Extended star-forming region within star-forming galaxies in a dense proto-cluster core at z=2.53

based on Suzuki et al. 2019, PASJ

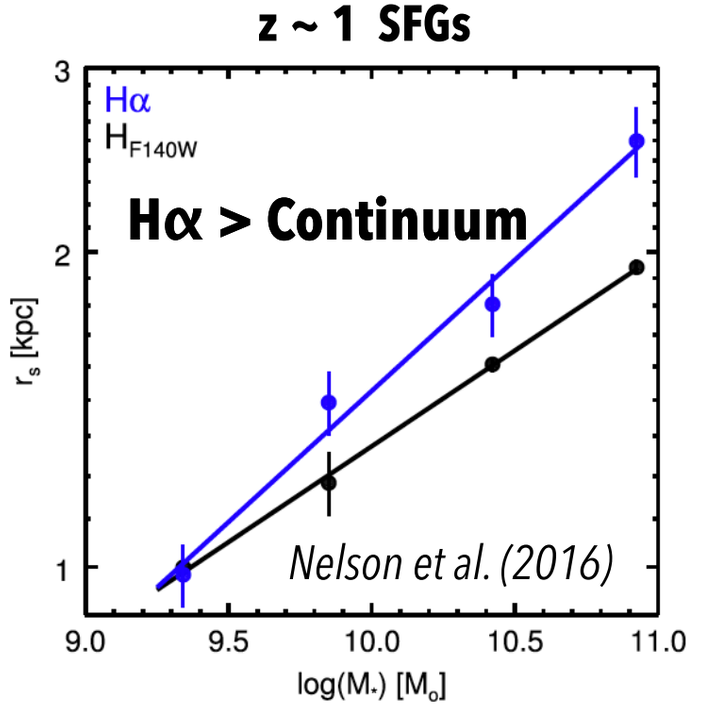
Tomoko Suzuki (Tohoku Univ. / NAOJ)

Y. Minowa, Y. Koyama (Subaru Telescope)
T. Kodama (Tohoku Univ.), M. Hayashi (NAOJ), R. Shimakawa,
I. Tanaka (Subaru Telescope), K.-i. Tadaki (NAOJ)

Structural growth of star-forming galaxies at high-z

- **Inside-out growth**
  (e.g., Trujillo+06; Nelson+16)

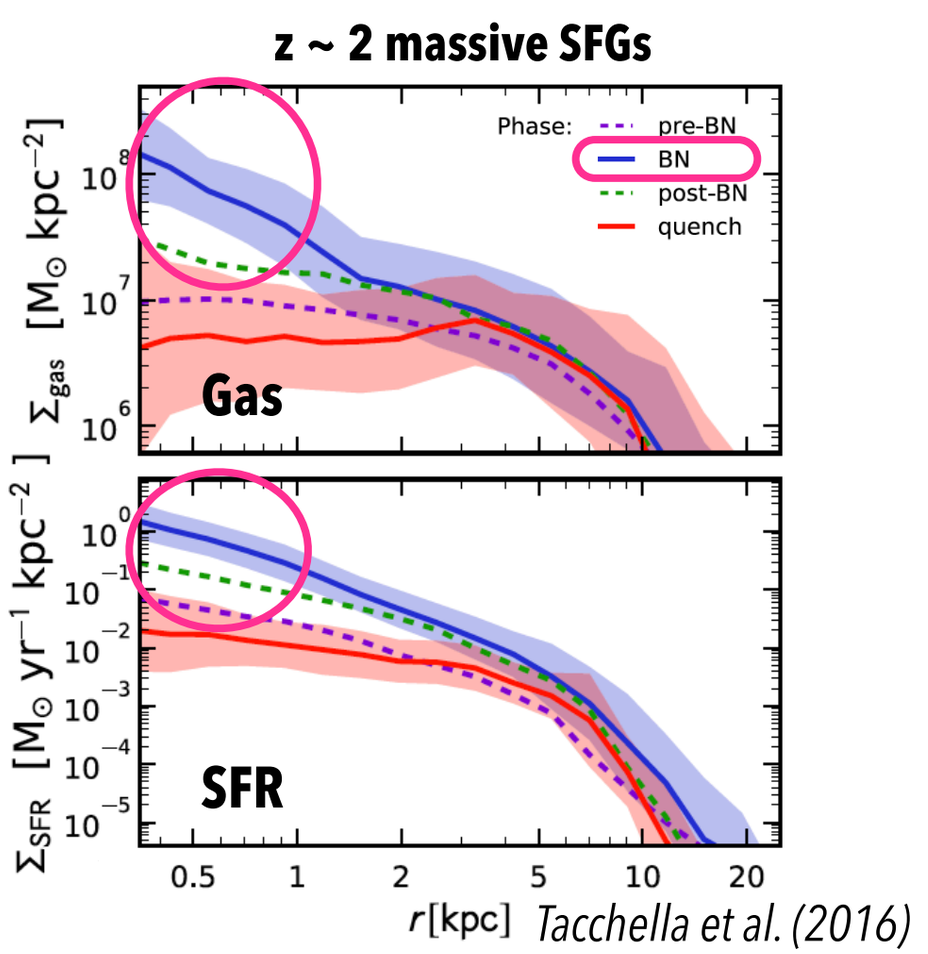
  Star-forming region is more extended than the stellar continuum



- **Wet compaction**
  (e.g., Zolotov+15; Tacchella+16)

  Induced by
  - Violent disk instability of gas-rich disk
  - Gas-rich major merger

  Centrally concentrated star formation



Environmental dependence?

In high-density environments…

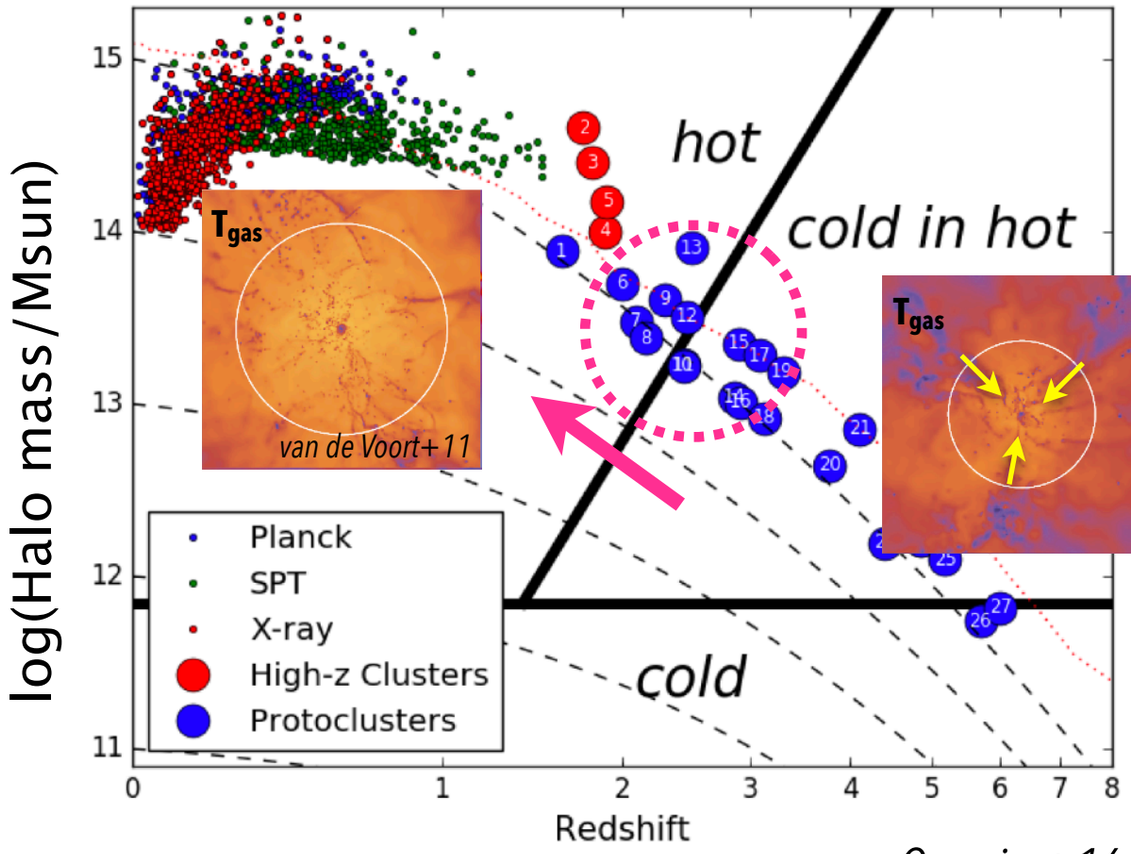
- **Different mode of gas accretion**

  (e.g., Dekel+09; van de Voort+11)

  Gas accretion is important to keep gas-rich unstable disks

- **Higher merger frequency**

  (e.g., Lotz+13; Hine+16)



Overzier+16

→ Relative dominance of the compaction event may change?

Investigate the spatial distribution of SF region for galaxies in high-density environments

Our project: AO+NB imaging for high-z galaxies

- co-PIs: Y. Minowa and Y. Koyama

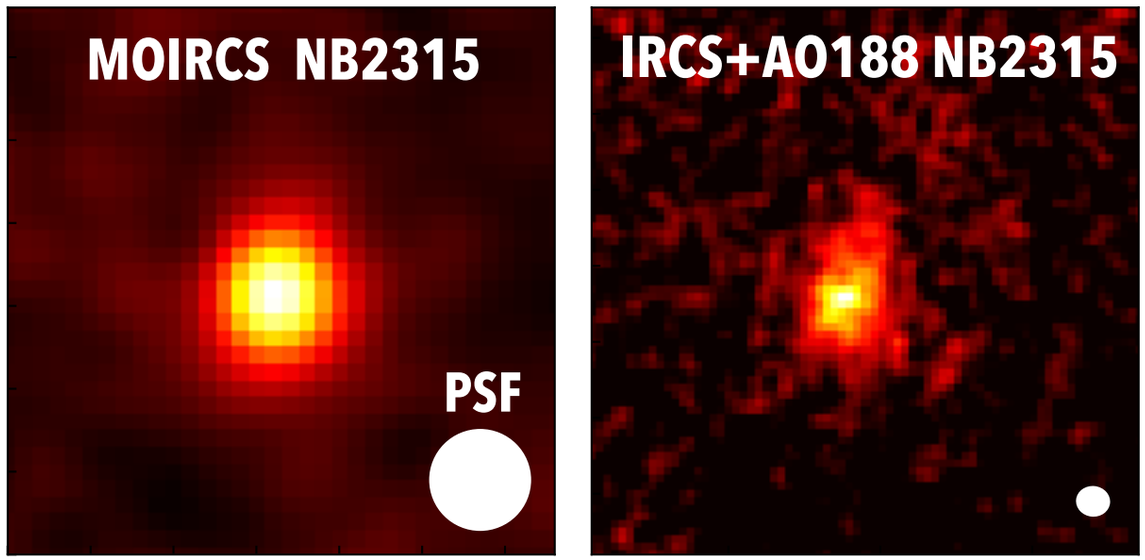
- Observation

  Imaging with Subaru/IRCS+AO188 and NB filter

  - **Spatially resolve line-emitting region**
    - 0.1-0.2 arcsec resolution

      → **1-2 kpc @ z~2**

Hα emitter at z = 2.5

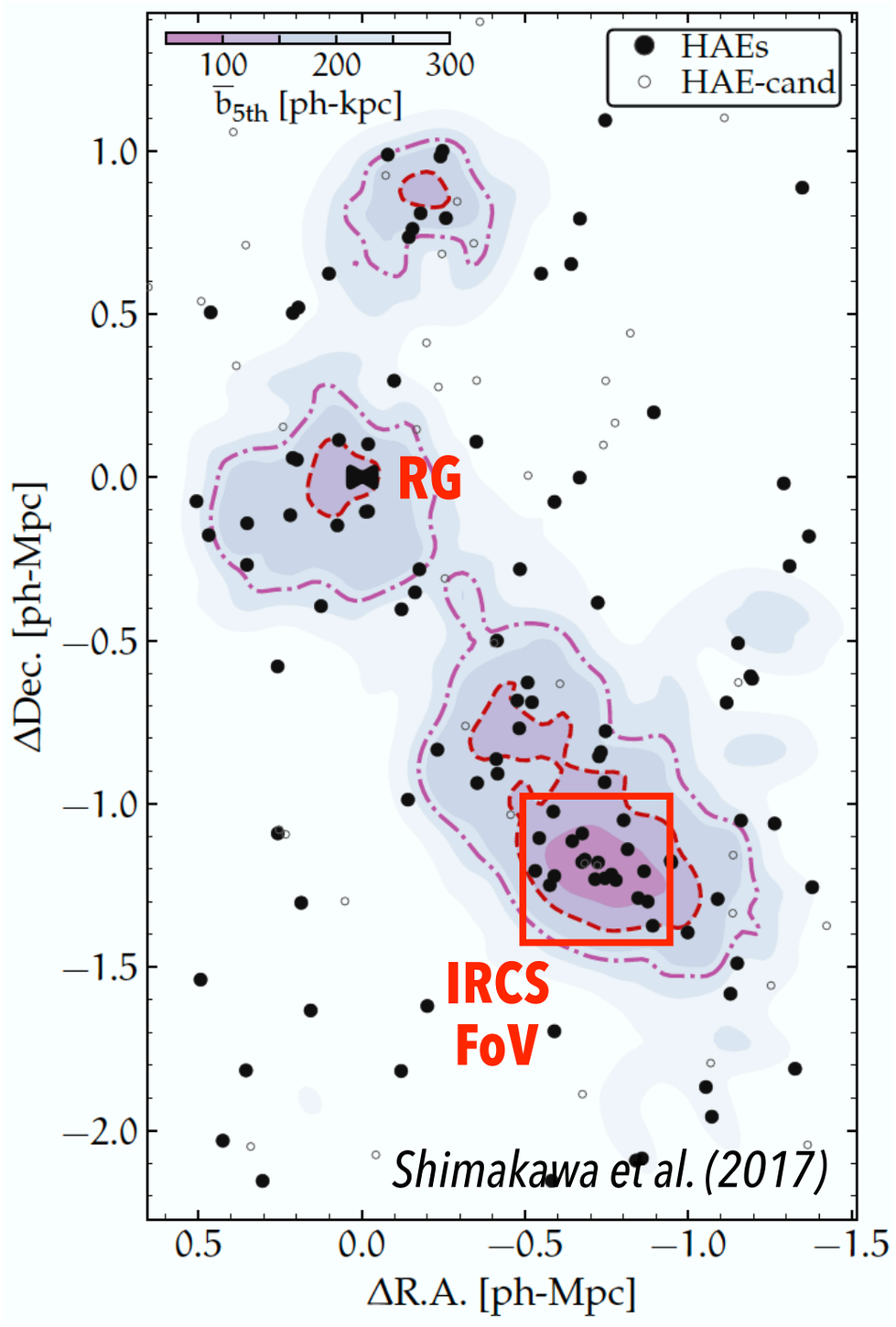


- Targets

  NB-selected Hα emitters at z = 2-2.5

  - General field: UDS, COSMOS (Minowa et al.)
  - Proto-cluster field: **USS1558 (This work)**, PKS1138

USS1558: a proto-cluster at z=2.53

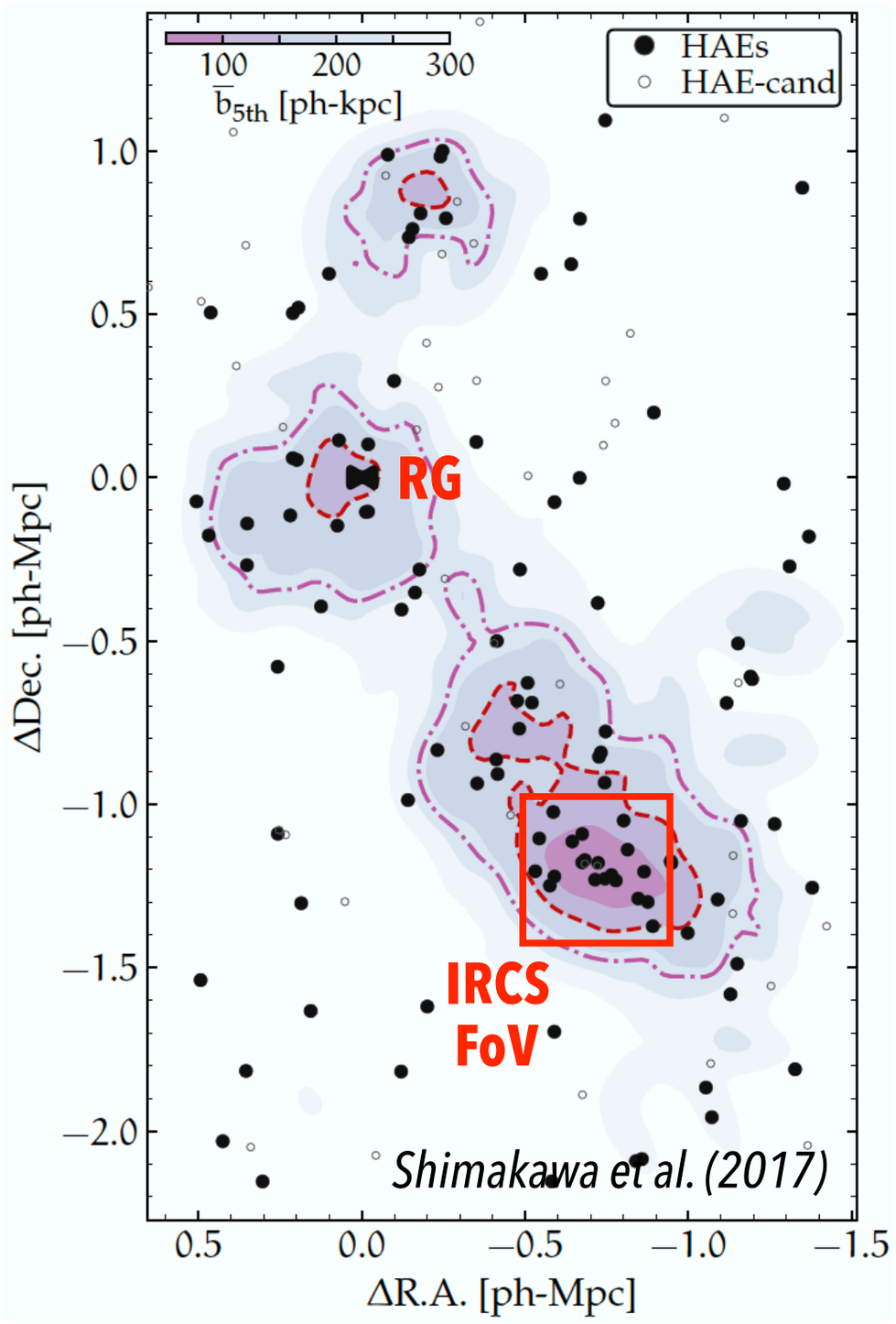


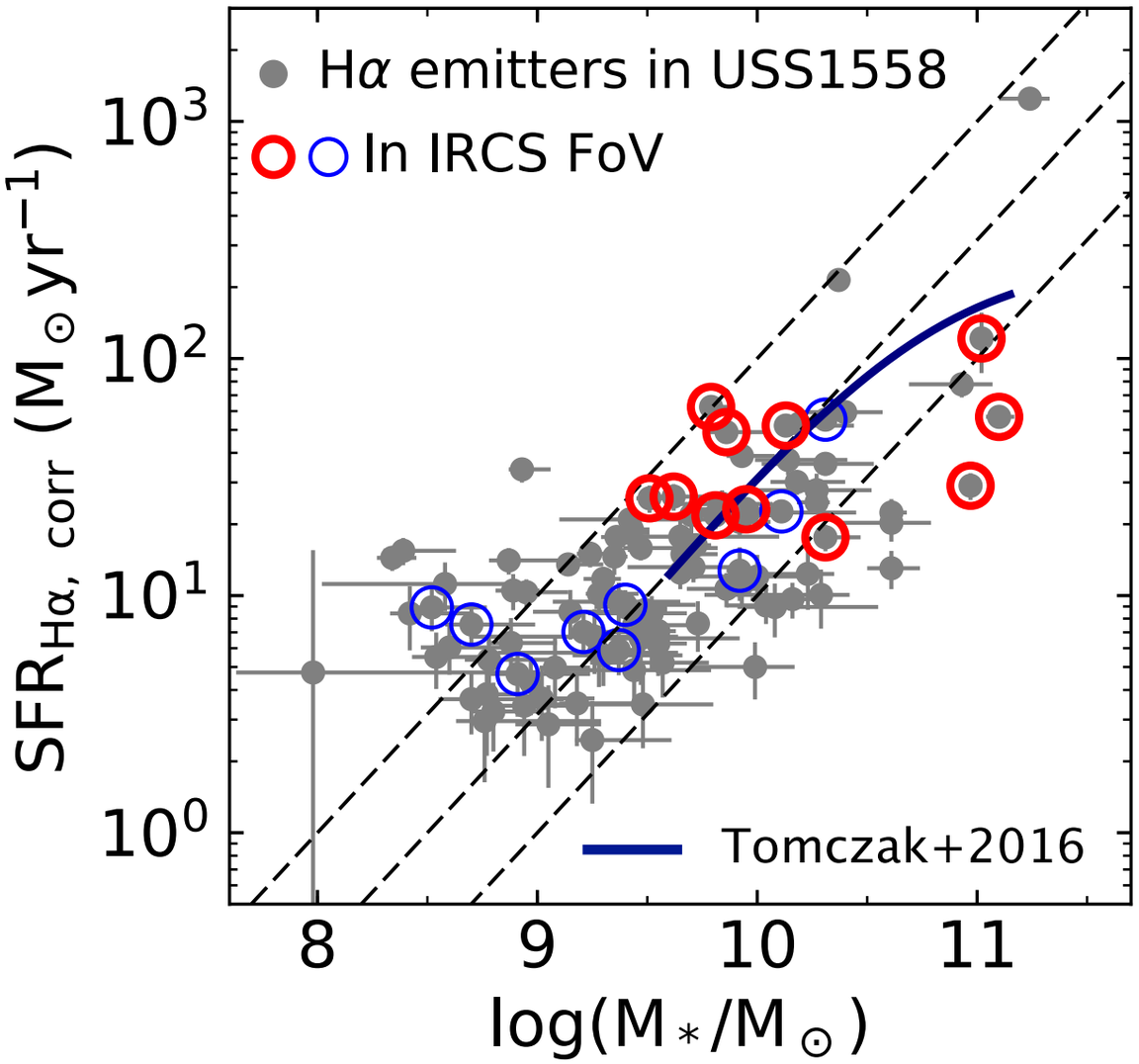
- A high-density region around a radio galaxy at z=2.53 (Kajisawa+06)

- Deep MOIRCS NB observation
  → 107 Hα emitters
  (Hayashi+16; Shimakawa+18)

- IRCS+AO188 observation
  - May 2013, 2014 (PI: Y. Koyama)
  - The densest group of HAEs
    → proto-cluster core

Targets on M*-SFR diagram

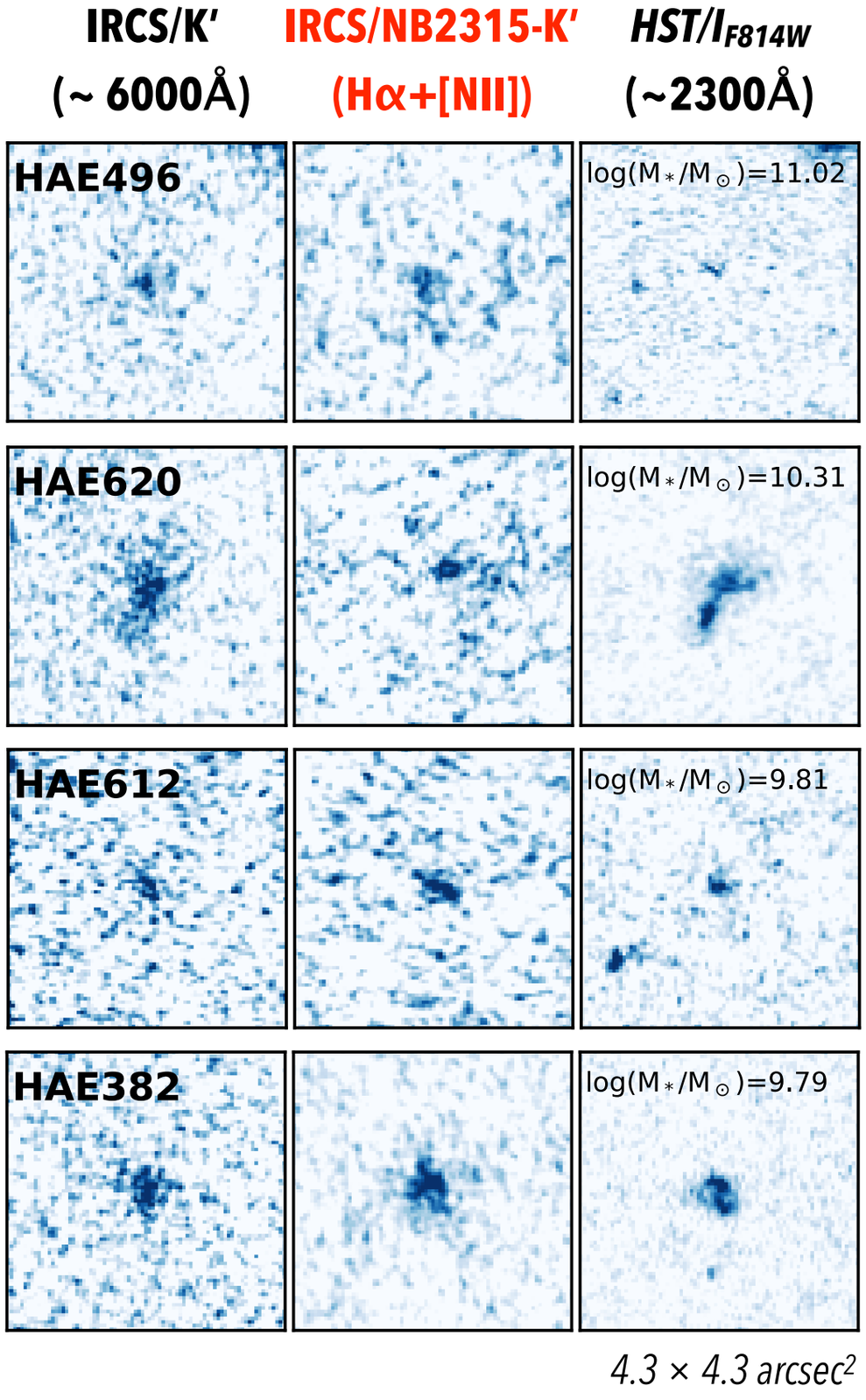




11 HAEs with $M_* > 10^{9.5}\ M_{sun}$

→ "Normal" star-forming galaxies around the main sequence

Obtained spatially resolved images



- Achieved PSF size
  0.25" → 2.5 kpc @z=2.5

- K' image = Stellar continuum
  → Stellar mass

- NB-K' image = Hα+[NII]
  → Star-forming region

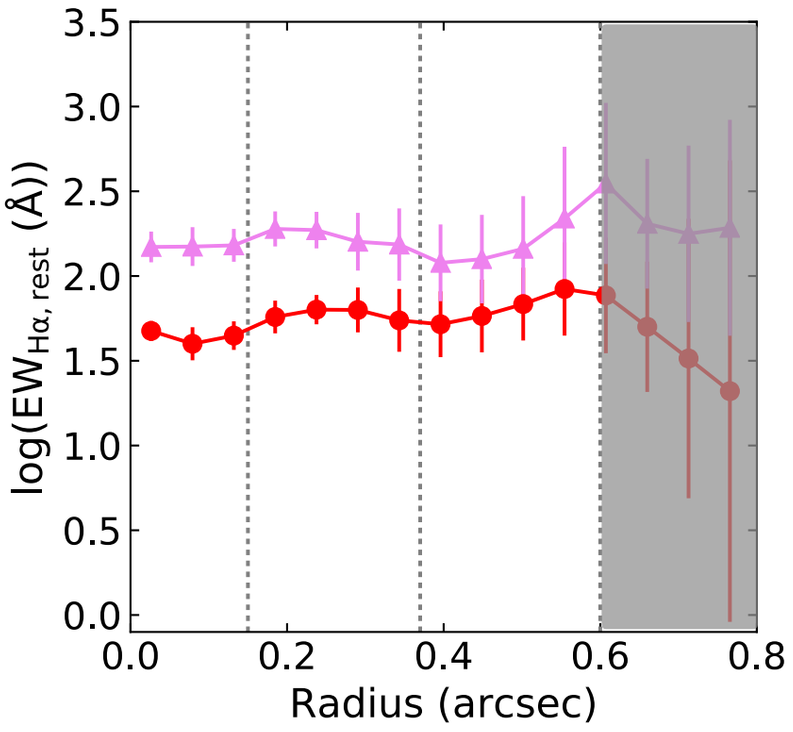
- HST/ACS images are available (Hayashi+)

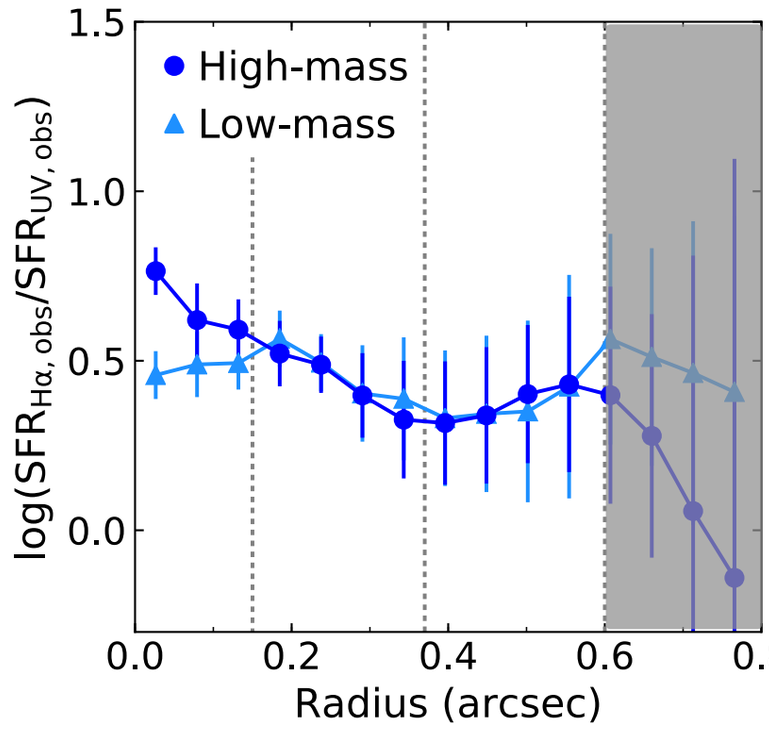
- Stacking analyses
  - High-mass (> 10^{10} M_{sun})
  - Low-mass (< 10^{10} M_{sun})

Radially dependent dust extinction for Hα

Locally calibrated relation by Koyama et al. (2015)

$$A_{H\alpha} = (0.101 \times \log \mathrm{EW}_{H\alpha} + 0.872) \times \underbrace{\log(H\alpha/\mathrm{UV})}_{\text{observed SFR ratio}} + (-0.776 \times \log \mathrm{EW}_{H\alpha} + 1.688)$$





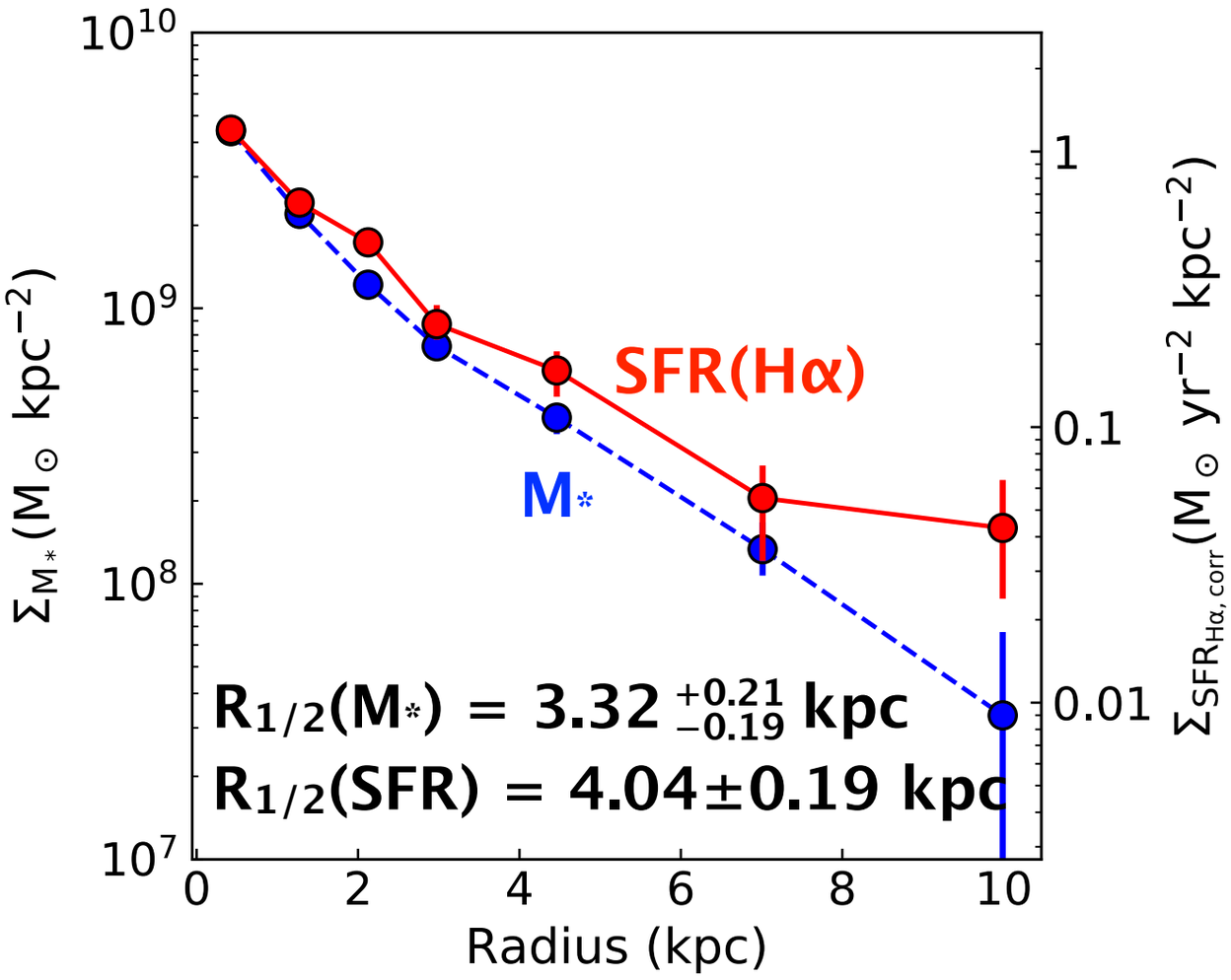
SFR$_{UV}$
→ HST/I$_{F814W}$

$A_{H\alpha}$ (mag)	< 1.2 kpc	1.2–3.0 kpc	3.0–4.8 kpc
High-mass	1.11	0.78	0.68
Low-mass	0.52	0.47	0.41

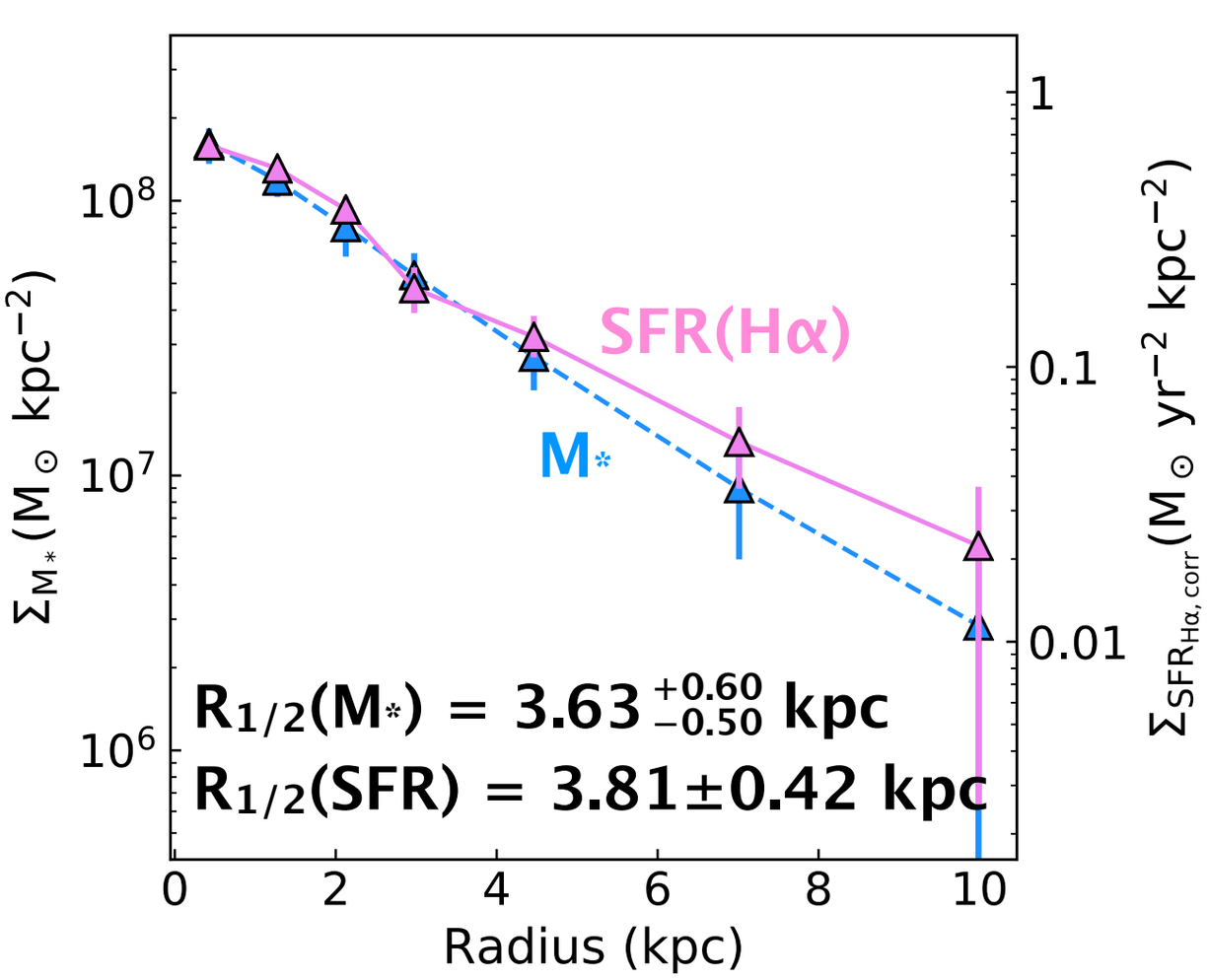
Higher A_{Ha} at the center (e.g., Nelson+16; Tacchella+18)

Extended star-forming region of massive SFGs

High-mass sub-sample
$10^{10} M_{sun} < M_* <= 10^{11.1} M_{sun}$



Low-mass sub-sample
$10^{9.5} M_{sun} < M_* < 10^{10} M_{sun}$

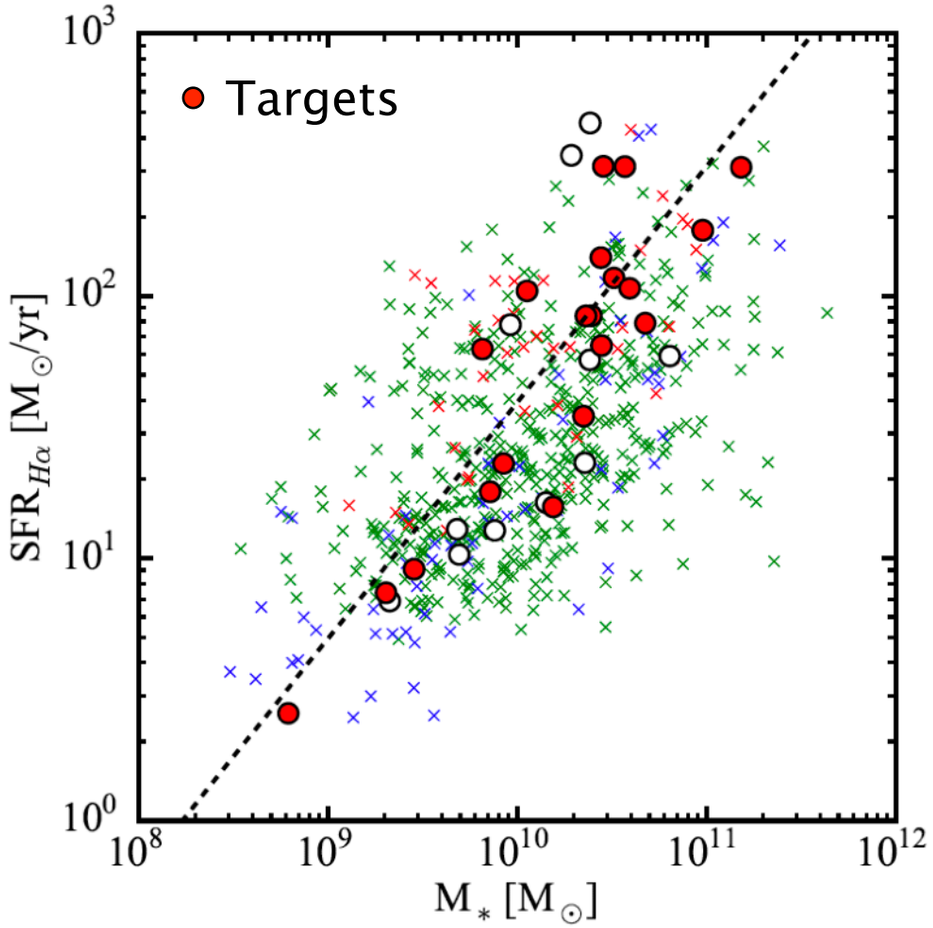


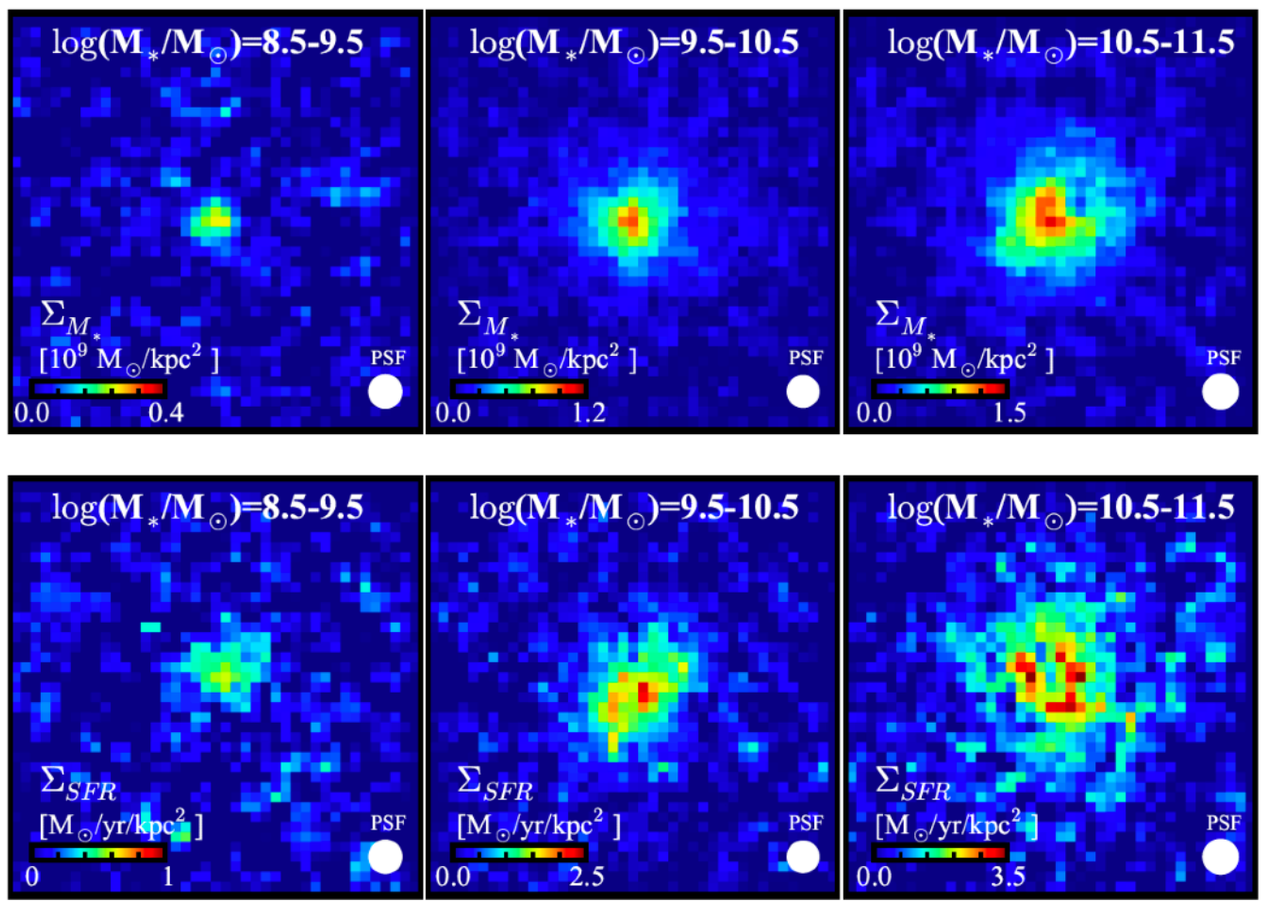
Star-forming region is further extended than underlying stellar structure

Field galaxies at similar redshifts

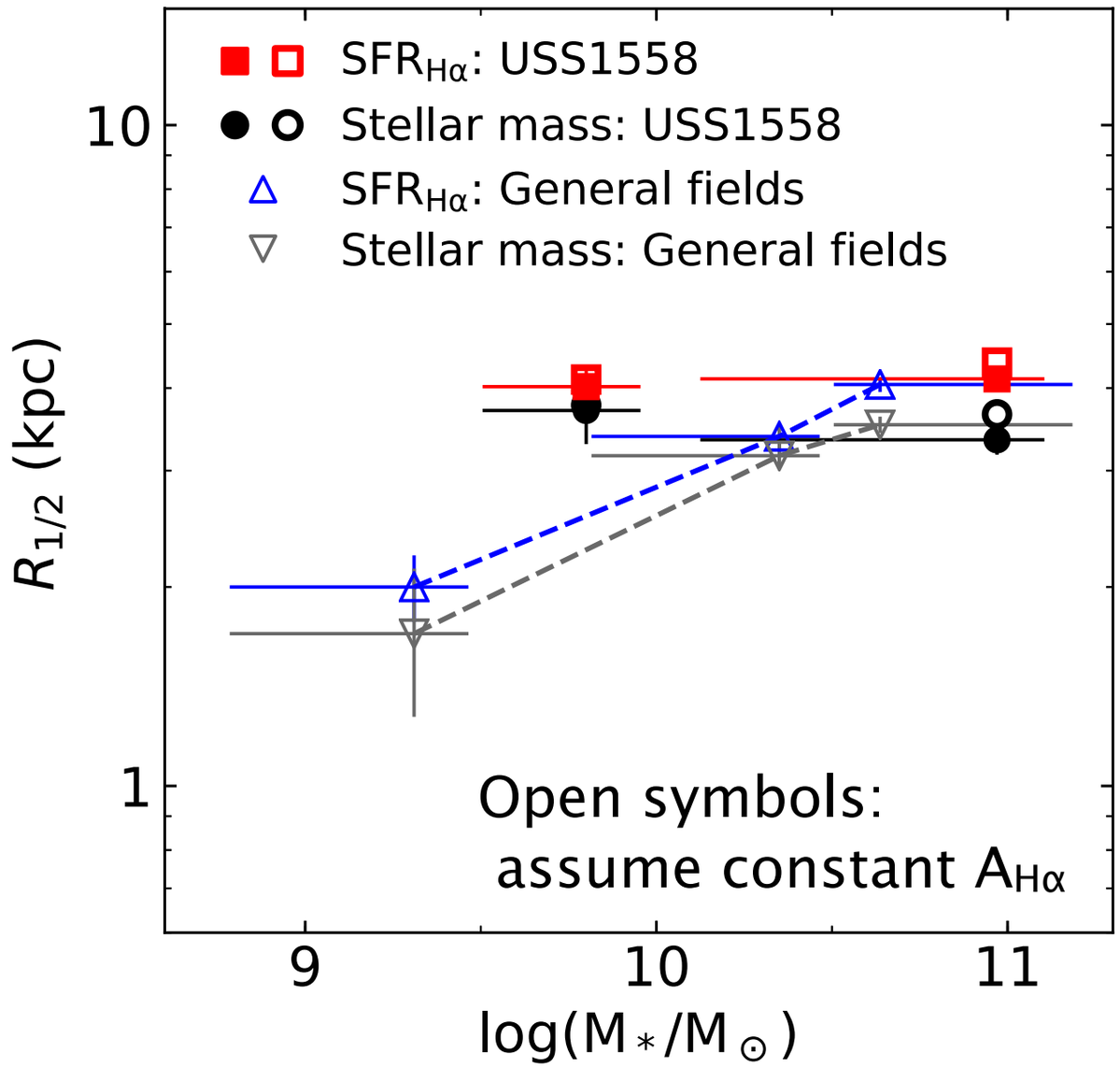
Minowa et al.

- 20 Hα emitters in the general fields (UDS+COSMOS)
- Three NB filters (z~2.2 and 2.5)
- Distribute around the main sequence at the epoch





Comparison with the field galaxies at z = 2-2.5



- **No clear environmental dependence for massive SFGs**
- **Structural growth is mainly driven by internal secular processes in both environments**

Summary

We conducted the AO-assisted K'+NB imaging observation with Subaru/IRCS+AO188 for the Hα emitters in the dense proto-cluster core at z =2.53

- Spatially resolve the Hα-emitting region within galaxies at z > 2

- **More extended star-forming region than stellar structure for the massive SFGs in the proto-cluster core**

- **No clear environmental dependence of the spatial extent of star-forming region**

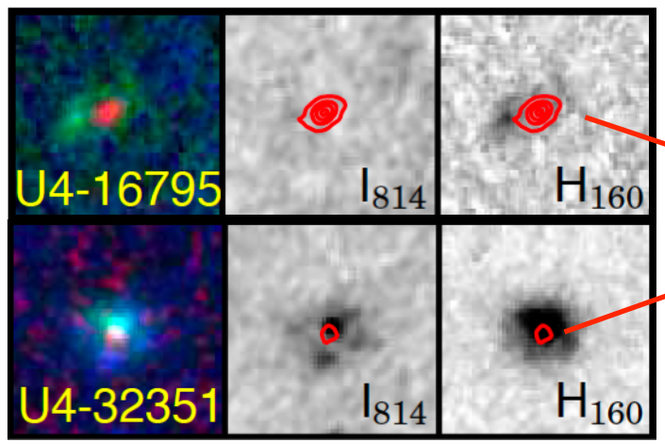
- Structural growth of massive SFGs at z=2-2.5 is likely dominated by the internal secular processes both in the general fields and the proto-cluster core.

Future prospects

- Star-forming region highly obscured by dust

  : High angular resolution observation of dust emission with ALMA

z~2 star-forming galaxies (Tadaki+17)



Compact dust emission within an extended stellar structure

- Internal structures for a larger number of individual galaxies

  : ULTIMATE-Subaru

  (GLAO+Wide-field imager)