Spectroscopic forecast of z>7quasar population with Roman

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with

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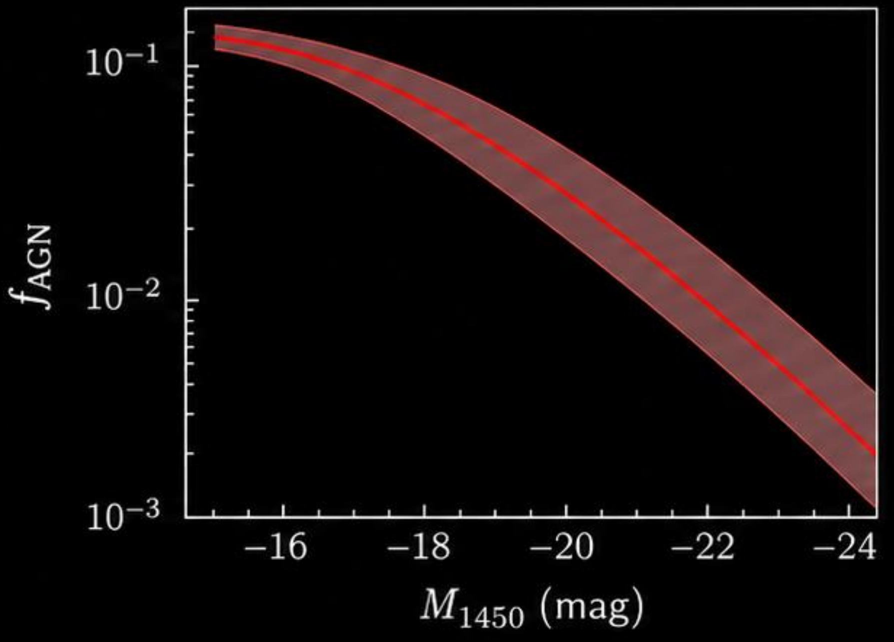
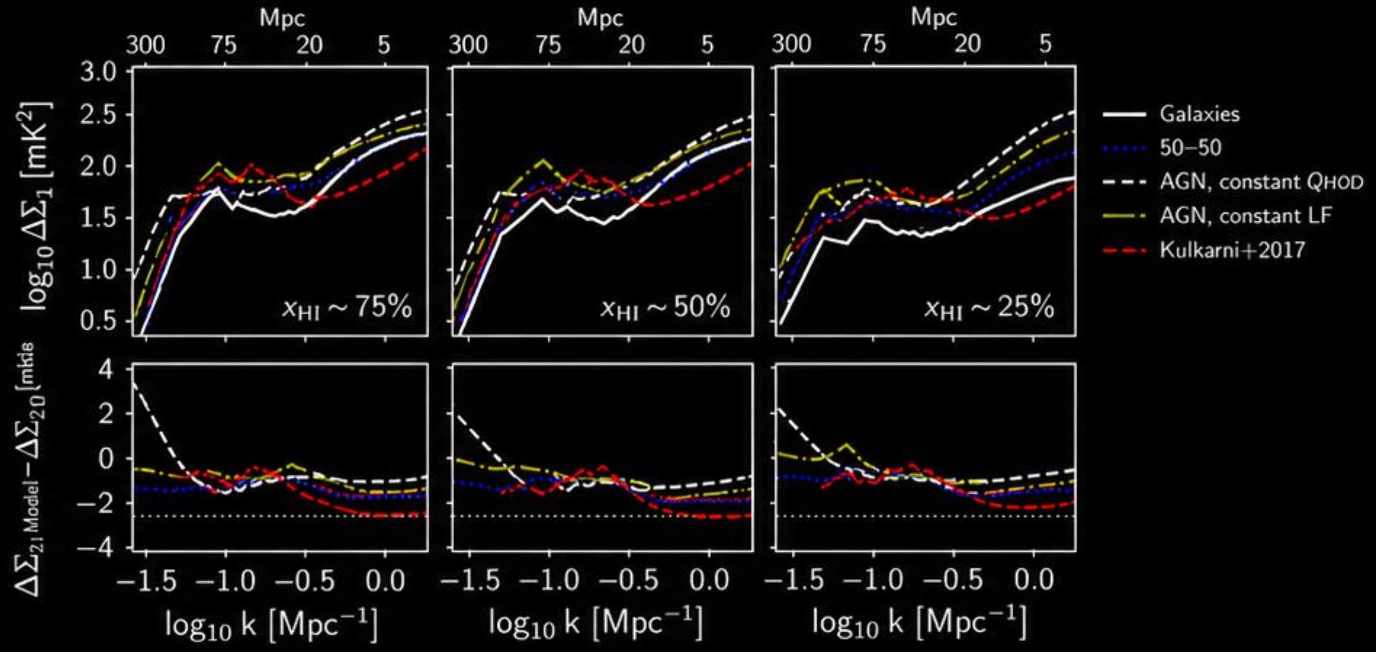
①

Canonical view: AGN contributed negligibly. Is it correct?

Jiang+25: AGN provide <33% of LyC photons at $z = 7.15$–7.75



Hassan+18: A 50–50 split between AGN & galaxy is possible in terms of LyC photons

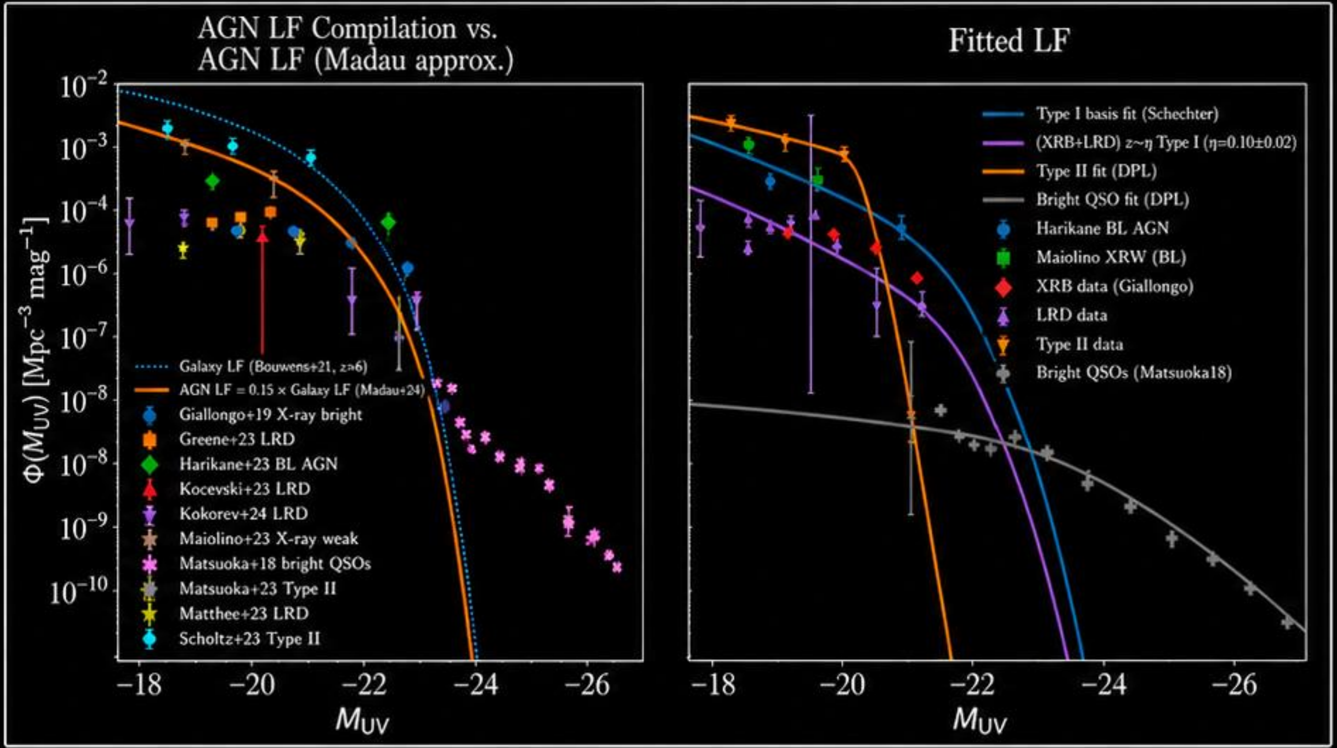


These results are not wrong. But there are limitations.

1 Bright QSO only. JWST shows an overdensity of faint AGN (Scholtz+24, Maiolino+24).	2 LyC escape fraction ~ 1 for all AGN. This could violate emissivity constraints.	3 No AGN feedback. Outflows have been seen at $z > 4$. Outflows could enhance ISM porosity.

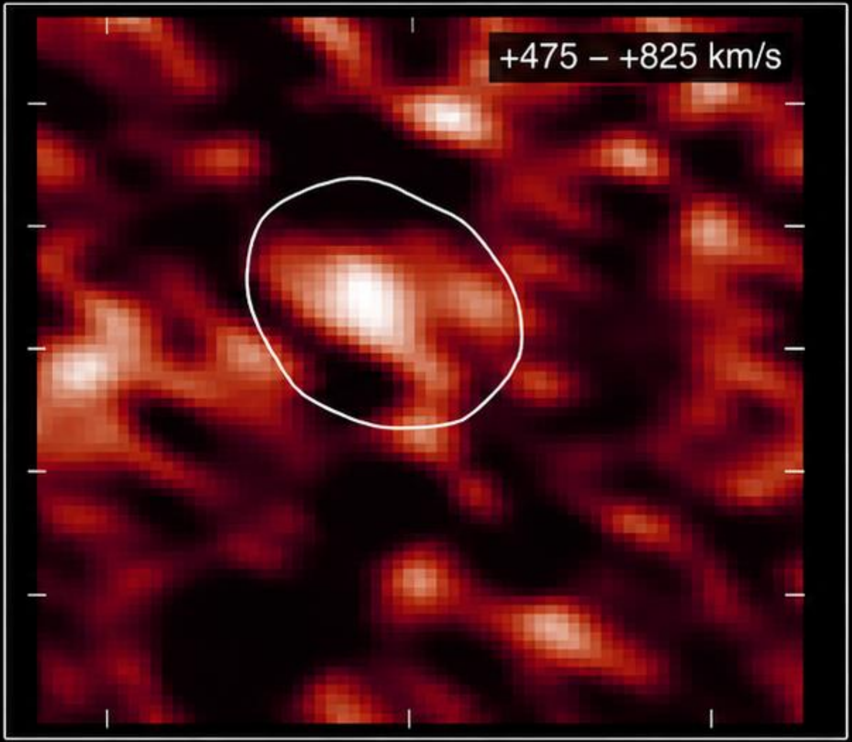
2 JWST reveals faint high-z AGN and prevalent outflows

JWST has shown the rise of
faint high-z AGN (Singha+26)



Faint AGN are ~1000× more common than bright QSOs.

In high-z QSOs we see
prevalent outflows (Spilker+25)



Outflows are observed at $z > 4$
and can increase ISM porosity.

See: Singha+26: https://arxiv.org/pdf/2510.26990

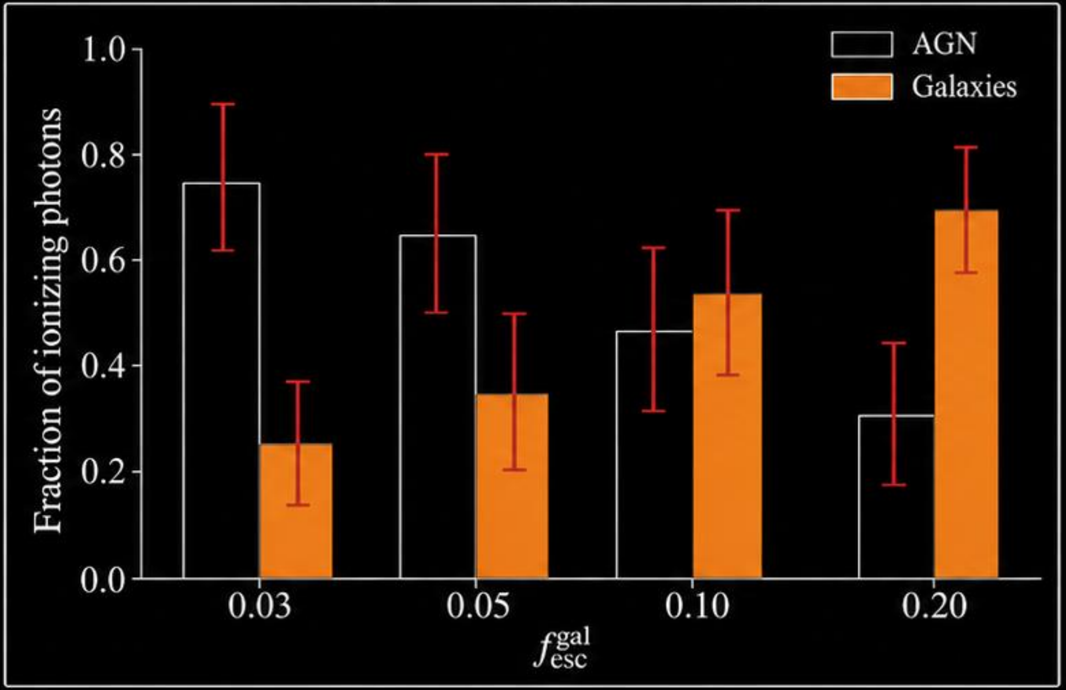
1 **Population shift:** JWST opened the faint-AGN regime beyond the classical bright-QSO picture.

2 **Physical shift:** Outflows provide a plausible pathway for enhanced LyC escape.

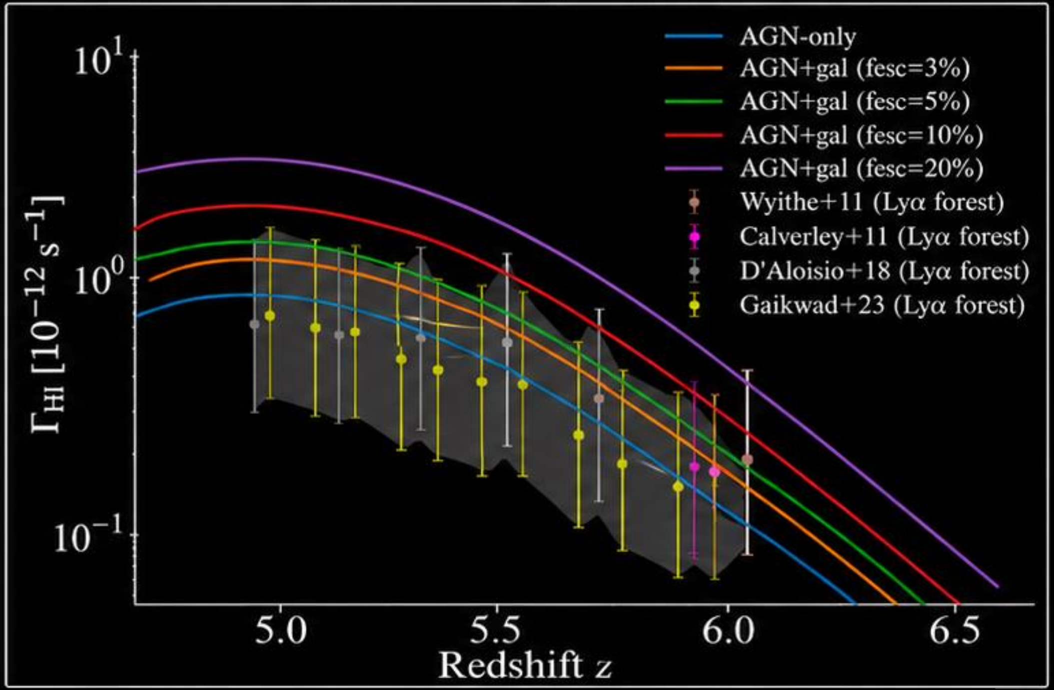
③ Faint AGN could contribute 31–75% of ionizing photons past $z > 5$ without overionizing the universe

(Singha+26)

Galaxy vs AGN photon budget



Even with AGN, the model stays within Lyα forest constraints



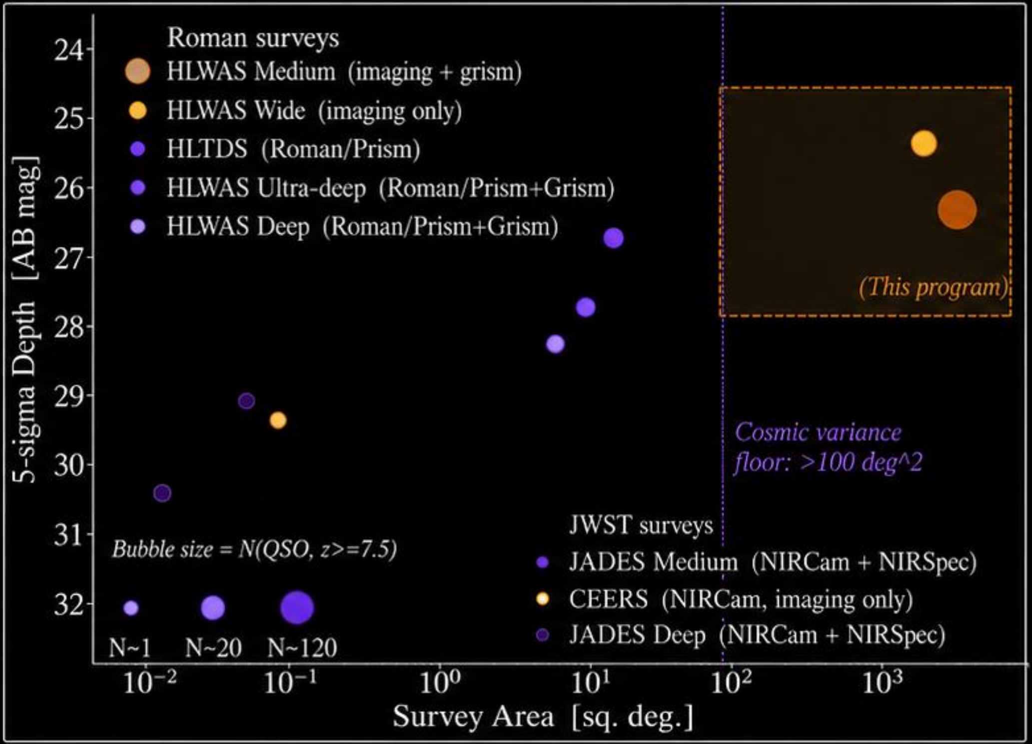
But what about the time when reionization was accelerating (z>7)?

① AGN and galaxies can have comparable contributions when galaxy escape fractions are modest.

② Very high galaxy escape fractions would overionize the universe; the photon budget acts as a guardrail.

4 JWST opened the faint-AGN regime, but the sample is small (Enter ROMAN. Larger FoV)

Survey regime: area vs. depth



JWST reaches the faint-AGN regime, but over small areas and with limited sample sizes.

Science traceability matrix

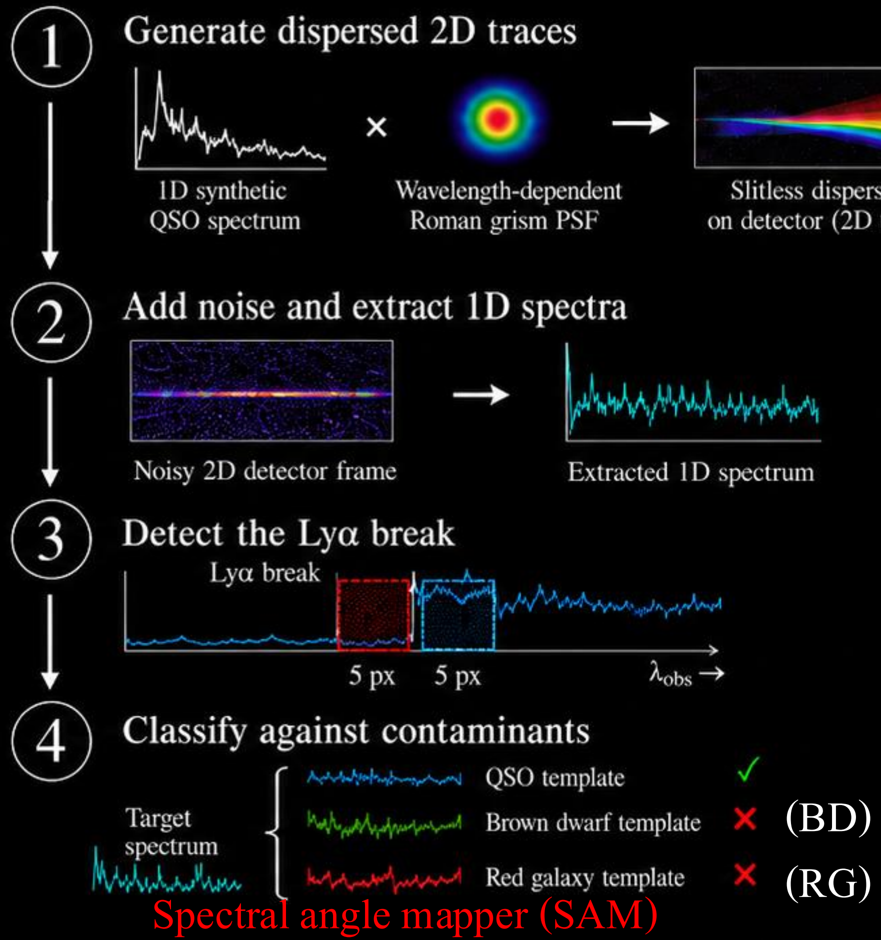
Science Goal	Observable	Requirement	HLWAS Medium
Faint-end QSO LF normalization (z >= 7.5)	Surface density Phi(M,z)	Wide area + spectrosc. selection	2415 sq.deg. + grism
Selection function C(J,z)	Completeness vs. mag & redshift	Grism + multiband imaging	F106/F129/F158 + grism
Reject low-z contamination	Spectral break confirmation	R ~ 460–890 1.0–1.93 um	Ly-alpha at z = 7.2–14.9
Cosmic variance control	N(QSO) >= N(min) [stat. floor]	Area > 100 deg^2 dPhi/Phi < 30%	2415 deg^2 >> threshold
Faint-end slope alpha	d log Phi / dM	Depth to M1450 ~ -22	26.5 AB at z ~ 9

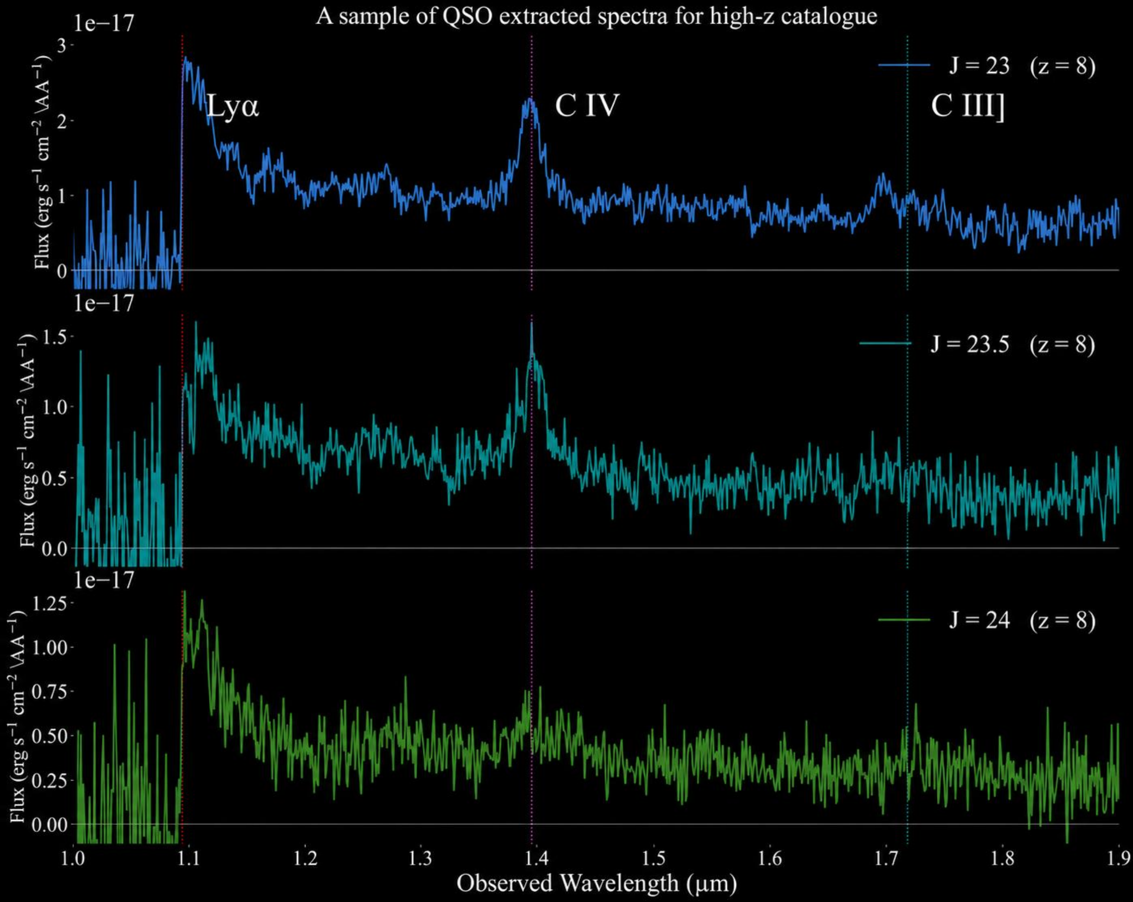
HLWAS Medium uniquely combines wide area, sufficient depth, and grism selection for faint high-z quasar abundance constraints.

1 JWST proved the population exists; Roman can measure it statistically.

2 Large FoV reduces cosmic variance and enables robust faint-QSO abundance constraints.

5 Simulate WFI grism spectra and classify high-z QSO (Singha+26)





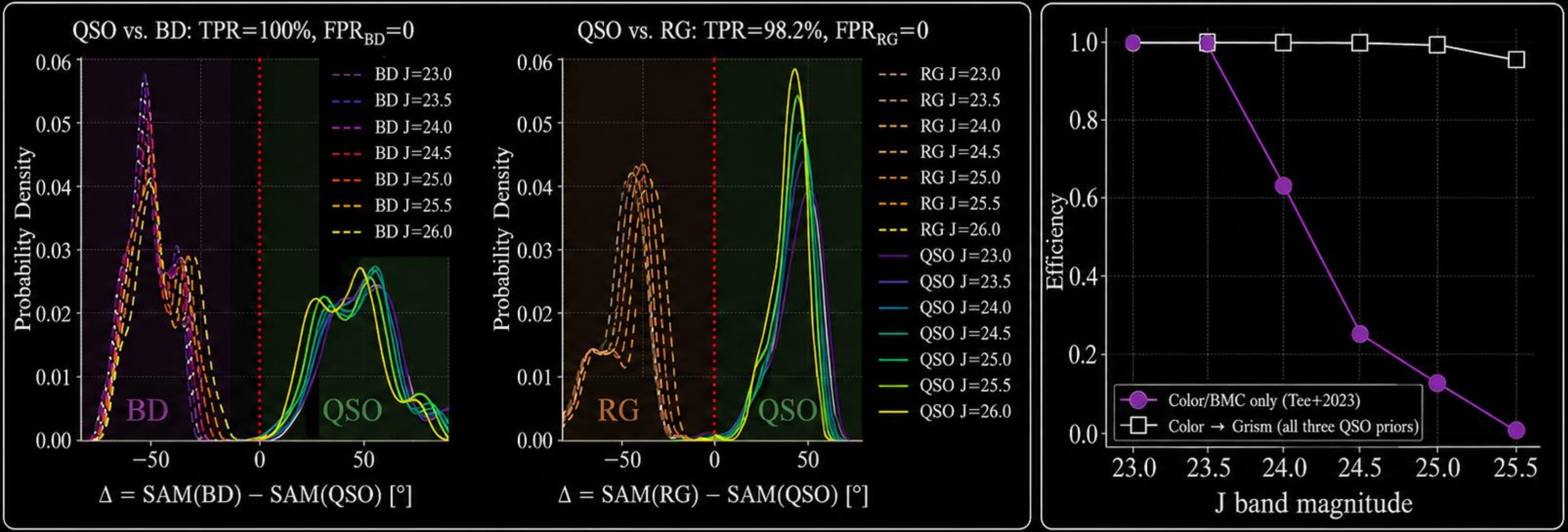
Roman grism simulations become a selection function $C(J, z)$ plus a spectroscopic confirmation step.

1 Detection yield is driven mainly by Lyα-break detectability.

2 Sample purity is driven by spectral-shape separation from contaminants.

⑥ Color + spectroscopy cleanly separates high-z QSOs from contaminants

(Singha+26)



SAM provides high-purity spectroscopic confirmation

① At Δ = 0, QSO spectra are cleanly separated from brown-dwarf and red-galaxy contaminants.

② Adding Roman grism confirmation boosts candidate efficiency from color-only selection to $\gtrsim$ 96–100%.

7

Looking Ahead

Cycle 1 archival program + denoising roadmap

Summer inter: Pei-Jun Huang

(Brown University)

1 Cycle 1 accepted archival proposal

Beyond the Bright Tail: Faint Reionization-Era Quasars with Archival Roman Grism Data

Program ID: 19108

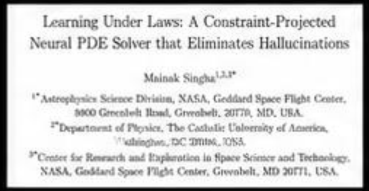
Type: Analysis (Small)

PI: Mainak Singha

Team: S. Malhotra, J. Rhoads, I. Wold, W. L. Tee

Goal: build archival Roman grism samples of faint reionization-era quasars.

Related method paper



Learning Under Laws: A Constraint-Projected Neural PDE Solver that Eliminates Hallucinations

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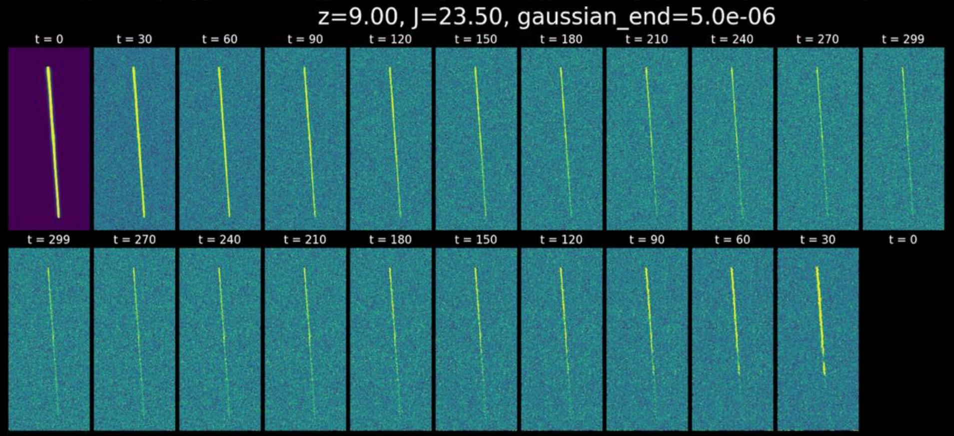
Learning Under Laws: A Constraint-Projected Neural PDE Solver that Eliminates Hallucinations

arXiv:2511.03578

Foundation for future physics-aware denoising

2 Intern work now: baseline denoising

Current work: denoising noisy Roman-like 2D traces



Next step: physics-aware denoising

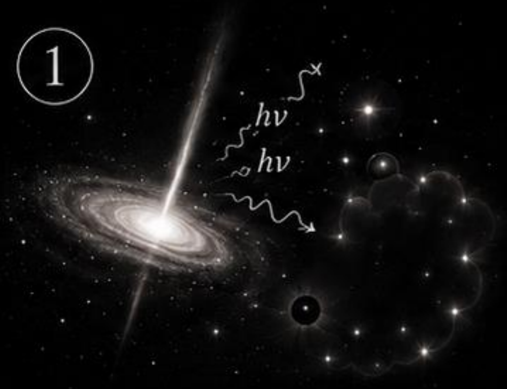
- Cleaner faint traces
- Better recovery at low S/N
- Preserve real spectral structure
- More reliable science products

From archival discovery to smarter denoising: building the path to fainter, cleaner Roman quasar science.

Summary

From faint-AGN reionization physics to Roman spectroscopic discovery

1

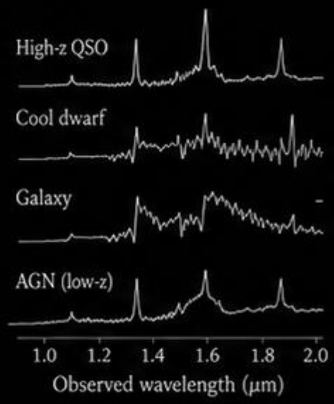


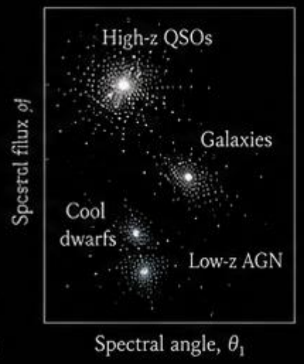
Faint AGN may provide ~31–75% of the hydrogen-ionizing photons at $z > 5$ – but current evidence is still limited by small sample sizes.

2

HLWAS Medium ($J \sim 26.5$, 2415 sq. deg.) opens the right discovery space for faint AGN.

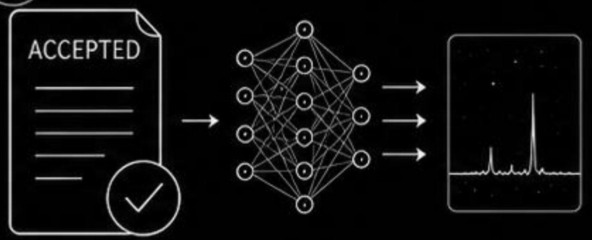
3





Spectral-angle classification can distinguish faint high-z QSOs from their main contaminants.

4



Cycle 1 archival program is accepted, and we are developing physics-aware deep-learning denoising to hunt even fainter QSOs.

Faint QSO paper: https://arxiv.org/pdf/2510.26990
Deep learning paper: https://arxiv.org/pdf/2511.03578