

# A tale of two galaxy types (and everything in between) inside a galaxy-cluster progenitor at $z \sim 3$

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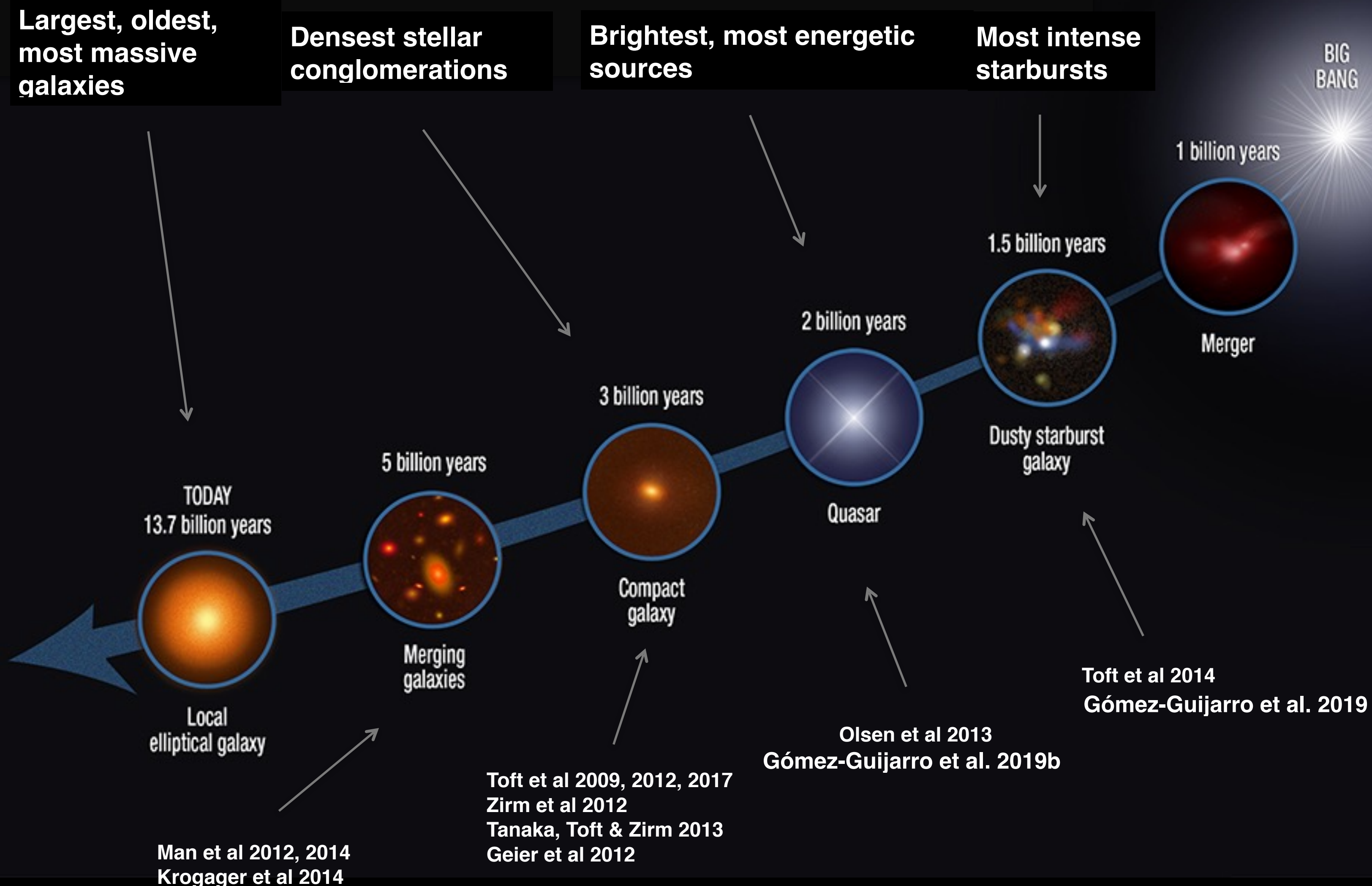
*Daddi+2021*

*Kalita+2021*

*Kalita+2021a (submitted to ApJL)*

*Kalita+ (in prep)*

# Evolution of massive elliptical galaxies



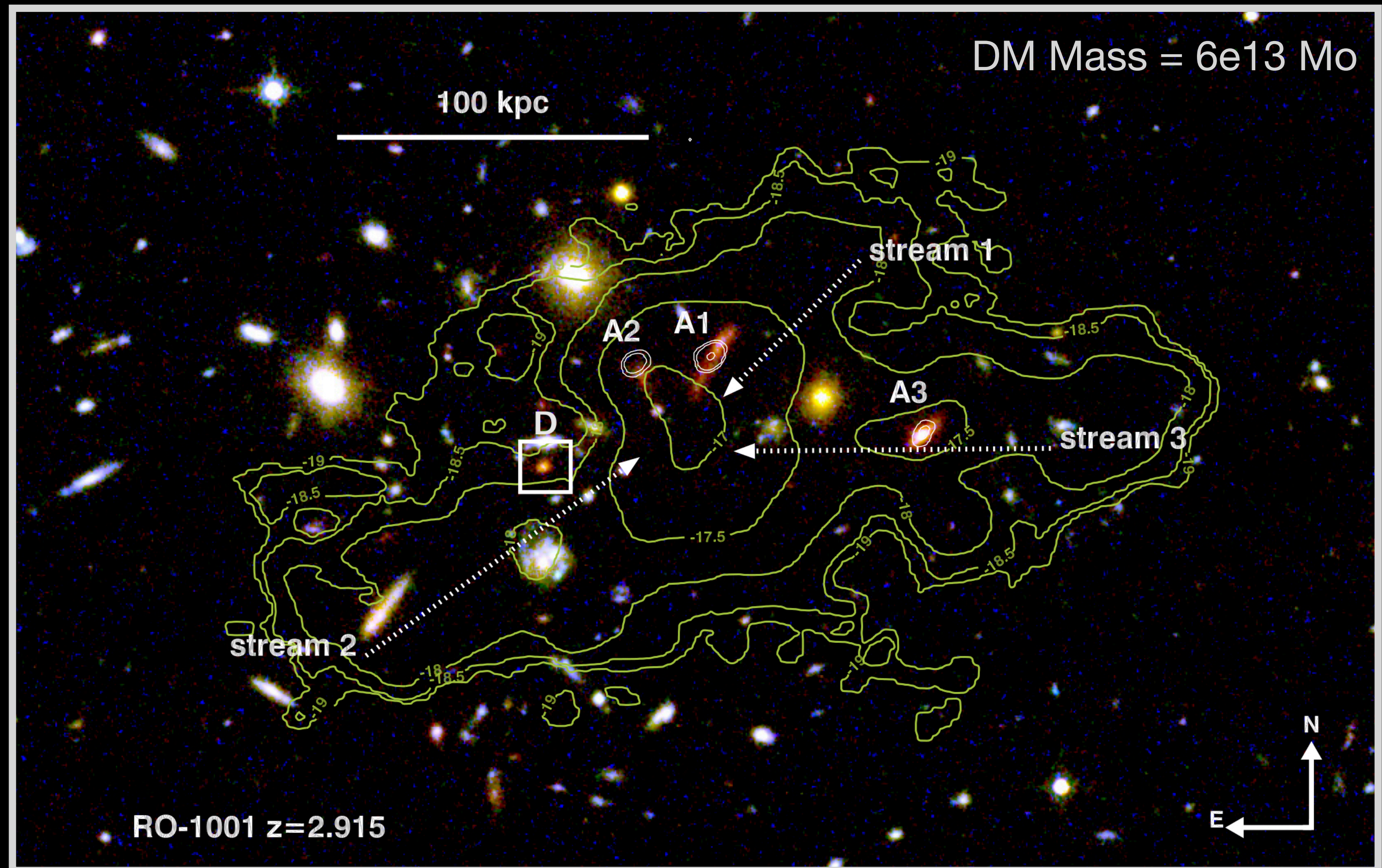
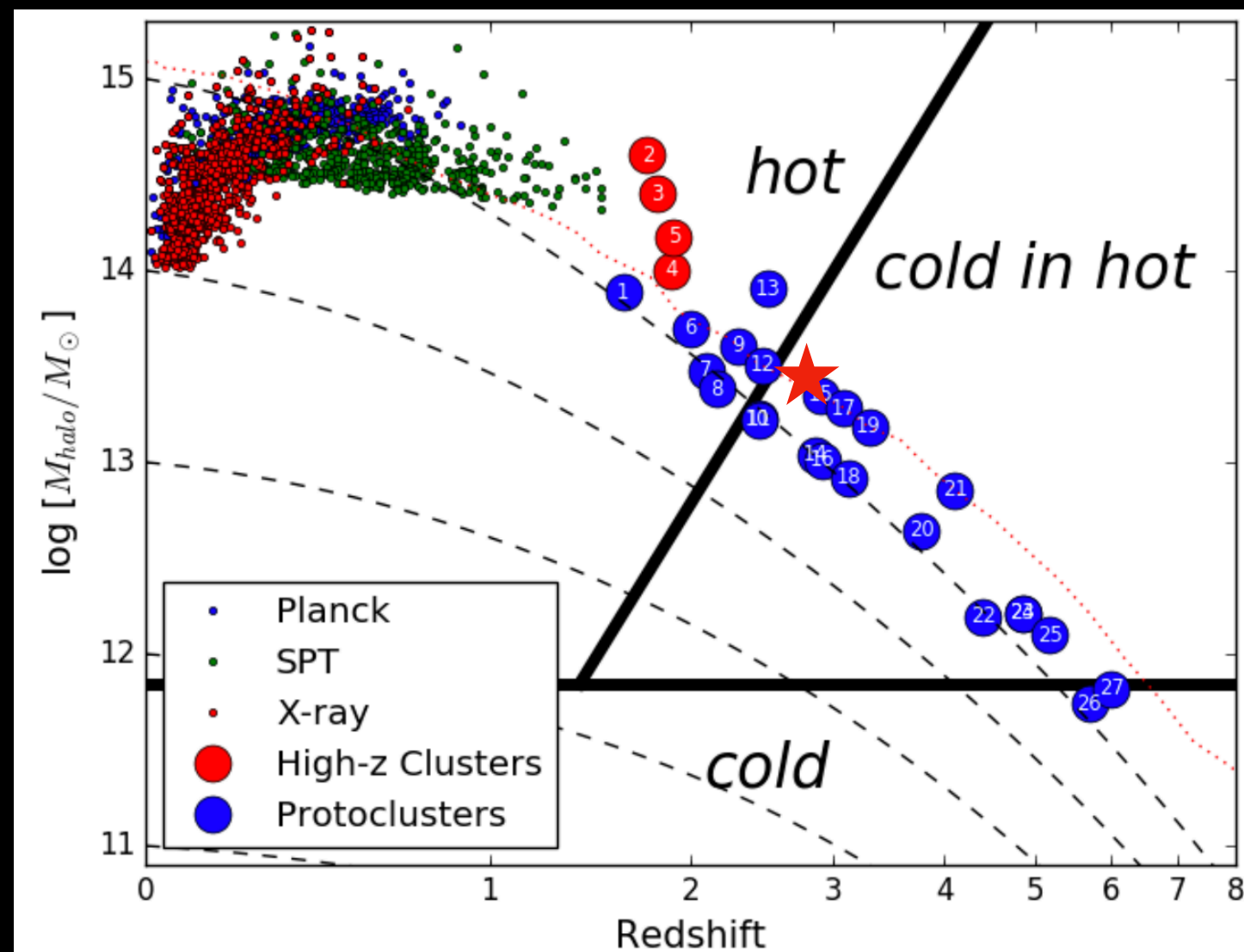
**Different processes  
in dense  
environments at  
high-z?**

**Multiwavelength  
studies of galaxy  
evolution and  
environment in  
cluster progenitors**



# The Galaxy Group RO-1001 ( $z=2.91$ )

- $12\sigma$  overdensity of optically faint radio sources (3 GHz) in the COSMOS 2-square-degree field.
- Spectroscopic confirmation: 3 SMGs
- Photometric confirmation: 1 QG (SFR  $<10$  Mo/yr)
- Gas accretion streams traced by Ly- $\alpha$





# Sub-millimeter galaxies

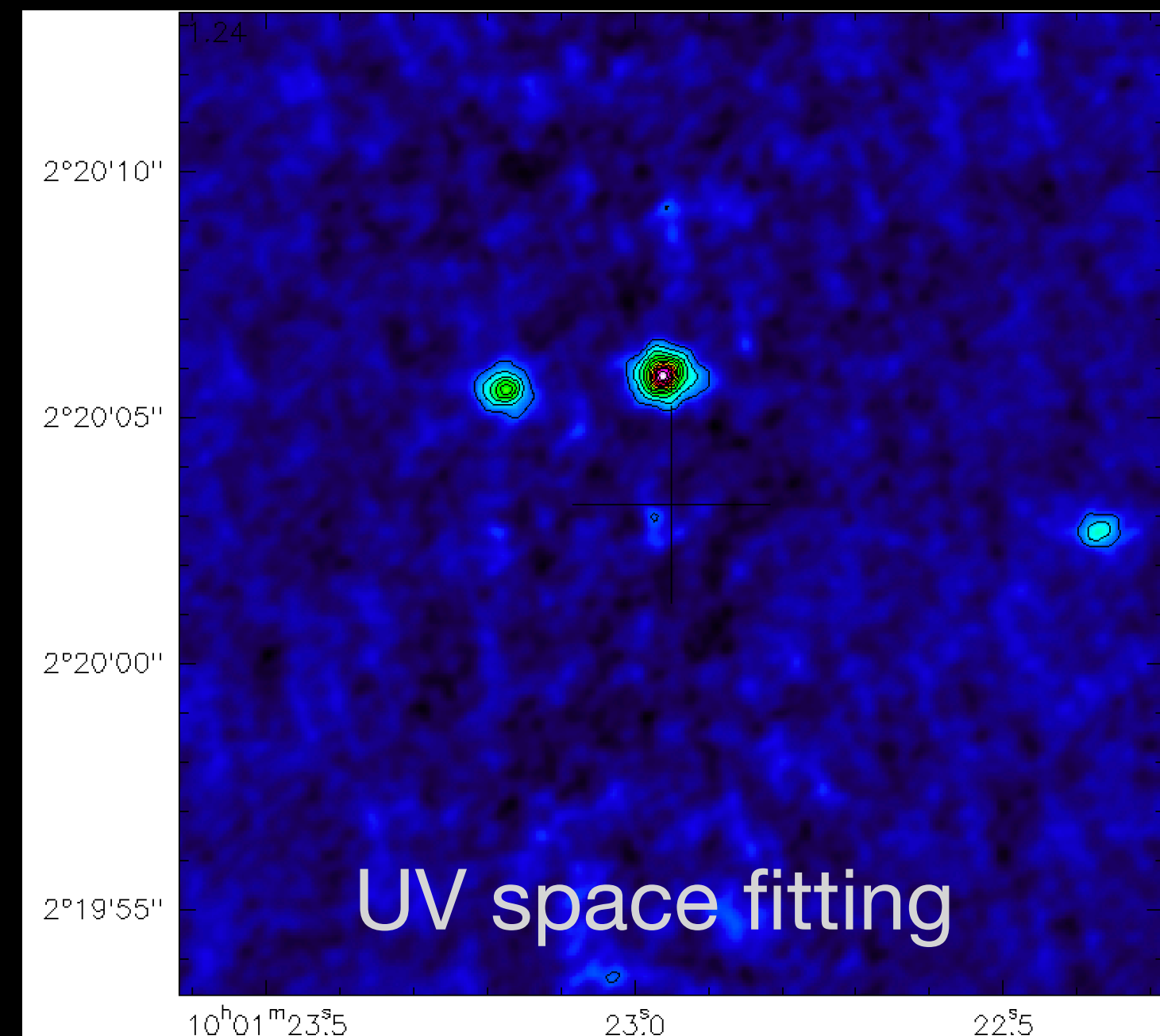
## HST/WFC3 + ALMA analysis

ALMA 870  $\mu\text{m}$ , PI: M. Rich

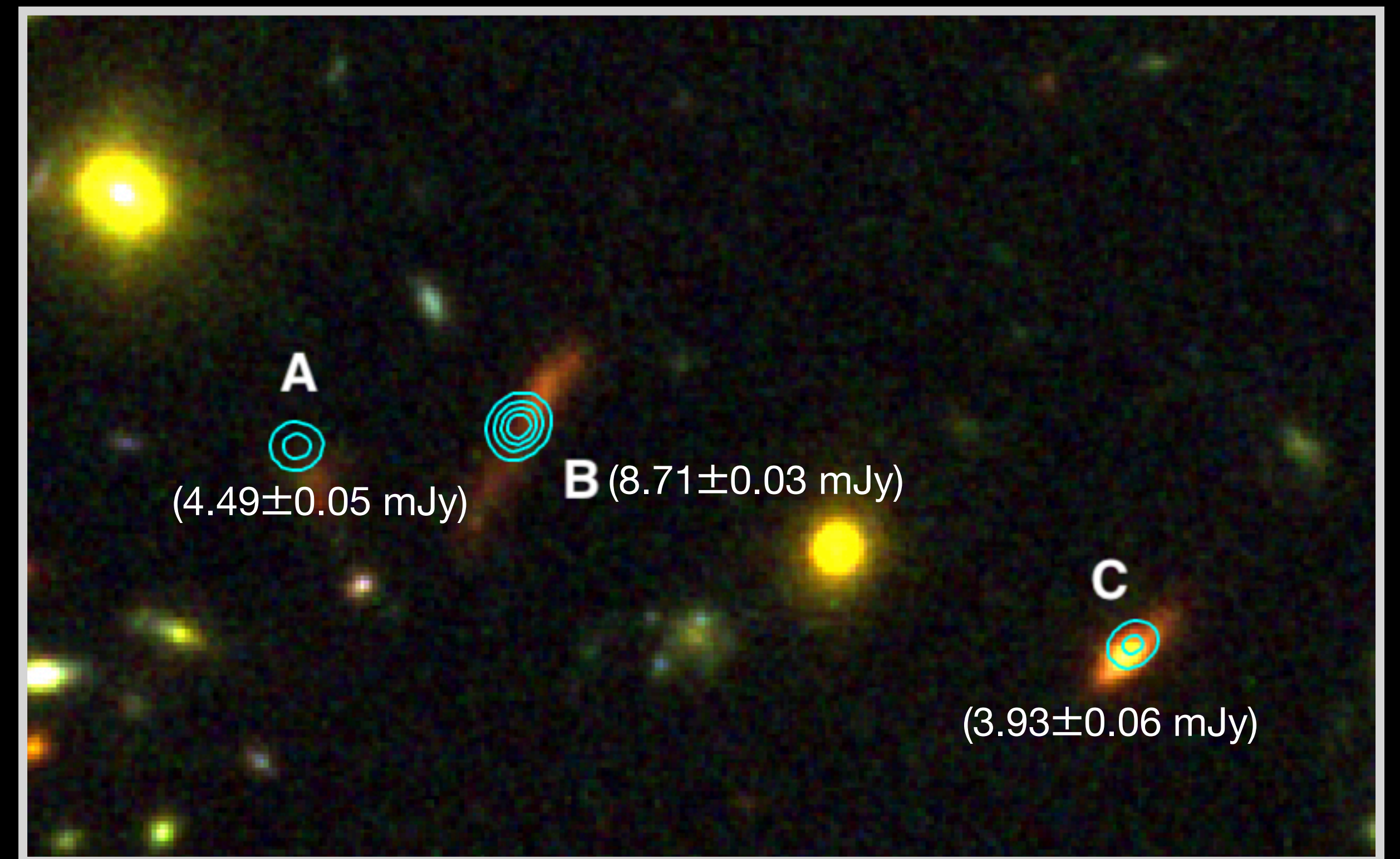
Noise RMS:  $\sim 30 \mu\text{Jy}/\text{beam}$

With 12 pointings covering  $\sim 22''$

Tot. Int: 7 hours

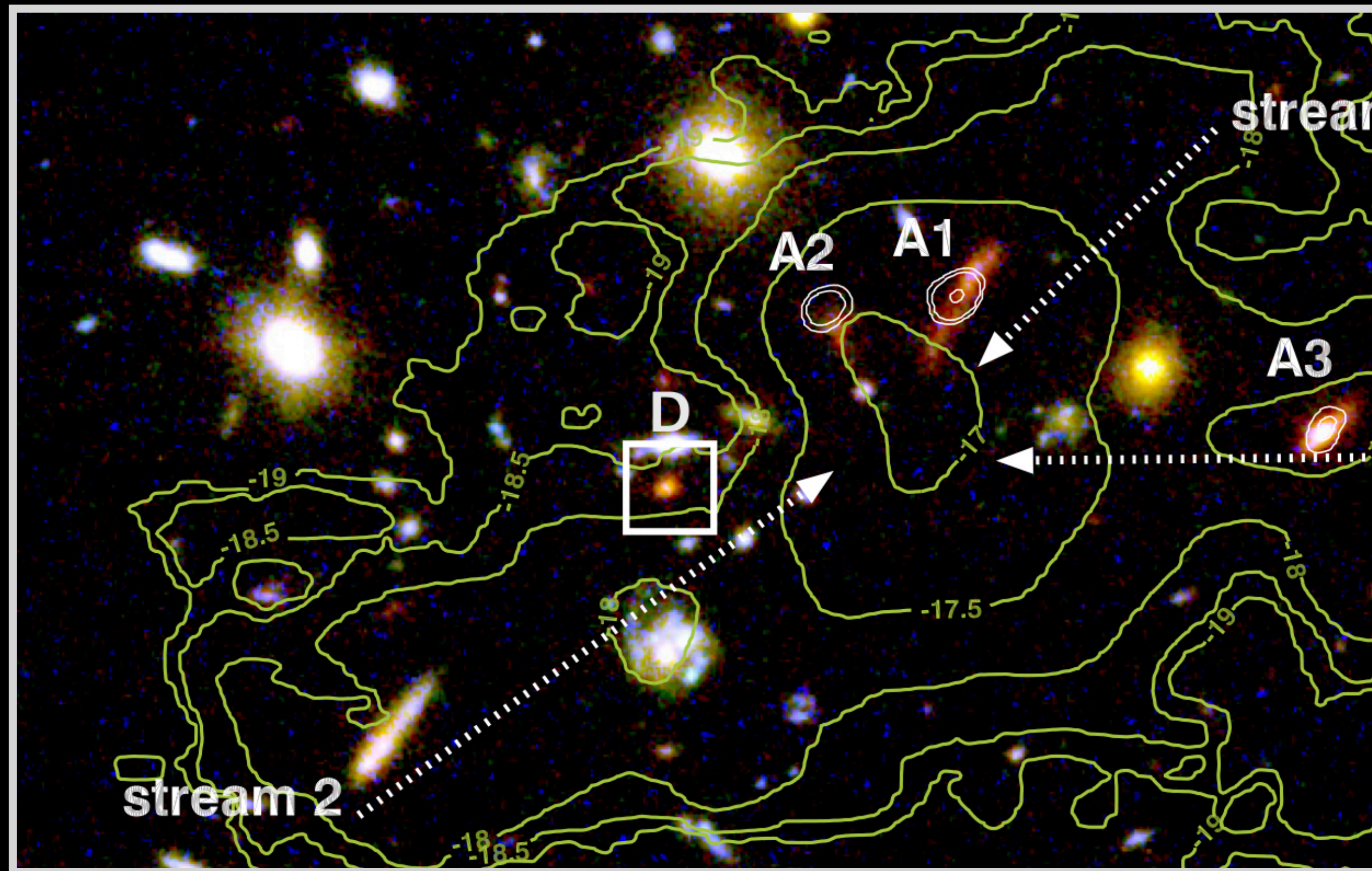


- Net SFR  $\sim 1250 \text{ Mo}/\text{yr}$
- Marked difference between NIR and sub-mm sizes suggestive of ongoing mergers
- The ALMA sub-mm show extremely compact cores ( $R_e < 1 \text{ kpc}$ )



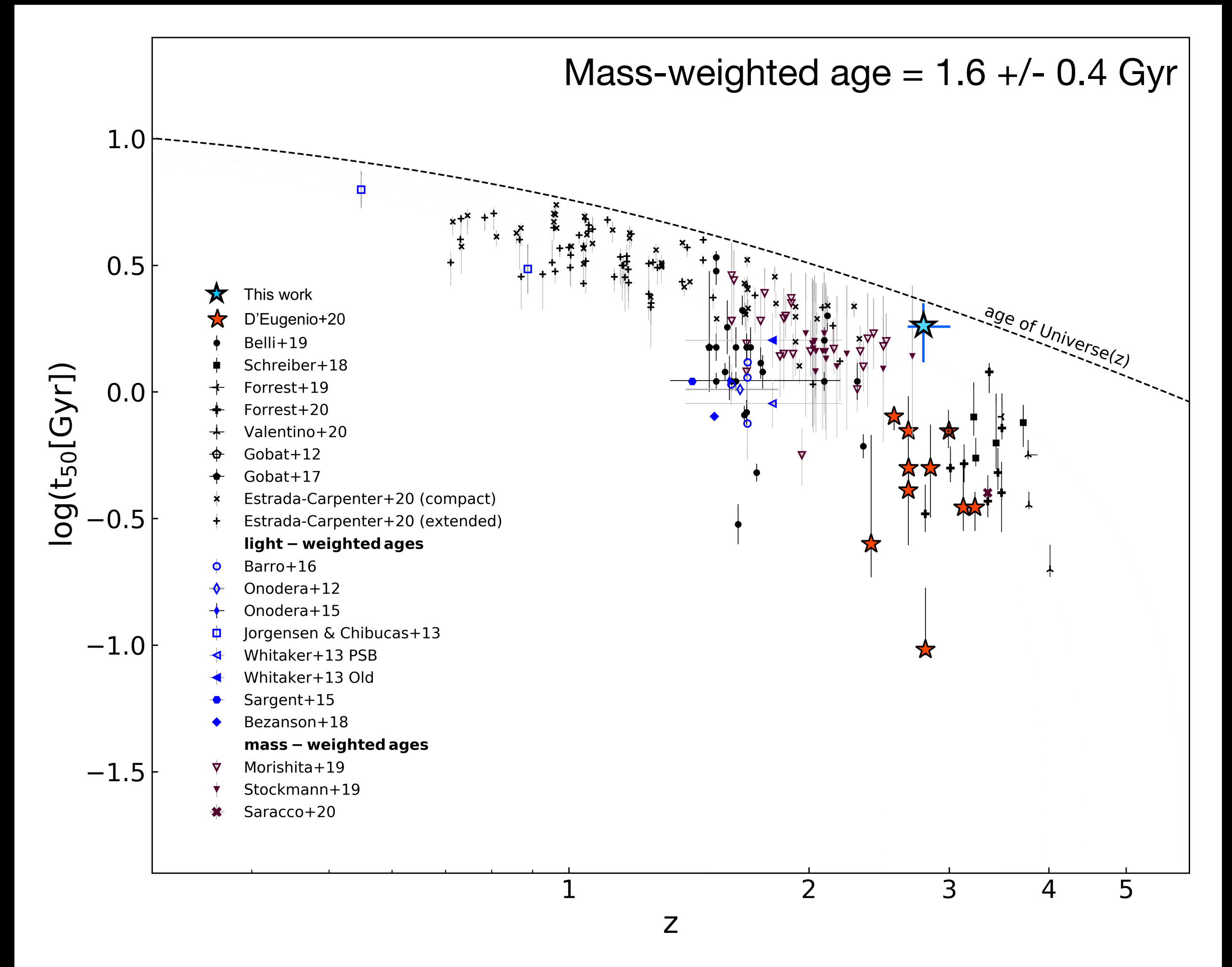
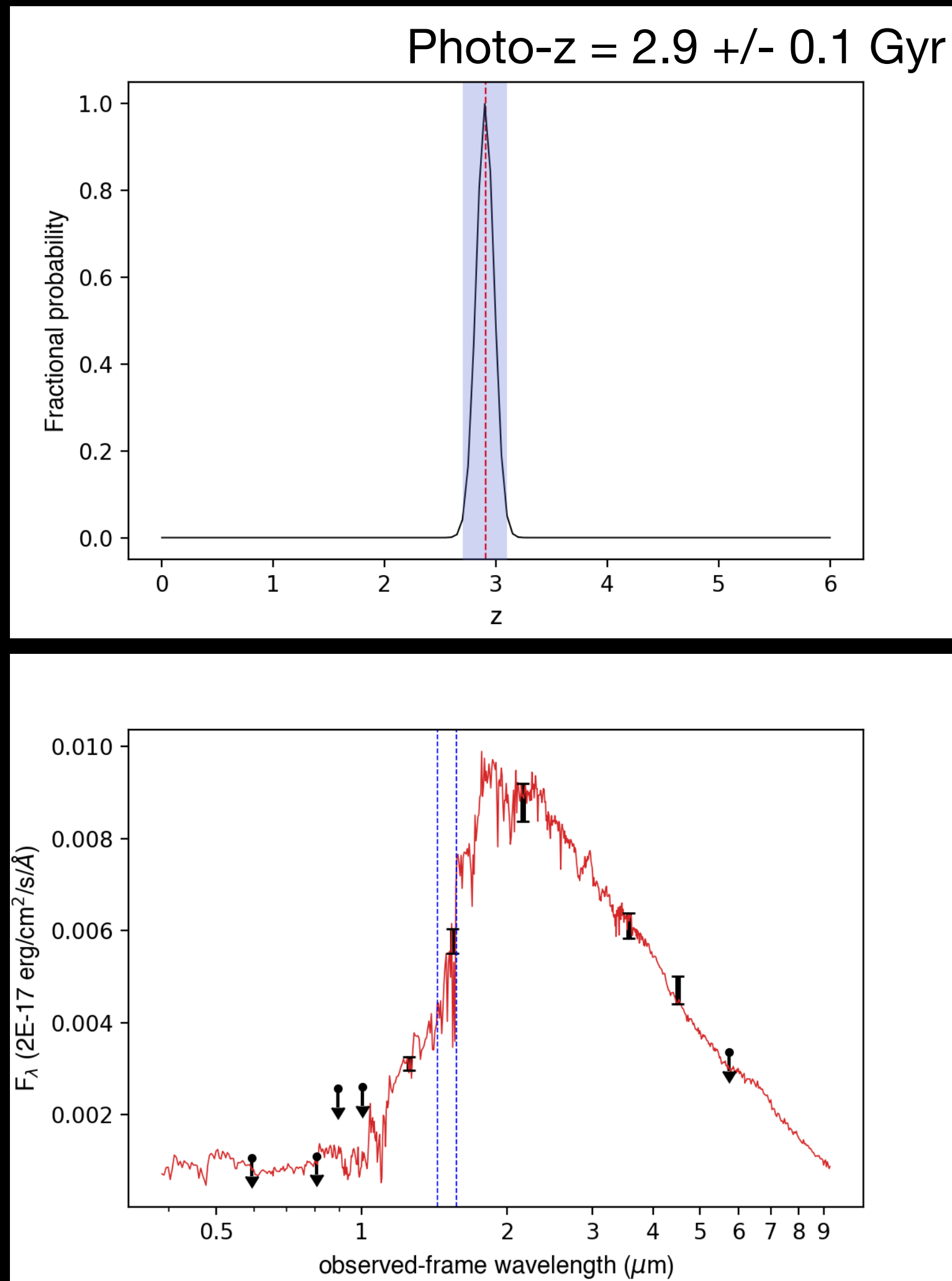


# An extremely rare ancient massive quiescent galaxy in a gas-rich environment





# An extremely rare ancient massive quiescent galaxy in a gas-rich environment





## **The presence of a QG in dense environment:**

- Rapid consumption of gas to quench
- Gas starvation not necessary

## **Maintaining quiescence for > 1 Gyr:**

- Recurring radio AGN activity (e.g., Olsen+13, Aird+19)



# Coexistence of two galaxy populations?

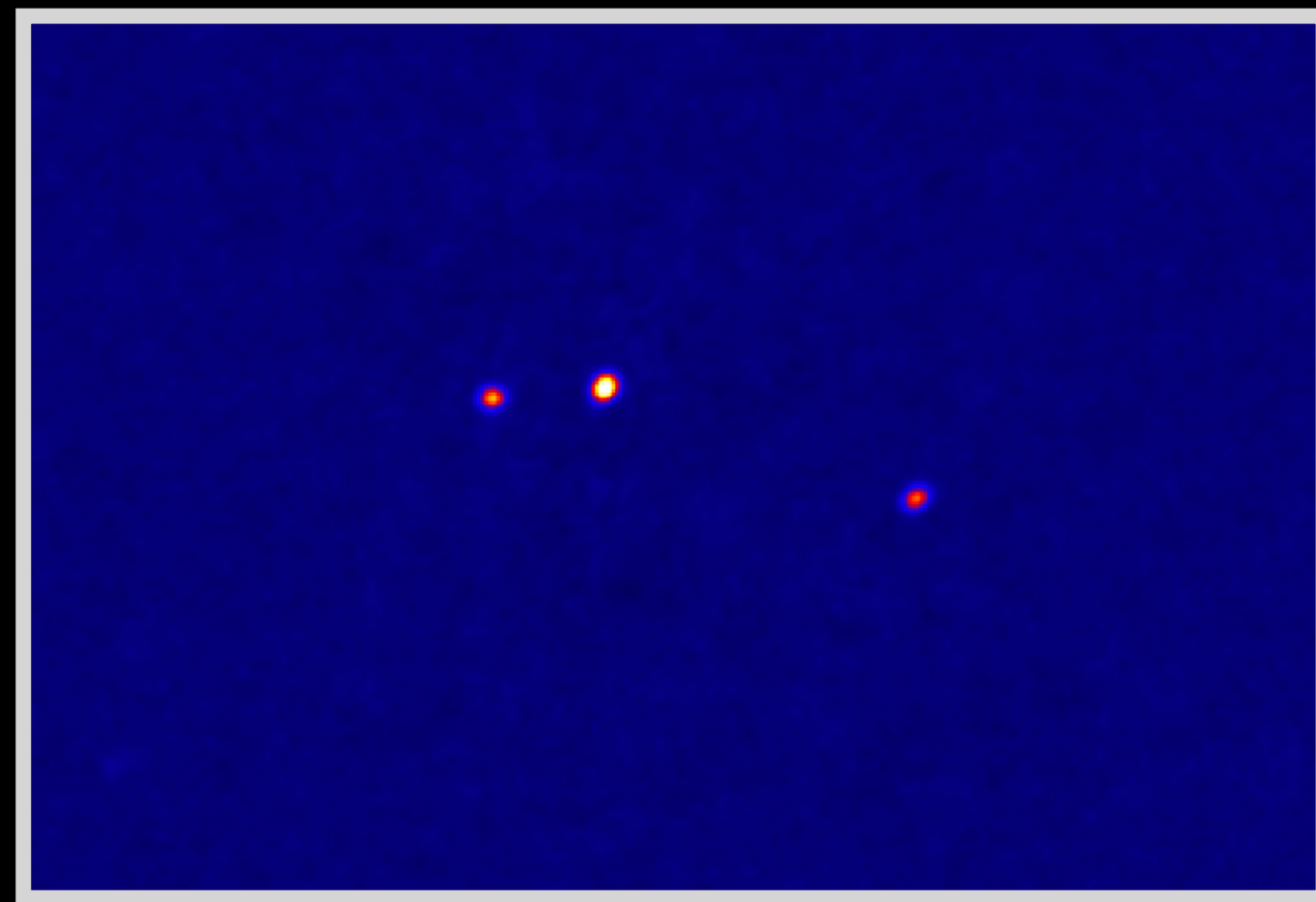
Different phase of evolution?

or

Different evolutionary trajectory?

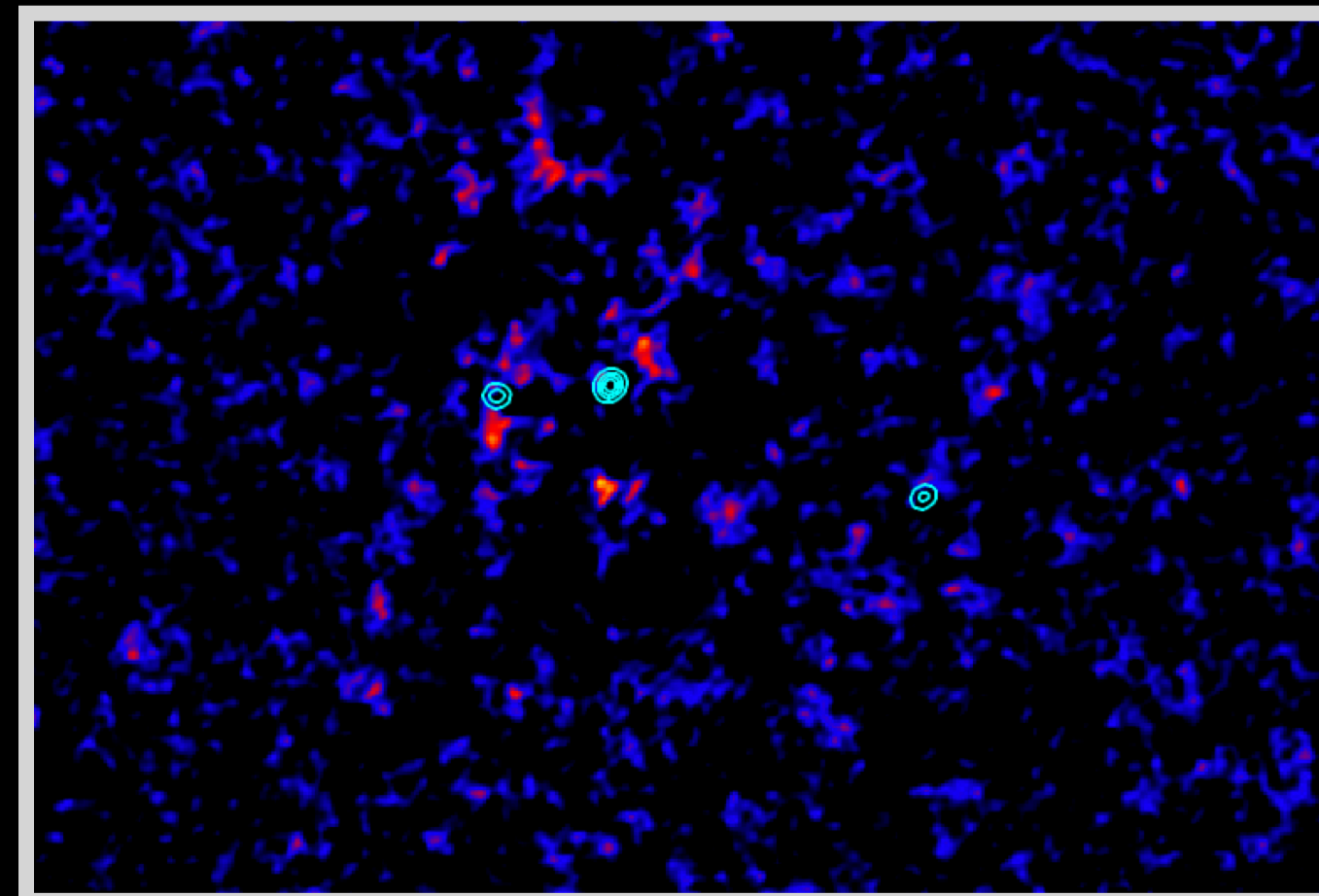


# Residual dust emission

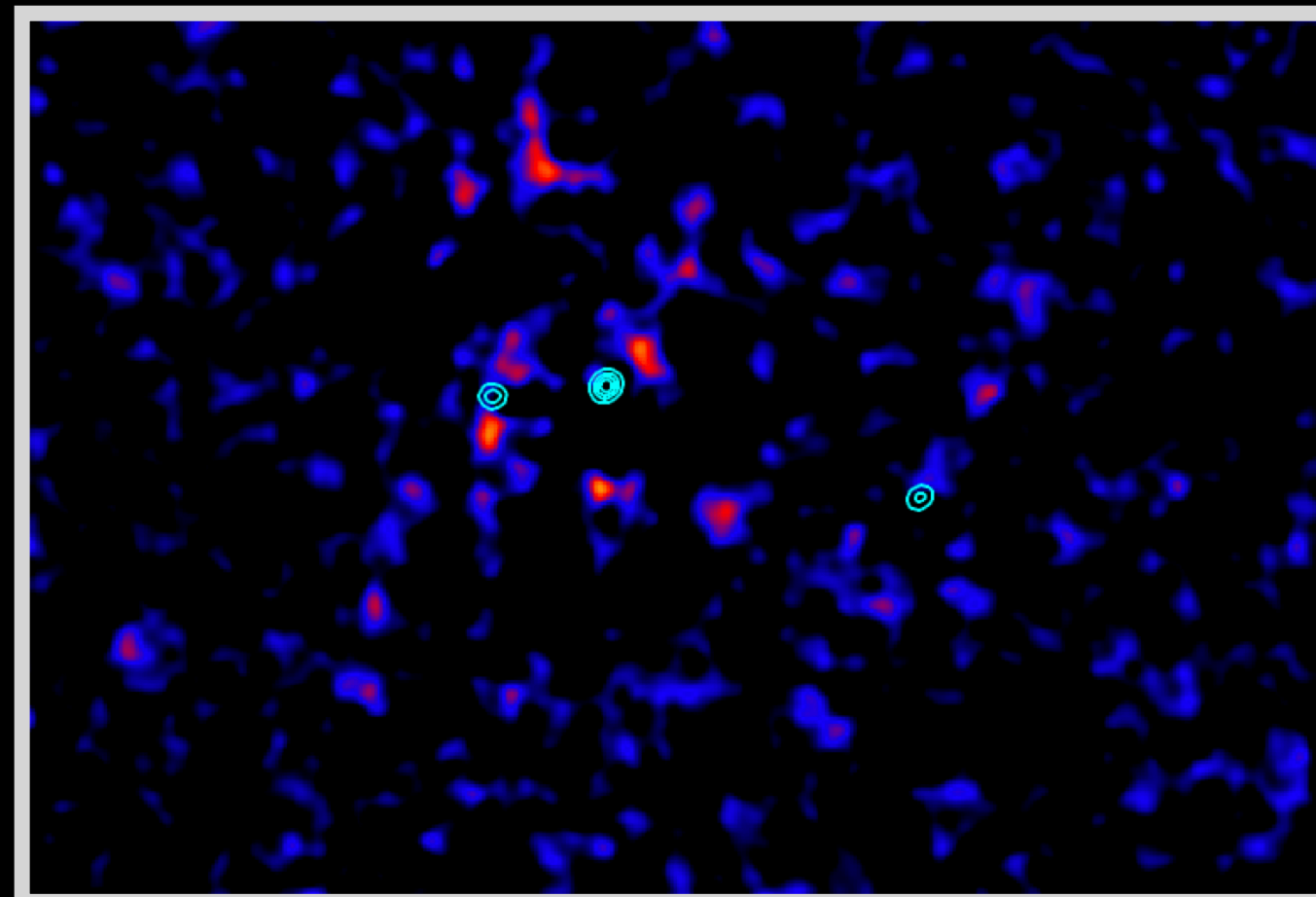


Fourier transform

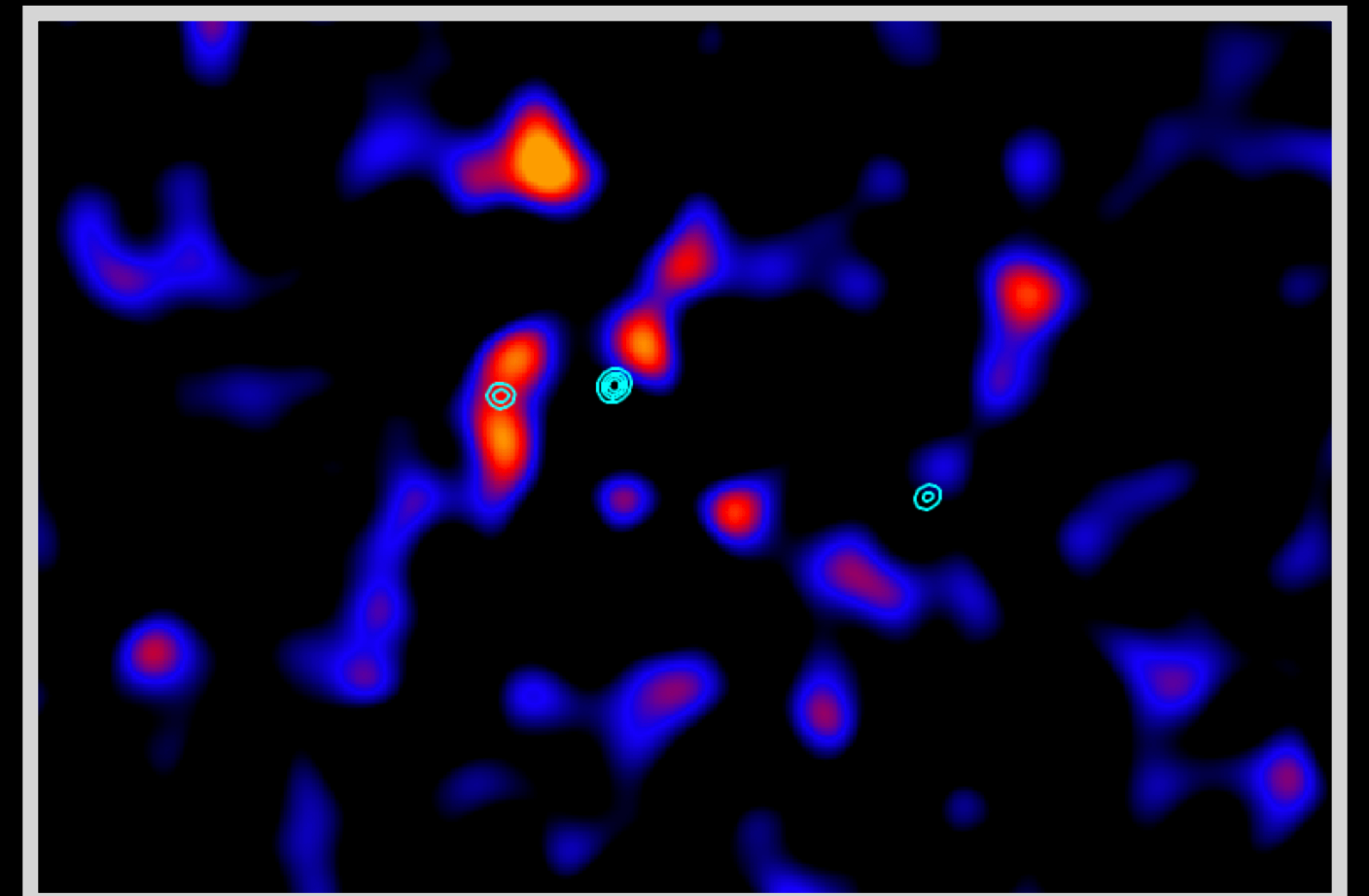
Fitting and subtracting  
Spergel Profiles (Spergel  
2010) in UV-space using  
GILDAS



No tapering

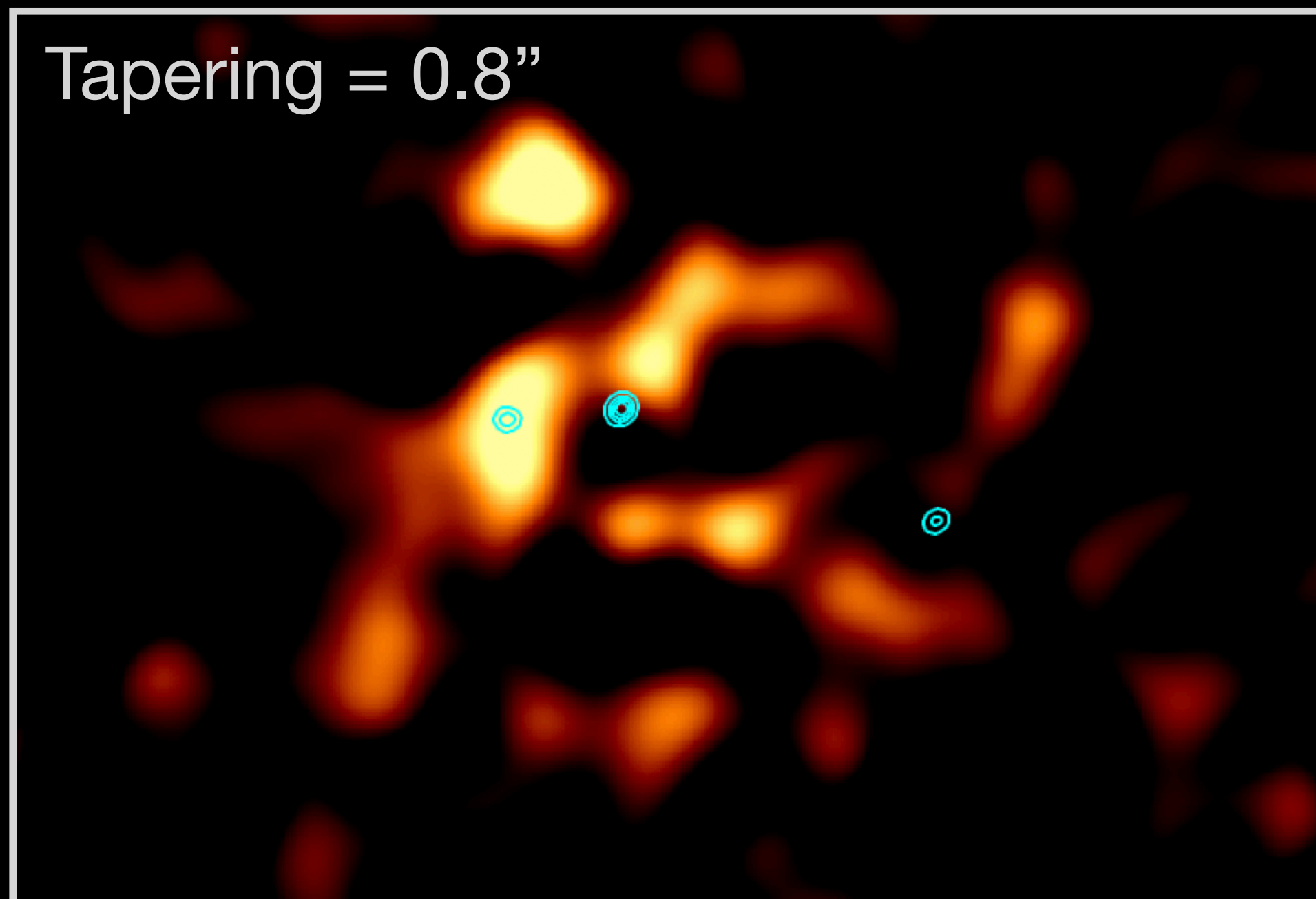


Tapering = 200 klambda



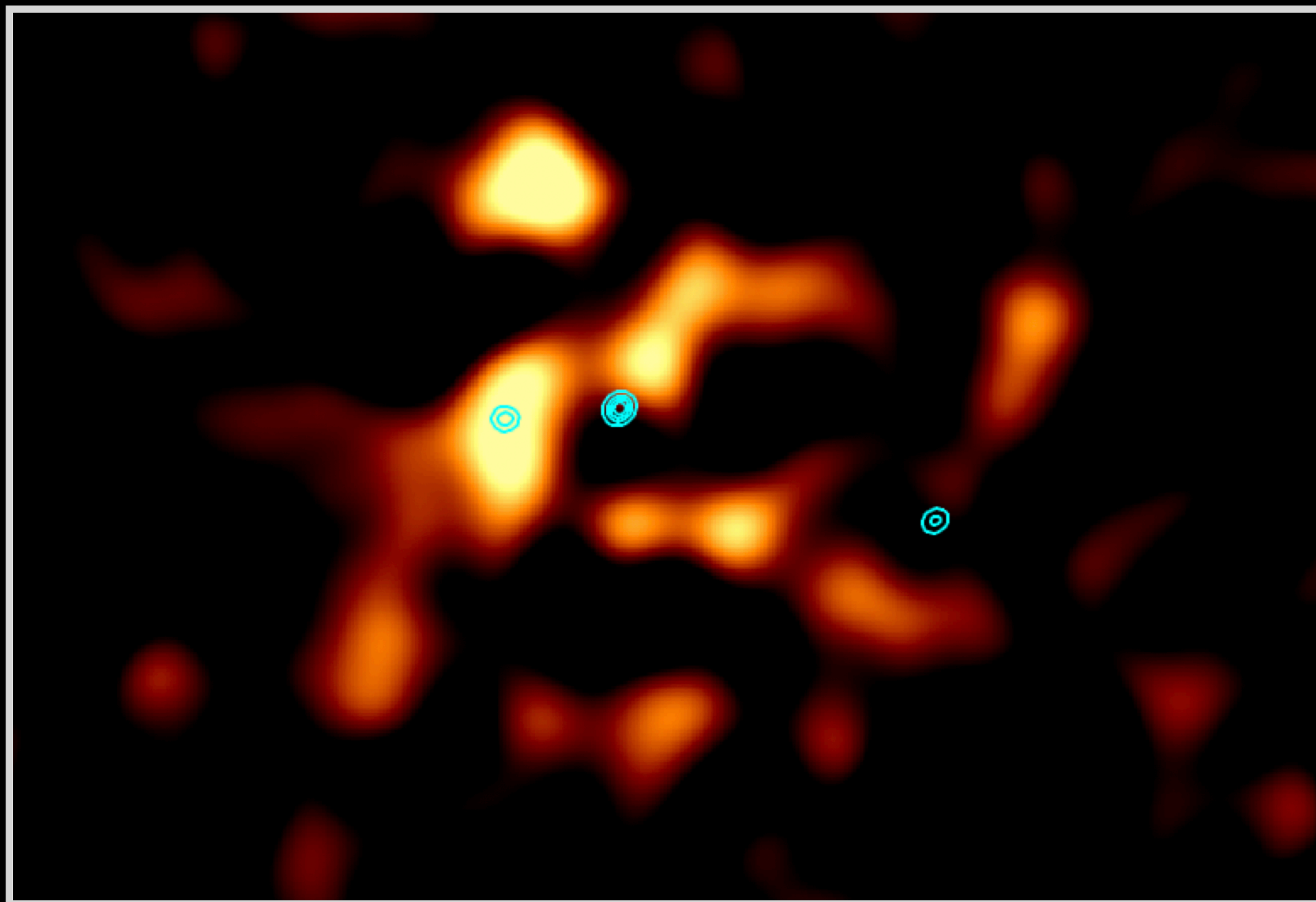
Tapering = 60 klambda

# Properties of the sources



- On an average 15–20% flux of the SMGs.
- Consistent with multi-wavelength observations.
- Inter-galactic dust emission could suggest additional modes of gas cooling (e.g. Montier & Giard 2004)
- Source of the dust: Intergalactic stellar population and/or tidally stripped material





A need for further sub-  
mm observations at  
lower resolutions ( $\sim 10''$ ):  
NICA2??



# Summary

- No detectable difference within SMGs compared to field.
- Presence of QG suggests passive evolution for  $>1$  Gyr within gas-rich environment.
- Abundance of dust substructures detected: further observations needed

