ACES: Resolving the super to subsonic gas transition in the Galactic center for the first time

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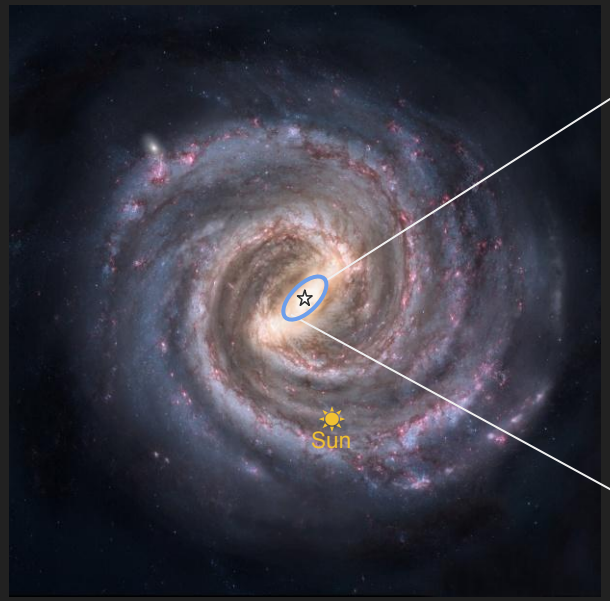
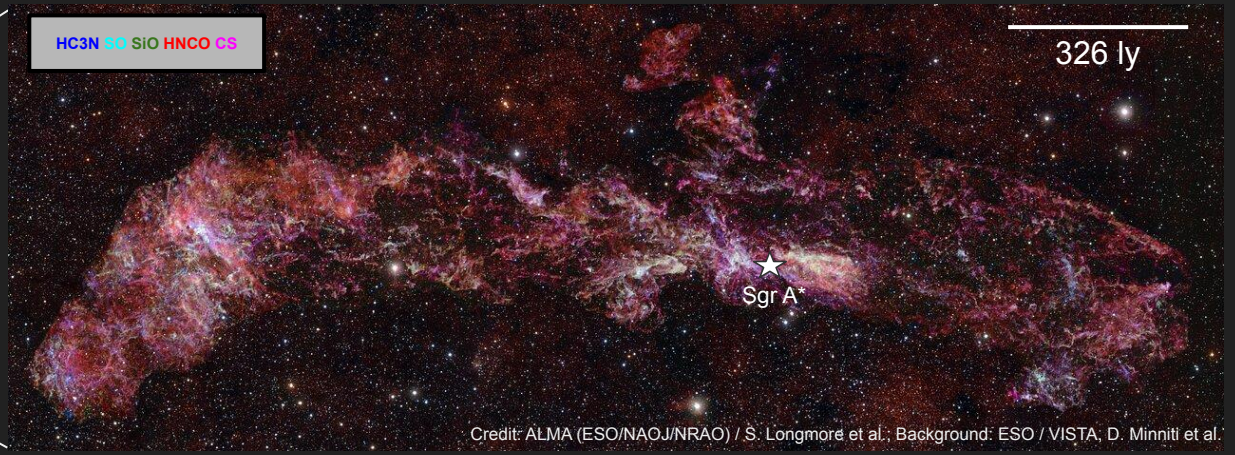
Galactic Center: A surprisingly inefficient star factory!

A window into how our own Solar system formed



ACES: The Milky Way's Central Molecular Zone (Gas + Stars)



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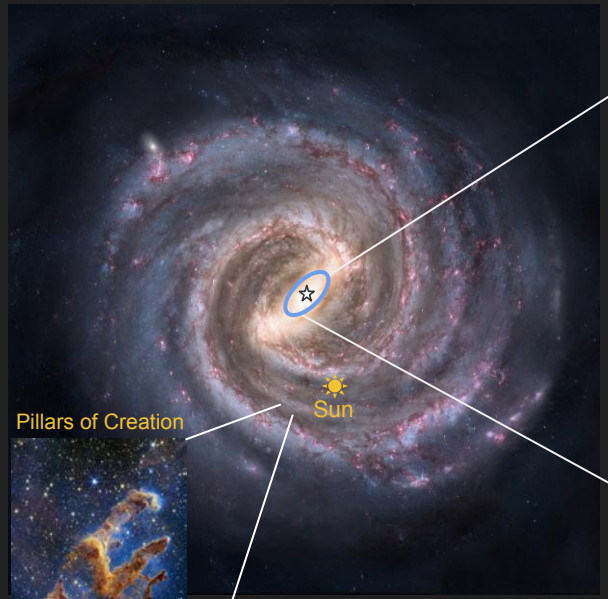


Pillars of Creation

Credit: JWST

Star formation rate $\propto$ gas density

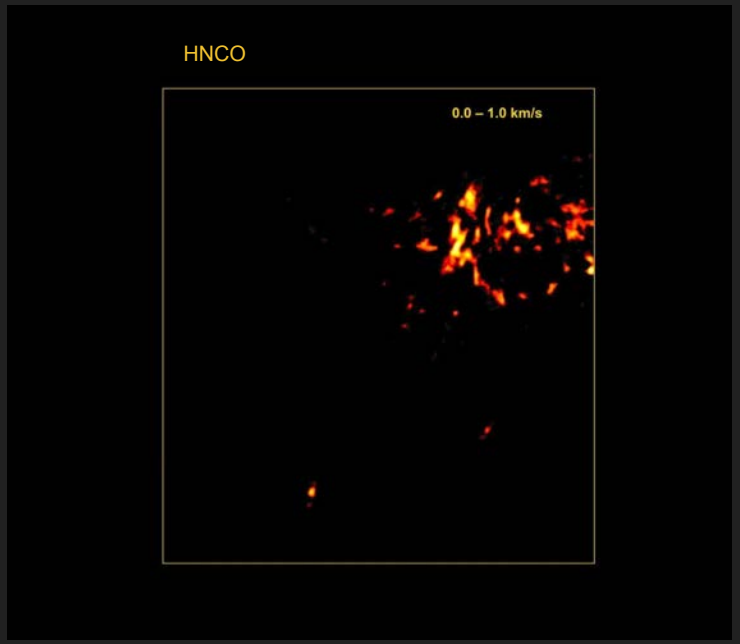
ACES: The Milky Way's Central Molecular Zone (Gas + Stars)

- ★ Why is star formation so inefficient in the Galactic Center?
- ★ CMZ: the closest lab for how stars like our Sun were born!

The suspect: Turbulence?

Turbulence tears clouds apart …

Swirling ball of gas in a CMZ cloud



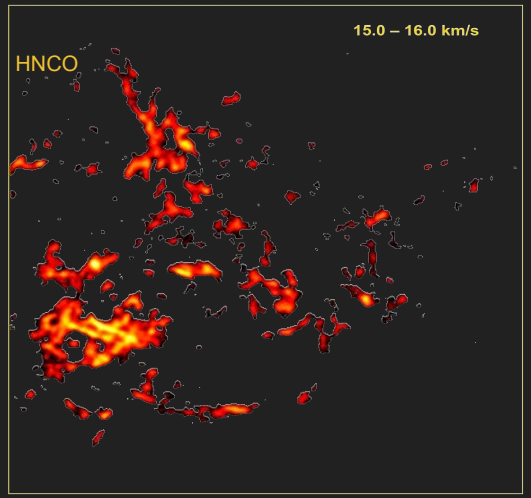
Islands of calm in a turbulent sea on Earth

Supersonic gas → subsonic gas → Early stage of star formation

The suspect: Turbulence?

Turbulence brings gas together …

Swirling ball of gas in a CMZ cloud



Islands of calm in a turbulent sea on Earth

★ Islands of calm in a turbulent sea = Zen state of gas in ISM

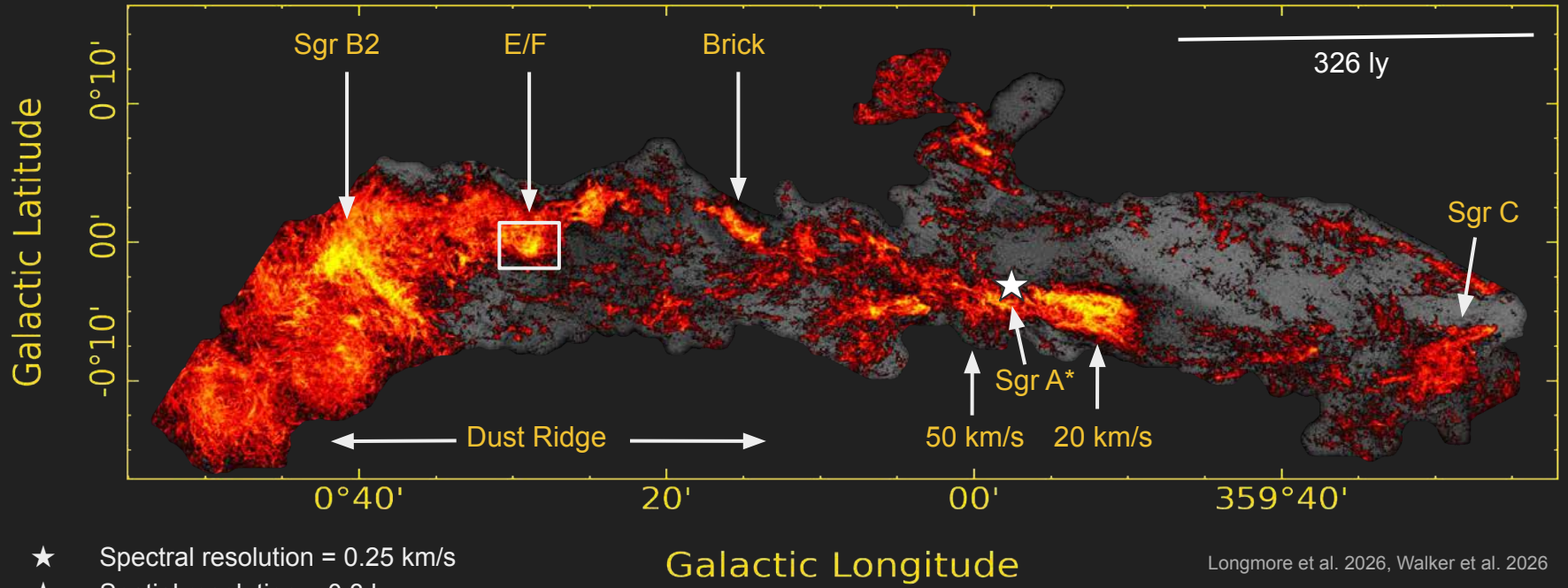
★ First direct observation in Perseus molecular cloud (Pineda et al. 2010)

★ Widespread subsonic gas motions in high mass star forming clouds (Henshaw et al. 2014, Sokolov et al. 2018, Li et al. 2020)

Galactic Center: Can we find Islands of calm?

ALMA Exploration CMZ Survey (ACES) does the magic!

HNCO (4-3) Peak Intensity Map of the CMZ



★ Spectral resolution = 0.25 km/s

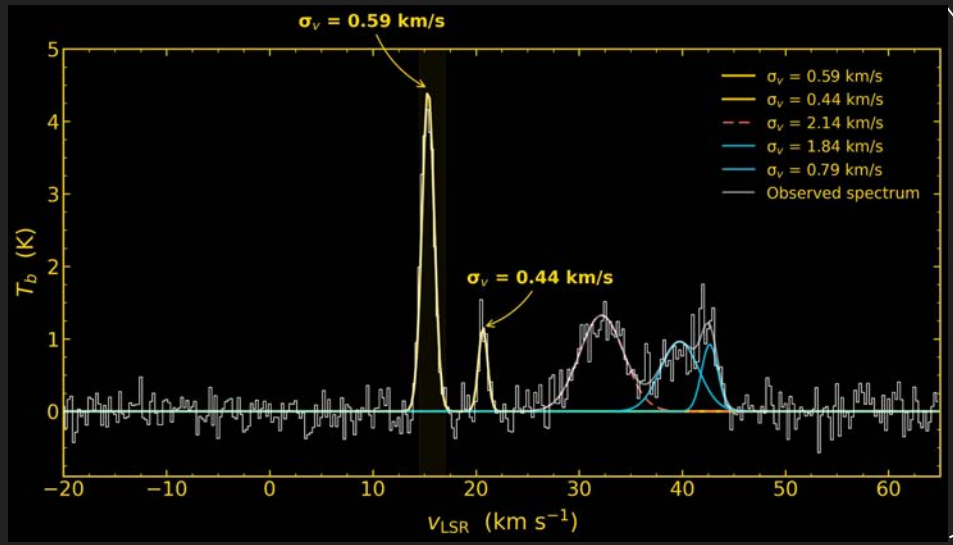
★ Spatial resolution = 0.3 ly

Longmore et al. 2026, Walker et al. 2026

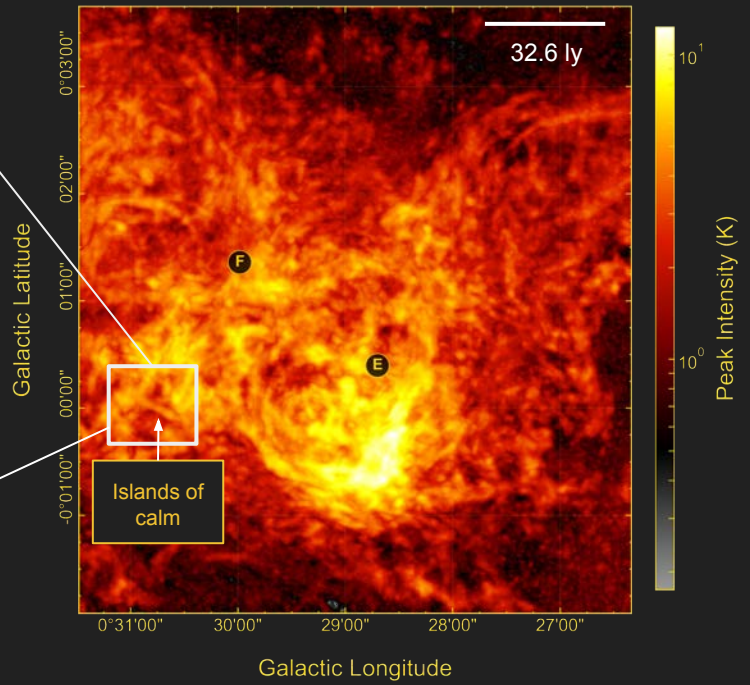
Galactic Center: Where is Islands of calm?

……. in the Dust Ridge

An Example Spectrum



HNCO (4-3) Peak Intensity map of Cloud E/F



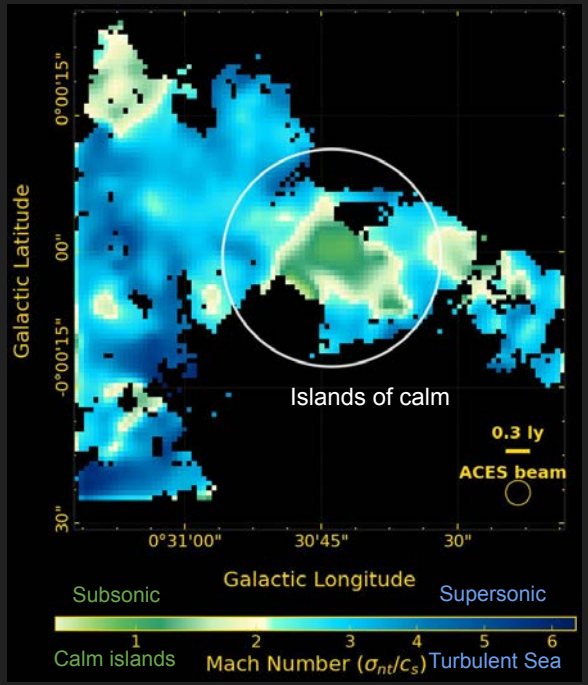
- ★ ~0.3 ly wide, ~2 ly long
- ★ Large σ_v = stormy, turbulent gas
- ★ Small σ_v = calm, coherent gas

Galactic Center: Islands of calm in a turbulent sea

Resolving the super to subsonic gas transition !

★ Calm (**subsonic**) gas surrounded by turbulent (**supersonic**) gas.

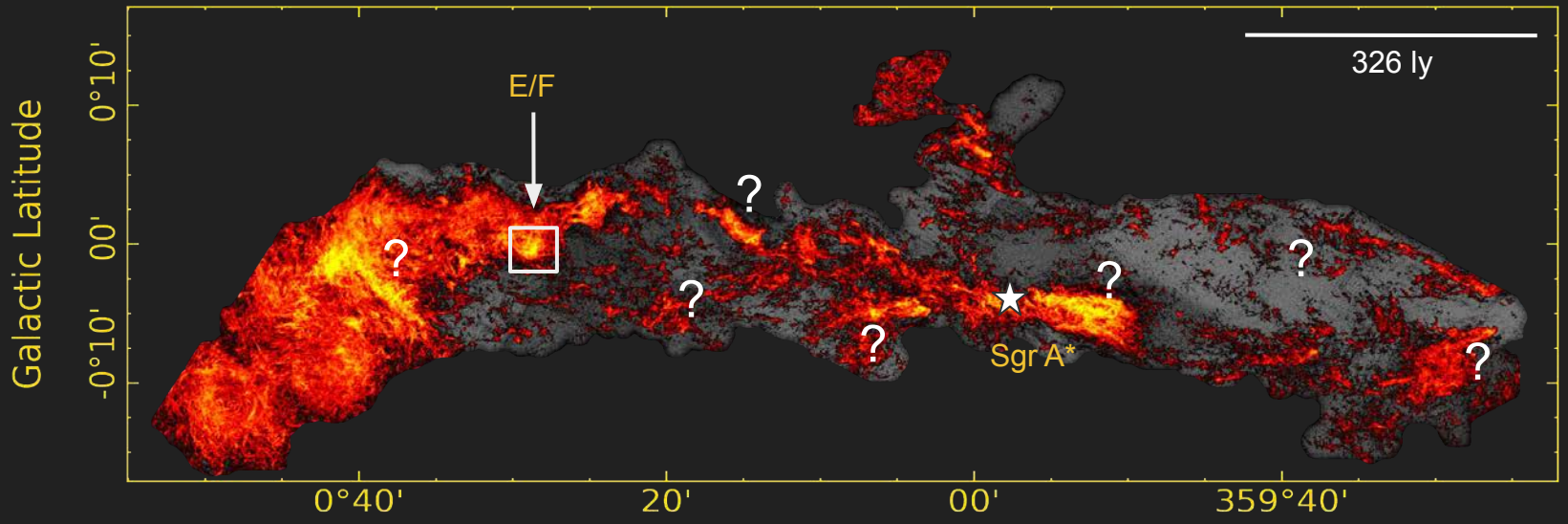
Islands of calm in the CMZ



Islands of calm on Earth

Galactic Center: Where will next generations of stars will form?

HNCO (4-3) Peak Intensity Map of the CMZ



- ★ Each pixel is a clue. Every Island of calm is a potential stellar birthsites.
- ★ ML tools to search Islands of calm

Longmore et al. 2026, Walker et al. 2026, Buddhacharya et al. in prep

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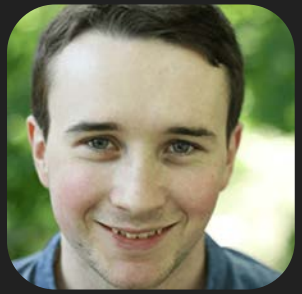

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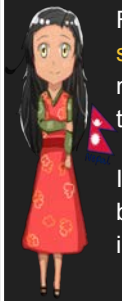
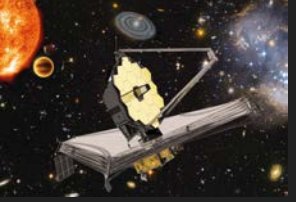
What we found and why it matters?



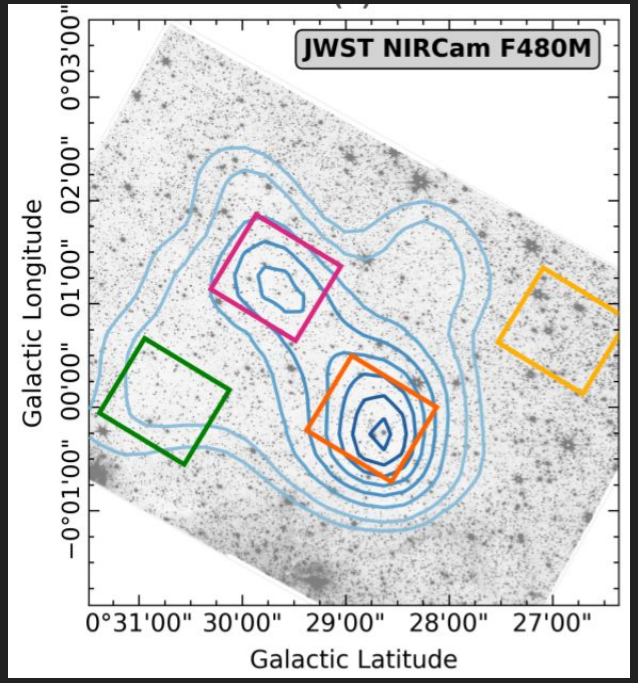
First detection of Islands of Calm in stormy Galactic Center where gravity may begin to overcome turbulence and trigger gas collapse.

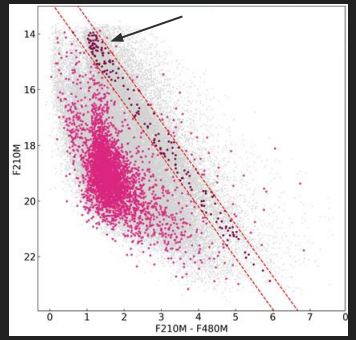
Initial conditions for star formation may be similar across diverse environments including where our Sun formed.

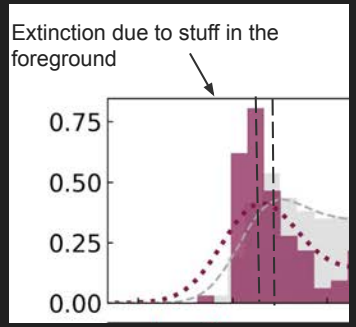
Additional Slides



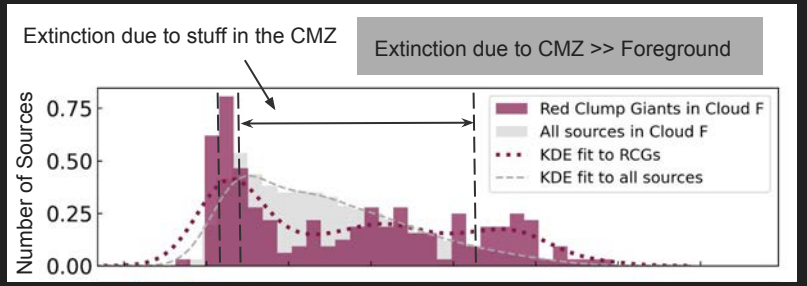
Red Clump Giants in Cloud E/F







- ★ Red Clump Giants are evolved, Helium-burning stars.
- ★ Standard light bulbs in space



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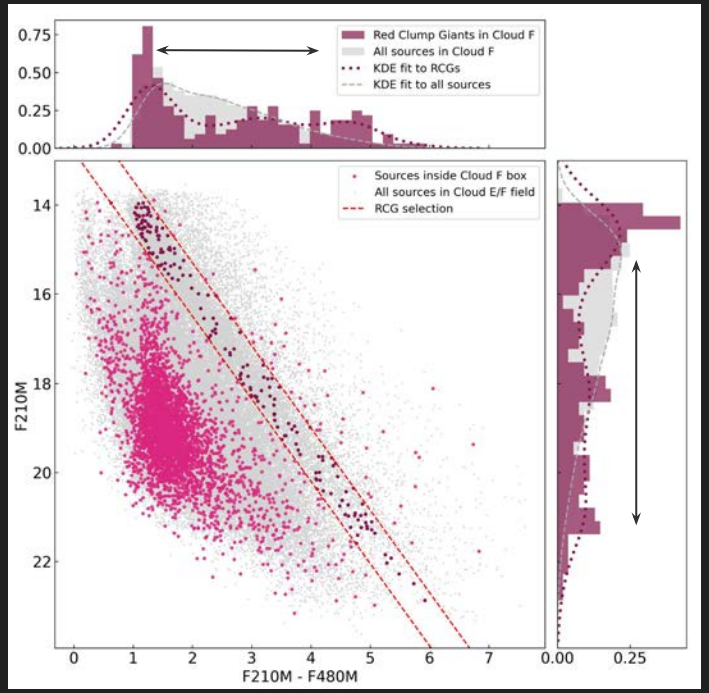
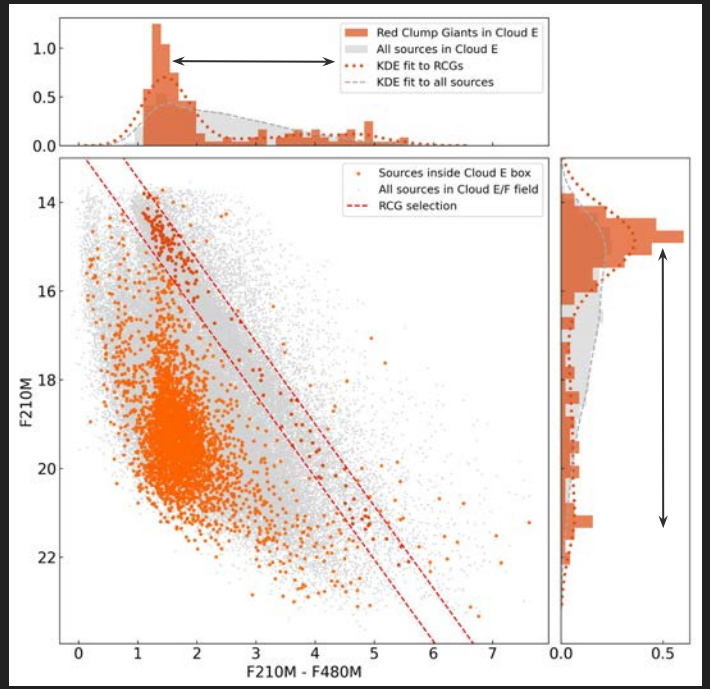


Two peaks in histograms = Extinction due to CMZ



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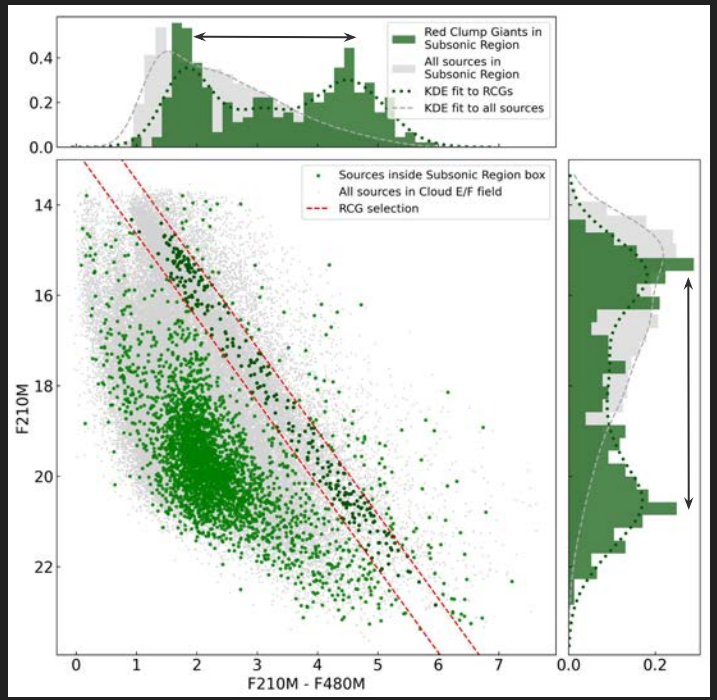
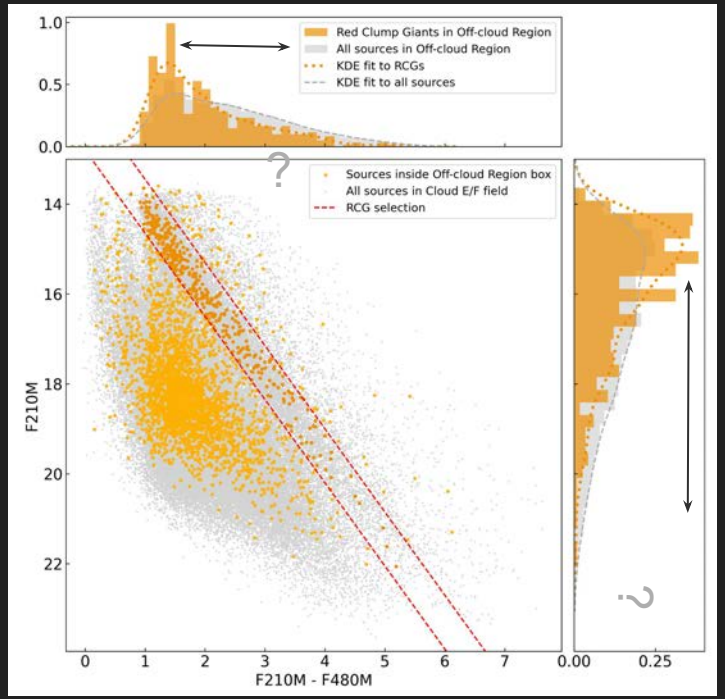
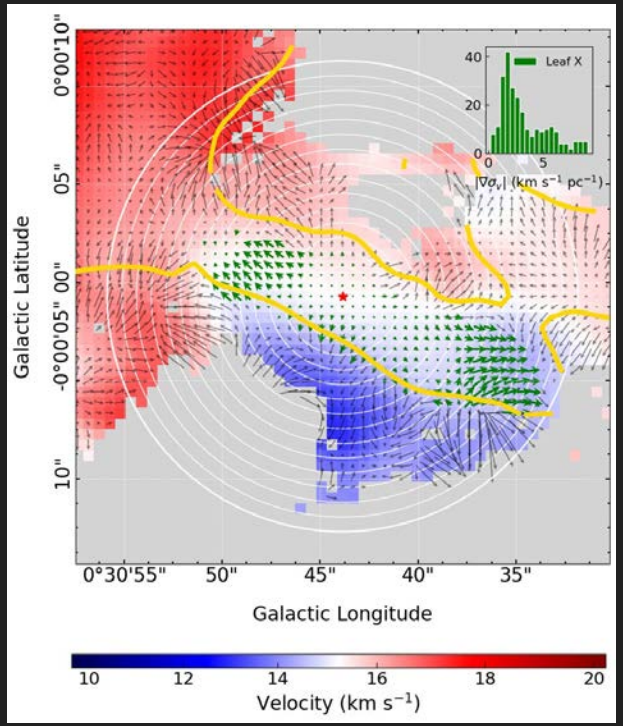


Two peaks in histograms in the SCR but not in the off-Cloud region

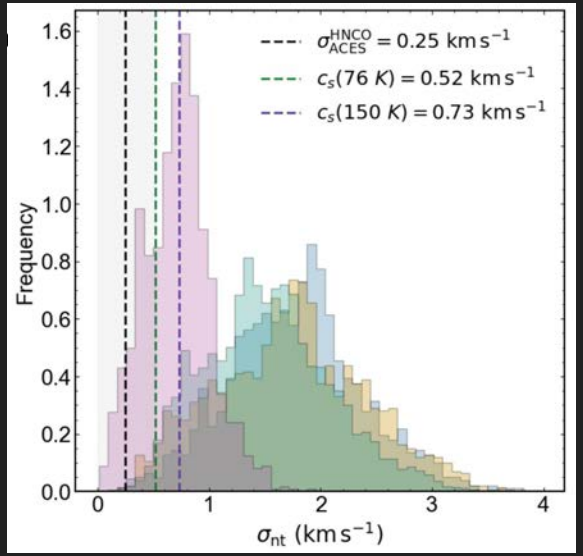


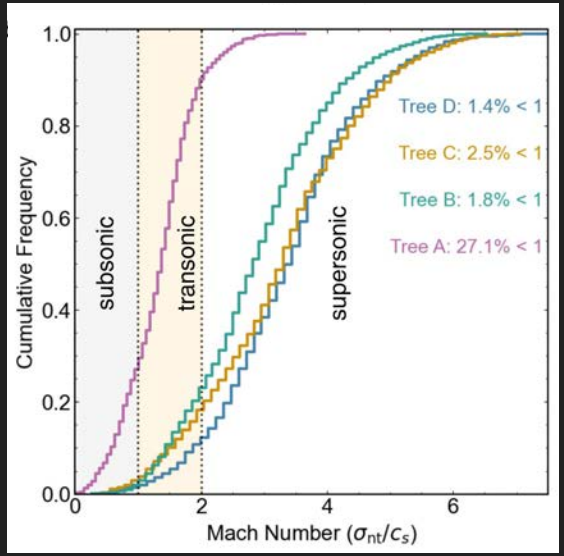
Velocity dispersion gradient: Transition to coherence

- ★ Length of vector = gradient magnitude
- ★ Anti-correlation between peak intensity and velocity dispersion

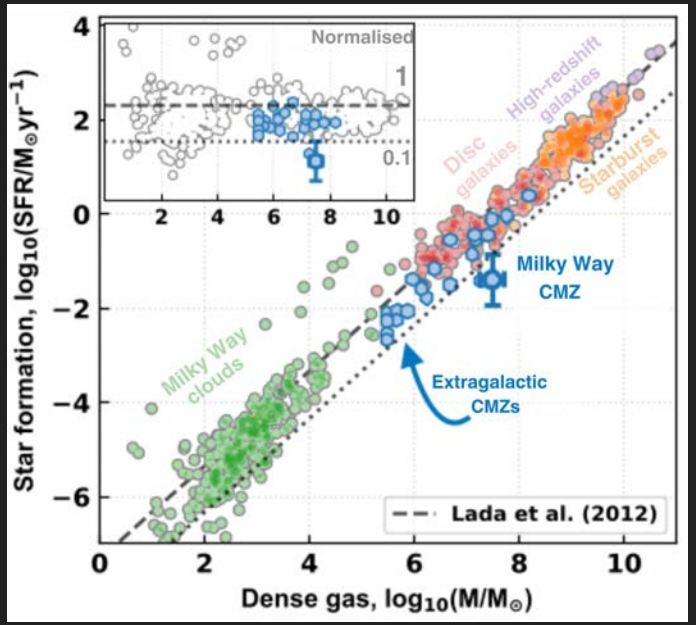


Mach number: Supersonic to subsonic gas transition

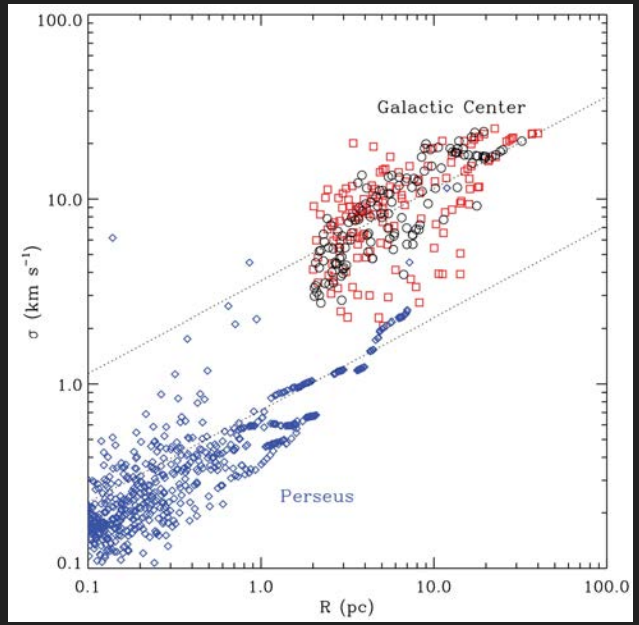




Star formation scenario

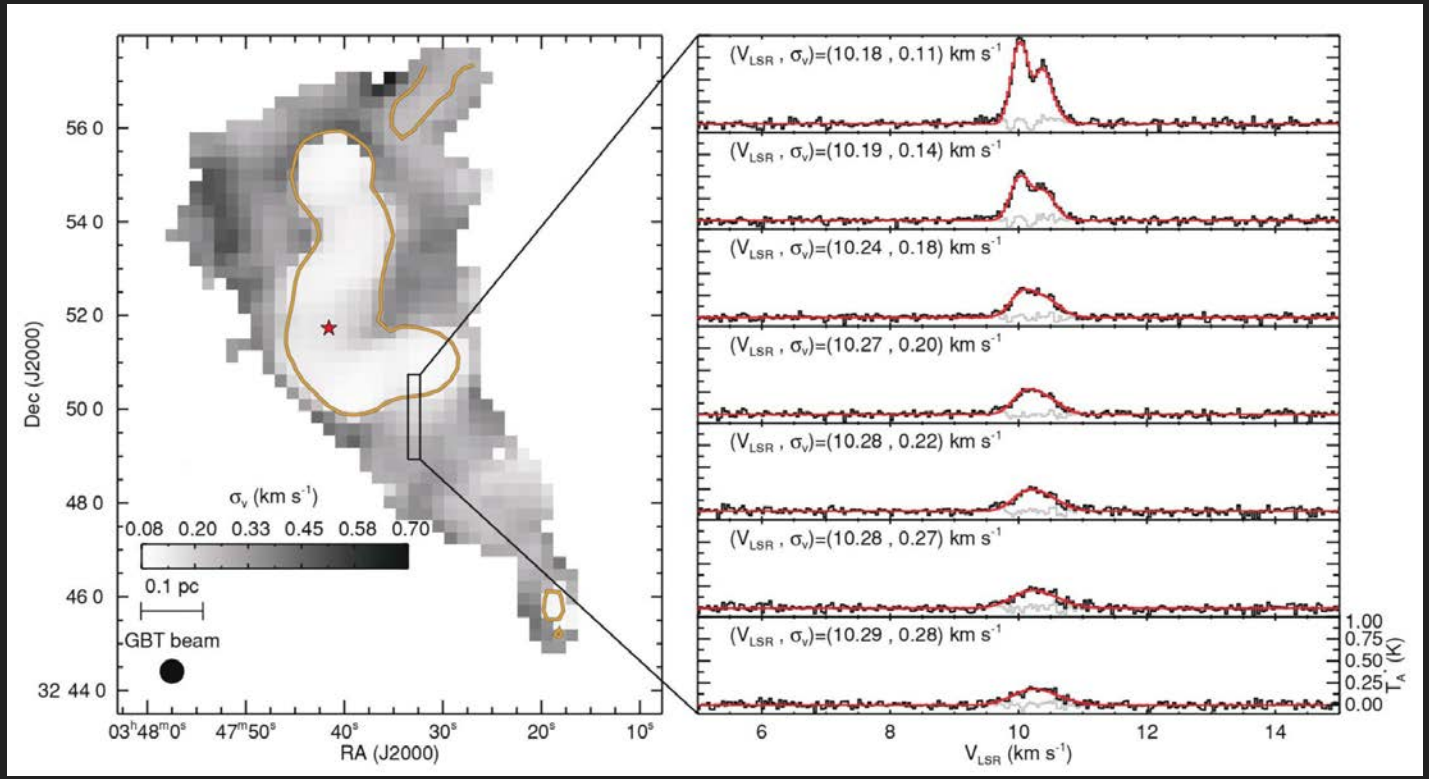


Lada et al. 2010, 2012, Longmore et al. 2013, Barnes et al. 2017, Henshaw et al. 2023



Shetty et al. 2012a

First observation in Perseus molecular cloud



Pineda et al. 2010