The Grism Lens-Amplified Survey from Space (GLASS)

Lyα Emitters at the Epoch of Reionization

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The GLASS Team

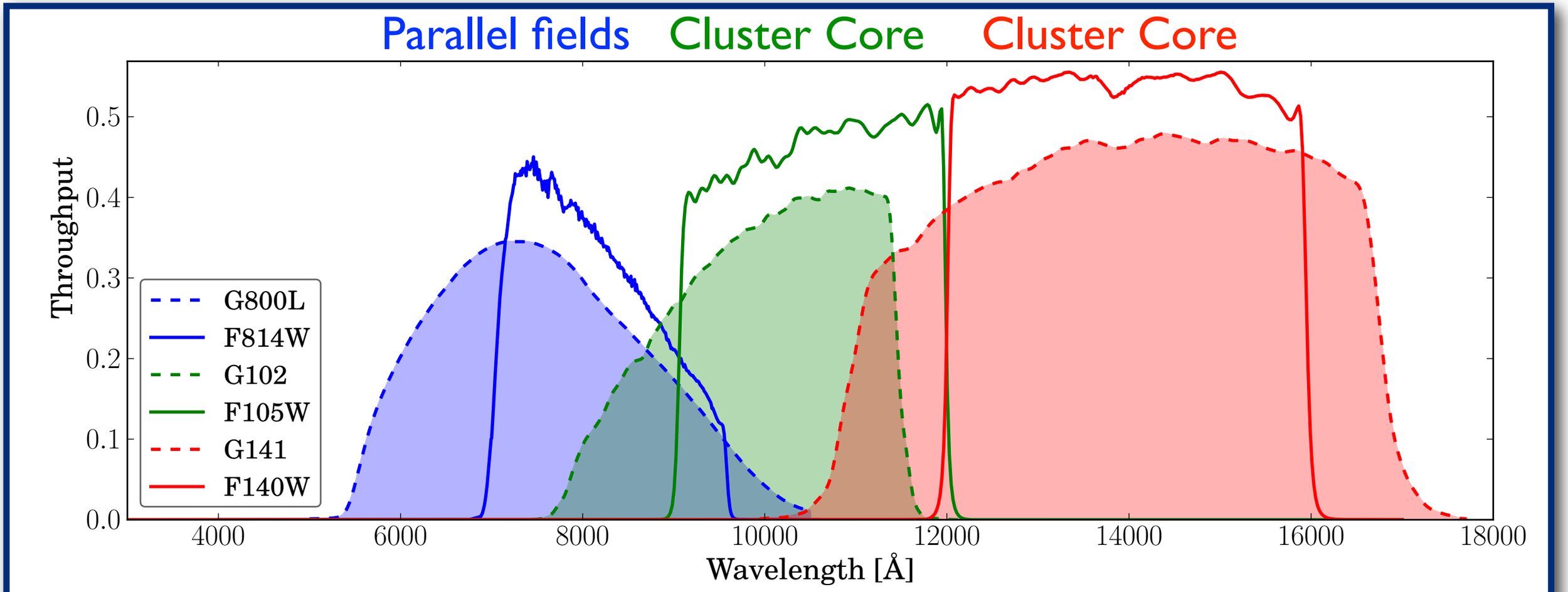
GLASS : Main Science Drivers

- P.I. Tommaso Treu (UCLA) **glass.physics.ucsb.edu**
- HST Grism Spectroscopy of 10 massive clusters
  - Incl. the 6 Hubble Frontier Fields & 8 CLASH Clusters

- Investigate the gas and galaxies at the EoR
  - 2nd part of this talk
- Assess the environmental dependence on galaxy evolution (Vulcani+in prep.)
- Describe how metals cycle in and out of galaxies (Jones+2015)
- SN searches in the HFF; e.g. SN Refsdal (Kelly+2015)

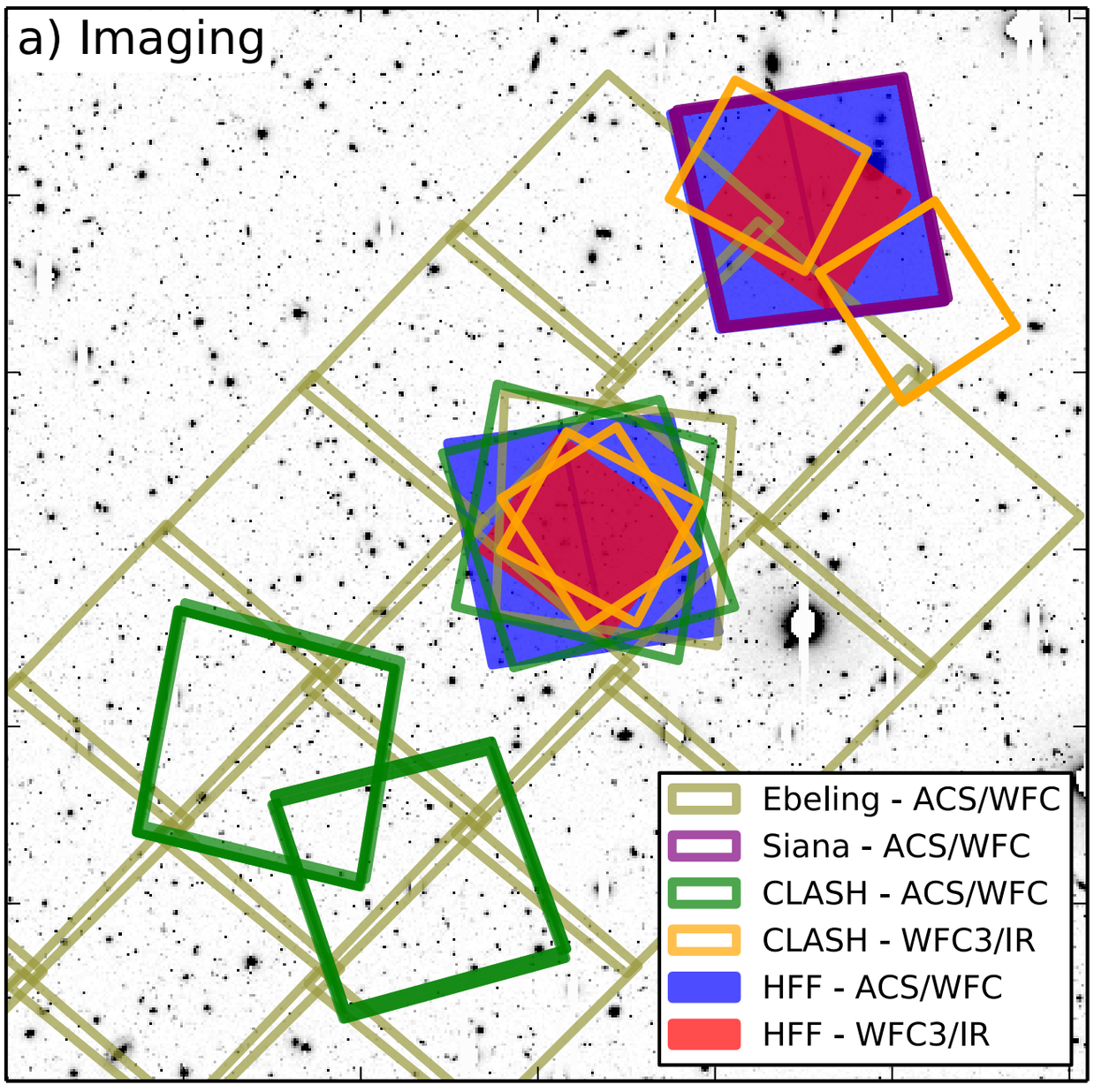
GLASS : Bands and Wavelength

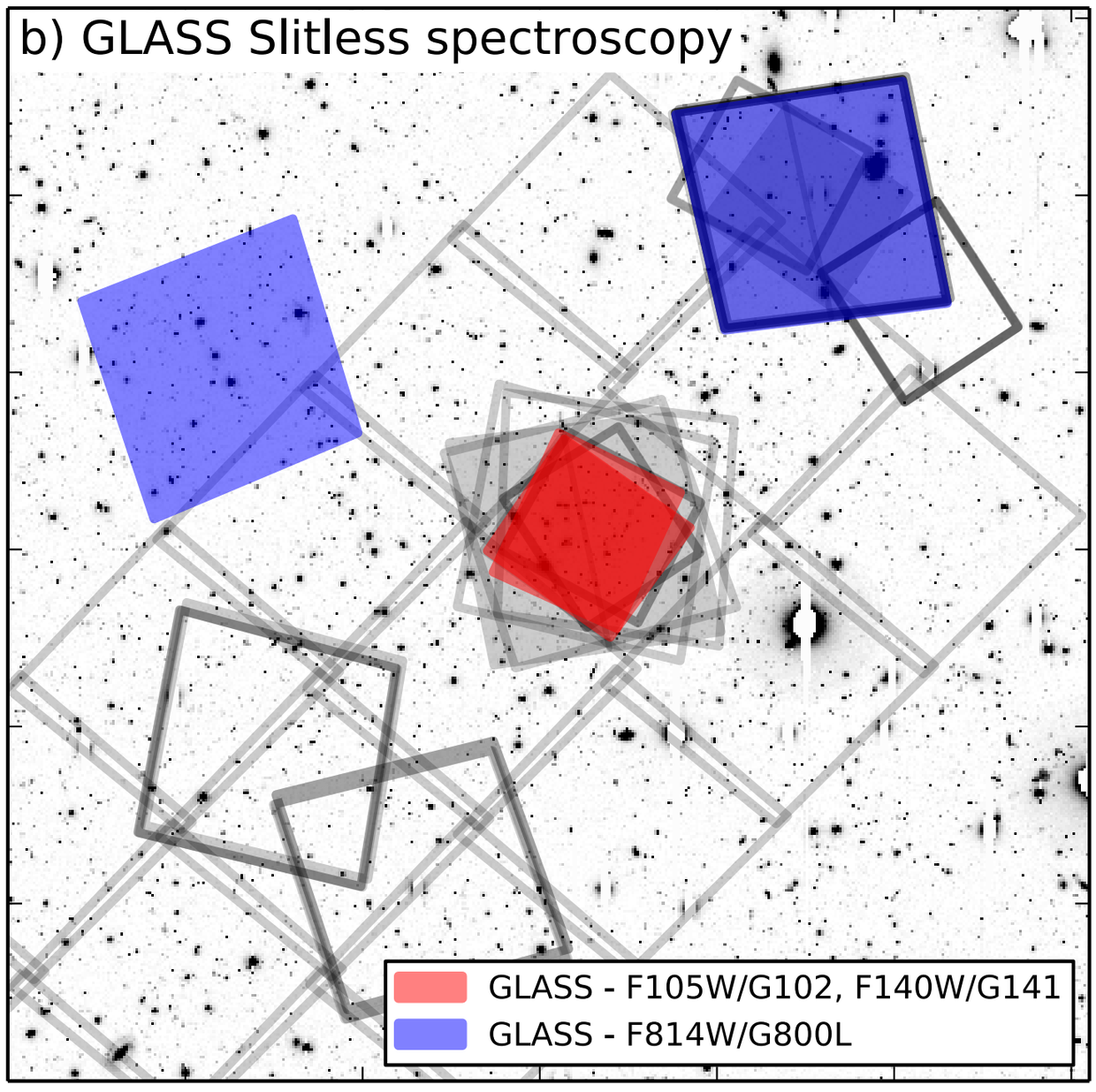
5.6 — Lyα redshift — 13.0



- Spectra of ~10000 (m_{F140W} < 24) with spectroscopic limits ~ 1e-18 erg/s/cm^2 ; KBS+(2014)

GLASS : Observing Strategy

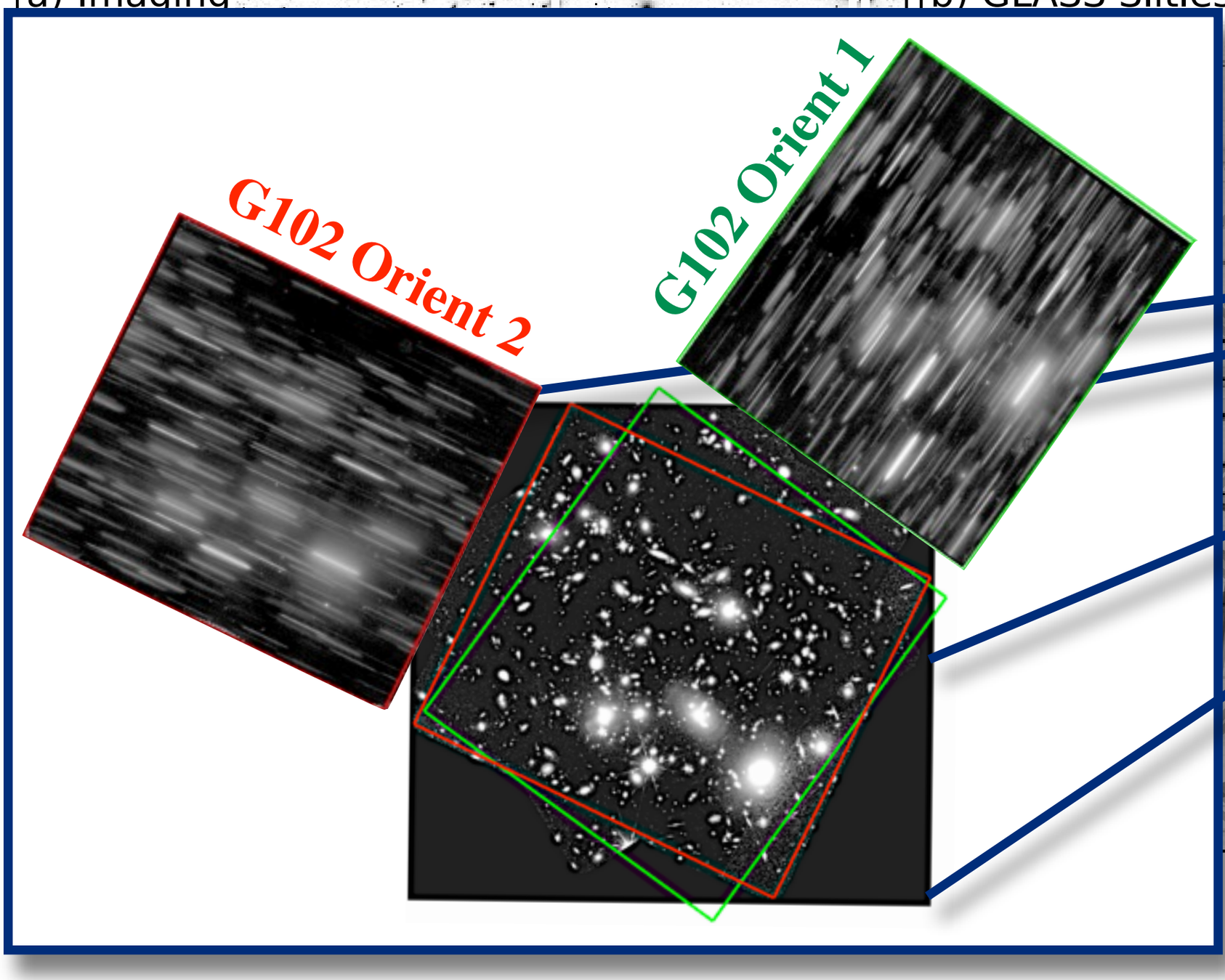




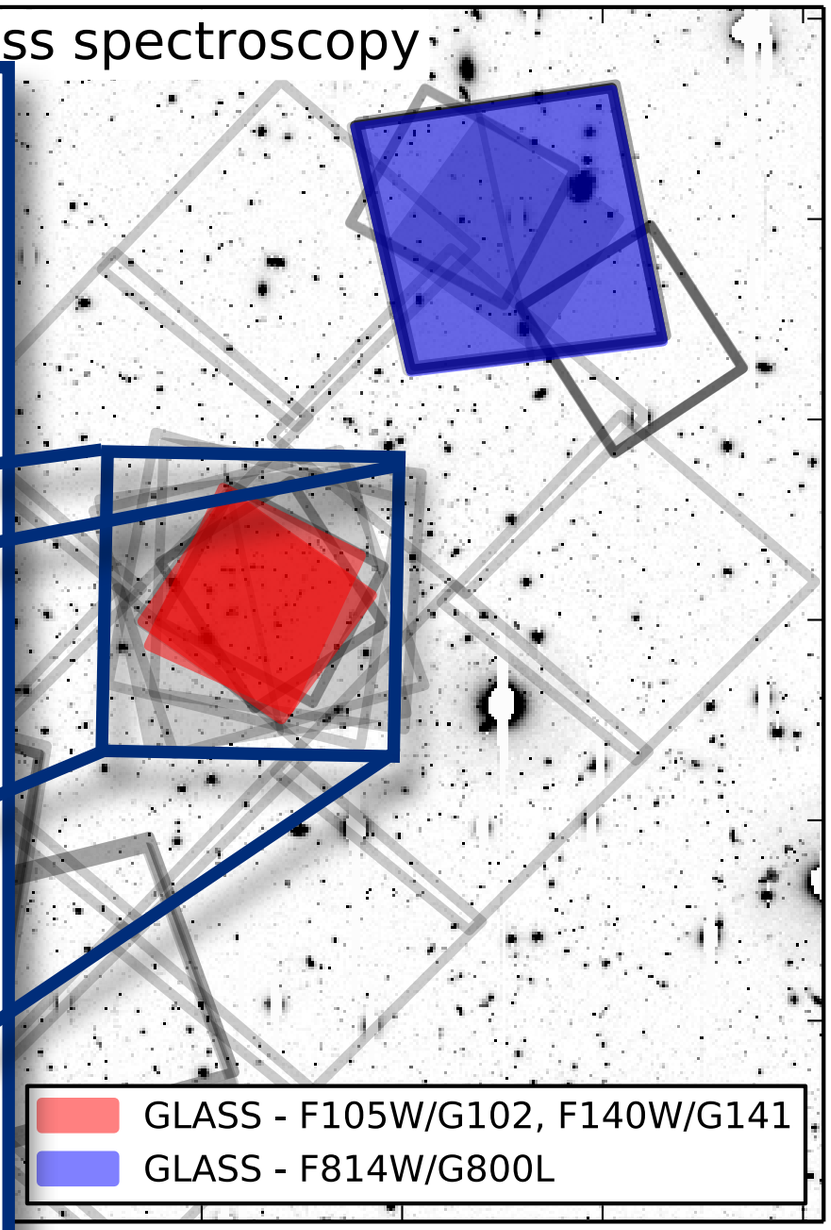
Treu, KBS+(2015) in prep.

GLASS : Observing Strategy

a) Imaging



b) GLASS Slitless spectroscopy

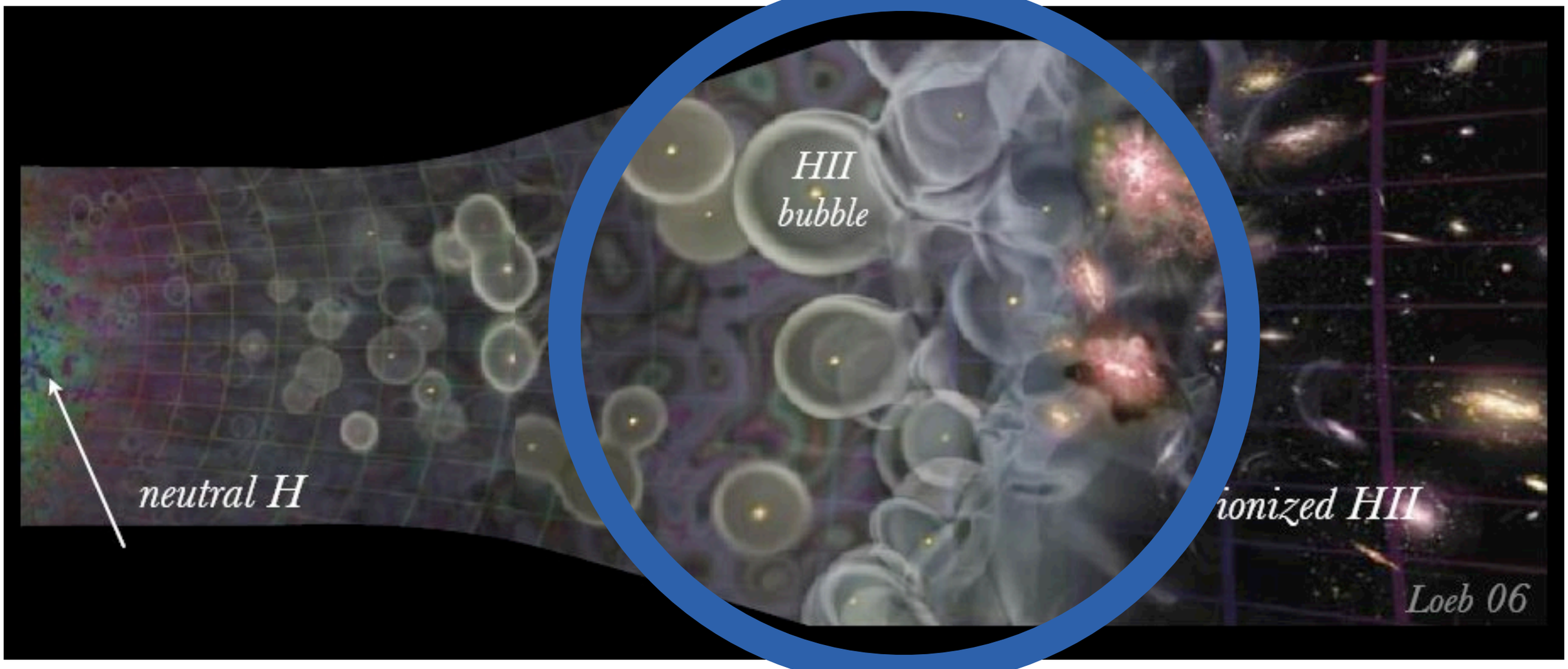


Treu, KBS+(2015) in prep.

GLASS Galaxies at z ≳ 7

- The heart of the Epoch of Reionization
- EoR: Transition from a neutral to an ionized IGM
  cf. talks by Bouwens, Atek/Kneib, Oesch, Trenti, Lorenzoni, etc.

z ← 1100 35 15 8 6



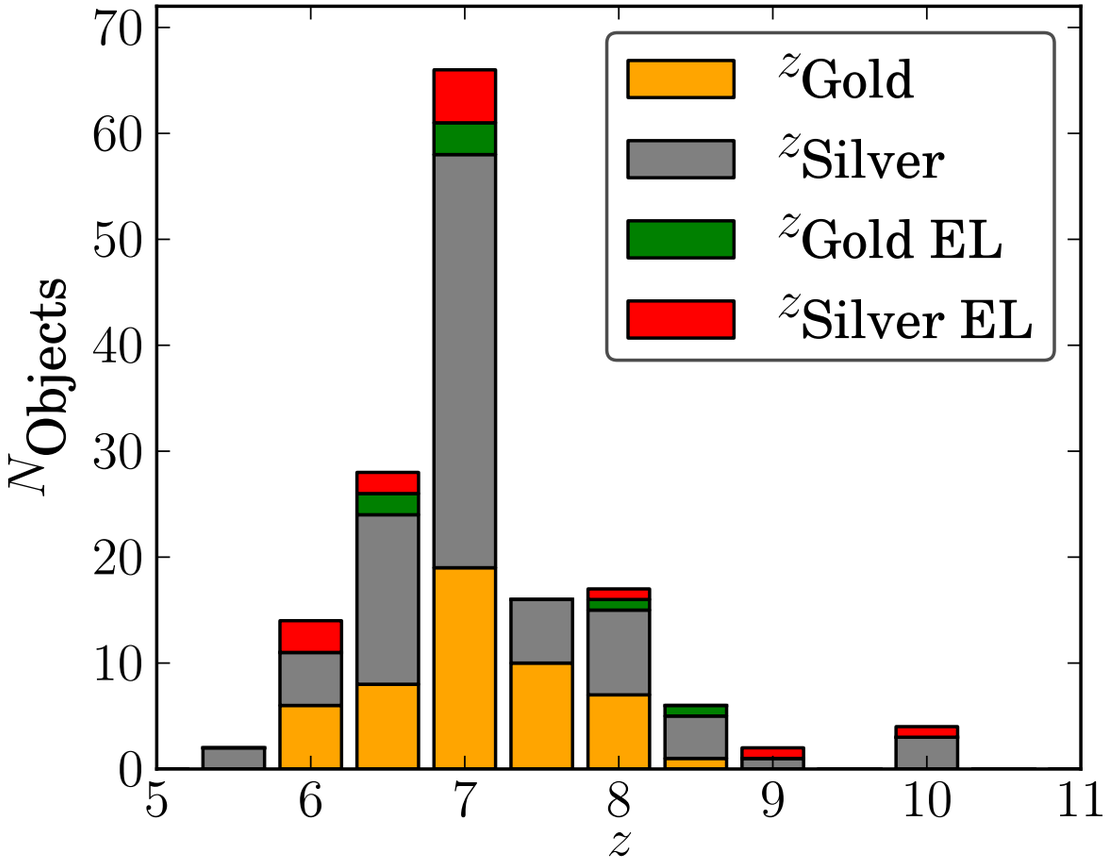
GLASS Galaxies at $z \gtrsim 7$

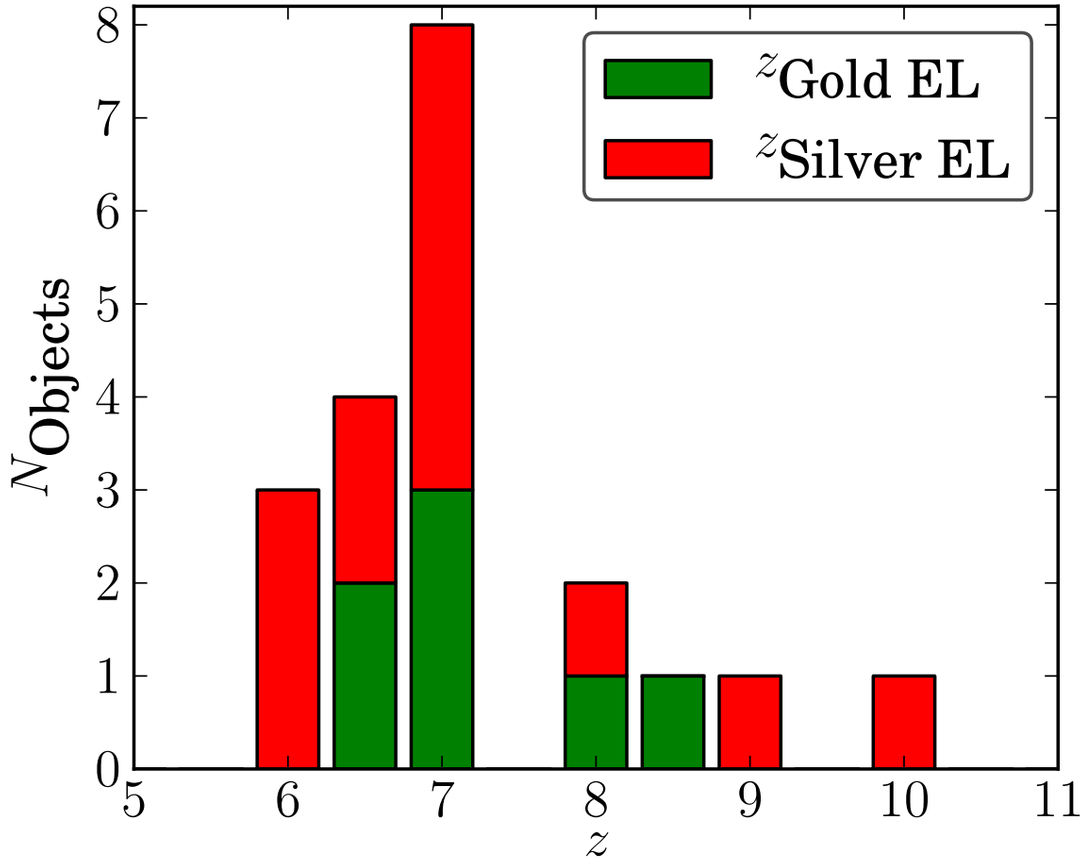
- Selected dropouts at $z \gtrsim 7$ in 6 first completed clusters
  - A2744, MACS0717, MACS1423, MACS2129, RXJ1347, RXJ2248
- Used >20 photometric selections:
  - Photo-z methods: BPZ (Benitez 2000) and EAzY (Brammer+2008)
  - Color selections: i, z, Y, J, JH dropouts
  - Selections published in the literature, e.g., Atek+(2013), Zheng+(2014), Ishigaki+(2014), Bradley+(2014), Karman+(2014)
- Resulted in more than 100 objects
- All GLASS spectra of these objects visually inspected by at least 2 team members to search for Lyα emission.

KBS+(2015) in prep.

GLASS Galaxies at $z \gtrsim 7$

- Divided objects into 4 samples:
  - Gold: Selected in 2 or more selections
  - Silver: Selected in just 1 selection
  - Gold_EL: Gold obj. with EL seen by at least 2 inspectors (+/- 50Å)
  - Silver_EL: Silver obj. with EL seen by at least 2 inspectors (+/- 50Å)

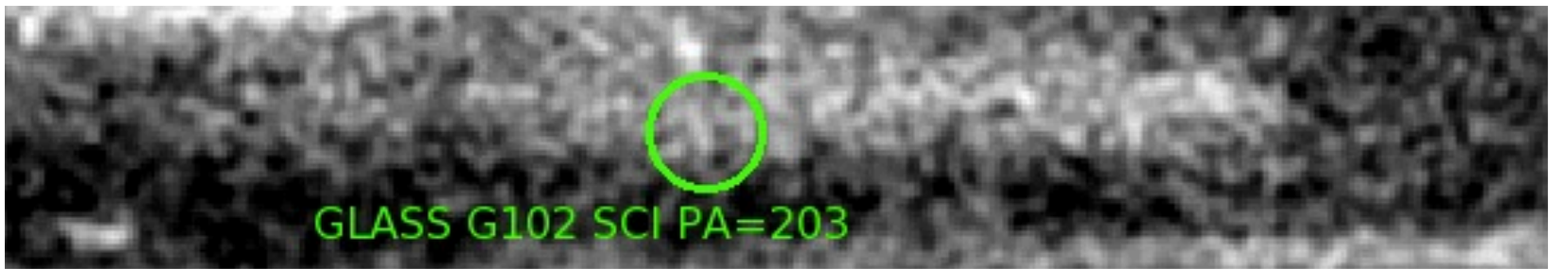




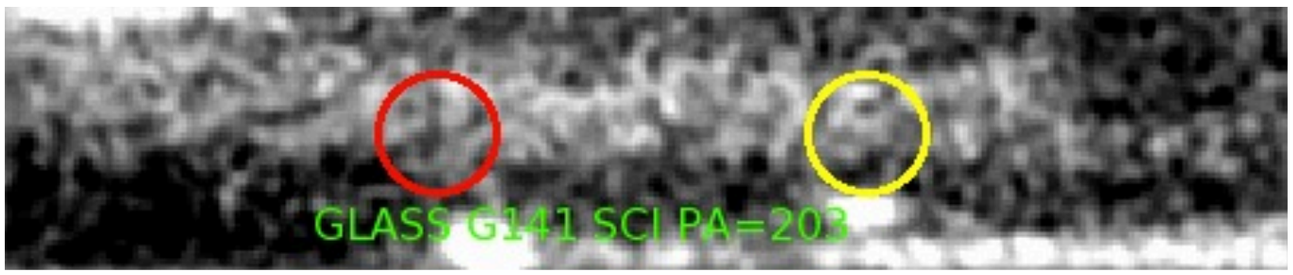
One Example…

- Independent DEIMOS detection (Huang+2015 in prep.)
- EW = 13 +/- 3.5 Å ; f_{line} = 0.45 +/- 0.12 [1e-17 erg/s/cm^2]

G102



G141



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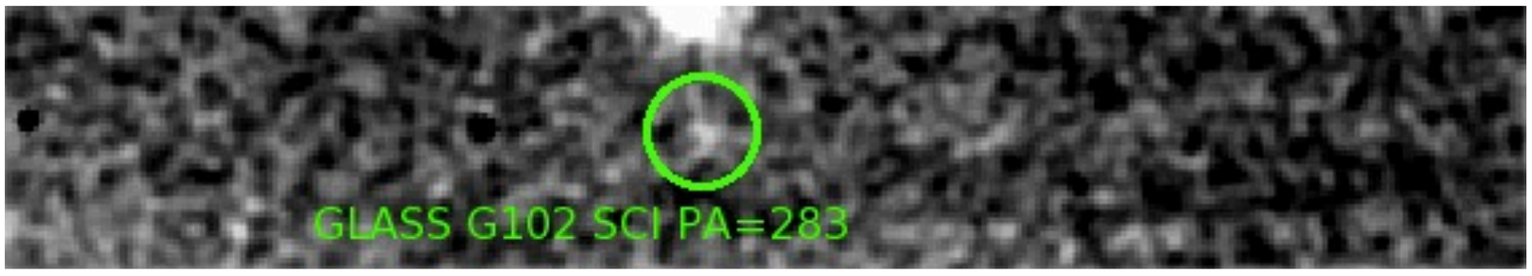

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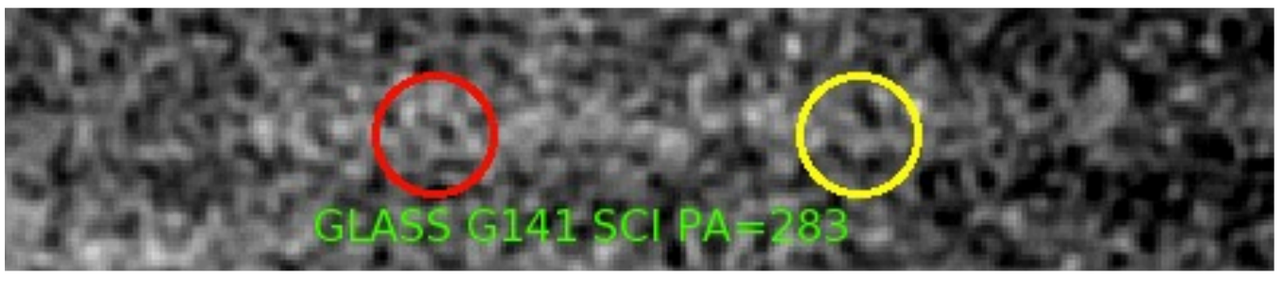


Green: Emission line
(Lyα or [OII]3727 ?)

Red: [OIII]5007 @ 12685Å
(if line is [OII]3727)

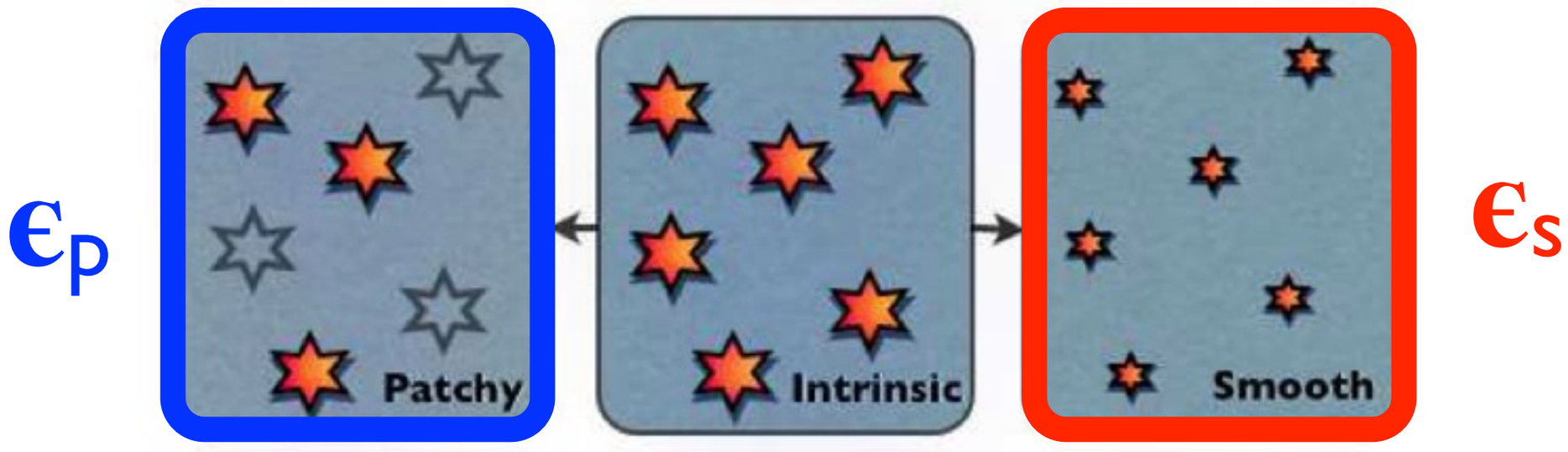
Yellow: CIII]1909 @ 14819Å
(if line is [Lyα])

z~1.5 → low Z → [OIII]/[OII] > 1
(Nagao+2006, Maiolino+2008)

Not seen so: Lyα at 6.7

EoR Inference: Treu+2012 Framework

- Initial EW distribution from Stark+2011
- Evolved through two models for EoR Lyα opacity evolution

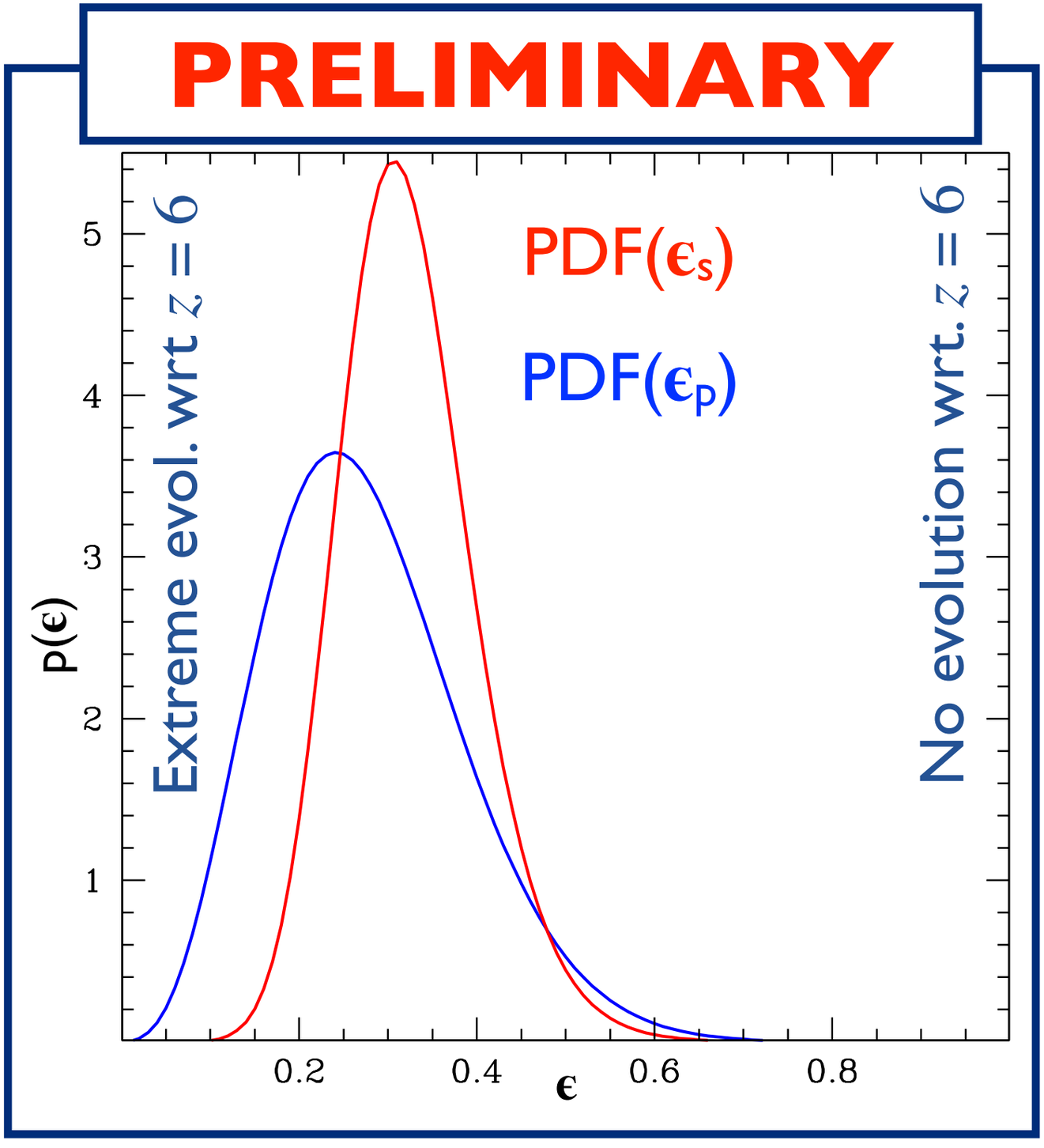


Tilvi et al. 2014

- Given an observed list of EW (limits) this can produce predicted PDF(ϵ)
- PDF(ϵ) predicts PDF(EW), i.e., p(Lyα | LBG), which can discriminate between models when compared to observations.

EoR Inference: Treu+2012 Framework

- 75 spectroscopic objects:
  - Gold, Gold_EL, Silver_EL
- EW limits and EWs
  - $\langle f_{1\sigma lim} \rangle \sim 2 \times 10^{-18}$ erg/s/cm^2
- Feed to the Treu+2012 framework



See also Treu,KBS+(2013; z~8), Pentericci+(2014; z~7) and Tilvi+(2014; z~8)

Take Home

GLASS

- Grism Spec of 10 clusters (HFF & CLASH)
- NIR 1σ flux limits ~ 10^{-18} erg/s/cm^2

Lyα at the EoR

- 100s EW limits from GLASS spectra
- PRELIMINARY EoR inference indicate strong evolution since z=6

THE GLASS TEAM

glass.physics.ucsb.edu

Attending DEEP15

- **Tommaso Treu**, PI (UCLA)
- Marusa Bradač (UCD)
- Gabriel Brammer (STScI)
- Mark Dijkstra (UoO)
- Alan Dressler (Carnegie Obs.)
- Adriano Fontana (INAF Rome)
- Raphael Gavazzi (IAP)
- Alaina Henry (NASA Goddard)
- Austin Hoag (UCD)
- Kuang-Han Huang (UCD)
- Tucker Jones (UCSB)
- Patrick Kelly (UCB)
- Matt Malkan (UCLA)
- Charlotte Mason (UCSB)
- Laura Pentericci (INAF Rome)
- Bianca Poggianti (INAF Padova)
- Kasper Schmidt (UCSB)
- Massimo Stiavelli (STScI)
- Michele Trenti (Melbourne)
- Anja vd Linden (DARK/Stanford)
- Benedetta Vulcani (KIPMU Tokyo)
- Xin Wang (UCSB)