

The Cool CGM of Individual Galaxies

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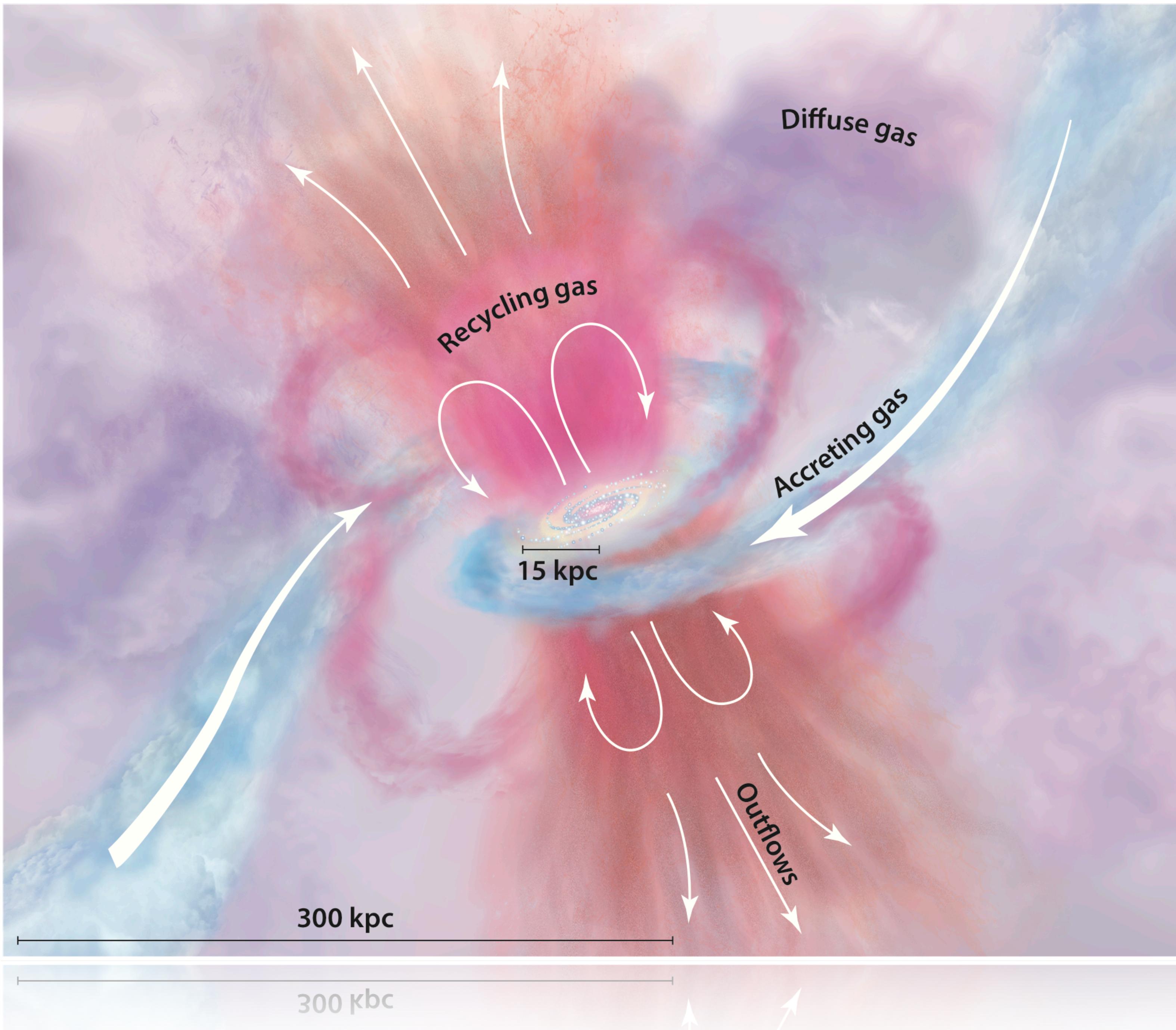
07/07/2025 @ Durham University

Circumgalactic Medium (CGM)

The Two Most Important Questions in Galaxy:

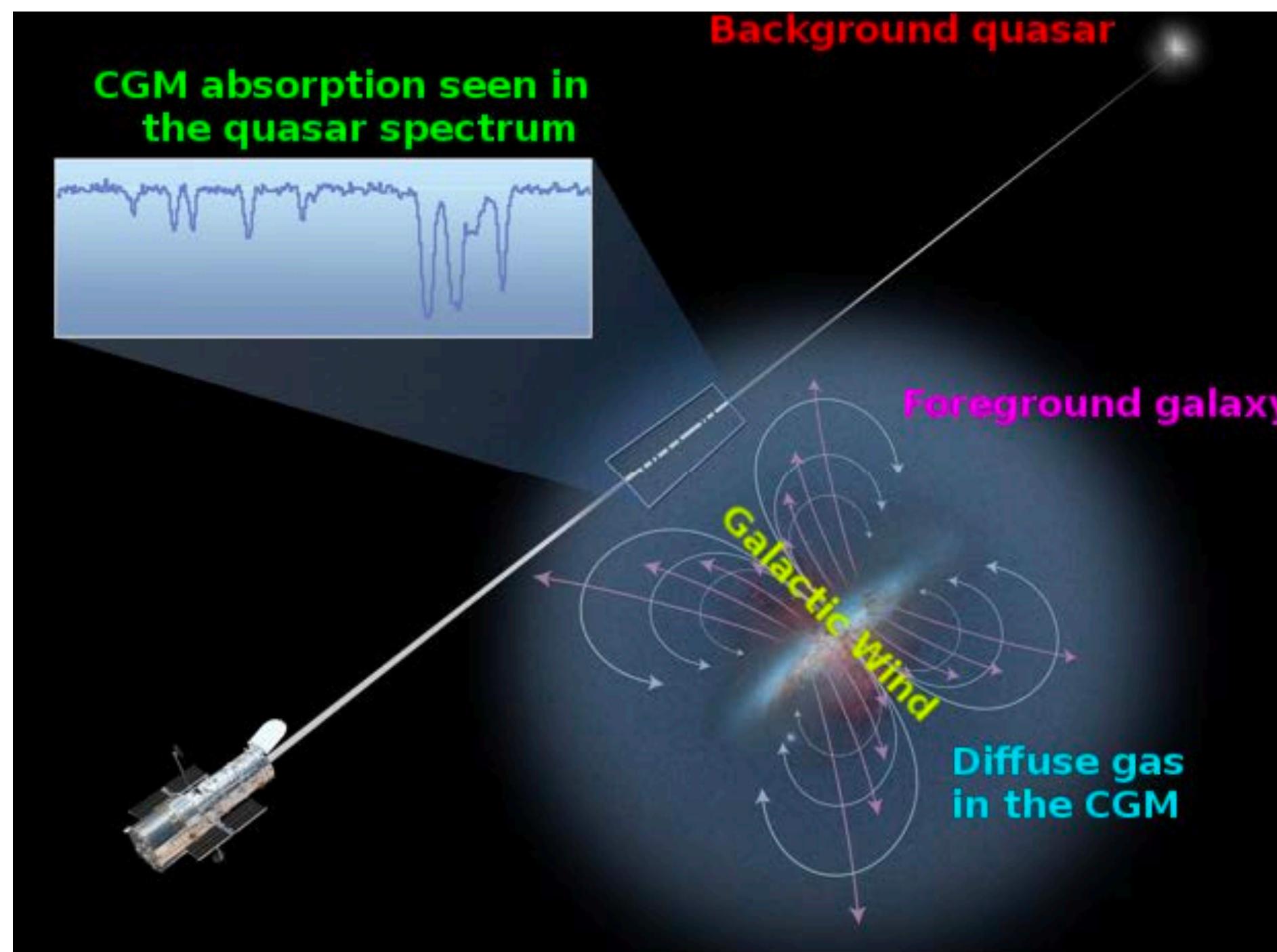
1. How the gas cool and feed the star formation (SF)?
2. How the SF activity terminates, namely quenching?

Tumlinson et al, 2017



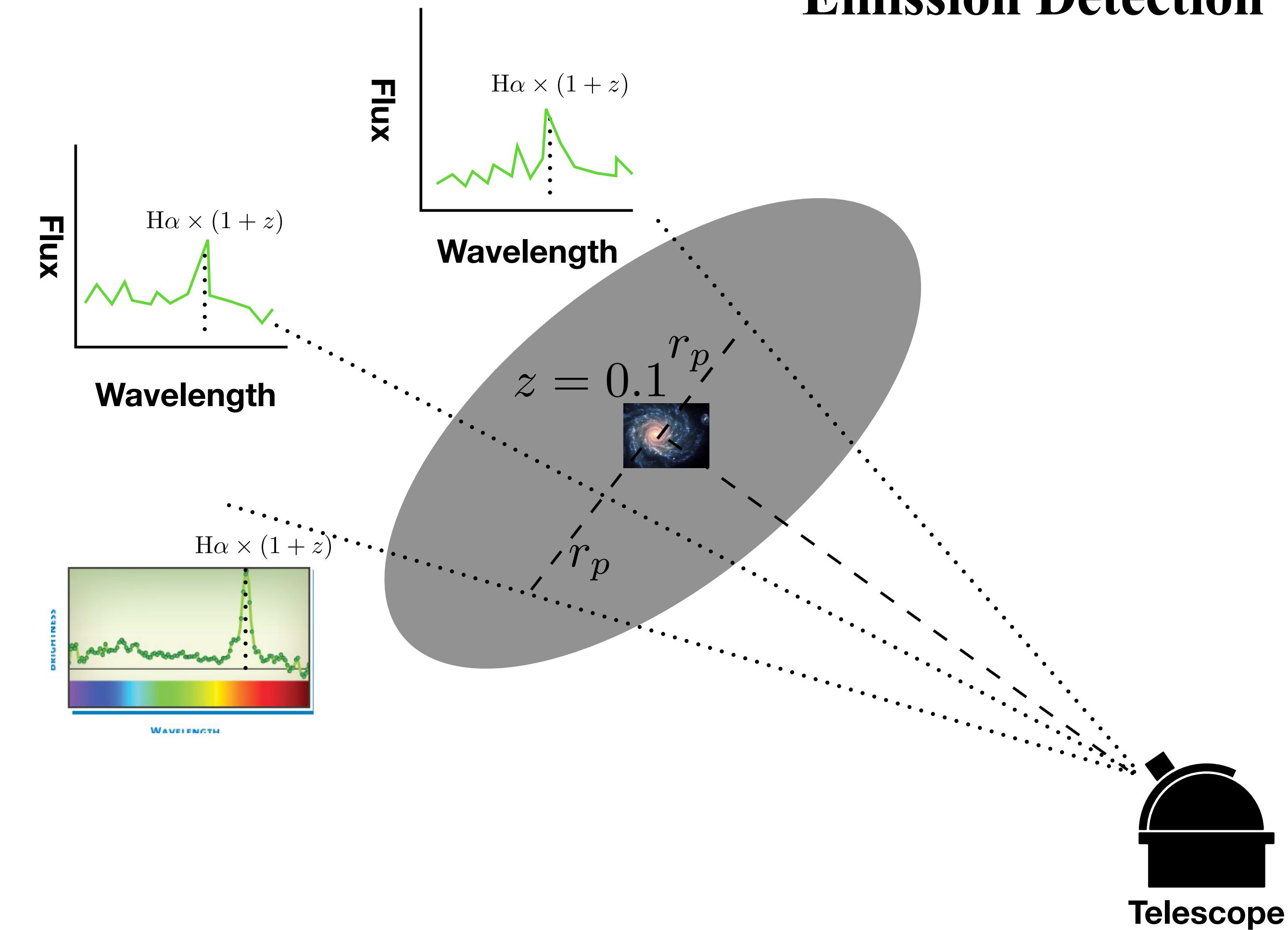
How to detect CGM?

Absorption Detection



Credit to Muzahid

Emission Detection

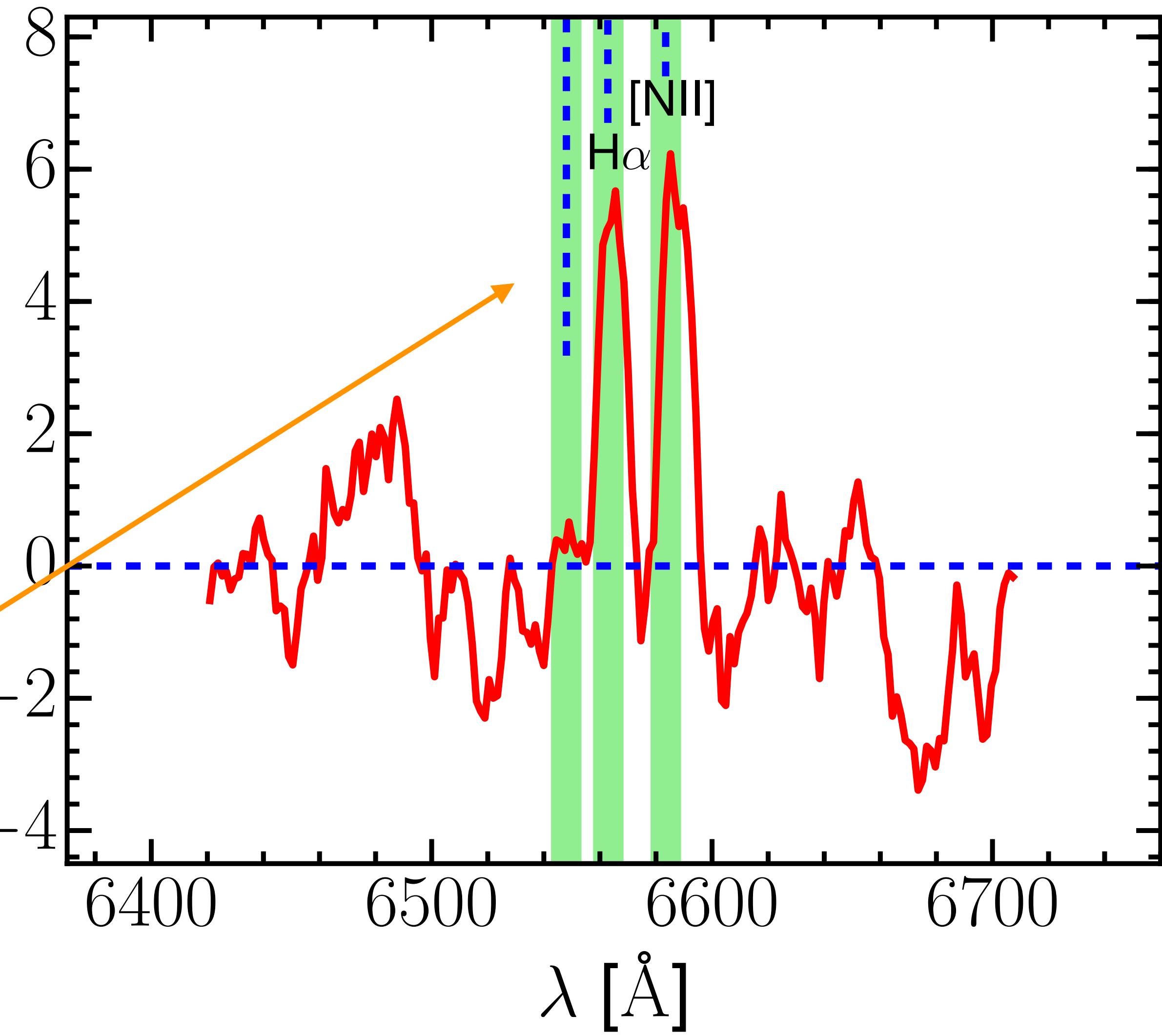


Stacked composite spectra for CGM emission

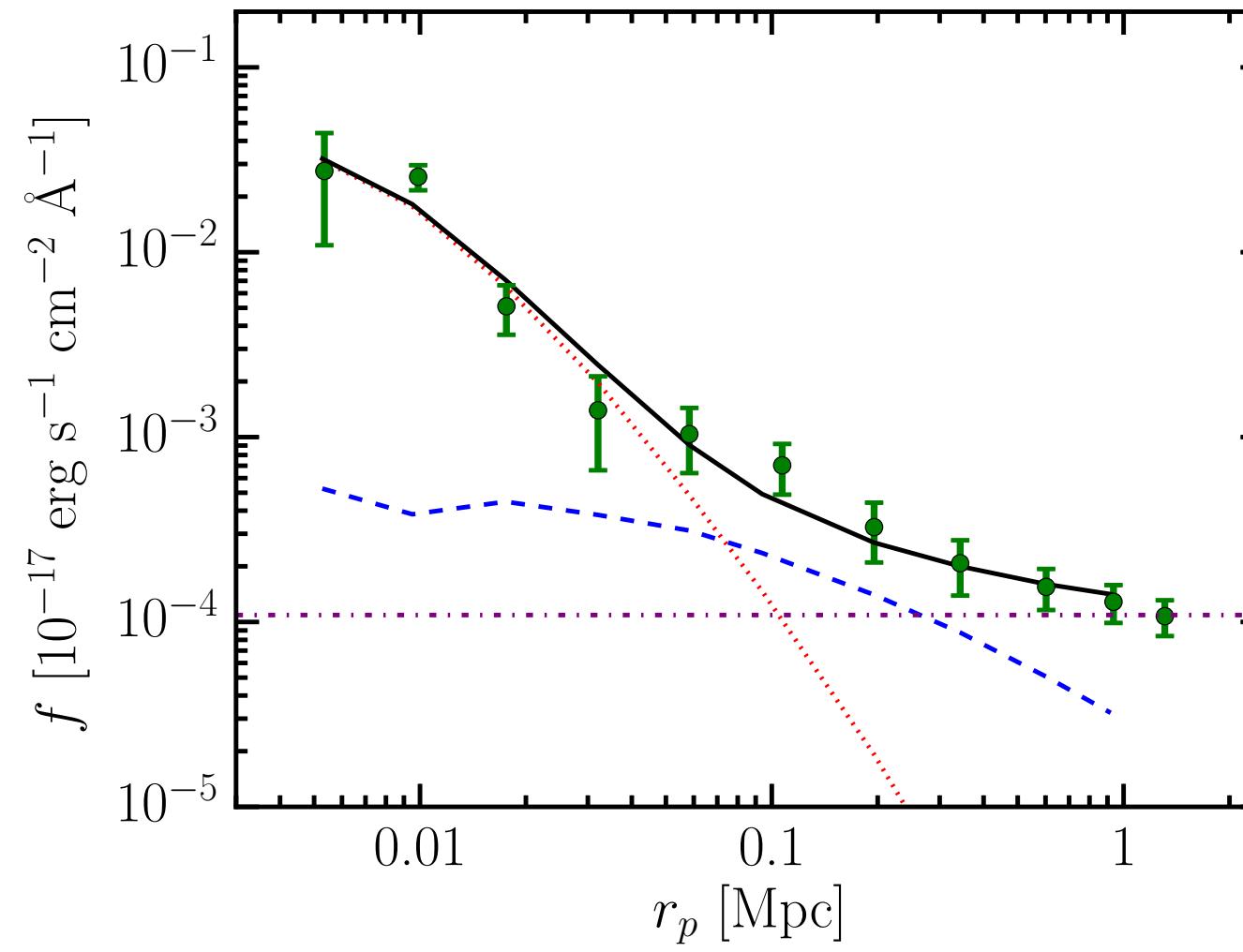
1. $\sim 500,000$ target galaxies
2. $10^9 < M_*/M_\odot < 10^{11.5}$
3. $0.02 < z < 0.2$
4. 8,000,000 pairs at $r_p < 2$ Mpc

Shaded region: Velocity
window $\sim \pm 275$ km/s

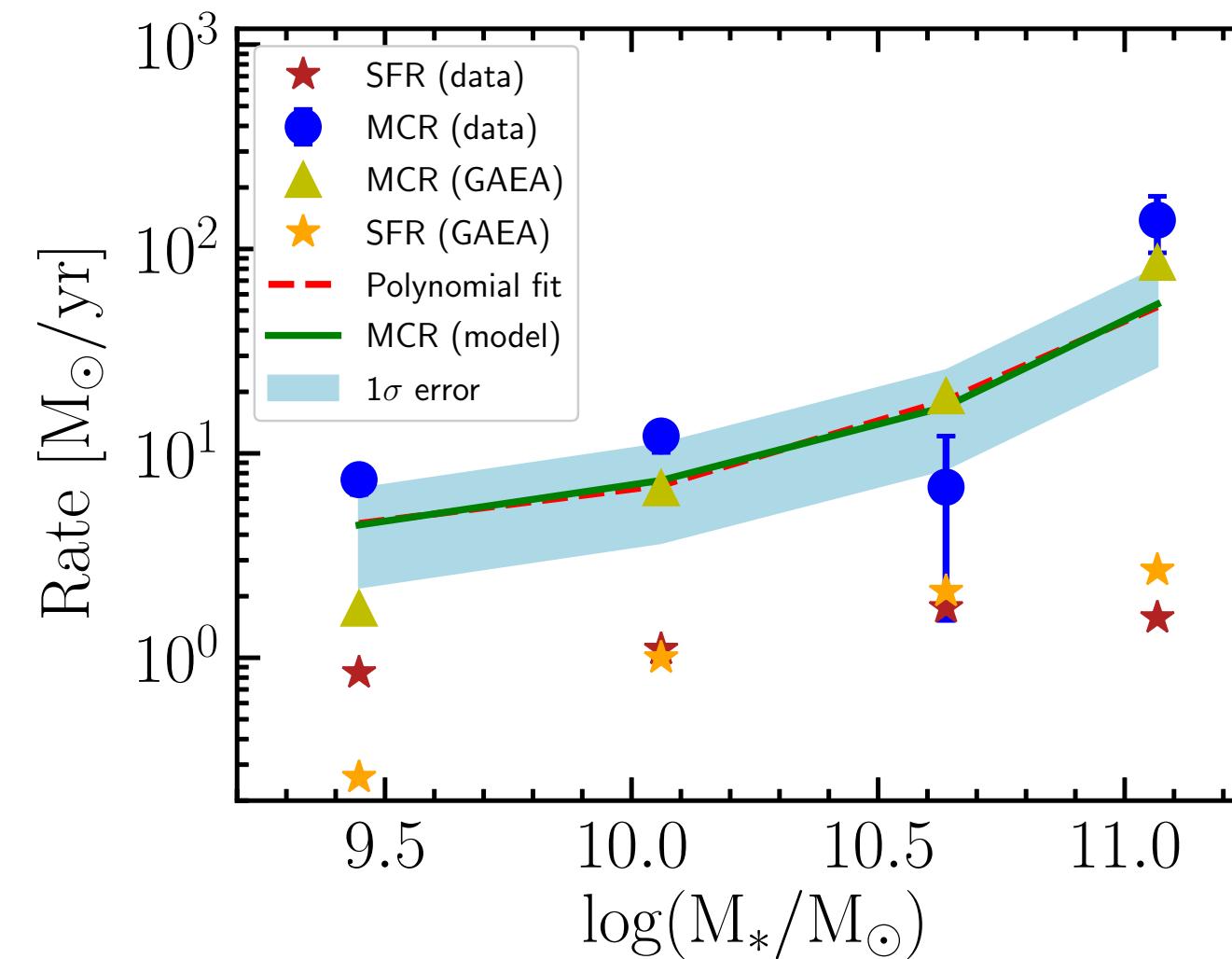
$$f [10^{-20} \text{ erg cm}^{-2} \text{s}^{-1} \text{\AA}^{-1}]$$



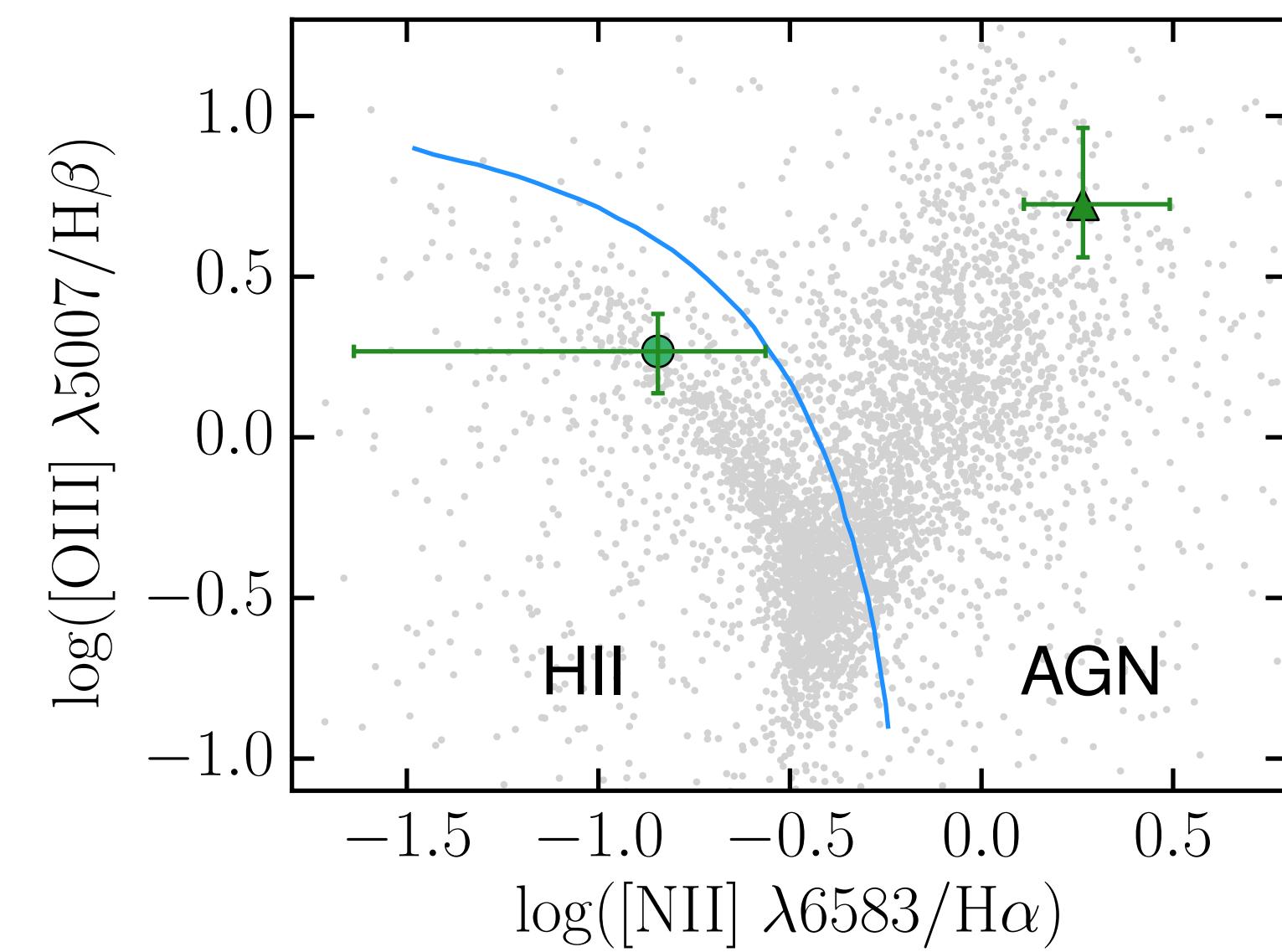
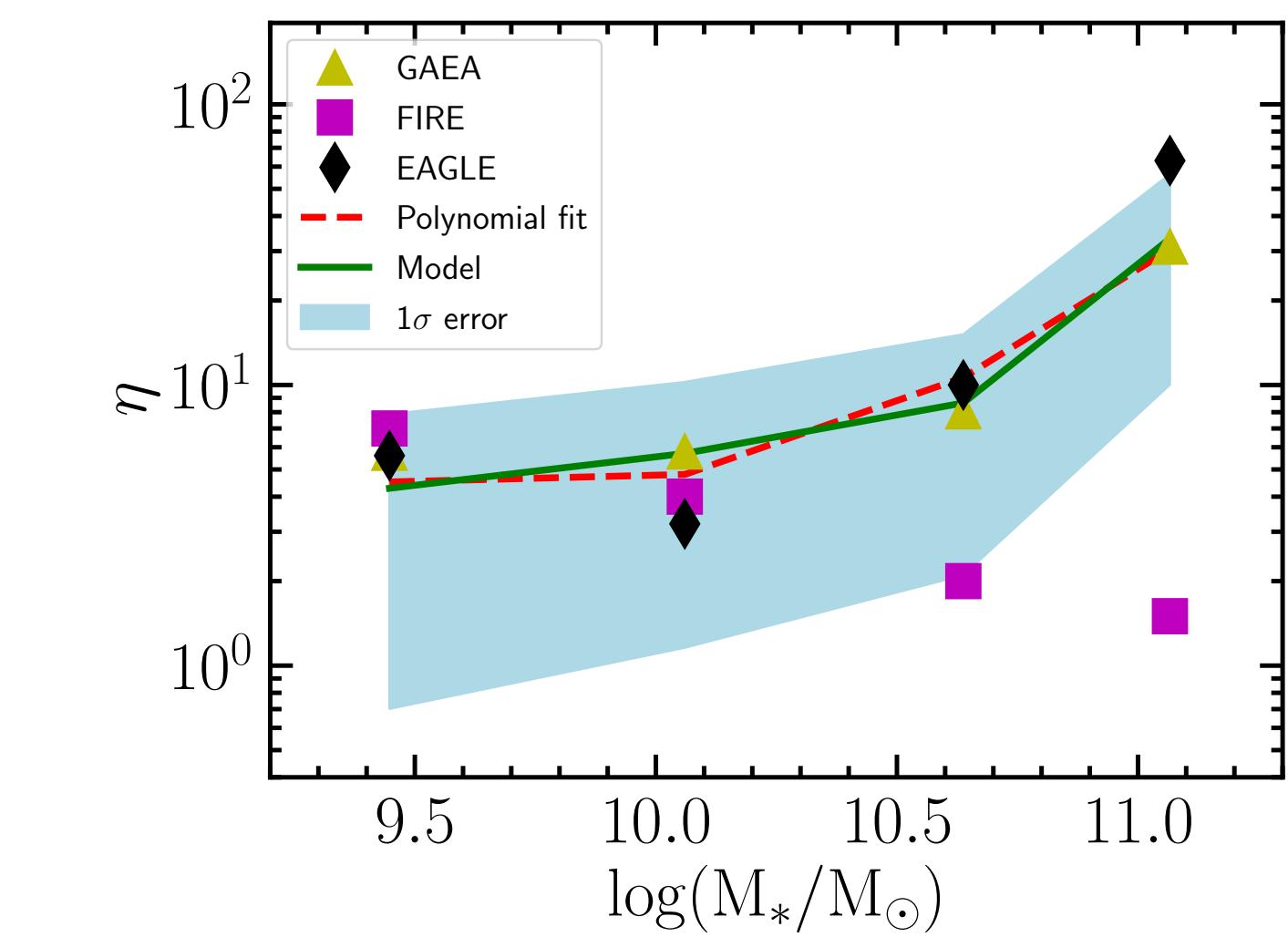
Zhang et al. 2016, $r_p < 50$ kpc



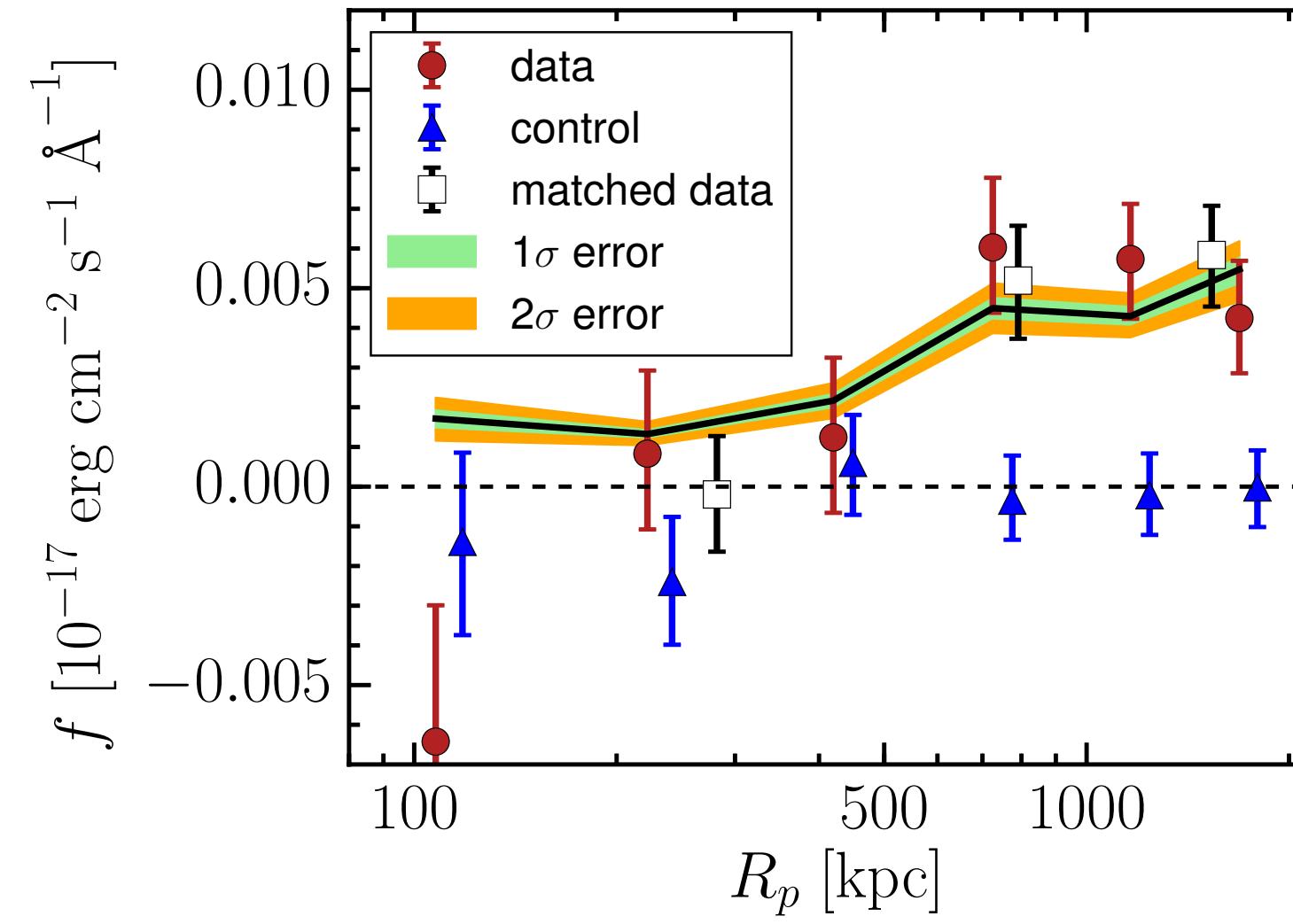
Emission detection, 2016, 2018a



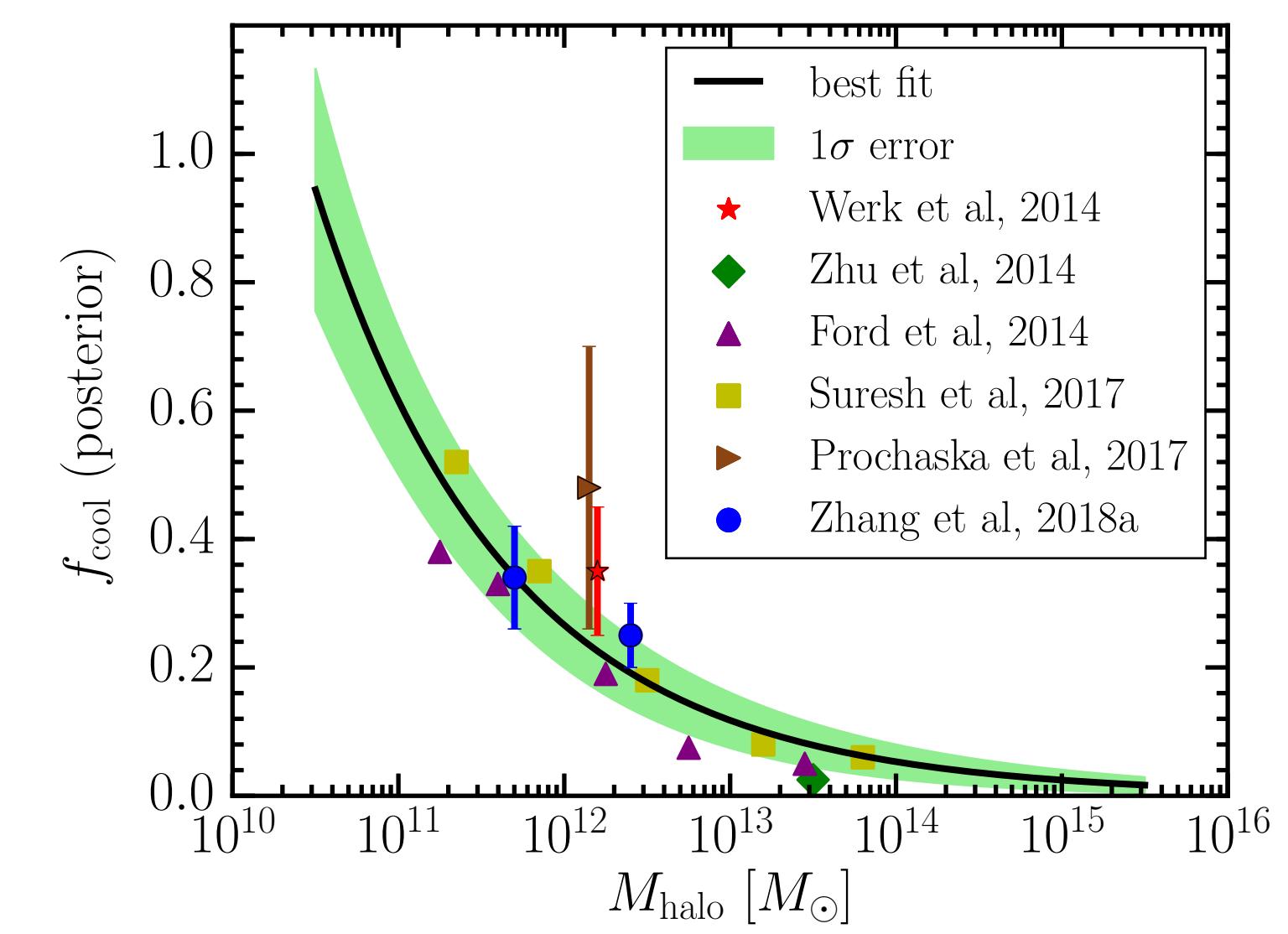
Cooling inflow and outflow, 2021



Ionization states, 2018b, 2022, 2024



Environ dependence, 2019

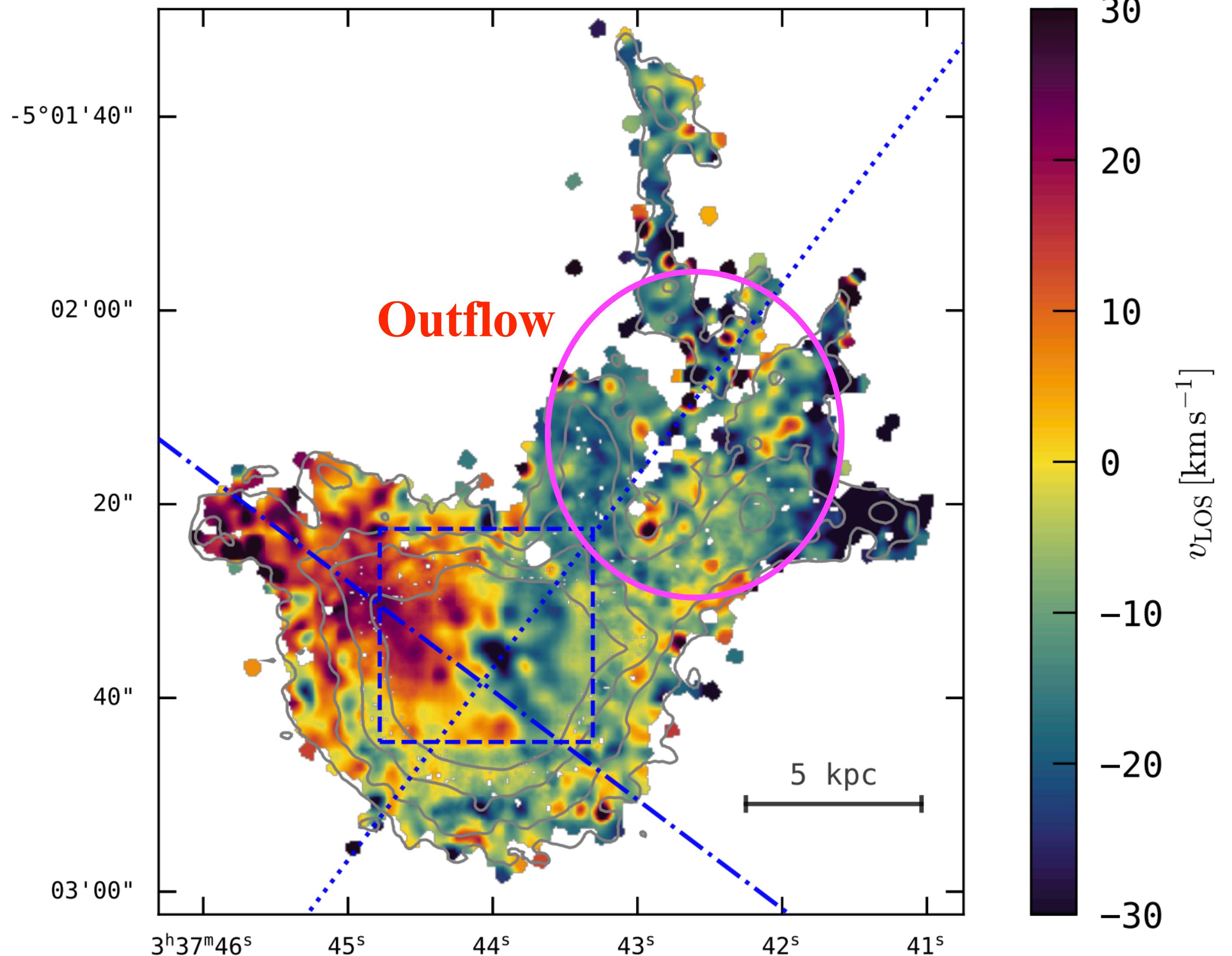


Mass dependence, 2020a 5

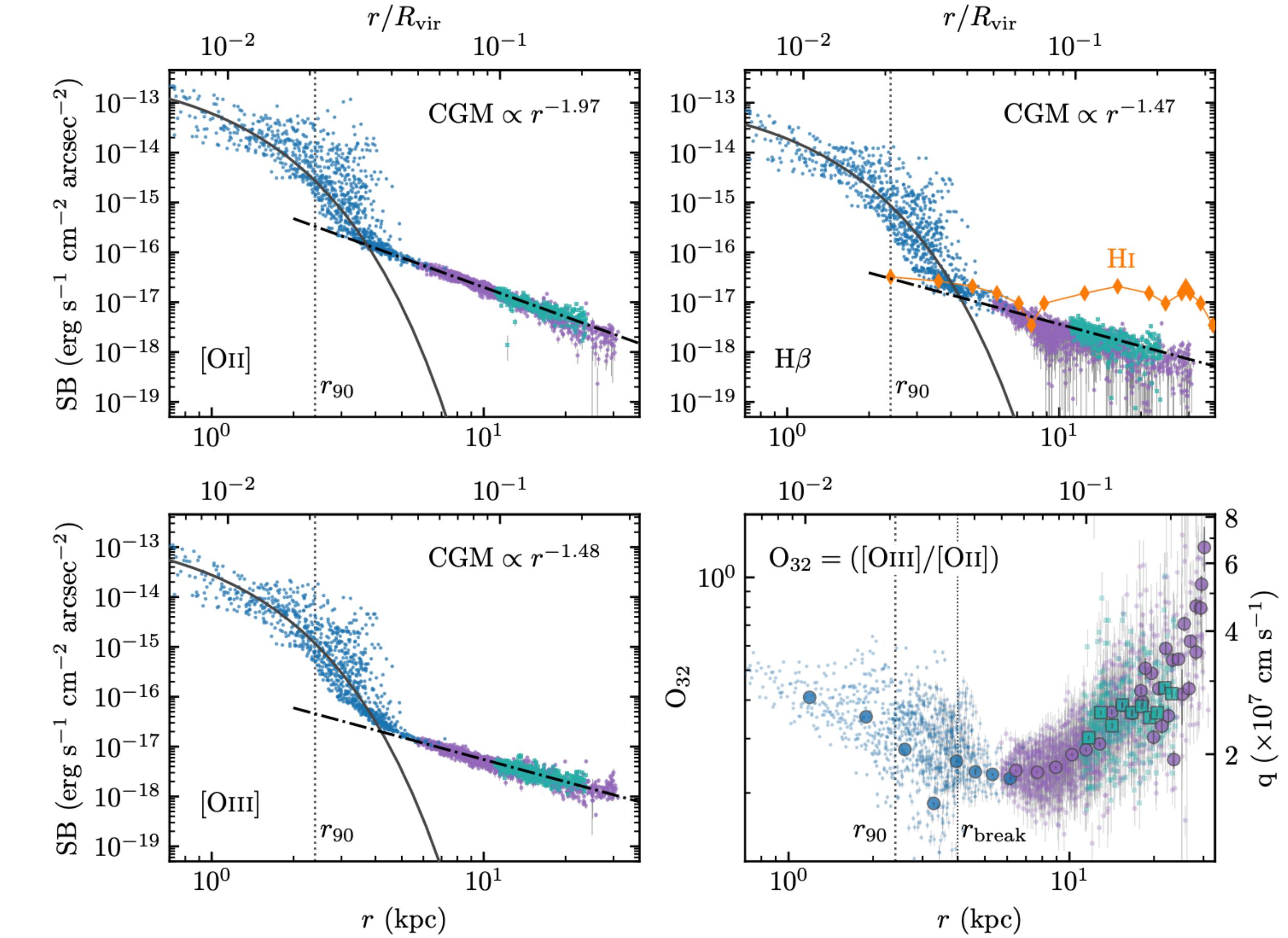
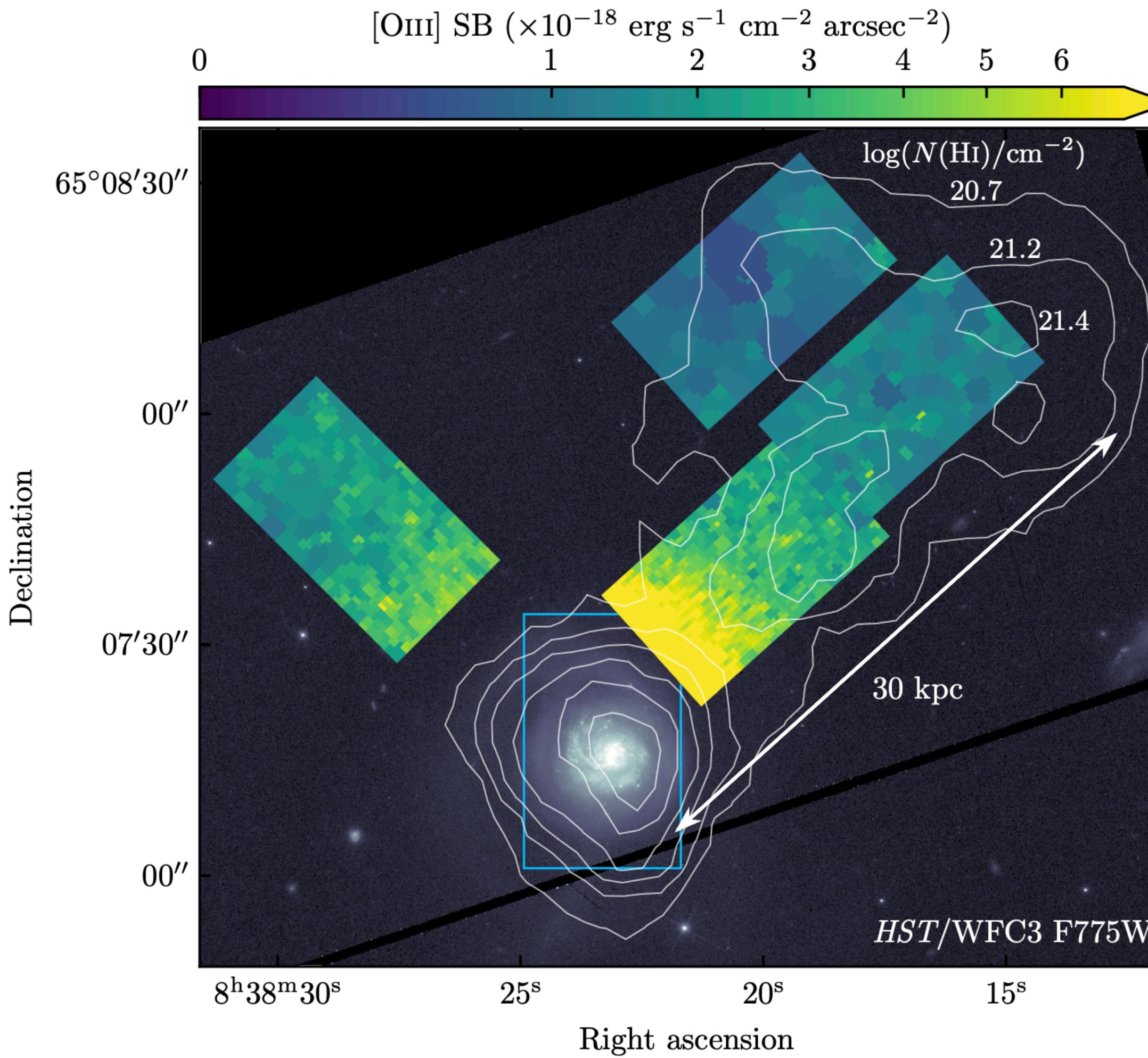
CGM Mapping using Keck

1. Blue compact dwarf galaxy.
2. $M_* = 6 \times 10^6 M_\odot$
3. Galaxy extension ~ 500 pc.
4. At $z = 0.01352$
5. Distance = 58.42 Mpc
6. Angular scale ~ 276 pc / ''

H α narrow-band image, width 2.5Å



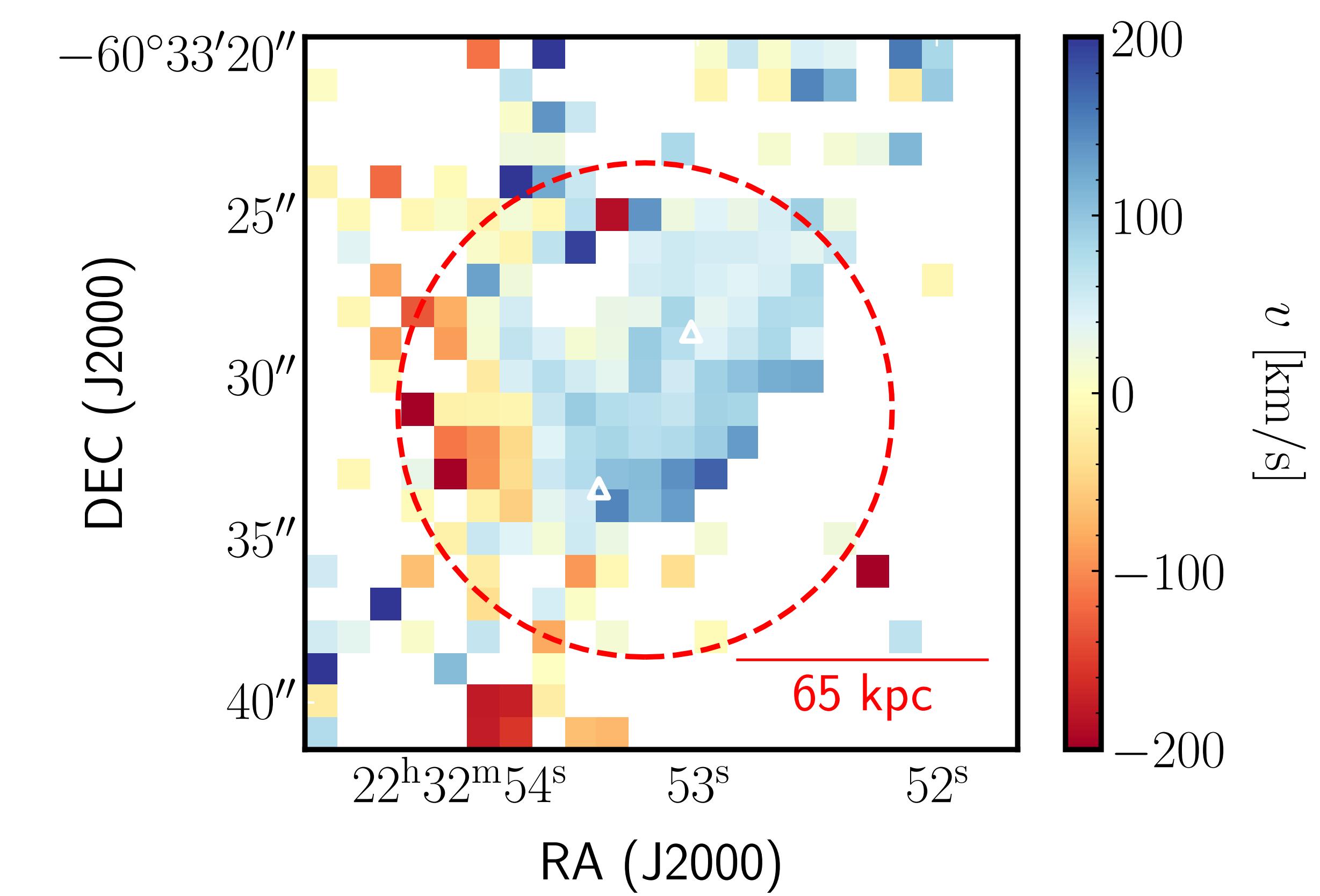
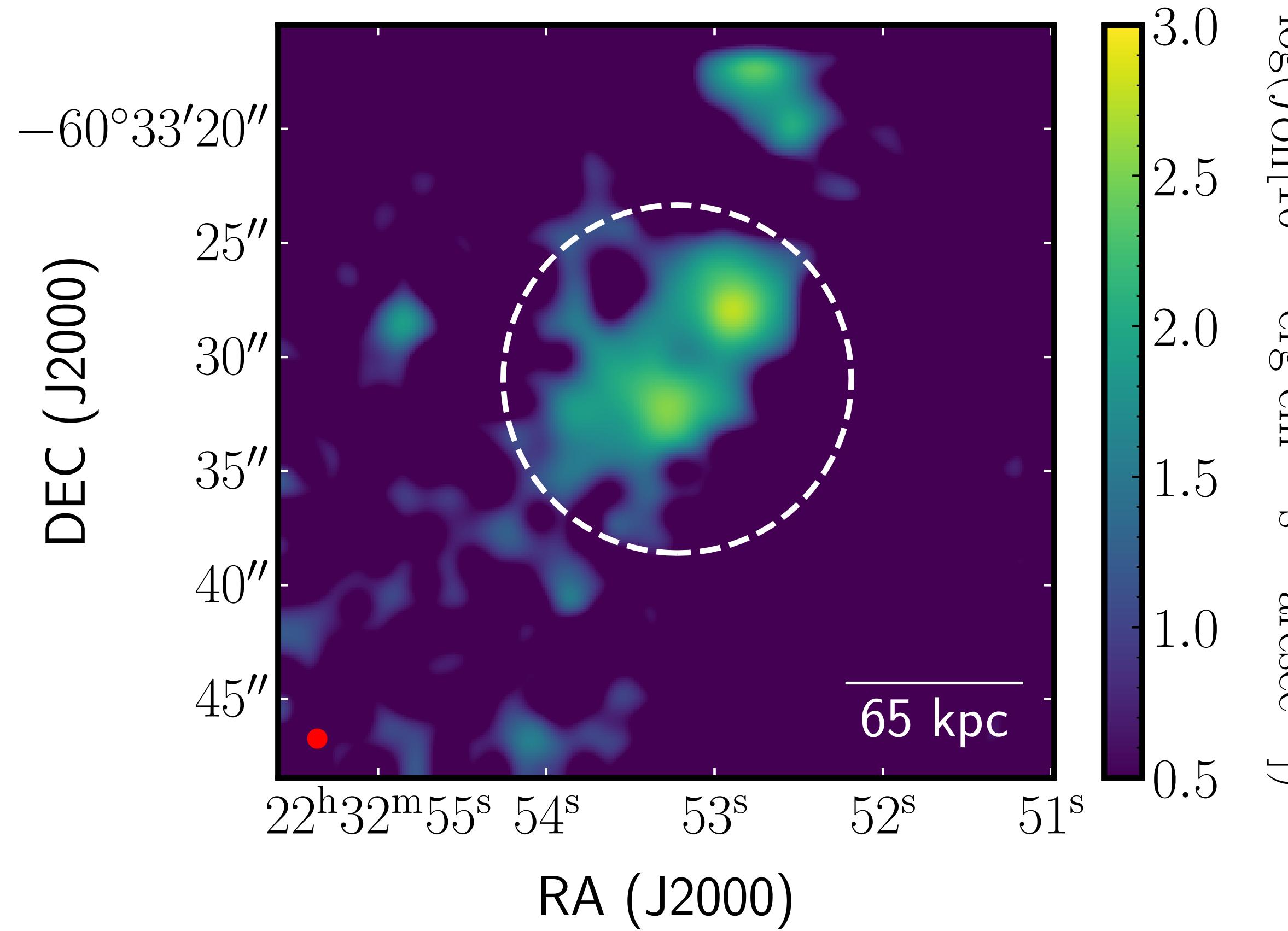
CGM Mapping using KCWI Data



Nielsen et al. 2024

1. Starburst galaxy at $z = 0.01911$, $M_* \sim 10^{10.0} M_\odot$, SFR $\sim 12.1 M_\odot/\text{y}$

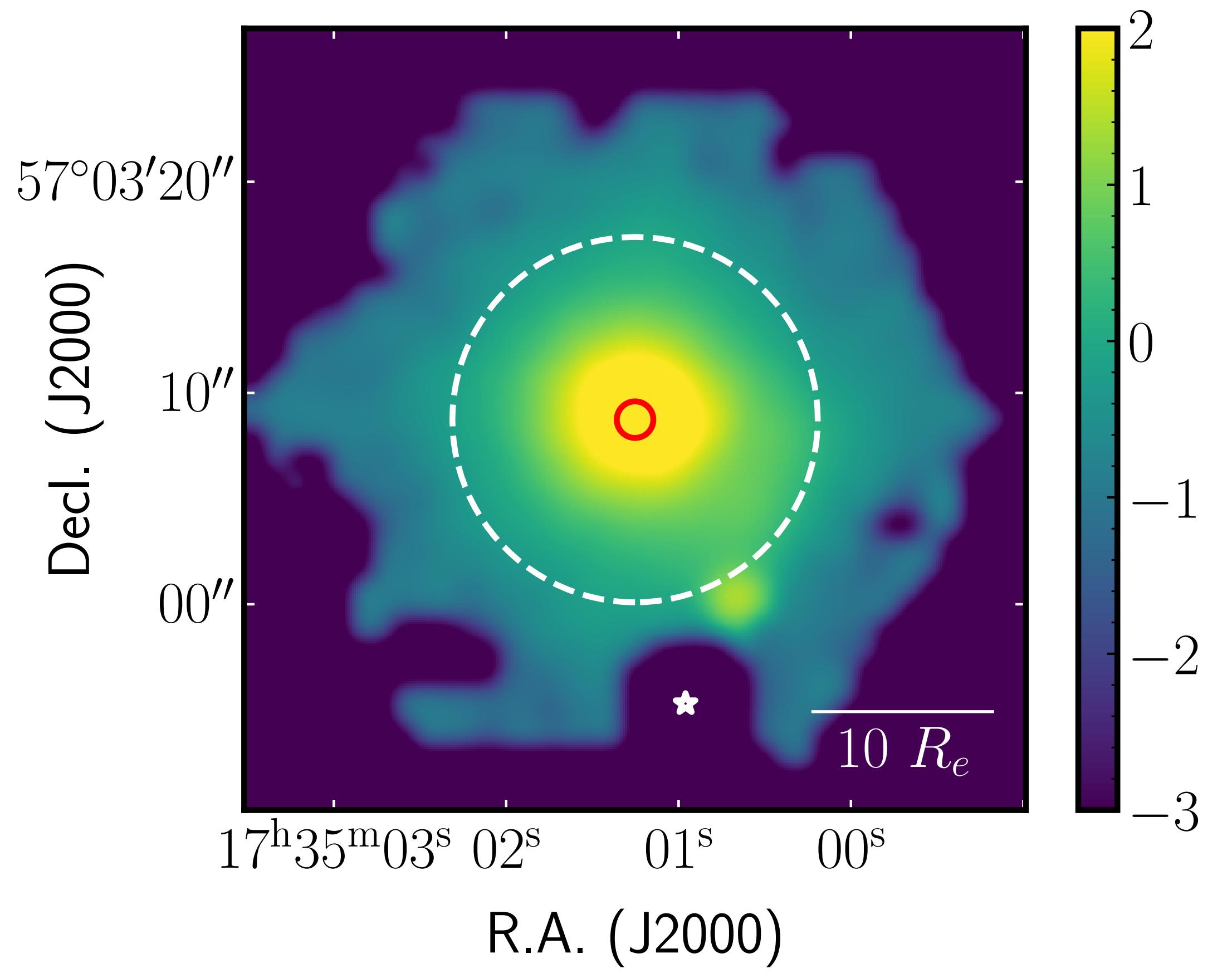
CGM Mapping using MUSE Data



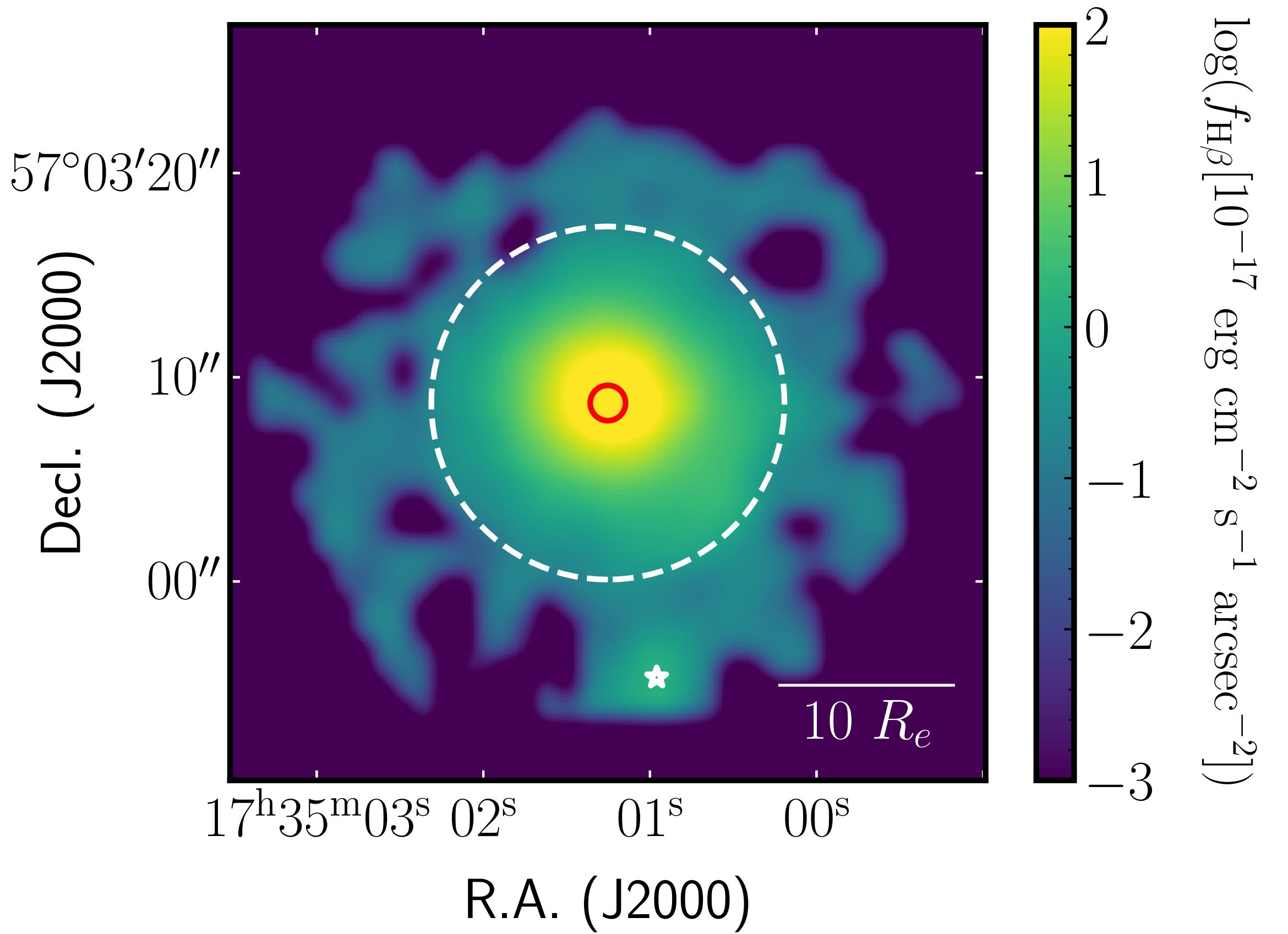
1. Interacting galaxies at $z = 1.284$, $M_* \sim 10^{10.5} M_\odot$, SFR $\sim 10 M_\odot/\text{yr}$
2. 12 Å [OII] narrow-band image, extends to ~ 130 physical kpc, and velocity field.

CGM Mapping using MaNGA

Zhang et al. 2025, in prep

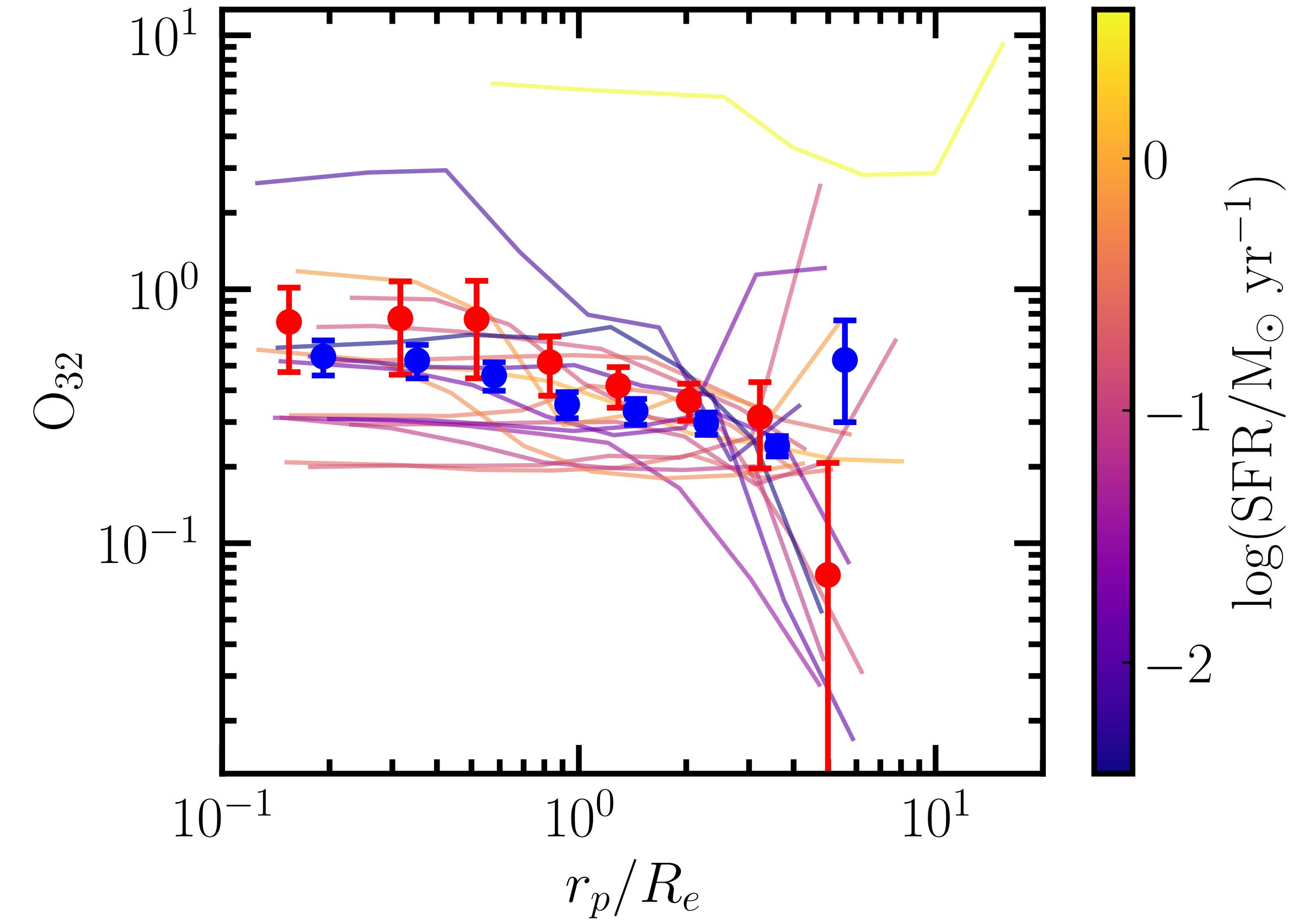
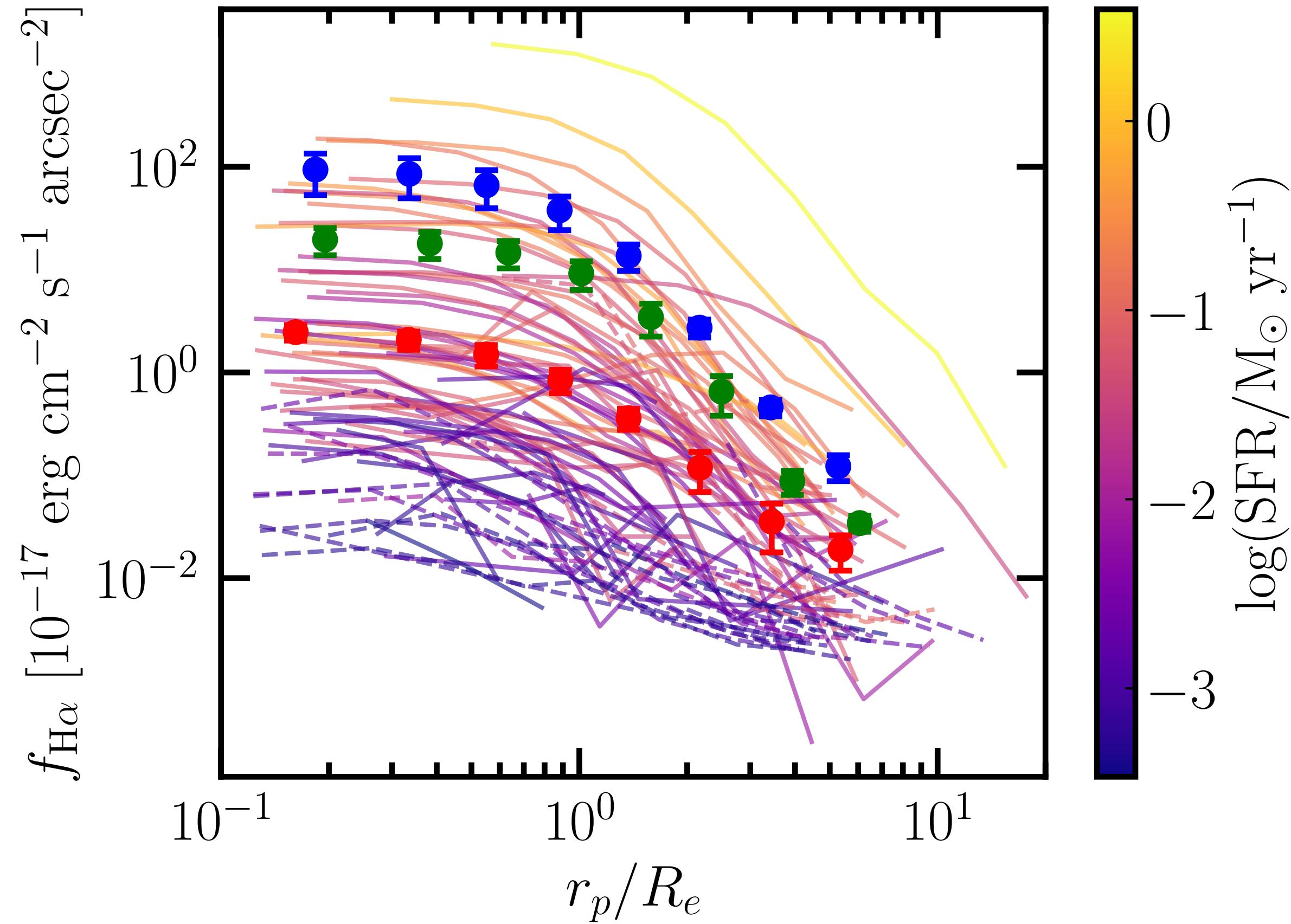


$$\log(f_{\text{H}\alpha} [10^{-17} \text{ erg cm}^{-2} \text{ s}^{-1} \text{ arcsec}^{-2}])$$



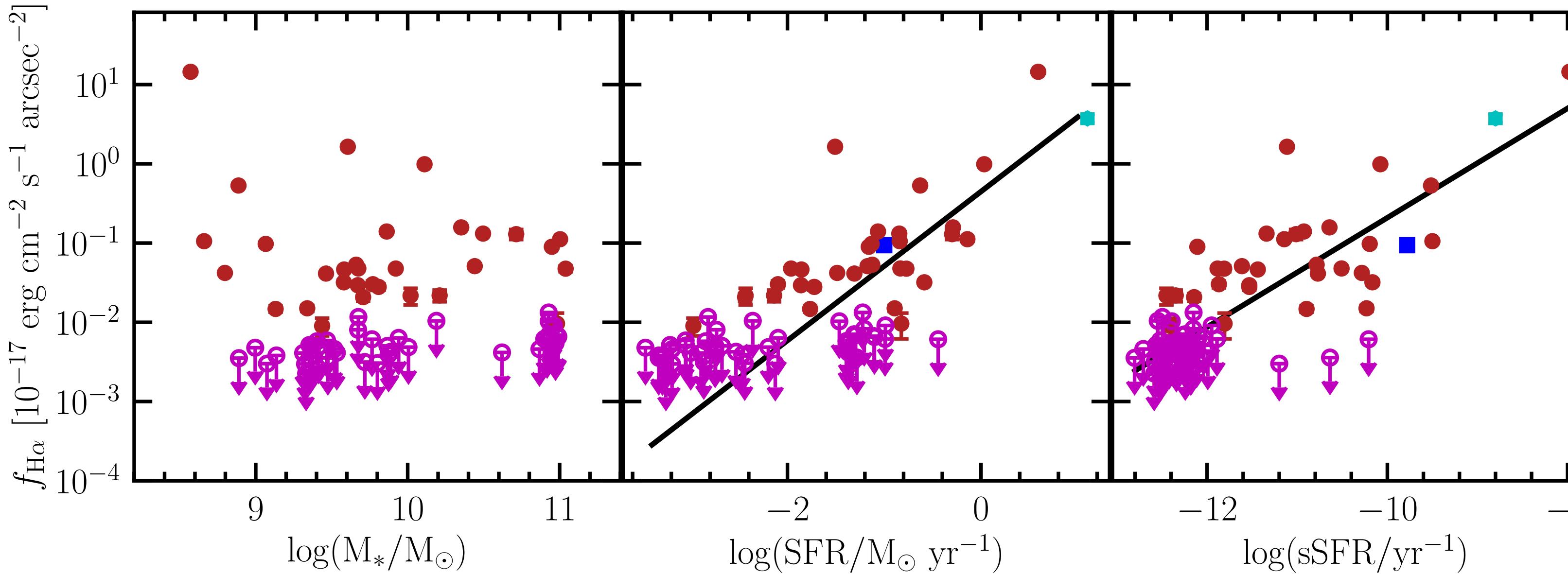
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1. Nearby star-burst galaxy $M_* \sim 10^{8.6} M_\odot$, SFR $\sim 3.9 M_\odot/\text{yr}$, $z = 0.04723$.
2. 8Å H α (left) and H β (right) narrow-band image, extends to ~ 17 kpc, $\sim 0.25 r_{\text{vir}}$.

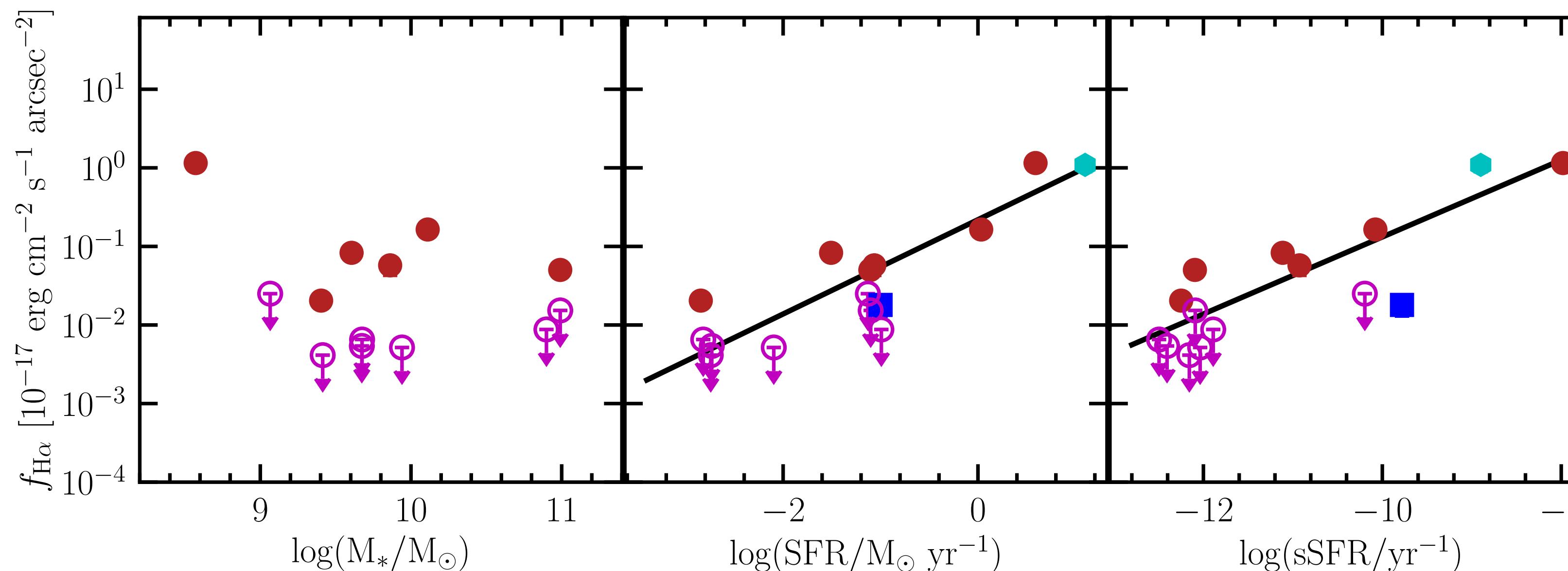


1. 72 galaxies with $\text{FOV} > 5 R_e$ of the galaxy, R_e is the half light radius of the galaxy.
2. O32 could be used to estimate the ionizing photon escape fraction.

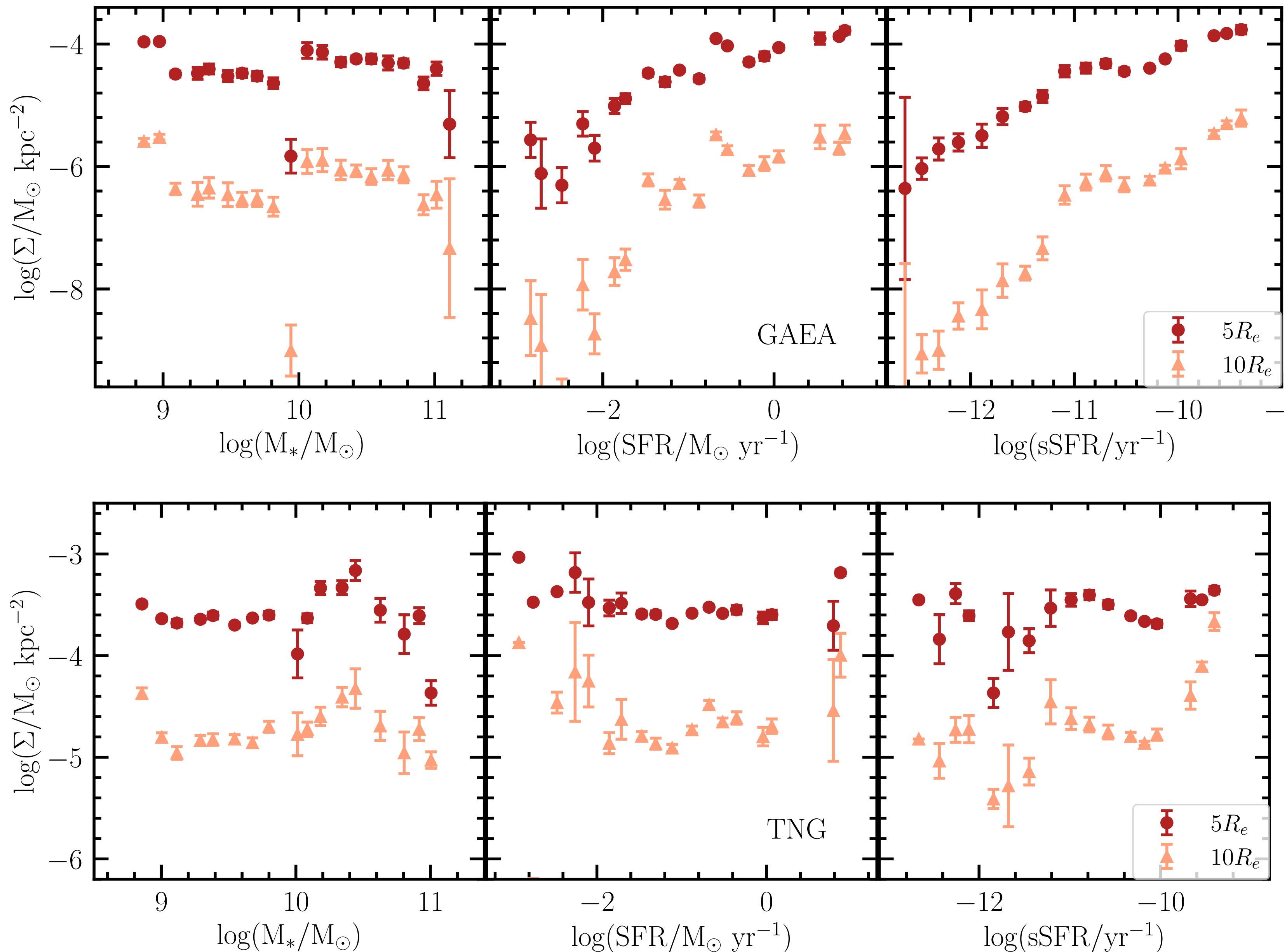
CGM Mapping using MaNGA



1. $\text{H}\alpha$ flux correlation with M_* , SFR, sSFR at $5 R_e$
(top) and $10 R_e$ (bottom)
2. Red for detections
3. Magenta for non-detection



CGM Mapping using MaNGA



1. Comparison to GAEA (SAM) and TNG (Hydro)
2. Cool gas surface density as a function of M_* , SFR, sSFR at $5 R_e$ and $10 R_e$
3. Not a direct comparison to our observations

Summary

- We are able to detection the inner cool CGM of individual galaxies.
- The radial profile has a turnover point at (1-2) R_e and the nature diverges at 3 R_e
- H α flux correlate well with galaxy's SFR, but not with its M_* .
- Comparison to GAEA and TNG, indicating the different sub-grid physics.