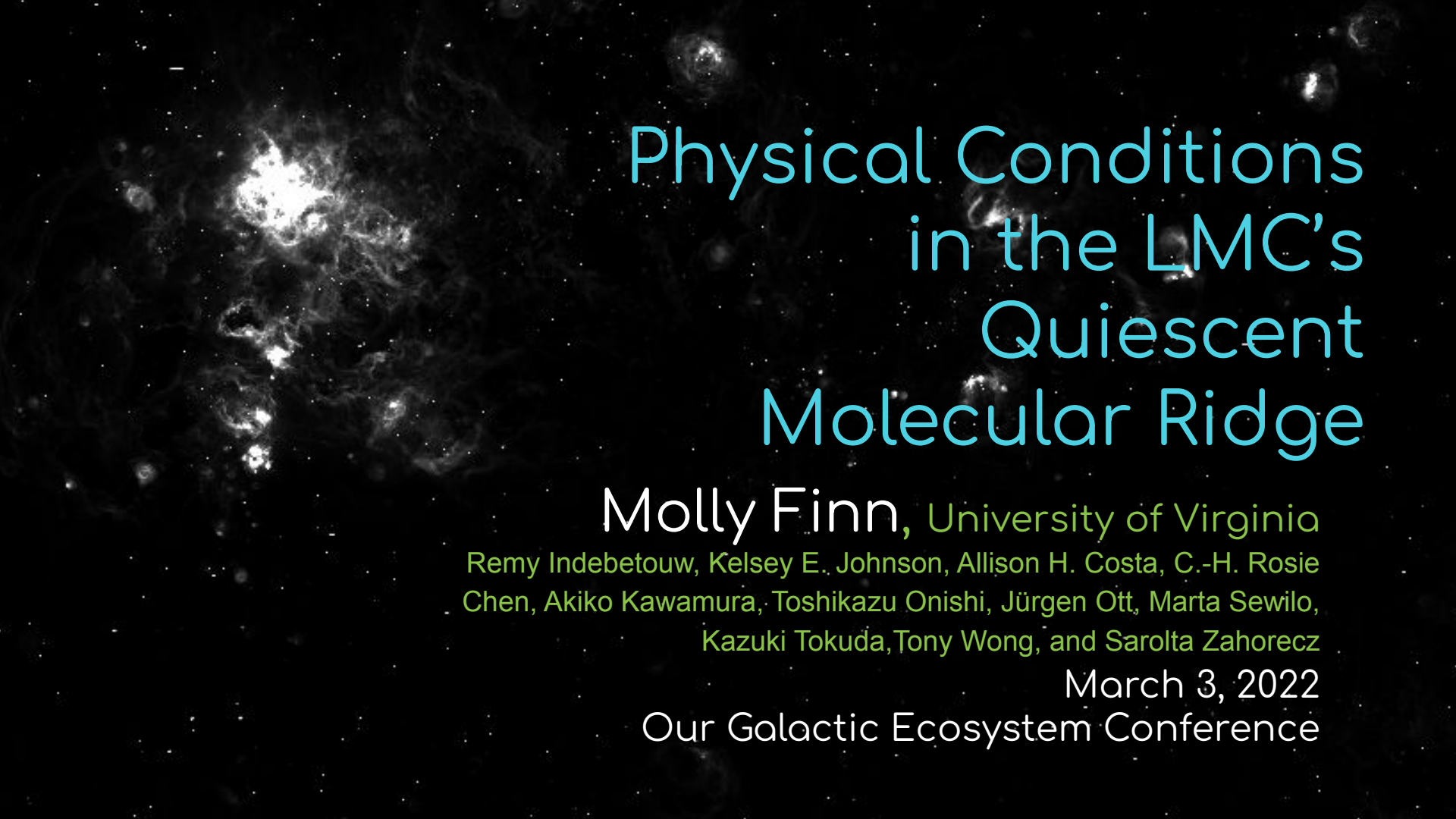
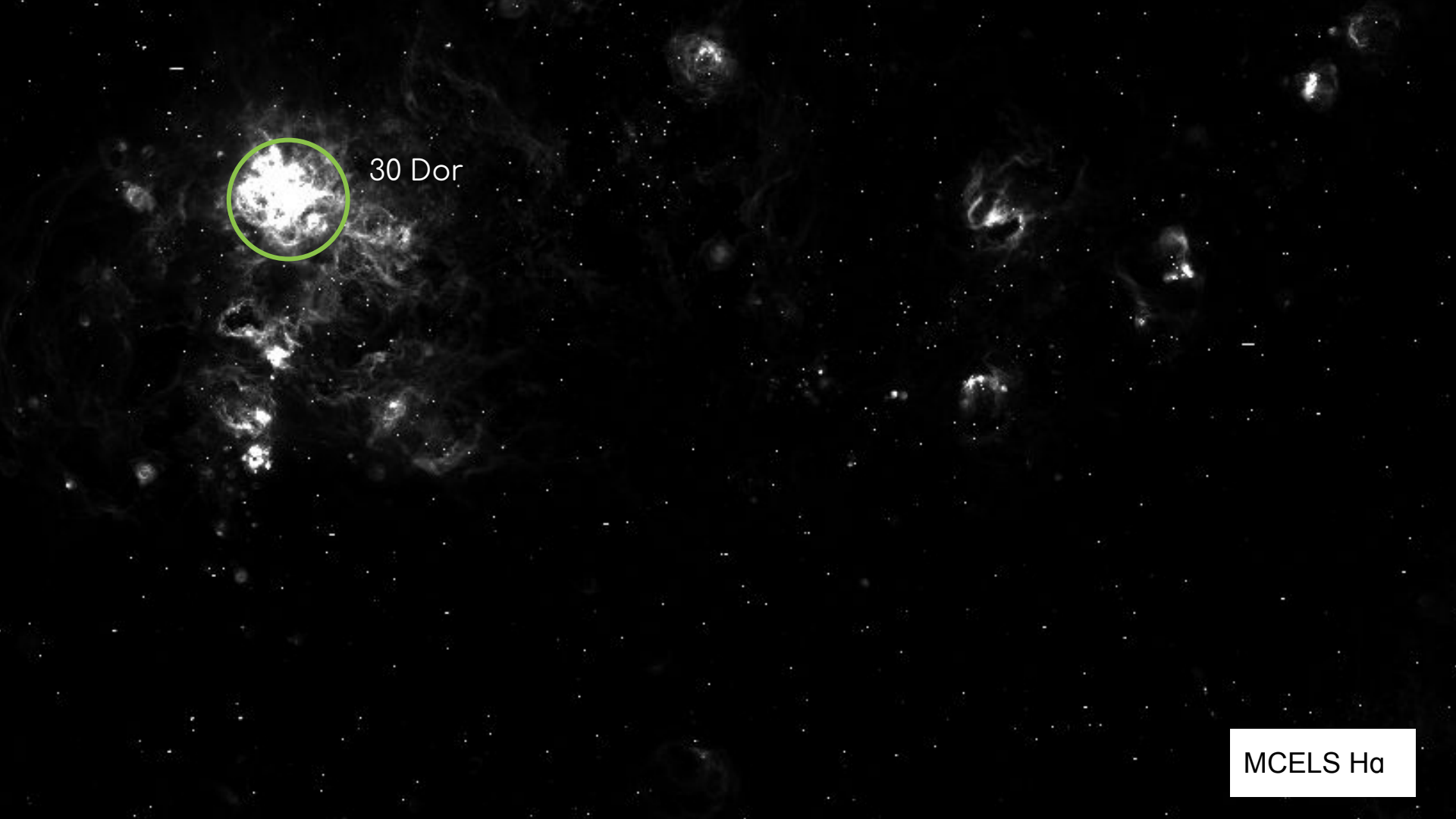


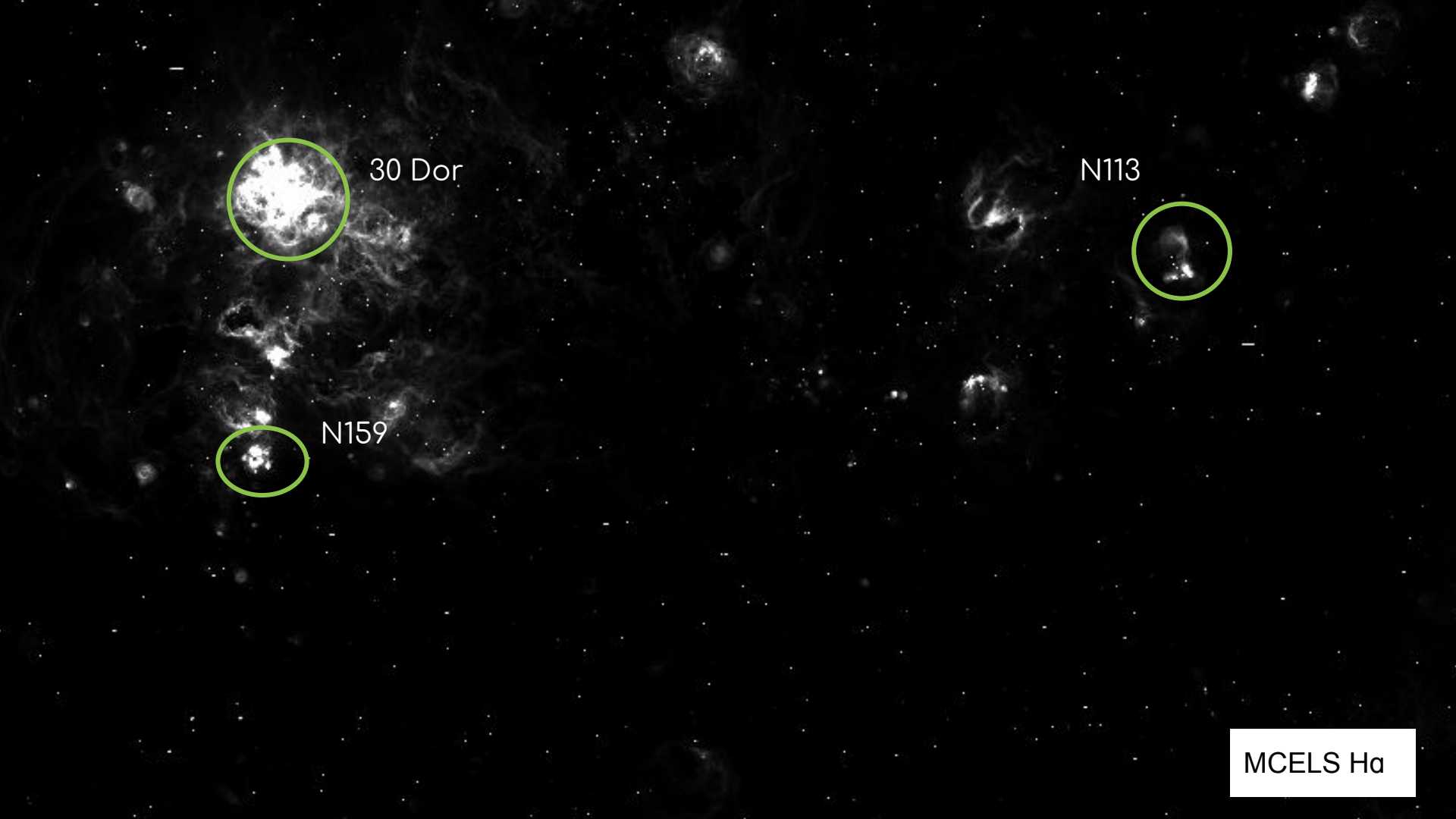
Physical Conditions in the LMC's Quiescent Molecular Ridge

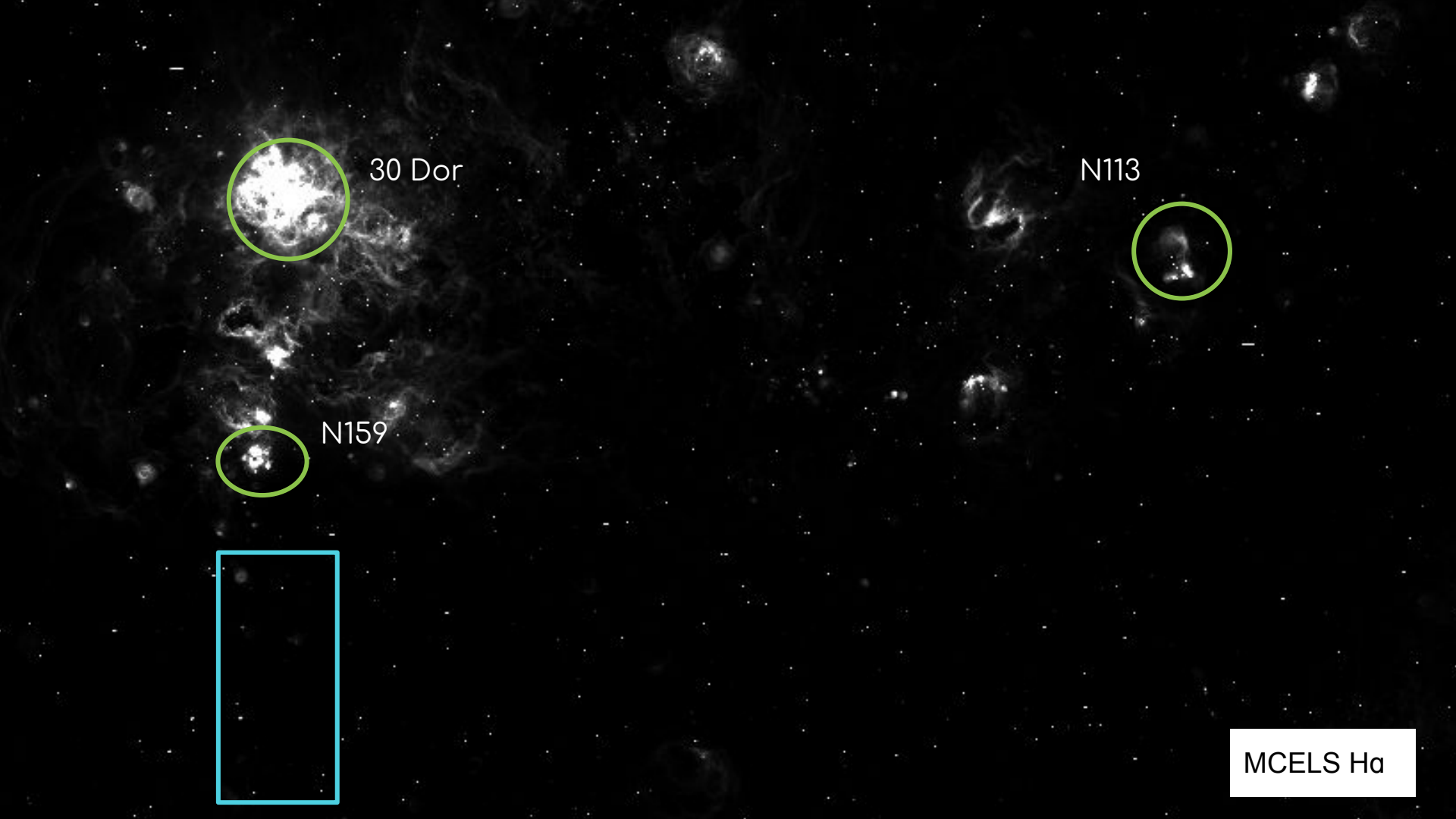
Molly Finn, University of Virginia
Remy Indebetouw, Kelsey E. Johnson, Allison H. Costa, C.-H. Rosie Chen, Akiko Kawamura, Toshikazu Onishi, Jürgen Ott, Marta Sewilo, Kazuki Tokuda, Tony Wong, and Sarolta Zahorecz

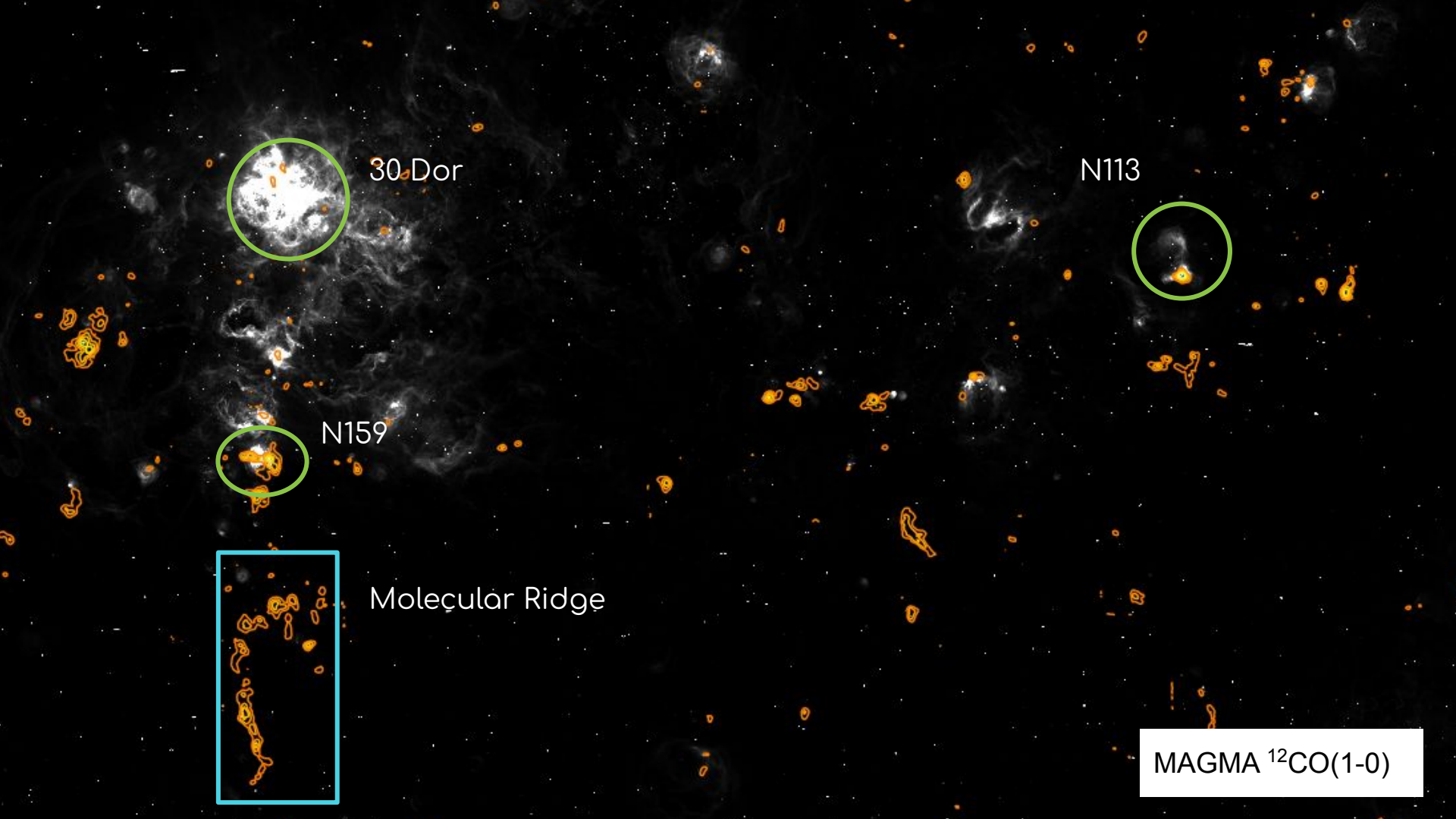
March 3, 2022
Our Galactic Ecosystem Conference

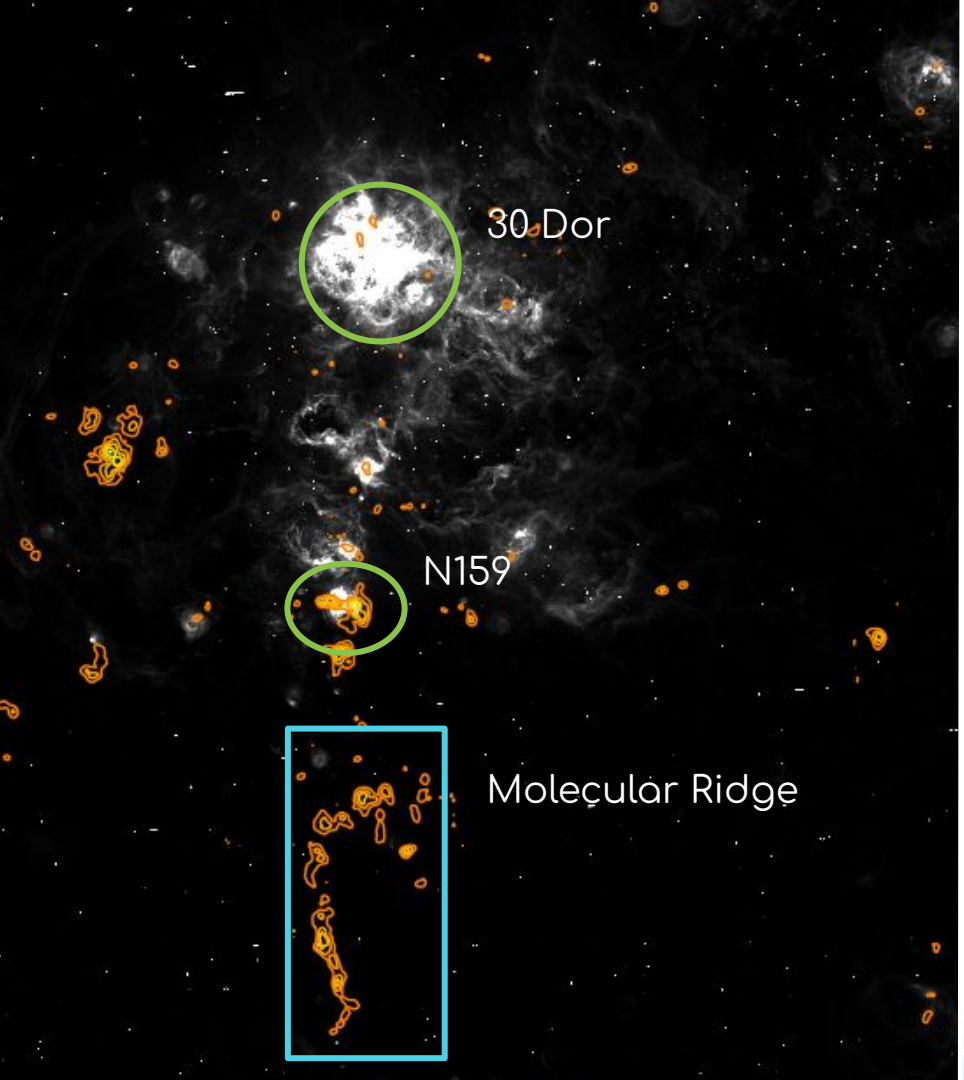

MCELS Hα


30 Dor
MCELS Hα


30 Dor
N113
N159
MCELS Hα

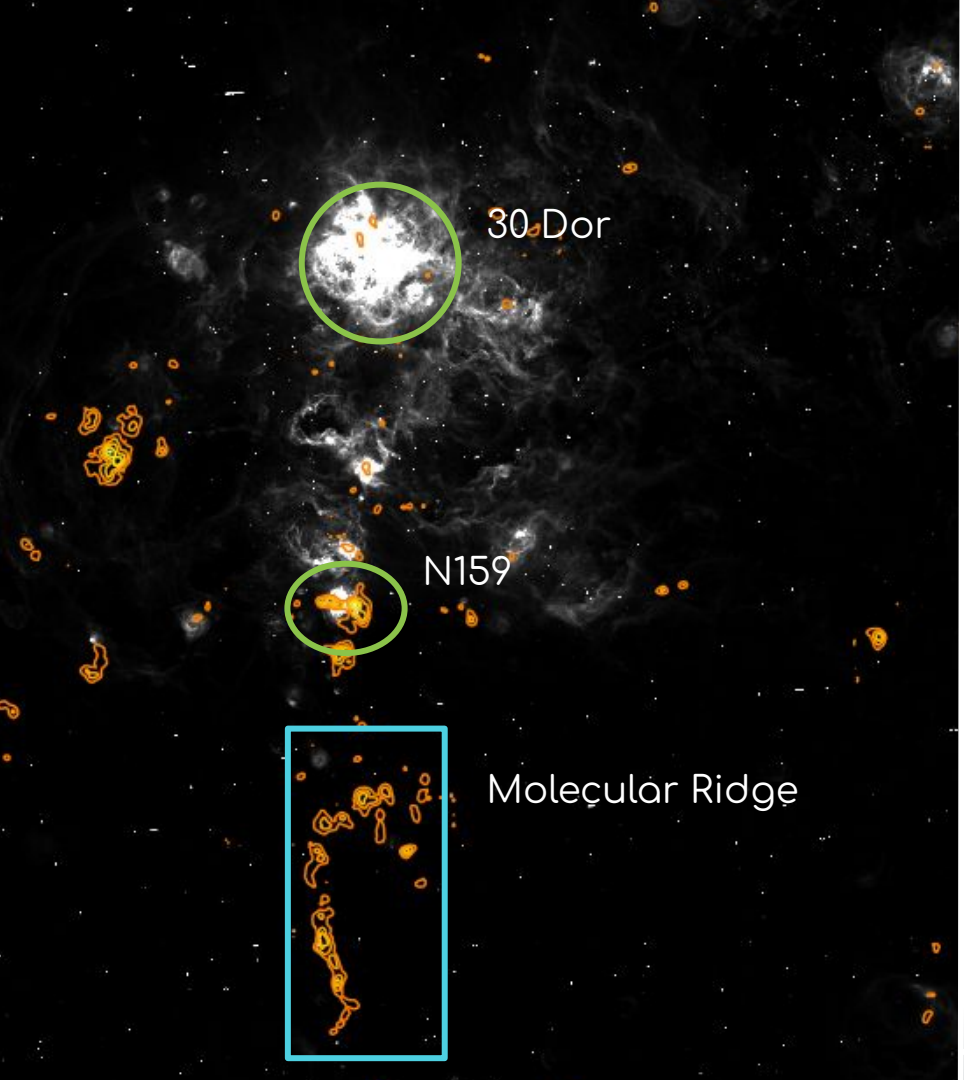

30 Dor
N113
N159
MCELS Hα


30 Dor
N113
N159
Molecular Ridge
MAGMA ^{12}CO(1-0)



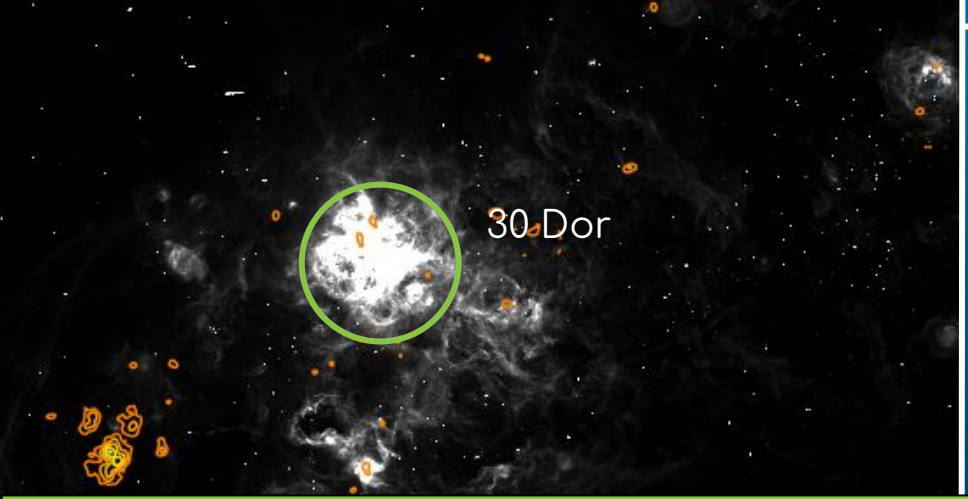
Molecular Ridge:

- Contains ⅓ of all CO-bright molecular gas in LMC



Molecular Ridge:

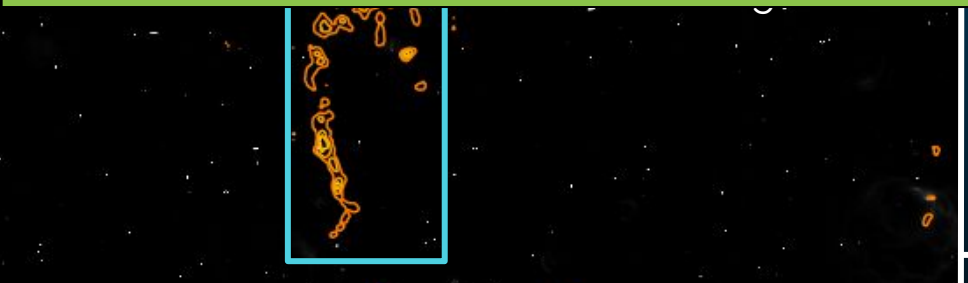
- Contains ⅓ of all CO-bright molecular gas in LMC
- Primarily forming low- and intermediate-mass clusters, below predictions from scaling relations



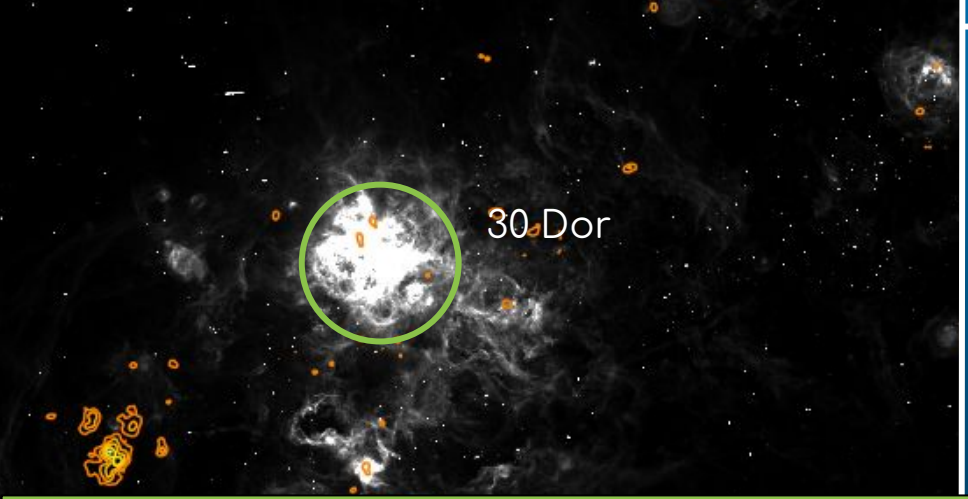
Molecular Ridge:

- Contains ⅓ of all CO-bright molecular gas in LMC

What physical conditions in the Ridge differ from the conditions in the massive star forming regions to its north?



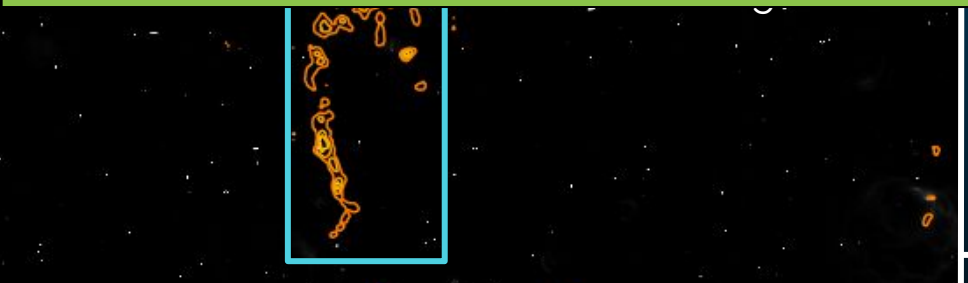
predictions from scaling relations



Molecular Ridge:

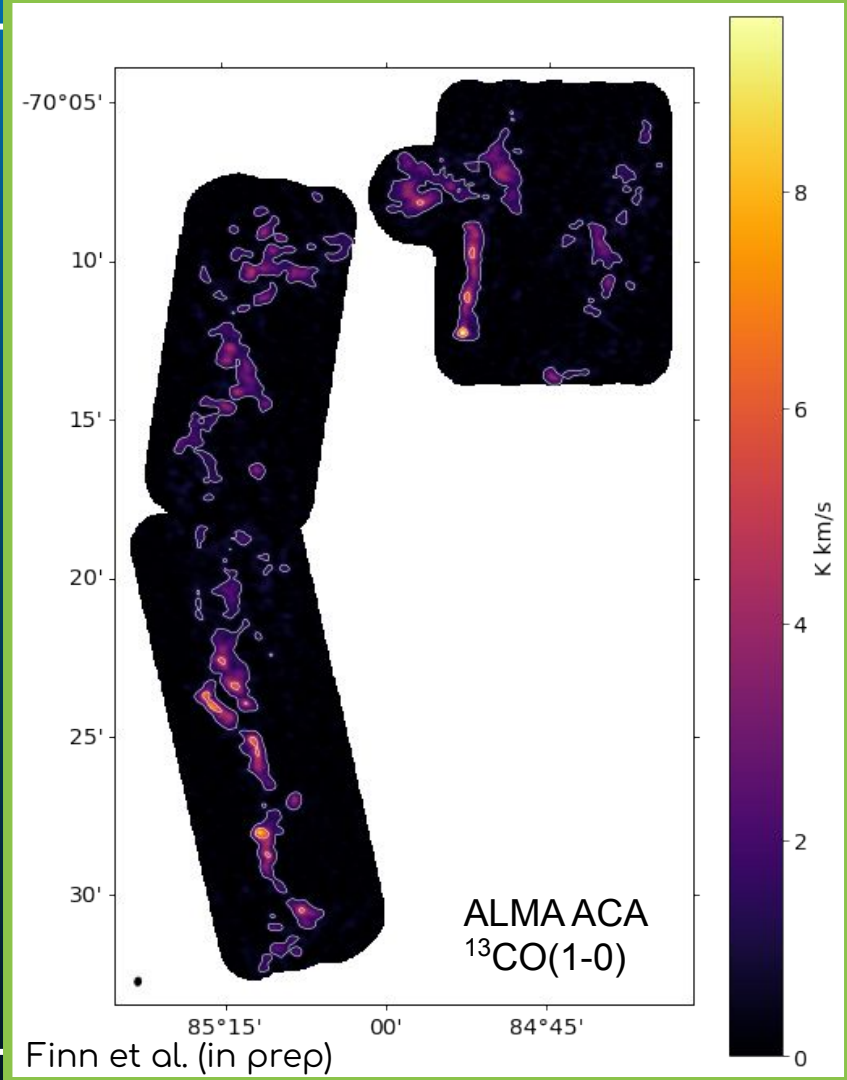
- Contains ⅓ of all CO-bright molecular gas in LMC

Is the Ridge not forming massive stars due to turbulence or magnetic support? Or does it lack dense gas?



predictions from scaling relations

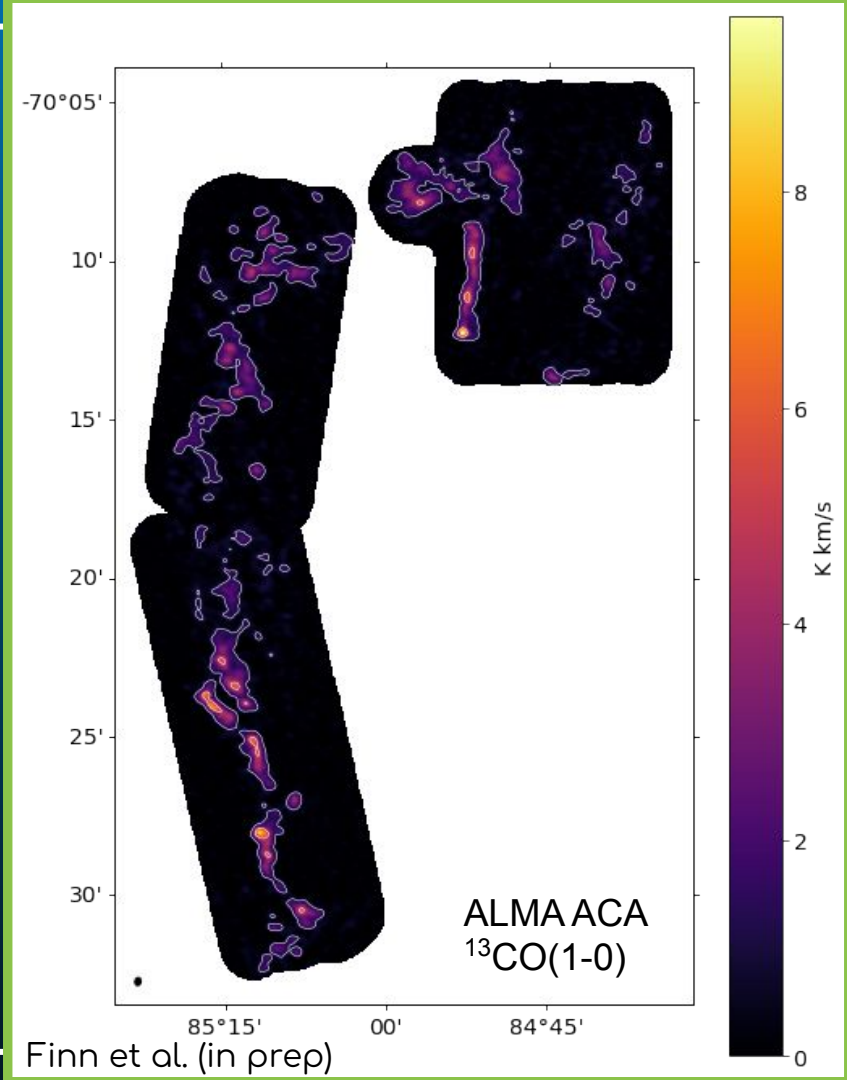
ALMA ACA map of 13CO(1-0) at 13” (~3 pc) resolution



Finn et al. (in prep)

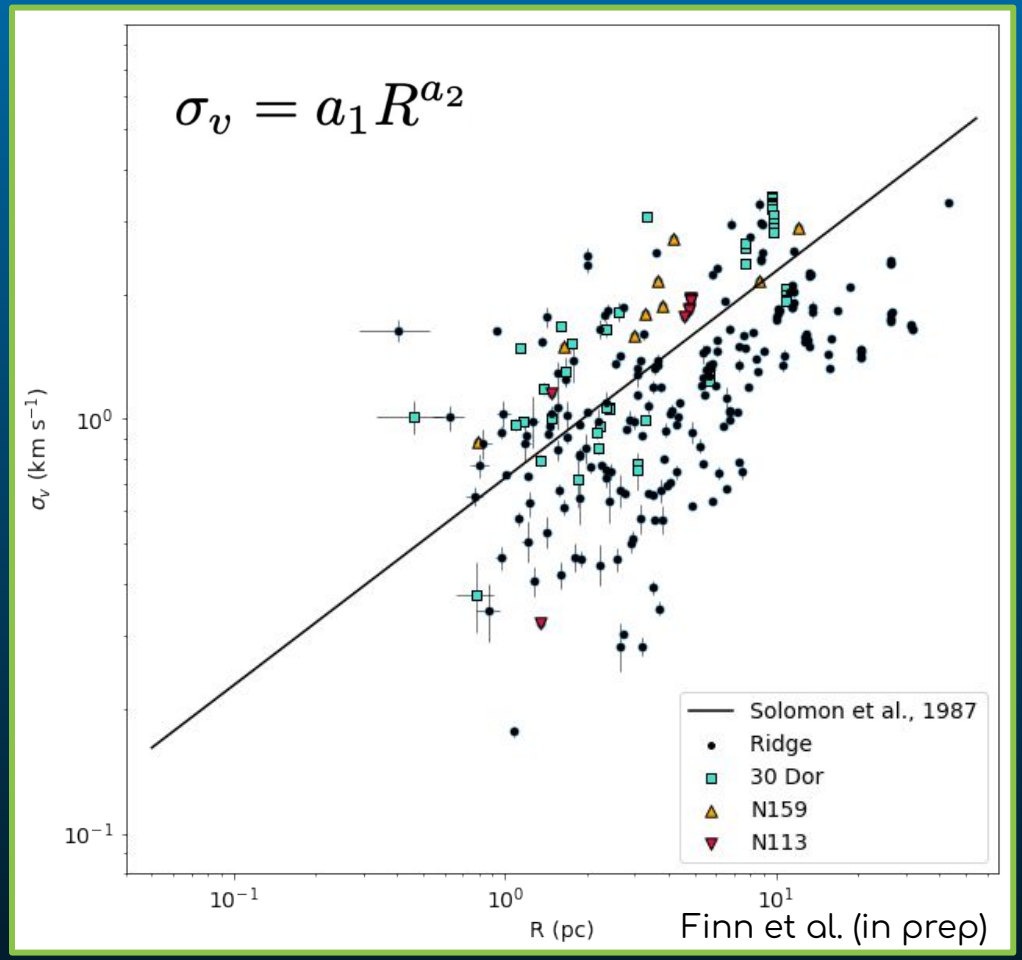
ALMA ACA map of 13CO(1-0) at 13” (~3 pc) resolution

Compare to dendrogram structures in 30 Dor, N159, and N113



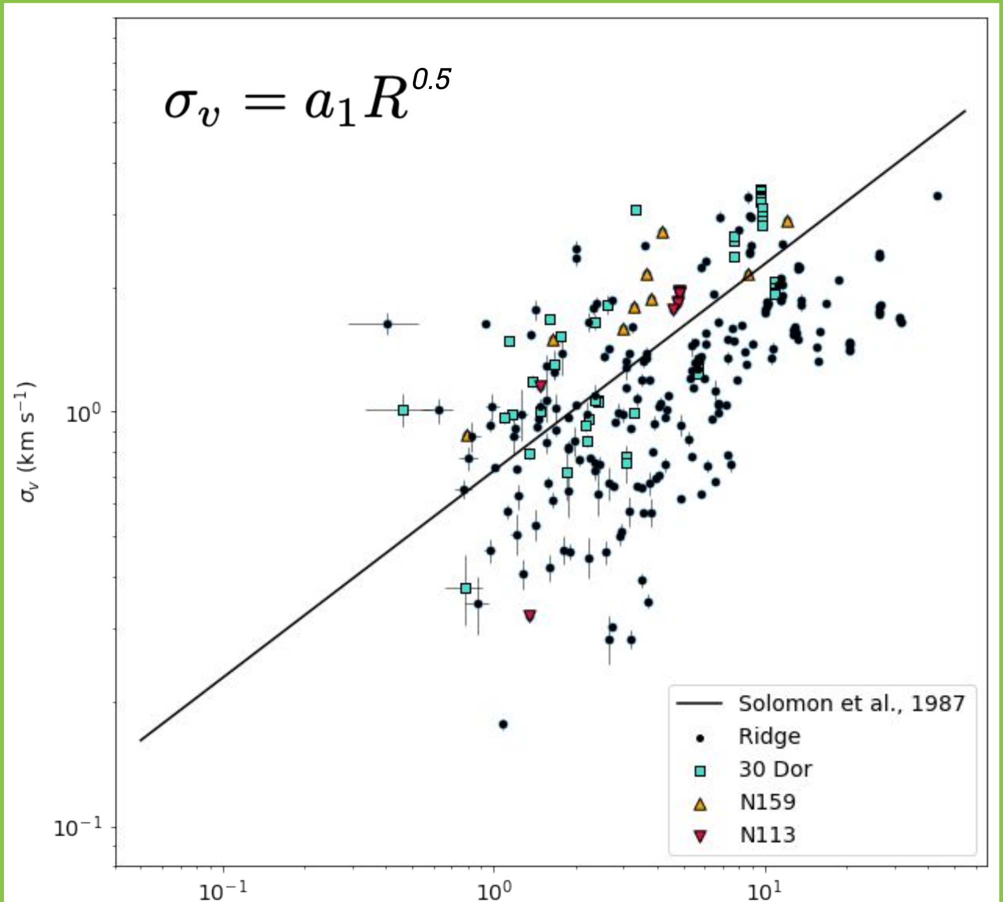
Finn et al. (in prep)

Size-linewidth relation



Finn et al. (in prep)

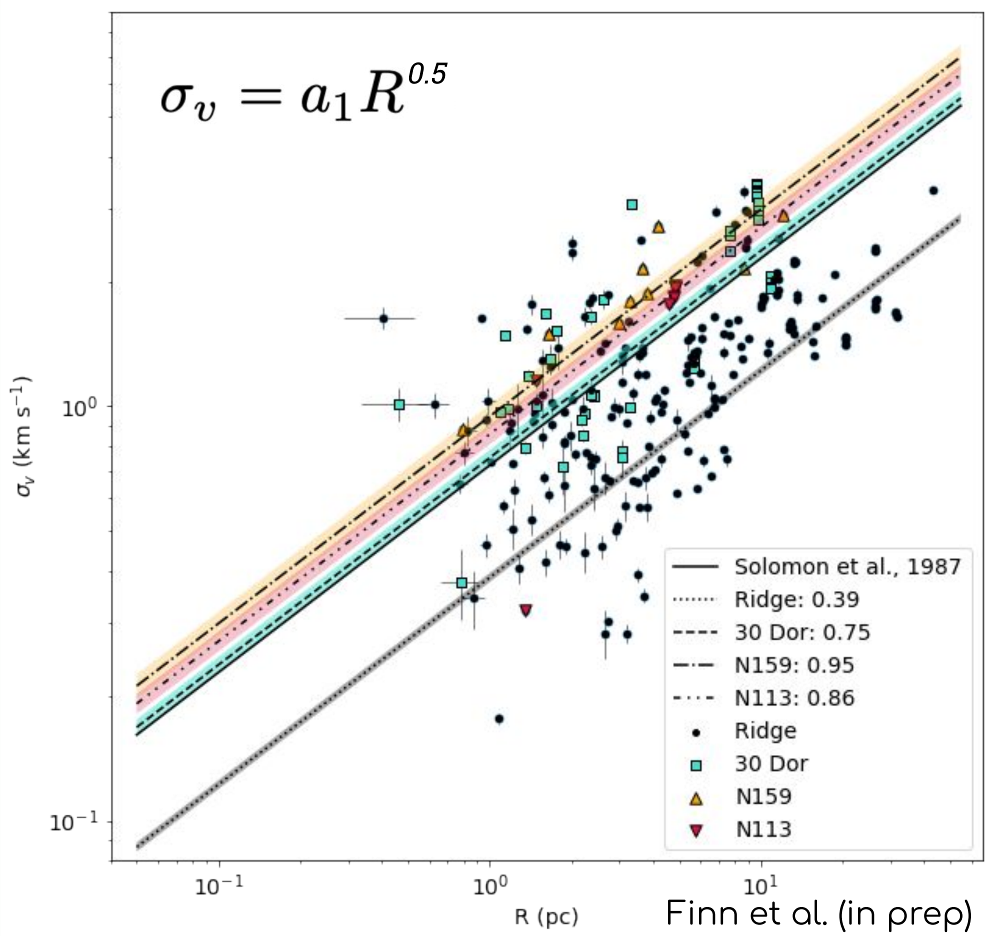
Size-linewidth relation



Finn et al. (in prep)

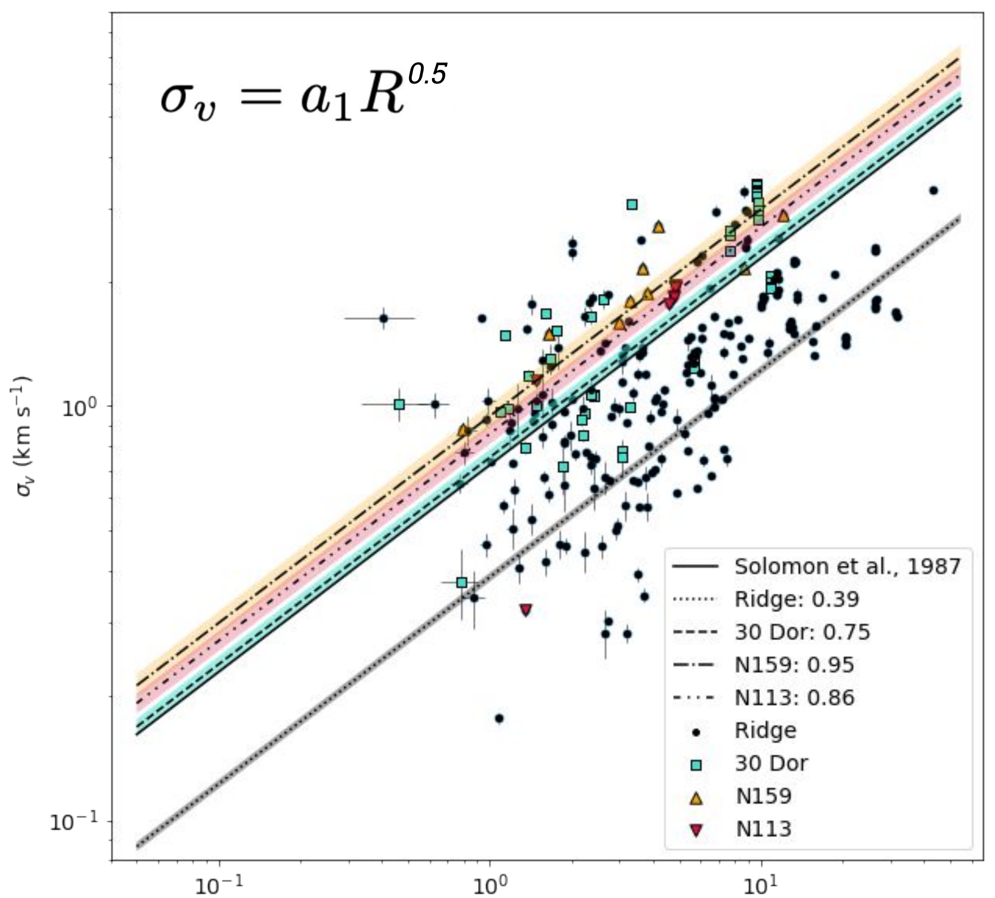
Size-linewidth relation

→ At a given size scale, the Ridge has less kinetic energy than 30 Dor, N159, and N113



Finn et al. (in prep)

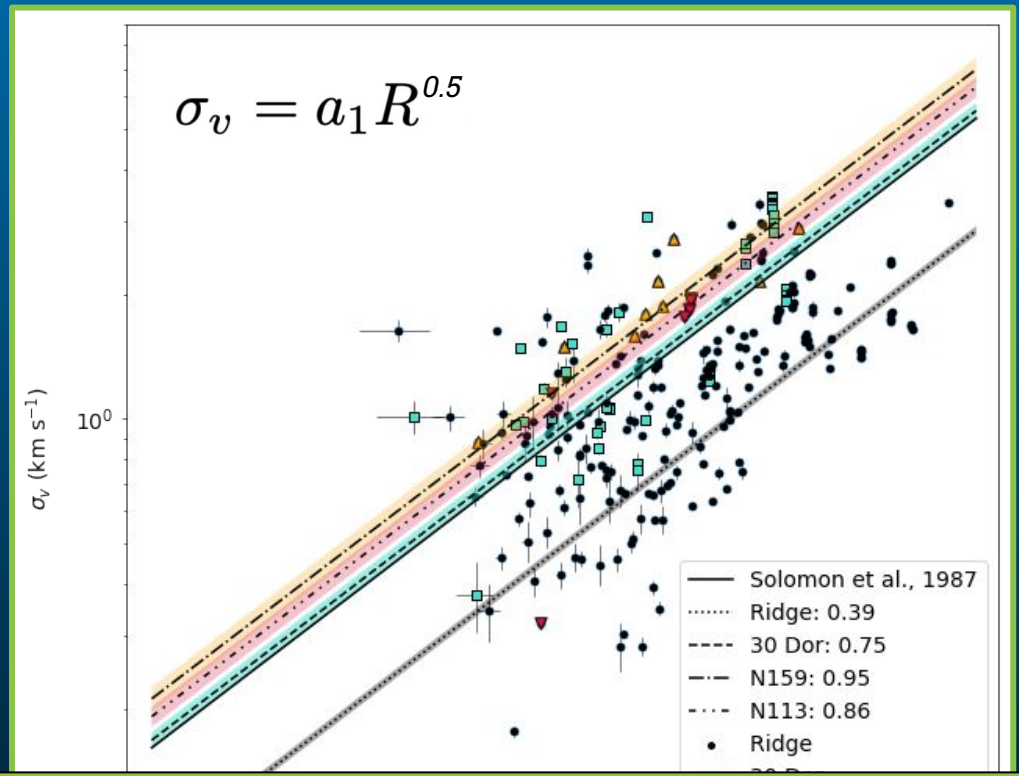
Size-linewidth relation



Finn et al. (in prep)

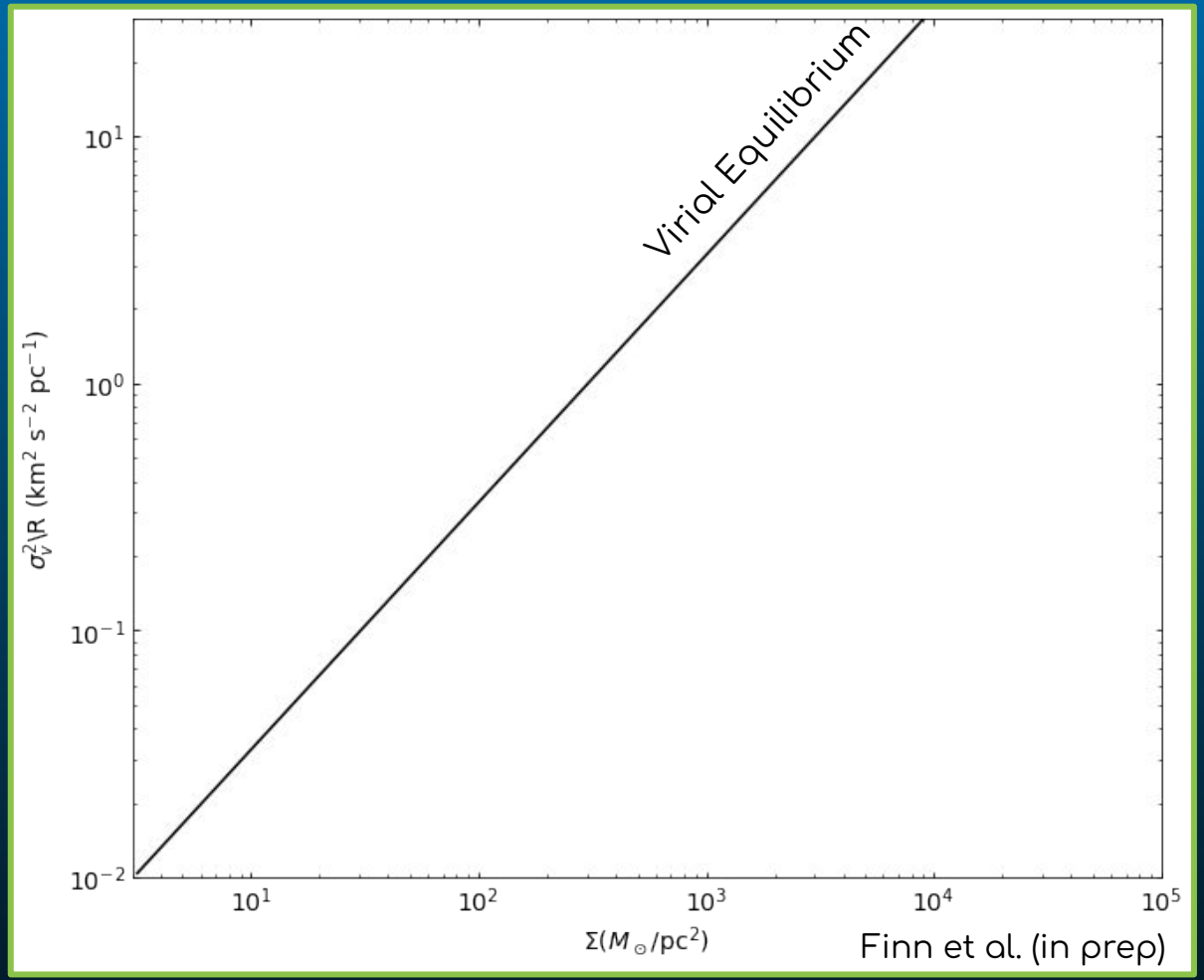
Size-linewidth relation

→ At a given size scale, the Ridge has less kinetic energy than 30 Dor, N159, and N113



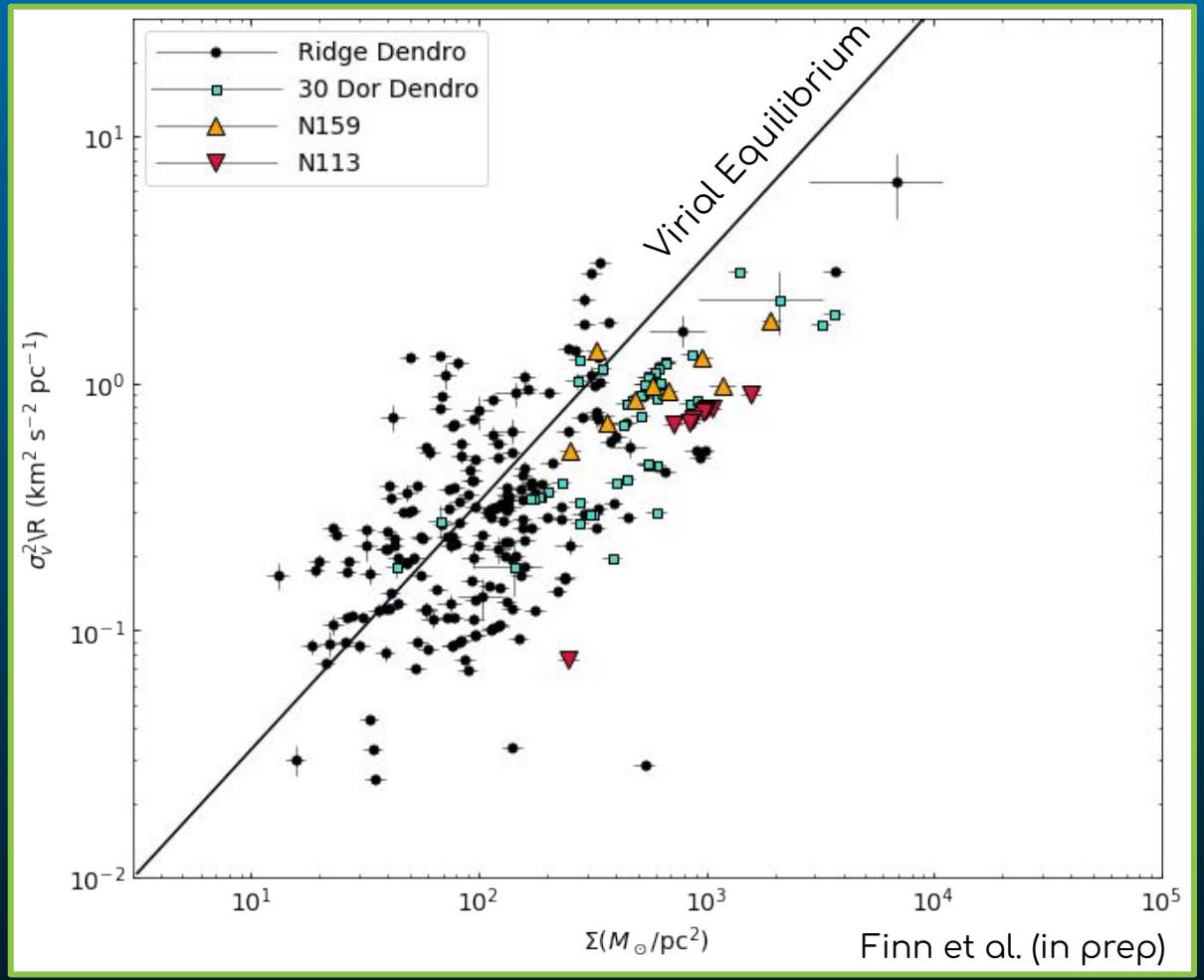
We can rule out turbulent support limiting star formation in the Ridge

Virial equilibrium: balance between potential and kinetic energies



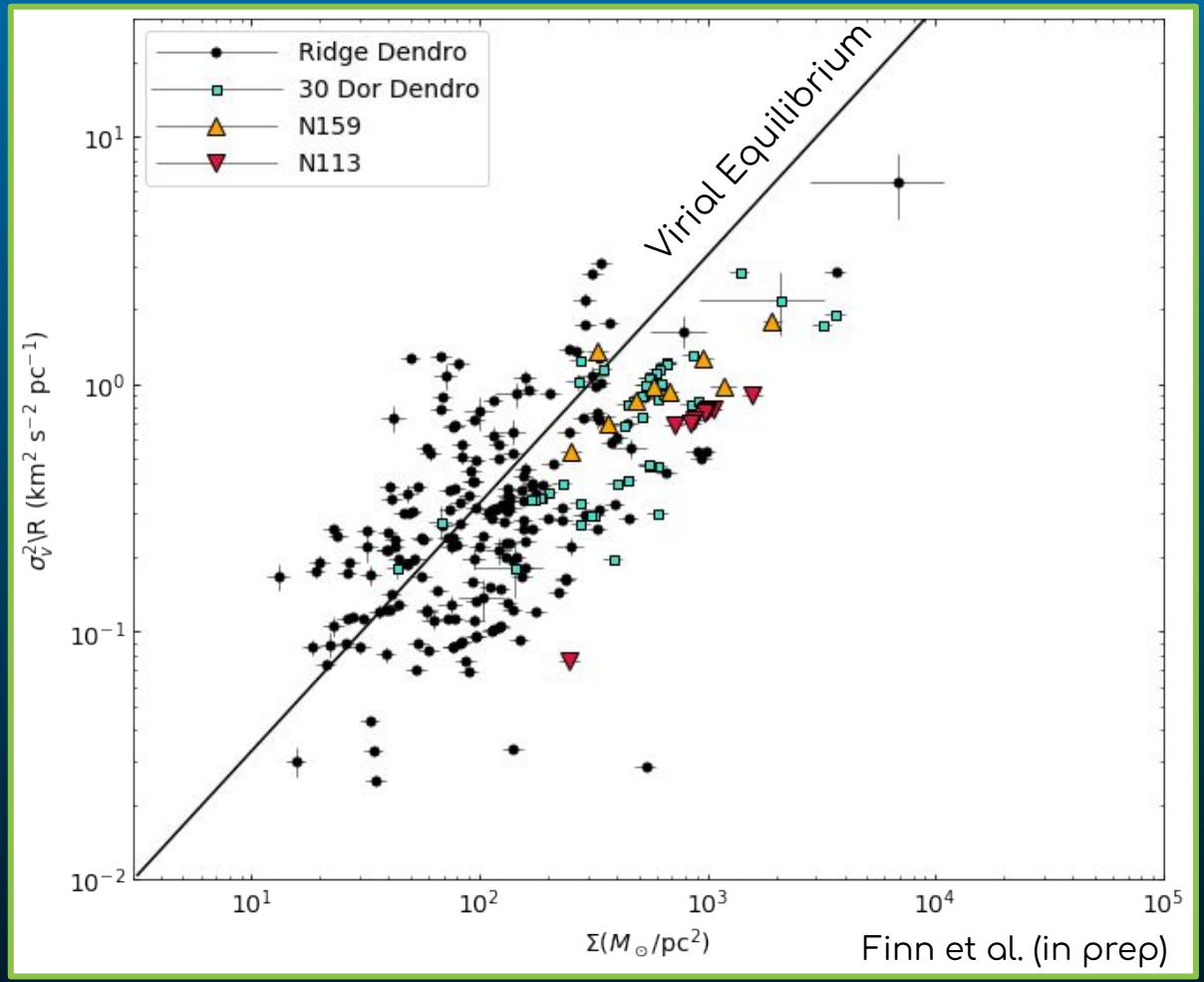
Finn et al. (in prep)

Virial equilibrium: balance between potential and kinetic energies



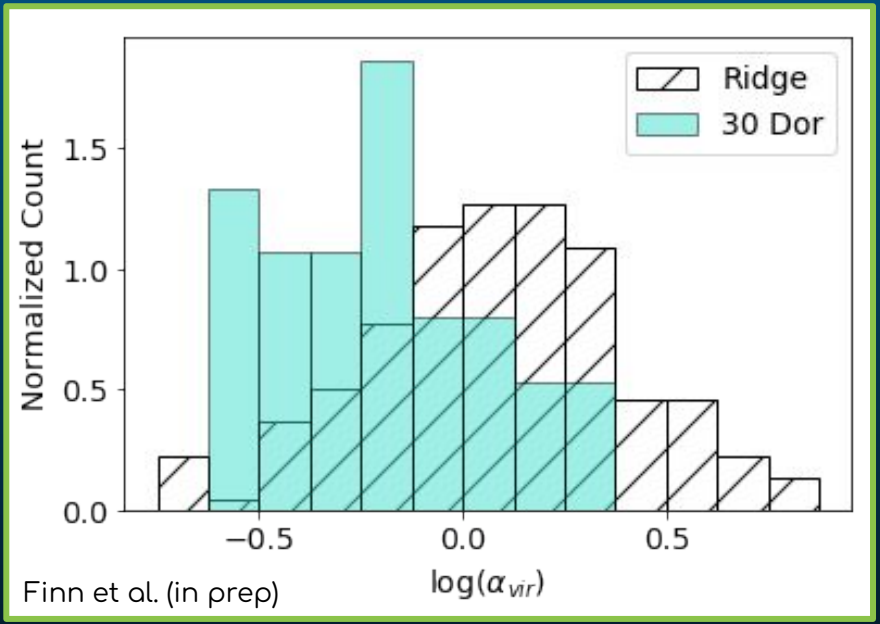
Virial equilibrium: balance between potential and kinetic energies

$$\alpha_{\rm vir} = \frac{5\sigma_v^2 R}{GM}$$



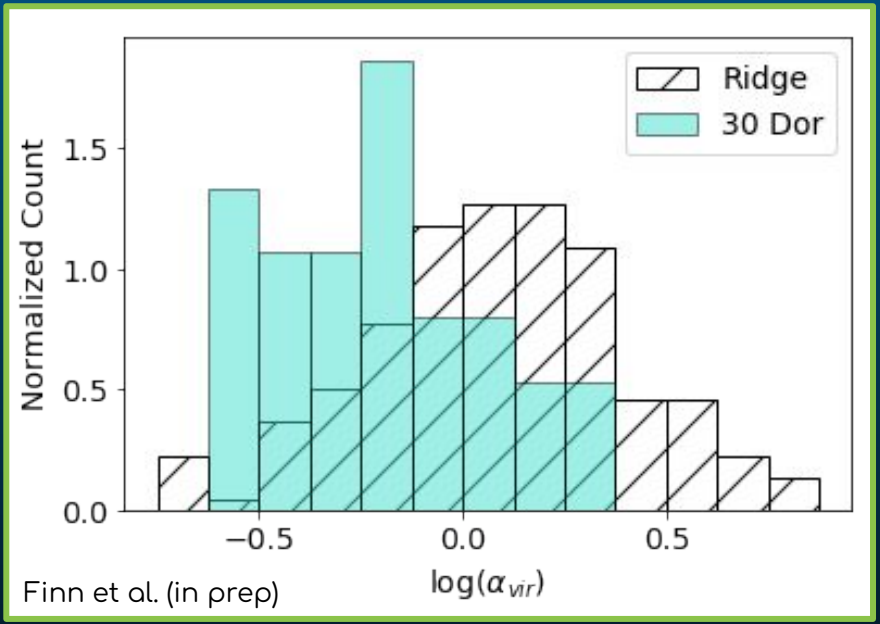
Finn et al. (in prep)

The Ridge has higher virial parameter than 30 Dor, despite its low kinetic energy



Finn et al. (in prep)

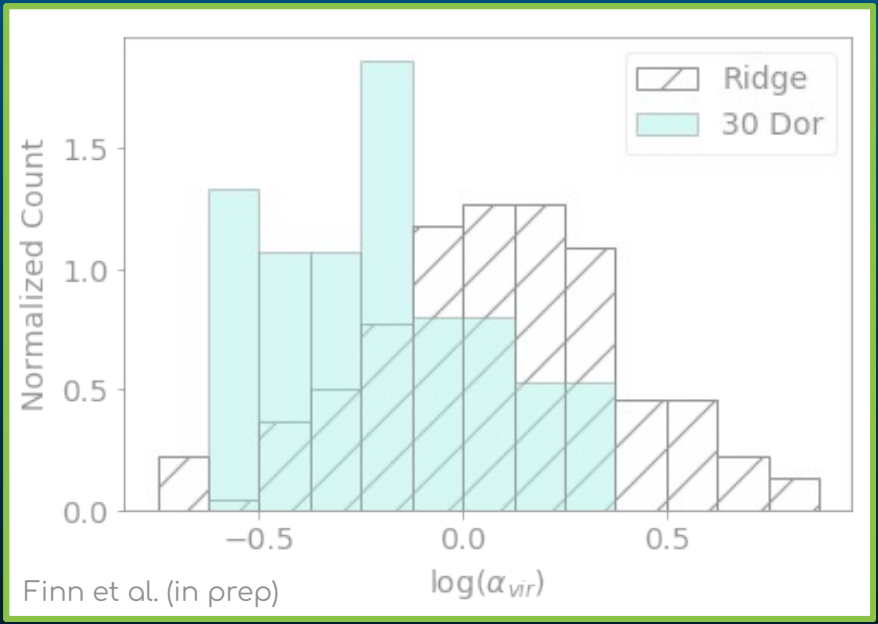
The Ridge has higher virial parameter than 30 Dor, despite its low kinetic energy

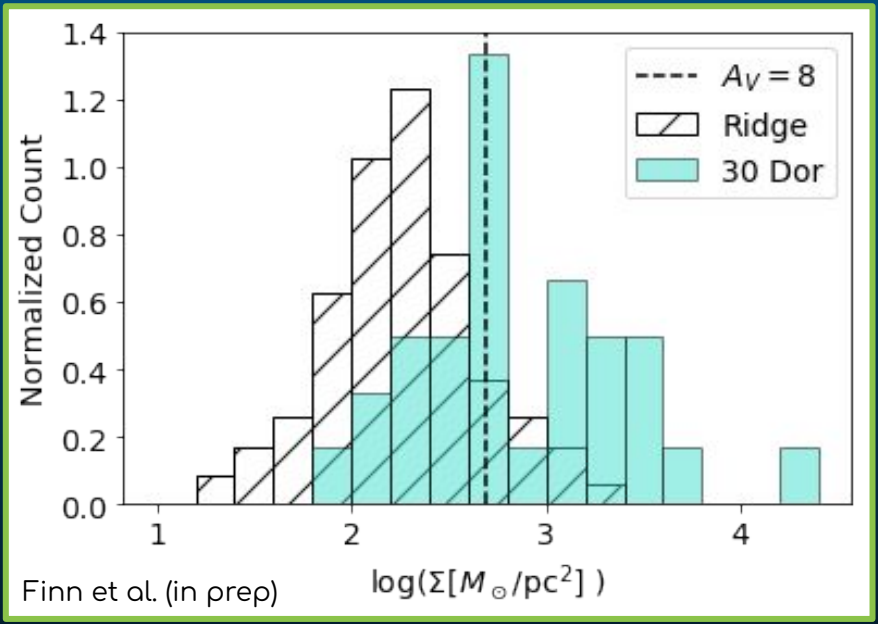


Finn et al. (in prep)

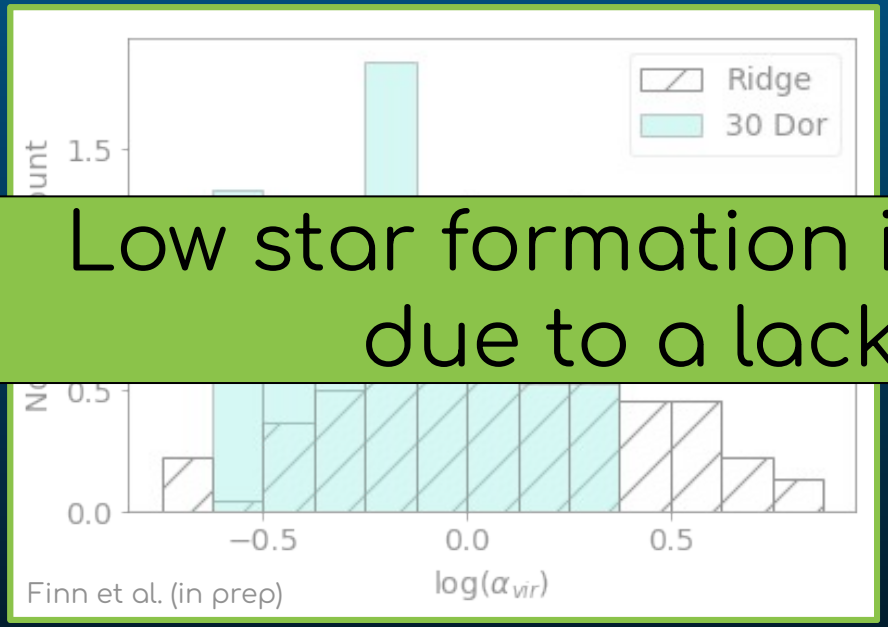
→ Needs low potential energy as well

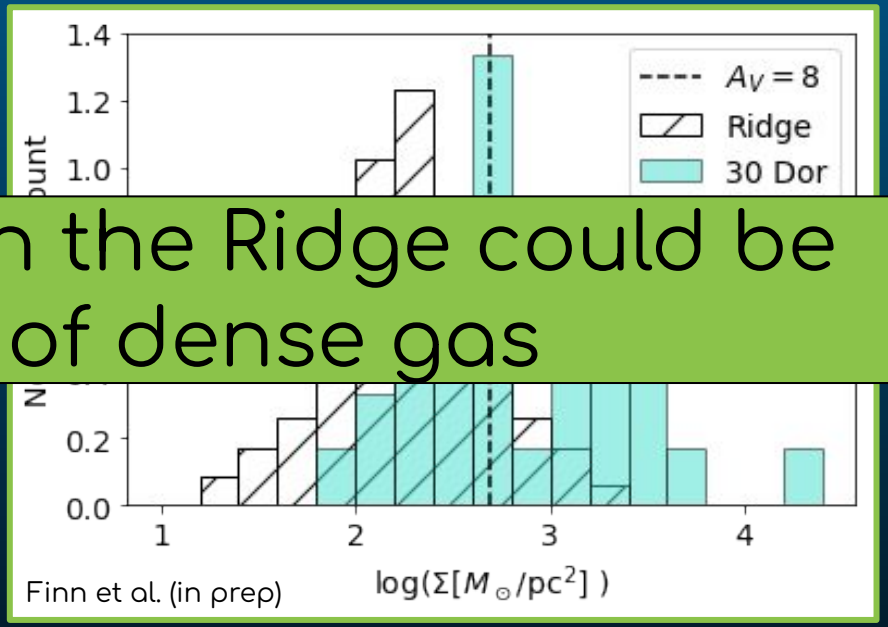
High virial parameter appears to be driven by low surface density





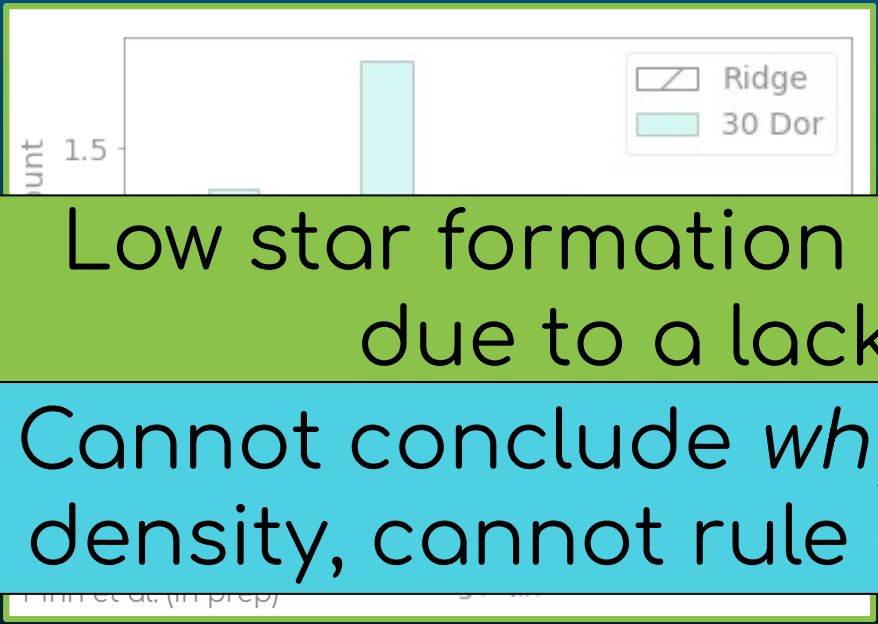
High virial parameter appears to be driven by low surface density

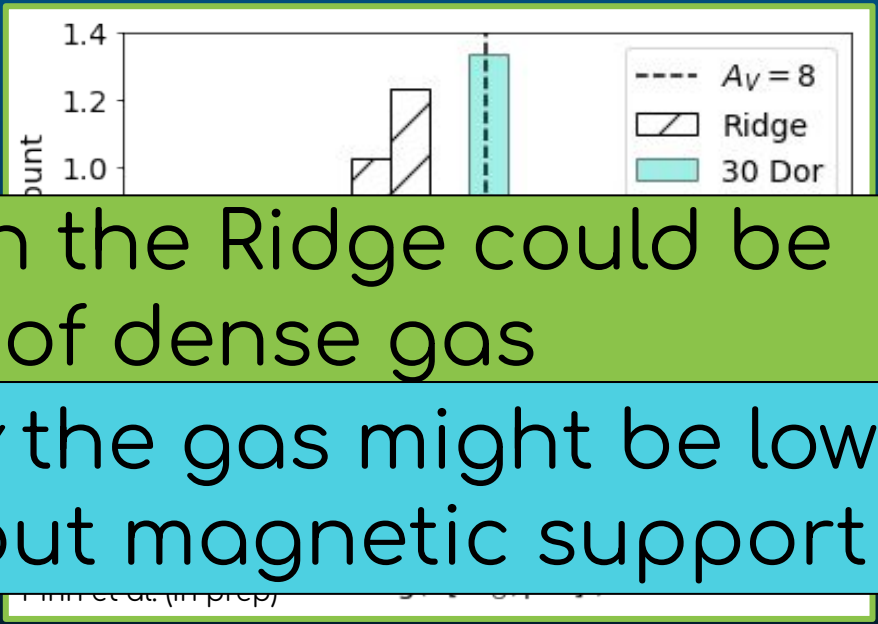




Low star formation in the Ridge could be due to a lack of dense gas

High virial parameter appears to be driven by low surface density

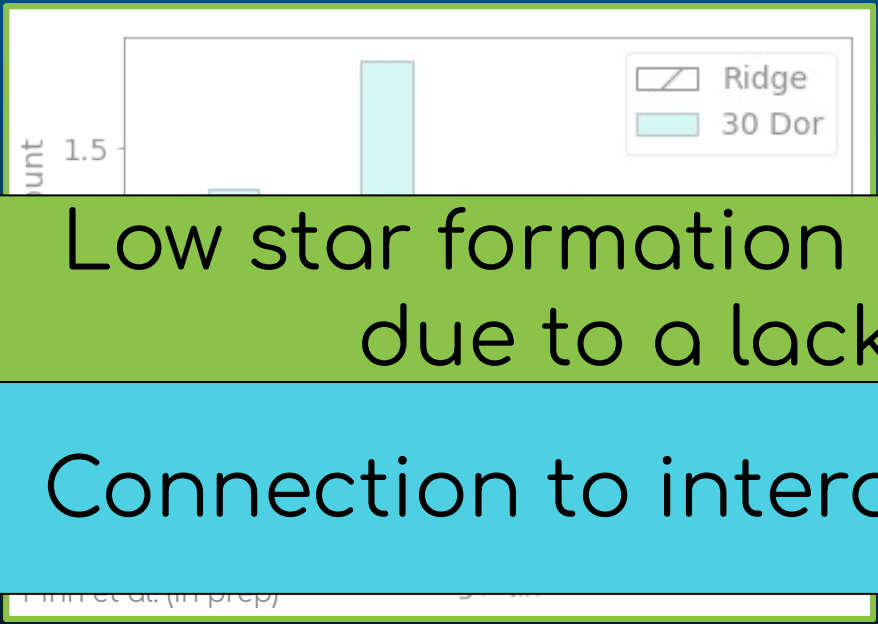


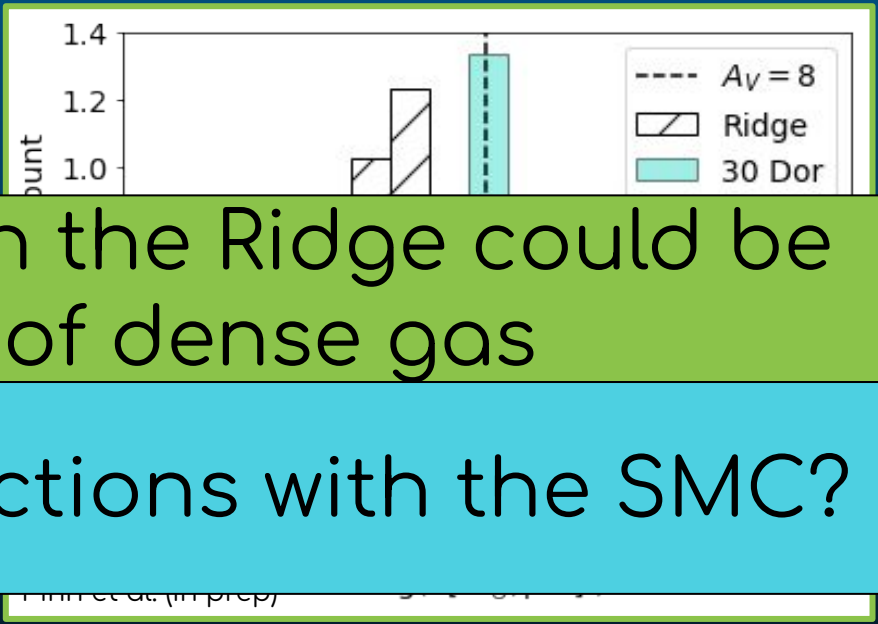


Low star formation in the Ridge could be due to a lack of dense gas

Cannot conclude *why* the gas might be low density, cannot rule out magnetic support

High virial parameter appears to be driven by low surface density



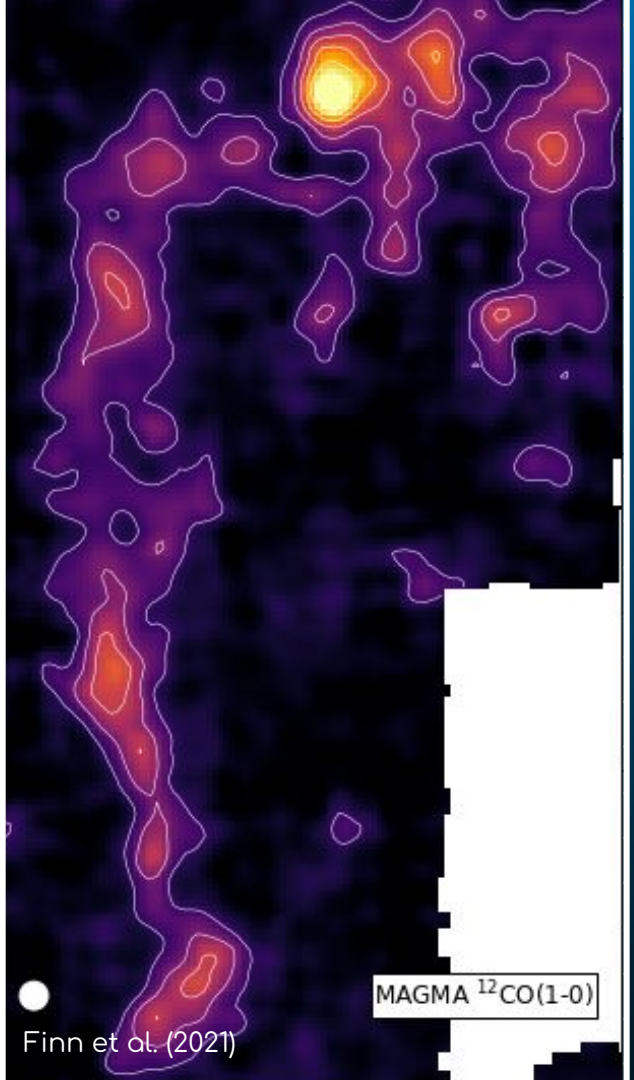


Low star formation in the Ridge could be due to a lack of dense gas

Connection to interactions with the SMC?

Fitting RADEX Models

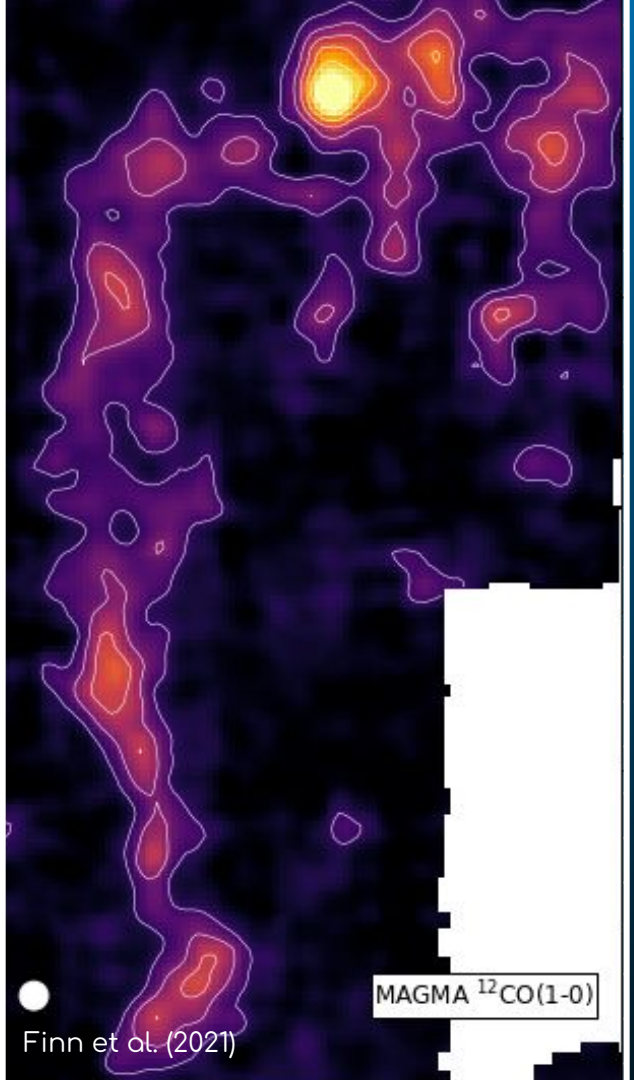
- Want to minimize* assumptions about the physical conditions of the gas



Finn et al. (2021)

Fitting RADEX Models

- Want to minimize* assumptions about the physical conditions of the gas
- Perform pixel-by-pixel fits to create maps of temperature, volume density, and column density



Finn et al. (2021)

Fitting RADEX Models

- Want to minimize* assumptions about the physical conditions of the gas
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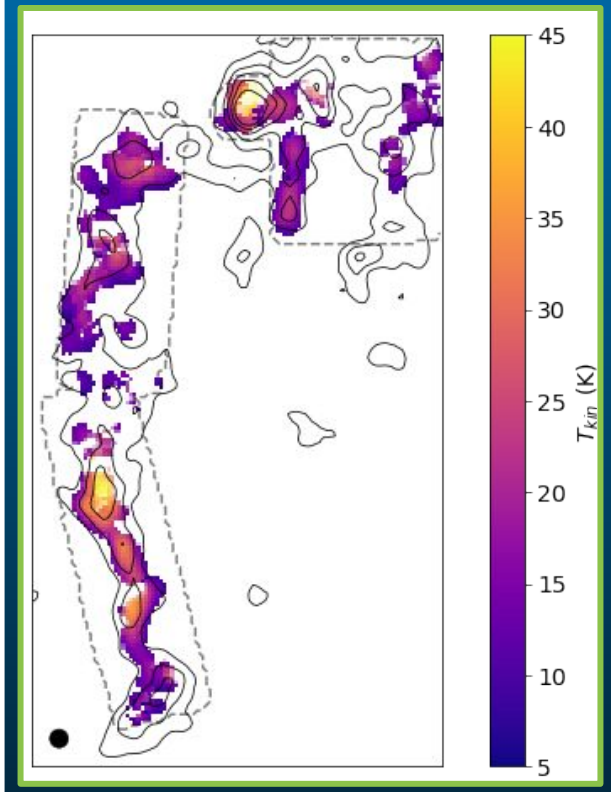
- Need multi-line observations with range of excitation parameters

Finn et al. (2021)

Fitting RADEX Models

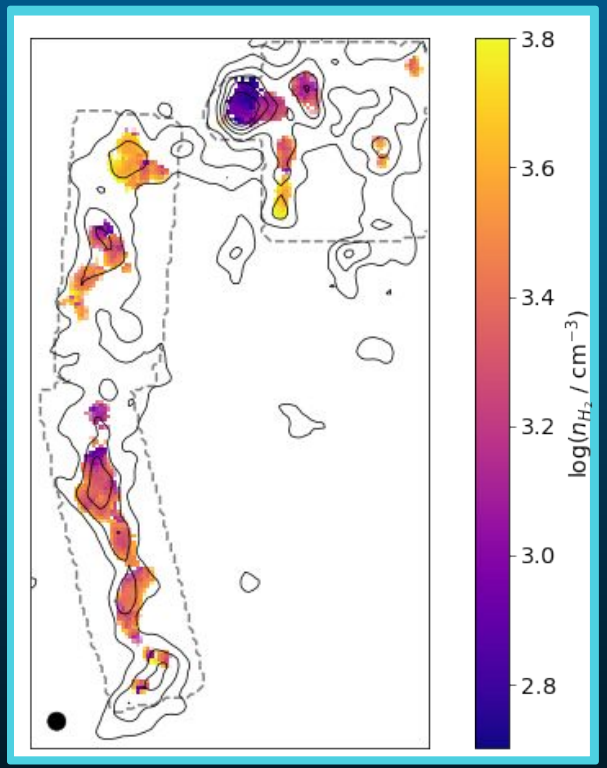
- Want to minimize* assumptions about the physical conditions of the gas
- Perform pixel-by-pixel fits to create maps of temperature, volume density, and column density
- Need multi-line observations with range of excitation parameters:
  ^{12}CO(1-0), ^{12}CO(2-1), ^{13}CO(1-0), ^{13}CO(2-1)

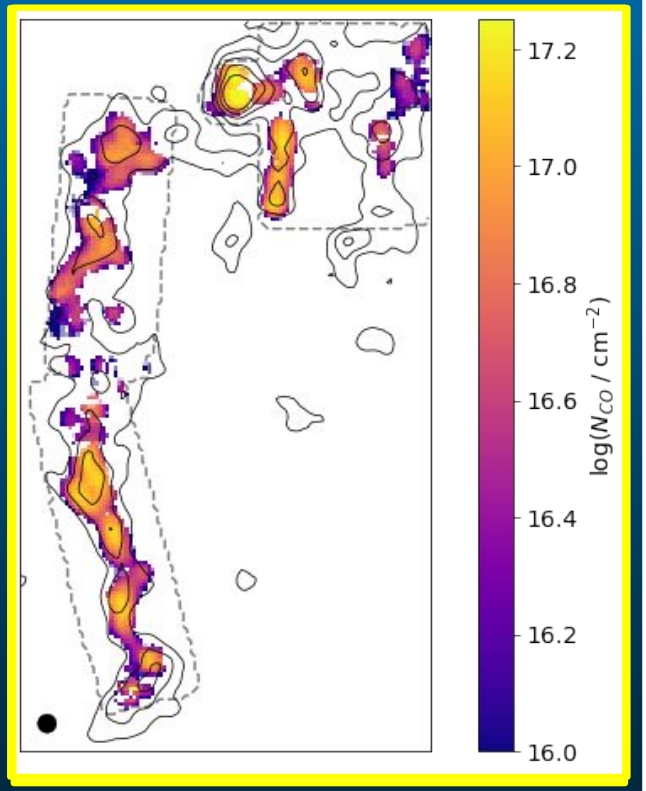
Finn et al. (2021)


45
40
35
30
25
20
15
10
5
T_{kin} (K)

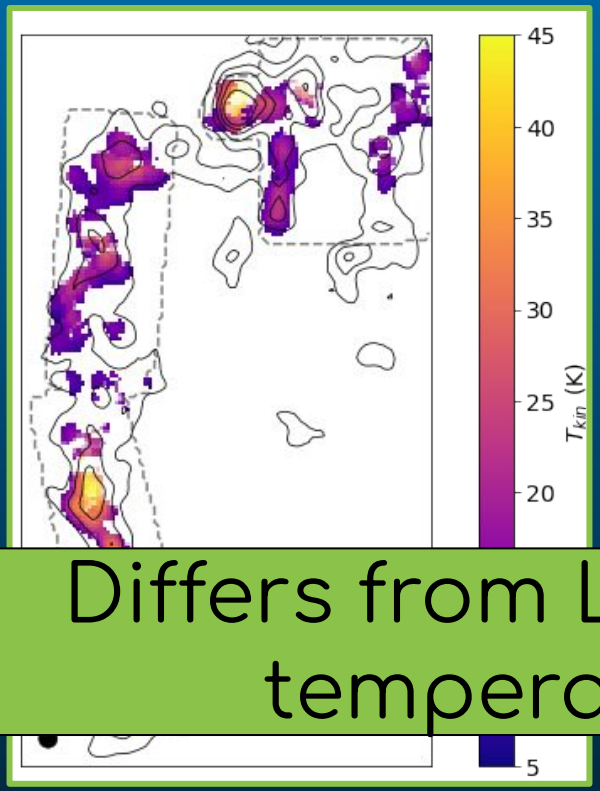
T_{kin}

n_{H2}

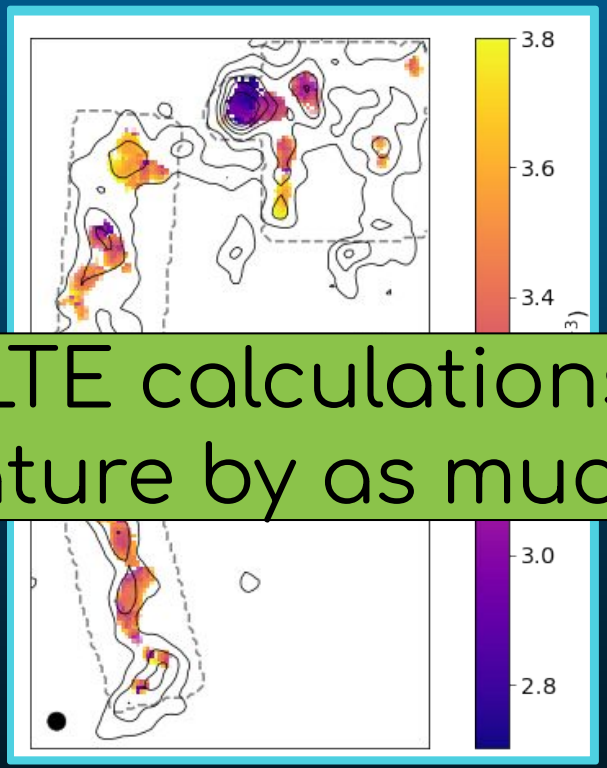

3.8
3.6
3.4
3.2
3.0
2.8
$\log(n_{H_2}$ / cm^{-3})

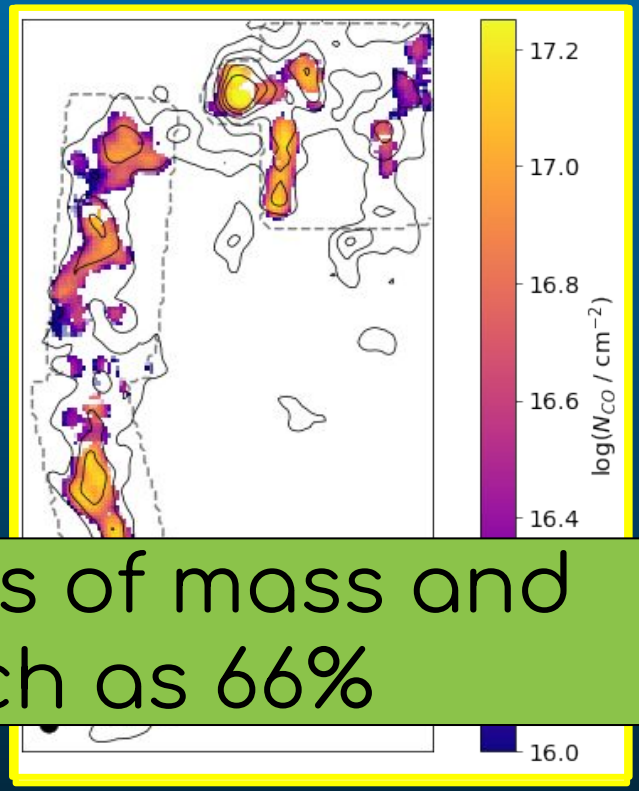

17.2
17.0
16.8
16.6
16.4
16.2
16.0
$\log(N_{CO}$ / cm^{-2})

N_{CO}



n_{H2}



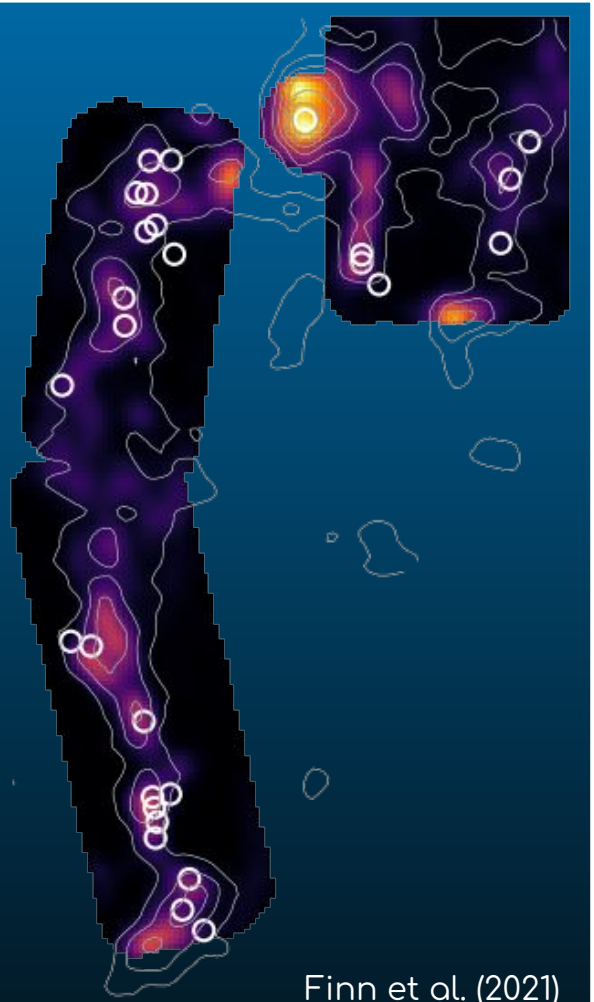


Differs from LTE calculations of mass and temperature by as much as 66%

T_{kin}

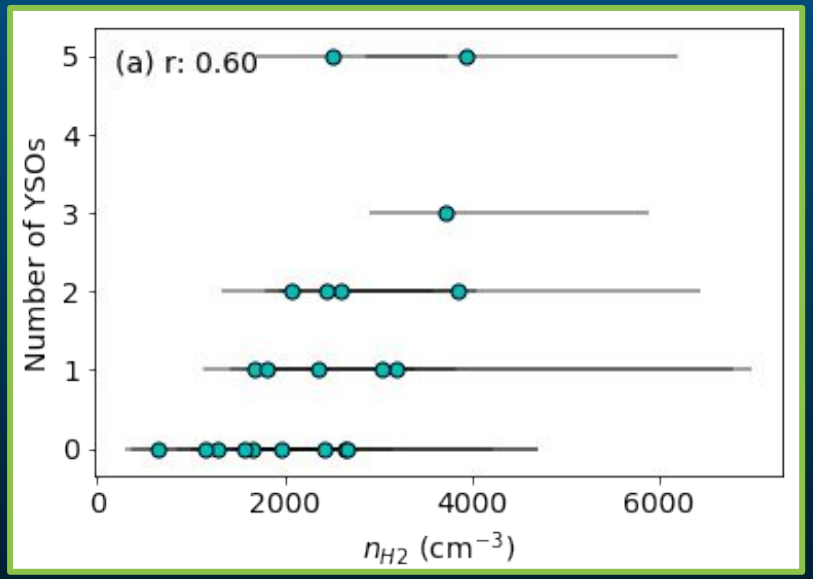
N_{CO}

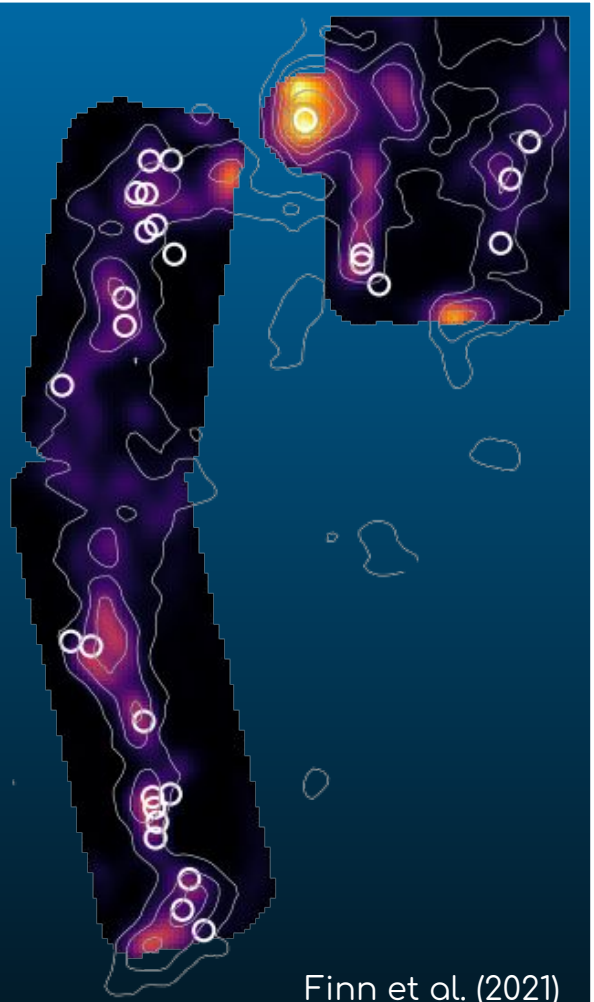
Match embedded YSOs to CO clumps



Finn et al. (2021)

The presence of YSOs in the Ridge is correlated with RADEX-fitted n_{H2}





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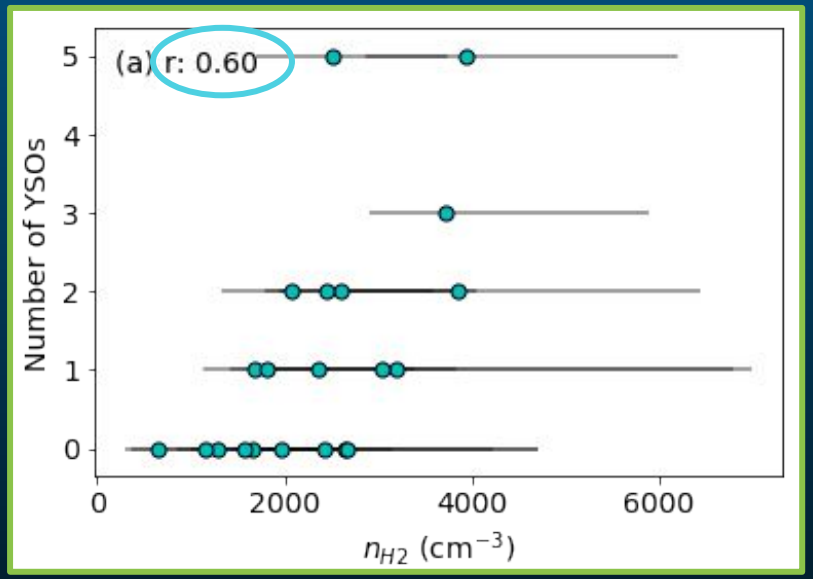
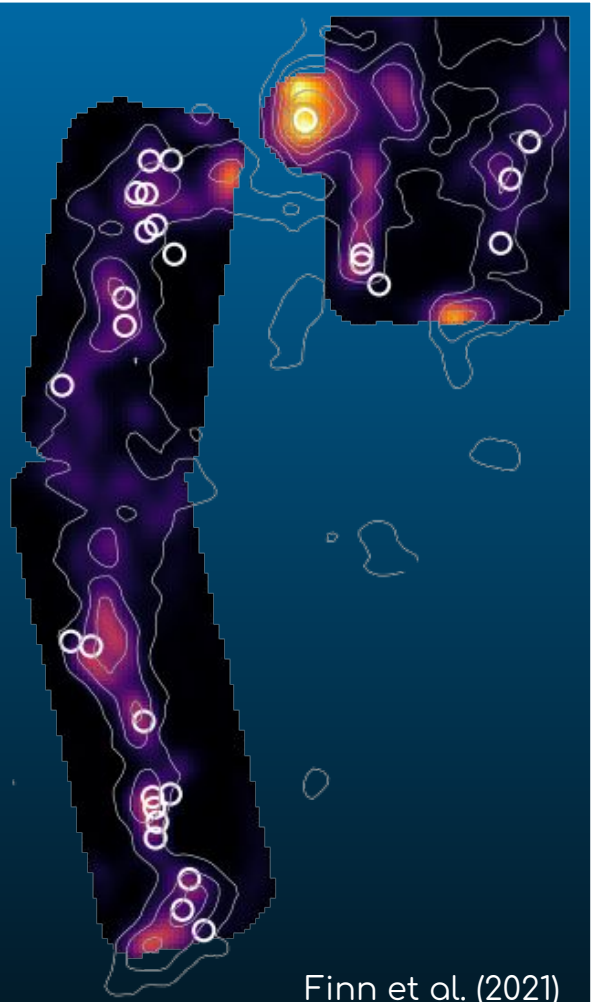
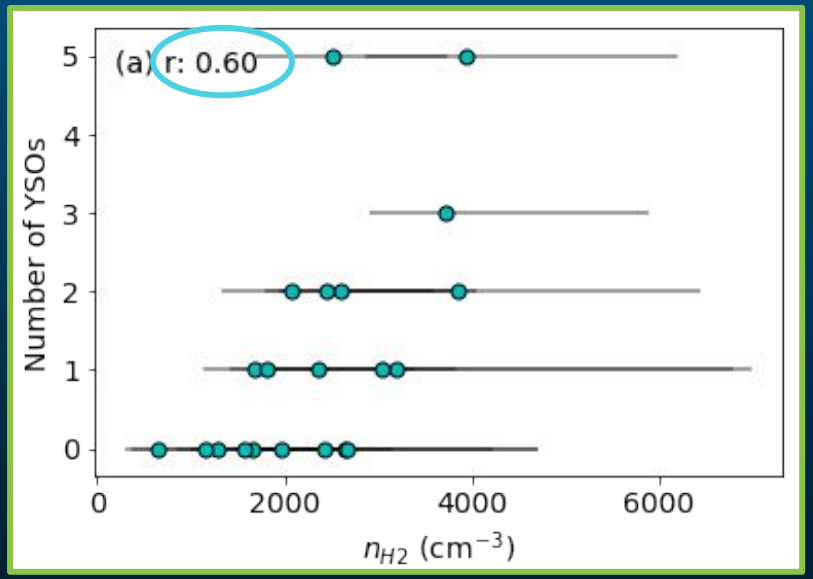
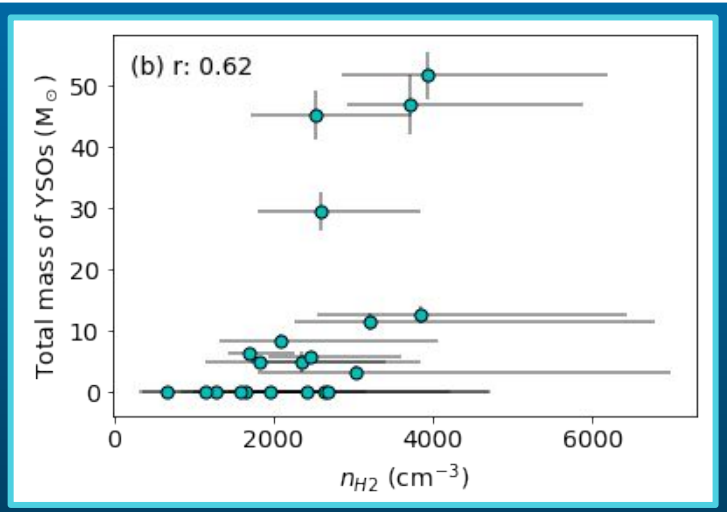


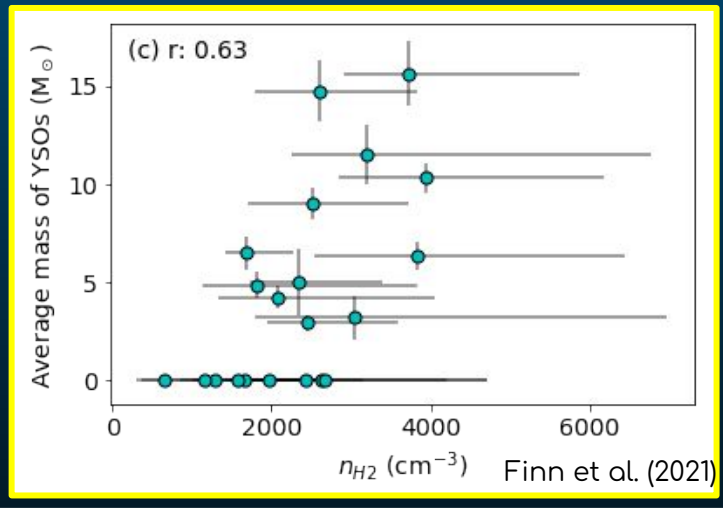


Finn et al. (2021)

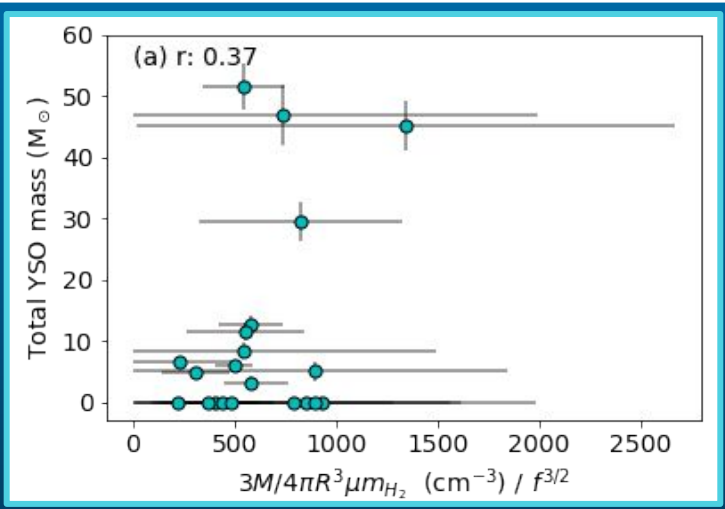
Also correlated with total mass and average mass of YSOs



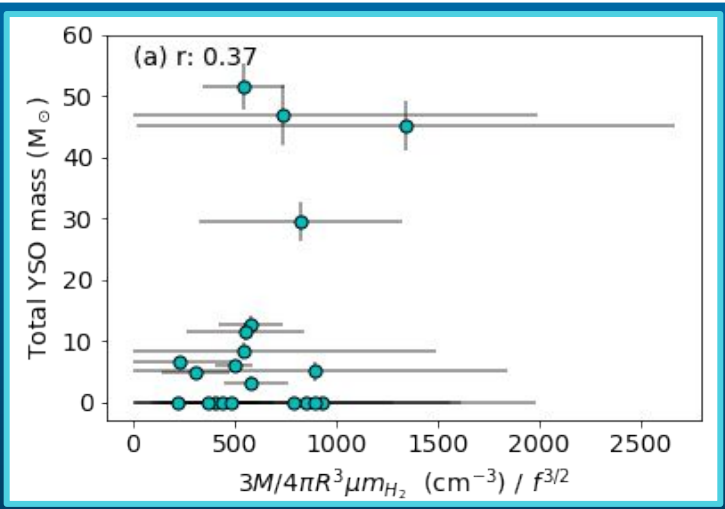


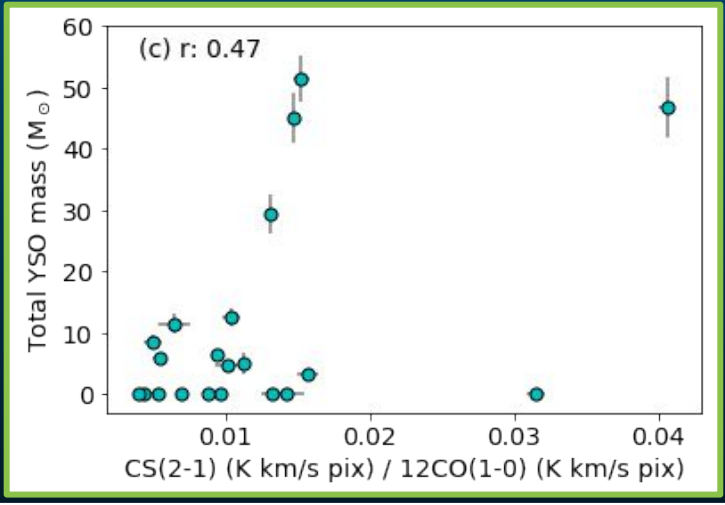


Finn et al. (2021)

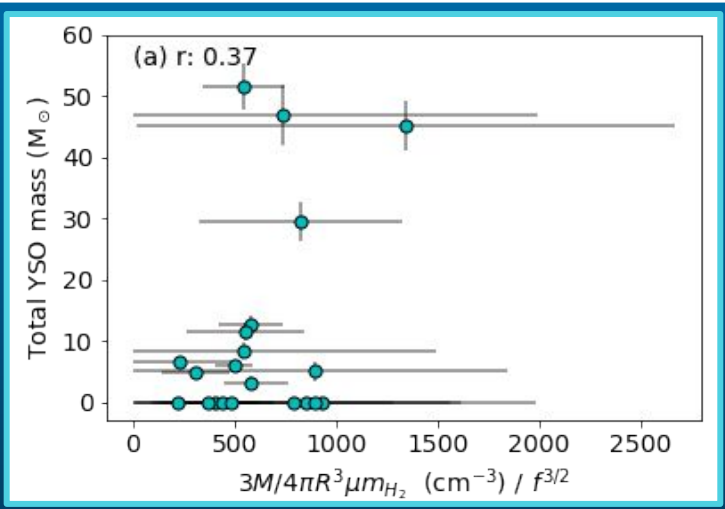


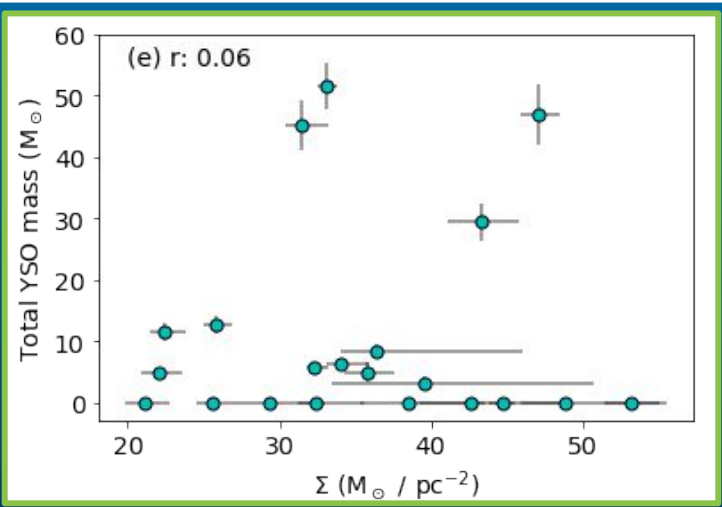
Finn et al. (2021)

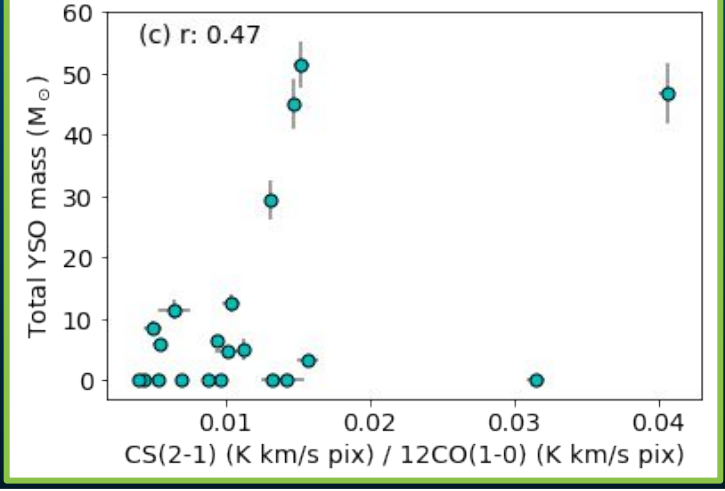




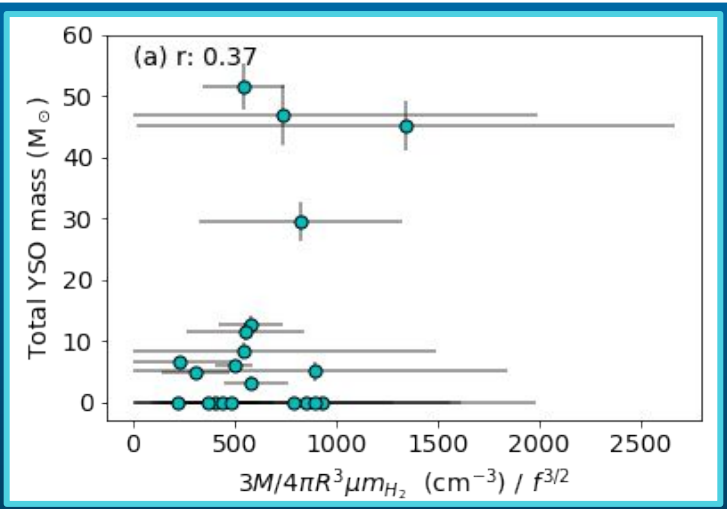
Finn et al. (2021)

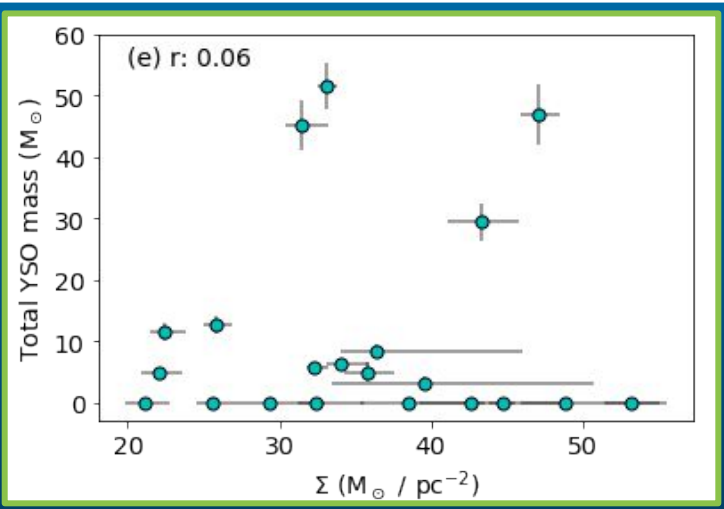


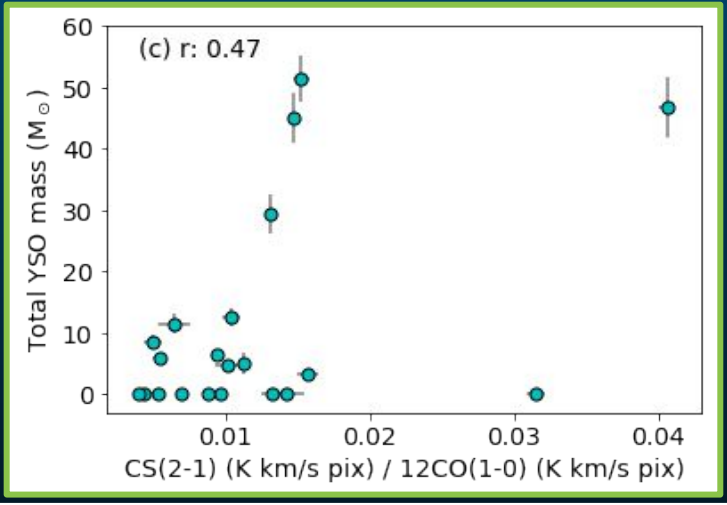


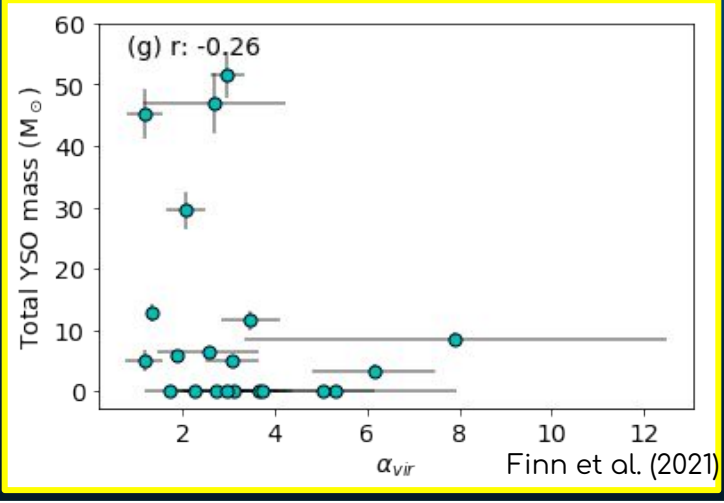


Finn et al. (2021)

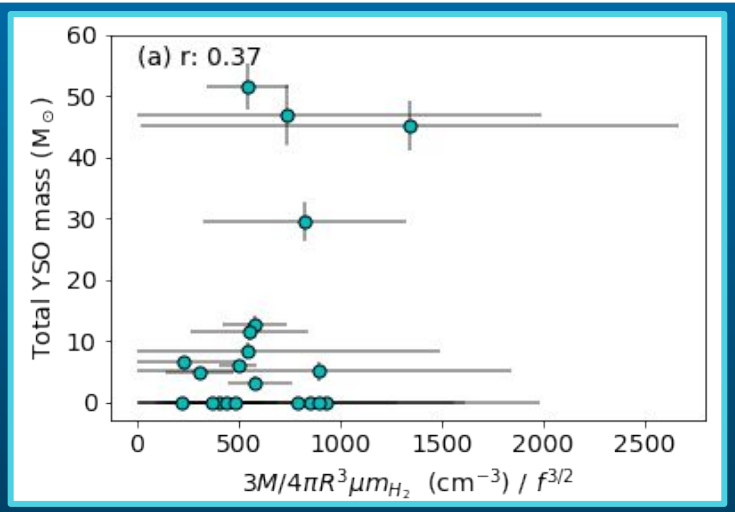


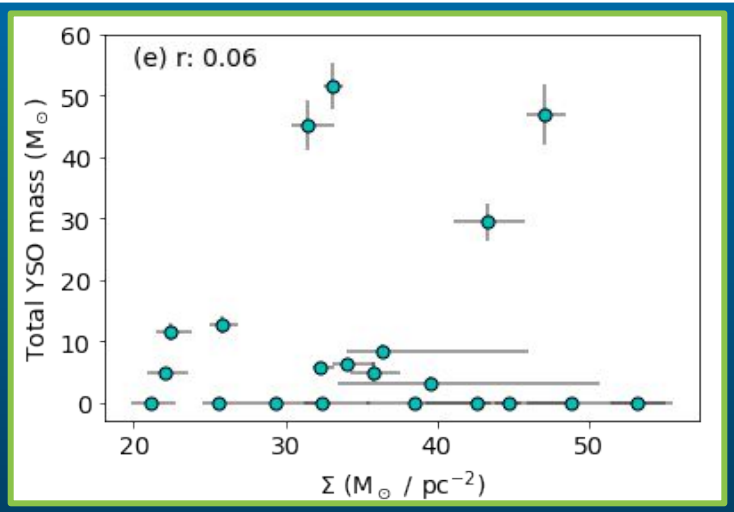


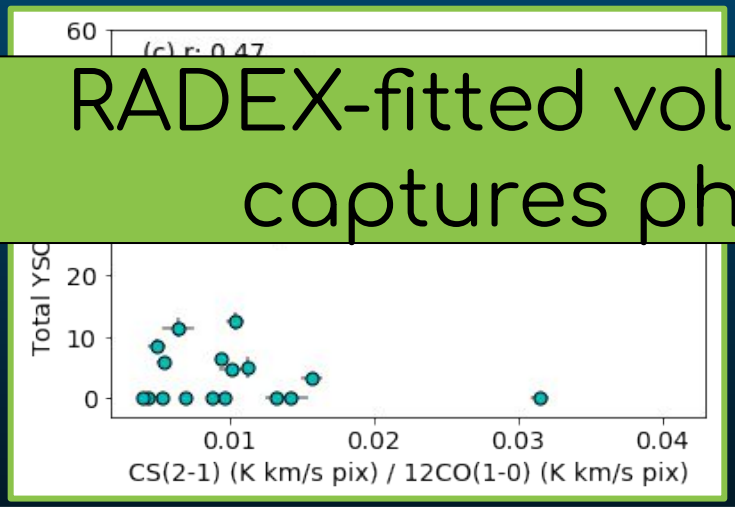


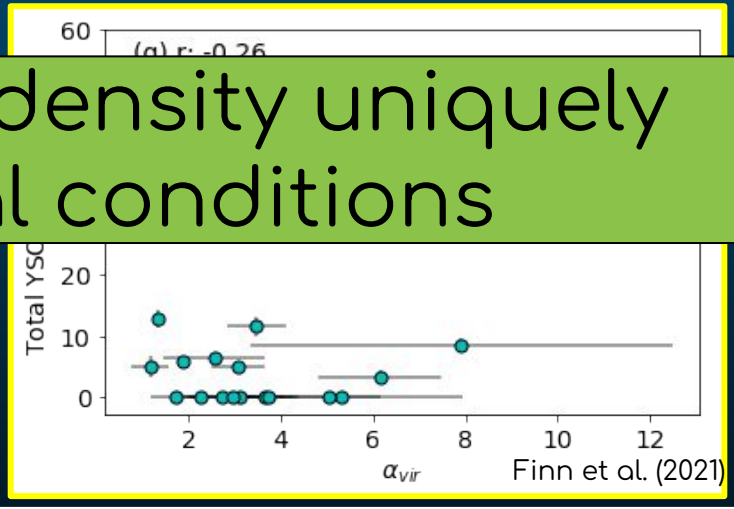


Finn et al. (2021)





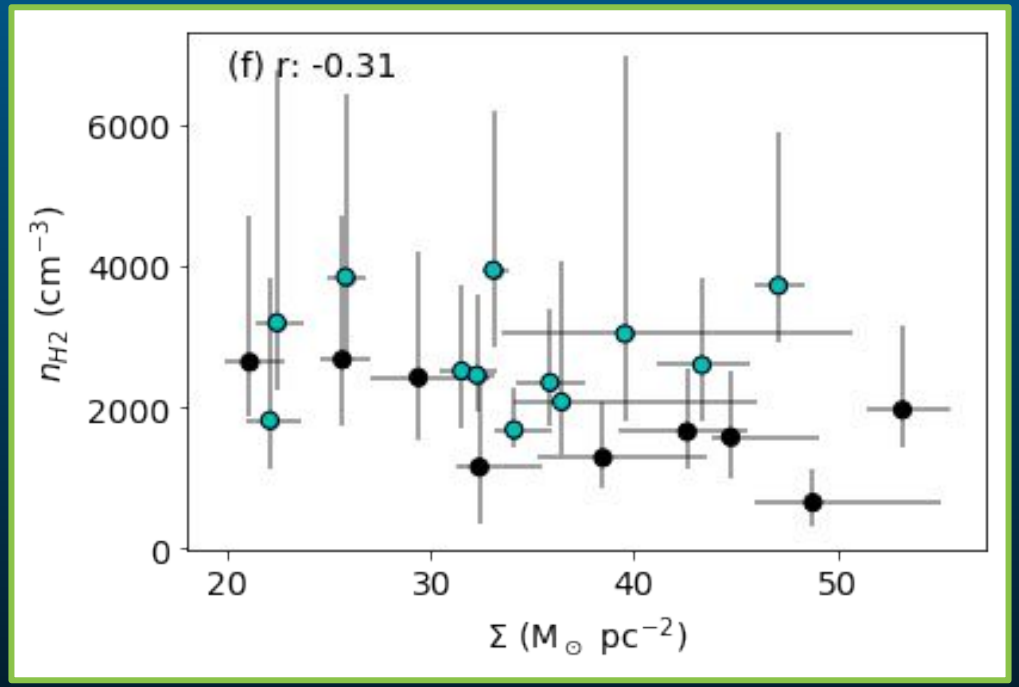




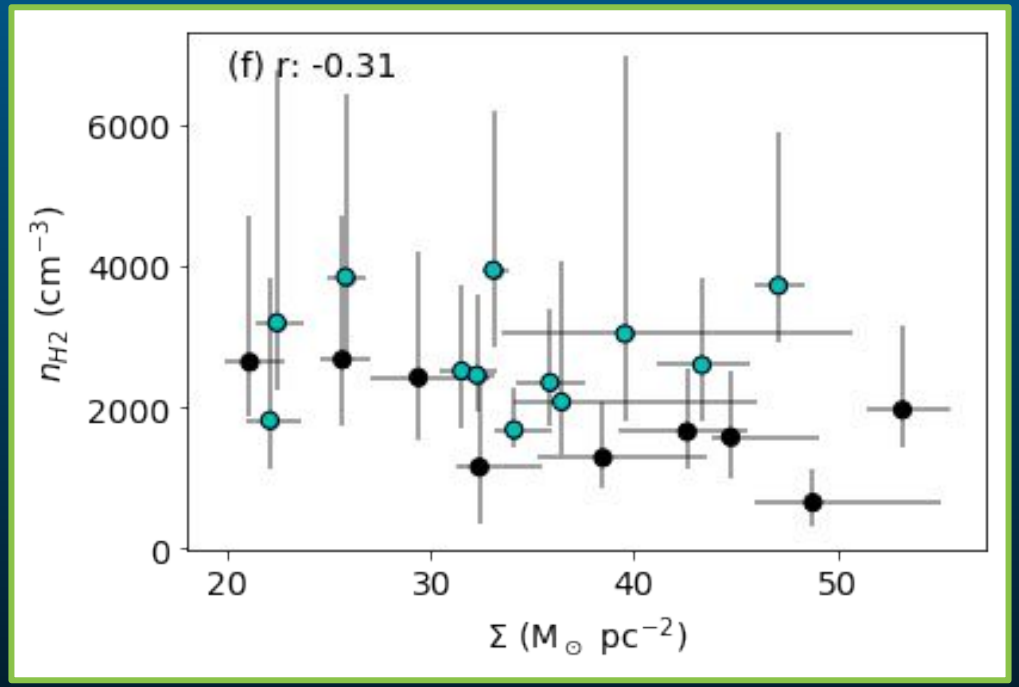
RADEX-fitted volume density uniquely captures physical conditions

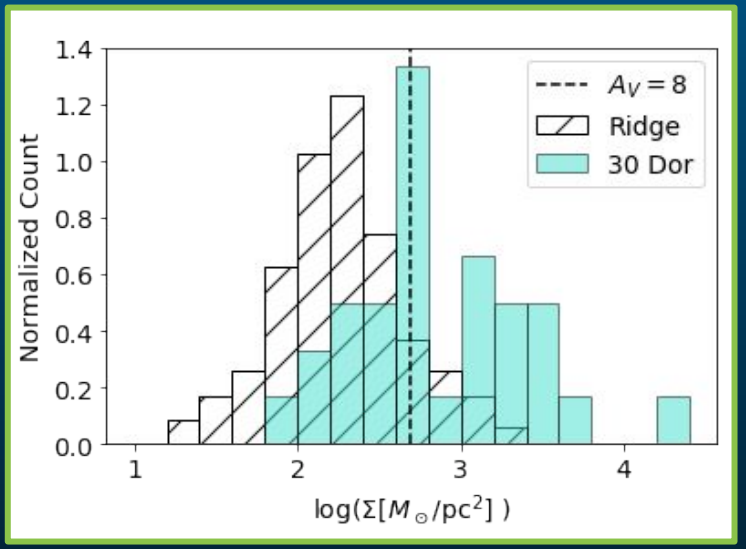
Finn et al. (2021)

Volume and surface density not particularly correlated



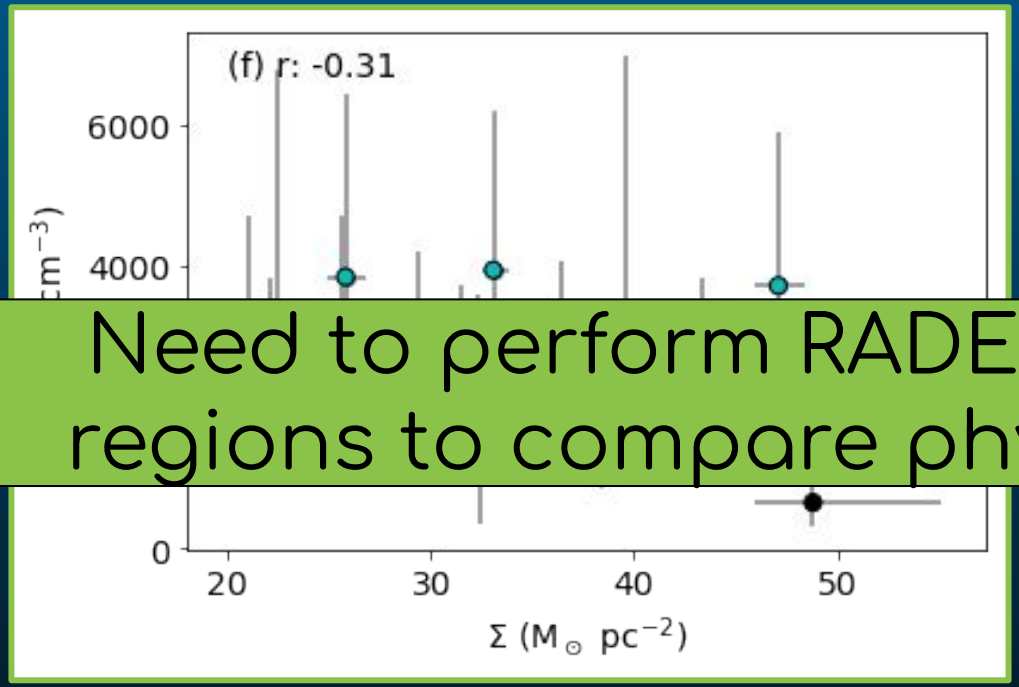
Volume and surface density not particularly correlated

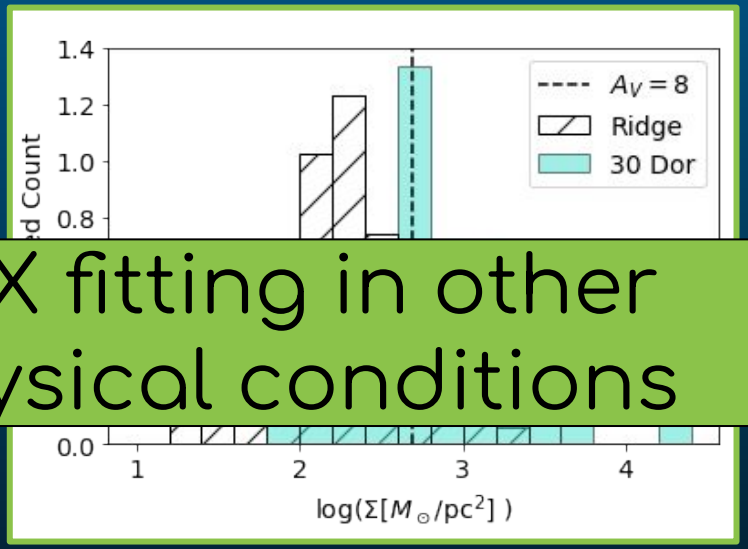




Finn et al. (2021)

Volume and surface density not particularly correlated





Need to perform RADEX fitting in other regions to compare physical conditions

Finn et al. (2021)

Summary and looking forward

- Quiescent Molecular Ridge in the LMC is most likely not forming massive stars because it lacks sufficiently dense gas and not because it is supported by turbulence
- Fitting RADEX models to CO emission can uniquely determine physical conditions that correlate with star formation
- We will expand out RADEX fitting to other regions and other sets of molecular lines to compare physical conditions in different galactic environments