The Gamma-Ray Milky Way above 10 GeV

Distinguishing Sources from Diffuse Emission with *Fermi*/LAT

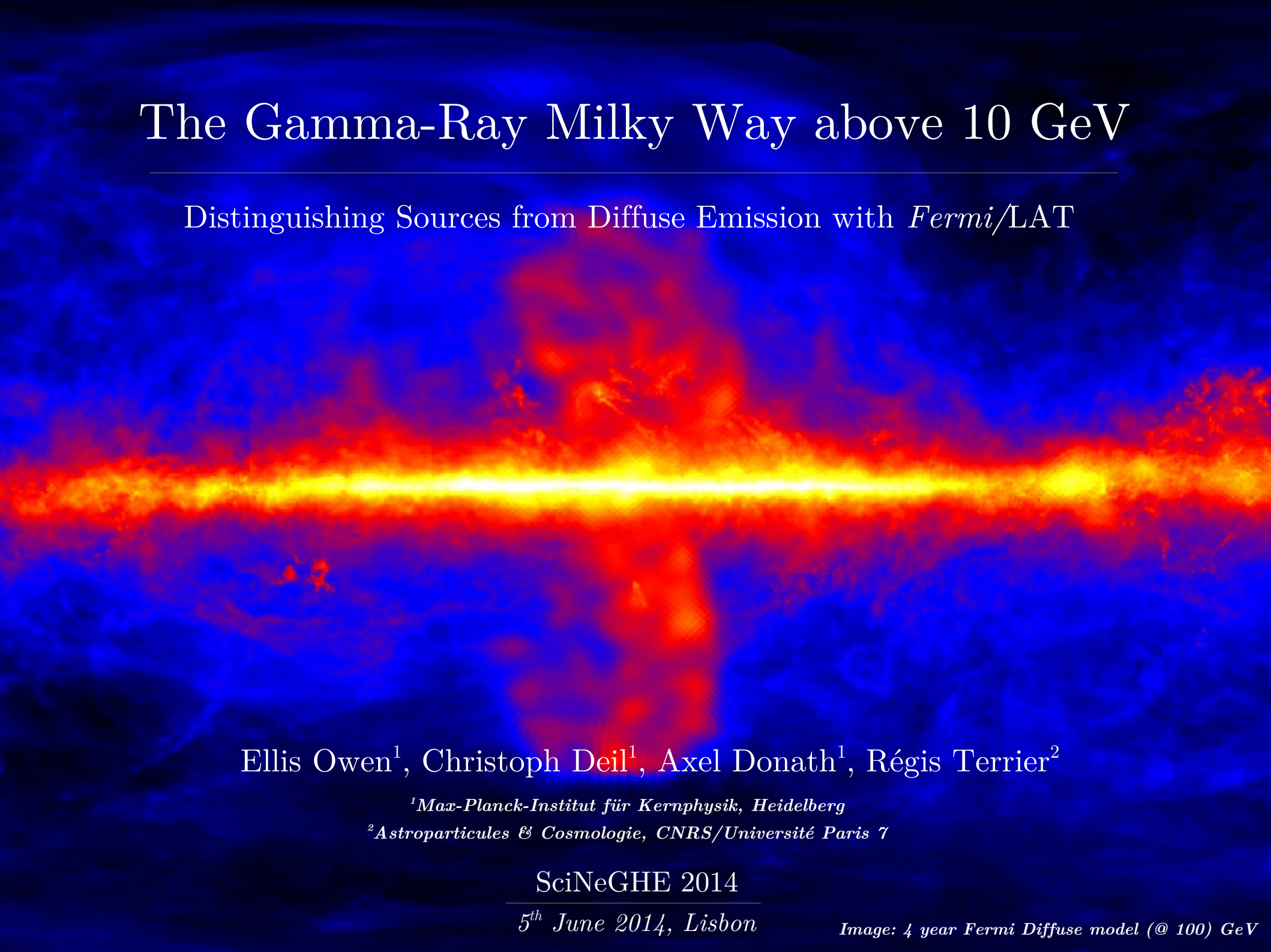

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Image: 4 year Fermi Diffuse model (@ 100) GeV

Outline

- A study to look at methods of **distinguishing Sources from Background Emission** in the Gamma-Ray Galactic Plane > 10 GeV
  - **Significance clipping** methods combined with elongated filter smoothing
    - Source clipping to offer an **estimation for background flux contribution** for data-sets, and leaving a residual of sources

- How to test the ability of a method distinguished Sources/Background?

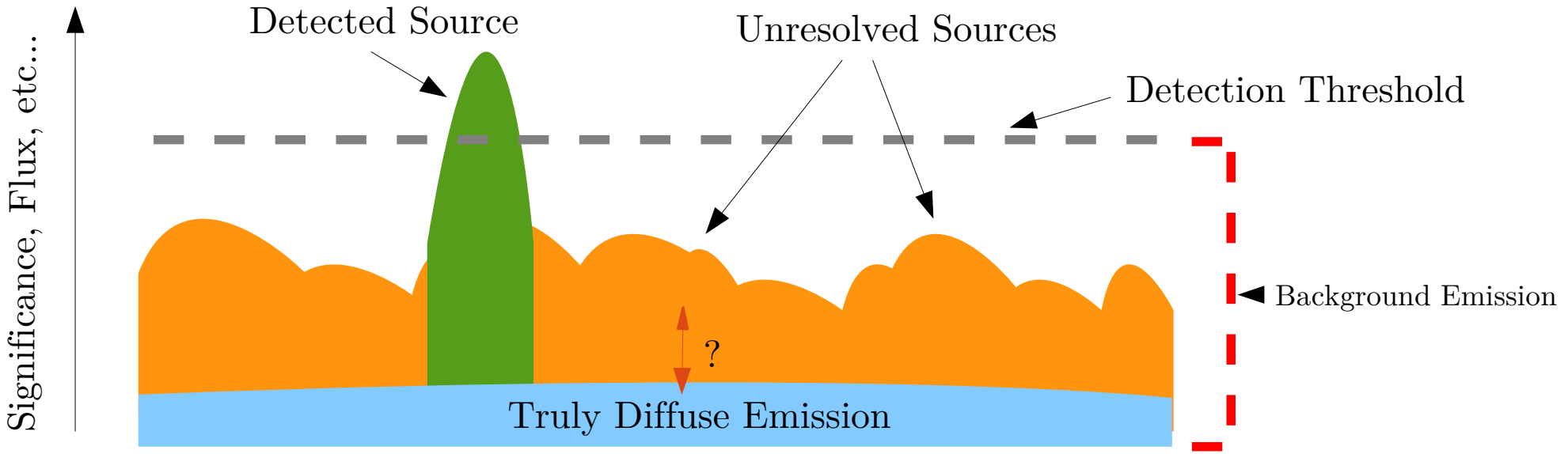
- Outline of how significance clipping type **methods** work

- Preliminary Application to *Fermi*/LAT **data** 10 GeV – 500 GeV
  - **Background Estimation**
  - **Comparison** of Estimated Background to Fermi Diffuse model as an existing representation of Galactic Background Flux contribution (gll_iem_v05.fits)

Next steps

- **Testing** the method
  - Model Galaxies:
    - **Background Model**
    - **Source Catalog**
      - Observational/Simulated

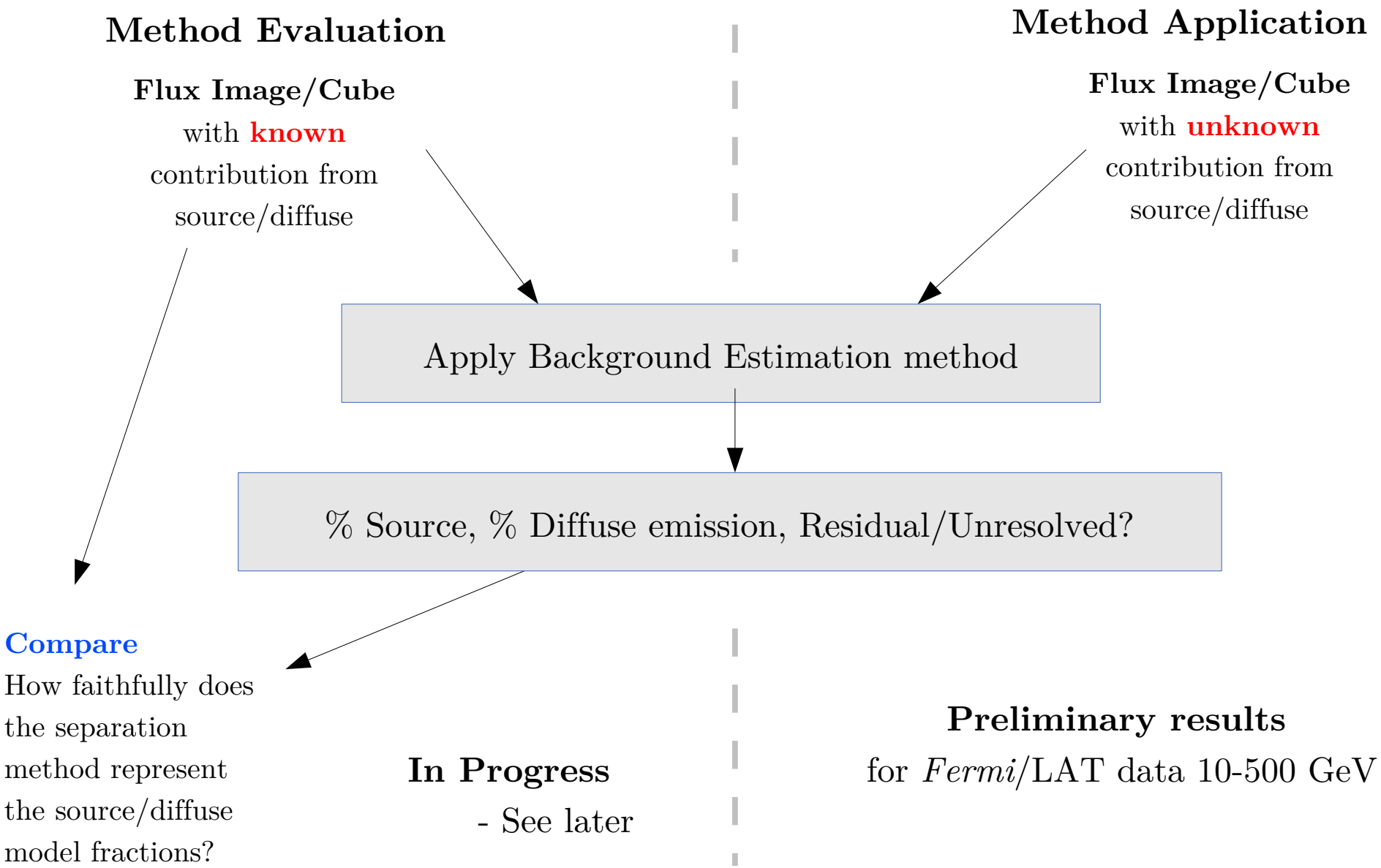
Introduction



- **Detected sources**; sources unambiguously detected above some threshold
- **Background** emission, comprising of
  - **Unresolved sources**
  - **Truly diffuse emission**, which is not directly attributed to sources

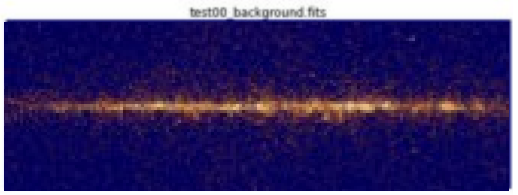
	Latitude Range	Longitude Range
Galactic Plane Region	-5<b<5	-100<l<100

Evaluating Background Estimation

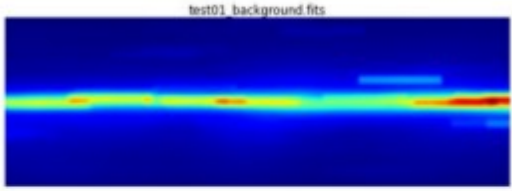


Outline of the Significance Clipping Method

- Iterative Scheme

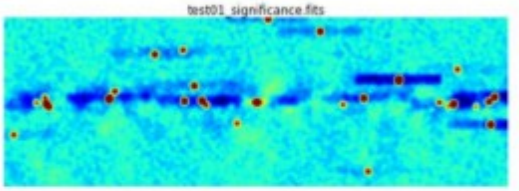


Counts

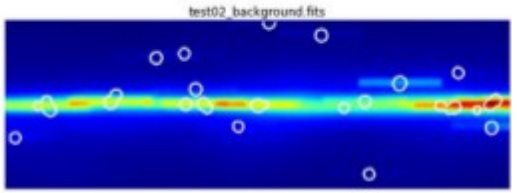


Background

Significance

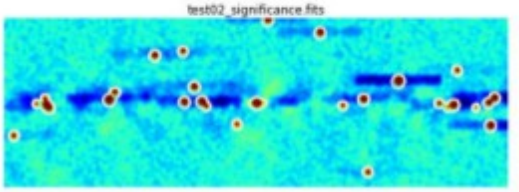


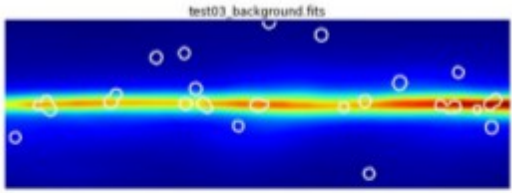
Mask



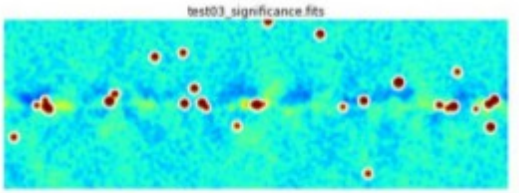
New Background

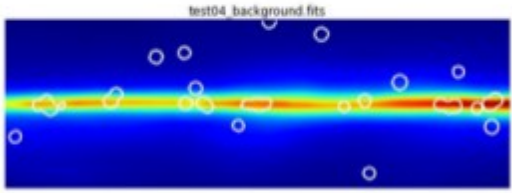
Significance



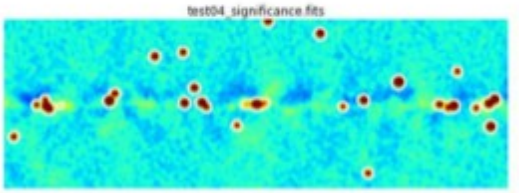


etc...





... until no change in mask (iteration **termination condition**)



Note:

Initial Background Estimate = Background-kernel convolved counts image

Parameters

Parameter	Value
significance cut off	4
correlation radius	0.3 deg
mask dilation radius	0.3 deg
height of background kernel	1 deg
width of background kernel	10 deg
Pixel size	0.1 deg

Low enough to detect sources, high enough to avoid triggering on Poisson up-fluctuations (*based on preliminary studies)*

Too large = too much background, too small = not enough counts

These parameters offer sensitivity fine-tuning... estimating the background for excluded regions

(For this study)

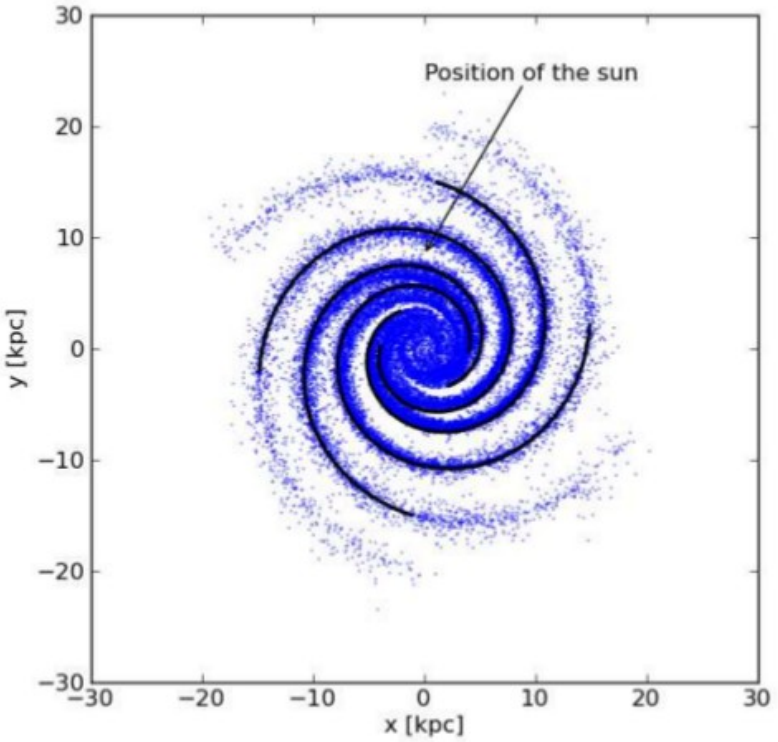
Input Models

- **Source** contribution + **Background** Contribution

In each of these cases, the background will be the Fermi Diffuse model (gll_iem_v05.fits)
- Based on gas maps, so will roughly follow shape of background emission

  - Population from **Source Catalog**
    - **1FHL**
  - **Simulated** galaxy populations

Source Model	Density at the Sun/kpc^{-3}	Minimum Luminosity /ph s^{-1}	Maximum Luminosity /ph s^{-1}
Galaxy Simulation 1	3	10^{34}	10^{37}
Galaxy Simulation 2	10	4×10^{33}	4×10^{36}
Galaxy Simulation 3	30	1.5×10^{33}	1.5×10^{36}



Note: Galaxy Simulations for the 10-500 GeV Energy Range

Input Models

- **Source** contribution + **Background** Contribution

In each of these cases, the background will be the Fermi Diffuse model (gll_iem_v05.fits)
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    - **1FHL**
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Source Model	**Total Flux/ph cm^{-2} s^{-1}**	**Flux in Galactic Region/ph cm^{-2} s^{-1}**	**Flux in Galactic Region/%**
Fermi 1FHL Catalog > 10 GeV	8.1e-08	2.3e-08	27.8
Galaxy Simulation 1	9.9e-08	8.5e-08	85.2
Galaxy Simulation 2	19e-08	13e-08	66.6
Galaxy Simulation 3	19e-08	14e-08	70.9

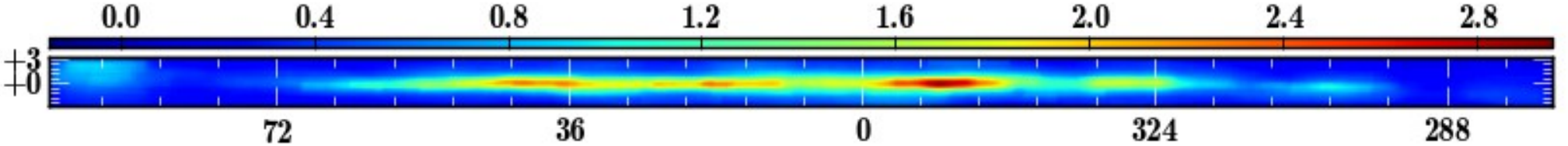
Using these models to evaluate the method is still a work in progress

However, preliminary results from application to Fermi/LAT data from 10-500 GeV

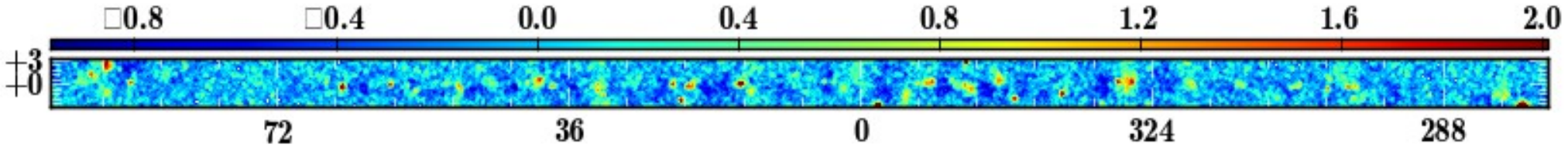
Background Estimation with *Fermi*/LAT data

- 10-500 GeV *Fermi*/LAT data
- Note slightly different latitude (+/- 3 degrees) and longitude (-100/+85 degrees)

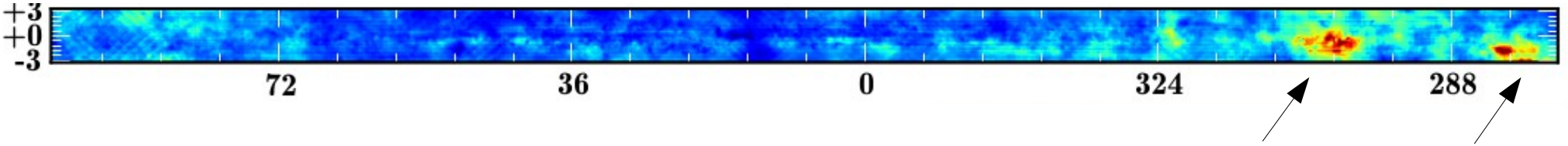
- Background Estimate Image



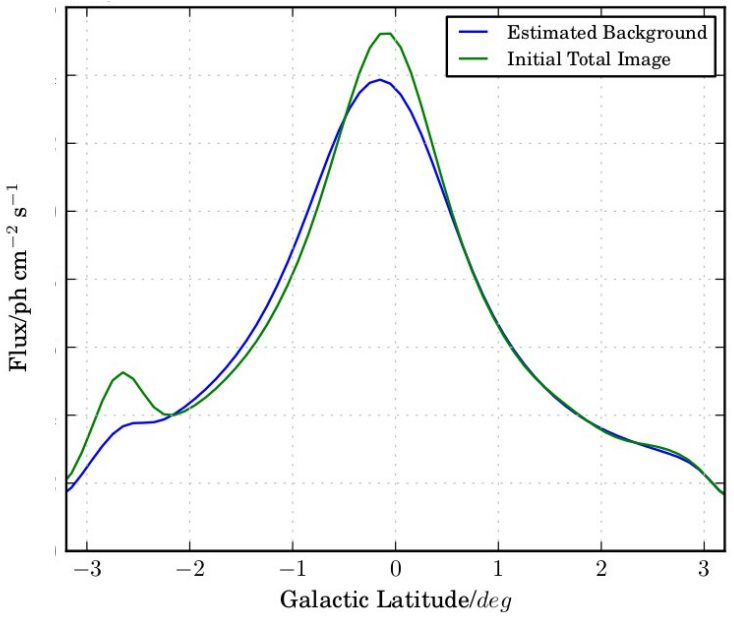
- Residual Significance Image

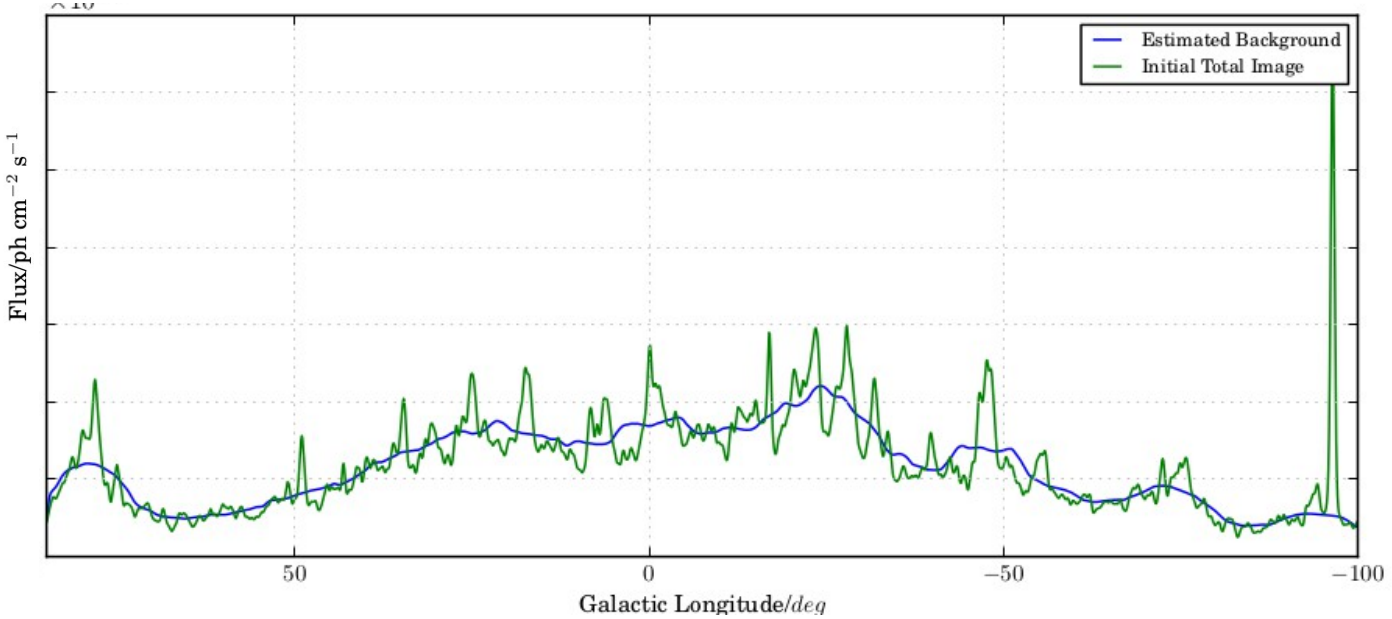


- Ratio Image to Fermi Diffuse Model: Background Estimation/Fermi Diffuse Model



Background Estimation with *Fermi*/LAT data



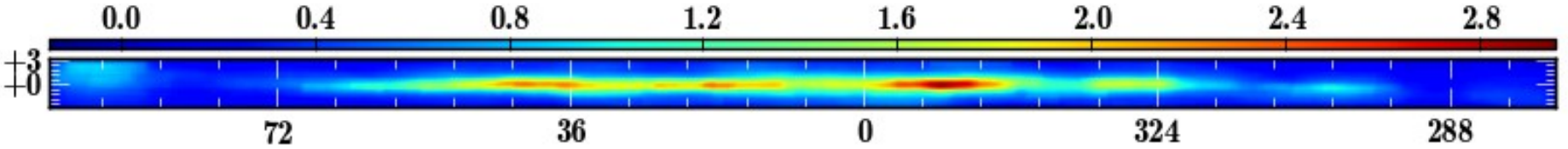


Summary

- Study of methods to separate source & diffuse emission using *Fermi*/LAT data above 10 GeV

- Compare fraction of source and diffuse emission in data and models (of known source/diffuse proportions) to evaluate methods ability to reproduce known priors and study their success in separating source populations from diffuse/unresolved backgrounds

- Work in progress, but already have some preliminary results



- We're developing a tool box for these kinds of studies – gammapy. Functionality for this analysis is being added to gammapy, an affiliated astropy Python package
  http://gammapy.readthedocs.org/en/latest/

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- We plan to continue & extend this study – please get in touch if interested!