GLAST Sensitivity to Point Sources of Dark Matter Annihilation

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Abstract. We study the prospects for detecting gamma-rays from point sources of Dark Matter annihilation with the space satellite GLAST. We apply the obtained results to the so-called *mini-spikes* scenario, where the annihilation signal originates from large Dark Matter overdensities around Intermediate Mass Black Holes. We find that if these objects exist in the Galaxy, not only GLAST should be able to detect them over a timescale as short as 2 months, but in many cases it should be possible to determine with good accuracy the mass of the annihilating Dark Matter particles, while null searches would place stringent constraints on this scenario.

Keywords: Dark matter, Gamma rays, Supersymmetry
PACS: 95.35.+d, 95.85.Pw, 95.55.Ka, 12.60.Jv

The space satellite GLAST is expected to play a crucial role in indirect DM 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 ($\sim$ 2.4 sr) field-of-view [1].

A theoretically particularly well-motivated type of DM candidate is the neutralino (see [2] for a classic review) that appears 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.

In order to study the LAT sensitivity for DM annihilation signals, we perform a 2 months scanning simulation of the gamma-ray sky as it will be observed by this instrument, based on a parametrization of the instrument response [3].

The extragalactic diffuse background was simulated by extending the EGRET observations to the LAT energy range. The galactic diffuse background model is implemented in the framework of the GALPROP code for cosmic-ray propagation and incorporates up-to-date surveys of the interstellar medium, as well as current models for the interstellar radiation field, updated production functions and inverse scattering calculations [4]. As motivated in [5] we will focus on DM candidates mainly annihilating into $b\bar{b}$, and discuss below how the detection of deviations from the corresponding gamma-ray spectrum may provide useful insights on the nature of the DM particles.

We divided the sky into regions of about 10 degrees in radius, and in each region we placed one DM source. Then, we considered each source separately and let the flux intensity vary from 10^{-4} to 2×10^{-3} ph m^{-2}s^{-1} above 20 MeV. For each intensity, we calculated the significance of the observed signal, given the local background counts, with a maximum likelihood analysis assuming Poisson statistics. By estimating the minimum flux required to discriminate the DM source from the background at a 5σ level on a grid of points uniformly distributed over the sky, we have obtained the sensitivity map shown in Fig. 1 (where we adopted a DM particle mass $m_\chi = 150$ GeV). The sensitivity appears to depend significantly on the Galactic longitude only along the Galactic disk, as expected. At high galactic latitudes a source as faint as 2×10^{-4} ph m^{-2}s^{-1} is resolved, while close to the galactic center a minimum flux of 1.5×10^{-3} ph m^{-2}s^{-1} is required. In a similar way, we can also produce a sensitivity map for a reliable identification of the DM spectral cutoff (see [5]). In Fig. 2 we show some illustrative examples of simulated sources. On the left there is an an example with a moderate diffuse background contribution and a source corresponding to EGRET's faintest detected source. For a more complete description of the figure see [5]. If we apply this analysis to the mini-spikes scenario discussed in Ref. [6], consisting of a population of $\sim$ 100 DM overdensities, dubbed mini-spikes, around Intermediate Mass Black Holes, we found that a large number of these objects can be detected and identified with GLAST, if they exist, while null searches would place extremely stringent constraints on the whole scenario. Although a set of fiducial astrophysical parameters was chosen for the mini-spike scenario, in order to perform this study, the analysis can easily,

CP921, *The First GLAST Symposium*
edited by S. Ritz, P. Michelson, and C. Meegan

and rapidly, be generalized to any other set of parameters.

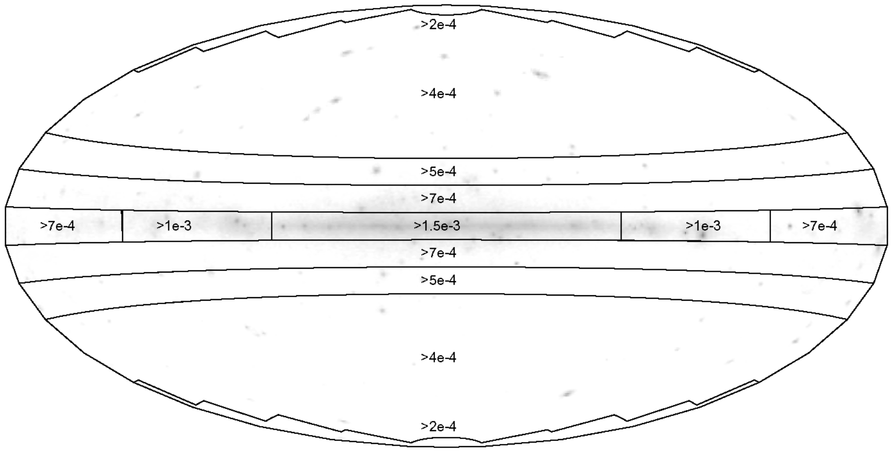

FIGURE 1. GLAST sensitivity map for the *detection* of point sources of Dark Matter annihilations, i.e. full-sky map in galactic coordinates of the minimum flux above 20 MeV, in units of [ph $m^{-2}s^{-1}$], that is required for a 5σ detection of an annihilation spectrum, assuming a DM particle with mass $m_\chi = 150$ GeV annihilating into $b\bar{b}$ (note, however, that the map does not depend very sensitively on DM properties). The map is relative to a 2 months observation period; for longer observation times, fluxes scale approximately as $t_{obs}^{-1/2}$. For reference, we also show the simulated gamma ray sky.

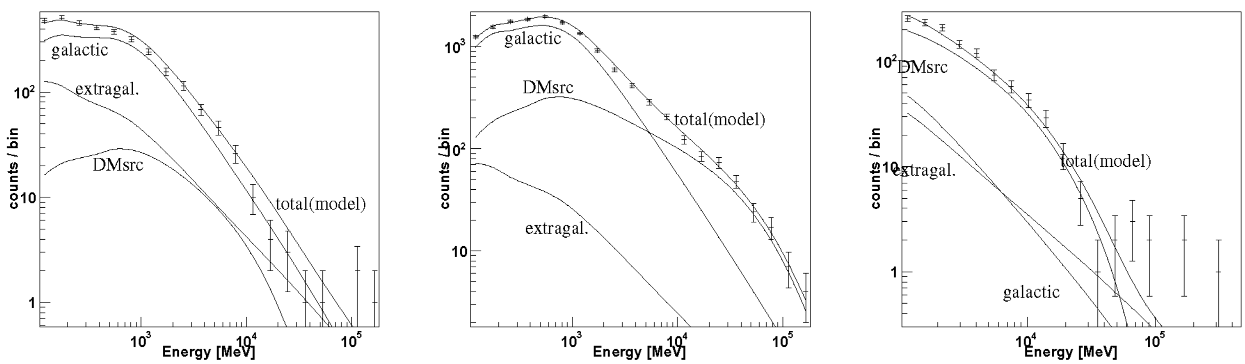

FIGURE 2. Examples of spectral fits of simulated DM point sources of intensity Φ, for different values of m_χ and different annihilation channels. On the left for $\Phi = 2\times10^{-3}$ ph m^{-2} s^{-1}, $m_\chi = 150$ GeV, $b\bar{b}$, (l,b)=(0,25); in the middle for $\Phi = 2\times10^{-2}$ ph m^{-2} s^{-1}, $m_\chi = 150$ GeV, $b\bar{b}$, (l,b)=(50,0) and on the right for $\Phi = 2\times10^{-2}$ ph m^{-2} s^{-1}, $m_\chi = 150$ GeV, 80 % $b\bar{b}$, 20 % e^+e^-, (l,b)=(0,50). Solid lines are fits obtained under the assumption of annihilation to $b\bar{b}$. For each model we also give the significance of the detection. Points with error bars are photon counts from the simulated observation.

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