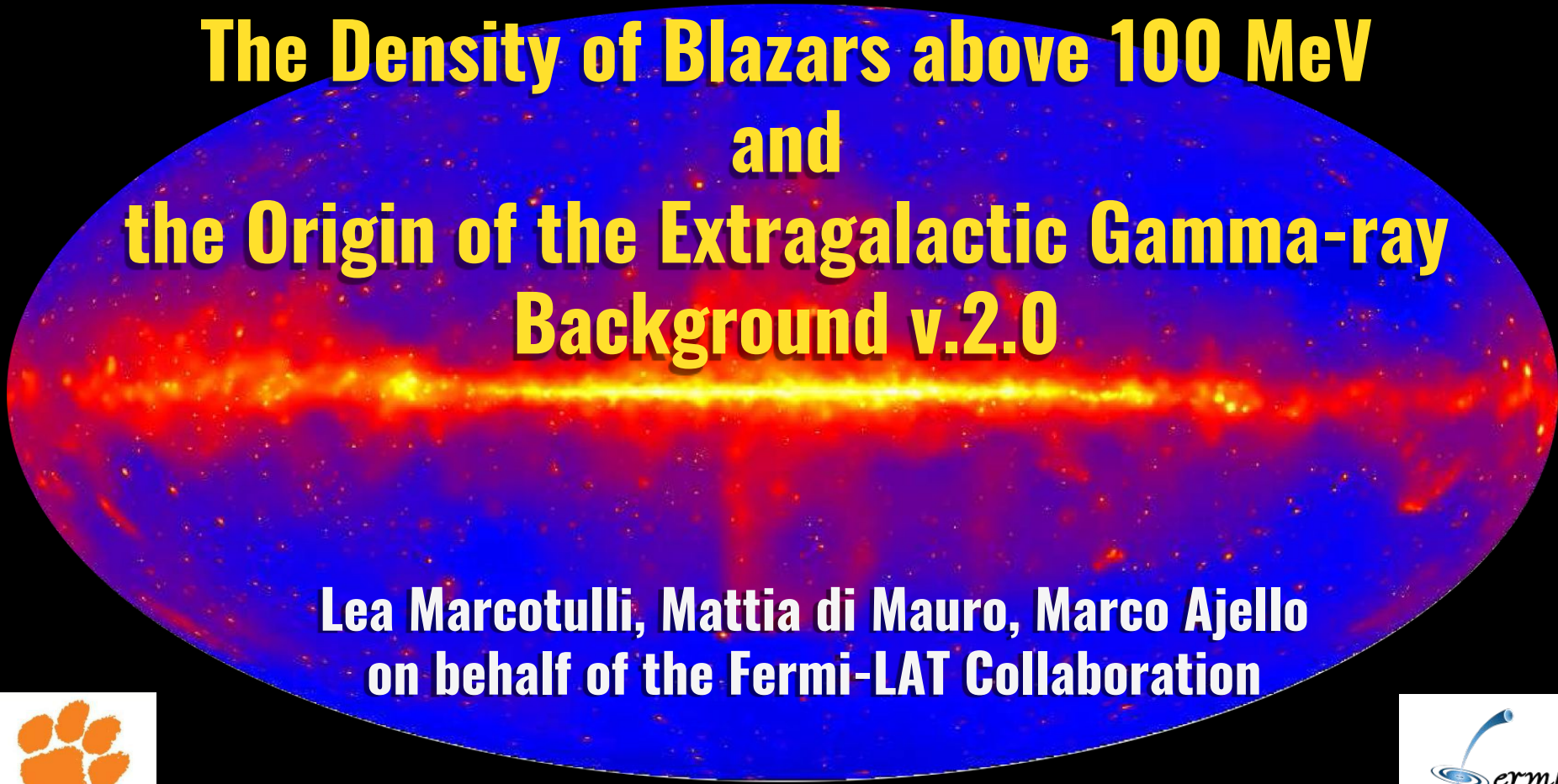
The Density of Blazars above 100 MeV and the Origin of the Extragalactic Gamma-ray Background v.2.0



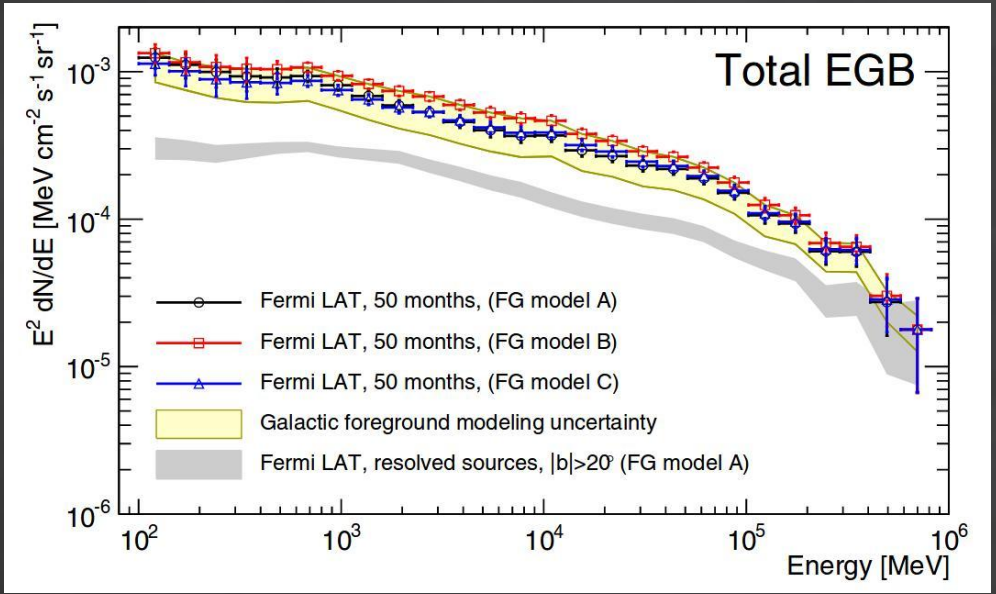
Lea Marcotulli, Mattia di Mauro, Marco Ajello
on behalf of the Fermi-LAT Collaboration

CLEMSON UNIVERSITY

8th International Fermi Symposium, 2018, Oct. 17th

Fermi Gamma-ray Space Telescope

The Extragalactic Gamma-Ray Background (EGB)



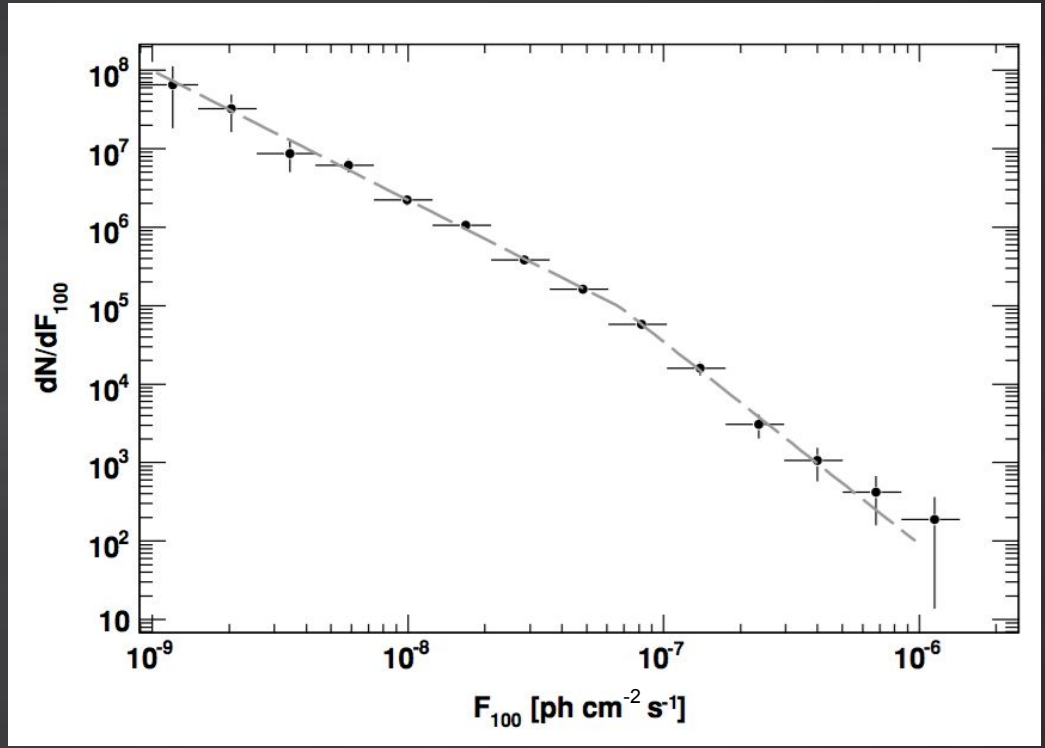
Ackermann et al., 2015

Resolved sources account for ~30% of the EGB below 100 GeV and for more than 50% above 100 GeV

Previous works

- The LAT has been in orbit for 10 years → significantly larger amount of data
- Pass 8 data set has increased energy sensitivity, particularly towards lower energies (< 200 MeV)

It is possible to accurately characterize the dN/dS from energies > 100 MeV



Abdo et al., 2010

Efficiency Correction Method Recipe

1) Detect real sources above Galactic latitudes (|b|>20°) using 8 years of Pass 8 data

2) Perform detailed Monte Carlo simulations to derive survey biases

3) Derive the efficiency of the LAT to account for these biases

4) Derive the intrinsic source count distribution of the blazar population

LAT data analysis

Data Set	Pass 8 (P305)
Event Class	SOURCE
Energy Range	100 MeV - 1 TeV
Time interval	2008 August 4 U.T. 15:43:36.00 to 2016 August 2 U.T. 05:44:11.99
ROI size	15°
IRF	P8R3 SOURCE V2
Diffuse Emission	Galdiff = 'gll_iem_v06_extended.fits' Isodiff = 'iso_P8R2_SOURCE_V6_v06_ext.txt'
Catalog/s	NONE

- PSF and zenith angle selection following FL8Y recommendations
- Iterative detection procedure: from the brightest to the faintest
- **Test for curvature**: bright sources fitted with both Power Law and Log Parabola spectra and, if significantly curved (TS_{CURV}>16), kept as Log Parabola

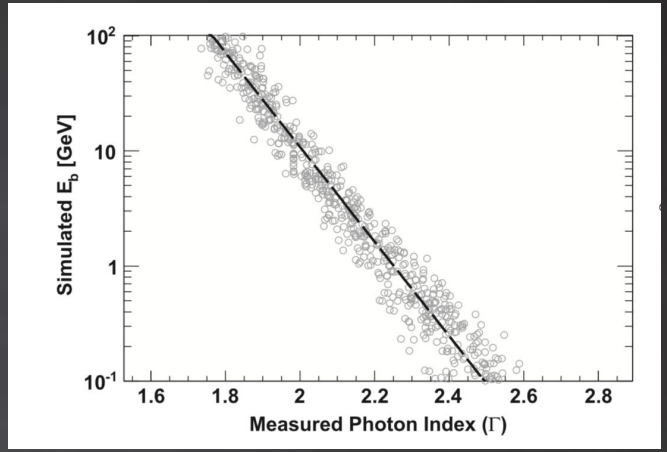
SIMULATIONS

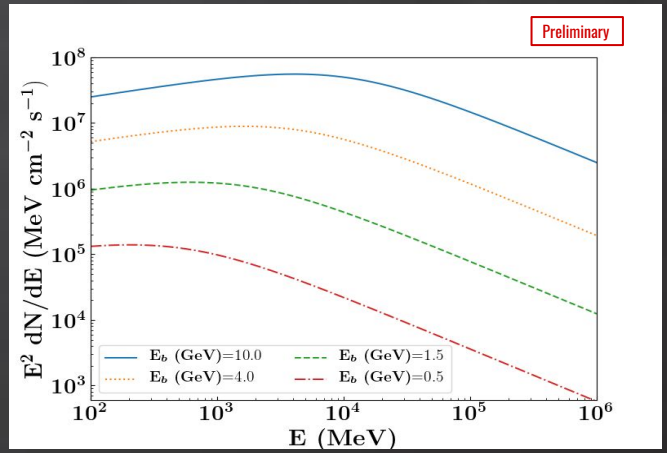
- Number of simulations: 6
- LogN-logS input shape very similar to the final one (iterative process)
- Flux Range: [10^{-11}, 10^{-6}] ph cm^{-2} s^{-1}
- Photon indices drawn from a Gaussian distribution <x>=2.45, σ=0.40
- Double power-law SED for simulated sources (following Ajello et al., 2015)

$$\frac{dN}{dE} = K\left[\left(\frac{E}{E_b}\right)^{\gamma_1} + \left(\frac{E}{E_b}\right)^{\gamma_2}\right]^{-1}$$

- γ_1=1.7 if E_b<100 GeV, otherwise drawn from a Gaussian distribution <x>=2.45, σ=0.40
- γ_2=2.8 (optimized already to reproduce 3FHL LogN-LogS)

Ajello et al. 2015





Marcotulli et al. in prep.

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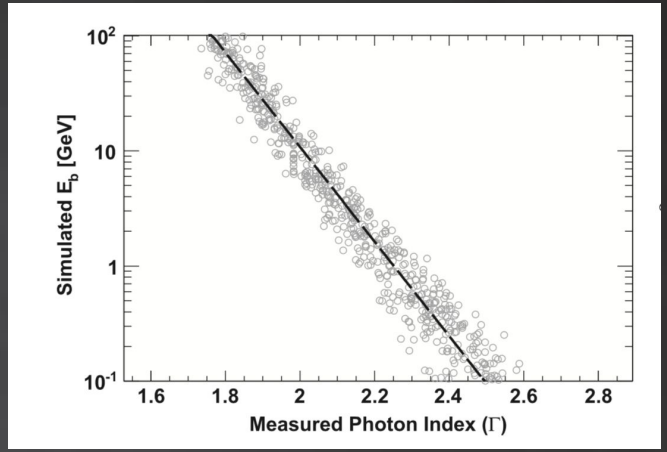
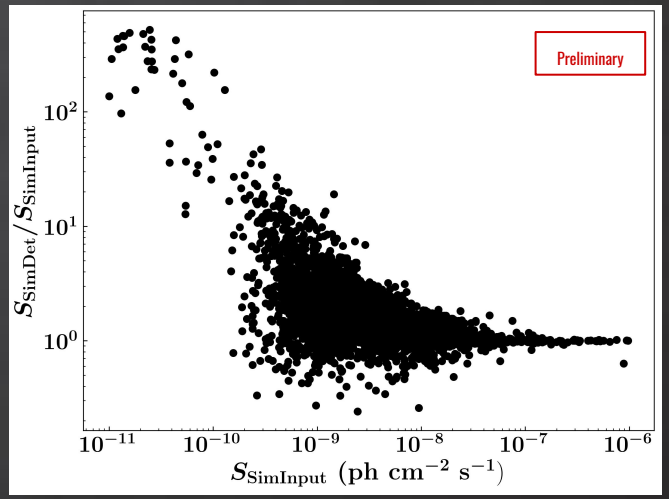


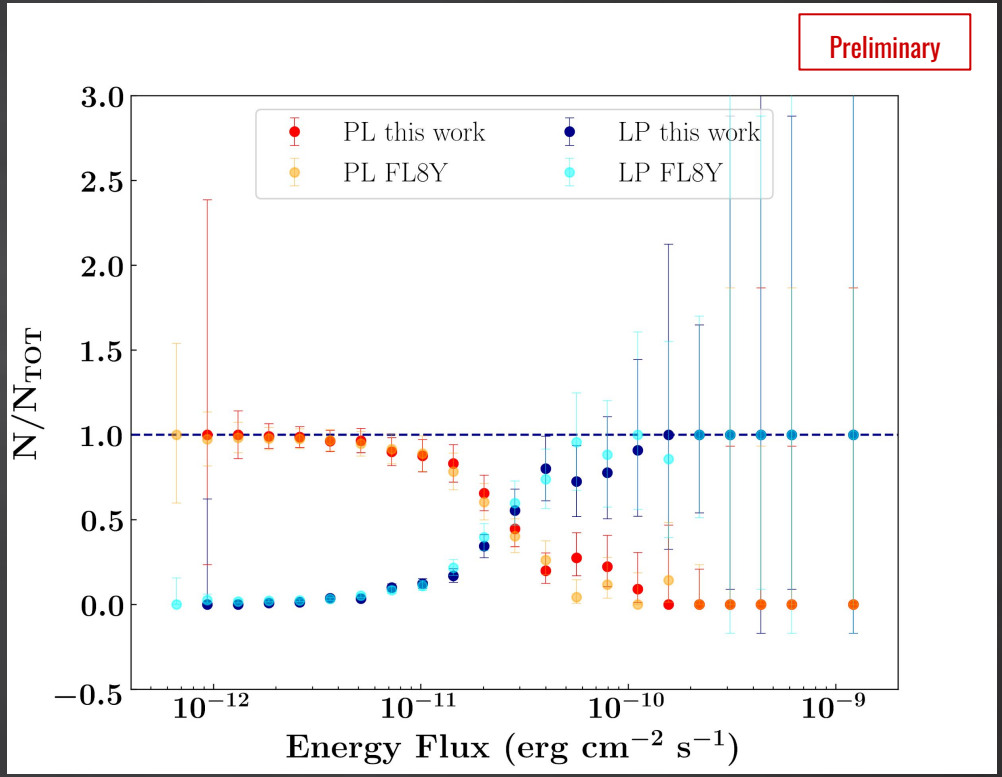


Marcotulli et al. in prep.

The real sky vs. FL8Y (fraction of PL and LP sources)

	This work	FL8Y
Total # sources |b|>20	2680	2930
Power Law	2410	2638
Log Parabola	270	248

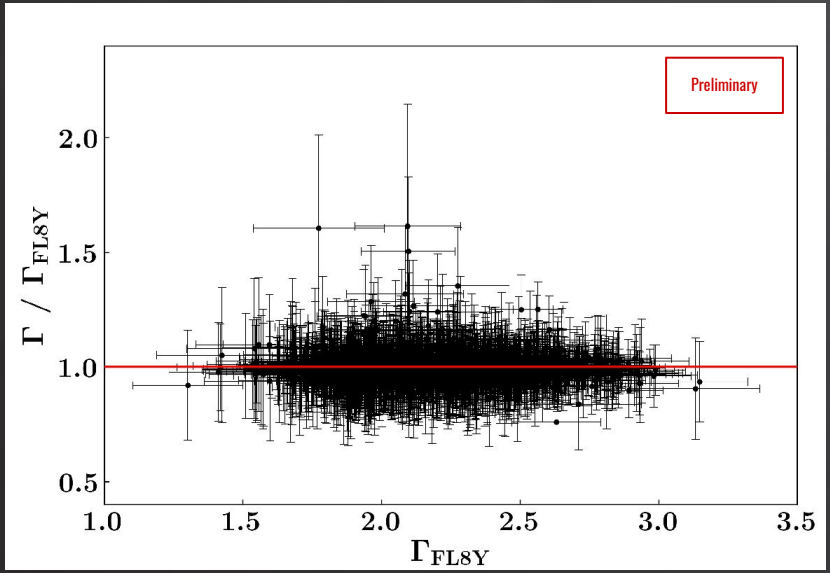
- Positional matches with 95% positional error: 2443



Marcotulli et al. in prep.

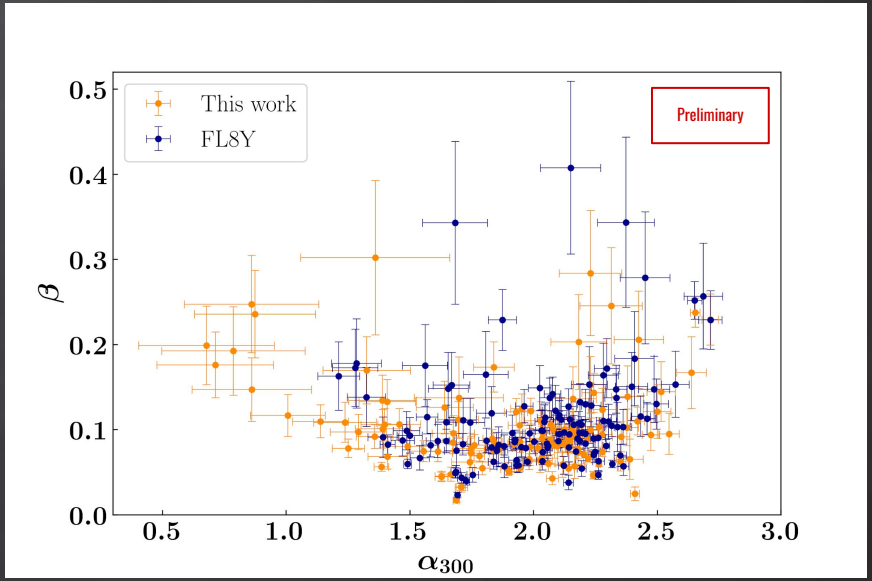
The real sky vs. FL8Y

Index comparison of matching Power Law sources, listed as blazars in FL8Y



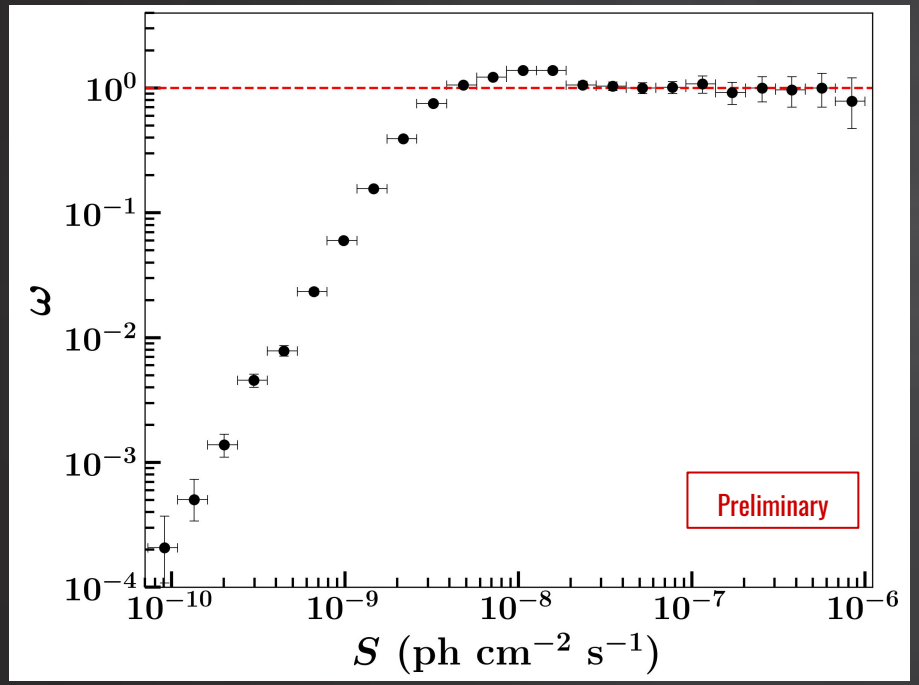
Index and beta comparison of matching Log Parabola sources, listed as blazars in FL8Y

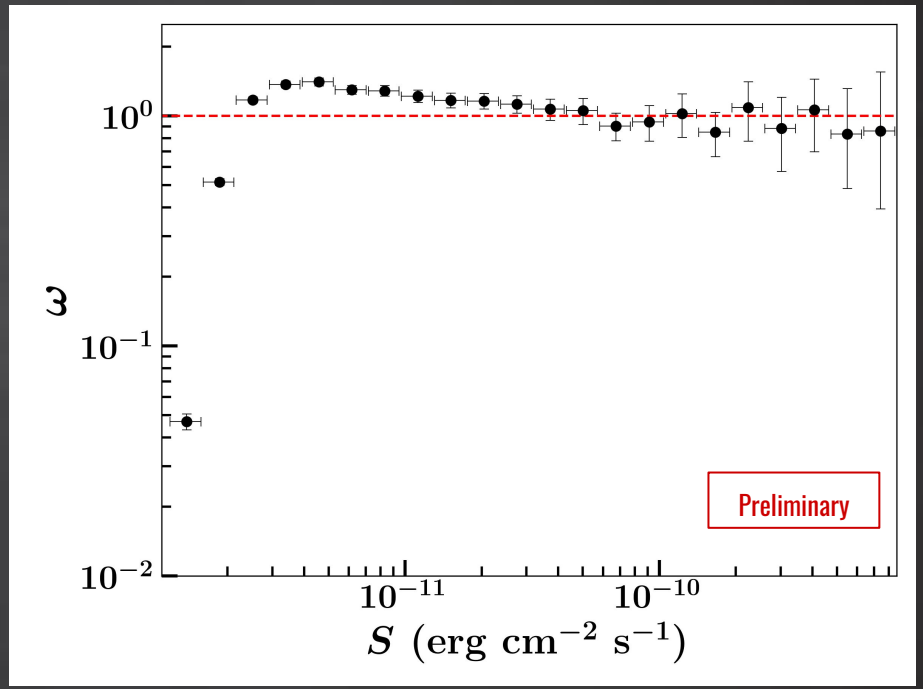
Marcotulli et al. in prep.



EFFICIENCY

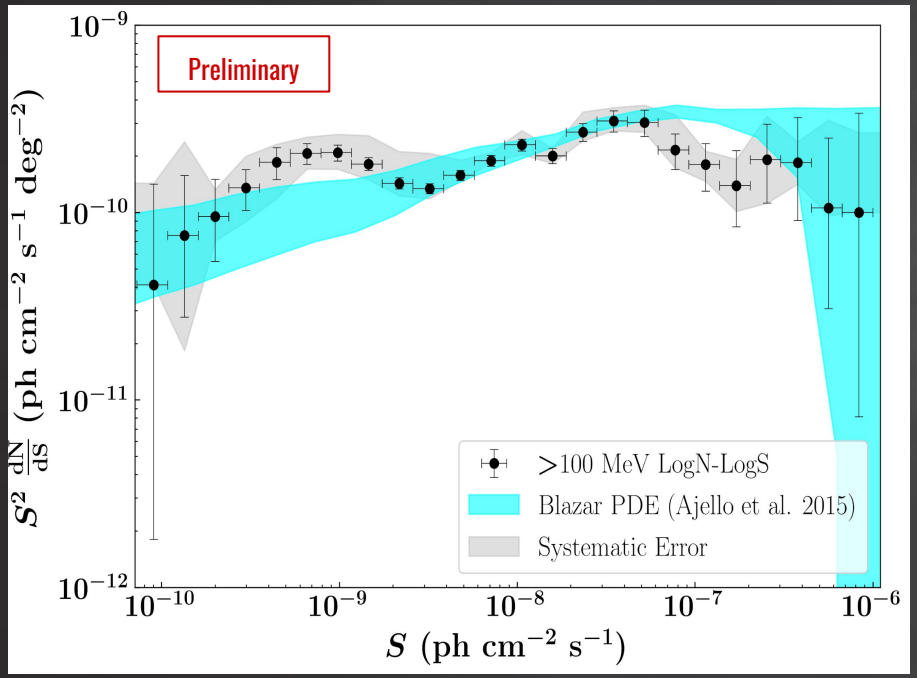
$$\omega = \frac{N_{SIM\ DET}}{N_{SIMULATED}}$$

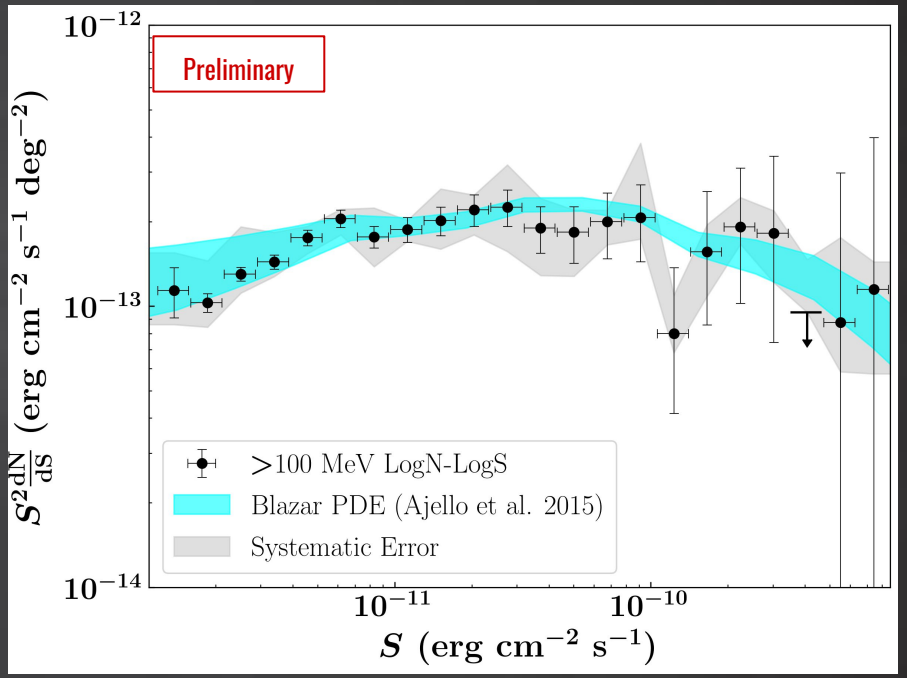




Marcotulli et al. in prep.

INTRINSIC SOURCE COUNT DISTRIBUTION



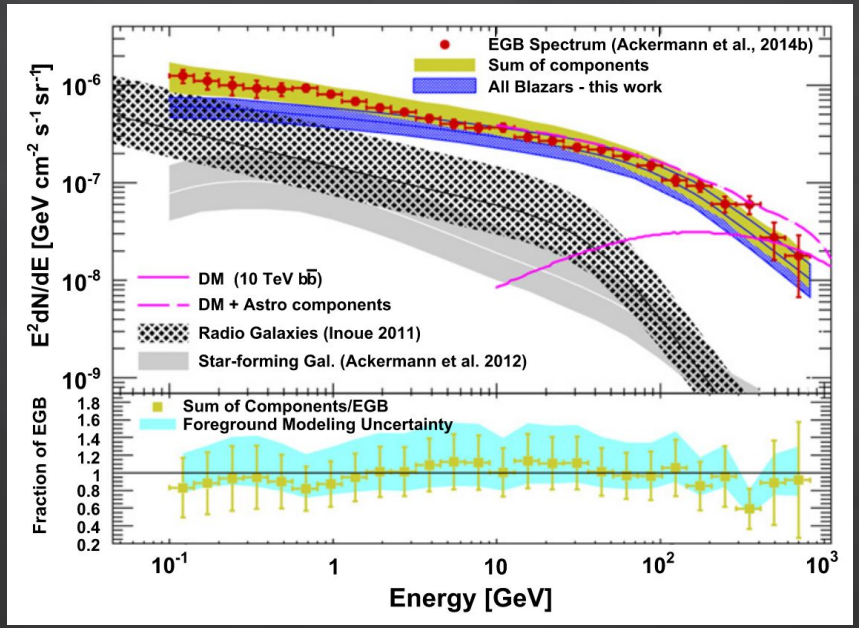


Marcotulli et al. in prep.

ORIGIN OF THE EGB

$$I_{EGB} = 6.9^{+2.27}_{-0.6} \times 10^{-6} (cm^{-2} s^{-1} sr^{-1})$$

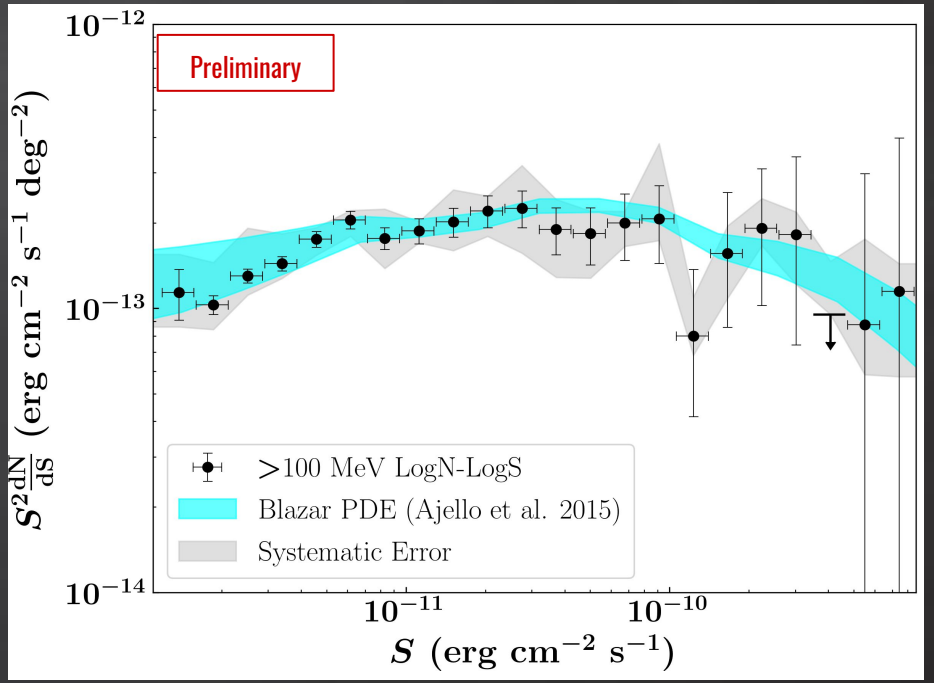
➔ Point-sources (i.e. blazars) account for 60^{+20}_{-5} % of the total EGB



Ajello et al. 2015; Di Mauro et al. 2015

Conclusion

- New analysis characterizes the logN-logS to a **factor of 10 lower fluxes** !
- The Primarily Density Evolution model is the preferred evolution model.
- This implies that point-sources (i.e. blazars) account for ~60 % of the total EGB
- Results are robust



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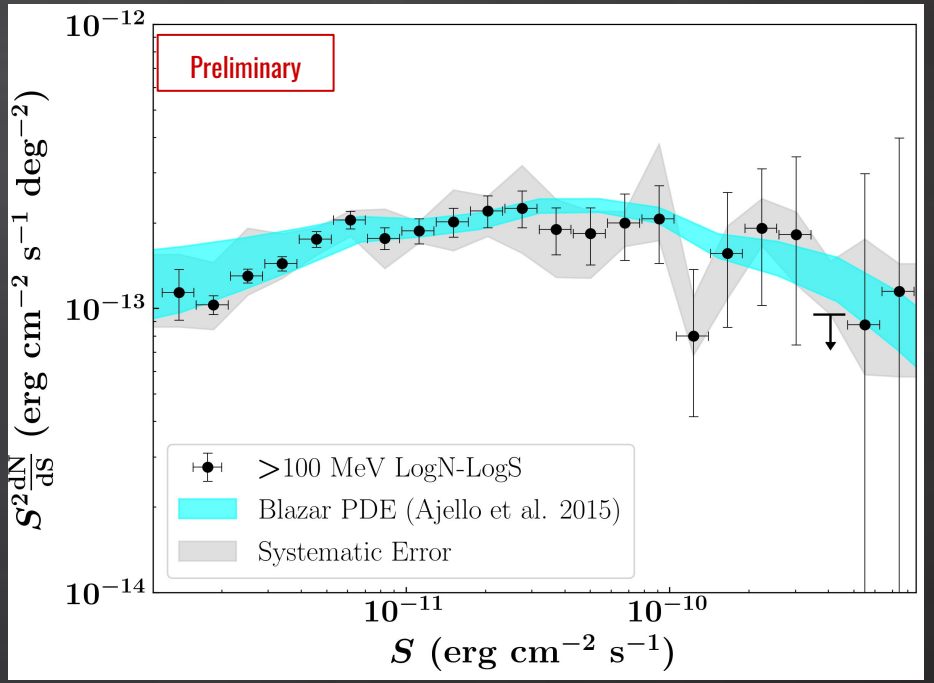

THANK YOU !

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EXTRA SLIDES

LAT data analysis

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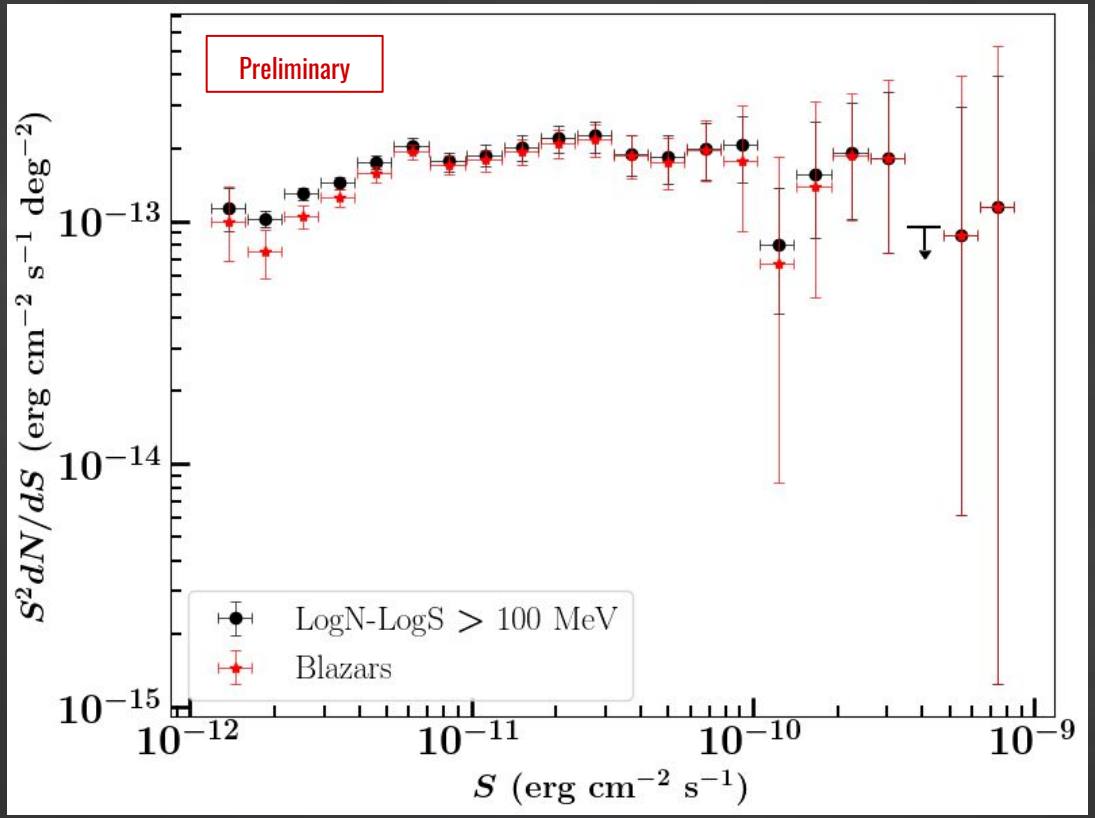
Diffuse Emission	Galdiff = 'gll_iem_v06_extended.fits' Isodiff = 'iso_P8R2_SOURCE_V6_v06_ext.txt'
Catalog/s	NONE

	100 MeV-300 MeV	300 MeV - 1 GeV	1 GeV - 1 TeV
PSF	2, 3	1, 2, 3	ALL
Zenith Angle	90°	100°	105°

Detection Pipeline

- Using FermiPy (http://fermipy.readthedocs.io/en/latest/)
- Divide the extragalactic sky in ROIs of 15°x15°, each having an overlap of 3° between adjacent ROIs (in case of detection of the same source in two ROIs, we choose the one closest to the center of its respective ROI)
- We binned the data with pixel size 0.1 deg and 8 energy bins per decade
- Iterative detection procedure: TS>64 separation 0.4° , TS>36 separation 0.3° , TS>20 separation 0.2°
- **Test for curvature**: if sources have TS>100, we fitted both Power Law and Log Parabola spectra and compute significance of curvature ($TS_{CURV} = 2 \times(\log L_{LP} - \log L_{PL})$). If TS_{CURV}>16, source kept as Log Parabola.

Blazars contribution



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