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

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♦ ISS and AMS-02
♦ The detector

Outline:
♦ Gamma astrophysics
♦ AMS-02 expected performances
♦ Conclusions
ISS and AMS-02
What is AMS?

Alpha Magnetic Spectrometer

A large acceptance magnetic spectrometer on the ISS

✦ Orbital parameters of ISS:
  → Orbital period  ~ 92min
  → Mean altitude  ~ 382km
  → Inclination    ~ 51.6°

✦ 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 Superconducting Magnet

12 racetrack coils + 2 dipole coils
2500 liters of superfluid helium

$BL^2 = 0.86 Tm^2$
AMS-02 Silicon Tracker

8 layers of double sided silicon sensors

6.5m² → 192 Ladders → 196k channels

σ(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)

\[
\sigma(E)/E = 3 \% \text{ @ 100 GeV}
\]

(p/e rejection of \( 10^3 \))

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astronomical object

200 sources not identified by an
7 pulsars
70 Active Galactic Nuclei (AGNs)

(variable sources, transients)

souces detected by EGRET
280 pointlike γ-ray

γ-ray Universe
Need "Right" ENVIRONMENTS?

- Neutron production
- Inverse Compton
- Synchrotron radiation

Need effcient ACCELERATION?

- Shock waves
- Electromagnetic
- Charged particles

Need powerful ENGINES?

- Magnetic energy
- Accretion energy
- Rotational energy
- Star explosions
- Astronomical objects supplying energy

How are γ-rays produced?
High energy photons detected with the Alpha Magnetic Spectrometer.

Fields at the surface librate $e_+e_-$, pointing along the magnetic axis. The axis of rotation is misaligned with the magnetic axis.

- Pulsars: Galactic sources
- How are $\gamma$-rays produced?
A blazar is called a jet. When the jet points towards Earth, the shock waves:

- Particle acceleration can occur by
  - Accretion disk. Magnetic fields generated from the rotation axes and confined by the jets of particles are ejected along the
- By a giant torus of gas and dust.

Very massive rotating black hole AGNs

Extragalactic sources:

How are γ-rays produced?
3 fundamental needs of $\gamma$-ray astrophysics

**Imaging** & **Field of Obs.**
$(\theta \sim 0.017 \rightarrow 0.17^\circ)$
$(\Omega \sim \pi)$

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

**Absolute Orient.: *Star Tracker***
\( \gamma \) detection with AMS-02

Conversion Mode

Calorimetric Mode

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Tracker performances

Energy range 1 – 100 GeV
E resolution 3 % @ 10 GeV
θ resolution 0.04° @ 10 GeV
Calorimeter performances

Energy range 10 – 1000 GeV
E resolution 3 % @ 100 GeV
Ω resolution 0.5° @ 100 GeV
Almost the same acceptance @ 10 GeV → 0.06 m²sr
Ground based experiments.
Complementary to satellite and
Enhanced energy interval.
Long observation period.
Sufficient rate for regular observation.
Efficiency.
Rough estimate of reconstruction
attitude model.

Estimate based on accurate orbit and

**Galactic sources**

Signal estimate from

Tracker
Calorimeter
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 $\gamma$-sensitivity lies in between EGRET and GLAST experiments.

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AMS-02 Time of Flight System

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

$\sigma(\beta)/\beta = 3.7\% \ @ \ \beta = 1$ (protons)
AMS-02 Transition Radiation Detector

The TRD support structure

20 layers of TRD 5248 straw tubes

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

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

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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)
Background for point sources

Attenuation and spectrum deformation

Origin and emission spectra

Diffuse Galactic Background

nn: nucleon-nucleon
EB: electron bremsstrahlung
IC: inverse Compton
ID: isotropic diffuse

Hunter et al., 1997
Diffuse Extragactic Background

$F(E) = k(E/E_o)^{-\alpha}$

$k = (7.32 \pm 0.34) \times 10^{-6}$

$\alpha = 2.10 \pm 0.03$

$E_o = 451$ MeV

$\langle \text{photons (cm}^2 \text{ sr MeV)}^{-1} \rangle$