The Detectability of Neutralino Dark Matter in the Large Magellanic Cloud

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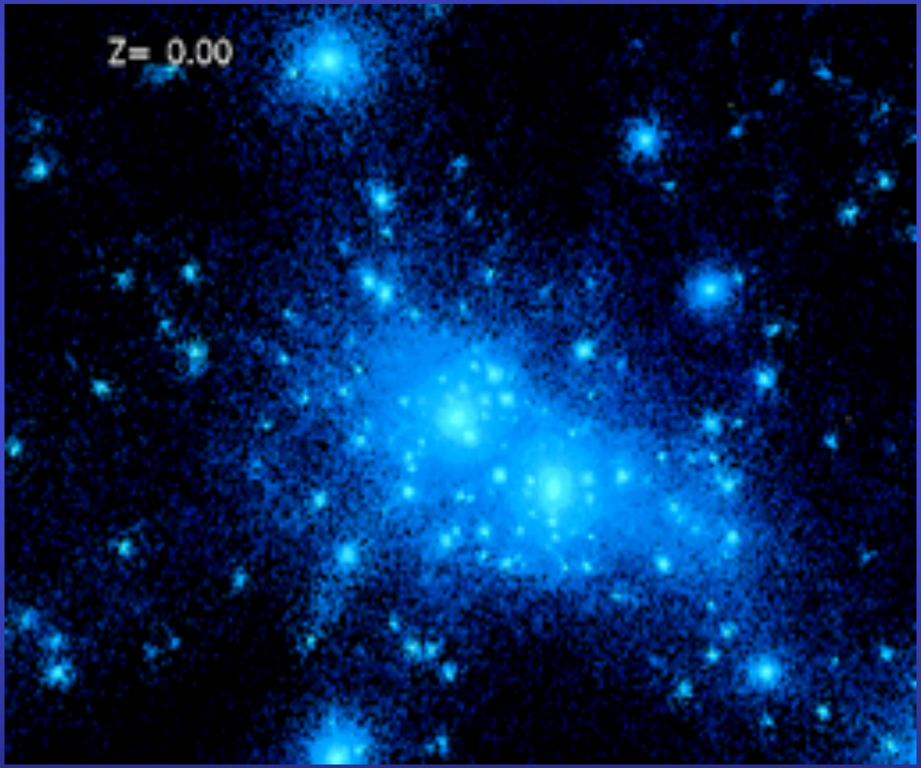
Outline

- The neutralino as Cold Dark Matter (CDM)
- How to detect neutralinos
- The Large Magellanic Cloud (LMC)
- Density profiles
- Gamma-ray emission
- Conclusions

Cold Dark Matter



Visualization by A. Kravtsov. Simulation by A. Kravtsov and A. Klypin at the National Center for Supercomputer Applications.

- successful theory
- predicts abundance of substructure
- neutralino is good candidate particle for CDM

Goal:

to investigate astrophysical and cosmological models

Working Assumption:

dark matter is the typical neutralino

(we use m_χ, $\langle\sigma v\rangle$, spectrum as input)

How to Detect a Neutralino

- Colliders – Tevatron, LHC
- Direct Detection – CDMS, DAMA, EDELWEISS, ZEPLIN1 and others
- Indirect Detection – telescopes to detect $\chi\bar{\chi}$ annihilation products including gamma-rays, synchrotron emission, neutrinos, and other particles

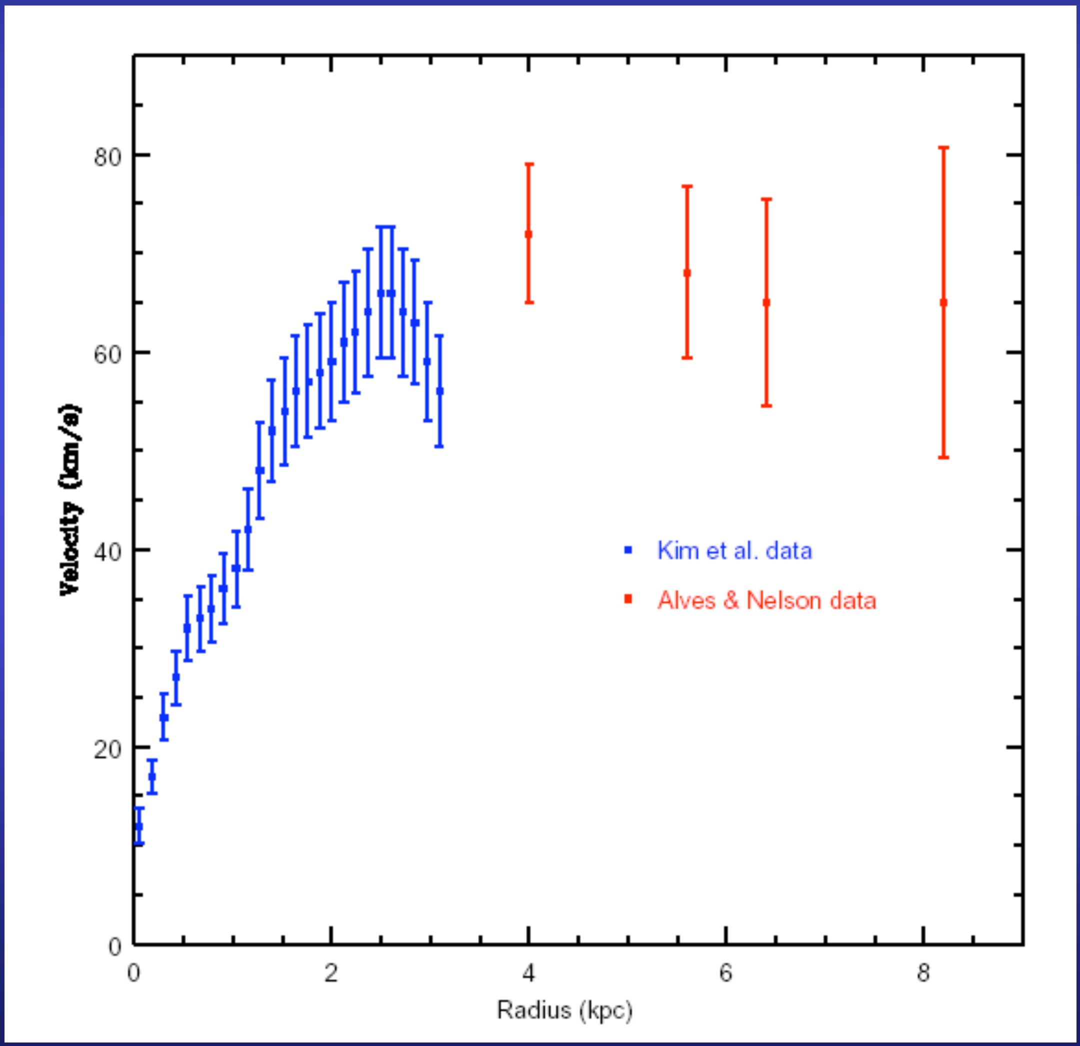
Previous Work

- Dark Matter Clumps – Bergström et al, Calcáneo-Roldán & Moore, Tasitsiomi & Olinto, Ullio et al, Berezinsky et al, Blasi et al, Taylor & Silk, and many others
- Dwarf Spheroidals – Baltz et al, Hooper et al, Evans et al, Tyler, Vassiliev, and others
- LMC – Gondolo (1993)
- M31, M87, Palomar 13, Galactic Center

Why look at the LMC?

- big
- nearby – 50 kpc
- we know where it is
- well-studied
- relatively clean signal
- significant DM content
  - mass ~ 9 x 10^9 M_{sun} within 9 kpc radius
  - bulge M/L of 20-50 (Sofue 1999)

Rotation Curve Data



- Kim et al. (1998): high resolution HI maps
- Alves & Nelson (2000): analysis of velocities of 422 carbon stars from Kunkel et al. (1997)
- radius range of 50 pc to 8.2 kpc

Modeling the Halo of the LMC

NFW profile

$$\rho(r) = \frac{\rho_o}{(r/r_s)\,(1 + r/r_s)^2}$$

Hayashi et al. profile

$$\rho(r) = \frac{f_t}{1 + (r/r_{te})^3}\,\rho_{NFW}$$

Isothermal with core

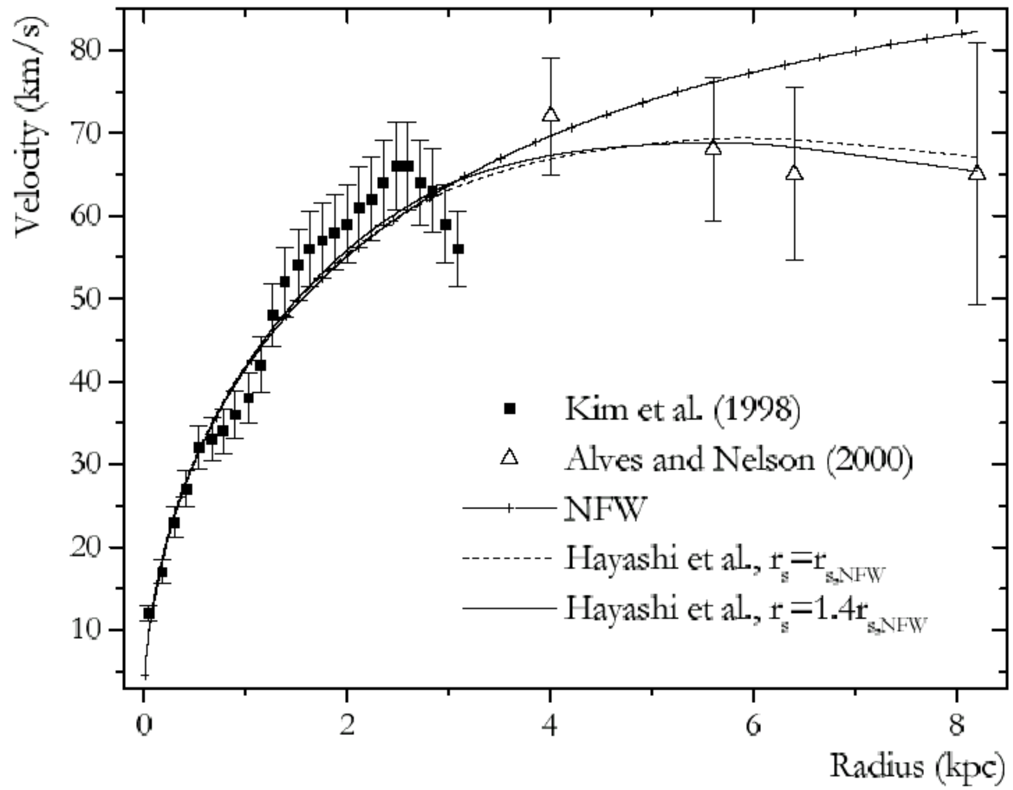
(core radius a = 1 kpc)

$$\rho(r) = \frac{\rho_o}{1 + (\frac{r}{a})^2}$$

Best-Fit Profiles

	ρ_0 (M_{sun}/kpc^3)	r_s (kpc)	r_{te} (kpc)
NFW	1.66×10^7	9.16	n/a
Hayashi et al.	8.18×10^6	9.16	6.12
Hayashi et al. (with tidal stripping*)	5.46×10^6	13.1	4.97

*simulations suggest tidal stripping may decrease scale radius by up to 30%.



Gamma-rays from neutralino annihilation: a WIMPy signal?

Continuum emission: from neutral pions in hadronic jets

Line emission: e.g. $\gamma\gamma$ line at $E=m_\chi$

Continuum Flux:

$$F = \frac{1}{2}\frac{1}{4\pi d^2}\int_0^{r_{max}} j d^3 r$$

$$K = \frac{1}{2}\frac{1}{4\pi d^2}\int_0^{r_{max}} \rho^2(r) d^3 r \qquad F = K\frac{N_\gamma \langle\sigma v\rangle_\gamma}{m_\chi^2}$$

Results: Continuum Gamma Rays

NFW: $K = 3.65 \times 10^{19}$

Hayashi et al: $K = 0.84\text{-}0.85 \times 10^{19}$

Isothermal w/ core: $K = 0.43 \times 10^{19}$

with K given in GeV^2/cm^5

EGRET measured flux of 14.4×10^{-8} $\gamma/cm^2/sec$ (E>100 MeV)

NFW max flux is ~3.3×10^{-9} $\gamma/cm^2/sec$ (E>100 MeV; m_χ=50 GeV; $\langle\sigma v_\gamma\rangle = 2 \times 10^{-26}$ cm^3/sec)

=> suggests significant gamma-ray flux due to CRs!

Relevant Backgrounds

GLAST:

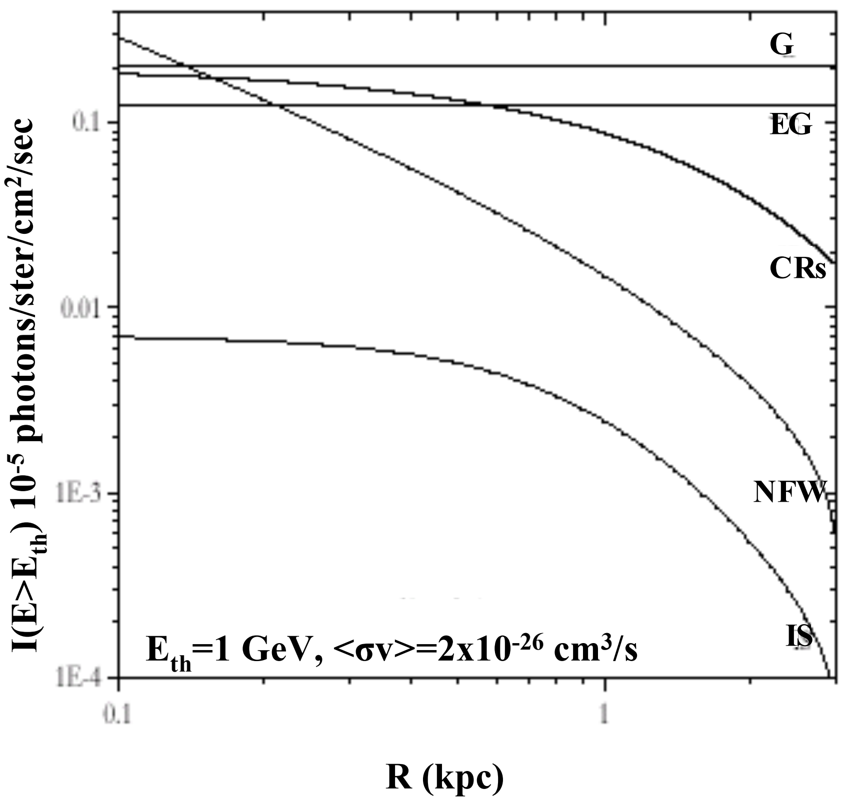
- galactic diffuse emission
- extragalactic diffuse emission
- CR-induced gamma-rays in LMC

ACTs (HESS, CANGAROO III):

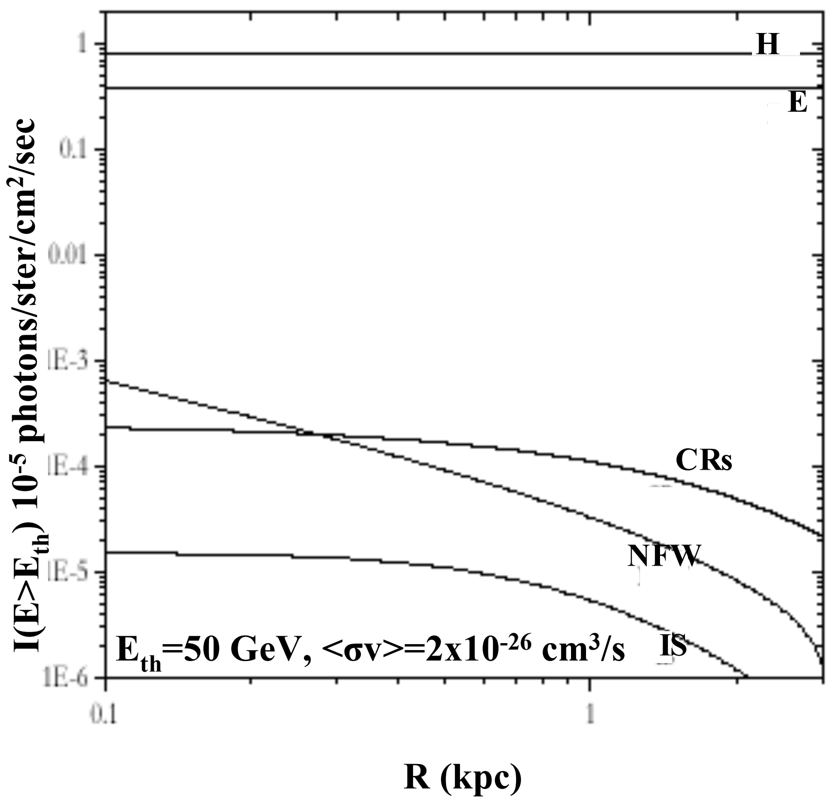
- hadronic CR showers
- electronic CR showers
- CR-induced gamma-rays in LMC

Radial Dependence of Backgrounds

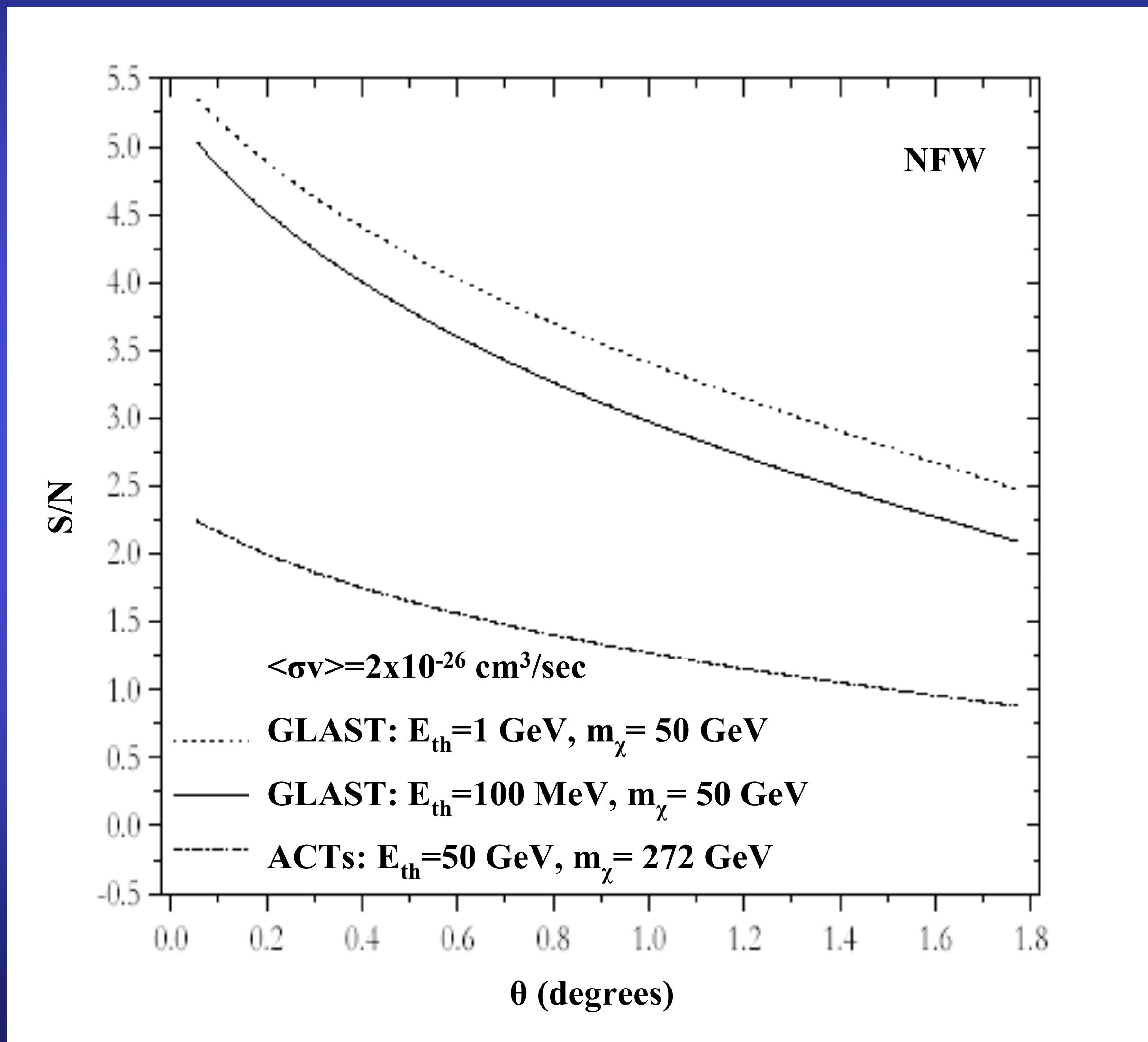
GLAST



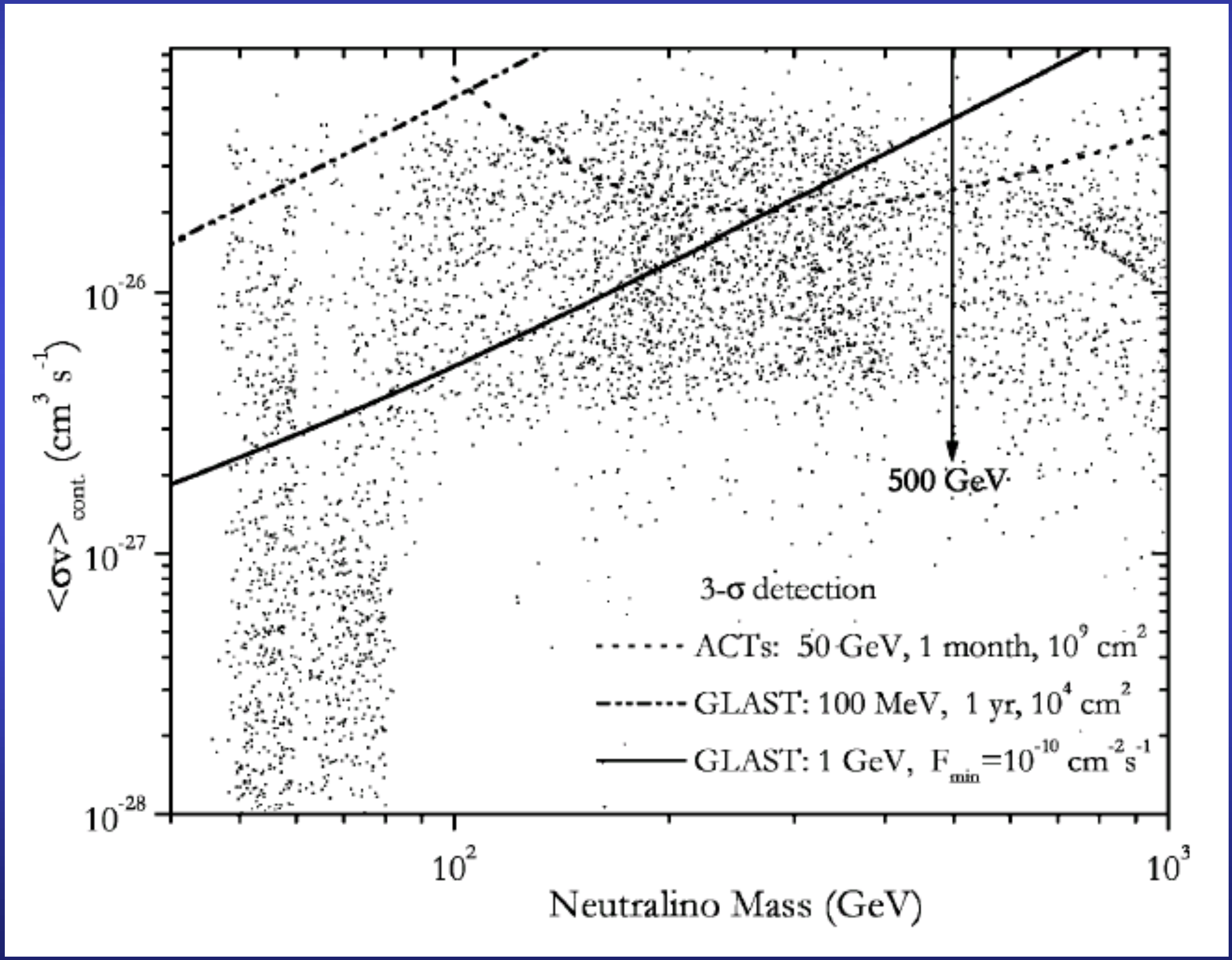
ACTs



Angular Dependence of S/N



Flux Results for Upcoming Instruments



Points representing viable SUSY models generated using DarkSUSY (Gondolo et al., 2002).

Review

- assumed typical neutralino DM
- modeled LMC using observational data and range of profiles
- calculated gamma-ray flux under these assumptions
- compared to old observations and considered possibilities with new instruments

Conclusions

- good possibilities with GLAST
- difficult to detect with ACTs
- baryonic compression may help (Prada et al 2004)
- direct/collider experiments can help focus search