AMS

A magnetic spectrometer on the International Space Station

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On behalf of the AMS collaboration

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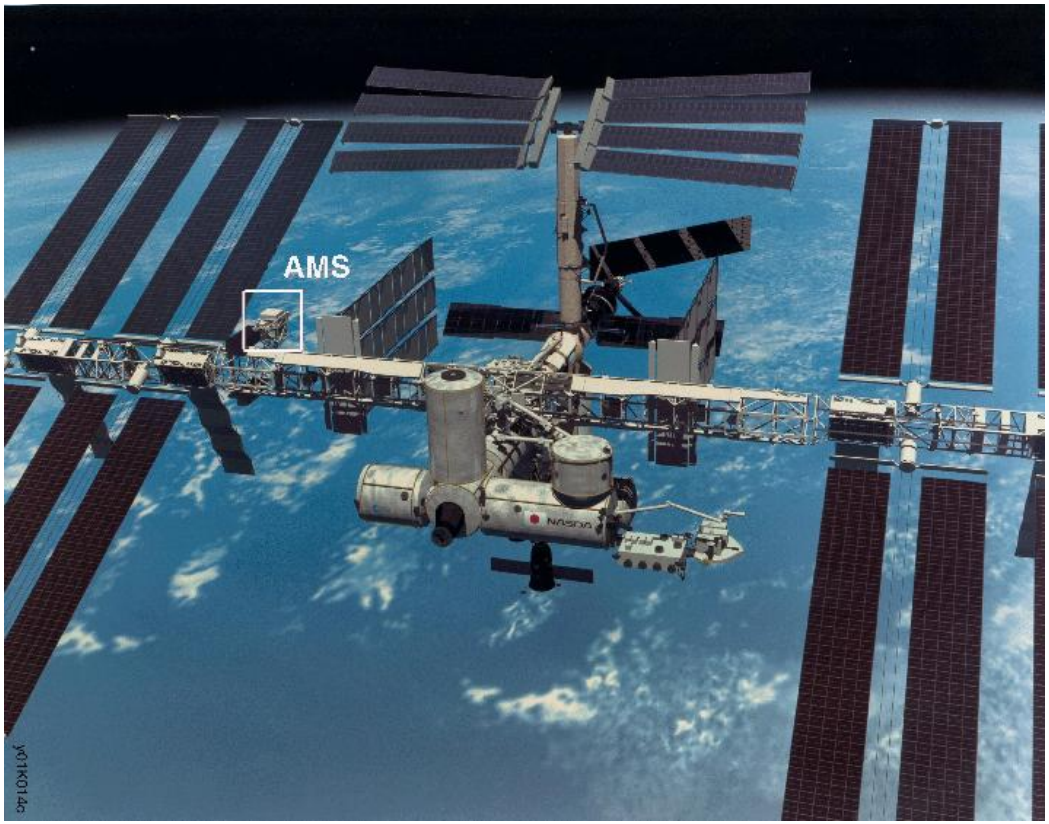
AMS on the International Space Station (ISS)

AMS is a magnetic spectrometer to be installed on the ISS in 2008 for at least 3 years. It is designed to study charged and neutral radiation in space.

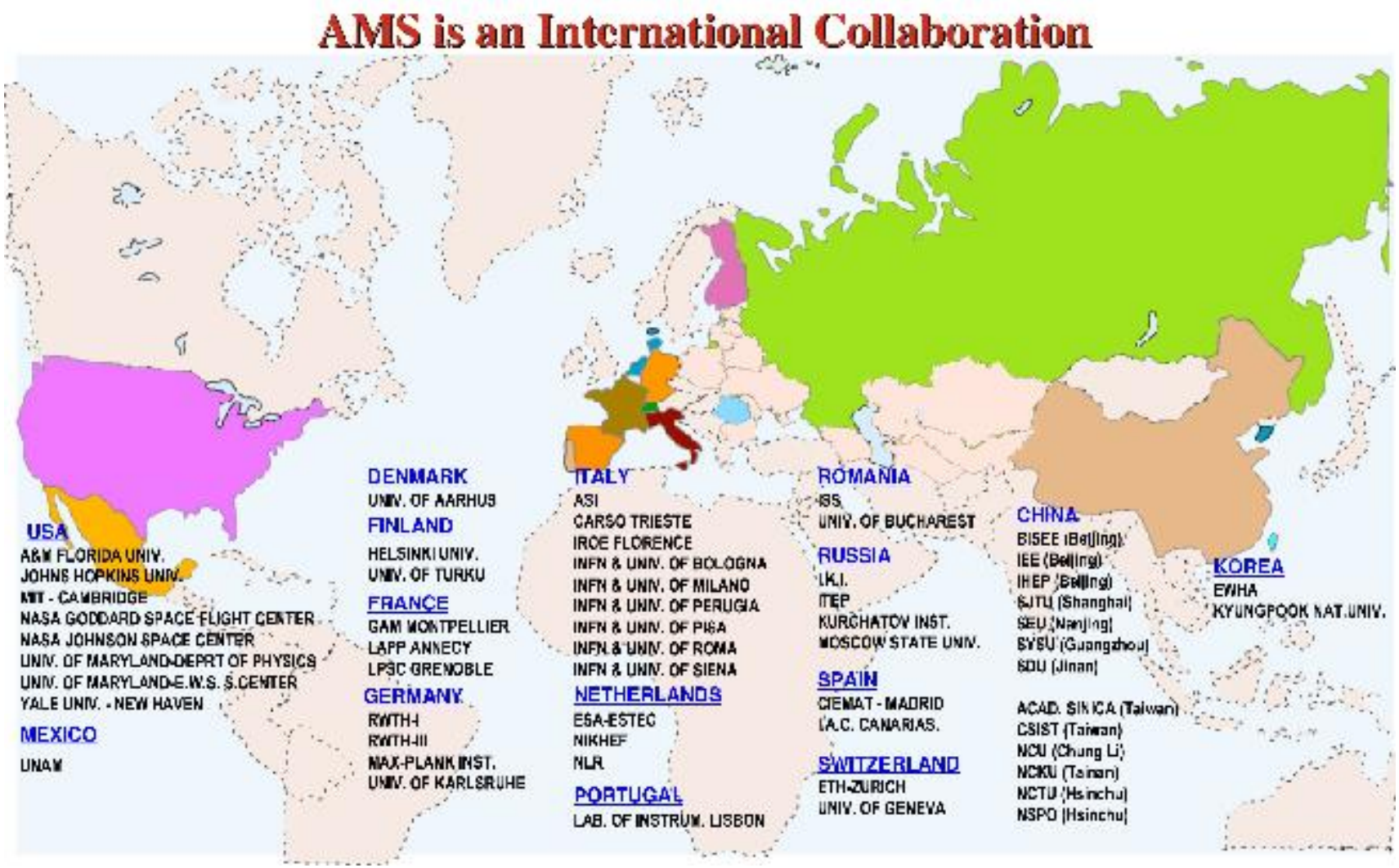
Physics issues

- *Cosmic Antimatter search*
  antimatter sensibility of the order 10^{-9}
- *Dark Matter search*
  through different signatures ($e^+, \bar{p}, \gamma$,...)
- *Relative abundance of different nuclei and isotopes* of primary cosmics rays with *charge identification up to Iron nuclei*
- γ *ray astrophysics*
- .....



J.Pochon,he-23
M.Sapinski, og-11 and og-22

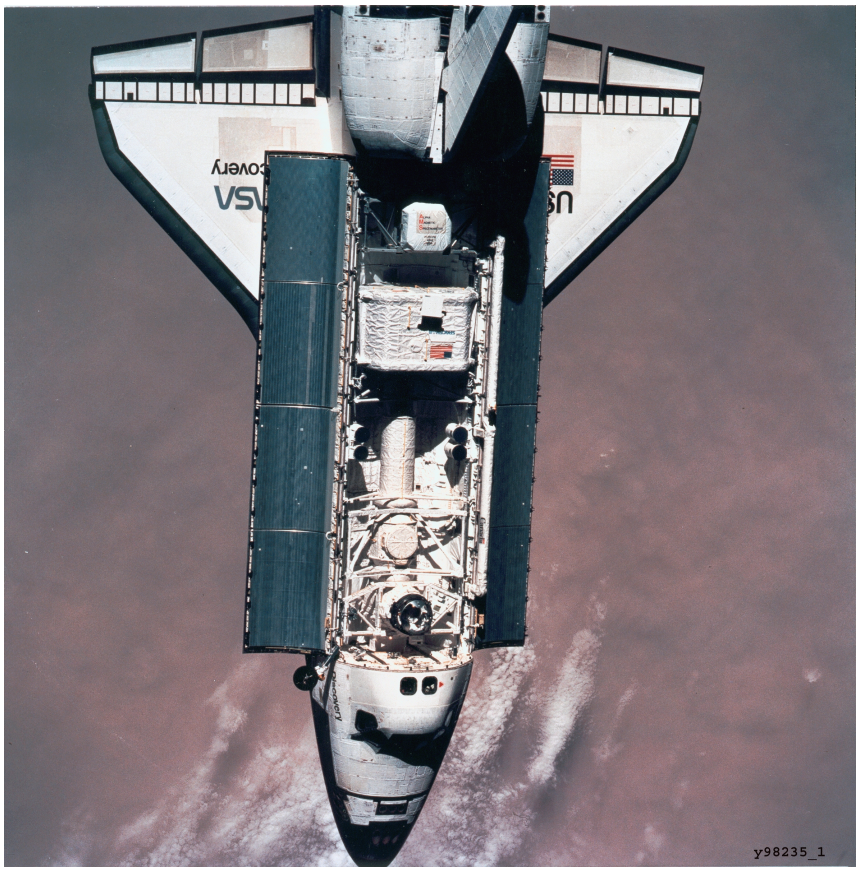
AMS Collaboration



~ 500 collaborators from 56 institutes in Asia, Europe and America.

AMS-01 Pilot Experiment: STS91, June 2-12, 1998

- Main goal: resupply MIR and crew exchange
- Qualification and test mission for AMS-01
- 10 days of data taking
  10^8 events registered
- Detector functioned without faults
- very interesting physics results
  - measurement of primary fluxes
    p, He, $e^{\pm}$...
  - detection of secondary fluxes
    geomagnetic field effects
  - antimatter sensitivity extended
    $\overline{\text{He}}$/He $\sim 10^{-6}$

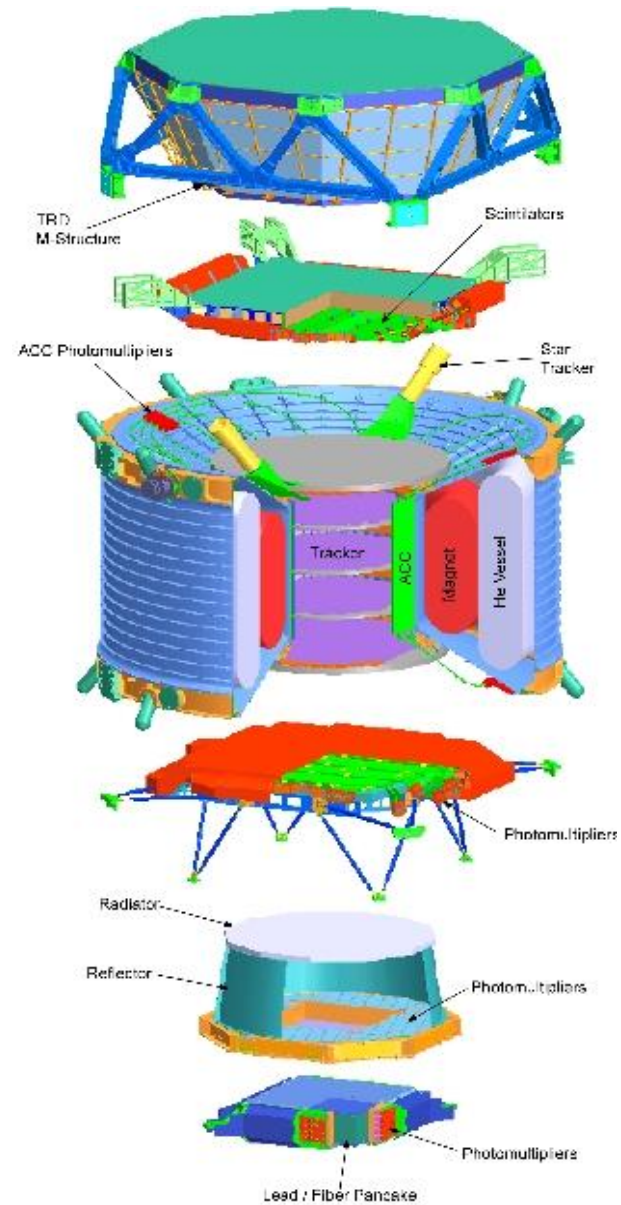


Six publications, comprehensive review in Phys.Rep.366 (2002)331-405

Lessons learned: more performant particle identification,
more redundancy, more open trigger

AMS-02 on International Space Station

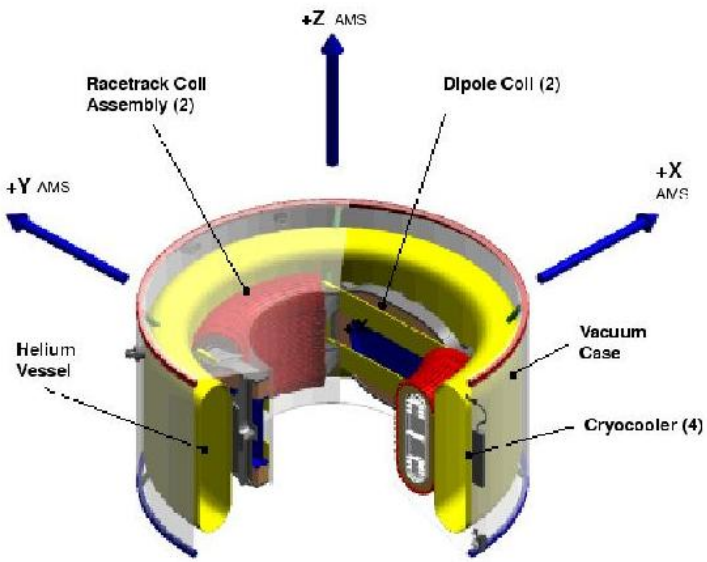
- **Improved capabilities**
  - Larger acceptance (~ 0.5 m^2·sr)
  - Superconduction magnet
    a magnetic field $\sim$ 6 times larger
  - Larger silicon Tracker
    8 layers ~ 6.7 m^2 of double-sided silicon
  - a momentum resolution improved
    by a factor ~ 10
- **New Detector systems**
  - Transition Radiation Detector (TRD)
  - New Cherenkov detector (RICH)
  - Electromagnetic Calorimeter (ECAL)
  - 2 camera Star Tracker and GPS system
- **A total of 227300 channels** producing
  7 Gbit/s, reduced by electronics to 2 Mbit/s
  downlink rate (A. Lebedev, X. Cai og-15)

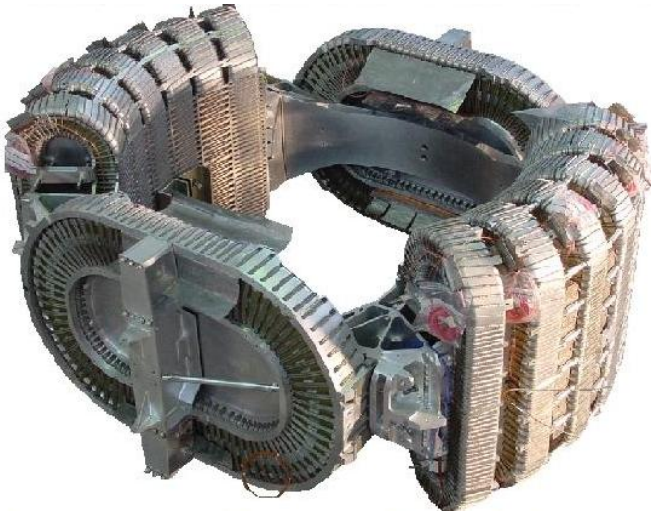


AMS-02: Superconducting Magnet

- 14 superconducting coils
- Geometrical configuration to ensure a null magnetic dipole moment
- Indirect cooling system based on superfluid helium
- Helium vessel: 2500 liters
- Dimensions: inner diameter 1.1m, weight: 2360 Kg
- an intense magnetic field: ~ 0.9 T
- a large bending power: ~ 0.8 T.m^2

▷ All coils are produced, tested individually at 1.8 K and assembled
▷ Vacuum vessel is completed
▷ Magnet delivered to CERN where the integration will start in 2006



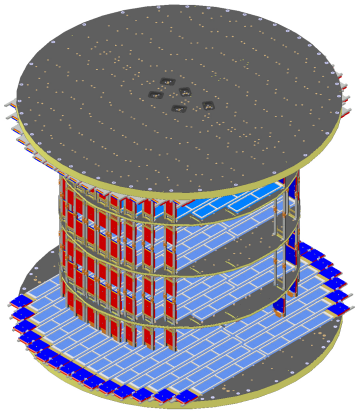


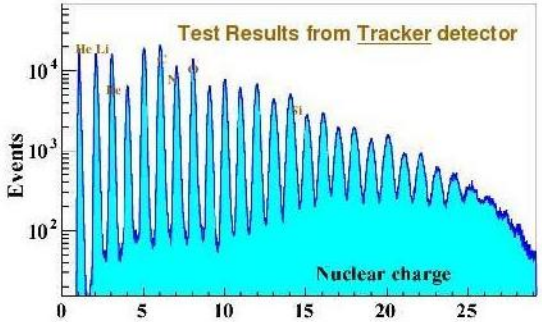
R.H. MacMahon he-24

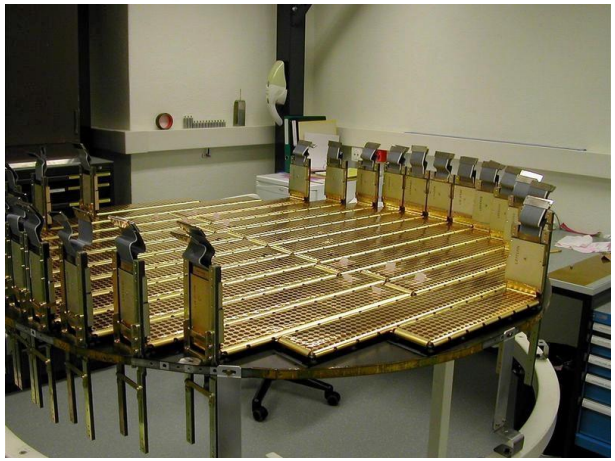
AMS-02 Spectrometer: Silicon Tracker

- Precise localisation of charged particles by double sided silicon sensors
- 8 layers of ~ 0.8 m^2 on five ultra-light supporting planes
- Total of $\sim$2500 silicon sensors
- 8 independent position measurements of a particle with $\sim$10μm resolution in bending direction, $\sim$30μm orthogonal
- Particle rigidity $R = \frac{\text{pc}}{|Z|\text{e}}$ up to a few TV
- Electric charge (Z) from energy loss dE/dx. Identification of elements up to iron possible
- Direction and energy of converted photons

▷ 100 % of sensors mounted
▷ 4 layers completely equipped
▷ All 8 layers equipped by December 2005





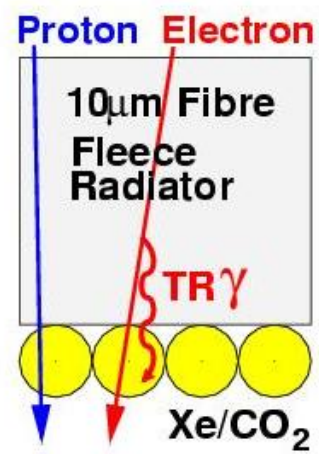


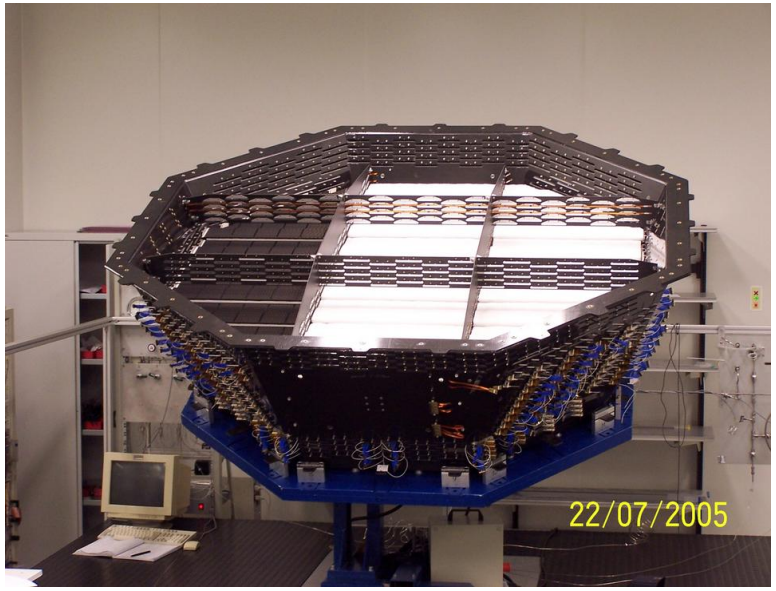
P. Zuccon he-24

AMS-02: Transition Radiation Detector

- Modules (328) made of fleece radiator and straw tubes
  - $E_\gamma \sim \gamma$(eV)
  - Emission probability small (10^{-2}) $N_\gamma \sim \alpha N_{transitions}$
  - TRD photons detected in proportional straw tubes Xe/CO_2
- 20 layers assembled in an octogonal shape structure
- Separation of e^-/e^+ from $\bar{p}/p$ up to 300 GeV

▷ All modules produced
▷ 14 layers with 220 modules inserted in supporting structure
▷ Detector finished in Spring 2006



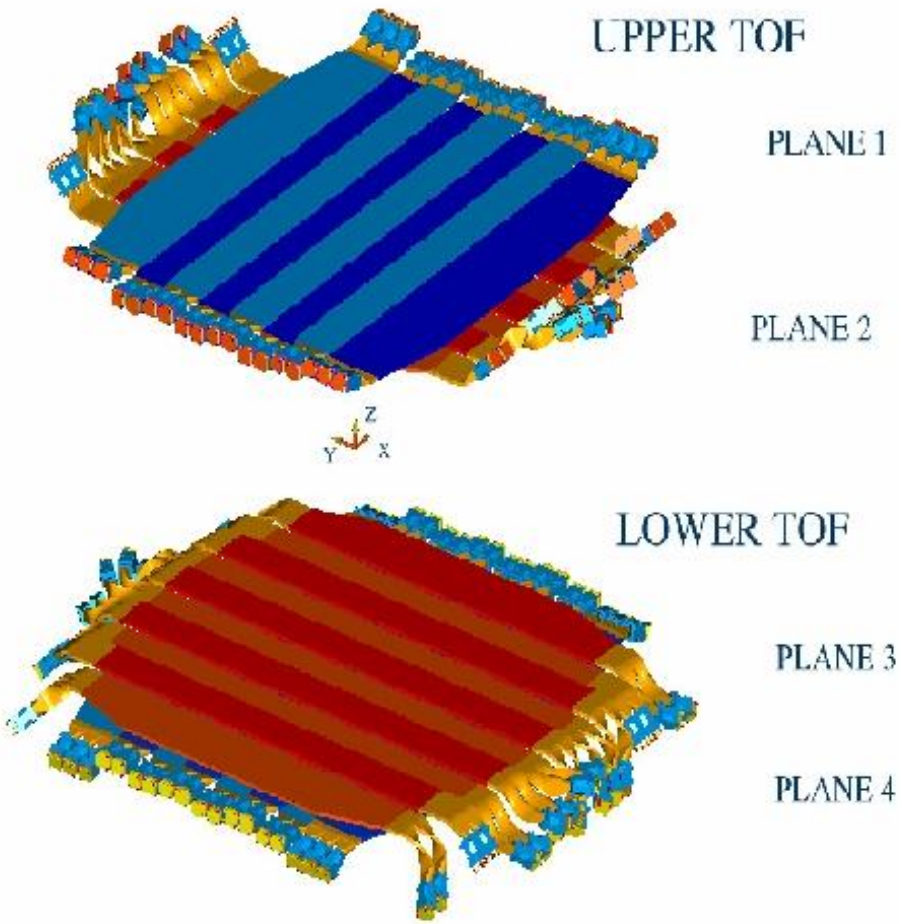


J. Olzem og-15
M. Schmanau og-15

AMS-02: Time-of-Flight Detector

- 4 scintillator planes
- A total of 34 crossed scintillator paddles, 1.6 m^2/plane
- Light guides twisted/bent and photo-tubes aligned with $\vec{B}$
- Principle trigger detector for charged particles
- Upgoing/downgoing particle separation
- Velocity measurement with $\Delta\beta/\beta \sim 3\%$ for protons
- Absolute charge measurement (up to $Z \sim 20$)

▷ All scintillator paddles produced
▷ Ready for integration in 2006

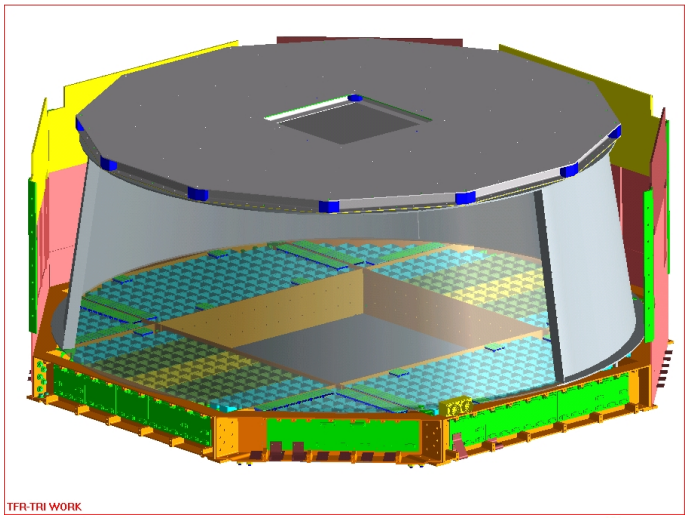


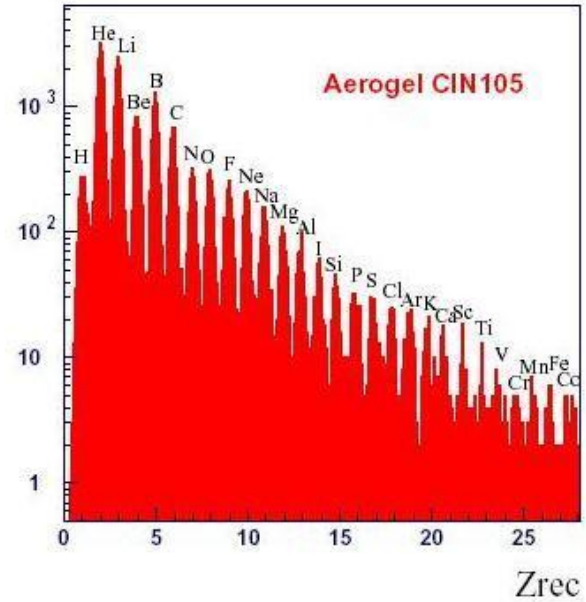
F. Giovacchini he-21
V. Bindi he-15
L. Quadrani he-21

AMS-02: Ring Imaging Cherenkov Detector

- Proximity focusing Ring Imaging Detector
- 2 different radiators:
  Aerogel, n=1.05, 2.7 cm thickness
  Sodium fluoride, n=1.336, 0.5 cm thickness
- Conical reflector
- Photomultiplier matrix (680)
- velocity measurement from emission angle
  $\Delta\beta/\beta \sim 0.1\%$ for single charge particles
- Number of photo-electrons measures Z
  ΔZ $\simeq$0.2-0.25 up to Fe
- directional sensitivity

▷ RICH is currently being assembled
▷ will be integrated in AMS in June 2006

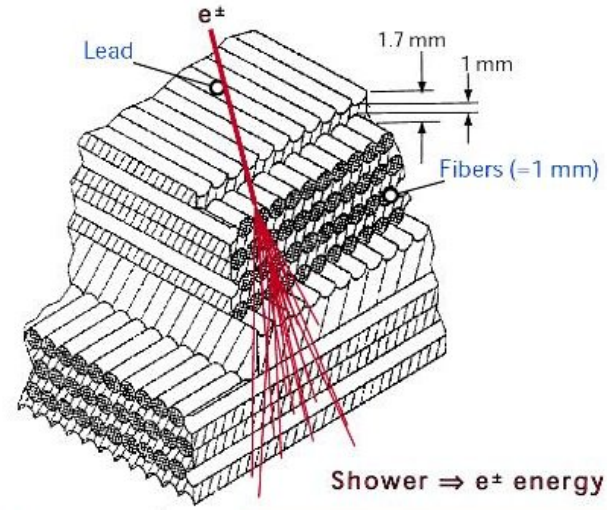


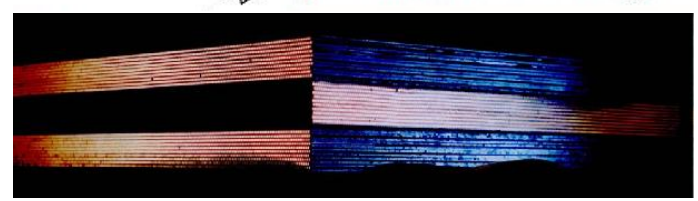


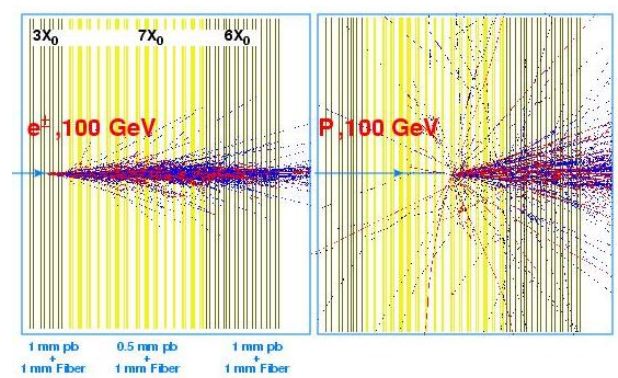
F. Barao og-15

AMS-02: Electromagnetic Calorimeter

- Lead scintillating fiber sandwich (640 kg), 3D sampling by crossed layer
- $\sim 17X_o$ radiation lenghts
- 9 superlayers piled up disposed along Y and X alternately
- Energy resolution (GeV) $\Delta E/E \simeq 10.1\%/\sqrt{E} \oplus 2.6\%$
- Distinction between hadrons and e/γ by shower shape
- Protons supressed by 10^{-4} up to 500 GeV. Together with TRD, rejection of hadrons/electrons $\geq 10^6$
- Independent γ detector, angular resolution $\sim 2°$, γ independently triggered







J. Pochon he-24

▷ All superlayers installed in mechanical structure

▷ Final calibration in e$^-$ test beam in 2006

Summary

AMS-02 is a magnetic spectrometer on ISS for long operation
$\longrightarrow$ International Collaboration
$\longrightarrow$ Large acceptance, multiple performant particle identification

- All sub detectors design and performance validated with several tests
- All sub detectors ready by mid 2006
- Integration will start at CERN in 2006
- The detector will be ready for launch end of 2007, and installed on the International Space Station for more than 3 years
- A diversified physics program
- explore the unknown