



PONTIFICIA
UNIVERSIDAD
CATÓLICA
DE CHILE



A gravitationally lensed Lyman Alpha Nebula along with a hint of ionizing LyC emission

Sam Kim (Center of Astro-engineering, PUC,
la silla MPG2.2m SA)

Nicolas Laporte, Franz Bauer (PUC), Leopoldo
Infante (PUC)

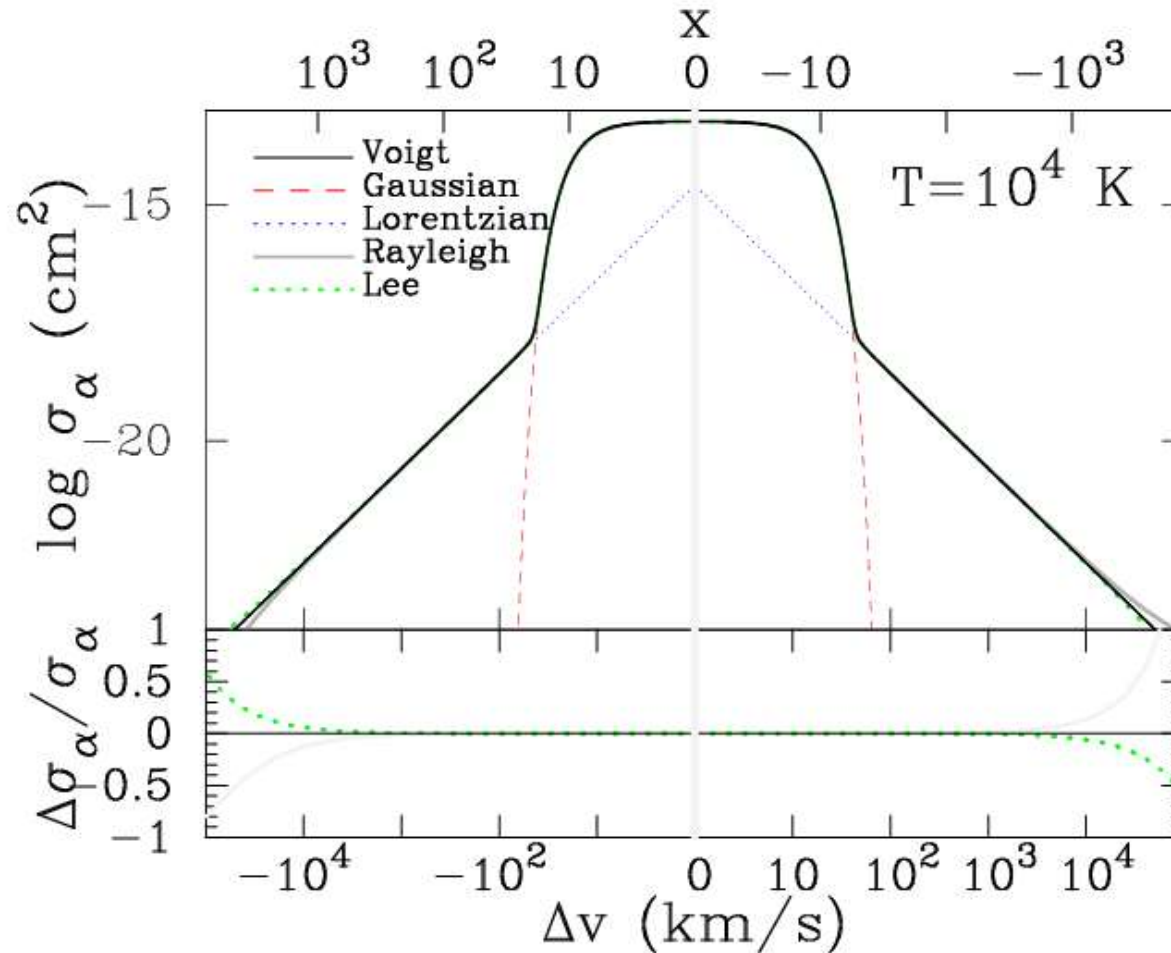
External collaboration: J. Richard, R. Pello,
S. Cantalupo. D. Bina.

An real example of candidate of lyman alpha continuum source and lyman alpha emission

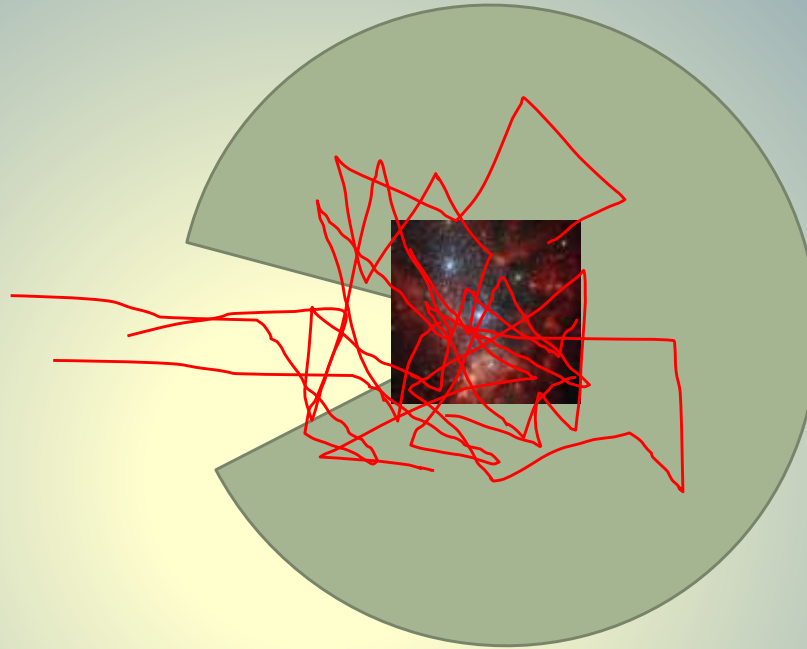
- Star-forming galaxies as leading candidate sources dominating cosmic reionization.
- The search for analogs at moderate redshift showing Lyman continuum (LyC) leakage is currently an active line of research.
- Because of the intergalactic medium (IGM) opacity, **direct observation of ionizing radiation during reionization is very much difficult.** → **$z < 4$ source could be better sample.**
- $z \sim 3$ LyC source could be better candidate than local LyC galaxy because of red UV slope in local star forming galaxy (dust ..etc...)
- LyC usually comes with Ly α

Lyman Alpha RT in opaque medium

Dijkstra 2014



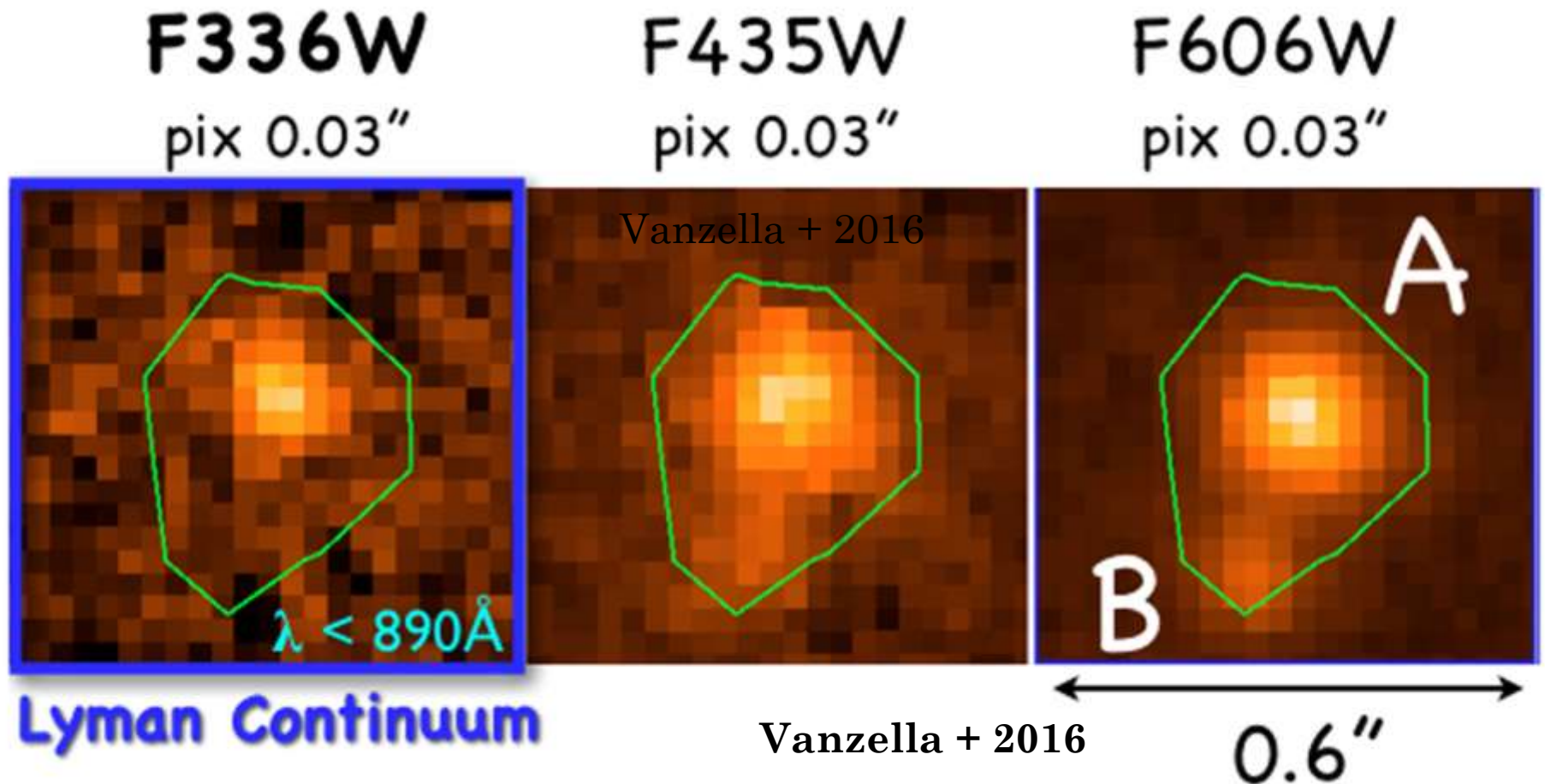
Lyman alpha – Continuum connection



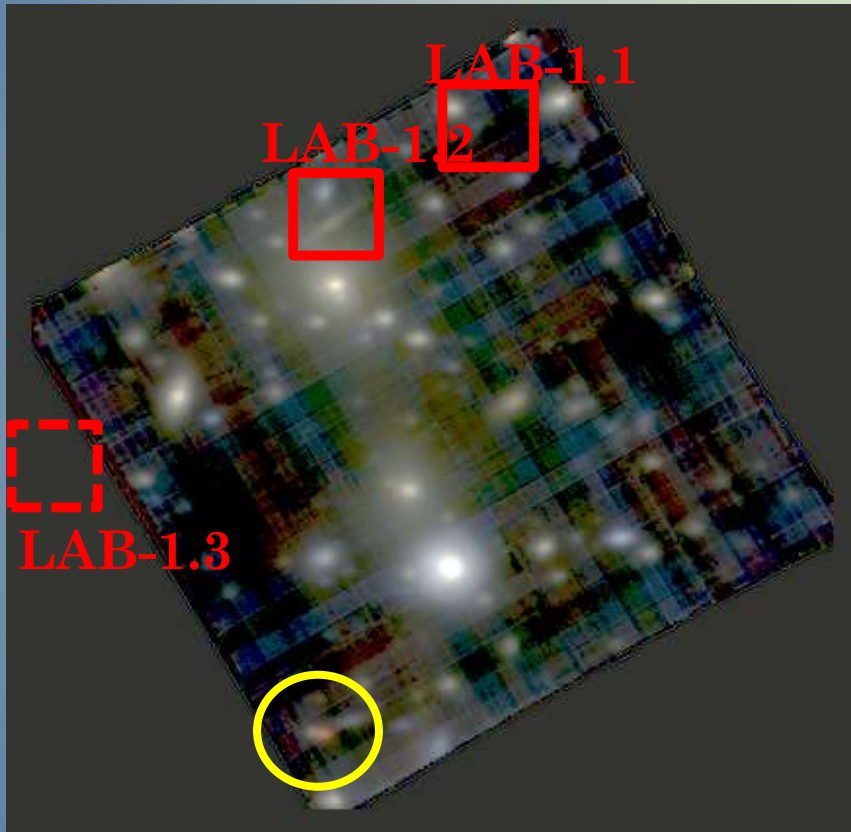
The presence of low N_{HI} (neutral hydrogen column density) 'holes' limits how much Ly α has to diffuse prior to escape: Ly α spectral lines of LyC emitting objects are narrower in frequency direction.

RARE!!

Ion2 (GOODS-South): the only LyC source spectroscopically confirmed (Vanzella + 2016, de Barros + 2016)



MACS0416 MUSE field



-11 hours exposure
(58 exposures in total)

-FWHM $\sim 0.8''$

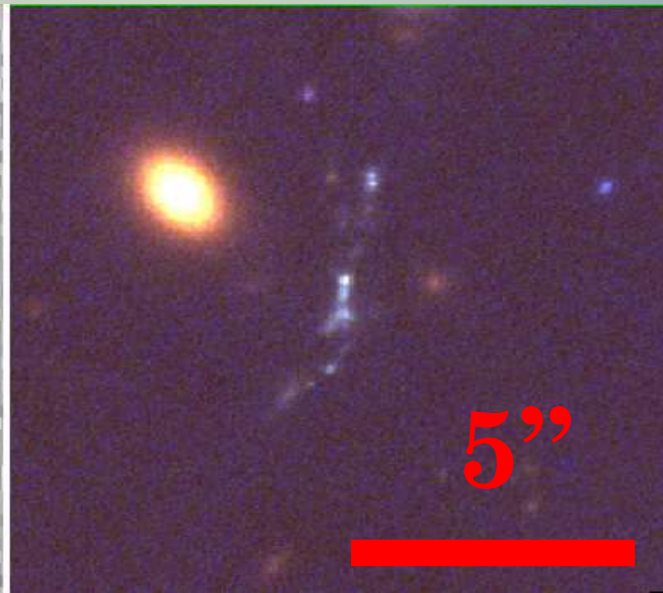
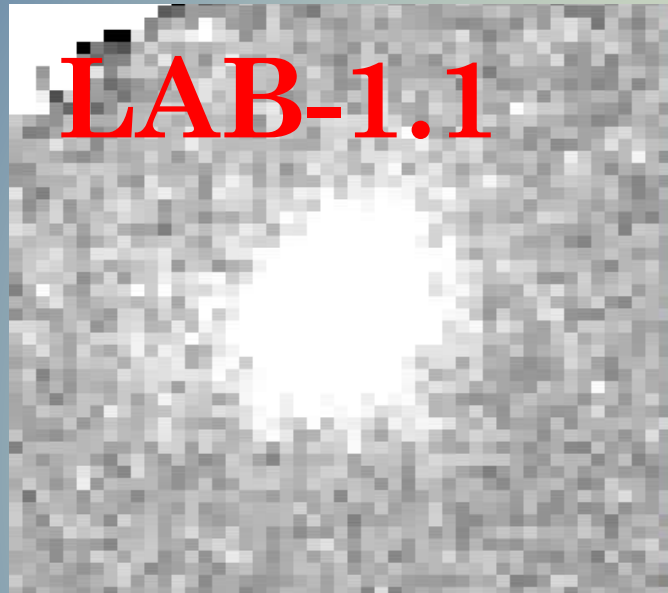
- $F_{\text{lim}} \sim 10^{-19} \text{ erg s}^{-1} \text{ cm}^{-2} \text{ arcsec}^{-2}$

-ZAP/MPDAF/muselet & CubEx package

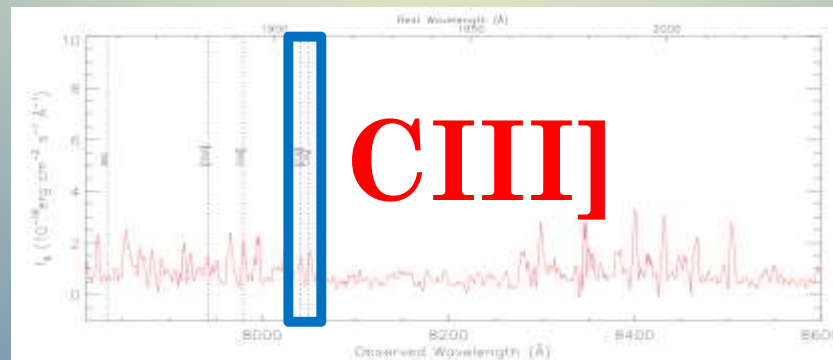
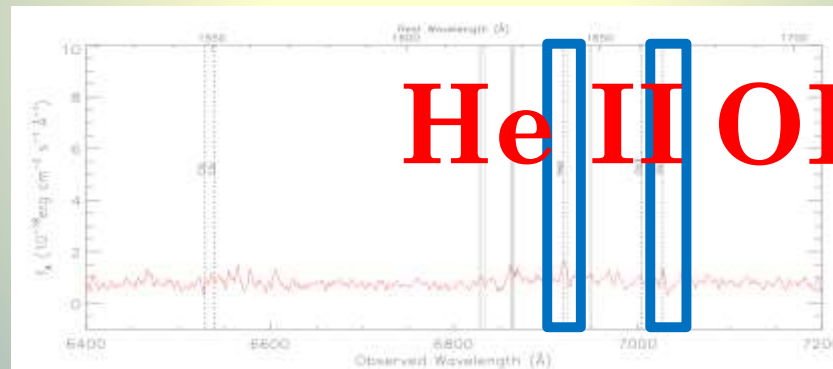
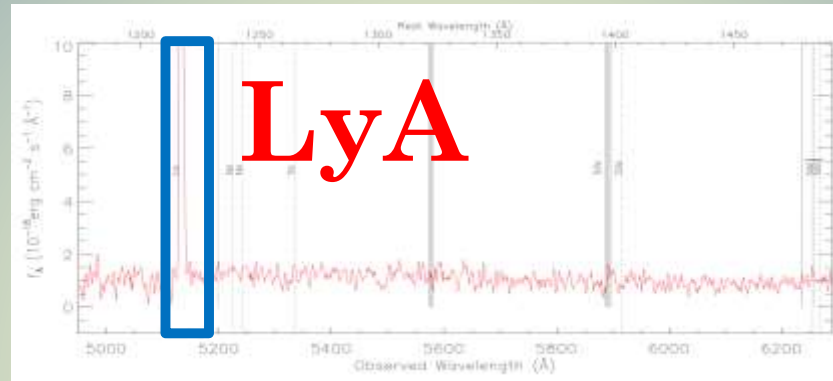
-Hundred of confirmed emission sources

- Source characterization by Kim, Bauer
(in prep)

Lensed LyA detection



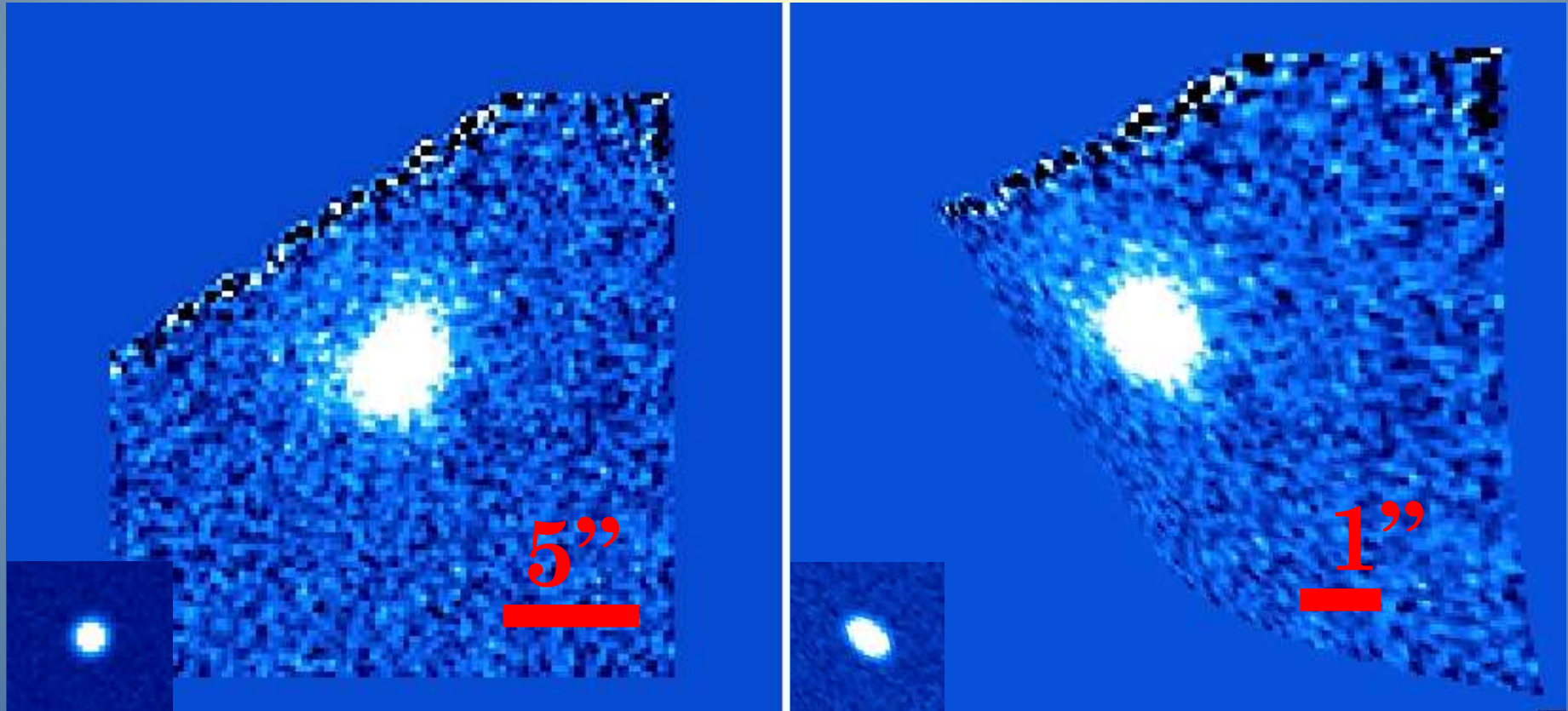
Redshift estimation with UV multiple emission lines ($z=3.2174$)



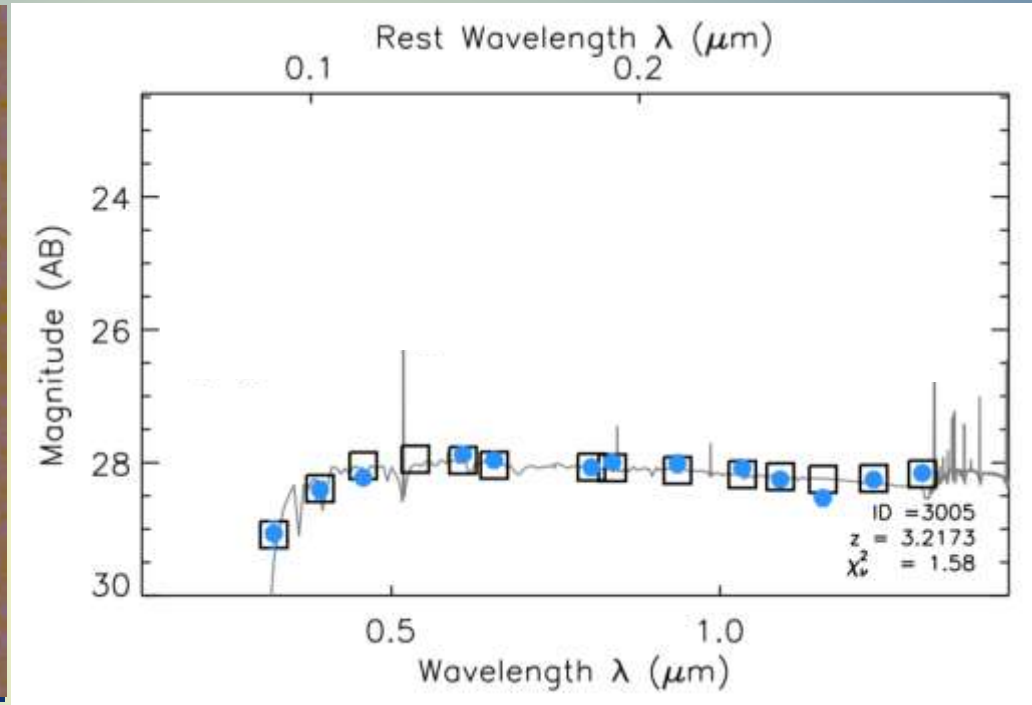
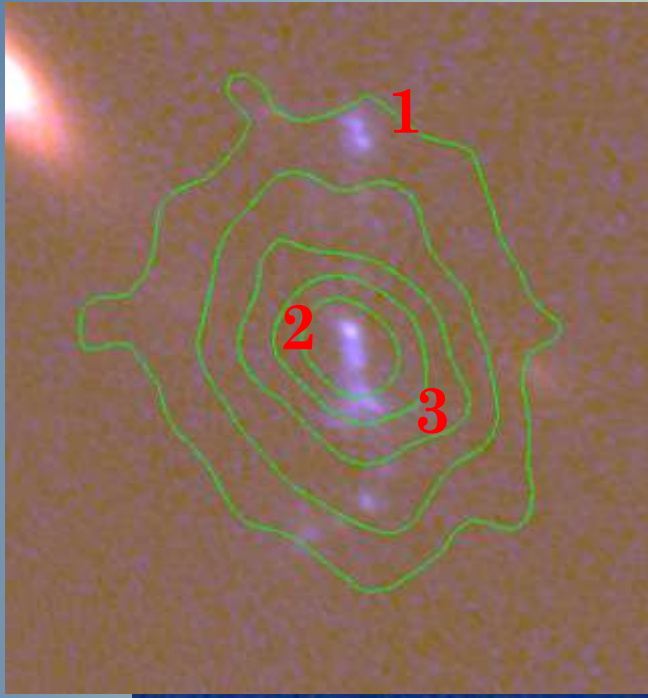
He II O III]

C III]

with CAT v.3 (lenstool)
Physical scale was derived !! With
this conversion.



Starforming rate for Luminosity Calculation



	Mass	SFR (M/yr)	AGE (Gyr)	Metal	Z_{phot}
1	3.63×10^7	0.37	245 Myr	0.17	3.353
2	3.46×10^7	0.47	180 Myr	0.15	3.168
3	5.01×10^7	0.36	340 Myr	0.18	3.211

Escape fraction close unity

- Standard relation between Luminosity and SFR
- Dijkstra & Jeason, Daniel 2013

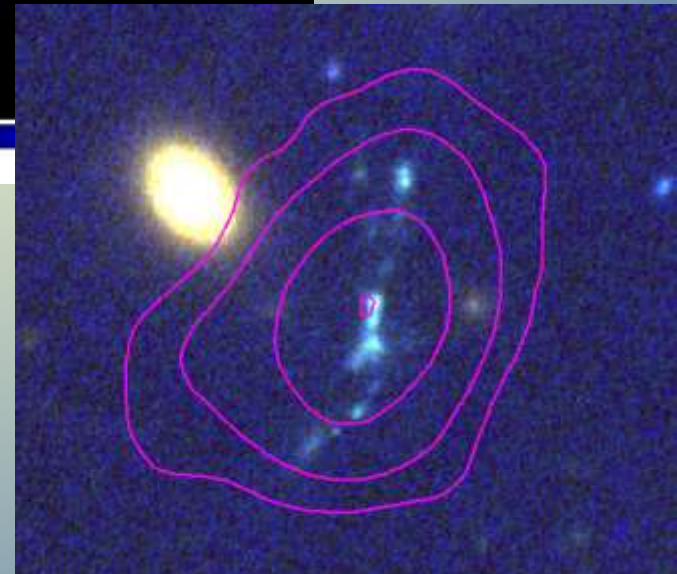
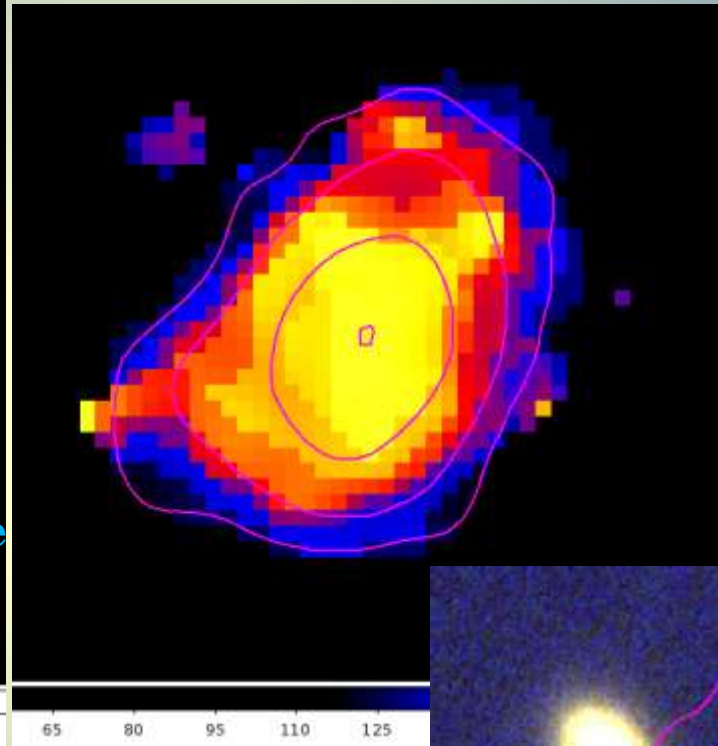
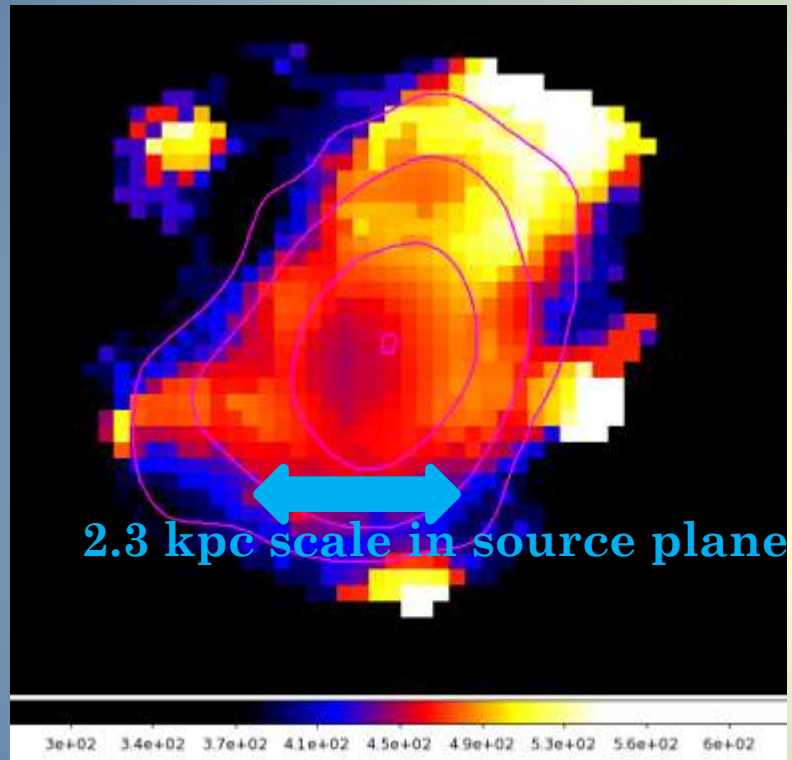
$L = 10^{42} \text{ erg/s} \times \text{SFR}$: that on average

$f_{\text{esc}} \sim 10\%$ at $z \sim 3$

MUSE 0416 LAB1

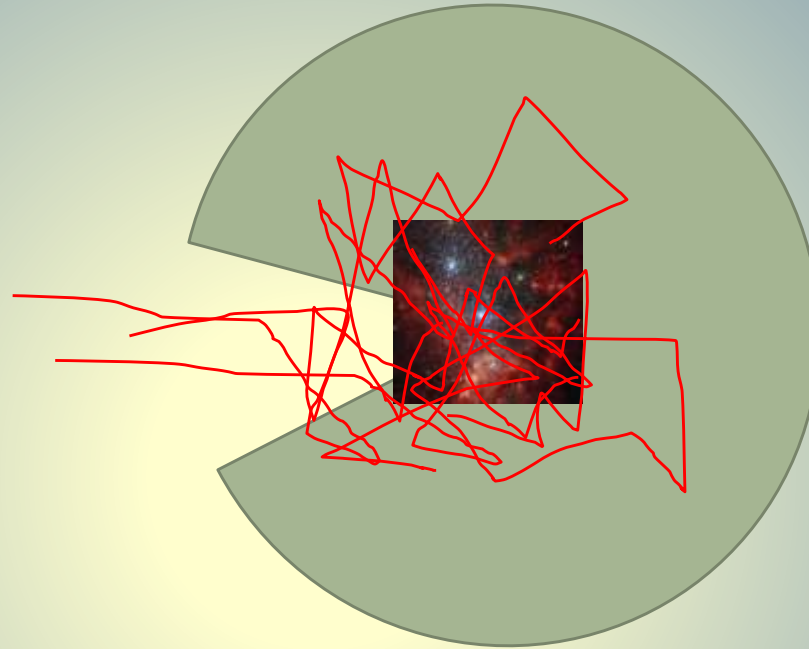
~ 1 why?

2D spectrum of outflow increase signature → simple shell model break down



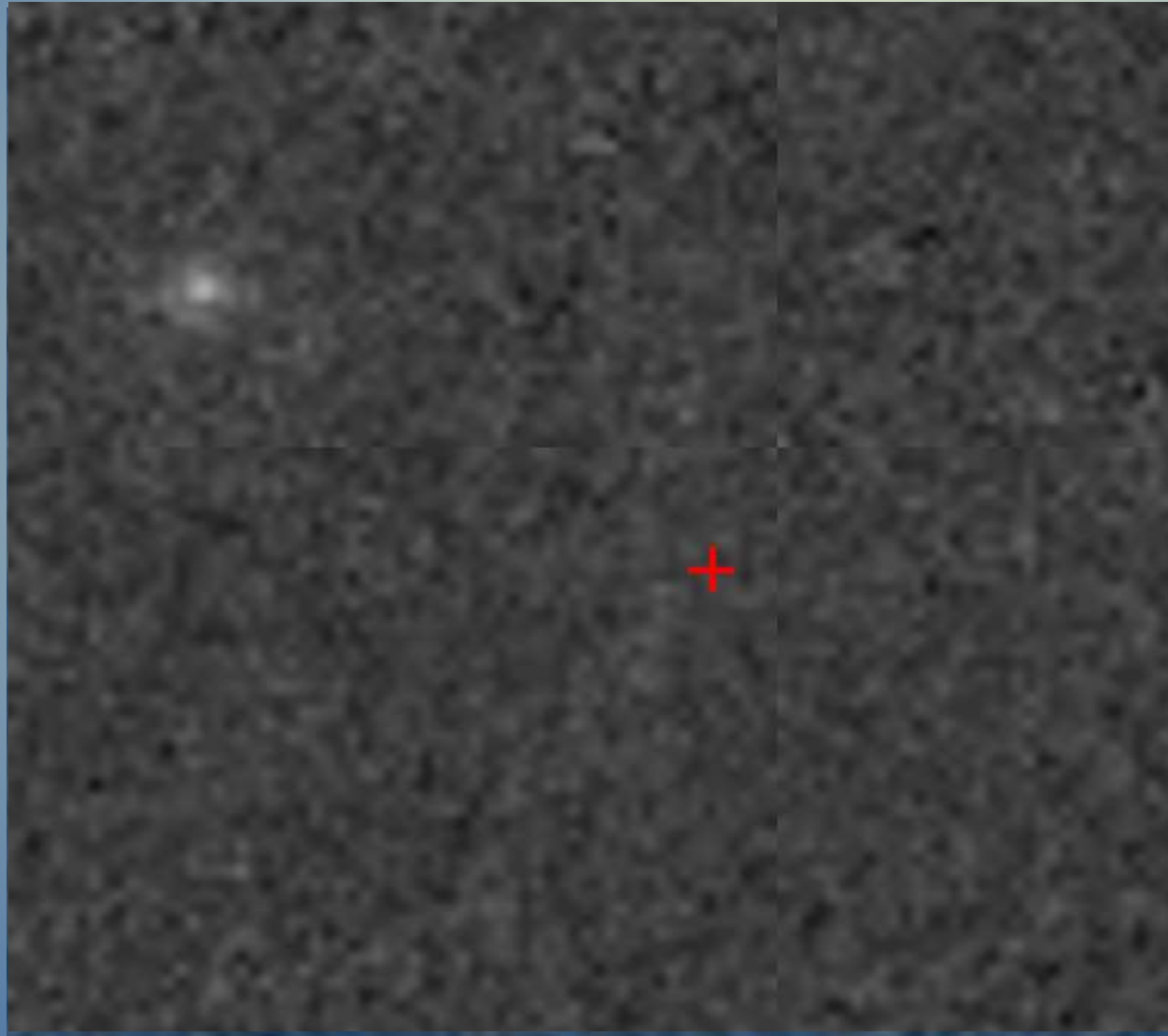
- Steidel+ 2010, Dalla Vecchia+ 2012
 - Momentum driven outflow
 - Feedback by pressure force

Lyman alpha – Continuum connection



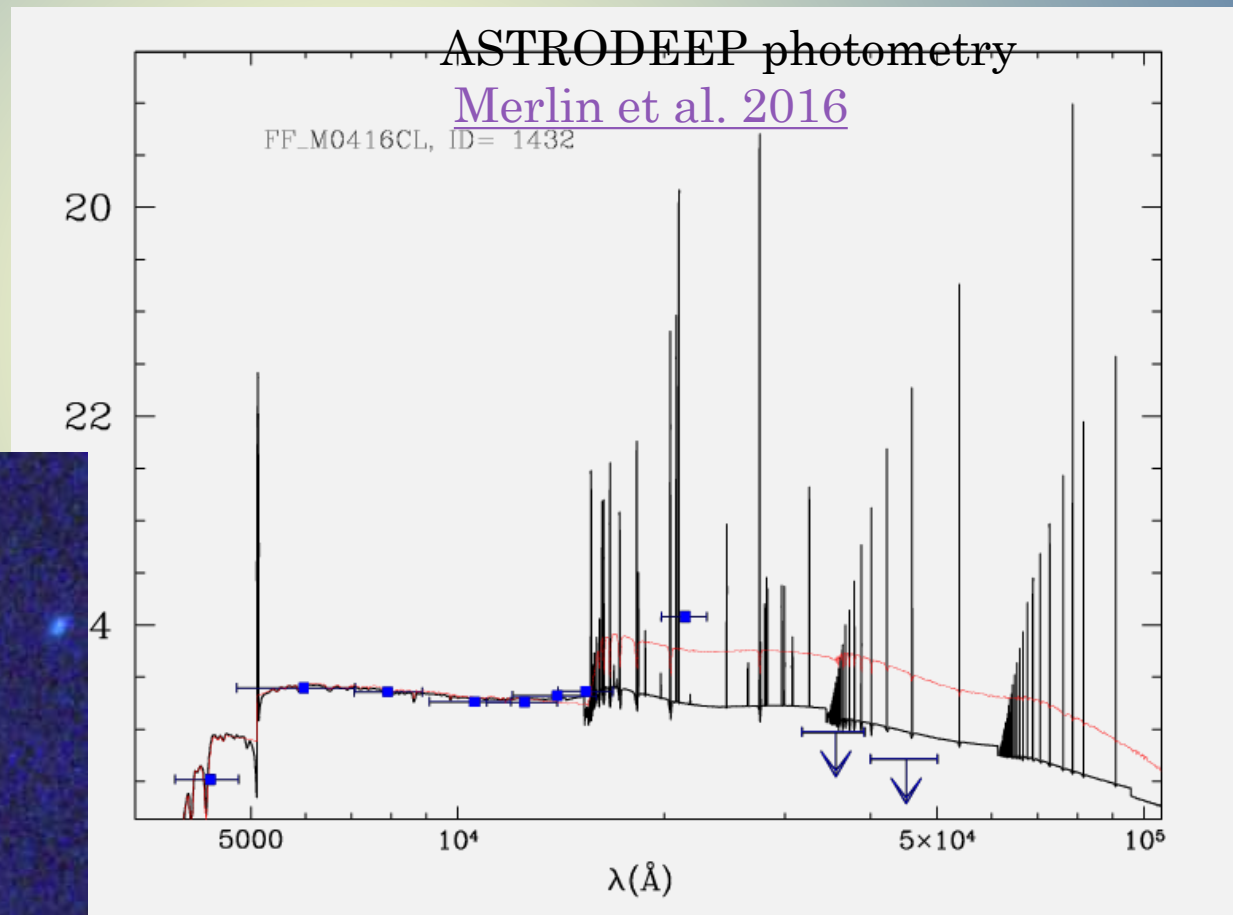
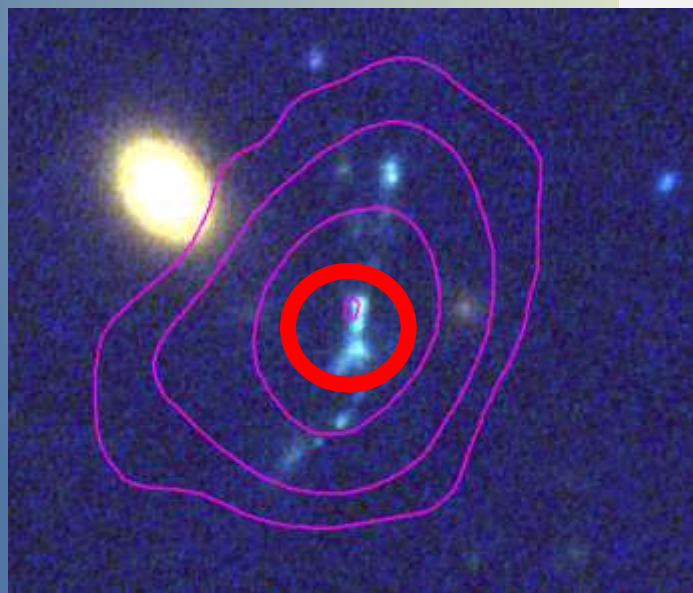
The presence of low NHI (neutral hydrogen column density) 'holes' limits how much Ly α has to diffuse prior to escape: Ly α spectral lines of LyC emitting objects are narrower in frequency direction.

Faint Ionizing Continuum Signal?



HFF+CLASH
F814W + F390W
F390W

Strong ionizing flux detected
in K-band excess (H beta).



Conclusion

- We used VLT/MUSE, to find redshifts of $z = 3.217$ faint and extended Ly α source which is gravitationally lensed
- Considering magnification factor ~ 9 (CATS V3.0 model) We are resolving extended Ly α nebular - LyC candidate into details.
- Conventional expanding shell model for Ly α profile is not consistent with MUSE 2D spectra.
- **Lyman continuum leakage could be associated with morphological complexity and extended Ly α .**