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Gamma-ray anisotropies with the Cherenkov Telescope Array

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Motivation

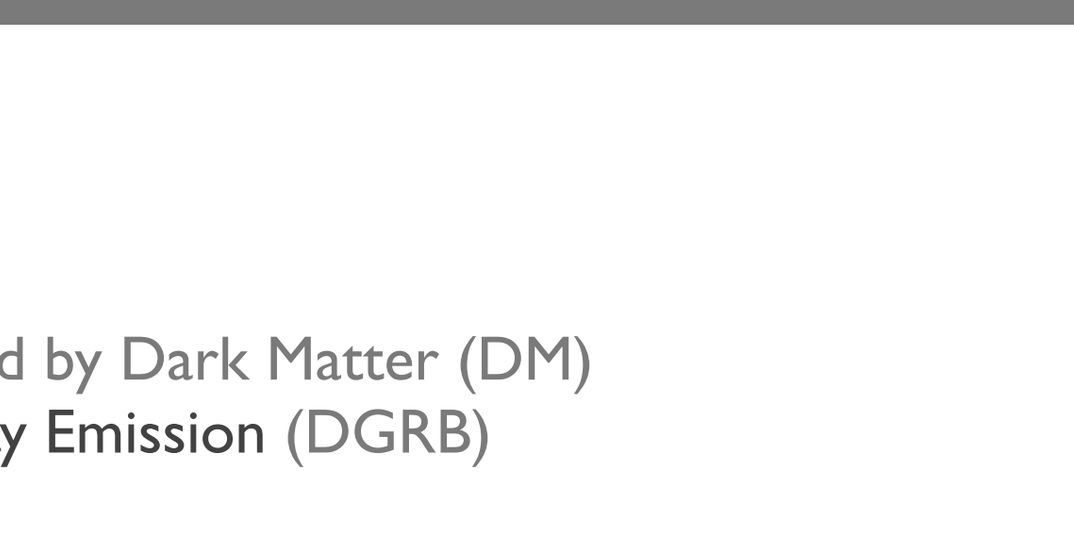
Looking for the cumulative emission produced by Dark Matter (DM) annihilations/decays in the Diffuse Gamma-Ray Emission (DGRB)

- unresolved sources

- signal depends on the average properties of DM (sub)halos

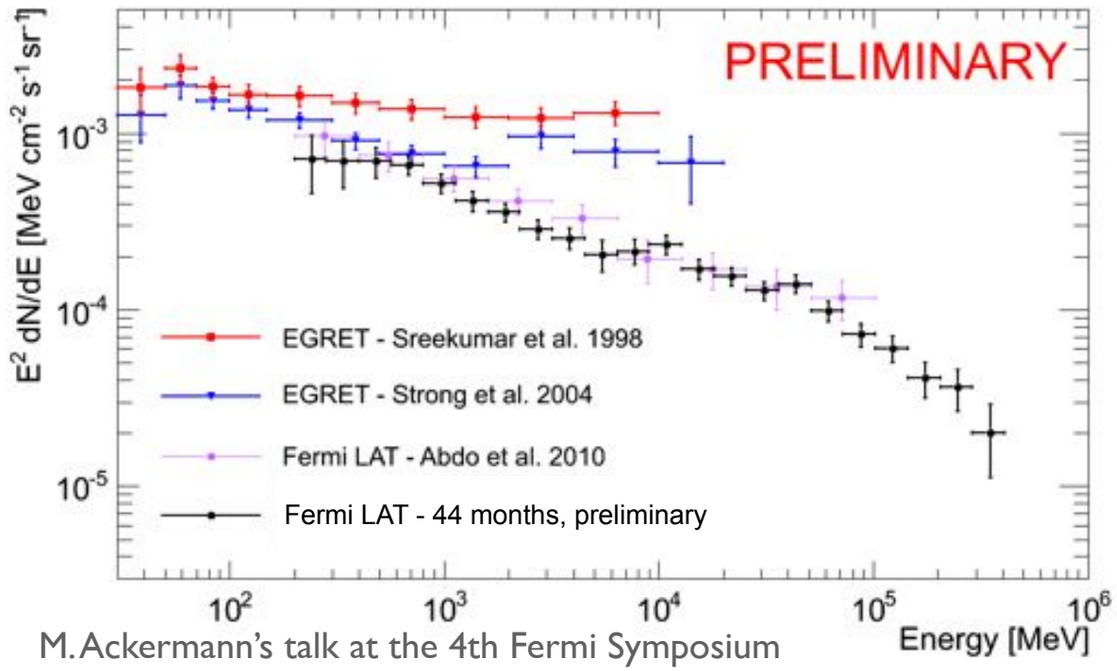
- tightly connected with astrophysics

- study of anisotropies can be more informative than focusing on intensity



units of 10^{-7} erg $cm^{-2}s^{-1}sr^{-1}$, 24 months, 100 MeV-10 GeV
www-glast.stanford.edu

The Diffuse Gamma-Ray Background (DGRB)



M. Ackermann's talk at the 4th Fermi Symposium

- residual emission after subtraction of Galactic foreground and point-sources

- multicomponent fit to Fermi-LAT data (0.2-820 GeV) in the region |b|>10 deg

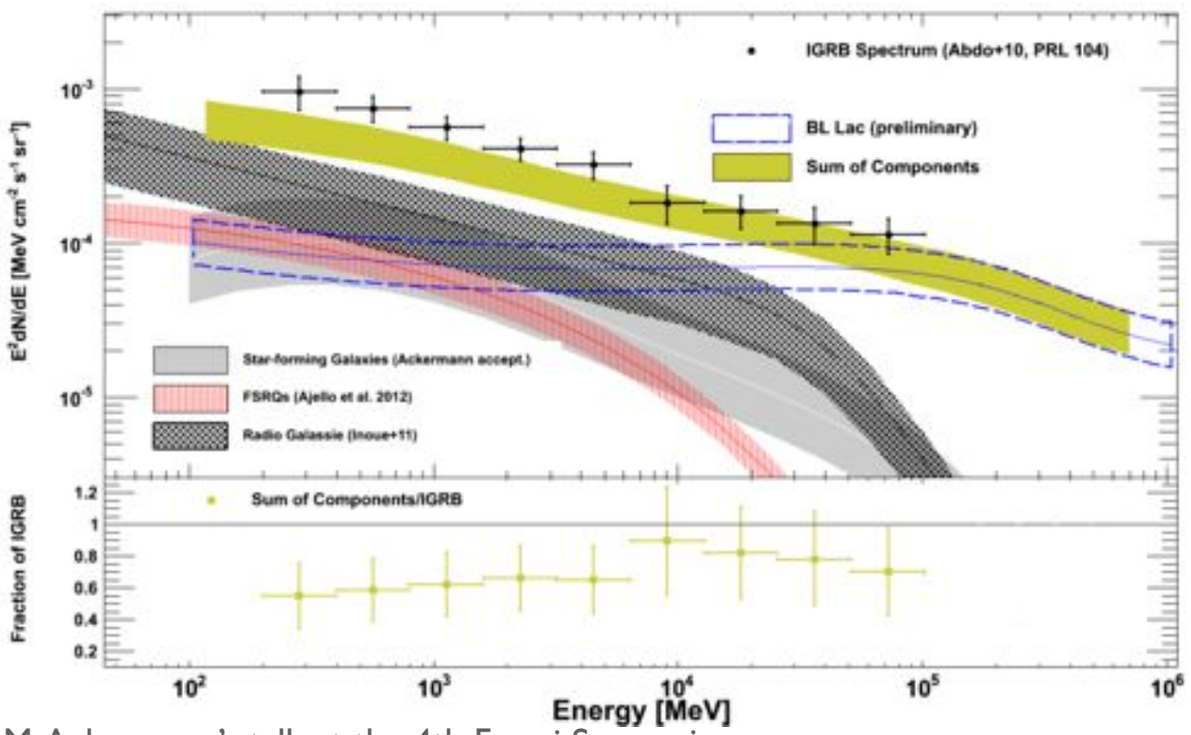
- compatible with power-law energy spectrum with a slope of -2.4, possible softening at high energies

The nature of the DGRB

- unresolved counterparts of the detected sources (blazars, star-forming galaxies, radio galaxies, ...)

- population studies (possibly at higher frequencies) estimate the unresolved component

- room for additional classes of sources



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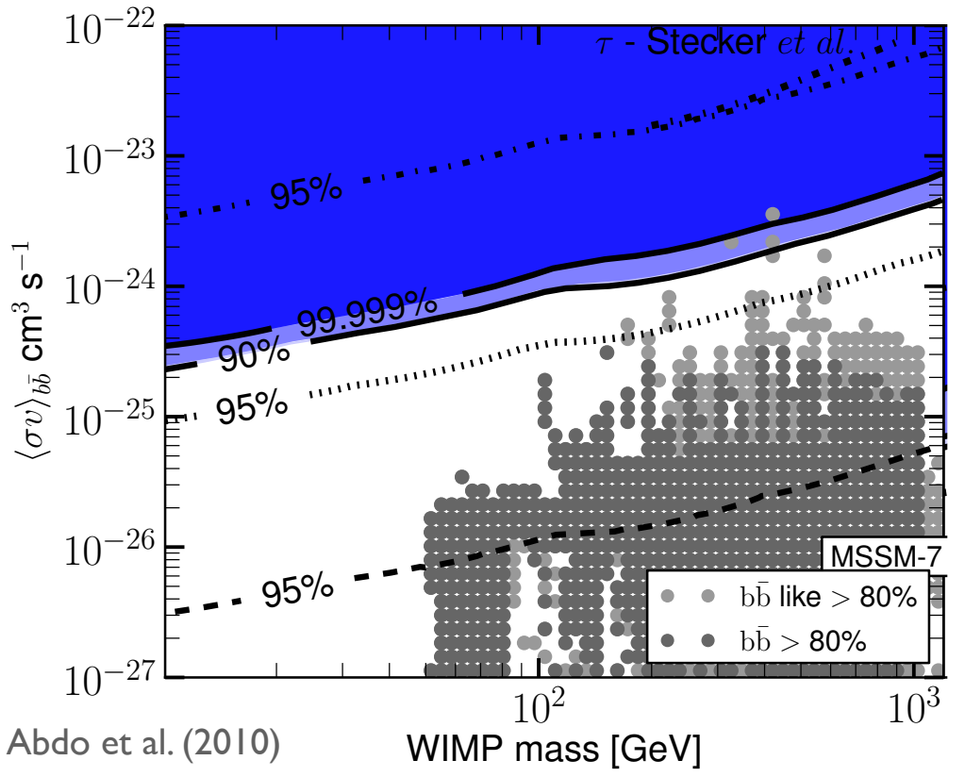
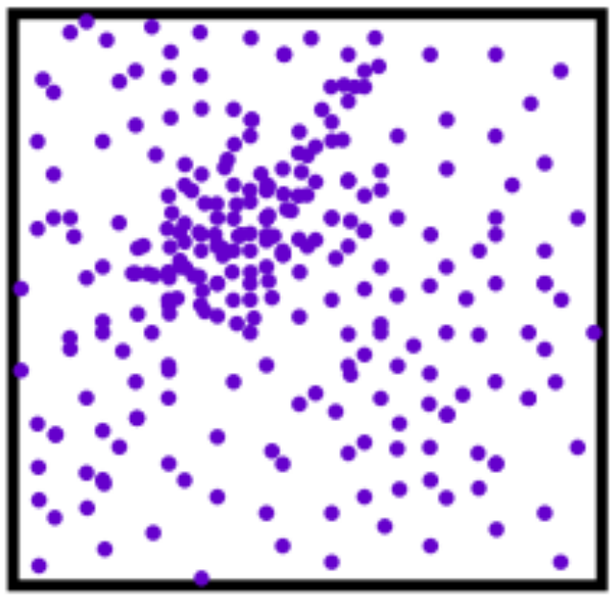
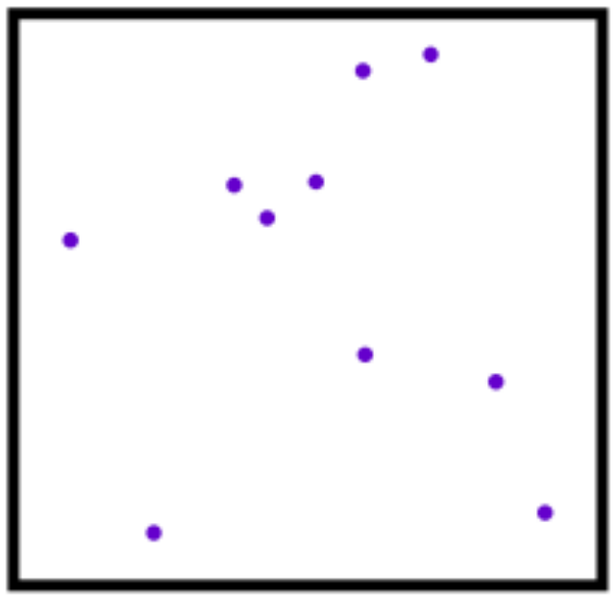


Abdo et al. (2010)

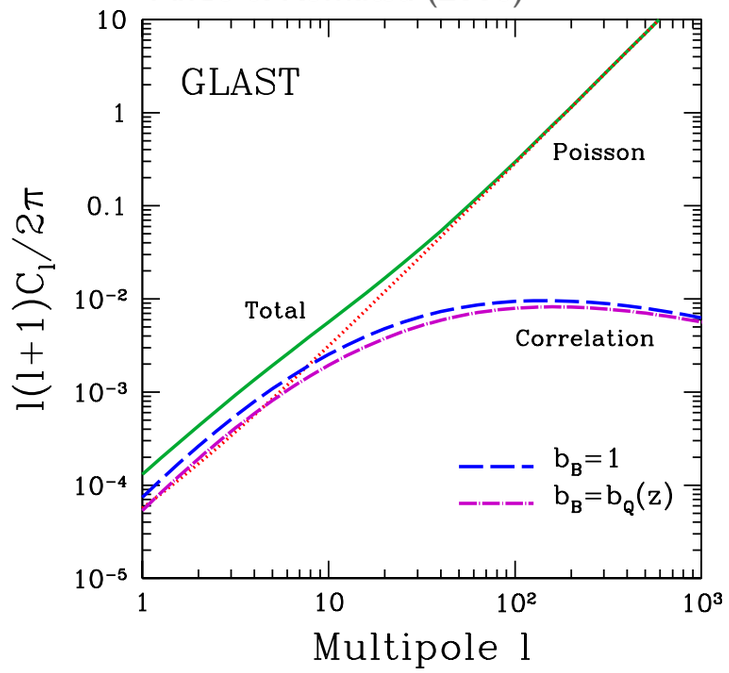
Anisotropies in the DGRB

- quantifies the fluctuations in a 2D map
- complementary information than intensity energy spectrum
- Poisson power spectrum (constant in multipole) that depends on the number of sources
- photon noise (again Poisson-like)

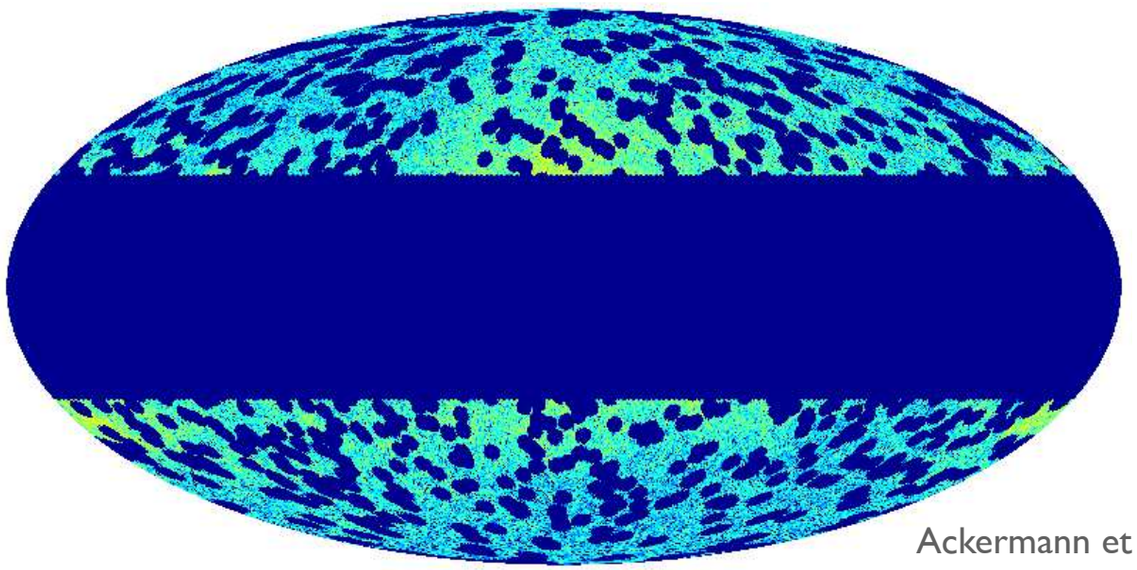




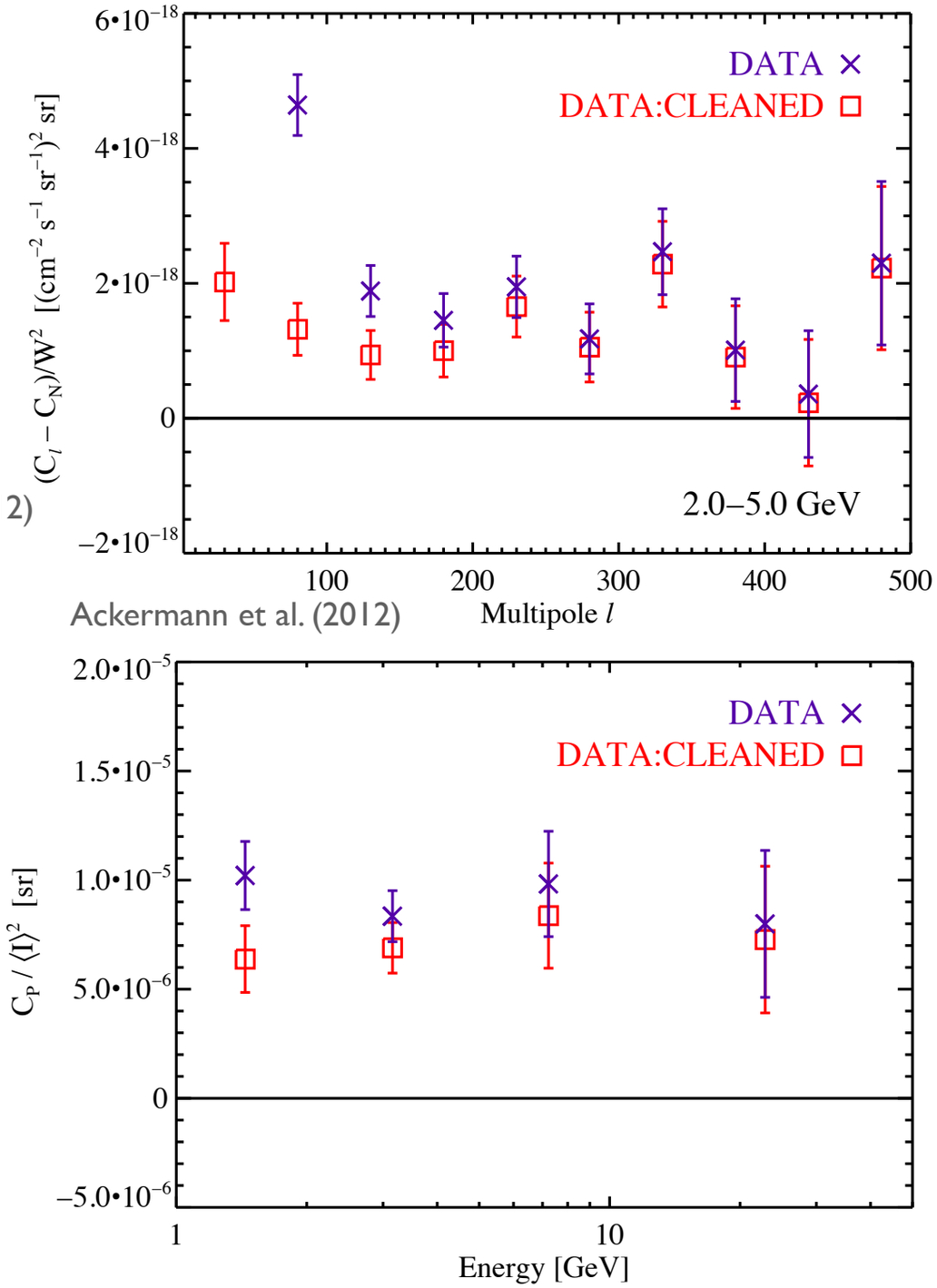
Ando & Komatsu (2006)



Fermi-LAT measurement of anisotropies

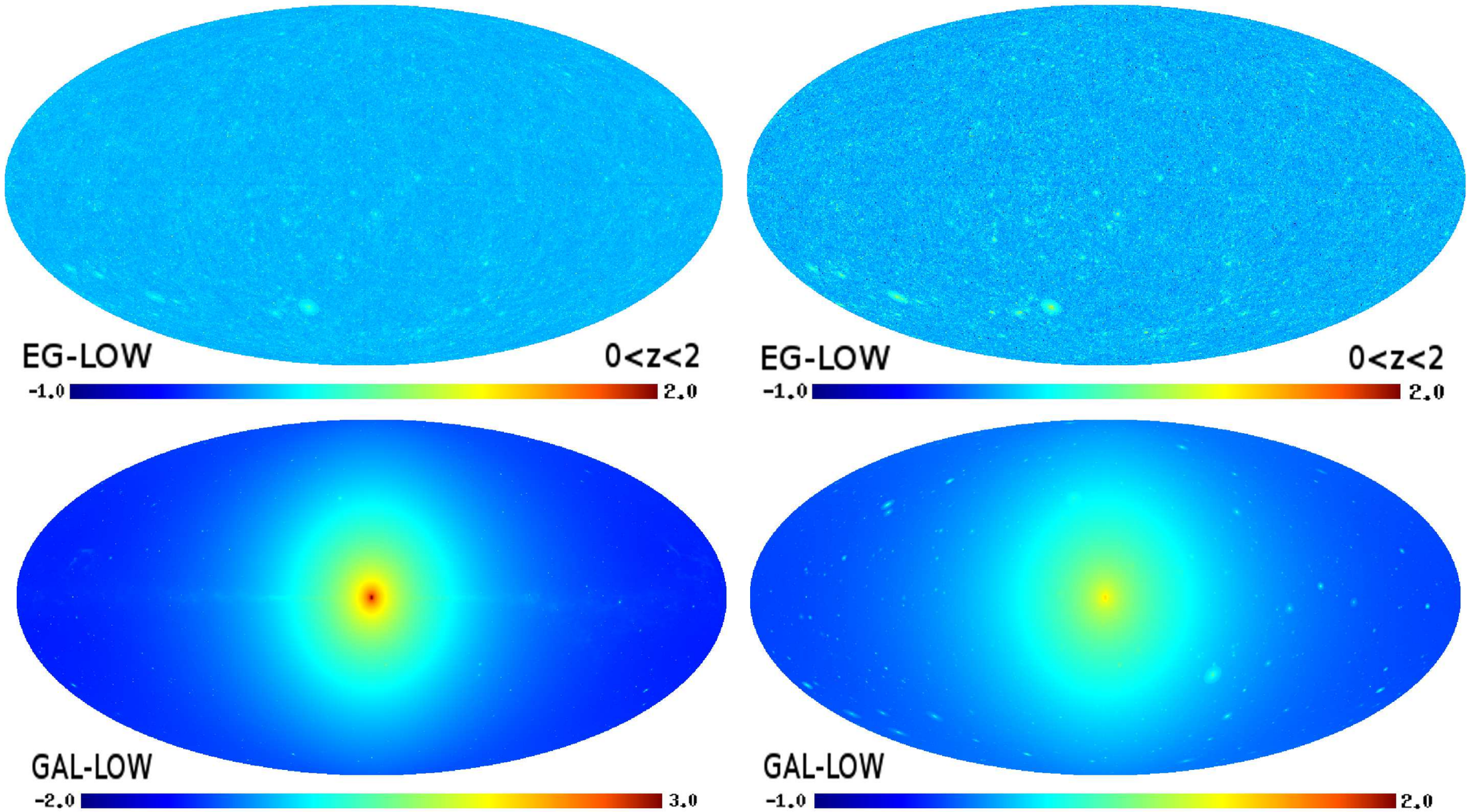


Ackermann et al. (2012)



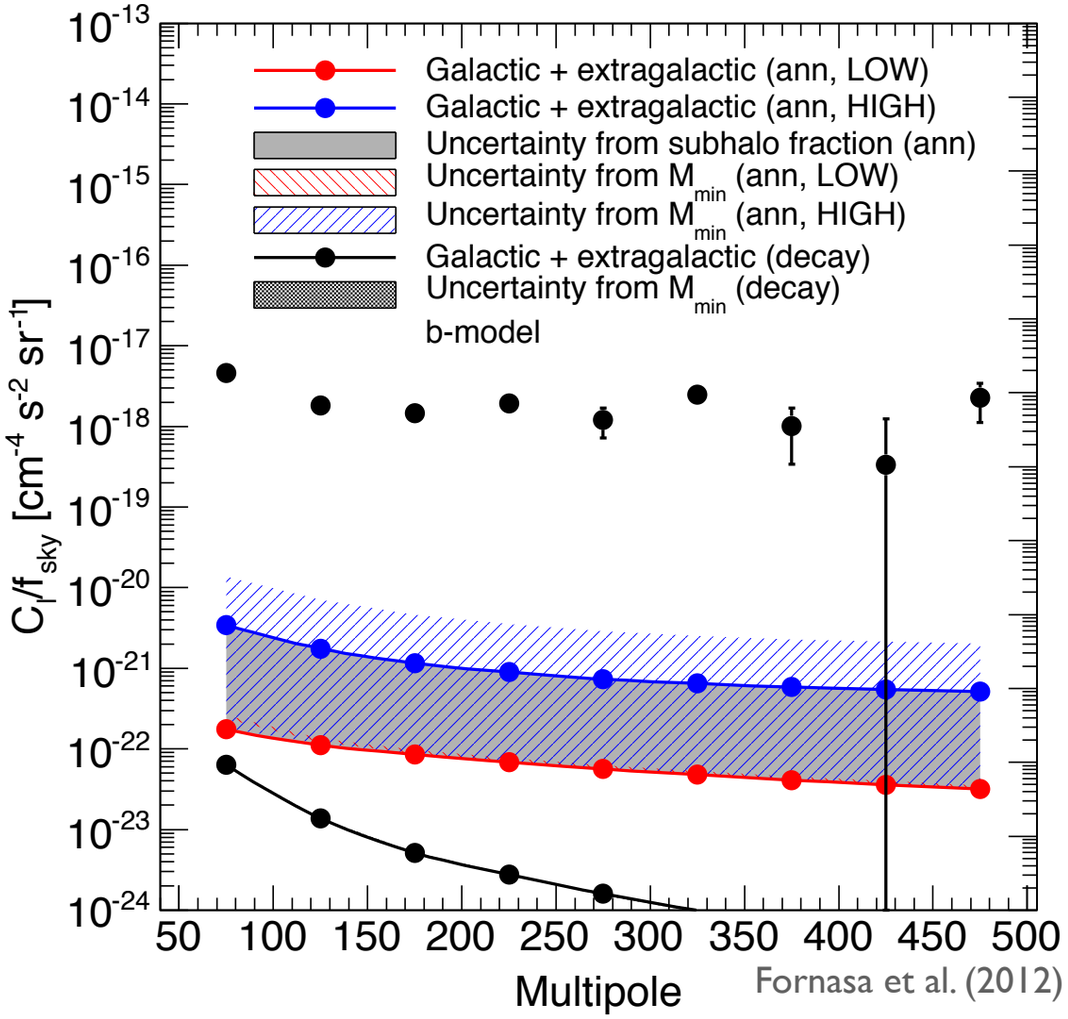
- Galactic foreground and point sources are masked not subtracted
- 22 months of data (4 energy bins between 1 and 50 GeV)
- signal region between multipole 155 and 504
- significance of the detection ranges from 7.1 to 2.4

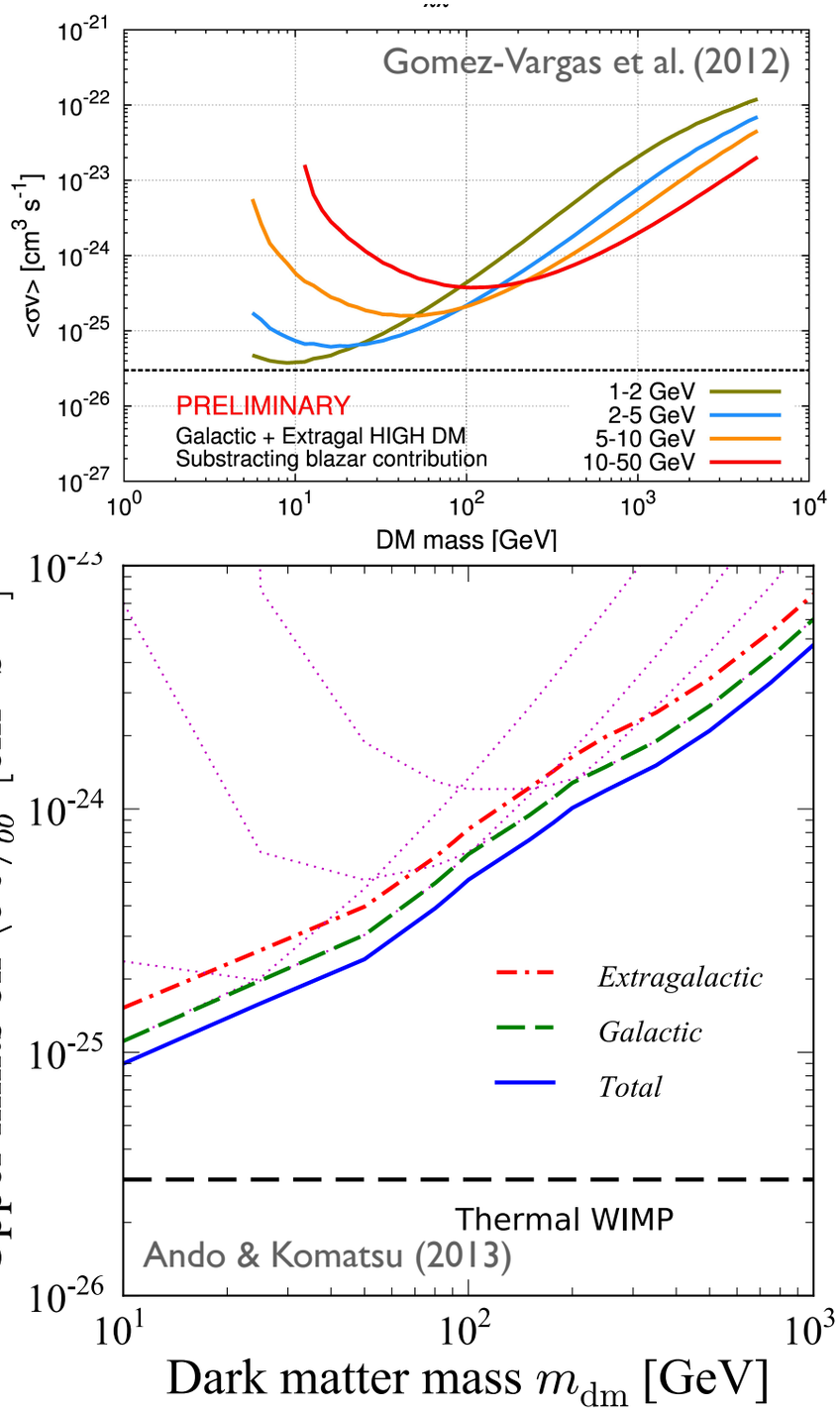
DM-induced anisotropies



E=4 GeV, $M_{min}=10^{-6}M_{\odot}$, m_{χ}=200 GeV, $\sigma v=3\times10^{-26}cm^3s^{-1}$ (annihilation), m_{χ}=2 TeV, $\tau=2\times10^{27}s$ (decay), b quarks
Fornasa et al. (2012)

DM-induced angular power spectrum





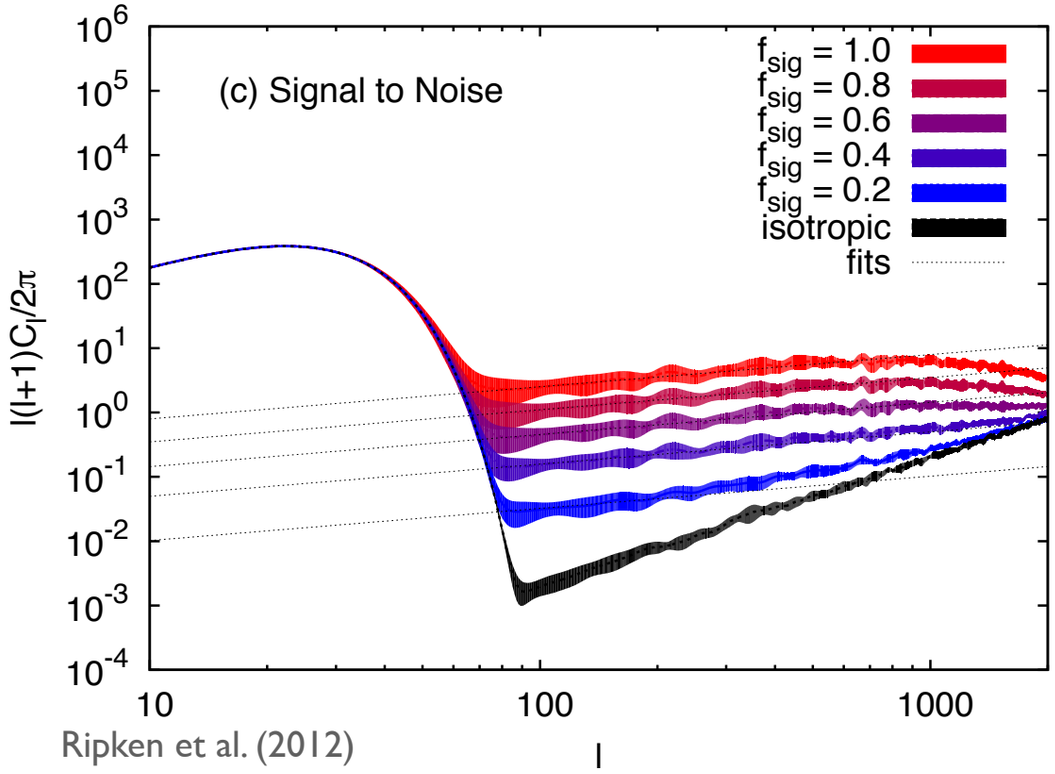
- Fermi-LAT APS measurement improves our knowledge of unresolved blazars (<24% of the DGRB intensity)

Measuring anisotropies with CTA

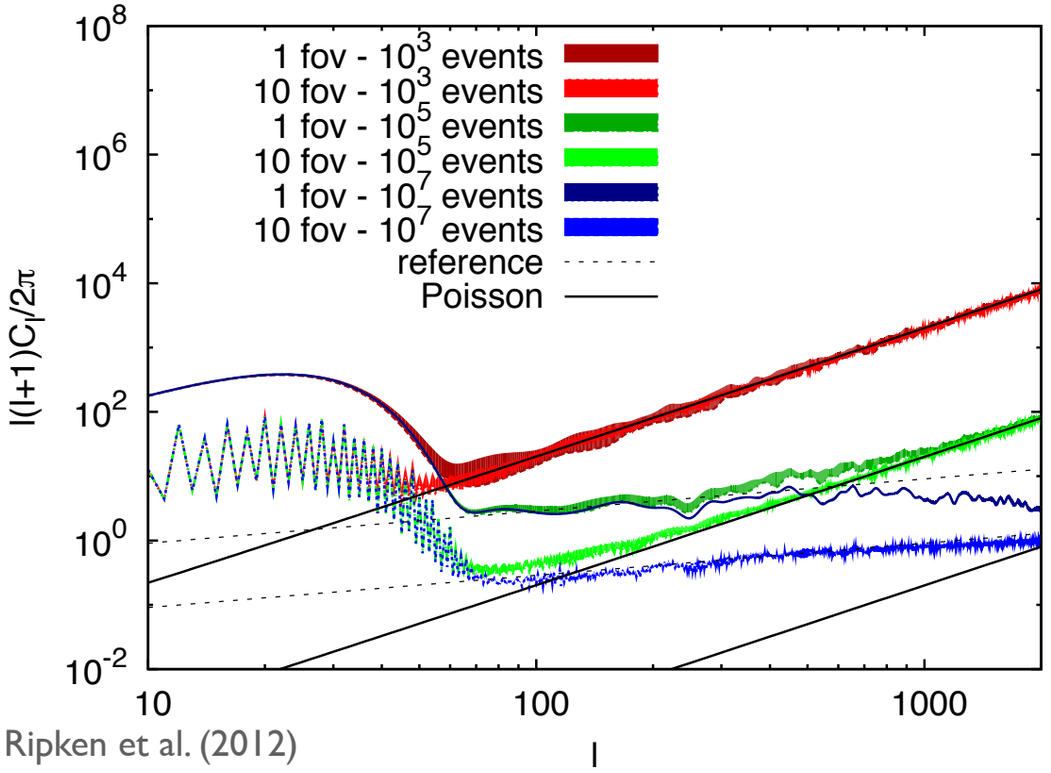
- studies performed within 1 fov with isotropic hadronic and electronic background

- total number of events sets the photon noise

- mock maps produced with a specific (reference) APS: can CTA detect such APS?



Ripken et al. (2012)



Ripken et al. (2012)

Sensitivity to DM

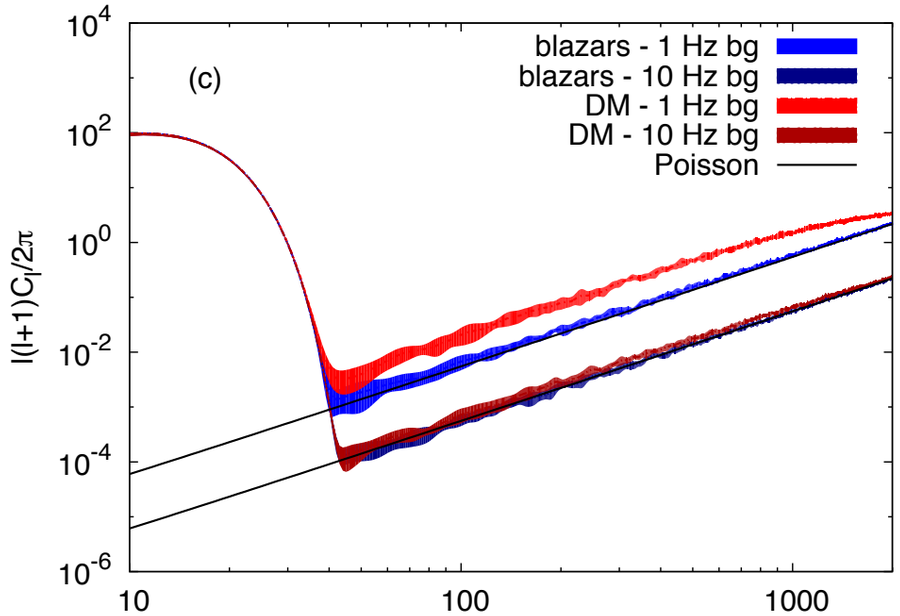
- model APS from astrophysics only to $C_P=10^{-5}$

- what is the contribution of DM to DGRB required to detect a deviation from the expected model APS?

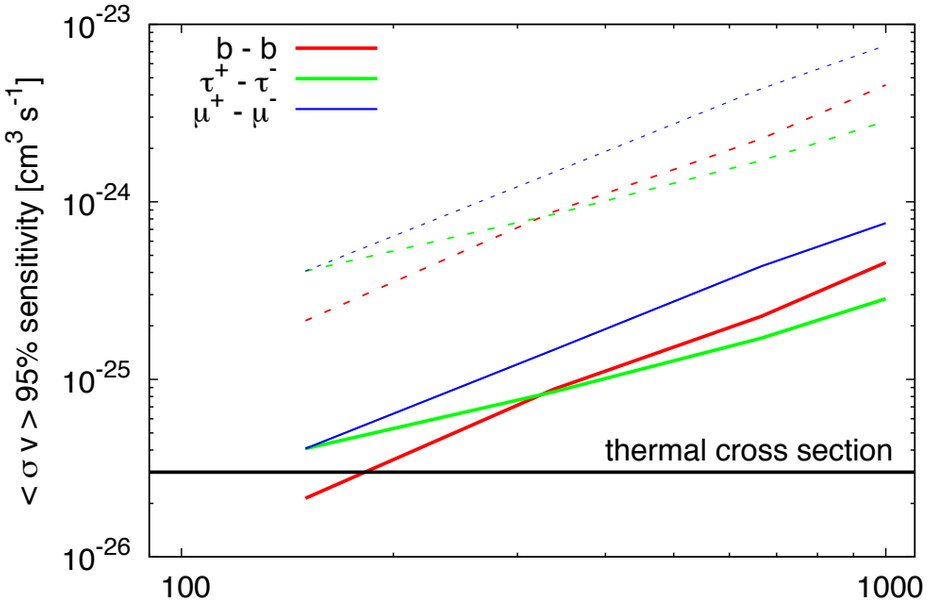
- mock maps produced with a specific (reference) APS: can CTA detect such APS?

Observation time [h]	Back. rate [Hz]	Sensitivity
100	1 (10)	30% (>46%)
300	1 (10)	15% (>46%)
1000	1 (10)	8% (30%)
10x100	1 (10)	15% (>46%)

Ripken et al. (2012)



Ripken et al. (2012)



Ripken et al. (2012)

Conclusions

• anisotropies in gamma-ray emission is a very rich and informative observable (both for DM and astrophysics)

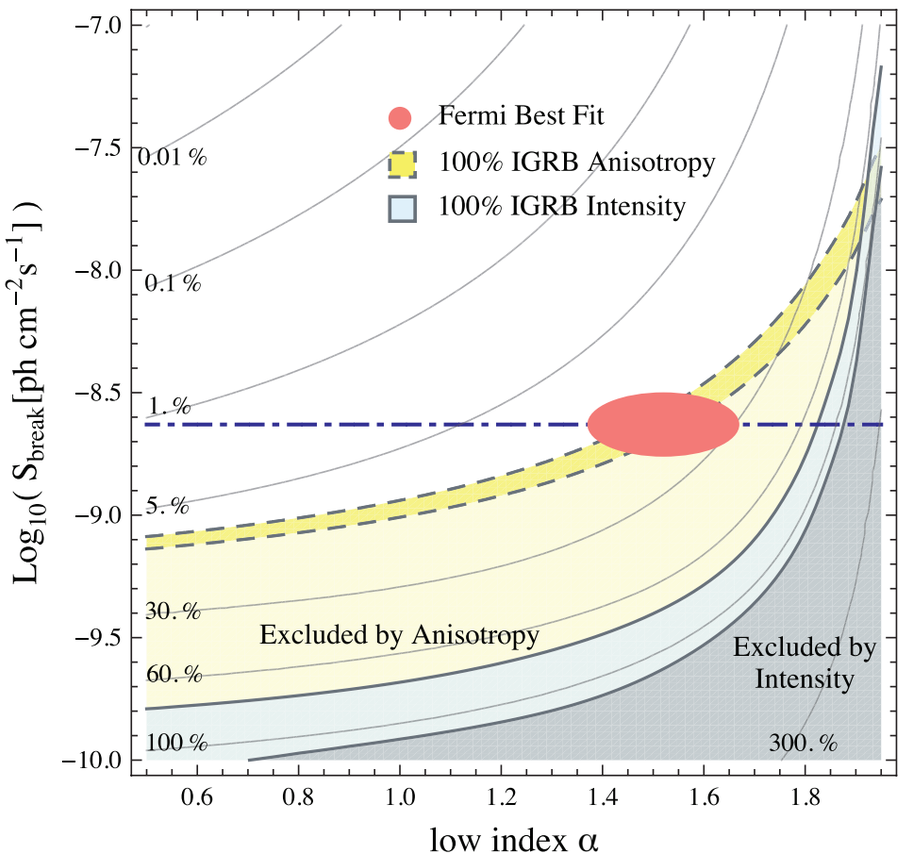
• data are available from Fermi-LAT and have been successfully used to extract information on astrophysical sources and to put constraints on DM

• preliminary studies on CTA potential to detect APS (and it almost comes for free)

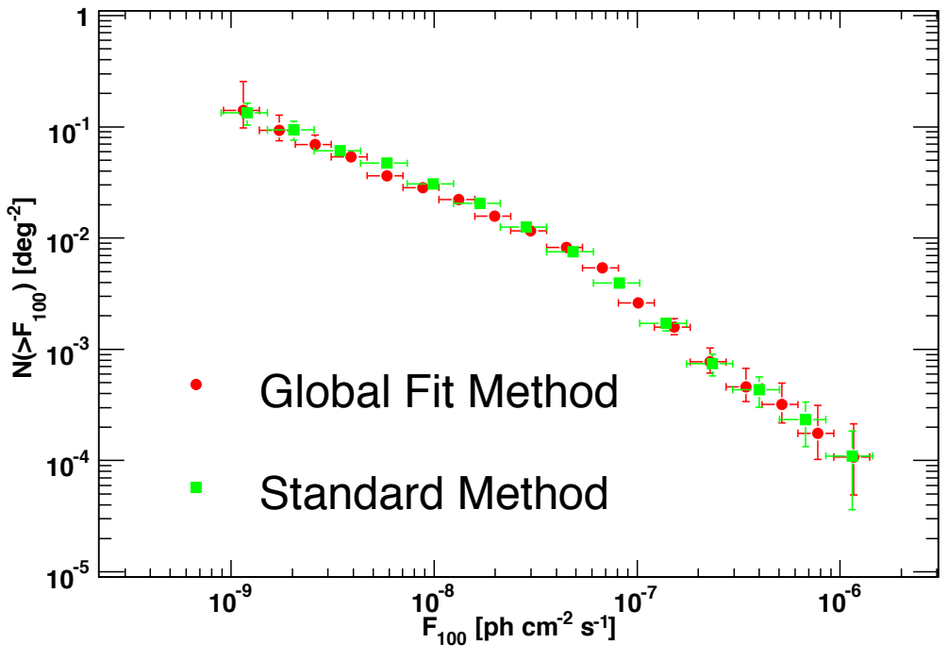
• sensitivity to DM is encouraging

APS constraints on blazars

Cuoco et al. (2012)



Abdo et al. (2010)



- S_{break} and α: parameters modelling unresolved blazars d*N*/d*S*
- **Poisson** APS constraints are stronger than the one from DGRB intensity
- Fermi-LAT APS measurement **improves our knowledge** of unresolved blazars (<24% of the DGRB intensity)

Fluctuation vs. intensity APS

- Fluctuation APS is a dimension-less quantity (independent on enegy)

$$a_{\ell,m}^{\rm fluct} = \int d\Omega_{\mathbf{n}} \frac{I(\mathbf{n}) - \langle I \rangle}{\langle I \rangle} Y^*_{\ell,m}(\mathbf{n}) \qquad C_\ell^{\rm fluct} = \sum_{|m|\leq\ell} |a_{\ell,m}^{\rm fluct}|^2$$

- Intenty APS is a dimension-ful quantity (scaling with energy like I^2)

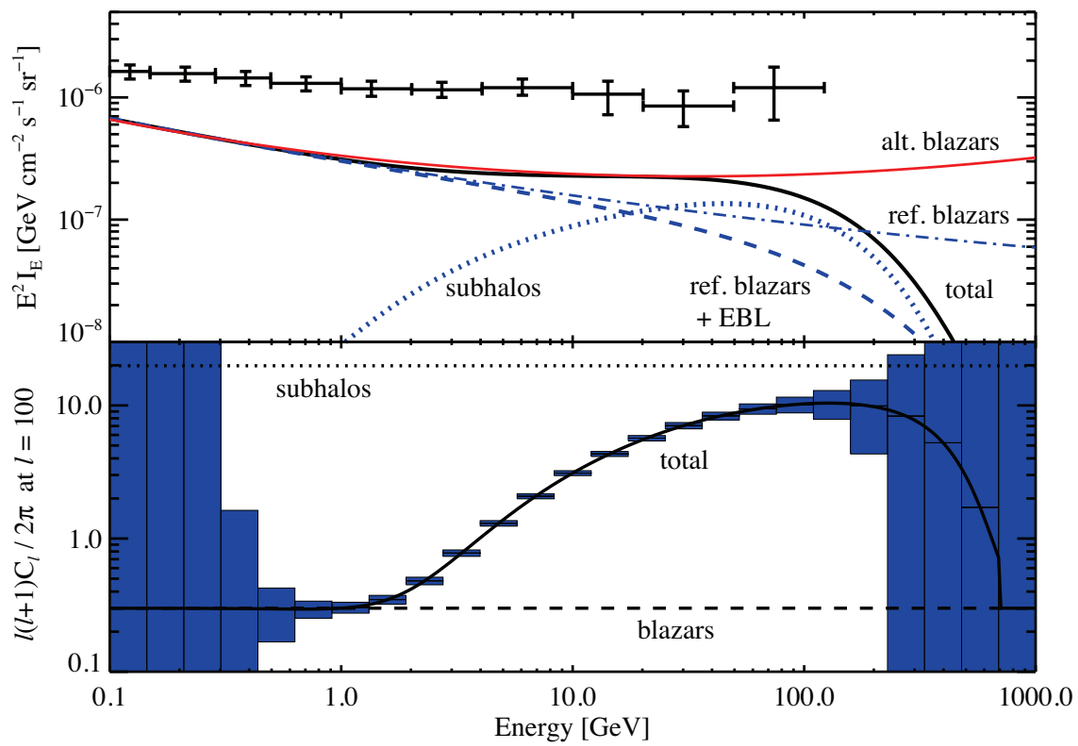
$$C_\ell^{\rm int} = C_\ell^{\rm fluct} \langle I \rangle^2$$

- summation rules

$$C_\ell^{\rm int} = C_{\ell,1}^{\rm int} + C_{\ell,2}^{\rm int}$$

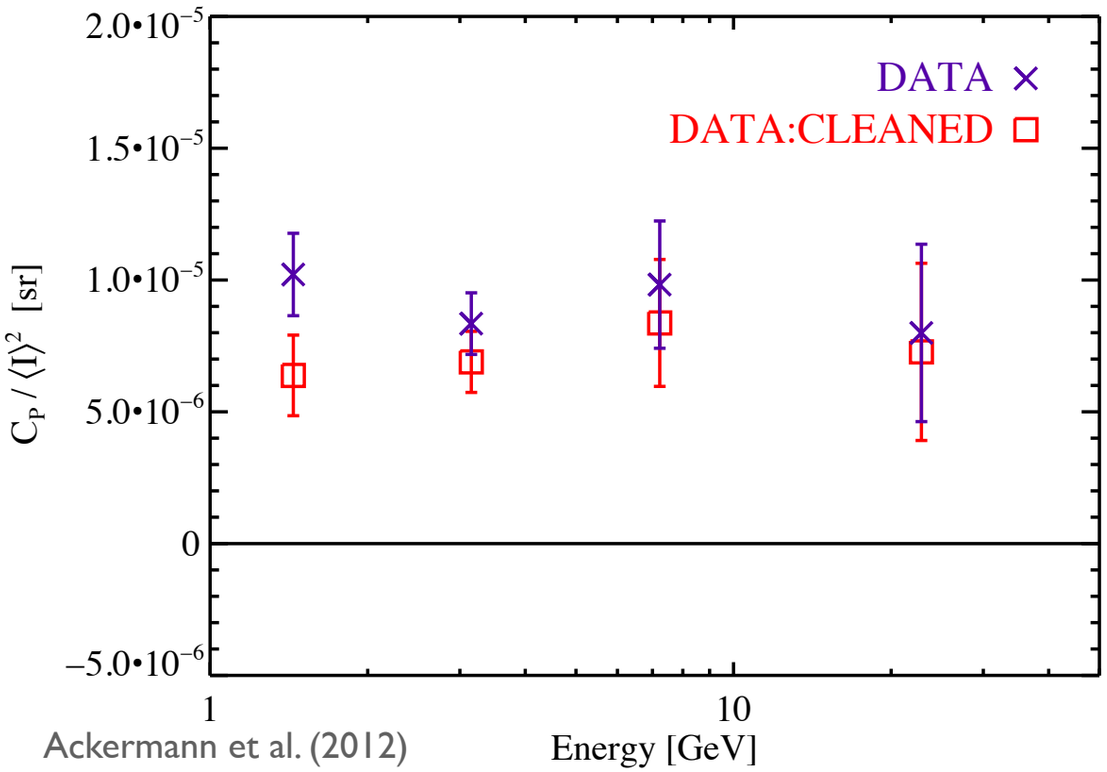
$$C_\ell^{\rm fluct} = \frac{\langle I_1 \rangle^2}{\langle I \rangle^2} C_{\ell,1}^{\rm fluct} + \frac{\langle I_2 \rangle^2}{\langle I \rangle^2} C_{\ell,2}^{\rm fluct}$$

Siegal-Gaskins and Pavlidou (2009)



Fluctuation vs. intensity APS

Fluctuation APS



Ackermann et al. (2012)

Intensity APS