AMS : Alpha Magnetic Spectrometer

- Introduction
  - Physics goals
  - Principle
- The AMS Instrument
  - Detector concept
  - Construction and performance
- Physics
  - Cosmic Rays
  - Dark Matter



Motivations Astrophysiques

- **Noyaux secondaires**

  CNO spallation → Li, Be, B

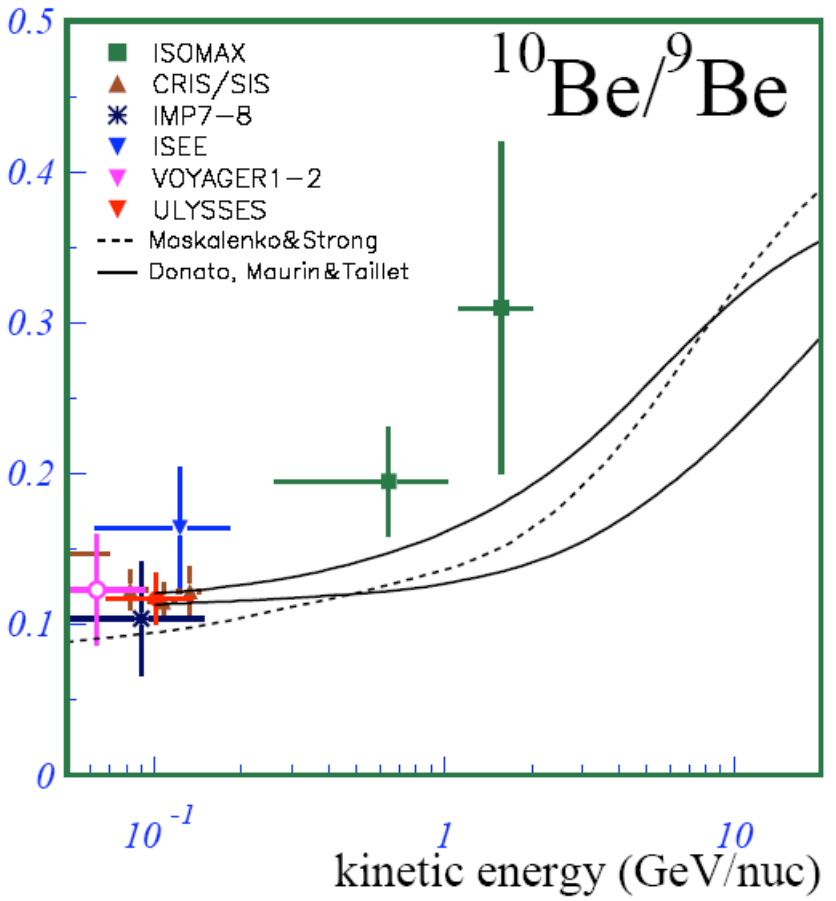
  Information sur la propagation des rayons cosmiques dans la galaxie

- **Horloge des rayons cosmiques (RC)**

  Présence de noyaux radioactifs tel le ^{10}Be ($t_{1/2}$~1.5 10^6 ans)

  ^{10}Be/^{9}Be apporte des informations sur le confinement des RC dans la galaxie

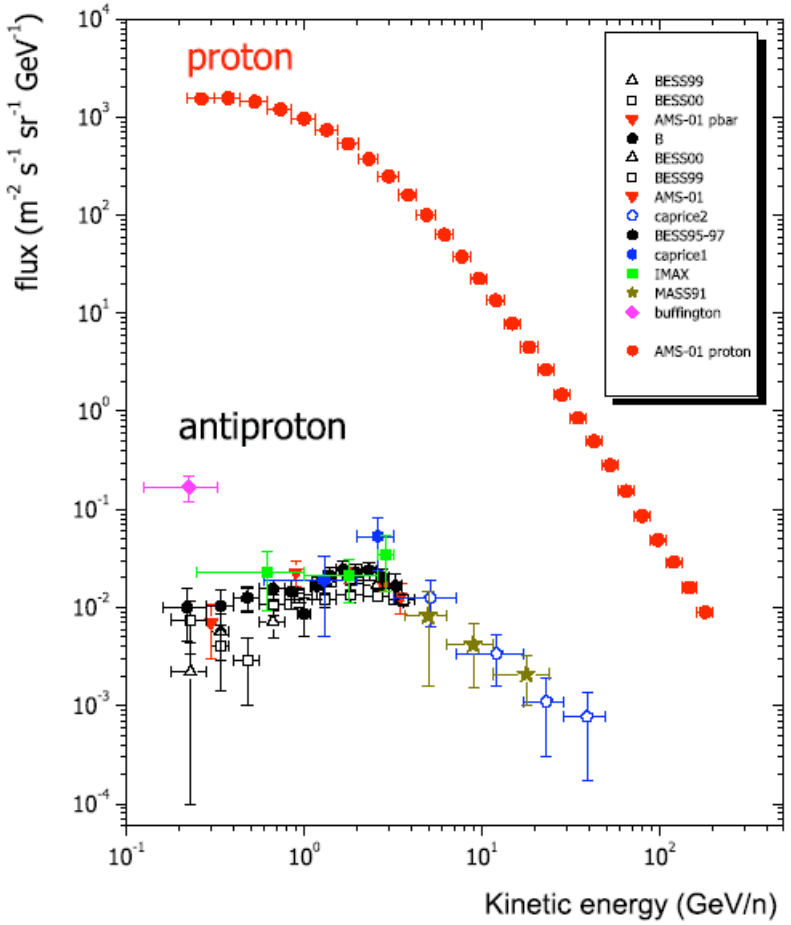
- **Mesures isotopiques actuelles:**
  - Faible statistique
  - Basse énergie



⇨ **Besoin d'améliorer les mesures actuelles isotopiques**

La quête de l'antimatière

- Matière et d'antimatière également produites après le Big Bang
- Qu'observe t on à présent ?
  - Faible flux d'antiparticules
    Provenant essentiellement de productions secondaires
  - Un rapport baryon-photon: $N_B/N\gamma \sim 10^{-10}$
    BBN prédiction $N_B/N\gamma \sim 10^{-19}$
- Différents modèles pour expliquer cette Asymétrie observée
  - mécanisme de baryogenèse, Violation CP, violation du nombre baryonique
  - Scénarios alternatifs avec la présence de bulles



$$\frac{\Phi_{\bar{p}}}{\Phi_p} \sim 10^{-4} - 10^{-5}$$

⇨ **La détection anti H*e* ou anti C pourrait révéler la présence de l'antimatière primordiale ou d'anti-étoiles (resp)**

La quête de la matière noire

Des mesures expérimentales: une large fraction de la matière est non baryonique

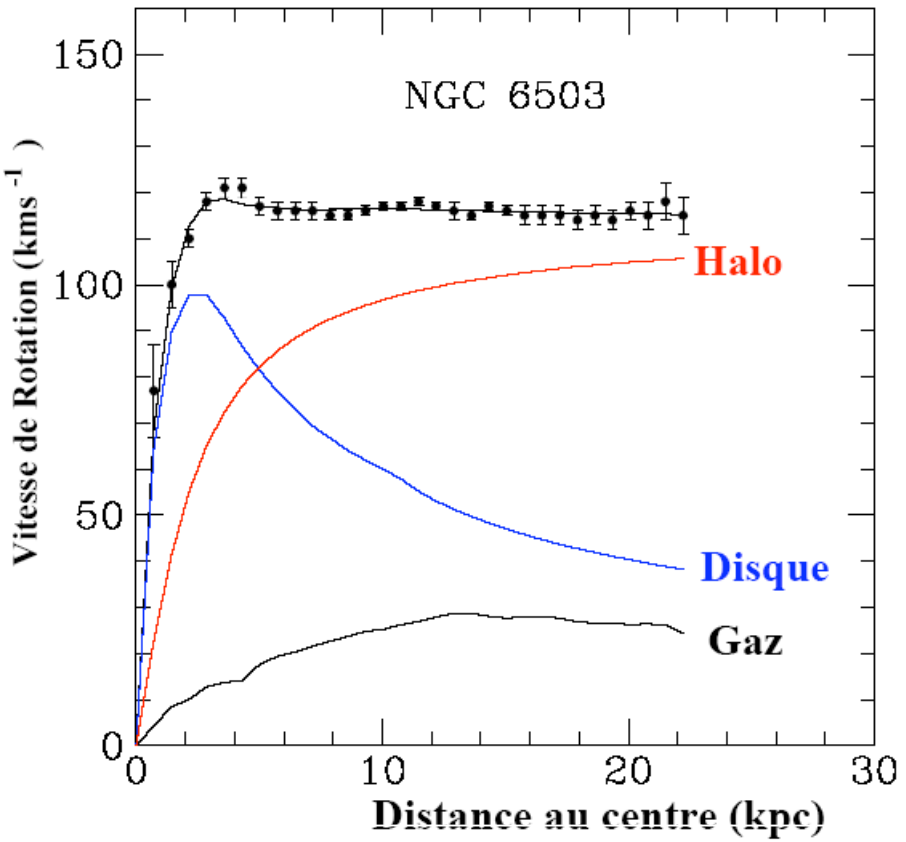
- L'essentiel de la masse de l'univers est cachée (90 %)

  Ω_m=0.3 (Ω_b=0.05, BBN)

- Courbes de rotation des galaxies indiquent la présence d'un halo galactique non lumineux

- Nature de la matière cachée ? WIMP ?

  la supersymétrie propose un candidat: χ



⇨ **distorsions possibles des spectres en: e^+,anti p,anti D, γ, produits d'annihilations des χ**

Mesures des flux des rayons cosmiques

- Loi de puissance en

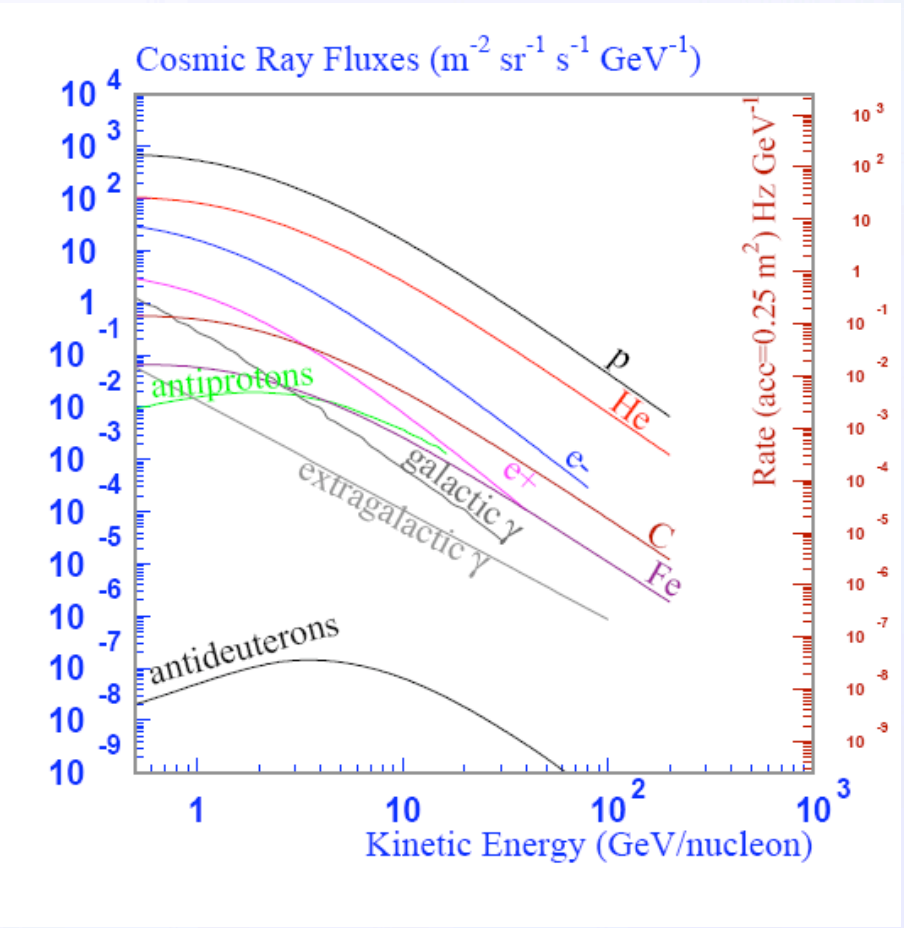
en $E^{-\gamma}$ γ[2-3]

- Les protons constituent

88 % du RC

- Signal:anti particule
  medure du fond(p,He,e)

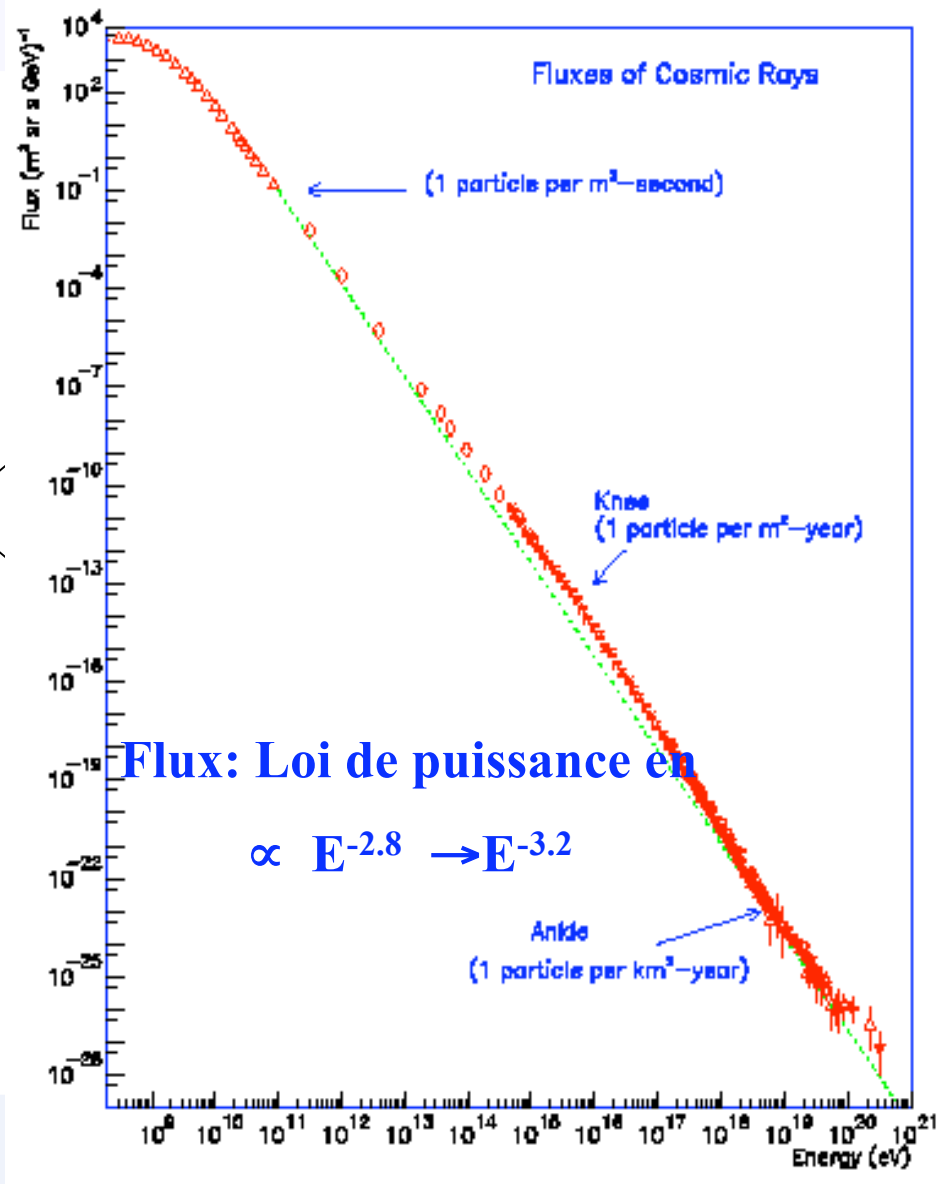
protons	~ 1
heliums	$\sim 10^{-1}$
electrons	$\sim 10^{-2}$
positrons	$\sim 10^{-3}$
carbon	$\sim 10^{-4}$
iron	$\sim 10^{-5}$



Les implications pour l'expérience

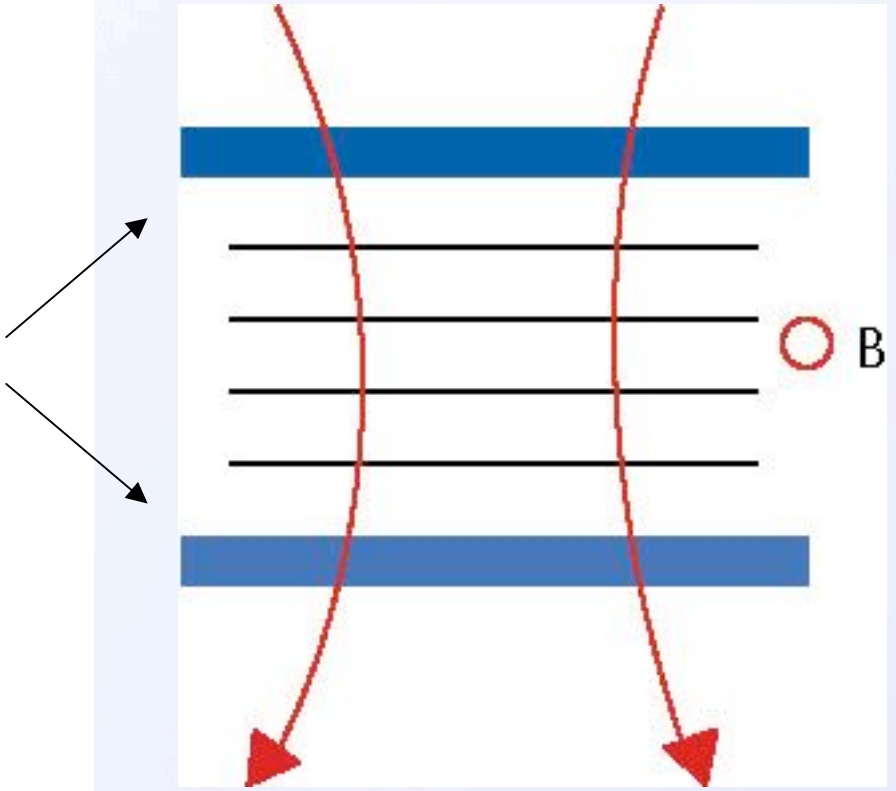
- Grande statistique en flux de particules primaires
- Identification: mesure de la charge et de la masse
- Rejection du fond des secondaires (interaction des primaires dans l'atmosphère)

⇨ **Nécessite de se placer dans l'espace longtemps (au moins 3 ans)**



Les implications pour le détecteur

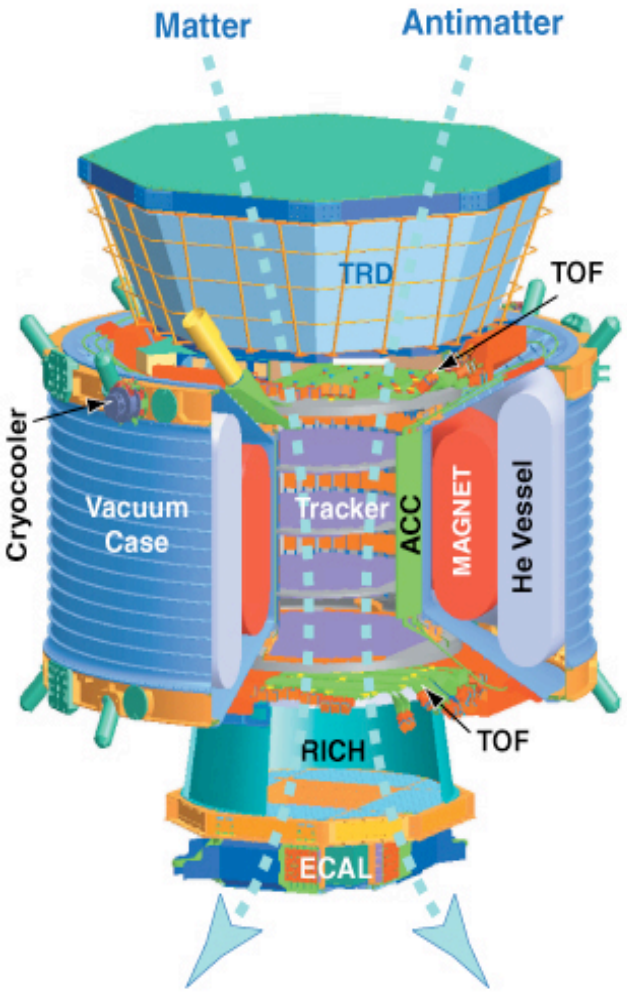
- Distinguer le signe de la charge de la particule
  - un aimant + traceur
  - mv/Z ∝ RB
- Distinguer le sens (haut/bas)
  - temps entre 2 compteurs
- Identifier la nature
  - masse m et charge
  - Particule electromagnetique
  - Separation e/p
- Redondance :
  - plusieurs systèmes différents pour mesurer Z, v



⇨ **Un détecteur type physique des hautes énergies**

AMS2: Alpha Magnetic Spectrometer

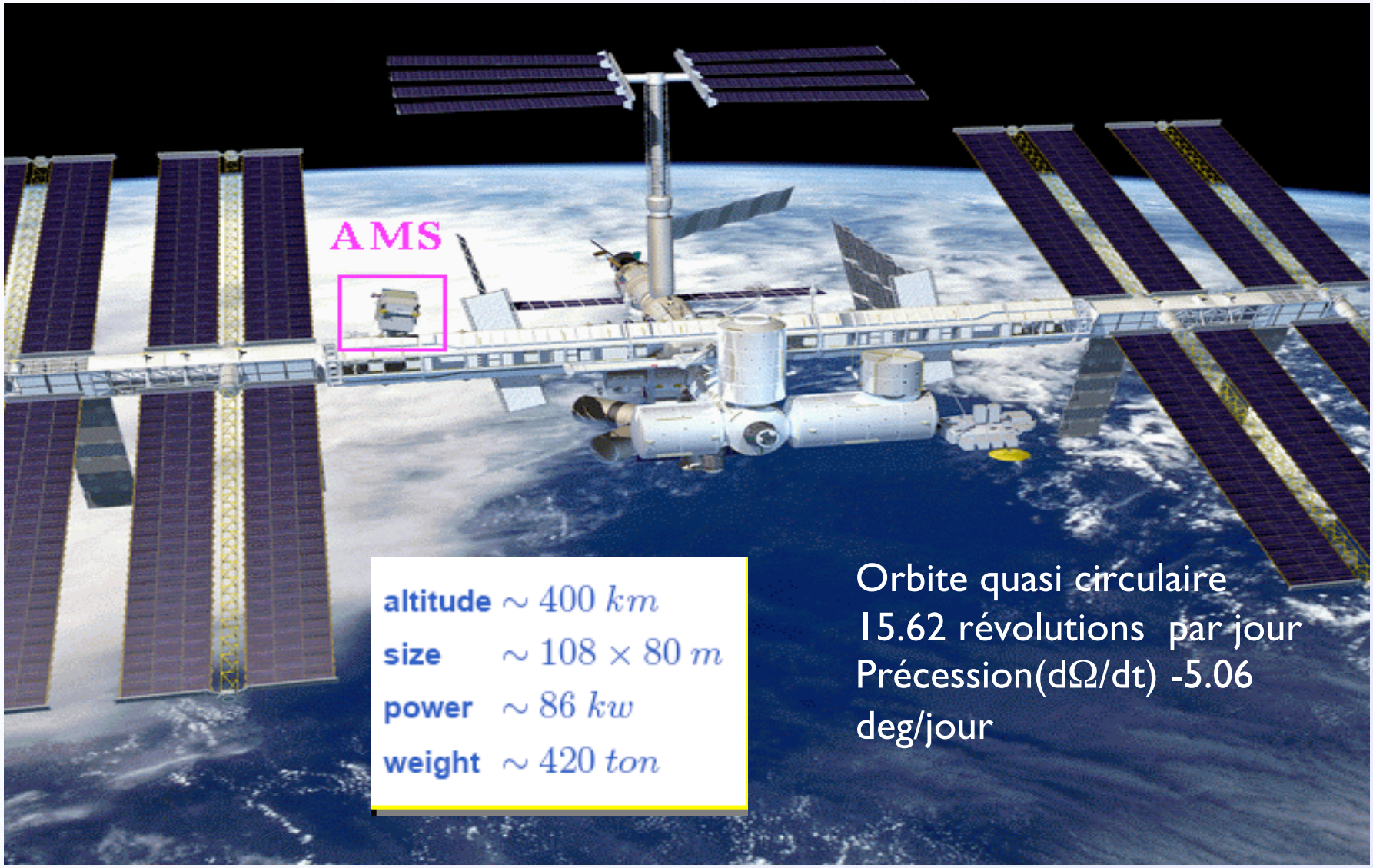
AMS: A TeV Magnetic Spectrometer in Space (3m x 3m x 3m, 7t)



300,000 channels of electronics $\Delta t = 100$ ps, $\Delta x = 10\mu$

0.3 TeV	e^-	e^+	P	$\bar{He}$	γ
TRD					
TOF					
Tracker					
RICH					
Calorimeter					

Where: International Space Station

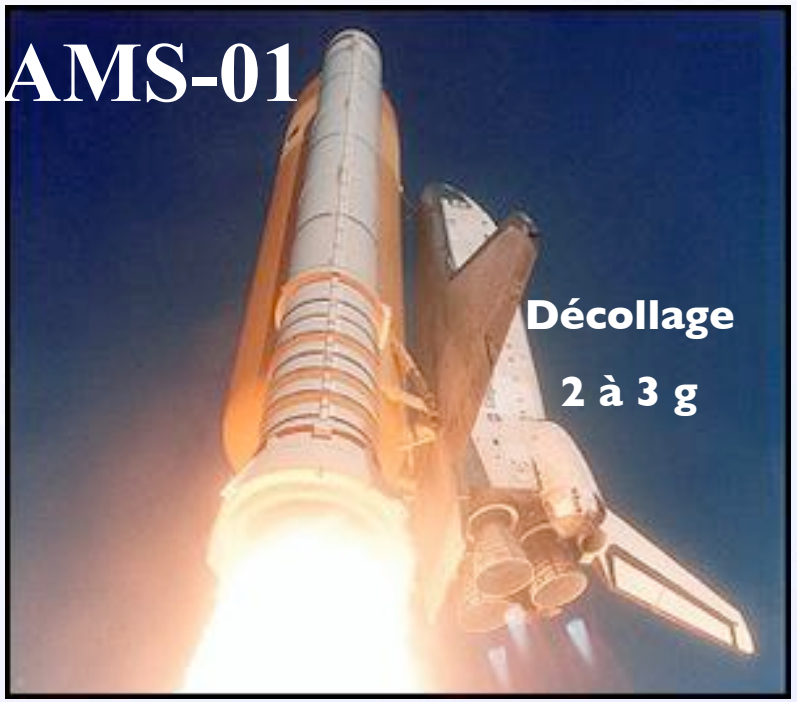


Orbite quasi circulaire
15.62 révolutions par jour
Précession(dΩ/dt) -5.06 deg/jour

Contraintes du spatial

- Poids : 7 tonnes maximum (exp. LHC ~ 1000 tonnes)
- Faible consommation : 2 kW (conso four électrique)
- Température: ± 50 ºC
- Sans assistance humaine redondance
- Vide
- Survivre au lancement
- Tests des qualifications spatiales (rayonnement,thermique et vibration)

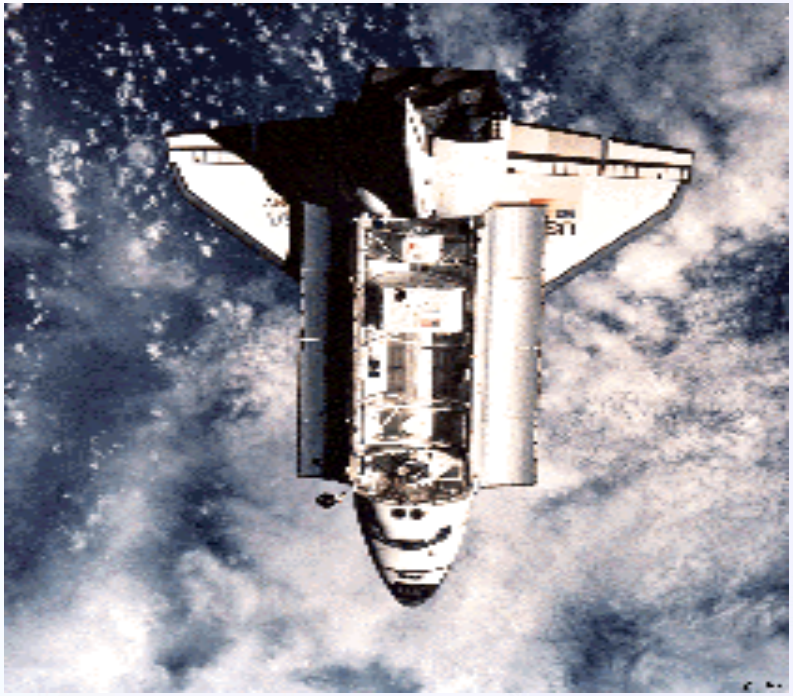
Test de faisabilité : AMS-01



Vol “test” précurseur en Juin 1998
10 jours sur la navette Discovery

Résultats de Physique :

Physics Report 366/6, August 2002, p333-404

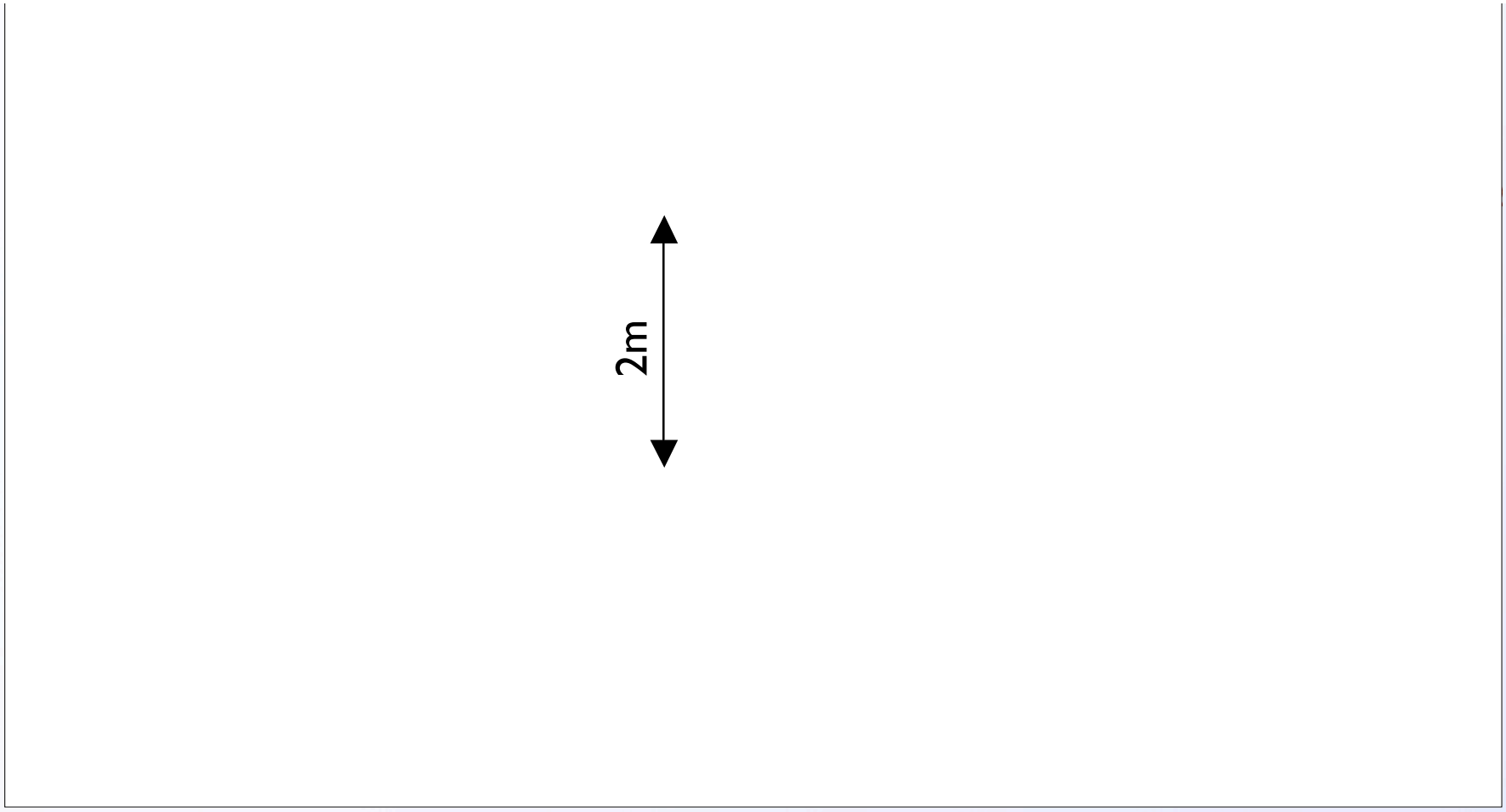


Choc atterrissage 12 g



Leçons apportées par AMS01:

- Accroître la performance de l ’identification des particules et séparation de charge
- Plus de redondance et de recouvrement
- Étendre le domaine en énergie



AMS1 vers AMS2

▷ Amélioration des performances

- Plus grande acceptance

  ~ 0.5 m^2.sr
- Un aimant supraconducteur

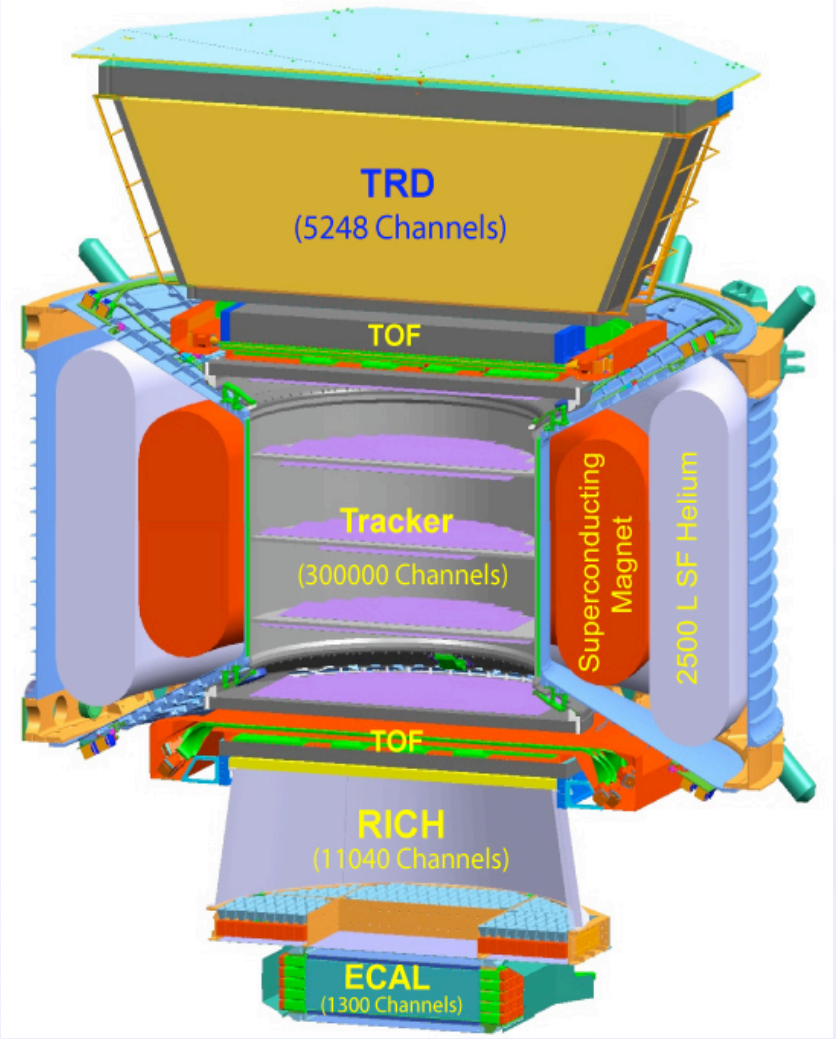
  Un champ magnétique ~ x 8
- Un trajectometre en silicium plus grand

  8 plans double-sided:

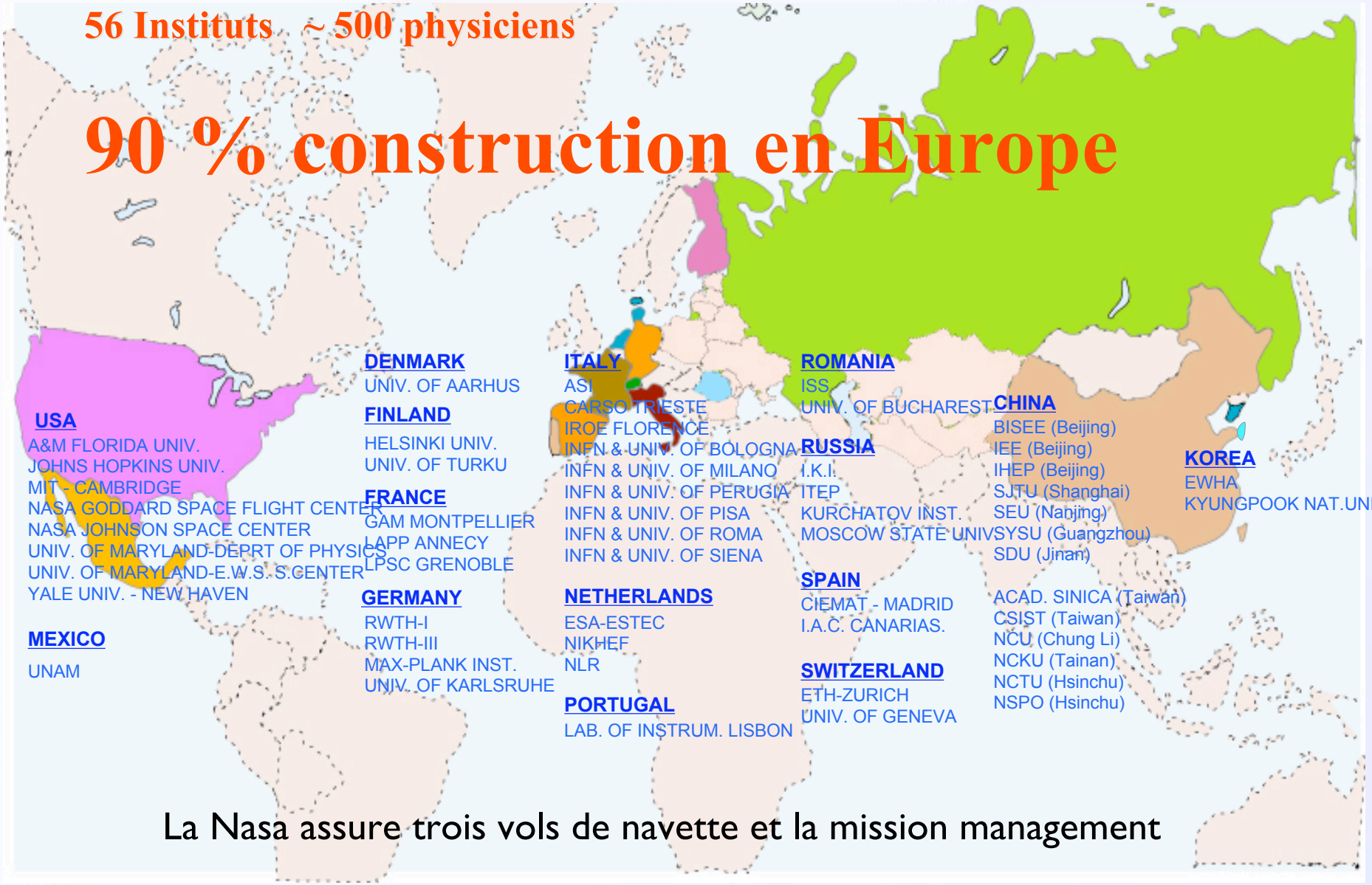
  ~6.5 m^2 de surface de Si
- Gain d'un facteur 10 sur la mesure de l'impulsion

▷ Nouveaux détecteurs

- Un détecteur à radiation de transition:TRD
- Un détecteur PID nouveau:RICH
- Un calorimètre électromagnétique:ECAL



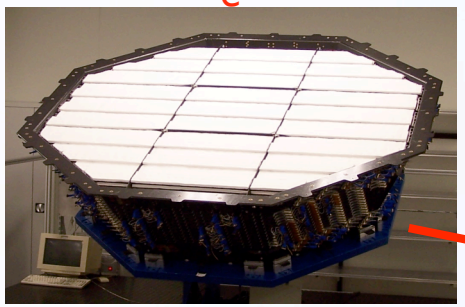
AMS2 une collaboration internationale



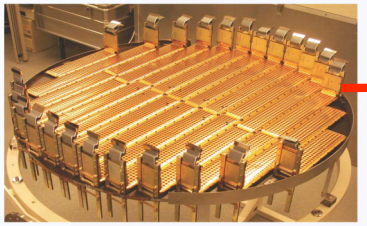
La Nasa assure trois vols de navette et la mission management

The AMS 02 Detector

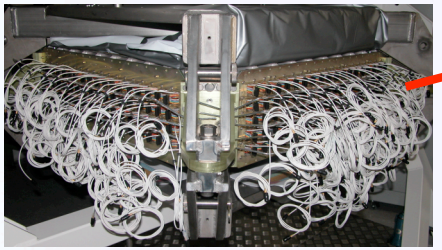
TRD
e

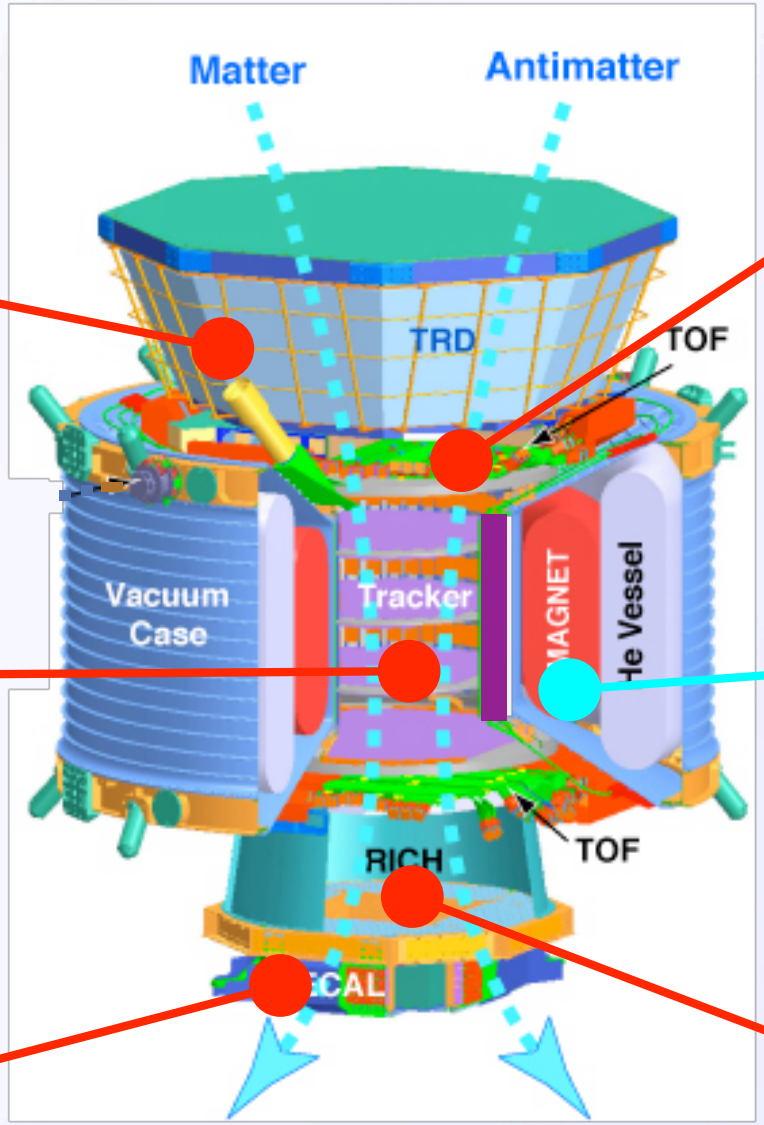


Silicon Tracker
Z, P



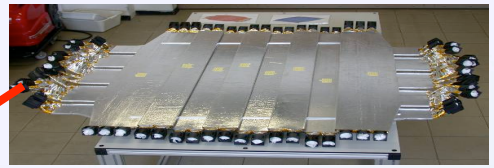
Calorimeter
e, γ



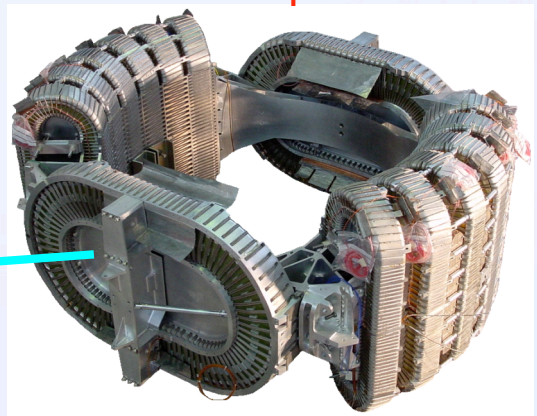


Size: 3m x 3m x 3m
Weight: 7 tons

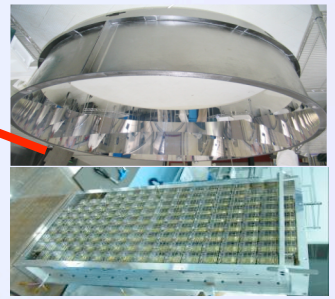
Time of Flight
v, Z



Magnet
P



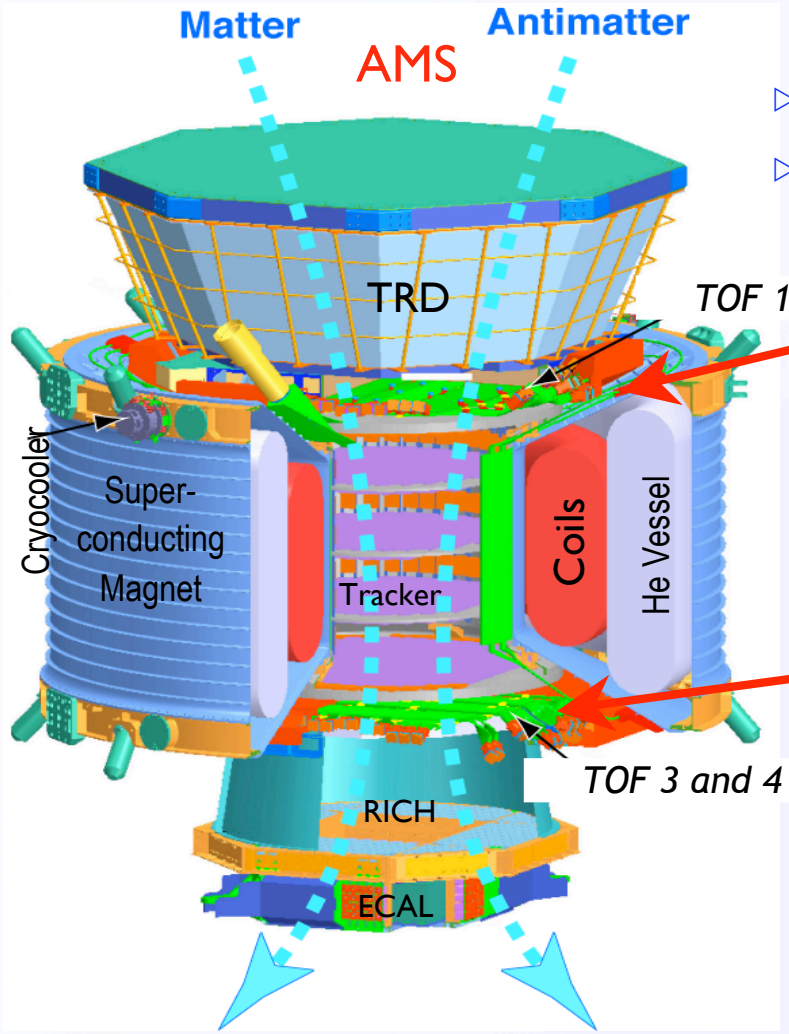
RICH
v, Z



Time Of Flight

- Velocity measurement, v=distance/Δt

  $\Delta\beta/\beta \approx 3\%$
- Charge measurement (Z^2)
- Trigger

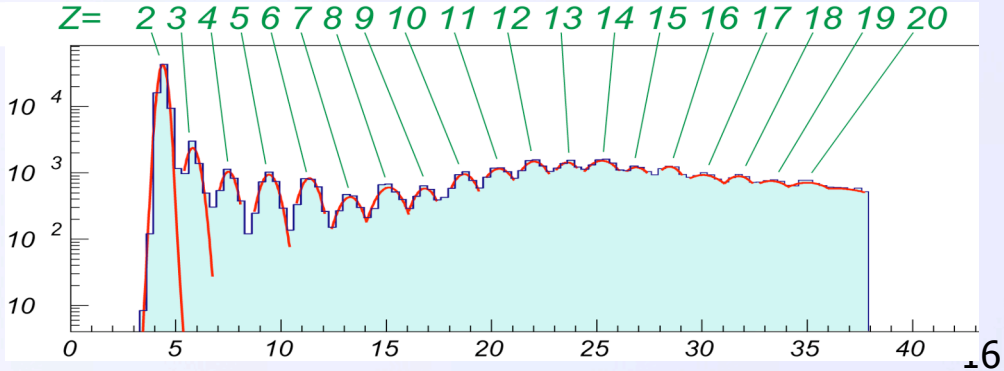




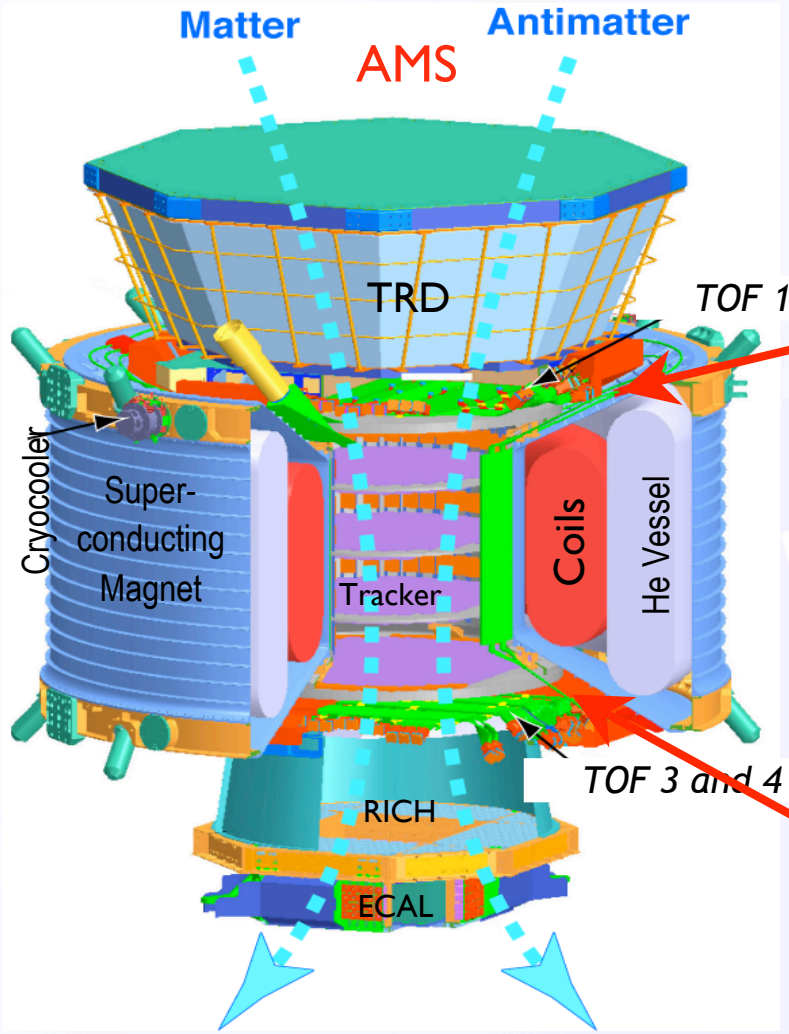
Δt>0

accuracy of 100 ps





Time Of Flight





PMTs

PMTs

Scintillator

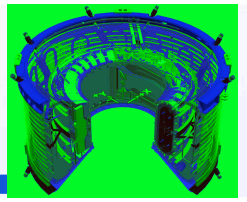


Light Guides

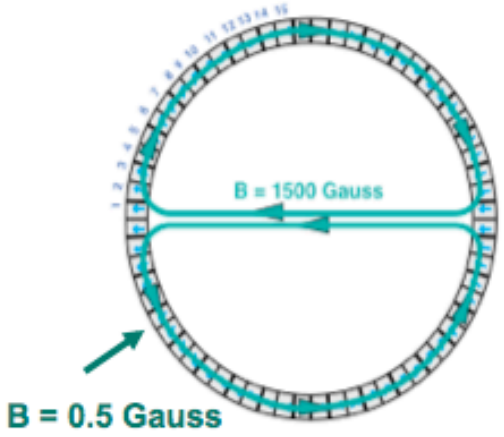
Light Guides



Magnet



There has never been a superconducting magnet in space
due to the extremely difficult technical challenges

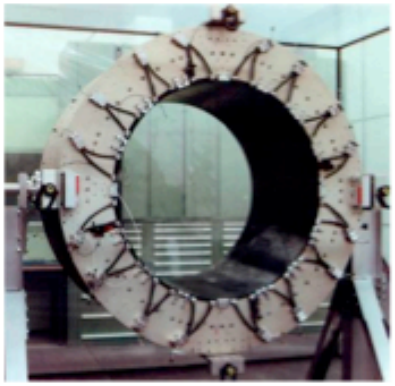


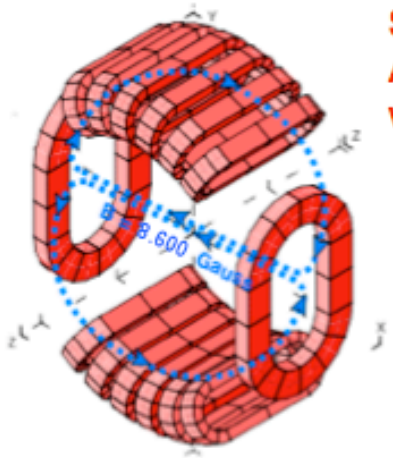
STEP ONE: AMS-01
A Permanent Magnet to fly on the Shuttle

1- Minimum torque from Earth's magnetic field

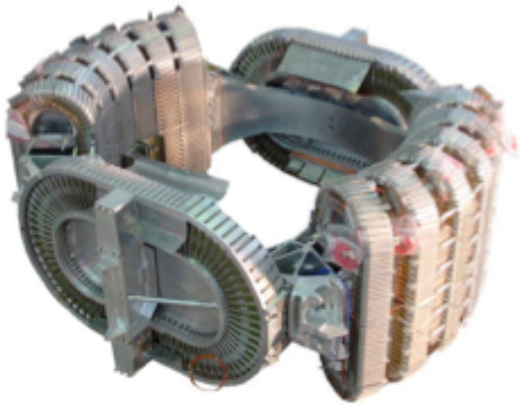
2- Minimum field leakage

3- Minimum weight: no iron

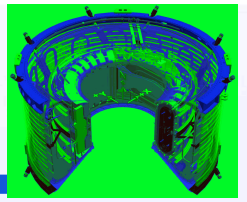




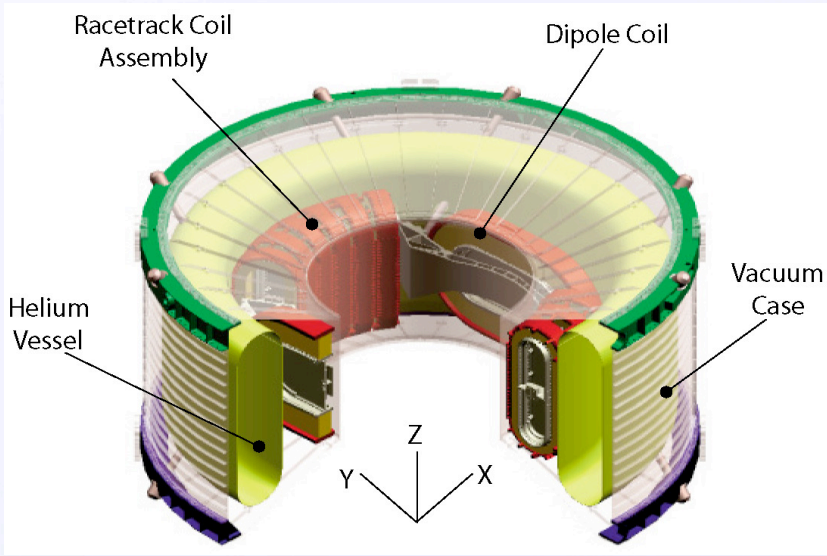
STEP TWO: AMS-02
A Superconducting Magnet
with the same field arrangement

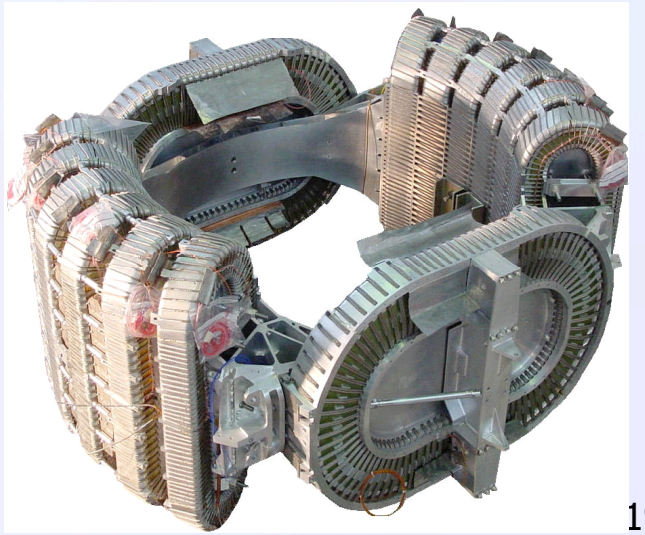


Superconducting Magnet

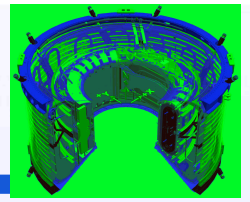


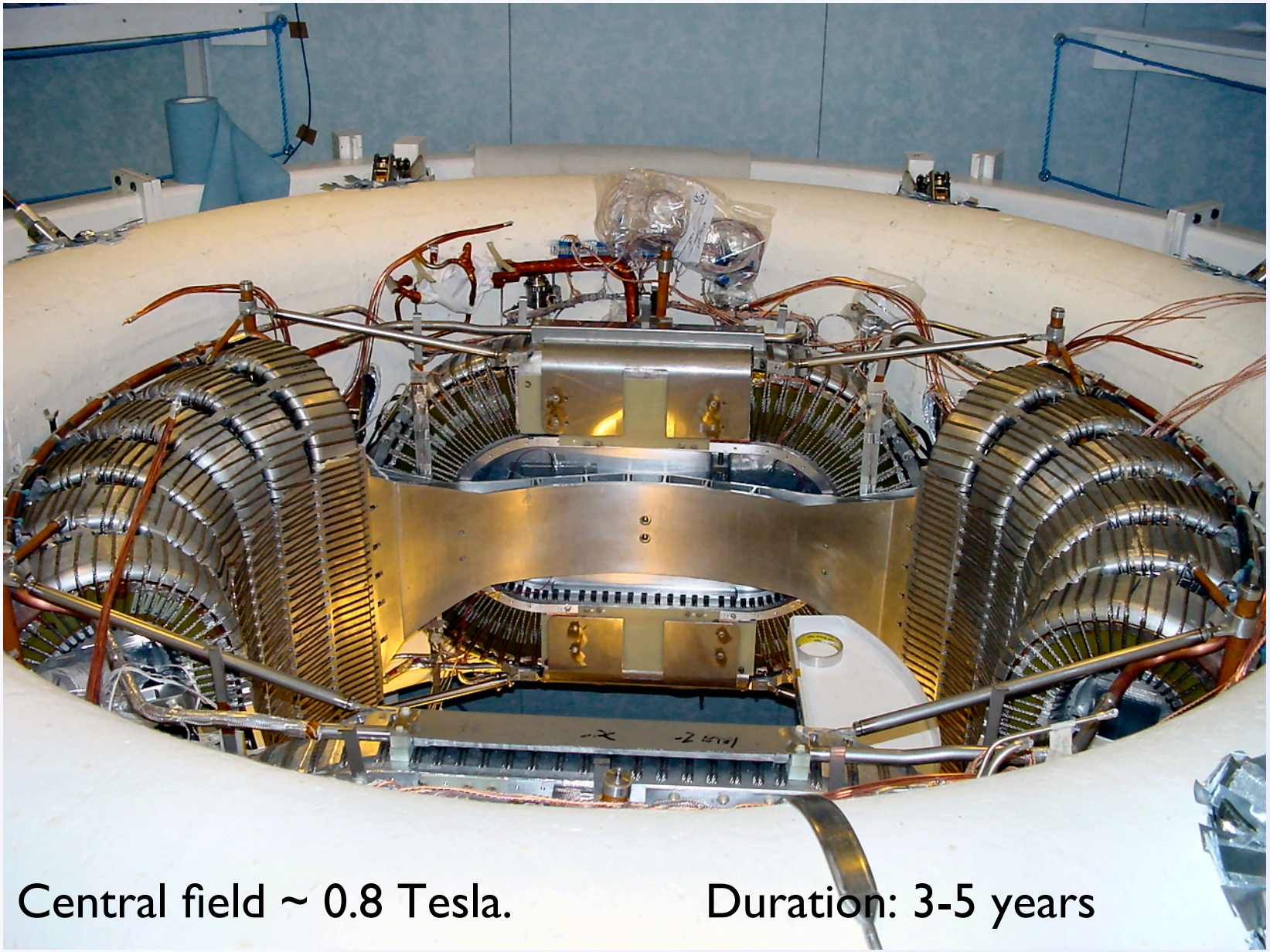
- 2 ‘dipole’ coil, 12 ‘racetrack’ coil (~ no magnetic dipole moment, 15 mT @230 cm)
- B~0.8 T, 1.1 m inner diameter, 2360 Kg weight,
- 55 Km of superconducting wire (NbTi/Cu embedded in pure aluminium)
- Indirect cooling with superfluid helium (1.8 K)
- 2500 liters helium vessel plus cryocoolers for 3 years operation





Magnet

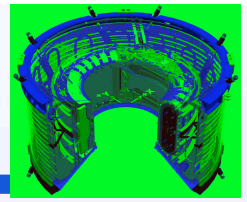




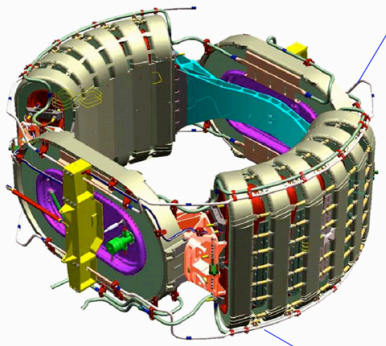
Central field ~ 0.8 Tesla.

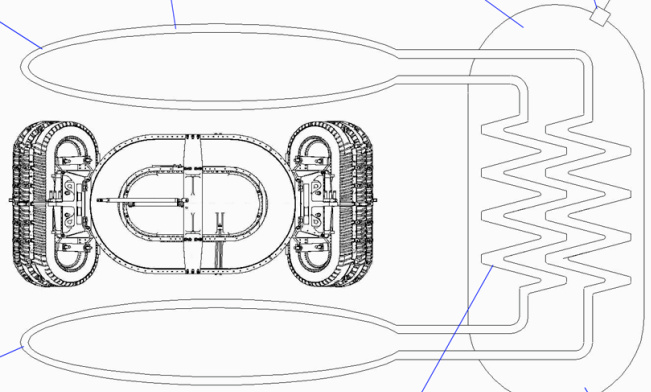
Duration: 3-5 years

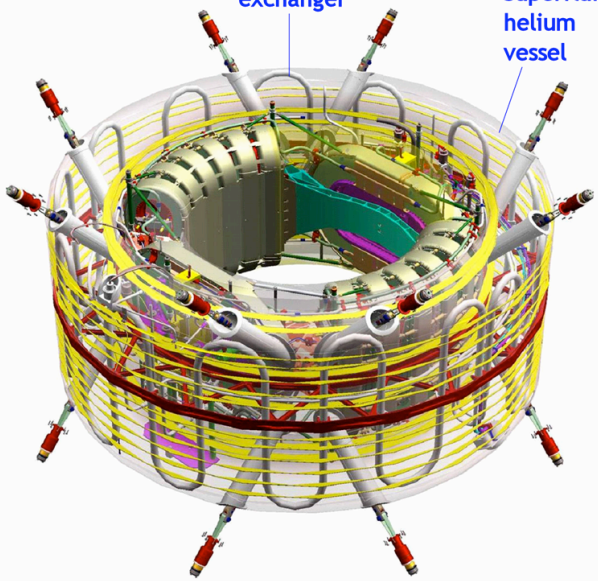
Magnet







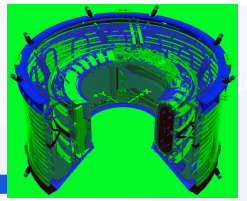


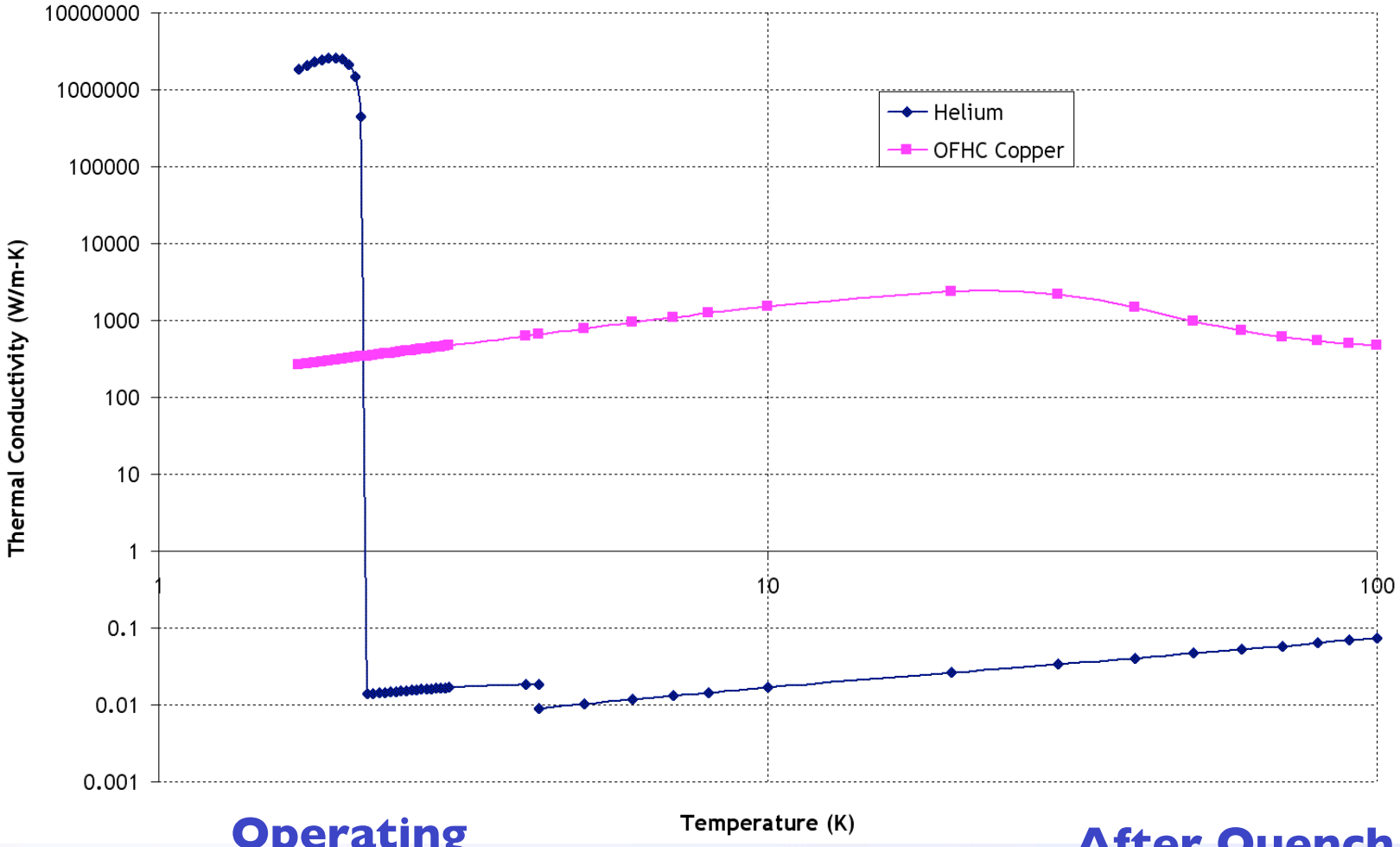


AMS uses a superfluid cooling loop which allows heat to be removed from the coils in a very efficient

and lightweight manner.

Magnet - Performance



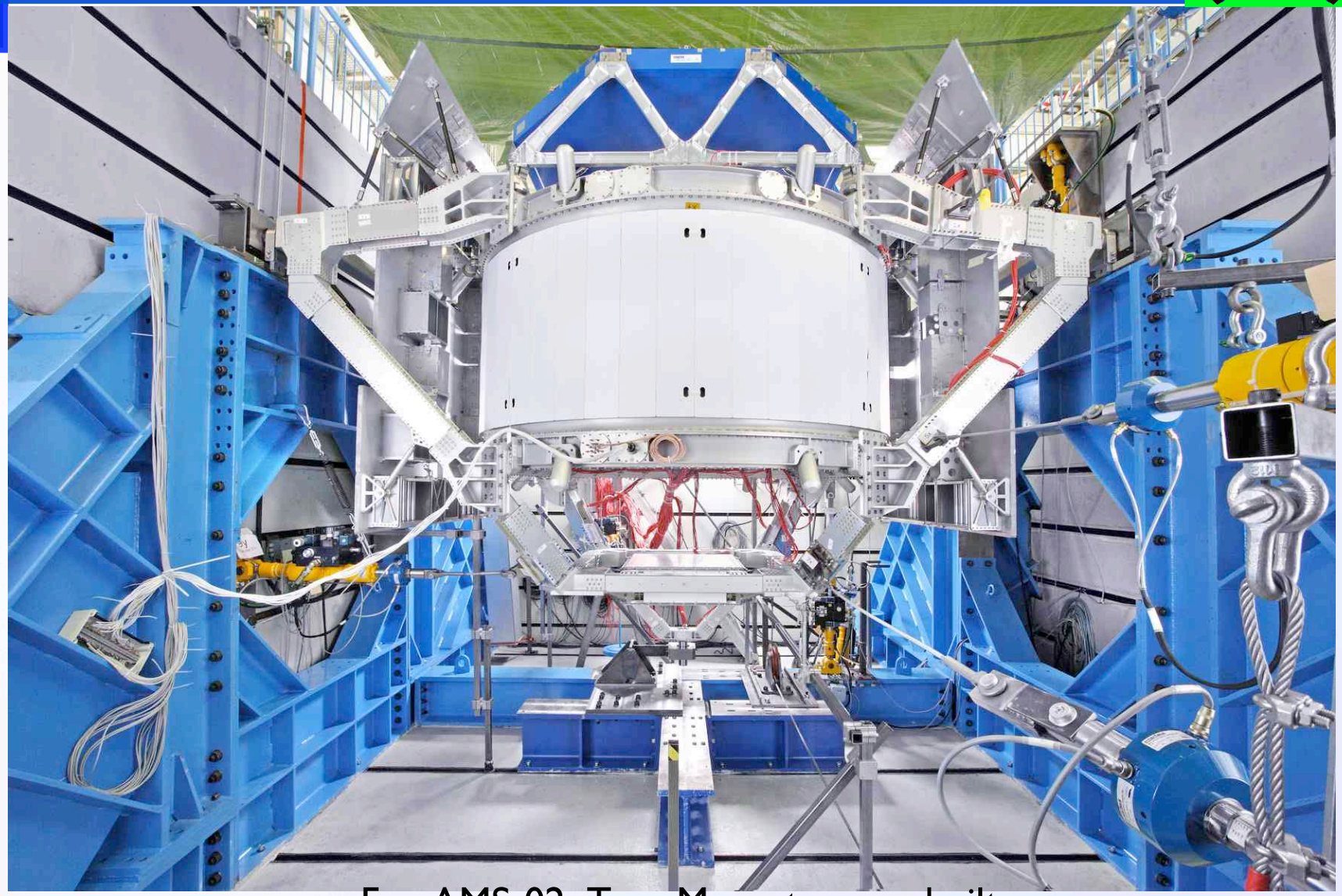


Operating Temperature, 1.8 K

After Quench Temperature ~70 K

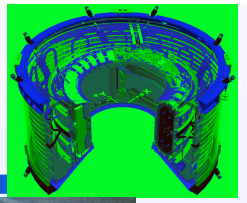
The thermal conductivity of helium has a unique characteristic at temperatures close to 2.2 K, so it can be used as a thermal switch to decouple the magnet from the helium tank.

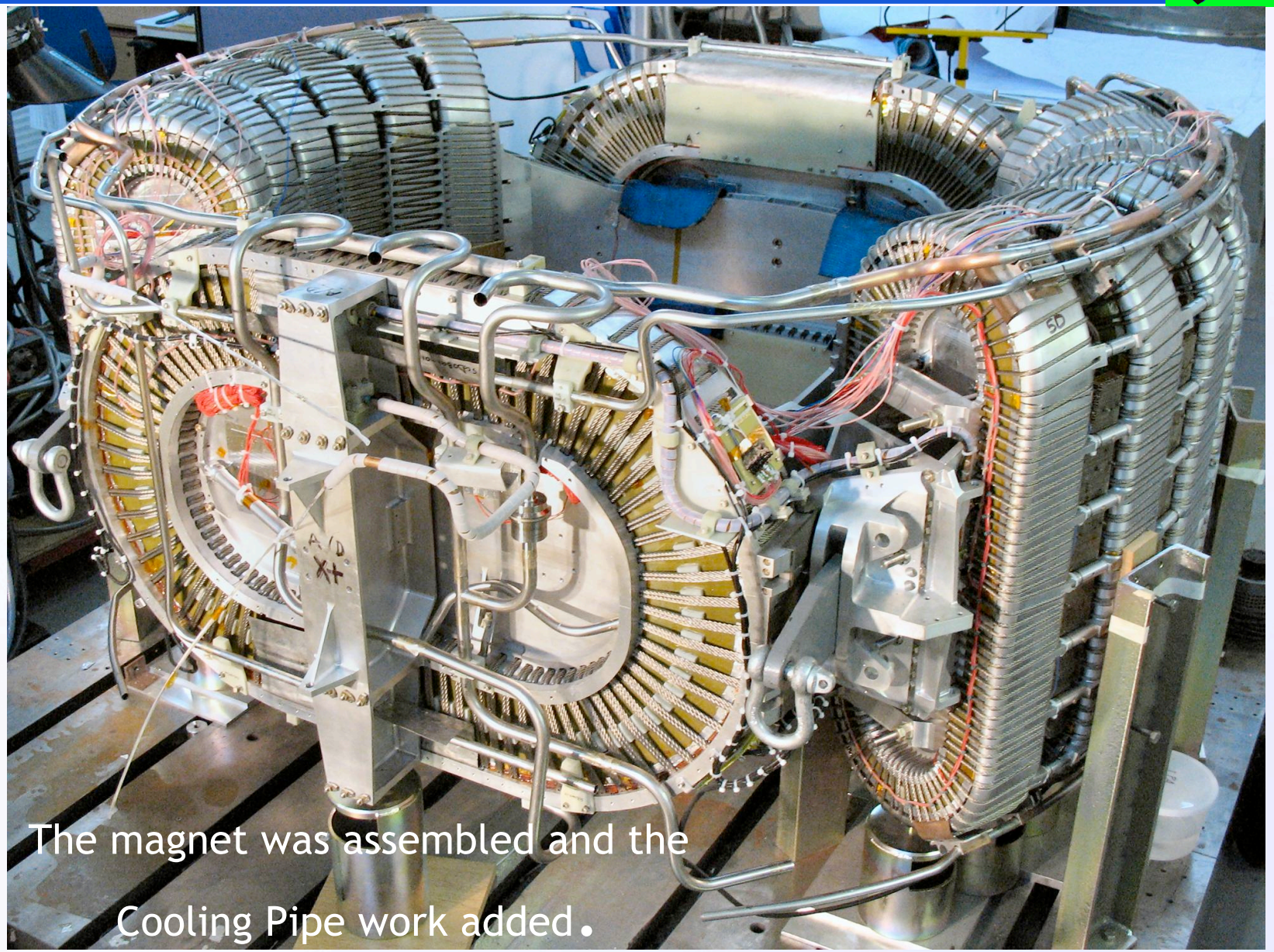
Superconducting Magnet - Tests



For AMS-02, Two Magnets were built:
One for Space Qualification Tests in Germany and Italy

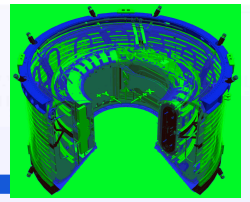
Super conducting Magnet





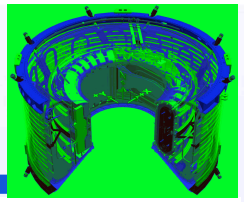
1. The magnet was assembled and the Cooling Pipe work added.

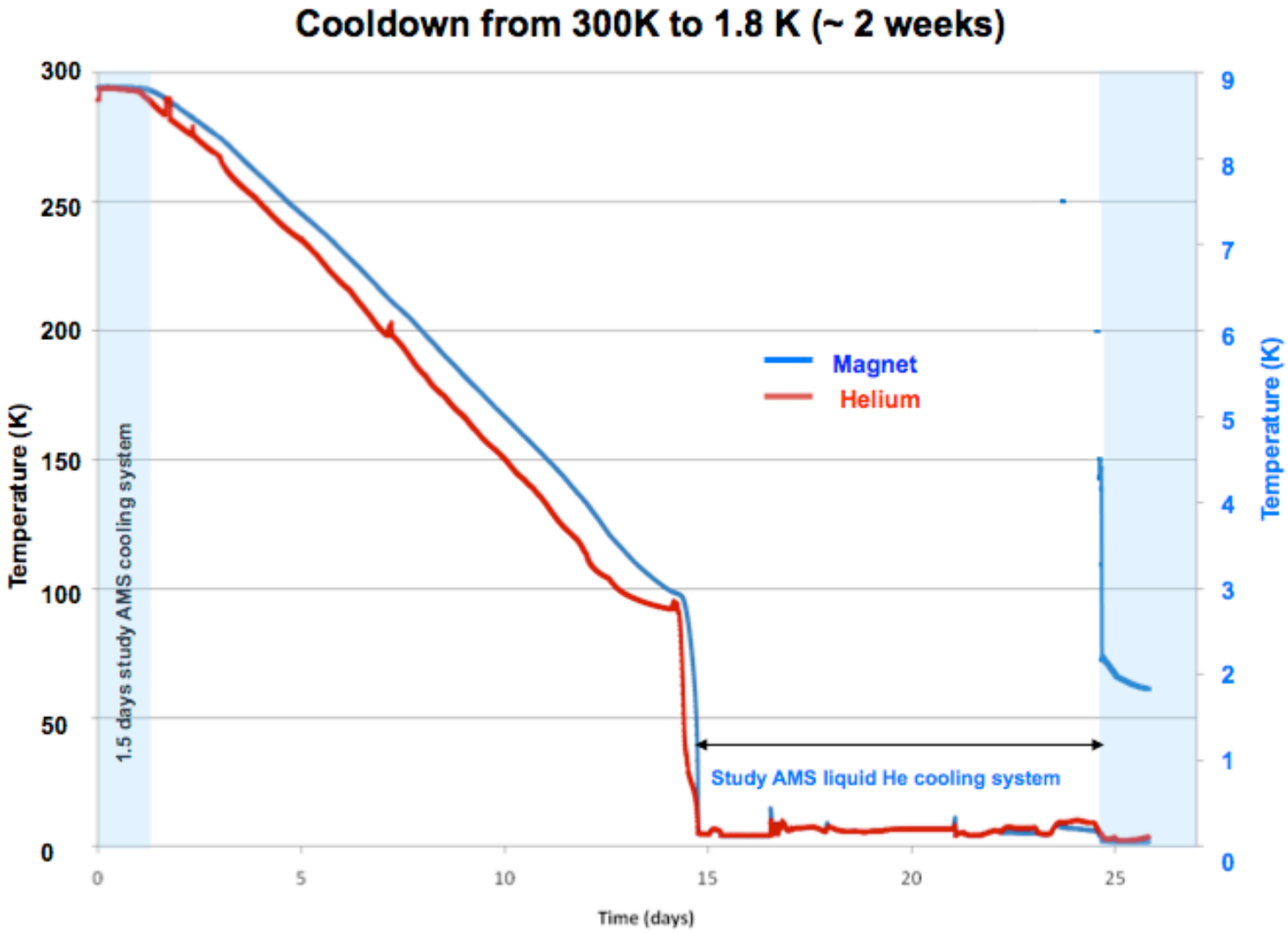
Magnet - Integration and Tests at Cern



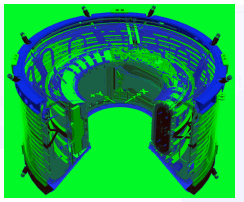


Superconducting Magnet

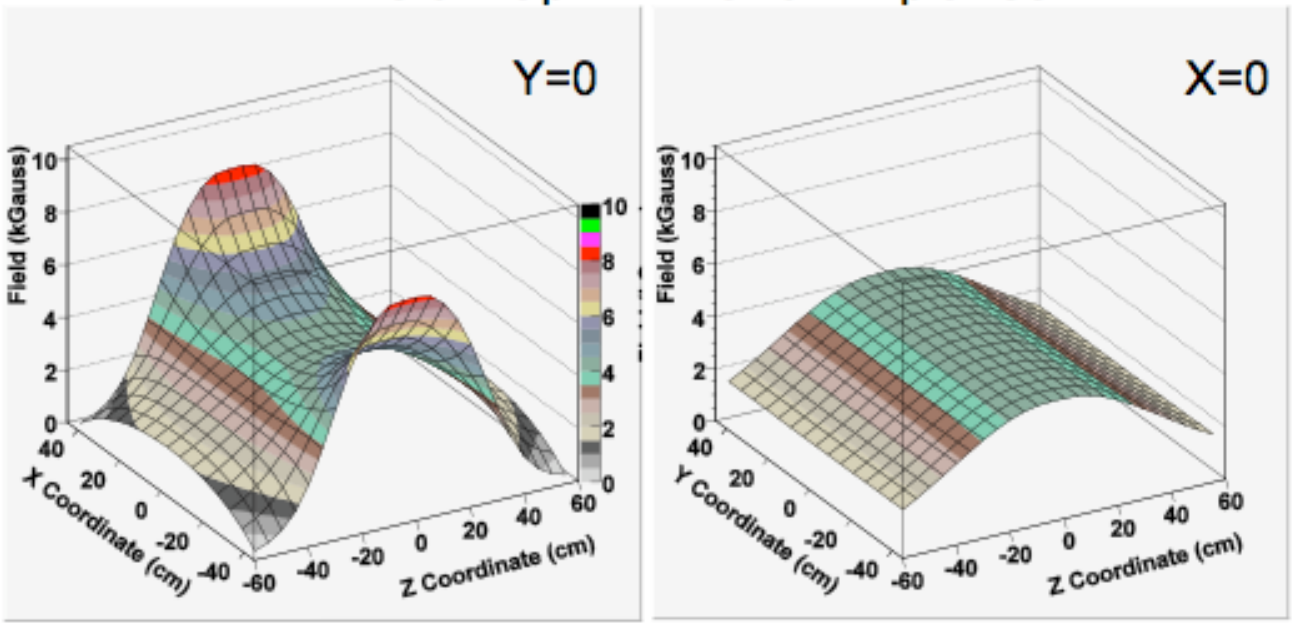




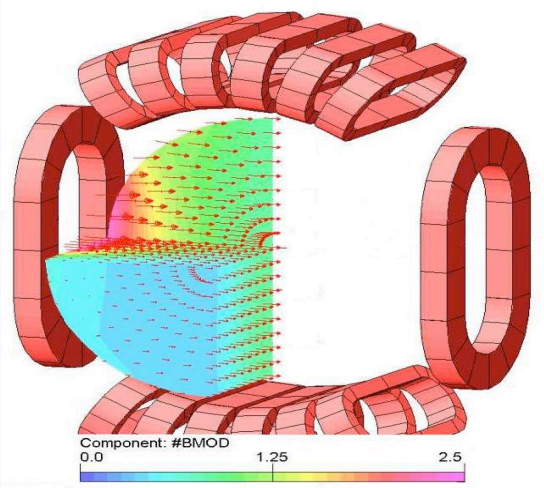
Magnet



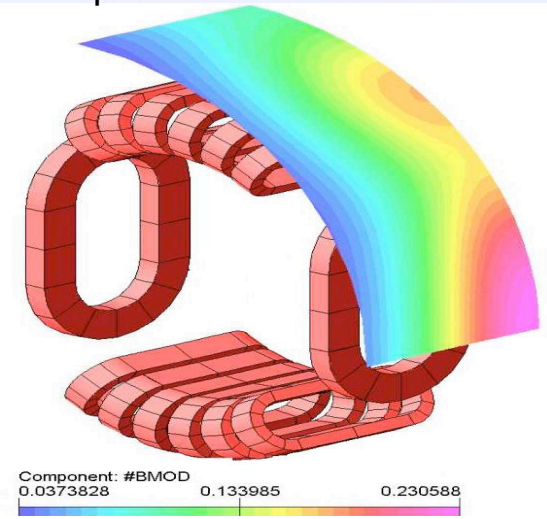
Field map in XZ and YZ planes



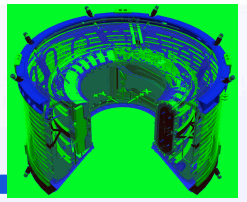
a high magnetic field inside the bore perpendicular to the detector axis.

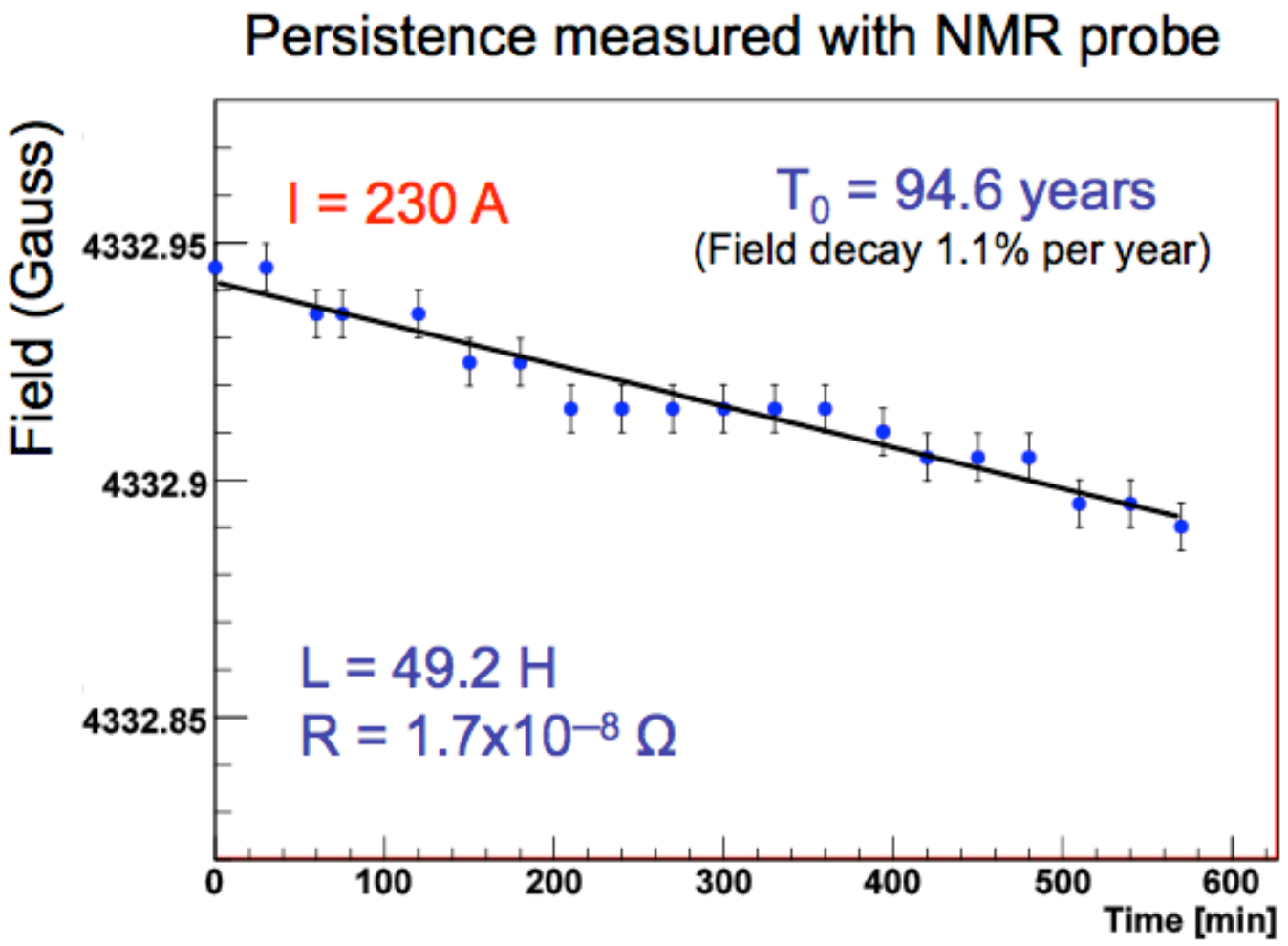


very low field outside the experiment, which prevents interference with ISS systems



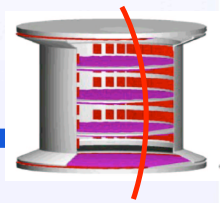
Magnet





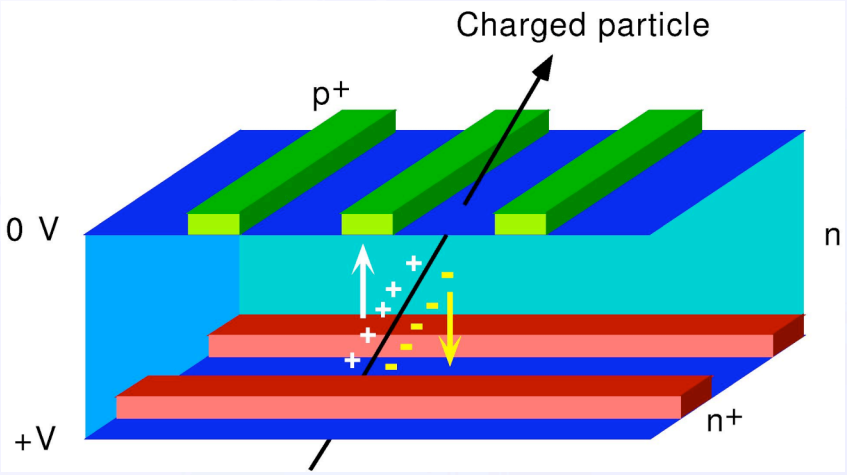
Once charged, the magnetic field will decay ~5% in 5 years.

Silicon Tracker



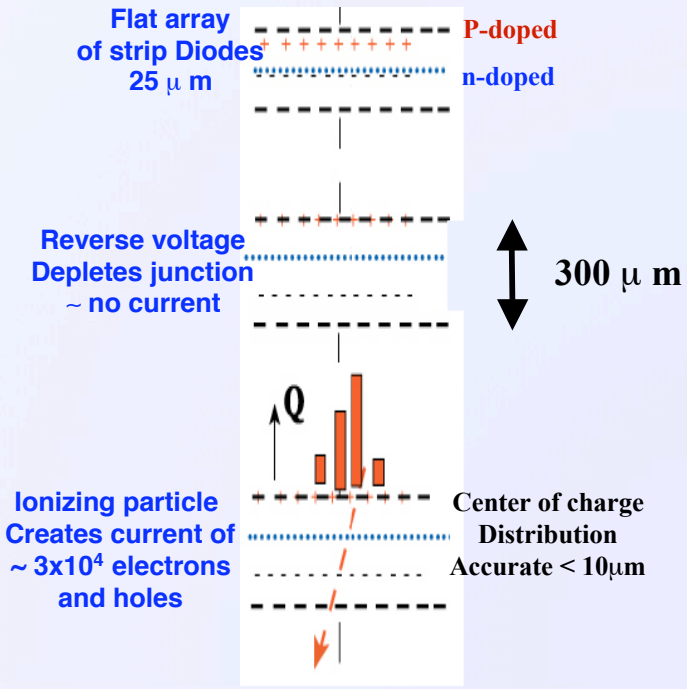
Principle

- The Tracker is built with close 2500 double sided silicon microstrip sensors, which allow to measure two coordinates with a single detector, reducing thus the material budget.

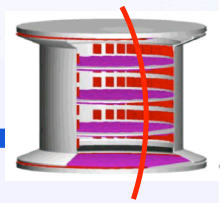


Measures:

- Rigidity P/Z up to few TV
- Energy loss, dE/dx propor to Z^2
- Direction and energy of converted photons



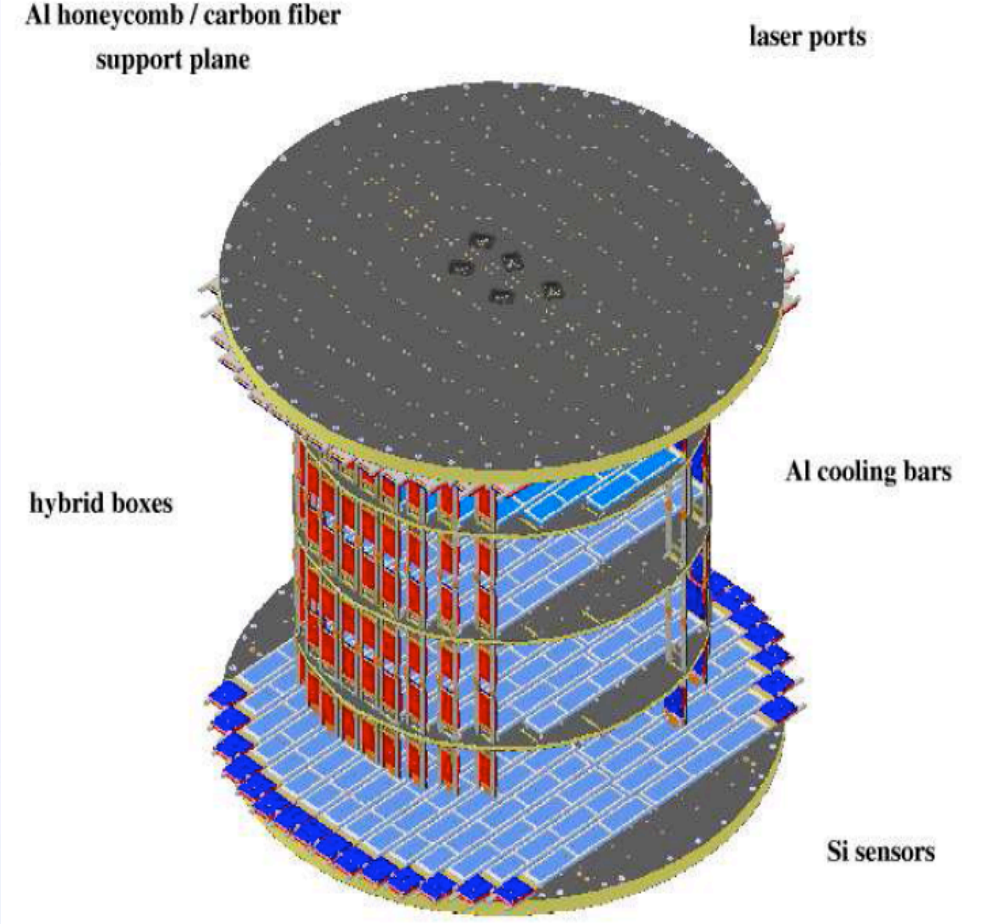
Silicon Tracker



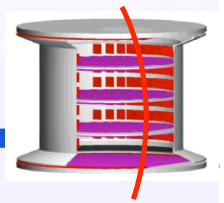
- 8 layers of double sided silicon detectors arranged in 192 ladders
- 5 honeycomb carbon fiber plane

  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 1.5% at 10 GeV
- high dynamic range front end for charge measurement
- wide temperature range

  (-20/+40 survival, -10/+25 oper.)

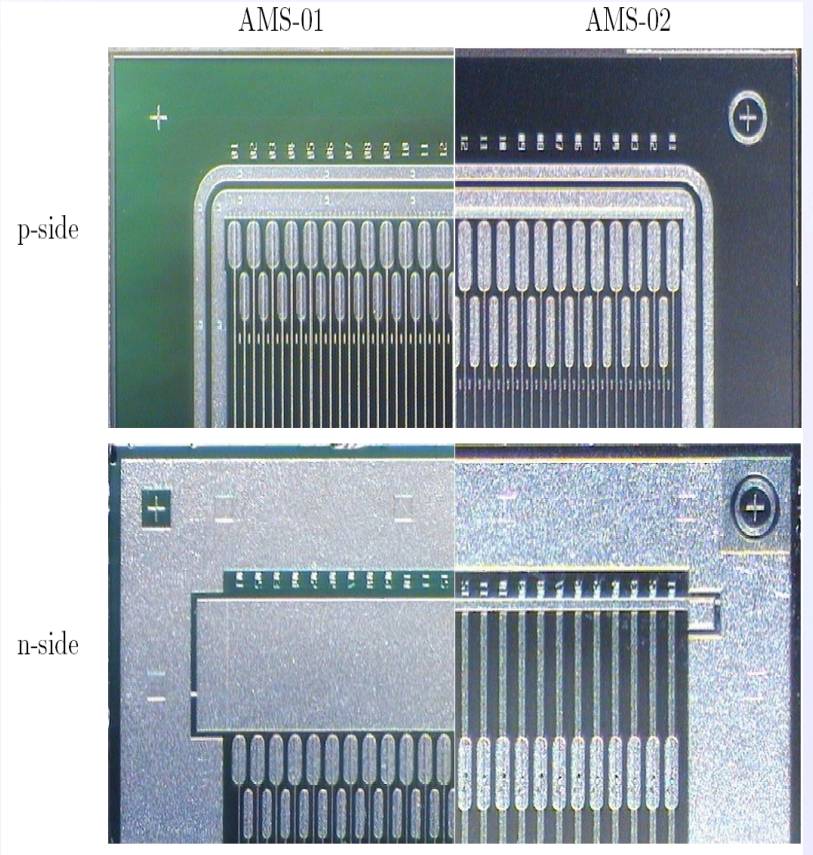


AMS02 Tracker - Silicon Sensors

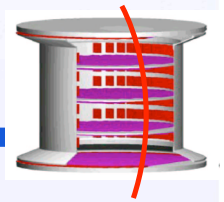


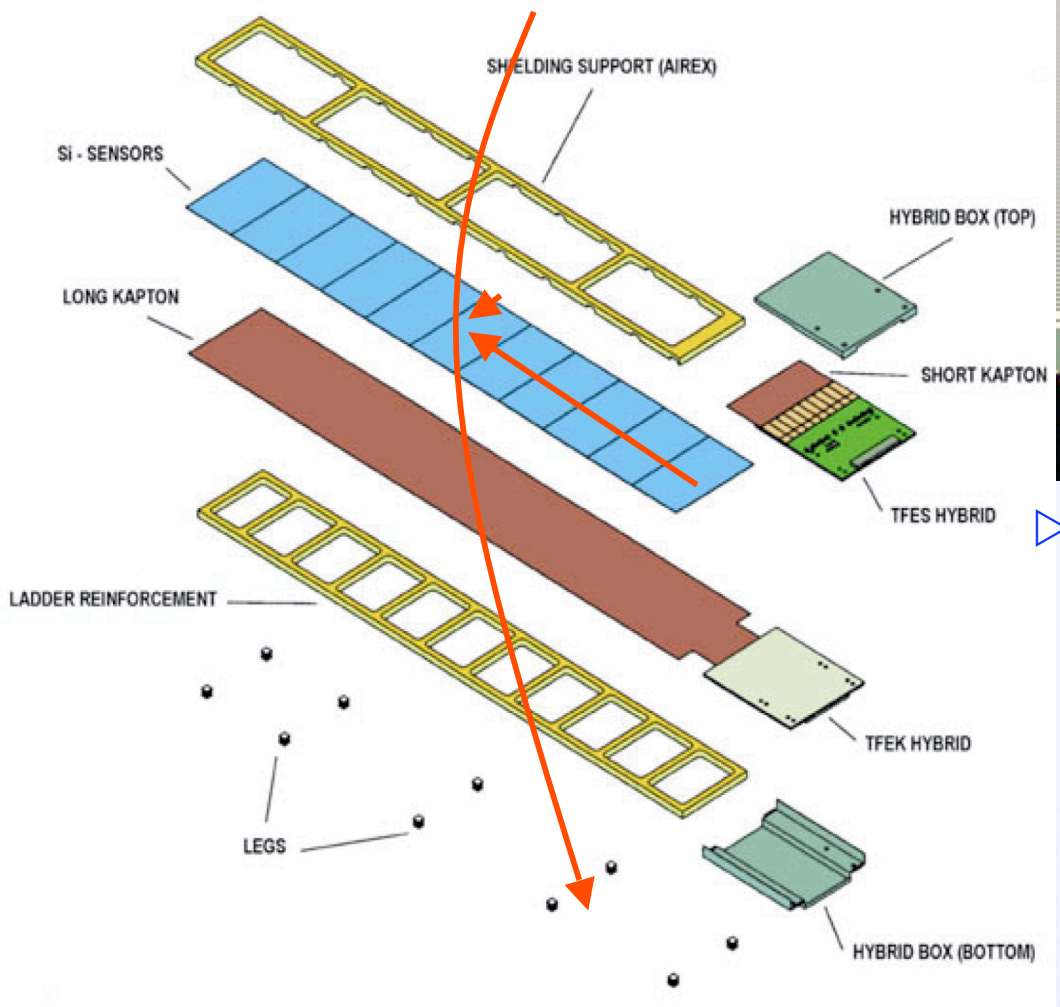
▷ AMS01 versus AMS01

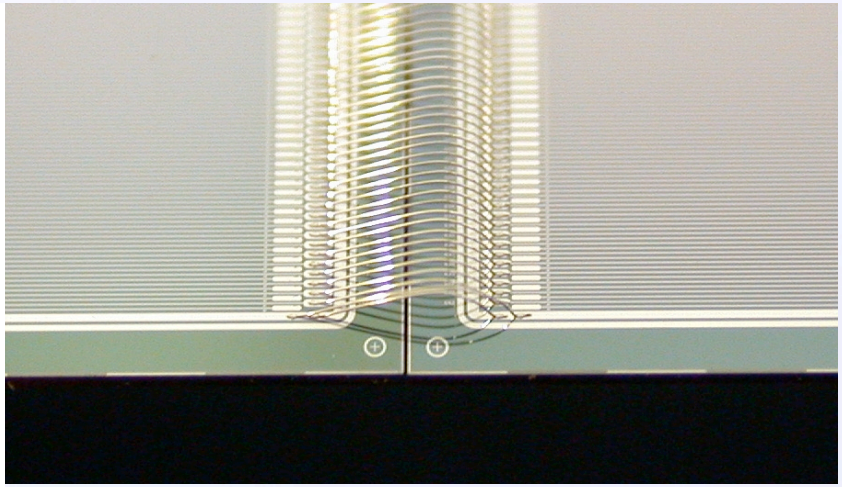
	AMS-01	AMS-02
Dimensions	72.045×41.360 mm^2	
Thickness	∼300 μm	
Active width, p side	70.595 mm	
Strip pitch, p side	27.5 μm	
no. of p-strips	2568	
no. of metal strips, p-side	1284	
no. of p-side readout strips	640	
Readout pitch, p side	110 μm	
Active width, n side	39.832 mm	
Strip pitch, n side	52 μm	104 μm
no. of n-strips	767	384
no. of metal strips, n-side	767	384
no. of n-side readout strips	192	
Readout pitch, n side	208 μm	



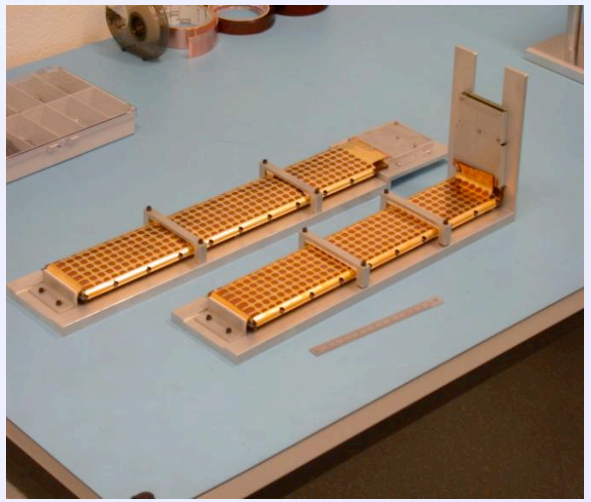
Silicon Tracker – ladders



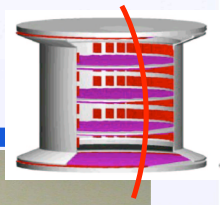




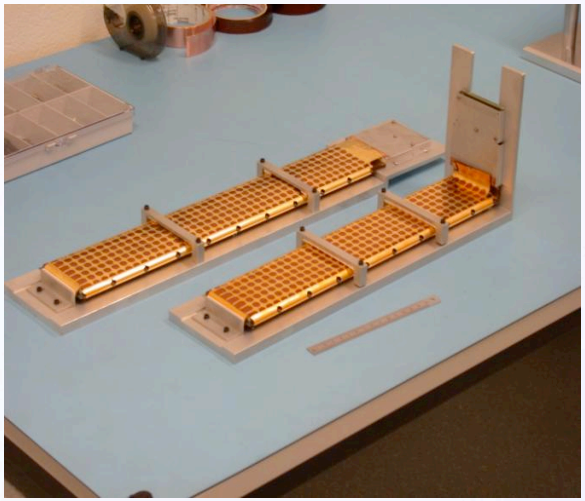
▷ 2 ladders ready to be installed

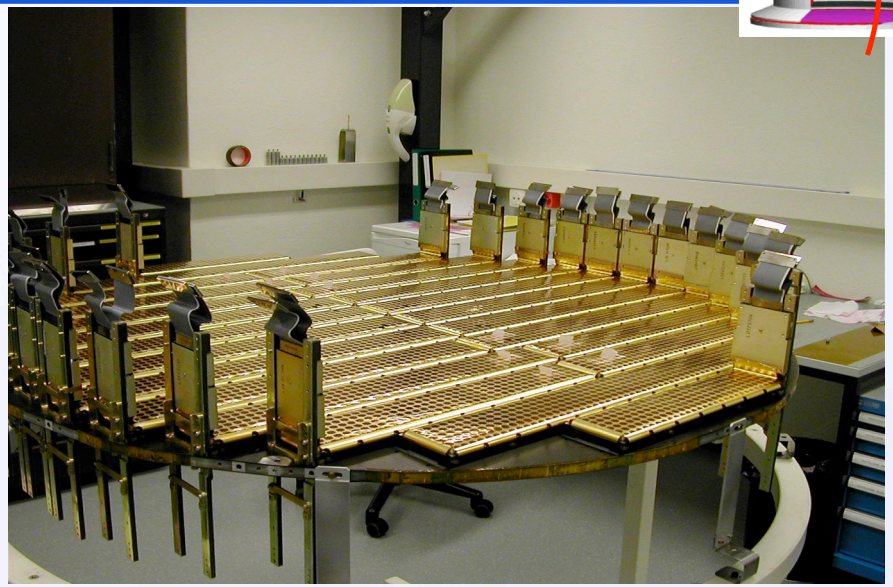


Silicon Tracker

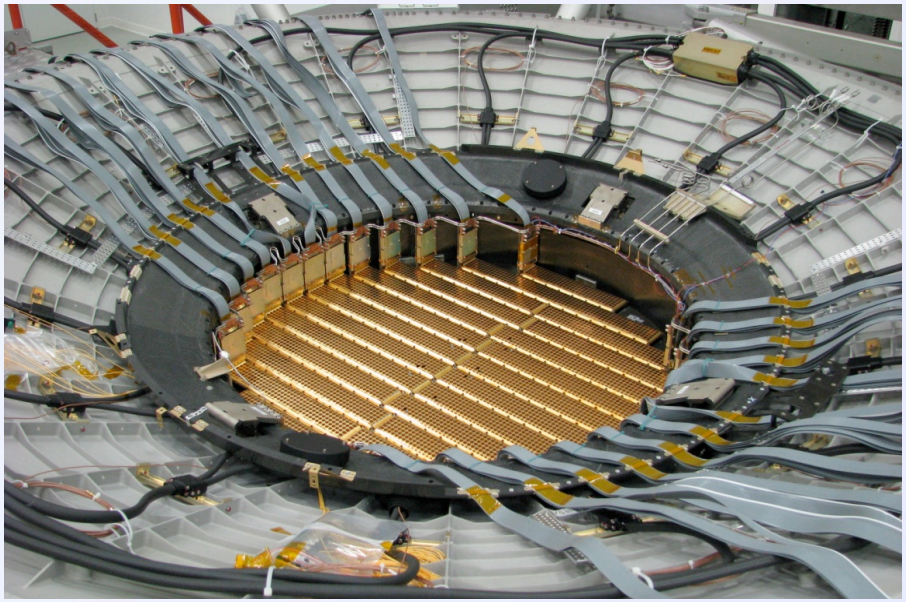


- 2 ladders ready to be installed



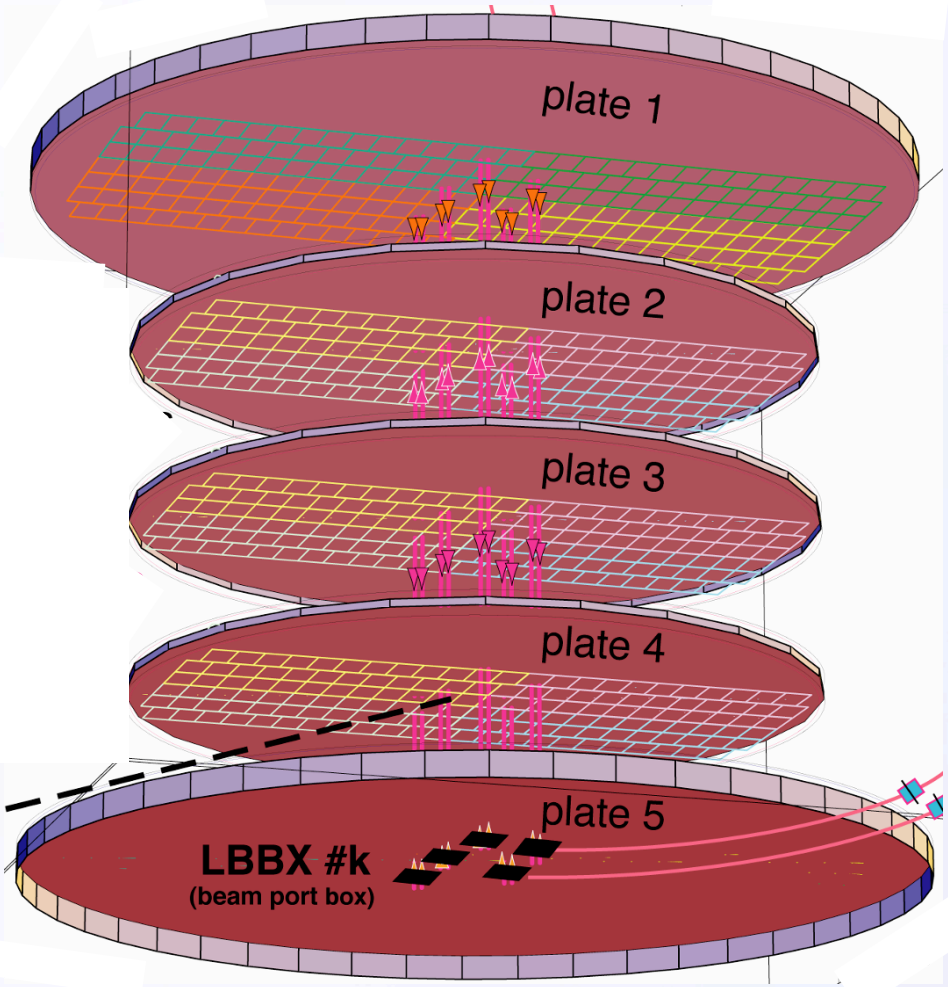


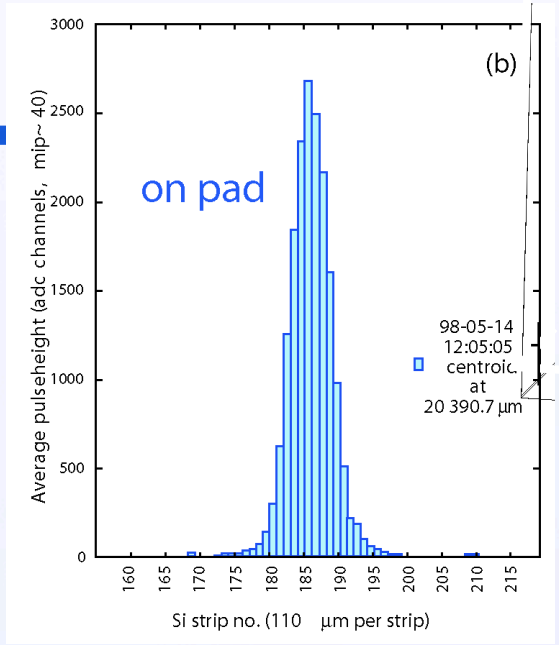
- 8 planes, 200 000 channels



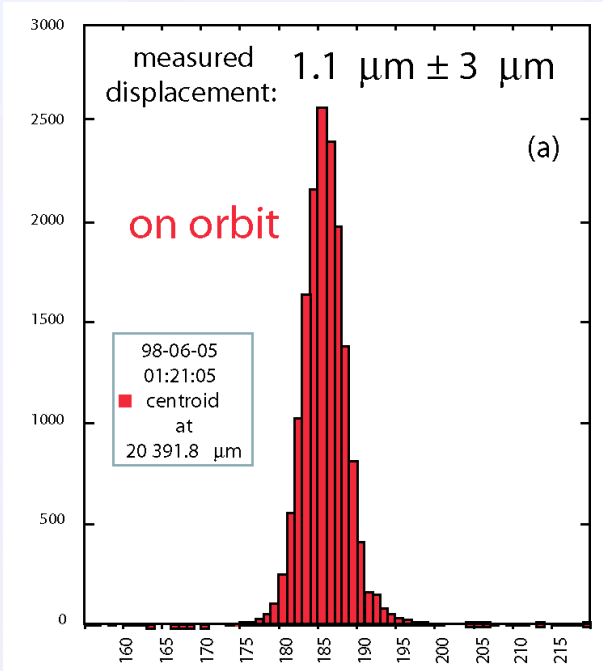
Silicon Tracker – Alignement

In space, the tracker position will be continuously monitored by 40 Laser beams.

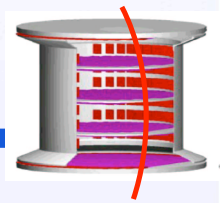




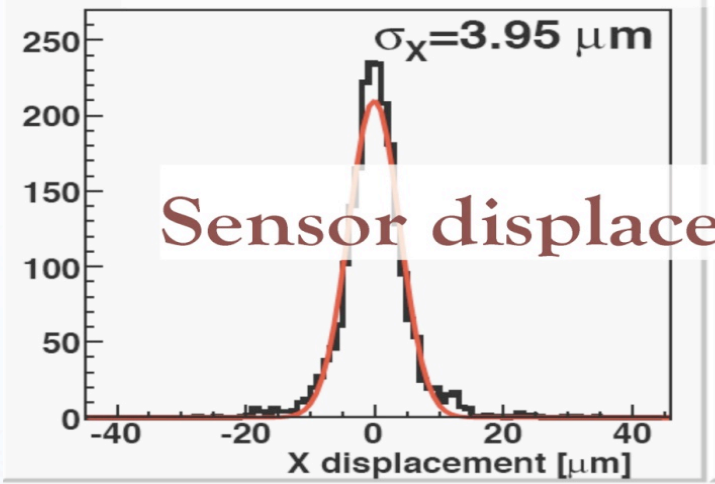
AMS-01

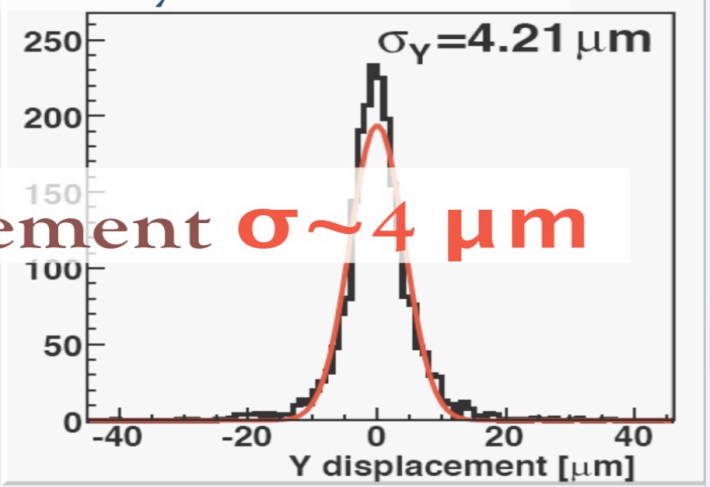


Silicon Tracker – Alignement



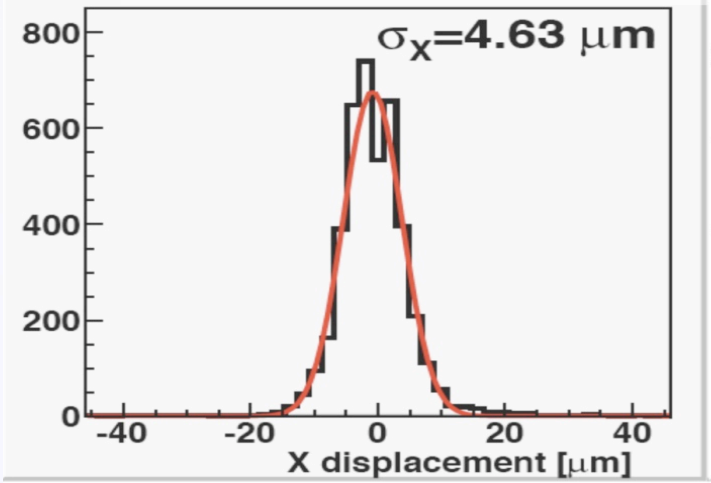
Cosmic rays

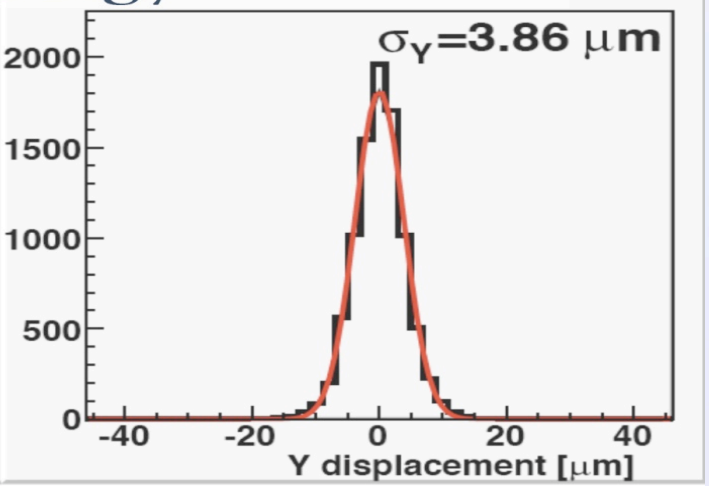




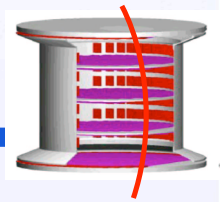
Sensor displacement σ~4 μm

Metrology





Silicon Tracker – Cluster



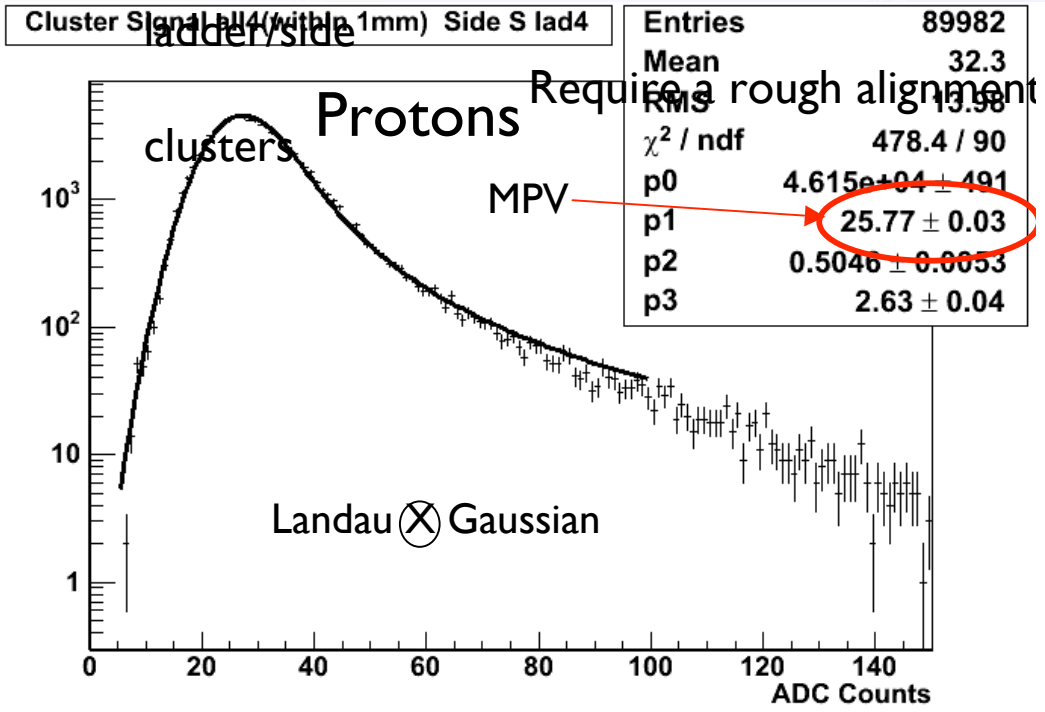
Clusterization:

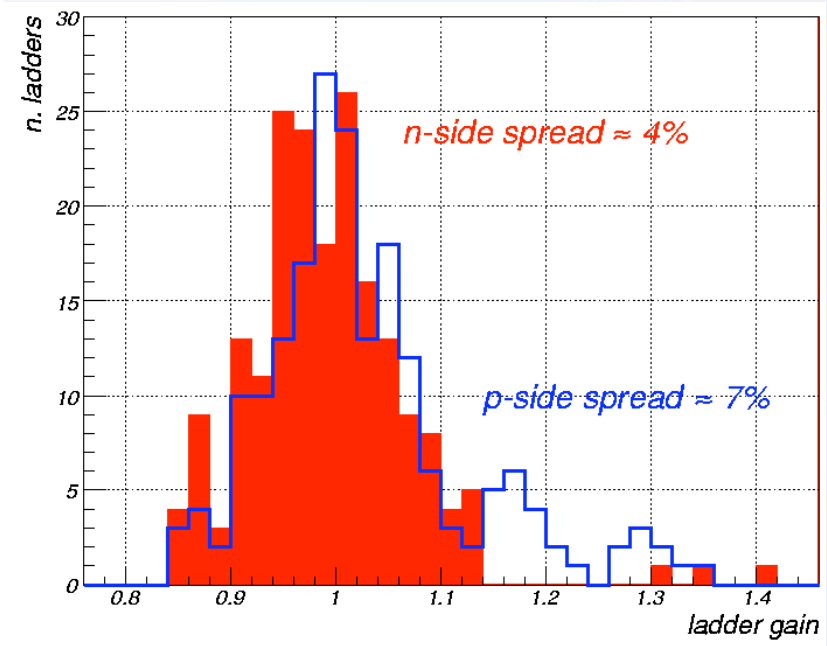
Find the seeds of the clusters (strip with S/N above threshold 3)

Build the cluster adding the neighbor strips with S/N above 1

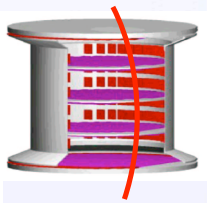
Consider only the highest cluster per ladder/side

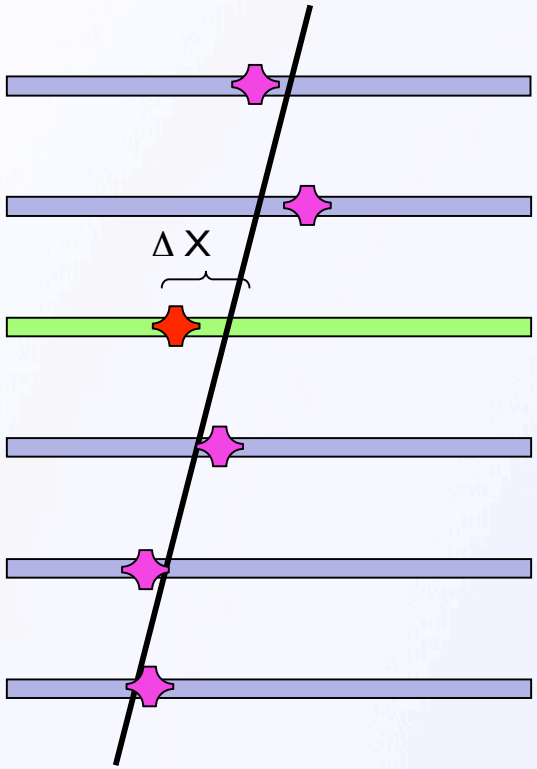
Require a rough alignment





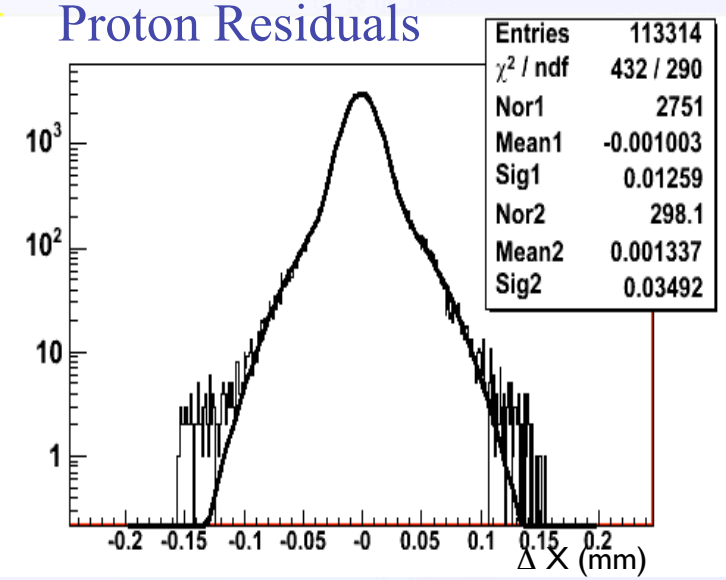
Silicon Tracker – reconstruction





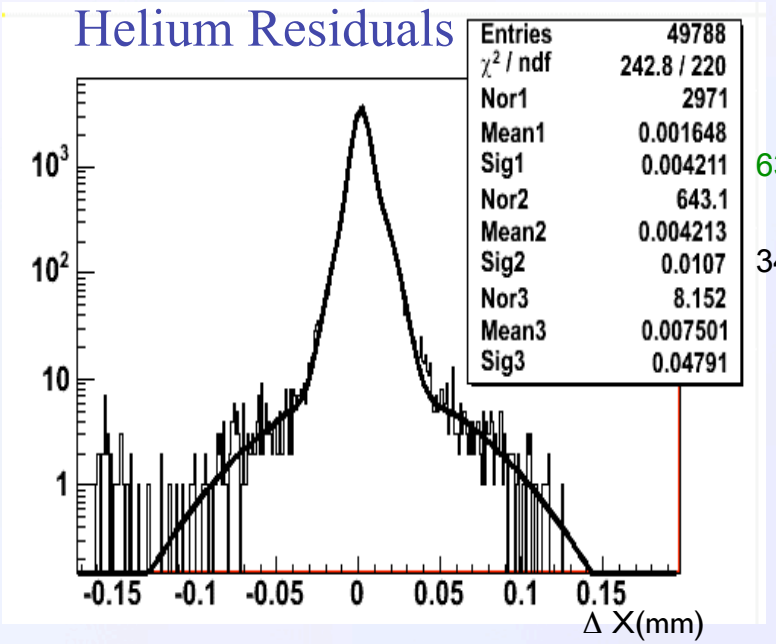
The distribution of Δ X is fitted with a double gaussian

Resolution = $\sigma_{\Delta X}$ - $\sigma_{\text{linear fit}}$



70% of events

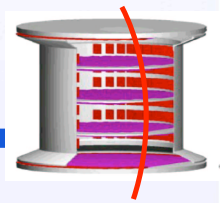
30% of events

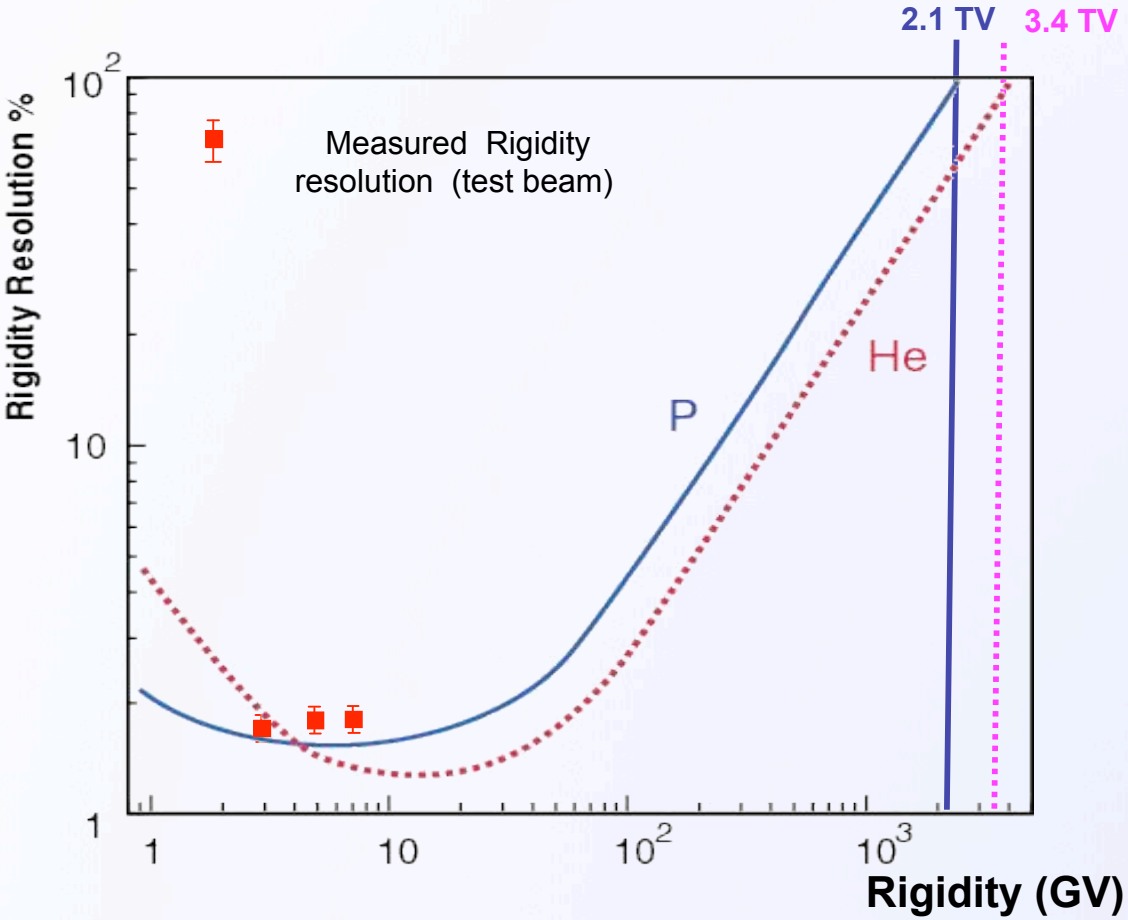


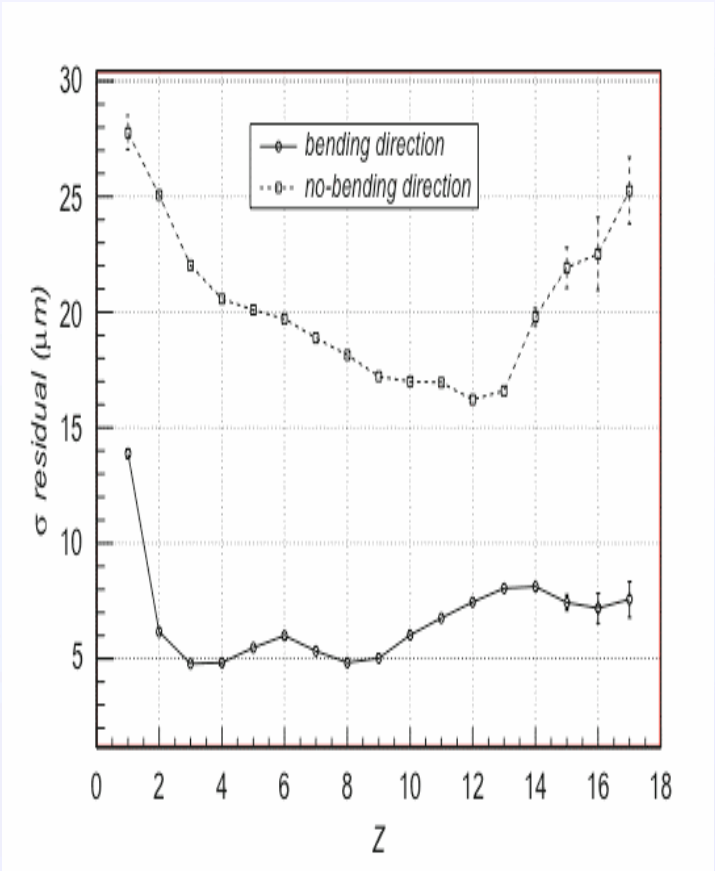
63% of events

34% of events

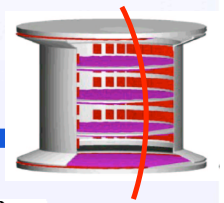
Silicon Tracker – Rigidity







Silicon Tracker – Charge measurement



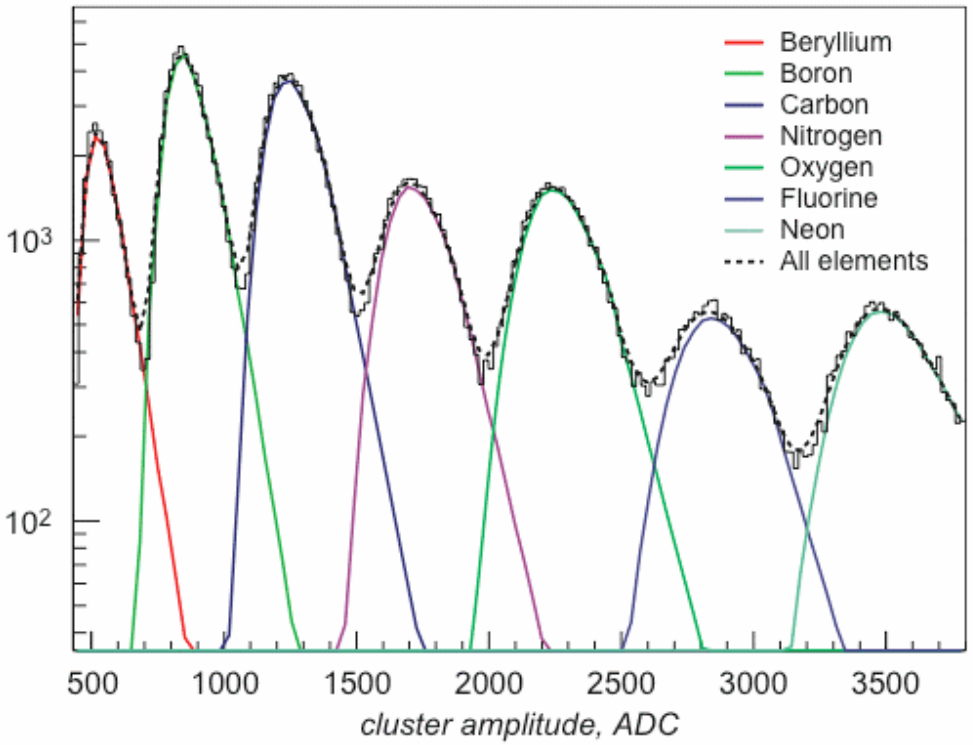
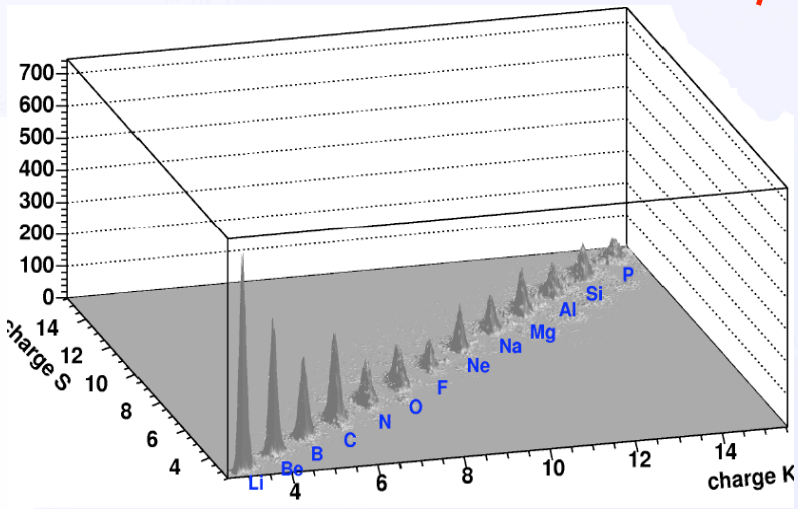
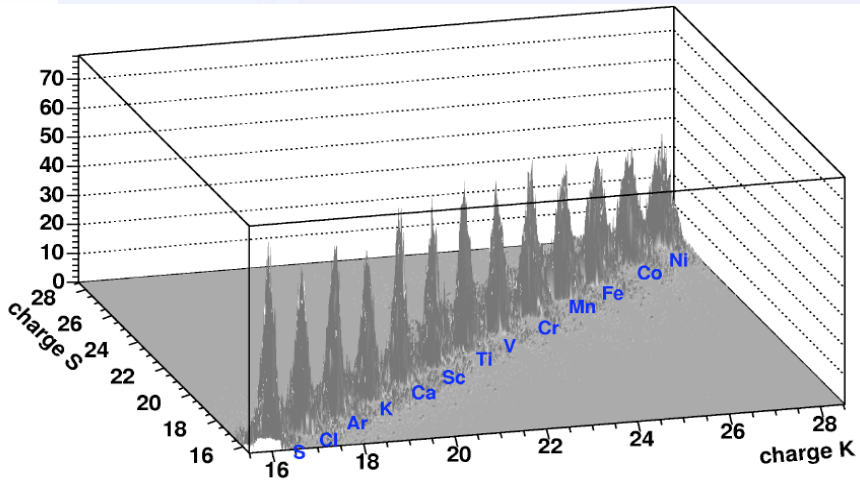
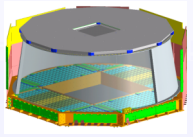


Fig. 4. Signals of charges up to Ne in the AMS tracker.

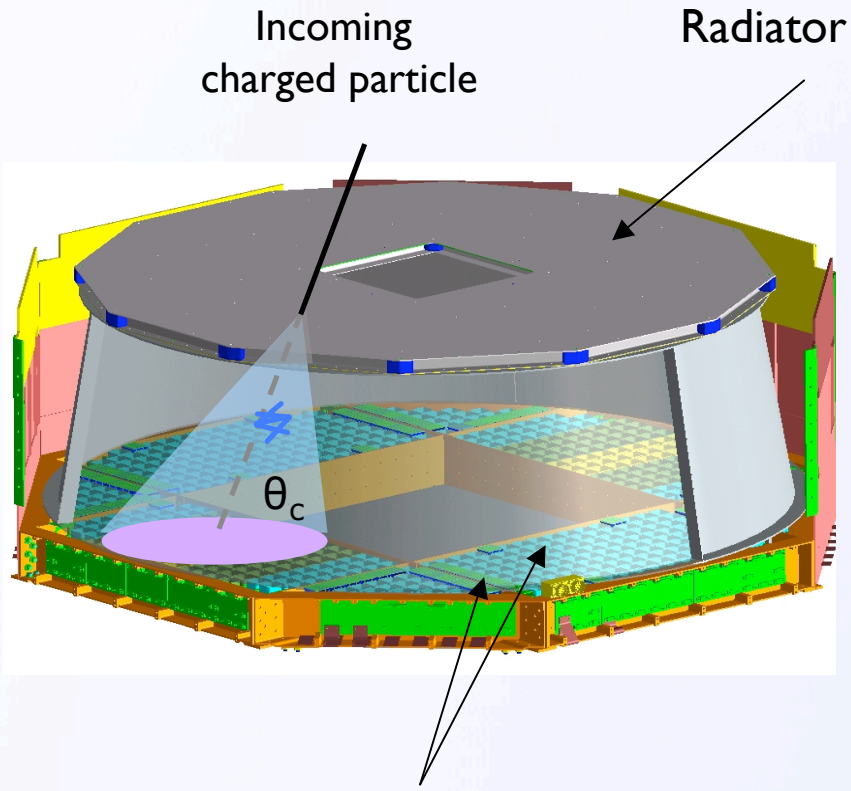




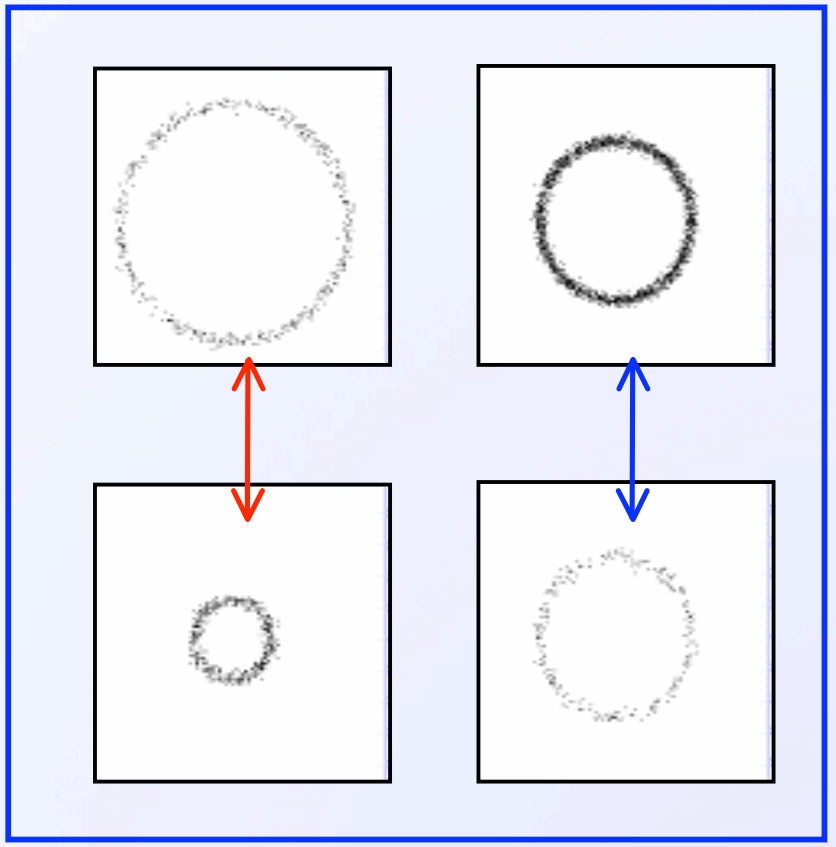
Ring Imaging Cherenkov



▷ Velocity and Charge measurements



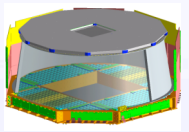
Photon Rings



β Velocity measurement (radius)
$\beta * n * \cos(\theta_c) = 1$

Z Electric Charge
Signal proportional to Z^2

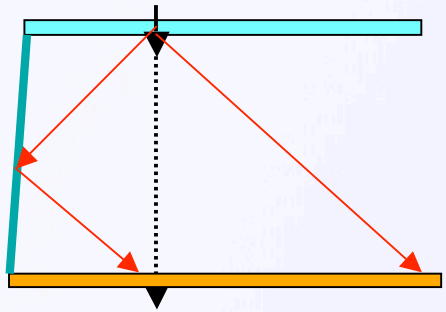
Ring Imaging Cerenkov

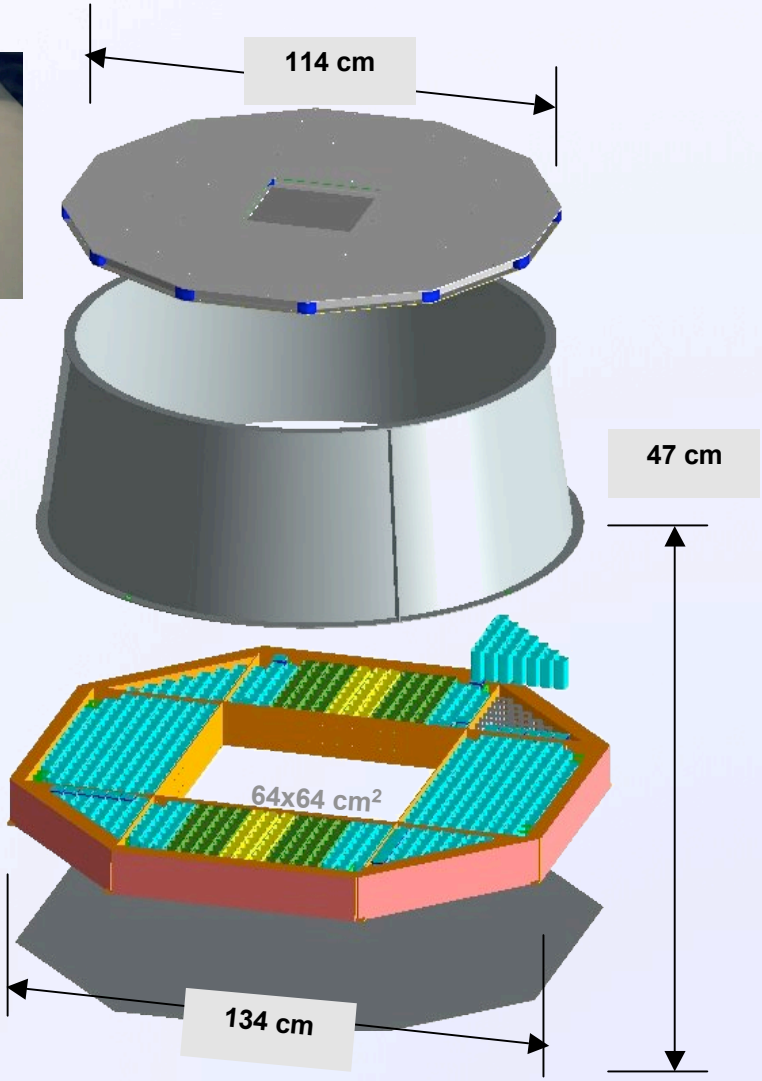


- **Dual solid radiator configuration**
  - Low index Aerogel (n=1.05)
  - Sodium fluoride (n=1.33)



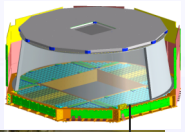
- **Conical Reflector**
  - ~ 30% of Cerenkov photons point outside of the detection array at the bottom plane

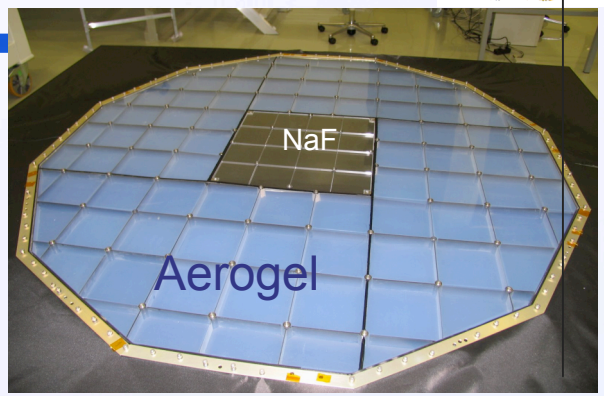




- **Photomultiplier matrix**
  - 10880 pixels Spatial granularity: 8.5 x 8.5 mm^2

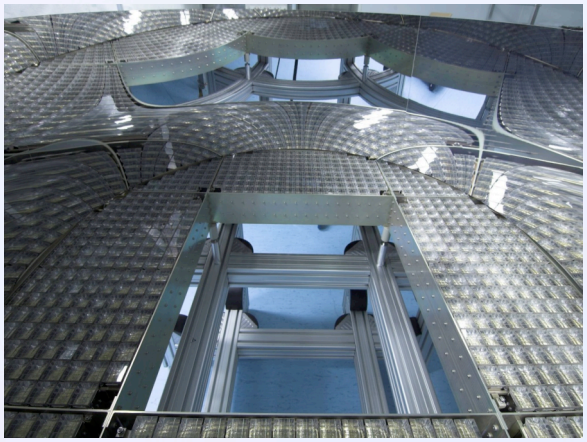
Ring Imaging Cerenkov



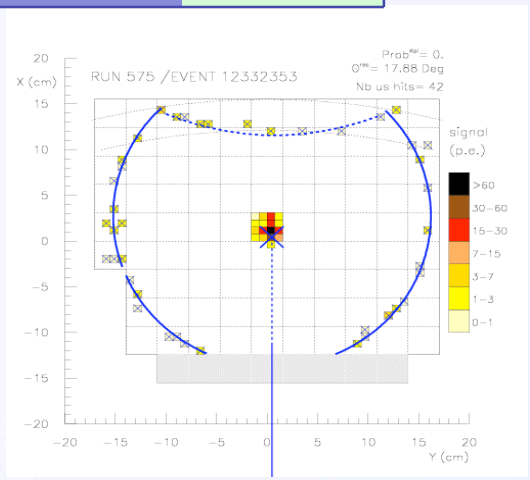


▶**Dual solid radiator configuration**

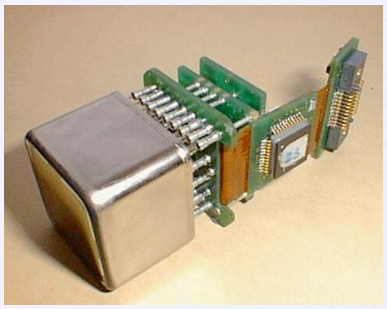
	Aerogel	NaF
Refraction Index	**1.05**	**1.33**
Opening angle (deg)	**17.8**	**41.5**
Velocity threshold	**0.952**	**0.752**

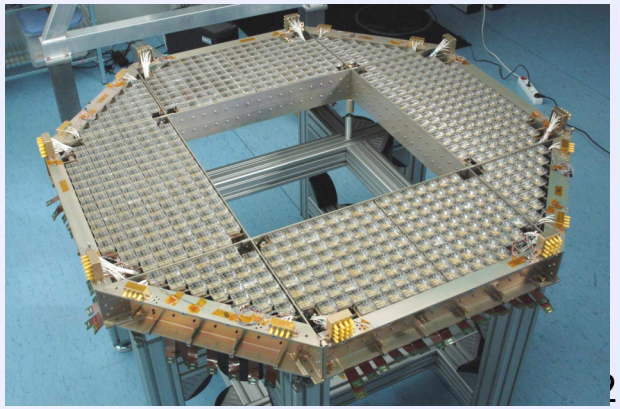


▶**Conical Reflector**

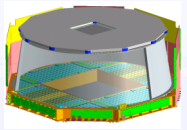


▶**Photomultiplier matrix**
10880 pixels

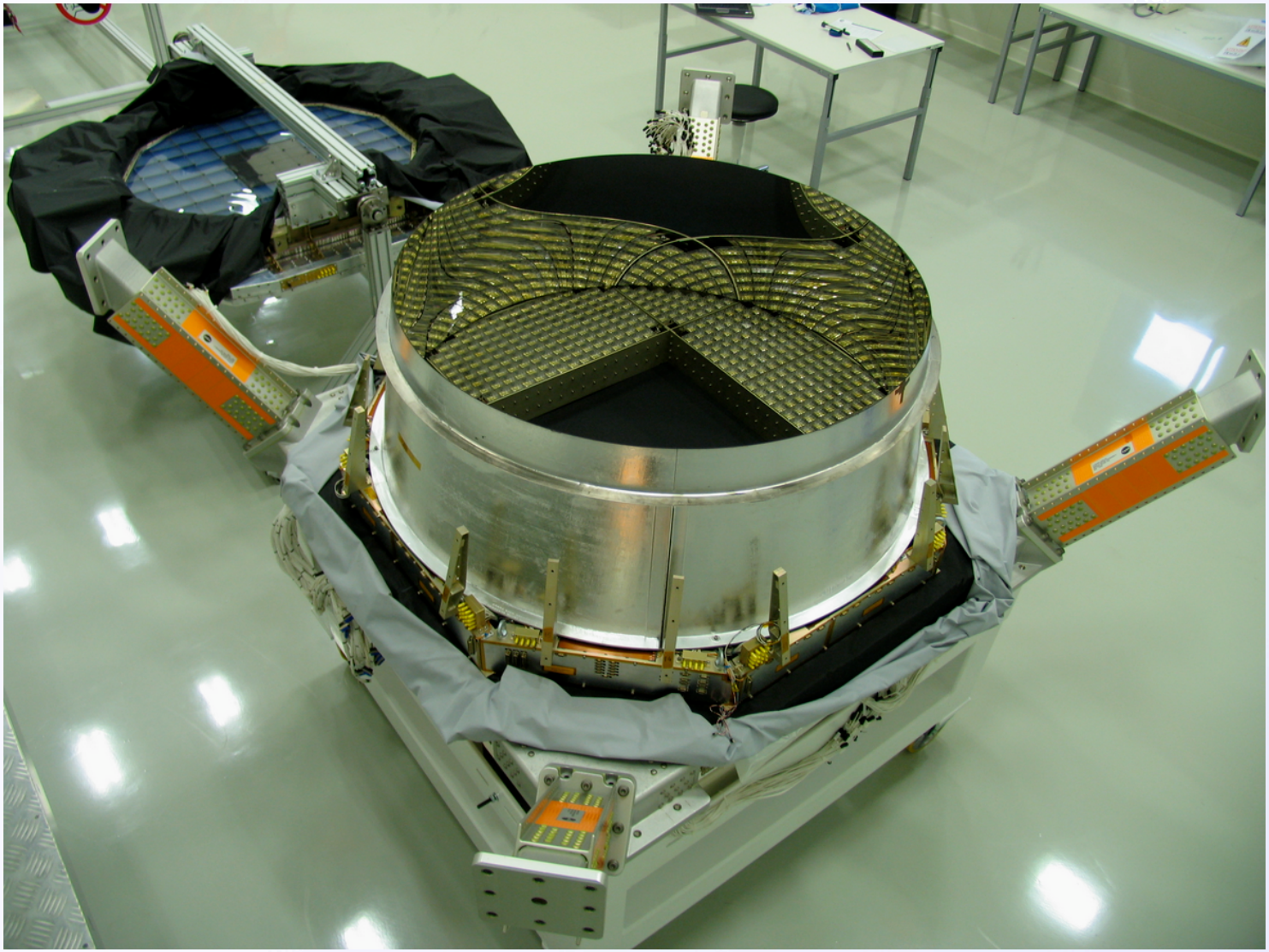




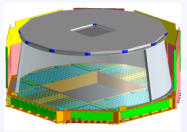
Ring Imaging Cerenkov



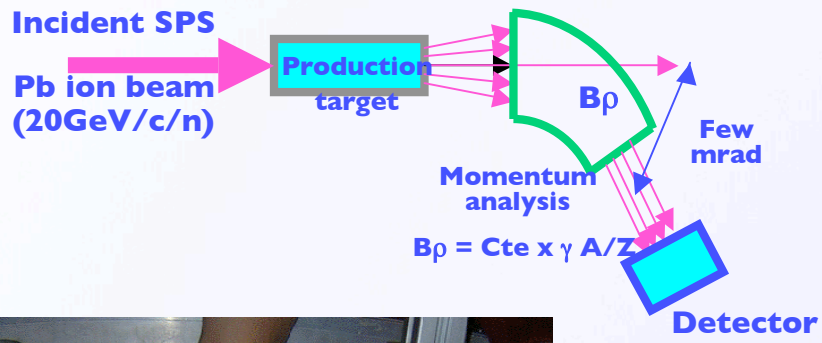
- Integration at Cern

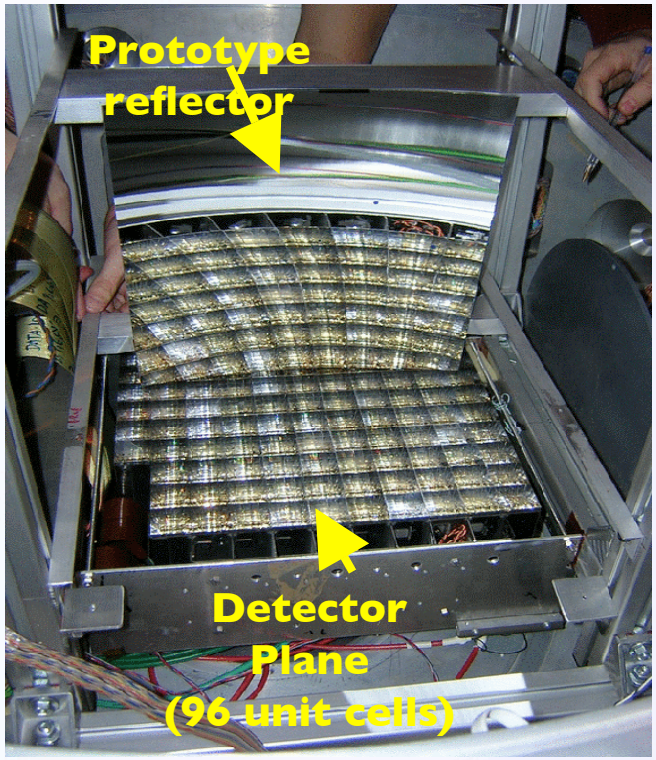


RICH – Performance

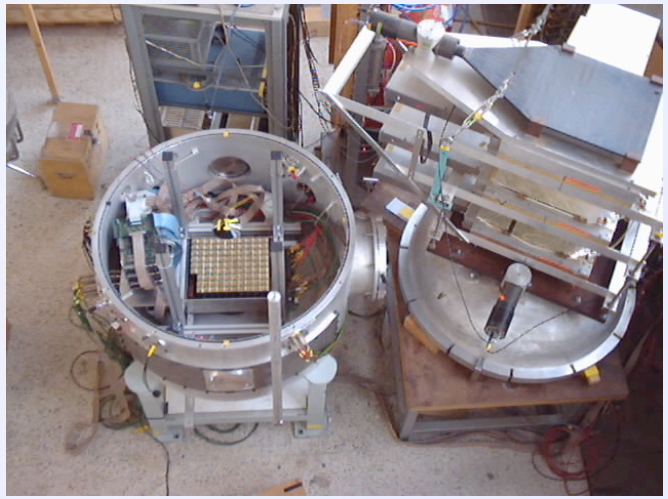


▷ Beam test Setup



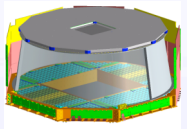


- ▷ 2002 20 GeV/n,
  Pb on Be target @ CERN
- ▷ 2003/ 158 GeV/n,
  In on Pb target @ CERN
- ▷ Cosmics

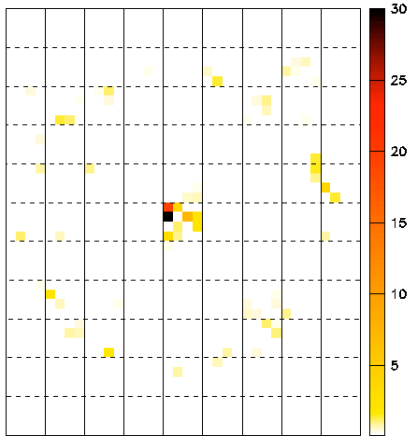


Cosmic ray station

RICH – Charge Measurement

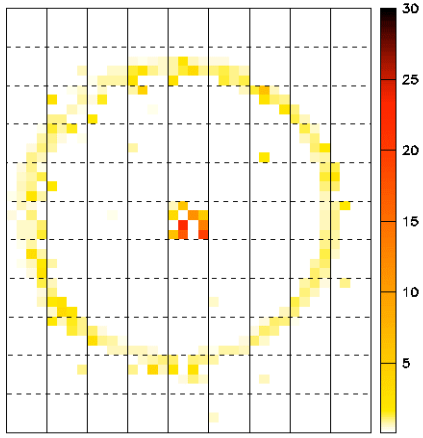


H

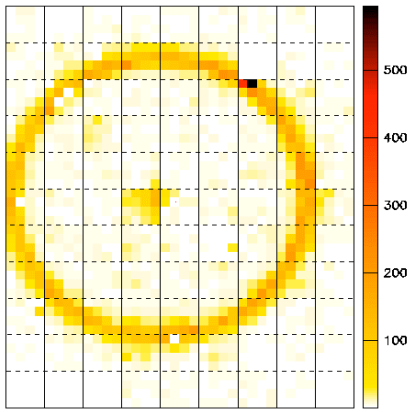


E_k/n=158 GeV/n

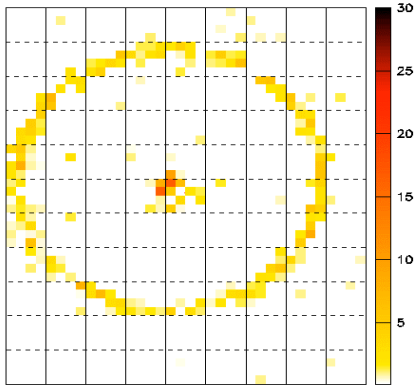
Li



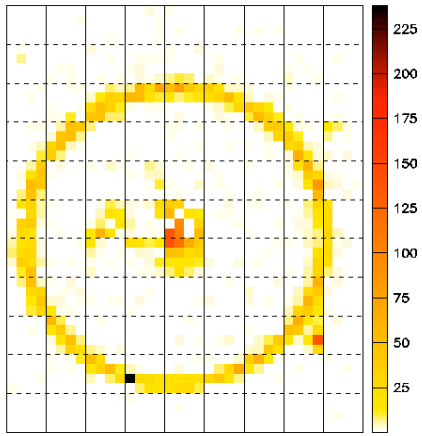
Fe



C



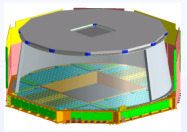
O

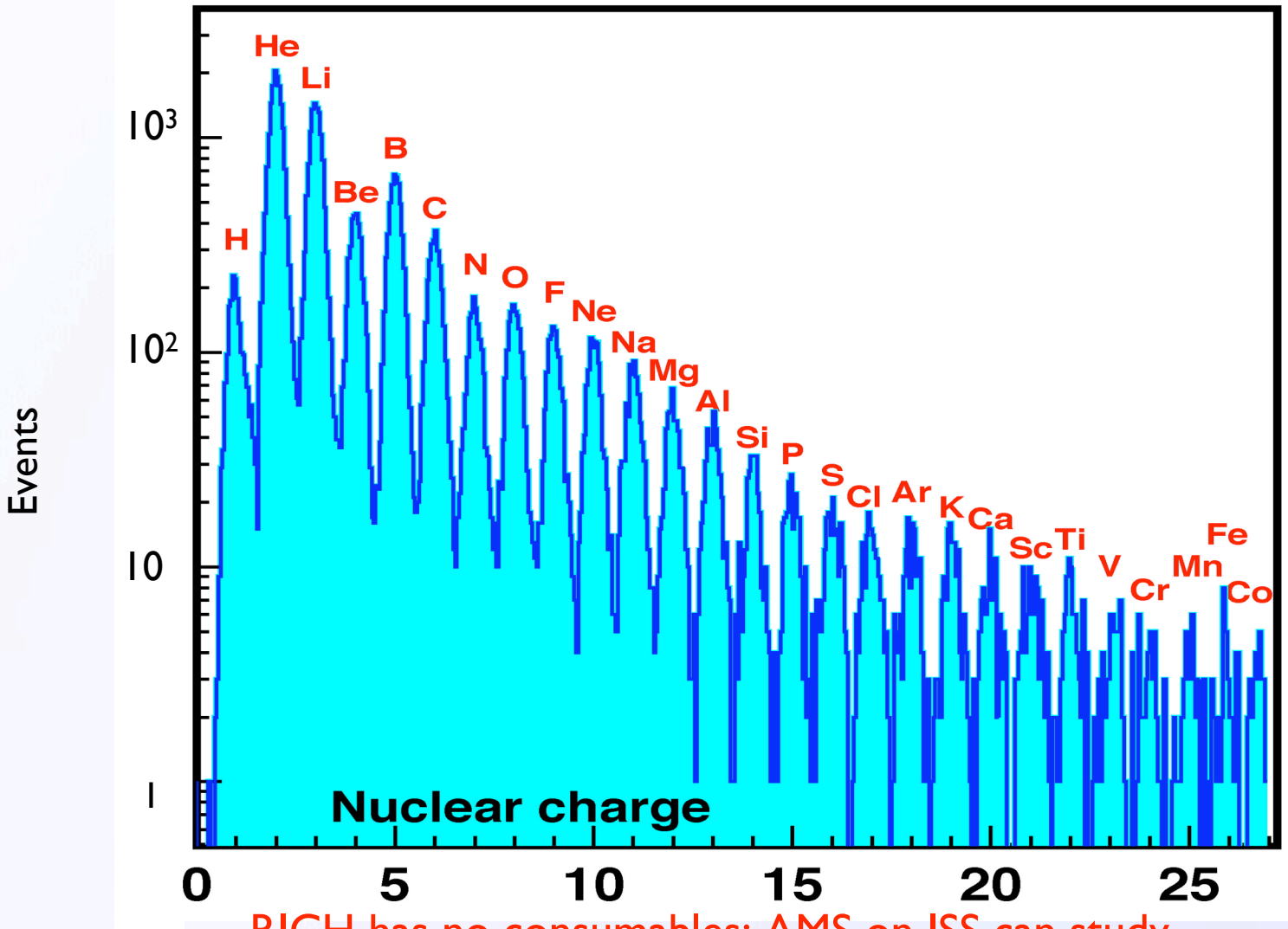


Collision products:

p, D, He^4, Li^6,…

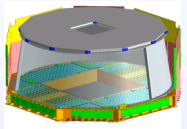
RICH – Charge Measurement





RICH has no consumables: AMS on ISS can study high energy cosmic ray spectra indefinitely

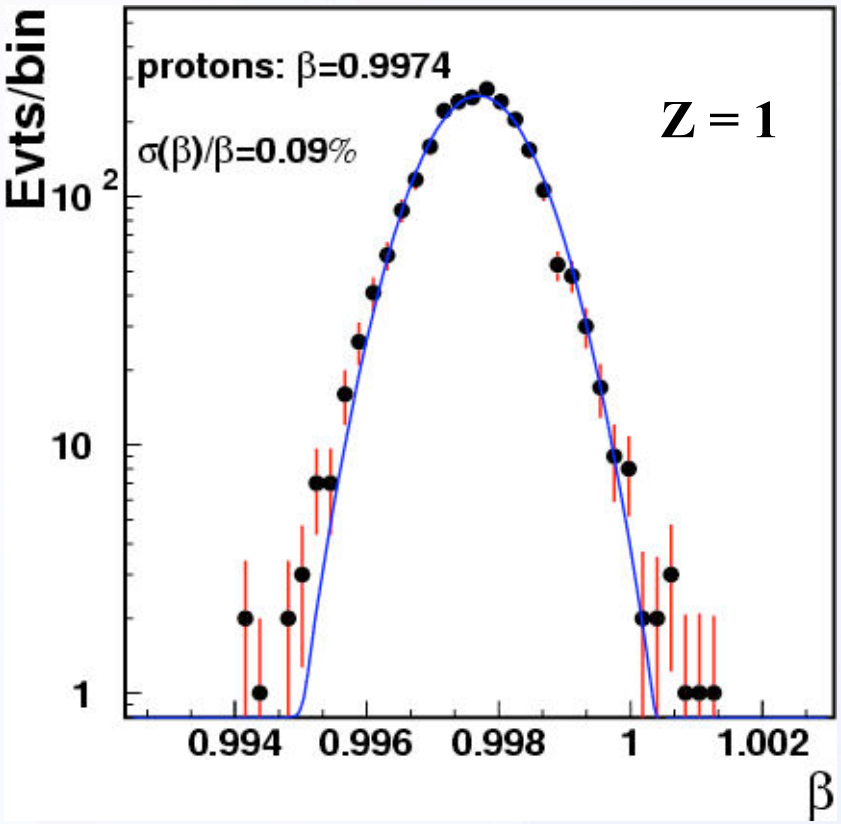
RICH – Velocity measurement

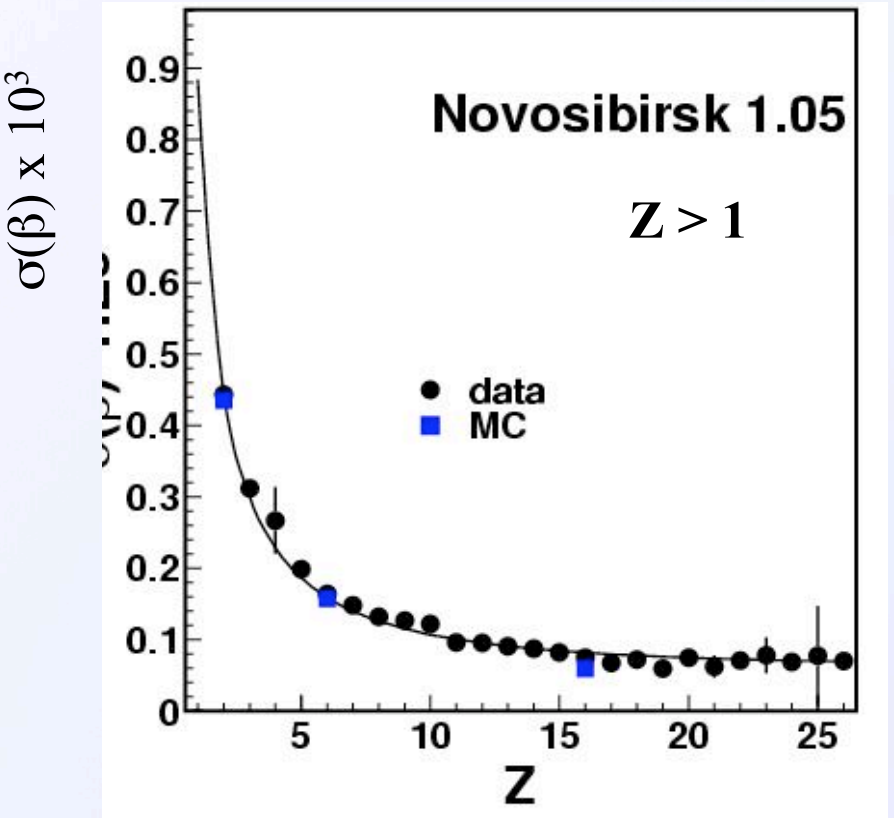


▷ Aerogel radiator (Beam test)

NaF

E_k/n=158 GeV/n

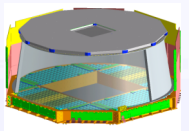




Resolution per hit is the same for direct and reflected hits

$$\left(\frac{\sigma_\beta}{\beta}\right)_{\blacksquare} \approx \frac{\blacksquare}{\blacksquare}\left(\frac{\sigma_\beta}{\beta}\right)_{\blacksquare=\blacksquare}$$

RICH – Velocity measurement

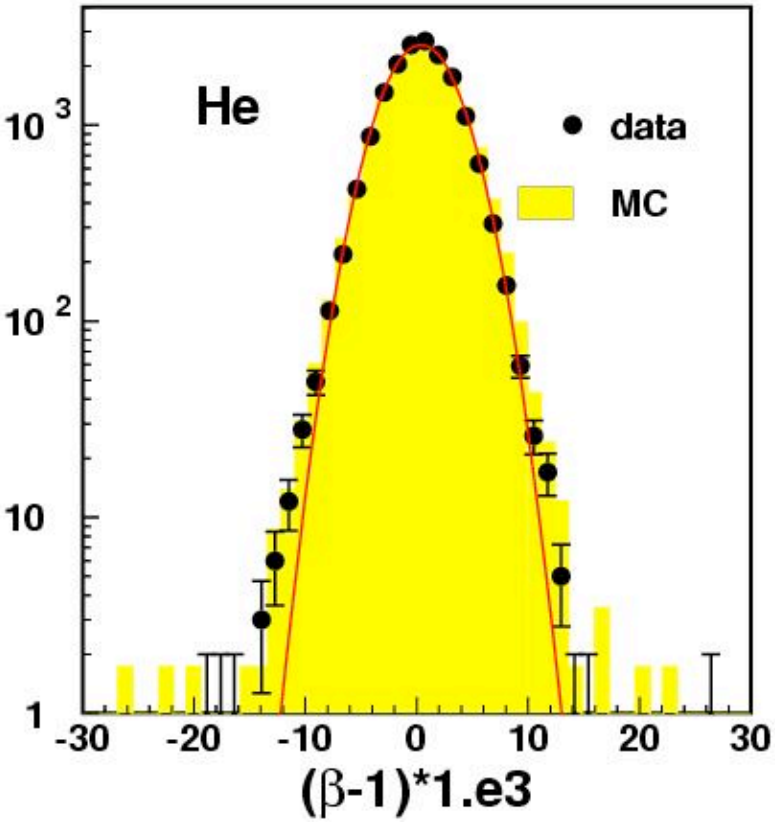


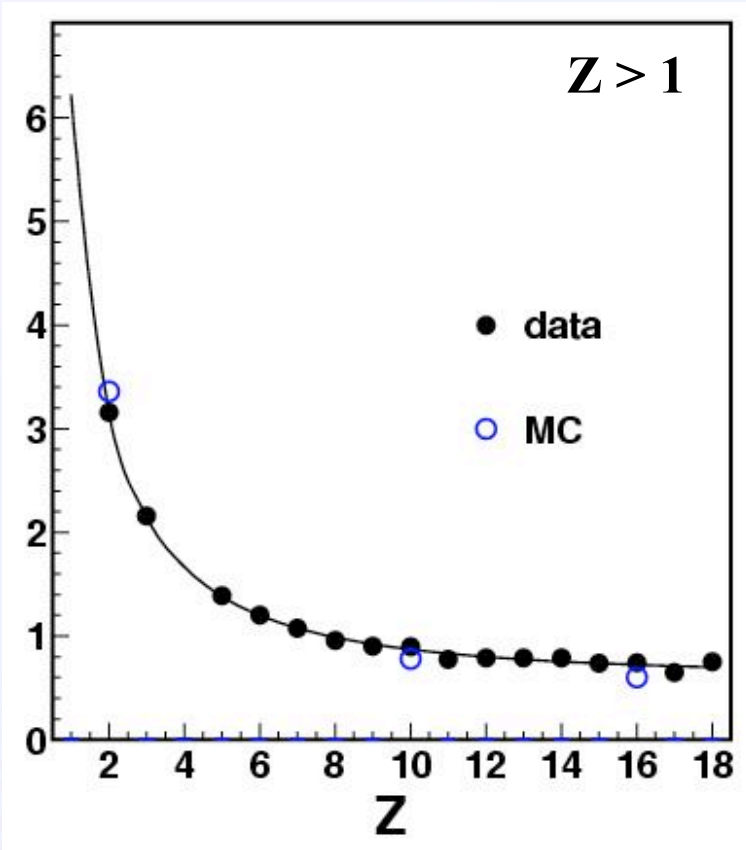
▷ NaF Radiator (Beam test)

NaF

E_k/n=158 GeV/n

$Z = 2$





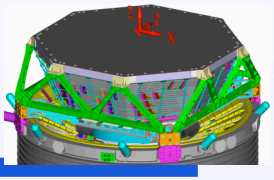
$$\left(\frac{\sigma_\beta}{\beta}\right)_{\blacksquare} \approx \frac{\blacksquare}{\blacksquare}\left(\frac{\sigma_\beta}{\beta}\right)_{\blacksquare=\blacksquare}$$

TRD - The AMS detector @ CERN

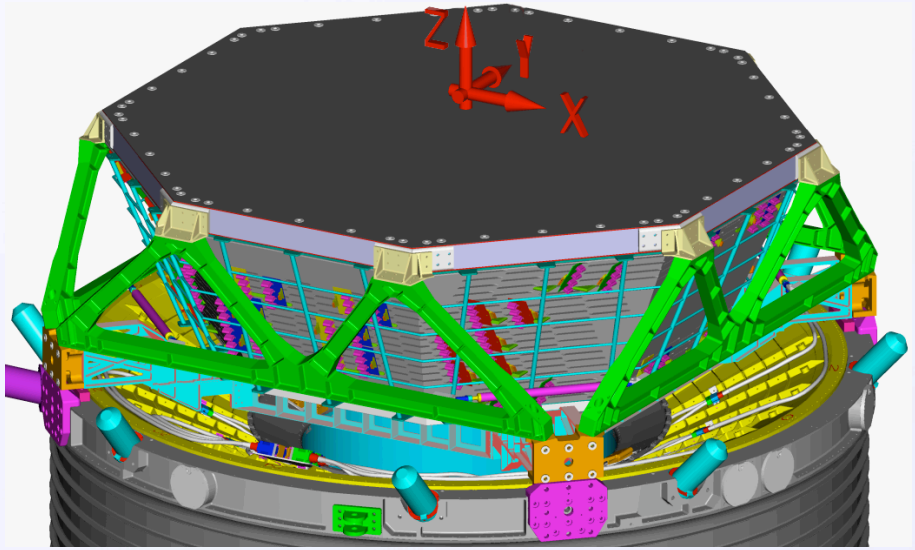
November 23, 2007



TRD



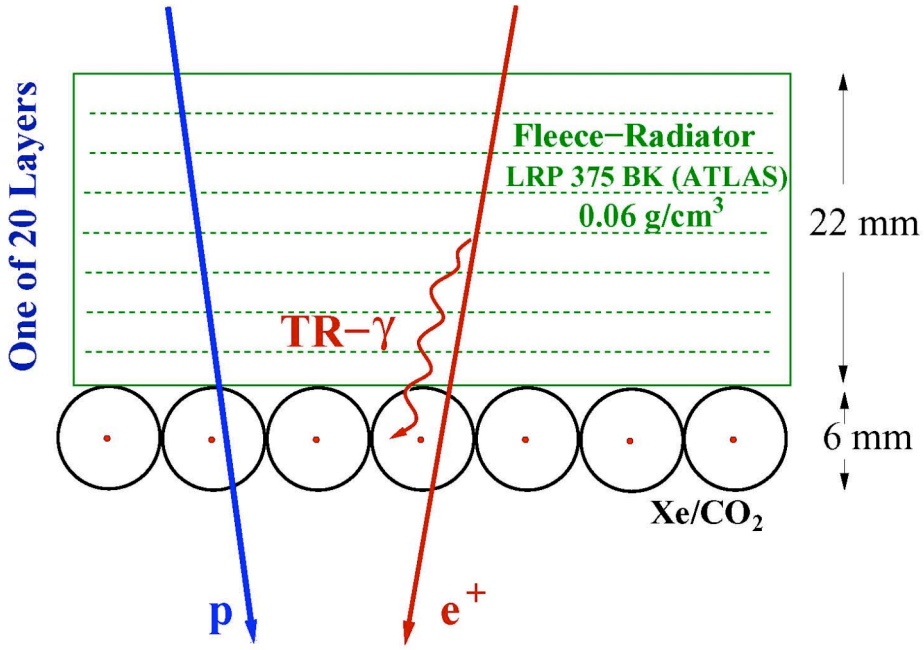
Proton rejection >10^2 1-300 GeV
acceptance: 0.45m^2sr



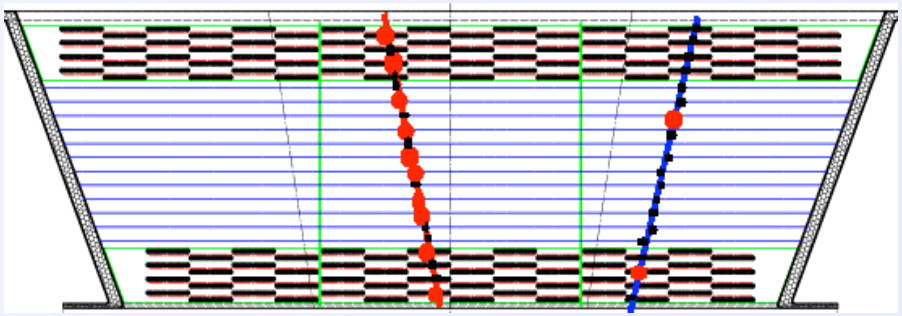
Choosen configuration for 60 cm height:
20 Layers each existing of:

- **22 mm fibre fleece**
- **Ø 6 mm straw tubes**

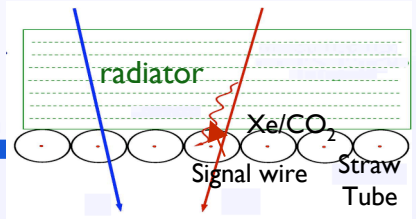
filled with Xe/CO_2 80%/20%



12 layers in the bending plane
2 x 4 layers in the non-bending plane



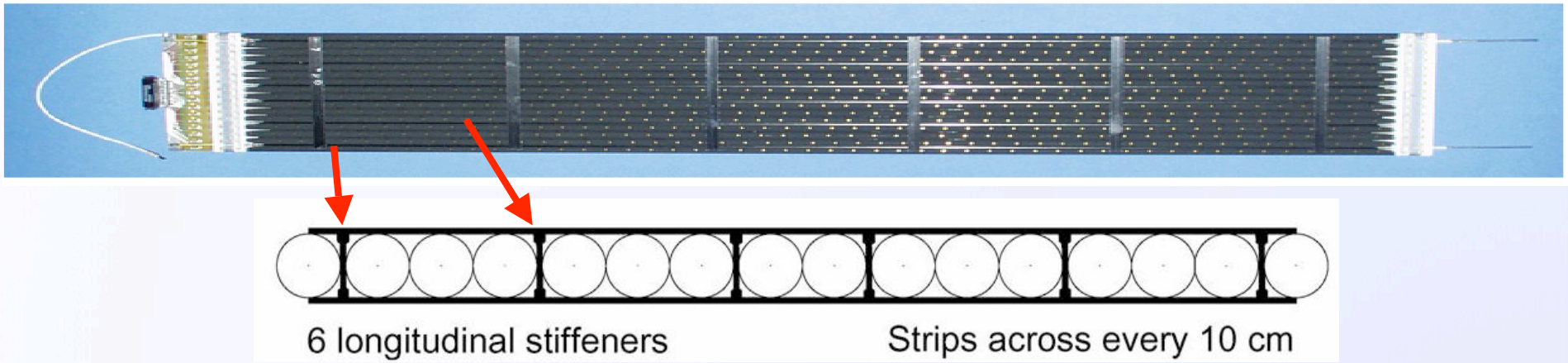
TRD



Straw tube proportional counter modules:

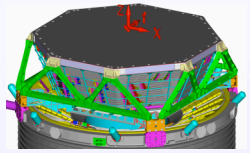
- Straw tubes: 72 μm multilayer aluminium kapton foil, Ø 6 mm , 0.8 ÷ 2.0 m length
- Wire: tungsten anode wire, 30 μm Ø, tension ≈ 100 g
- Gas mixture: Xe / CO_2 (80% / 20%)
- Operating HV ~ 1380 V → Gasgain of ~ 3000
- 1 Module → 16 Straws, centered 100 μm mechanical accuracy

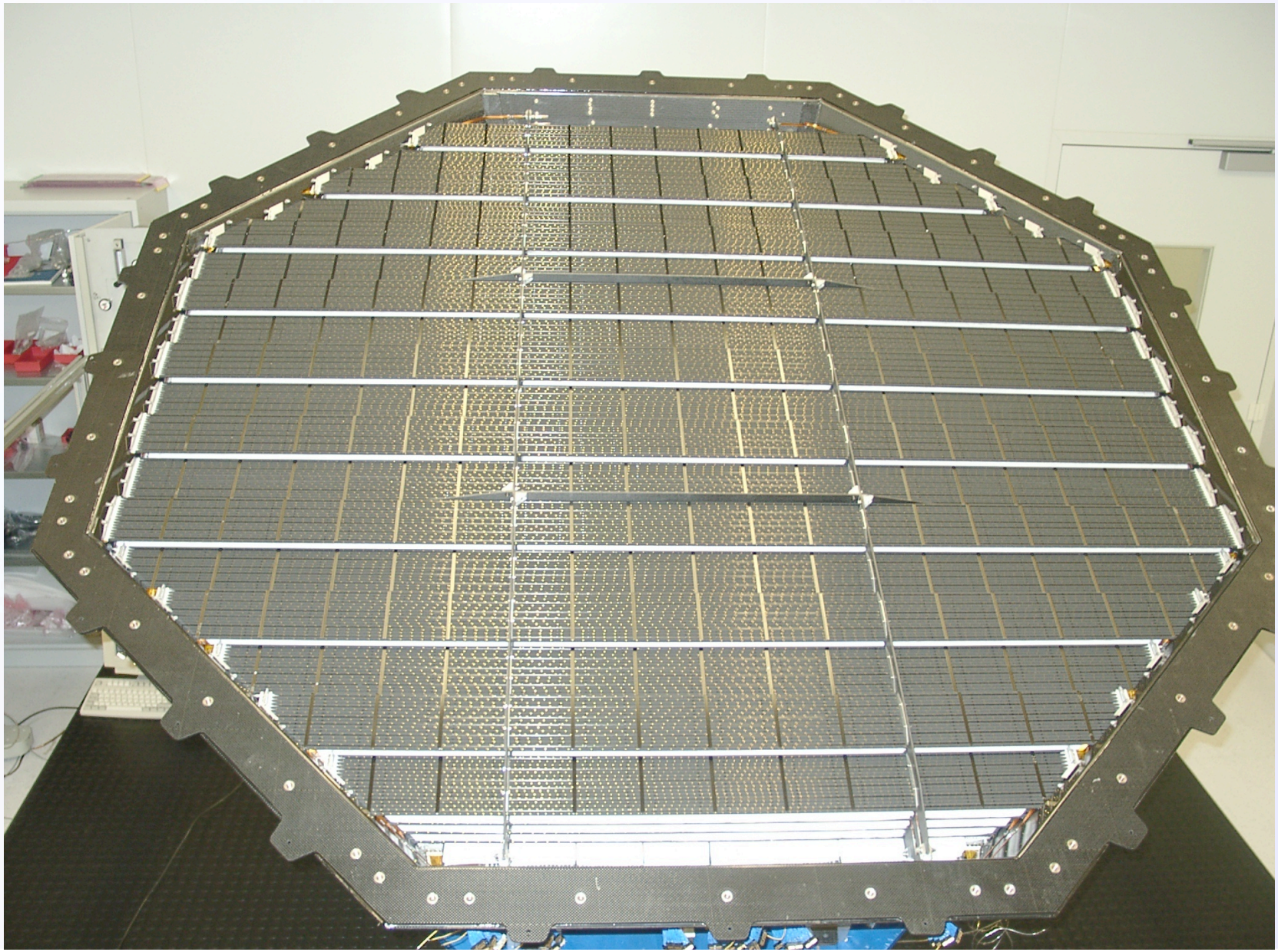
328 Modules → 5248 Straw tubes



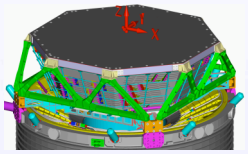
Challenge : RIGIDITY , GAS TIGHTNESS

TRD - Octogon fully integrated



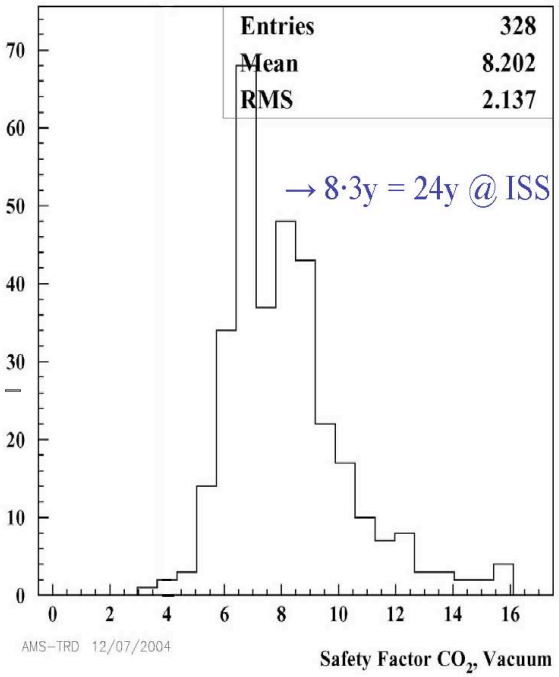


TRD - CO_2 Leak test in vacuum

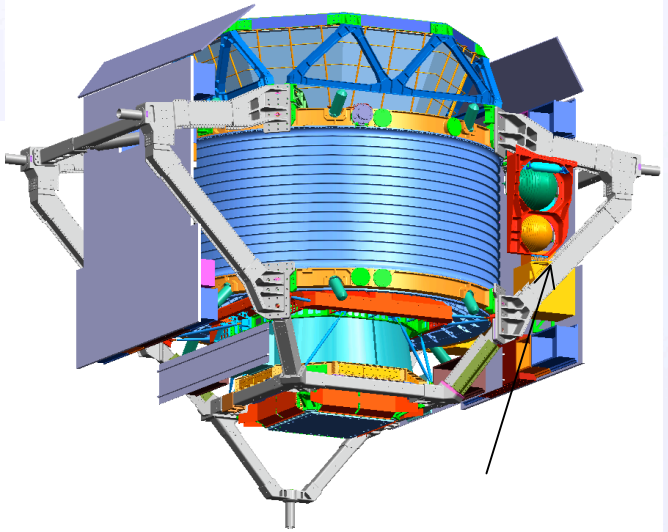


TRD: 328 Flight Module Gastightness

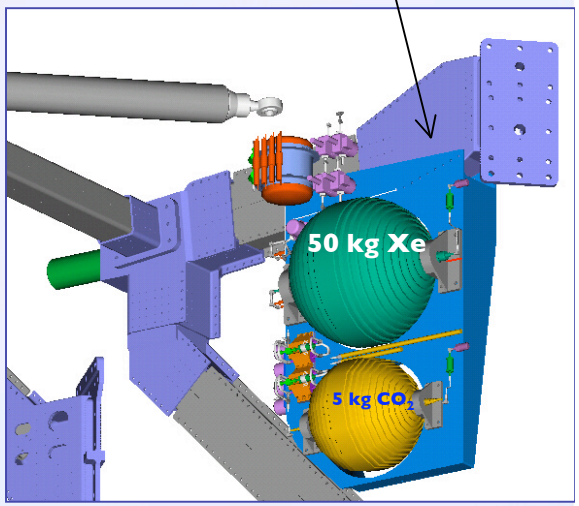




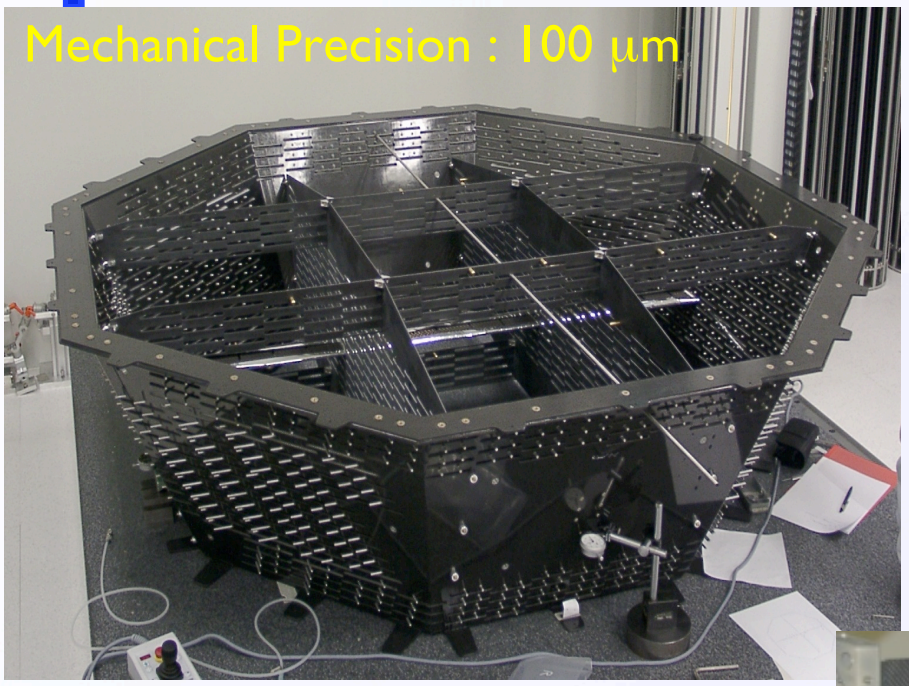
CO_2 Leaktest in Vacuum	Straws @ 1bar:	$1.85 \cdot 10^{-5}$ l mbar/s/m_{CH} ≡ SF 13.7
$1m_{CH}$ = 16 straws of 1m [+2 endpcs]	Typ. Module [1.5m] :	$3.1 \cdot 10^{-5}$ l mbar/s/m_{CH} ≡ SF 8.2



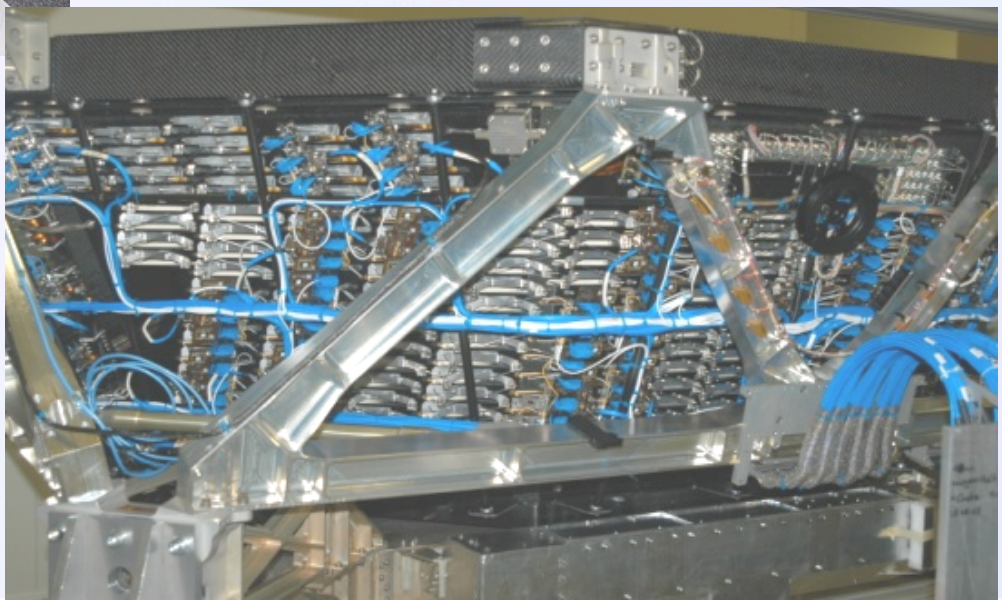
TRD Gas Supply System



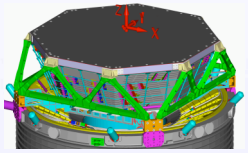
TRD - Flight Support Structure



RWTH Physics AC-I

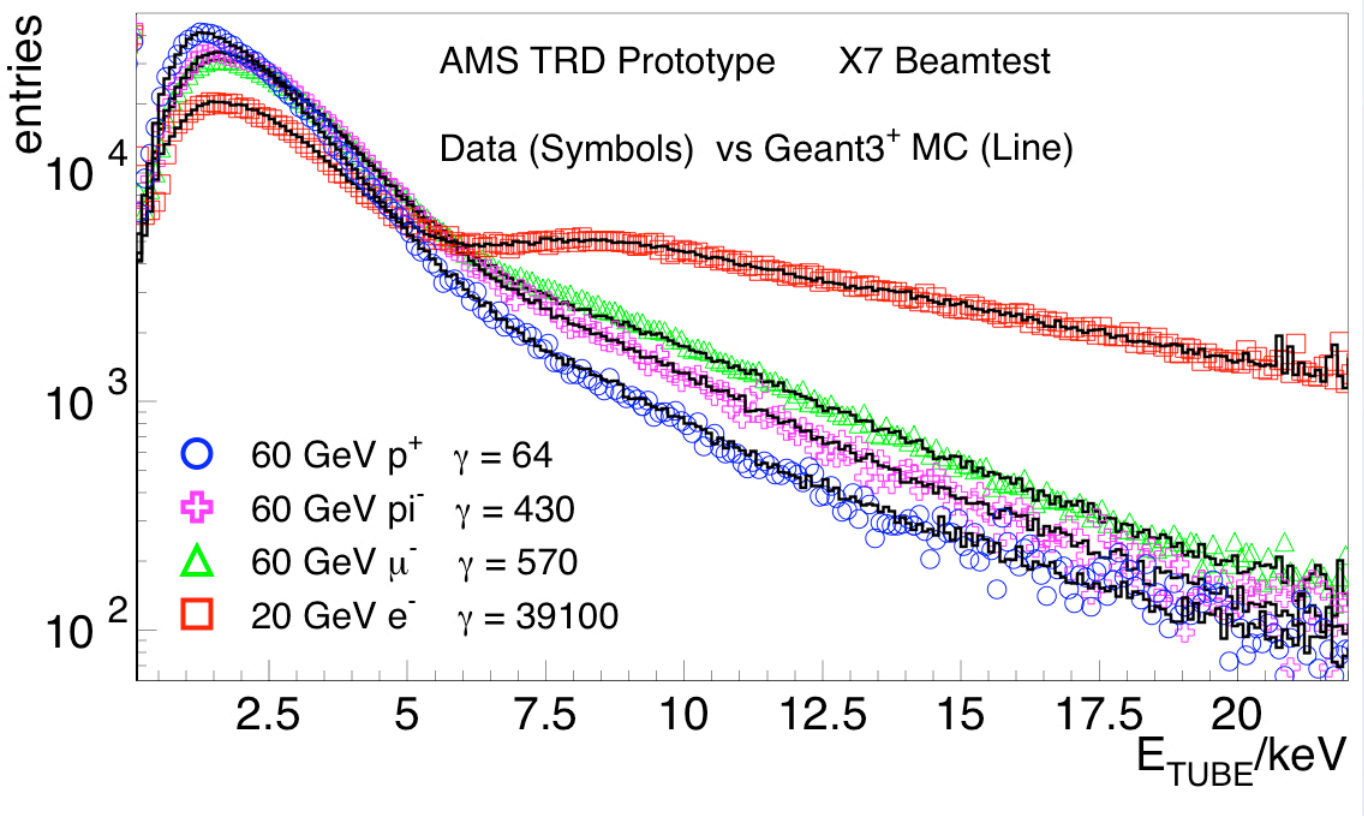


TDR – test beam results

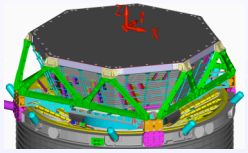


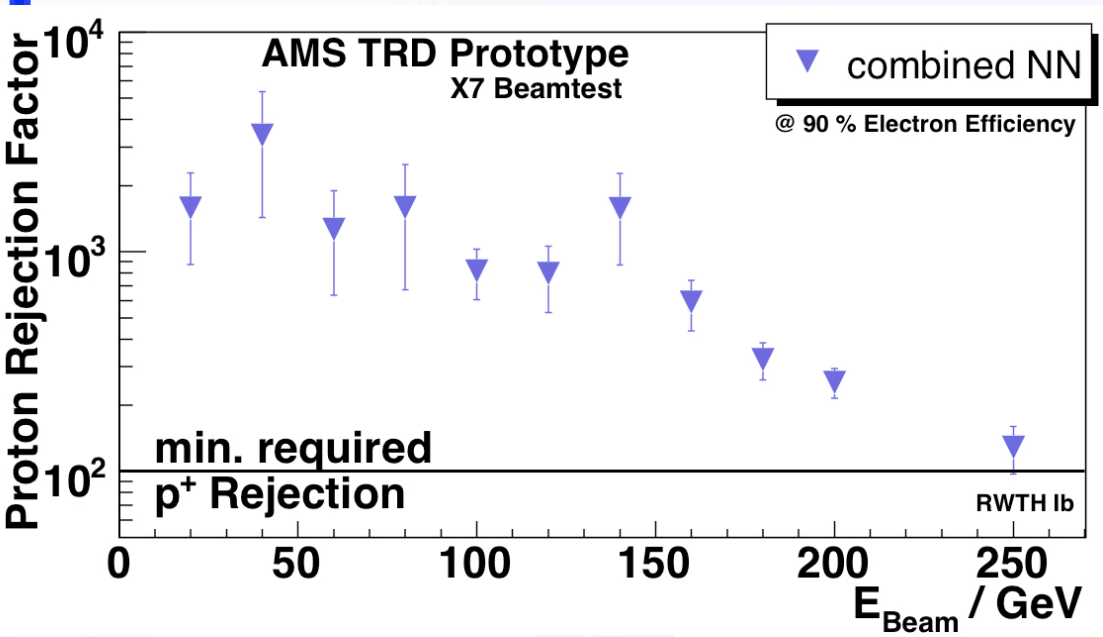
20 layer TRD detector in the test beam at CERN in 2000

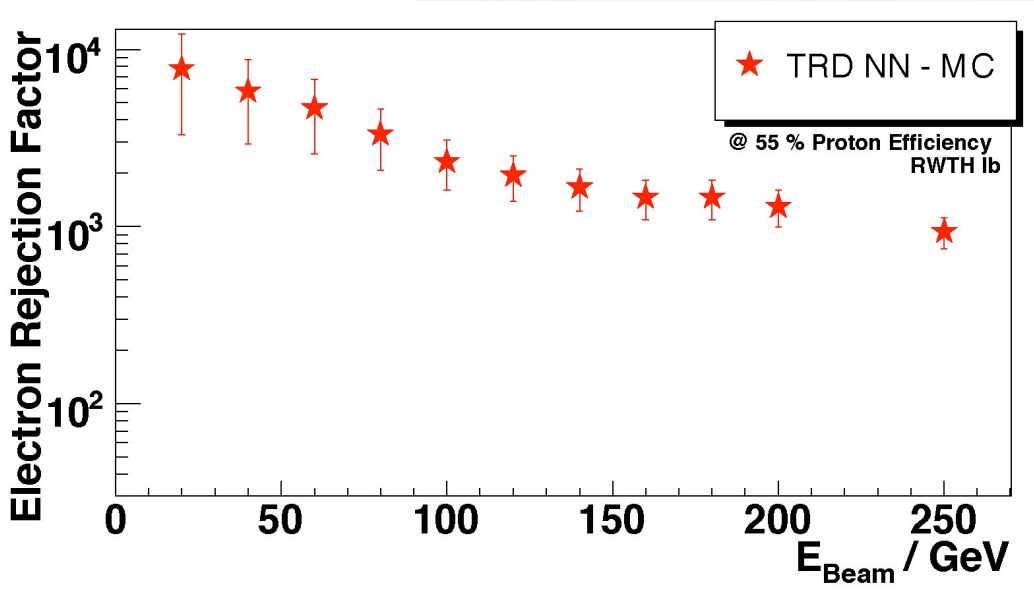
3 million events of p,e,μ,π @ 5-250 GeV



TDR – Test Beam Results

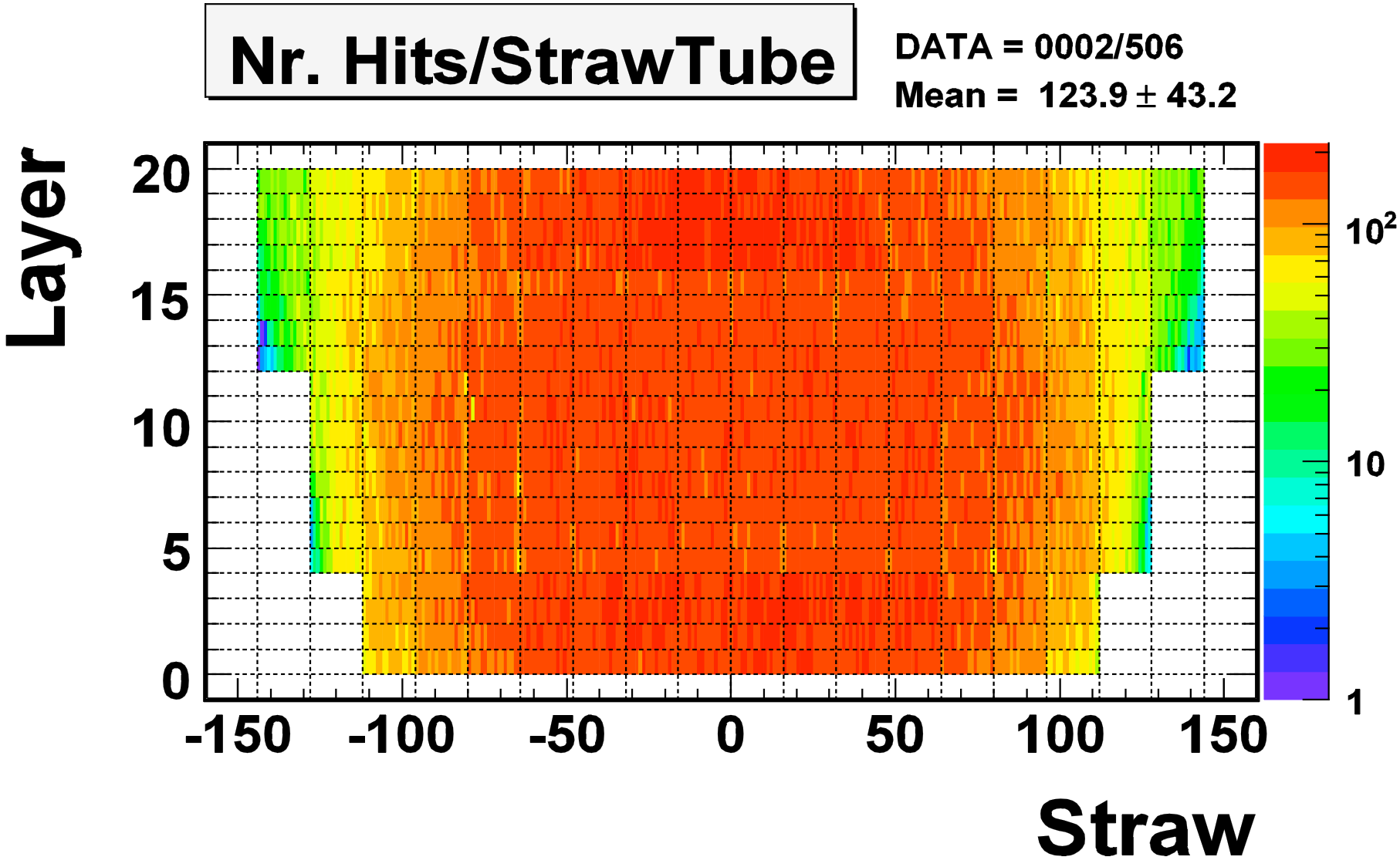




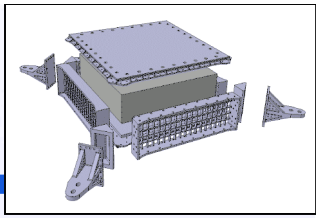


TRD - cosmic muons

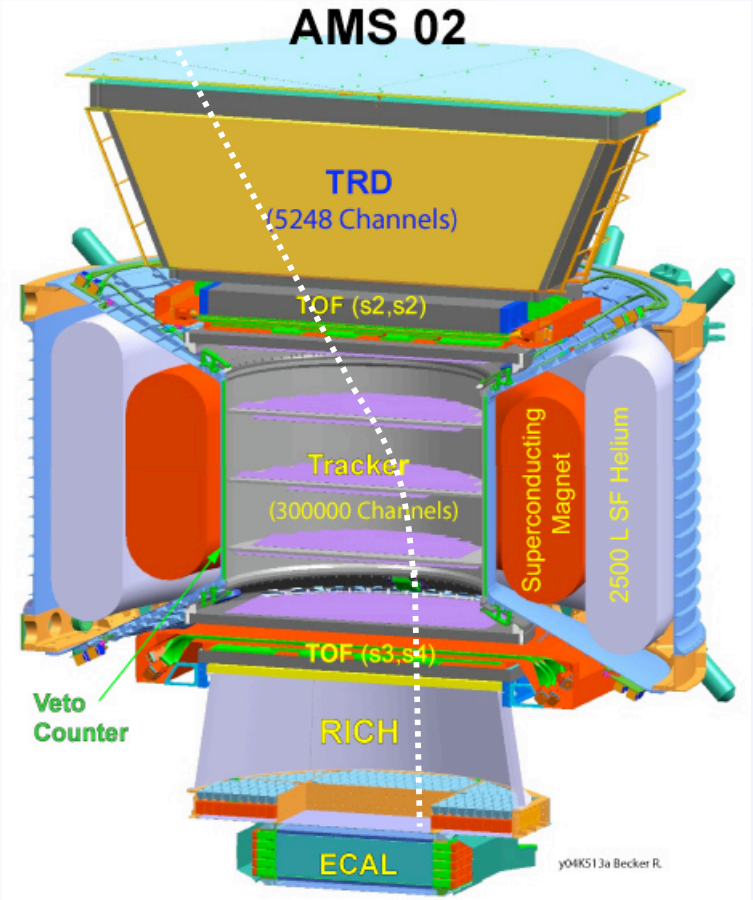
Occupancy of 5248 straws



Electromagnetic Calorimeter



3D imaging calorimeter



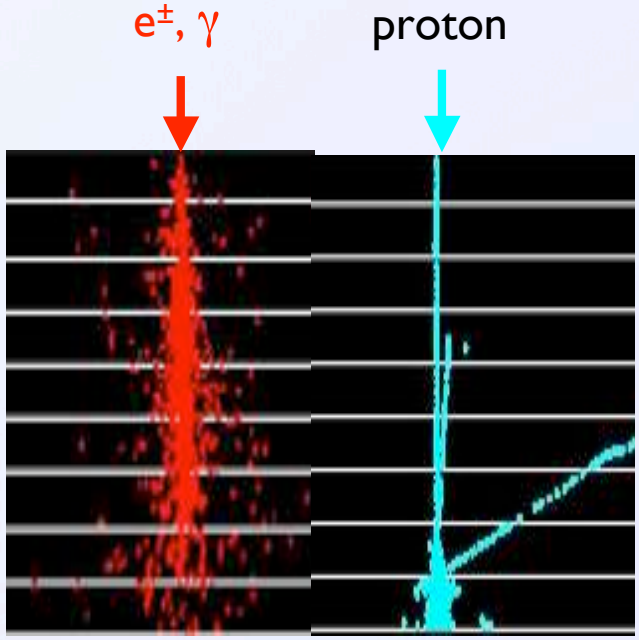
ECAL: last subdetector crossed by particles from outer space

:

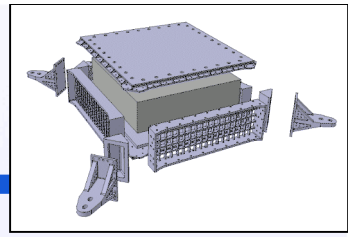
▷ Particle ID (e.m showers vs. hadron cascades)

▷ Energy measurement (e^+,e^-,γ) (up to 1TeV)

▷ Trigger system: on non interacting photons



Electromagnetic Calorimeter

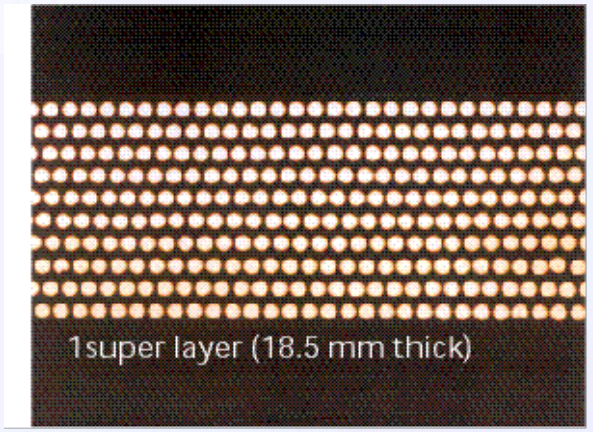


3D shower reconstruction

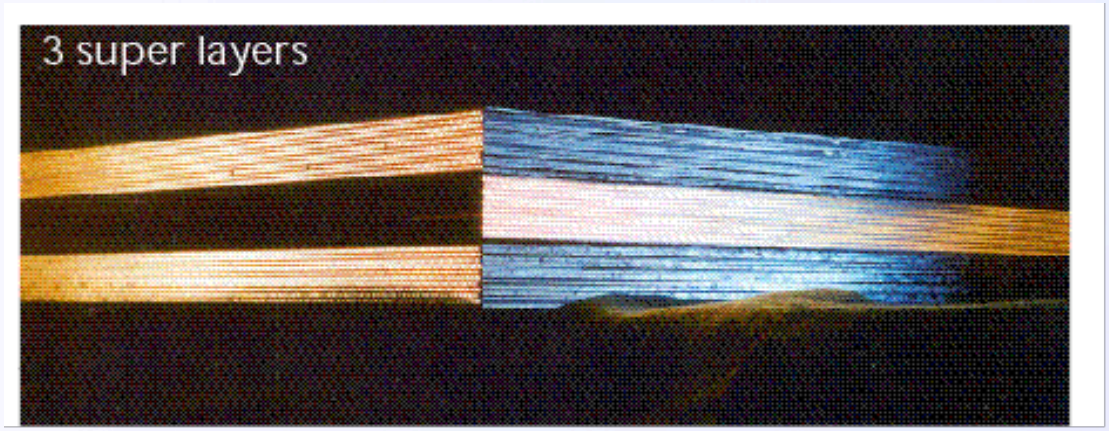
- Sampling calorimeter
- Pb/scintillating fibers structure

  volume ratio Pb:fibers:glue : 60:34:6
  dimensions : 658 × 658 × 166.5 mm^3
  weight : 498 kg

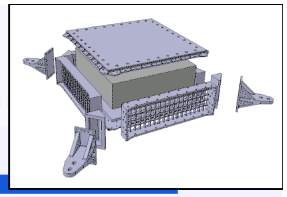
- Pile up of 9 “Superlayers” (>16 rad.lengths)



10 000 fibers, ϕ = 1 mm
distributed uniformly
Inside 1,200 lb of lead



Electromagnetic Calorimeter



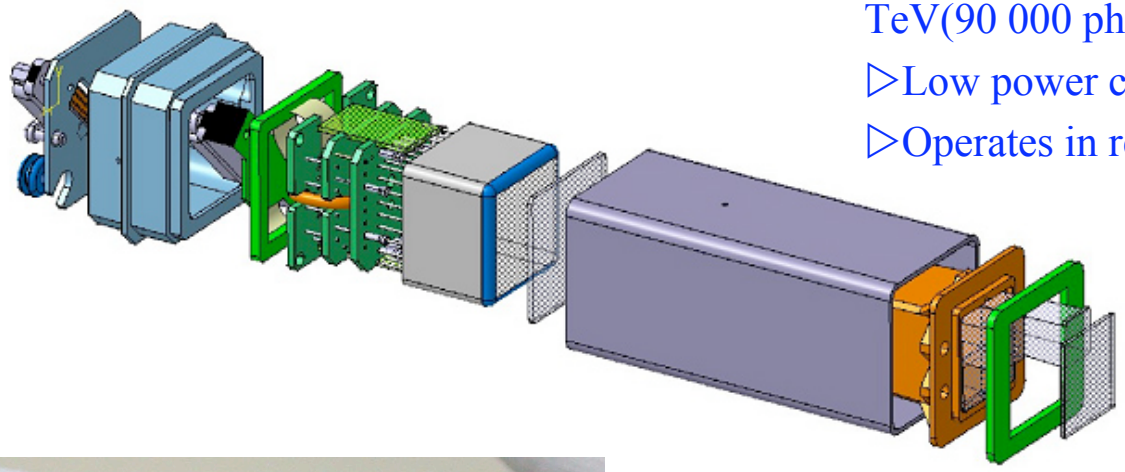
Light collection system

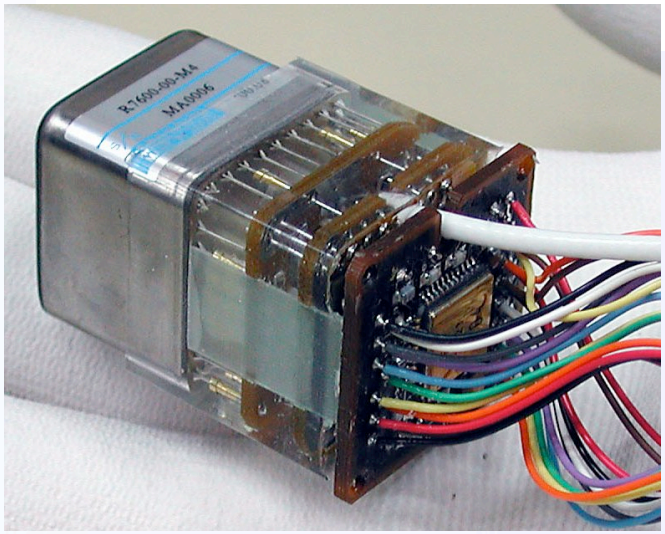
▷Detect the MIP (~8 photo electrons)

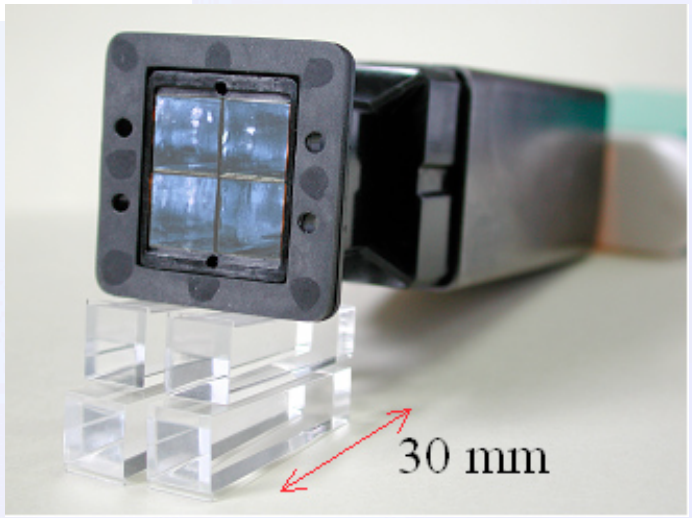
▷ Detect the maximum of the shower for ~1 TeV(90 000 photo- electrons)

▷Low power consumption 20 mW per channel

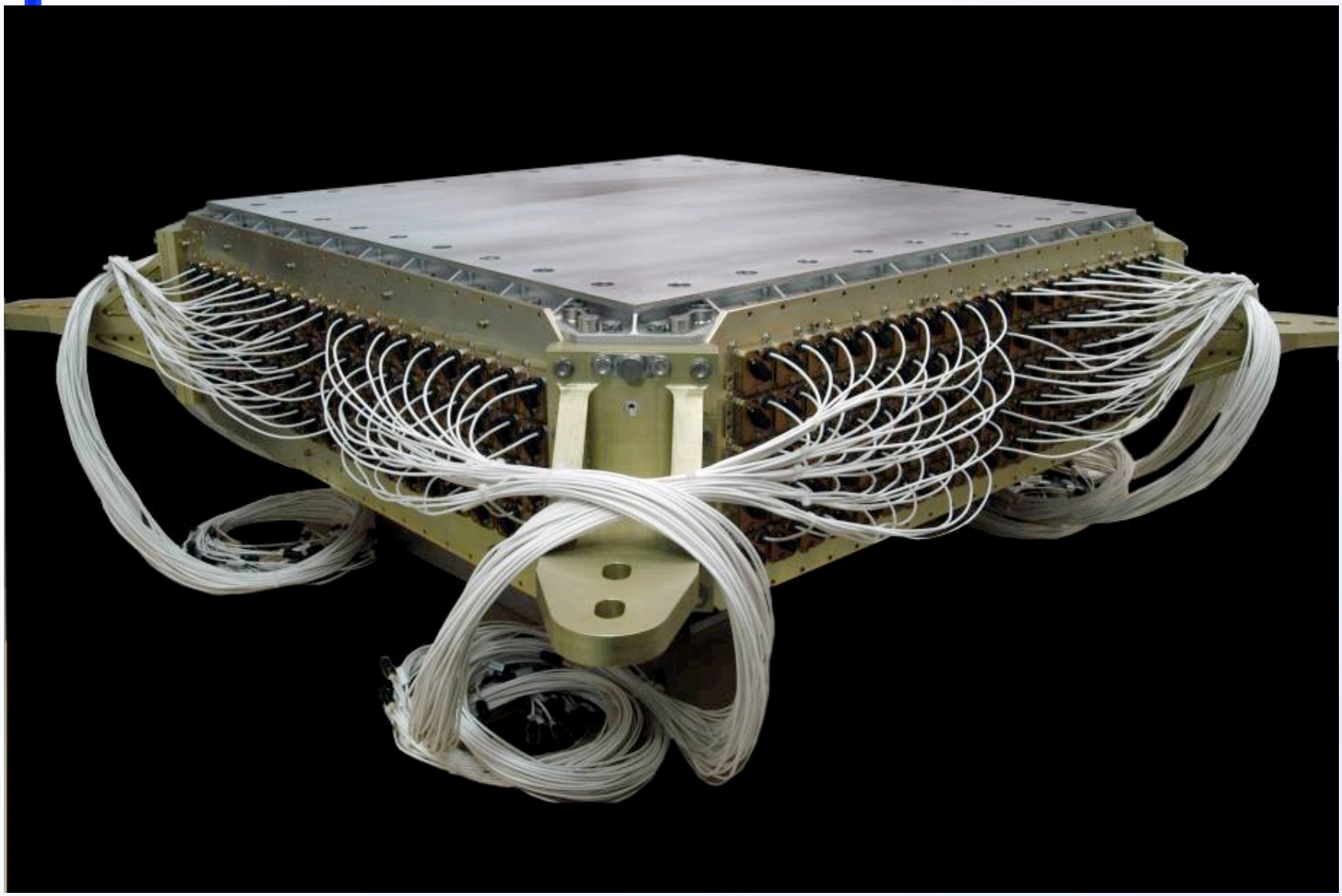
▷Operates in residual magnetic field of 200 Gauss



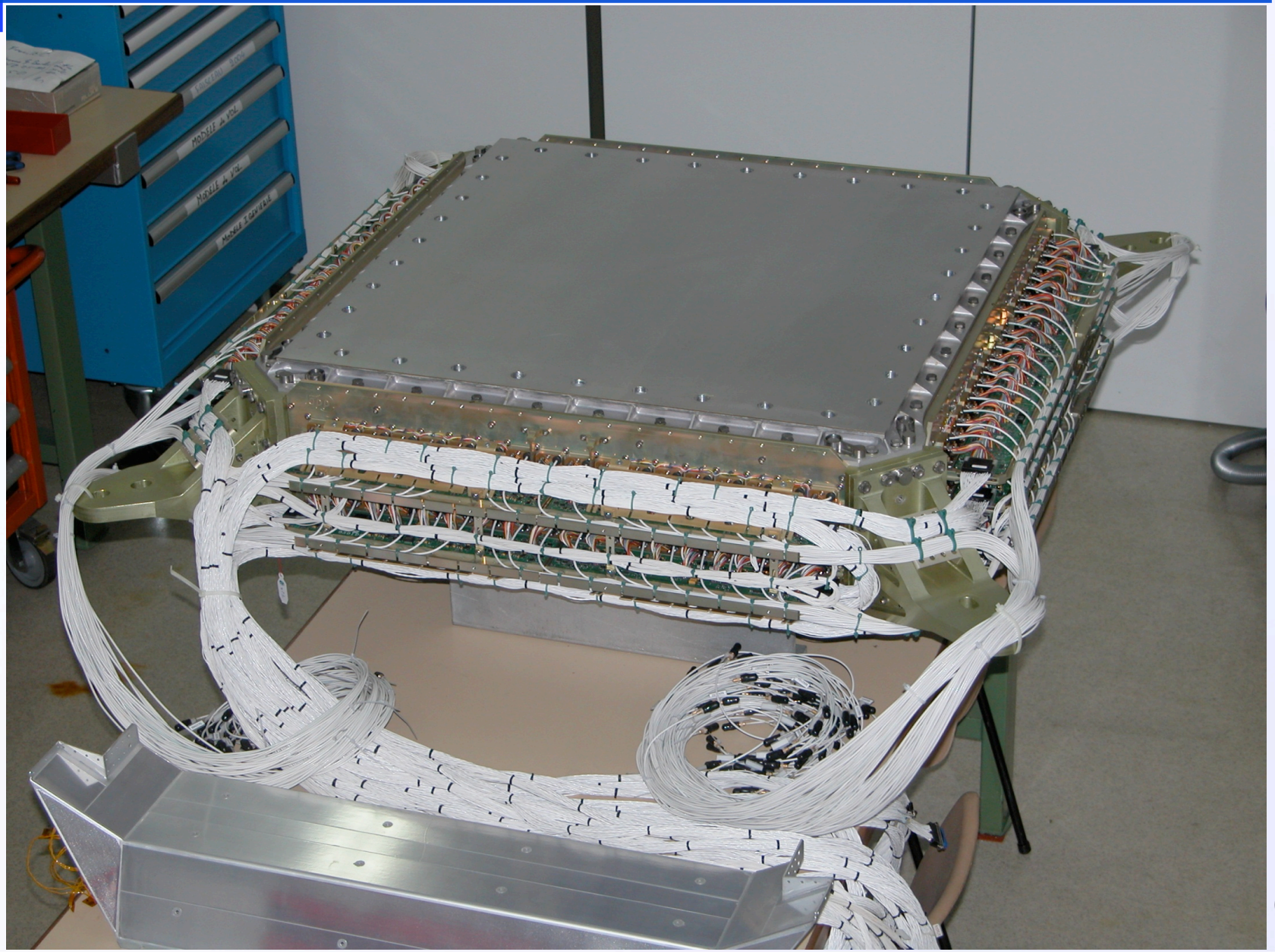




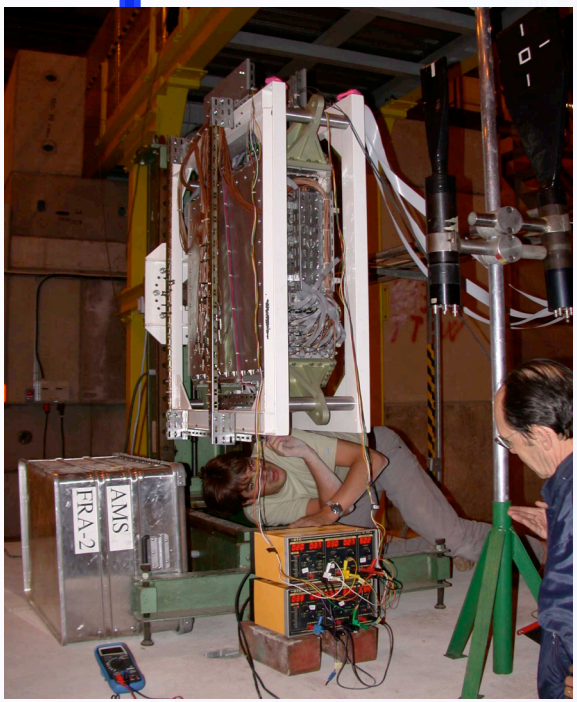
ECAL Construction



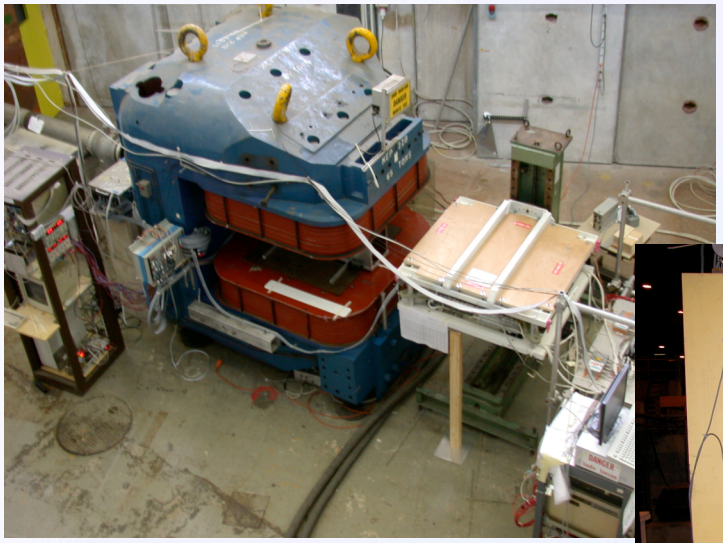
ECAL Construction



ECAL – Beam test



▷ Since 2002



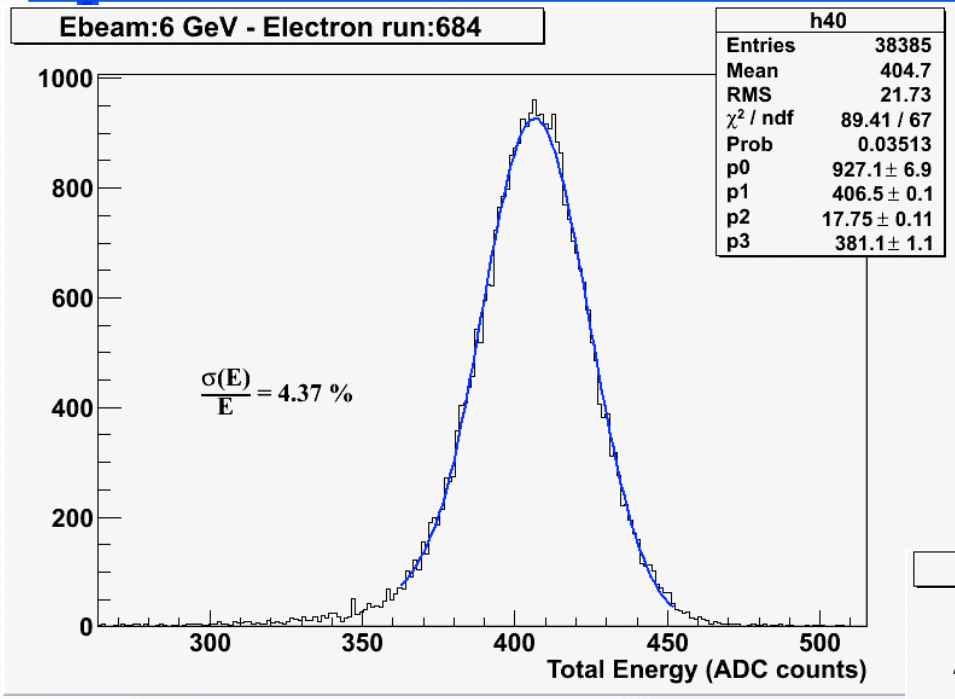


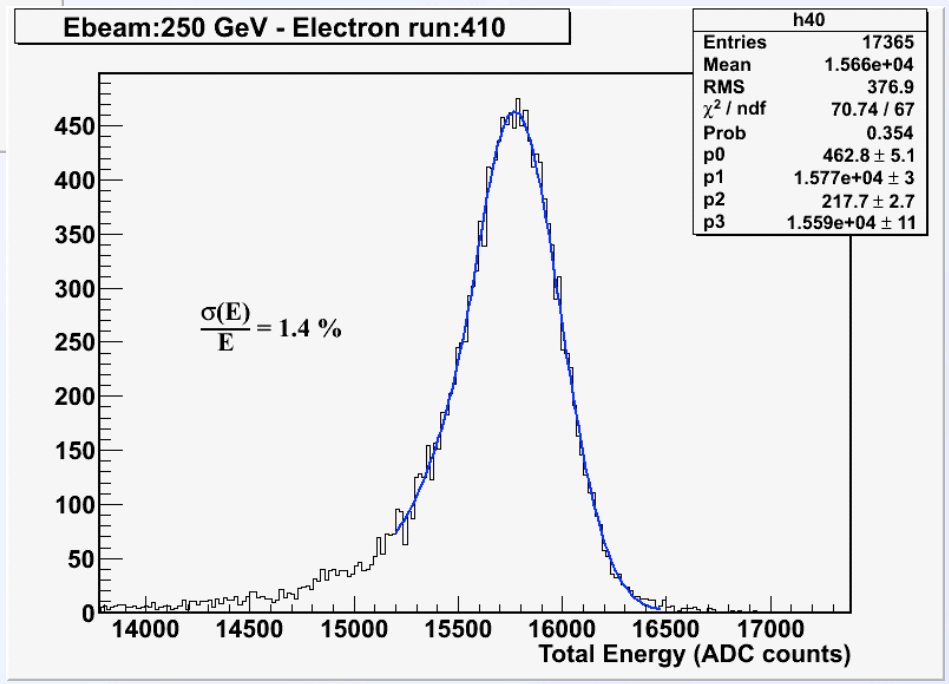
2002
QM; validation of the front end, HV supply and light collection system

2004
Qualified Model
Validation of the standalone trigger

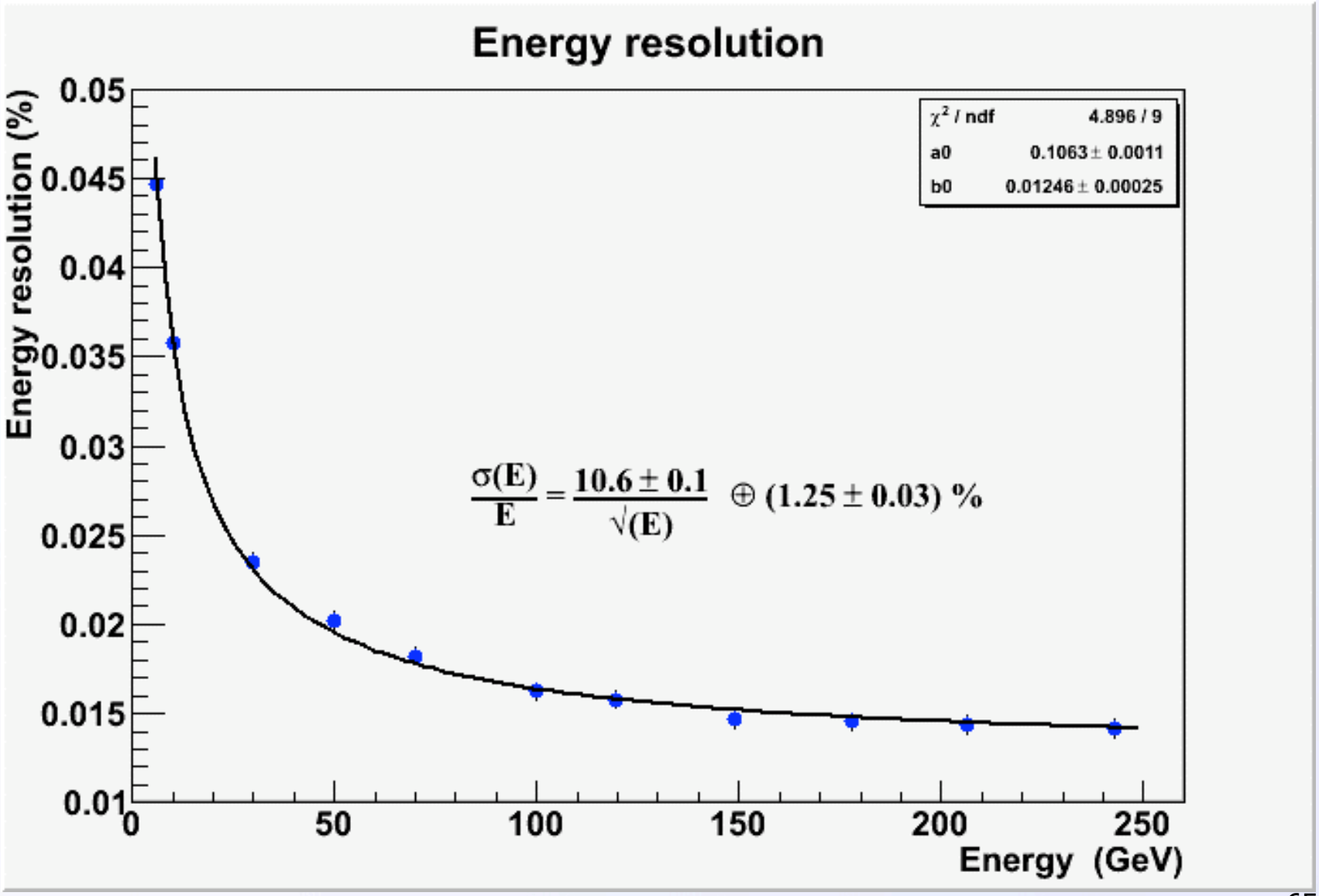
2006-2007
Flight Model

ECAL performance



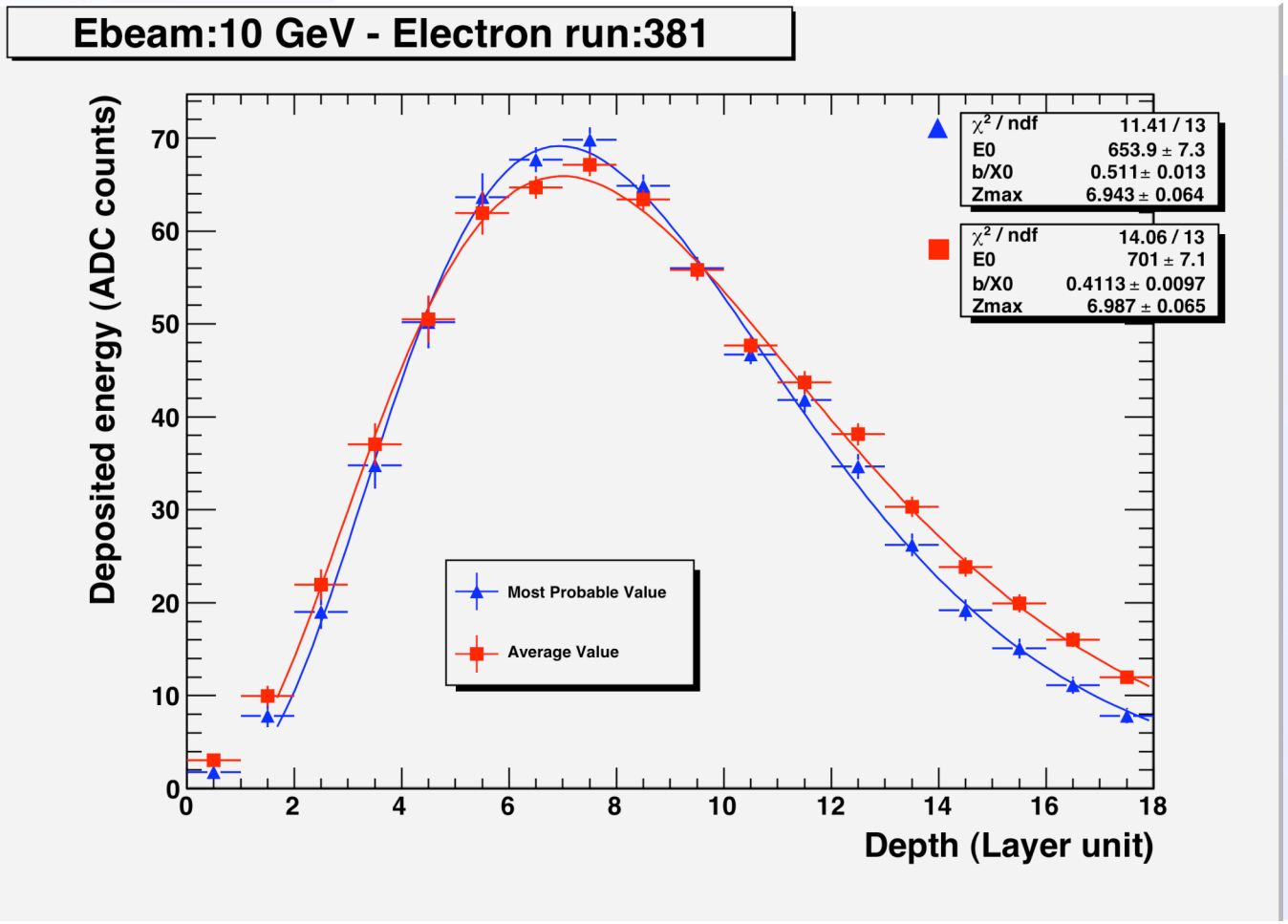


ECAL performance

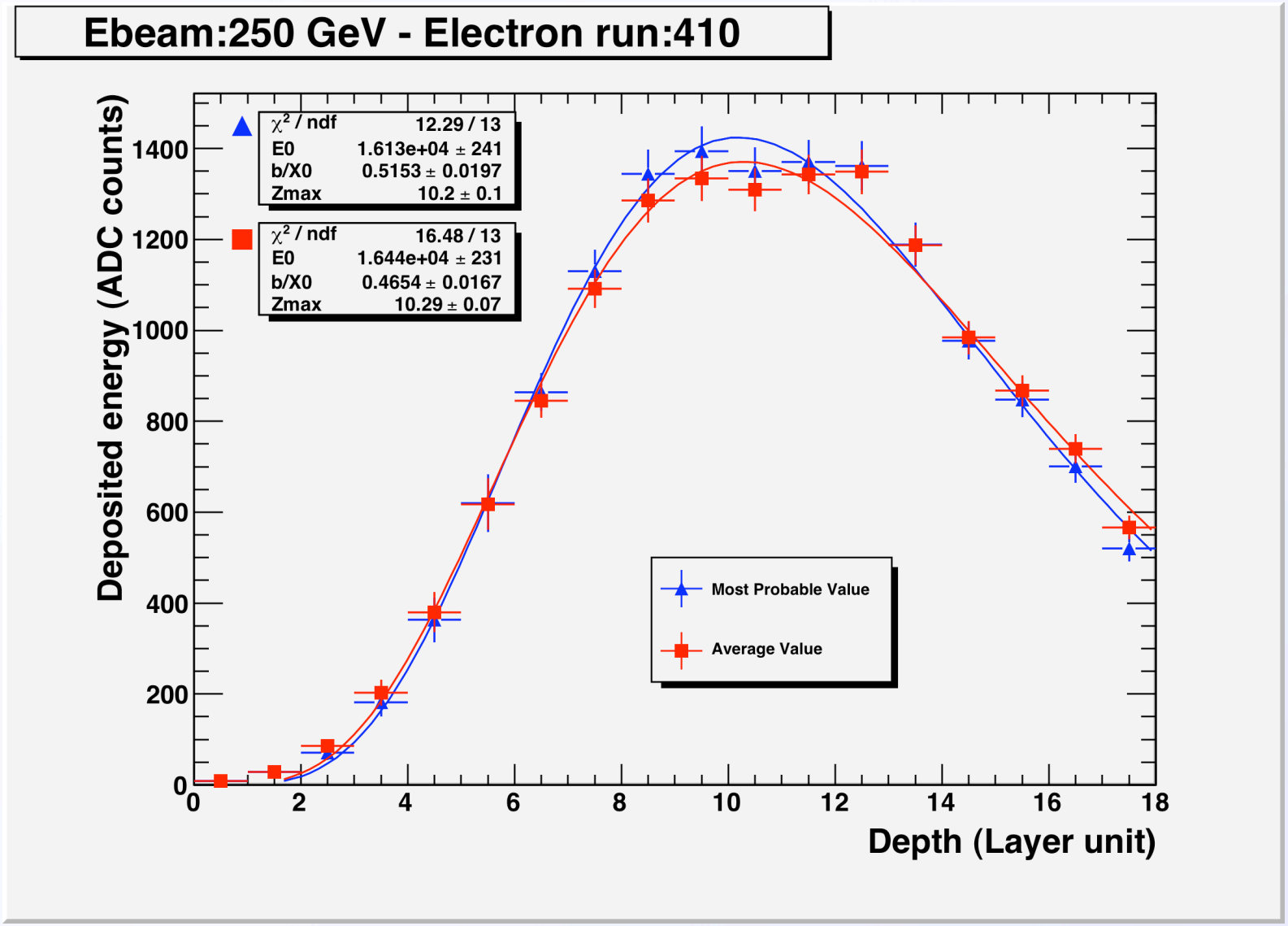


ECAL performance

$$\frac{dE}{dz} = E_0 \times \frac{b}{X_0} \times \frac{e^{-\frac{b}{X_0}z}\left(\frac{b}{X_0}z\right)^{\frac{b}{X_0}z_{max}}}{\Gamma(\frac{b}{X_0}z_{max}+1)}$$

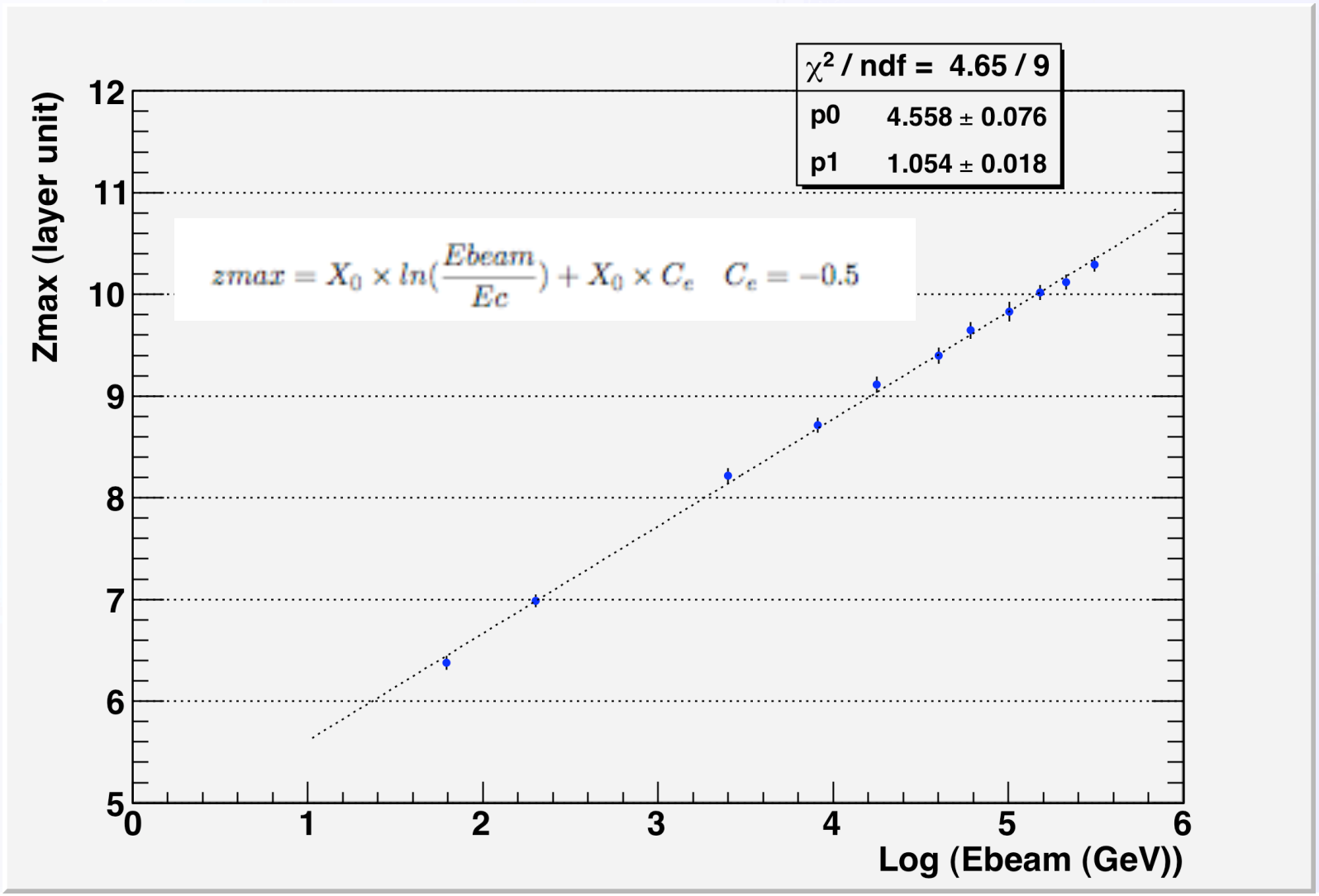


ECAL performance



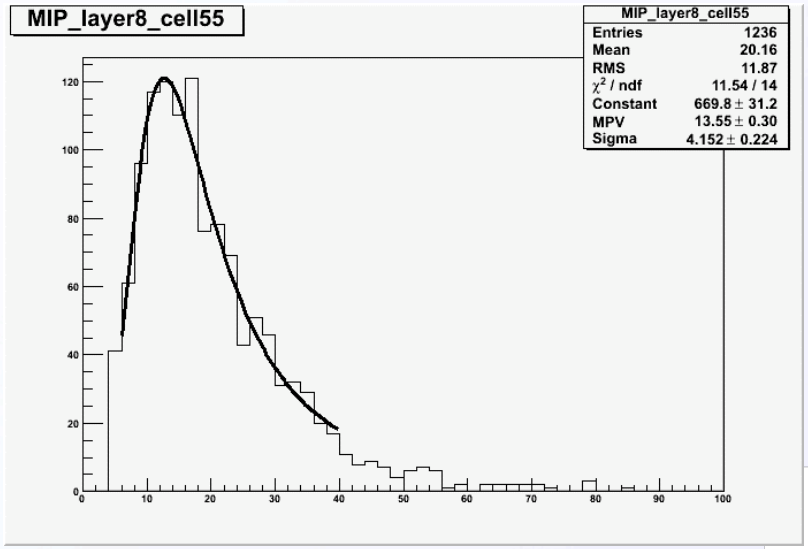
ECAL performance

- Total Radiation Length ~17 X_0

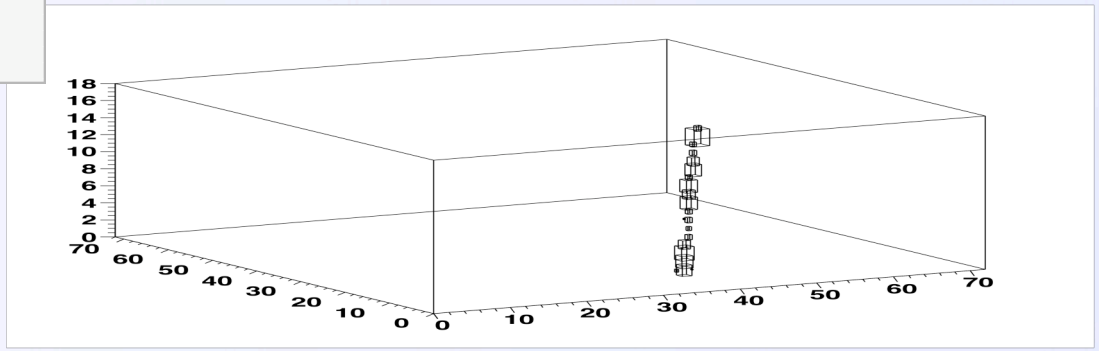


Rich + ECAL

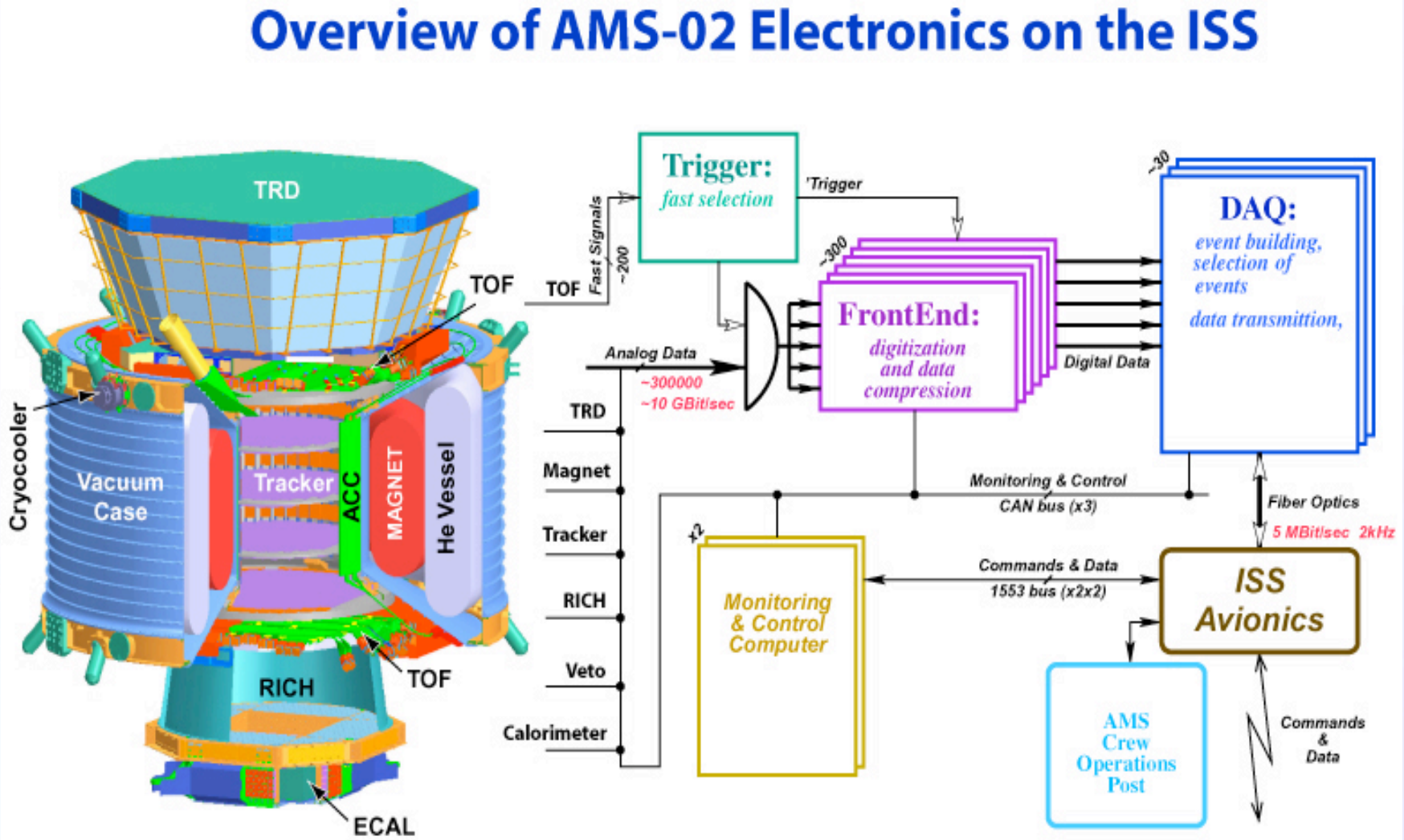
- Cosmics tests and analysis







AMS- Electronics

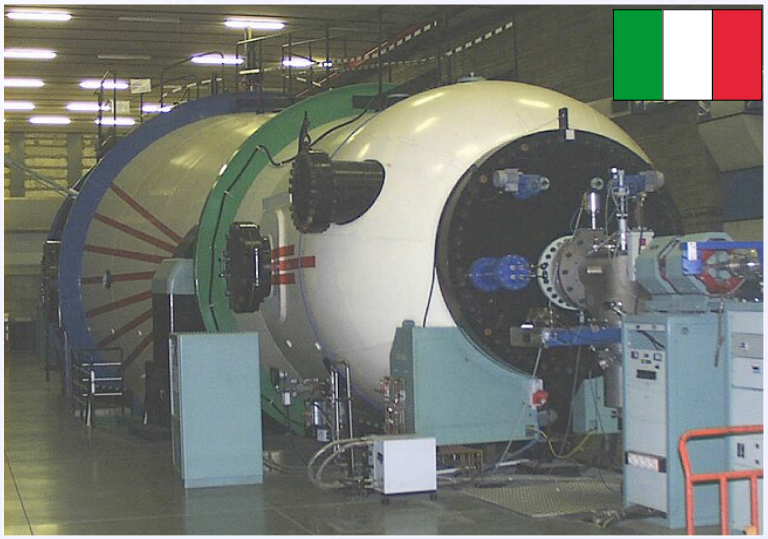


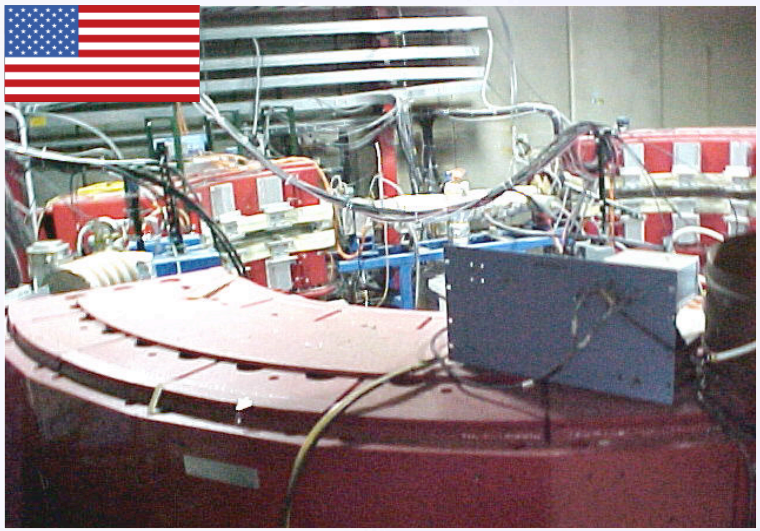
AMS requires fast (10 times faster than current space electronics) and reliable electronics.
Starting with selection of components: without the protection of the atmosphere, heavy ion radiation in space can disrupt command and control.

Where: International Space Station

Extensive accelerator radiation tests were made to select state of the art components that tolerate the radiation environment of space.









Data Transfert



2 Mbits/sec average science data downlink rate

ACOP (AMS Crew Operation Post) allows ISS local storage and backup of data when downlink is off.

Main processing center at CERN

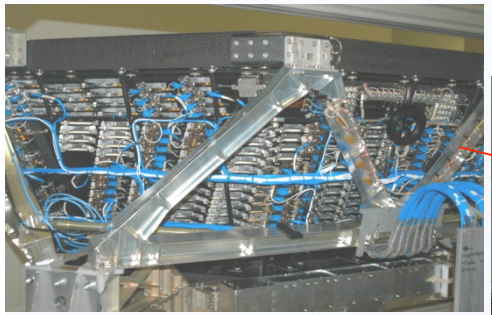
ACOP	AMS Crew Operation Post
POCC	Payload Operation Control Center
SOC	Science Operation Center
MSFC	Marshall Space Flight Center (Al)
JSC	Johnson Space Flight Center (Tx)

The AMS Detector

Particles are identified by their mass, charge and energy.

TRD

Electrons



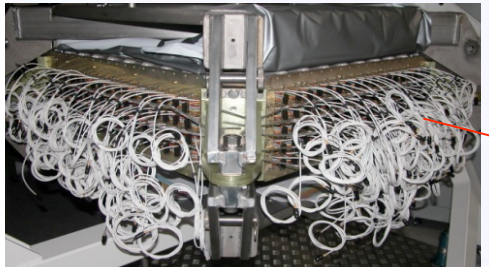
Silicon Tracker

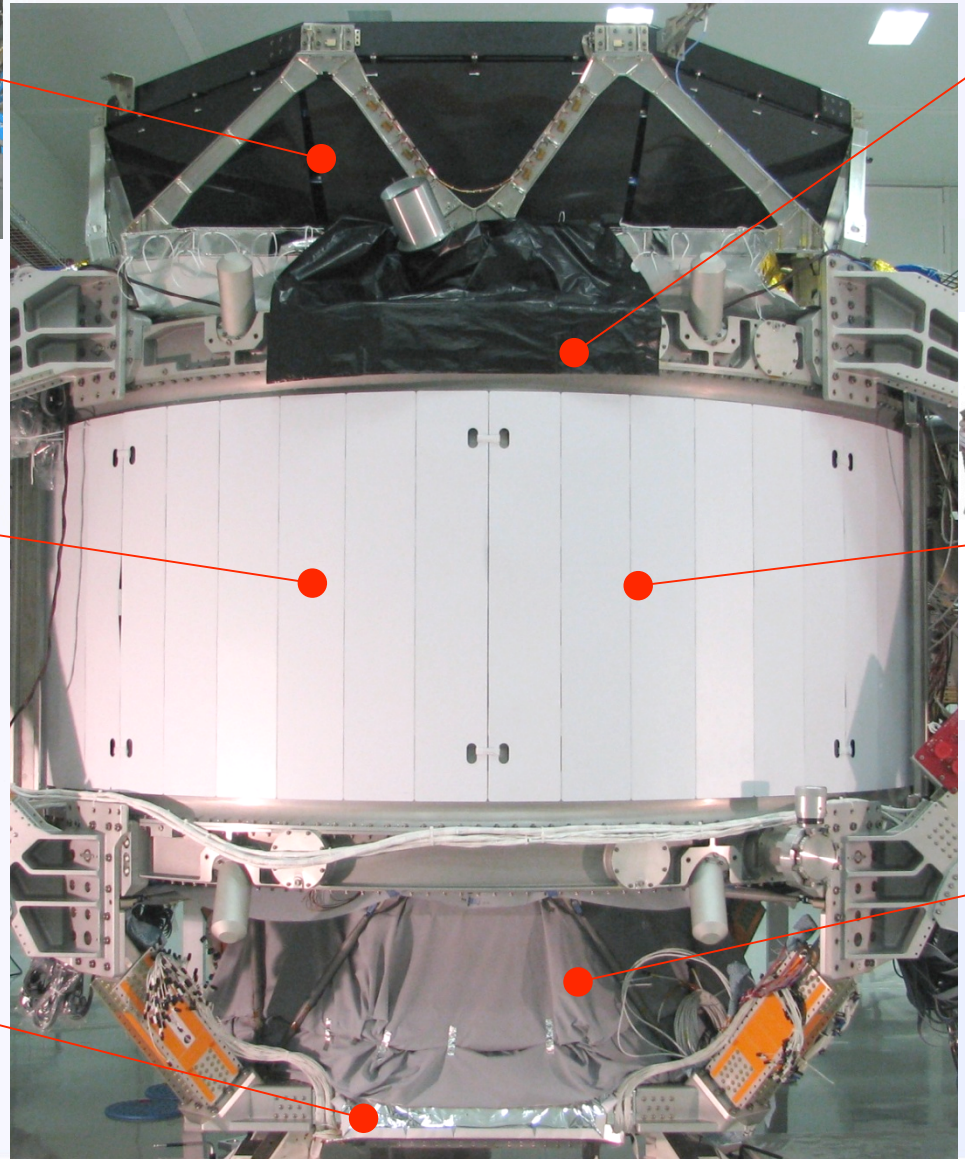
Mass, Charge, Energy



ECAL

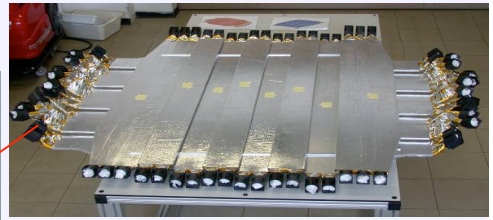
Electrons, Gamma-rays





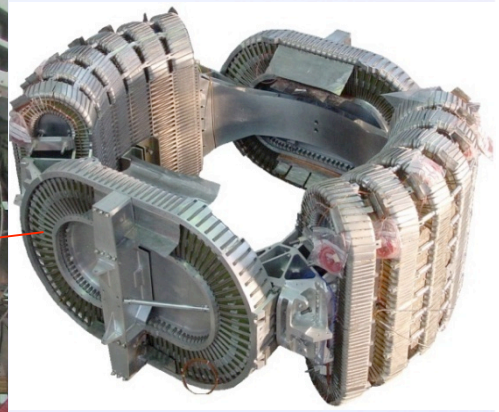
TOF

Mass, Charge, Energy



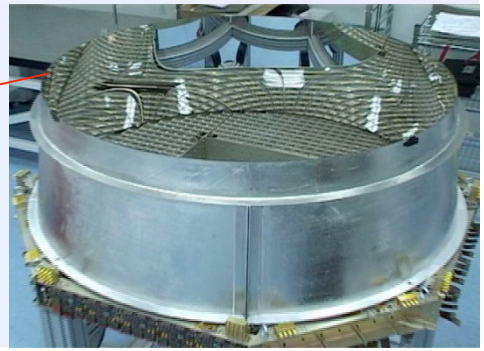
Magnet

Mass, ± Charge, Energy



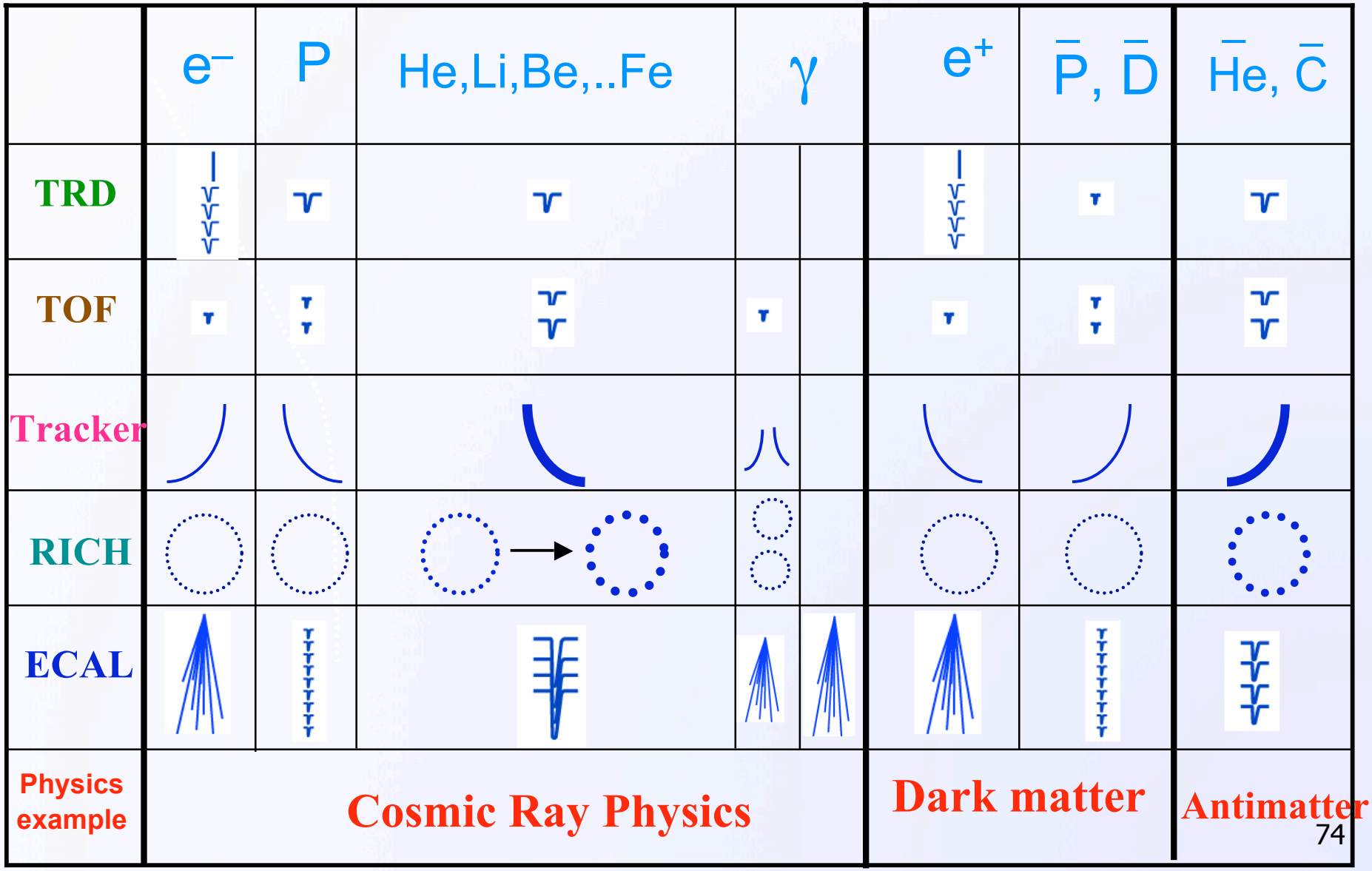
RICH

Mass, Charge, Energy



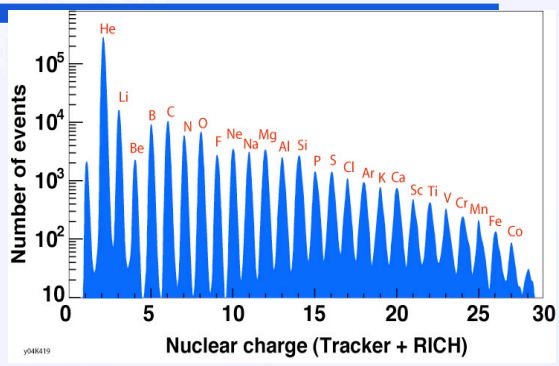
Characteristics of AMS

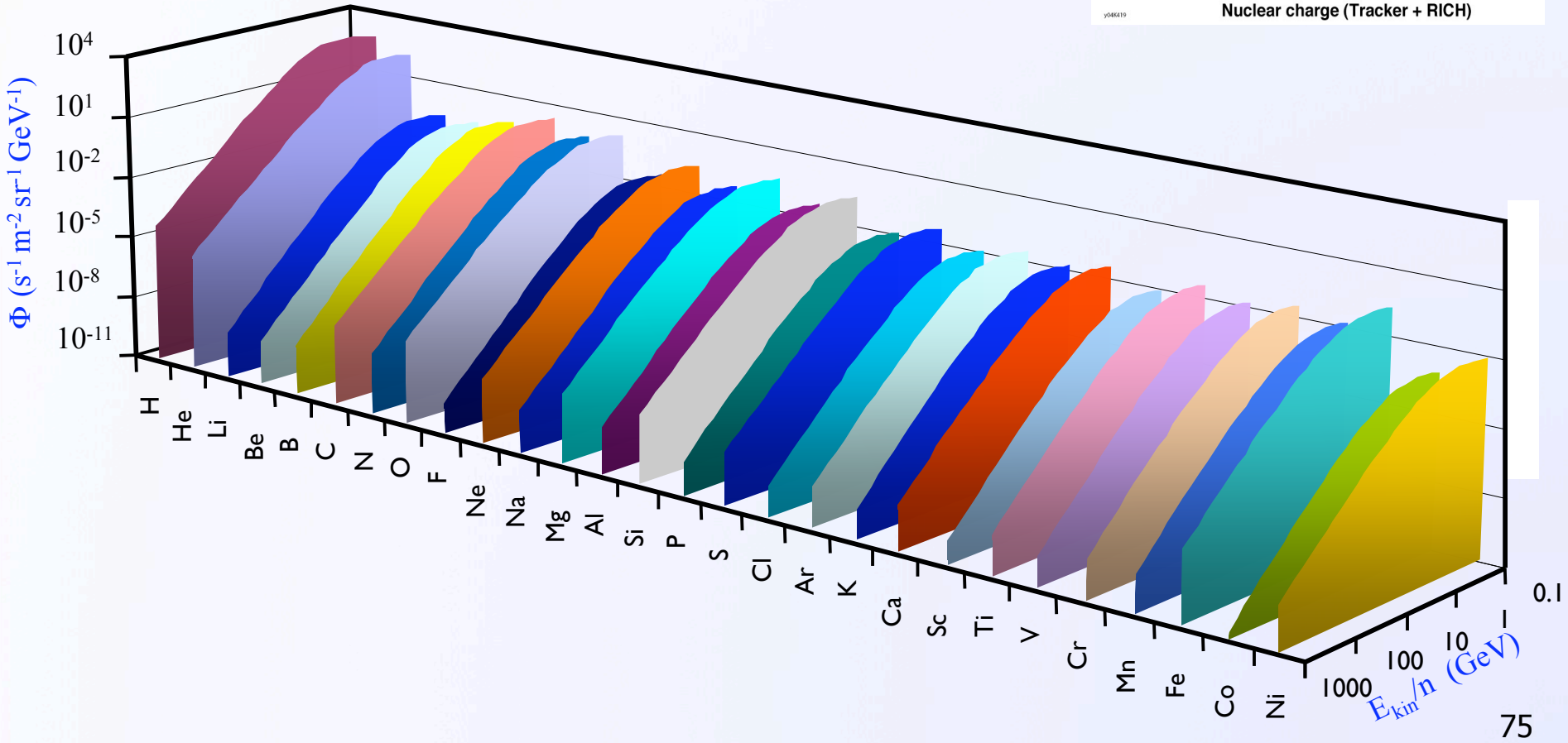
$\Delta t = 100$ ps, $\Delta x = 10$ μm, $\Delta v/v = 0.001$



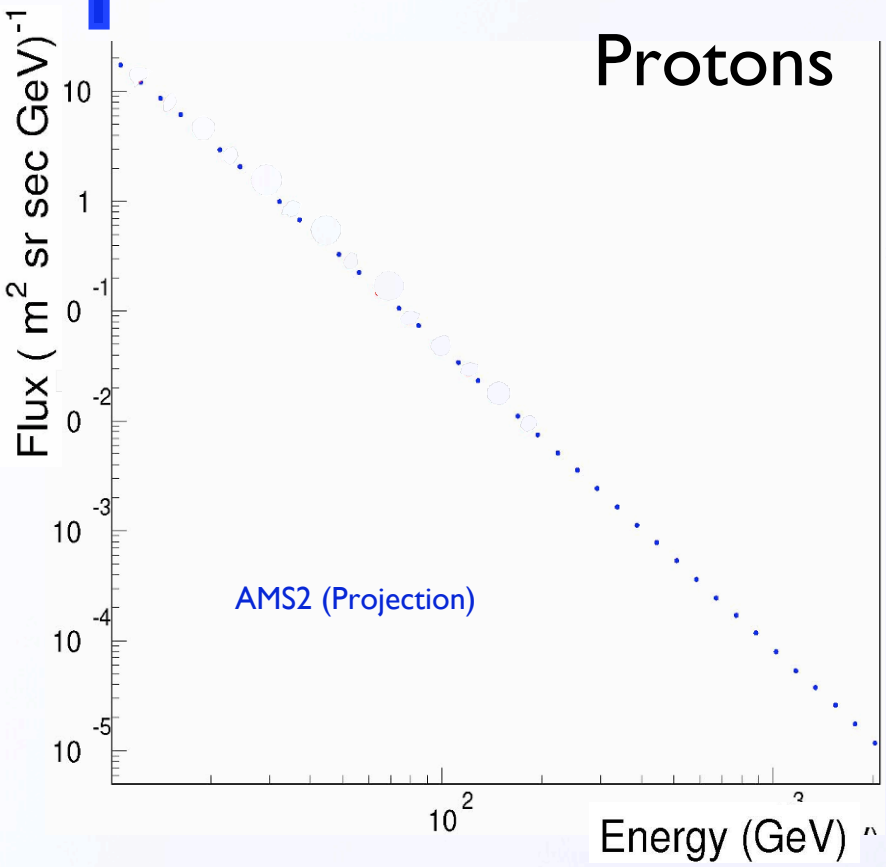
Precision study on the property of cosmic rays

- Composition at different energies
(1 GeV, 100 GeV, 1 TeV)

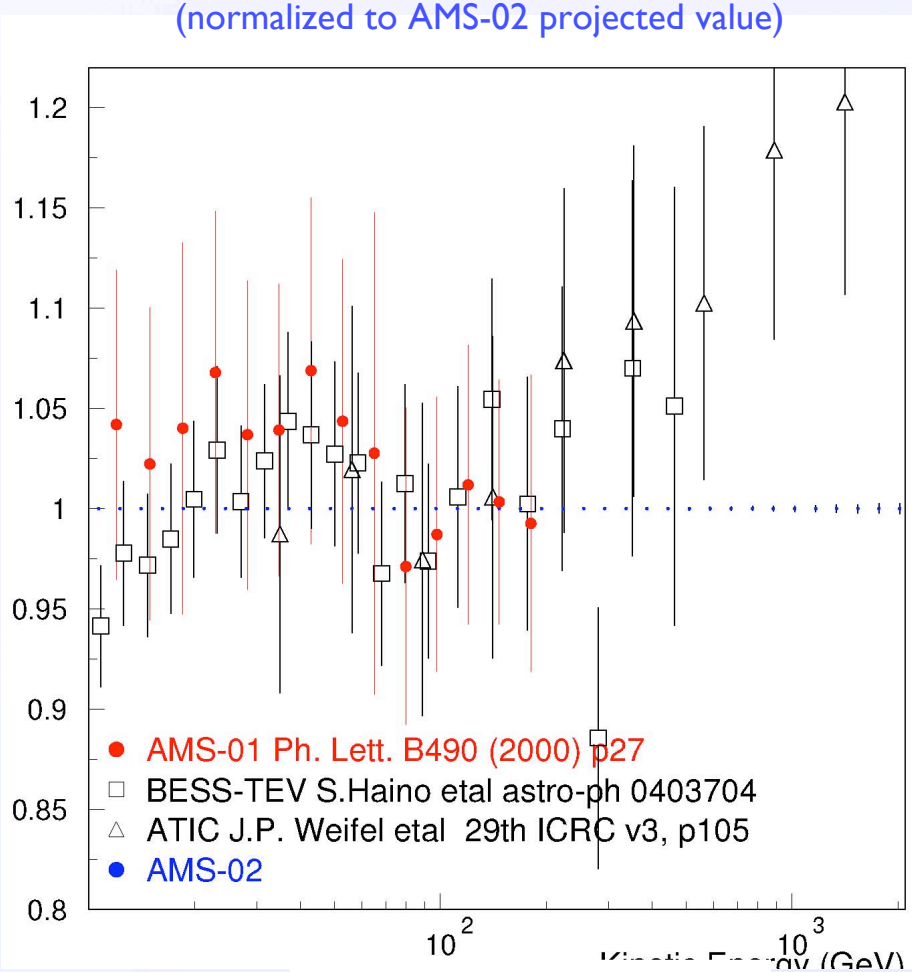




Proton

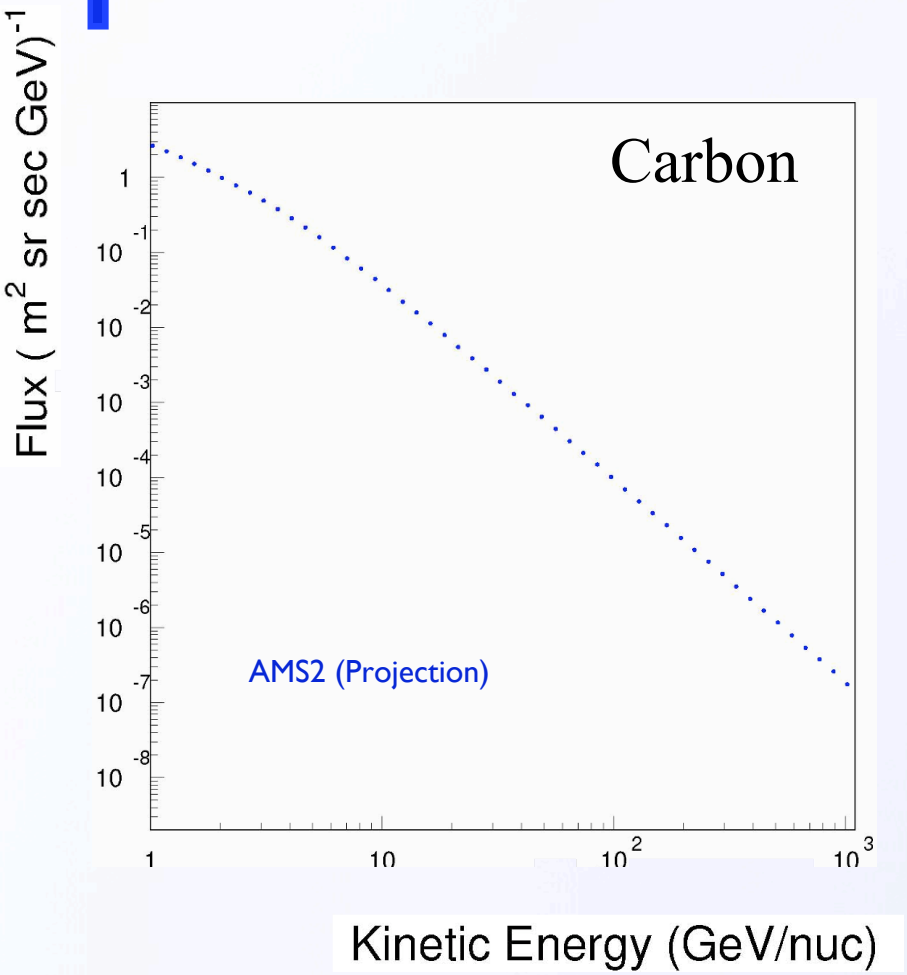


Relative Proton Fluxes
(normalized to AMS-02 projected value)

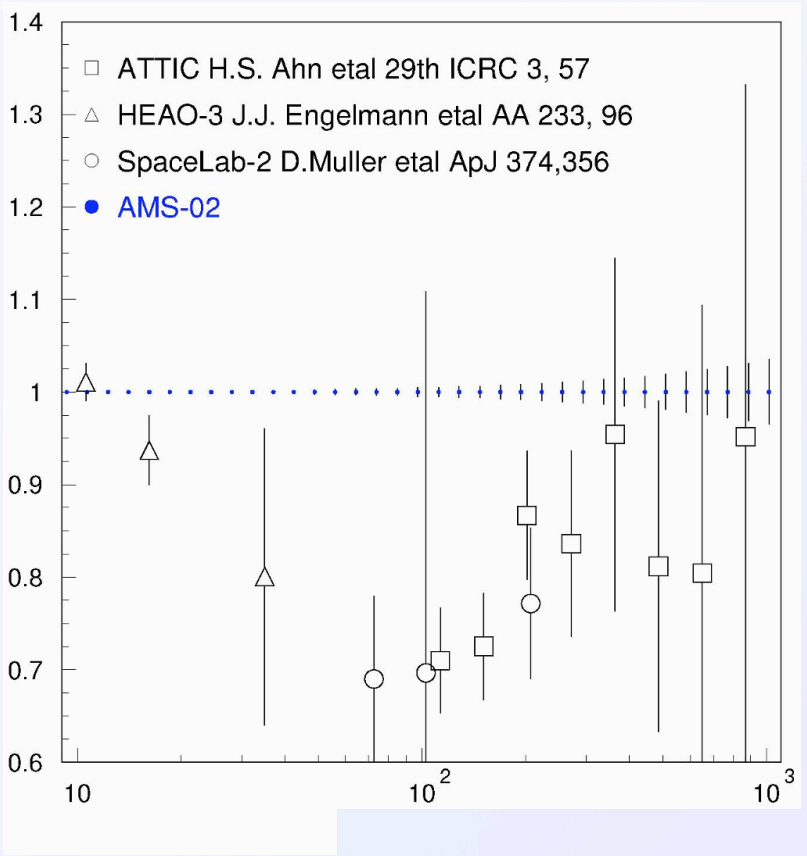


Caveat: Pamela and Tracer, not yet included in the comparison

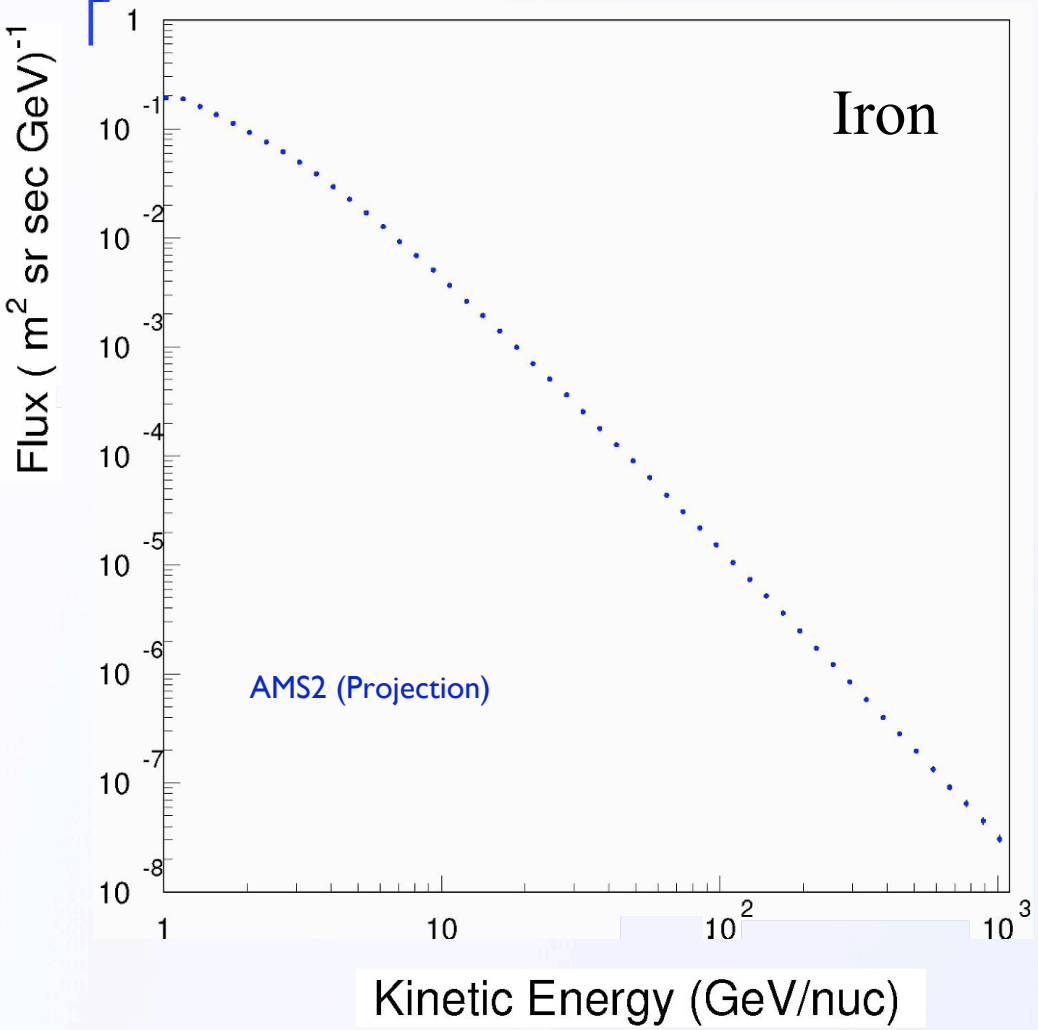
Carbon



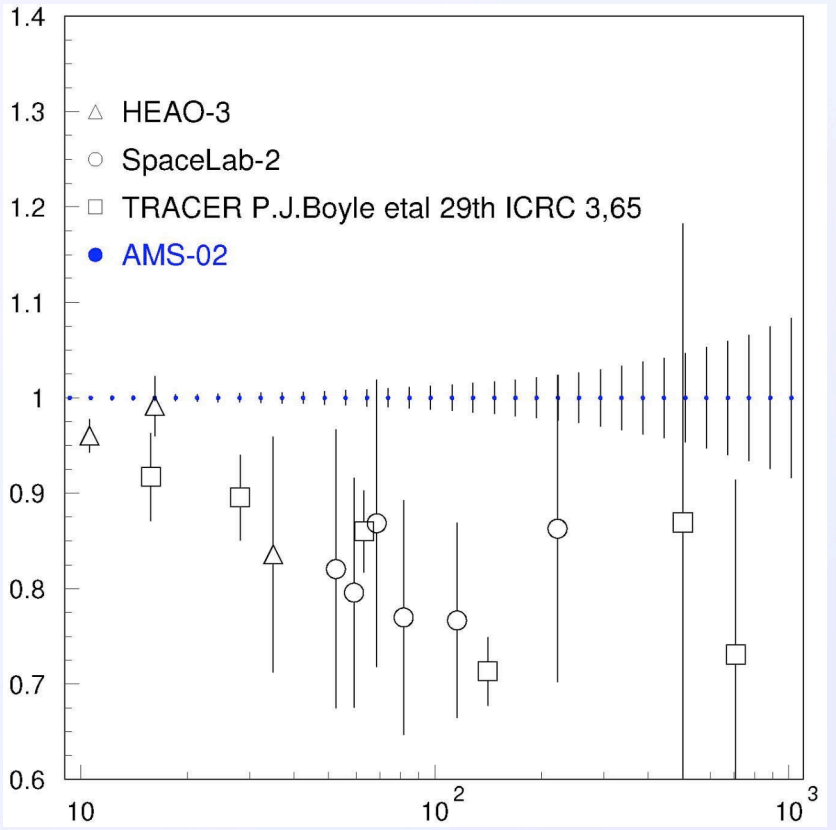
Relative C Fluxes



Iron



Relative Fe Fluxes



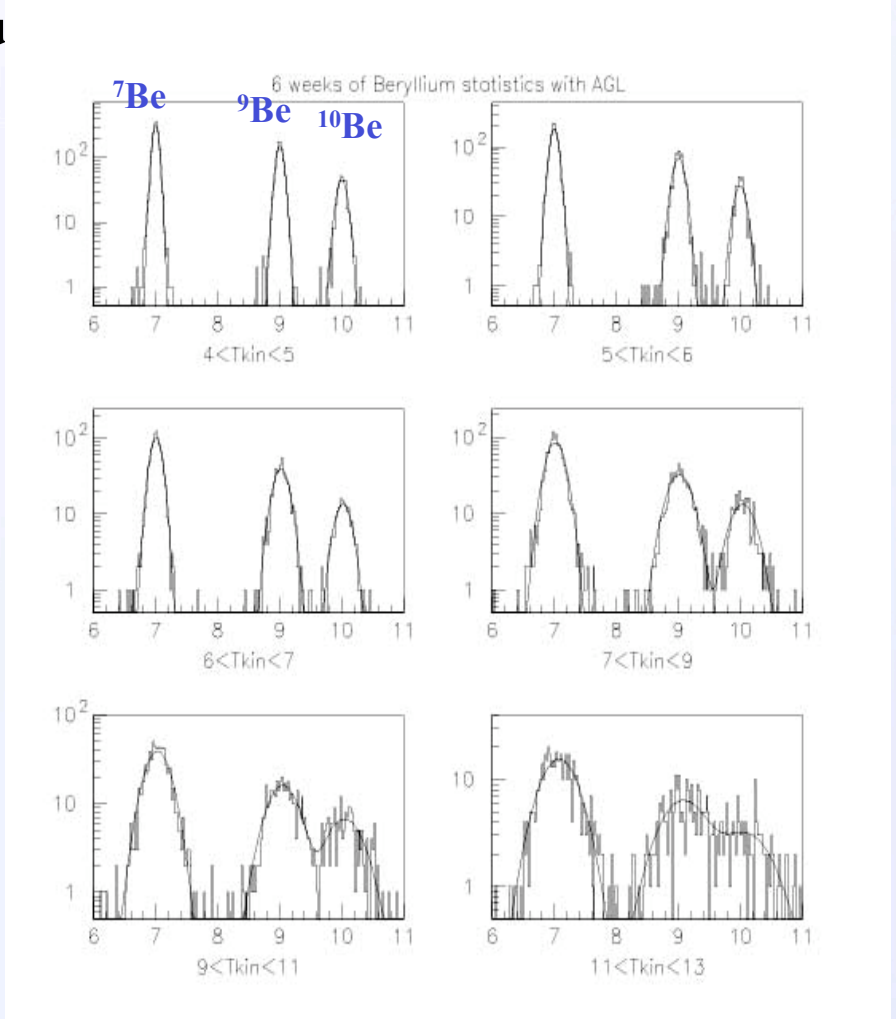
Cosmic ray confinement time

$^{12}C+H->{}^{9}Be$ stable secondary nucleus

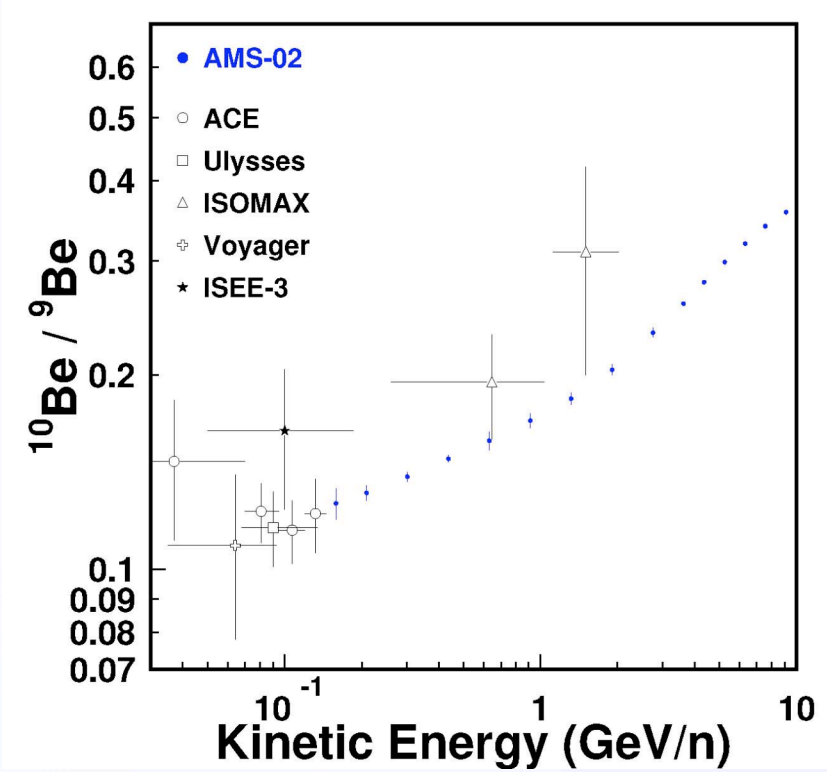
$^{12}C+H->{}^{10}Be$ unstable secondary nucleu ($t_{lifetime}$~4Myr)

Key points:

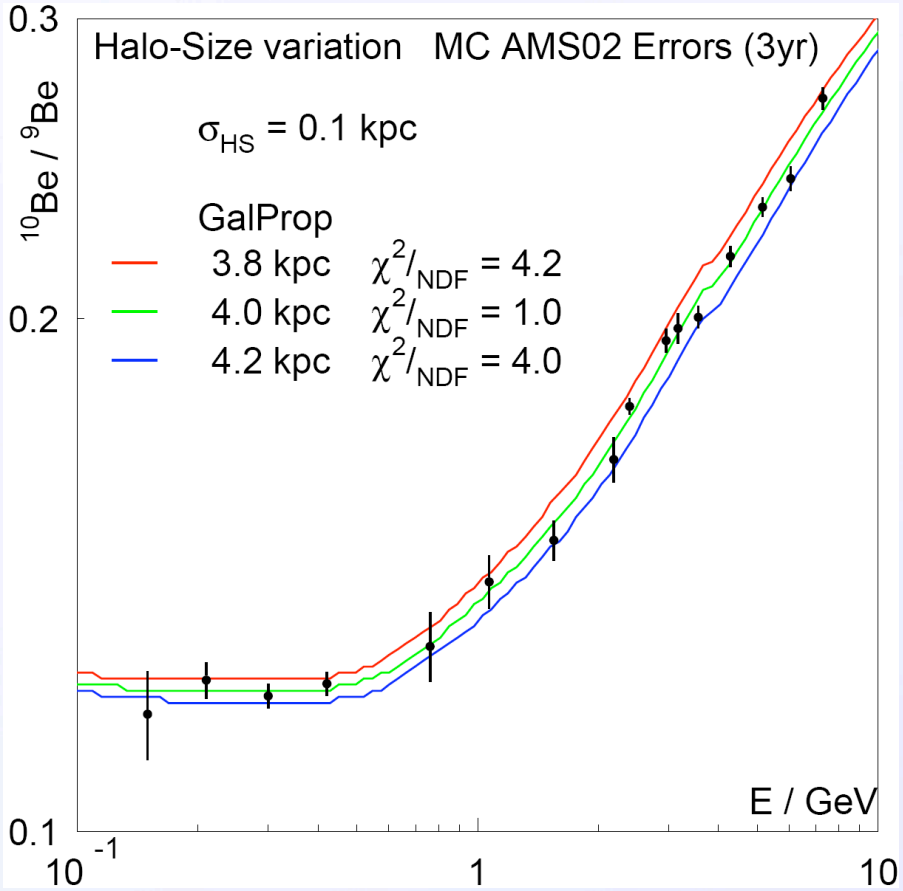
- ▷Accurate energy measurement
- ▷ Particle identification
- ▷ Detection Redondancy
  - ▷Background spectrum measurements
  - ▷Cross calibration
- ▷ High statistics



Cosmic ray confinement time



10^5 ^{10}Be 0.5-10 GeV in 3 years



^{10}Be/^{9}Be will tell us about the time spent in the galaxy for nuclei

20 MYears @ 1 GeV

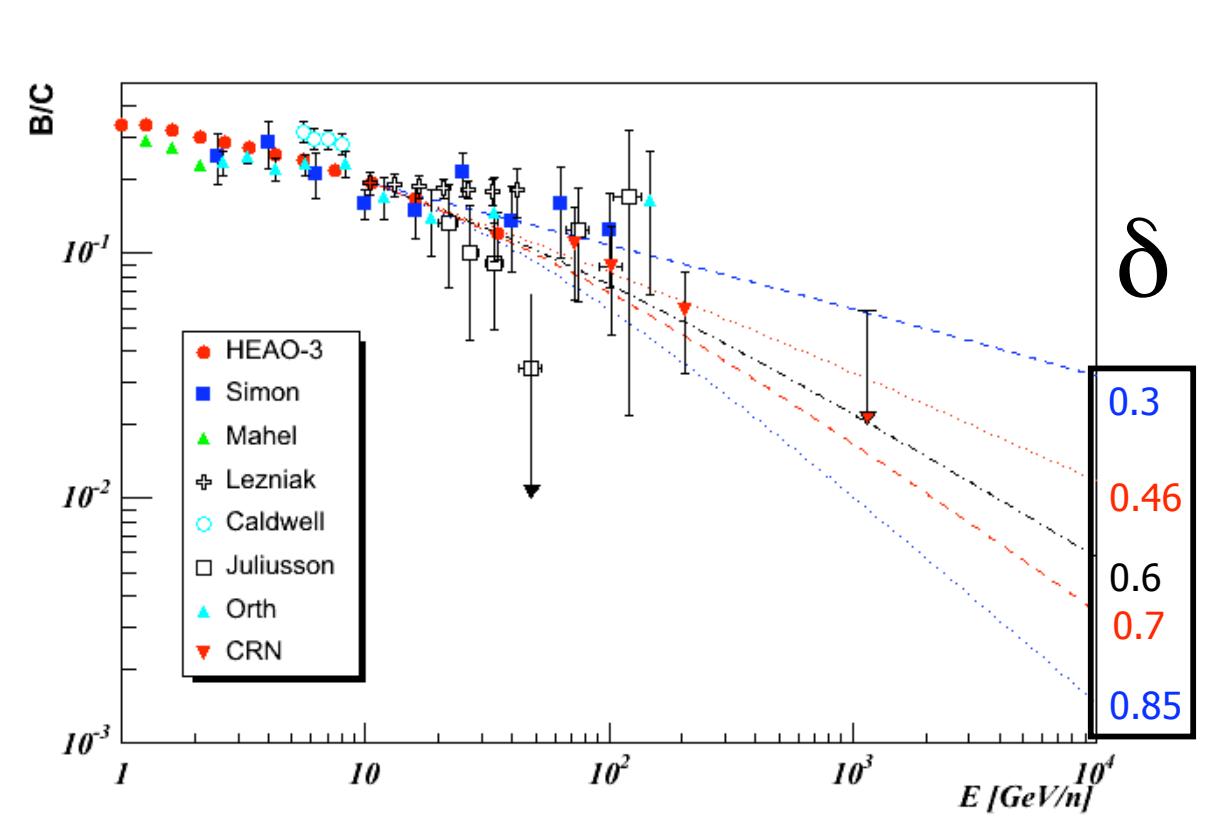
Astrophysics

- Propagation parameters (diffusion coefficient)

secondary /primary

Diffusion dominating at

E/n> 100 GeV



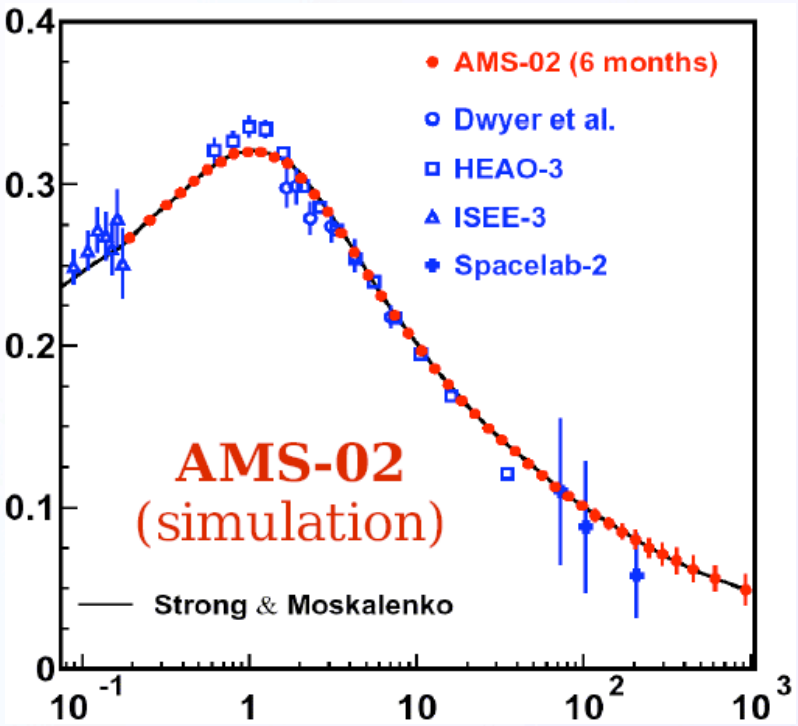
- $N_B = \sigma_{spall} N_C / E^{\delta}$
- $N_{Sec}/N_{Prim} \sim E^{-\delta}$

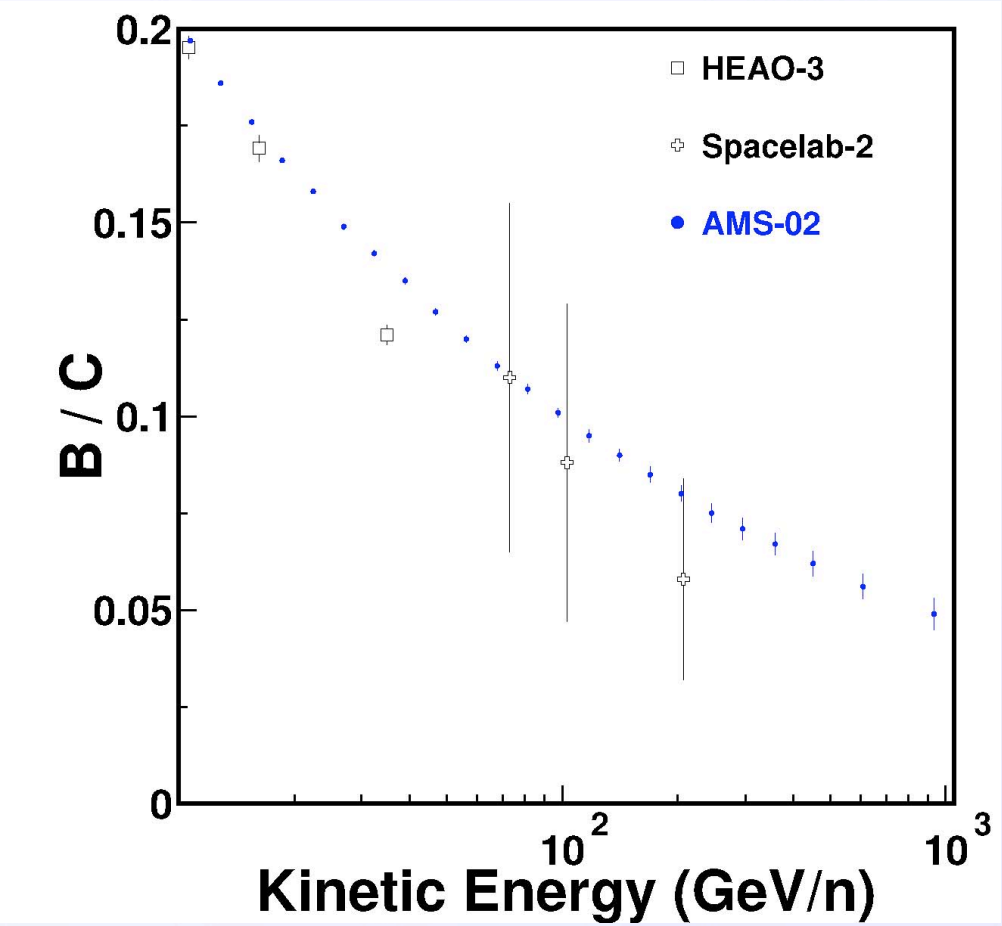
- Accuracy of 10%
- Constraints on propagation of another nuclei (anti-protons …) , path length

Astrophysics

- Propagation parameters (diffusion coefficient)

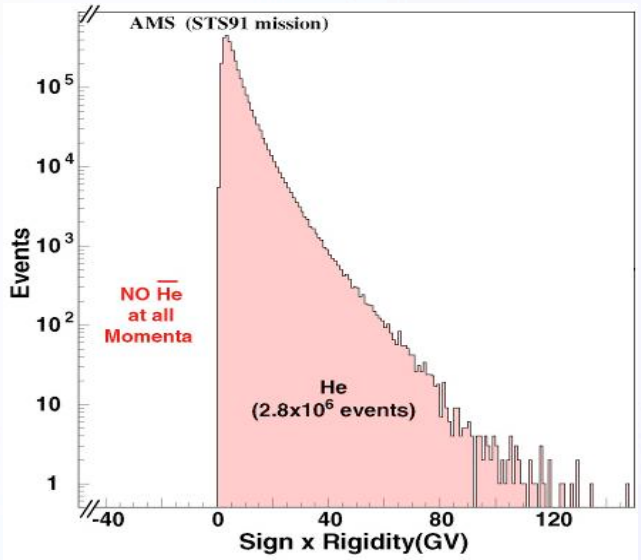
10^4 B > 100 GeV/n in 3 years

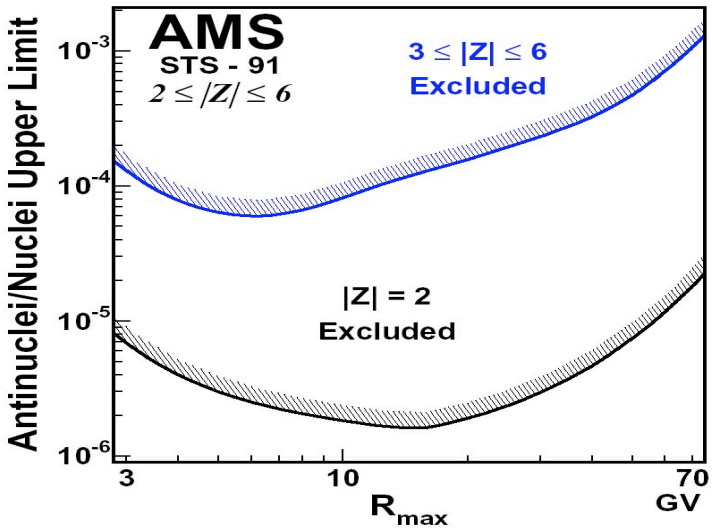


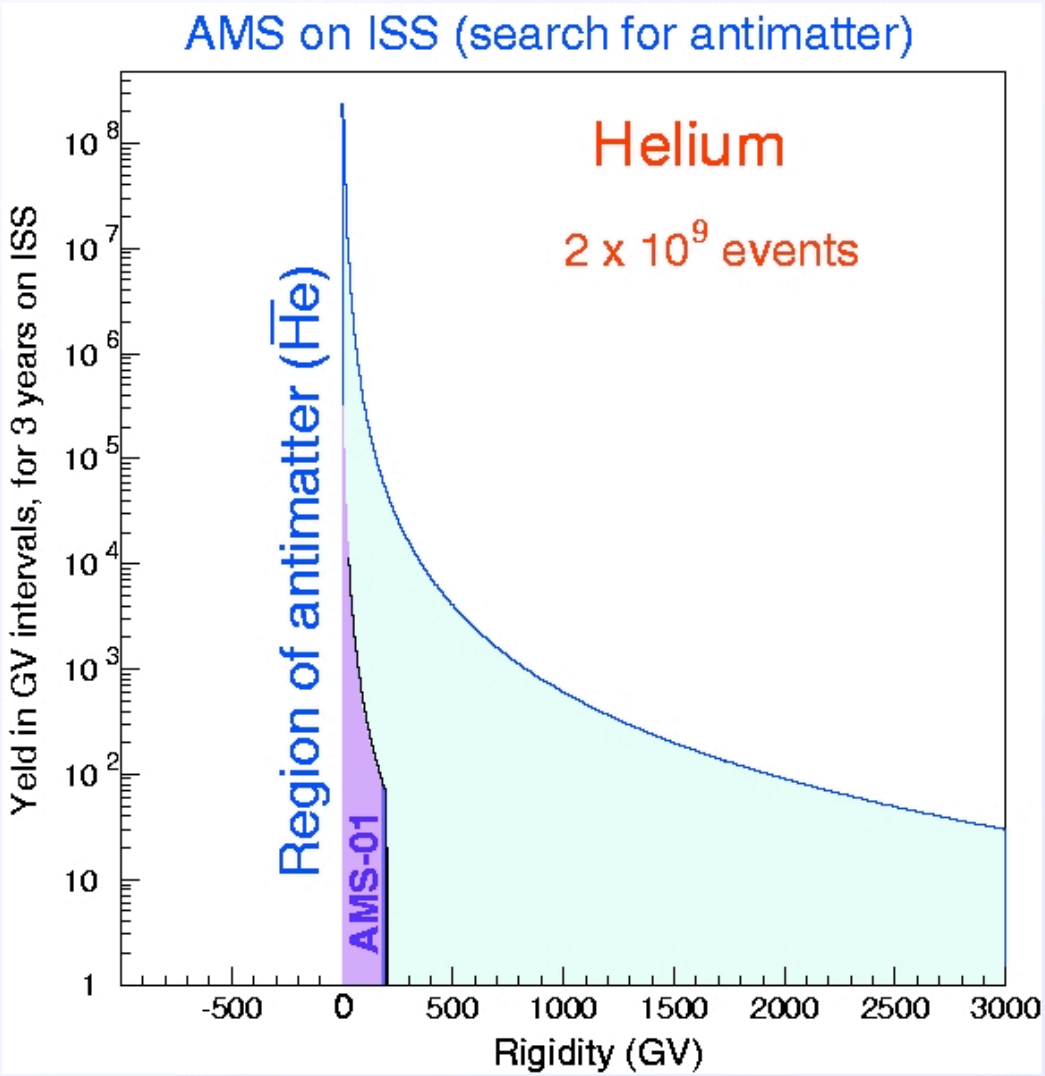


Antimatter (Anti He)

AMS-01

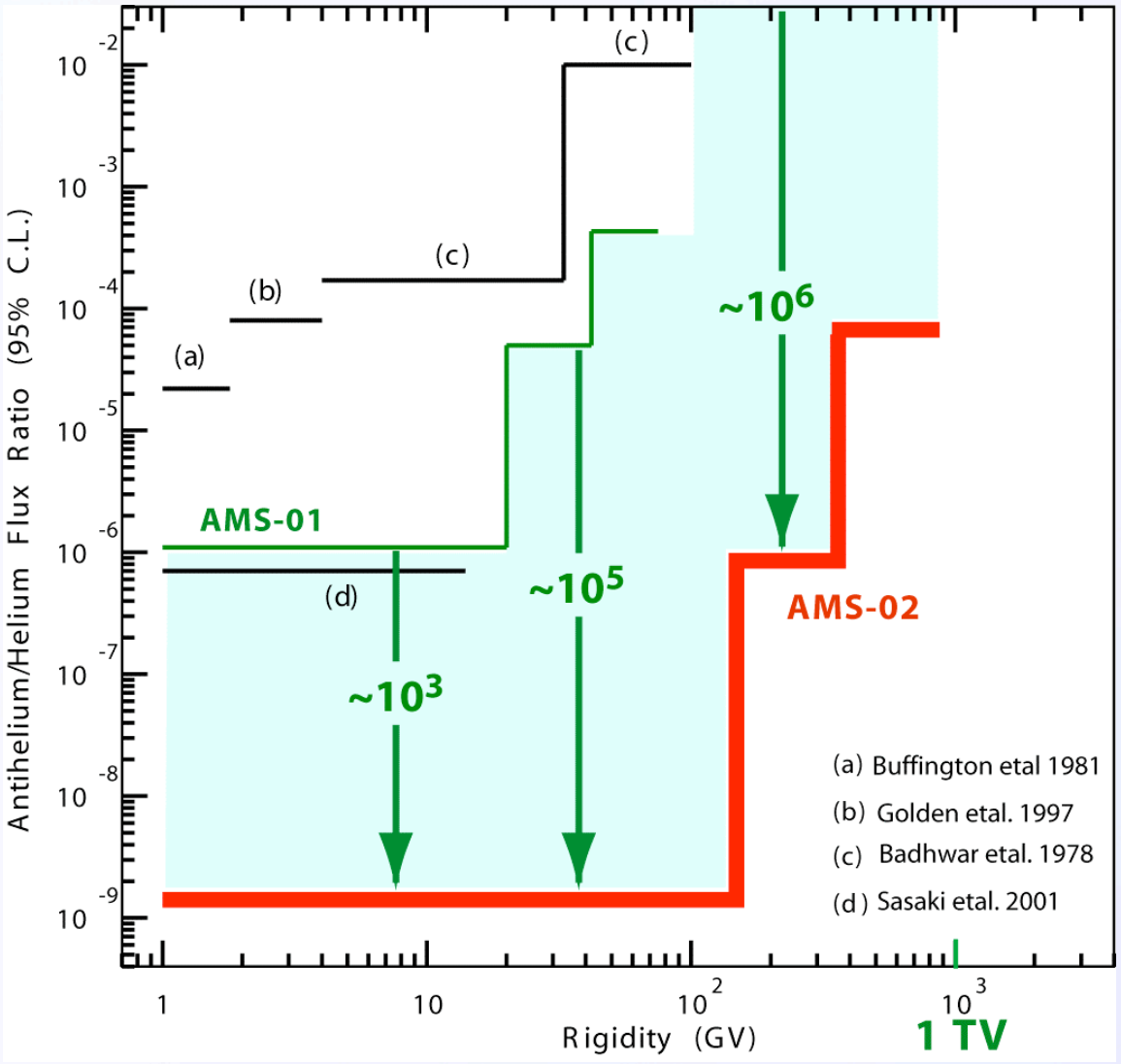




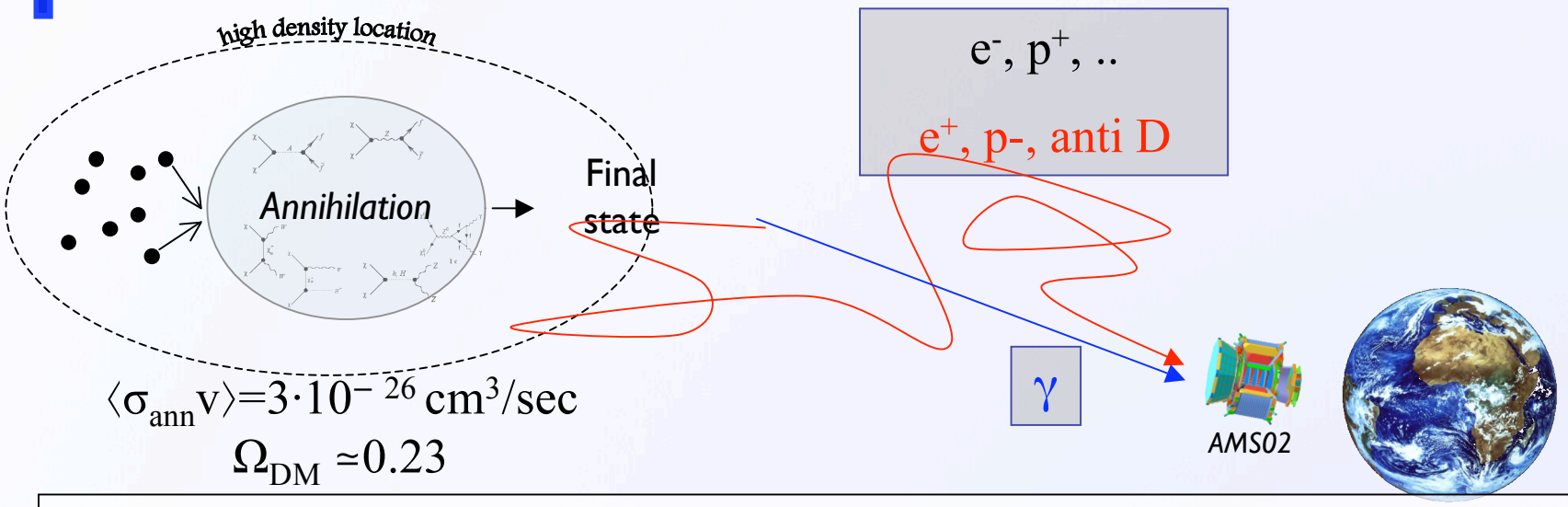


Antimatter

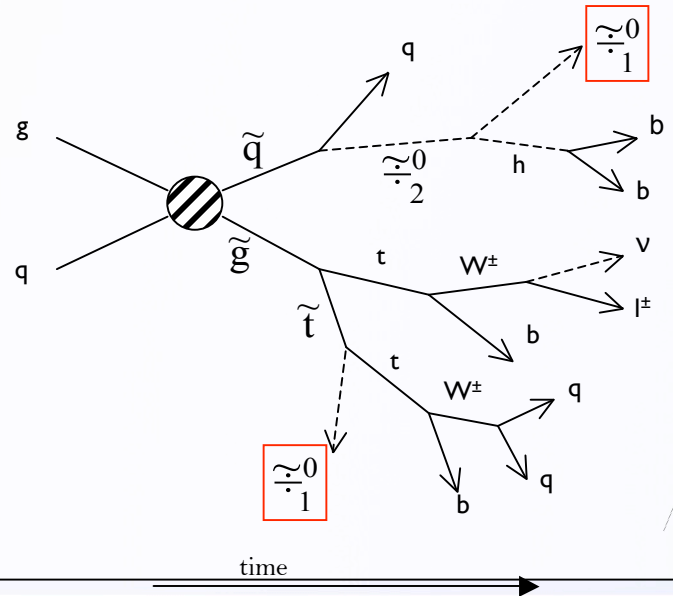
AMS-02 Antihelium Sensitivity



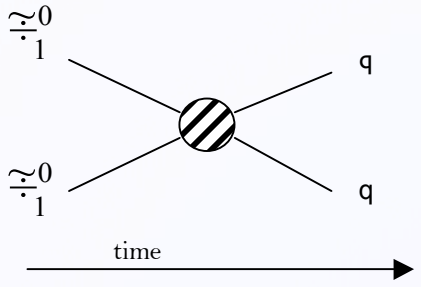
Indirect search for dark matter



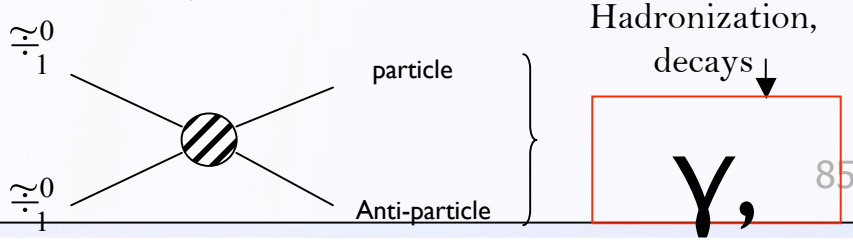
DARK MATTER SEARCHES IN COLLIDER EXPERIMENTS



INDIRECT SEARCH FOR DARK MATTER

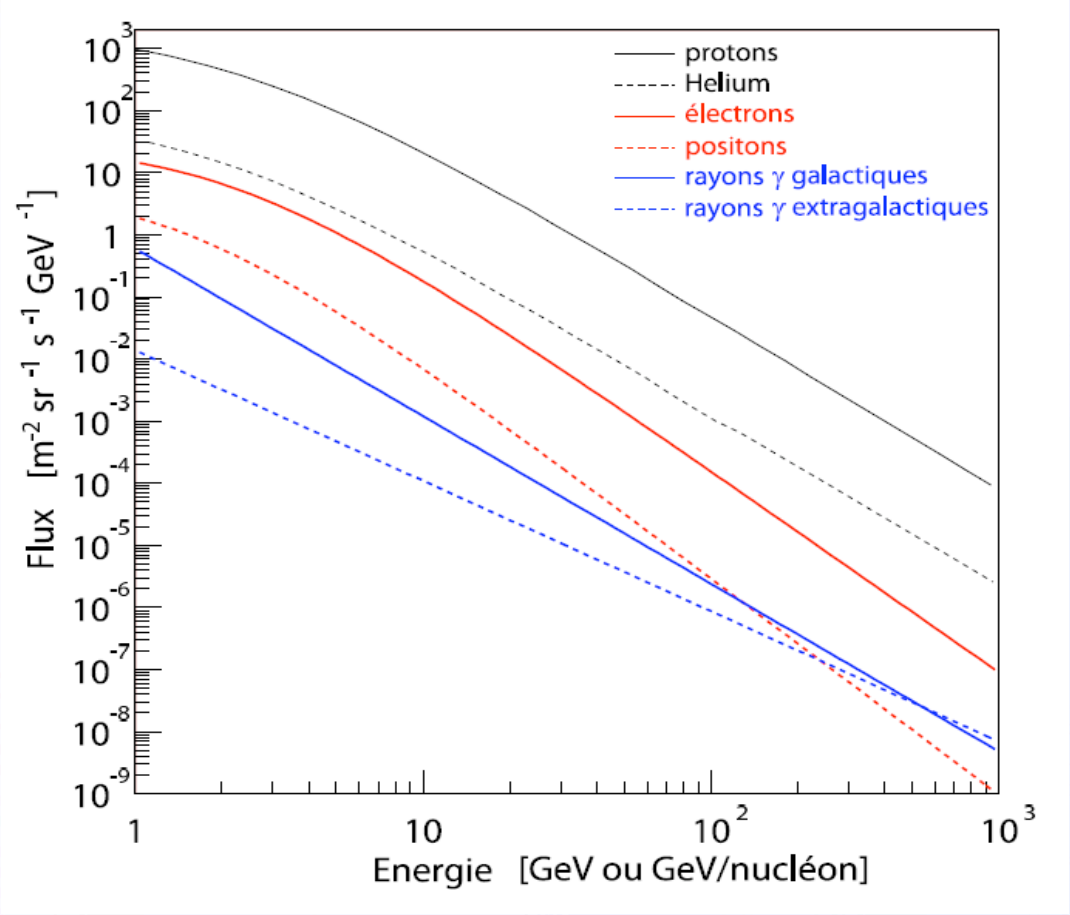


More generally,



Background rejection

Indirect searches for anomalies in the CR spectra : e+, p, γ, D from 1 GeV to 1 TeV



Key points:

- ▷ Accurate energy measurement
- ▷ Particle identification
- ▷ Detection Redondancy
  - ▷Background spectrum measurements
  - ▷Cross calibration
- ▷ High statistics

Signal fluxes

In the Earth vicinity,

- Neutral messenger : γ, ν

$$\Phi^{SUSY}_{\gamma,\nu} = \frac{1}{4\pi} \sum_{f.s.} \left(\frac{dN_{\gamma,\nu}}{dE} \right)_{f.s.} B_{f.s.} \frac{< \sigma_{ann} v >}{m_\chi^2} \int_{l.o.s.} \frac{\rho_\chi^2}{2} dl$$

Particle physics (Standard Model)

Particle physics (new physics)

Astrophysics

- Charged particles

$$Q_{charged} = \frac{dN}{dE} \frac{< \sigma v >}{2m_\chi^2} \rho_\chi^2$$

↳ source term for the propagation equations

e^+, p, D : *specific propagation equations*

Tree-level final states

$$B_{f.s.}\frac{<\sigma_{ann}v>}{m_\chi^2}$$

Annihilation of 2 neutralinos $\chi\,\chi \rightarrow$

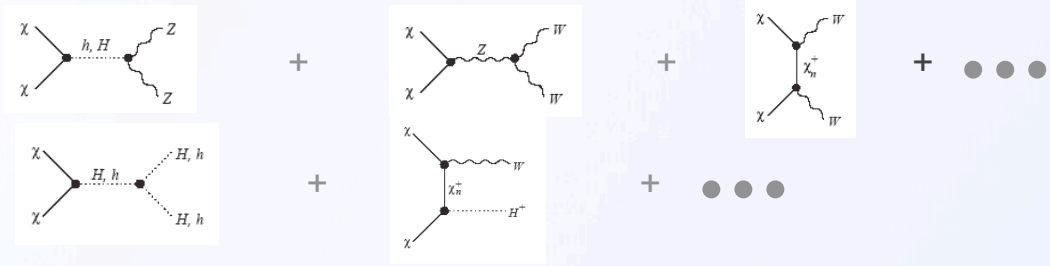
- fermion / anti-fermion

uu, cc, tt, dd, ss, bb, e^+e^-, $\mu^+\mu^-$, $\tau^+\tau^-$, $\nu_i\nu_i$



- Gauge and/or Higgs bosons

W^+W^-, $Z°Z°$, $Z°h°$, $Z°A°$, $Z°H°$, $W^\pm H^\mp$, $h°h°$, $h°H°$, $h°A°$, $H°H°$, $H°A°$, H^+H^-, $A°A°$



Hadronization

Decays

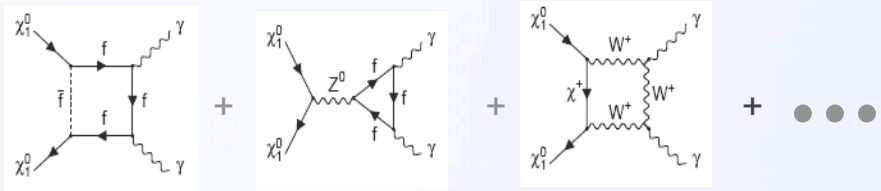
Continuous spectra for γ, e^+, p-, antiD

Source

- $\gamma\gamma$, $\gamma Z°$, gg

Mono-energetic lines

$$\gamma\gamma \;:\; E_\gamma = m_\chi \;(N_\gamma = 2)$$

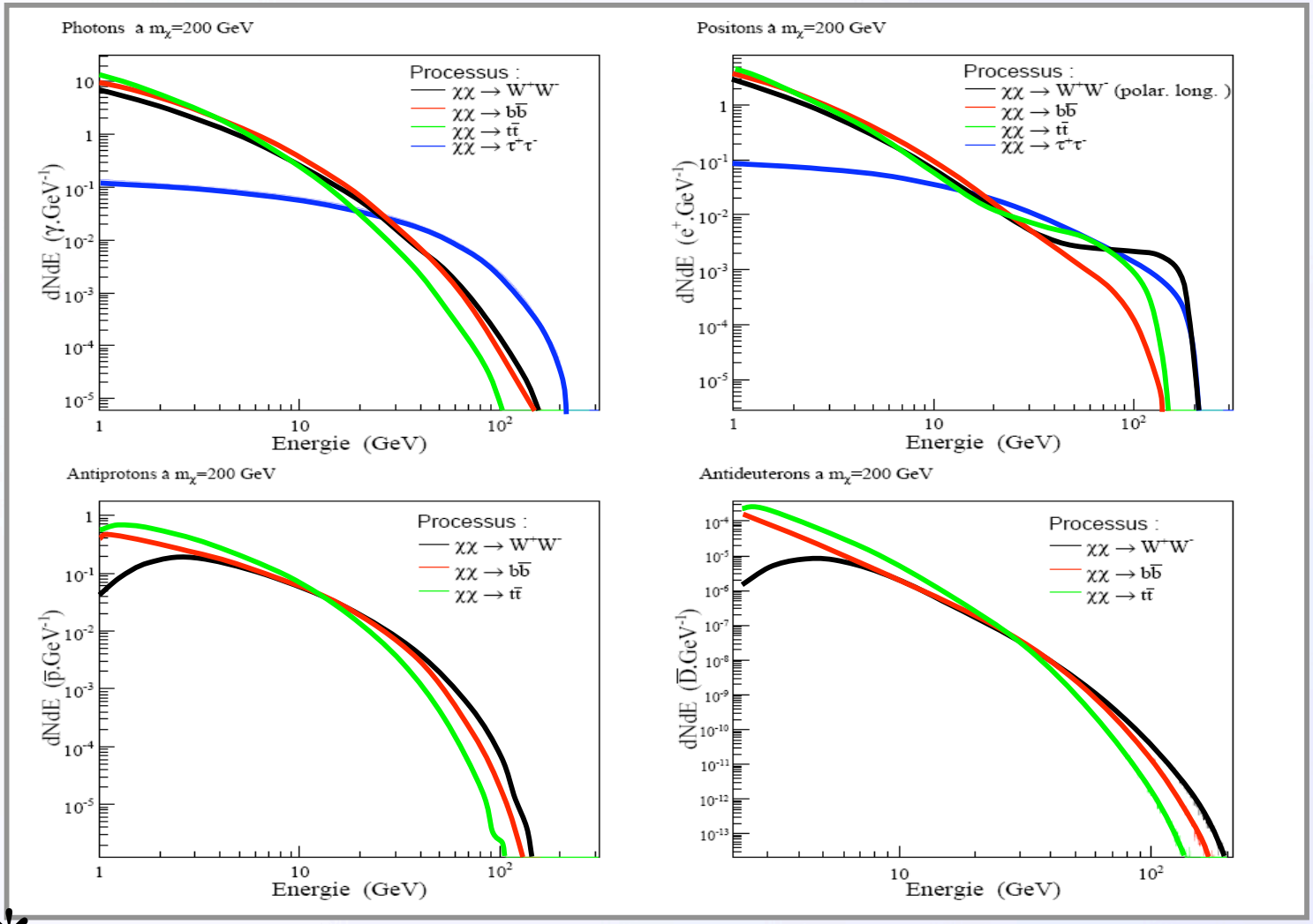


$$\gamma Z^0 \;:\; E_\gamma = m_\chi\left[1-\left(\frac{m_{Z^0}}{2m_\chi}\right)^2\right] \;(N_\gamma = 1)$$

Energy Spectra at the "source"

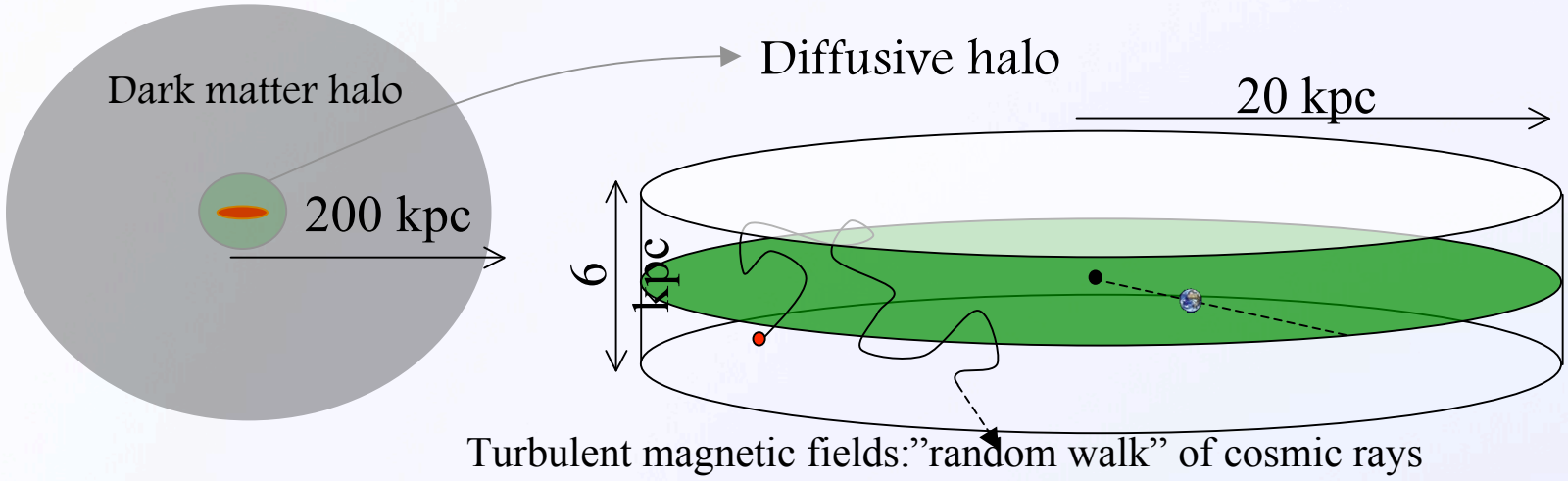
$$\left(\frac{dN_{\gamma,\nu}}{dE}\right)$$

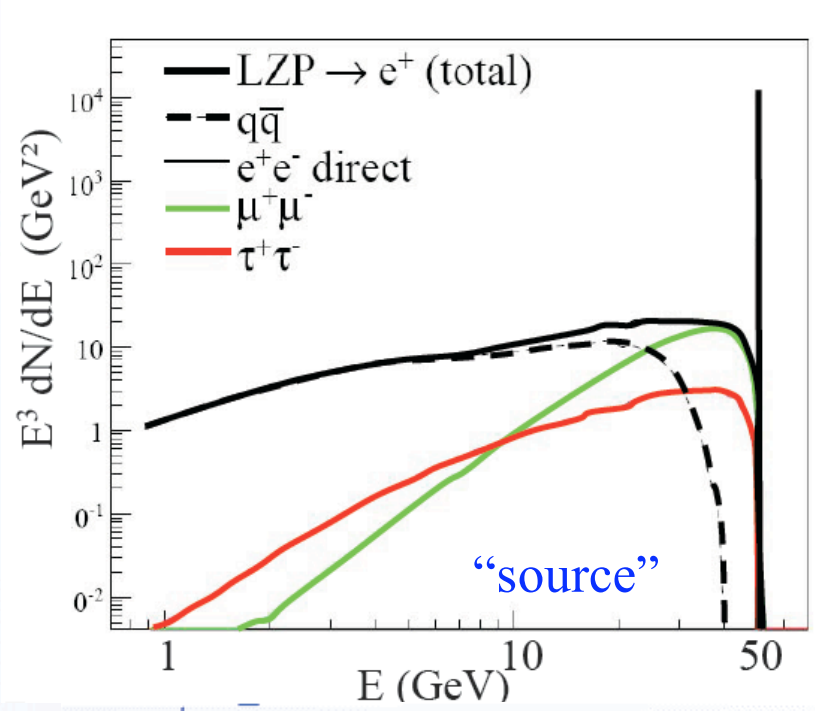
- After including hadronisation and particle decays*

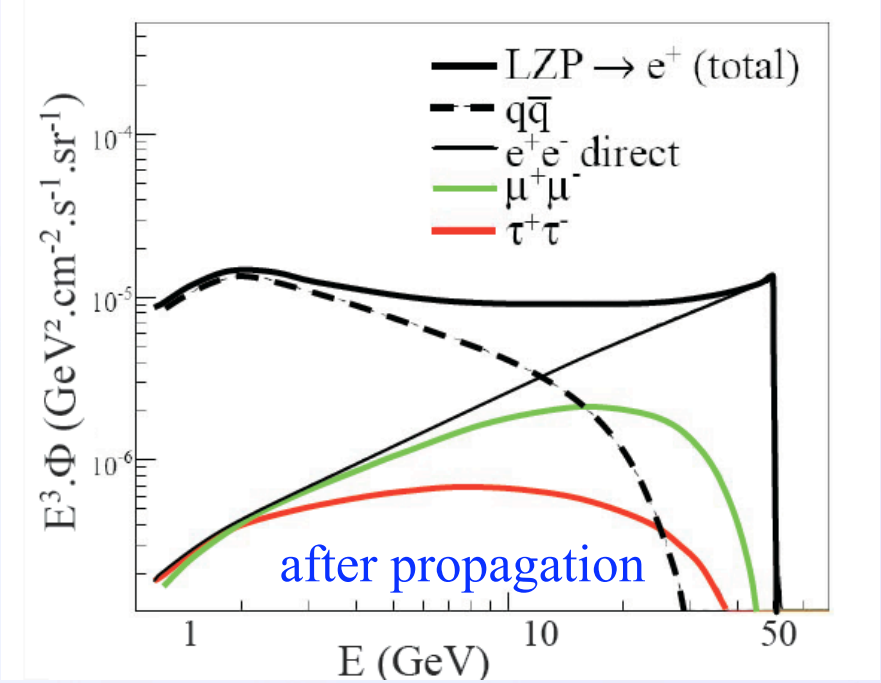


*(Pythia or Herwig) interfaced with micrOMEGAS

Including propagation of charged particles







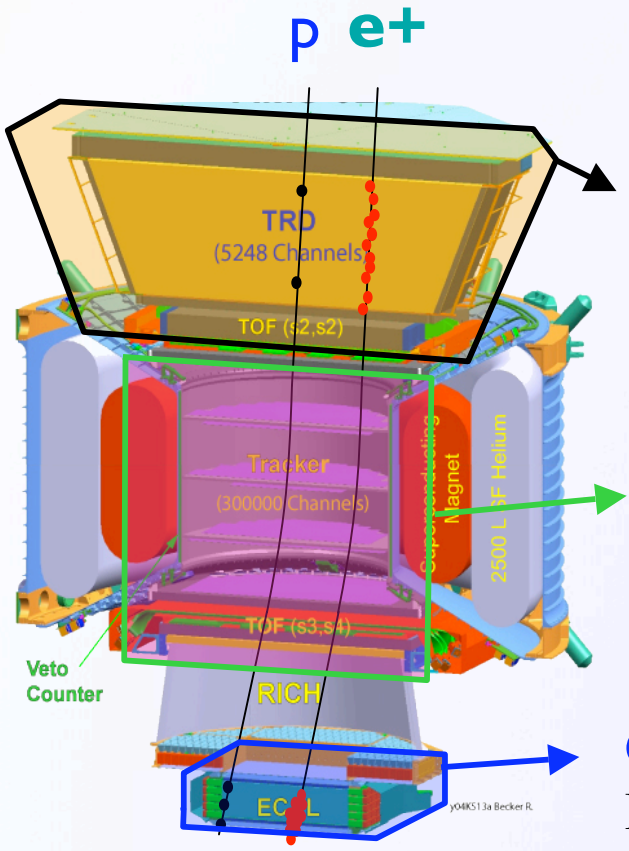
$\bar{p}, e^+, \bar{D}$: specific propagation equations

Positron

e^+

▷ Background

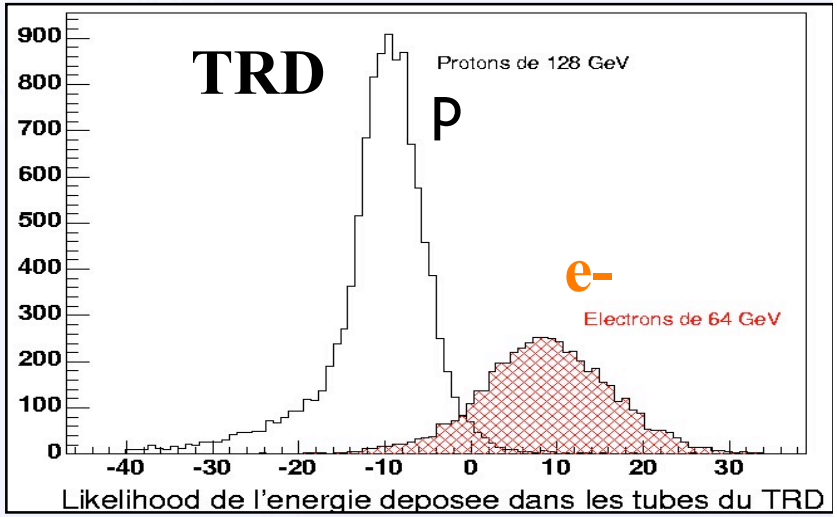
- protons : $\Phi_p \sim 10^{3\text{-}4} * \Phi_{e+}$
- electrons : $\Phi_{e-} \sim 10 * \Phi_{e+}$

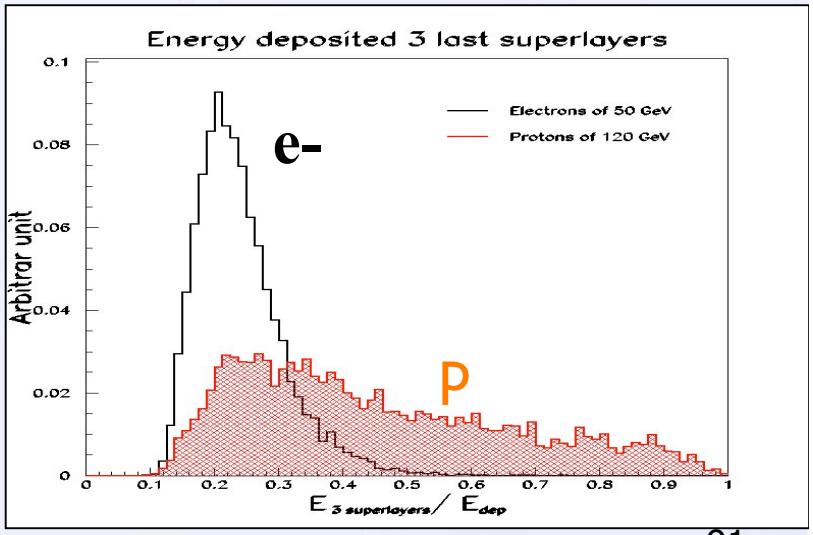


TRD :
Deposited energy

Tracker / calorimeter:
E/p ratio

Calorimeter :
Electromagnetic shower properties





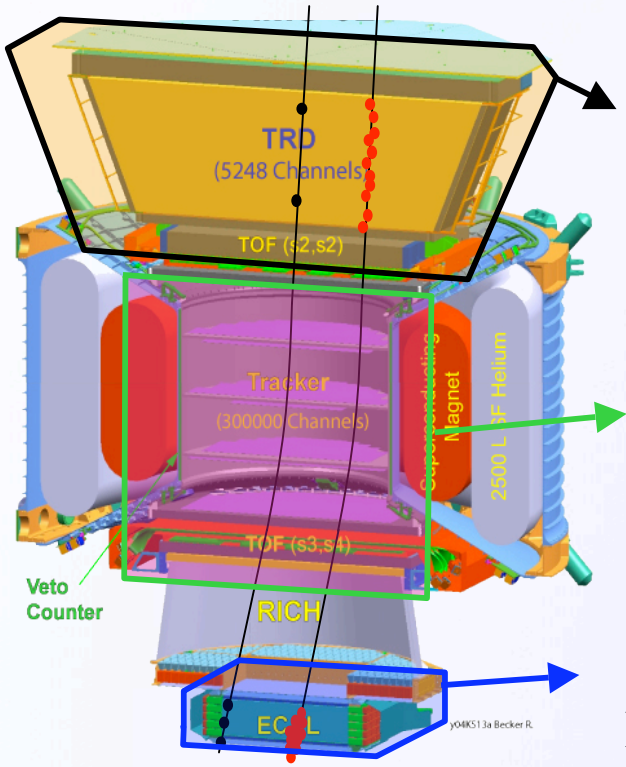
Positron

e^+

▷ Background

- protons : $\Phi_p \sim 10^{3\text{-}4} * \Phi_{e+}$
- electrons : $\Phi_{e^-} \sim 10 * \Phi_{e+}$

p e+

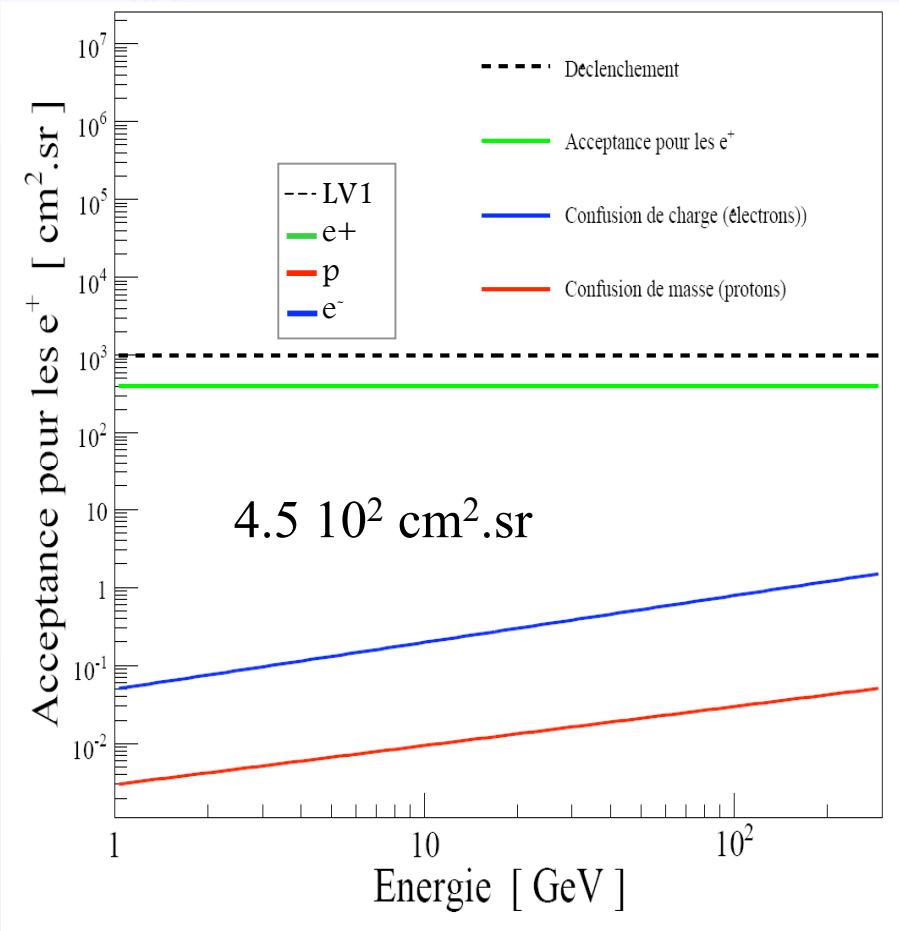


TRD : Deposited energy

Tracker / calorimeter: E/p ratio

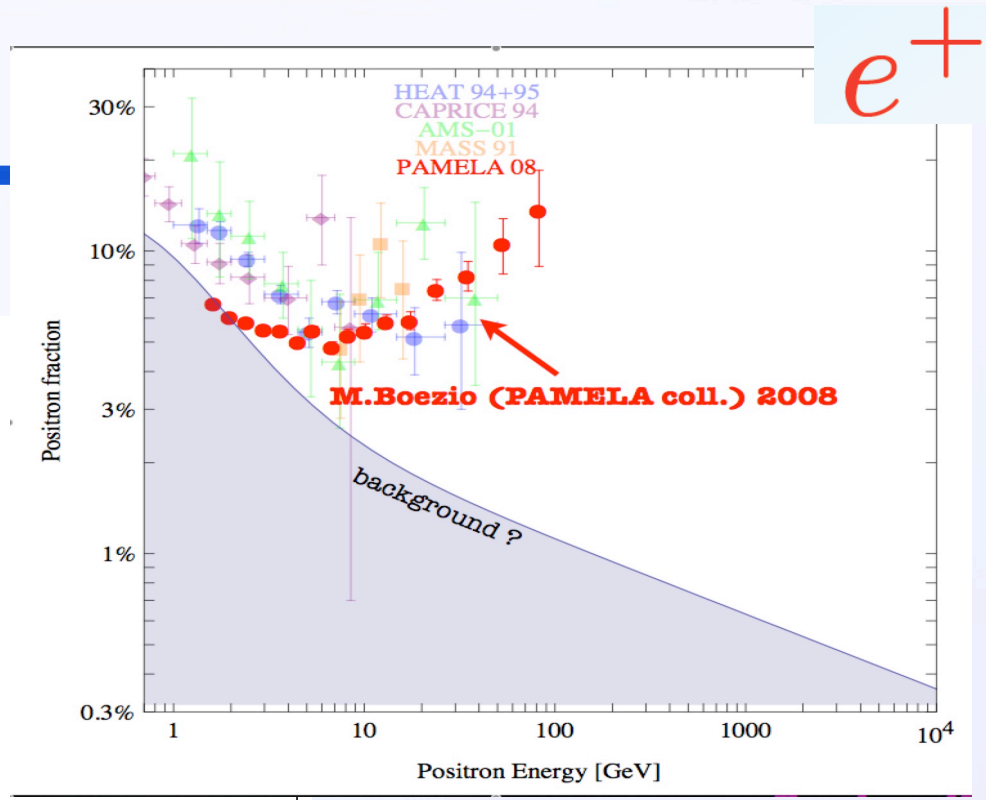
Calorimeter : Electromagnetic shower properties

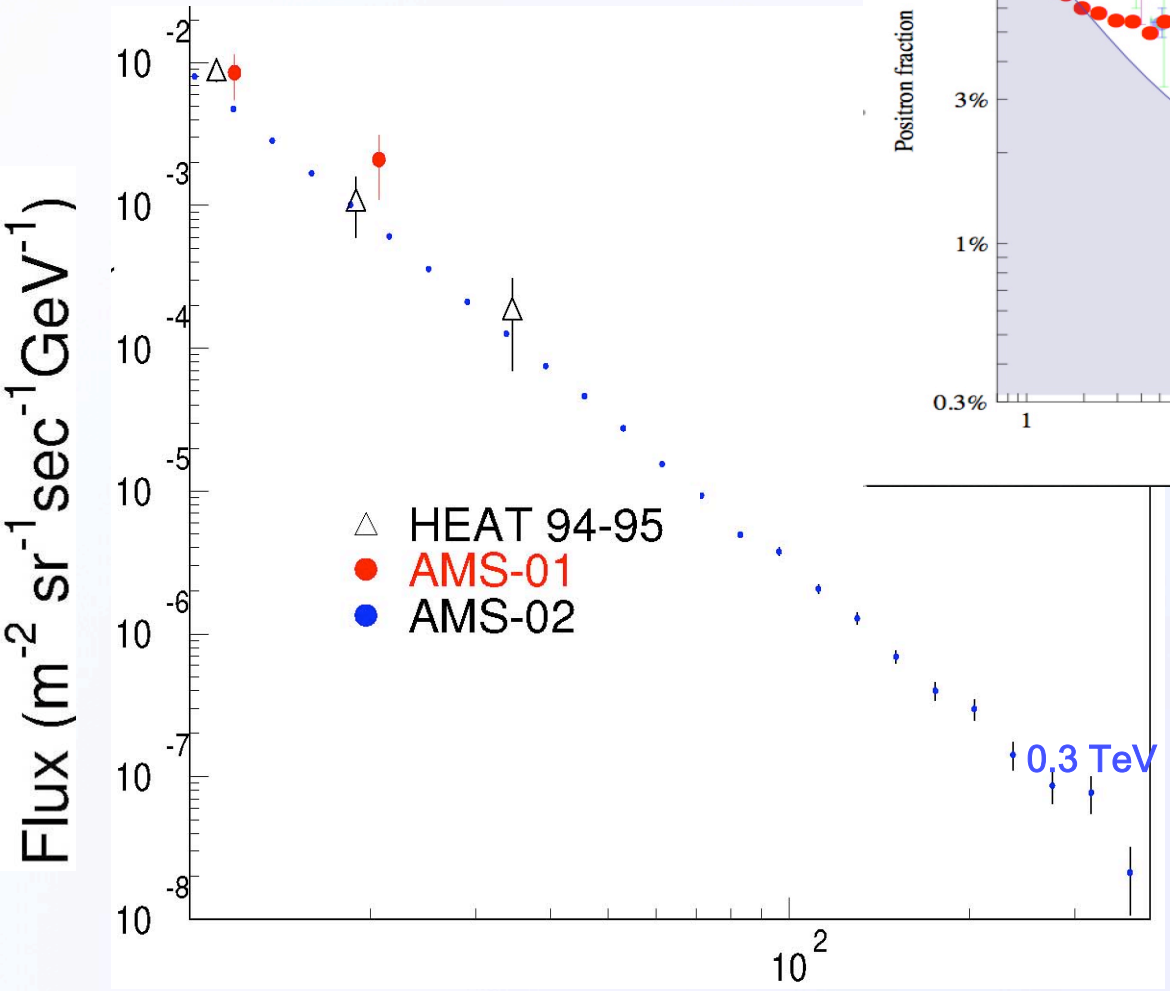
$A_{e+} / A_p \sim 10^5$



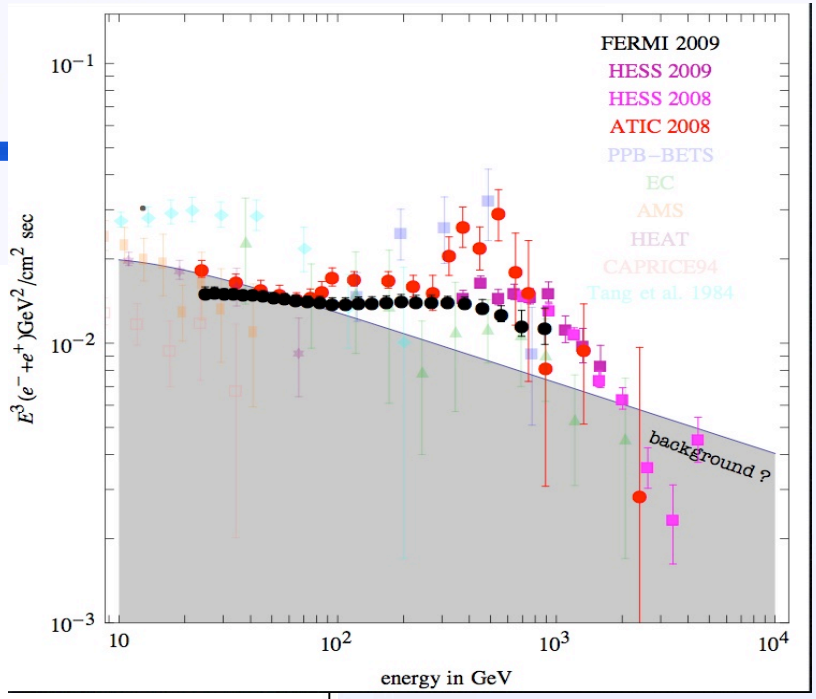
e^+ : 1 GeV ~ 300 GeV

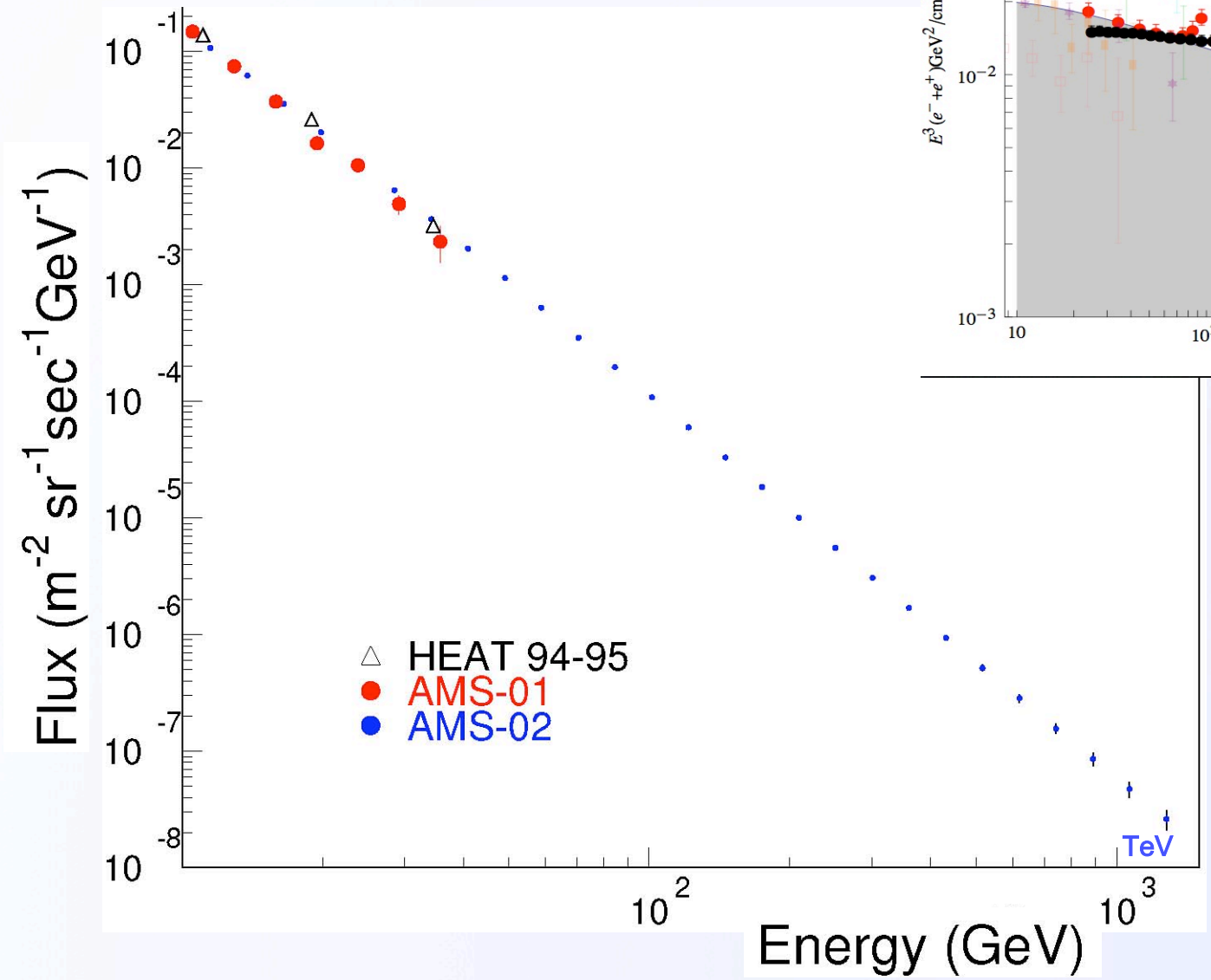
Positron


e^+
HEAT 94+95
CAPRICE 94
AMS−01
MASS 91
PAMELA 08
M.Boezio (PAMELA coll.) 2008
background ?
Positron fraction
30%
10%
3%
1%
0.3%
1
10
100
1000
10^4
Positron Energy [GeV]


Flux (m^{-2} sr^{-1} sec^{-1} GeV^{-1})
HEAT 94-95
AMS-01
AMS-02
0.3 TeV
10^2
Energy (GeV)

Electrons


FERMI 2009
HESS 2009
HESS 2008
ATIC 2008
PPB−BETS
EC
AMS
HEAT
CAPRICE94
Tang et al. 1984
background ?
$E^3(e^-+e^+)\mathrm{GeV}^2/\mathrm{cm}^2\,\mathrm{sec}$
energy in GeV

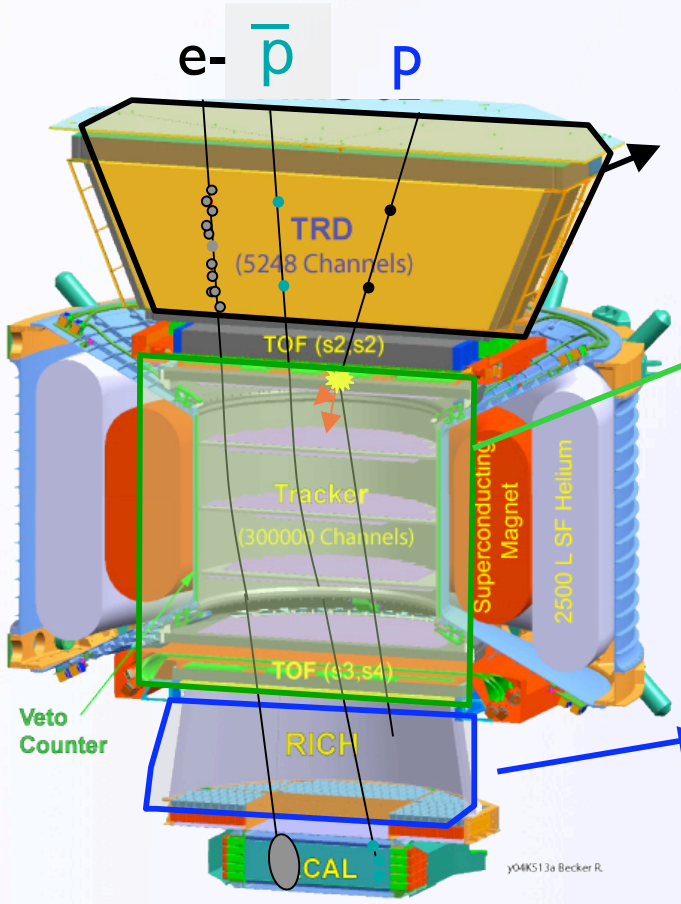

Flux (m^{-2} sr^{-1} sec^{-1} GeV^{-1})
HEAT 94-95
AMS-01
AMS-02
TeV
Energy (GeV)

Anti protons

$\bar{p}$

Background

- protons $\Phi_p \sim 10^{4\text{-}5} * \Phi_{\bar{p}}$
- electrons $\Phi_{e^-} \sim 10^{3} * \Phi_{\bar{p}}$

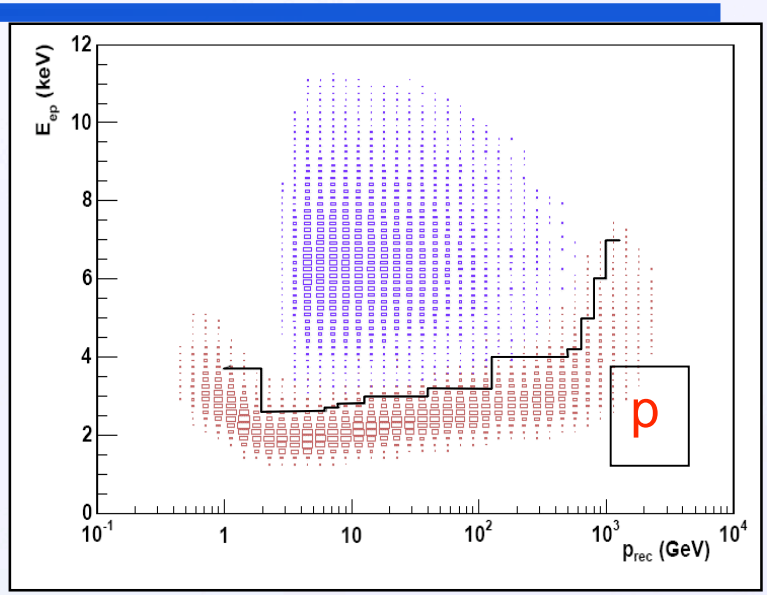


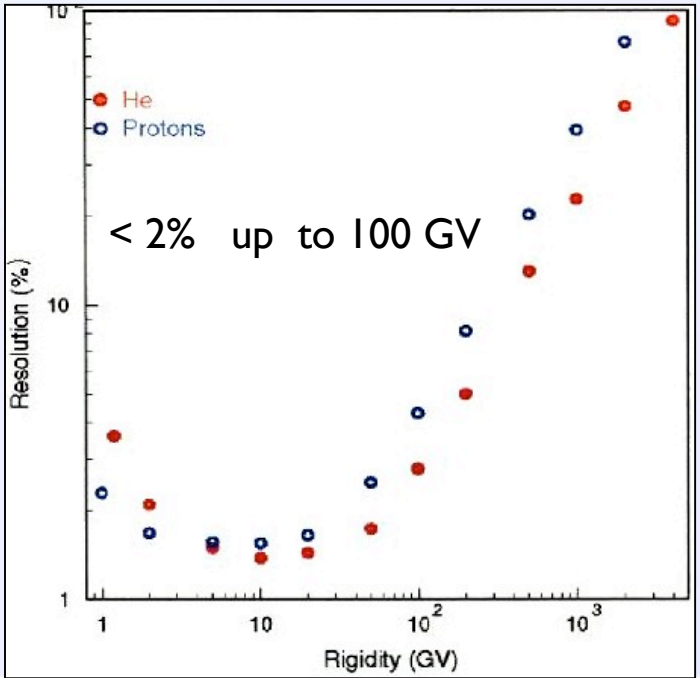
TRD :
Deposited energy

Tracker :
Rejection of events with interactions

Tracker/calorimeter:
E/p ratio

RICH:
β measurement





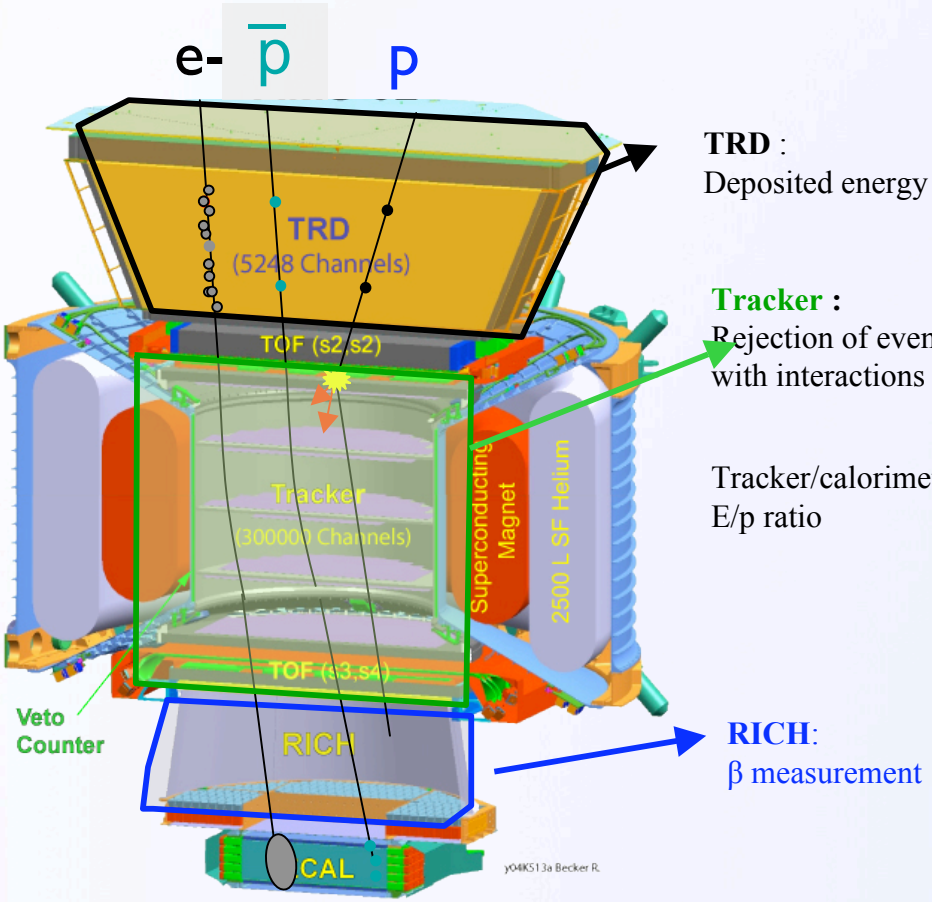
Anti protons

$\bar{p}$

Background

- protons $\Phi_p \sim 10^{4\text{-}5} * \Phi_{\bar{p}}$
- electrons $\Phi_{e^-} \sim 10^{3} * \Phi_{\bar{p}}$

$A_p / A_{\bar{p}} \sim 10^6$

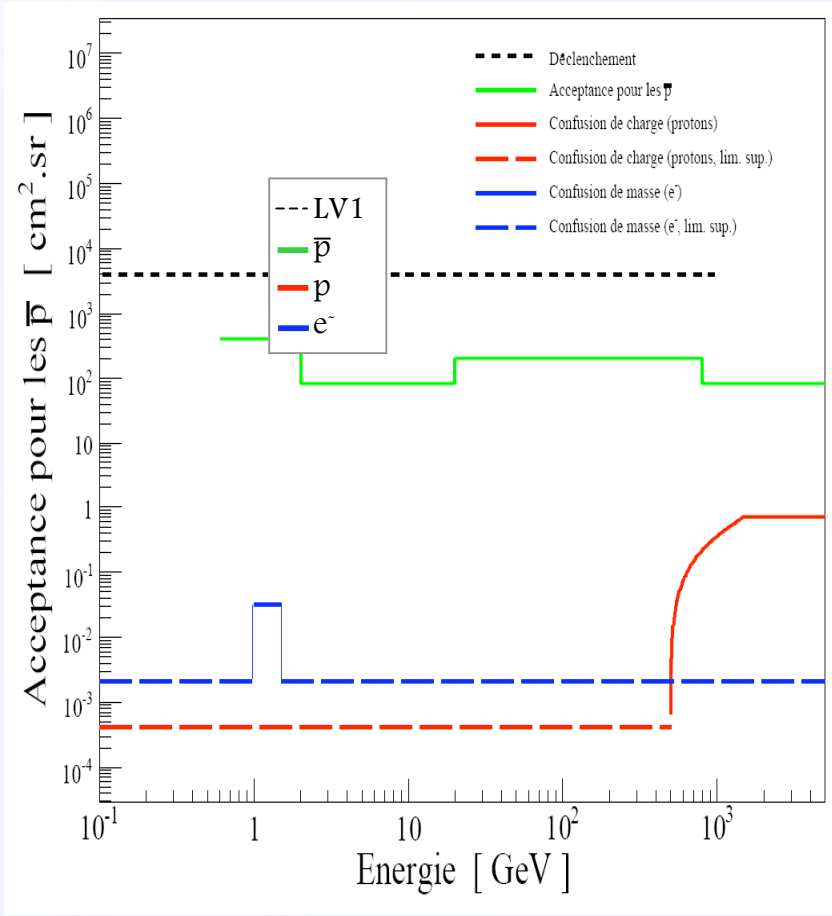


TRD :
Deposited energy

Tracker :
Rejection of events with interactions

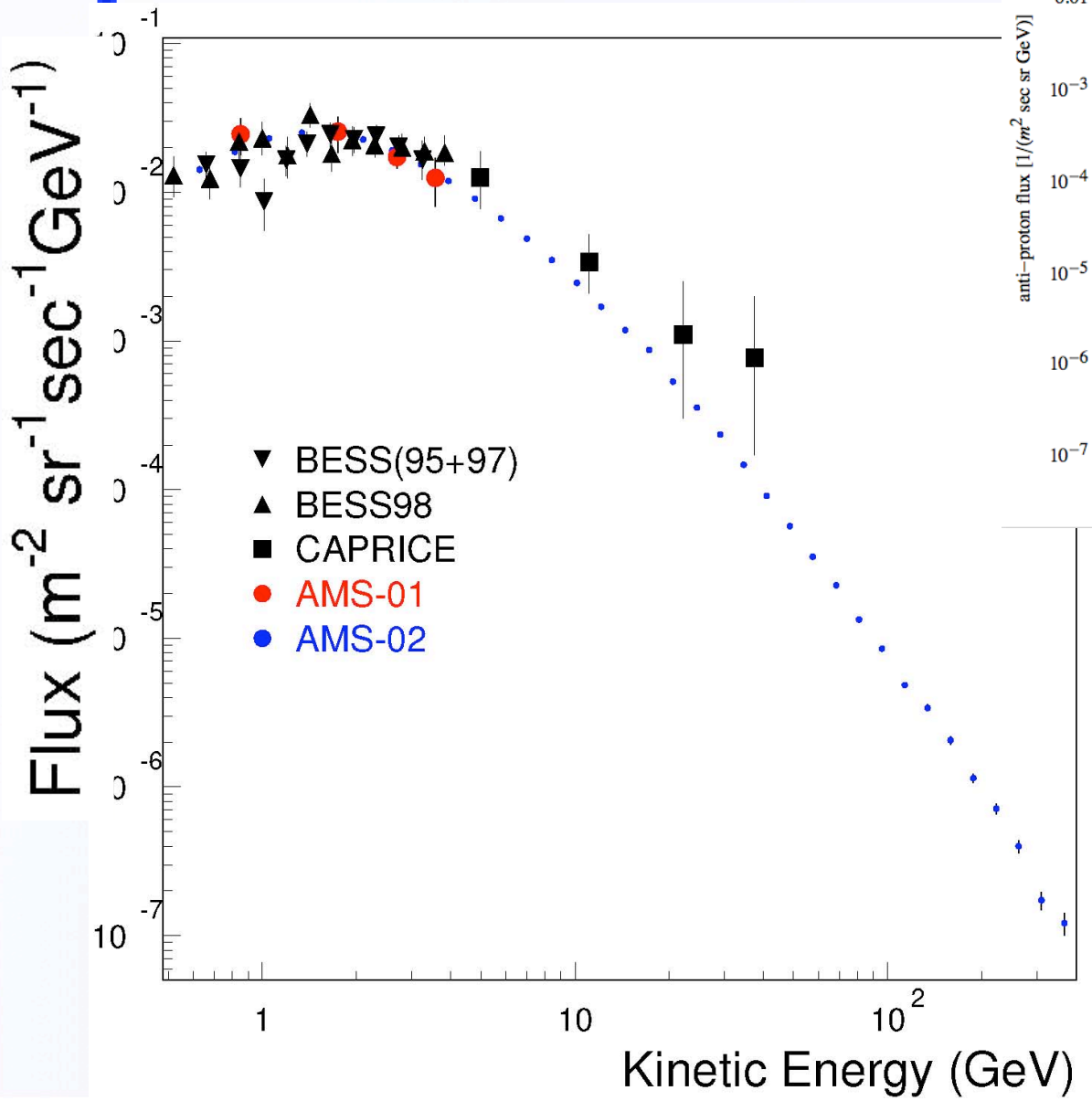
Tracker/calorimeter:
E/p ratio

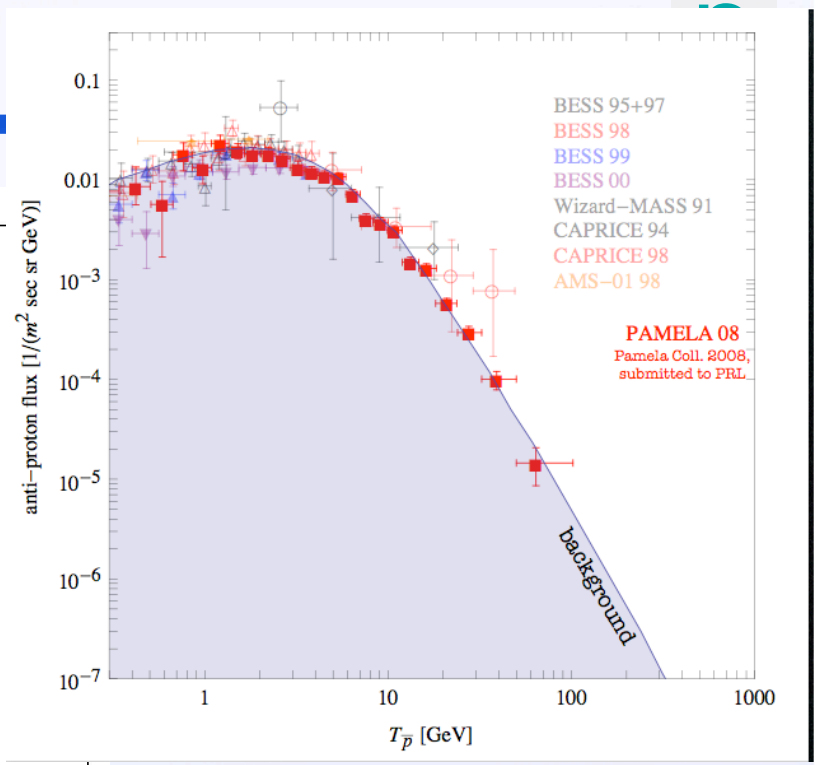
RICH:
β measurement



Range : 0.8 GeV ~ 600 GeV

Anti protons





About 1000 anti p, collected,

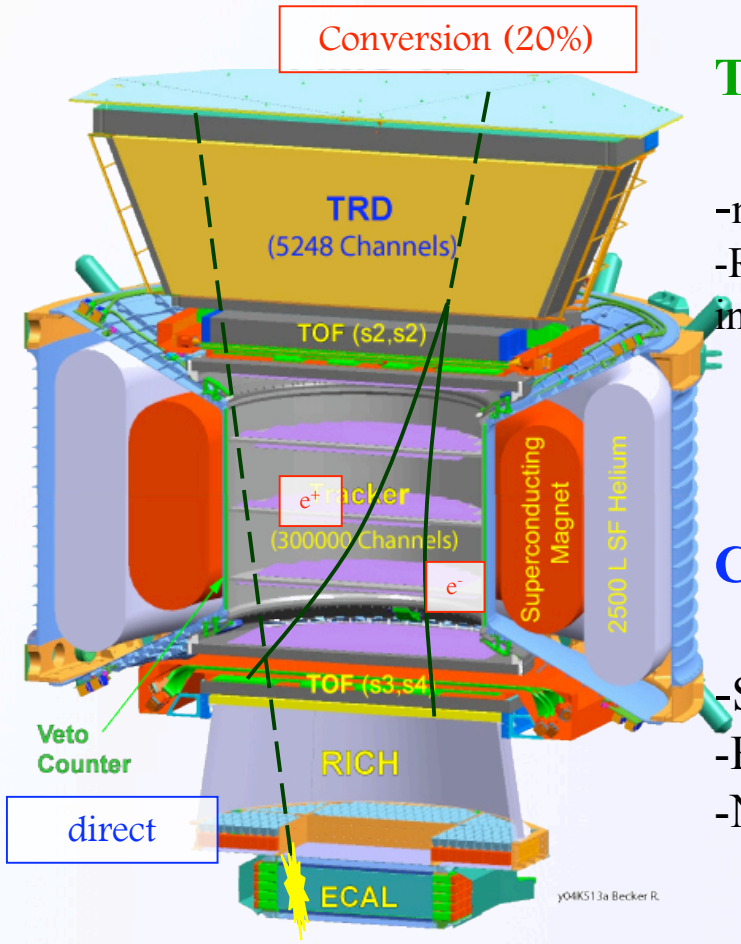
No excess

Gamma rays

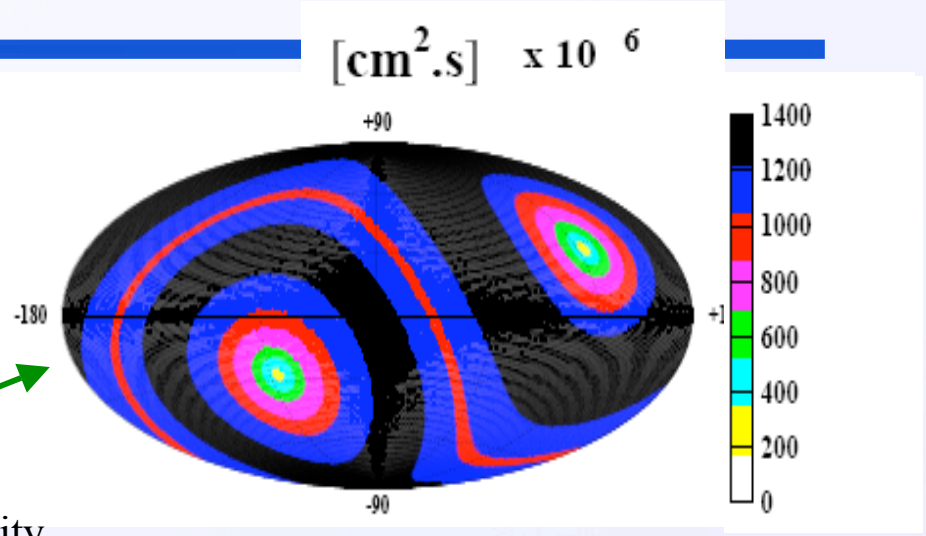
γ

Background

- Protons $\Phi_p \sim 10^{5-7} * \Phi_\gamma$
- electrons $\Phi_{e^-} \sim 10^{4} * \Phi_\gamma$

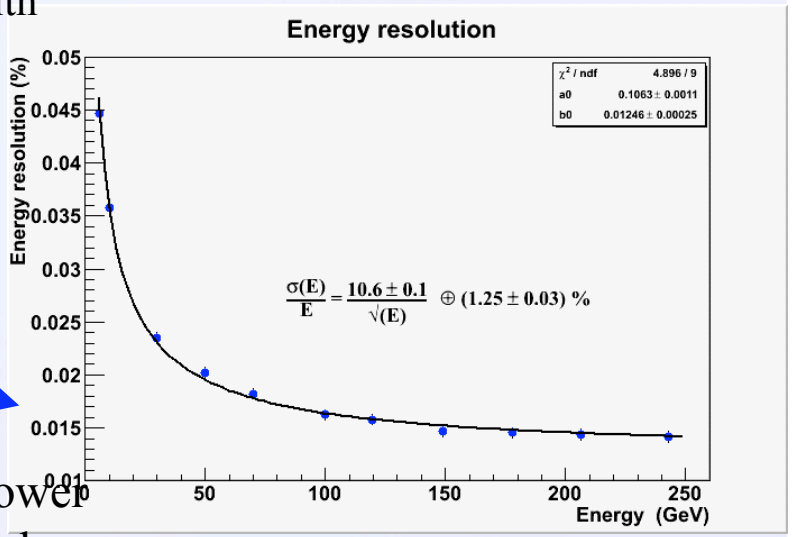


Tracker :



-no TRD activity
-Rejection of events with interaction

Calorimeter



-Standalone trigger
-Electromagnetic shower
-No interaction elsewhere

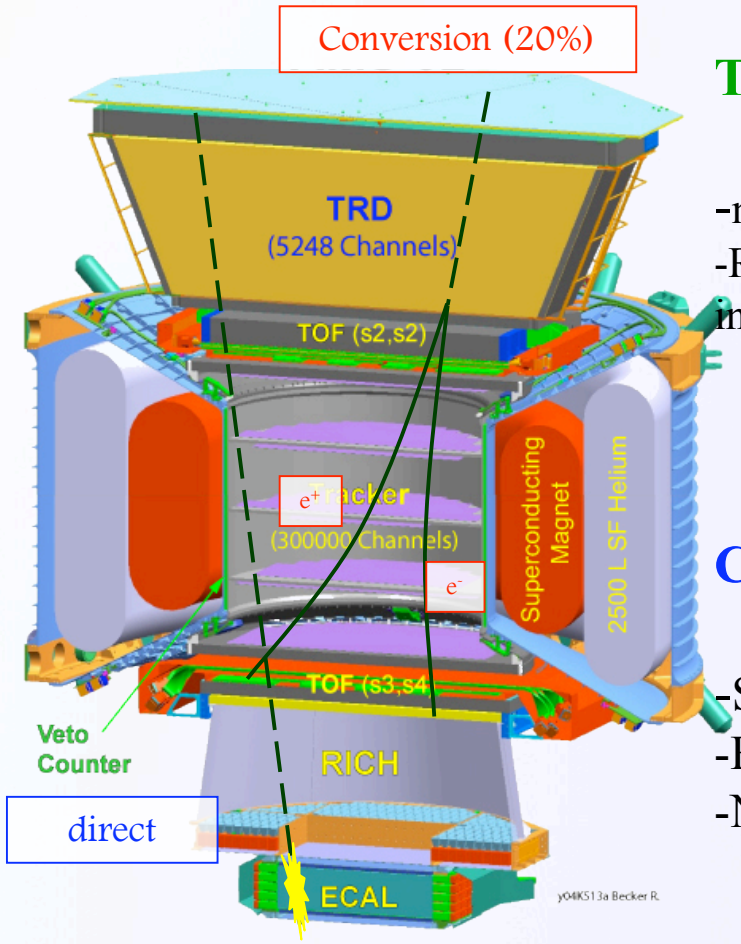
Gamma rays

γ

▷ Background

- Protons $\Phi_p \sim 10^{5-7} * \Phi_\gamma$
- electrons $\Phi_{e^-} \sim 10^{4} * \Phi_\gamma$

$A_\gamma / A_p \sim 10^7$

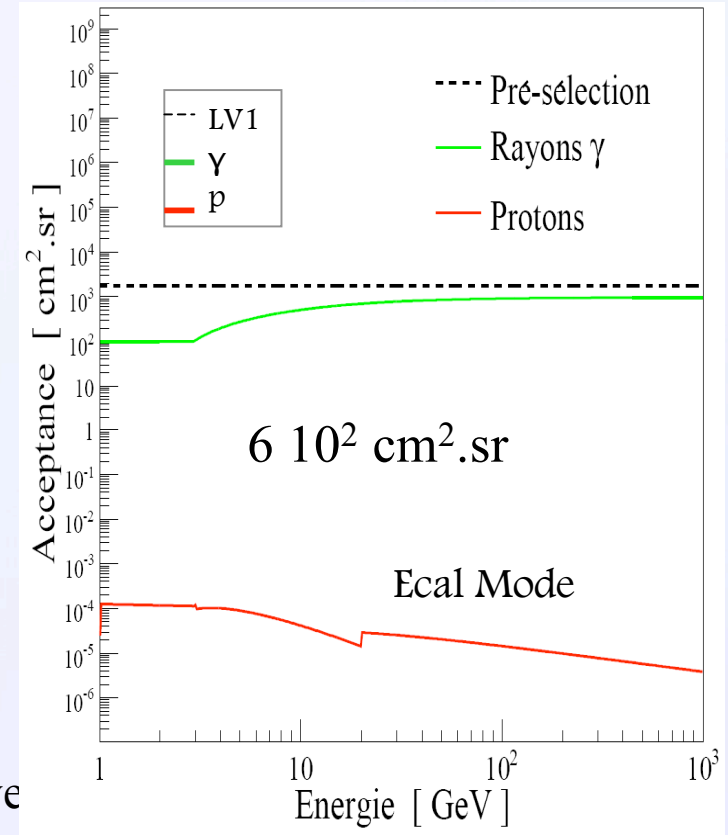


Tracker :

-no TRD activity
-Rejection of events with interaction

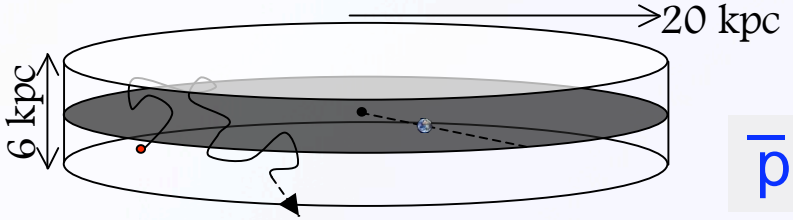
Calorimeter

-Standalone trigger
-Electromagnetic showe
-No interaction elsewhere

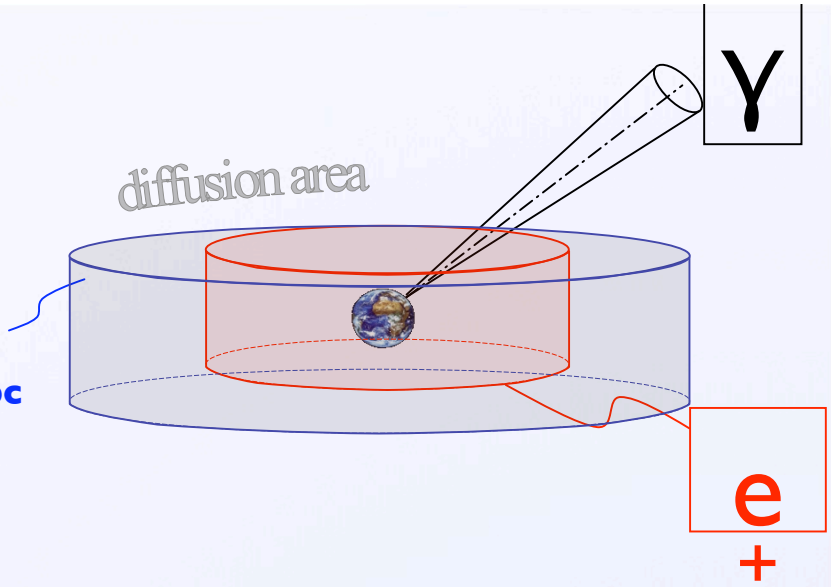


γ : 3 GeV ~ 1 TeV

complementary analyses

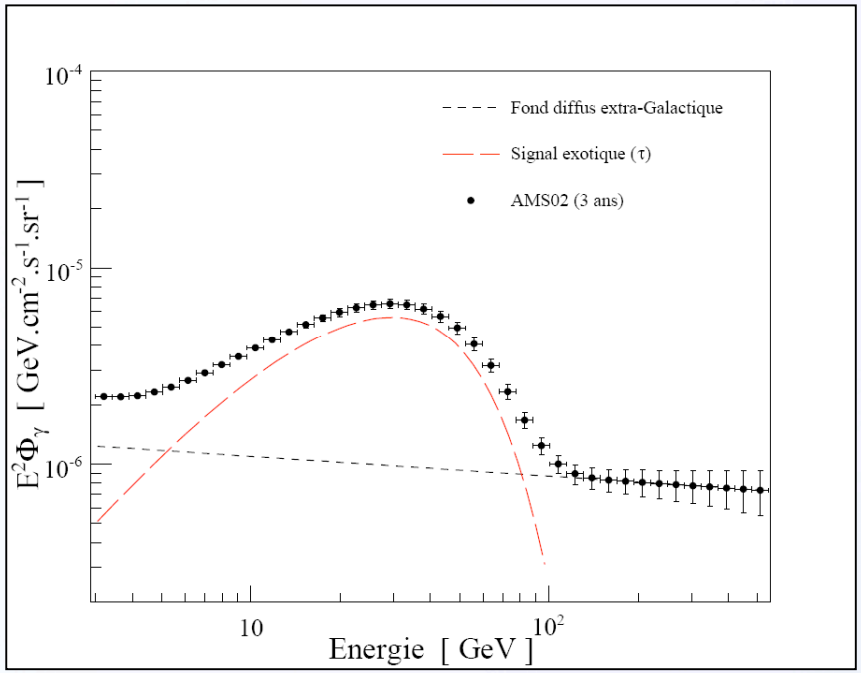


$\bar{p}$ ~10 kpc

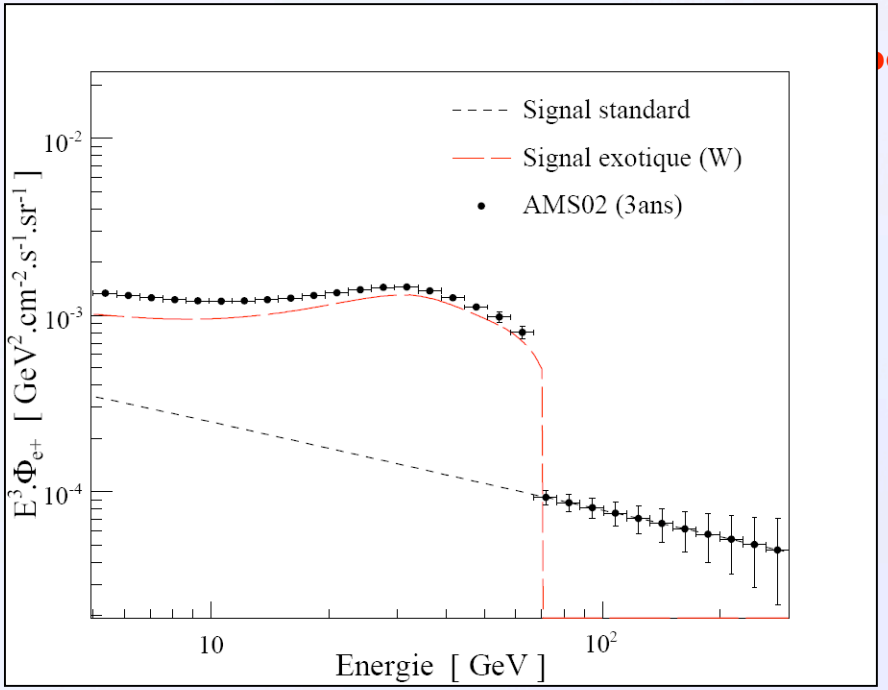


Dark matter halo = 10× diffusive zone

Top : LSP (SUSY)– 151 GeV



$A_\gamma / A_p \sim 10^7$



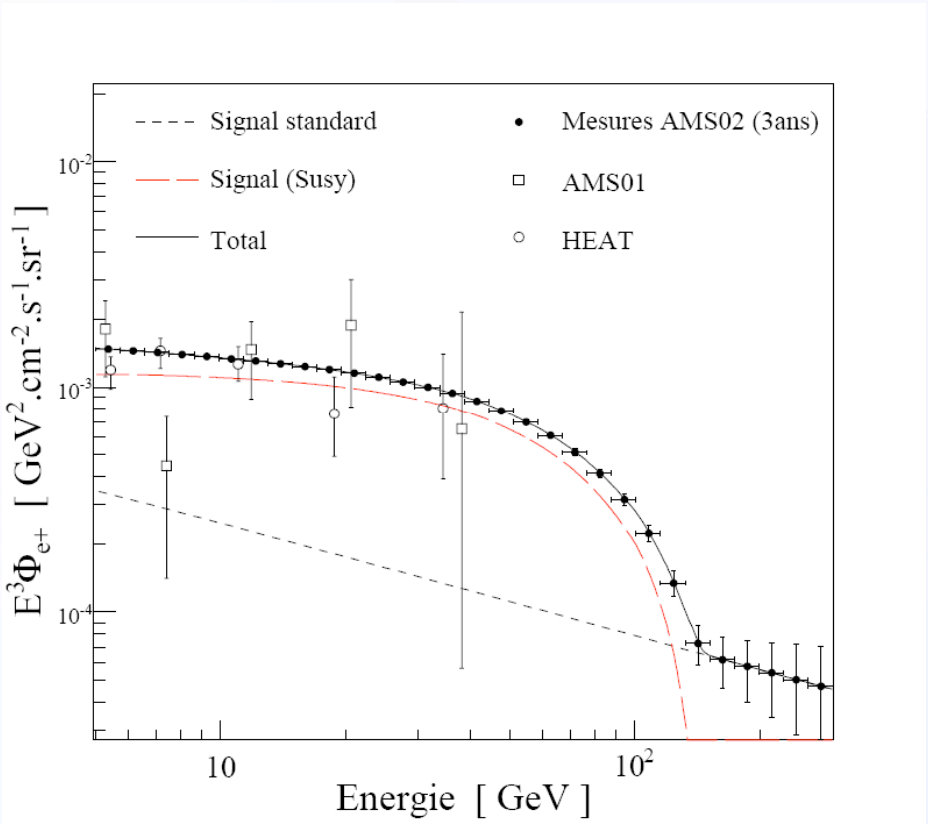
$A_{e+} / A_p \sim 10^5$

LSP/LZP separation/ Spectrum shape

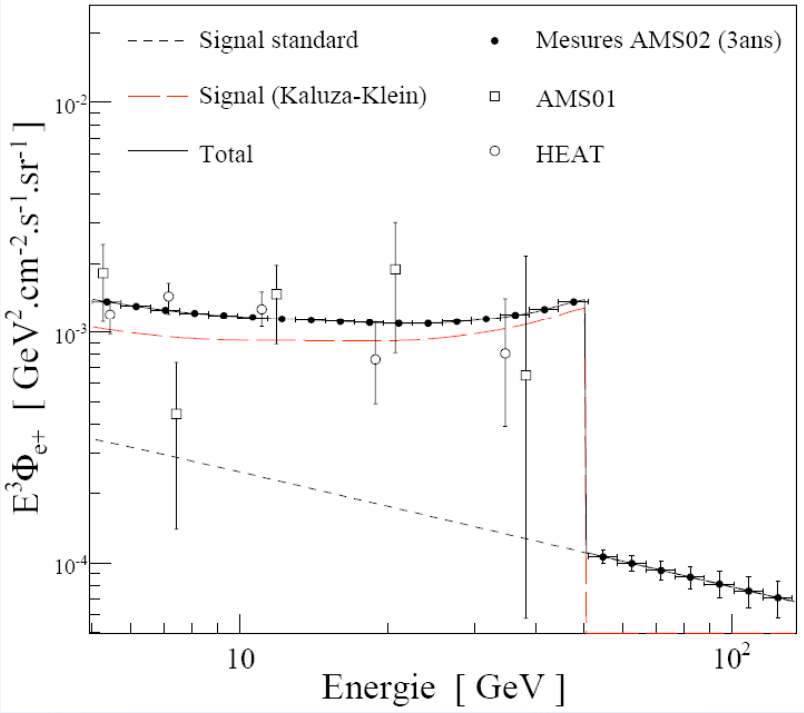
Expected spectra (3 years) – IMBH scenario

e^+

$E^{(2-3)}*\Phi(i)(GeV^{1-2}cm^{-2}s^{-1}str^{-1})$



Top : LSP (SUSY)– 151 GeV



Bottom : LZP (X-dim)– 50 GeV

Milestones

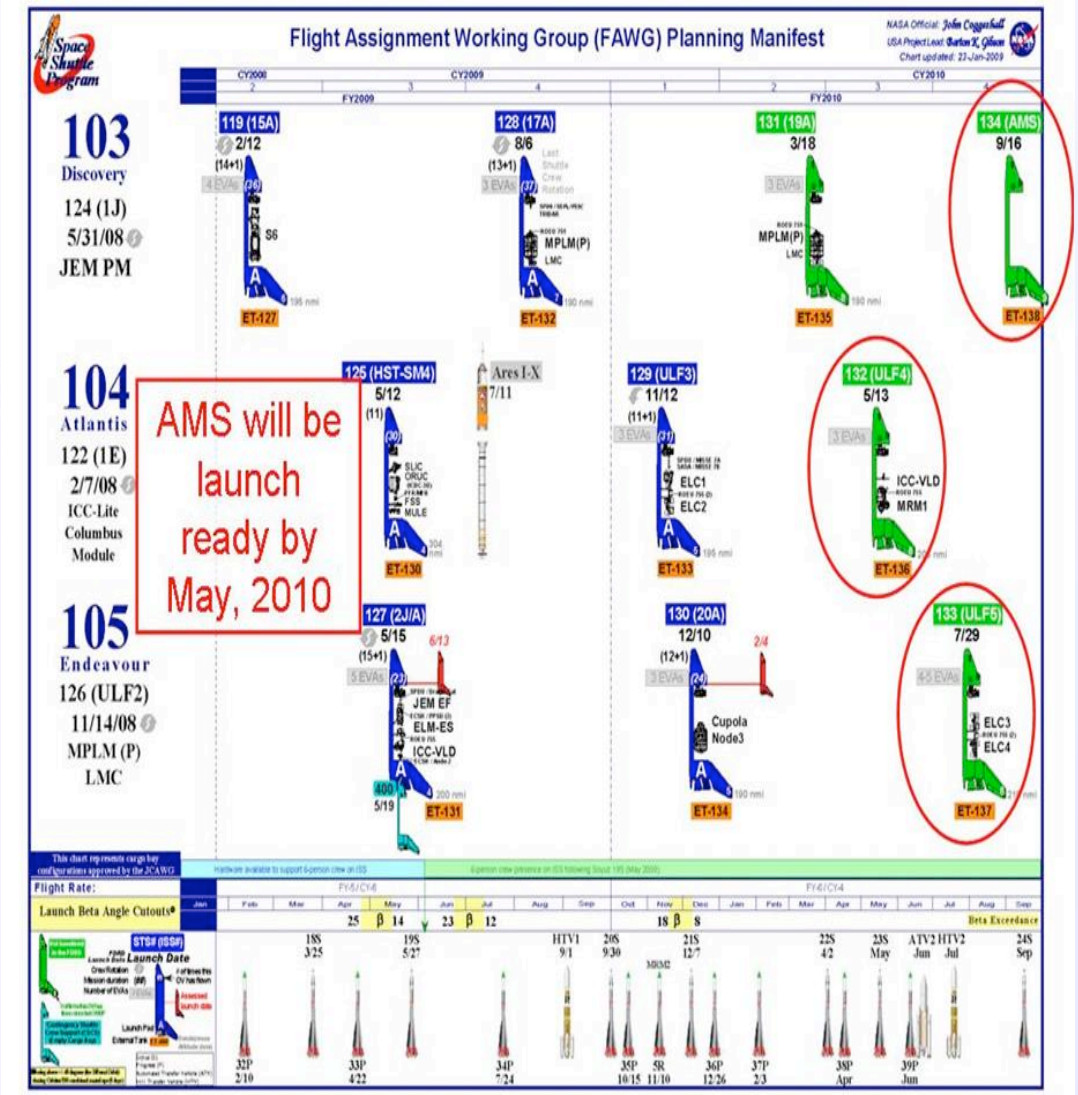
- Vacuum chamber welded
- Integration:
  - October to December
- Test beam:
  - One week in December
- Thermal tests in Nordwick(ESA) + EMI tests
  - January->February



First tests without the magnet, Oct 2008

2010 ….

- In Kennedy Space Center, end of March
  - 4 months of test
- Launch September 16th 2010 STS 134
- After the launch
  - 6 weeks in Houston, JSC
  - Then Cern where the Payload Operation Center (POC) and the Scientific Operation Center (SOC) are located



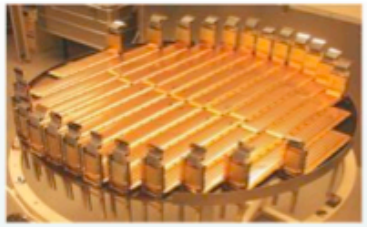
Statut des détecteurs

Construction of the detectors is complete

TRD
e

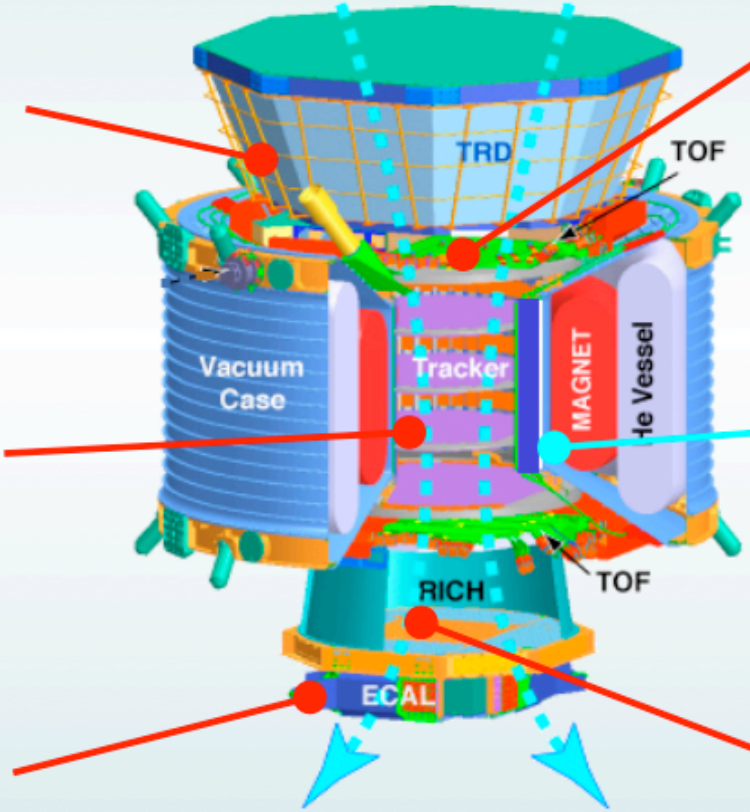


Silicon Tracker
Z, P



Calorimeter
e, γ

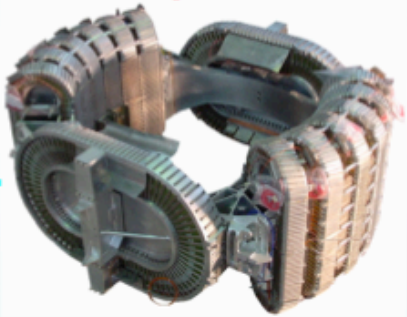




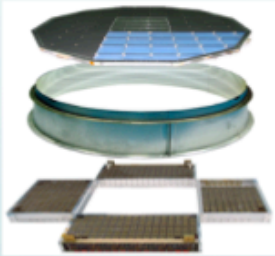
Time of Flight
v, Z



Magnet
p



RICH
v, Z

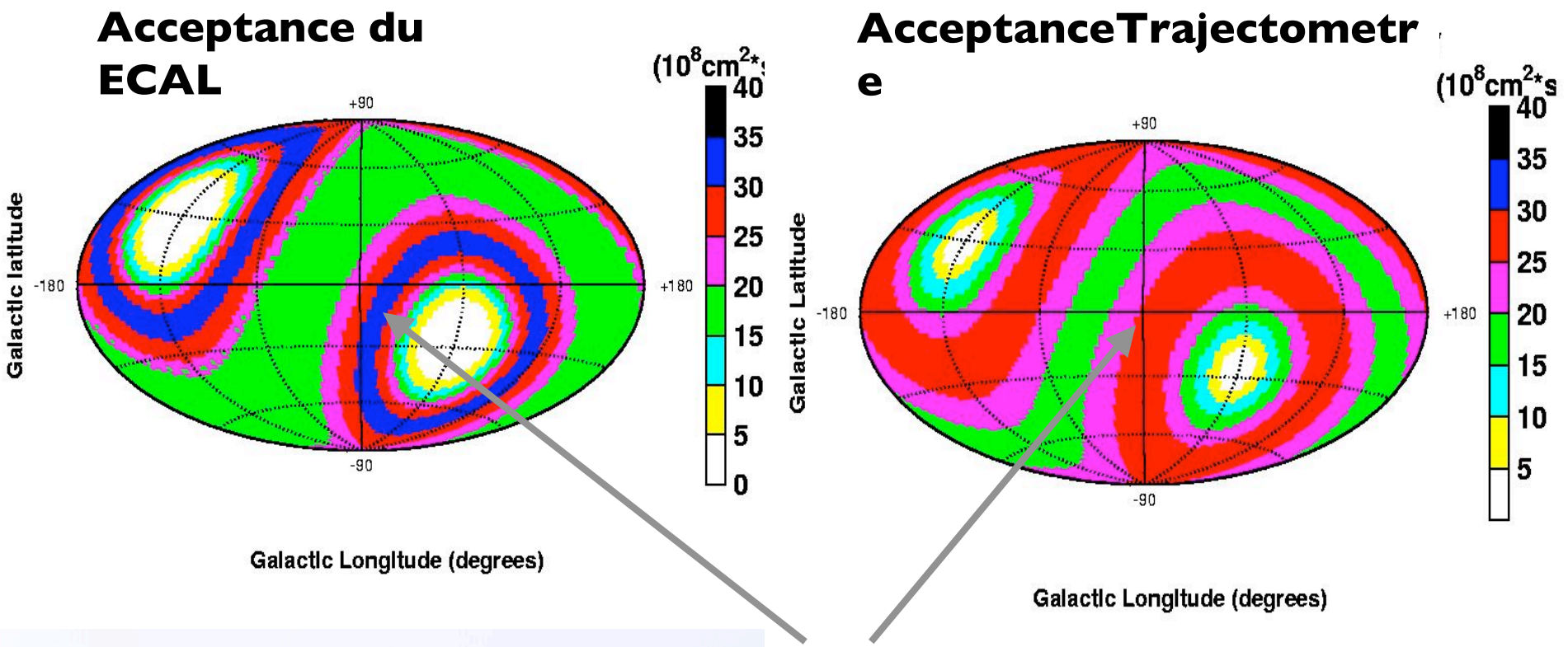


Size: 3m x 3m x 3m

Geometrical acceptance : 0.5 m².sr

Couverture du ciel

Acceptance pendant pendant ~1 an



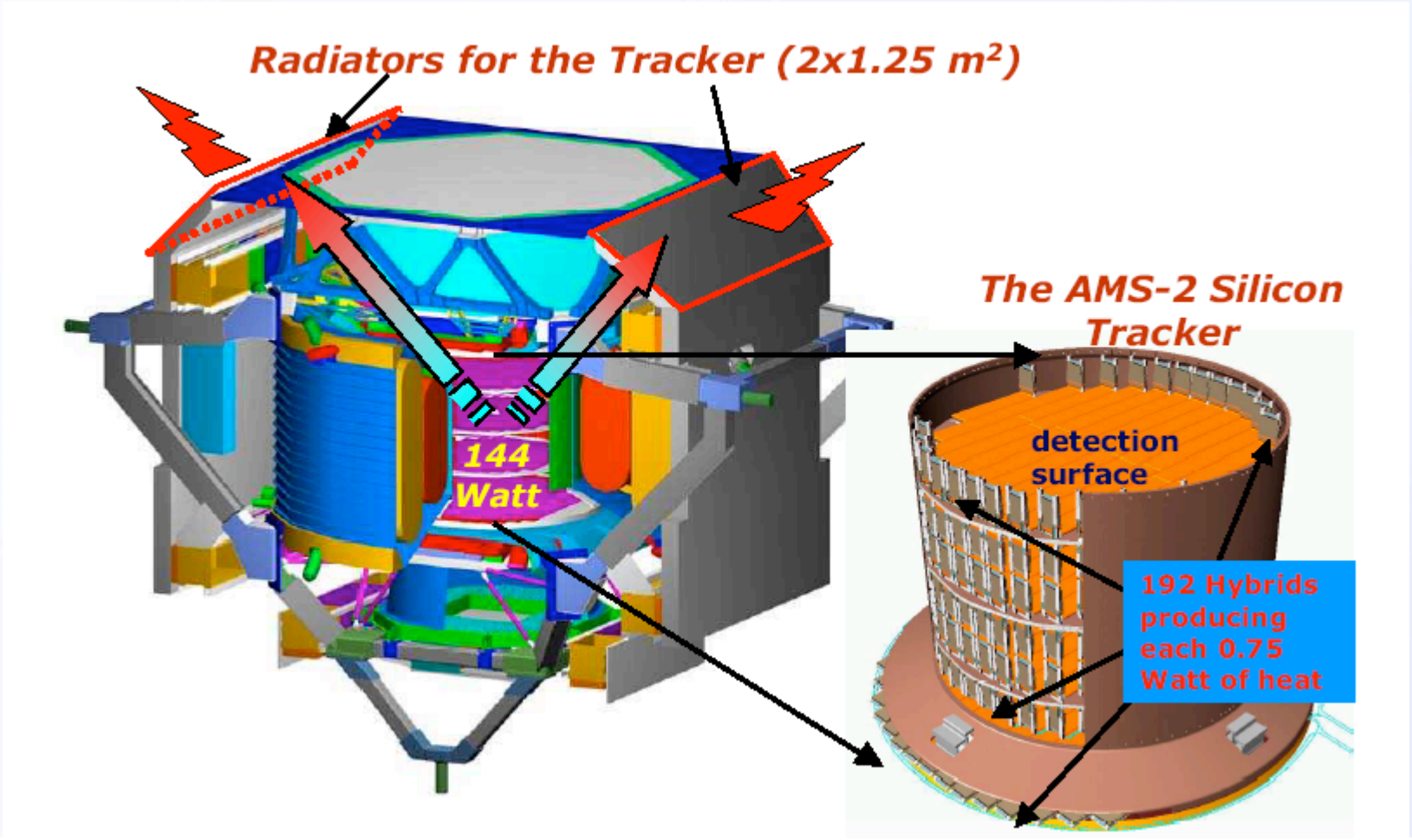
Centre galactiq

Tracker Thermal Control System

Two-phase pumped CO_2 loops

The most advanced cooling technology for space

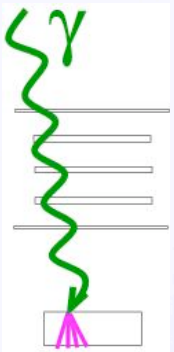
Key technology for robotic or manned space exploration



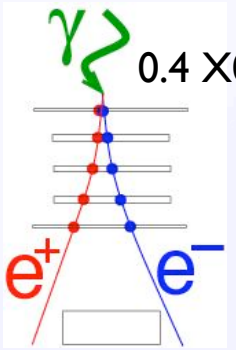
18 x/y samplings

AMS02 GAMMA DETECTION

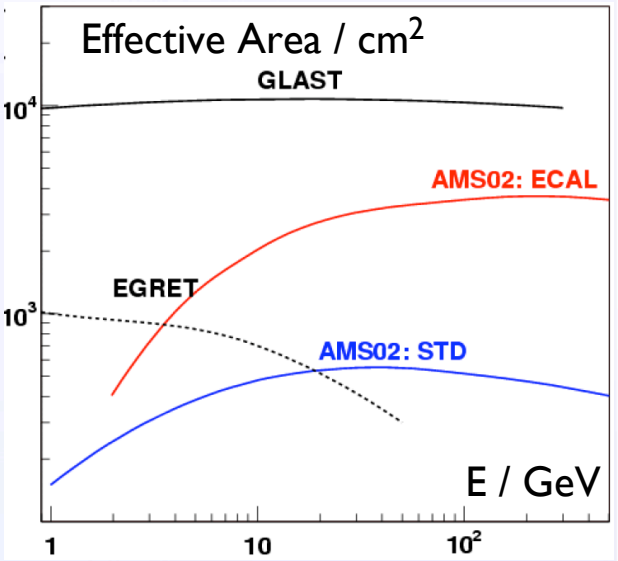
Energy and angle	1 GeV – 1 TeV
h/e Separation:	10^3 shower-shape
Acceptance:	0.05m^{2}sr

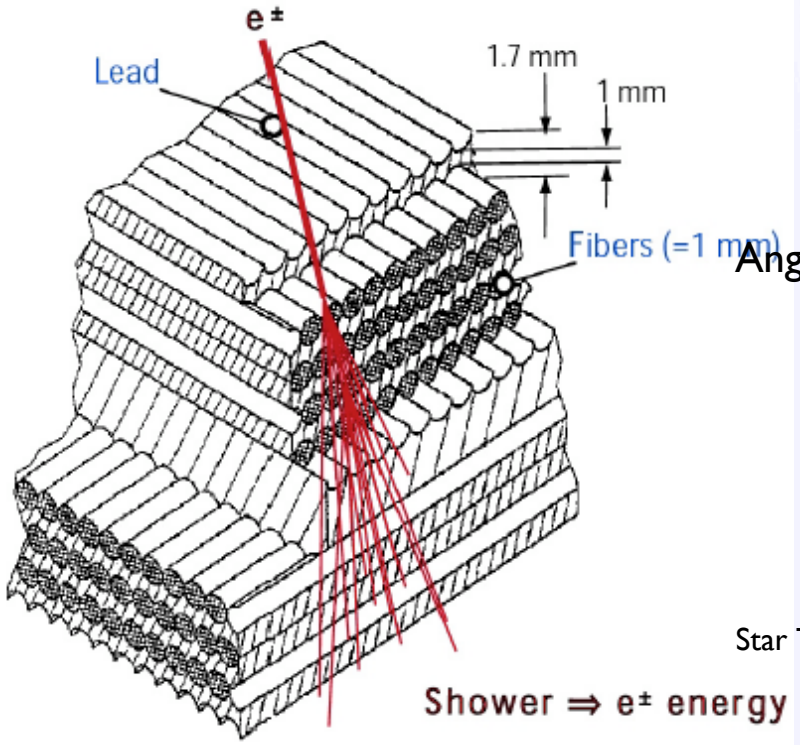


ECAL



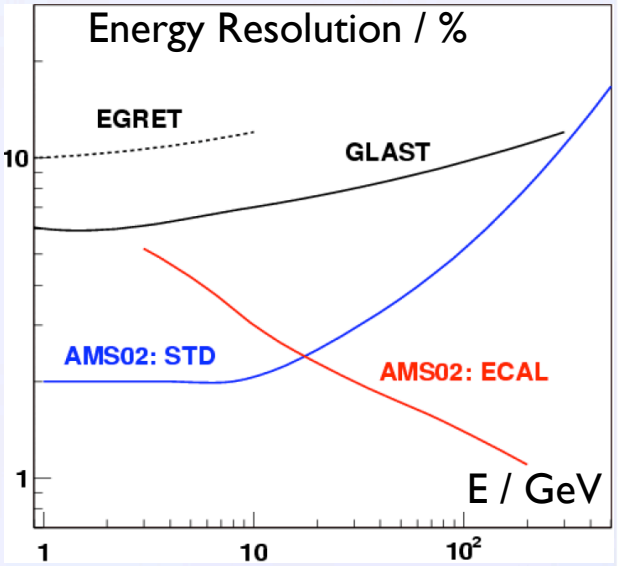
Conversion





Angular Resolution / deg

Star Tracker: 30“

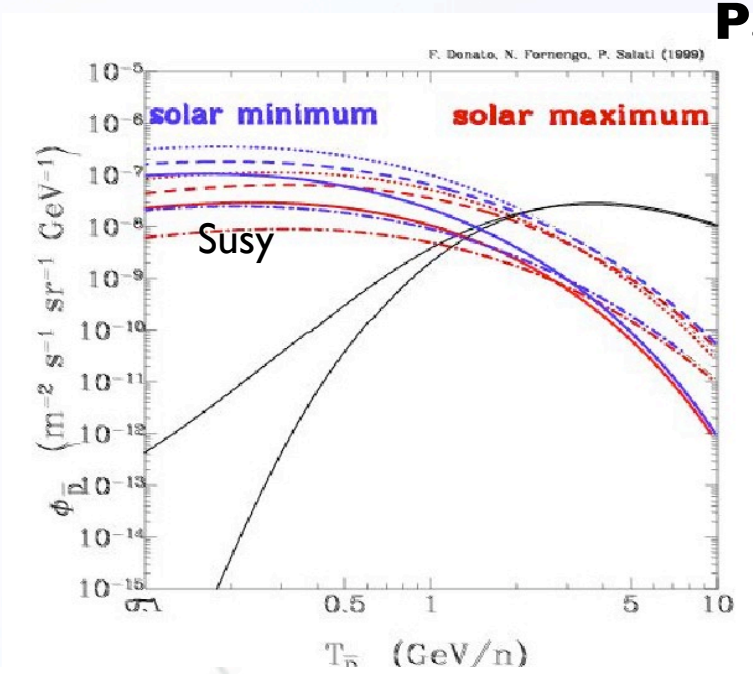


E / GeV

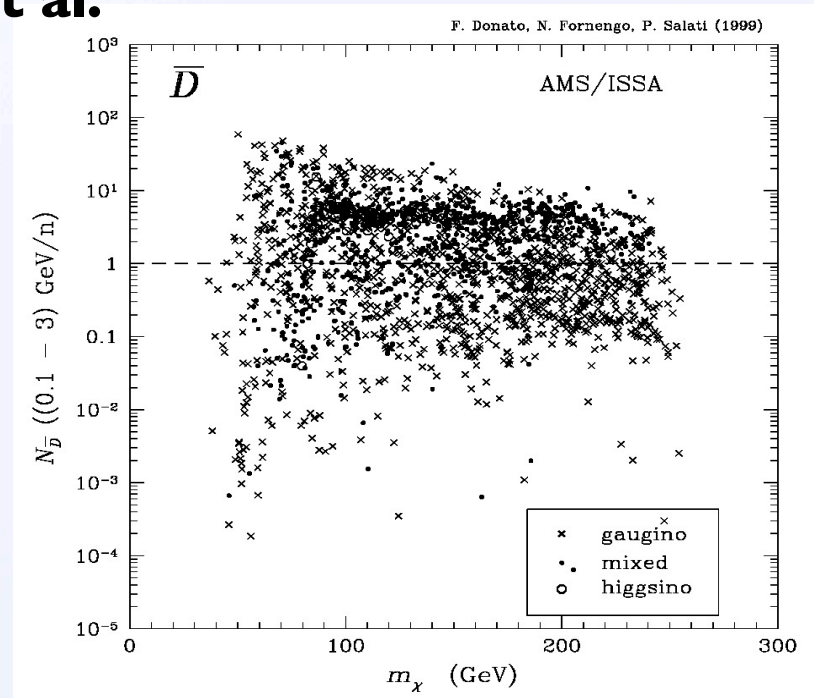
Recherche de matière noire

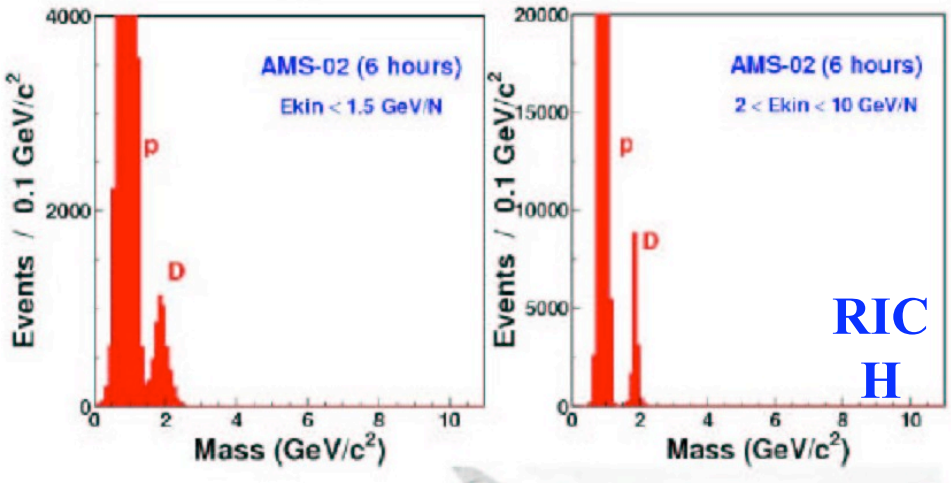
Spectres signal et bruit de fond distincts

P.Salati et al.



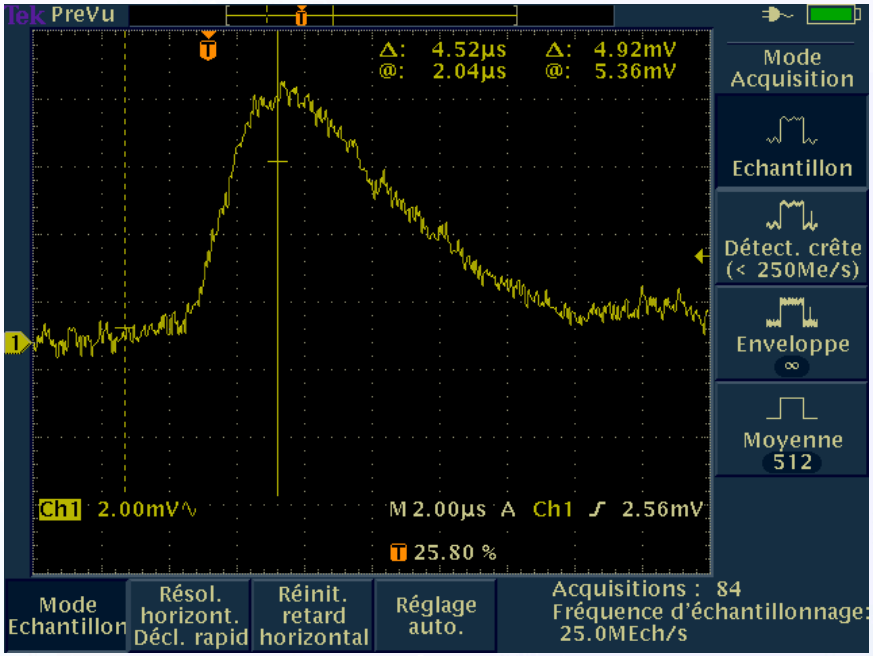
3 ans

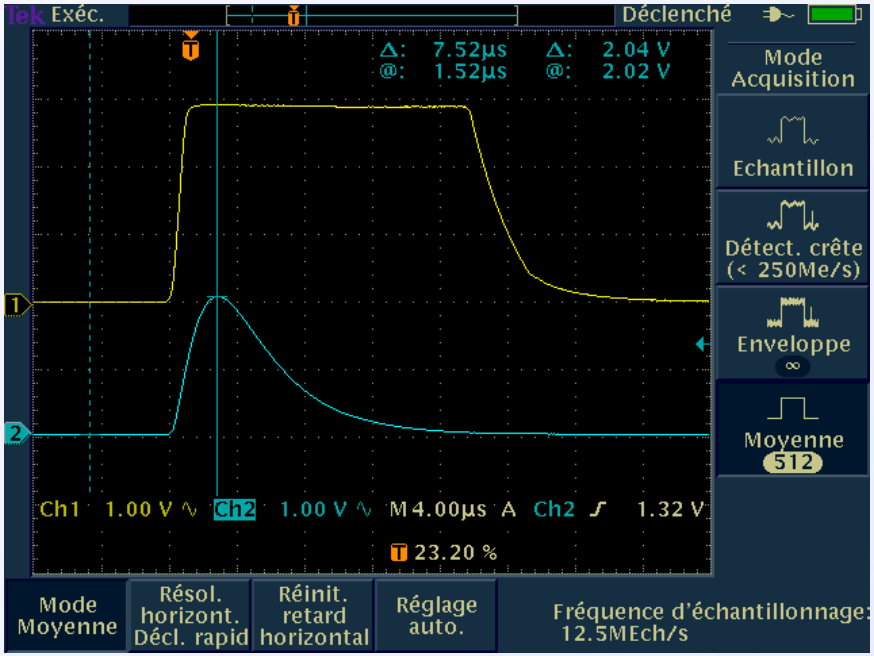




- **Bruit de fond attendu :**
  ~ 0.7 events < 3 GeV/n
  13 events > 3 GeV/n
- **Clumps**

Electromagnetic Calorimeter





1 MIP signal out of
high gain channel

2000 pC signal out of
low gain channel (blue)
(high gain channel (yellow is saturated)