

CHIMPS2

Resolving Star Formation in the Galactic Plane

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Tracing the Flow: Galactic Environments and the Formation of Massive Stars
3rd July, 2018

Outline

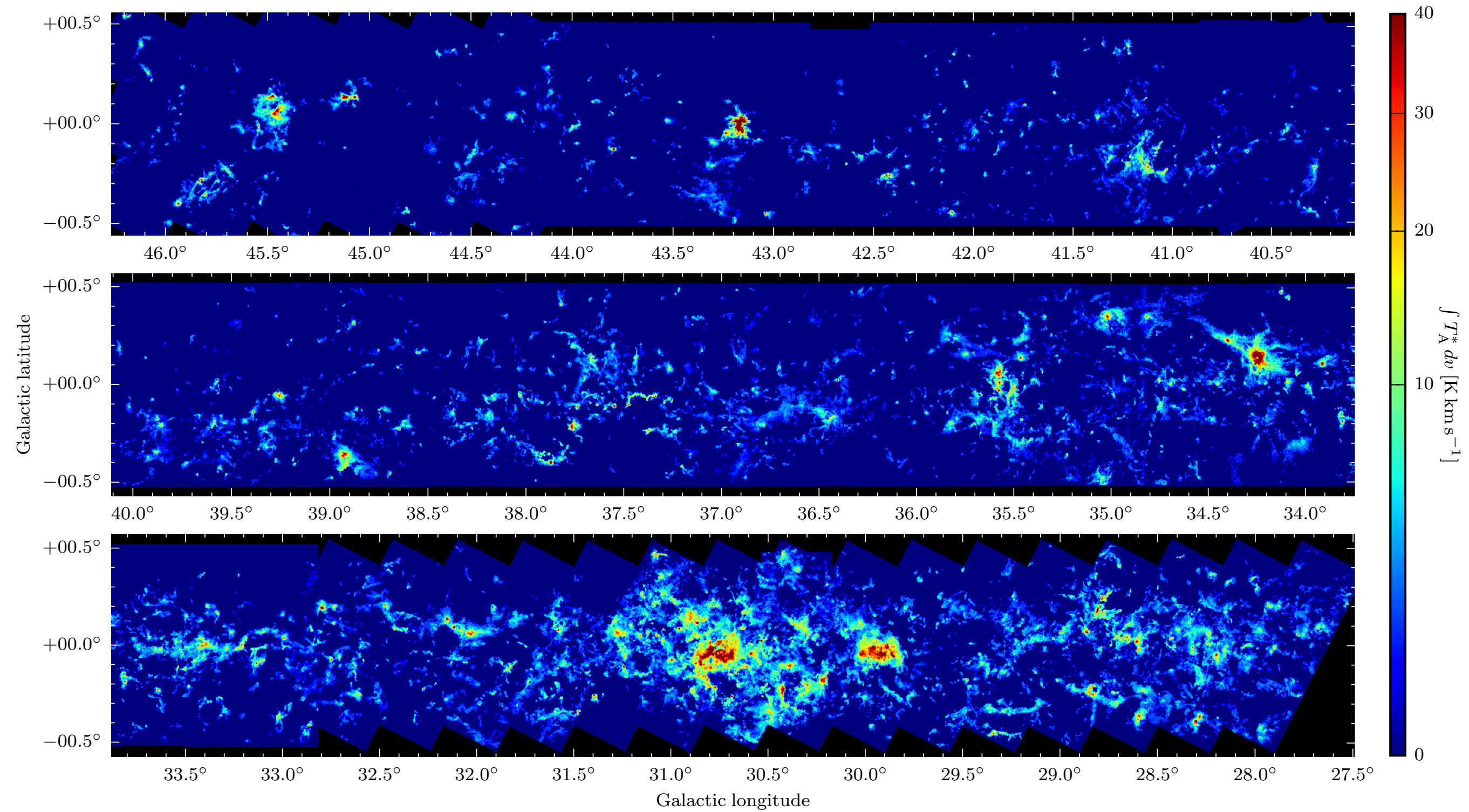
- Introduce CHIMPS
- The LTE analysis performed on these data, and the resulting column density maps.
- Maps of clump formation efficiency
- CHIMPS2 Introduction and early data
- Very early science from the new survey

CHIMPS

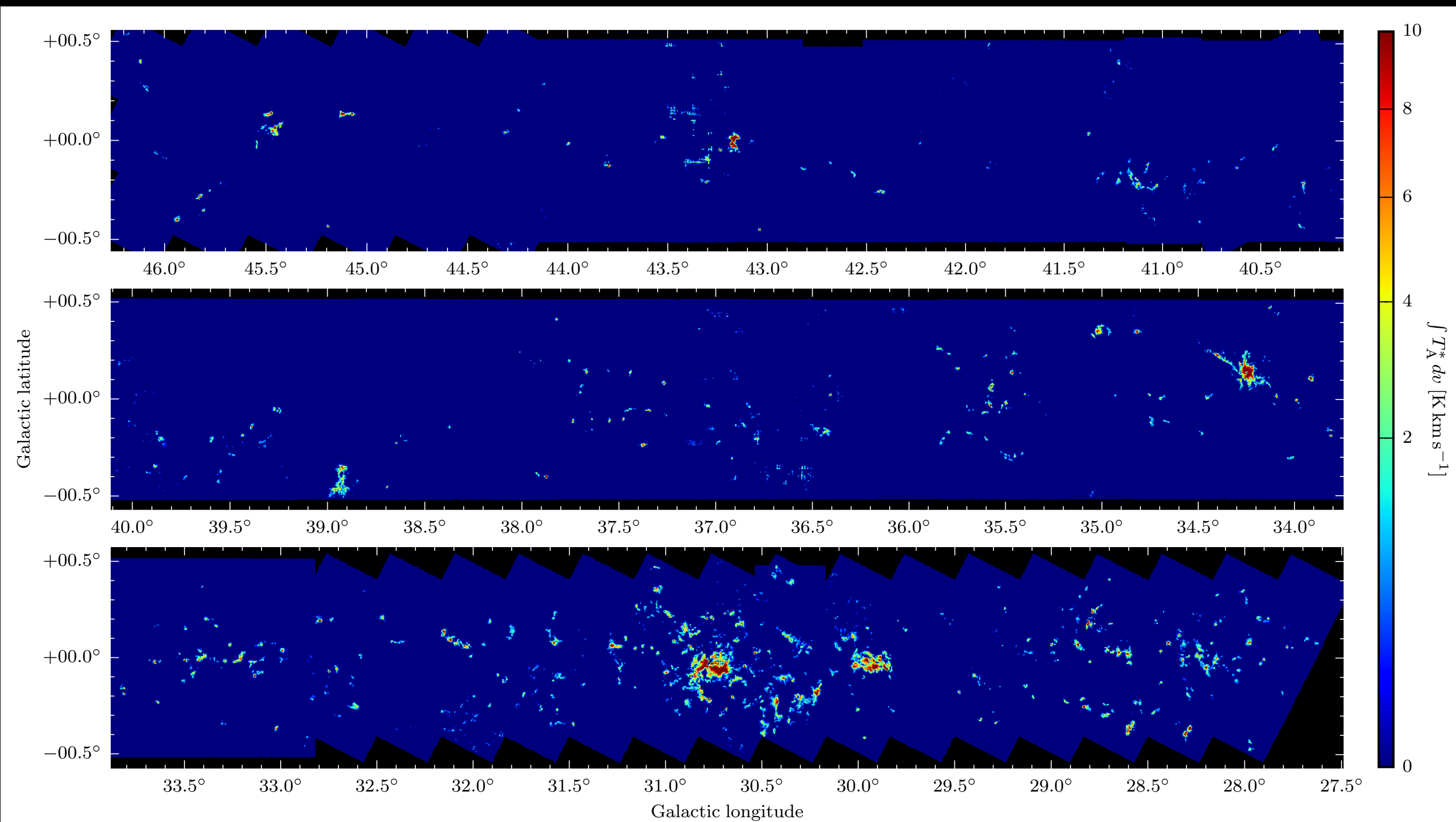
The $^{13}\text{CO}/\text{C}^{18}\text{O}$ (J=3-2) Heterodyne Inner Milky Way Plane Survey

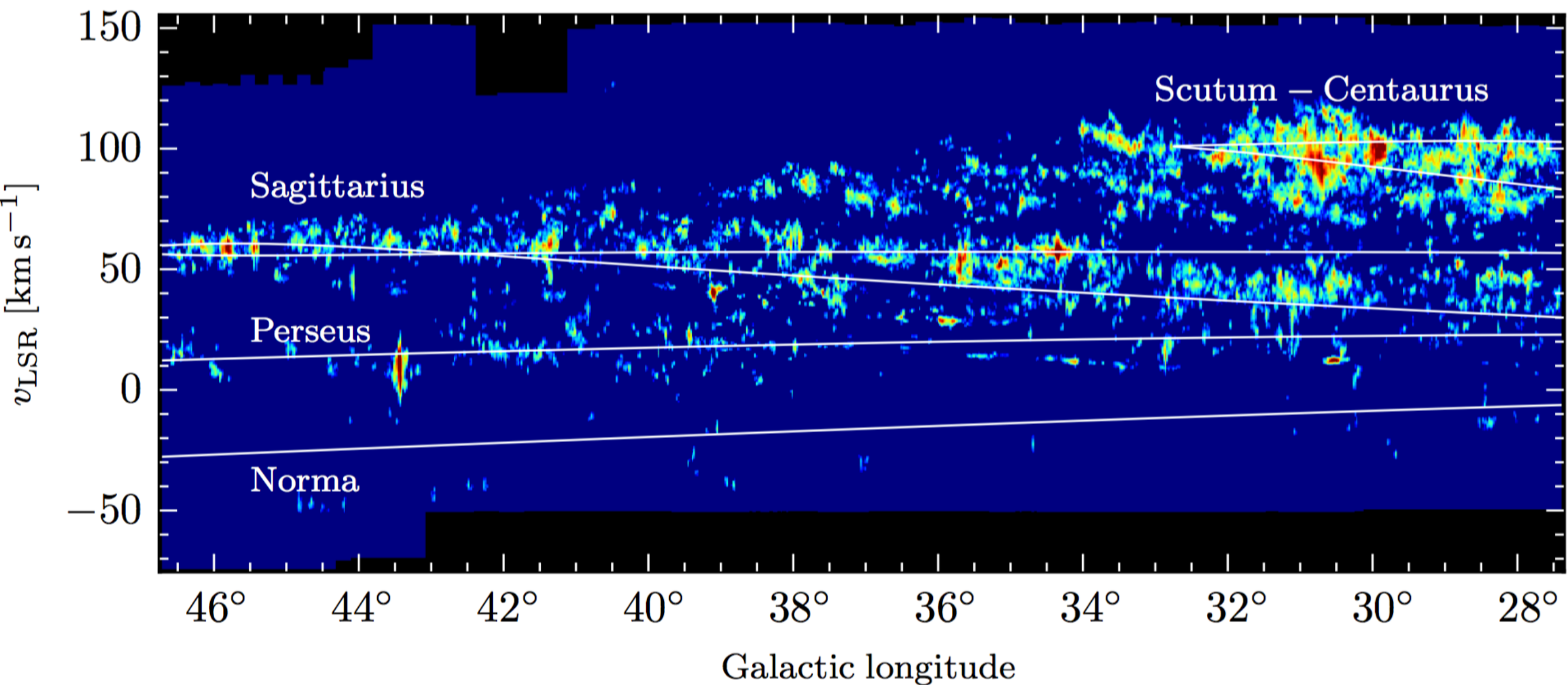
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- The background image is a polar projection map of the Milky Way galaxy. It shows the central bulge and several spiral arms. Labels include 'Galactic Longitude' at the top, '75,000 ly', '60,000 ly', '45,000 ly', '15,000 ly', 'Orion Spur', 'Perseus Arm', 'Outer Arm', 'Long Bar', 'Far 3kpc Arm', 'Near 3kpc Arm', 'Sagittarius Arm', and 'Galactic Bar'. A green wedge is overlaid on the map, pointing towards the center of the galaxy, indicating the survey area. The wedge is bounded by Galactic Longitudes of approximately 27.5° and 46.3° and Galactic Latitudes of approximately ±0.5°.
- JCMT (15m) with HARP
 - ^{13}CO (3-2) & C^{18}O (3-2)
 - Dense gas ($n_{\text{crit}} \sim 10^4 \text{ cm}^{-3}$)
 - High optical depth: cloud interiors
 - $27.5^\circ < l < 46.3^\circ$ and $|b| < 0.5^\circ$ (19 deg^2) spectral survey
 - Spatial resolution $\sim 15''$
 - Velocity resolution 0.5 km/s
(raw channel width 0.055 km/s)
 - 200 km/s coverage $\sim -50\text{--}150 \text{ km/s}$
 - Sensitivity $\sigma(T_{\text{mb}}) < 1 \text{ K}$ per channel
 - $T_{\text{A}}^* \sim 0.6 \text{ K/channel}$ for ^{13}CO
 - $T_{\text{A}}^* \sim 0.7 \text{ K/channel}$ for C^{18}O

^{13}CO (3–2)

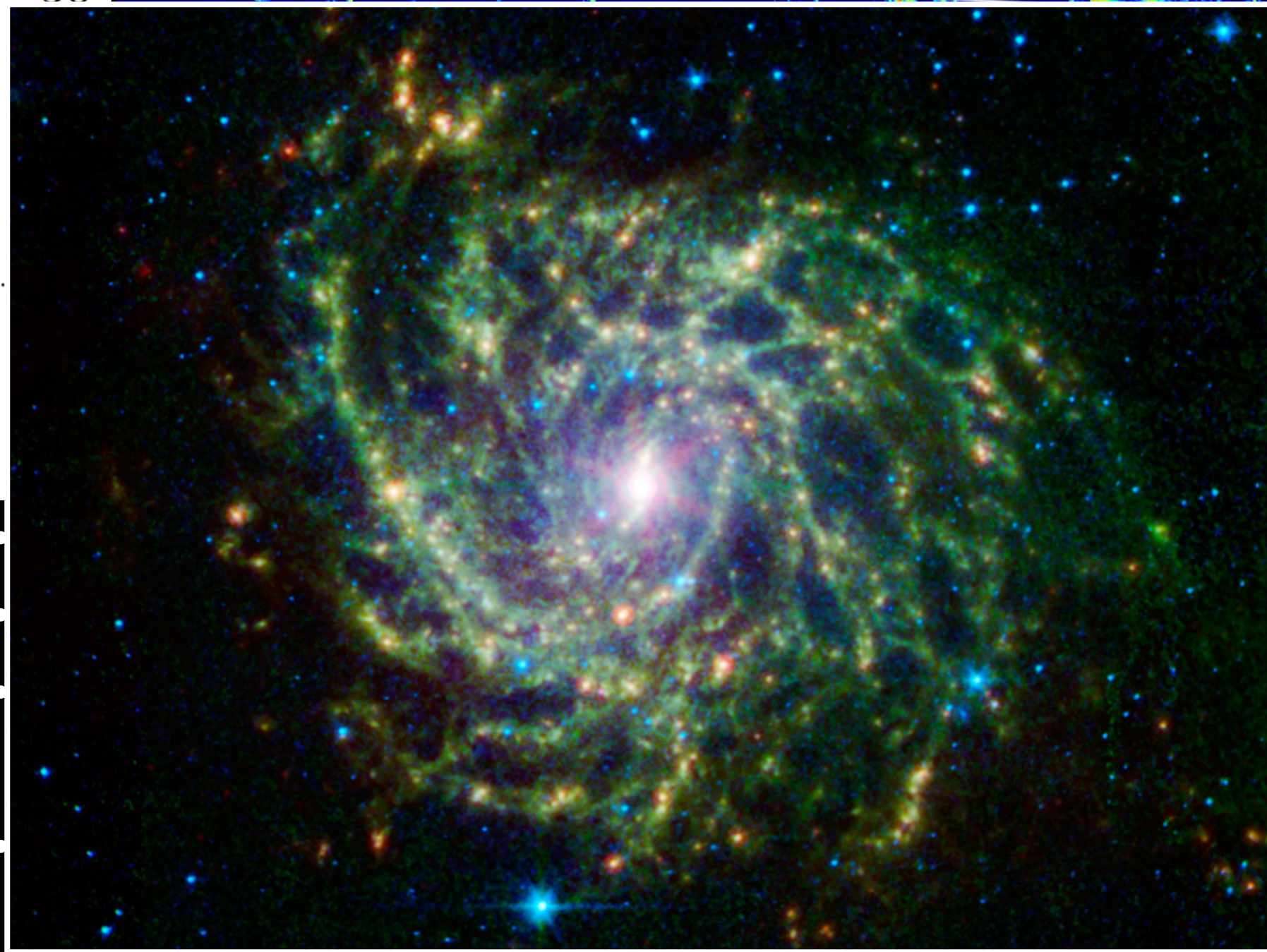
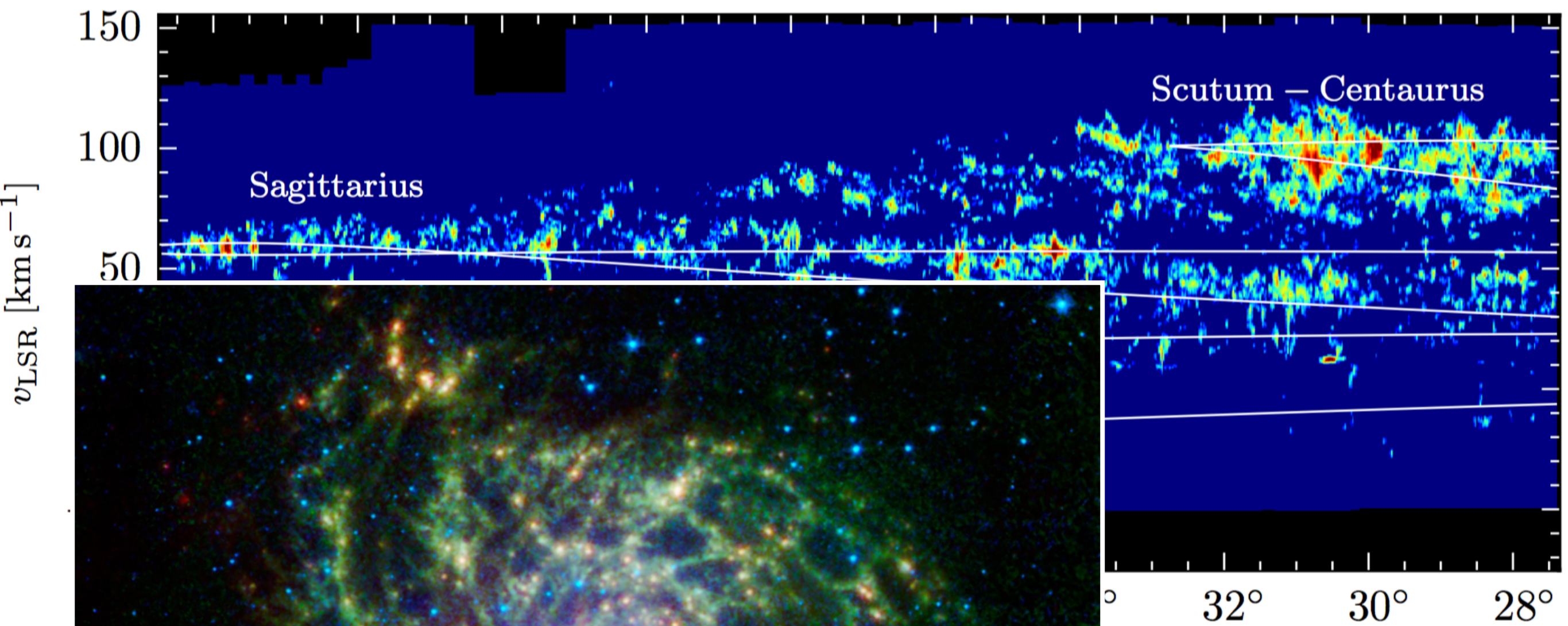


C¹⁸O (3–2)





- Exceptional clarity of spiral structure
- Test of spiral models (Taylor+Cordes93, Cordes+04)
- Structure between Scutum and Sagittarius arms (e.g. Stark & Lee 06)
 - Armlet/ inter-arm filament/ filaments?
- More large-scale filaments ('bones')?
 - e.g. Abreu-Vicente+16, Ragan+14, Zucker+14, Li+13...



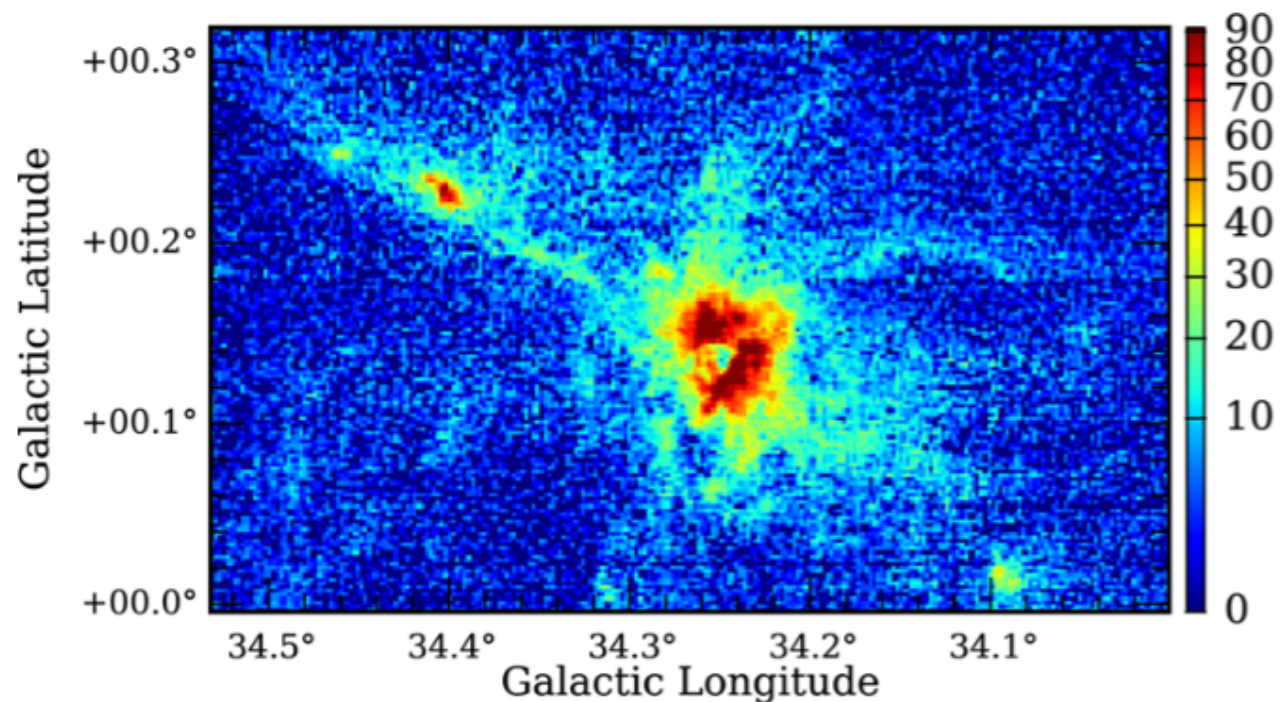
Rigby+16

ark & Lee 06)

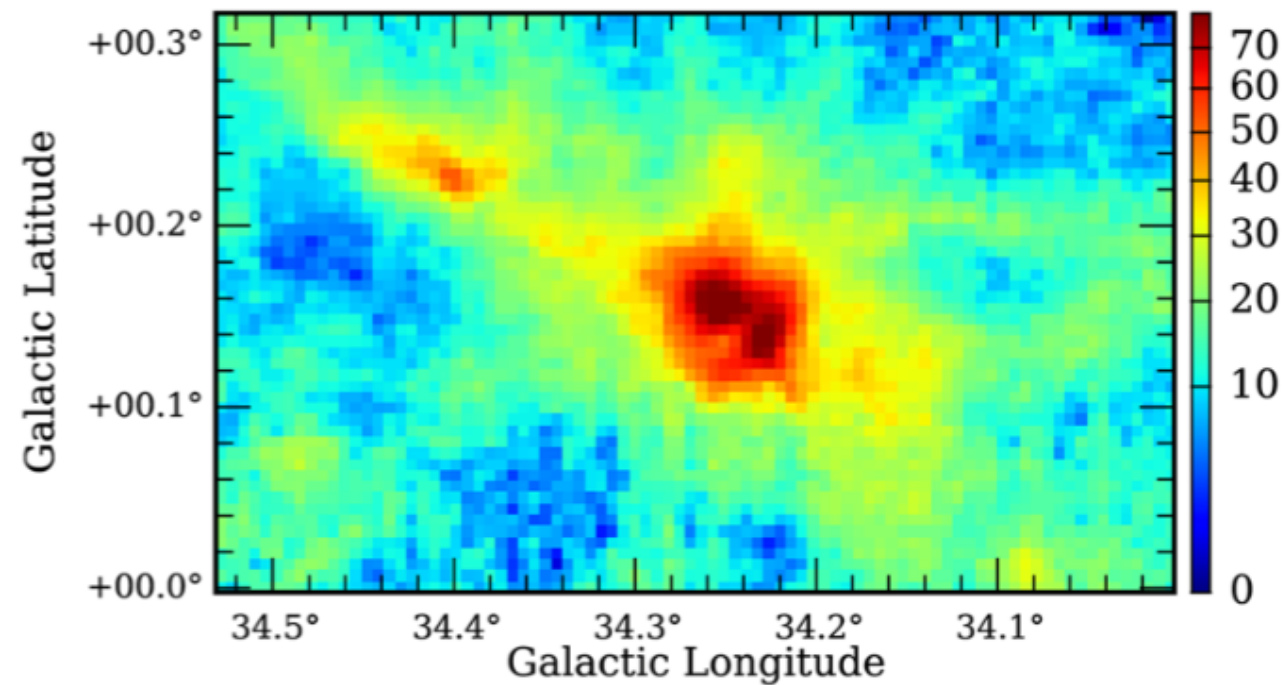
B...

CHIMPS, COHRS, GRS

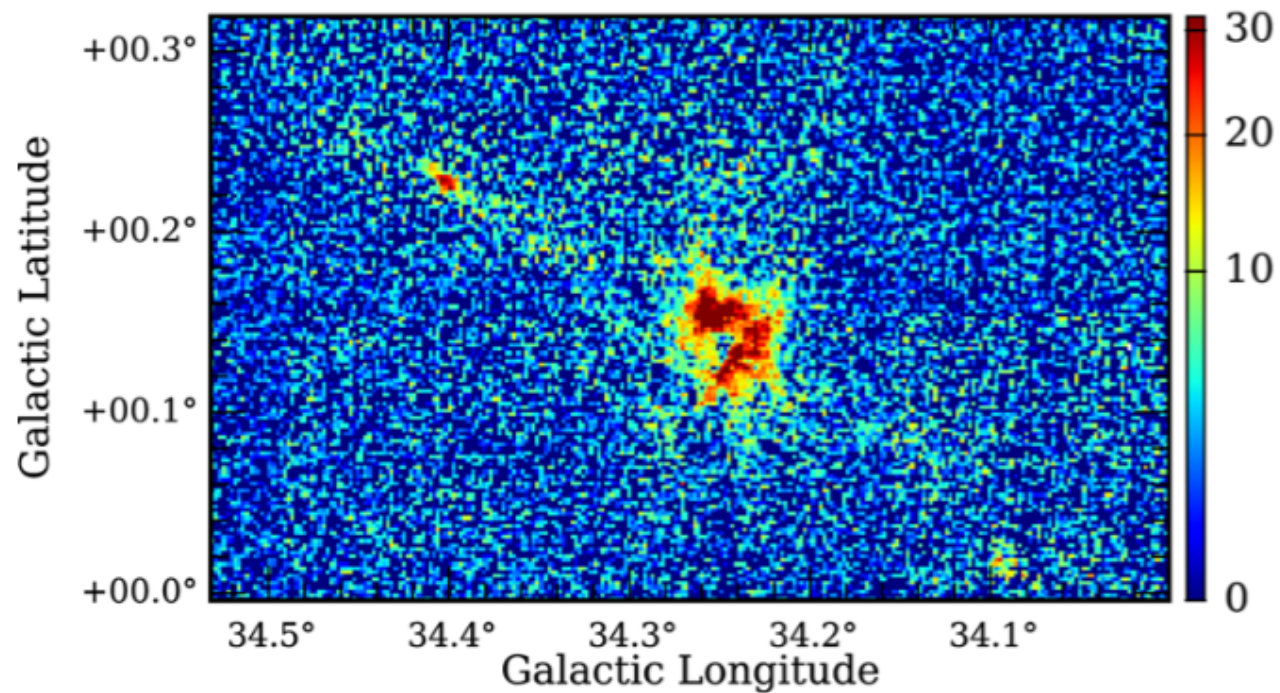
CHIMPS ^{13}CO ($J=3 \rightarrow 2$)



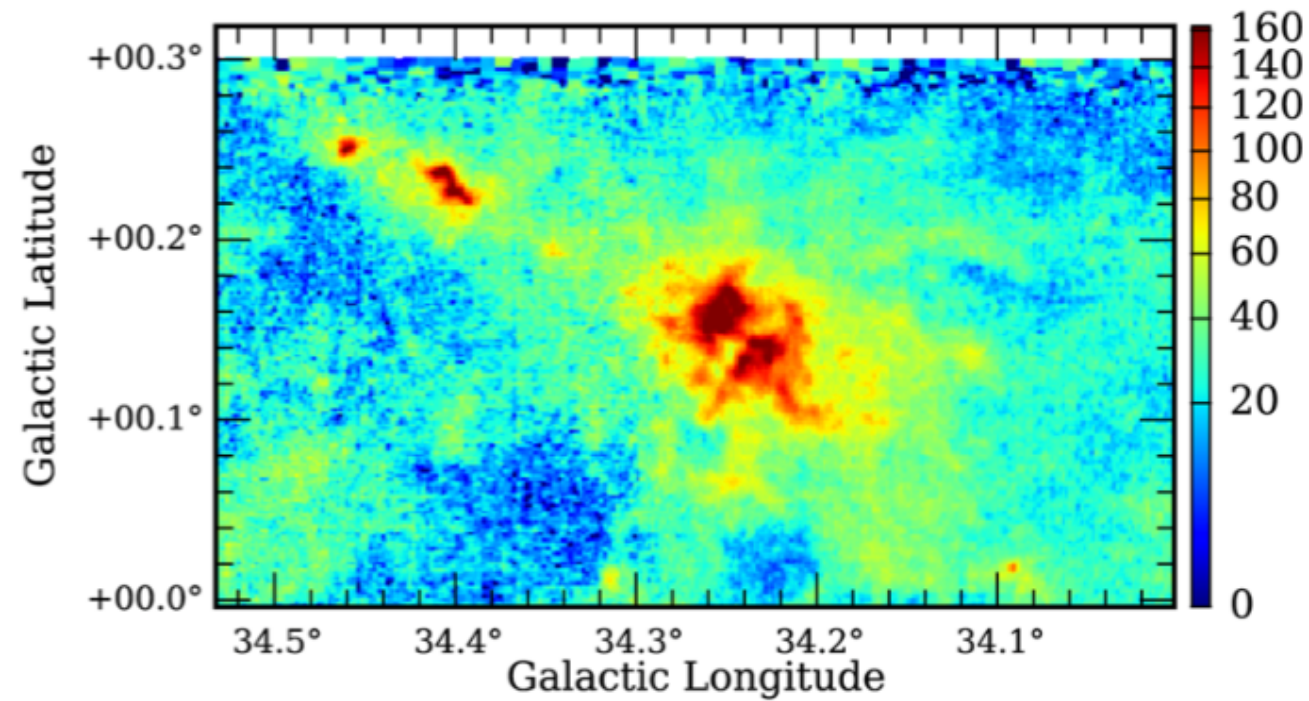
GRS ^{13}CO ($J=1 \rightarrow 0$)



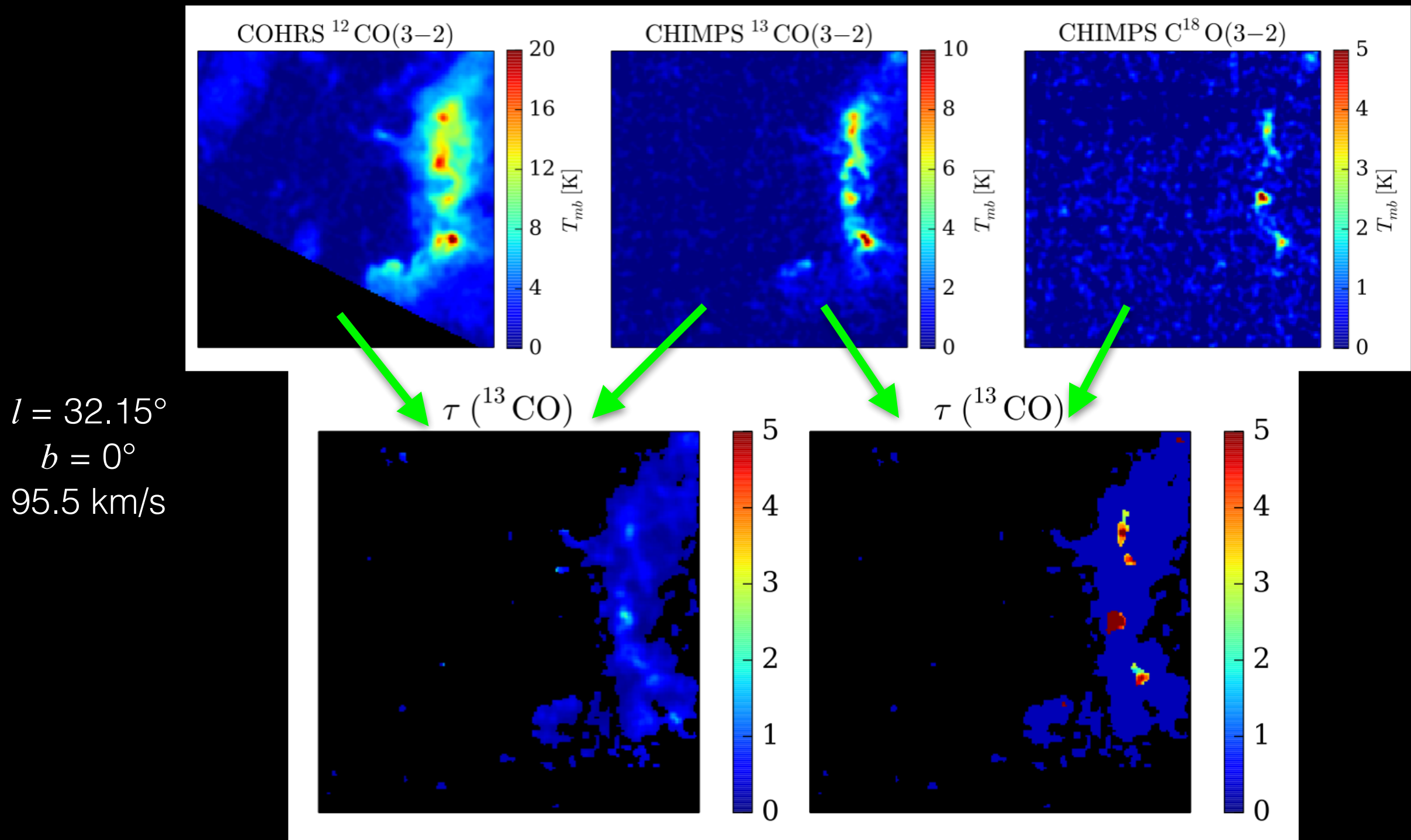
CHIMPS C^{18}O ($J=3 \rightarrow 2$)



COHRS ^{12}CO ($J=3 \rightarrow 2$)

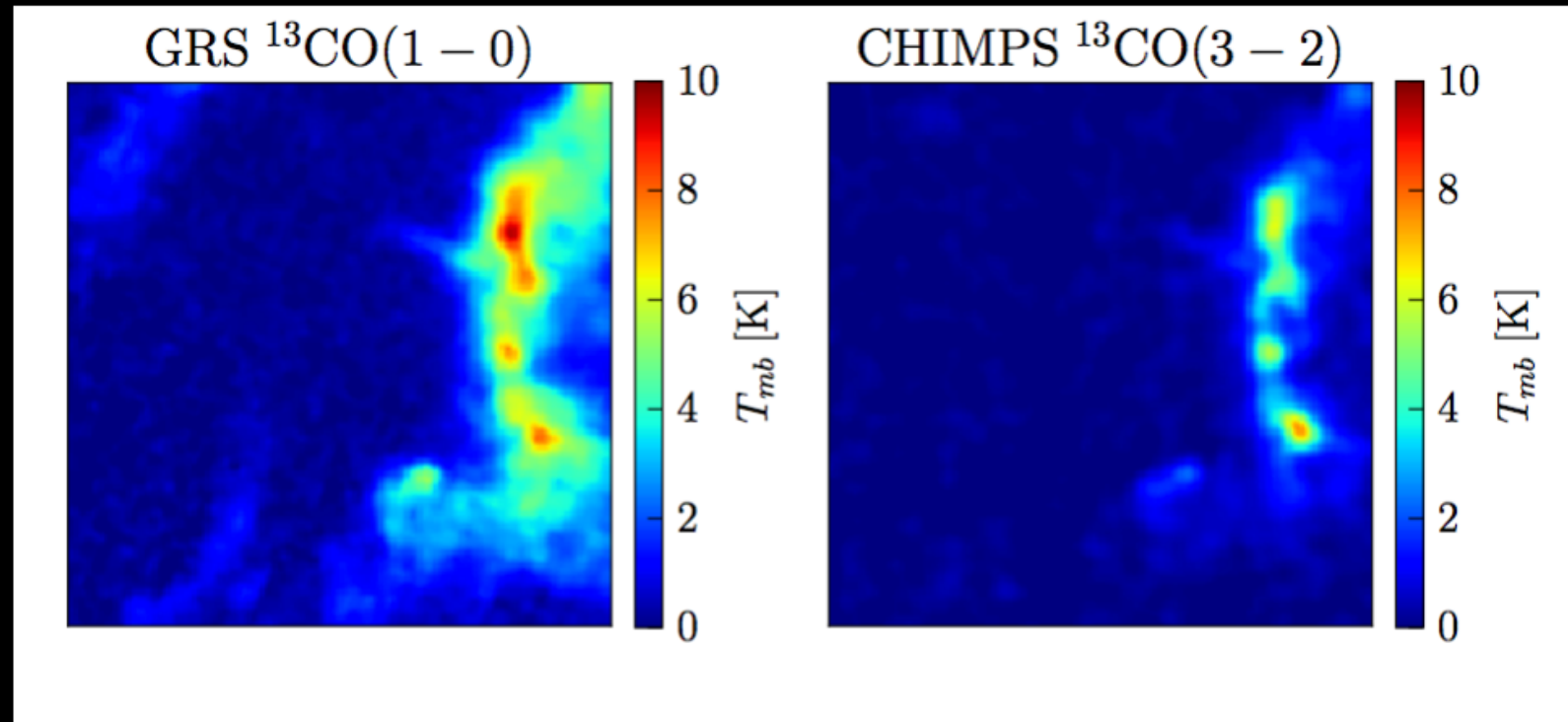


Optical depth



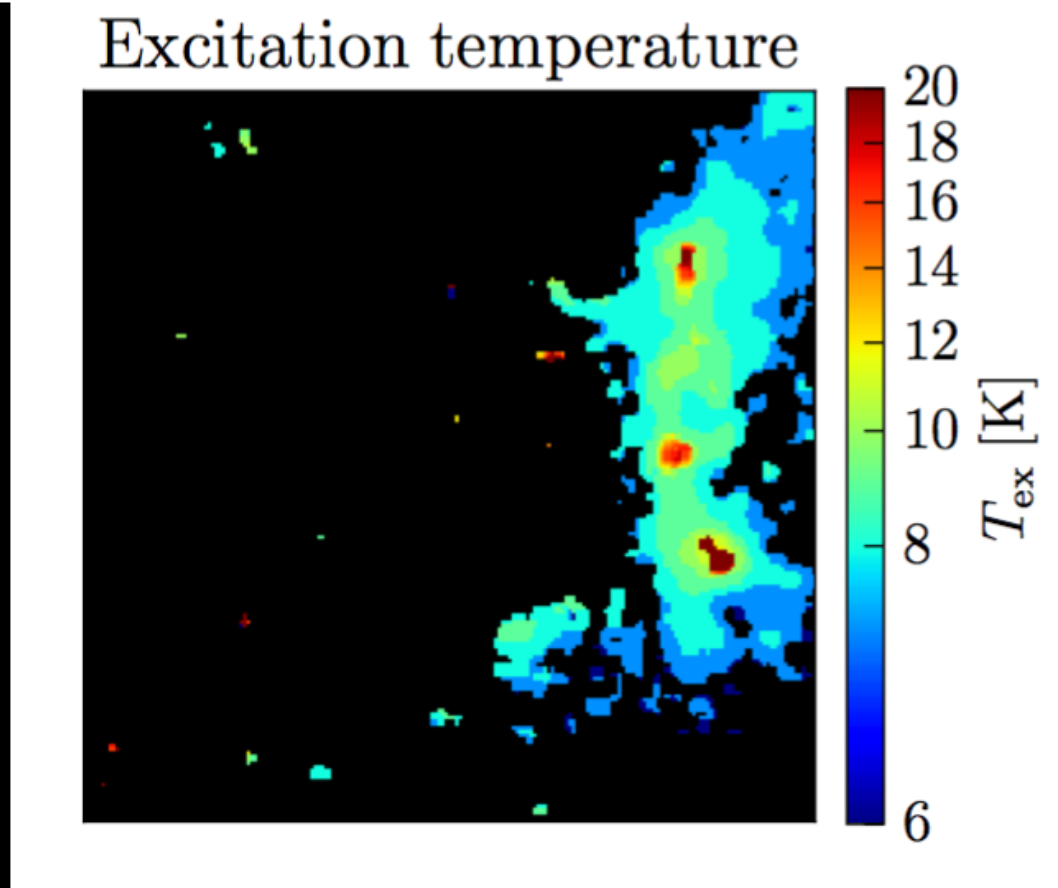
- Not quite a full complement of isotopologue tracers

Excitation temperature



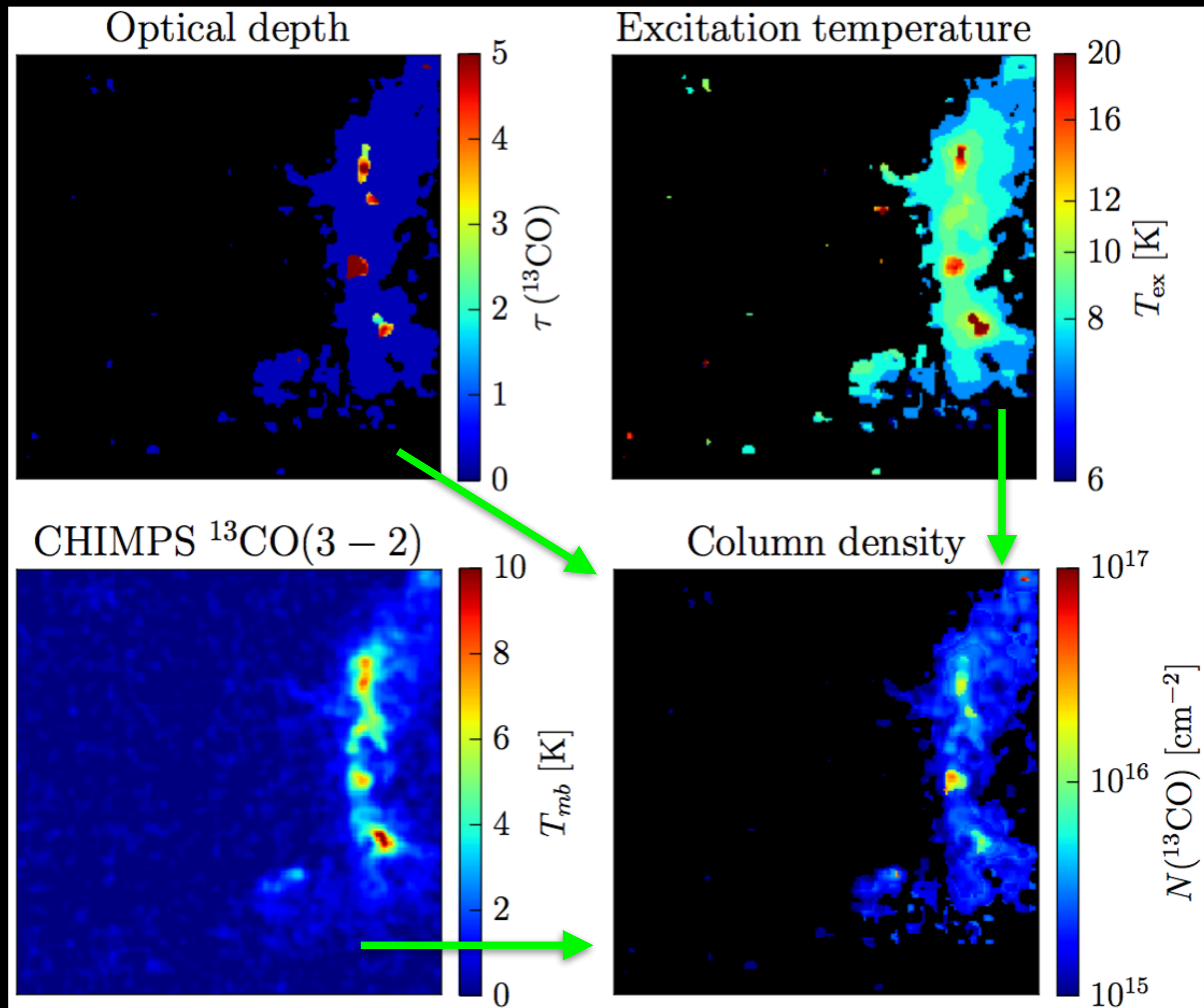
$l = 32.15^\circ$
 $b = 0^\circ$
 95.5 km/s

- 46" resolution,
 interpolated to 27.4"
 $\Rightarrow \pm 30\%$ in N

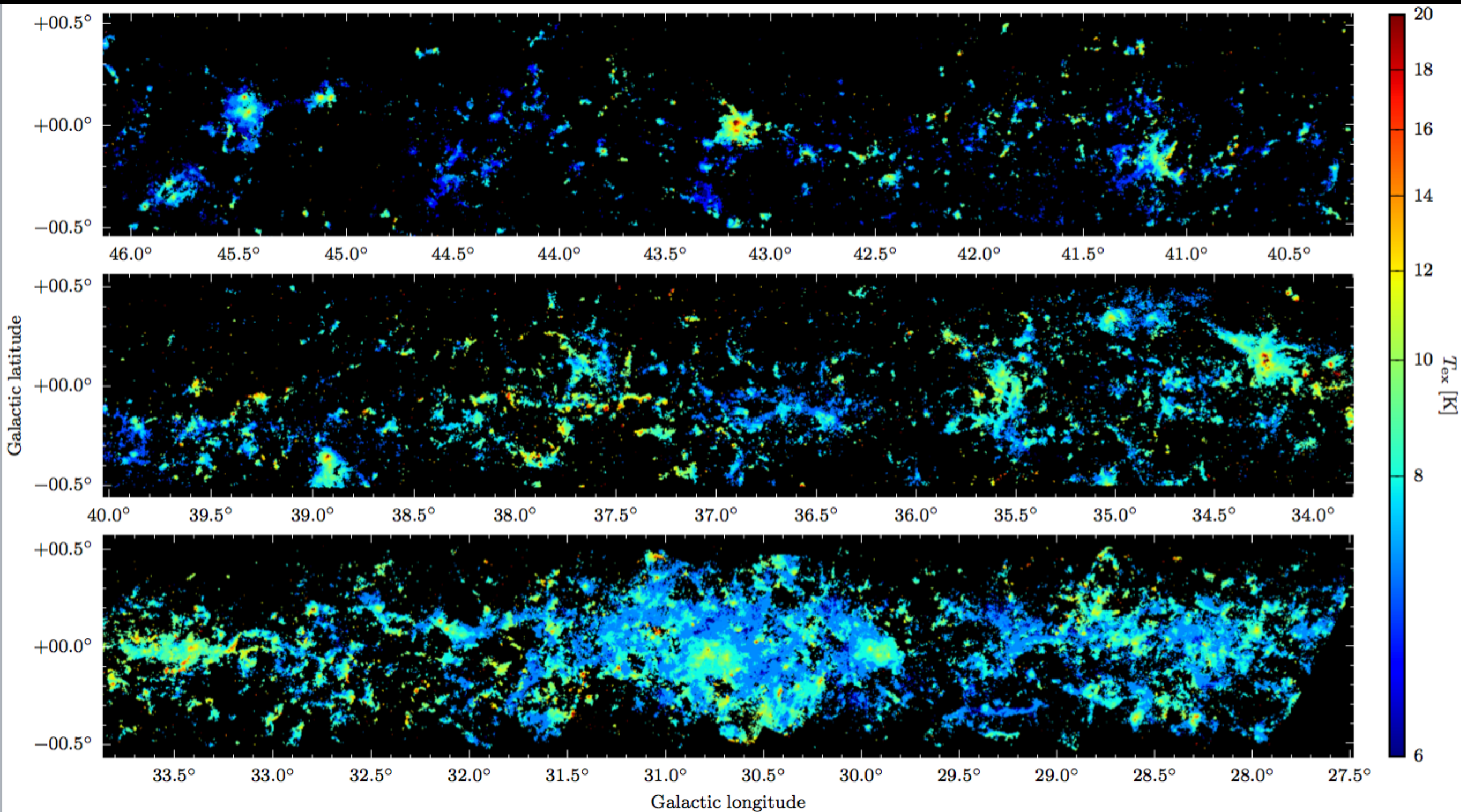


Approximated in
 an optically thin
 and optically thick
 case due to lack
 of $\text{C}^{18}\text{O}(1-0)$

$l = 32.15^\circ$
 $b = 0^\circ$
95.5 km/s



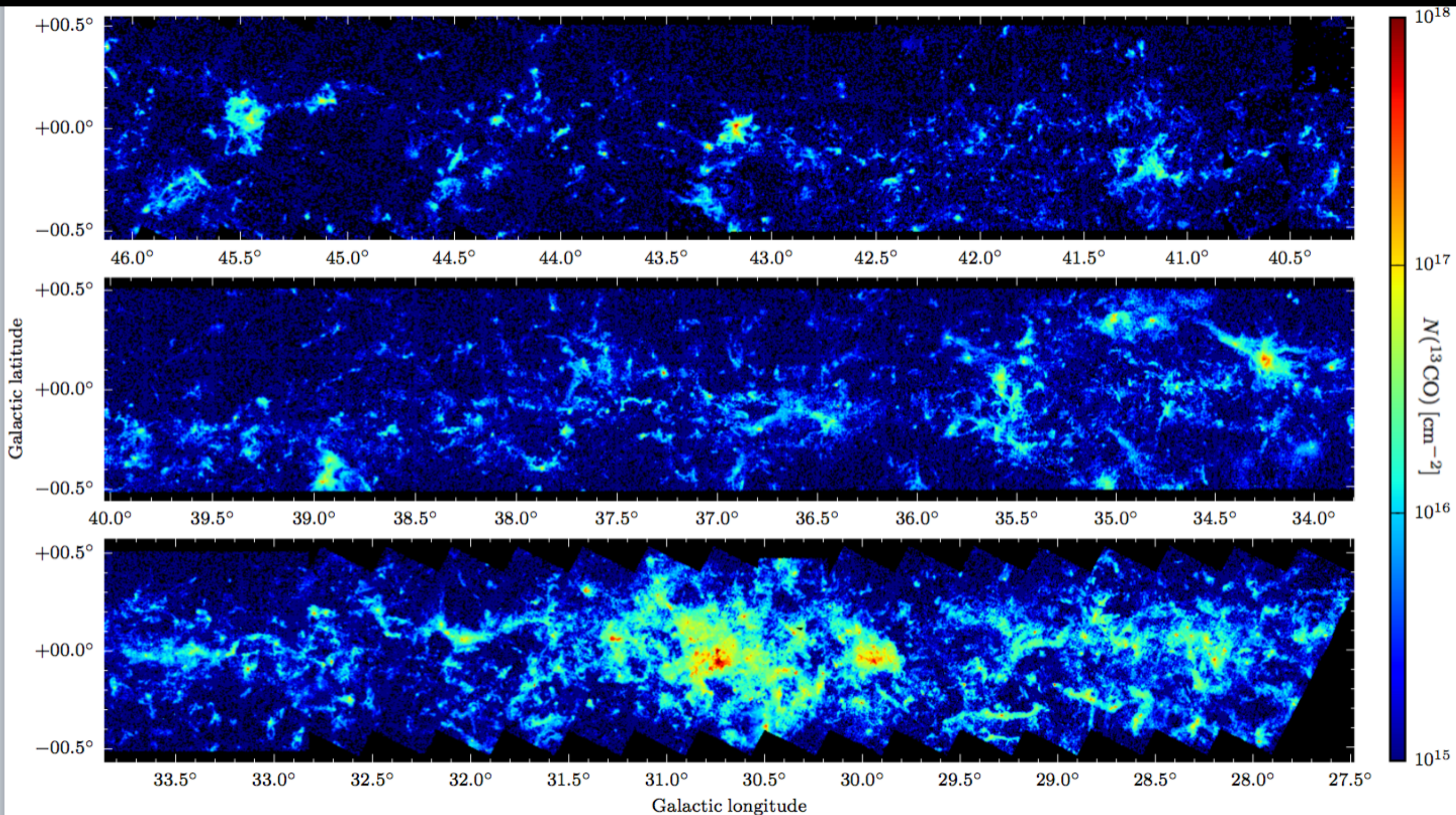
Median excitation temperature /spectrum $\sim 8 - 10$ K



46'' resolution

^{13}CO (3 – 2) column density

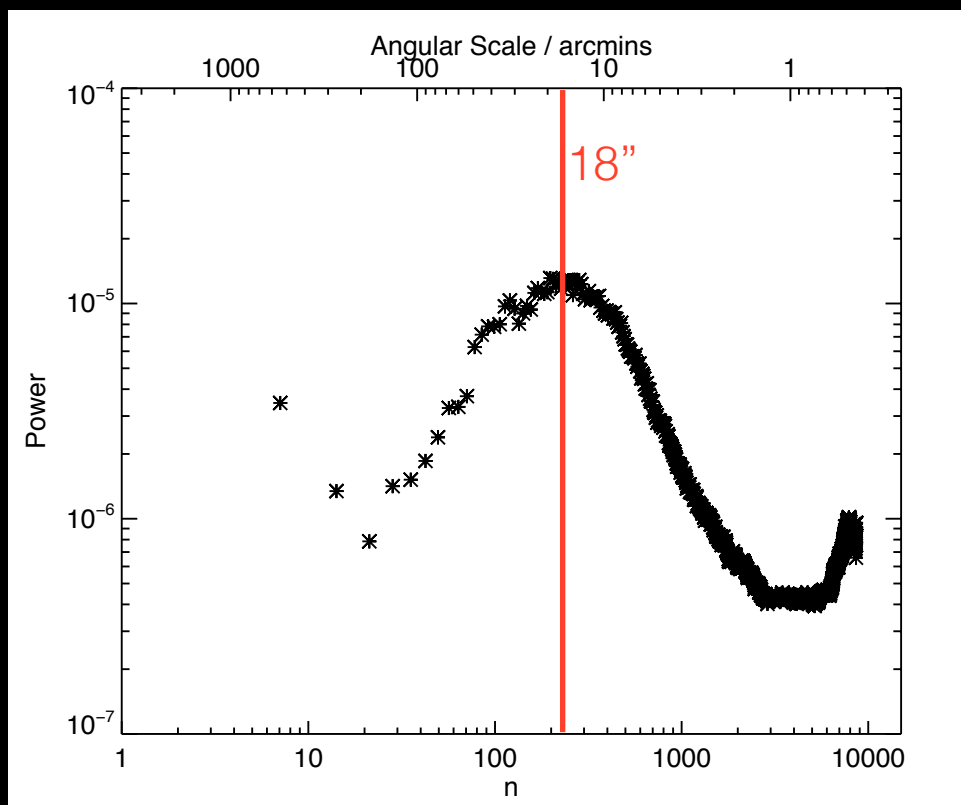
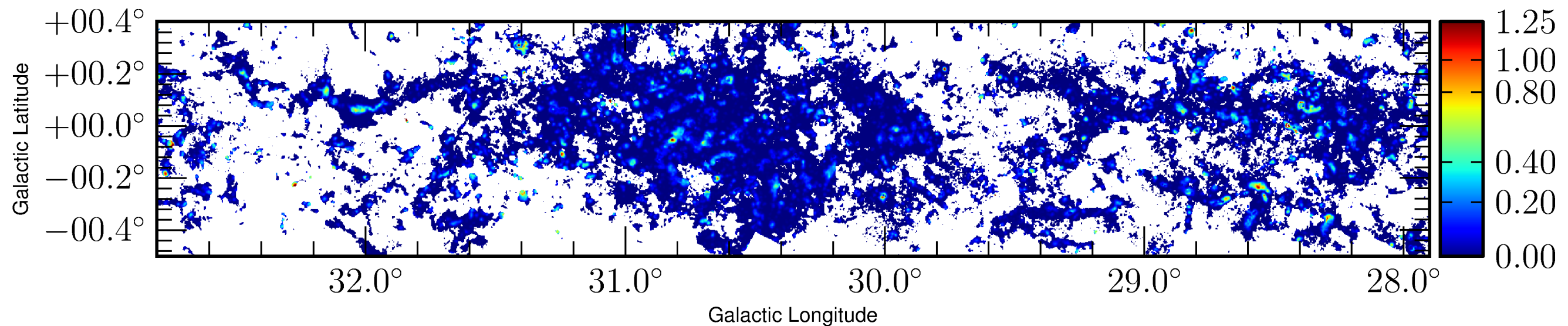
$N(\text{H}_2) \sim 10^{24} \text{ cm}^{-2}$



27.4" resolution

$N(\text{H}_2) \sim 10^{21} \text{ cm}^{-2}$

CFE Maps

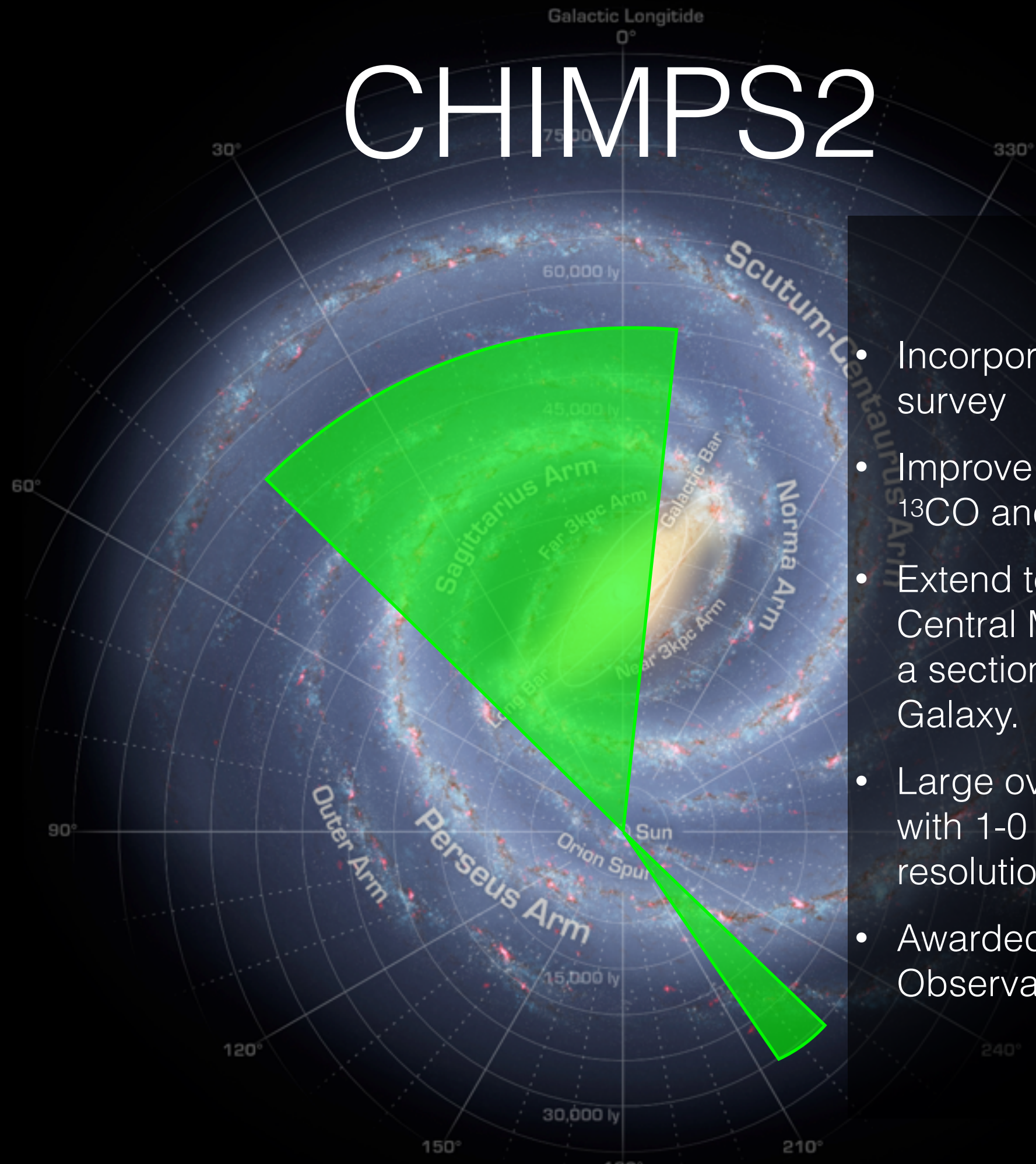


Clump formation efficiency (CFE) maps -
using JCMT Plane Survey data (Eden+17)
and CHIMPS data

Improvements coming!

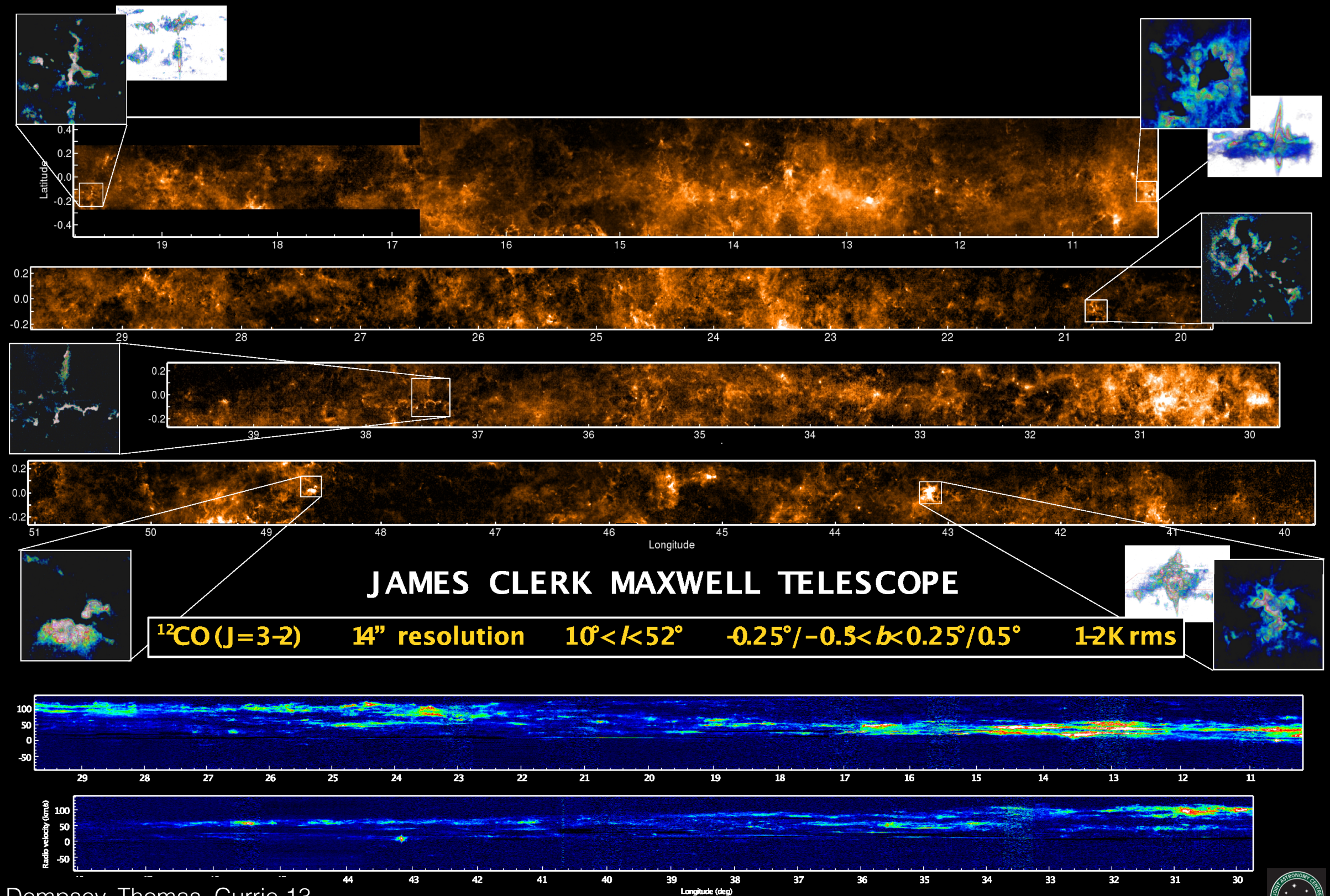
- JPS column densities calculated using the PPMAP method
- Comparisons to simulations

CHIMPS2

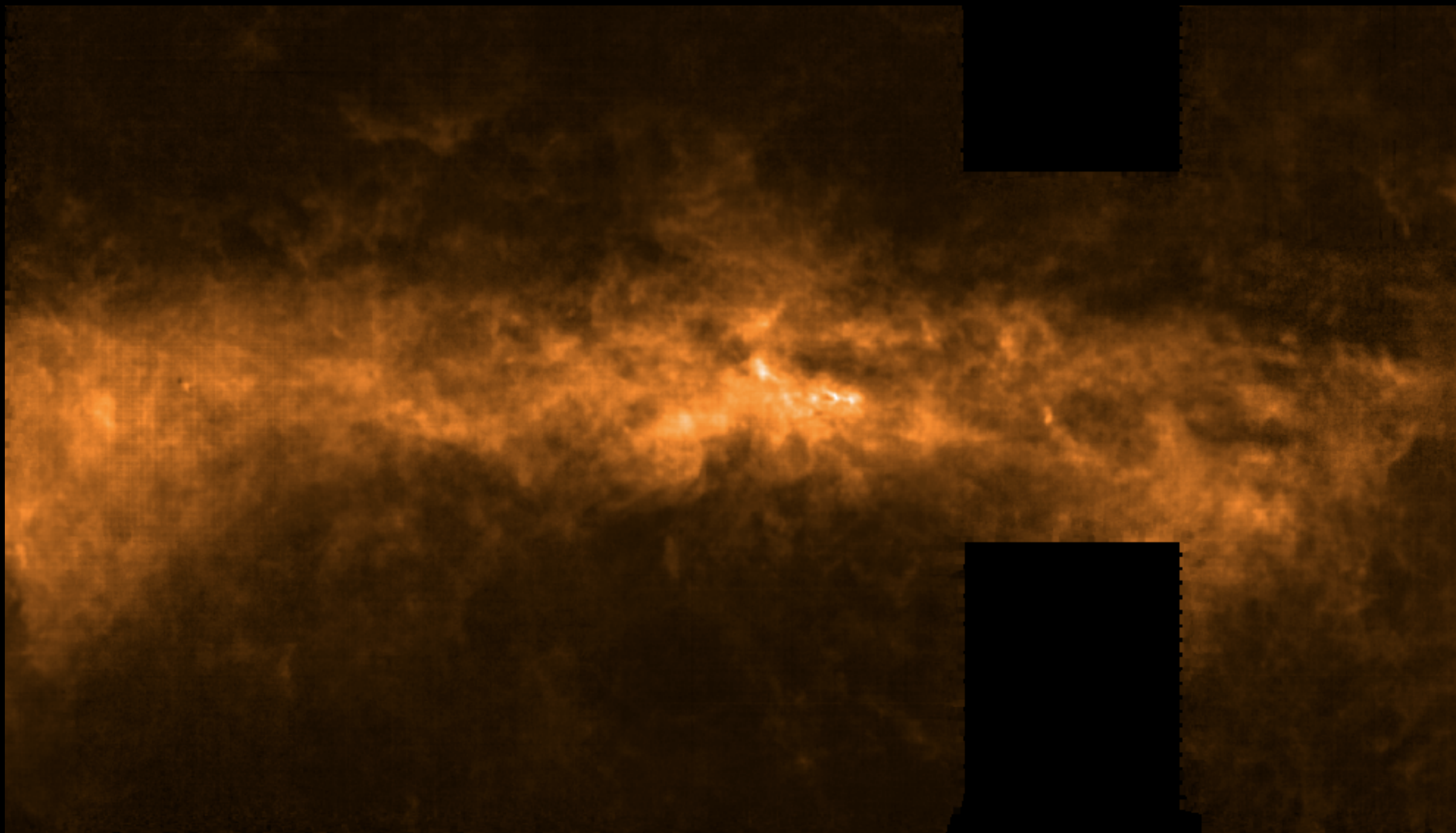


- Incorporate new COHRS survey
- Improve coverage in ^{12}CO , ^{13}CO and C^{18}O (3-2)
- Extend to Inner Galaxy and Central Molecular Zone, and a section in the Outer Galaxy.
- Large overlap with FUGIN with 1-0 lines at matching resolution.
- Awarded 404 hours. Observations are ongoing

COHRS - ^{12}CO

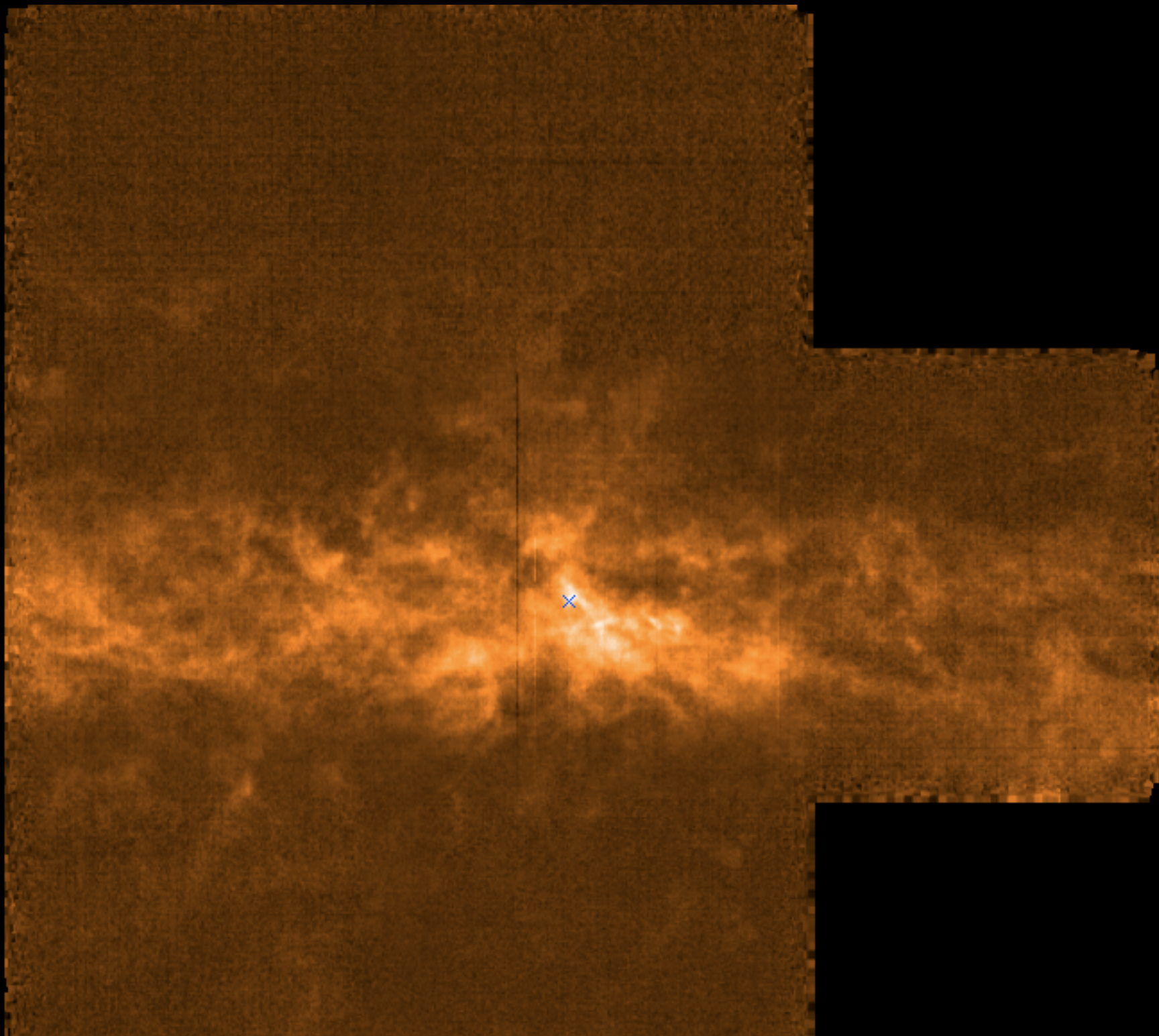


CHIMPS2 CMZ



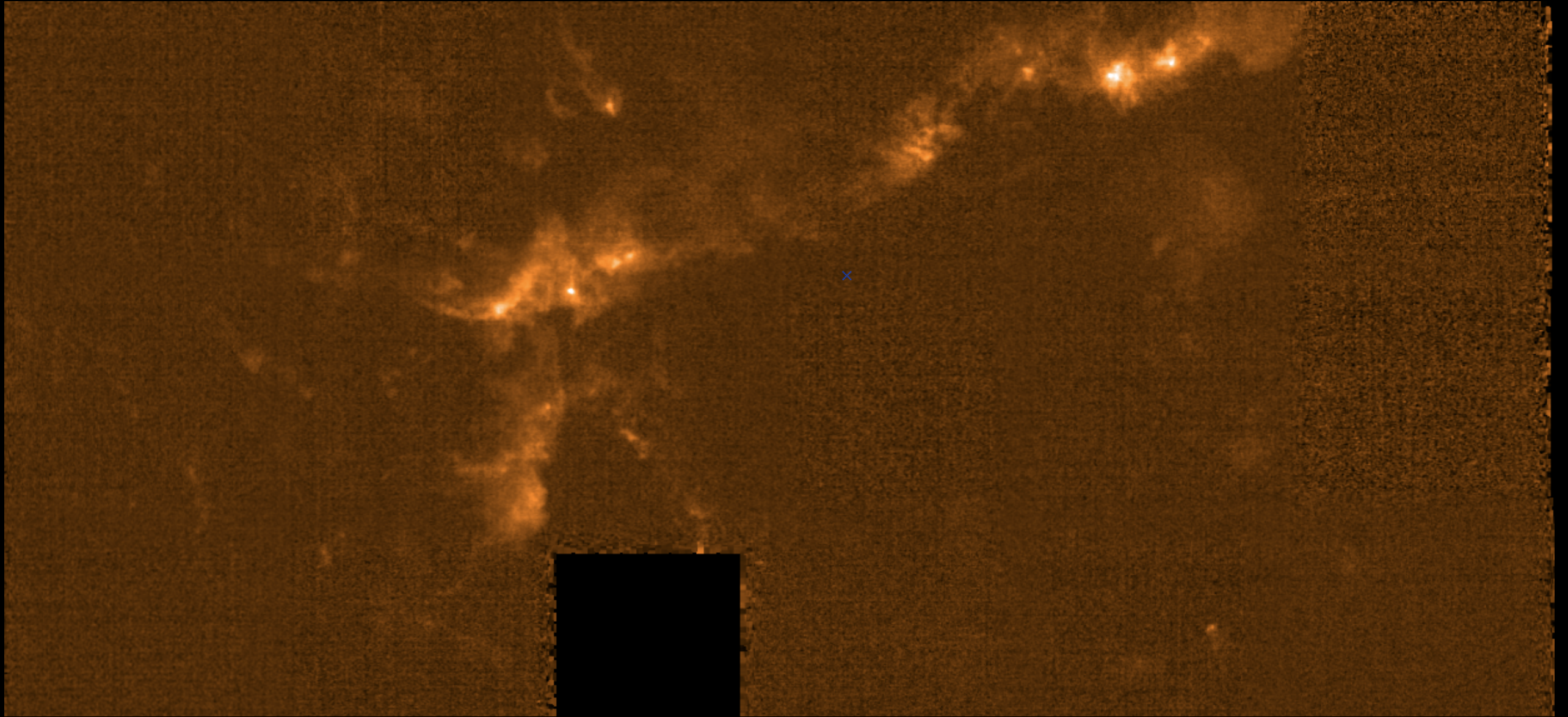
^{12}CO

CHIMPS2 CMZ



^{13}CO

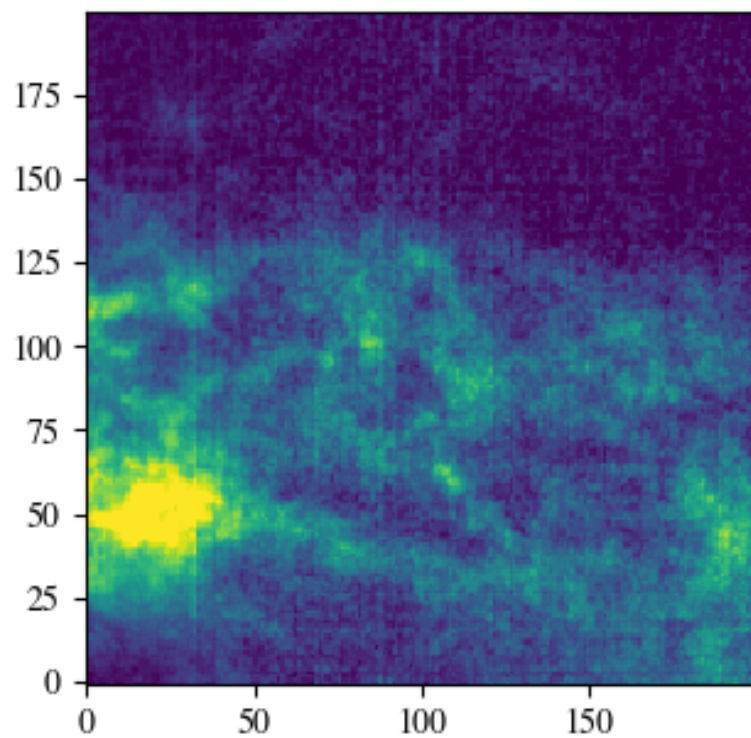
CHIMPS2 Outer Galaxy



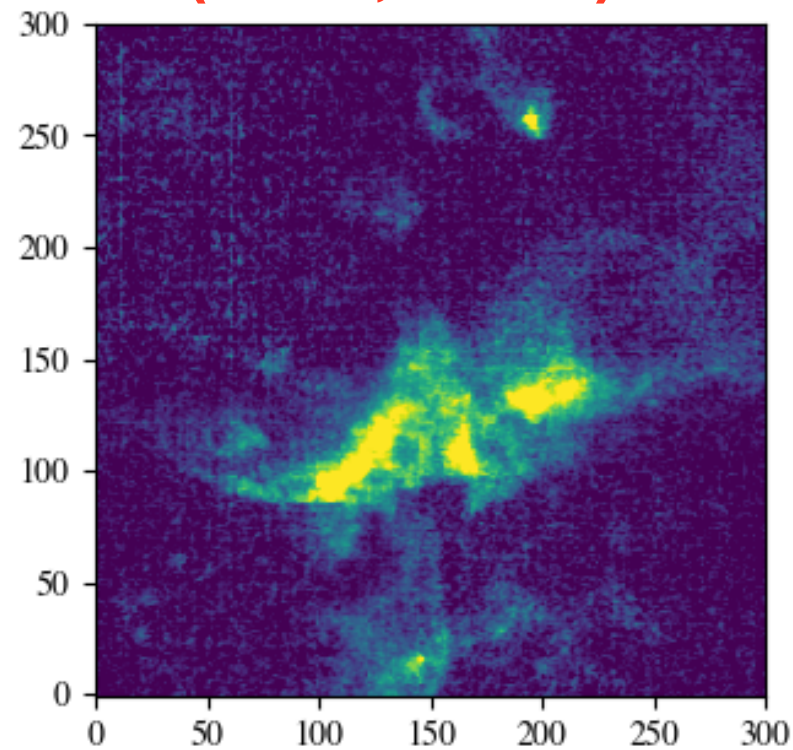
^{12}CO

Turbulent Properties

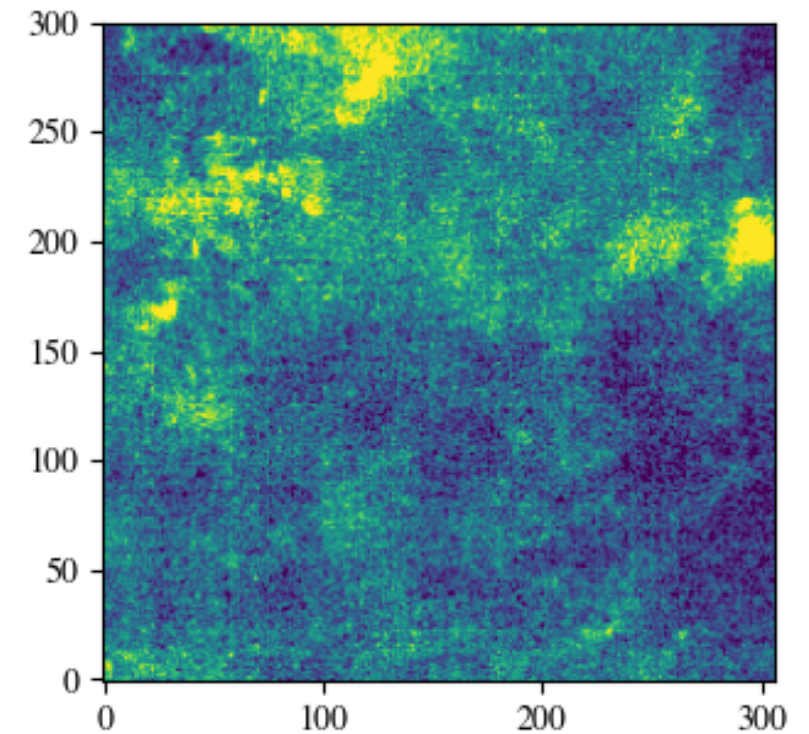
CMZ



**Outer Galaxy
(^{12}CO , $l=217^\circ$)**

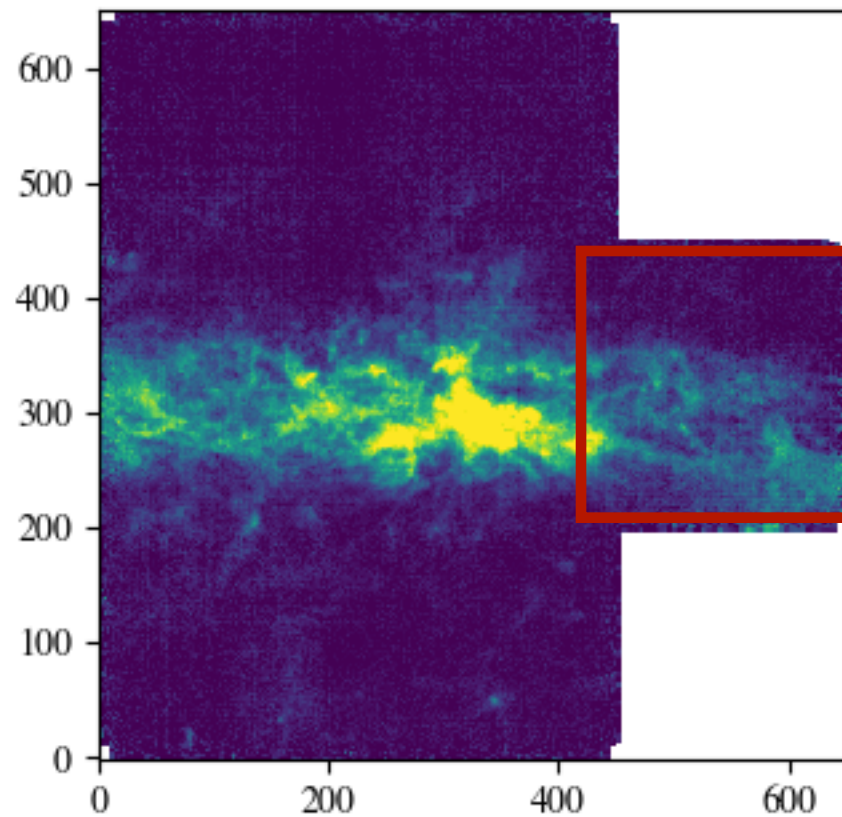


**Inner Galaxy
(^{12}CO , $l=37.5^\circ$)**

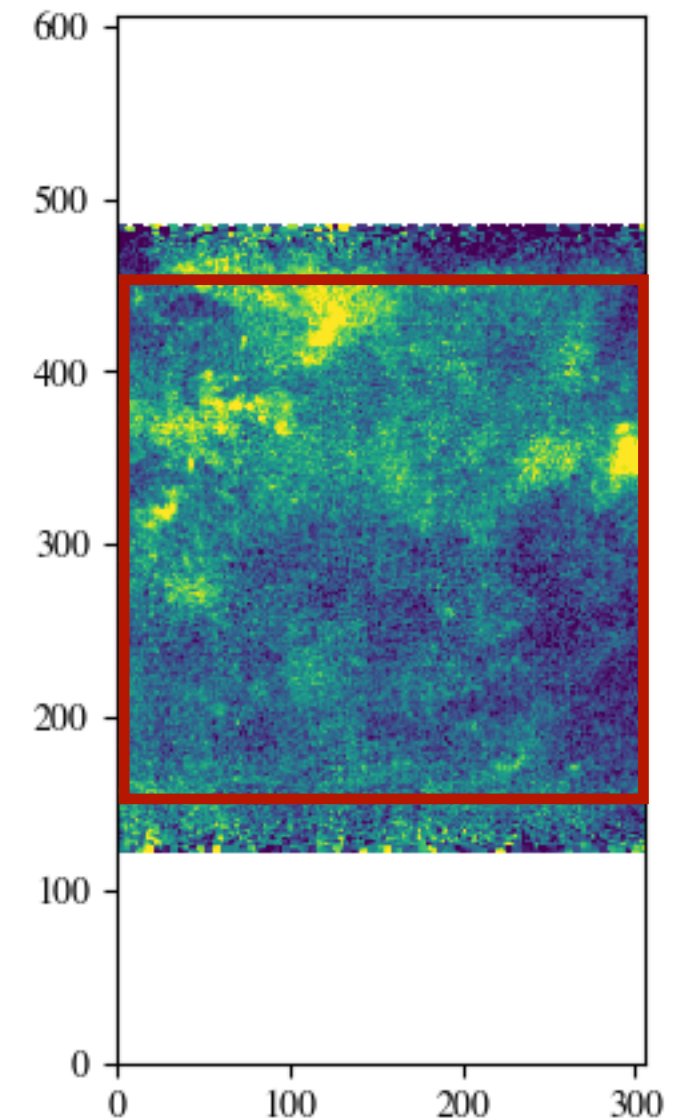
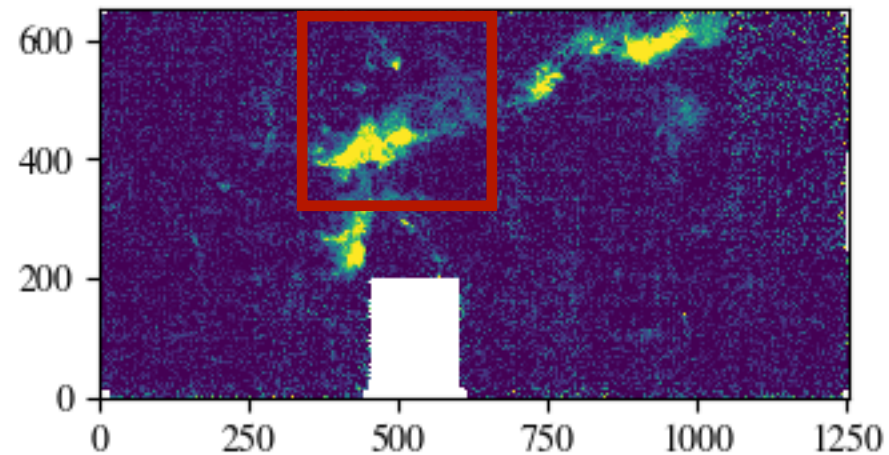


Inner Galaxy (12CO, $l=37.5^\circ$)

CMZ

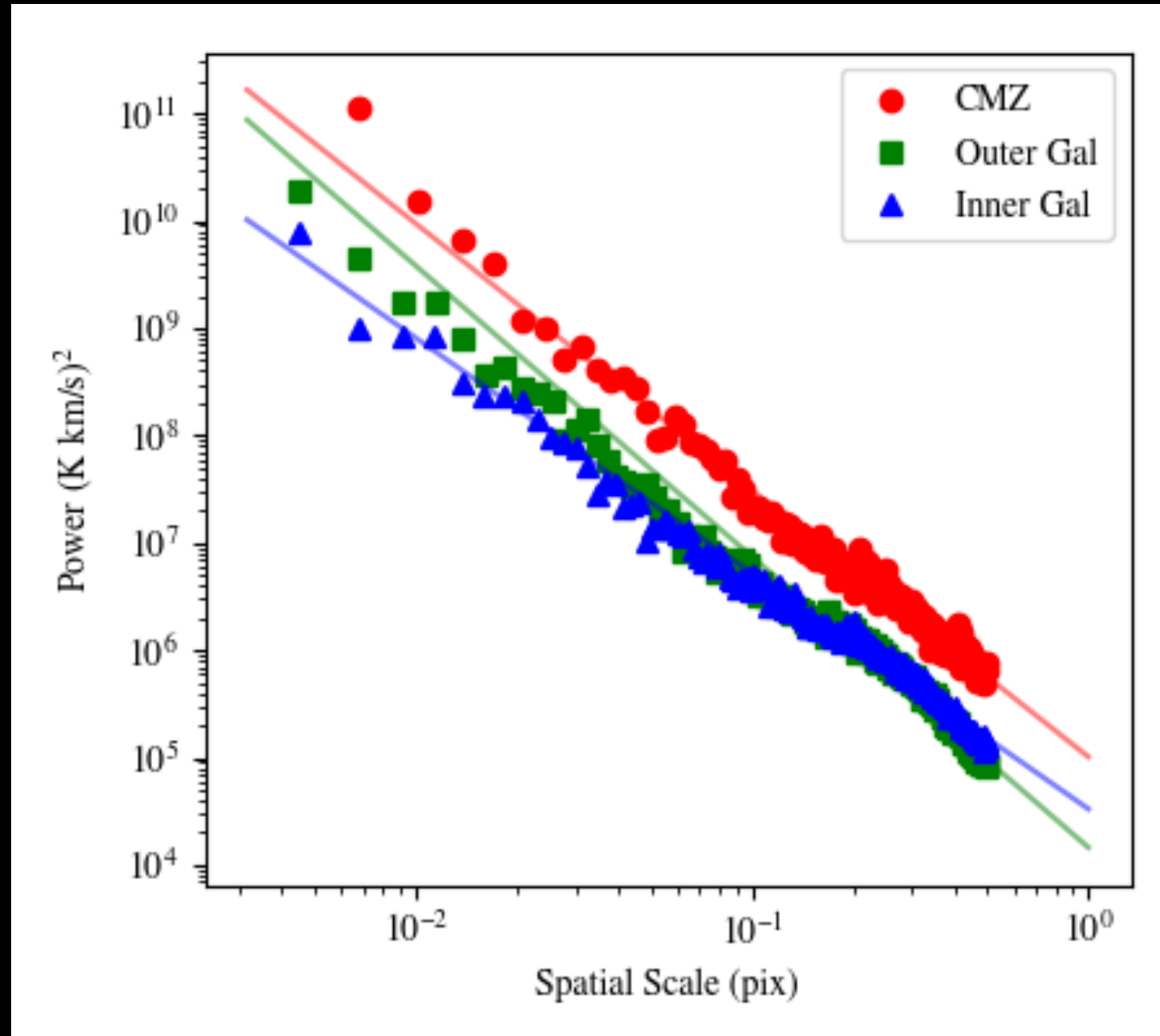


Outer Galaxy (12CO, $l=217^\circ$)



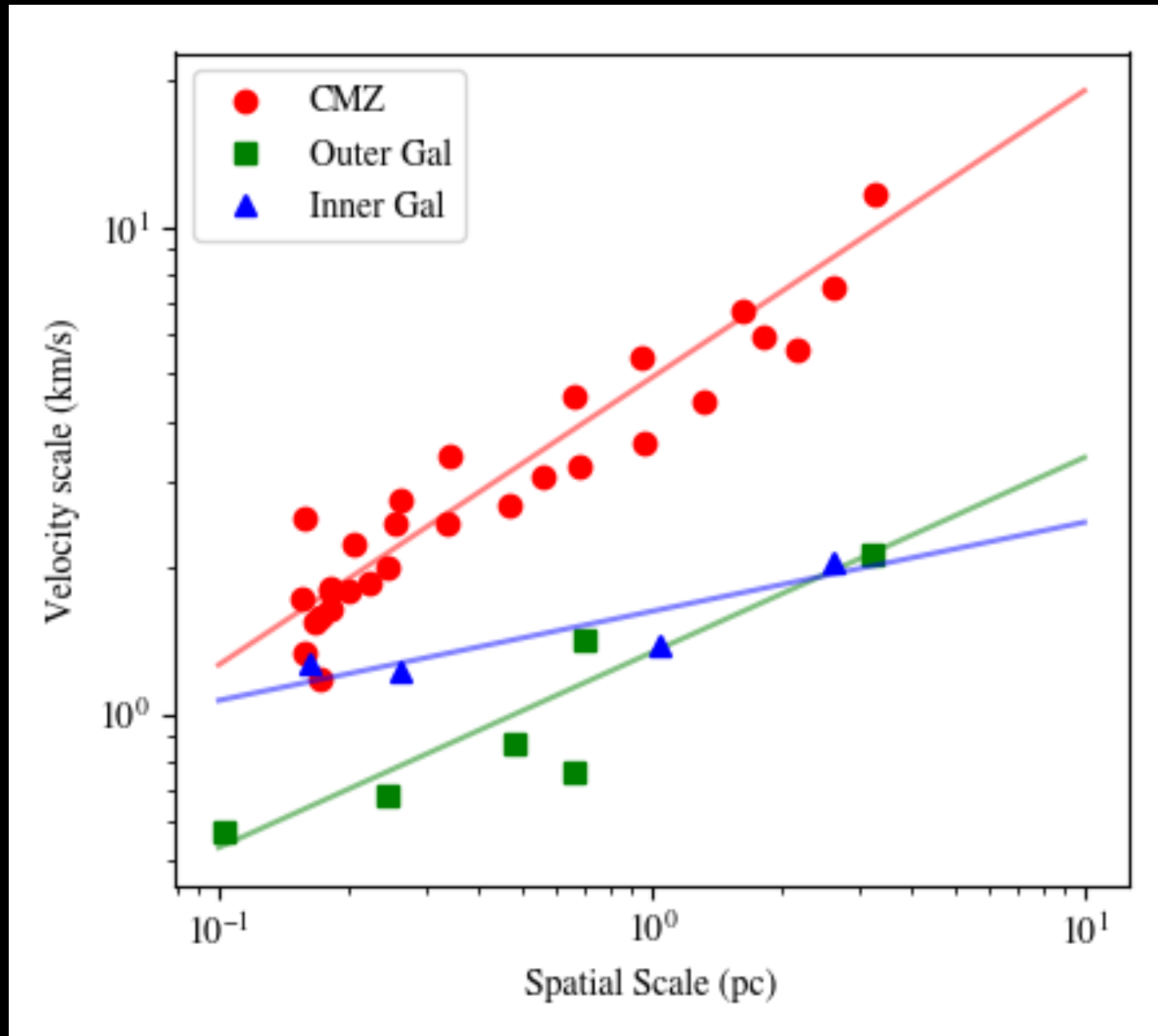
Extract boxes for analysis using TurbuStat package
(Koch+17)

Comparing Spatial Power Spectrum

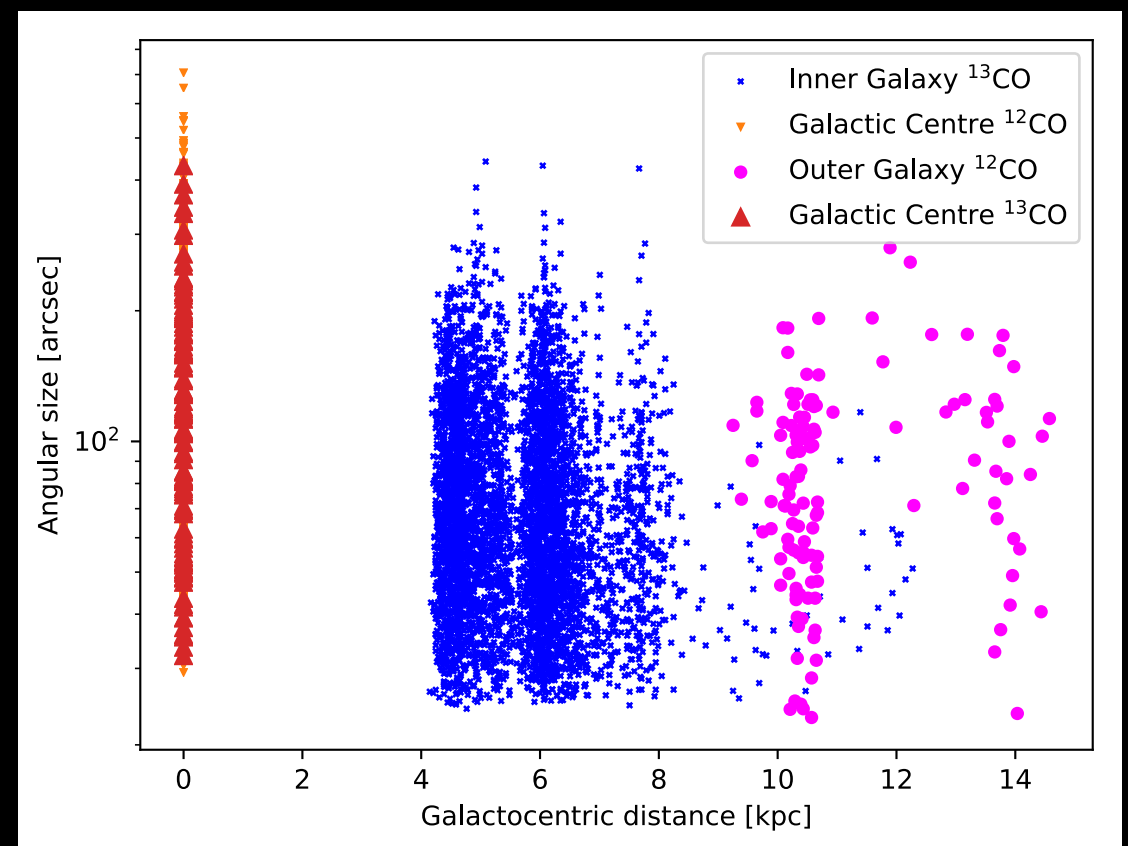
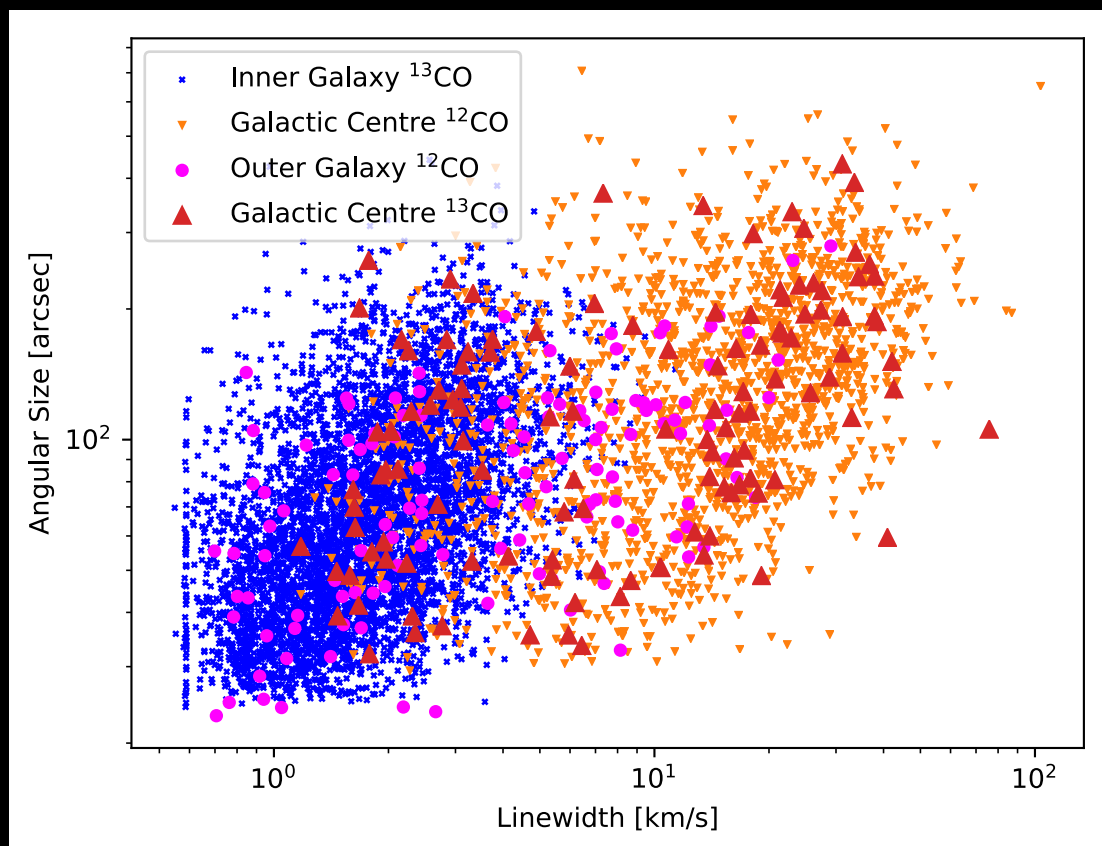
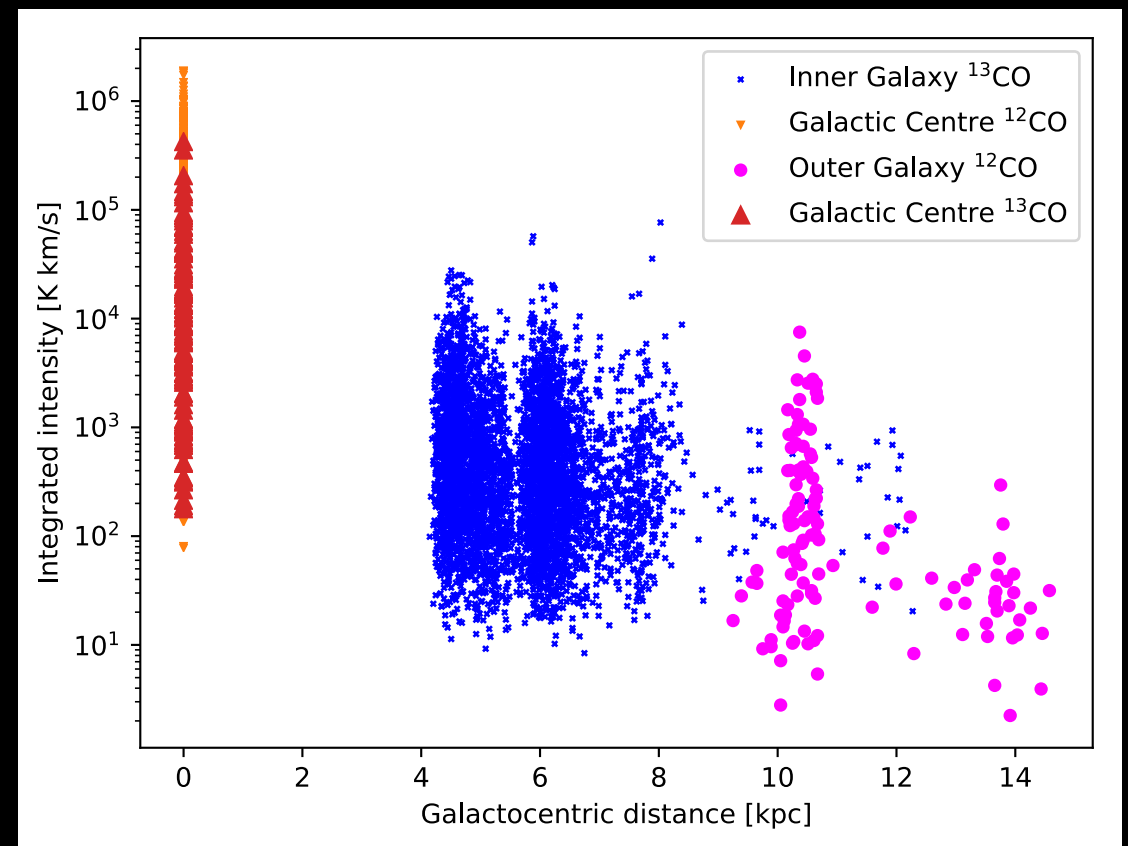
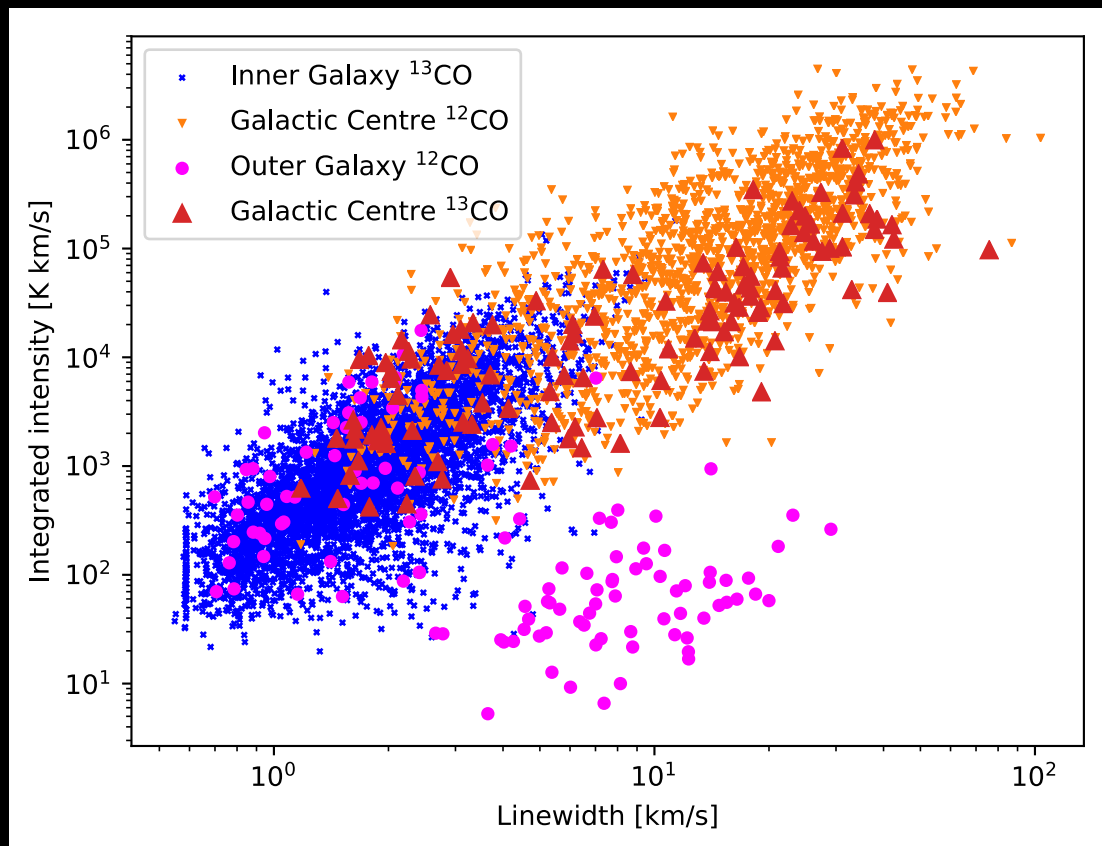


Similar slopes across regions

PCA Analysis of size-line width



PCA attempts to measure the size-line width relationship within resolved molecular clouds. CMZ shows increased velocity widths at common spatial scale.



Conclusions

- CHIMPS data is available
- CHIMPS column density and temperature maps coming soon
- New JCMT survey, CHIMPS2 supplying new molecular data across vast Galactic environments.