Dark Matter searches with AMS-02

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ABSTRACT

The Alpha Magnetic Spectrometer (AMS) is a particle physics experiment to be installed on the International Space Station (ISS) for, at least, a three year mission. The purpose of the experiment is a high statistics measurement of charged particles and nuclei from ~ 0.1 GeV to ~ 1 TeV, in order to provide a sensitive search for cosmic antimatter $\bar{H}e$ and indirect dark matter and to study the properties of cosmic rays. The construction of the detector will be completed by 2006 [1]. We describe the detector and the physics searches for antimatter and dark matter.

1. Introduction

AMS is a large acceptance, superconducting magnetic spectrometer which will measure, on board of ISS, charged cosmic rays spectra of elements with Z up to ~ 25 and energies up to TeV with good point source localization and will provide the most sensitive search for the origin of dark matter [2]. Being this experiment onto the ISS, severe constraints due to both launch and space environment are present; therefore special care had to be taken on the design of the thermal and cooling systems and mechanics to insure excellent reliability.

2. Ams-02 detector

A precursor version of the detector (AMS-01) operated successfully in a 10-days NASA Shuttle flight in June 1998 [3]. The AMS-02 detector is due to be completed by the end of 2006 and installed in the ISS at the end of 2007 - beginning 2008. The experiment will be monitored and controlled remotely by the Payload Operations Command Centers (POCC) and data recorded continuously at 2 Mb/s (also in situ in the AMS Crew Operation Post (ACOP)). Fig.1 shows the AMS-02 detector components.

There are, from top to bottom, the following components:

- A 20 layers Transition Radiation Detector (TRD) that will assure a rejection factor p $(\bar{p})/e^-$ (e^+) of 10^2 - 10^3 in the energy range from 1.5 to 300 GeV;
- A 2 x 2 layers of Time Of Flight (TOF) hodoscope with 120 ps precision timing provides dE/dx measurements and the primary trigger;
- The Superconducting Magnet provides a bending power of 0.8 Tm^2 in a volume of $0.5\mathrm{m}^3$;

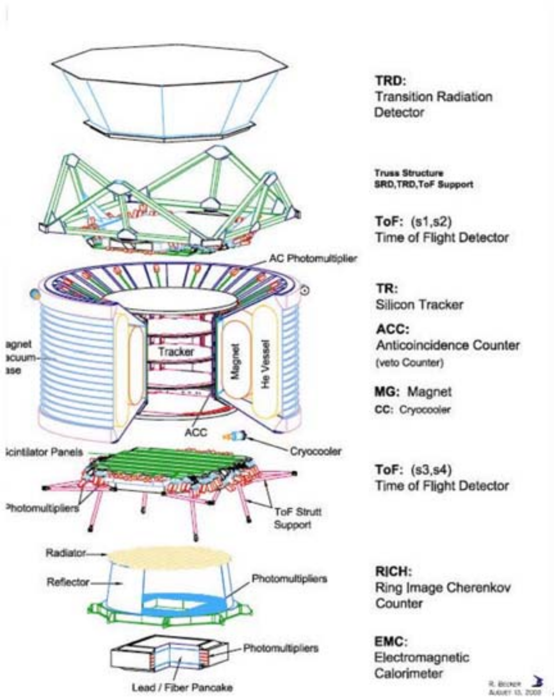

Figure 1: The AMS-02 Detector components

- 8 layers of double sided silicon detectors (6.45 m^2) give a coordinate resolution of 10μm -(30μm) in the bending (non bending) plane;
- Veto Counter vetoes particles not fully traversing the magnet field;
- A Ring Imaging CHerenkov counter (RICH) will measures the velocity (0.1% accuracy) and charge ($|q|$) of the incident particle;
- A 3-D sampling Electromagnetic CALorimeter (ECAL) made of 15 X_0 lead and plastic scintillating fibers measures the energy of gamma rays, electrons and positrons in the range of 1.5 GeV - 1 TeV giving a rejection factor hadrons/electrons of 10^4.

The detector is built with redundant philosophy: the charge is measured independently by the Tracker, the RICH and the TOF; the sign of the charge and momentum by the 8 layers of the tracker inside the magnet. The velocity β is measured by TOF, TRD and RICH with accuracy of 0.1% ; hadron rejection is provided by TRD and ECAL for a total factor better $\sim 10^6$.

3. Dark Matter: indirect searches.

In the Universe only a small fraction less than 5% of its mass is luminous. The rest is accounted as Dark matter and Dark Energy; and both have astrophysical and cosmological evidence. An excellent candidate for being the responsible of missing matter of the Universe is the Lightest Susy Particle which, in the MSSM, is the neutralino χ^0, a neutral scalar boson, antiparticle of itself. Among the product of its annihilation are $\bar{p}$, e^+, $\bar{D}$ and γ-rays. Due to the presence of magnetic fields inside the Galaxy it is not possible to determine the sources of charged particles, but it is possible to measure their total flux spectrum [4].

3.1. Anti-proton flux

The measurements of CR $\bar{p}$ fluxes are limited and with large errors. In three years AMS-02 will measure the spectrum very precisely up to 300 GeV with a few percent energy resolution; it will allow the observation of an excess of high energy $\bar{p}$ coming from annihilation of high mass neutralinos as shown in Fig, 2.a.

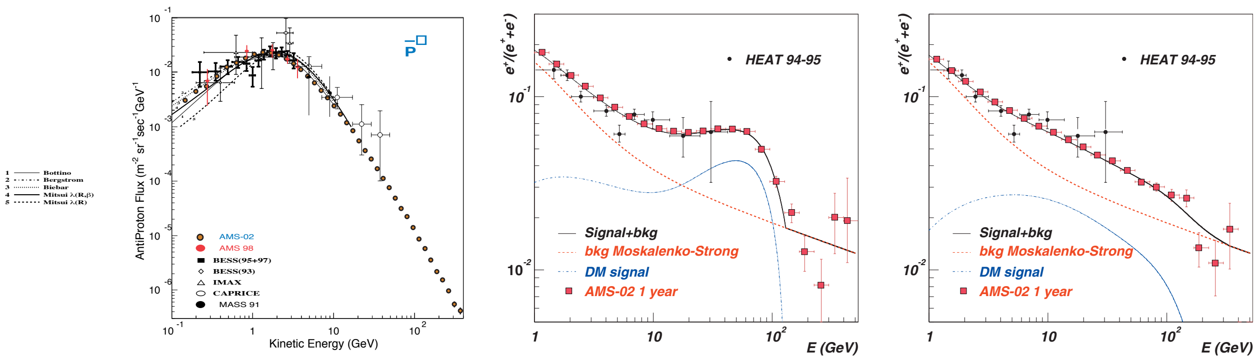

Figure 2: a - Ams-02 three years anti-p flux and b,c - Positron from annihilation of m_χ130 GeV and 330 GeV respectively

3.2. Positron flux

Several models are used to simulate the e^+ production by χ^0 annihilation in the galactic halo with two values of the mass 130 GeV and 336 GeV and boosted to fit the HEAT data. Figs. 2.2 and 2.3 show the results of simulation and the AMS-02 expectations after one year of data taking.

3.3. Gamma Rays flux

This measurement will give also the position of the source, being γ rays not sensitive to intergalactic magnetic fields. The AMS-02 potential for mSUGRA Dark Matter detection was simulated with various benchmark models and the expected numbers of γ in three year exposure are shown in Table 1, while Fig.4 shows the γ flux as function of m_χ for two different Navarro-Frenk-White parameterizations [5].

4. Acknowledgements

I wish to thank B. Borgia, S. Gentile and S. Rosier-Lees for many very useful discus-

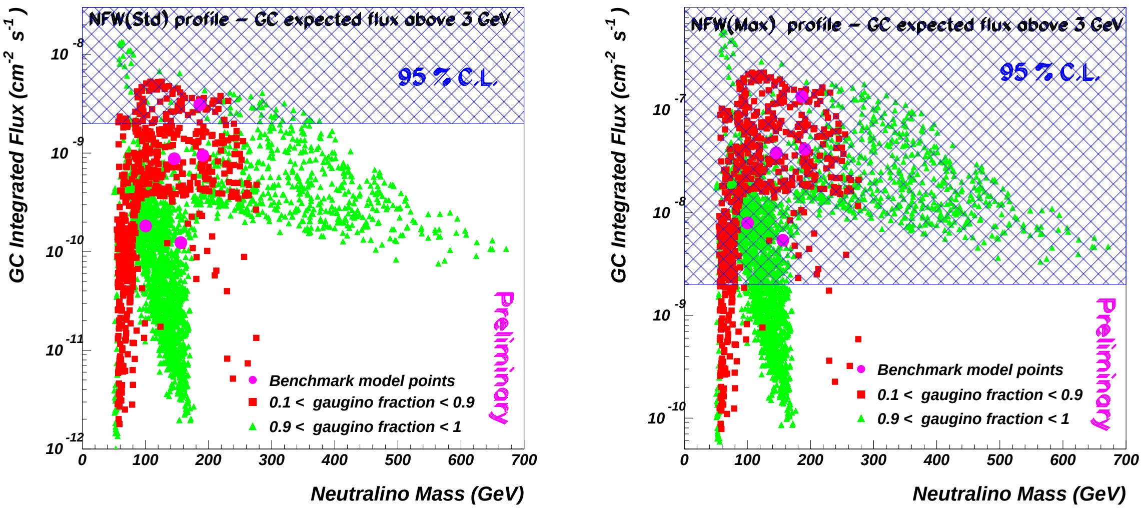

Figure 3: Integrated NFW profiles

Table 1: Number of γ's from the Galactic Center for different mSUGRA benchmark model

Model	N_γ for generic NFW	N_γ for maximal NFW
B	1.5	83
C	0.1	6
G	0.6	45
I	3.6	258
L	15.0	597

sions. We thank all the many organizations and individuals that have contributed to the design and construction of AMS-02 [6].

5. References

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