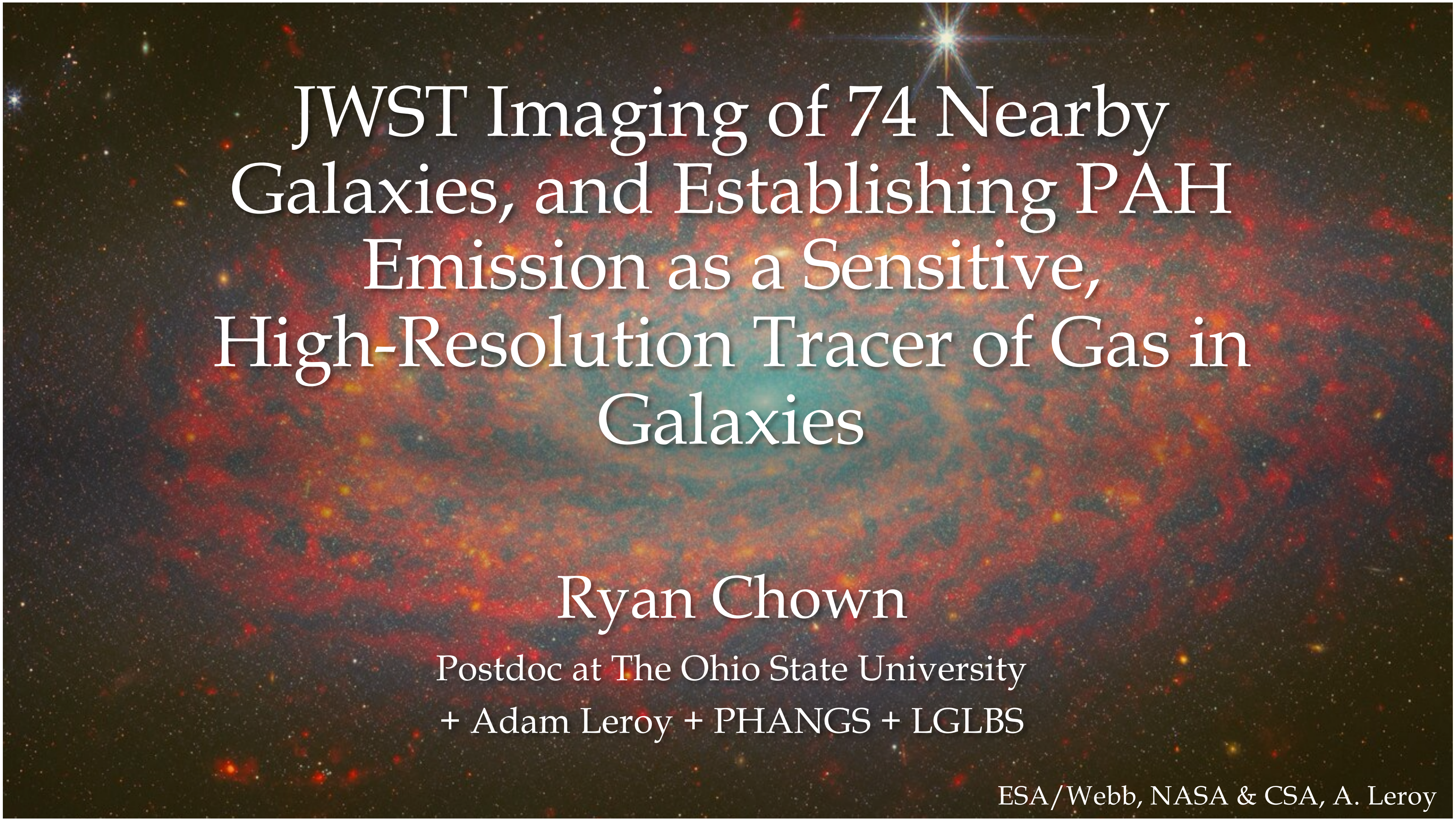
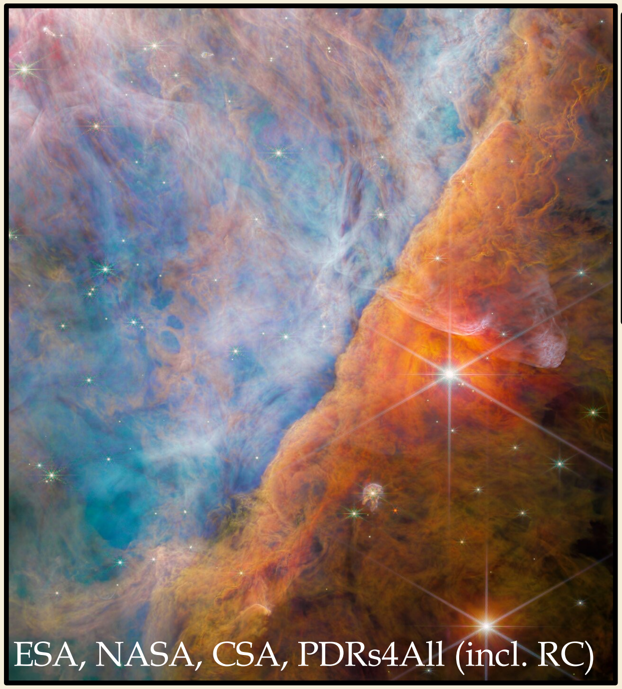
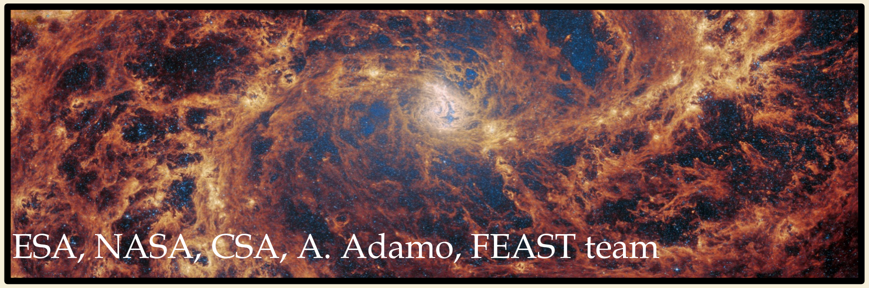

JWST Imaging of 74 Nearby Galaxies, and Establishing PAH Emission as a Sensitive, High-Resolution Tracer of Gas in Galaxies
Ryan Chown
Postdoc at The Ohio State University
+ Adam Leroy + PHANGS + LGLBS
ESA/Webb, NASA & CSA, A. Leroy

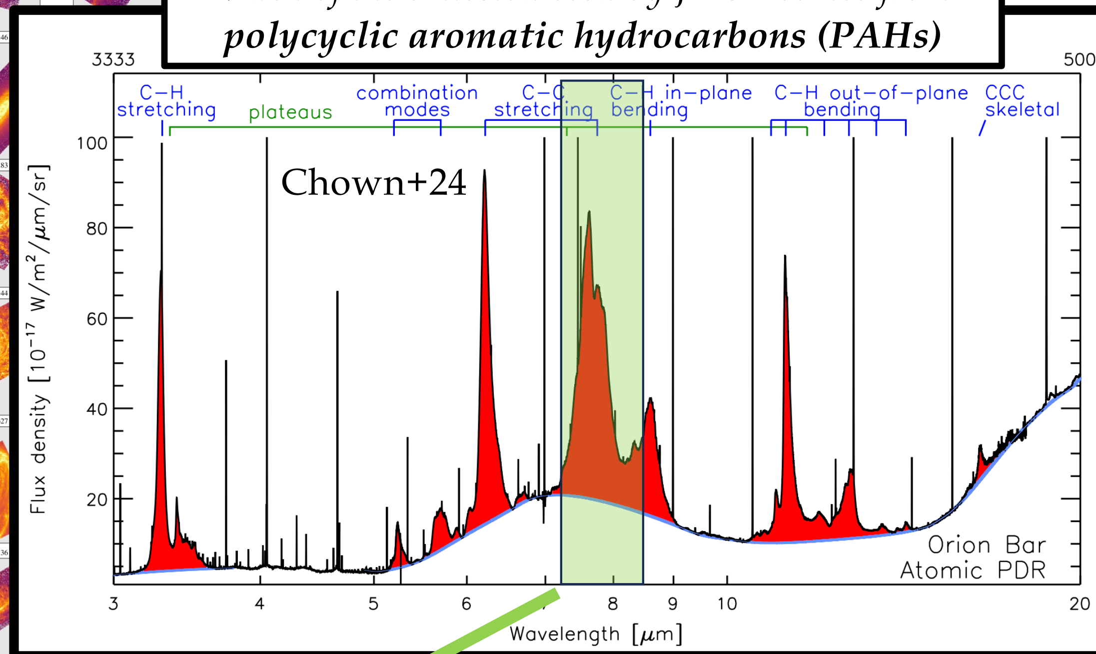
ISM Mapping in the JWST Era

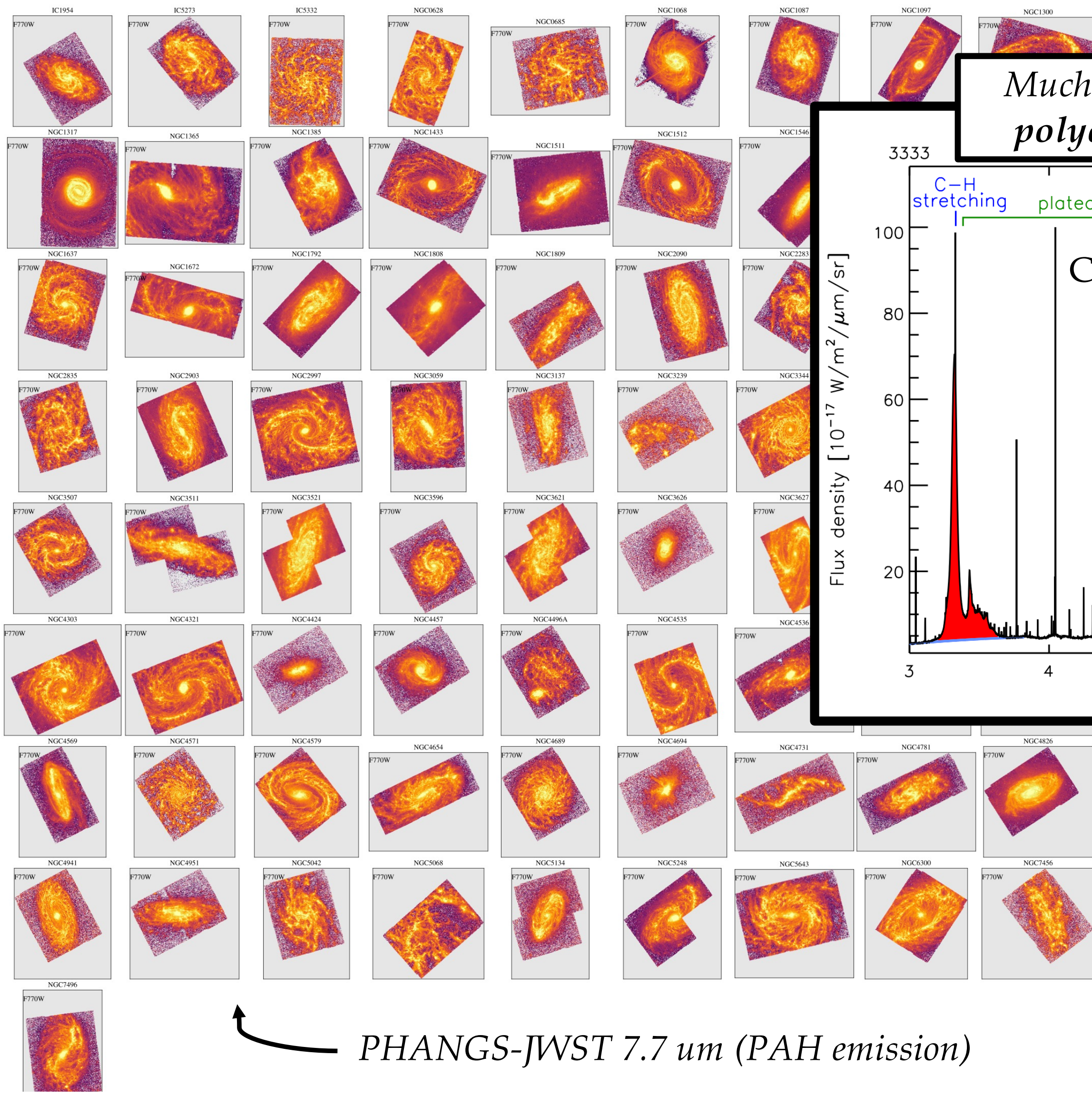




Ryan Chown (chown.5@osu.edu)

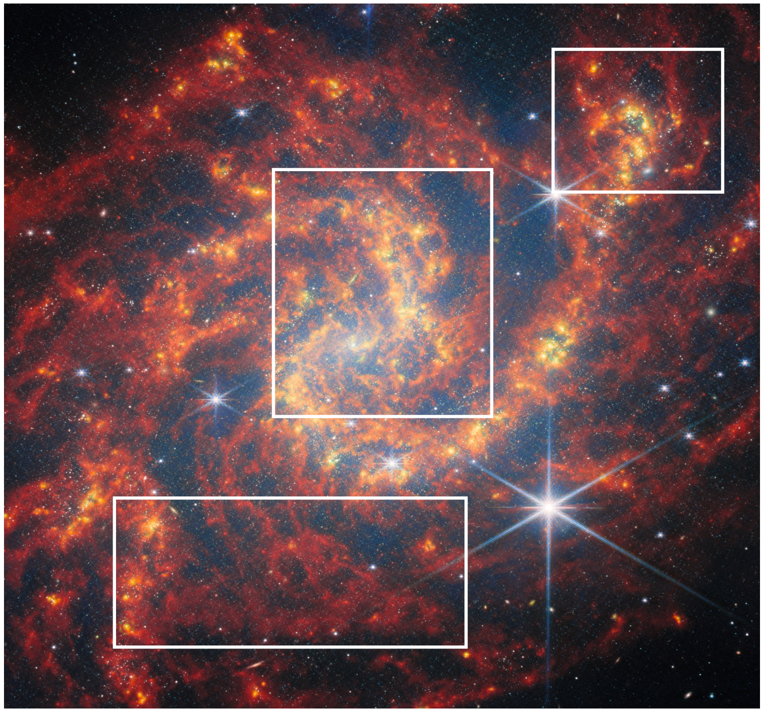
Much of the emission seen by JWST comes from ***polycyclic aromatic hydrocarbons (PAHs)***

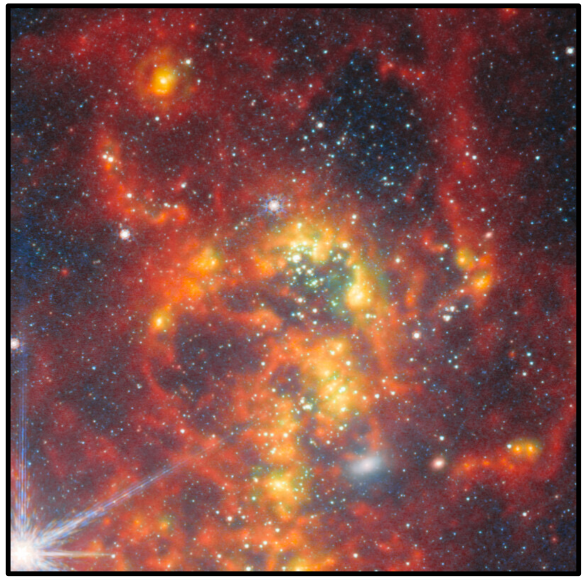




↑ *PHANGS-JWST 7.7 um (PAH emission)*

- 19 galaxies, PI J. C. Lee
- 55 galaxies, PI A. Leroy
- See Chown+25a

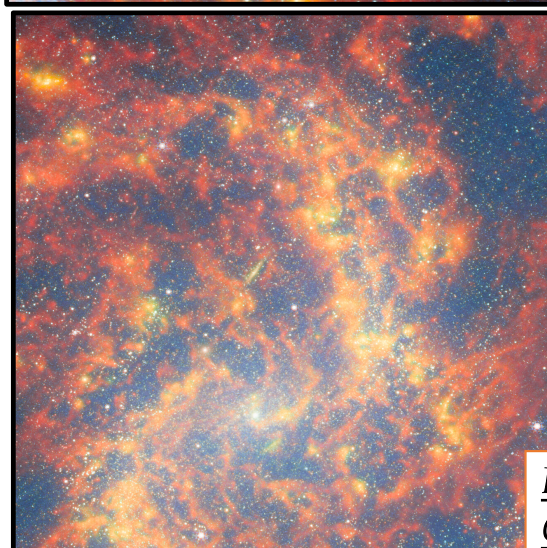




PHANGS

Physics at High Angular Resolution in Nearby Galaxies

- The PHANGS-JWST data are absolutely ***stunning***!
- 74 with JWST NIRCam + MIRI imaging at 15-120 pc resolution!
  - 19 galaxies, PI J. C. Lee
  - 55 galaxies, PI A. Leroy
  - See Chown+25a



Blue & green: *stars*
Orange & red: *PAHs and dust*

Approaches for Mapping H_2

H₂ column density = CO surface brightness × CO-to-H₂ conversion factor

$$N(H_2) = I_{CO} \times X_{CO}(Z, \ldots)$$

To answer questions about molecular clouds like

- How are they structured?
- How efficiently do they turn into stars?

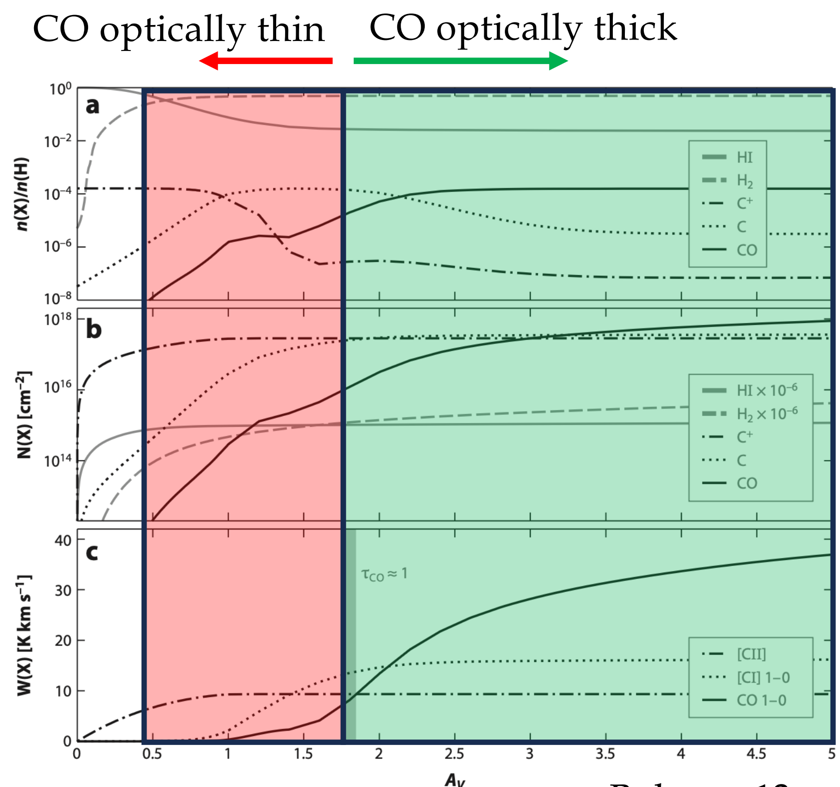
… we need CO, the standard tracer of cold H_2 (Bolatto+13)

Drawbacks:

- τ: "akin to using the presence of a brick wall to estimate the depth of the building behind it" – Kennicutt & Evans 2012
- Highly uncertain CO-H_2 conversion factor
- Low metallicity: compact CO emission (e.g. Rubio+15, Schruba+17), CO-dark gas (e.g. Jameson+18, Madden+20)

Complimentary/alternative approaches:

- Dust (e.g., Leroy+11), PAHs (Gao+19, Cortzen+19, Chown+21, Leroy+23, Whitcomb+23, Chown+25a)



Bolatto+13

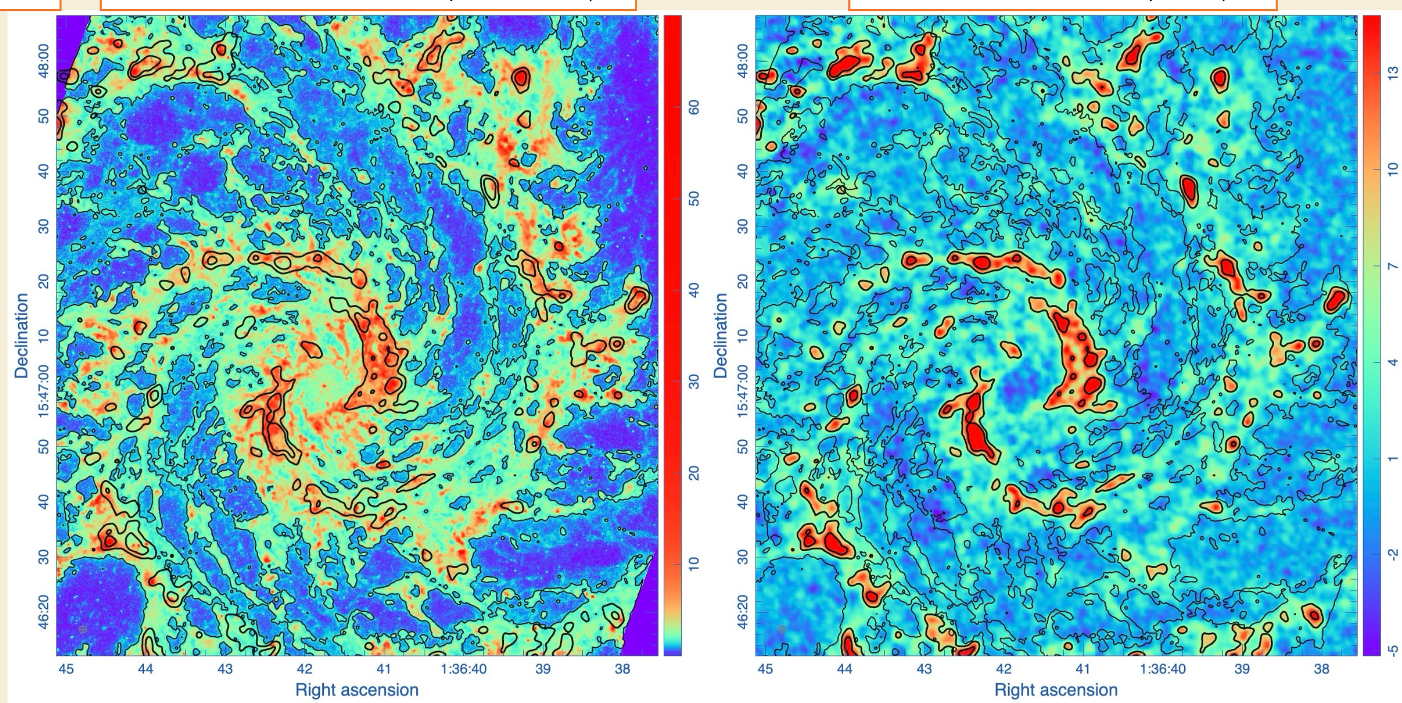
PAH Maps Look Like CO Maps

… with higher resolution and much better sensitivity!

NGC 628

JWST 7.7 um (PAHs)

ALMA CO(2-1)



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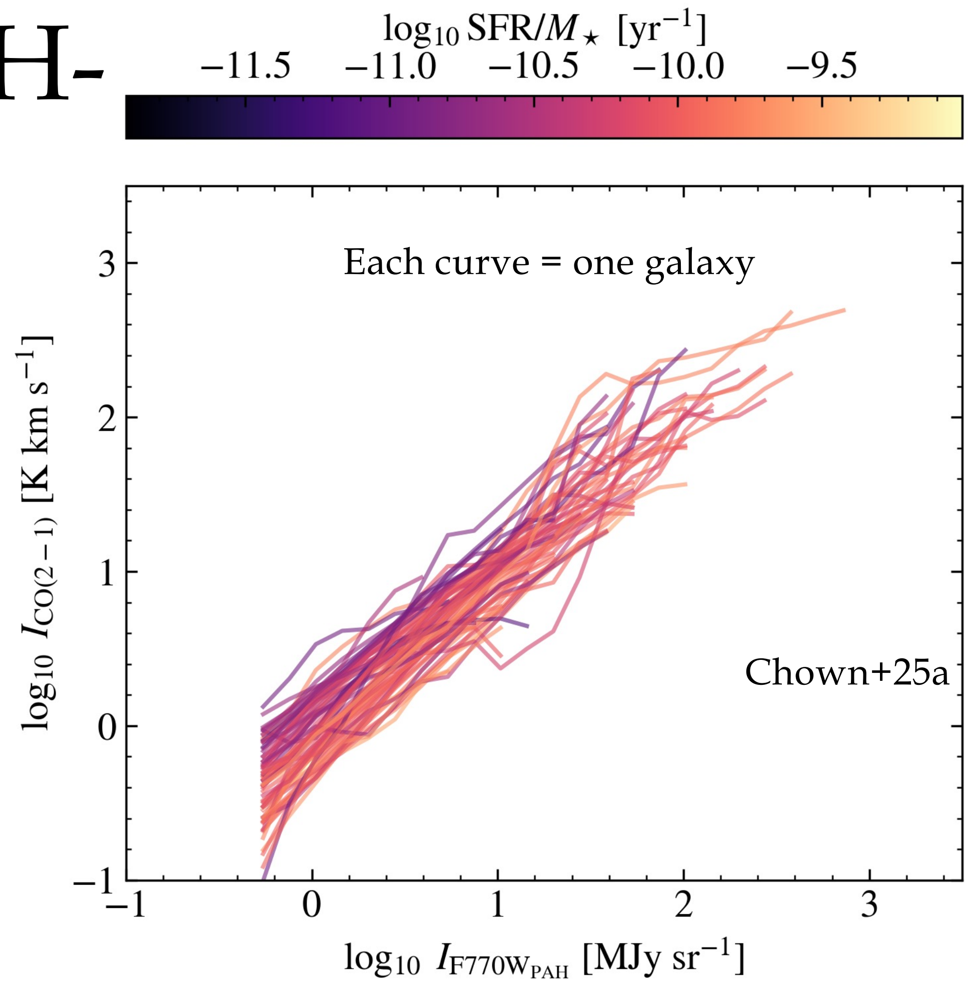
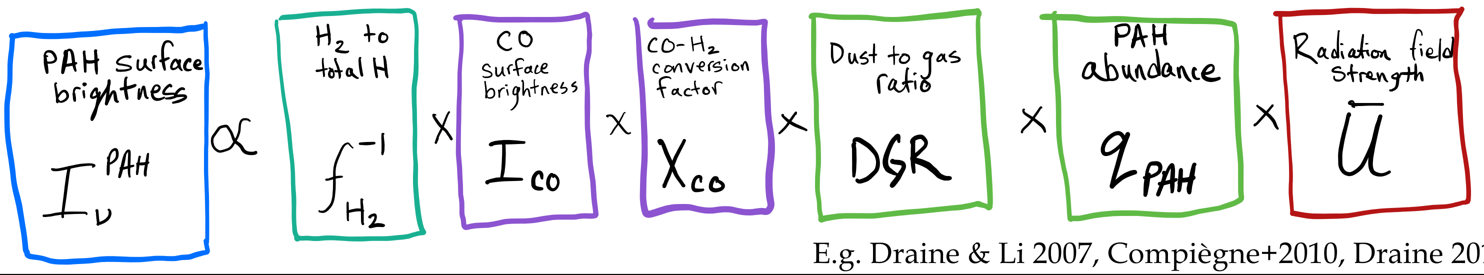
Quantifying the PAH-CO Relationship

Chown+25a

- I_{CO} vs I_{PAH} at ~100 pc scale resolution across 70 galaxies with PHANGS JWST and ALMA (Chown et al. 2025a)
- Tight (r=0.6-0.9) power-law n=0.8-1.3 correlations between CO(2-1) and PAH emission (F335M, F770W, F1130W)
- Offsets from galaxy to galaxy due to physics



Drivers of PAH-CO Variations



E.g. Draine & Li 2007, Compiègne+2010, Draine 2011

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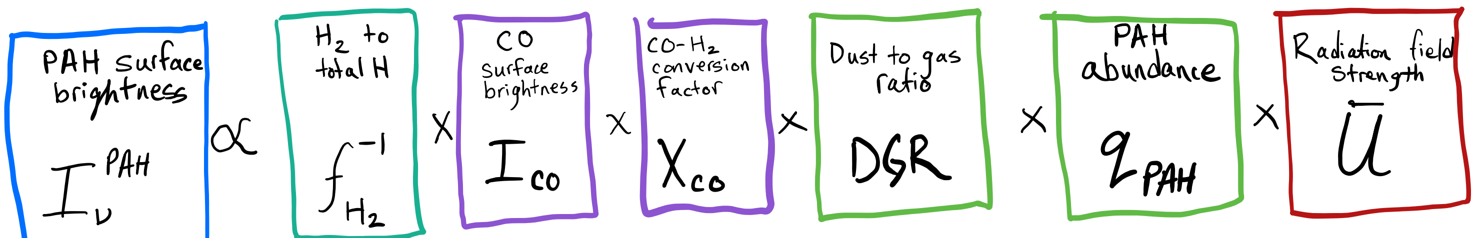
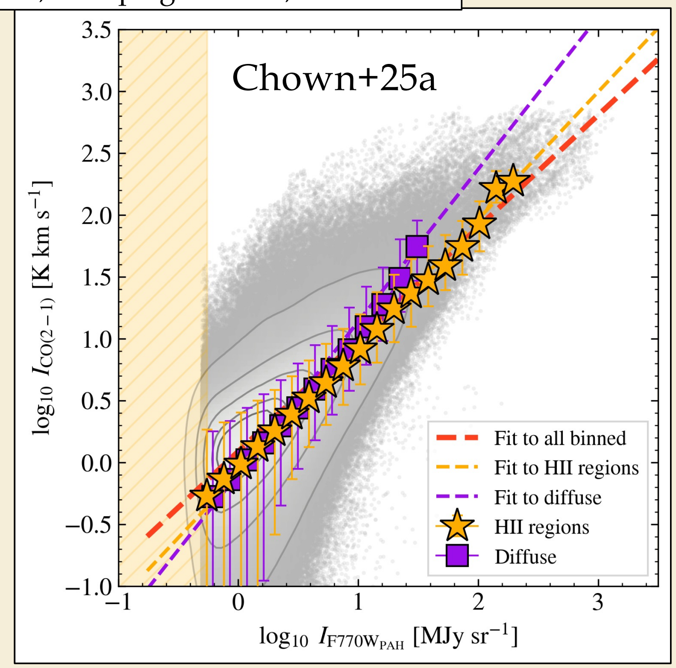
Drivers of PAH-CO Variations



E.g. Draine & Li 2007, Compiègne+2010, Draine 2011

1. Regions with nebular emission vs those with diffuse gas

- Unresolved at 1" res., but might expect ↓ X_{CO}, ↓ q_{PAH}, ↑ U, ↑ DGR
- In PHANGS, HII regions are brighter overall, but no major differences in CO/PAH

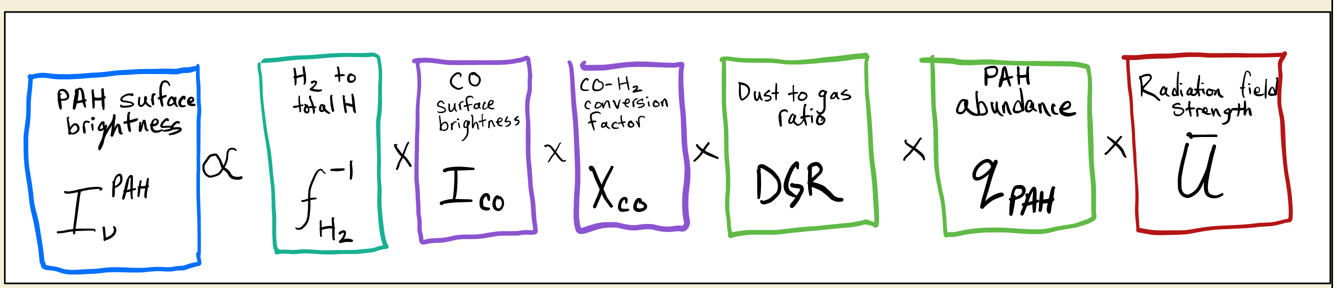


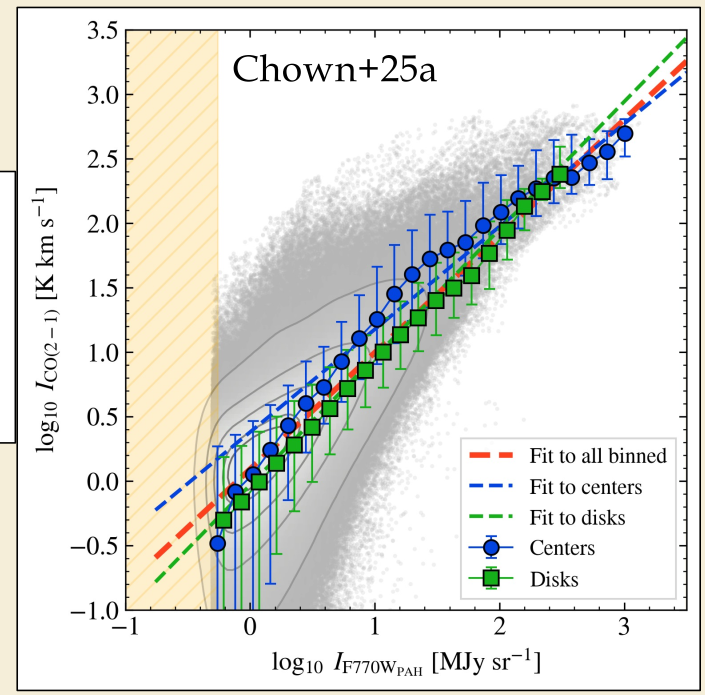
Ryan Chown (chown.5@osu.edu)

Drivers of PAH-CO Variations

2. Galaxy centers/CMZs versus disks

- Centers brighter overall, higher CO/PAH ratios than disks
- Centers: ↓ X_{CO}, ↓ q_{PAH}(?), ↑ U, ↑ DGR
  - X_{CO} may be the dominant factor





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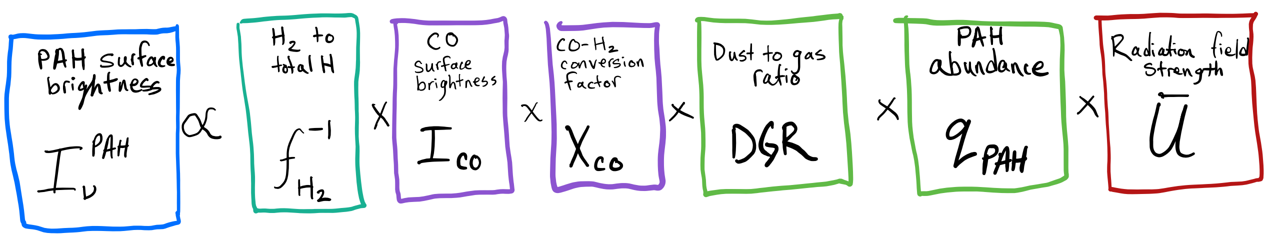
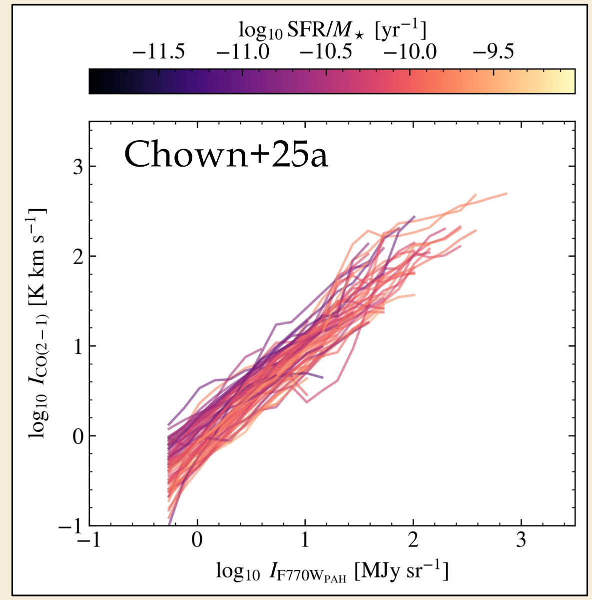
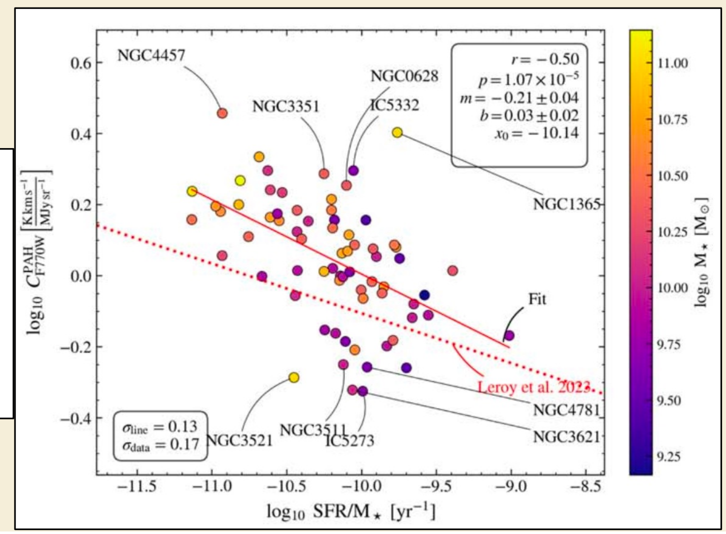
Drivers of PAH-CO Variations

3. Do any galaxy properties correlate w/ CO/PAH normalization?

- Yes! log SSFR and log M* are best
- Physics of the relationship
- Application to CO tracing (see Chown+25a for fitting functions for JWST 3.3, 7.7, and 11.3 um to CO(2-1))







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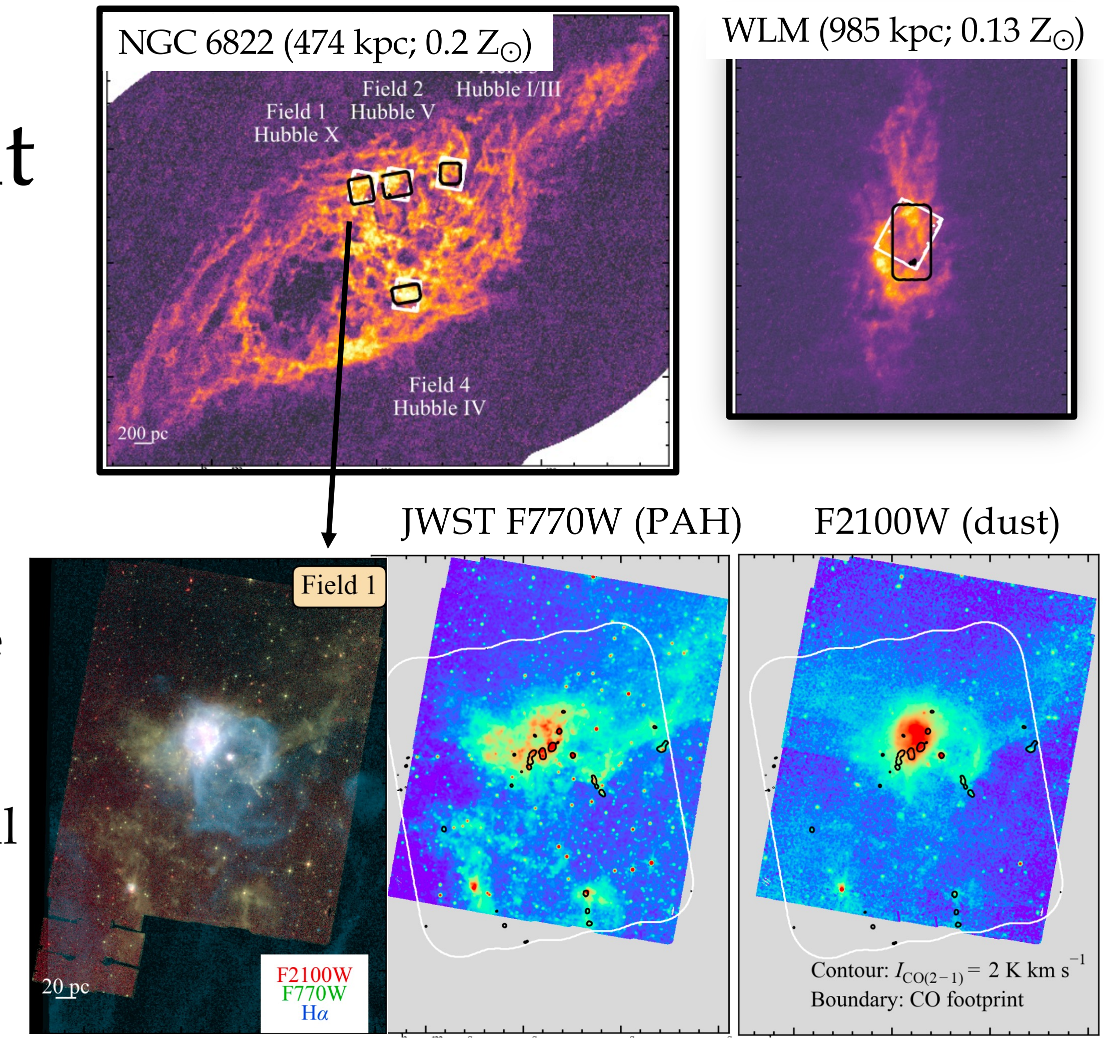
PAH-Gas Relations at Low Metallicity

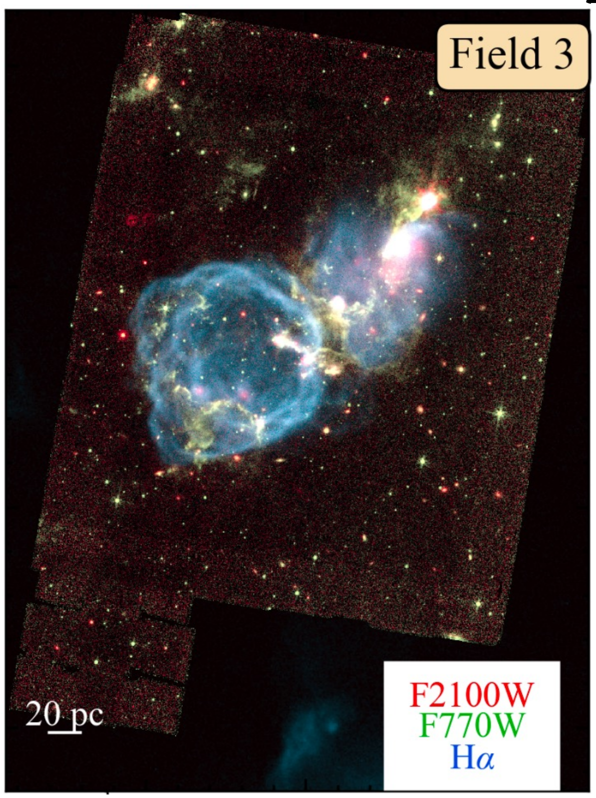
Chown+25b

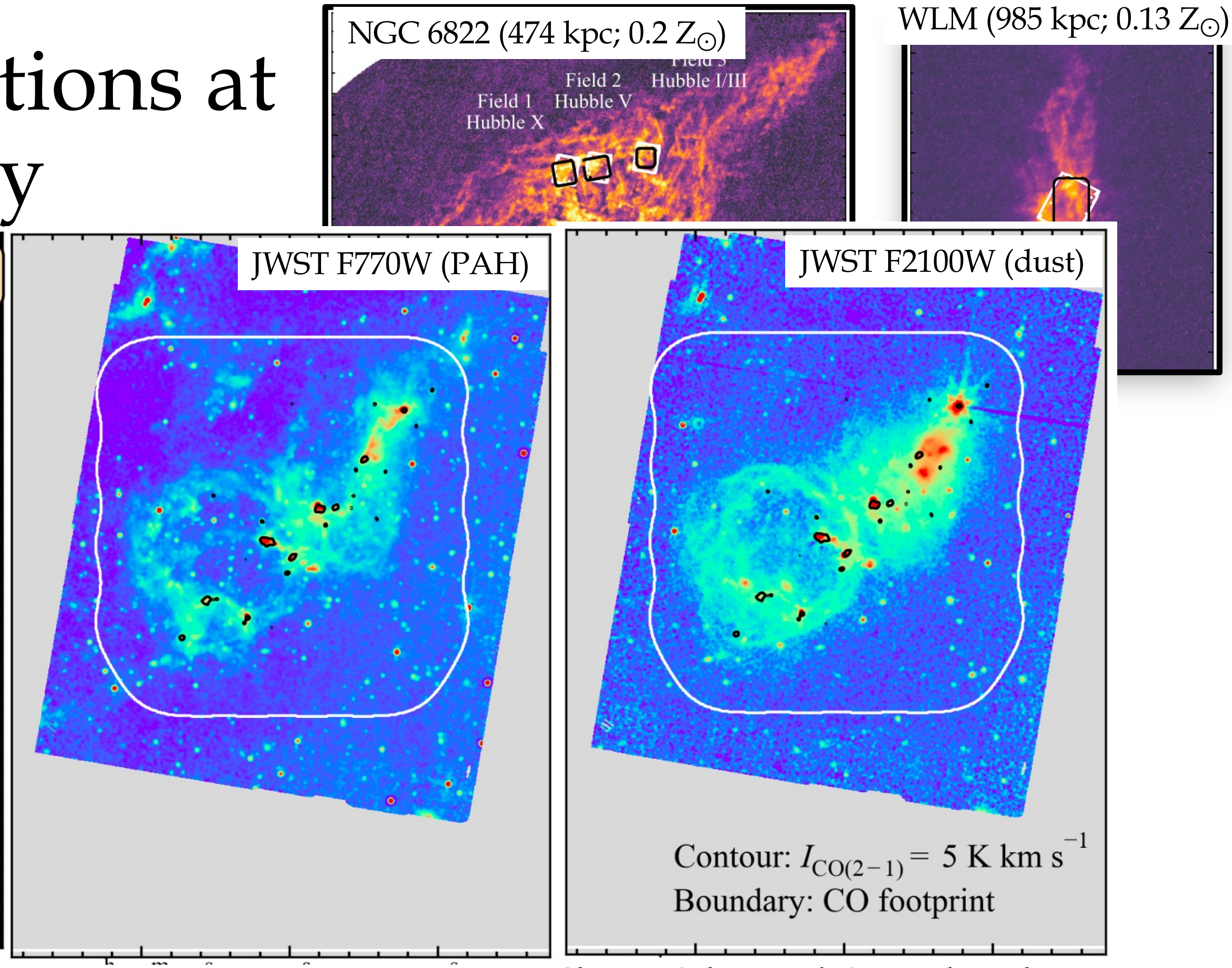
- Z is a key parameter
- Dwarfs: ↑ X_{CO}, ↓ qPAH, ↓ U, ↓ DGR
- CO-emitting regions are ~2 pc in size at low Z (Rubio+15; Madden+20; Hunter+24)
- JWST PAH and dust emission in local dwarfs show *much* more structure than CO



Chown+25b; Pingel+24; Koch+ subm.

PAH-Gas Relations at Low Metallicity





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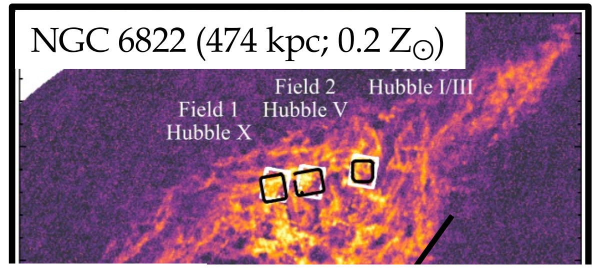
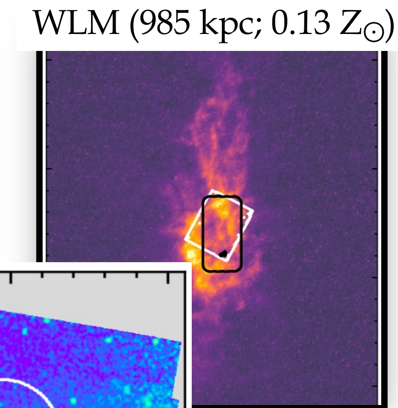
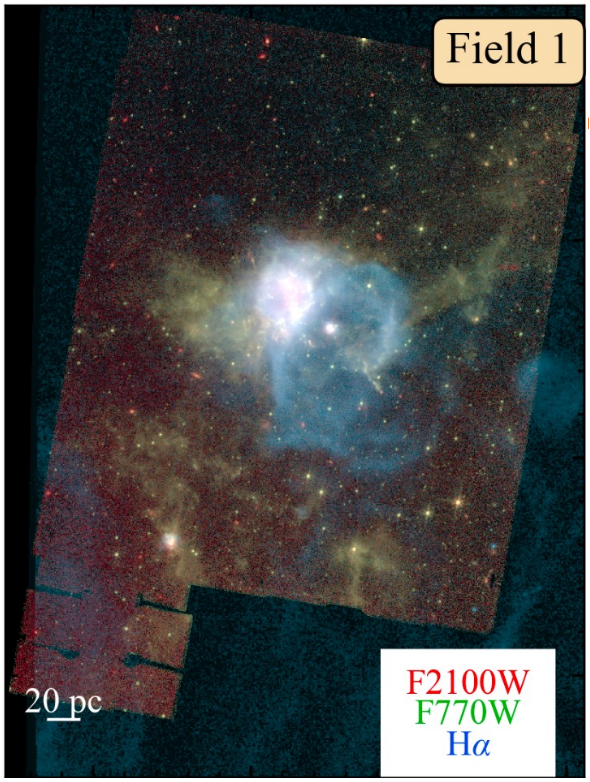
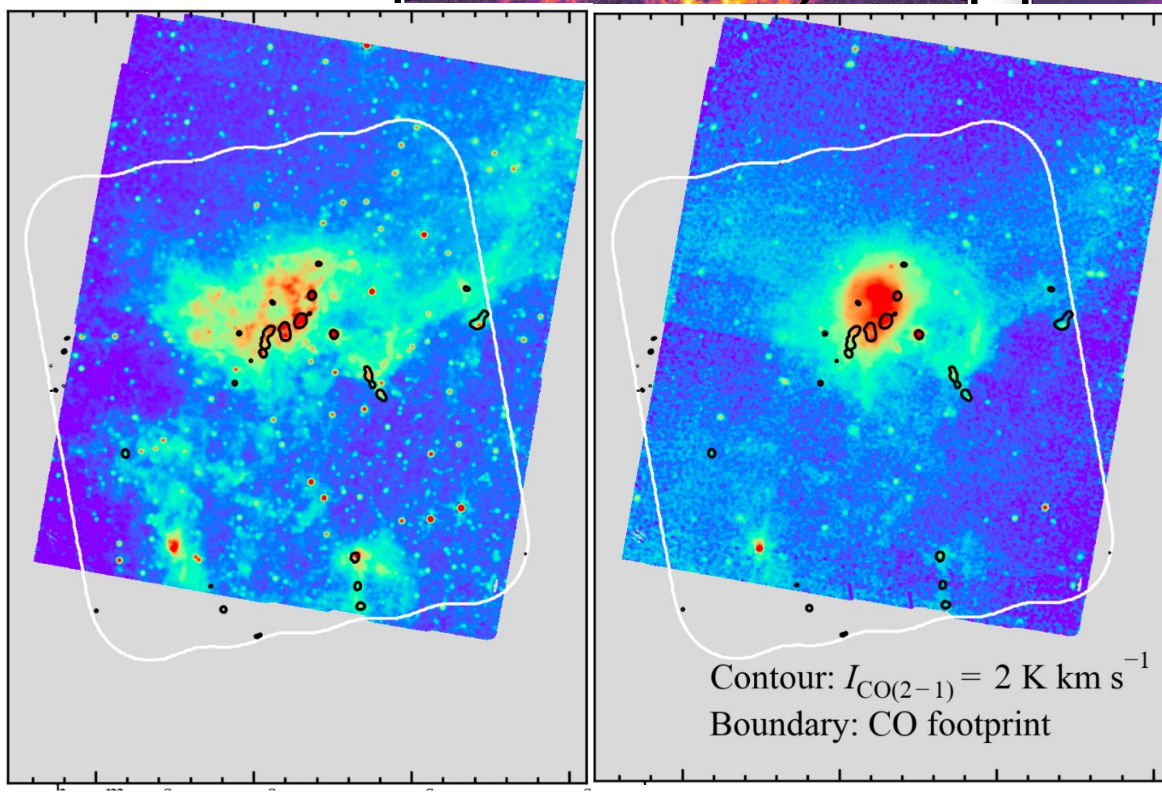








ALMA CO(2-1) being collected (PI Chown)

Ryan Chown (chown.5@osu.edu)

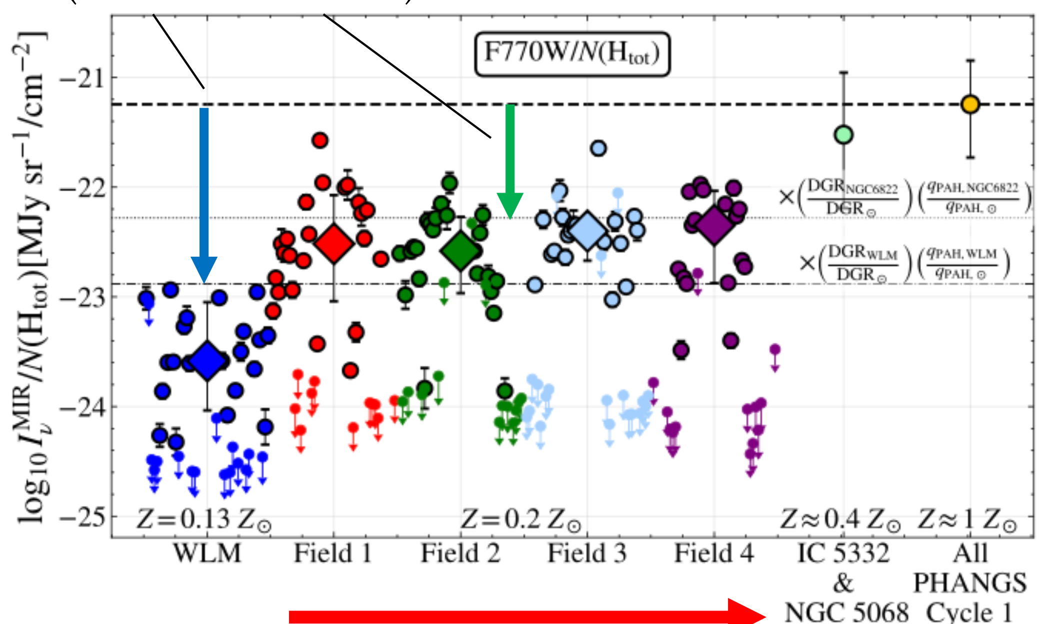
Chown+25b; Pingel+24; Koch+ subm.

PAH-Gas Relations at Low Metallicity

Chown+25b

- Z is a key parameter
- Dwarfs: ↑ X_{CO}, ↓ qPAH, ↓ U, ↓ DGR
- CO/MIR ratios not too different from PHANGS
- MIR/gas (LGLBS HI + ALMA CO) ratios suppressed like DGR and q_{PAH}

Suppression expected from DGR and q_{PAH} (**WLM** & **NGC 6822**)



Increasing Z

Chown+25b; Pingel+24; Koch+ subm.

PAH-Gas Relations at Low Metallicity

Chown+25b

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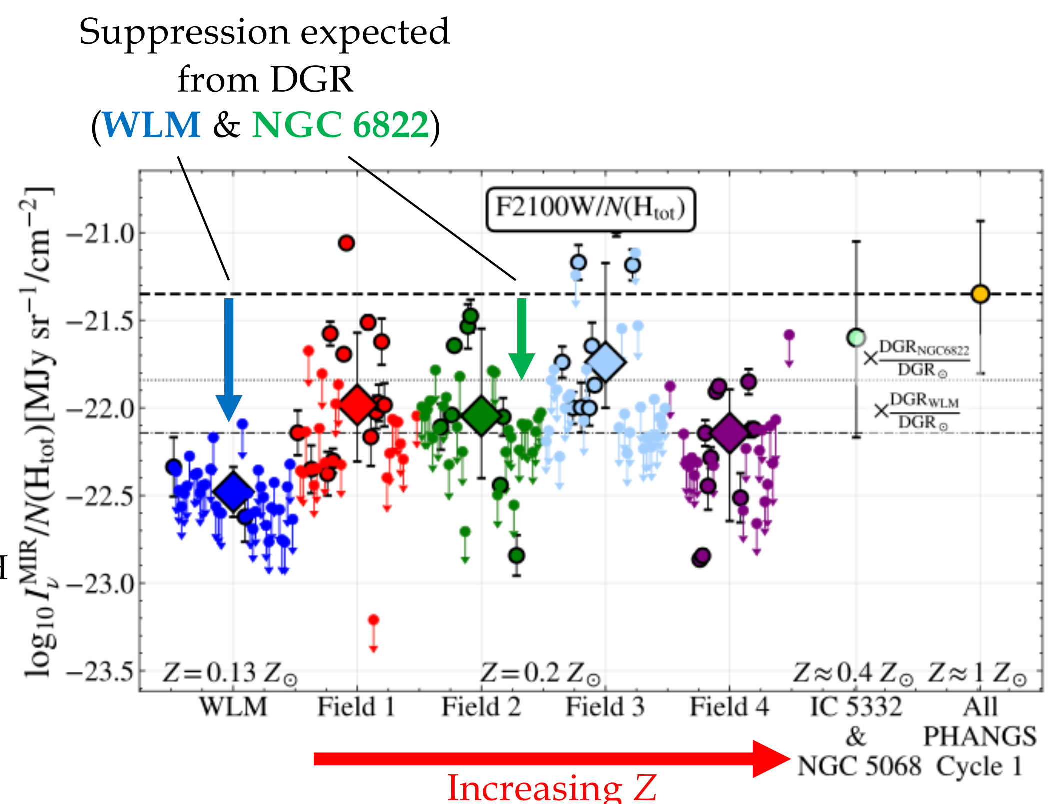

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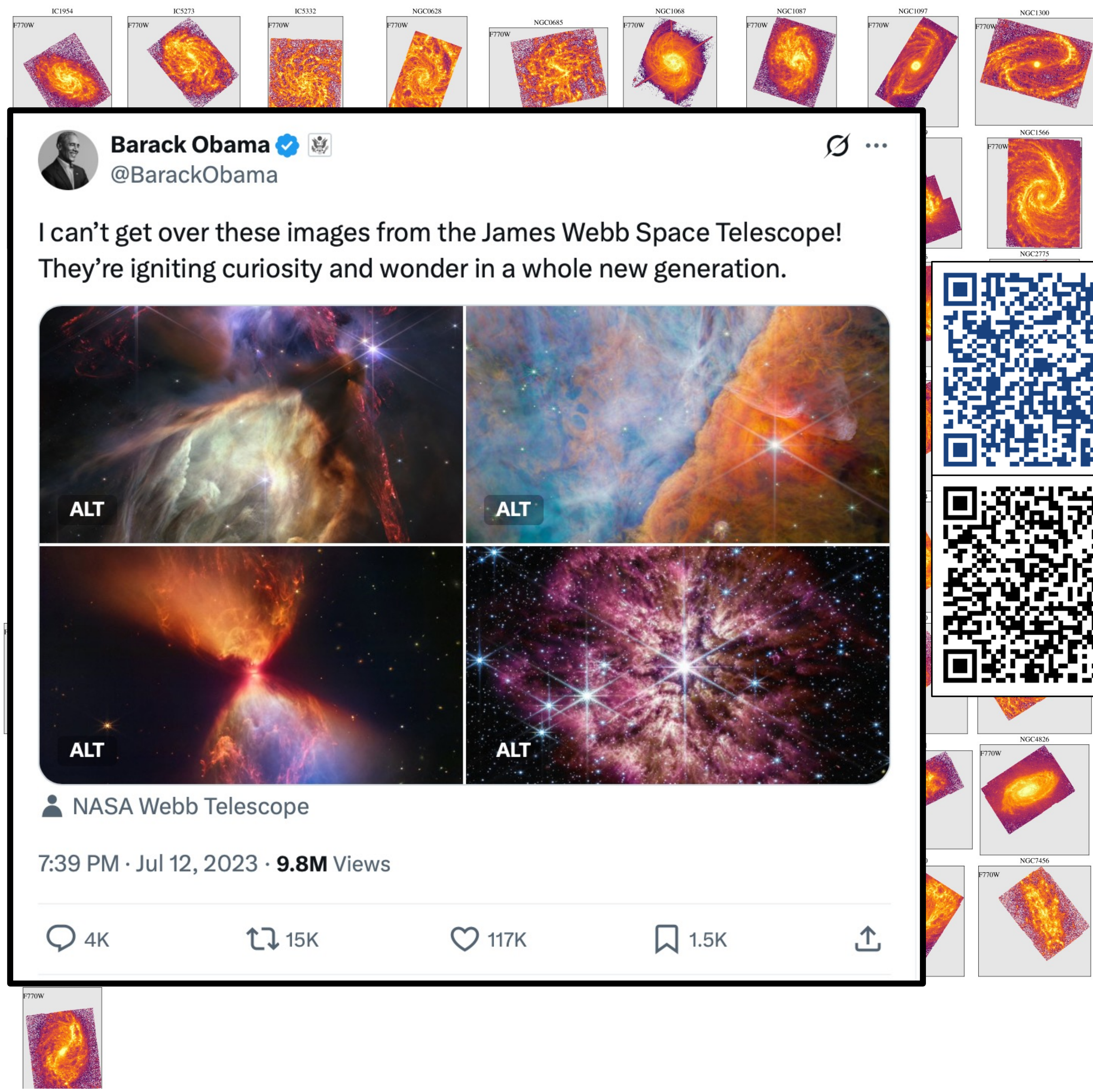

Summary: Transforming Our View of Cold Gas in Galaxies

- PAHs: very sensitive, high-resolution tracer of cold gas
- Calibrated across 70 galaxies, linear relationship with CO (**Chown+25a, in press**)
- CO+HI+PAHs at ~2pc resolution in local dwarfs (**Chown+25b, accepted**)
- **Enables new science:**
  - Tests of dust models
  - Turn every JWST PAH picture into a gas picture
  - Characterize ISM structure with transformative level of detail
  - Map the structure of molecular clouds with incredible detail offered by JWST
- **Ongoing + future work:**
  - Resolved comparison of qPAH, U, HI, CO, PAH in subset (**Chown+25c, in prep.**)
  - Full quantification of secondary dependencies across environments
  - Explore the non-linear regime (thermal dust, LIRGs and high redshift galaxies)