Searching for dark matter in the Milky Way halo with GLAST

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Dark Matter

• Evidence for Dark matter
  – Rotation Curves
  – Cluster Dynamics
  – Necessary for Structure formation

• Many candidates for the Dark Matter particle: axion, neutralino, sneutrino, gravitino, and others.
  – Considering neutralino for this analysis.

“Bullet Cluster” (astro-ph/0608407)
Gamma-Ray Large Area Space Telescope (GLAST) Detector

- Segmented anticoincidence detector
- 16 Tower modules in 4 x 4 array
- Each module contains
  - 18 Layers of Silicon Tracker interleaved with Tungsten
  - 8 Layer CsI crystal calorimeter
- For $\gamma$-ray energies above 1 GeV
  - Angular resolution of better than 1°
  - Effective Area $\sim 8000 \text{ cm}^2$
- Launch Scheduled for December 2007
GLAST Full Sky simulations

Full Simulation
(Seth Digel)

Dark Matter
(Baltz et. al. 2006)
Why look in the MW halo?

- High Statistics from using the whole sky
- Allows for sampling of the DM spectra
- Less uncertainties in dark matter profiles outside the galactic center
- Avoid high density of astrophysical sources at the galactic center

(Y. Edmonds et al, First GLAST Symposium, 2007)
Energy Distribution

- With the high statistics from the halo we can measure the spectra of the dark matter signal
- Notice the separation between the diffuse model (black) and the dark matter (colored)
Search for DM over the full Sky

- Pseudoexperiments
  - Sample the model distribution to create an ensemble of independent replications of the same experiment
  - With the samples from *gtobssim* we create pseudo experiments and fit the 3D sky (l,b, and Log E)
  - We extract a fitted mass and number of signal events for each pseudoexperiment
  - From the distribution of fitted signal we can extract the sensitivity for dark matter detection with GLAST
Diffuse and Dark Matter Intensity Maps

- Current contributions to the analysis
  - Dark Matter model
    - Navarro, Frenk, and White (NFW) Dark Matter Profile (Navarro et. al. 1997)
    - Neutralino Mass 50 GeV - 425 GeV
      - Continuum gammas (b-bbar final state only)
  - Diffuse Model
    - Choose the diffuse model GALDEF 599278 “conventional” model
Diffuse and Dark Matter Intensity Maps

Conventional Diffuse Model (E > 1 GeV)

10^{-12} 10^{-11} 10^{-10} 10^{-9} 10^{-8} 10^{-7}

150 GeV Wimp (E > 1 GeV)

10^{-11} 10^{-10} 10^{-9} 10^{-8} 10^{-7}

Galactic Latitude

Galactic Longitude
Simple Test Case

• 1000 Pseudo Experiments
  – 1 Diffuse Model (conventional model, GALDEF 599278)
  – 150 GeV Neutralino Mass
    • NFW Profile
    • \( \langle \sigma v \rangle = 3 \times 10^{-26} \text{ cm}^3 \text{ s}^{-1} \)

• 16 Masses from 50-425 GeV

• For 1 year of GLAST with \( gtobssim \) we obtain
  – 10,200,000 Diffuse Events
  – 5,869 Events from 150 GeV Dark Matter model
Example Log Likelihood

Plot shows a sample fit of a single pseudoexperiment
Each point corresponds to the fit for that mass to the pseudoexperiment
We then repeat this process for each pseudoexperiment

fitted mass 154 +/- 20 GeV
With 1000 pseudoexperiments we obtain a single point in the sensitivity for GLAST. We will then run pseudoexperiments for various masses and cross-sections to obtain the full sensitivity plot.
Summary

• Searching for Dark Matter in the halo allows for high statistics and avoids some of the problems at the Galactic center

• Using pseudoexperiments we can extract the sensitivity of the GLAST experiment to diffuse dark matter emission

• In the future, we plan to add astrophysical sources and examine the systematic errors varying the diffuse model parameters

• Results from this analysis will be included in a pre-launch paper discussing the physics analyses of the GLAST Dark Matter & New Physics Science Group