Dark Matter Searches with AMS-02 Experiment

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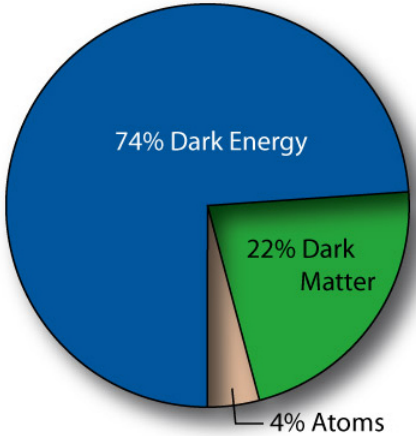
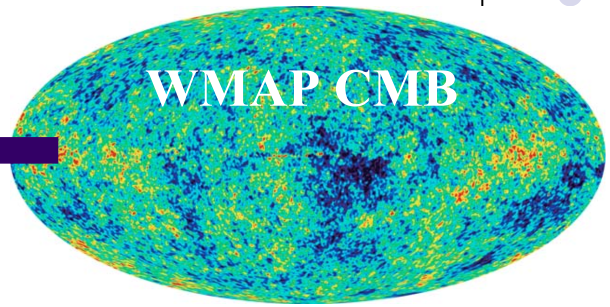
For the AMS Collaboration

XIII Lomonosov Conference

MSU, 29 August, 2007

Dark Matter mystery





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 $\tilde{\chi}^0$) 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. Anti-deuterons and γ-ray can also be good signature.

Alpha Magnetic Spectrometer science

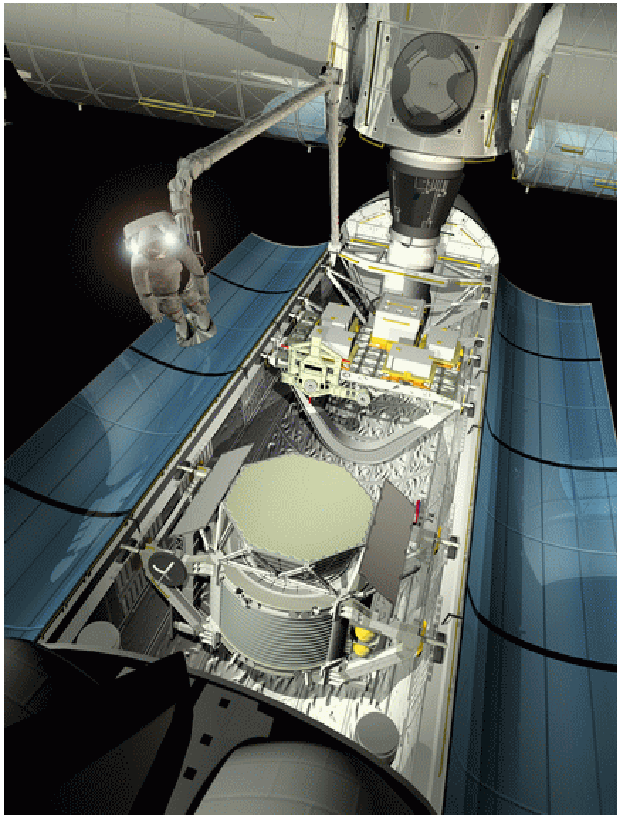
The **AMS** is a particle physics experiment in space. It will be launch ready by December 2008 for 3 year mission on board of ISS. The precursor mission: AMS-01 June 1998, STS-91.

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

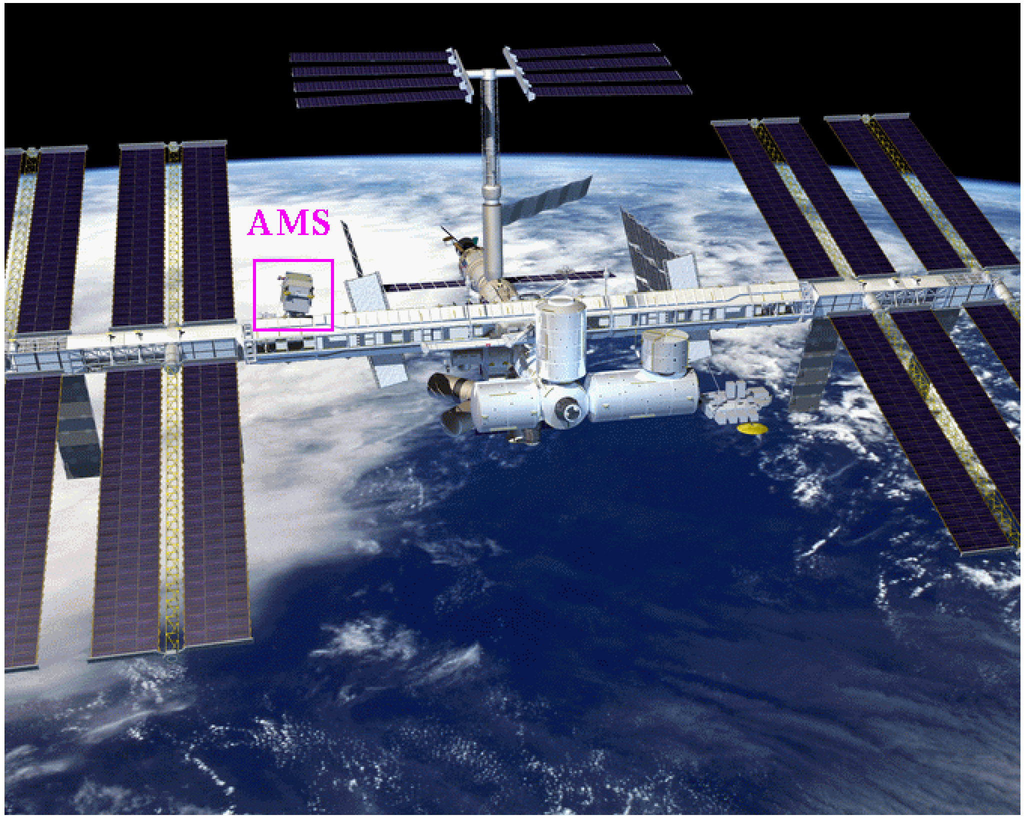
- **Search for new physics:** Antimatter searches: anti-Helium, anti-nuclei in Space. Dark Matter searches: anti-protons, anti-deuterons, positrons, γ.

AMS-02 instrument

AMS Installation in 2009

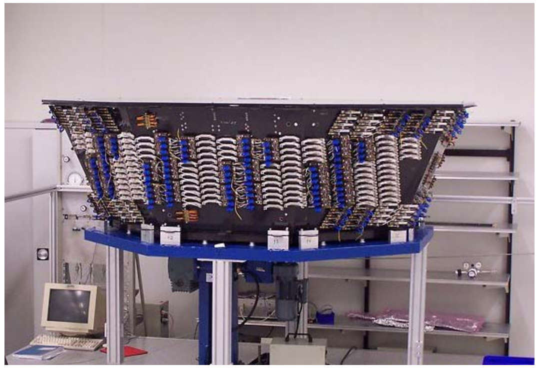


3 Year mission on board of ISS



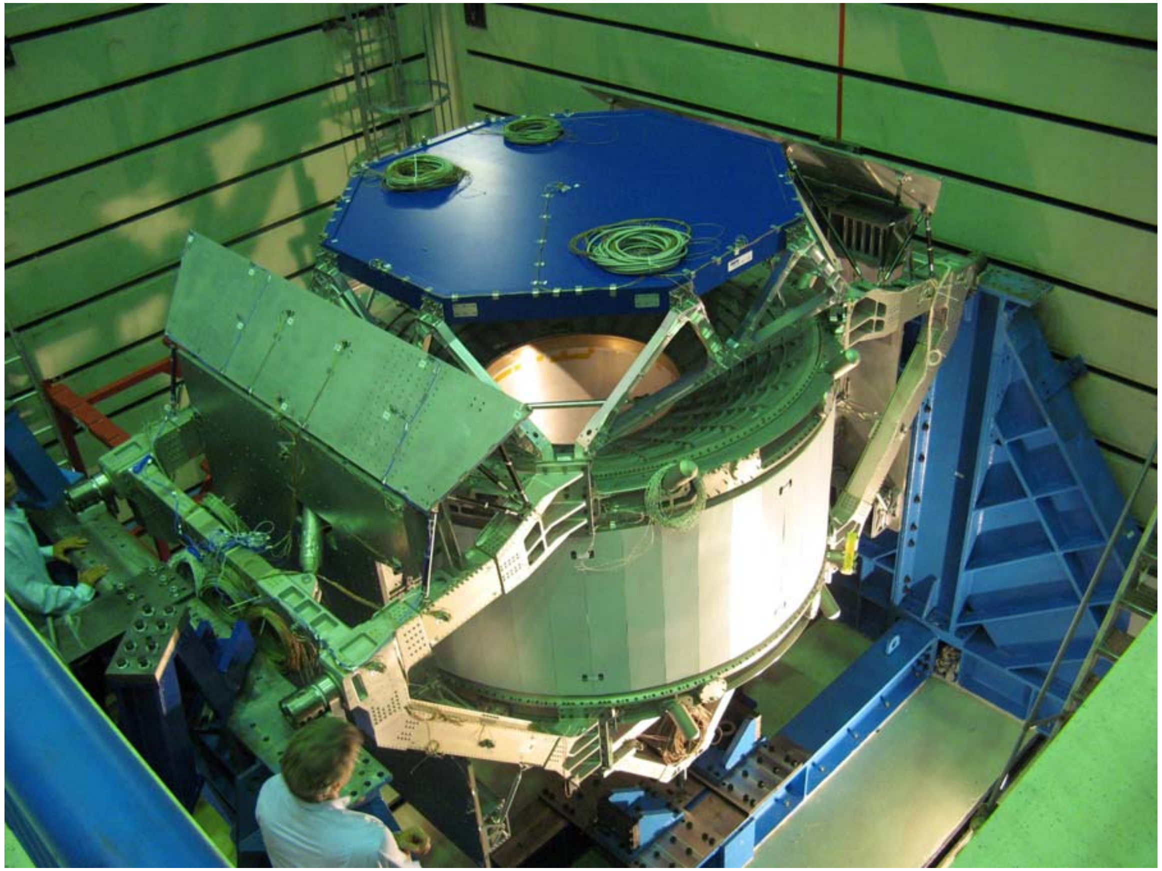
AMS-02 Instrument

AMS TRD



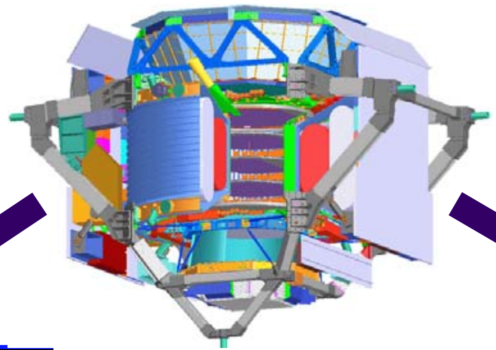
AMS ECAL

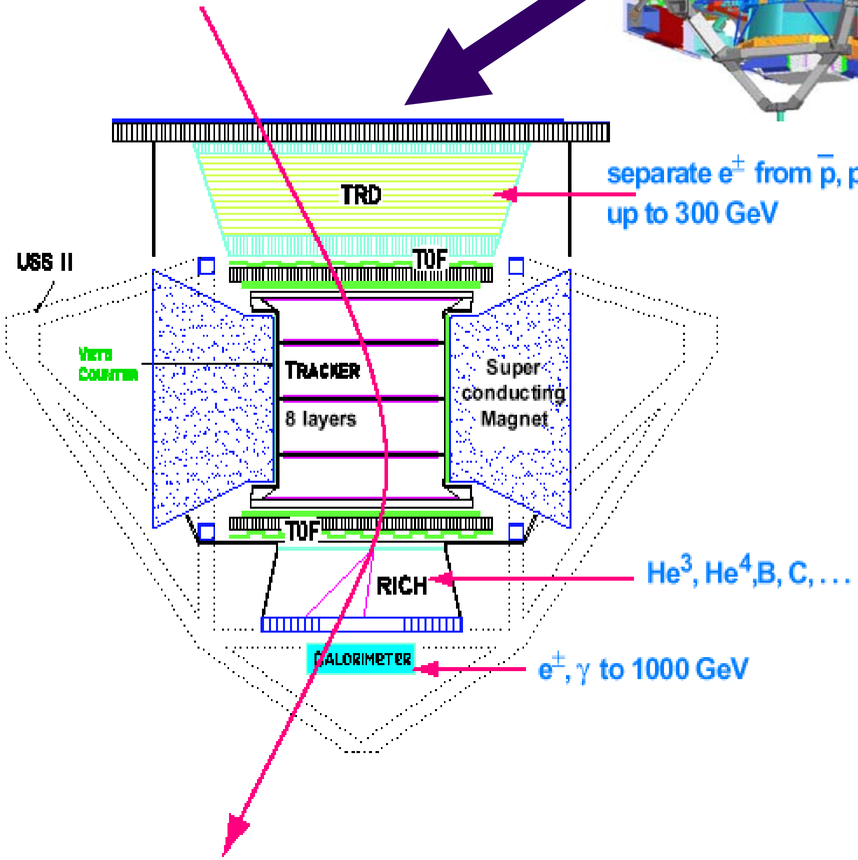
AMS STA vibration test

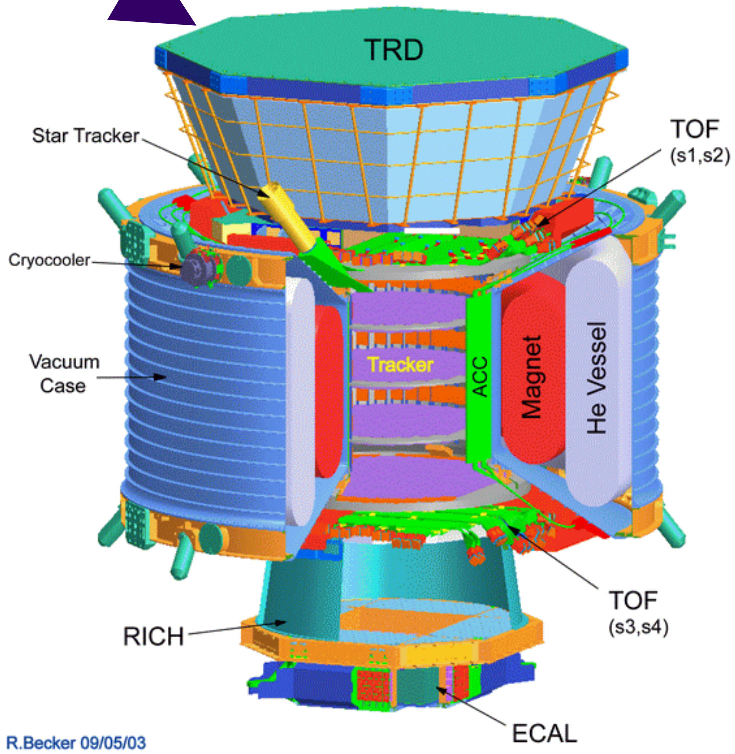


IABG - Munich

AMS-02 instrument



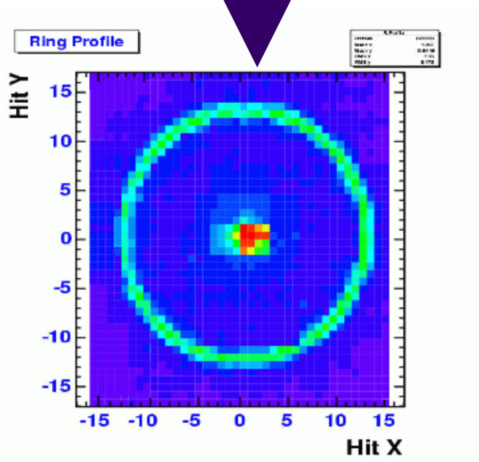


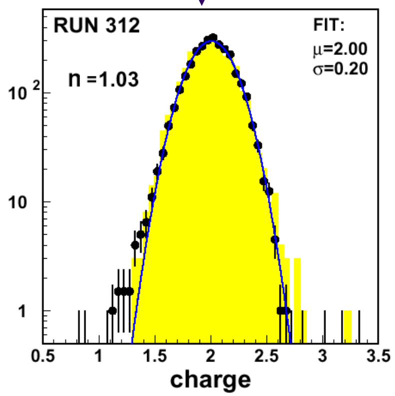


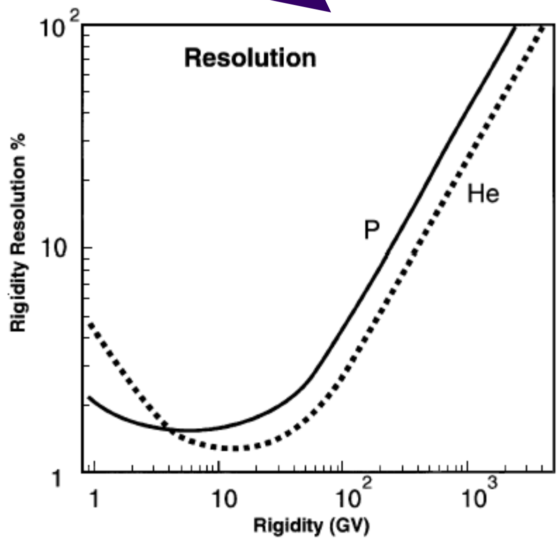
AMS-02 instrument

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

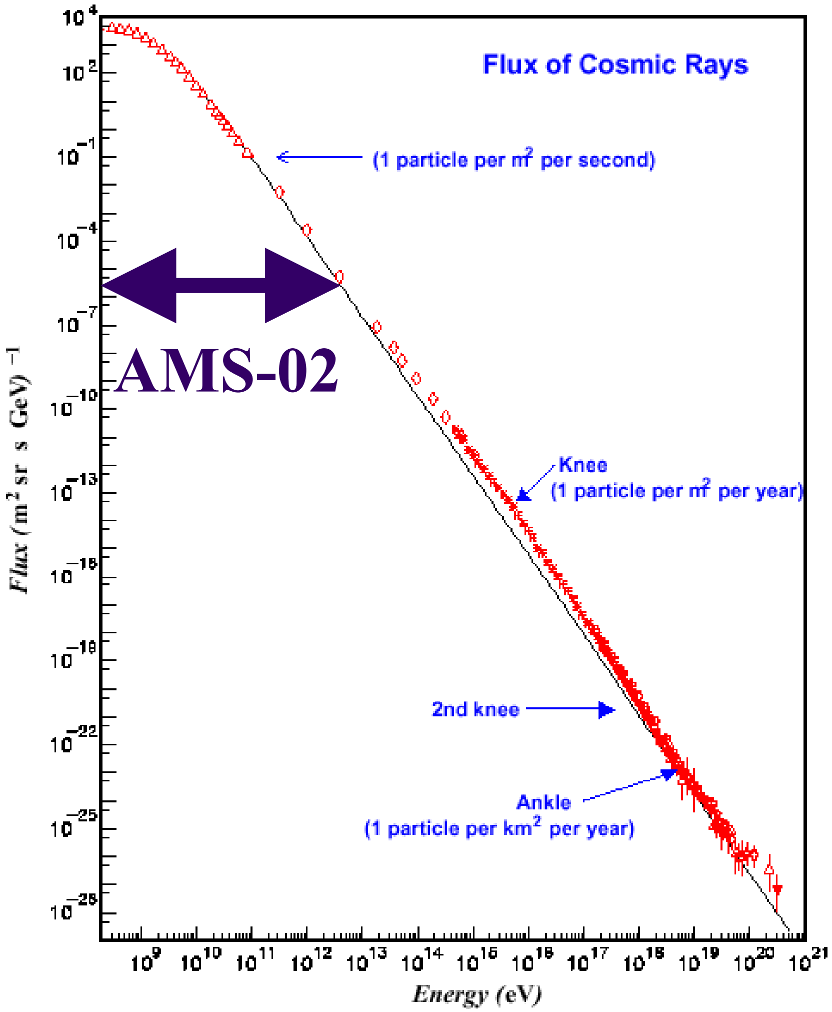




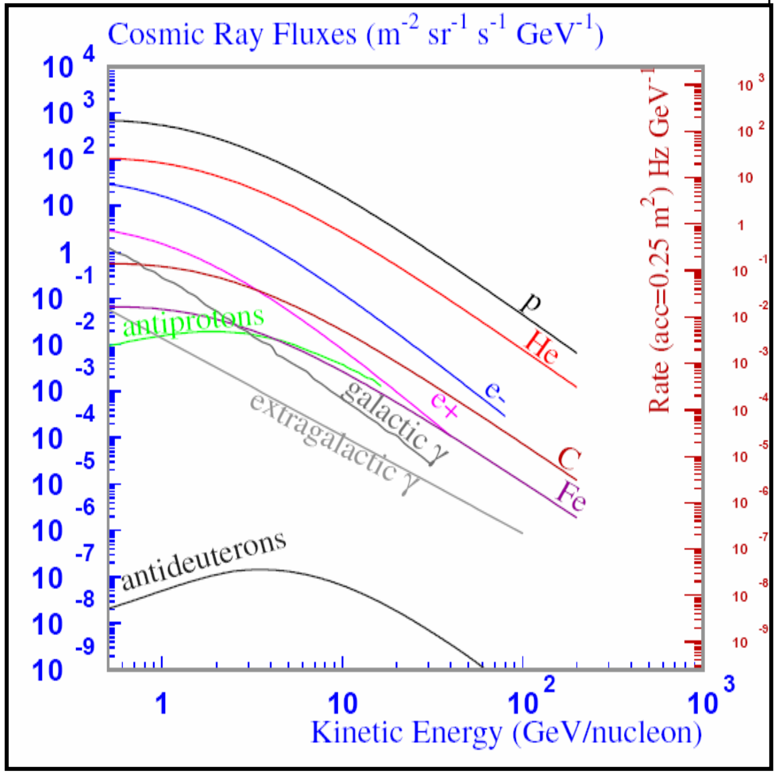


Cosmic Ray fluxes and composition

AMS-02 energy region



Particle fluxes

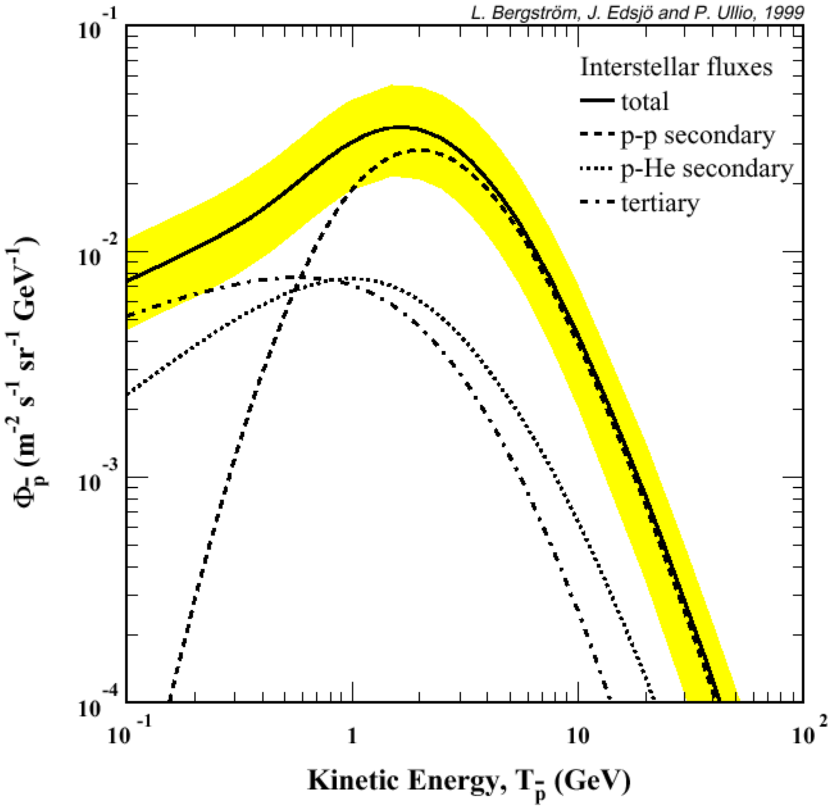


Expected DM signals are largely dominated by proton and electron backgrounds

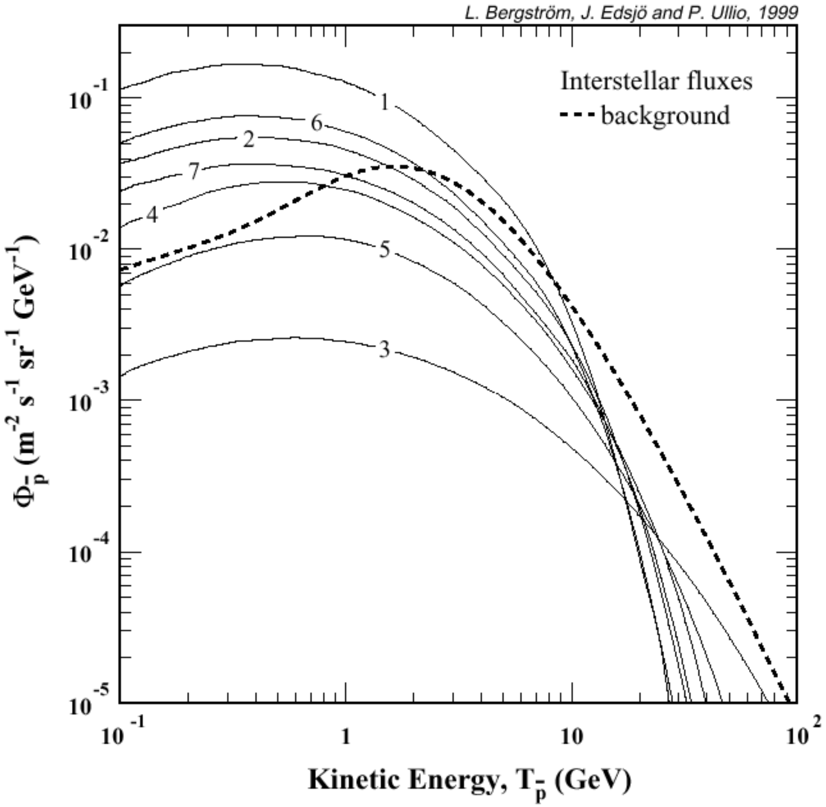
Dark Matter expected signals

Antiprotons

Yellow band shows the uncertainty of the standard interstellar spectrum



Secondary antiprotons



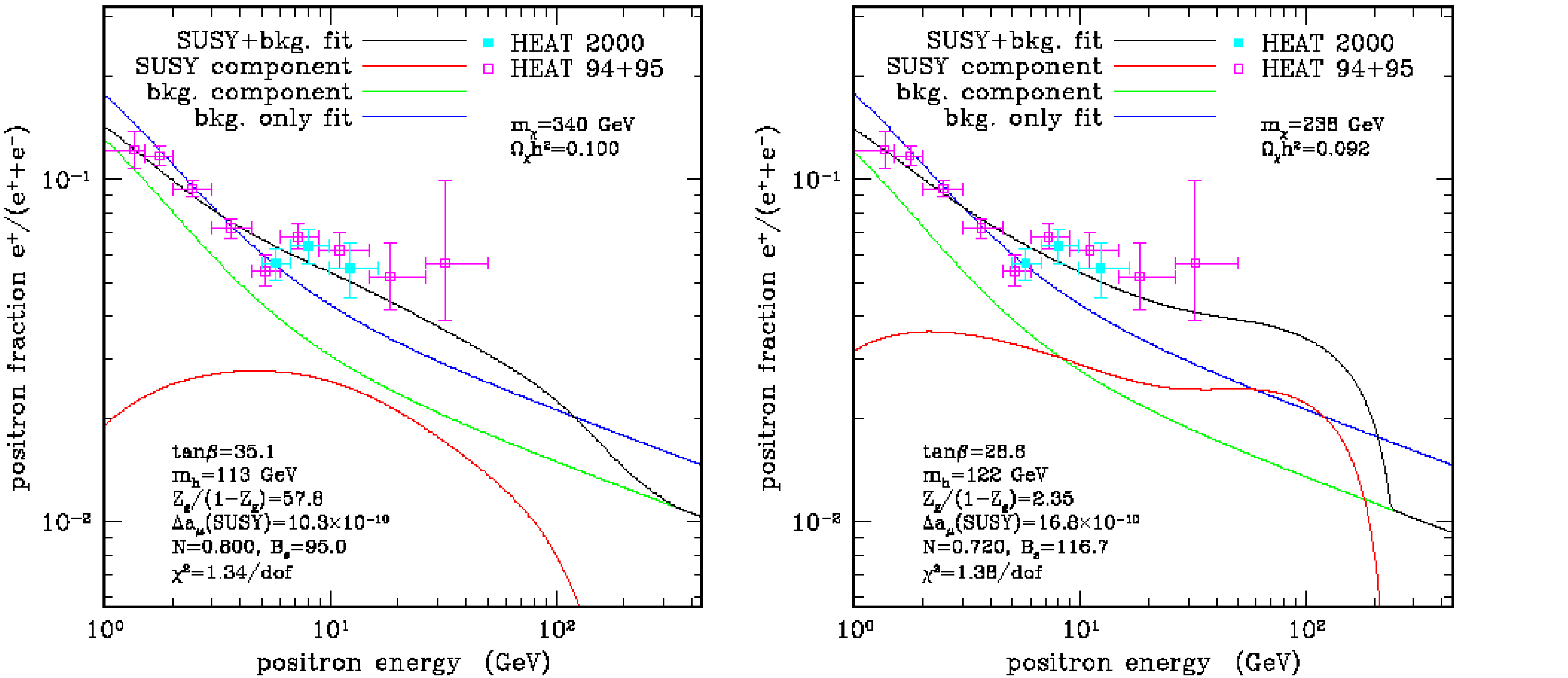
Primary from SUSY $\tilde{\chi}_1^0$ annihilation

Dark Matter expected signals

Positrons

astro-ph/0109318

“HEAT bump” fit with the SUSY DM signal



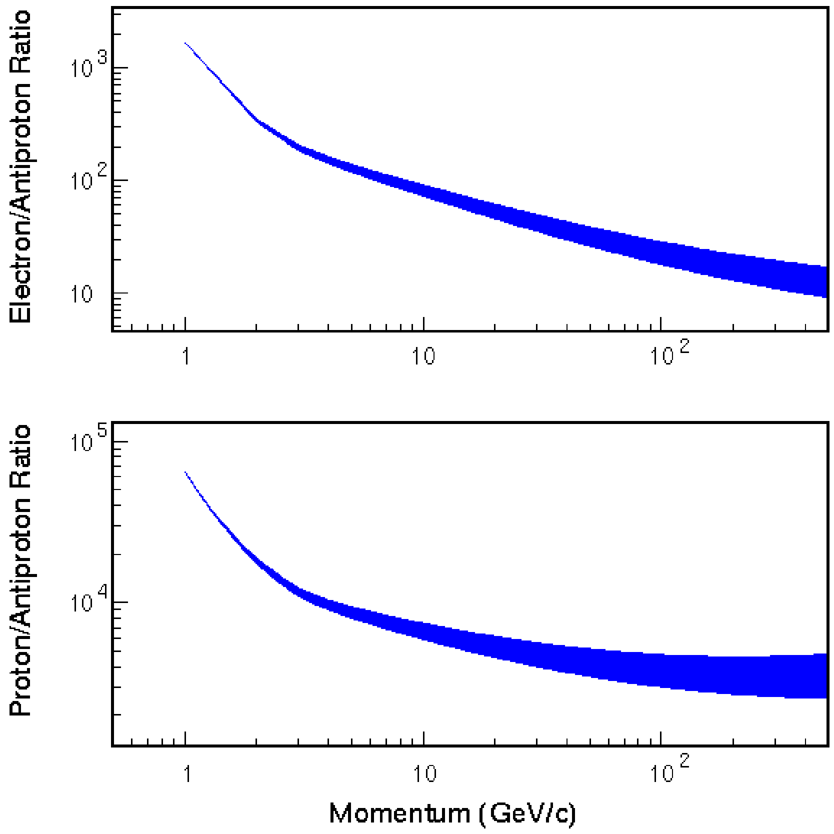
Baltz et.al. found a SUSY signal enhancement ~30-100 is necessary to fit data.

Searches for Dark Matter with AMS

Antiprotons

Background to antiproton signal ratios.

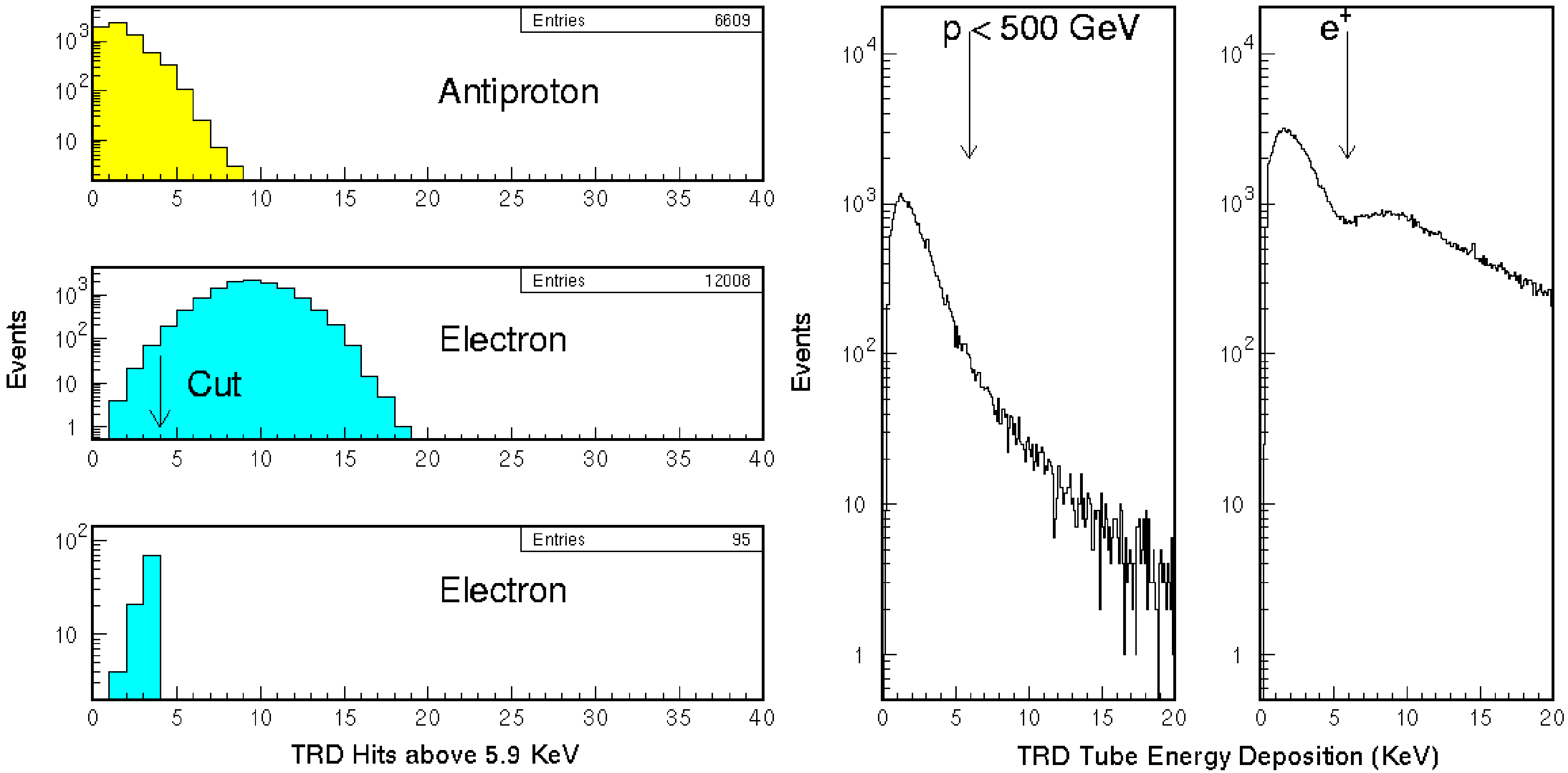
Monte-Carlo feasibility study was performed. Over 10^9 MC events containing $p^{\pm}$, He, $e^{\pm}$, and γ were fully simulated, passing through AMS-02 detector model and then reconstructed.



Searches for Dark Matter with AMS

Antiprotons

Antiproton signal selection cuts using TRD



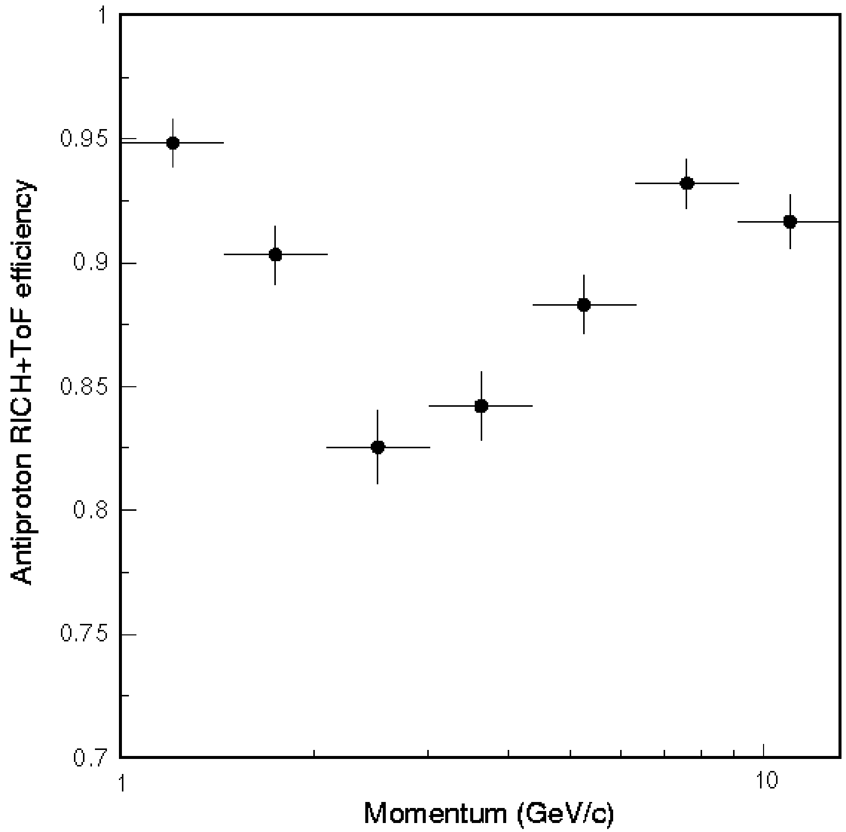
Searches for Dark Matter with AMS

Antiprotons

Combined RICH + ToF selection efficiency

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

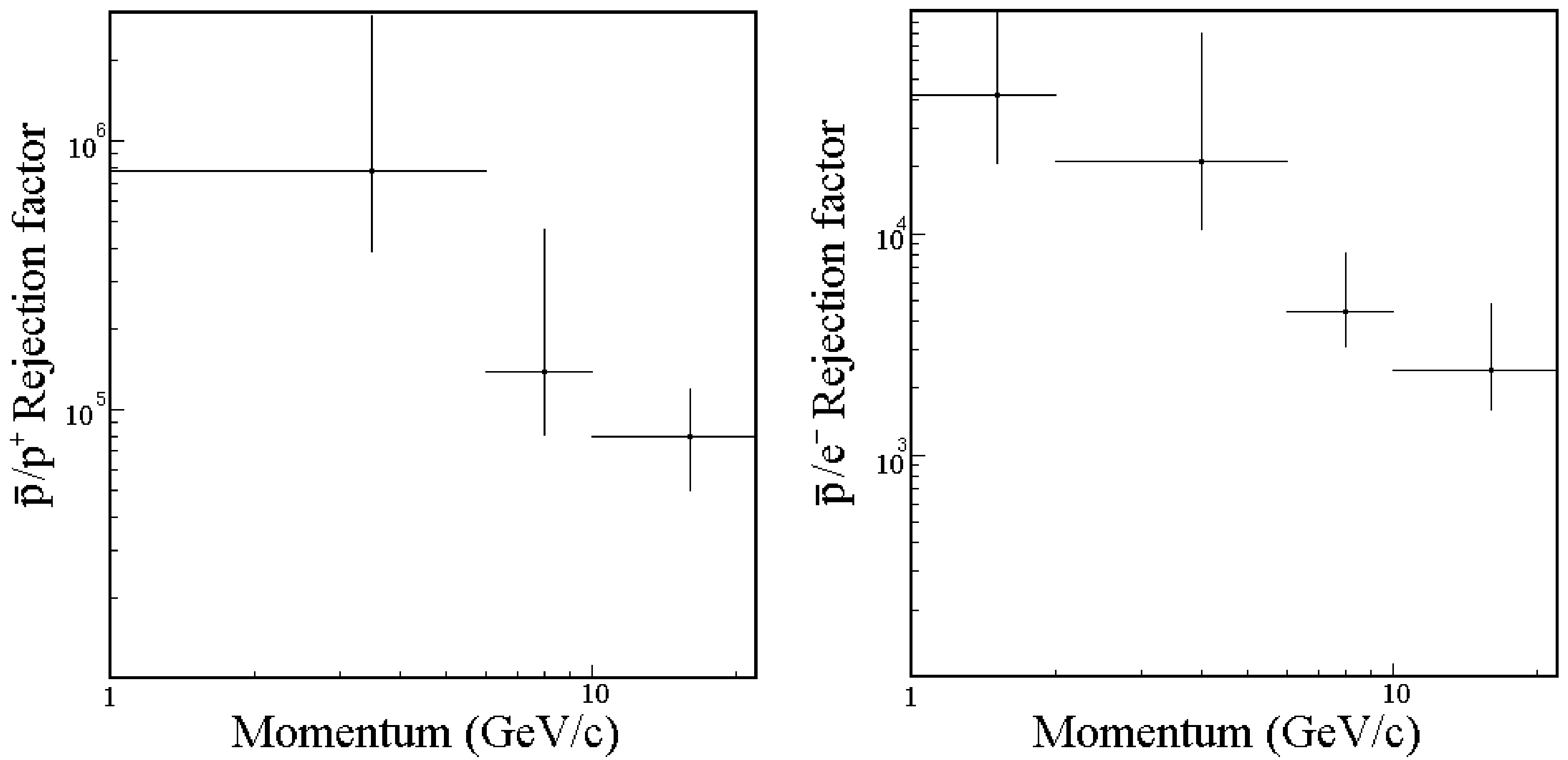
This method is also efficient against misreconstructed events, affected by interactions inside the detector.



Searches for Dark Matter with AMS

Antiprotons

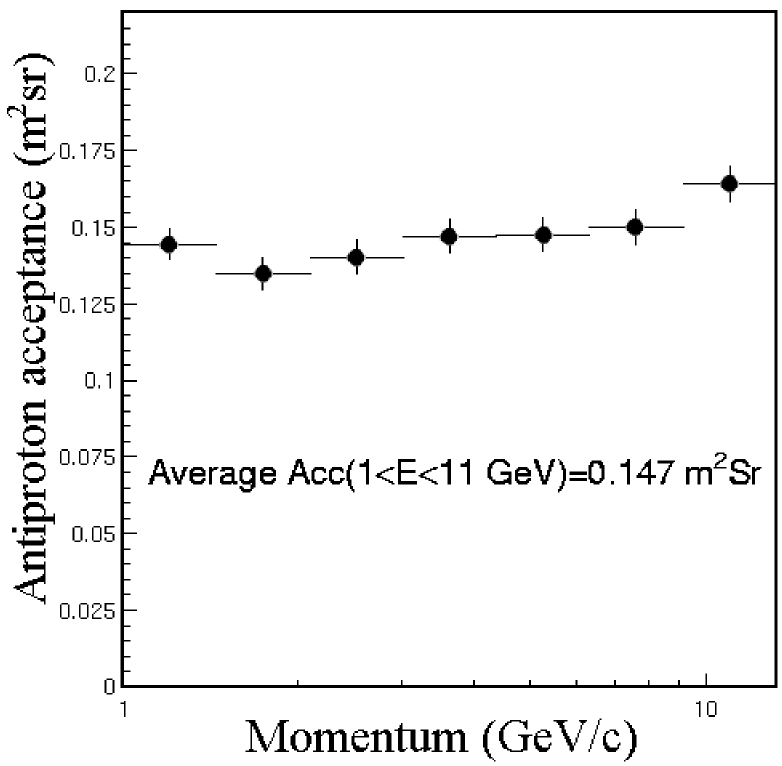
The proton and electron background rejection power

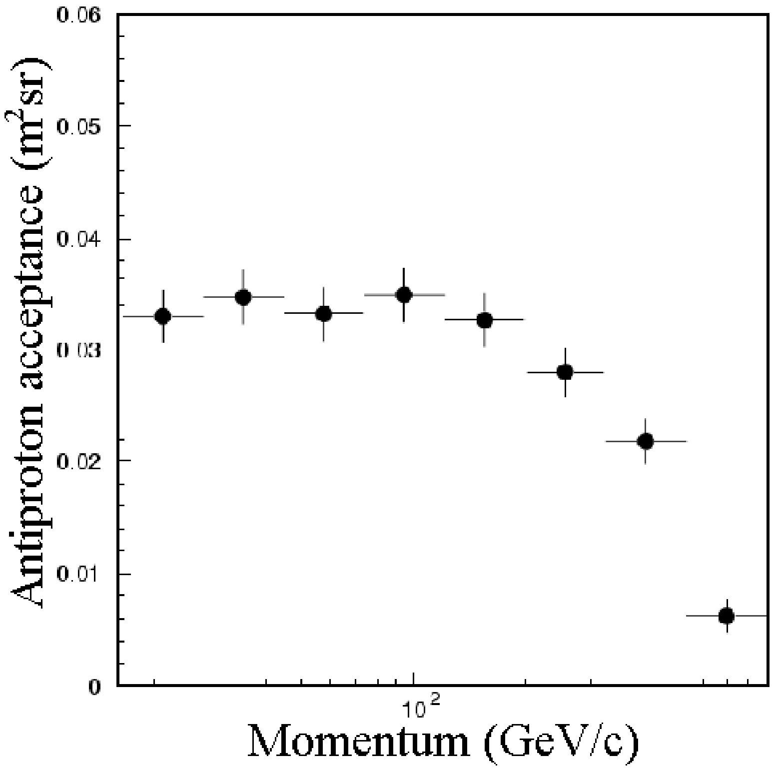


Searches for Dark Matter with AMS

Antiprotons

The acceptance for the antiproton signal including the selection efficiency

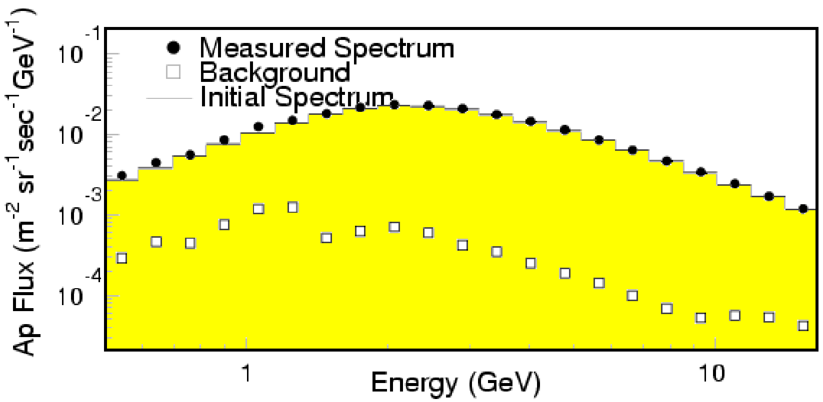


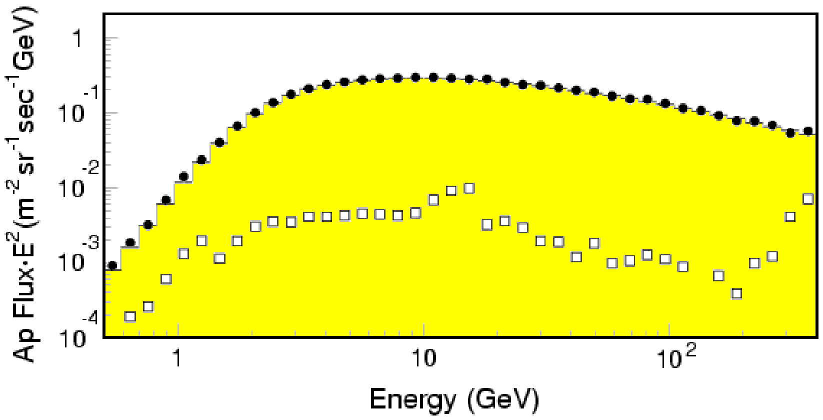


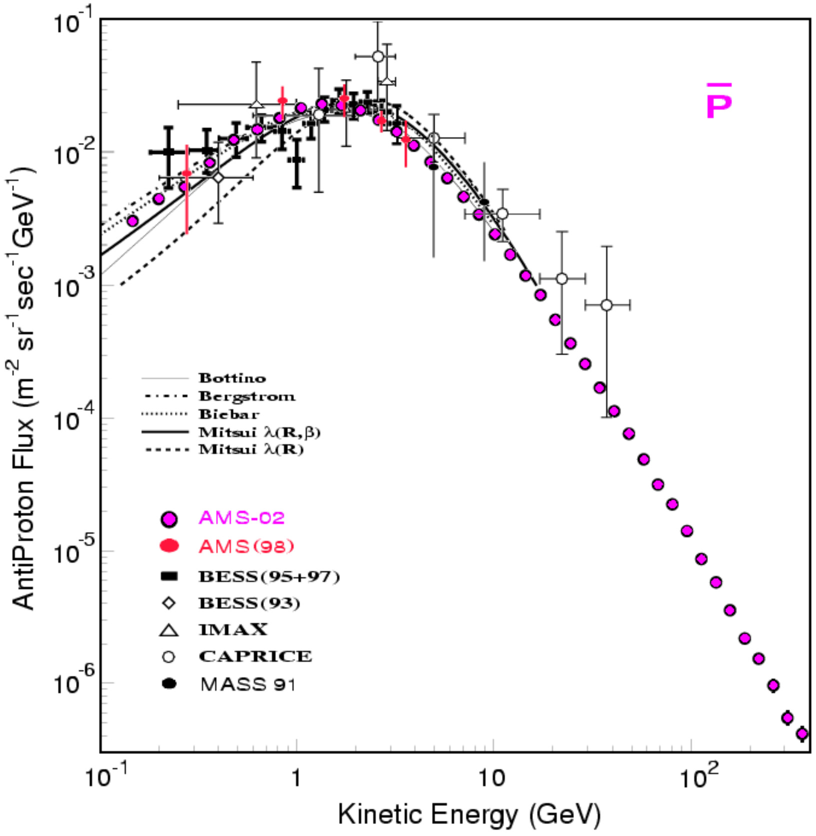
Searches for Dark Matter with AMS

Antiprotons

The expected antiproton spectrum measured by AMS-02 in 3 years



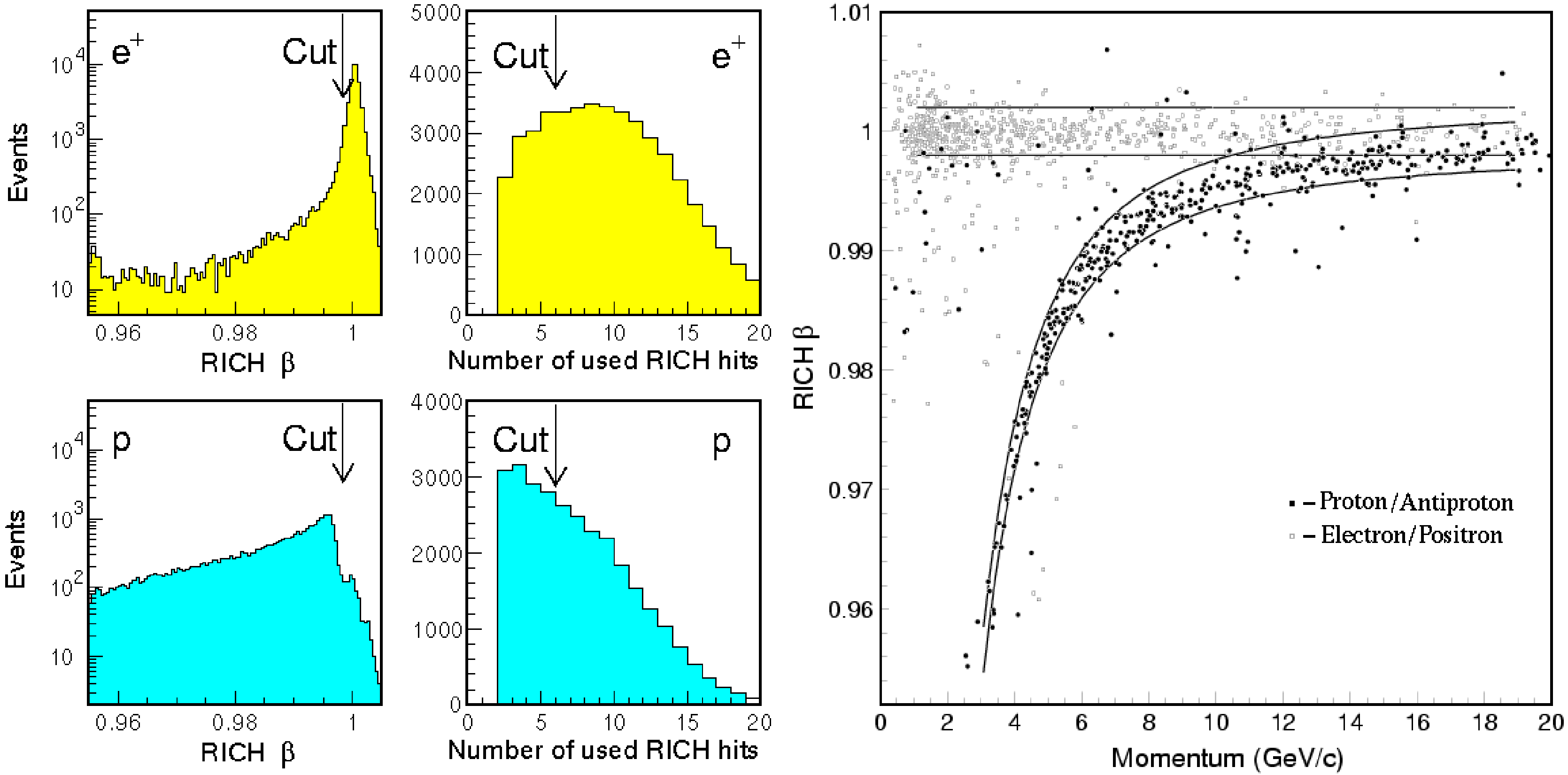




Searches for Dark Matter with AMS

Positrons

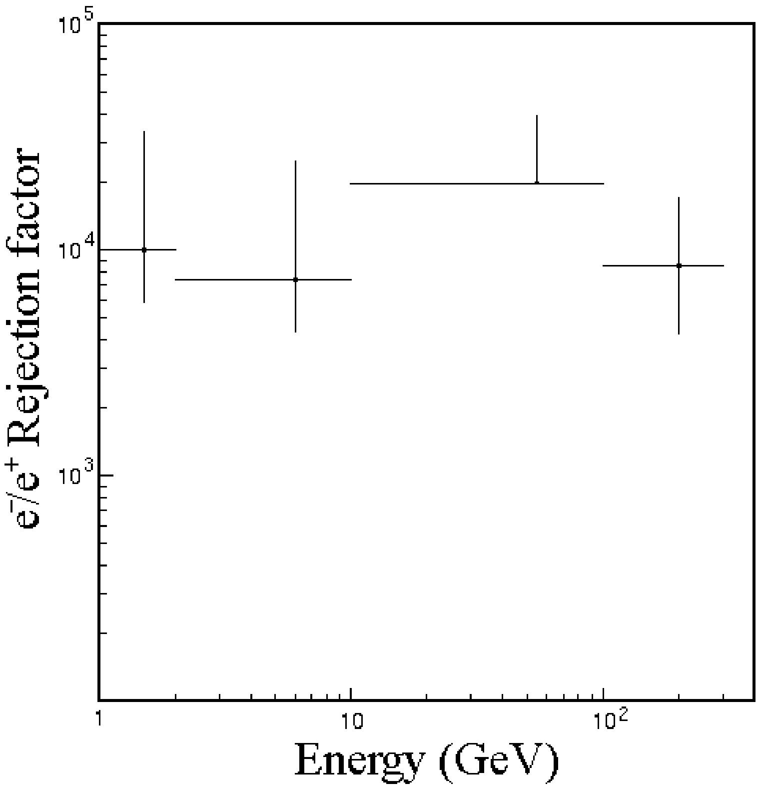
Positron signal selection cuts using RICH

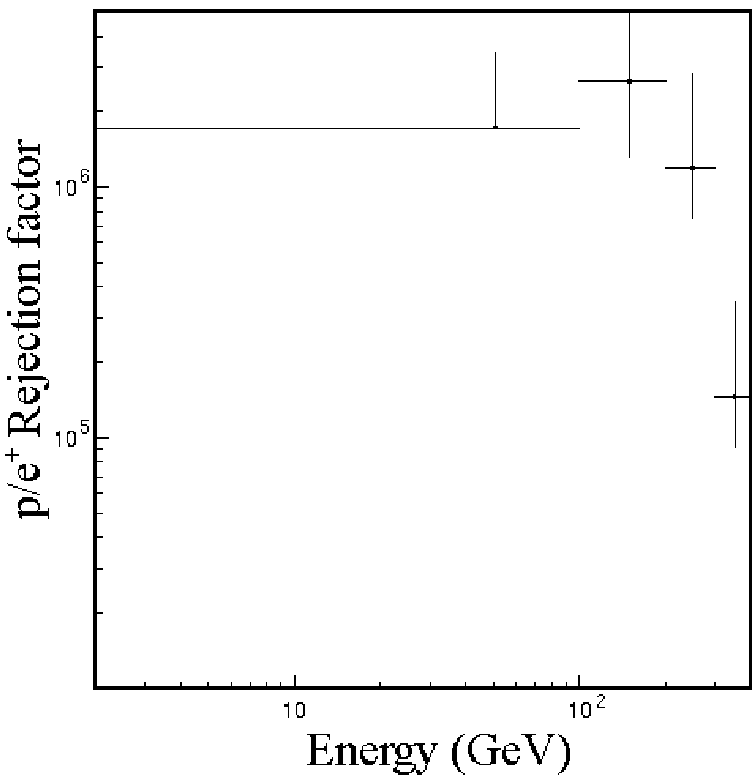


Searches for Dark Matter with AMS

Positrons

The proton and electron background rejection power



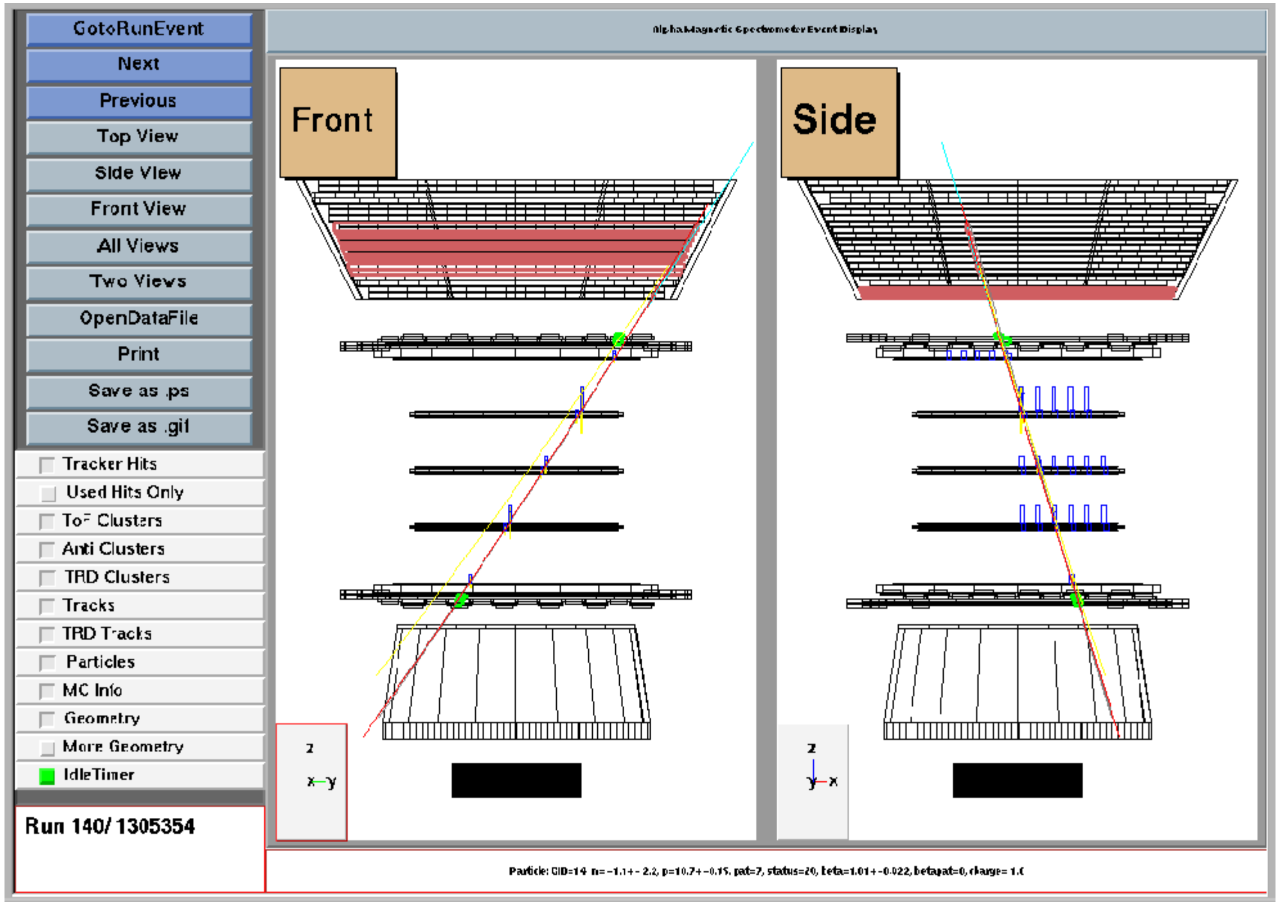


Searches for Dark Matter with AMS

Positrons

The survived background MC event scanned with AMS-02 Event Display

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

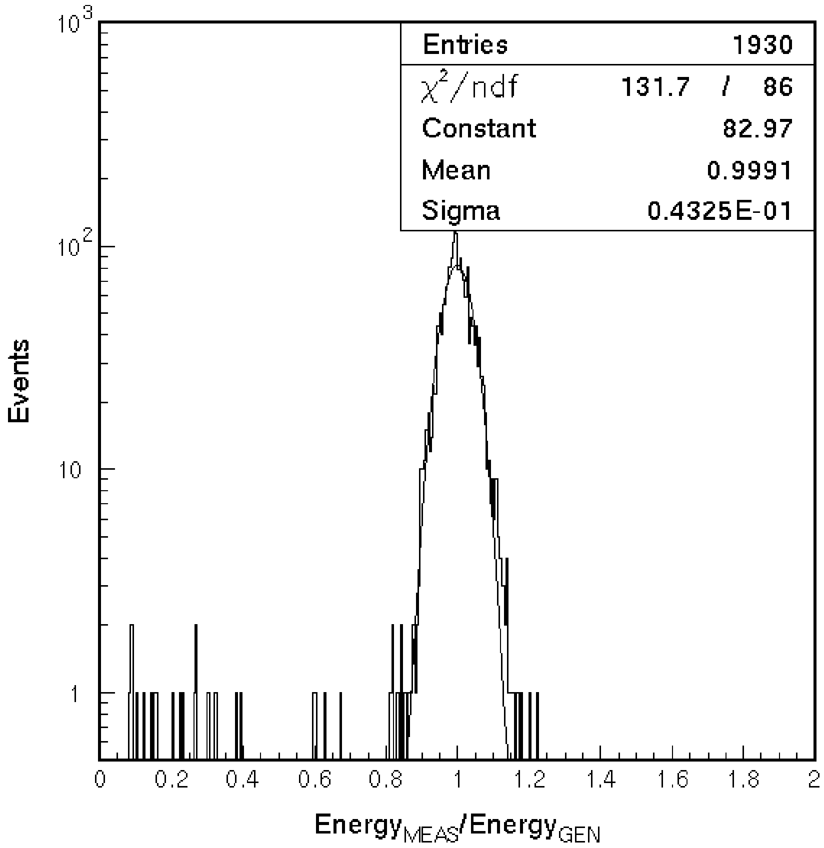


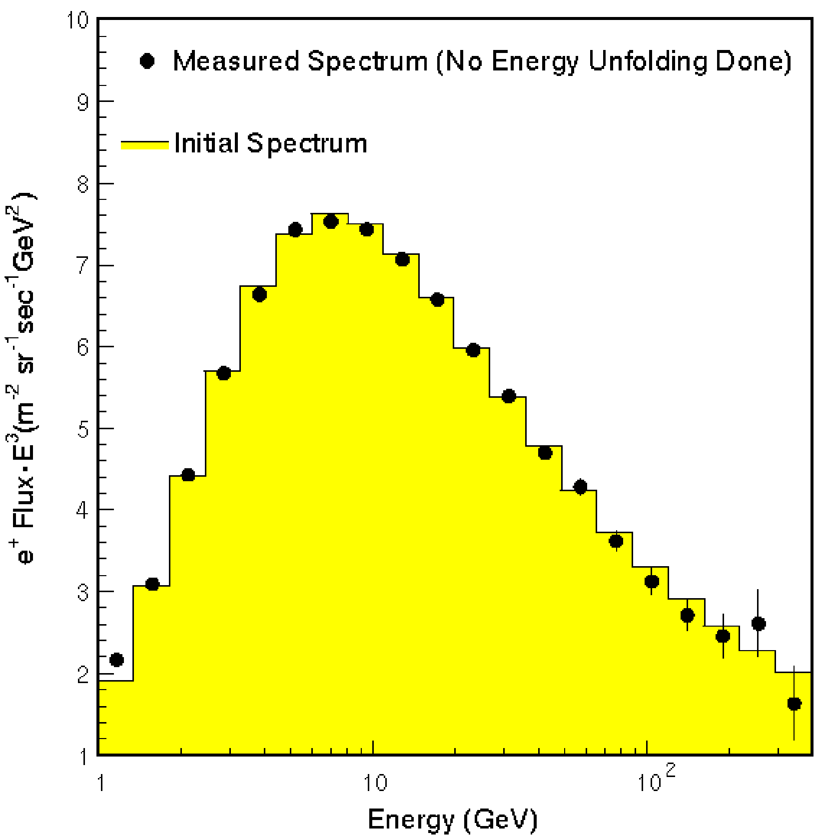
Generated at P=10.7GeV/c

Searches for Dark Matter with AMS

Positrons

The expected positron spectrum measured by AMS-02 in 3 years



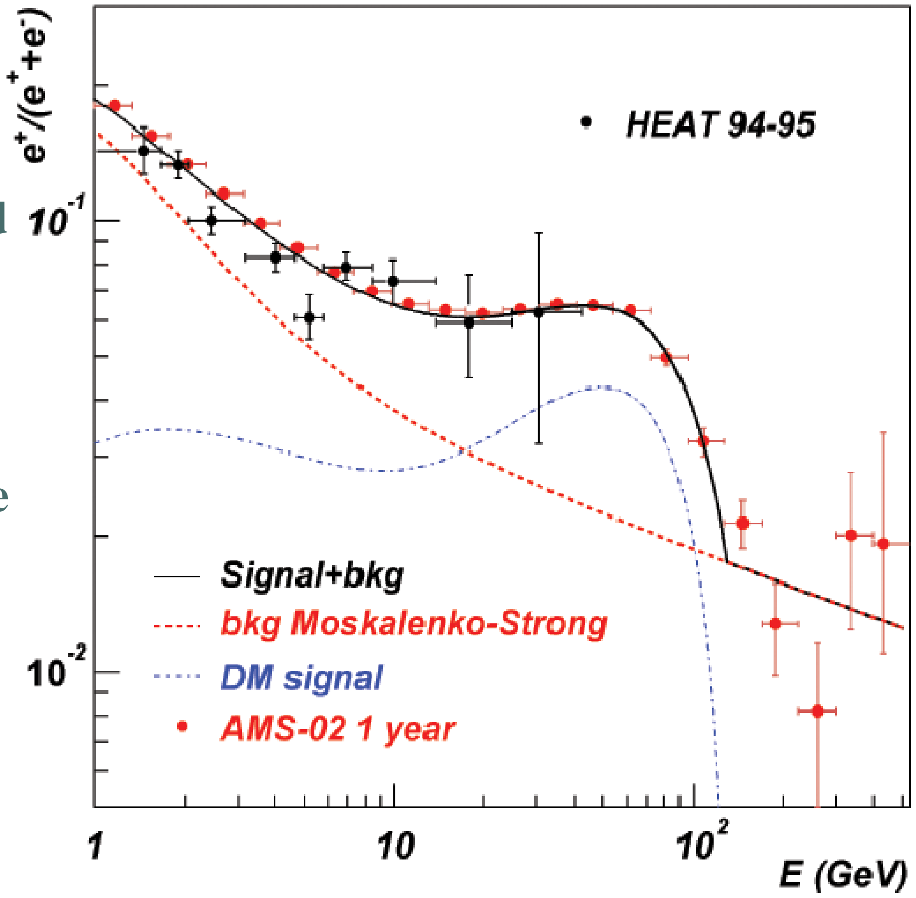


Searches for Dark Matter with AMS

Positrons

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

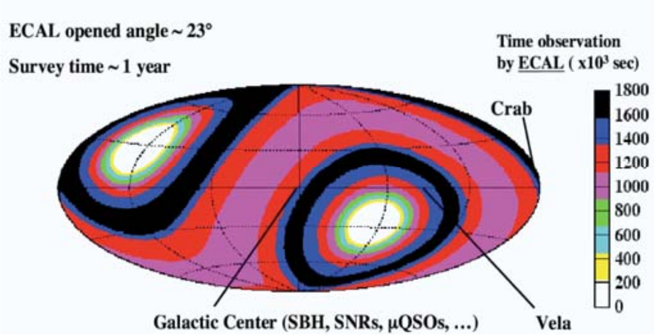
AMS will dramatically improve the measurement both in range and accuracy (stat. error ~ 1% at 50 GeV).

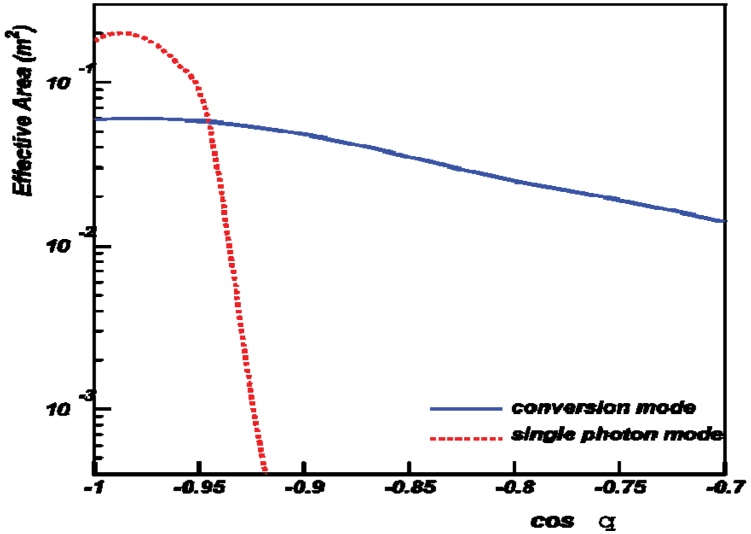


Searches for Dark Matter with AMS

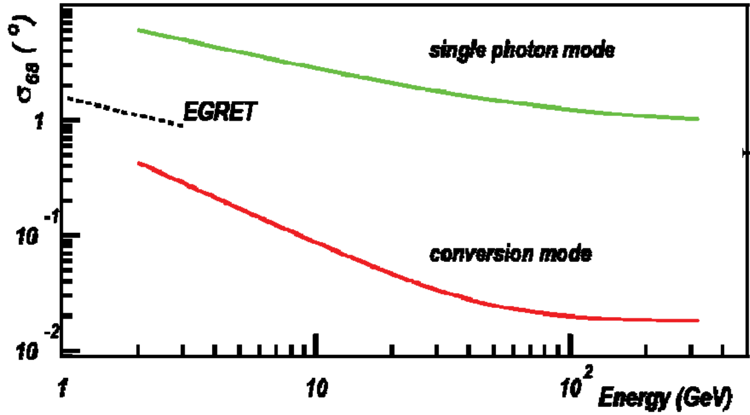
Gamma

Sky coverage and effective area

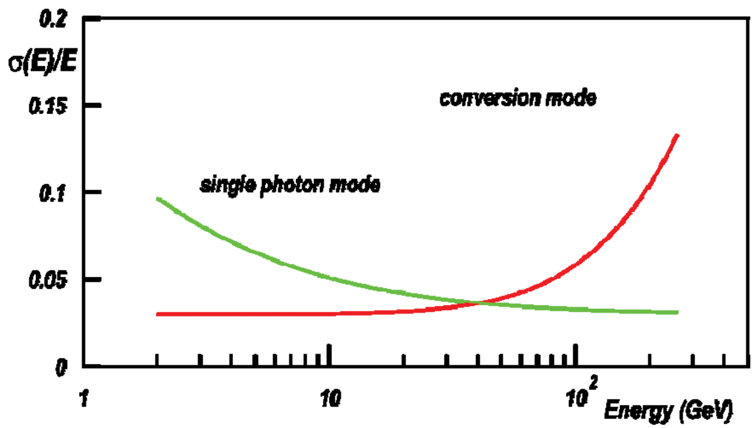




Angular and energy resolution



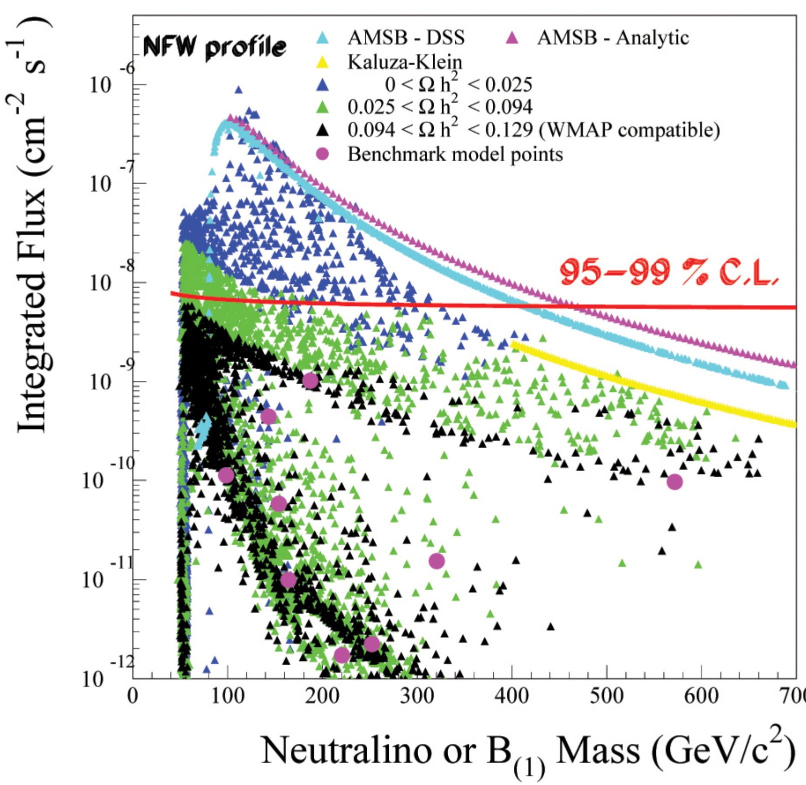
astro-ph/0508349



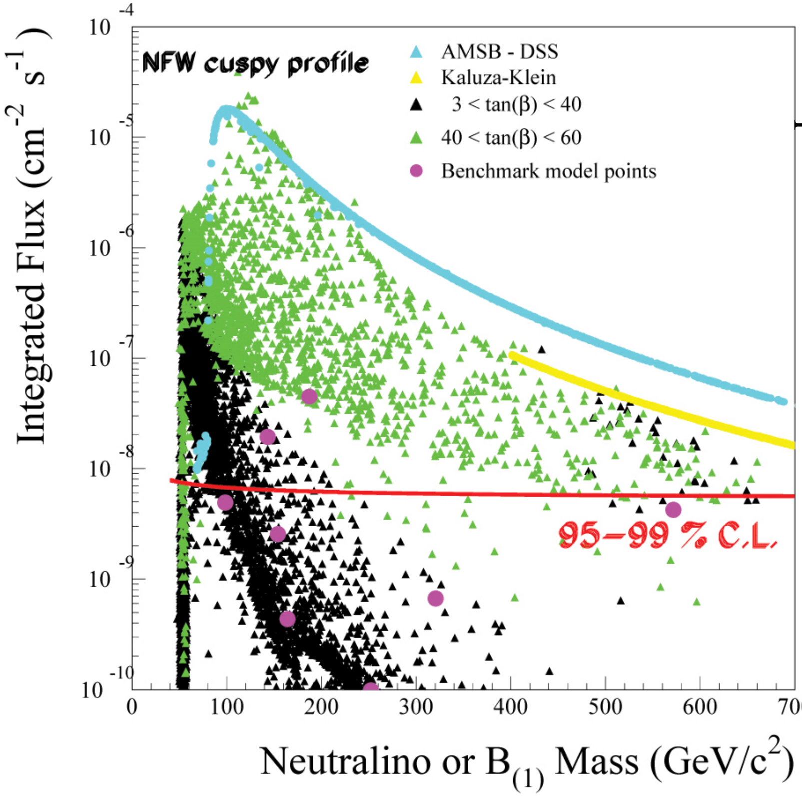
Searches for Dark Matter with AMS

Gamma

No additional boost factor was applied



Sensitivity for AMSB, KK and large tan (β)

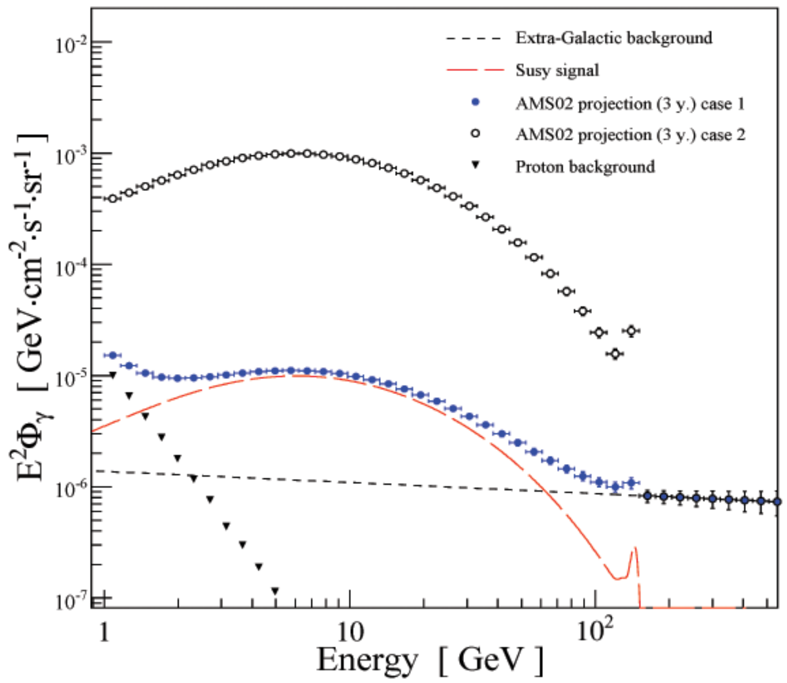


astro-ph/0508349

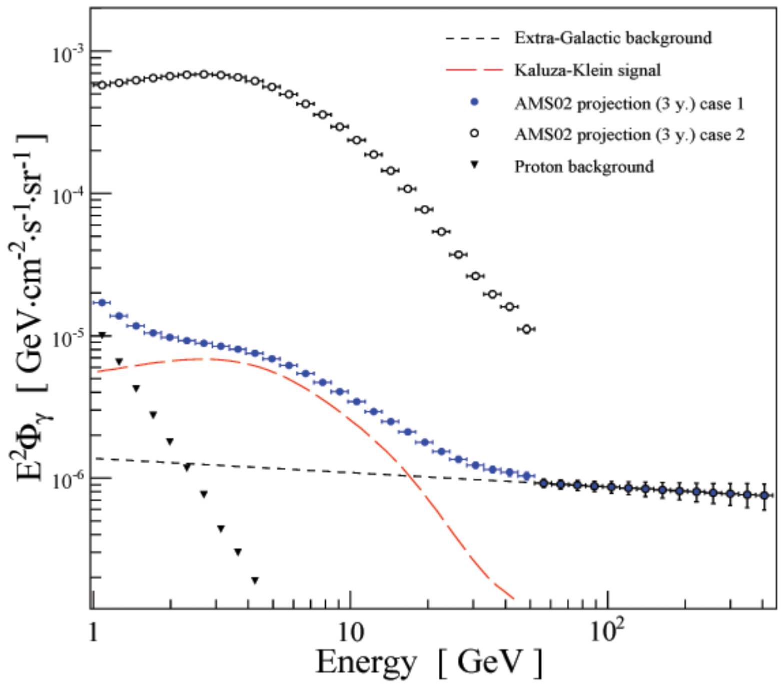
Searches for Dark Matter with AMS

Gamma

DM search assuming a 150GeV SUSY $\tilde{\chi}_1^0$



DM search assuming a 50GeV KK boson



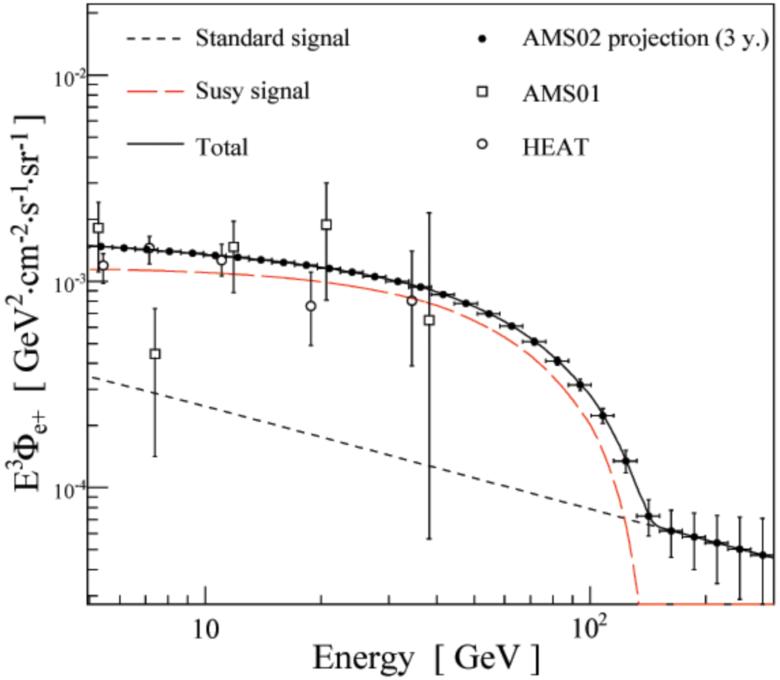
icrc-07/0618

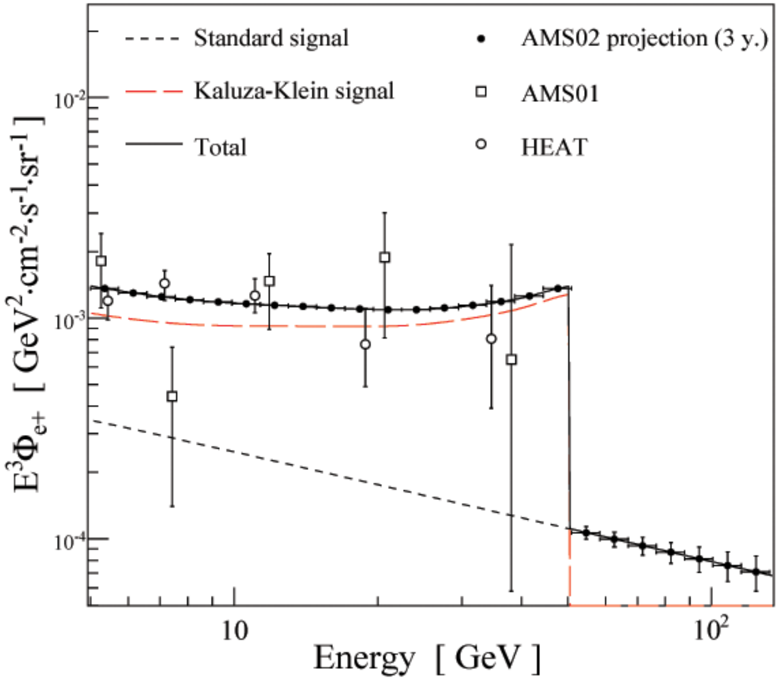
IMBH associated DM clumps at different distance: 20 kpc (case 1) and 2 kpc (case 2)

Searches for Dark Matter with AMS

Positrons

DM search assuming a 150GeV SUSY $\tilde{\chi}_1^0$ **DM search assuming a 50GeV KK boson**





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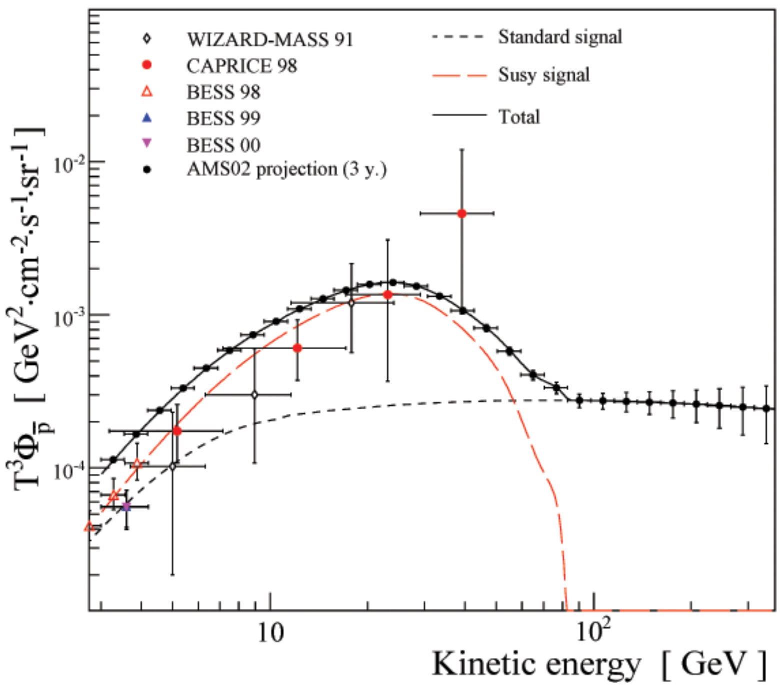
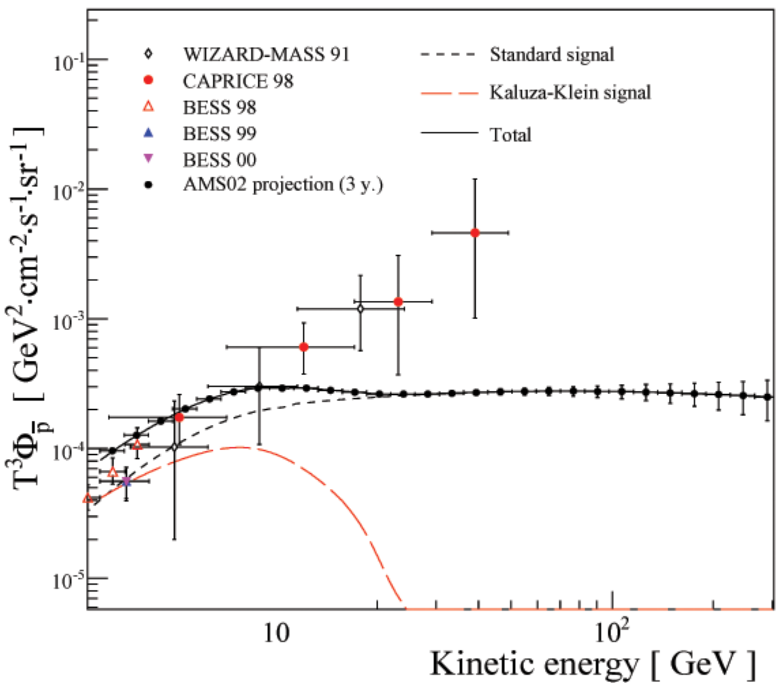
Searches for Dark Matter with AMS

Antiprotons

DM search assuming a 150GeV SUSY $\tilde{\chi}_1^0$



DM search assuming a 50GeV KK boson



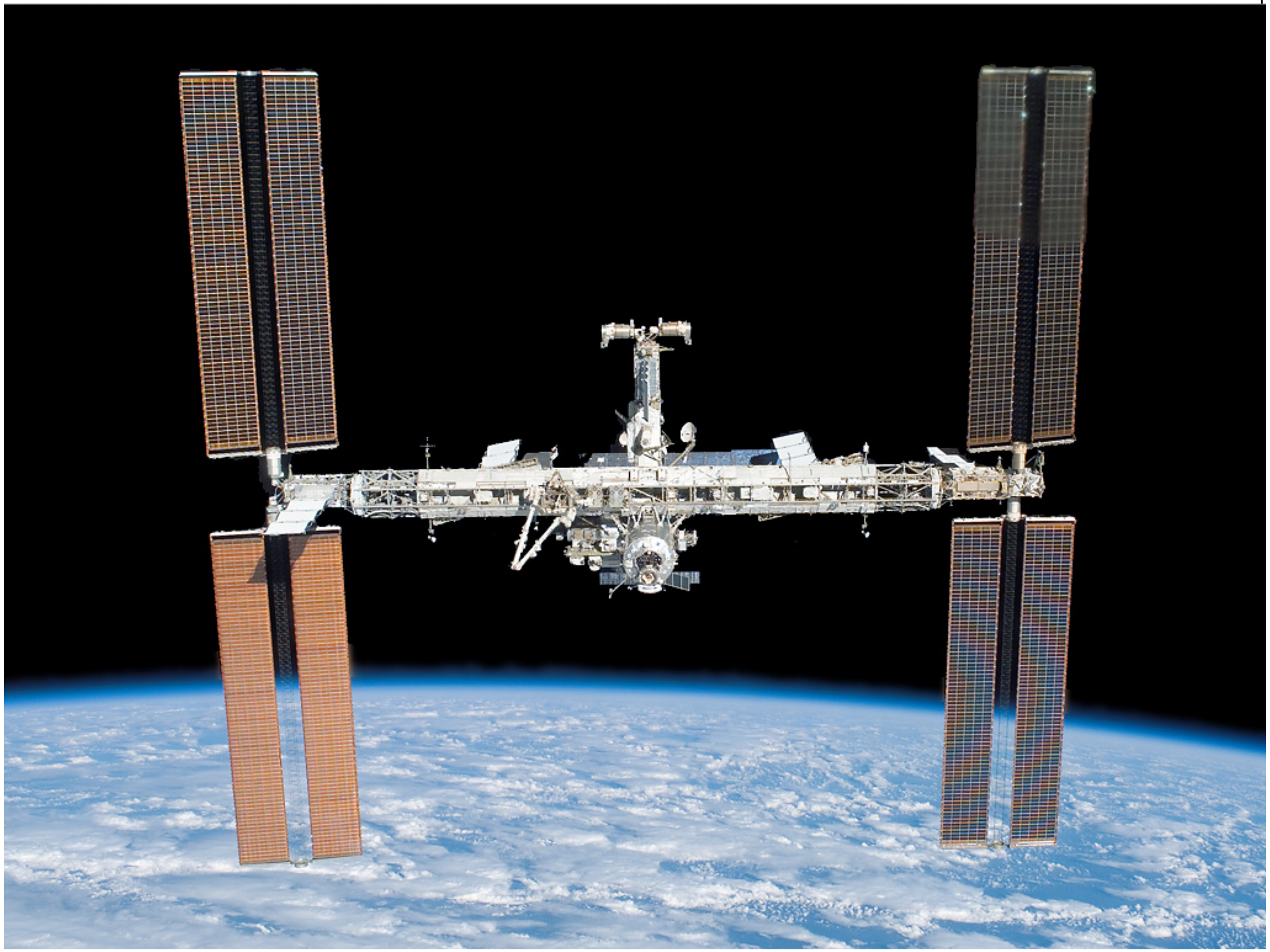
icrc-07/0618

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.

Latest ISS Configuration



Picture taken by STS117 Atlantis crew on 19 June 2007