The extragalactic gamma-ray background

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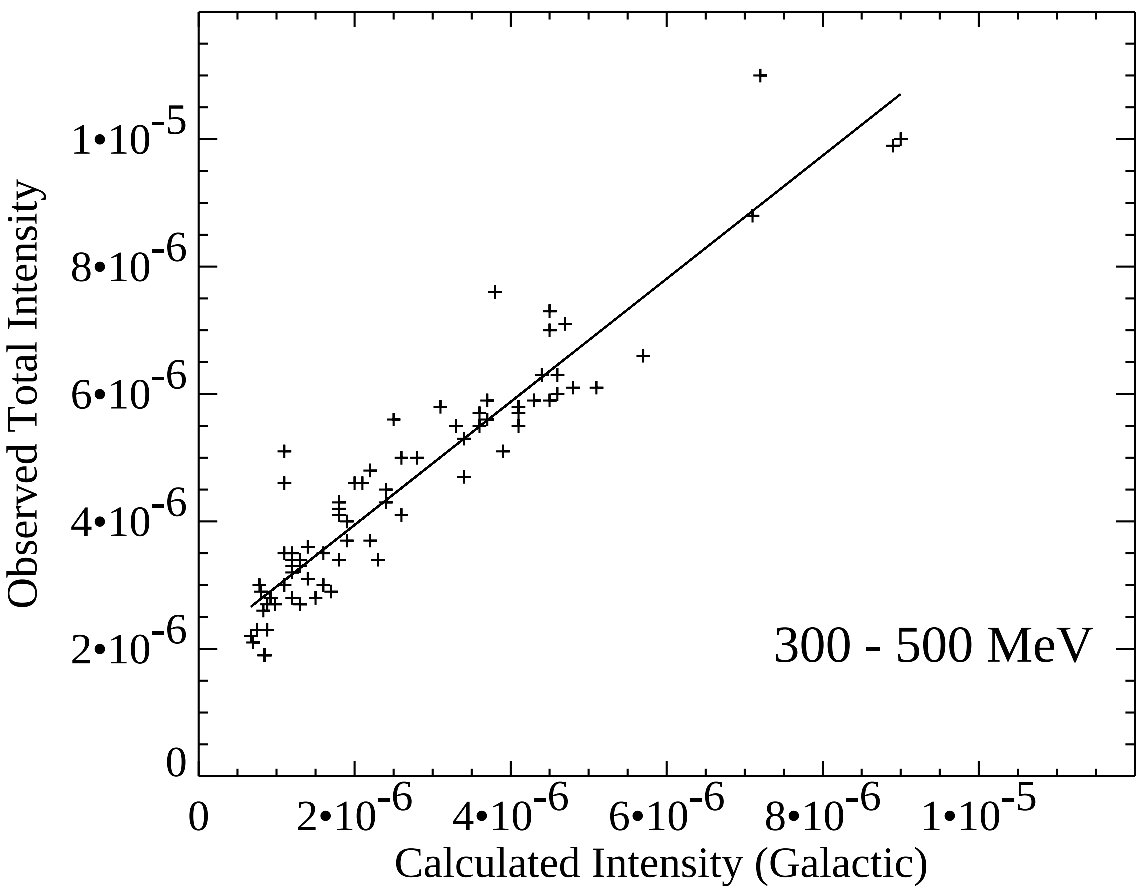
- How do we measure the EDGB?
- Are our methods reliable?
- What causes the EDGB?
- Outlook

EGRET range



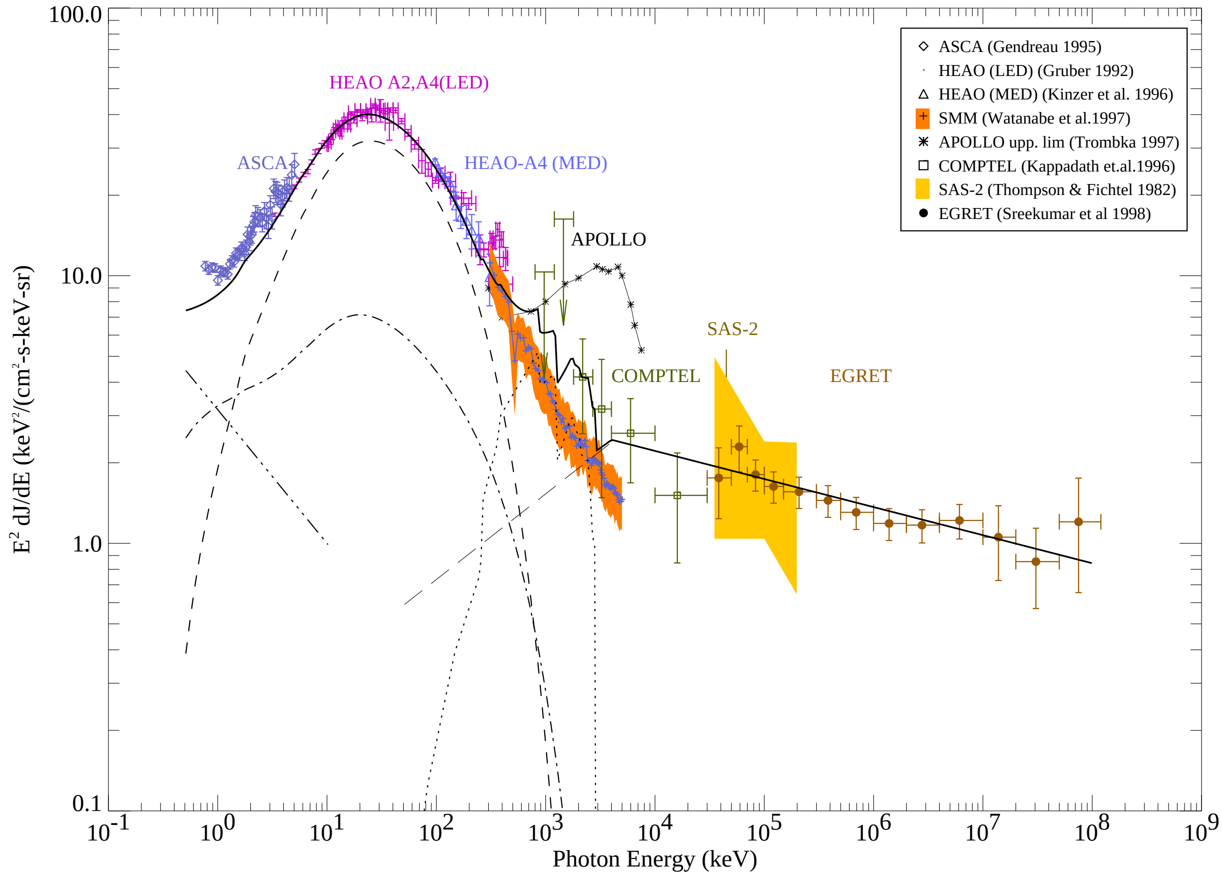
Linear fit of observed intensity versus Galactic model intensity.

Extrapolate to zero intensity of Galactic emission.

(Sreekumar et al., ApJ 494)

COMPTEL range

Subtract instrumental background (Kappadath et al., A&AS 120).



Intensity above 100 MeV: $(1.45 \pm 0.05) \cdot 10^{-5}$ ph. cm^{-2} sec^{-1} sr^{-1}

Spectral index: 2.1 ± 0.03

But be careful!

Galactic IC intensity may be up to 40 % of the EDGB (Pohl & Esposito 1998).

EGRET model for galactic emission is wrong above 1 GeV.

$\Rightarrow$ The true uncertainty probably exceeds the statistical one.

The spectrum above 10 MeV excludes exotic models.

– Primordial black hole evaporation

– Annihilation of supersymmetric particles

– Baryon-symmetric Big Bang

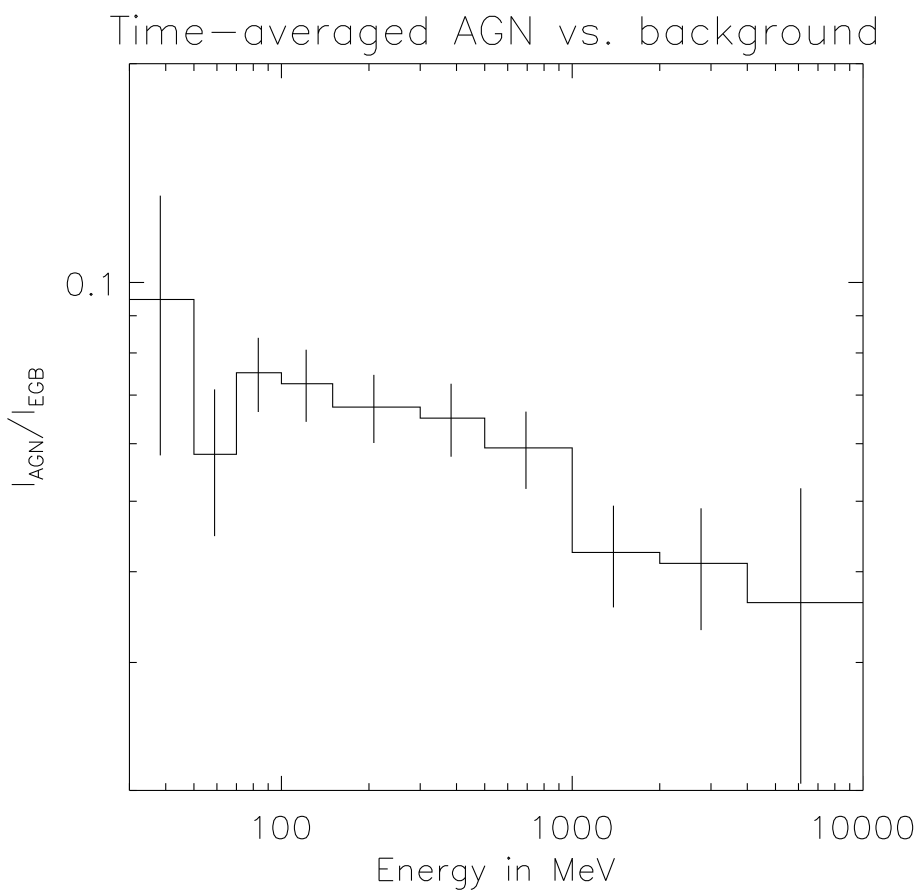
Clusters and normal Galaxies contribute $\lesssim$10%.

Cascading of TeV photons contributes only above 1 GeV ($\rightarrow$ Coppi)

Is the remainder caused by unresolved AGN?

Do the spectra of AGN fit to that of the background?

Stack the observed intensity of all AGN.



Mean AGN spectrum is slightly softer $3.5\,\sigma\,!$

BL Lacs are weaker than FSRQ and may have a harder spectrum.

A correlation between γ-ray and radio emission of AGN?

$L_\gamma = 10^{-10.67}\, L_r$ (Stecker et al., 1993)

$L_\gamma = 10^{-9.84}\, L_r$ (Padovani et al., 1993)

$L_\gamma = 10^{-10.23}\, L_r$ (Setti and Woltjer, 1994)

$L_\gamma = 10^{-9.8}\, L_r\,,\ \rho_\gamma = 0.07\, \rho_r$ (Salomon & Stecker, 1994)

Consider selection effects:

Dynamical range of EGRET data: ~ 20

Reluctance to identify with FSRQ of $S(5\ \mathrm{GHz}) \leq 1$ Jy

No evidence for a correlation (Mücke et al. 1997) !!

New ideas required !

Direct determination of the luminosity function.

(Chiang and Mukherjee, ApJ 496)

(Mukherjee and Chiang, ApP 11)

– V_e/V_a method to determine evolution

– Assume form $P(L) = P_0\, L^{-s}\,, \quad L \geq L_{min}$

Integrate luminosity function over distance to get AGN contribution to EDGB.

AGN cause $\sim$30% of the extragalactic γ-ray background.

Fair reliability !

The method does not differentiate FSRQs and BL Lacs.

Emission model approach (Mücke and Pohl, MNRAS 312)

1) Make a model for the γ-ray production in the jet.

2) Find the power distribution for the energy supply of the jet.

Time-dependent Inverse Compton spectra following injection of relativistic electrons. (Dermer and Schlickeiser, ApJ 416)

Take from radio source studies (Padovani, Urry, Stickel):

– the distribution of jet Lorentz factors $P(\Gamma)$

– luminosity and density evolution

– functional form for energy input $\rho(E_{in}) = \rho_0 \, E_{in}^{-\delta}\ ,\ E_{in} \geq E_1$.

2 Unknowns:

ρ_0

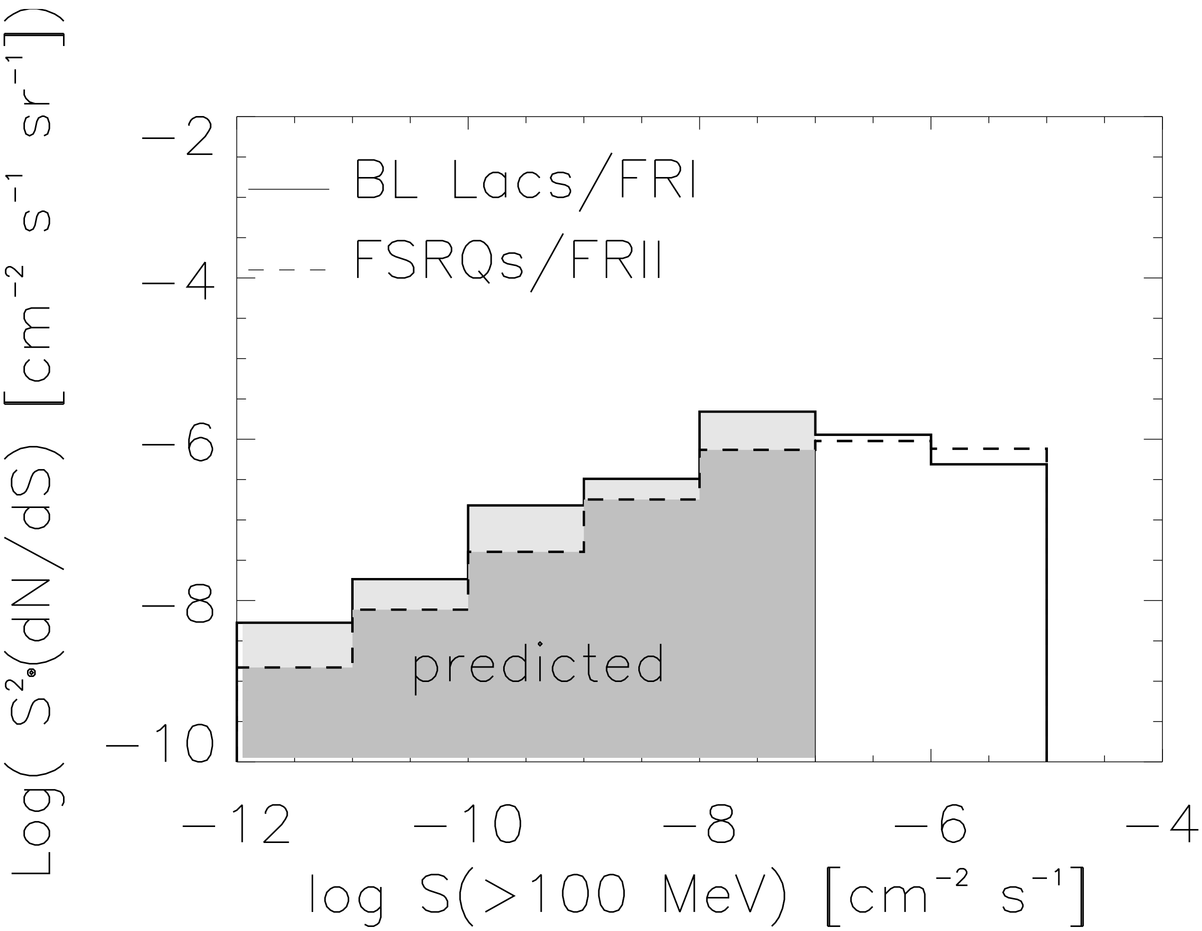
E_1

2 data sets:

Redshift distribution

log N/log S

Do a Monte-Carlo . . .



AGN cause 20%-40% of the extragalactic γ-ray background.

BL Lacs/FR1 contribute twice as much as FSRQ/FR2.

How reliable is the result?

Probably okay for FSRQ

– Total number of objects right

– Good statistic in data

Perhaps terribly wrong for BL Lacs

– Total number of objects too small

– Minimum power input E_1 too high

– May have to try more complex $\rho(E_{in})$

– We have to assume a luminous accretion disk

– We have neglected Synchrotron-Self-Compton emission