Comprehensive JWST+ALMA Study on the Extended Lyα Emitters Himiko and CR7 at z~7

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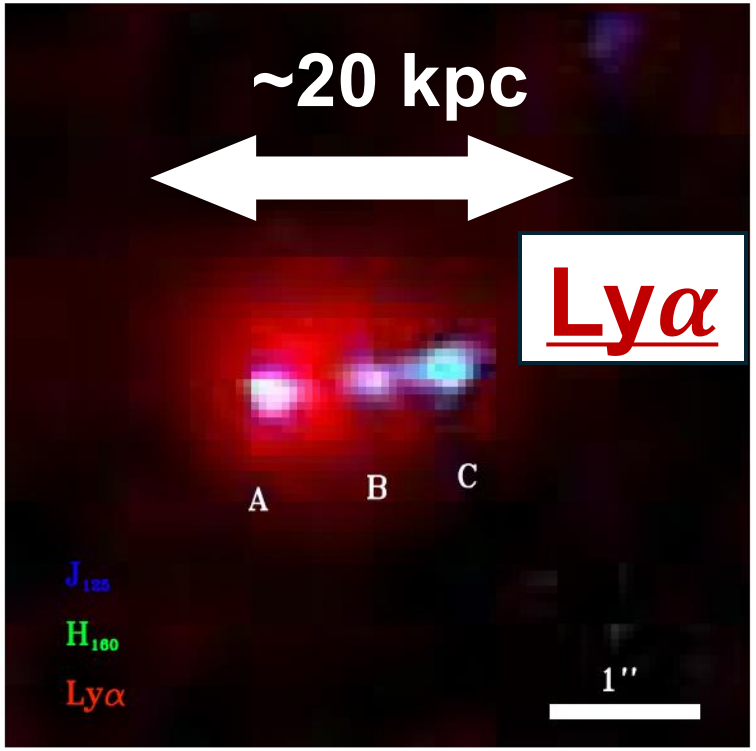
What are Himiko and CR7?

- **Extended** (~20 kpc), **UV bright** (M_{UV}~-22) LAEs at z=6.6
- Three clumps

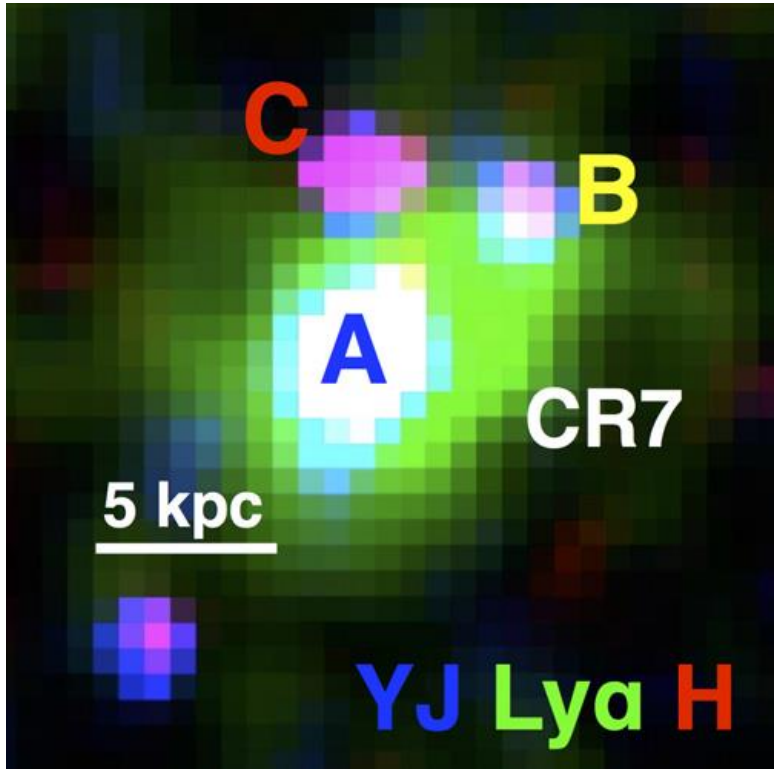
several kpc
(typical size)

Himiko



Ouchi et al. (2013)

CR7



Sobral et al. (2015)

What are Himiko and CR7?

Goals: Uncovering the Physical Origins of

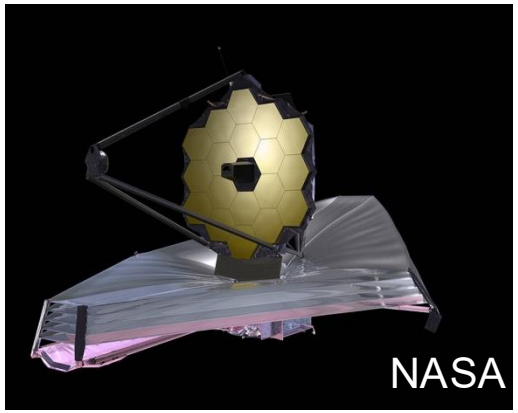
- Extended Lyα
- Bright UV Cont.

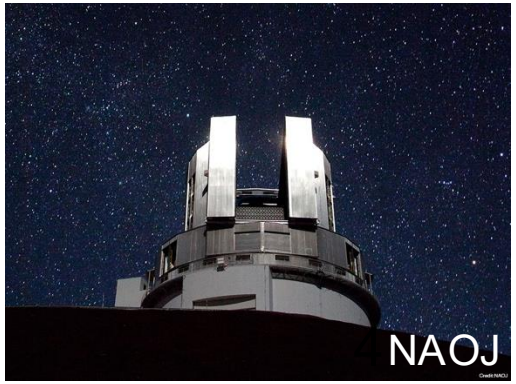
Data

- **JWST** (0.6-5μm, rest-frame UV to optical at z~6)
  - Spectroscopy: NIRSpec IFU (~5hrs, PID:1215, 1217)
    - Great thanks: GTO GA-NIFS Team incl. Luetzgendorf+
  - Photometry: NIRCam (PRIMER, COSMOS-Web)

- **ALMA** (Band 6, [CII]158μm, dust cont.)
  - Himiko: PI: Ouchi (~6hrs, #2011.0.00115.S, #2012.1.00033.S)
  - CR7: PI: Sobral (~6hrs, #2015.1.00122)

- **Subaru** (Lyα at z=6.6)
  - Hyper Suprime-Cam SSP ultra-deep imaging (~14hrs)
  - Narrowband NB921 (~9215Å)

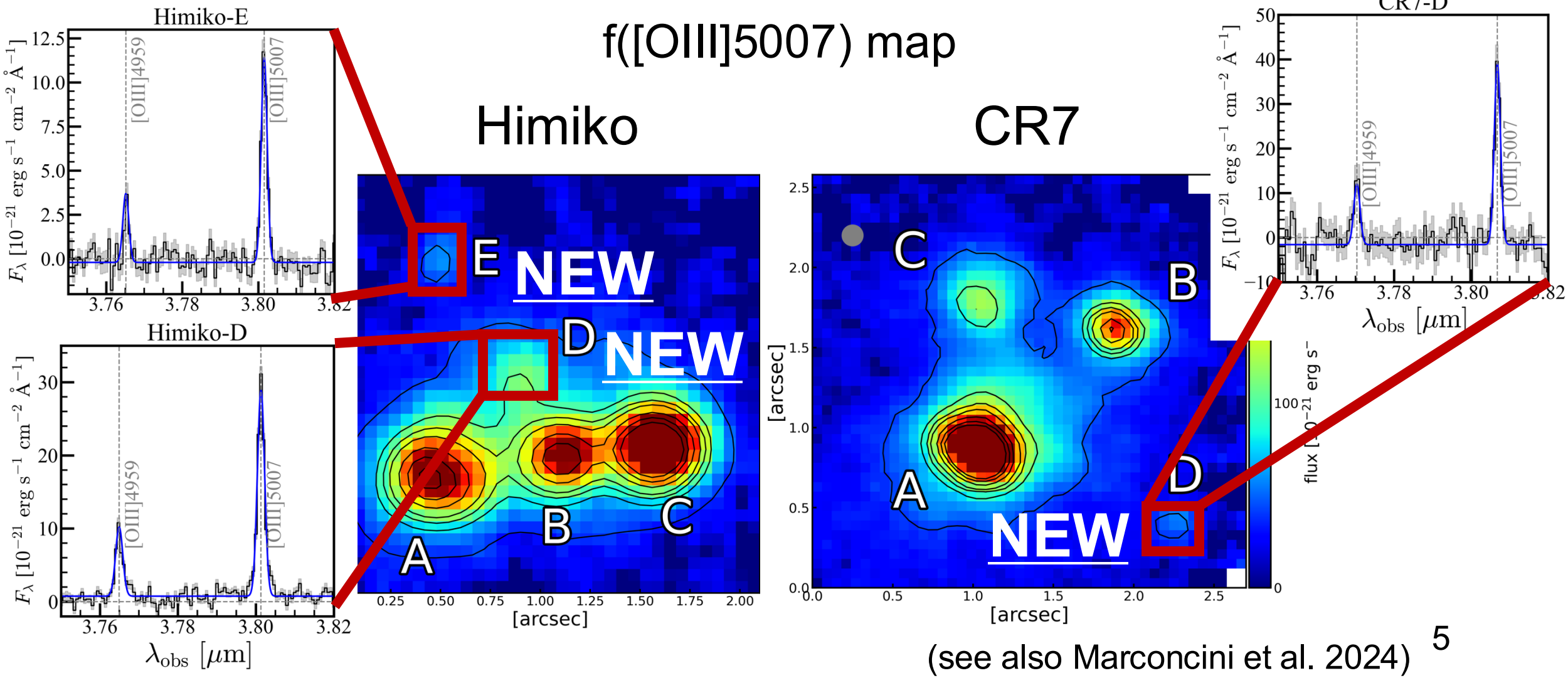




Multiple clumps

- Himiko (5 clumps), CR7 (4 clumps) → Complex structures

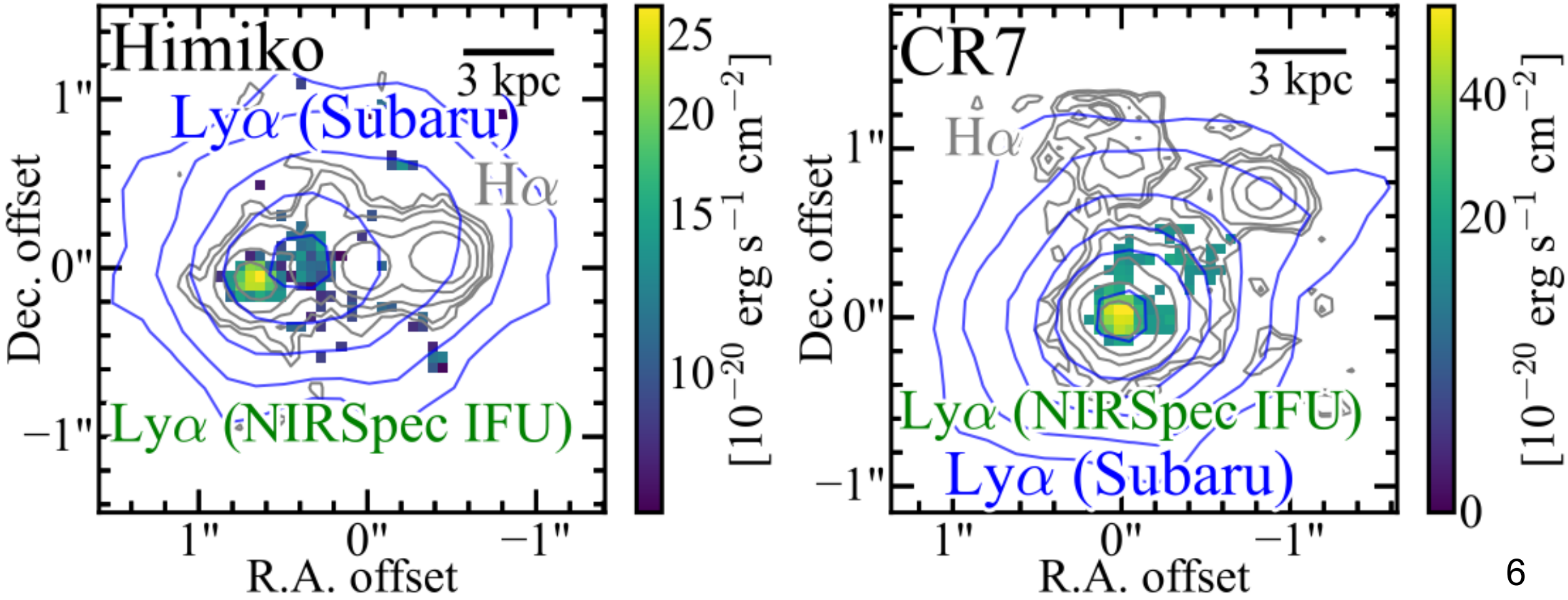
f([OIII]5007) map



(see also Marconcini et al. 2024)

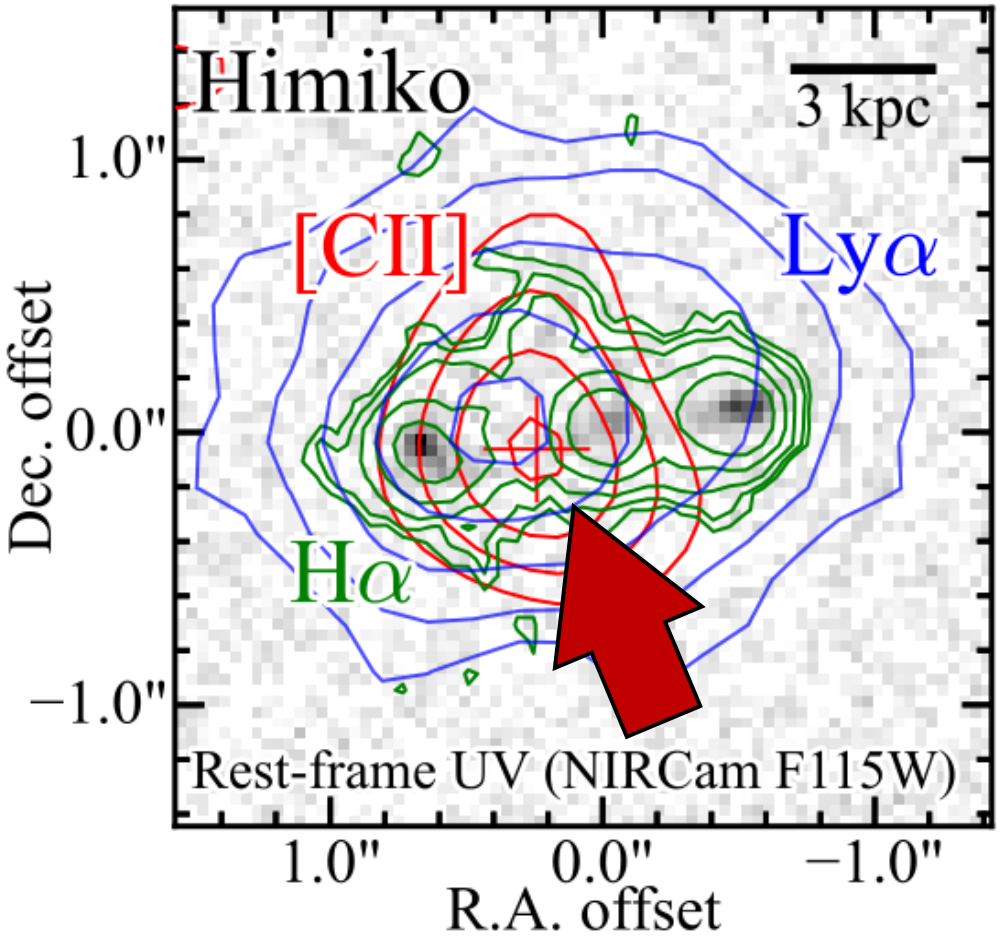
Lyα Emission (JWST+Subaru)

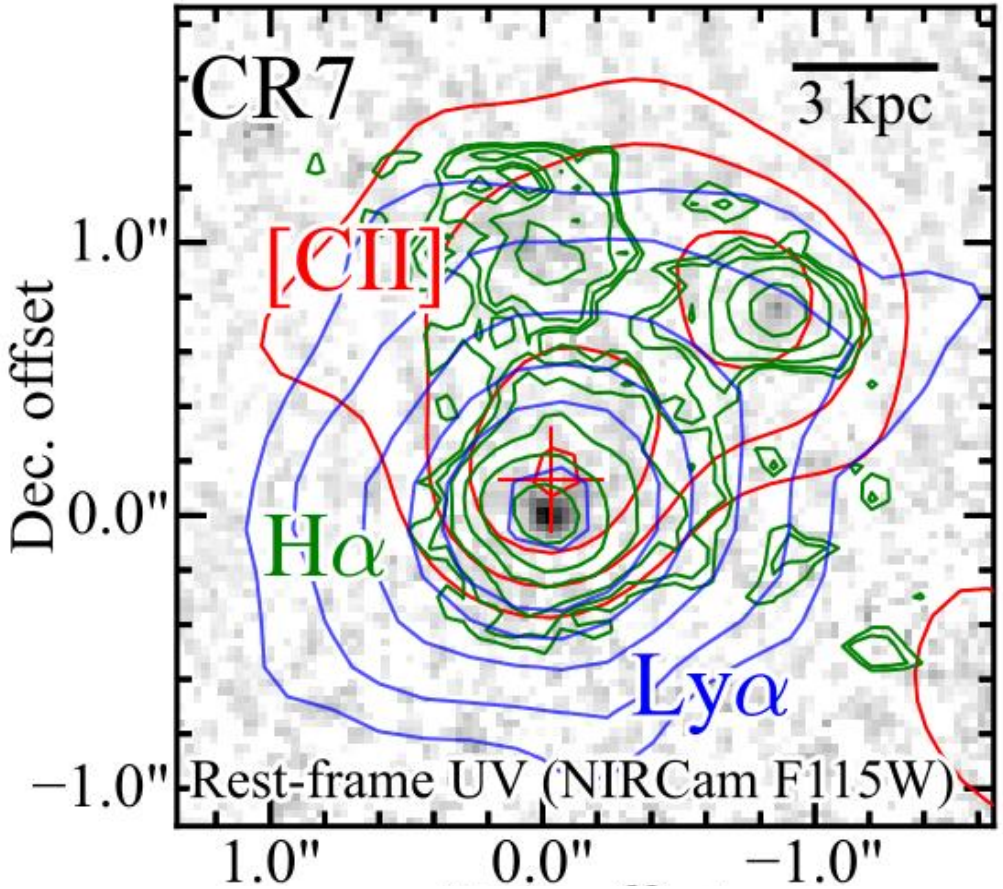
- Lyα is strong around Himiko-A and CR7-A.
- Subaru NB is still powerful in tracing the extended Lyα.



Multiwavelength view (JWST+ALMA+Subaru)

- Himiko: **Offset** between [CII], Lyα and UV, Hα
  → PDR/extended gas distribution beyond stellar clumps?



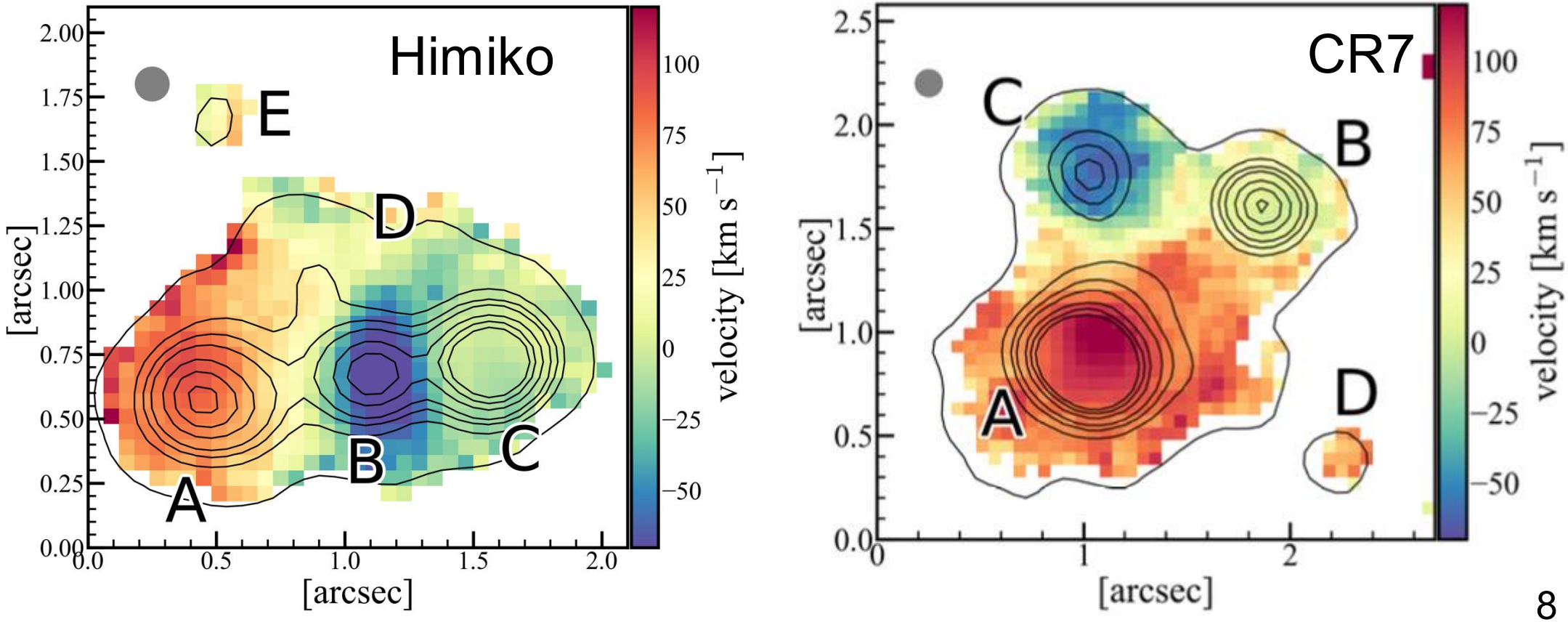


(see also Carniani+18, Matthee+17, Sobral+19)

Velocity Map

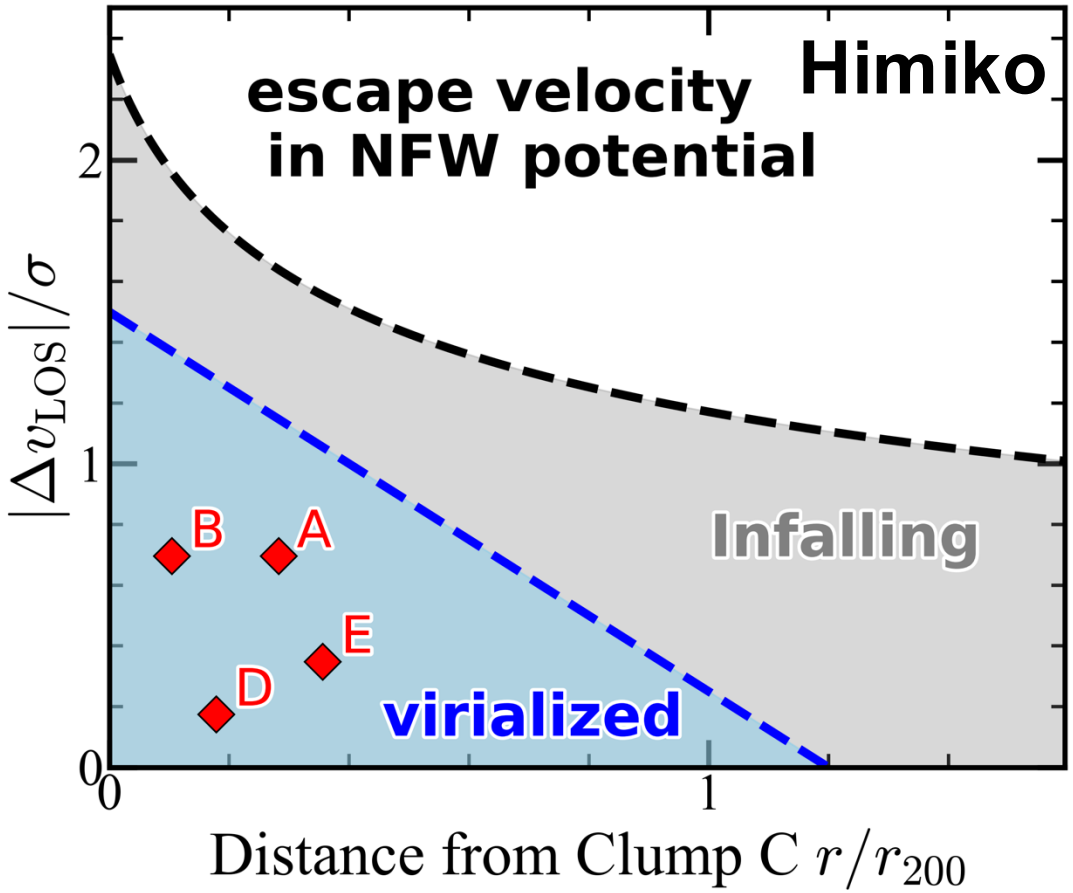
- Small spatial/velocity offset (<7 kpc, <200 km/s)

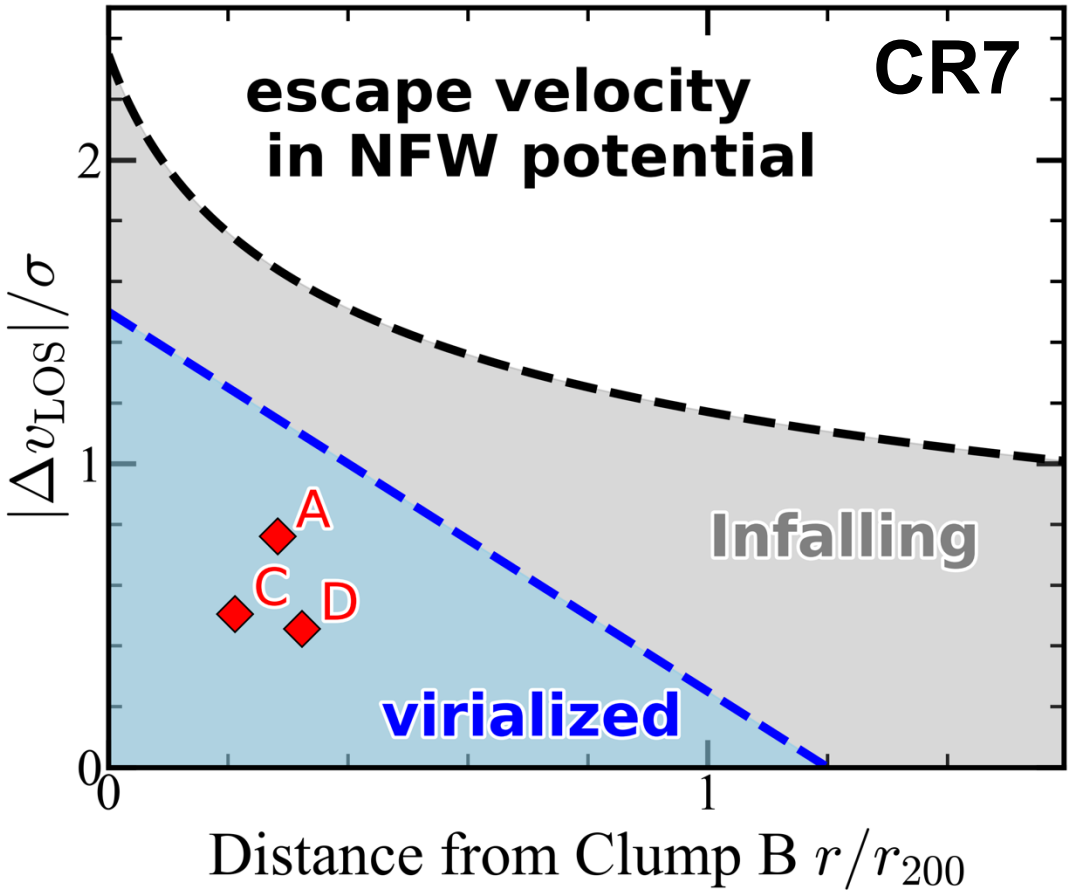
[OIII]5007 velocity map



Velocity and Spatial Offset

- Small spatial/velocity offset (<7 kpc, <200 km/s)→ virialized regime
- each clump: M_*~10^9 $M_\odot$ → **Major mergers**

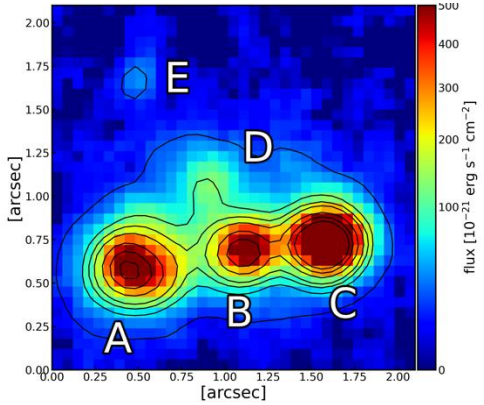




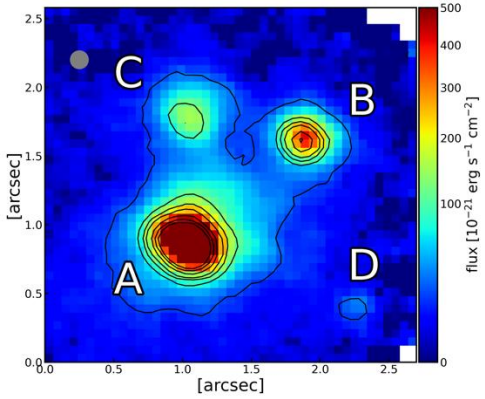
AGN signature in Himiko-B

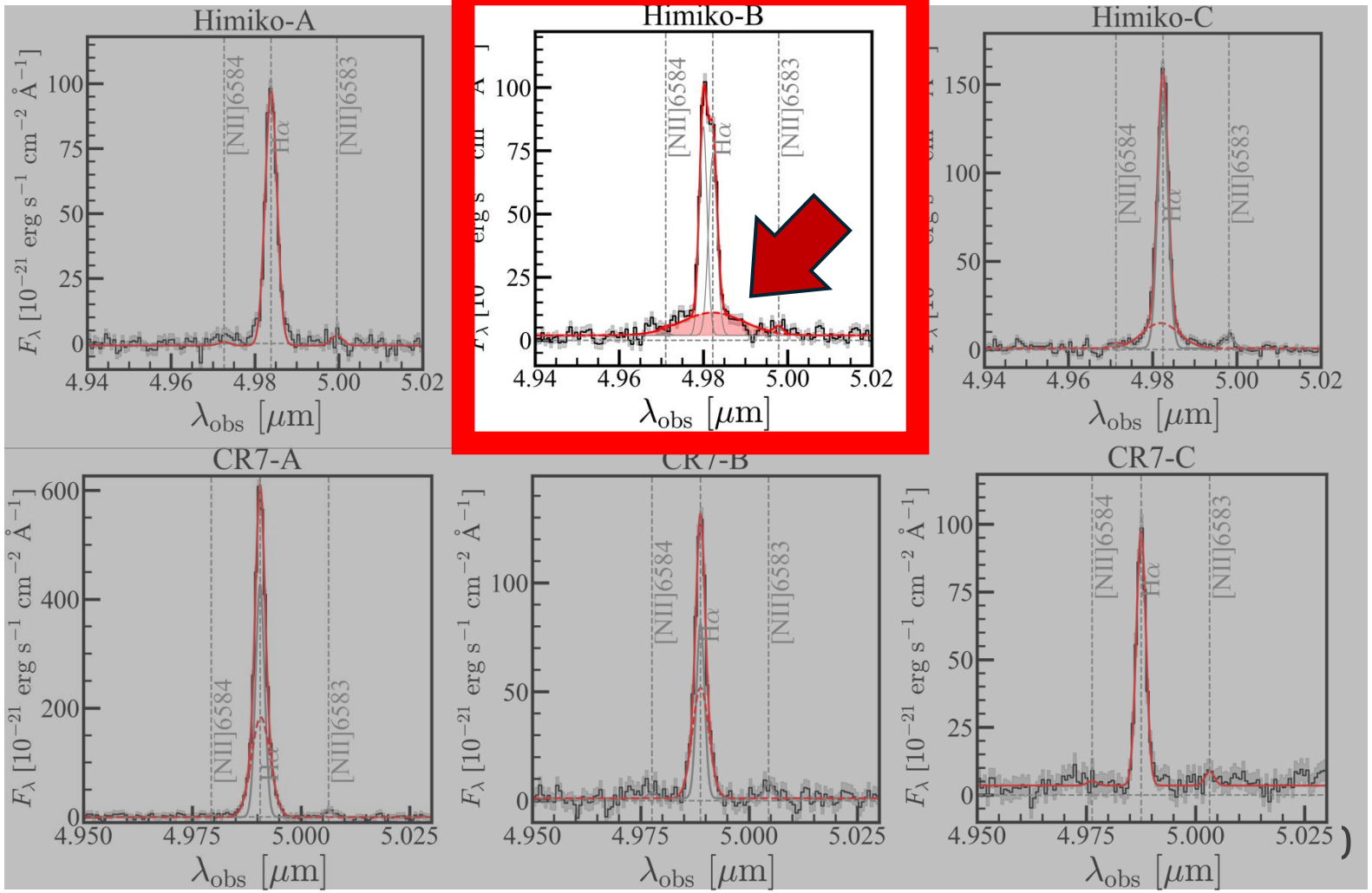
- Himiko-B: Broad Hα (FWHM>1000 km/s), narrow [OIII] (<400 km/s) → **AGN** (M_{BH}~$10^{6.6}$ $M_\odot$)

Himiko



CR7





Comparisons with Numerical Simulations

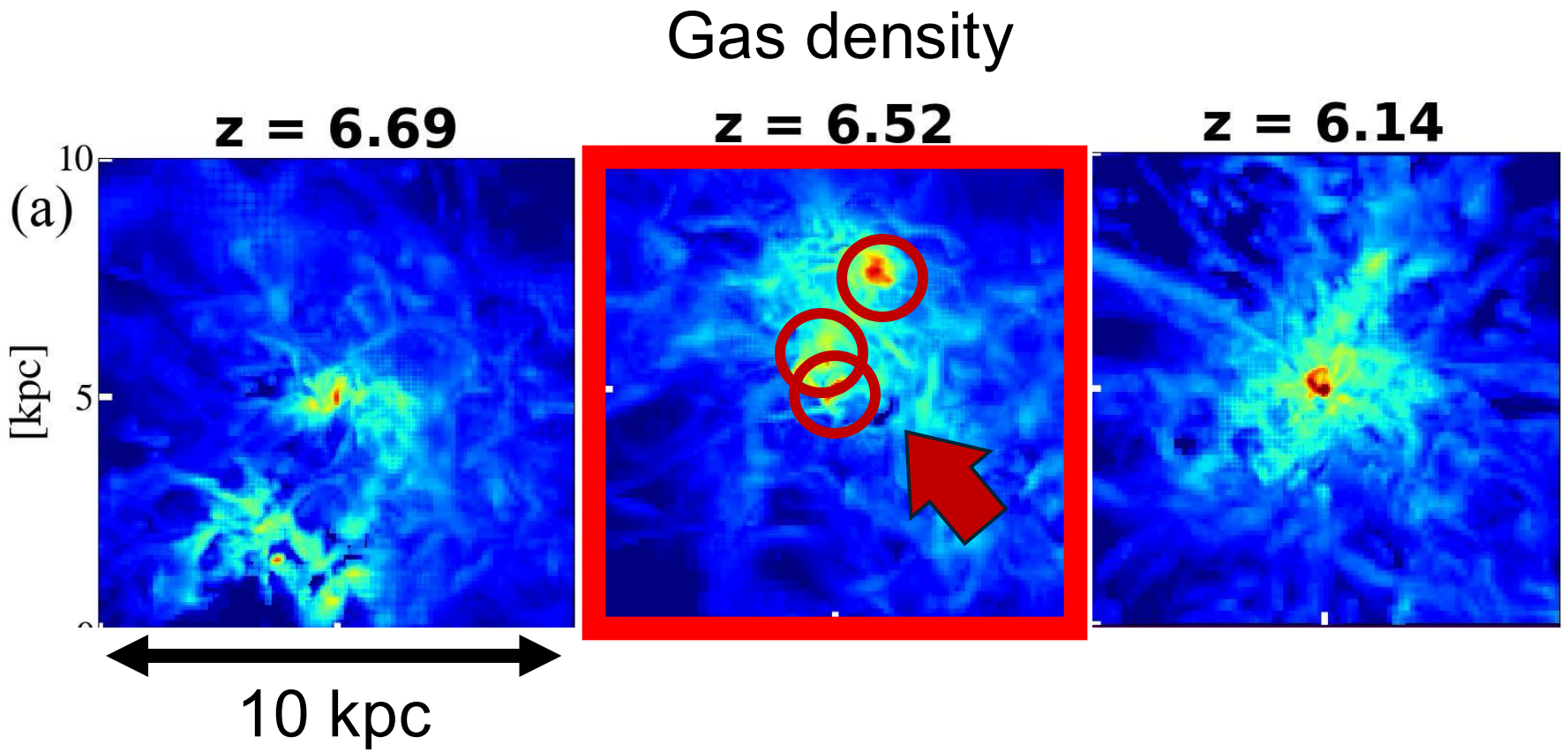
- FirstLight (Ceverino+17): incl. dust cont.
- FOREVER22 (Yajima+22, 23): incl. Lyα radiative transfer calculation

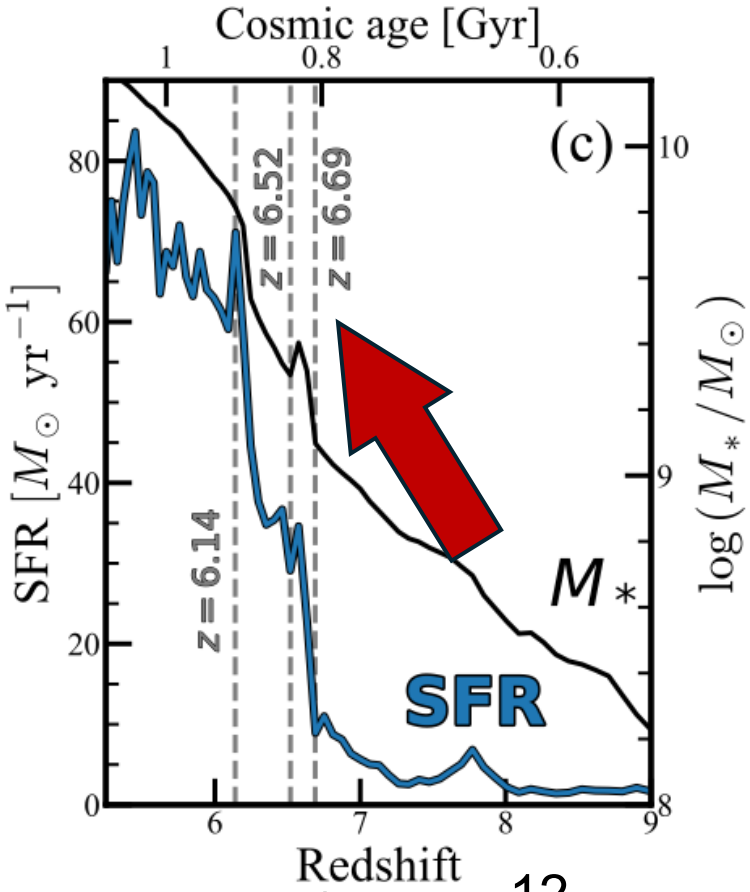
- Searching for Himiko-type object ($z\sim7$, $M_*\sim10^9\,M_\odot$, SFR~30 $M_\odot$/yr, clumpy)
  → We successfully find Himiko-type objects.
  → Himiko-type object merges into a single galaxy in the simulation.

Comparisons with Numerical Simulations

FirstLight

- Star-burst induced by mergers → UV bright (Himiko/CR7)





(see also Nakazato+24)

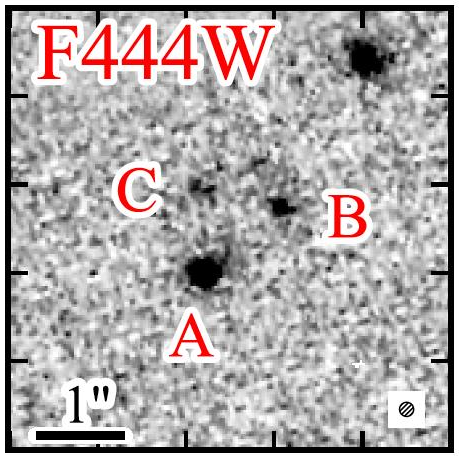
Reproducing Lyα emission

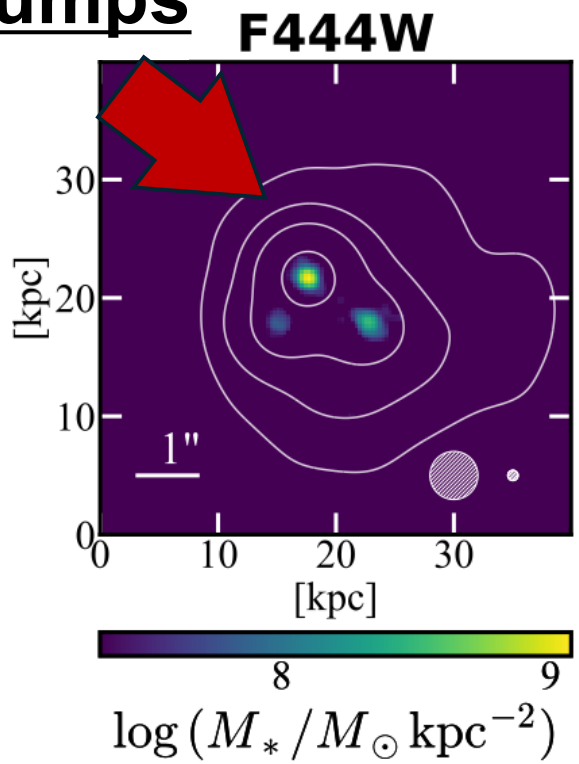
FOREVER22: Himiko-type object shows extended Lyα.

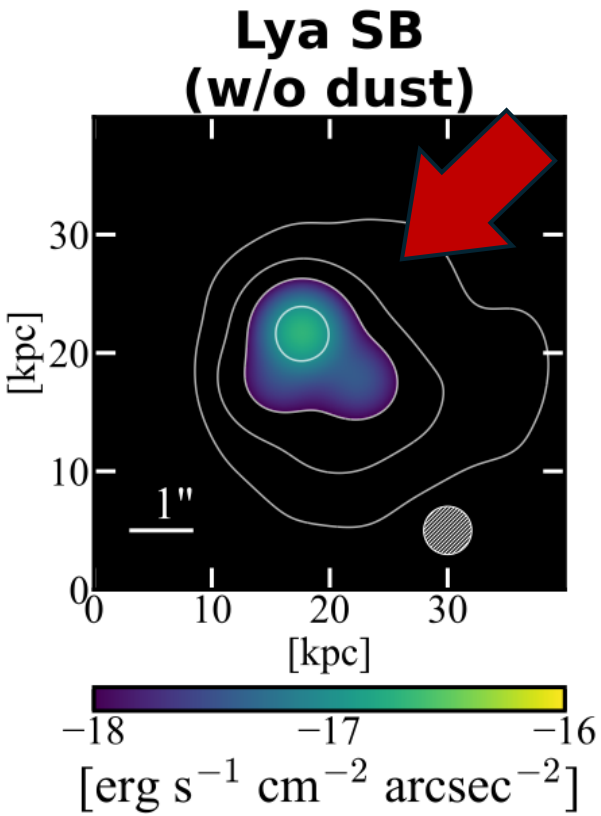
- Extended Lyα→ resonance scattering, gravitational cooling?

Merging stellar clumps

CR7

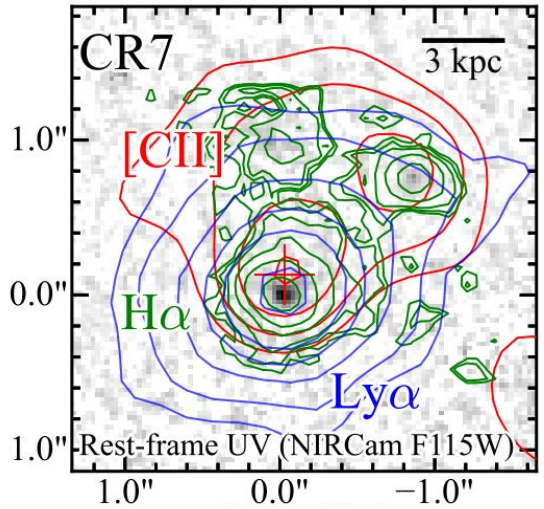






Extended Lyα

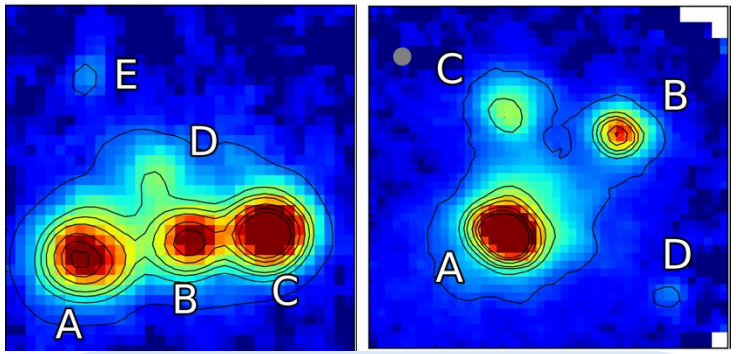
CR7



(see also Witten+24)

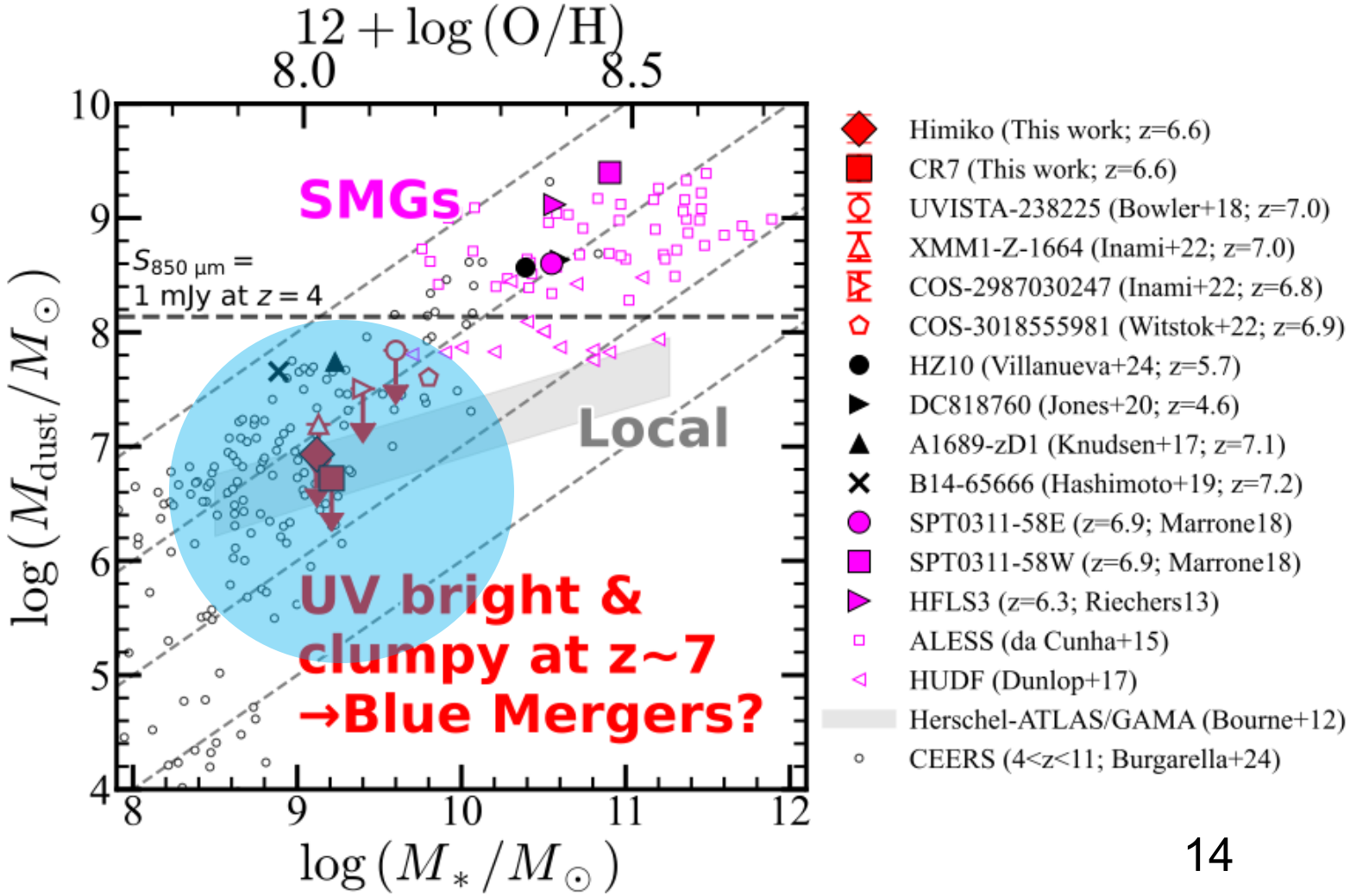
Comparison with other (merger) galaxies

- ALMA dust cont.: non-detection → $M_{dust} < 9 \times 10^6\ M_\odot$



Blue mergers

- **extended Lyα**
- low M_*
- dust poor
- low metallicity



Summary

- Exploring Himiko and CR7 with JWST, ALMA, and Subaru
- Masses and velocity maps
  - comparable stellar mass (~10^9 $M_\odot$)
  - small spatial/velocity offsets (<7 kpc & <200 km/s) → virialized regime
    → Major mergers, also indicated by FirstLight simulation
- <u>Suggestions from our study</u>
  - Why extended Lyα?
    - Extended gas caused by gravitational interactions

    → also reproduced by merging galaxies in the Lyα simulation
    (resonance scattering, gravitational cooling?)
  - Why UV bright?
    - Starburst caused by mergers, AGN activity (Himiko-B)