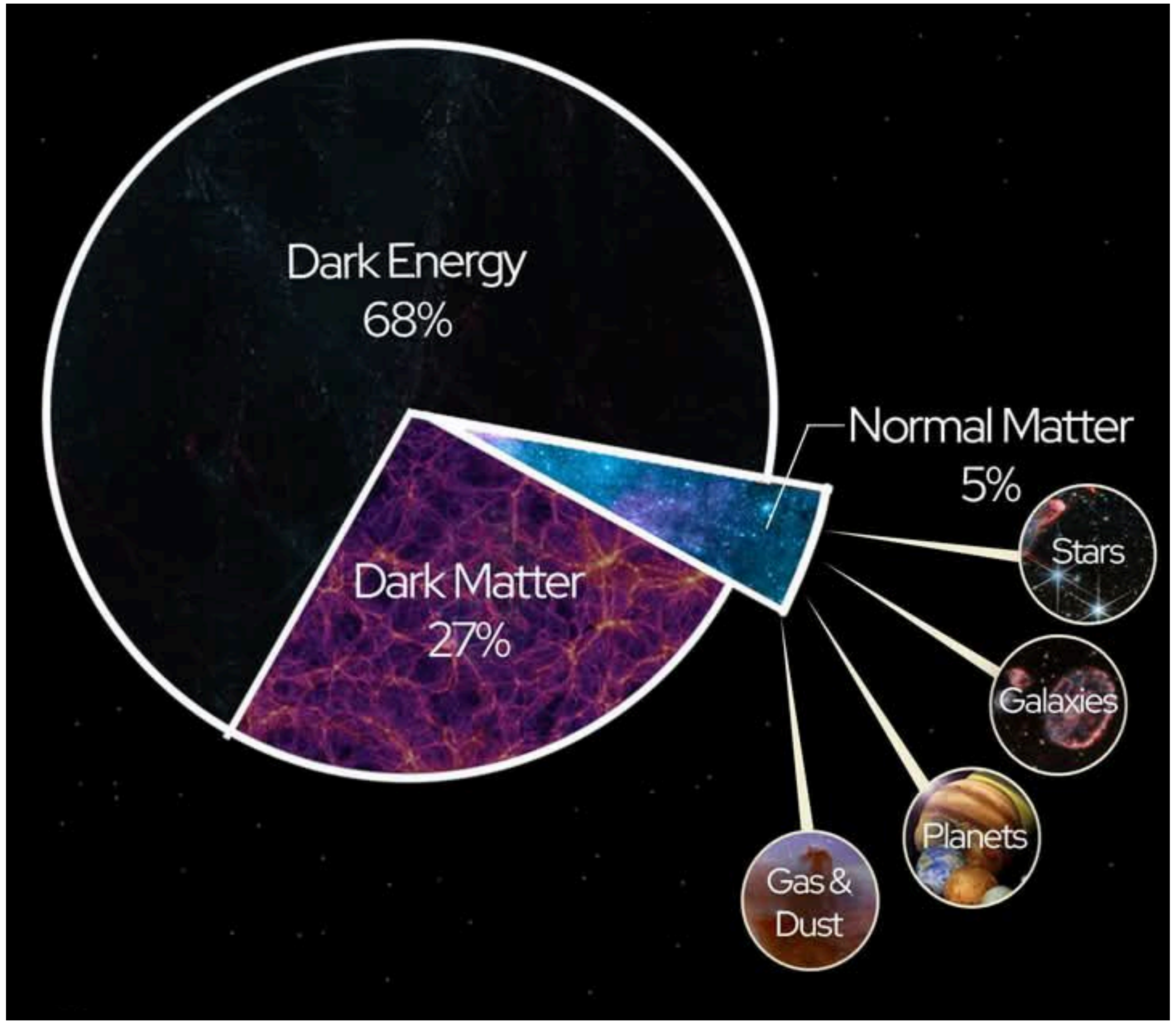
Unveiling the correlation between the 2175Å UV bump, PAH emission, and gas-phase metallicity at cosmic noon

A multi-wavelength study with JWST, VLT, and Keck

PhD supervisors: Irene Shivaei, Pablo Pérez-González
Collaborators: Leindert Boogaard, Andrew Mizener, Daniela Calzetti

The role of dust in galaxies



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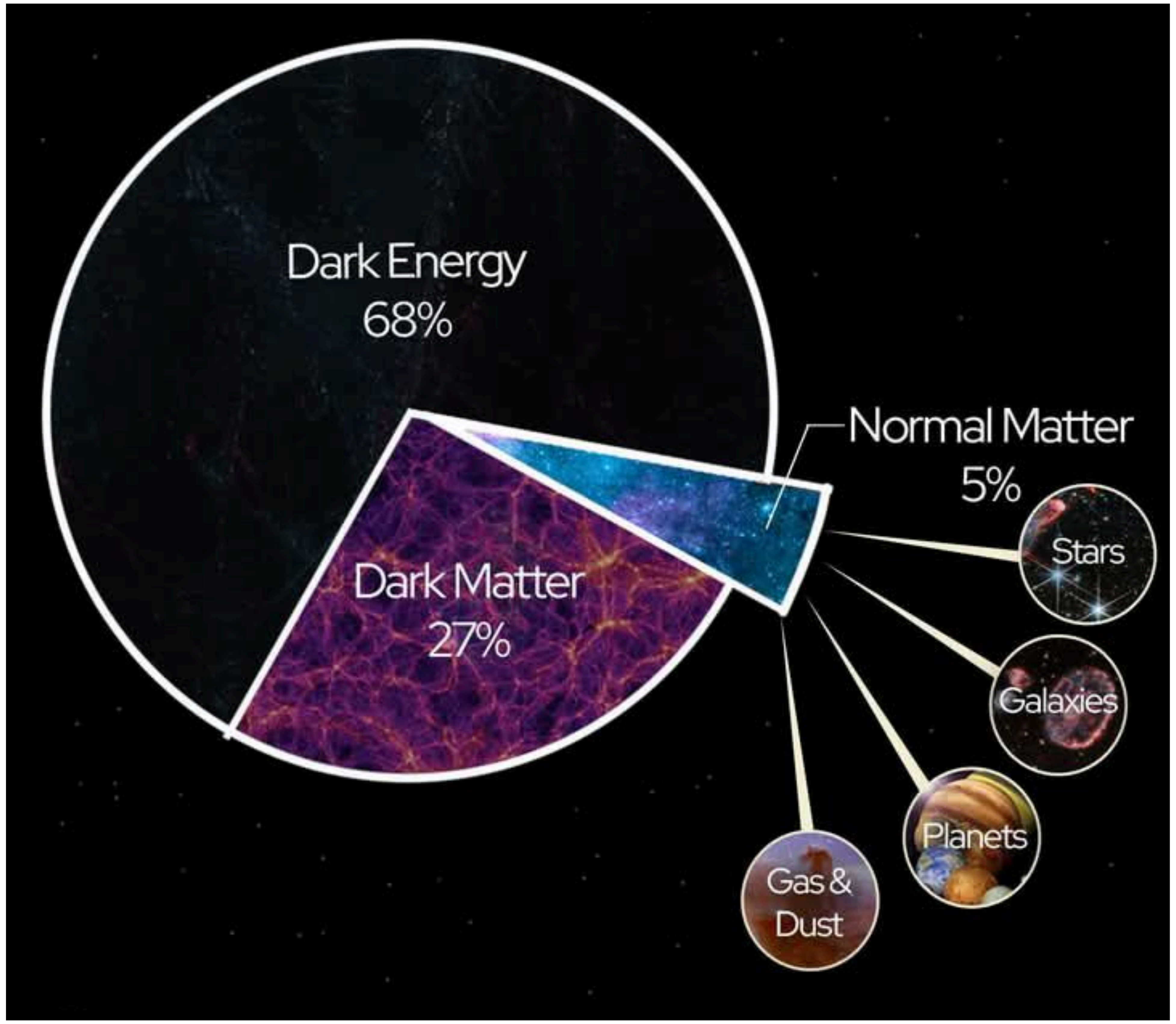
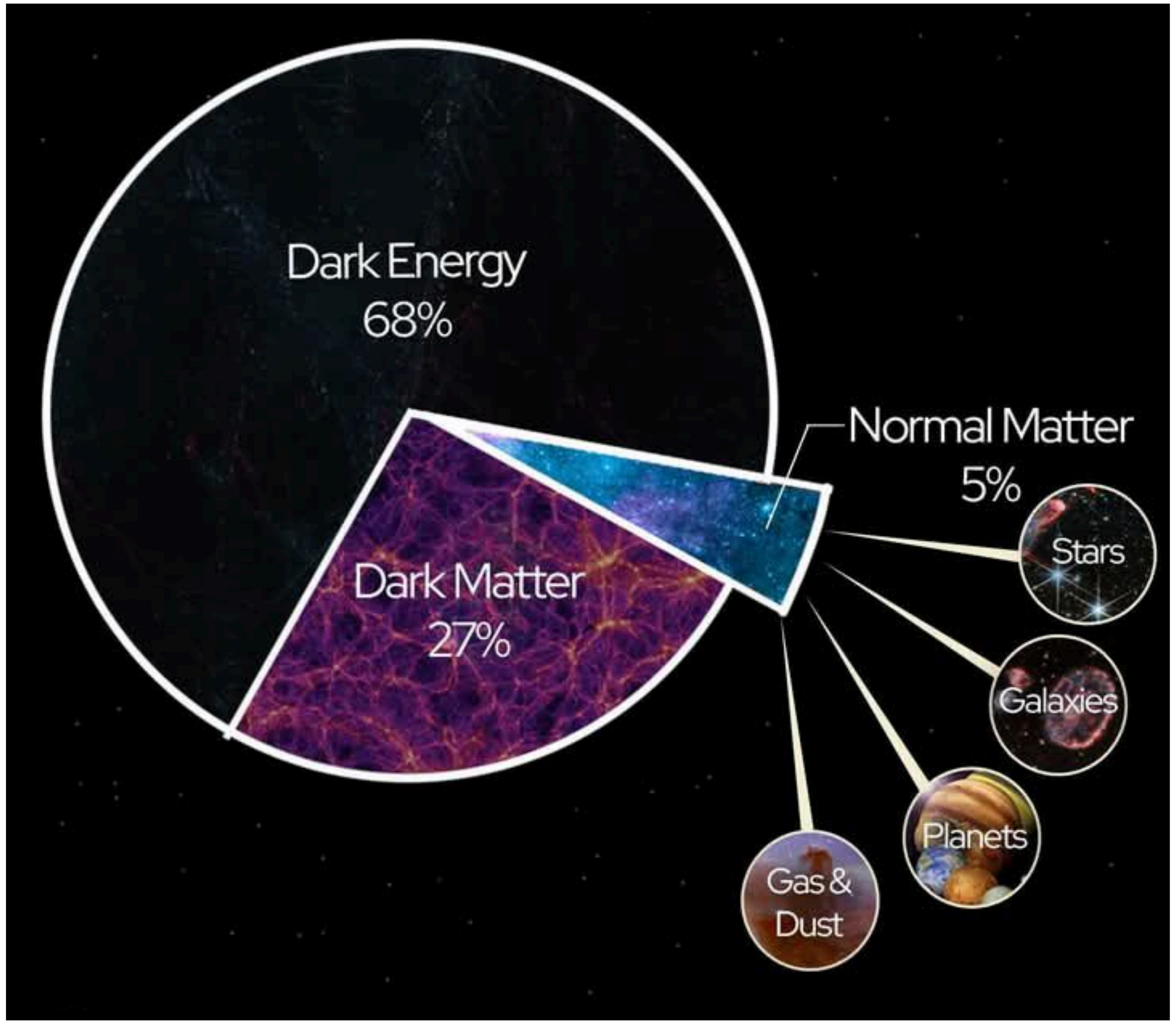


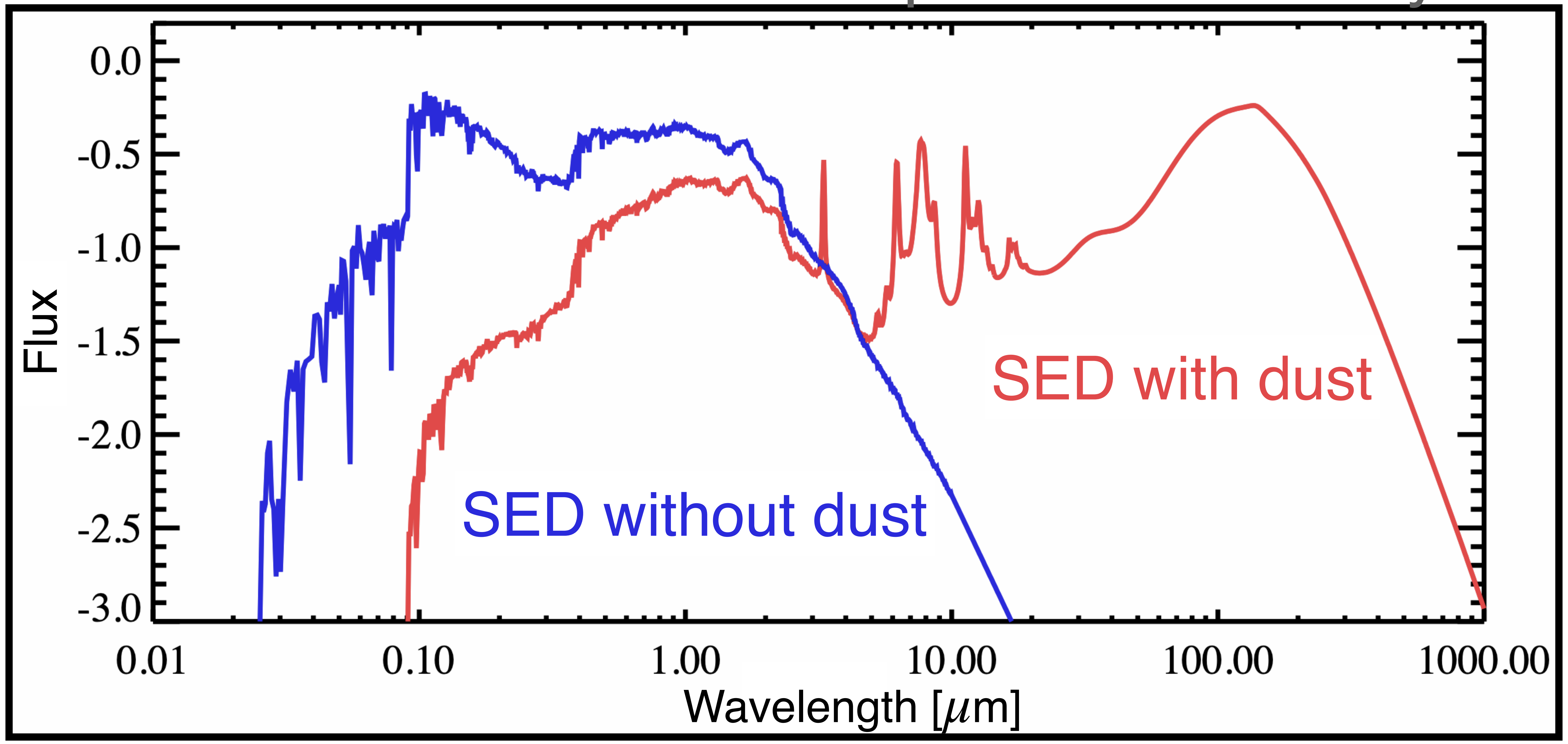
Dust is responsible for

- Absorption of optical+UV photons
- Scattering of optical+UV photons
- Re-emission of IR photons

The role of dust in galaxies



Adapted from Conroy+13



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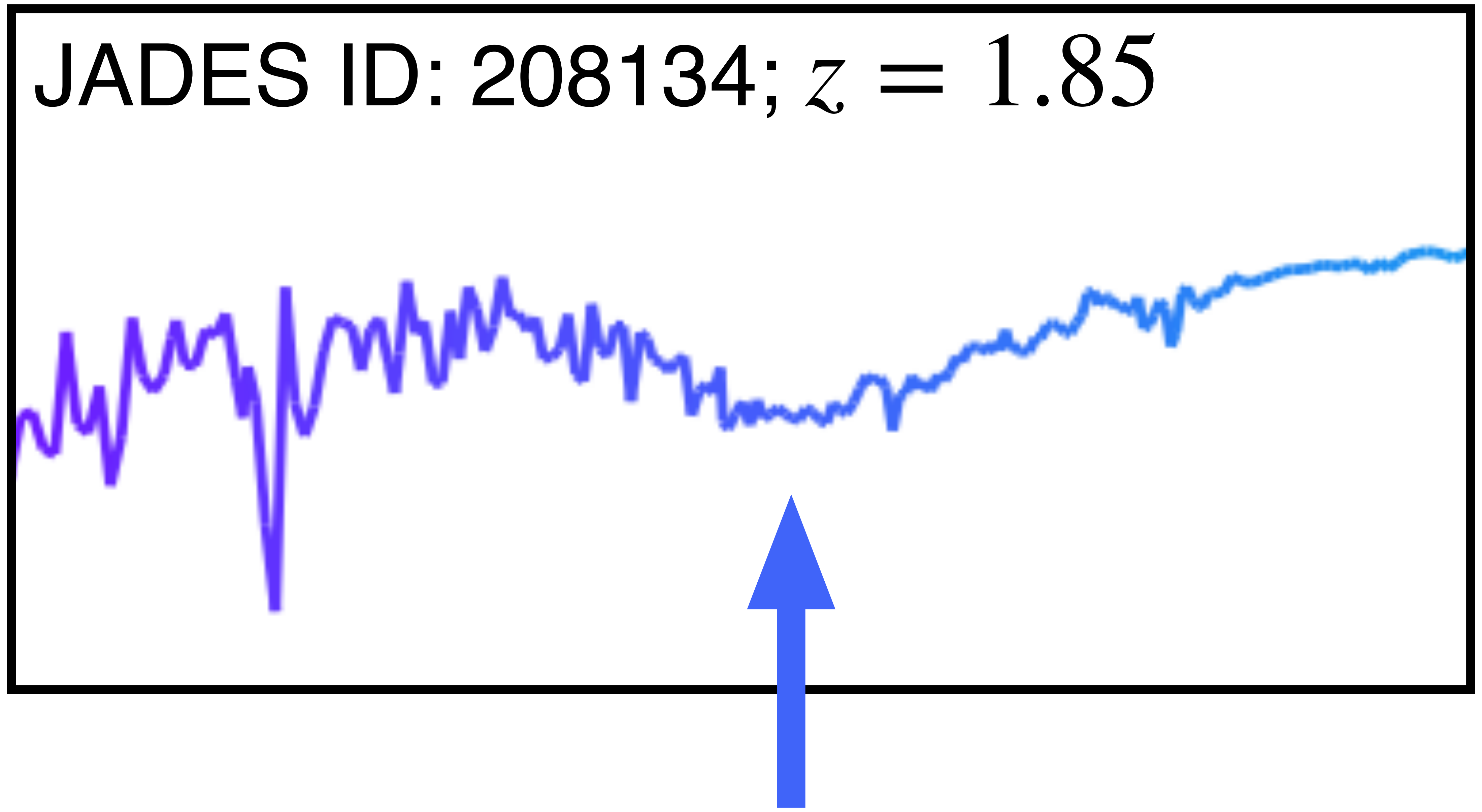
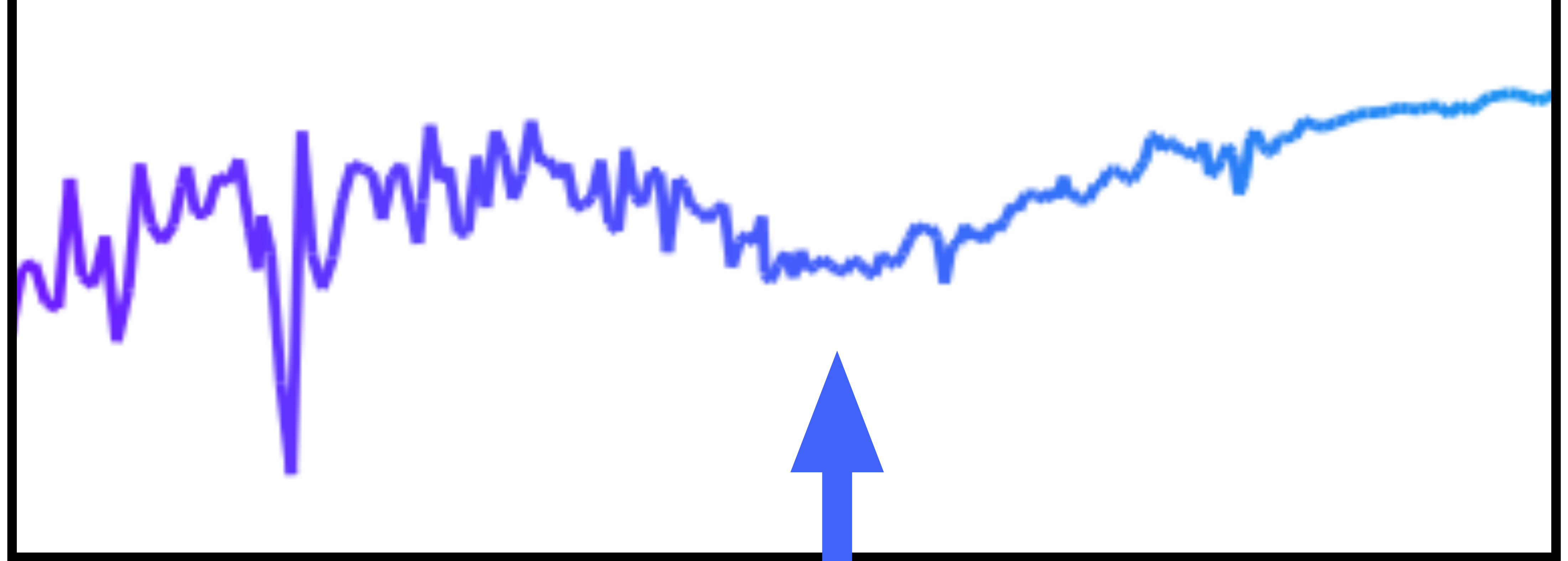
The UV 2175Å attenuation bump and PAH emission

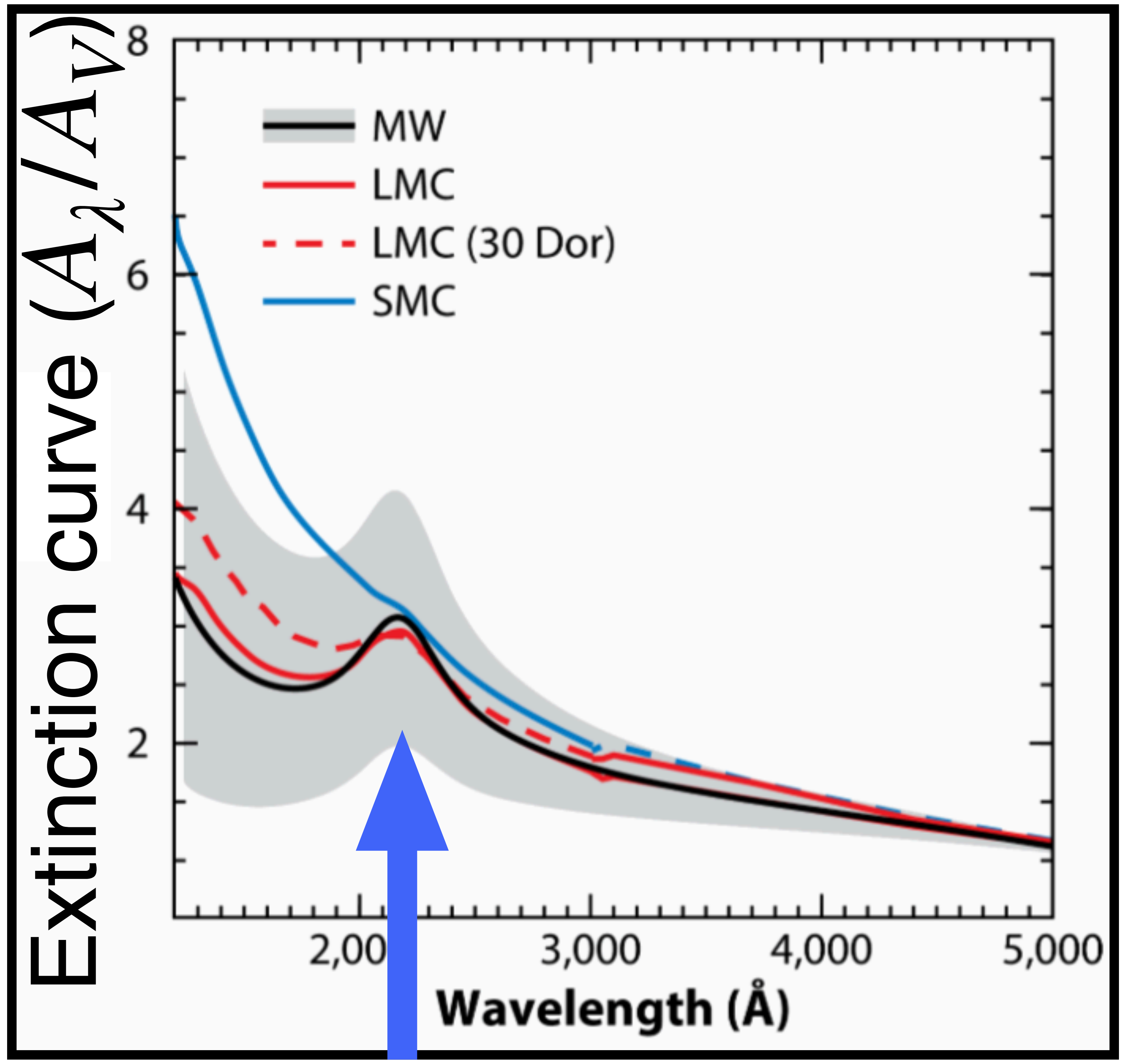


The UV 2175Å attenuation bump and PAH emission

JADES ID: 208134; $z = 1.85$



Salim & Narayanan+20



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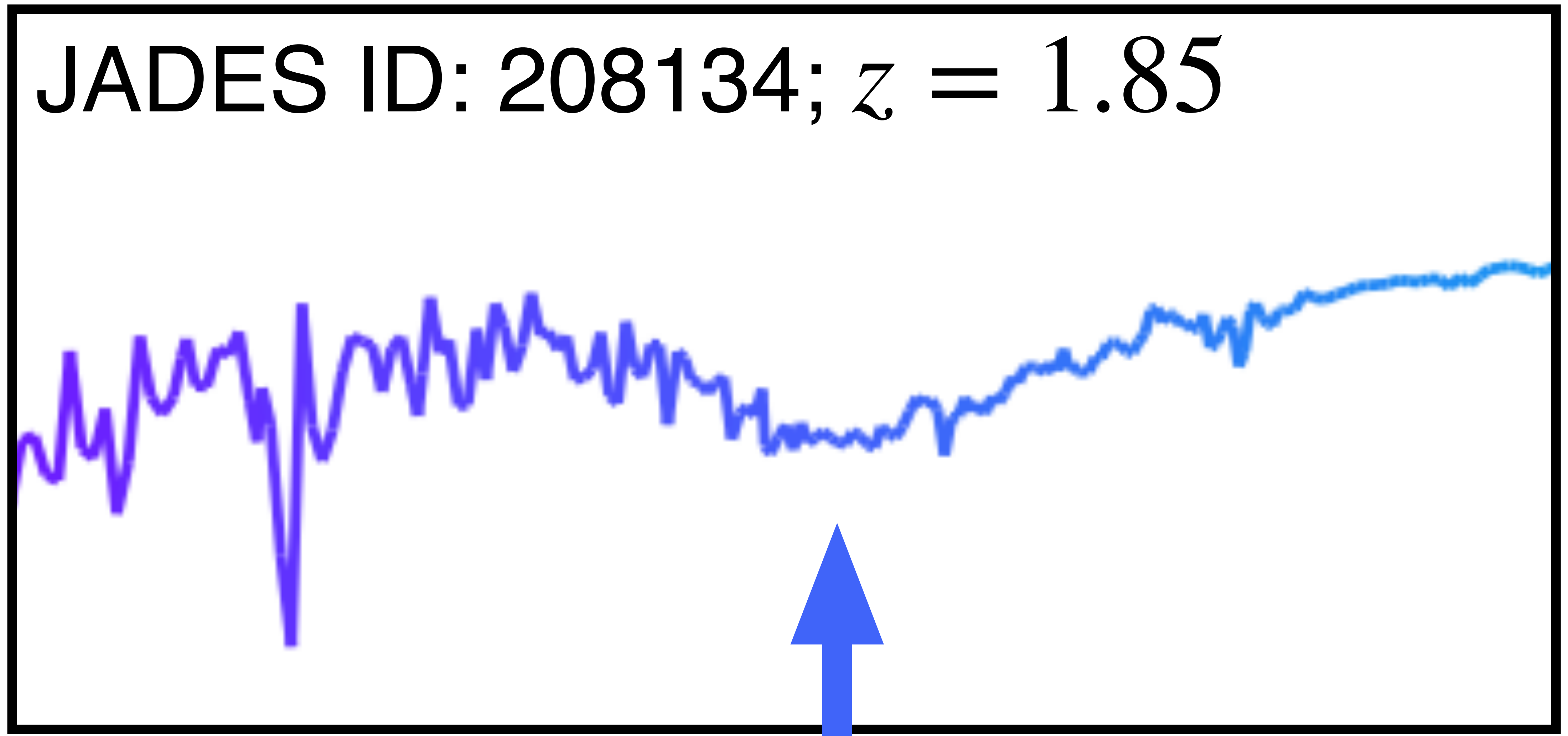
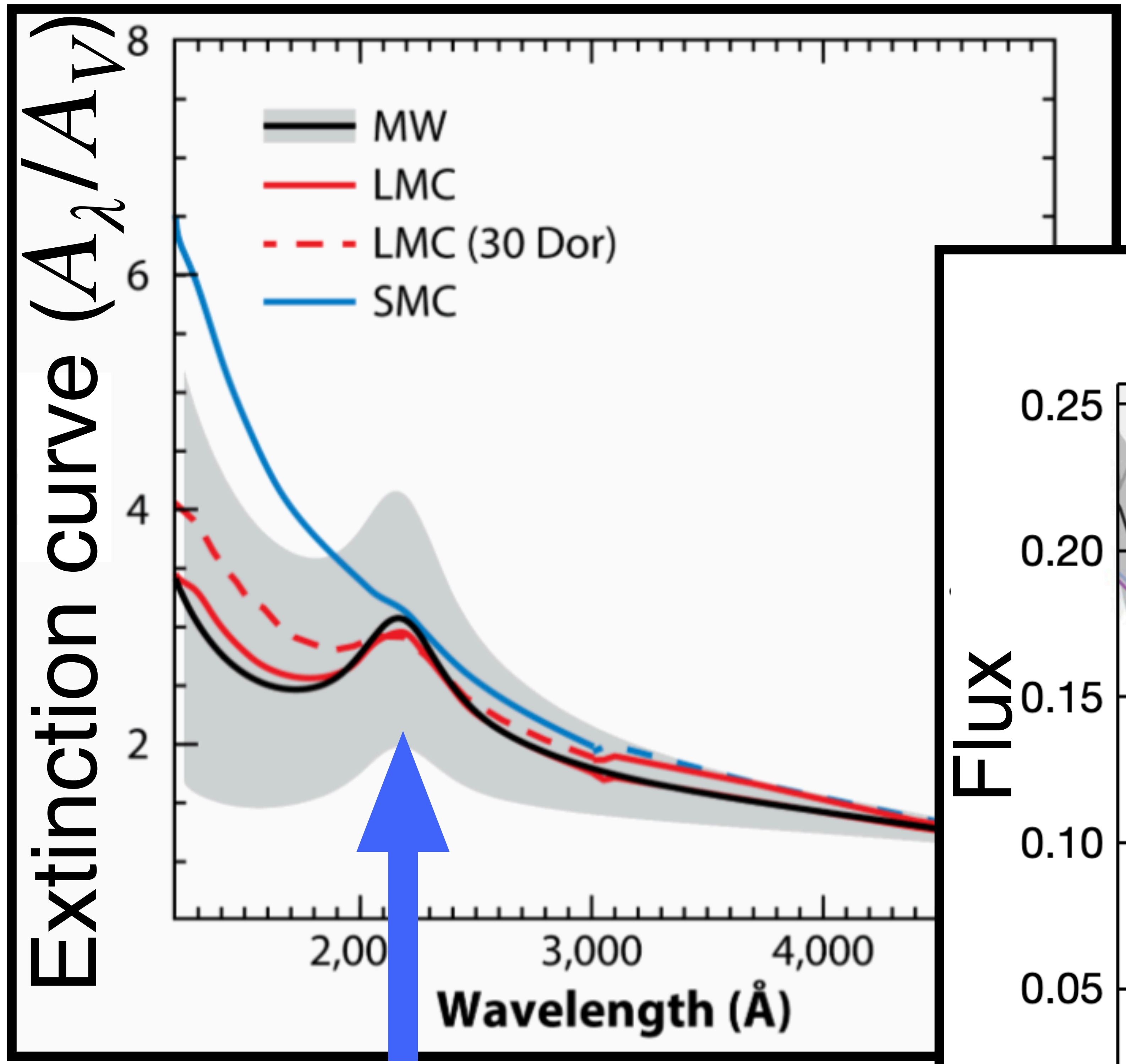
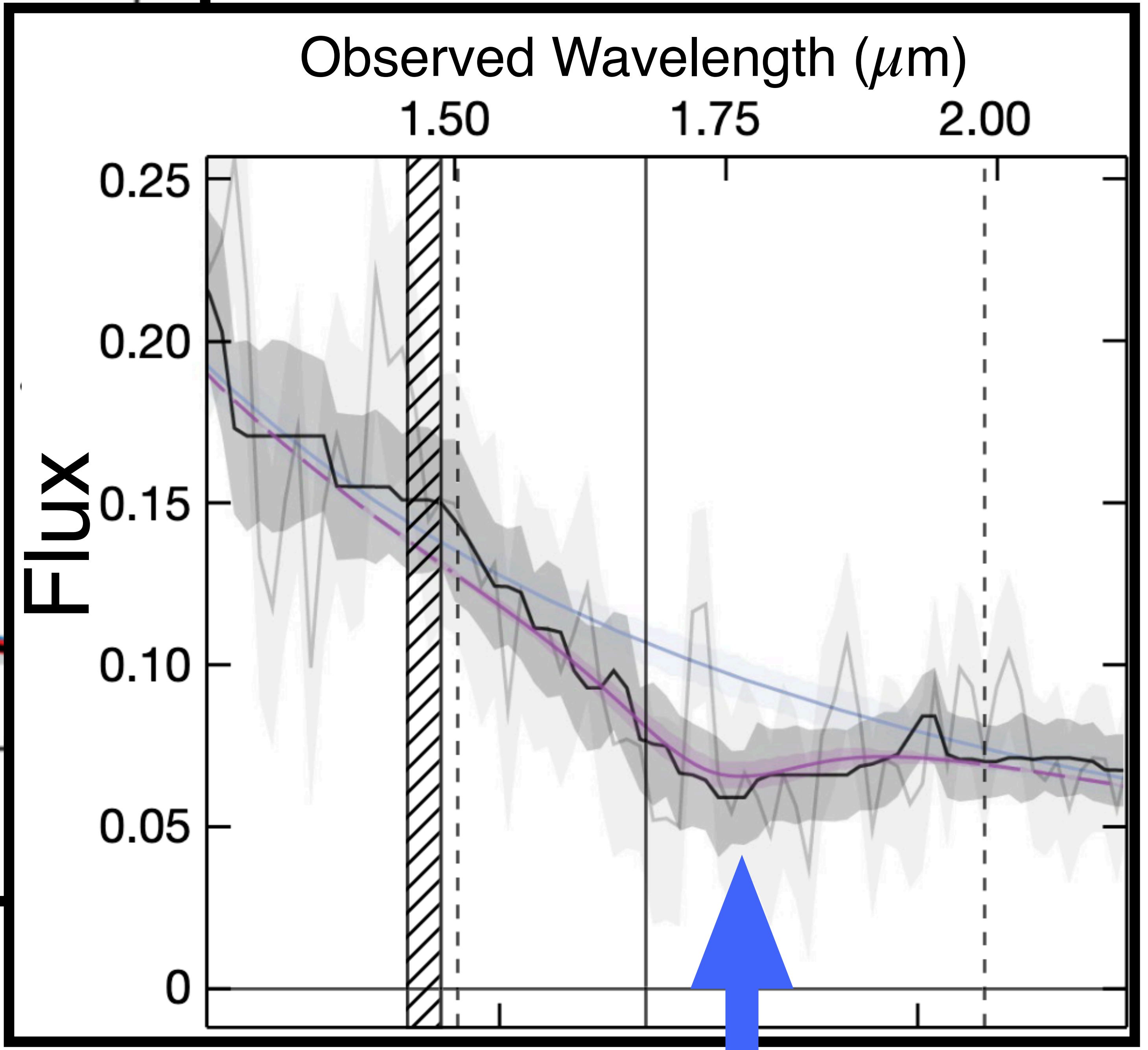


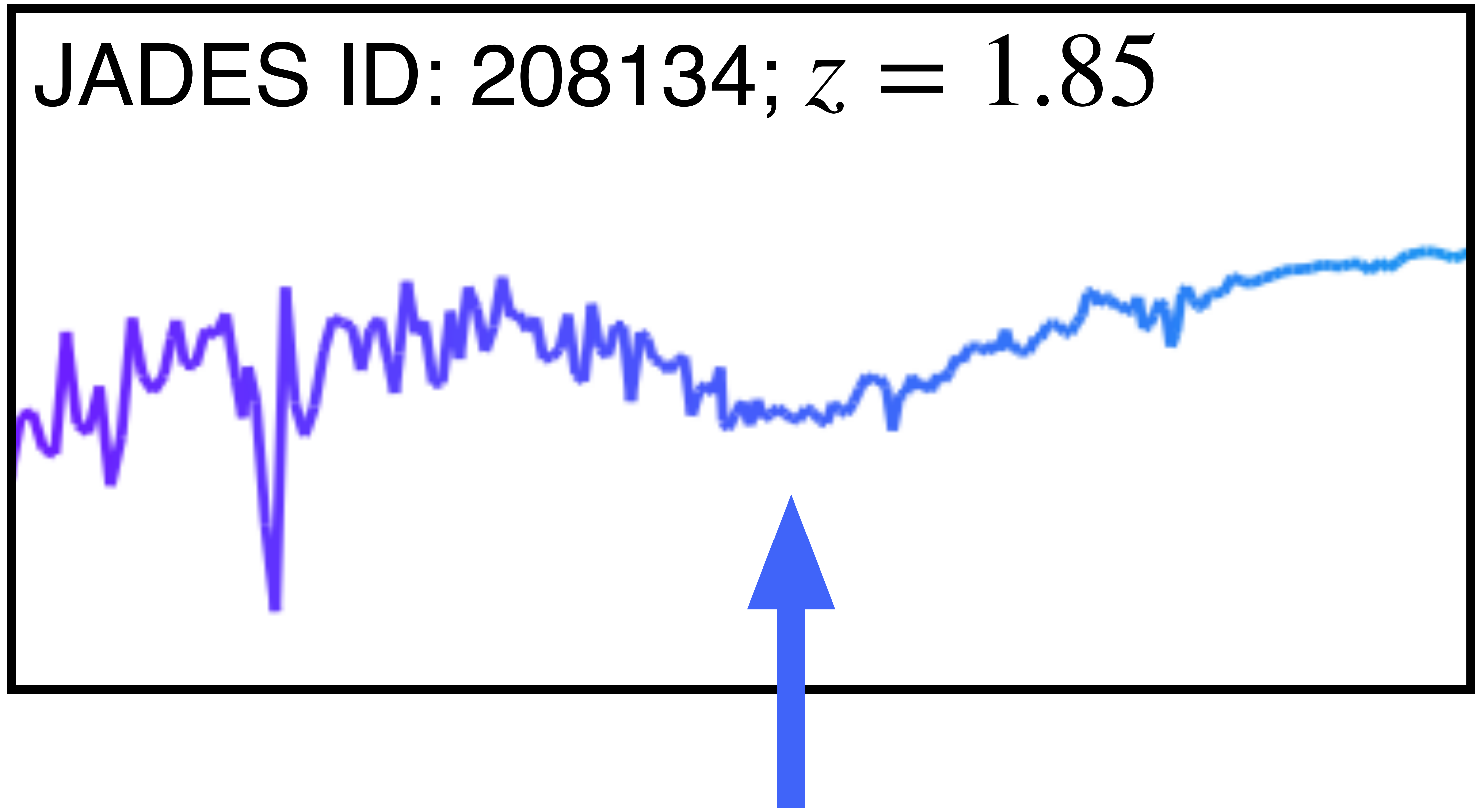
Salim & Narayanan+20

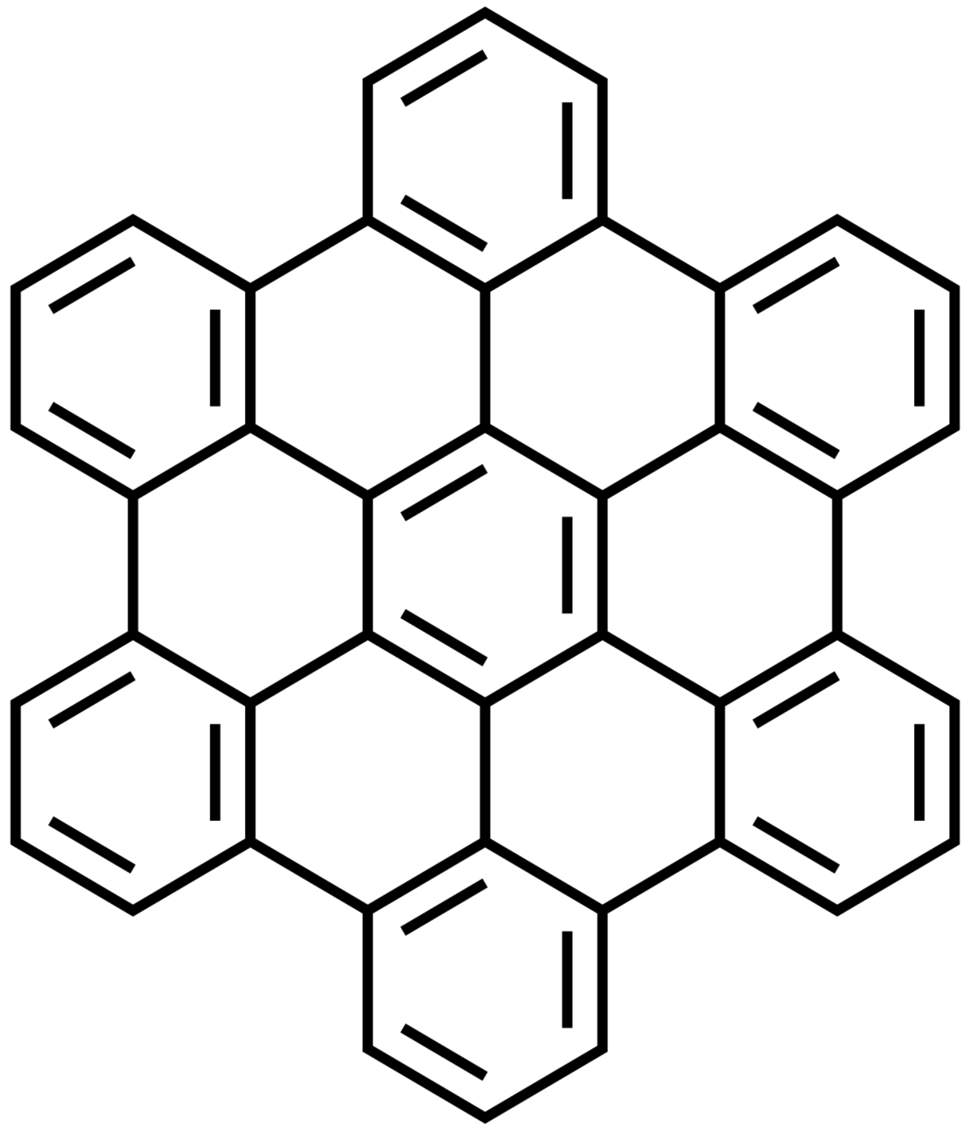




$z > 7$ galaxy (Witstok+23)

The UV 2175Å attenuation bump and PAH emission

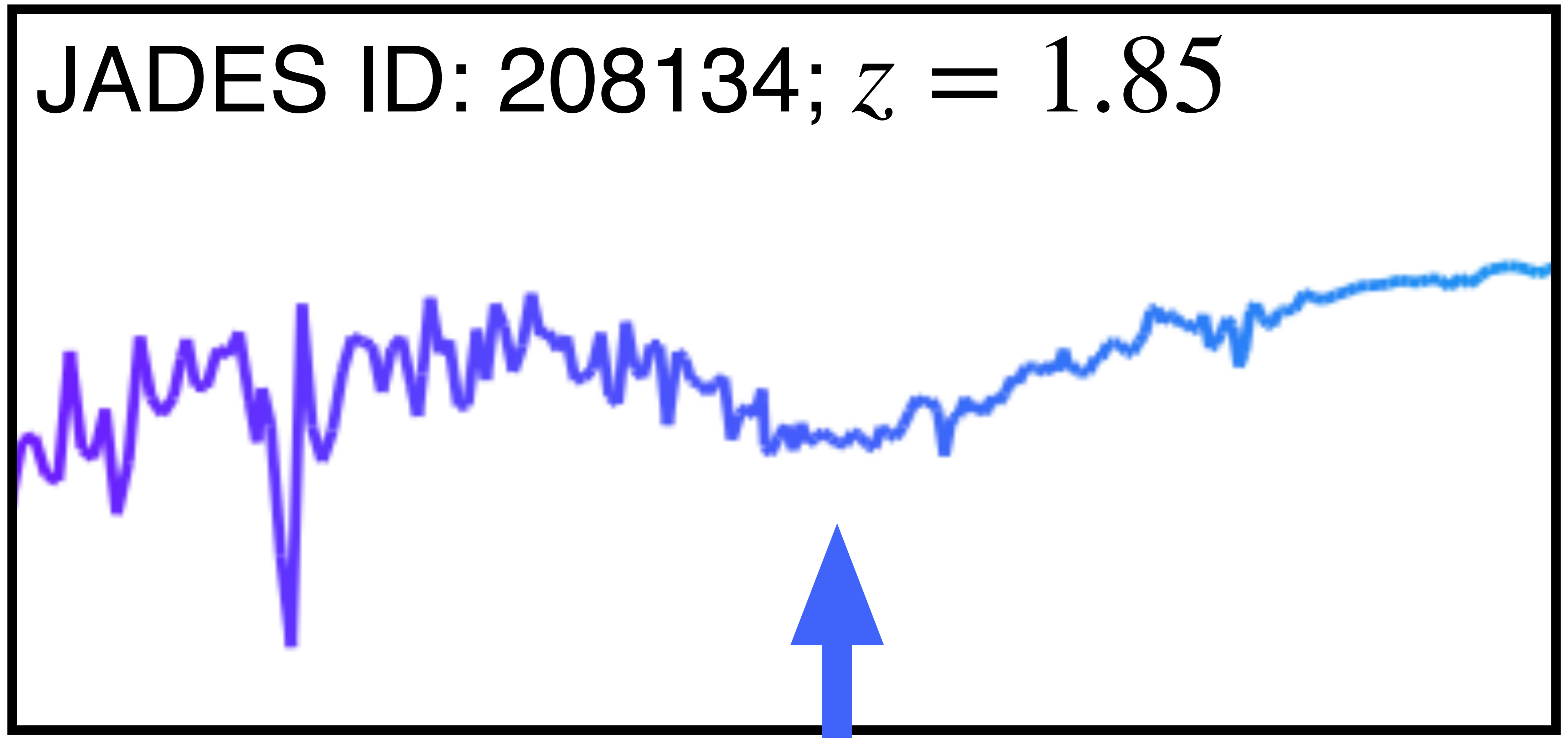


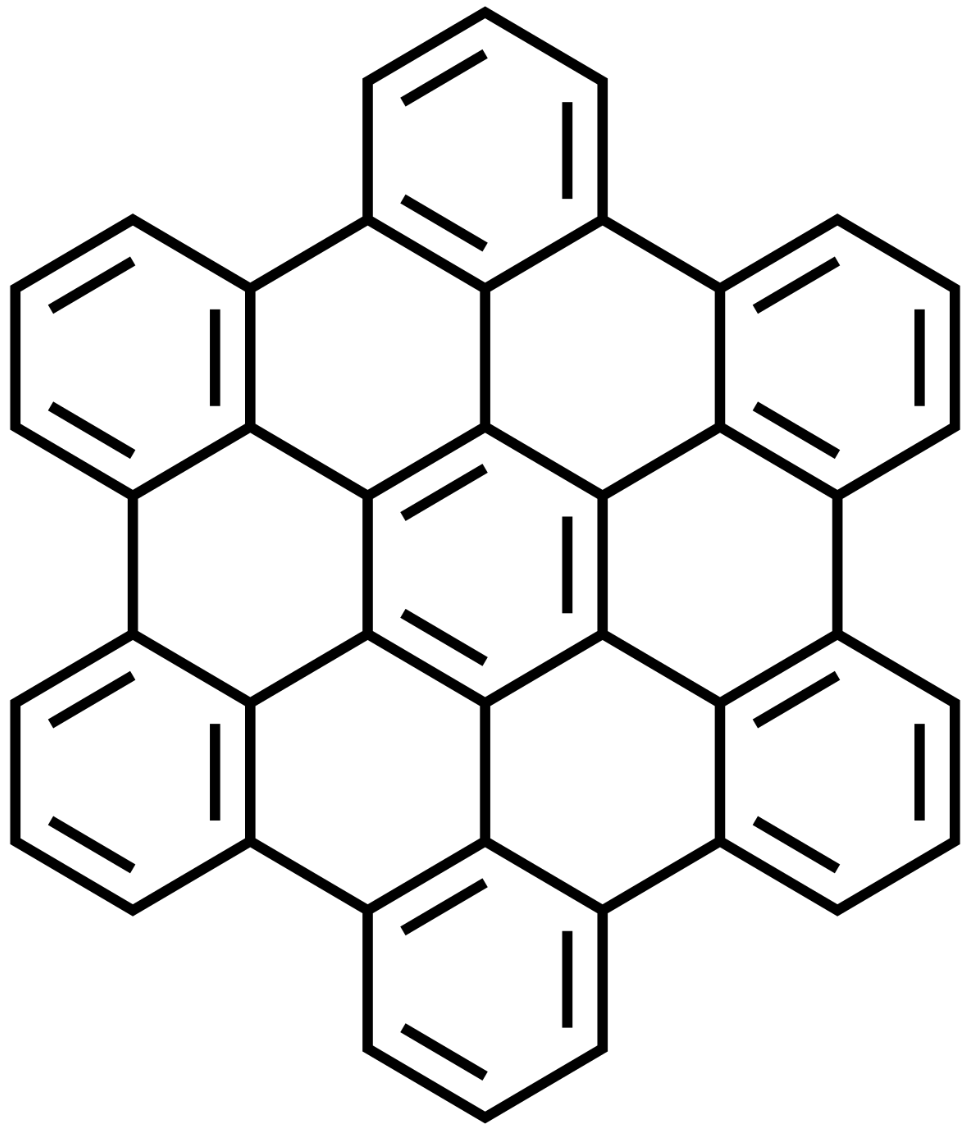


Polycyclic Aromatic
Hydrocarbons (PAH)

The UV 2175Å attenuation bump and PAH emission

Absorb UV photons



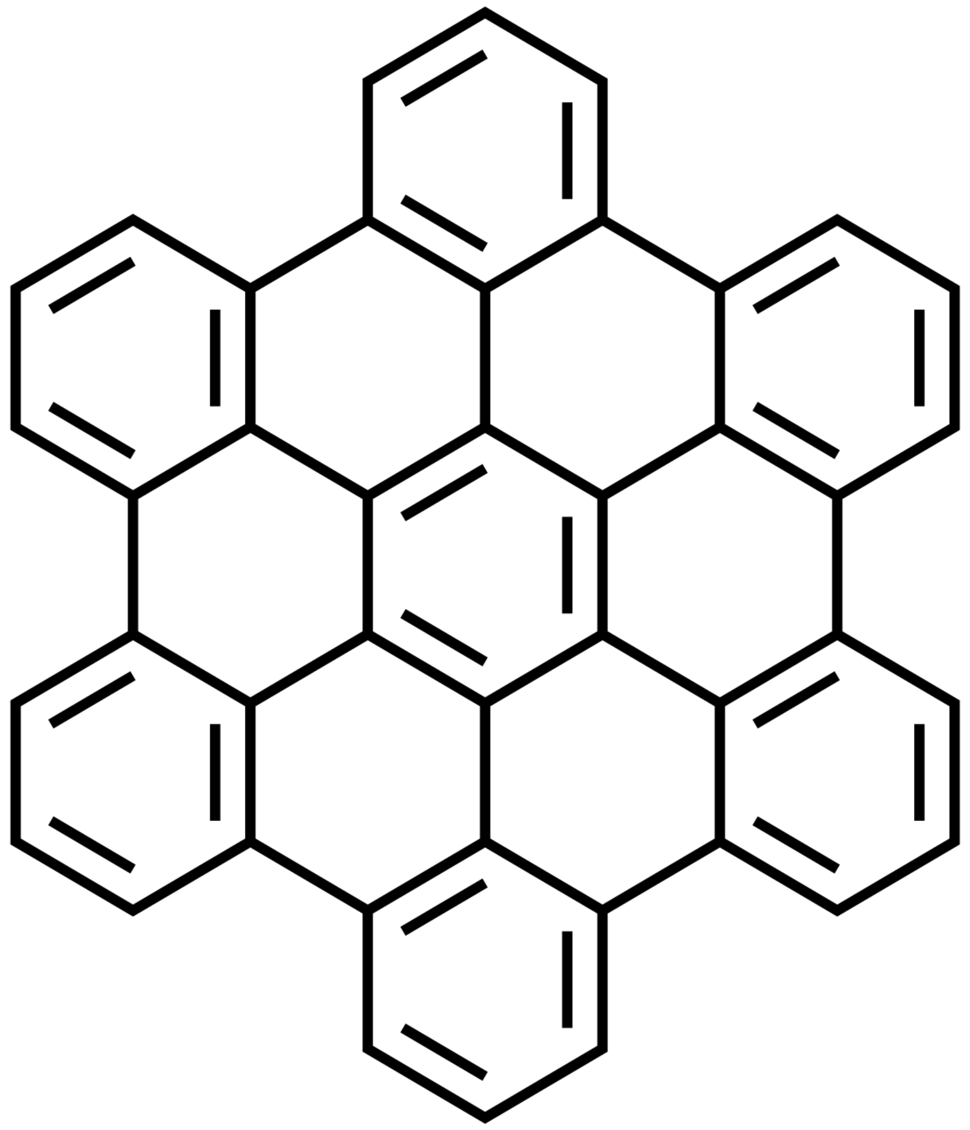


Polycyclic Aromatic Hydrocarbons (PAH)

The UV 2175Å attenuation bump and PAH emission

Absorb UV photons

Re-emit in the IR



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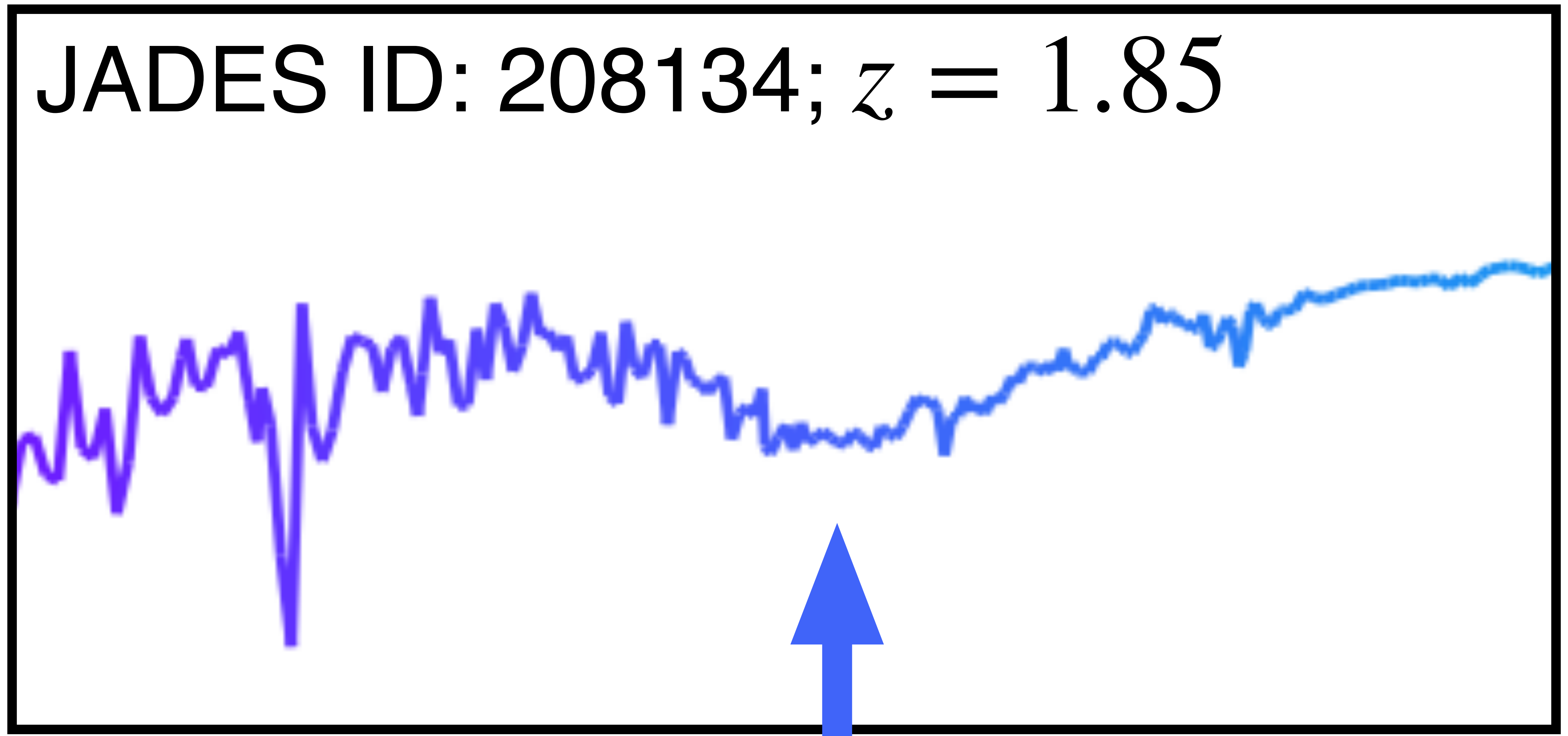
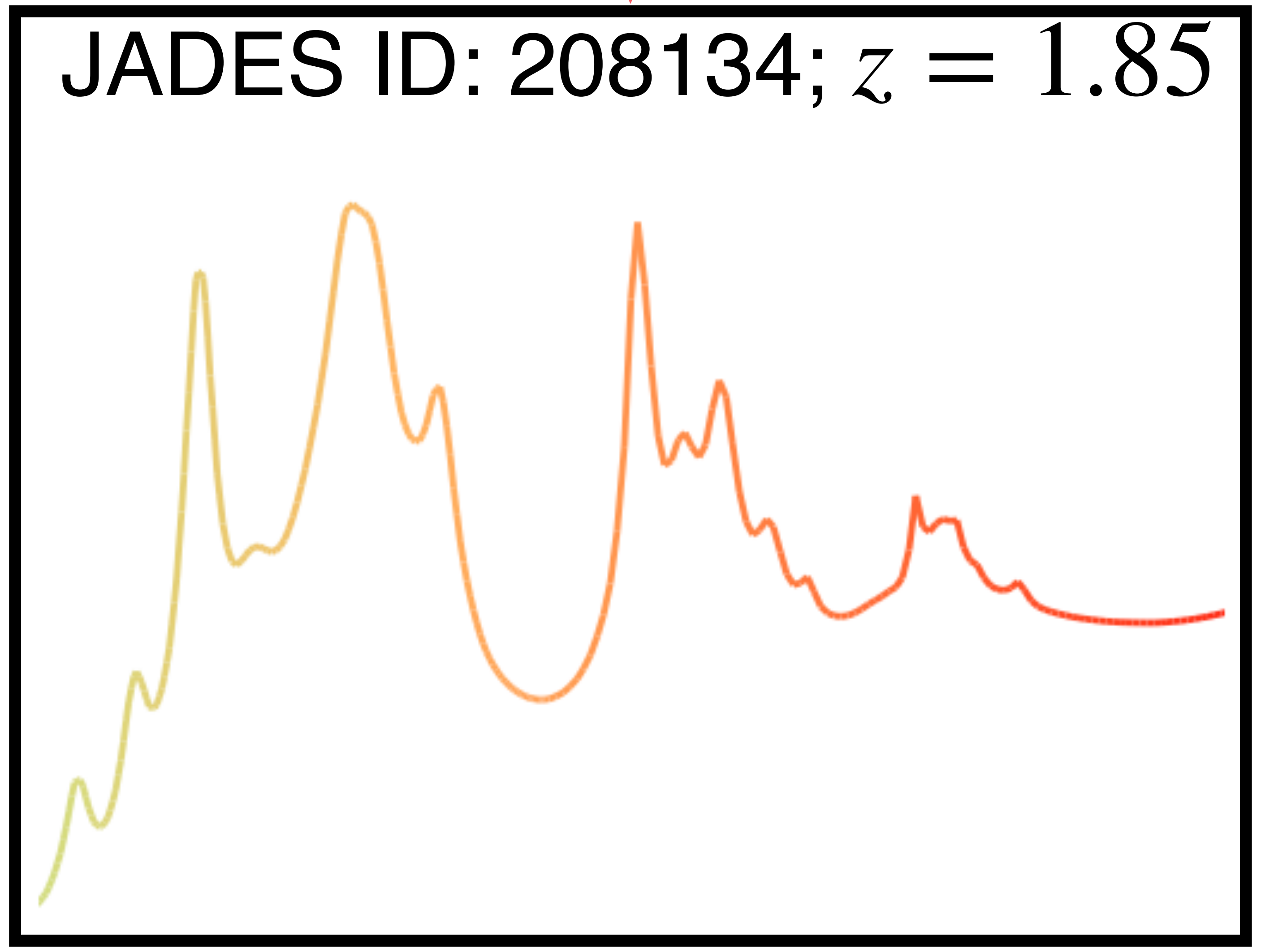
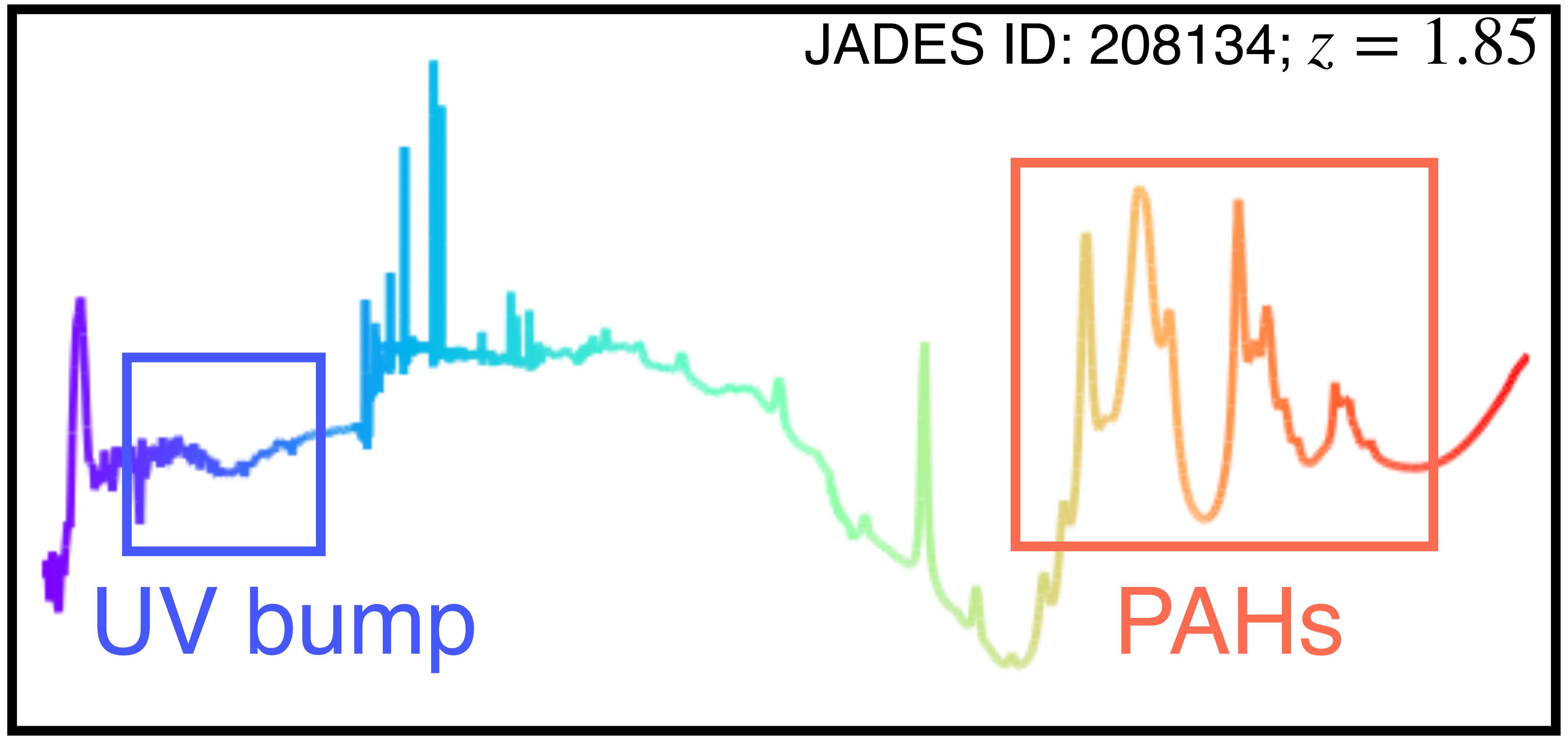




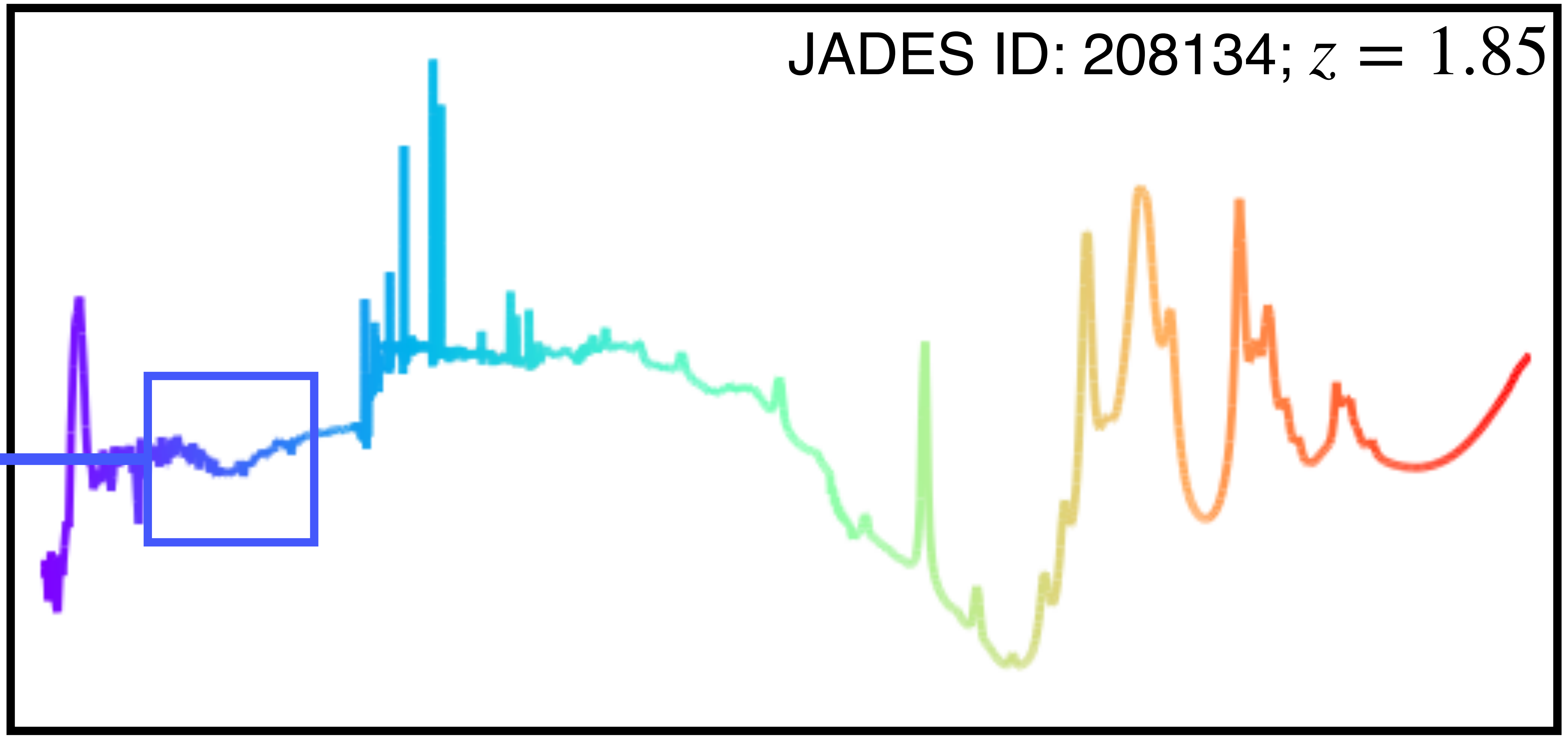
Objectives

- Characterize the relationship between the UV 2175Å bump and PAH emission at cosmic noon
- Investigate how gas-phase metallicity (based on strong emission line measurements) affects both of these properties
- Examine how these properties relate to other galaxy parameters



Sample

- MUSE *Hubble* Ultra Deep Field (HUDF) Survey (Bacon+17, Inami+17)
- 120 galaxies
- $1.5 < z < 2.7$



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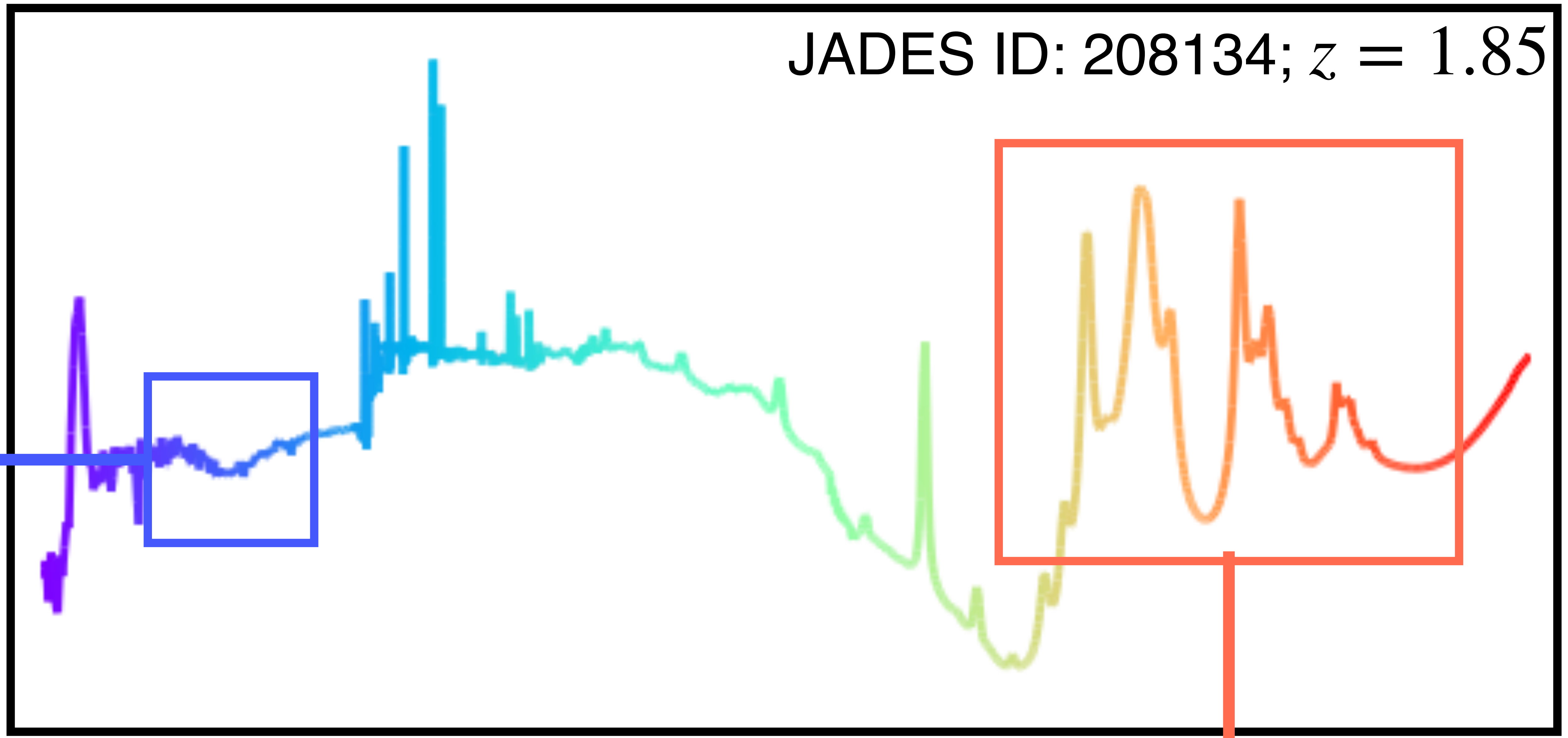

- JWST/MIRI data covering PAHs
- 120 galaxies → 49 galaxies

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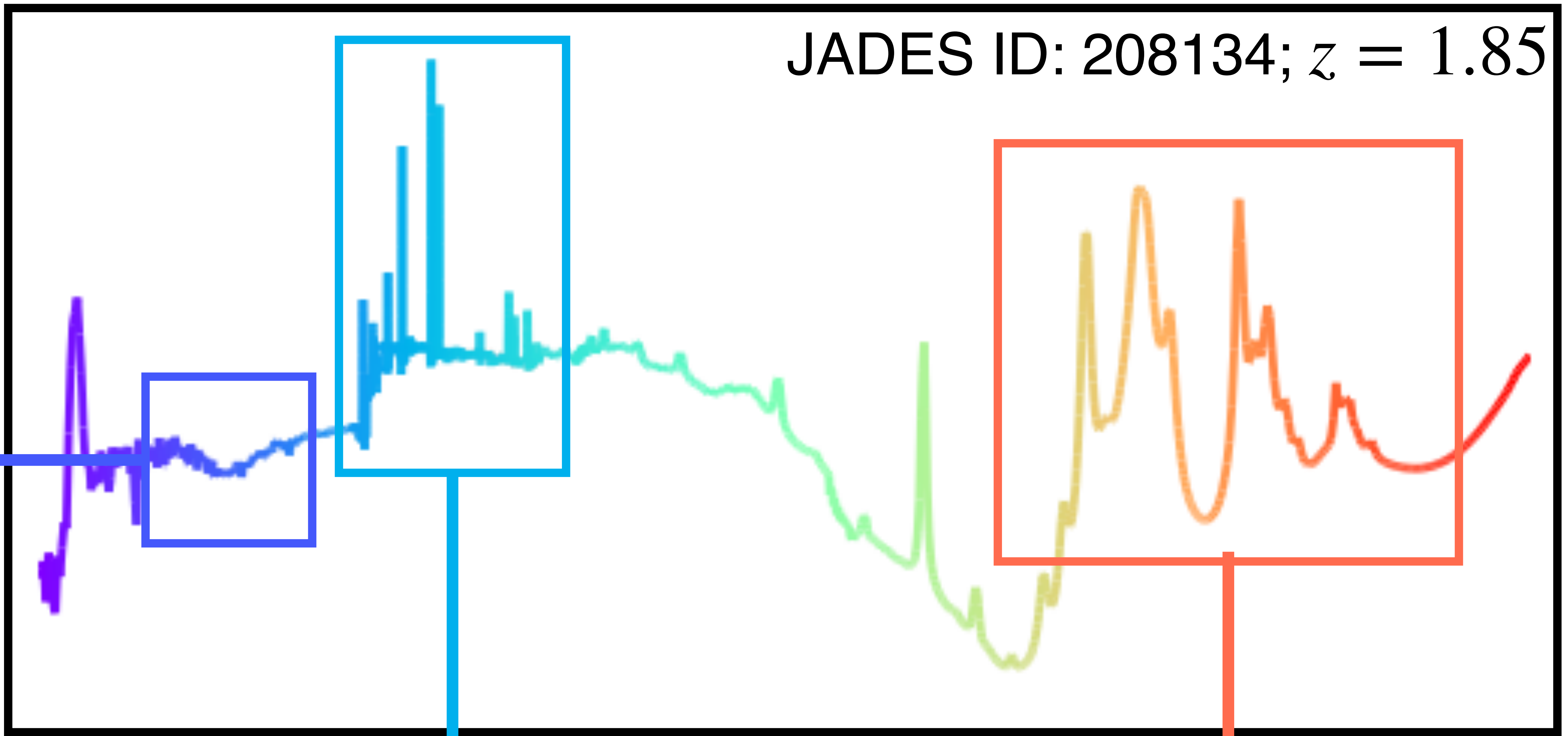

- Keck/MOSFIRE + JWST/NIRSpec emission line fluxes
- 49 galaxies → 19 galaxies

- JWST/MIRI data covering PAHs
- 120 galaxies → 49 galaxies

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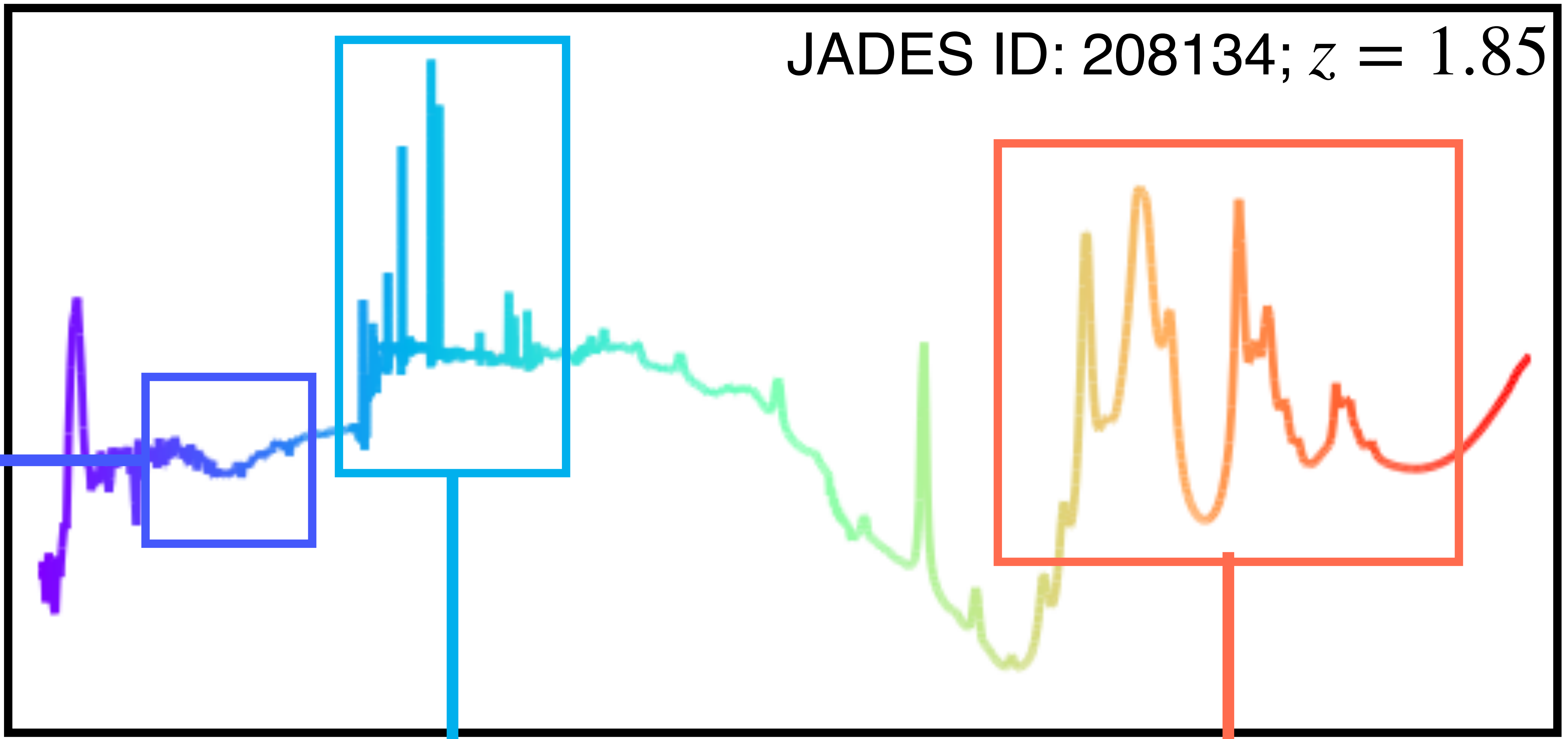


Two samples:

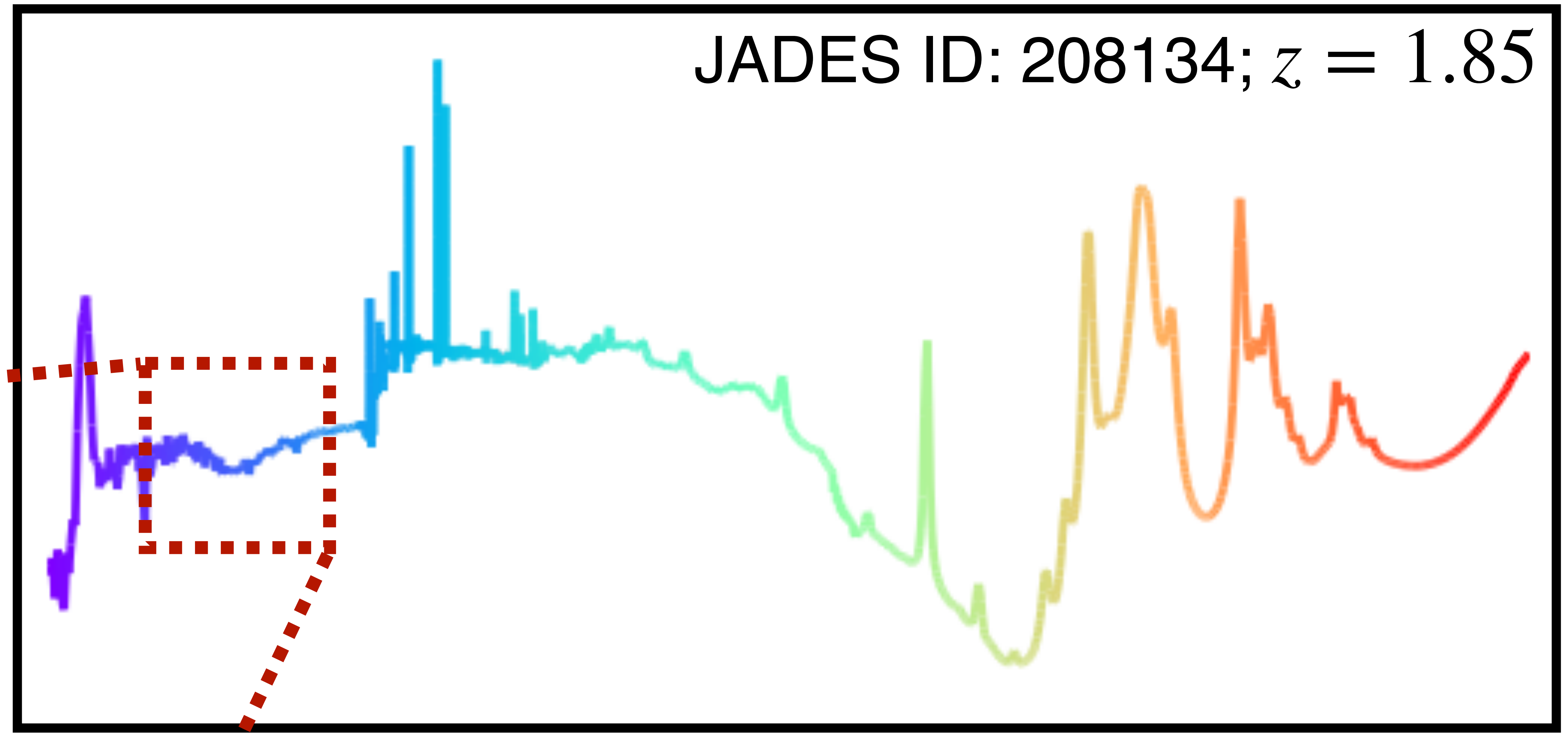
- Final sample with UV bump + PAHs → 49 galaxies
- Subsample with metallicity measurements → 19 galaxies

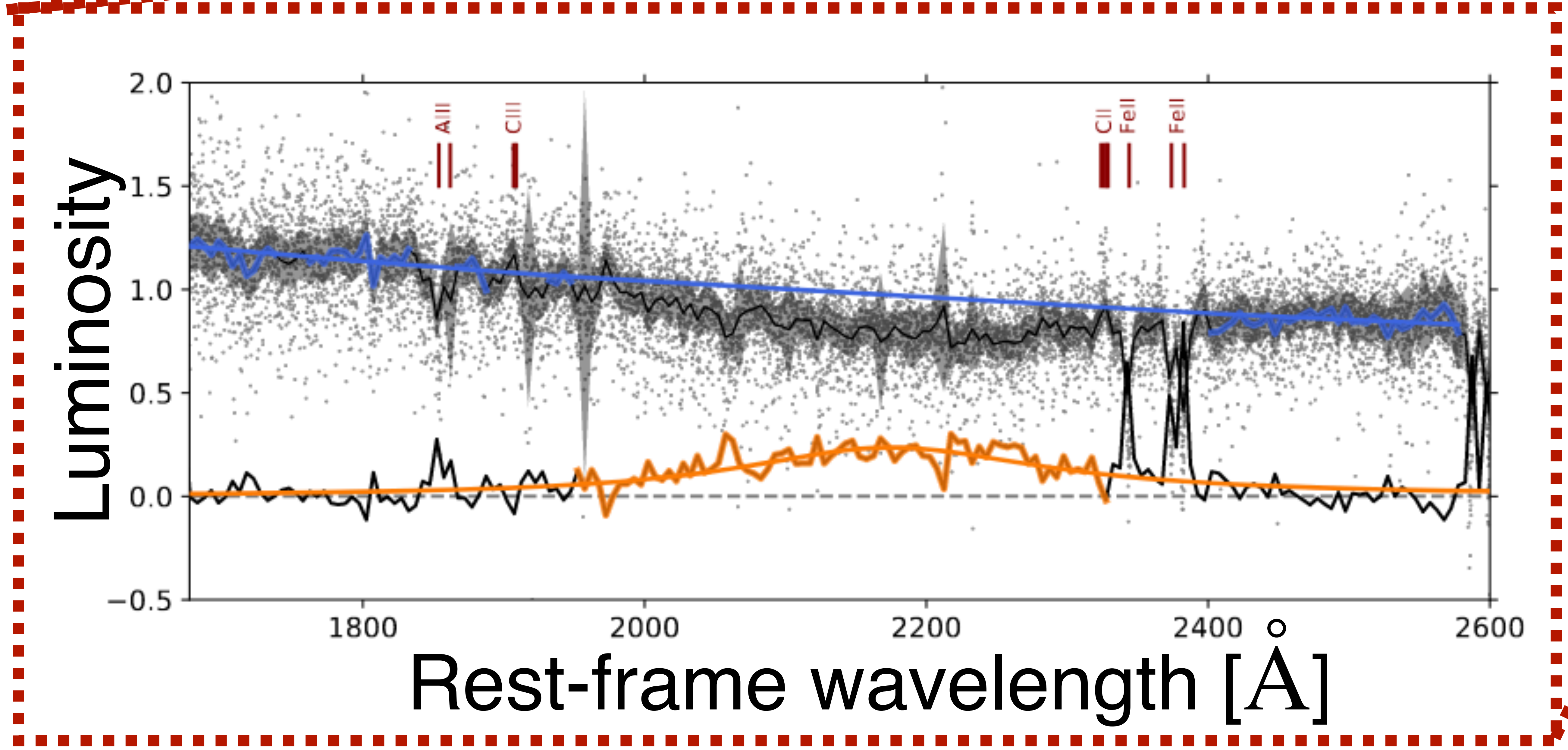
- Keck/MOSFIRE + JWST/NIRSpec emission line fluxes
- 49 galaxies → 19 galaxies

- JWST/MIRI data covering PAHs
- 120 galaxies → 49 galaxies

Data and methods

- UV bump: VLT/ MUSE data (Bacon+17, Inami+17)

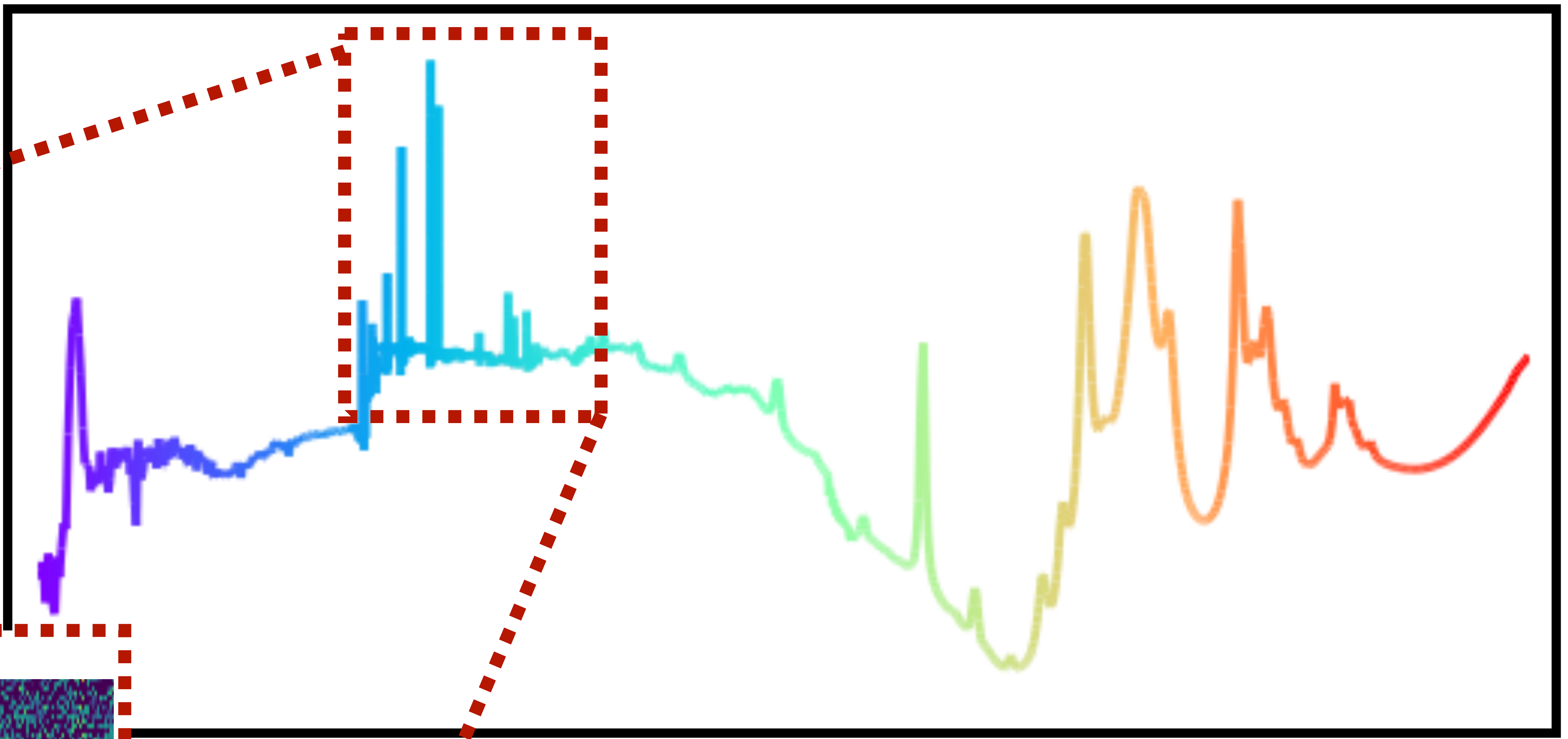


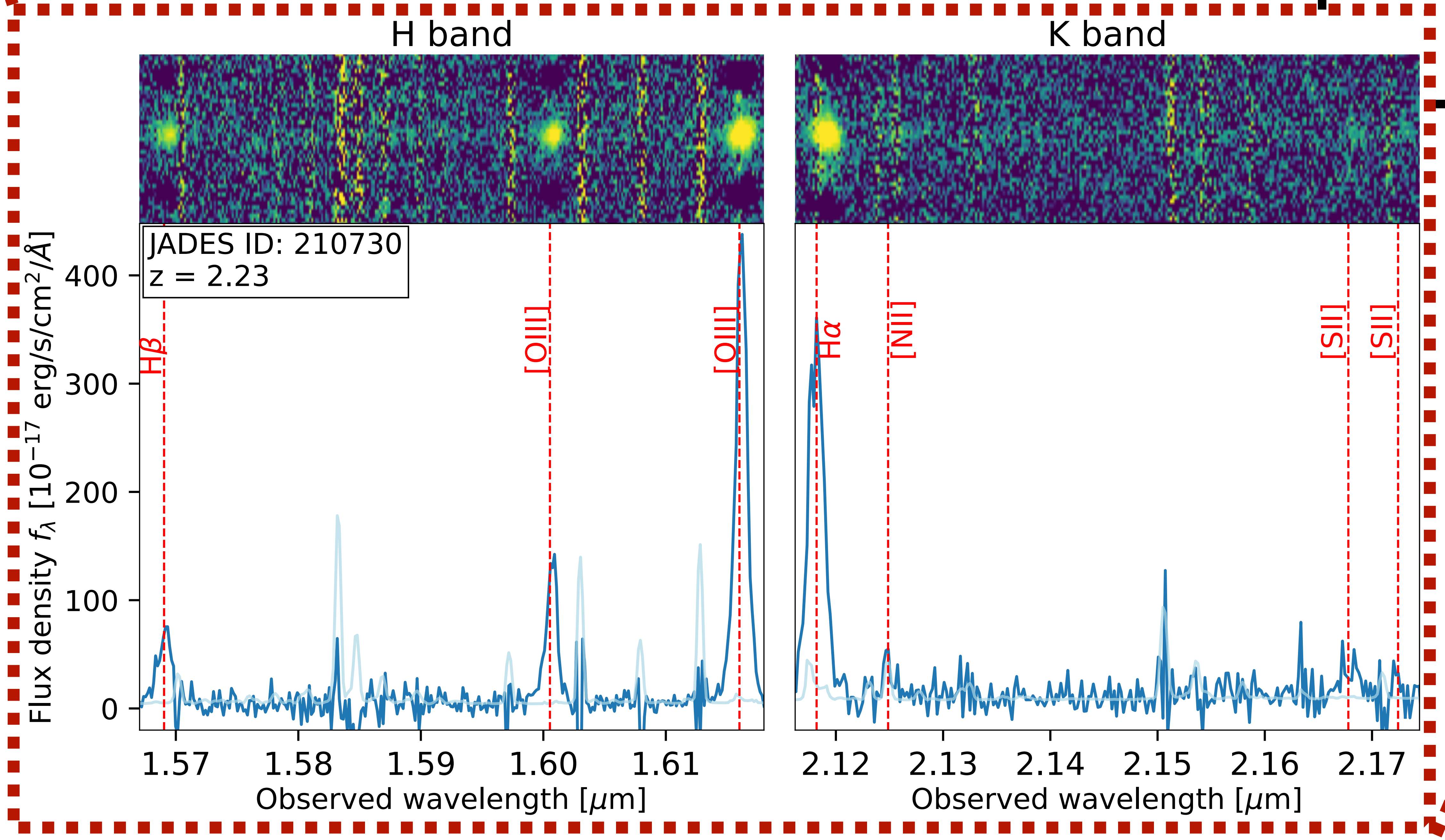


Shivaei+22

Data and methods

- UV bump: VLT/ MUSE data (Bacon+17, Inami+17)
- Gas-phase metallicities: Keck/MOSFIRE observations (observing programs 2022B+2024B, PIs: D. Calzetti and I. Shivaei)





Arriscado *et al.* in prep.

Data and methods

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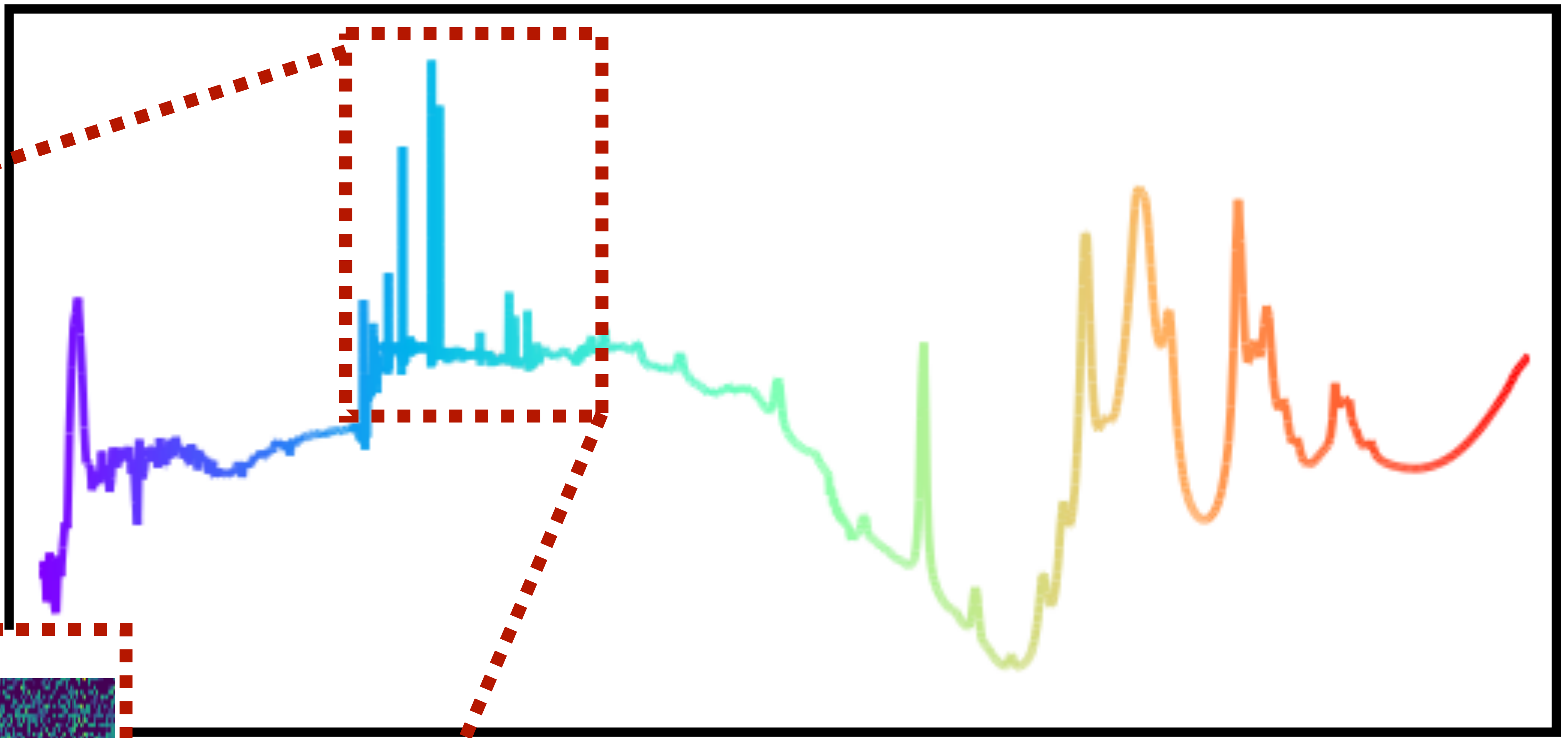
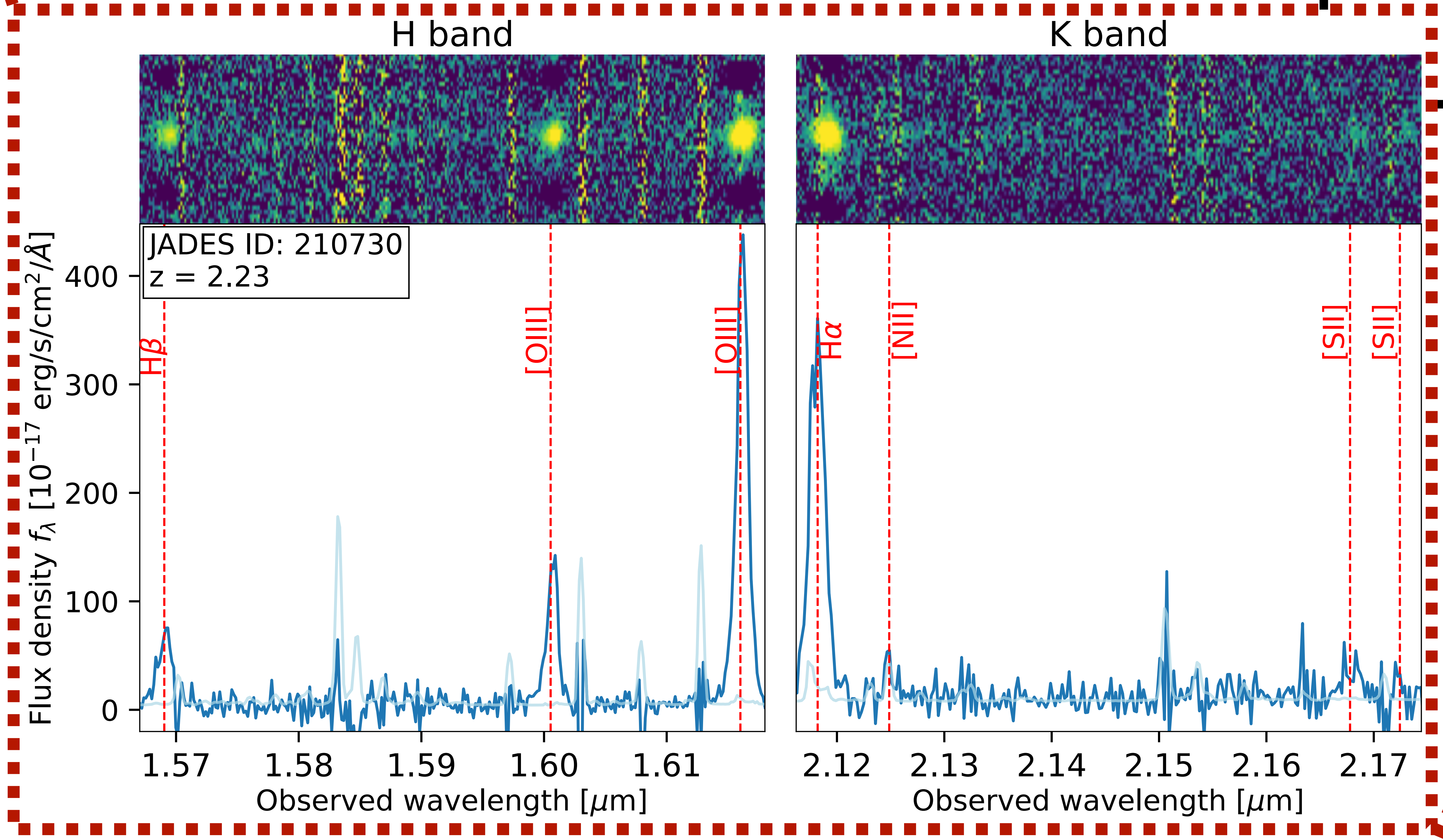


Andrew Mizener (PhD @ UMass)

W. M. KECK OBSERVATORY
Maunakea Island of Hawai'i



+ data reduction with PypeIt (Prochaska+20)

Arriscado *et al.* in prep.

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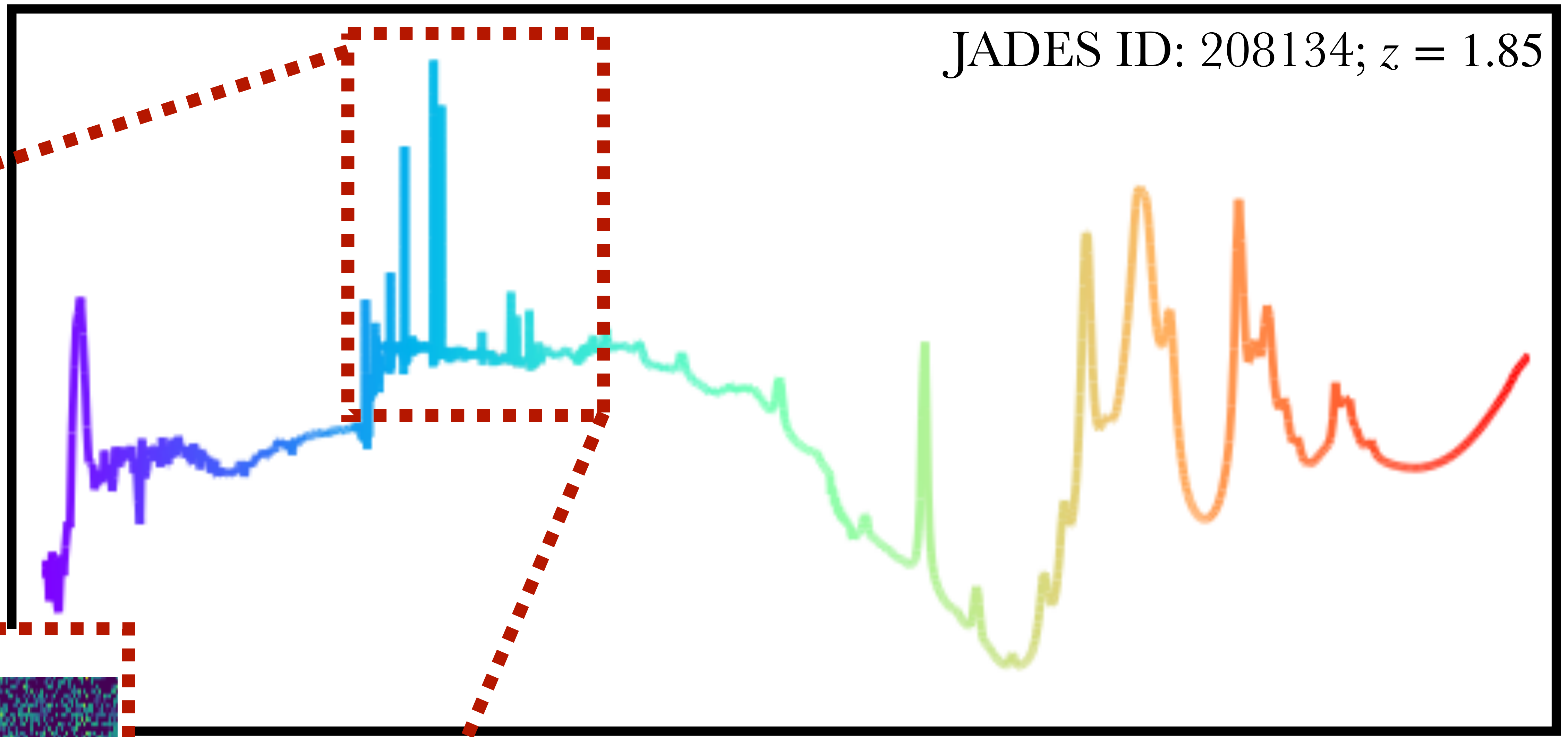

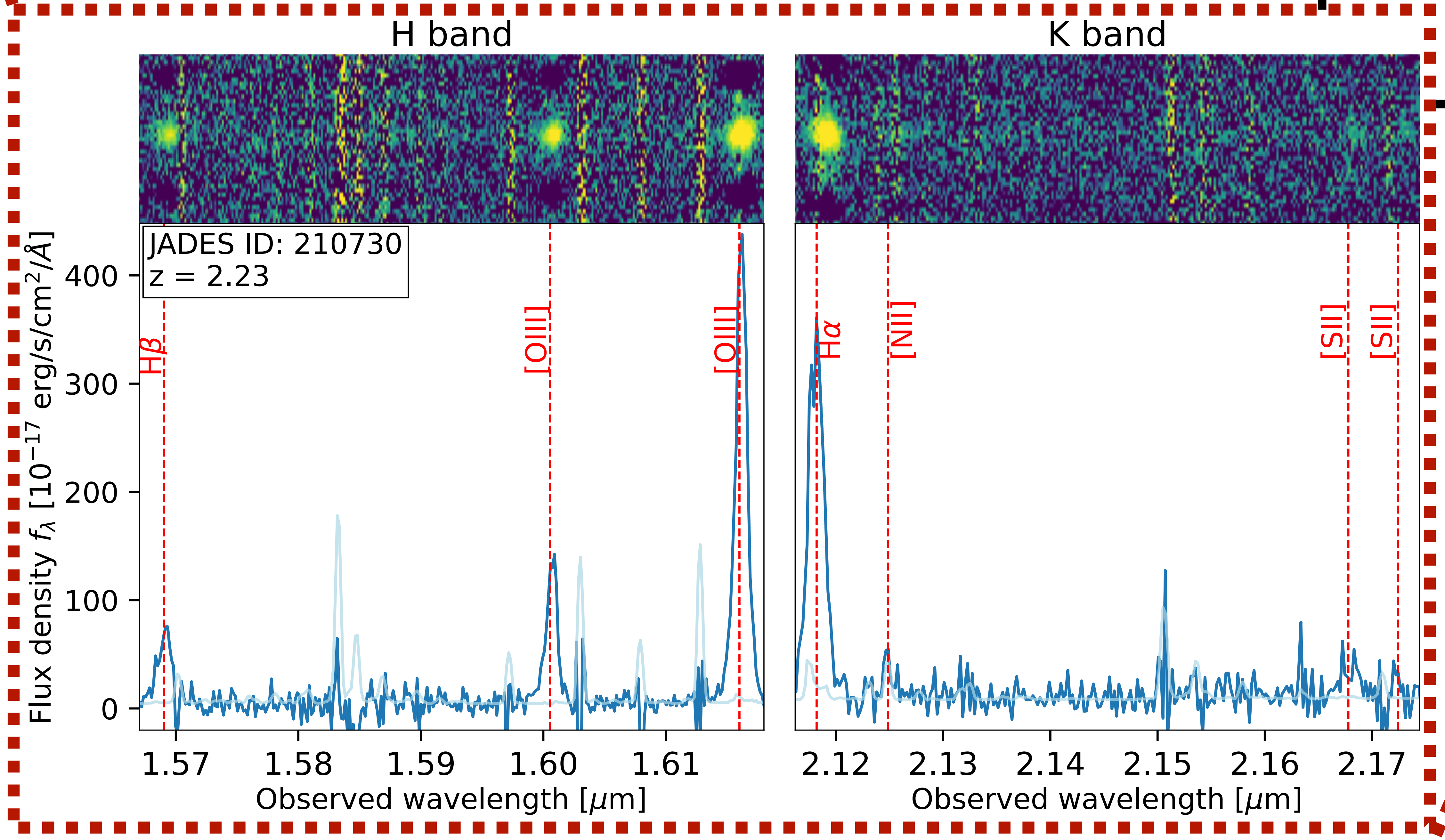

+ Flux measurements from JADES (Scholtz+25) and SMILES (Zhu+25)

+ Metallicity calibrations from Sanders+25

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JADES JWST ADVANCED DEEP EXTRAGALACTIC SURVEY

Arriscado *et al.* in prep.

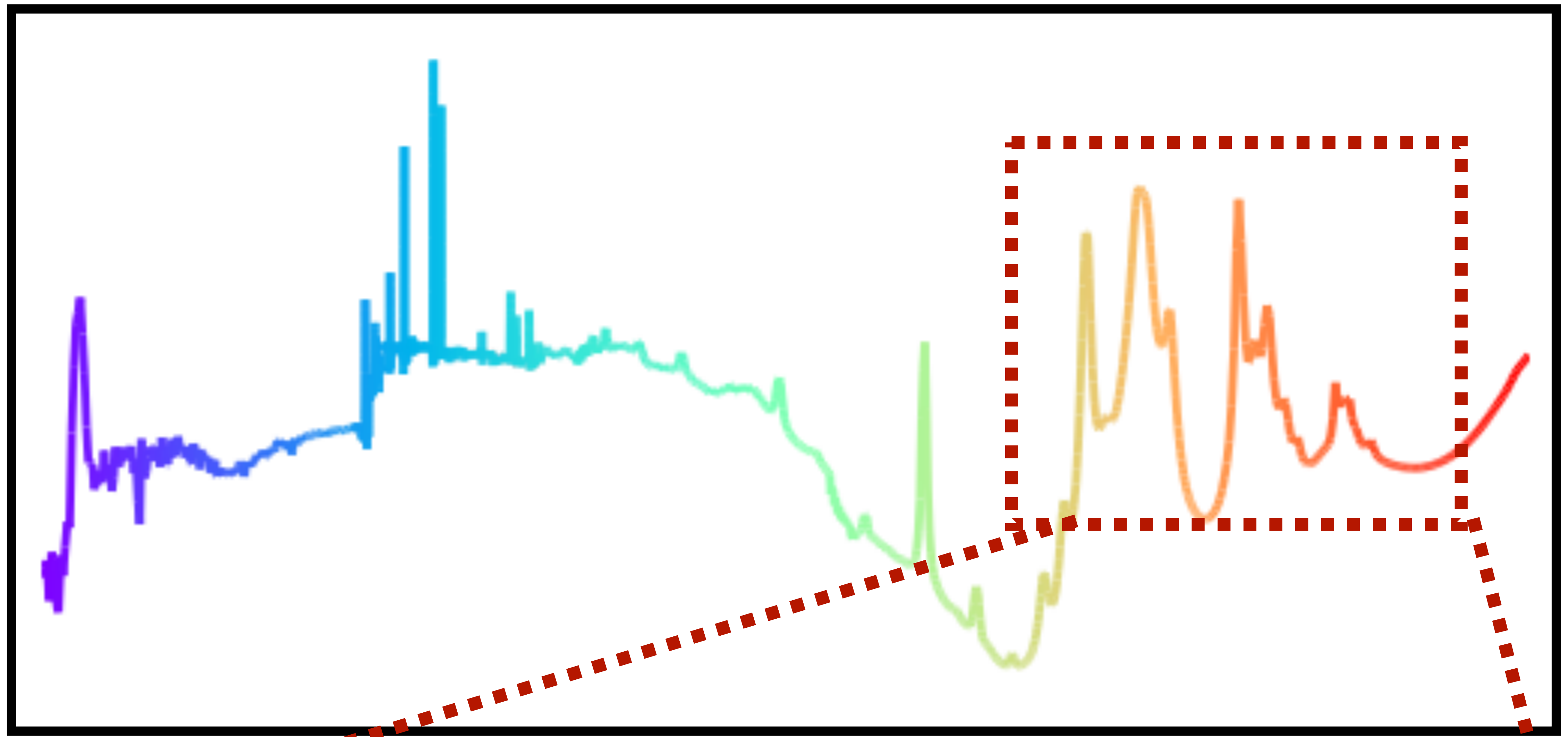
Data and methods

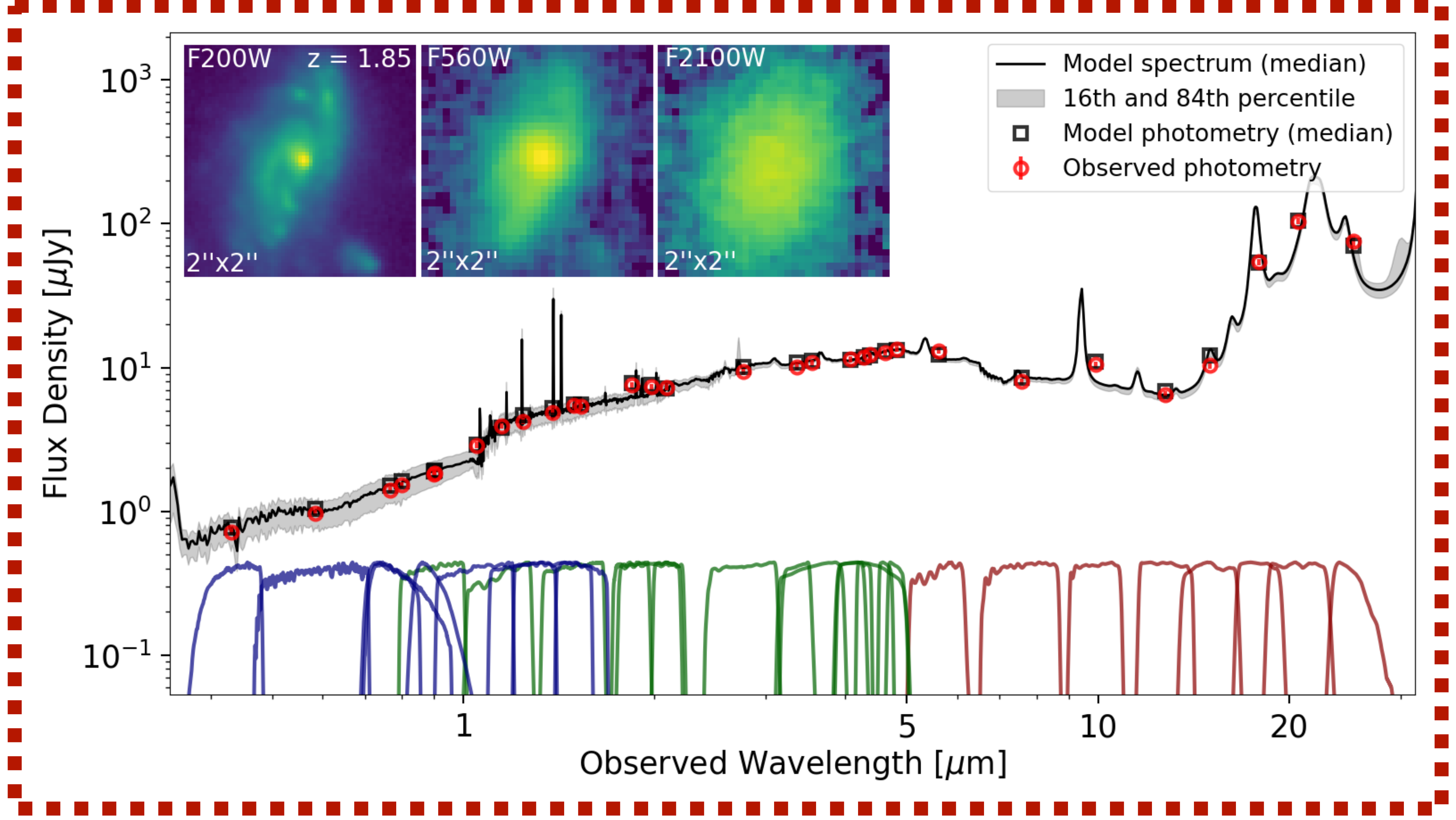
- UV bump: VLT/ MUSE data (Bacon+17, Inami+17)

- Gas-phase metallicities: Keck/MOSFIRE observations (observing programs 2022B+2024B, PIs: D. Calzetti and I. Shivaei)

- PAH emission: JWST/MIRI (SMILES; Alberts+24) + SED fitting (Prospector)

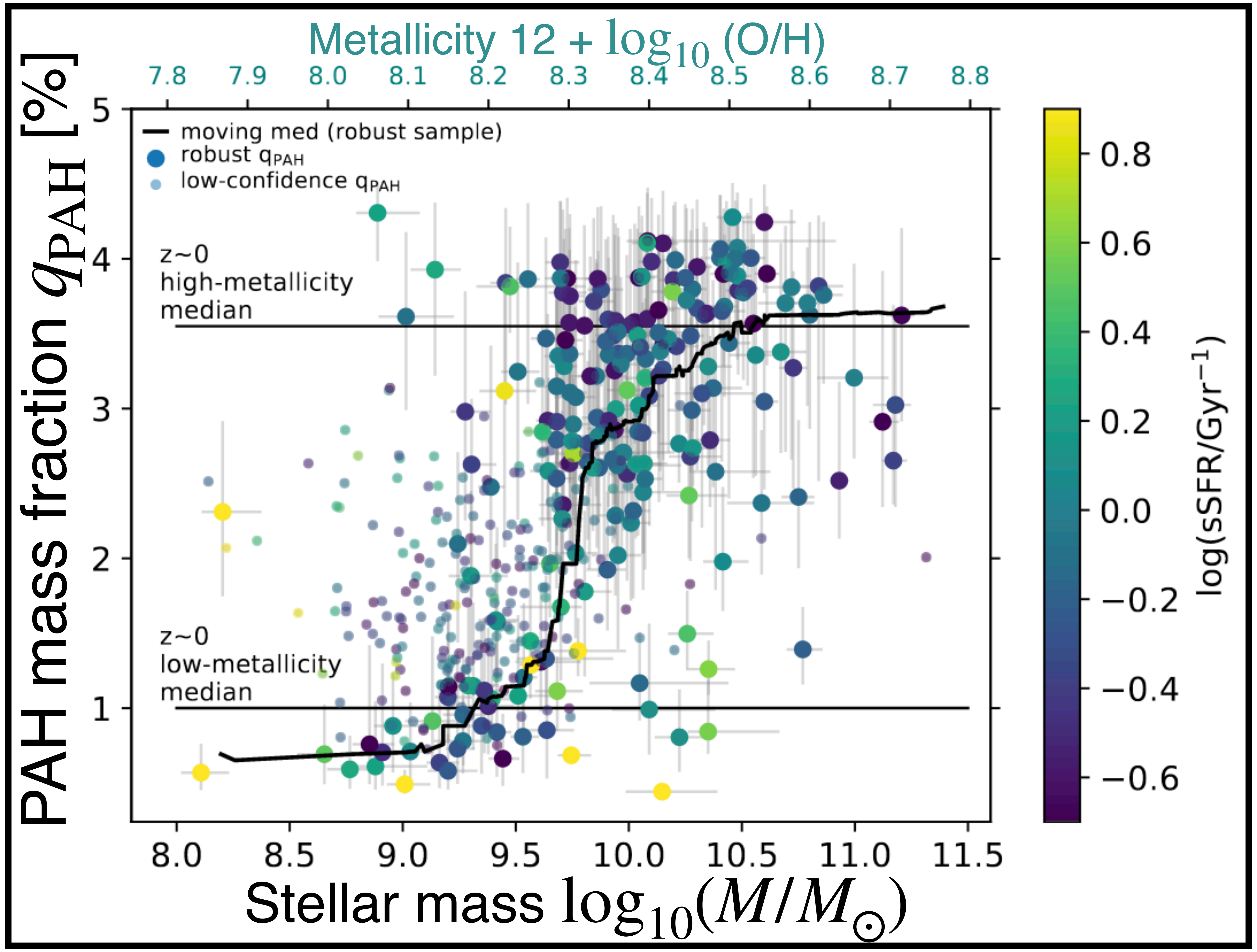
+ JWST/NIRCam (JADES; Eisenstein+23)





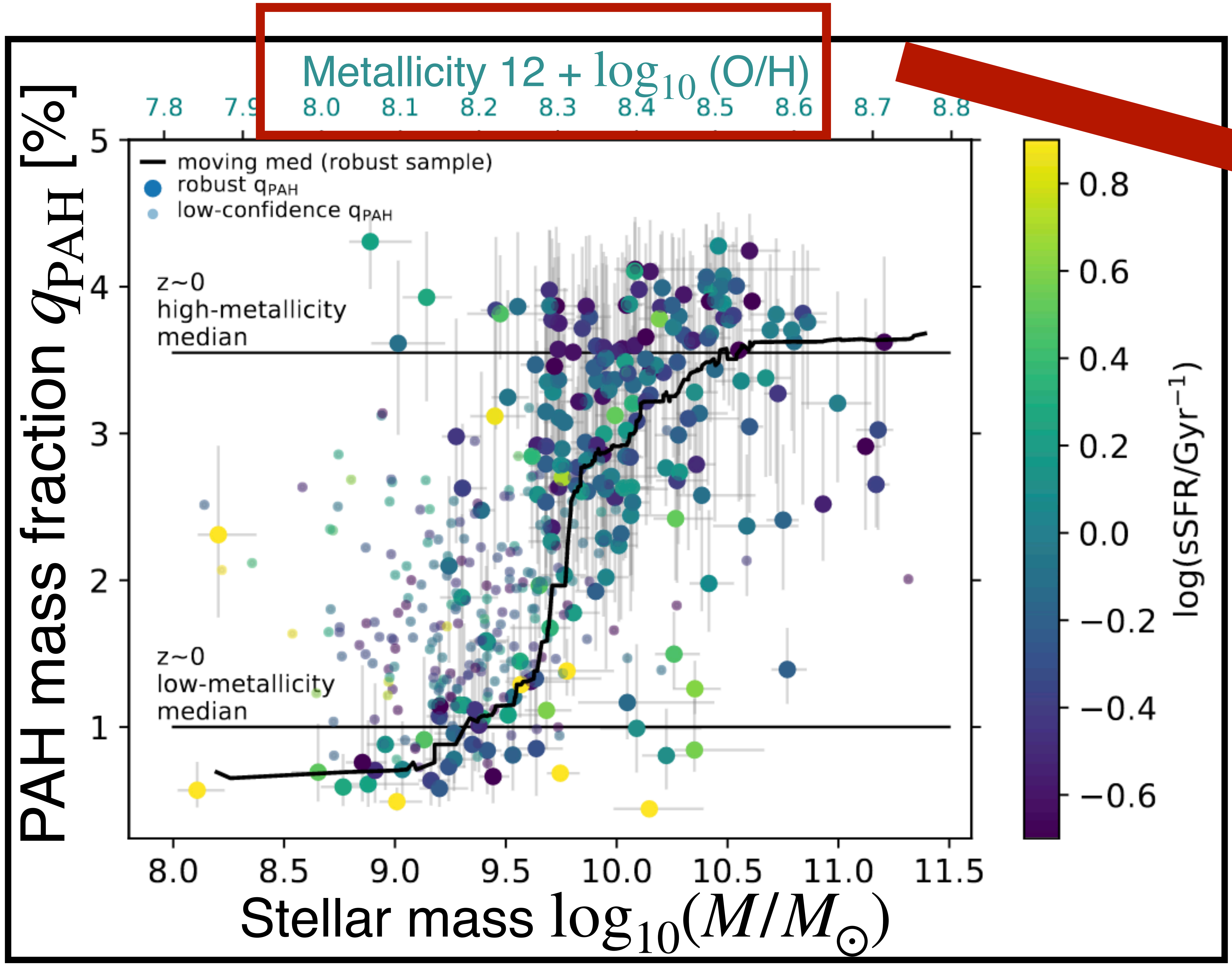
Arriscado *et al.* in prep.

Results: PAH emission and stellar mass/metallicity



$z = 0.7 - 2$ galaxies; Shivaei+24

Results: PAH emission and stellar mass/metallicity



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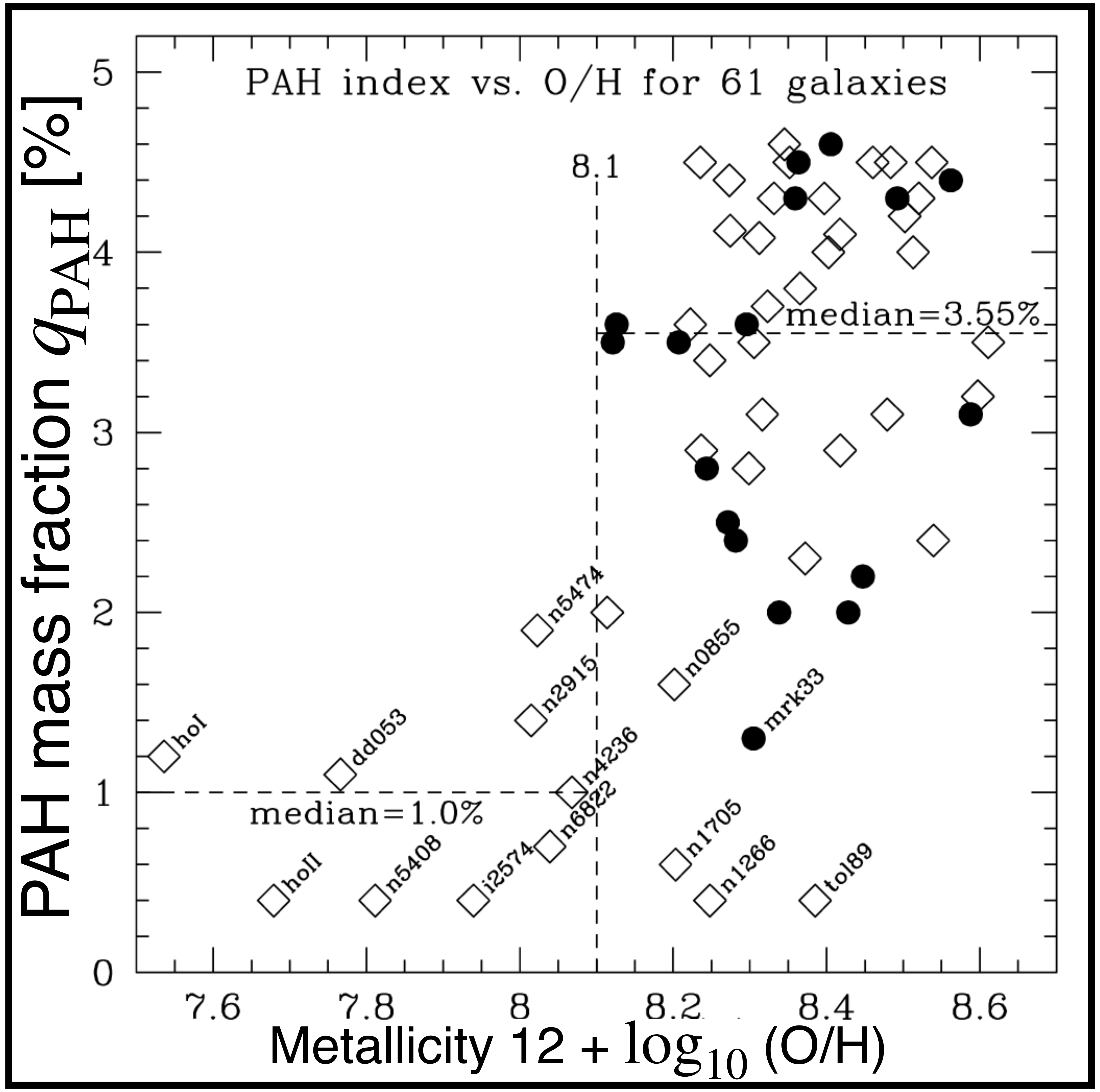
Metallicities derived from the MZR!

Results: PAH emission and stellar mass/metallicity



$z \sim 0$ galaxies; Draine+07

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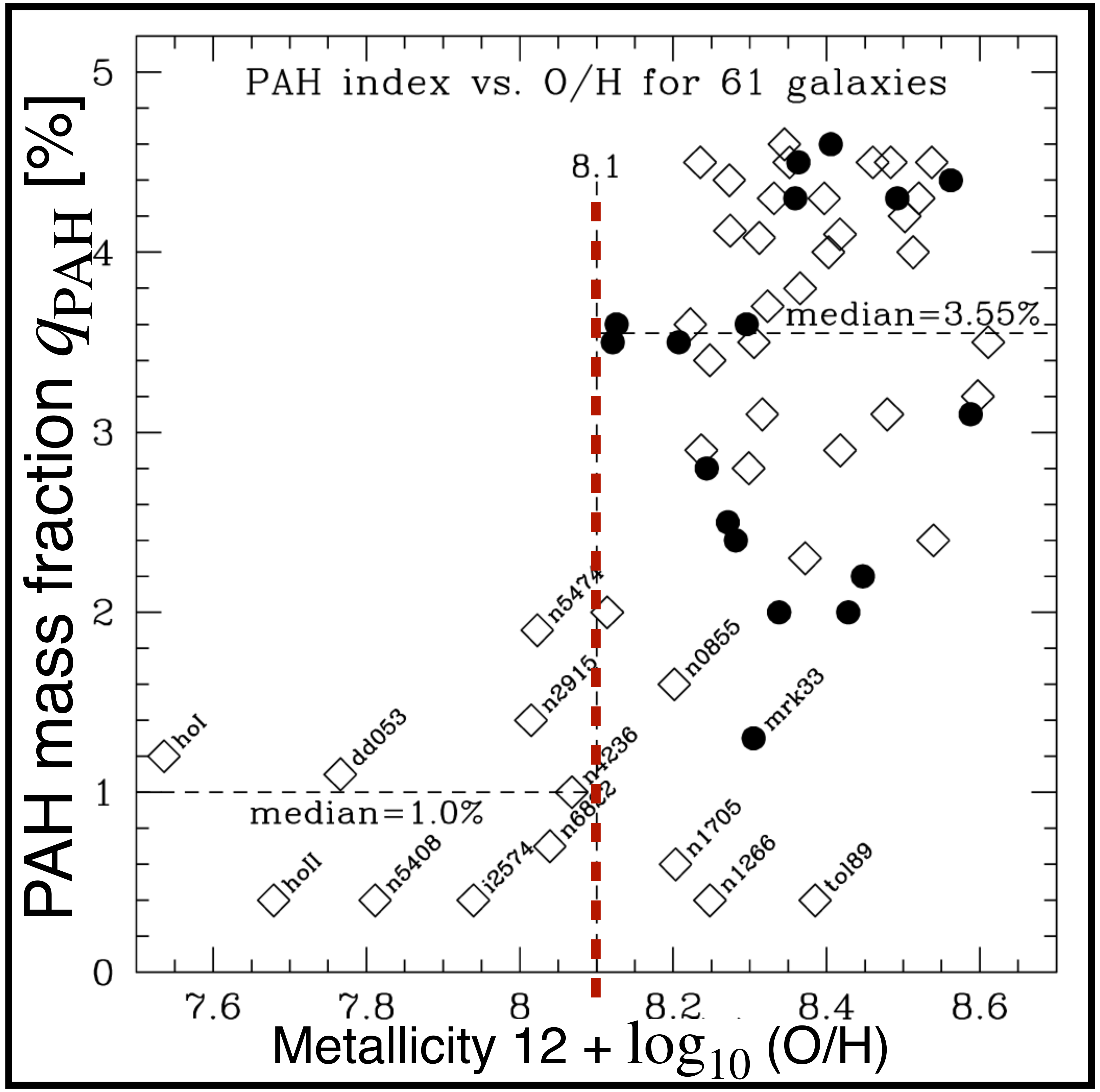

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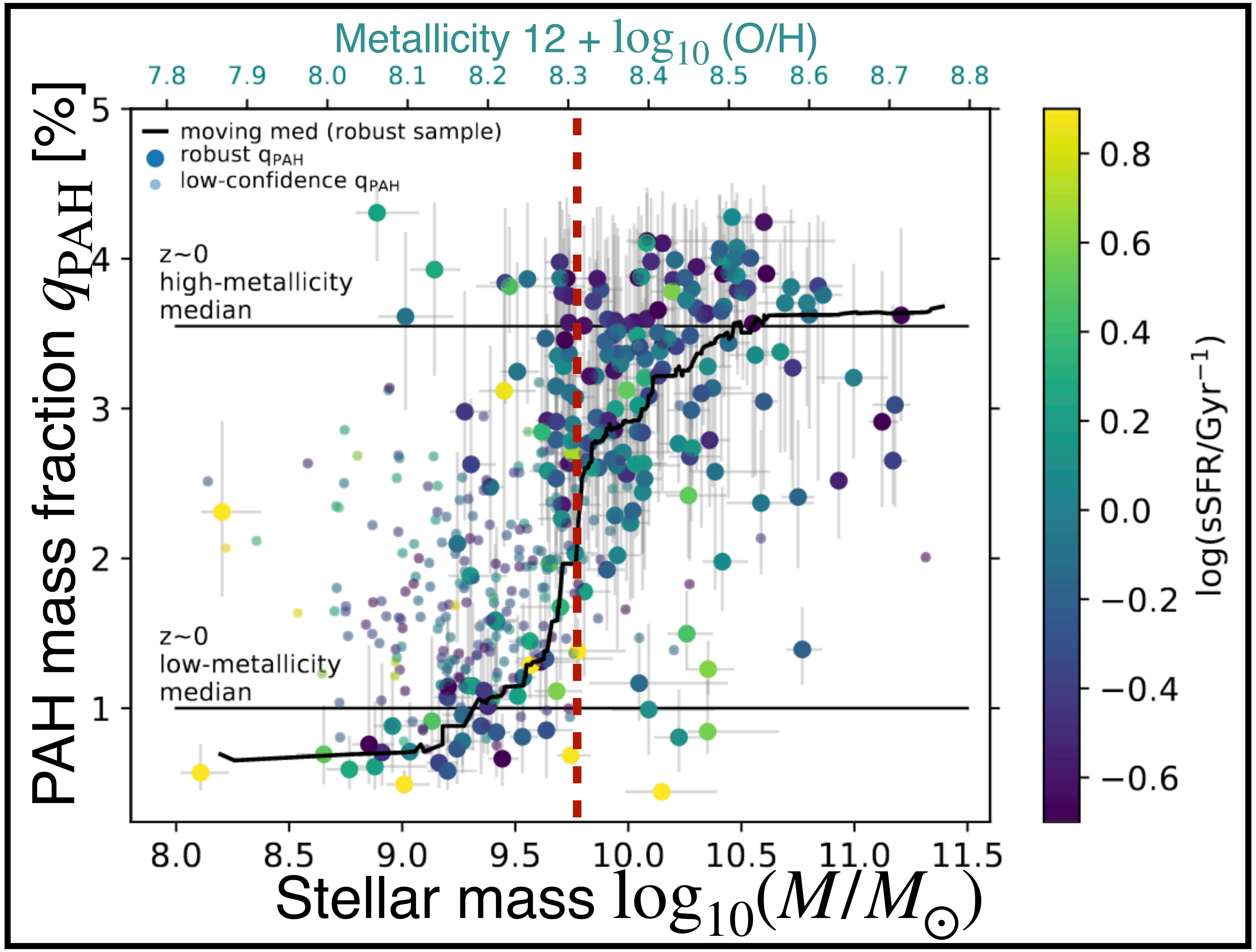

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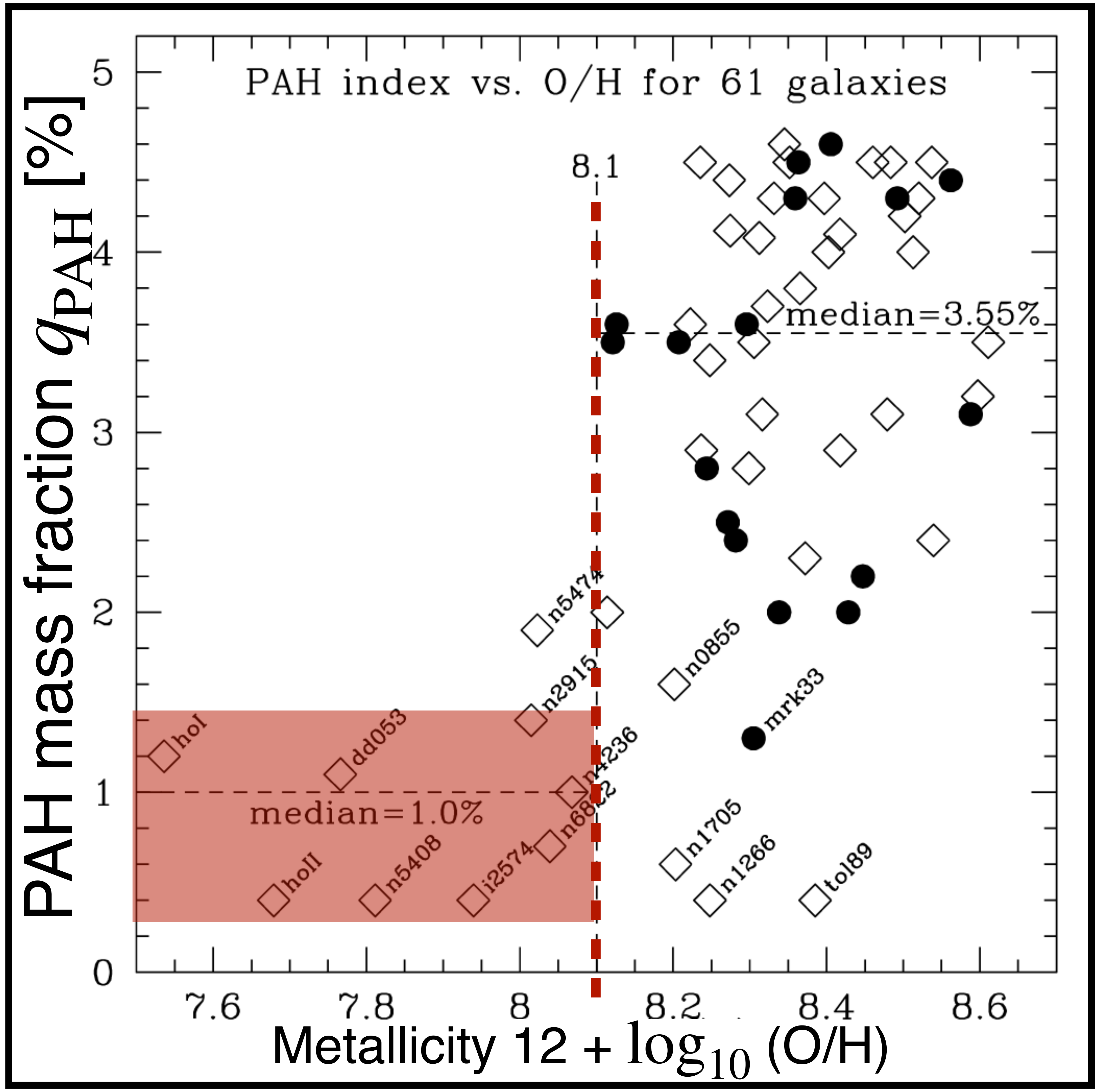

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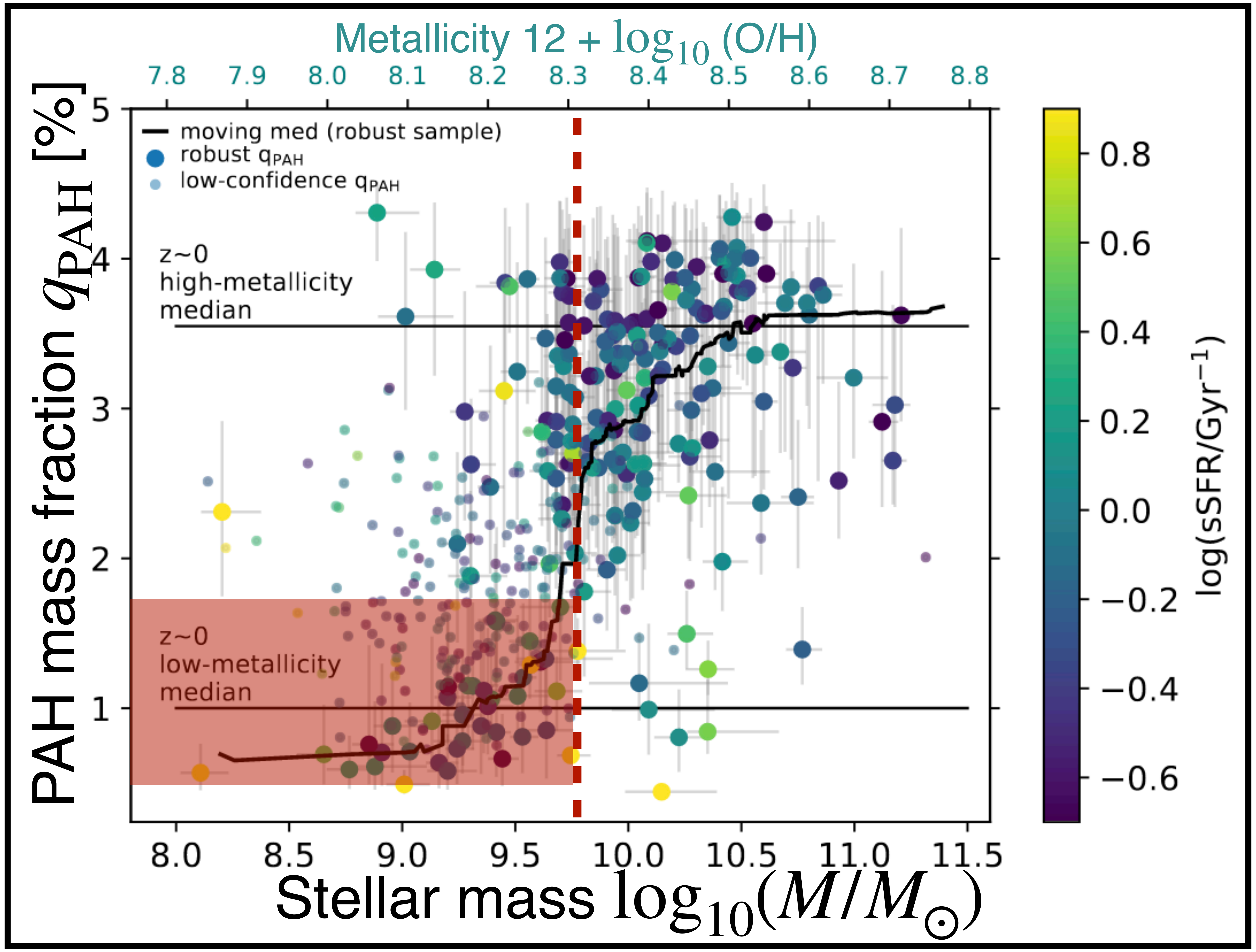

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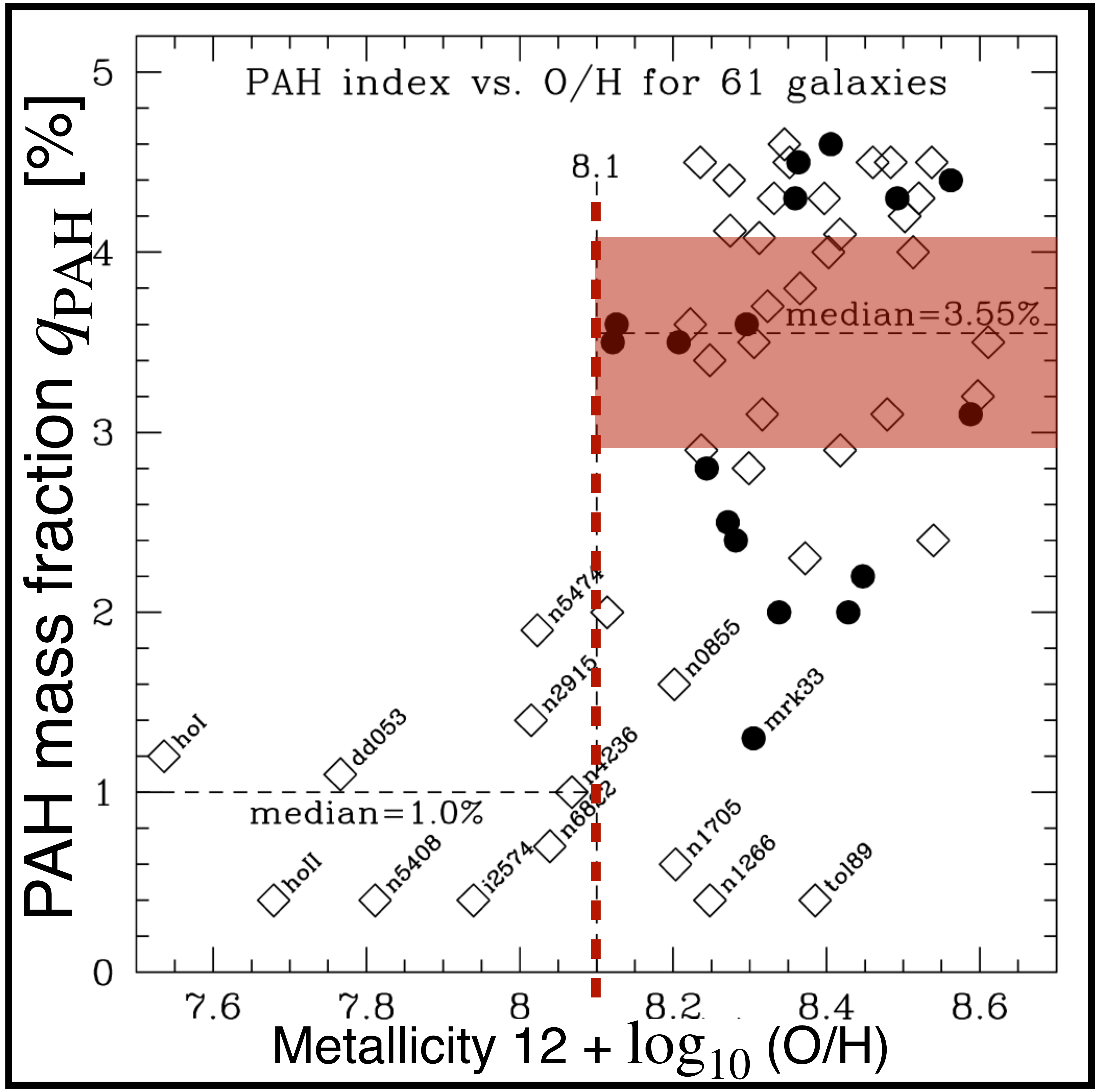

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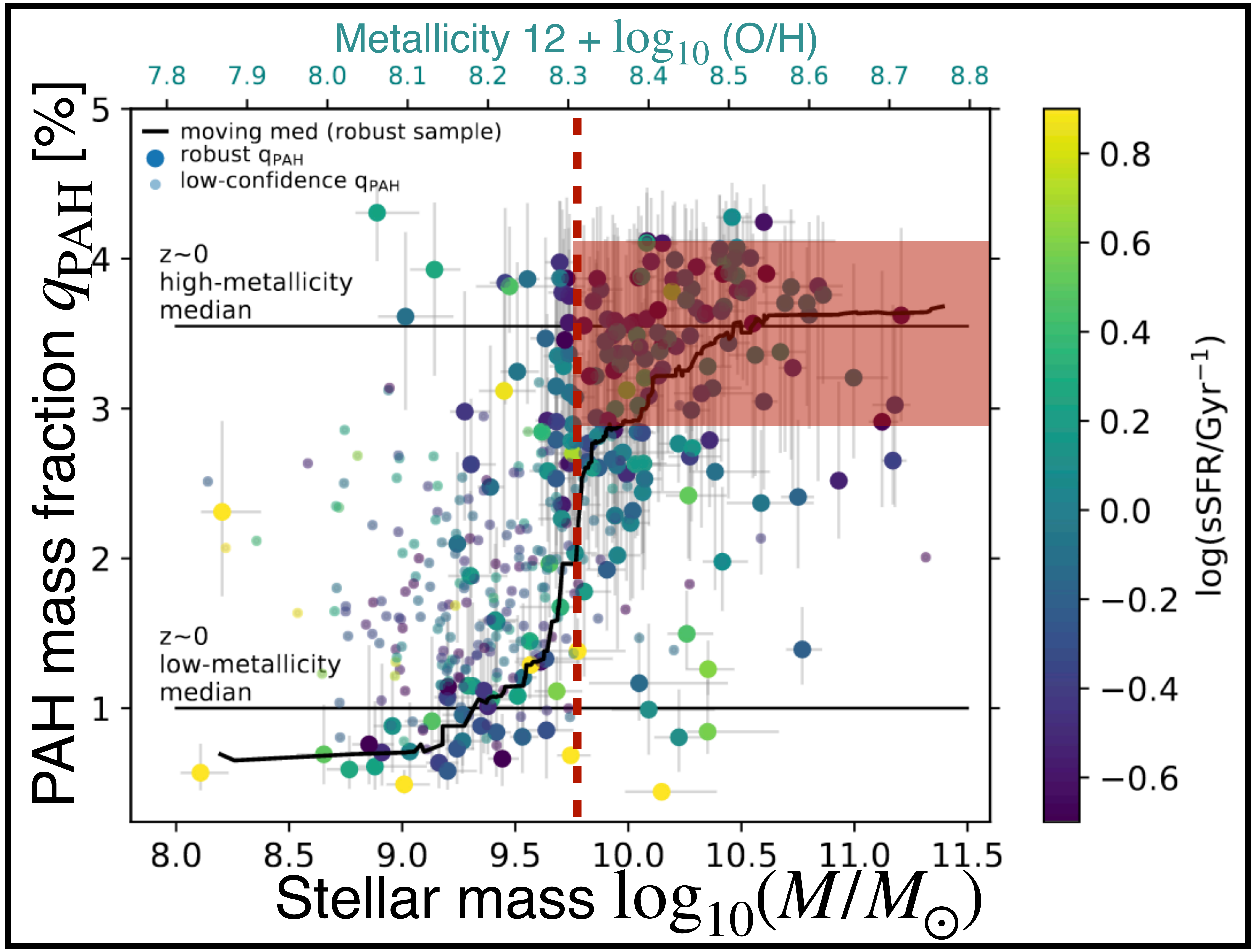

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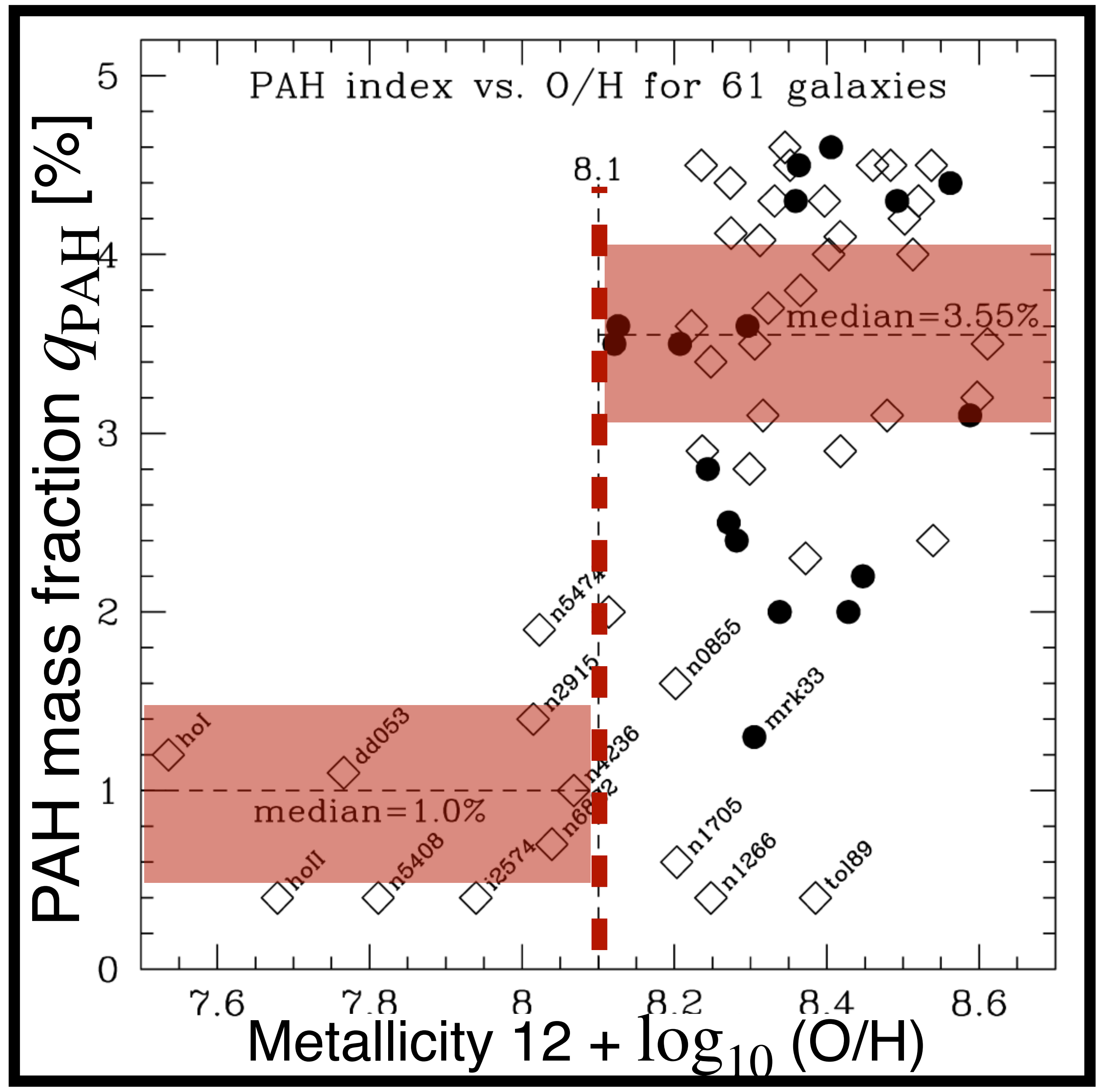

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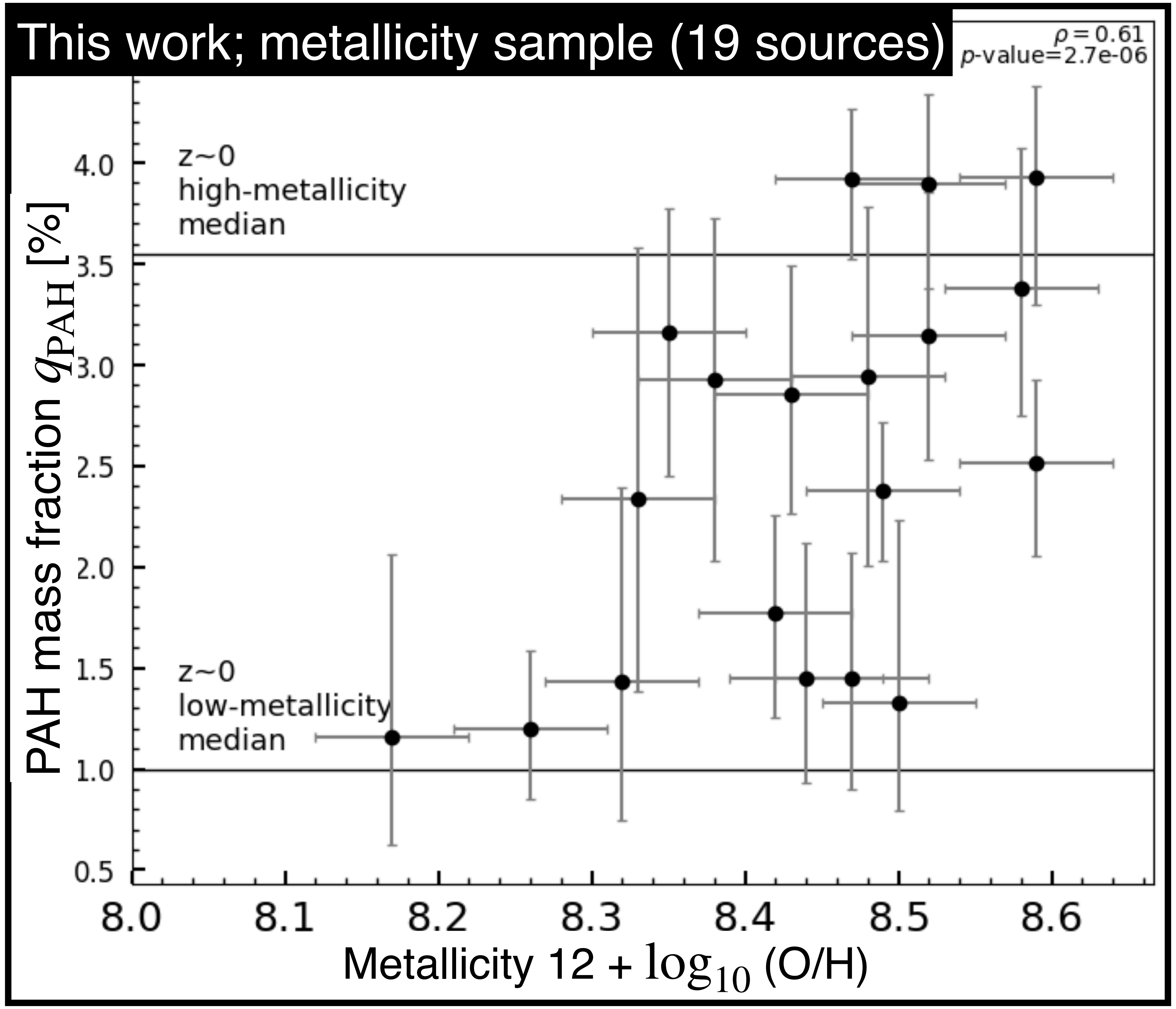

$z \sim 2$ galaxies; Arriscado *et al.* in prep.

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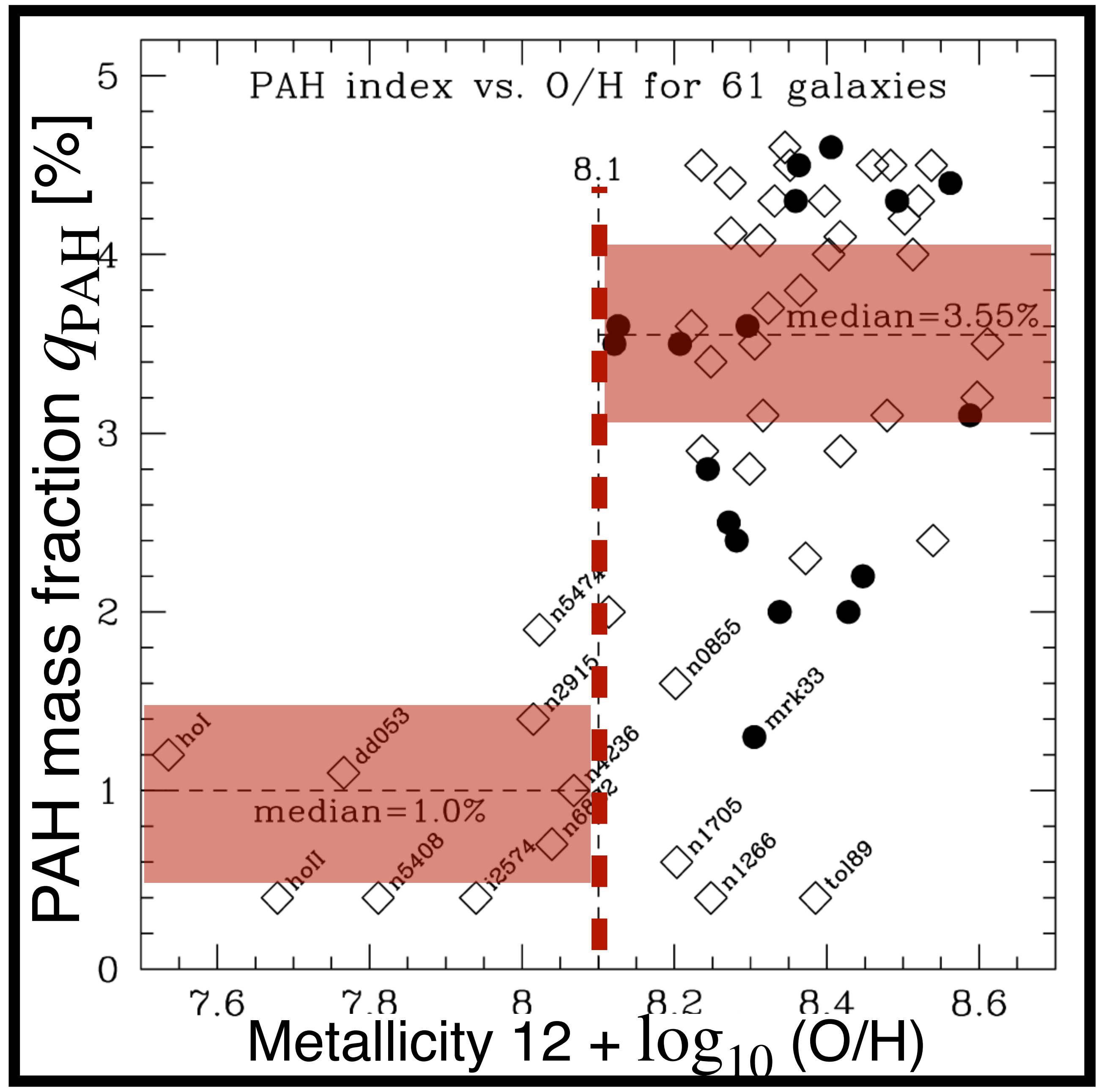

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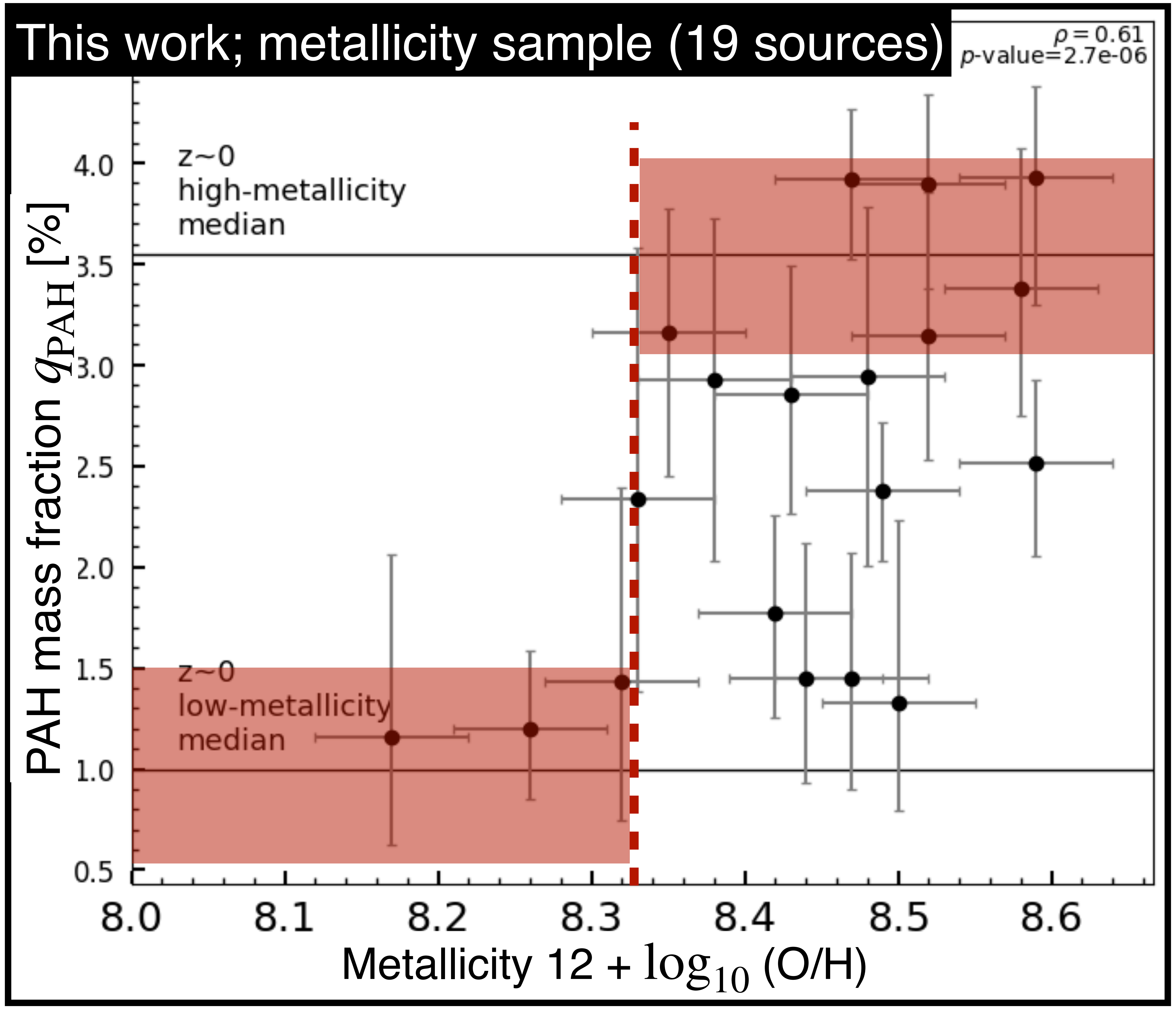

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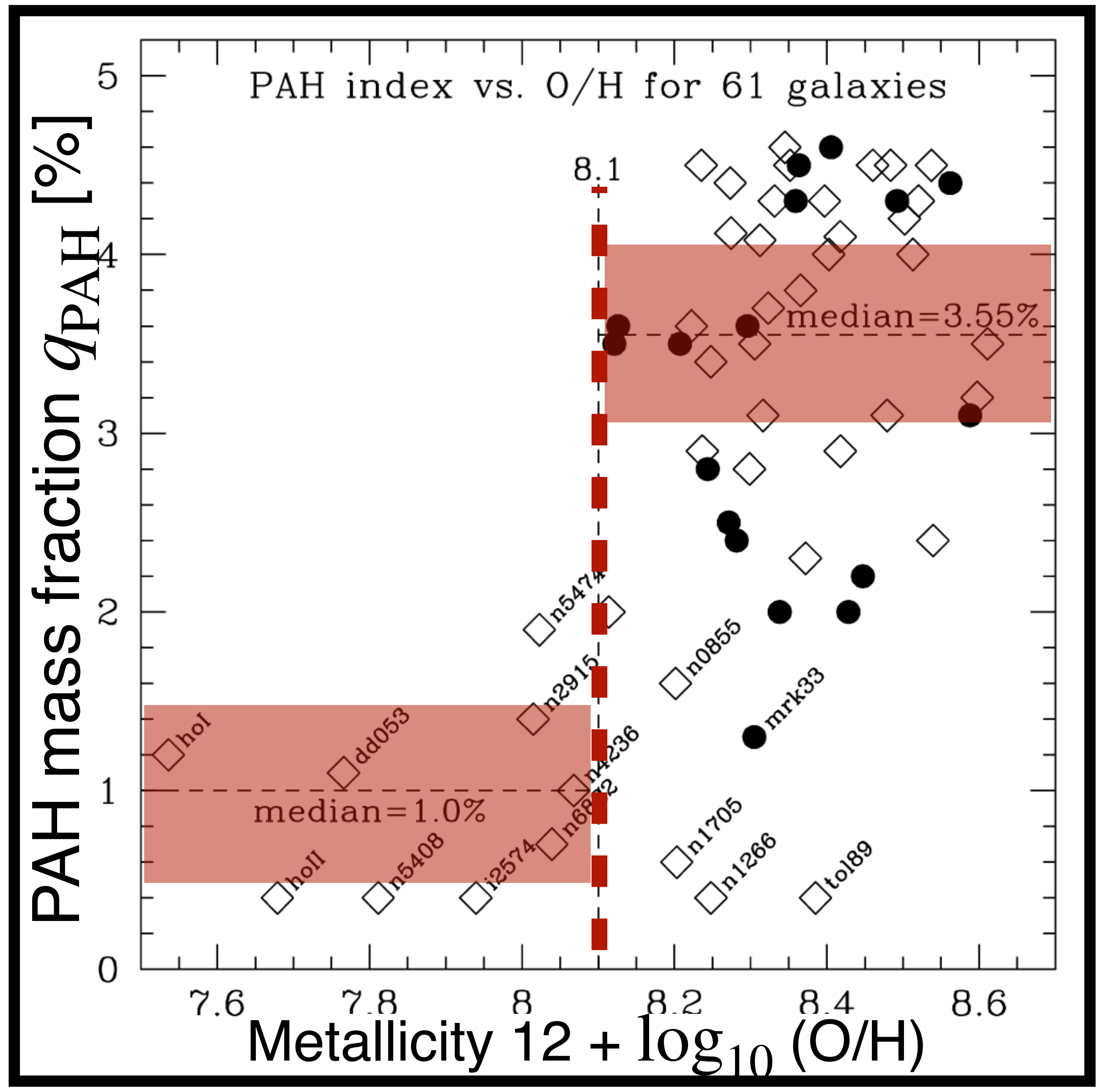
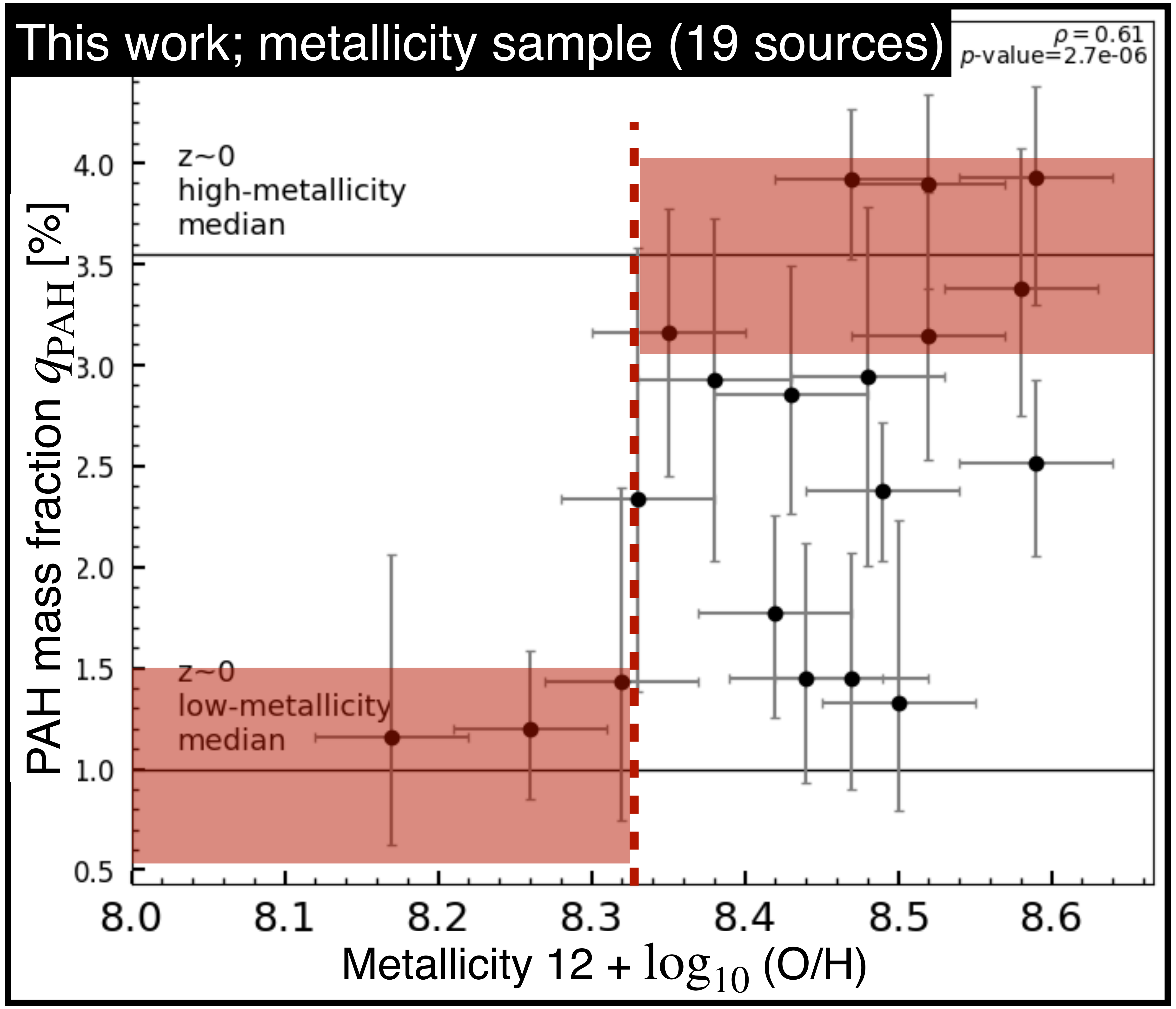


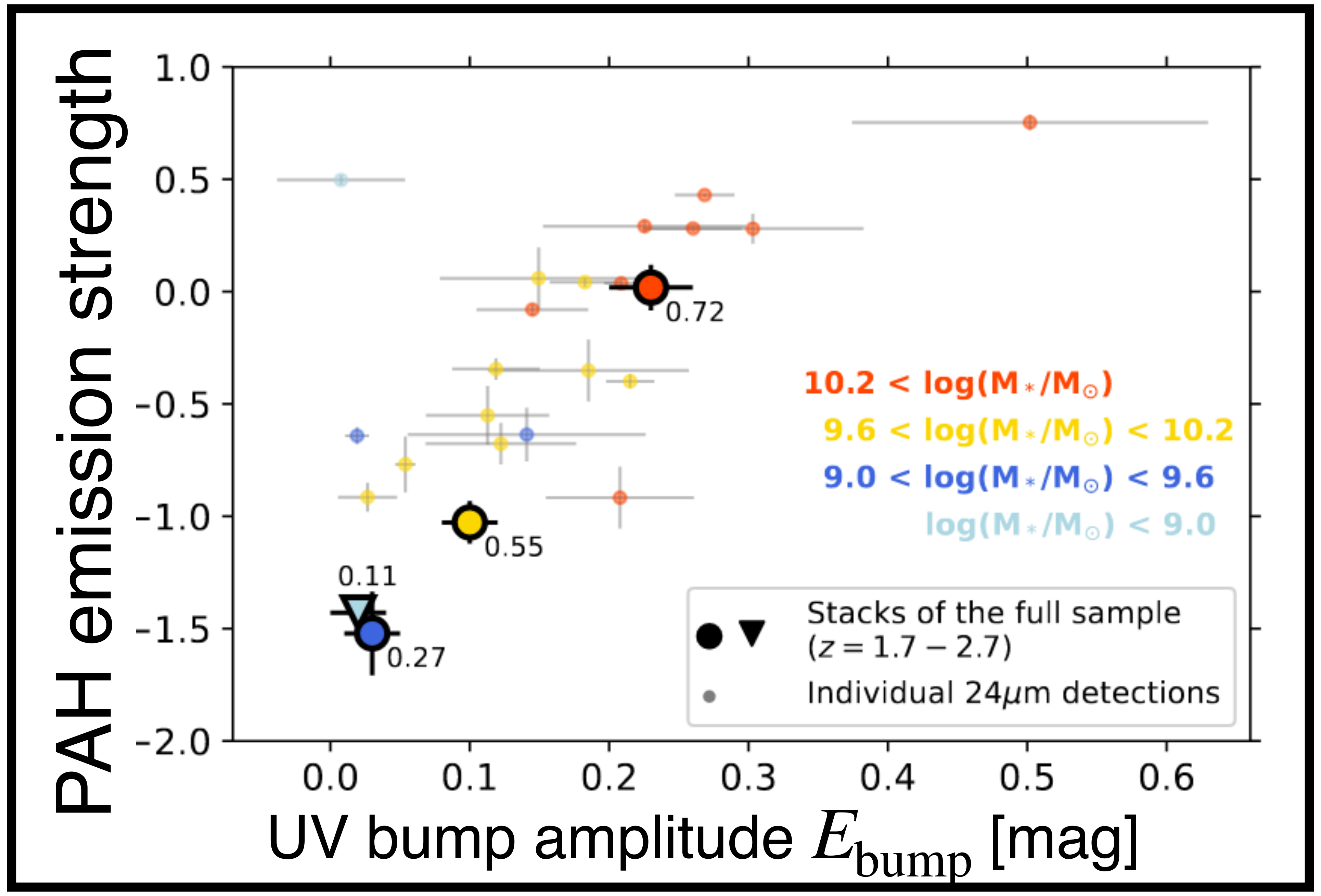
$z \sim 0$ galaxies; Draine+07

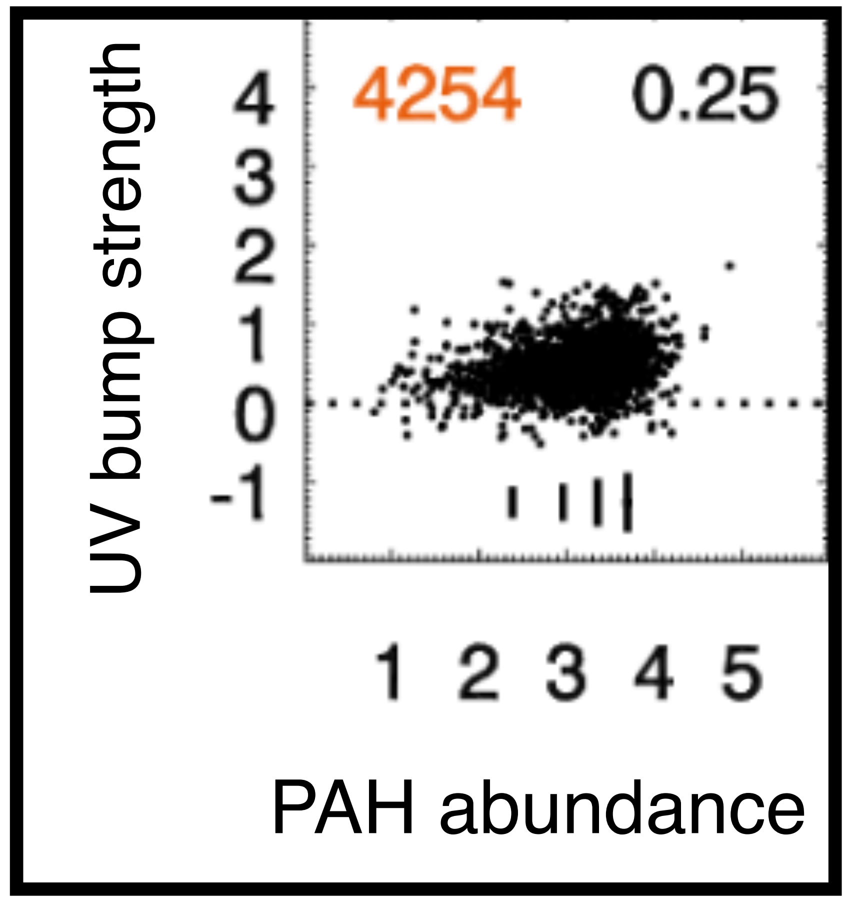
PAH emission correlates with metallicity, supporting a scenario where low-metallicity regions have a lower abundance of PAH molecules



$z \sim 2$ galaxies; Arriscado *et al.* in prep.

Results: PAH emission, UV bump, and stellar mass





$z \sim 2$ galaxies; Shivaei+22

Local galaxies; Battisti+24

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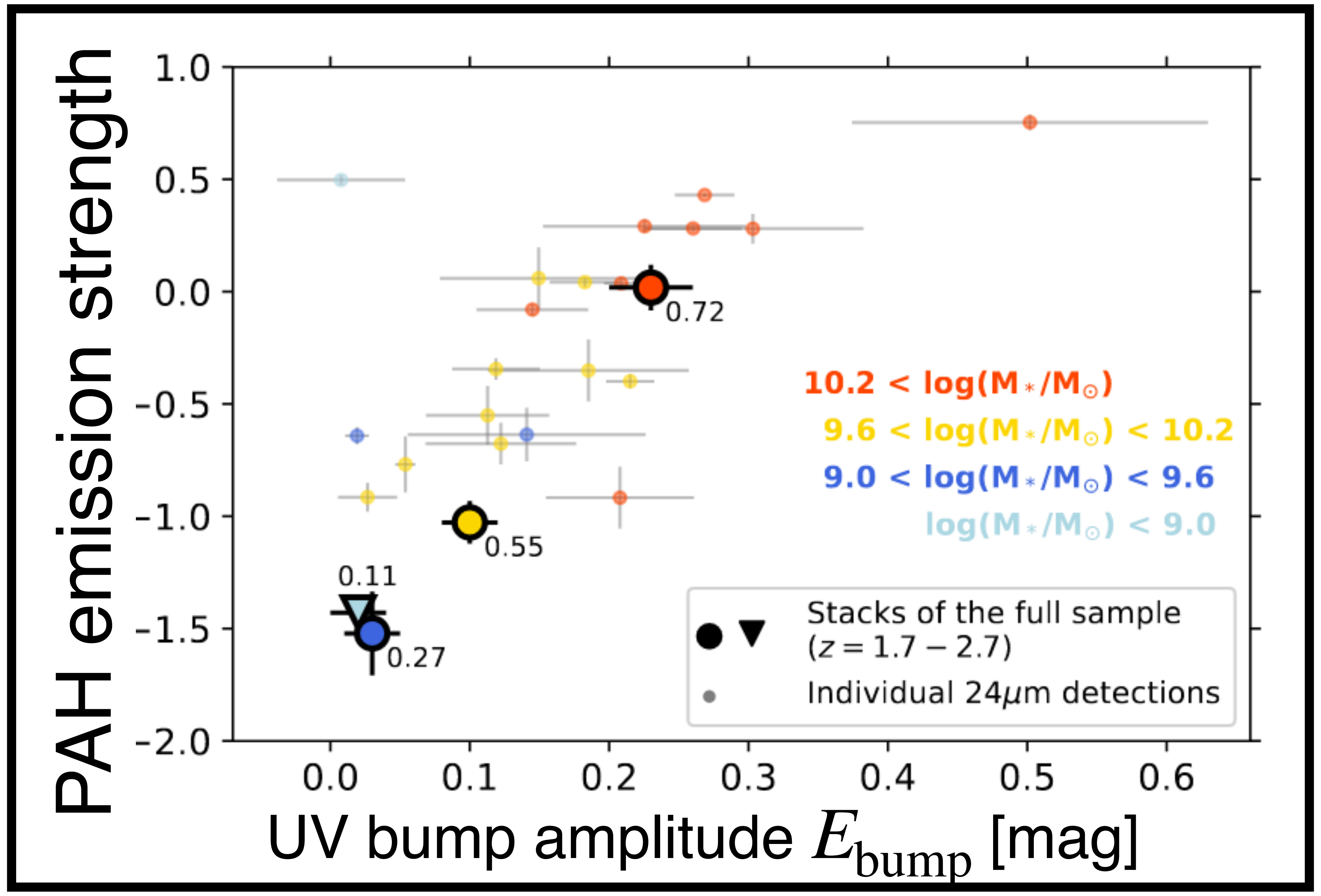

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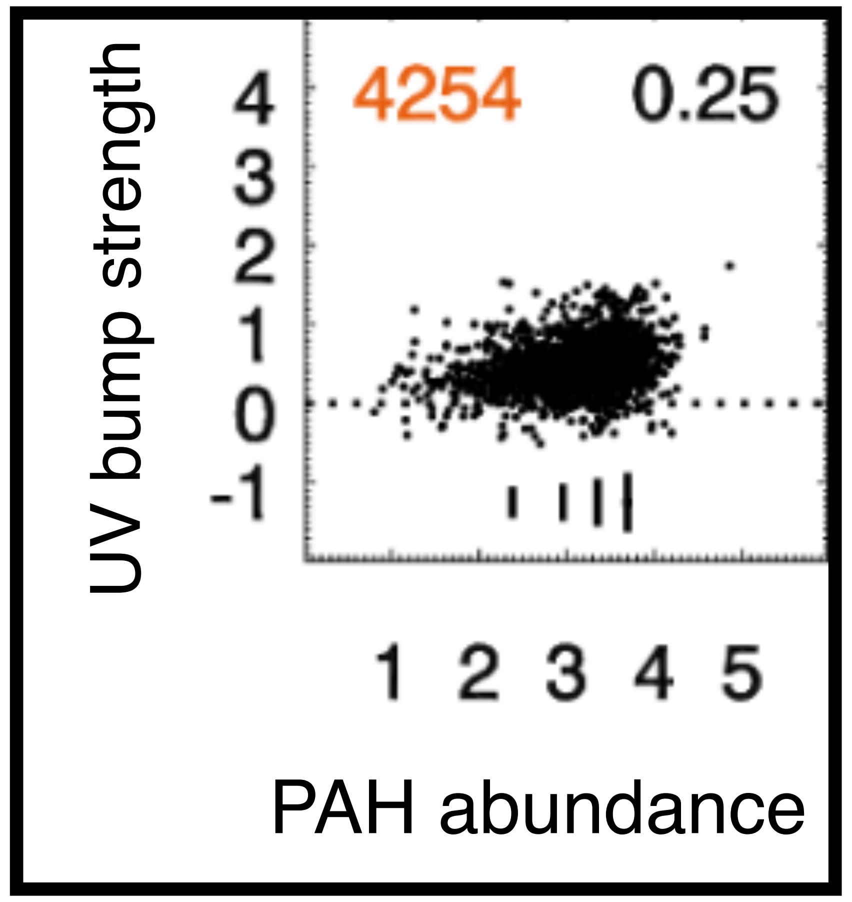

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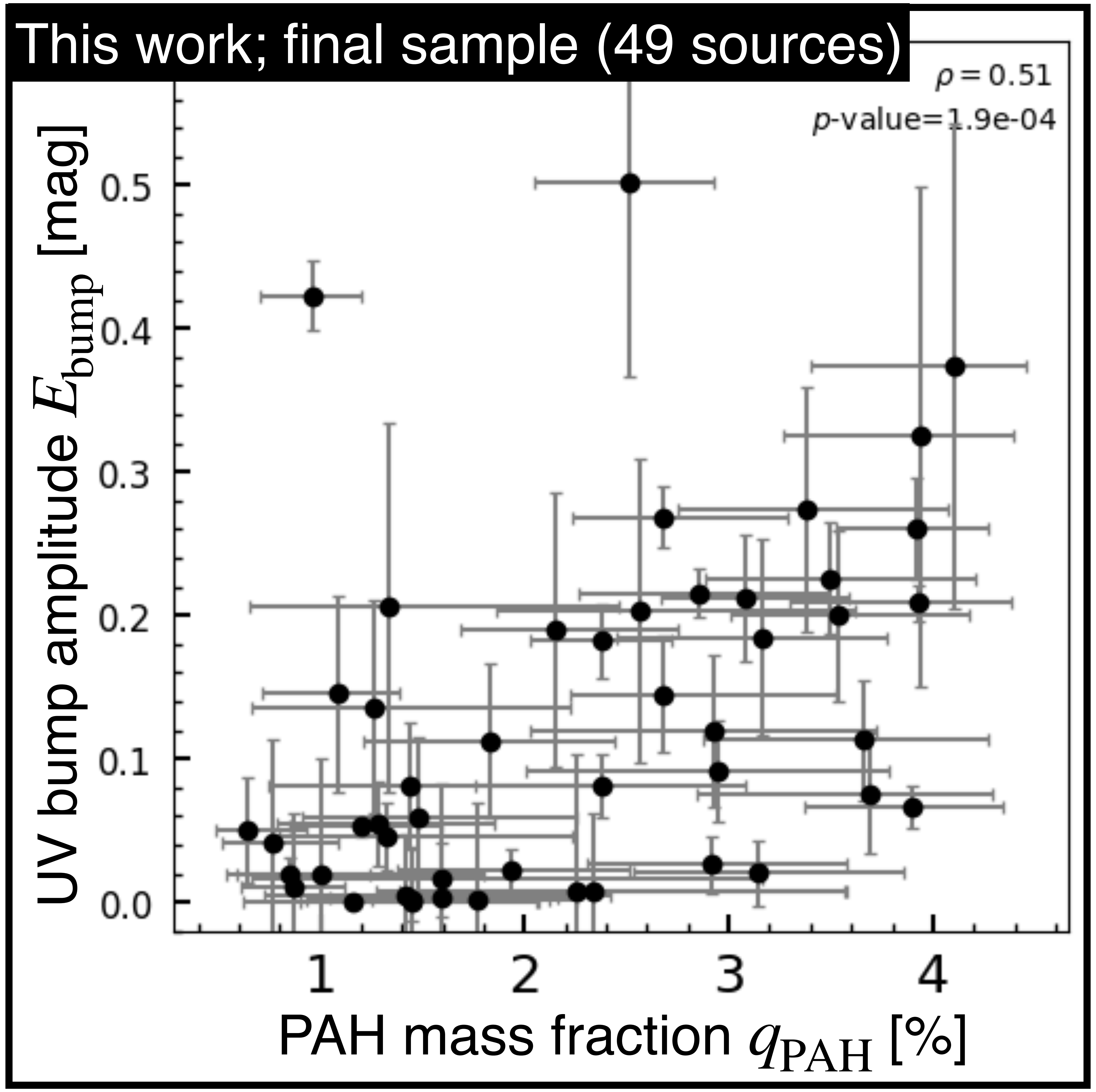

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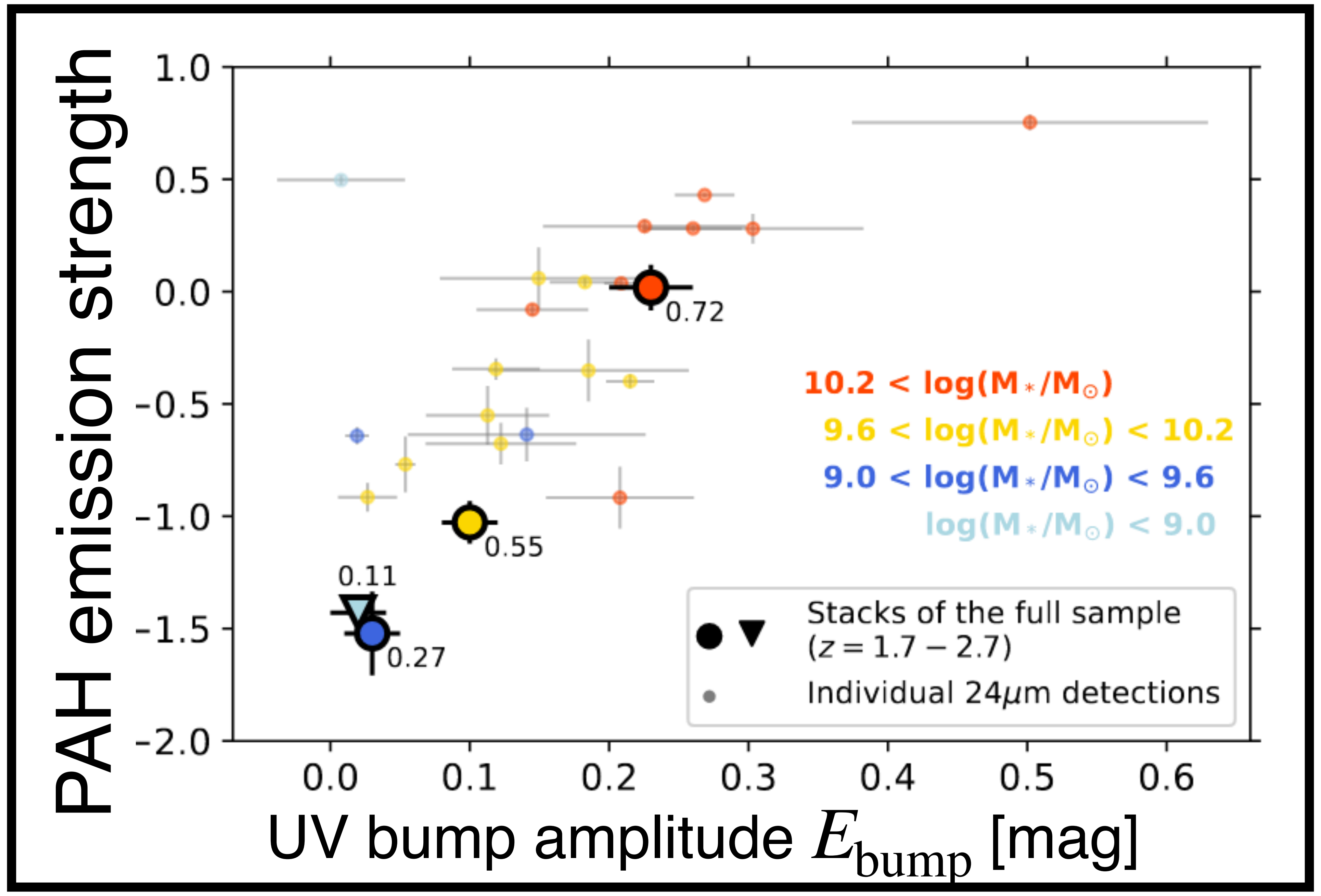

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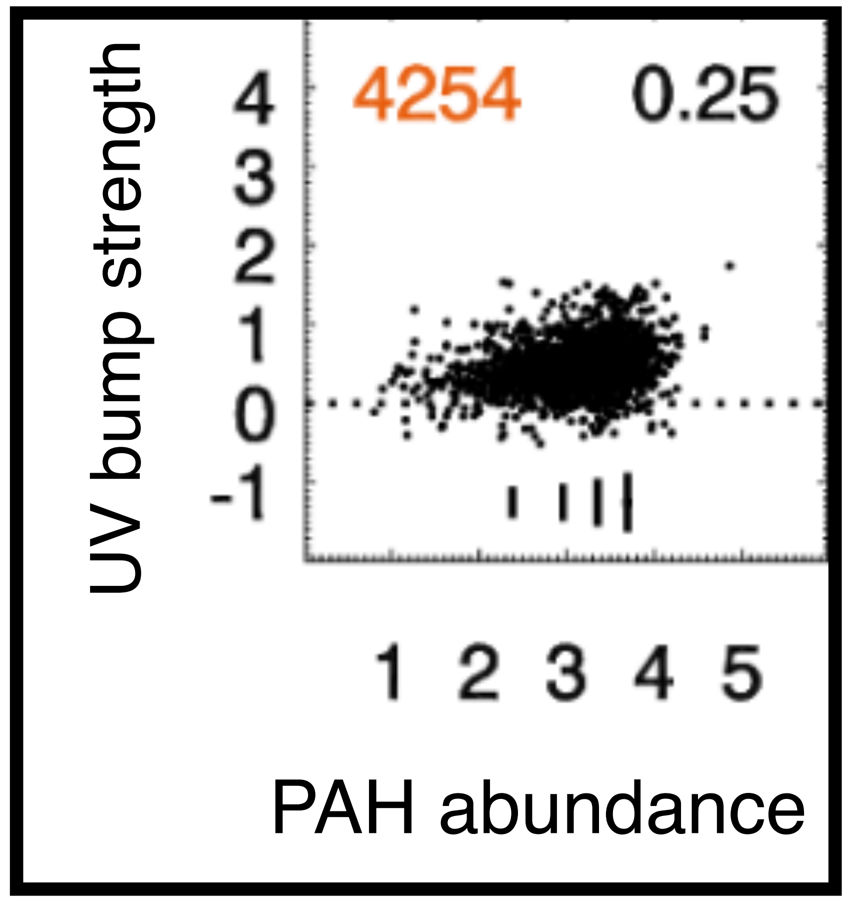

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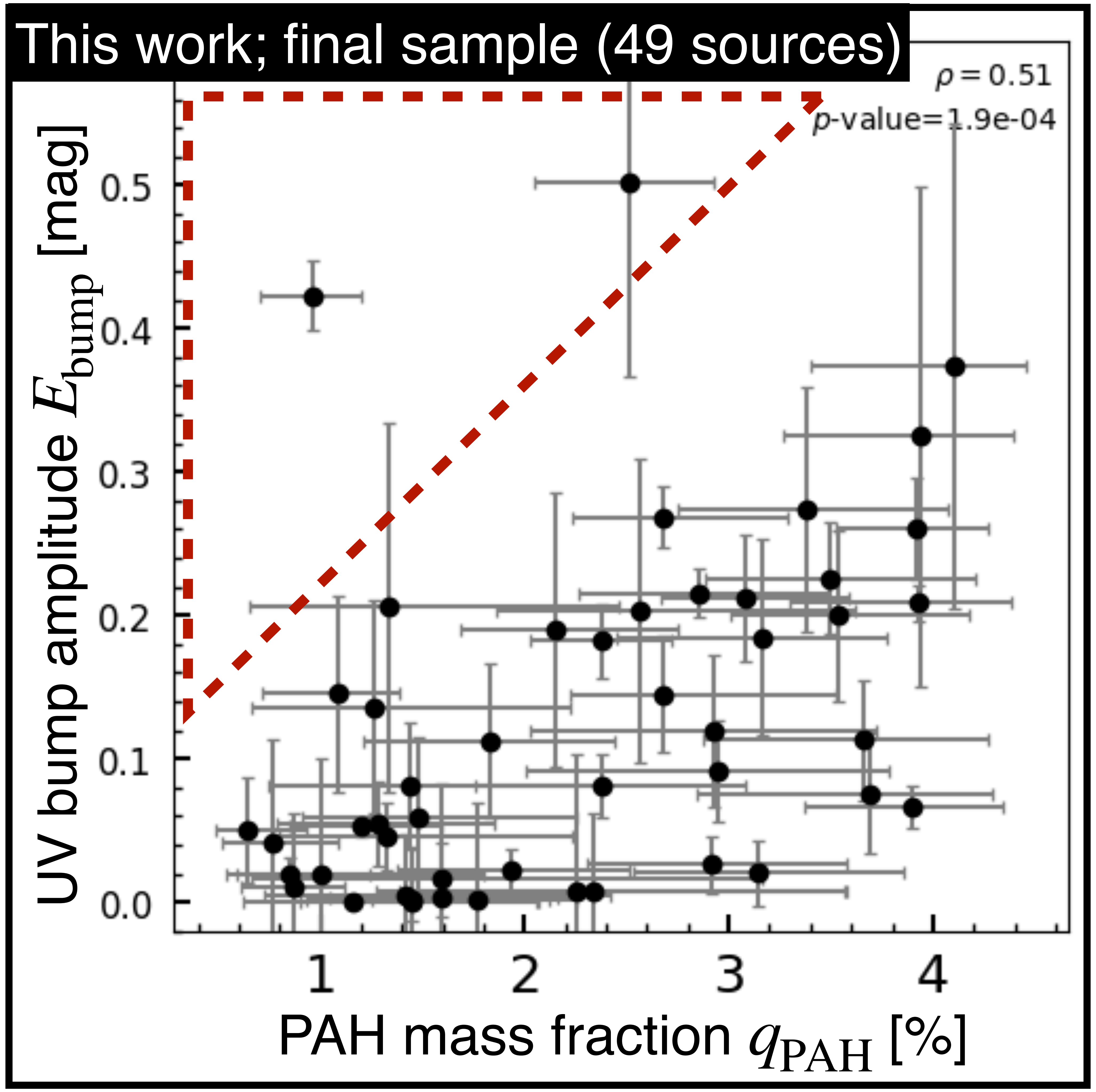

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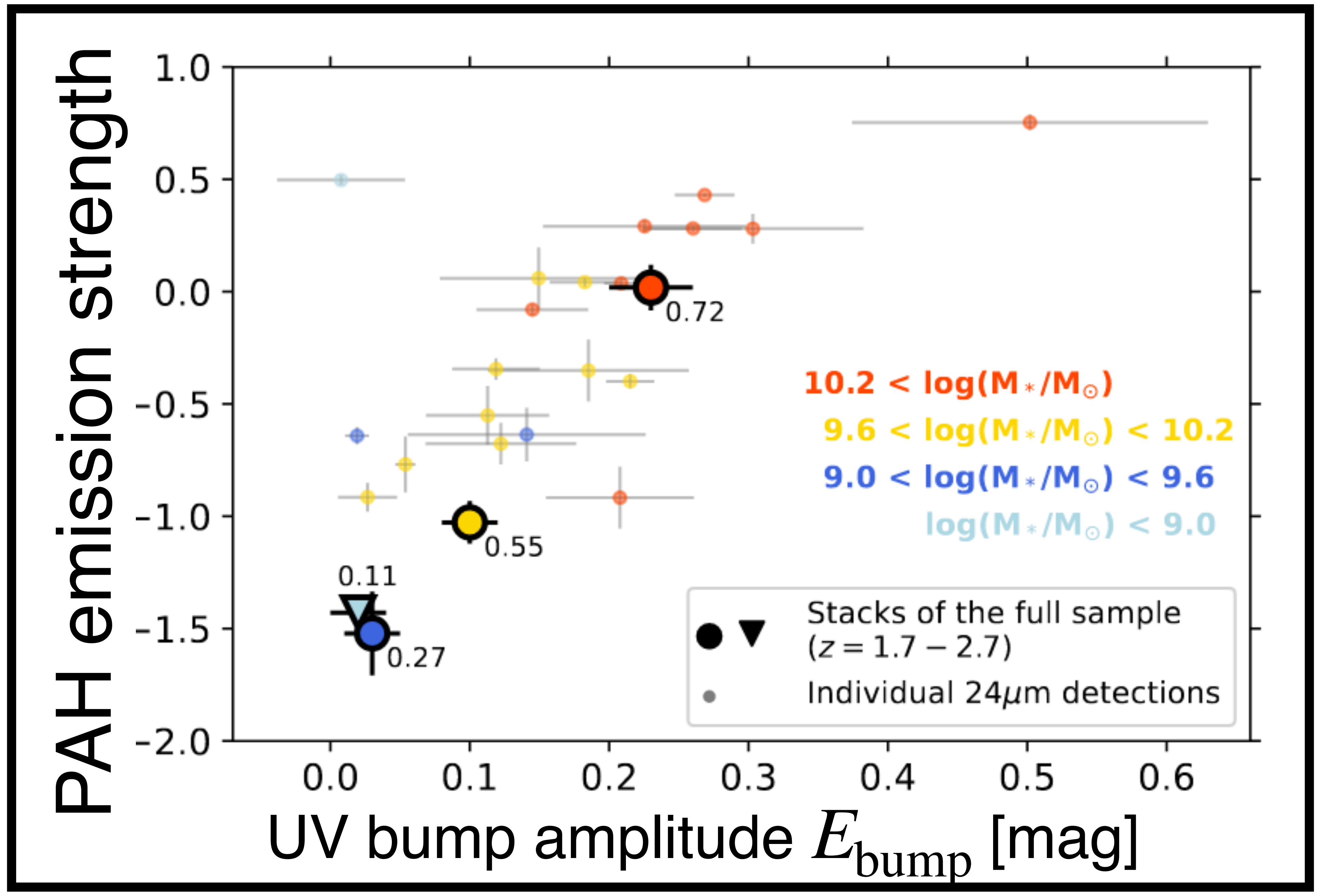

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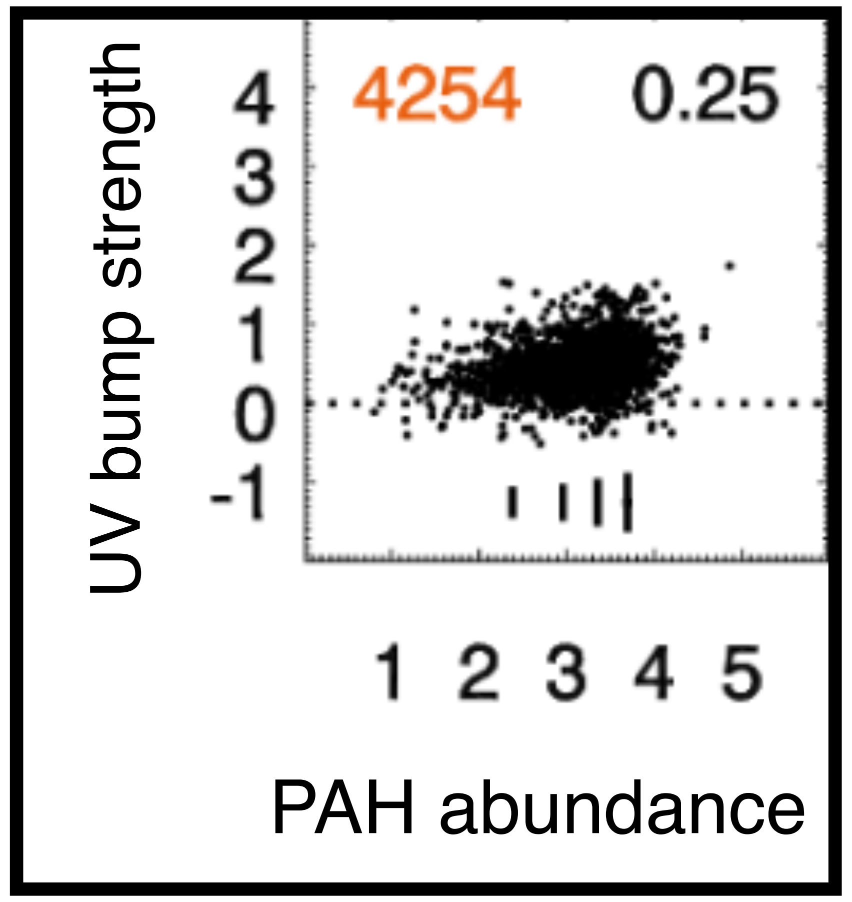

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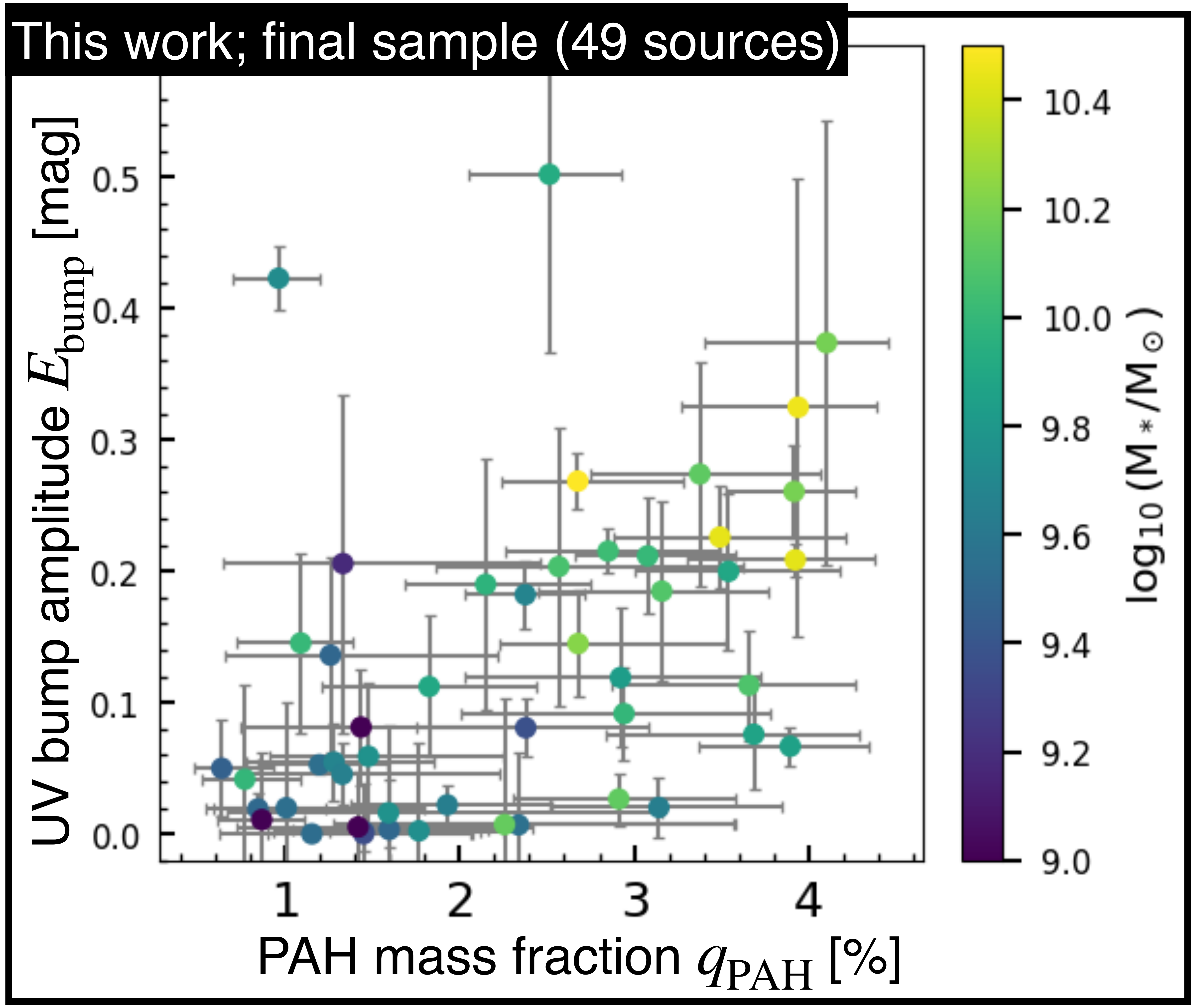

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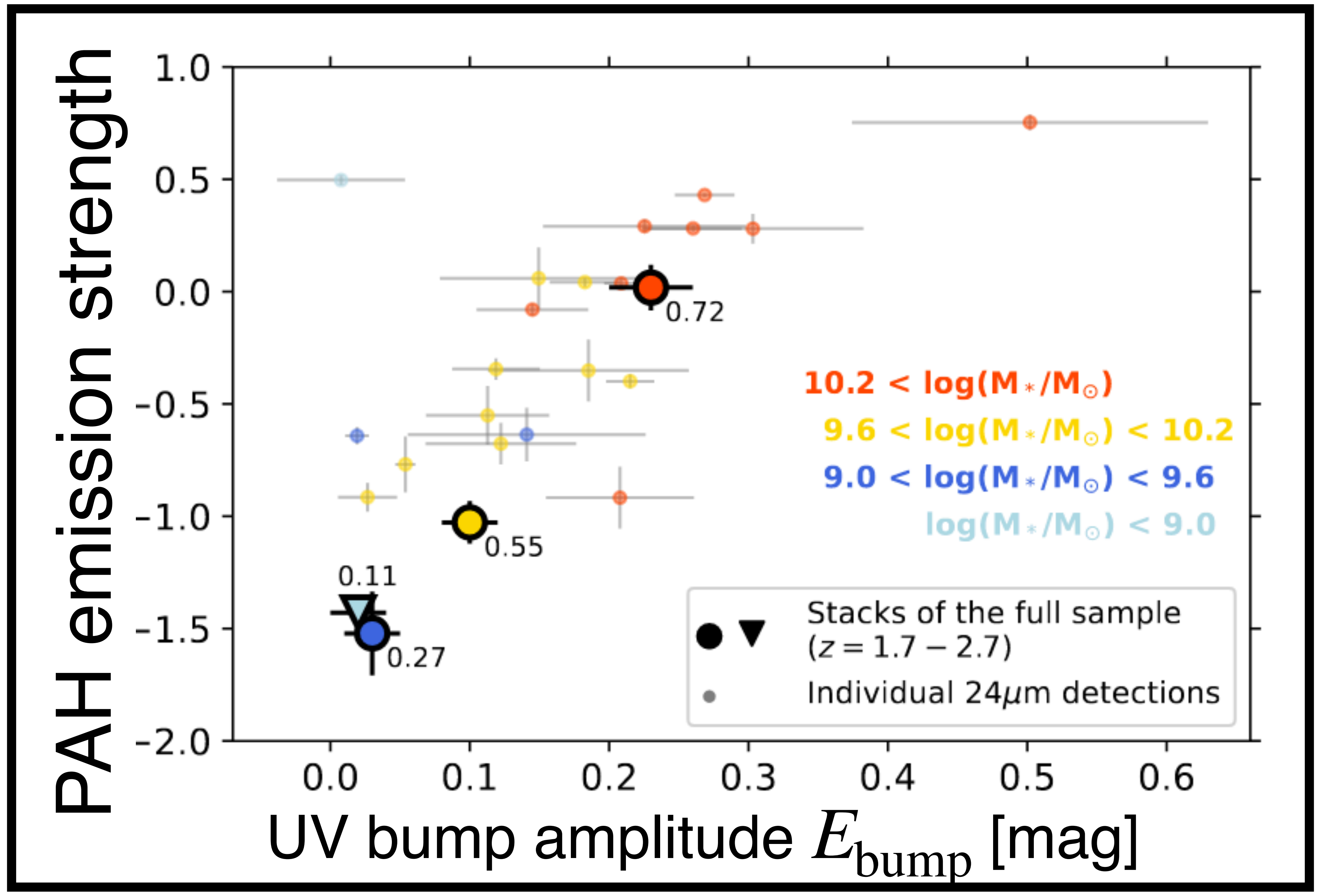
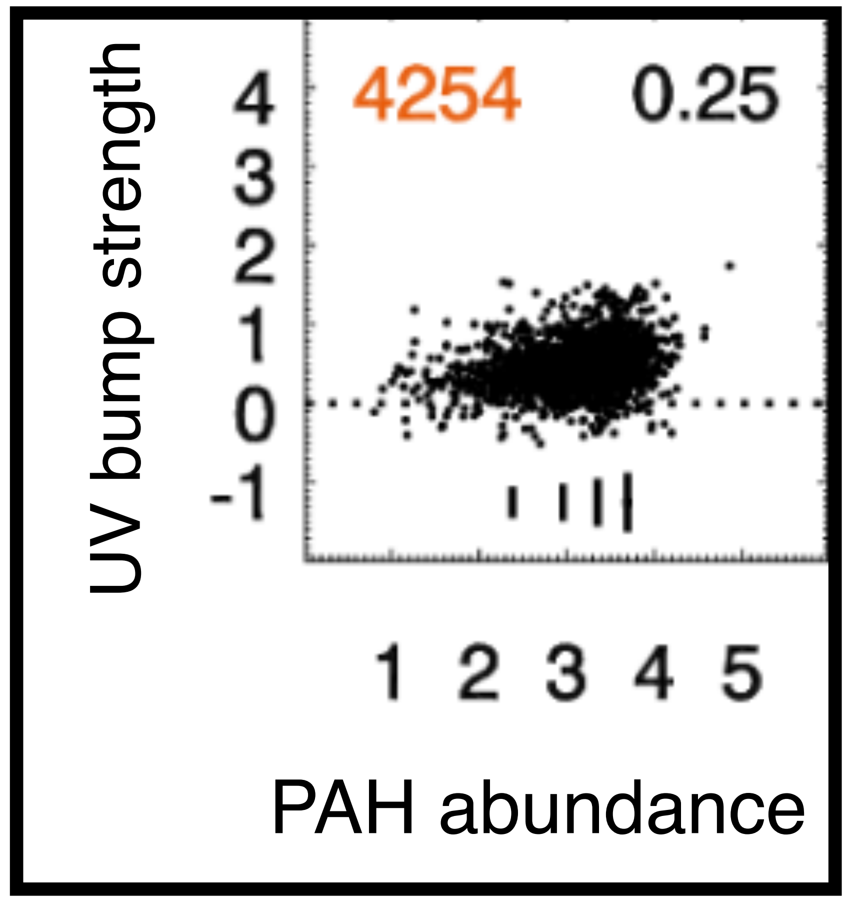
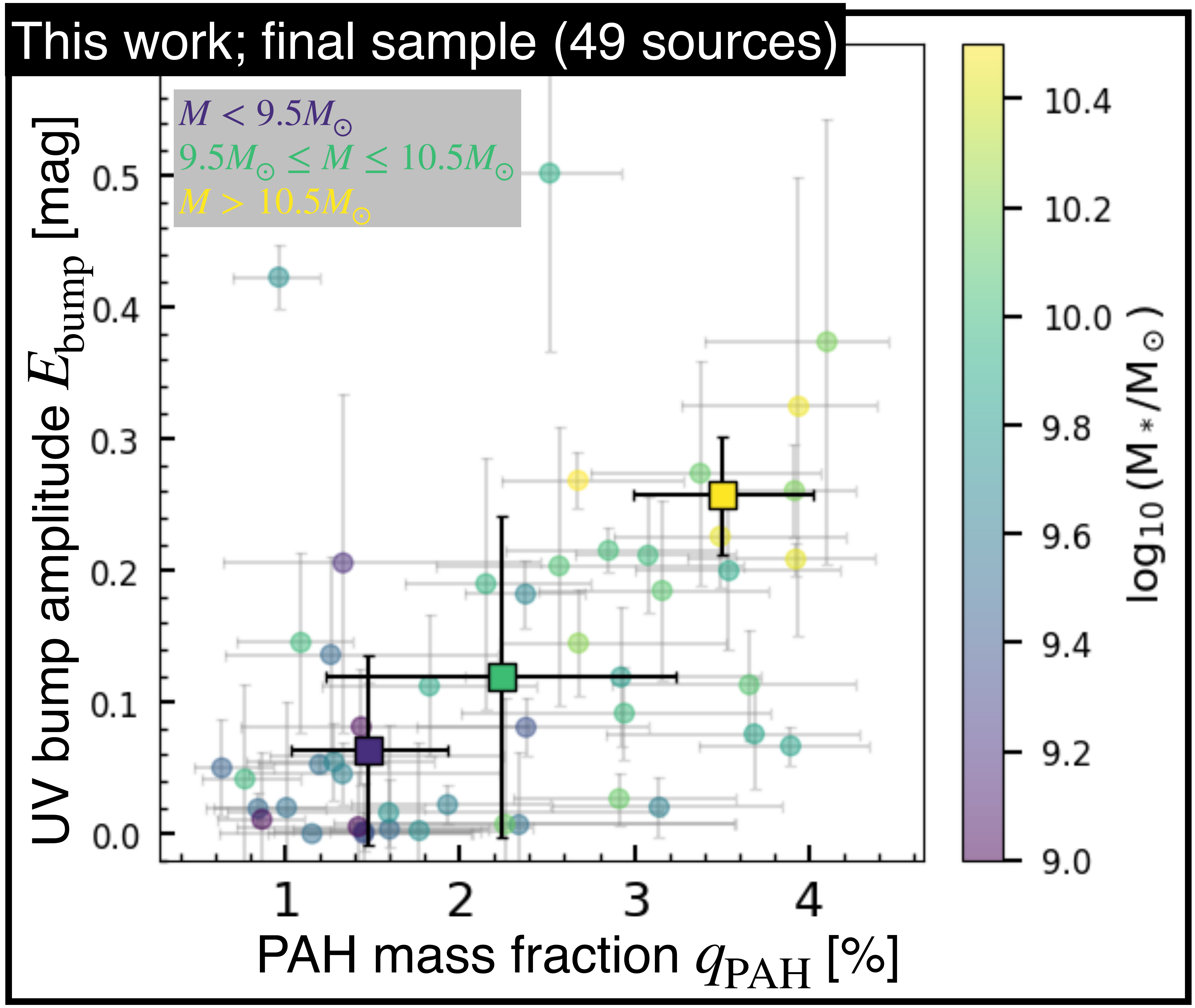


$z \sim 2$ galaxies; Shivaei+22

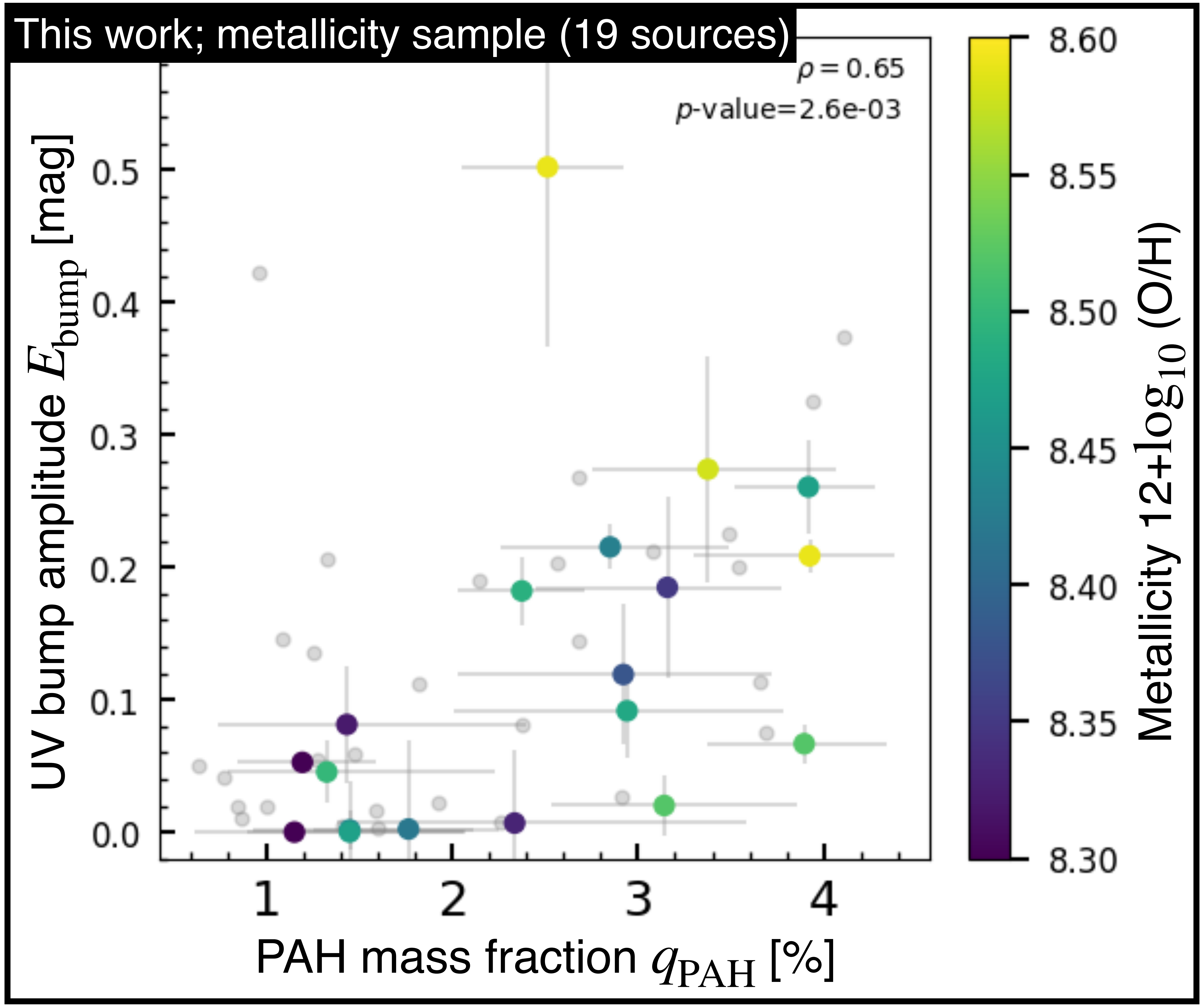


Local galaxies; Battisti+24



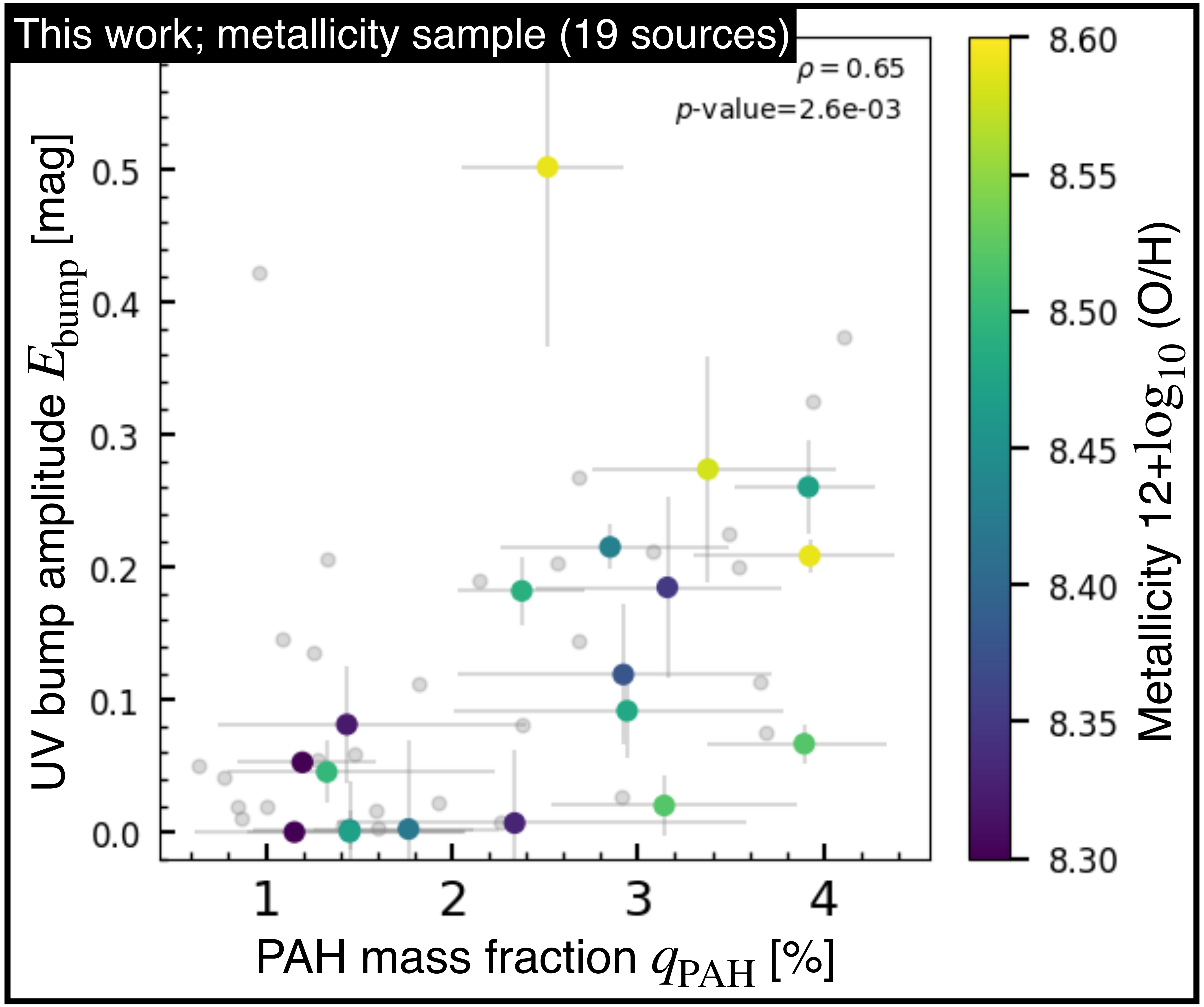
$z \sim 2$ galaxies; Arriscado *et al.* in prep.

Results: PAH emission, UV bump, and metallicity



$z \sim 2$ galaxies; Arriscado *et al.* in prep.

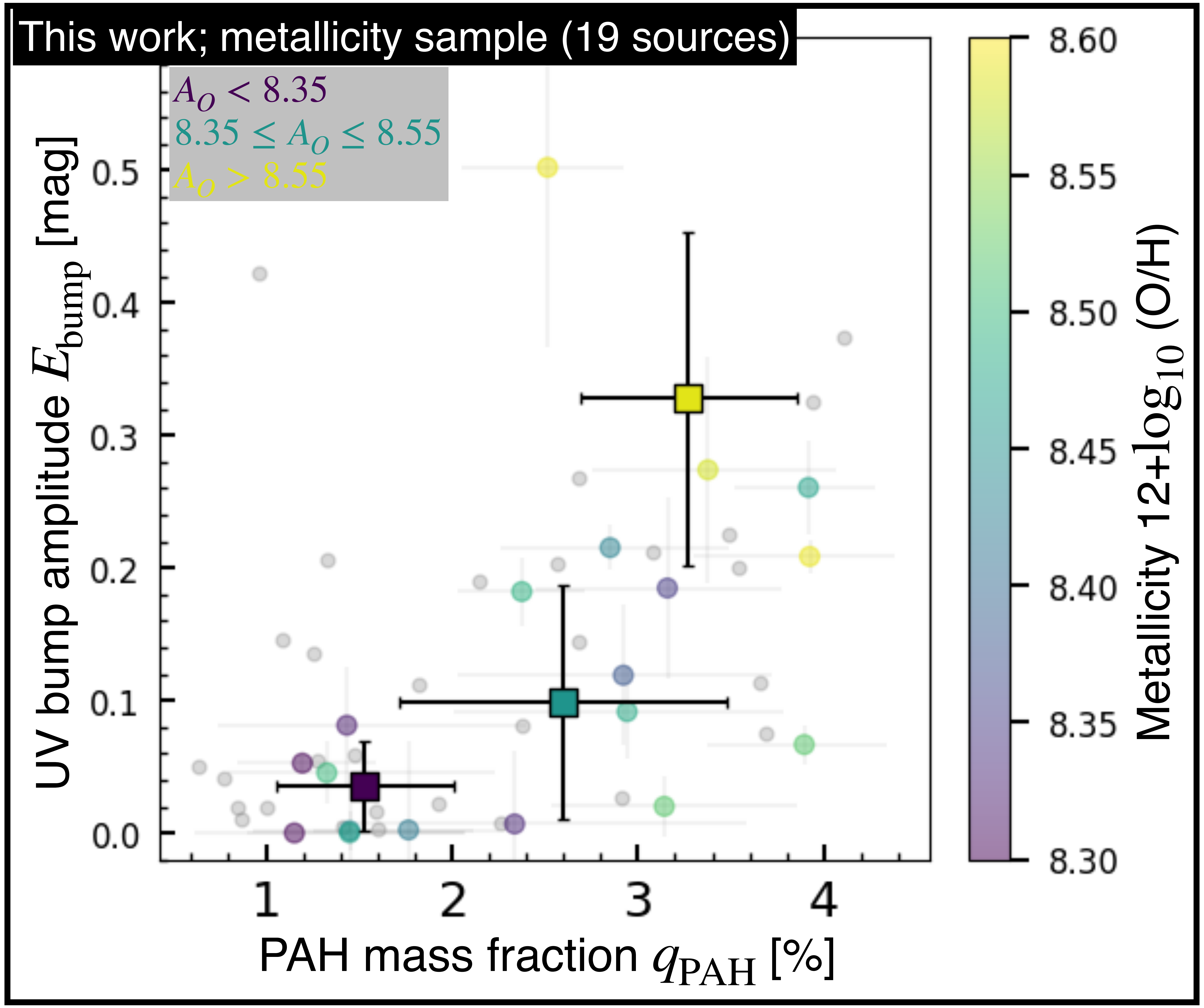
Results: PAH emission, UV bump, and metallicity



First time: correlation between PAH emission, UV bump attenuation and gas-phase metallicity measurements from strong emission line calibrations

$z \sim 2$ galaxies; Arriscado *et al.* in prep.

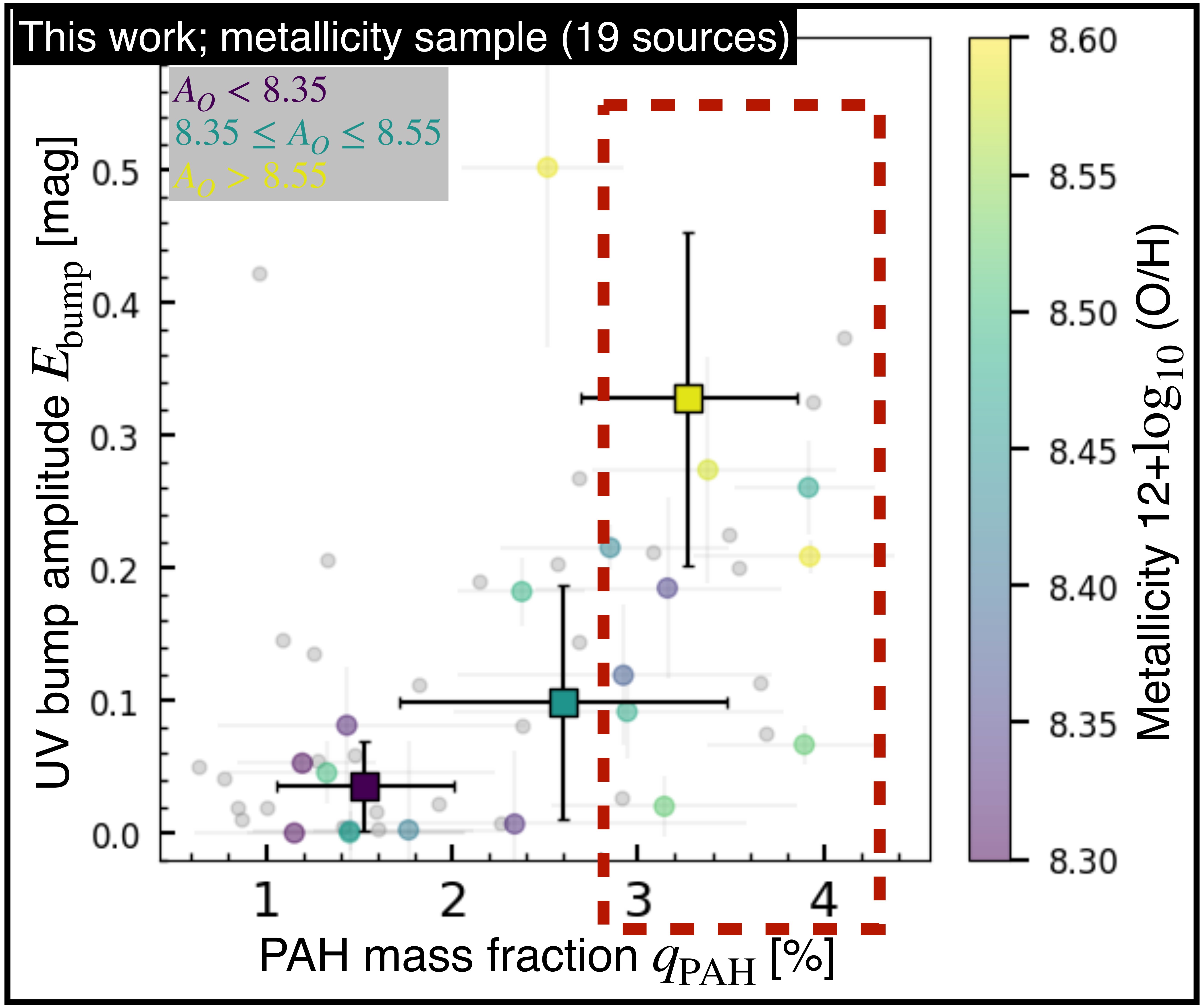
Results: PAH emission, UV bump, and metallicity



First time: correlation between PAH emission, UV bump attenuation and gas-phase metallicity measurements from strong emission line calibrations

$z \sim 2$ galaxies; Arriscado *et al.* in prep.

Results: PAH emission, UV bump, and metallicity



First time: correlation between PAH emission, UV bump attenuation and gas-phase metallicity measurements from strong emission line calibrations

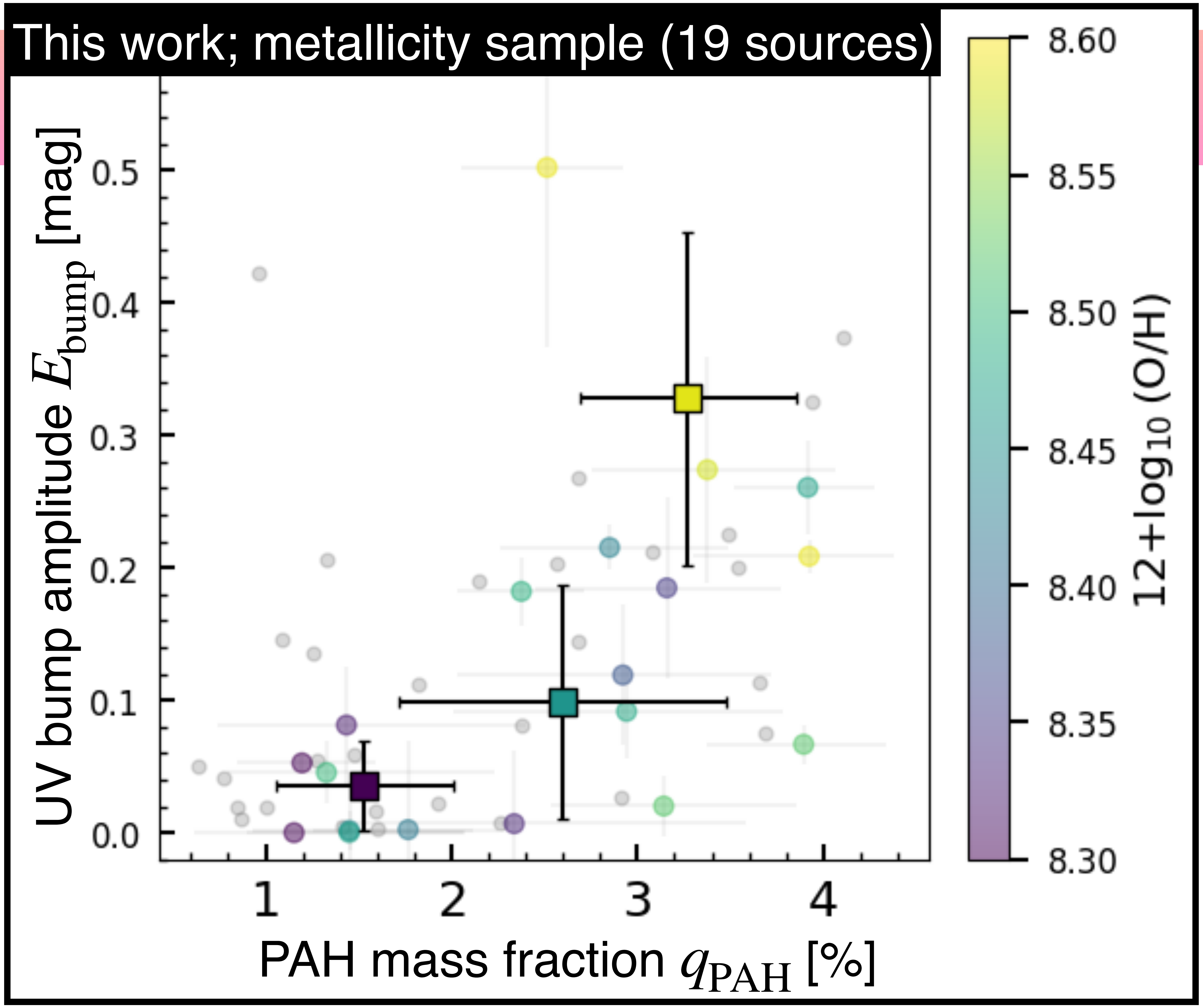
$z \sim 2$ galaxies; Arriscado *et al.* in prep.

Summary

- We present for the **first time** a study between **PAH emission**, **UV bump attenuation** and **gas-phase metallicity** measurements from strong emission line calibrations at cosmic noon.

- The results support that PAHs are the **main carriers** of the bump, but that there are additional mechanisms at play that we still don’t understand.

- Both PAH emission and UV bump strength correlate with metallicity, supporting a scenario where **low-metallicity regions have a lower abundance of PAH molecules**, which results in **low bump strength** (or no bump).



$z \sim 2$ galaxies; Arriscado *et al.* in prep.

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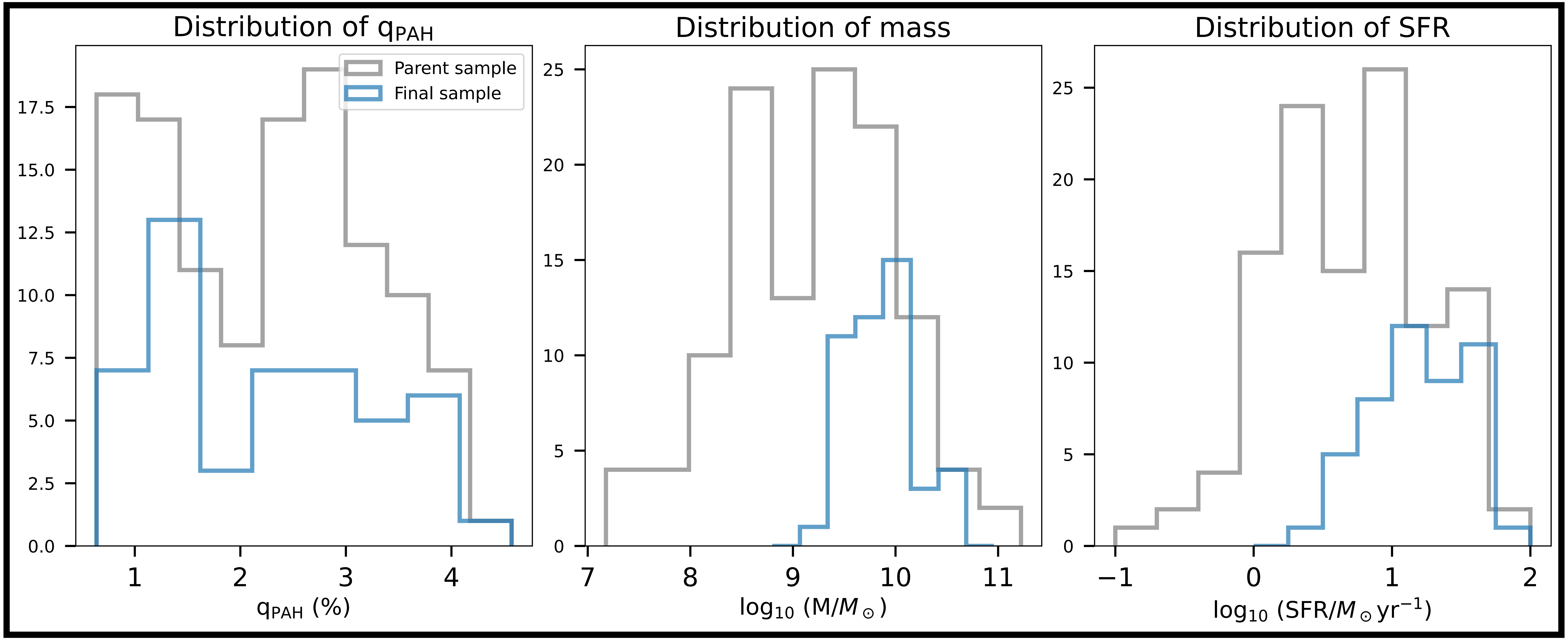
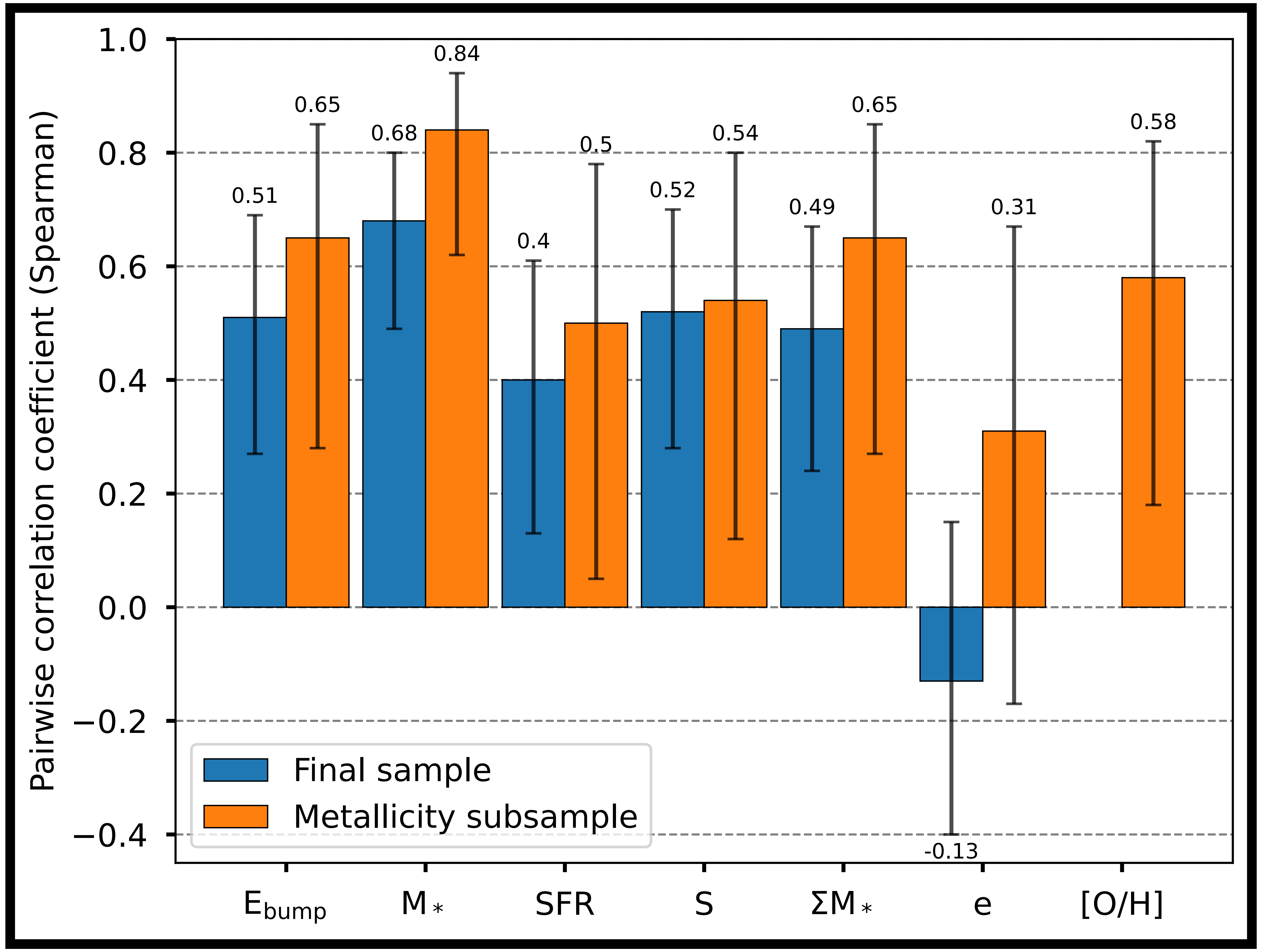
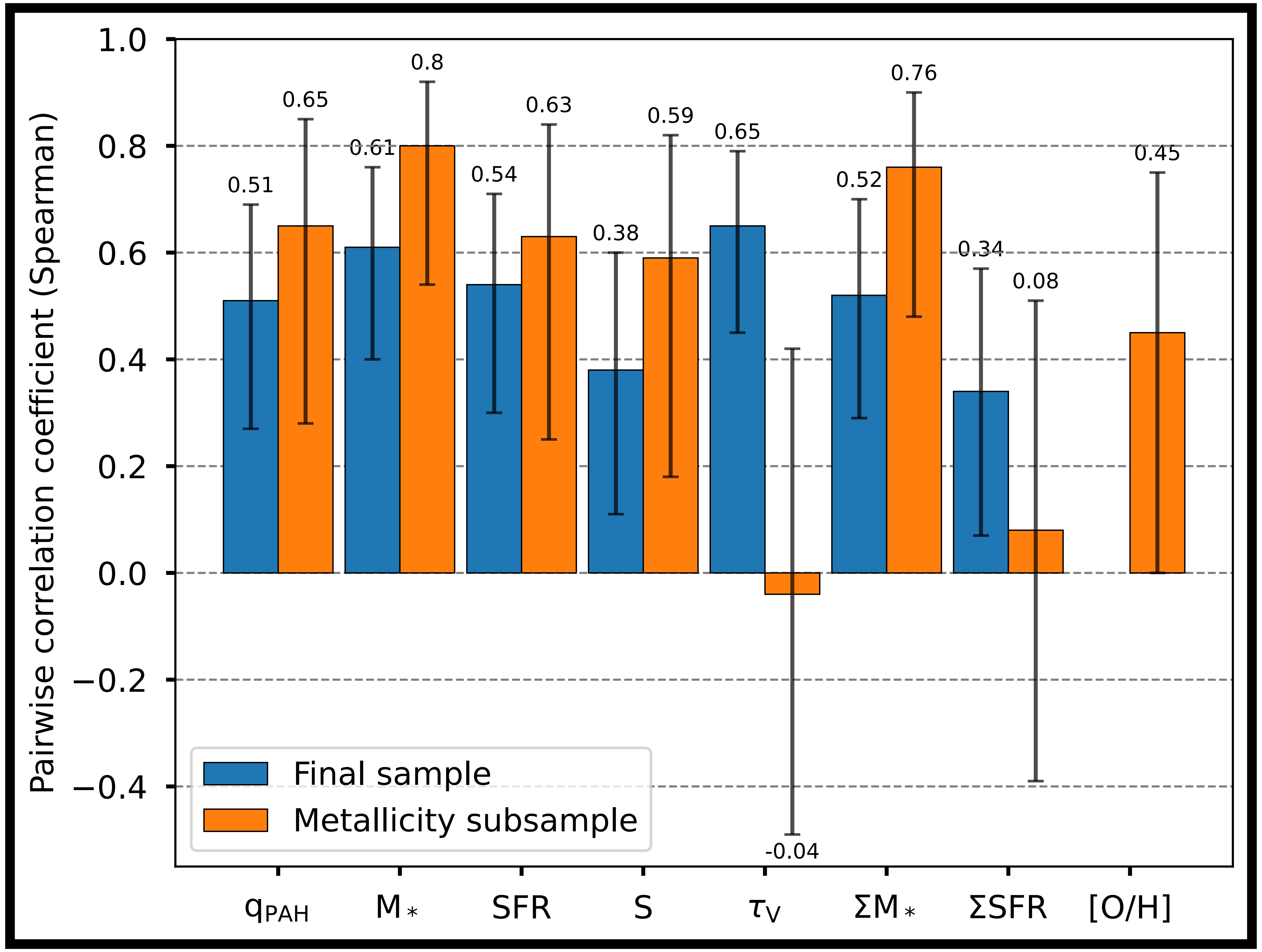
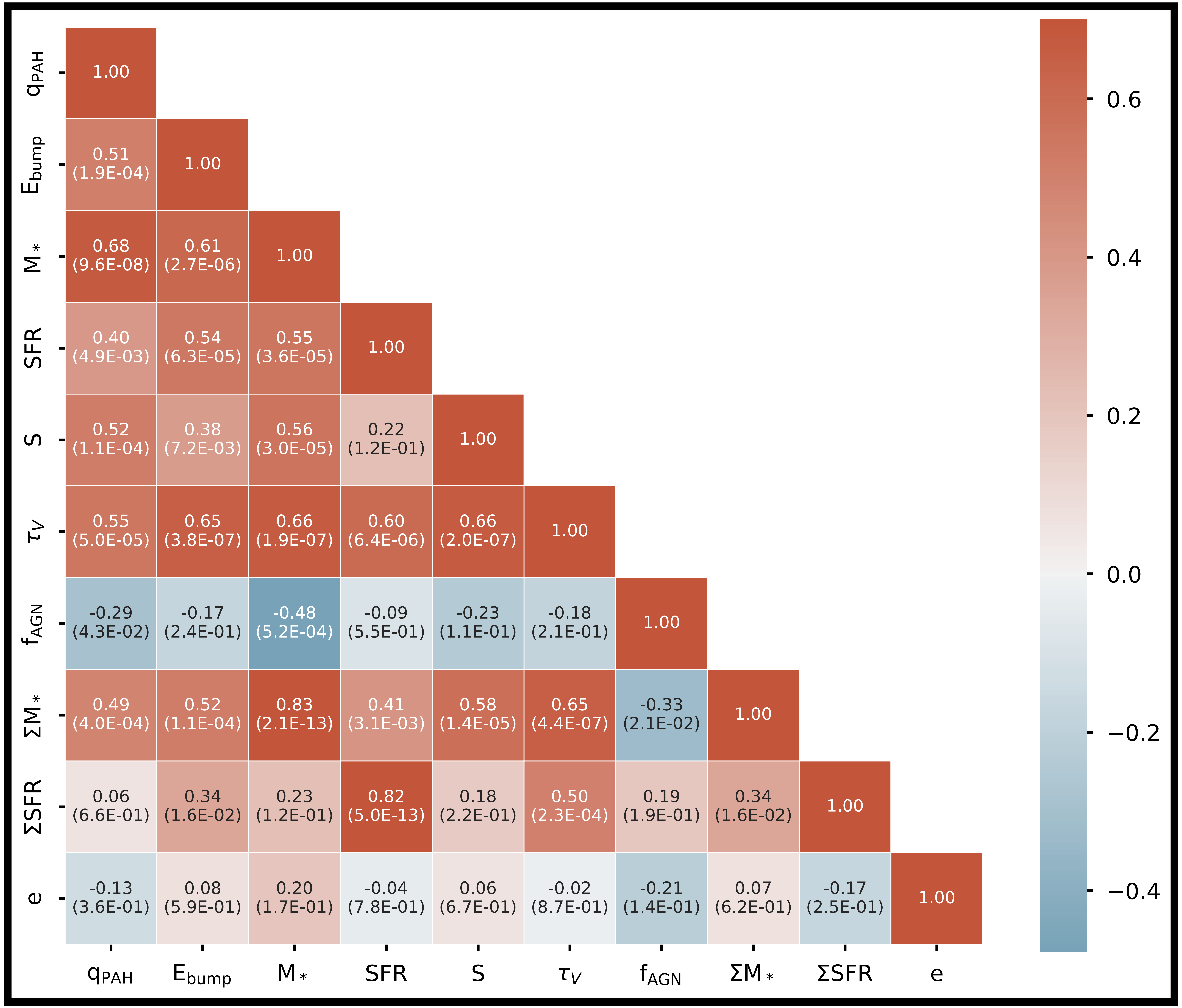

Distribution of q_{PAH}
Parent sample
Final sample
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
1
2
3
4
q_{PAH} (%)
Distribution of mass
25
20
15
10
5
0
7
8
9
10
11
$\log_{10}$ $(M/M_\odot)$
Distribution of SFR
25
20
15
10
5
0
−1
0
1
2
$\log_{10}$ $(SFR/M_\odot yr^{-1})$

Spearman pairwise correlation coefficients with q_{PAH}

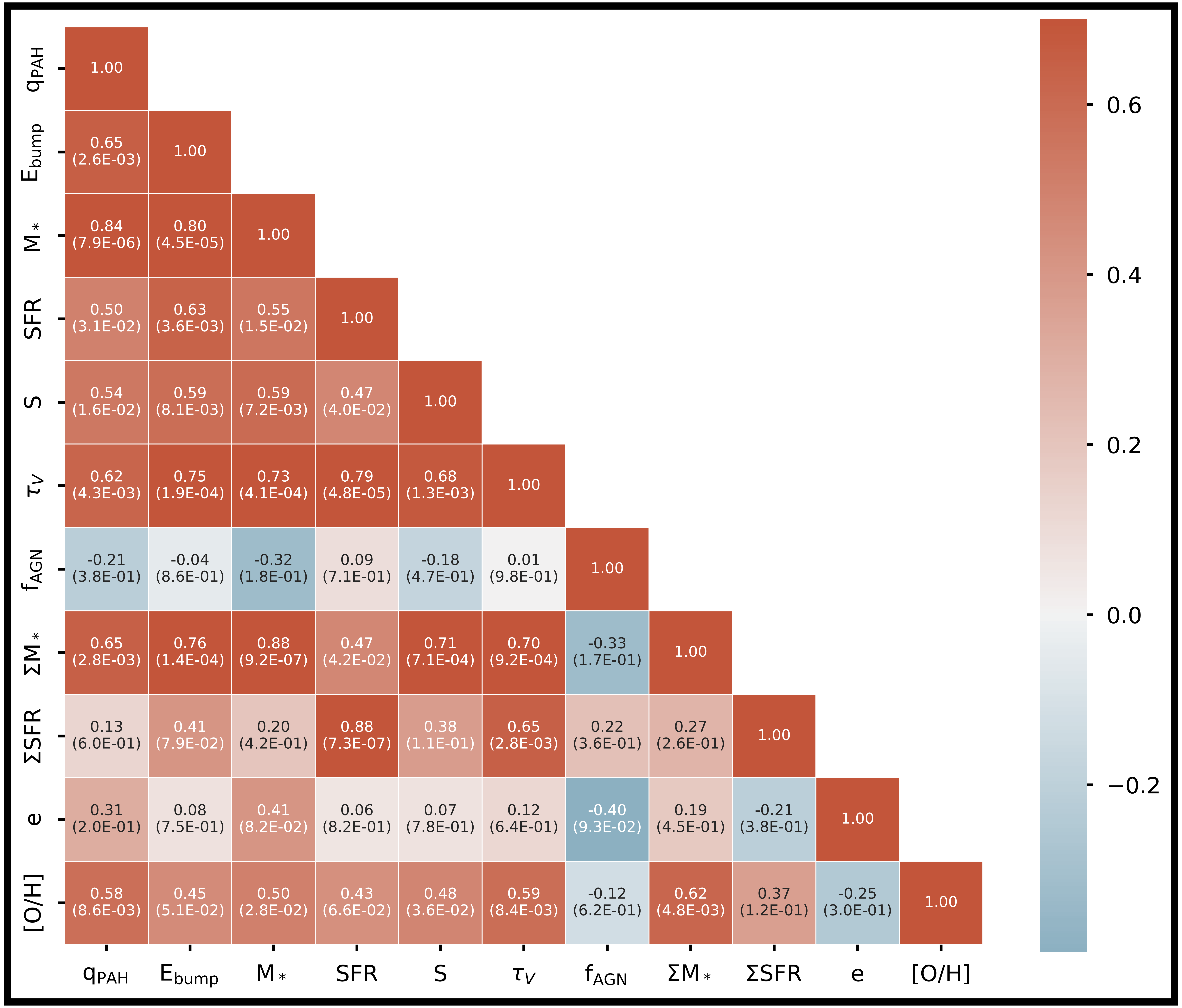


Spearman pairwise correlation coefficients with E_{bump}





Final sample: 49 galaxies



Metallicity sample: 19 galaxies