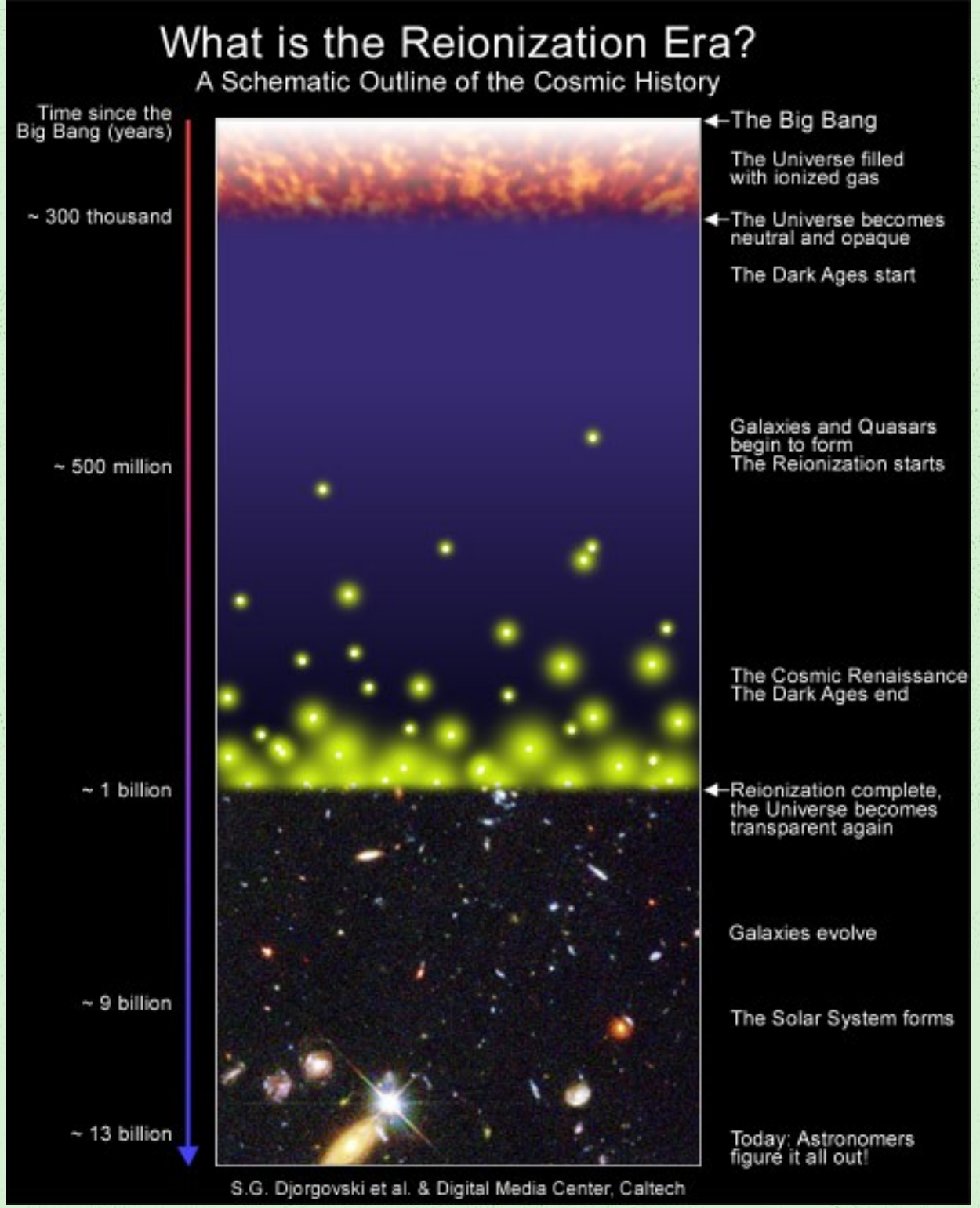
On the relative contribution of AGNs and Galaxies to Reionization

Fabio Fontanot AGN13 12/10/18

OSSERVATORIO ASTRONOMICO DI TRIESTE
INAF ISTITUTO NAZIONALE DI ASTROFISICA


What is the Reionization Era?
A Schematic Outline of the Cosmic History
Time since the Big Bang (years)
~ 300 thousand
~ 500 million
~ 1 billion
~ 9 billion
~ 13 billion
The Big Bang
The Universe filled with ionized gas
The Universe becomes neutral and opaque
The Dark Ages start
Galaxies and Quasars begin to form
The Reionization starts
The Cosmic Renaissance
The Dark Ages end
Reionization complete, the Universe becomes transparent again
Galaxies evolve
The Solar System forms
Today: Astronomers figure it all out!
S.G. Djorgovski et al. & Digital Media Center, Caltech

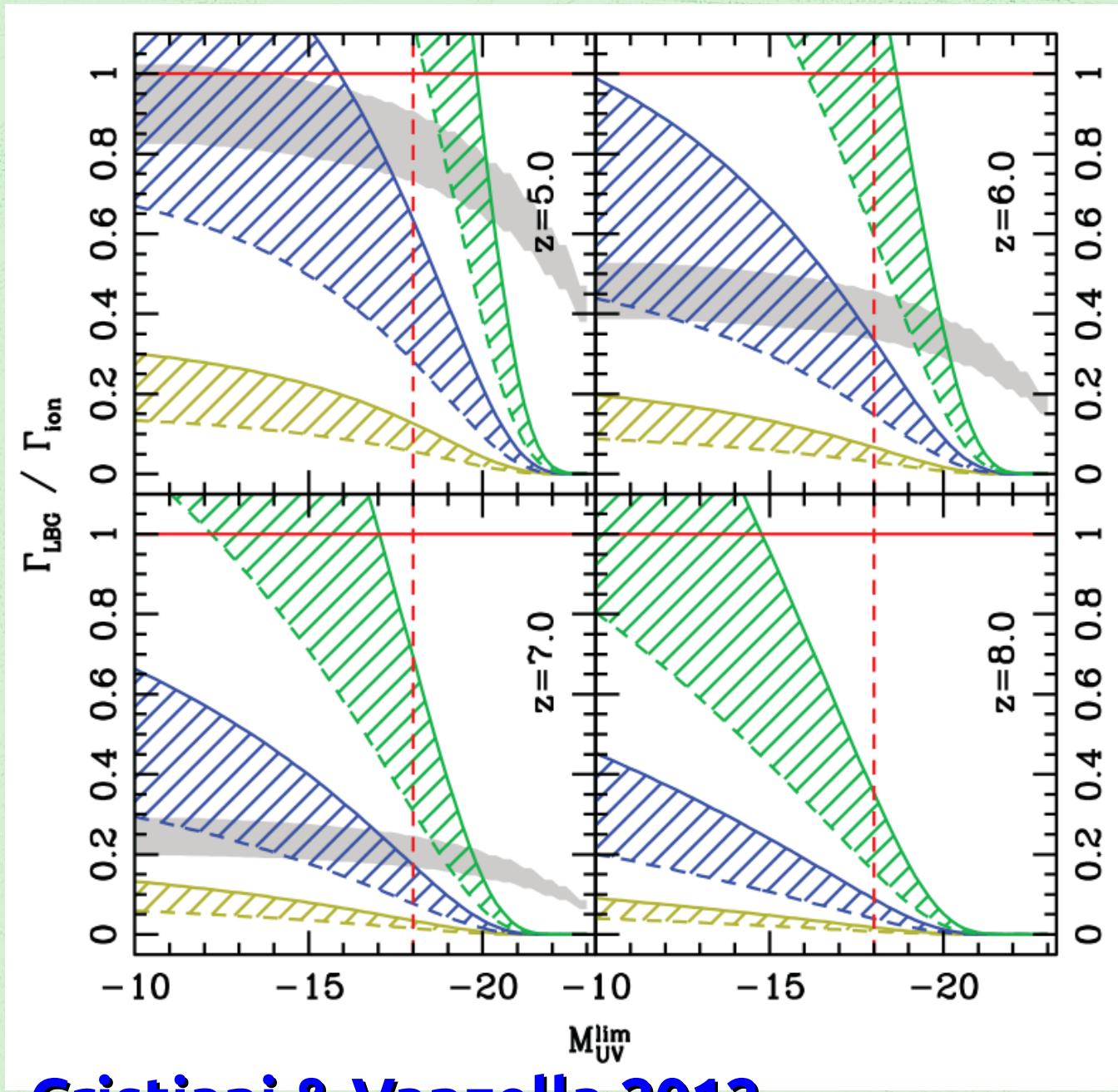
Reionization Sources

- **Active Galactic Nuclei vs Galaxies as main source of ionizing photons**

Reionization Sources

- Active Galactic Nuclei vs Galaxies as main source of ionizing photons
- Extrapolating high-z LFs
- Uncertainties
  - Faint end slopes of LFs
  - Integration limit (faintest existing objects)
  - Escape fraction (f_esc)
  - Dependence on galaxy properties (M*, SFR, Z) and redshift

LBG Contribution



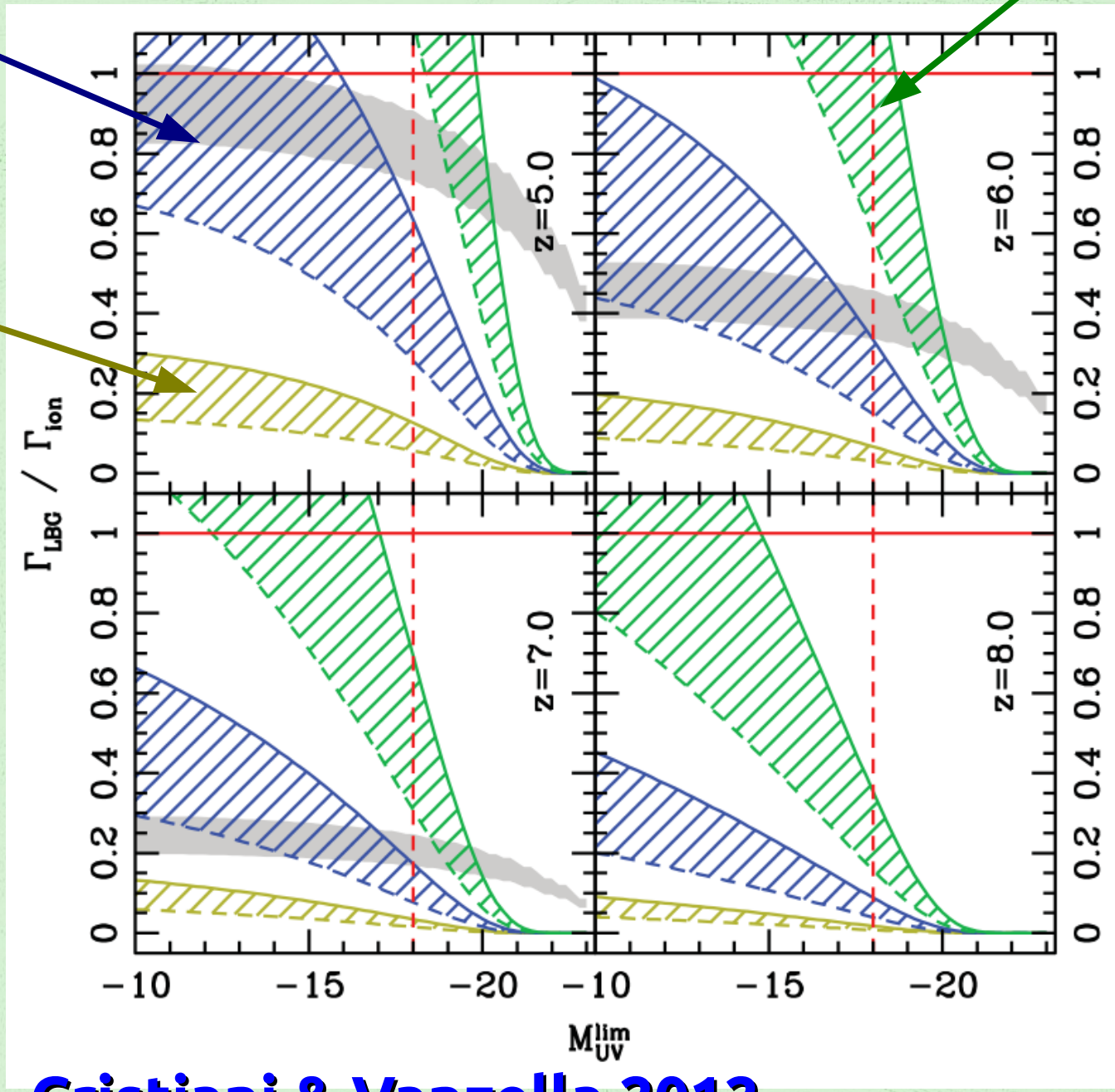
Fontanot, Cristiani & Vanzella 2012

LBG Contribution

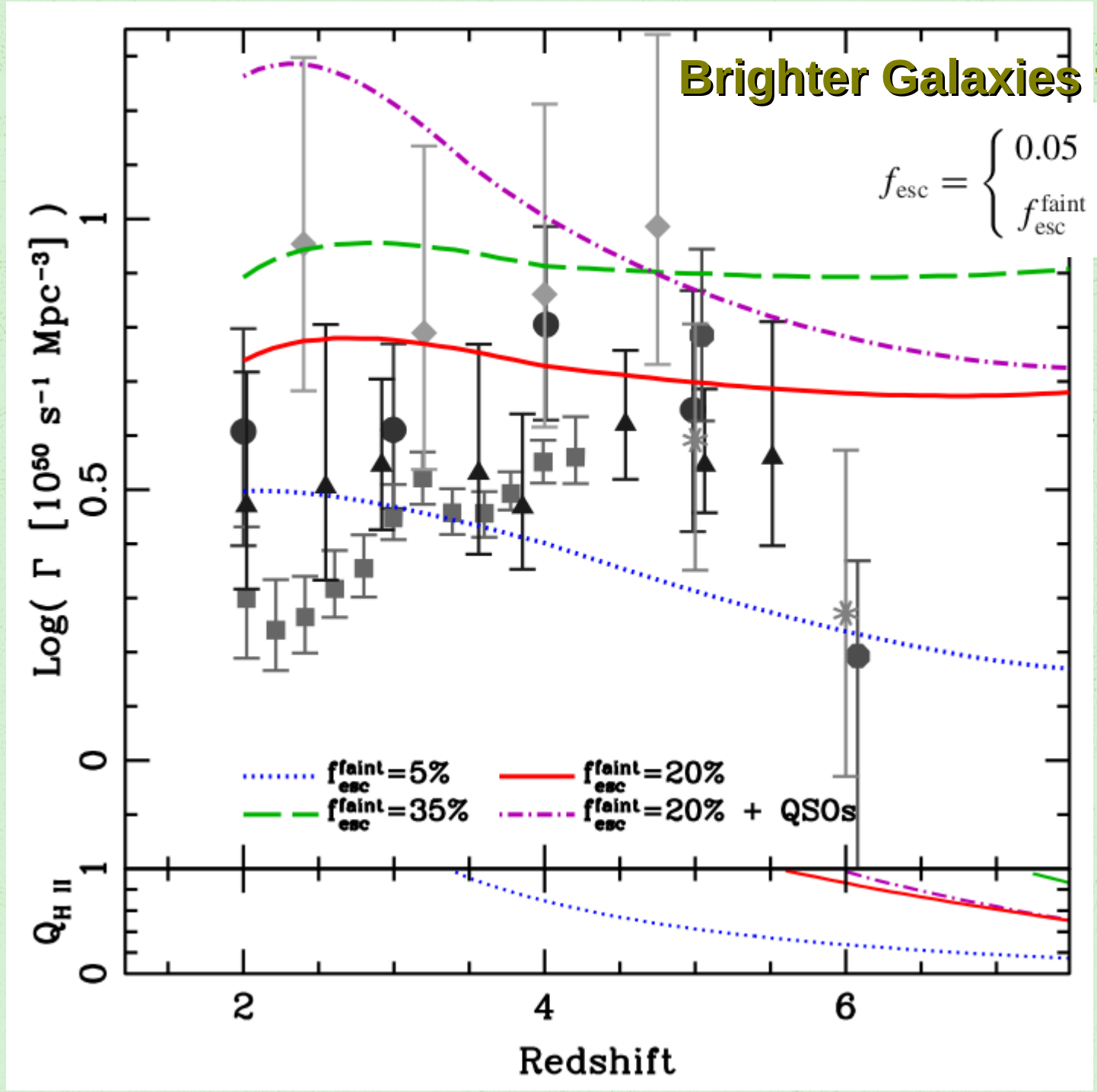
f_esc=0.05

f_esc=0.20

f_esc=0.01

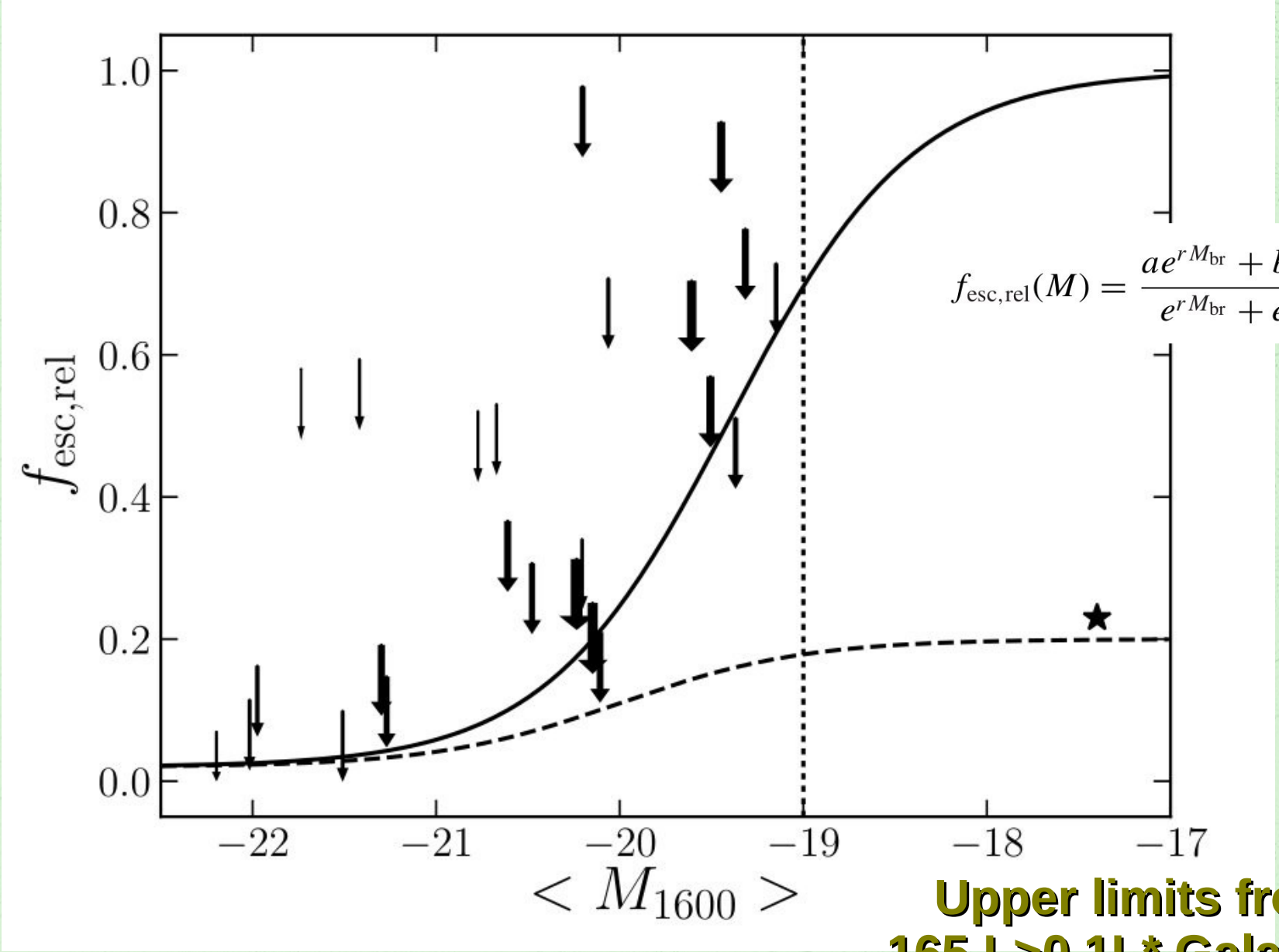


Fontanot, Cristiani & Vanzella 2012



Fontanot+14 Fixed Thermal History + Varying Escape Fraction

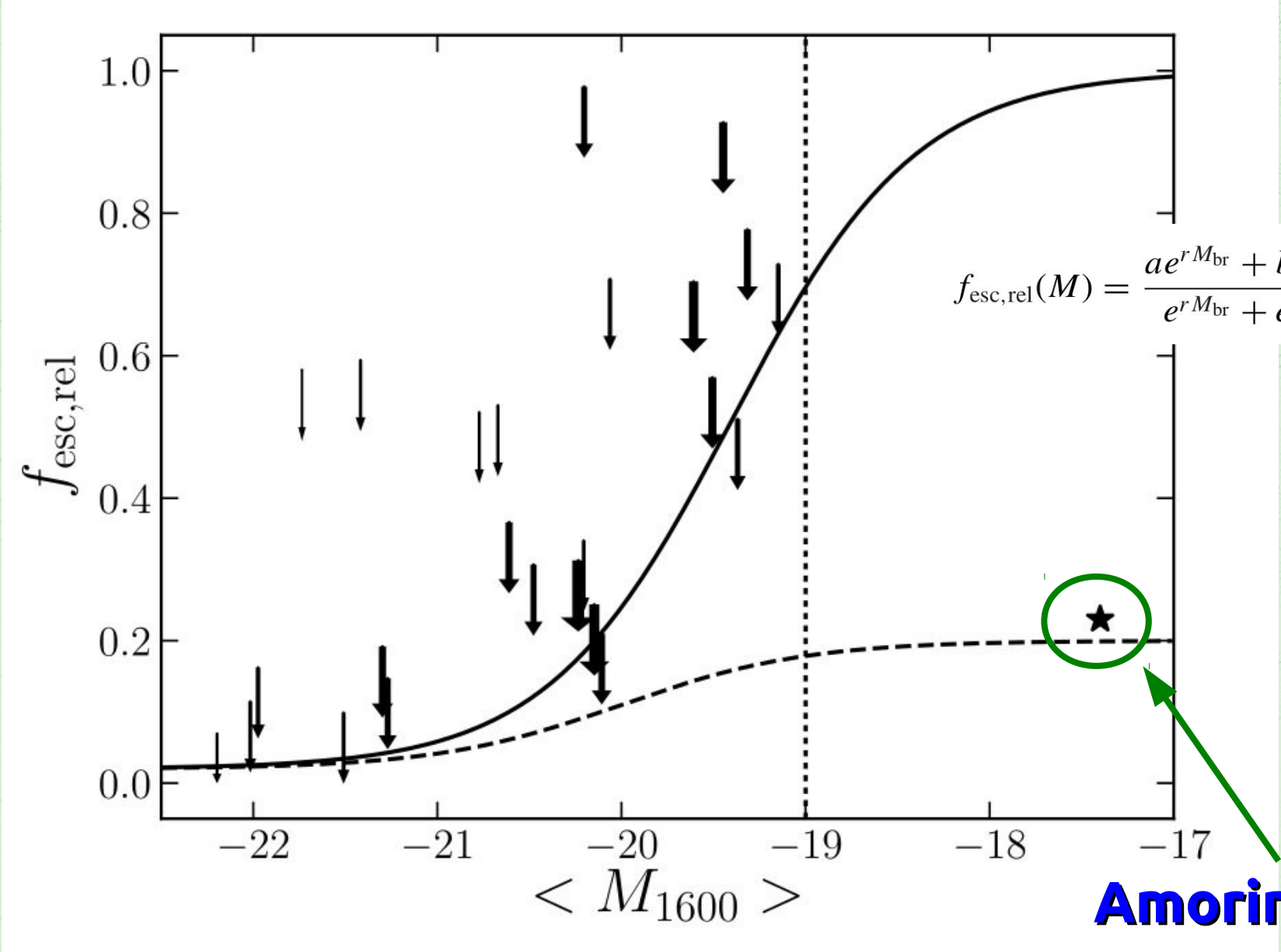
A sample of faint galaxies …



Upper limits from 165 L>0.1L* Galaxies @3<z<4

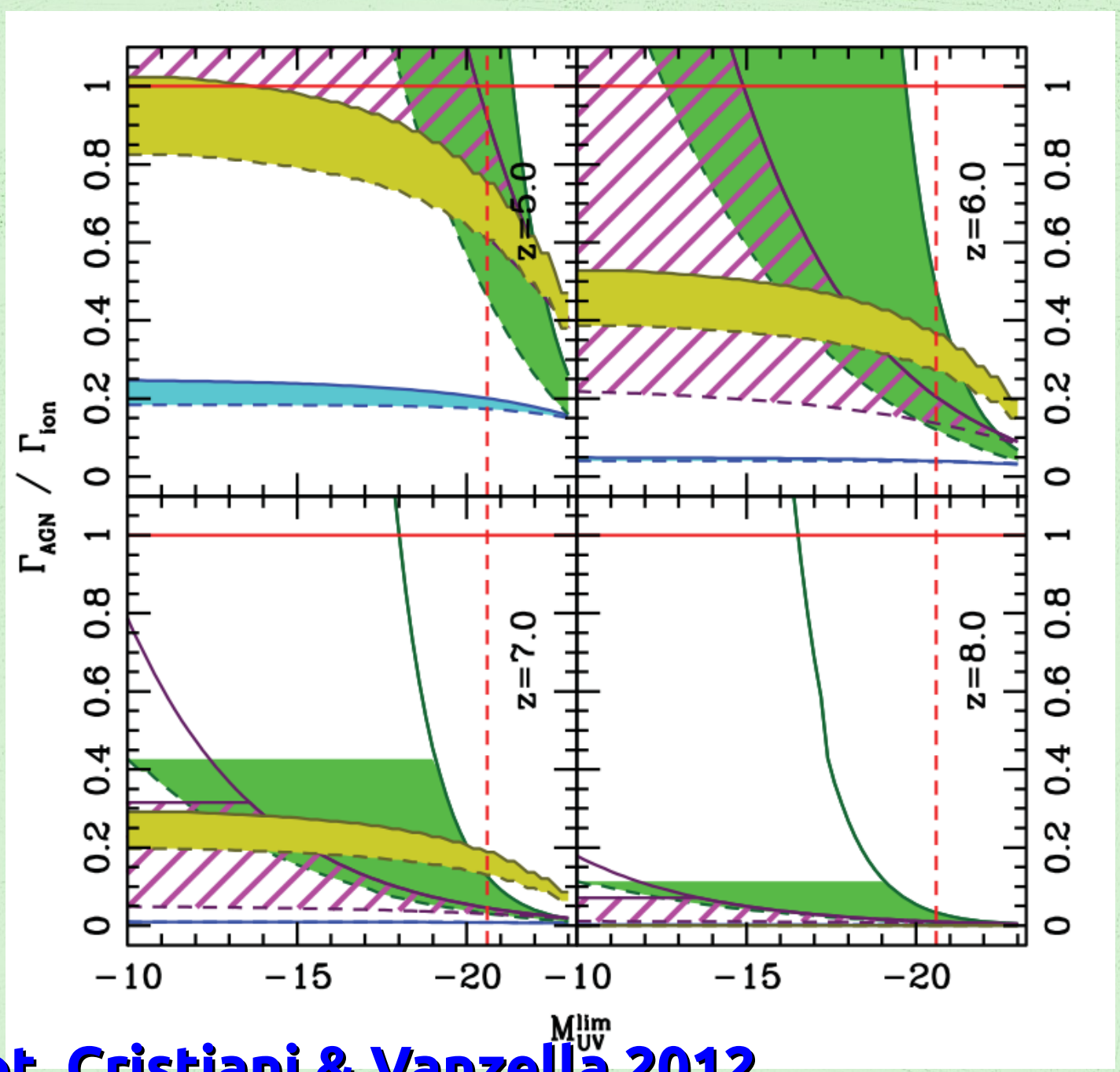
Japelj+17

A sample of faint galaxies ...



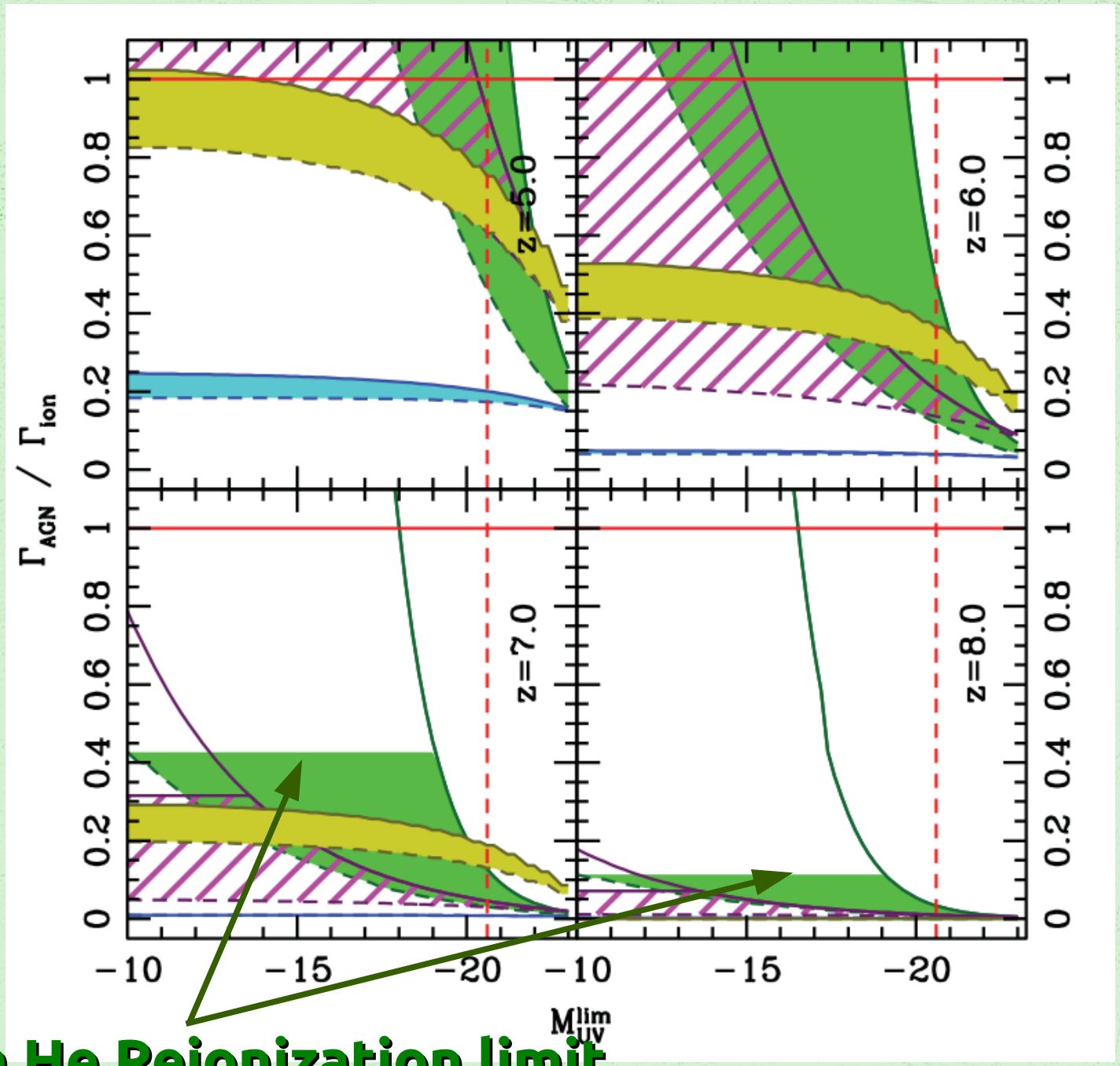
Japelj+17

AGN Contribution



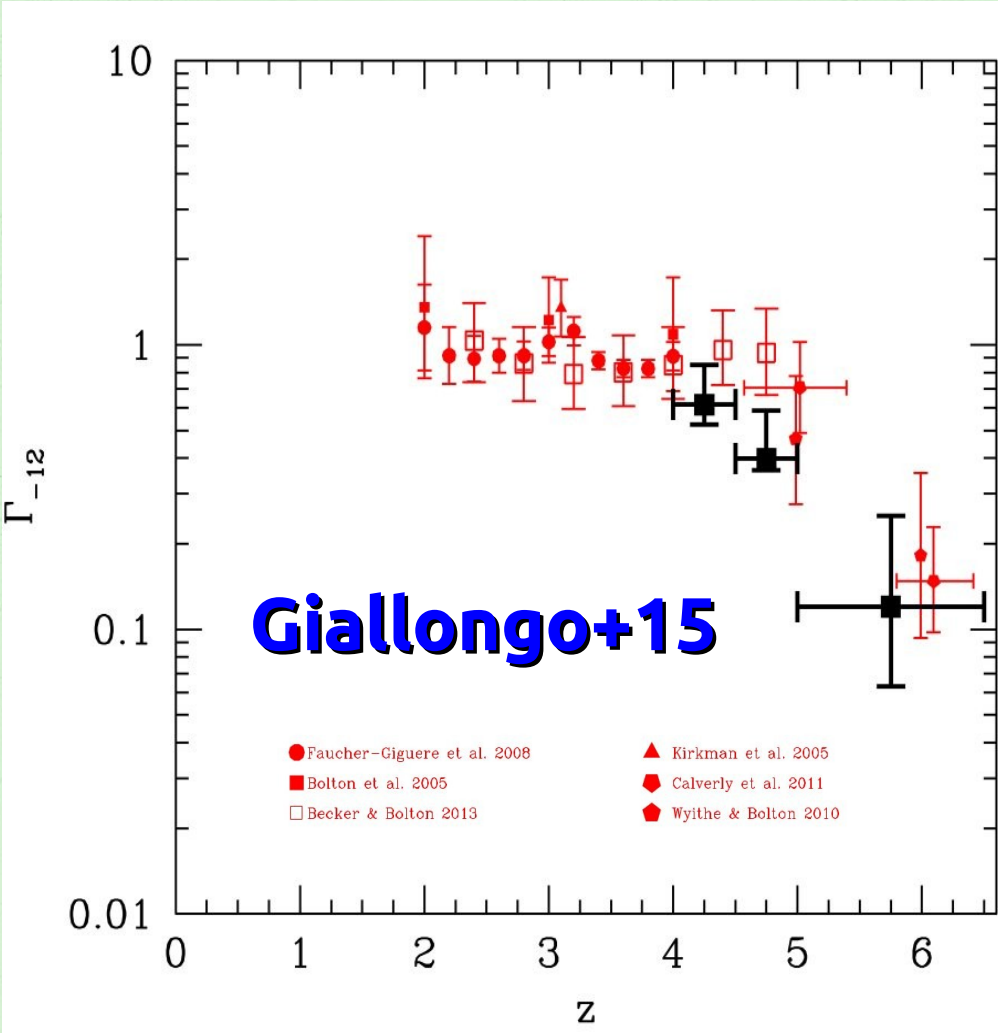
Fontanot, Cristiani & Vanzella 2012

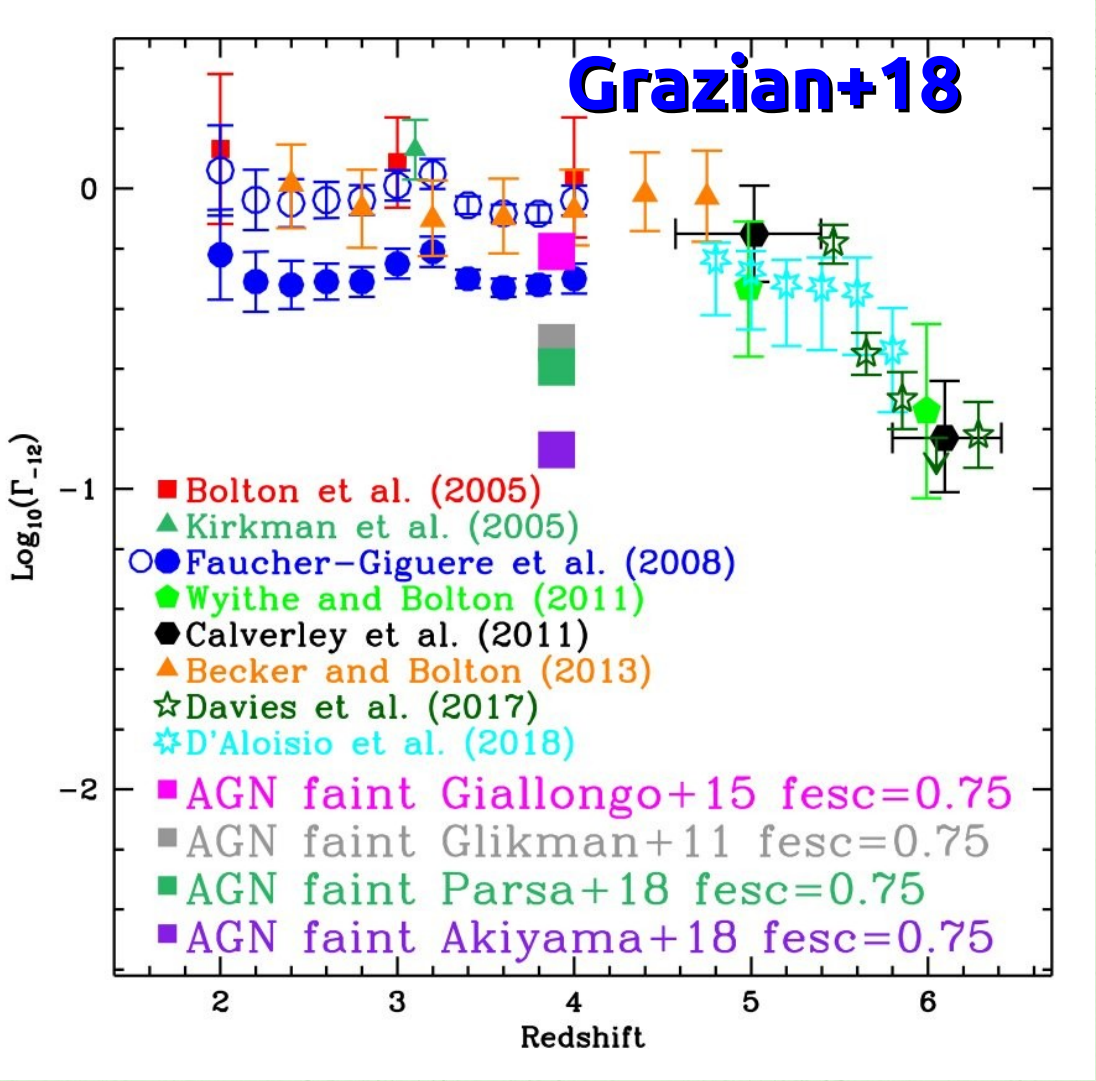
AGN Contribution f_agn=1.0



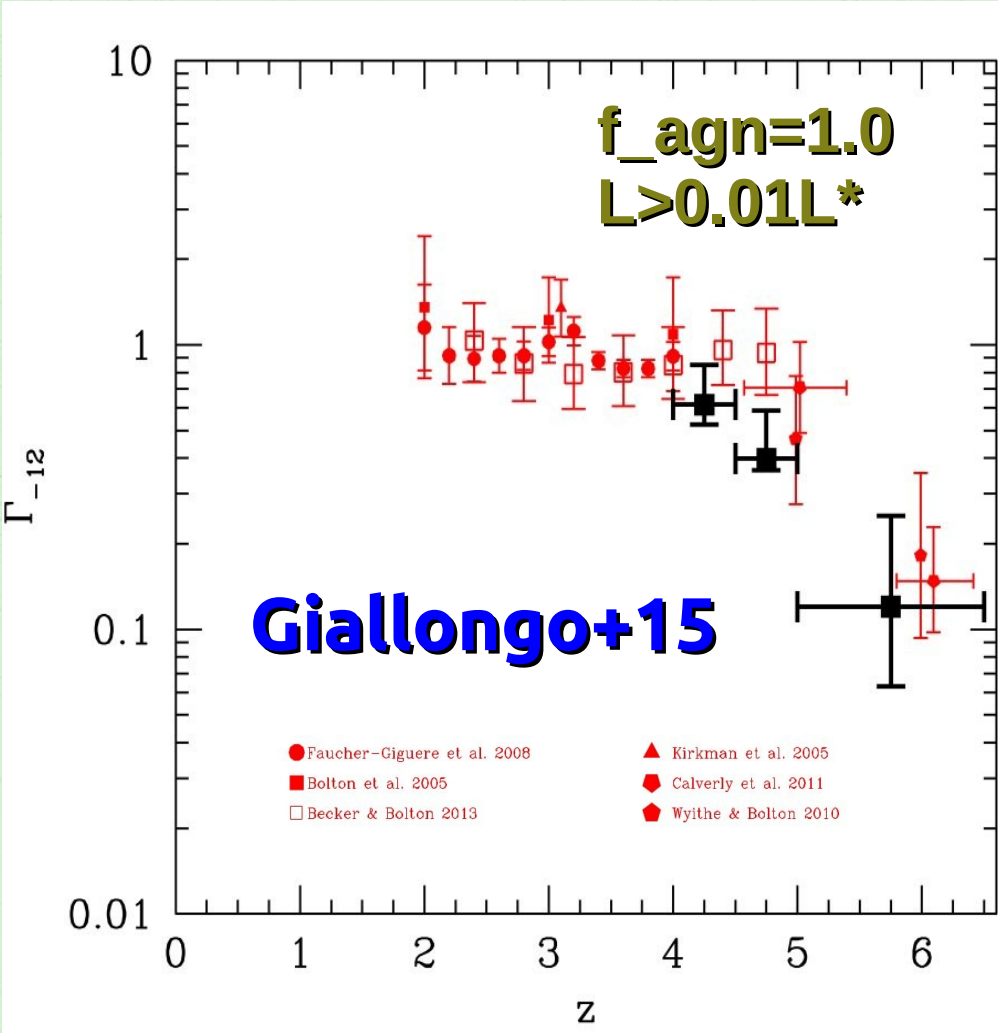
Uniform He Reionization limit

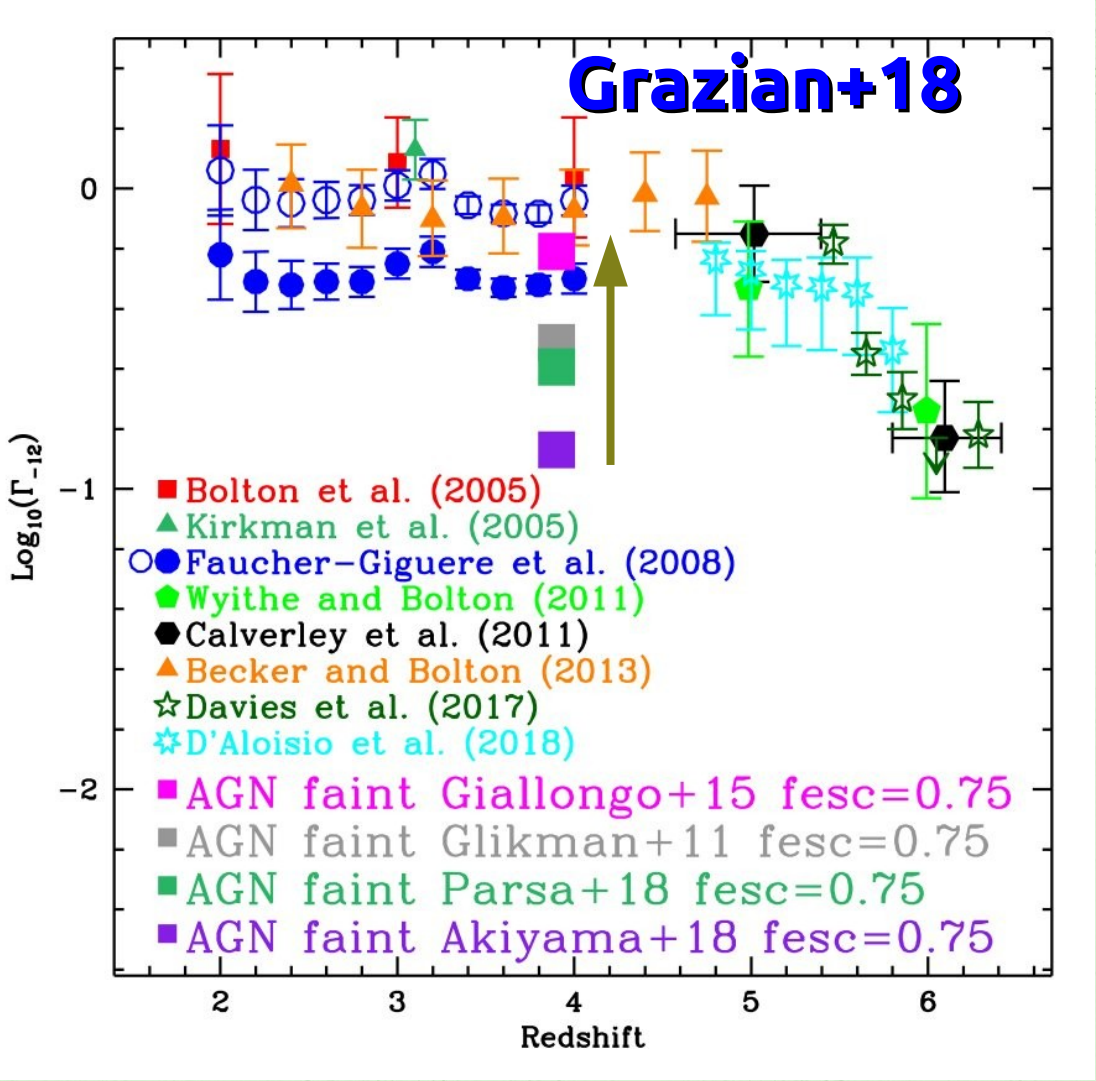
AGN Contribution





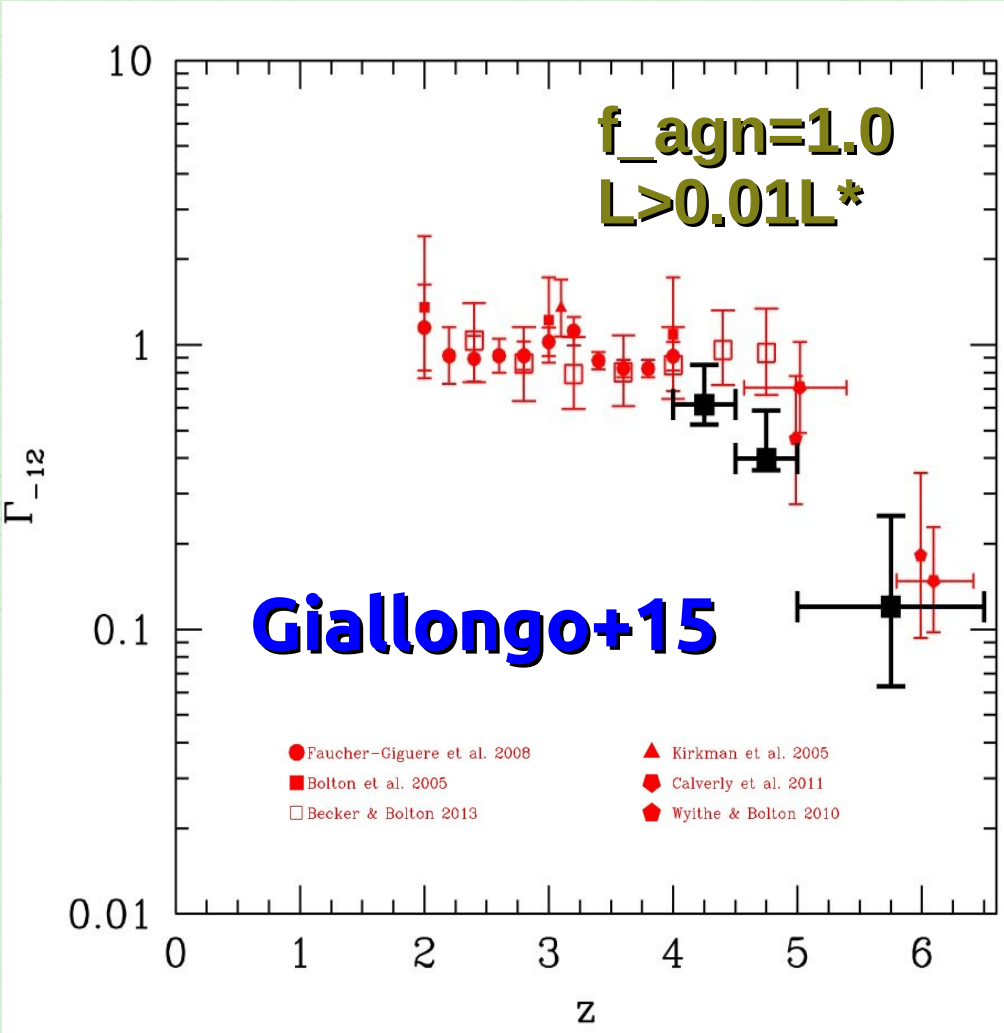
AGN Contribution: steepening of LF

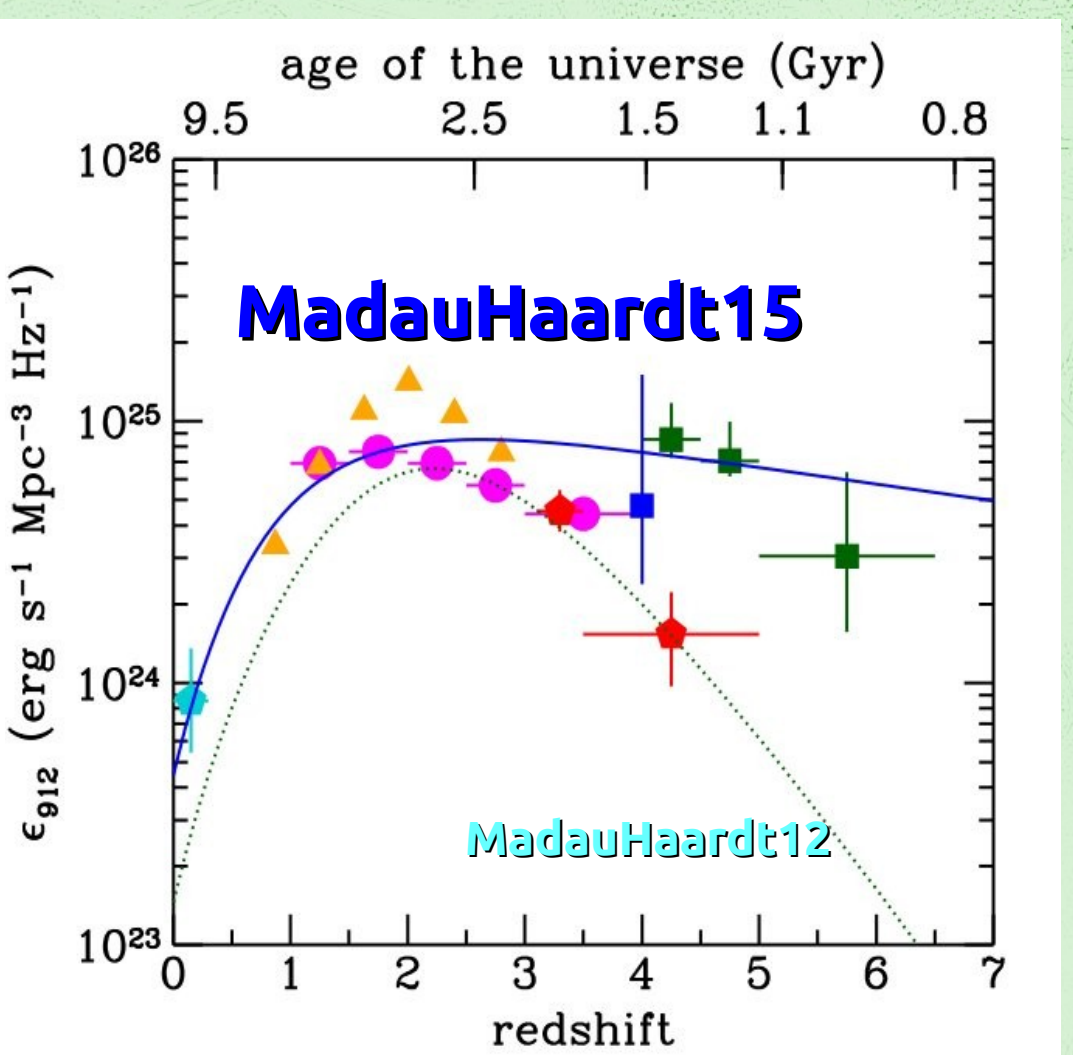




Inhomogeous He Reionization

AGN Contribution: steepening of LF

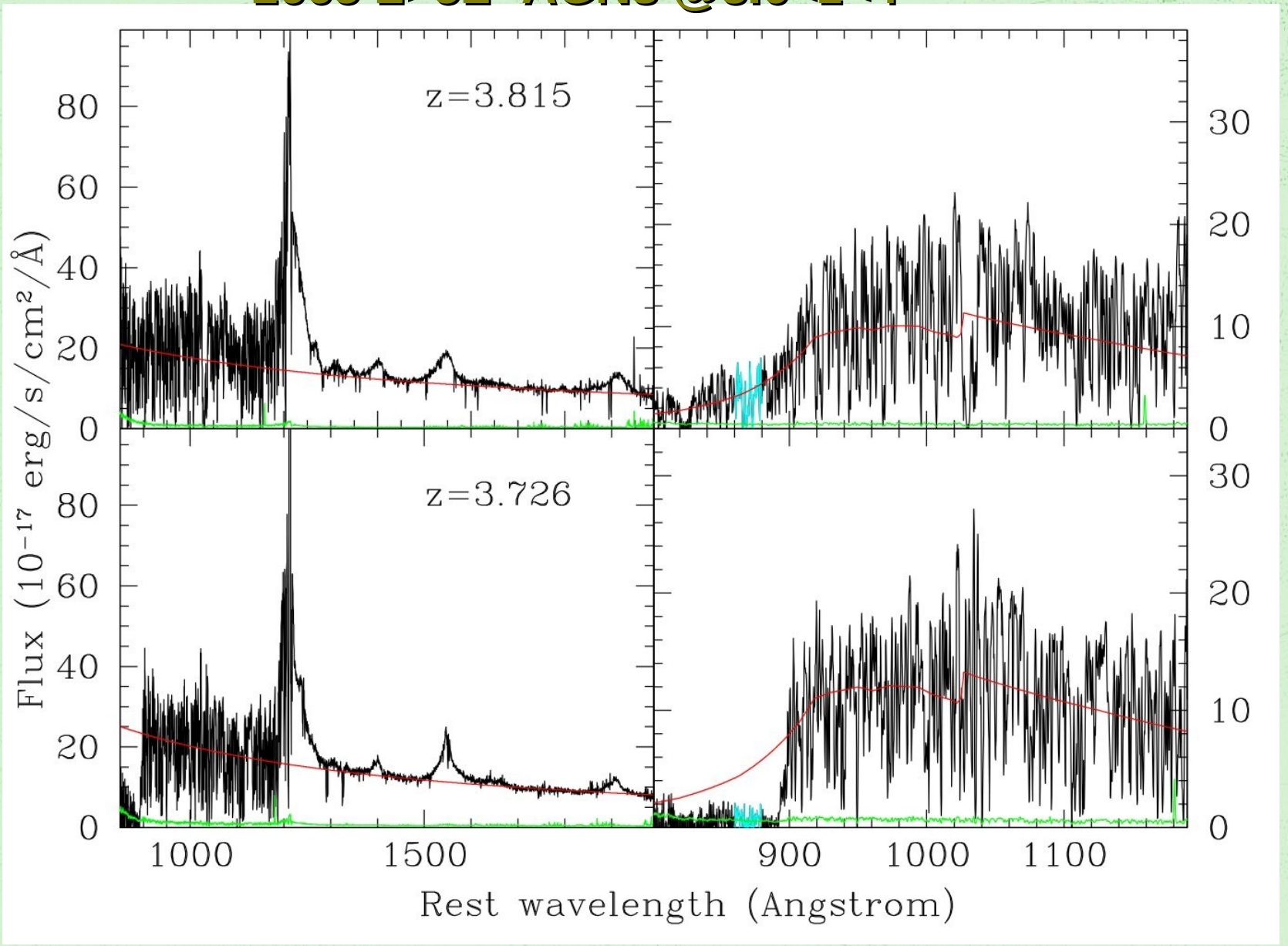




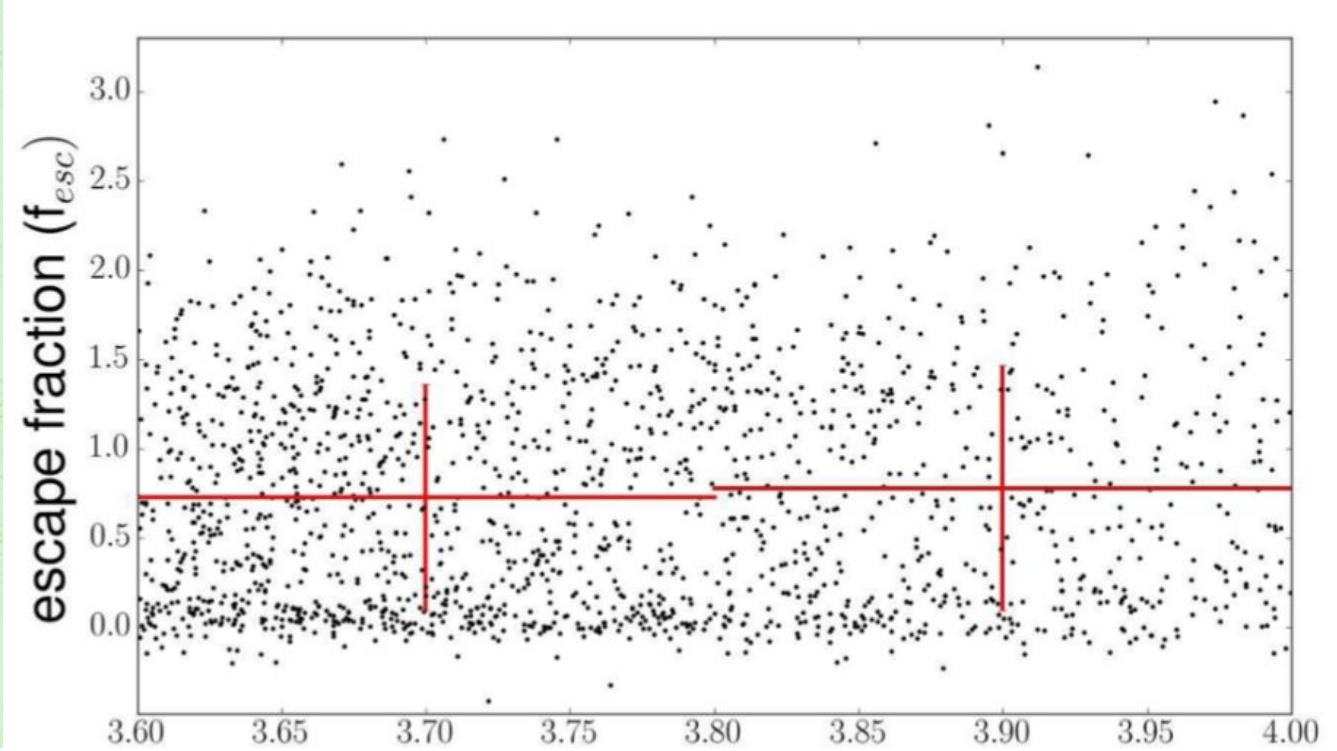
Inhomogeous He Reionization

A sample of (relatively) bright AGNs ...

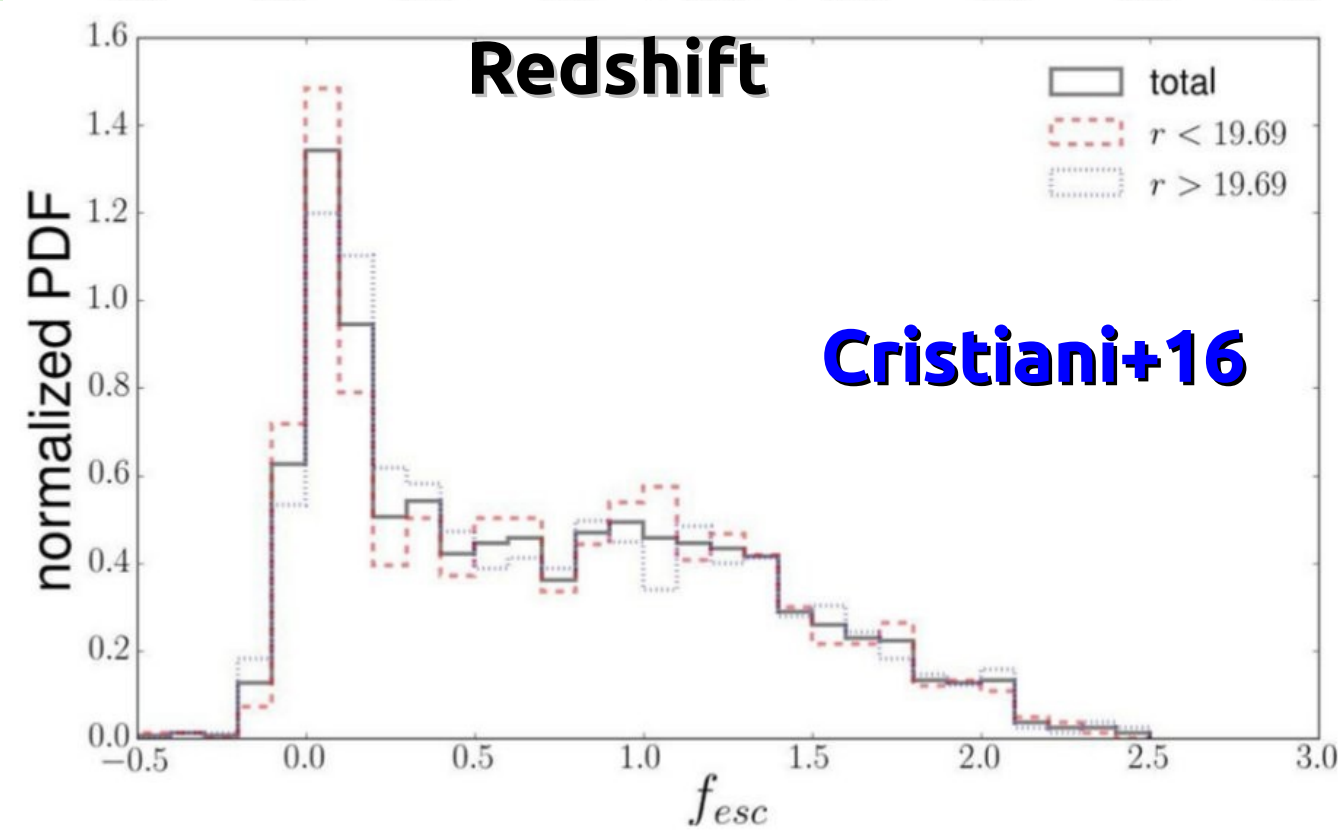
1665 L>5L* AGNs @3.6<z<4



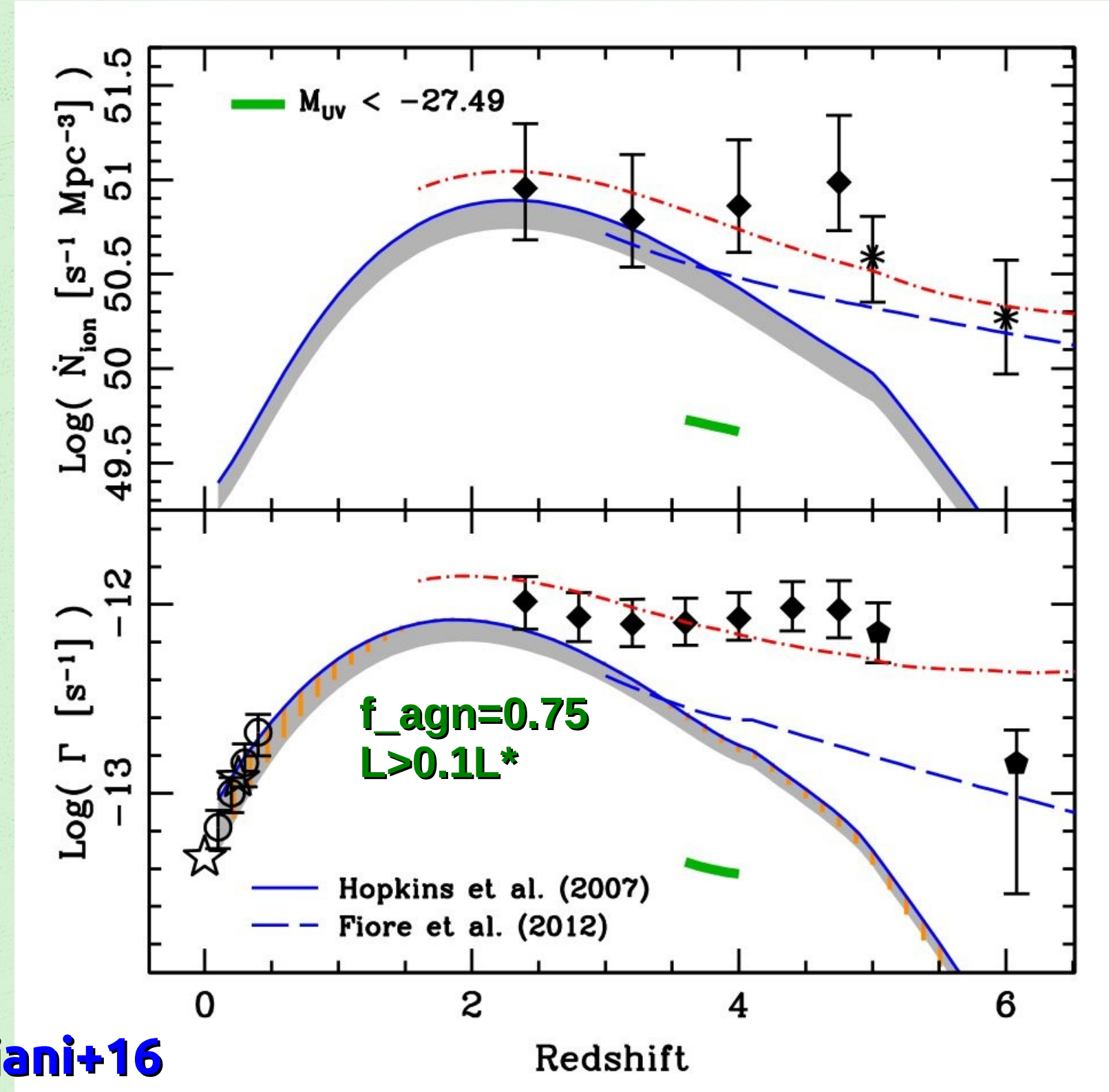
Cristiani+16



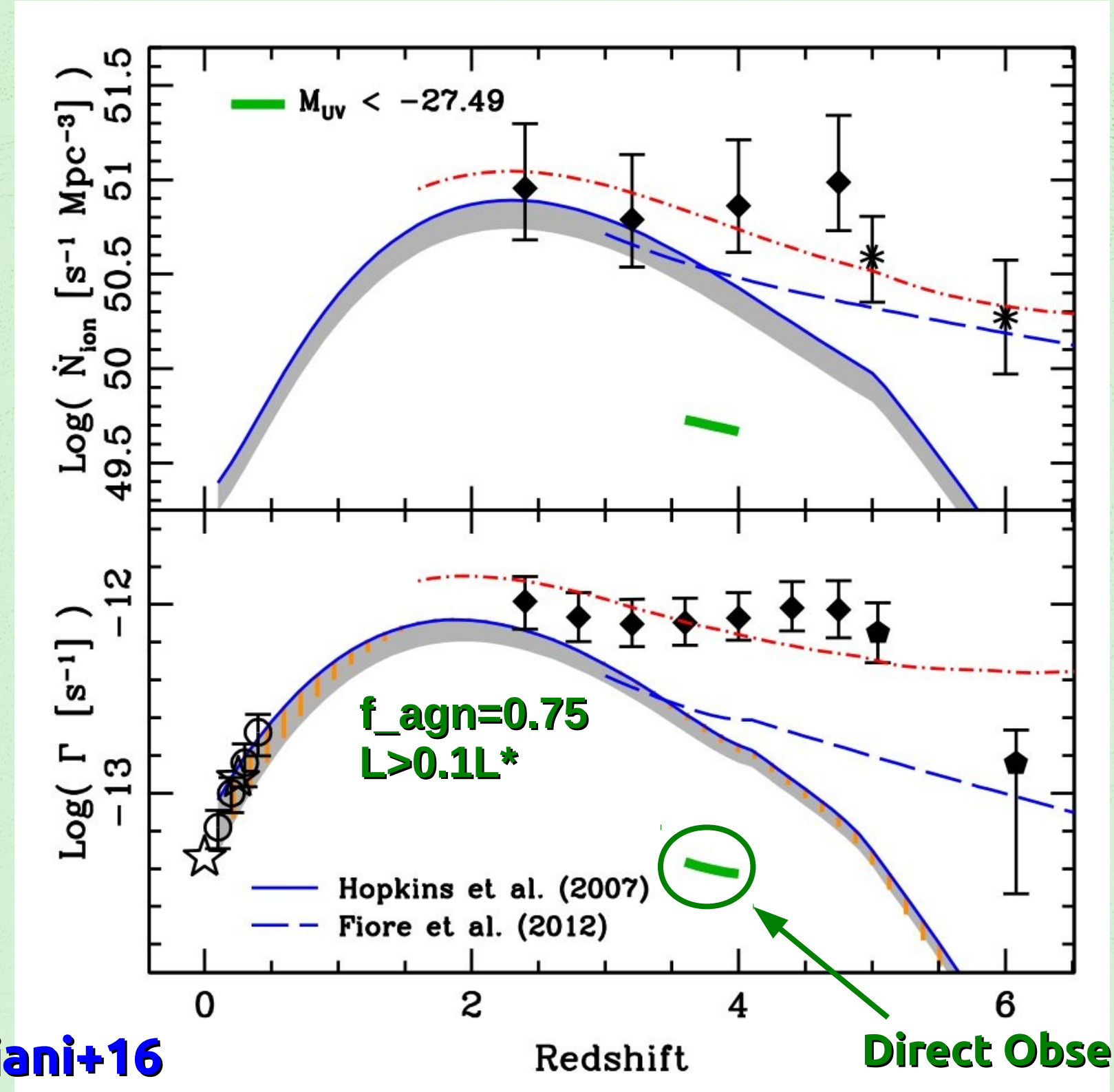
Redshift



Cristiani+16

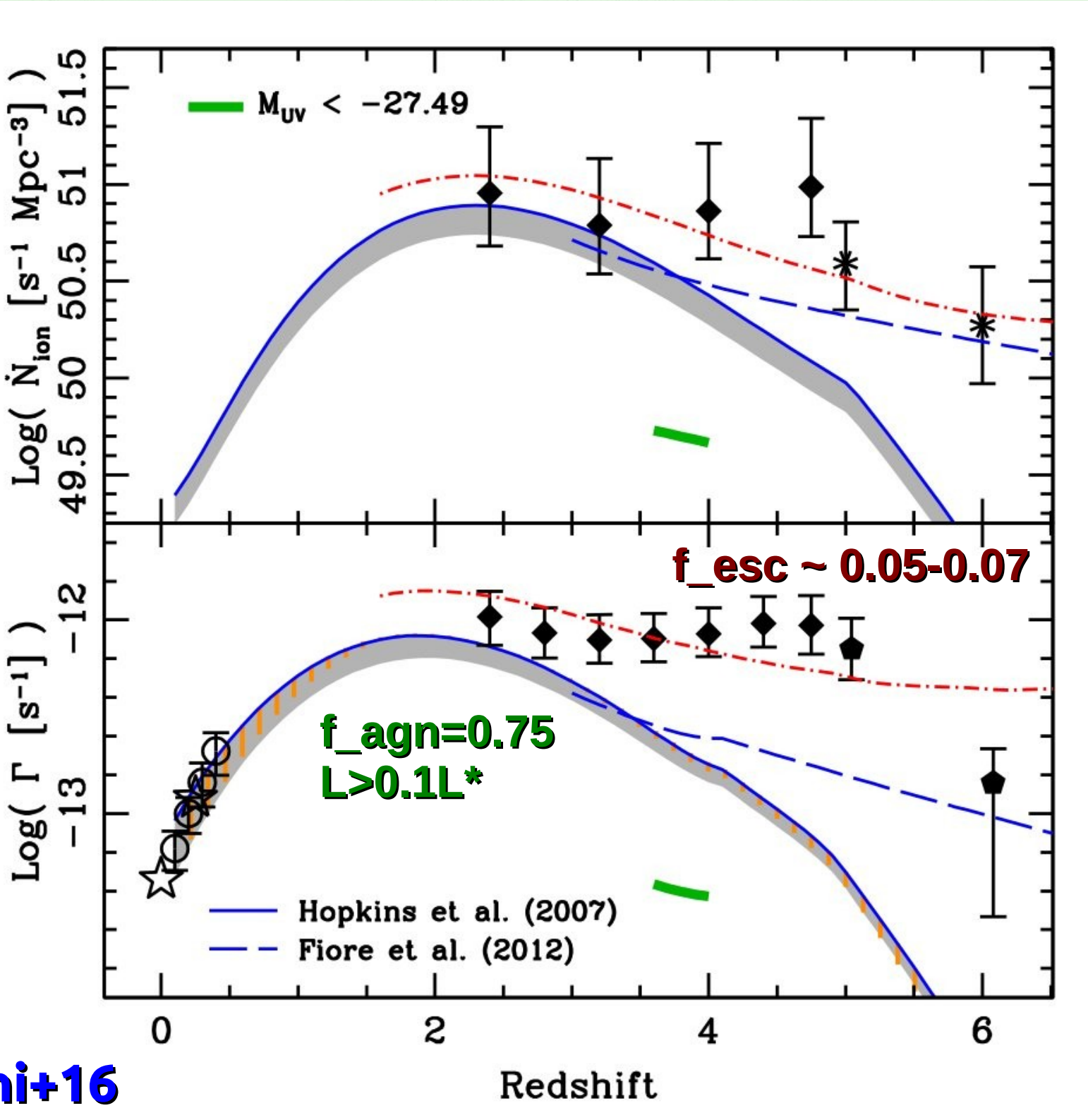


Cristiani+16



Cristiani+16

Direct Observations



Cristiani+16

Conclusions

- **AGN provide a relevant contribution to reionization**
  - **Debate is open if they close the photon budget**
  - **Open problems with HeII reonization (Garaldi+18: wavelenght dependent f_agn?)**
- **Sources fainter than the current limits should provide a relevant contribution to reionization (both galaxies and AGNs)**
  - **Galaxies: faint sources should be characterised by escape fractions larger than the current estimates for brighter galaxies**
  - **AGNs: faint sources should be characterised by escape fractions as large as the current estimates for bright QSO**
    - **Going deeper: Grazian+18 (L~L*) Di Gioia+in prep**