A New Method for Characterizing Unresolved Point Sources: applications to *Fermi* Gamma-Ray Data

Ben Safdi

Massachusetts Institute of Technology

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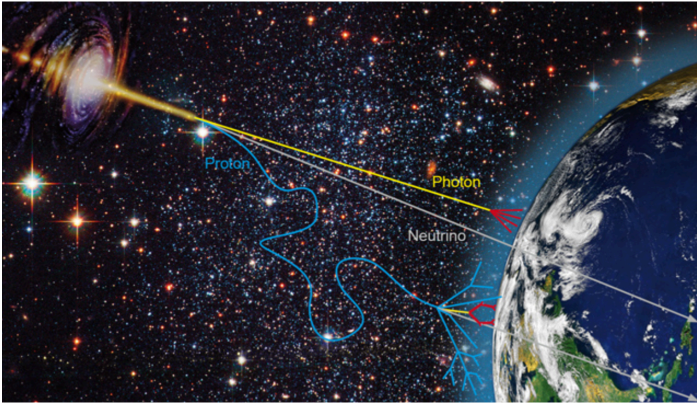
B.S., S. Lee, M. Lisanti, and B.S., S. Lee, M. Lisanti, T. Slatyer, W. Xue
[1412.6099 and 1506.05124]

Multi-messenger approach to astrophysical neutrinos



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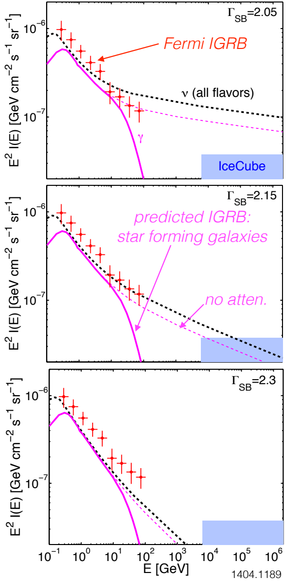

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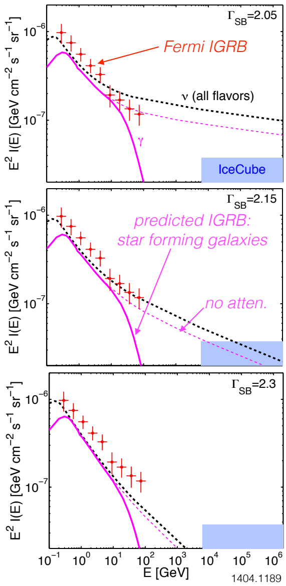

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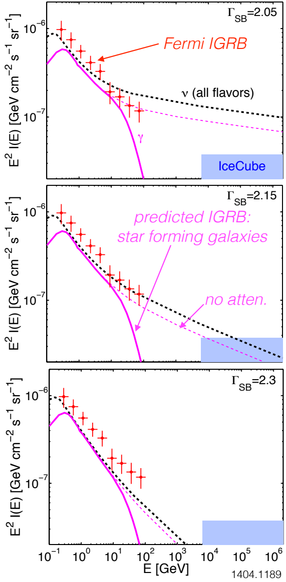

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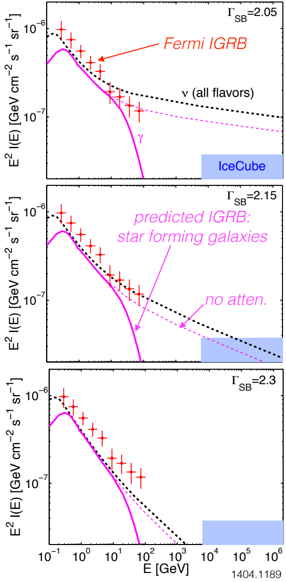

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- Ex: pp in star-forming galaxies–both ν's and γ's as secondaries
- ν and γ spectral index = source spectra index = Γ
- Star-forming galaxies faint but numerous: contribute to isotropic gamma-ray background (IGRB)

Multi-messenger approach to astrophysical neutrinos

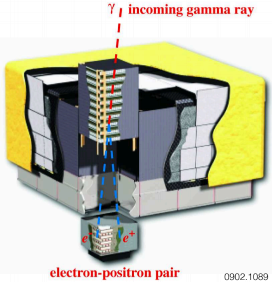
Import to understand contributions from unresolved PSs (*e.g.*, blazars) to IGRB to constrain diffuse contributions (*e.g.*, star-forming galaxies)

PSs important for gamma-ray signals of DM

Import to understand contributions from unresolved PSs to gamma-ray background to constrain contributions from dark matter (DM)

The Fermi Large-Area Telescope (LAT)

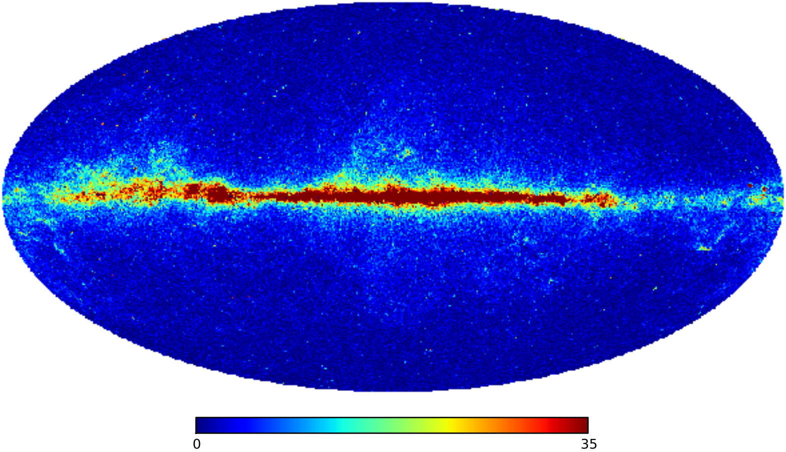
Fermi (NASA)



0902.1089

The Fermi Gamma-Ray Sky

Data taken from ~August 4, 2008 to December 5, 2013
HEALPIX $nside = 128$ ($N_{\text{pix}} = 196,608$)



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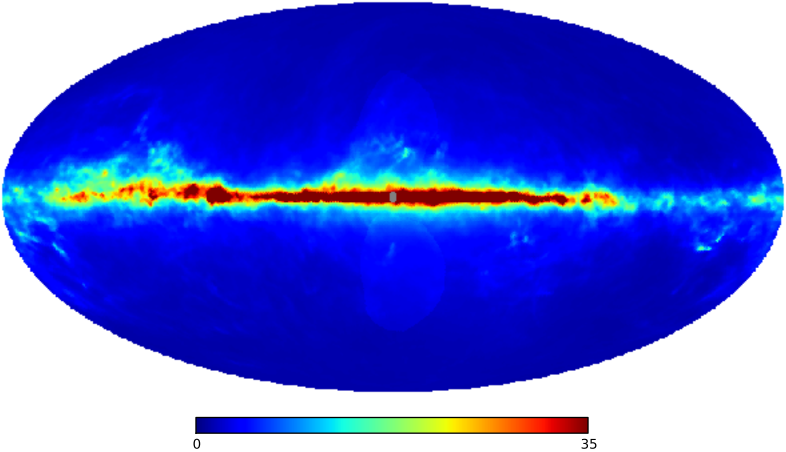
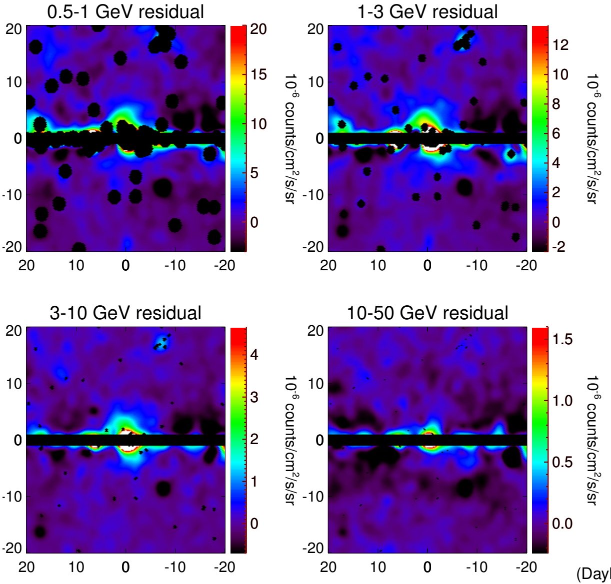
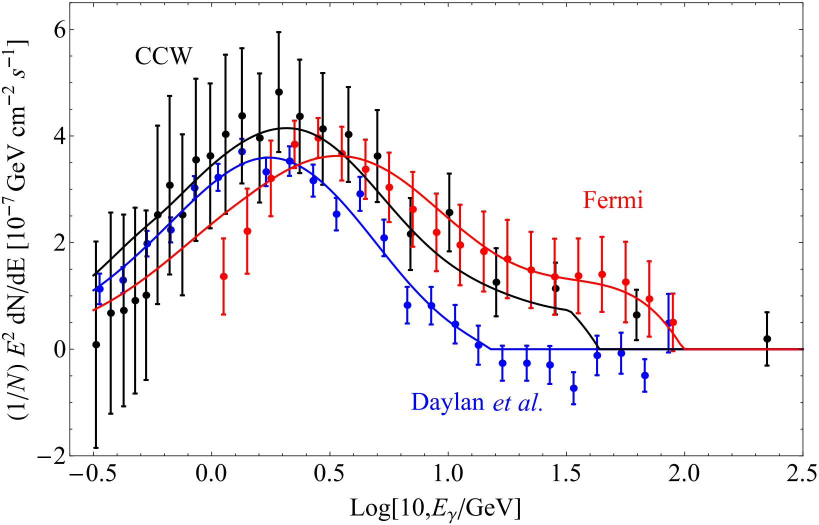


GeV Excess: Inner Galaxy



(Daylan et al.)

GeV Excess: Spectrum



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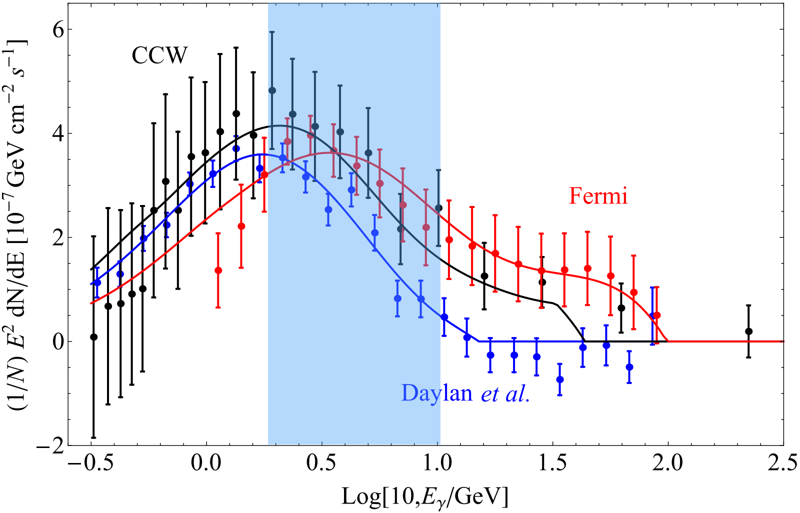

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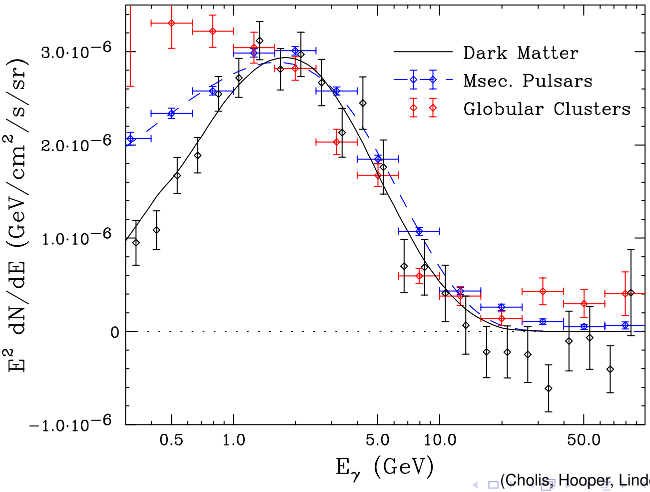
Pulsars: Spectrum

Millisecond pulsar spectrum similar to excess (from 61 millisecond pulsars and 36 globular clusters)

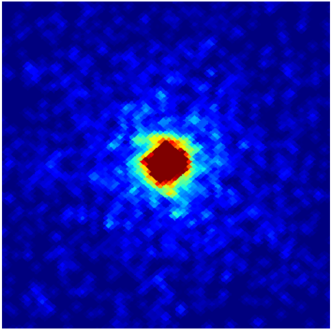


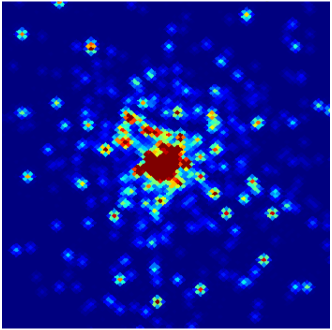
(Cholis, Hooper, Linden)

Astrophysical Scenarios

Can we use the *Fermi* data to differentiate between smooth and unresolved PS emission?

Photon Statistics: DM vs. Point Sources





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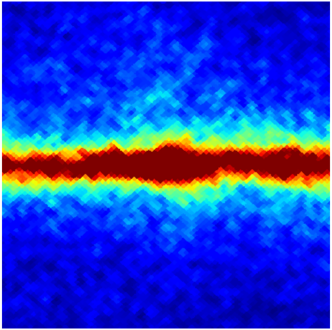

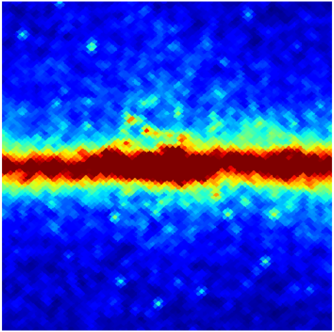

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- Straightforward modification to include PSF (Malyshev & Hogg)

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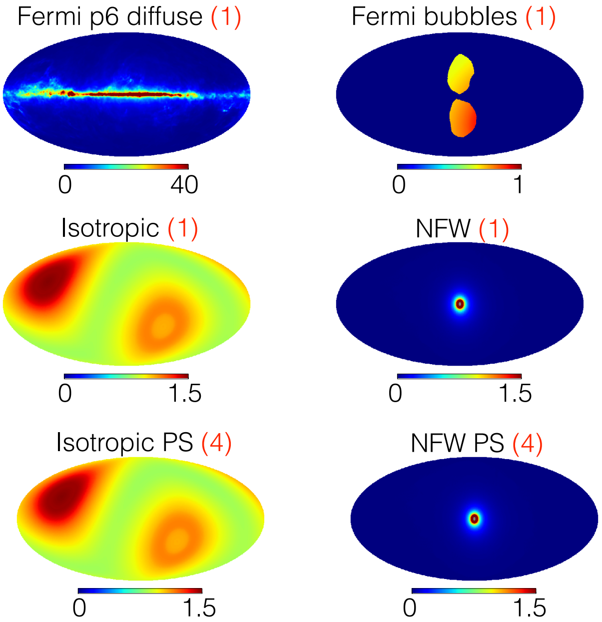
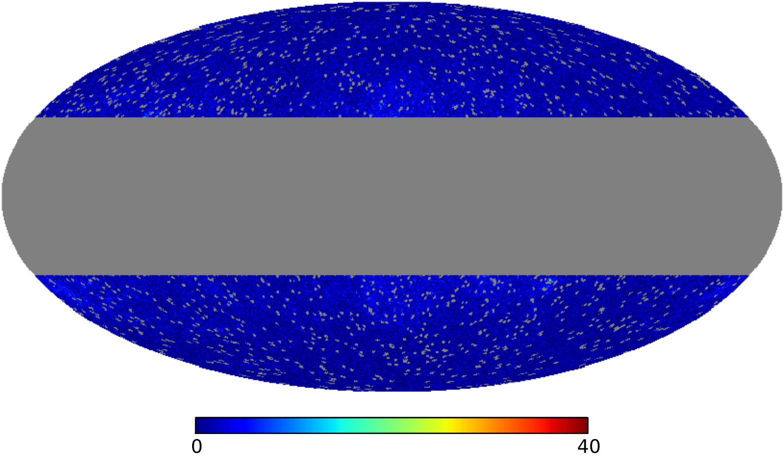
The models: templates



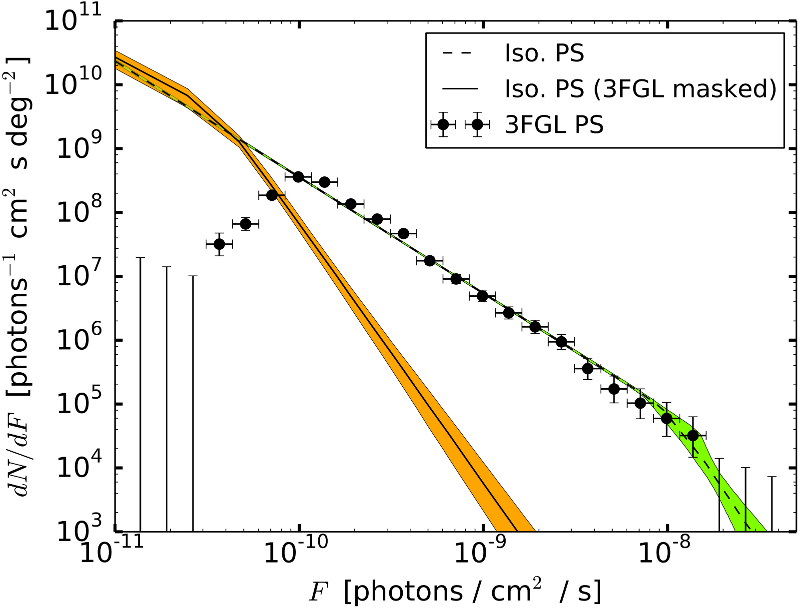
Isotropic point sources

- Region: mask 30° around plane

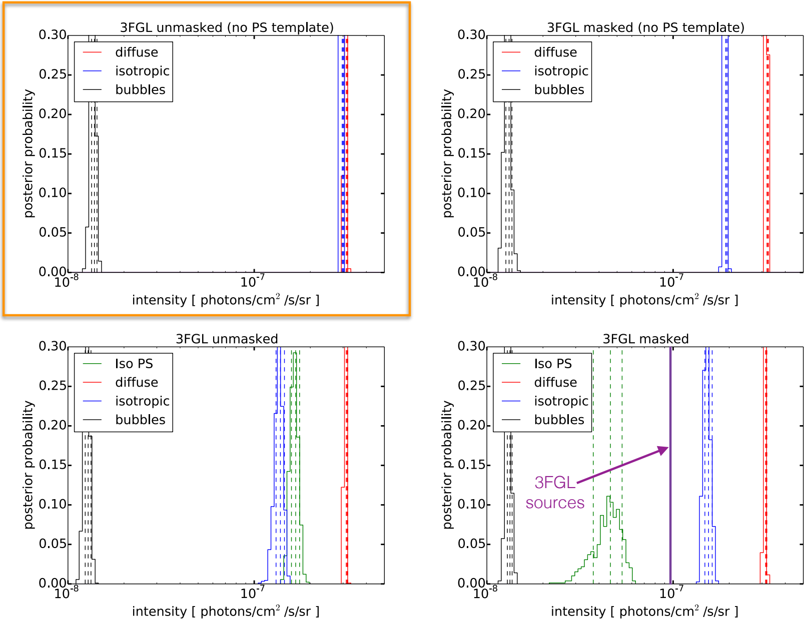


- include diffuse, bubbles, isotropic, and isotropic PS

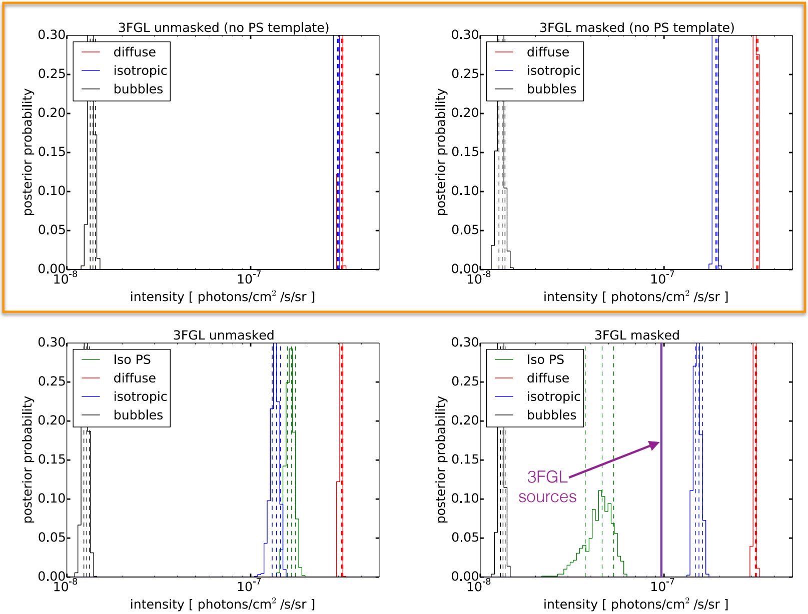
Isotropic point sources: source-count function



Isotropic point sources: intensities



Isotropic point sources: fluxes



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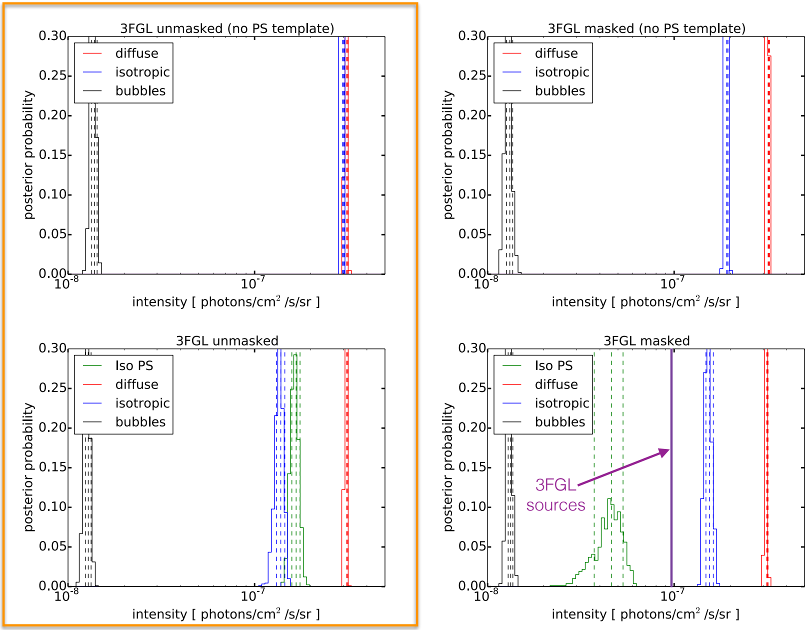

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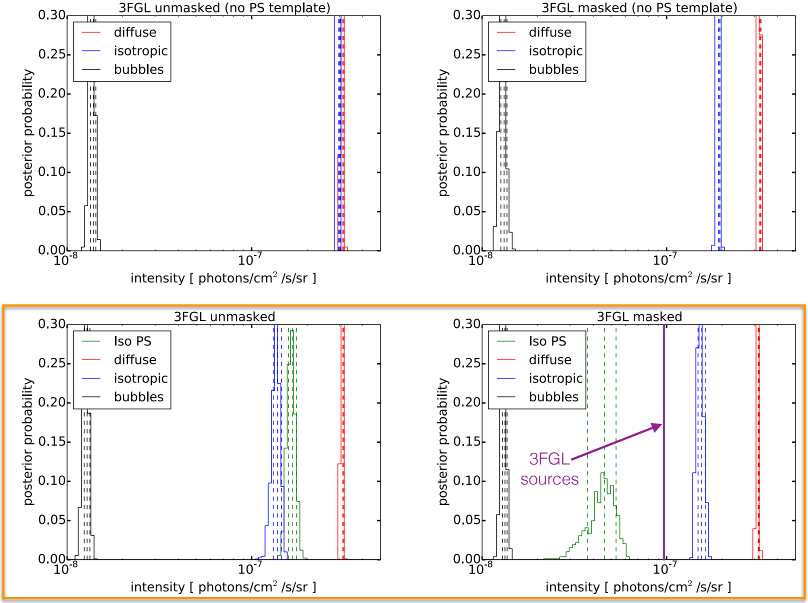
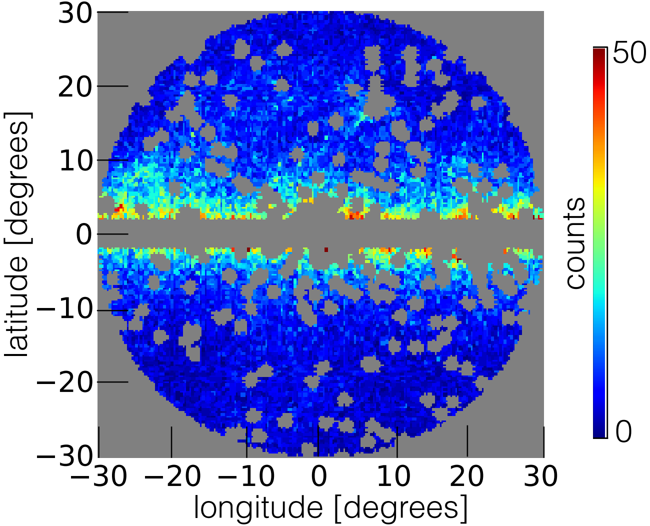
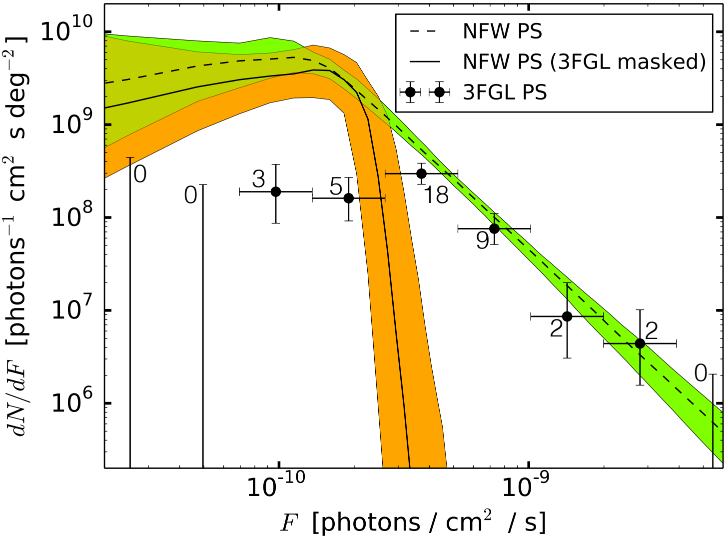


Region: mask 4° around plane, out to 30°



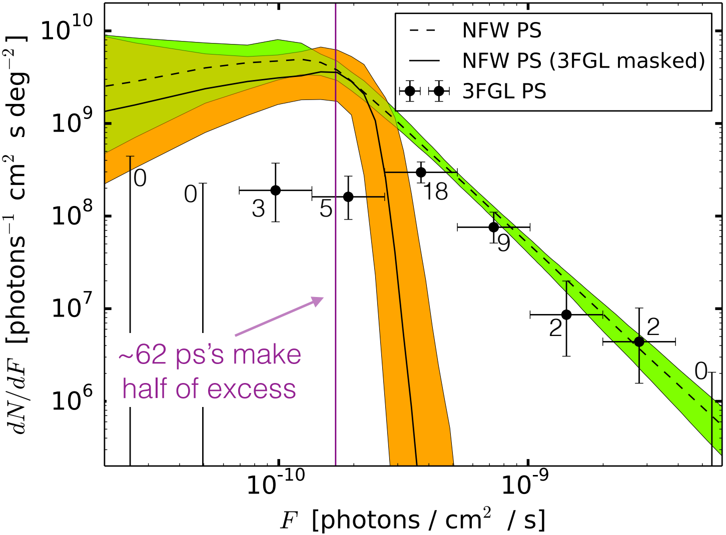
NFW point sources: source-count function

- For ROI out to 10°, with 4° around plane masked



NFW point sources: source-count function

- Prediction: ∼200 PS's in inner galaxy (large uncertainties)



NFW point sources: flux fraction

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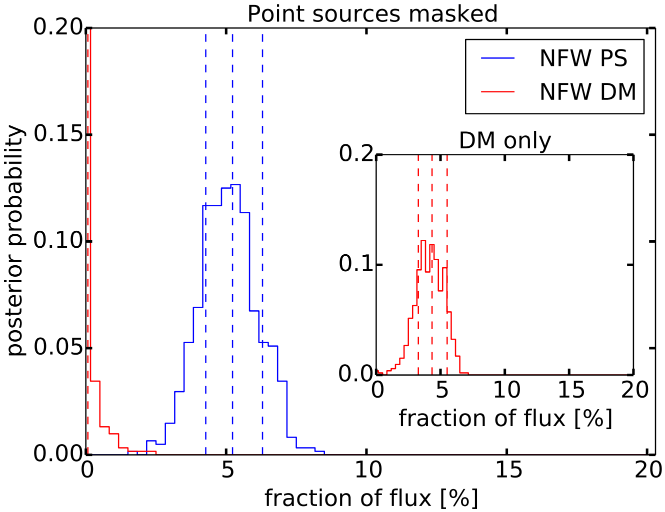

Model comparison

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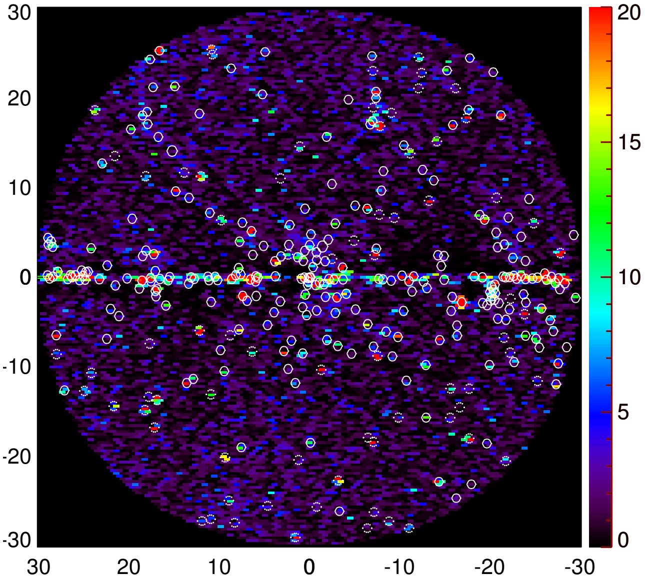
Tentative conclusion: GeV excess better fit by point-source emission than smooth (DM) emission

Where are the PSs? $-\log[1 - \mathrm{CDF}(\text{data; DM model})]$



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- Future: cross-correlate CDF map with other surveys (IceCube, other wavelengths, ...)
- Future: constrain IceCube scenarios using high-lat results
- Future: potentially use NPTF on IceCube data for PS search

Questions?