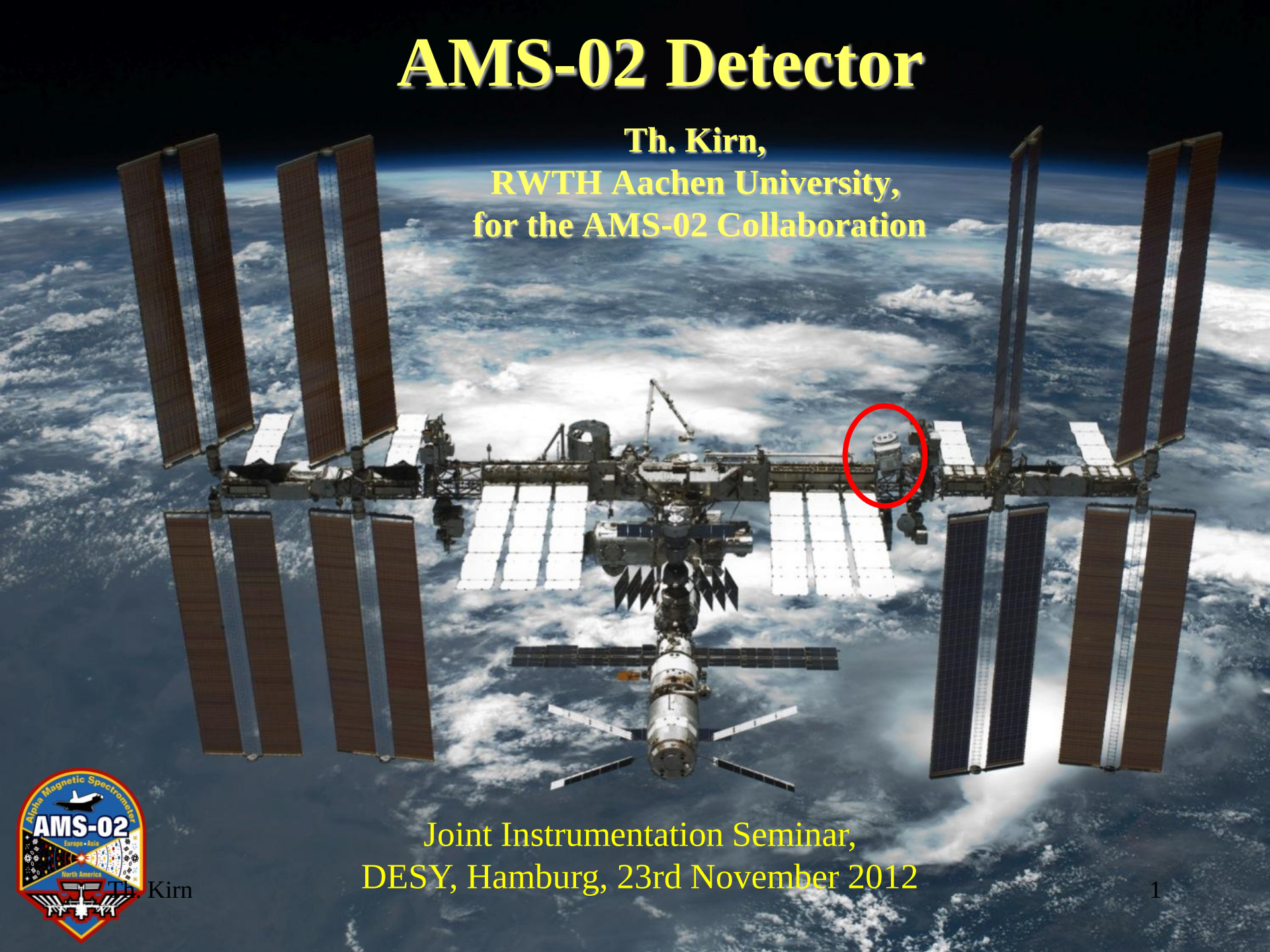
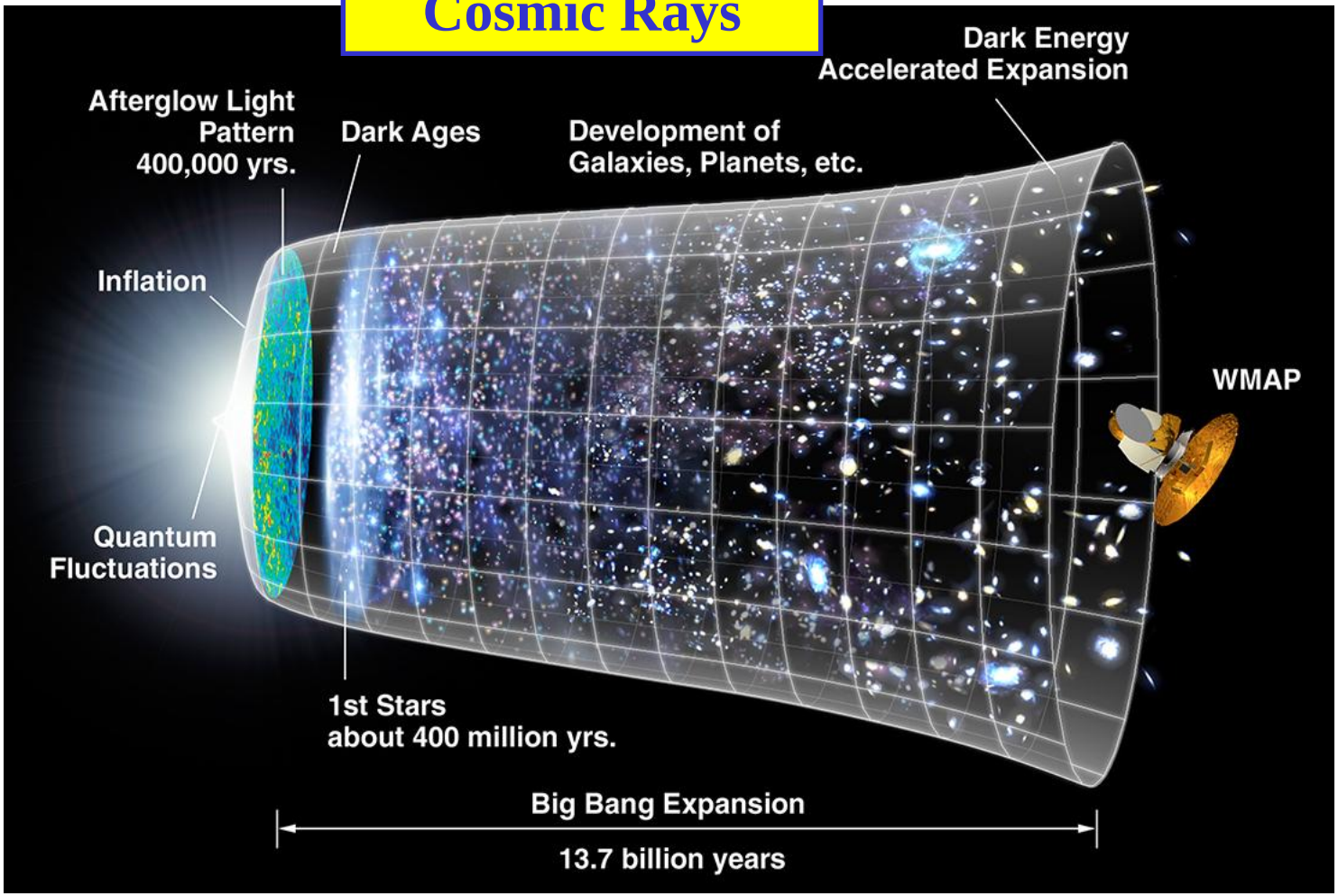
AMS-02 Detector

Th. Kirn,
RWTH Aachen University,
for the AMS-02 Collaboration



Joint Instrumentation Seminar,
DESY, Hamburg, 23rd November 2012

Cosmic Rays



- What are the building blocks of the universe?
- How did it evolve into ist current state?
- What is the nature of dark matter?
- Anti-nuclei from anti-galaxies?

Cosmic Rays

p

$\pi \rightarrow \mu \rightarrow e$

p, He, γ, e^-,
C, N, O, ...

CR-Sources
Production, Acceleration

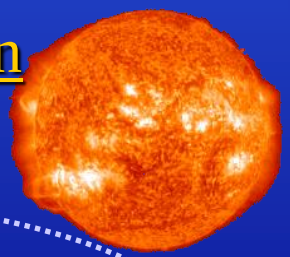
Galactic : SNRs, Pulsars,
Extragalactic : AGN, ..
Exotic : GRBs, ..
DarkMatter : WIMPs
$\chi\chi \rightarrow e^+ , p^- , \gamma, \nu, ..$

CR-Propagation

- Interaction with ISM and fields
- Reacceleration

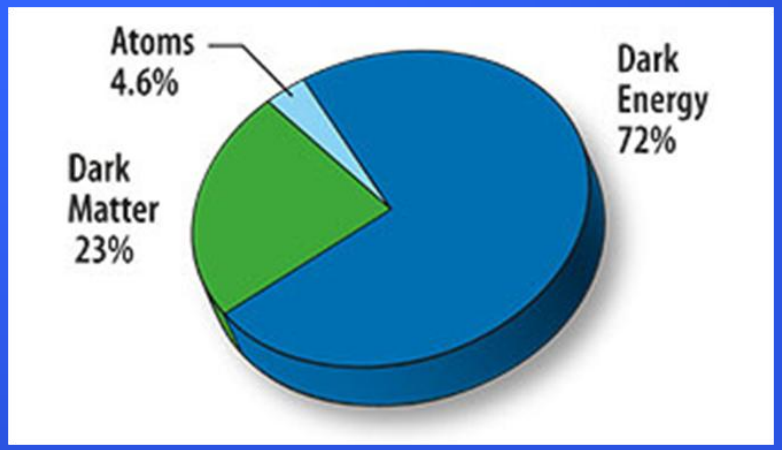
→ p, p^-, He, γ, e^-, e^+,
μ^-, μ^+, Li, Be, B,
C, N, O, isotopes, …

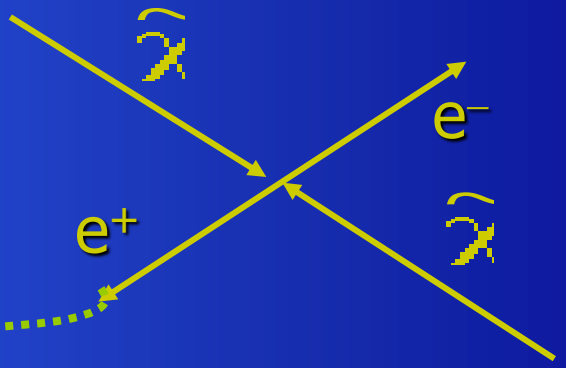
Solar Modulation



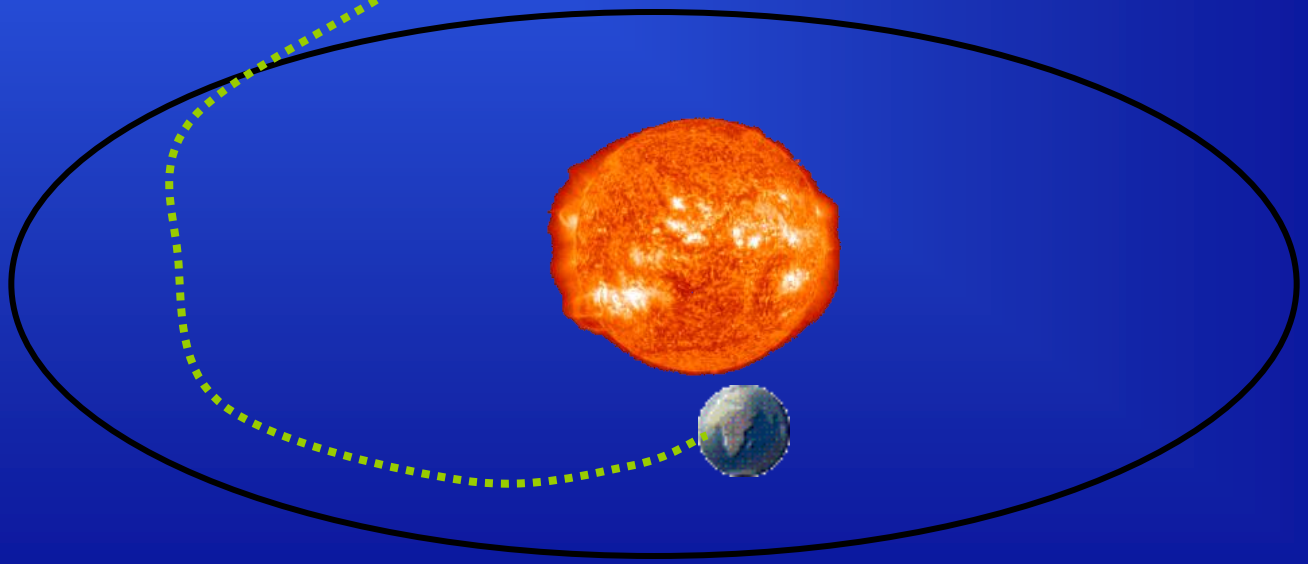
Geomagnetic Cutoff
Atmospheric Interactions

Dark Matter

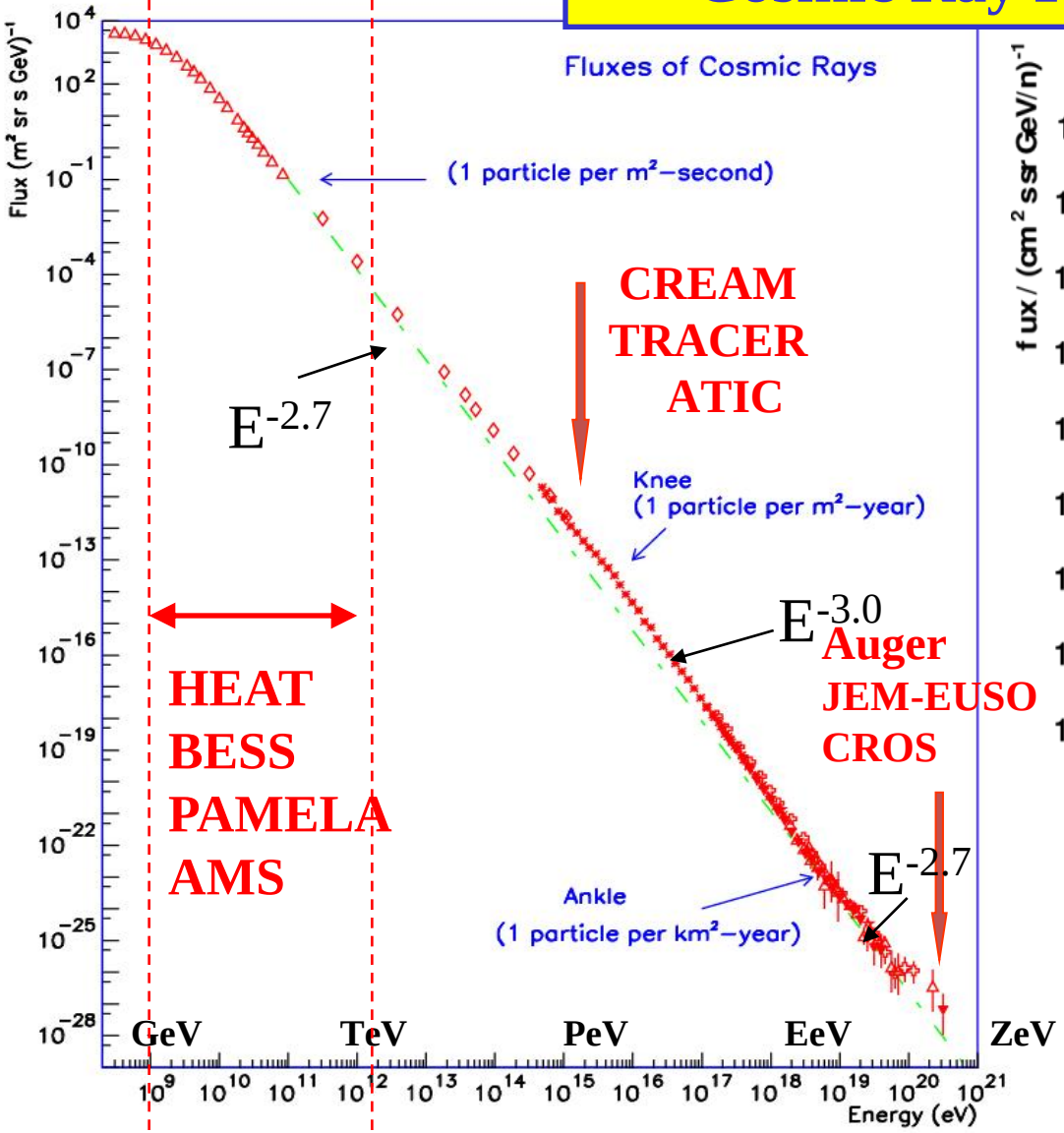


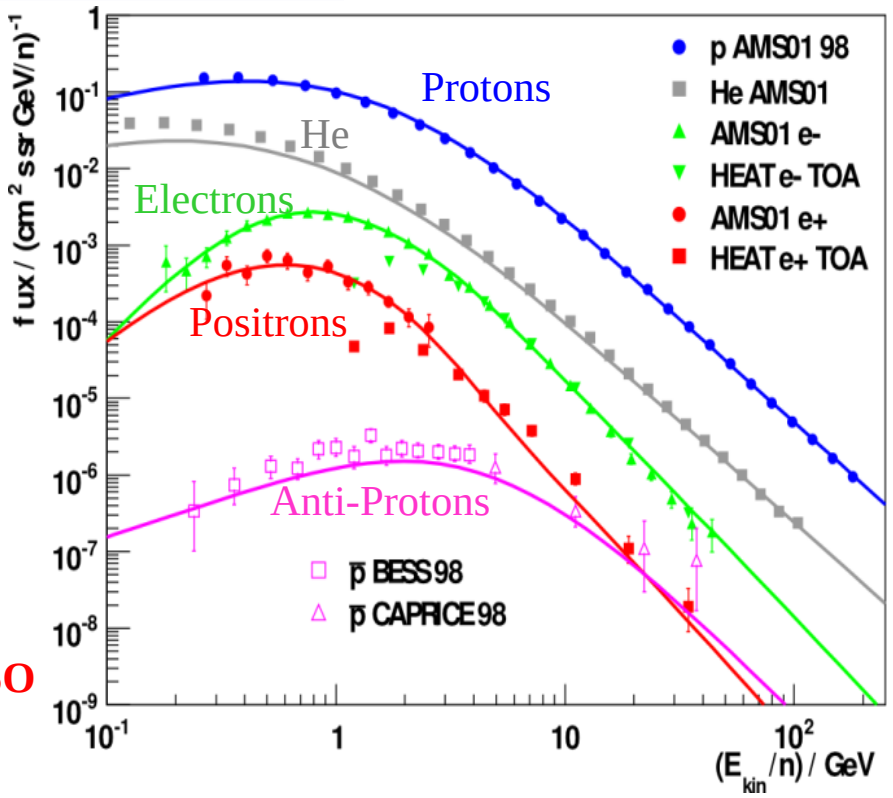


$\chi + \bar{\chi} \rightarrow X + \bar{e}, \bar{p}, \bar{D}$



Cosmic Ray Fluxes





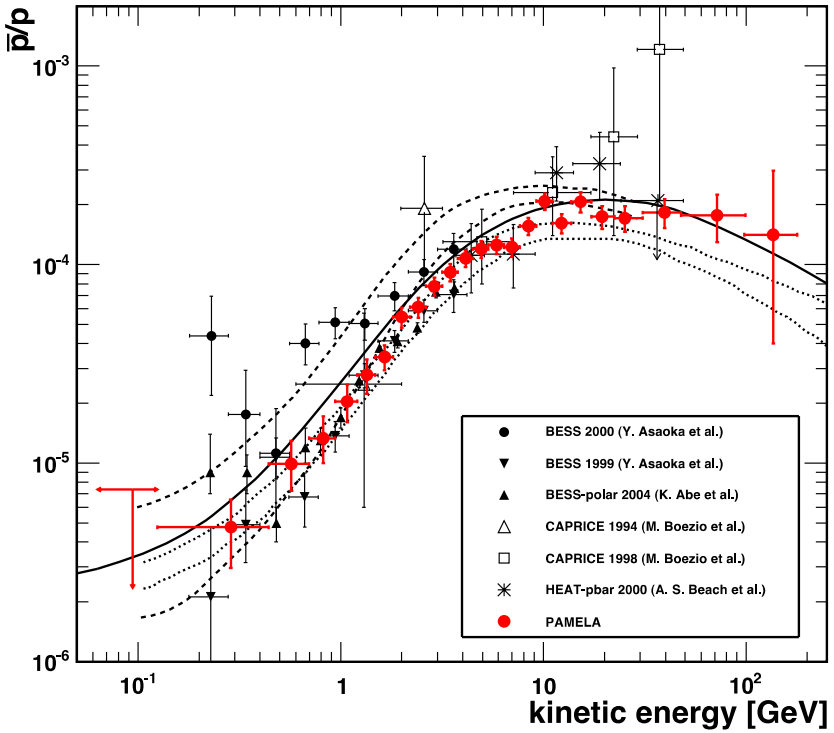
Cosmic Ray Composition:

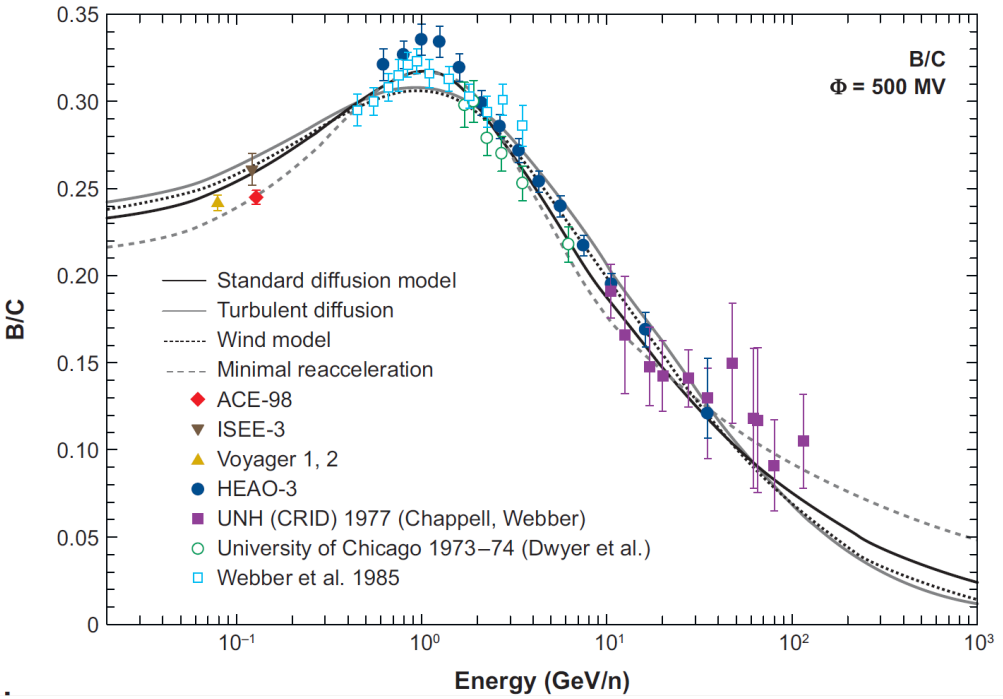
Protons	88 %
Helium	10 %
e^-	1 %
e^+	0.1 %
Antiprotons	0.01 %

Cosmic Ray Fluxes

- Antiproton spectrum and B/C-ratio compatible with secondary production

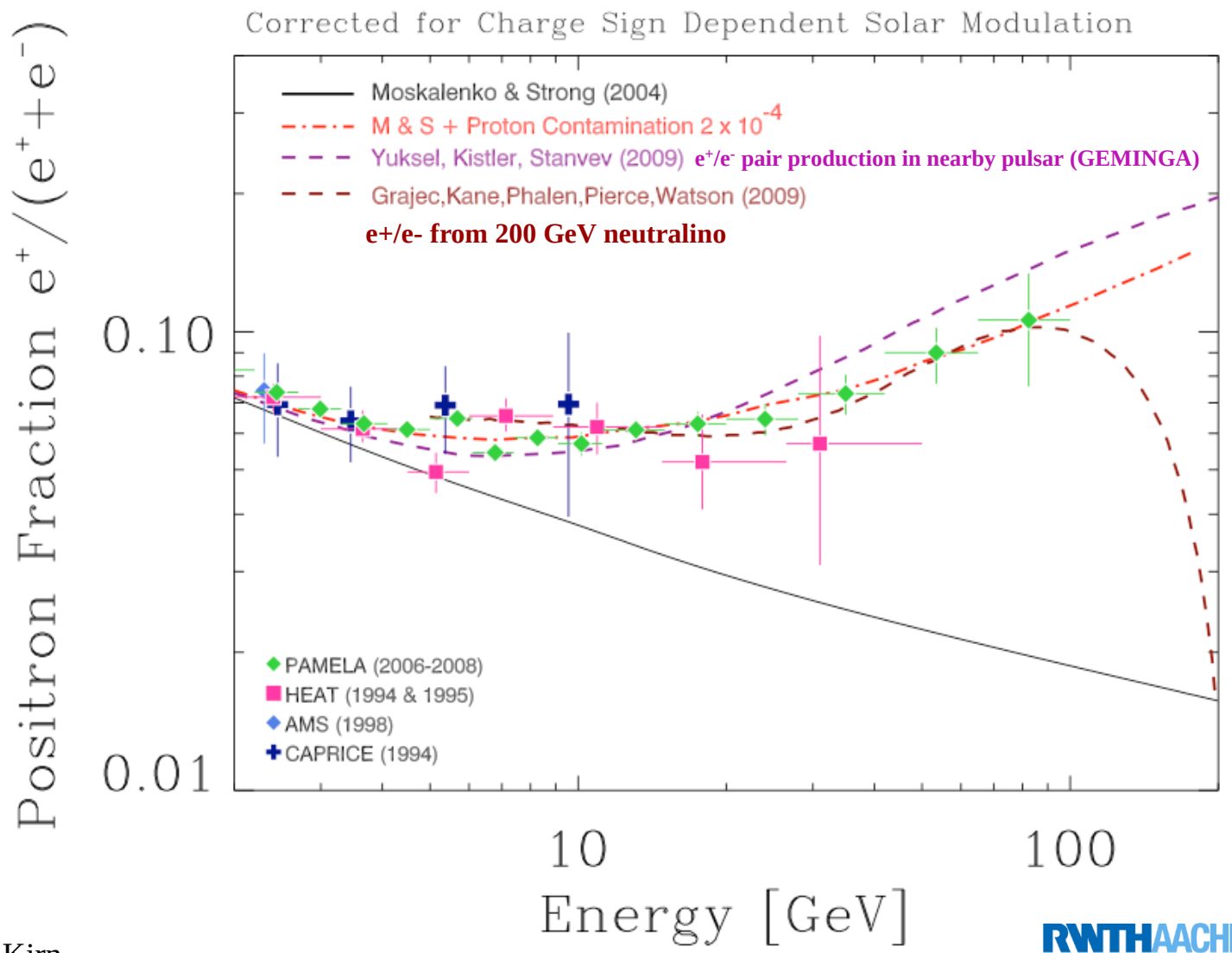
O. Adriani et al., Phys.Rev.Lett.105:121101,2010.





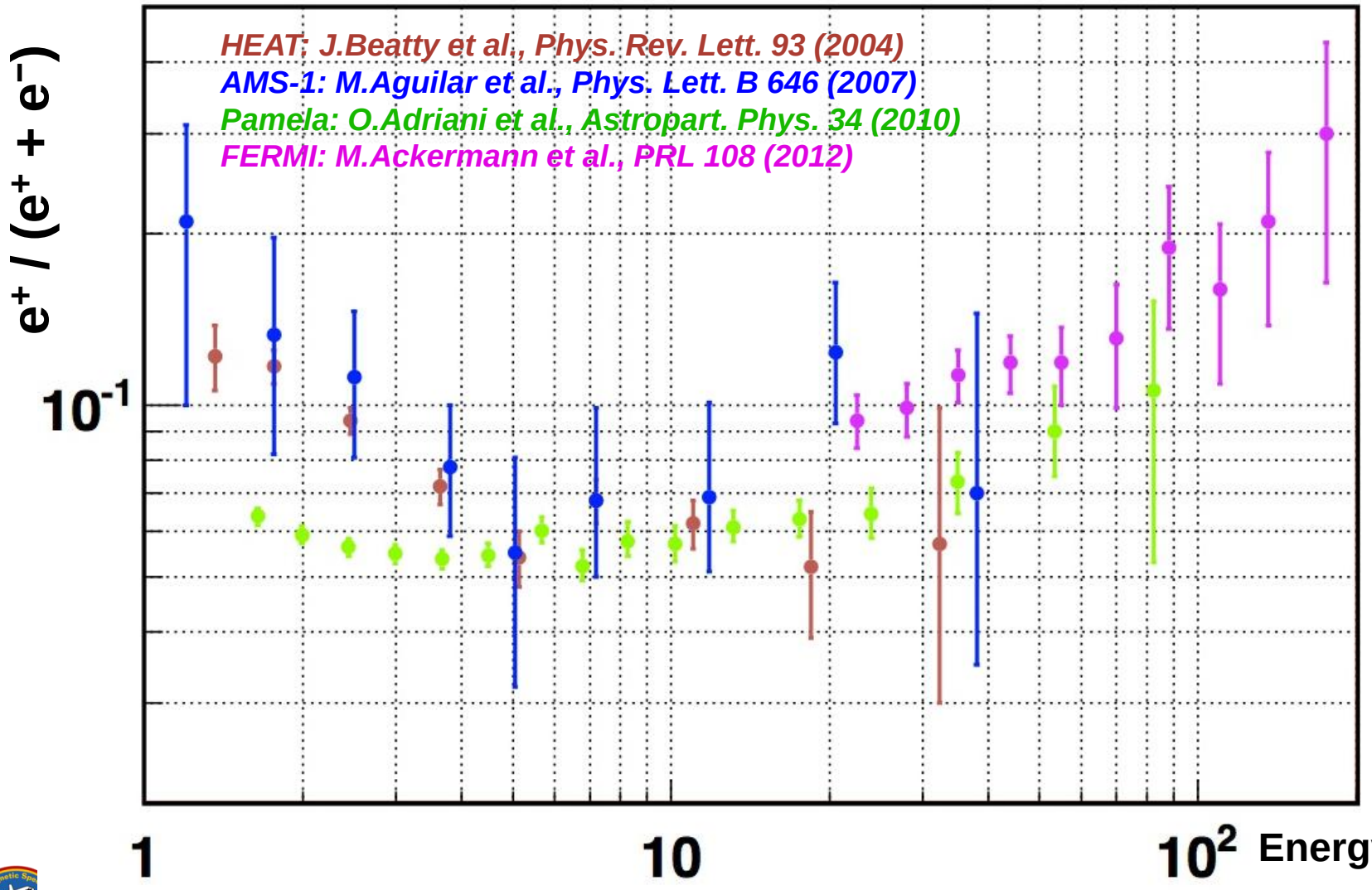
Cosmic Ray Fluxes

- Astrophysical or DM source or?



Cosmic Ray Fluxes

- Positron fraction show unusual shape, astrophysical or DM source?



Detector Requirements:
Antimatter Dark Matter Astrophysics

Signal from neutralino annihilation

Spectra: $\bar{e}$, $\bar{p}$, γ

Proton supression by 10^6
Electron supression by 10^4
Gamma reconstruction (energy / angle)

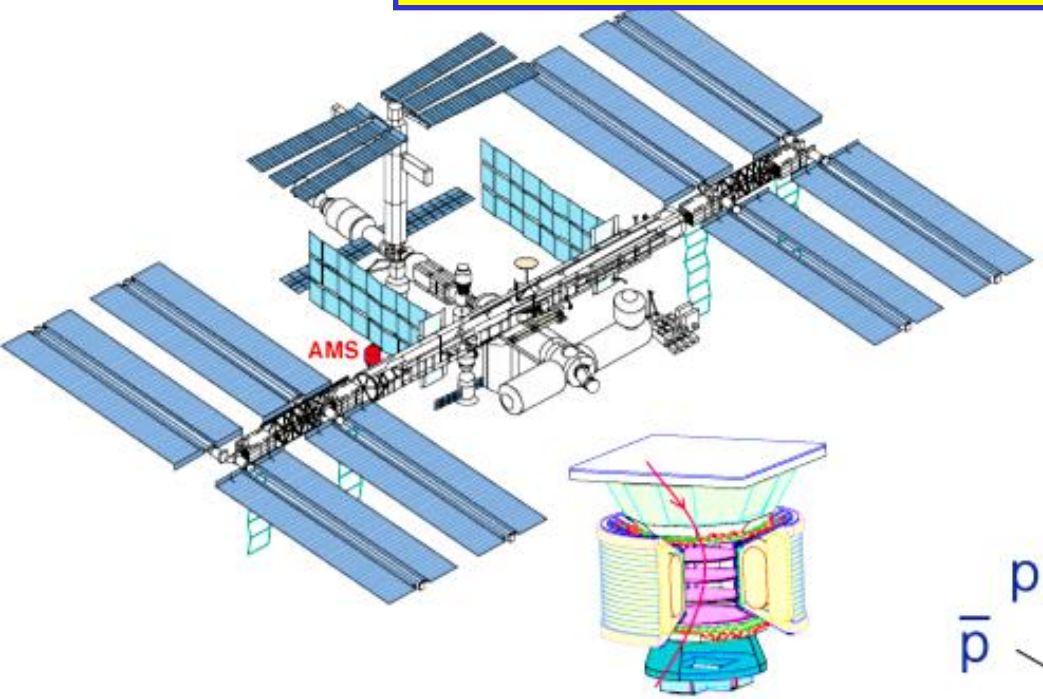
Galactic models (secondaries + propagation)

Nuclear abundance: B, C, ^{10}Be, ^{9}Be, ...
Standard particles: e, p

Tracking and charge / isotope separation

- **Charge identification**
- **Rigidity measurement**
- **Velocity measurement**
- **e.m. energy measurement**
- **e/p separation**
- **Albedo rejection**
- **Strong system redundancy**

Fundamental Science on ISS



1- Neutral component:

g, n

Hubble, Chandra, GLAST, JWST, JDEM

Discoveries:
(1) Pulsar,
(2) Microwave,
(3) Binary Pulsars,
(4) X Ray sources, solar neutrinos
(5) Dark Matter, Dark Energy

… …

2- Charged component: He, Be, C, Fe

e^+ e^- p $\bar{p}$ $\overline{He}$,

WHIPPLE, HESS, VERITAS, …

HiRes

SUPER K

AUGER

Need to go to space to make the first precision measurement of charged cosmic rays

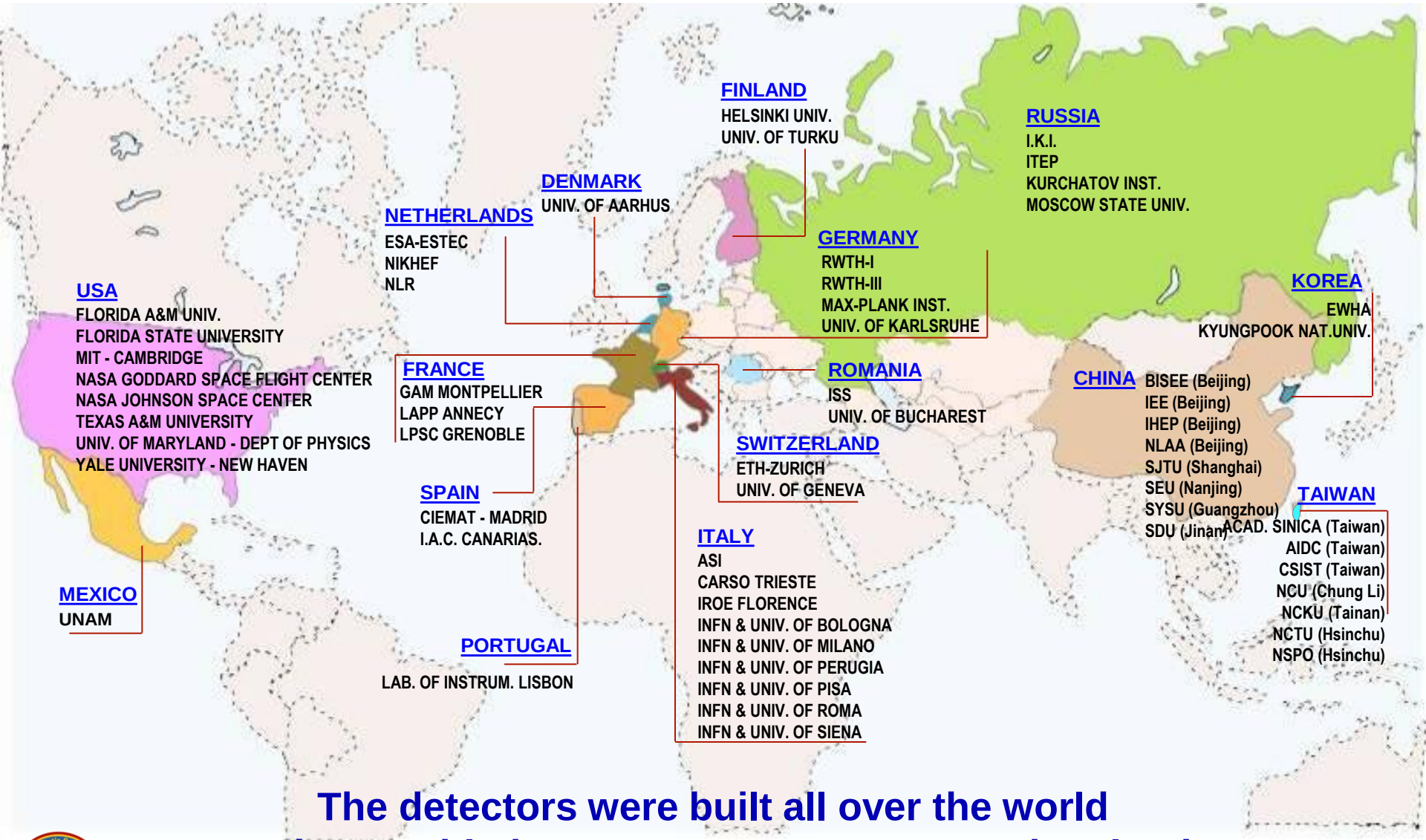
ISS: Space, a new environment for experiment

- Acceleration during start/ landing up to 9g

- Operation in vacuum
- Temperature variations: -80 up to +60 °C
- Deposition limits on ISS < $1 \cdot 10^{-14}$ g/s/cm^2
- Weight limited to 7.5 t
- Power consumption limited to 2 kW
- Single powersupply at 120 V
- Datarate 10 Mbit/s via 1 datalink

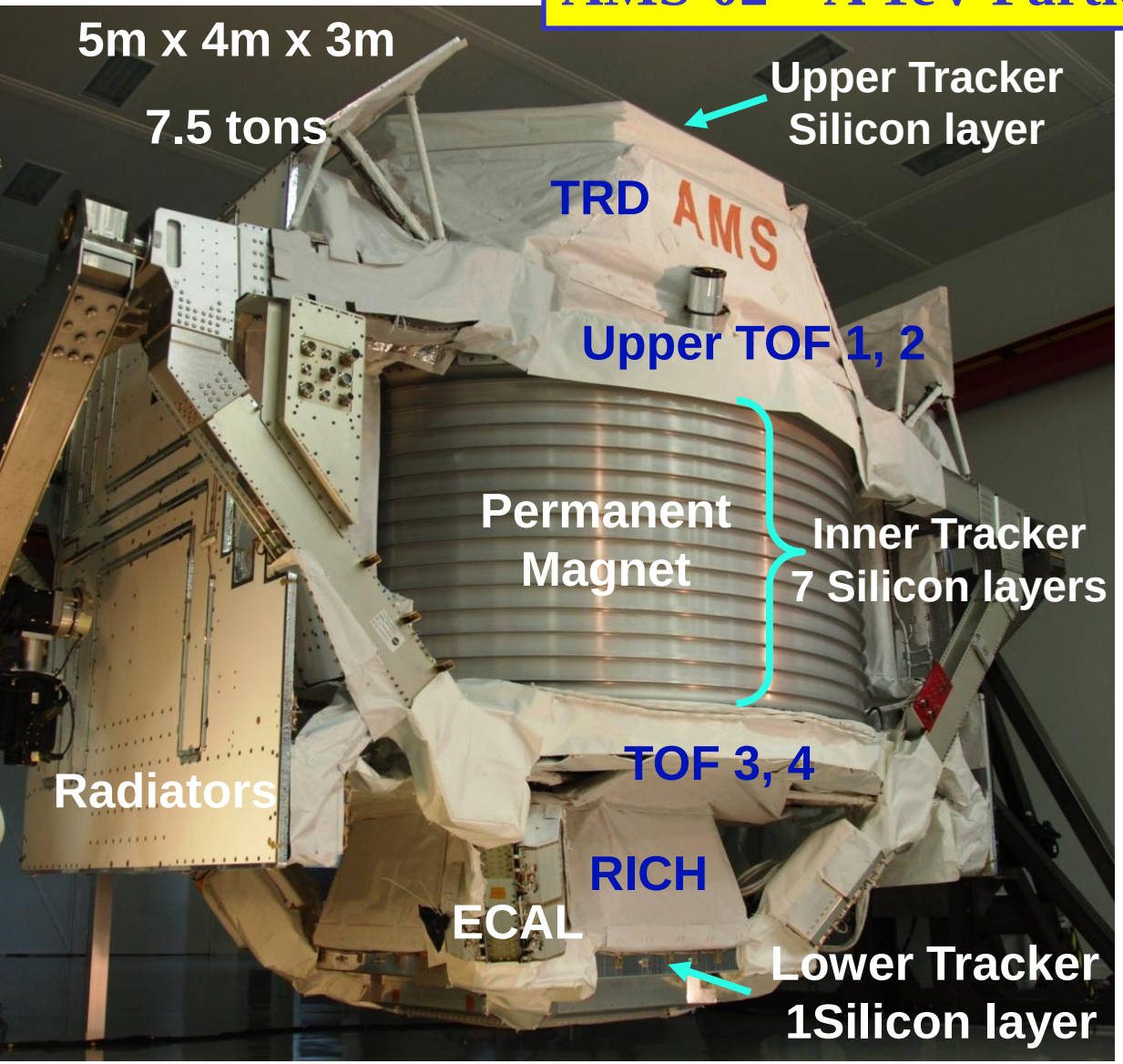
AMS is US Dept of Energy (DOE) led International Collaboration

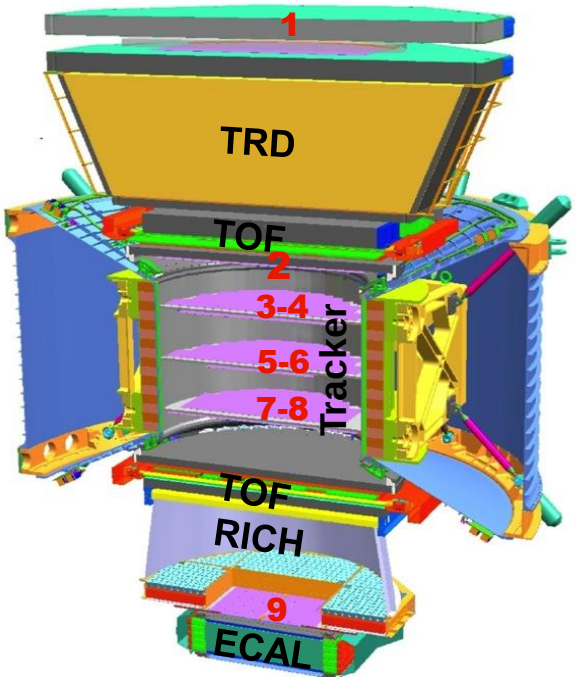
16 Countries, 60 Institutes and 600 Physicists, 17 years



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

AMS-02 – A TeV Particle Spectrometer





ISS Lifetime extended until at least 2020 / 2028 (March 2010)

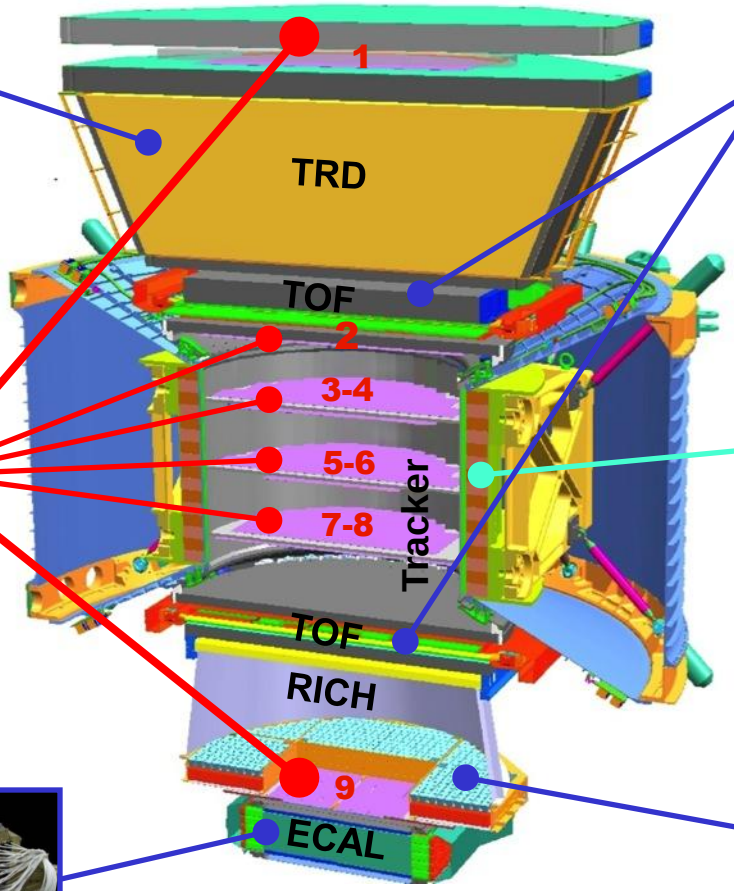
→ Switch to AMS-01 permanent magnet (B=0.14T)
→Tracker reconfigured
→ 'external' layers

AMS-02 – A TeV Particle Spectrometer

TRD
Separation $e^{\pm}$:p

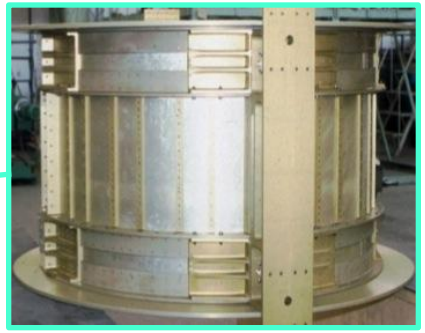
TOF
Z, E

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

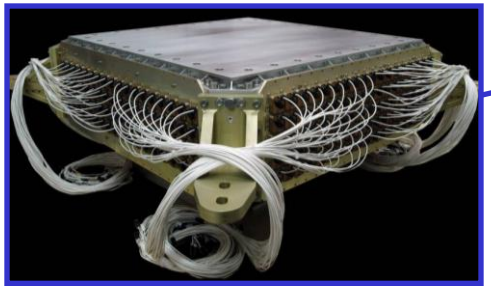


Silicon Tracker
Z, P

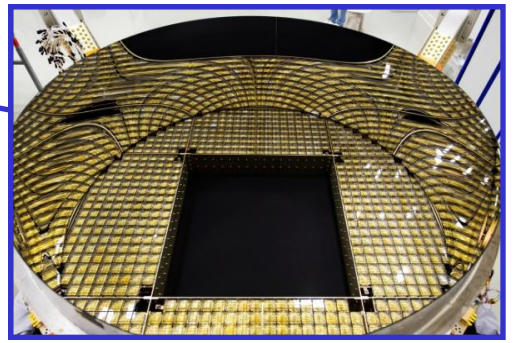
Magnet



ECAL
E of $e^{\pm}$, γ



RICH
Z, E

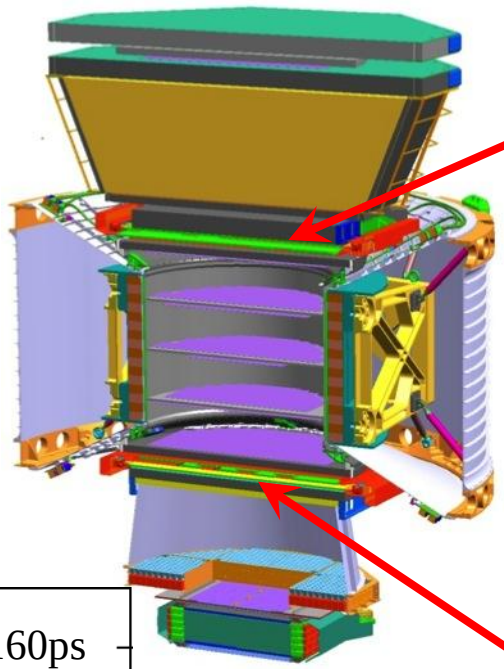


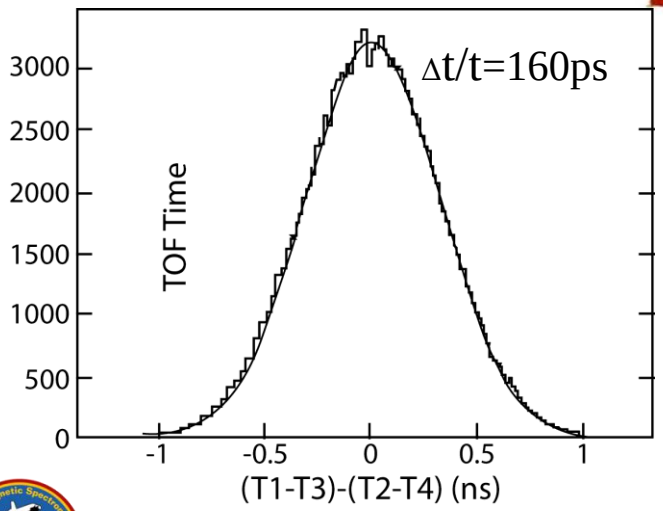
Z, P are measured independently by the Tracker, RICH, TOF and ECAL

AMS-02 – Time of Flight (TOF)

Measures Velocity and Charge of particles

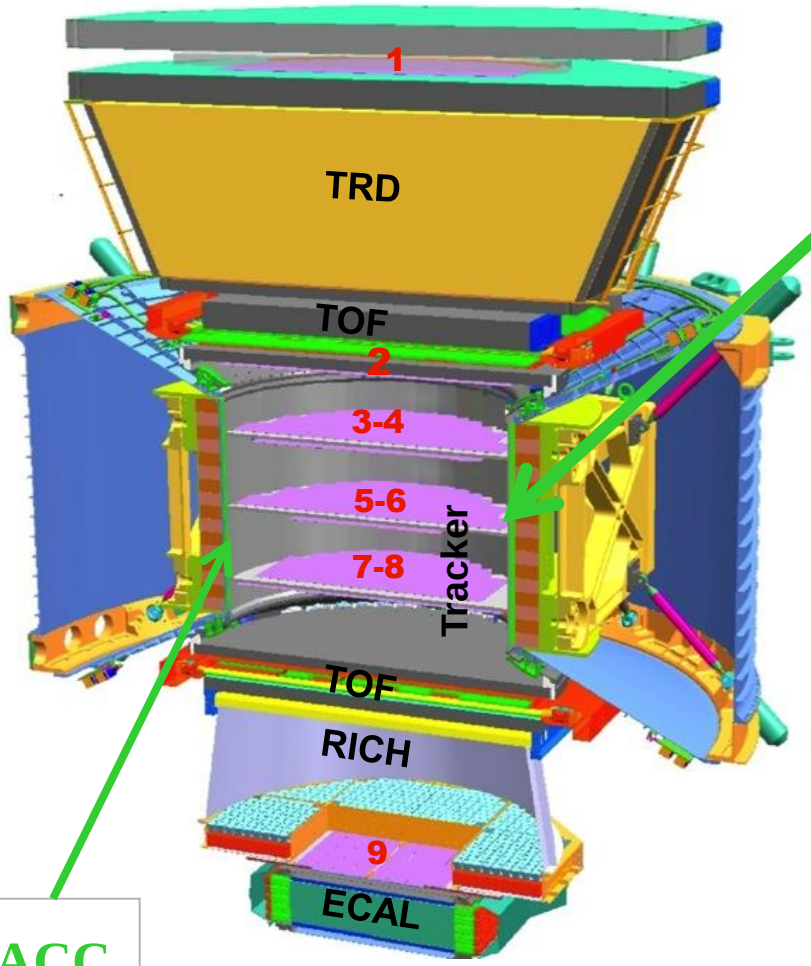
- **Provides trigger for charged particles**
- **Measures time of relativistic particles to 160 ps,**
  β dE/dX: Z;





Fine Mesh PMTs + plastic scintillators

AMS-02 – AntiCoincidence Counter System (ACC)



ACC surrounds inner silicon tracker inside magnet.
Rejects particles that leave or enter AMS-02 through inner shell of the magnet → protection against misidentification of matter nuclei as antimatter nuclei.

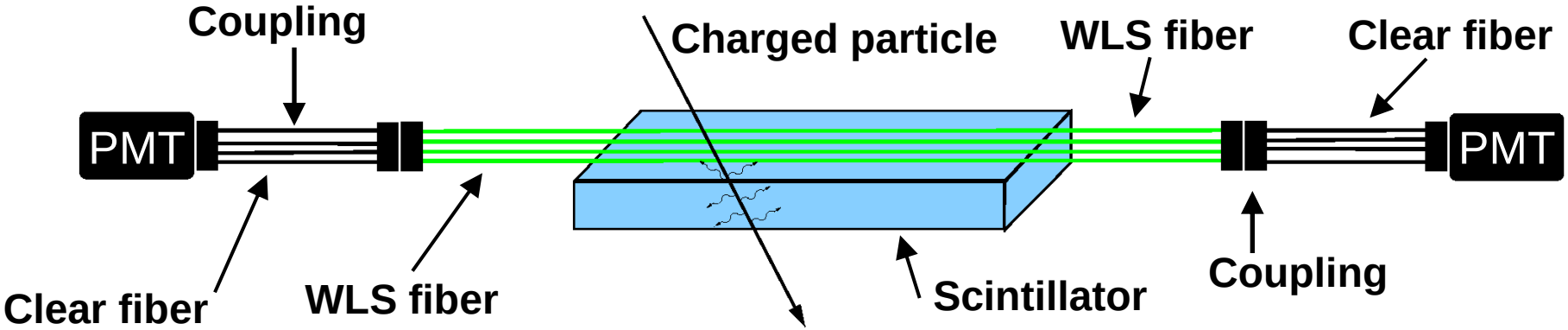
Requirements:

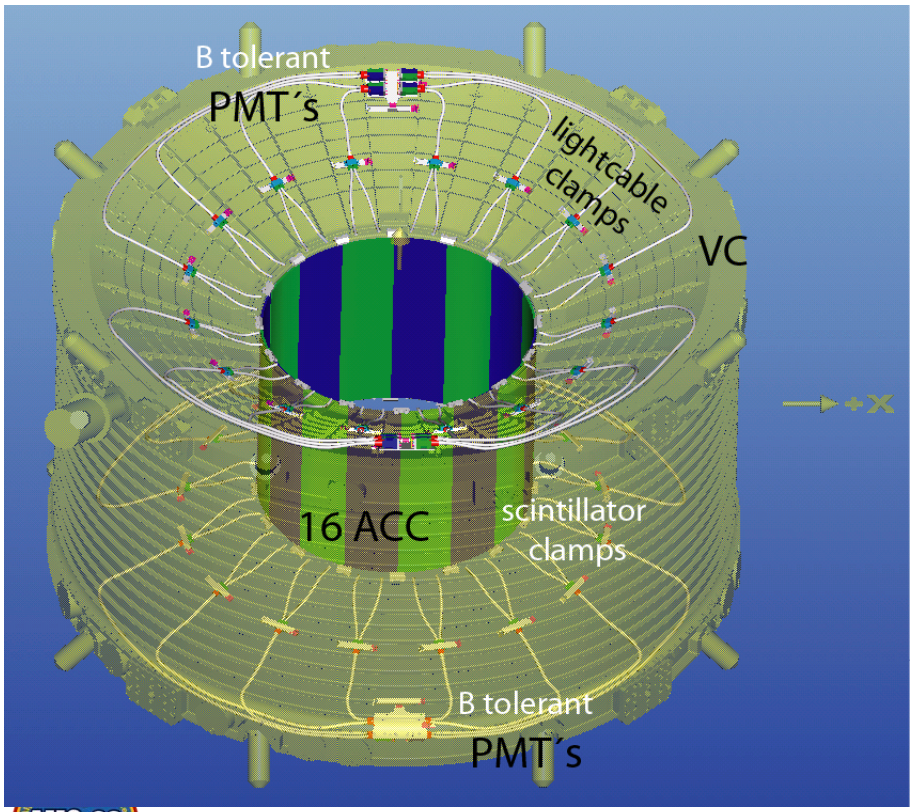
- **High detection efficiency (0.9999)**
- **operational in high magnetic field**
- **fast response for trigger**

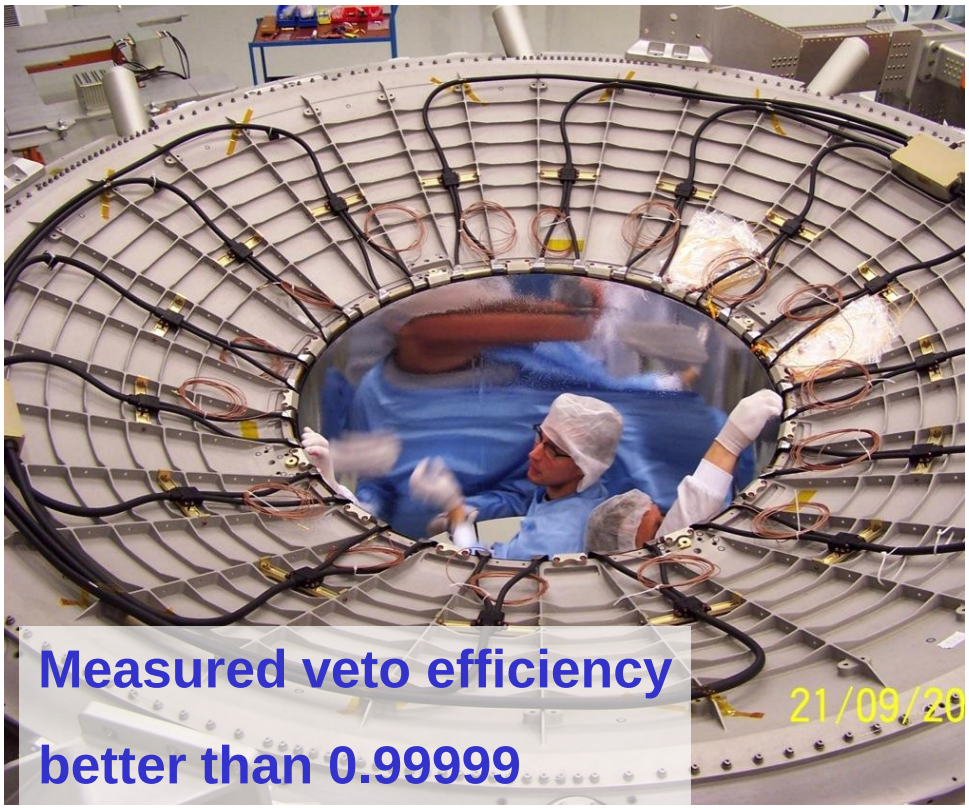
Fine Mesh PMTs + plastic scintillator

Measured veto efficiency better than 0.99999

AMS-02 – AntiCoincidence Counter System (ACC)



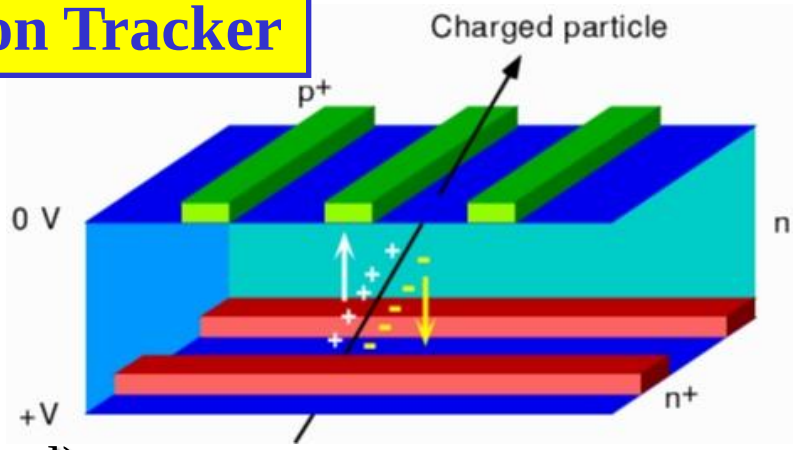




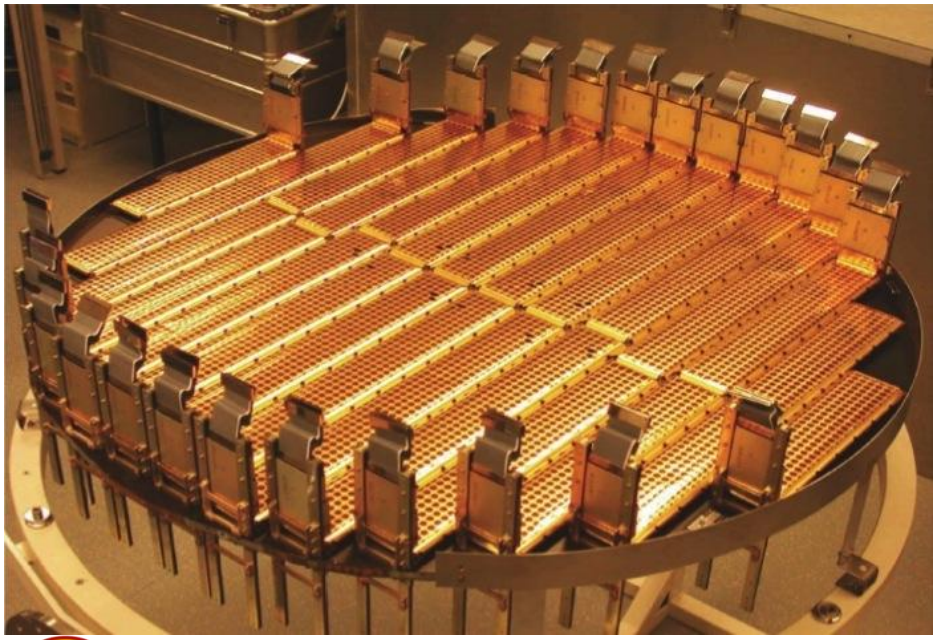
AMS-02 – Silicon Tracker

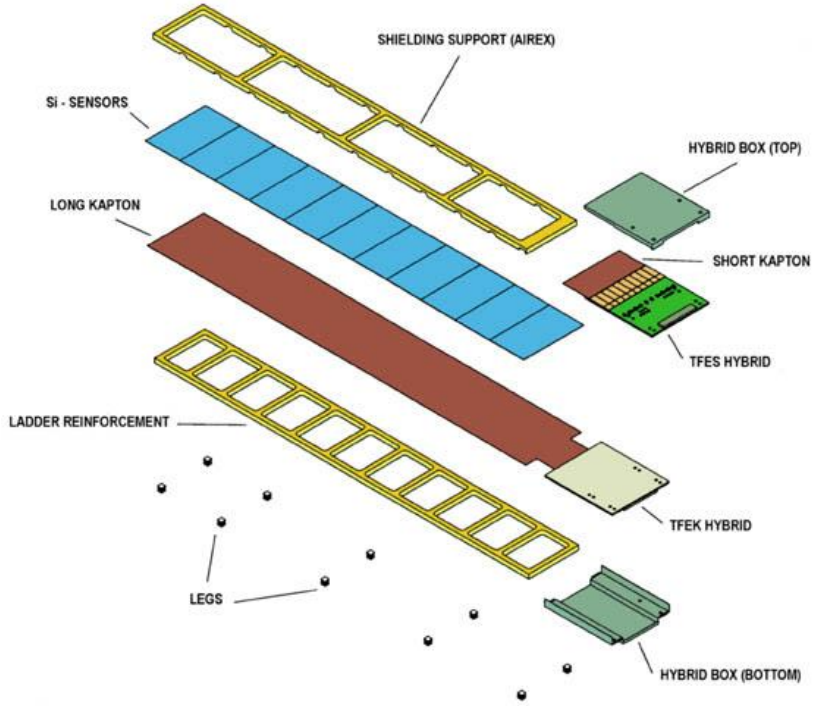
Measurement:

Position and Charge (large dynamic range)



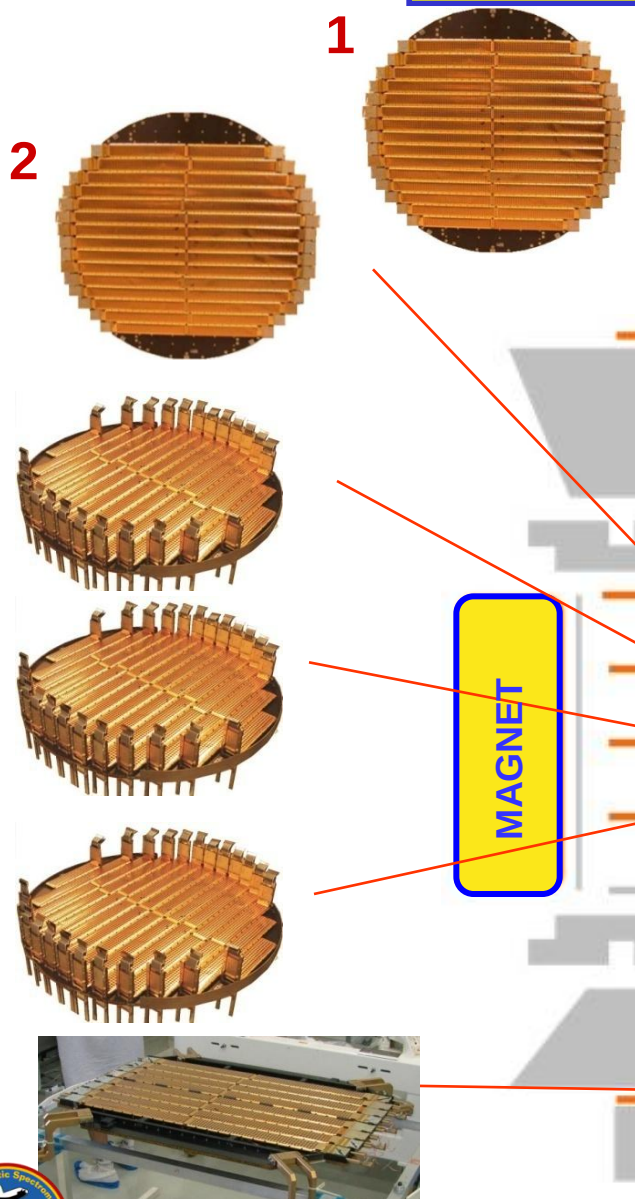
- Thickness: 300 μm
- Strip every 25 μm
- Read-out 1 strip/4: 100 μm
- Total 200’000 channels
- 9 layers of XY sensors on 6 rigid planes (7 m² total)
- Spatial resolution σ~10μm

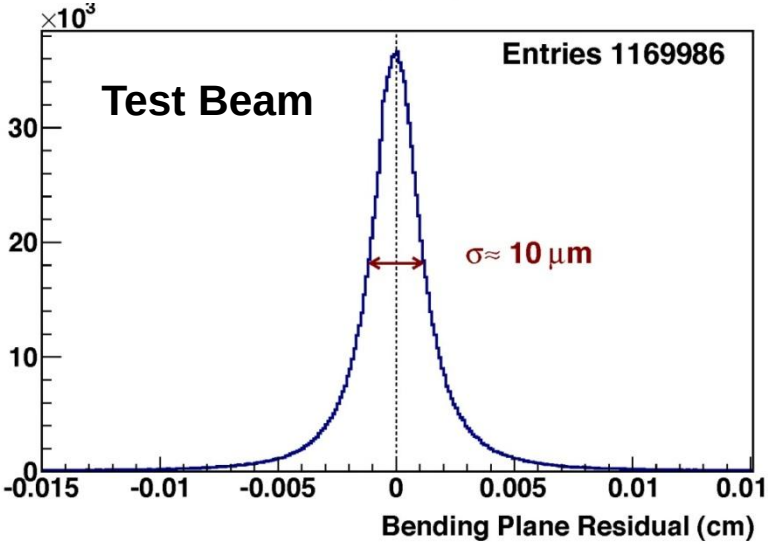




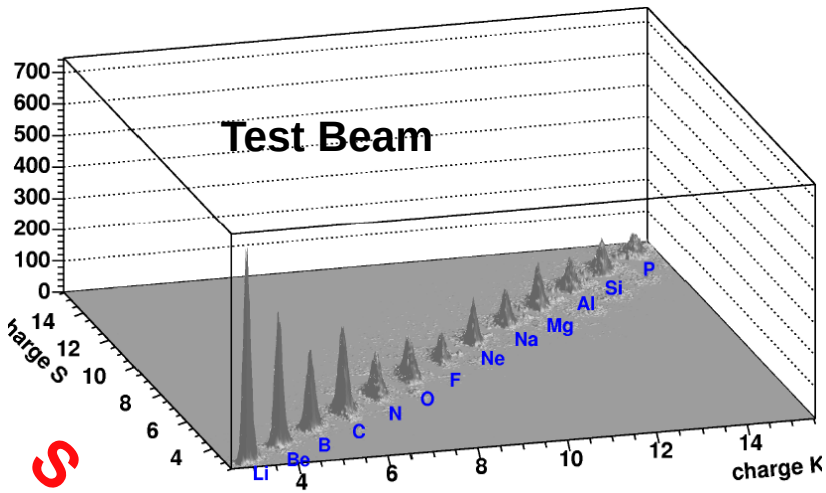
AMS-02 – Silicon Tracker

9 layers of XY sensors on 6 rigid planes (7 m² total)

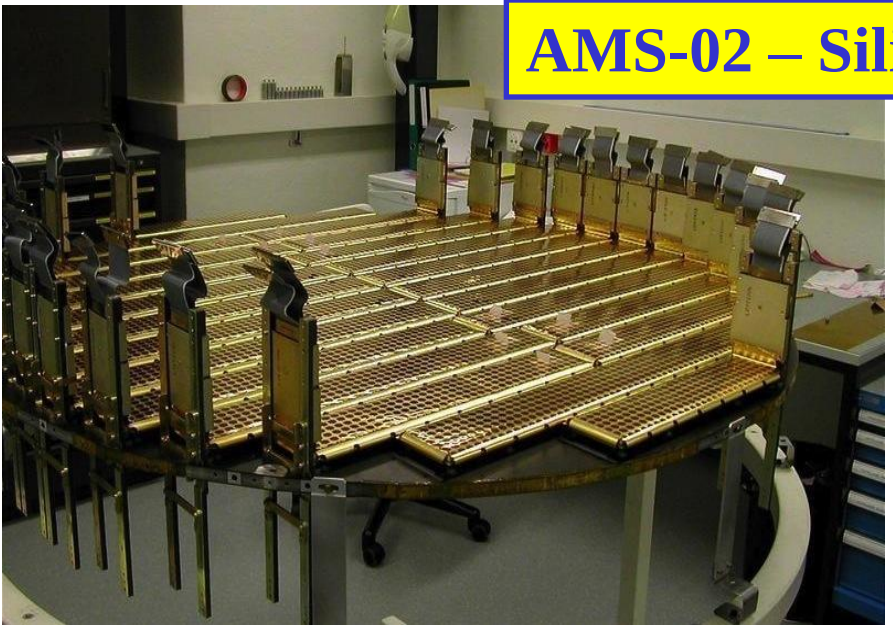


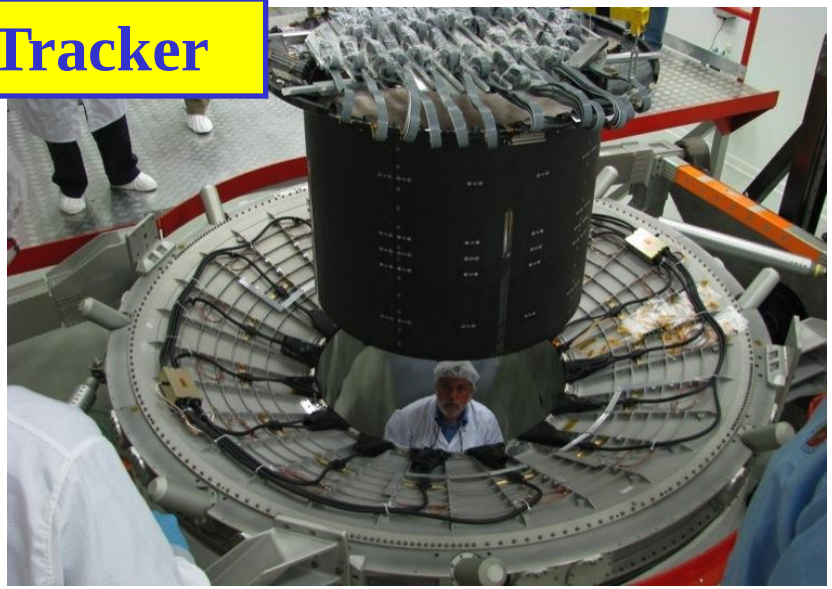


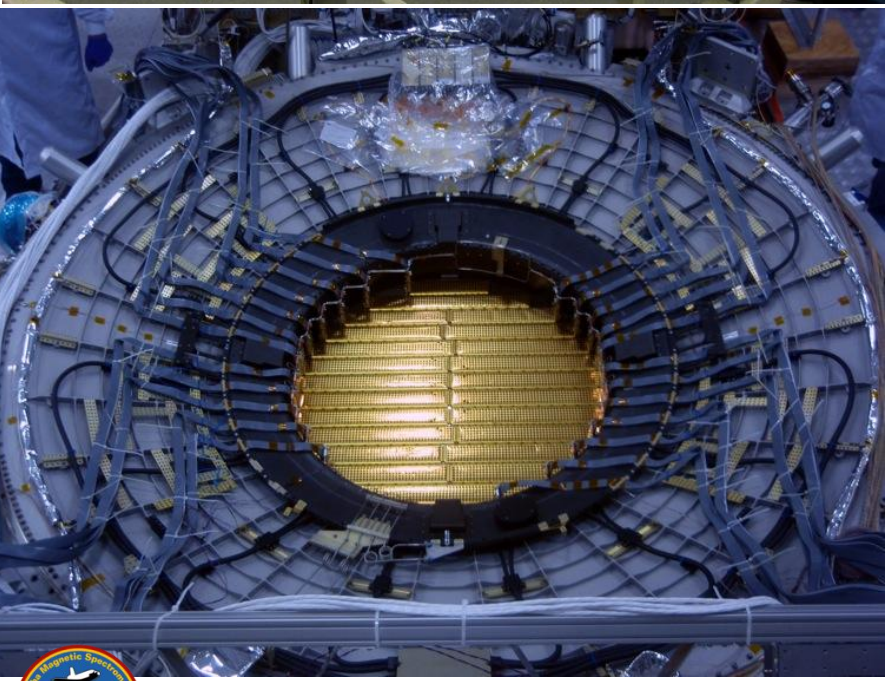
dE/dX: identify nuclei

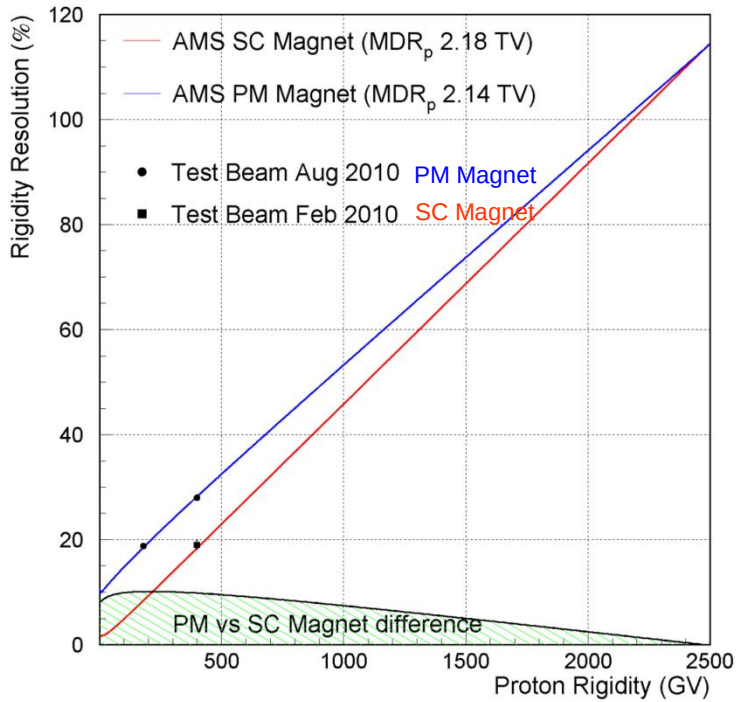


AMS-02 – Silicon Tracker





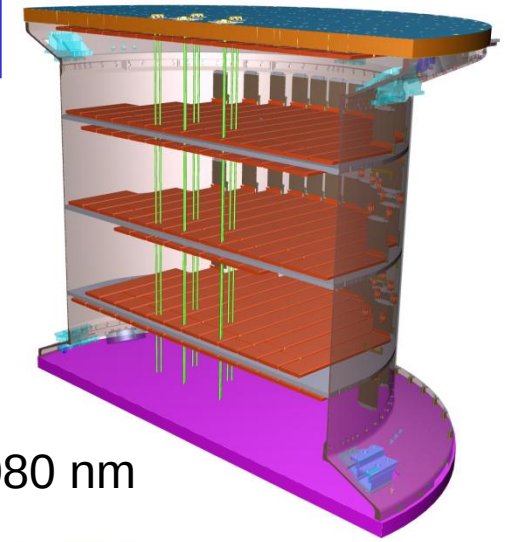




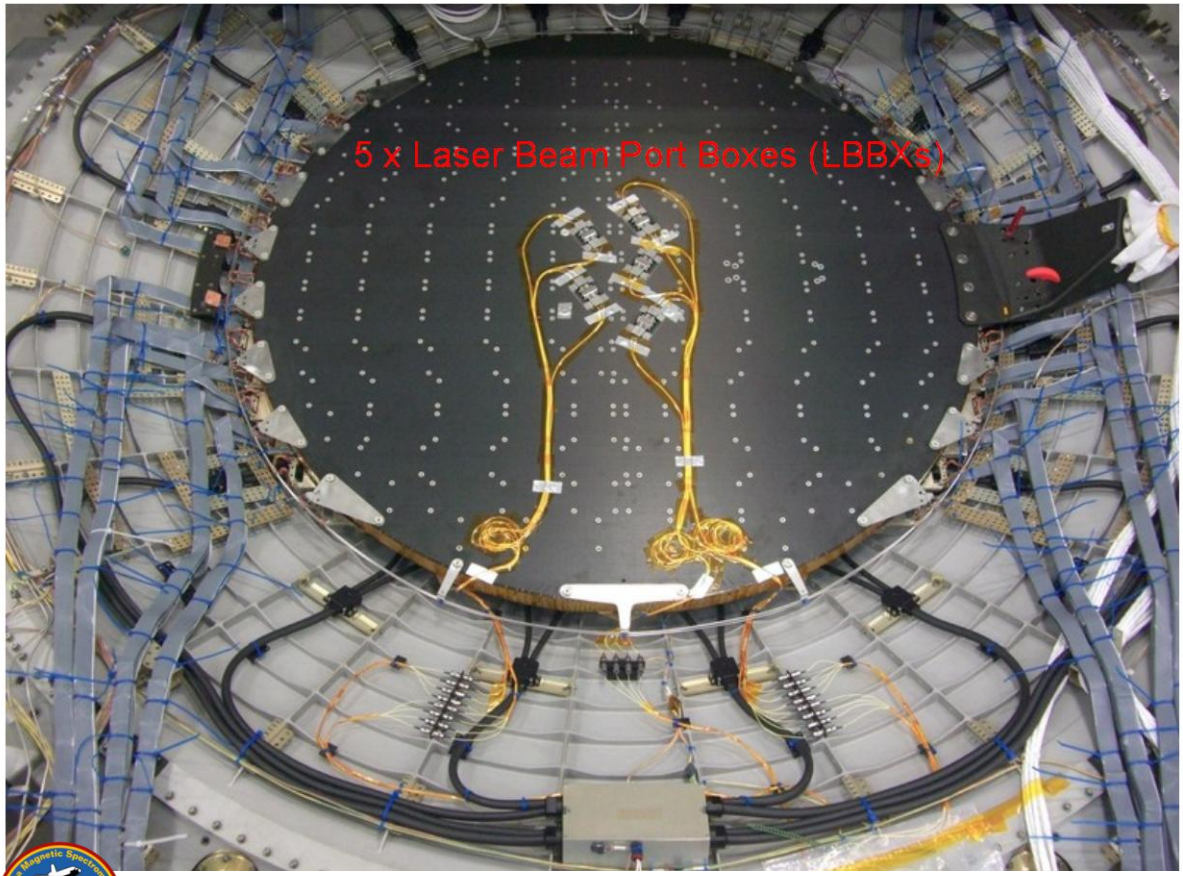
AMS-02 – Silicon Tracker, Tracker Alignment System (TAS)

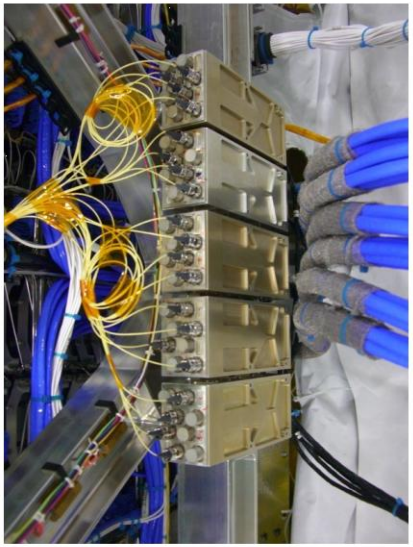
20 laser beams for movement survey with accuracy of 3 µm

Goals of TAS:
1. Alignment for the Tracker
2. Monitoring Tracker Movement



1080 nm

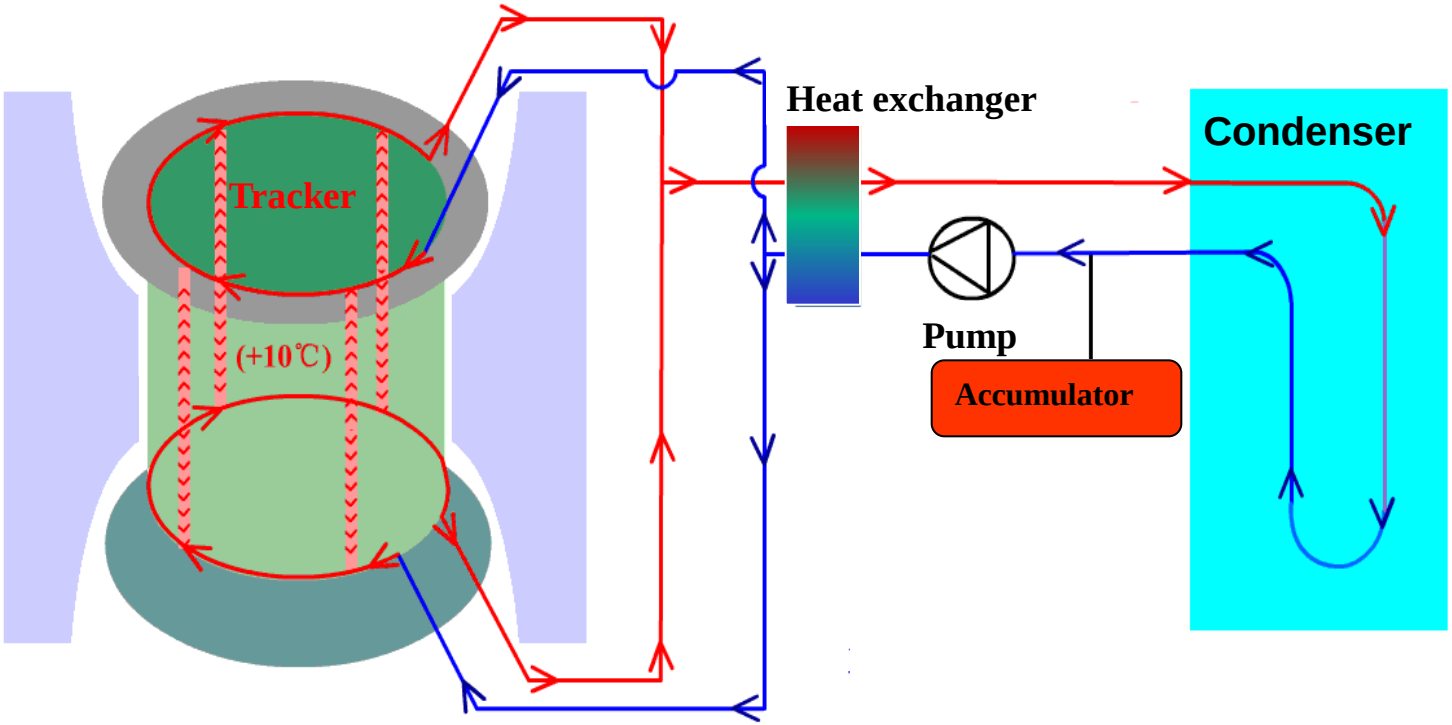




Laser Fiber Couplers (LFCRs)

AMS-02 – Silicon Tracker

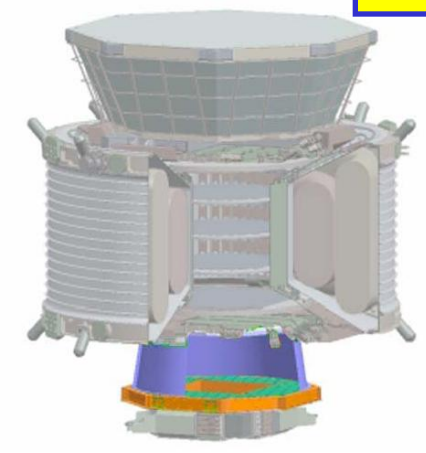
Cooling of the front-end electronics by *thermal bars* and two phase CO_2 circuit at 50 bar pressure.

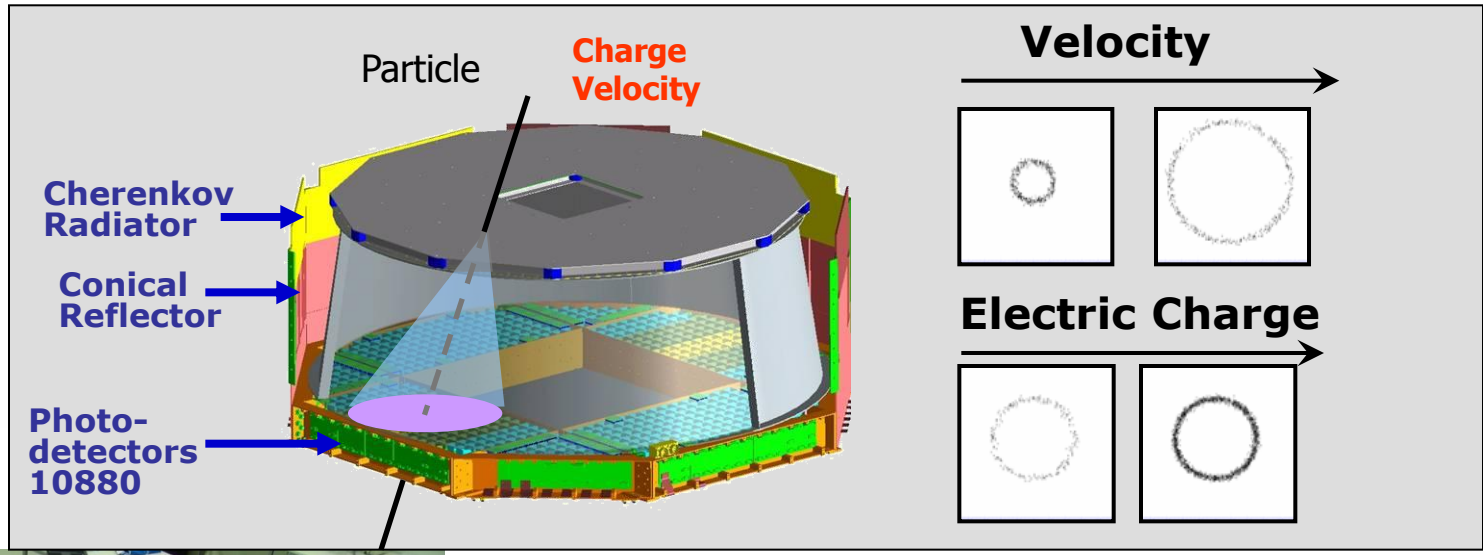


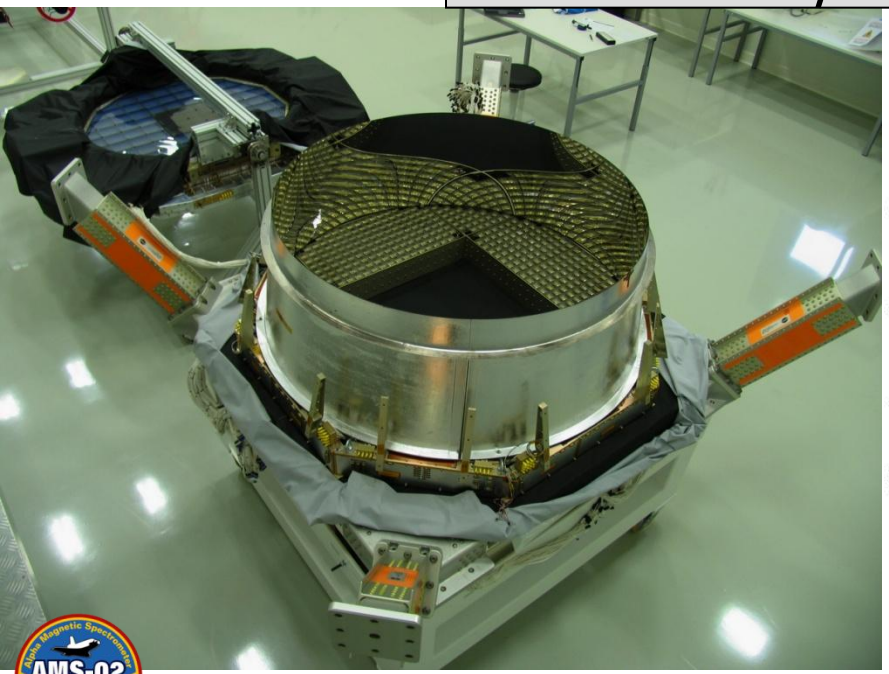
Red line: CO_2 gas/liquid two phase

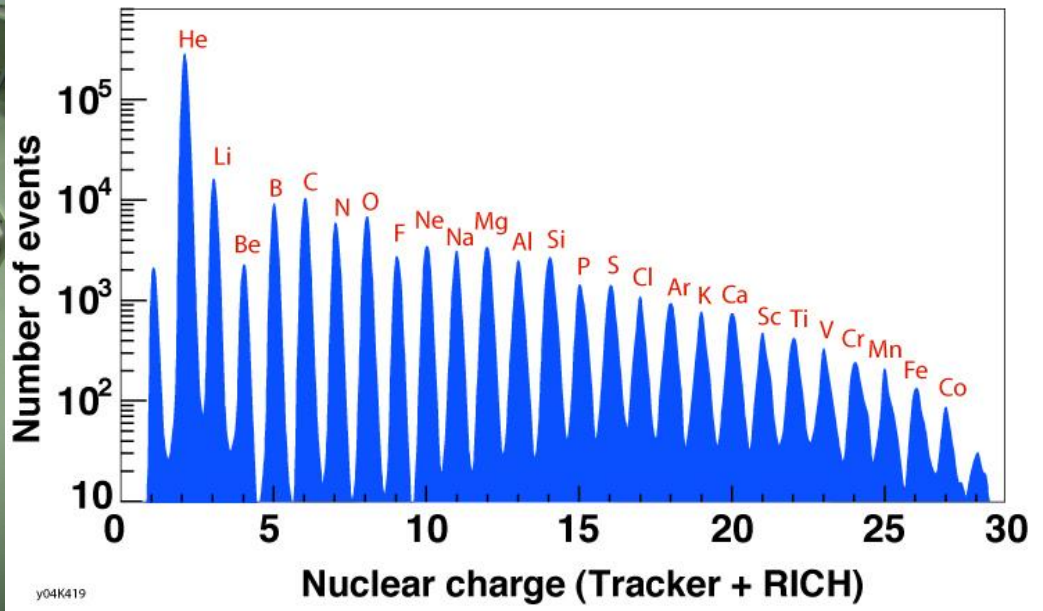
Blue line: CO_2 liquid phase

AMS-02 – Ring Imaging Cherenkov Counter (RICH)

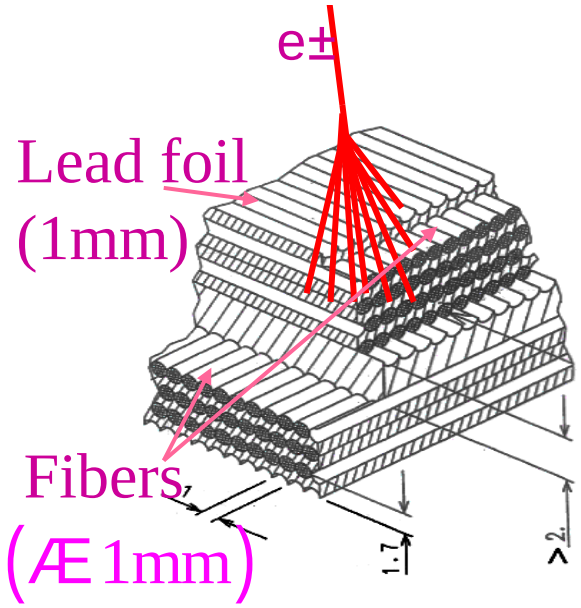




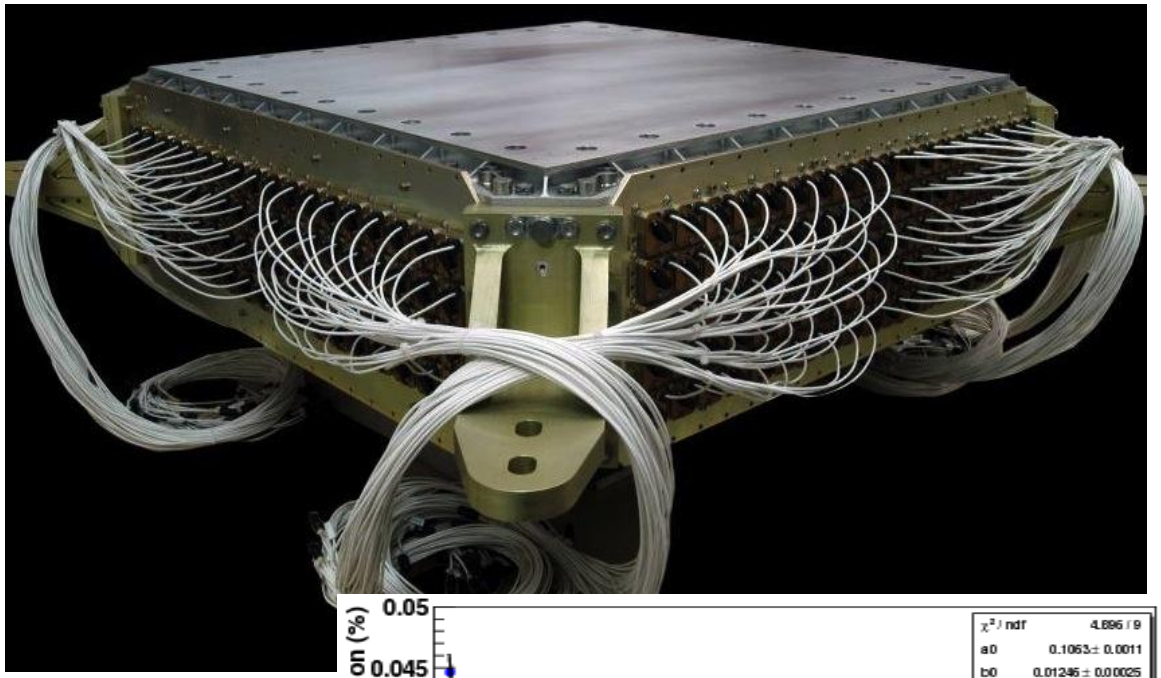


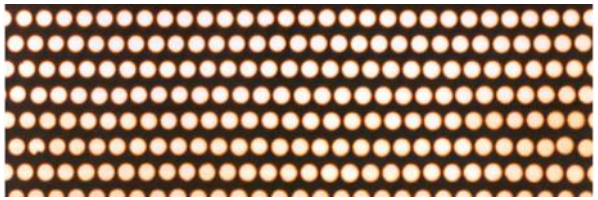


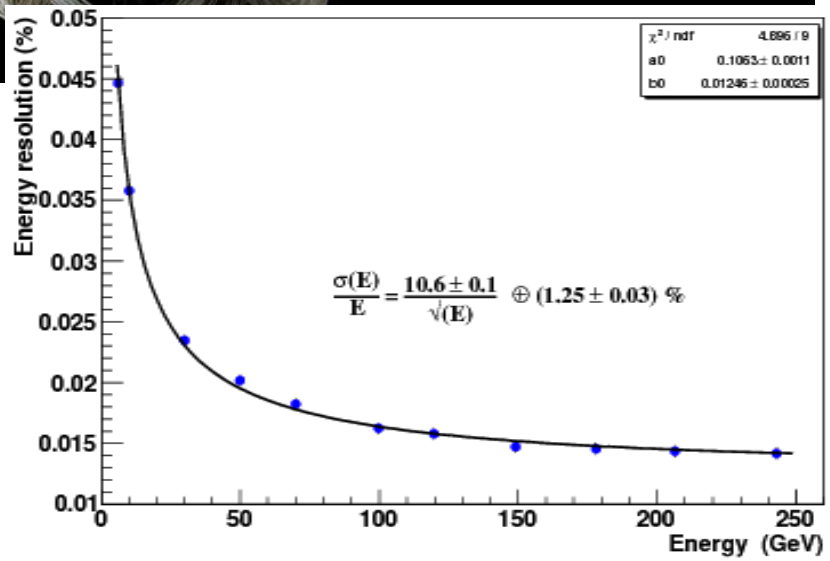
AMS-02 – Electromagnetic Calorimeter (ECAL)



A precision 3-dimensional measurement of the directions and energies of light rays and electrons up to 1 TeV







50,000 fibers, ∅ =1mm, distributed uniformly inside 1,200 lb of lead , 17X_0

Th. Kirn

AMS-02 – Transition Radiation Detector (TRD)

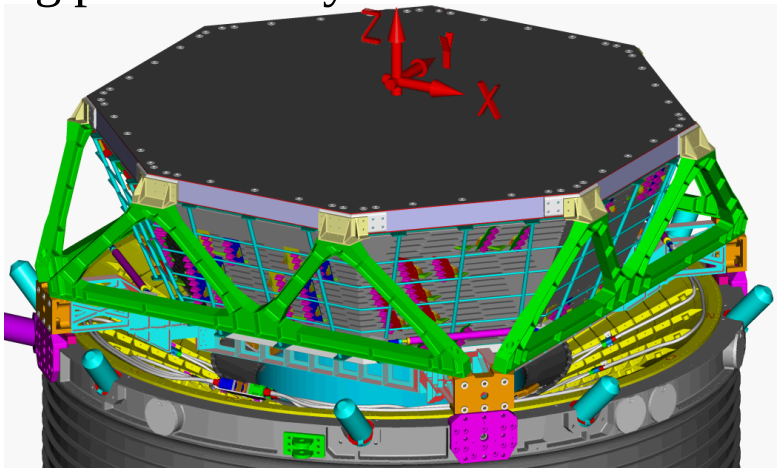
Choosen configuration for 60 cm height:

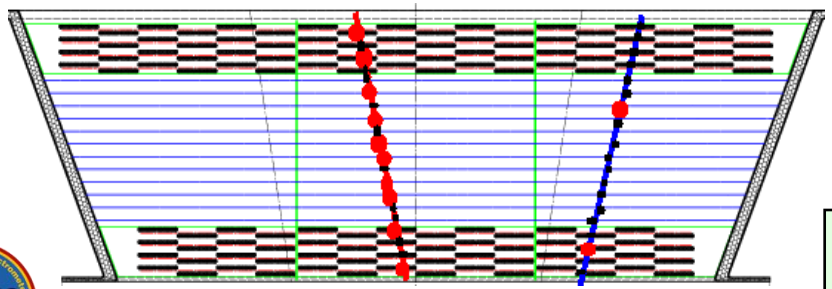
20 Layers each existing of:

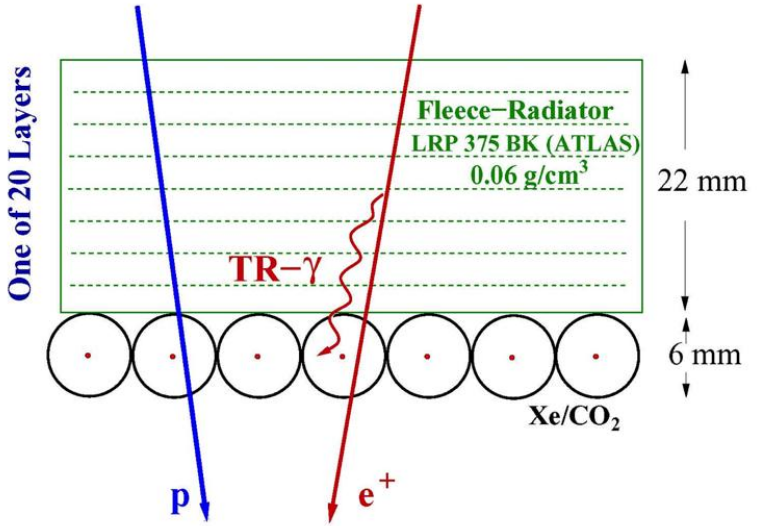
- 22 mm fibre fleece
- Ø 6 mm straw tubes (Xe/CO_2 80%/20%)

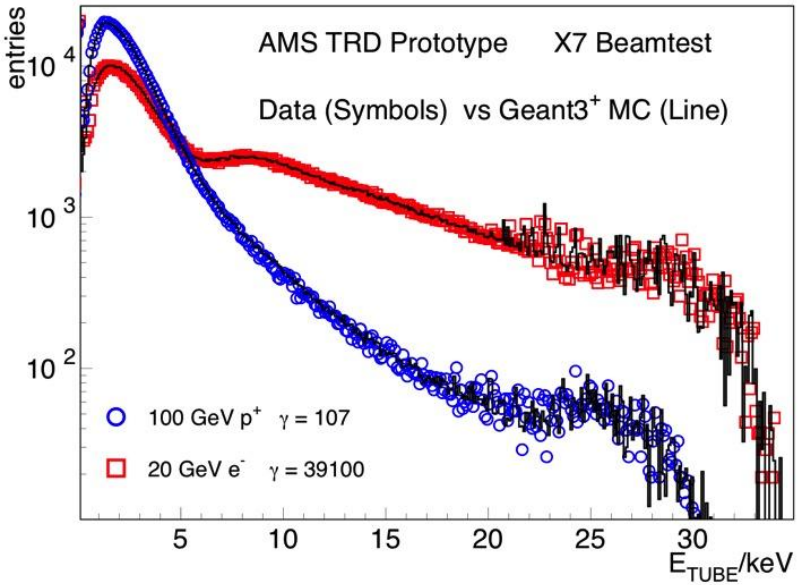
Non-bending plane: 2x4 layers

Bending plane: 12 layers



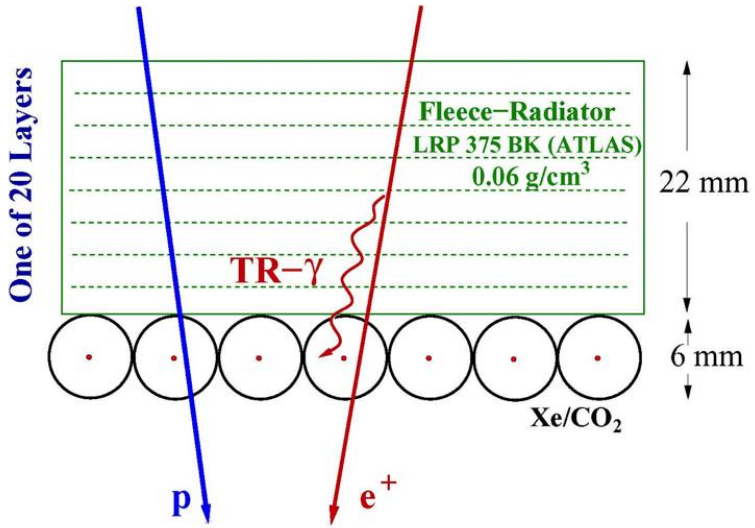


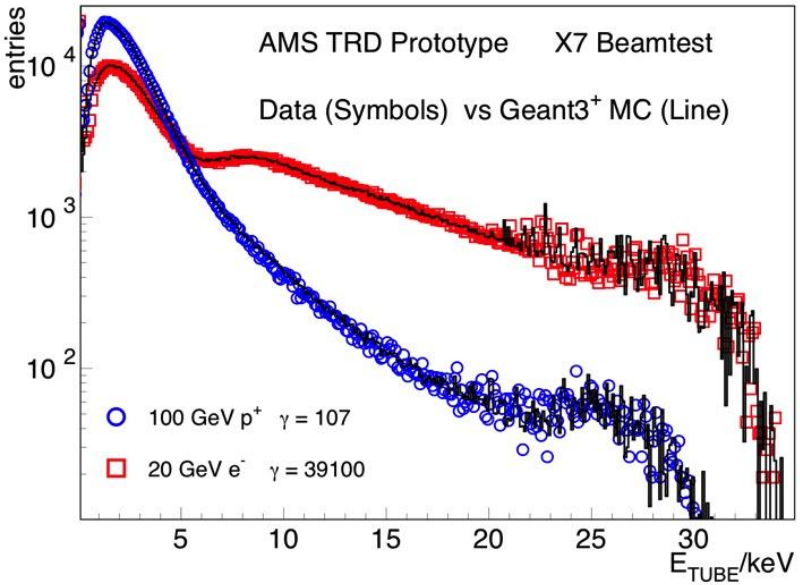


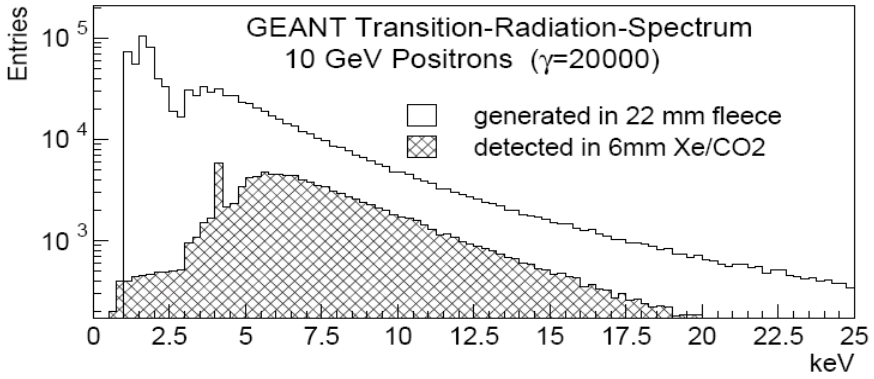


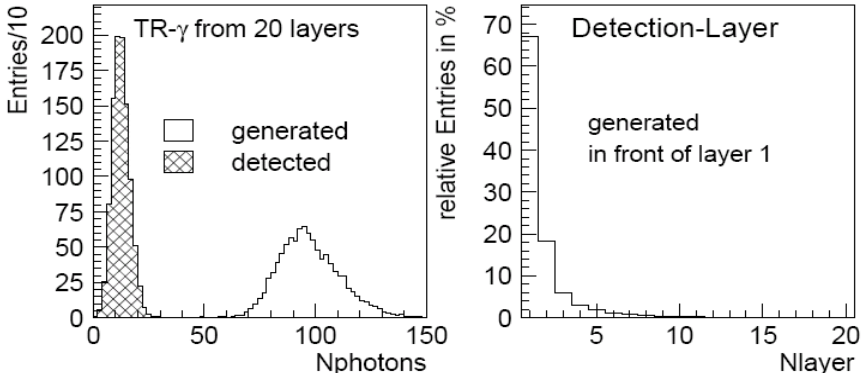
p^+ rejection $>10^2$ 1-300 GeV 0.5m^2sr

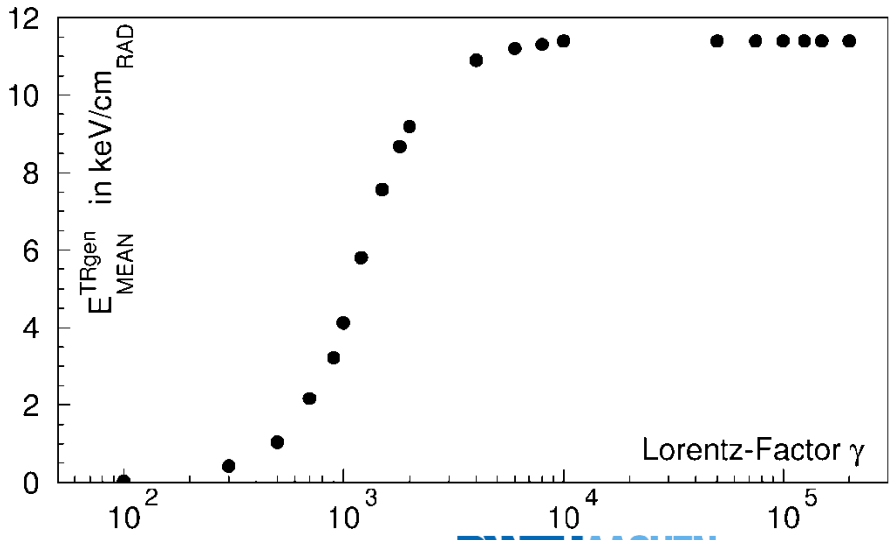
AMS-02 – TRD


One of 20 Layers
Fleece–Radiator
LRP 375 BK (ATLAS)
0.06 g/cm3
22 mm
TR–γ
6 mm
Xe/CO2
p
e+


entries
AMS TRD Prototype X7 Beamtest
Data (Symbols) vs Geant3+ MC (Line)
100 GeV p+ γ = 107
20 GeV e- γ = 39100
ETUBE/keV


Entries
GEANT Transition-Radiation-Spectrum
10 GeV Positrons (γ=20000)
generated in 22 mm fleece
detected in 6mm Xe/CO2
keV


Entries/10
TR-γ from 20 layers
generated
detected
Nphotons
relative Entries in %
Detection-Layer
generated
in front of layer 1
Nlayer


E TRgen MEAN in keV/cm RAD
Lorentz-Factor γ

AMS-02 TRD: Radiator

Radiator LRP 375 BK:

Polyethylene/Polypropylene fibers

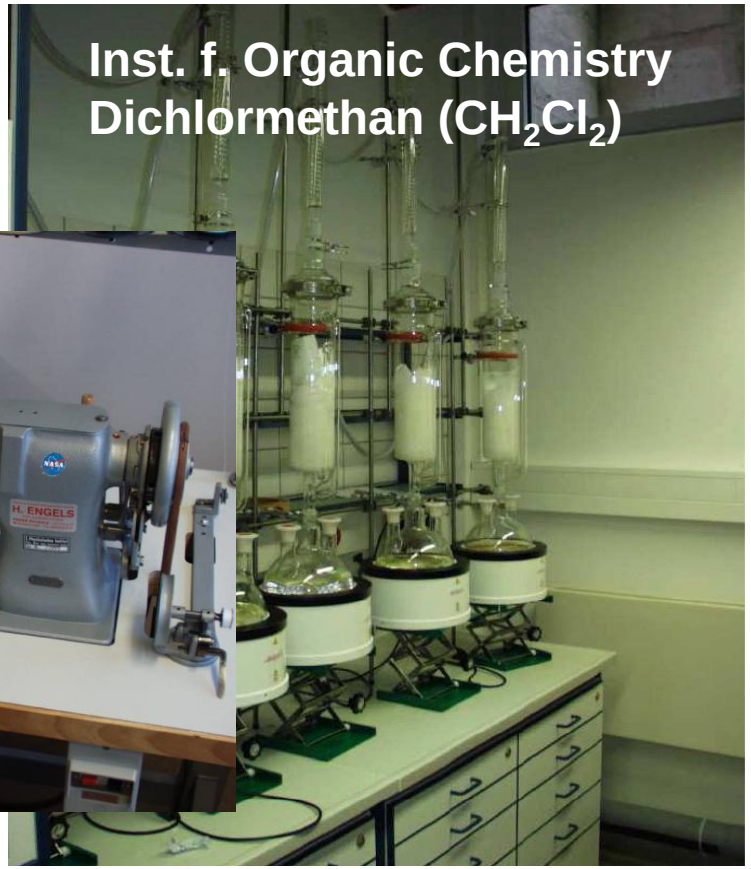
Effective fiber diameter: 10 μm

Radiator thickness: 22 mm

Density: 0.06 g/cm^3

Cleaning with Dichlormethane CH_2Cl_2

→ dM/dt ≈ 10^{-12} g/s/cm^2

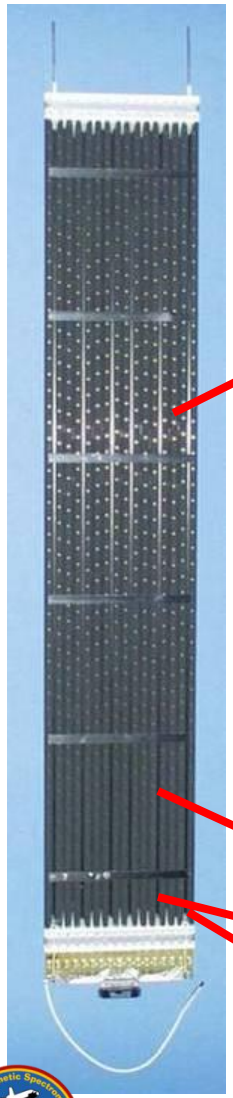


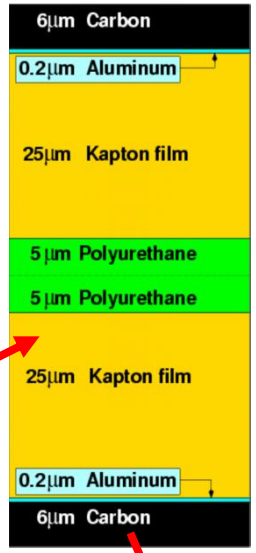
4000 individual pieces cut to length

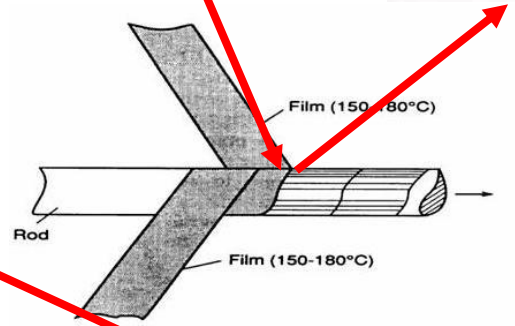
AMS-02 – TRD: Straw Modules

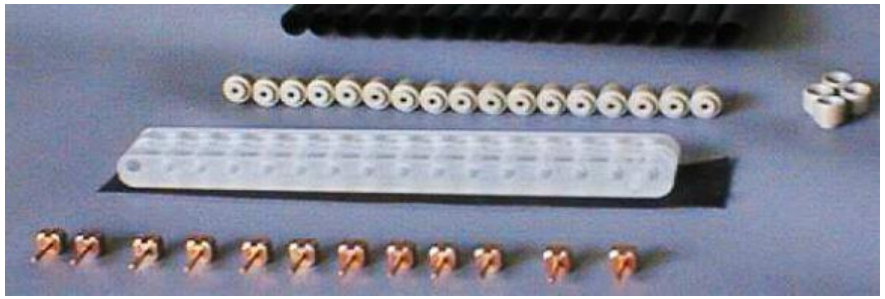
Straw tube proportional counter modules:

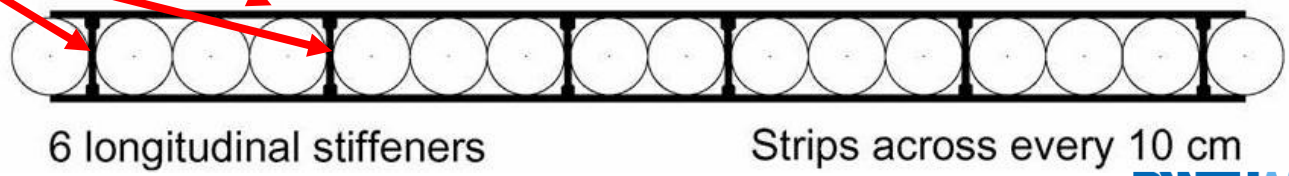
- Straw tubes: 72 μm multilayer aluminium kapton foil, Ø 6 mm , 0.8 2.0 m length
- Wire: tungsten anode wire, 30 μm Ø, tension ≈ 100 g
- Gas mixture: Xe / CO_2 (80% / 20%) → to be optimized
- Operating HV ~ 1460 V → Gasgain of ~ 3000
- 1 Module → 16 Straws, 100 μm mechanical accuracy
- 328 Modules → 5248 Straws



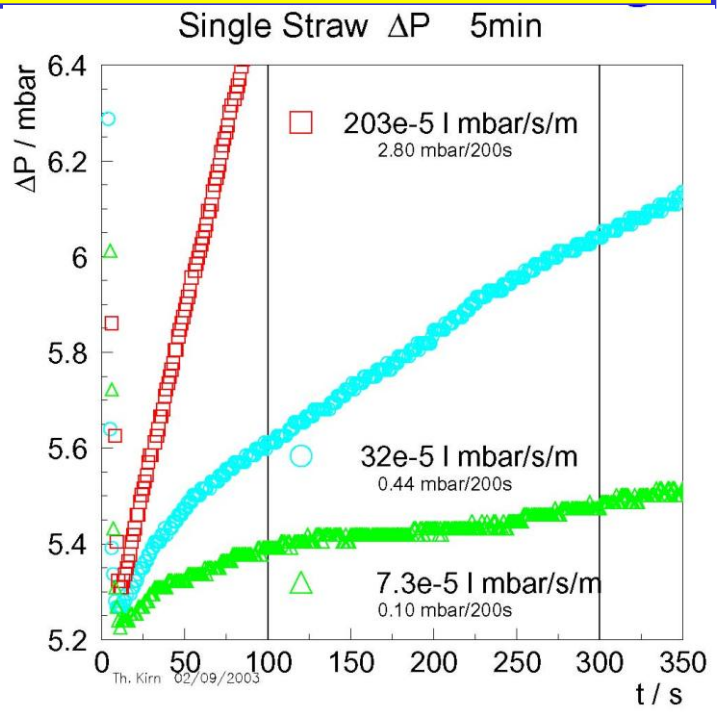


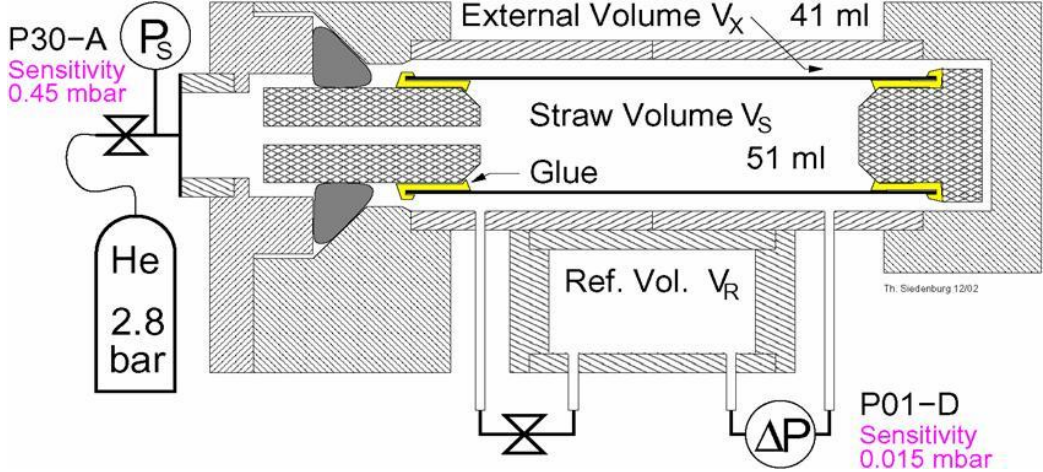


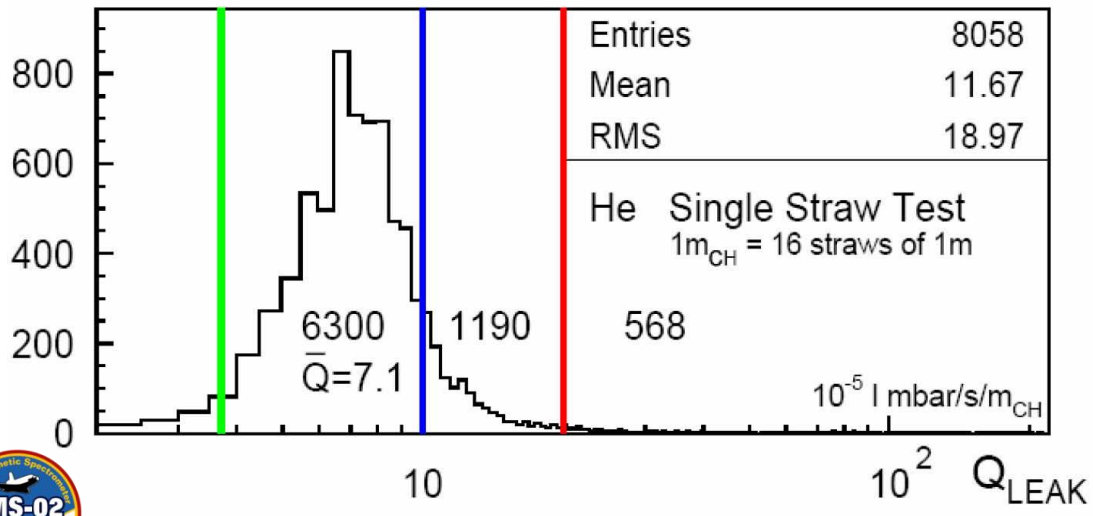


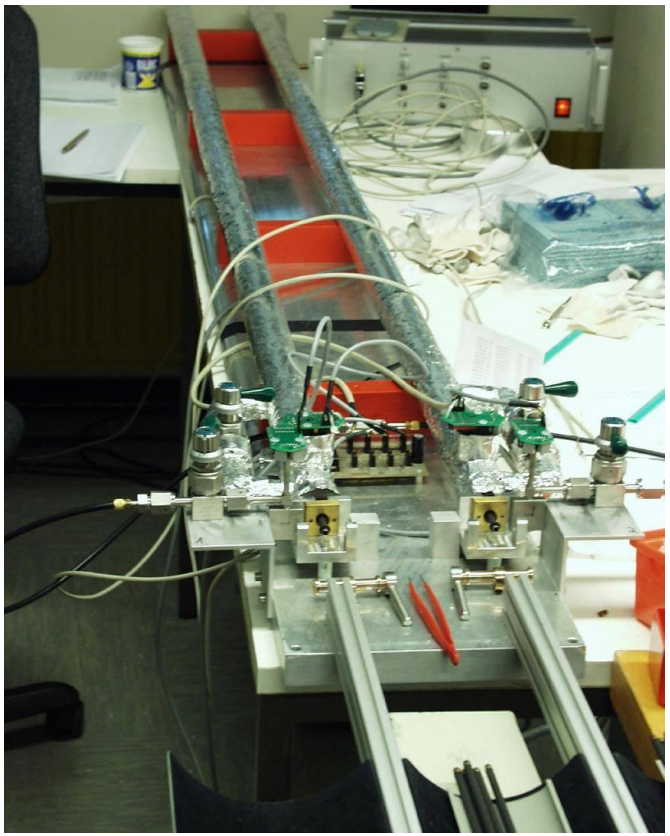


AMS-02 TRD:Gastightness

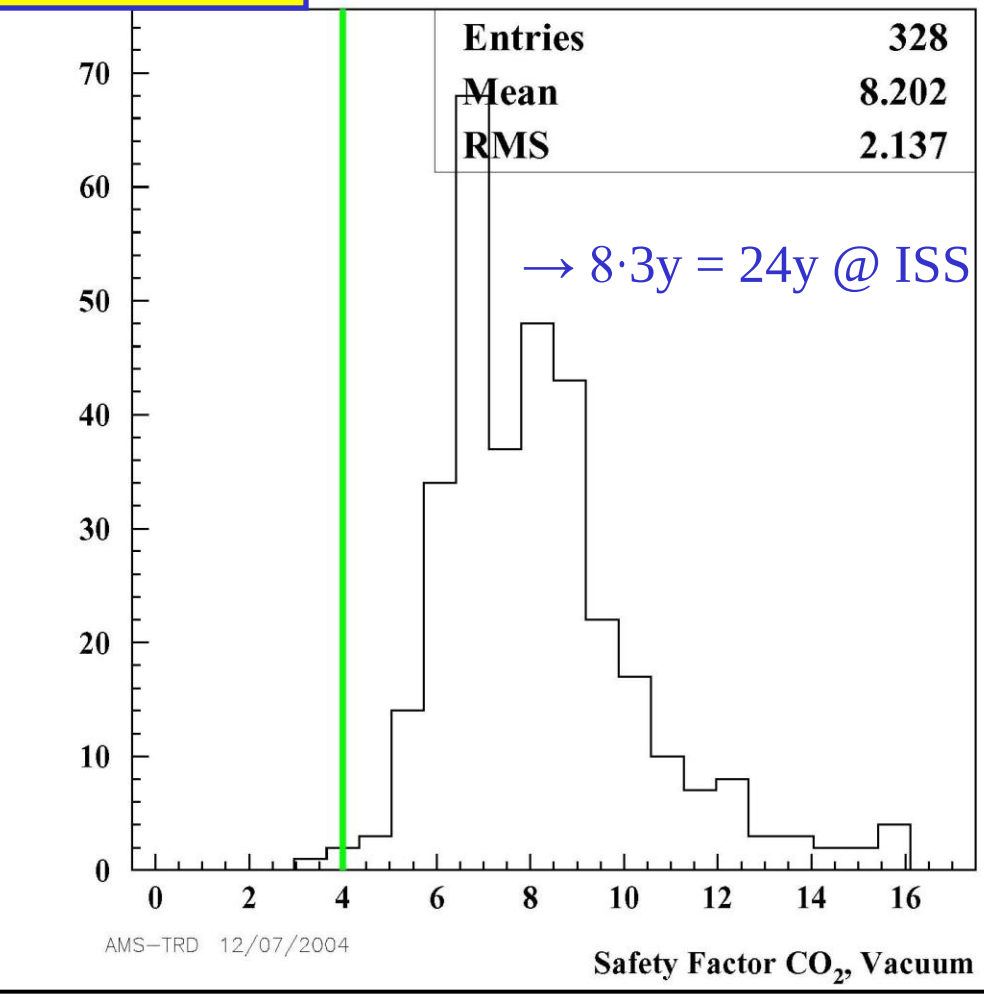








AMS-02 TRD: Gastightness



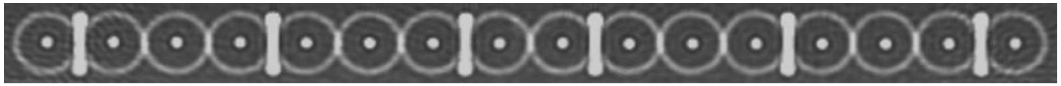
CO_2 Leaktest in Vacuum Straws @ 1bar

$1m_{CH}$ = 16 straws of 1m [+2 endpcs] Typ. Module [1.5m]: $3.1 \cdot 10^{-5}$ l mbar/s/m_{CH} ≡ SF 8.2

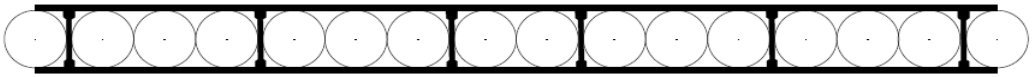
Gas Tightness measured in safety factors SF, SF=1 → $25.3 \cdot 10^{-5}$ l mbar/s/m_{CH}

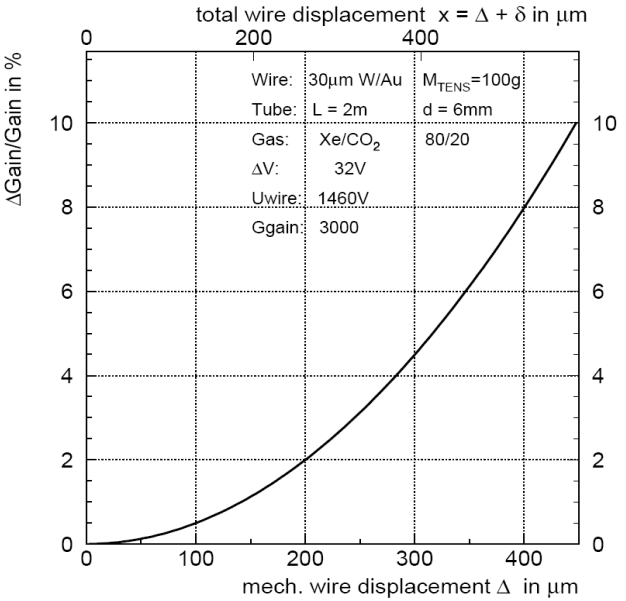
AMS-02 TRD: Computer Tomography X-Ray

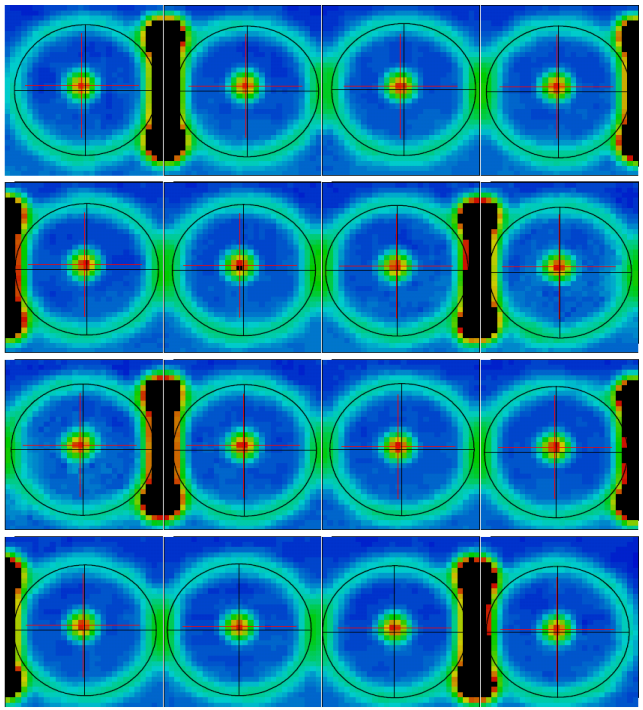
Luisenhospital Aachen (GE 16-Channel CT)



Dicom Image File



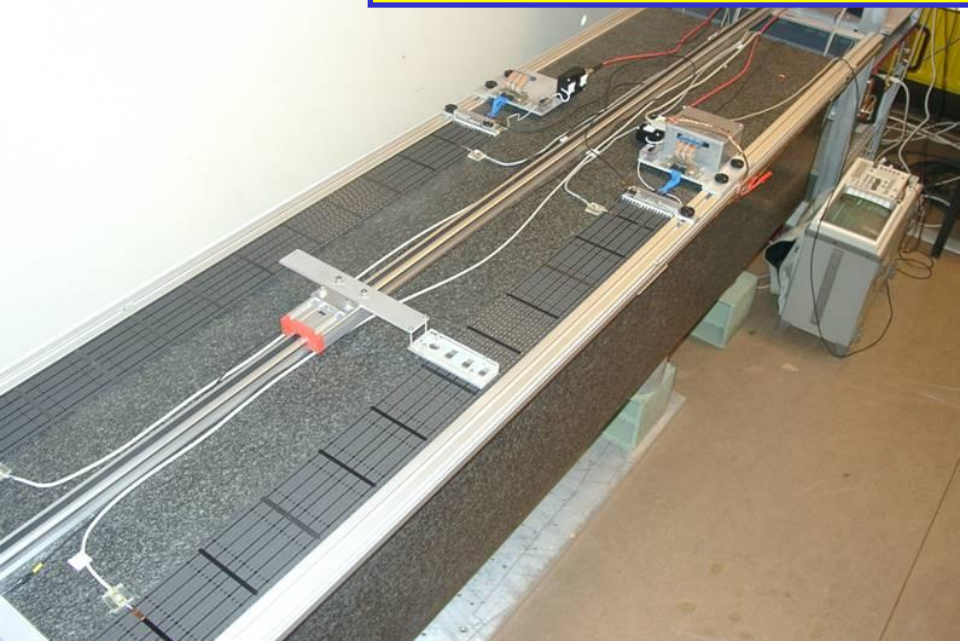




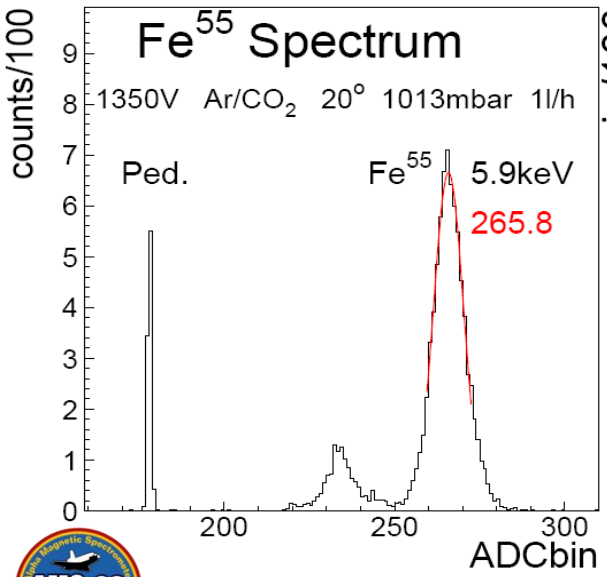
Wire- and Tube-xy-Fit ($\sigma \approx 10 \mu m$)

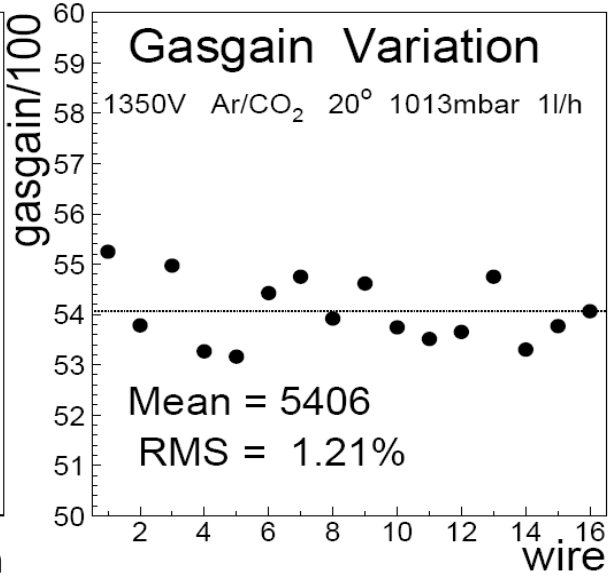
Th. Kirn

AMS-02 TRD: Gasgain

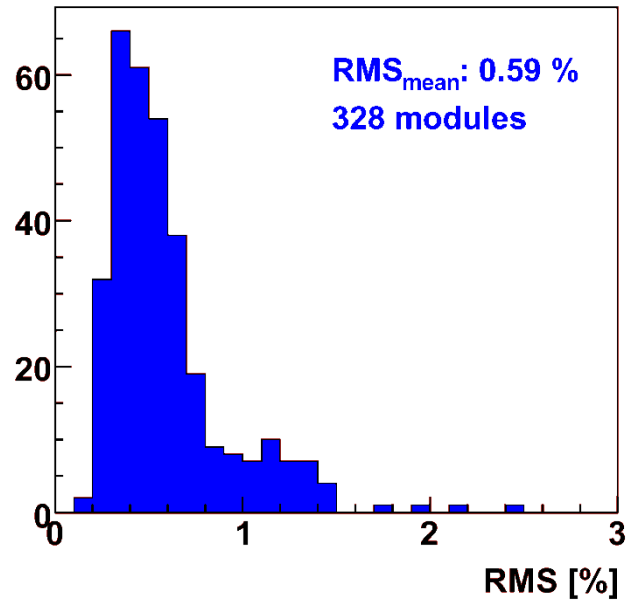


0.1	0.3	0.5	0.7	0.9	1.1	1.3	1.5	1.7	1.9m	Straw
3.2	1.5	4.2	1.8	5.7	7.1	5.2	4.2	0.2	-0.9	1
0.1	-0.1	0.2	1.0	4.1	3.8	2.9	1.8	-1.2	-2.4	2
-2.0	-0.7	0.2	0.5	0.1	3.2	4.2	-0.6	-2.9	-3.8	3
-2.6	-1.3	-2.1	0.4	0.6	2.5	2.8	-0.6	-2.8	-4.6	4
-2.9	-3.3	-1.4	-1.1	0.8	3.2	1.7	0.7	-3.0	-3.7	5
-3.7	-1.4	-4.0	-1.2	-0.9	1.4	2.8	-0.6	-1.9	-4.7	6
-1.9	-2.6	-1.1	-2.1	0.7	2.7	1.9	0.6	-2.9	-3.0	7
-2.4	-0.5	-1.0	0.8	1.1	2.3	2.1	-0.6	-2.0	-3.6	8
0.6	-1.0	1.0	0.4	5.8	5.6	1.6	2.8	-1.1	-1.1	9
-0.1	-1.2	0.3	0.5	2.8	3.6	0.9	0.8	-1.4	-2.7	10
-2.1	-0.6	-1.4	-1.0	0.4	1.6	2.1	-1.7	-3.6	-4.4	11
-2.3	-1.7	-0.5	-1.5	1.3	2.0	-0.1	-0.3	-4.8	-5.0	12
-2.1	-0.3	-0.6	0.7	2.2	1.9	3.4	0.4	-3.1	-5.1	13
-0.7	-1.4	0.8	-1.1	1.9	4.2	1.7	0.5	-3.0	-3.1	14
-1.6	-0.1	-2.1	1.8	2.6	2.2	2.7	1.0	-0.7	-2.9	15
-1.9	1.3	-0.7	2.4	1.6	3.1	4.5	1.6	-0.6	-4.2	16

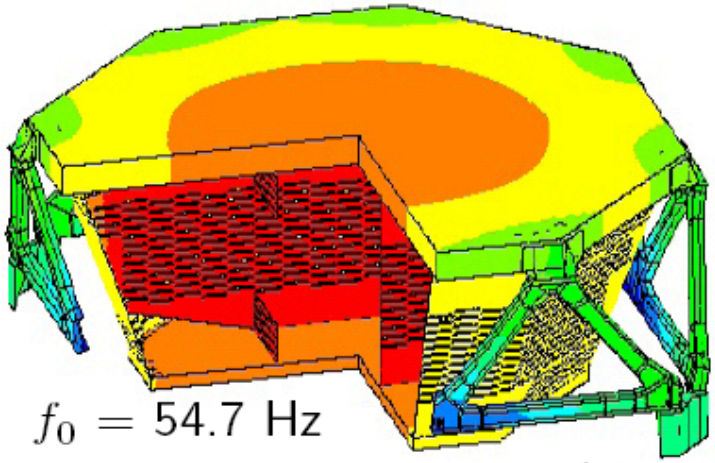




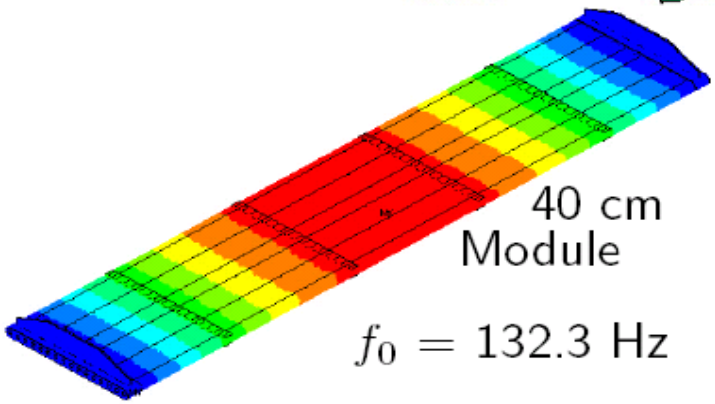
RMS gasgain



AMS-02 TRD: Space Qualification Tests



$f_0 = 54.7$ Hz

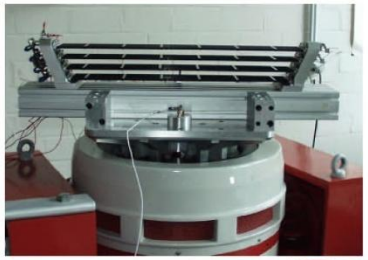


40 cm Module

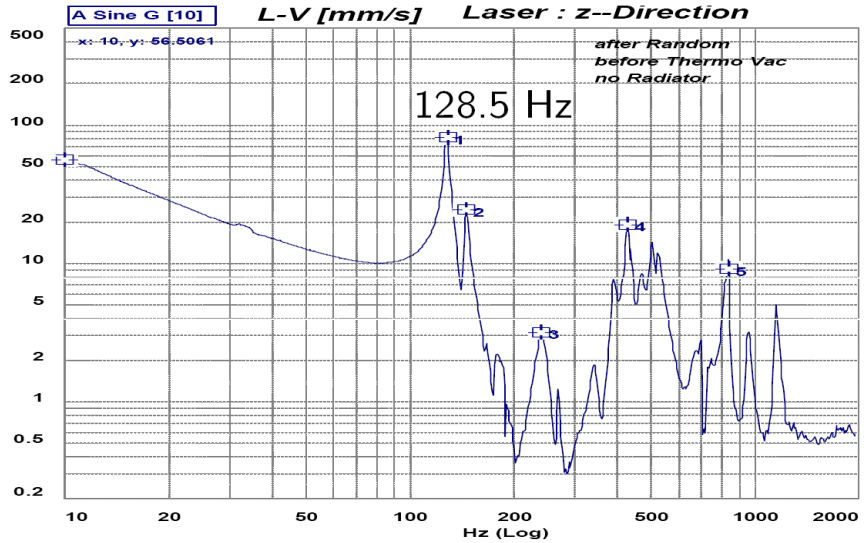
$f_0 = 132.3$ Hz

FEC coupled load modal analysis

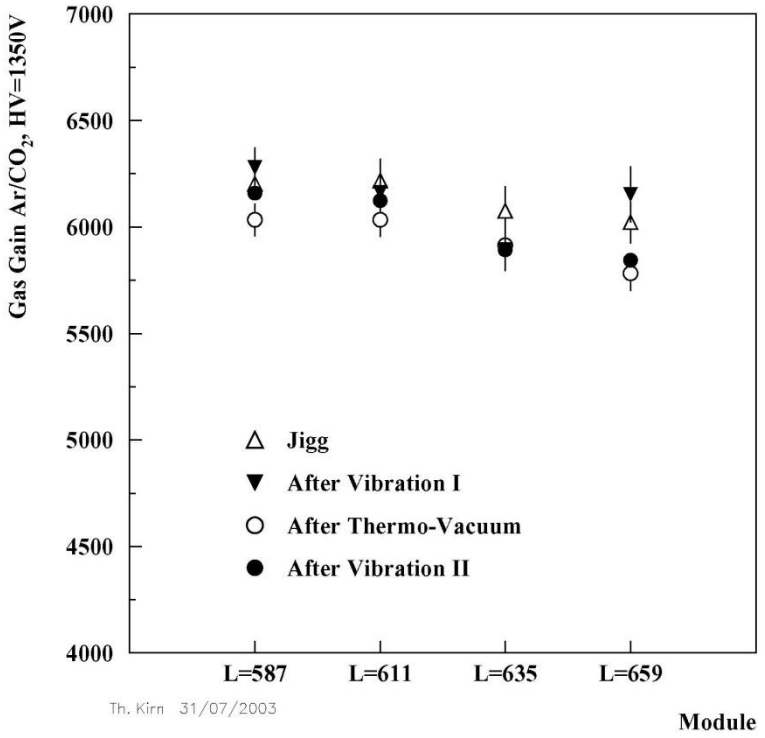
Parameters from static measurements
Verify with component vibration tests

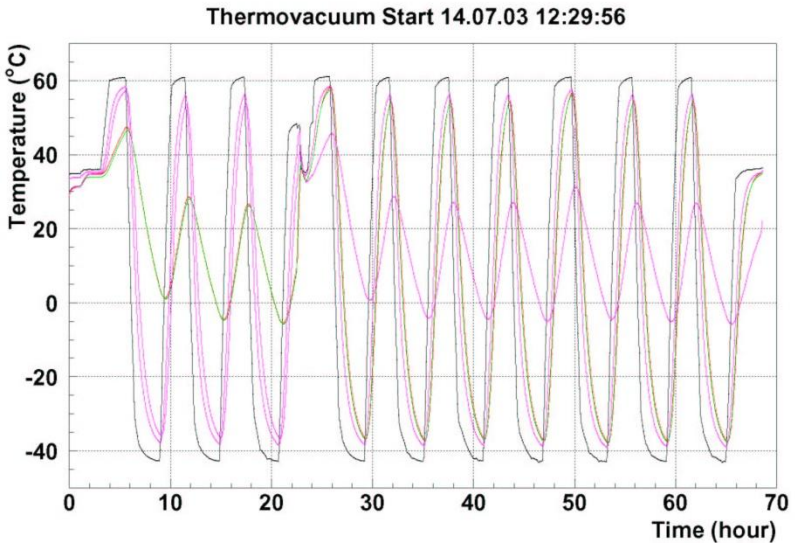


Vibration-Test-Cycle:
- Sine Sweep 0.5g (10-2000Hz)
- Random Spectrum $a_{RMS} = 6.8$g
- Sine Sweep 0.5g (10-2000Hz)



AMS-02 TRD: Space Qualification Tests





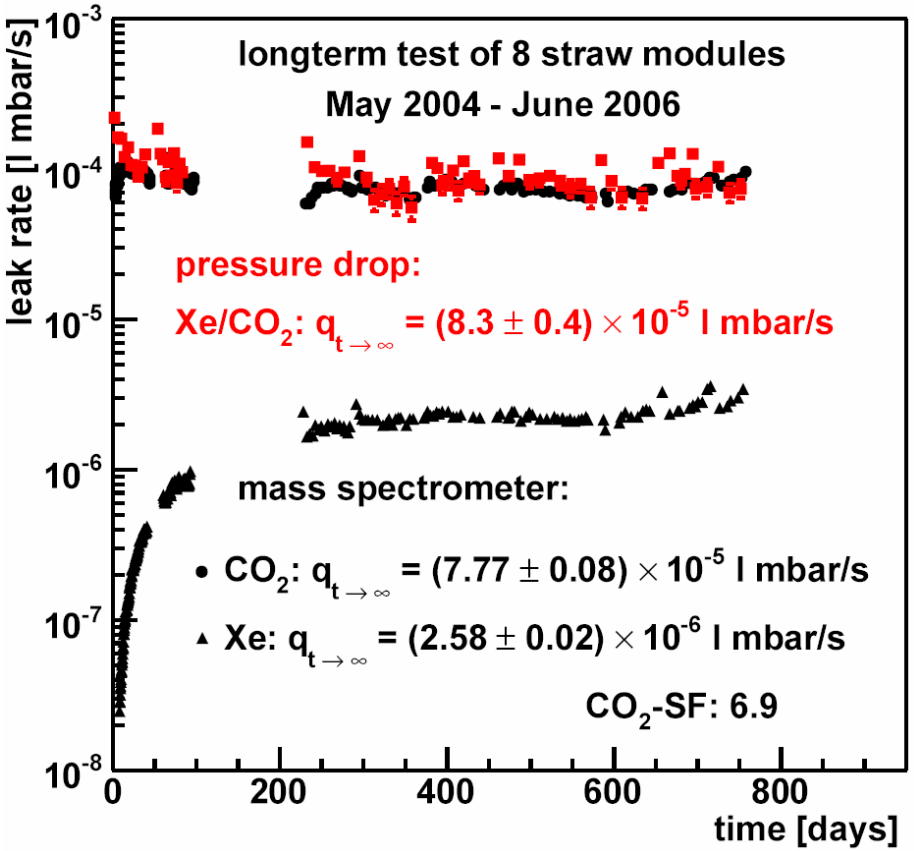
No significant changes in:

- Gasgain
- Gastightness

→ Straw Modules space qualified

AMS-02 TRD: Longterm Tests

Stable Operation for 2 years



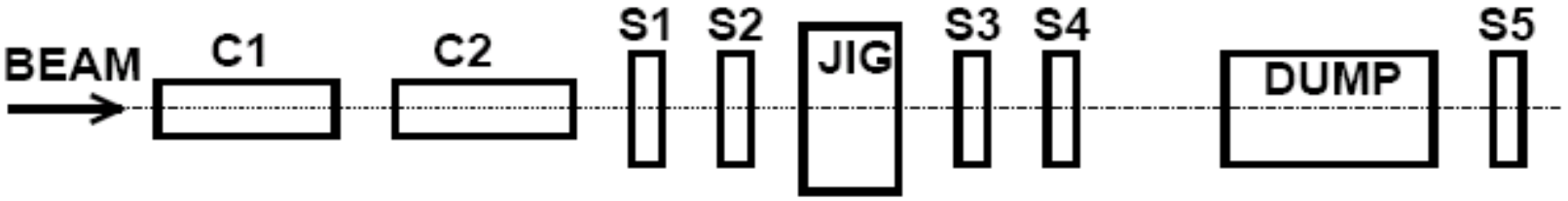
1 Gasgroup → 8 Modules

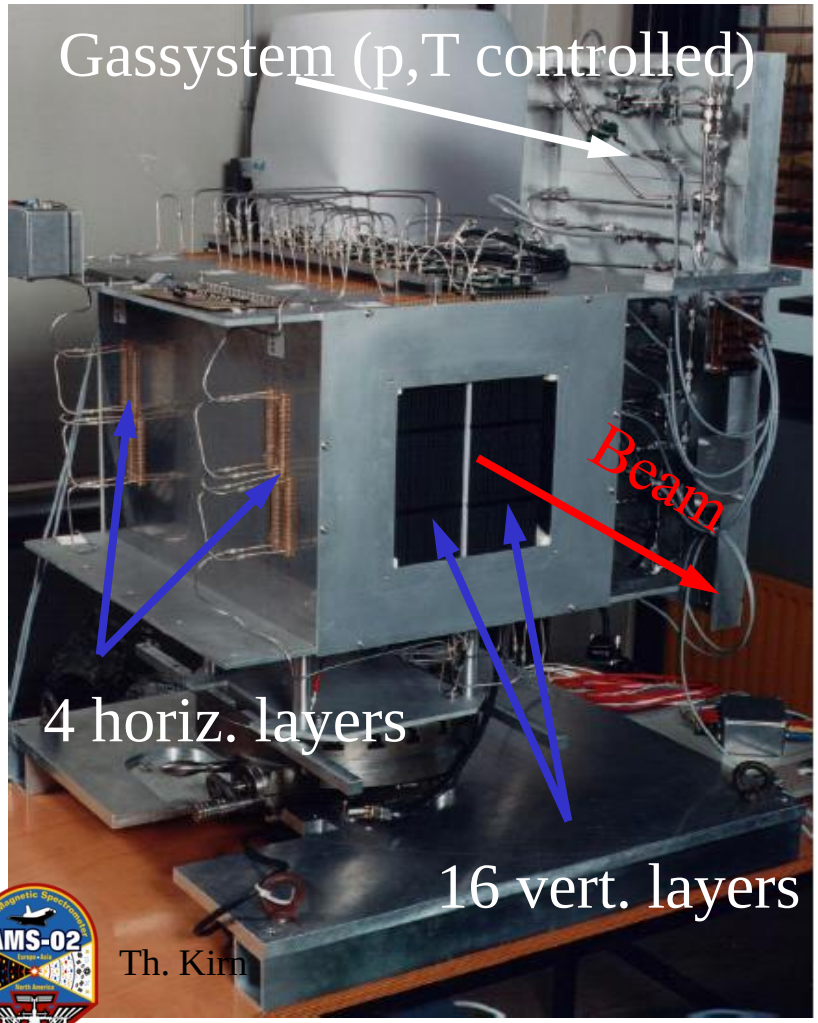
Fe^{55} – Monitoring

Pressure-Drop Measurements

Mass-Spectrometer Measurements

AMS-02 – TRD: Performance, 20 Layer Prototype





Beamtest @ CERN 2000

PS (T9) & SPS (X7, H6):

Recorded events: $3 \cdot 10^6$

Particles: e^-, μ^-, π^+ 10 - 100 GeV

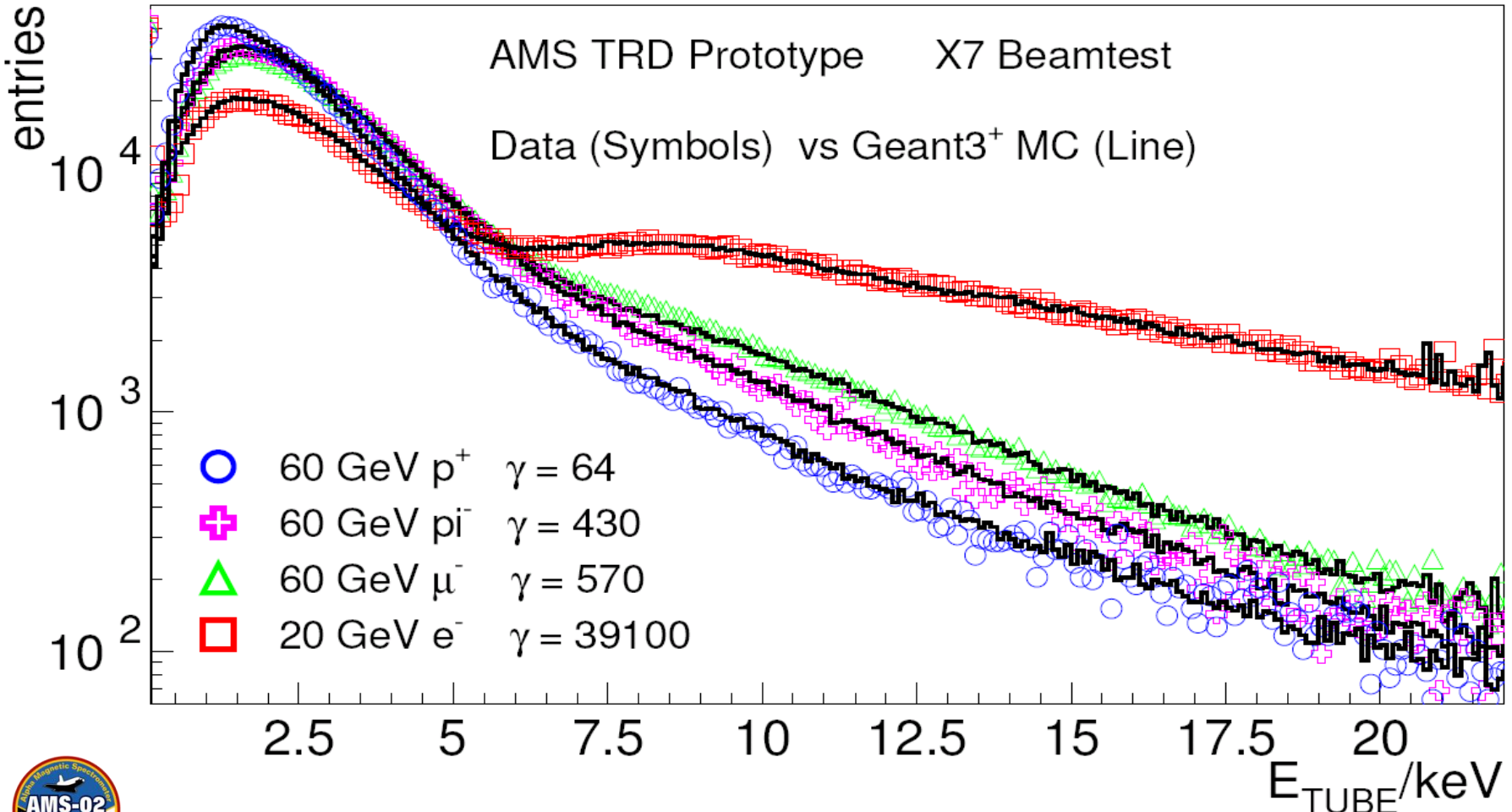
Protons 10 - 250 GeV

AMS-02 – TRD: TRD Spectra with Geant 3$^+$ MC

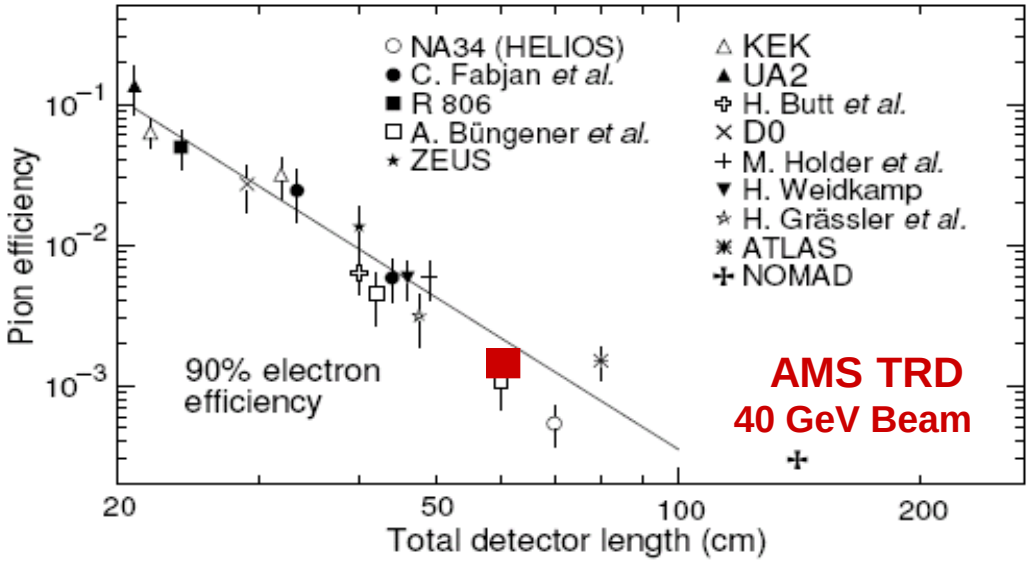
dE/dX in thin gas-layers V. Ermilova, NIM A **145** (1977) 555

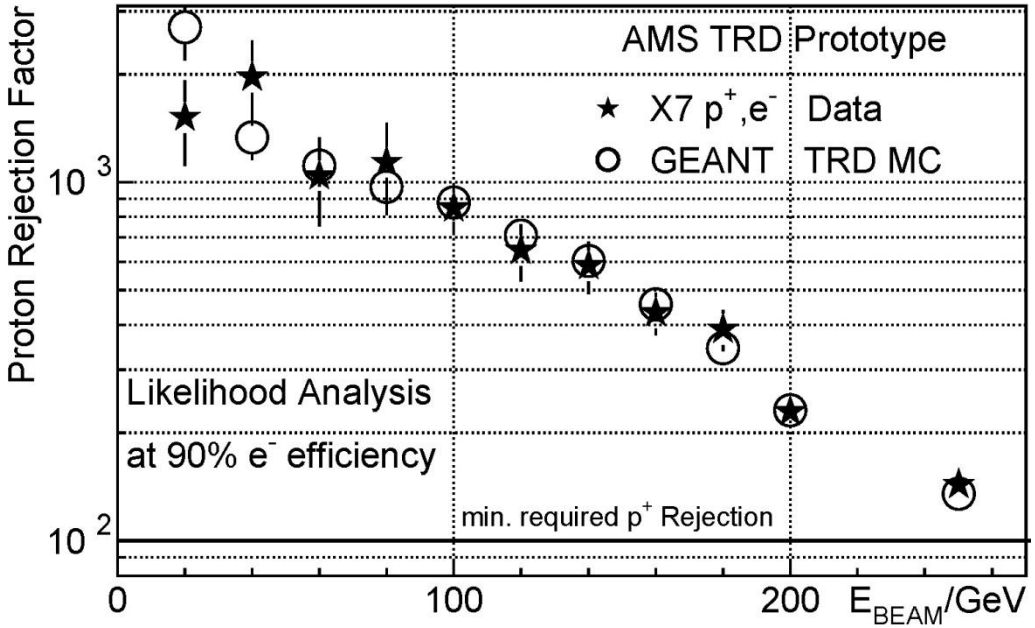
TR gener. and absorp. M. Cherry, Phys.Rev.Lett. D **10** (1974) 3594

Implement. V. Saveliev (HERA-B) G.M. Garibian, NIM A **125** (1975) 133

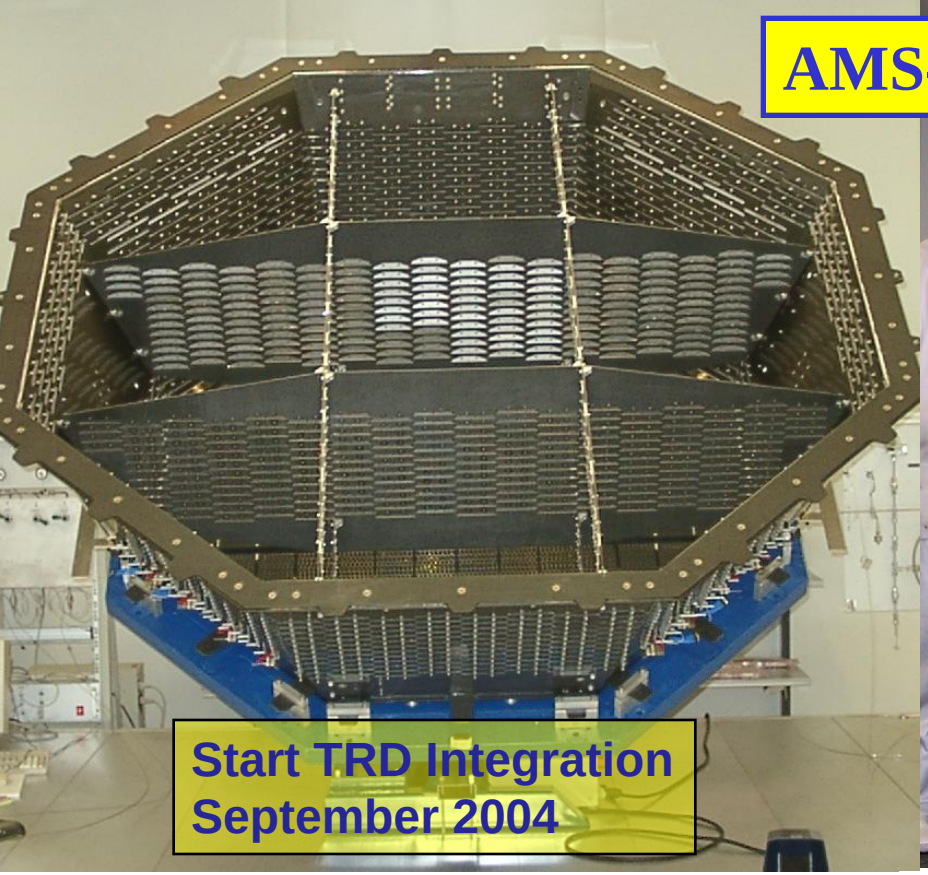


AMS-02 – TRD: Performance, 20 Layer Prototype



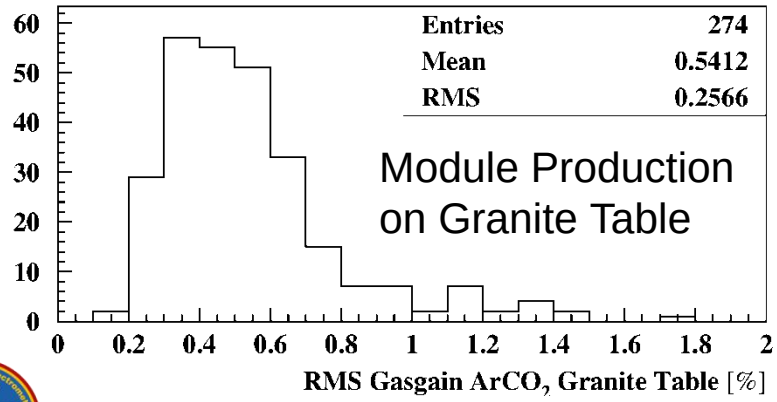


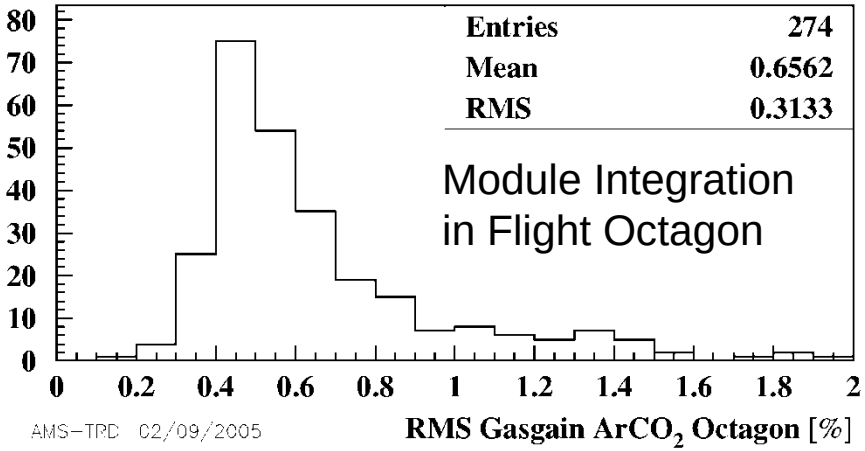
AMS-02 – TRD



Start TRD Integration
September 2004

End TRD Module Integration
October 2005

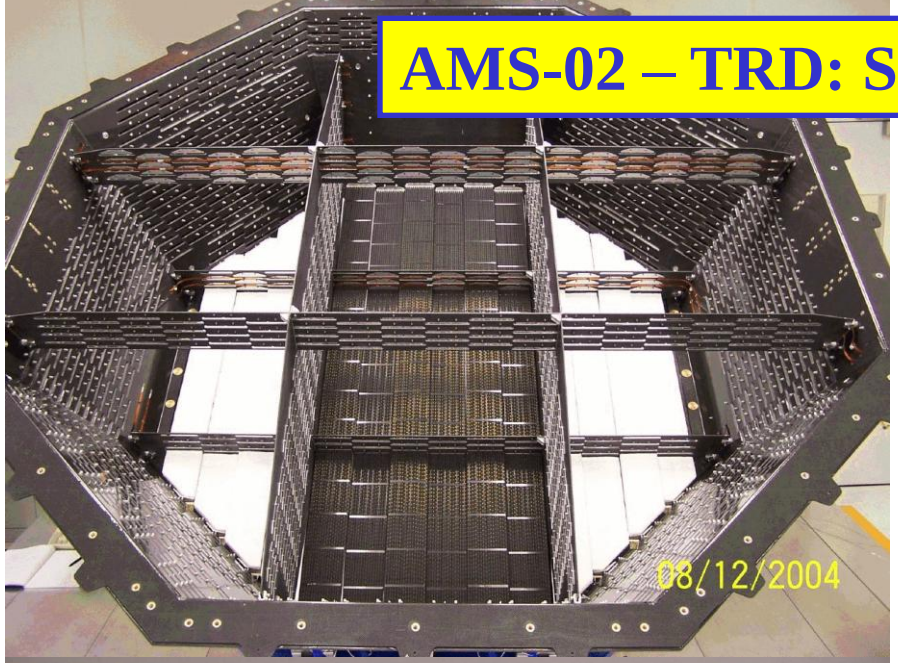


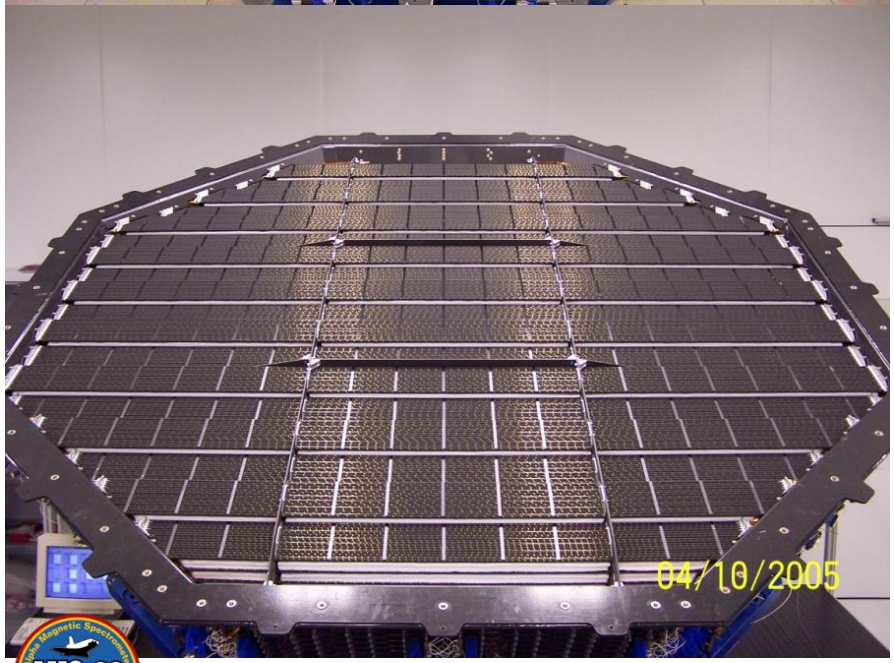


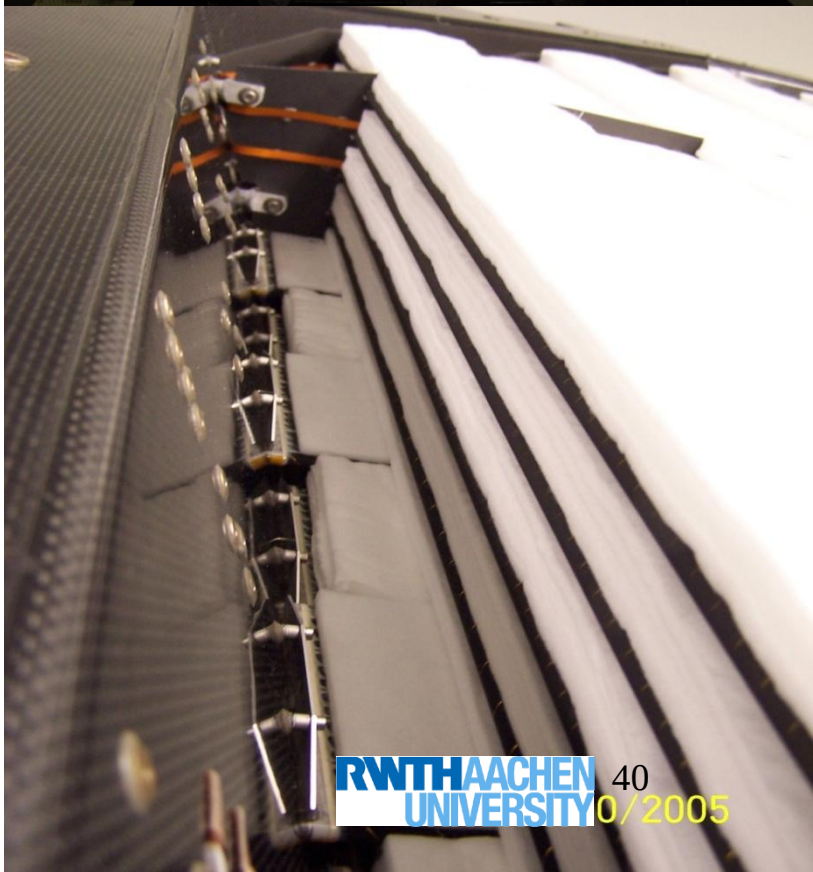
Th. Kirn

UNIVERSITY

AMS-02 – TRD: Straw Module Integration



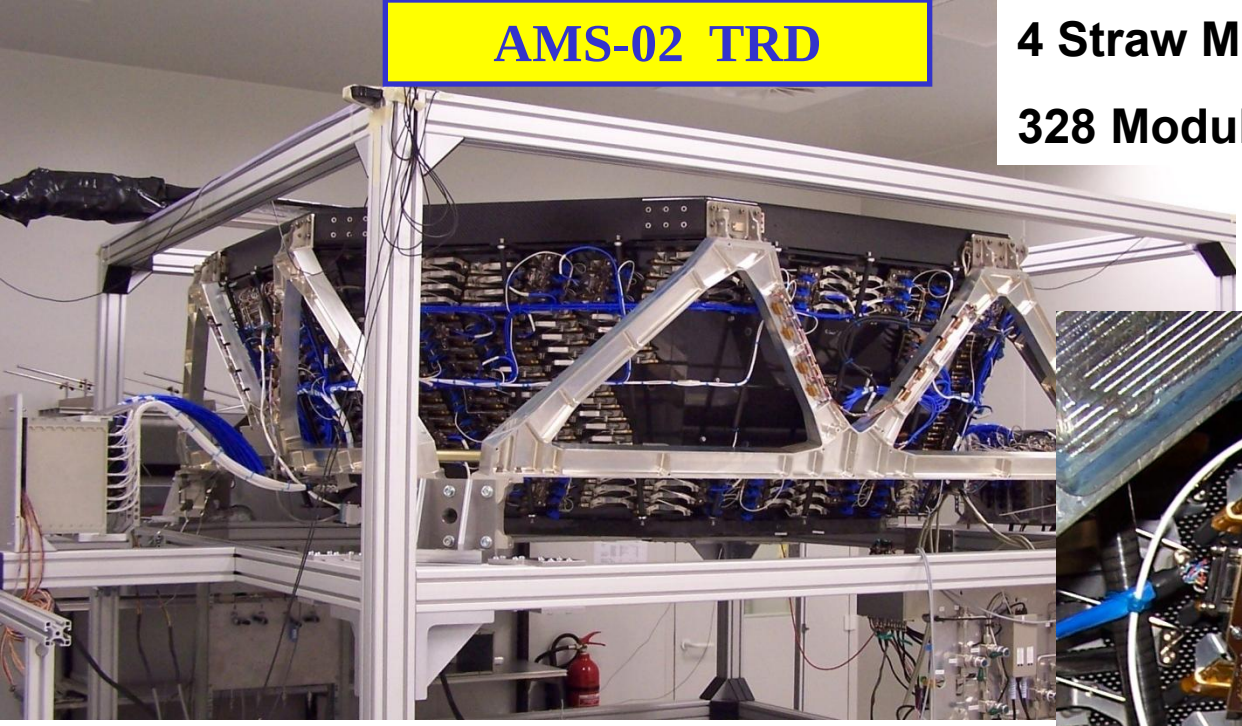


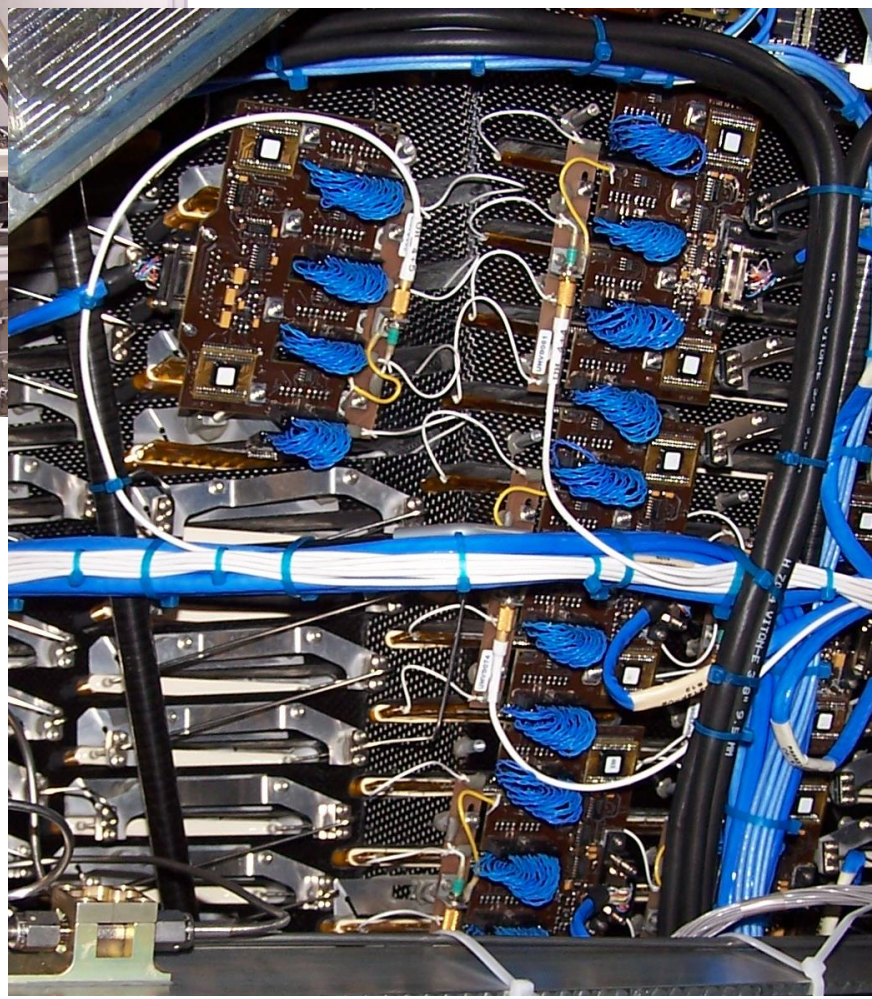


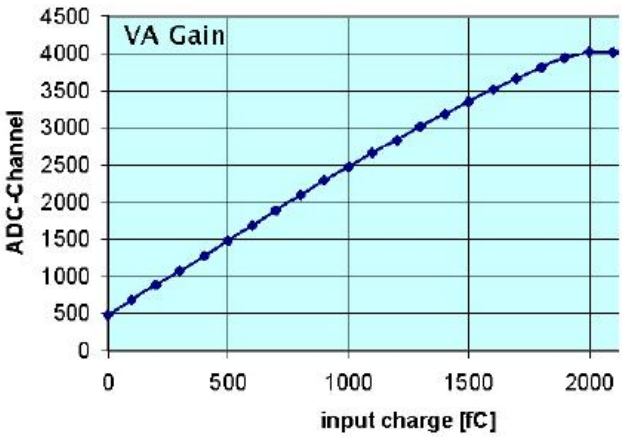
AMS-02 TRD

4 Straw Modules → 1 Readout Group

328 Modules → 82 Readout Groups



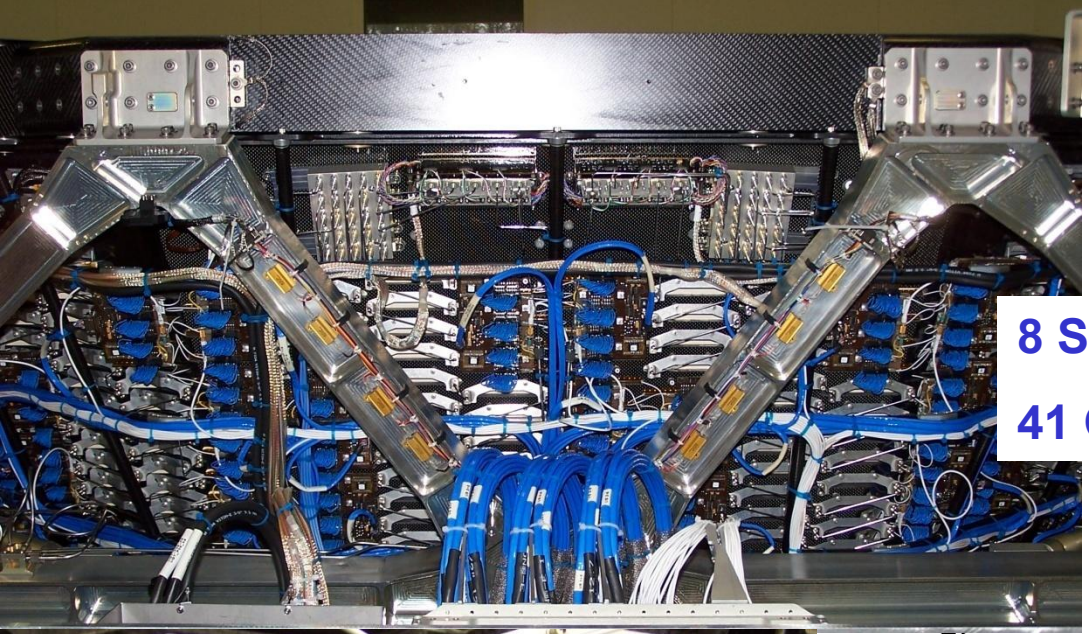




Power: 20W/5248 Channels

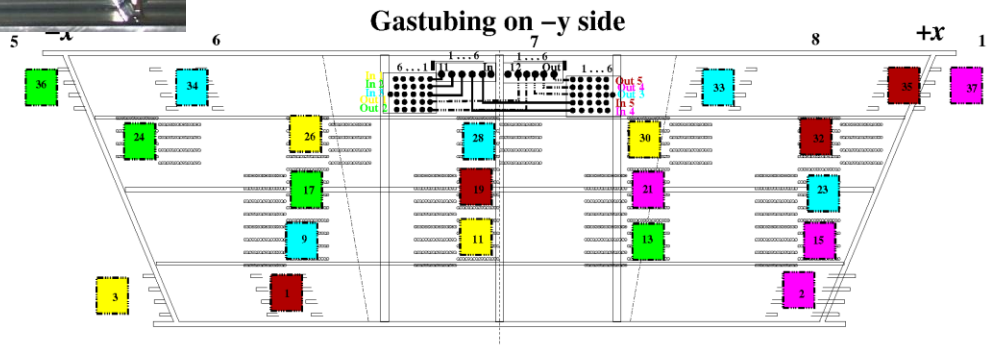
MIP MOP (G=3000)	30 fC 60 bins
MIP S/N	> 60/2
Range	60 MIPs

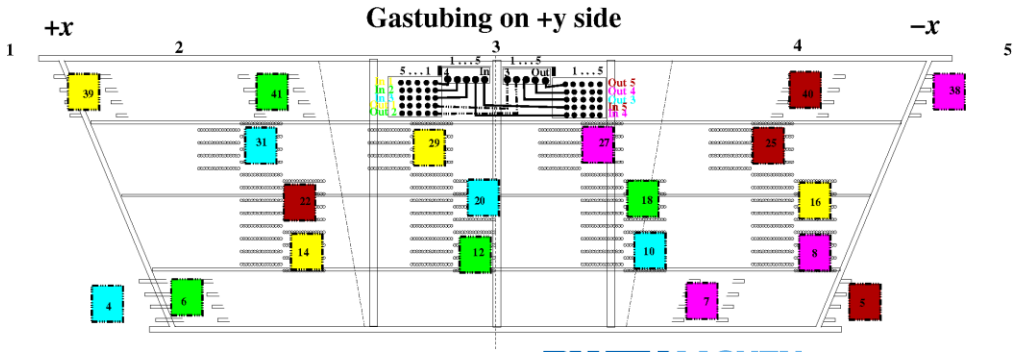
AMS-02 TRD



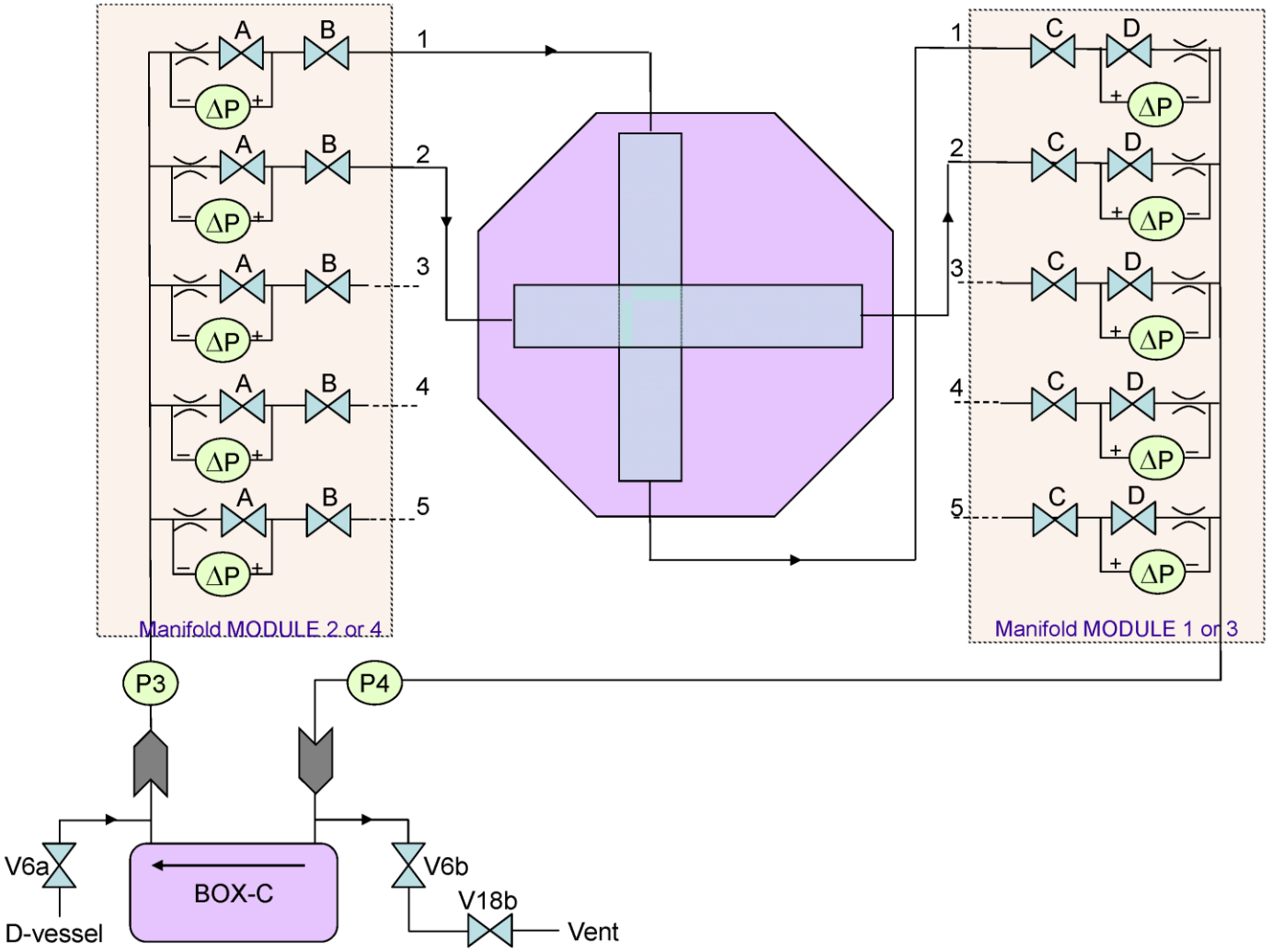
8 Straw Modules → 1 Gas Tower

41 Gas Towers → 10 Gas Circuits

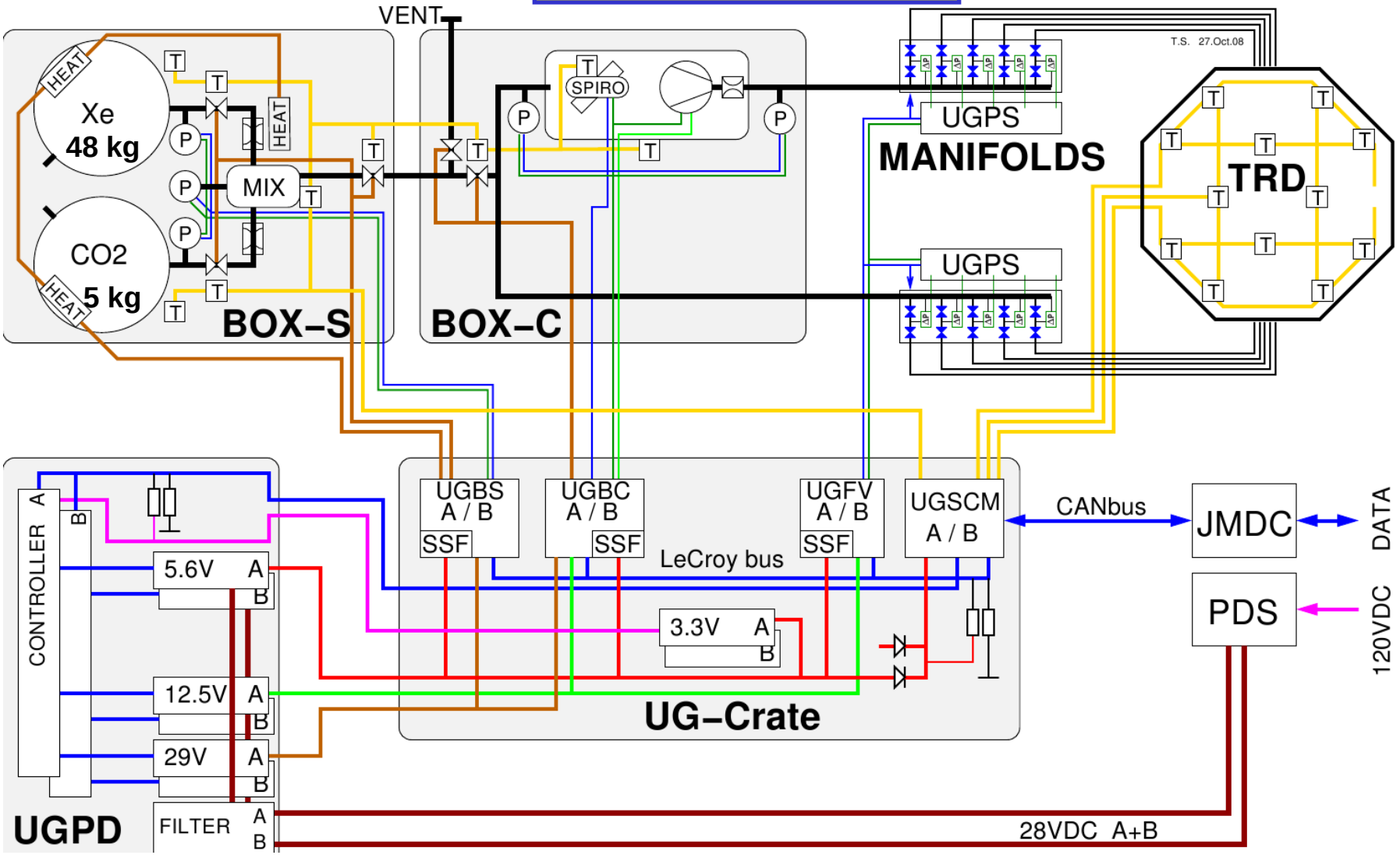




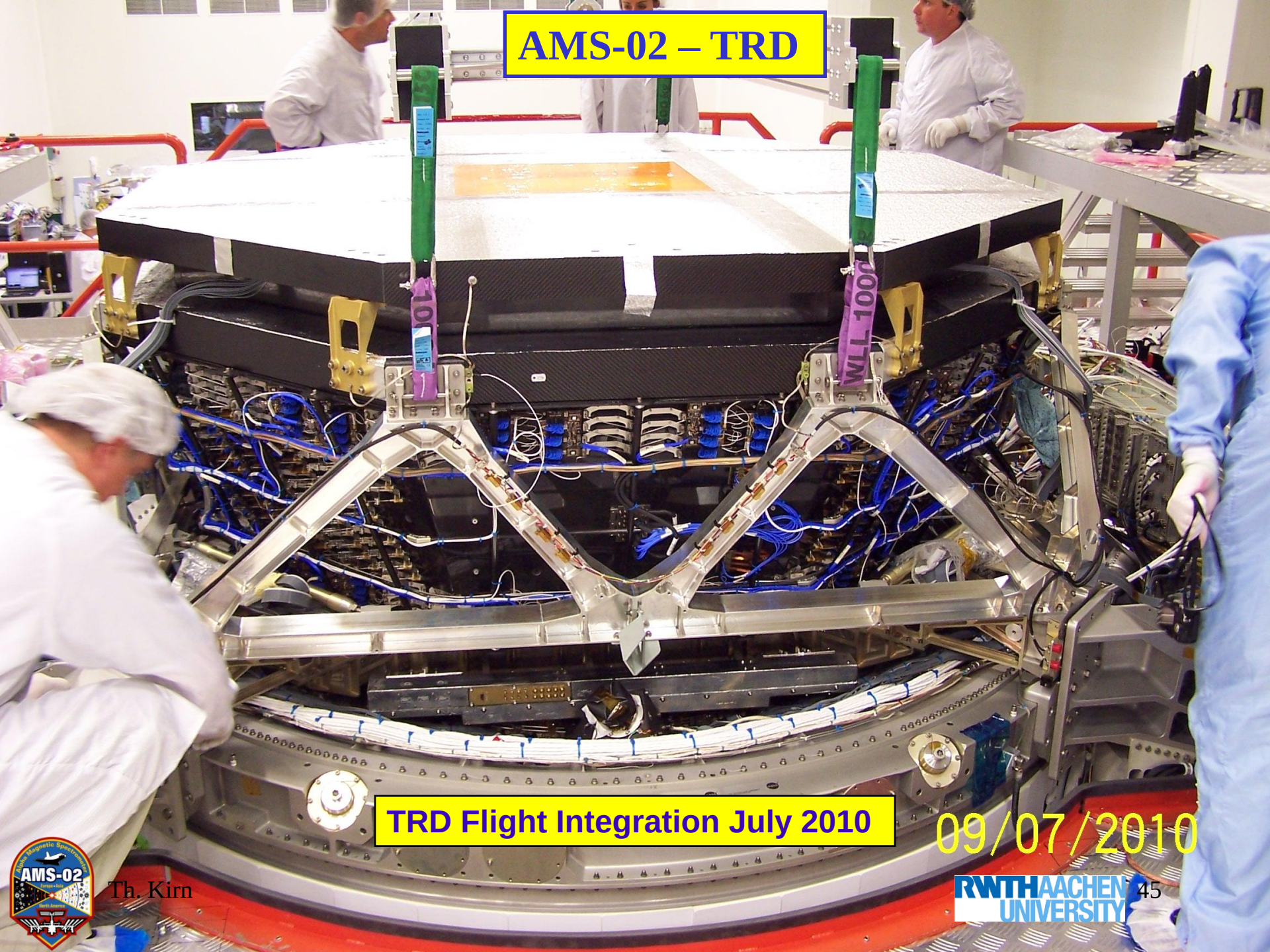
AMS-02 TRD Gassystem



AMS-02 TRD


VENT
HEAT
Xe
48 kg
CO2
5 kg
HEAT
MIX
HEAT
BOX–S
SPIRO
BOX–C
T.S. 27.Oct.08
UGPS
MANIFOLDS
UGPS
TRD
UGBS
A / B
SSF
UGBC
A / B
SSF
LeCroy bus
UGFV
A / B
SSF
UGSCM
A / B
CANbus
JMDC
DATA
PDS
120VDC
CONTROLLER
5.6V
12.5V
29V
FILTER
3.3V
UG–Crate
UGPD
28VDC A+B

AMS-02 – TRD



TRD Flight Integration July 2010

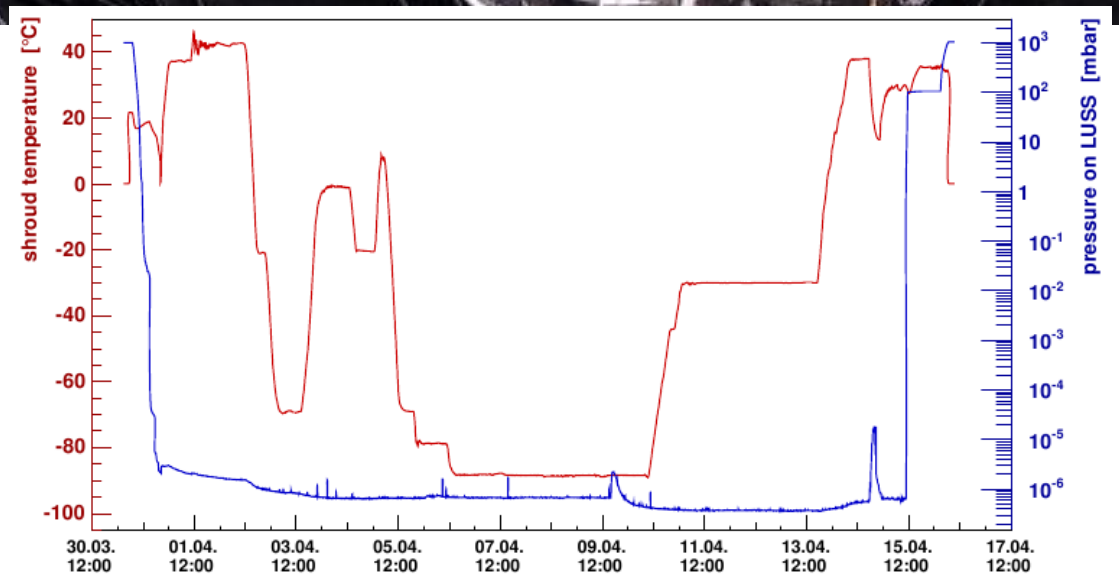
09/07/2010

AMS-02
Space Qualification Tests

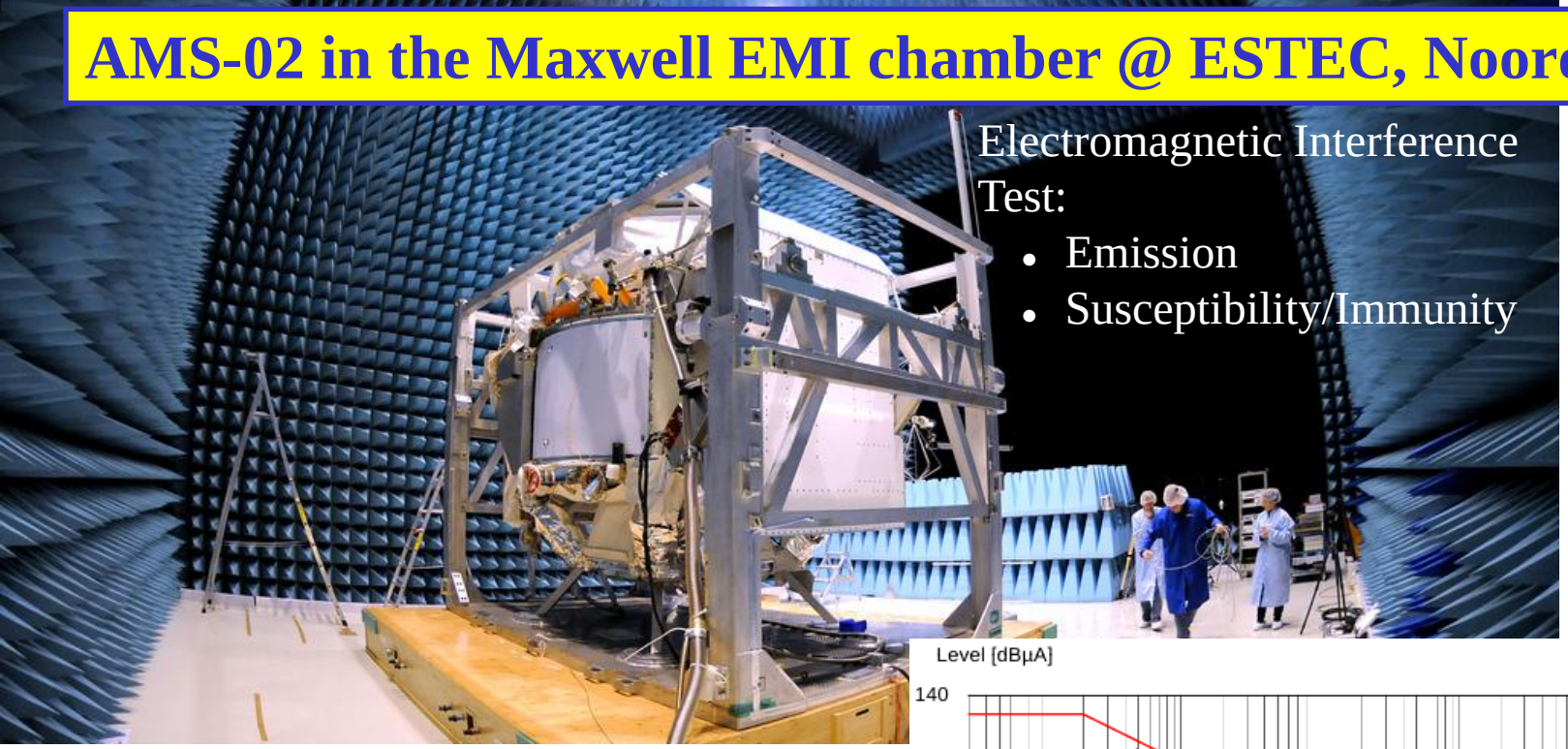
AMS-02 Transport

CERN – ESTEC 12. Februar 2010

AMS-02 in Thermal Vacuum Chamber @ ESTEC, Noordwijk



AMS-02 in the Maxwell EMI chamber @ ESTEC, Noordwijk

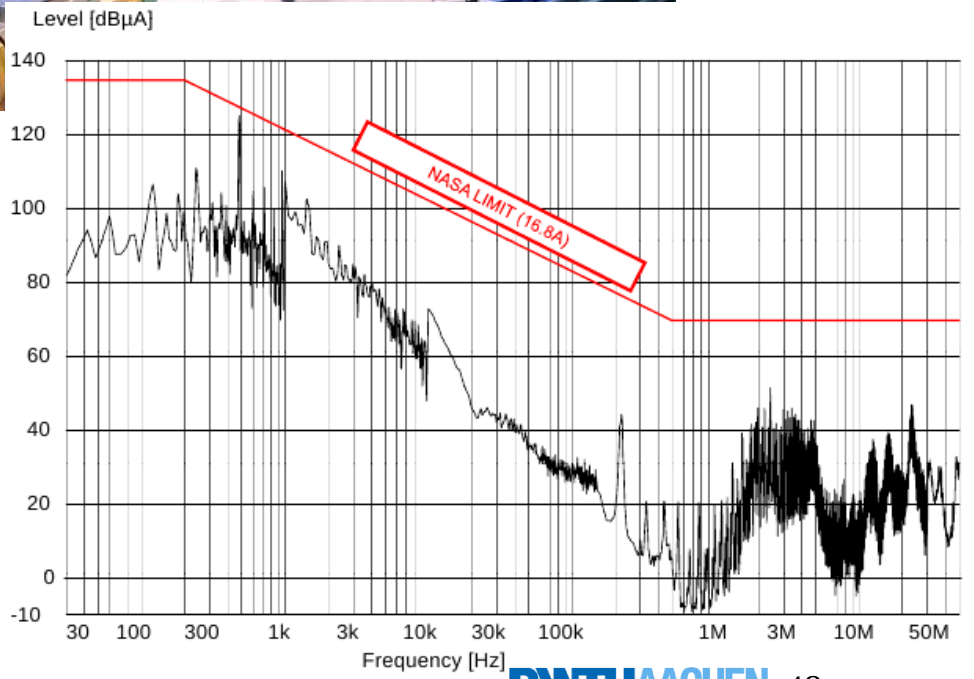


Electromagnetic Interference Test:

- Emission
- Susceptibility/Immunity

EMI emission profile:

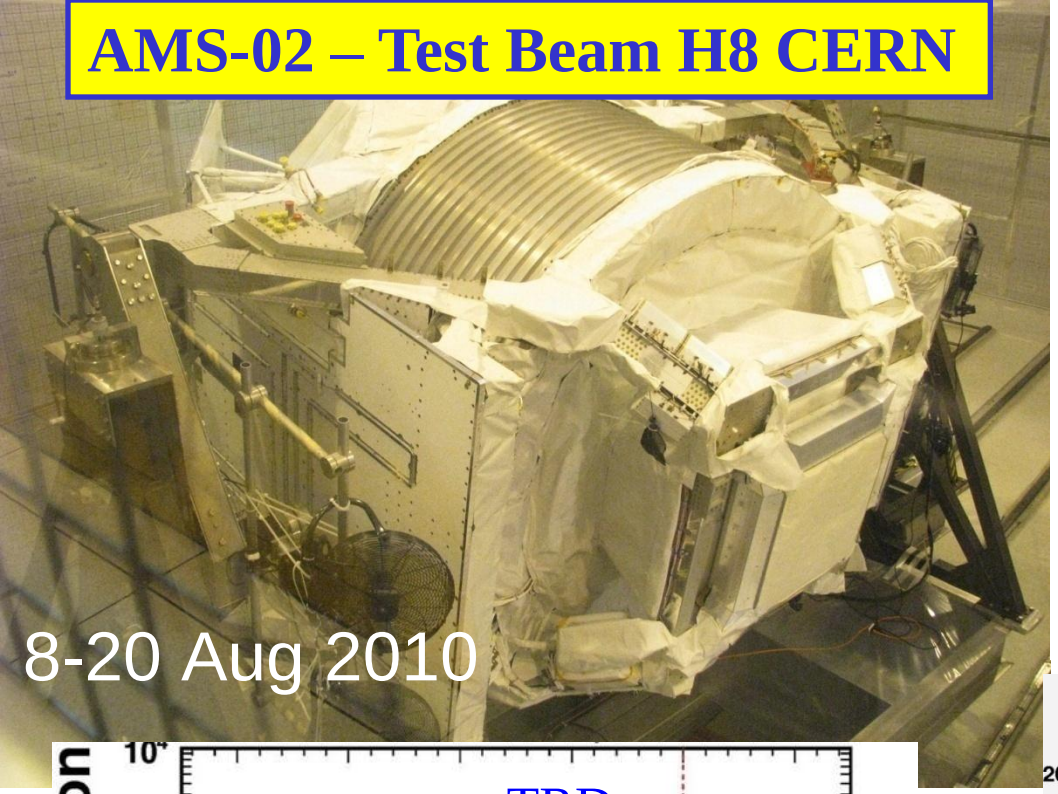
- Range 30 Hz – 50 MHz
- Limit set by Nasa not exceeded

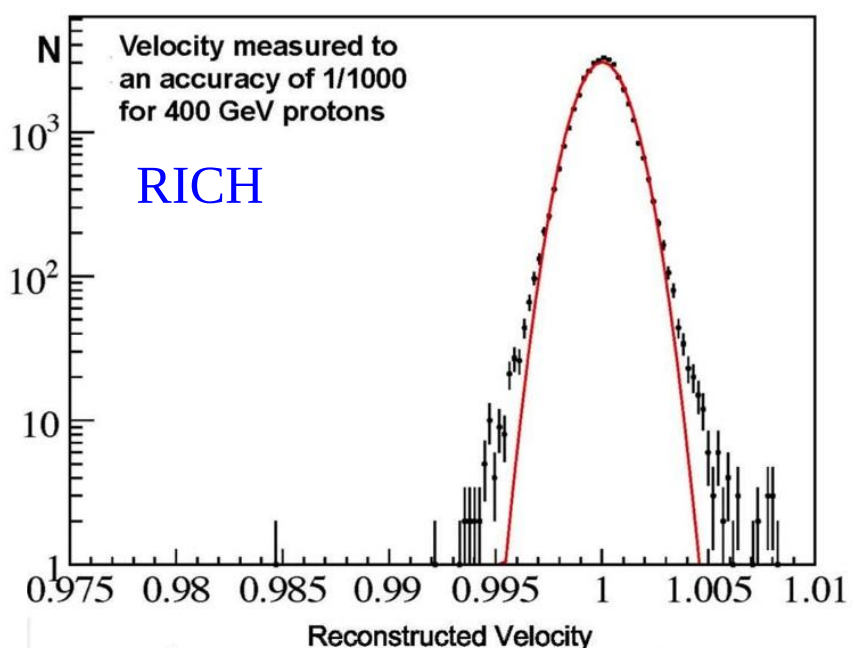


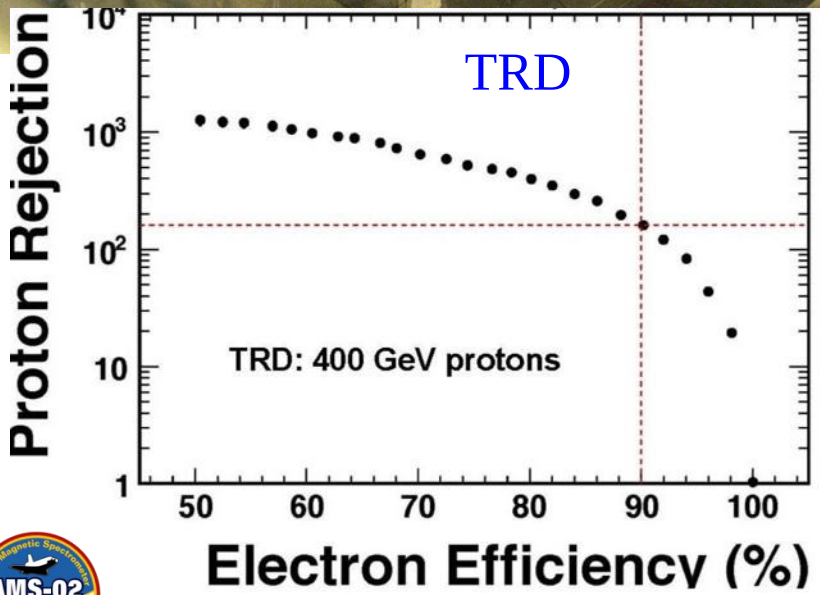
EMI susceptibility (not shown):

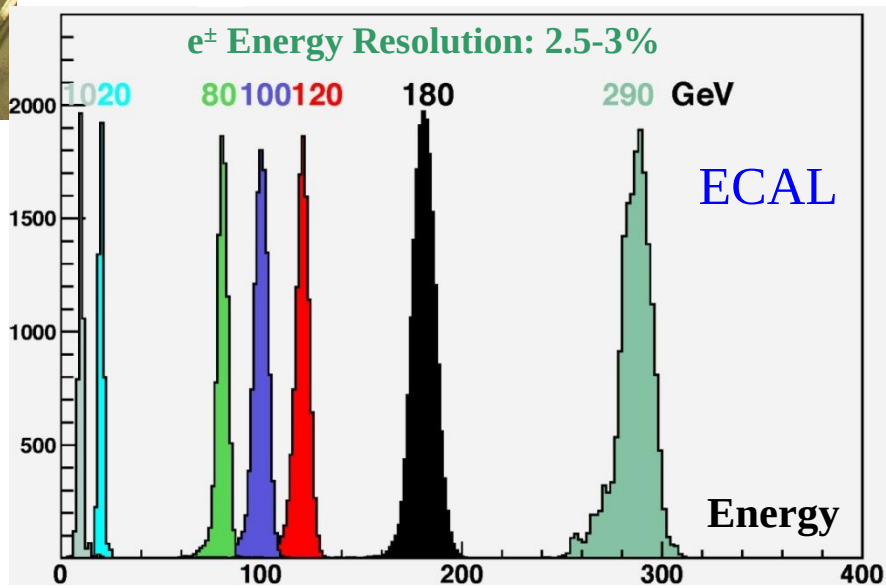
- Interference at 80 MHz (TDCs)
- No major issues

AMS-02 – Test Beam H8 CERN



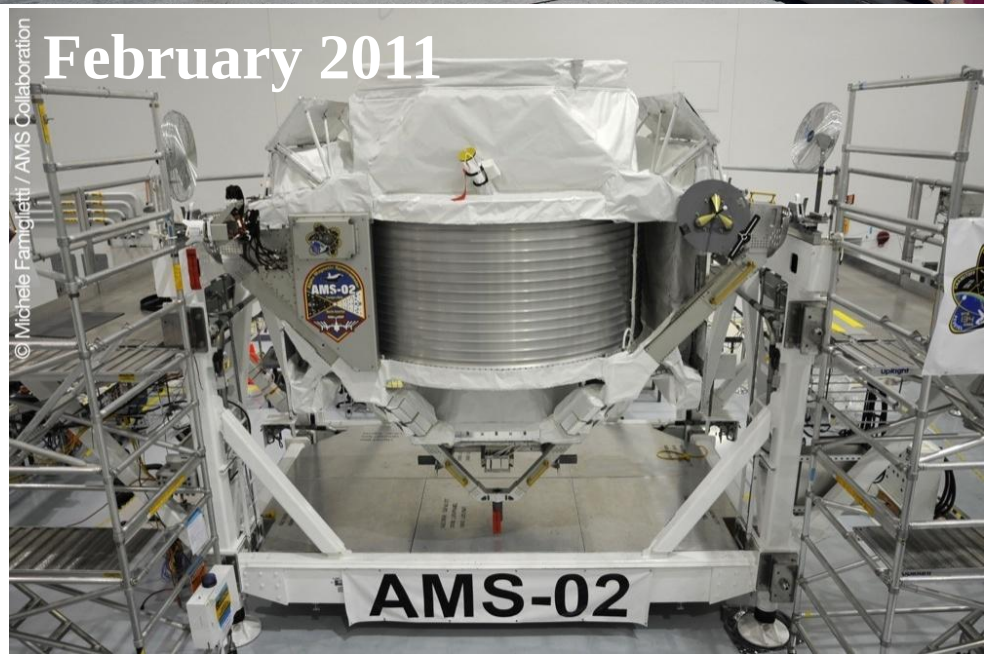






AMS-02 Transport CERN to KSC

Arrival of US Air Force C5 Galaxy at Geneva – 25 Aug 2010

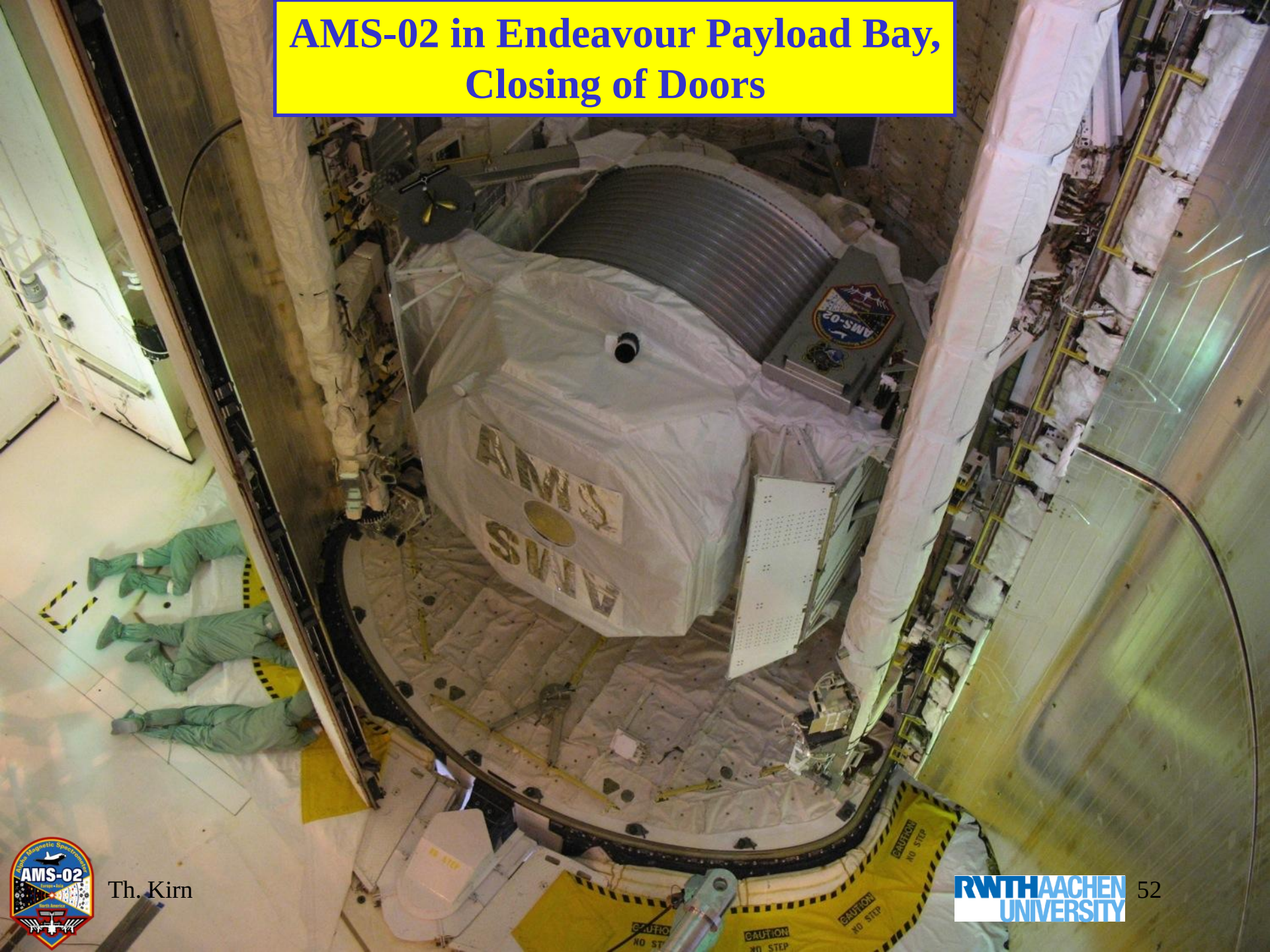


AMS-02 in the Space Station Processing Facility (SSPF), ready for installation into the Space Shuttle

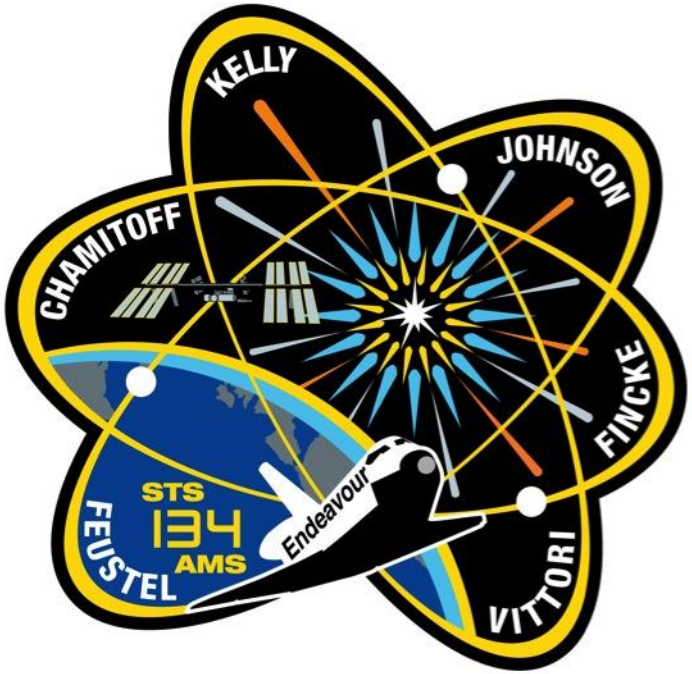
Extended data taking periods to verify detector performance

AMS-02 @ Launch Pad

AMS-02 in Endeavour Payload Bay, Closing of Doors

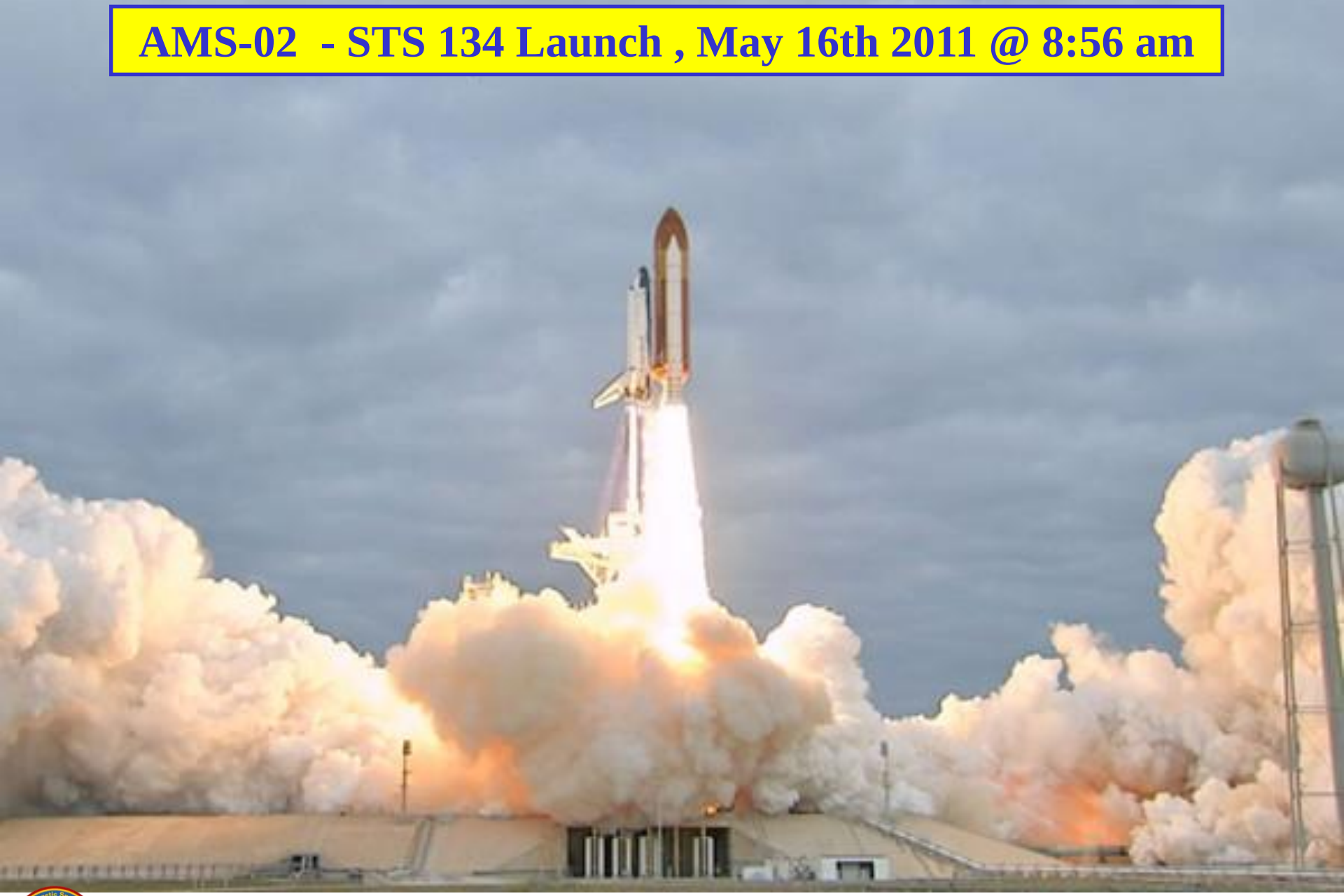


AMS-02 - STS 134 Launch Countdown



The STS-134 crew leaves the Operations & Checkout building on their way to the Launch Pad, May 16, 2011

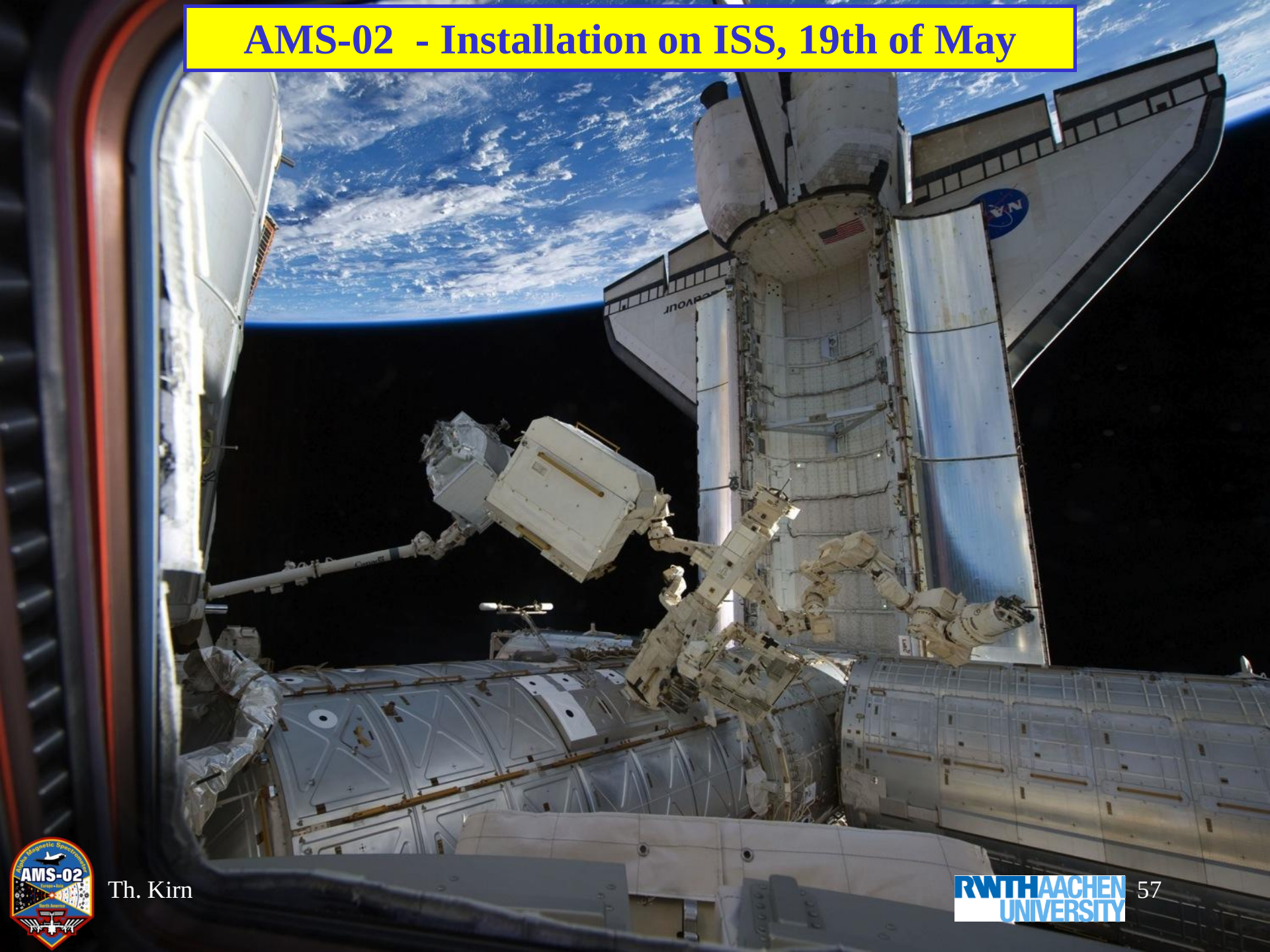
AMS-02 - STS 134 Launch , May 16th 2011 @ 8:56 am



AMS-02 - STS 134 approaches ISS

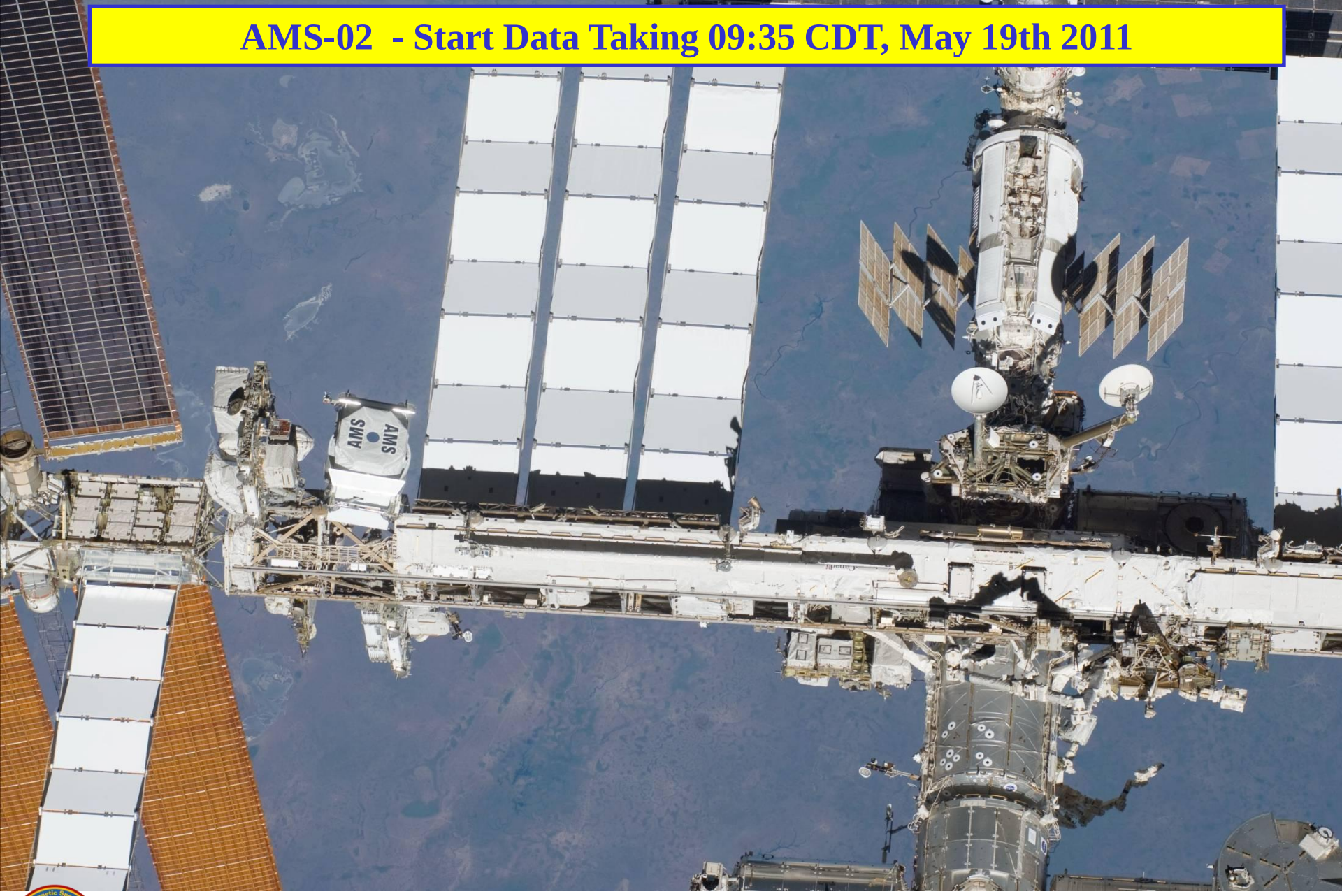
AMS-02 - Installation on ISS, 19th of May

AMS-02 - Installation on ISS, 19th of May

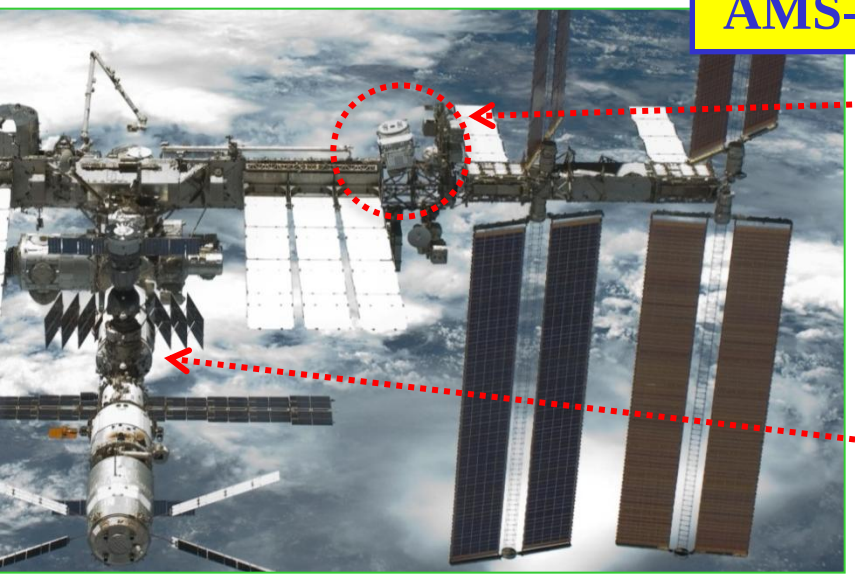


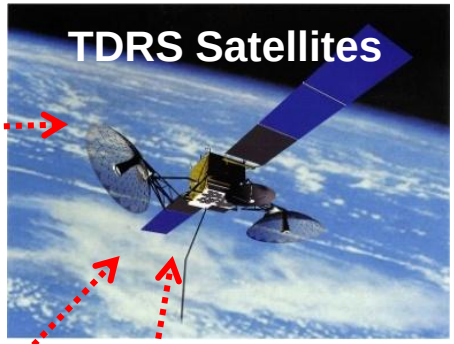
AMS-02 - Installation on ISS Truss at 05:15 CDT, May 19th 2011

AMS-02 - Start Data Taking 09:35 CDT, May 19th 2011



AMS-02 - Operations





Ku-Band
High Rate (down):
Events <10Mbit/s>

Flight Operations

Ground Operations

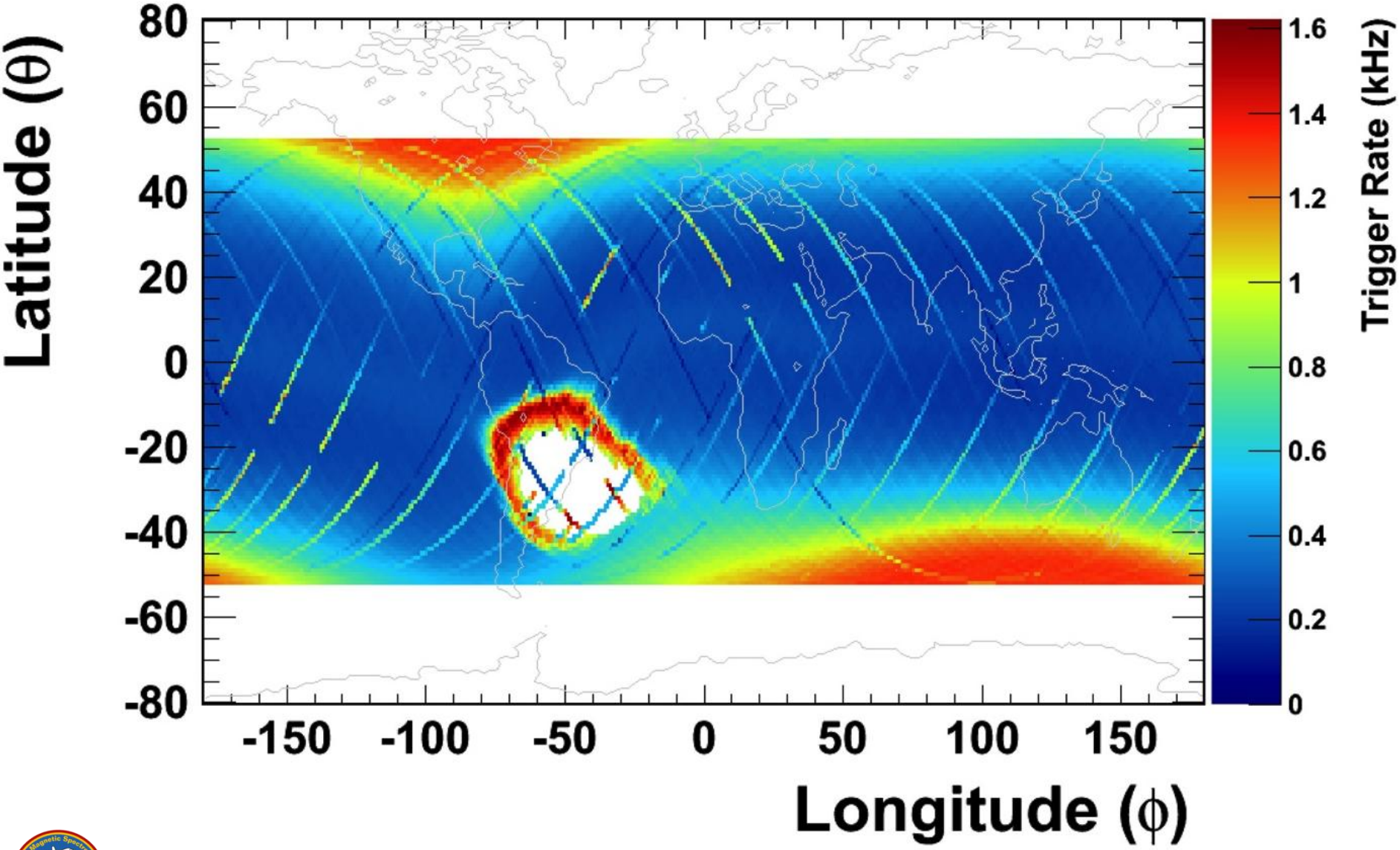
S-Band
Low Rate (up & down):
Commanding: 1 Kbit/s
Monitoring: 30 Kbit/s

AMS Payload Operations Control and Science Operations Centers (POCC, SOC) at CERN

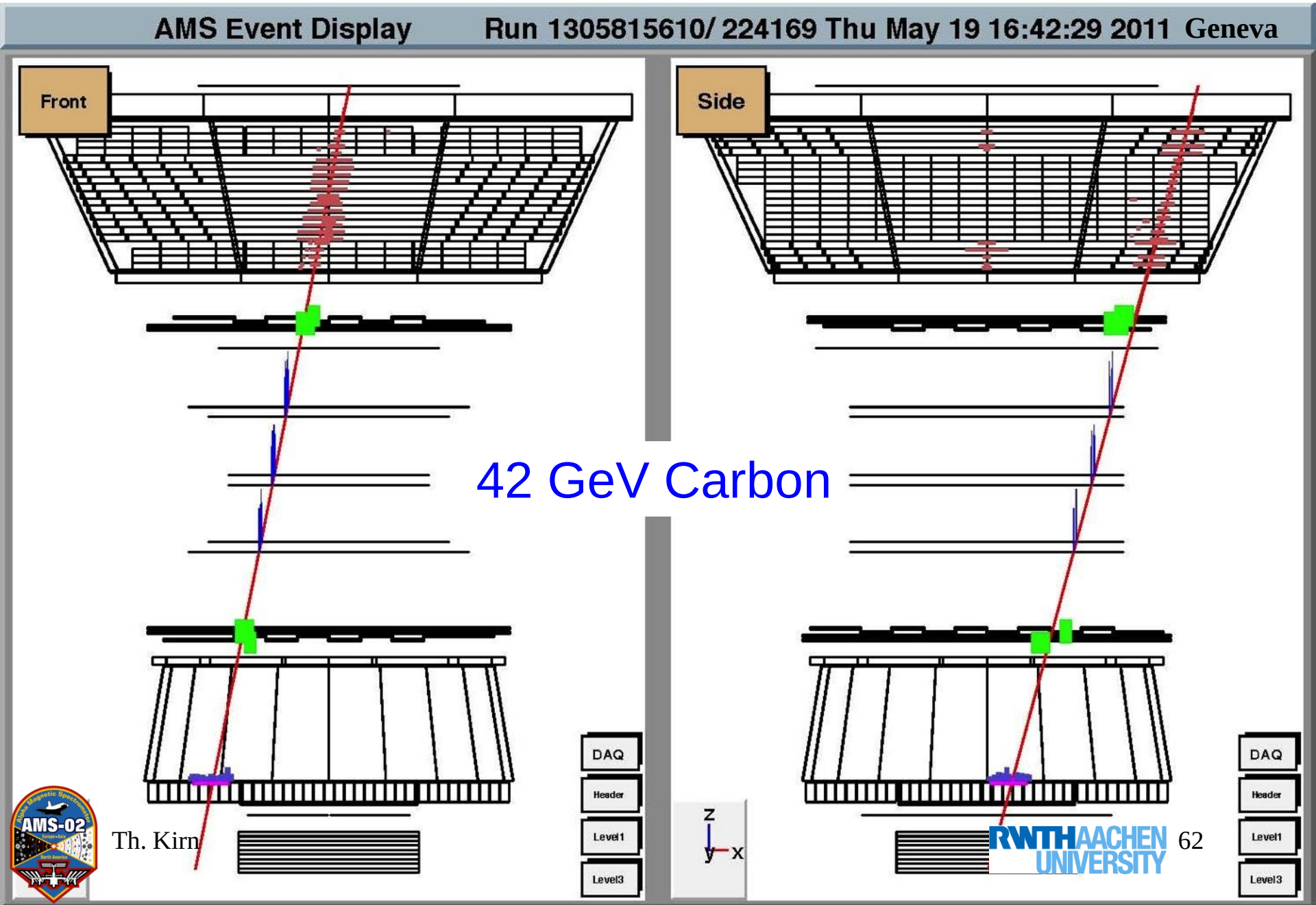
AMS Computers at MSFC, AL

White Sands Ground Terminal, NM

AMS-02 - Trigger Rate



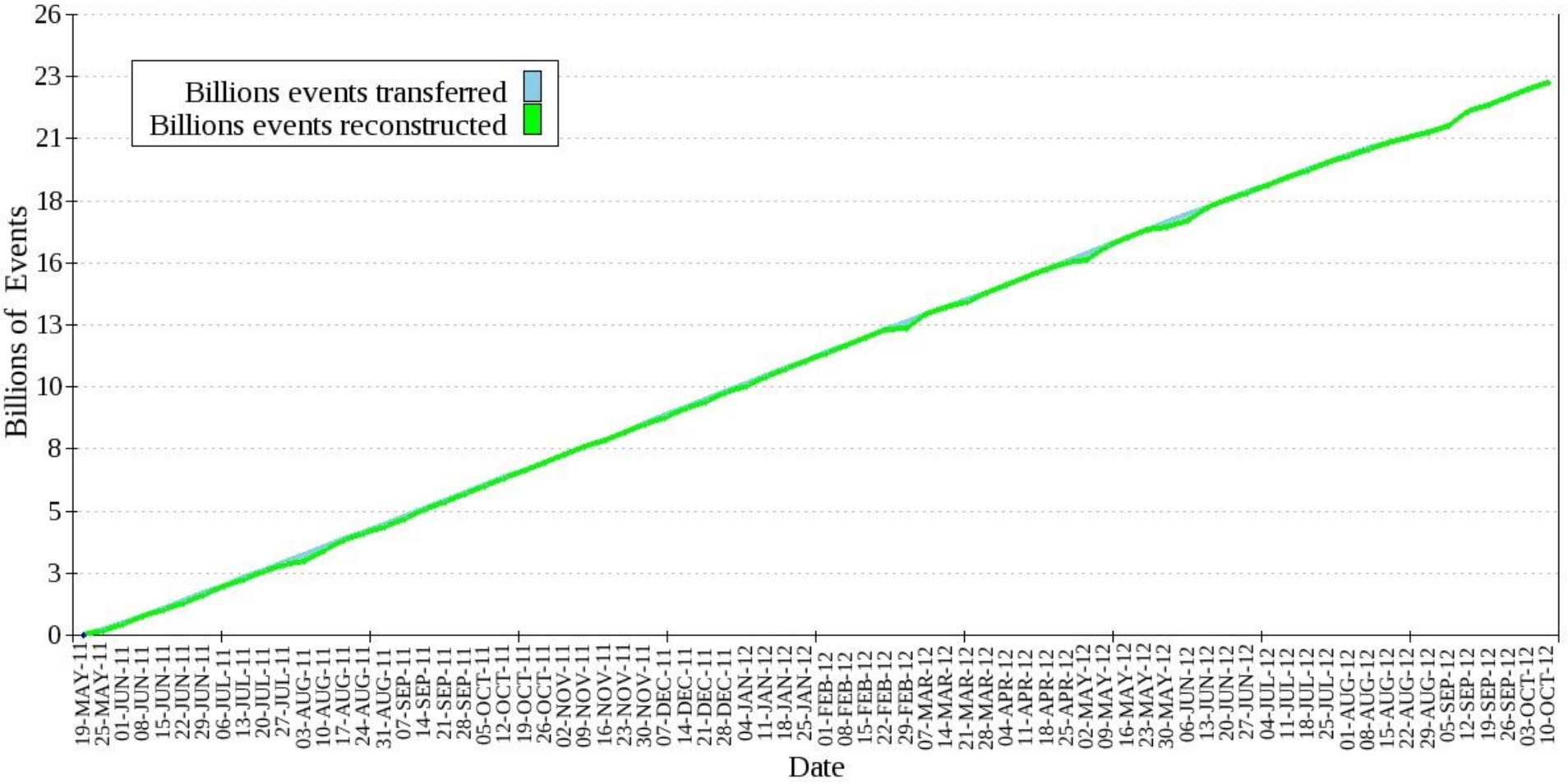
AMS-02 - Start Data Taking 09:35 CDT, May 19th 2011



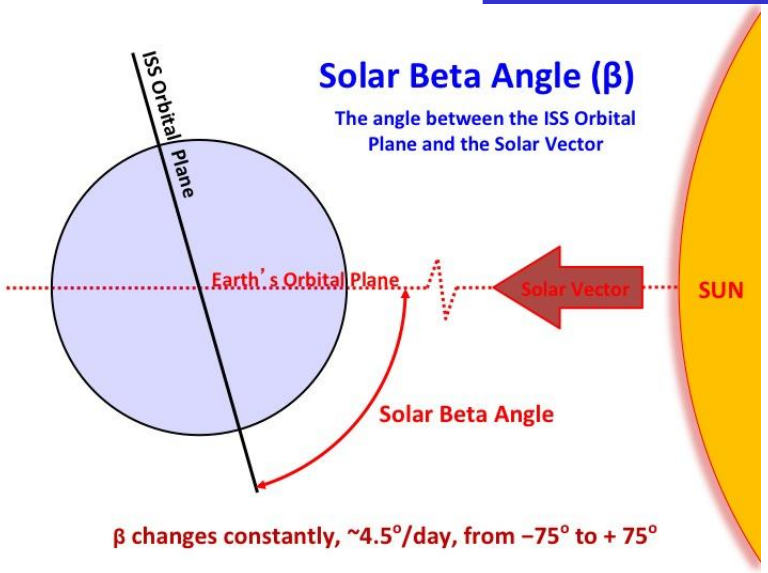
AMS-02 - Performance

http://ams.cern.ch/ProdPlot/plotiss1.php

More than 24 Billion Triggers recorded



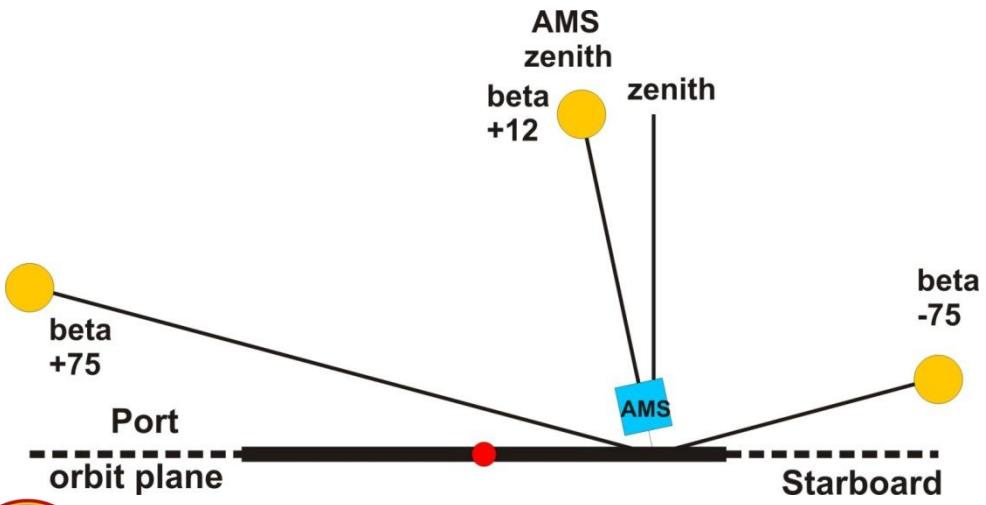
AMS-02 - Thermal Control

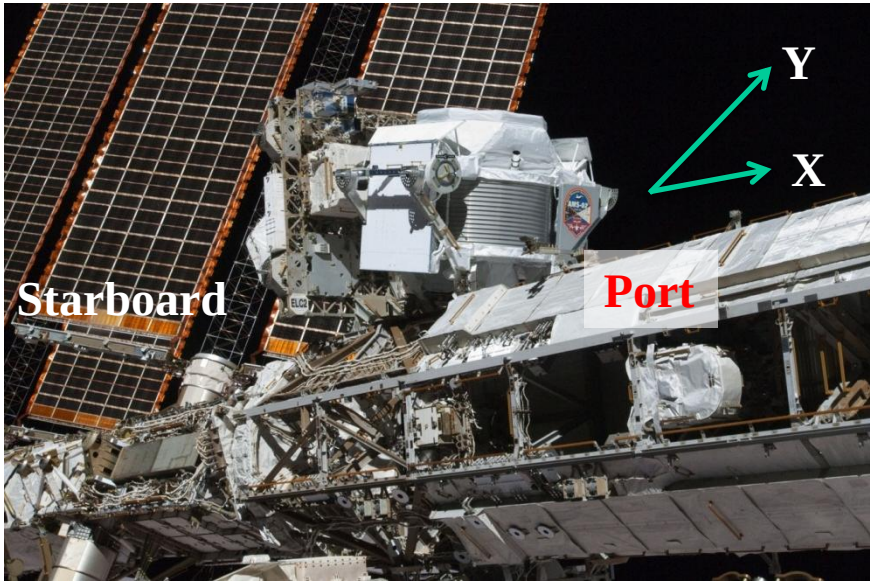


Thermal environment on ISS is constantly changing due to:

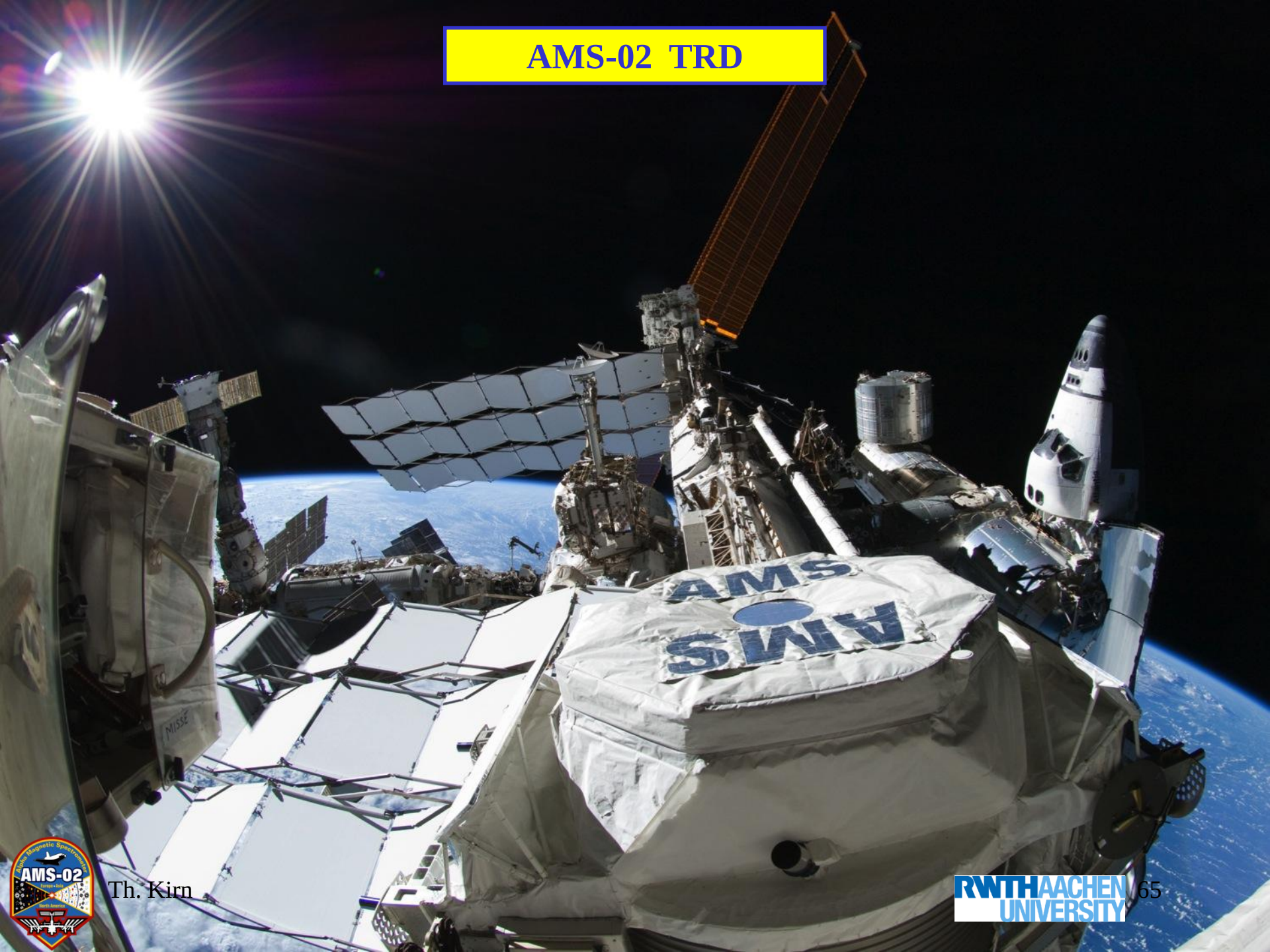
- **Solar Beta Angle (β)**
- **Position of the ISS Radiators and Solar Arrays**
- **ISS Attitude**

Over 1100 temperature sensors are monitored to assure components stay within thermal limits and to avoid permanent damage.



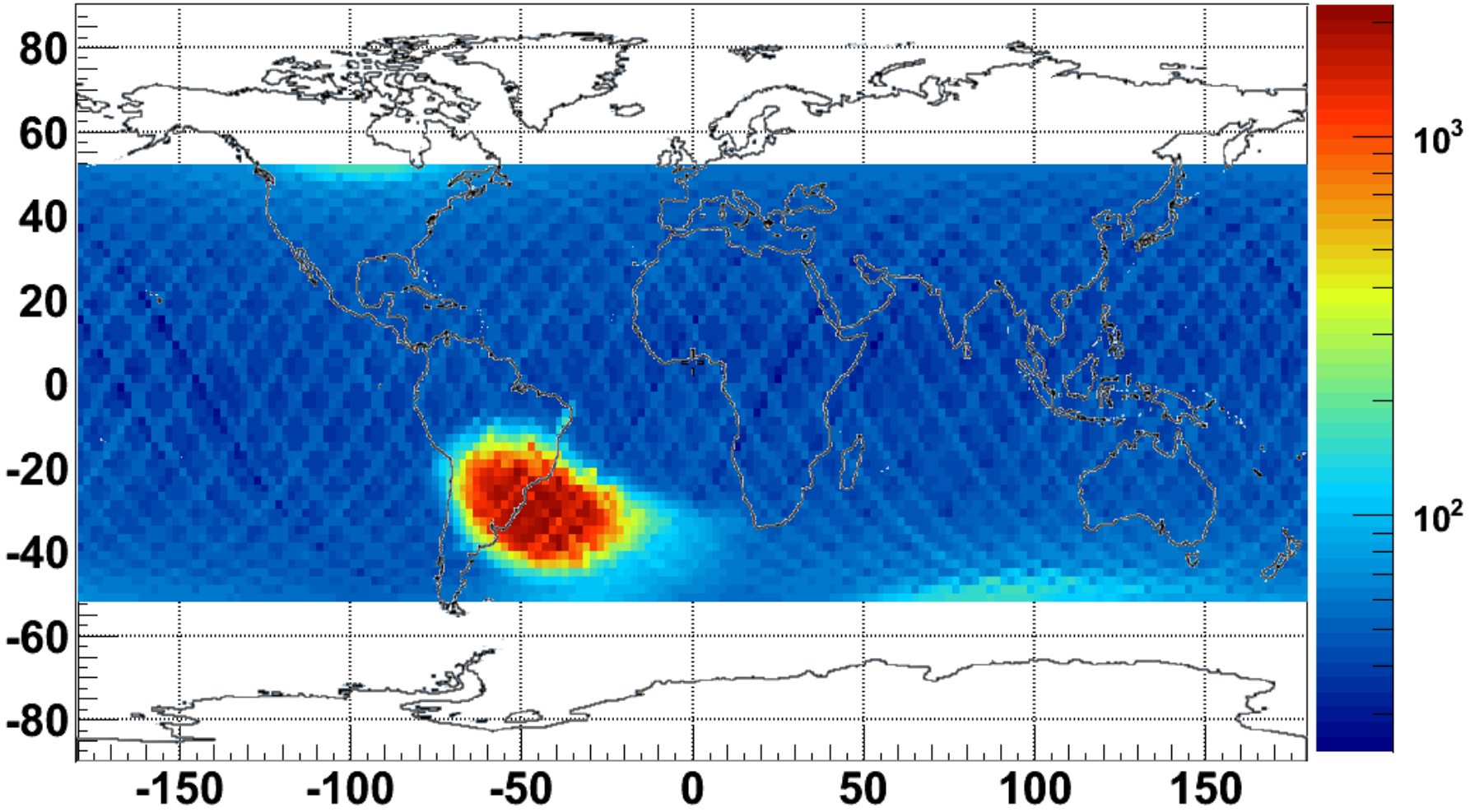


AMS-02 TRD

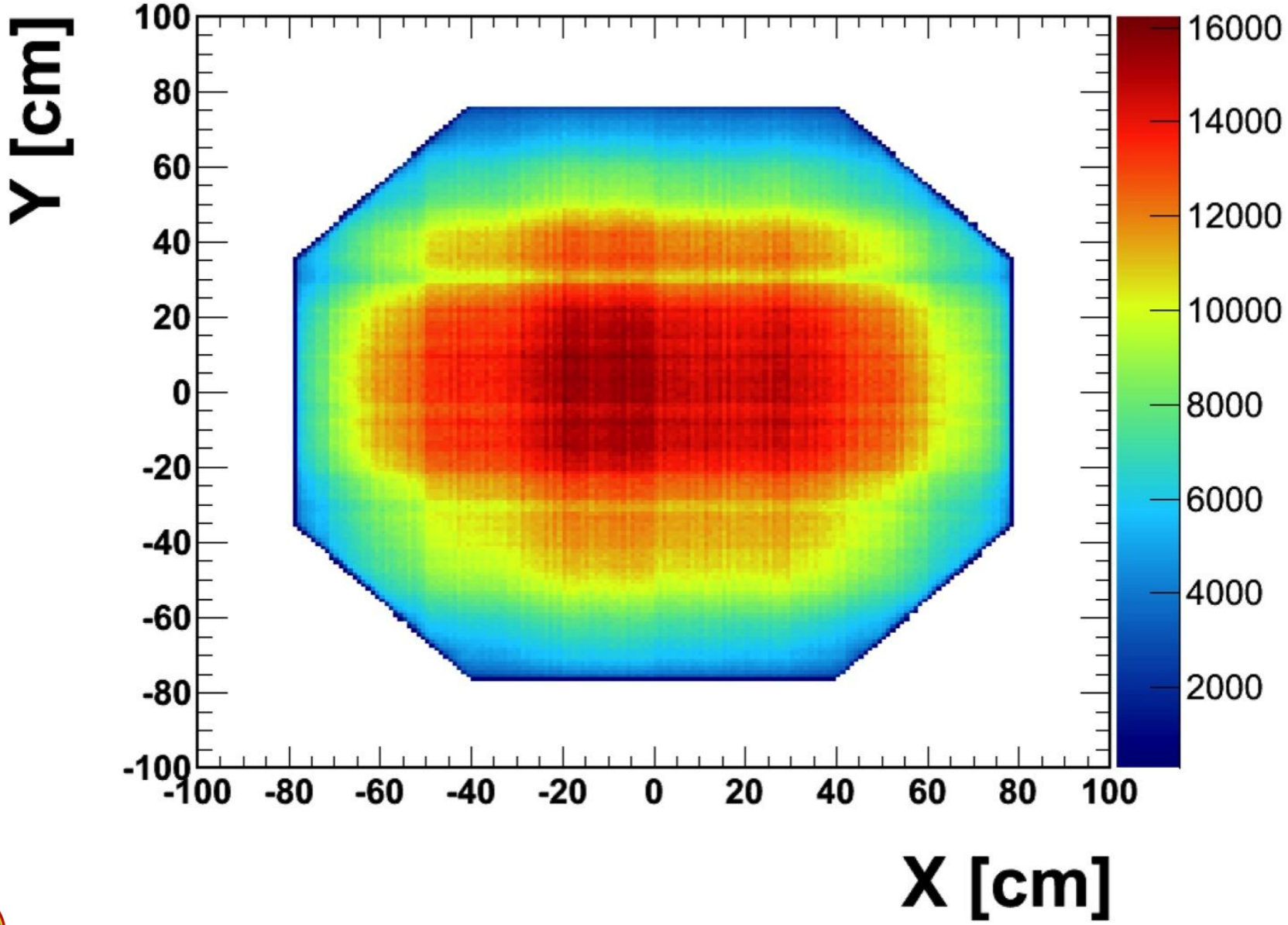


AMS-02 TRD

TRD Hits per event

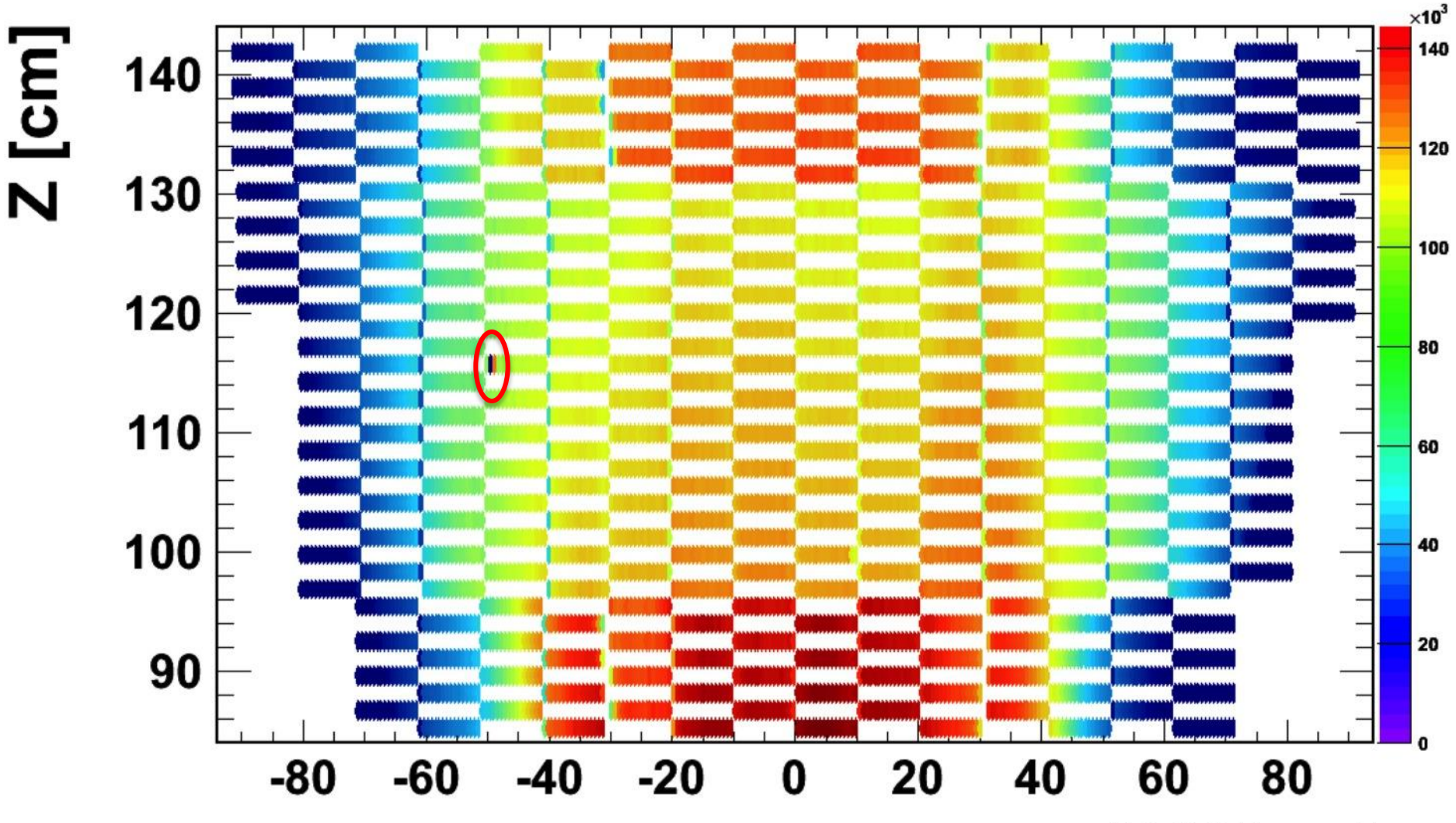


AMS-02 TRD - Occupancy



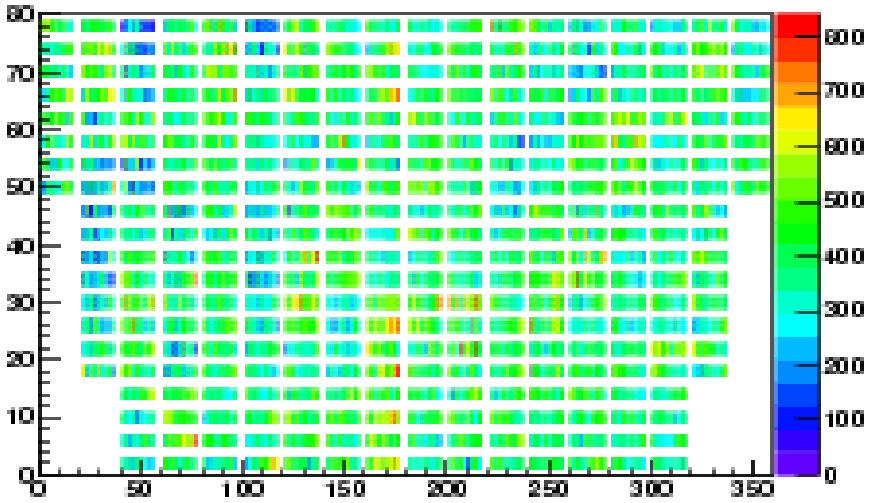
AMS-02 TRD - Occupancy

AMS TRD Occupancy
5246/5248 Channels within specification.

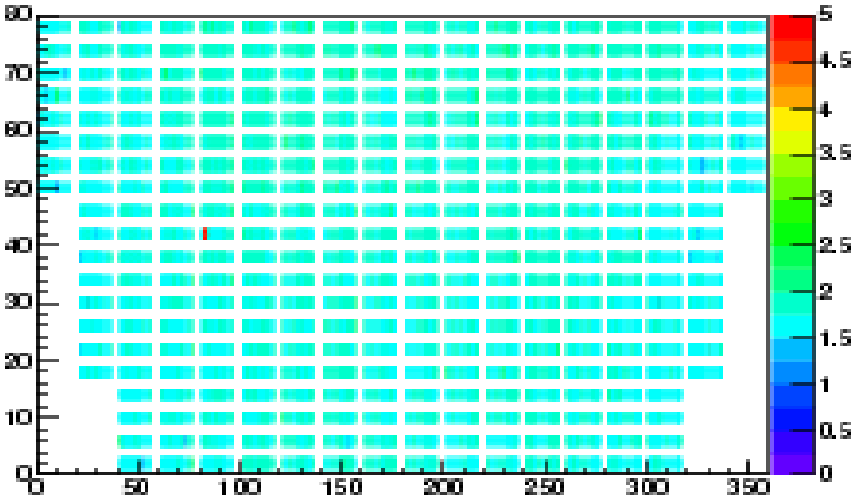


AMS-02 TRD – Amplitude/Noise

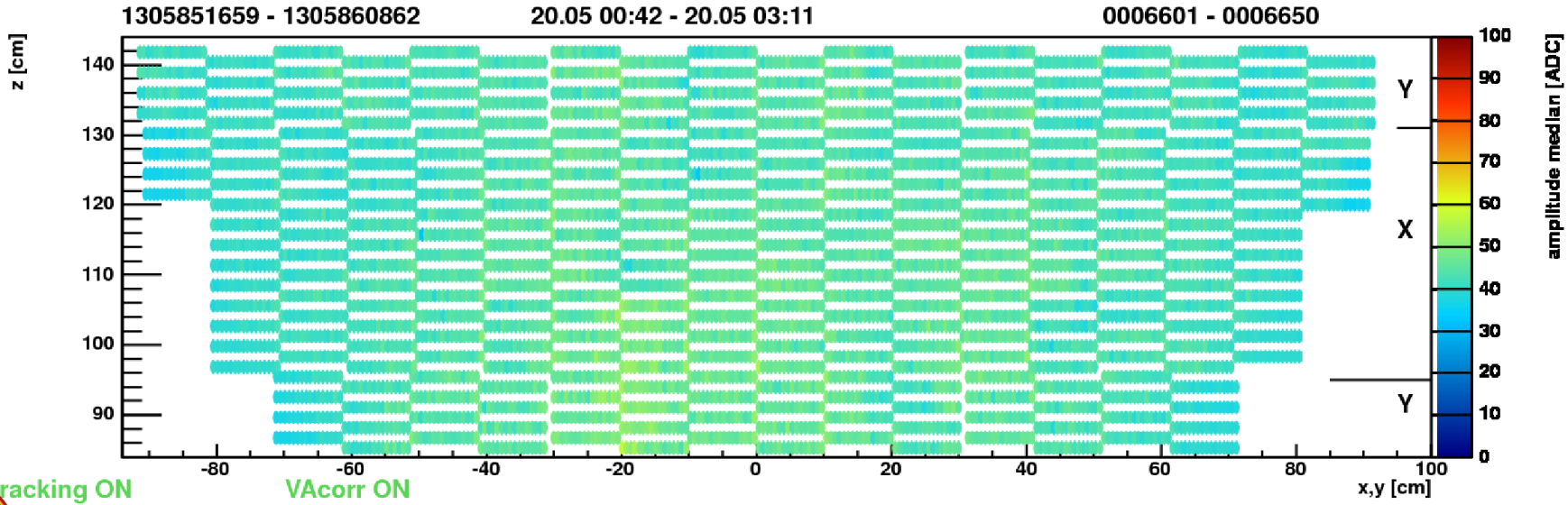
Pedestal



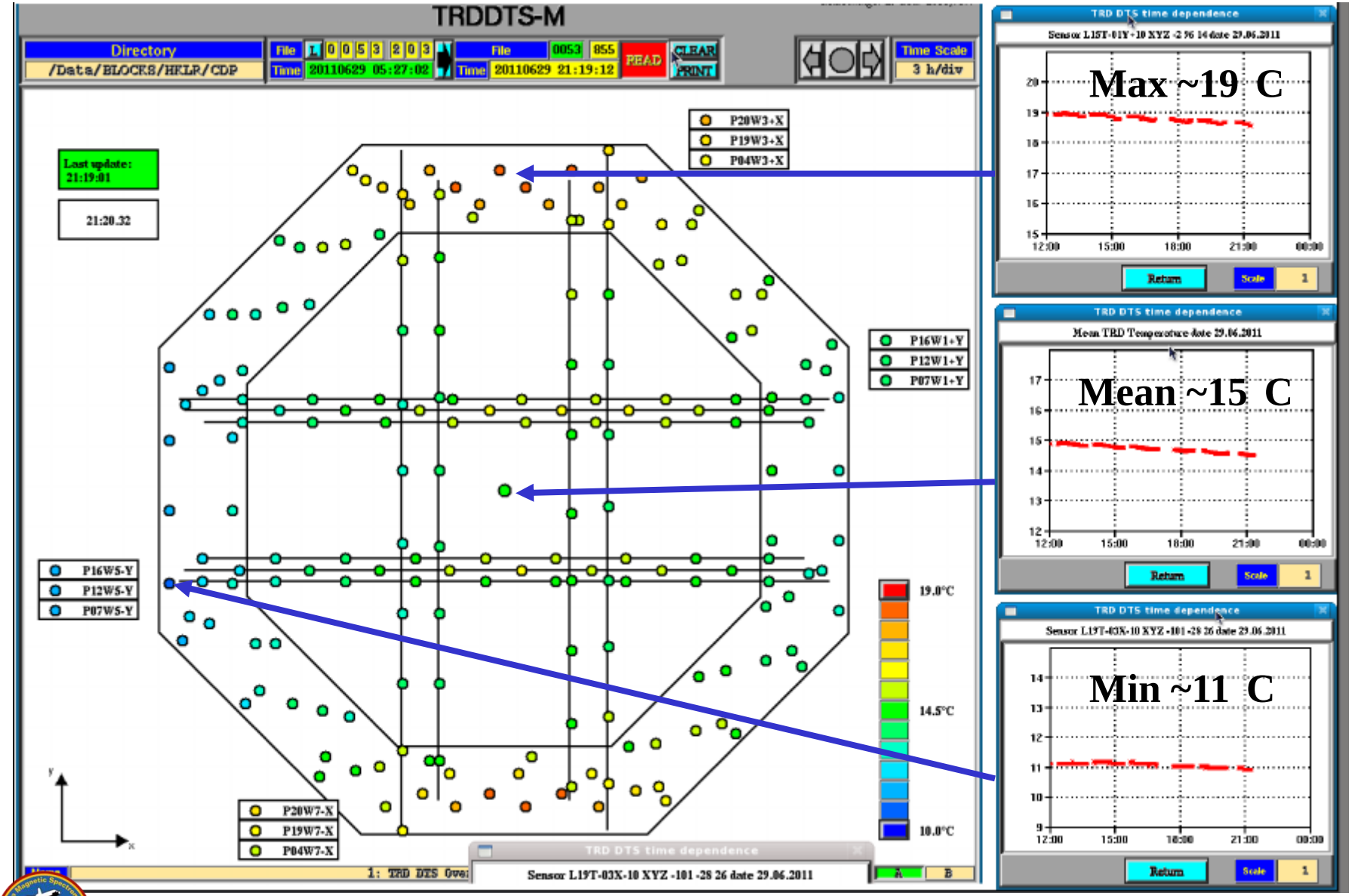
Noise



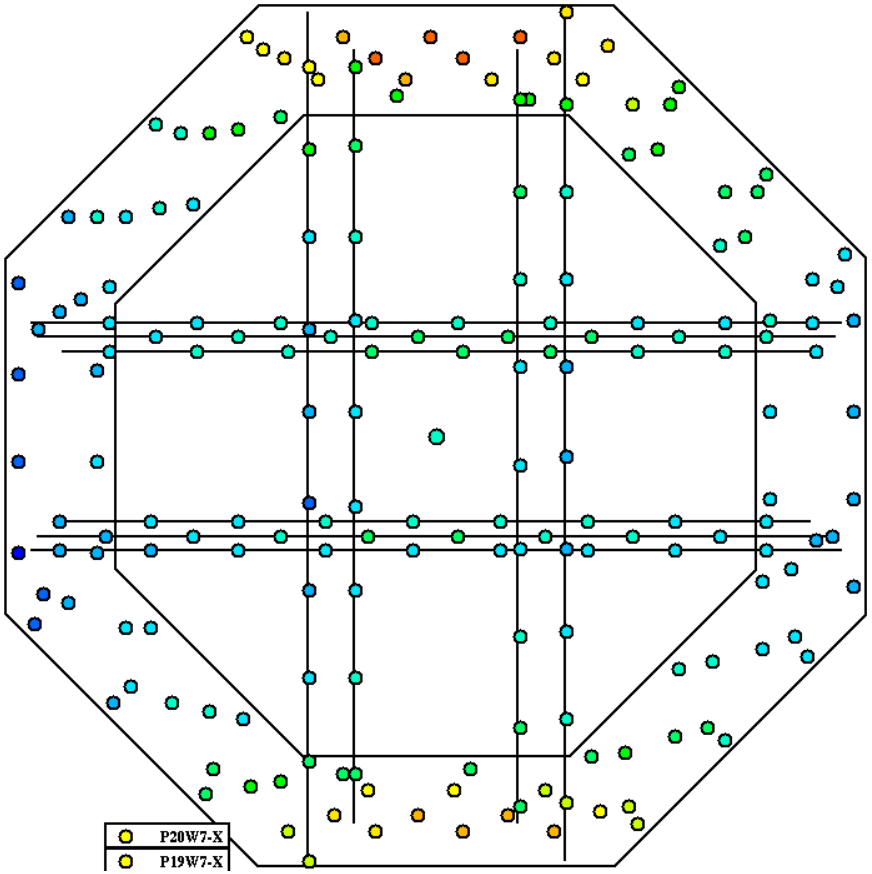
Amplitude on track

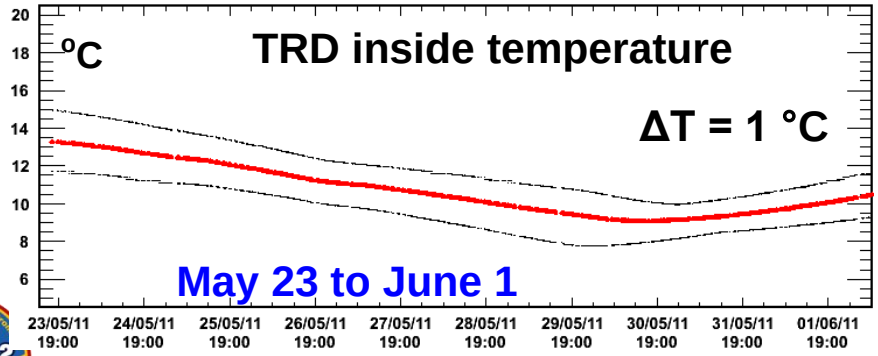


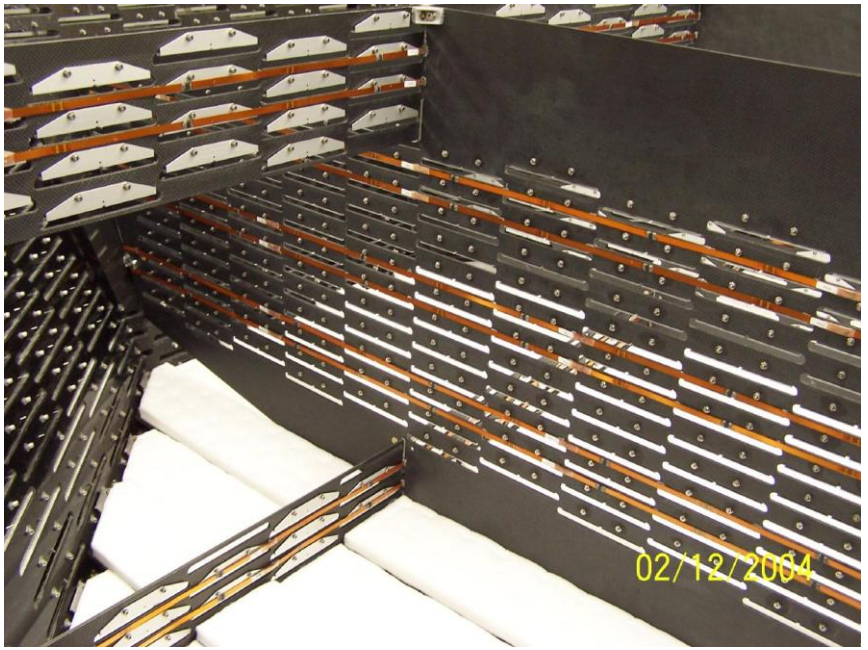
AMS-02 TRD – Temperature Monitoring



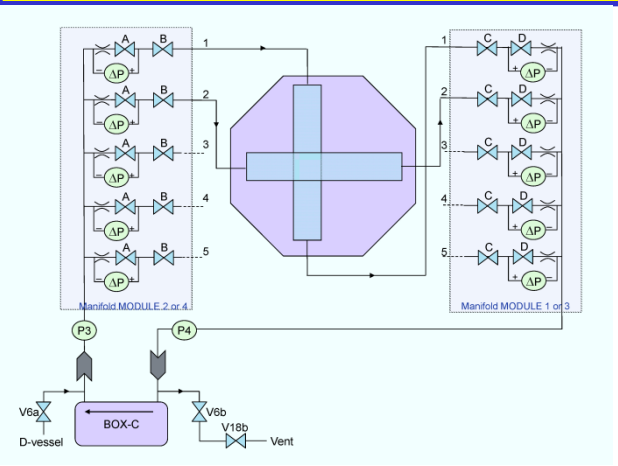
AMS-02 TRD – Temperature Monitoring

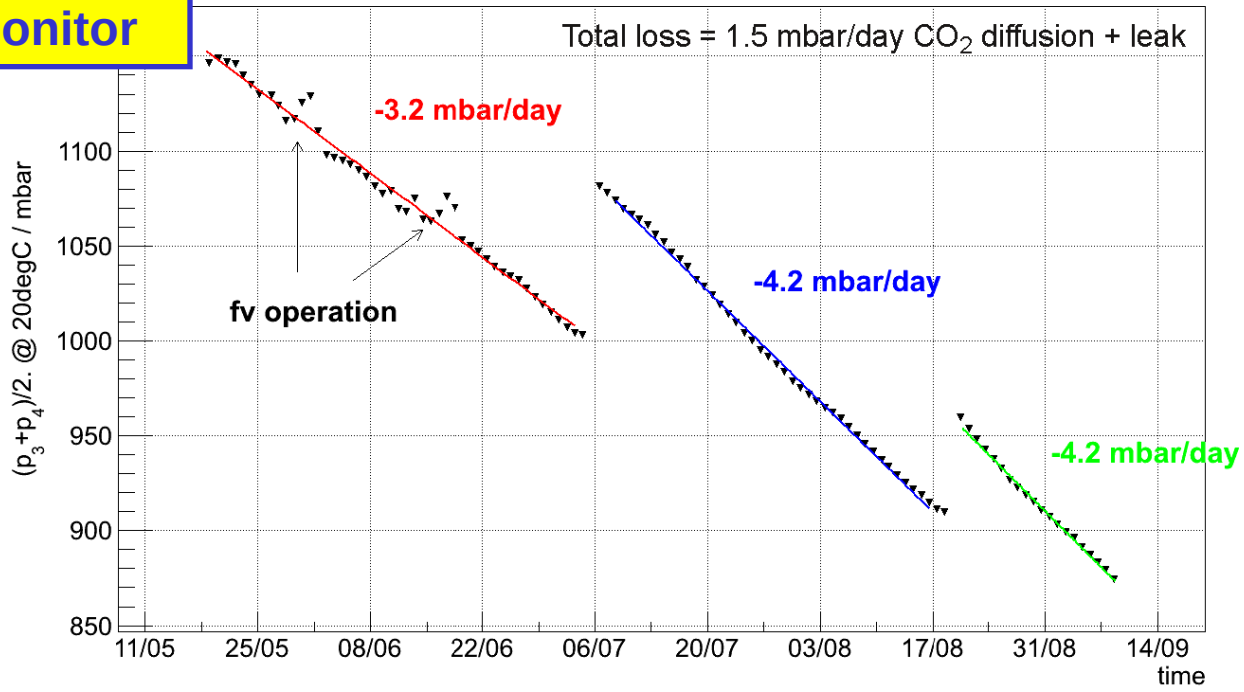




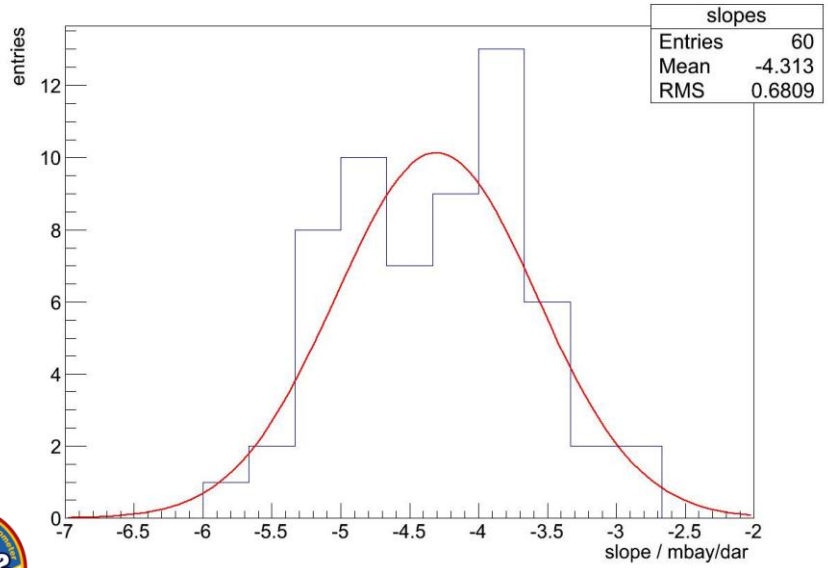


AMS-02 TRD – Pressure Monitor





Pressure loss week by week – projection of absolute slope



Total CO_2 storage: 5kg

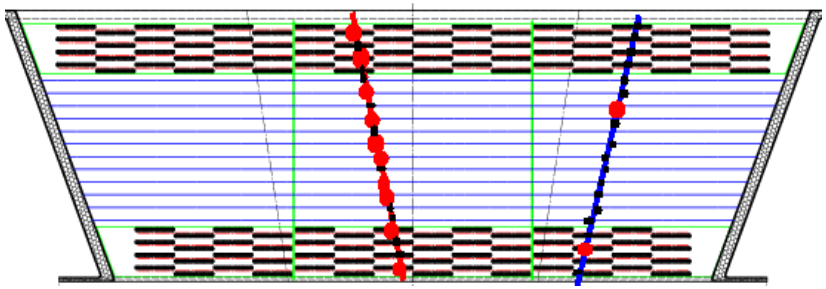
Xe/CO_2 - mixture:

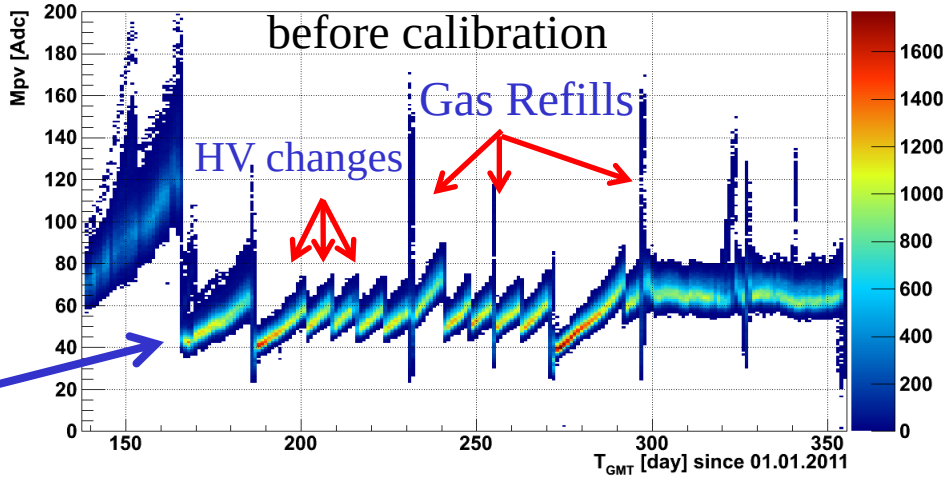
80%/20% → 90% / 10%

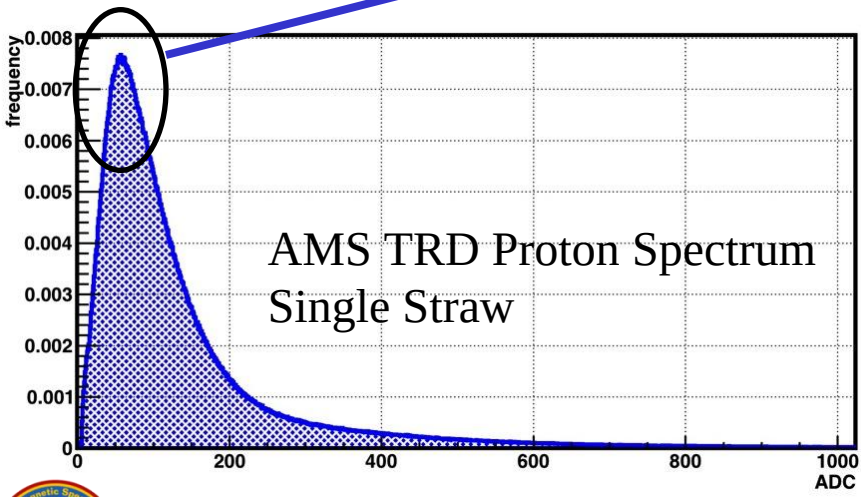
→ CO_2 lasts for 34 years > ISS Lifetime

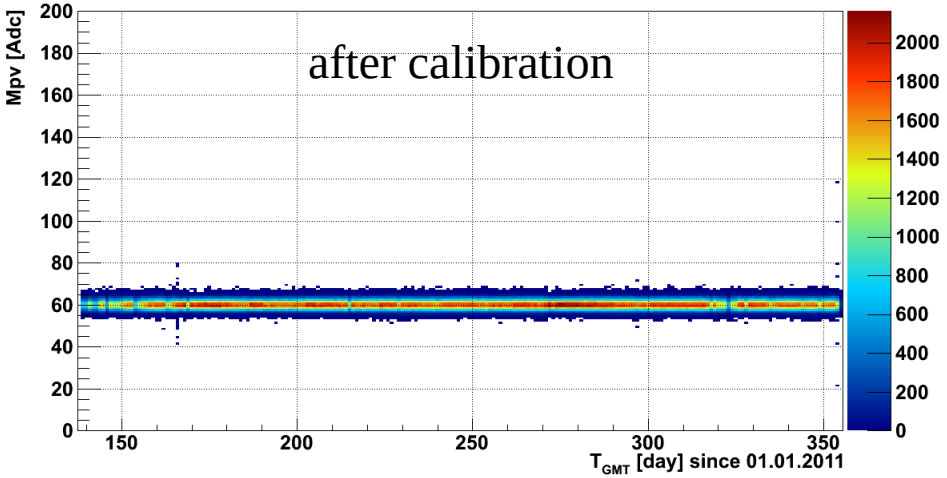
AMS-02 TRD Gain Calibration

TRD signal is depending on temperature, pressure, gas composition and HV changes :
→ Cosmic ray protons can be used to calibrate the detector response to 3% accuracy.



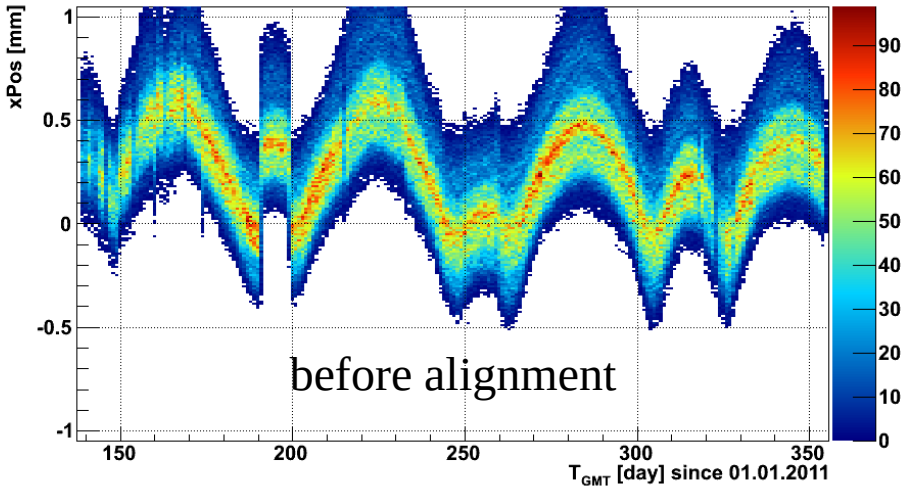


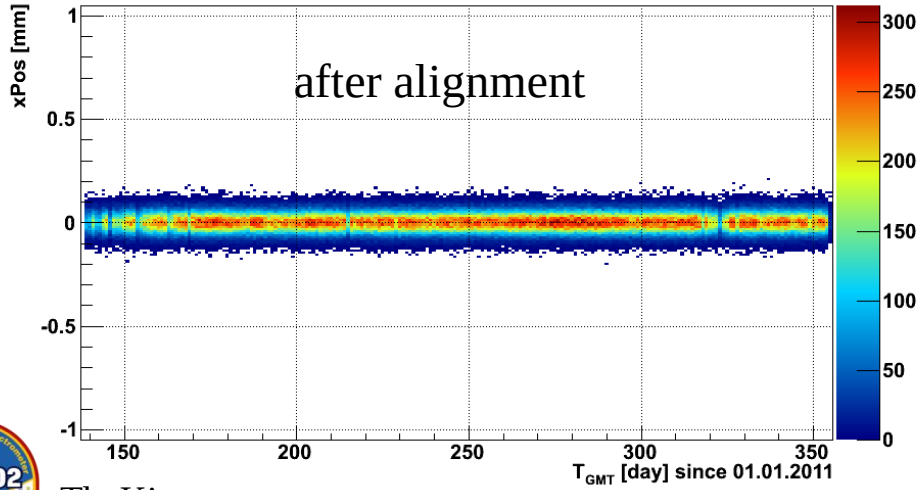




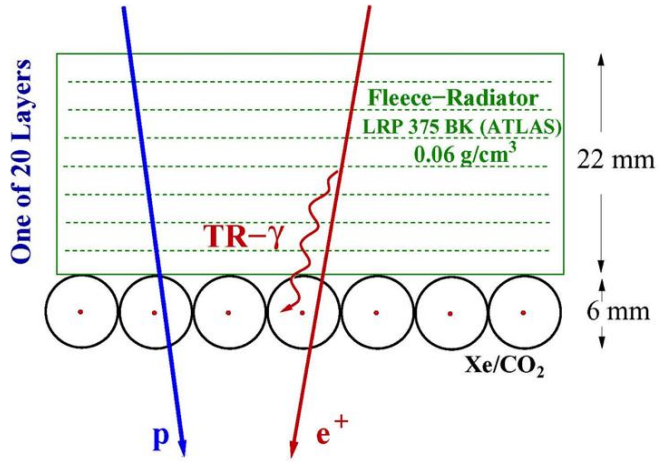
AMS-02 TRD Alignment

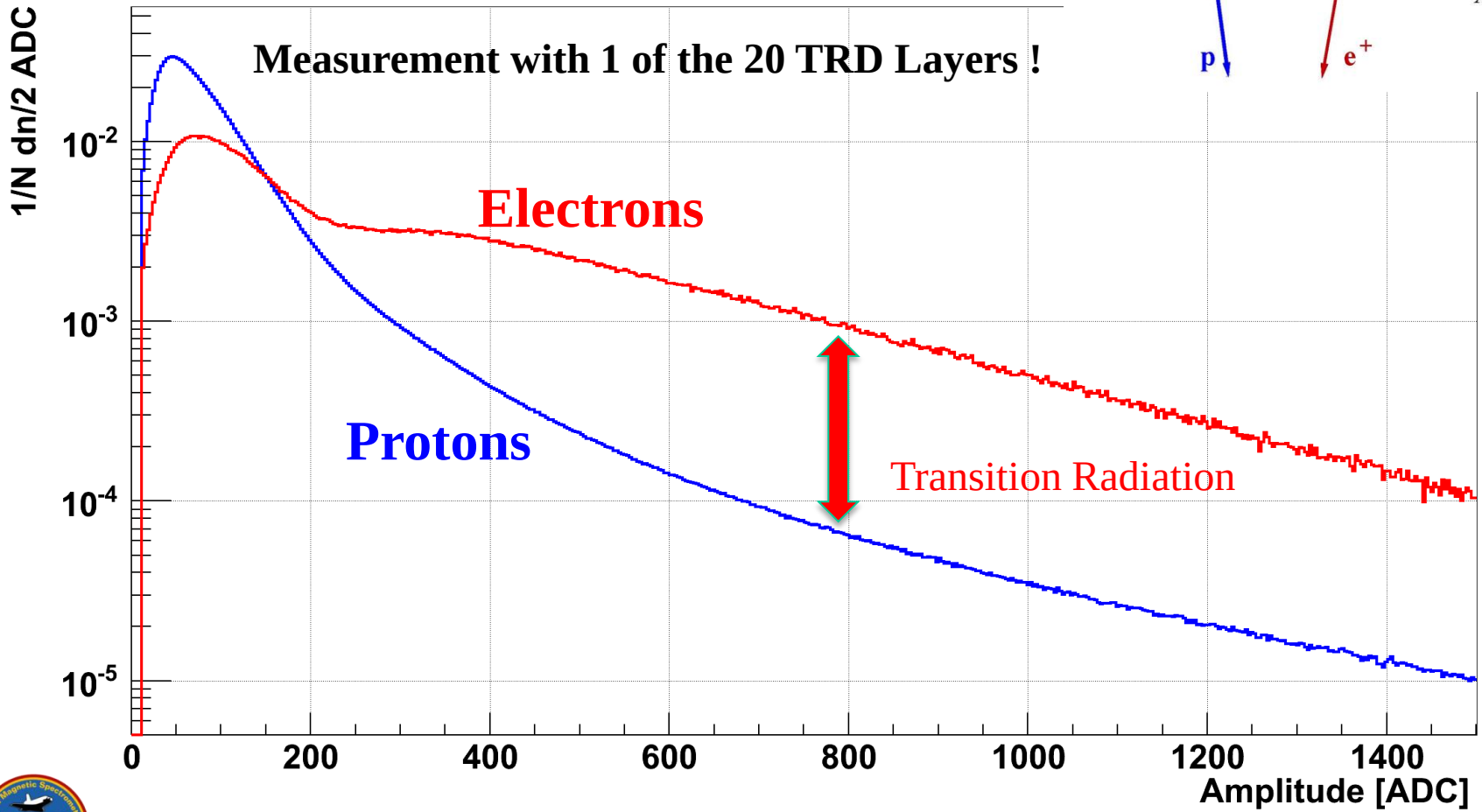
TRD is moving on top of inner tracker by up to 1mm due to temperature variations
→ Cosmic ray protons can be used to aligne each straw module to an accuracy of 4%.



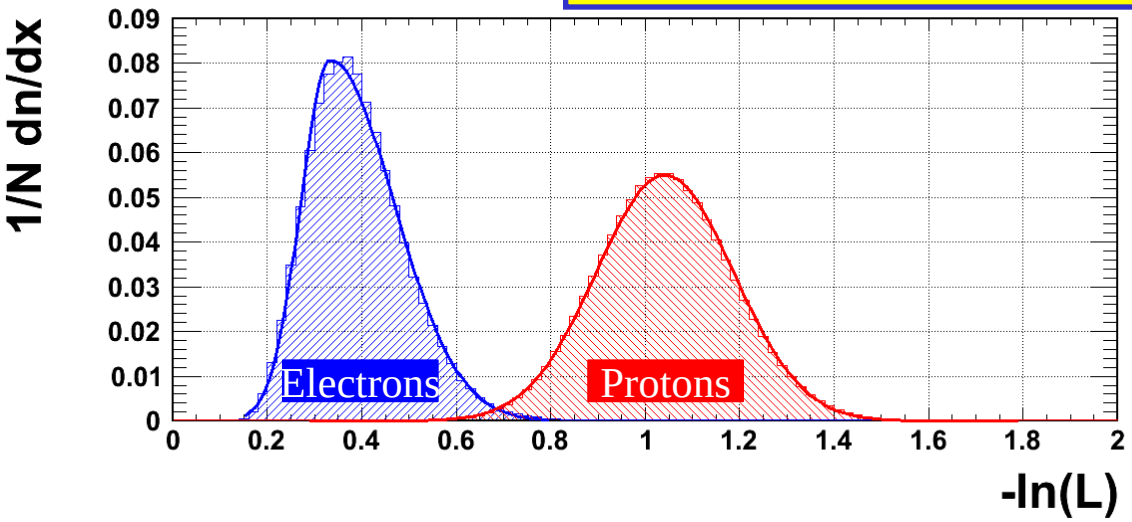


AMS-02 TRD Proton Rejection on ISS



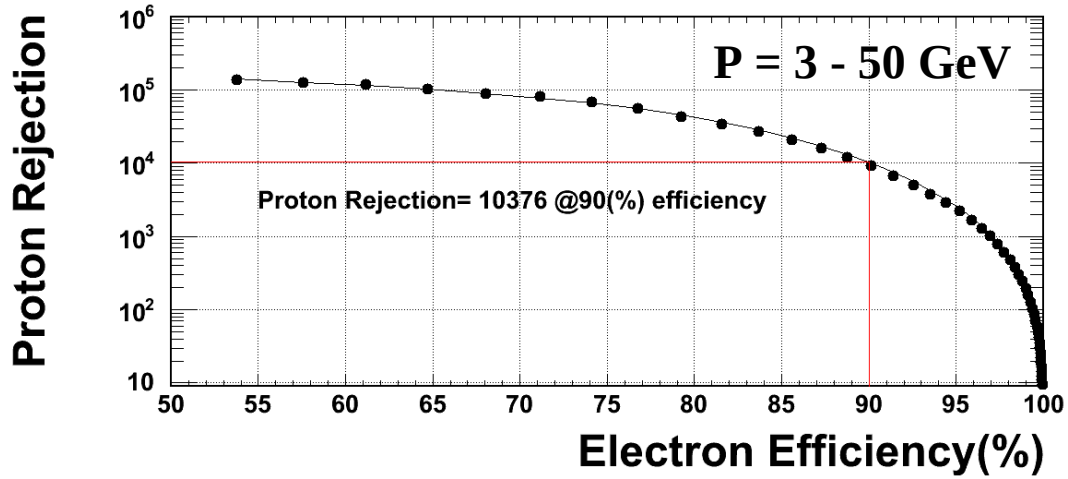


AMS-02 TRD Proton Rejection

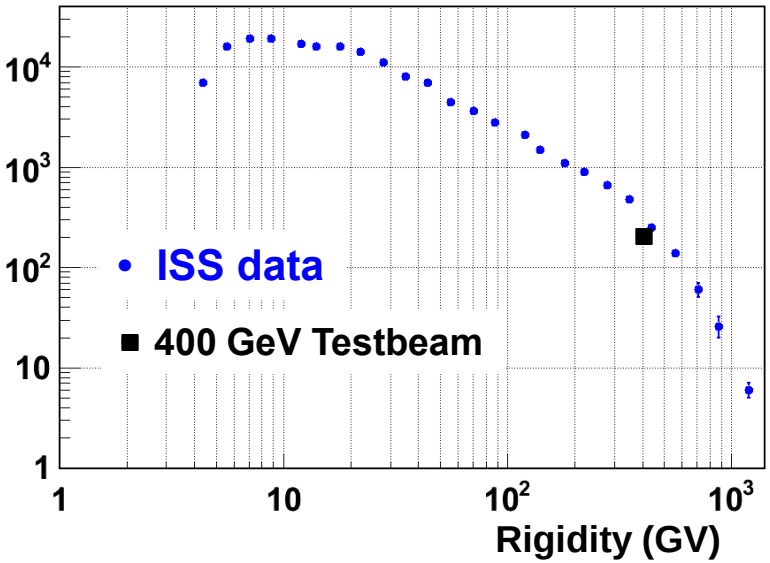


$$\bar{P}_{e/p} = \sqrt[n]{\prod_i^n P_{e/p}^{(i)}(E)}$$

$$L = \frac{\bar{P}_e}{\bar{P}_p + \bar{P}_e}$$



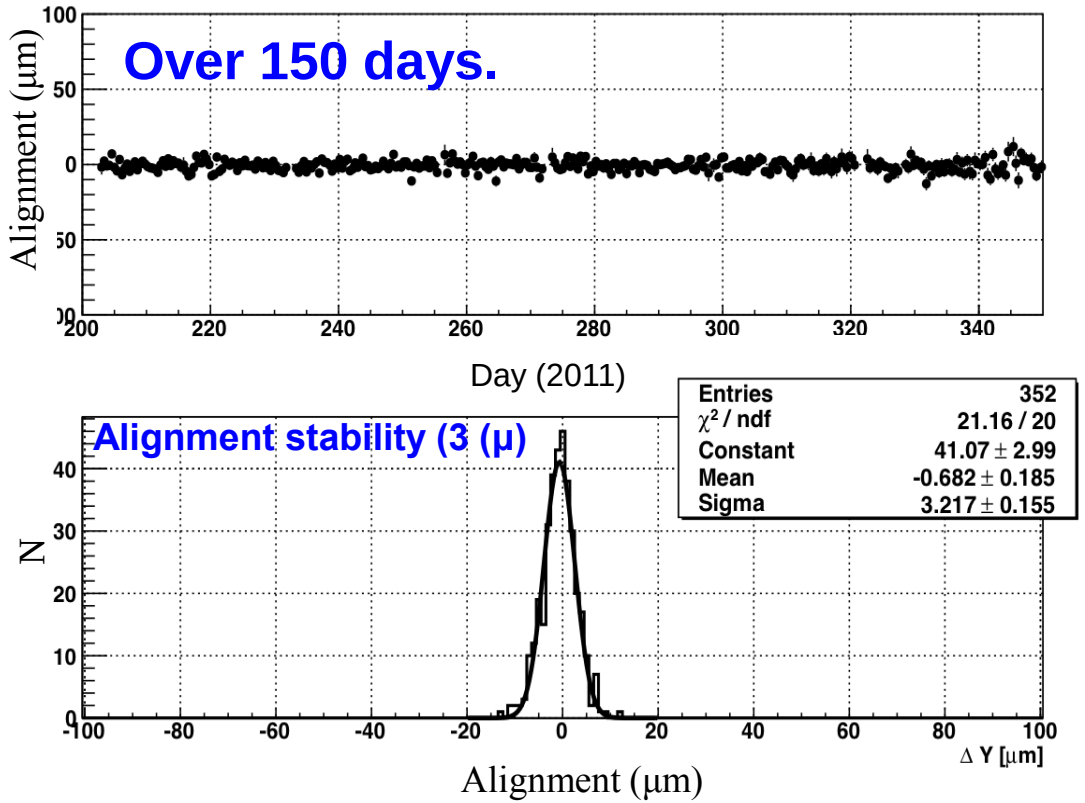
Proton rejection at 90% e^+ efficiency

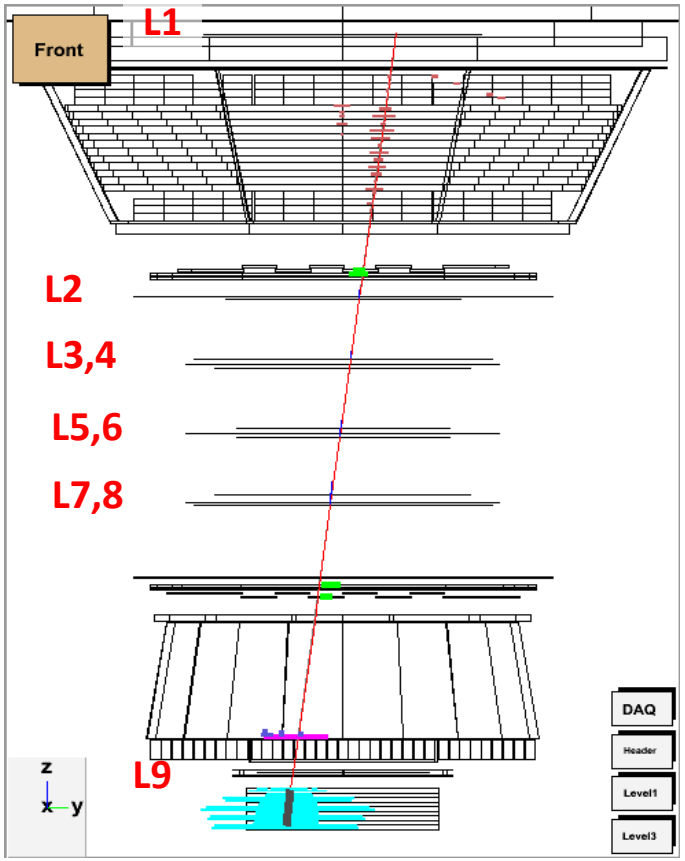


AMS-02 Tracker: Data on ISS

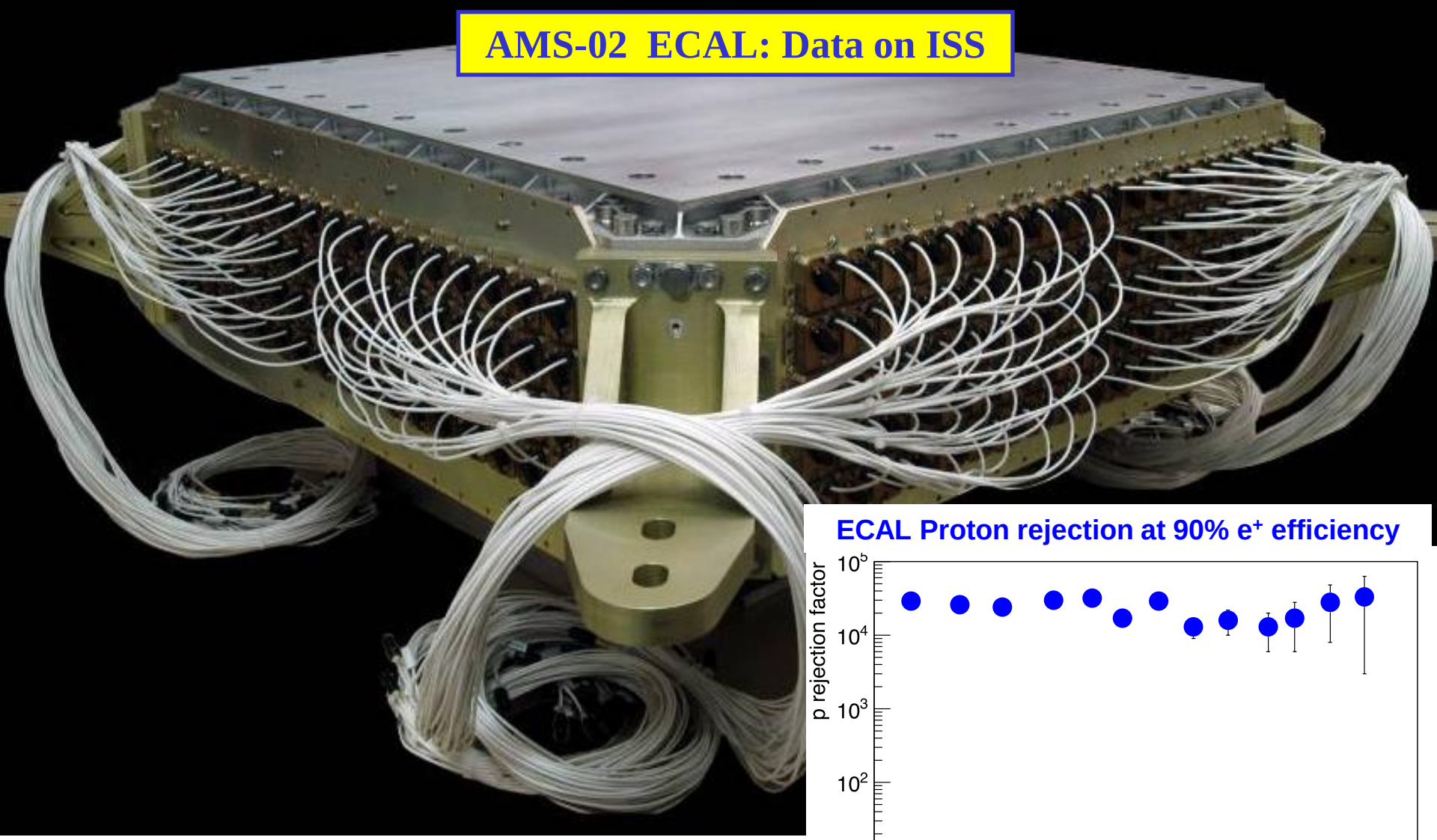
The alignment stability (3 microns) of the uppermost Tracker plane (1).

Over 150 days.

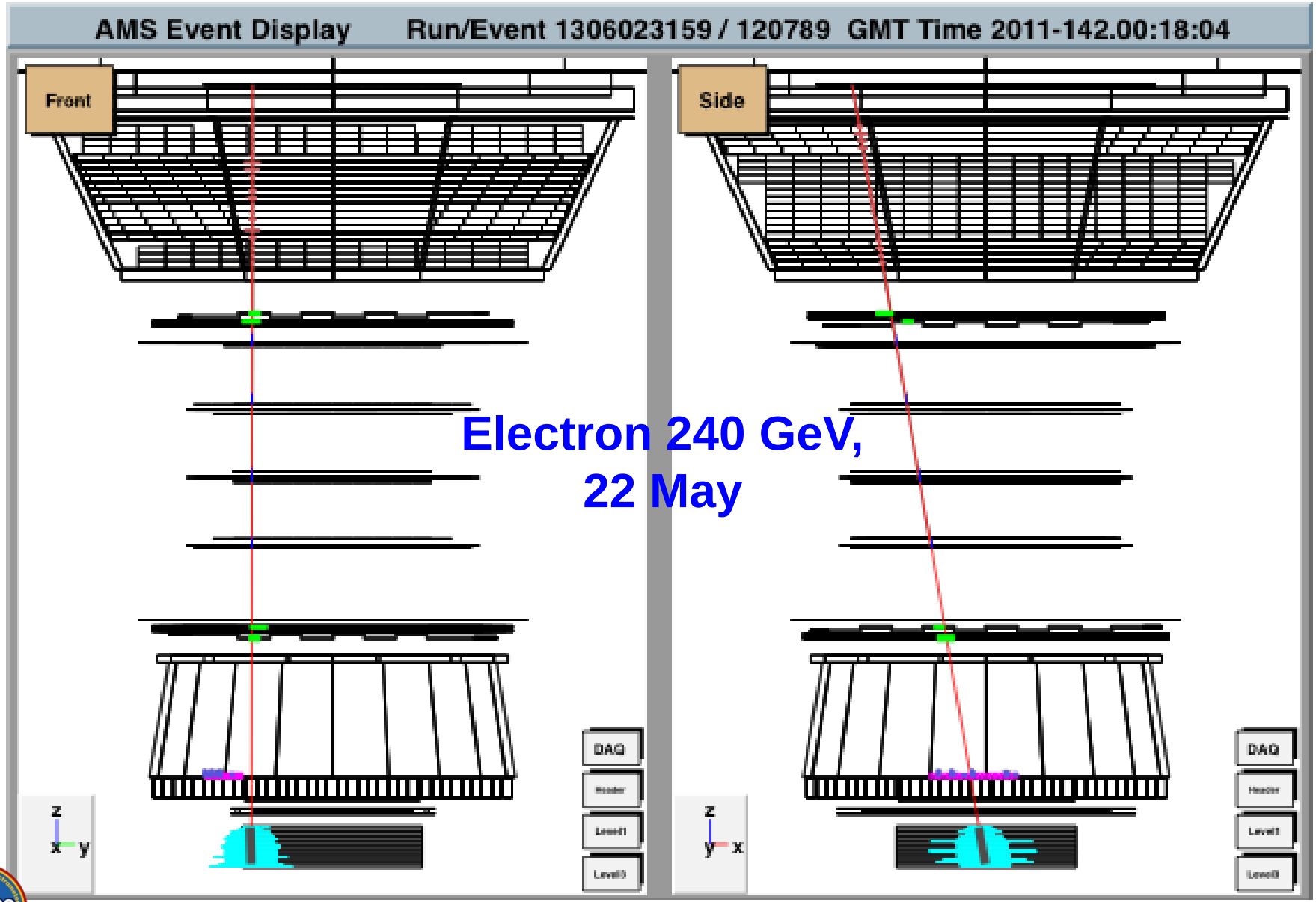




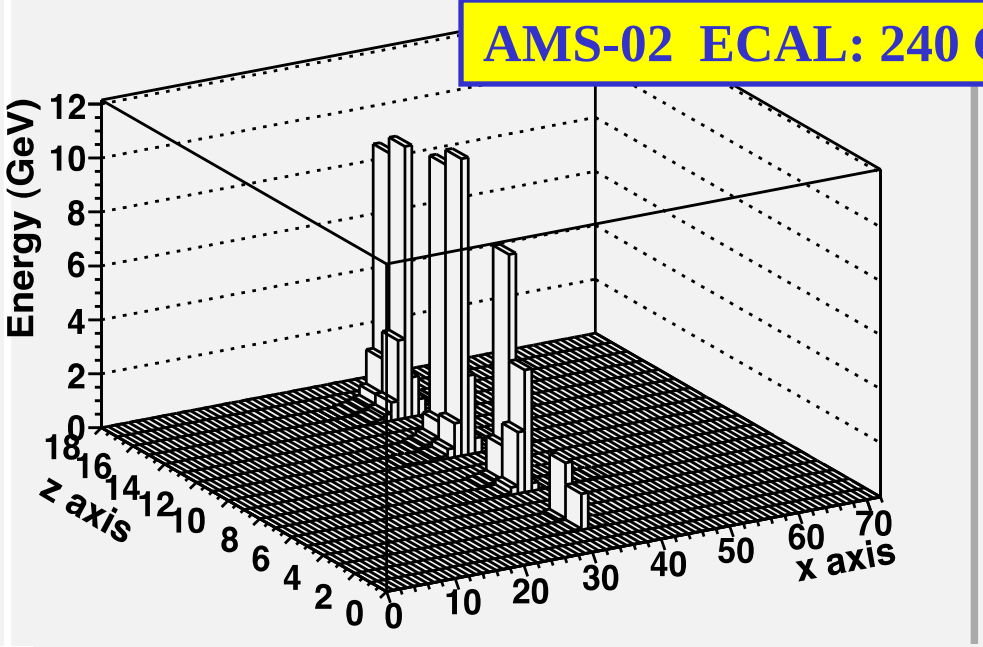
AMS-02 ECAL: Data on ISS

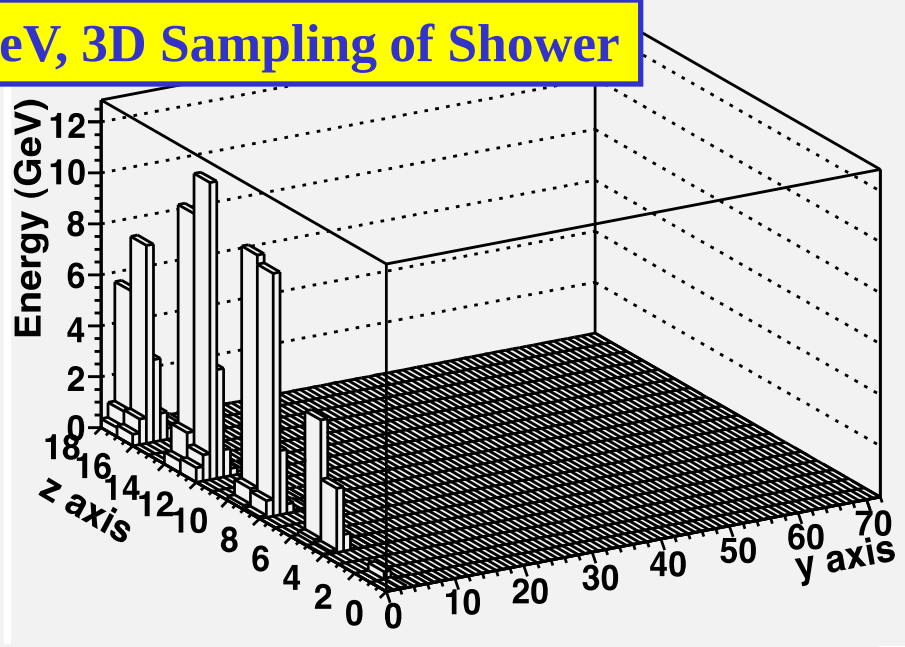


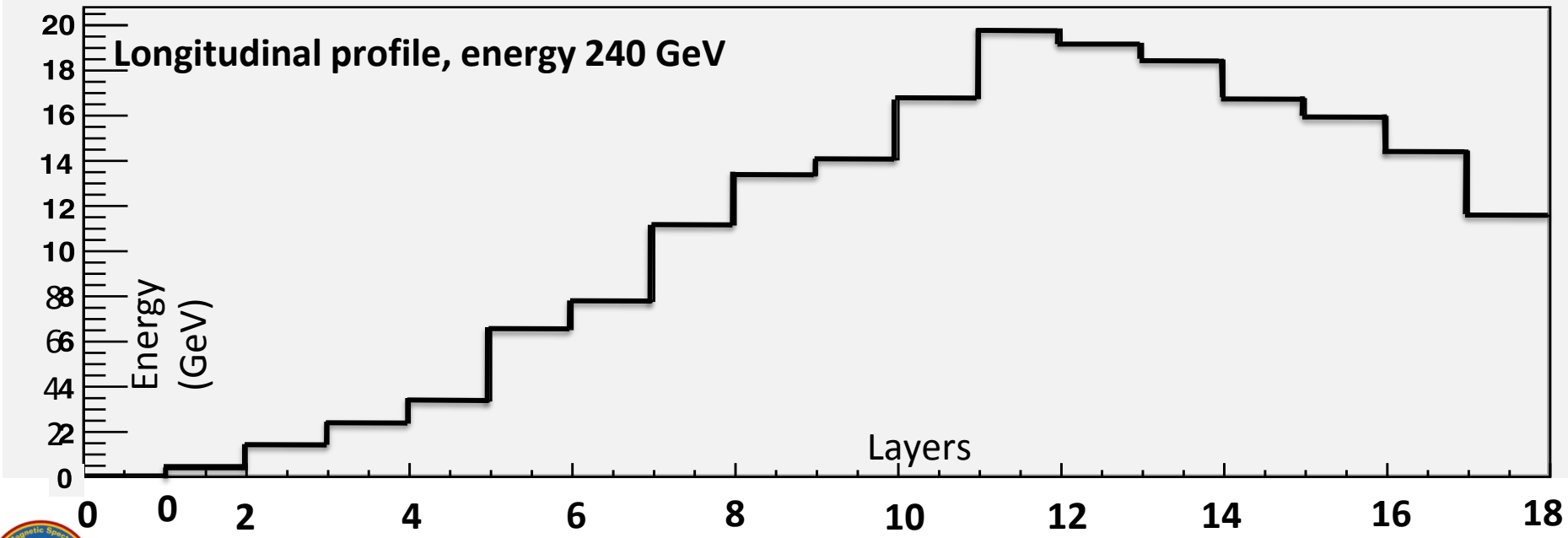
AMS-02 Data on ISS



AMS-02 ECAL: 240 GeV, 3D Sampling of Shower







Electron 1.03 TeV

AMS-02 Data on ISS

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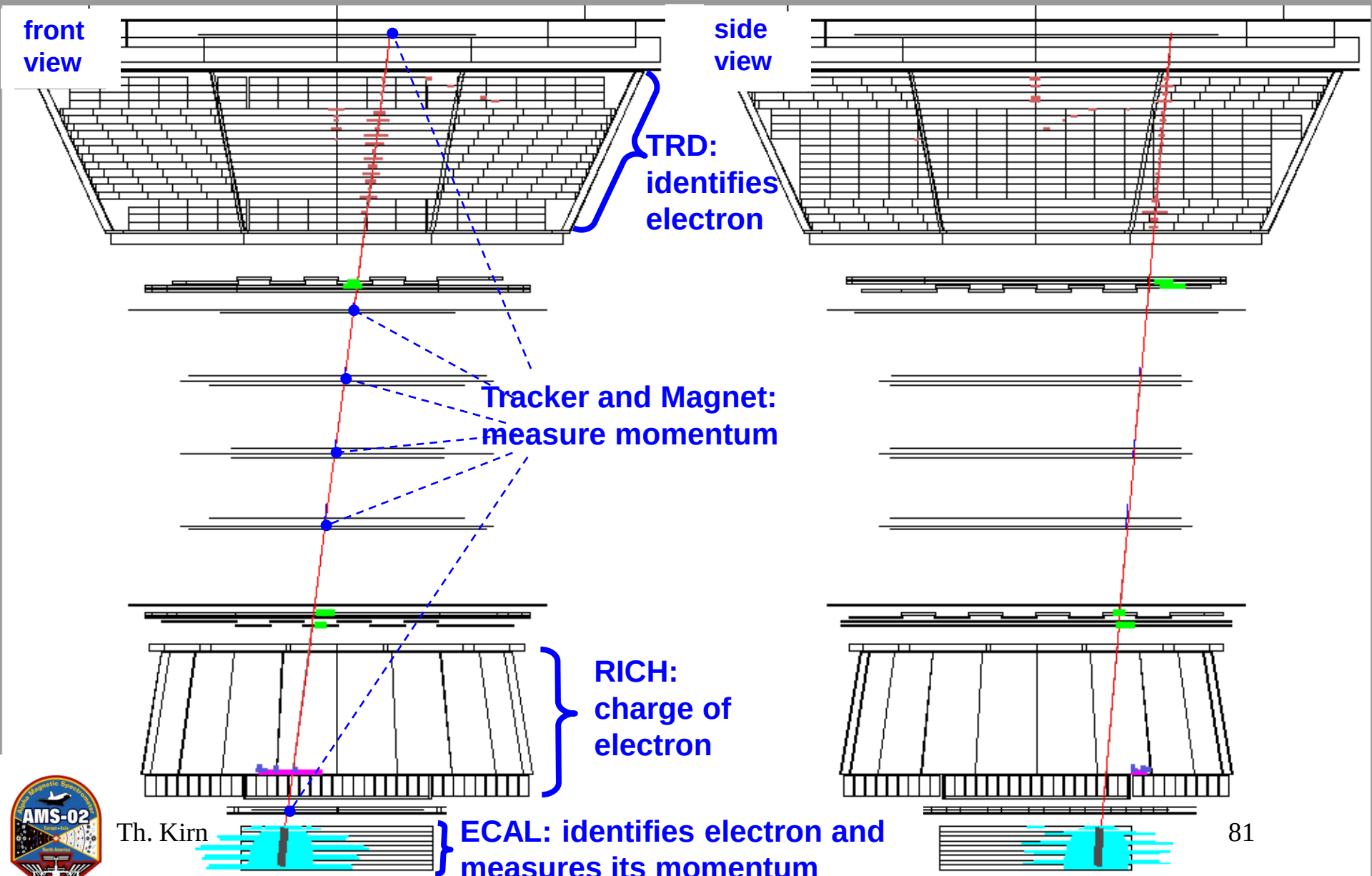
AMS Event Display Run/Event 1315754945 / 173049 GMT Time 2011-254.15:31:15



Electron E=1.1 GeV

Run/Event 1315150703/ 667540

AMS-02 Data on ISS

Positron E=1.1 GeV

Run/Event 1316182344/ 919896

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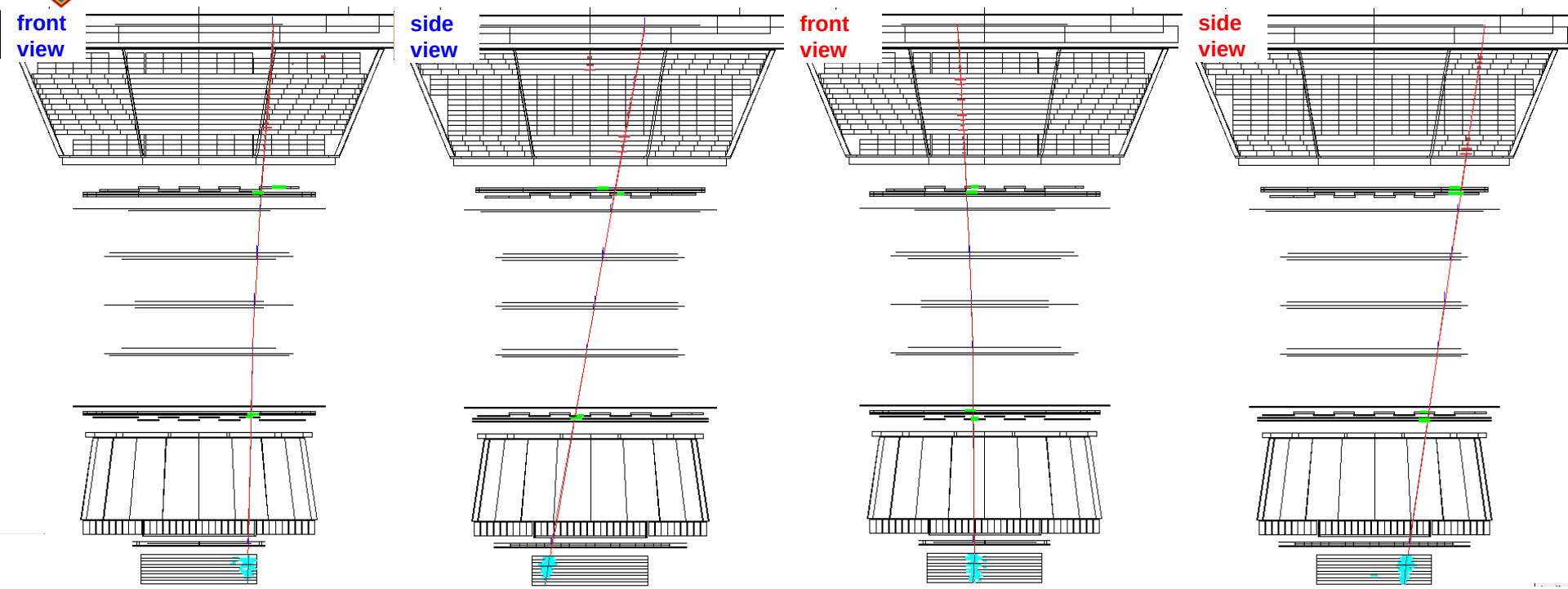

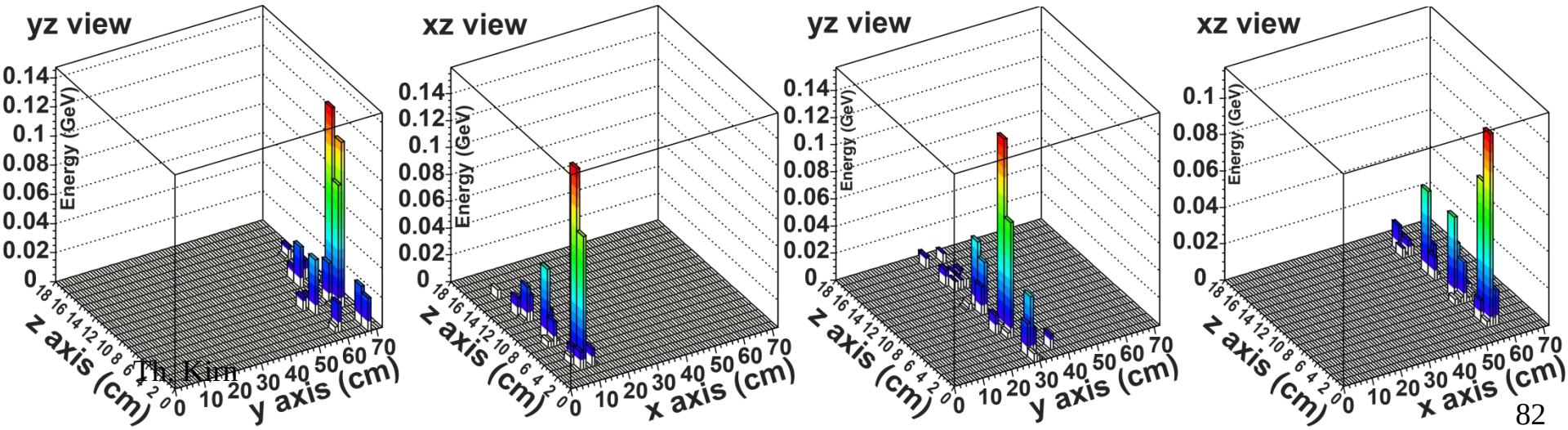

Th. Kirn

Electron E=10.1 GeV

Run/Event 1314950197/ 296945

AMS-02 Data on ISS

Positron E=9.5 GeV

Run/Event 1316692684/ 283617

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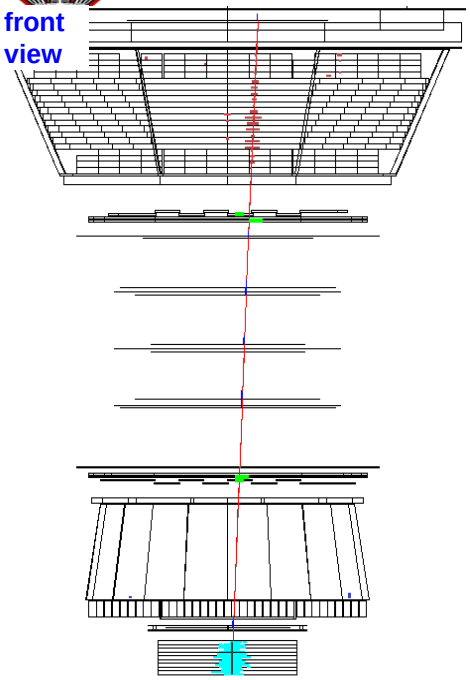
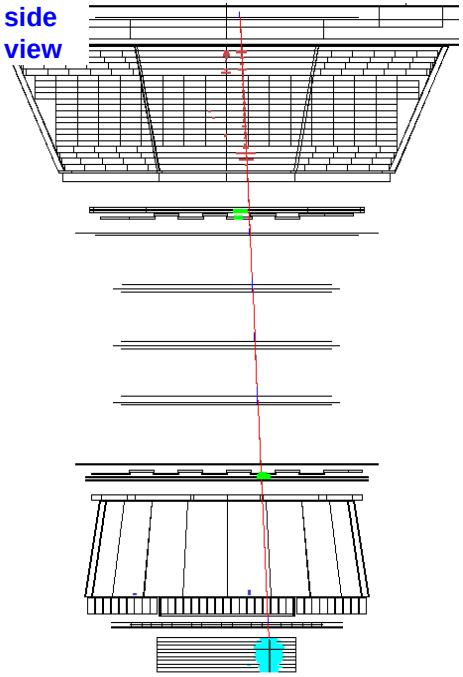
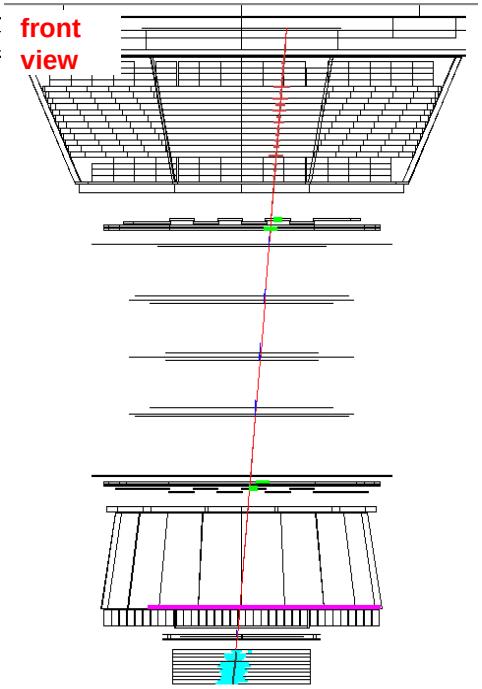
front view



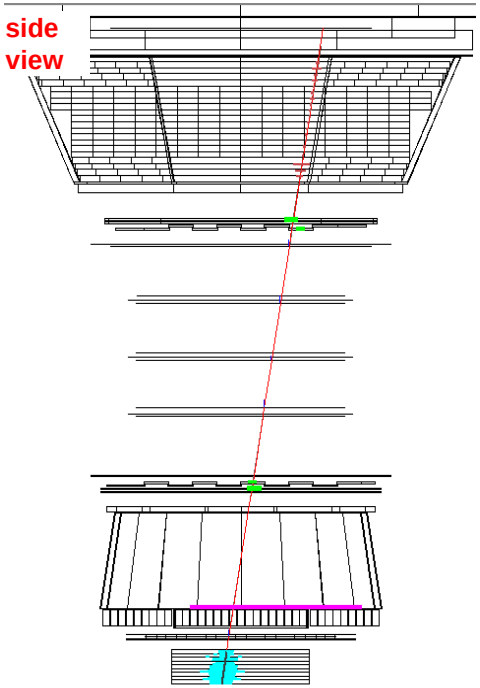
side view

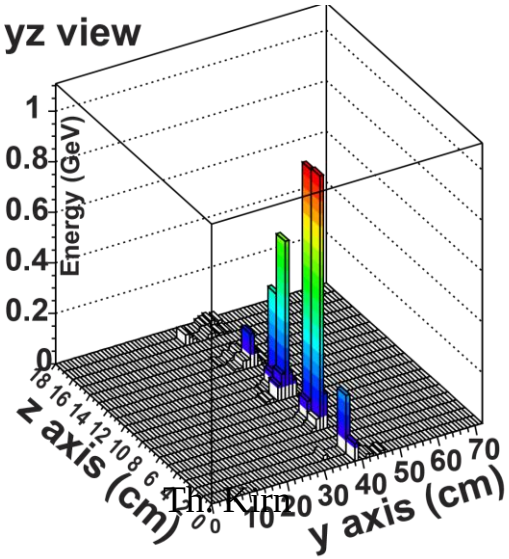


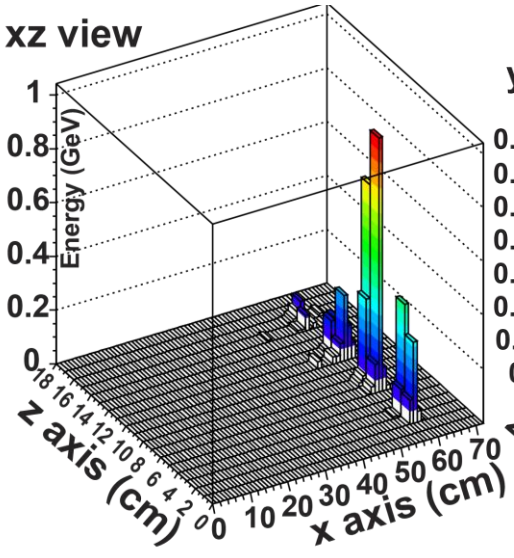
front view

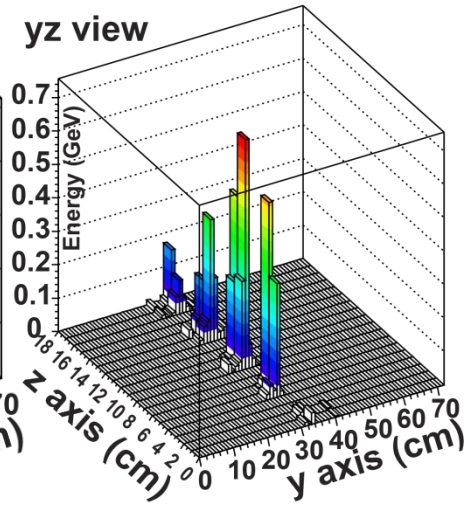


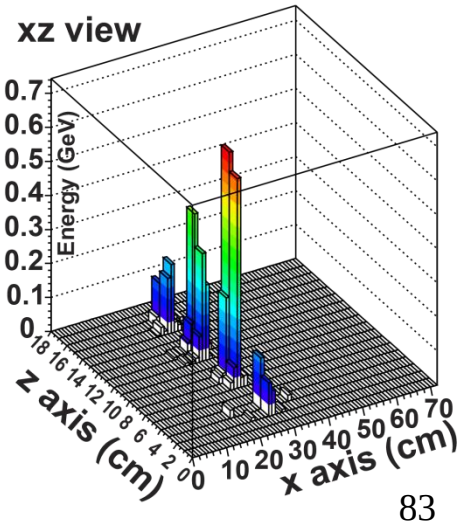
side view











Th. Kirn

AMS-02 Data on ISS

Electron E=99 GeV

Run/Event 1318944028/ 505503

Positron E=100 GeV

Run/Event 1334274023/ 338433

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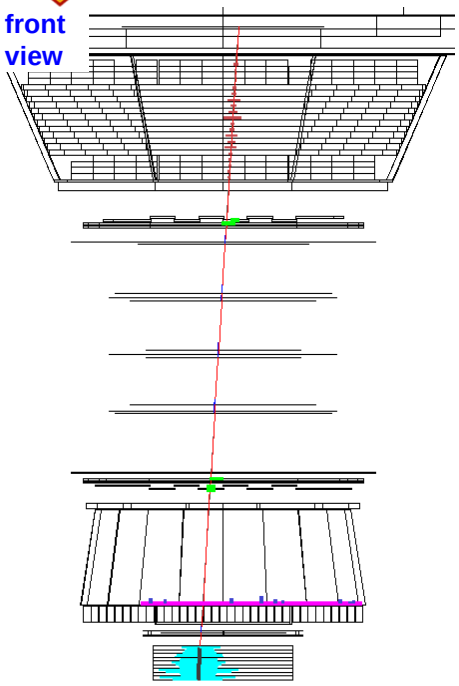

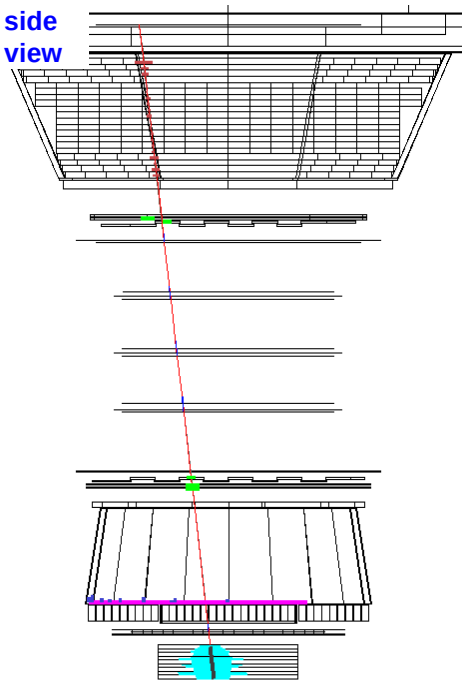

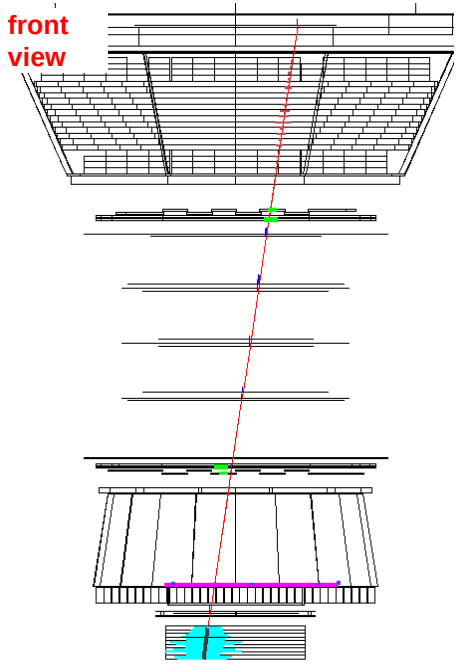

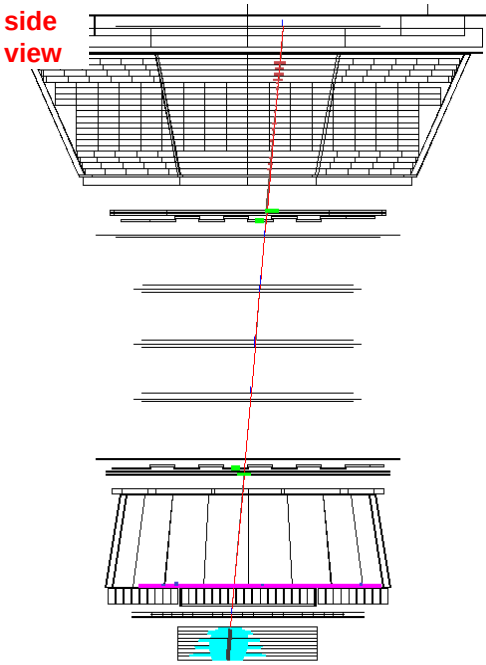

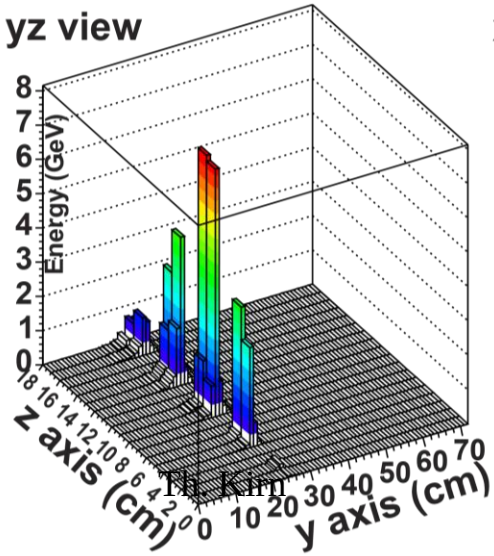

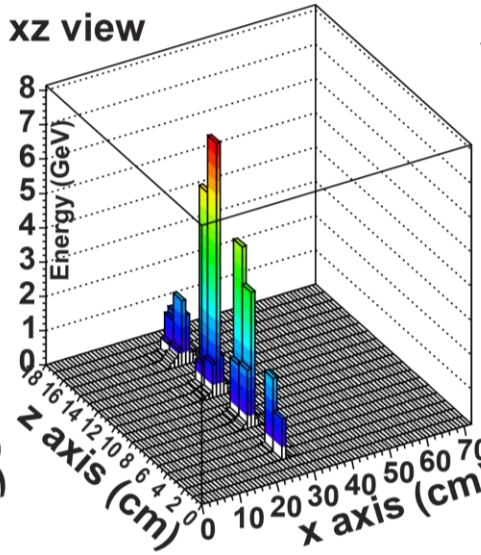

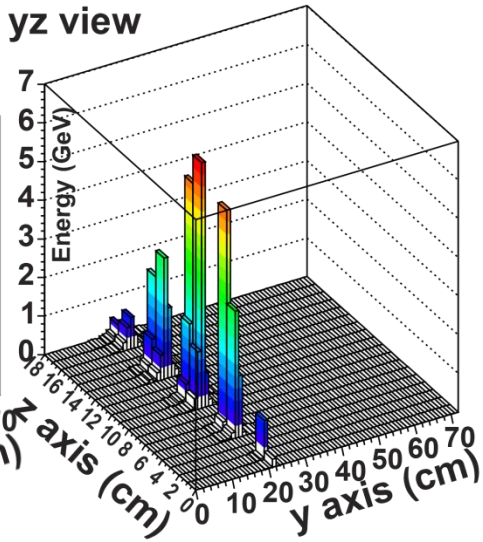

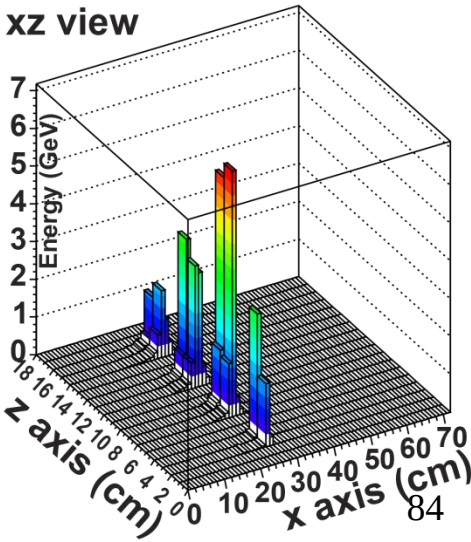

Th. Kirn

Electron E=982 GeV

Run/Event 1329775818/ 60709

AMS-02 Data on ISS

Positron E=636 GeV

Run/Event 133119-743/ 56950

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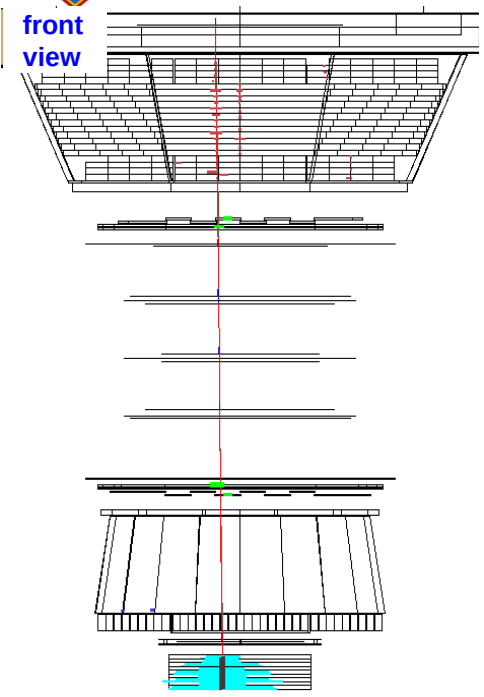
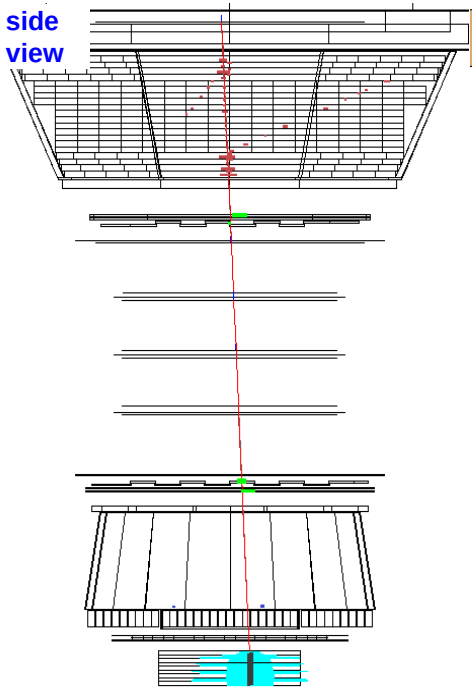
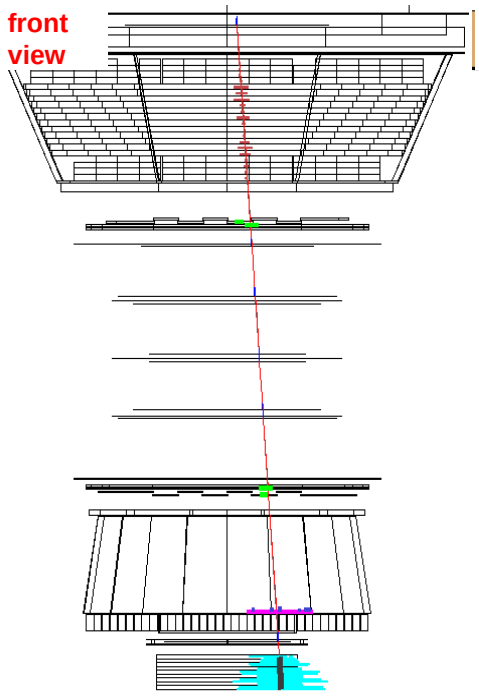
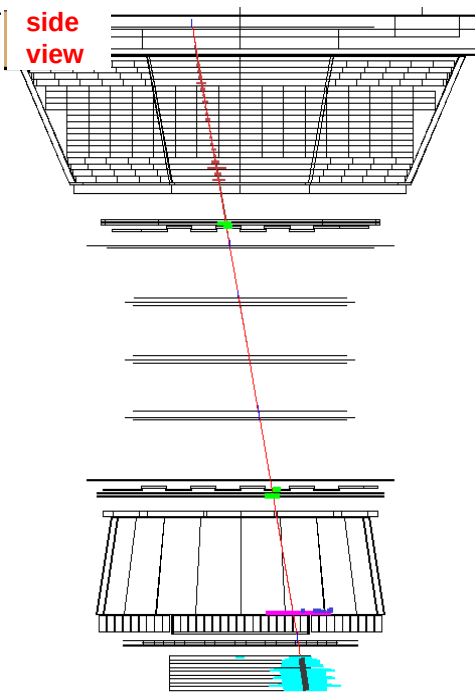
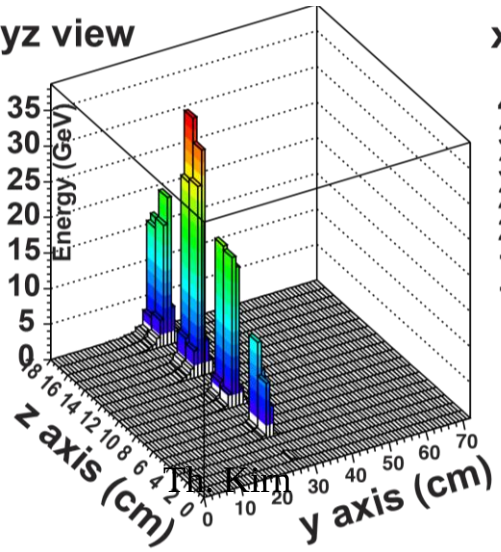
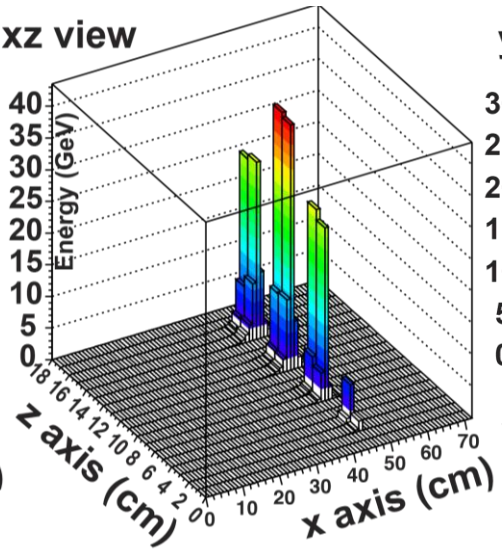


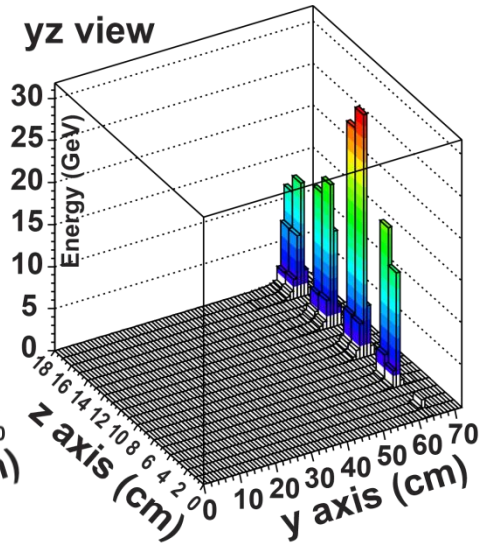


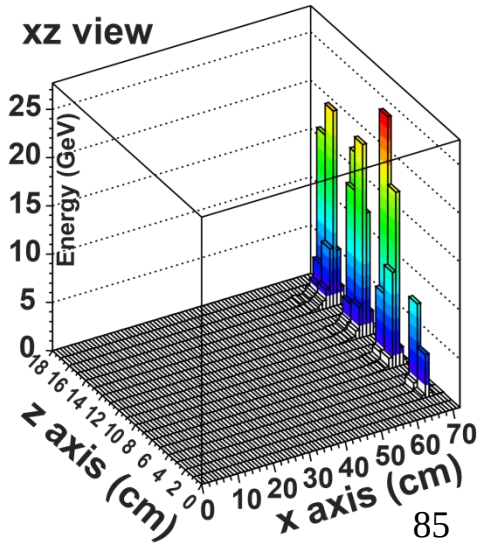






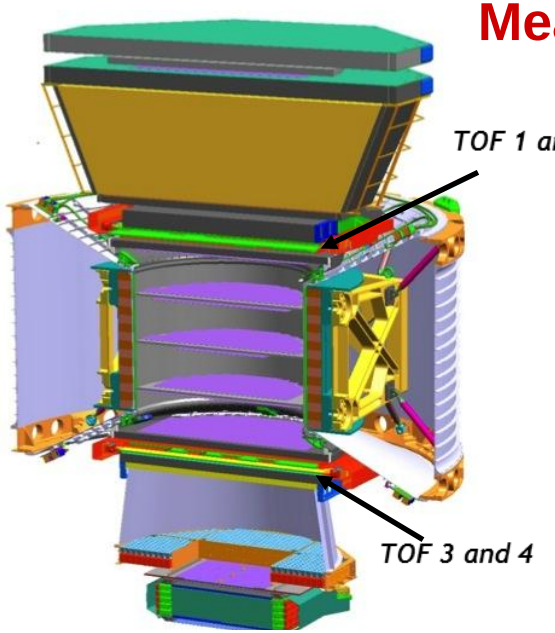


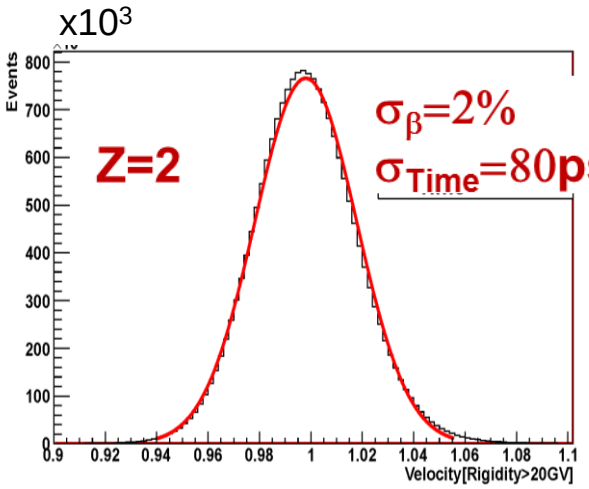


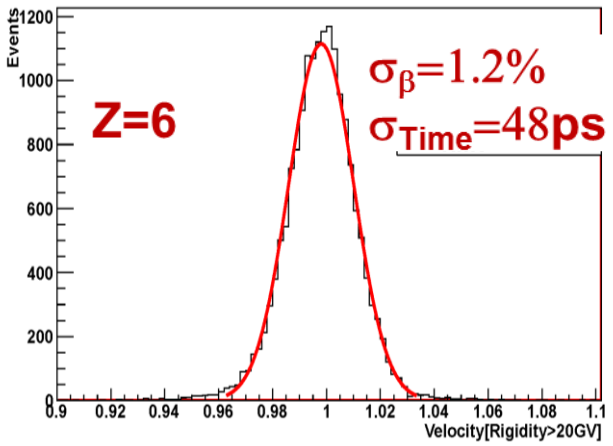


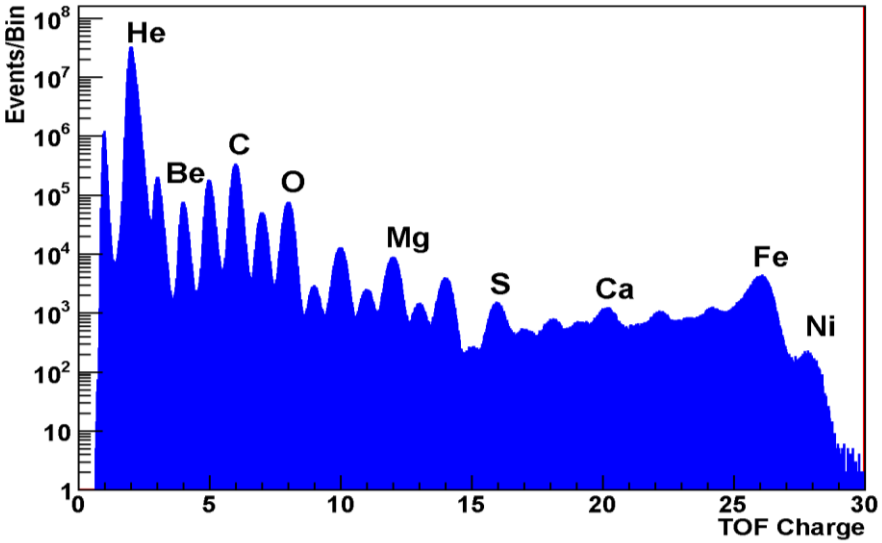
AMS-02 – Time of Flight (TOF)

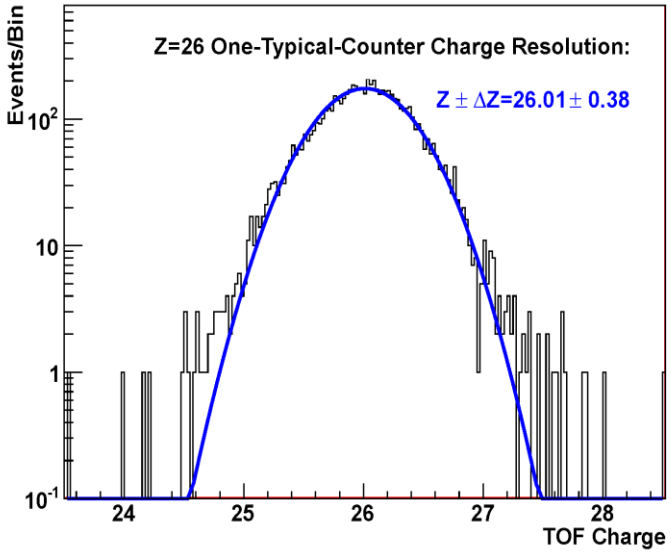
Measures Velocity and Charge of particles



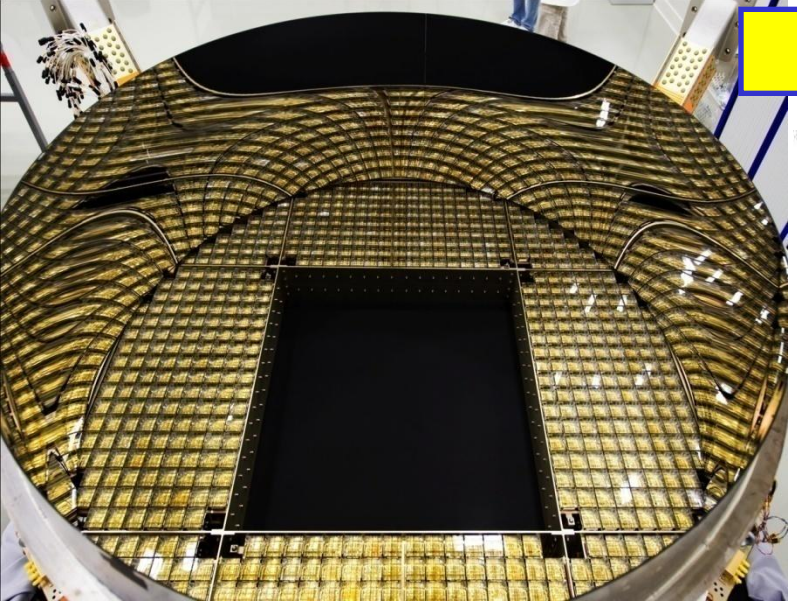


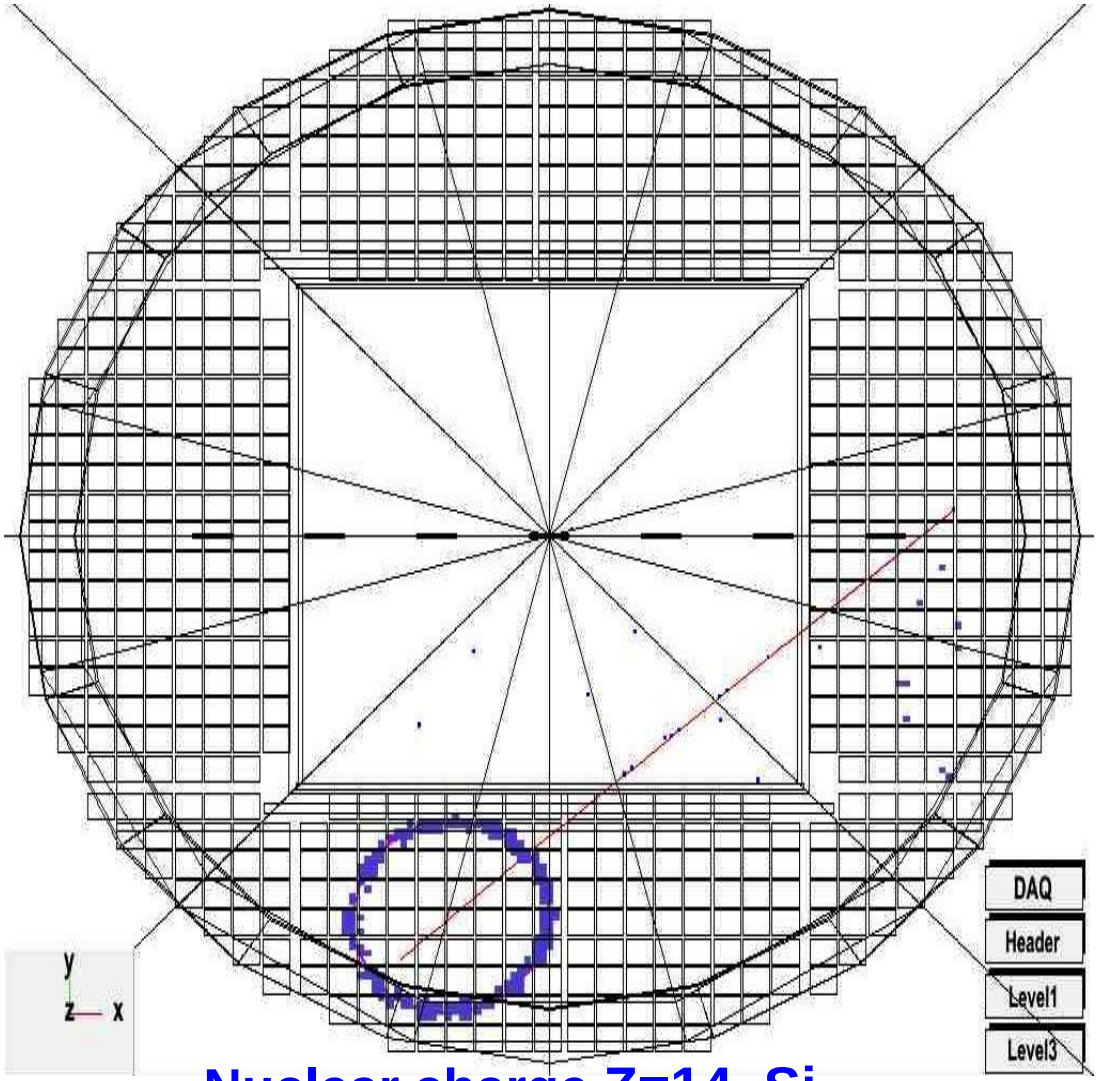


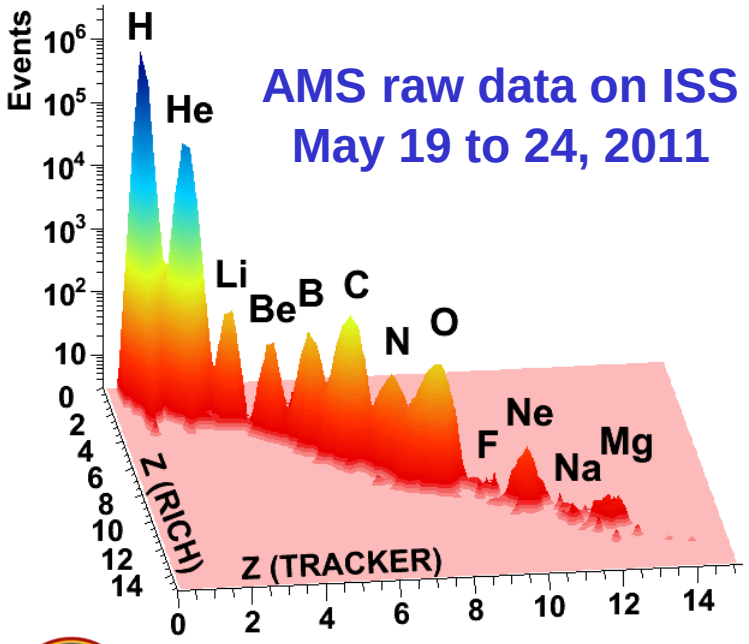




AMS-02 RICH



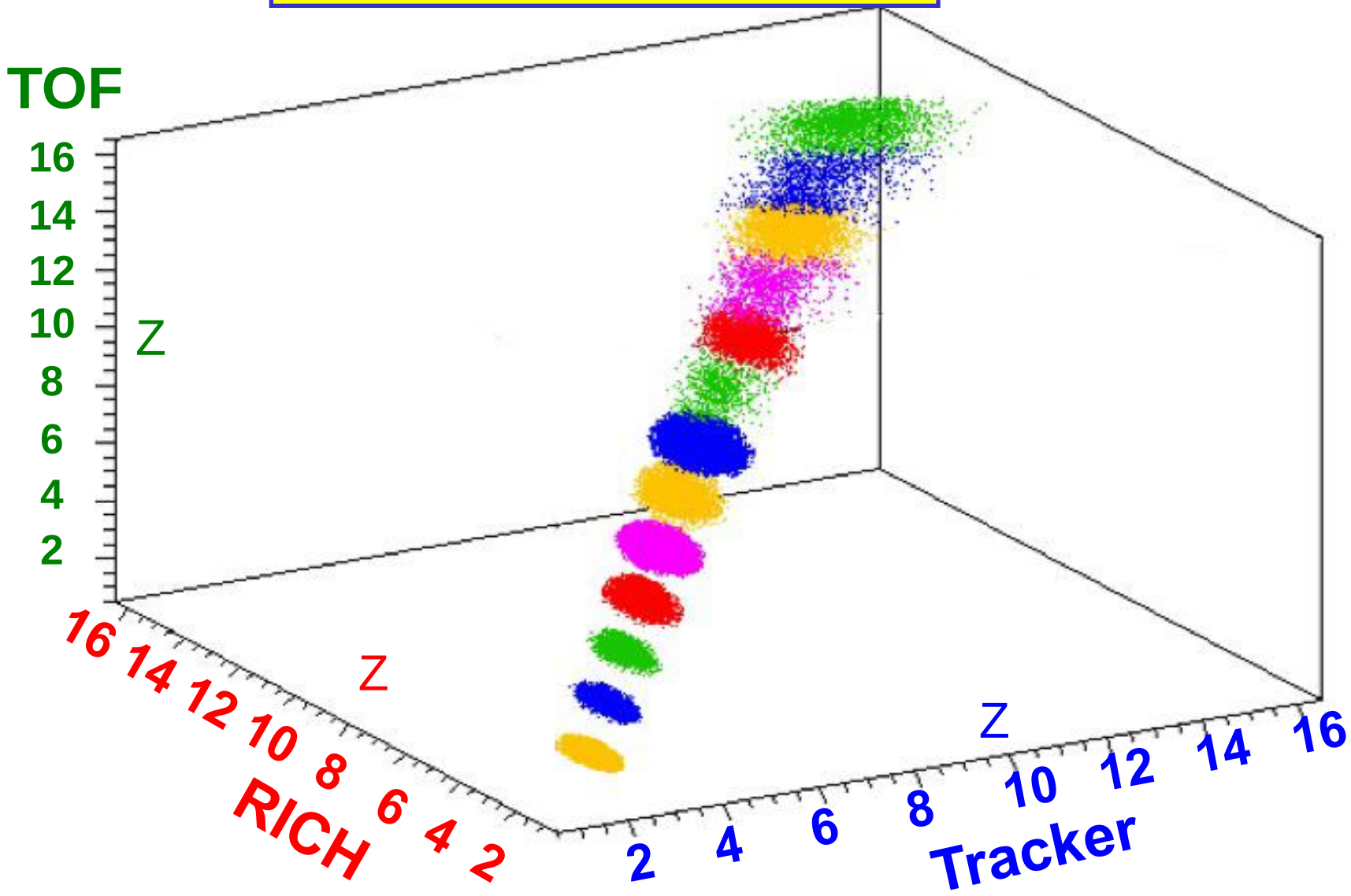




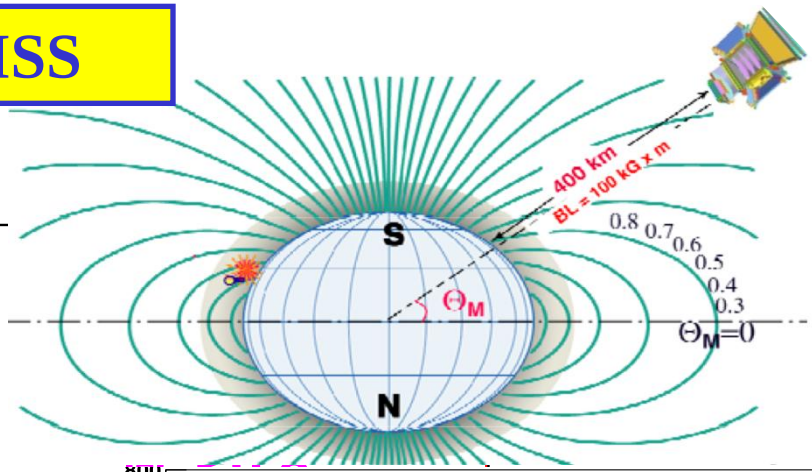
AMS raw data on ISS
May 19 to 24, 2011

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

AMS-02 Charge Identification



AMS-02 Data on ISS



$1.0<\Theta_M$

$0.6<\Theta_M<0.8$

$0.4<\Theta_M<0.6$

$\Theta_M<0.2$

Z=2 OverCutoff β<0.85

^{4}He

3.65±0.09

Z=2 UnderCutoff β<0.85

^{3}He

2.86±0.04

Rigidity (GV)

AMS-02 - Physics Expectations: $e^+/(e^+ + e^-)$

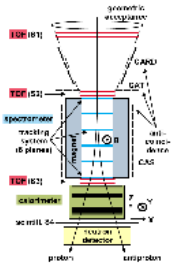
First publication will be on the $e^+/(e^+ + e^-)$ ratio over the $e^\pm$ energy range from 0.5 GeV to 100 GeV to an accuracy of 1 to 2%.

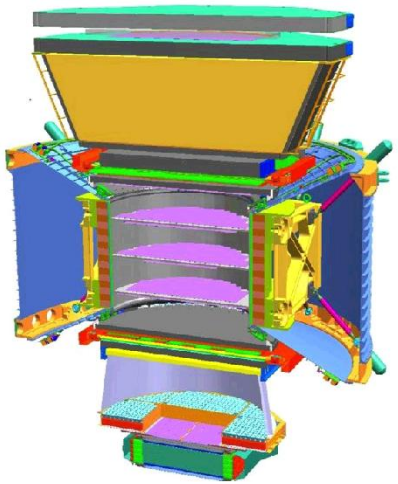
The $e^+/(e^+ + e^-)$ ratio is a sensitive indicator of neutralinos as a candidate of dark matter.

In the energy range between 65 to 100 GeV, there are 1,600 background free positron events.

The $e^+/(e^+ + e^-)$ ratio will be extended to 200, 300, 400, 500 GeV,…,

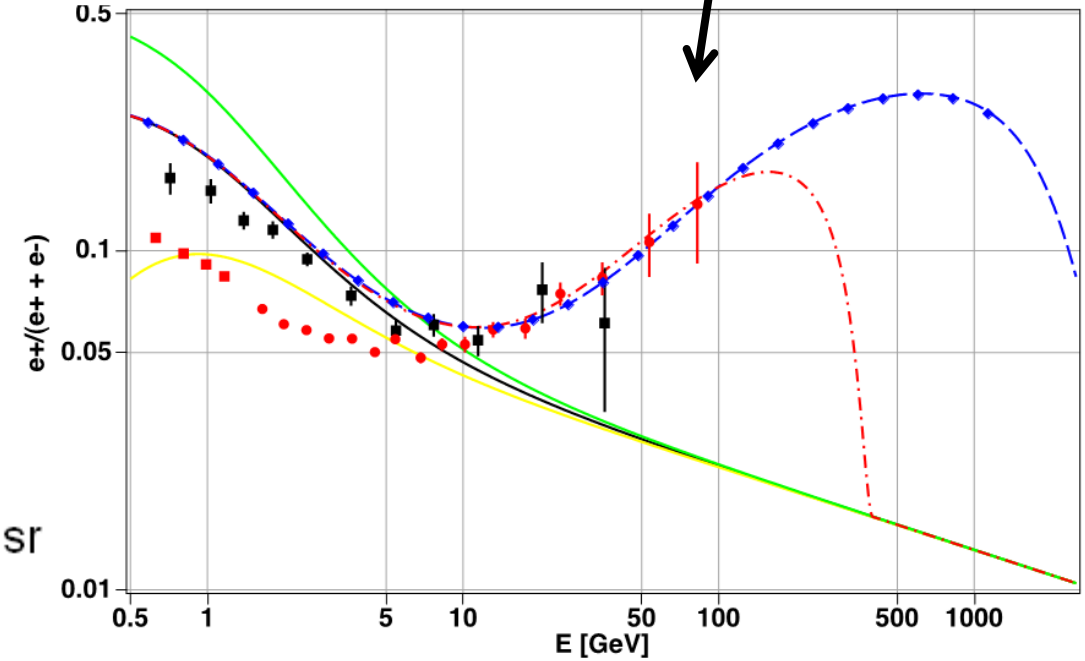
question of statistics.





GF: 21.5 cm^2 sr GF: 250 – 3500 cm^2 sr

AMS-02 prediction, statistical error after 10 years

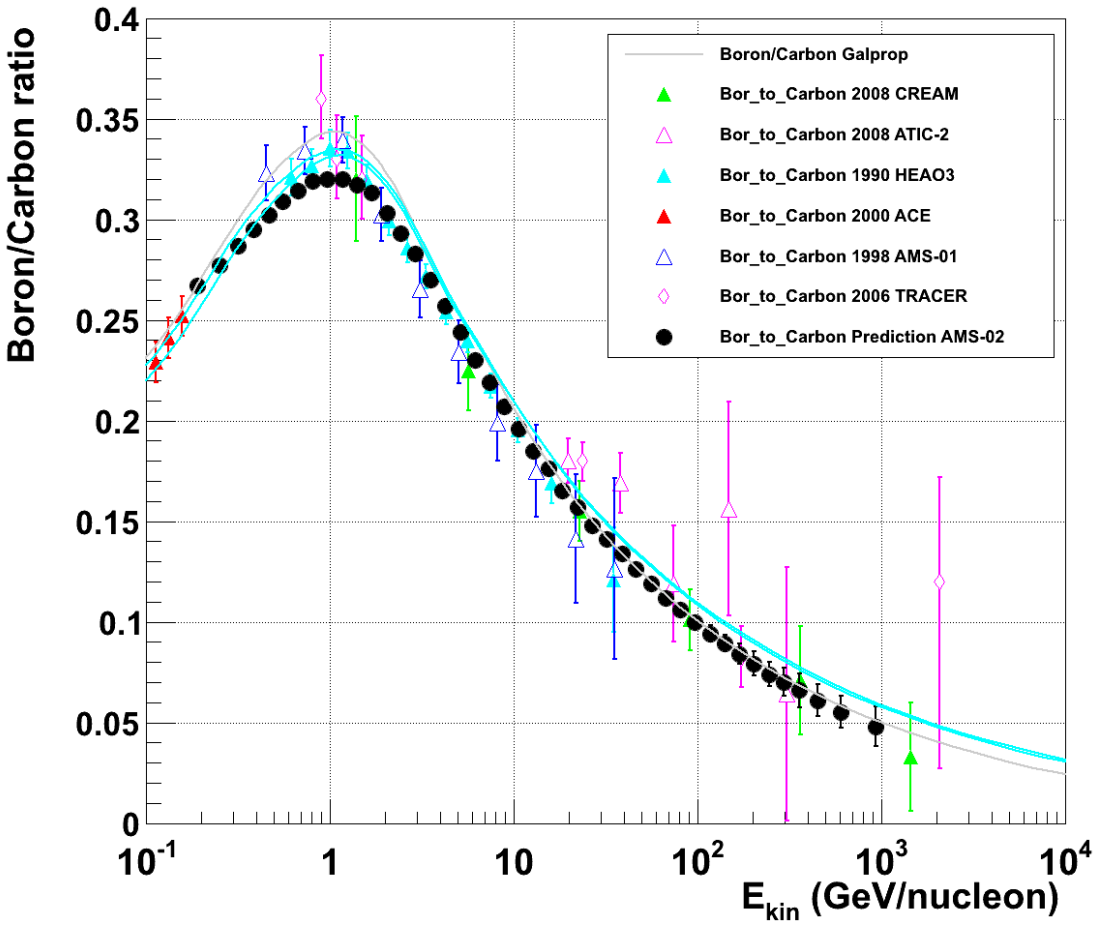


AMS-02 - Physics Expectations: B/C-Ratio

Precise measurement of the energy spectra of B/C provides information on Cosmic Ray Interactions and Propagation

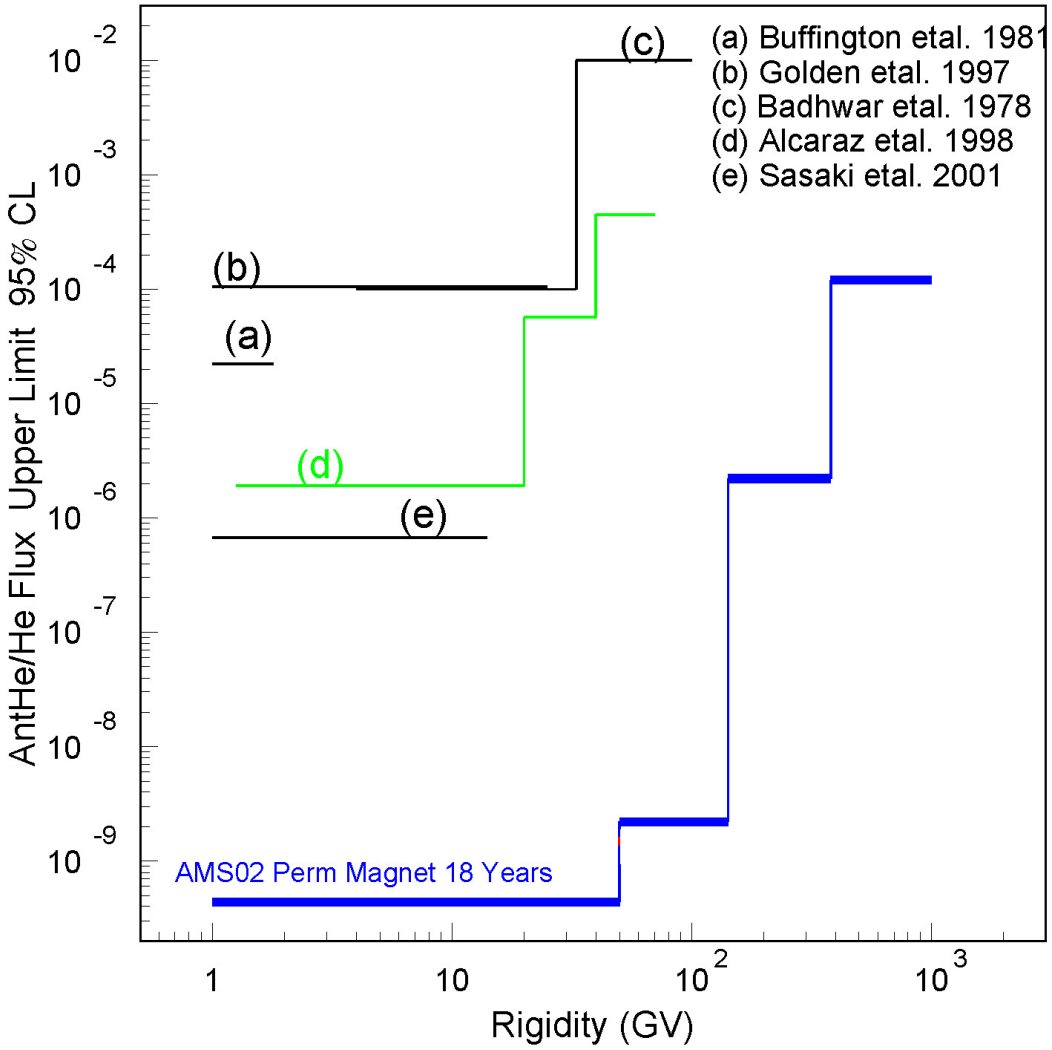
Interactions with the Interstellar Medium:

C + (p,He) → B + ...

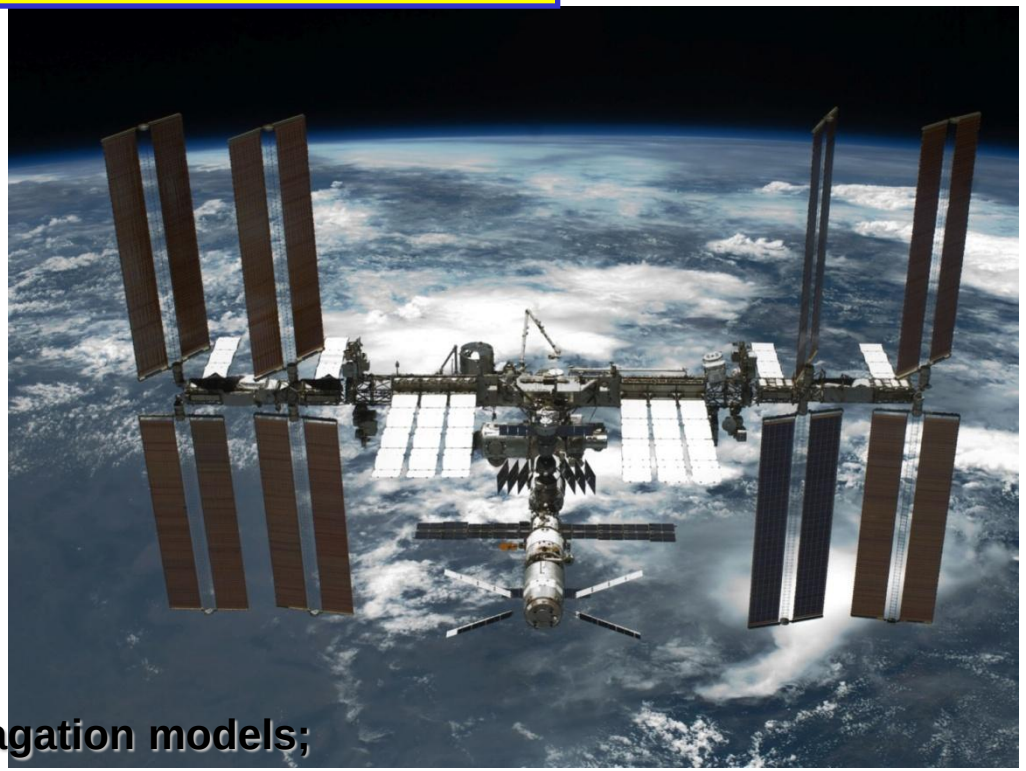


AMS-02 - Physics Expectations: Antimatter-Direct Search

Increase in sensitivity: x 10^3 – 10^6
Increase in energy to ~TeV



AMS-02 - Physics Potentials



- **Searches for primordial antimatter:**

  Anti-nuclei: **He, …**

- **Dark Matter searches:**
  - **e^+ , $e^\pm$, p , …**
  - simultaneous observation of several signal channels.
- **Searches for new forms of matter:**

  strangelets, **…**

- **Measuring CR spectra – refining propagation models;**
- **Identification of local sources of high energy photons (~TeV):**

  SNR, Pulsars, …

- **Study effects of solar modulation on CR spectra over 11 year solar cycle**

"The most exciting objective of AMS is to probe the unknown;
to search for phenomena which exist in nature
that we have not yet imagined nor had the tools to discover."

S. Ting

RWTH AACHEN UNIVERSITY