Measurement of anisotropies in the large-scale diffuse gamma-ray emission

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Summary

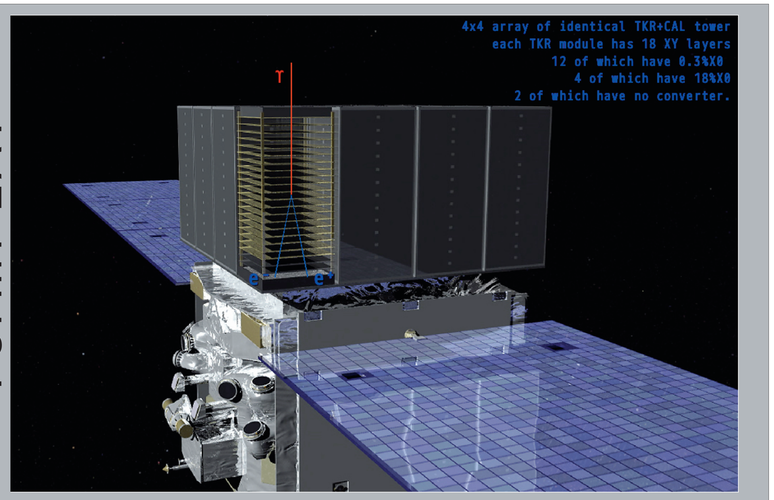
§ We have performed the first measurement of the angular power spectrum in the large-scale diffuse emission at energies from 1-50 GeV.

§ We have compared results from data and a simulated model (Galactic diffuse + 11-month sources + isotropic) to identify significant differences in anisotropy properties.

§ We have found that: at multipoles greater than ~ 100, the excess power in the data suggest a contribution from a point source population not present in the model. Also, at large angular scales (l<100) angular power above the noise is seen in the data and model, probably due to contamination from the galactic diffuse.

§ Due to decresasing photon statistics, the amplitude of anisotropies detectable by this analysis decreases with increasing energy. For this reason, the non-detection of power above the noise level at 10-50 GeV does not exclude the presence of anisotropies at the level of those detected at 1-10 GeV

Fermi-LAT



The Fermi Gamma-Ray Telescope, launched on June 11th 2008 from Cape Cañaveral, performs gamma-ray measurements over the whole celestial sphere.

The LAT measures the tracks of the electron and positron that result when an incident gamma ray undergoes pair conversion in a thin, tungsten foil, and measures the energy of the subsequent electromagnetic shower that develops in the telescope's calorimeter.

Energy range: 20 MeV to > 300 GeV.

Angular resolution ~ 0.1 deg above 10 GeV.

Field of View (FoV) ~ 2.4 sr.

Uniform sky exposure of ~ 30 minutes every 3 hours.

Introduction

The angular distribution of photons in the diffuse gamma-ray background contains information about the presence of unresolved source populations (USP).

Fluctuations on small scales may originate from an USP if they are different from those expected from the Poisson noise due to finite statistics.

Recent studies have predicted the contributions to the angular power spectrum from extragalactic and galactic dark matter annihilation or decay.

I present the results of an anisotropy analysisof the diffuse emission measured by the Fermi-LAT

There are predictions for the angular power spectra of various unresolved gamma-ray populations in the literature, e.g. [1-5]. Predicted values of Cl at l=100 cover a large range, e.g., ~ 1e-4 for blazars [1], ~ 1e-7 for starforming galaxies [2], and ~ 1e-4 to ~1 for dark matter [3, 4, 5] .

The angular power spectrum (APS) as a metric for anisotropy

We consider the APS C_l of intensity fluctuatios,

$$\delta I(\psi) = \frac{I(\psi) - \langle I \rangle}{\langle I \rangle}$$

where $I(\psi)$ is the intensity in the direction ψ

The APS is given by $C_l = \langle |a_{lm}|^2 \rangle$ where a_{lm} are determined by expanding $\delta I(\psi)$ in spherical harmonics,

$$\delta I(\psi) = \sum_{l,m} a_{lm} Y_{lm}$$

Method

-> Select regions of the sky which are relatively clean

* mask sources in the 11-month catalog within a 2 deg angular radius.
* mask the galactic plane |b|<30 deg

-> Calculate angular power spectrum of the data in several energy binsusing the HEALPix package (Gorski et al. 2005).

-> Focus on multipoles greater than 100 (angular scales <1-2 deg), because the contamination from Galactic diffuse is likely to be small.

-> Compare results from data and simulated model to identify significant differences in anisotropy properties.

-> Error bars on points indicate 1-sigma statistical uncertainty in the measurement; systematic uncertanties are NOT included.

Data

~22 months of data

diffuse class events

energy range: 1 GeV - 50 GeV

5 energy bins for APS

instrument response P6V3, for data and simulations

binned into order 9 HEALPix maps, pixels of ~0.1 deg/side

Simulations

model simulated with gtobssim (Fermi Science Tools)

GAL: Galactic diffuse model (gll_iem_v02.fit)

CAT: 11-months source catalog

ISO: isotropic background (isotropic_iem_v02.txt)

MODEL = GAL + CAT + ISO

Measurement uncertainties

1-sigma statistical uncertainty on the measurement

Sample variance

$$\delta C_l = \sqrt{\frac{2}{(2l+1)\Delta l f_{sky}}} \left(W_l^2 C_l^s + C_N \right)$$

$$W_l = W_{l,pix} e^{-l^2 \sigma_b^2 / 2}$$

Pixel window function of the map

Beam window function of the experiment

$$C_N = \langle I \rangle^2 \frac{4\pi f_{sky}}{N_\gamma}$$

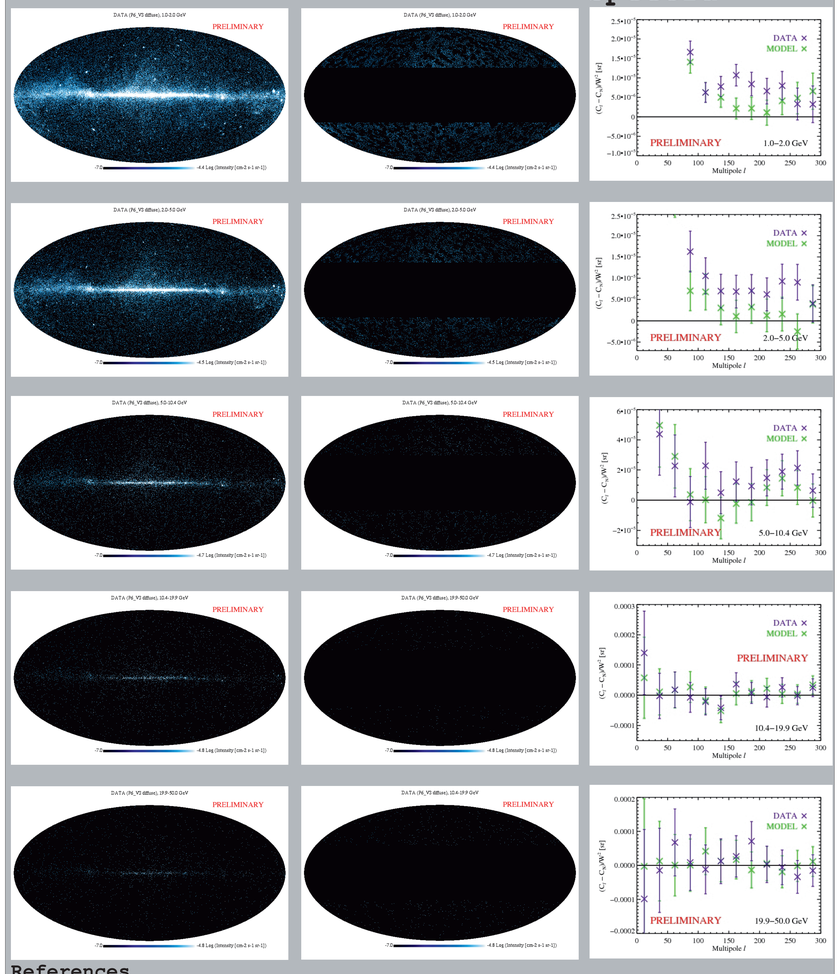
Noise power spectrum

Results

Data

Masked Data

Fluctuation Angular Power Spectra



References

[1] S. Ando, E. Komatsu, T. Narumoto & T.Totani. MNRAS 376 (2007) 1635.

[2] S. Ando, V. Pavlidou. MNRAS 400 (2009) 2122.

[3] A. Cuoco, A. Sellerholm, J. Conrad & S. Hannestad. arXiv:1005.0843.

[4] J. M. Siegal-Gaskins. JCAP 0810 (2008) 040.

[5] S. Ando. Phys. Rev. D 80 (2009) 023520.

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