THE Ly-α HALO AROUND QUASARS AS EVIDENCE OF THE EFFECT OF AGN OUTFLOWS ON THE CGM?

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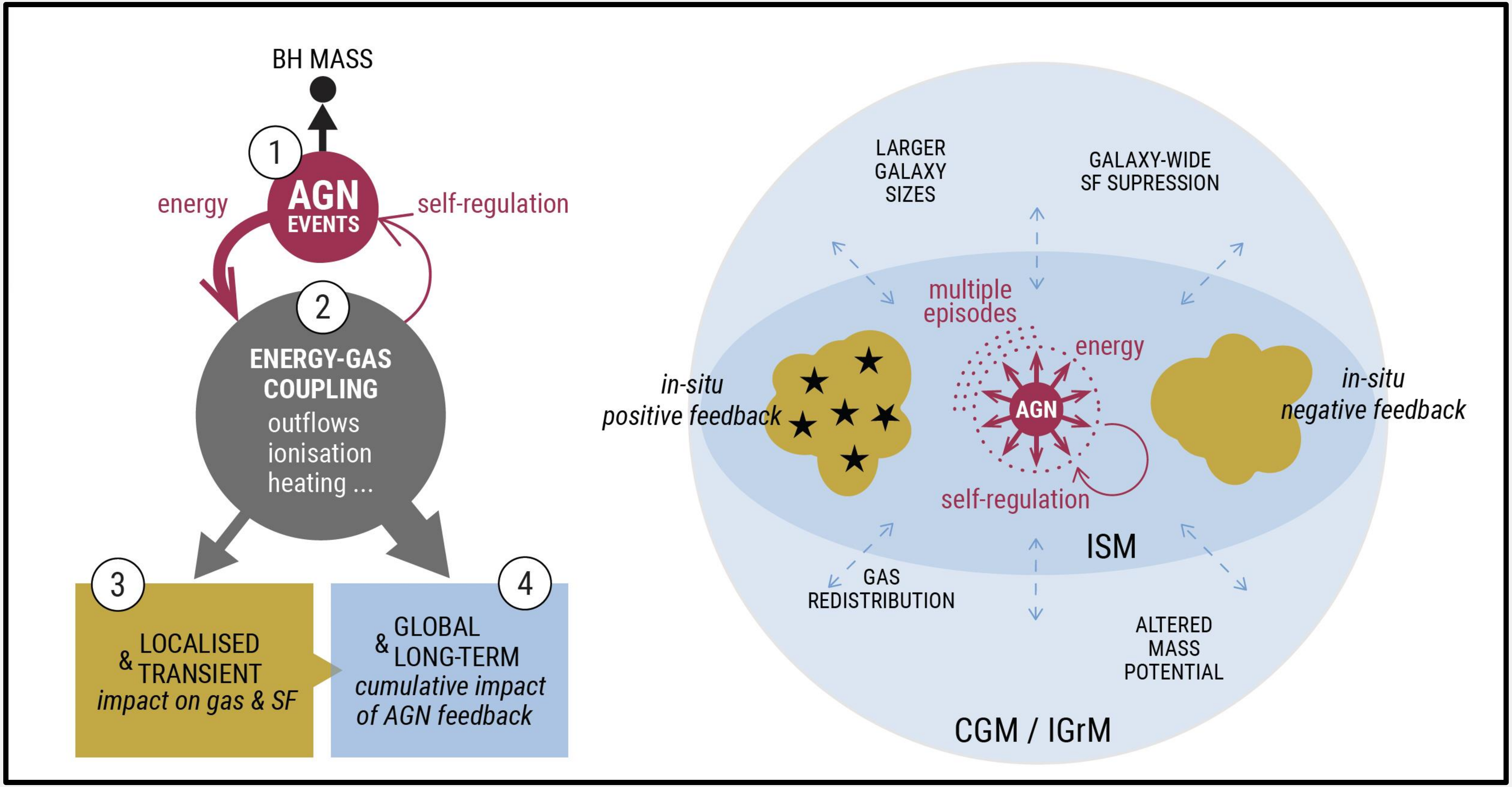
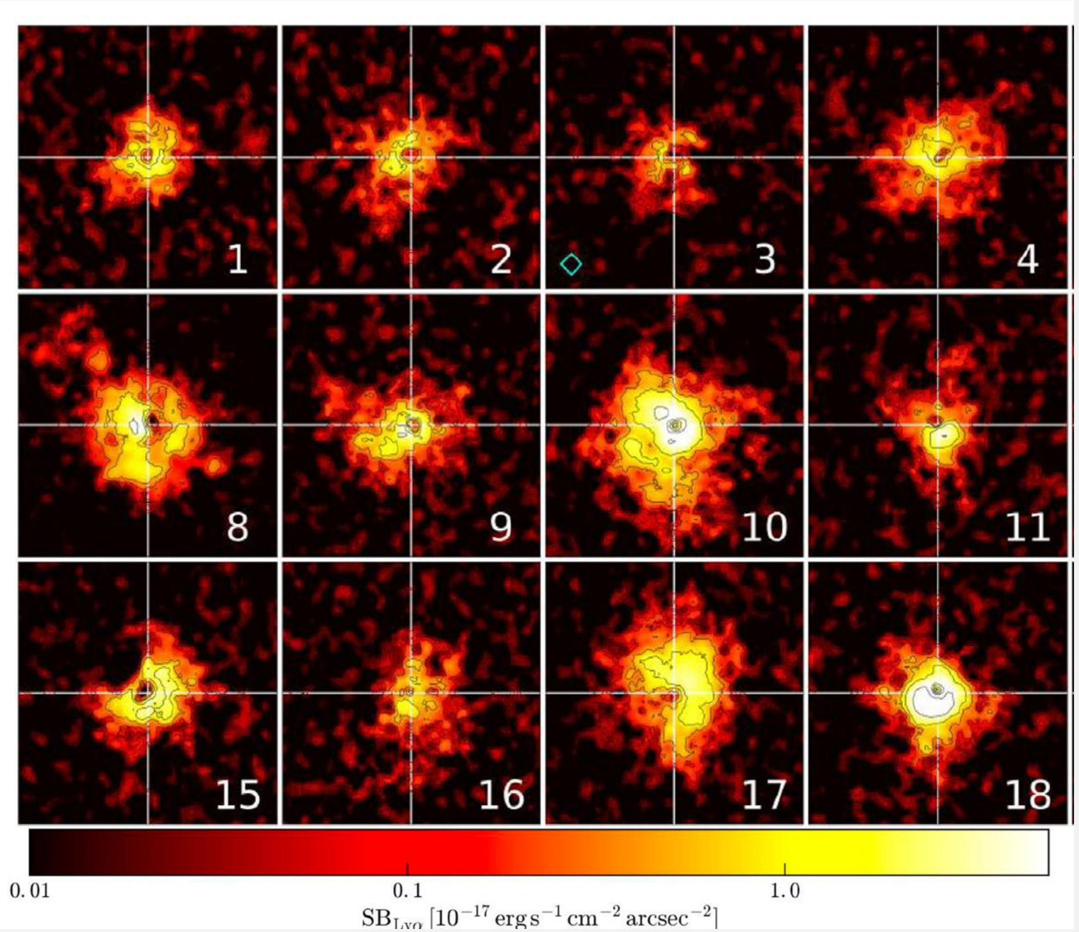
Escape of Lyman radiation from galactic labyrinths, Crete, 2025



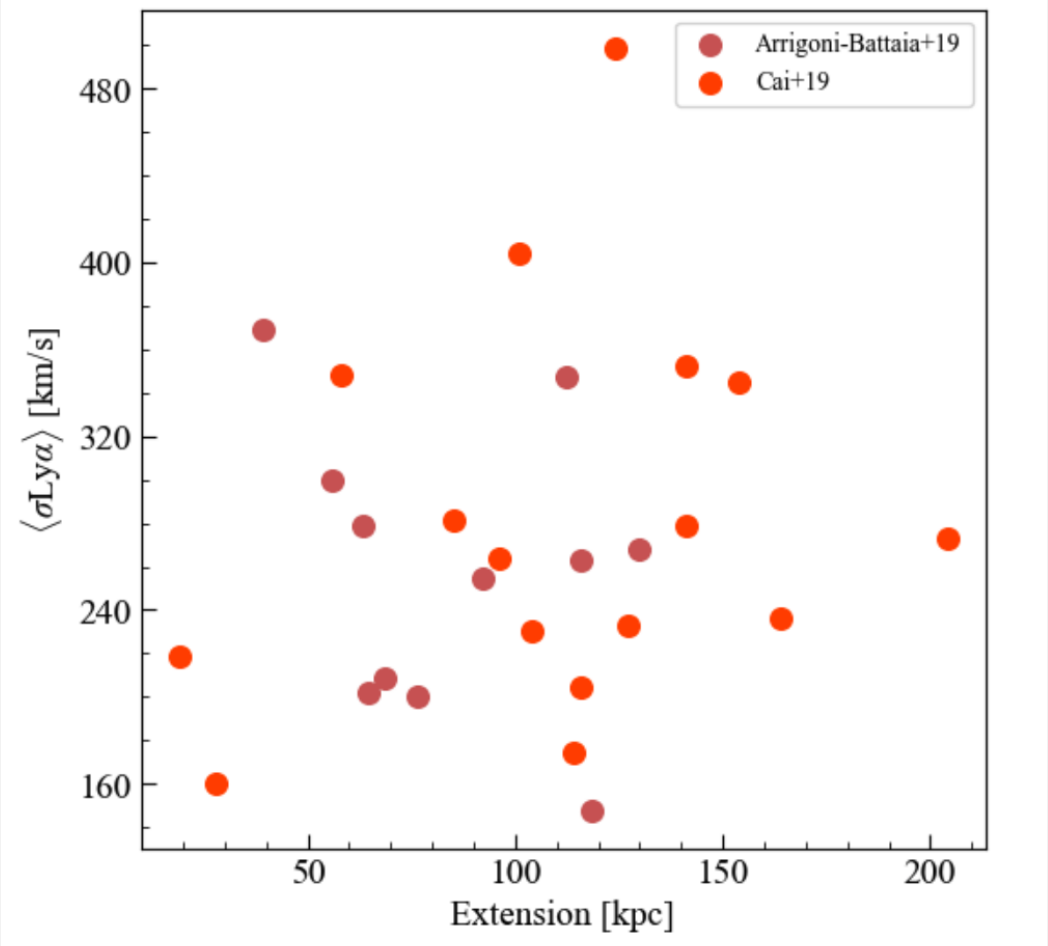
Harrison & Ramos Almeida 2024

Ly-α nebulae around high z quasars

observational evidence

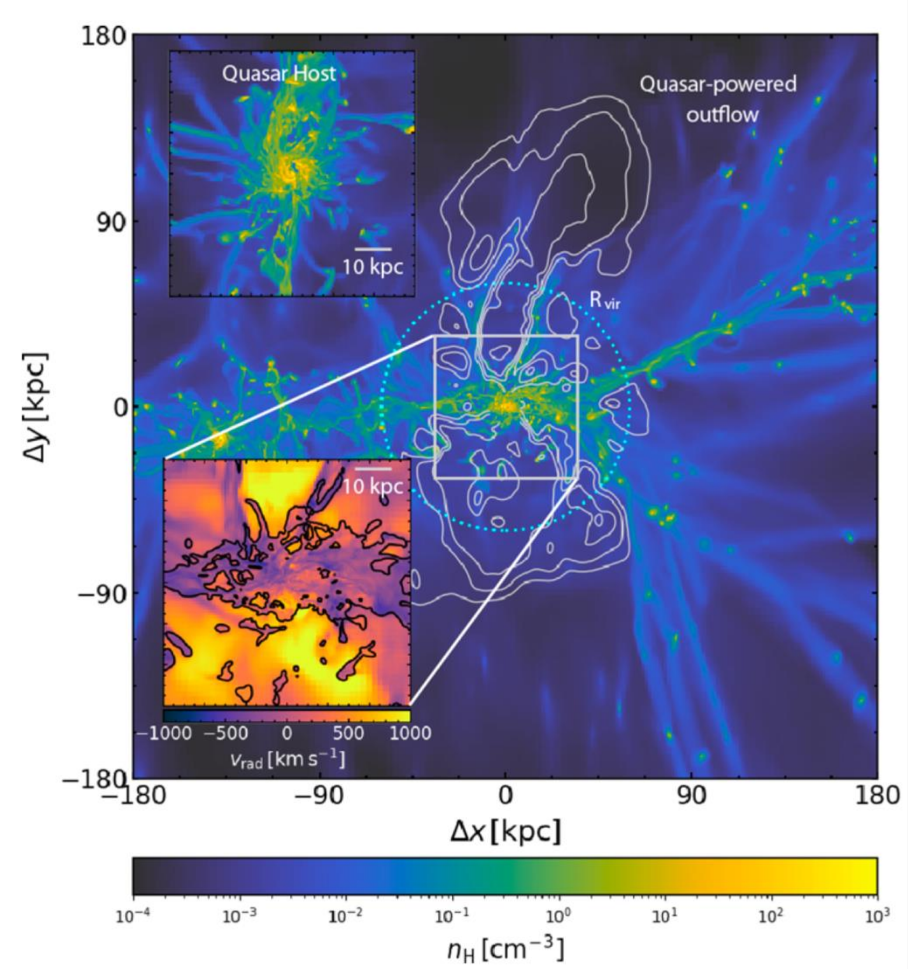


Arrigoni-Battaia+19



Ly-α nebulae around high z quasars

theoretical perspective



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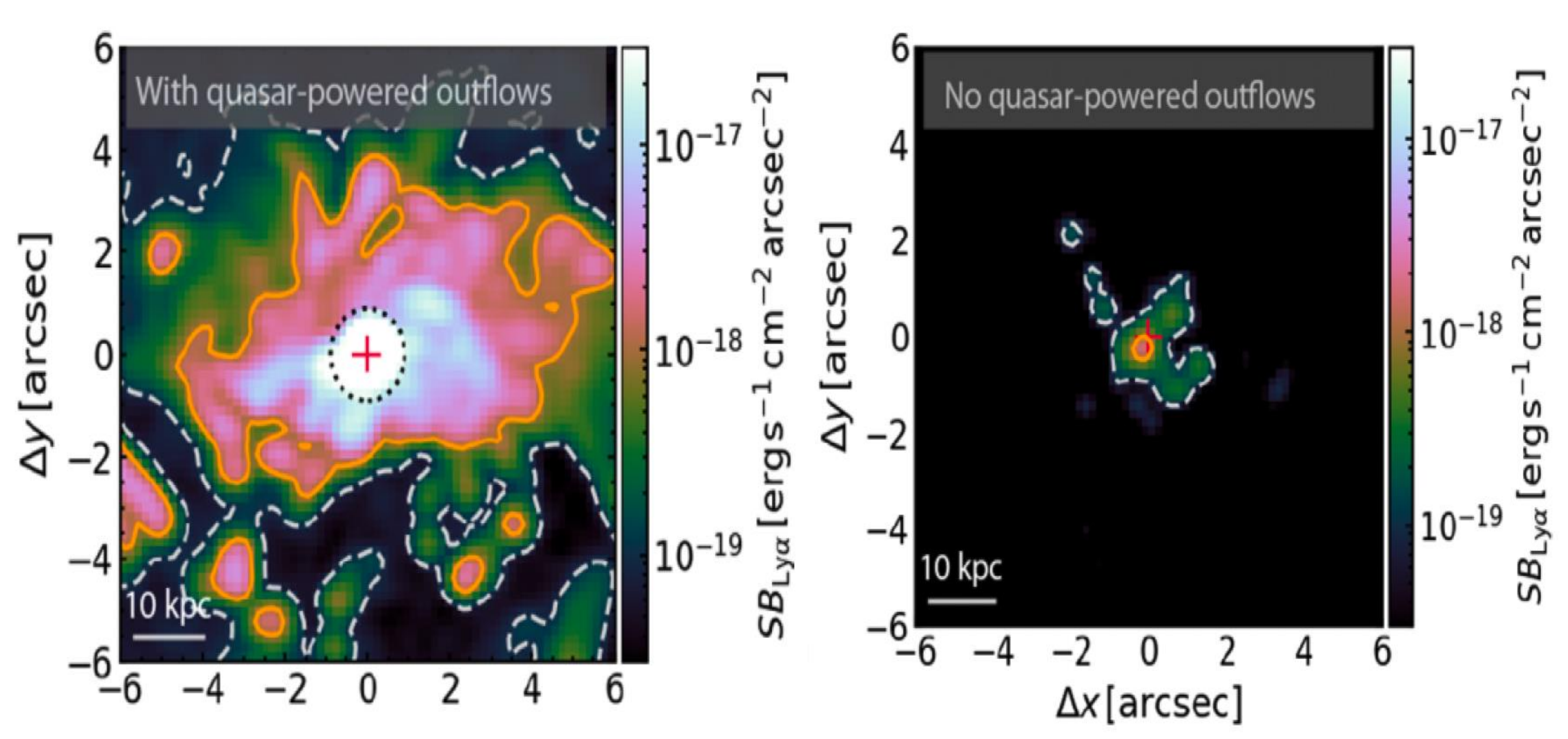
- Cosmological RHD simulation + RASCAS radiative transfer code
- z ~ 6
- Spherical volume R ~ 300 kpc
- Ly-α γ transfer: scattering process

Ly-α nebulae around high z quasars

theoretical perspective



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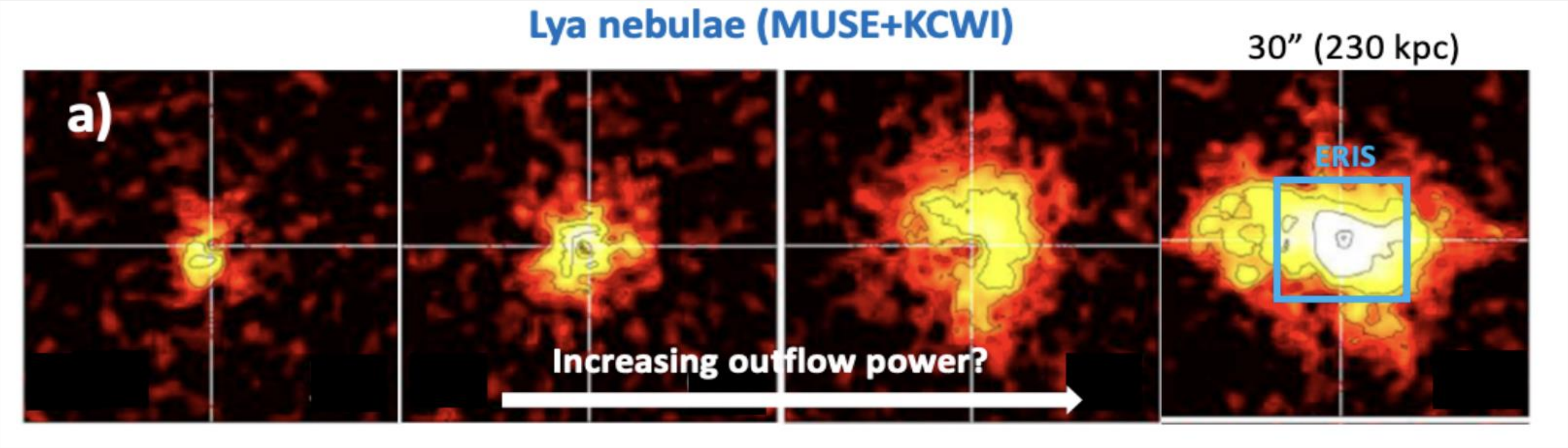
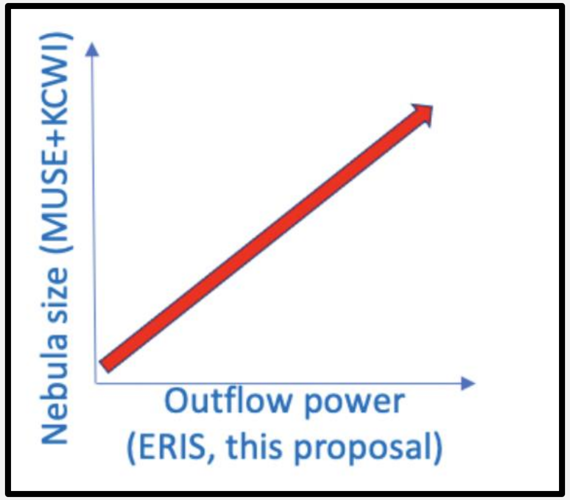
- d = 70 kpc
- L_{bol} = 3 x 10^{47} erg s^{-1}
- z = 6.2
- Feedback on at z = 6.5

OBSERVATIONAL TEST



Arrigoni Battaia+19



SAMPLE

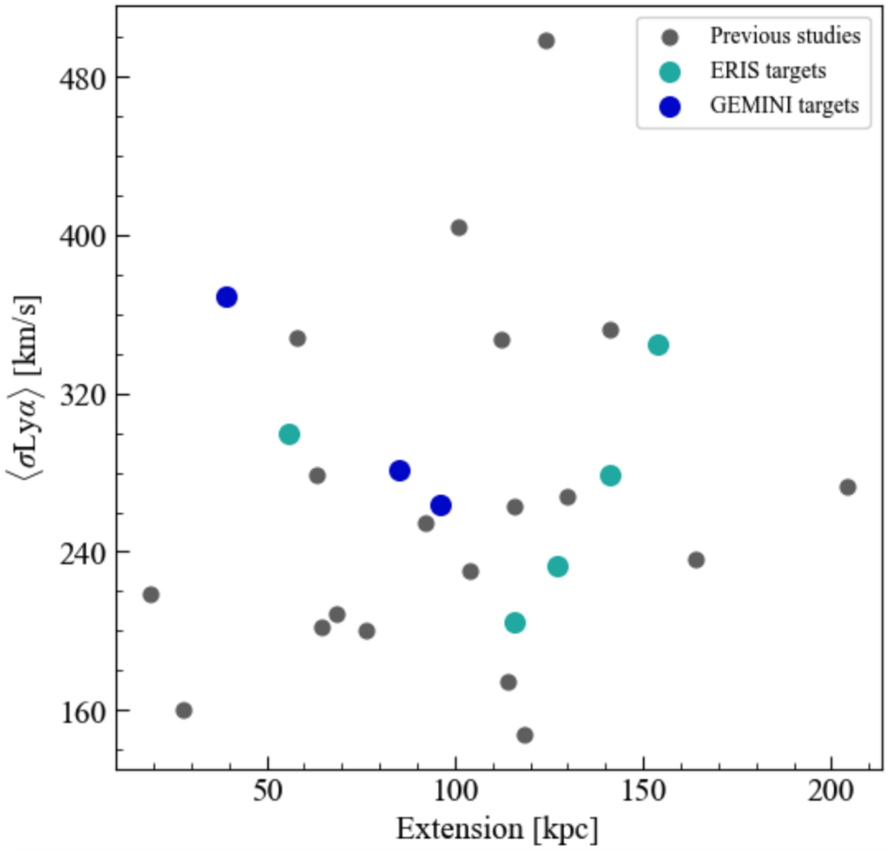
1 **Lyα nebulae** from **MUSE** (Arrigoni Battaia et al. 2019) / **KCWI** (Cai et al. 2019)

2 **NIR spectra** from **VLT/ERIS** and **GEMINI/GNIRS LR-IFU**

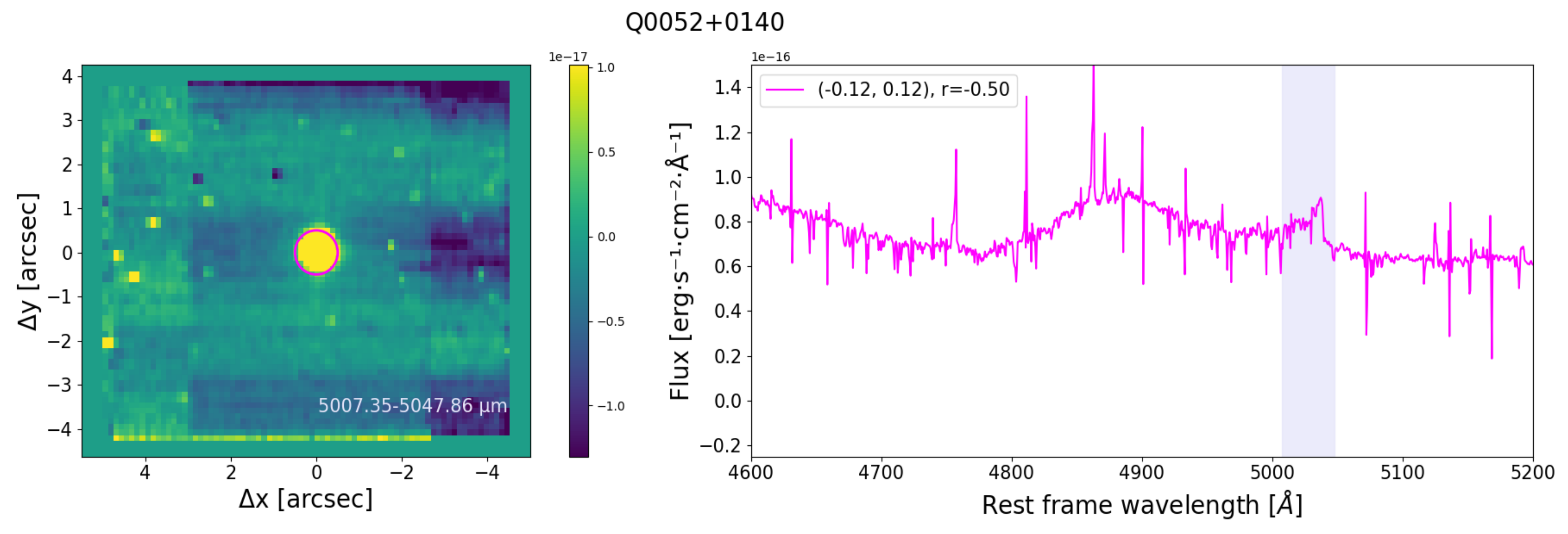
20 < size < 180 kpc
150 < σ < 400 km/s

Target	z
Q0052+0140	2.291
Q2121+0052	2.373
Q0050+0051	2.241
Q2123-0050	2.280
J1426+2555	2.255
J0814+3250	2.219
J2319-1040	3.160
J1427-0029	3.357

ESO/VLT Program 113.26AT

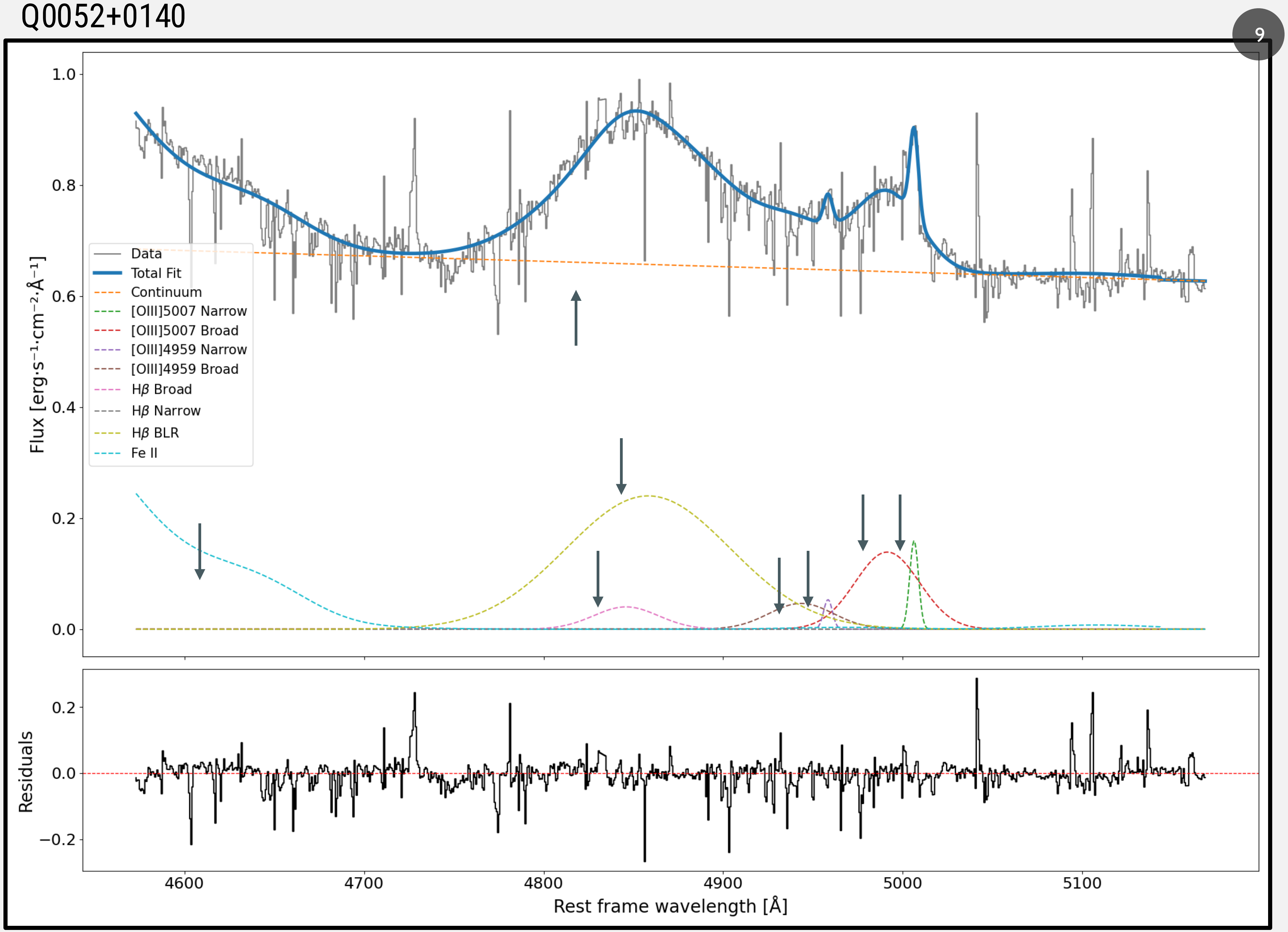


INTEGRATED SPECTRA



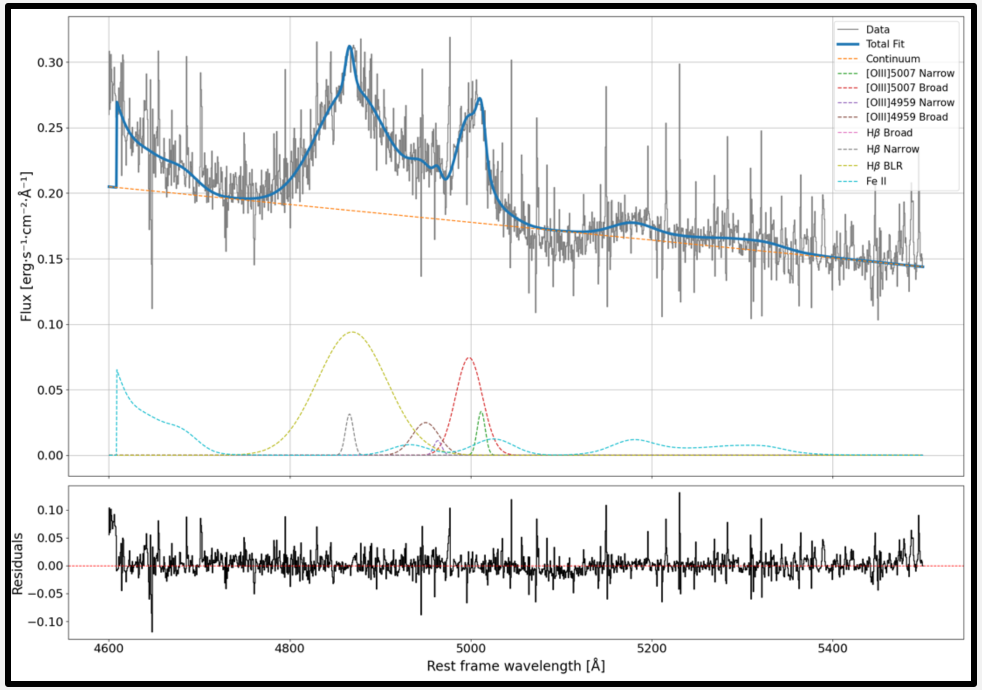
TRACING OUTFLOWS

[OIII] λ5007, 4959 Å
forbidden line

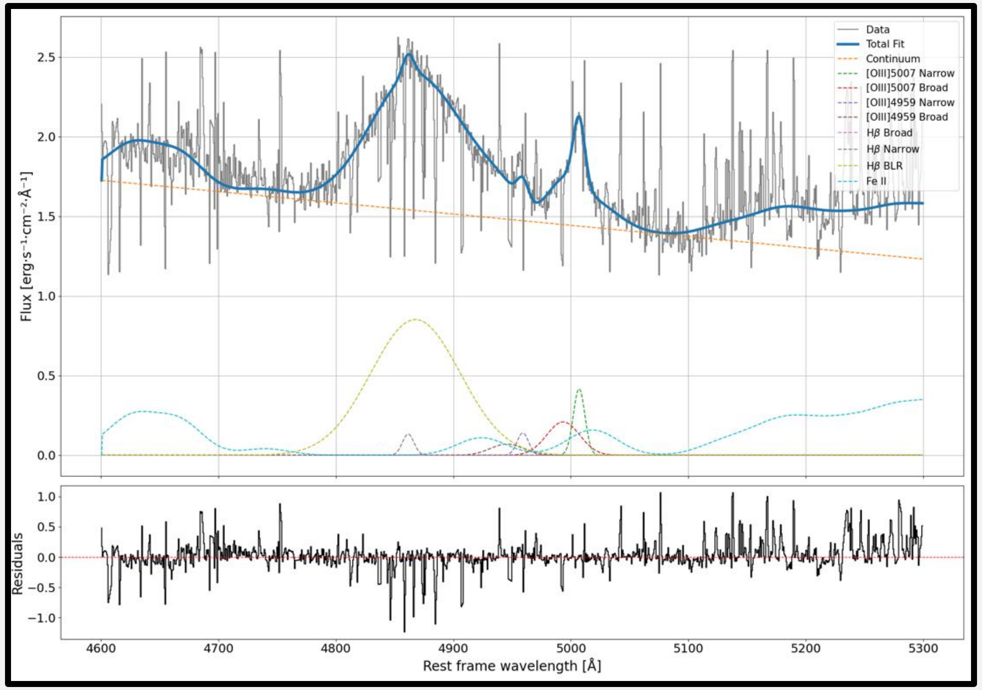


FIRST RESULTS

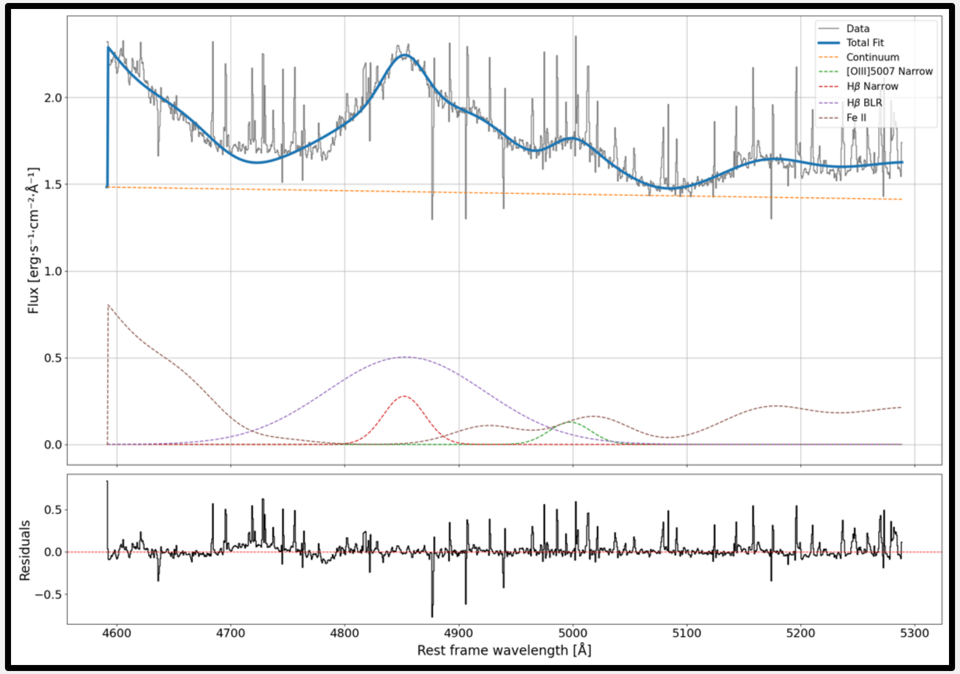
Q0050+0051



Q2121+0052



Q2123-0050



Outflow detection

OUTFLOW PROPERTIES

Uniformly filled biconical outflow

Outflow mass

$$M^{\rm out}_{\rm [O\,III]} = 0.8 \times 10^{8} M_{\odot} \left(\frac{1}{10^{\rm [O/H]-[O/H]_{\odot}}} \right) \left(\frac{L_{\rm [O\,III]}}{10^{44}\,{\rm erg\,s^{-1}}} \right) \left(\frac{< n_e >}{500\,{\rm cm^{-3}}} \right)^{-1}$$

Outflow mass rate

$$\dot{M}^{\rm out}_{\rm [O\,III]\,,cone} = 3 \cdot v_{\rm out} \frac{M_{\rm out}}{R_{\rm out}}$$

Outflow power

$$\dot{E}^{\rm out}_{\rm kin\ ,[O\,III]} = \frac{3}{2} \frac{M^{\rm out}_{\rm [O\,III]} v^{3}_{\rm out}}{R_{\rm out}}$$

(e.g. Kakkad+20, Tozzi+24, Husemann+16, Harrison+14)

FIRST RESULTS

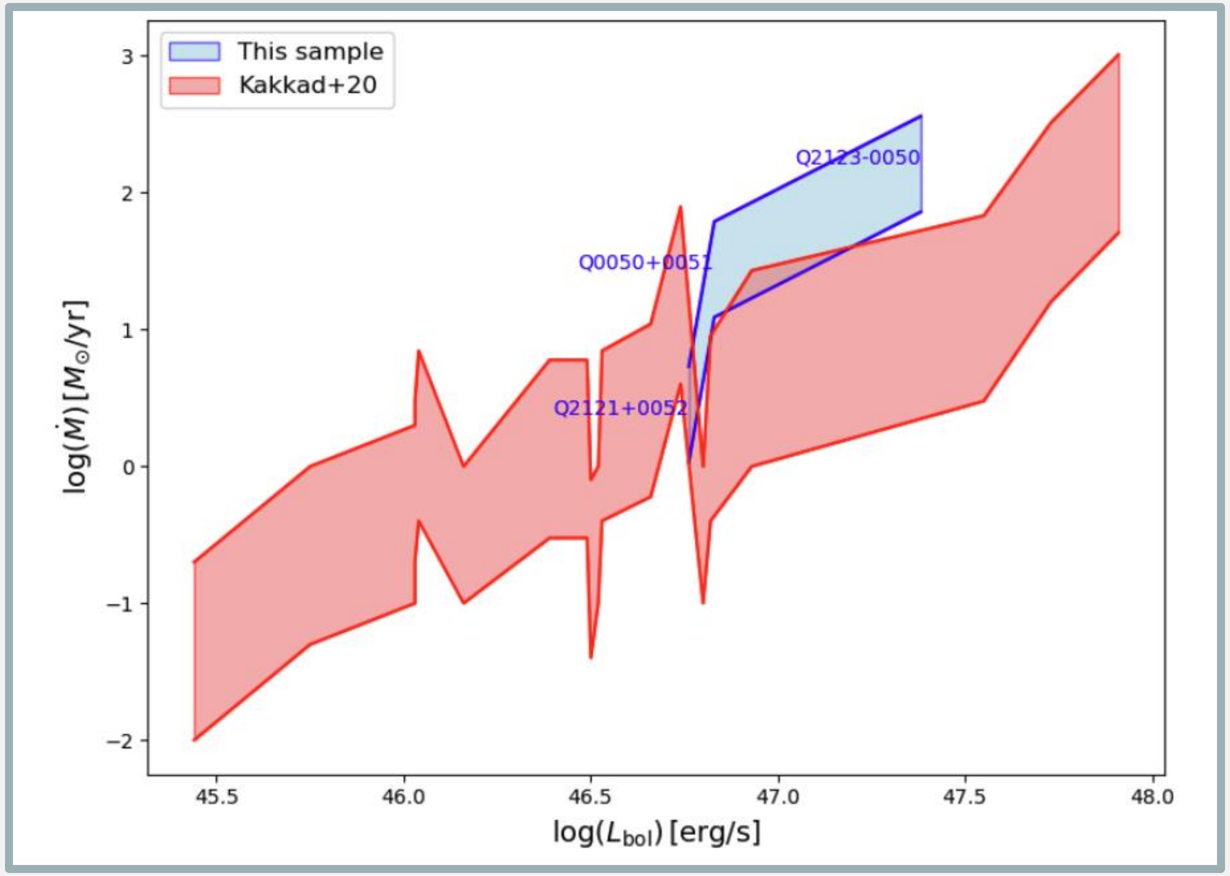
!

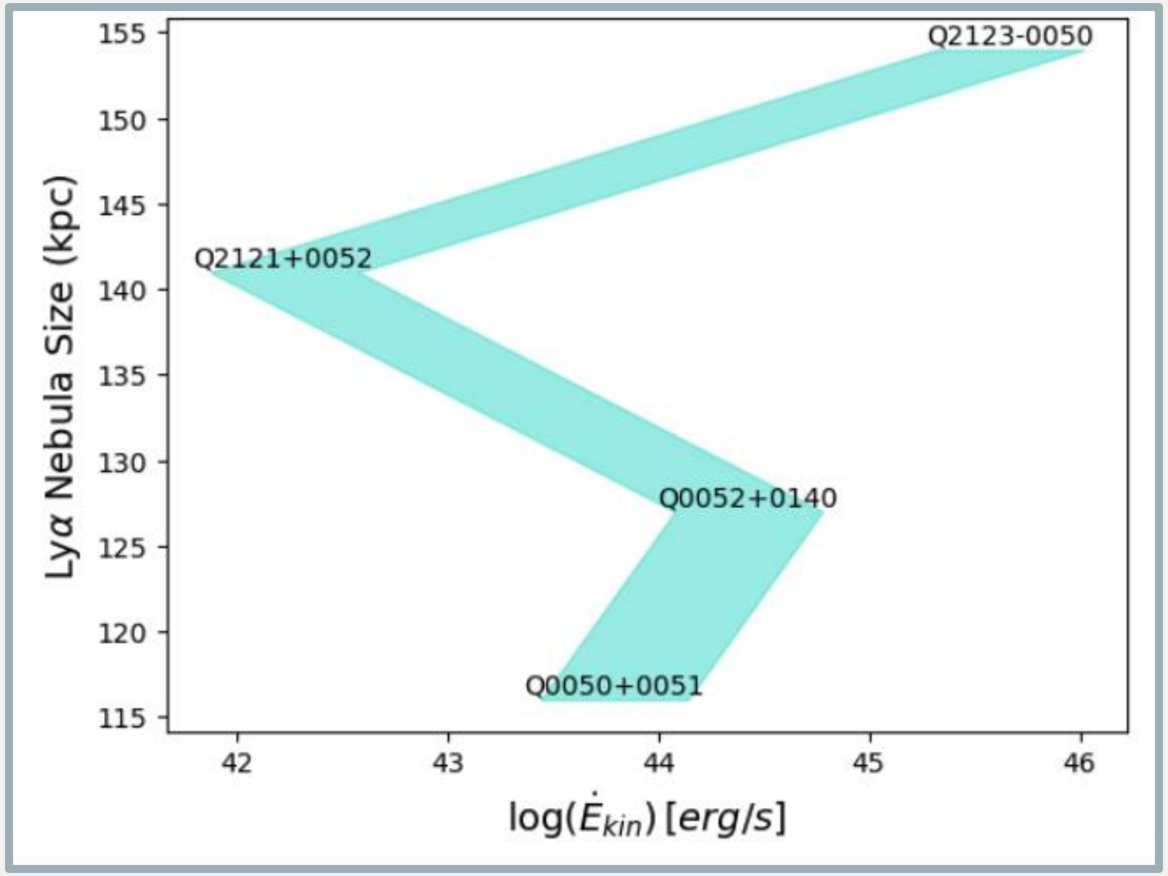
Assumptions (Kakkad+20,Tozzi+24):

- All oxygen is ionized to O^{2+}
- Electron temperature ~10^4 K
- Metallicity [O/H] of outflow is solar
- Electron density n_e = 500-10^4 cm^{-3}

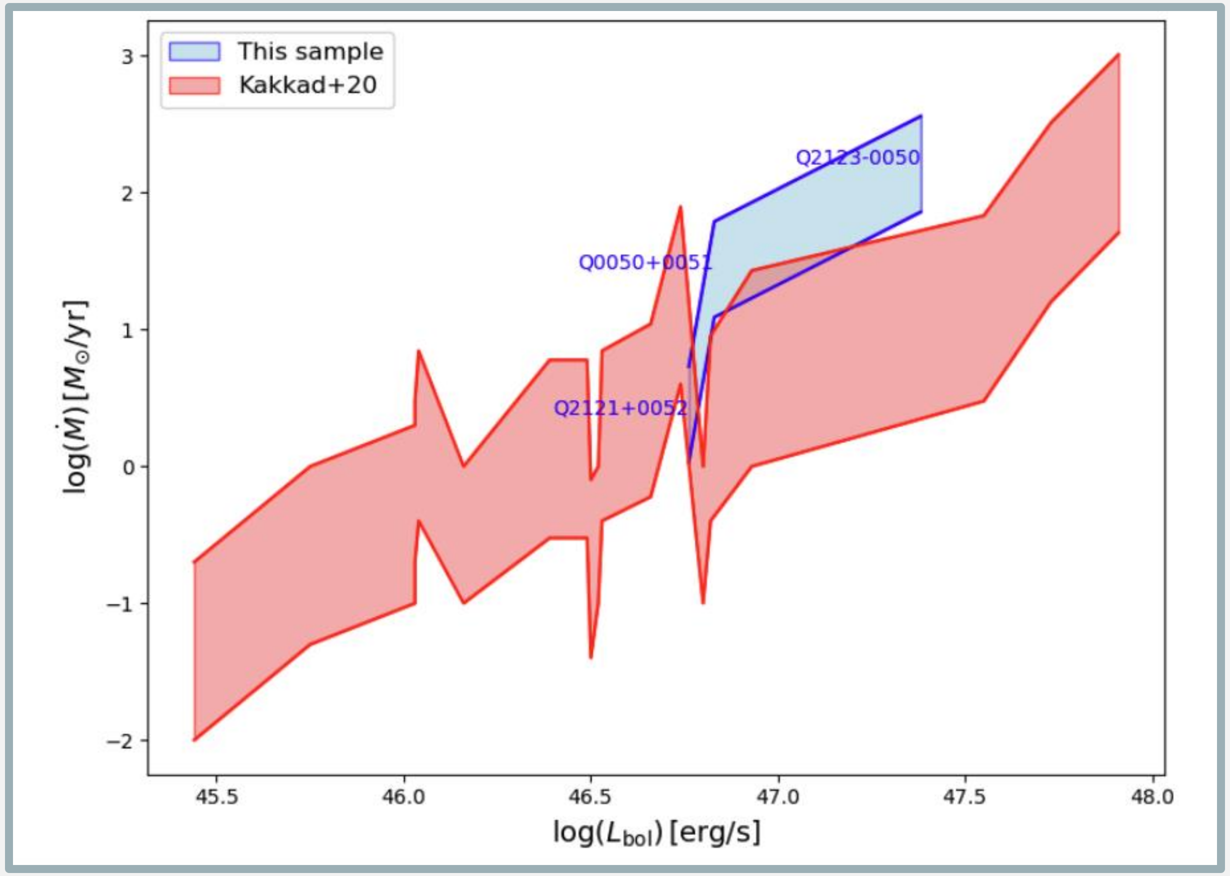
Target	$L_{[OIII]}$ (erg/s)	R_{out} (kpc)	M_{out}^{ion} ($M_\odot$)	$\log(\dot{M}_{out}^{ion})$ ($M_\odot$/yr)	$\dot{E}_k^{ion}$ (erg/s)
Q0050+0051	8.07e42	4.22	6.46e6 - 3.23e7	1.09 - 1.79	2.77e43 - 1.38e44
Q0052+0140	2.72e43	4.20	2.17e7 - 1.09e8	1.66 - 2.36	1.2e44 - 6.00e44
Q2121+0052	1.55e42	5.22	1.24e6 - 6.22e6	0.03 - 0.73	7.48e41 - 3.74e42
Q2123-0050	2.66e43	8.41	2.13e7 - 1.06e8	1.86 - 2.56	2.09e45 - 1.04e46

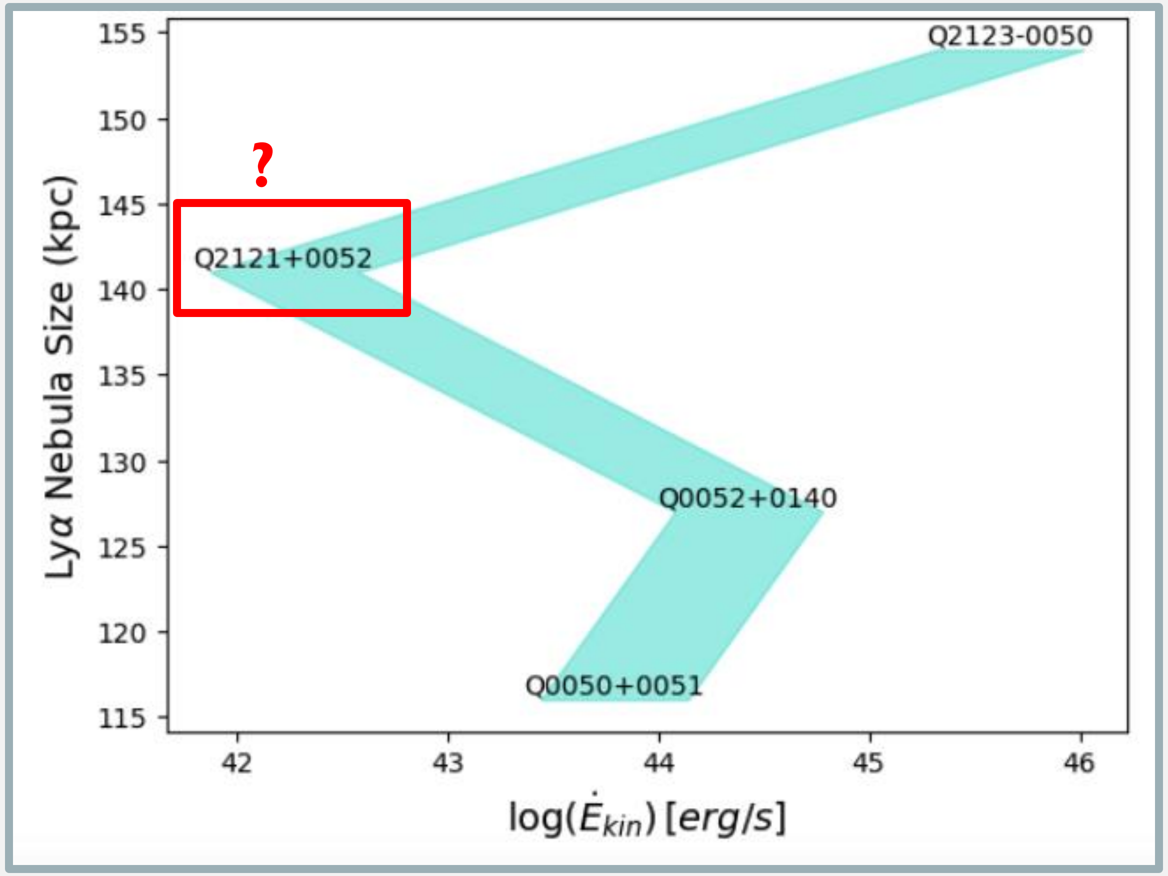
FIRST RESULTS

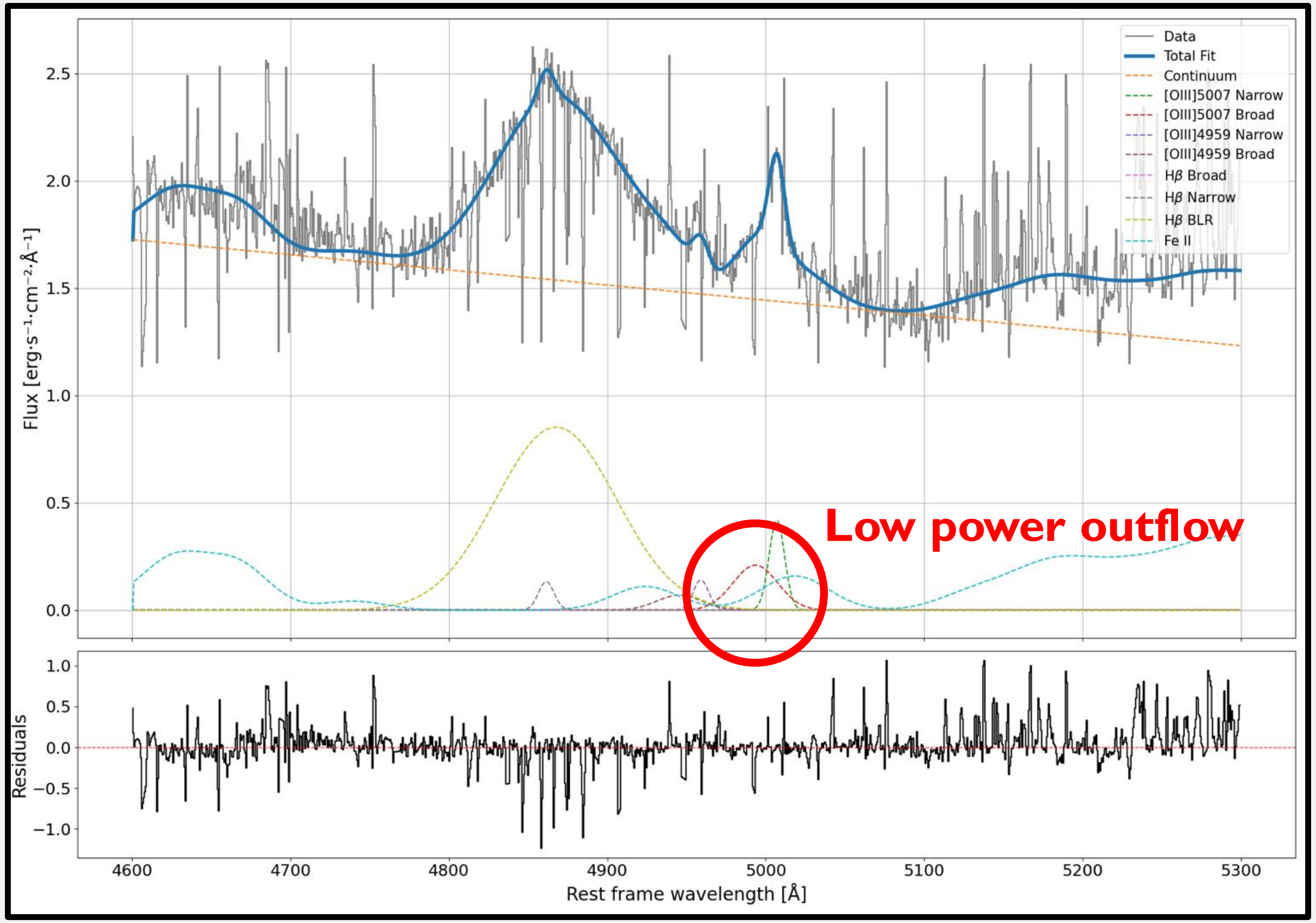




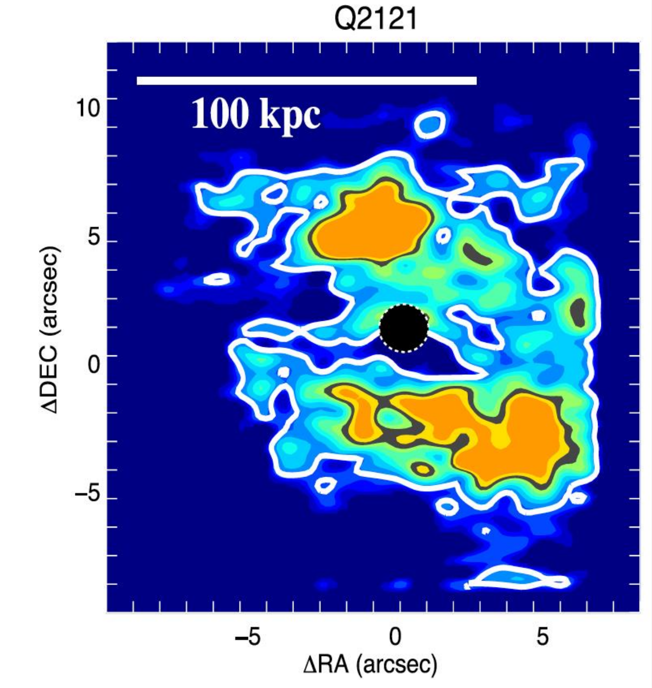
FIRST RESULTS







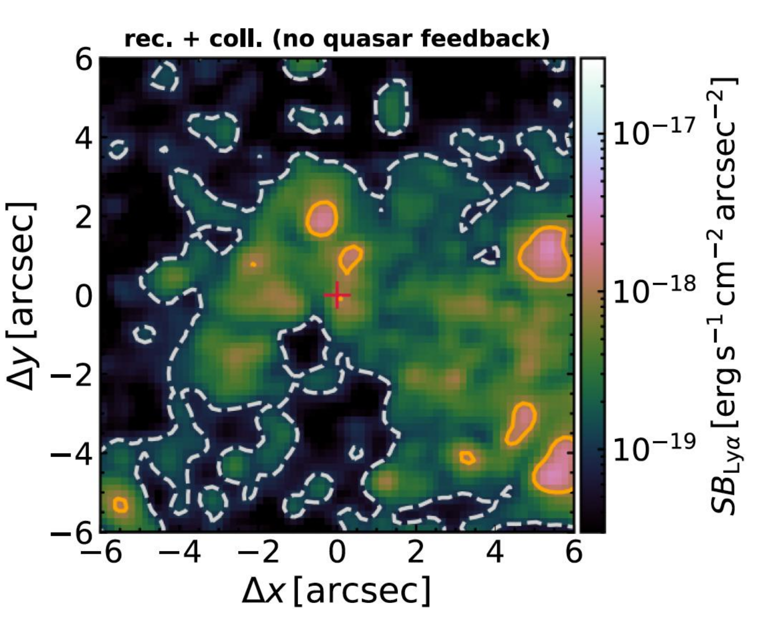
Observation



Cai+19

$\stackrel{?}{=}$

Simulation



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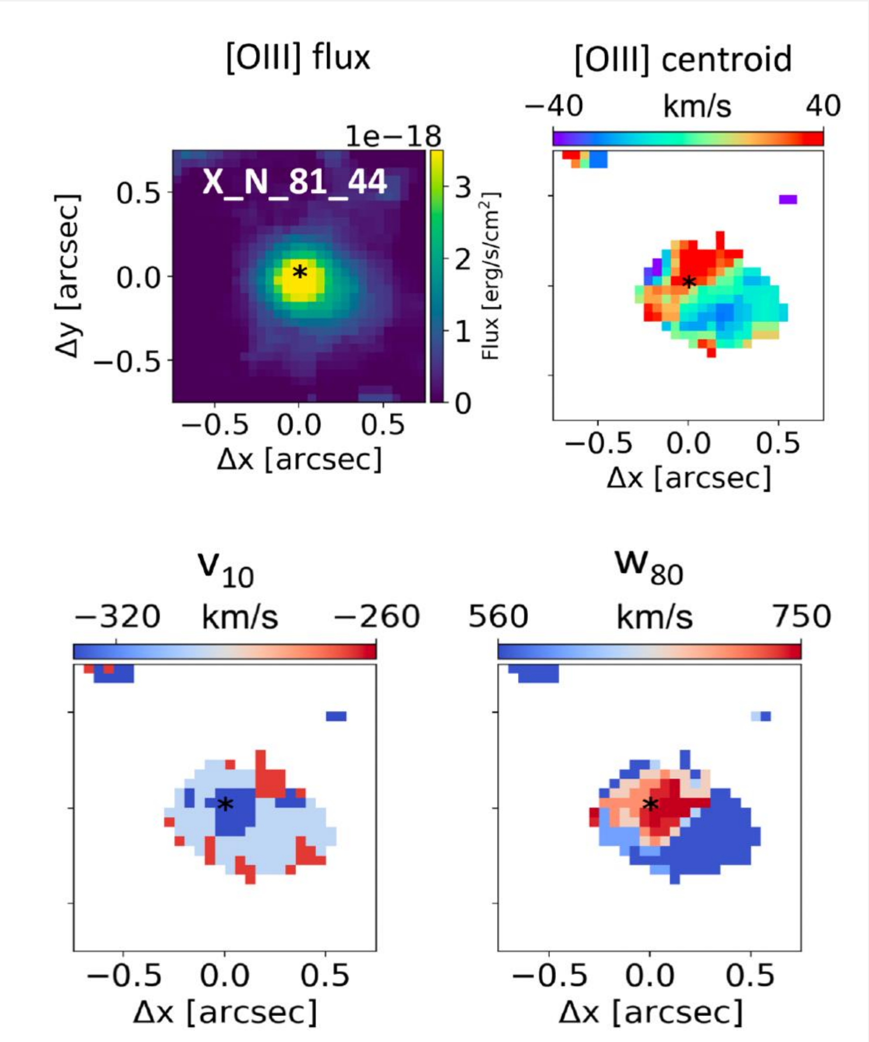
NEXT STEPS

- Spatially resolved velocity maps

Further tests:

- $L_{Ly\alpha}$ halo vs. $\dot{E}_{kin}$ outflow
- SB(Lyα) halo profile vs. $\dot{E}_{kin}$ outflow
- Lyα powering mechanism (Lyα/Hα) (e.g. Langen+23)
- Galaxy/AGN dust vs. $L_{Ly\alpha}$ halo



Kakkad+20

SUMMARY

- AGN-driven outflows might have an impact on the CGM properties of galaxies.
- Observational studies have detected the CGM in emission (e.g. Ly-α) around high redshift quasars.
- Simulations predict the need of quasar driven outflows to reproduce observed Ly-α haloes around high redshift quasars.
- We routinely detect ionized outflow (as traced by [OIII]) in the ISM of bright quasars hosting extended Ly-α haloes.
- First results show a correlation between the Outflow kinetic power and the extension of the Lya nebulae.