Searching for Supersymmetric Dark Matter with the AMS-01 Space Experiment

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NEPPSR V

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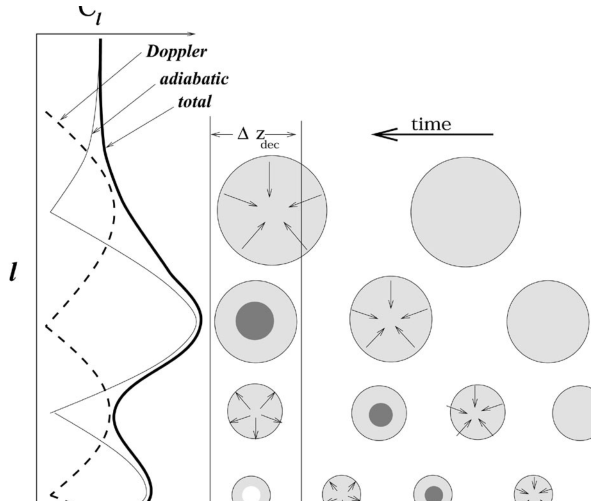
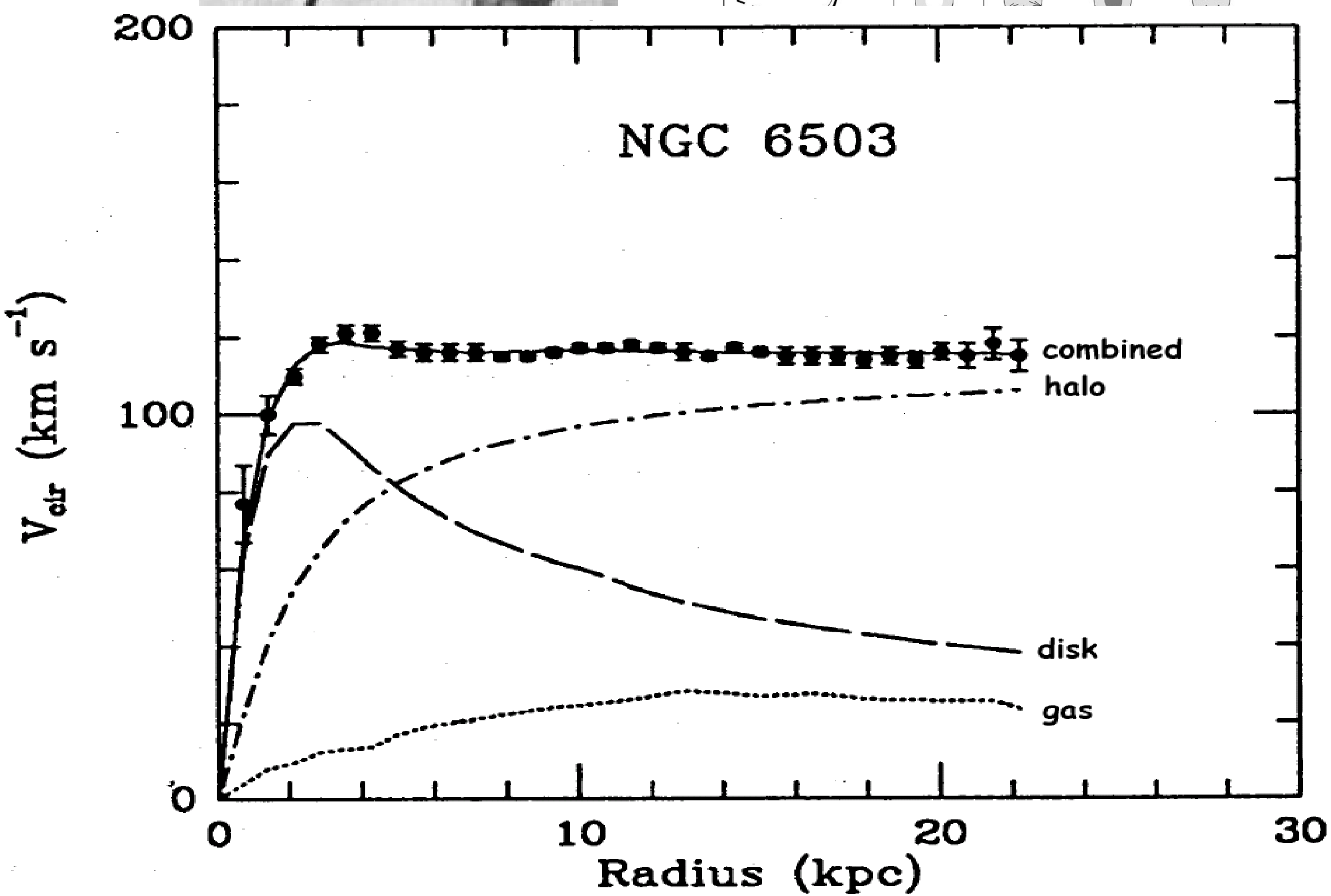
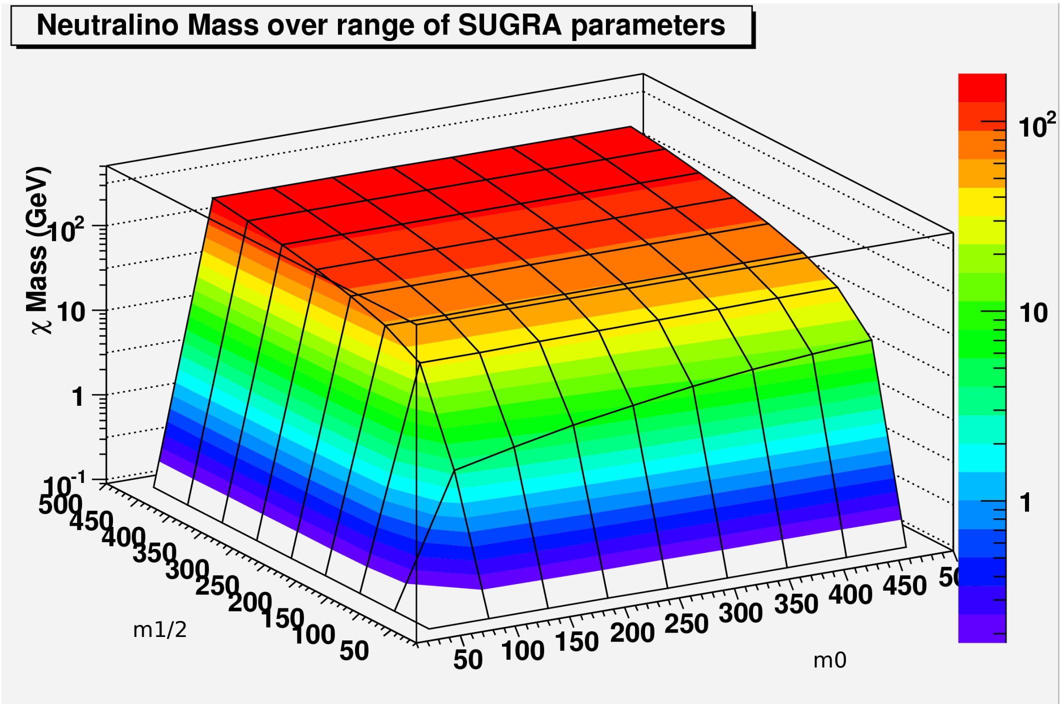
Why Dark Matter?



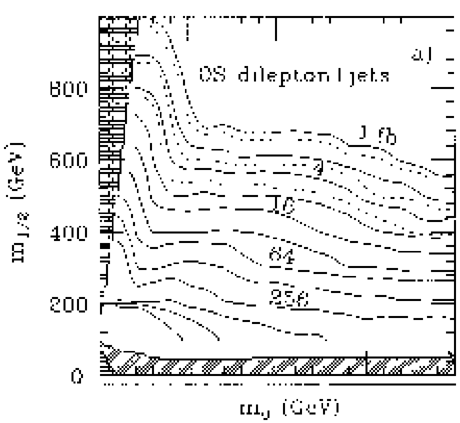


- Explains motion of clusters
- Explains cosmological structure
- Explains galactic rotation curves (Isothermal Halo)

Supersymmetry ♥ Dark Matter

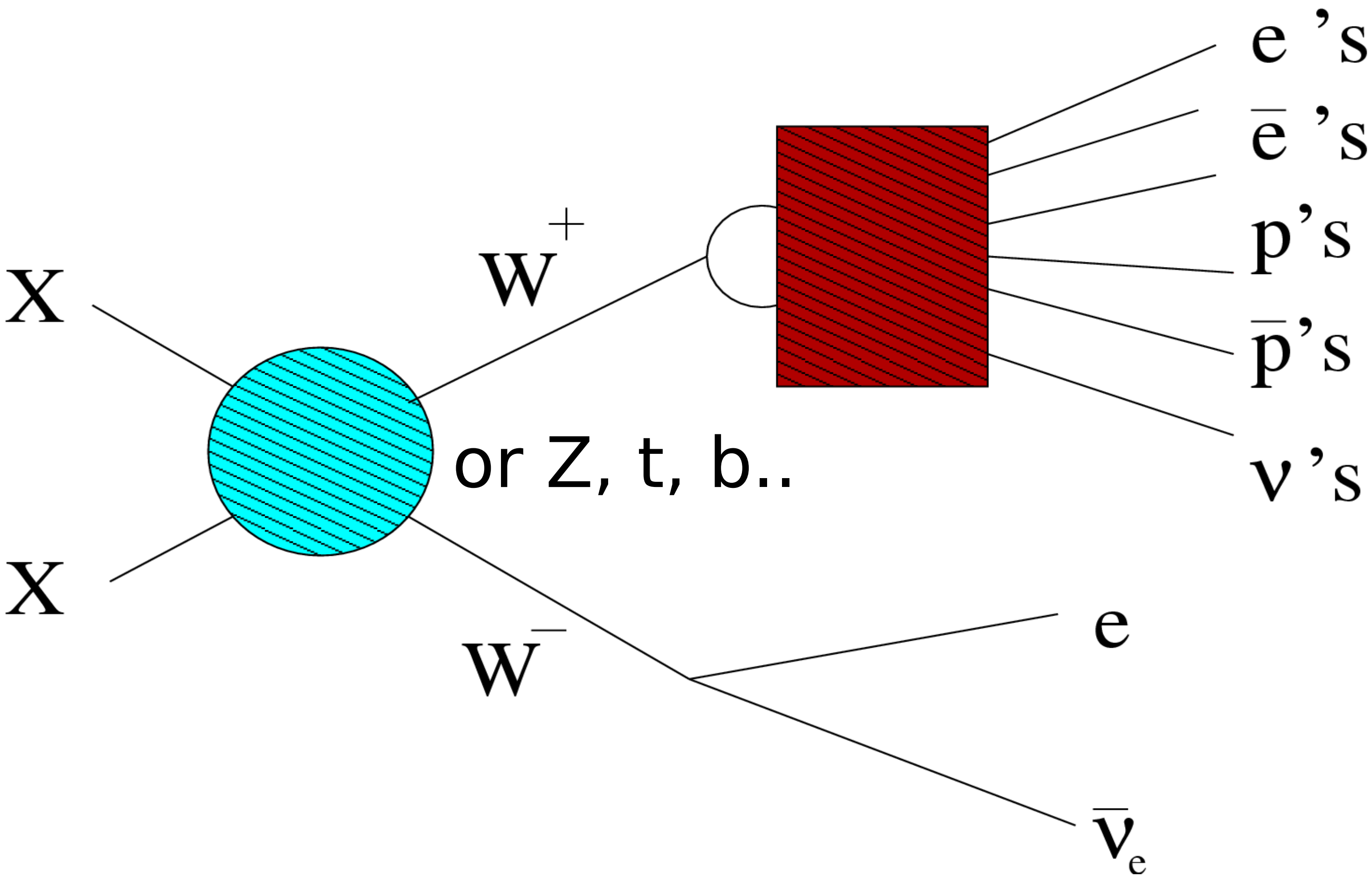


- Predicts the lightest particle, the neutralino, is neutral, massive, and doesn't decay (usually)
- Predicts the neutralino is formed in quantities in the big bang just about enough to account for the mass of dark matter (sometimes)
- Predicts neutralino masses from 100 GeV to 1 Tev (not infrequently)
- Has many unknown parameters (always)



This is the kind of plot one finds in a "Supersymmetry at the LHC" paper

Neutralino Annihilation



Neutralinos may annihilate through many channels, but in the end there are only electrons, protons, neutrinos, their antiparticles, and photons remaining.

Cosmic Rays

Fermi Acceleration

$$P(\text{still in shock at time t } t) = k^t$$

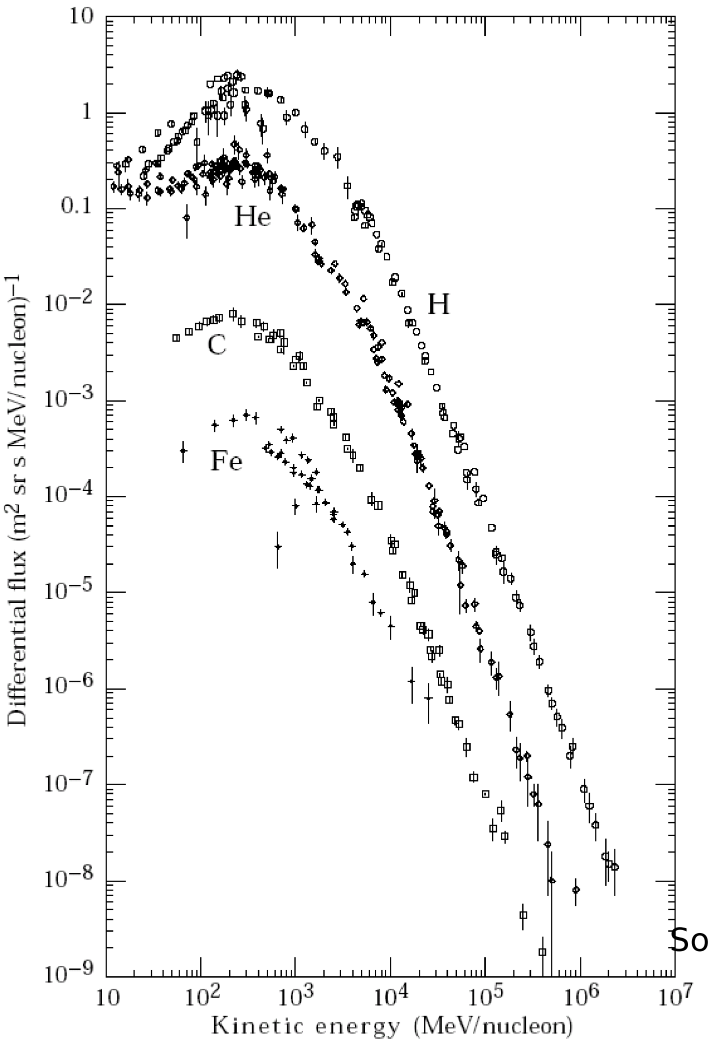
$$E \propto \exp(t) \rightarrow$$

$$P(\text{has energy } E) = k^{\ln E} = E^{\ln k}$$

- Origin: Fermi acceleration of charged particles across supernova shocks
- Constant probability of escape per crossing, and constant energy fraction gain leads to power law spectral shape

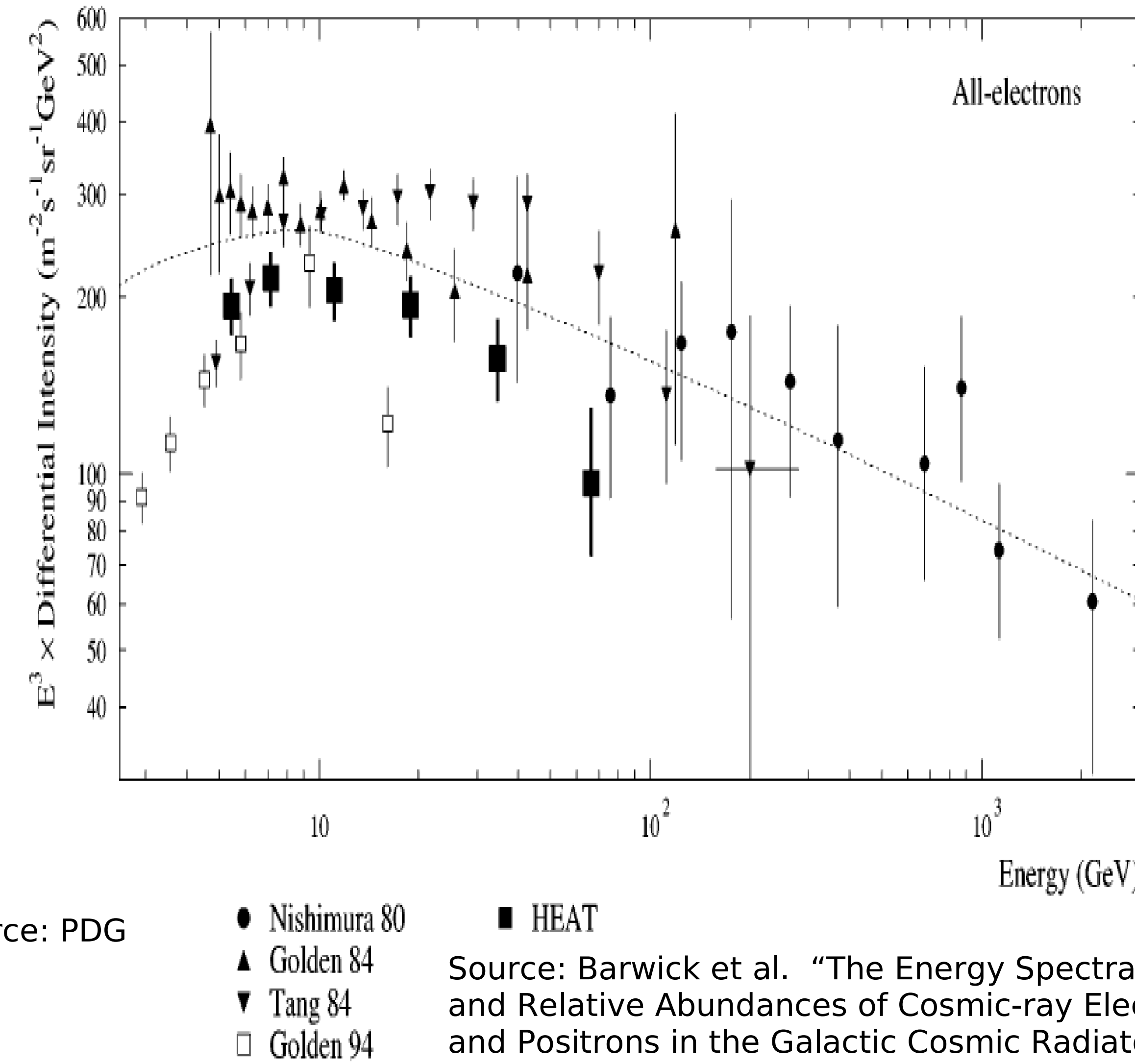
Cosmic Rays

Nuclei Spectra



Source: PDG

Electron Spectrum

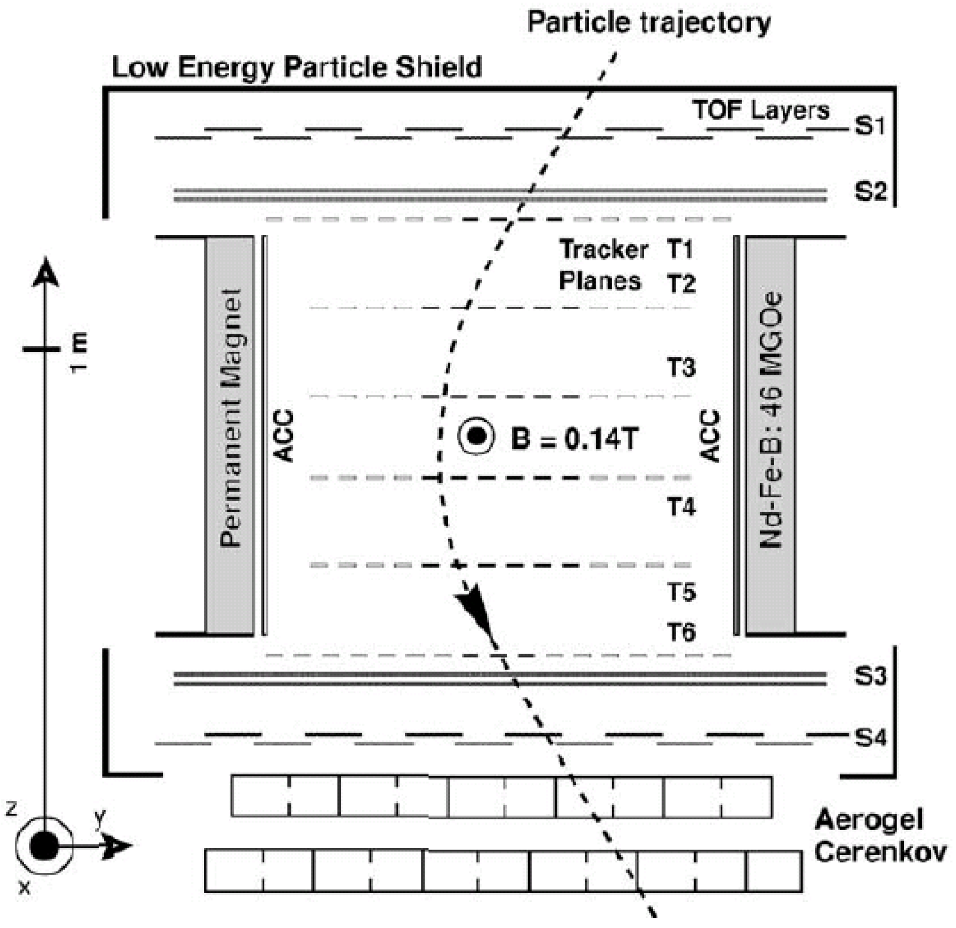


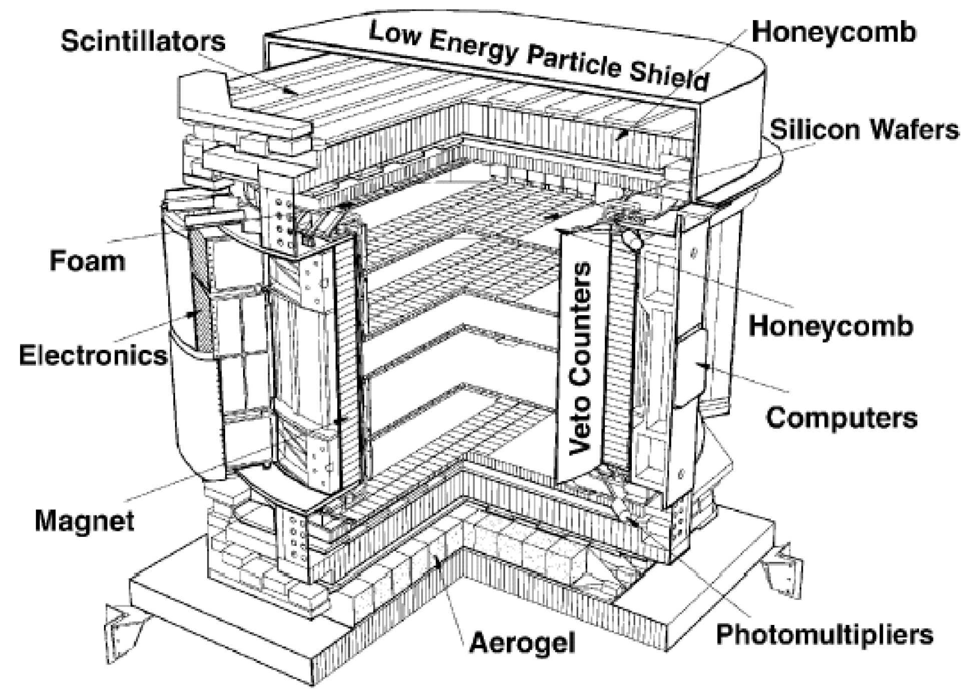
Source: Barwick et al. “The Energy Spectra and Relative Abundances of Cosmic-ray Electrons and Positrons in the Galactic Cosmic Radiaton”, *The Astrophysical Journal* 498(2), May 1998

The electron flux is 1000 times smaller than the proton flux

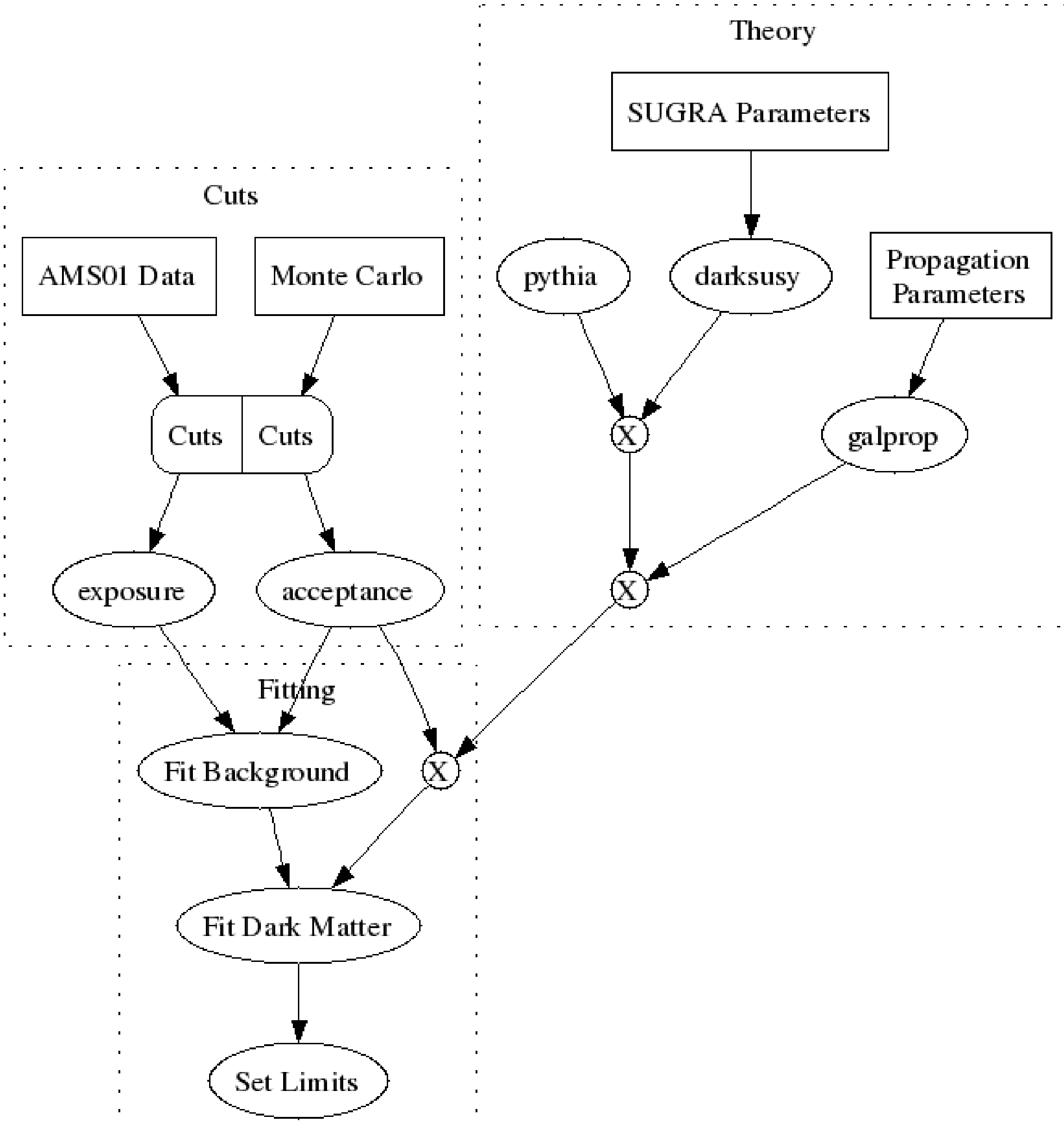
The AMS-01 Experiment

Flown June 2 – June 12, 1998 on Space Shuttle Flight STS-91



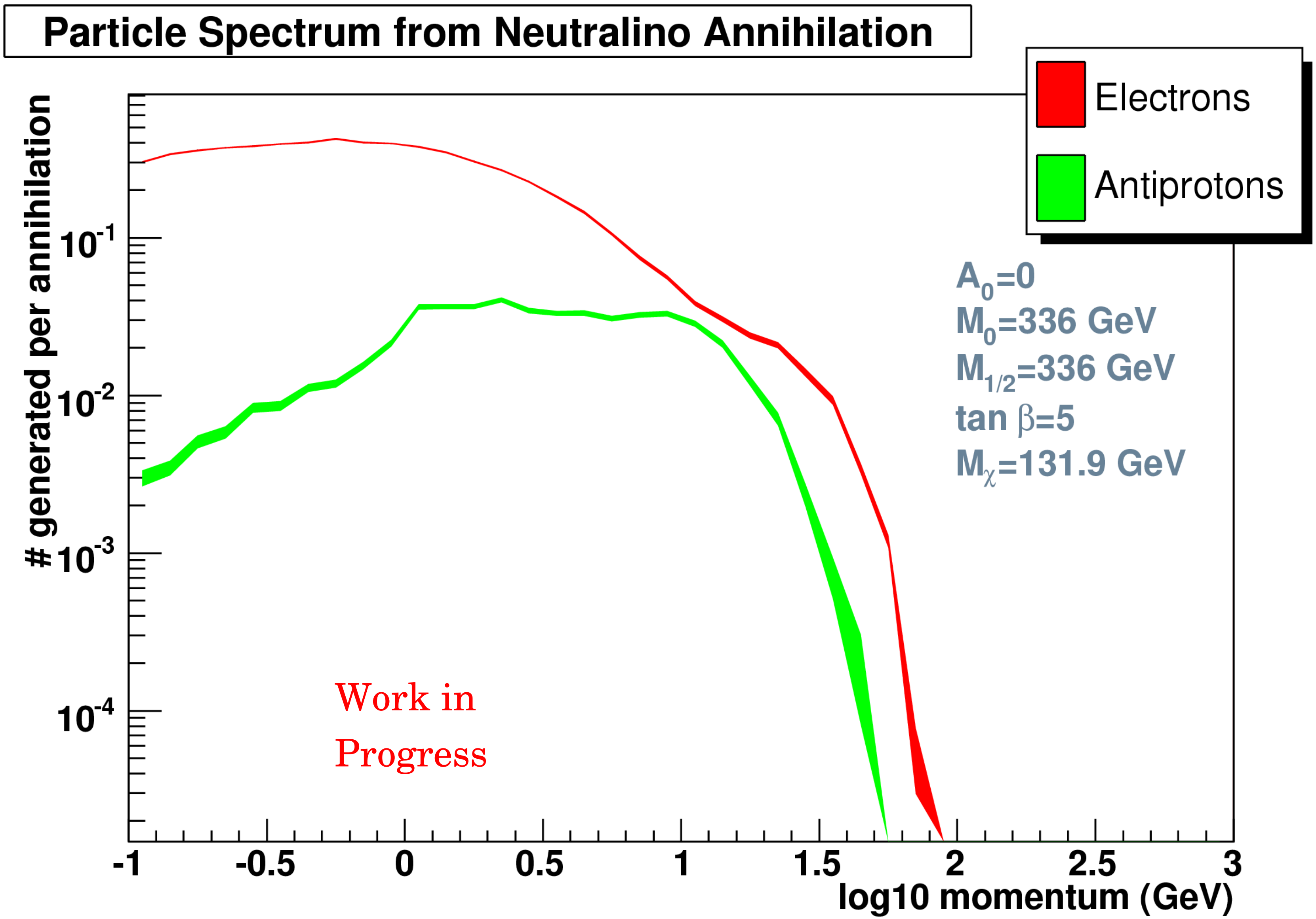


My Procedure



1)From supersymmetric parameters, calculate particle spectra
2)Remove as much background from AMS data as possible
3)Use remaining AMS data to place a limit on neutralino annihilation cross section
4)If my limit is below actual cross section, those supersymmetric parameters are ruled out

Neutralino Annihilation

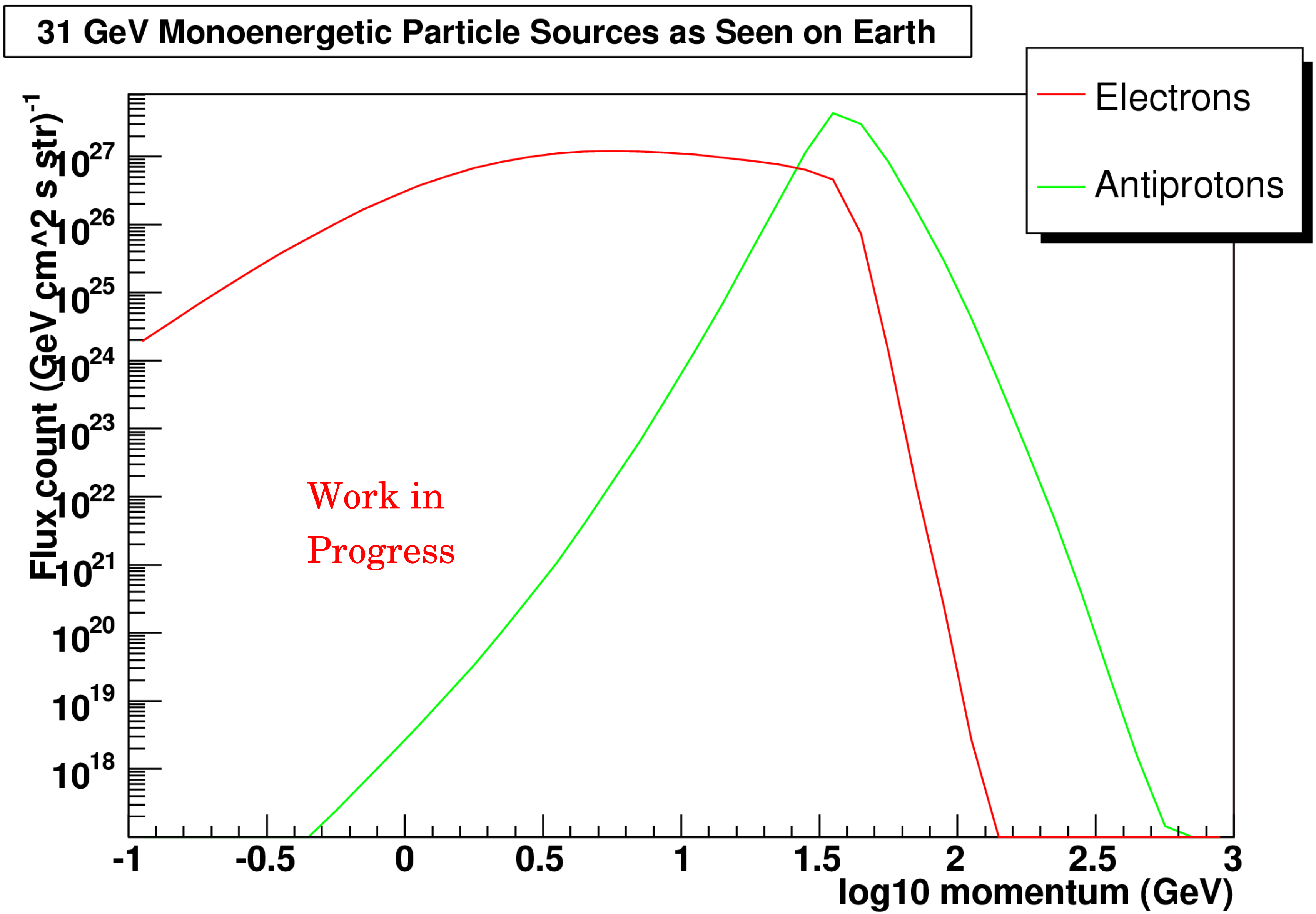


Given Supersymmetric parameters, the programs DarkSusy and Pythia will generate the particle spectrum from neutralino annihilation

DarkSusy: P. Gondolo, J. Edsjö, P. Ullio, L. Bergstöm, M. Schelke and E.A. Baltz,JCAP 0407 (2004) 008 [astro-ph/0406204]

·Pythia: T. Sjöstrand, P. Edén, C. Friberg, L. Lönnblad, G. Miu, S. Mrenna and E. Norrbin, Computer Phys. Commun. 135 (2001) 238 (LU TP 00-30, hep-ph/0010017)

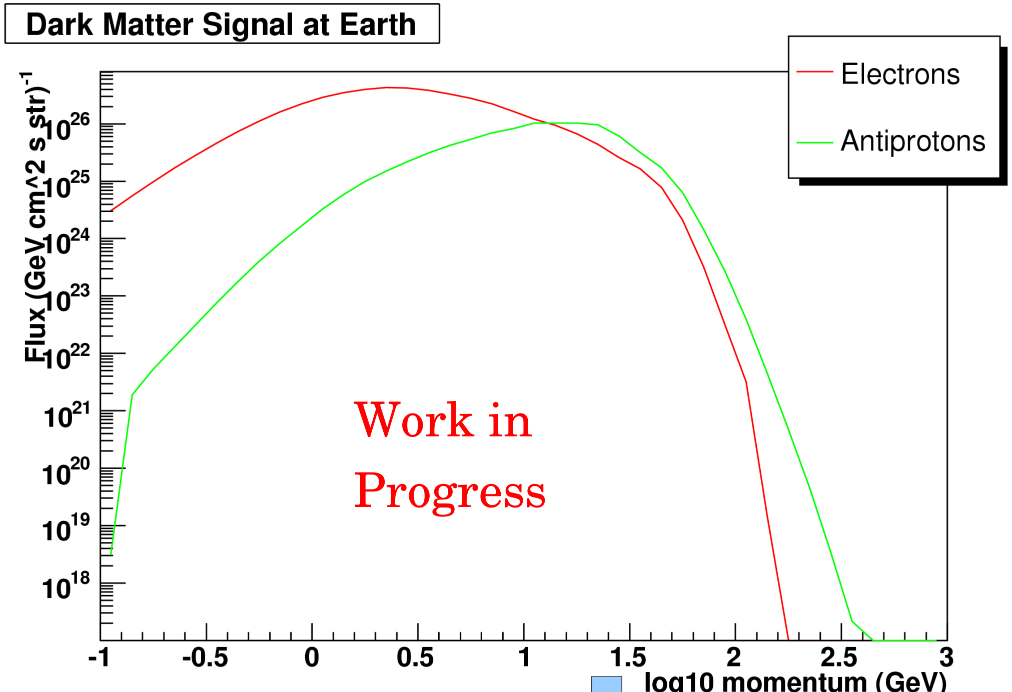
Galactic Propagation

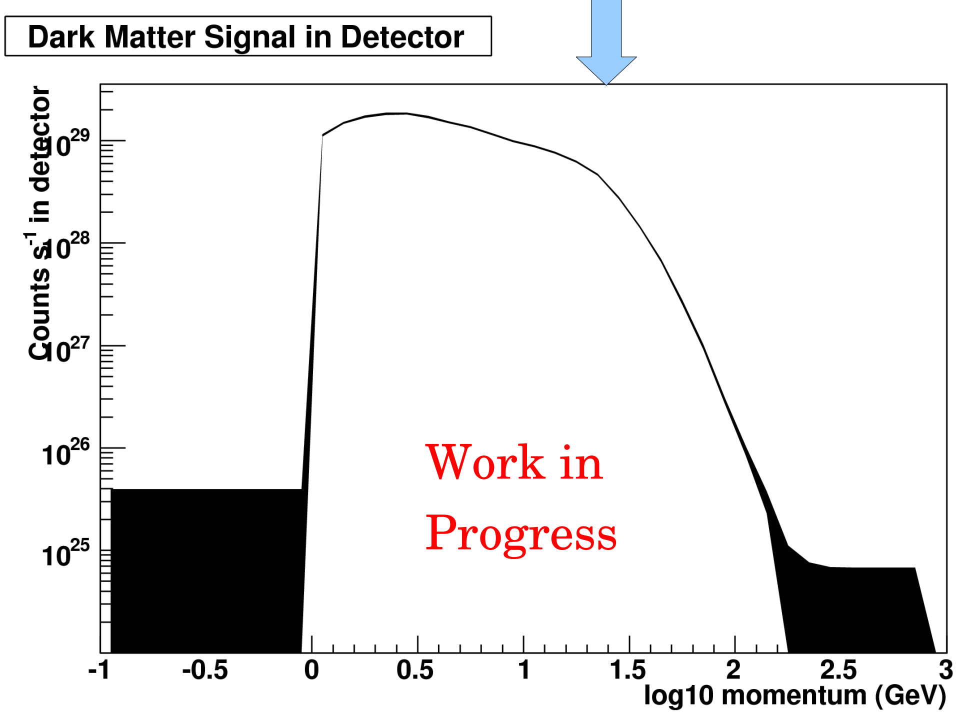


The program Galprop predicts how galactic magnetic fields and shock waves distort the spectra. The effect of the solar wind on lower energy particles is also accounted for.

Galprop: Strong A.W., Moskalenko I.V,"Propagation of cosmic-ray nucleons in the Galaxy" (1998) ApJ 509 , 212

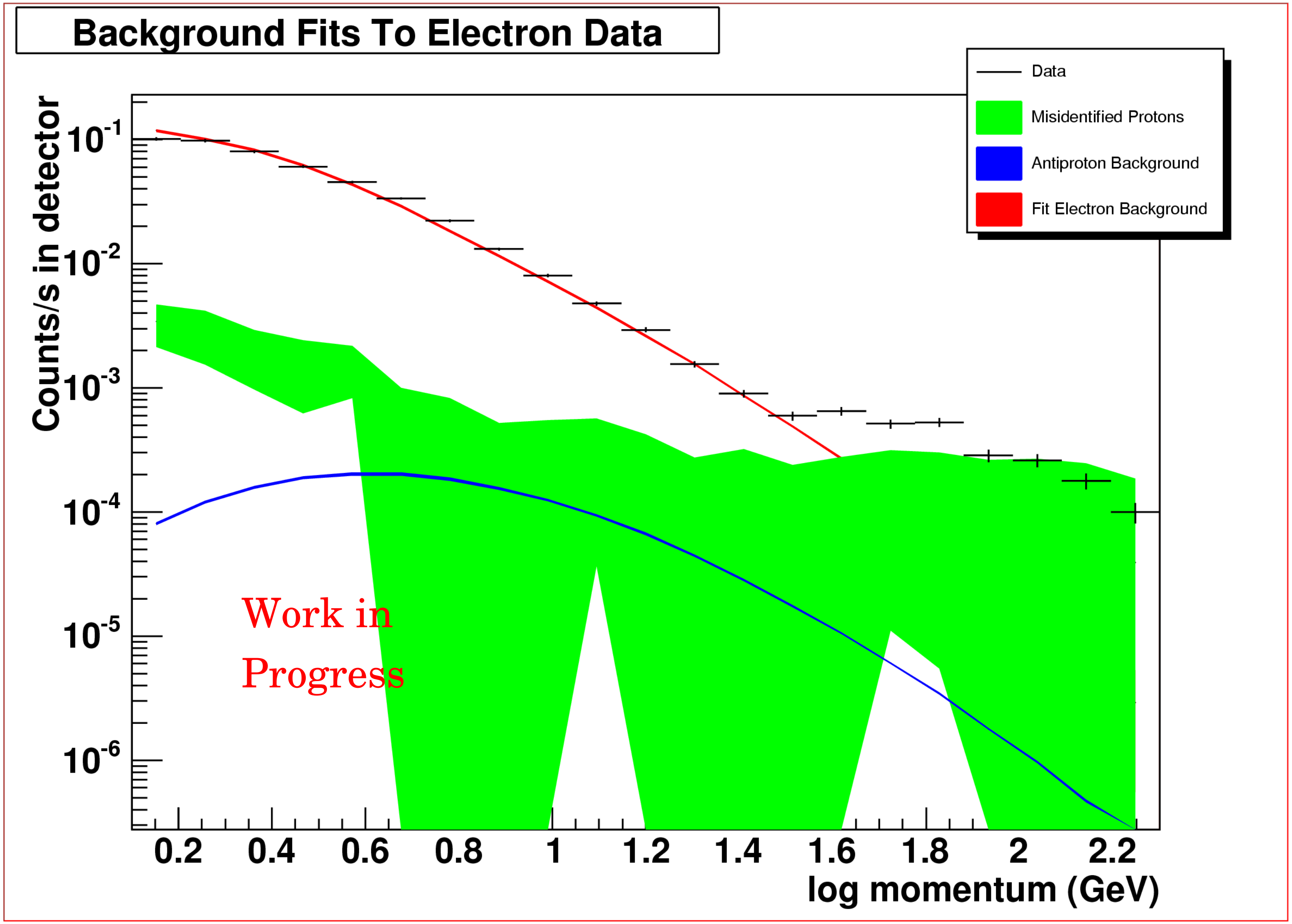
Detector Acceptance





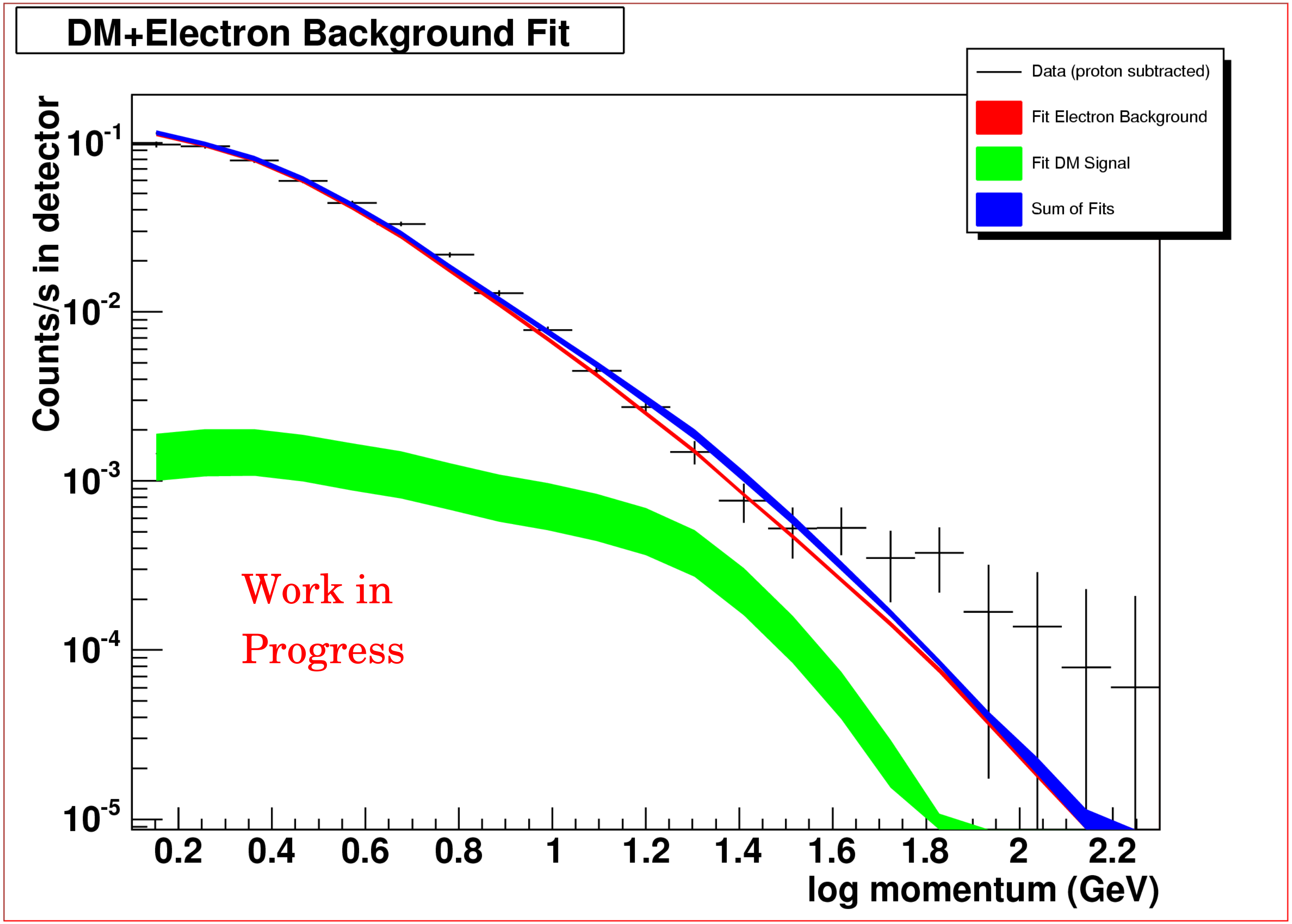
- Need to convert flux to counts per second in each energy bin in the detector.
- The detector has a different efficiency at different energies
- The detector makes mistakes in measuring momentum
- The detector makes mistakes in what is a proton and what is an electron
- We use Monte Carlo to predict the acceptance matrix that deals with all of this.

AMS-01 Data



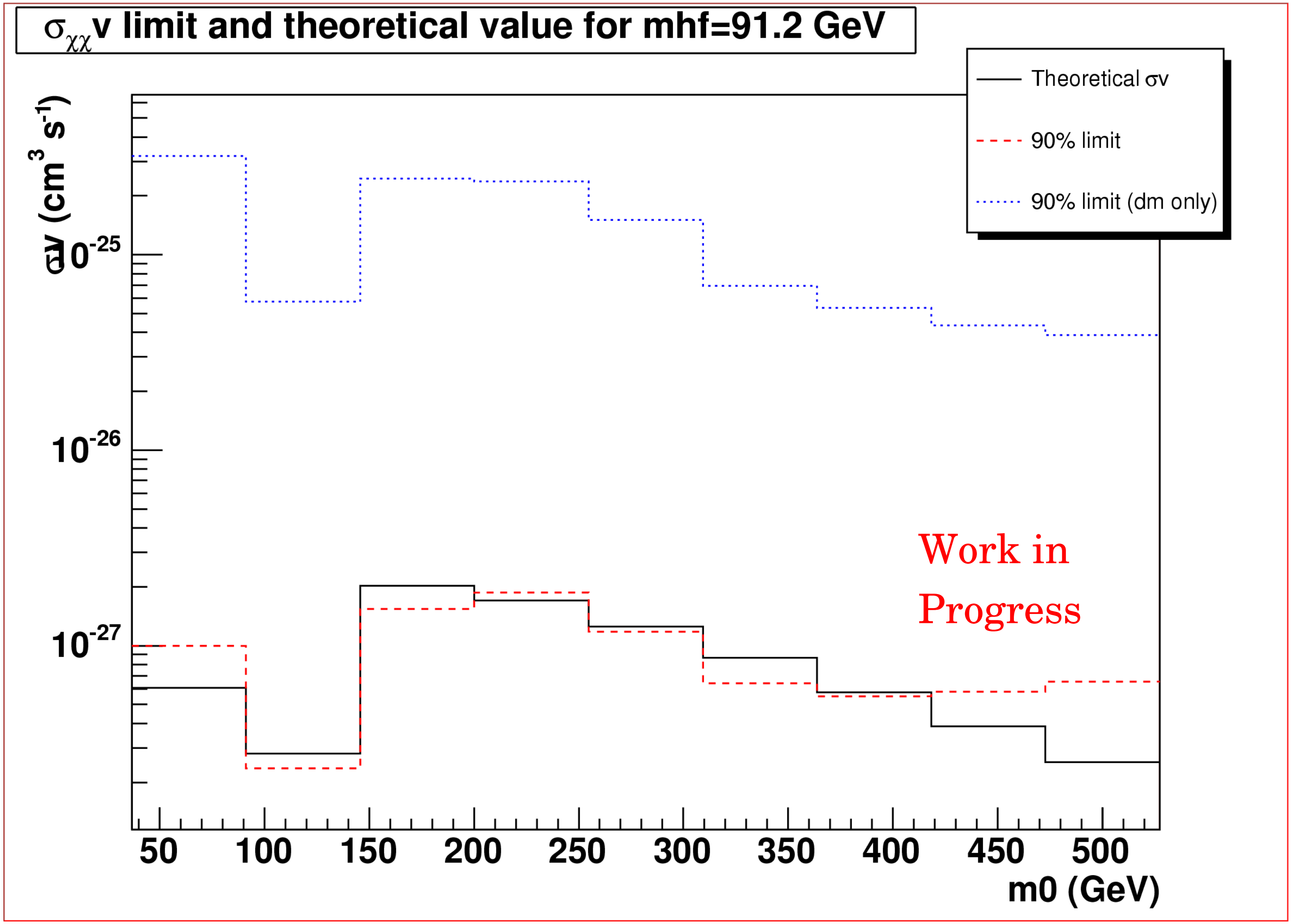
The power law electron spectrum is not the only background; at high energies charge -1 data is dominated by protons whose charge has been misidentified by the detector. The antiproton background is not significant.

Fitting Dark Matter Signal



Being able to fit both background and signal depends on the two having a different shape. Sensitivity is higher at lower energies because there are more statistics and less pollution from protons.

Comparing with Supersymmetric Predictions



Background subtraction gives limits of 2 orders magnitude better; just enough to rule out some areas of supersymmetric space, it seems.

What's Left

- Is the Supersymmetric parameter space I explore complimentary or different from that of the LHC? (or has it already been done)
- How does this compare to other dark matter experiments: Gamma rays, direct detectors?
- Write Thesis Proposal!
- Go back and do everything right this time.