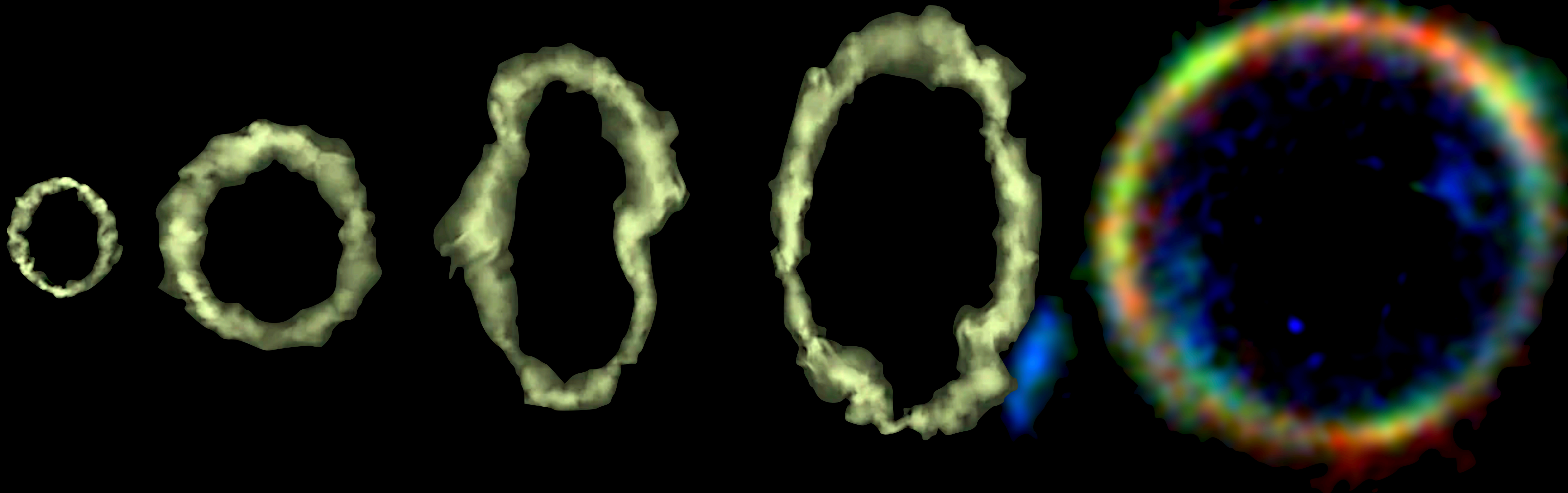


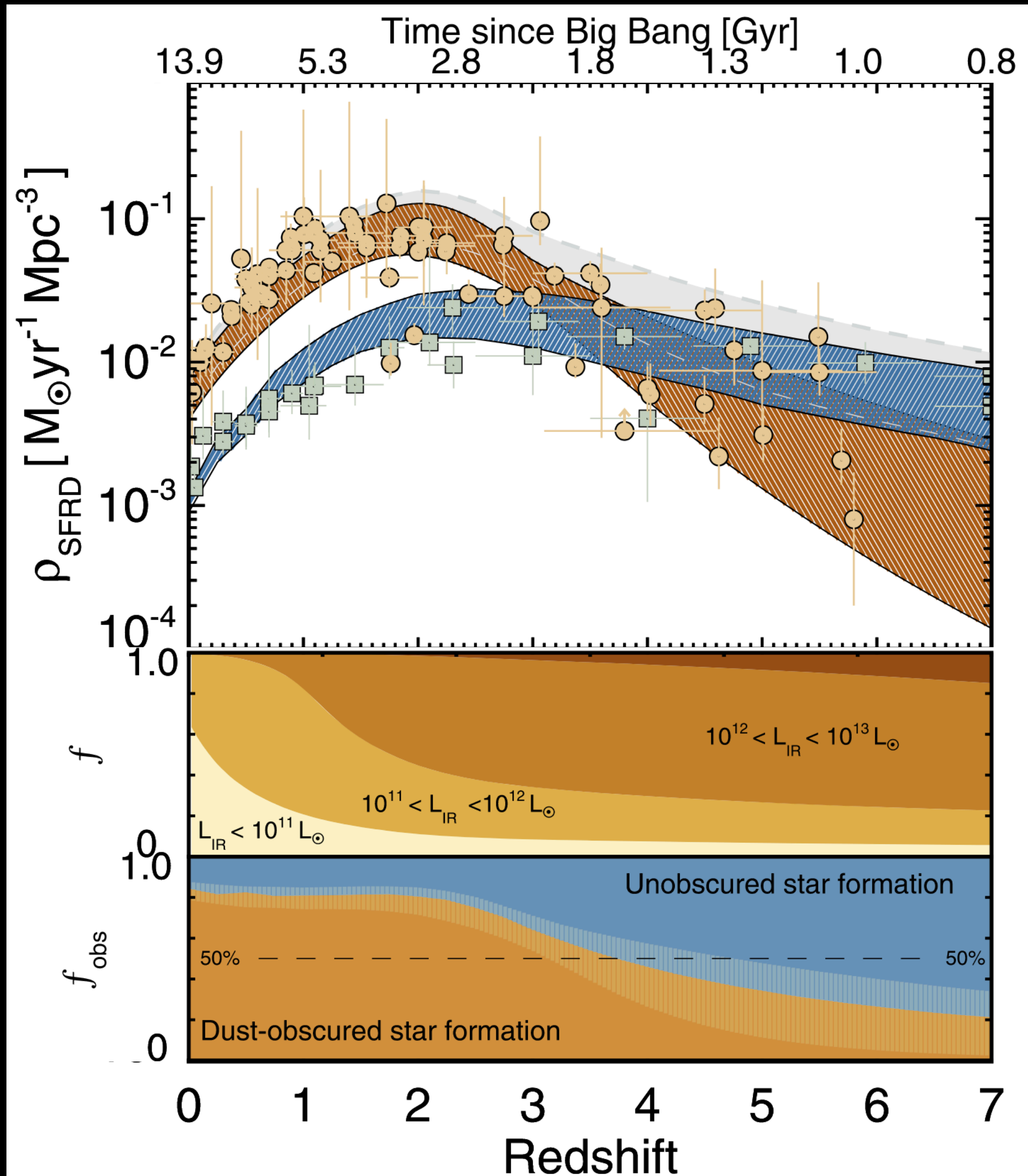
Charting the Rise of Small Dust Grains from Reionization to the Present (with the SALTUS Probe Concept)

Justin Spilker, Texas A&M University

with thanks to the JWST TEMPLATES team and the SALTUS team



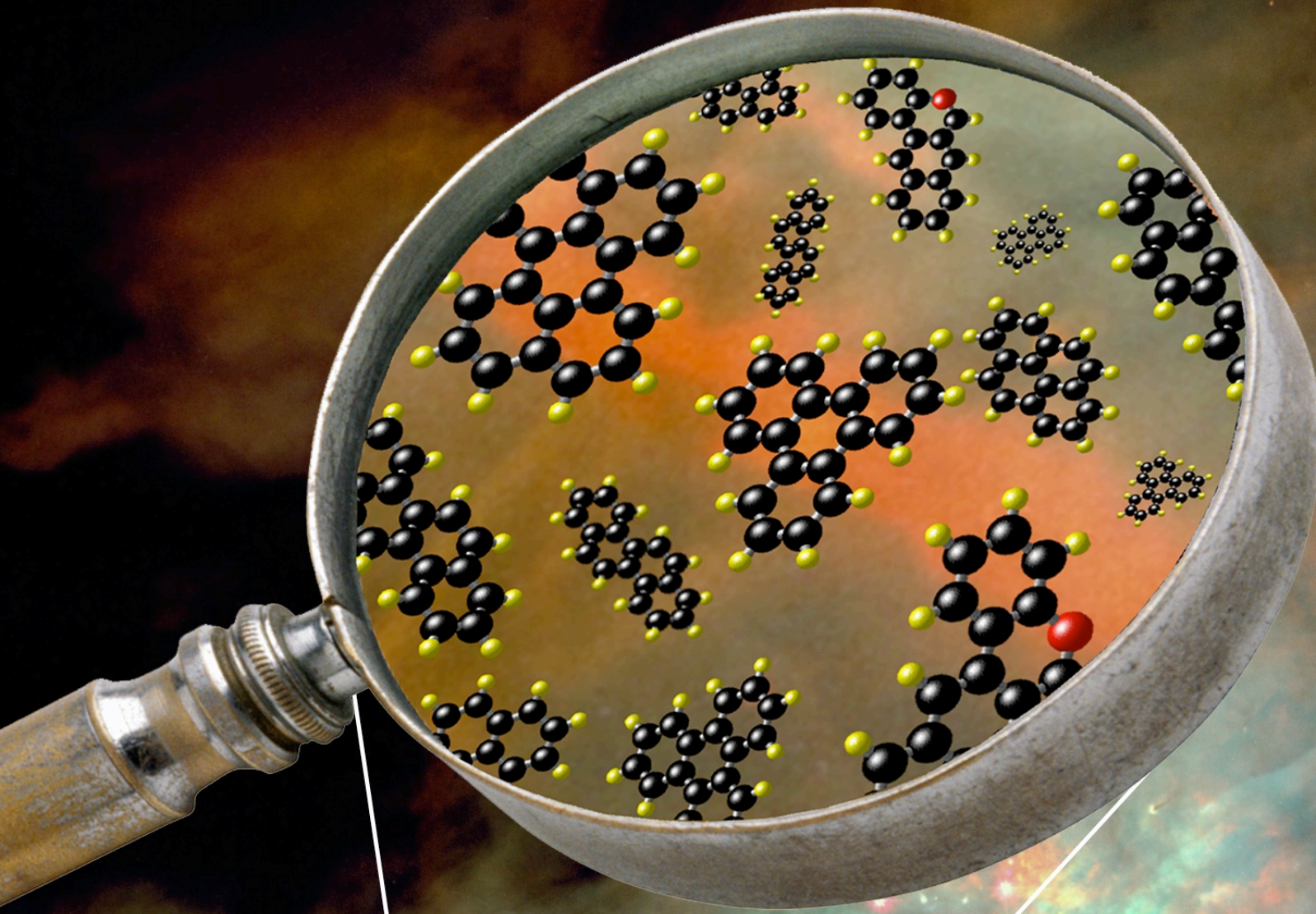
The Dusty Early Universe



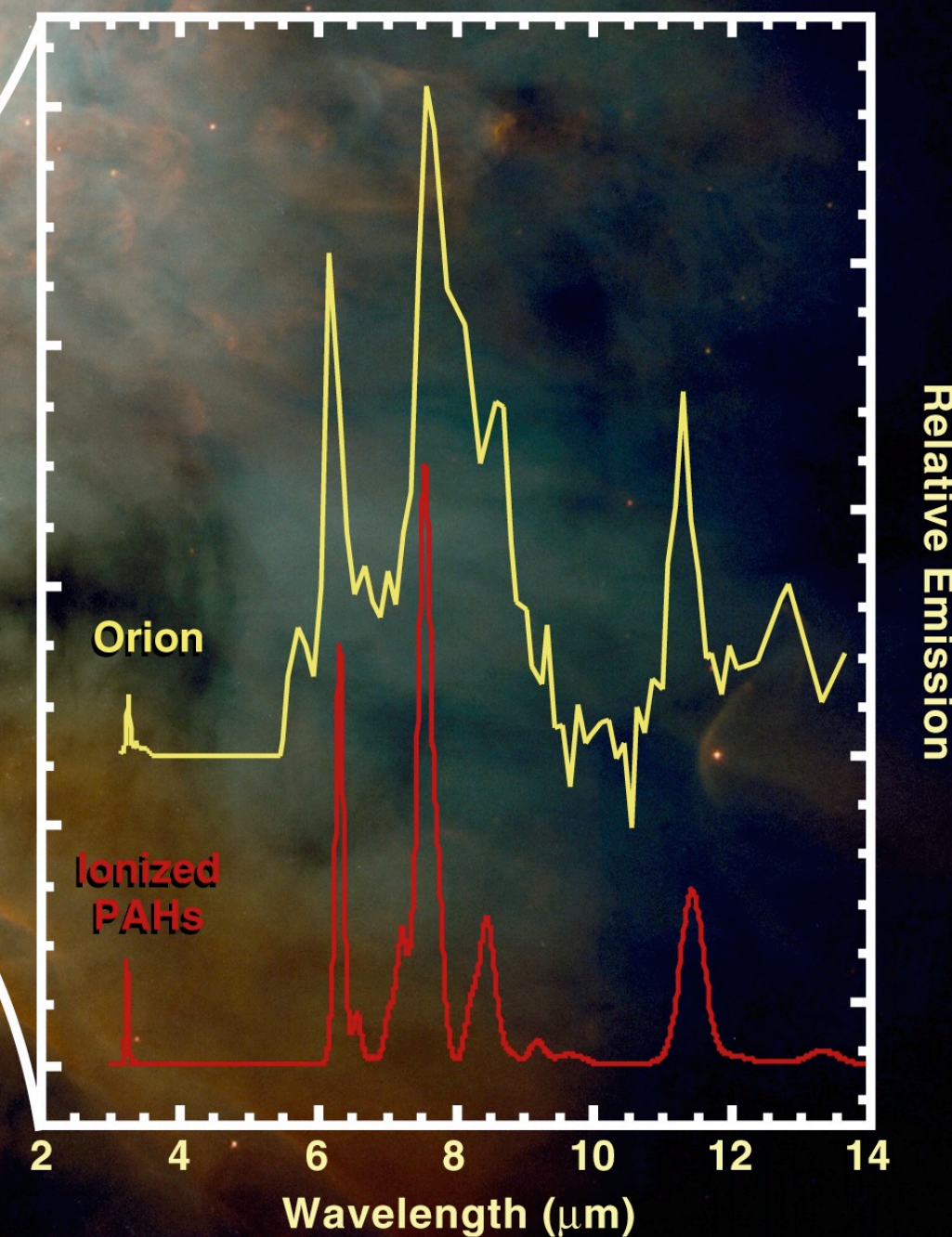
- Dusty star formation has dominated for (at least) the last ~ 10 billion years
- At early times, most obscured star formation happened in rare, luminous “monsters”

Zavala+2021

PAHs - Big Molecules, Small Dust?



- Polycyclic Aromatic Hydrocarbons - Big carbon honeycomb-shaped molecules, dozens or hundreds of atoms!
- Closely related to dust grains (although the connection isn't clear)
- Very bright, very broad features in the mid-infrared



PAH 3.3um - THE High-z PAH Diagnostic for JWST

- For $z > 3$, only the 3.3um PAH feature is accessible by JWST
- Practically, most observers will need to avoid MIRI channel 4 ($>18\mu\text{m}$), $z < \sim 4.4$

Optimistic max redshift: 7.4
Realistic max redshift: 4.4

3.5	2.6	1.5	0.6
1.9	1.3	0.6	0.05

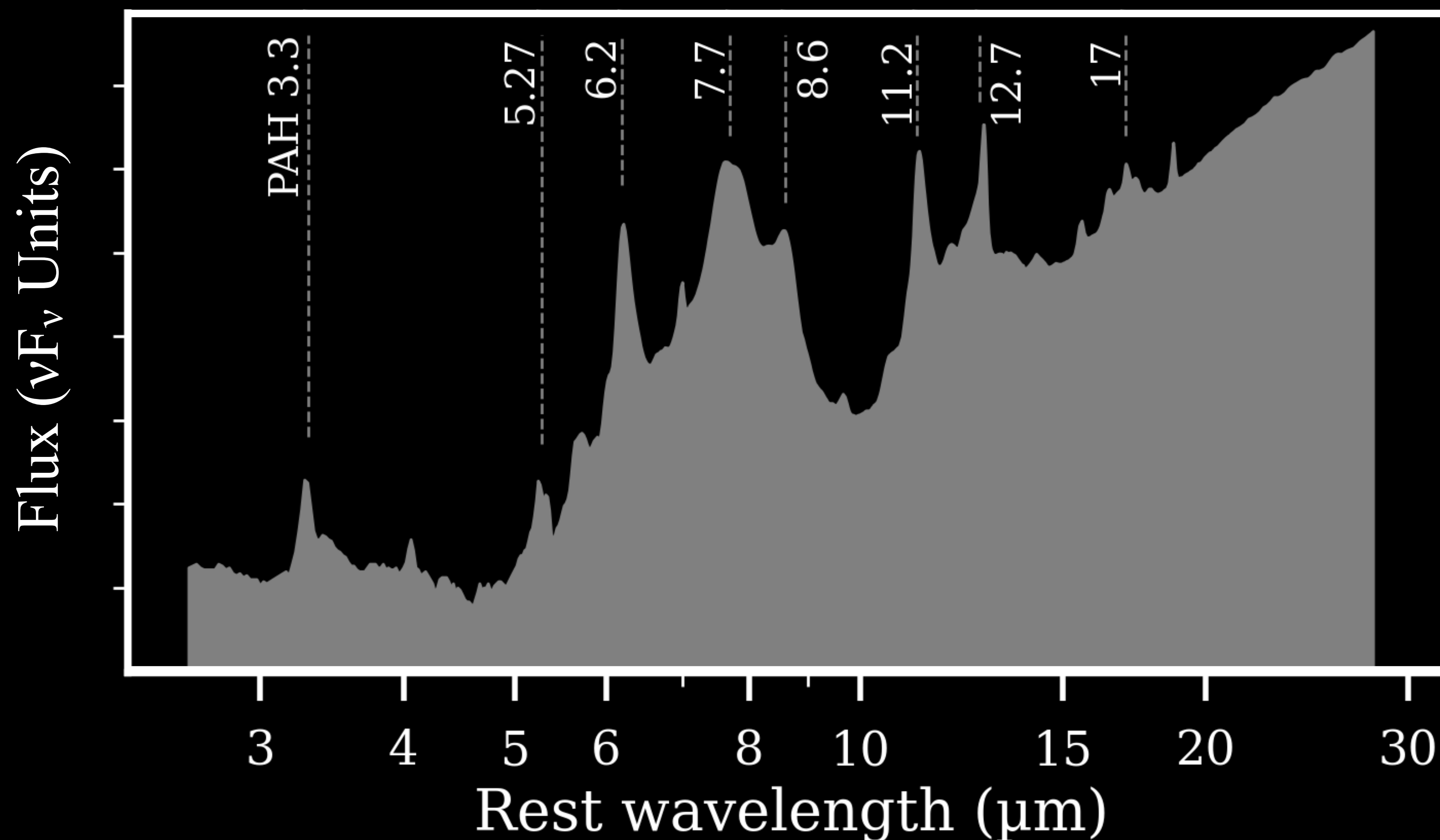
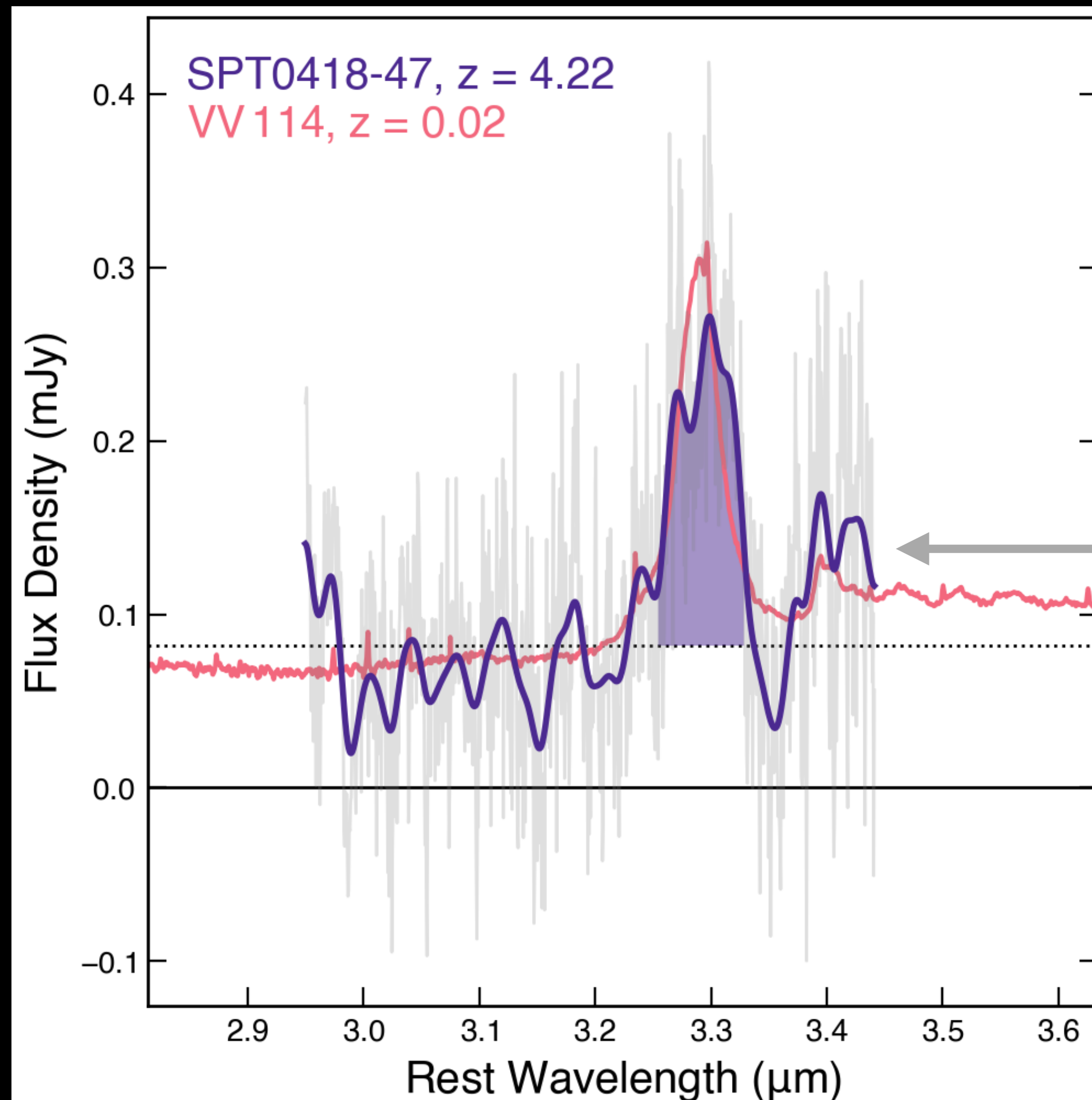


Image shamelessly
swiped from
Thomas Lai

JWST Makes the Most Distant PAH Detection

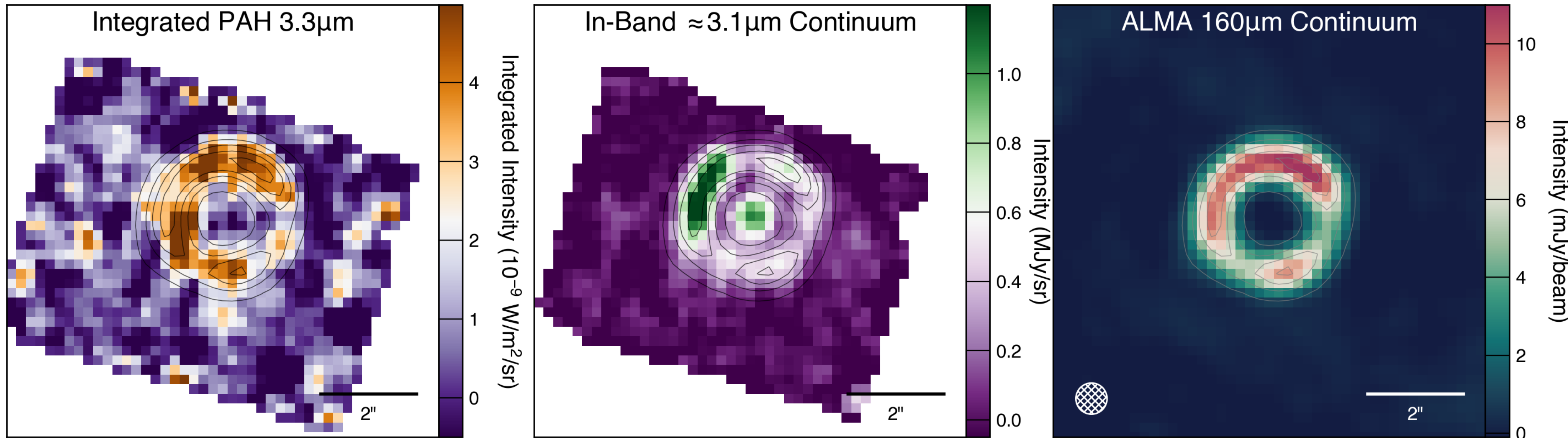
- PAH 3.3 μ m clearly detected at $z = 4.225$, ~1 hour on source!
- This is the highest-redshift detection of any PAH feature



Aliphatic 3.4 μ m ???

Resolving Small Dust at High Redshift

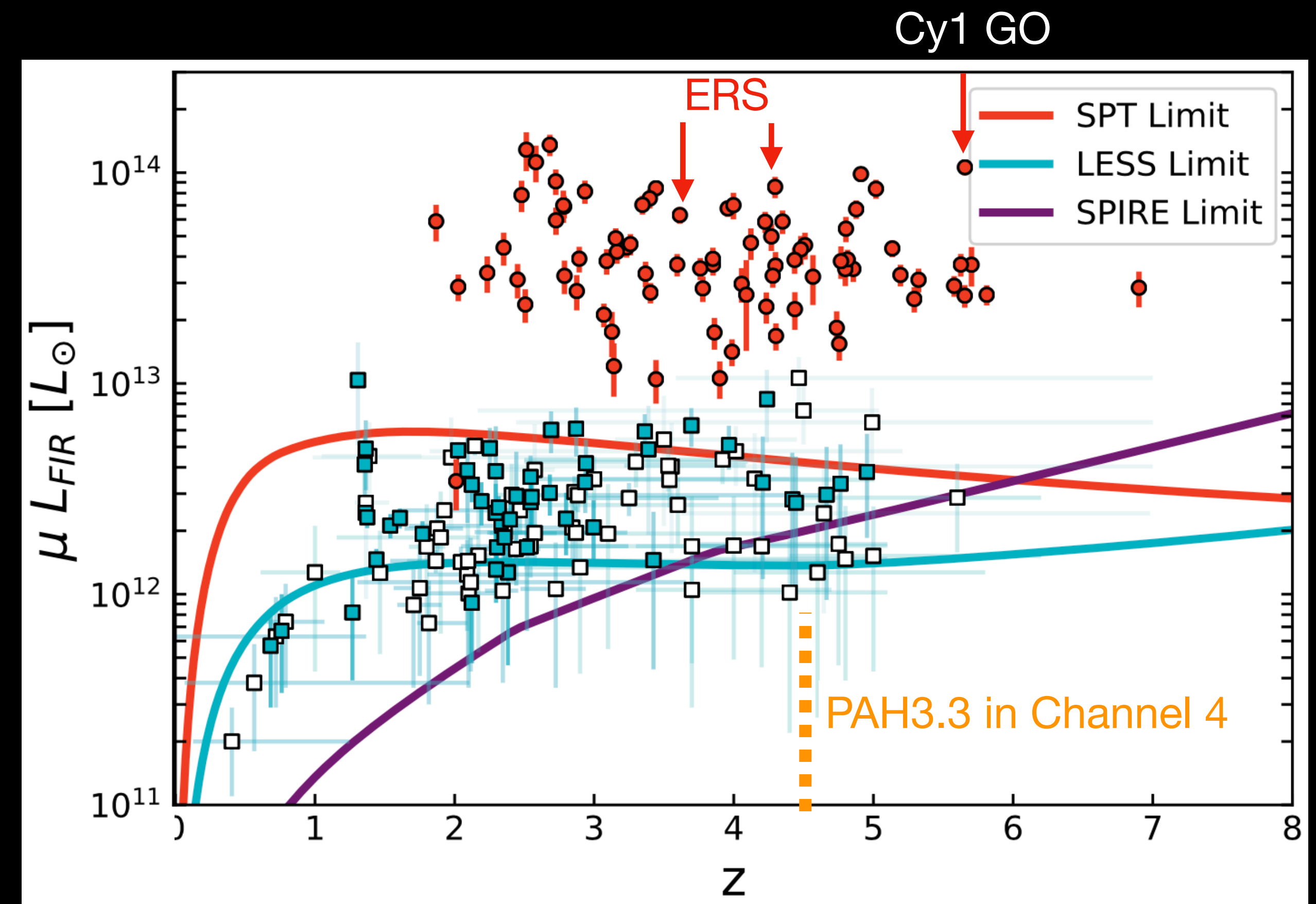
- JWST not only detects but spatially resolves the PAH emission!
- PAH, mid-IR continuum, and far-IR continuum all qualitatively different from each other



ALMA data at exactly matched resolution by the magic of interferometry

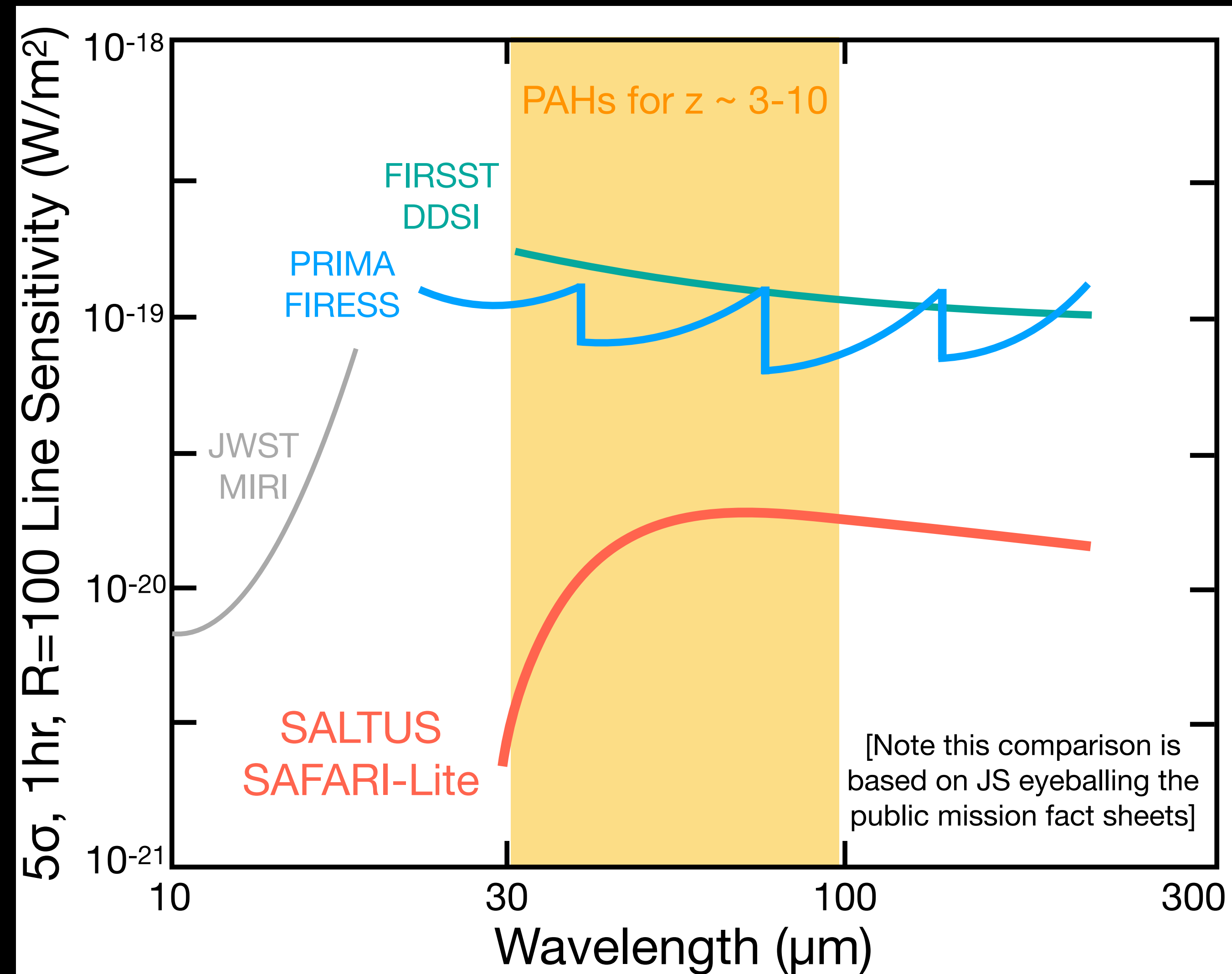
How much high-z PAH work will JWST really do?

- Realistically, JWST will not be detecting PAH3.3 at $z > 4$ routinely
- There just aren't enough very luminous lensed sources for this to be practical
- Lower-z ($z \sim 1-3$) significantly easier... but was also done extensively with Spitzer



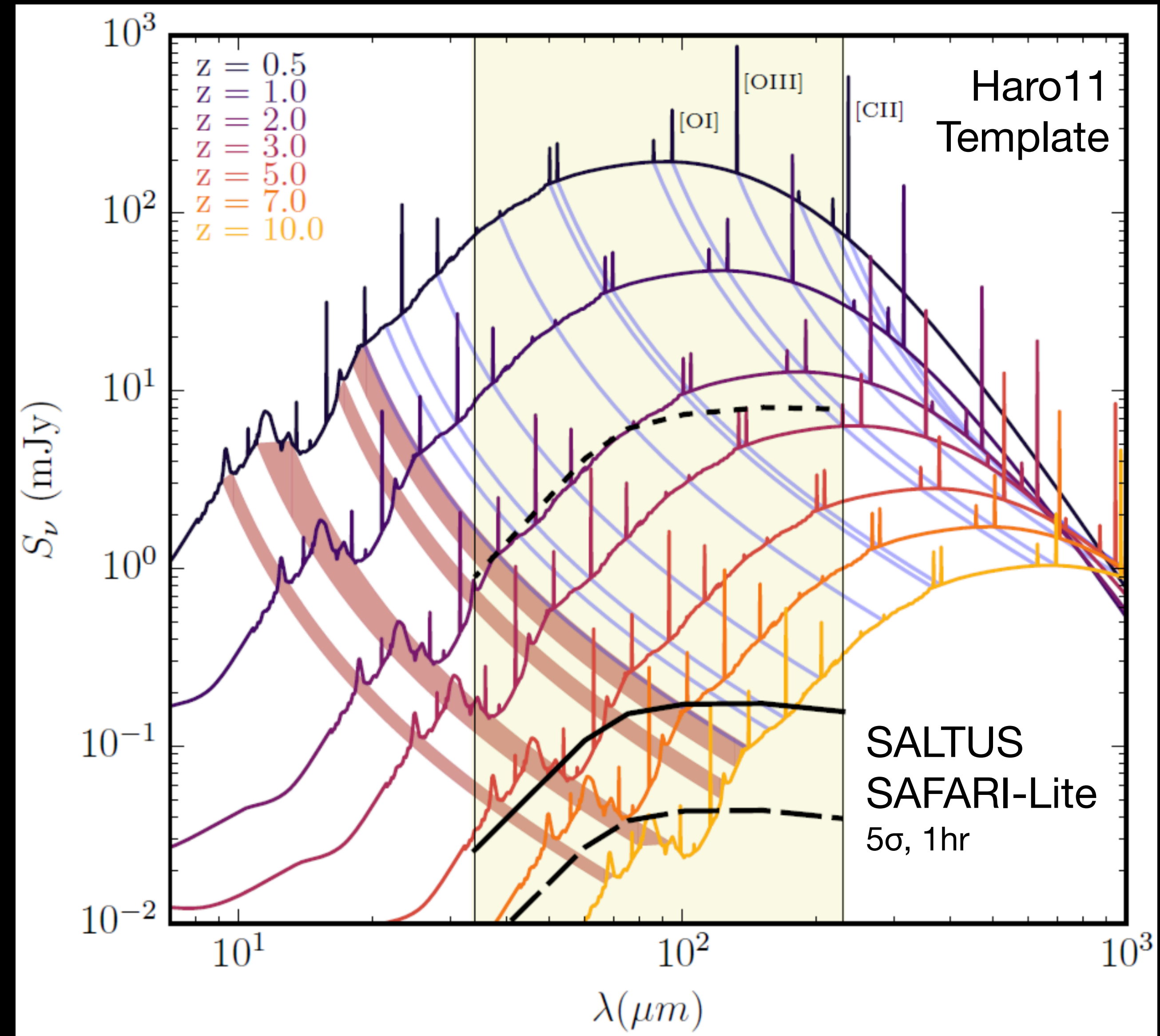
High-z PAHs with a Far-IR Probe Mission

- To make progress, we need much greater sensitivity, and far-IR wavelength coverage!
- Any of the probe concepts would be able to detect the full suite of PAHs to $z \sim 3-4$
- SALTUS in particular has the sensitivity at $< \sim 100 \mu\text{m}$ to detect PAHs to $z \sim 10$ (if they exist)



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Conclusions

- PAHs are the only spectroscopic signatures of dust
- We need a far-IR space mission to detect PAHs in the early universe - JWST helps, but this is far-IR science!
- Any of these probes would make progress; SALTUS in particular has extremely high sensitivity to detect redshifted PAH features

