Simulation of Gamma Rays from Proton Interaction in Local Galaxies

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The GLAST Large Area Telescope (LAT) will provide unprecedented opportunities to detect cosmic GeV gamma rays, thanks to its large effective area, field of view and angular resolution compared with earlier telescopes. Such cosmic gamma rays can be produced by interactions of accelerated protons (or hadrons/nuclei) with surrounding ambient material. Sources include high energy jets in active galactic nuclei (AGN) and gamma-ray bursts (GRBs) as well as extended sources, such as the Large Magellanic Cloud (LMC), supernova remnants (SNRs) and dark matter clumps. For Galactic sources, gamma rays produced by protons interacting with dark clouds may become a serious background (or foreground) contribution. We have calculated the expected gamma-ray spectrum for an isotropic proton distribution in the LMC and simulated a one month GLAST-LAT observation.

INTRODUCTION

It is widely accepted that the diffuse Galactic gamma-ray emission in the GeV range is dominated by decays of neutral pions produced in interactions of cosmic rays and matter. With the sensitivity of the GLAST-LAT it is likely that overdense regions in the Galaxy as well as local external galaxies will be detected as extended sources. The proximity of the LMC makes it a good candidate.

SIMULATING THE LMC

The Large Magellanic Cloud, at a distance of about 51 kpc, is predicted to contribute to the diffuse gamma-ray emission through interactions of cosmic rays (mainly protons) with the interstellar matter in the LMC. Using EGRET, Sreekumar et al. (1992) measured the integrated gamma-ray flux above 100 MeV from the LMC region to be $(1.9 \pm 0.4)\times10^{-7}$ ph. cm^{-2} s^{-1}.

We have simulated the gamma-ray emission due to protons interacting with atomic hydrogen (HI) in the LMC. We take the HI column density (figure 1) from the ATCA/Parkes 21 cm survey (Kim et al. 2003) and used our parameterization of the inclusive gamma-ray cross section (Kamae et al. 2006) to calculate the expected total flux (> 100 MeV) 2.0×10^{-7} ph. cm^{-2} s^{-1} ($274^\circ \le l \le 284^\circ$, $-38^\circ \le b \le -28^\circ$).

Figure 2 shows the predicted flux and the GLAST-LAT differential sensitivity. Simulating a one month observation with the GLAST-LAT yields the gamma-ray image of the LMC as in figure 3.

Future work will include estimates of the H2 density from recent CO surveys (NANTEN) and simulations of the SMC, local dark clouds and perhaps also M31. We will also utilize the deconvolution technique by Tajima (2007) and apply it to EGRET observations.

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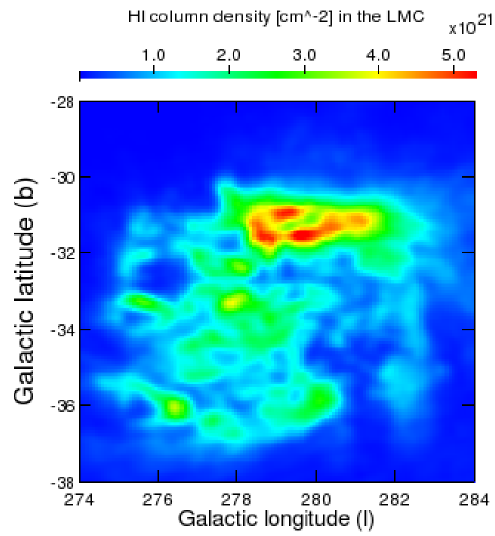

Fig. 1 Column density of atomic hydrogen (HI) in the LMC (Kim et al 2003). The intensity range is from 0 to 6 × 10^{21} atoms cm^{-2}. The angular resolution is 0.07º.

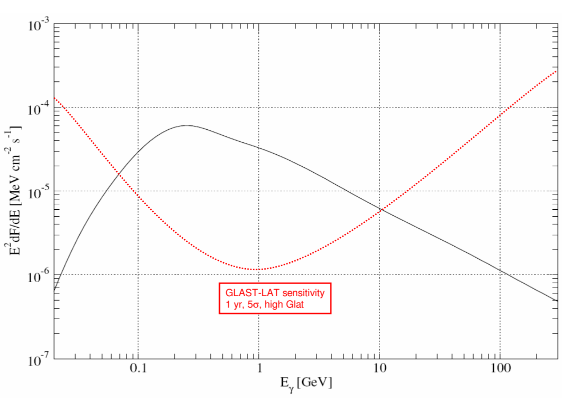

Fig. 2 Predicted gamma-ray flux in the GLAST-LAT range assuming a proton spectrum equal to the local interstellar spectrum, $J_p(E) \propto E^{-2.75}$ (Boezio et al. 2002). Dashed line is the GLAST-LAT differential sensitivity.

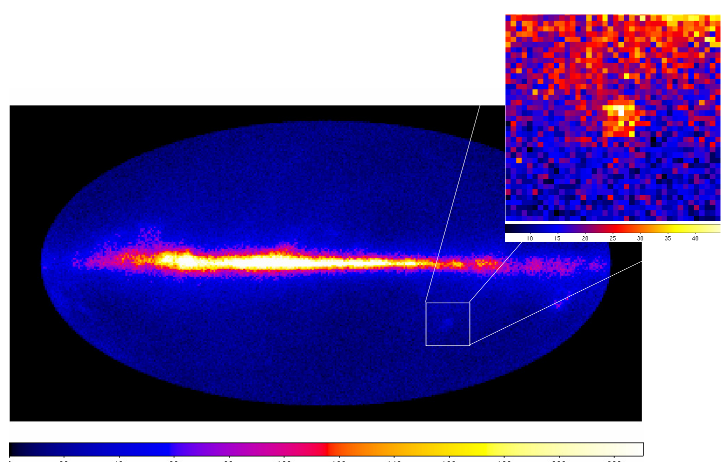

Fig. 3 Gamma-ray all sky count map (1ºx1º bins) from a one month GLAST-LAT simulation of the LMC with both Galactic diffuse and extragalactic background. The inset is a 40ºx40º count map centered on the LMC (l=281º, b=-33º).

References

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Note

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