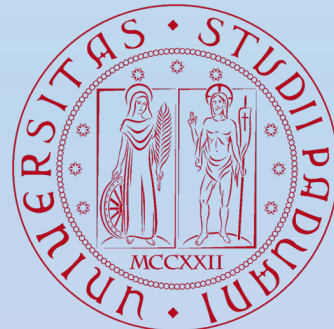




THE ORIGIN OF THE $Ly\alpha$ EMISSION FROM THE POLARIZED SPECTRUM OF A STAR-FORMING HIGH- z GALAXY

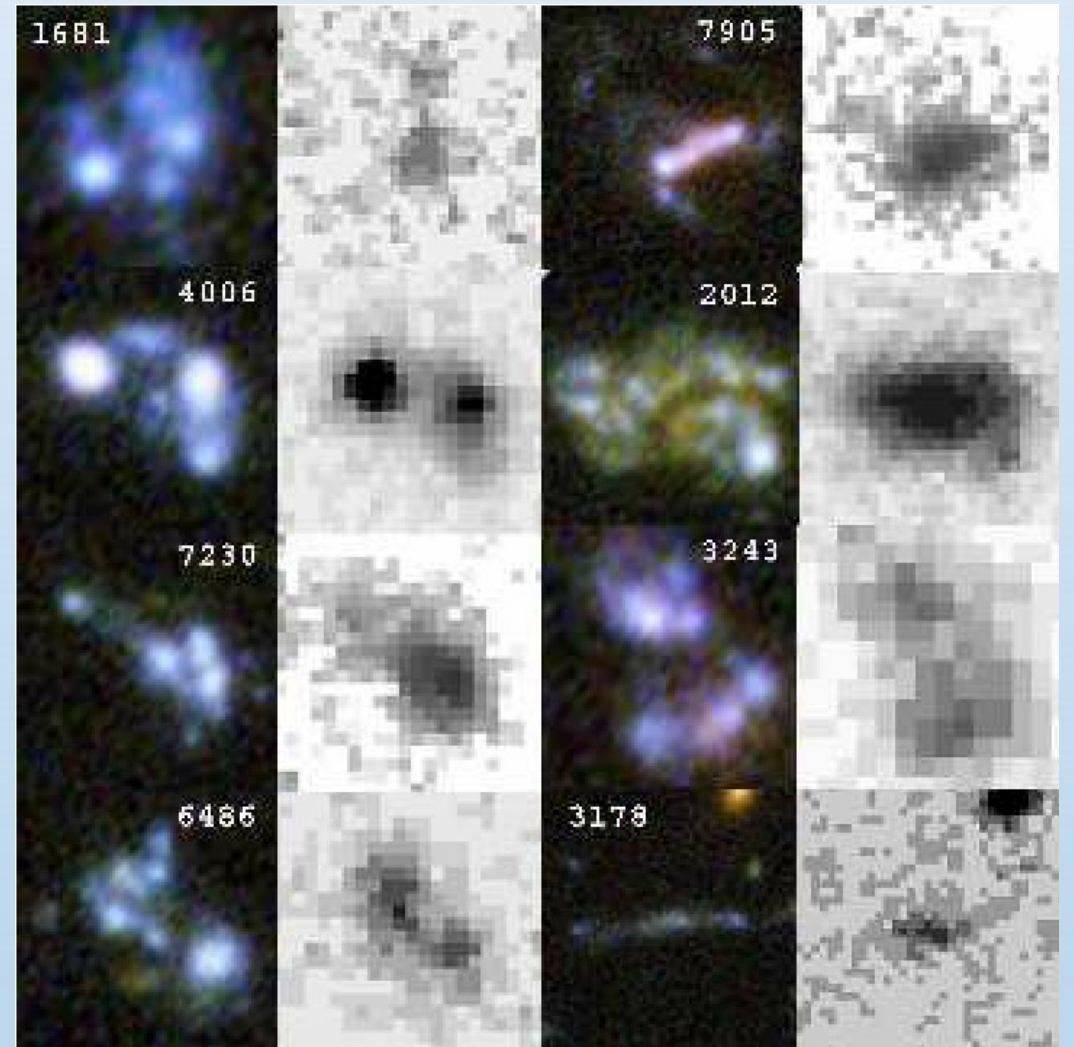
A. Bolamperti,
J. Vernet, A. Zanella,
et al.



High-z clumps

Clumpy morphology:
star-forming regions with

- $R \lesssim 1$ kpc
- $M_* \sim 10^7 - 10^9 M_\odot$
- $\text{SFR} \sim 0.1 - 10 M_\odot/\text{yr}$

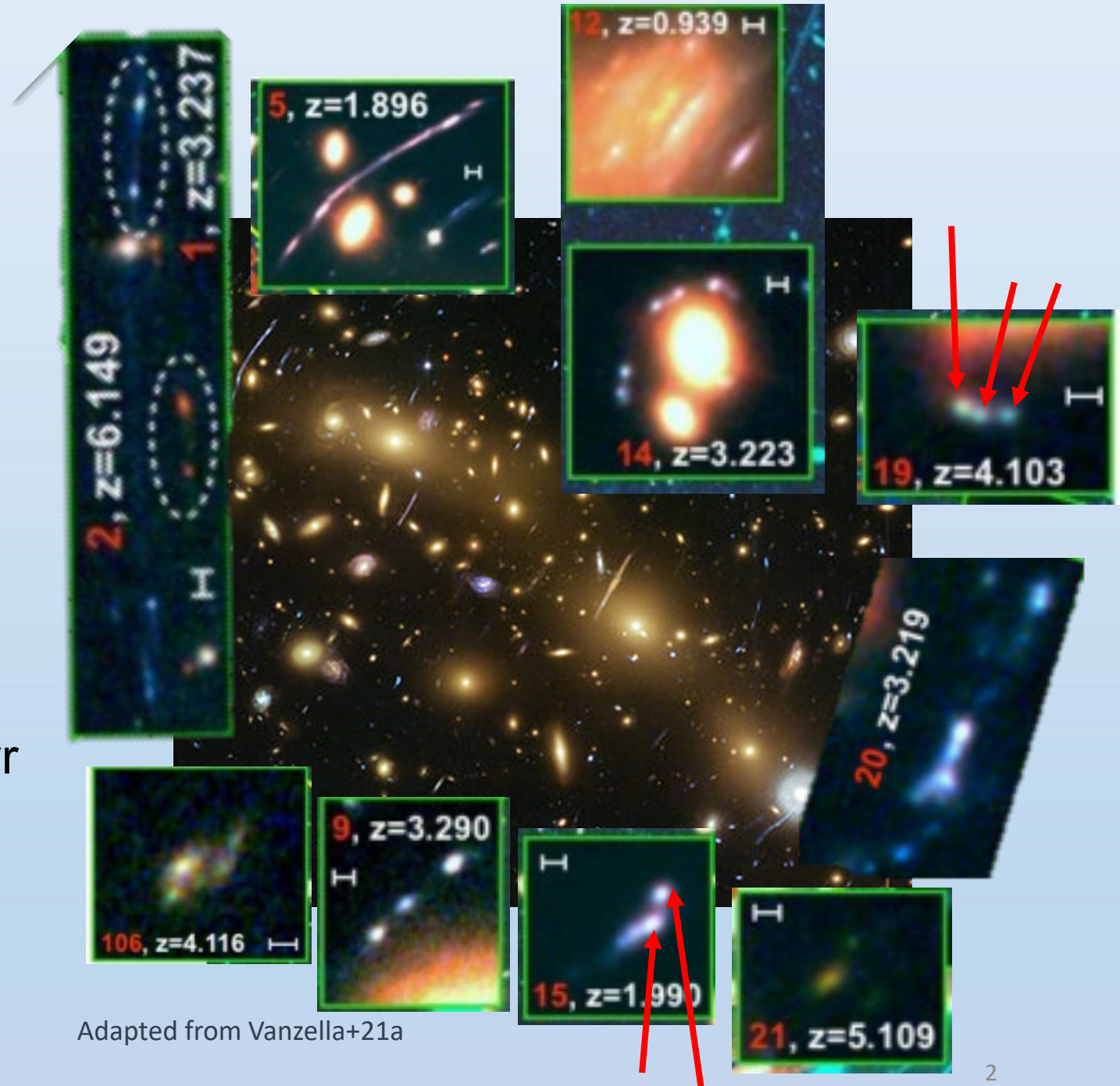


Eight clumpy galaxies in the UDF.
From Elmegreen+2009

High-z clumps

Clumpy morphology:
star-forming regions with

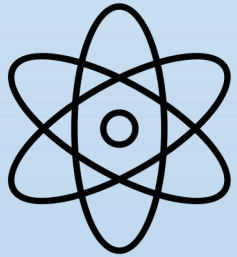
- $R \lesssim 1 \text{ kpc} \sim 10 \text{ pc}$
- $M_* \sim 10^7 - 10^9 M_\odot$
- $\text{SFR} \sim 0.1 - 10 M_\odot/\text{yr}$



Adapted from Vanzella+21a

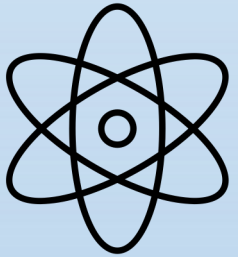
The Lyman- α issue

TRACER OF
IONIZED HYDROGEN

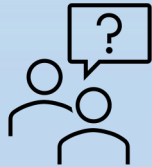


The Lyman- α issue

TRACER OF
IONIZED HYDROGEN

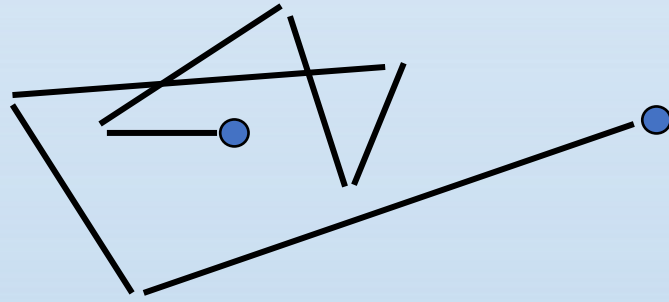


ORIGIN

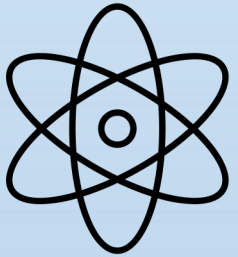


The Lyman- α issue

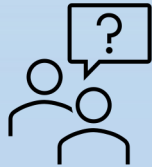
RESONANT



TRACER OF
IONIZED HYDROGEN

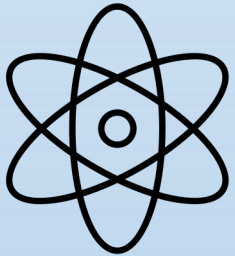


ORIGIN

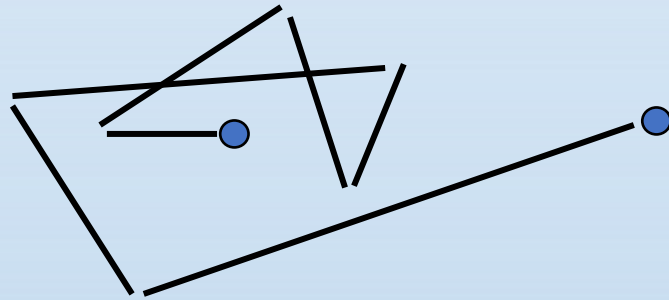


The Lyman- α issue

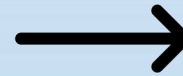
TRACER OF
IONIZED HYDROGEN



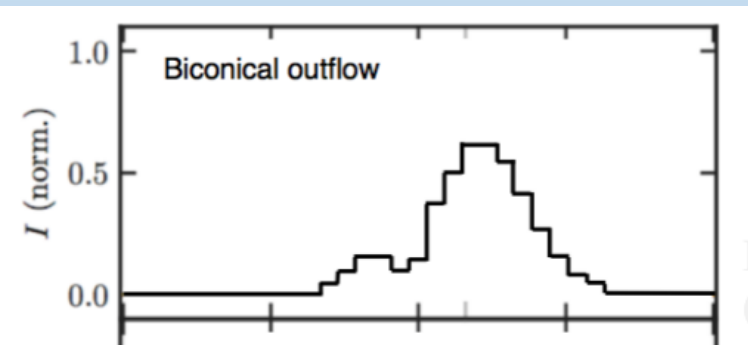
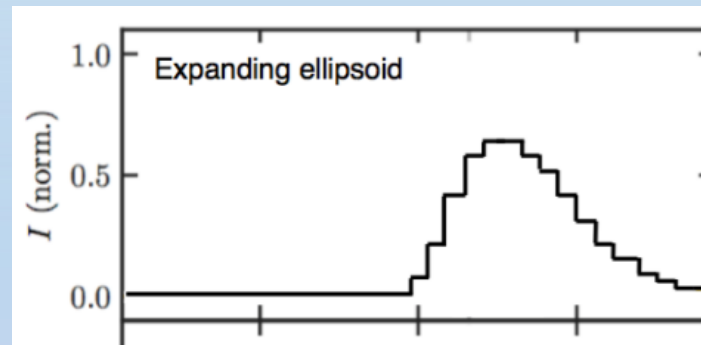
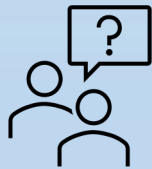
RESONANT



**DIFFERENT PROCESSES
PRODUCE SIMILAR SPECTRA**

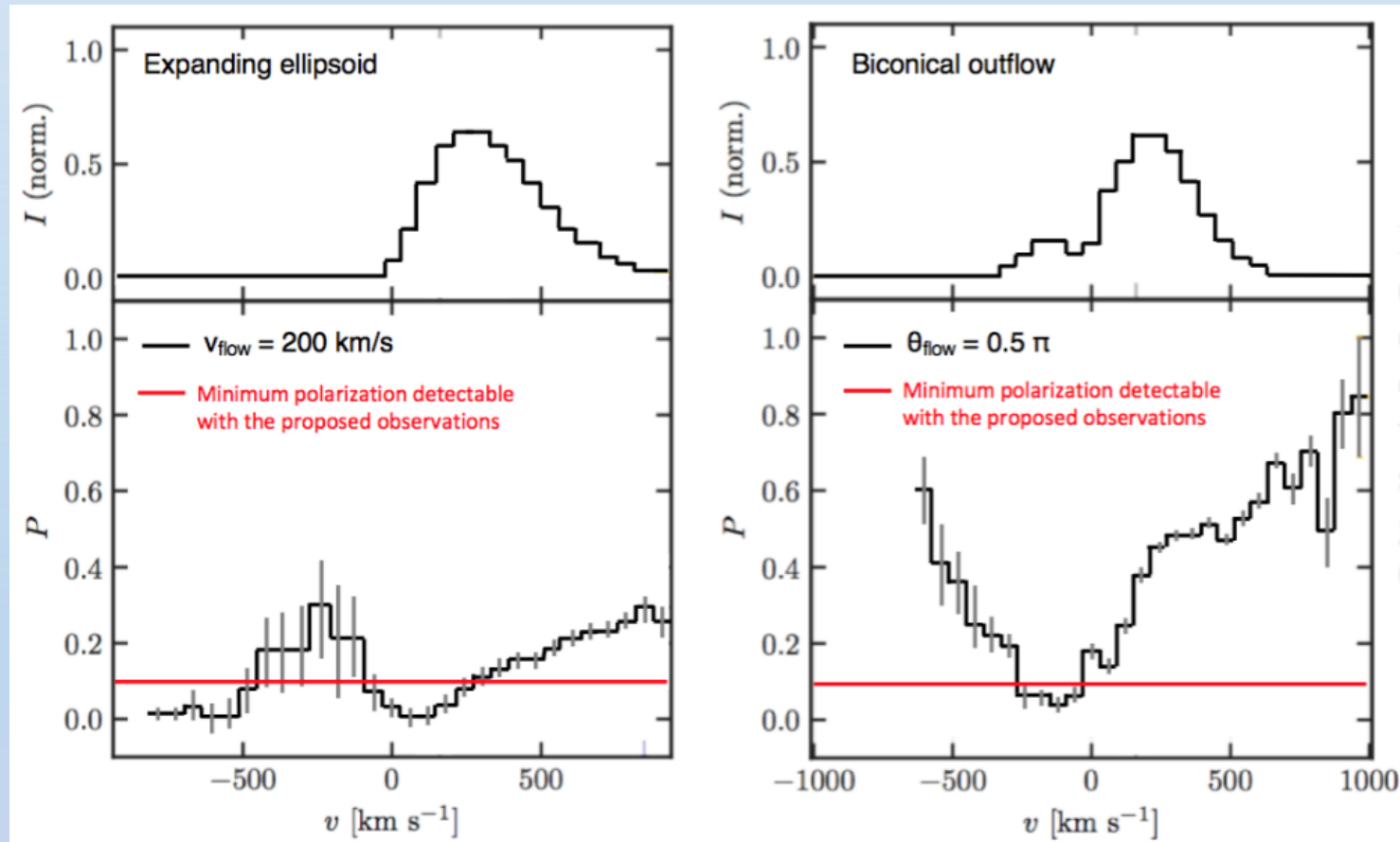


ORIGIN



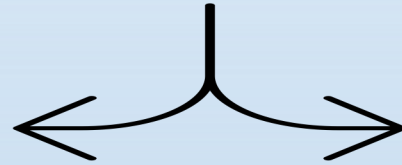
How polarization can solve the puzzle

DIFFERENT MODELS PRODUCE SIMILAR SPECTRA,
BUT DIFFERENT POLARIZED SPECTRA



How polarization can solve the puzzle

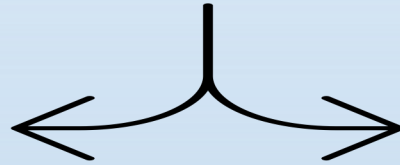
AND Ly α POLARIZATION LEVELS



How polarization can solve the puzzle

AND Ly α POLARIZATION LEVELS

$(P < \text{few } \%)$



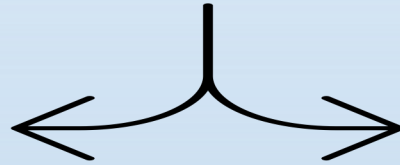
- in-situ Ly α emission due to extended star formation or cooling
- (never detected before at $z \sim 3$)

How polarization can solve the puzzle

AND Ly α POLARIZATION LEVELS

($P < \text{few } \%$)

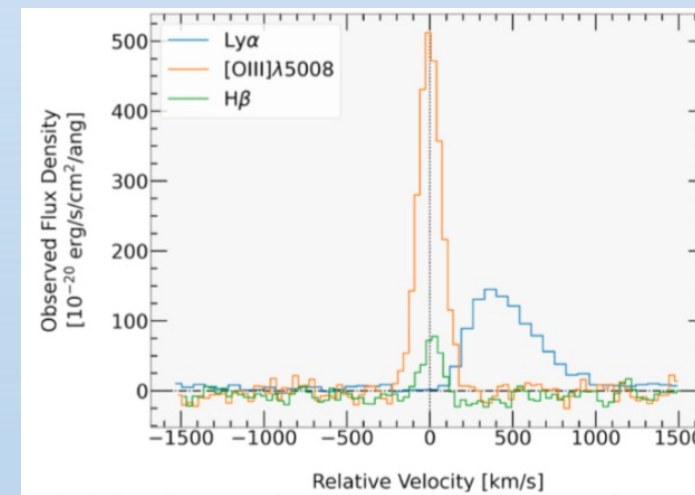
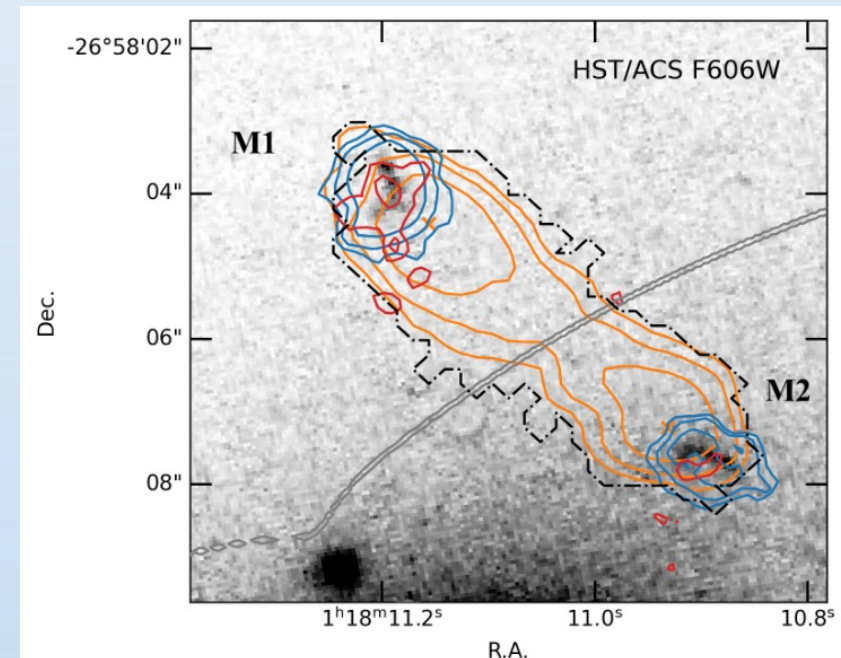
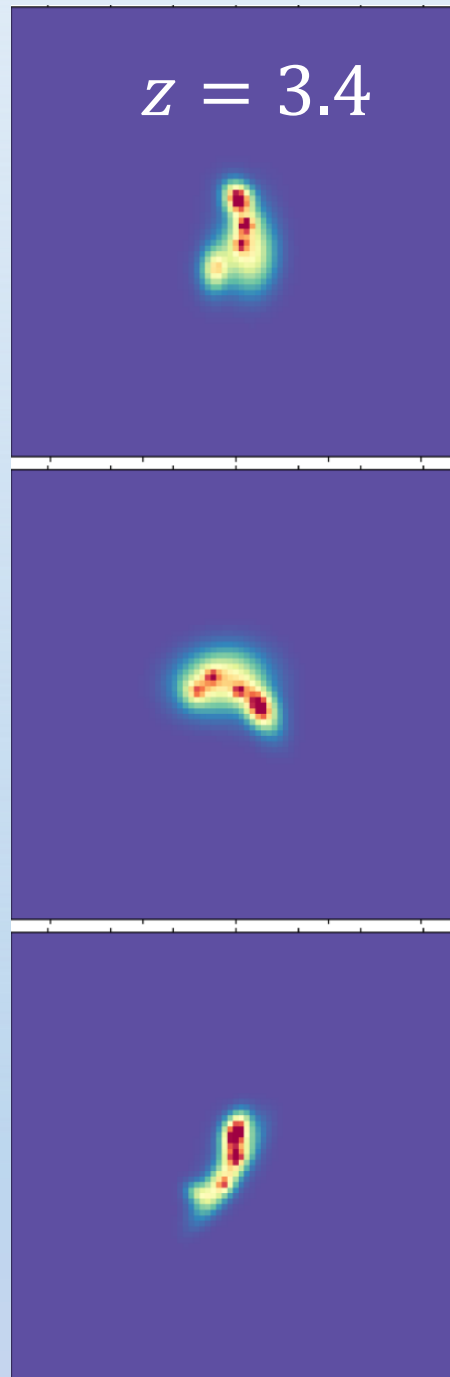
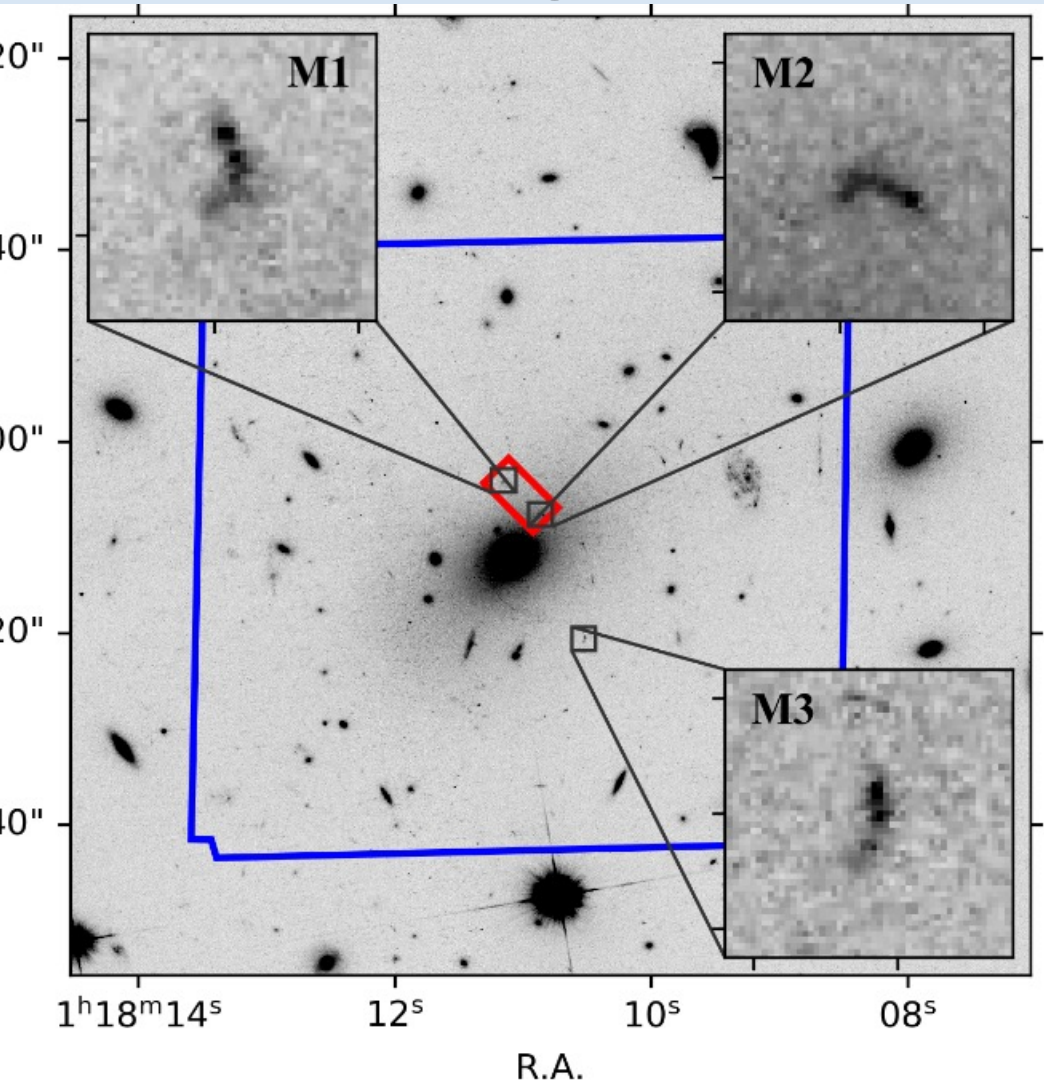
- in-situ Ly α emission due to extended star formation or cooling
- (never detected before at $z \sim 3$)



($P < 20 \%$)

- Ly α photons are produced in star-forming clumps, and then scattered out (P up to 40% – 80%).
- Reconstruct the geometry (i.e., static or expanding ellipsoid, biconical outflow) of the scattering medium and constrain the feedback properties of the clumps.
- unambiguous signature of the scattering nature of the Ly α halos, and distribution of circumgalactic gas

The target

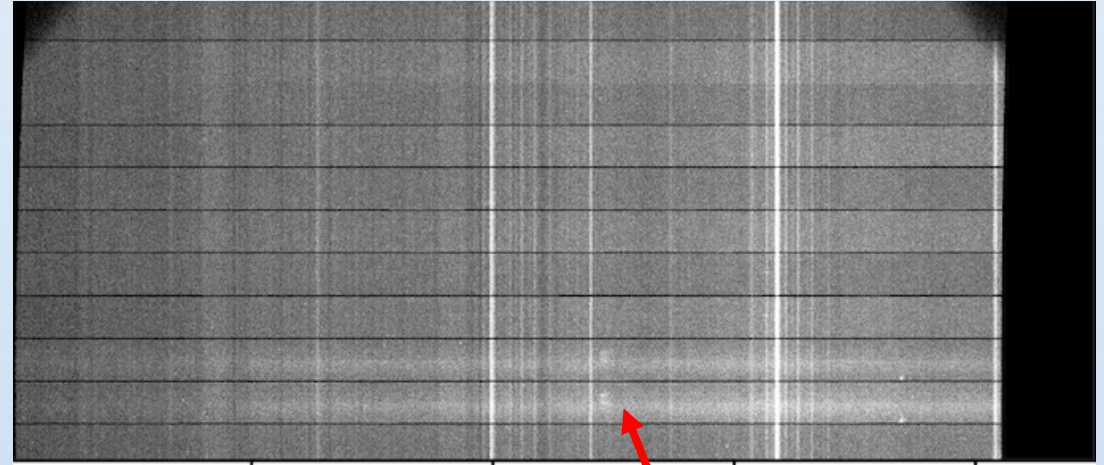


MUSE, ALMA, HST, SINFONI
(+lensing model)

The observations

18 hours with FORS2 PMOS
(spectropolarimetric mode)

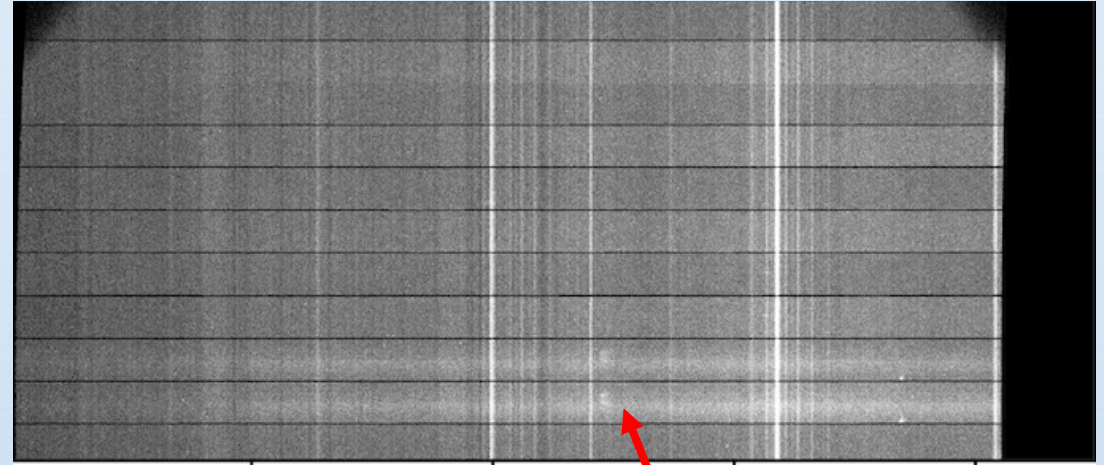
Observed between September 2021 and August 2022



The observations

18 hours with FORS2 PMOS
(spectropolarimetric mode)

Observed between September 2021 and August 2022



Spatial direction

image 0.0°

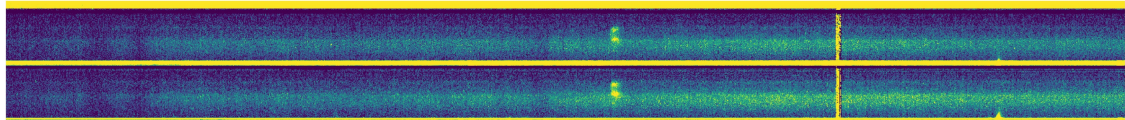


image 45.0°

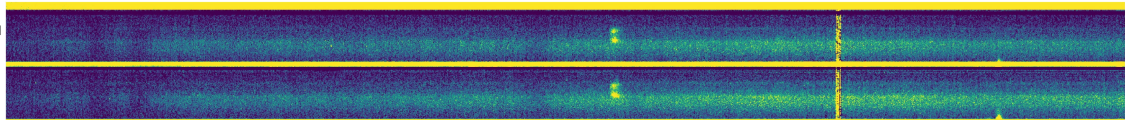


image 22.5°

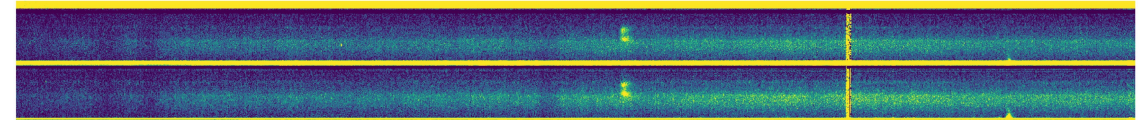
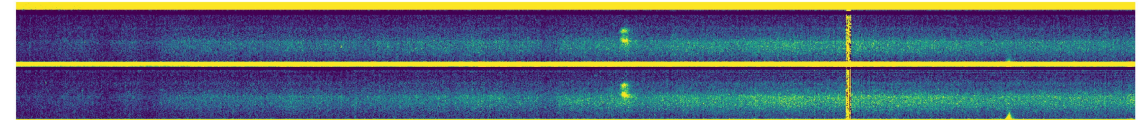


image 67.5°



Spectral direction

Results

Measure the intensity I for all the orientations and E/O channels



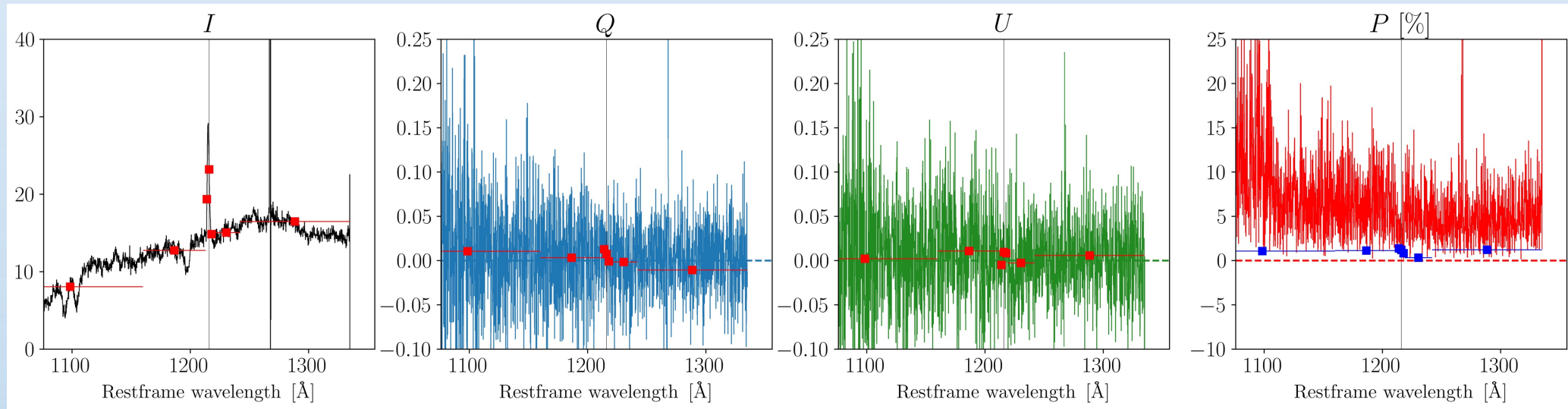
Stokes parameters Q and U



polarization $P = \sqrt{U^2 + Q^2}$

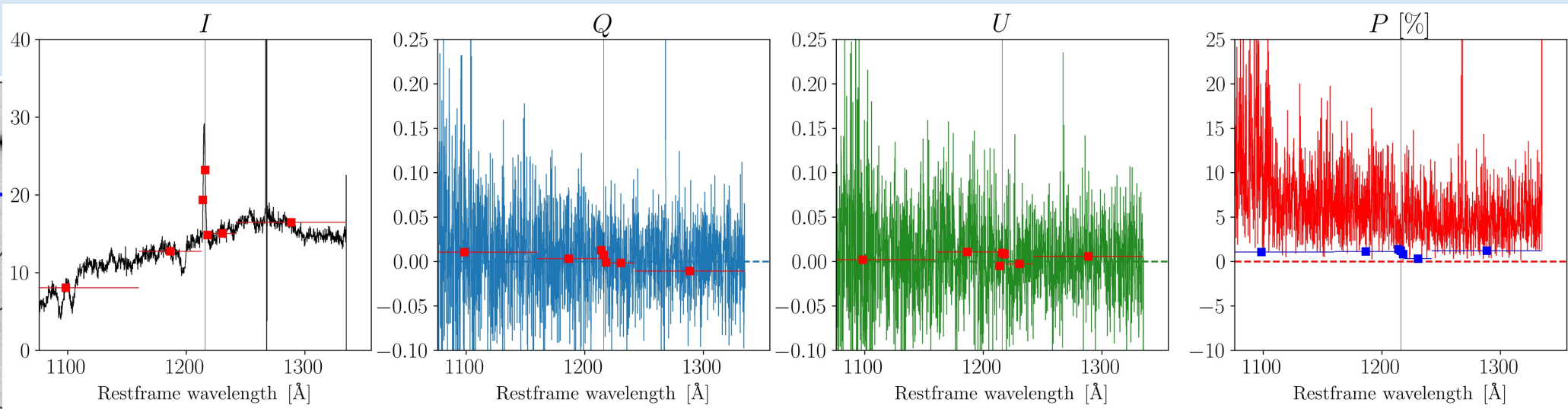
Results

$$\text{polarization } P = \sqrt{U^2 + Q^2}$$



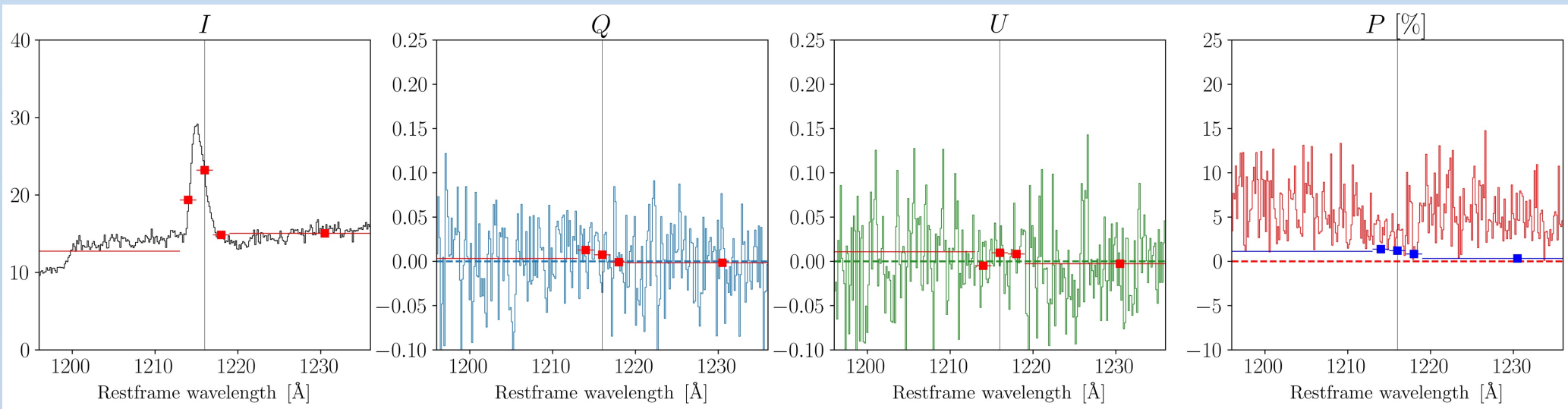
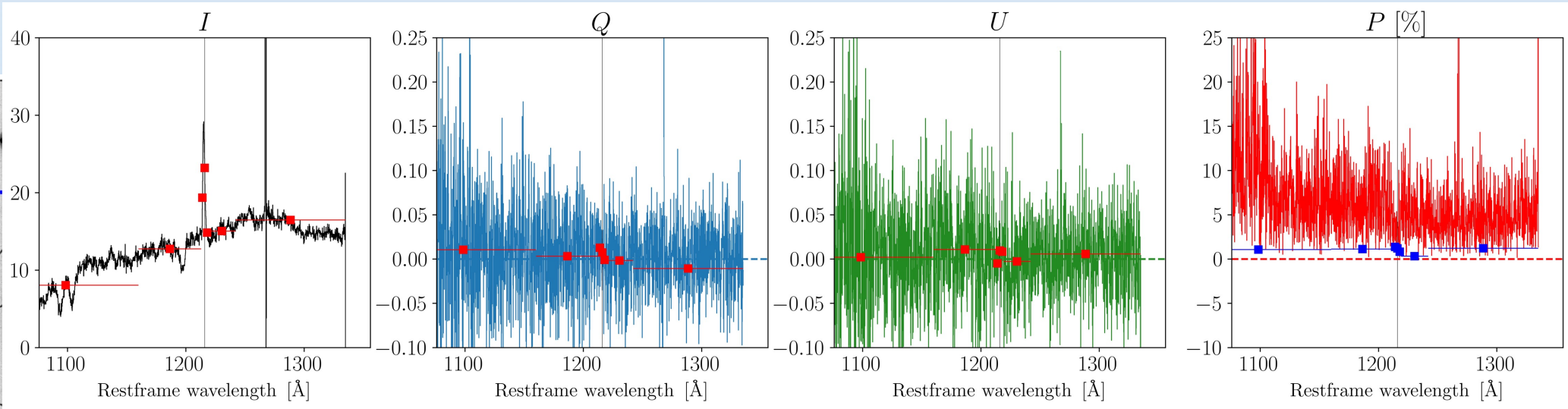
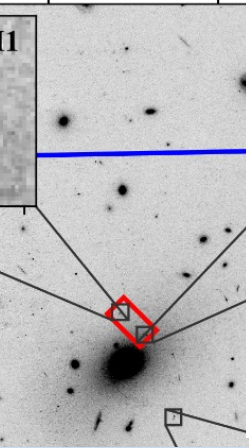
Results

$$\text{polarization } P = \sqrt{U^2 + Q^2}$$

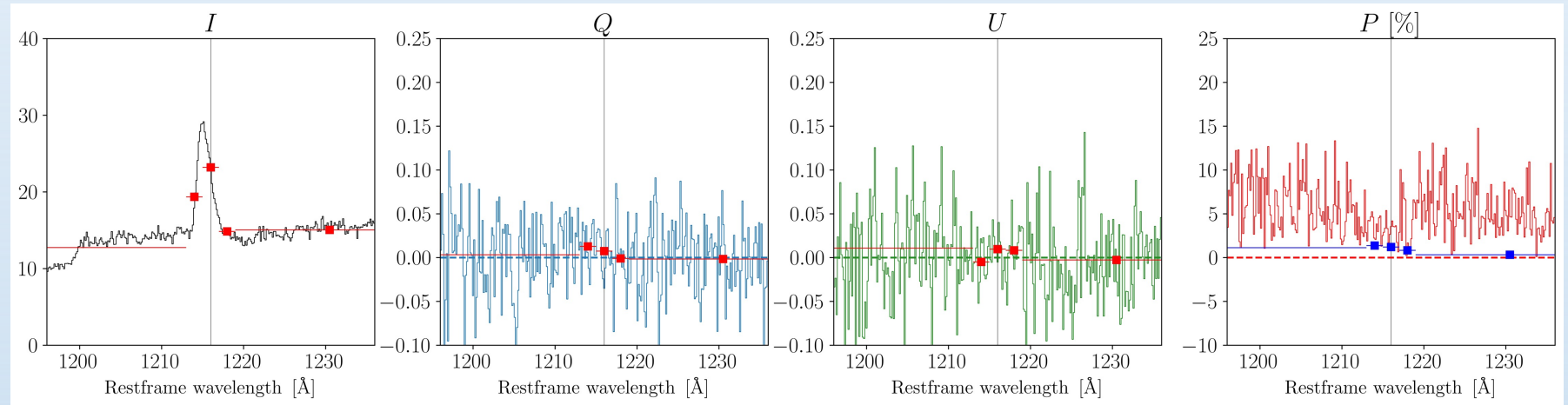


Results

$$\text{polarization } P = \sqrt{U^2 + Q^2}$$

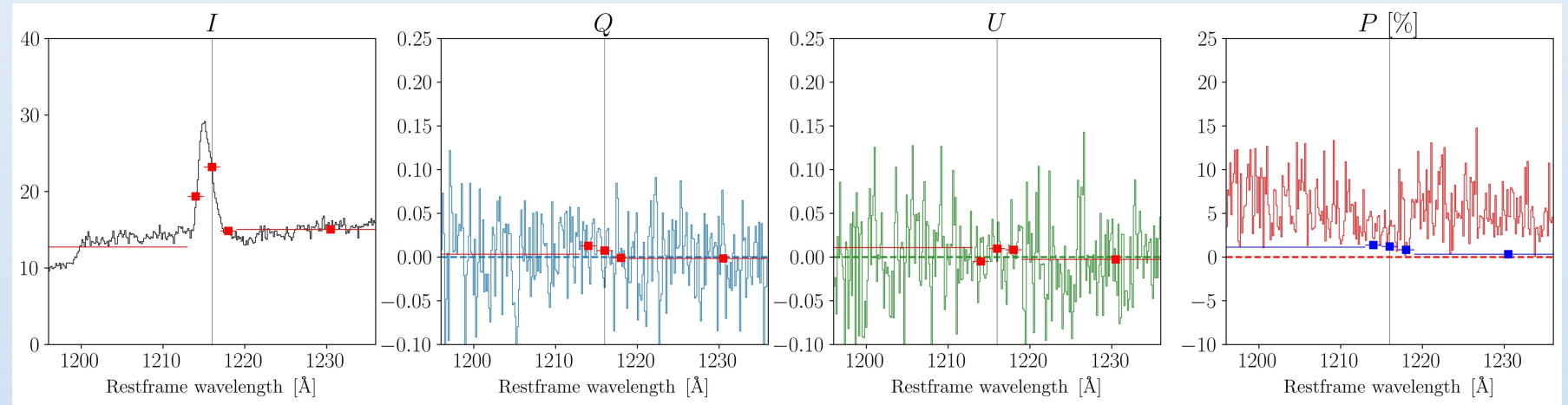


$$\text{polarization } P = \sqrt{U^2 + Q^2}$$

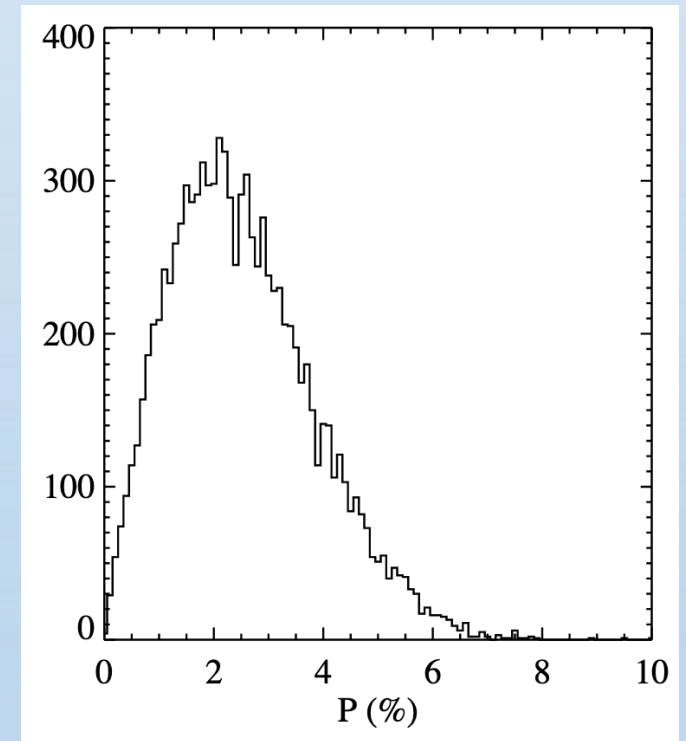


- Bias at low S/N
- Estimate the uncertainties (put upper limit)
- Dilution

$$\text{polarization } P = \sqrt{U^2 + Q^2}$$

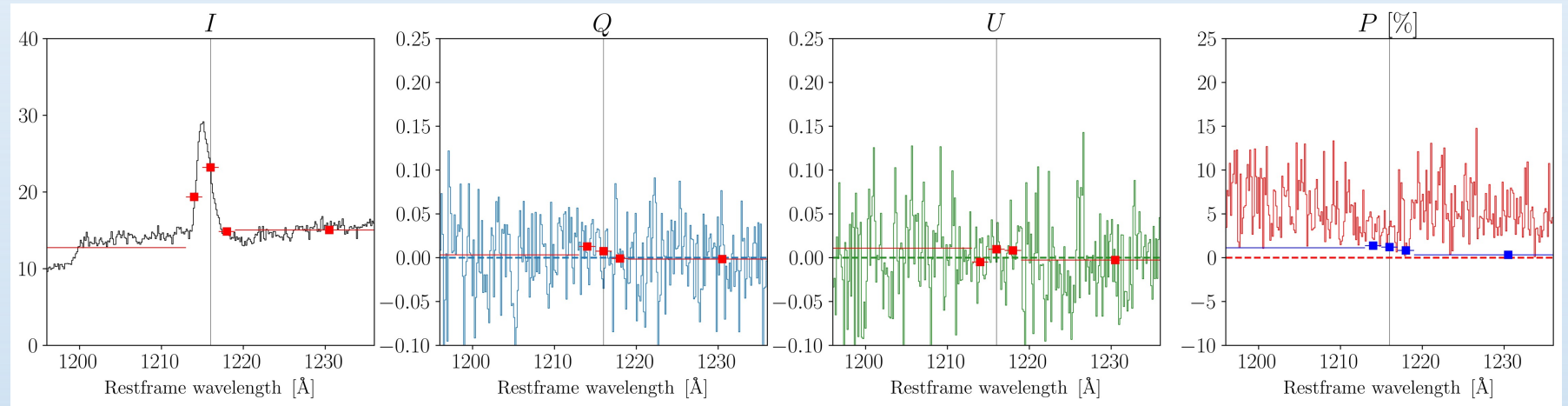


- Bias at low S/N
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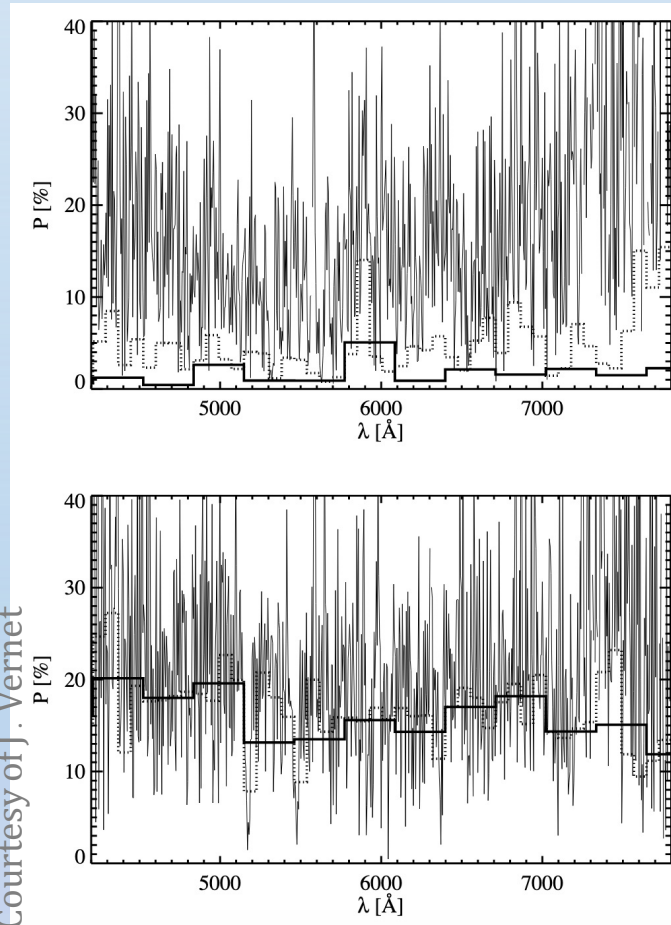


Courtesy of J. Vernet

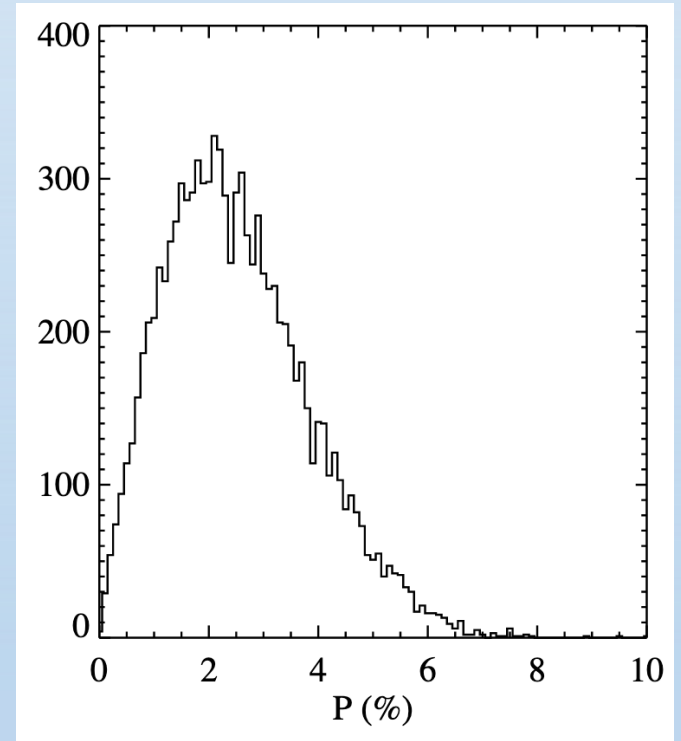
polarization $P = \sqrt{U^2 + Q^2}$



- Bias at low S/N
- Estimate the uncertainties (put upper limit)
- Dilution



Courtesy of J. Vernet



Courtesy of J. Vernet

Conclusions and outlook

- $P < 3\%$
- Scattering is not the main source of observed Ly α flux
- gas cooling or fluorescent radiation from an external ionizing field emission never observed at $z = 3$
- Analysis require a very careful approach with P close to 0
- Extend the sample, estimate bias, uncertainties, rule out models