ELT Observations of the Cosmic Dawn

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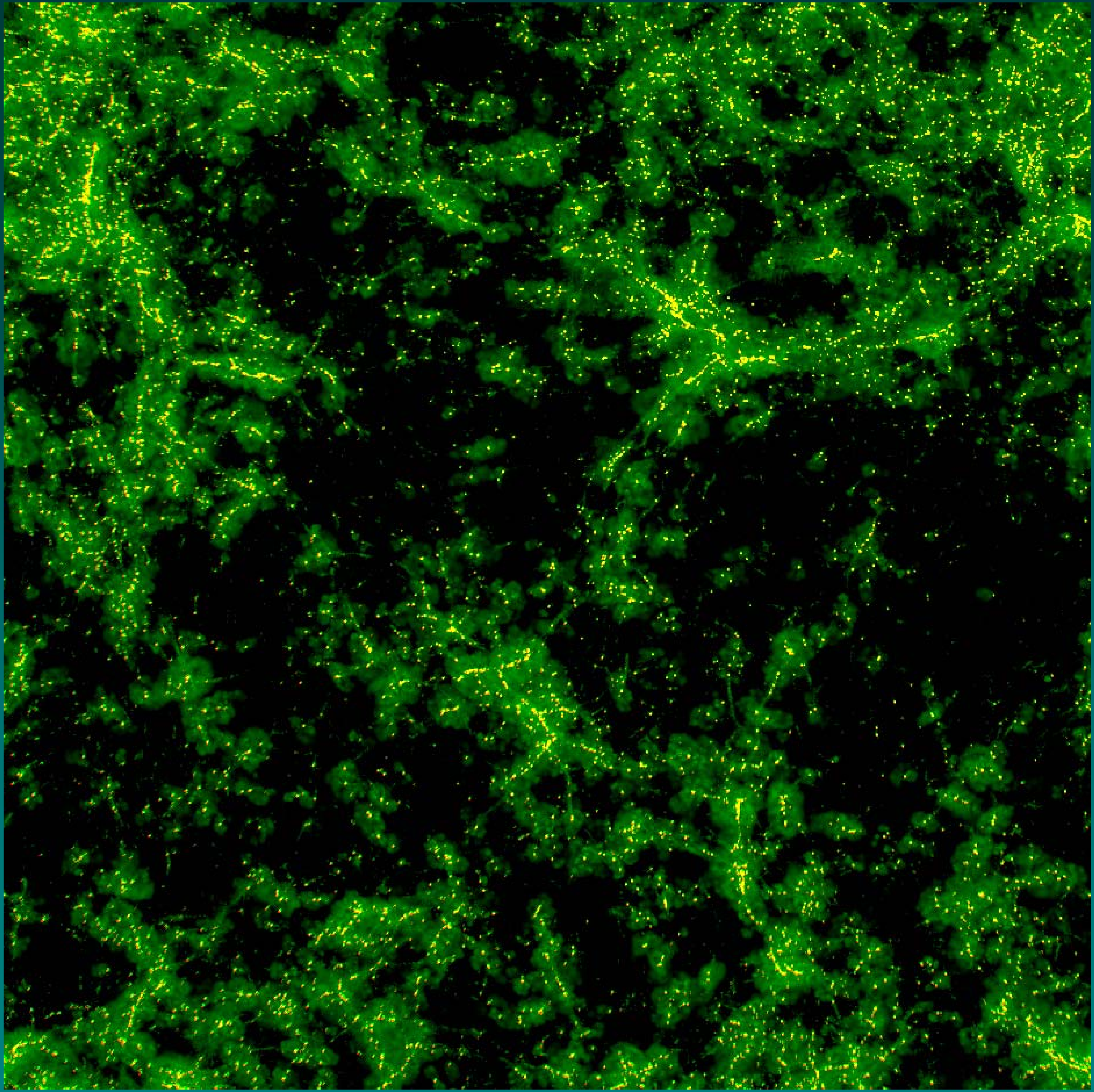
Re-ionization History of the Universe

- Epoch of reionization marks a phase transition in the universe
- WMAP polarisation measurements put first ionizing objects at $z>15$ (Spergel et al 2003) at the end of the “dark ages”
- Gunn-Peterson trough in high-z QSOs demonstrate that this process was not complete until $z\sim6$
- Epoch $7<z<15$ is the “cosmic dawn”

The z=10 Universe

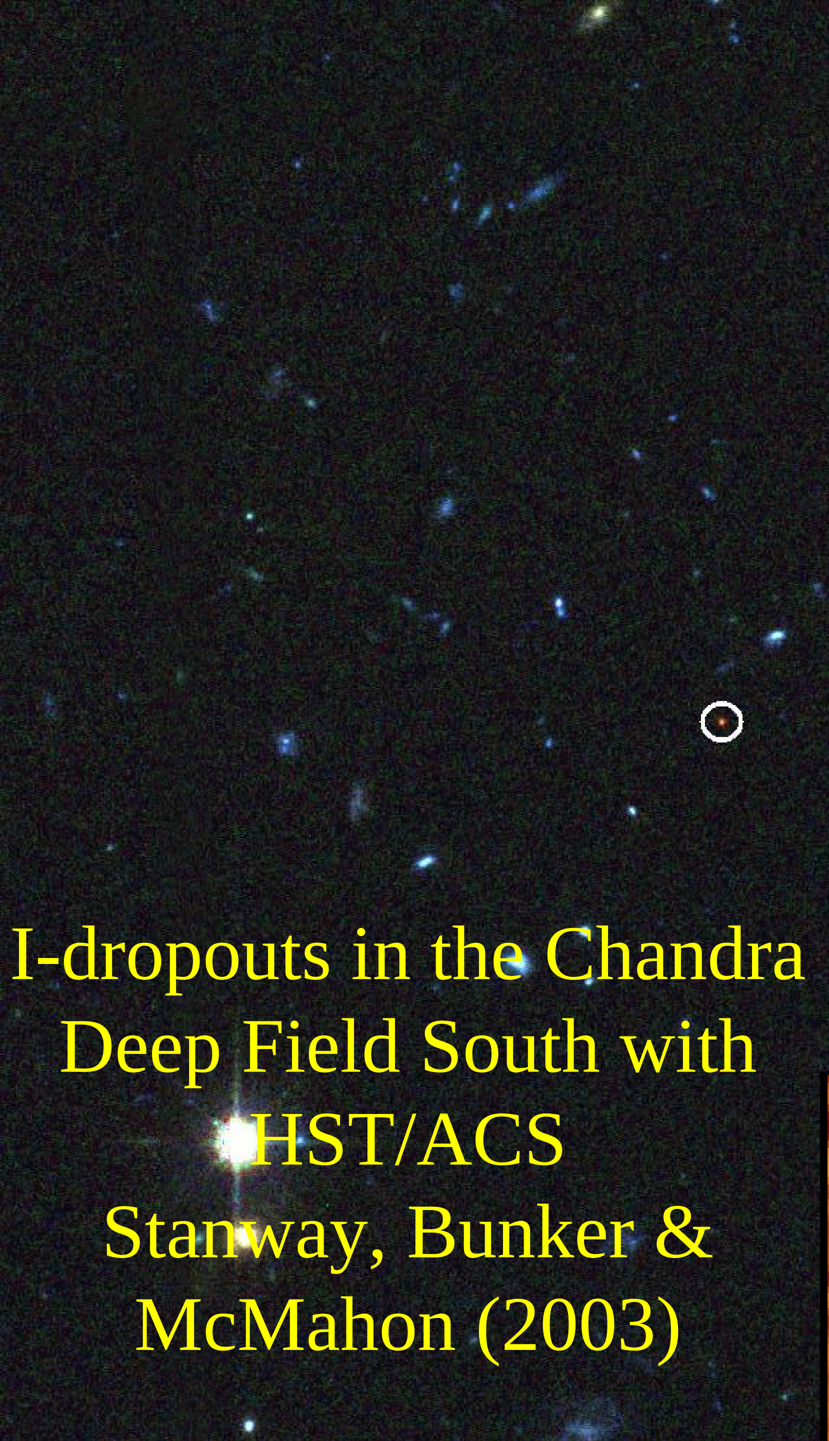
Springel & Hernquist

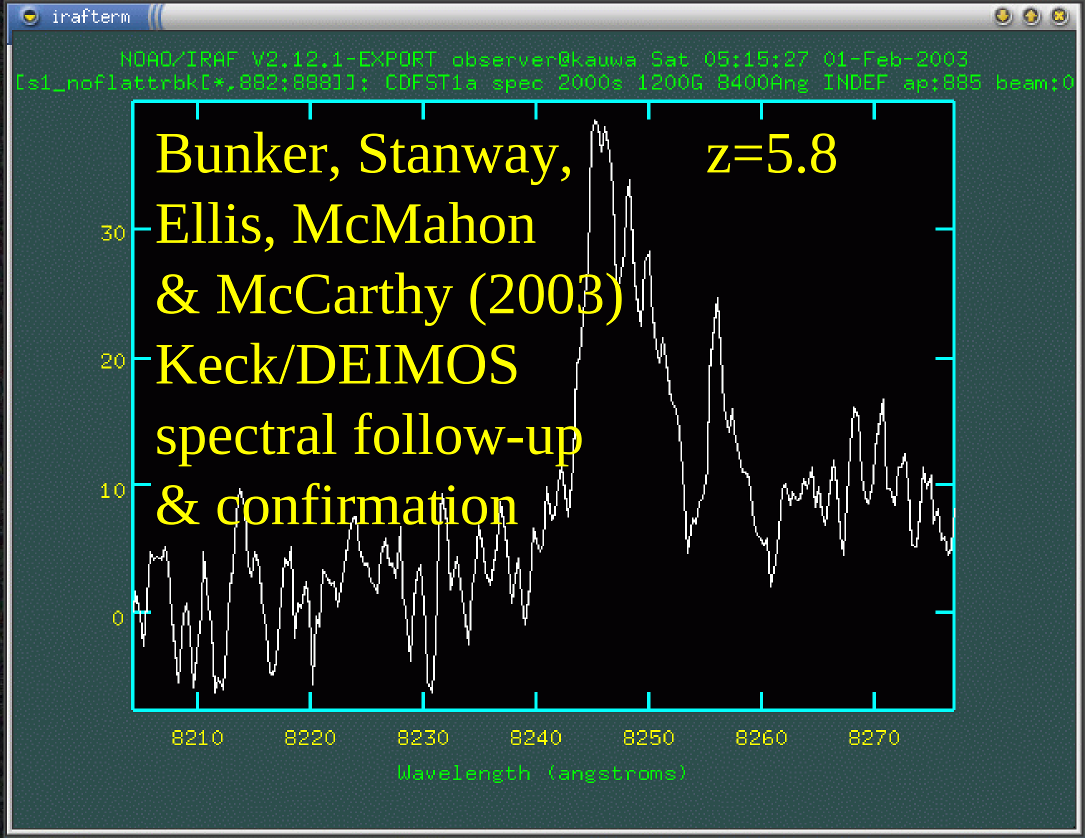
Lyman-α:
Green = IGM cooling
Yellow = stars

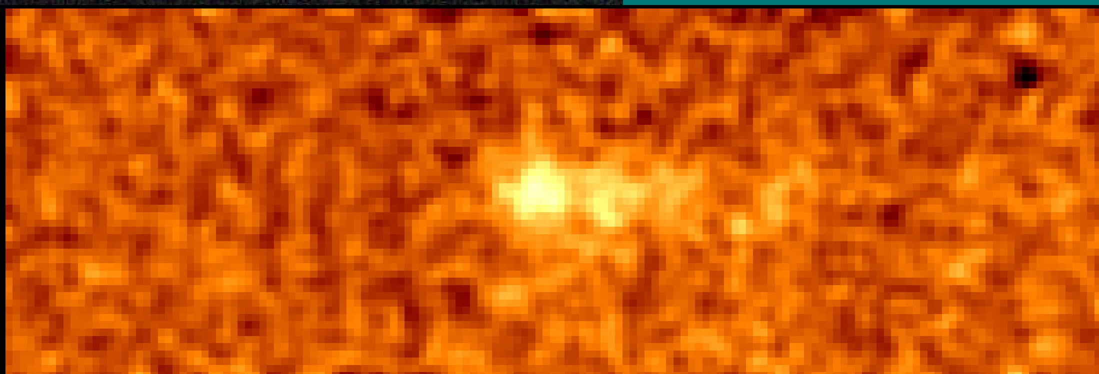


Probing the Cosmic Dawn Using High-z Lyman-α Emitters

- Independent probe of the ionization state of the IGM
- Complementary to tomographic probes of the IGM using QSOs/GRBs
- Census of the entire baryonic component of the universe at this epoch
- Probe galaxy formation/IGM energetics and metal enrichment
- Observe first sub-galactic components predicted by hierarchical models of galaxy formation



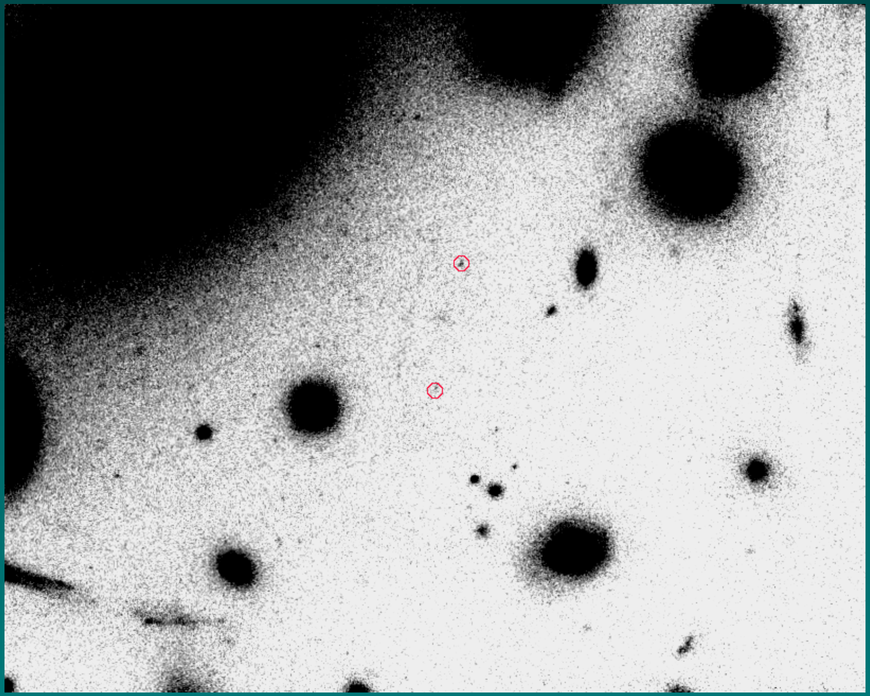


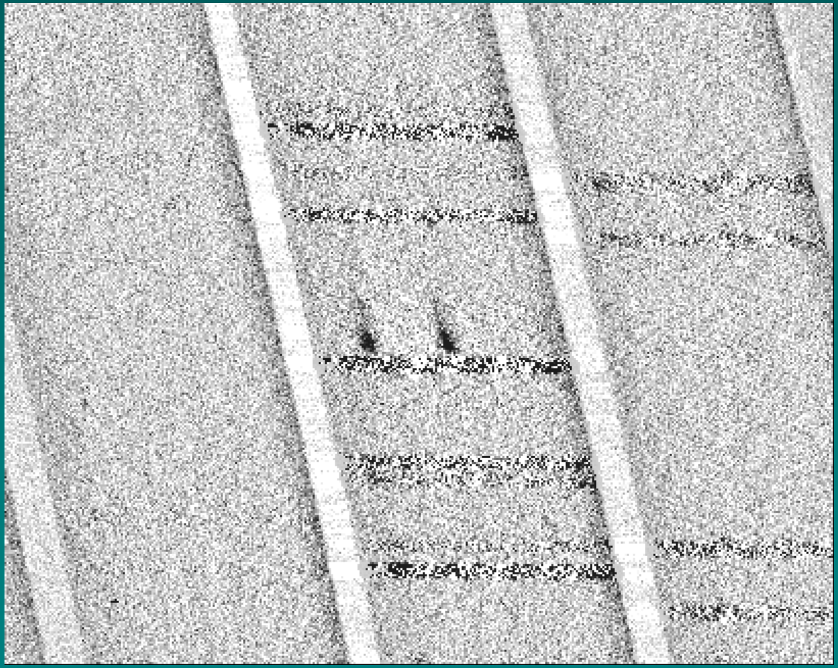


I-dropouts in the Chandra Deep Field South with HST/ACS

Stanway, Bunker & McMahon (2003)

High-z Lyman-α Emitters

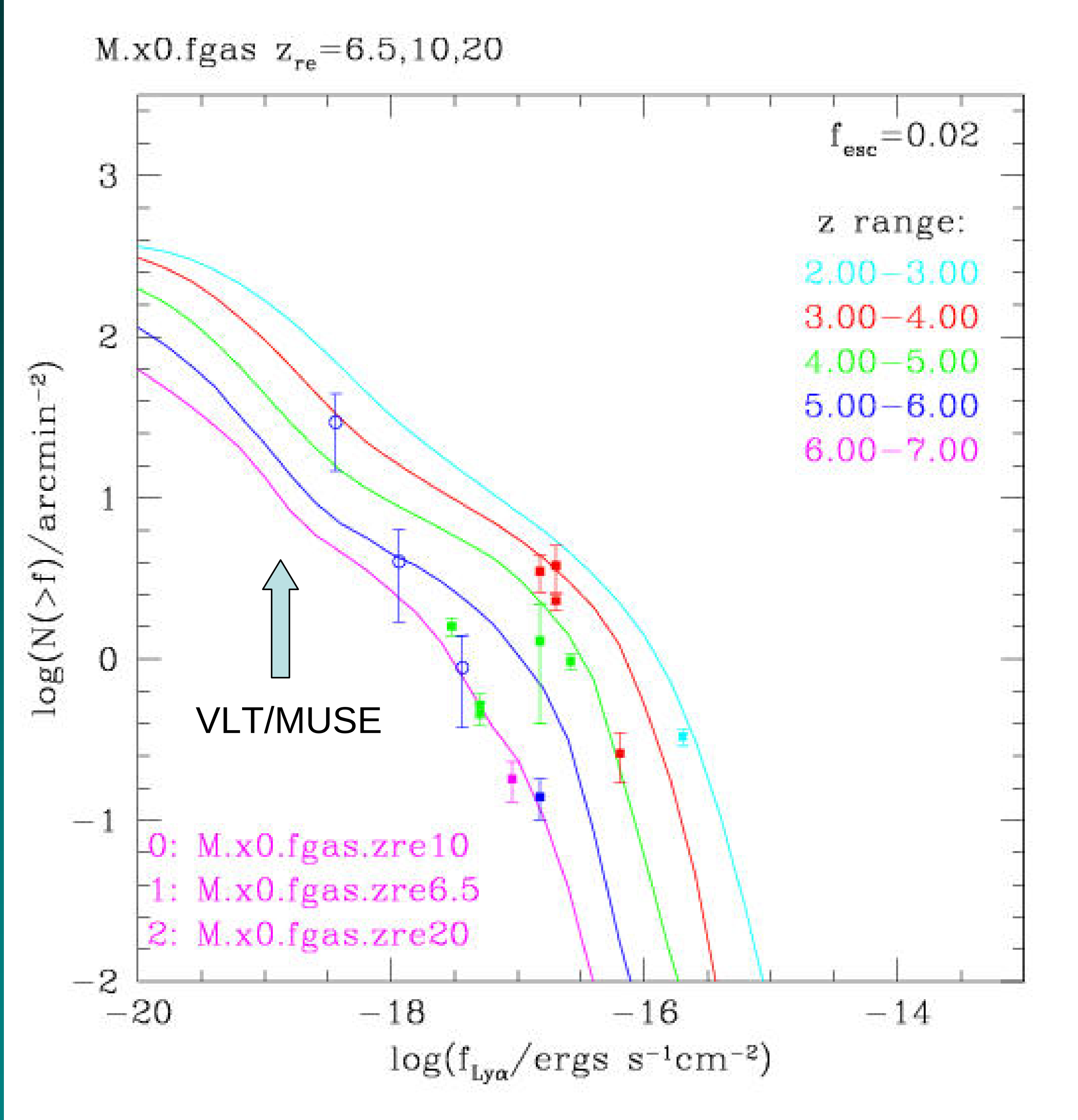




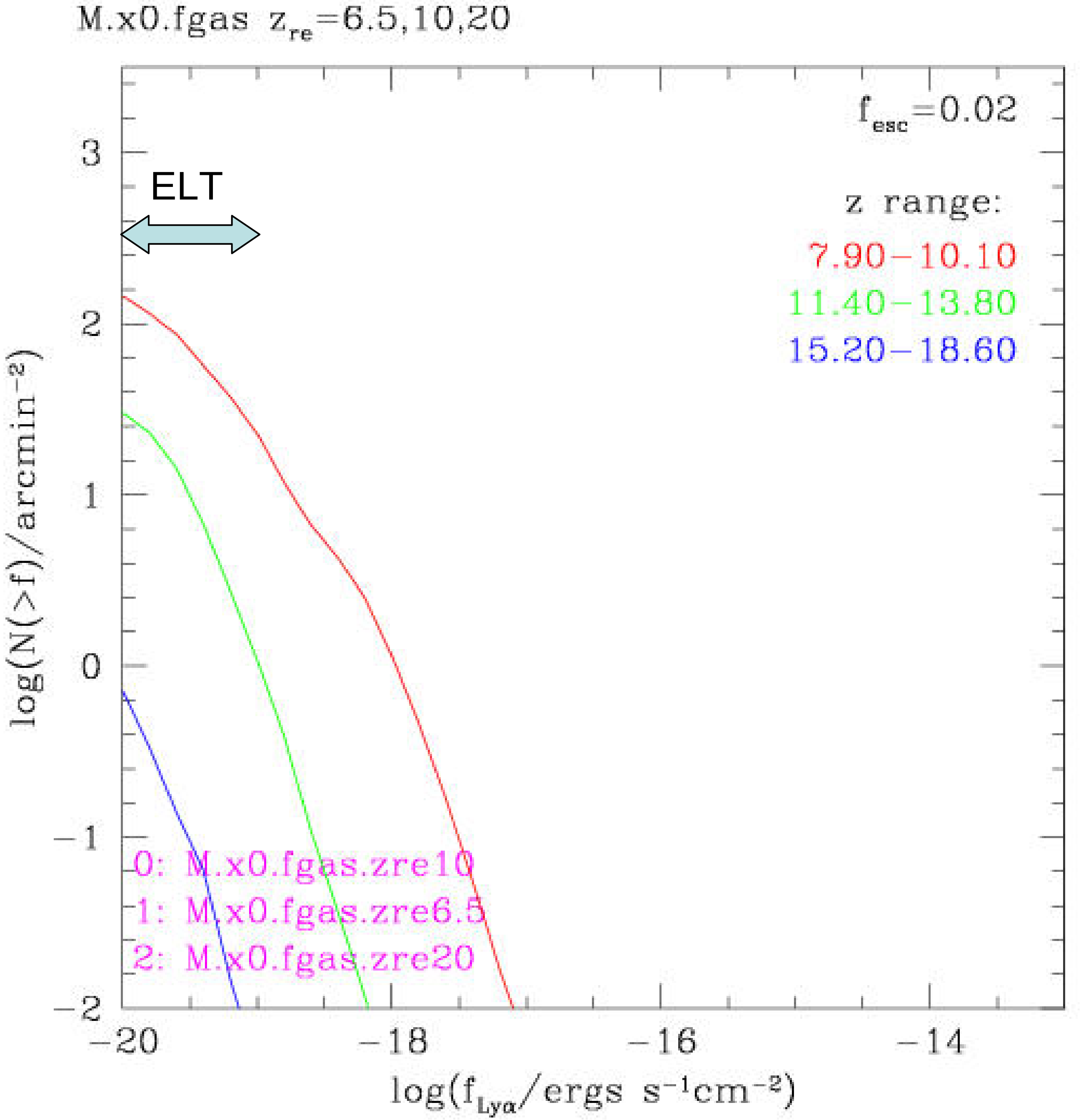
Ellis et al. z=5.6 lensed Lyman Alpha emitters
Brighter object observed I=26, lensed by factor ~33

How many sources ?

- GALFORM Predictions for Lyα Number Counts
- Semi-analytic model for galaxy formation (Baugh et al 2004)
- Concensus cosmology
- Formalism includes mergers and feedback
- Model successfully reproduces galaxy LF over a wide range of redshifts and wavebands (inc sub-mm)
- Very simple Lyman-α modelling
  - assume all stellar Lyman continuum absorbed
  - assume 2% of Lyα from recombination escapes (escape fraction tuned to match observations at z~3 and flux of 2×10^{-17} (ergs cm^{-2} s^{-1})
- Typical hosts ~10^8 M_{Sun}, nano-Jy (m_{AB}>31) objects at z>10! ~few 100 pc in size (~ 30m diffraction limit at 2μm)



Le Delliou et al (astro-ph/ 0405304)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f_esc=0.02
ELT
z range:
7.90−10.10
11.40−13.80
15.20−18.60
0: M.x0.fgas.zre10
1: M.x0.fgas.zre6.5
2: M.x0.fgas.zre20
log(N(>f)/arcmin^-2)
log(f_Lyα/ergs s^-1cm^-2)
3
2
1
0
−1
−2
−20
−18
−16
−14

Conclusions

- ELT observations of Lyman-α emitters at z>7 can probe the cosmic dawn when proto-galaxies emerge from the dark ages
- Requires large collecting area, near-IR integral-field spectroscopy and/or narrow band imaging and near-IR MOS
- Observe line fluxes, line profiles, sizes, clustering, continuum fluxes
- Complementary studies to JWST, LOFAR, ALMA