

A Probabilistic Catalogue of Unresolved High Latitude *Fermi* LAT Sources

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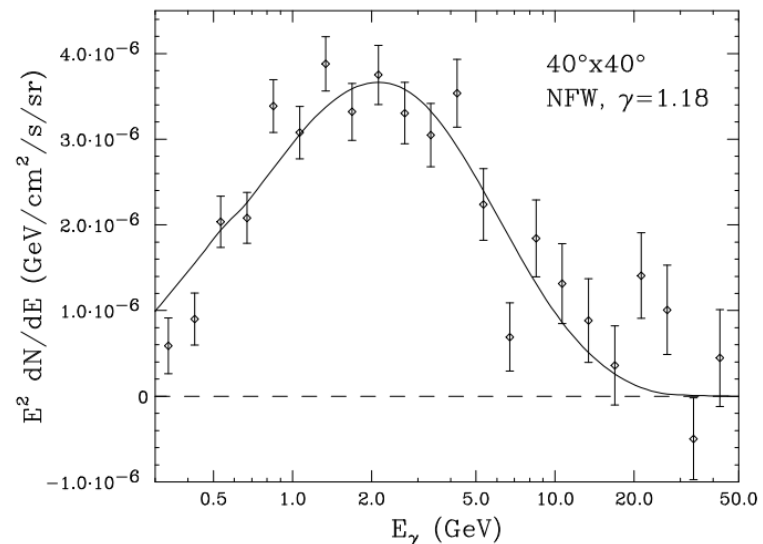
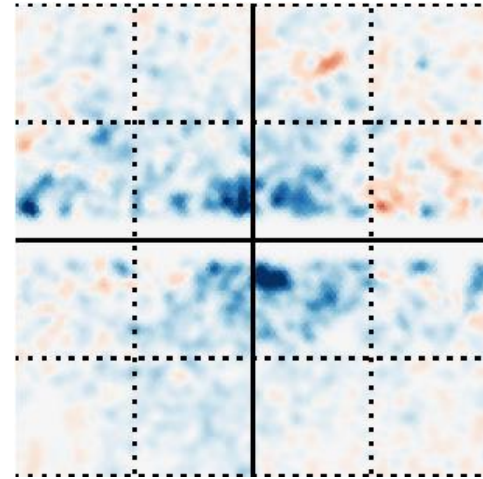
9 December 2015

Gamma Rays and Dark Matter, Obergurgl



GeV Excess Interpretations

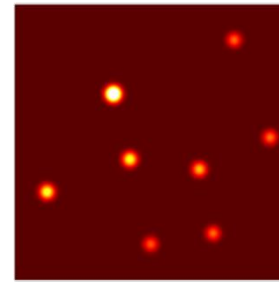
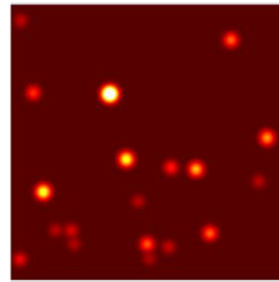
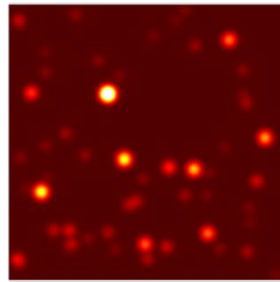
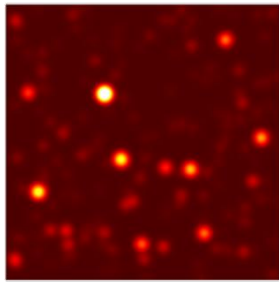
- Excess about Galactic Centre in *Fermi* LAT data
- Morphology, intensity, and spectrum compatible with dark matter interpretations
- May also be interpreted as a new population of faint point sources



Point Source Populations vs Diffuse Sources

increasing F_{min}, I_{iso}
constant $\int I d\Omega$

infinite counts



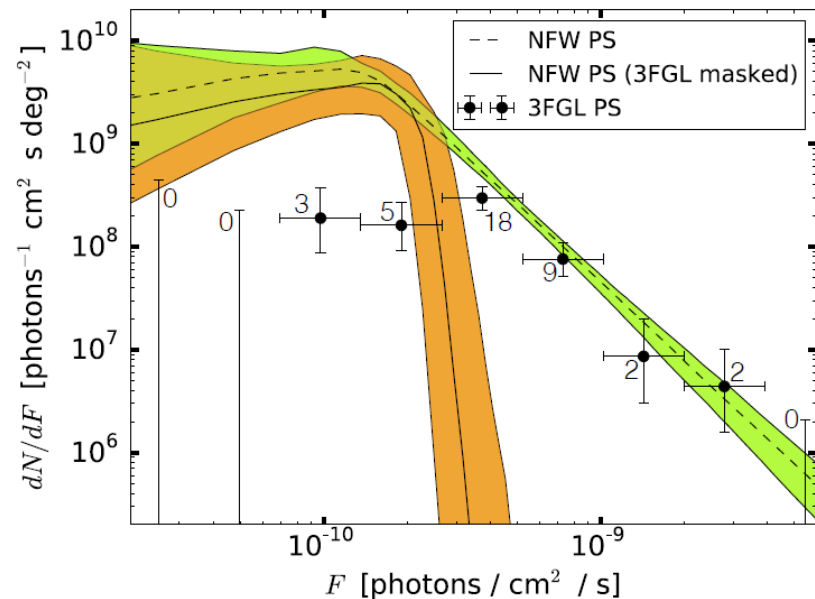
finite counts

Counting statistics introduce a point source detection threshold
But even sources fainter than this threshold can affect image

Non-Poissonian Template Fitting

- A point source population with a given spatial distribution can be treated as a diffuse source with non-Poissonian statistics
- Lee et al. 2015 greatly favours a point source interpretation of the GeV Excess
- Inferred population's luminosity function peaks just below *Fermi* LAT detection threshold

(cp. talks by RODD and ZEHLIN)



NFW template point sources

NFW template point sources minus 3FGL

(Deterministic) Catalogues

- A (deterministic) catalogue is a list of point source candidates above some inclusion threshold F_{incl}

$$Data, F_{incl} \rightarrow \{\ell_i \pm \sigma_{\ell_i}, \ell_i \pm \sigma_{\ell_i}, F_i \pm \sigma_{F_i}\}_{i=1}^N$$

- **Inclusion threshold = detection threshold:**
Almost all catalogue sources are true sources
But faint true sources are not in the catalogue
- **Inclusion threshold < detection threshold:**
More faint true sources are included in the catalogue
But many catalogue sources are not true sources
The data is overfitted

Probabilistic Catalogues

- A probabilistic catalogue is a probability distribution over the space of lists of point source candidates

$$P(\{\ell_i, \mathcal{b}_i, F_i\}_{i=1}^N | Data)$$

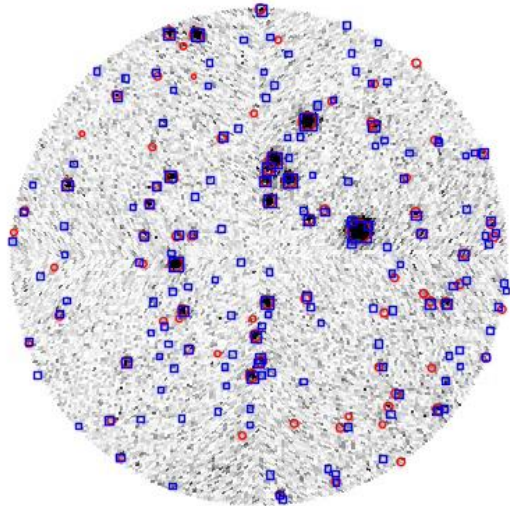
- Sampling the probabilistic catalogue provides an ensemble of catalogues consistent with the data
- This ensemble captures the degeneracies of point source identification
- The reality of a single faint point source candidate will be very uncertain, but the properties of a faint population are constrained
- I currently use Brendon BREWER's DNest3+RJObject to sample
- This technique is a different approach to the GeV Excess that retains more information than non-Poissonian template fitting

Validation at High Latitude

- North Galactic Pole $b > 70^\circ$ ($N_{pix} = 23\,544$)
- Region includes 84 3FGL sources
- Run with ~ 900 core-hours
- Diffuse sources:
 - Galactic diffuse emission
 - Isotropic emission
- Point source population:
 - Mostly distant active galaxies
 - Assumed to be isotropically distributed
 - Unknown flux distribution parameterized as power law

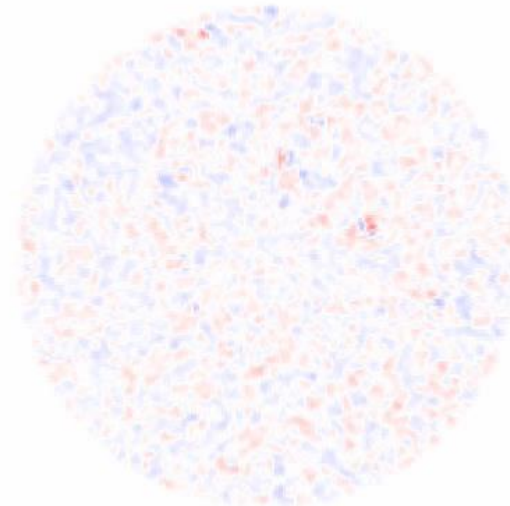
Probabilistic Catalogue Samples

Data w/ Overlays



0 10 photons

Residuals

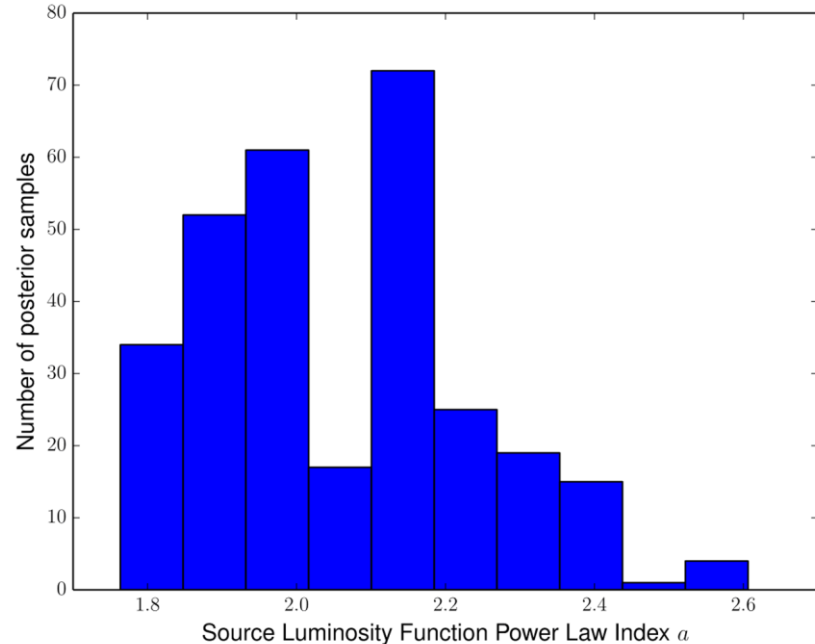
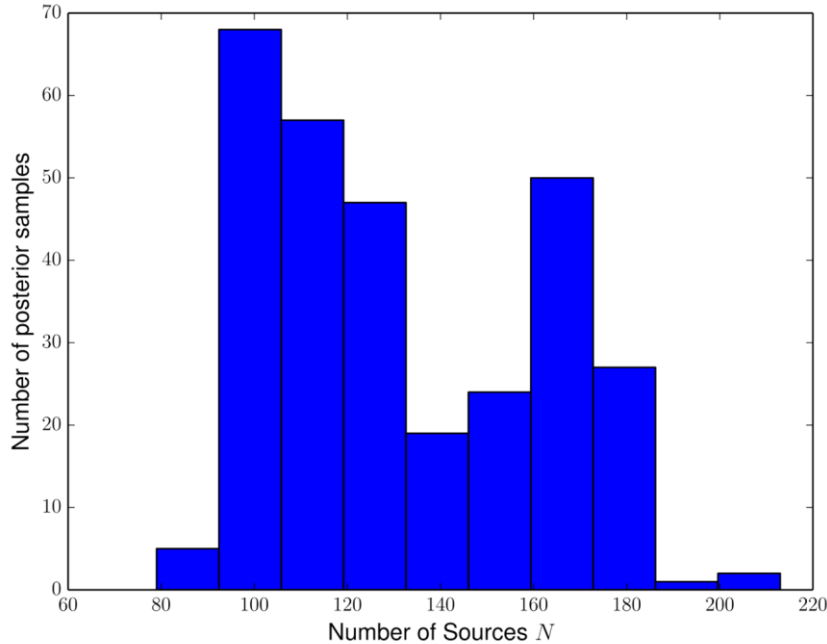


-8 8 photons

red circles – 3FGL point sources
blue squares – point source candidates

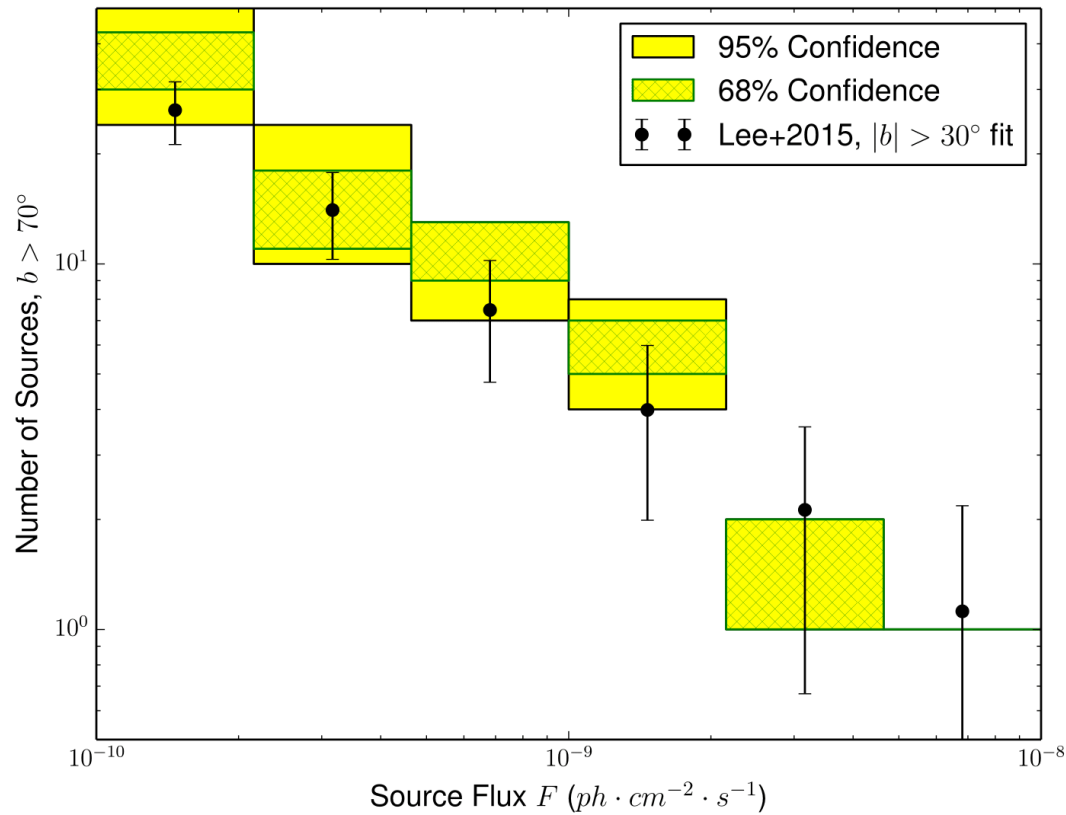
Pass 8 SOURCE
1-3 GeV
Weeks 9-217

Point Source Population Constraints



Pass 8 SOURCE
1-3 GeV
Weeks 9-217

Comparison



Pass 8 ULTRACLEANVETO PSF3
1.893-11.943 GeV
Weeks 9-365

Conclusion

- Constraining the point source contribution to the GeV Excess essential to its interpretation
- A point source population can be distinguished from a diffuse source, even if the individual sources are below the detection threshold
- Probabilistic catalogues capture the degeneracies of point source identification
- We have constructed a probabilistic catalogue for high latitude *Fermi* LAT sources in reasonable agreement with the 3FGL and non-Poissonian template fitting
- Stay tuned for Galactic Centre results...