Annihilation radiation from neutralinos in dwarf galaxies

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Outline

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2. Local concentrations of DM.

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3. Gamma-rays from neutralino annihilations.

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4. Conclusions.

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It is of importance to identify the best places to search for any annihilation signal.

The gamma-ray signal

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$$\Phi \sim < \sigma v > \mathcal{N} \frac{1}{m_\xi^2} \int_{los} \rho^2 dl$$

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For a given candidate, it is advantageous to focus on high density regions nearby.

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It is now largely accepted by astronomers that bright galaxies like the MW do not have cusped dark haloes today. Feedback from star formation may provide a resolution with CDM theories. Binney, Gerhard & Silk 01

Some of the predictions for a substantial enhancement in the γ-ray signal might be too optimistic. Stoehr et. al. 03

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Most dwarf spheroidals do not contain gas and so the structure of the dark haloes must be inferred from stellar motions. For the two nearest dSphs - Draco & Sagittarius - there is no direct evidence either for or against central cusps. Having a very large M/L ratio, they offer the best prospects for constraining the LSP parameter space.

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The first set of models of dwarf spheroidal galaxies is the cored spherical power-law models:

$$\rho_{pow}(r) \equiv \frac{v_a^2 r_c^\alpha}{4\pi G} \frac{3r_c^2 + r^2(1-\alpha)}{(r_c^2 + r^2)^{2+\alpha/2}}.$$

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There are two free parameters determining the shape of the profile. The tidal radius must also be estimated.

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$$M(r) = -\frac{r\left\langle v_r^2\right\rangle}{G}\left(\frac{d\log\nu}{d\log r} + \frac{d\log\left\langle v_r^2\right\rangle}{d\log r} + 2\beta\right).$$

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The extent of the dark matter haloes is derived from the Roche criterion:

$$\frac{M_{dSph}(r_t)}{r_t^3} = \frac{M_{MW}(r_{dSph} - r_t)}{(r_{dSph} - r_t)^3},$$

Gamma-rays from neutralino annihilations

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Supersymmetry alleviates the hierarchy problem in the standard model of particle Physics. In models where *R-parity* is conserved, it is common to find in the spectrum a neutral stable particle with mass and interactions at the weak scale. Its relic density can fall in the range favoured by observations. The neutralino can annihilate, giving photons, via higher order processes. `Jungman et. al. 96, Bergström & Ullio 97`

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The most general MSSM has too many parameters and some assumptions are required for doing phenomenology. One approach is to assume some simplified pattern of supersymmetry-breaking at the GUT scale. We focus on mSUGRA models with universal gaugino, scalar masses and trilinear terms at the supergravity scale. We scan the mSUGRA parameter scale and compute the renormalization-group evolution down to the weak scale. Drees et. al. 97, Feng et. al. 00, Ellis et. al. 03

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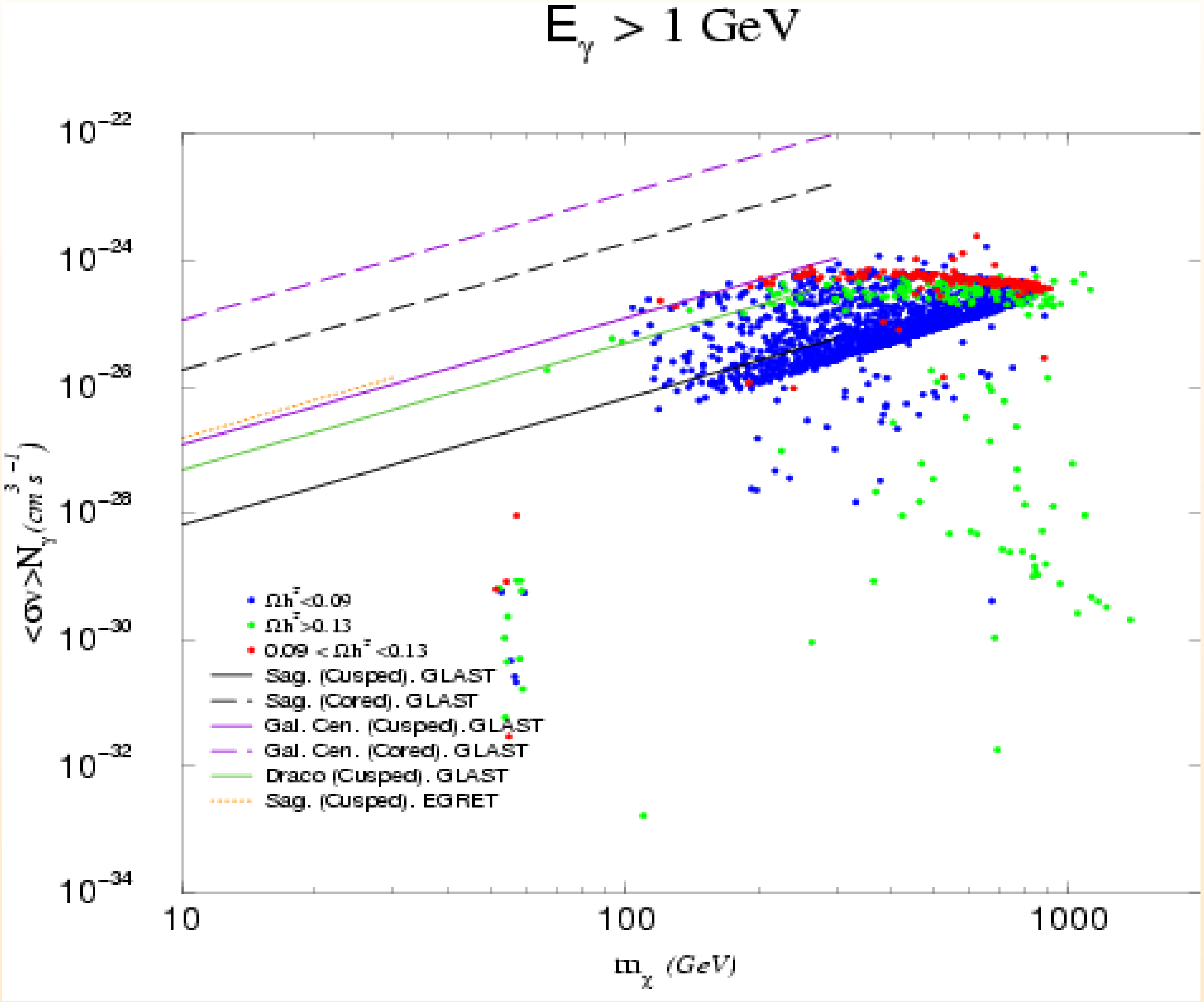
Once at the weak scale, we select the feasible models compatible with both accelerator limits and relic density constraints. Then the γ-ray yield is evaluated and limits from ACTs and satellites on $< \sigma v >$ are derived. Edsjo & Gondolo 97

Continuous emission



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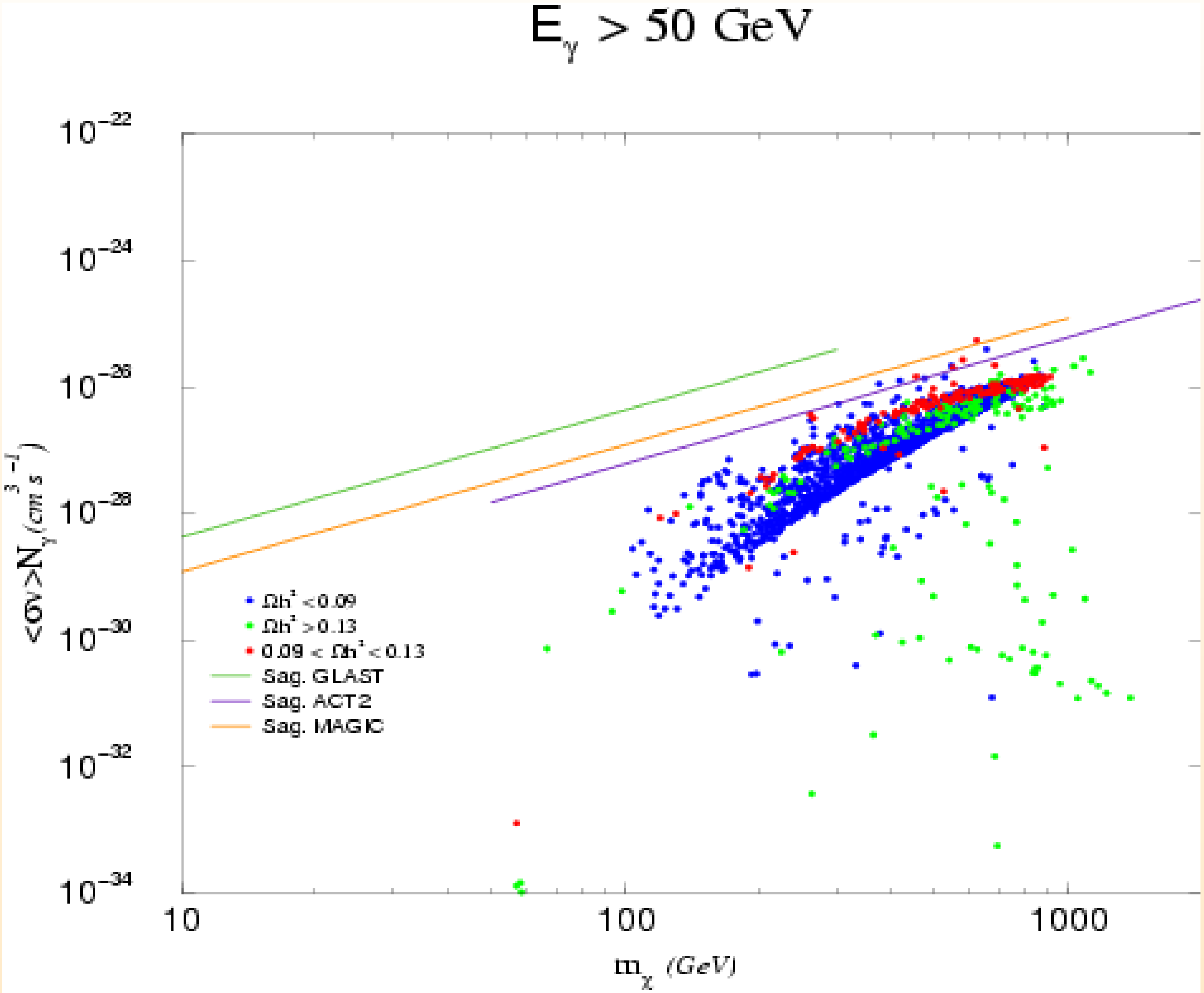
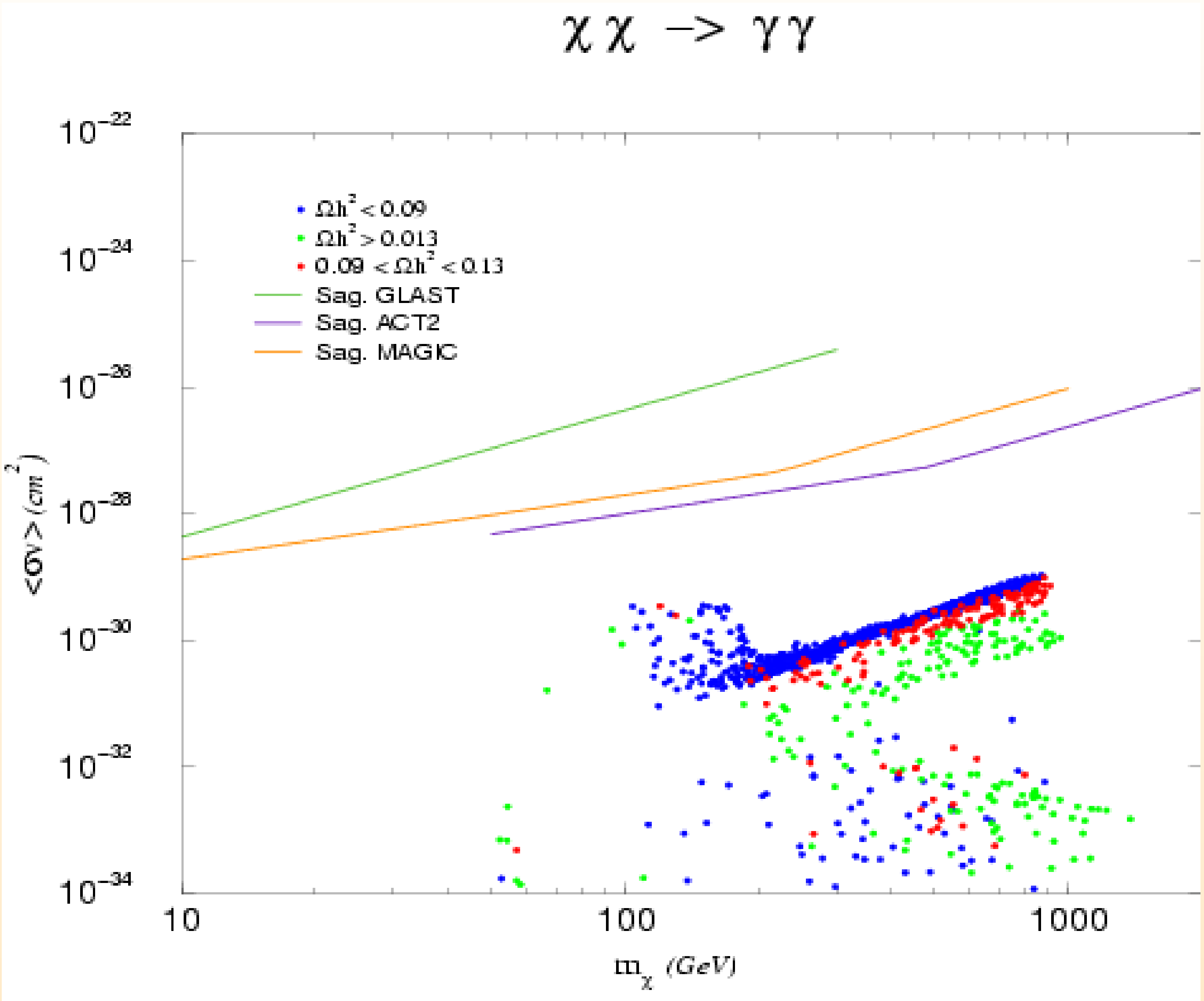


Discrete γ-lines



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The high mass-to light ratios of the local Group dSphs makes them likely targets for GLAST and second generation ACTs, the closest one, the Sagittarius, being the most promising target of all. The detection of monochromatic lines will be difficult but GLAST could detect the excess continuous emission from Sagittarius.

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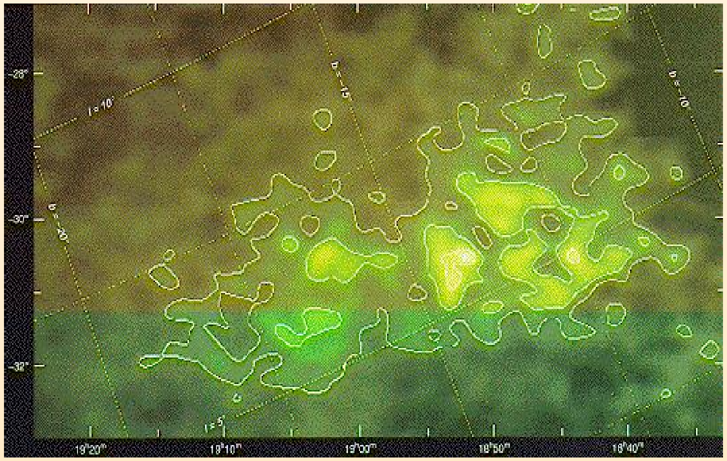
Dark Matter searches complement and benefit from terrestrial accelerator experiments, but also from progress on astrophysics.

The Sagittarius dSph

The recently discovered Sagittarius dSph is the closest example in our neighbourhood giving larger fluxes. Recent observations have found two characteristics of this galaxy that confirm its high DM content:

1. Absence of interstellar matter and/or young stars. It has only an old yellowish stellar population like low surface brightness galaxies.

2. It orbits the Milky Way in less than a billion years. Surprisingly it has not been disrupted after ten crossings of the central dense region of the Galaxy.



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$\left\langle v_r^2 \right\rangle$ is the radial velocity dispersion available from observations. Its gradient is obtained by fitting to the simple functional form $v_0^2 r^2/(r^2+a^2)$. `Kleyna et. al. 02`

ν, the luminosity density, is taken as a Plumer profile:

$$\nu = \frac{\nu_0 r_0^5}{(r_0^2 + r^2)^{5/2}},$$

with $r_0 = 9.71' \approx 0.23$ kpc.

β is the eccentricity assumed, where consistent, to be zero.

Parameter scan

m_0 (GeV)	$m_{1/2}$ (GeV)	$\tan\beta$	A_0 (GeV)
10-10000	10-10000	1-60	10-10000

10^5 mSUGRA models drawn from this region are generated and consistently evolved down to the electroweak scale with SoftSusy. Correct electroweak symmetry breaking and unification of the couplings are enforced. The latest accelerator bounds are also imposed.

The relic density is computed with Micromegas (and double checked with DarkSusy) and those models falling in the region $0.1 < \Omega_m h^2 < 0.2$ are selected.

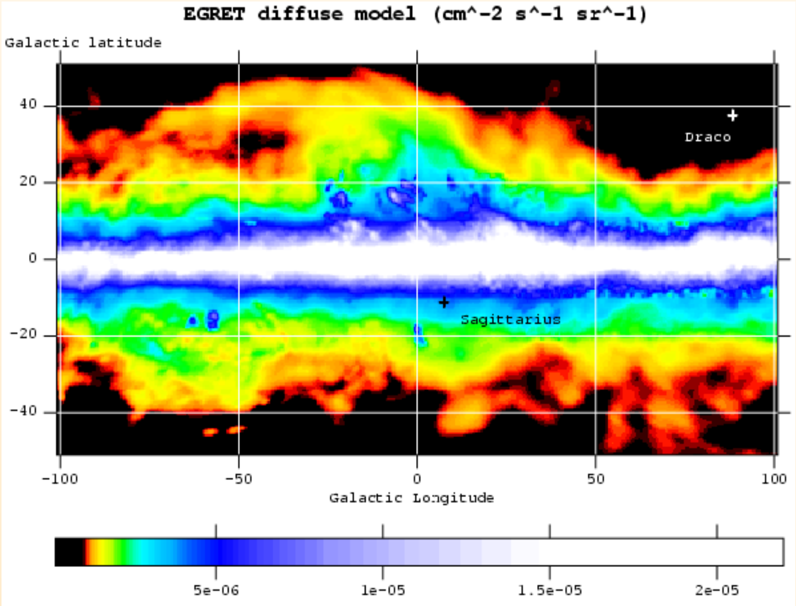
DarkSusy is used to compute cross sections of annihilation into photons.

Selected models are not currently ruled out by direct detection methods or neutrino searches.

HE γ-ray detectors

Air Cerenkov Telescopes have high energy thresholds, moderate energy resolution and large angular accuracy. *Satellites* have good energy and angular resolution.

The diffuse γ background, which depends on the sky coordinates, affects all detectors. ACTs suffer, in addition, from hadronic and electronic backgrounds.



HE γ-ray detectors

	Hess(I)	Veritas	EGRET	Glast	Whip
Energy	40 GeV-10 TeV	50 GeV- 10 TeV	20 MeV-30 GeV	20 MeV- 300 GeV	250 G
σ_E/E	$\approx 10\%$	$\approx 15\%$	$< 10\%$	$\approx 5\% > 10 GeV$	30%
$A_{eff} cm^2$	$10^8 (> 100$ GeV)	$10^8 (> 100$ GeV)	1.510^3	10^4	3.51
$\Phi_{min} cm^{-2} s^{-1}$ steady	$810^{-12} (> 100$ GeV)	$910^{-12} (> 100$ GeV)	$10^{-7} (> 100$ MeV)	$310^{-9} (> 100$ MeV)	
Ang. res. (single γ)	$< 0.1^o$ at 100 GeV	$< 0.1^o$ at 100 GeV	$< 5.8^o$ at 100 MeV	2^o at 100 MeV 0.1^o at 10 GeV	0.15
Field of view	$4.3^o - 5^o$	3.5^o	0.5 sr	2.4 sr	0.001

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