GLAST PROBES ANCIENT RADIATION FIELDS FROM EARLY GALAXY EVOLUTION

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Absorption of Cosmic Gamma Rays from Blazars

Electron-Positron Pair Production Interactions of γ-rays with Intergalactic Low Energy Photons;

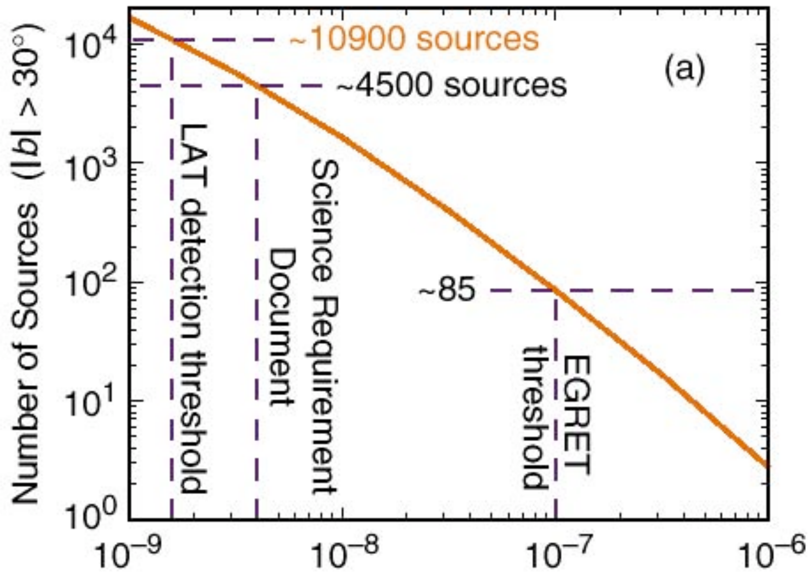
Stecker, et al. 1992, ApJ 390,L49;

Stecker et al. 2006, ApJ 648, 774;

Stecker & Scully 2006, ApJ, 652, L9

AGN: What GLAST will do

EGRET has detected ~ 90 AGN. Extrapolating, GLAST should expect to see dramatically more – many thousands:



• measure AGN contribution to the high energy diffuse extra-galactic background.

•constrain acceleration and emission models.

• Large acceptance and field of view allow relatively fast monitoring for variability over time -- correlate with other detectors at other wavelengths.

•Probe energy roll-offs with distance (light-light attenuation): info on era of galaxy formation.

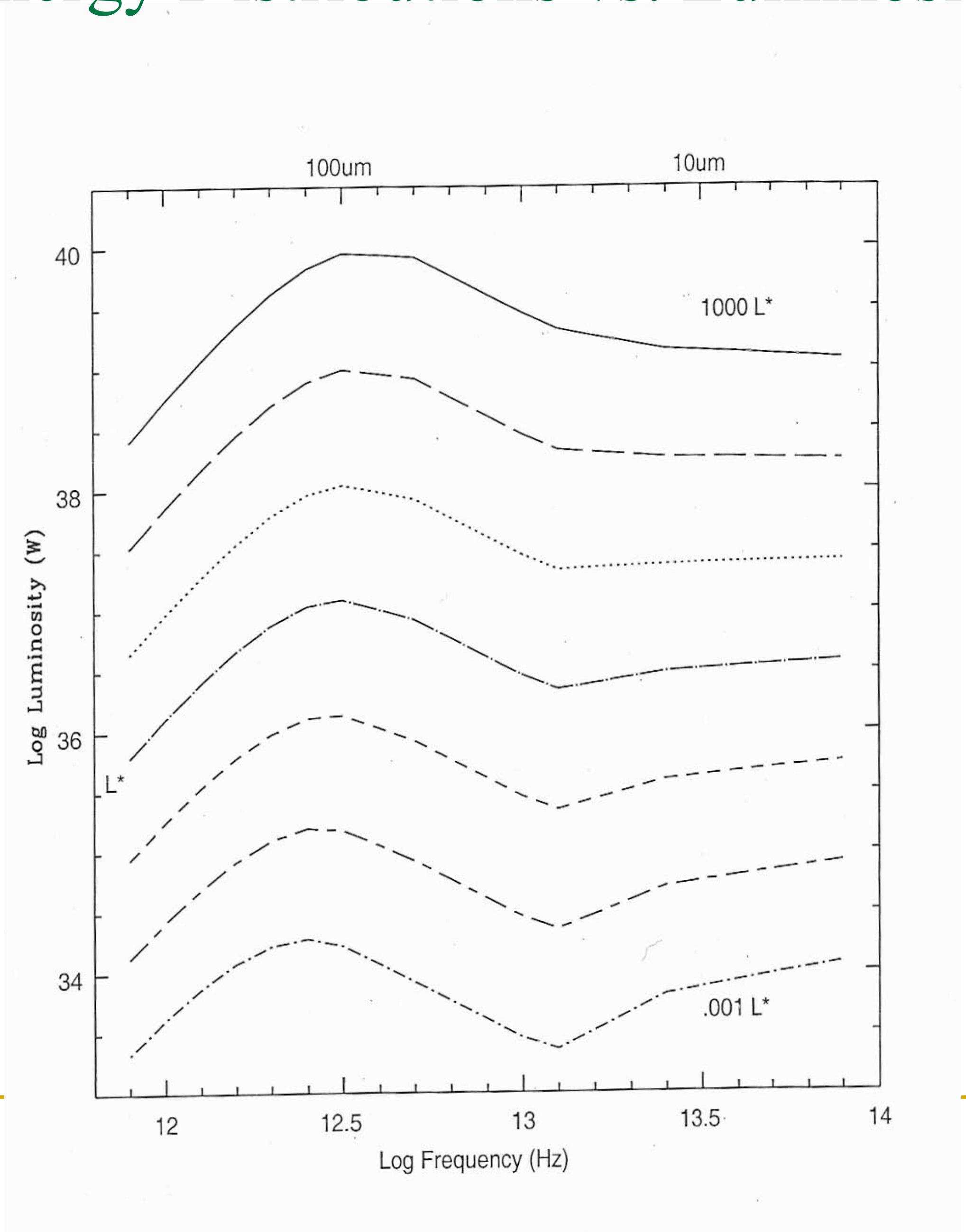
• Long mission life to see weak sources and transients.

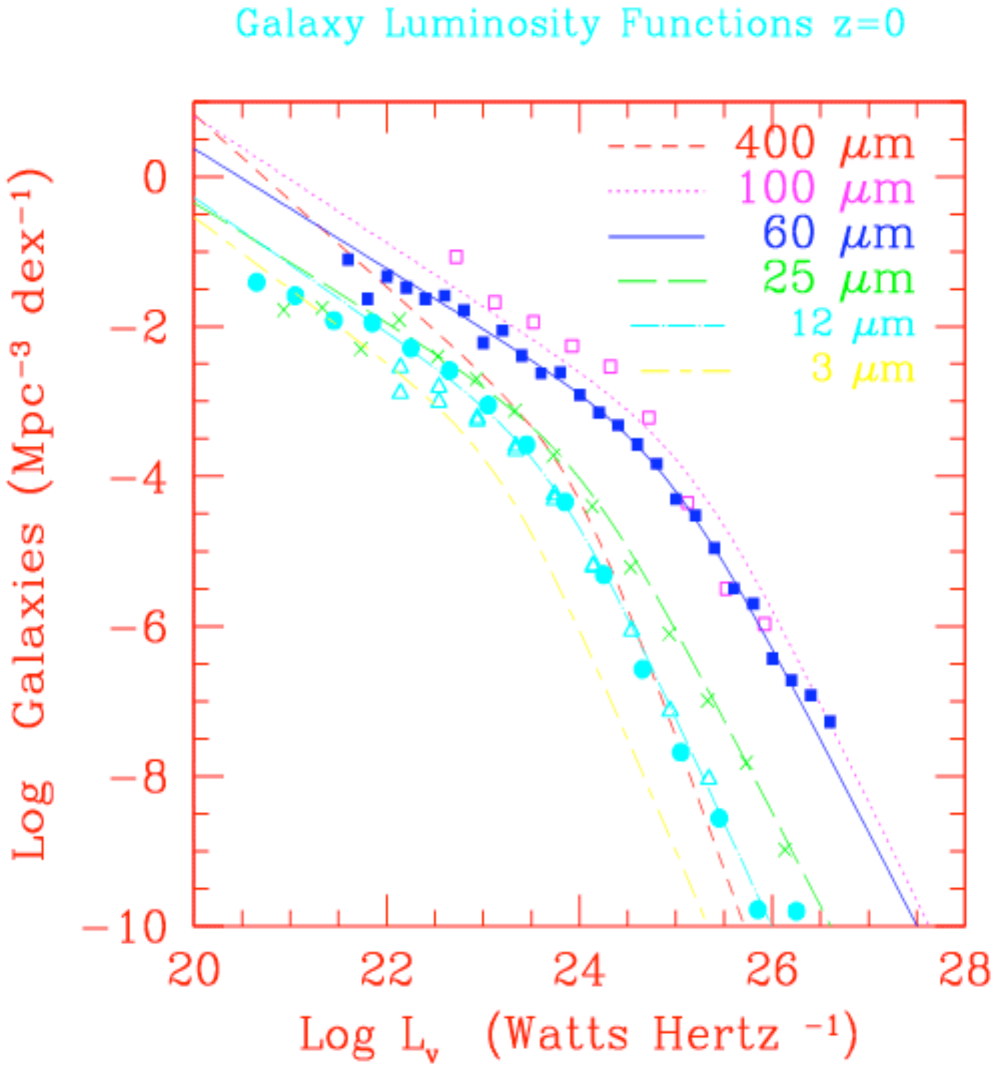
Joining the unique capabilities of GLAST with other detectors will provide a powerful tool.

Theoretical Calculations: Input

- Spectral Energy Distributions of Galaxies
- Galaxy Luminosity Functions (LF)
- Redshift Dependence of Galaxy LFs

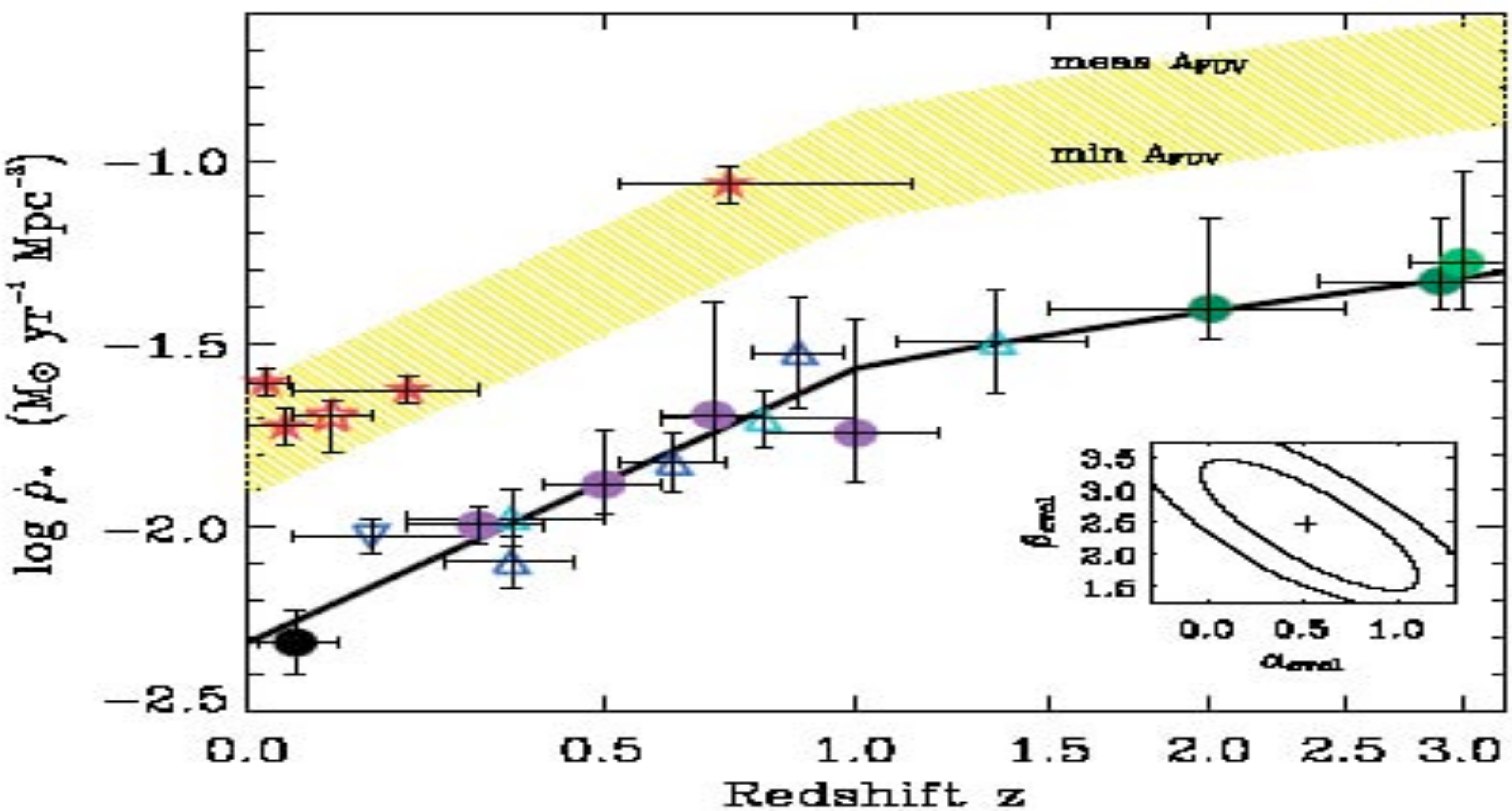
Spectral Energy Distributions vs. Luminosity



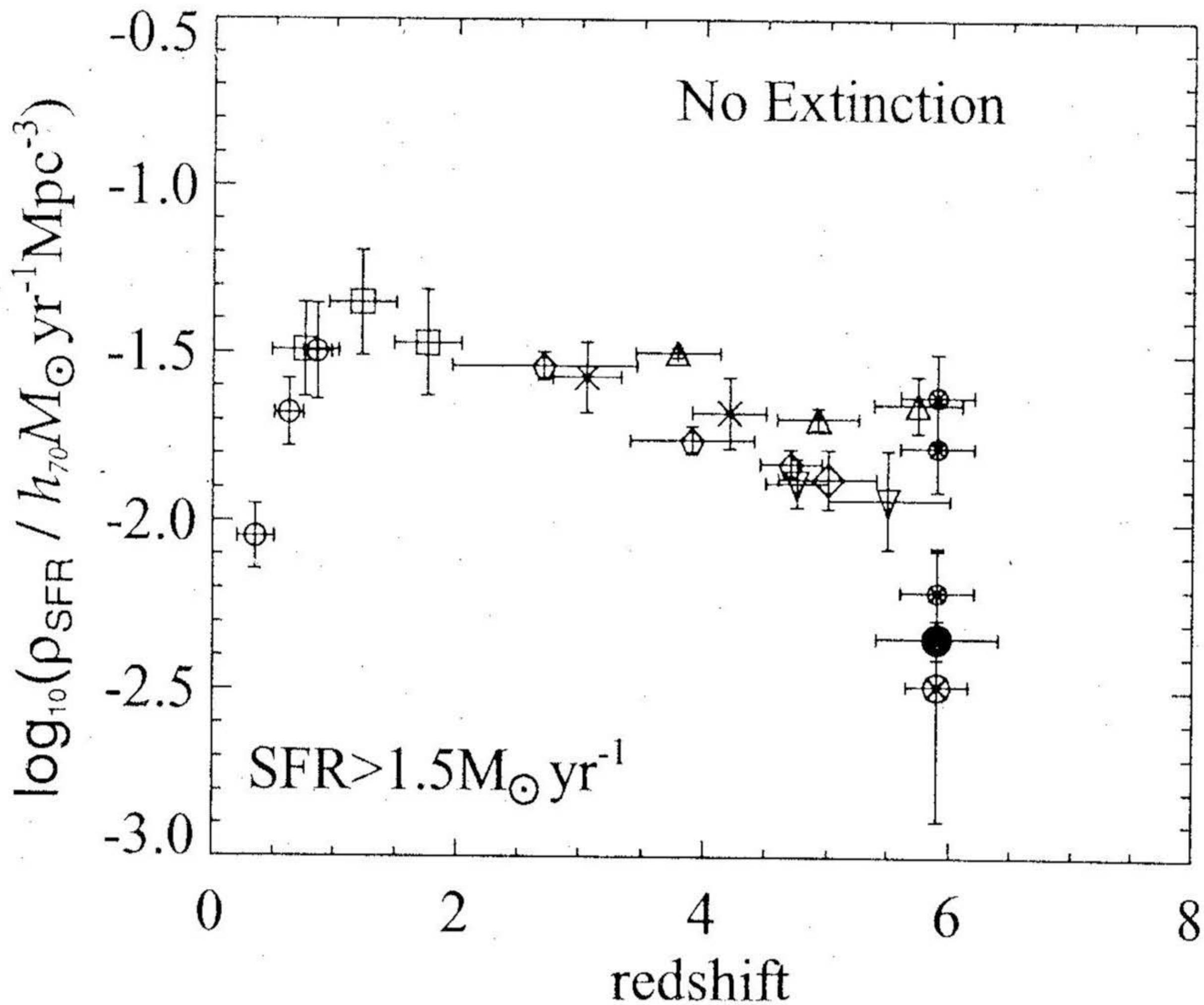


Galaxy Luminosity Functions z=0
400 μm
100 μm
60 μm
25 μm
12 μm
3 μm
Log Galaxies (Mpc⁻³ dex⁻¹)
0
−2
−4
−6
−8
−10
20
22
24
26
28
Log Lν (Watts Hertz ⁻¹)

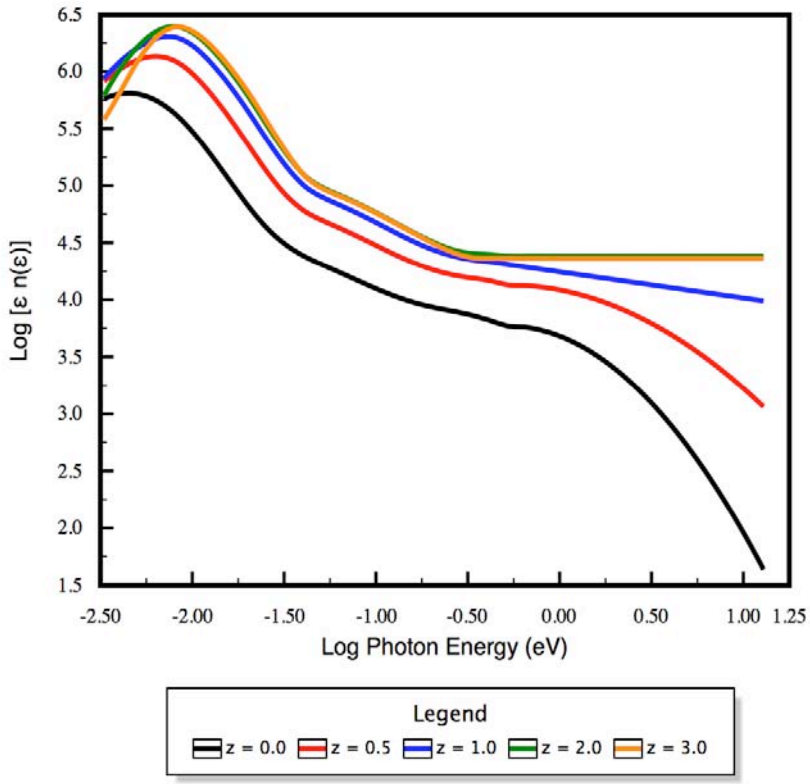
Star Formation Rate *v.* Redshift from Spitzer Data (Schiminovich *et al.* 2005)



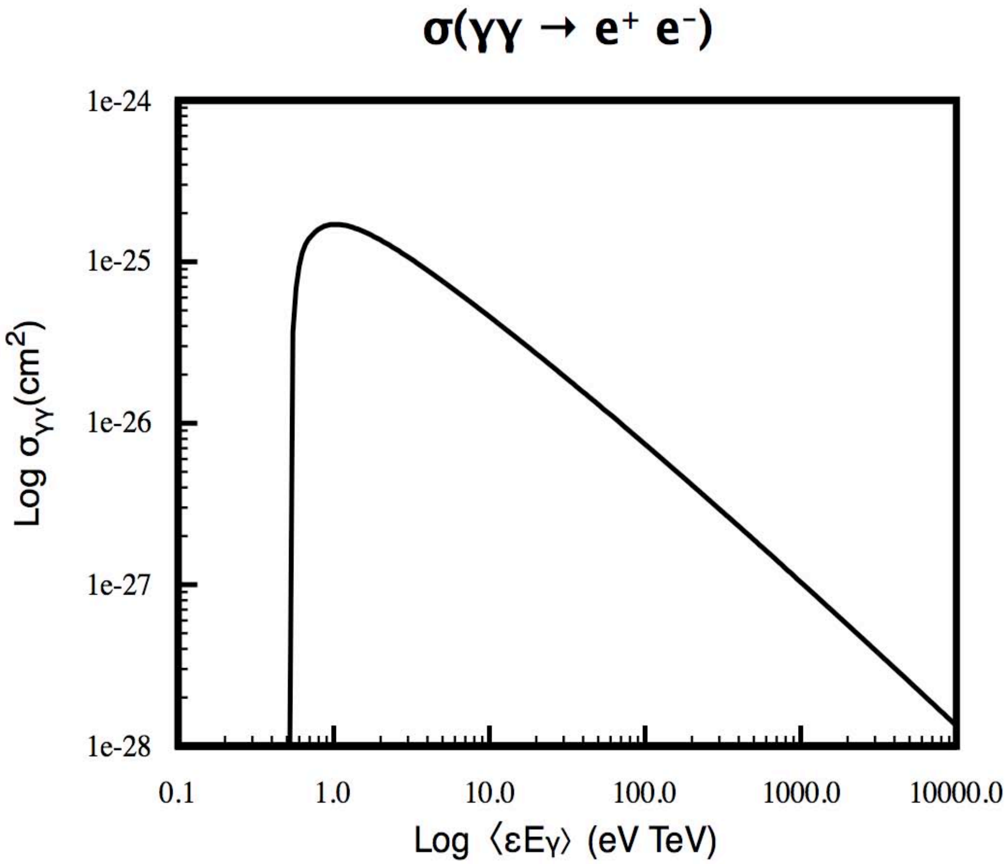
Star Formation Rate vs Redshift (Bunker et al. 2004)



Photon Density Spectra



Pair Production Cross Section



$$\tau(E_\gamma, z) = \int_0^{z_{Source}} dz \frac{dl}{dz} \int_0^2 dx \frac{x}{2} \int_{\frac{2m_e^2c^4}{E_\gamma x(1+z)}}^{\infty} d\varepsilon \; n(\varepsilon, z) \sigma(s)$$

$$s = 2xE_\gamma \varepsilon (1+z)$$

$$E_\gamma = E_\gamma (z=0)$$

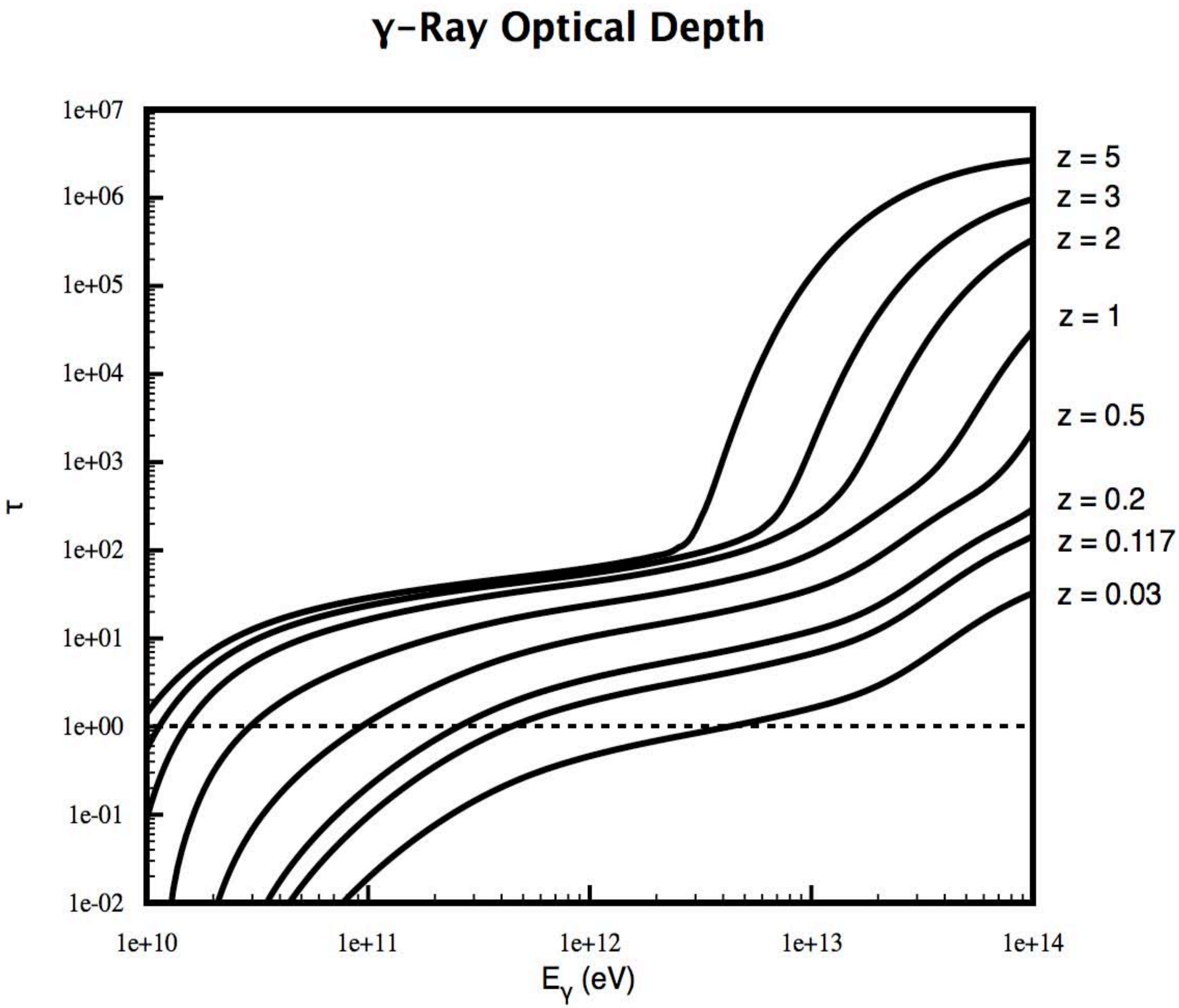
$$x = 1 - \cos\theta$$

$$\varepsilon = \varepsilon(z)$$

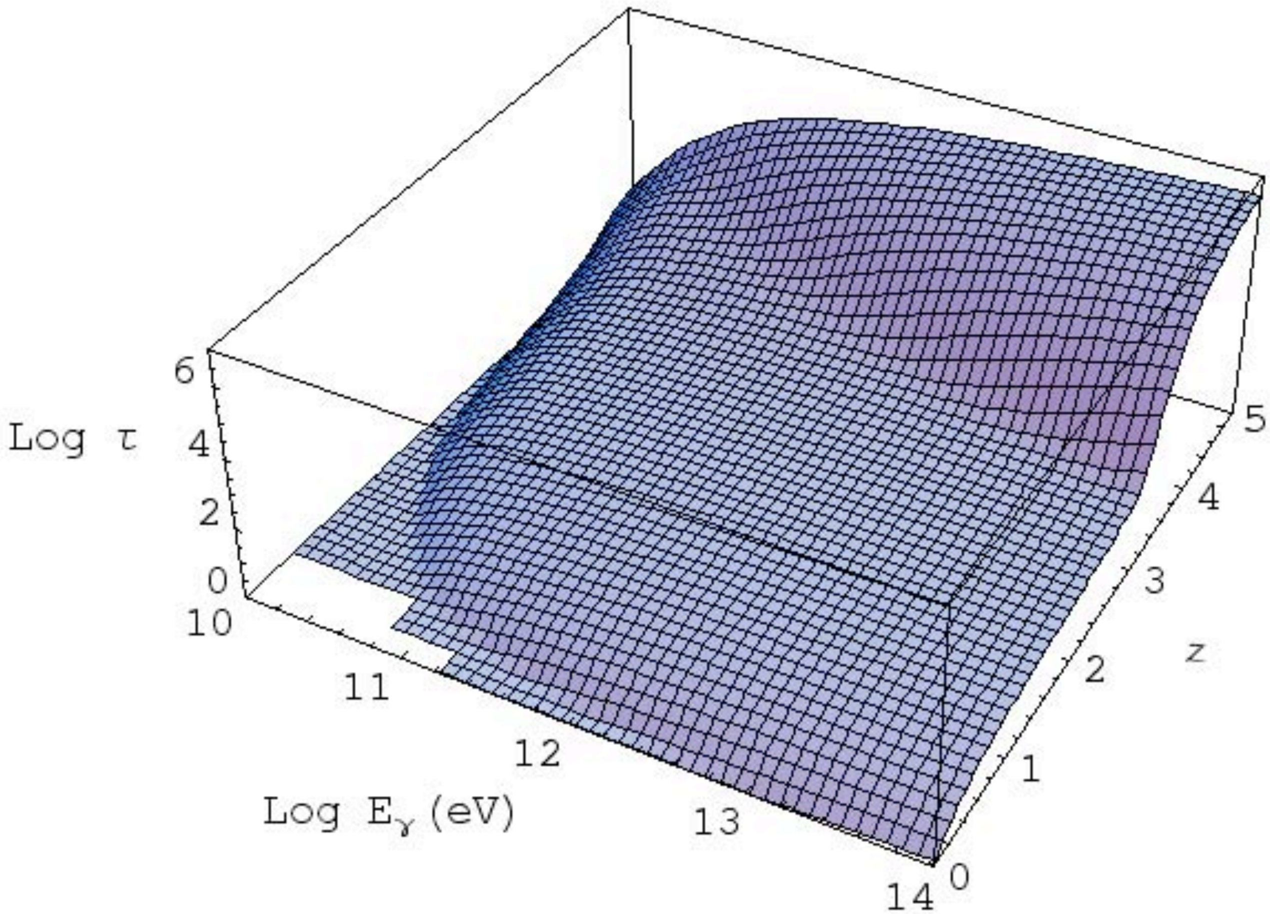
$$\sigma(s) = \sigma_0 (1-\beta^2) \left[2\beta(\beta^2 - 2) + (3 - \beta^4) \ln\left(\frac{1+\beta}{1-\beta} \right) \right]$$

$$\frac{dl}{dz} = \frac{c}{H_0} (1+z)^{-1} \left[\Omega_\Lambda + \Omega_m (1+z)^3 \right]^{-1/2}$$

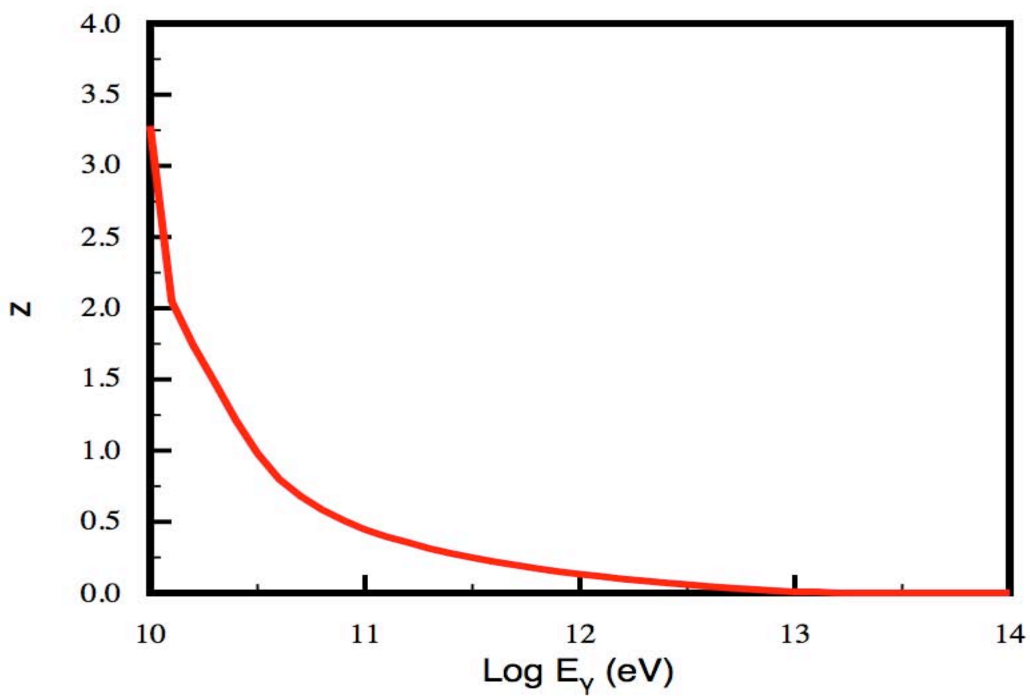
γ-Ray Optical Depth



Optical Depth *vs* Energy and Redshift



$\tau(E_{\gamma,crit}, z) = 1$



PROPOSED GLAST OBSERVING PROGRAM

Observe Many Blazars at Redshifts > 0.5 in the Energy Range between 10 and 30 GeV

In this Energy and Redshift Range, Our Calculations Predict Sharp Absorption Cutoffs Caused by Interactions with UV Photons Near the Lyman Limit

The Resulting Observations will Probe the

Evolution of Total Galaxies at High Redshifts through their Contribution to the Ancient Background Photon Fields