High energy photons detection with the Alpha Magnetic Spectrometer on the ISS

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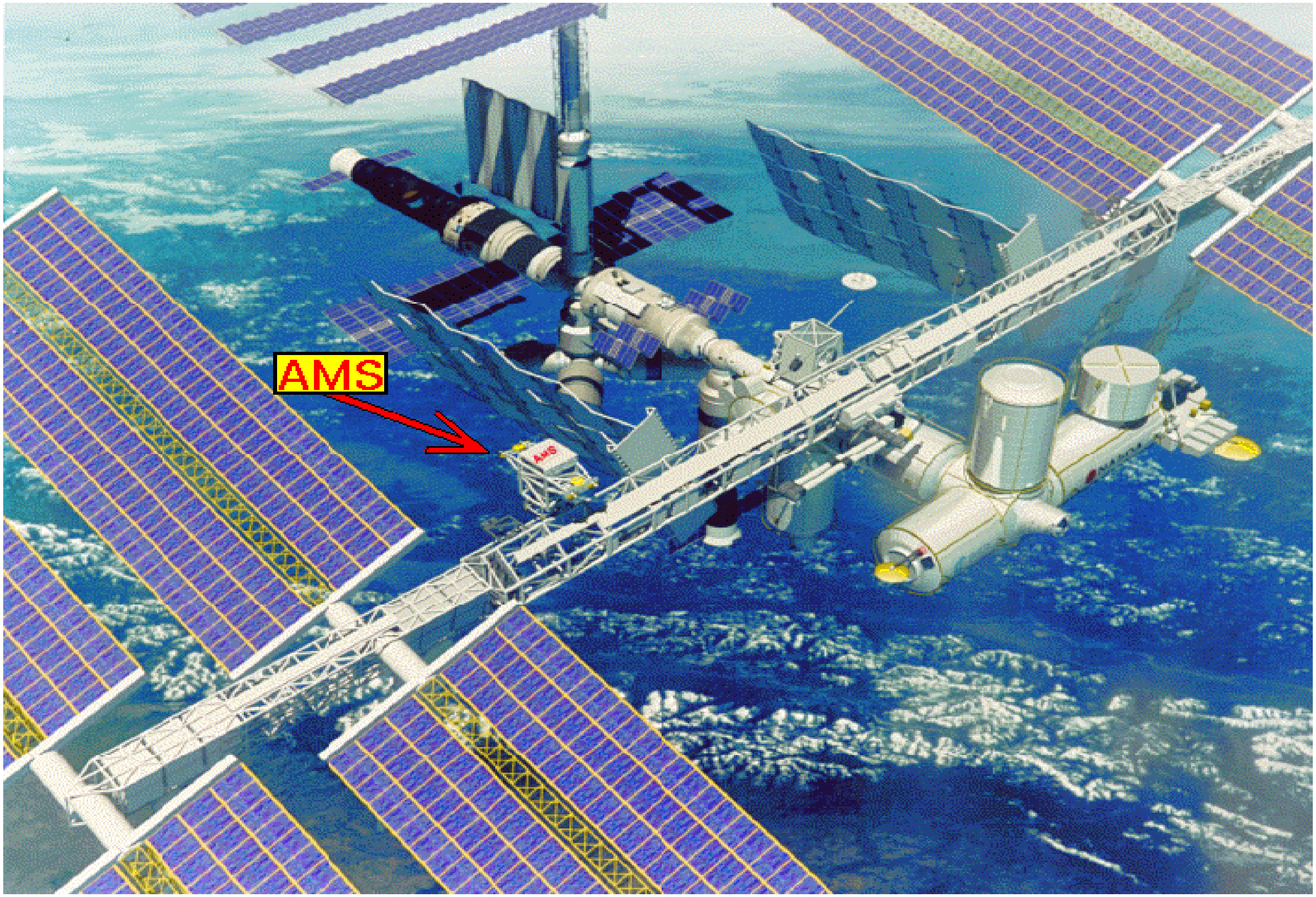
February 28 - March 1, 2002
Meeting of the SPS - EPFL, Switzerland

Outline:

- ISS and AMS-02
- The detector
- Gamma astrophysics
- AMS-02 expected performances
- Conclusions

ISS and AMS-02



What is AMS ?

*A*lpha *M*agnetic *S*pectrometer

A large acceptance magnetic spectrometer on the ISS

Orbital parameters of ISS:

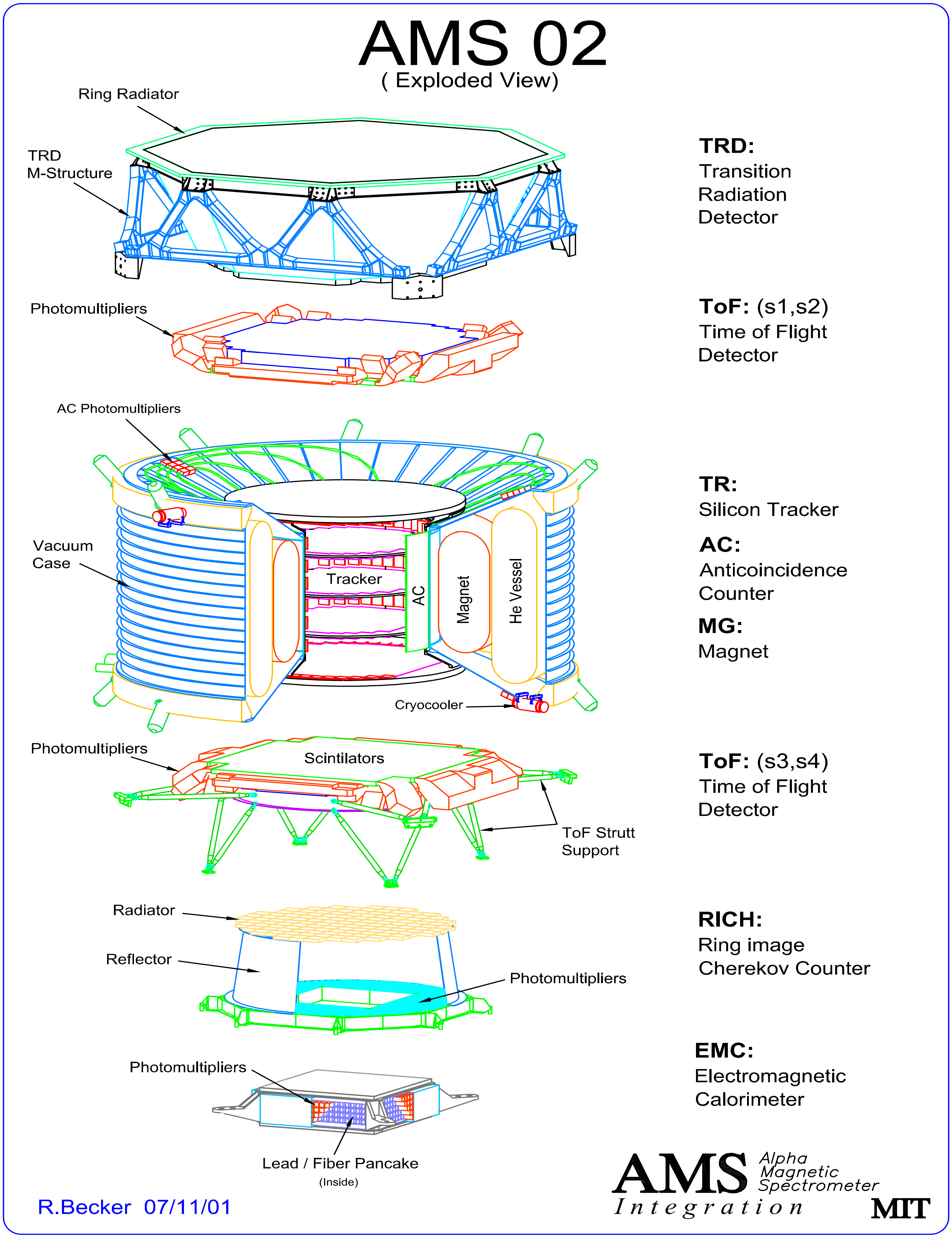
→ *Orbital period* $\sim 92min$
→ *Mean altitude* $\sim 382km$
→ *Inclination* $\sim 51.6^o$

Main physics topics:

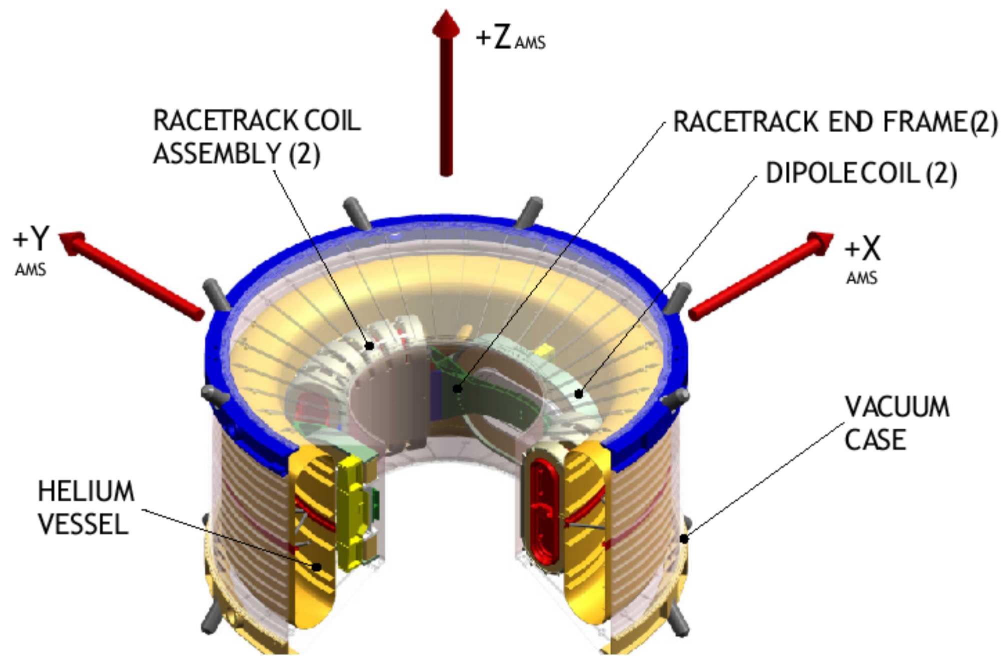
→ *dark matter*
→ *antimatter*
→ *origin and transport of cosmics rays*
detected through charged particles.

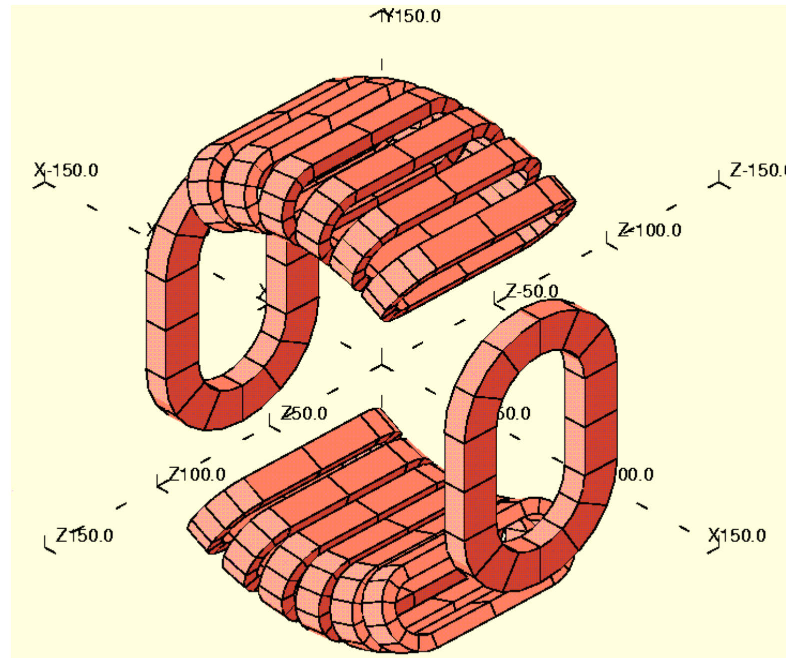
→ *Study of γ-ray from galactic and extragalactic sources*

AMS-02 detector



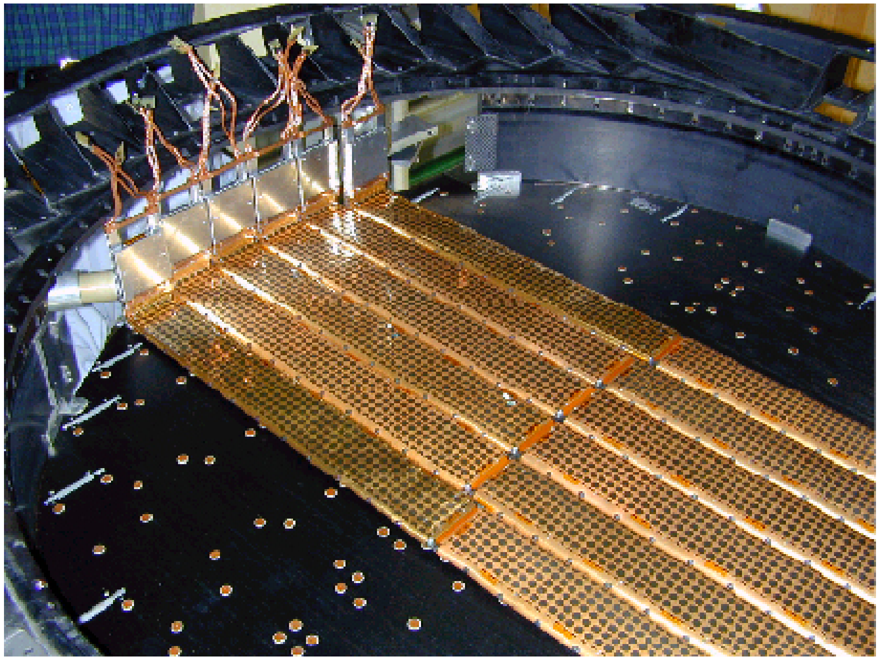
AMS-02 Superconducting Magnet

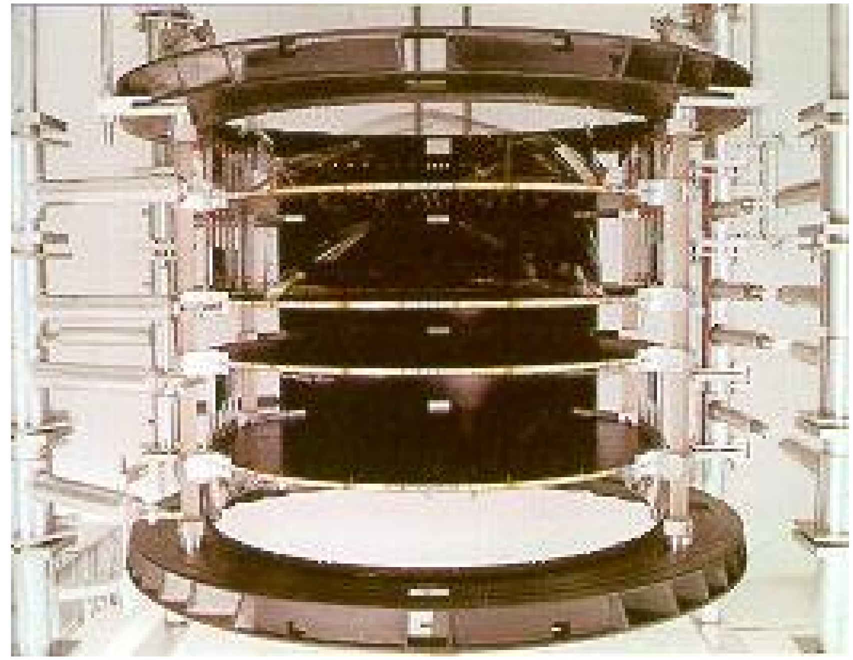




12 racetrack coils + 2 dipole coils
2500 liters of superfluid helium
$$BL^2 = 0.86Tm^2$$

AMS-02 Silicon Tracker





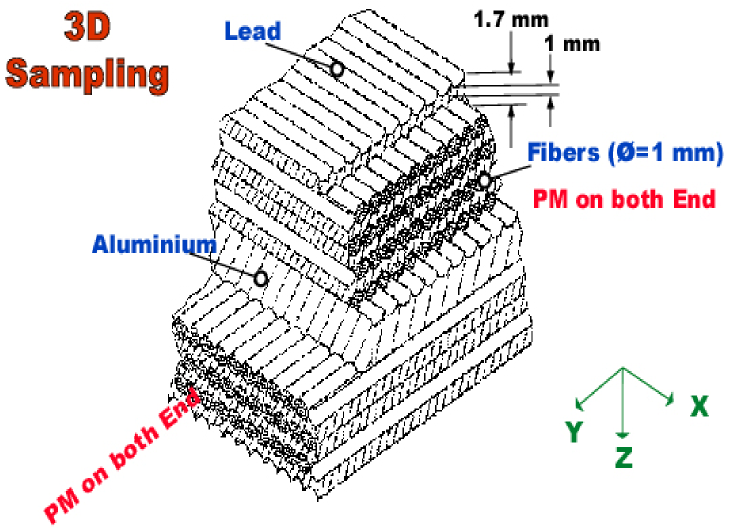
8 layers of double sided silicon sensors

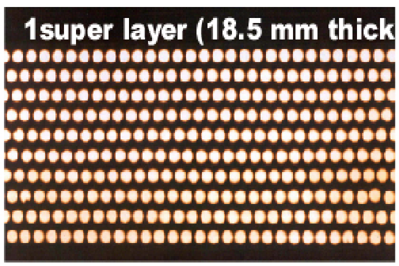
$6.5m^2 \rightarrow 192$ **Ladders** $\rightarrow 196k$ **channels**

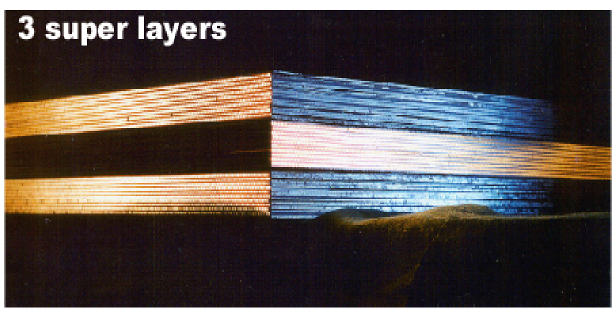
$\sigma(p)/p = 1.5$ **% @** 10 **GeV**

max detec. rigidity $= 2.6$ **TV**

AMS-02 Electromagnetic Calorimeter



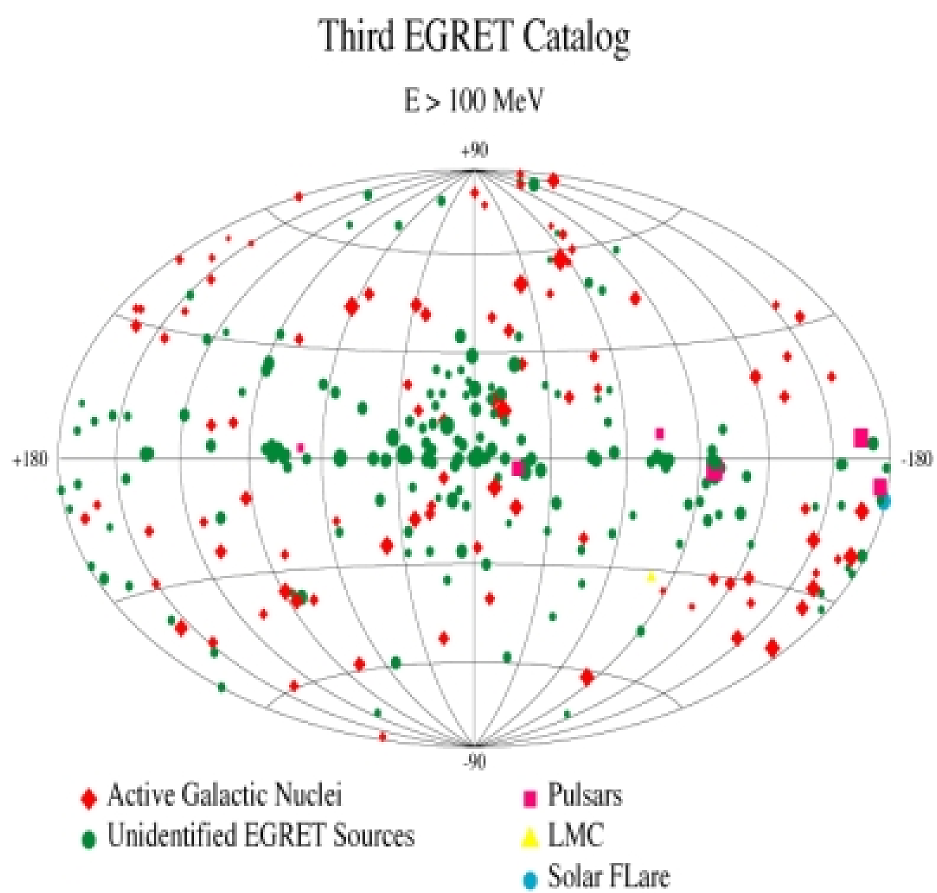




9 super layers of Sci-Fi/Lead (15 X_0)
(324 multianode PMTs)

$\sigma(E)/E = 3$ **% @ 100 GeV**
(p/e rejection of 10^3)

γ-*Ray Universe*



$\sim$ 280 pointlike γ-ray sources detected by EGRET (variable sources, transients)

- $\sim$ 70 Active Galactic Nuclei (AGNs)
- $\sim$ 7 Pulsars
- $\sim$ 200 sources not identified by an astronomical object

How are γ-rays produced ?

Need powerful ENGINES!

$\rightarrow$ *astronomical objects supplying energy*

- Star explosions
- Rotational energy
- Accretion energy
- Magnetic energy

Need efficient ACCELERATION!

$\rightarrow$ *charged particles*

- Electromagnetic
- Shock waves

Need "right" ENVIRONMENTS!

$\rightarrow$ *γs production*

- Synchrotron radiation
- Inverse Compton
- π^0-production

How are γ-rays produced ?

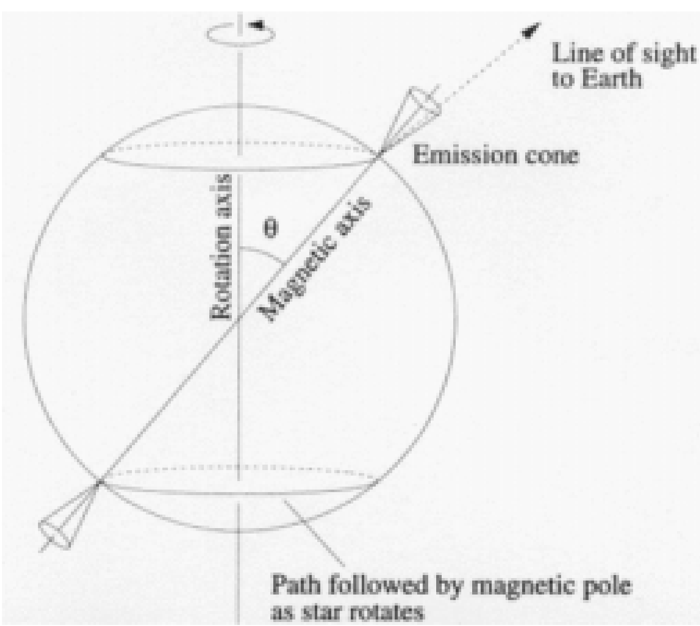
Galactic sources:

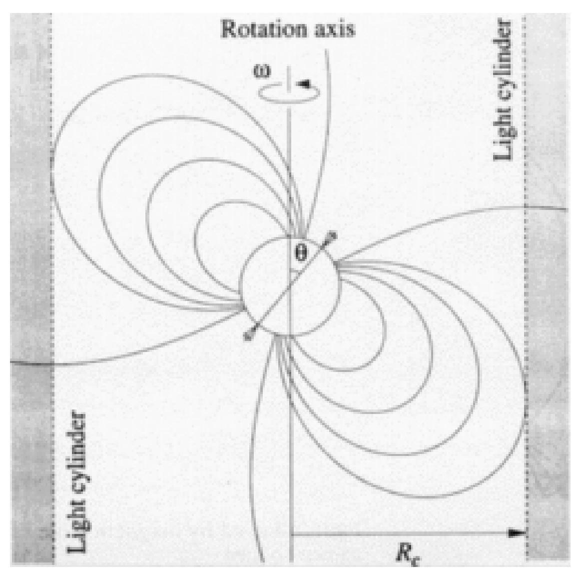
Pulsars

Rotating neutron stars from supernovae remnants, for which the axis of rotation is misaligned with the magnetic axis.

- Fields at the surface liberate e^-, e^+, p which are then accelerated by the magnetosphere.

Carroll & Ostlie 1996





How are γ-rays produced ?

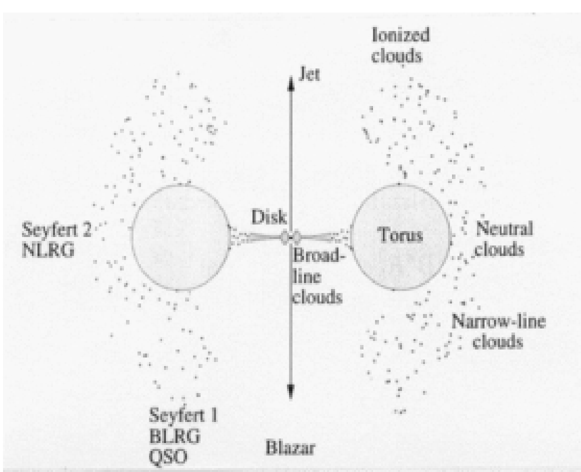
Extragalactic sources:

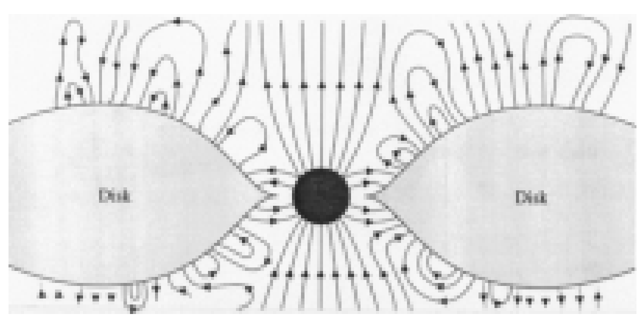
AGNs

Very massive rotating black hole surrounded by its accretion disk and by a giant torus of gas and dust.

- Jets of particles are ejected along the rotation axis and confined by the magnetic fields generated from the accretion disk.
- Particle acceleration can occurs by shock waves.

Urry & Padovani 1995





- When the jet points towards Earth the object is called ***blazar***.

3 fundamental needs of γ-ray astrophysics

Imaging & **Field of Obs.**

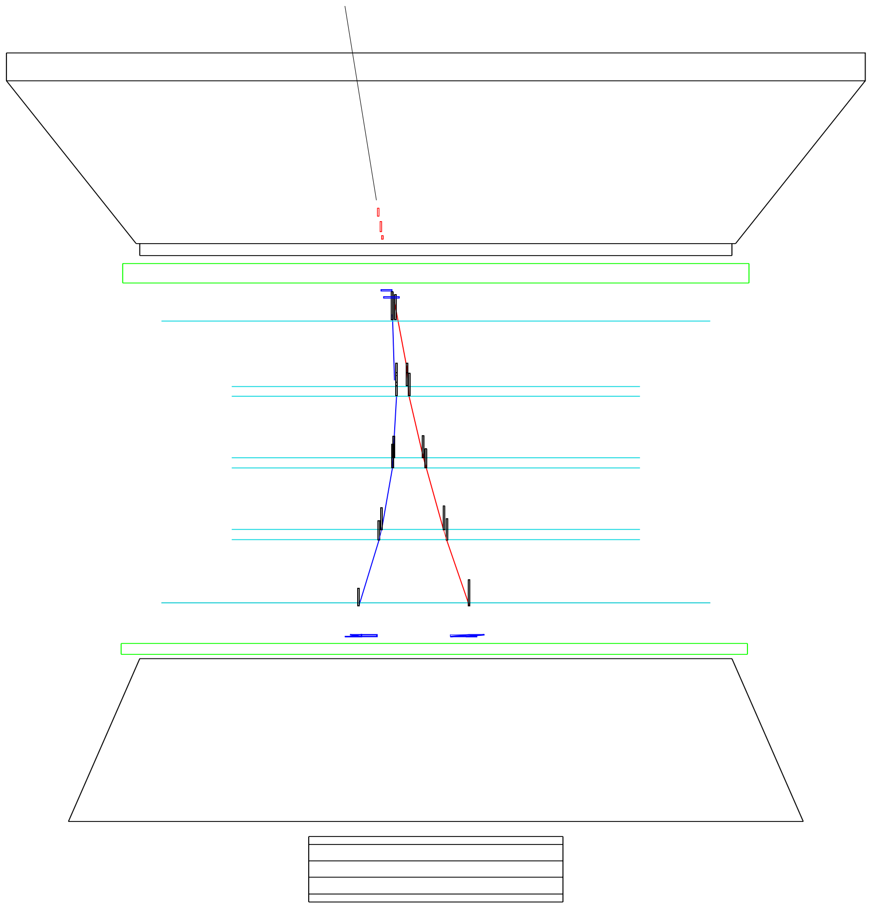
$(\theta \sim 0.017 \rightarrow 0.17^o)$ $(\Omega \sim \pi)$

Absolute Timing $(1 \rightarrow 10 \mu s)$

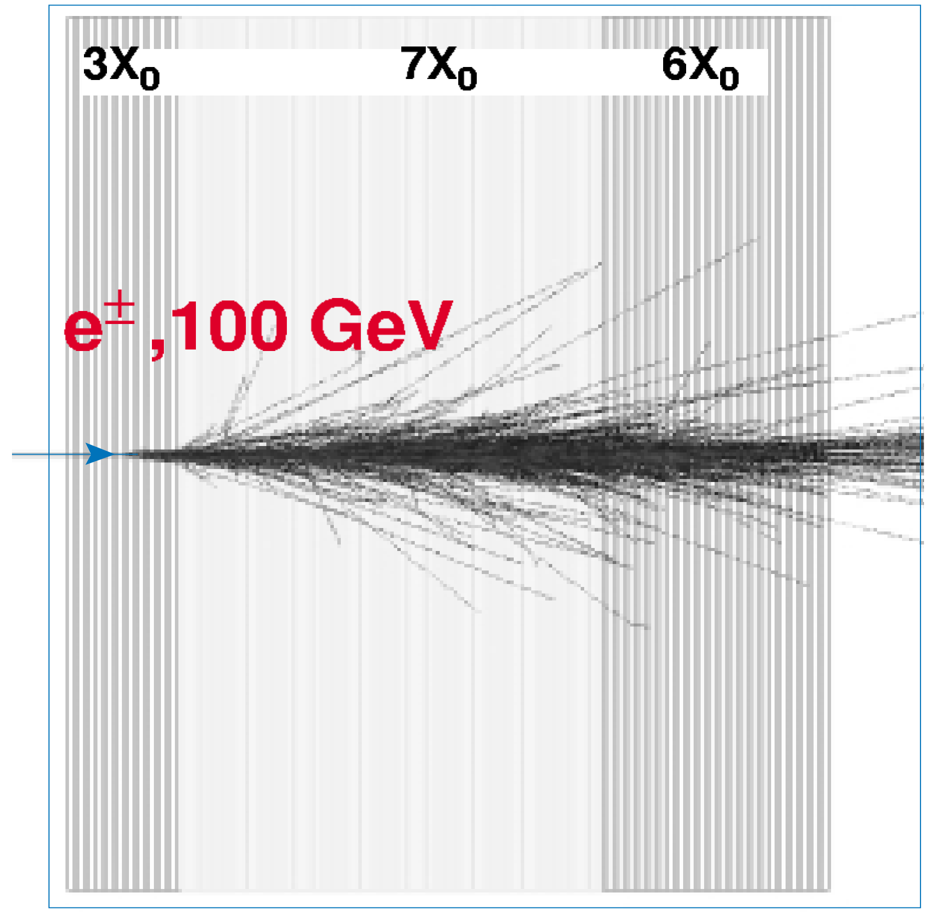
Absolute Orient.: ***Star Tracker***

γ *detection with AMS-02*

Conversion Mode

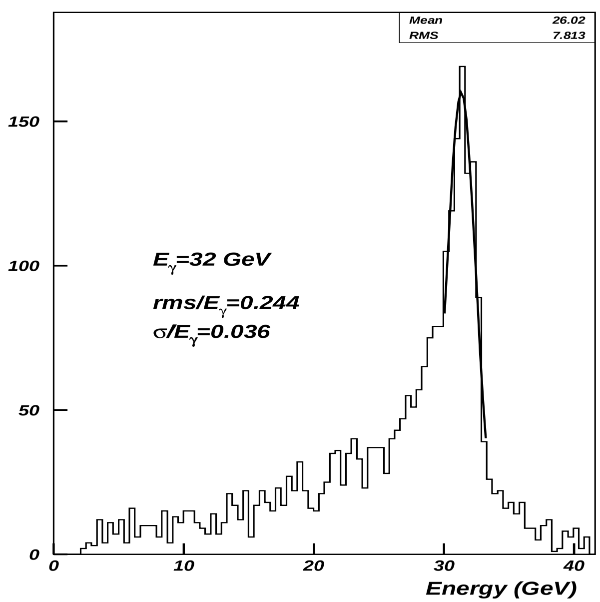


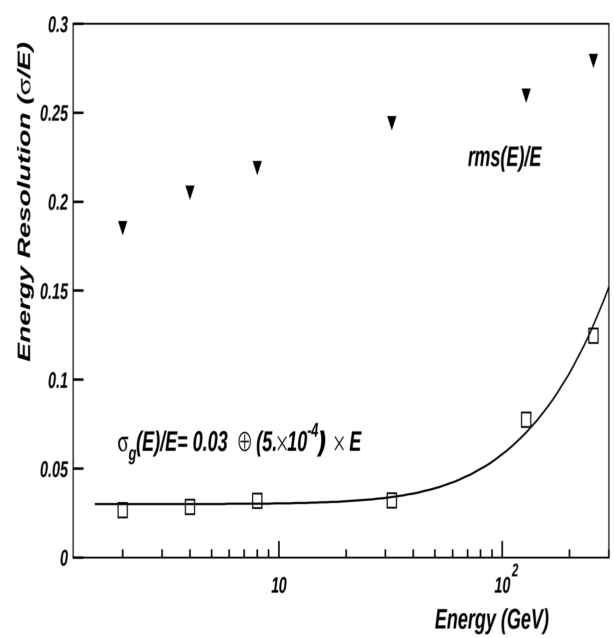
Calorimetric Mode

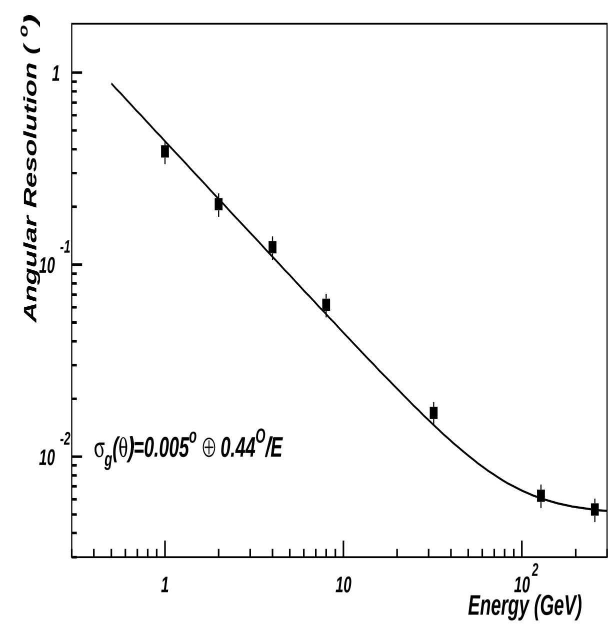


Tracker performances

Energy range	$1 - 100$ **GeV**
E resolution	$3\ \%$ **@** 10 **GeV**
Θ resolution	0.04^o **@** 10 **GeV**

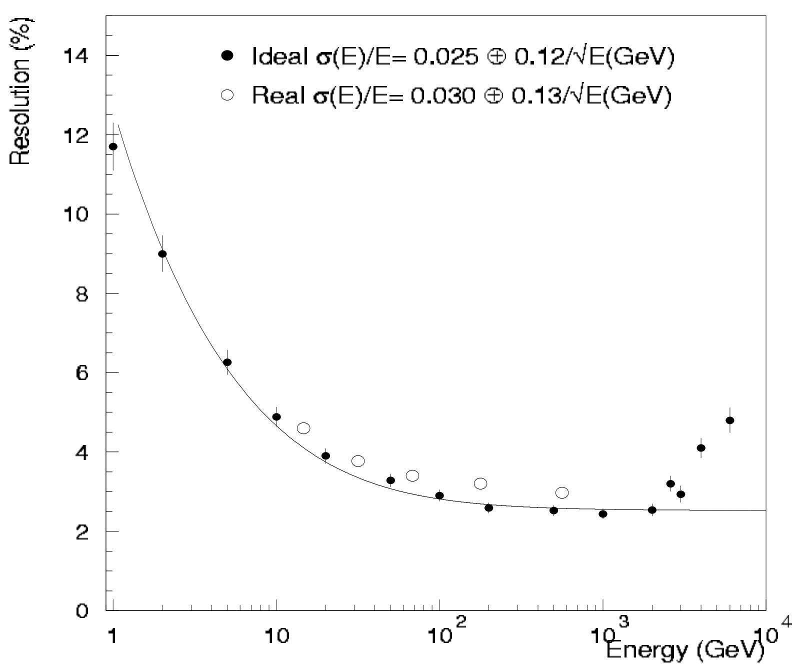


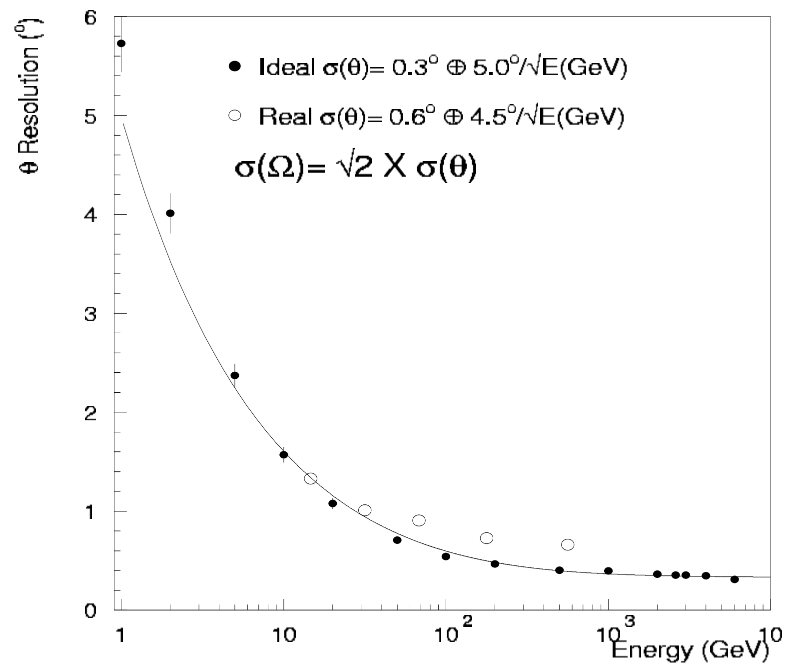




Calorimeter performances

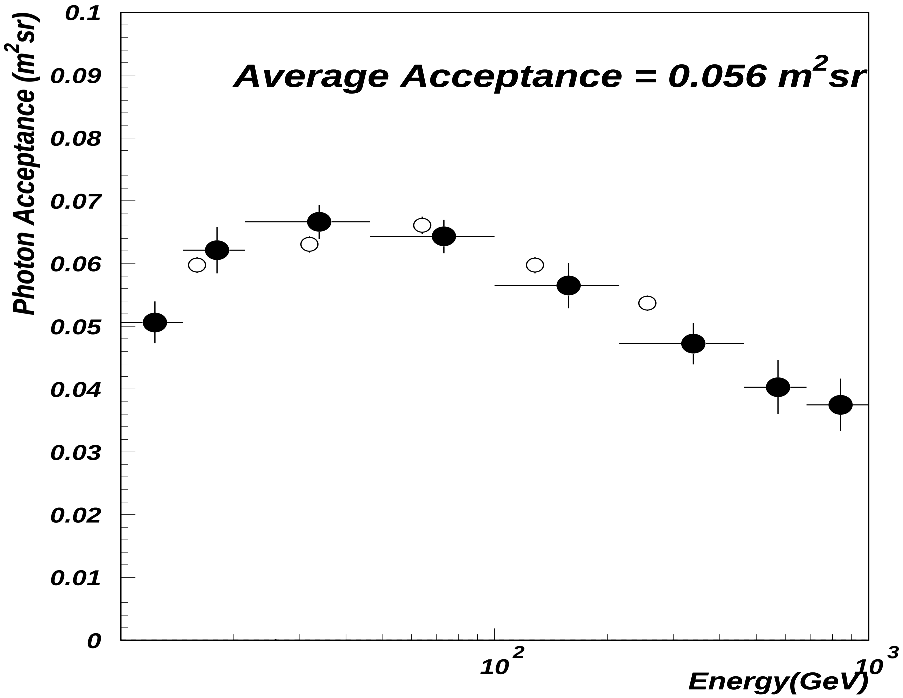
Energy range	10 – 1000 **GeV**
E resolution	3 % @ 100 **GeV**
Θ resolution	0.5^o @ 100 **GeV**



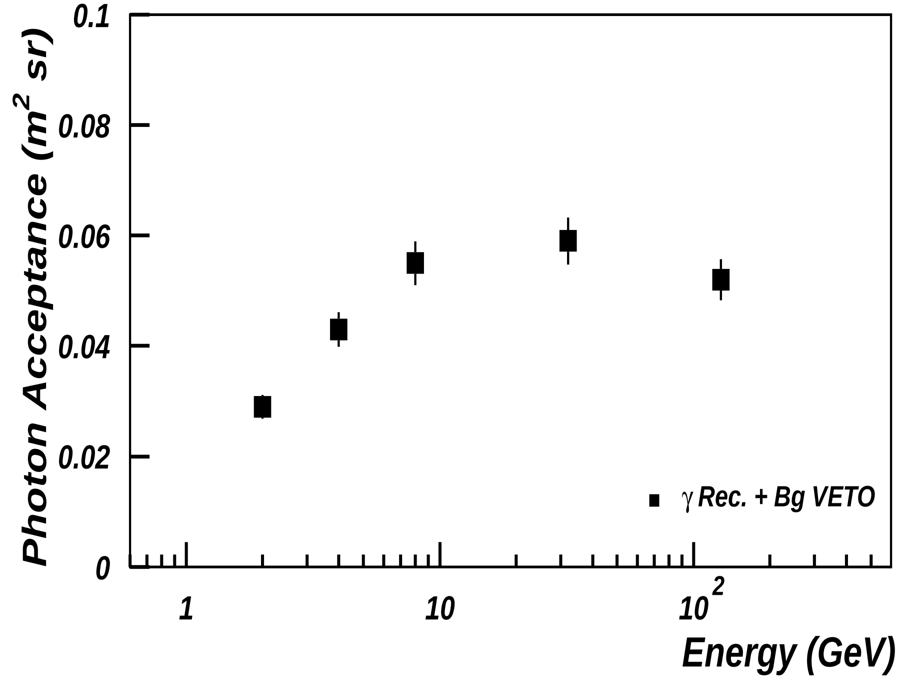


AMS-02 tracker and calorimeter acceptances

Calorimeter



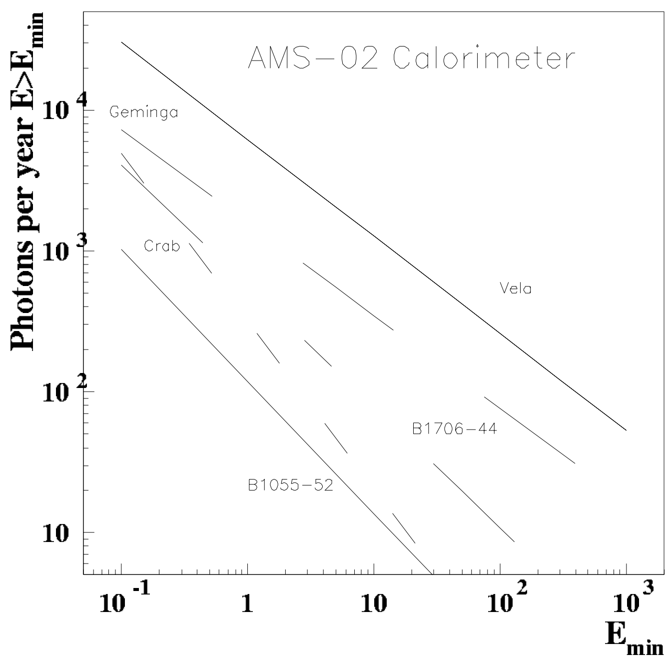
Tracker



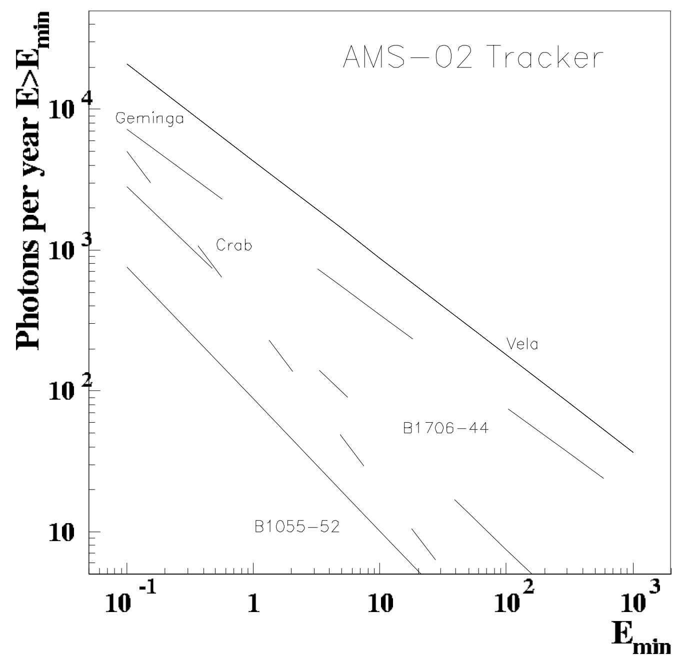
Almost the same acceptance @ 10 GeV $\rightarrow 0.06 m^2 sr$

Signal estimate from Galactic sources

Calorimeter



Tracker



- Estimate based on accurate orbit and attitude model.
- Rough estimate of reconstruction efficiency.
- Sufficient rate for regular observation.
- Long observation period.
- Enlarged energy interval.
- Complementary to satellite and ground based experiments.

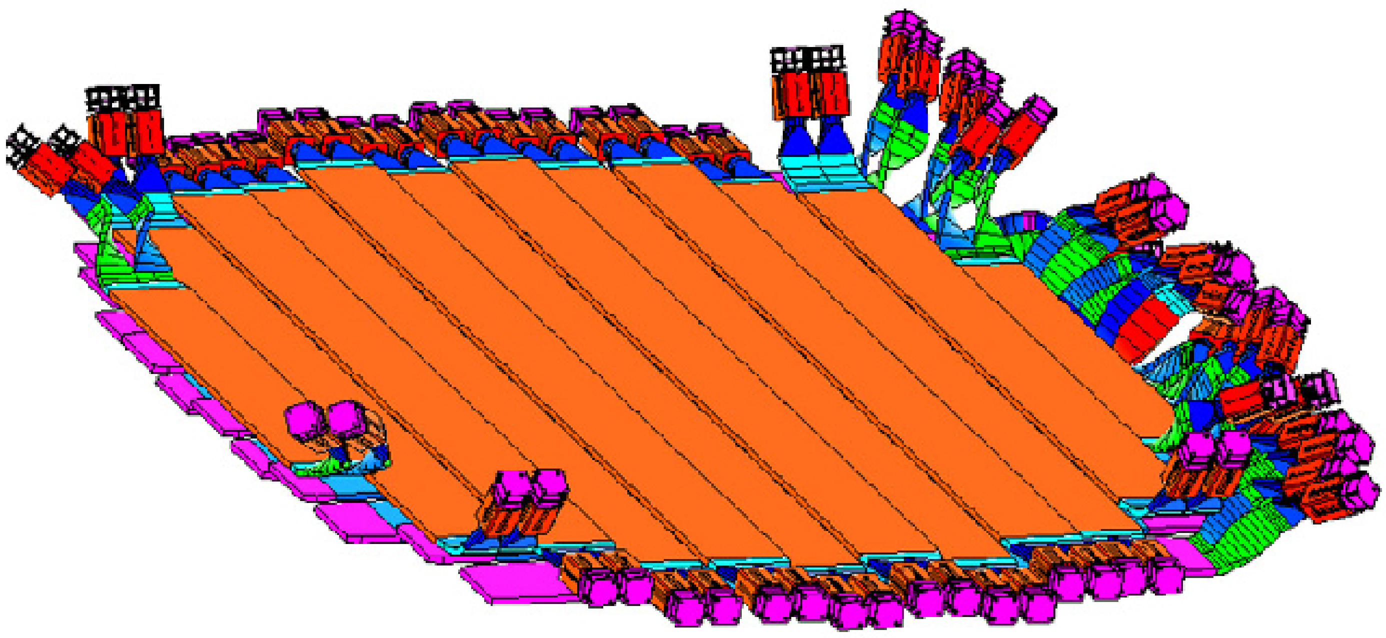
Conclusions

- AMS-02 is approved by NASA to operate on the ISS for 3 years.
- AMS-02 will be ready to fly in the beginning of 2005.
- AMS-02 large acceptance and long exposure time will allow an unprecedented sensitive study of Cosmic Rays.
- Interesting Galactic and Extragalactic source measurements can be made.
- AMS-02 γ-sensitivity lies in between EGRET and GLAST experiments.

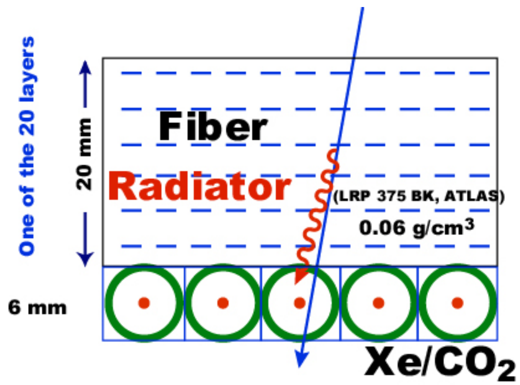
AMS-02 Time of Flight System

4 planes + 12 scintillator paddles
(seen by 2 PMTs on each side)

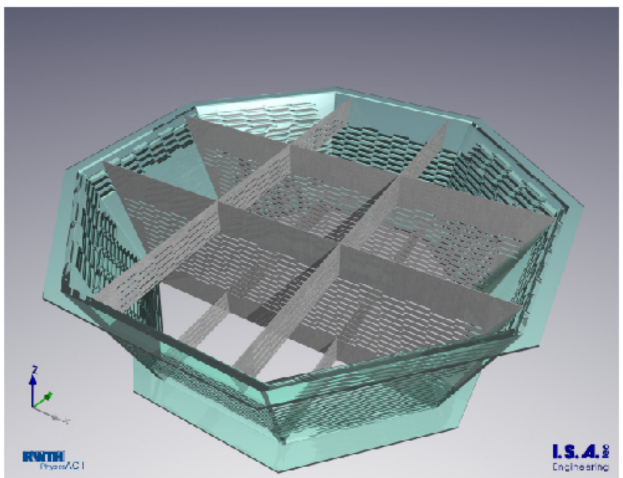
$\sigma(\beta)/\beta = 3.7\ \%$ @ $\beta = 1$ (protons)



AMS-02 Transition Radiation Detector

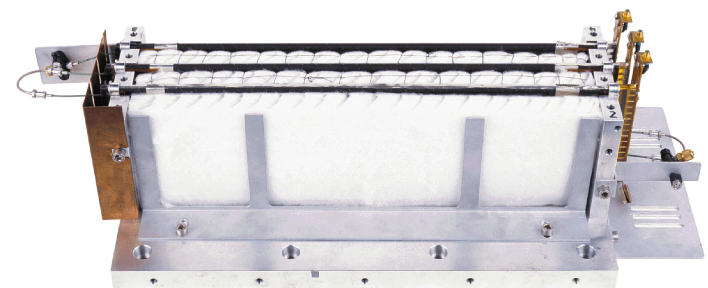


The TRD support structure



Top 4 layers (measure y coordinate), 12 layers (x), 4 layers (y)

y01K142b Figure 146

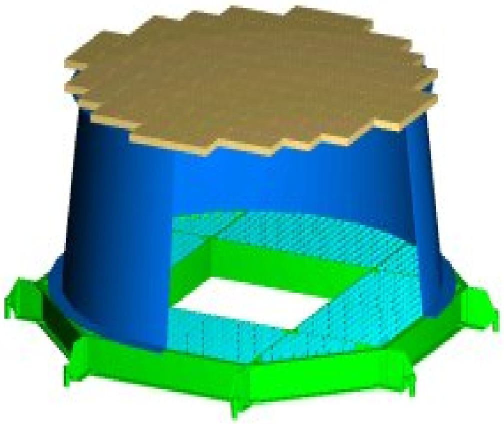


y2K093Aachen

20 layers of TRD
5248 straw tubes

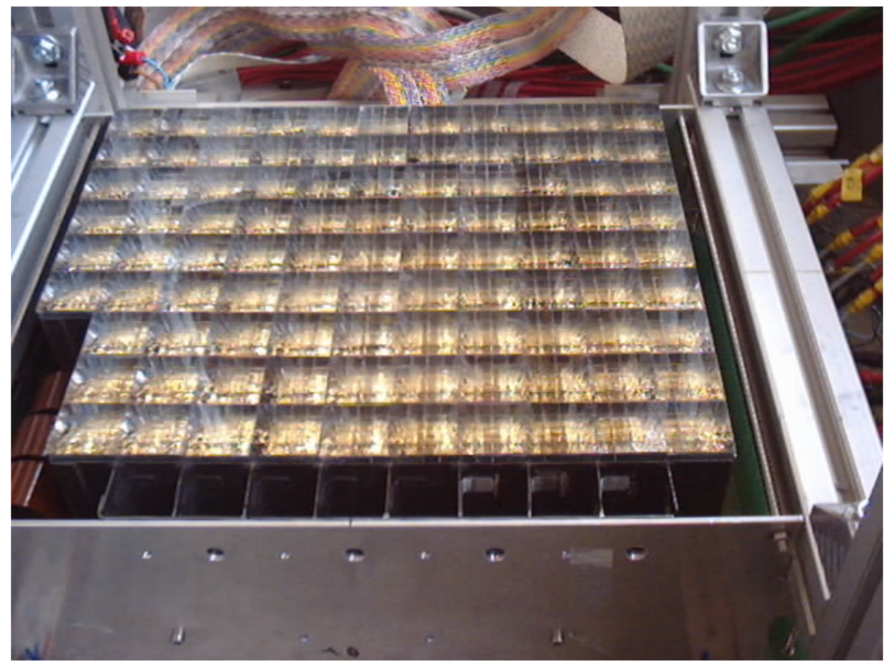
h/e rejection of $10^2 - 10^3$
(in the range $3 - 300$ GeV)

AMS-02 Ring Imaging Cerenkov Counter

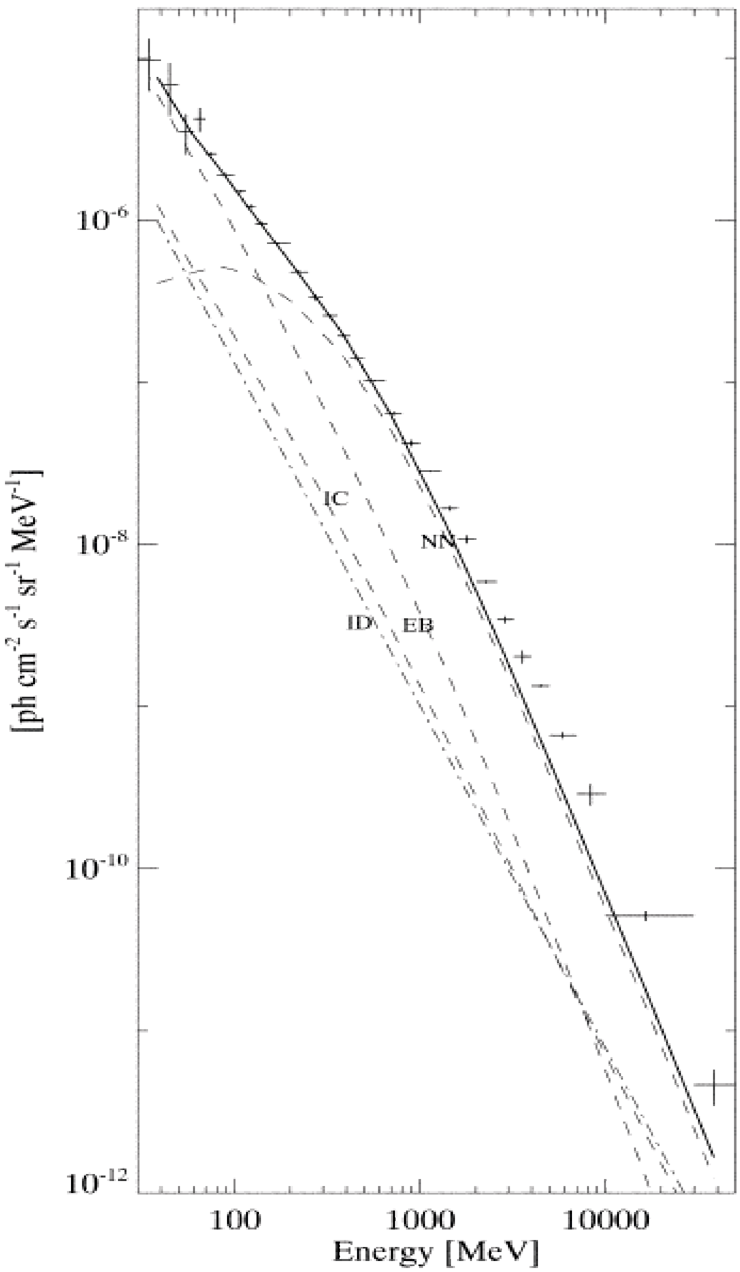


3 cm silica aerogel ($n = 1.05$) radiator
680 multianode PMTs

$\sigma(\beta)/\beta = 0.1\ \%$ @ $\beta = 1$ (protons)



Diffuse Galactic Background



ID: isotropic diffuse

IC: inverse Compton

EB: electron bremsstrahlung

NN: nucleon-nucleon

- Origin and emission spectra
- Attenuation and spectrum deformation
- Background for point sources

Diffuse Extragactic Background

Sreekumar et al., 1998