The Extragalactic Background Light gamma-gamma absorption of Very-High-Energy gamma-rays *from cosmological gamma-rays sources*

Hassan Abdalla

Supervisor: Prof. M. Böttcher

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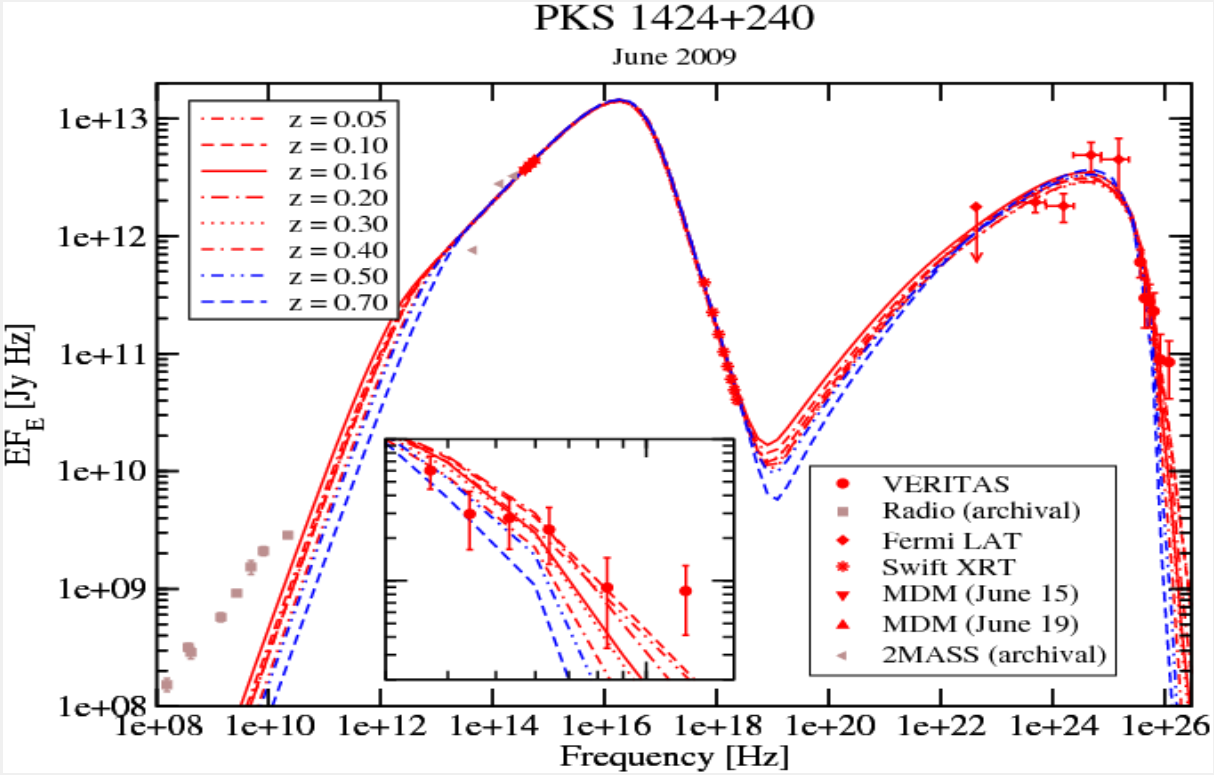
NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Very High Energy Gamma Rays (VHE; more than 100 GeV) from Cosmological Gamma Ray Sources such as Blazars can be absorbed by the Extragalactic Background light (EBL).

This leads to a high-energy "cut-off " at the VHE end of Blazar spectra.

- *The probability of absorption depends on the photon energy and redshift.*
- *This process has been intensively studied during the last few decades (e.g., Stecker 1969 …. Aharonian et al. 2006).*

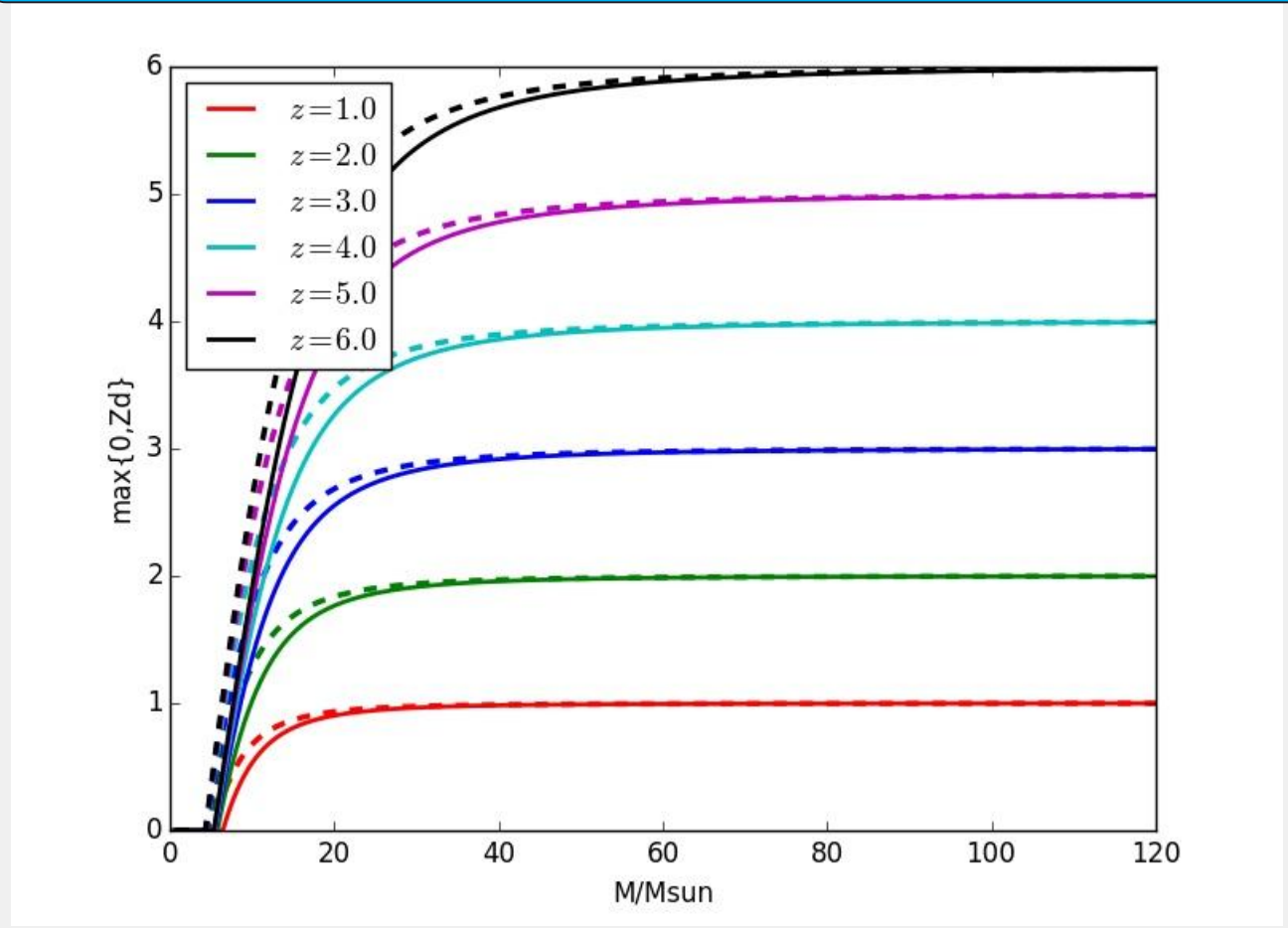


Acciari et al. 2010

EBL Calculation:

Star from its birth at redshift **z** to the redshift which it has evolved away from the main sequence $Z_d(M,z)$

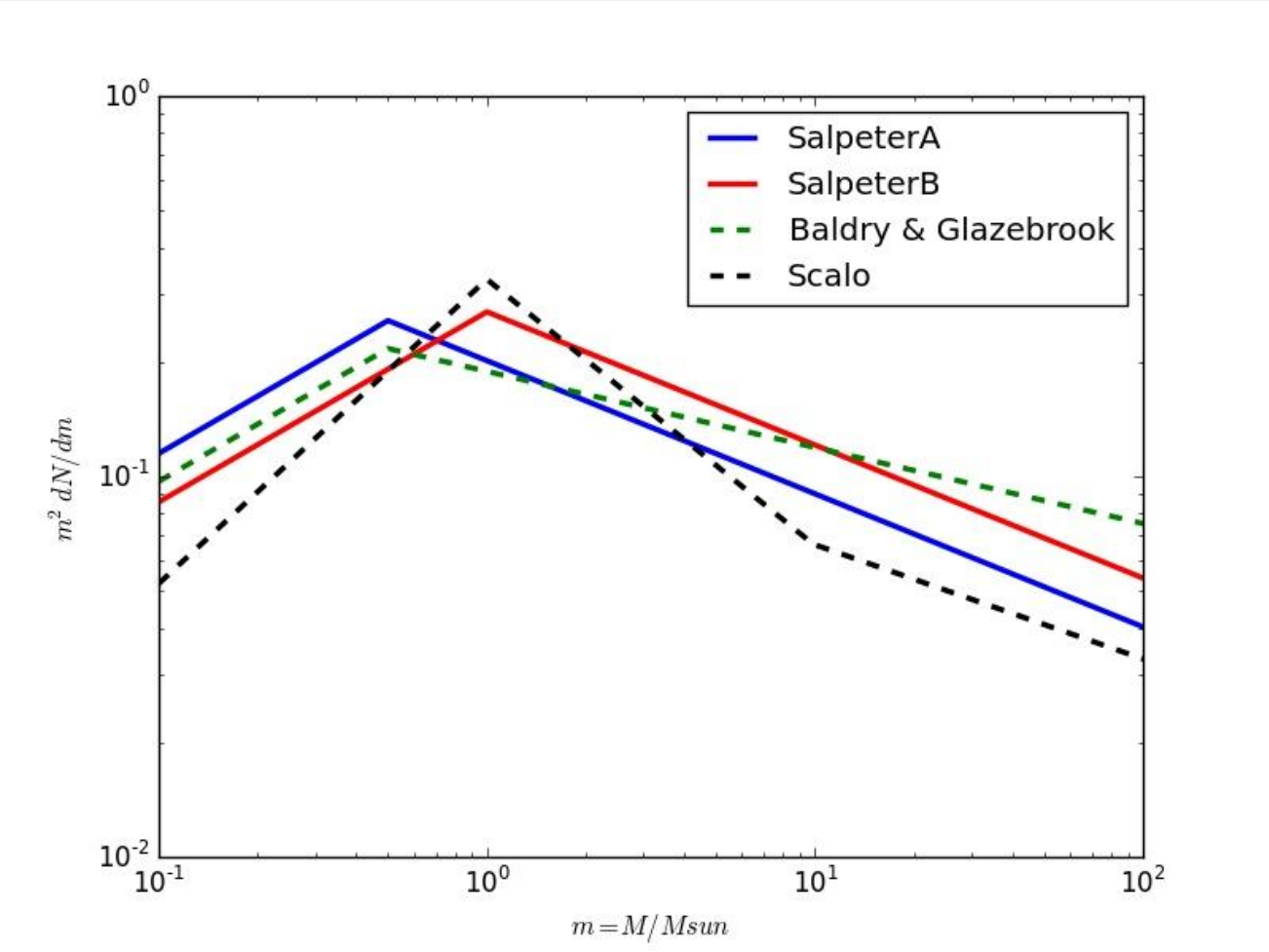
$$Z_d(M,z) = -1 + \left(-\frac{\Omega_\Lambda}{\Omega_m} \operatorname{sech}\left[\frac{3}{2} H_0 t_* + \tanh^{-1} \sqrt{1 + \frac{\Omega_m}{\Omega_\Lambda} (1+z)^3} \right]^2 \right)^{\frac{1}{3}}.$$



Reproduction from *Razzaque et al. (2009)*

EBL Calculation:

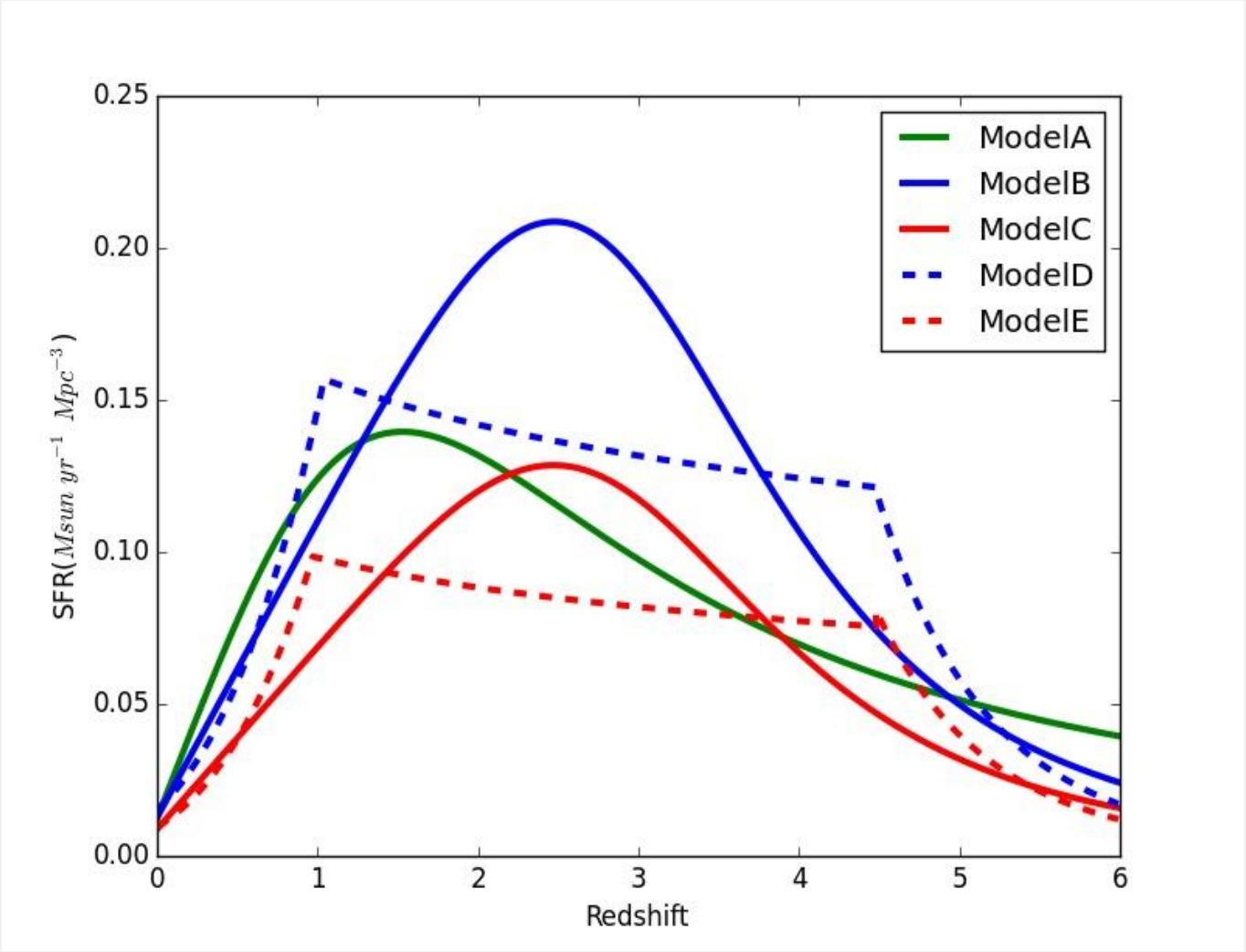
Initial Mass Function (IMF):



Reproduction from *Razzaque et al. (2009)*

EBL Calculation:

Star Formation Rate (SFR):



Reproduction from *Razzaque et al. (2009*

EBL Calculation:

The integrated number of photons that have been emitted from star birth to the present epoch $\frac{dN(\epsilon,M)}{d\epsilon}$

$$\frac{dN(\epsilon,M)}{d\epsilon} = \int_{\max\{0,z_d(M,z')\}}^{z} dz' \frac{dt}{dz'} \frac{dN(\epsilon',M)}{d\epsilon'\,dt}(1+z')$$

$$\frac{1}{-\mathbf{H_0}(\mathbf{1}+\mathbf{z})\sqrt{\mathbf{\Omega_m}(\mathbf{1}+\mathbf{z})^3+\mathbf{\Omega_\Lambda}}}$$

$$\frac{dN(\epsilon',M)}{d\epsilon'\,dt} = \pi R^2 c \frac{dN}{d\epsilon'\,dV}$$

Total number of photons emitted per unit energy and time interval

Differential number density of thermal Black Body photons

EBL Calculation:

$$\frac{dN(\epsilon, z=0)}{d\epsilon\, dV} = N \int_{Z=0}^{\infty} dz'' \frac{dt}{dz''} \psi(z'') \int_{M\_min}^{M\_max} dM \frac{dN}{dM} \int_{\max\{0, Z_d(M,z'')\}}^{z''} dz'' \frac{dt}{dz'} f_{esc}(\epsilon') \frac{dN(\epsilon', M)}{d\epsilon'\, dt} (1+z')$$

Star Formation Rate

Initial Mass Function

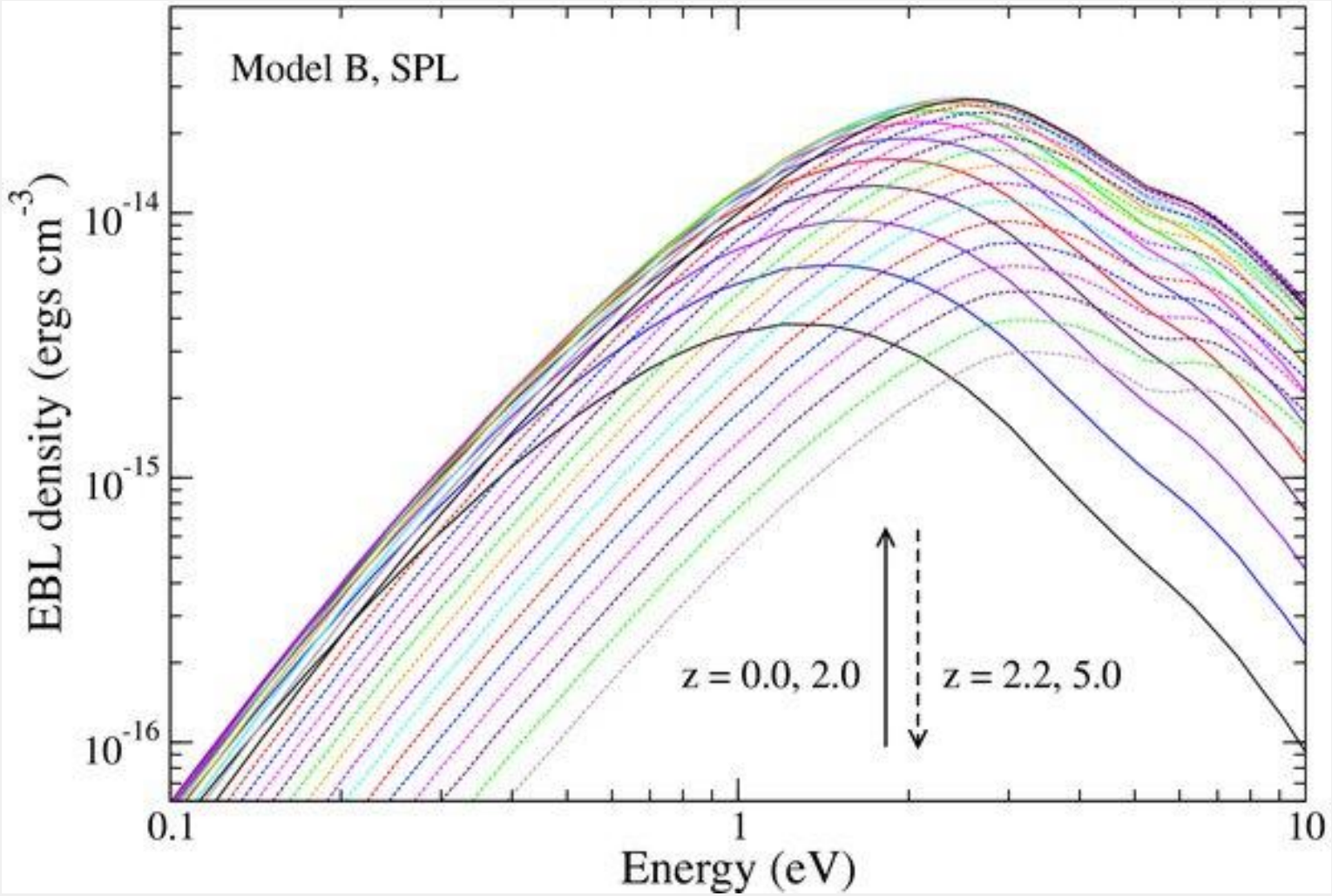
Escape fractions of photons from the host galaxy

Note: *The EBL energy density measured at redshift* ***z = z1*** *can be* ***transformed*** *from z = 0 by calculating the* ***comoving*** *energy density and volume as:* $\epsilon_1 \Rightarrow \epsilon(1+z1)$ and $V_1 \Rightarrow \frac{V}{(1+z1)^3}$

$$\epsilon\, \mu_\epsilon = (1+z)^4 \epsilon^2 \frac{dN(\epsilon, z)}{d\epsilon dV}$$

Razzaque et al. (2009)

The comoving photon energy with different redshift z for EBL model

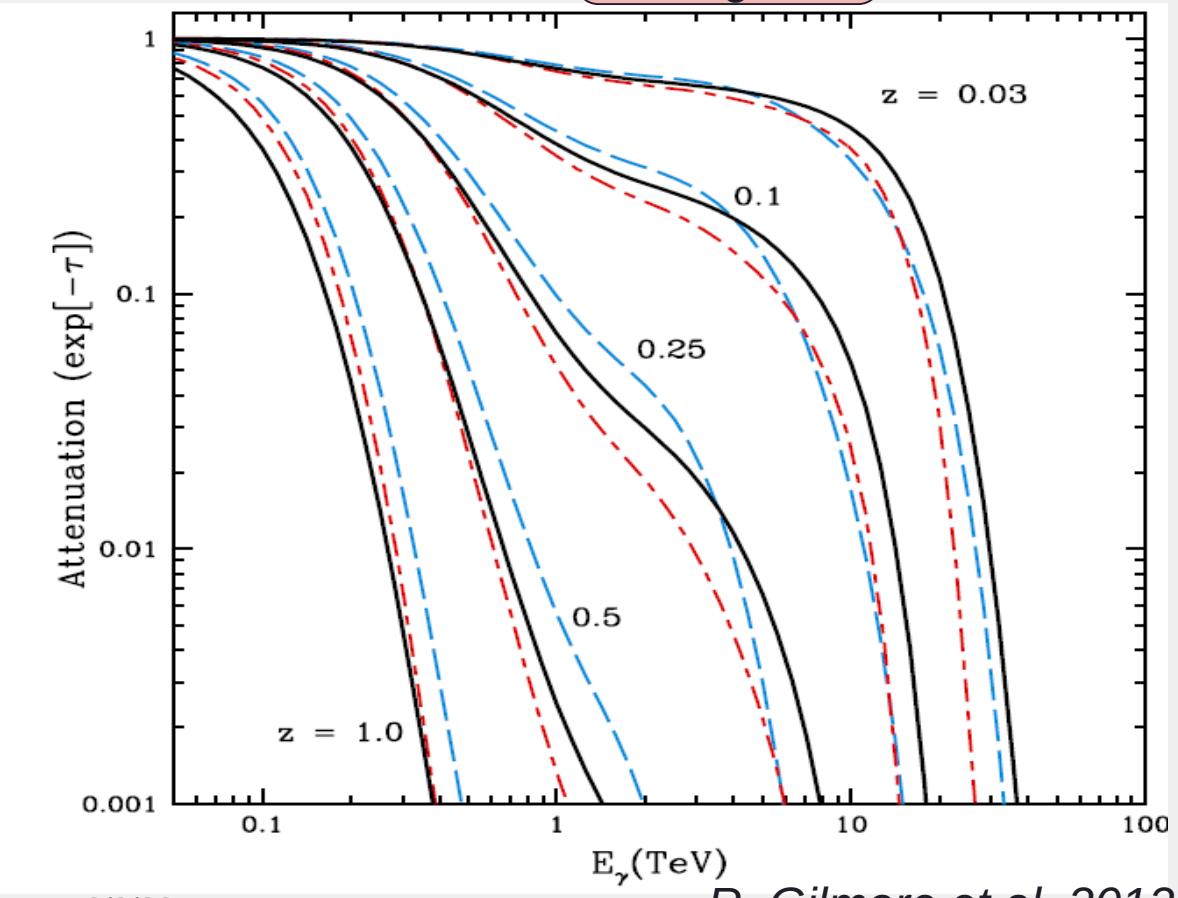


Razzaque et al. (2009)

Gamma-Ray attenuation:

$$\tau(E,z) = \int_0^z \left(\frac{dl'}{dz'}\right) dz' \int_0^2 d\mu \frac{\mu}{2} \int_{\varepsilon_{min}}^{\infty} d\varepsilon' \, \sigma_{\gamma\gamma}(\beta') \, n(\varepsilon', z')$$

- distance
- Interaction angle
- Cross section
- EBL photon energy density



As we notice from this figure:

The universe should be opaque to VHE gamma rays at high redshift

*(ie. More than **1TeV** with redshift higher than **0 .6**)*

R. Gilmore et al. 2012

But from recent Observation:

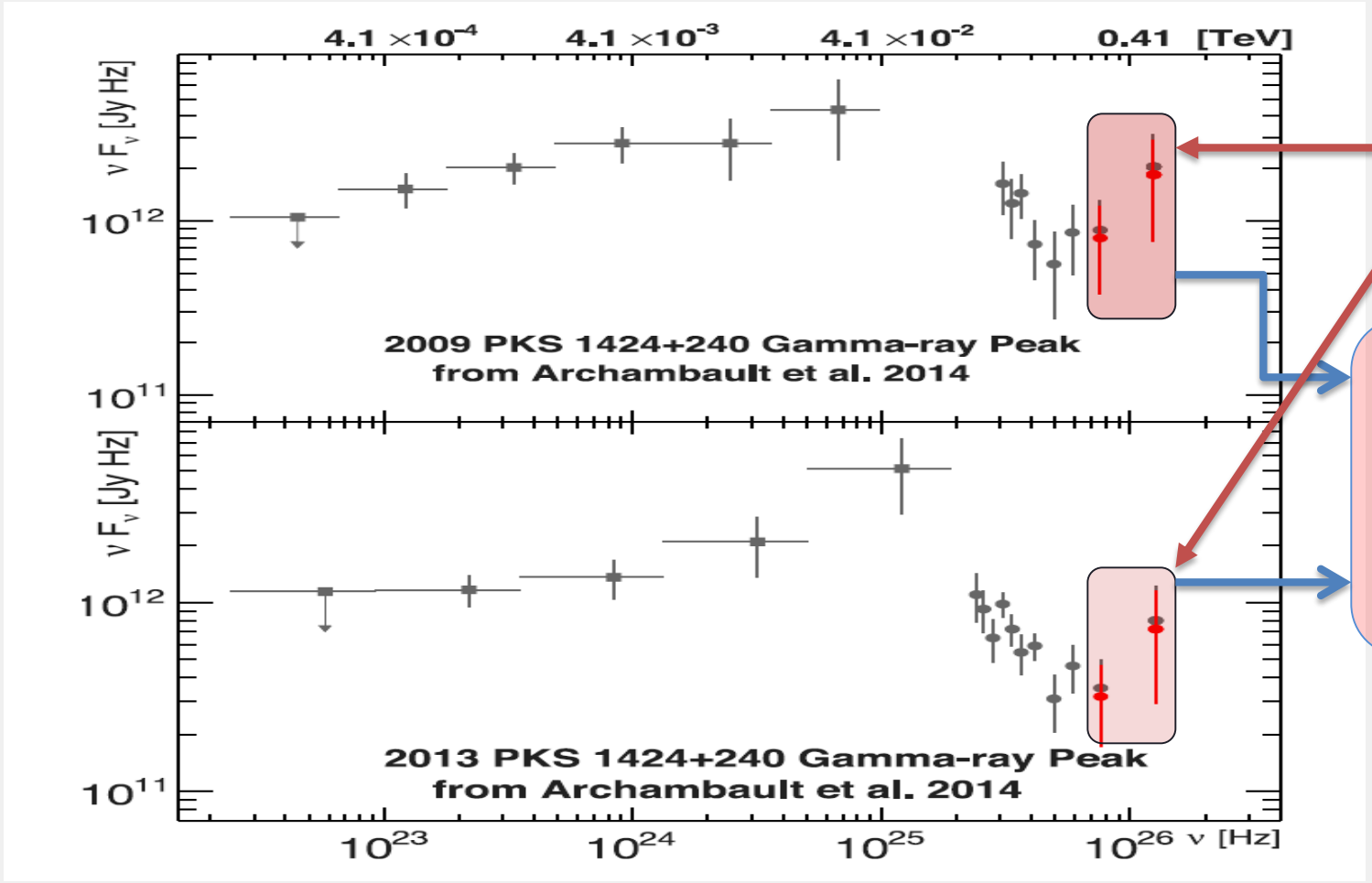
The universe is more transparent to the VHE-Gamma Rays

than was *expected !*

Archambault et al. 2014

Inhomogeneities in the EBL distribution:

Furnis et al., found possible correlation between detected VHE gamma rays sources and cosmic void along the line of sight!



TO EXPLAIN THIS V H E SIGNATURES IN THE SPECTRA OF DISTANT BLAZARS

There are Possible solutions:

- ***Existence of exotic Axion Like Particles (ALPs)***

  Dominguez et al. 2011

- ***Interactions of extragalactic Ultrahigh Energy Cosmic Rays (UHECR)***

  Essey et al. 2010

- ***The existence of cosmic voids between the Blazar and the observer on the earth, which means the EBL not homogeneous.***

  Furniss et al. 2013

Inhomogeneity in the EBL distribution:

Summary:

This problem also maybe due to:

- Misunderstanding of the emission mechanisms in the Blazars and/or the propagation of VHE photons through the Inter Galactic Meduim.
- EBL physics not well understood

In our current work we are trying to study the expected inhomogeneity of the EBL, in particular if the line of sight to a Blazar is passing through large voids in intergalactic space!

Thank you !!!

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