Indirect Search for Dark Matter with AMS-02

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For the AMS Collaboration

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The **AMS** is a particle physics experiment in space. It will be launch ready by September 2007 for 3 year mission on board of ISS. The precursor mission: AMS-01 June 1998, STS-91.

**Study of the Nature's beam:**  
Cosmic ray hadron and lepton components. Fluxes, abundances. Acceleration, propagation mechanism, interaction with ISM.

**Search for new physics:**  
Antimatter searches: Anti-Helium, Antinuclei in Space.  
Dark Matter searches: Antiprotons, Antideuterons, Positrons, $\gamma$
The evidence for the existence of Dark Matter comes from the observation of rotation velocities across the spiral galaxies, derived from the variation in the red-shift. The observation is consistent with the gravitation motion only if:

The matter in the Universe is mostly non luminous Dark Matter.

If the Dark Matter (or a fraction of it) is non-baryonic and consists of almost non-interacting massive particles WIMP’s (like SUSY neutralinos $\chi$) it can be detected in Cosmic Rays through its annihilation into positrons or antiprotons, resulting in deviations (in case of antiprotons) or structures (positrons) to be seen in the otherwise predictable spectra. Antideuterons and $\gamma$-ray can also be good signature.
AMS-02 instrument

3 Year mission on ISS

AMS Installation in 2008
AMS-02 instrument

separate $e^+$ from $\bar{p}, p$ up to 300 GeV

$e^+, \gamma$ to 1000 GeV

He$^3$, He$^4$, B, C, …
The AMS-02 instrument will be the first magnetic spectrometer in space capable of measuring cosmic rays from under the geomagnetic cutoff up to TeV region with energy resolution of a few percent and angular resolution of 0.01-1°.

Superconducting Magnet $B L^2 = 0.9 \, \text{Tm}^2$
Silicon Tracker $R_{\text{Max}} = 3 \, \text{TV}$, $dE/dx$
TRD $h/e = 10^2 - 10^3$
TOF $\sigma_t = 120 \, \text{ps}$, $dE/dx$
ECAL $h/e = O(10^3)$, $E_{\text{em}}$
RICH $\Delta\beta/\beta = 0.07-0.1\%$, $Z$ resolution

AMS-02 magnetic spectrometer
Rigidity resolution
Cosmic Ray fluxes and composition

Flux of Cosmic Rays

AMS-02

Cosmic Ray Fluxes (m\(^{-2}\) sr\(^{-1}\) s\(^{-1}\) GeV\(^{-1}\))

Kinetic Energy (GeV/nucleon)
Dark Matter expected signals

Antiprotons

Background

Primary antiprotons from SUSY $\chi$ annihilation

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Baltz et al. found a SUSY signal enhancement $\sim 30-100$ (clumpy DM) necessary to fit data.

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Searches for Dark Matter with AMS-02

Antiprotons

Monte-Carlo feasibility study was performed. Over $10^9$ MC events containing $p^\pm$, He, $e^\pm$, and $\gamma$ were fully simulated, passing through AMS-02 detector model and then reconstructed.
Searches for Dark Matter with AMS-02

Antiprotons
Good particle identification based on velocity measurement is necessary to reject $\sim 10^3$ electron background which can fake an antiproton event.

This method is also efficient against misreconstructed events, affected by interactions inside the detector.
Searches for Dark Matter with AMS-02

Antiprotons

\[ \frac{\bar{p}}{p} \text{ Rejection factor} \]

\[ \frac{\bar{p}}{e^-} \text{ Rejection factor} \]

Momentum (GeV/c)

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Searches for Dark Matter with AMS-02

Antiprotons

Average \( \text{Acc}(1<E<11 \text{ GeV}) = 0.147 \text{ m}^2 \text{Sr} \)
Searches for Dark Matter with AMS-02

Antiprotons
Searches for Dark Matter with AMS-02

Positrons
Searches for Dark Matter with AMS-02

Positrons

![Graphs showing the rejection factors for positron and proton energies.](image)
Searches for Dark Matter with AMS-02

Positrons

1 survived $p^+$ background event from one million rejected.

$P = 10.2$ GeV/c
Searches for Dark Matter with AMS-02

Positrons
Searches for Dark Matter with AMS-02

Positrons

HEAT has confirmed the excess of cosmic ray positrons at around 10 GeV.

AMS will dramatically improve the measurement both in range and accuracy (stat. error \(\sim 1\%\) at 50 GeV).

One of the most favorable SUSY scenario
Searches for Dark Matter with AMS-02

**Gamma**

AMS-02 Sky coverage and Effective area.

AMS-02 Angular and Energy resolution.

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 Searches for Dark Matter with AMS-02

Gamma

No additional boost factor was applied. Good sensitivity for AMSB, KK and large tan (β)
Conclusions

• During the three year mission in space, AMS-02 will perform precise, high statistics cosmic ray measurements in the 1 GeV to few TeV energy range.
• It will allow to combine all indirect Dark Matter search channels, constraining the existing models and will have a high discovery potential of the Dark Matter signal.
• Whenever new sensitivities are reached, exciting and unexpected discoveries become possible.