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*
- *\( \gamma \) ray astrophysics*
- ................

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

AMS is an International 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 \(p, \text{He}, e^{\pm}\)...
  - Detection of secondary fluxes geomagnetic field effects
  - Antimatter sensitivity extended \(\overline{\text{He}}/\text{He} \sim 10^{-6}\)


Lessons learned: more performant particle identification, more redundancy, more open trigger
AMS-02 on International Space Station

- **Improved capabilities**
  - Larger acceptance ($\sim 0.5 \text{ m}^2\cdot\text{sr}$)
  - Superconduction magnet
    a magnetic field $\sim 6$ times larger
  - Larger silicon Tracker
    8 layers $\sim 6.7 \text{ m}^2$ of double-sided silicon
  - a momentum resolution improved by a factor $\sim 10$

- **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: \( \sim 0.9 \) T
- a large bending power: \( \sim 0.8 \) 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 \( \sim 0.8 \text{ m}^2 \) on five ultra-light supporting planes
- Total of \( \sim 2500 \) silicon sensors
- 8 independent position measurements of a particle with \( \sim 10 \mu \text{m} \) resolution in bending direction, \( \sim 30 \mu \text{m} \) orthogonal
- Particle rigidity \( R = \frac{pc}{|Z|e} \) 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 ($10^{-2}$)
    $N_{\gamma} \sim \alpha N_{\text{transitions}}$
  - 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 m²/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 $Z$ $\Delta Z \simeq 0.2-0.25$ up to Fe
- directional sensitivity

▷ RICH is currently being assembled
▷ will be integrated in AMS in June 2006
AMS-02: Electromagnetic Calorimeter

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

▷ All superlayers installed in mechanical structure
▷ Final calibration in $e^-$ test beam in 2006

J. Pochon he-24

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ICRC2005
Summary

AMS-02 is a magnetic spectrometer on ISS for long operation
  → International Collaboration
  → 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