





***Constraining the Evolution of
Protoplanetary Disks in Young
Stellar Clusters
(Boyden & Eisner 2020, 2022)***

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University of Arizona
Advisor: Joshua Eisner

Protoplanetary disk evolution in *young stellar clusters*



Example: ONC

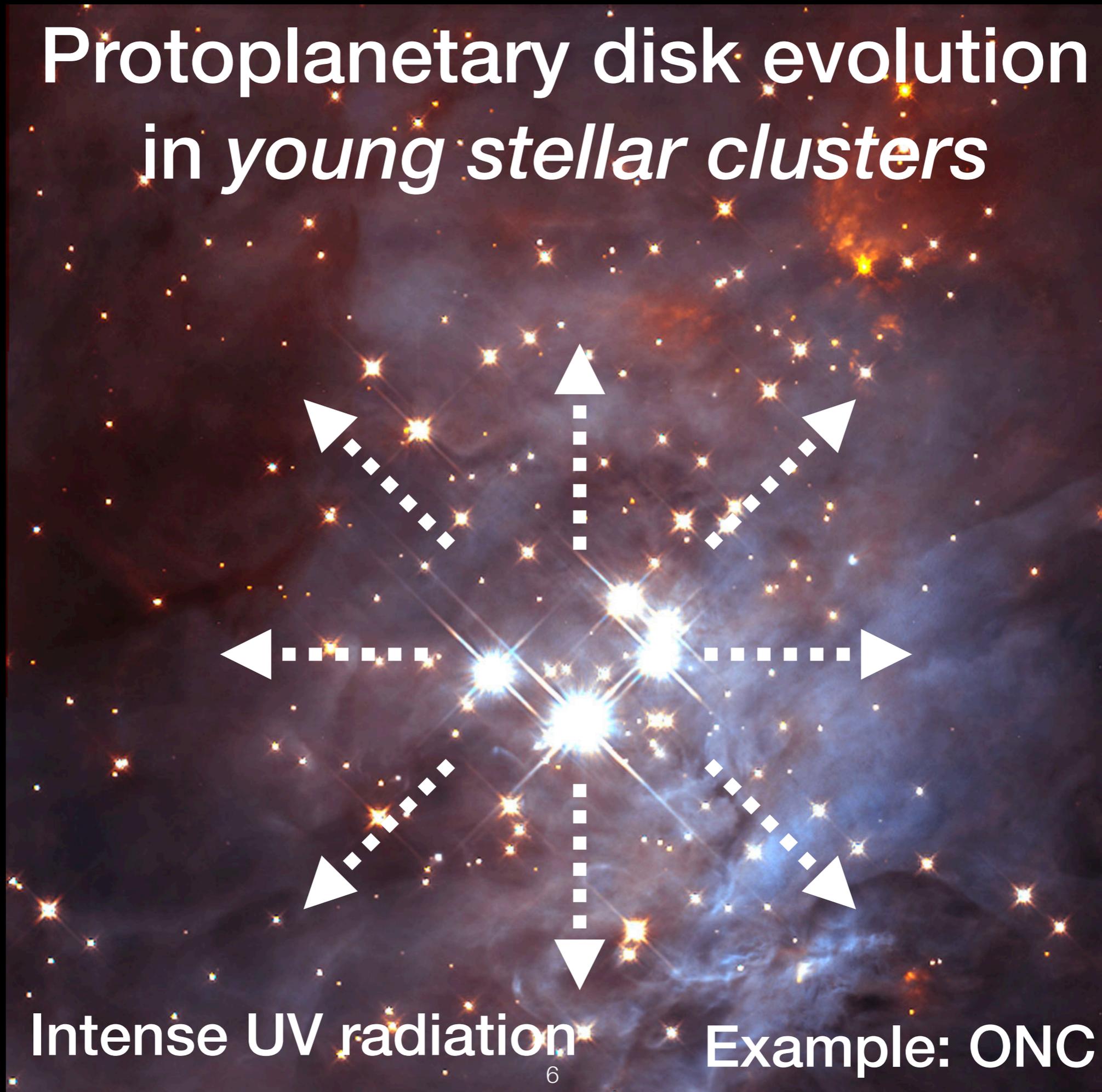
Protoplanetary disk evolution in *young stellar clusters*



Massive Stars

Example: ONC

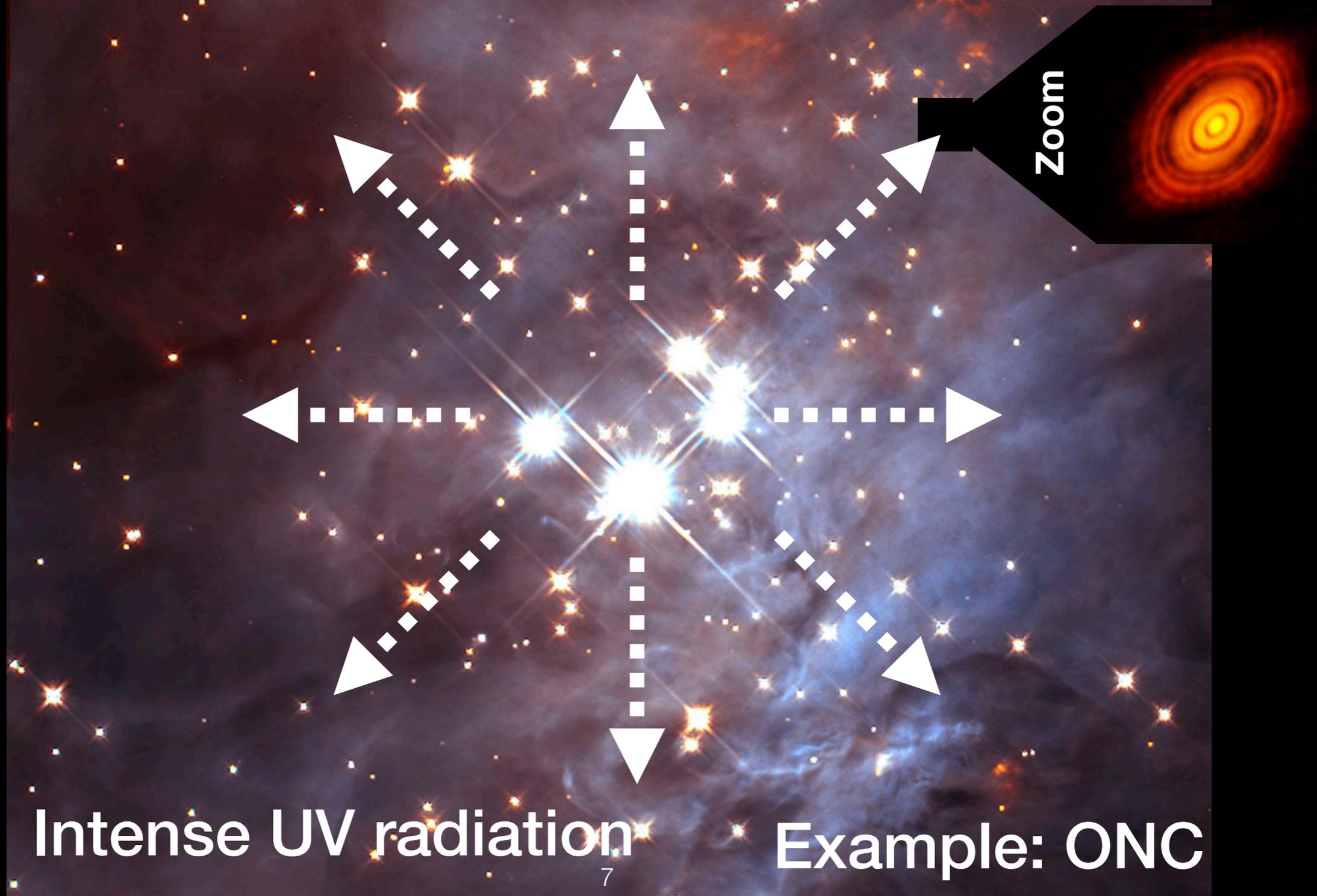
Protoplanetary disk evolution in *young stellar clusters*



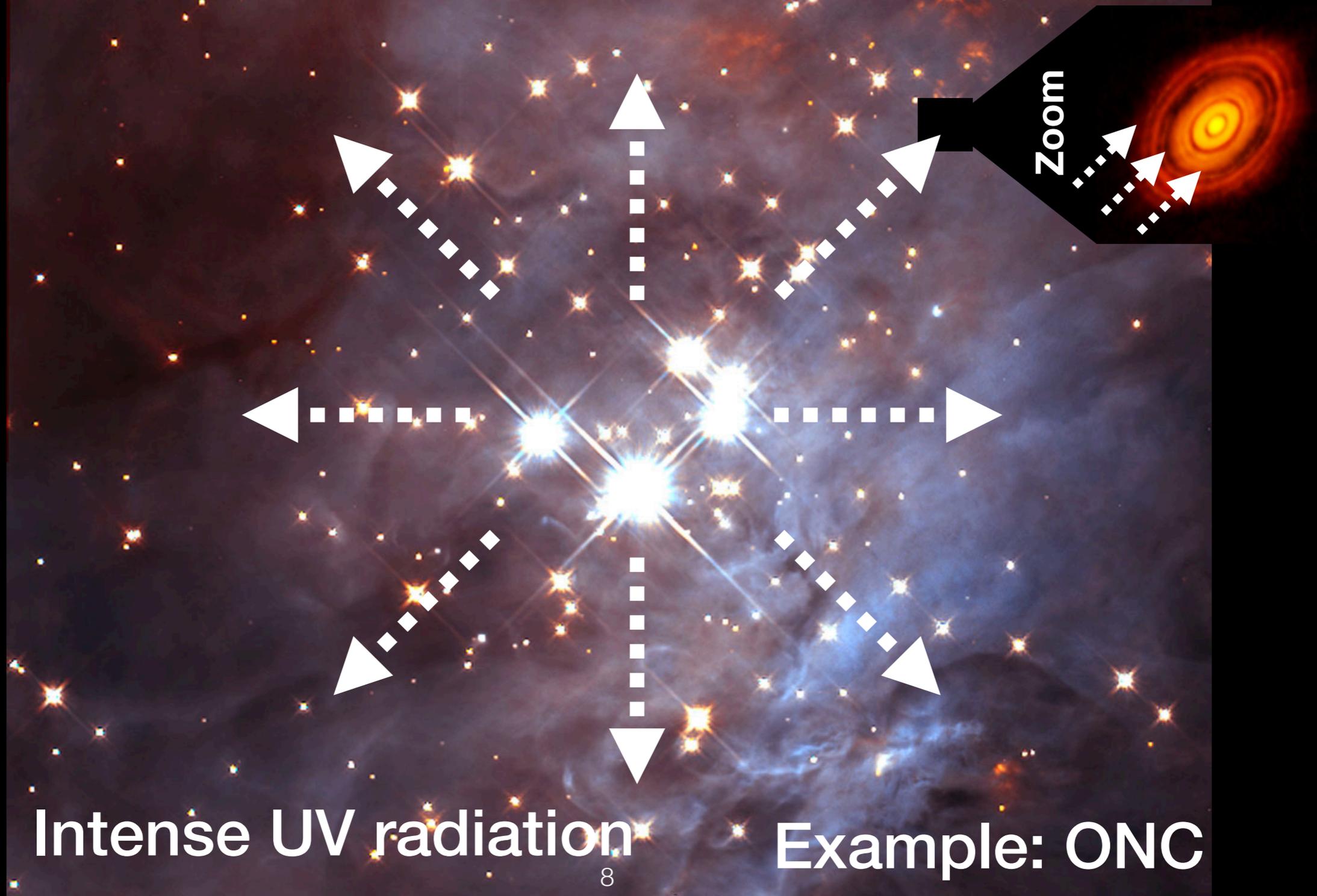
Intense UV radiation

Example: ONC

Protoplanetary disk evolution in *young stellar clusters*



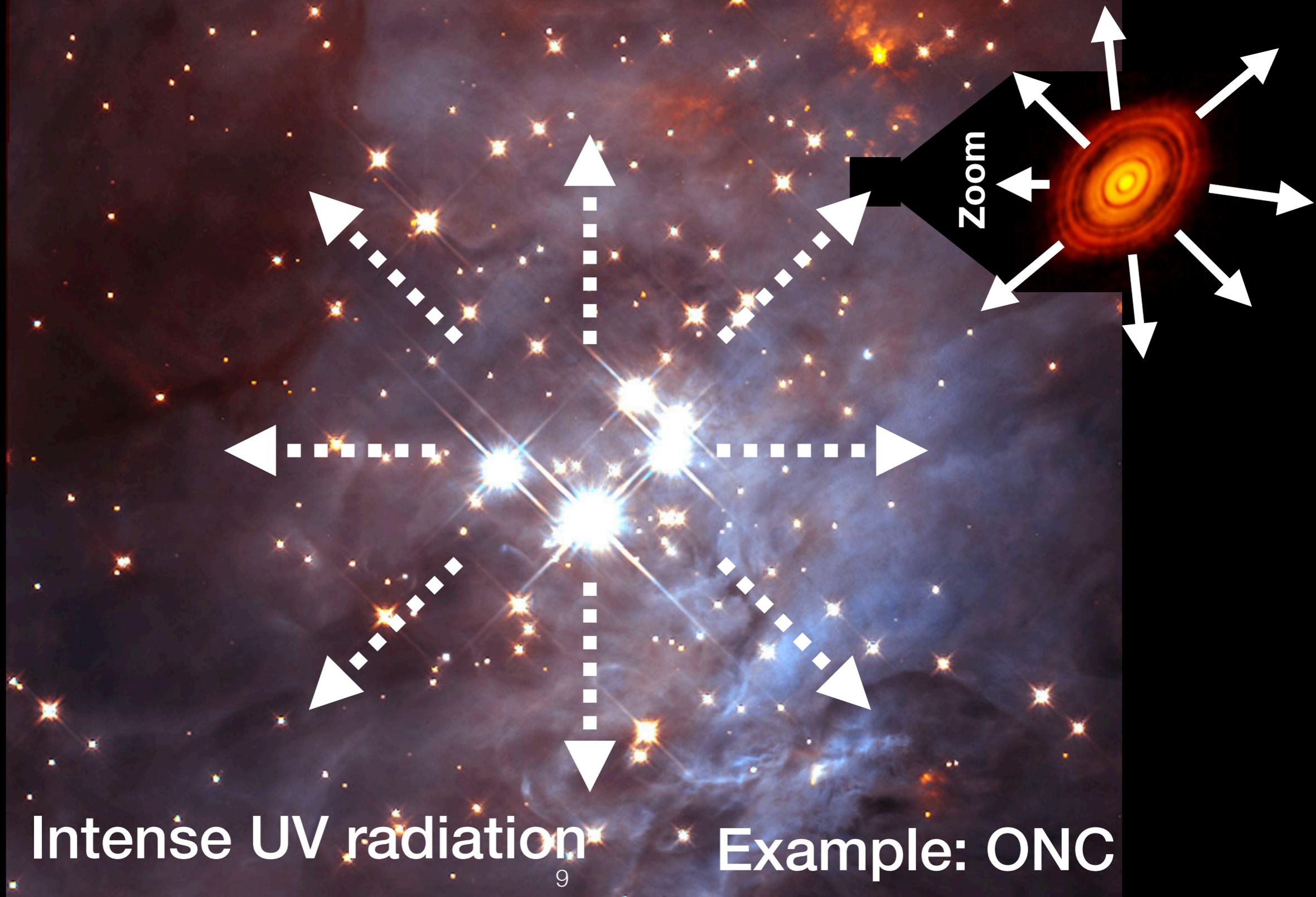
Protoplanetary disk evolution in *young stellar clusters*



Intense UV radiation

Example: ONC

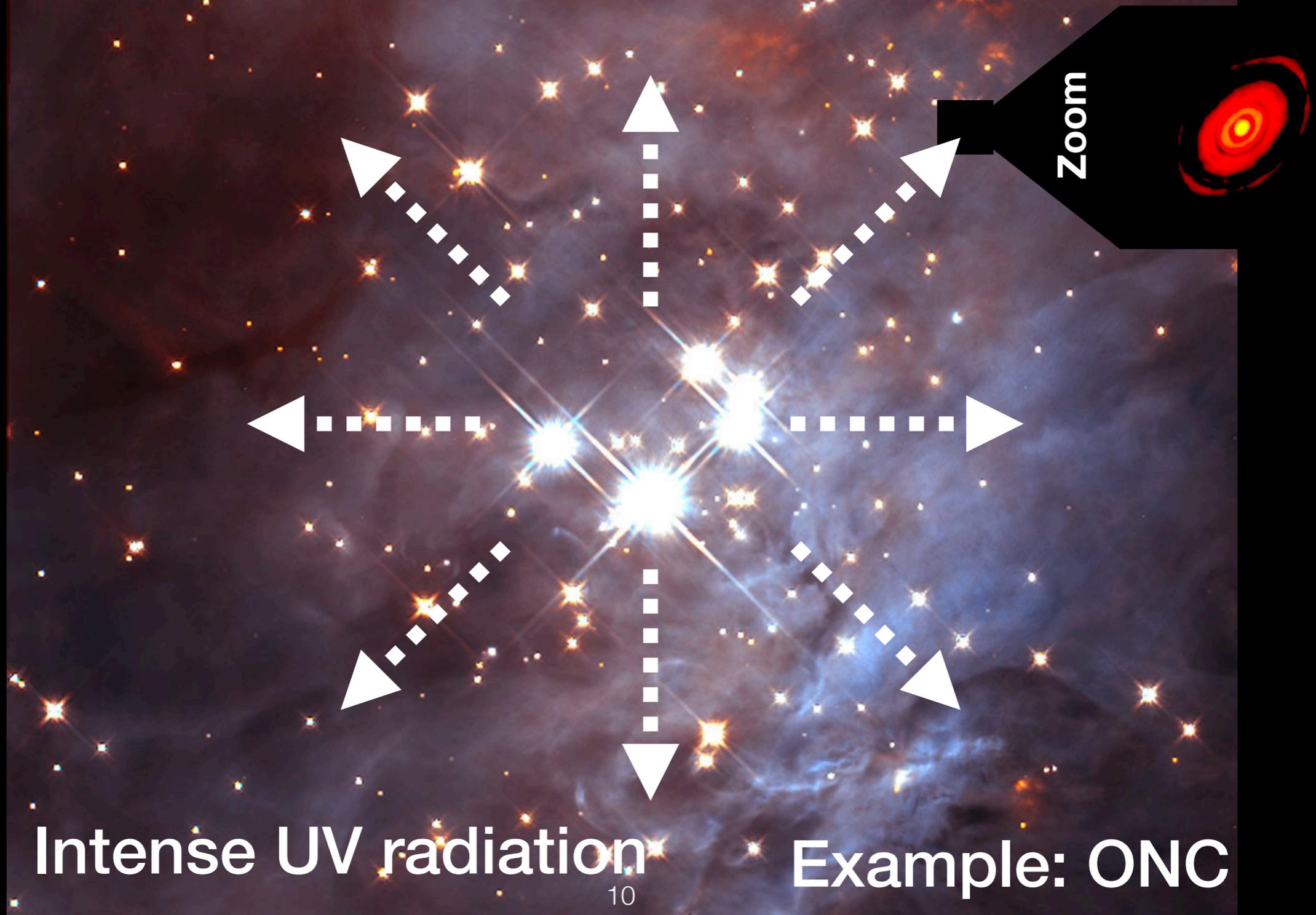
Protoplanetary disk evolution in *young stellar clusters*



Intense UV radiation

Example: ONC

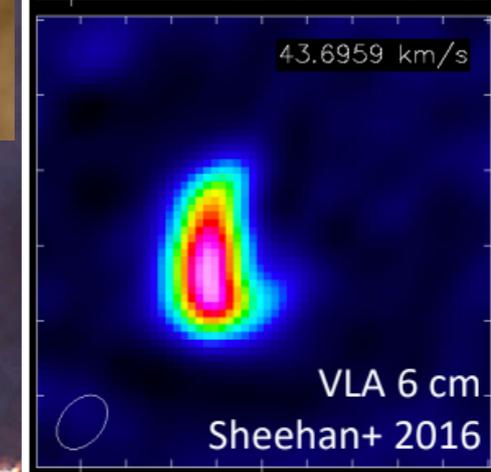
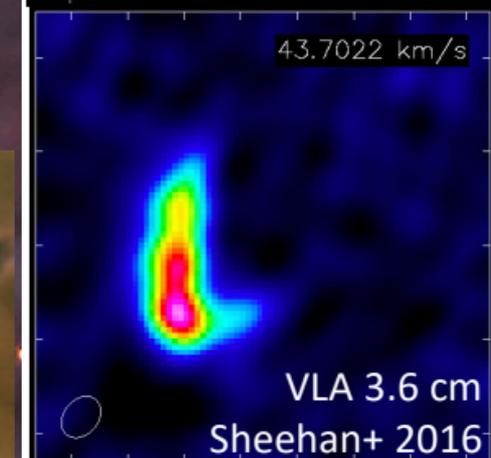
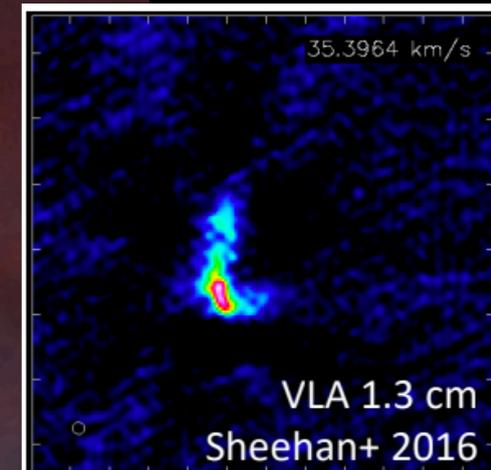
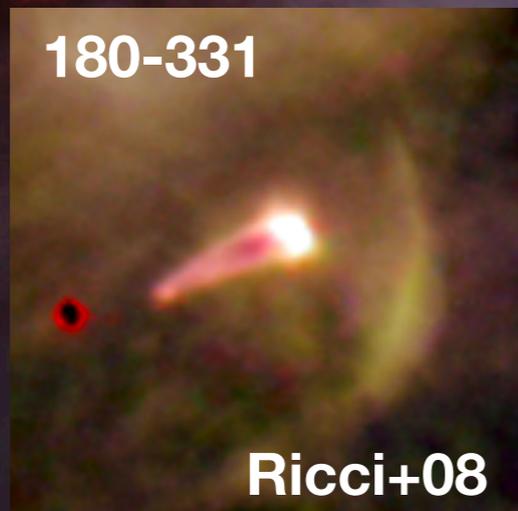
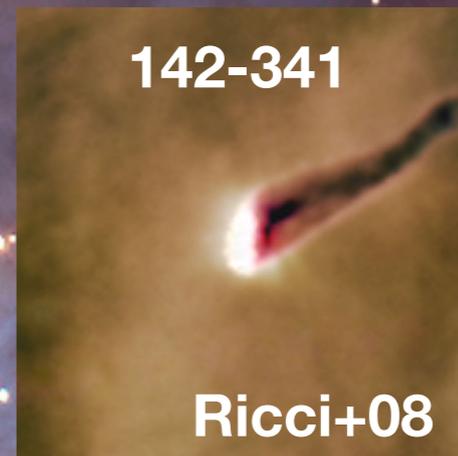
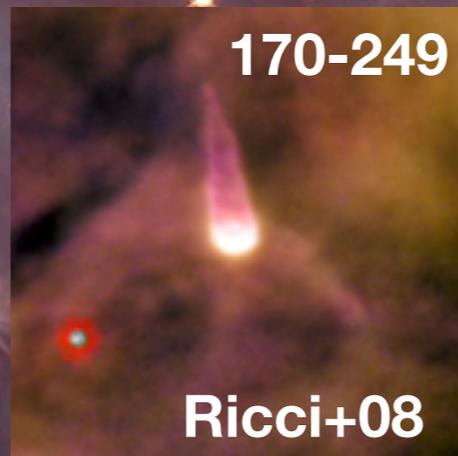
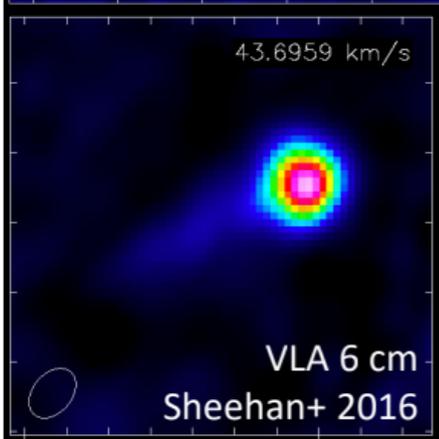
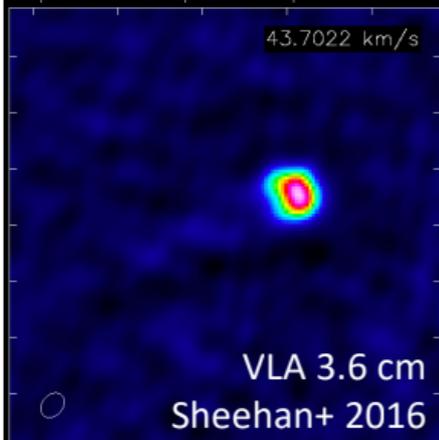
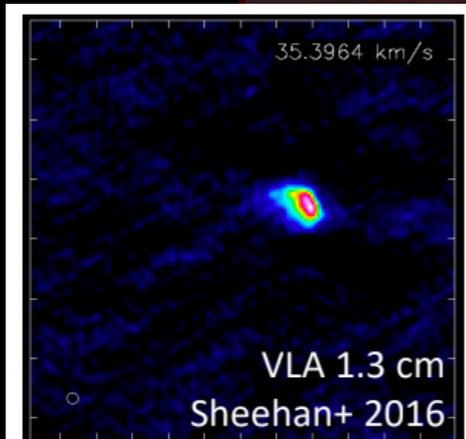
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Intense UV radiation

Example: ONC

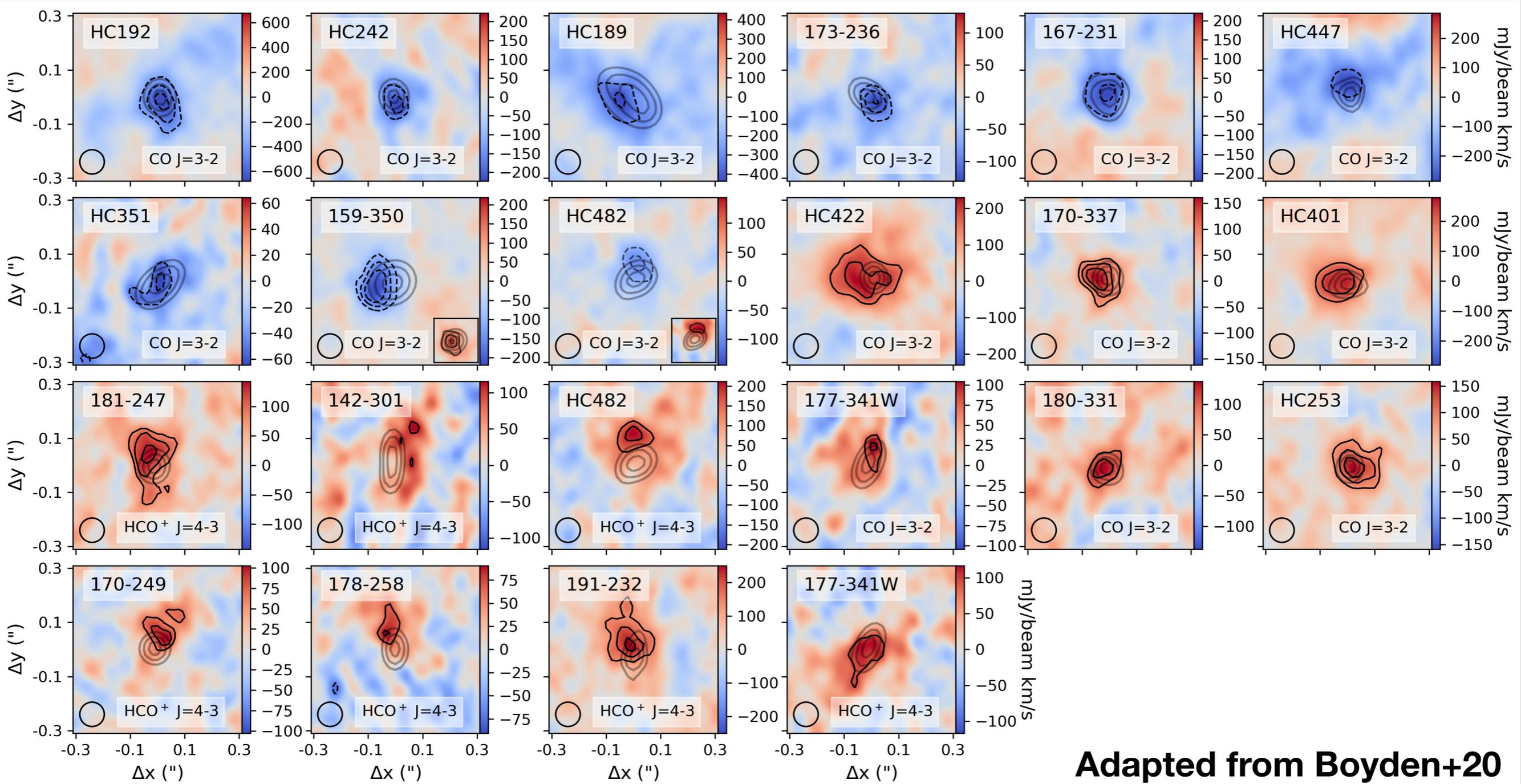
Protoplanetary disk evolution in *young stellar clusters*



“Proplyds”

Gaseous Circumstellar Disks in the ONC

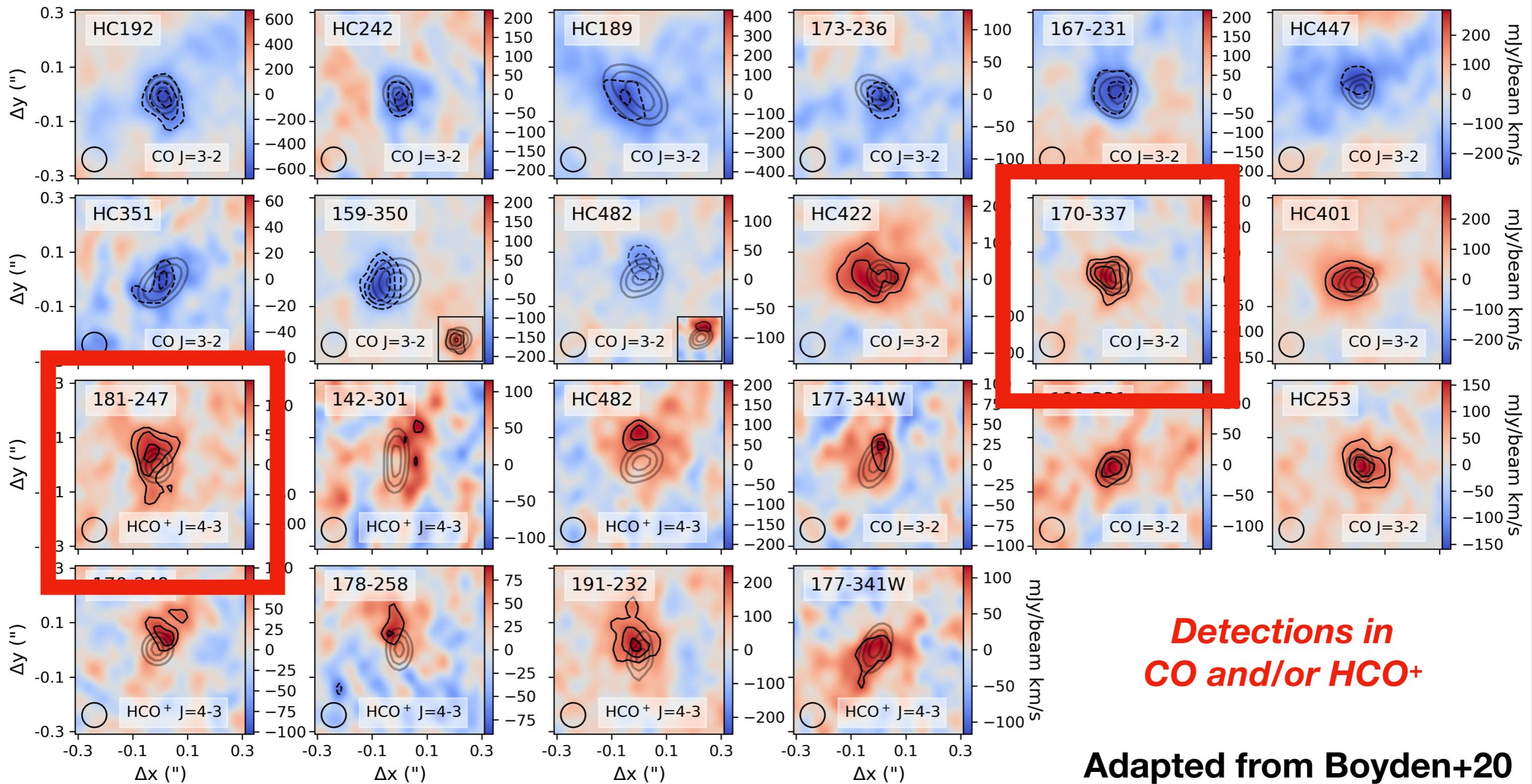
Gaseous Circumstellar Disks in the ONC



ADS Link

Largest Sample of ALMA-detected
gas disks in a clustered SFR

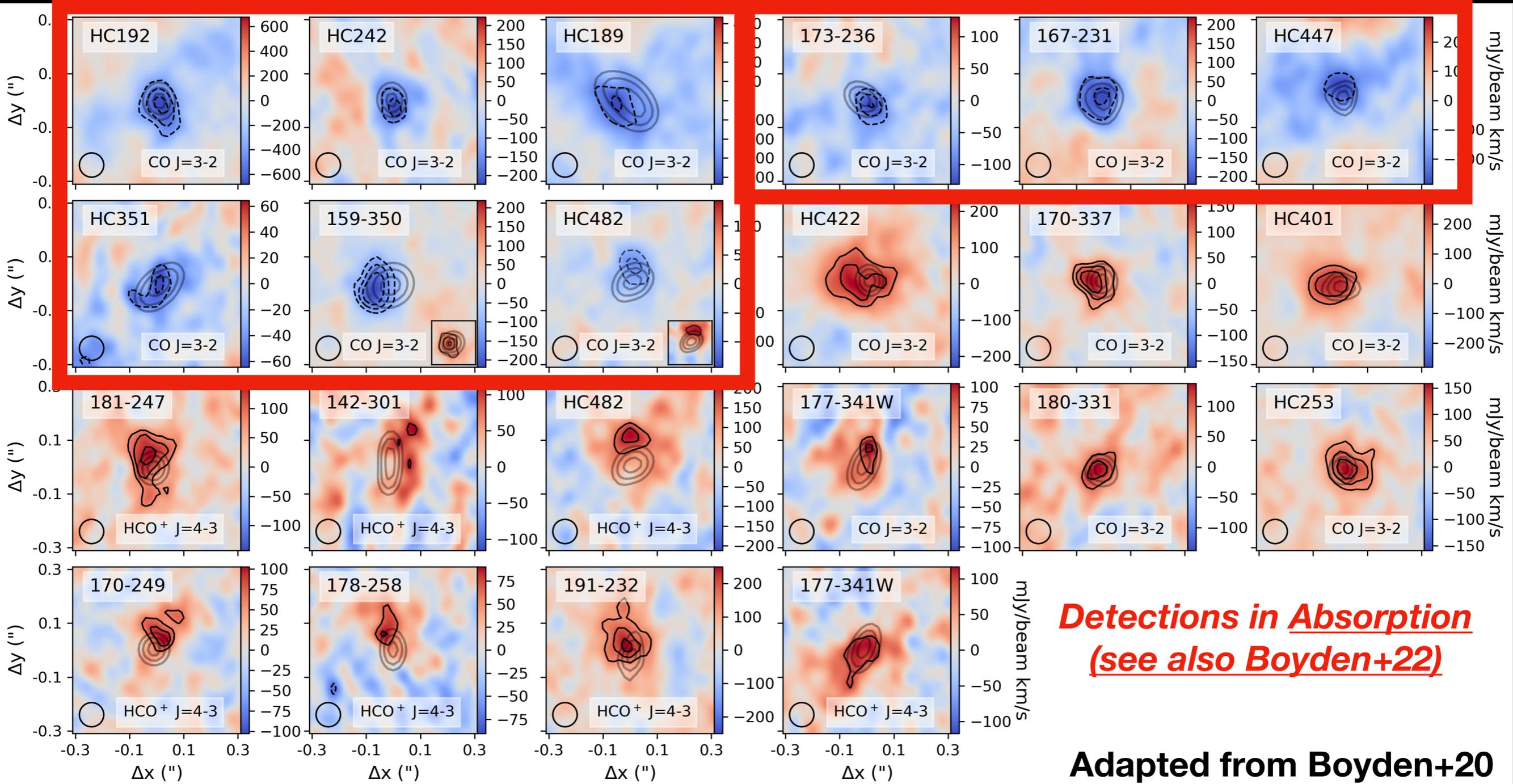
Gaseous Circumstellar Disks in the ONC



ADS Link

Largest Sample of ALMA-detected gas disks in a clustered SFR

Gaseous Circumstellar Disks in the ONC

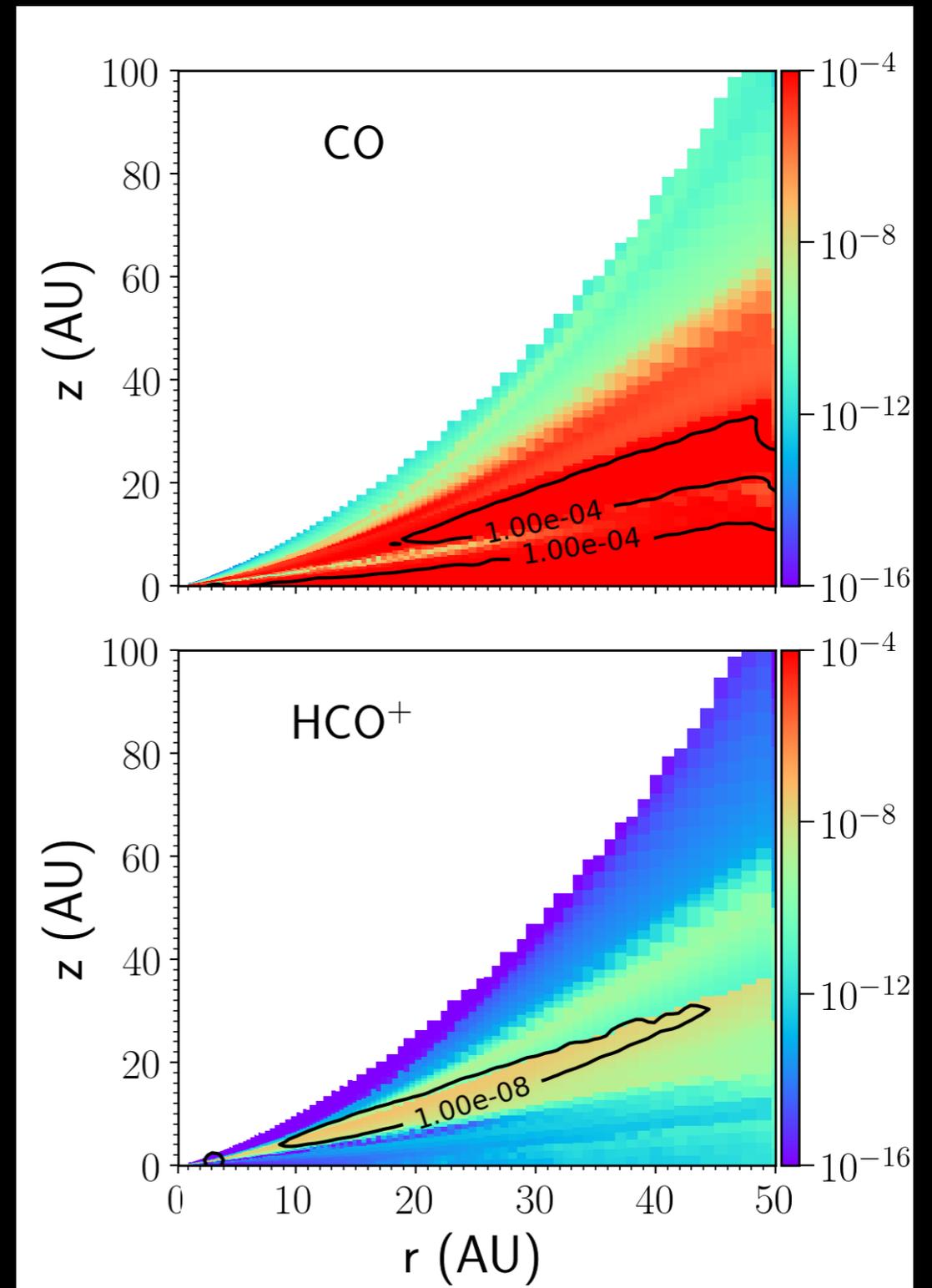


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Largest Sample of ALMA-detected gas disks in a clustered SFR

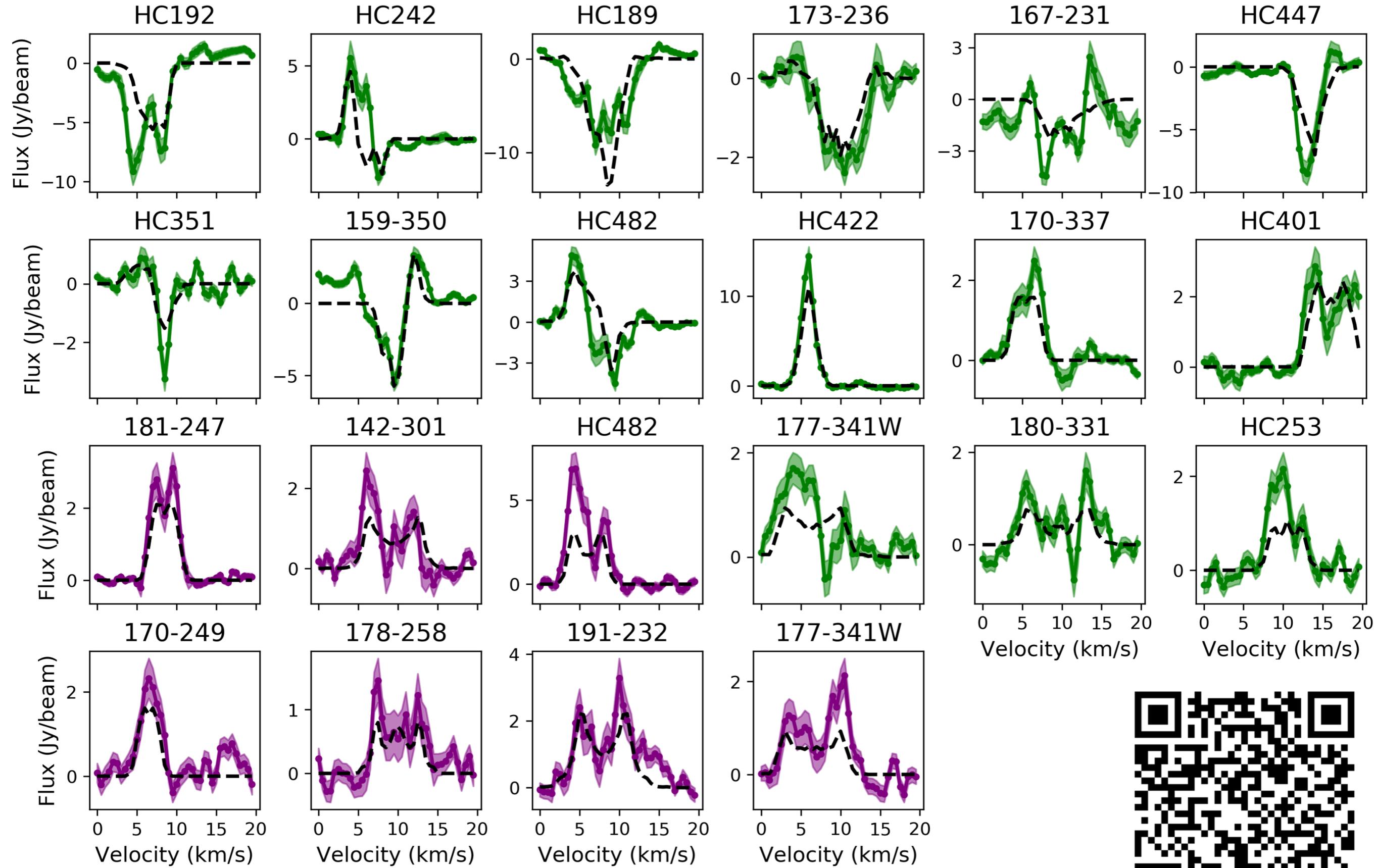
Thermochemical Modeling Procedure

- Using the Thermochemical code RAC2D (Du+14), we:
 - Generated a large grid of model disks as a function of
 - Disk dust and gas masses
 - UV/X-ray radiation fields
 - Disk Sizes
 - Viewing Geometry
 - Central Stellar Mass
 - Fitted a large grid of models to ALMA continuum observations + ALMA observations of CO emission, CO absorption, and/or HCO⁺ emission



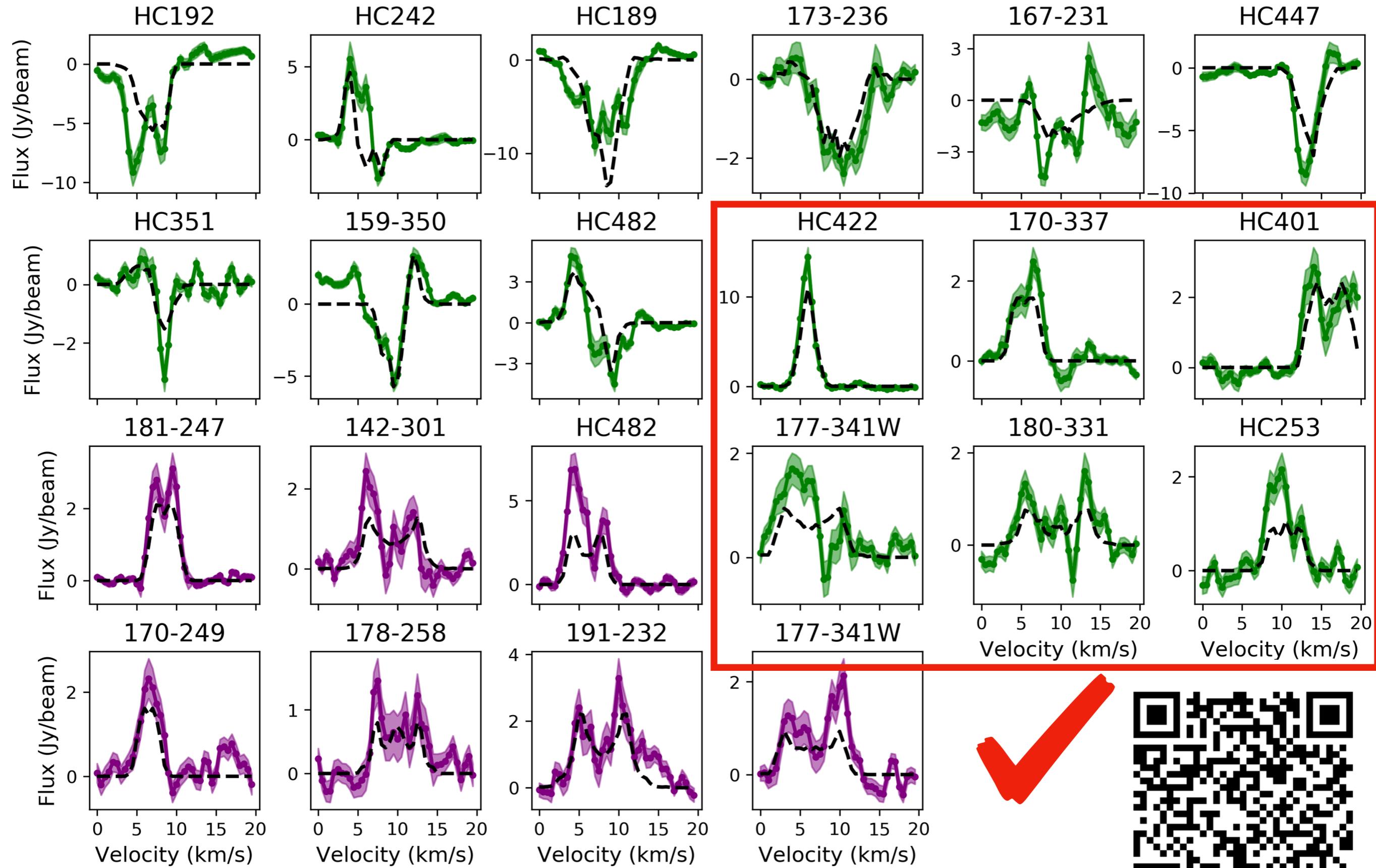
Boyden+22

Full Modeling Results

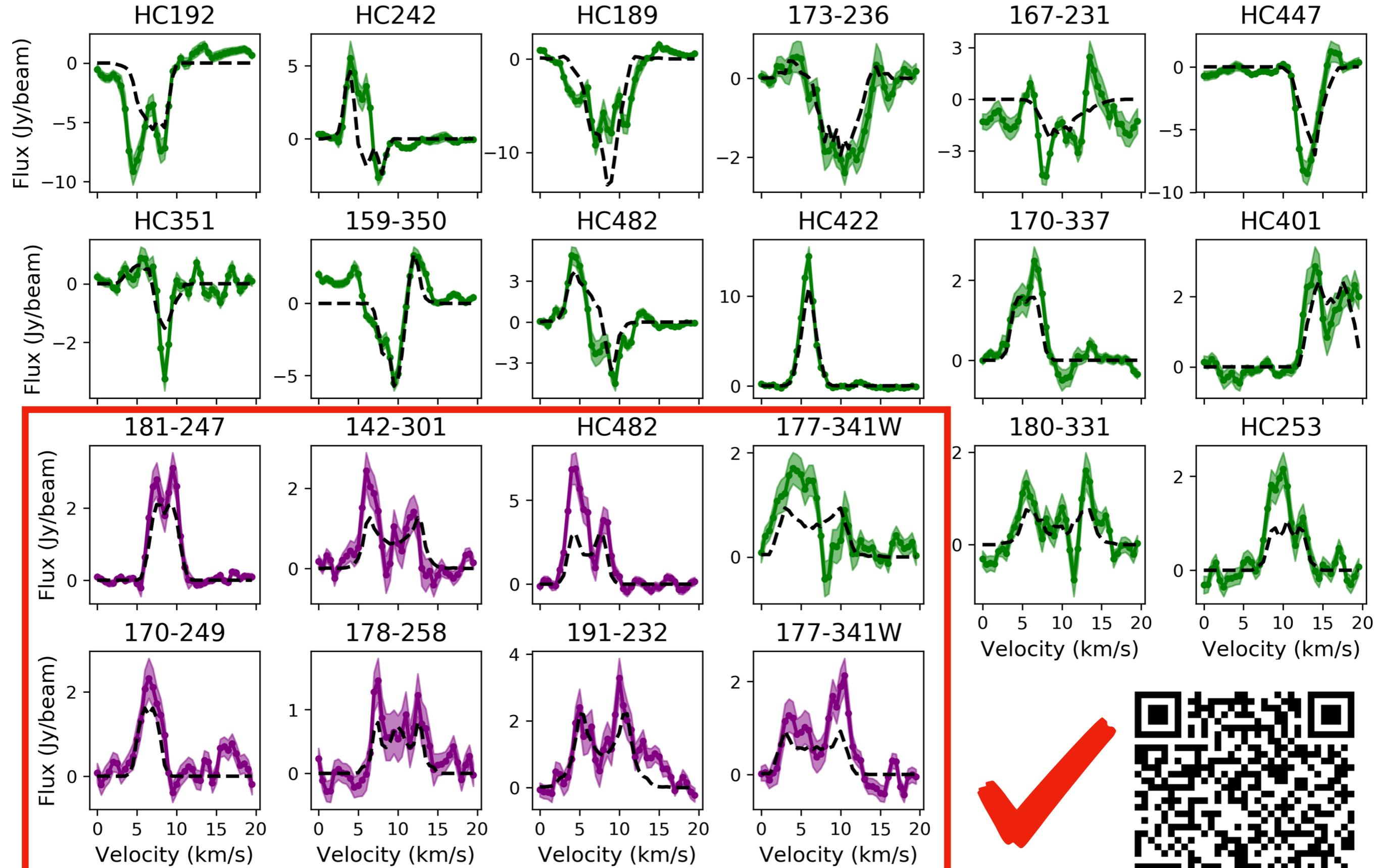


Full Modeling Results

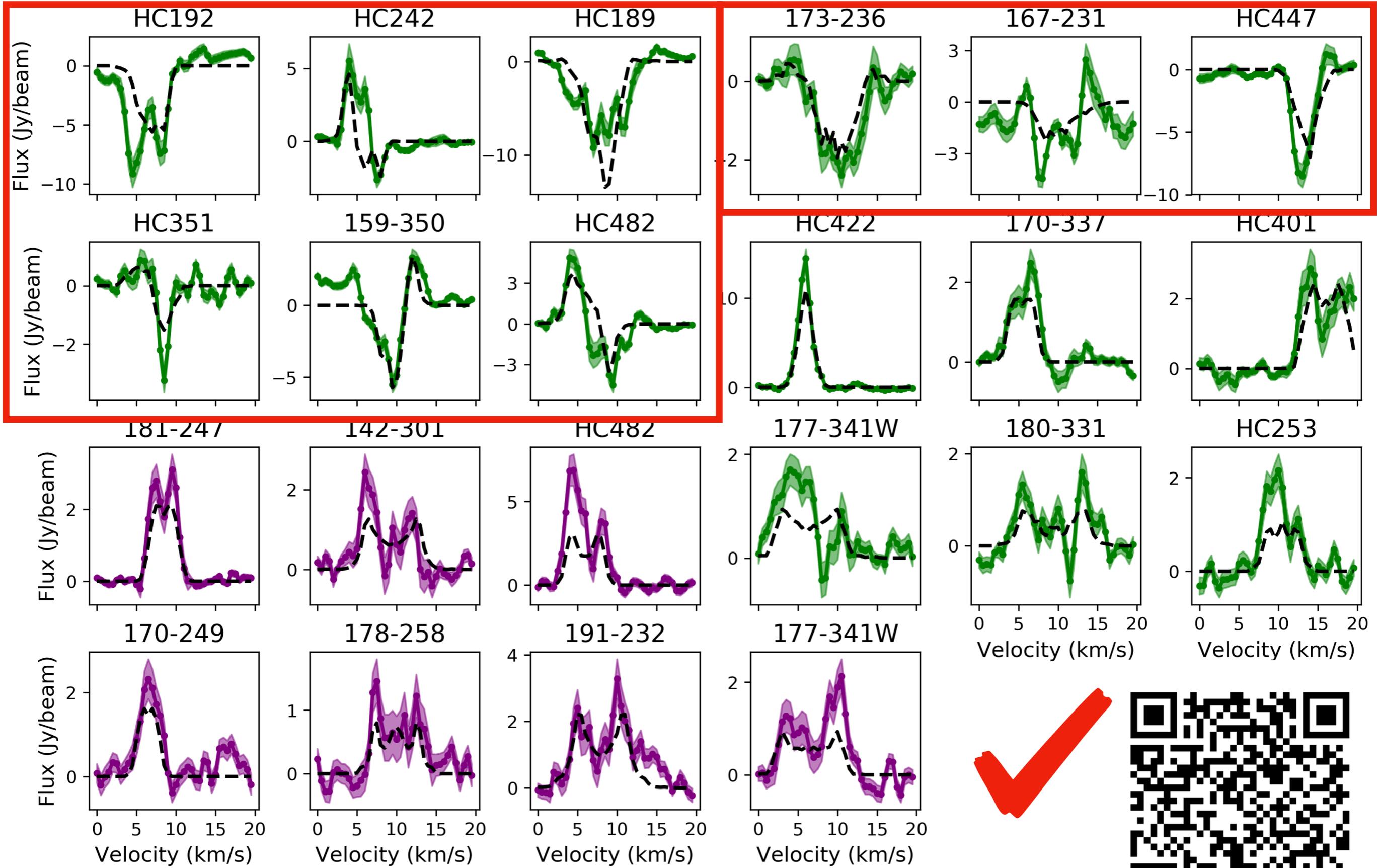
CO emission



HCO⁺ emission Full Modeling Results



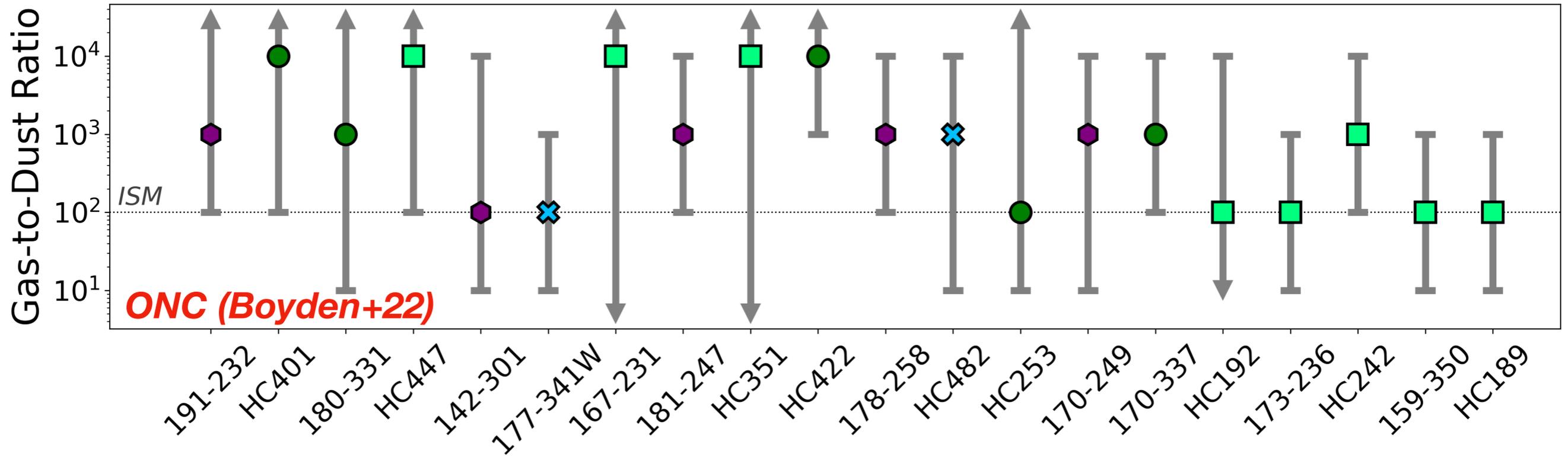
Full Modeling Results CO absorption



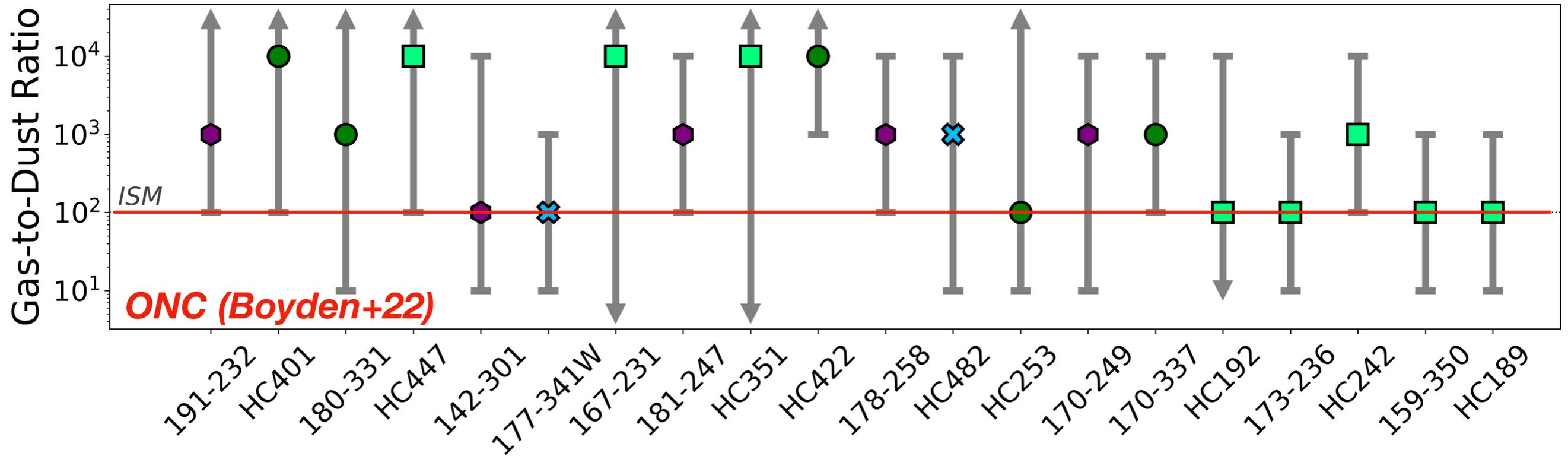
ADS Link



Gas-to-Dust Ratios

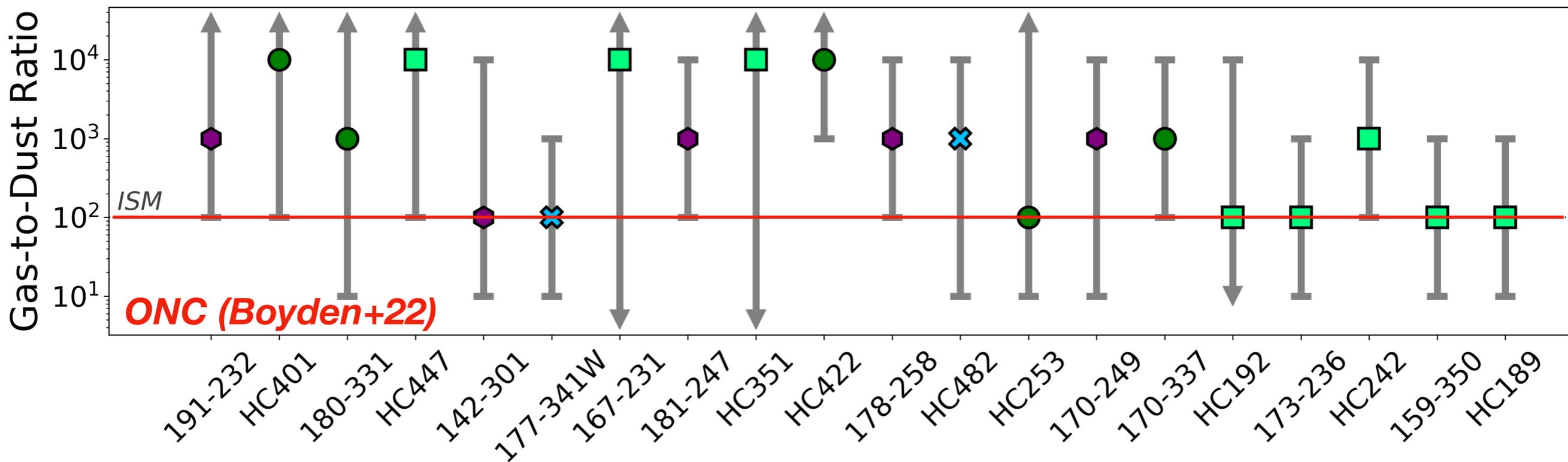


Gas-to-Dust Ratios

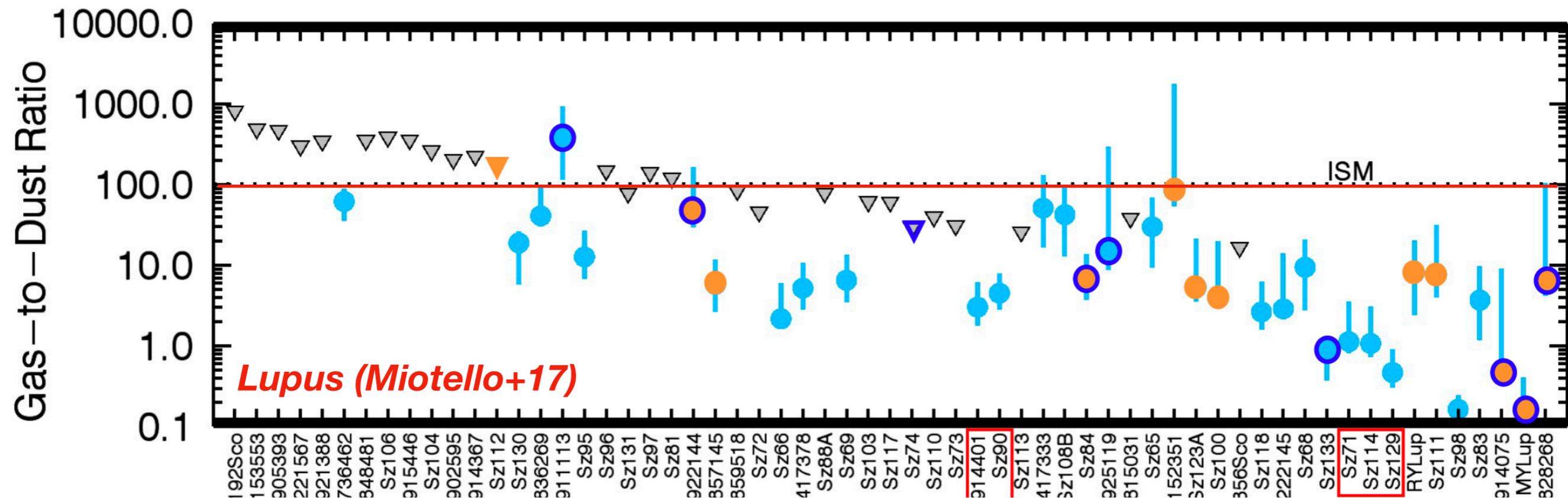


Consistent with (or greater than) expected ISM values

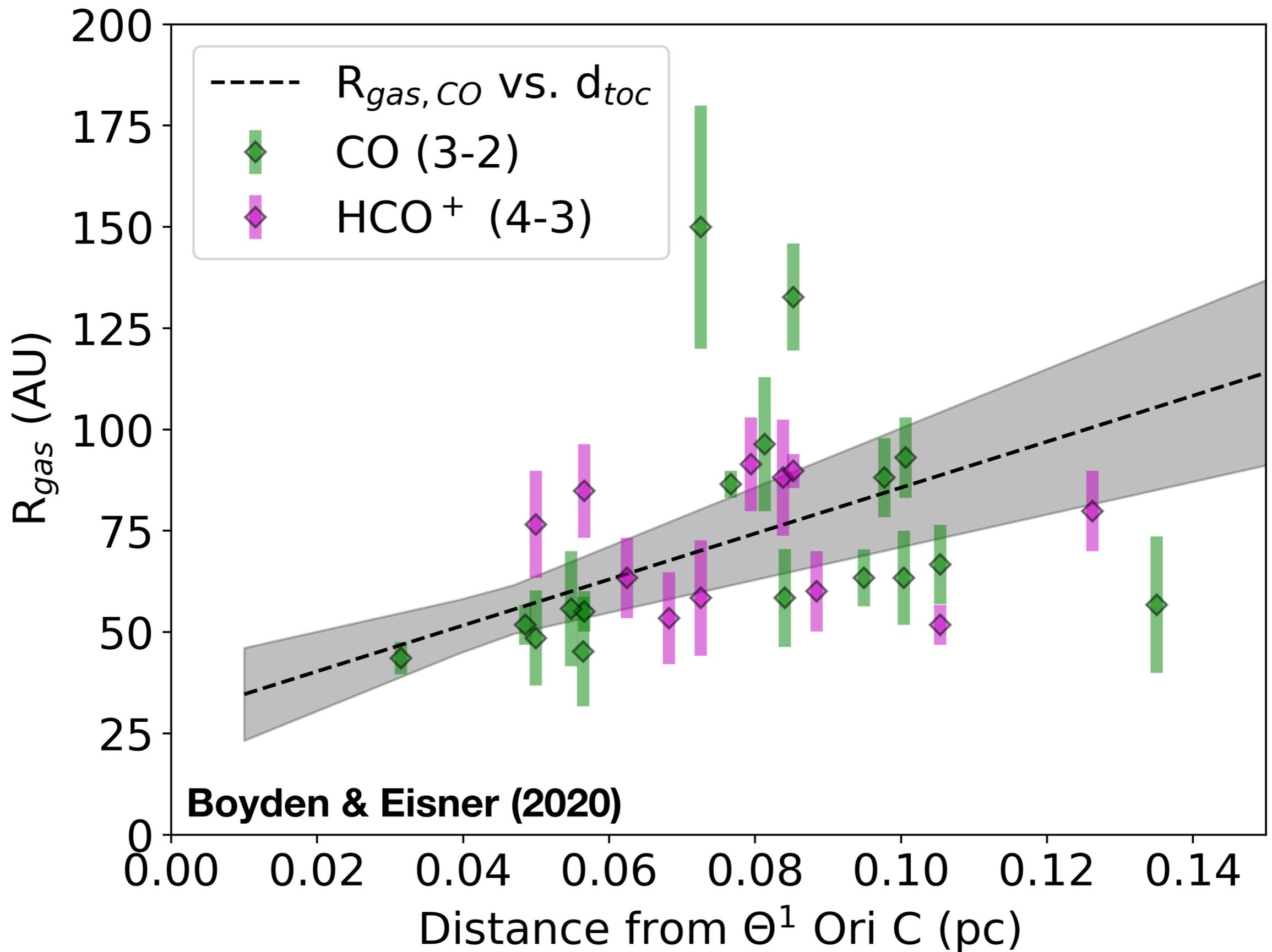
Gas-to-Dust Ratios



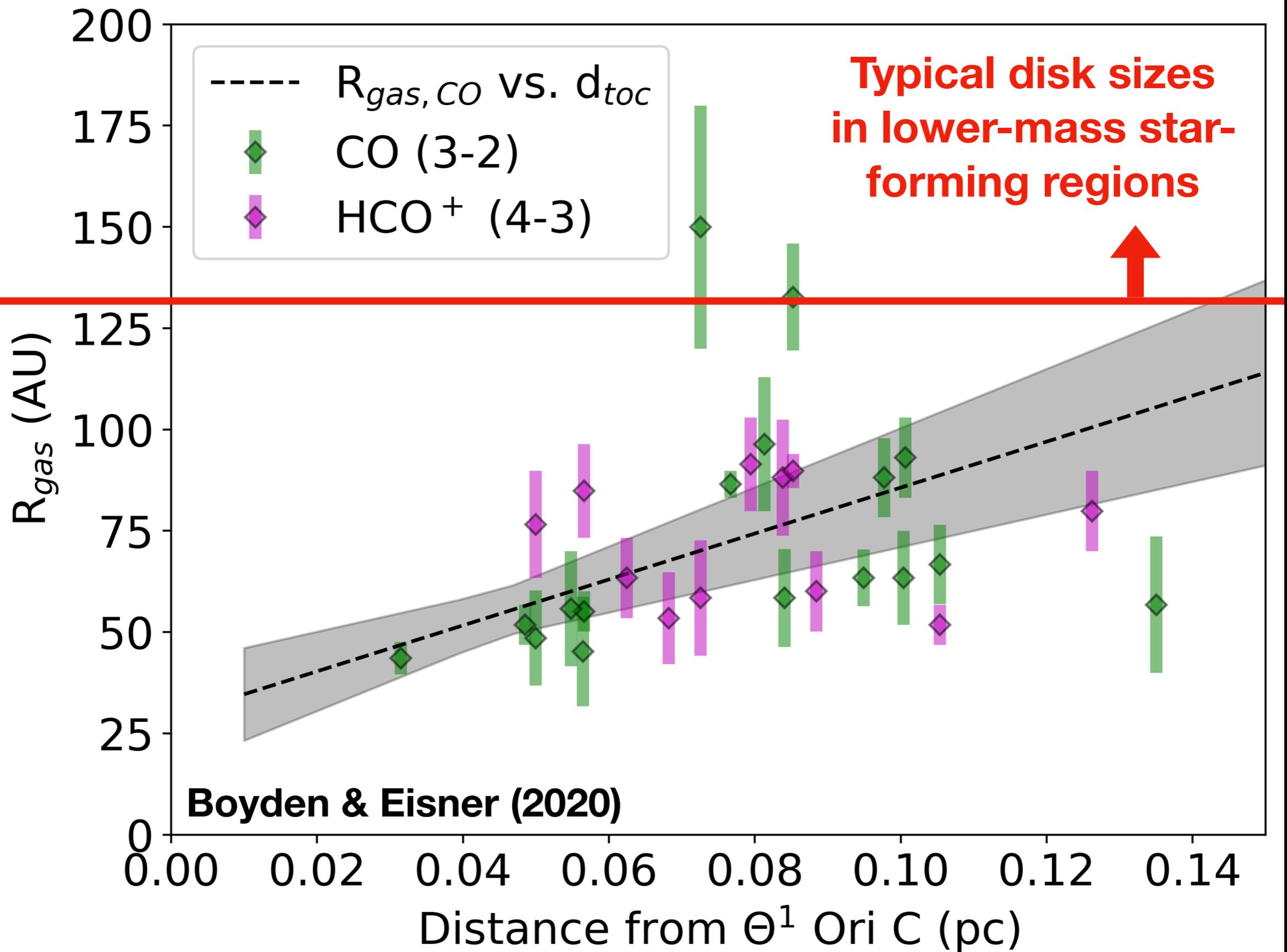
Higher gas-to-dust ratios in ONC vs. lower-mass SFRs



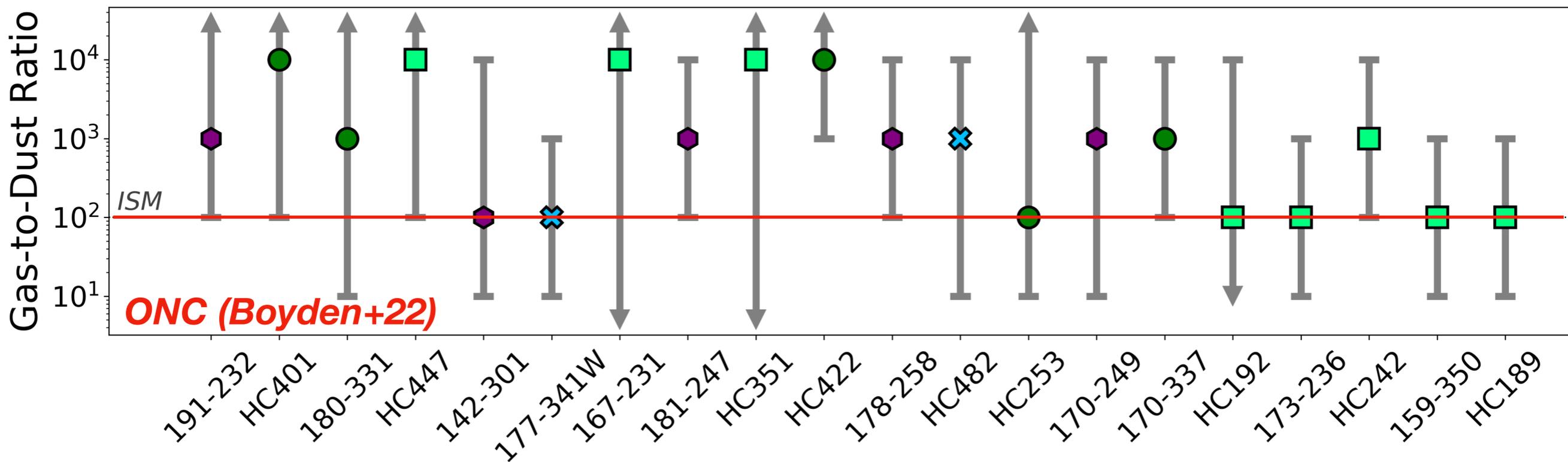
Compact Disks in the ONC



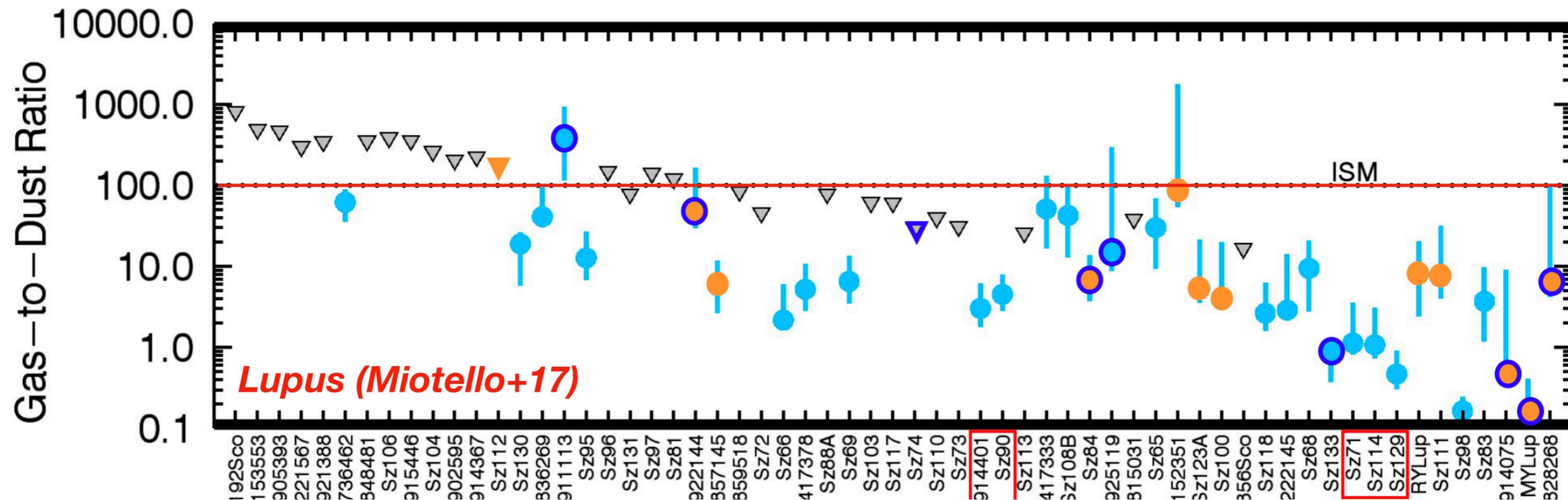
Compact Disks in the ONC



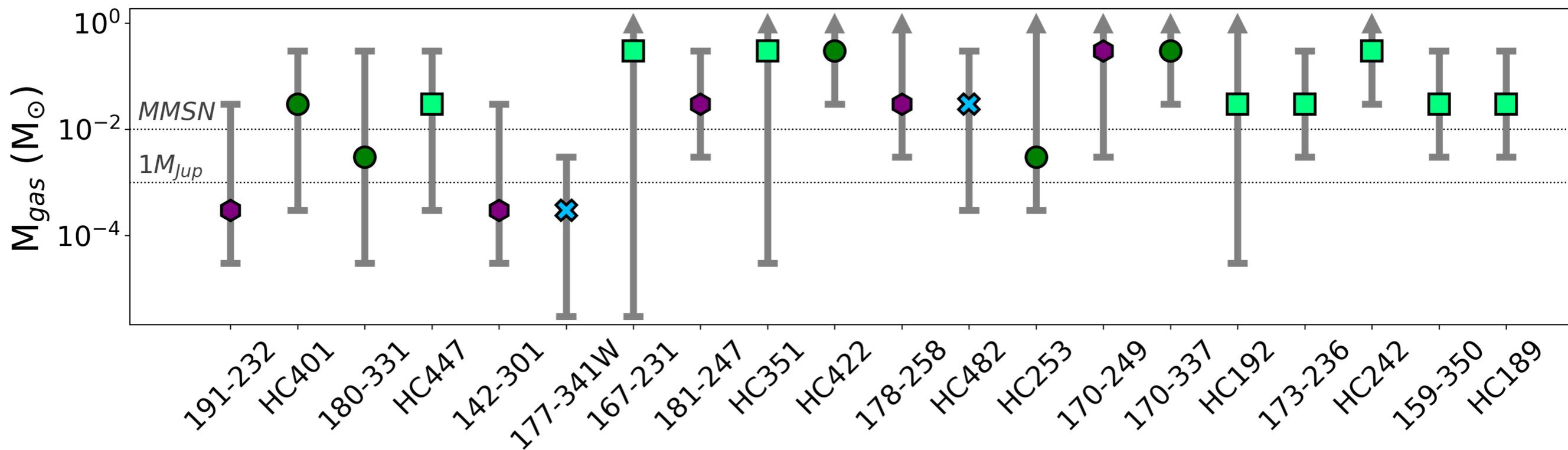
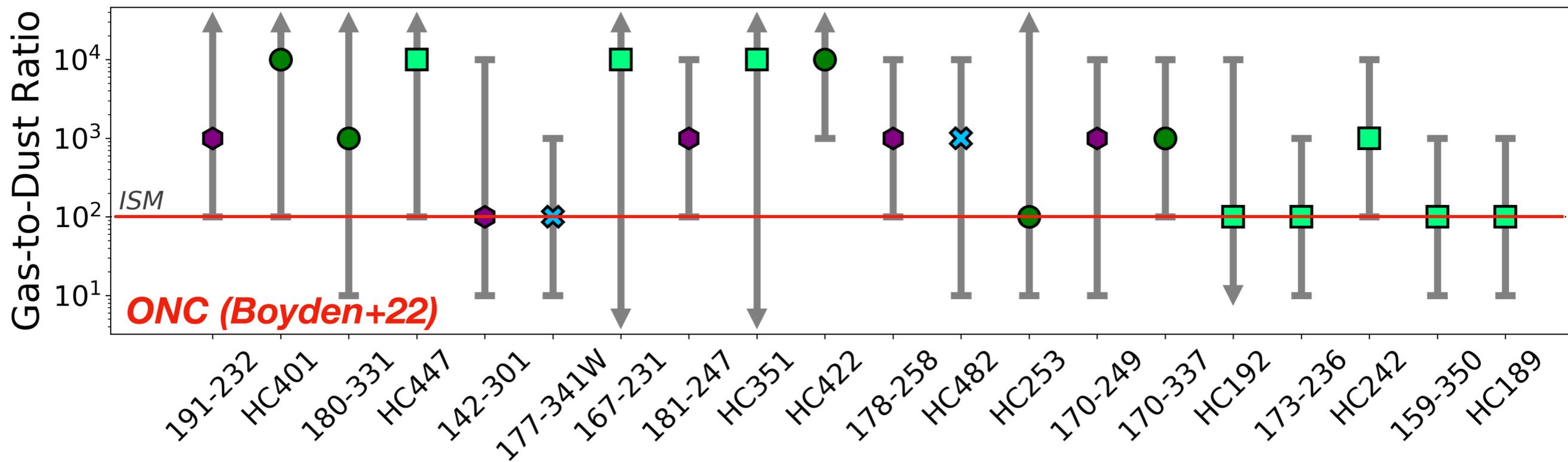
Gas-to-Dust Ratios



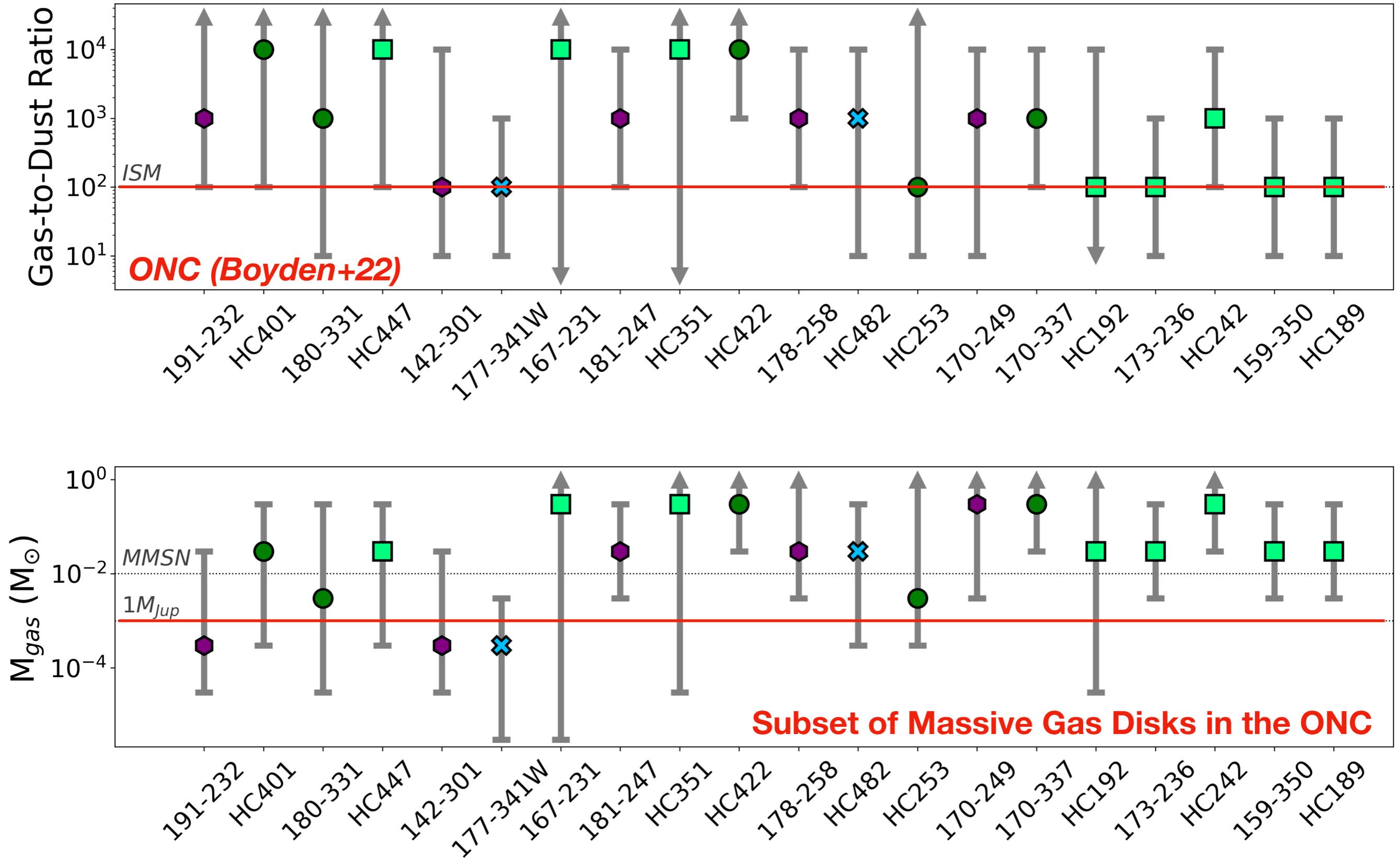
Reduced CO Depletion in the ONC



Gas-Rich Disks in the ONC

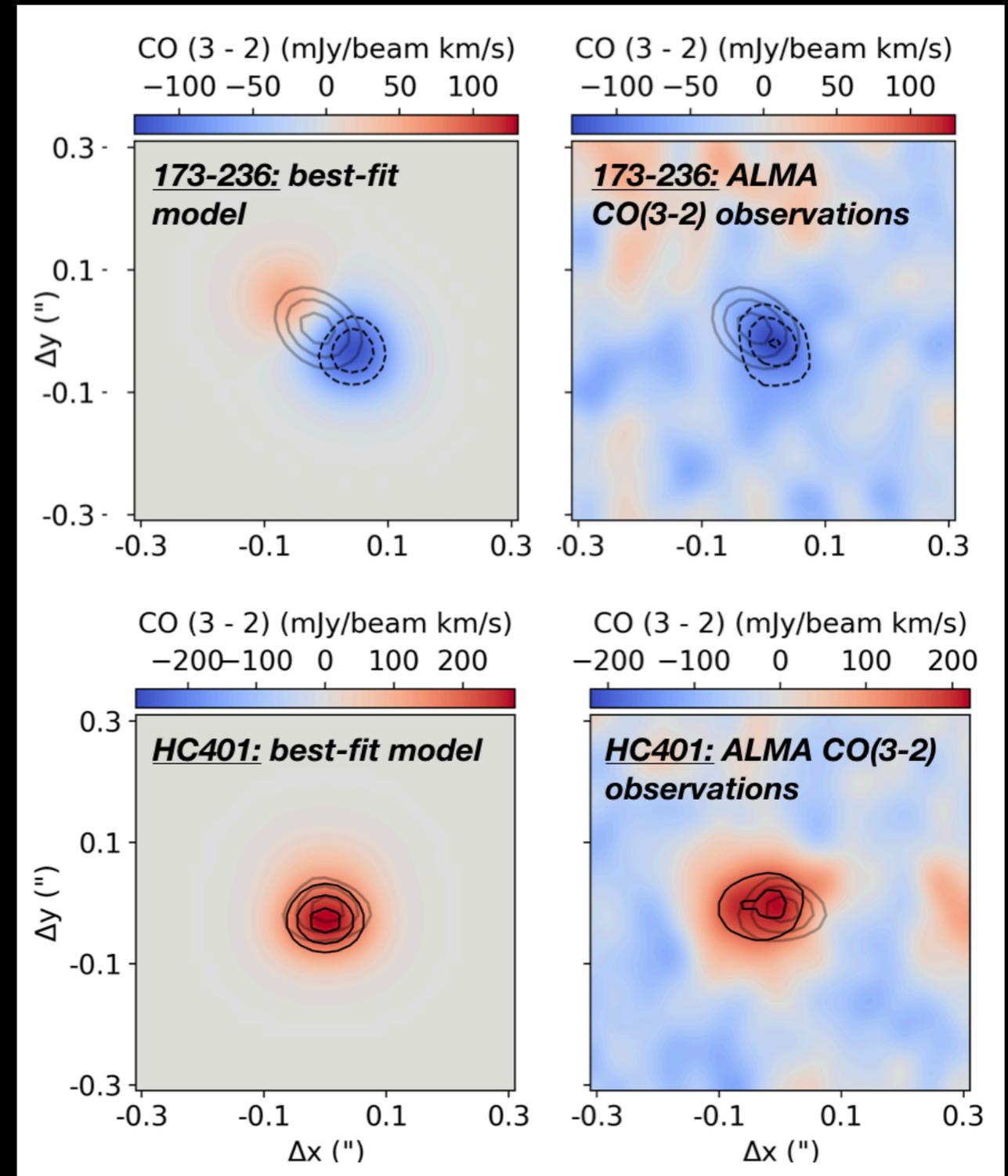


Gas-Rich Disks in the ONC



Takeaways

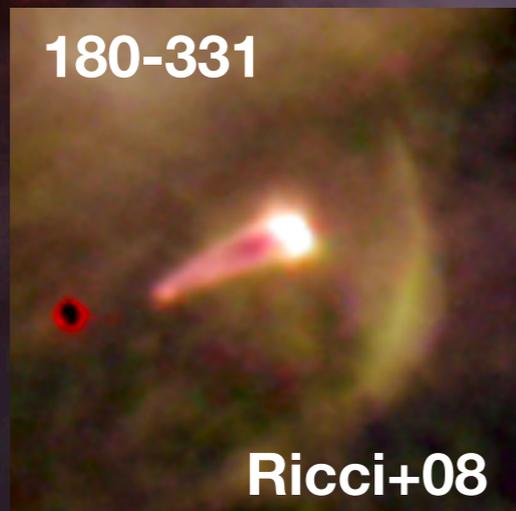
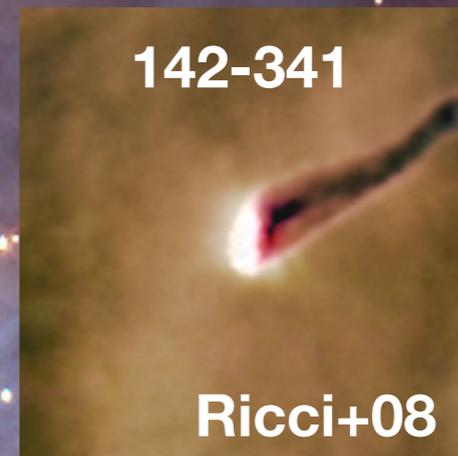
- 1. Gaseous Circumstellar Disks in the ONC are massive, compact, and gas-rich**
- 2. ISM-like gas-to-dust ratios: evidence for reduced CO depletion in ONC disks**
- 3. Massive gas disks in the ONC have enough material to form giant, Jupiter-like planets**
- 4. Future Work: follow up ALMA/VLA observations in ONC, NGC 1977, & NGC 2024**



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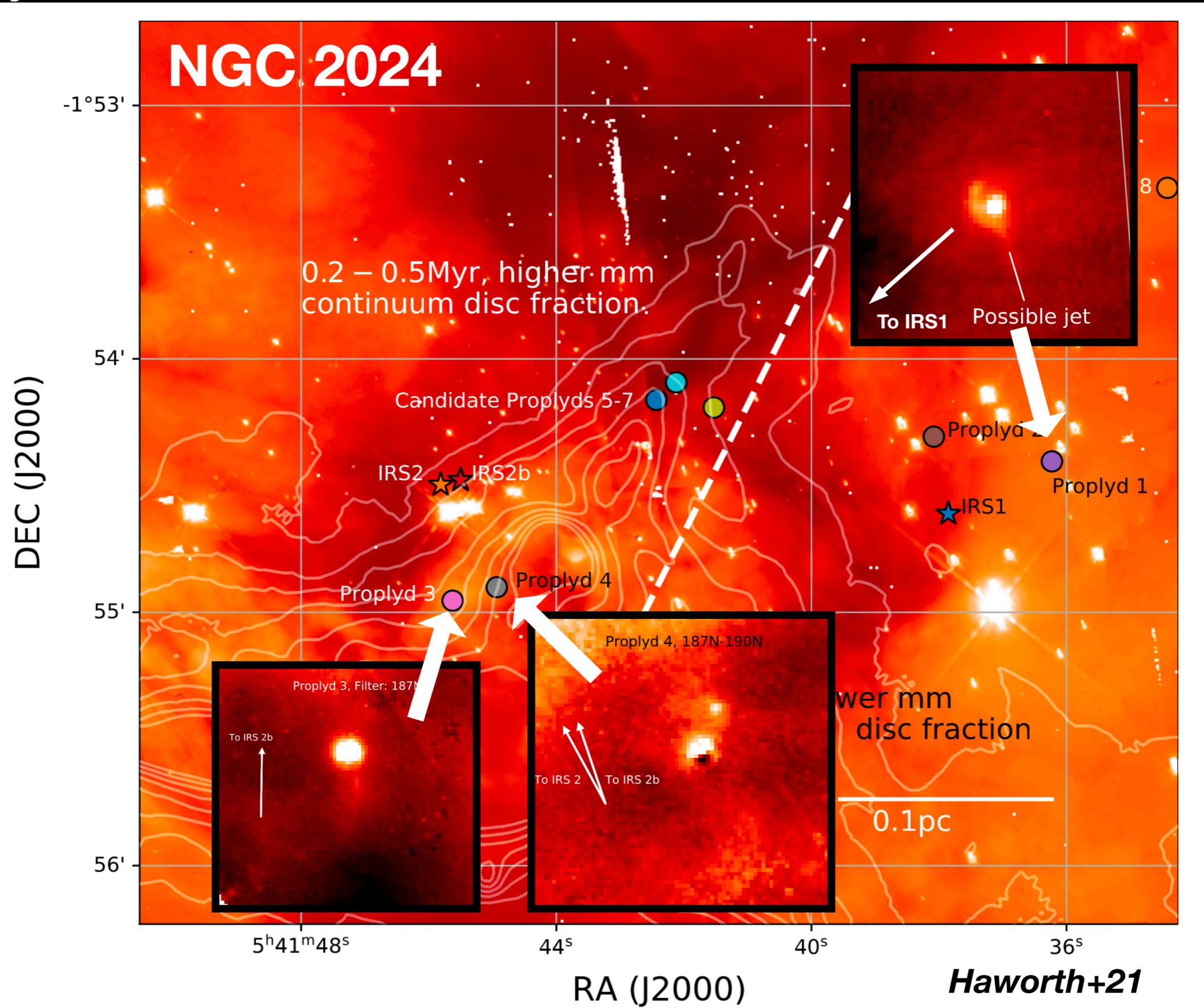
Additional Slides

Protoplanetary disk evolution in *young stellar clusters*

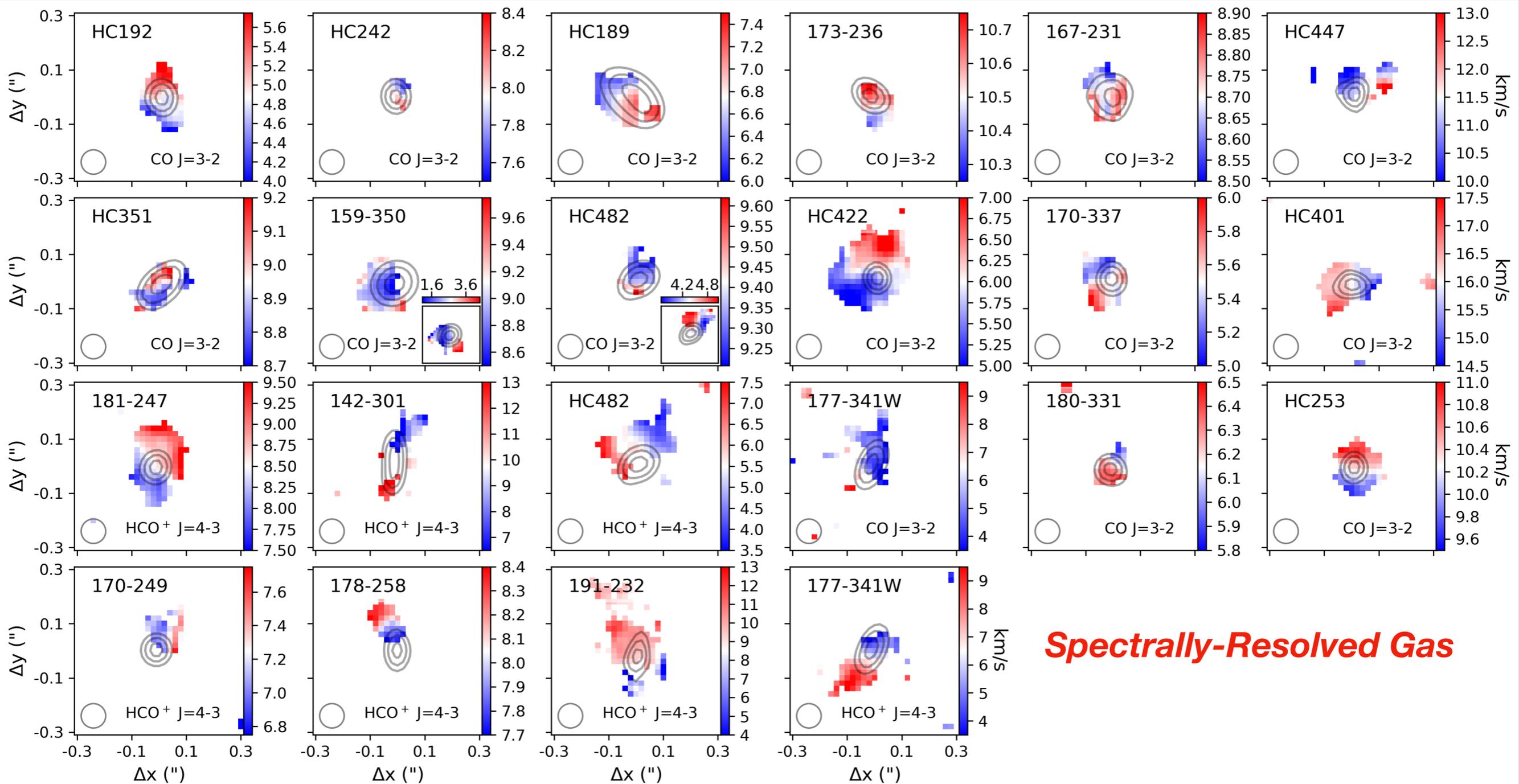


“Proplyds”

Current Research: “completing the census of proplyds in NGC 2024 and NGC 1977 with the VLA”



Gaseous Circumstellar Disks in the ONC

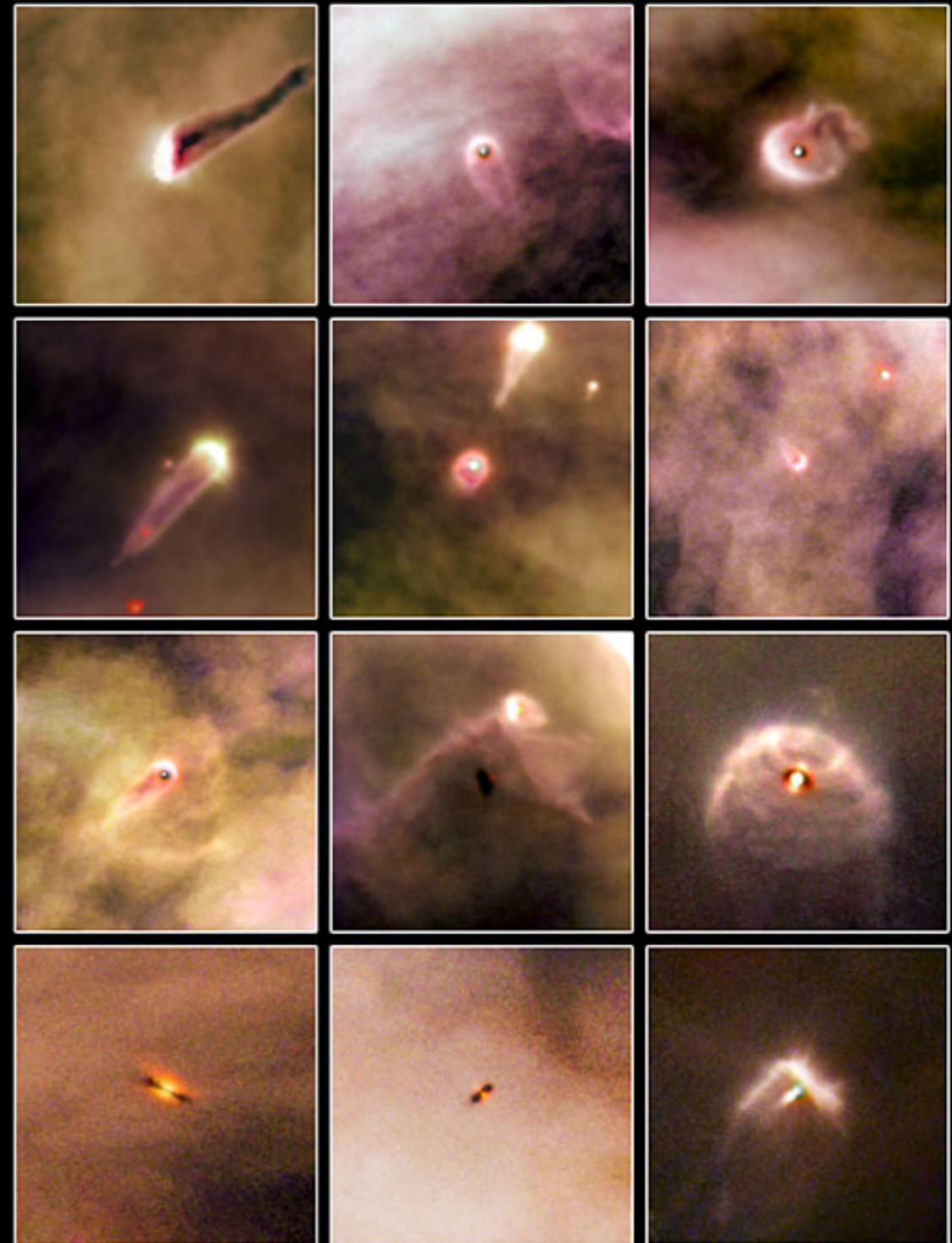


ADS Link

**Largest Sample of ALMA-detected
gas disks in a clustered SFR**

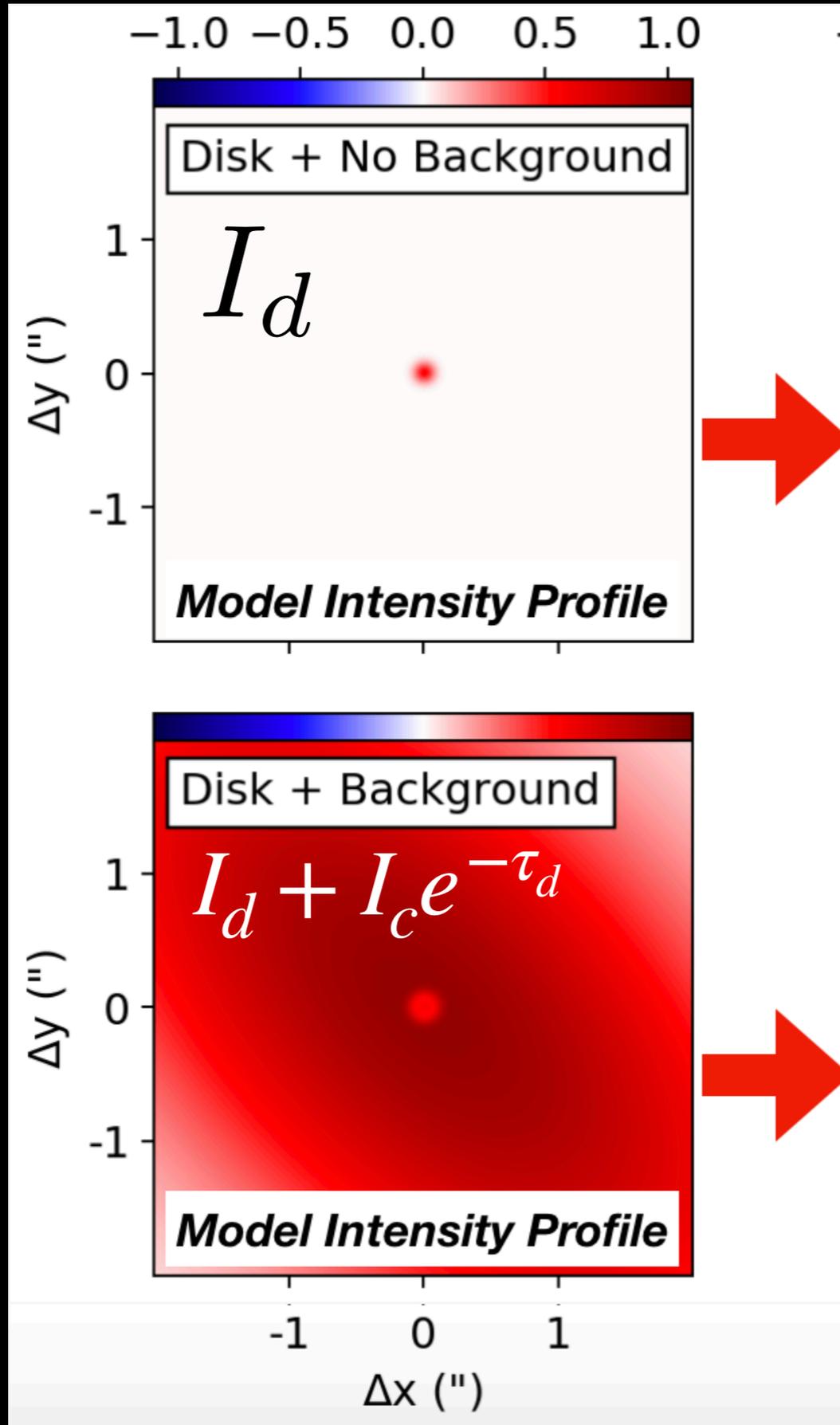
“Constraining the Evolution of Protoplanetary Disks in Clustered SFRs”

- **Thesis Goal:** constrain the impact of the stellar cluster environment on the molecular gas compositions of protoplanetary disks
 - What are the typical molecular gas masses and sizes of disks in clustered SFRs?
 - What are the gas-to-dust ratios?
 - Are the molecular gas compositions of disks different in clustered vs. lower-mass star-forming regions?

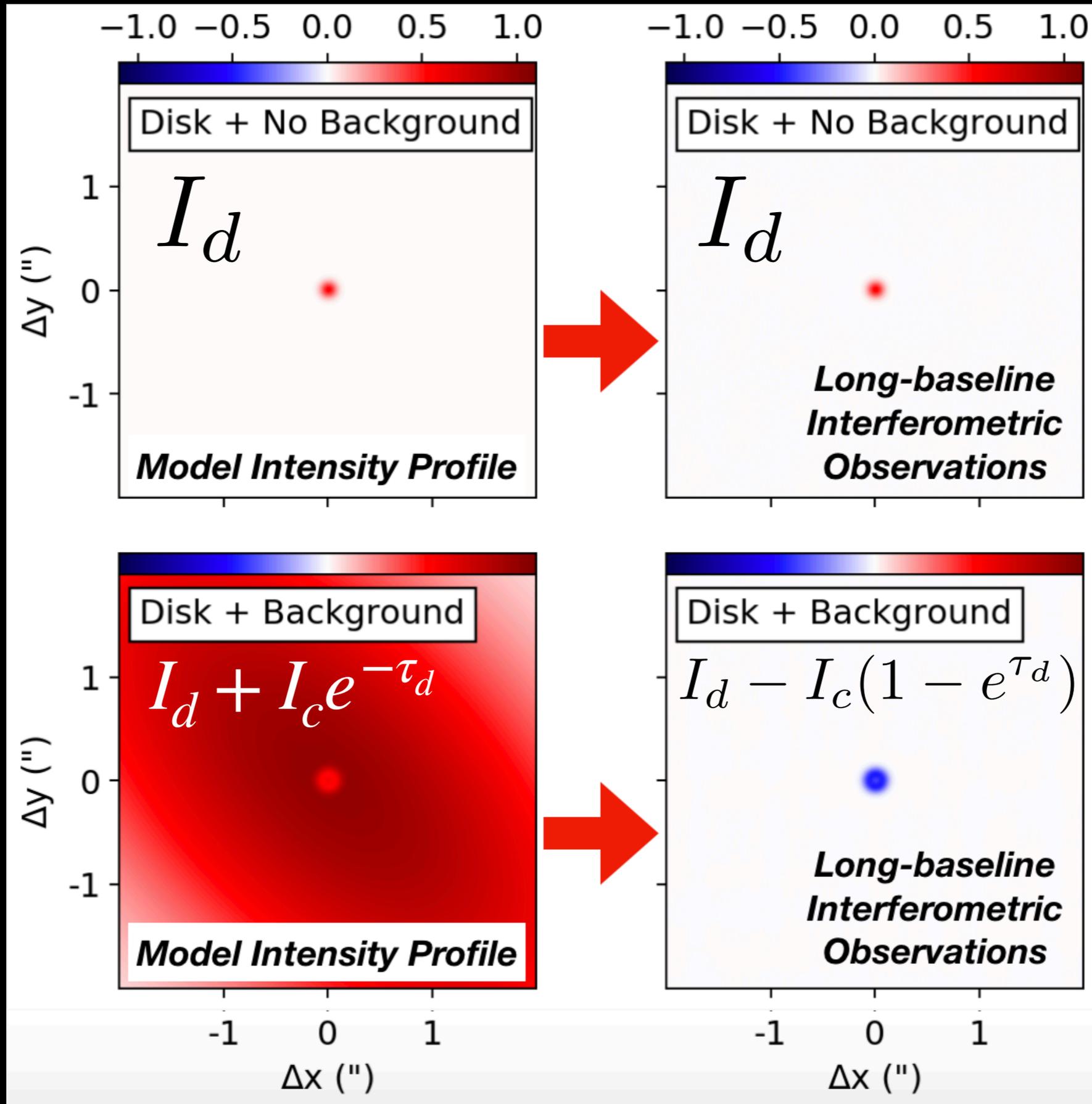


Credit: ESA

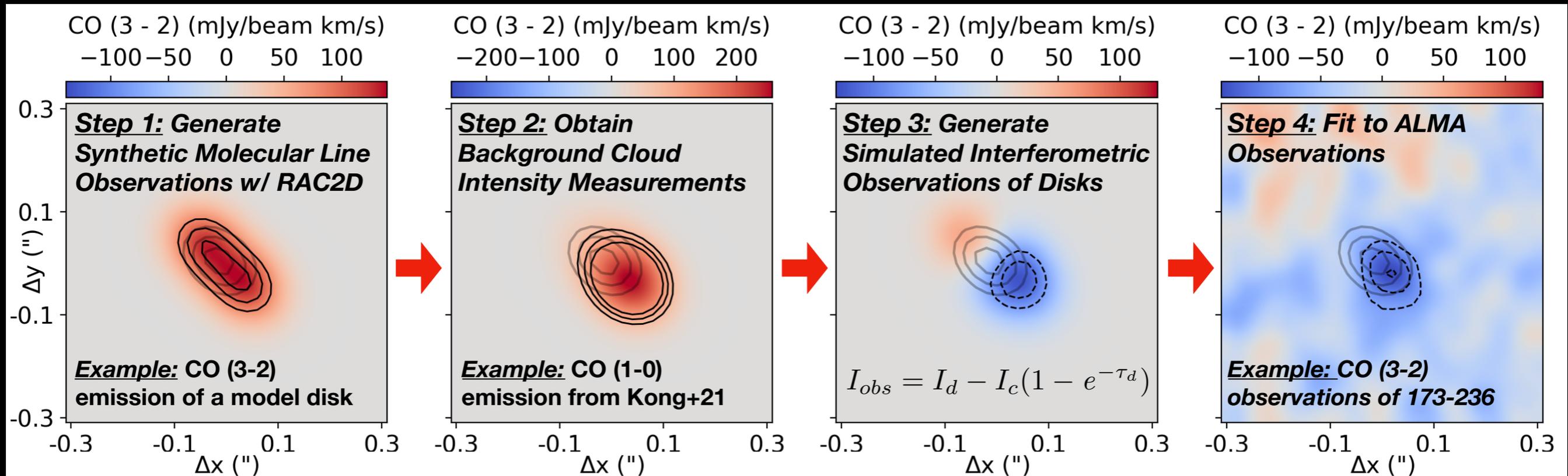
Treatment of CO absorption



Treatment of CO absorption

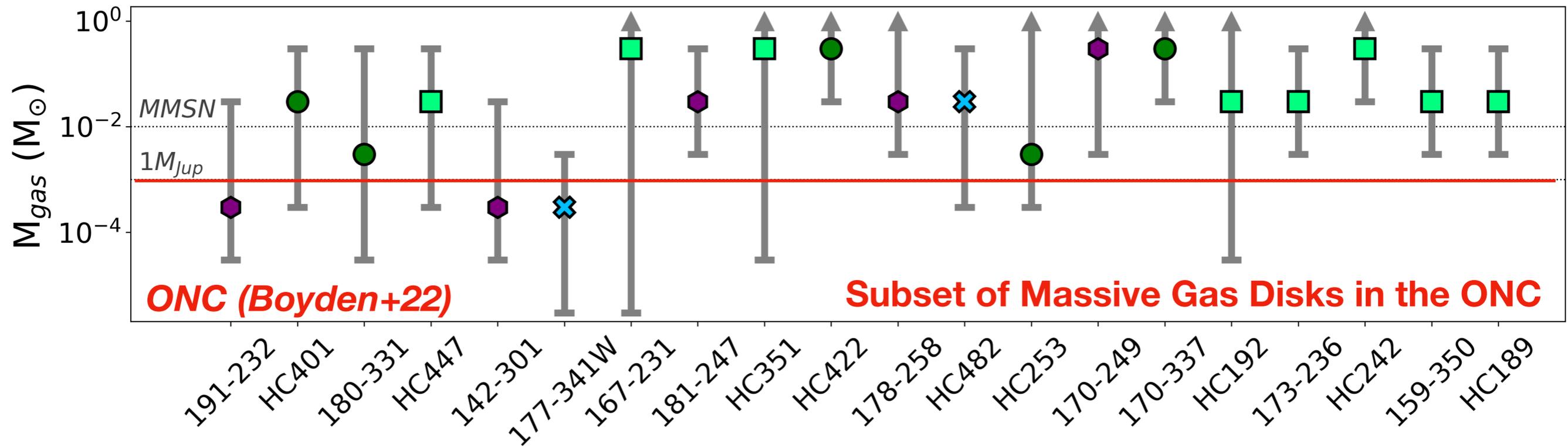


CO Absorption Example: “173-236”



*fitting performed on channel maps

Disk Masses & External Photoevaporation

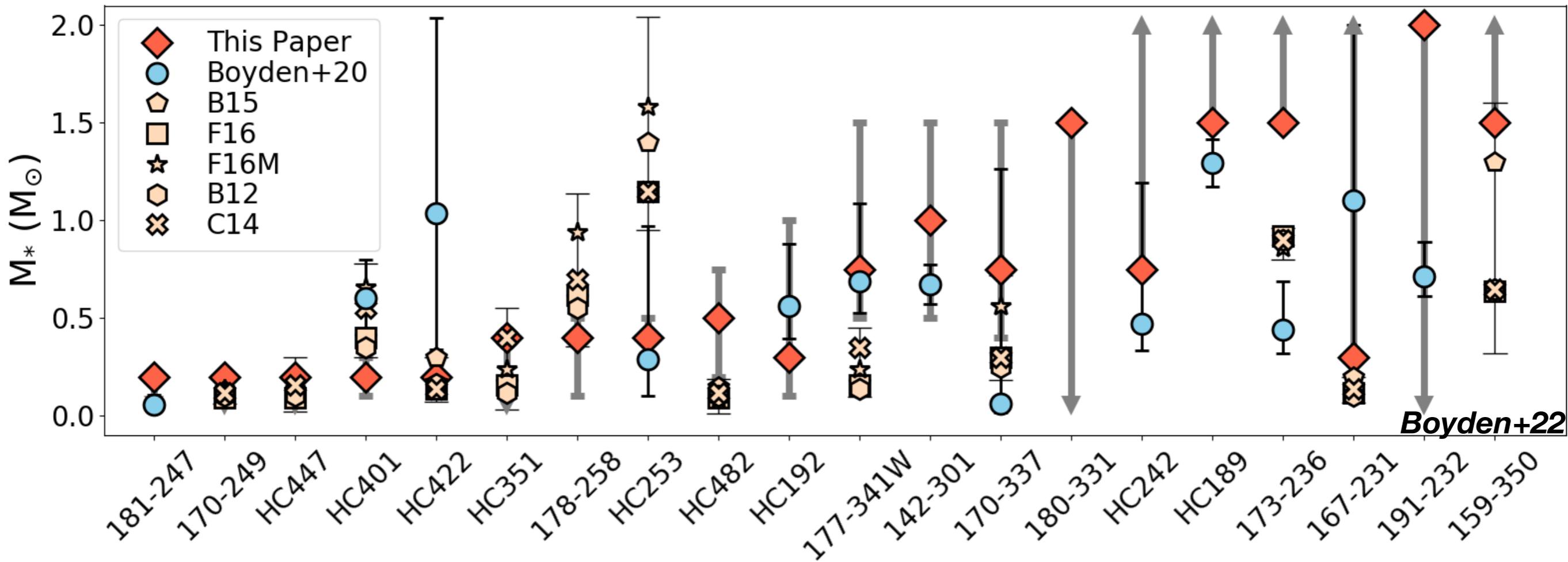


**Interpretation 1: Modeled, ALMA-
*detected gas disks are younger
than the average cluster member
(Winter+19)***

**Interpretation 2: External
Photoevaporation has recently
begun operating in all of the ONC
(Qiao+22)**

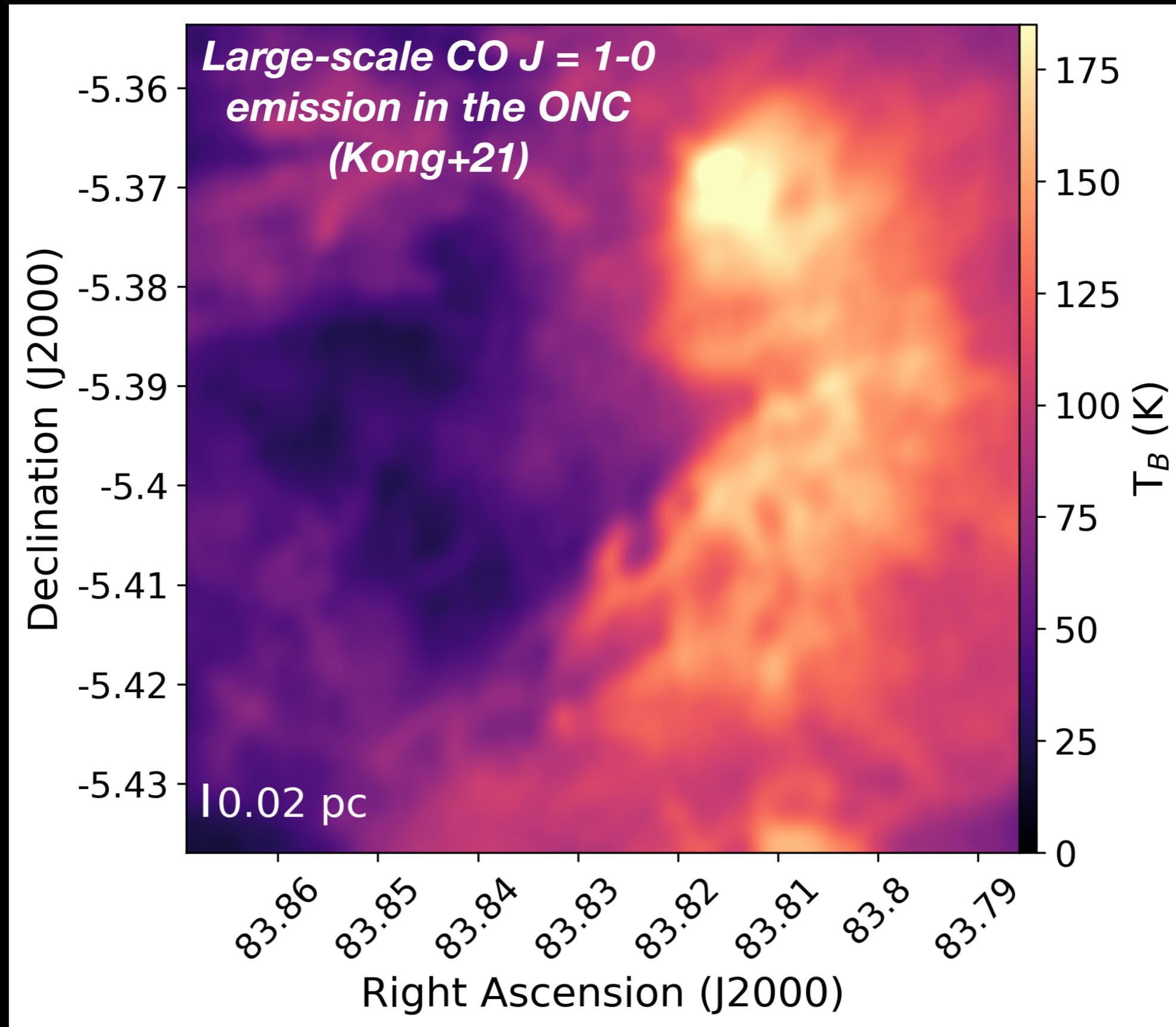
***Need increased sample
of gas detections!***

Dynamically Derived Stellar Masses

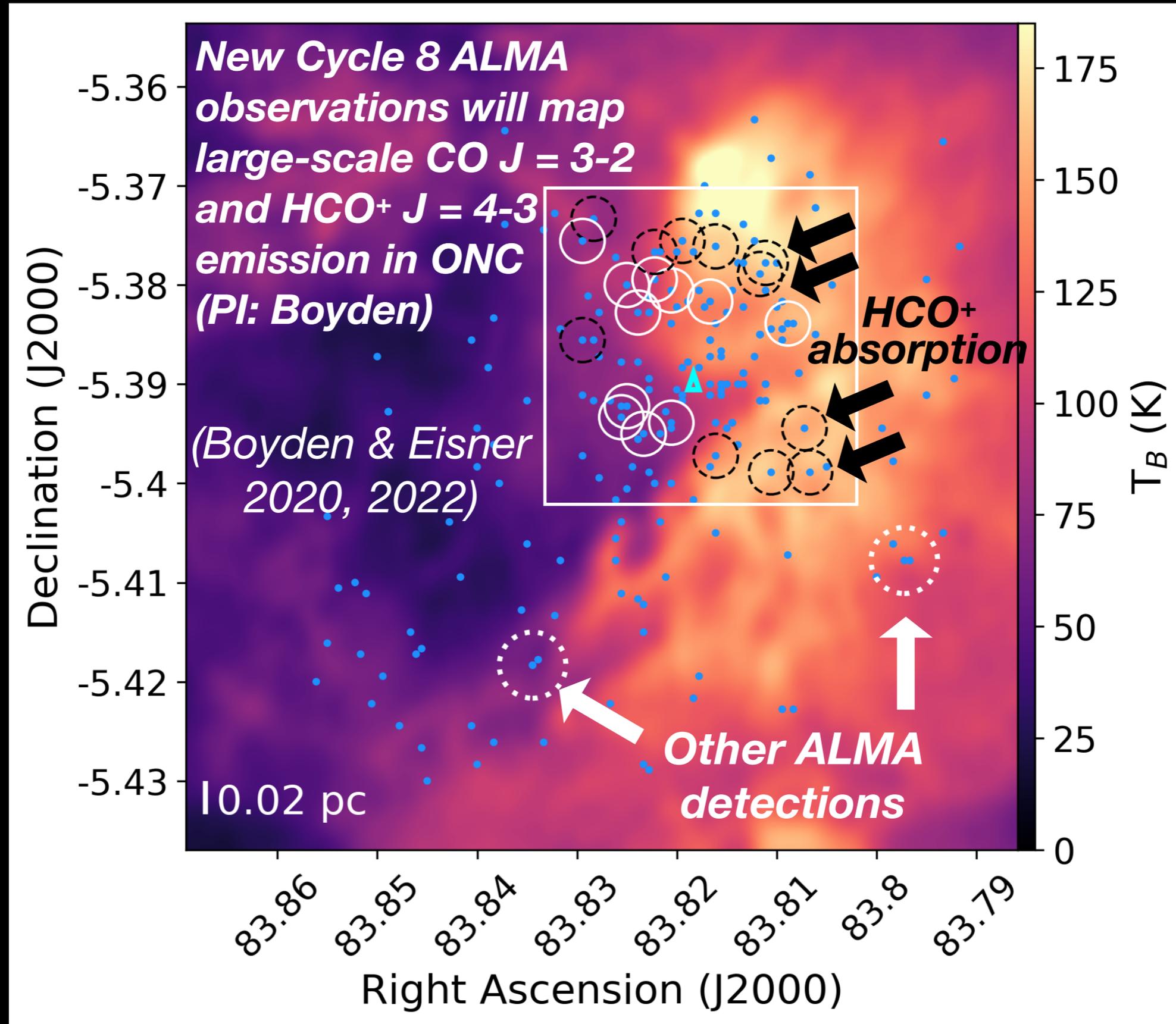


- Dynamically-derived stellar masses are consistent with spectroscopically-derived stellar masses
- 100% increase in dynamical masses measurement at $M_{\text{star}} < 0.2_{\odot}$
- 100% increase in dynamical masses measurement at $0.2_{\odot} < M_{\text{star}} < 0.5_{\odot}$

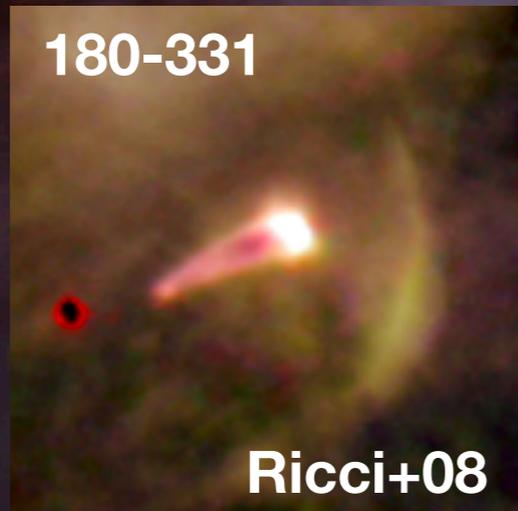
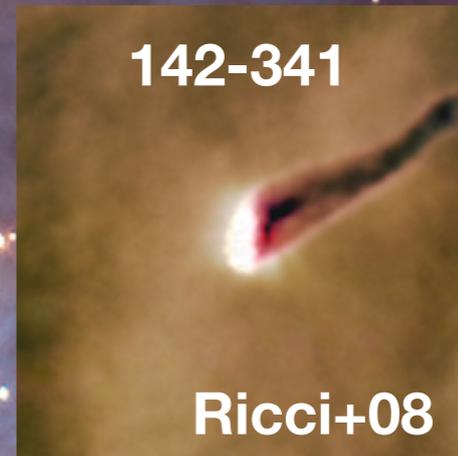
Current Research: “Measuring the Background Temperature of Orion Nebula Cluster Disks”



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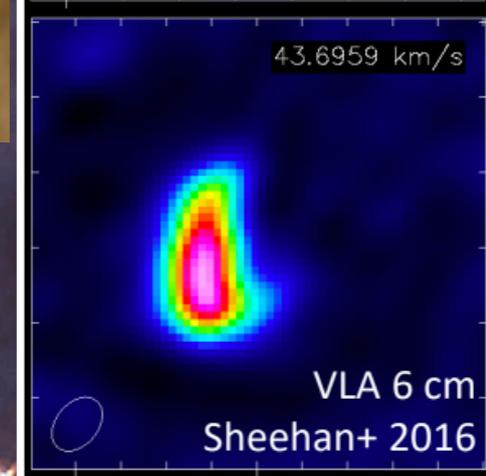
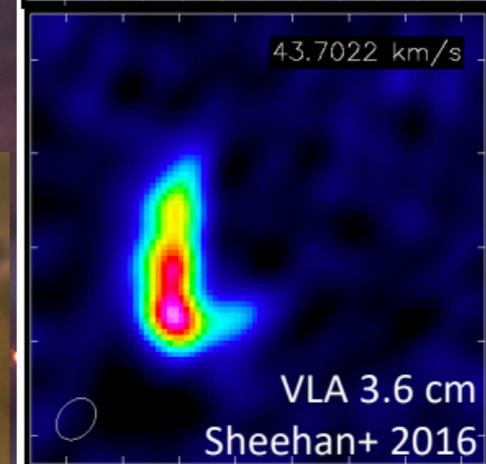
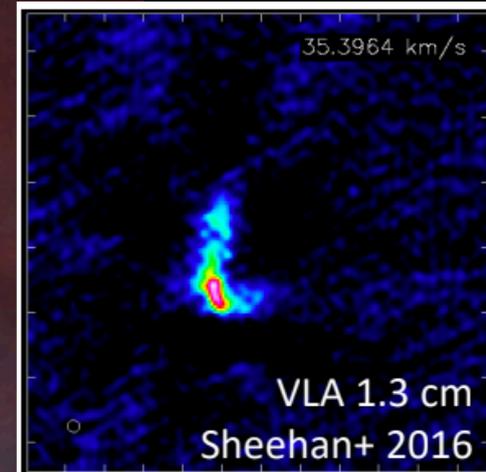
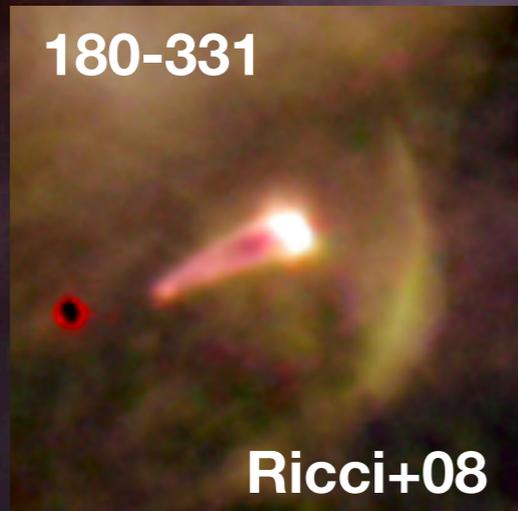
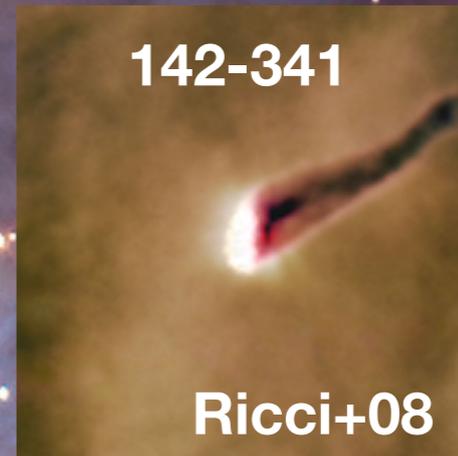
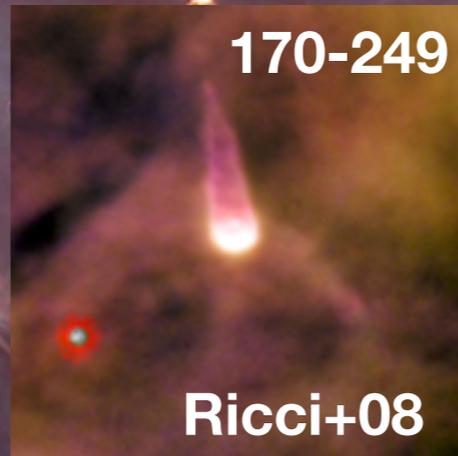
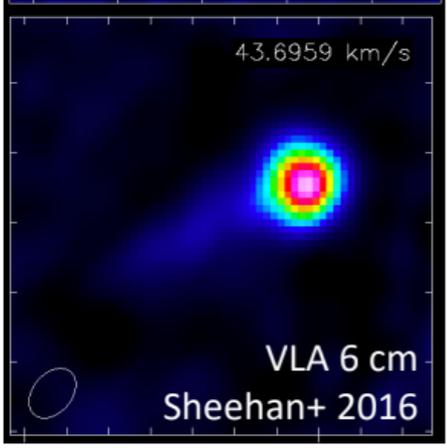
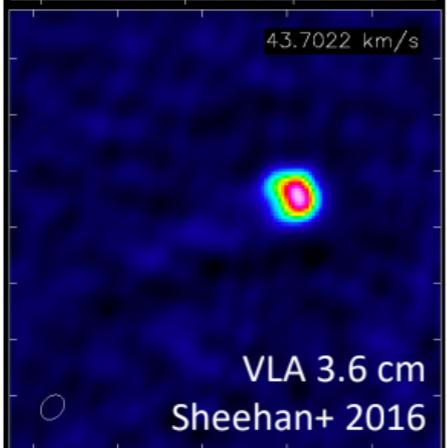
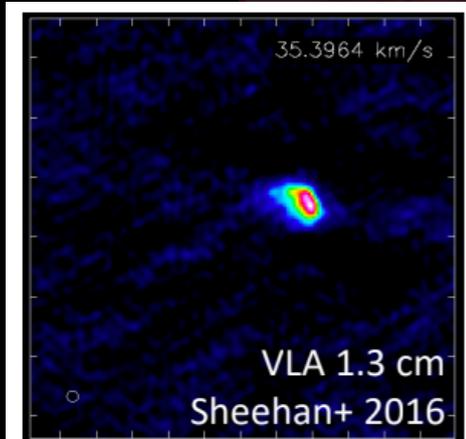


Protoplanetary disk evolution in *young stellar clusters*



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