The Indirect Search for Dark Matter from the centre of the Galaxy with the Fermi/LAT

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on behalf of the Fermi Large Area Telescope Collaboration
Trieste, Sept 10 2010

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Attacking the Galactic Center
Spectral lines:
No astrophysical uncertainties, good source id, but low statistics

Galactic center:
Good statistics but source confusion/diffuse background

Satellites:
Low background and good source id, but low statistics

Milky Way halo:
Large statistics but diffuse background

Search Strategies


And electrons!
and
Anisotropies

Galaxy clusters:
Low background but low statistics

Extra-galactic:
Large statistics, but astrophysics, galactic diffuse background

Trieste, Sept 10 2010 Aldo Morselli, INFN Roma Tor Vergata
Milky Way Dark Matter Profiles

DM density profile fundamental for indirect gamma-ray detection

DM distribution not experimentally known in the GC region

$$\rho(r) = \rho_\odot \left[ \frac{r_\odot}{r} \right]^\gamma \left[ \frac{1 + (r_\odot/r_s)\alpha}{1 + (r/r_s)\alpha} \right]^{(\beta-\gamma)/\alpha}$$

<table>
<thead>
<tr>
<th>Halo model</th>
<th>$\alpha$</th>
<th>$\beta$</th>
<th>$\gamma$</th>
<th>$r_s$ in kpc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cored isothermal</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Navarro, Frenk, White Moore</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Einasto</td>
<td>$\alpha = 0.17$</td>
<td></td>
<td></td>
<td>$r_s = 20$ kpc $\rho_s = 0.06$ GeV/cm$^3$</td>
</tr>
</tbody>
</table>

A.Lapi et al. arXiv:0912.1766

All profiles are normalized to the local density 0.3 GeV cm$^{-3}$ at the Sun's location $r \approx 8.5$ kpc
Different spatial behaviour for decaying or annihilating dark matter

The angular profile of the gamma-ray signal is shown, as function of the angle $\theta$ to the centre of the galaxy for a Navarro-Frenk-White (NFW) halo distribution for decaying DM, solid (red) line, compared to the case of self-annihilating DM, dashed (blue) line.

G. Bertone et al. 2007, JCAP 11, 003B
Differential yield for each annihilation channel

- Quite distinctive spectrum (no power-law)
- Solid lines are the total yields, while the dashed lines are components not due to $\pi^0$ decays

WIMP mass=200GeV

Differential yield for $b\bar{b}$ for different neutralino mass.

Search for Dark Matter in the Galactic Center

• Steep DM profiles ⇒ Expect large DM annihilation/decay signal from the GC!

• Good understanding of the astrophysical background is crucial to extract a potential DM signal from this complicated region of the sky:
  
  • source confusion: energetic sources near to or in the line of sight of the GC
  
  • diffuse emission modeling: uncertainties on the intensity and spectra of the CRs and distribution of gas and radiation field targets along the line of sight
Fermi LAT Observations of the GC

• Extragalactic Diffuse modelled as an isotropic $+3^\circ$ emission with a template spectrum.
• Red and blue profiles do not include point sources
• The diffuse gamma-ray intensity in the GC region is intense & not dominated by the GC region
• Systematic uncertainties in the GC contribution remain large, interstellar radiation and gas

S. Digel, Fermi Symp, Fermi LAT Coll. in preparation
Preliminary Analysis

7° x 7° Region Of Interest centered at RA=266.46° Dec=-28.97°
- 11 months of data
- events from 400 MeV to 100 GeV
- IRFs Pass6_v3
- Diffuse Class events, converting in the front part of the tracker
- Model of the Galactic Center includes:
  - 11 sources from Fermi 1st year Catalog (inside or very near the ROI)
  - Galactic and Extragalactic Diffuse Background
- Binned likelihood analysis using the GTLIKE tool, developed by the Fermi/LAT collaboration
Spectrum  \((E > 400 \text{ MeV}, 7^\circ \times 7^\circ \text{ region centered on the Galactic Center analyzed with binned likelihood analysis})\)

- Preliminary data (stat. error)
- Best diffuse model and isotropic emission
- 12 Fermi 1 year catalog sources

**GC Residuals**  
7°×7° region centered on the Galactic Center  
11 months of data, E >400 MeV, front-converting events analyzed with binned likelihood analysis

- The systematic uncertainty of the effective area (blue area) of the LAT is ~10% at 100 MeV, decreasing to 5% at 560 MeV and increasing to 20% at 10 GeV

![Graph showing GC Residuals](image-url)
Model generally reproduces data well within uncertainties. The model somewhat under-predicts the data in the few GeV range (spatial residuals under investigation).

Any attempt to disentangle a potential dark matter signal from the galactic center region requires a detailed understanding of the conventional astrophysics and instrumental effects.

More prosaic explanations must be ruled out before invoking a contribution from dark matter if an excess is found (e.g. modeling of the diffuse emission, unresolved sources, ....).

Analysis in progress to updated constraints on annihilation cross section.