# JWST/NIRSpec Observation of High Redshift Type -1 AGN

**Piyali Ganguly**
**Inter-University Centre for Astronomy and Astrophysics (IUCAA)**
**piyalig@iucaa.in**

**October, 2025**

The Astrophysical Journal, 959:39 (18pp), 2023 December 10 https://doi.org/10.3847/1538-4357/ad029e


# A JWST/NIRSpec First Census of Broad-line AGNs at $z = 4$–7: Detection of 10 Faint AGNs with $M_{\rm BH} \sim 10^6$–$10^8\,M_\odot$ and Their Host Galaxy Properties

Yuichi Harikane[1], Yechi Zhang[1,2], Kimihiko Nakajima[3], Masami Ouchi[1,3,4], Yuki Isobe[1,5], Yoshiaki Ono[1], Shun Hatano[3,6], Yi Xu[1,2], and Hiroya Umeda[1,5]
[1] Institute for Cosmic Ray Research, The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8582, Japan; hari@icrr.u-tokyo.ac.jp
[2] Department of Astronomy, Graduate School of Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo 113-0033, Japan
[3] National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[4] Kavli Institute for the Physics and Mathematics of the Universe (WPI), University of Tokyo, Kashiwa, Chiba 277-8583, Japan
[5] Department of Physics, Graduate School of Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo 113-0033, Japan
[6] Department of Astronomical Science, The Graduate University for Advanced Studies, SOKENDAI, 2-21-1 Osawa, Mitaka, Tokyo, 181-8588, Japan
*Received 2023 March 21; revised 2023 October 4; accepted 2023 October 5; published 2023 December 5*

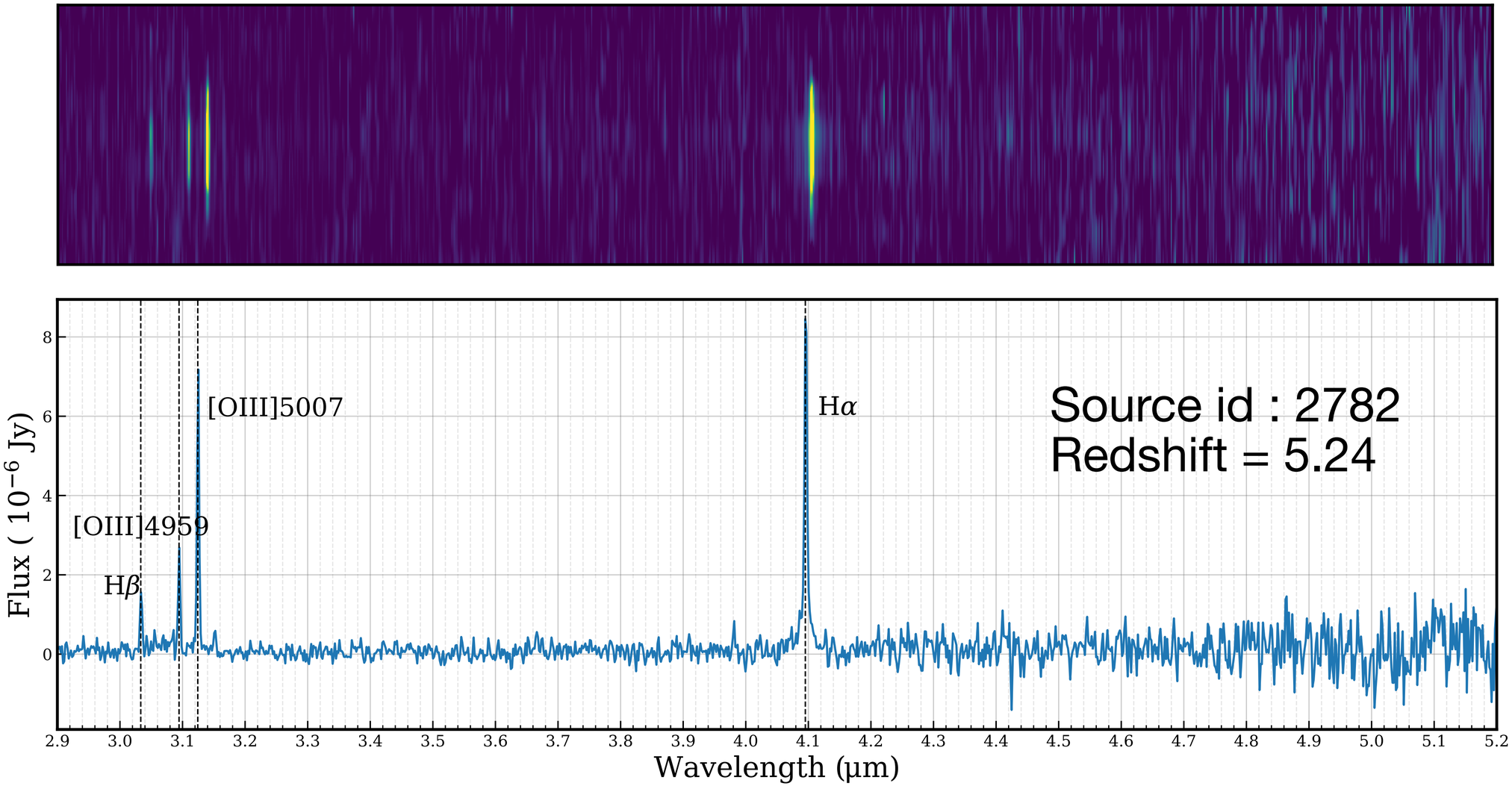
## Abstract

We present the first statistical sample of faint type 1 AGNs at $z > 4$ identified by JWST/NIRSpec deep spectroscopy. Among the 185 galaxies at $z_{\rm spec} = 3.8$–8.9 confirmed with NIRSpec, our systematic search for broad-line emission reveals 10 type 1 AGNs at $z = 4.015$–6.936 whose broad component is only seen in the permitted H$\alpha$ line and not in the forbidden [O III]$\lambda$5007 line that is detected with greater significance than H$\alpha$. The broad H$\alpha$ line widths of FWHM $\simeq 1000$–$6000\,{\rm km\,s^{-1}}$ suggest that the AGNs have low-mass black holes with $M_{\rm BH} \sim 10^6$–$10^8\,M_\odot$, remarkably lower than those of low-luminosity quasars previously identified at $z > 4$ with ground-based telescopes. JWST and Hubble Space Telescope high-resolution images reveal that the majority of them show extended morphologies indicating significant contribution to the total lights from their host galaxies

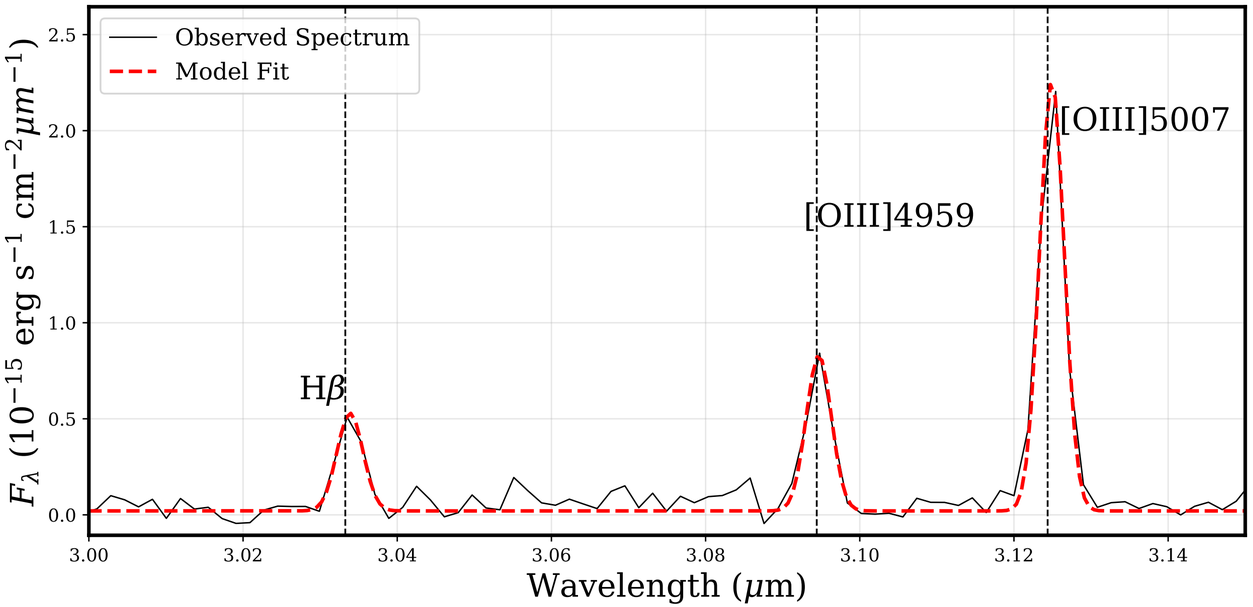
# Details of Observation

- Cosmic Evolution Early Release Science (CEERS; Proposal Id-1345, PI: S. Finkelstein [Finkelstein et al. 2023])
- NIRSpec Multi Object Spectroscopy
- Medium resolution grating ( R ~ 1000)
- Wavelength coverage - 2.9 - 5.3 $\mu m$
- Exposure - 0.86 hr

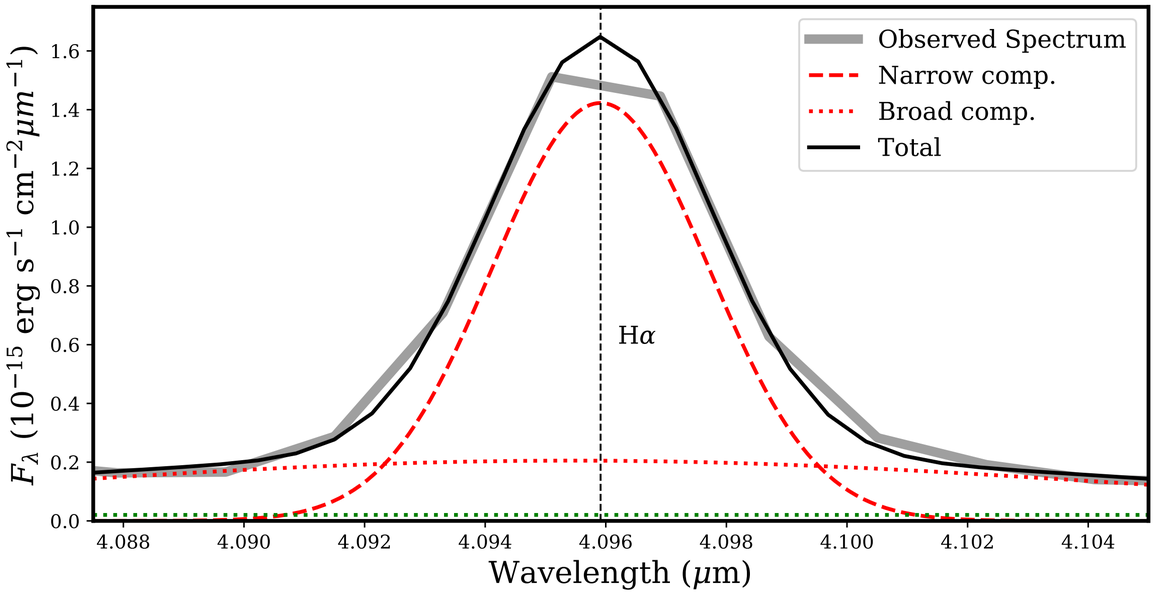
# Extracted Spectrum



# Emission lines




Narrow lines width < 500 km/s




Narrow line width ~ 309 km/s

Broad line width ~ 1626 km/s

Fitted broad and narrow emission lines

# Black hole mass estimation

$$L_{H\alpha,\ broad} \sim 2.7 \times 10^{42}\ ergs/s$$

$$\mathrm{FWHM}_{H\alpha,\ broad} \sim 1626\ km/s$$

$$M_{BH} = 2 \times 10^6 M_\odot \times \left( \frac{L_{H\alpha,broad}}{10^{42}\ ergs/s} \right)^{0.55} \times \left( \frac{\mathrm{FWHM}_{H\alpha,broad}}{10^3\ km/s} \right)^{2.06}$$

[Green & Ho (2005)]

$$\boxed{M_{BH} \sim 9.3 \times 10^6 M_\odot}$$

# JWST Discoveries

- JWST is detecting more AGNs at high redshift in low-luminosity and low-mass regimes
- Reveals interesting features of early supermassive black holes compared to local population
    - Show higher bolometric luminosity compared to the AGN with same $M_{BH}$
    - Over-massive relative to host galaxy stellar mass
- More studies will reveal how SMBH evolve in cosmic history

*Thank You*