

Indirect Dark Matter Searches in the Milky Way Center with the LAT on board Fermi

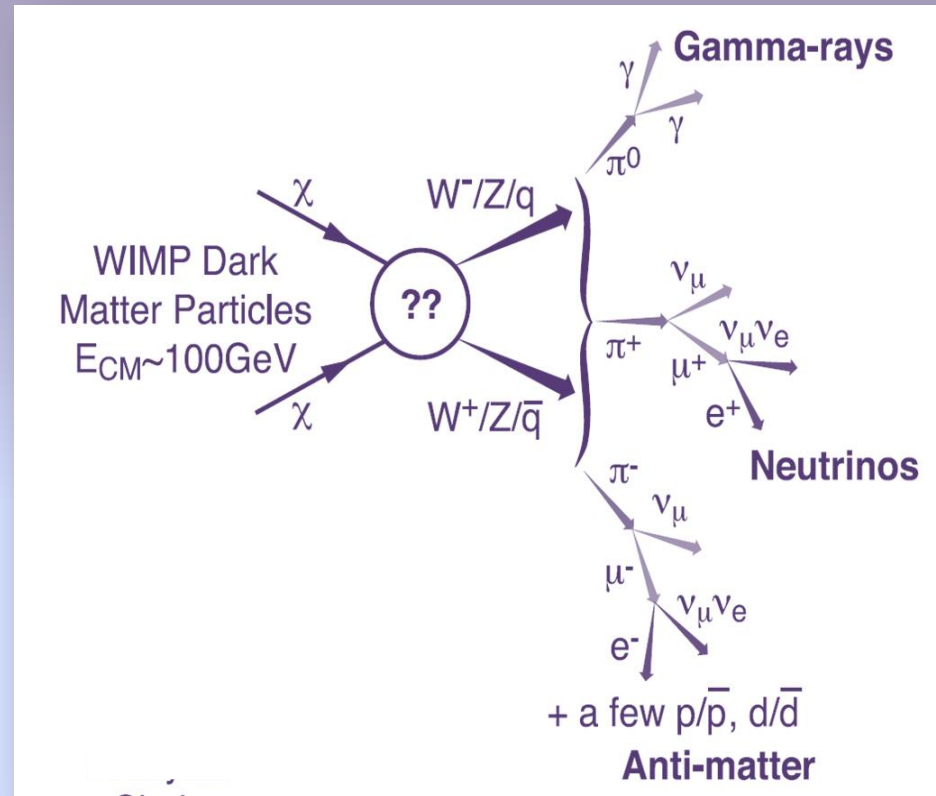
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on behalf of the Fermi LAT Collaboration**

Outline

- Gamma rays from Dark Matter
- Dark Matter distribution in the GC
- Signatures from DM annihilation
- The Galactic Center
 - Other wavelengths & previous observations
 - Diffuse emission & point sources
- Likelihood analysis of the Galactic Center
- Summary and Conclusions

Gamma rays from annihilating Dark Matter

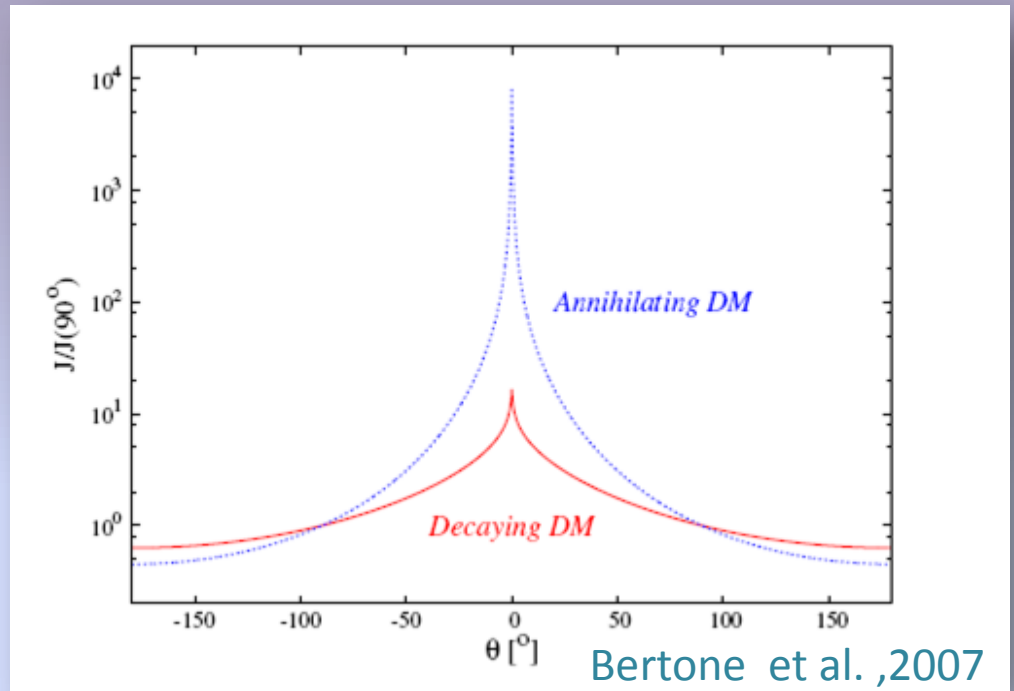
- Dark matter particles might produce gamma rays by self-annihilation.
- Gamma-ray continuum with cut-off at DM mass from hadronization
- Gamma-Gamma production suppressed (10^{-3} - 10^{-4})



$$\phi_{WIMP}(E, \psi) = \frac{1}{2} \frac{\langle \sigma v \rangle}{4\pi} \sum_f \frac{dN_f}{dE} B_f \int_{l.o.s} dl(\psi) \frac{\rho(l)^2}{m_{WIMP}^2}$$

Gamma rays from decaying dark matter

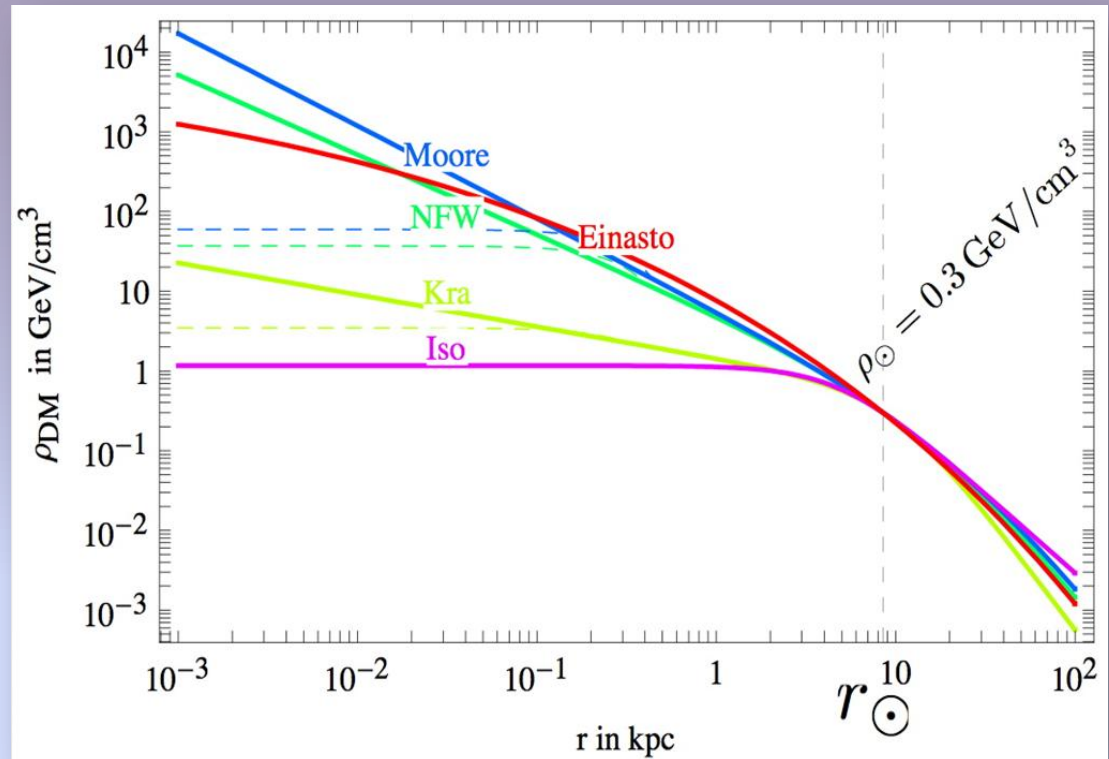
- Pseudo-stable DM particles might decay in gamma rays
- DM life-time in the order of 10^{27} s



$$\frac{d\Phi_\gamma}{dE_\gamma}(E_\gamma, \Omega) = \frac{\Gamma}{4\pi m_{\text{DM}}} \frac{dN_\gamma}{dE_\gamma} \int_{\text{los}} \rho_{\text{DM}}(r, \Omega) dr$$

Dark Matter density profile

- DM density profile fundamental for indirect gamma-ray detection
- DM distribution not experimentally known in the GC region
- Parametrization from N-Body Simulations



$$\rho(r) = \frac{\rho_s}{(r/r_s)^\gamma (1 + (r/r_s)^\alpha)^{(\beta-\gamma)/\alpha}}$$

$$\rho(r) = \frac{\rho_s}{2^{(\beta-\gamma)}} \exp \left[-\frac{2}{\alpha} \left\{ \left(\frac{r}{r_s} \right)^\alpha - 1 \right\} \right]$$

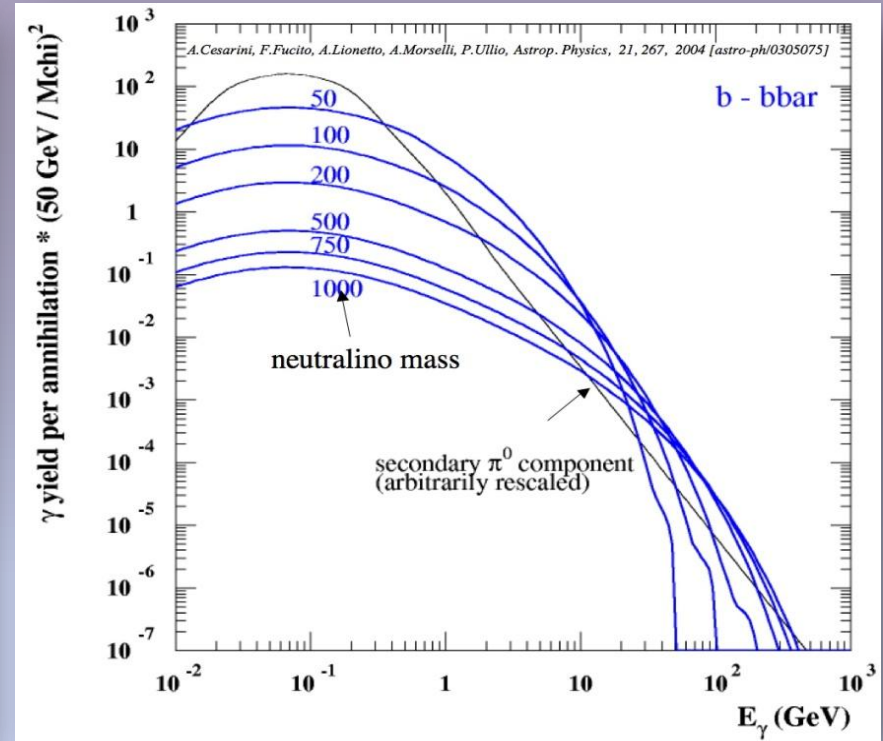
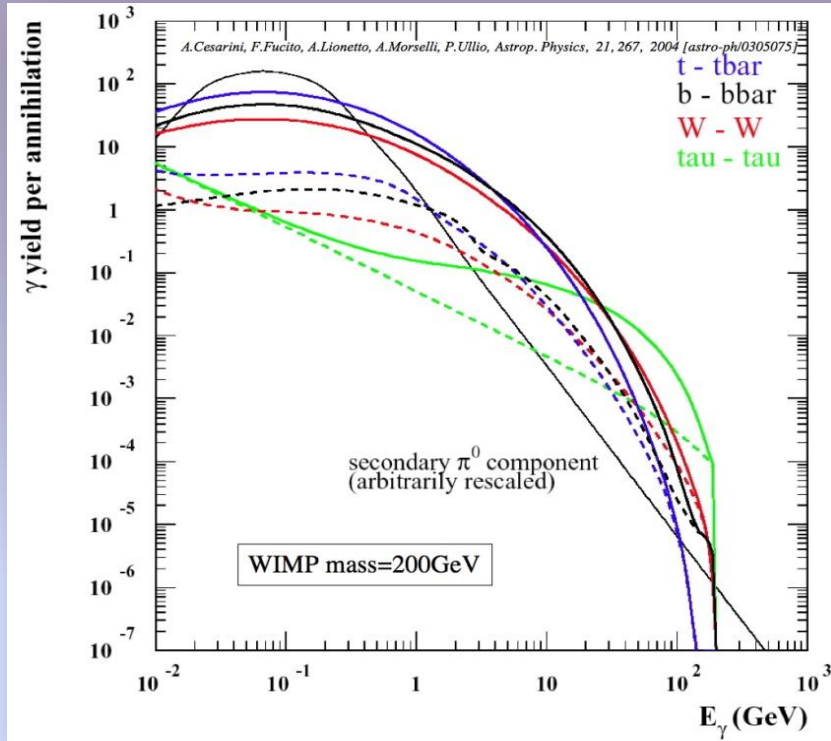
$$\alpha=1.5 \quad \beta=3 \quad \gamma=1.5 \quad r_s = 30 \text{ kpc}$$

$$\alpha=1 \quad \beta=3 \quad \gamma=1 \quad r_s = 20 \text{ kpc}$$

$$\alpha=2 \quad \beta=2 \quad \gamma=0 \quad r_s = 5 \text{ kpc}$$

$$\alpha=0.17 \quad r_s = 20 \text{ kpc}$$

Dark Matter signature



- Quite distinctive spectrum (no power-law)
- Dark Matter annihilation emission is not point-like.
- ... nor isotropic or Galactic-Ridge like (Dodelson et al 2007, arXiv0711:4621)
- Optimal Region of Interest from 0.5 to 10 deg
- Optimal energy threshold from 0.1 to 1 GeV

The Galactic Center

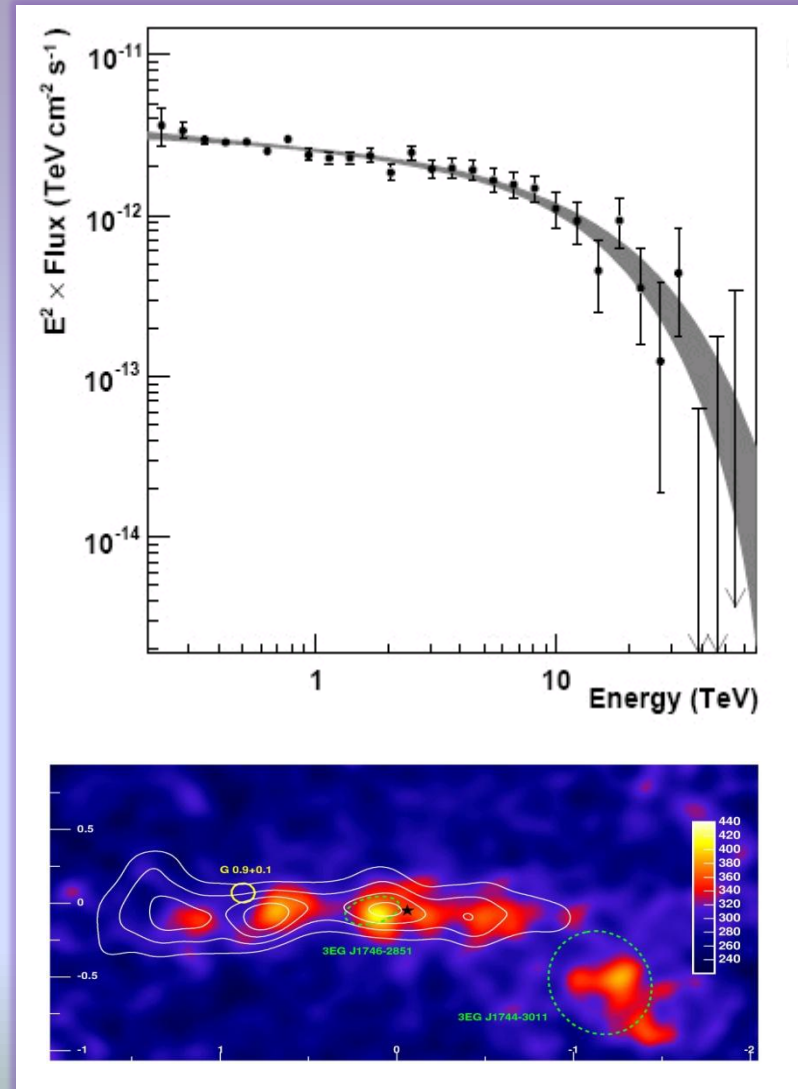
- Other Wavelengths: TeV -

TeV Galactic Center Source:

- Detected by CANGAROO [Tsuchiya et al. 2004], VERITAS [Kosack et al. 2004], HESS [Aharonian et al. 2004] and MAGIC [Albert et al. 2006]
- Energy spectrum compatible with both a power law spectrum with an exponential cut-off and a broken power law spectrum. [Aharonian et al. 2009]
- Position of HESS J1745-290 agrees well with location of other two counterpart candidates, Sgr A* and G359.95-0.04 [van Eldik et al. 2007]

Diffuse TeV emission

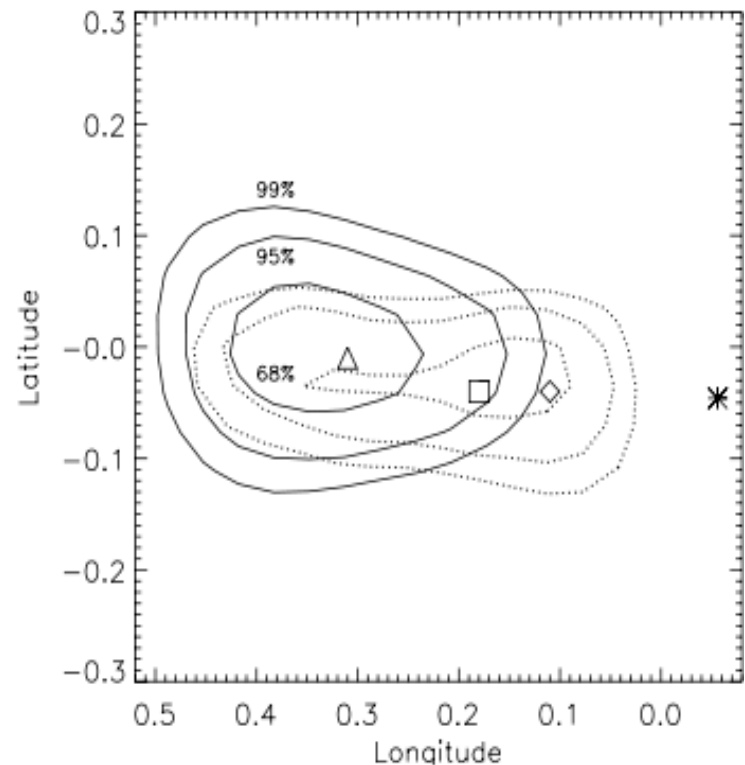
appears spatially correlated with dense cores of molecular clouds



The Galactic Center

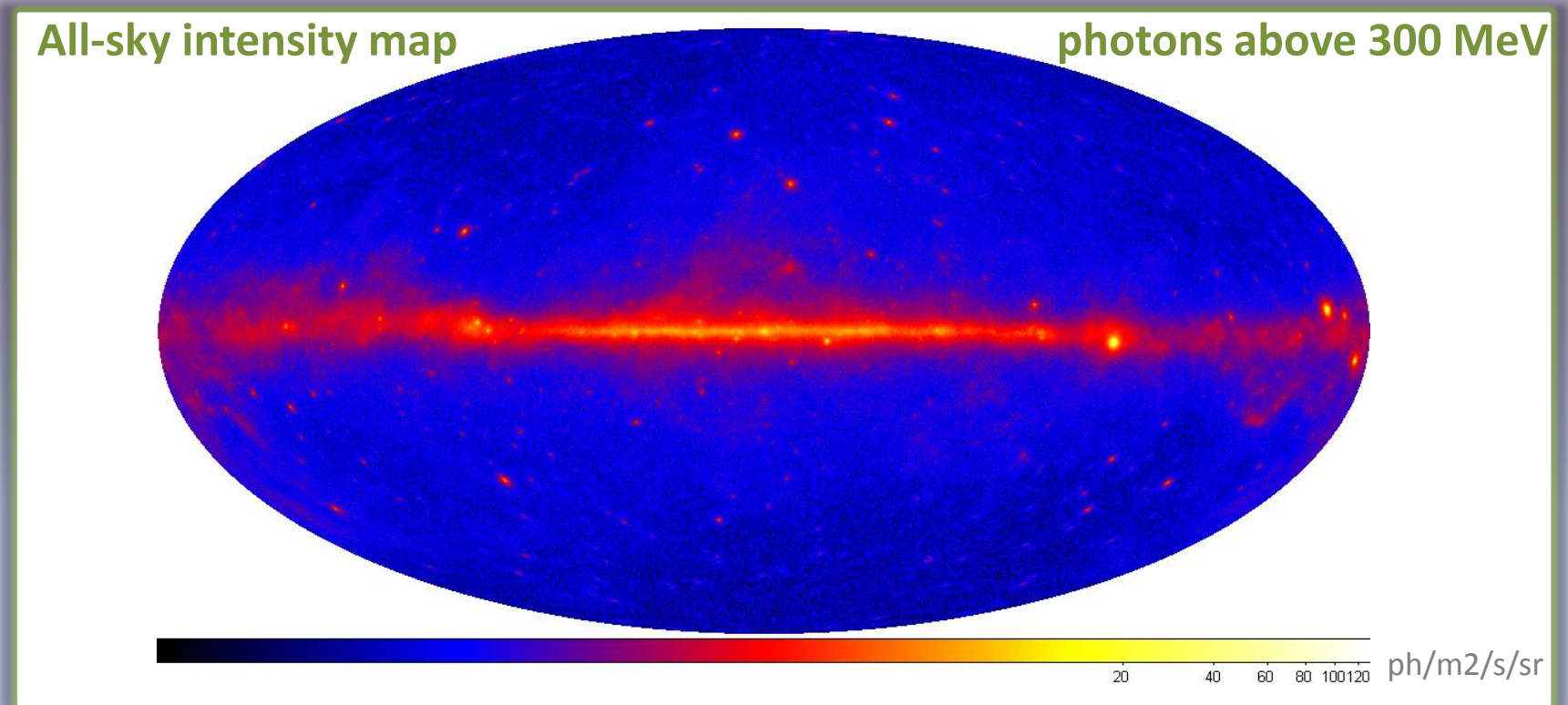
- Previous GeV Experiments: EGRET-

- 3EG J1746-2851 – GeV point source of detected by EGRET [Mayer-Hasselwander et al. 1998]
- No firm identification with sources in other frequency bands



[Pohl 2005, ApJ 626,174]

The Galactic Center - First year Fermi Catalog -



- Fermi 1st year Catalog (Astrophys.J.Suppl. 188:405-436,2010)
- 1451 sources in the 100 MeV to 100 GeV energy range, significance over 4σ
- 11 sources within/very close to the RoI
- Modelled as Point-Like Power Laws

The Galactic Center

- Galactic and Extragalactic Background -

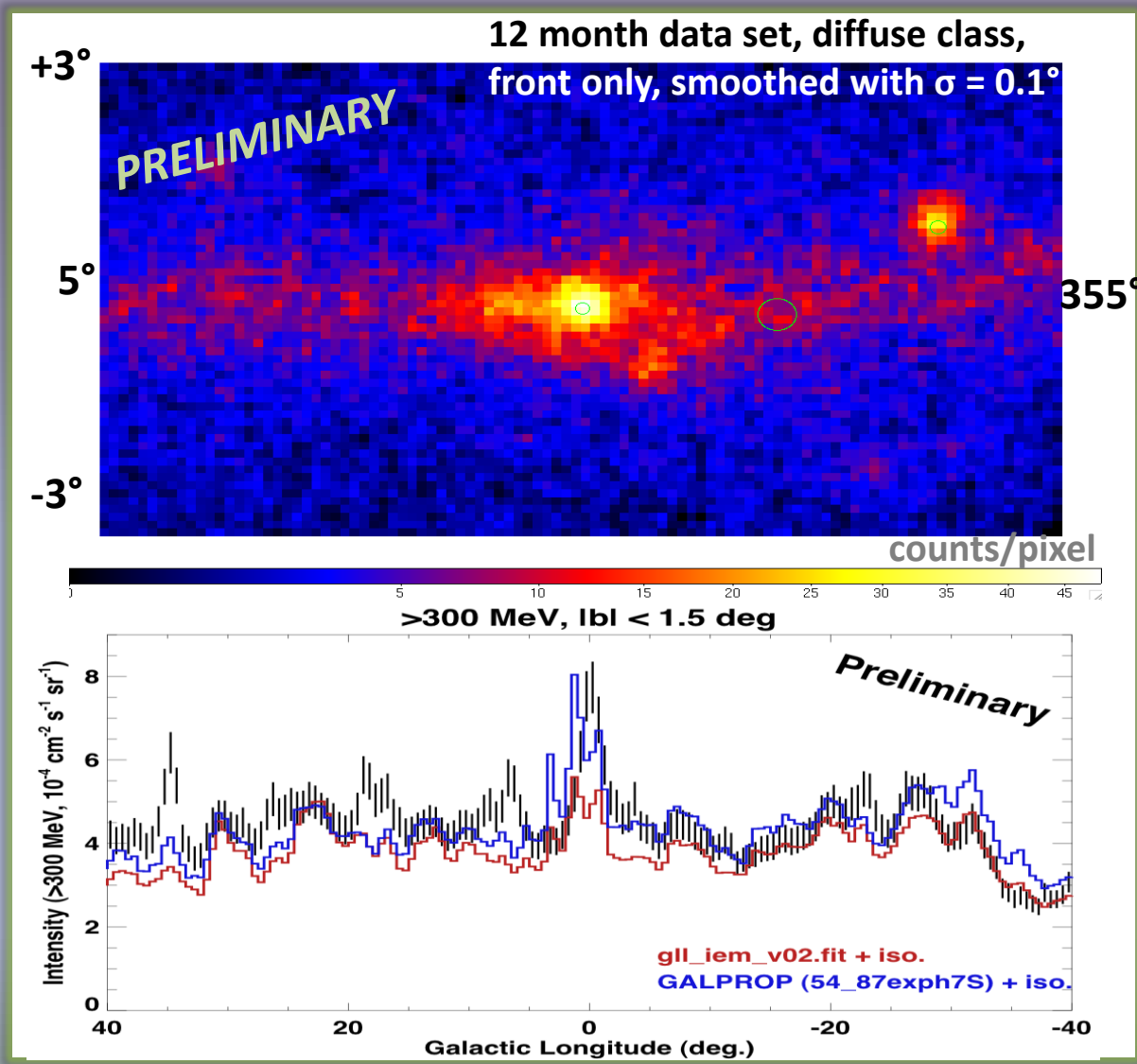
Galactic Diffuse Emission

• Modelled using the GALPROP code, the realization used was *gll-iem-54-87Xexph7S*.

• During the likelihood maximization only the normalization of the GALPROP model is varied, not its components

Extragalactic Diffuse

Modelled as an isotropic emission with a template spectrum.



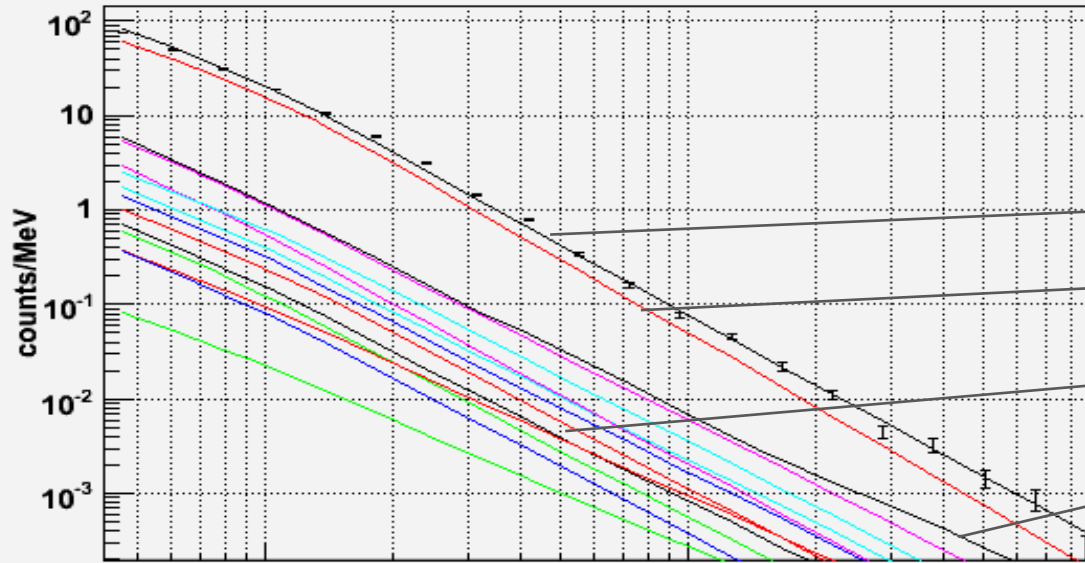
Preliminary Analysis

- $7^\circ \times 7^\circ$ 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

Preliminary Analysis

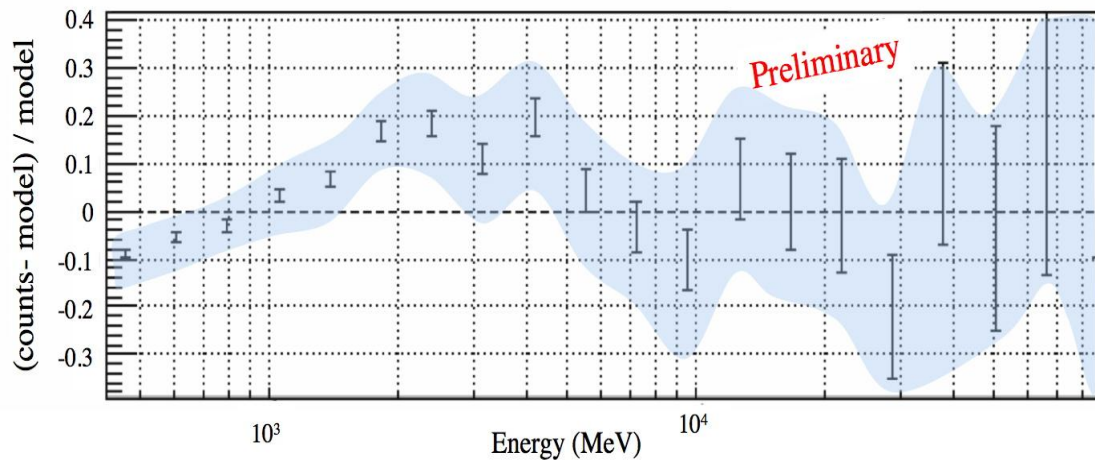
- Results -

arXiv:0912.3828



Spectra from Likelihood analysis

- ┆ Observed Data
- Sum of all components
- Galactic Diffuse Emission
- Detected Sources
- Isotropic Extragalactic



Residuals

- The residuals suggest an unmodelled excess in the 2-5 GeV range
- Blue area shows systematic errors on the effective area

Summary and Conclusions

- 11 months Fermi observations of a $7^\circ \times 7^\circ$ RoI centered at RA=266.46° Dec=-28.97°
- Modelled with 11 sources + Galactic and Extragalactic diffuse emission
- 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 DM signal from the GC 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. diffuse emission, unresolved sources...)
- Analysis in progress to updated constraints on annihilation cross section