Estimate for GLAST LAT Milky Way dark matter WIMP Line Sensitivity

KIPAC-SLAC, Stanford University

Jeff Scargle
NASA Ames Research Center

Jan Conrad
KTH Stockholm

Abstract: The LAT Dark Matter and New Physics Working group has been developing approaches for the indirect astrophysical detection of annihilation of dark matter. Our work has assumed that a significant component of dark matter is a new type of Weakly Interacting Massive Particle (WIMP). The annihilation of two WIMPS mostly results in the production of a large number of high energy gamma rays (> 1 GeV) that can be well measured in the GLAST LAT. These searches involve strategies for observation of the galactic center, galactic halo (optimized diffuse all sky analysis), galactic satellites (almost point, high latitude, sources), and cosmological signals in the extra-galactic diffuse. There is also the possibility to observe lines from annihilation into gamma-gamma and/or gamma-Z final states. In the usual SUSY theories these line decays occur at the 0.01% to 1% branching fraction level. The estimates of LAT sensitivity (at 5 sigma) and upper limits (upper limit at the 95% confidence level) depend upon the WIMP model (e.g., line energy and 1 or 2 lines), the DM halo model, and other astrophysical backgrounds. Thus estimates of LAT sensitivity to lines can vary over orders of magnitude depending upon which models are chosen. Preparations for searches with the GLAST LAT for WIMP lines and example sensitivities will be presented.

This work is supported by Stanford University and the Stanford Linear Accelerator Center (SLAC) under DoE contract number DE-AC-03-76-SFO0515 and NASA grant number NAS5-00147 and the NASA Applied Information Systems Research Program. Non-US sources of funding also support the efforts of GLAST LAT collaborators in France, Italy, Japan, and Sweden.

WIMP annihilation cross section at freeze out versus the current time

- WIMP annihilation cross section can be written as $\sigma \propto A^{-1}N^{-1}$
- $A$ is a independent of $v_f$, the freeze out velocity
- $N$ is weakly dependent on $v_f$, quark LOCC2 and LOCC4

Procedure to Calculate LAT Line Sensitivity

1. Run GLAST LAT simulation for a point source at high latitude ($\theta > 70^\circ$, $|\beta| > 20^\circ$) and with a very narrow Gaussian energy distribution ($\Delta E = 10^3$ to 10^5 times the best fit energy)
2. Fit the resulting LAT data to obtain a double Gaussian distribution for $E_1$ = 20, 25, 30, 50, 100 GeV
3. Find continuous intersections for $E_1$, $E_2$, for all $E_1$ and $E_2 = 1.5, 5, 10$ GeV
4. Generate 5 year sky diffuse background from (72-842.51) GeV (GSPC) and astrophysical diffuse for $E_1$ = 10 GeV
5. Assume an annihilation rate of $10^3$ events per second from $E_1 = 20$ GeV
6. An excellent fit for the background is obtained over the range of energy
7. Extract GLAST LAT 5$\sigma$ signal sensitivity for 5 years by bootstrapping the distribution of background and MC generated signal for $E_1$ with 1000 bootstrap per $E_1$, $E_2$, and $N$ and calculate $\chi^2$ of fit
8. Similarly, extract 5$\sigma$ CL, sensitivity for GLAST LAT 5 years by bootstrapping the data and MC generated signal for $E_1$, $E_2$, and $N$, and calculate $\chi^2$ of fit
9. In these fits, $E_1$, $E_2$, and $N$, are fixed at the Poisson resolution fit to $E_1$, $E_2$, and $N$, for the number of events in distribution

Suitable combinations of $E_1$, $E_2$, and $N$ were used to determine the LAT 5$\sigma$ sensitivity for 5 years of operation of the GLAST LAT. The results of this analysis are presented in this work and are a function of the WIMP mass, the line energy and the branching fraction of the WIMP decay to gamma-rays. Further, the results demonstrate the potential of the GLAST LAT for the indirect detection of dark matter in the form of gamma rays and the importance of understanding the astrophysical backgrounds.