Excess in Extragalactic Near-infrared Background?

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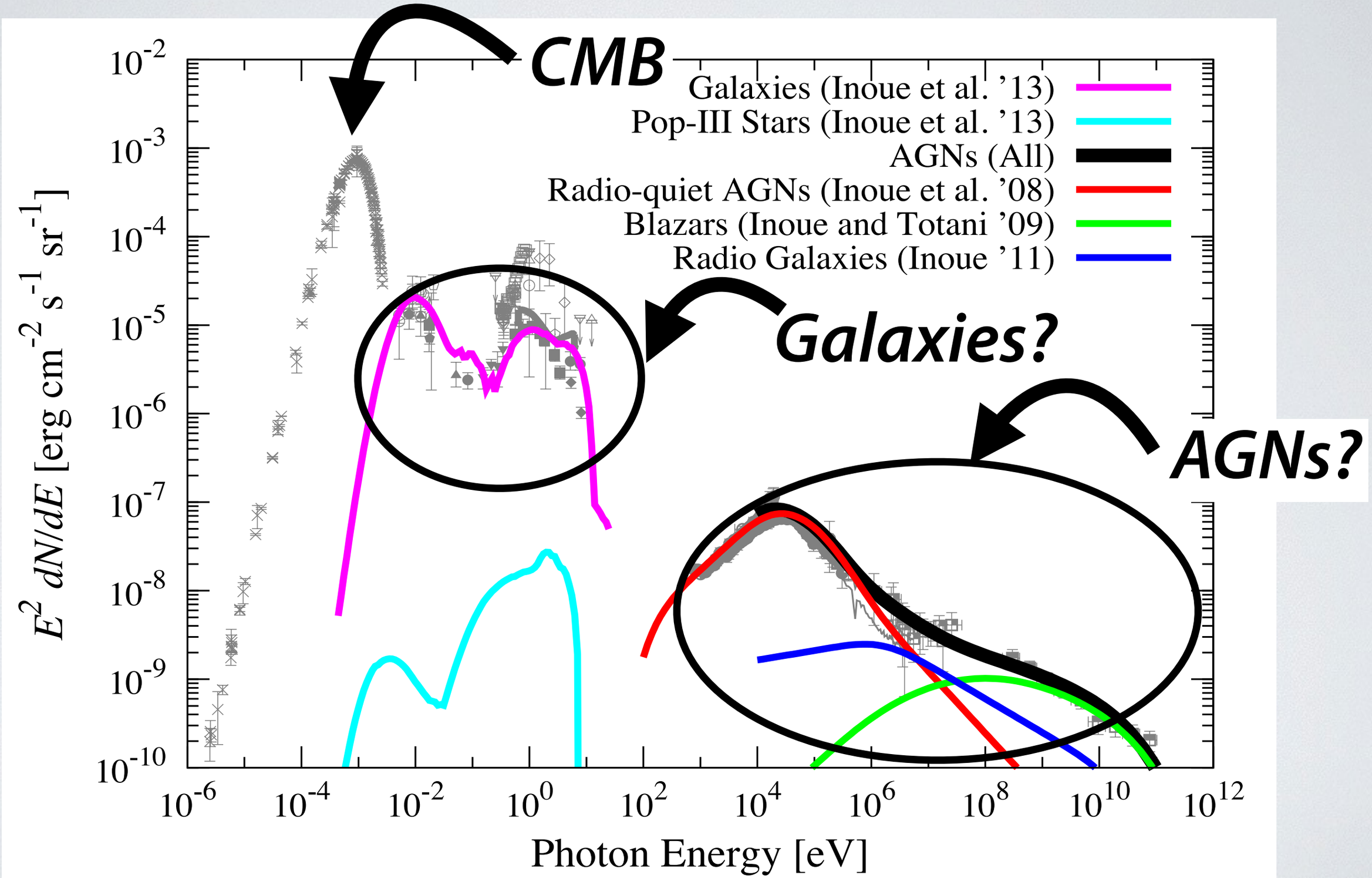
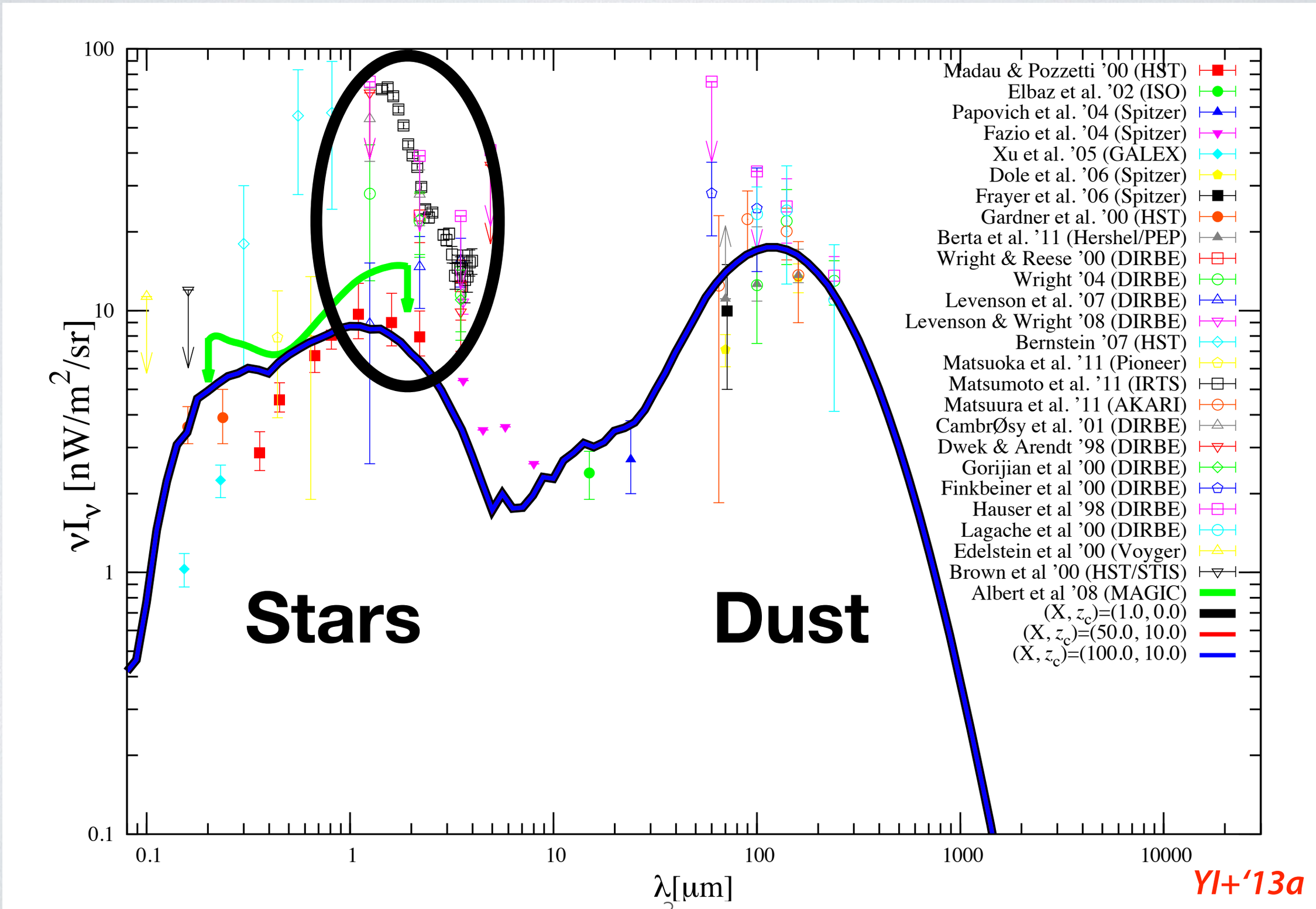
Cosmic Background Radiation

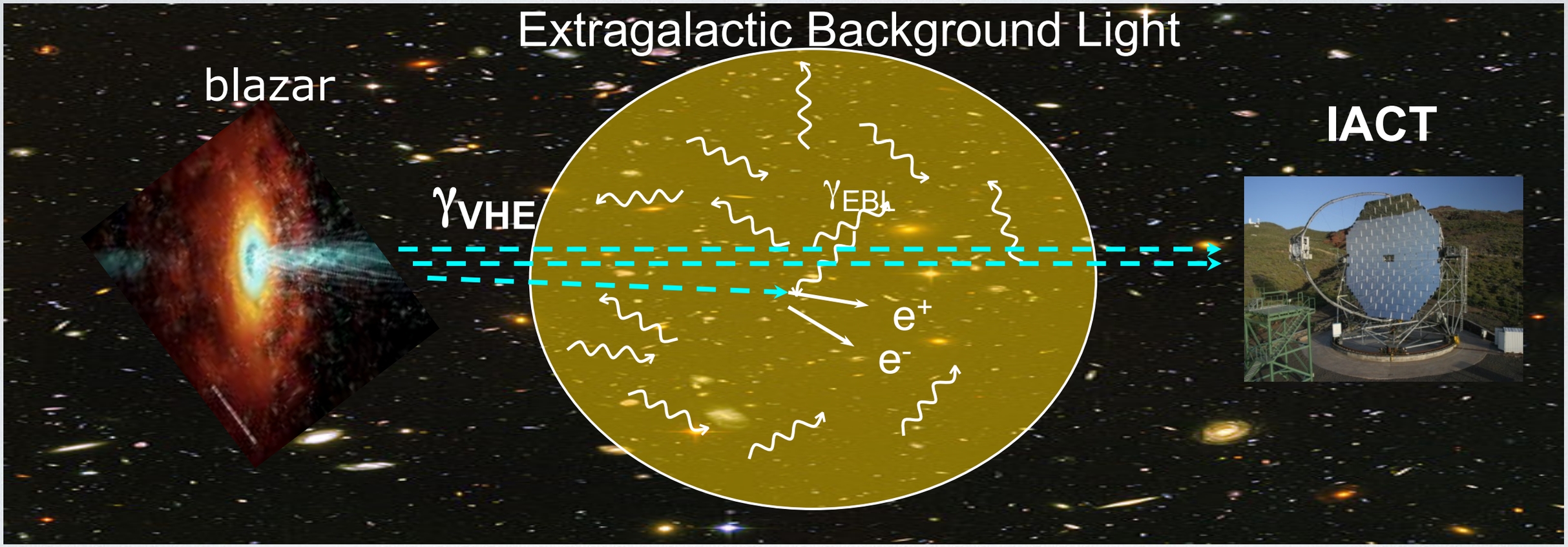


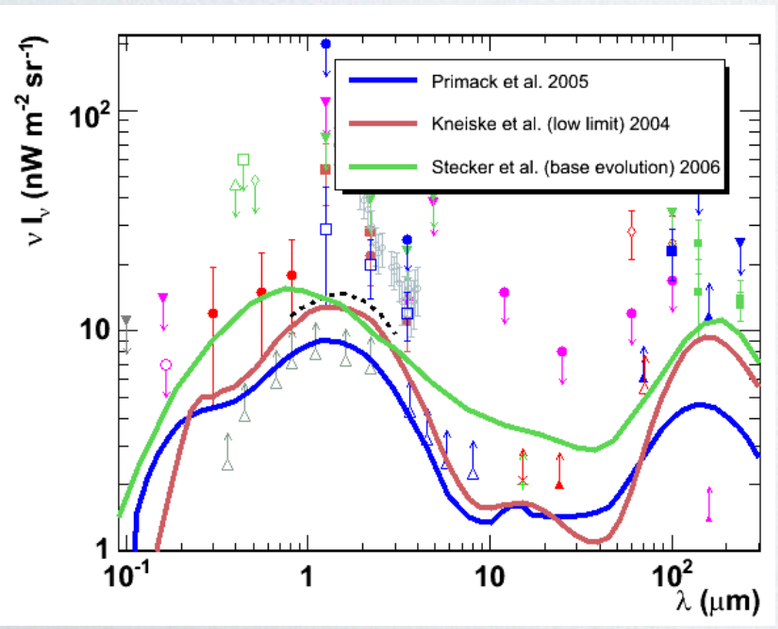
Extragalactic Background Light (EBL)

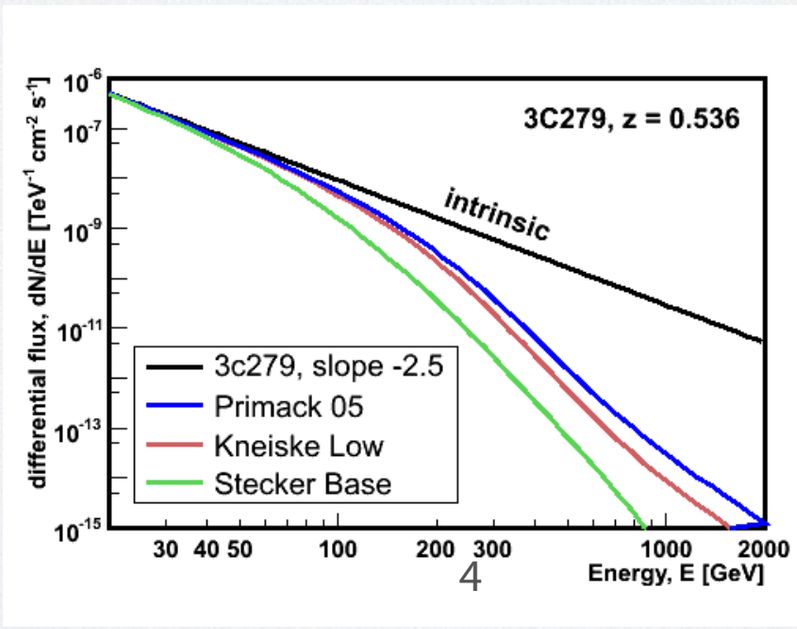


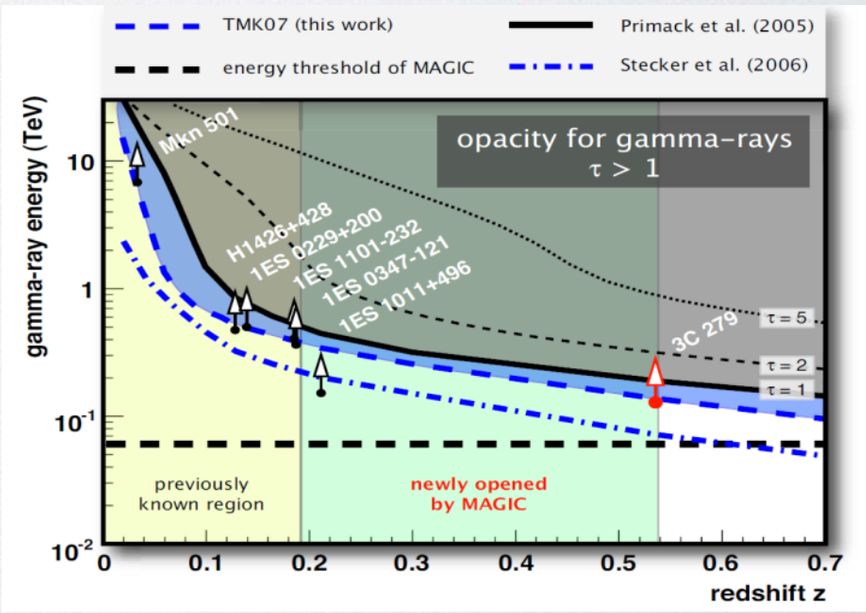
YI+'13a

Gamma rays are attenuated by EBL

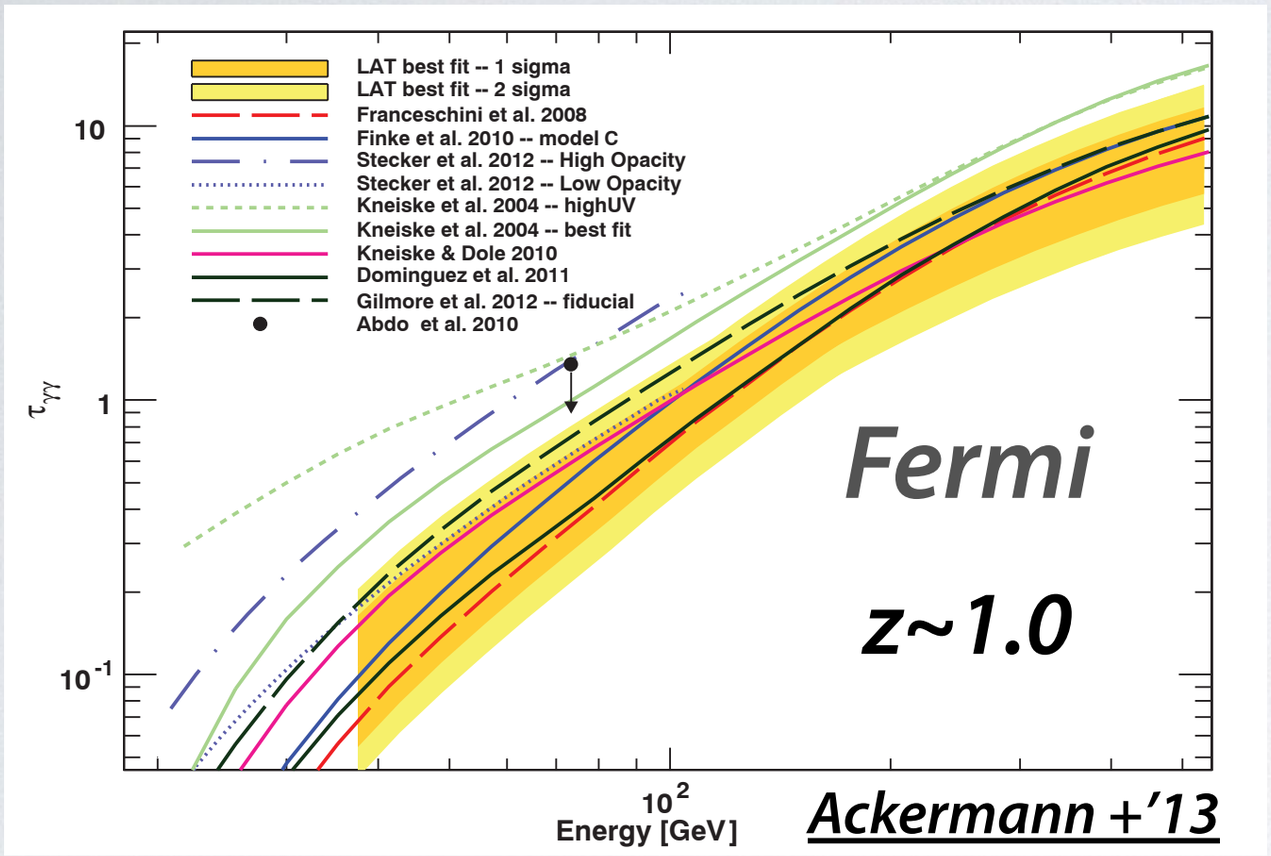




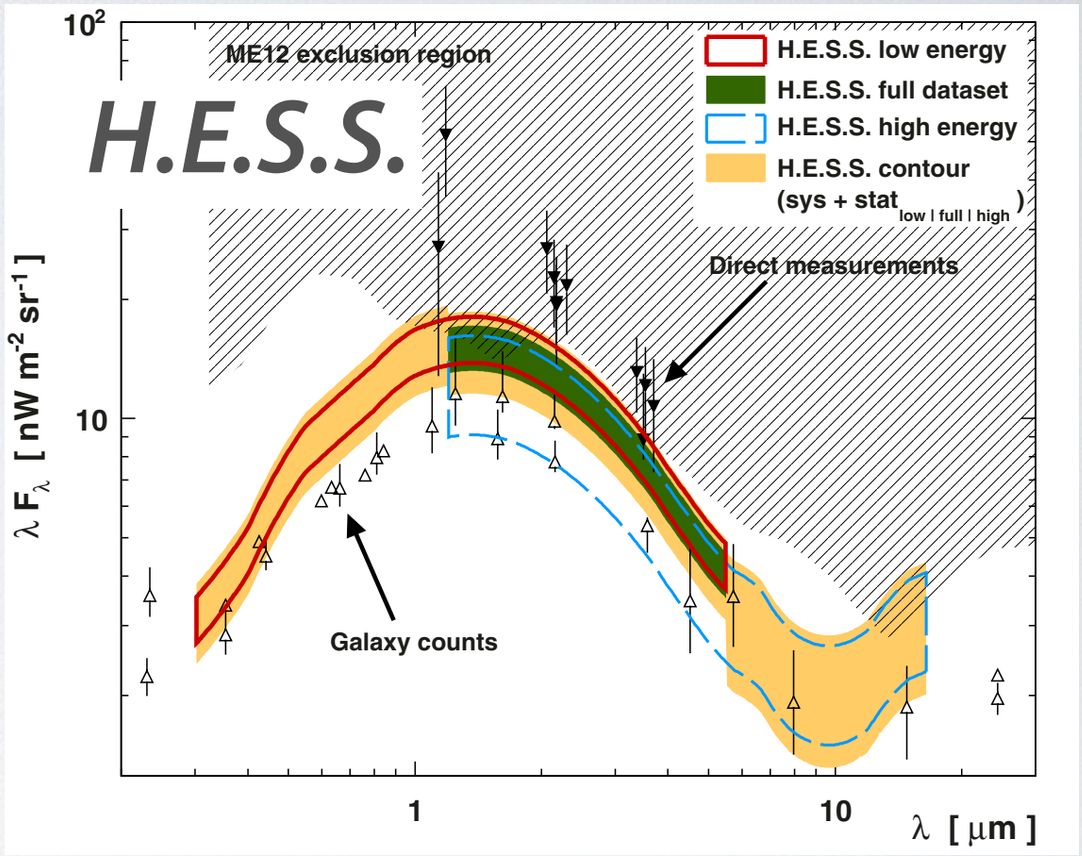




EBL Constraints from Gamma Rays



Ackermann +'13

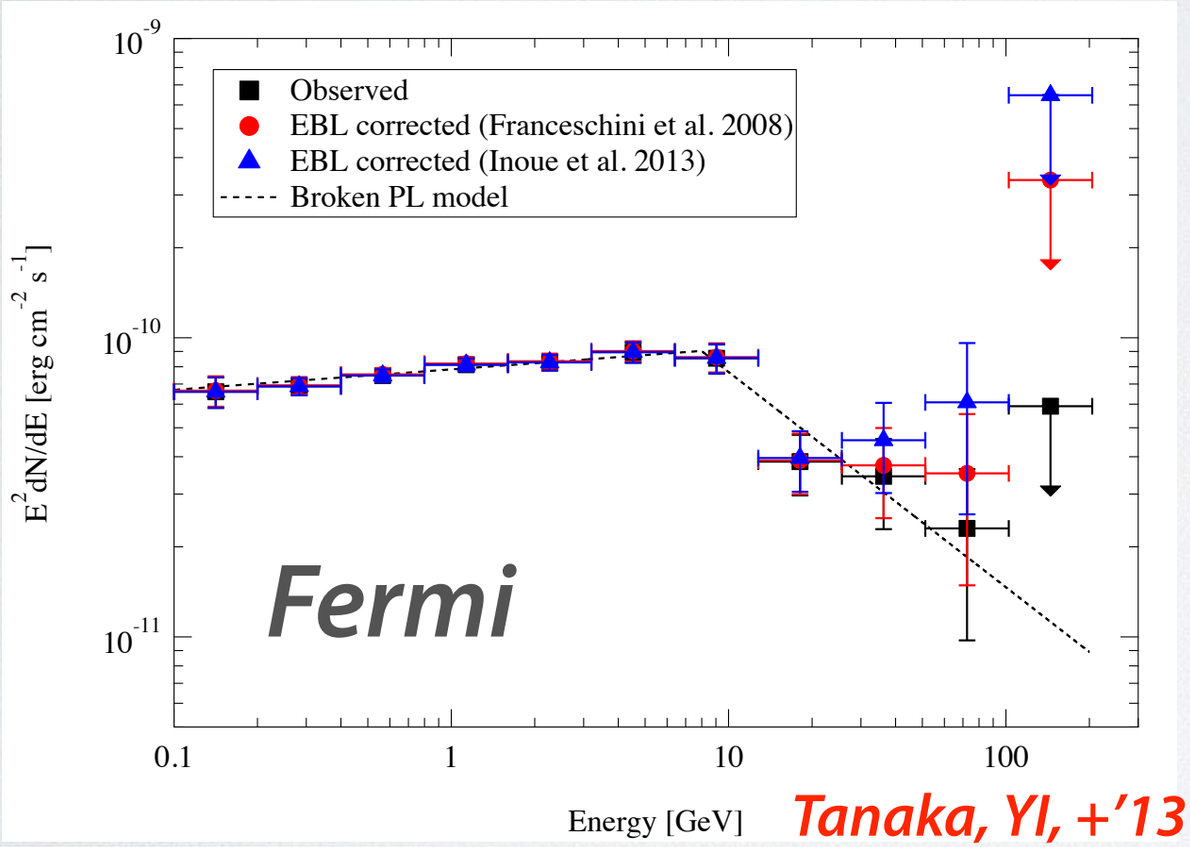


Abramowski +'13

- 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).
  - assuming simple log-parabola or power-law spectra.
- See Dominguez's talk.

>100 GeV Gamma Rays from z=1.1

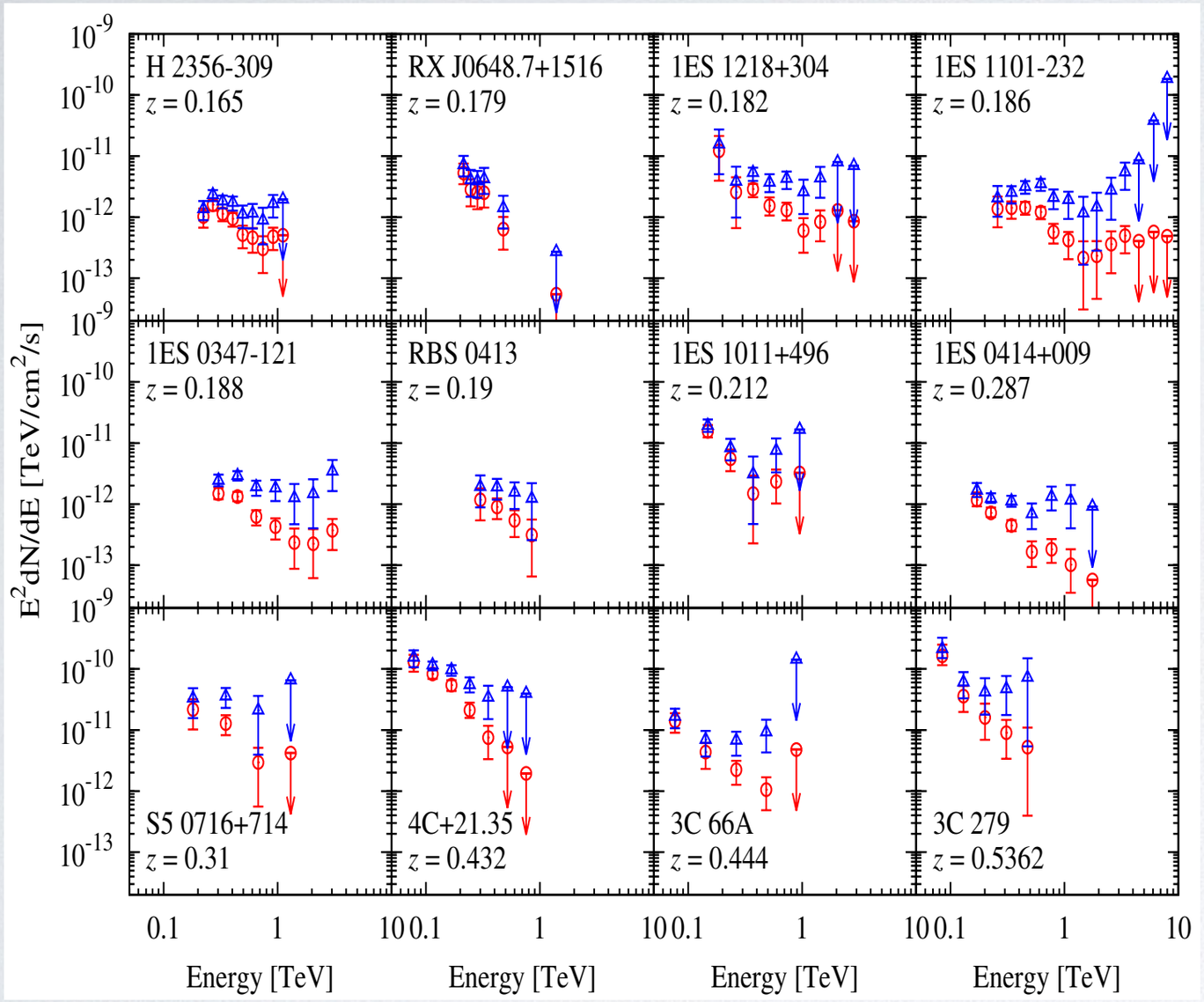
PKS 0426-380 at z=1.1



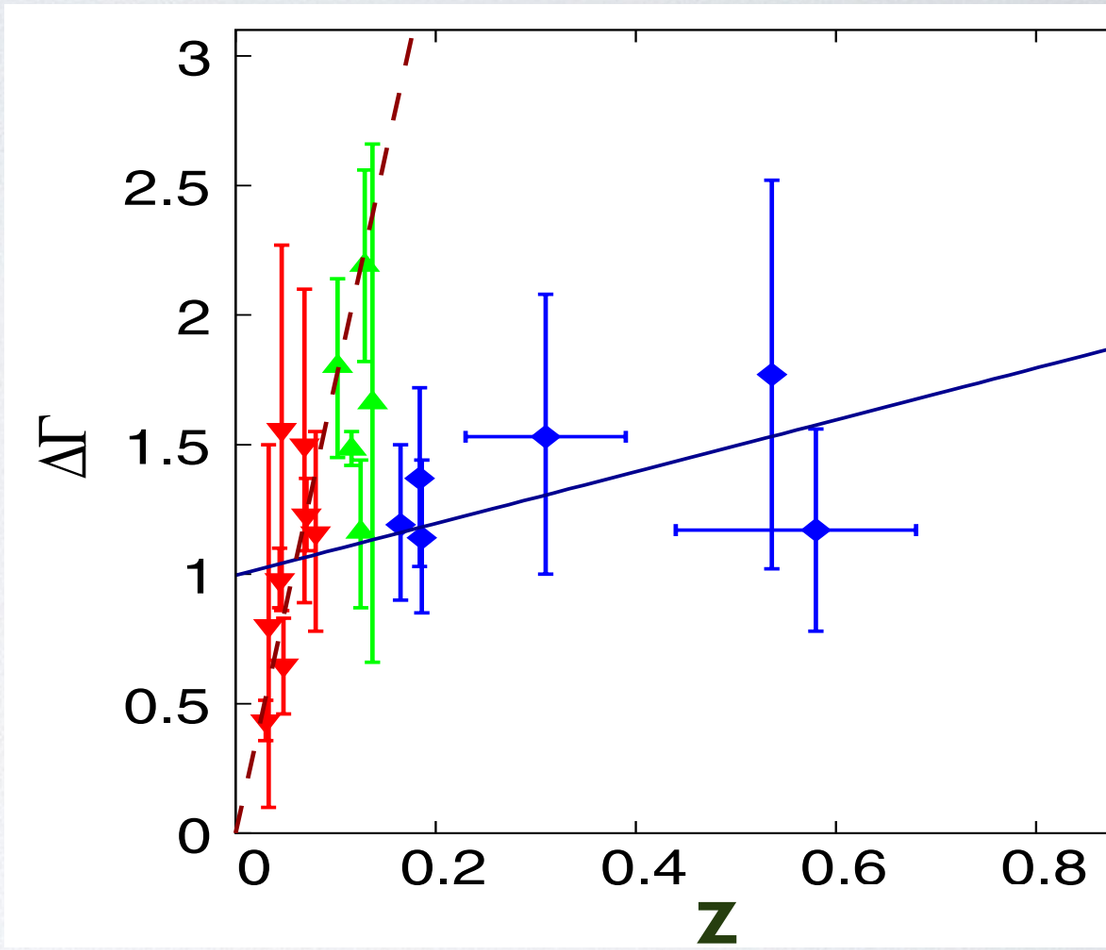
Tanaka, YI, +'13

- Distant very high energy (VHE) sources show spectral hardening and do **not** show short time variabilities.

Is VHE Spectral Hardening Universal?



YI+'13a



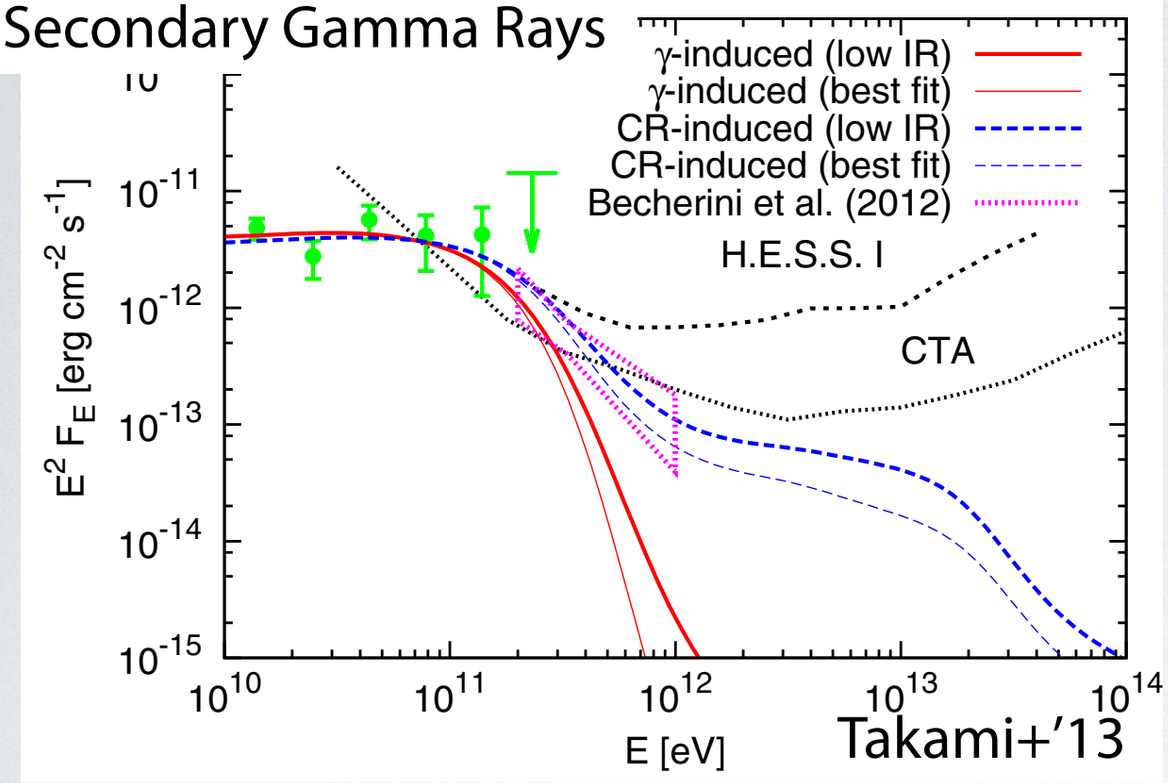
Essey & Kusenko '12

- Spectra of blazars at z > 0.15 show hardening from a few hundred GeV (Finke+'10, YI+'13, Essey & Kusenko '12).

Secondary Gamma Rays? Stochastic Acceleration?

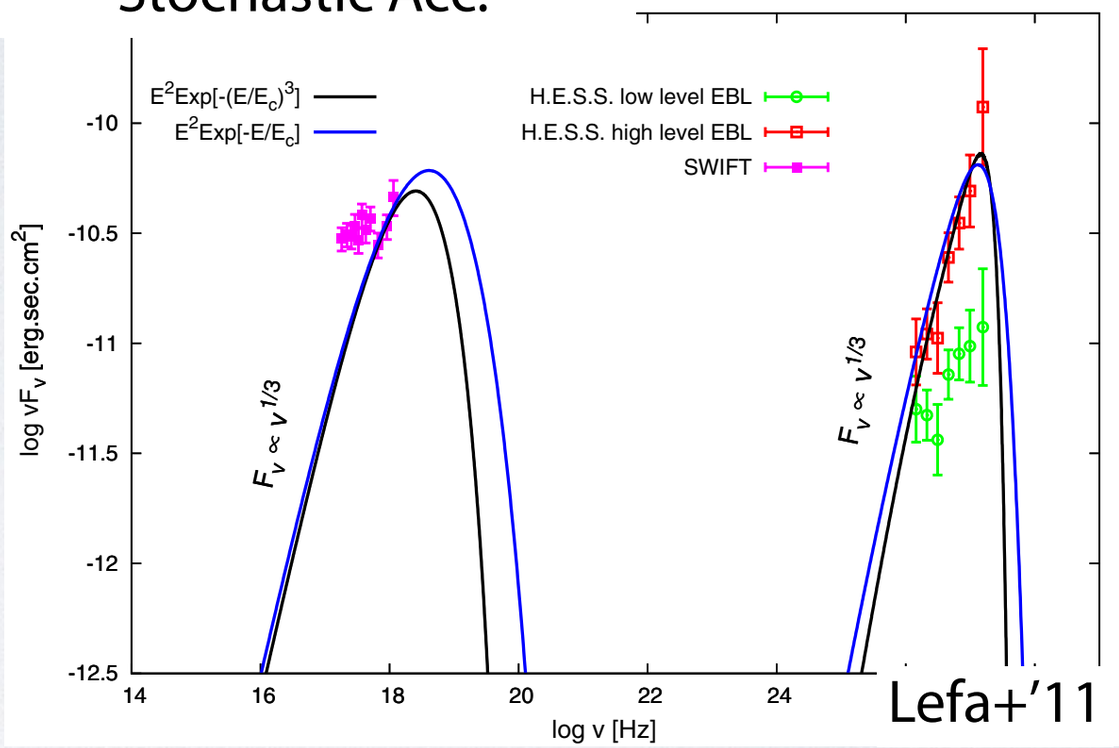
KUV 00311-1938 (z=0.61)

Secondary Gamma Rays



1ES 0229+200 (z=0.1396)

Stochastic Acc.



- Secondary gamma rays from cosmic rays along line of sight

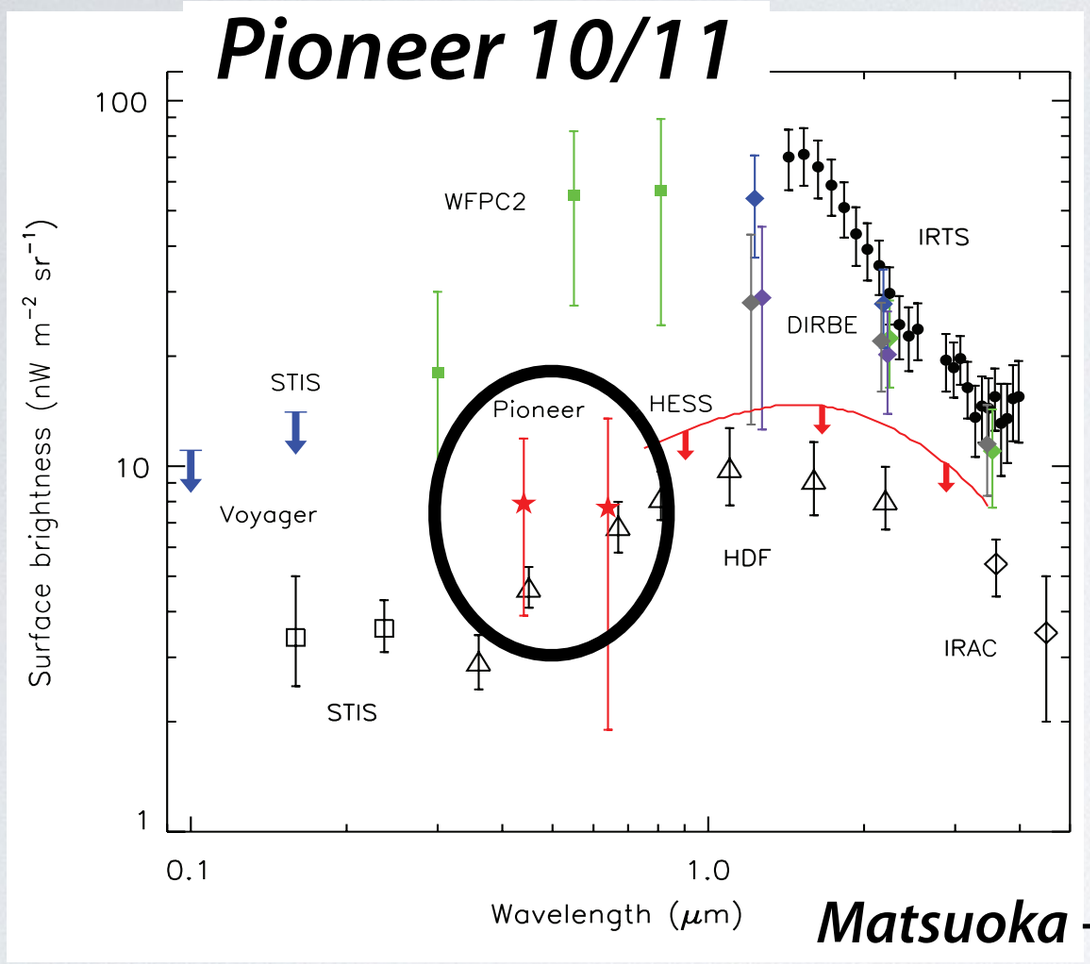
  (Essey & Kusenko '10, Essey+'10, Essey+'11, Murase+'12, Takami+'13).

  - CTA will statistically test this scenario through logN-logS (YI +'14)

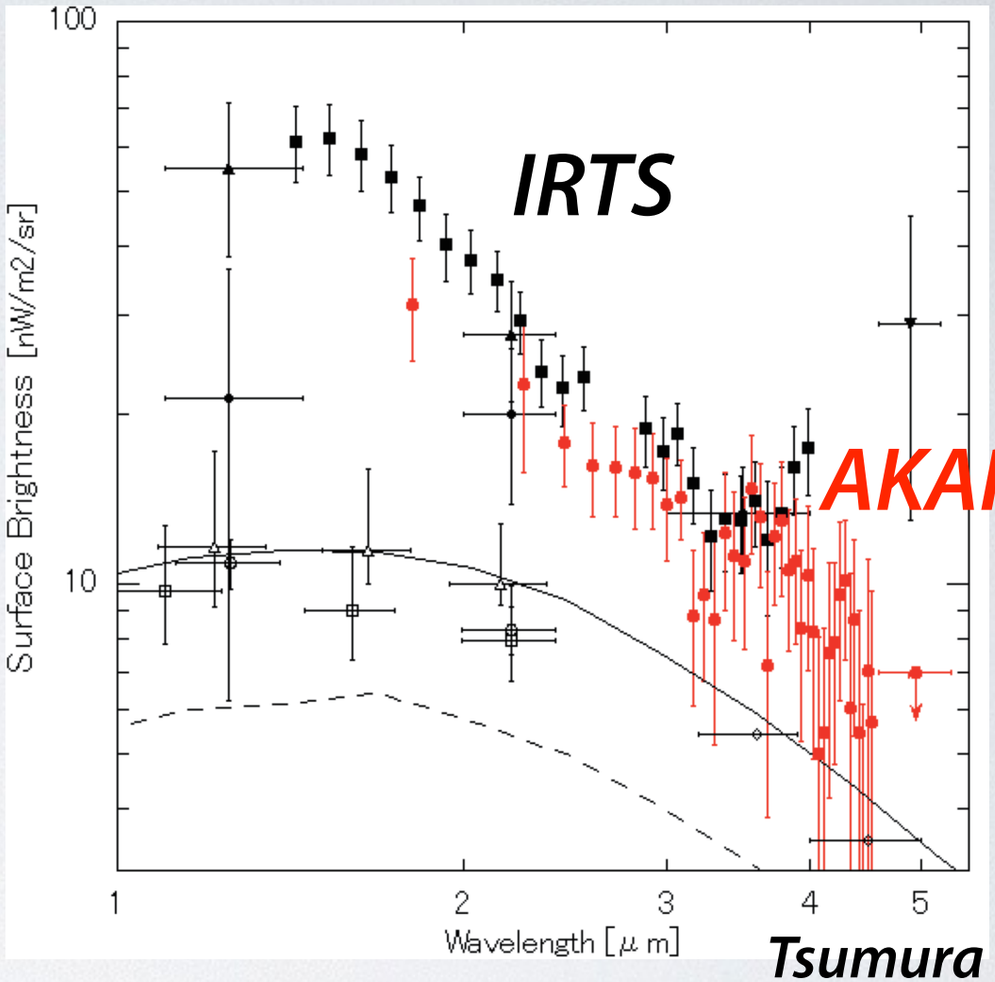
- Stochastic acceleration can generate hard electron spectra

  (Stawarz & Petrosian '08, Lefa+'11).

Direct Measurement of EBL



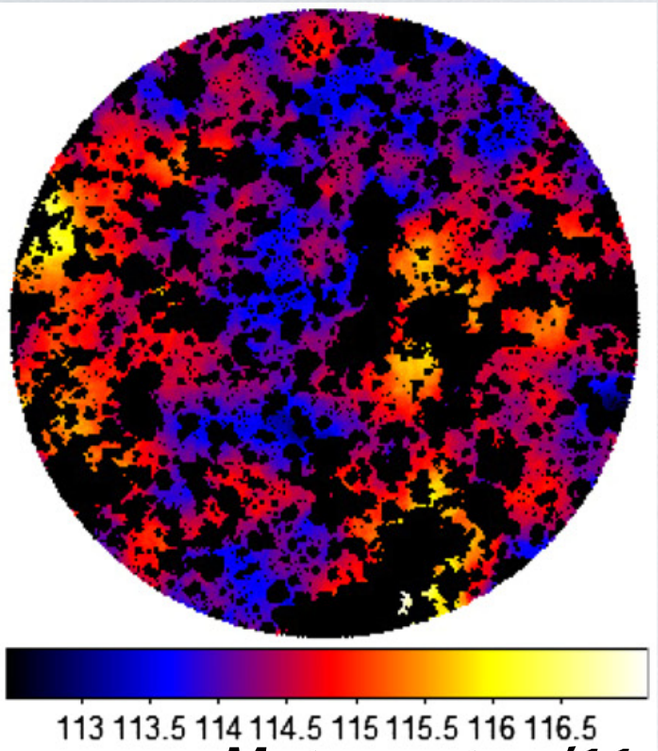
Matsuoka +'11



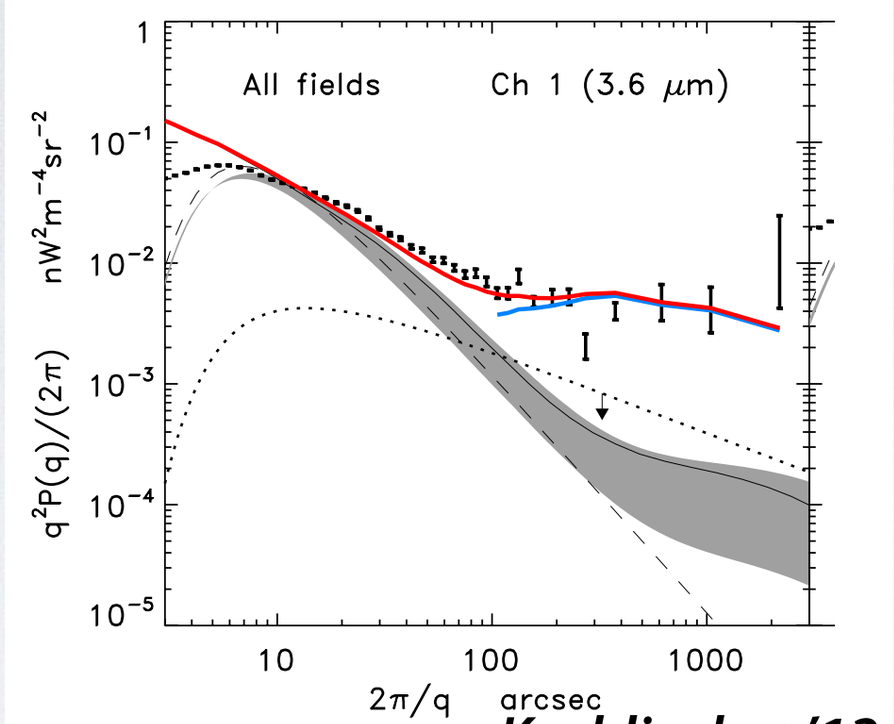
Tsumura +'13

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

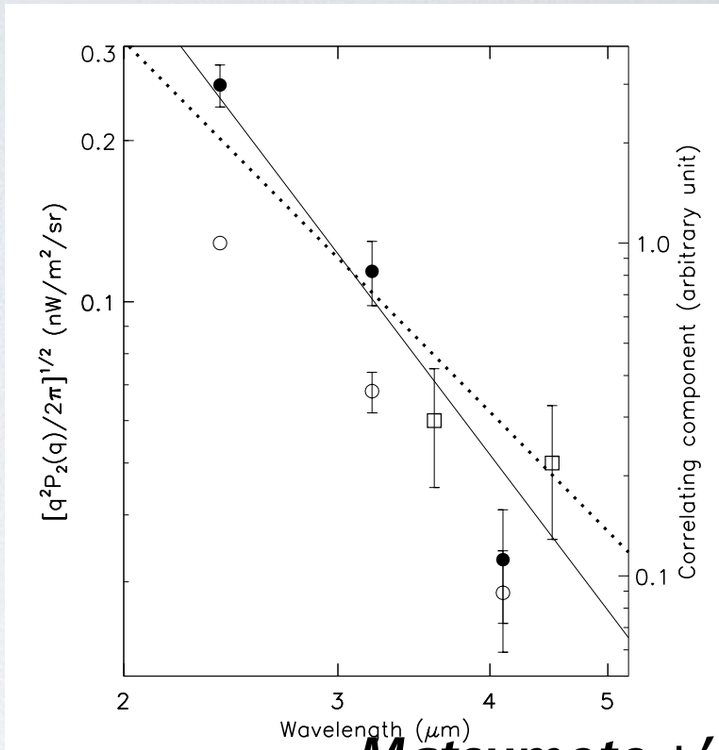
NIR Sky Fluctuation



Matsumoto +'11



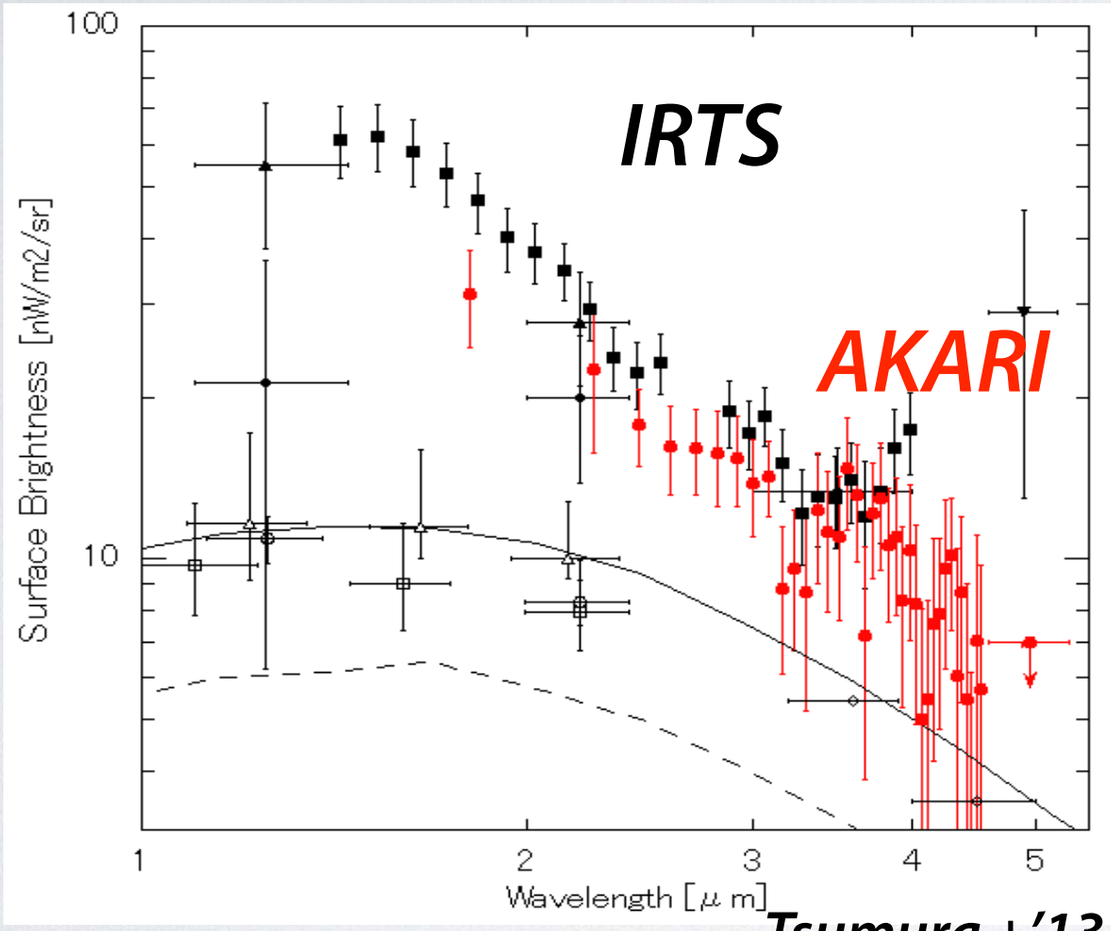
Kashlinsky+'12



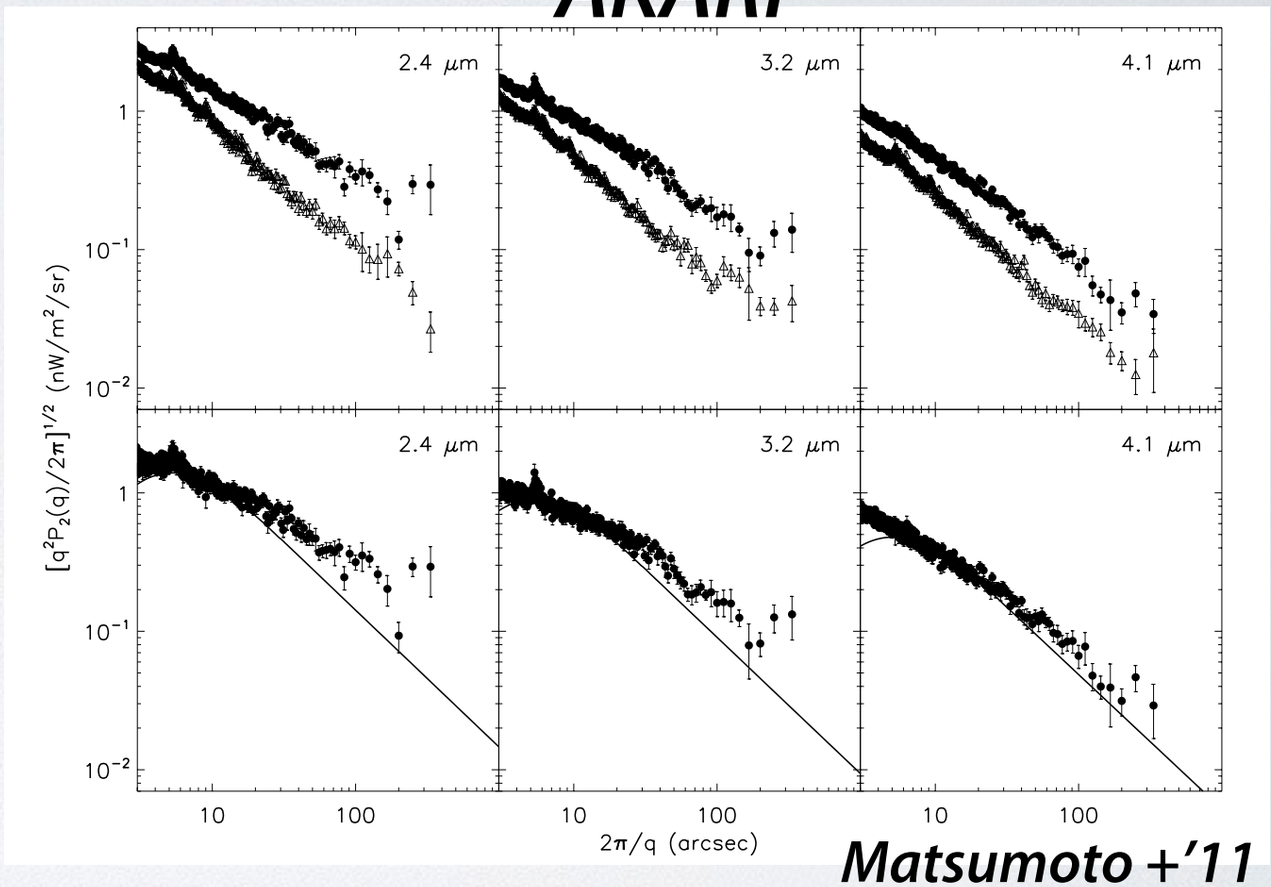
Matsumoto +'11

- 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?



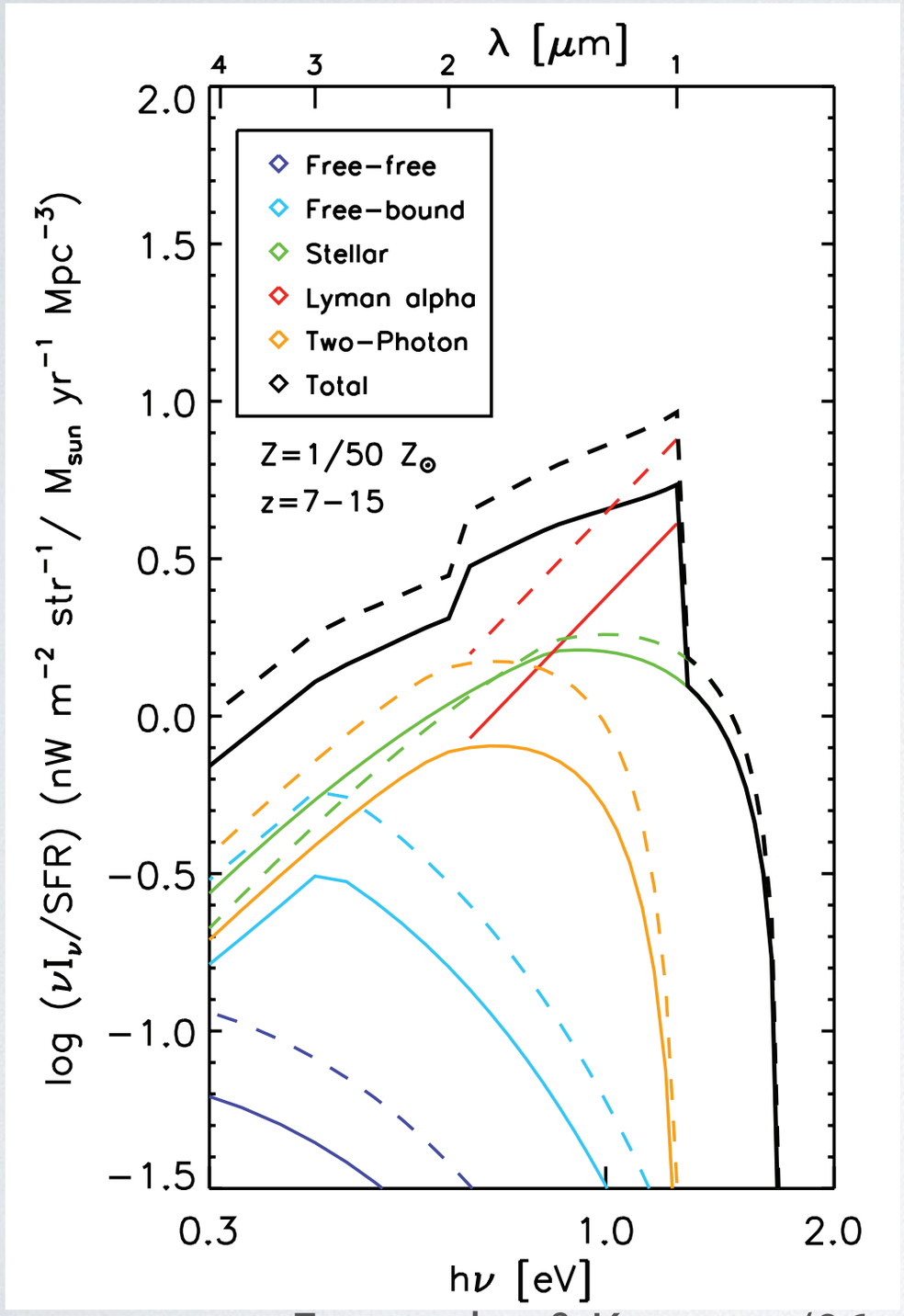
Tsumura +'13



Matsumoto +'11

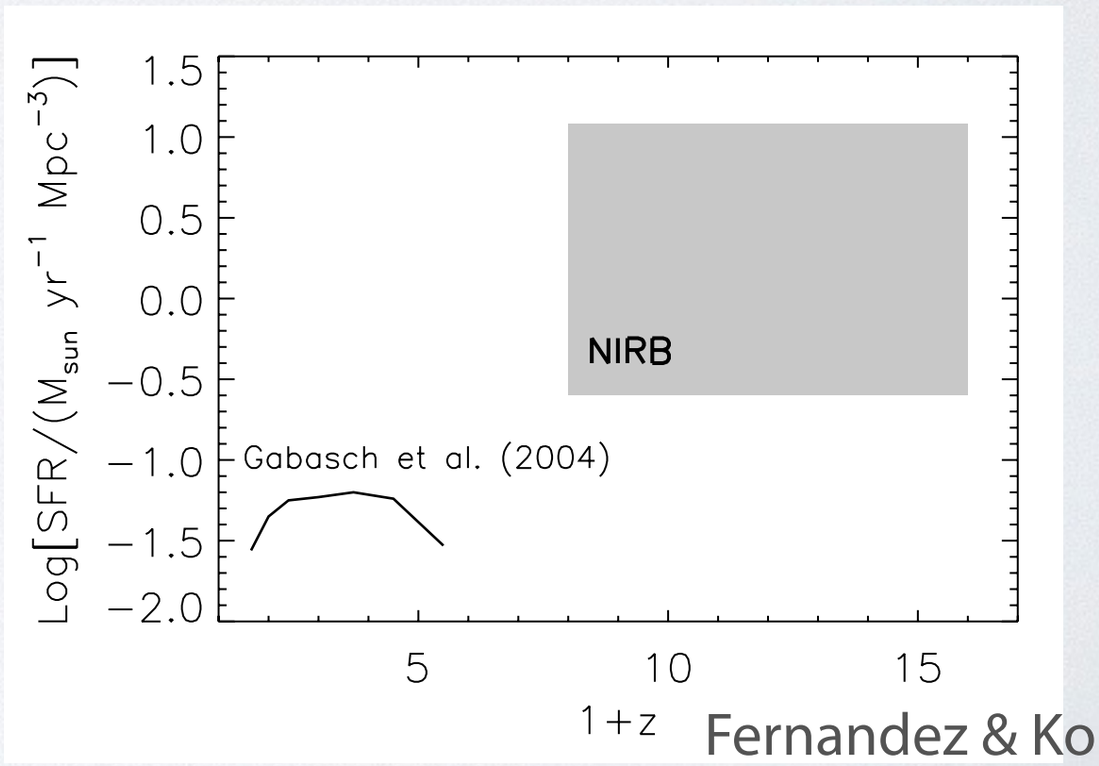
- A component other than galaxies should significantly contribute to the NIR EBL.

First stars ?



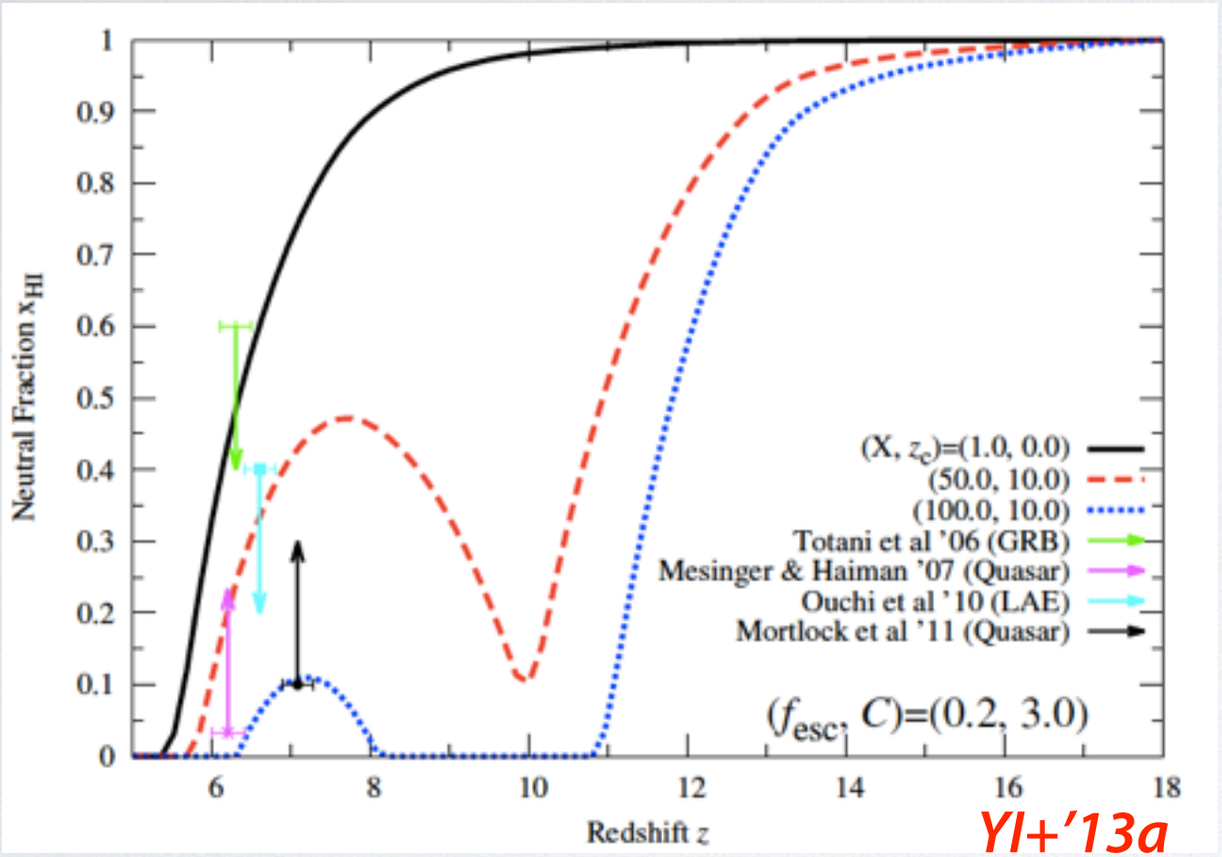
Fernandez & Komatsu '06

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

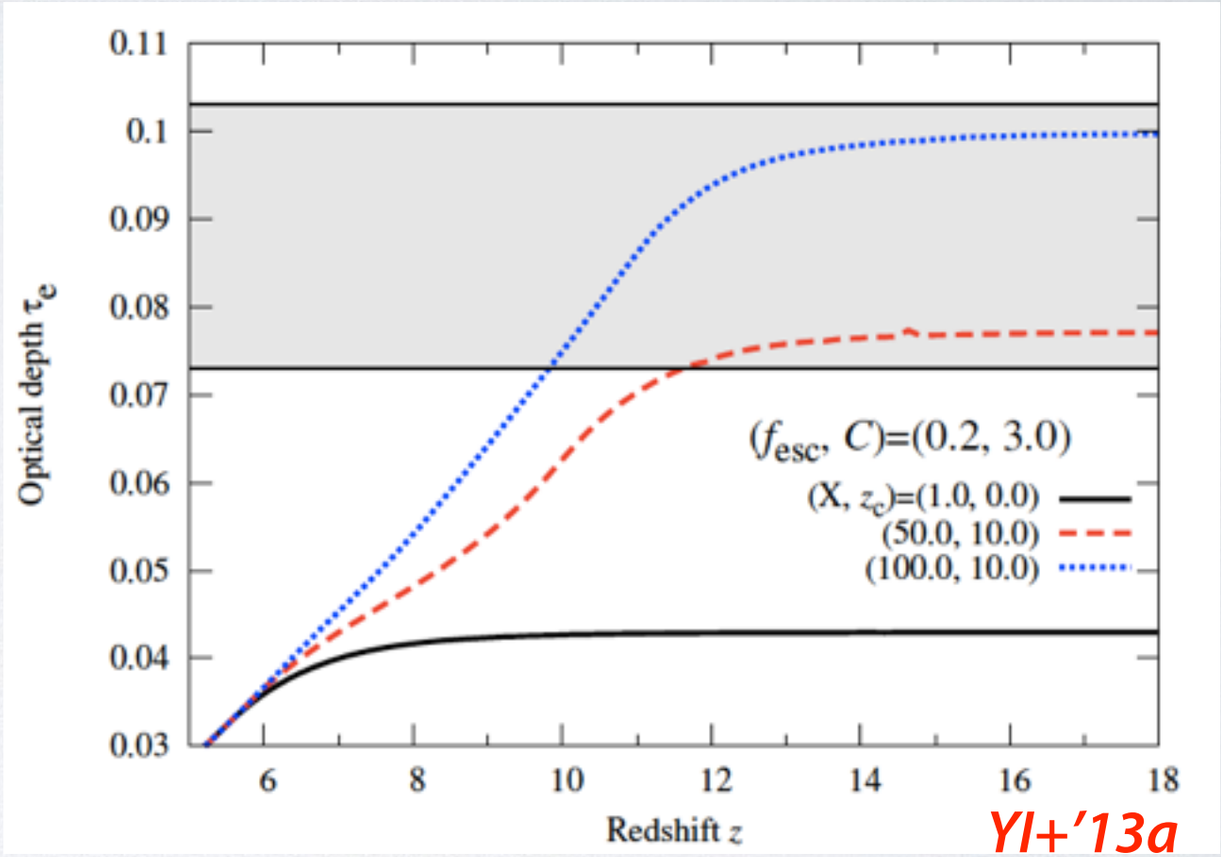


Fernandez & Komatsu '06

Reionization Constraints



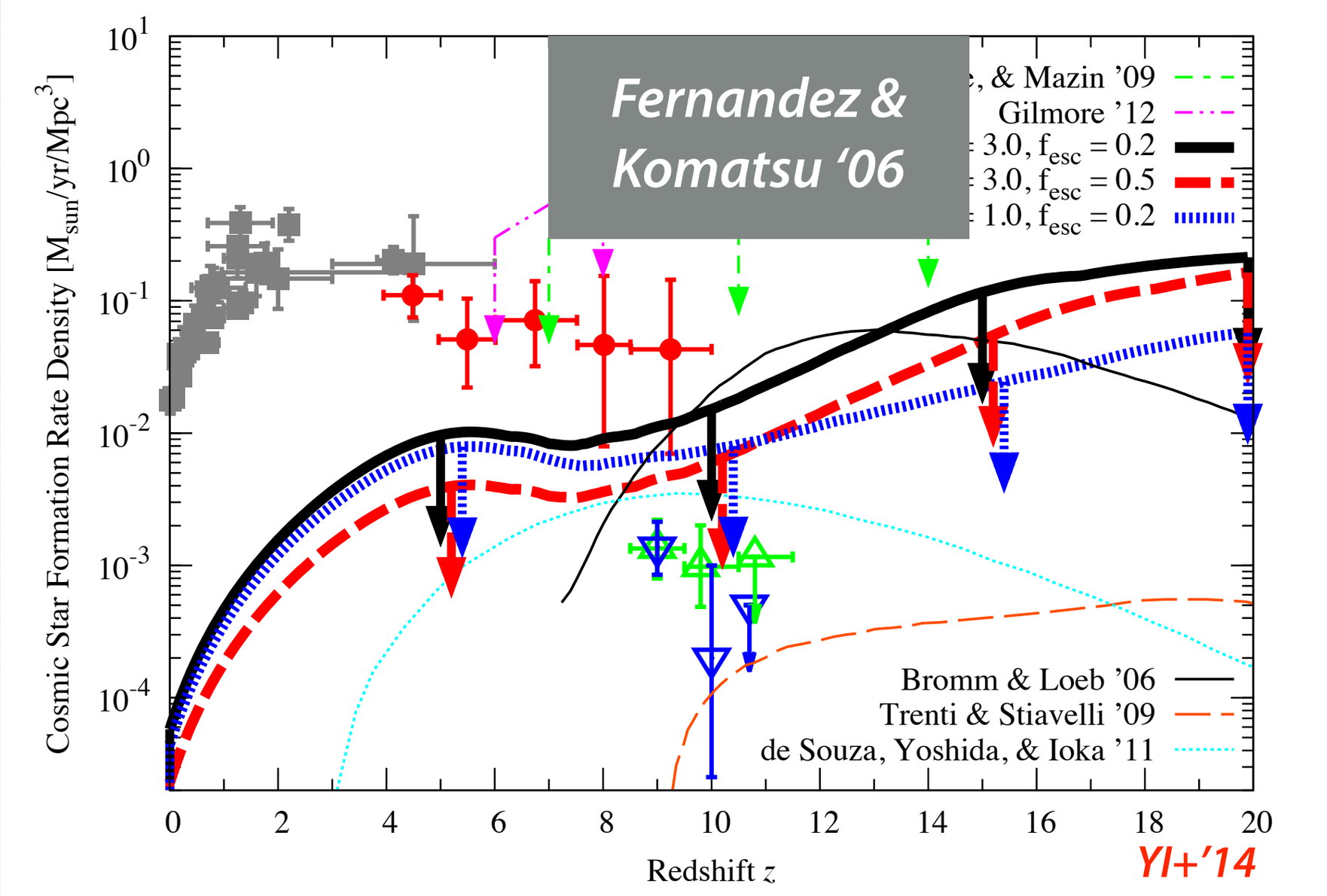
Neutral Hydrogen Fraction



Electron Thomson scattering opacity

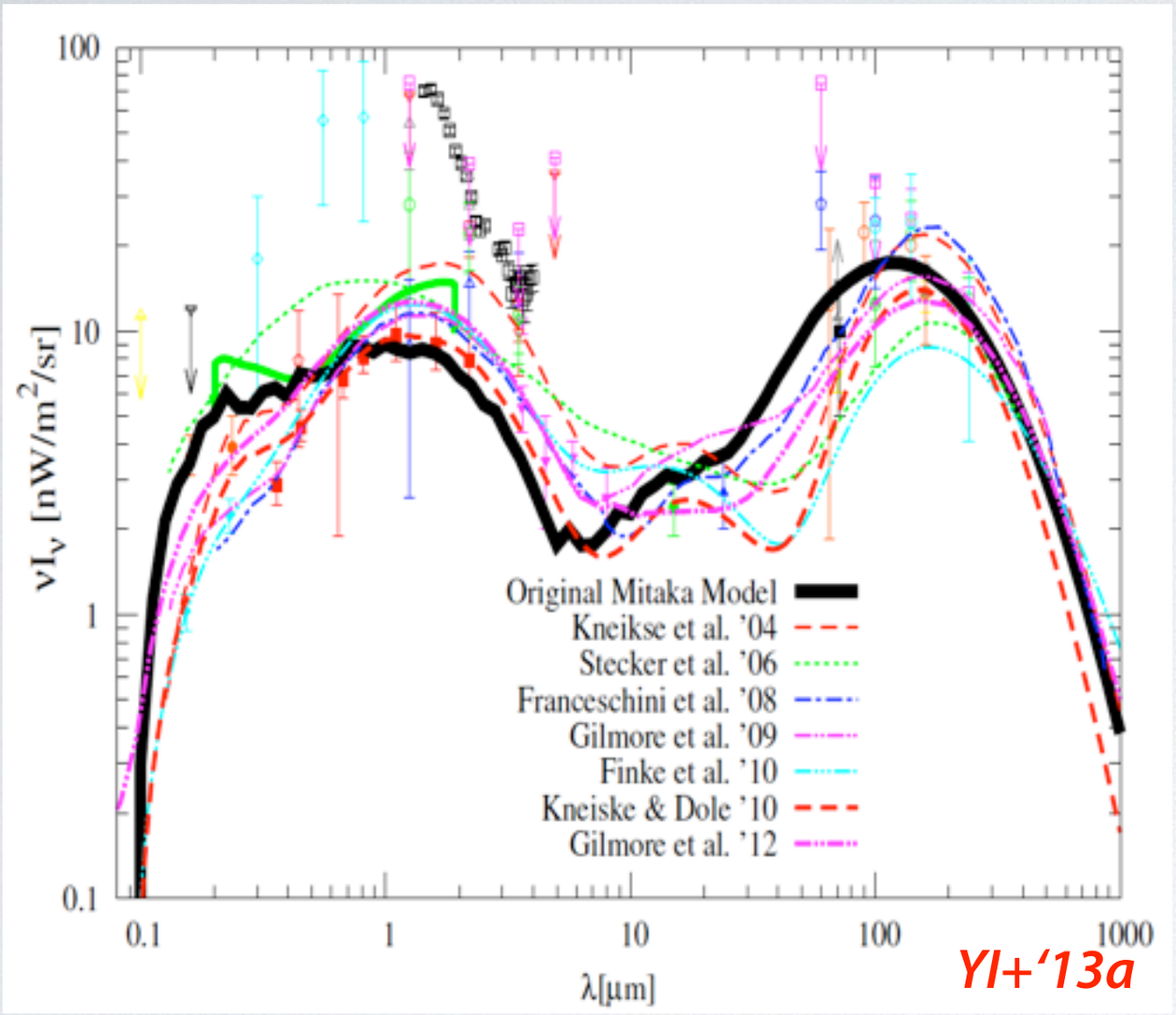
- Ionizing photon emissivity of first stars can not violate these observed reionization data.

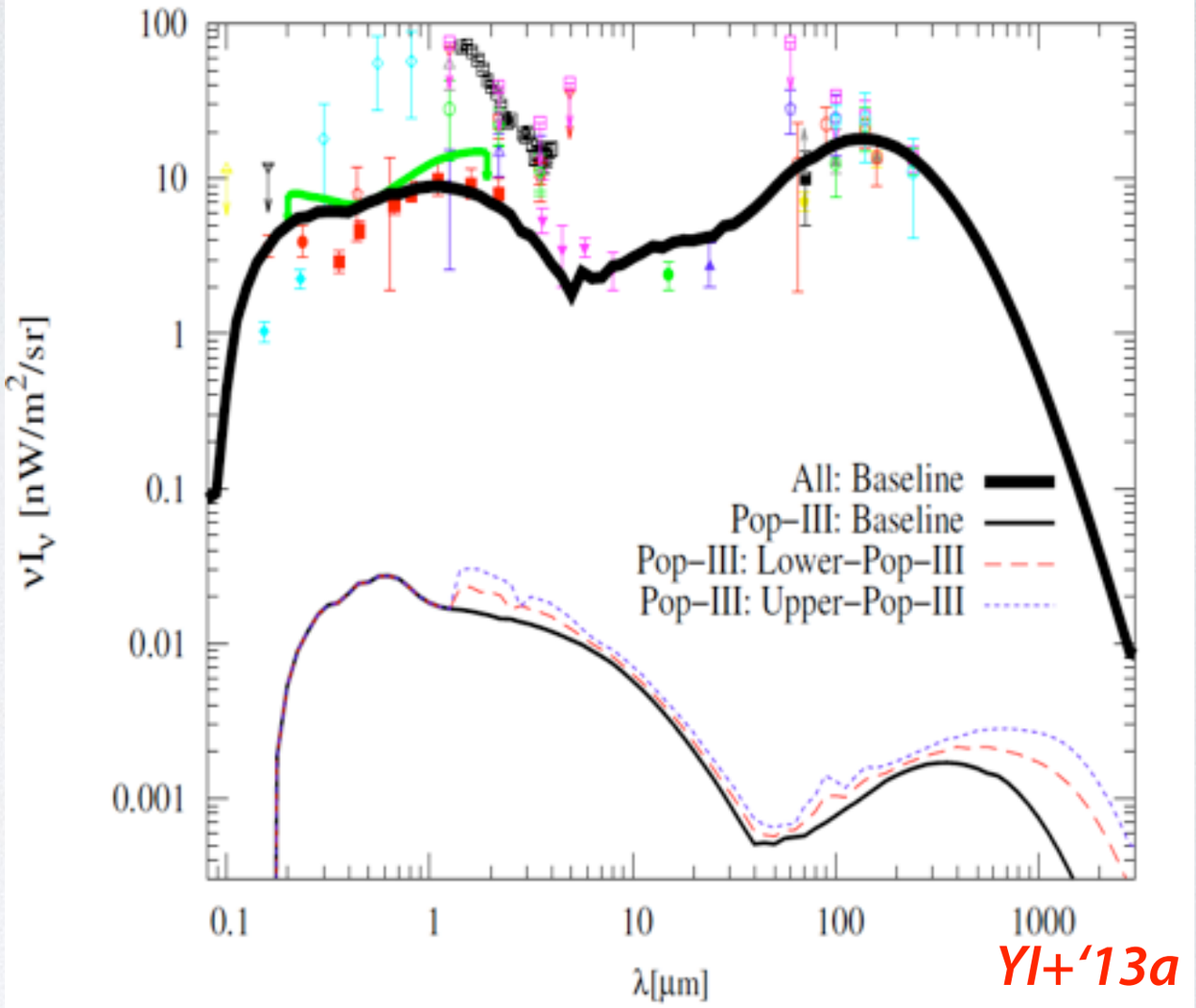
Constraints on First Stars



- 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)

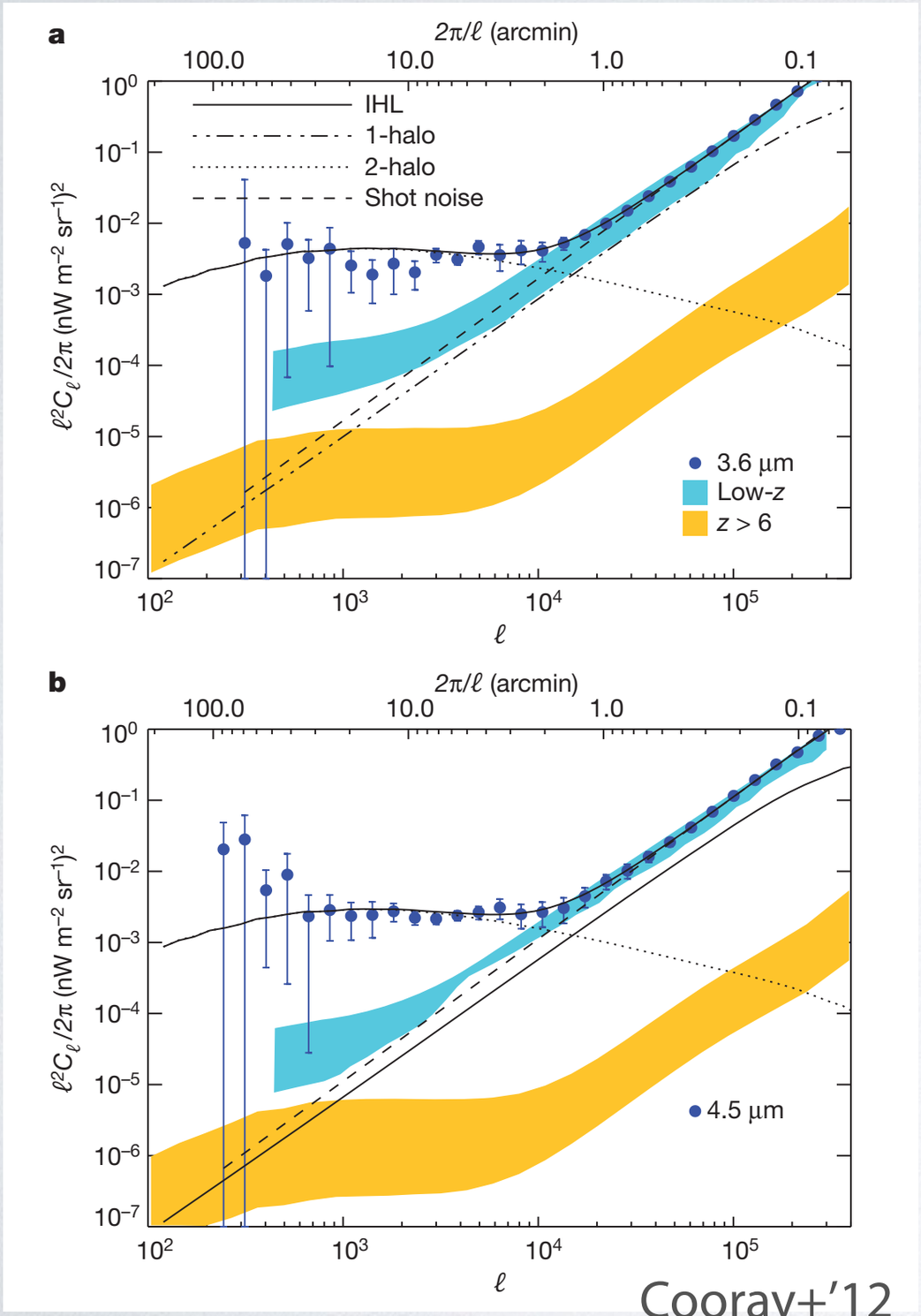
Semi-analytical Galaxy Formation Model with First Stars



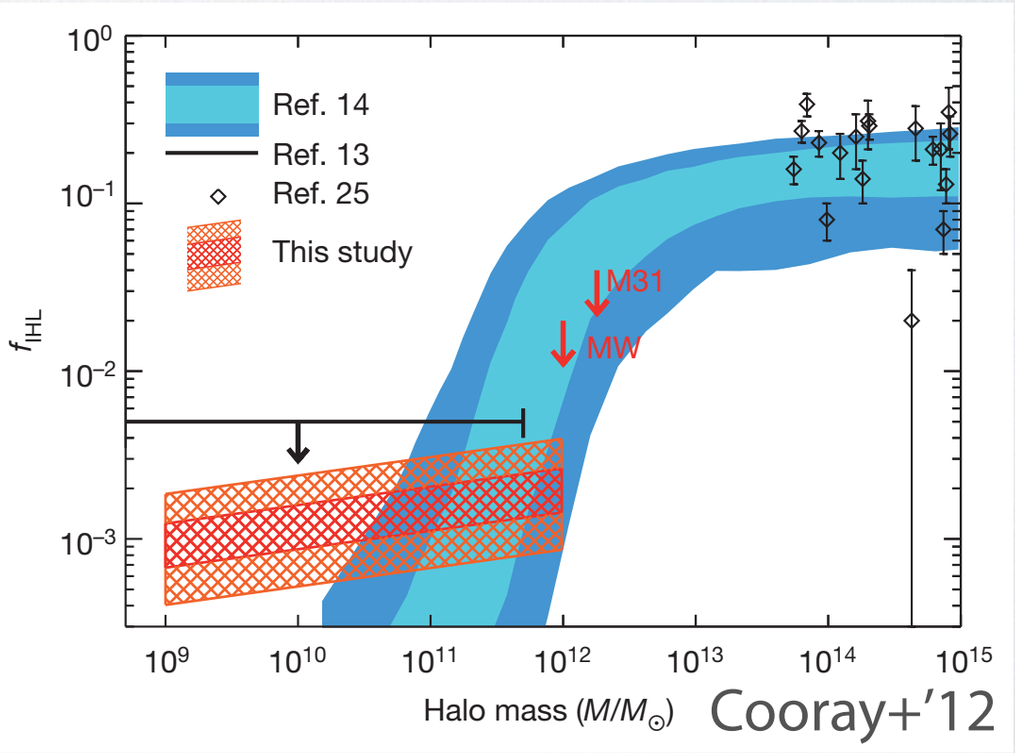


- A galaxy formation model including first stars which is consistent with reionization data.
- Pop-III contribution is <0.5% of total NIR EBL.

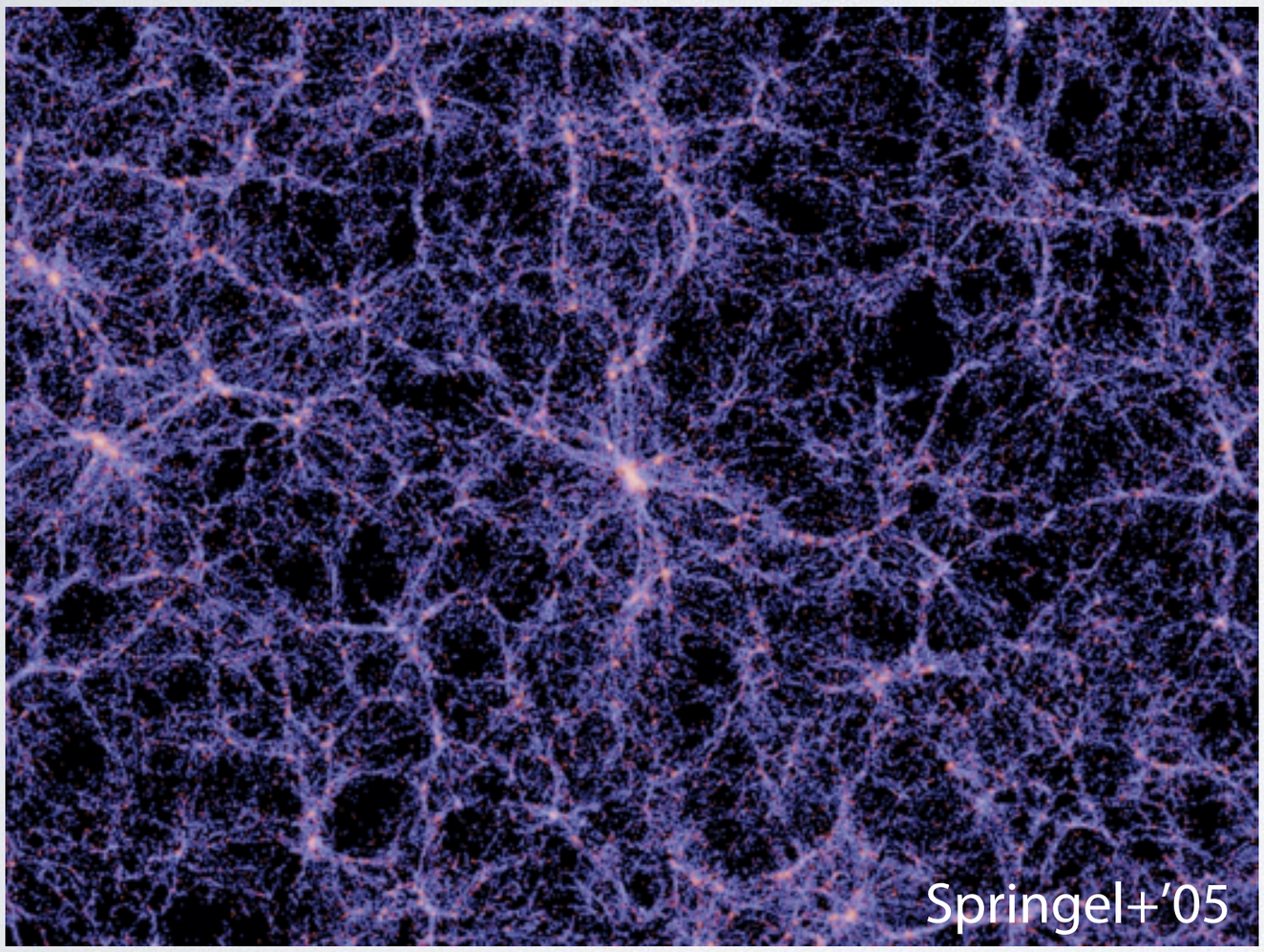
IntraHalo Stars?



- Stars stripped from host galaxies by major mergers.
  - Intrahalo stars may create a fluctuation peak at l~1000.

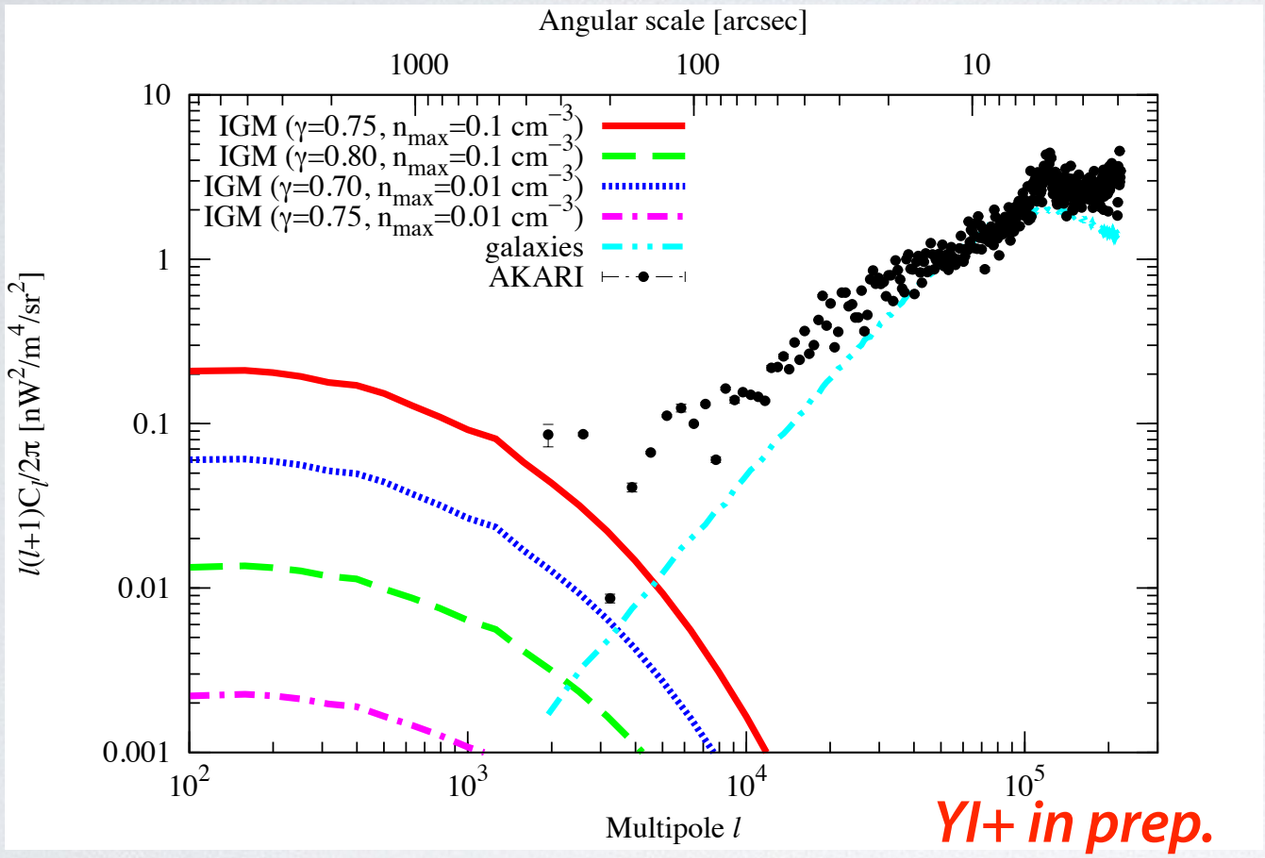


Intergalactic Medium (IGM) and EBL



- IGM are heated up to $>10^4$ K.
- IGM are kept ionised
- most of baryons are not in galaxies but in IGM (Fukugita & Peebles '04).
- IGM are inhomogeneously distributed.

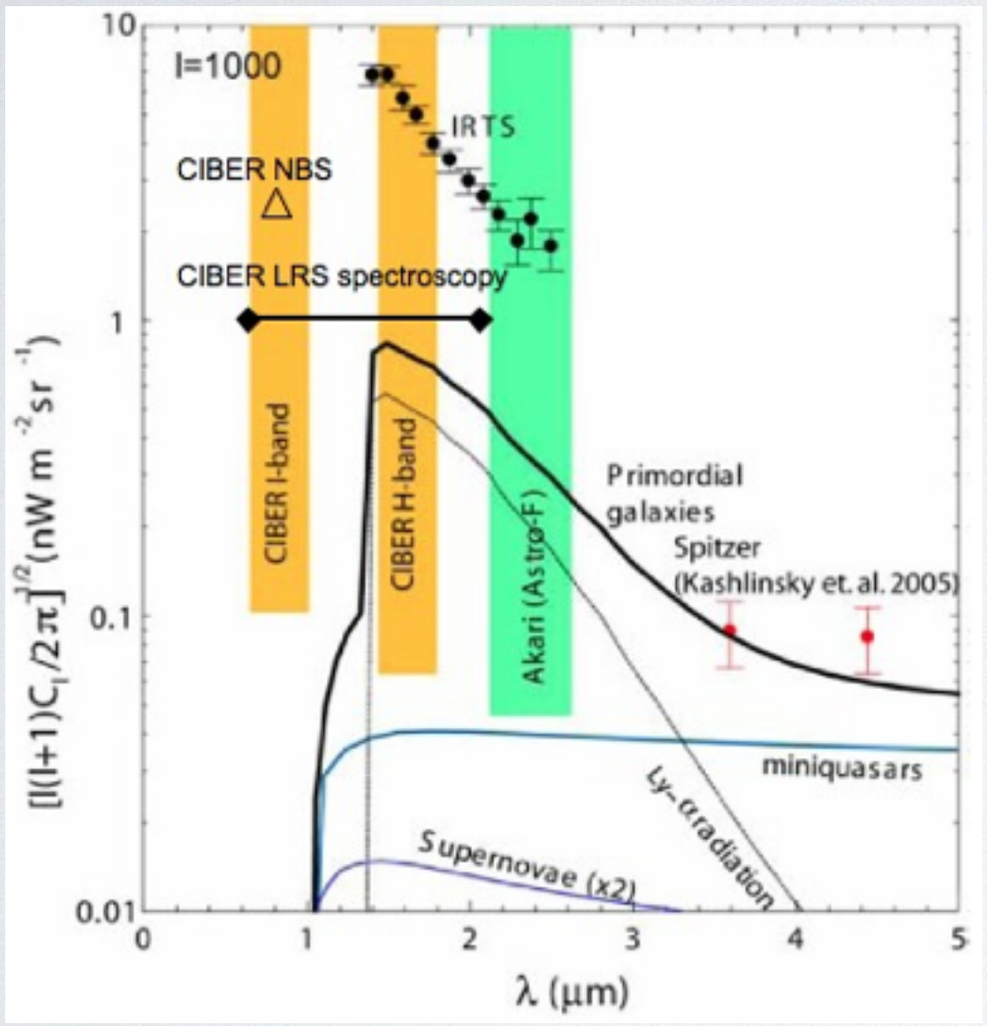
IGM EBL Fluctuation



EBL Fluctuation at 2.4 um

- Free-free and free-bound emission contribute.
- Density and temperature relation in IGM is uncertain.
- need to check the required UV background intensity, compare with fluctuations in other wavelengths.

What comes next?



- ***CIBER*** Rocket Measurements
  - high resolution narrow band spectrometer to determine the zodiacal light flux level
  - low resolution spectrometer between 0.8-2.0 um
  - two color wide-field imager
- Flight data have already obtained.
- CIBER-2 is also being developed.

Summary

- VHE distant sources show unexpected spectral hardening.
  - It may not be straightforward to constrain EBL further through gamma-ray observations.
- NIR background shows an excess from galaxies in its spectrum and its fluctuation.
  - CIBER will tell us more detailed information.