Can Gamma-ray Observations Probe the Cosmic Infrared Background Radiation?

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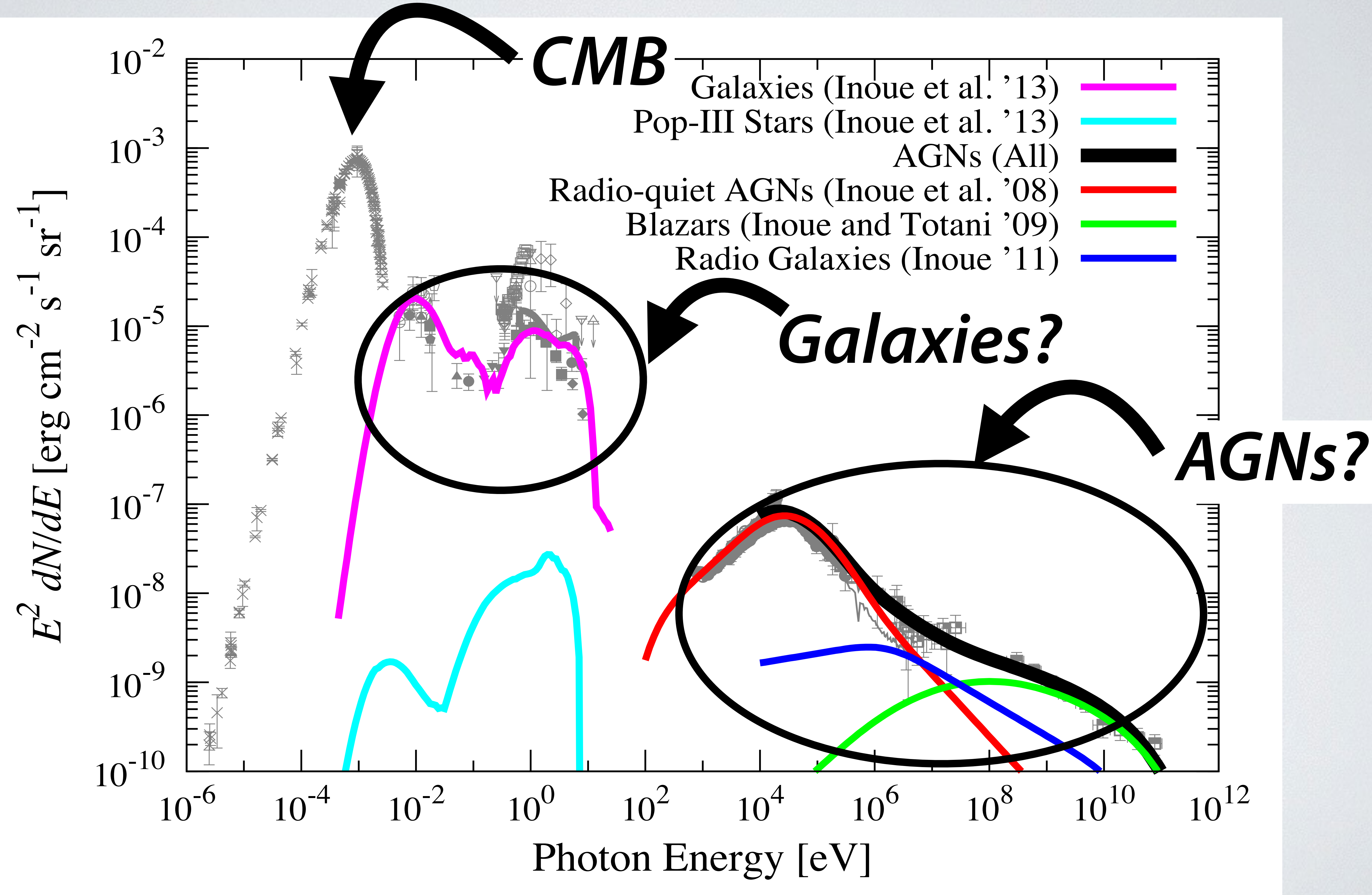
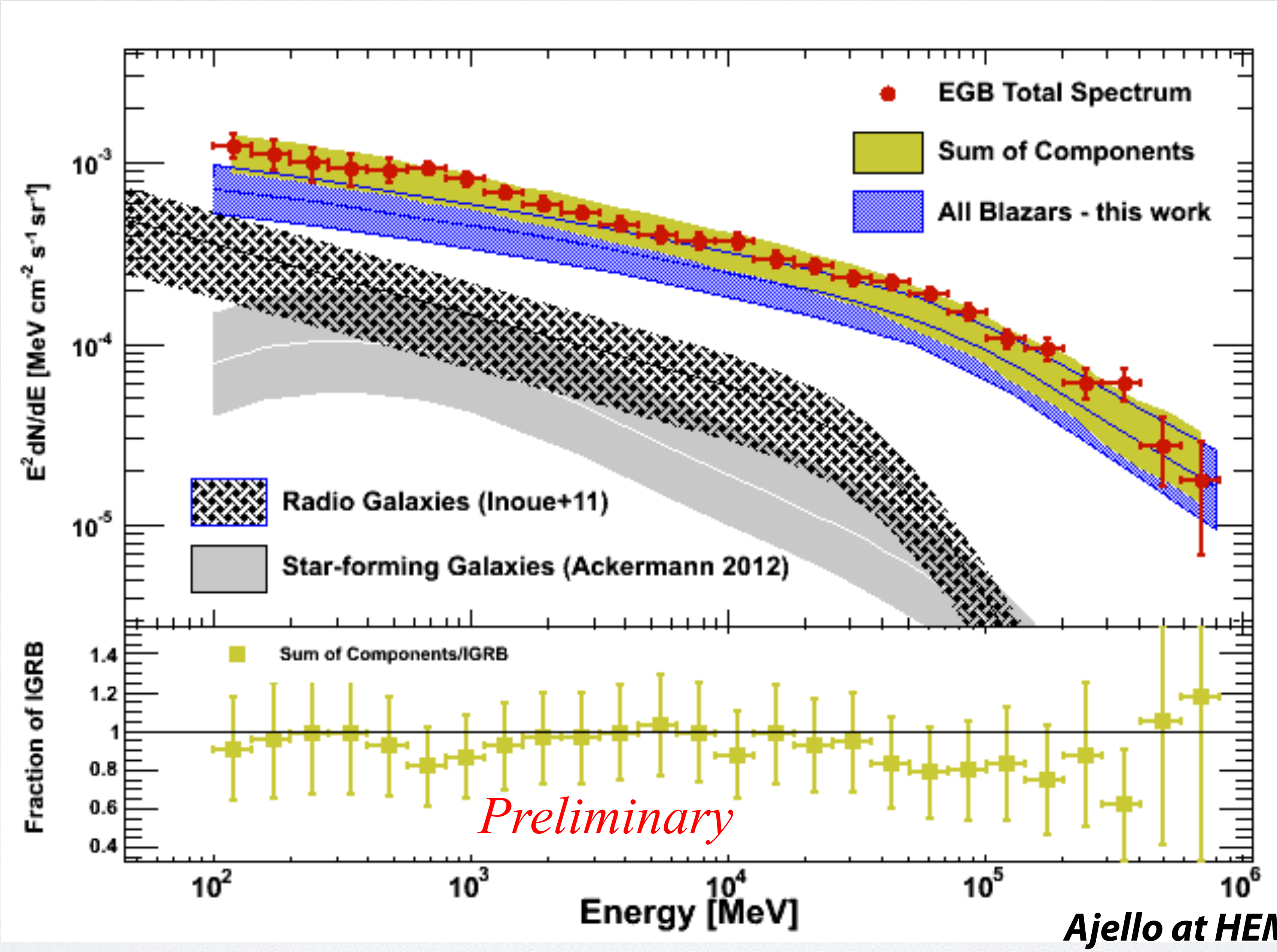
Cosmic Background Radiation



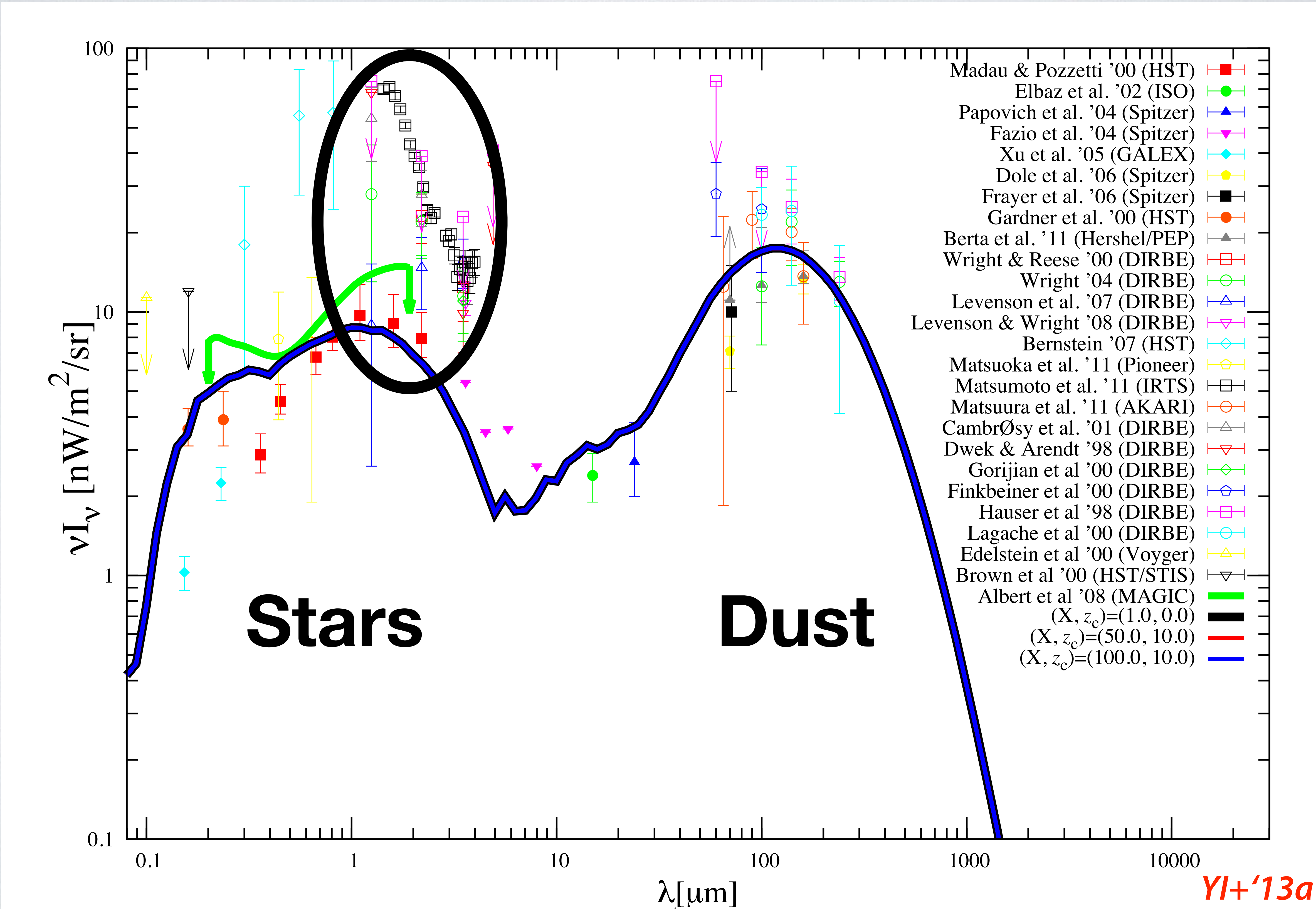
Cosmic Gamma-ray Background



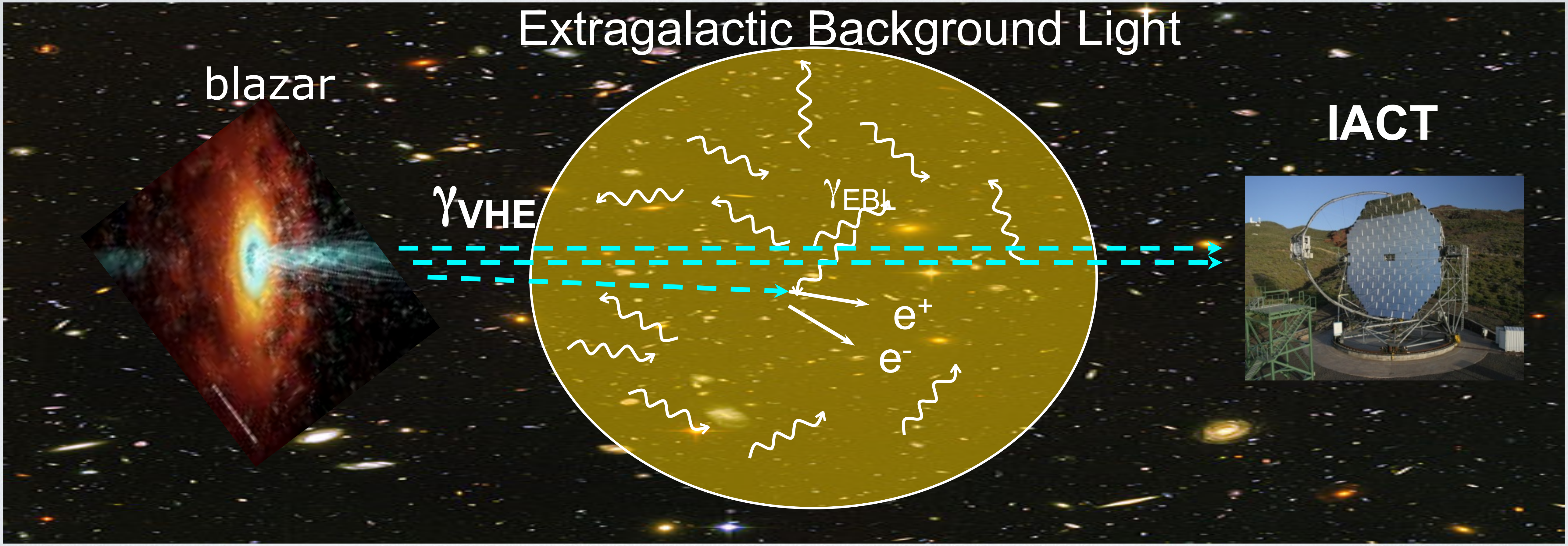
Ajello at HEM14

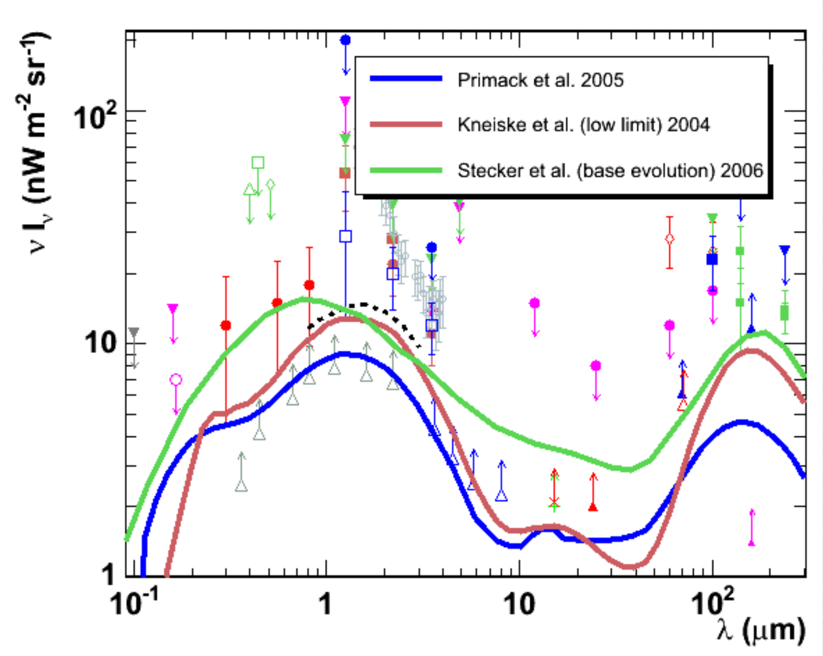
- FSRQs (Ajello+'12), BL Lacs (Ajello+'14), Radio gals. (YI'11), & Star-forming gals. (Ackermann+'12)

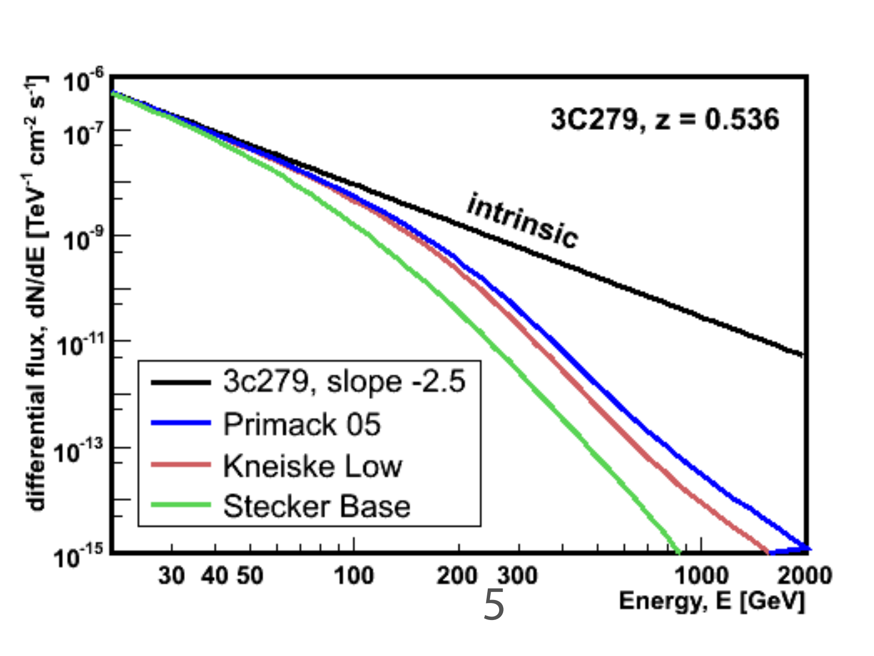
Extragalactic Background Light (EBL)

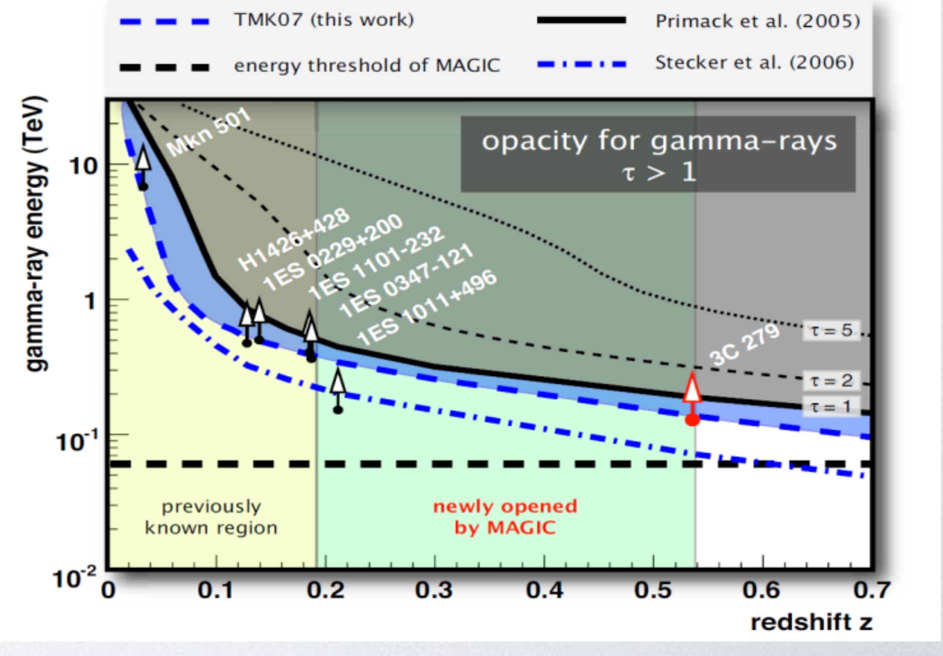


Gamma rays are attenuated by EBL

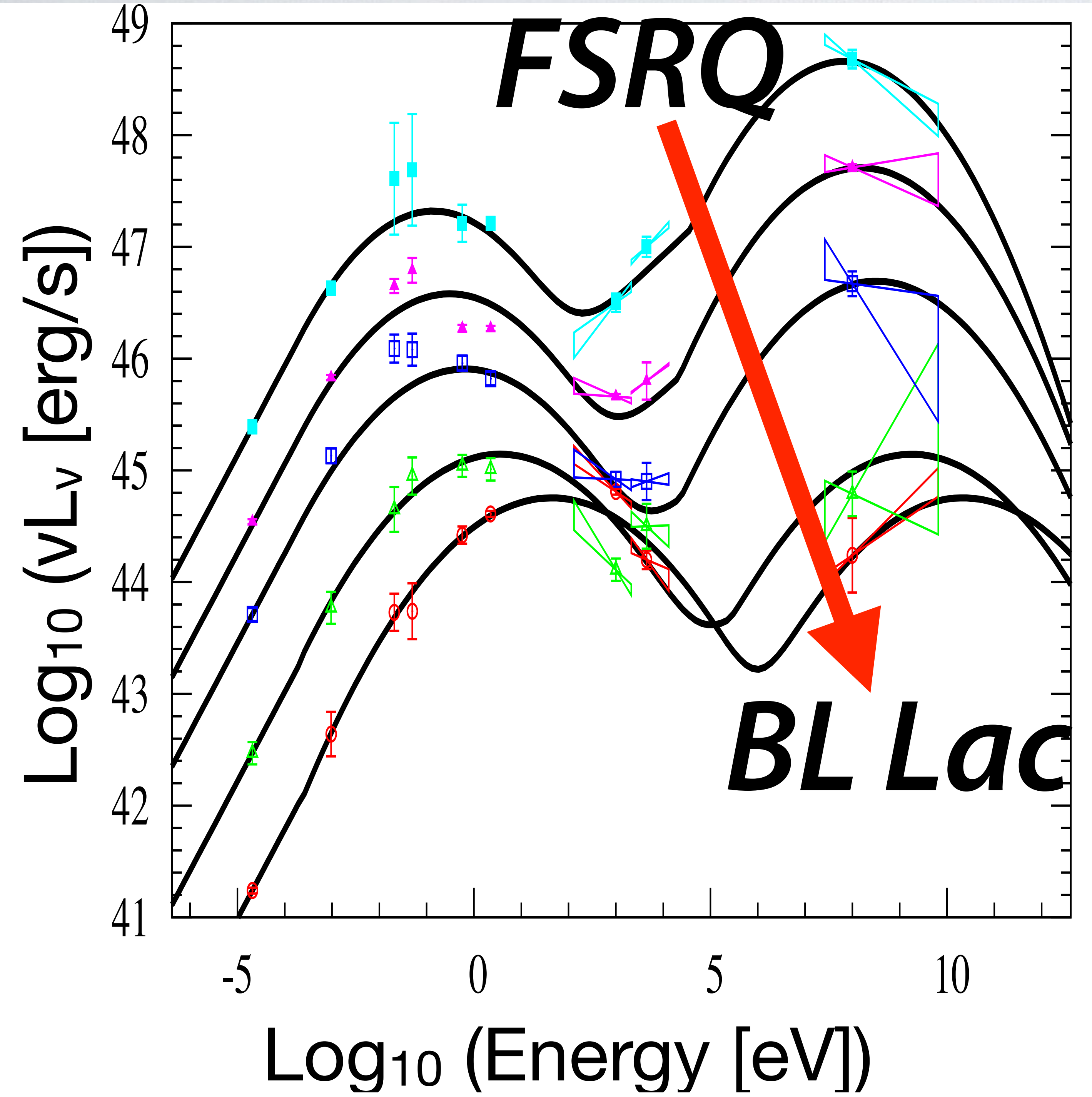








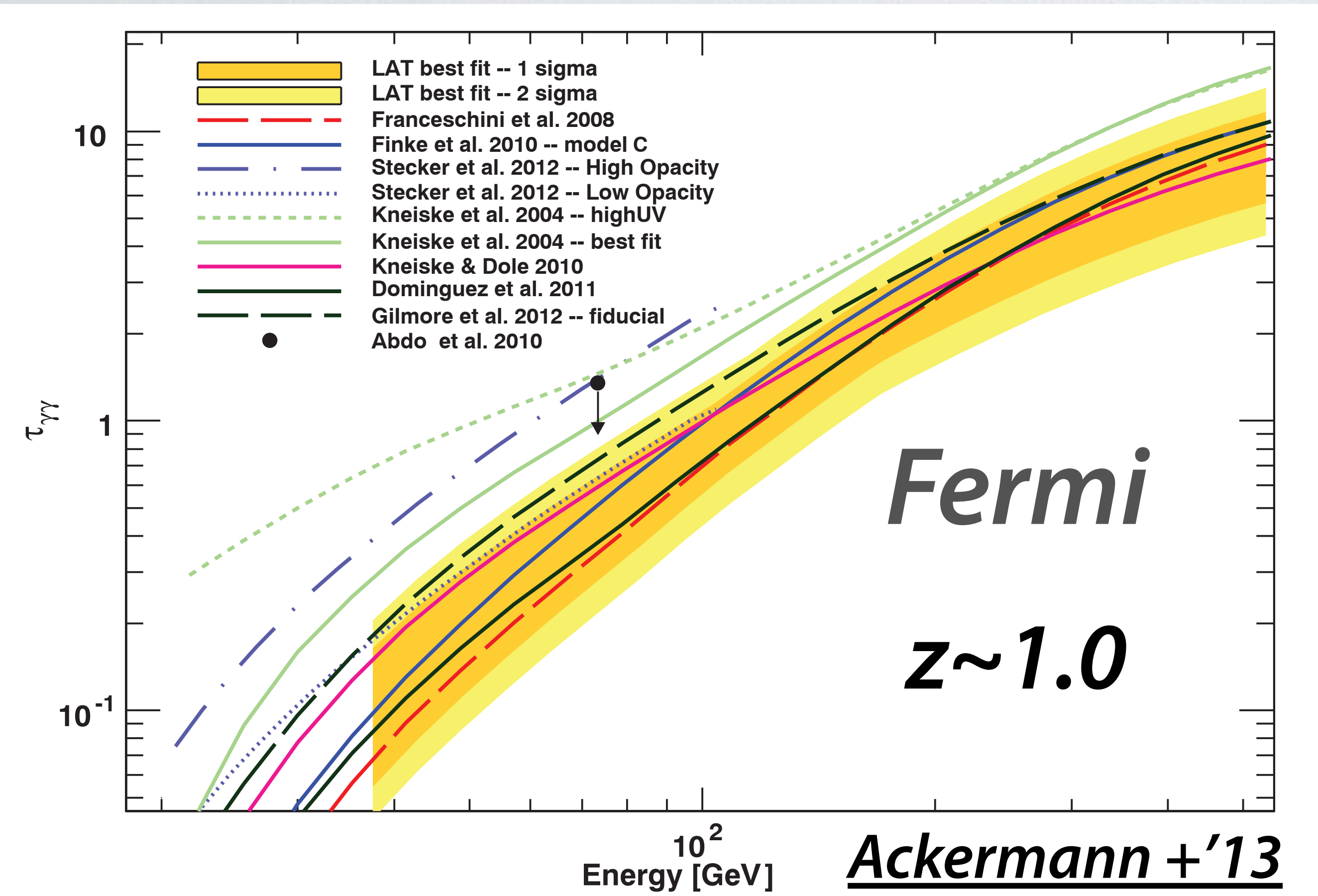
Blazars



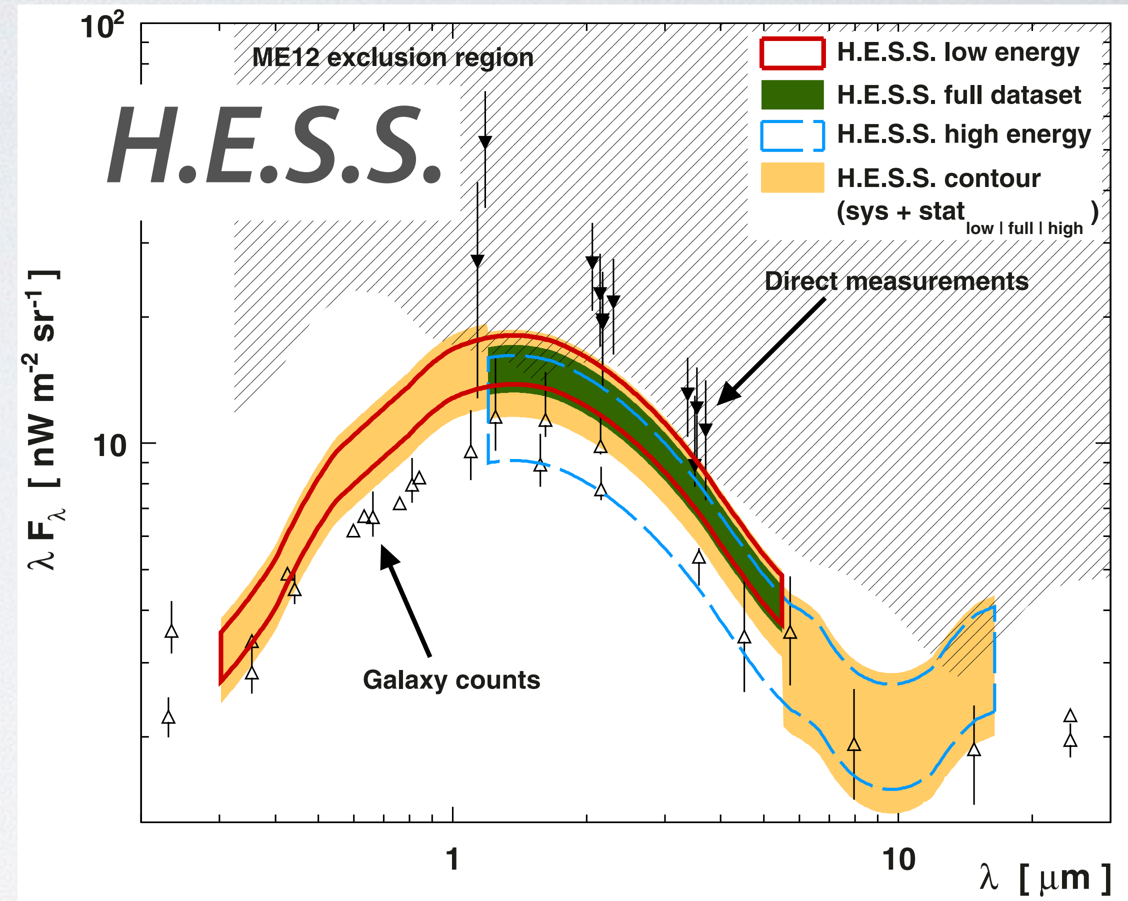
Fossati+'98, Kubo+'98,
YI & Totani '09

- Non-thermal emission from radio to gamma-ray
- Two peaks
  - Synchrotron
  - Inverse Compton
- Luminous blazars tend to have lower peak energies (Fossati+'98, Kubo+'98)

EBL Constraints from Gamma Rays



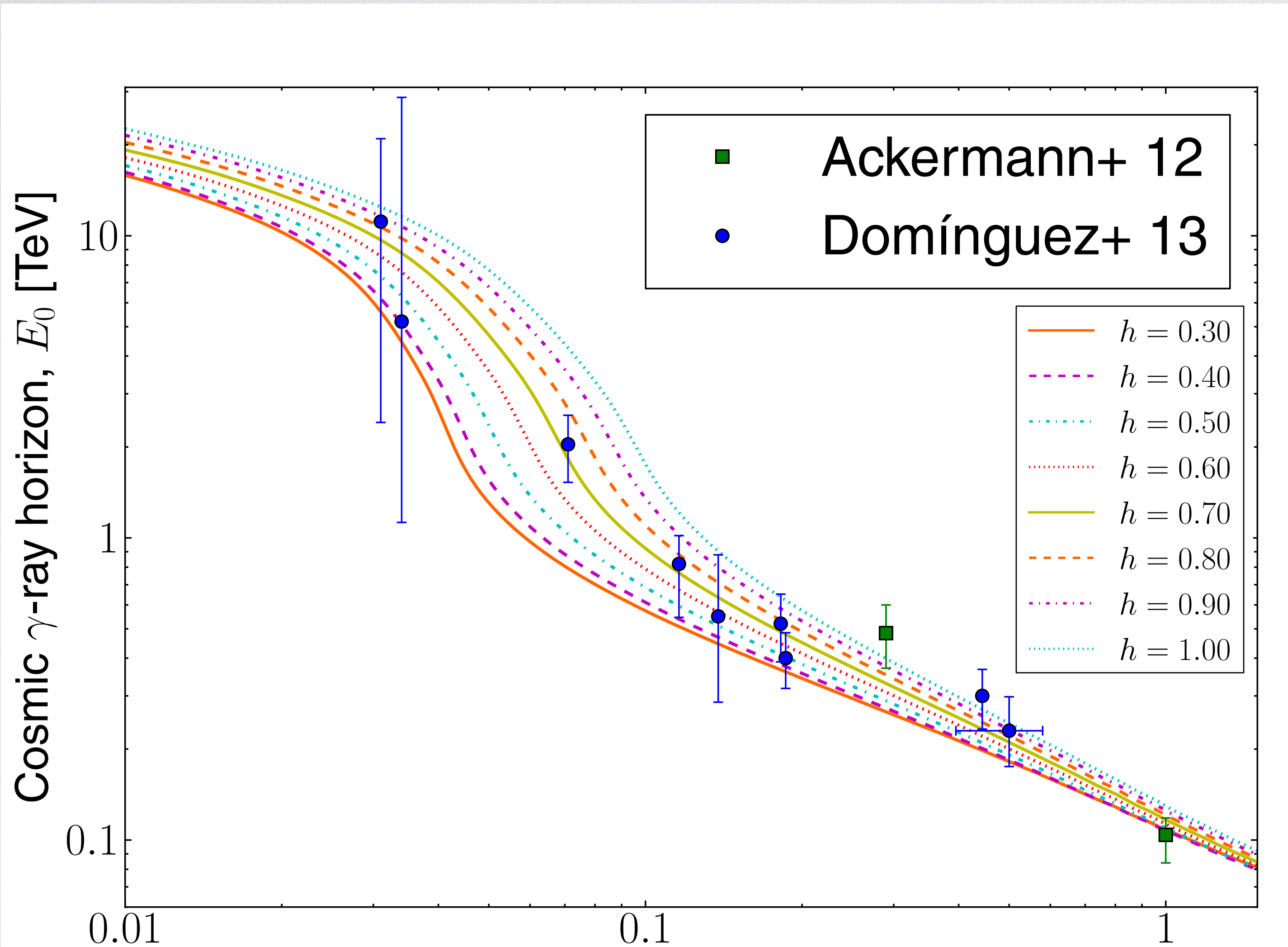
Ackermann +'13



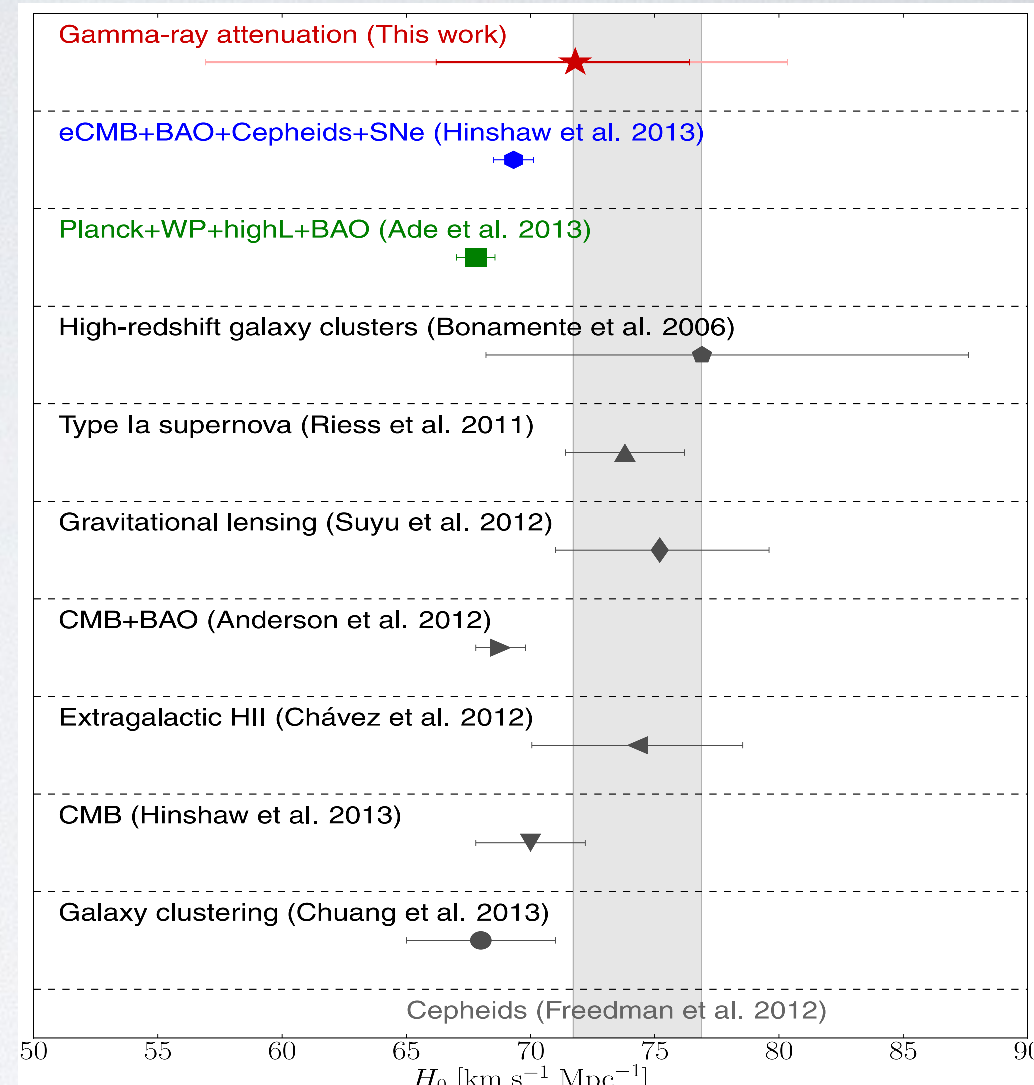
Abramowski +'13

- Fermi and H.E.S.S. derived the EBL opacity or intensity using the **combined** spectra of blazars (see also Gong & Cooray '13, Dominguez +'13).
  - Inconsistent with the NIR EBL excess.
- They assume simple log-parabola or power-law spectra.

Dark Energy & Gamma rays?



Dominguez & Prada '13



Dominguez & Prada '13

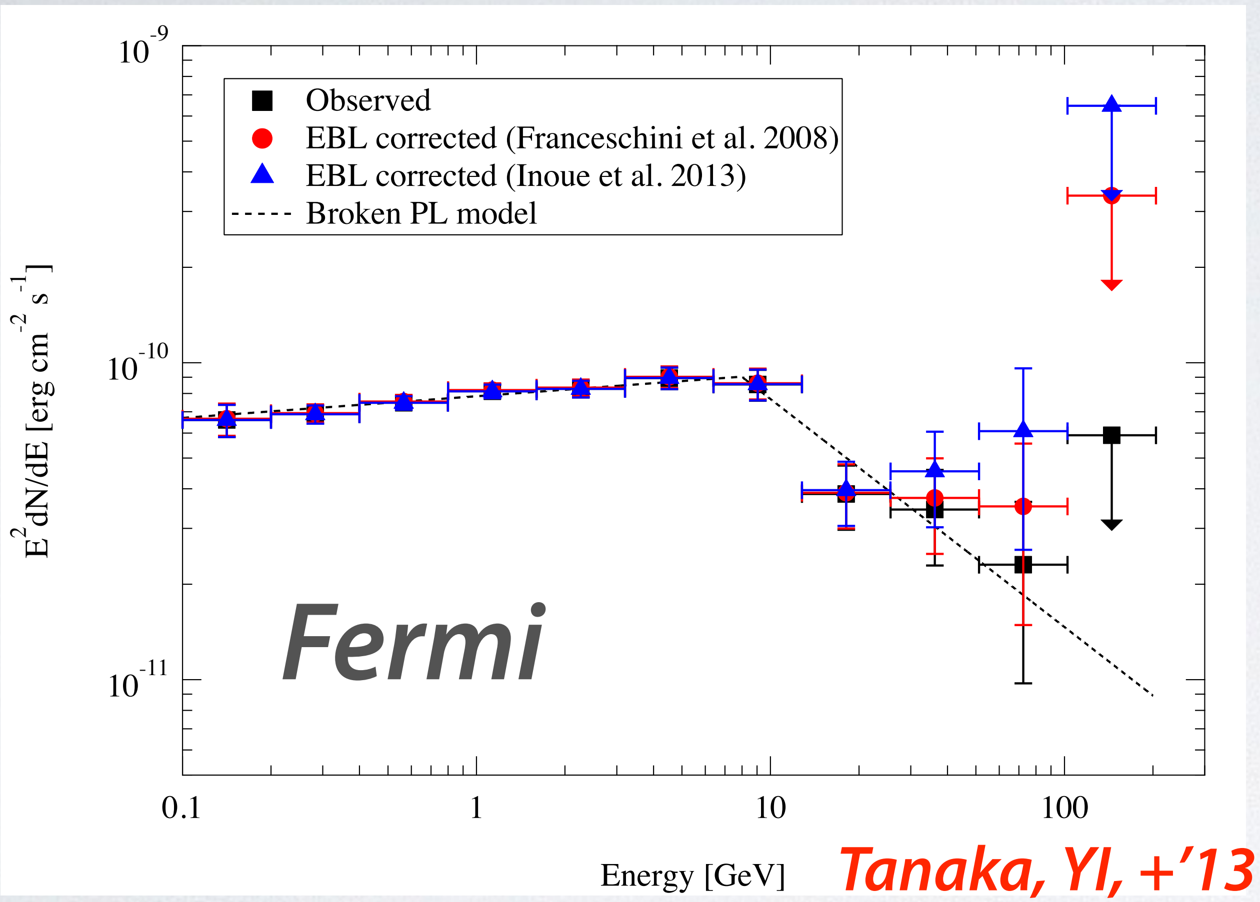
- Derive the cosmic expansion rate using gamma-ray horizon.
- Future data may allow to constrain cosmological parameters.

Spectra Assumption

- Log-parabola (+ exp. cutoff)
- Single power-law (+ exp. cutoff)
- SSC

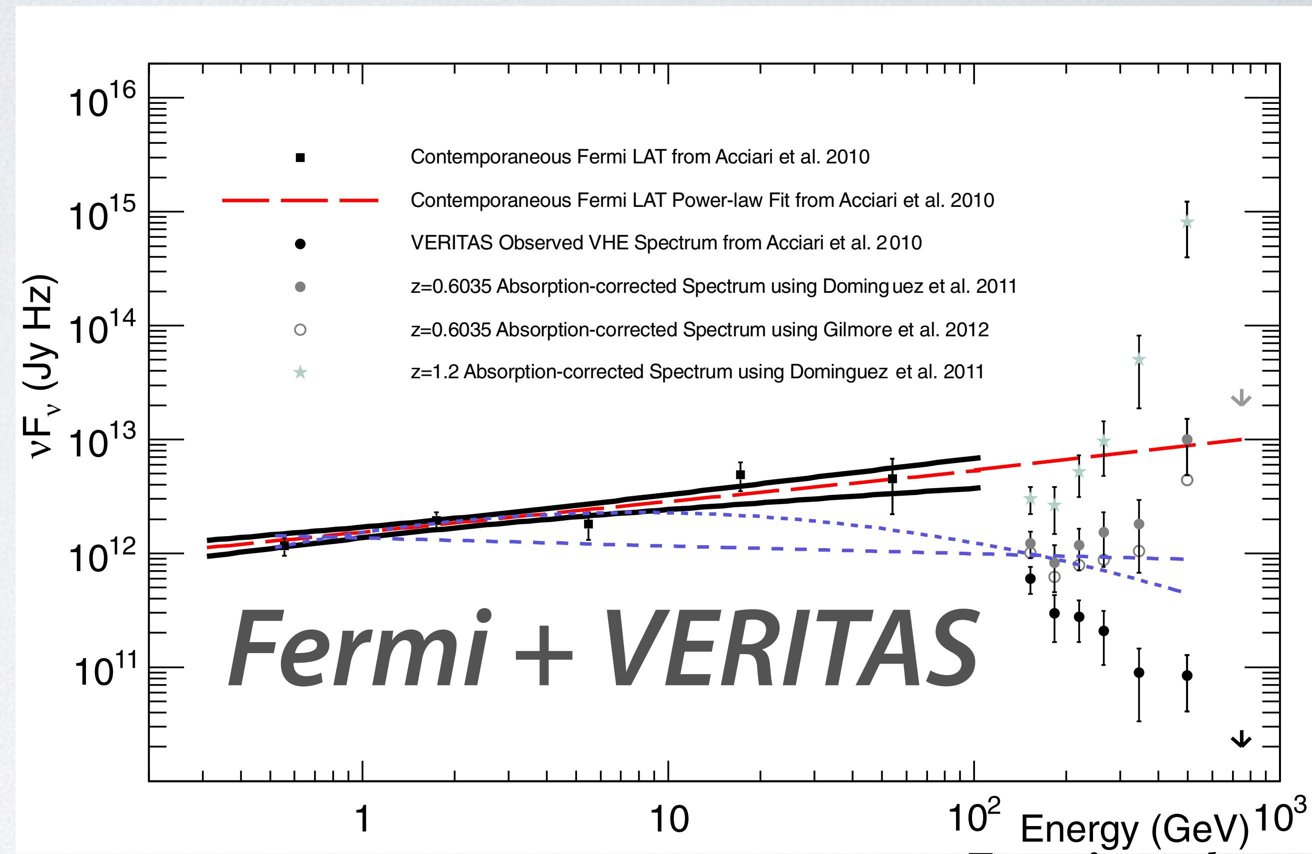
>100 GeV Gamma Rays from z=1.1 & z>0.6

PKS 0426-380 at z=1.1



Tanaka, YI, +'13

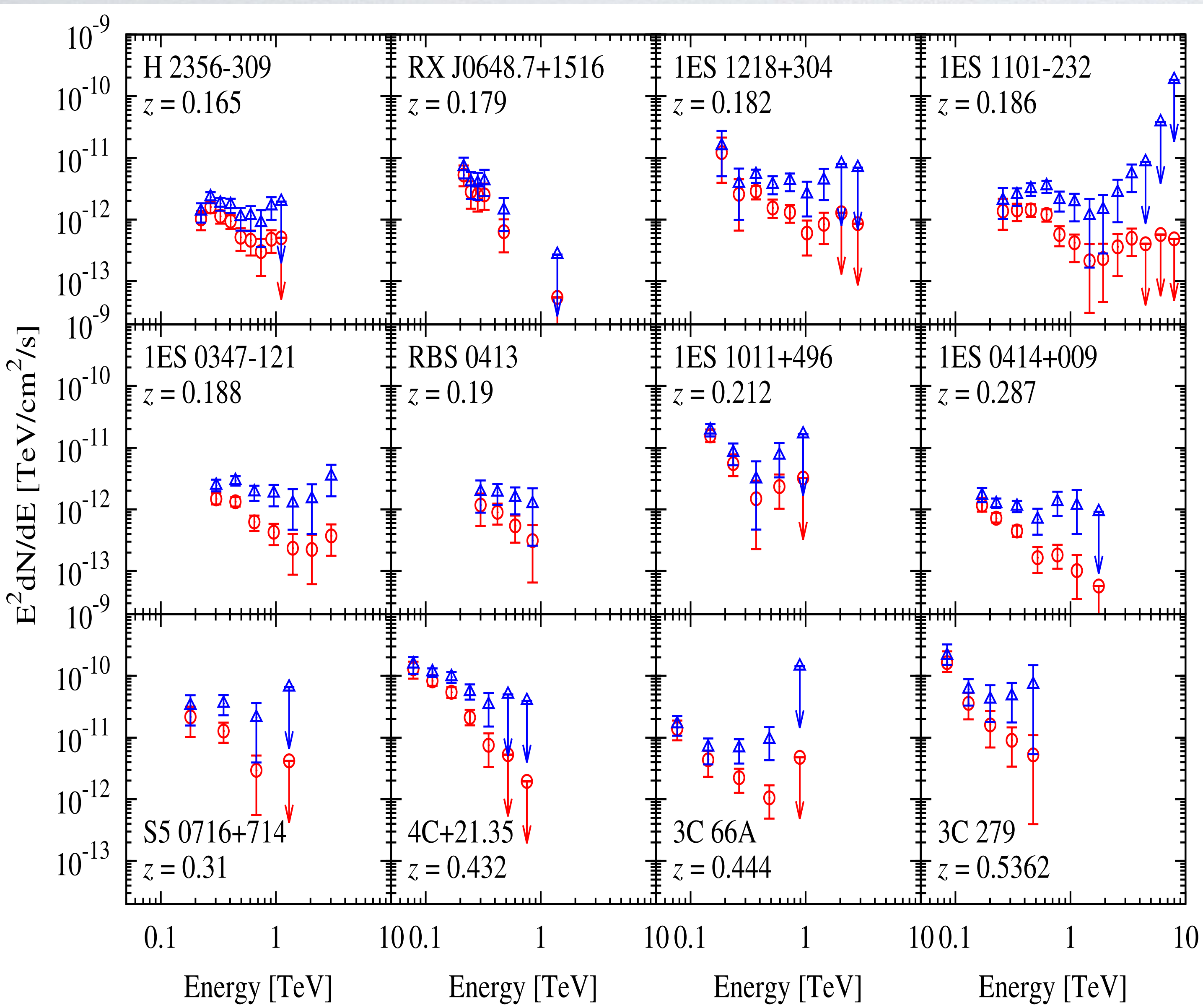
PKS 1424+240 at z > 0.6



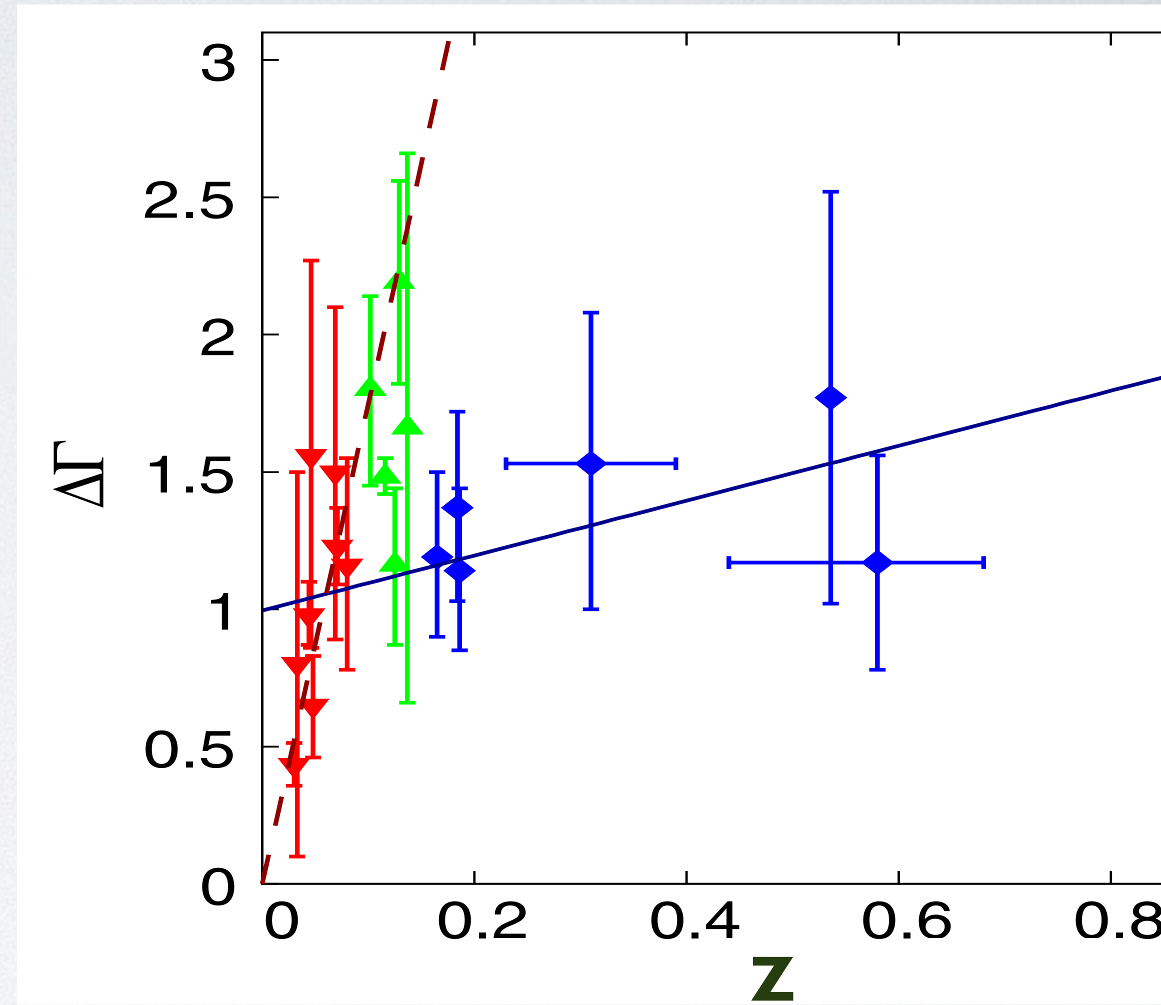
Furniss +'13

- Distant very high energy (VHE) sources show spectral hardening.

Is VHE Spectral Hardening Universal?



Yl+'13a

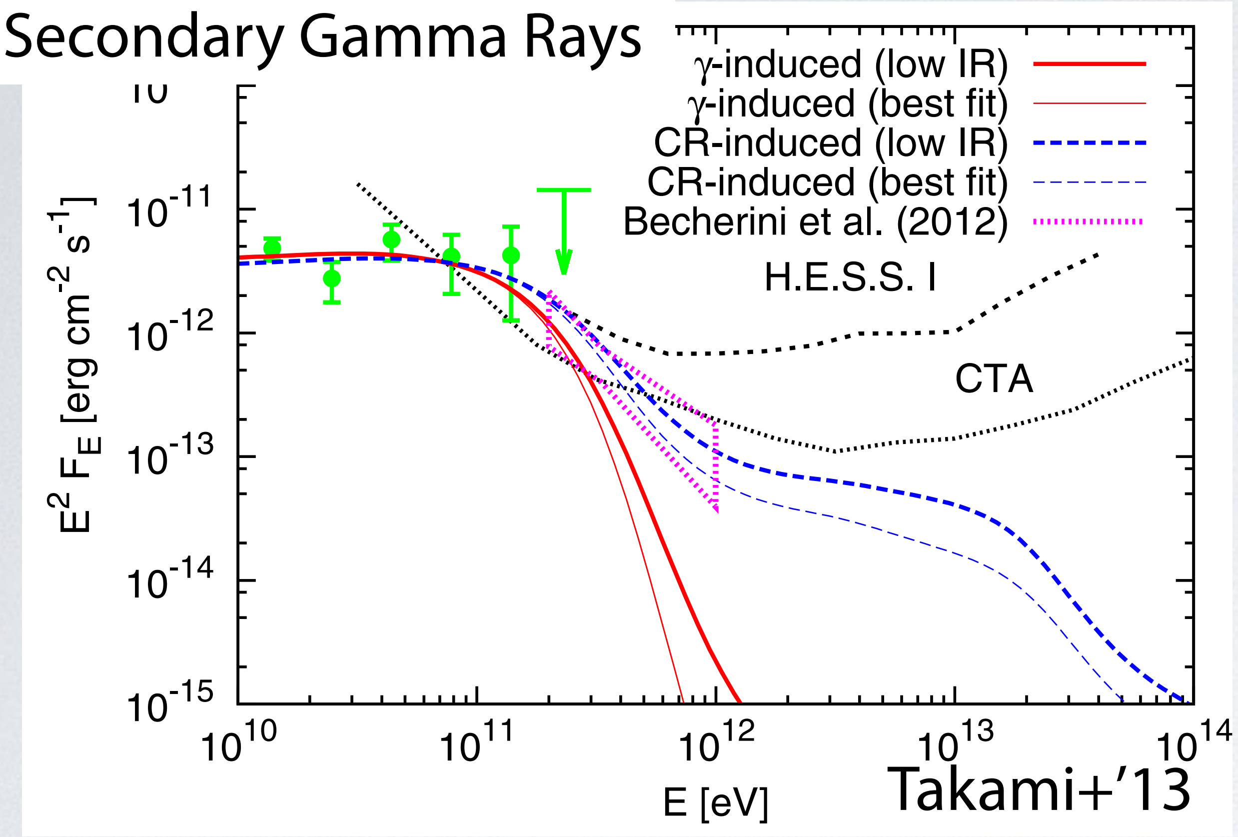


Essey & Kusenko '12

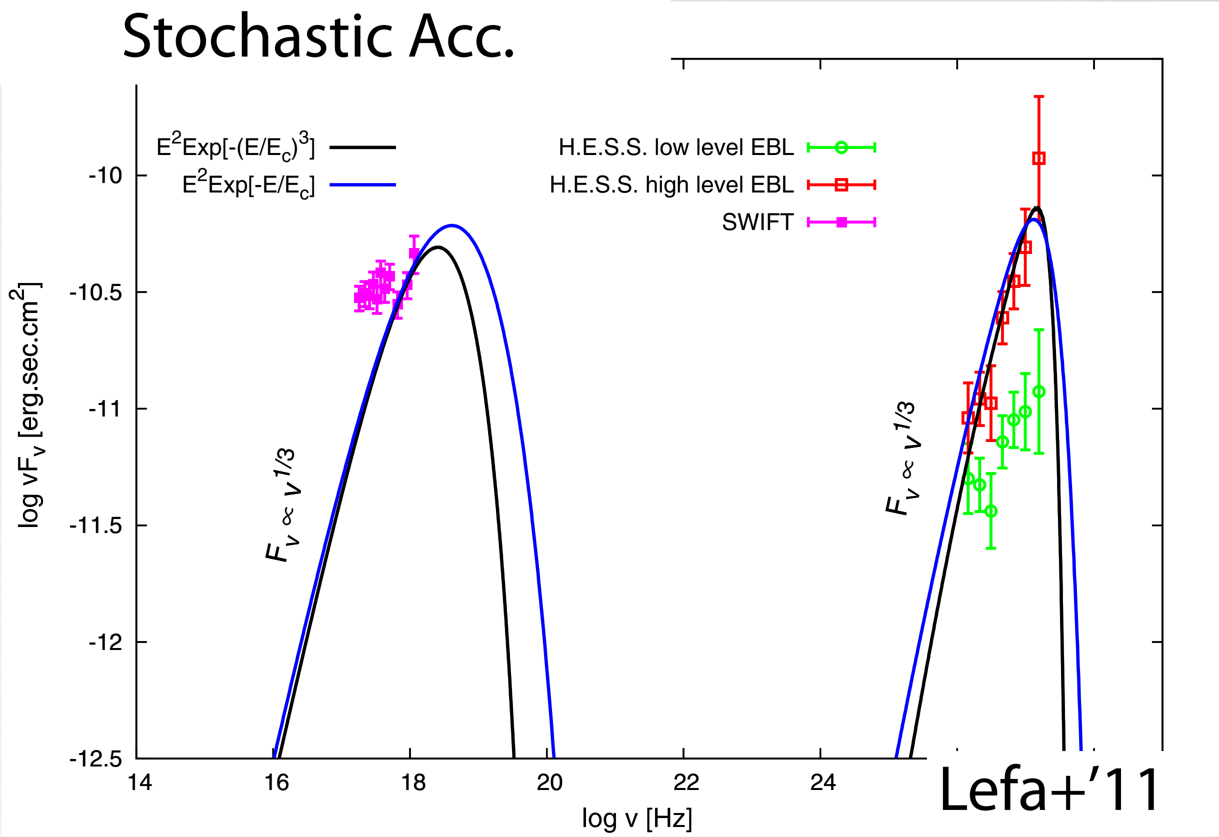
- Spectra of blazars at z > 0.15 show hardening from a few hundred GeV.

Secondary Gamma Rays? Stochastic Acceleration?

KUV 00311-1938 (z=0.61)
Secondary Gamma Rays

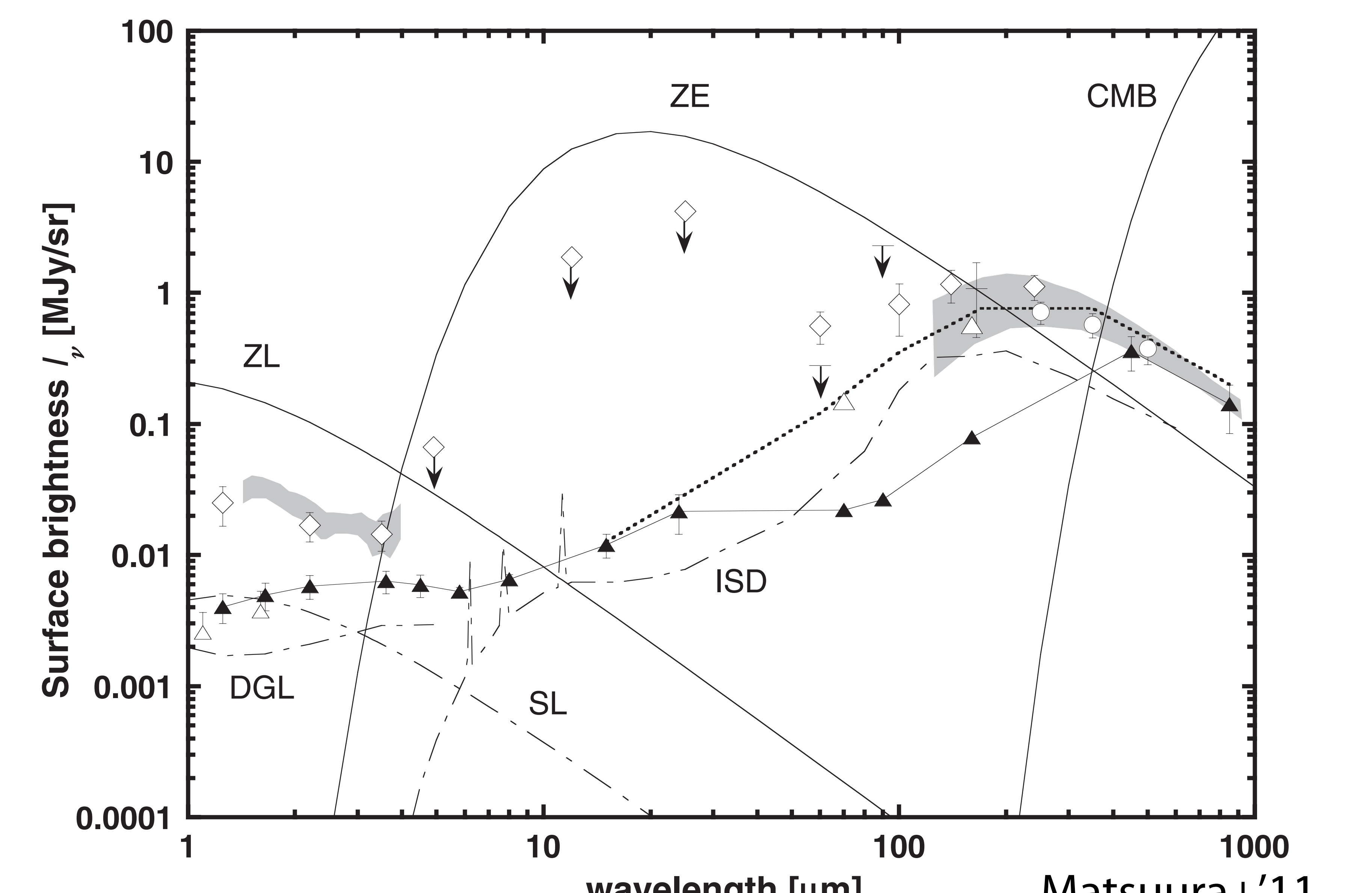


1ES 0229+200 (z=0.1396)
Stochastic Acc.



- Secondary gamma rays from cosmic rays along line of sight
  (Essey & Kusenko '10, Essey+'10, Essey+'11, Murase+'12, Takami+'13)
- Stochastic acceleration can generate hard electron spectra
  (Stawarz & Petrosian '08, Lefa+'11, Asano+'14).
- Lepto-hadronic scenario (Inoue-san's talk).

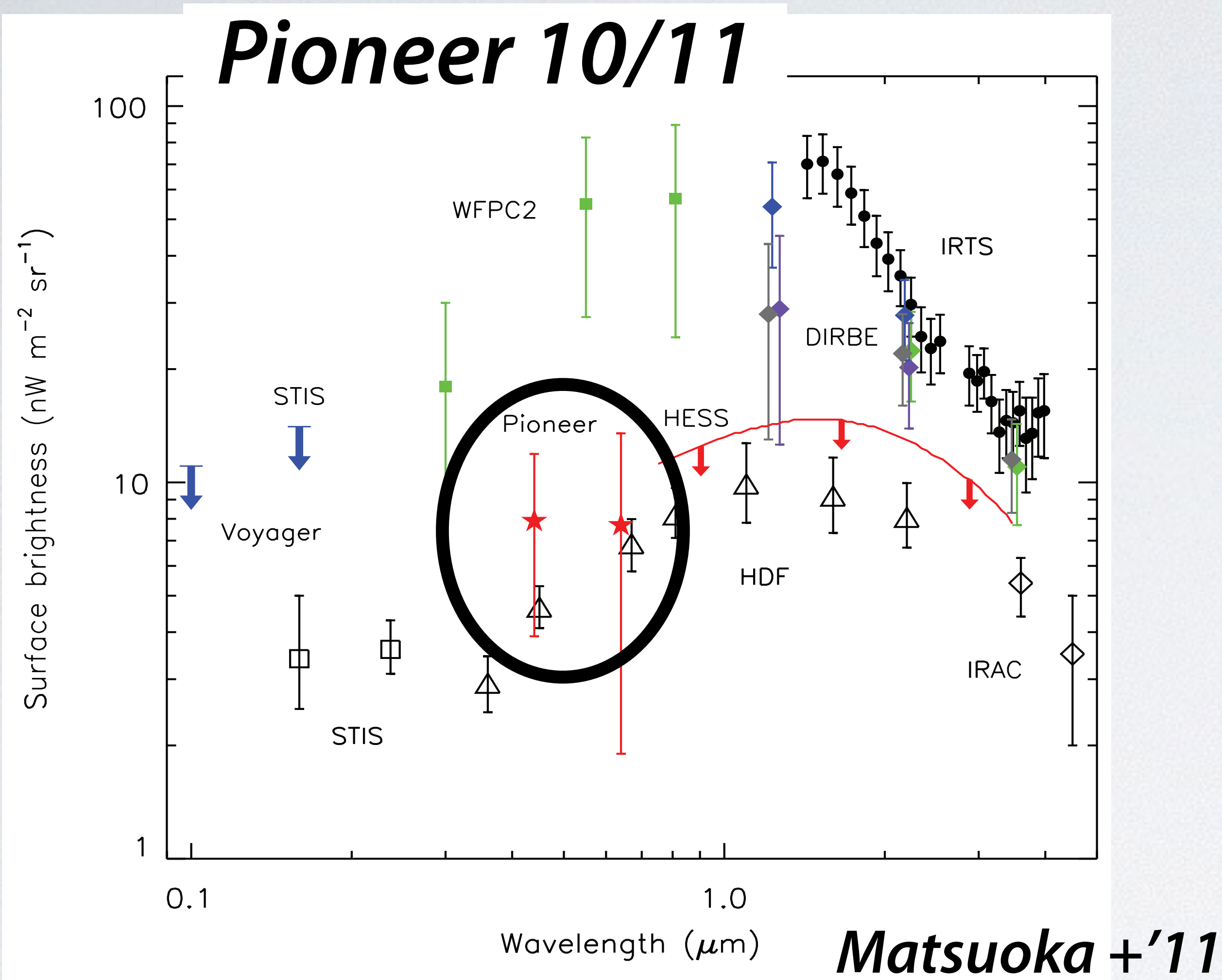
Direct Measurement of EBL

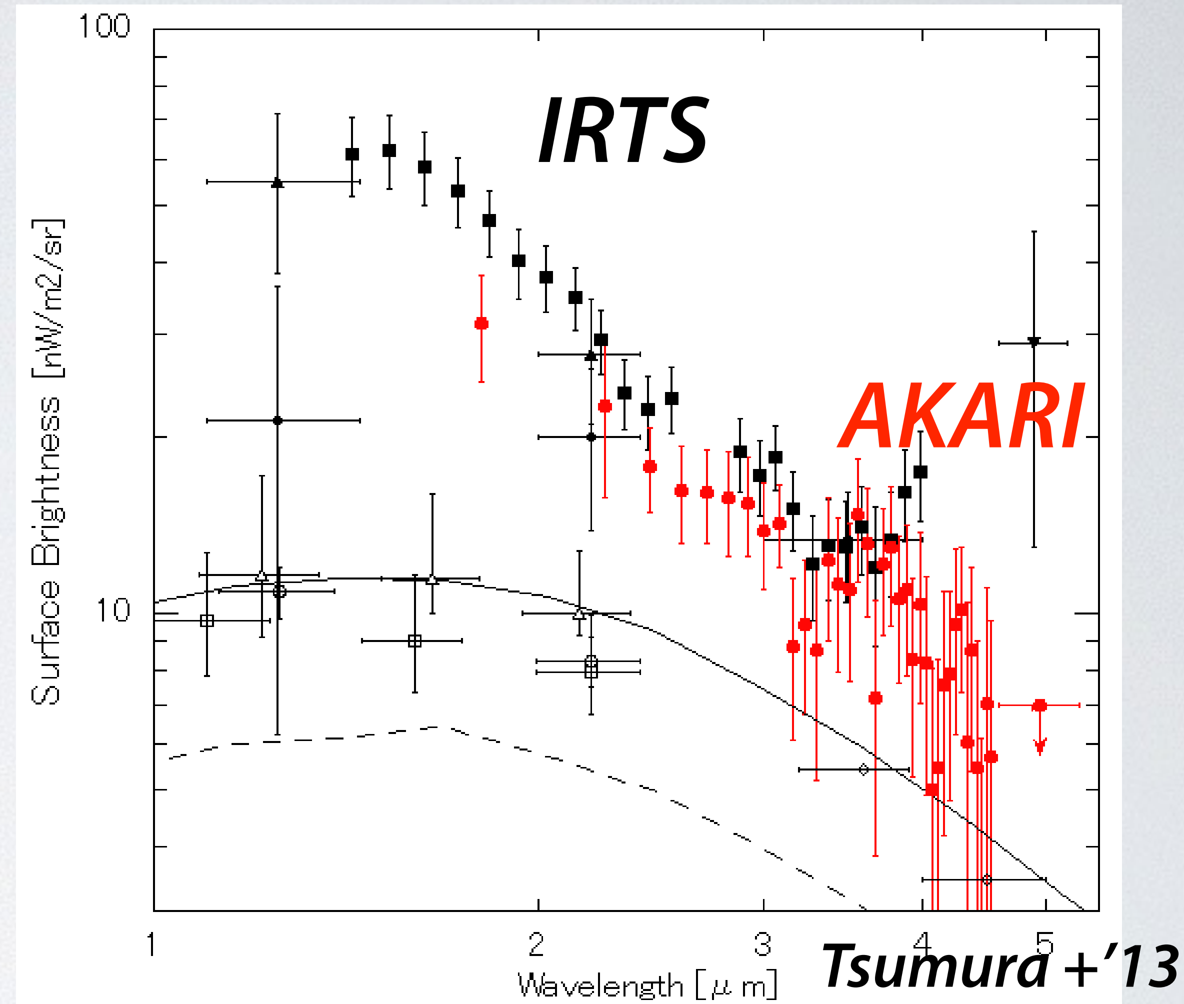


Matsuura+'11

- Foreground: Zodiacal light, Diffuse galactic light, Star light.

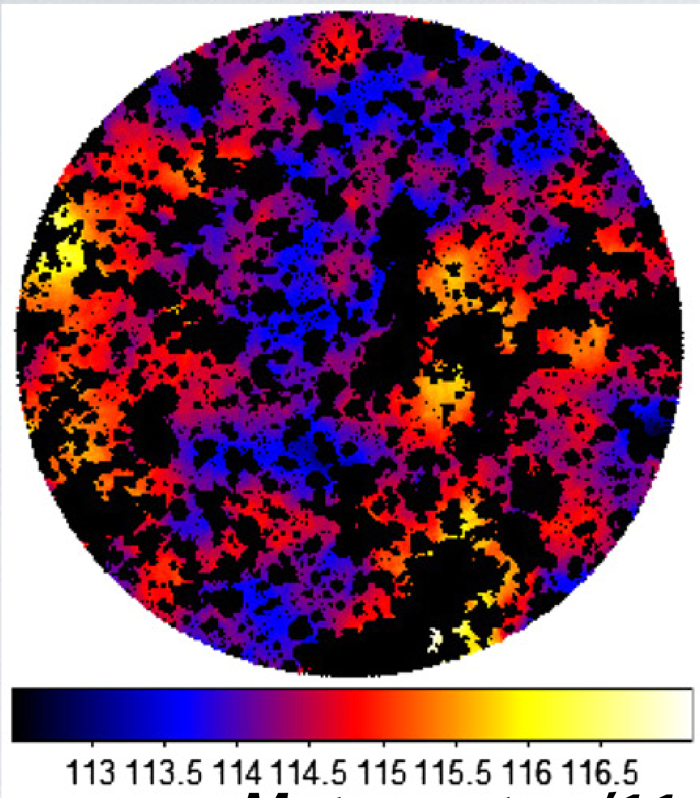
Direct Measurement of EBL



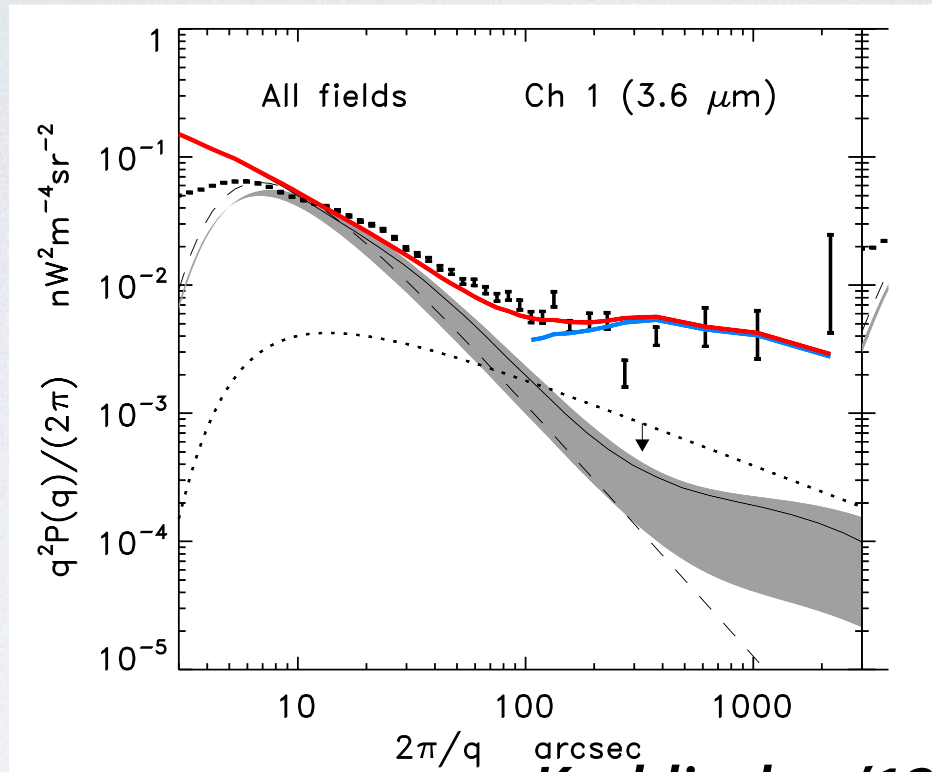


- Pioneer 10/11 measurements are consistent with galaxy counts.
- Recent AKARI measurements are consistent with IRTS.
- EBL peak at near infrared?

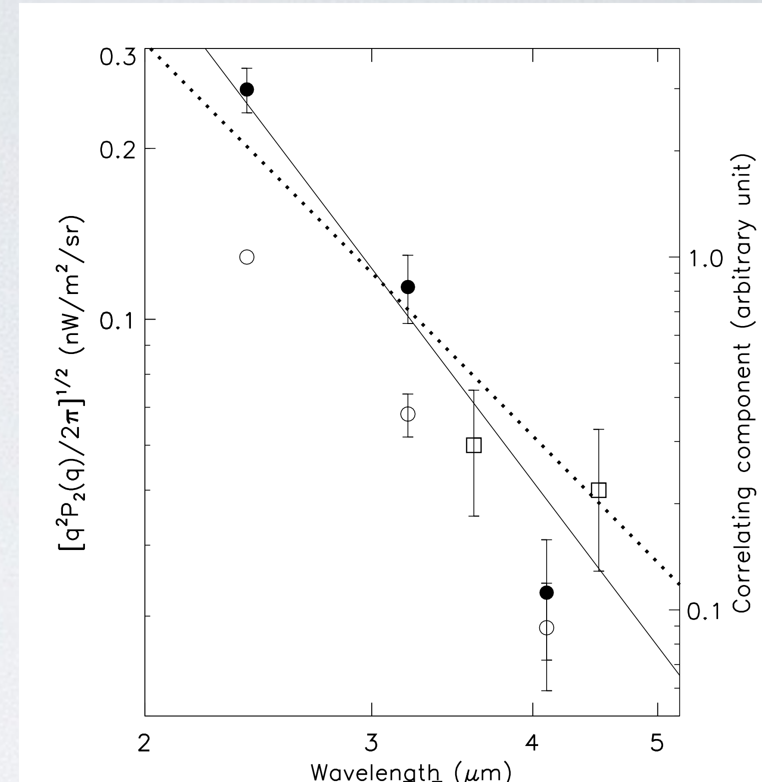
NIR Sky Fluctuation



Matsumoto +'11



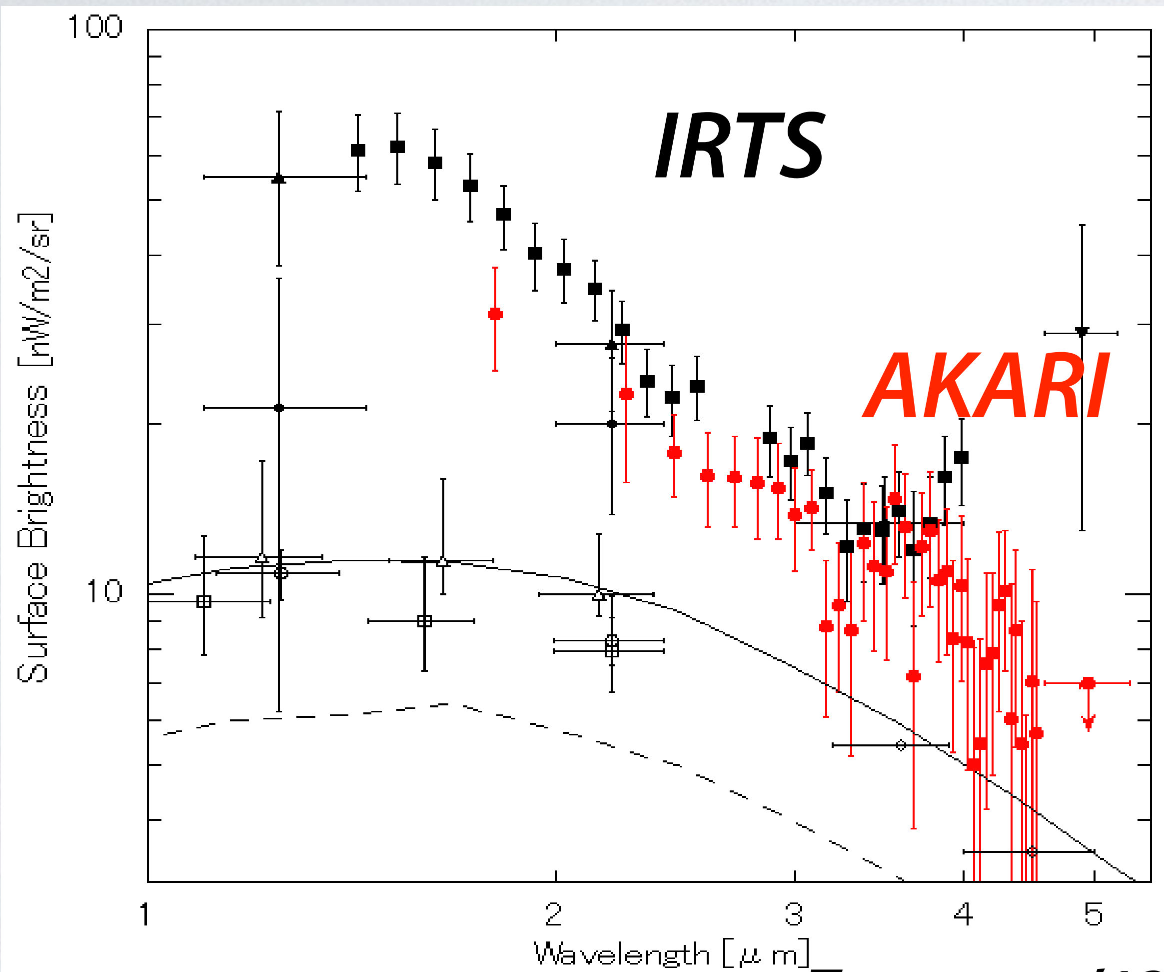
Kashlinsky+'12



Matsumoto +'11

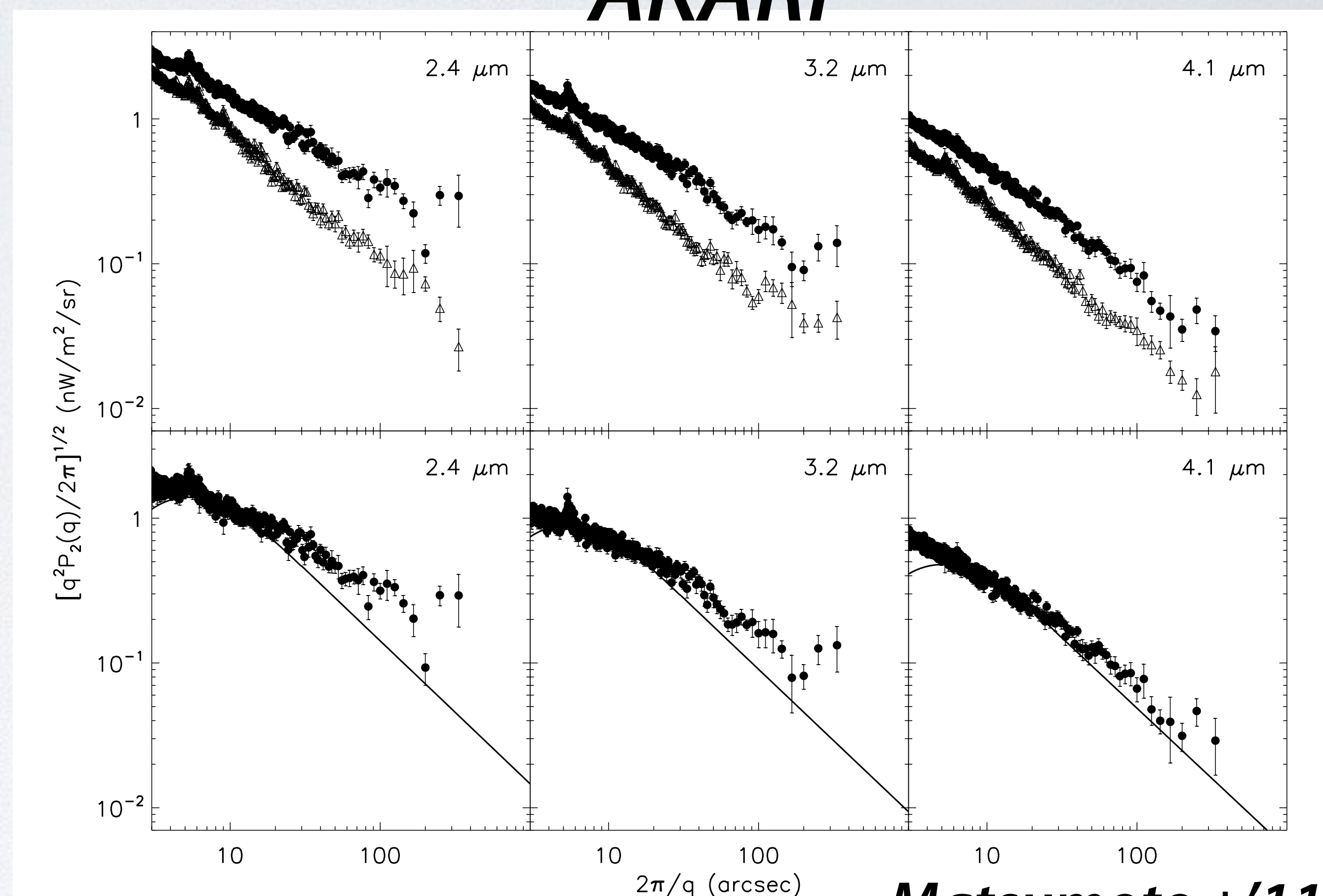
- AKARI & Spitzer reported NIR background fluctuation at 2.4, 3.2, 3.6, 4.1 and 4.5 um (Kashlinsky+'05, '07, '12, Matsumoto+'11, Cooray+'12).
  - 15-20% of CIB fluctuation is correlated with CXB (Cappelluti+'13).
- The angular power spectrum at large scales is close to the shape of a Rayleigh-Jeans spectrum, λ^{-3} (Matsumoto+'11, Cooray+'12)

Can we explain the NIR EBL excess in spectrum and fluctuation?



Tsumura +'13

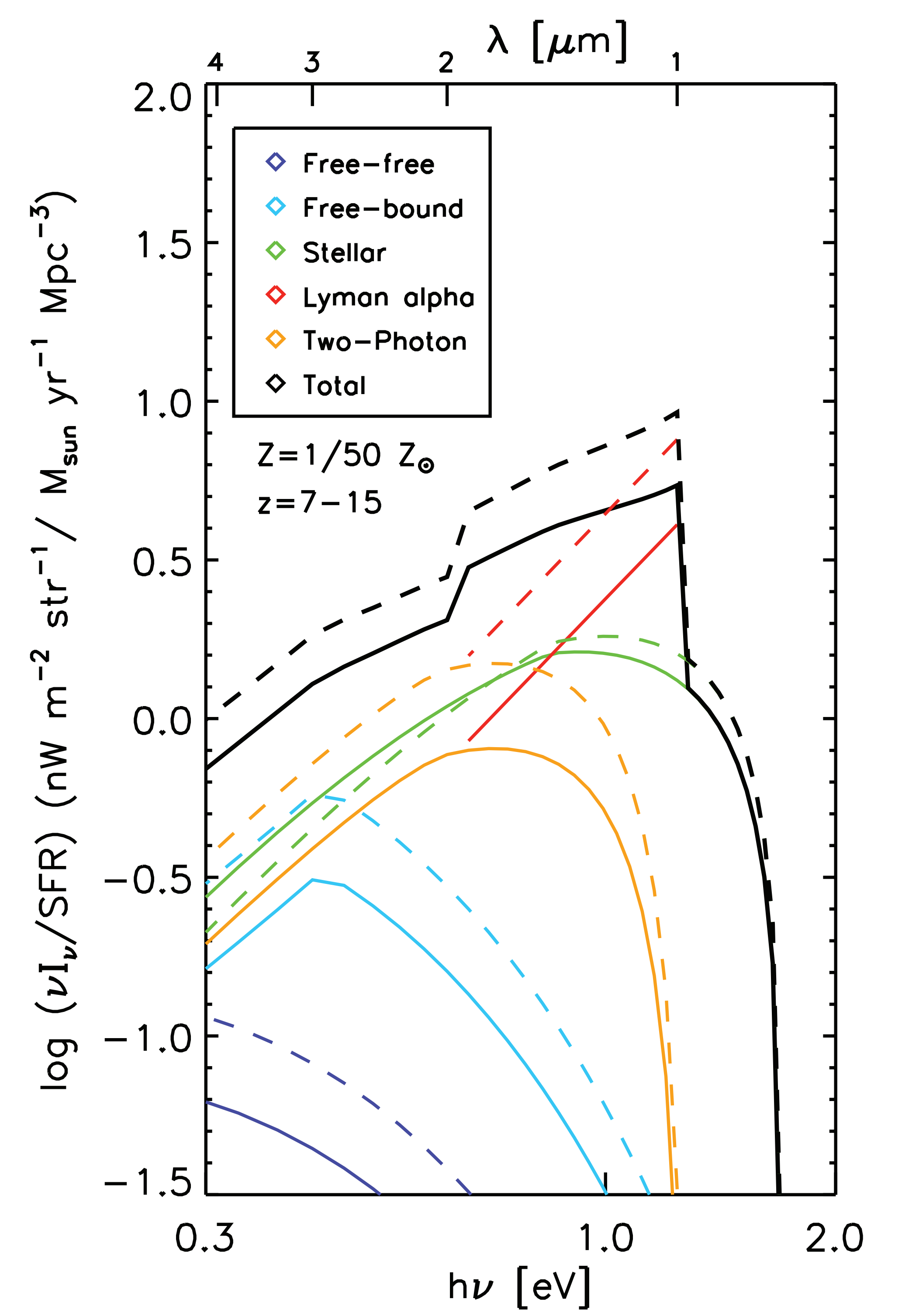
AKARI



Matsumoto +'11

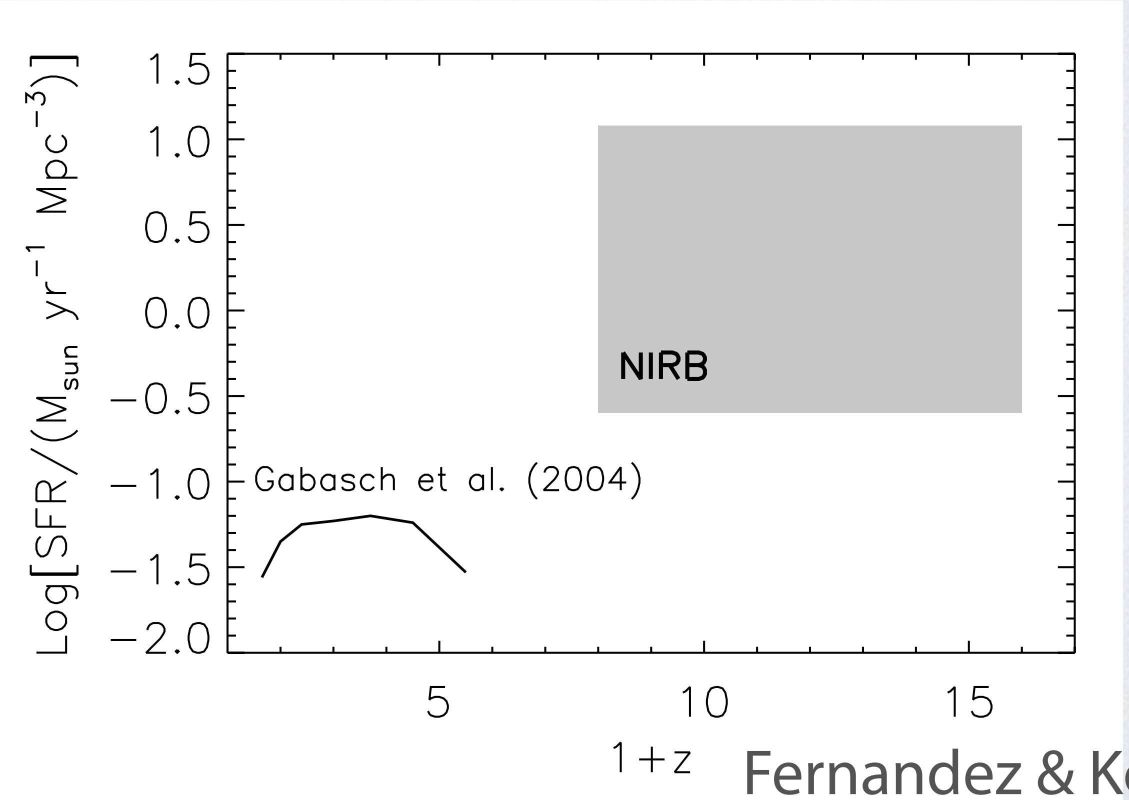
- A component other than galaxies should significantly contribute to the NIR EBL.

First stars ?



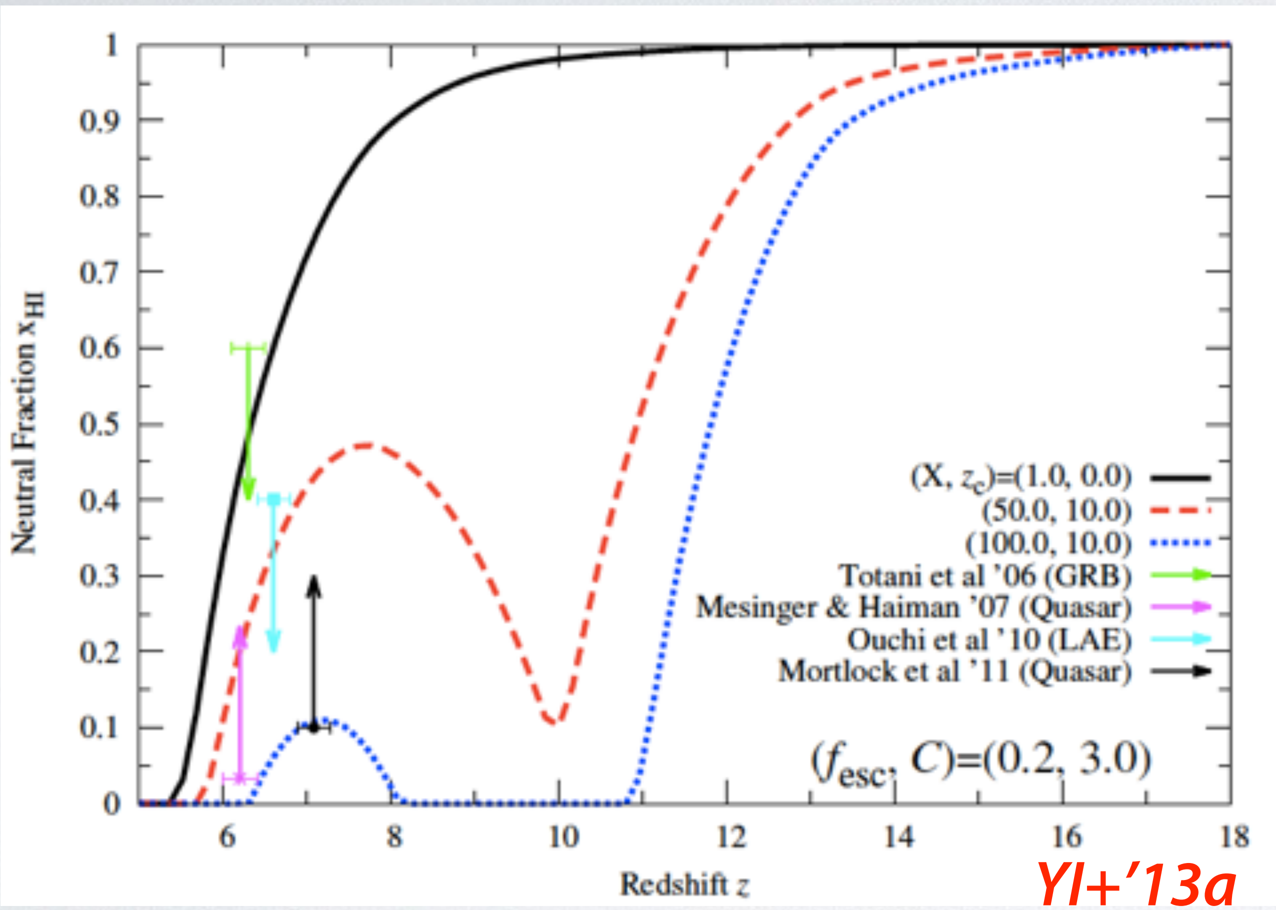
Fernandez & Komatsu '06

- Lyman alpha photons from z~10 will redshifted to ~1 um at z=0.
- We might see the light for first stars.
- But, we need very high first star formation rate density.

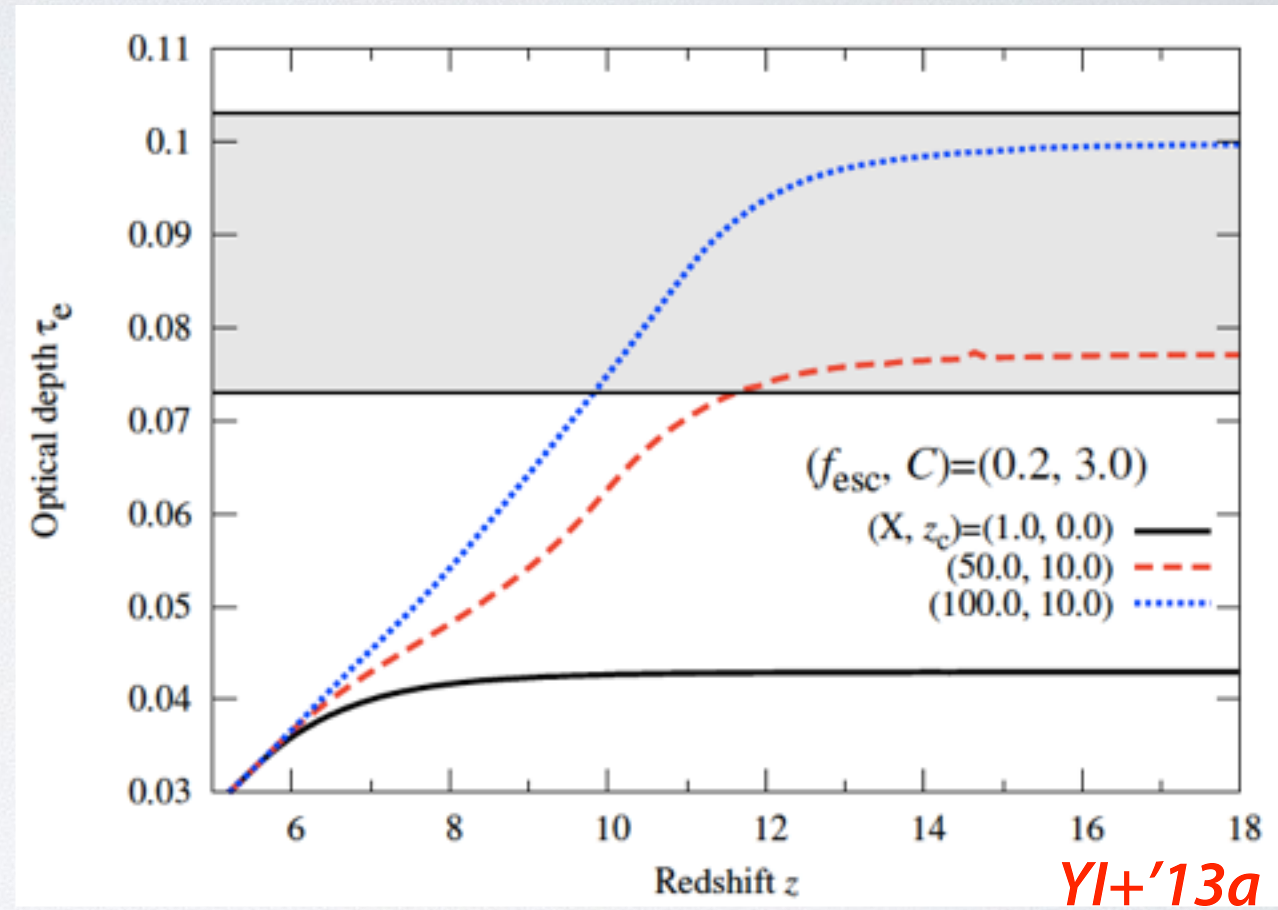


Fernandez & Komatsu '06

Reionization Constraints



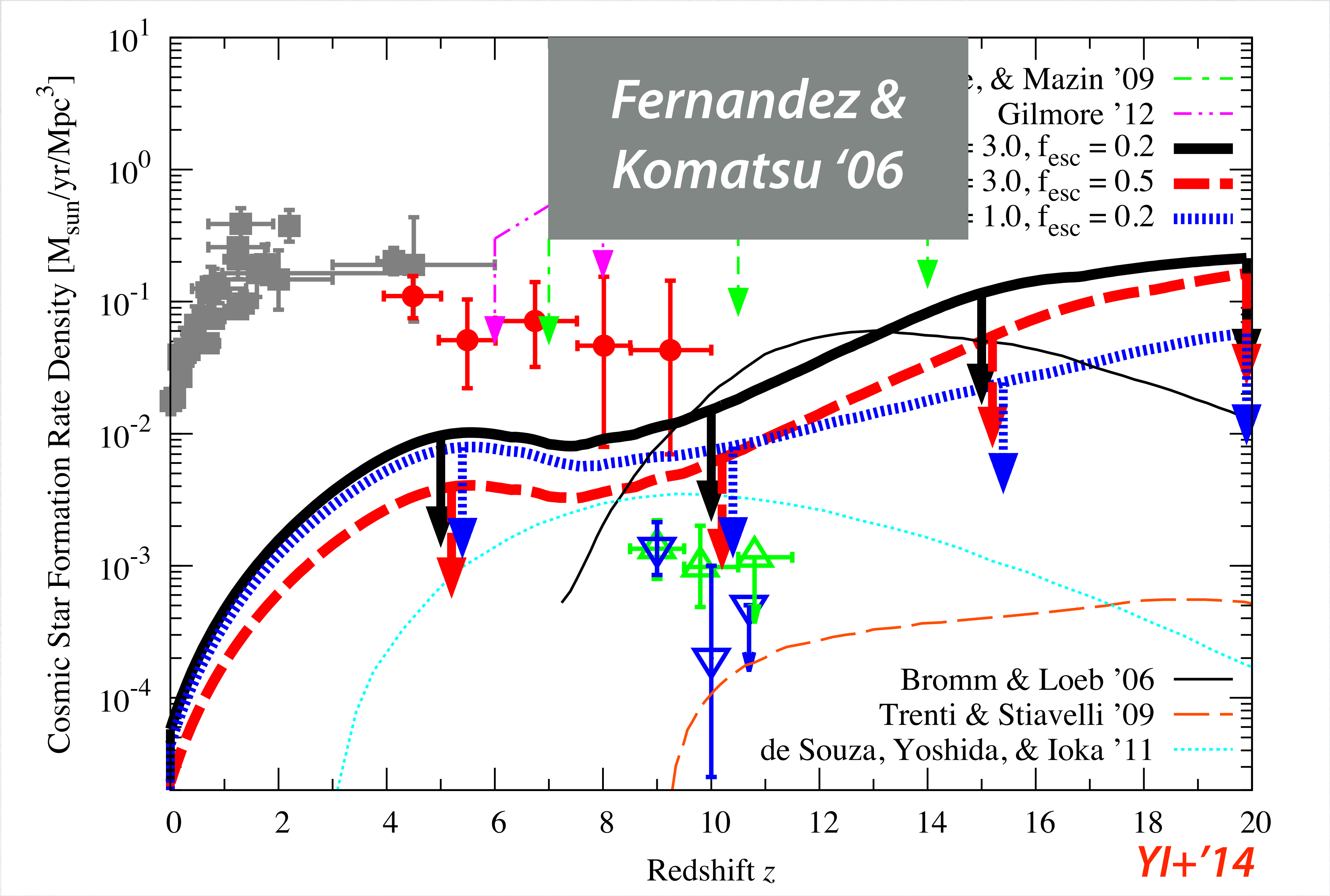
Neutral Hydrogen Fraction



Electron Thomson scattering opacity

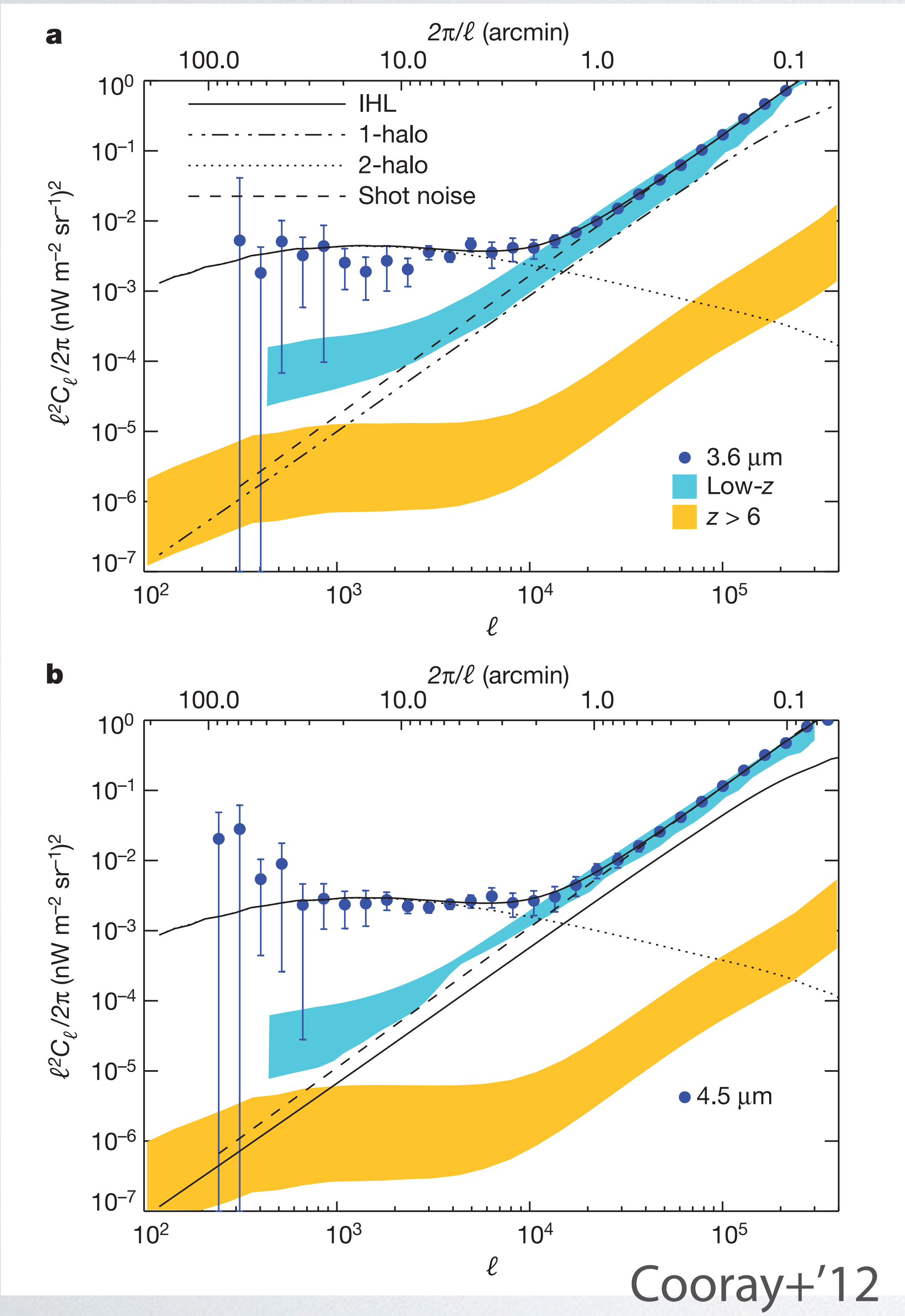
- Ionizing photon emissivity of first stars can not violate these observed reionization data.

Constraints on First Stars

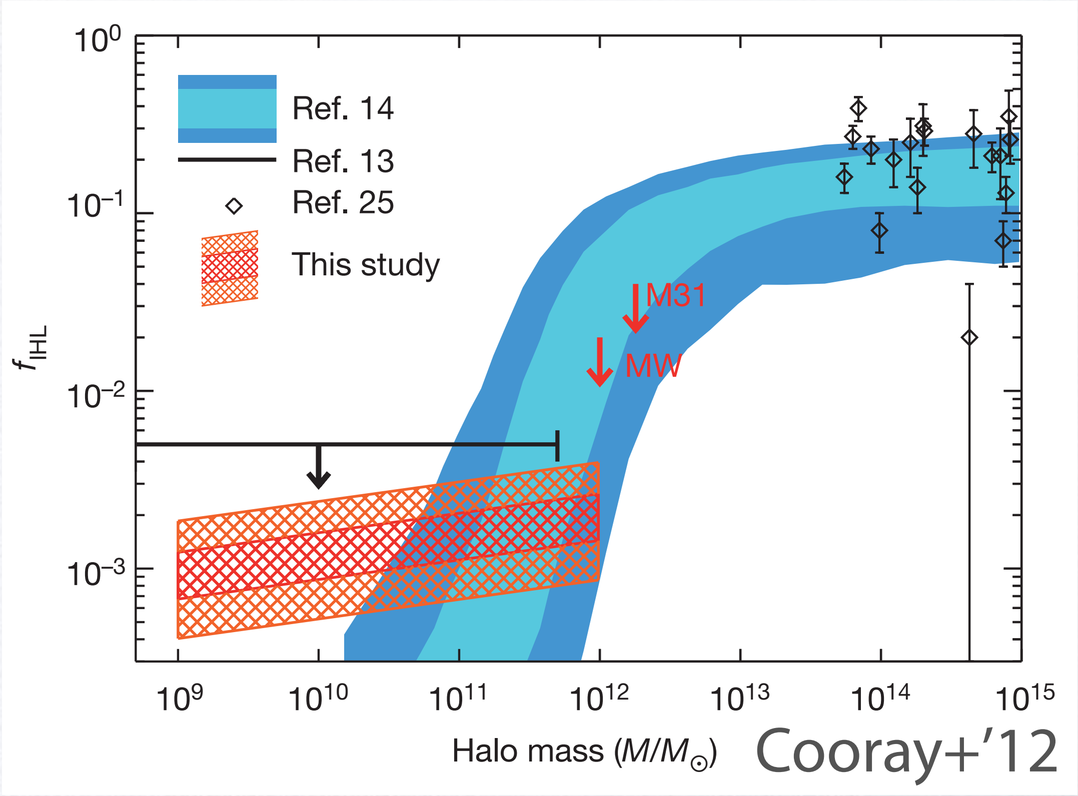


- Combining reionization and distant gamma-ray data (E<100 GeV).
- The required first star formation rate density is inconsistent with reionization data (e.g. Madau & Silk '05; YI+'14)

Intracluster Halo Stars?



- Stars stripped from host galaxies by major mergers.
    - Intrahalo stars may create a fluctuation peak at l~1000.
- Is this population already taken into account in galaxy counts?

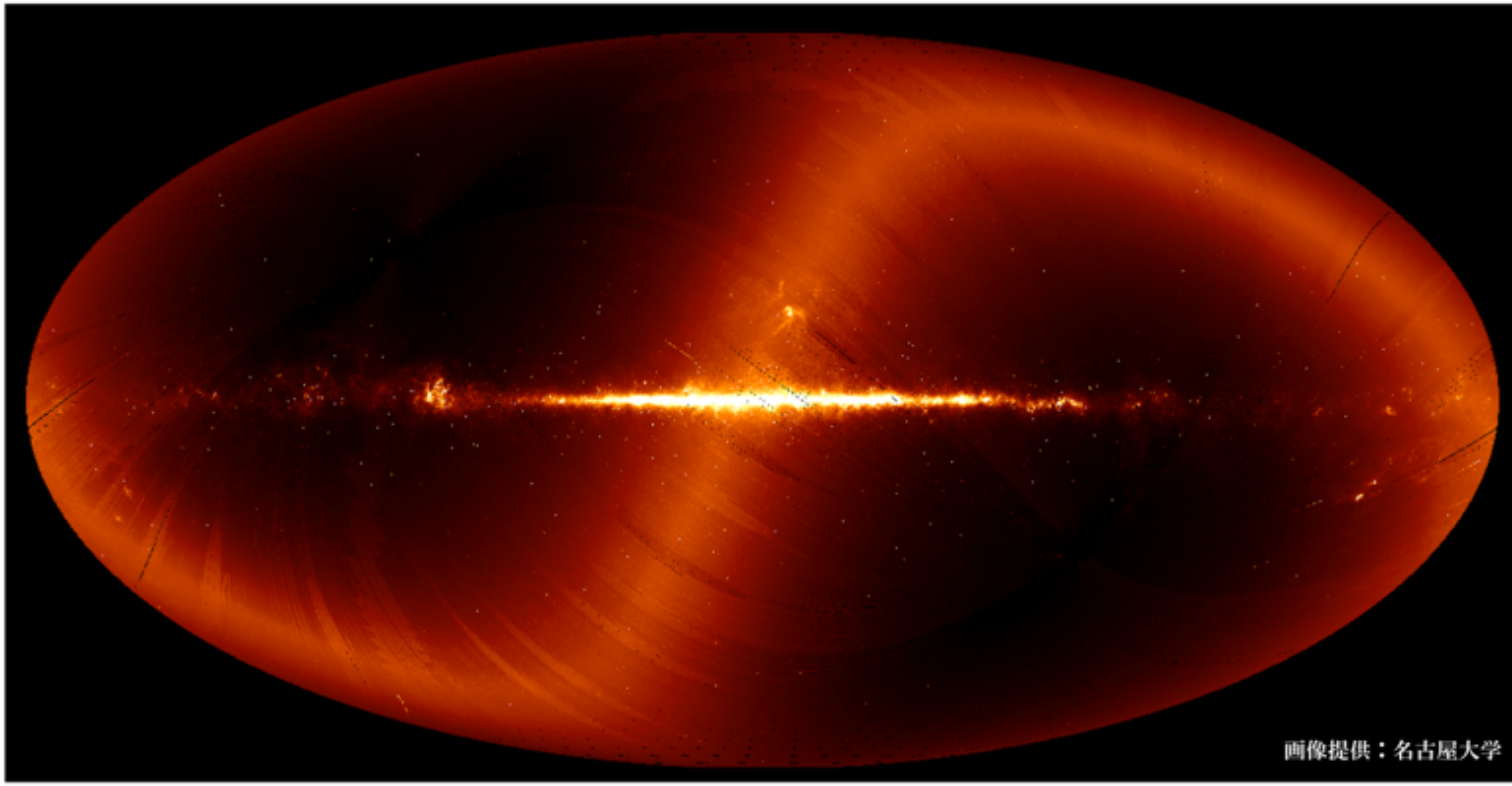


Summary

- Gamma-ray observations constrain EBL with various techniques.
  - But, VHE distant sources show unexpected spectral hardening.
  - It may not be straightforward to constrain EBL further through gamma-ray observations of blazars.
- Direct EBL measurement is hampered by foreground emission (x~100 times higher flux).
  - Another component appears in angular power spectrum.

宇宙近赤外背景放射の観測と理論

Top　Program　Participants　Info　Photo



Date

2014年10月6日-8日

Location

About This Workshop

宇宙背景放射の研究は宇宙の構造形成史を理解する上では欠かせない。中でも、近赤外背景放射は銀河形成にともなう放射の集積と考えられていたが、IRTS や AKARI により銀河だけでは説明できない成分がスペクトルや揺らぎに観測されている。一方で、近年のフェルミガ

ww.astro.isas.jaxa.jp/~yinoue/CIB_ws/program.html