Protoplanetary Disks in the Orion Nebula Cluster (ONC): *Gas-Disk Morphologies and Kinematics as seen with ALMA*

Ryan Boyden

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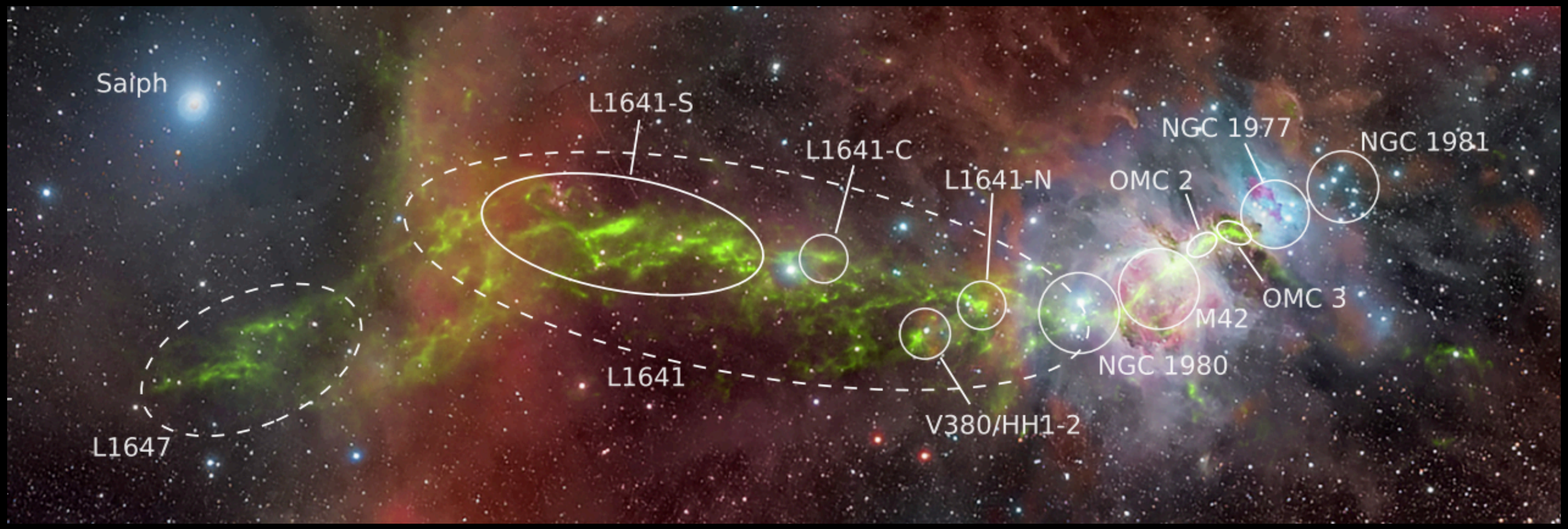
Orion Molecular Cloud

- Nearest example of massive star formation: ~400 pc



- The Orion A Filament contains multiple **Rich Clusters**, such as the ONC, NGC 1977 and NGC 1980

Figure: Meingast+2016

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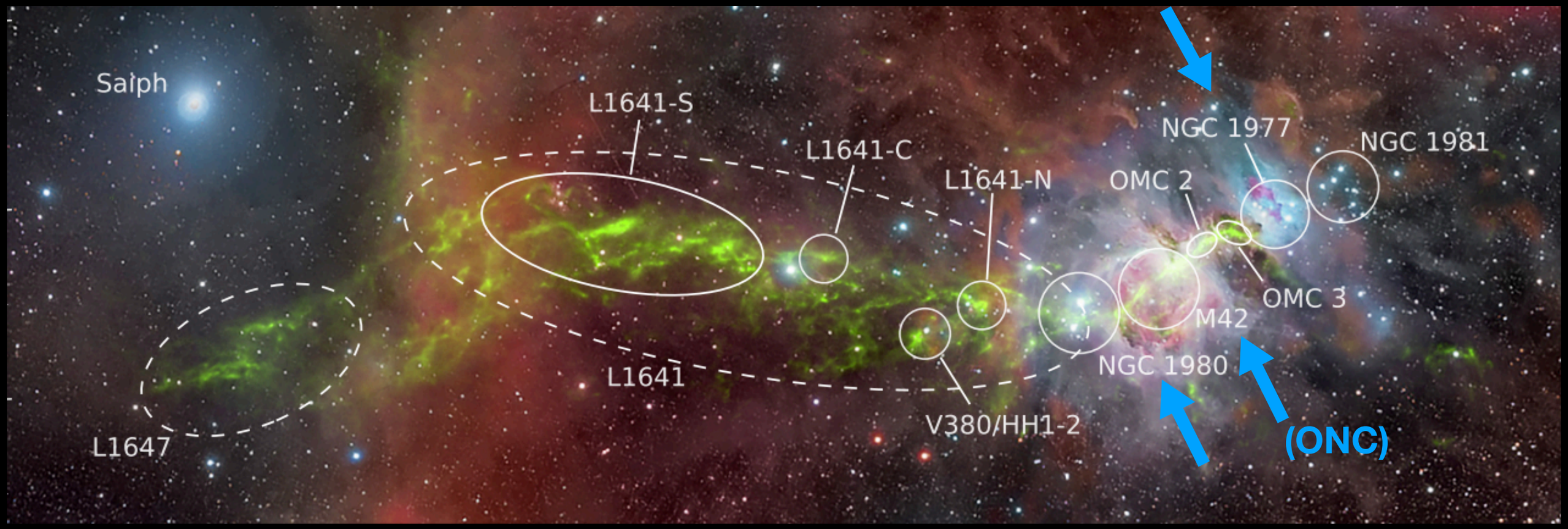
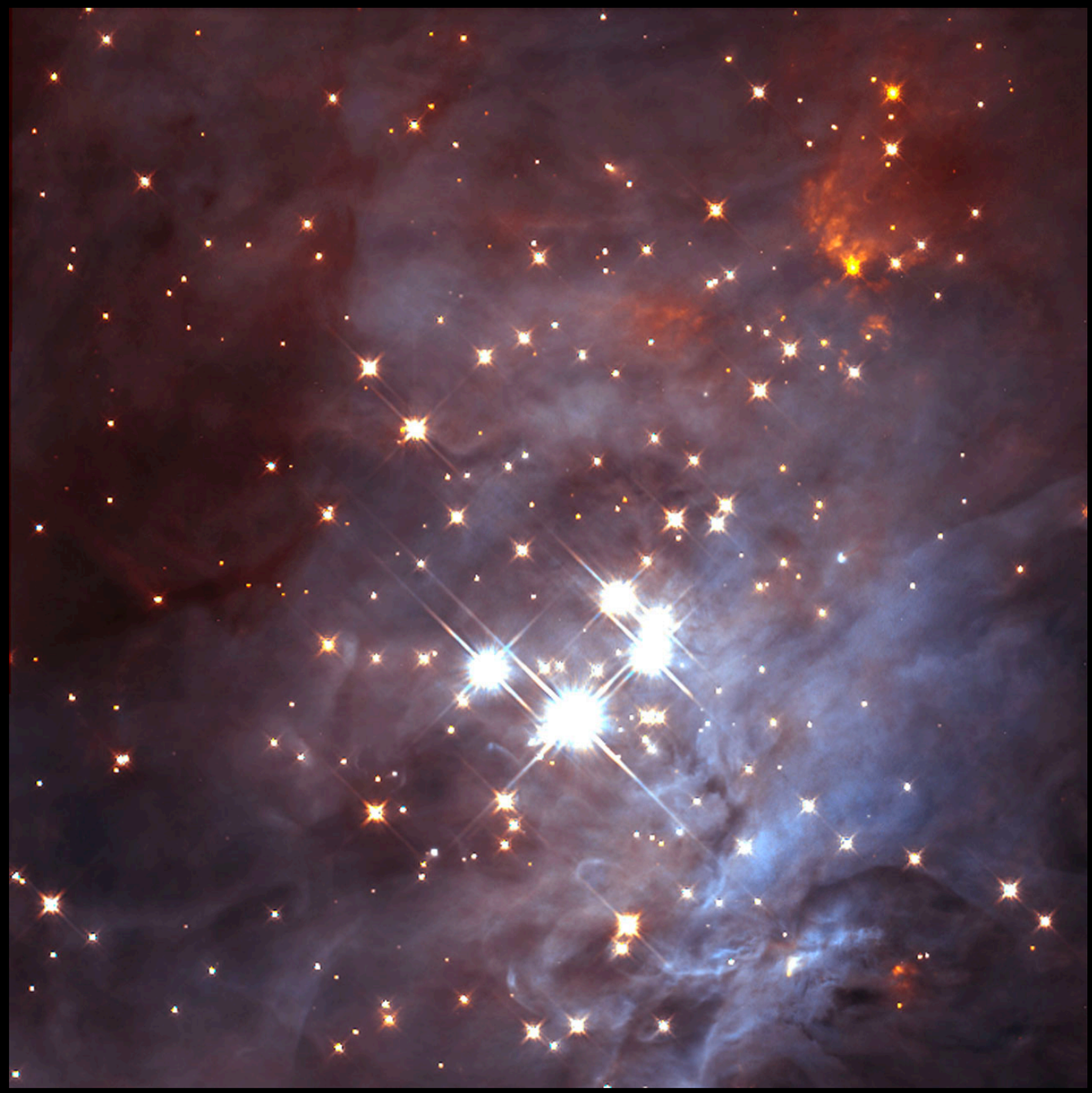


- The Orion A Filament contains multiple **Rich Clusters**, such as the ONC, NGC 1977 and NGC 1980

Figure: Meingast+2016

Orion Nebula Cluster

- Contains:
  - >100 disk-bearing, low mass stars
  - Massive Trapezium (OB) Stars
- Important properties of the ONC
  - High Stellar Density
  - Intense UV irradiation from the Trapezium Stars
    - “proplyds"



Credit: NASA

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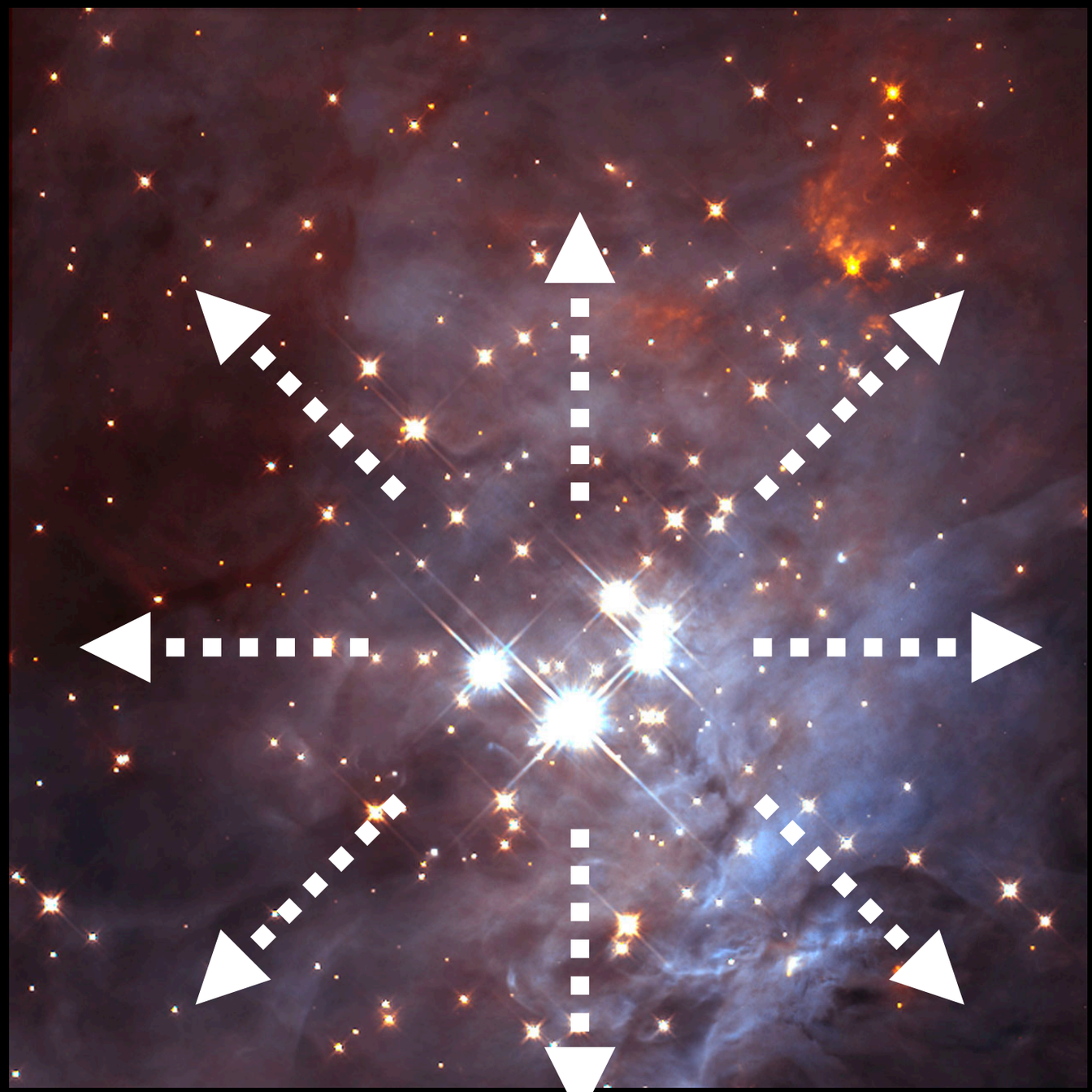

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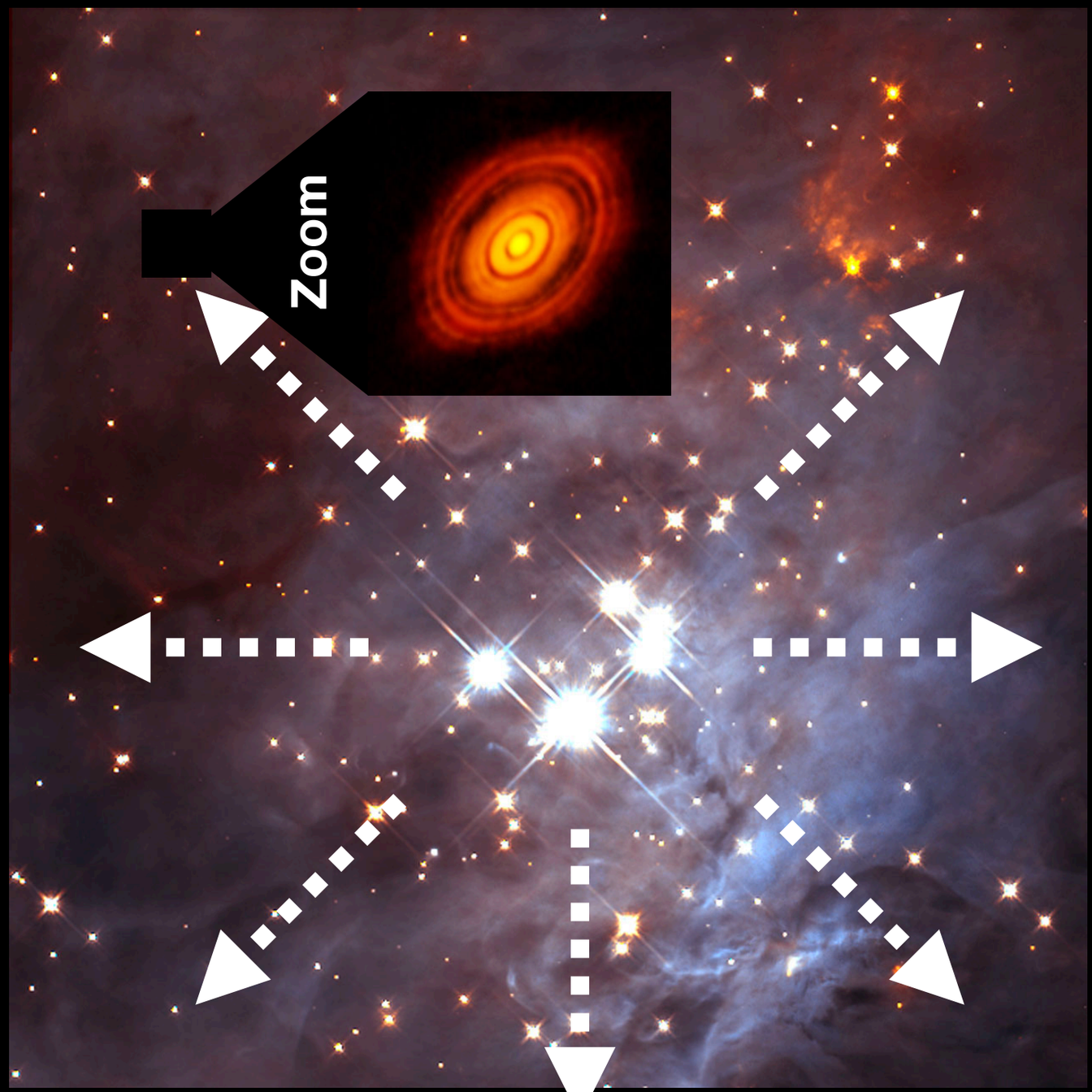

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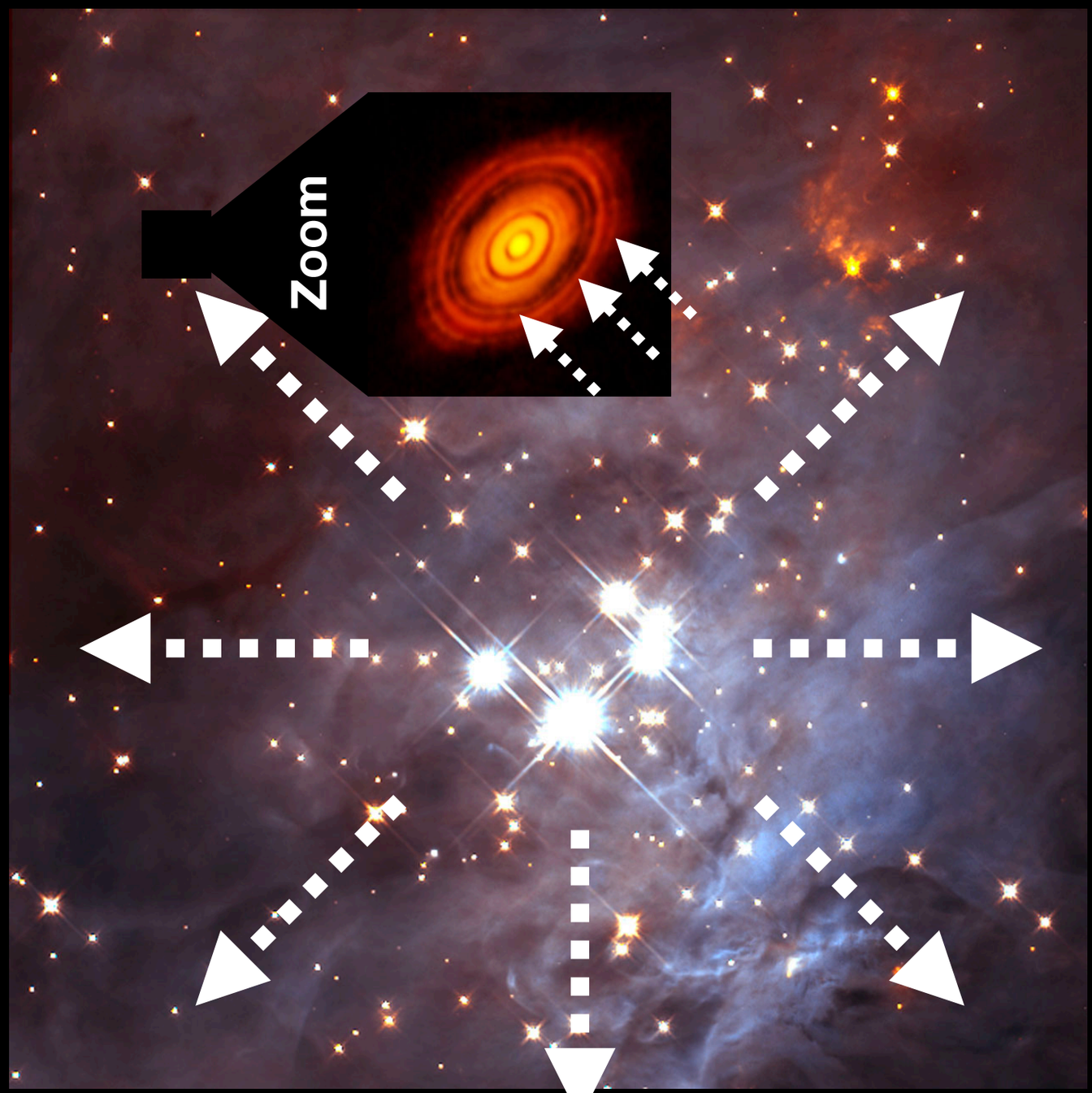

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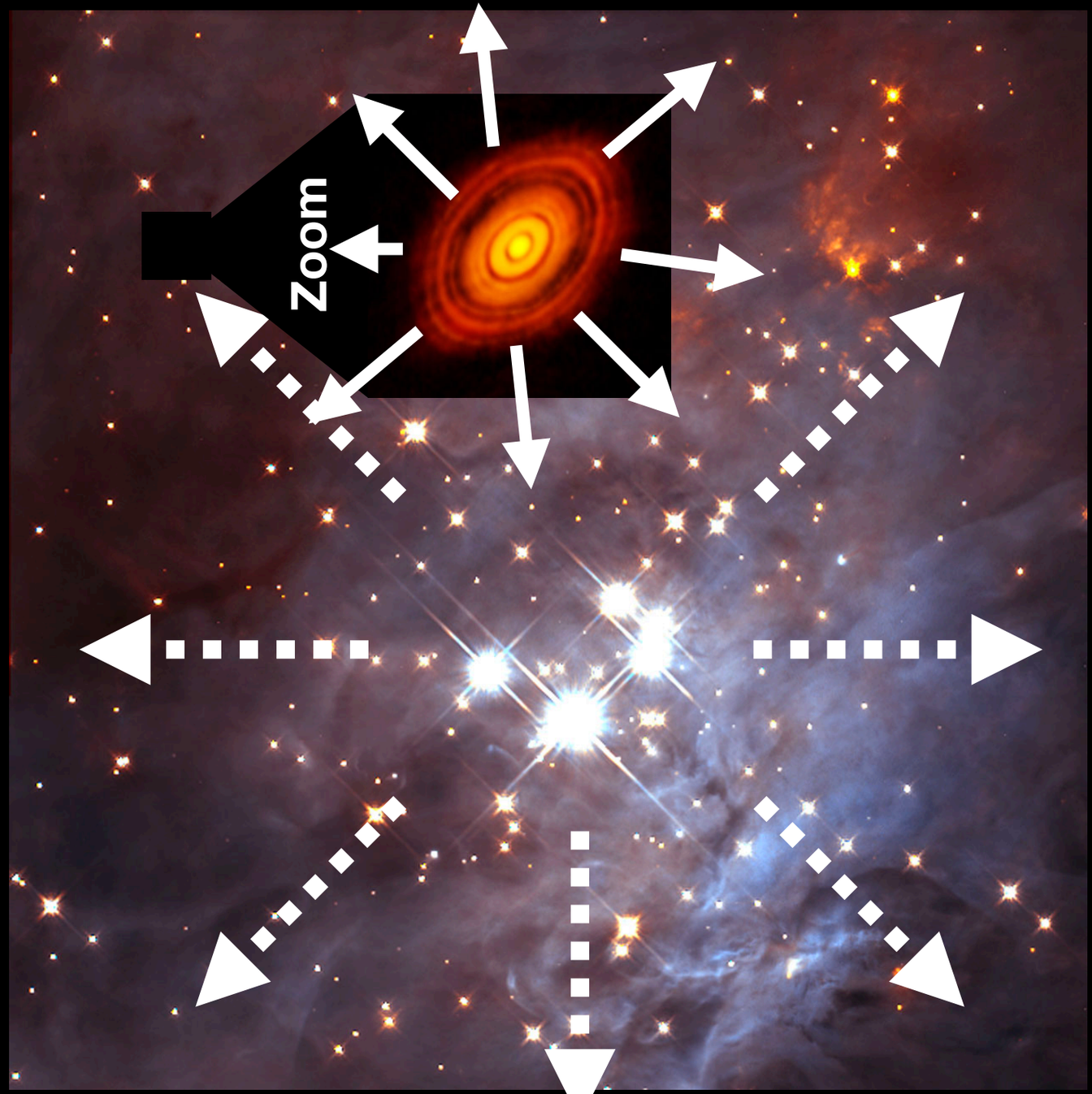

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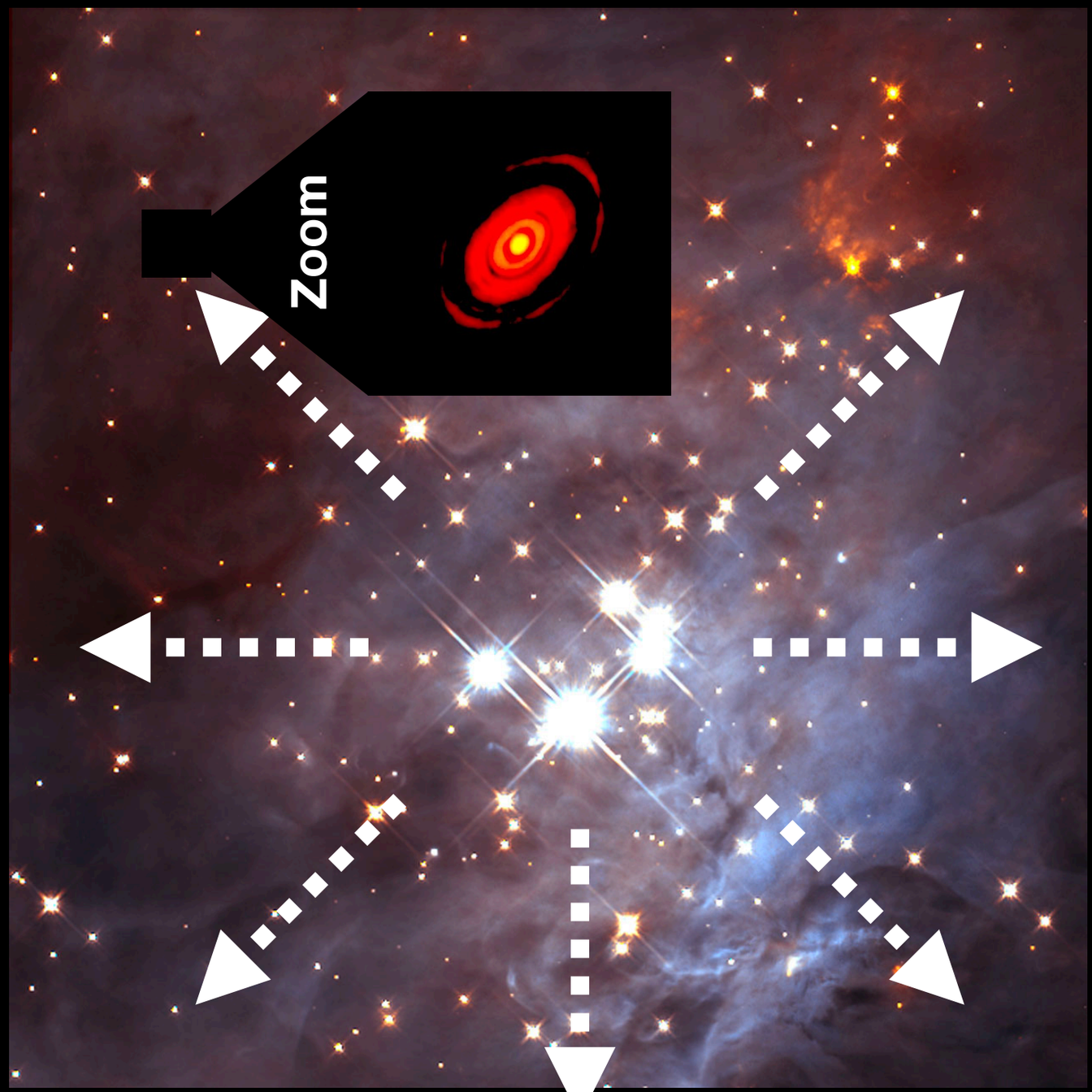
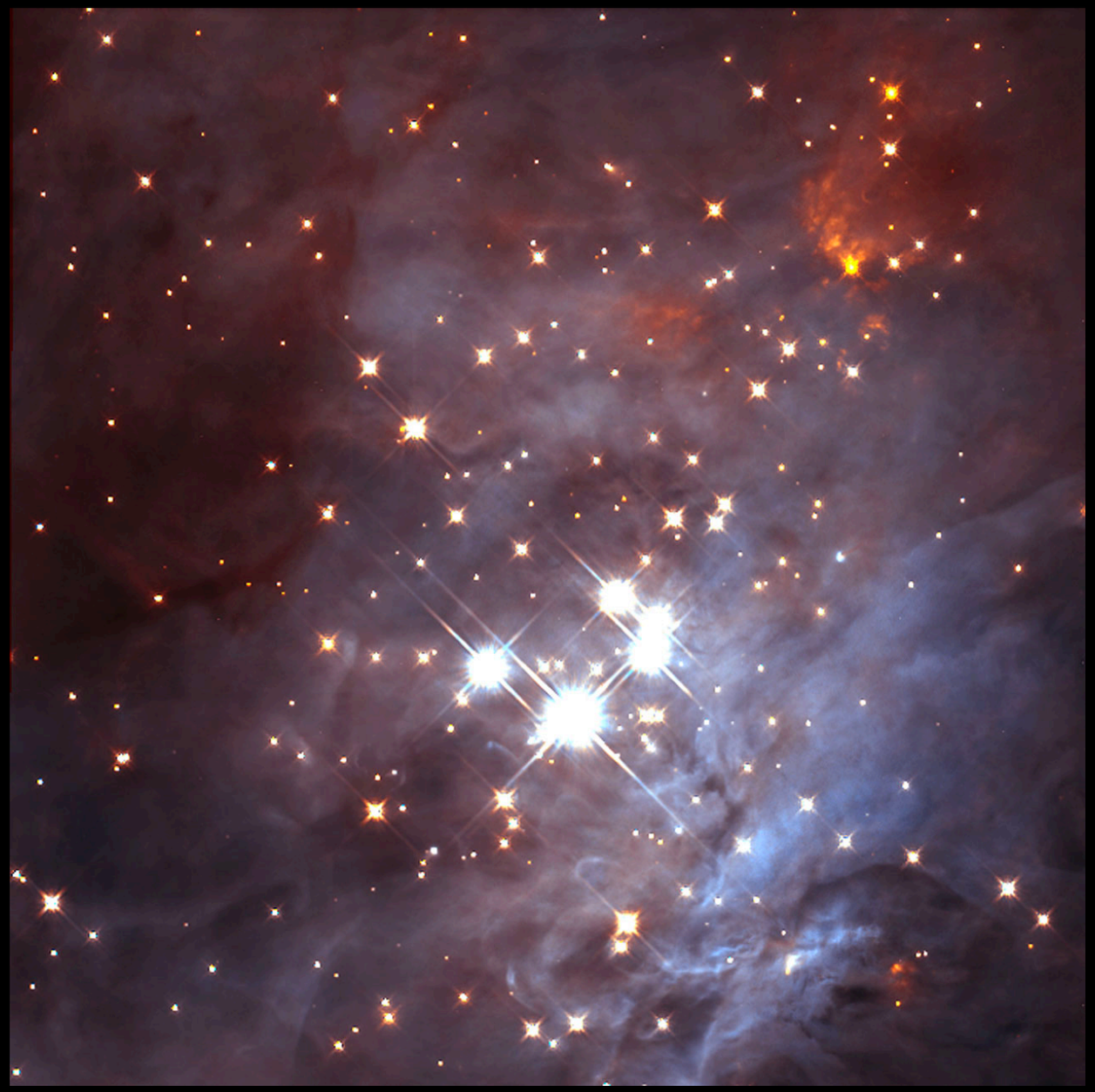


Credit: NASA

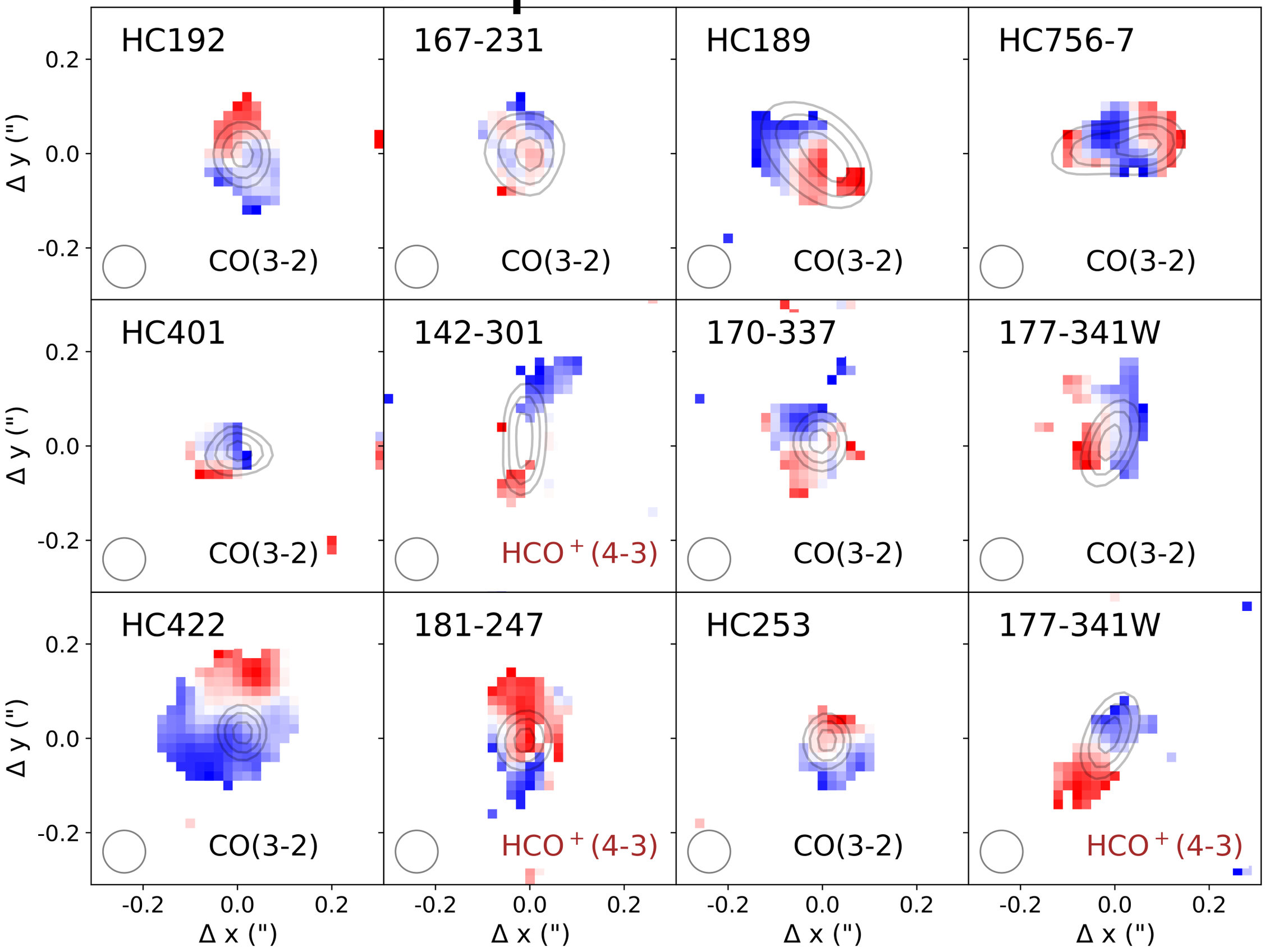
ALMA Program
Probing Planet-forming Zones in ONC Disks

- Cycle 4, #2015.1.00534.S
  - PI: Eisner
  - Central 1.5’ x 1.5’ ONC region
  - Sensitivity: 0.1 mJy / beam
  - Resolution: 0.08” (~35 AU)
- Scientific Goals
  - Detect the disks in dust, CO (3-2), and HCO^+ (4-3)
  - Measure dust and gas properties and compare with other regions



Credit: NASA

Example Detections



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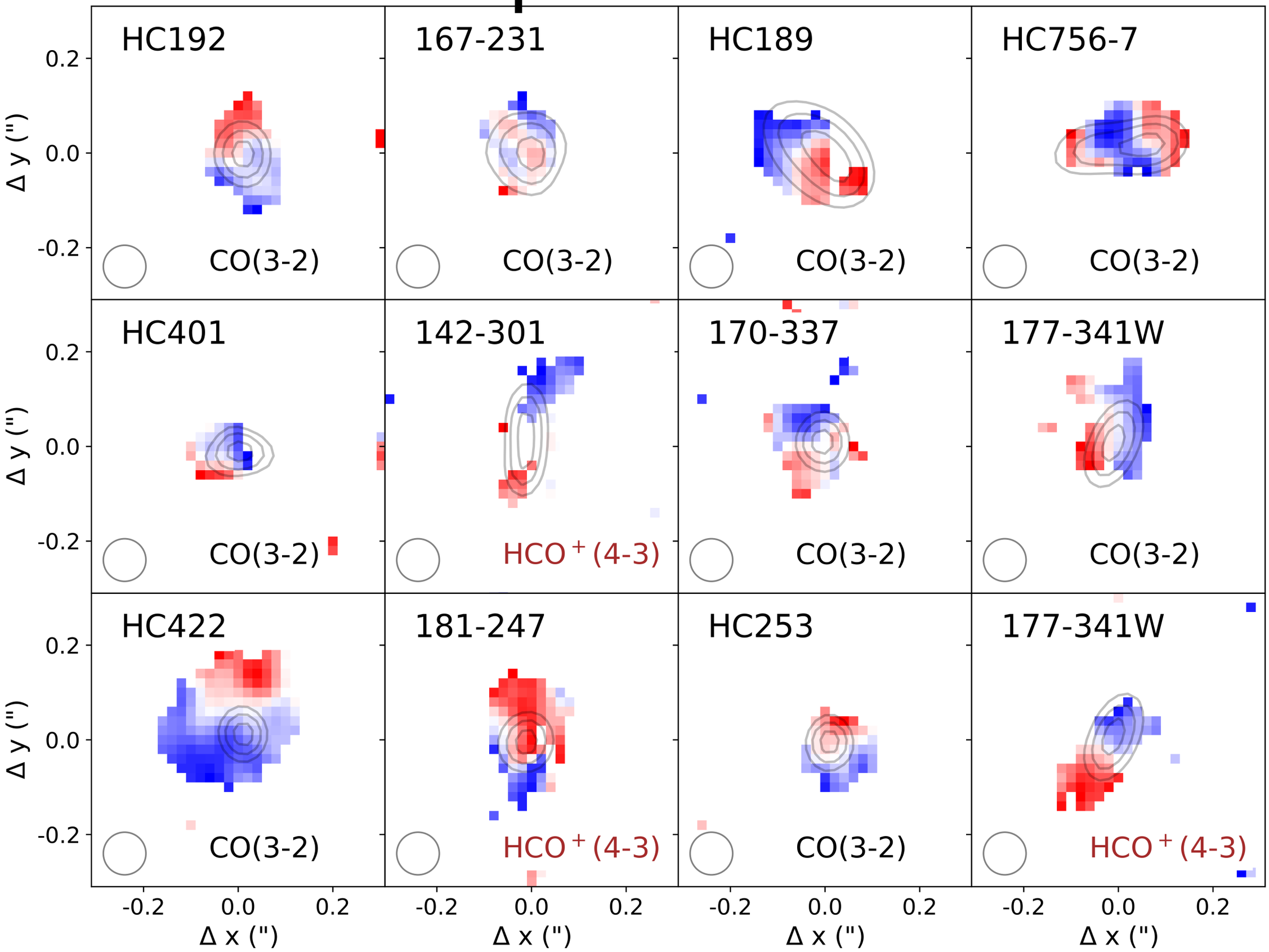
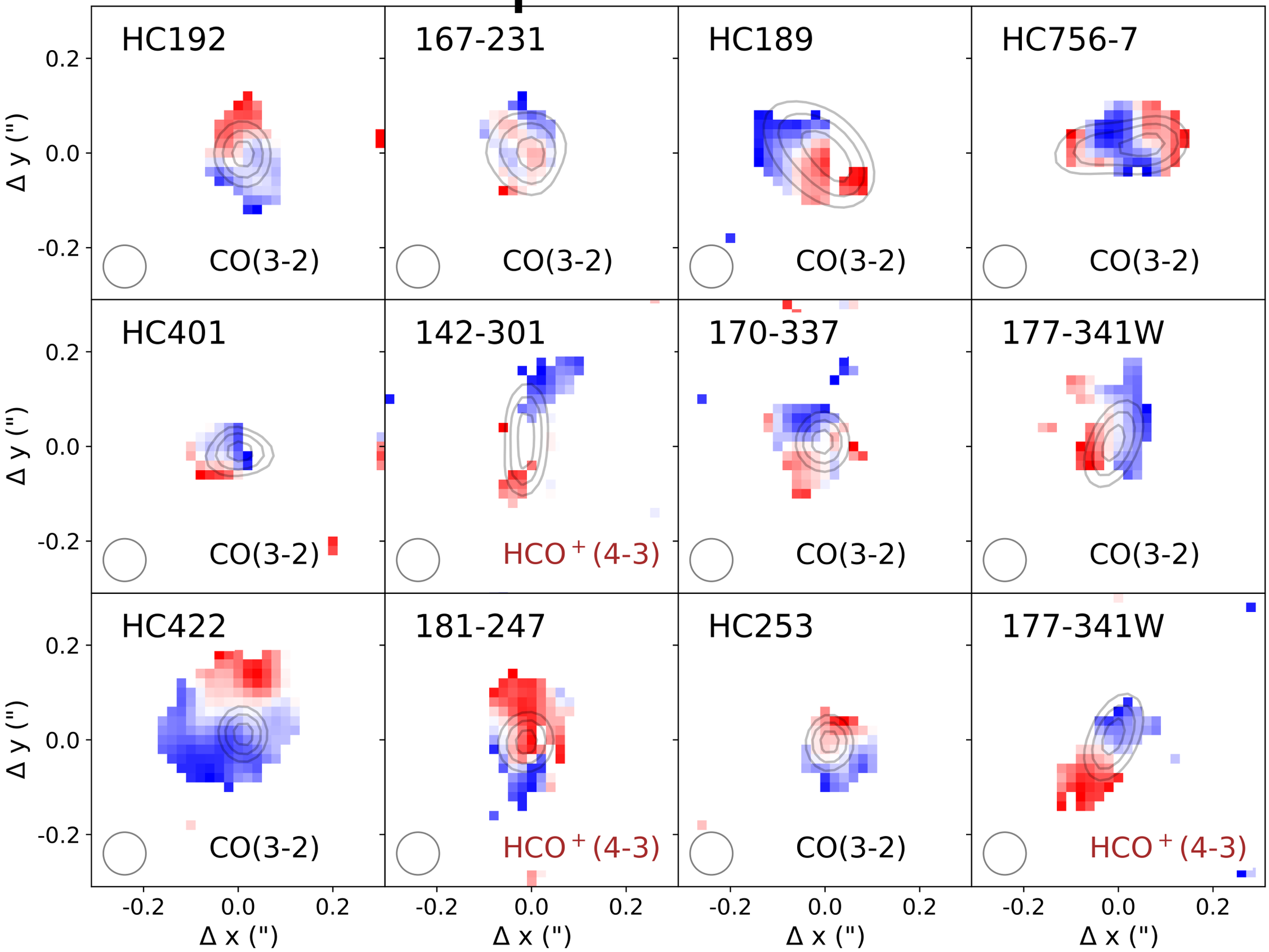


Dust: Eisner et al. (2018)

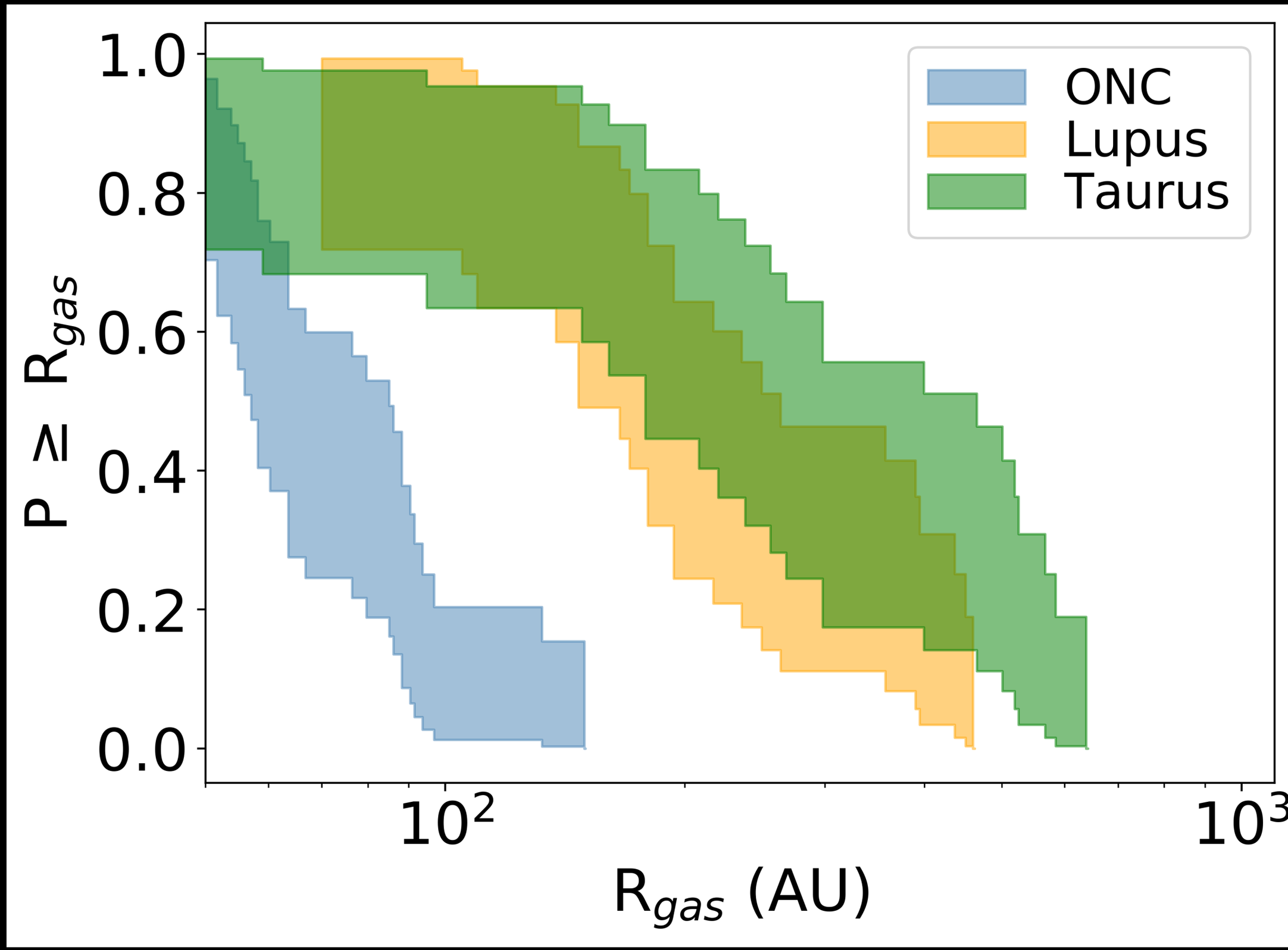
Example Detections



Gas: Boyden & Eisner in review

Gas Size Distribution

Gas Size Distribution



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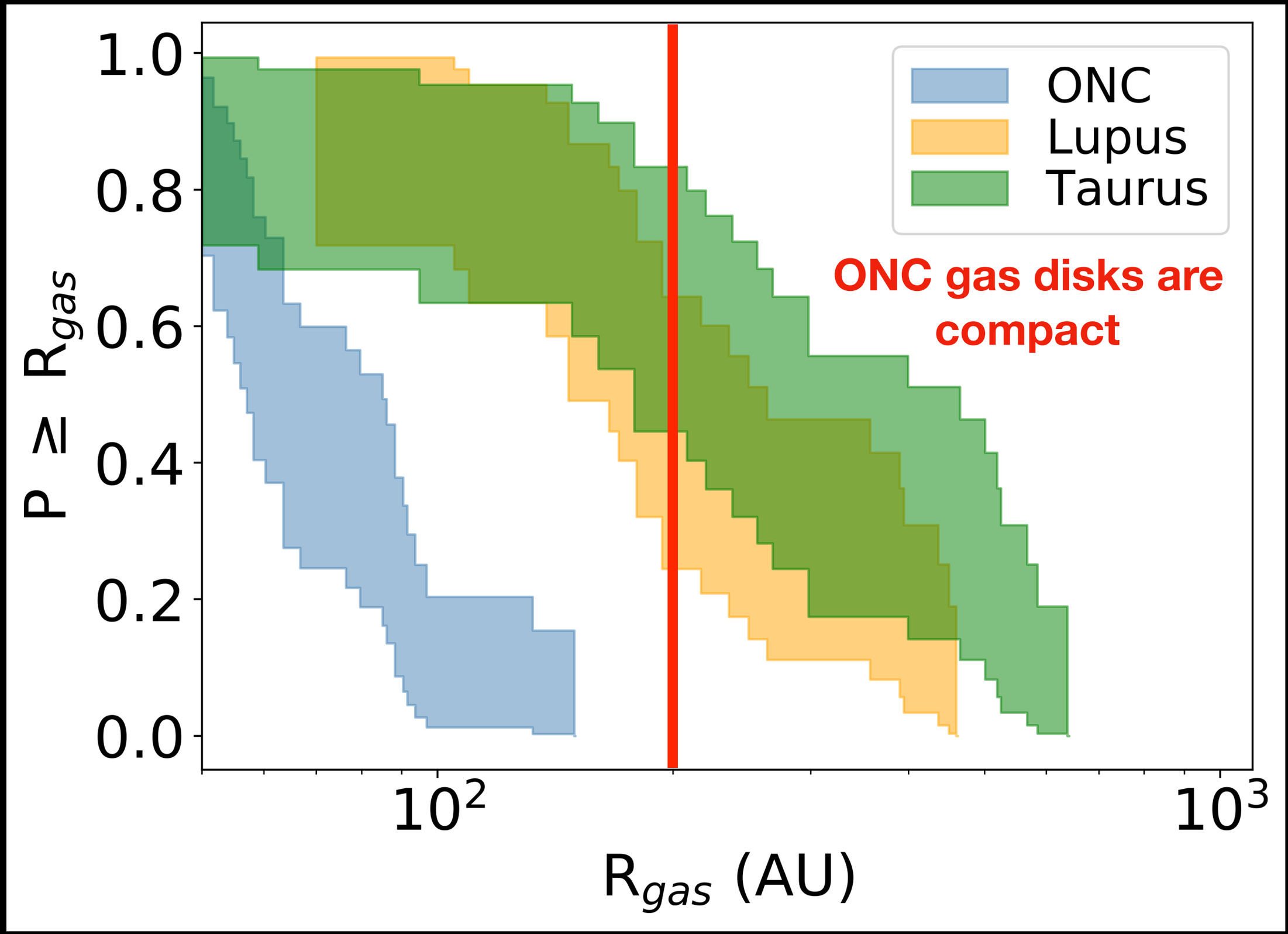
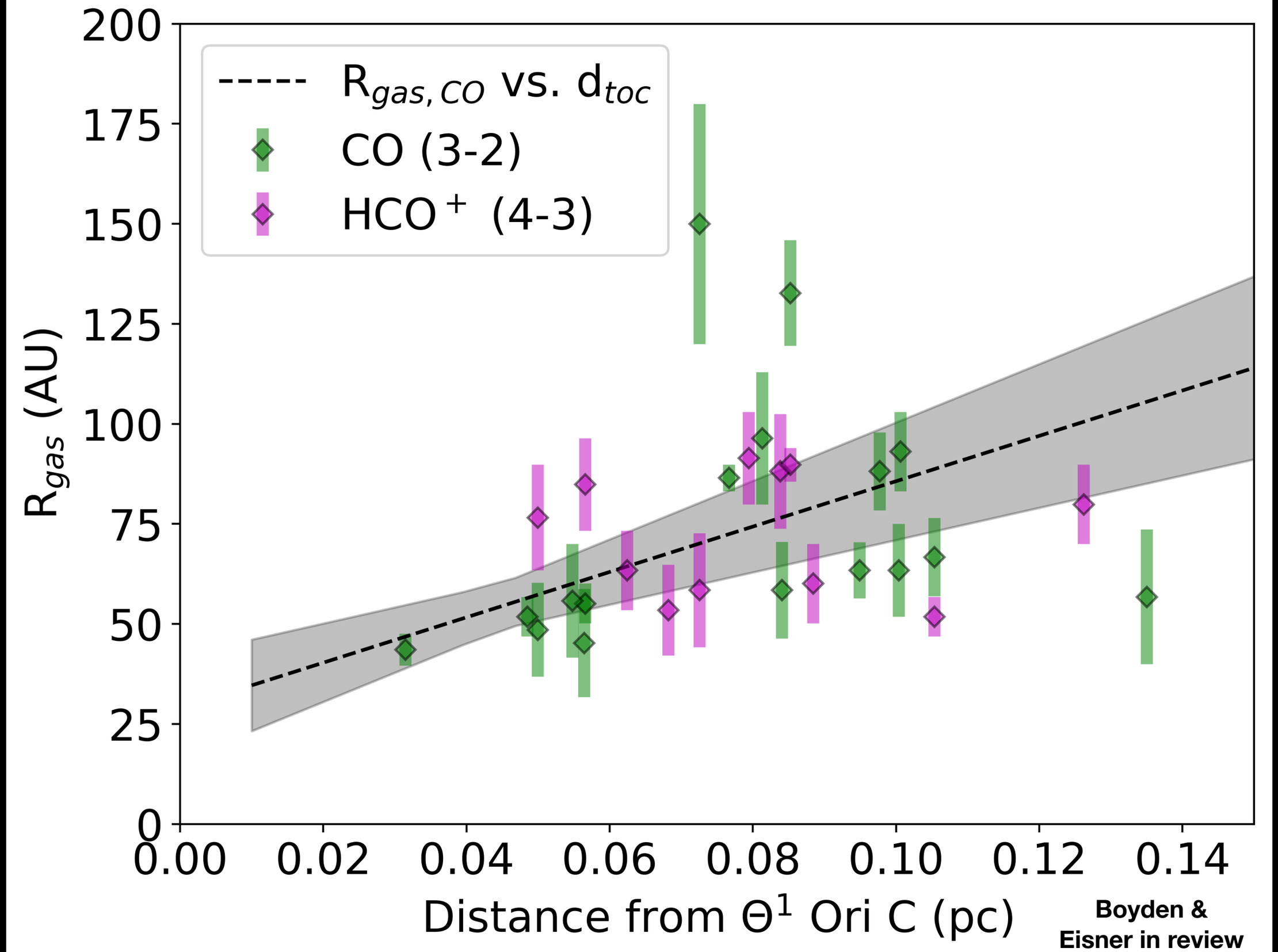


Boyden & Eisner in review

R_{gas} Correlations



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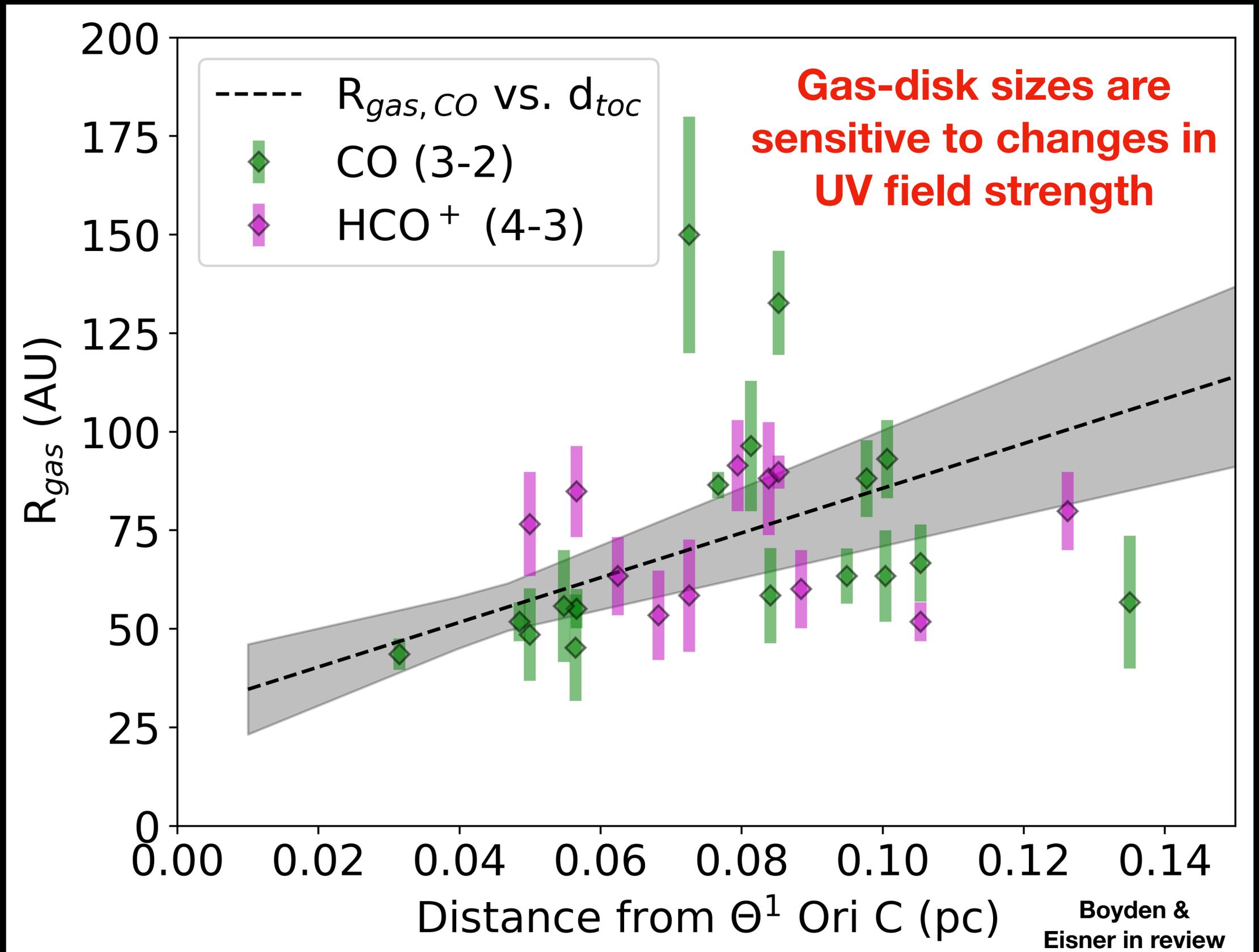
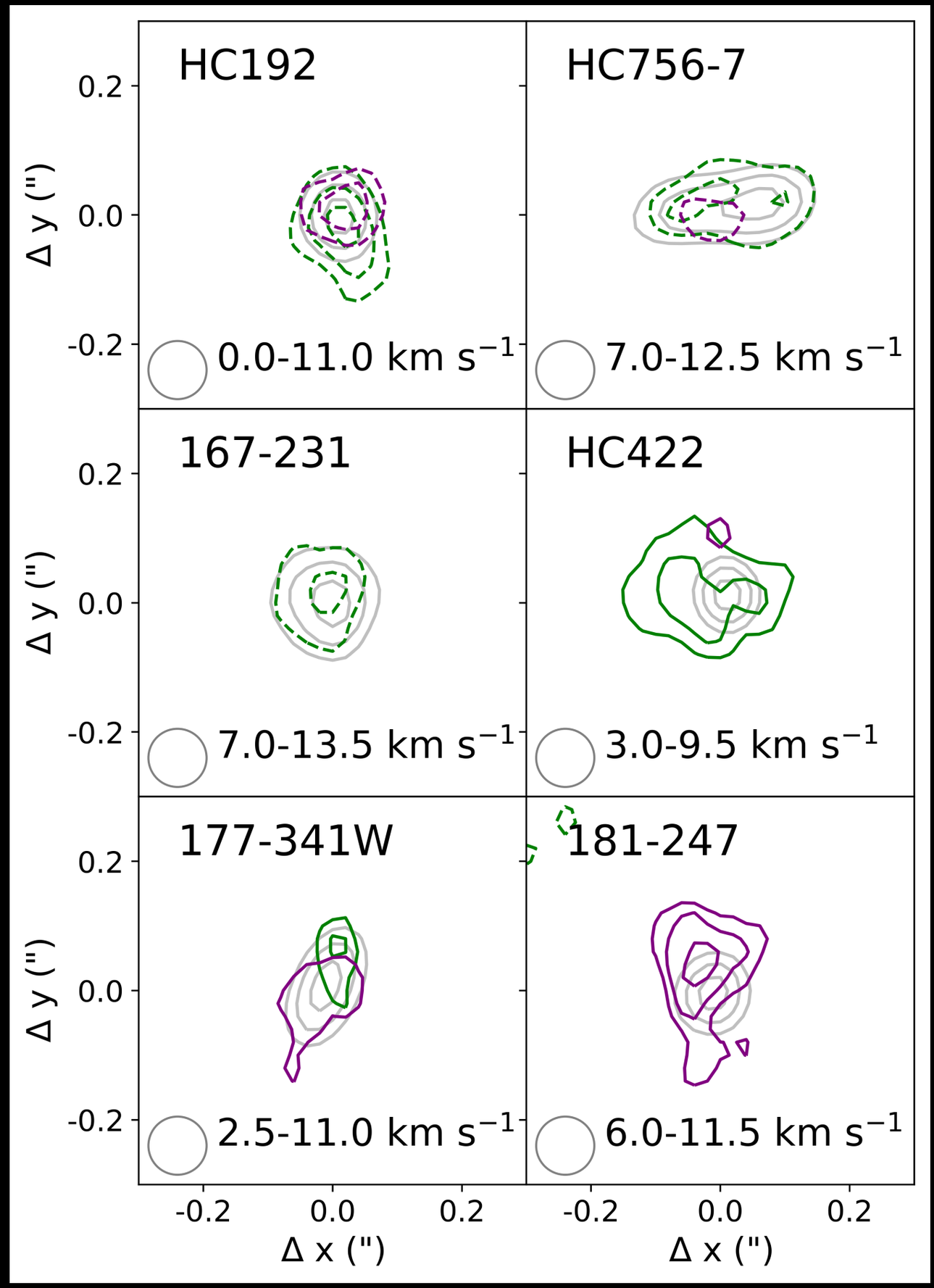


Takeaways

1. **Disks (gas+dust) in the ONC are impacted by the rich cluster environment**
   - e.g., they are compact, and their properties correlate with the distance from θ^1 Ori C
2. **Observed kinematics of the ONC gas disks are consistent with Keplerian rotation**
3. **Future Work: follow-up ALMA observations, radiative transfer modeling, etc.**
4. **Discuss further? Contact me at rboyden@email.arizona.edu**



Green: CO **Solid: Emission**
Purple: HCO+ **Dashed: Absorption**

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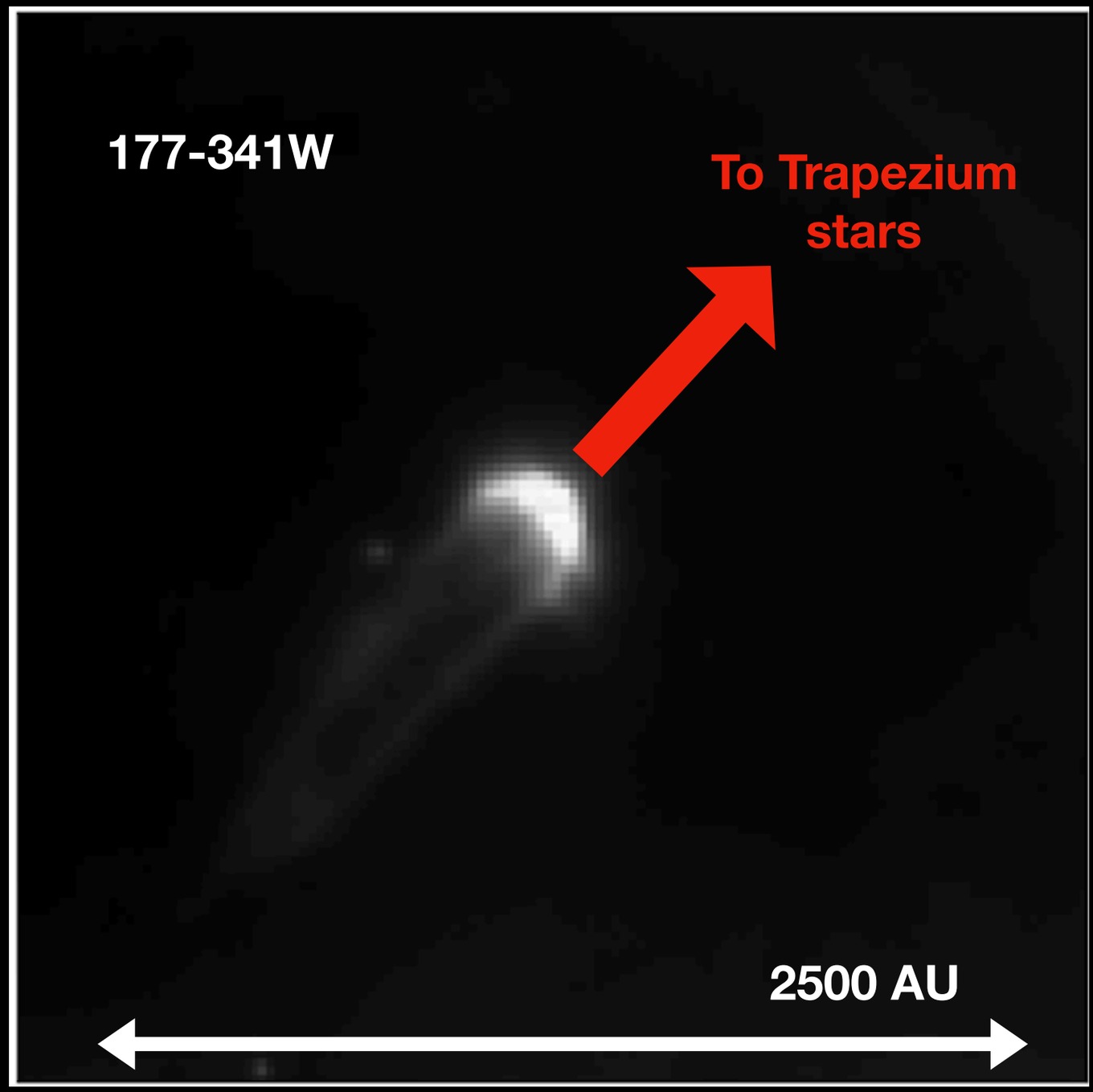
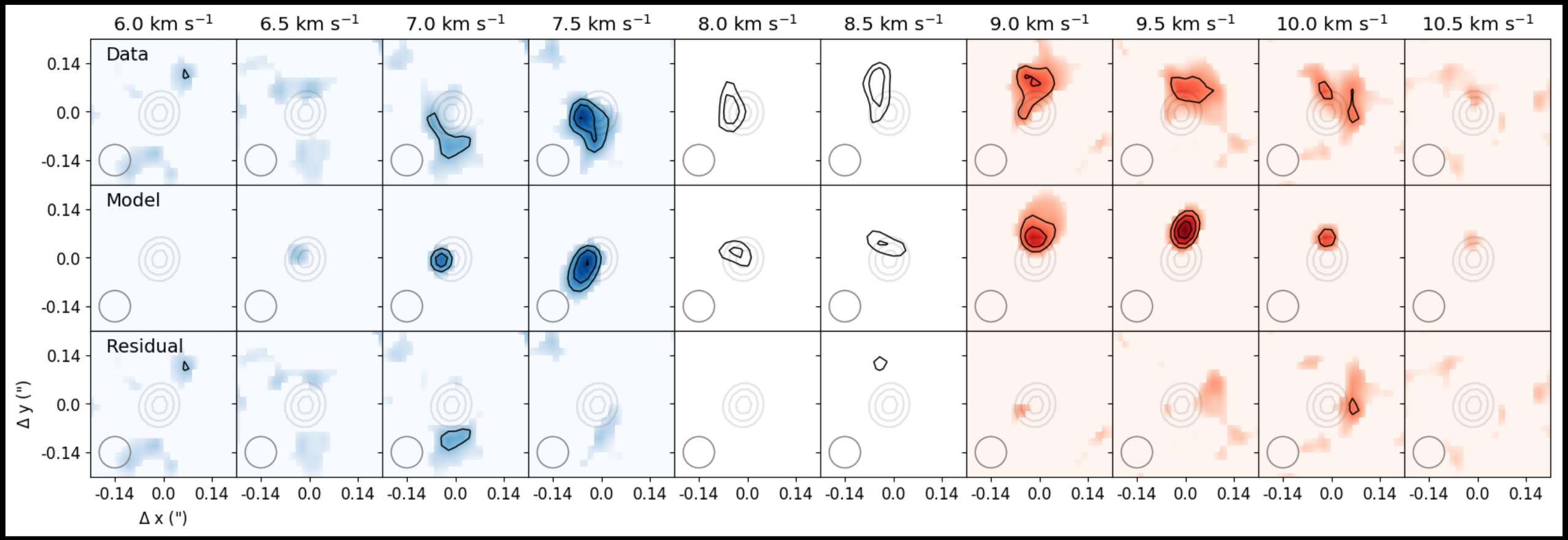


Ricci et al. (2008)

Keplerian Modeling

“181-247”; HCO^+ (4-3)



Blue-Shifted Emission

~Rest Emission

Red-Shifted Emission

Boyden & Eisner in review

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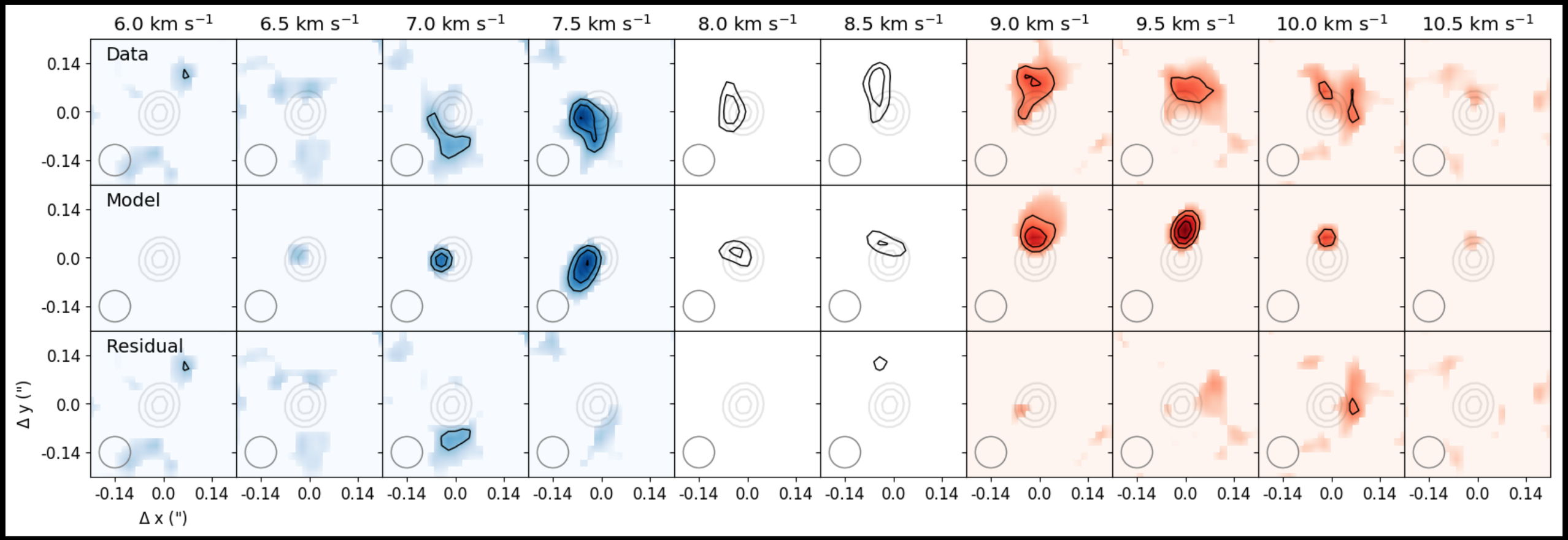

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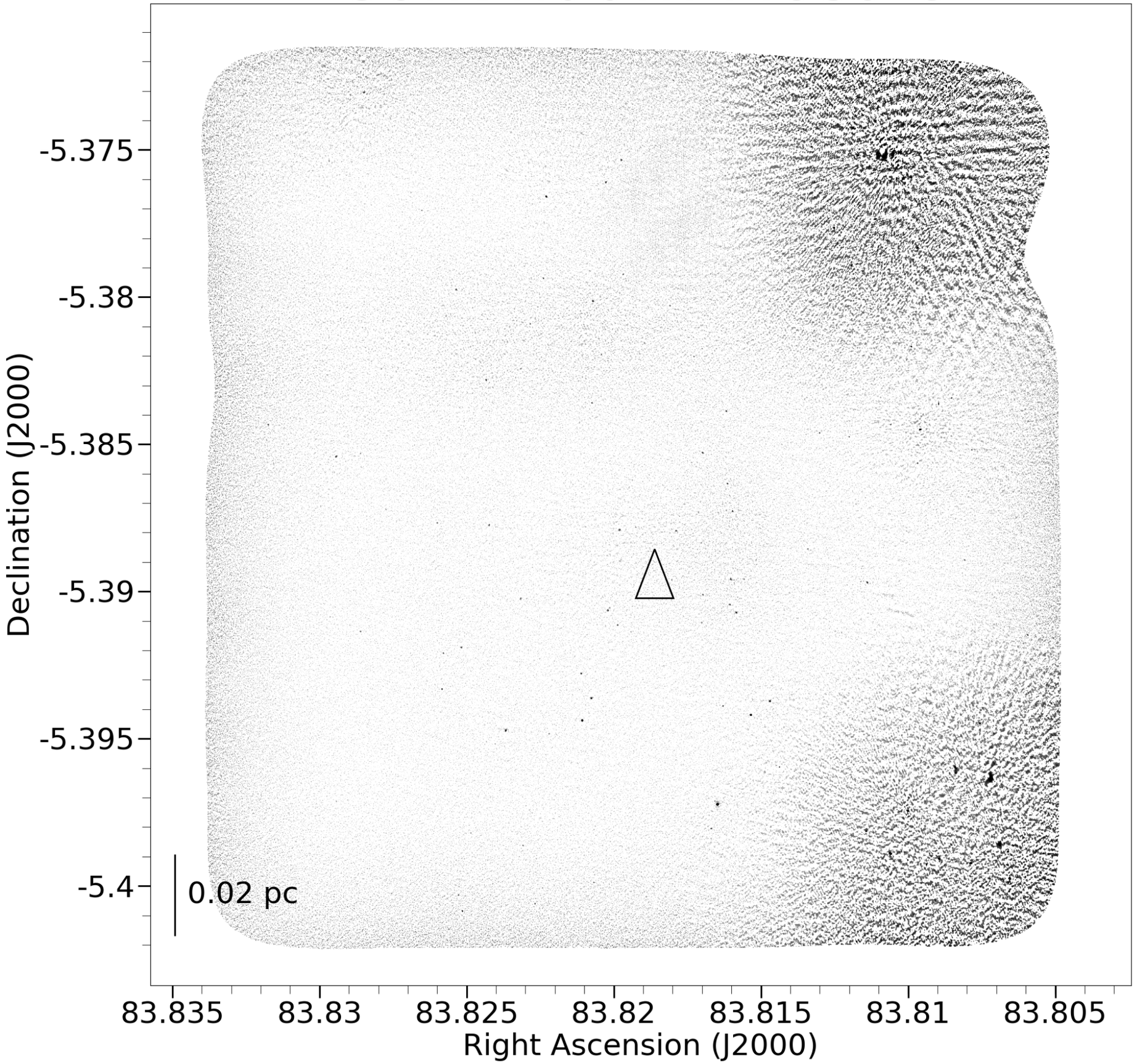
Continuum Mosaic



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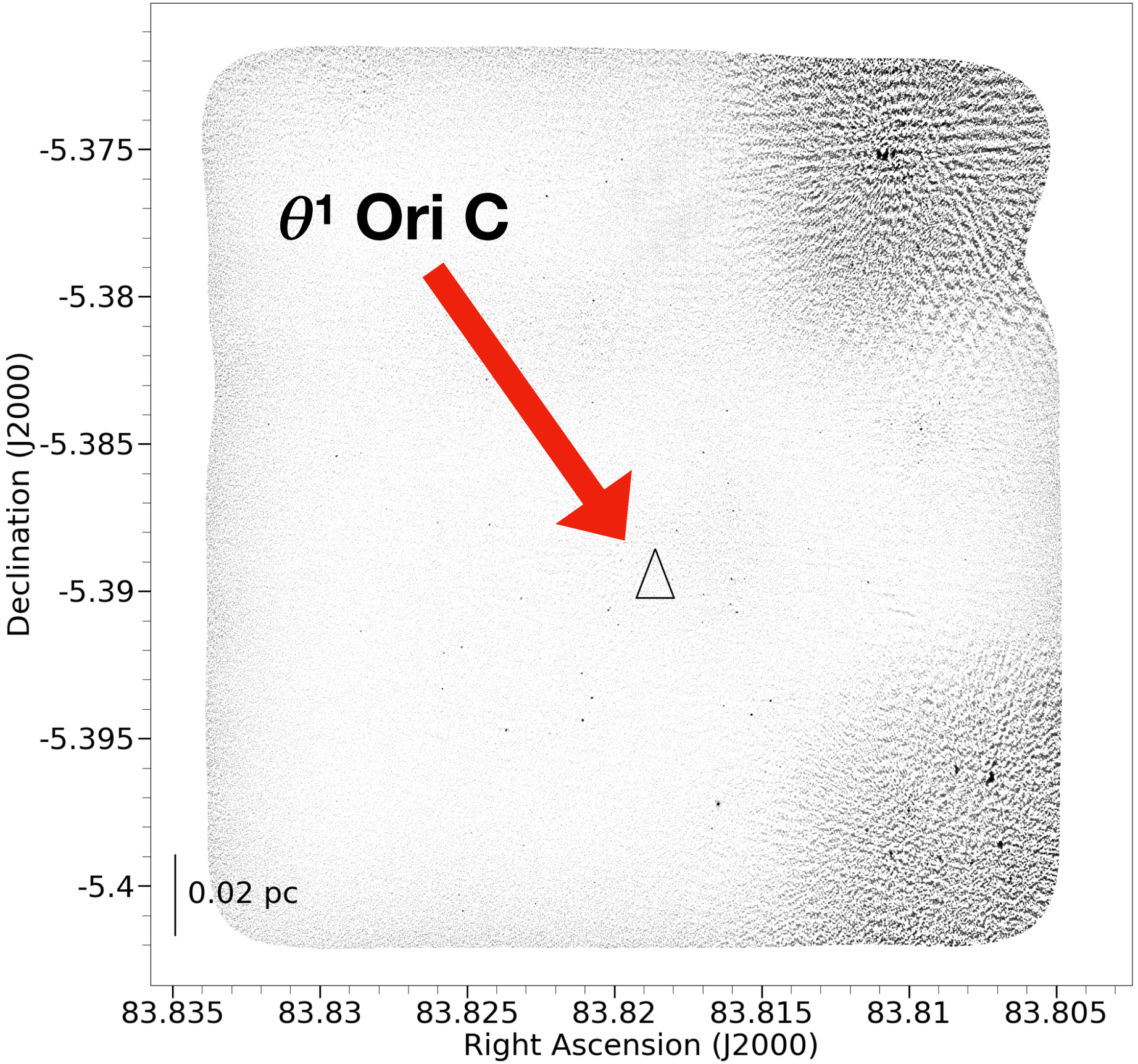

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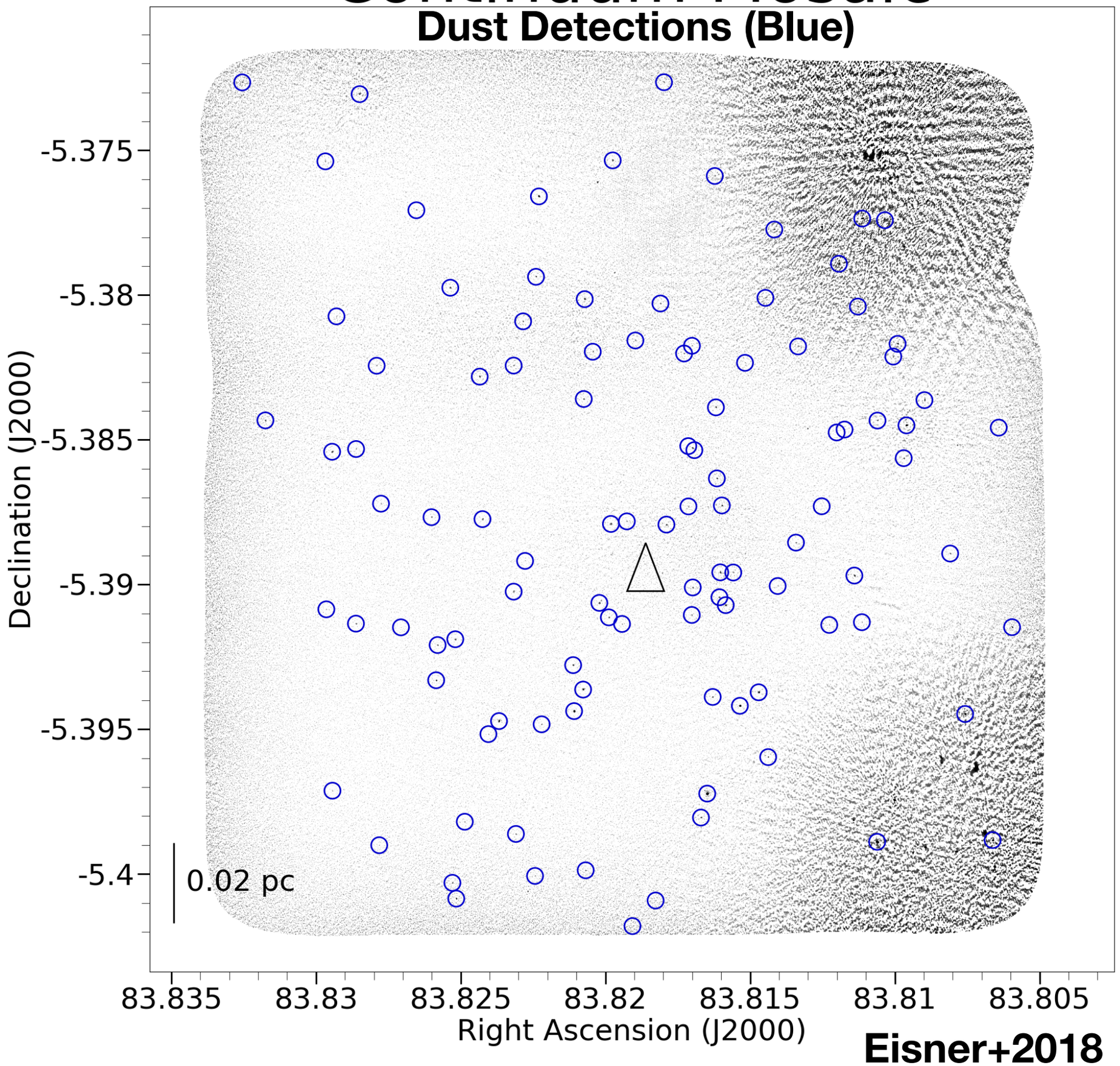
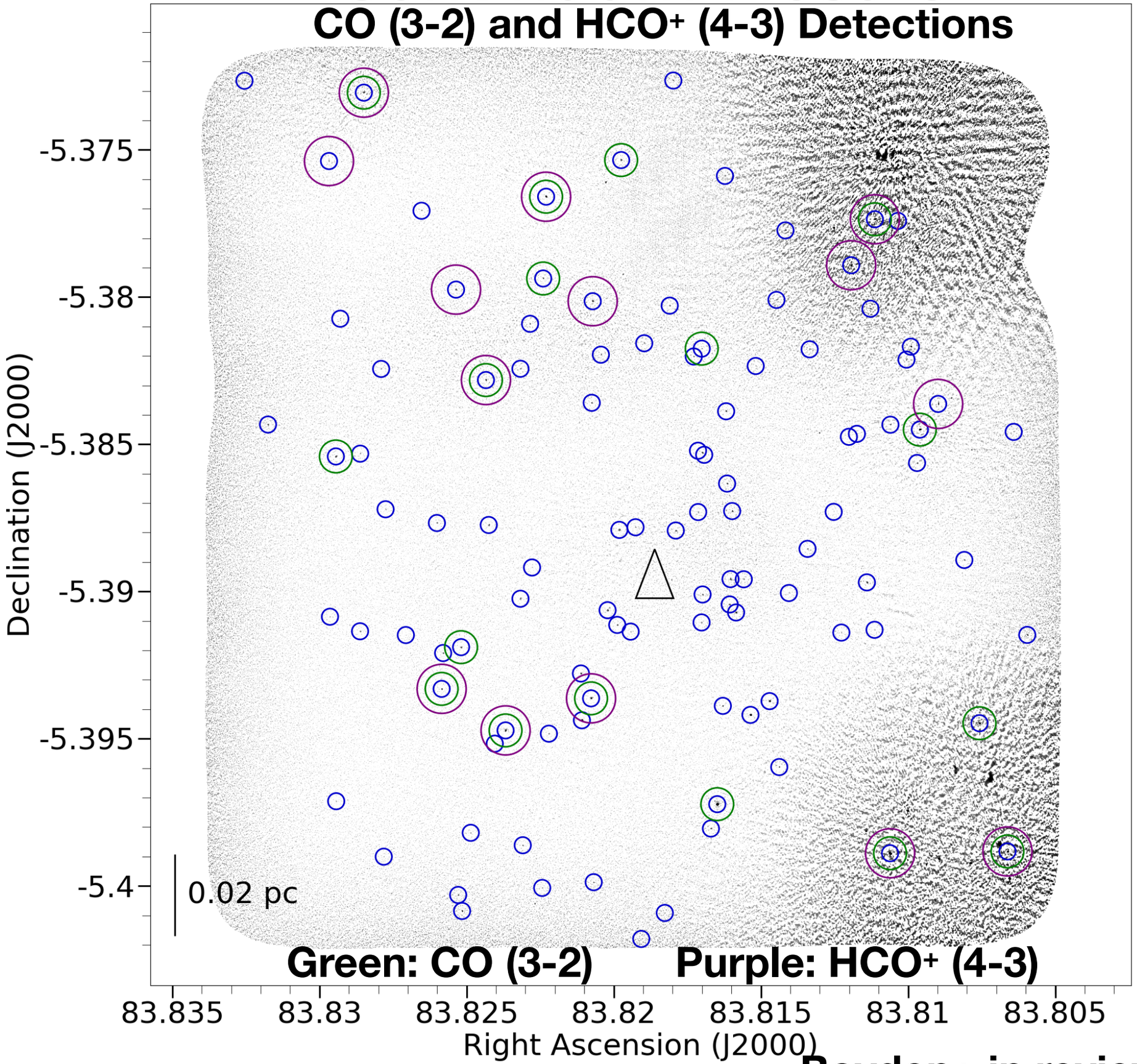


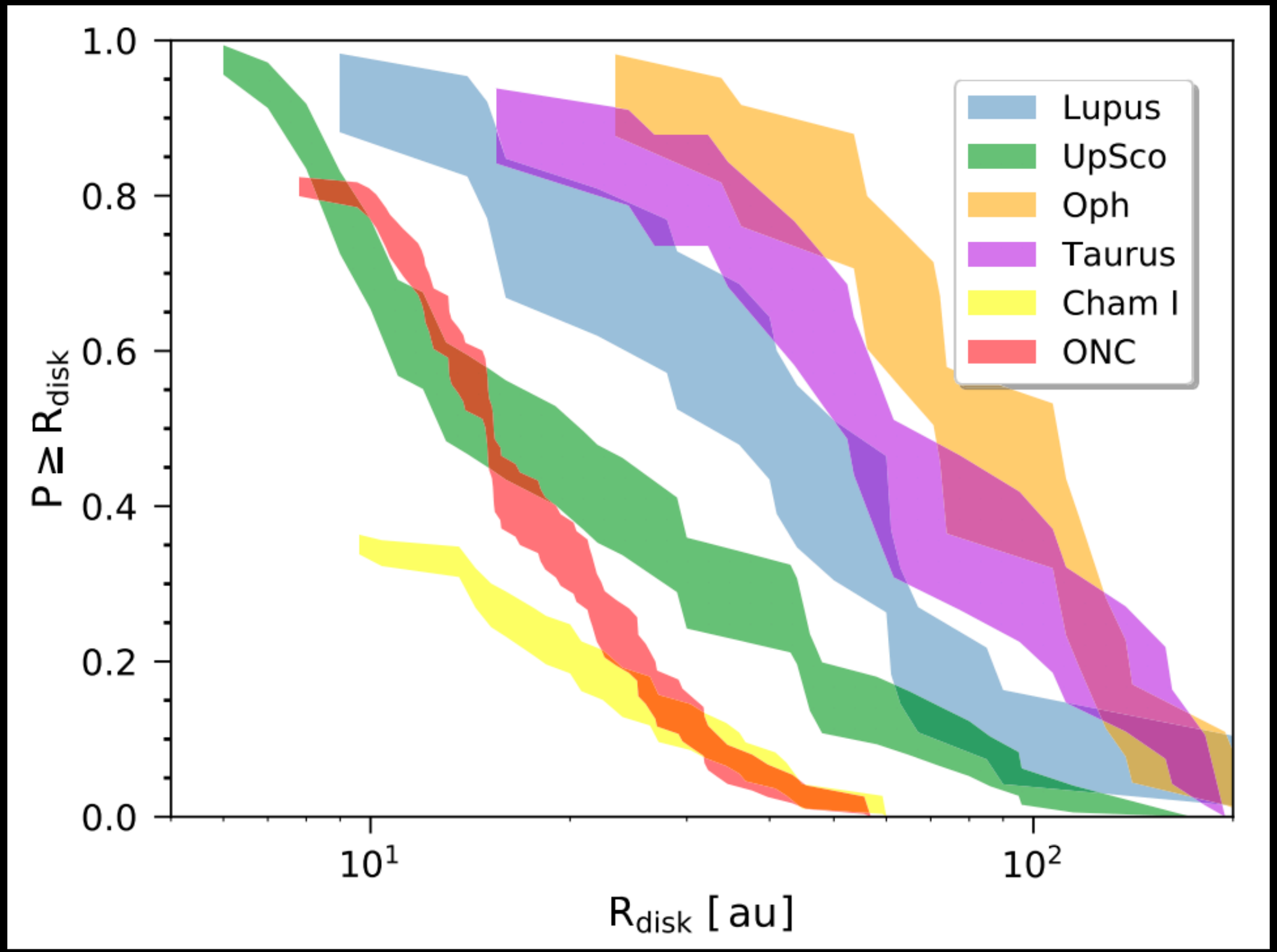
Continuum Mosaic

CO (3-2) and HCO+ (4-3) Detections

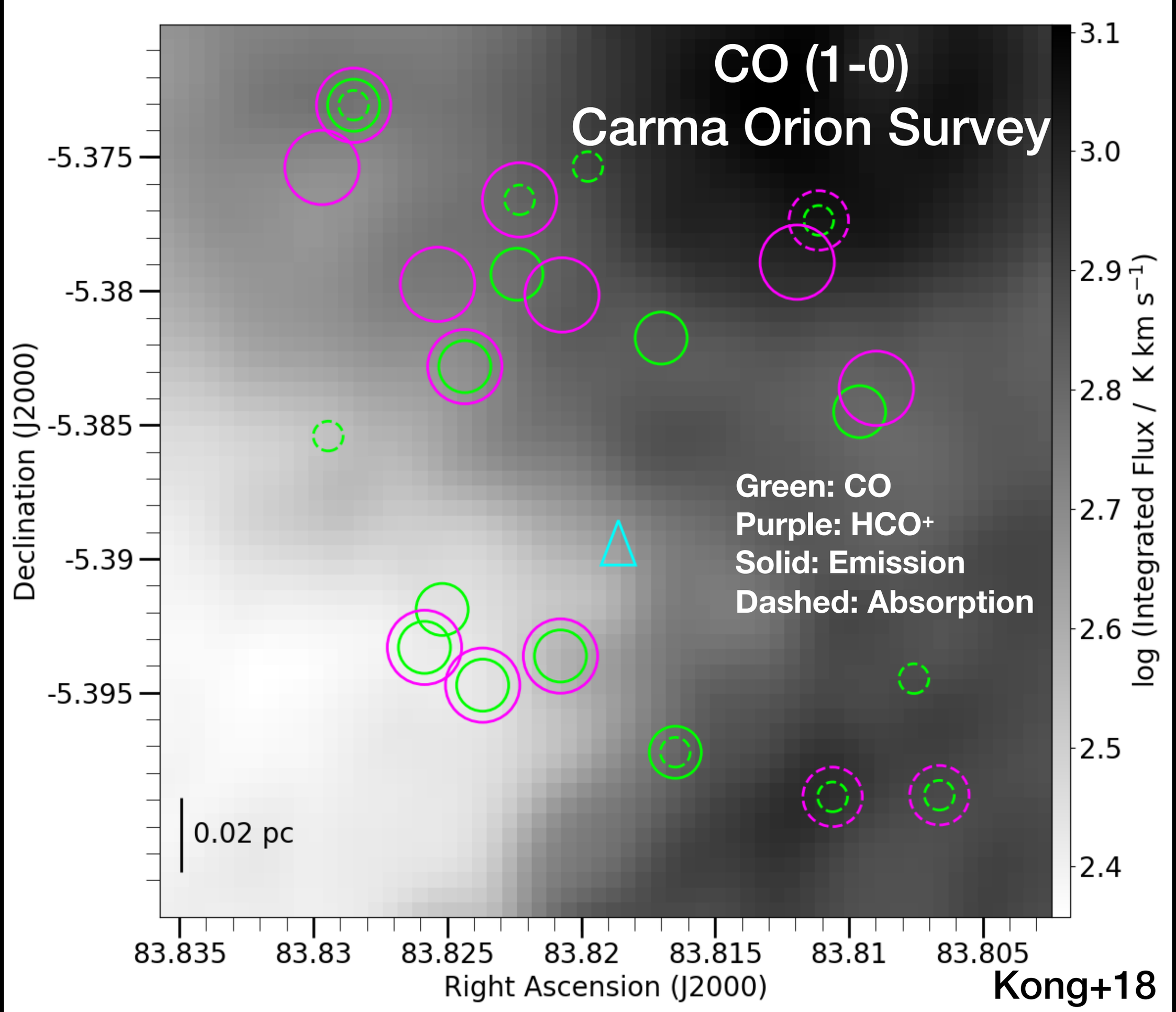


Boyden+ in review

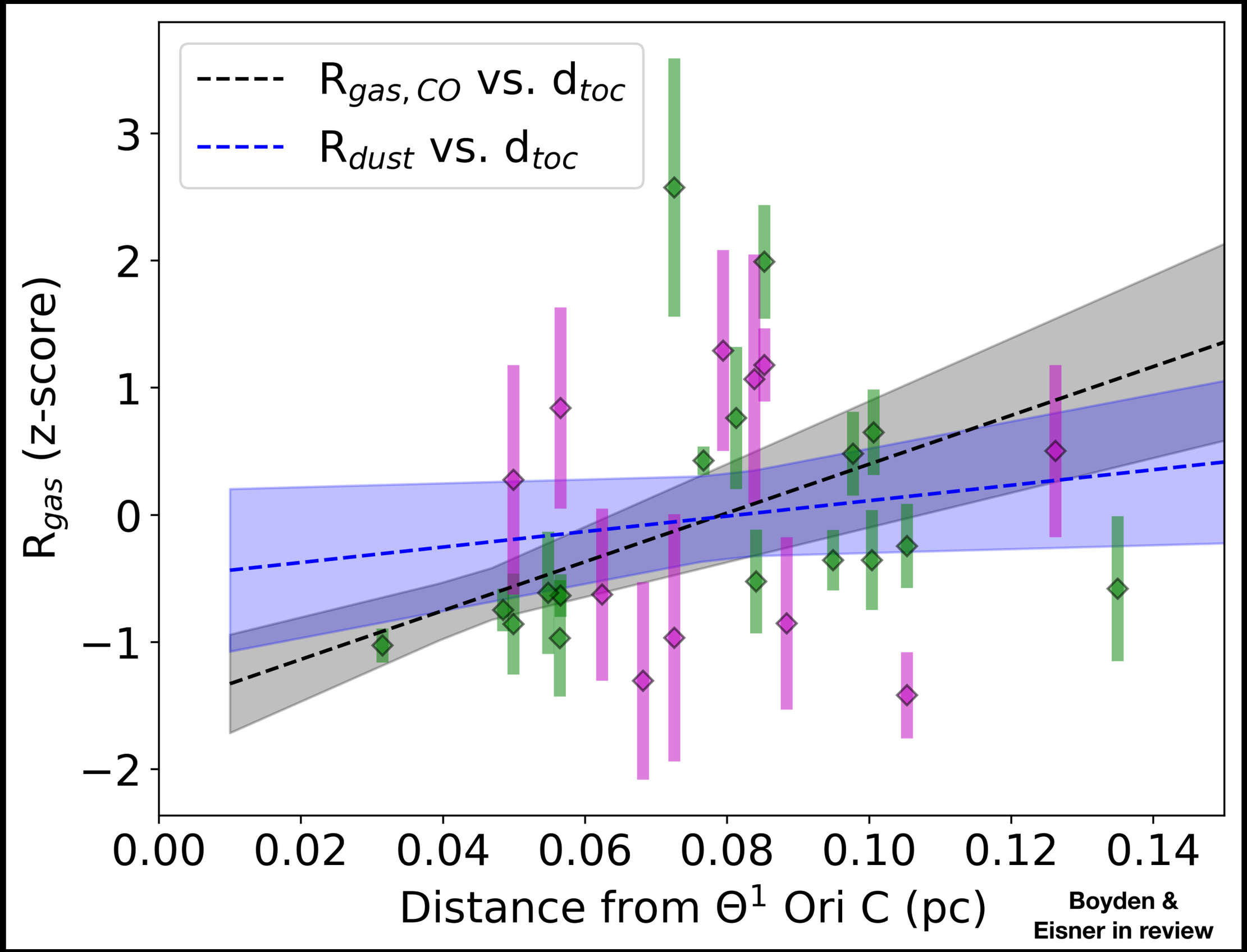
Dust-Disk Sizes



Eisner et al. 2018


CO (1-0)
Carma Orion Survey
Green: CO
Purple: HCO+
Solid: Emission
Dashed: Absorption
0.02 pc
-5.375
-5.38
-5.385
-5.39
-5.395
Declination (J2000)
83.835
83.83
83.825
83.82
83.815
83.81
83.805
Right Ascension (J2000)
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
log (Integrated Flux / K km s−1)
Kong+18

R_{gas} Correlations



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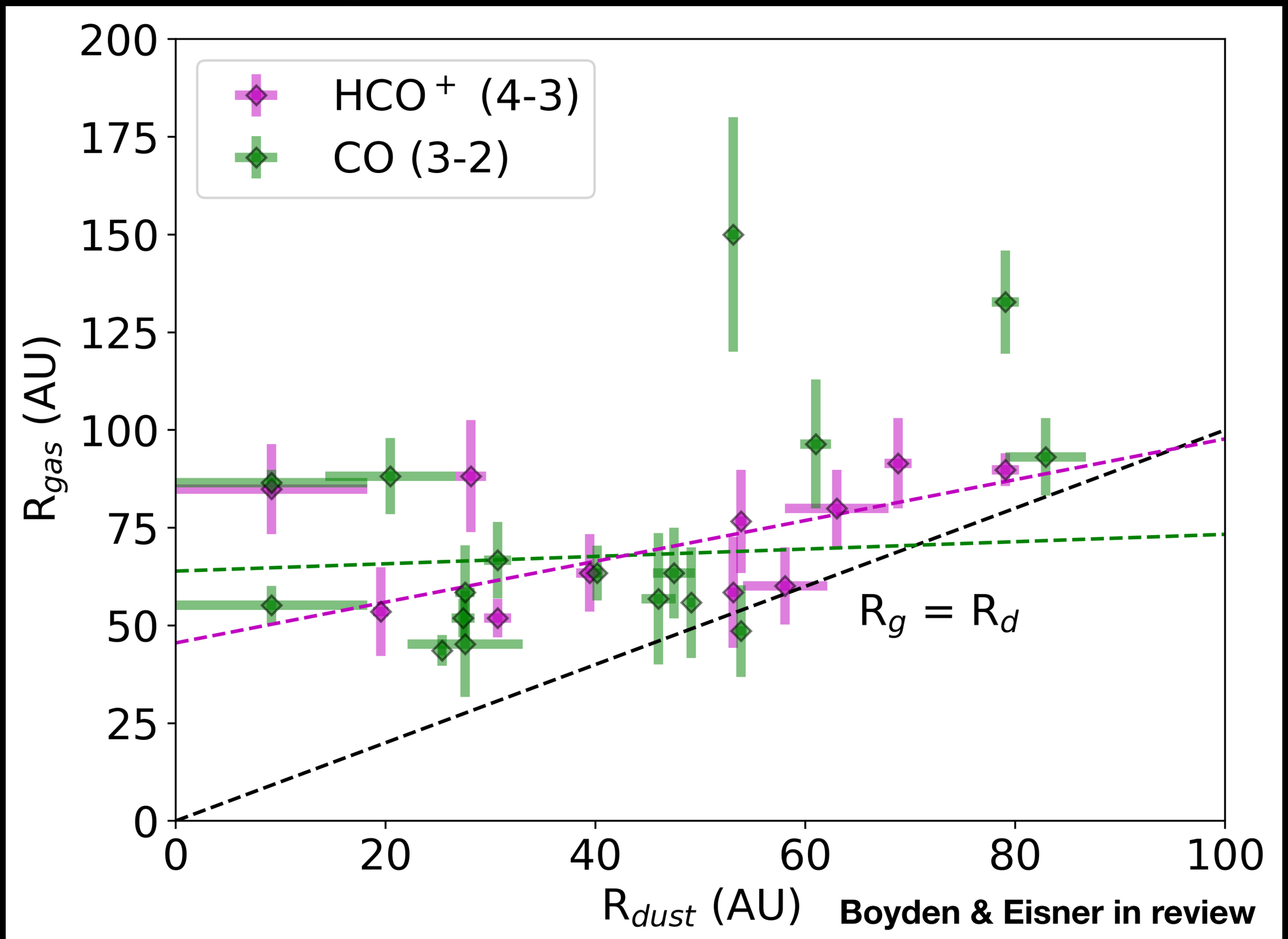

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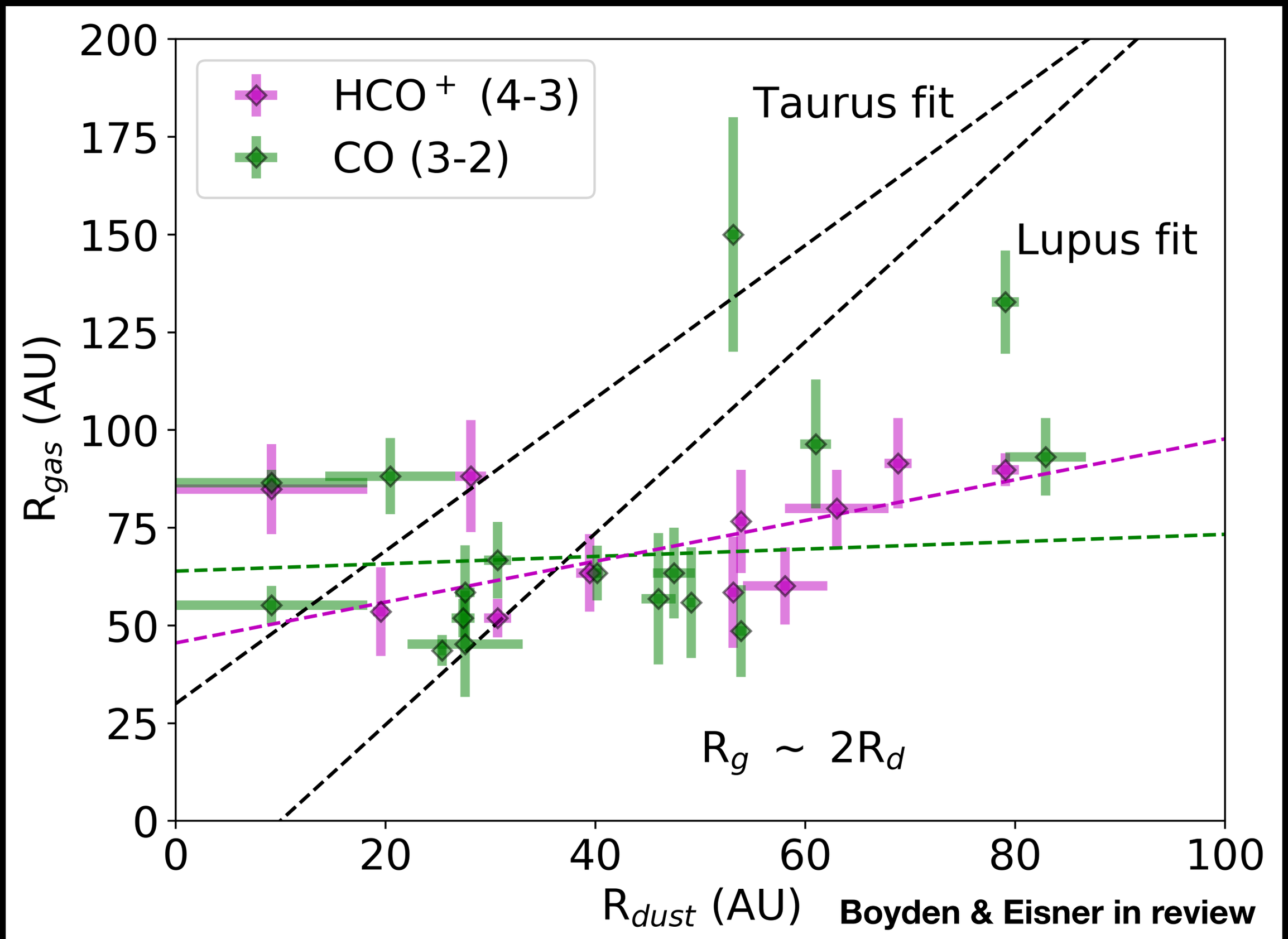
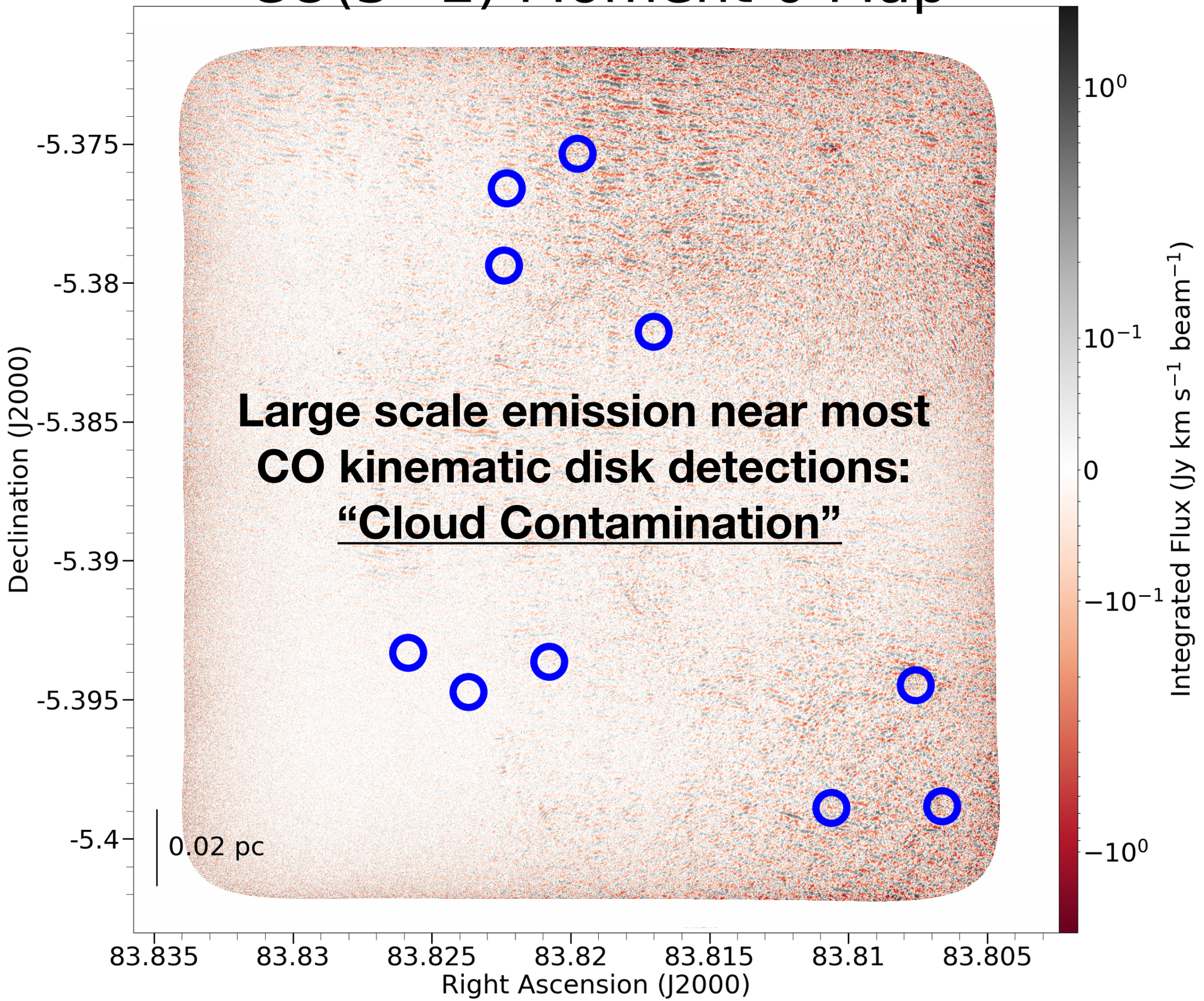


CO(3−2) Moment 0 Map



Dynamical Masses