GLAST and the future of High Energy Gamma-ray astrophysics

Aldo Morselli
INFN Roma Tor Vergata, Via della Ricerca Scientifica 1 I00133 Roma, Italy
on behalf of the GLAST Collaboration
E-mail: aldo.morselli@roma2.infn.it

Abstract. The Gamma-ray Large Area Space Telescope (GLAST) is a mission that is being built by an international collaboration with contributions from space agencies, high-energy particle physics institutes, and universities in France, Italy, Japan, Sweden and the United States to measure the cosmic gamma-ray flux in the energy range 20 MeV to 300 GeV, with supporting measurements for gamma-ray bursts from 10 keV to 25 MeV. With its launch in early 2008, GLAST will open a new and important window on a wide variety of high energy phenomena, including black holes and active galactic nuclei; gamma-ray bursts; the origin of cosmic rays and supernova remnants; and searches for hypothetical new phenomena such as supersymmetric dark matter annihilations, Lorentz invariance violation, and exotic relics from the Big Bang.

1. Introduction
A revolution is underway in our understanding of the high-energy sky. The early SAS-2 and COS-B missions led to the EGRET instrument on the Compton Gamma-Ray Observatory. EGRET performed the first all-sky survey above 50 MeV and made breakthrough observations of high-energy gamma-ray blazars, pulsars, delayed emission from gamma-ray bursts, high-energy solar flares, and diffuse radiation from our Galaxy and beyond that have all changed our view of the high-energy Universe. The largest class(es) of high-energy sources revealed by EGRET have not yet been identified. The Large Area Telescope (LAT) on the Gamma-ray Large Area Space Telescope (GLAST) mission, offers enormous opportunities for determining the nature of these sources and advancing knowledge in astronomy, astrophysics, and particle physics.

To make significant progress in understanding the high-energy sky, the GLAST LAT, shown in Fig.1, has good angular resolution for source localization and multi-wavelength studies, high sensitivity over a broad field-of-view to monitor variability and detect transients, good calorimetry over an extended energy band to study spectral breaks and cut-offs, and good calibration and stability for absolute, long term flux measurement. Table 1 summarizes the scientific performance capabilities of the LAT. More informations can be found in [1],[2],[3].

GLAST is expected to play a crucial role in indirect Dark Ma searches, thanks both to its ability to perform observations at energy scales comparable to the mass of common DM candidates and to its potential of making deep full-sky maps in gamma-rays, thanks to its large field-of-view.

A theoretically particularly well-motivated type of Weakly Interacting Massive Particle (WIMP) dark matter candidate is the neutralino (see [4] for a classic review) that appears
Table 1. GLAST LAT instrument parameters and performances.
1. Maximum (as function of energy) effective area at normal incidence. Includes inefficiencies necessary to achieve required background rejection. Effective area peak is typically in the 1 to 10 GeV range.
2. High latitude source of $10^{-7}$ cm$^{-2}$s$^{-1}$ flux at $\geq$100 MeV with a photon spectral index of -2.0 above a flat background and assuming no spectral cut-off at high energy; 1 sigma radius; 1-year survey.
3. Assuming a high-latitude diffuse flux of $1.5 \cdot 10^{-5}$ cm$^{-2}$s$^{-1}$ sr$^{-1}$ at $\geq$100 MeV assuming a photon spectral index of -2.1 with no spectral cut-off.

Figure 1. GLAST LAT scheme

in most supersymmetric extensions to the SM as the lightest supersymmetric particle (LSP) and is given by a linear combination of the superpartners of the gauge and Higgs fields.

As an example we show in Figure 2 our estimates of GLAST sensitivity to a dark matter signal via the observation of WIMP annihilation photons (continuum spectrum) in the $m_{1/2}$
Figure 2. GLAST LAT scheme

and $m_0$ mSUGRA parameter plane for $\tan \beta = 55$ and the comparison with the exclusion limits from LHC, LC [5]. This figures have been obtained performing a detailed scan in the mSUGRA parameter space, computing for each model the neutralino induced $\gamma$-ray flux and the relic density. For the region in red, the cosmologically allowed WIMP region, the signal above the blue line ($M_{WIMP} \sim 200$ GeV) is not observable by GLAST due the higher WIMP mass as one moves to higher $m_{1/2}$. The dark matter halo used for the GLAST indirect search sensitivity estimate is a truncated Navarro Frank and White (NFW) halo profile as used in [6],[7]. For steeper halo profiles (like the Moore profile) the GLAST limits move up, covering a wider WMAP [8] allowed region, while for less steep profile (like the isothermal profile) the GLAST limits move down, covering less WMAP allowed region.

A complete study of the Dark Matter search GLAST capabilities is underway [9].

References
[1] P. Michelson et al., [The GLAST LAT Collaboration], The Large Area Telescope on the GLAST Mission, in preparation.
[2] http://www-glast.stanford.edu/, LAT Performance Specifications:
http://www-glast.slac.stanford.edu/software/IS/glast_lat_performance.htm
[3] F. Belli et al., NIM A 570 (2007) 276-280
[4] G. Jungman, M. Kamionkowski and K. Griest, Phys. Rept. 267, 195 (1996) [arXiv:hep-ph/9506380].
[5] H. Baer, et al., JCAP 0408 (2004) 005
[6] A. Cesarini, F. Fucito, A. Lionetto, A. Morselli and P. Ullio, Astropart. Phys. 21 (2004) 267 [astro-ph/0305075].
[7] A. Morselli, A. Lionetto, E. Nuss on the behalf of the GLAST Collaboration, First GLAST Symposium 5-8 February 2007, Stanford University, AIP CP921, 2007, pg.181-183 [astro-ph/0709.1613]
[8] D. N. Spergel, et al., the WMAP Collaboration, astro-ph/0603449
[9] E. A. Baltz et al., Sensitivity of the GLAST Large Area Telescope to Dark Matter annihilation signals, in preparation.