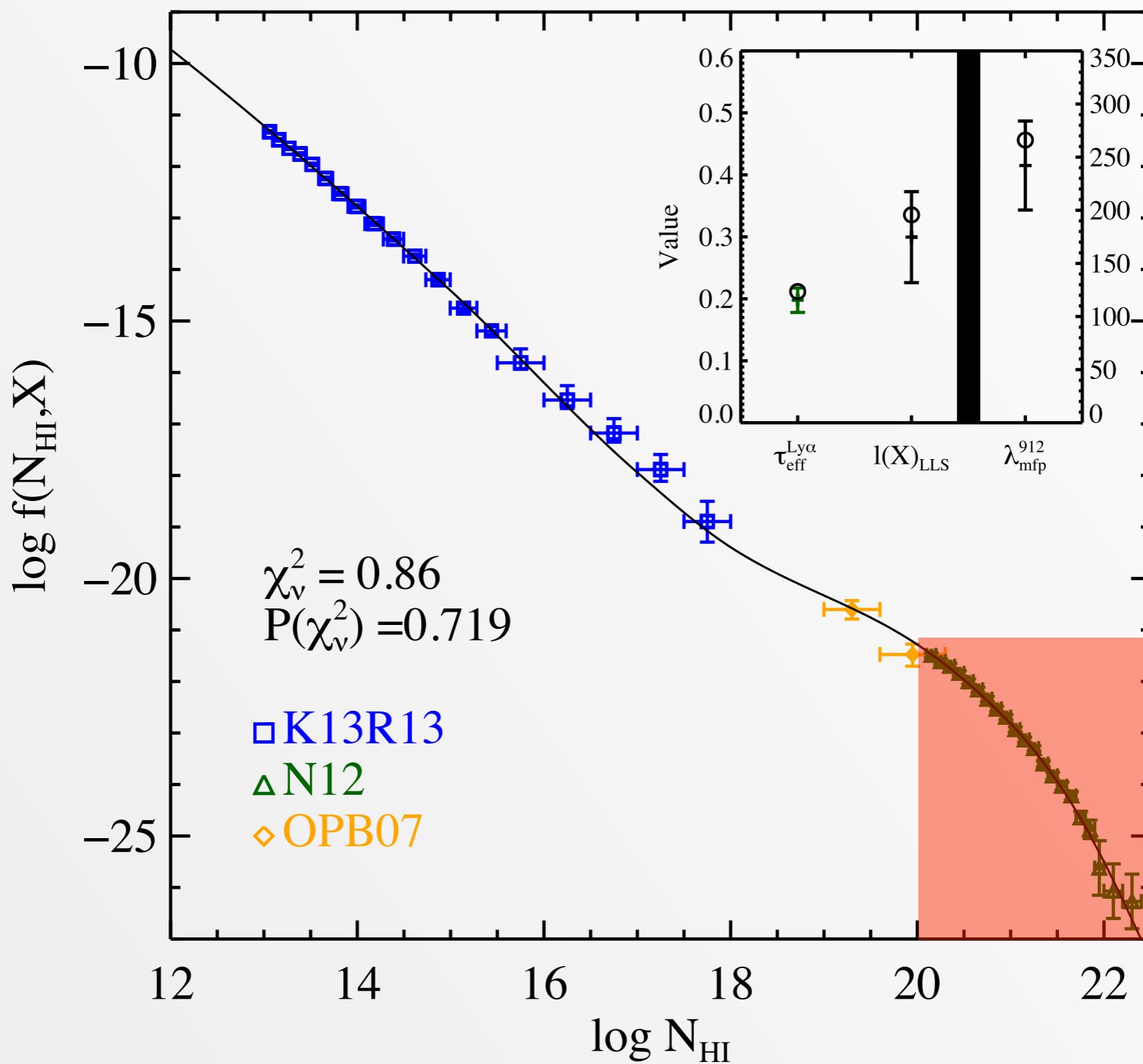


# Damped Ly $\alpha$ Systems



# Imaging DLAs Directly (or not)

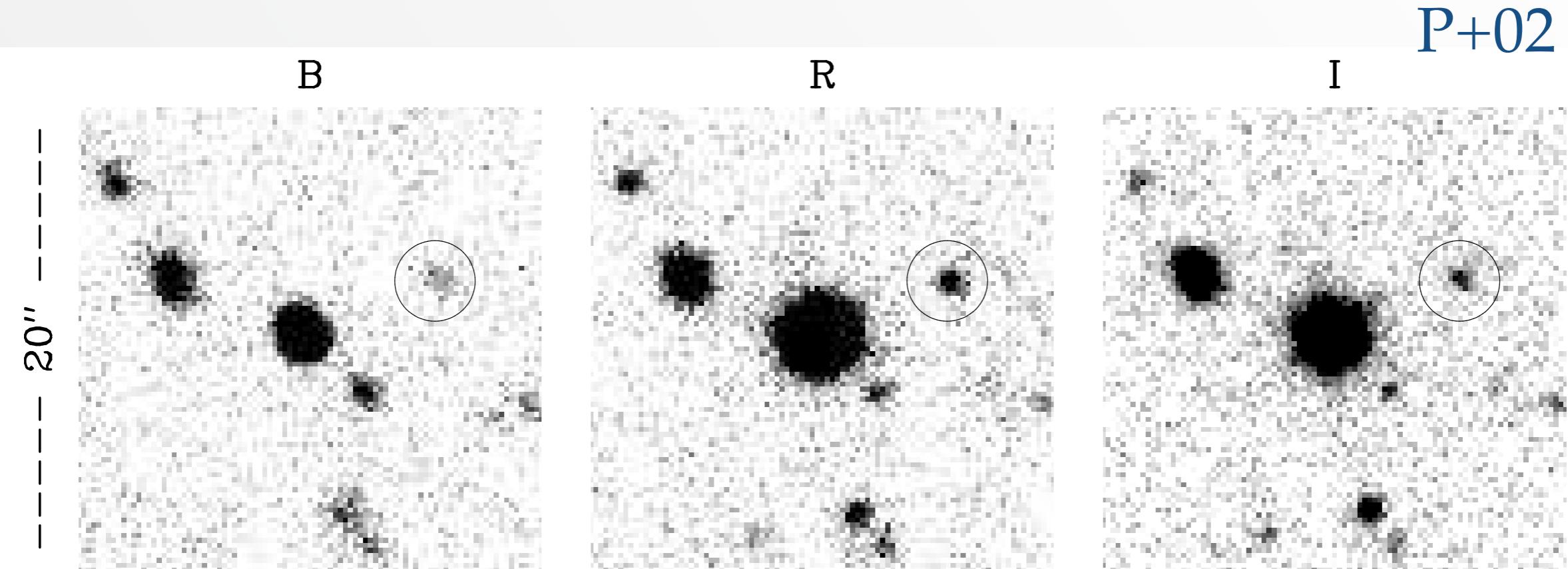
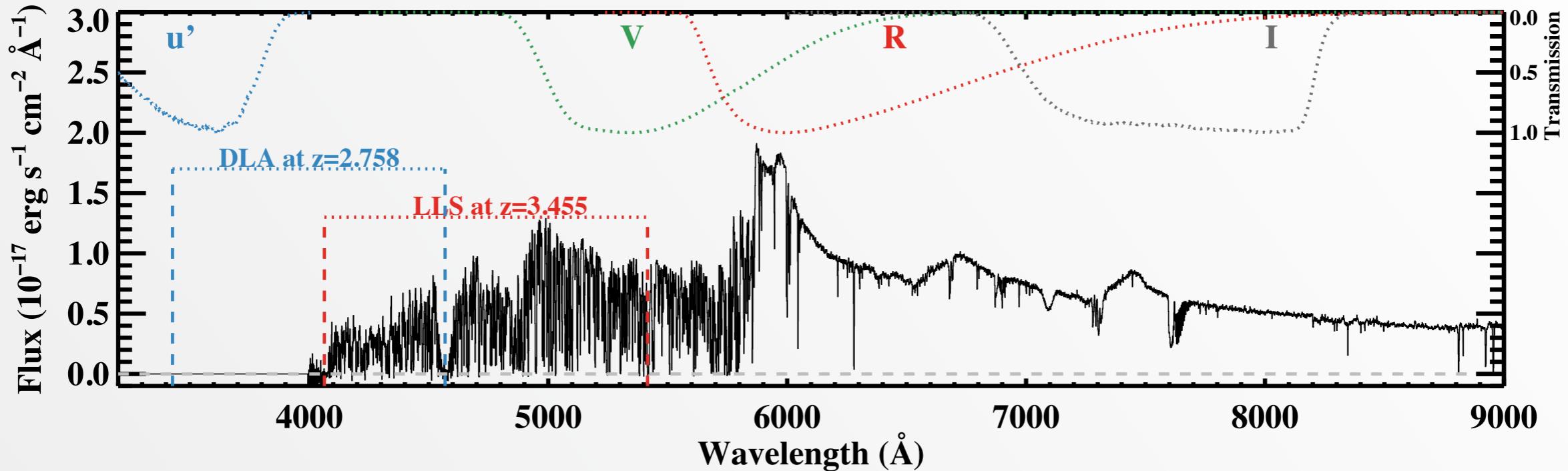


FIG. 7.— Close-up *BRI* images ( $20'' \times 20''$ ) centered on the quasar PSS0132+13. The object identified to the right of the quasar is the only significant *B*-band dropout in this region and has a photometric redshift  $z_{phot} = 3.6$ .

- Deep broad-band imaging
  - i.e. Lyman break technique
  - Rarely identify nearby counter-parts
    - Too faint?
    - Too close to the background QSO??

# Clever Imaging of DLAs

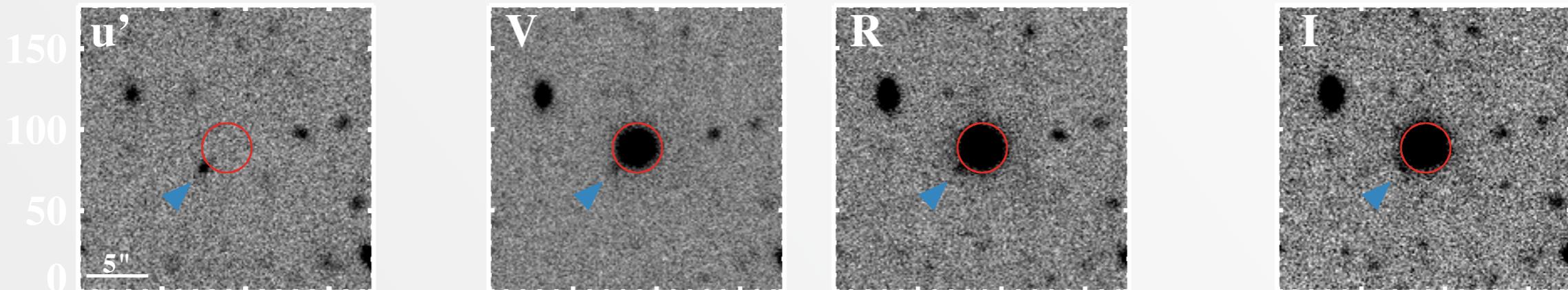
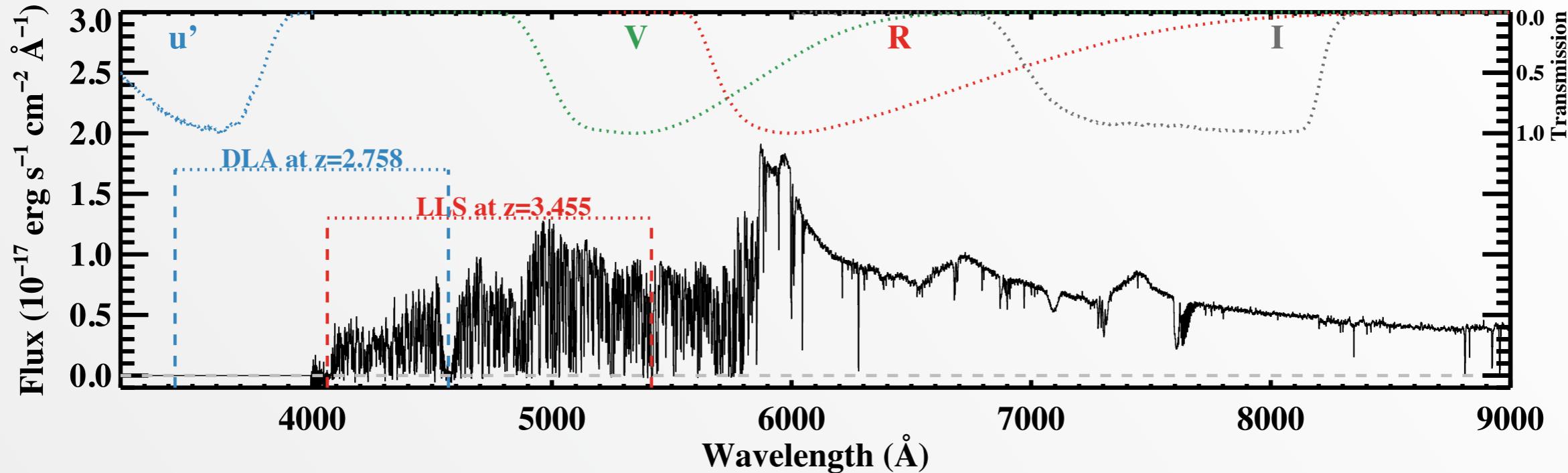
Fumagalli+10, 14



- Identify a sightline with one DLA and one LLS
  - $z_{\text{LLS}} > z_{\text{DLA}}$
  - The Lyman limit of the LLS serves as a blocking filter
  - Image the DLA in the FUV blueward of this ‘filter’
  - IGM utility at its finest!

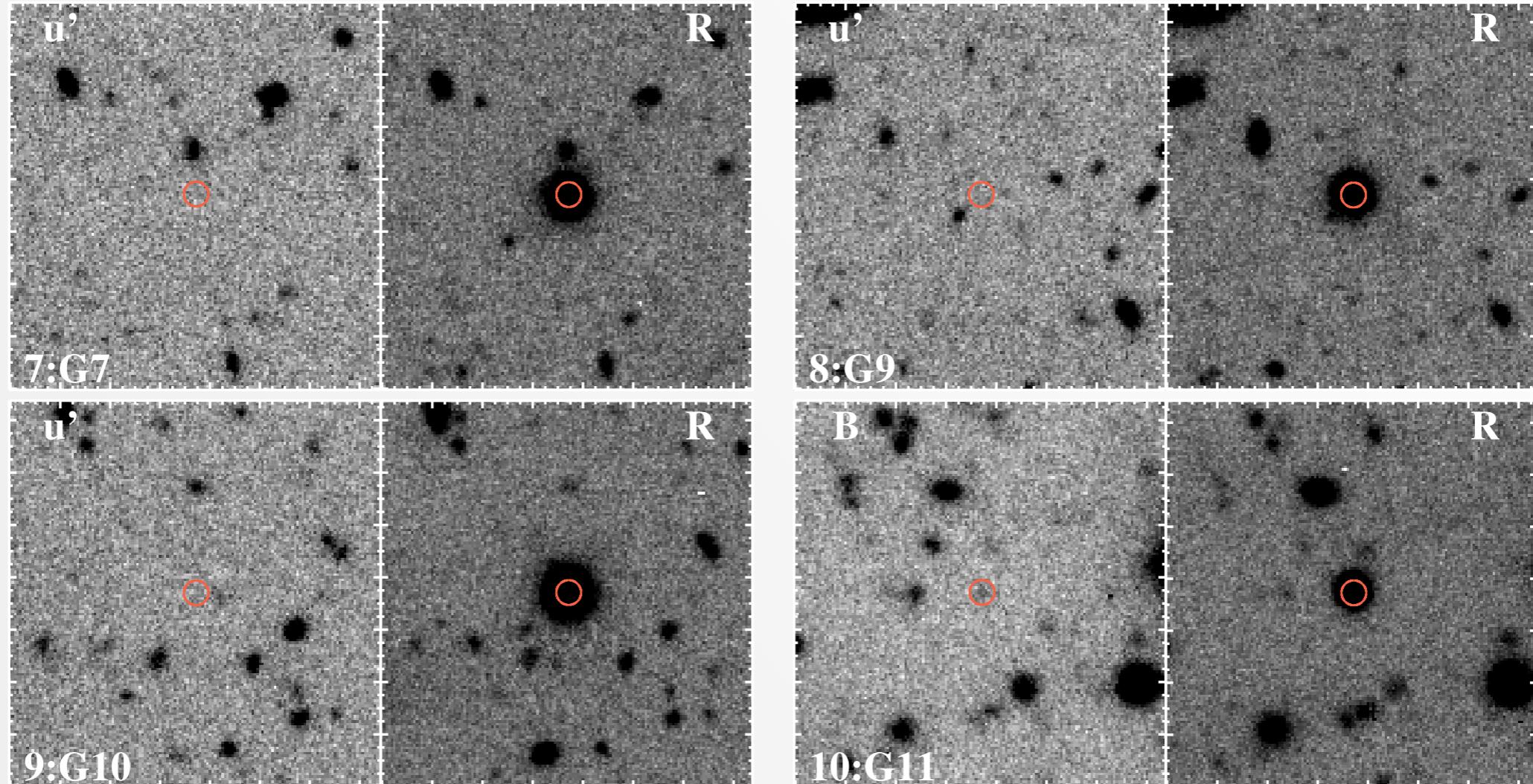
# Clever Imaging of DLAs

Fumagalli+14



- Quasar ‘disappears’
  - Allowing for a deep search underneath

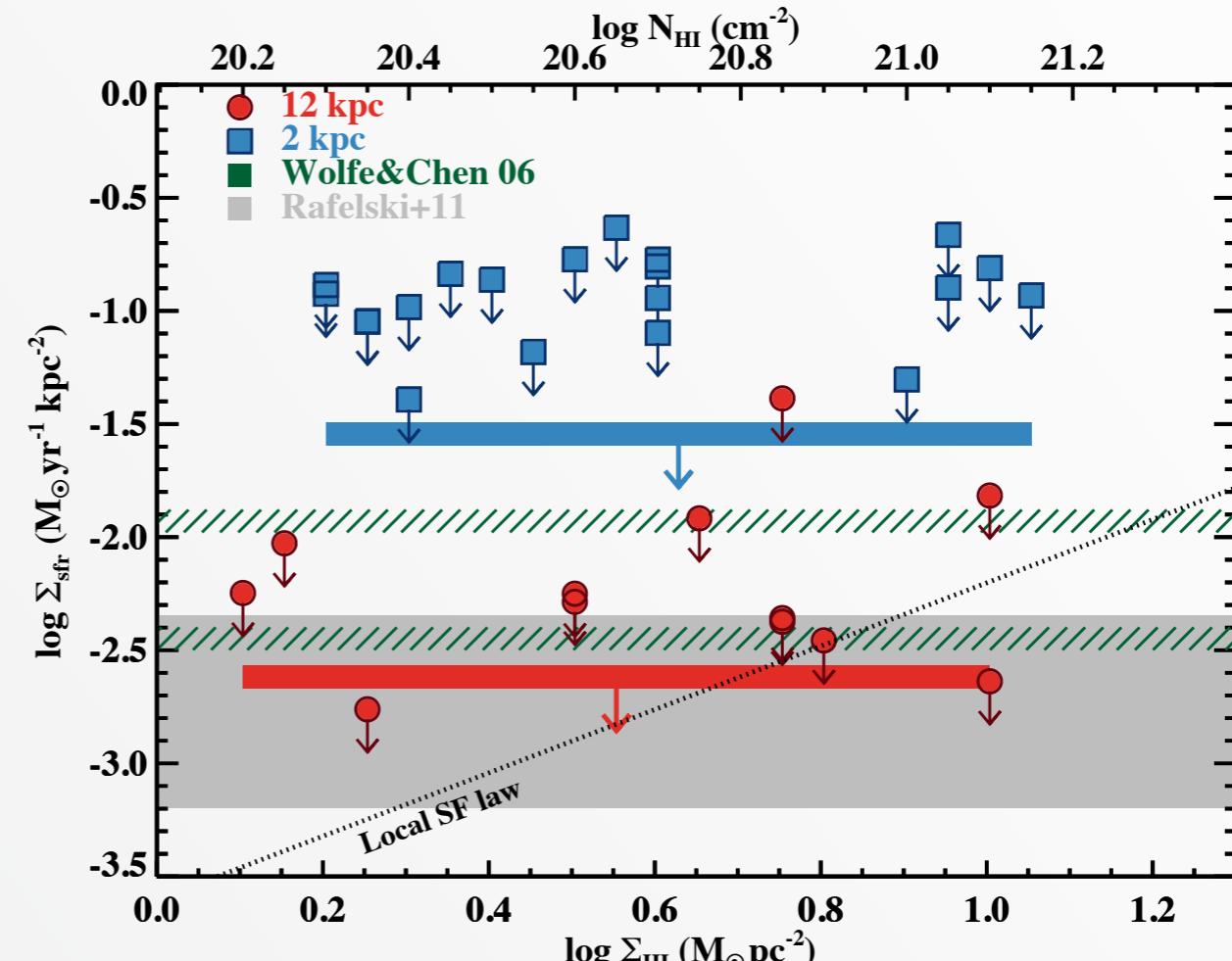
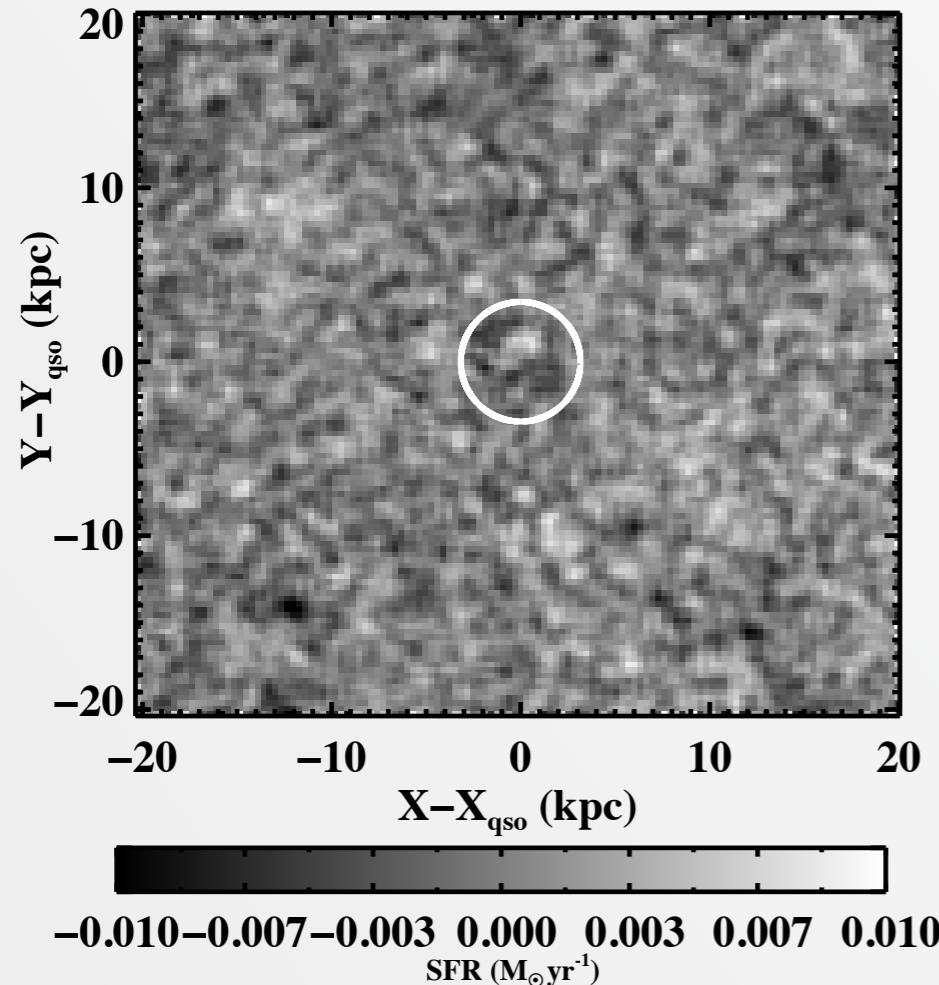
# Fumagalli+14 Clever Imaging of DLAs



- Rarely identify a source within several arcsec
  - i.e. less than 20 kpc
- Random background sources dominate at >50kpc

# Clever Imaging of DLAs

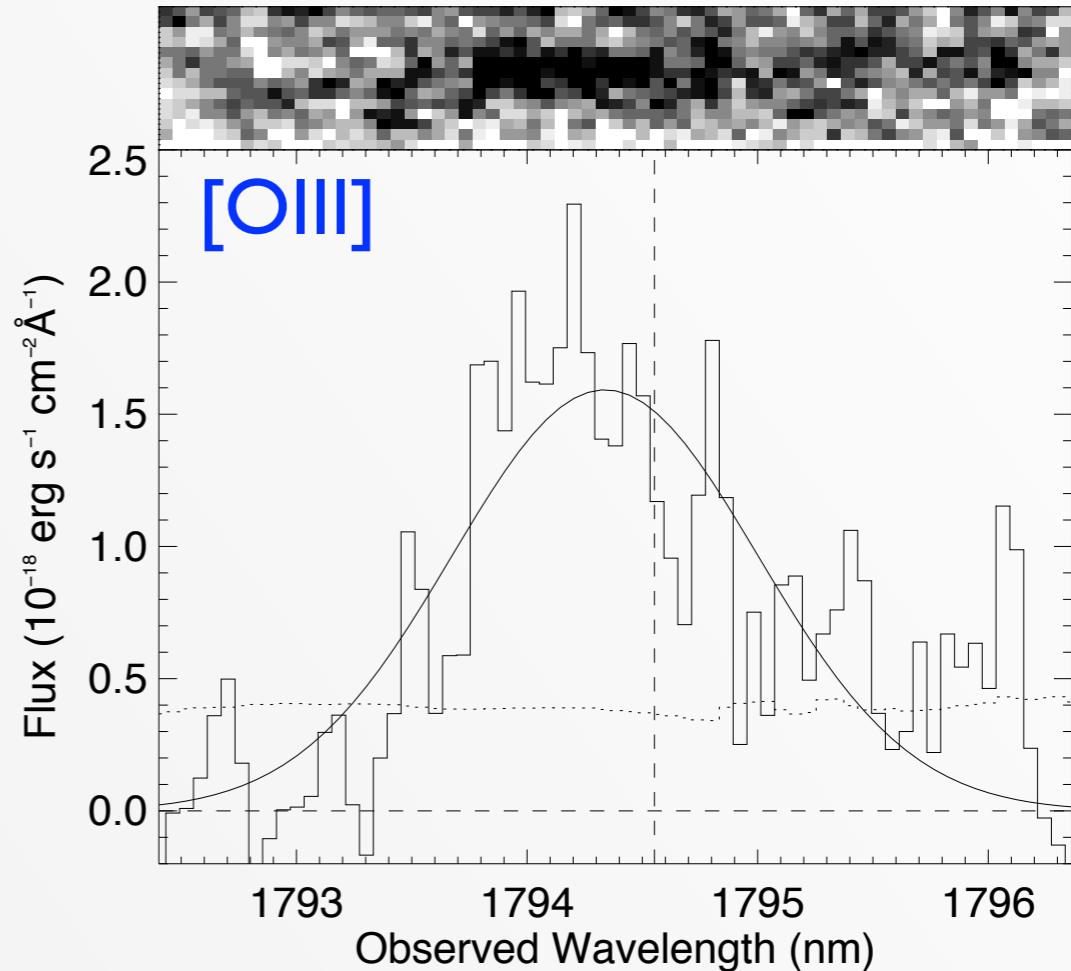
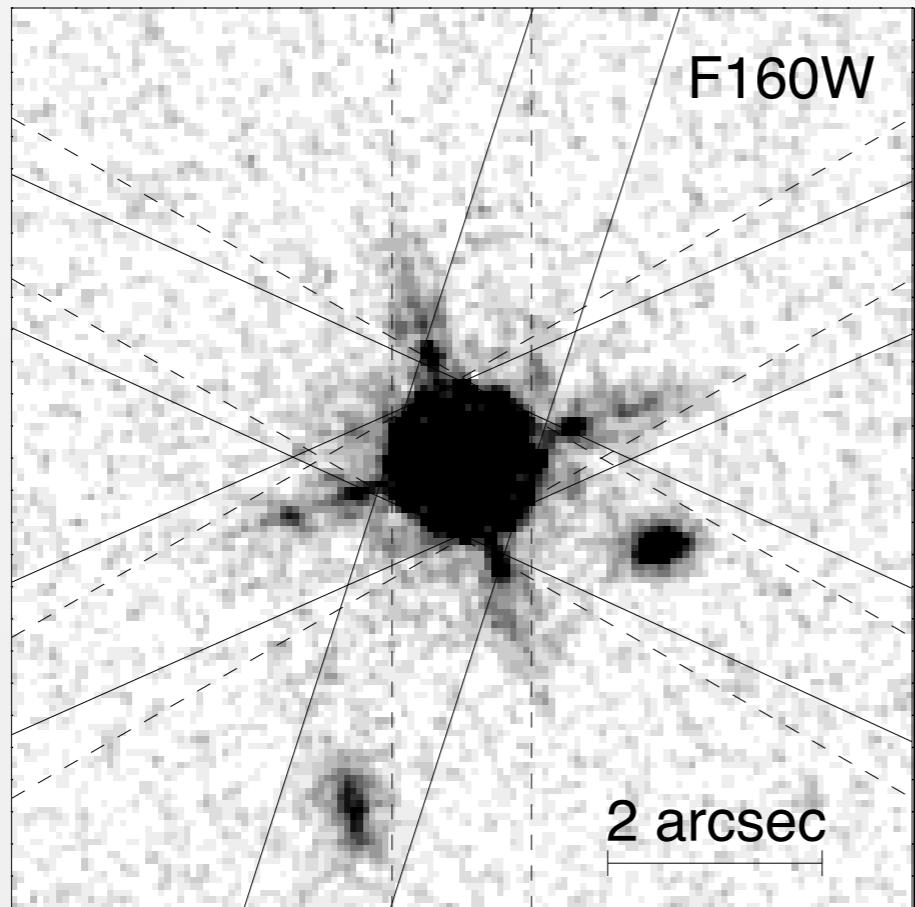
Fumagalli+15



- Stacked non-detection
  - $\text{SFR} < 0.3 \text{ Msun/yr}$  (under the QSO)
  - Consistent with HI/SFR 'laws'

# Random Slit Placement

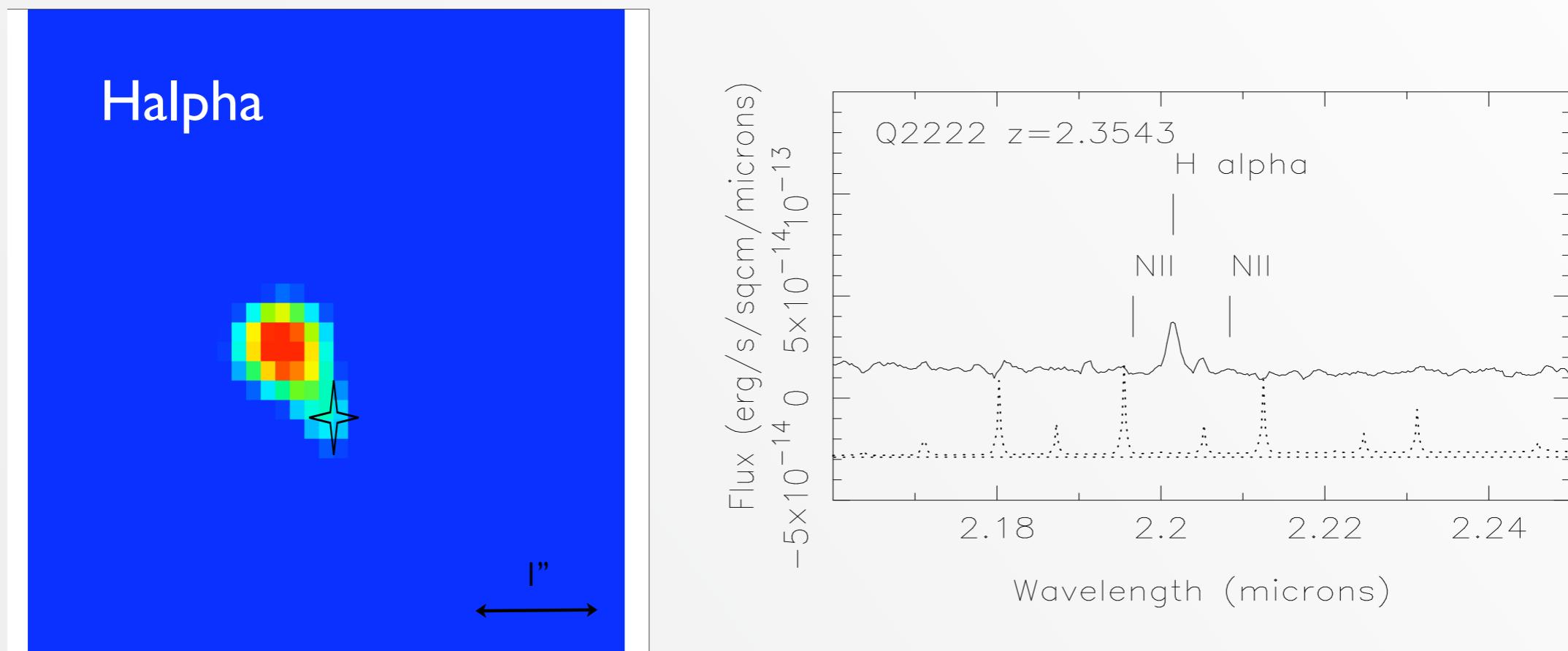
Fynbo+13



- Targeting higher metallicity DLAs
- Several successes (e.g. Fynbo et al. 2013)
  - SFR of several to tens Msun/yr
  - Impact parameters of <10 kpc (biased)

# Near-IR IFU

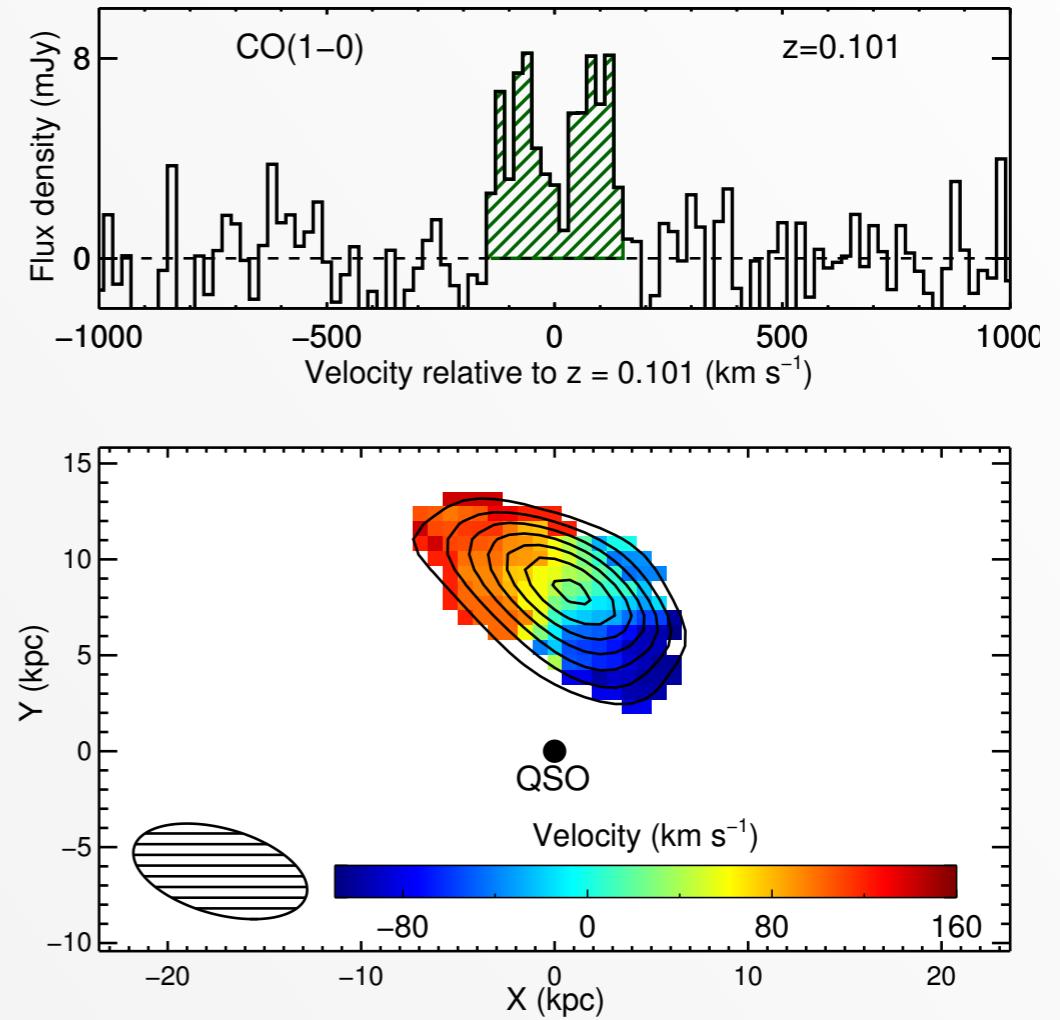
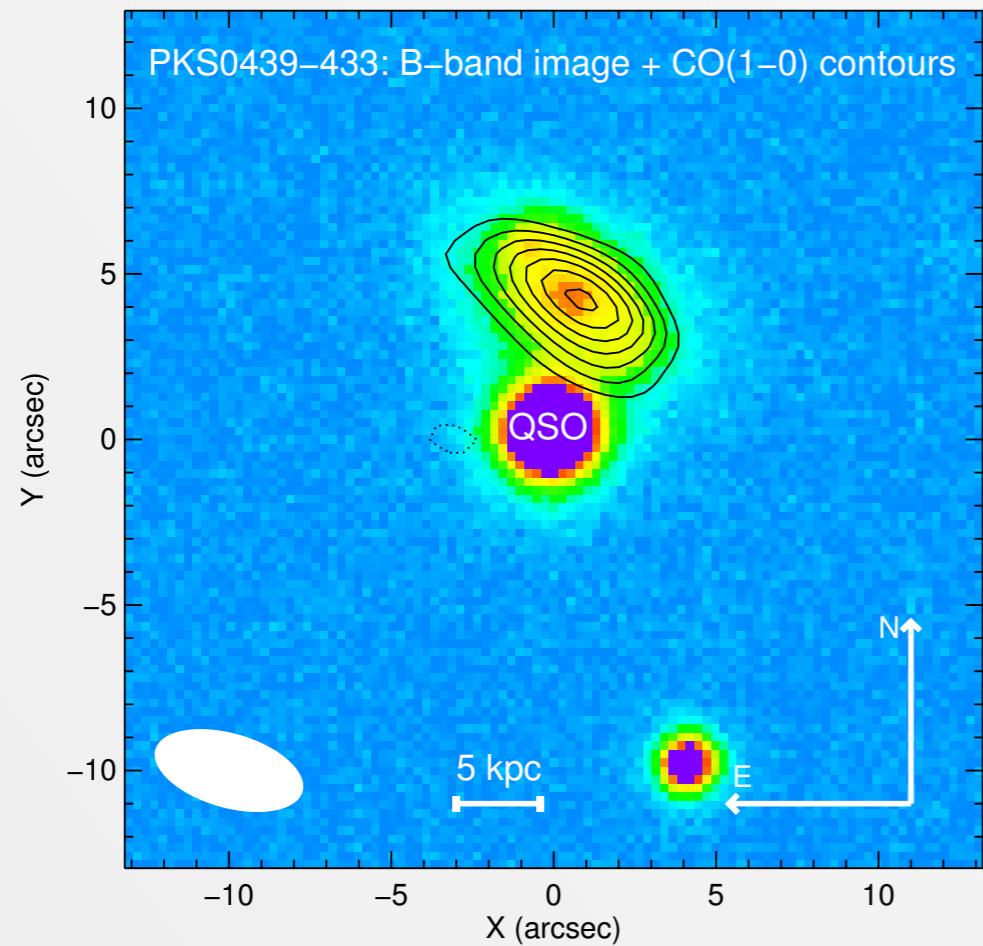
Peroux+12; Jorgensen+14; Wang+15



- Spectral imaging search for Halpha emission
- Limited FOV and sensitivity
  - Several positive detections ( $SFR \sim 17 \text{ Msun/yr}$ )
  - Predominantly non-detections

# CO (Interferometry)

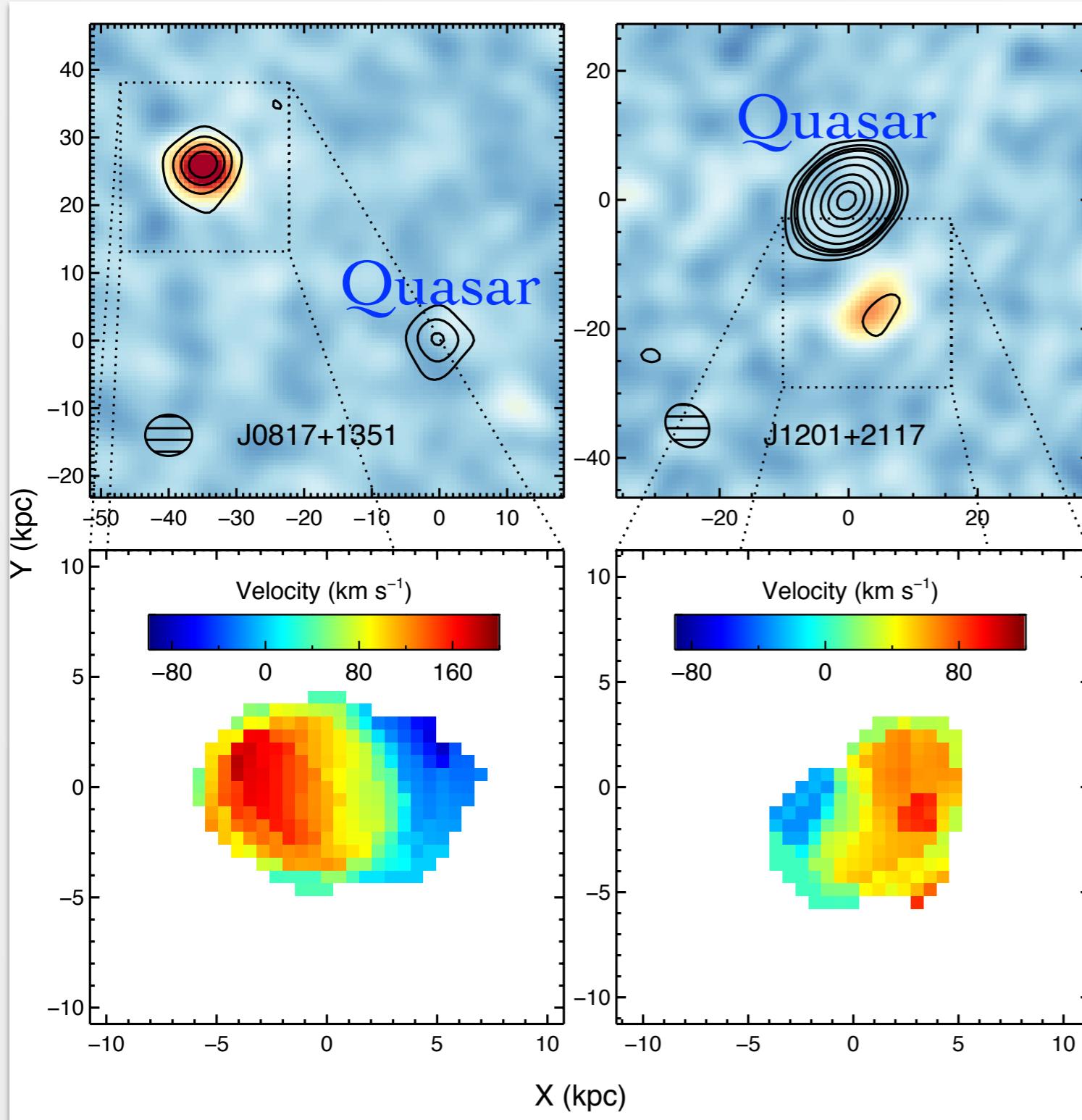
Neeleman+16



- Targeted  $z < 1$  DLAs
  - Several with known counterparts
  - Began with higher metallicity DLAs
- ALMA CO data cubes
  - Sensitive to  $\sim 10^9 \text{ M}_{\odot}$

# CII 158 micron emission (Interferometry)

Neeleman+16b



- Targeted  $z \sim 4$  DLAs
  - Best sensitivity for 158 microns
- Again, started with a biased sample
- ALMA data cubes
  - Sensitive to  $SFR \sim 10 \text{ Msun/yr}$
- Results
  - Positive detections
  - 20-30 kpc offset!
  - Signatures of rotation