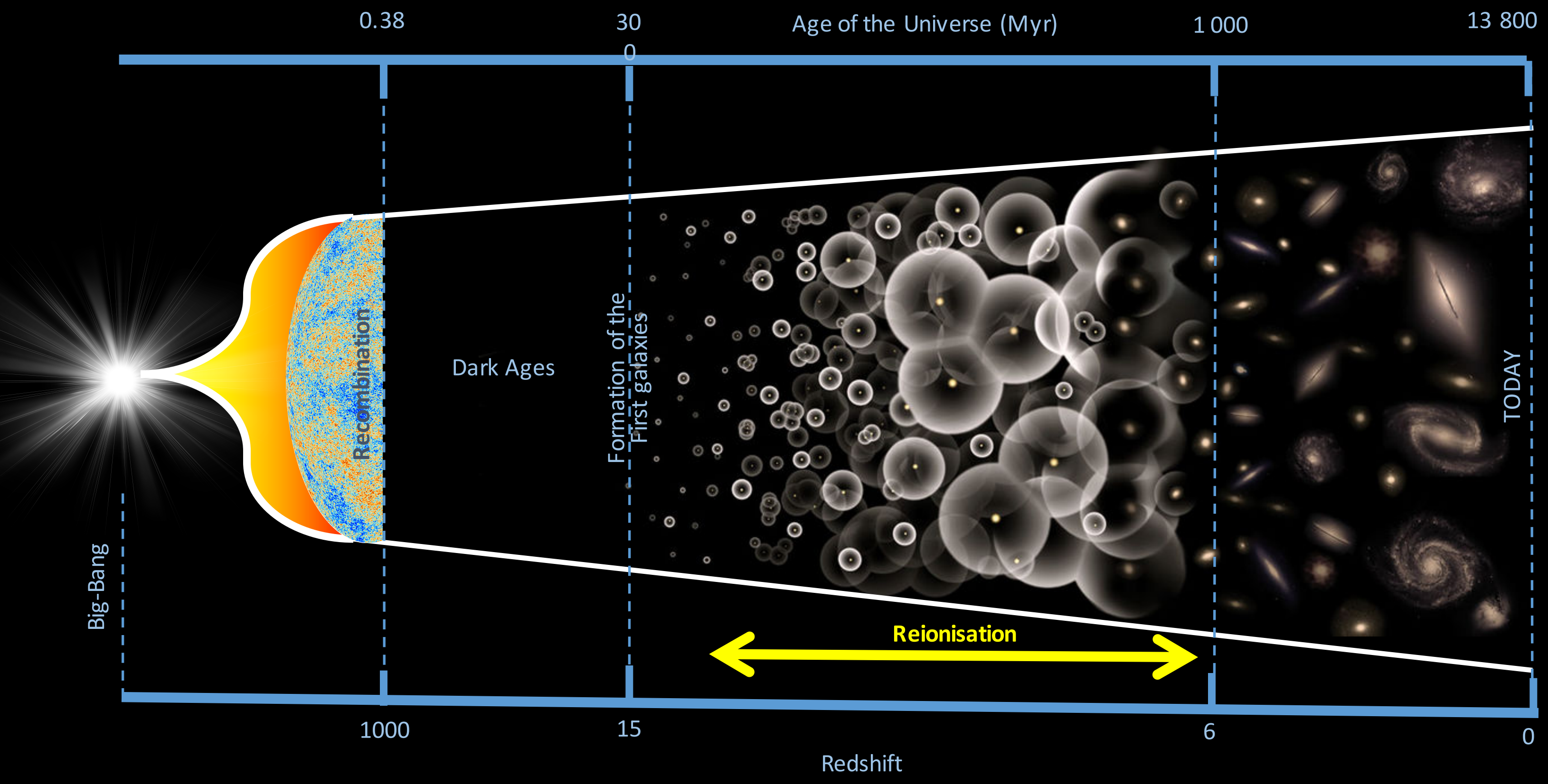
Search for AGN in the reionisation era

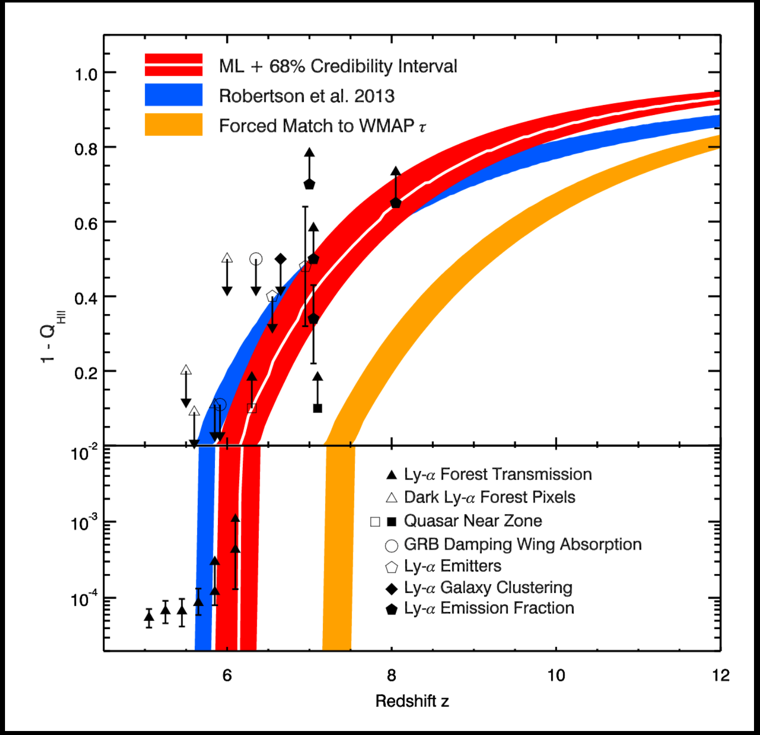
Nicolas Laporte – 18th September 2019
KICC 10th Anniversary

R. Ellis (UCL) – K. Nakajima (ESO) – H. Katz (U. Oxford) - G. Roberts-Borsani (UCL) –
A. Zitrin (Ben Gurion University) – D. Stark (Arizona) – R. Mainali (Arizona) – R. Pelló (LAM)



KEY QUESTIONS

1. When did the first galaxies form in the early Universe ?
2. Is there a significant contribution to reionisation from AGN ?



Robertson et al. (2015)

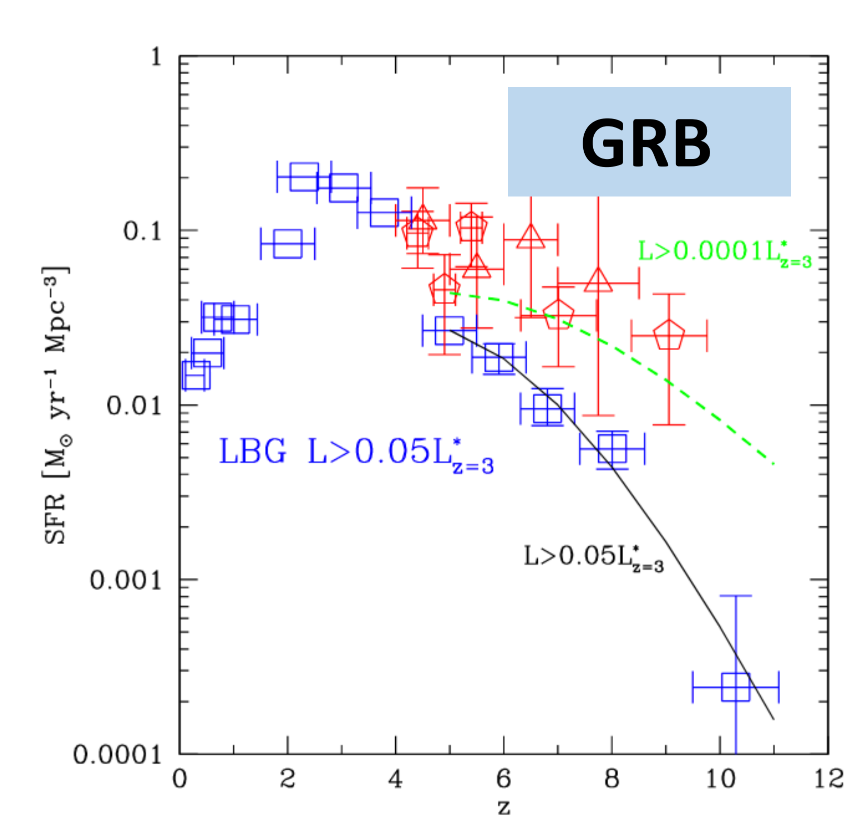
See also Bouwens et al. (2016)

WHAT WE KNOW

1. ***From Planck*** : at z≈7.5, 50% of HI is ionised
2. ***From LBG surveys*** : observable LBGs account for ≈50% of the required ionising flux

   ➔ other sources ? Less luminous LBGs ? AGN ?

The other candidates ?



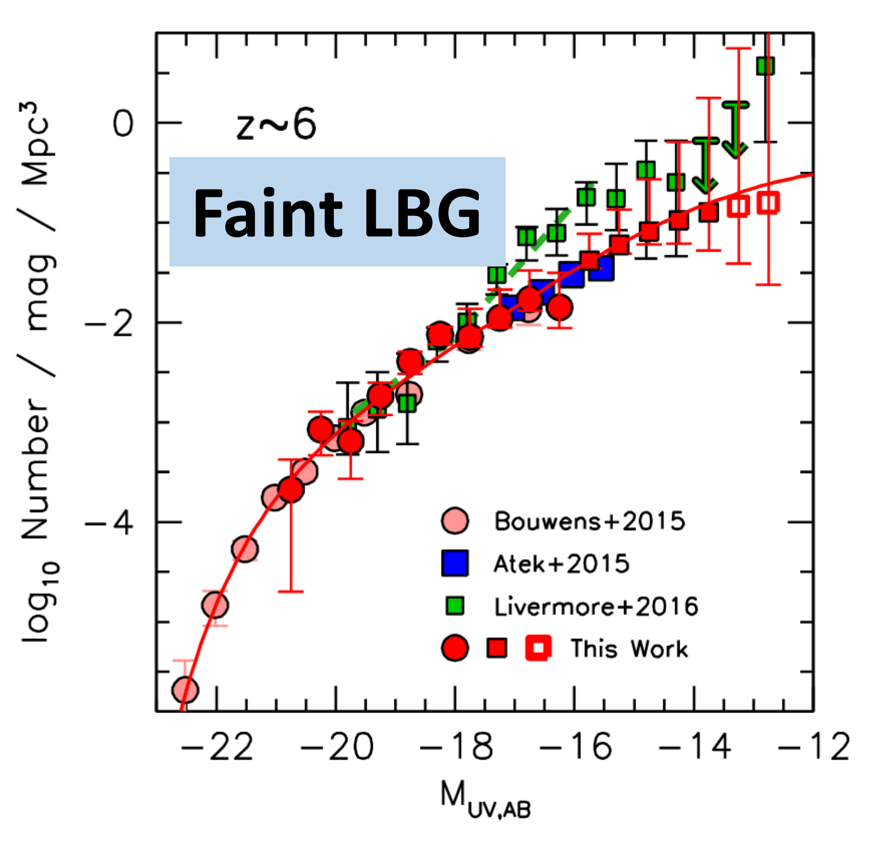
Trenti et al. (2012)

Based on the few GRBs detections at z>6, it seems that their contribution is not negligible.

Need more detections (eg. SVOM)

The faint LBGs may have a non-negligible contribution. But they are well below the limit of current telescopes

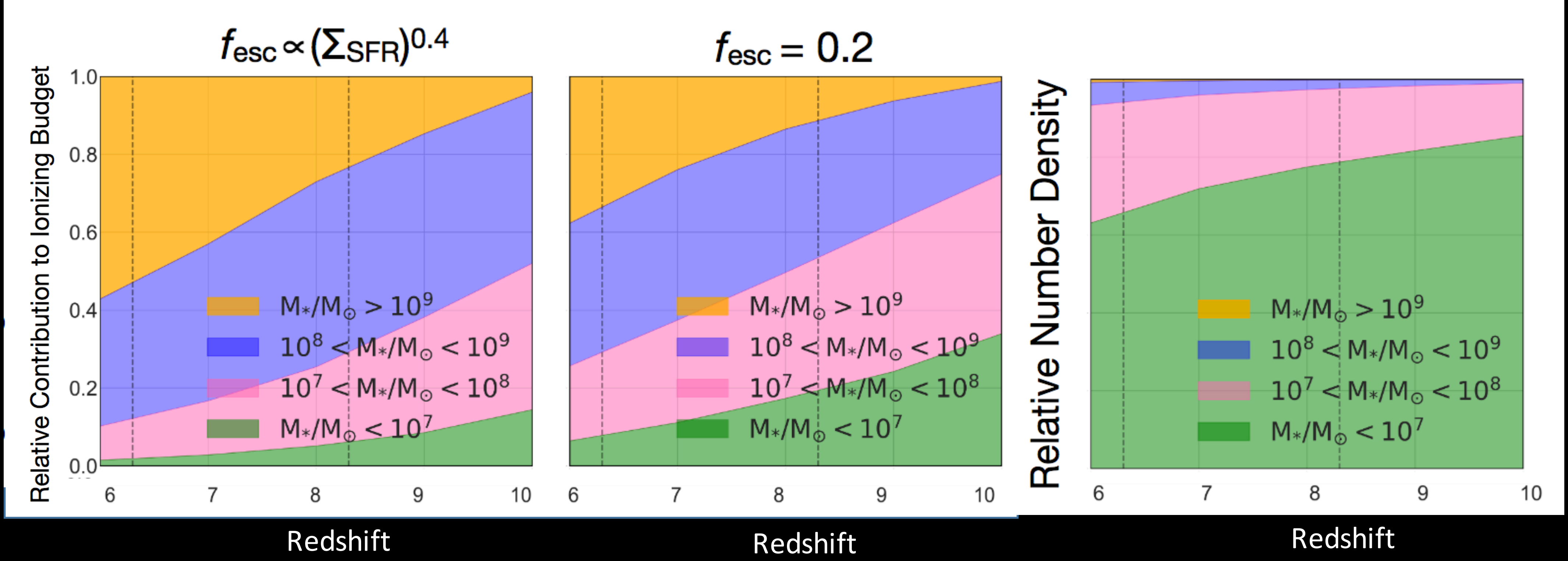
Need to constrain the faint-end of the UV LF (e.g. JWST)



Bouwens et al. (2017)

A major contribution from massive galaxies ?

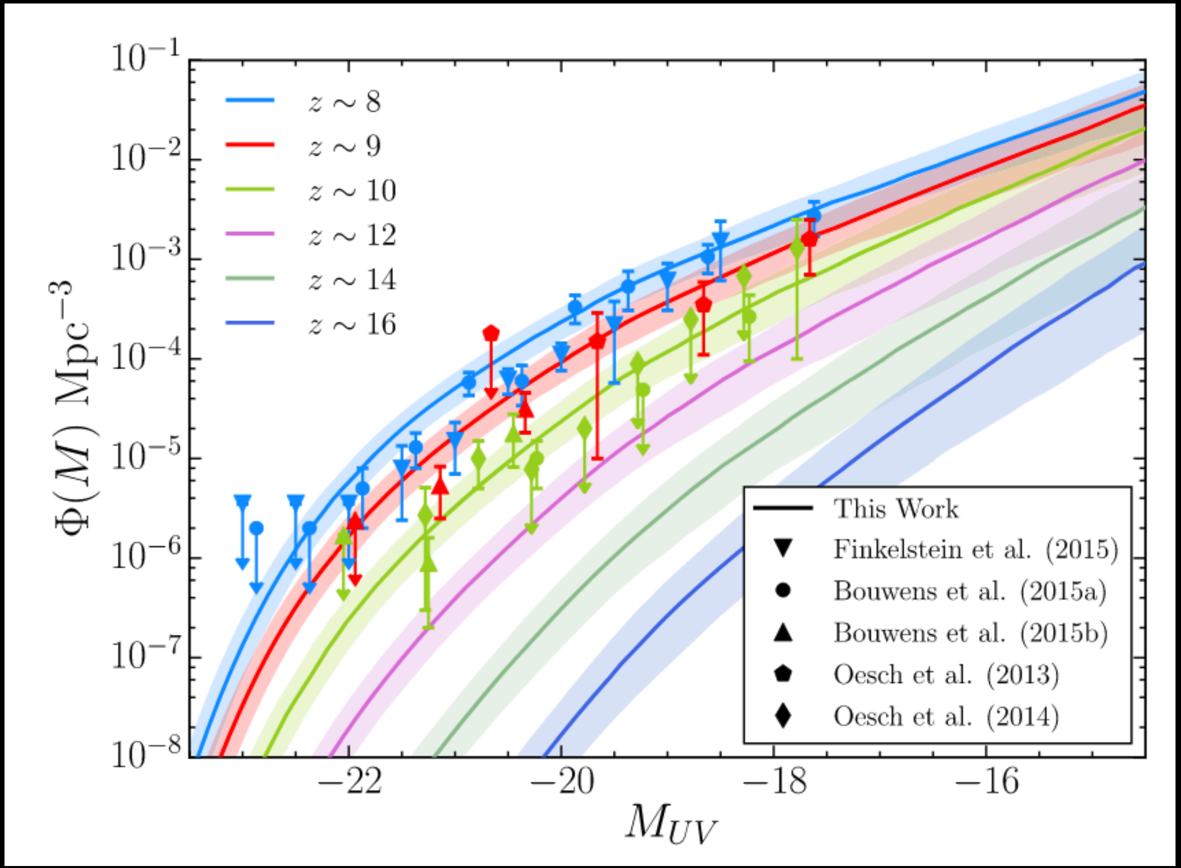
Naidu et al. (2019)



A recent high-resolution N-body, dark-matter simulation (Tacchella et al. 2018) aiming to match the rapid end to the reionisation (*see Richard's talk*) suggests that ≈80% of the reionisation budget comes from M_{UV}<-18 and M_*>$10^8 M_o$ (Naidu et al. 2019)

This population of sources only represents 5% of the total population of galaxies.

Massive galaxies hosting AGN activity at z>7 may be rare

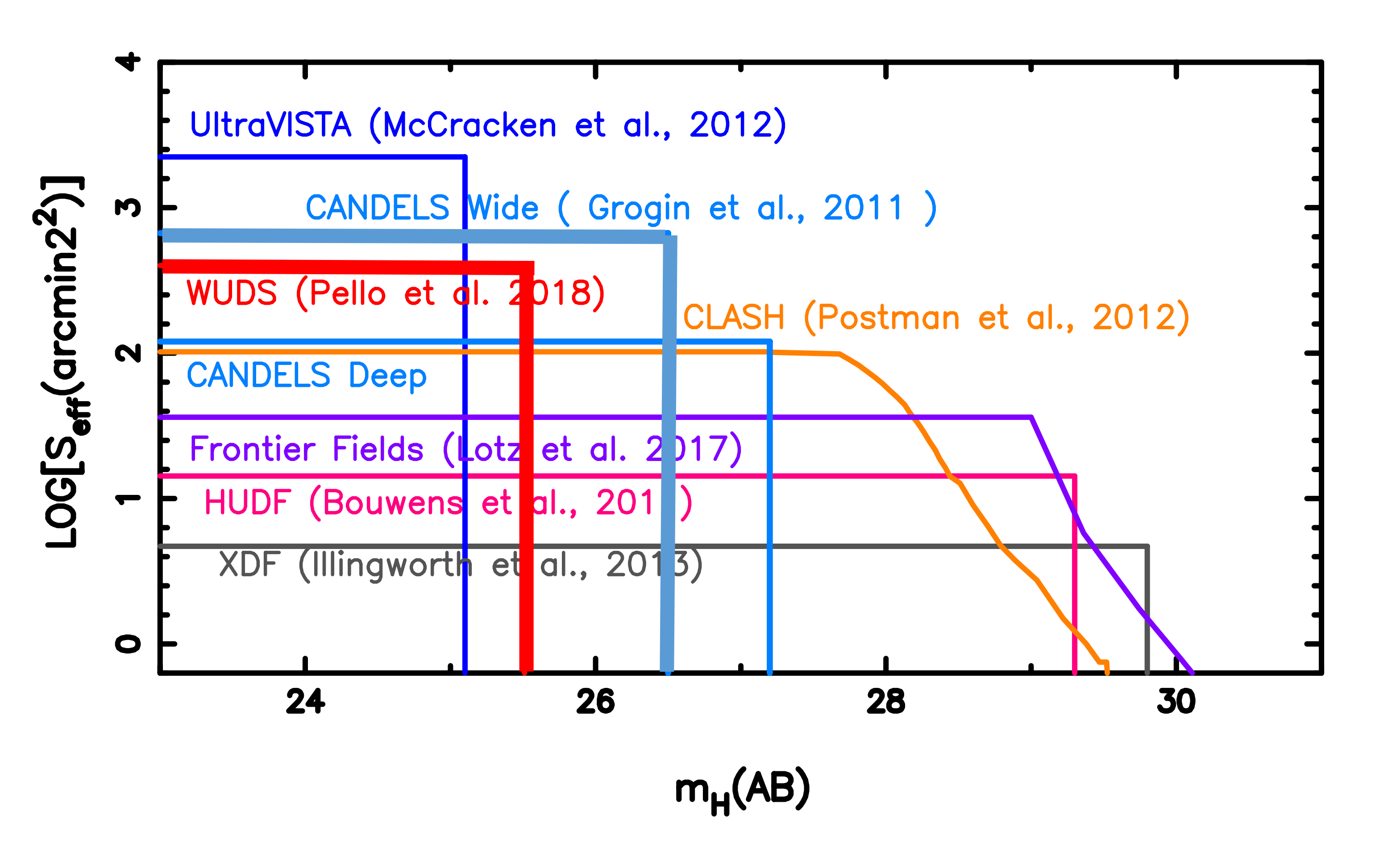


Mason et al. (2015)

- The most massive galaxies are expected to be the most luminous objects at a given redshift.
- They are also the best candidates to host AGN activity
- But as it is observed or expected by simulations, the density of massive objects is small at very high redshift.

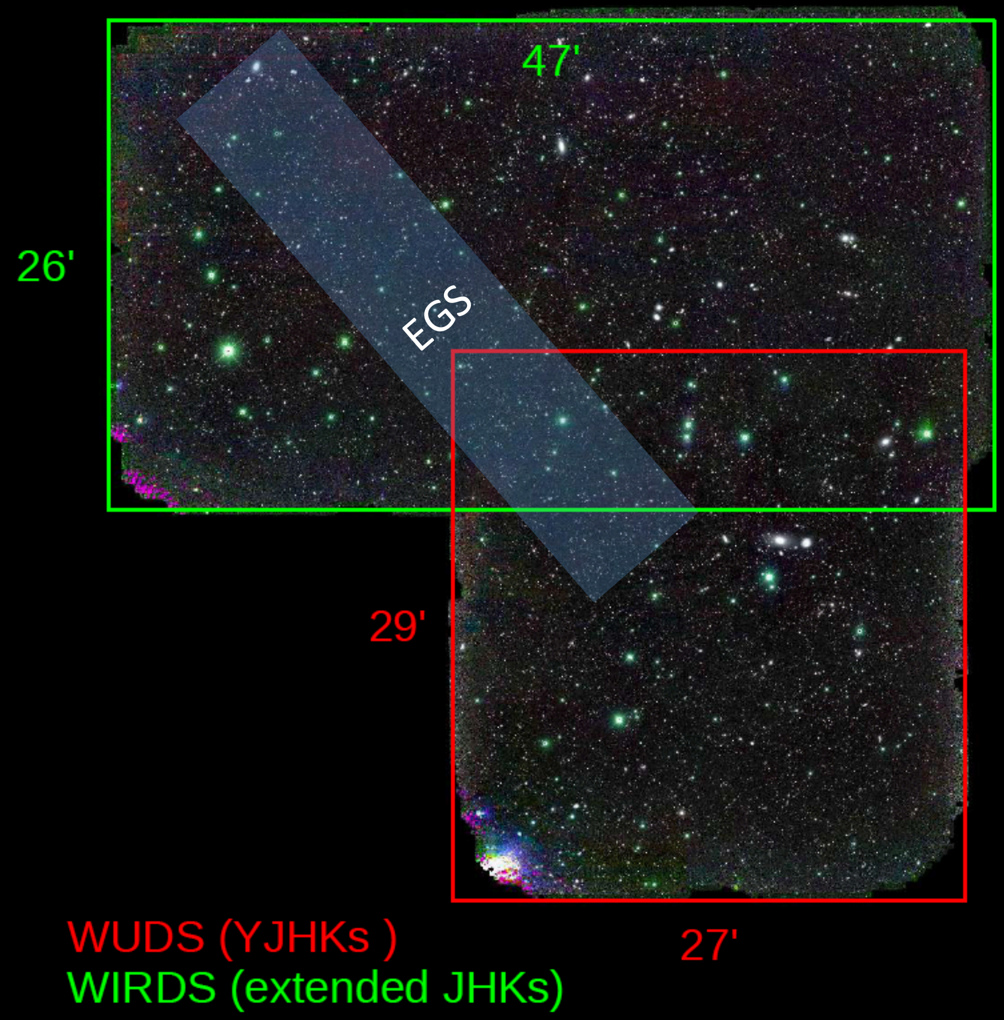
➔ According to simulations, one needs to cover a very large field of view to detect massive galaxies at z>6, which are the best candidates to host AGN.

Searching for AGN in wide deep field surveys



- CANDELS is one of the largest field in NIR, with deep data at optical wavelength.
- The recent WIRCam Ultra Deep Survey (Pelló et al. 2018) is another interesting field to search for massive galaxies at z>6

An brief introduction to the WUDS survey



Pelló , NL et al. (2018)

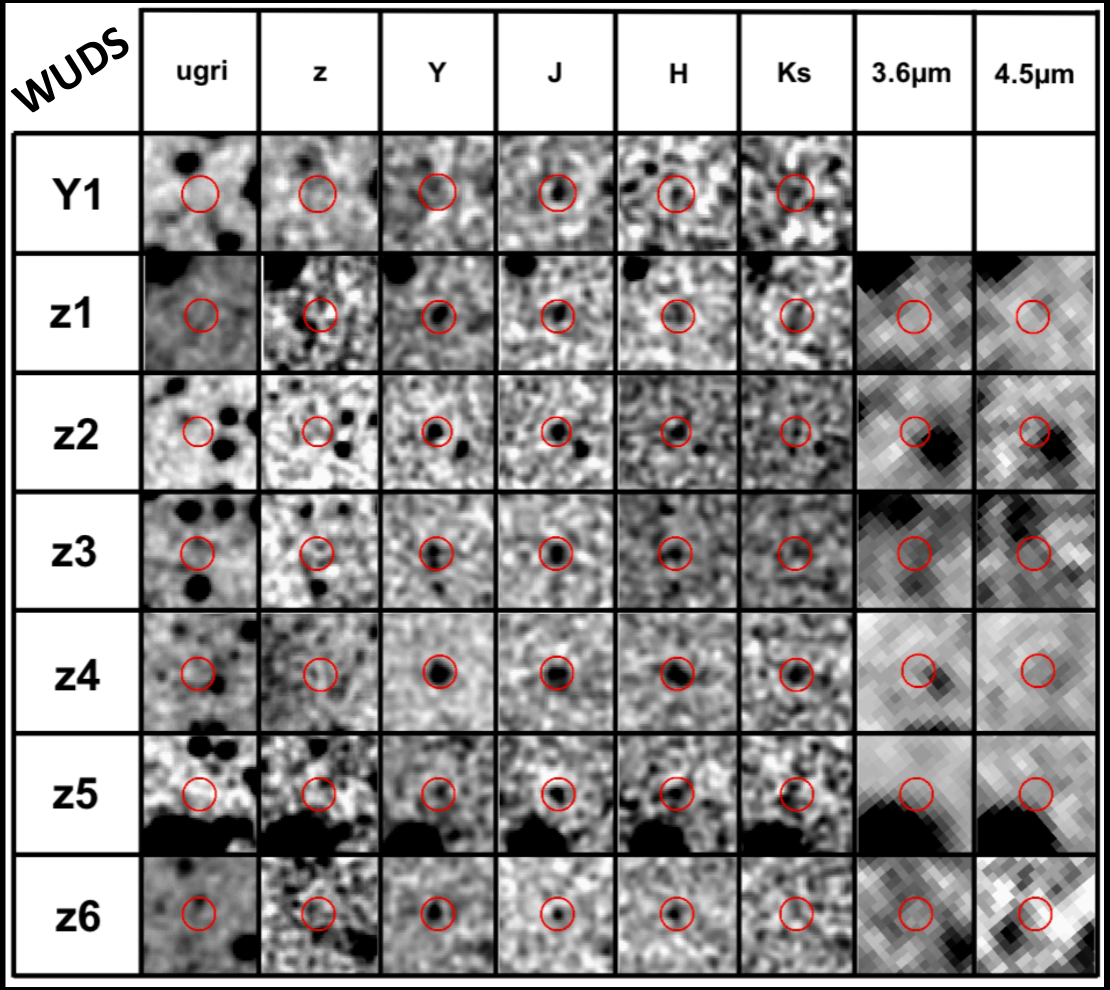
- 50hrs WIRCAM/CFHT in Y-,J-,H- and Ks bands
- Optical data from the CFHT-LS

- 5σ depths : 26.5 AB (Y) ; 26.1 (J) ; 25.5 (H, Ks)
- Effective surface : 400 arcmin^2

- Reduced data available at : http://wuds.irap.omp.eu/

- Expected number of M_{UV} < -20 : 9 at z>7.5

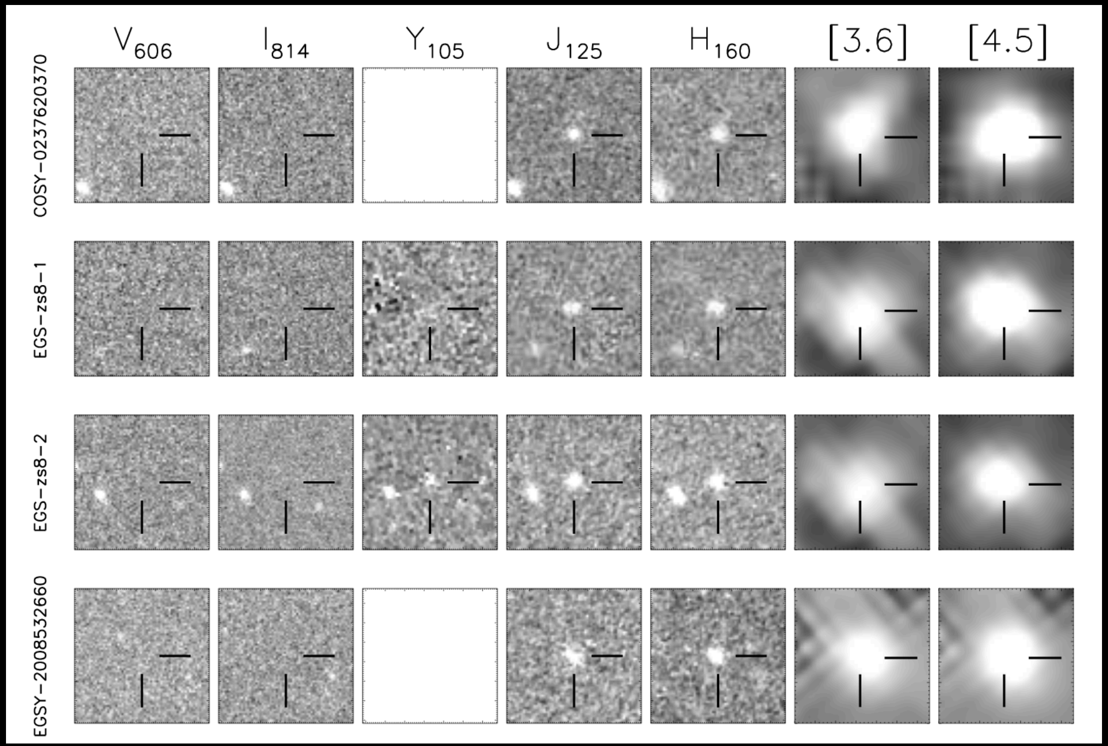
Overview of the selected z> 7 sample



Laporte et al. (sub.)

H-band : 24.3 – 25.6 AB

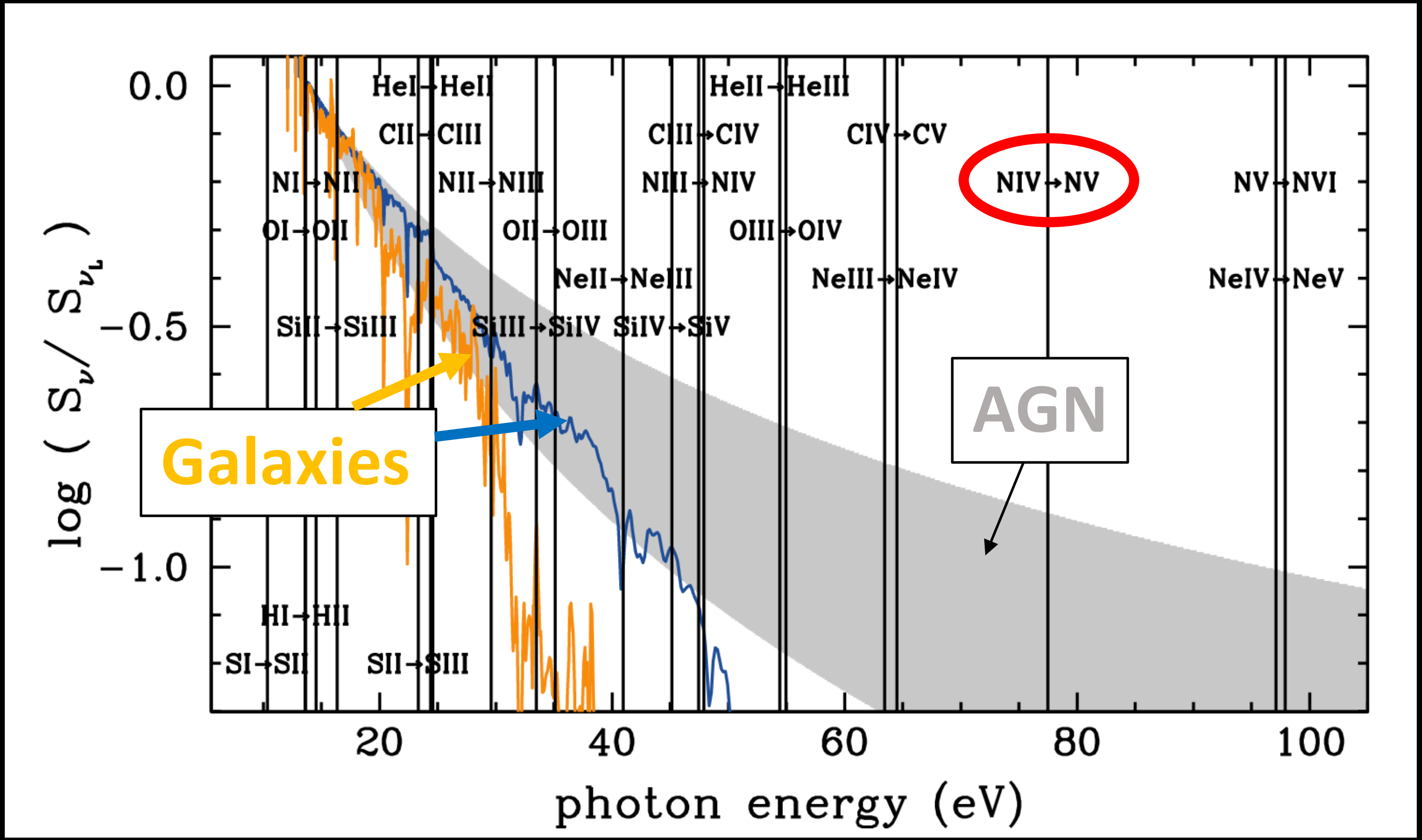
Roberts-Borsani et al. (2016)



H-band : 25.0– 25.3 AB

These are the brightest galaxies in the WUDS and CANDELS surveys, they are therefore excellent candidates for hosting AGN

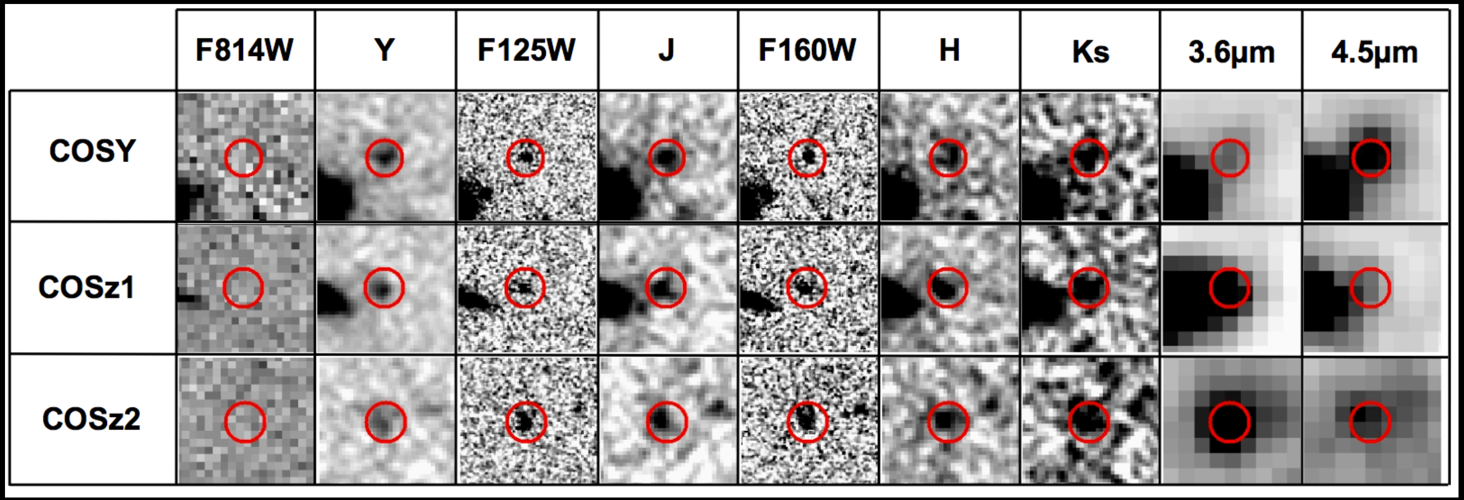
NIR spectroscopic follow-up to confirm the *AGN nature* of these massive galaxies



Feltre et al. (2016)

- The species requiring ionisation energies greater than 50eV are the most promising indicators of the presence of an AGN.
- The hardness of the "AGN" radiation field permits Nitrogen to be quadruply ionised (NV)
- This line is difficult to reconcile with star-forming galaxy radiation field.

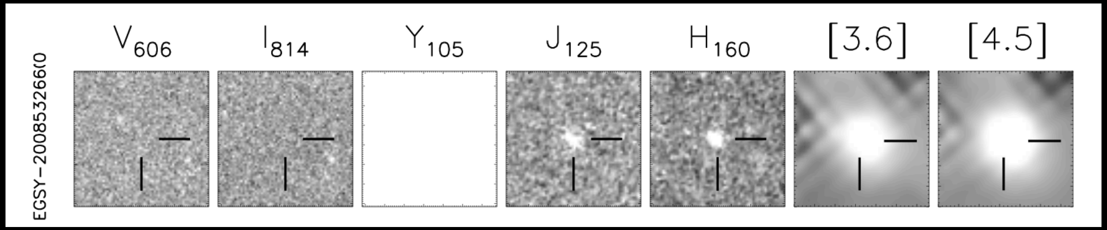
A survey of massive z>7 galaxies for AGN activity



No Ly-α,
but CIII at z=6.85

Broad Ly-α
at z=6.82

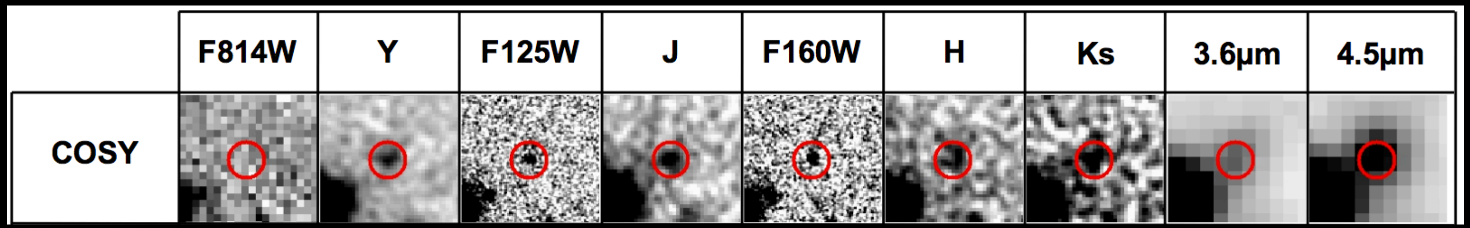
Redshift also confirmed with the detection of [CII]158μm (Smit et al. 2018)



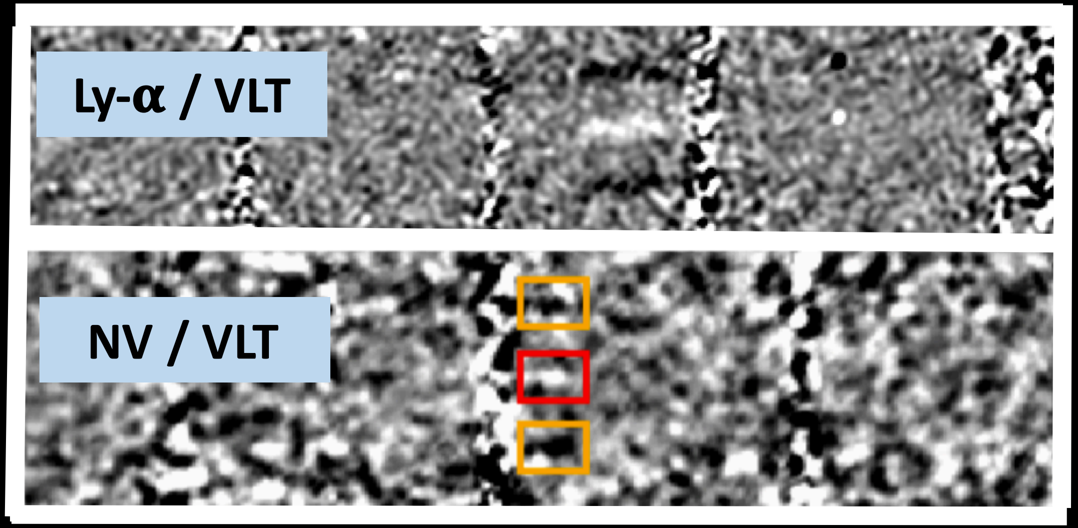
- 50hrs program with XSHOOTER/VLT (097.A-0043, PI: R. Ellis)
- 3 targets : the brightest targets selected in CANDELS (COSMOS field)

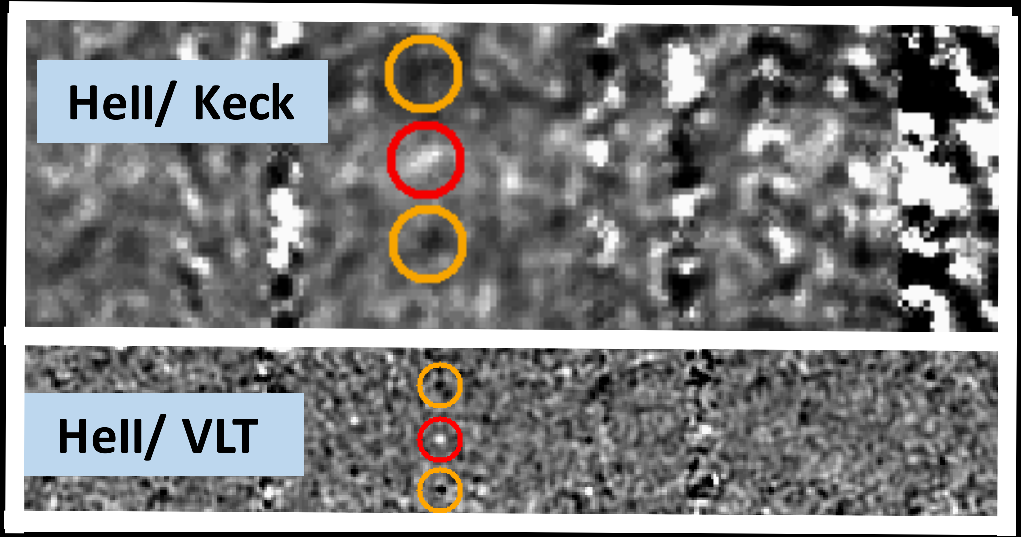
- 5hrs on MOSFIRE/Keck
- 1 target selected in CANDELS (EGS field)

Strong case for an AGN at z≈7.15



- 11h20 on source
- 3 emission lines : Ly-a (8σ), NV(5σ) and HeII (4σ)
- HeII line confirmed by MOSFIRE/Keck observations
- ΔLy-a≈290 km/s

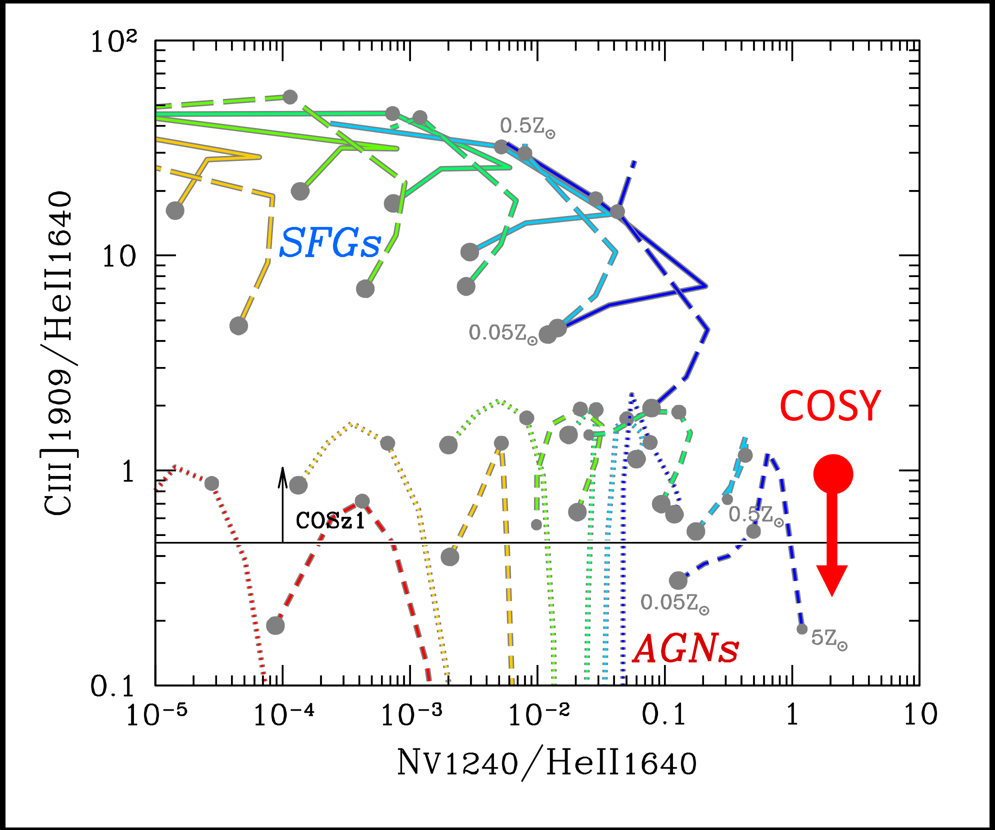




- No detection on Chandra data (X-ray)
- Redshift consistent with [CII] detection (Pentericci et al. 2016)

Laporte et al. (2017)

Photoionization modeling



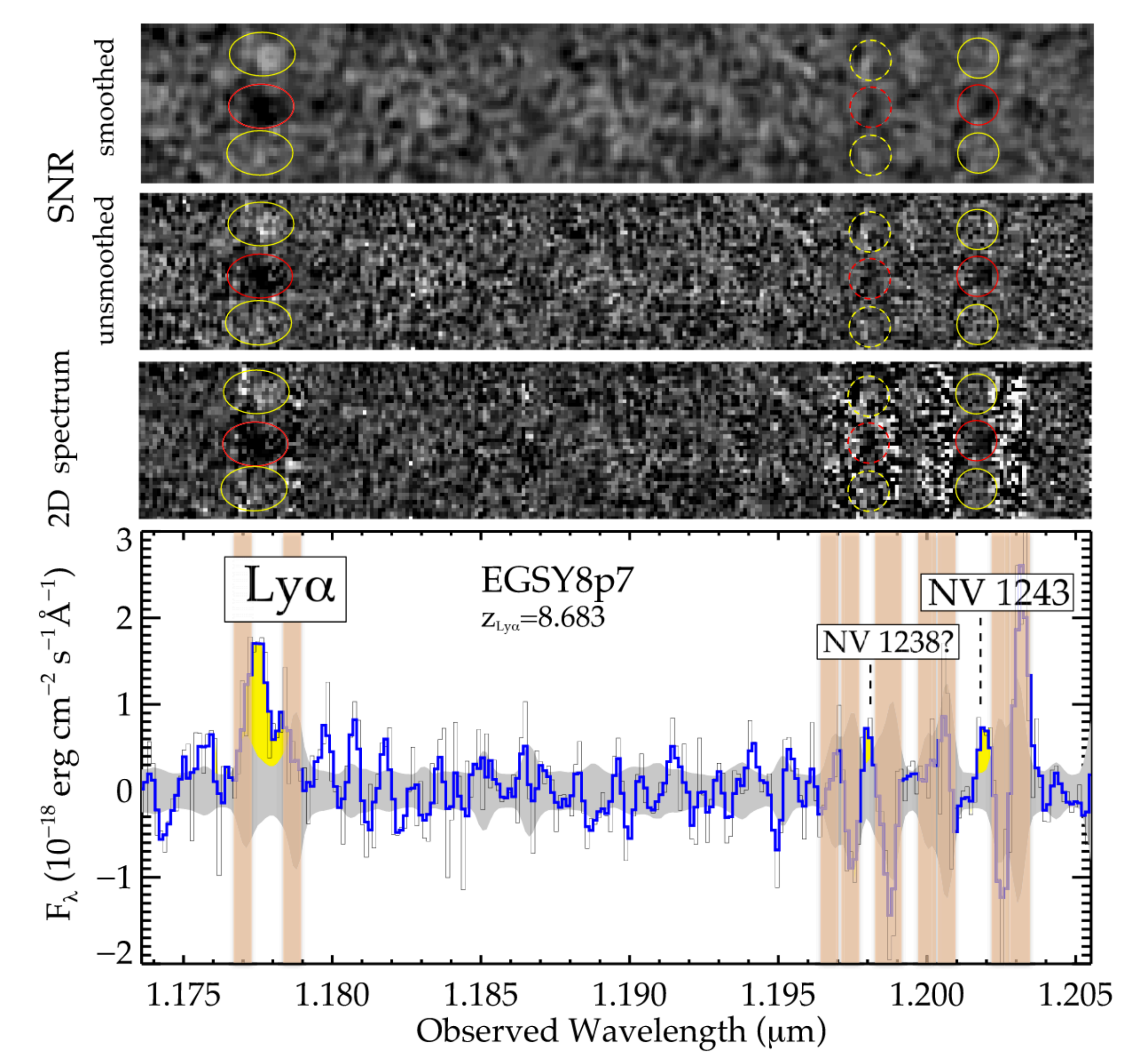
Laporte et al. (2017)

We used photoionization models (Nakajima et al. 2017) to determine the nature of this z=7.15 object.

The fluxes ratios we measured using NV, HeII and CIII emission lines are irreconcilable with a normal star forming radiation field.

In the two other COSMOS targeted objects we found no evidence for AGN activity.

Tentative evidence for AGN activity at z=8.68 ?

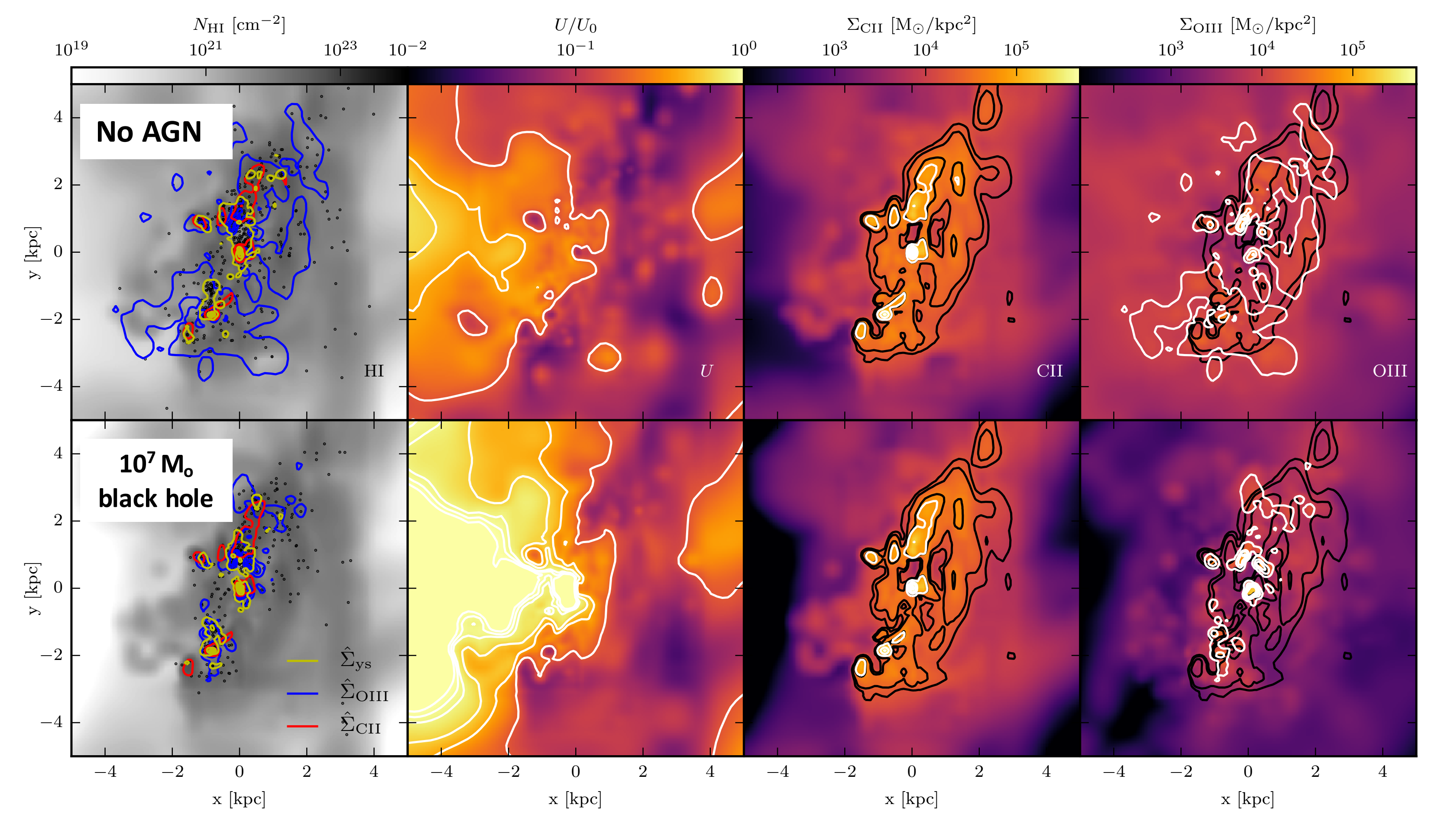


- 5 hrs on source with MOSFIRE Keck
- 2 emission lines : Ly-a (8σ) and NV(5σ)
- ΔLy-a≈360 km/s

- The absence of other emission lines (HeII, CIV, CIII) makes the situation less conclusive
- Other data are needed to determine the nature of this object.

Mainali, ..,NL et al. (2018)

Confirming the AGN nature with ALMA



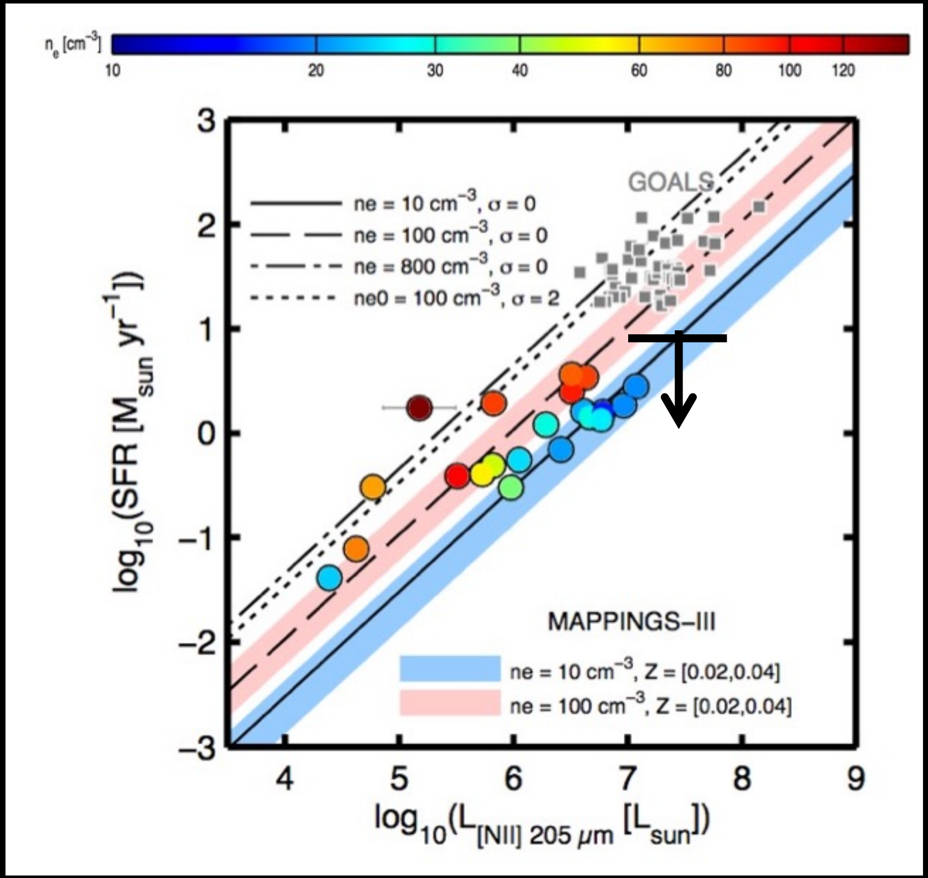
Hydrodynamics simulations show that the presence of an AGN at very high redshift changes the distribution of OIII]88µm.

In an AGN at very high redshift, the distribution of OIII]88 µm is narrower compared to what is observed without AGN.

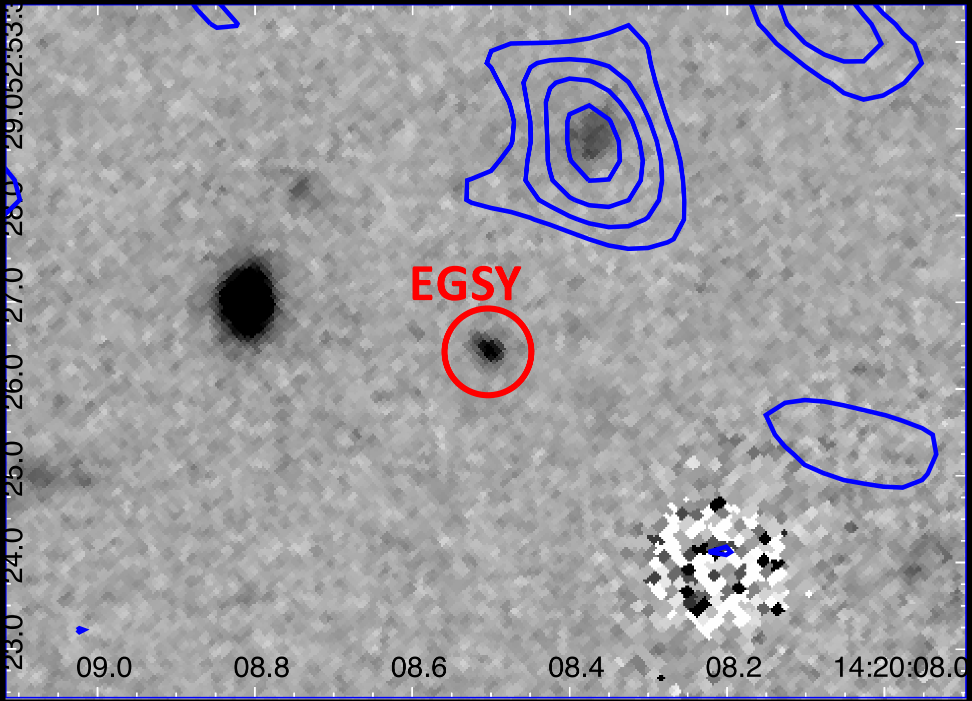
The CII]158 µm distribution is not affected by the presence or not of a central black hole.

Katz et al. (in prep)

Sub-mm observation of the z=8.68 AGN candidate : absence of dust and [NII]205µm



Herrera-Camus et al. (2016)



Laporte et al. (in prep)

- 11hrs on source
- Winter 2018 (PI: Laporte)

- RMS on line : 0.3mJy/beam
- RMS on dust : 20µJy/beam

M_{dust} (2σ) < 2x10^6 M$_\odot$

L_{NII} (2σ) < 1.5x10^7 L$_\odot$

The absence of dust, as well as the absence of NII]205µm challenge the AGN hypothesis, but more data are clearly needed.

Summary and Conclusions

- The observable LBGs account for 50% of the photons budget required to the reionisation
- Among other reionising sources, AGN are expected to play a non-negligible role.
- To study AGN contribution, one can search for the most massive objects in large deep blank fields
- We used two deep surveys to search for AGN : CANDELS and WUDS

- We selected 11 objects at z>7
- NIR Spectroscopic follow-up of 4 of them suggests that 2 may host AGN
- The absence of dust and the non-detection of [NII]205µm in one of them may challenge this hypothesis.
- More AGN candidates are clearly needed to improve the constraints on their contribution to reionisation.