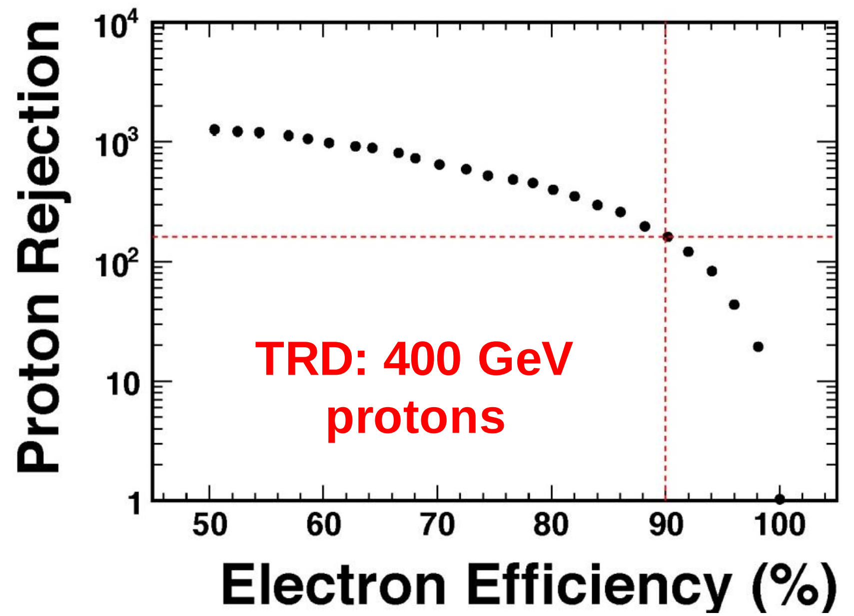
CERN Accelerator Complex

Beam test calibration 8-20 Aug 2010









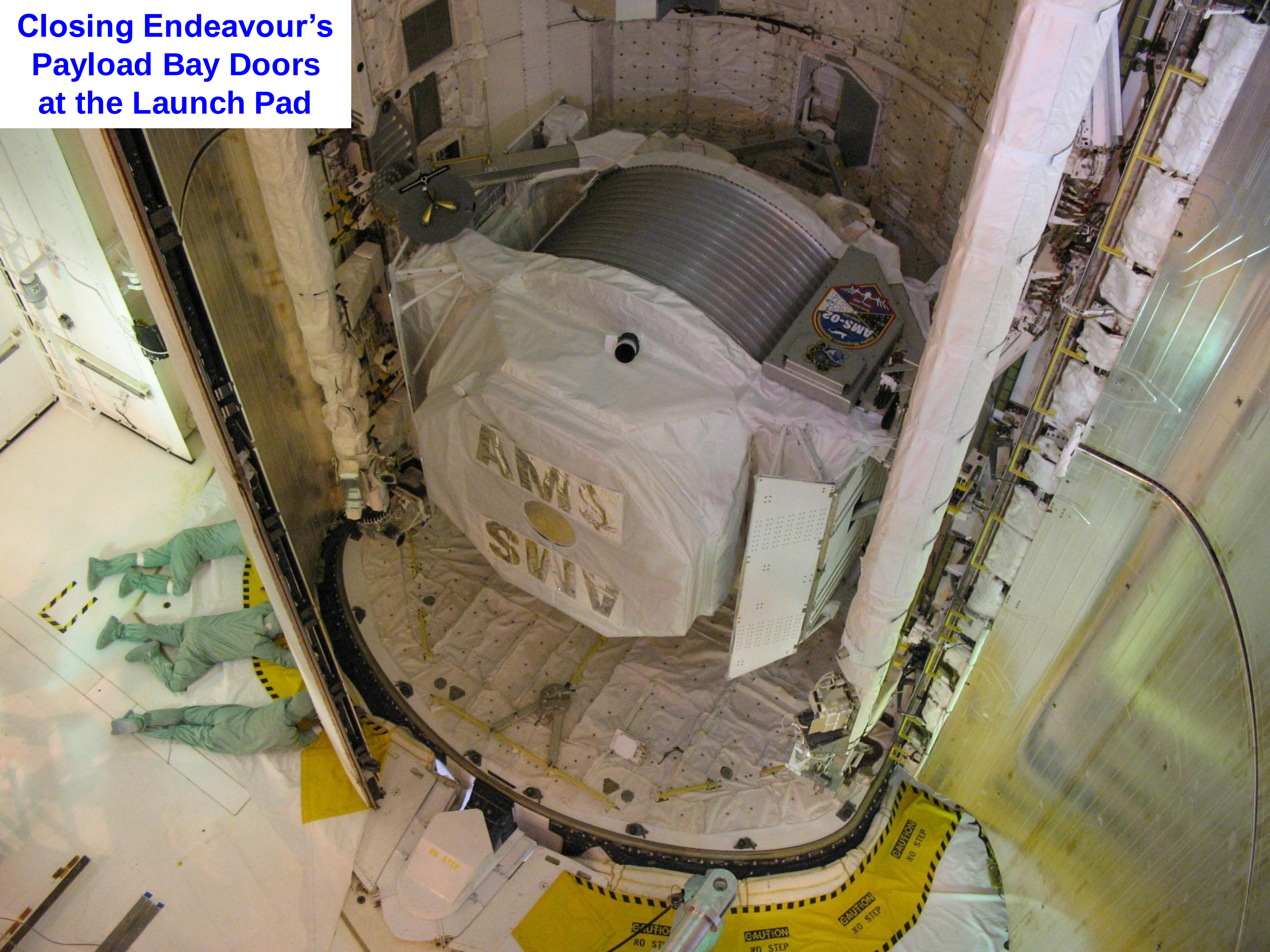
Moving to NASA Kennedy Space Center

Arrival of the AMS C5 at Geneva – 25 Aug 2010

AMS in the Space Station Processing Facility (SSPF), ready for installation into the Space Shuttle

Loading of AMS into a US Air Force C5-M at Geneva Airport – 25 Aug 2010

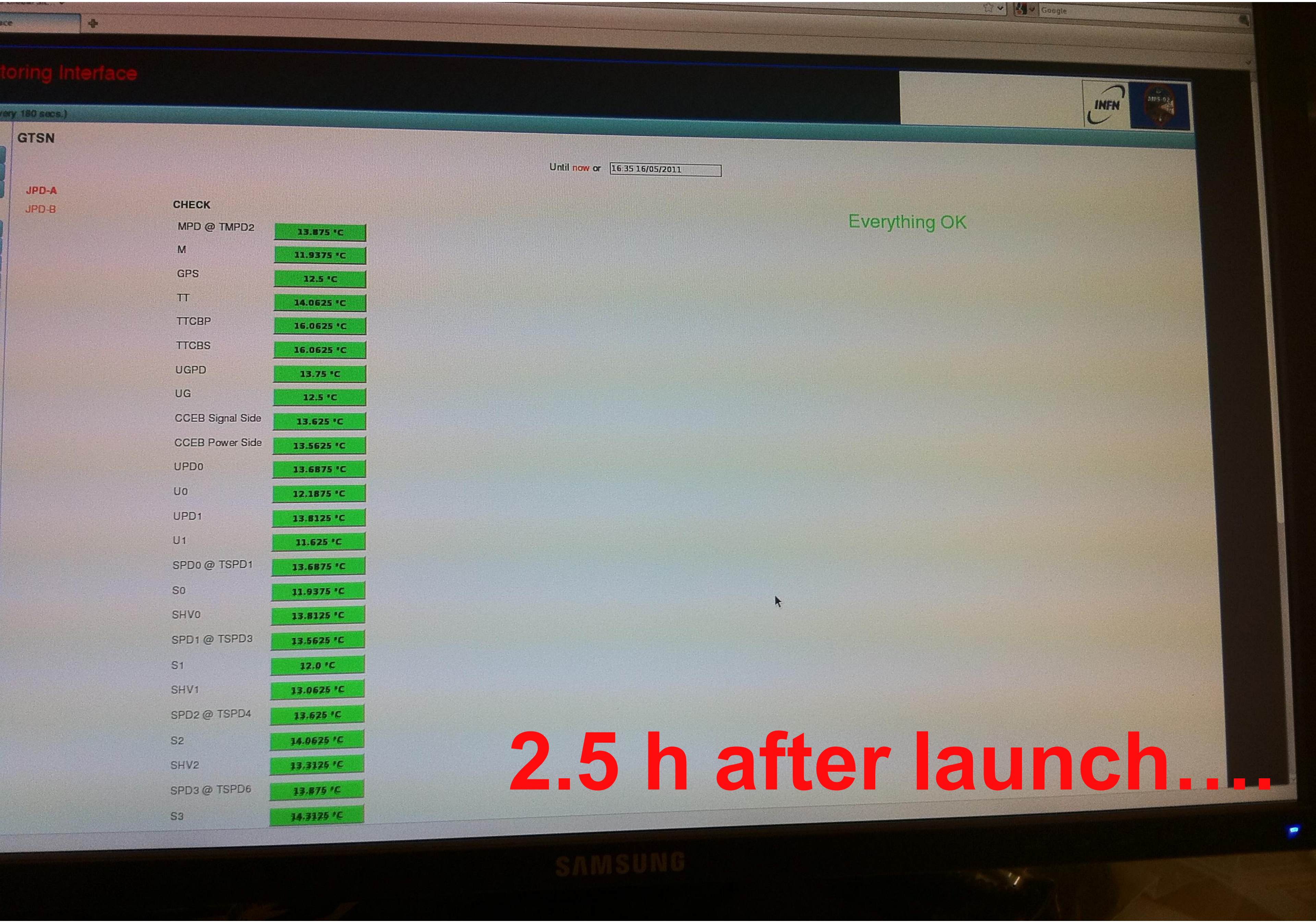
Closing Endeavour's Payload Bay Doors at the Launch Pad



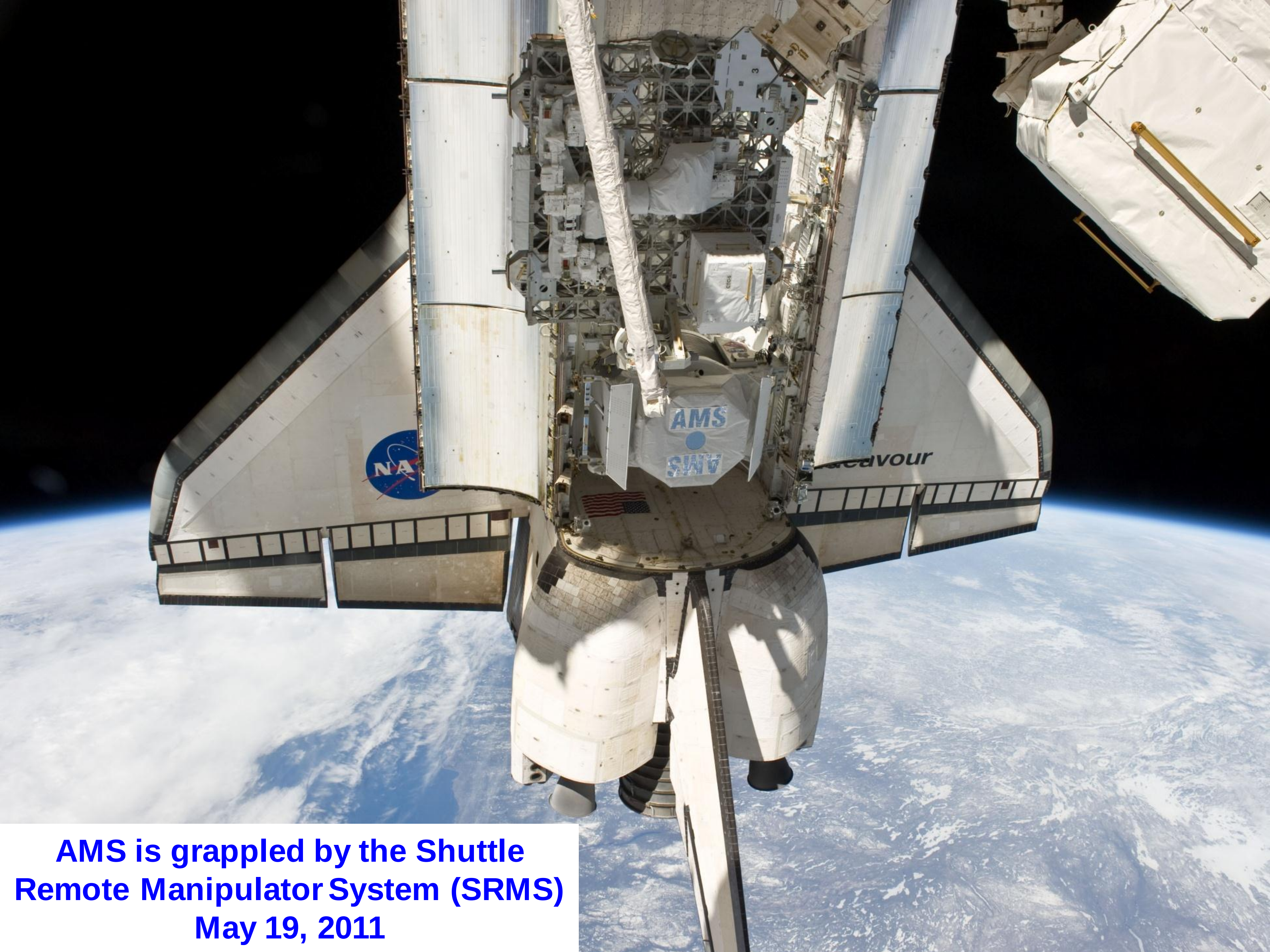

STS-134 launch May 16, 2011 @ 08:56 AM

Endeavour approaches the International Space Station

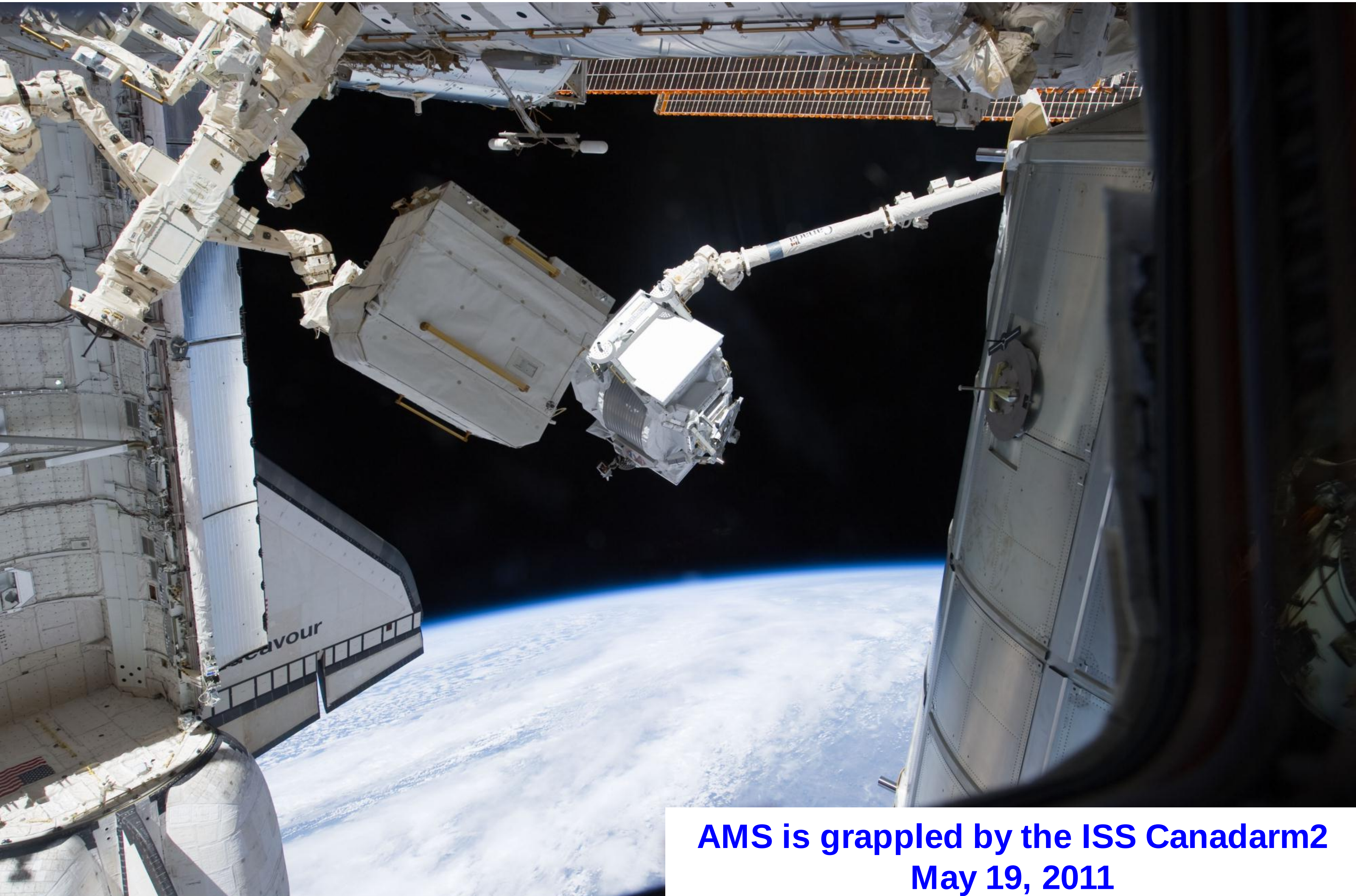
Monitoring AMS from NASA Johnson Space Center



2.5 h after launch....



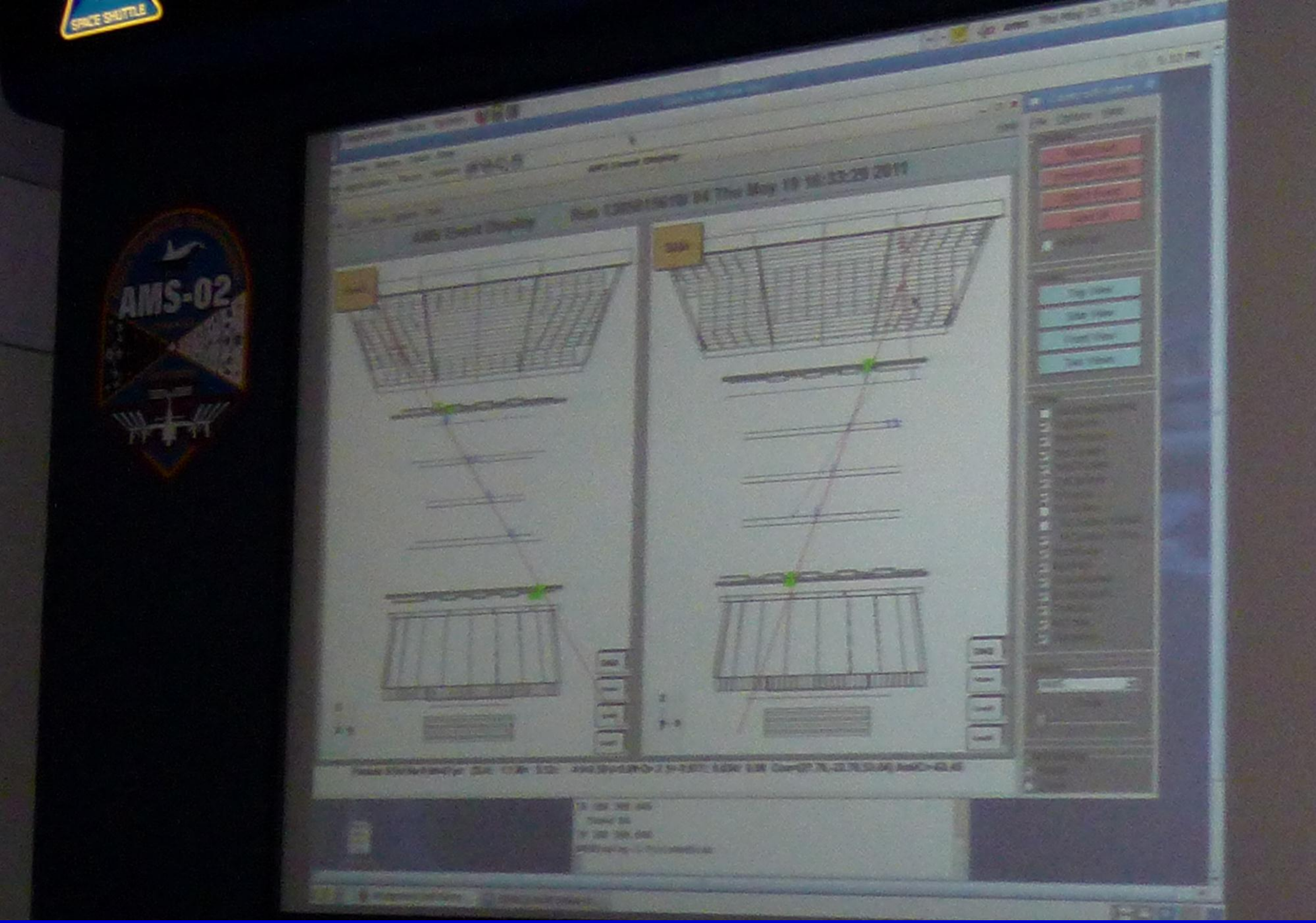
AMS is grappled by the Shuttle Remote Manipulator System (SRMS)
May 19, 2011



AMS is grappled by the ISS Canadarm2
May 19, 2011

May 19: AMS installed on ISS 5:15 CDT, start taking data 9:35 CDT

During the first week, we collected 100 million cosmic rays



One of the Firsts AMS-02 Event in Space as seen in Houston

A smiling collaboration with the PI, Prof. S.C.C. Ting after the first hours of operations

Science Data Flow

AMS on the ISS

AMS

NASA channels

MSFC POIC, AL

AMS GSC

Internet

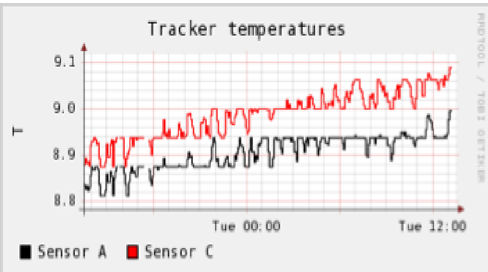
JSC, TX

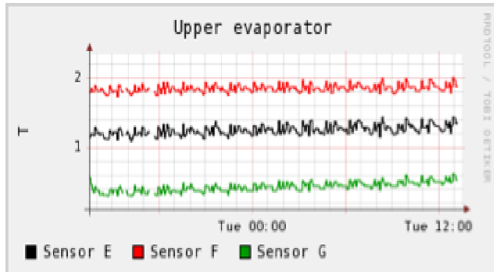
AMS backup POCC for CERN POCC

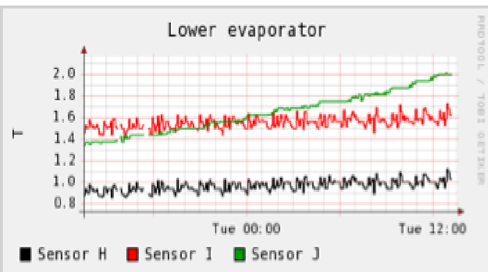
CERN

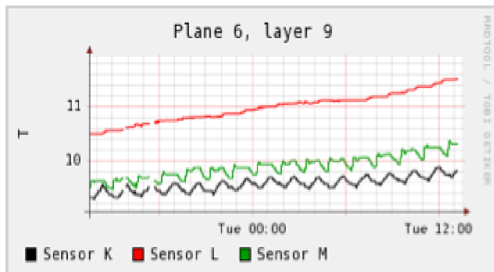
AMS POCC
Main operations centre
(from June 23, 2011)

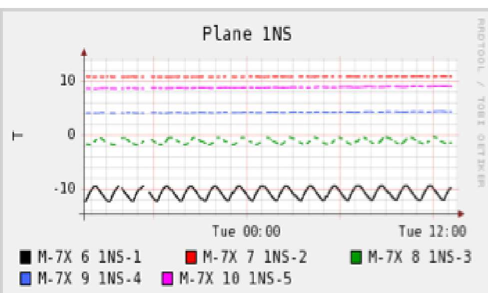
In flight experience: Tracker cooling and currents

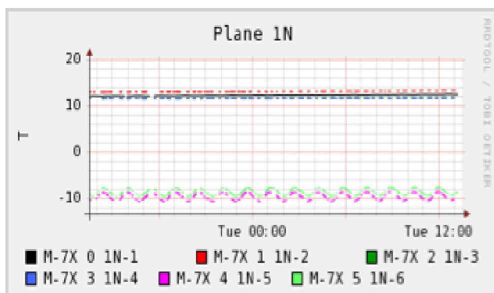


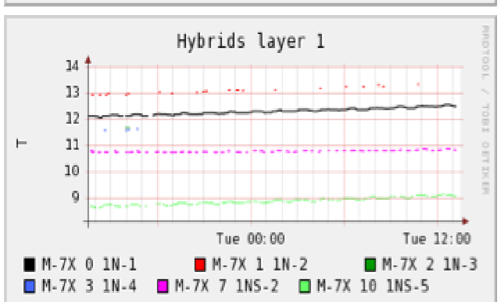


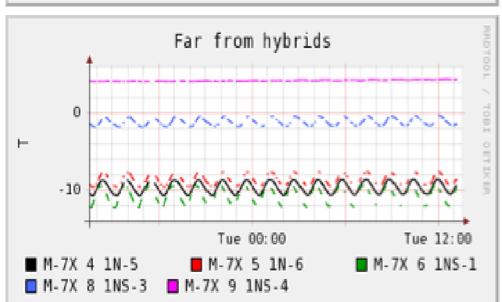


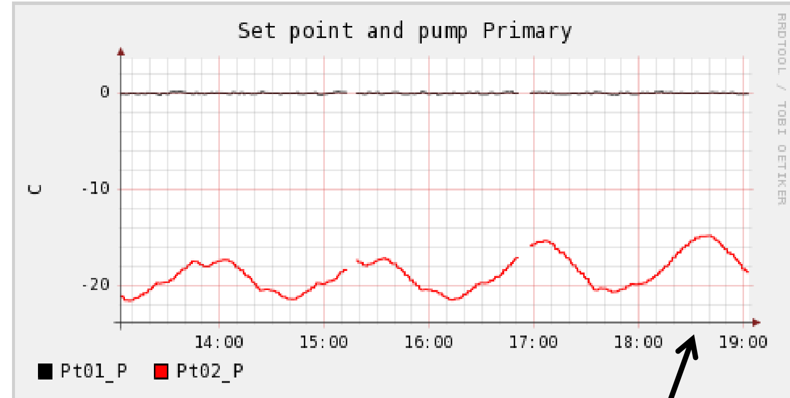






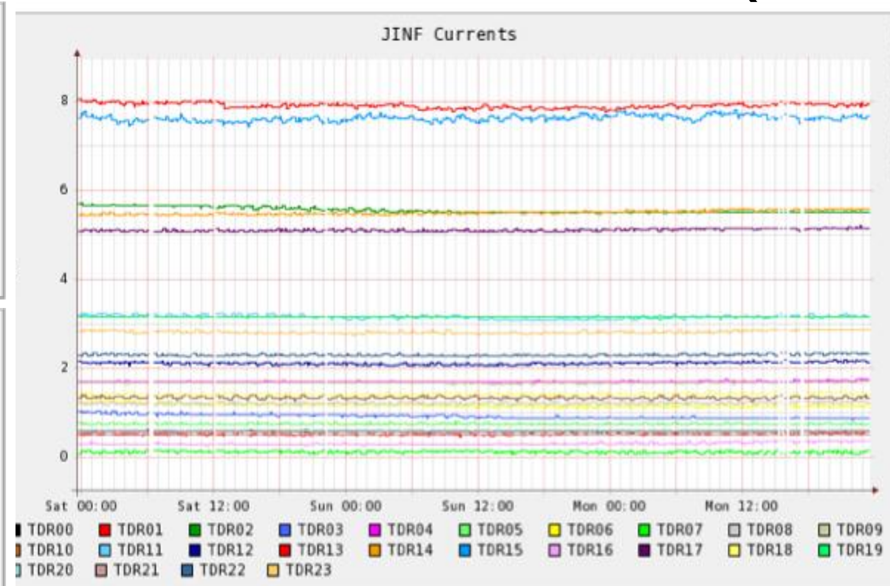




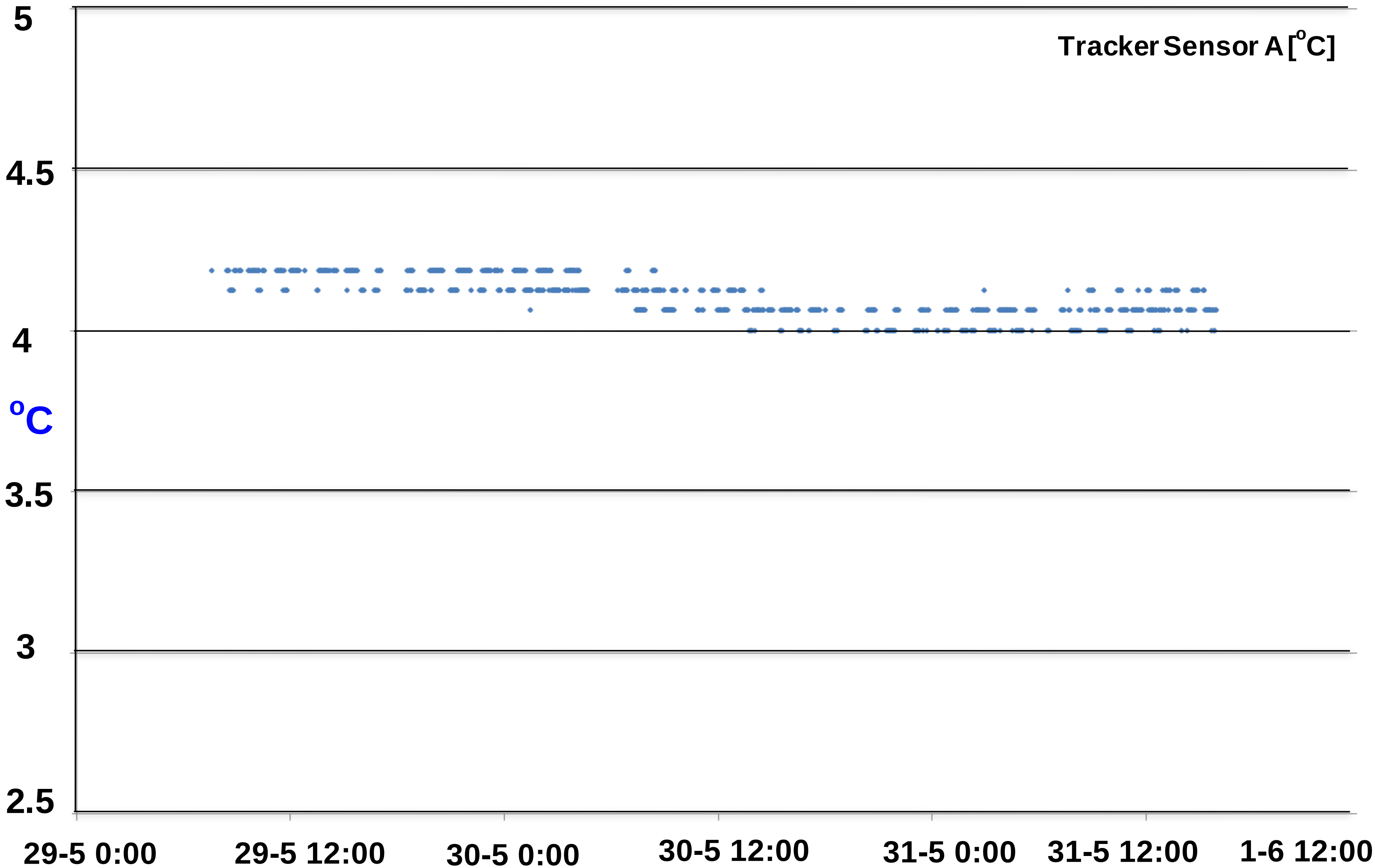


✓**Tracker and TTCS temperatures**

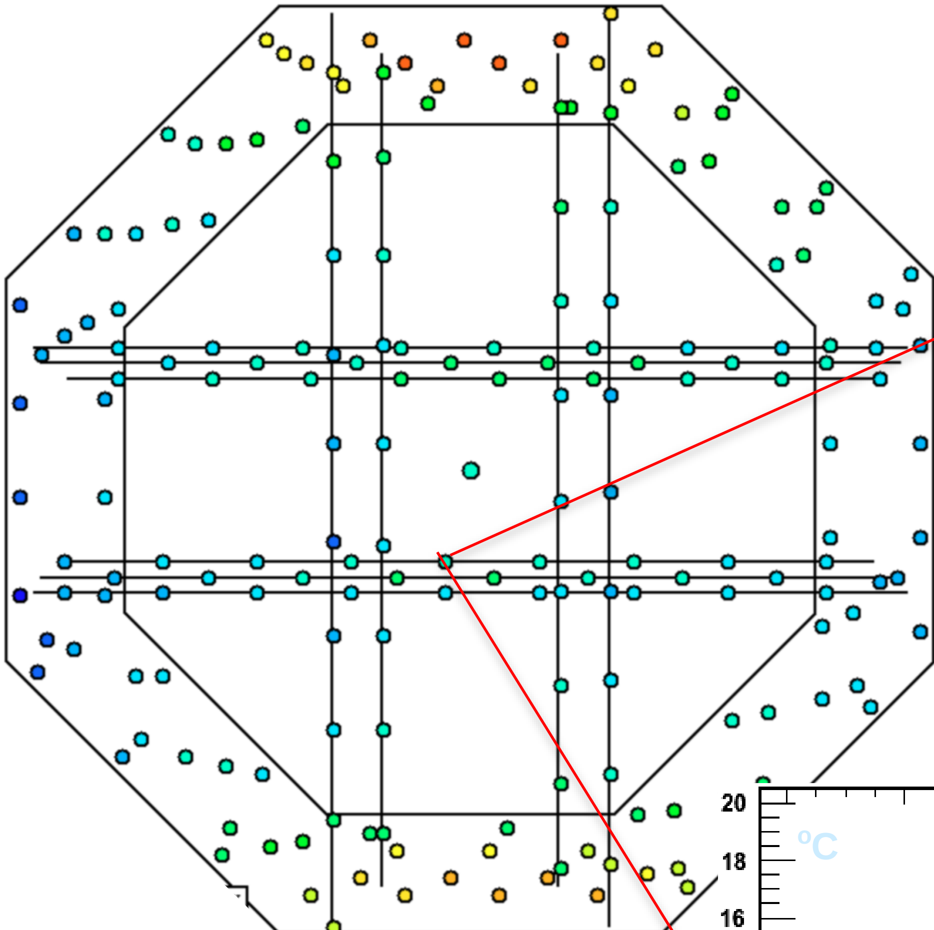
✓**Crates and TDRs currents**

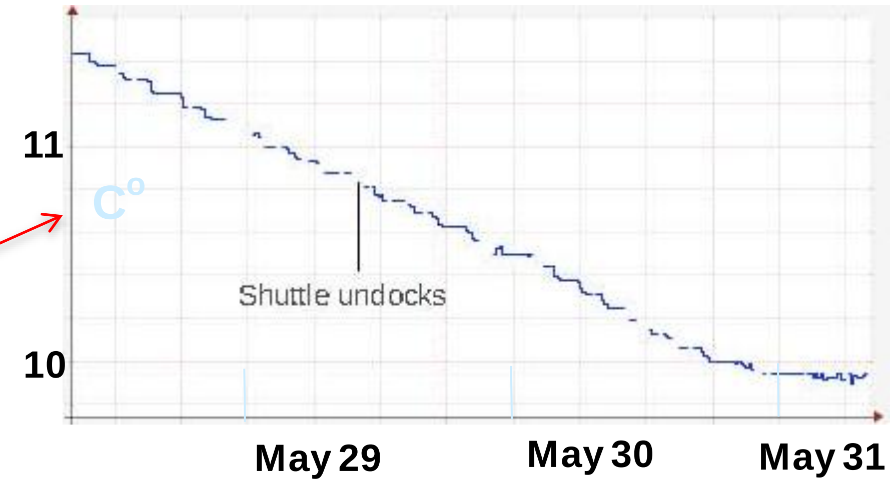


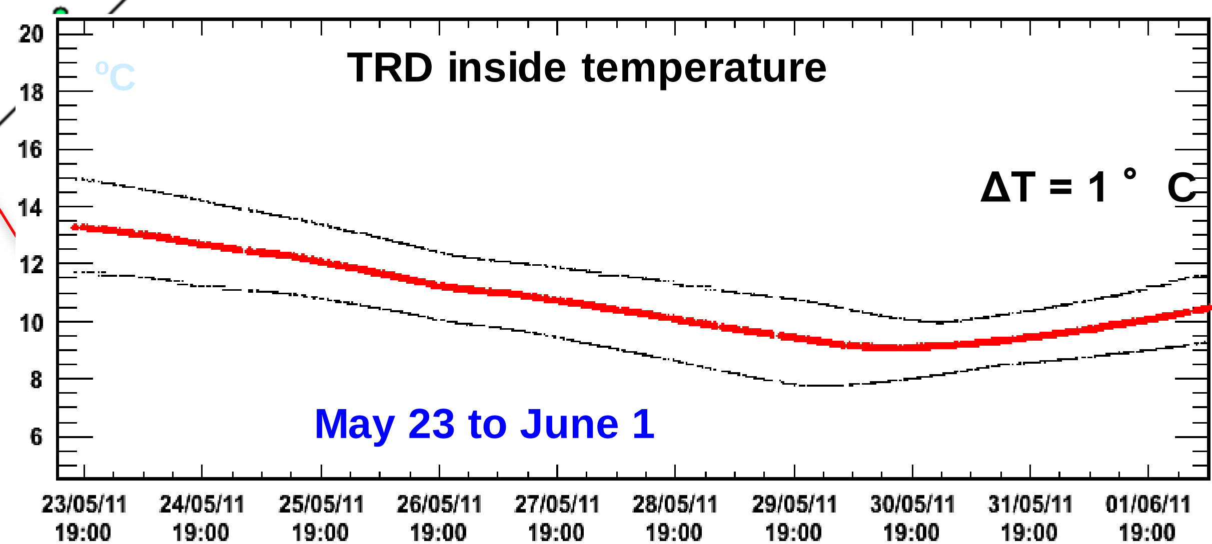
Tracker Temperature is stable on ISS



TRD Temperature Monitoring on ISS, to be within ±2C°

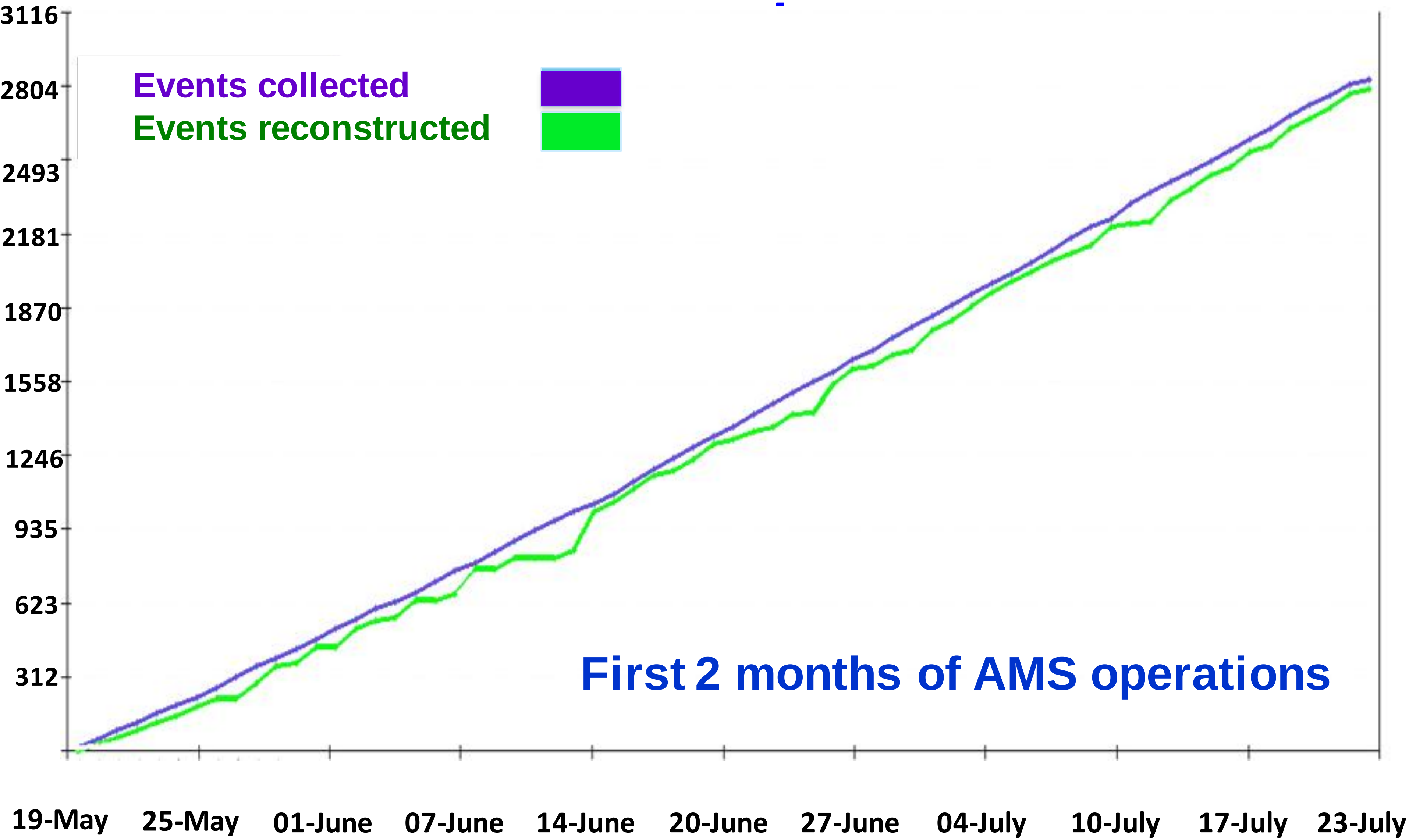




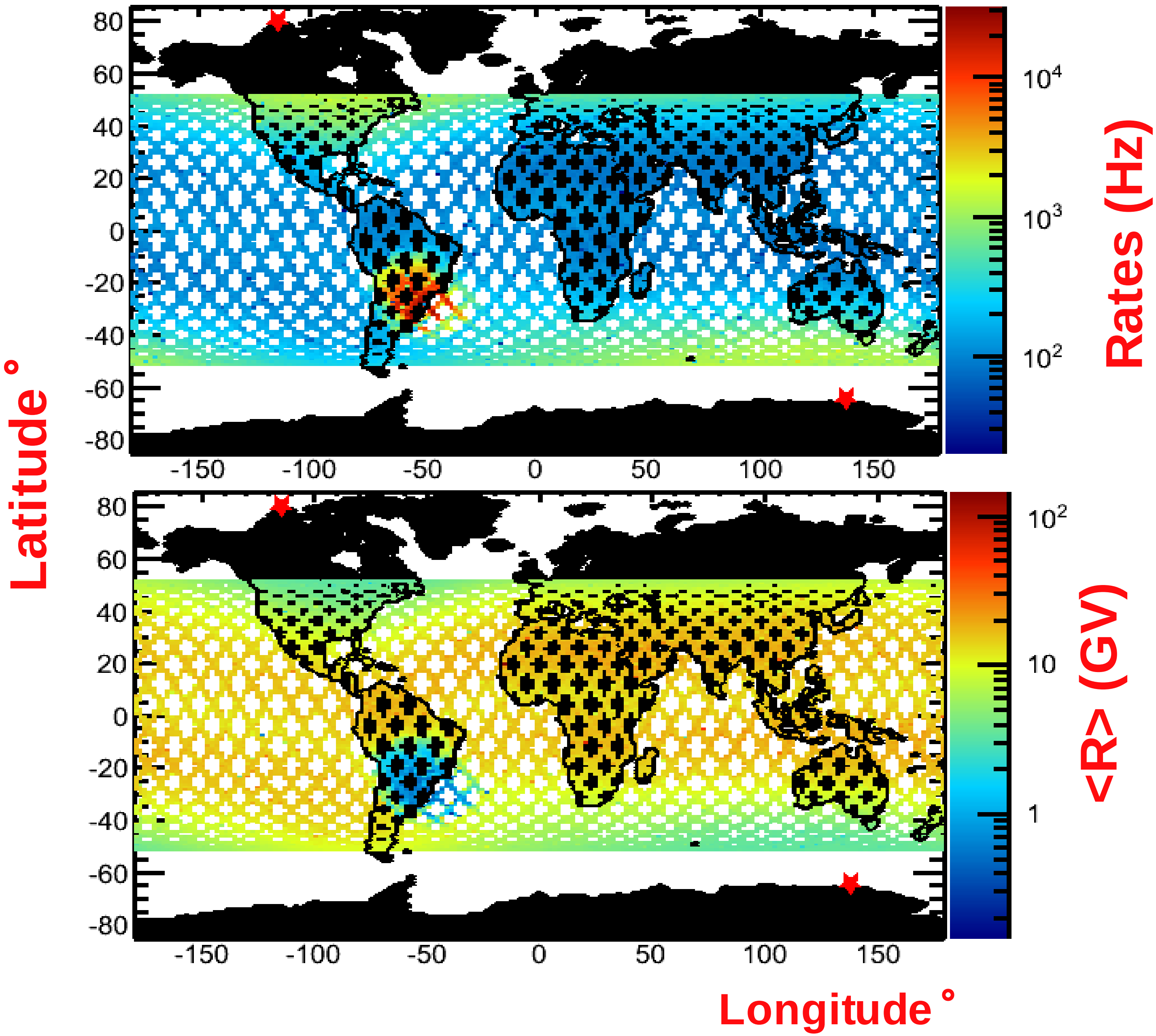


AMS data on ISS

AMS collected over 3 billion

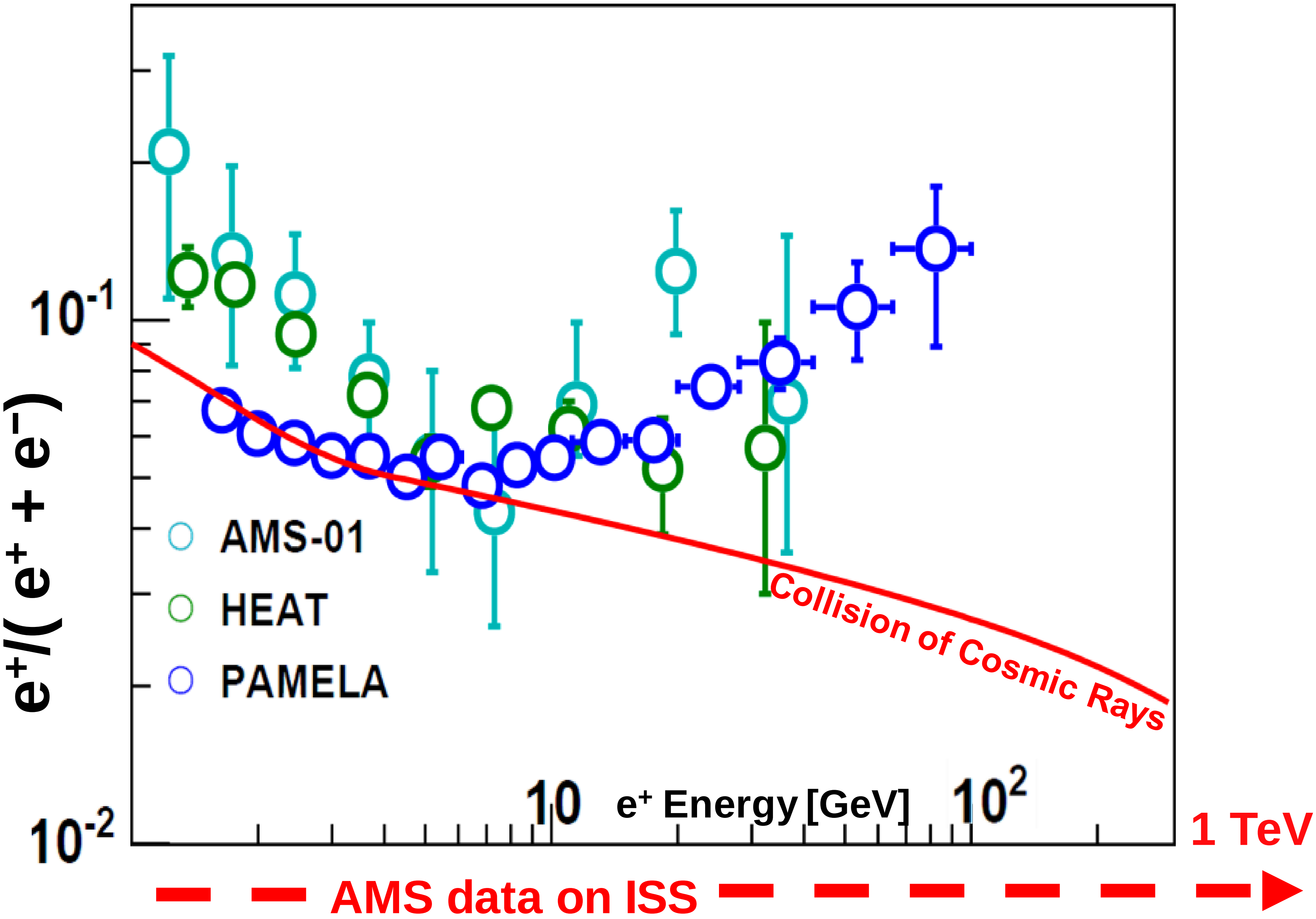


ISS orbit ≈ 390 km, 51.7° , 90 minutes

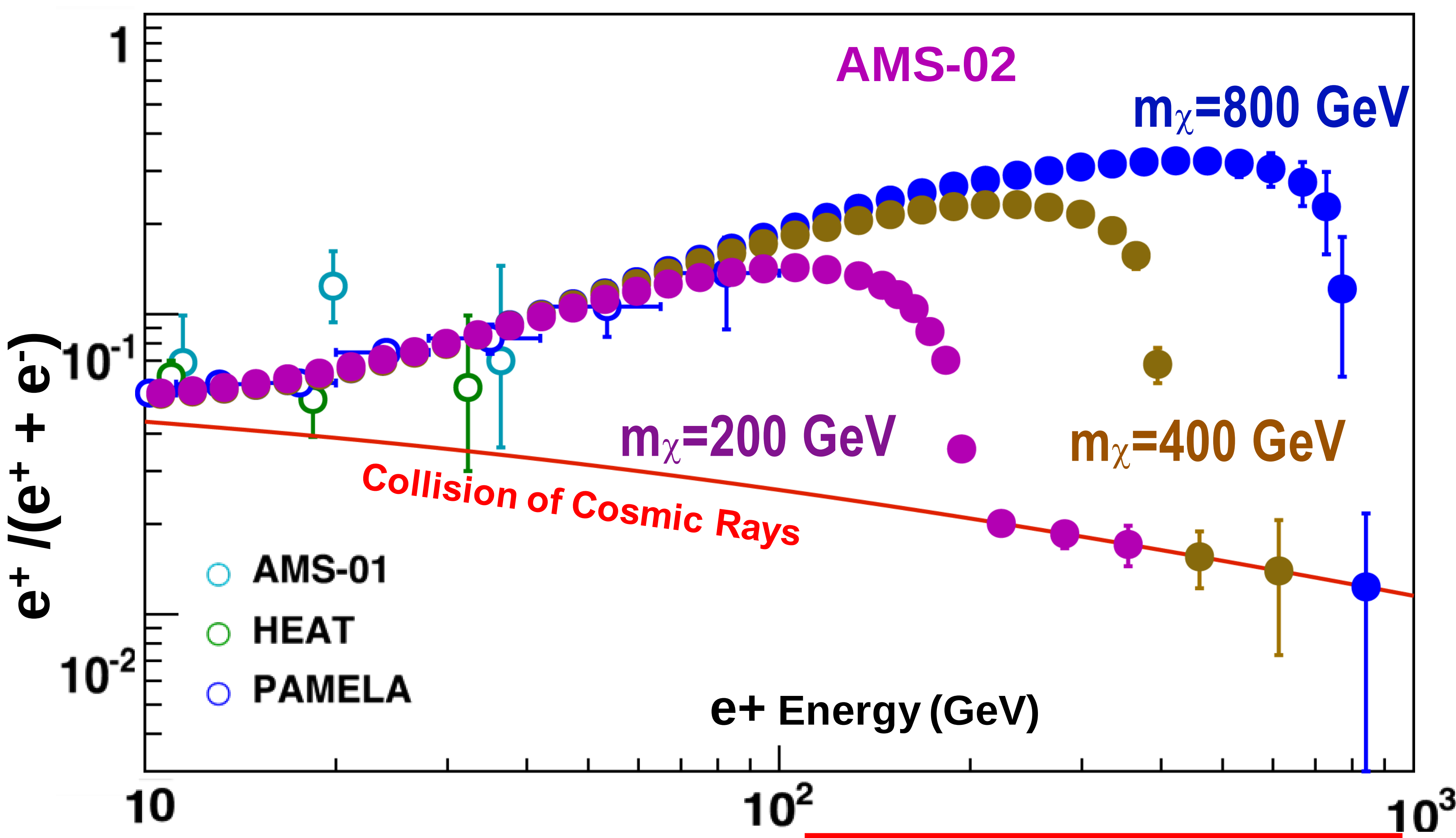


The leading candidate for Dark Matter is a SUSY neutralino (χ^0)

Collisions of χ^0 will produce excess in the spectra of e^+ different from known cosmic ray collisions

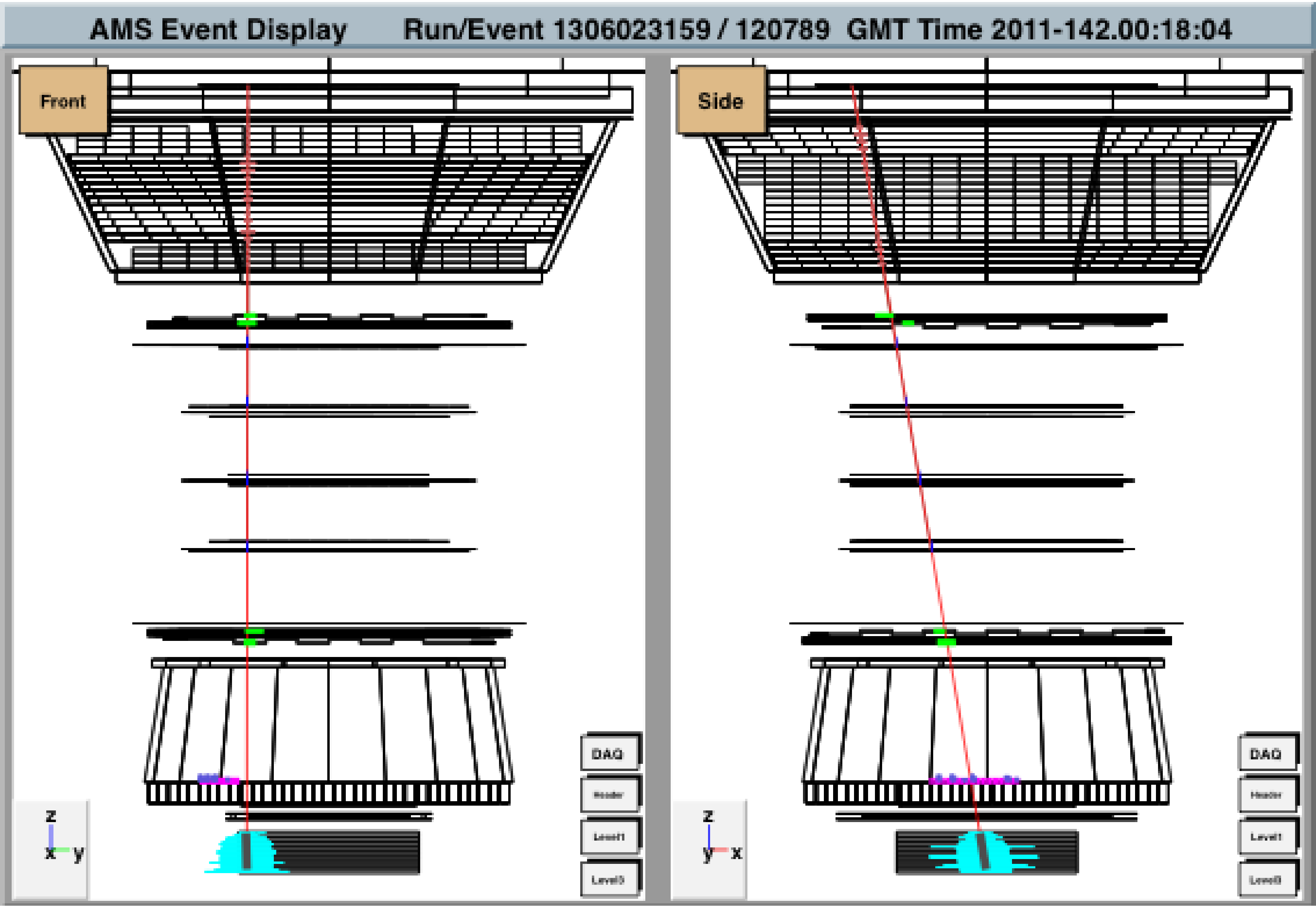


Detection of High Mass Dark Matter from ISS

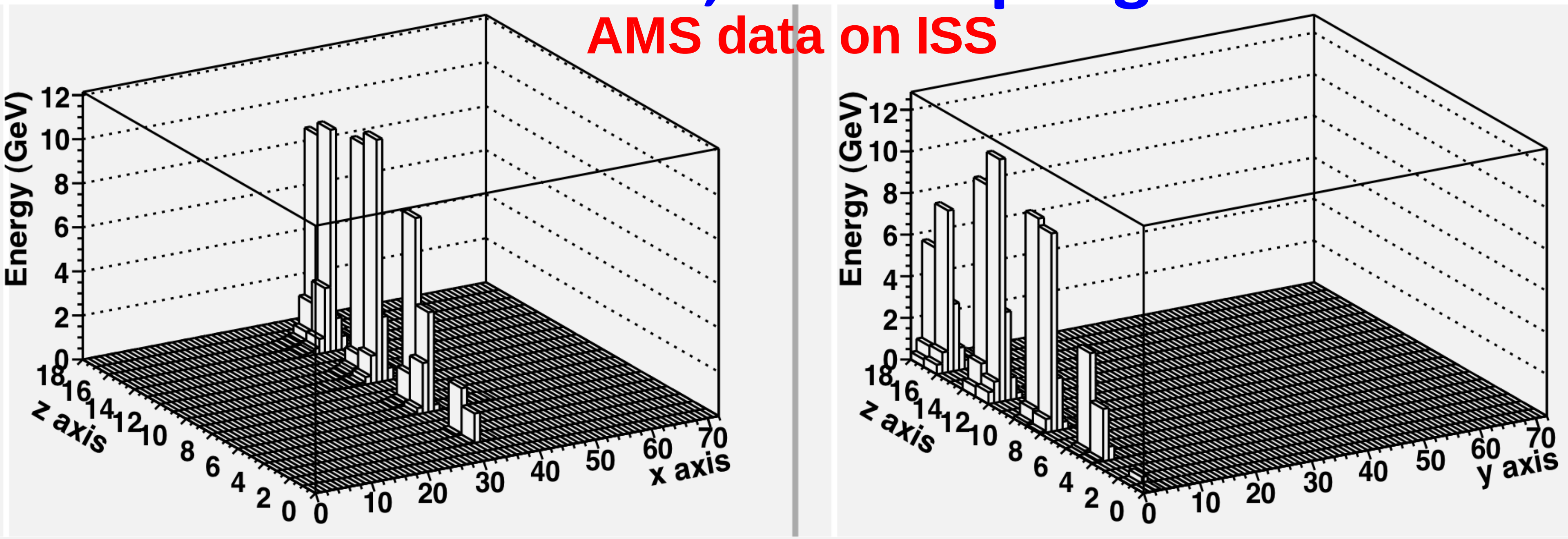


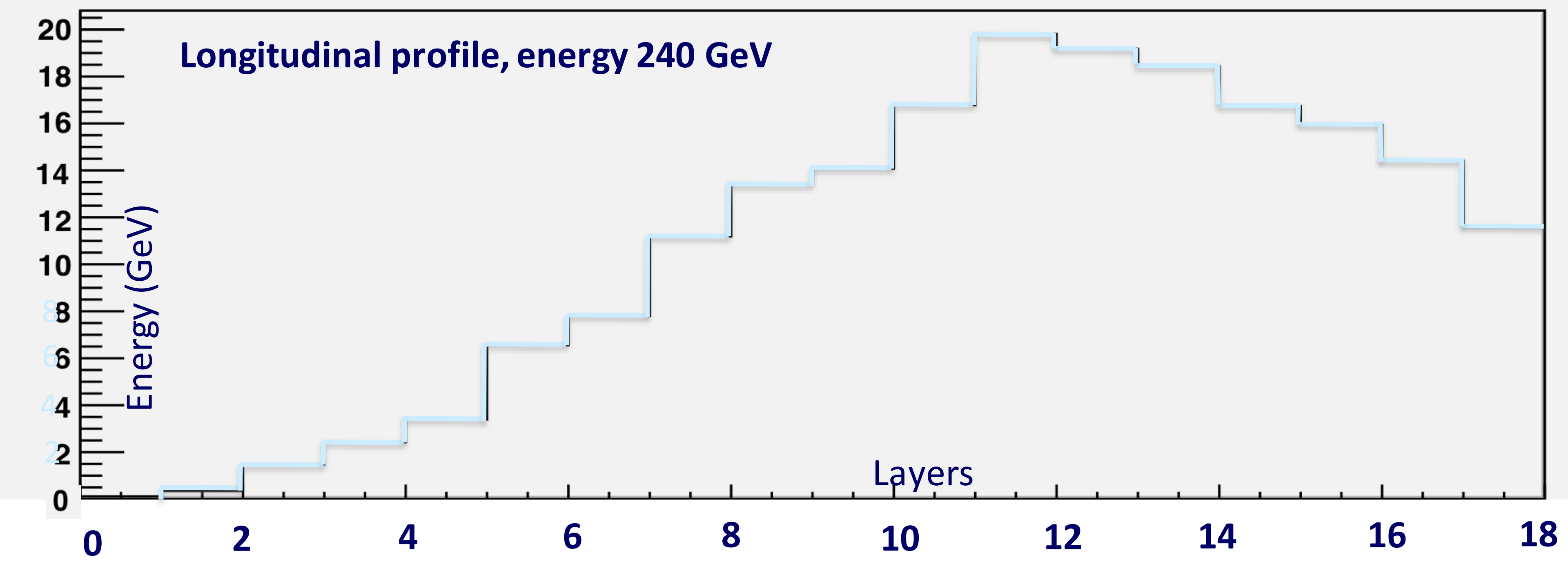
Events sample in first week

AMS data on ISS Electron 240 GeV, 22 May



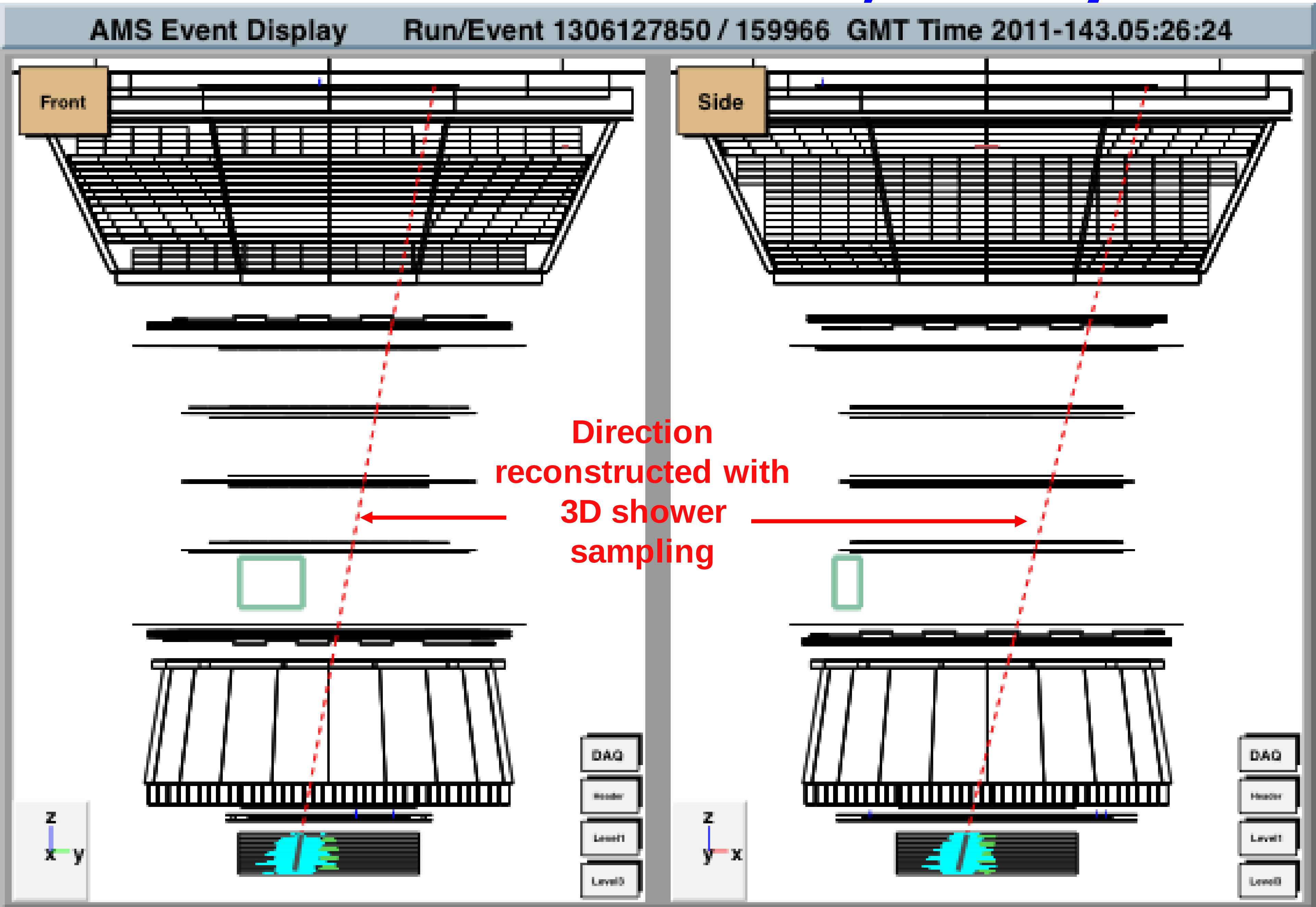
240 GeV Electron, 3D Sampling of Shower





AMS data on ISS

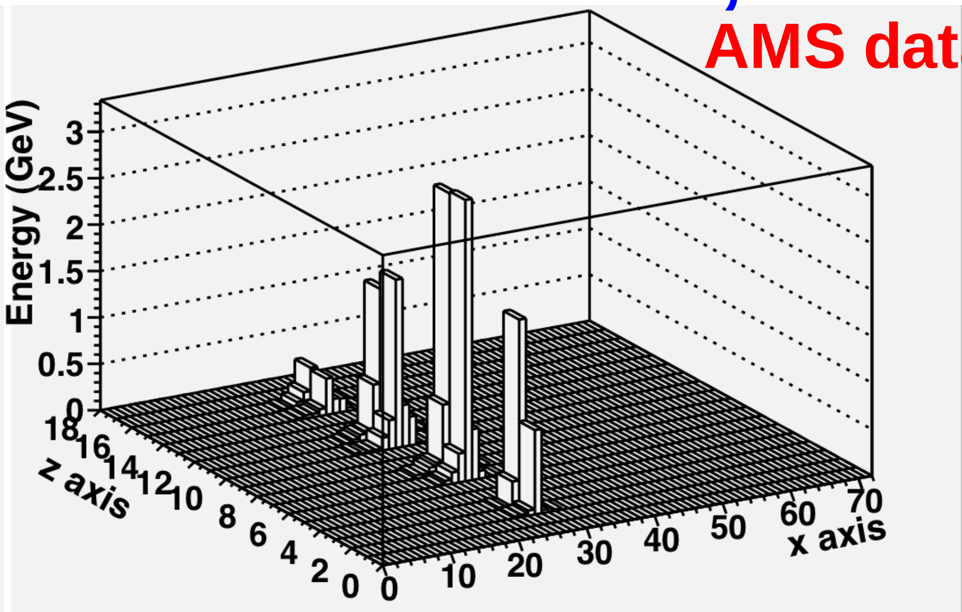
Photon 40 GeV, 23 May

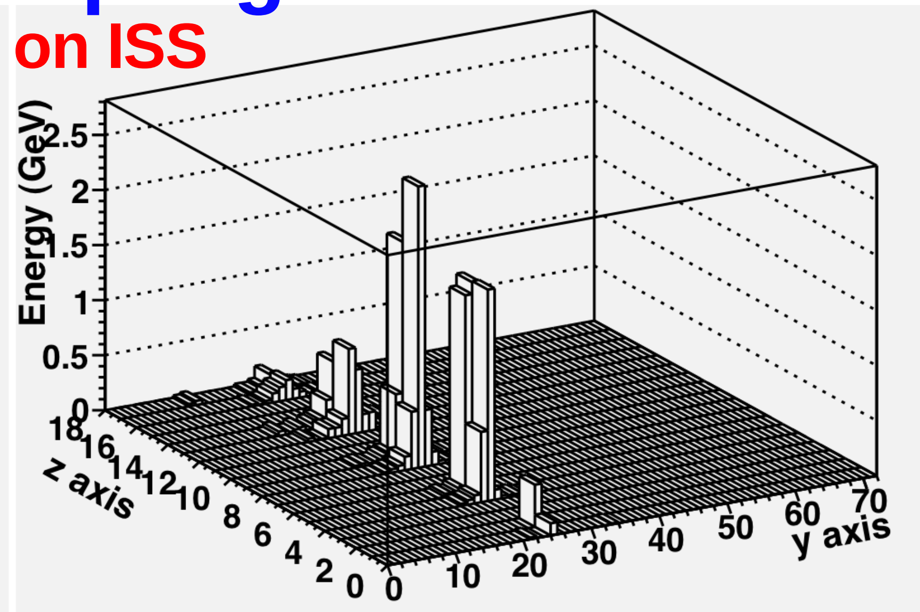


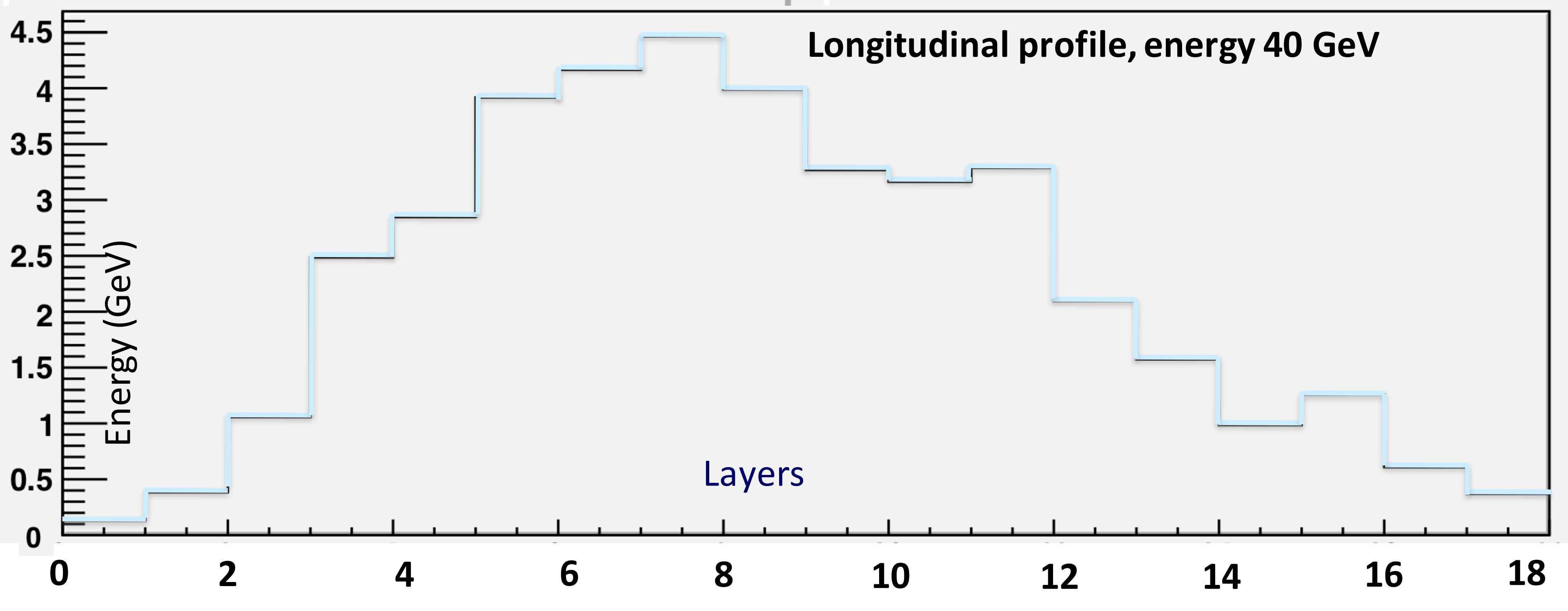
Direction reconstructed with 3D shower sampling

Gamma 40 GeV, 3D Sampling of Shower

AMS data on ISS

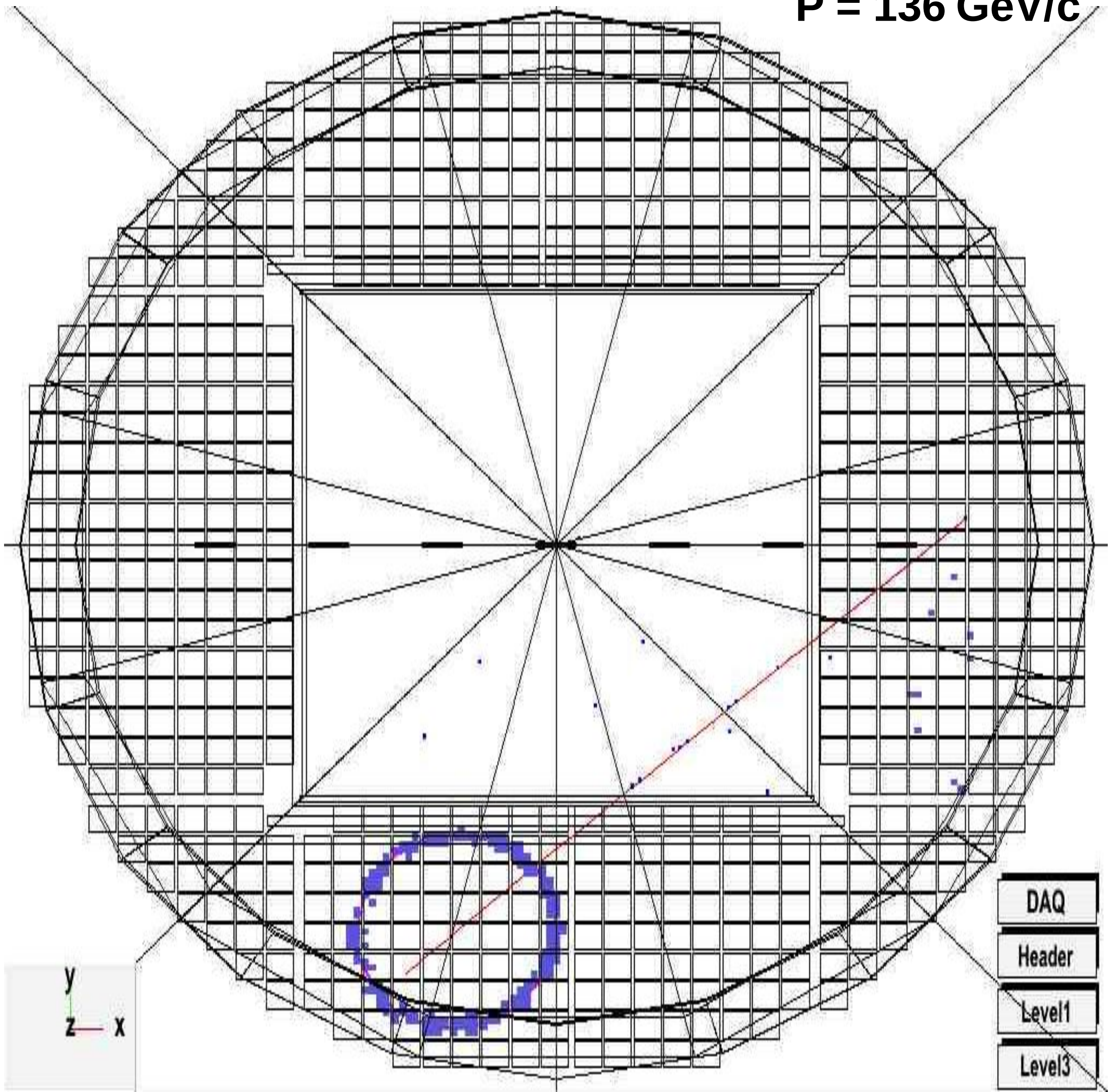






AMS data on ISS

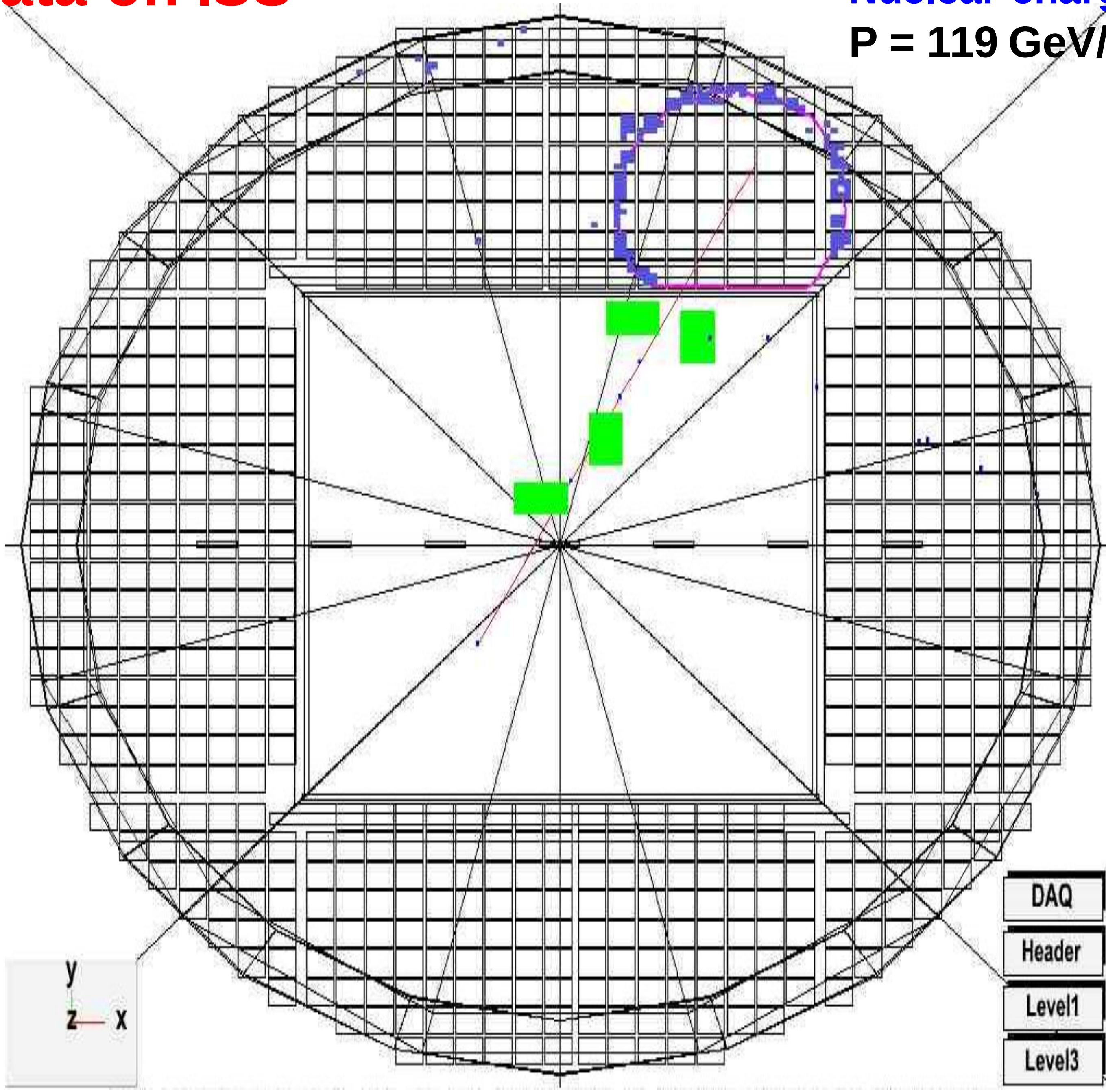
Nuclear charge Z=14, Si
P = 136 GeV/c

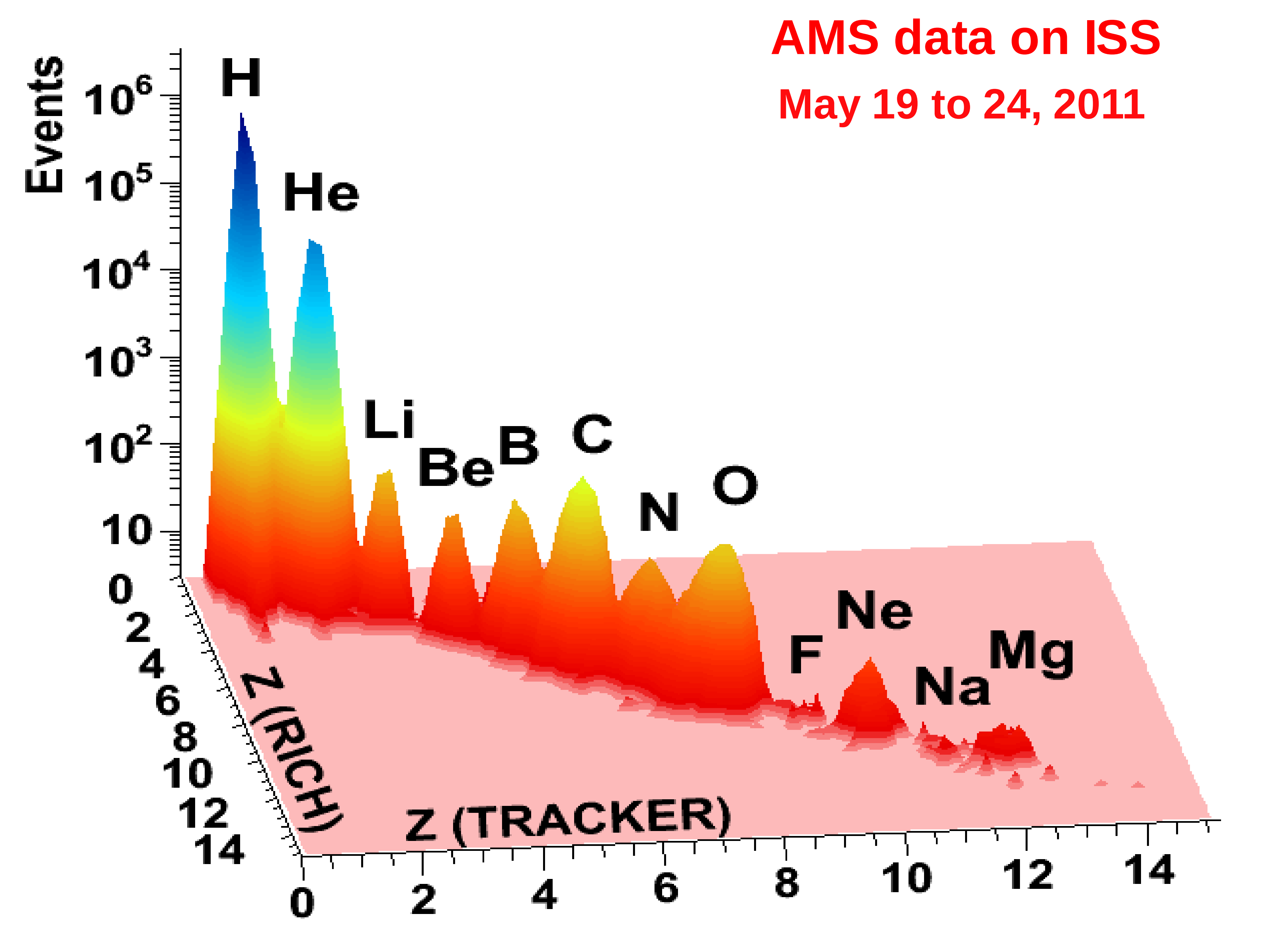


AMS data on ISS

Nuclear charge Z=8, O

P = 119 GeV/c



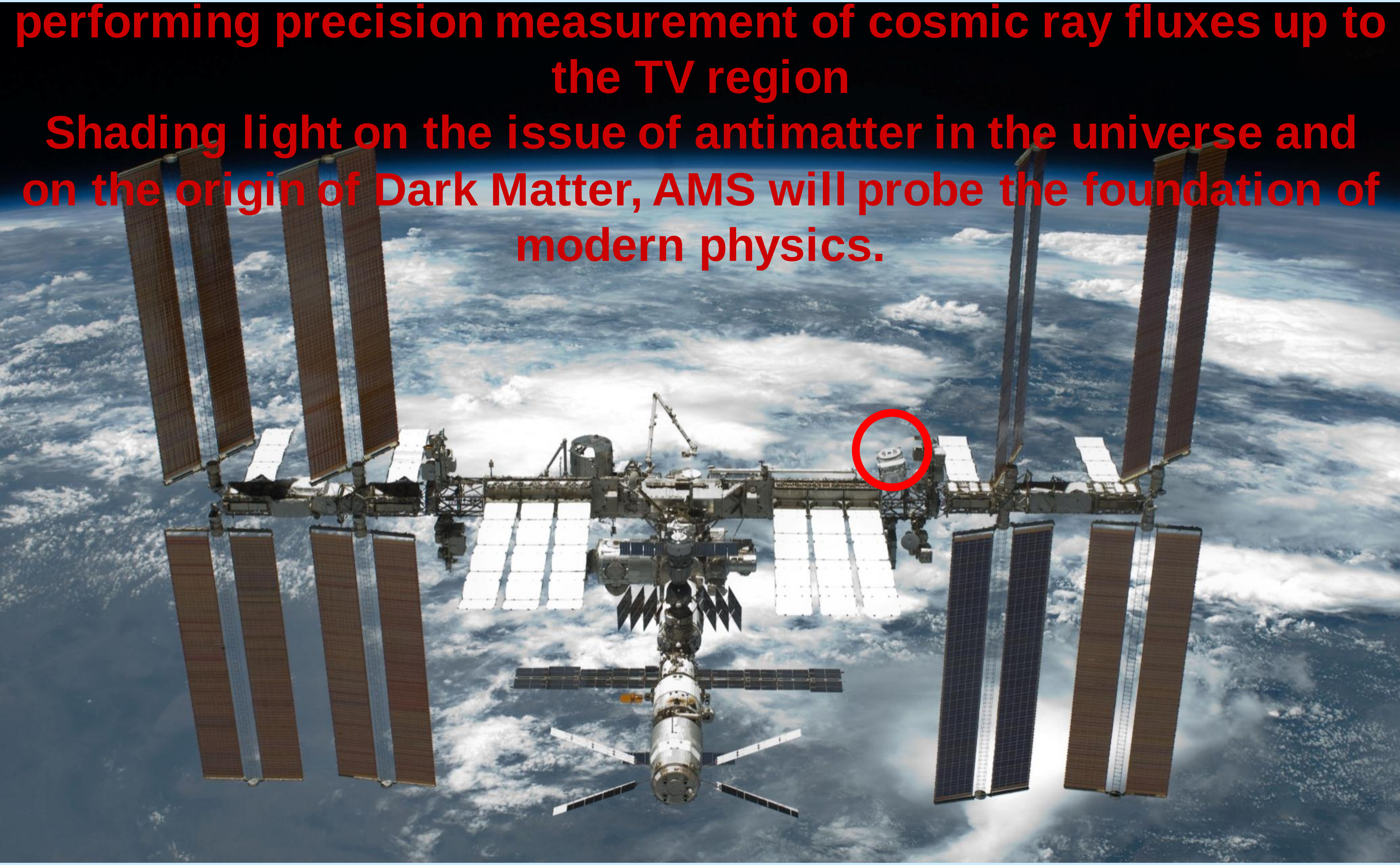


AMS data on ISS
May 19 to 24, 2011
Events
10^6
10^5
10^4
10^3
10^2
10
0
H
He
Li
Be
B
C
N
O
F
Ne
Na
Mg
Z (RICH)
Z (TRACKER)
0
2
4
6
8
10
12
14
0
2
4
6
8
10
12
14

AMS is steadily taking data on the ISS since ~2 months

performing precision measurement of cosmic ray fluxes up to the TV region

Shading light on the issue of antimatter in the universe and on the origin of Dark Matter, AMS will probe the foundation of modern physics.



AMS will continue taking data for the entire ISS lifetime (~20 years)