# AMS02: Status and perspectives

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AMS02

## Outline

- What is AMS?: aims.
- Some historics: AMS01 very briefly.
- AMS02 description:
  - Experiment location.
  - Current detector design.
  - Schedule.
- AMS02 potencial.
- Conclusions.

AMS02: Outline

## AMS: What it is and why

The primordial antimatter content of the universe is unknown, and even if there is any at all...

- Direct observation and COBE data excludes the presence of large regions of antimatter in a radius of $\sim 10 Mpc$.
- However there are lots of models allowing its existence[a]:
  - Alternating layers of matter-antimatter.
  - Bubbles of size $<$10Mpc of antimatter in a matter sea.
  - Very small and sparse antimatter regions (stellar size).

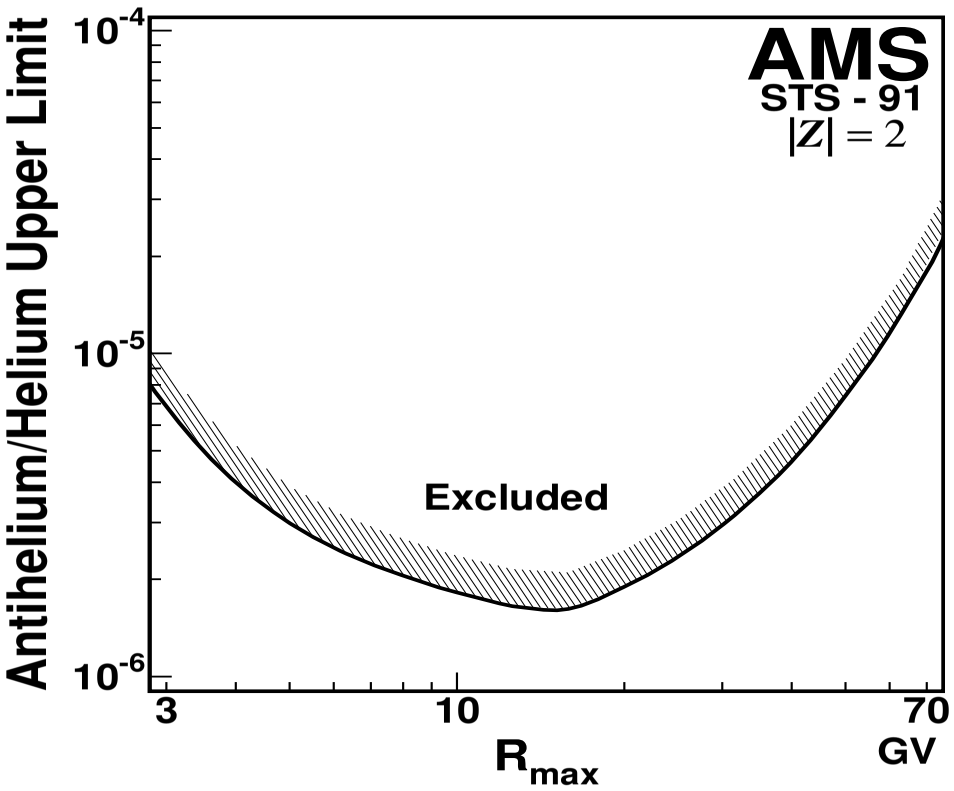
[a] hep-ph/9605280

# How to look for it?

- Look for annihilation products.
  Unsuccessful by now and not a good idea if the regions are sparse and small enough.

- **Look for antistars products and primordial $\bar{H}e$.**
  Better idea. Antinuclei of $|Z| > 1$ are hardly produced by cosmic rays interactions.

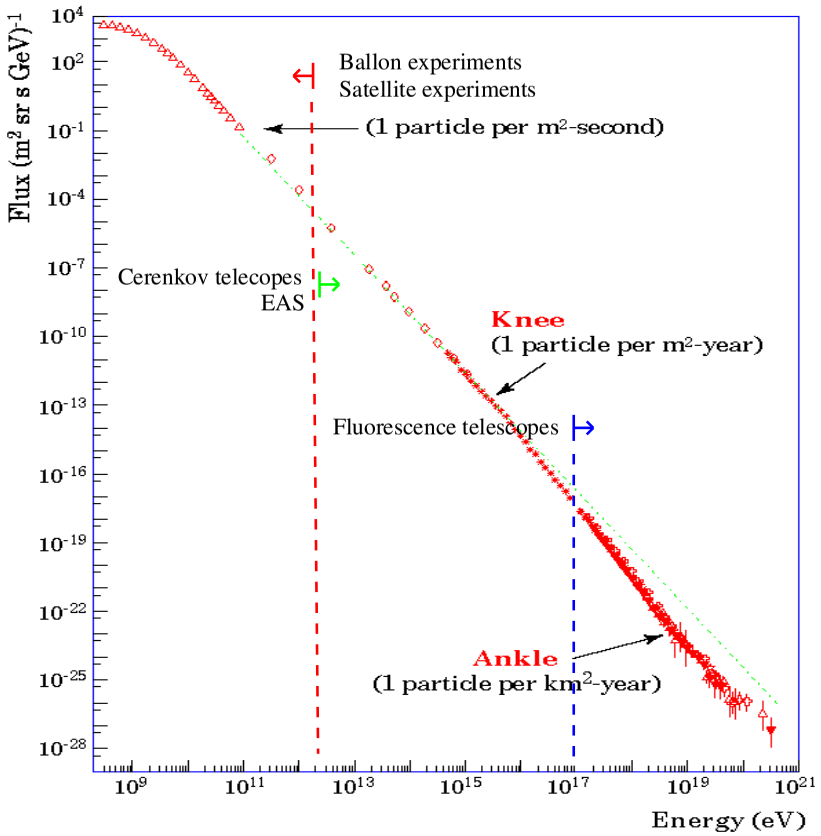
Presently it has been carried out several times unsuccessfully...



# Where to do it?

We need

- Very large statistics of primary cosmic rays.
- Very good particle identification, including charge sign reconstruction.




**A spectrometer in the space for a long time is the best option.**

# What is AMS?

## Alpha Magnetic Spectrometer

A large acceptance magnetic spectrometer aboard the **ISS**[a]

At such height (∼430Km) the atmosphere is subtle.

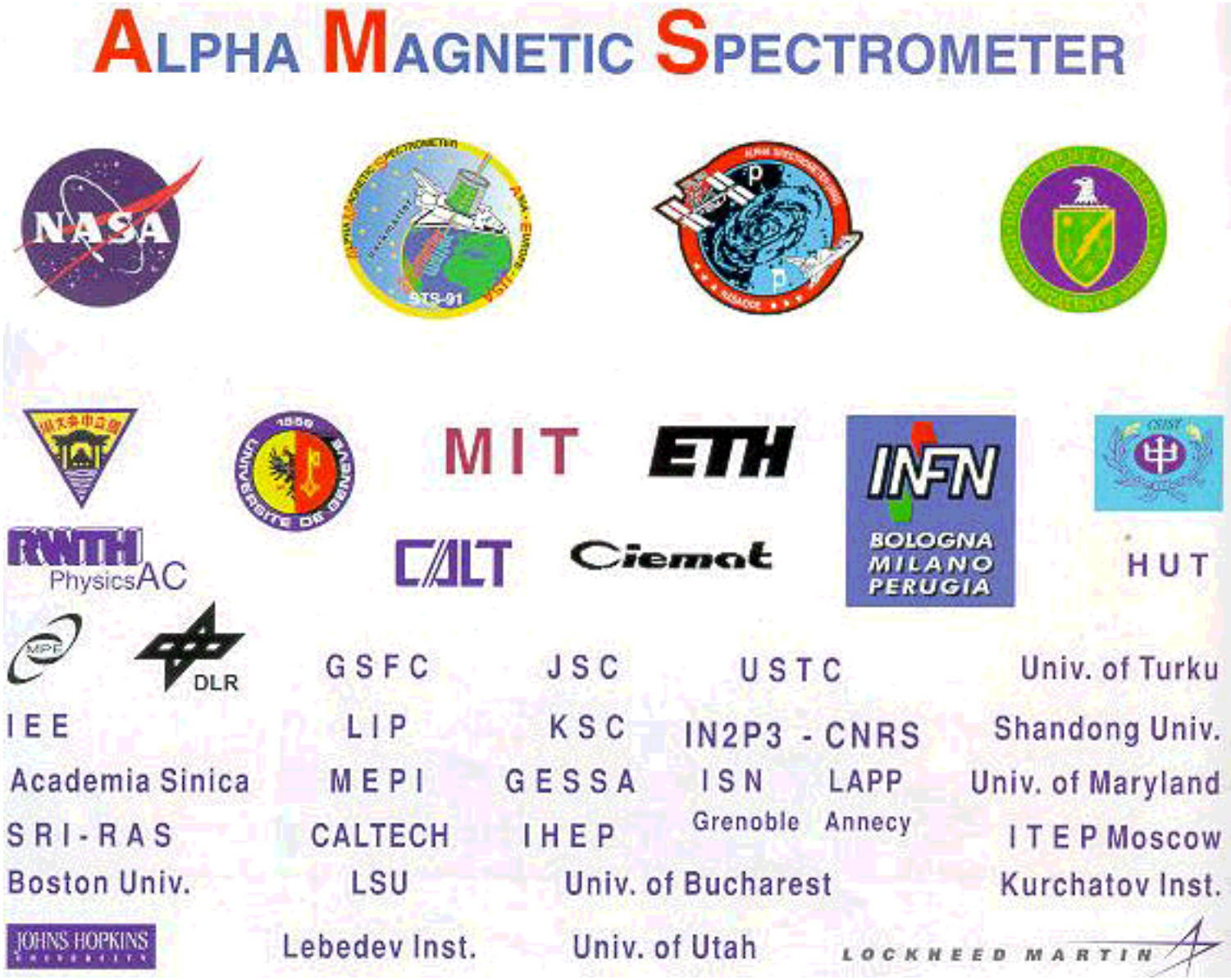

HEP methods are very good for the goals, but we have not experience in that environment.

The detector must be very robust.

And for the same price we have some other interesting results

- Dark matter search from $\chi\chi \to gg, WW, ZZ$.
- High statistics study of cosmic rays confinement in the galaxy from isotopic studies in unexplored regions.
- High statistics determination of heavy nuclei spectra.

[a] Old $\alpha$-station.

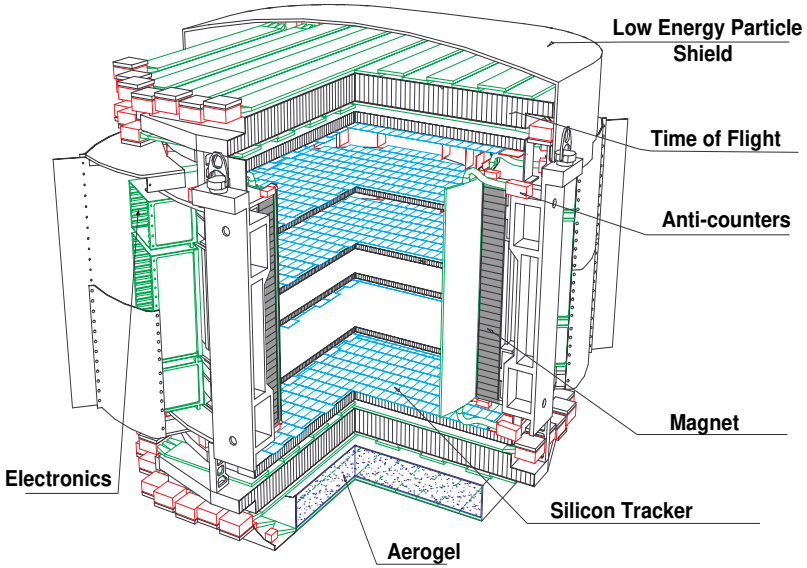



Collaboration

# AMS01 very briefly

Test flight aboard shuttle...

- Detector acceptance $\sim 0.3 m^2 sr$.
- 10 days at $\sim 370 Km$ of altitude.
- 100 hours of data: $\sim 10^8$ events.
  - p/Z and charge sign measured by TRACKER.
  - $\beta$ measured by TOF.
  - $|Z|$ measured by TOF and TRACKER.




**GOALS: Study of feasibility and of the backgrounds for the ISS mission.**

The experiment flown in the STS-91 mission of the DISCOVERY in 1998.

- Physics results
  - Search for antihelium.

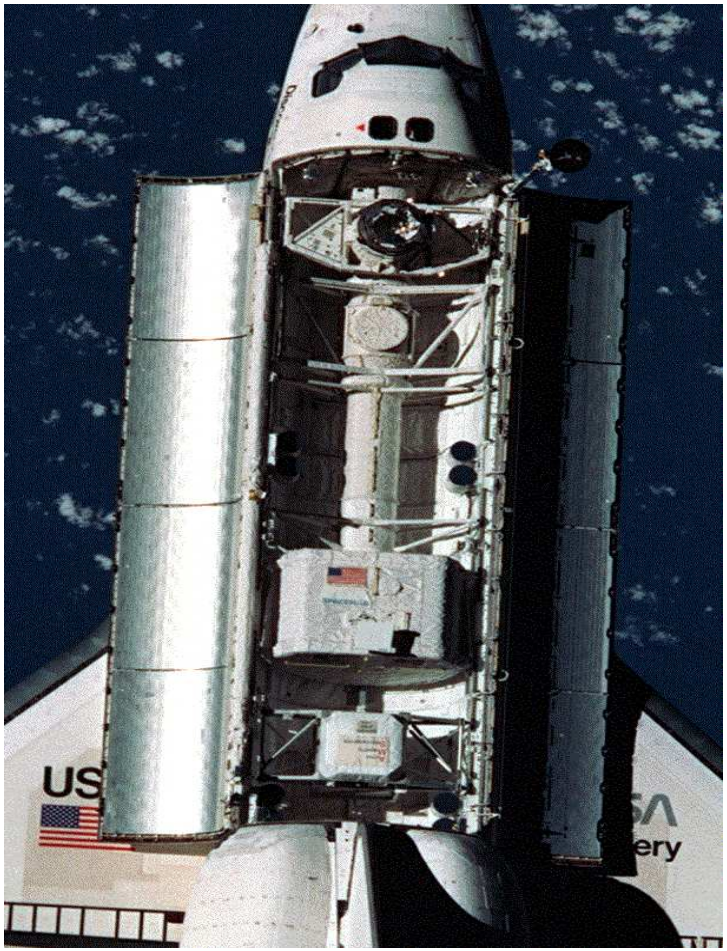
    Phys. Lett. B461 (2 Sep 1999) 387-396
  - Primary cosmic protons spectrum.

    Phys. Lett. B490 (28 Sep 2000) 27-35
- Study of background:
  - Protons in near earth orbit.

    Phys. Lett. B472 (26 Jan 2000) 215-226
  - Leptons in near earth orbit.

    Phys. Lett. B484 (27 Jun 2000) 10-22
  - Helium in near earth orbit.

    Phys. Lett. B, in preparation.



**Mission successful**

**Starting point for ISS one: AMS02**

AMS01 briefly

# AMS02: the location

- **WHERE**

  **Altitude:** 430∼460 Km

  **Latitude:** $52^0 \sim -52^0$

  **Longitude:** $0^0 \sim 360^0$

  16 orbits per day

- **WHEN**

  **Launch date:** October 2003

  **Final of detector operation:** 2007(?)

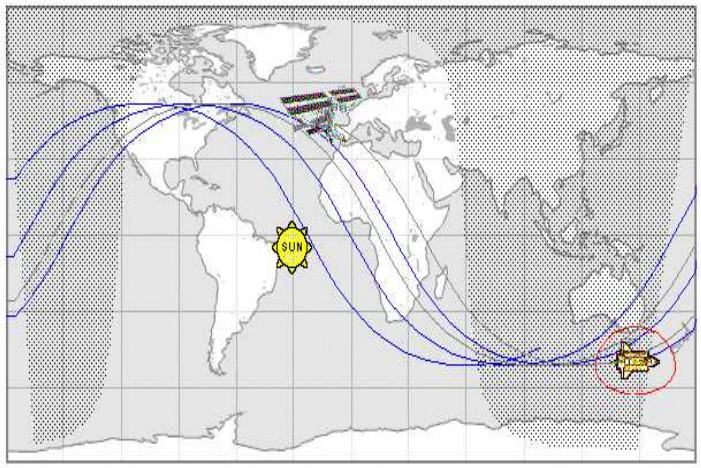
- **SPACE ENVIRONMENT**

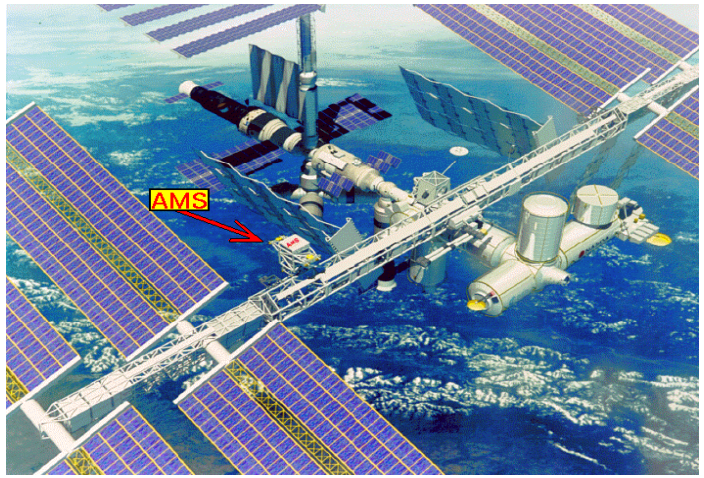
  **Temperature:** $-60^0 C \sim 40^0 C$

  **Pressure:** Negligible

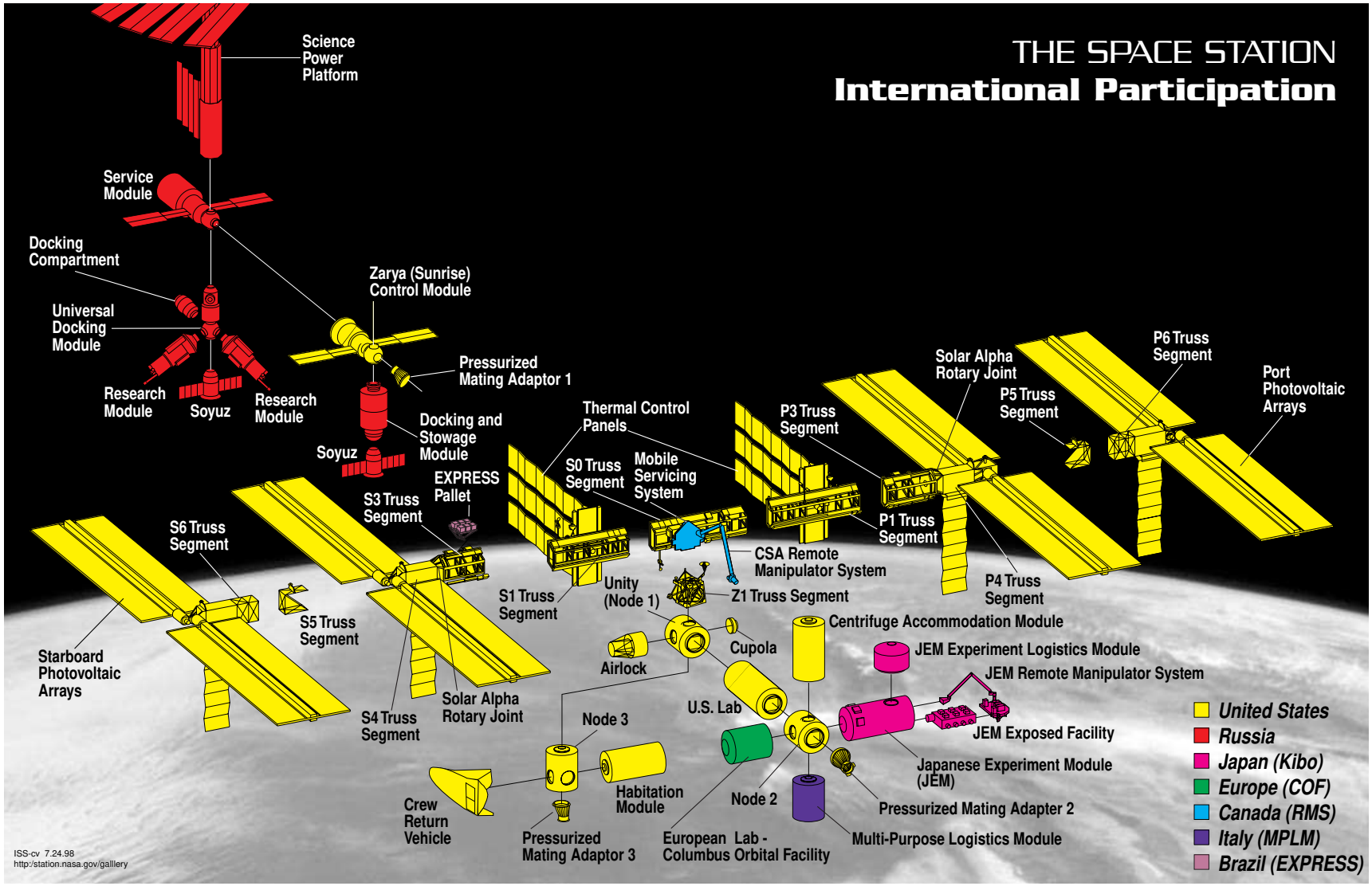
  **Geomagnetic field:** $\sim 0.5$ Gauss

  High rate of heavy nuclei radiation.



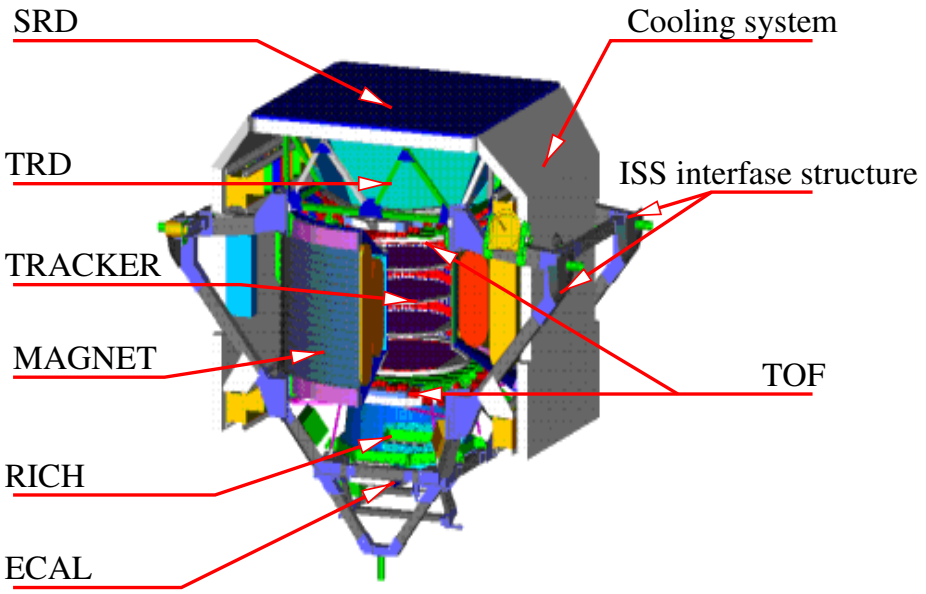

AMS02


THE SPACE STATION
International Participation
Science Power Platform
Service Module
Docking Compartment
Universal Docking Module
Research Module
Soyuz
Research Module
Zarya (Sunrise) Control Module
Pressurized Mating Adaptor 1
Soyuz
Docking and Stowage Module
EXPRESS Pallet
S3 Truss Segment
S6 Truss Segment
S5 Truss Segment
S4 Truss Segment
Solar Alpha Rotary Joint
Starboard Photovoltaic Arrays
Thermal Control Panels
S0 Truss Segment
Mobile Servicing System
S1 Truss Segment
Unity (Node 1)
Airlock
Cupola
Node 3
Crew Return Vehicle
Habitation Module
Pressurized Mating Adaptor 3
U.S. Lab
Node 2
European Lab - Columbus Orbital Facility
CSA Remote Manipulator System
Z1 Truss Segment
P3 Truss Segment
P1 Truss Segment
P4 Truss Segment
Solar Alpha Rotary Joint
P5 Truss Segment
P6 Truss Segment
Port Photovoltaic Arrays
Centrifuge Accommodation Module
JEM Experiment Logistics Module
JEM Remote Manipulator System
JEM Exposed Facility
Japanese Experiment Module (JEM)
Pressurized Mating Adapter 2
Multi-Purpose Logistics Module
United States
Russia
Japan (Kibo)
Europe (COF)
Canada (RMS)
Italy (MPLM)
Brazil (EXPRESS)
ISS-cv 7.24.98
http:/station.nasa.gov/gallery

AMS02

# AMS02: the detector

- **Particle bending**
  - · Superconducting magnet.
- **Particle direction**
  - · Time-of-Flight (TOF).
- **Rigidity** $(R = p/Z)$
  - · Silicon TRACKER.
- **Particle** $\beta$
  - · TOF at low energy.
  - · RICH at high energy.
- **Charge**
  - · TOF and TRACKER energy deposition.
  - · RICH photon counting.
- **PID**
  - · TRD+ECAL




**Acceptance:** $\sim 0.5\, m^2\ sr$

AMS02

# Time-of-Flight

4 scintillator planes with 14 bars of 11cm in alternating directions.
It provides with...

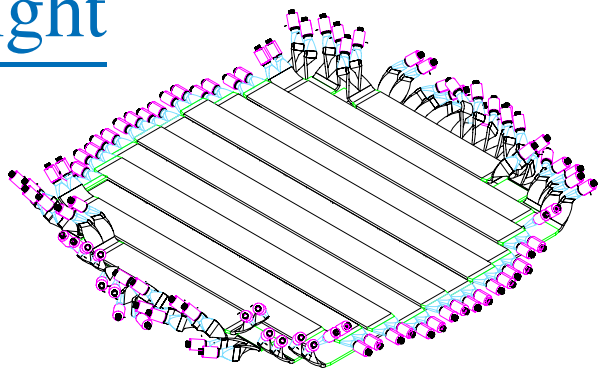
- Fast trigger.
- Velocity measurement.
- Absolute charge measurement.
- upward/downward particle separation.

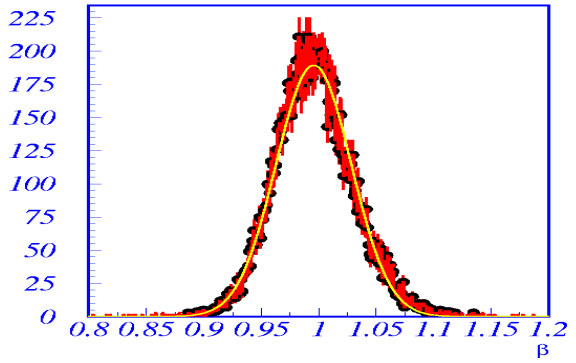
**Tested in the AMS01 flight.**

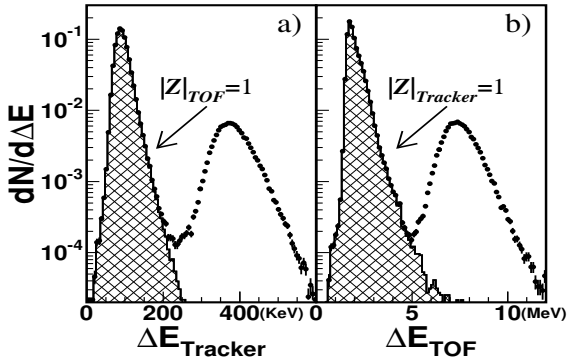
$\Delta\beta/\beta \sim 3\%$

$\Delta x \sim 2$ cm

up/down separation $\sim 10^{-8}$





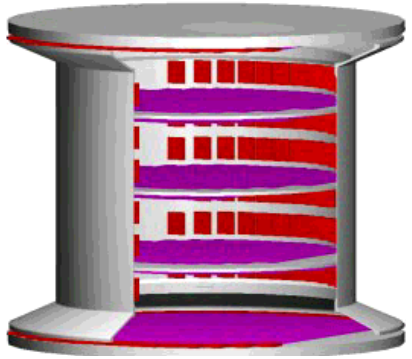




AMS02

# Silicon TRACKER

8 planes of double sided silicon microstrips detectors inside the superconducting magnet.
It provides with...

- $3^{rd}$ level trigger.
- Rigidity measurement.($1 \sim 10^3$ GV)
- Charge measurement.

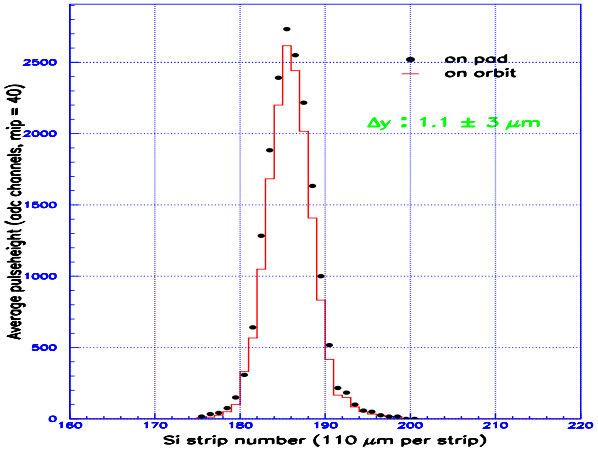


**AMS01 prototype extended**

$\sigma_y \simeq 10\mu m$ (bending plane)

$\sigma_x \simeq 30\mu m$ (non-bending plane)

$\frac{\Delta R}{R} \simeq 2\%$ for 10GV protons




Alignment system: IR laser.

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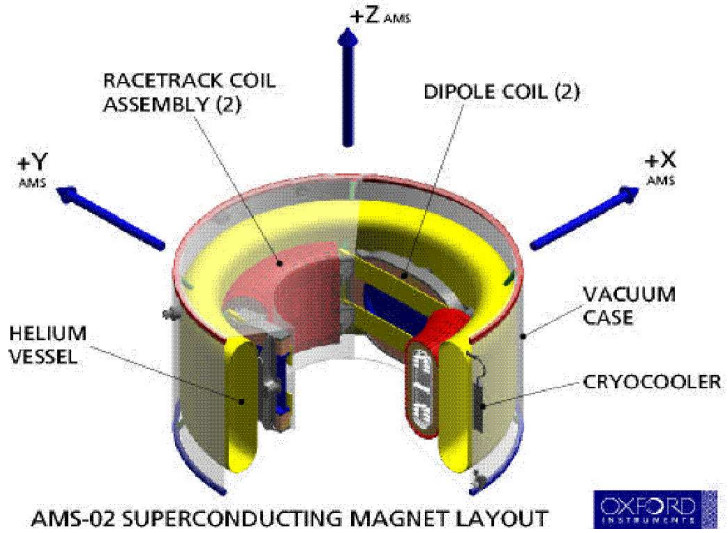
# Superconducting Magnet

It provides the power analysis of the tracker.

- **Central field:** Dipolar of 0.87T in the X direction.
- **Refrigeration:** Liquid Helium (1.8K)
- **Stray field:** Below 15.5mT at 230cm of the centre.




First superconducting magnet in space

**New technology being developed**

**Magnetic field energy:5MJ**

- Quenching probability below $10^{-6}$ in the 3 years.
- New liquid helium containers.

Power supply design specially demanding (CIEMAT task)

AMS02

## $\mathcal{S}$ynchrotron $\mathcal{R}$adiation$\mathcal{D}$etector

$2 \times 3m^2$ plane covered of $25 \times 25 \times 2mm^3$ scintillator crystals to detect the primary synchrotron radiation in earth's B field.
It provides with...

- Charge sign measurement.
  Until $\sim 1TeV$ for e, $1PeV$ for nuclei.
- Separation electron/nuclei.

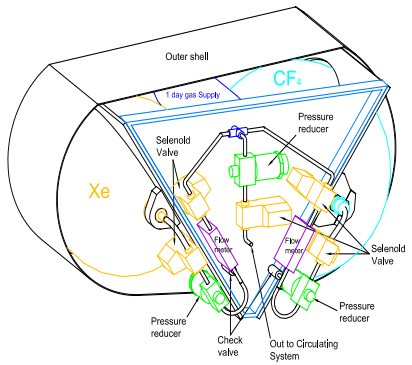
**Very experimental detector**

Test flight in April 2001 to study performance and space qualification.

## $\mathcal{T}$ransition $\mathcal{R}$adiation$\mathcal{D}$etector

20 layers of foam used as radiators separated by drift tubes with a gain of $\sim 10^4$.
It provides with...

- Hadron identification.
- e/h separation up to 100GeV.
- Main goal: e/p rejection $\sim 10^{-3}$ with 90% electron efficiency.




Gas system must be adapted to vacuum

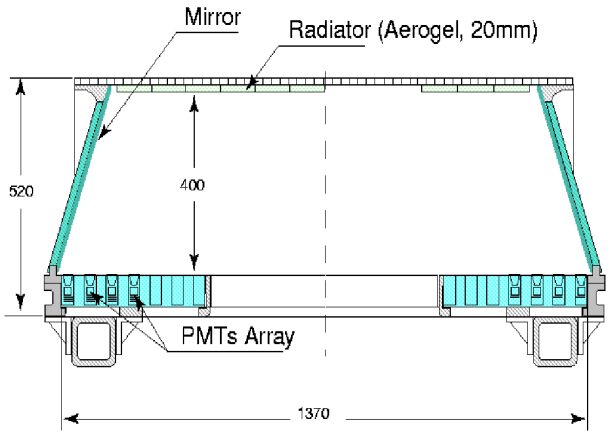
AMS02

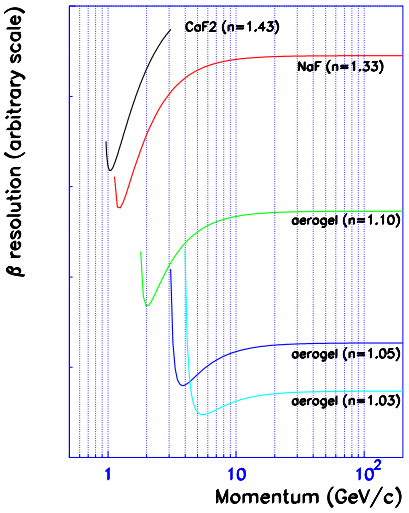
# RICH

Proximity focusing RICH with radiator of aerogel.
It provides with...

- Rejection of albedo above the threshold.
- Measurement of $\beta$ above threshold.
  n=1.05$\rightarrow\beta_{min} \simeq 0.95$
  n=1.03$\rightarrow\beta_{min} \simeq 0.97$
- Isotope identification and chemical composition up to $Z \simeq 26$.
  $\Delta m/m = \Delta P/P \oplus \gamma^2 \Delta\beta/\beta$
- e/p separation redundancy.

$$\frac{\Delta\beta}{\beta} \lesssim 0.1\%$$




- **Acceptance:** $\sim 0.4 m^2\, sr$
- **Pixelsize:** $7.5 \times 7.5 mm^2$
- $N_\gamma$ **at** $\beta = 1$**:** $\sim 10$ (z=1,n=1.05)

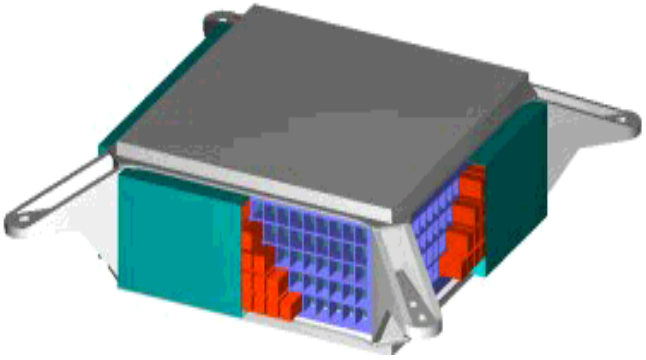
AMS02

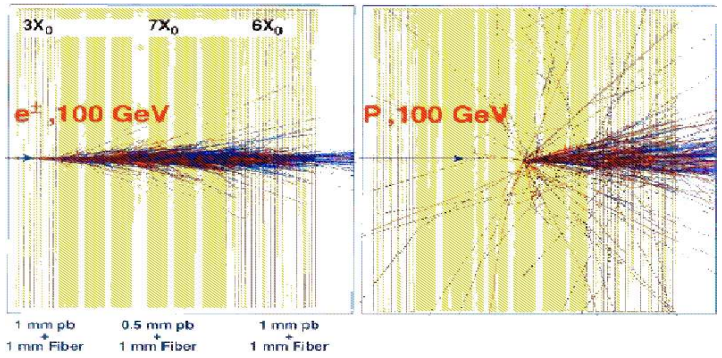
# ECAL

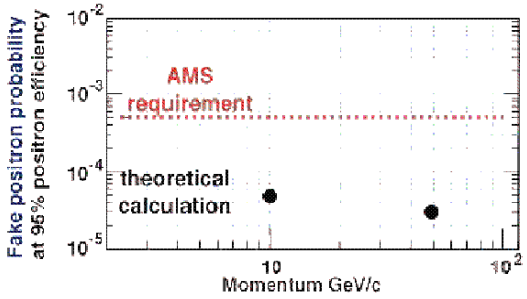
$16.5 X_0$ in 10 superlayers, each one with 10 scintillators fiber planes and lead pancakes.
It provides with...

- e/h separation.
  $10^{-4}$ level in 1∼100 GeV
- High energy $\gamma$ detection with good angular resolution.
- Measurement of neutral particles
  $n, \bar{n}$ and $\gamma$

$\frac{\Delta E}{E} \simeq 1.46\%$ **at 100GeV**

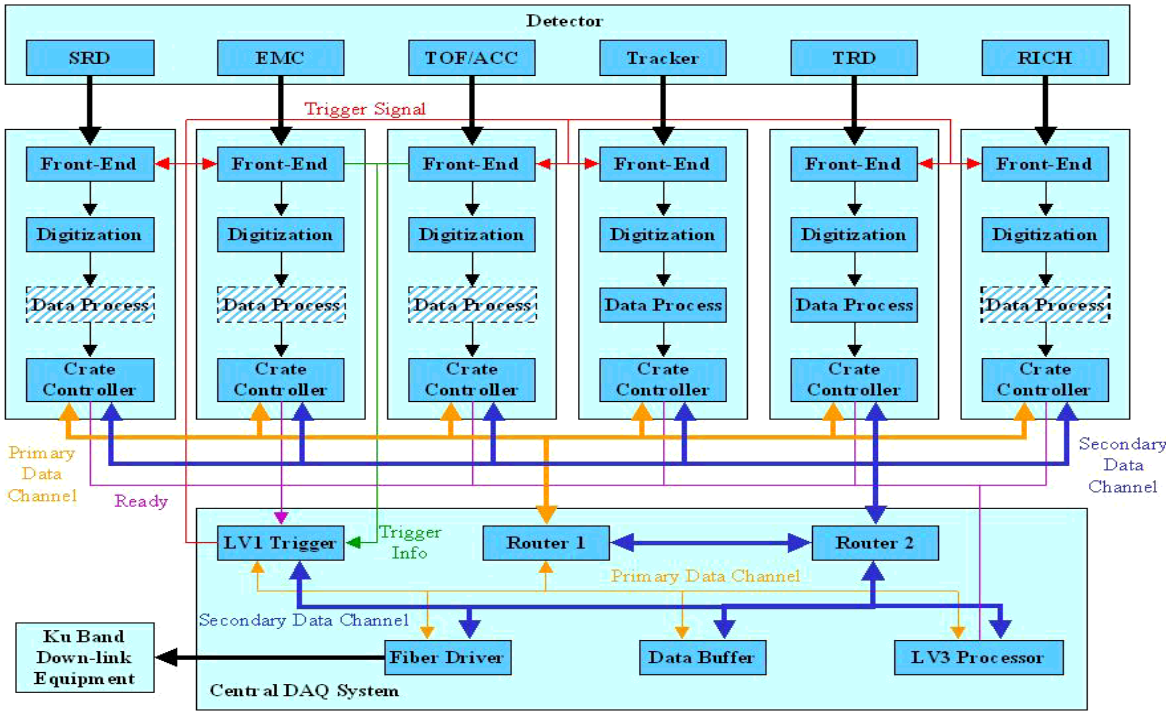





AMS02

# Data acquisition system

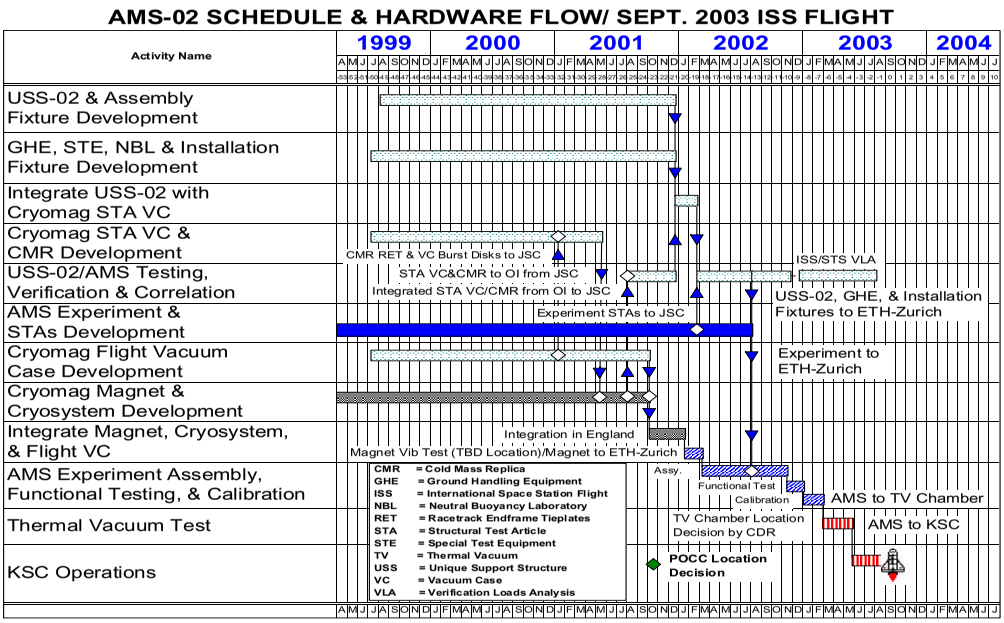



- All the electronics must be radiation tolerant.
- Data sent to ground in real time and stored in hard disks on board.
- Max. event rate $\approx 2kHz$.
- Link speed 100Mbs≈10Mbytes/sec.

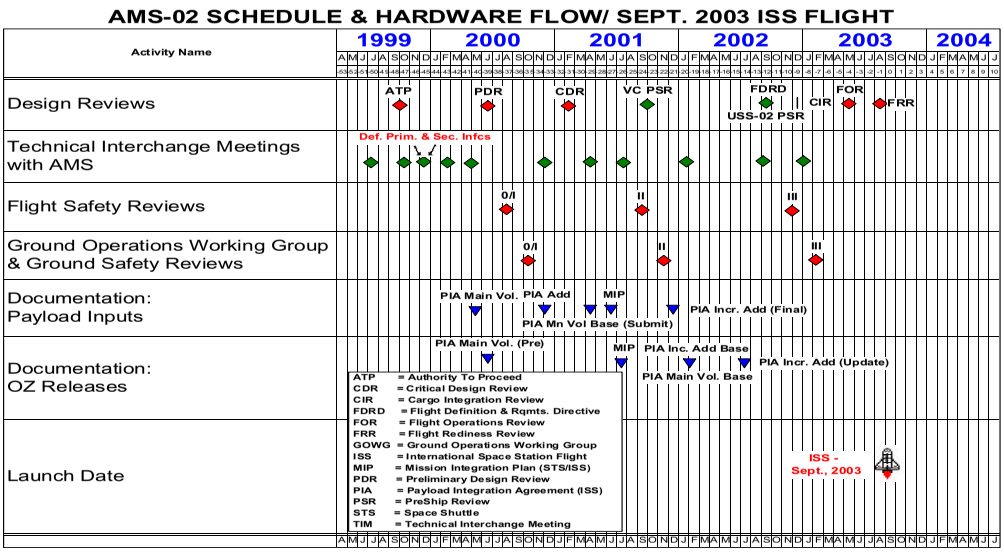
**Based in AMS01 experience**

AMS02

# Where do we stand?




Trent Martin (281) 335-2139 April 27, 2000 Rev. 2b




Trent Martin (281) 335-2139 April 27, 2000 Rev. 2b

- All the designs essentials completed.
- Starting prototypes construction and testing.

AMS02

# AMS02:Perspectives

- After three years very large statistics is expected.

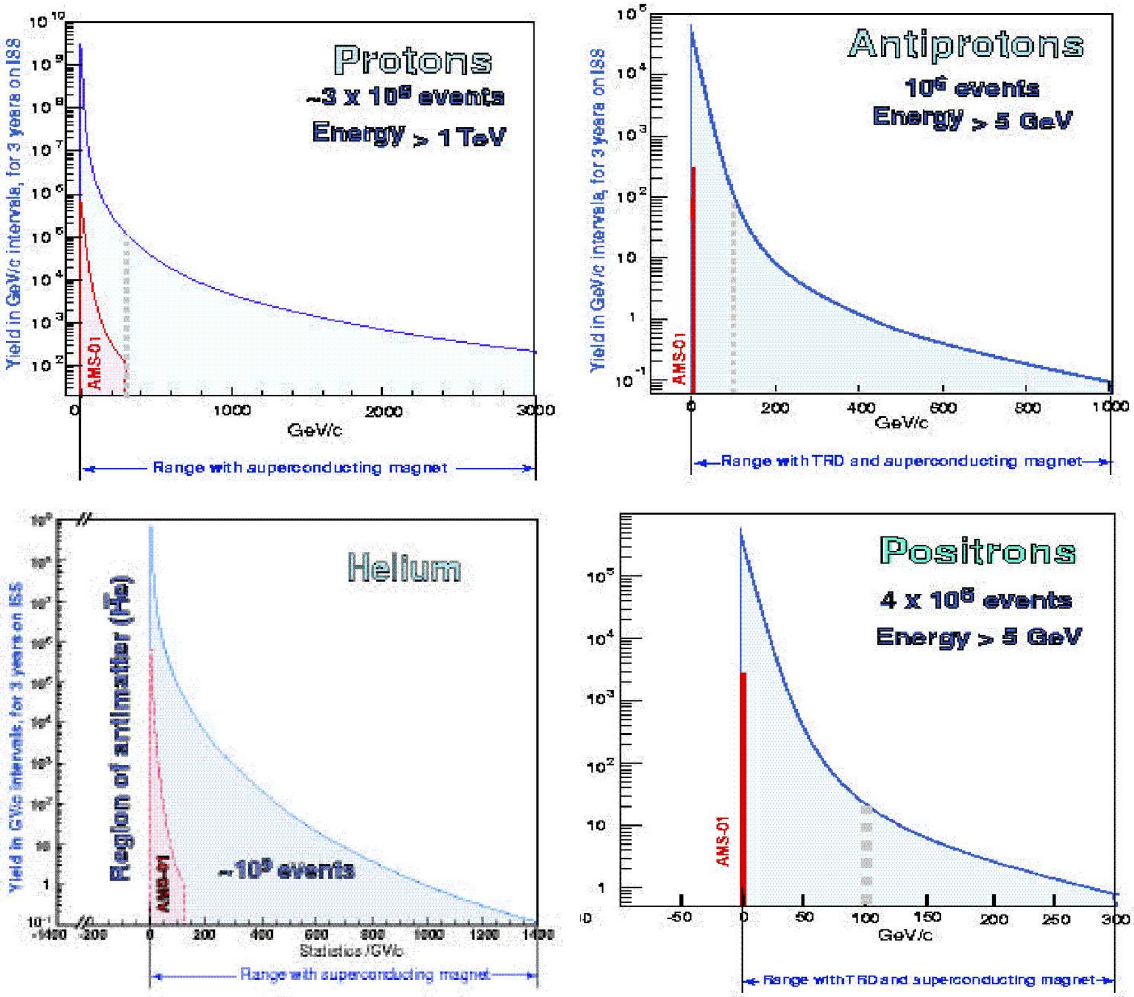
| Above | $> 1GeV/c$ | $> 5GeV/c$ | $> 10GeV/c$ | $> 100GeV/c$ | $> 1TeV/c$ |
|---|---|---|---|---|---|
| **Protons** | | | $6.1 \cdot 10^9$ | $1.5 \cdot 10^8$ | $2.5 \cdot 10^6$ |
| **Electrons** | $1.4 \cdot 10^8$ | $7.3 \cdot 10^7$ | $6.8 \cdot 10^6$ | $7.2 \cdot 10^4$ | $5.4 \cdot 10^2$ |
| **Positrons** | $9 \cdot 10^6$ | $3.8 \cdot 10^6$ | $3 \cdot 10^5$ | $1.6 \cdot 10^3$ | 6 |
| **Antiprotons** | $1.5 \cdot 10^6$ | $1.1 \cdot 10^6$ | $1.4 \cdot 109^4$ | $3.2 \cdot 10^3$ | $5.8 \cdot 10^2$ |
| **Helium** | $6.4 \cdot 10^8$ | $4.3 \cdot 10^8$ | $2.1 \cdot 10^8$ | $7.3 \cdot 10^6$ | $1.7 \cdot 10^5$ |

- Before AMS01 there was
  - $\sim$ 1500 positrons.
  - $\sim$ 75 antiprotons.
  - $\sim 10^6$ helium nuclei.

  in all the energy range.

Perspectives

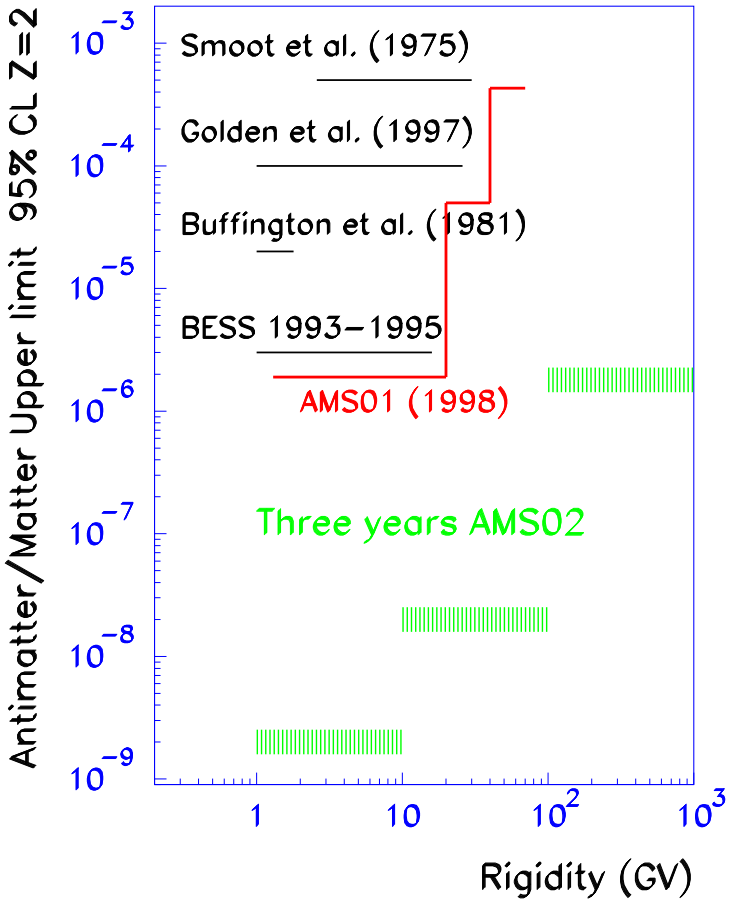
**AMS02 is more than simply large statistics!!!**




**An unexplored energy region will be covered.**

Perspectives

# Antimatter search



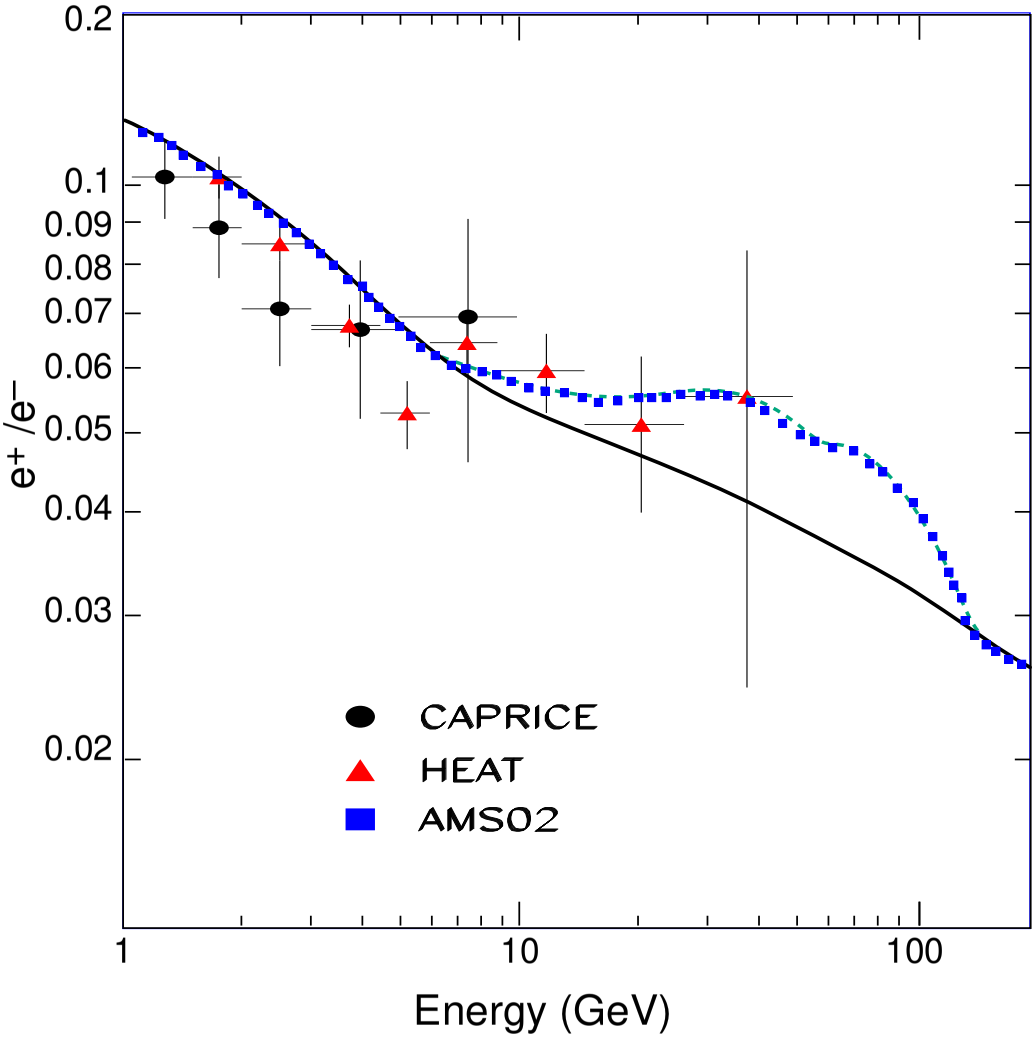

AMS02 expectatives...

- Improve the current limit upper limit in three orders of magnitude if no antihelium is observed.
- Extend the search energy range above 1 TeV for the first time.
- Increase the sensibility to $|Z| > 2$ antinuclei search by 100 up to $Z \simeq 25$.

Perspectives

# Dark matter ($\chi$) search

AMS02 sensivity to $\chi$ with m=275GeV.

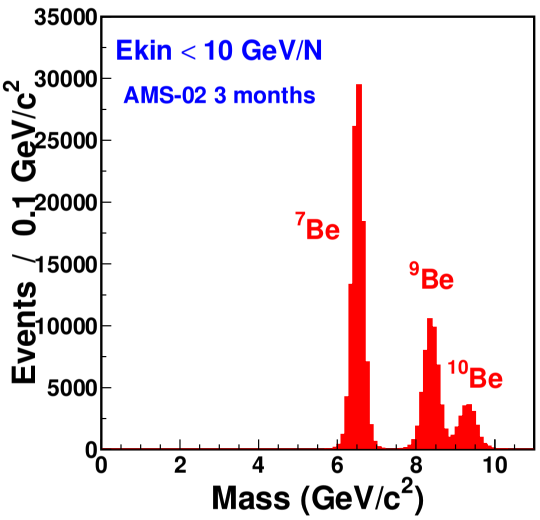


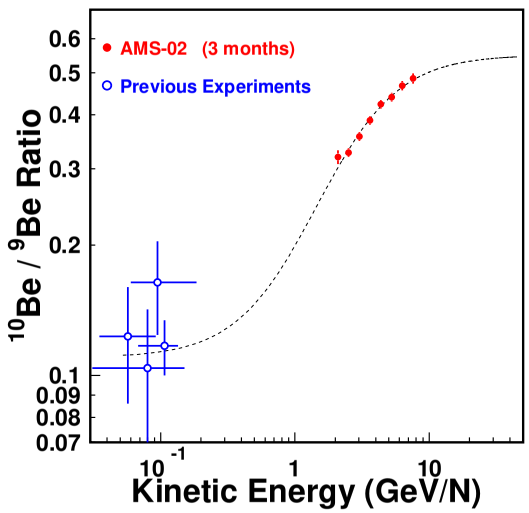

Perspectives

# Cosmic rays propagation

AMS02 will perform not only chemical composition studies, but also isotopic composition studies increasing out knowledge on galactic propagation thanks to the RICH detector...

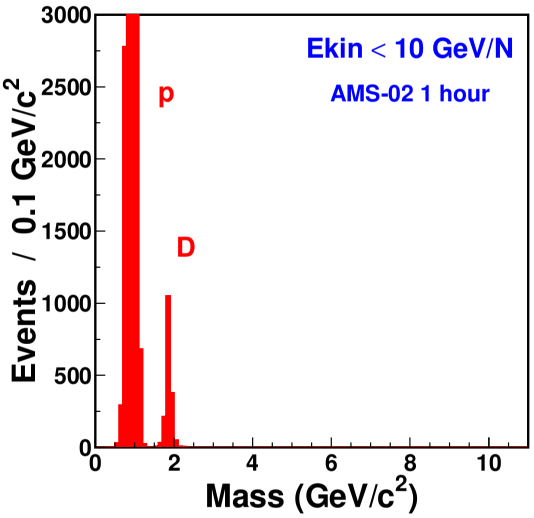
- Mean confinement time from Berilium isotopic content.
- Mean galaxy depth from B/C ratio.
- Halo size from isotopic content[a].
- ...

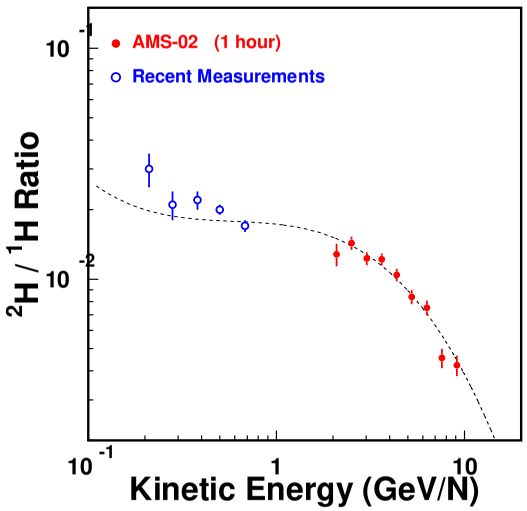


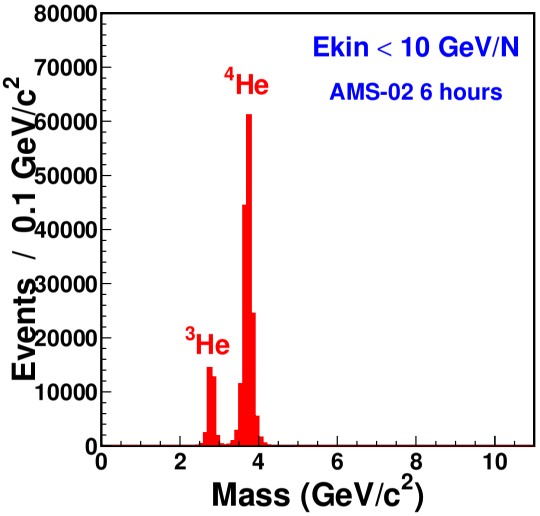



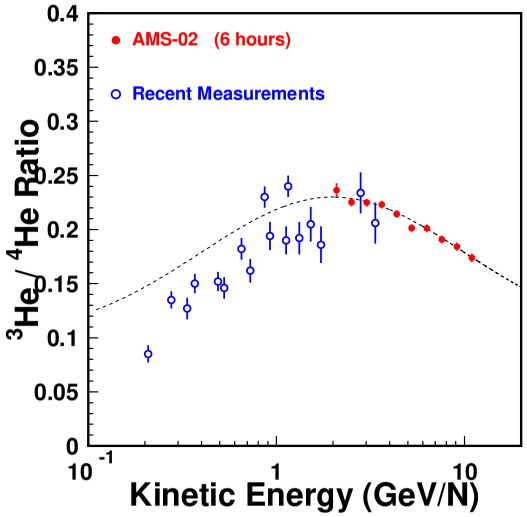

[a] astro-ph/0101068

Perspectives




Perspectives

# Conclusions

- AMS02 detector will be installed on ISS on year 2003 for (at least) three years of data taking.
- The physics aims are:
  - Search for antimatter (main goal).
  - Search for darkmatter (neutralino).
  - Study of cosmic rays chemical and isotopic composition.
- The AMS01 precursor detector has provided important information on operating in space conditions.

Perspectives