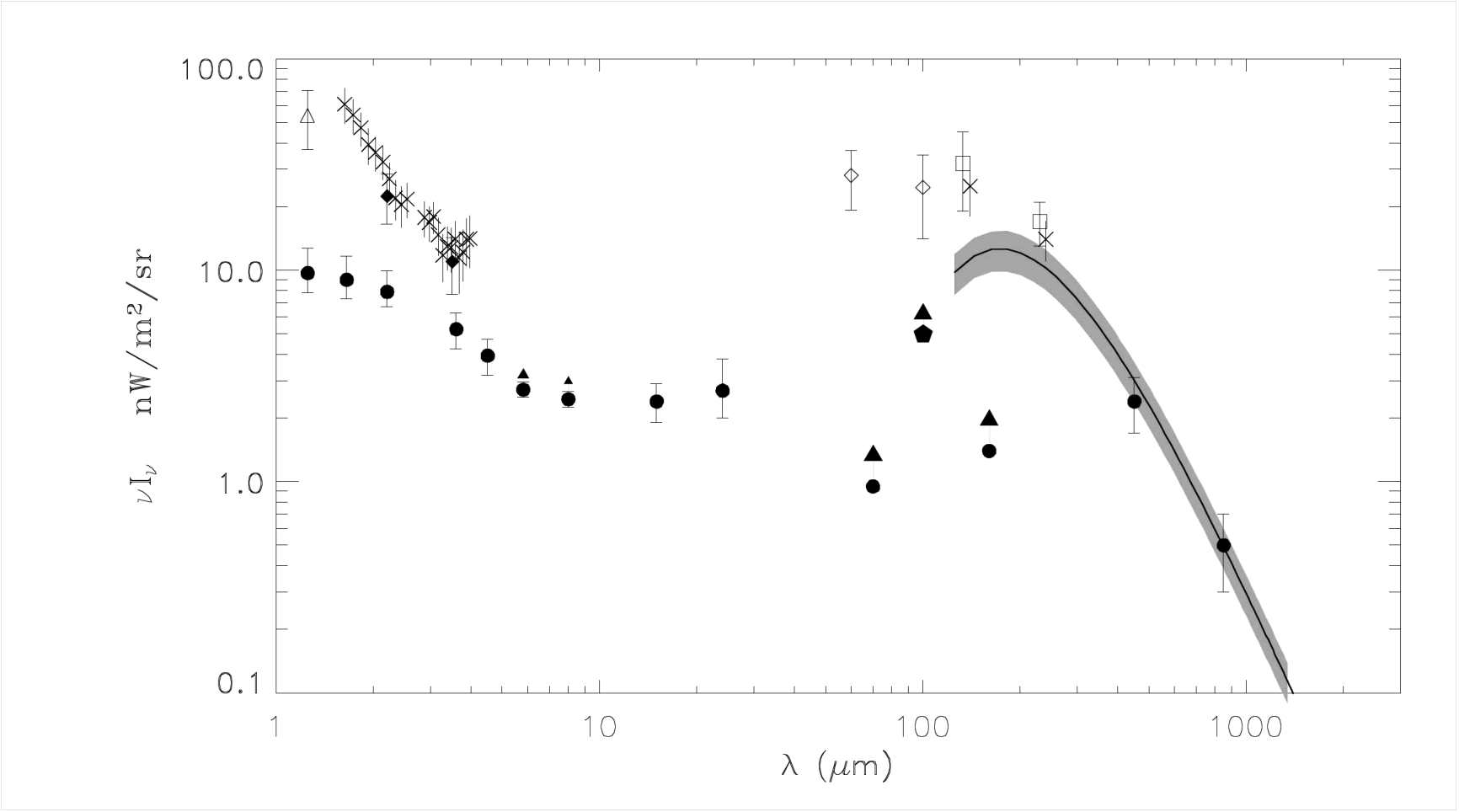
SEARCHING FOR IMPRINT OF POPULATION 3 ERA IN SPECTRA OF HIGH-z GLAST GRB's

Sasha (A.) Kashlinsky, David Band

• There is now strong evidence of significant energy release during first stars (Pop 3) era

• This energy, released at z>10 or so, should leave a distinct imprint in spectra of high-z GLAST sources via 2-photon absorption

• Uncovering this with GLAST measurements will provide important direct evidence of Population III era emissions



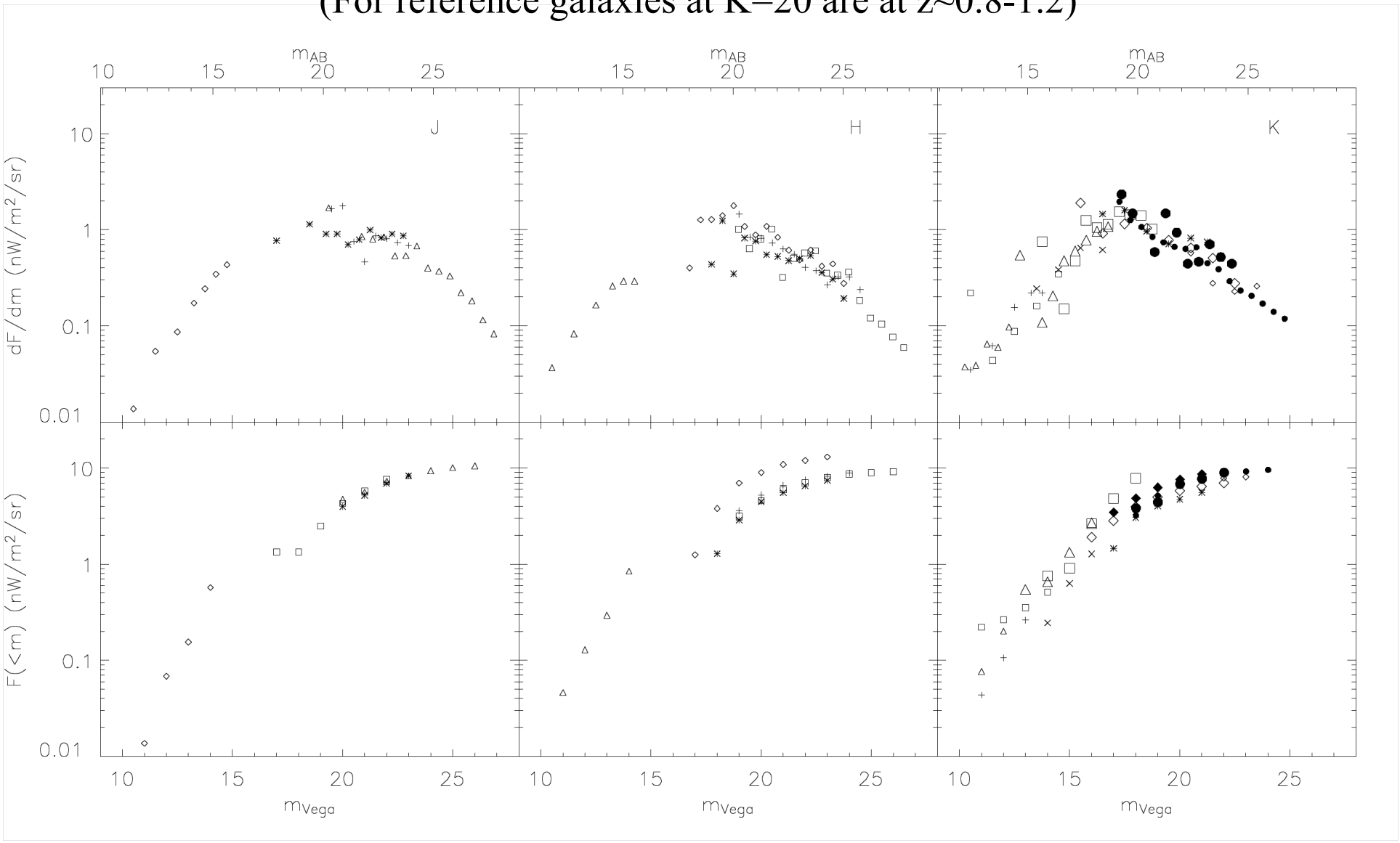
Cosmic infrared background: measurements vs galaxies contribution

From Kashlinsky 2005, Physics Reports, 409, 361

The observed CIB excess can be reproduced with only ~2-4 % of the baryons having gone through Pop 3 (Kashlinsky 2005, Ap.J. Lett., 633, L5).

CIB due to J, H, K galaxy counts

(For reference galaxies at K=20 are at z~0.8-1.2)



Diffuse background from Pop 3 *(Kashlinsky et al 2004)*

$\int M\, n(M)\, dM = \Omega_{baryon}\, 3H_0^2/8\pi G\, f_*$ f_* fraction in Pop 3

$$\frac{dF}{dt} = \frac{\int Ln(M)dM}{4\pi d_L{}^2}\frac{dV}{dt}(1+z)$$

$dV = 4\,\pi\, cd_L^2(1+z)^{-1}\, dt$; $L \approx L_{Edd} \propto M$; $t_L = \epsilon\, Mc^2/L << t(z=20)$

$$\nu I_\nu = \frac{3}{8\pi}\frac{1}{4\pi R_H{}^2}\frac{c^5}{G}\varepsilon\Omega_{baryon} f_* \cong 1.2\times 10^4 \frac{\Omega_{baryon}}{0.044}\frac{\varepsilon}{0.007} h^2 f_* \frac{nW}{m^2 sr}$$

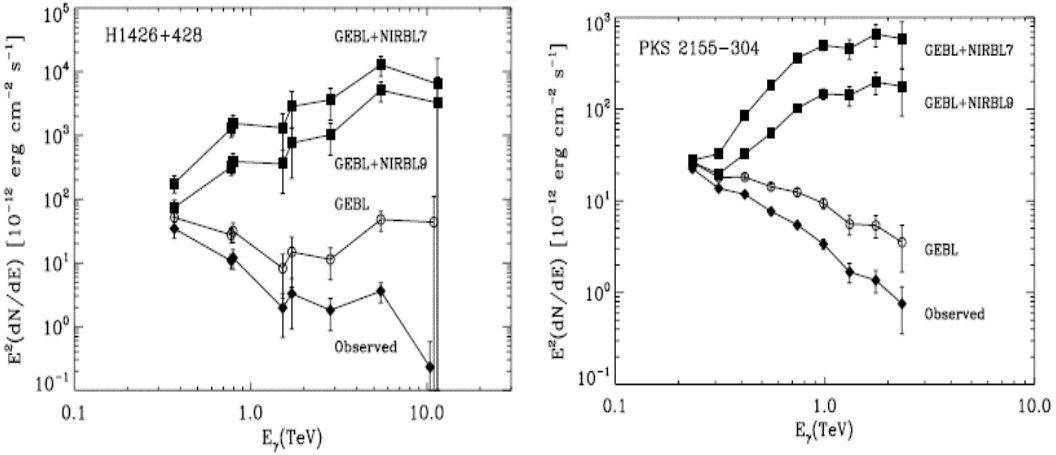
CIB data give:

F_{NIRBE} = 29+/-13 nW/m^2/sr F(λ>:10μm) < 10 nW/m^2/sr

This can be reproduced with

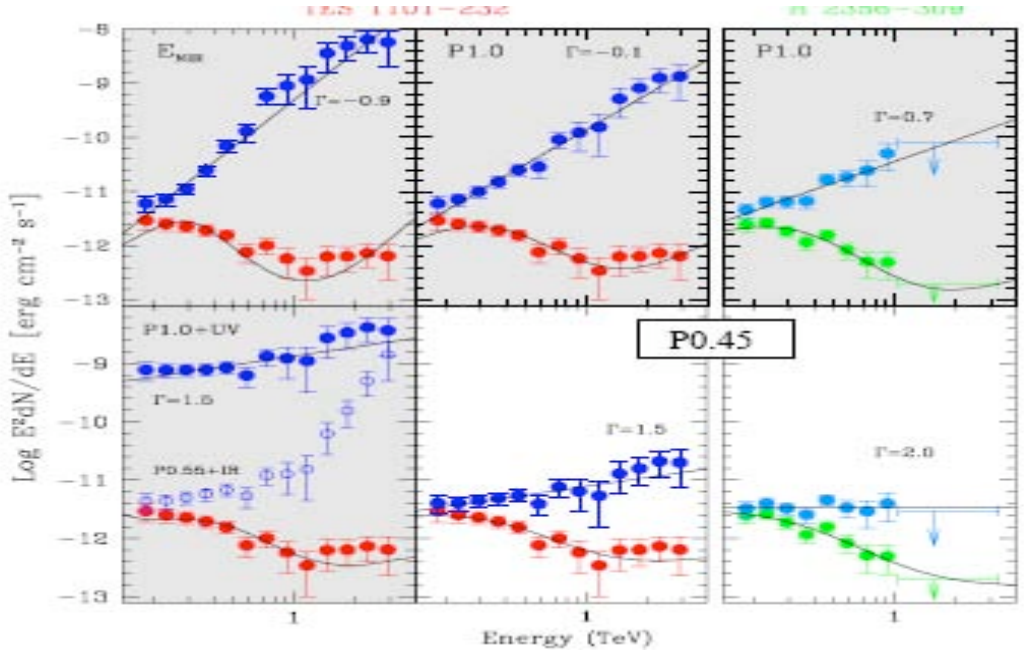
f_* = 4 +/- 2 % for ϵ=0.007

Near-IR CIB constraints from nearby blazars



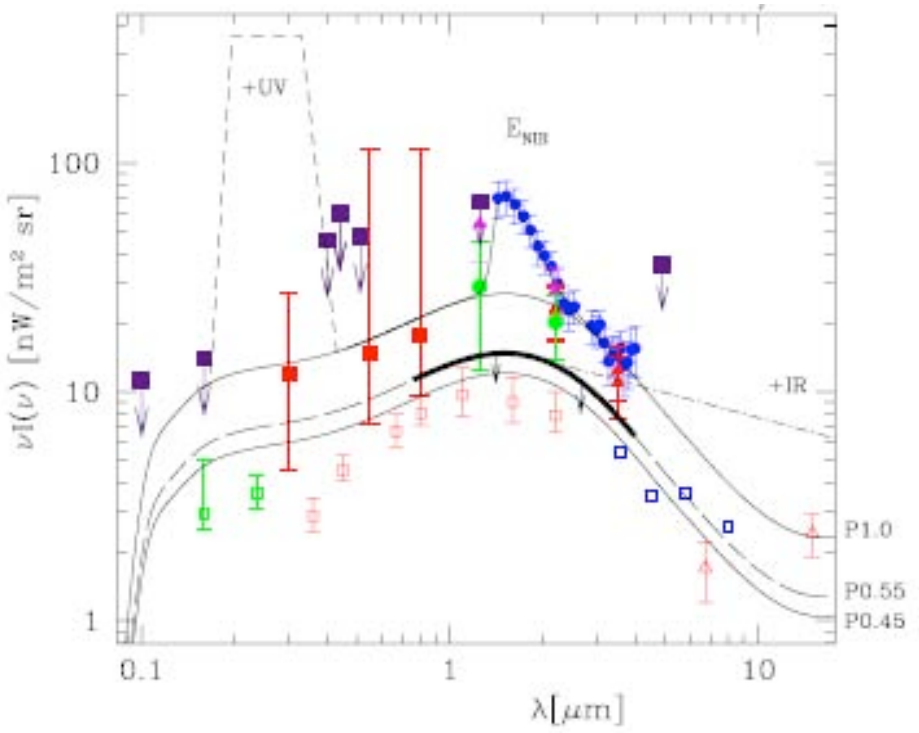
Dwek et al (2006)

z ~ 0.13

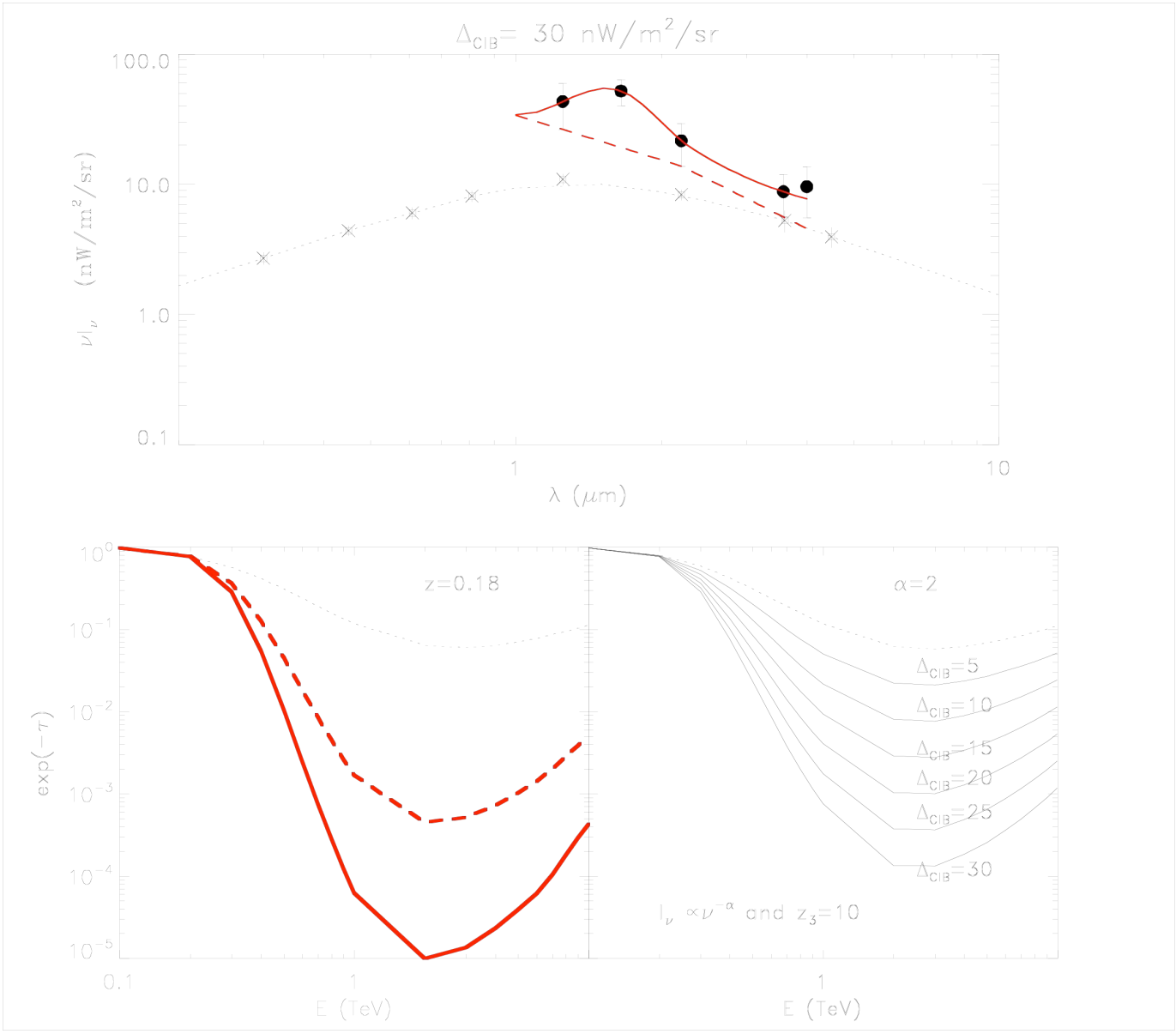


Aharonian et al (2006)

z ~ 0.18



From Aharonian et al (2006)



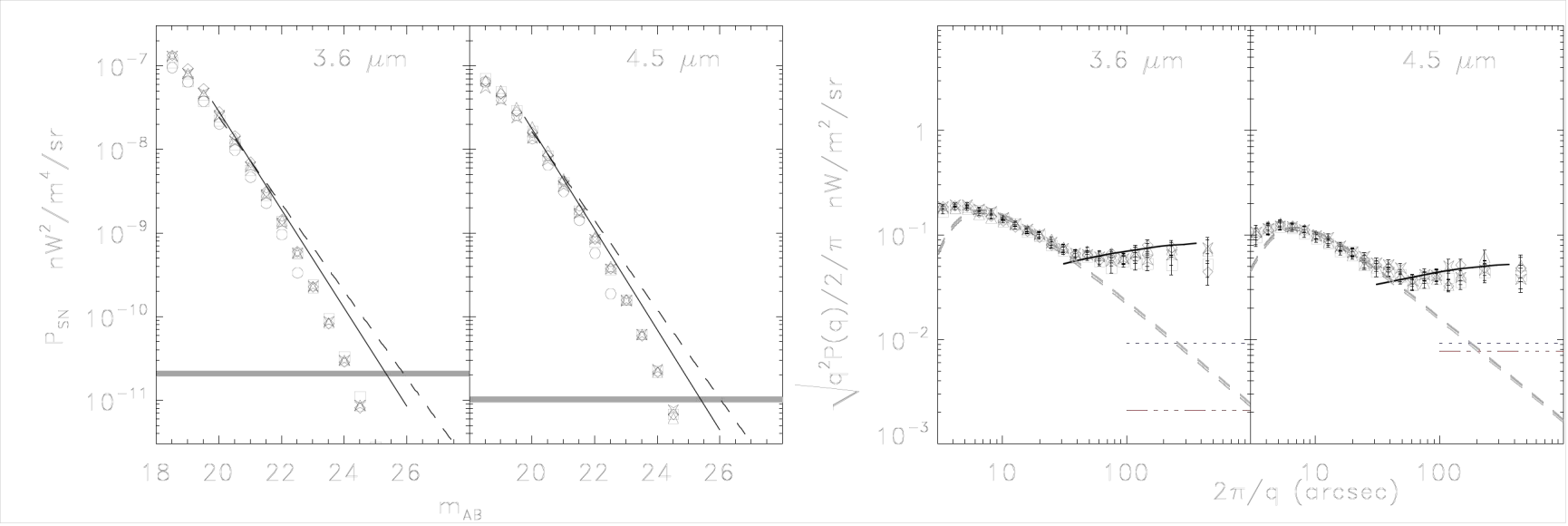
From Kashlinsky (2006, astro-ph/0610943)

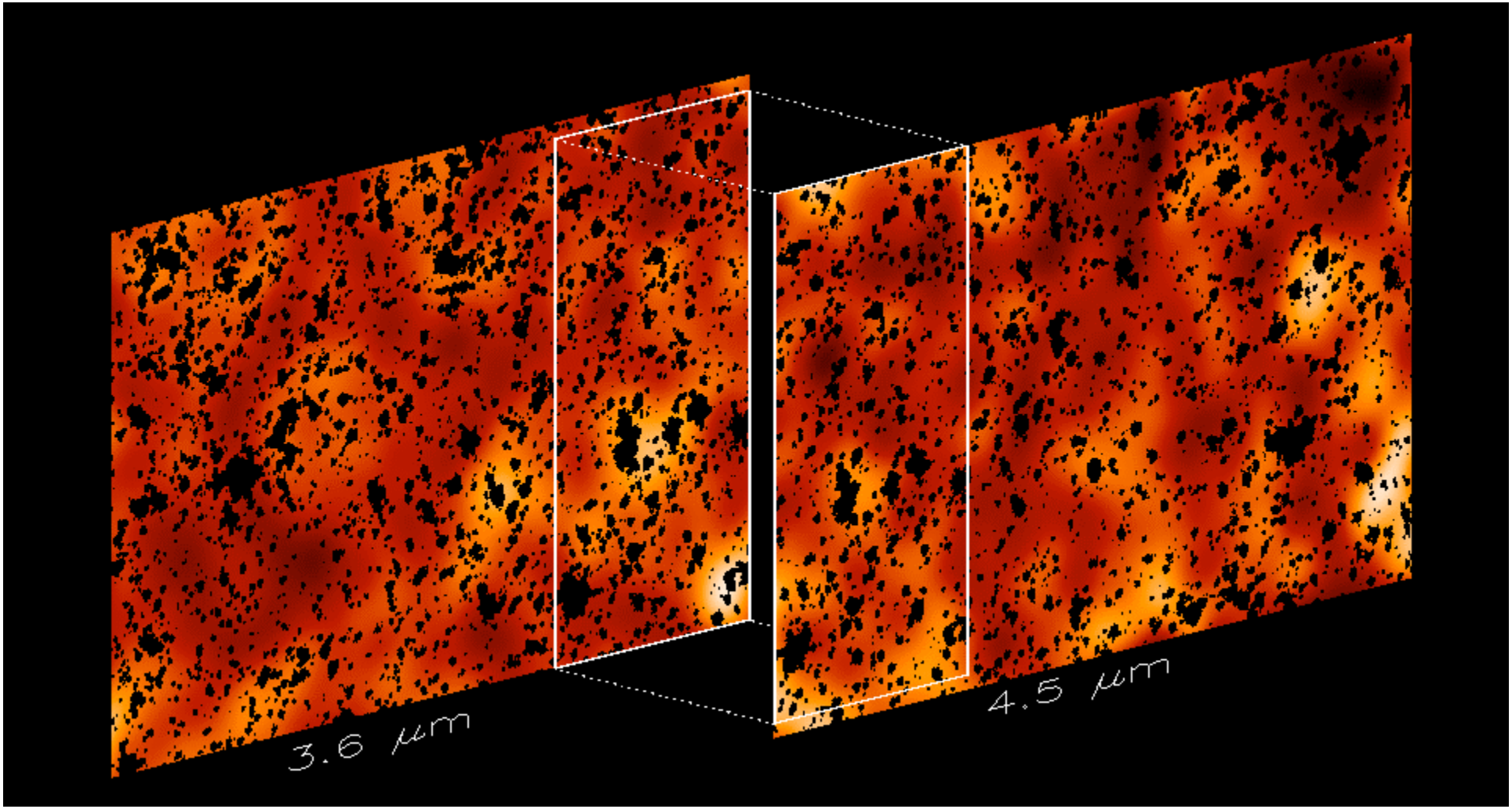
More direct evidence for significant emissions from early epochs is produced from studies of CIB fluctuations in deep Spitzer data (*Kashlinsky, Arendt, Mather & Moseley 2005, Nature, 438,45 and 2007, ApJL, 654, L1 and L5 – reviewed also in Nature's N&V on 3 Nov 2005 and 4 Jan 2007)*

Residual CIB fluctuations in Spitzer GOODS images from Kashlinsky et al 2007 a,b:

Shot noise of remaining populations:

Measured CIB fluctuations from remaining populations:



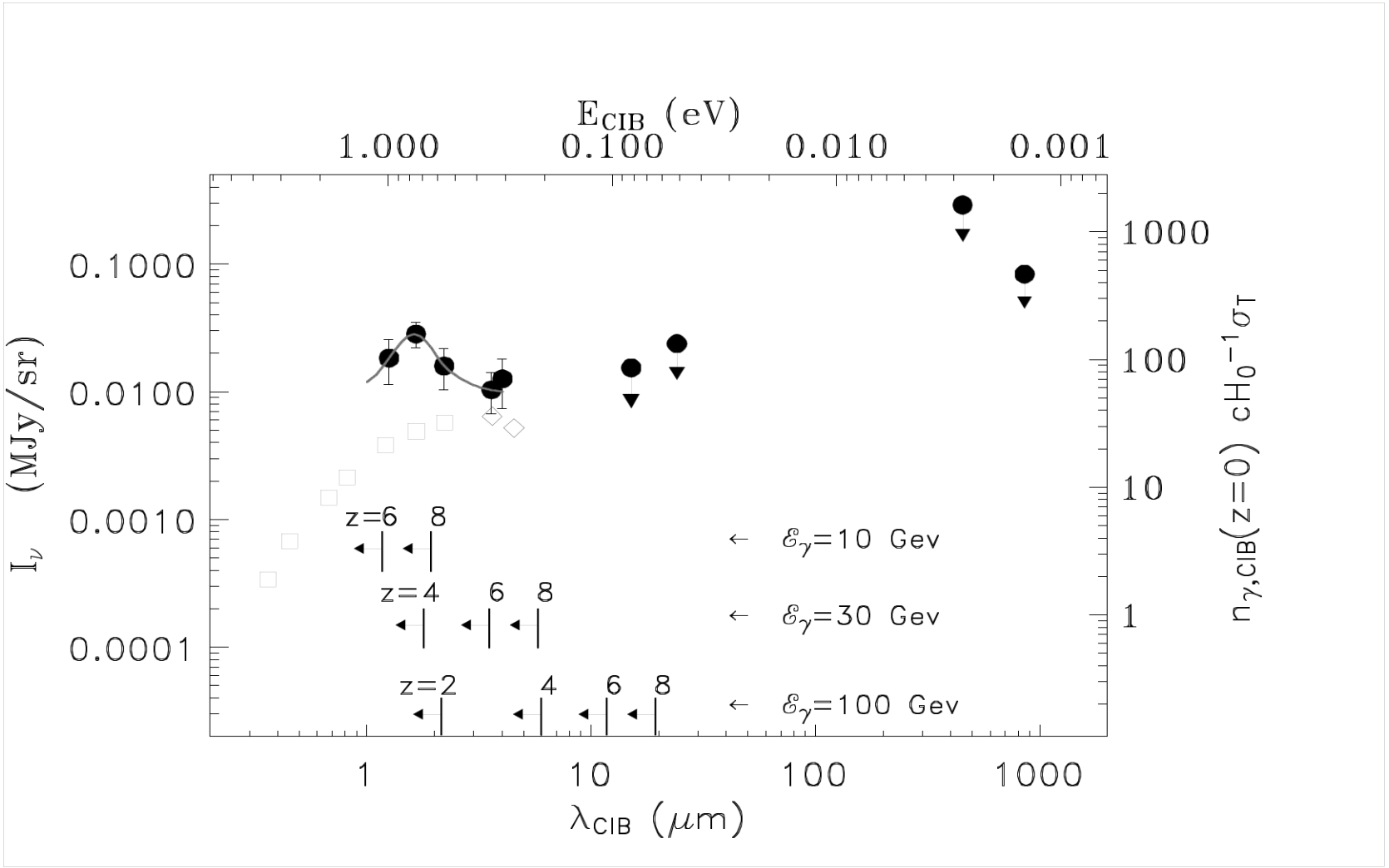

3.6 μm
4.5 μm

Measurements of CIB fluctuations indicate:

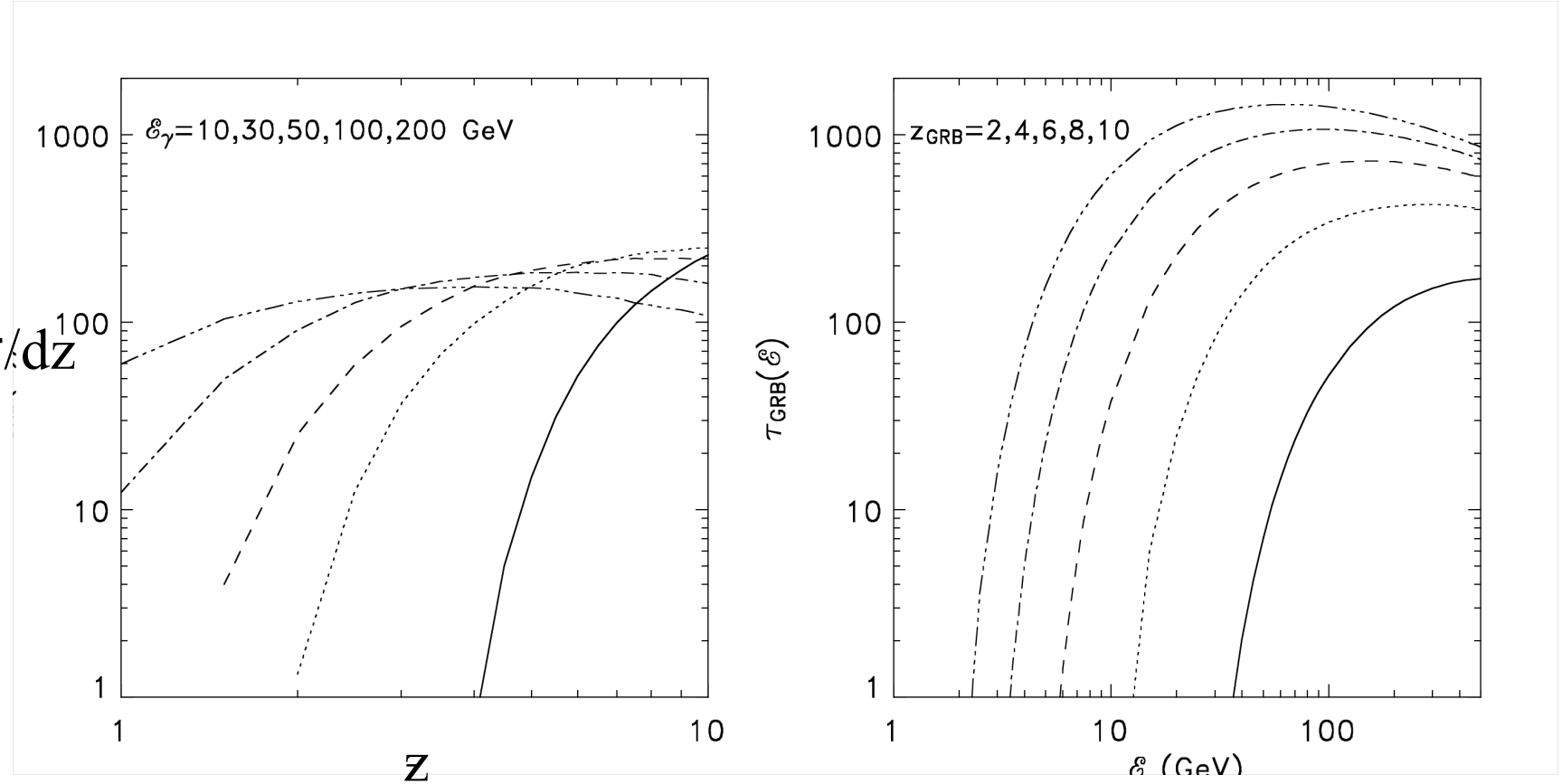
- *The amplitude of the fluctuations implies CIB levels at 3.6 mic produced by these populations of >1-2 nW/m^2/sr*
- These populations are such that they produce at most only low levels of the shot noise, but significant clustering component.
- This in turn implies that the sources producing these fluctuations are individually faint with flux < 10-20 nJy
- Such sources are very likely located at very early times of the Universe'e evolution.
- *At z=10 the Lyman cutoff for these emission is at λ~1 (z/10) μm, so the GLAST/LAT limit of 300 GeV implies that these photons can be detected via 2-photon absorption*

Pop 3 live at z > 10; hence any photons from them were produced then so that $n_\gamma \propto (1+z)^3$ or

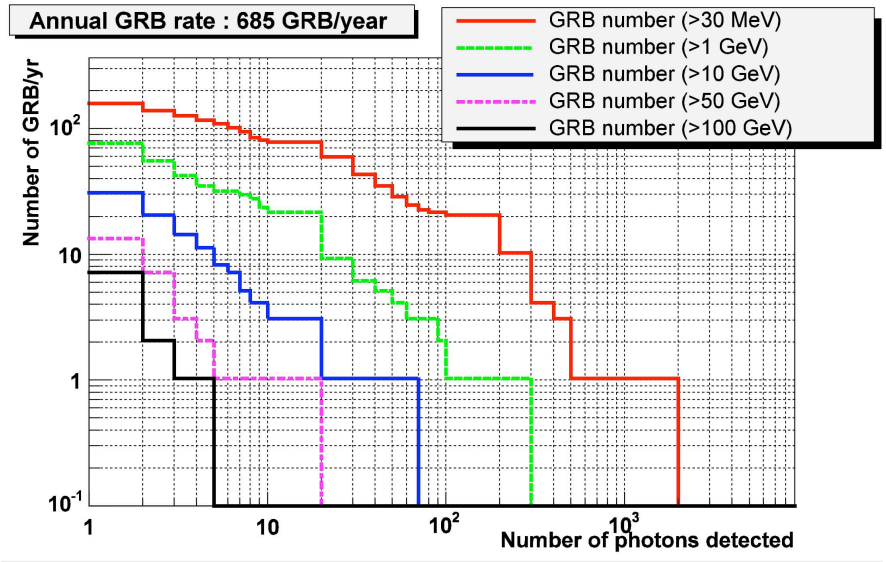
$$4\pi/c\ I_\nu/h_{Planck}(1+z)^3 \text{ per } d\ln E = 0.6\ I_\nu(\text{MJy/sr})\ (1+z)^3 \text{cm}^{-3}$$



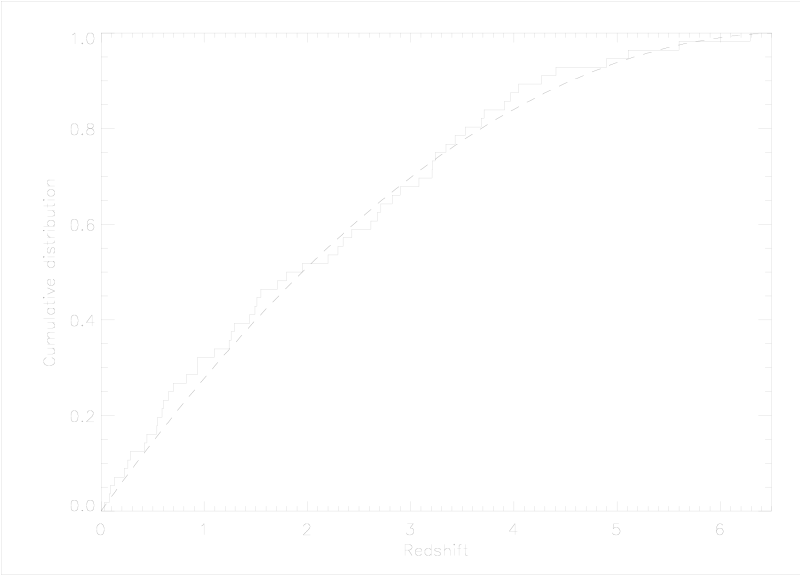
Two photon absorption due to these CIB photons would lead to a sharp cutoff at $\epsilon = 260\ (1+z_{GRB})^{-2}$ GeV in the spectra of any high-energy GLAST sources such as GRB's:



Observability of the ‘right’ GRB’s with GLAST



From Omodei 2006



Cumulative z-distribution of Swift bursts with known z (solid curve) vs empirical approximation from Band

- We expect enough GRB’s observable with GLAST at z>2-5 to statistically determine the existence of and emissions from Pop 3 era at z>10
- The GLAST energy range of <300 GeV is sufficient for these purposes.
- We estimate that GLAST will detect ~7 GRBs/yr with observable P3 cutoffs
- High-z (>3-5) blazars will also provide a good data sample after ~ 1-2 yr