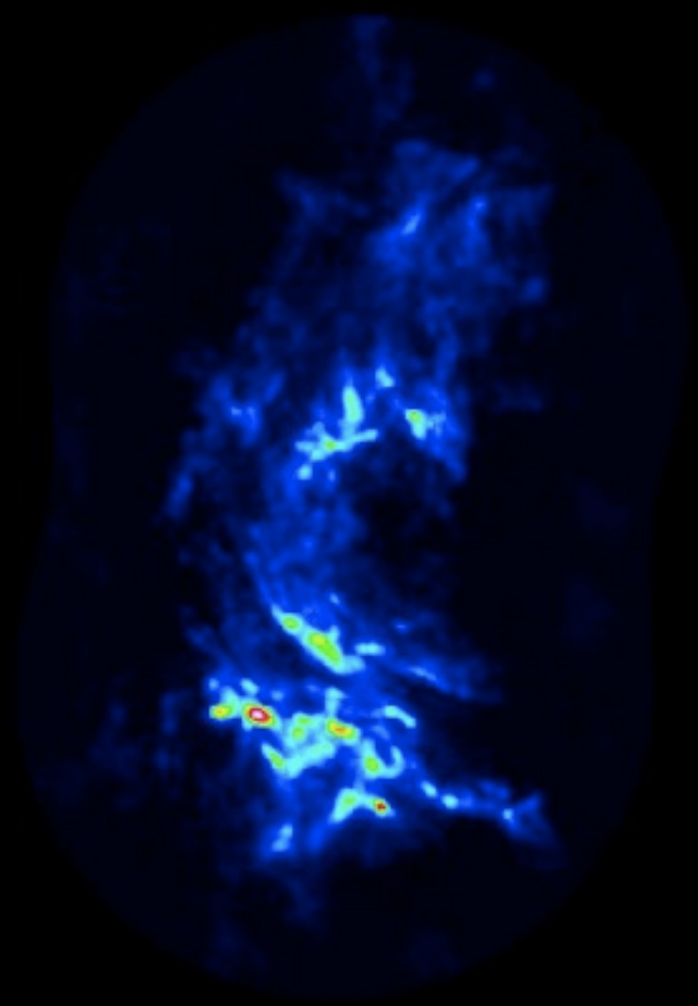
Hot Gas, Masers, and Cloud Collisions:

The extreme properties of molecular gas at the heart of the Milky Way Galaxy



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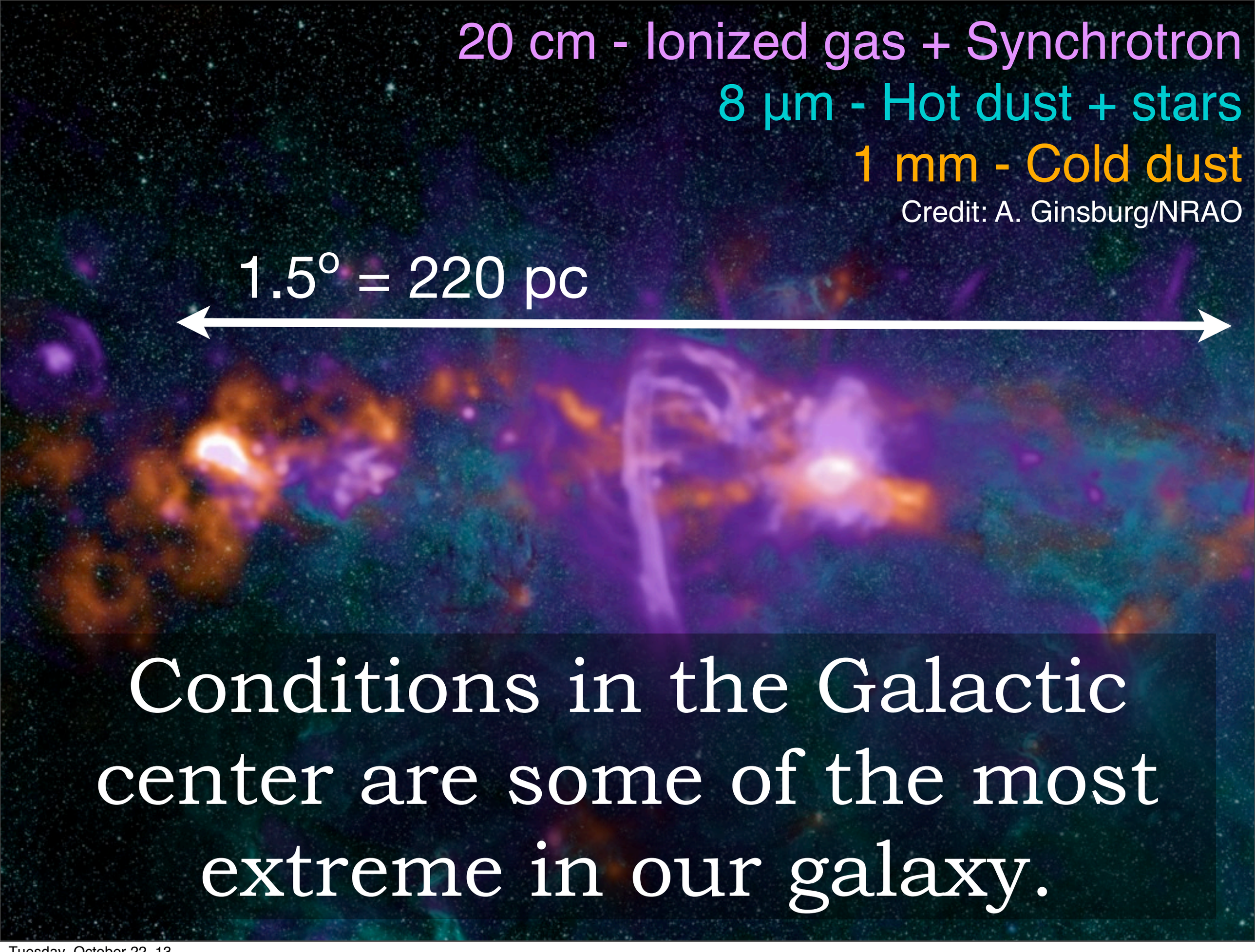
Cornelia Lang (U. Iowa)
Mark Morris (UCLA)
Juergen Ott (NRAO)
Natalie Butterfield (U. Iowa)
Dominic Ludovici (U. Iowa)
Susan Schmitz (U. Iowa)
Anika Schmeideke (U. Köln)



Conditions in the Galactic center are some of the most extreme in our galaxy.

Survey Details

Karl G. Jansky Very Large Array

DnC configuration (2” resolution, or **0.1 pc**)

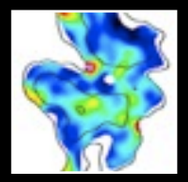
24-25, 27, & 36 GHz, covering 4 GHz continuum bandwidth, NH_3, CH_3OH, HC_3N, and 3 recombination lines

Multiple lines of NH_3, HC_3N, CH_3OH → Determine physical conditions in the raw materials for **future** star formation

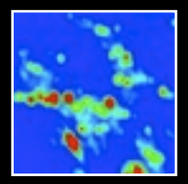
Sensitive Continuum Maps → Trace ionized gas and stellar winds from **past and current** star formation

Hydrogen Recombination lines → Compare the kinematics of the ionized and molecular gas

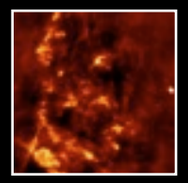
M0.25+0.01 *(The Brick)*



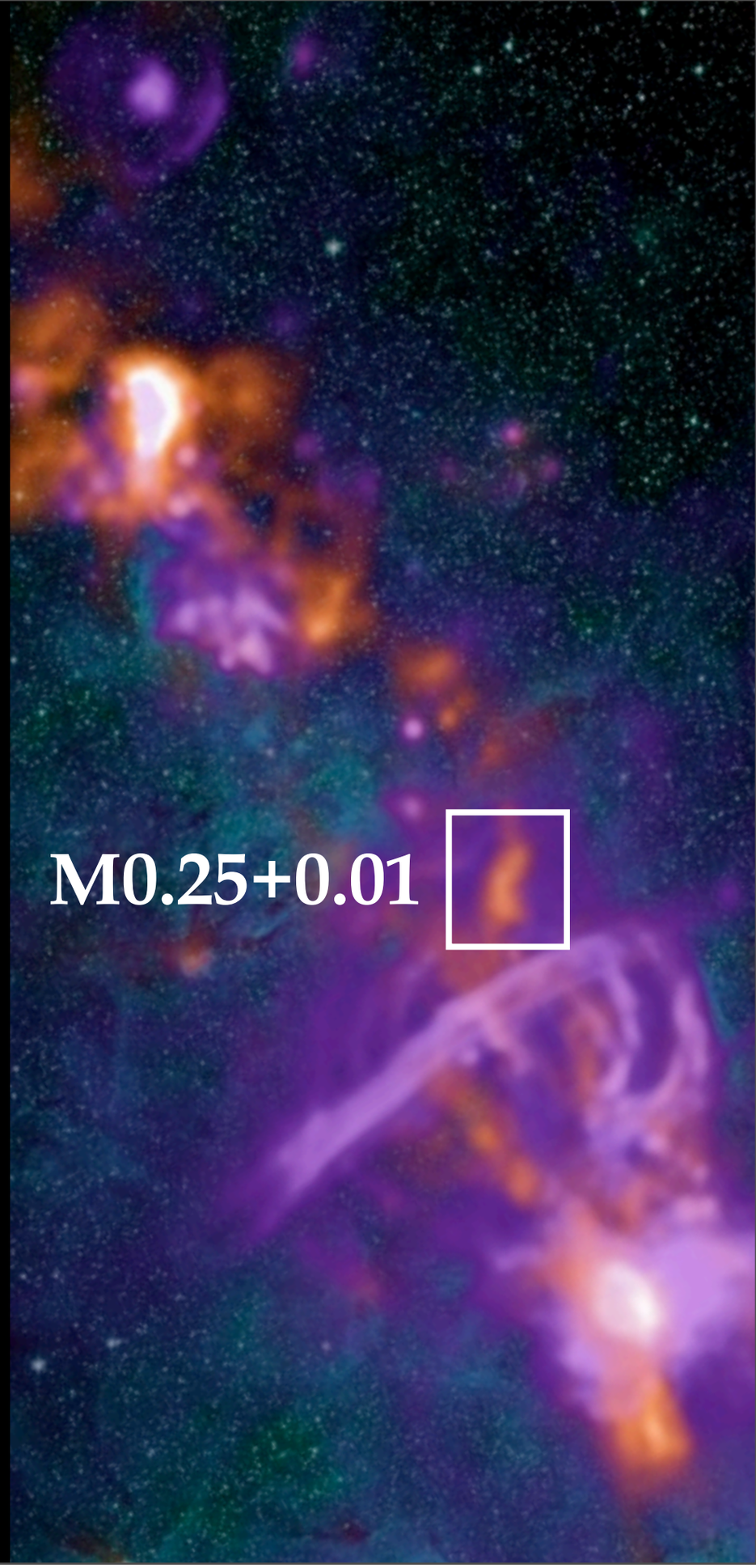
Physical Conditions



Methanol masers



Nature of the Radio continuum



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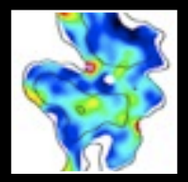

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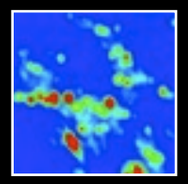

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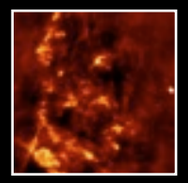
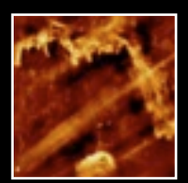
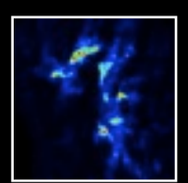


Nature of the Radio continuum

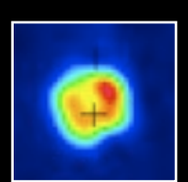
Survey Preview



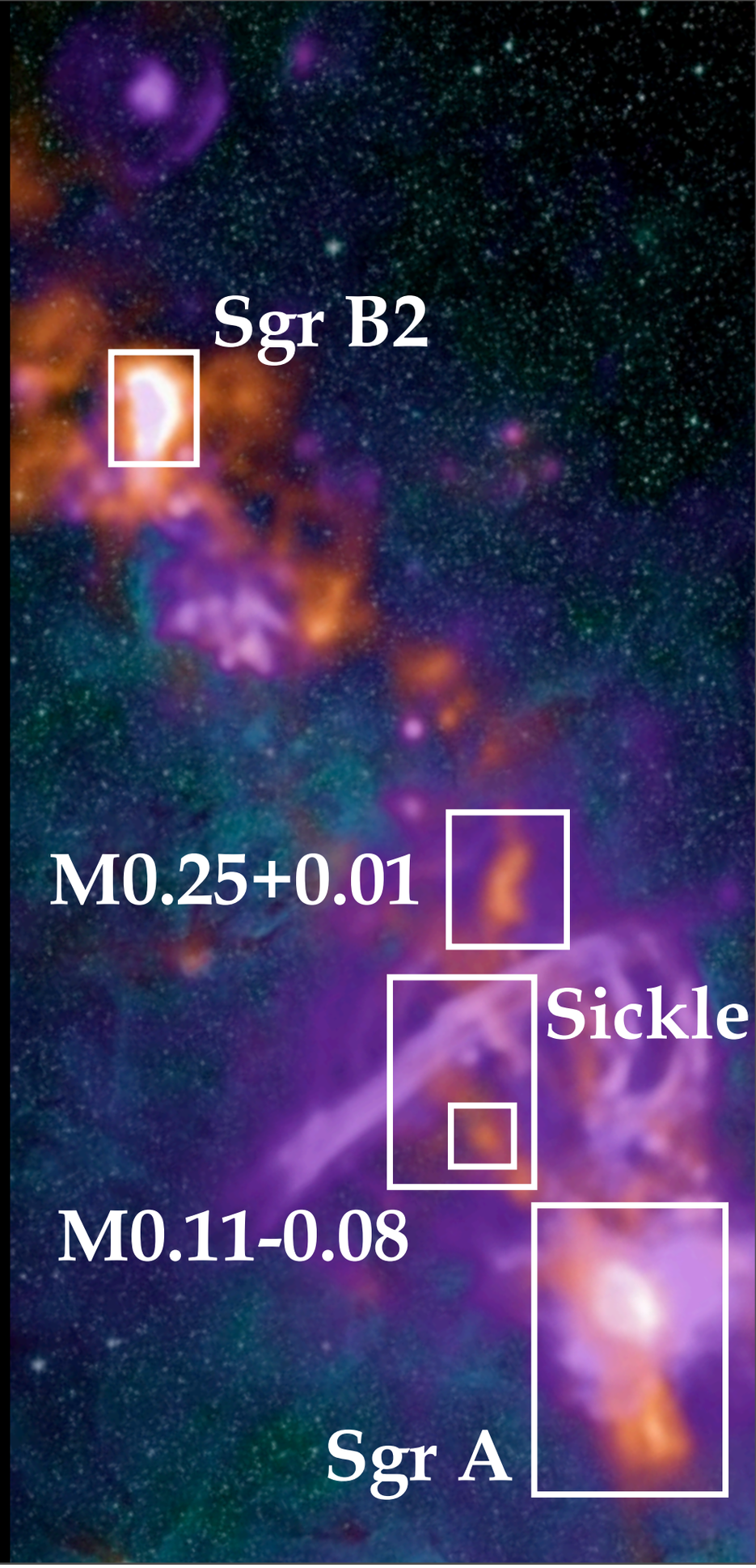
the Sickle



Sgr A



Sgr B2



NH_3

(1,1)

(2,2)

5 pc

(3,3)

(4,4)

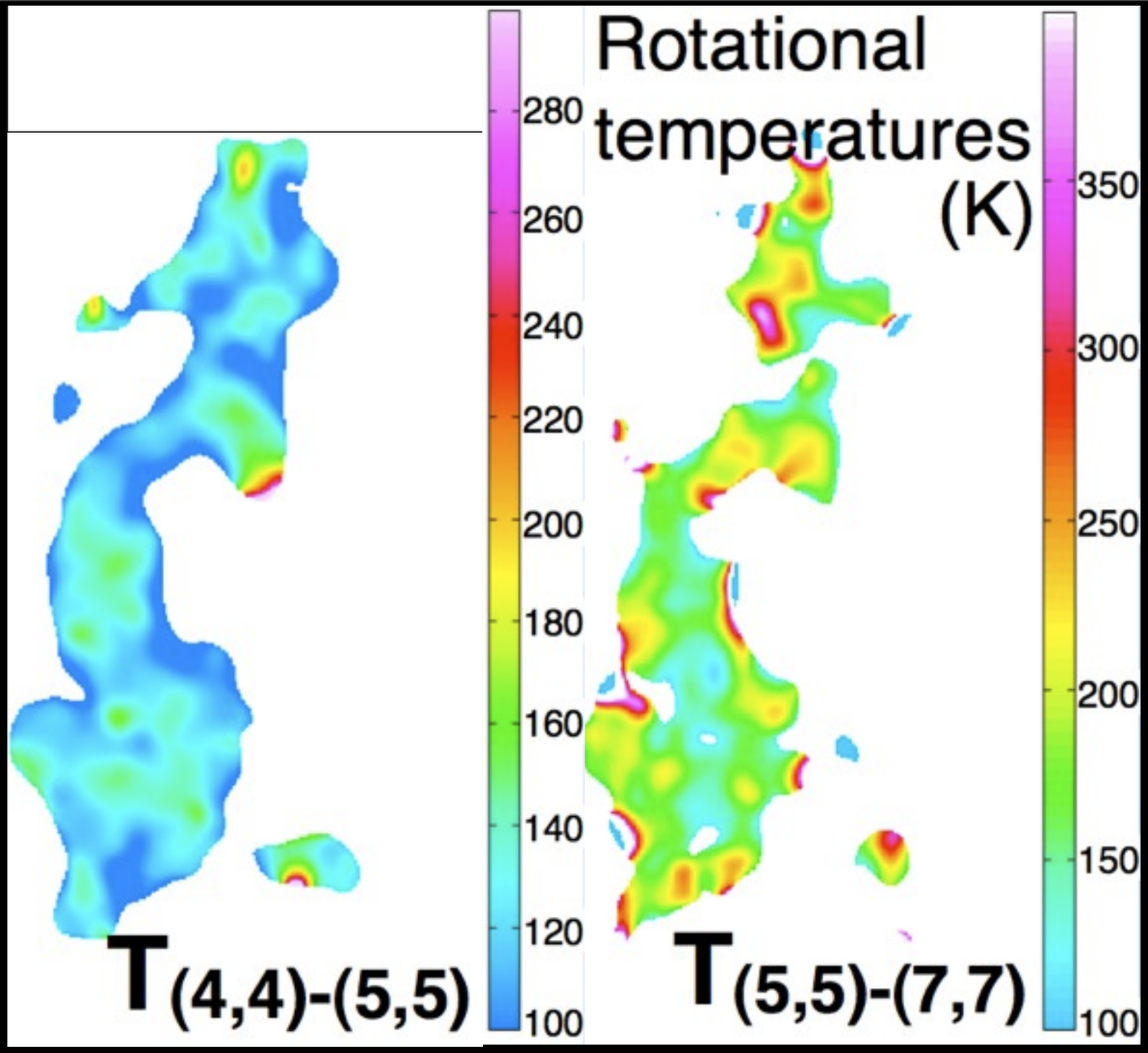
(5,5)

(6,6)

Mills+
in prep.

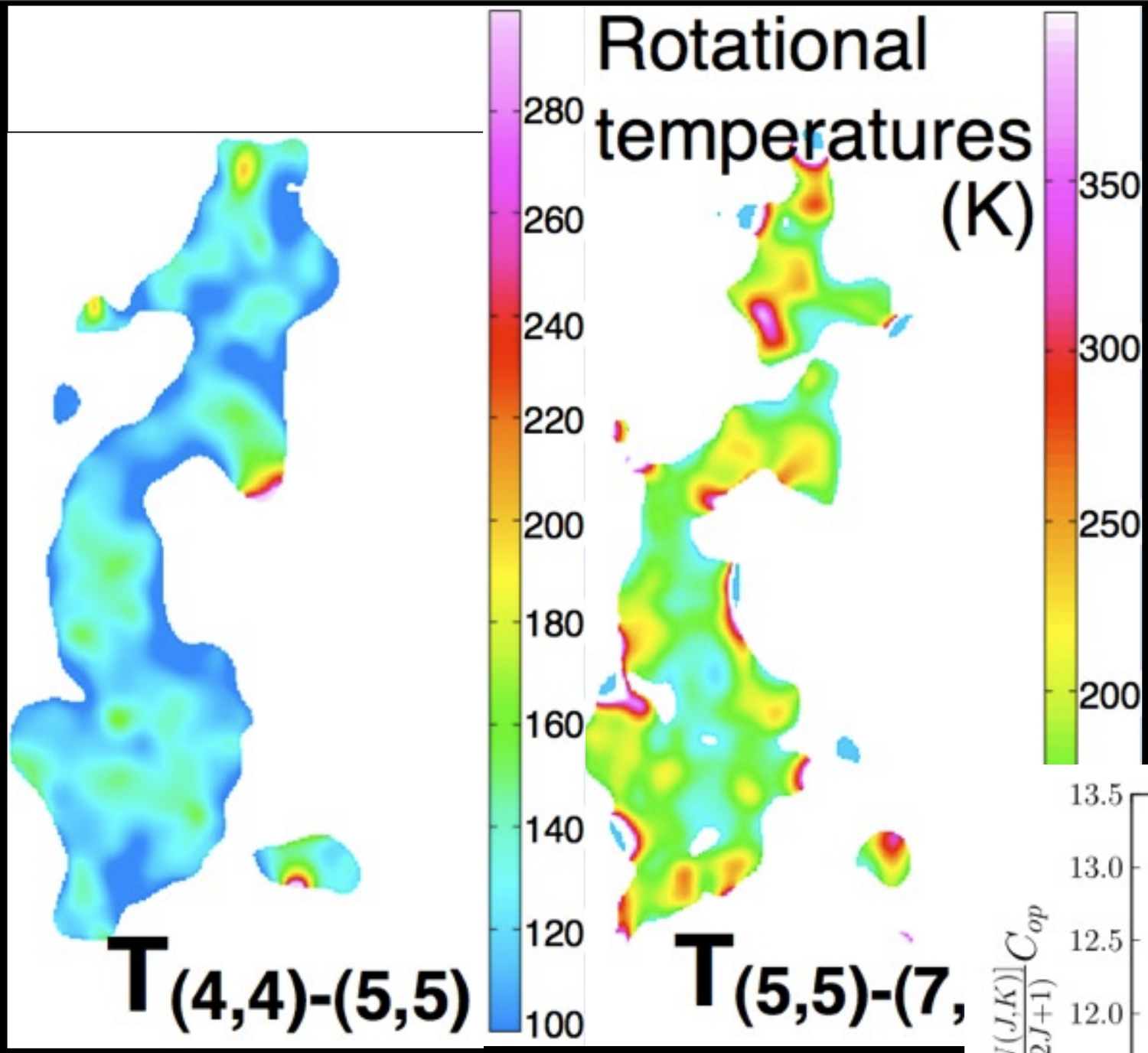
M0.25+0.01

Can measure
temperatures



Lines above (4,4) trace temperatures 100-200 K

Mills+ in prep



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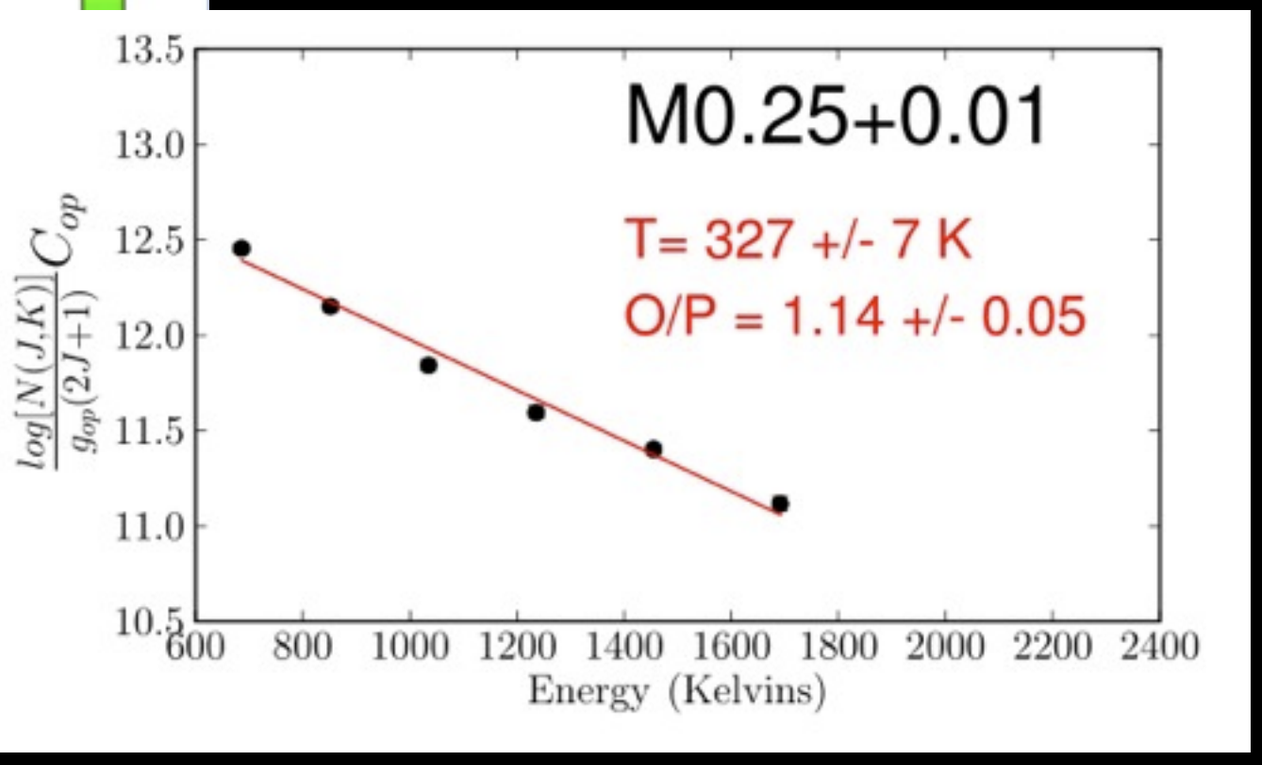
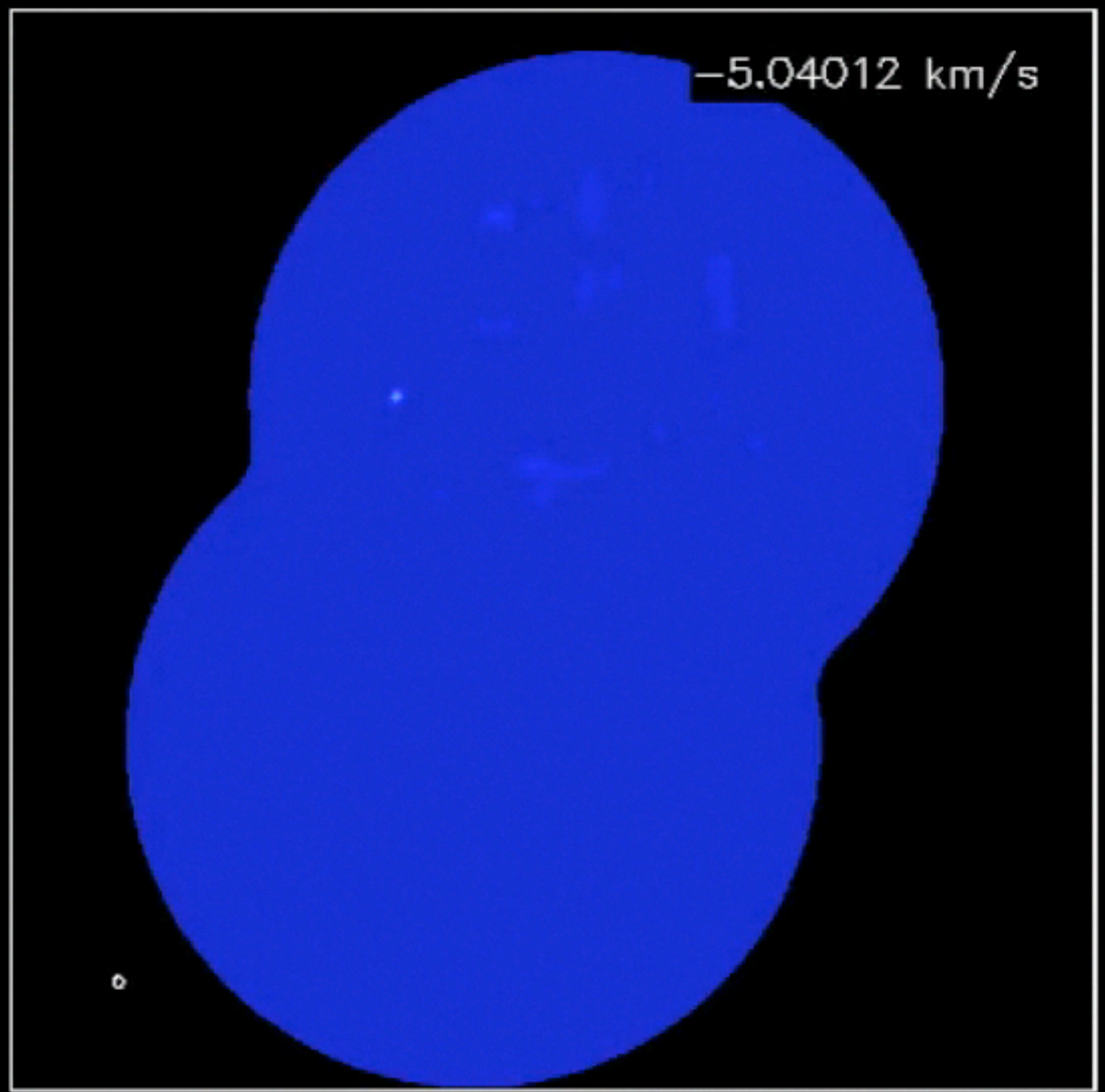


Also a >300 K component detected with NH_3 lines above (8,8) with the GBT

Mills & Morris 2013

36 GHz Methanol point sources: Masers?

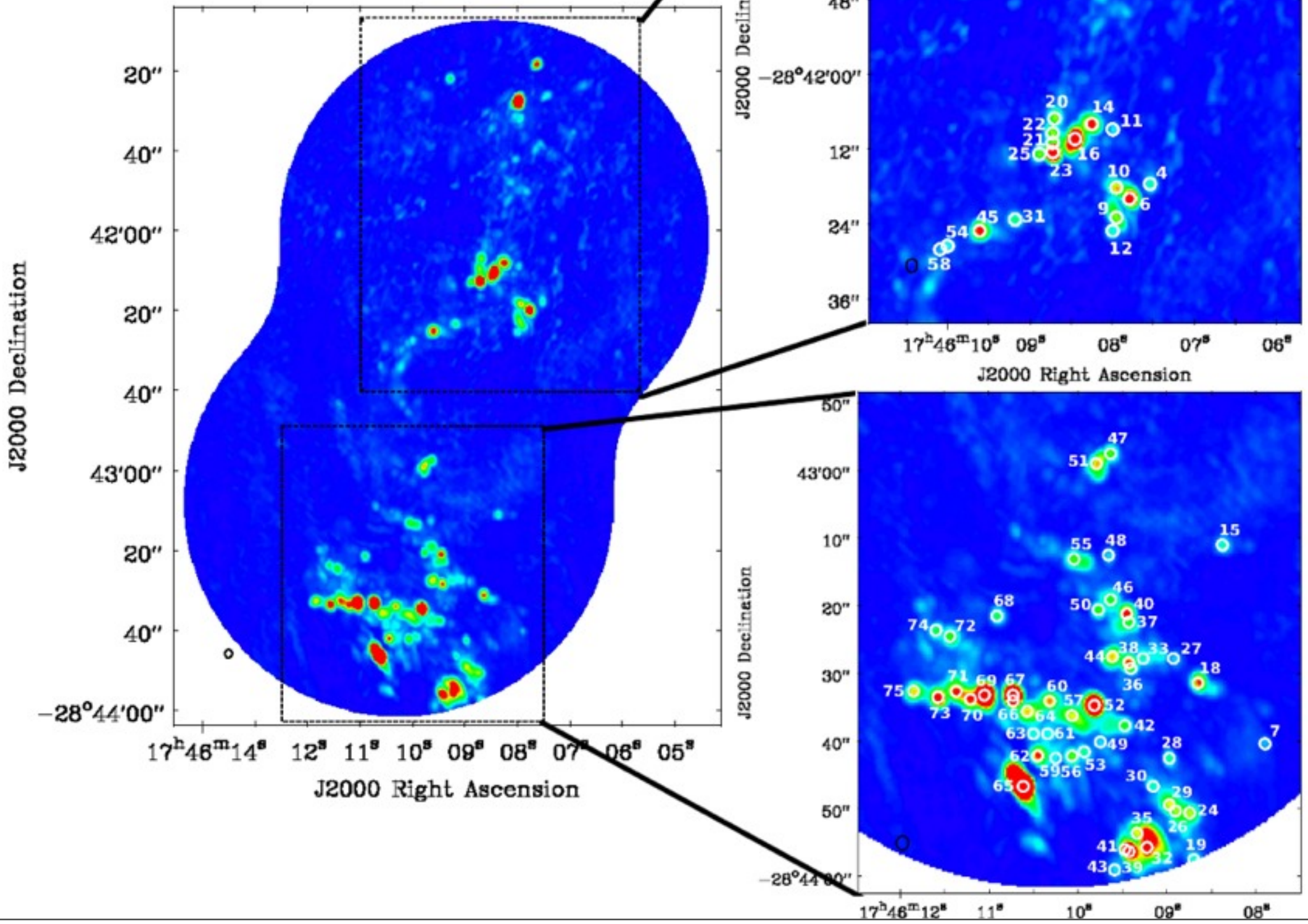


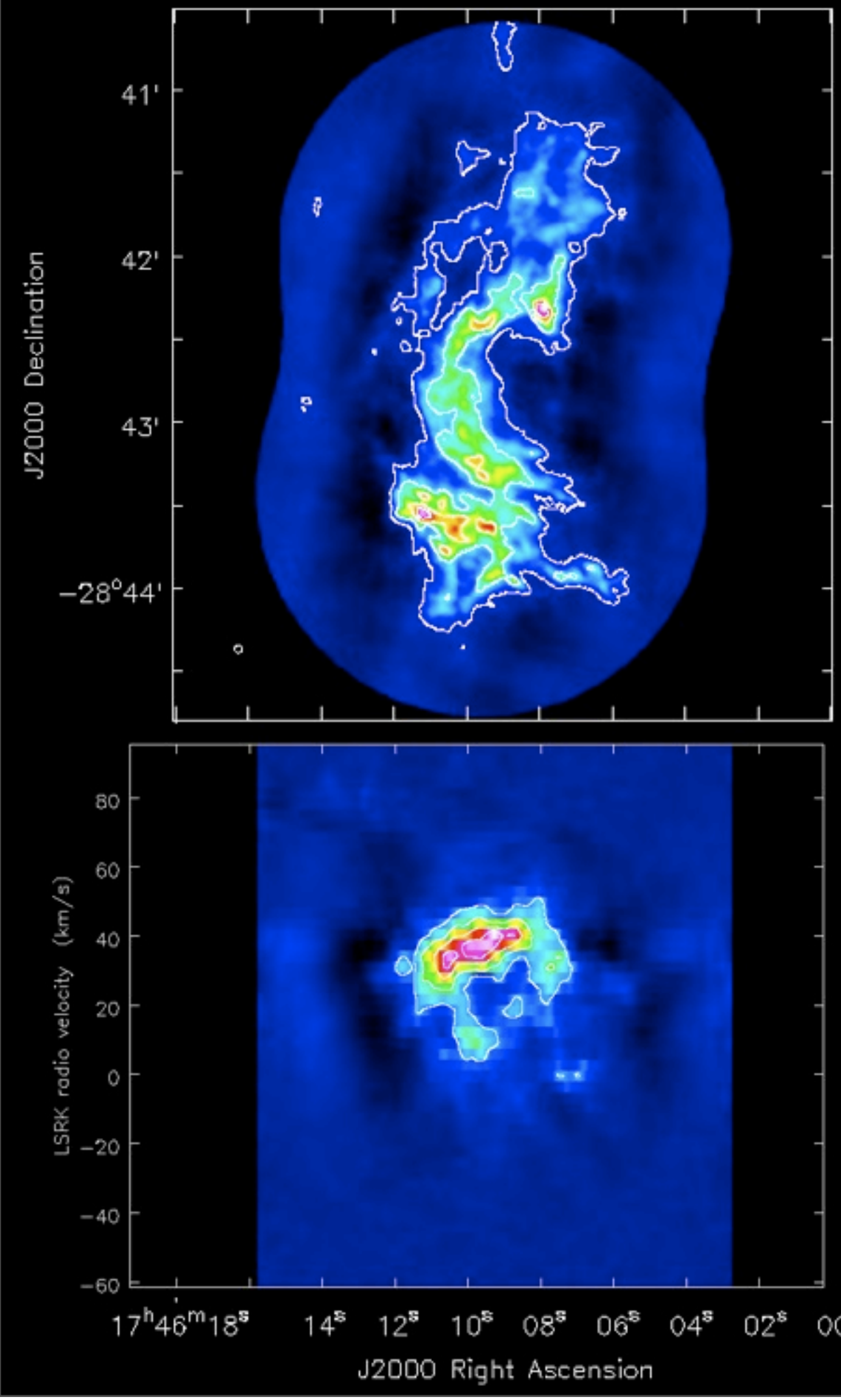
Mills+ in prep.

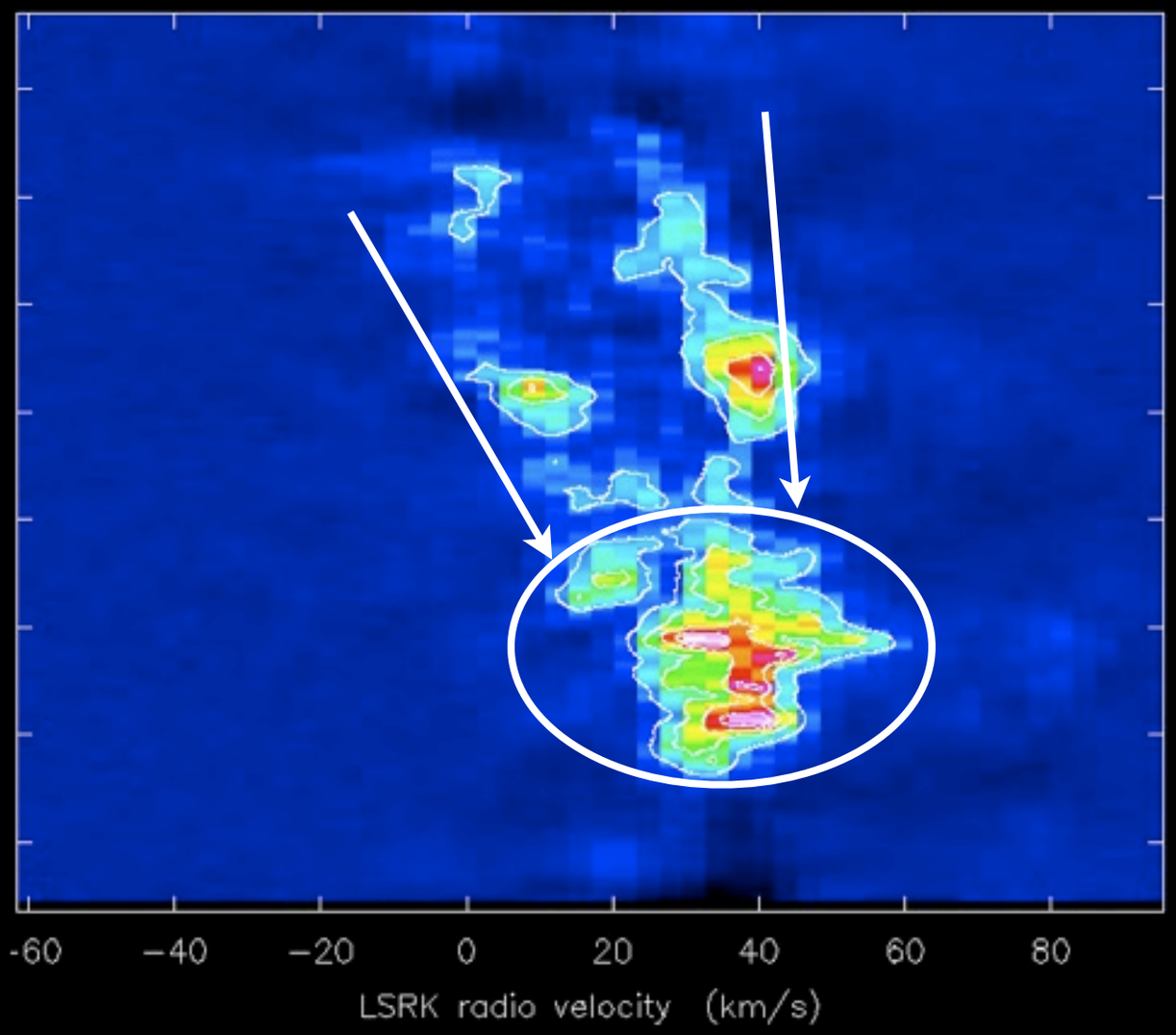
Yusef Zadeh+ 2013.

75 maser candidates

29 have $T_B > 1000$ K

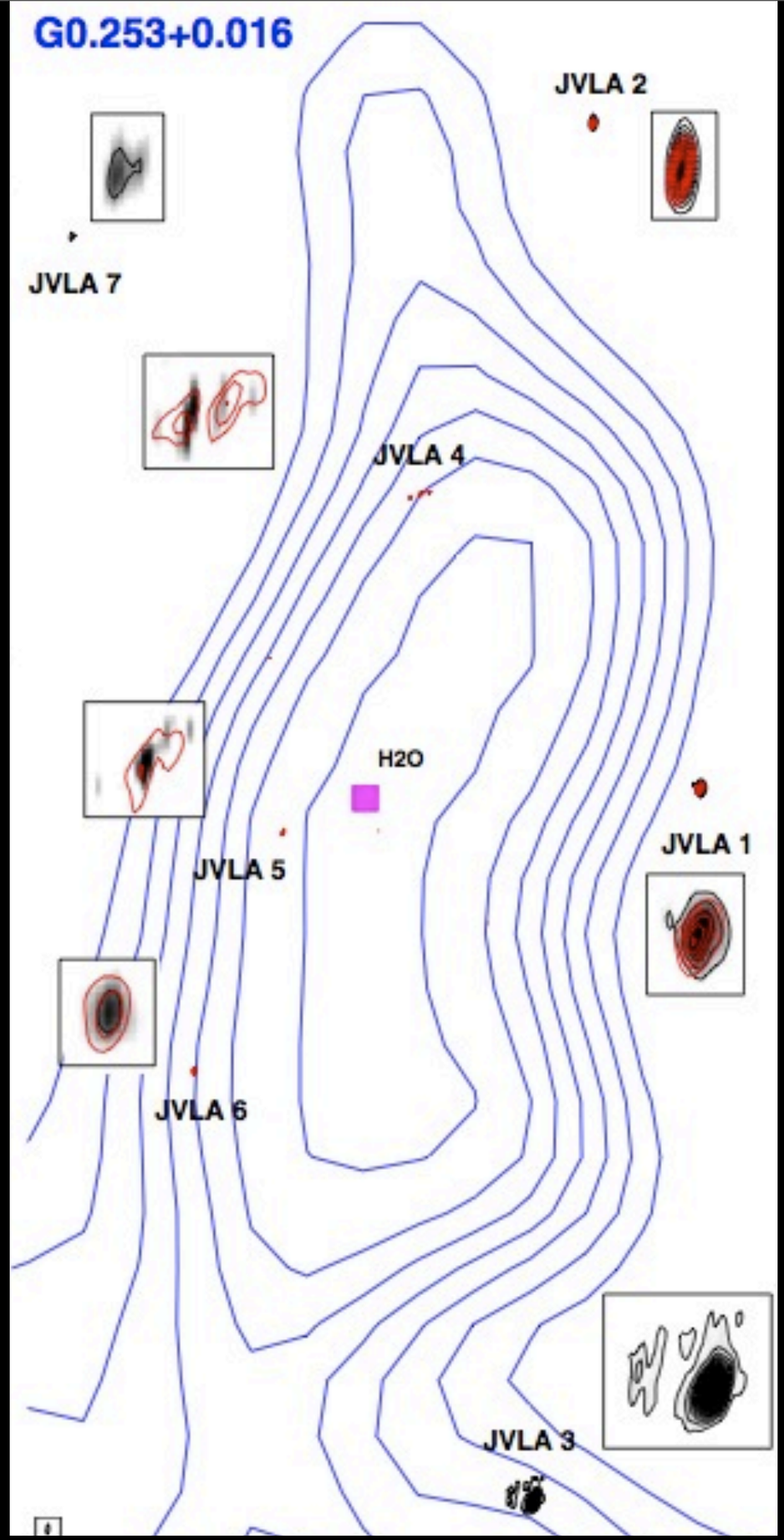






2/3 of maser candidates in the southern region

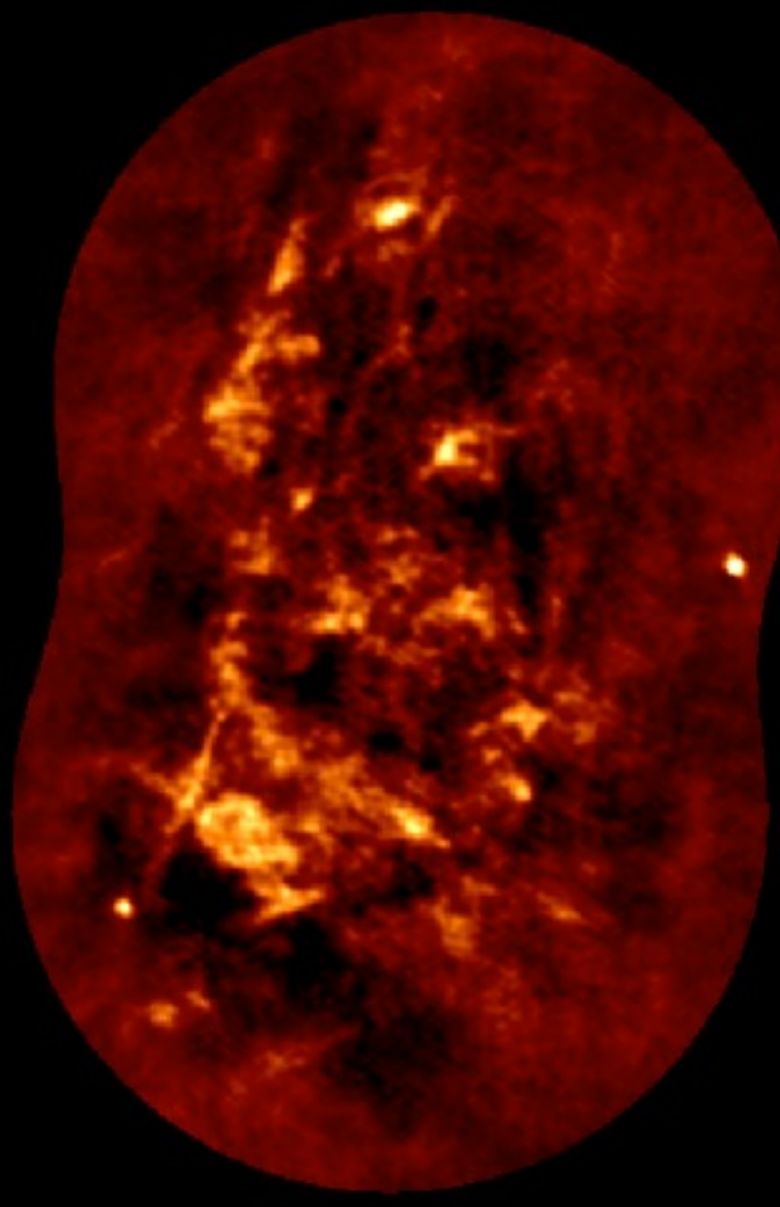
Suggests a kinematic or shock origin for the masers



But is there Star Formation?

Rodriguez+ 2013.

But is there Star Formation?



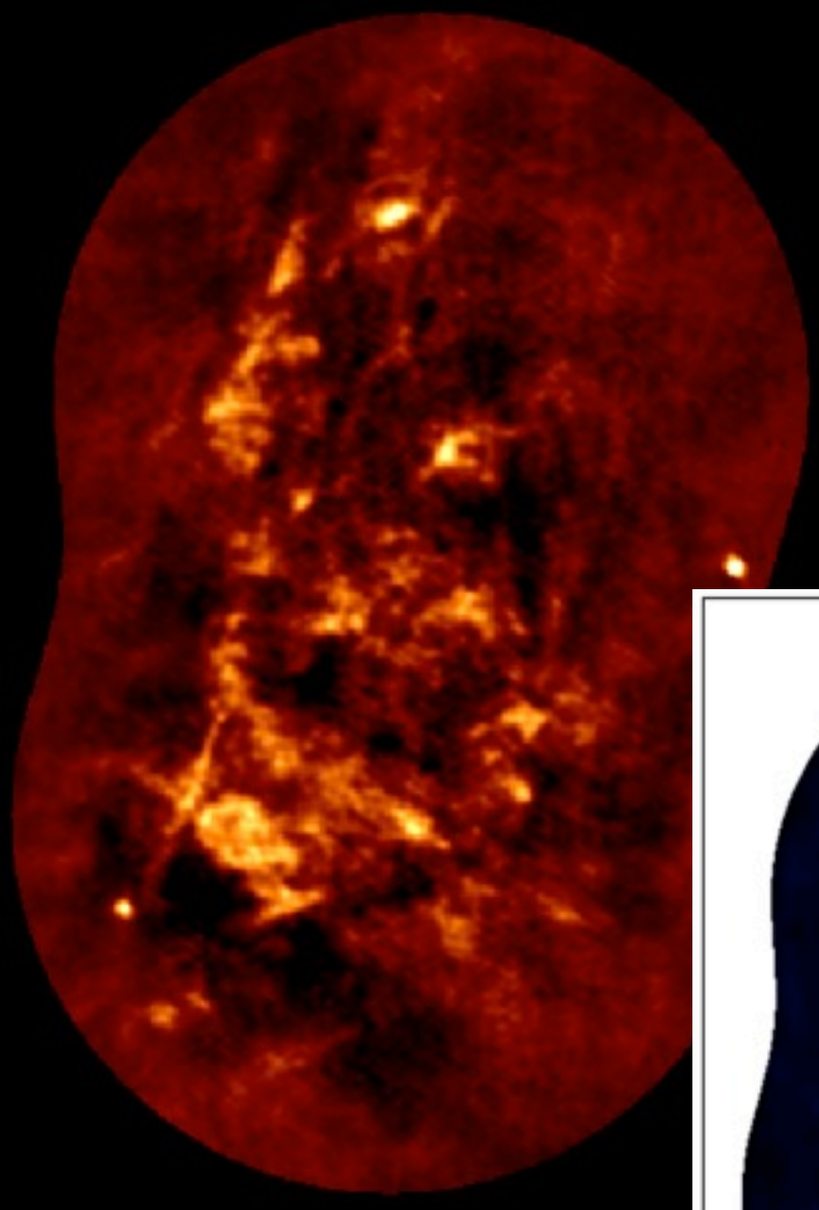
25 GHz continuum image.

Brightest feature ~ 800 μJy

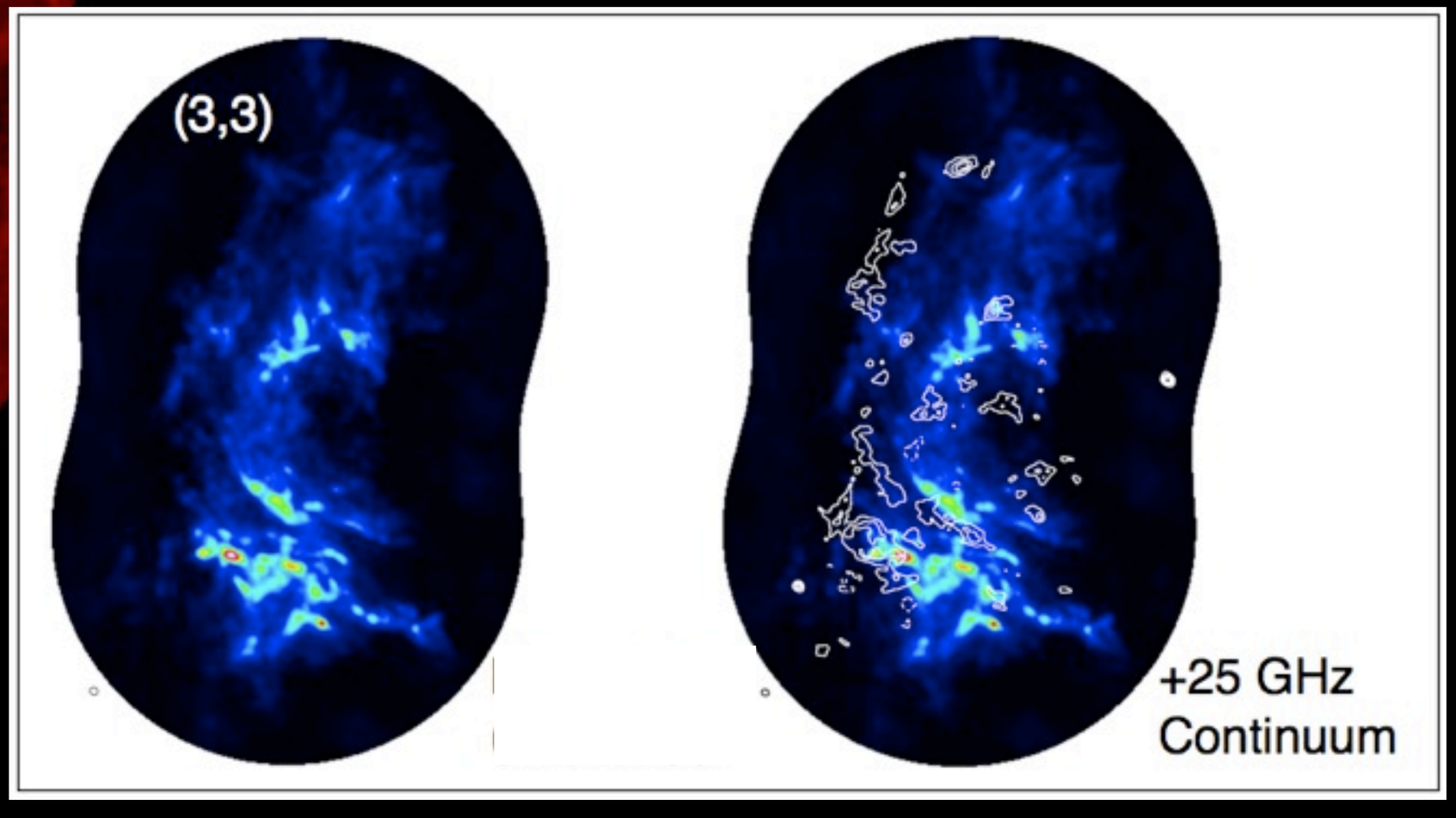
Mills+ in prep.

But is there Star Formation?

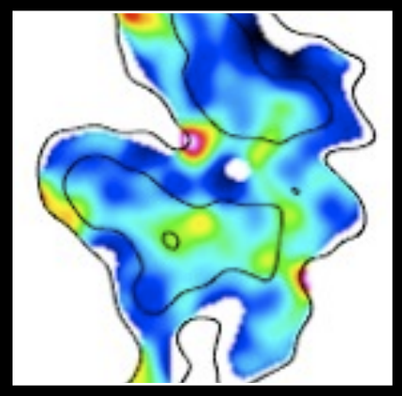
...No



Mills+ in prep.

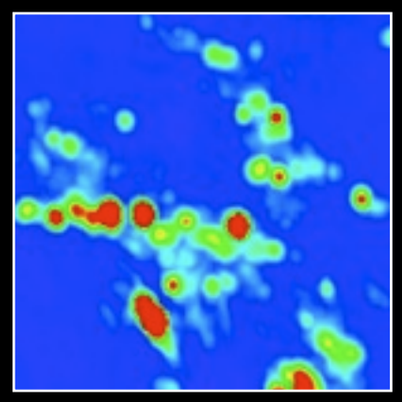


M0.25+0.01 (See also P27, Johnston+, P23 Contreras+)



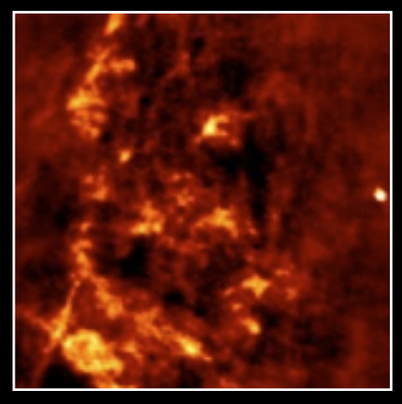
Ammonia traces a warm/hot (100-300 K) gas component, even on 0.1 parsec scales

(See also P12, Ao+)



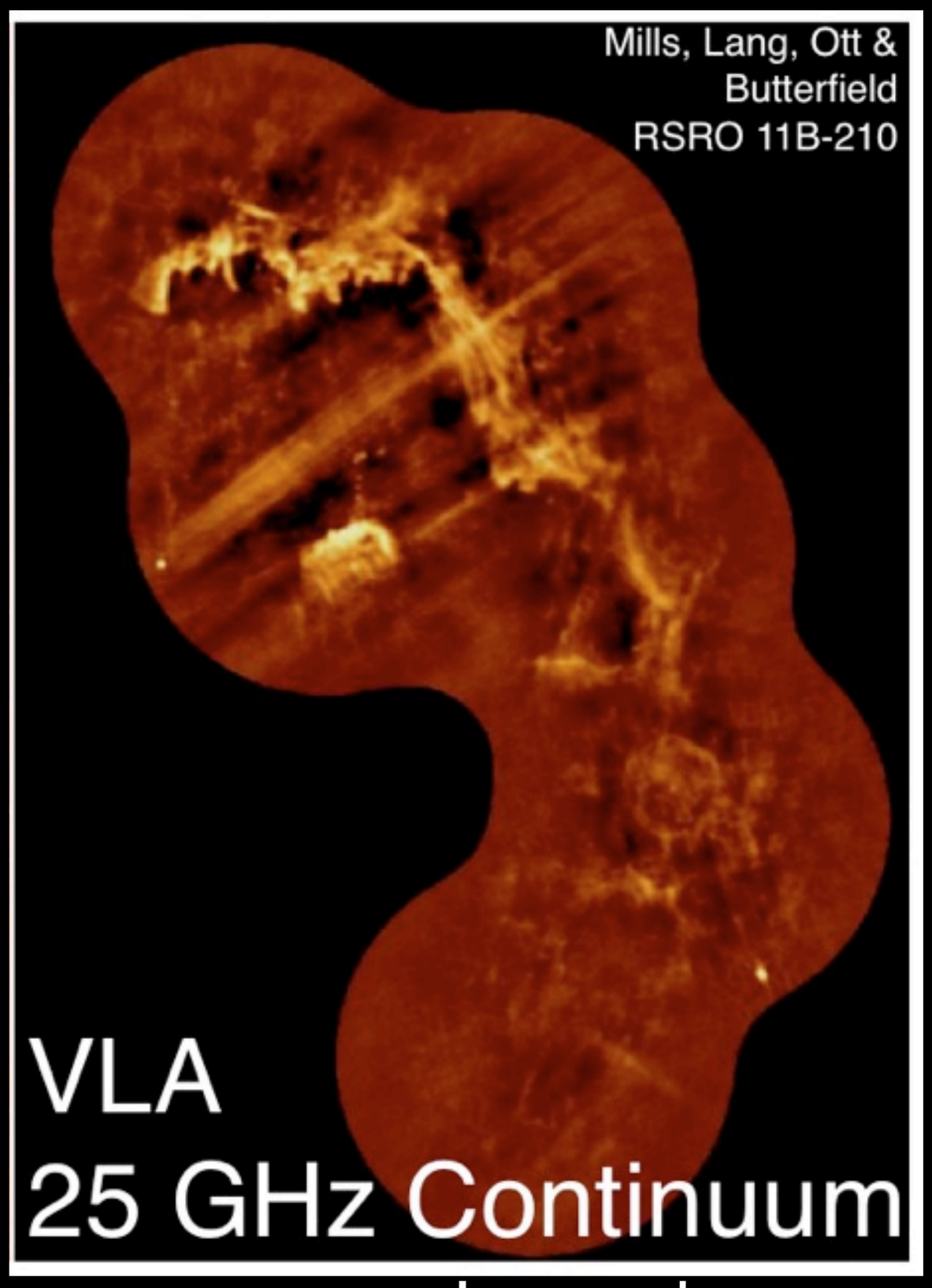
Masers are non-uniformly distributed, concentrated in the south.
Likely trace large-scale shocks

(See also P31, Pihlström+, P35 Sjouwerman+)



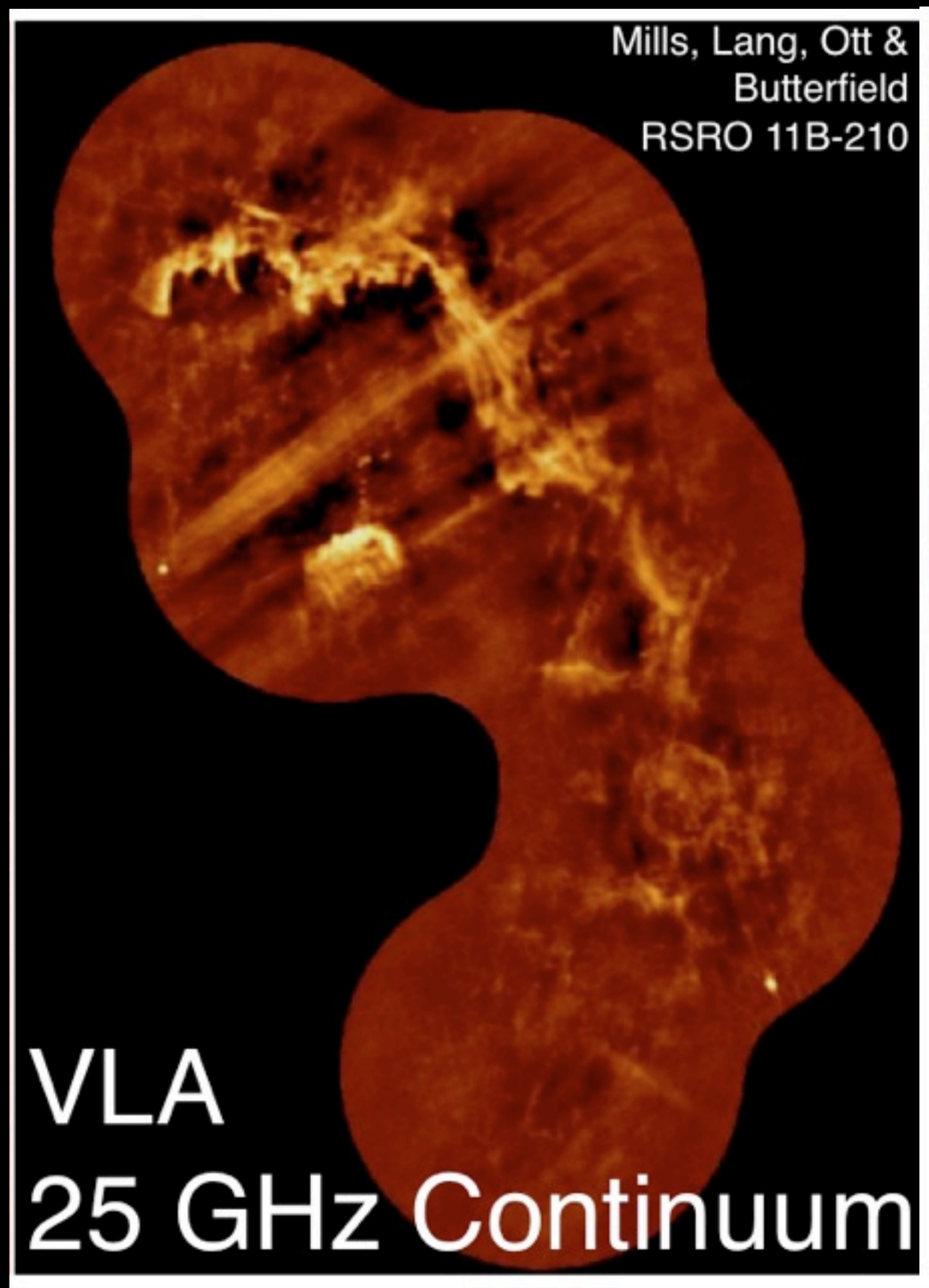
Radio continuum appears primarily consistent with being free-free emission, externally ionized

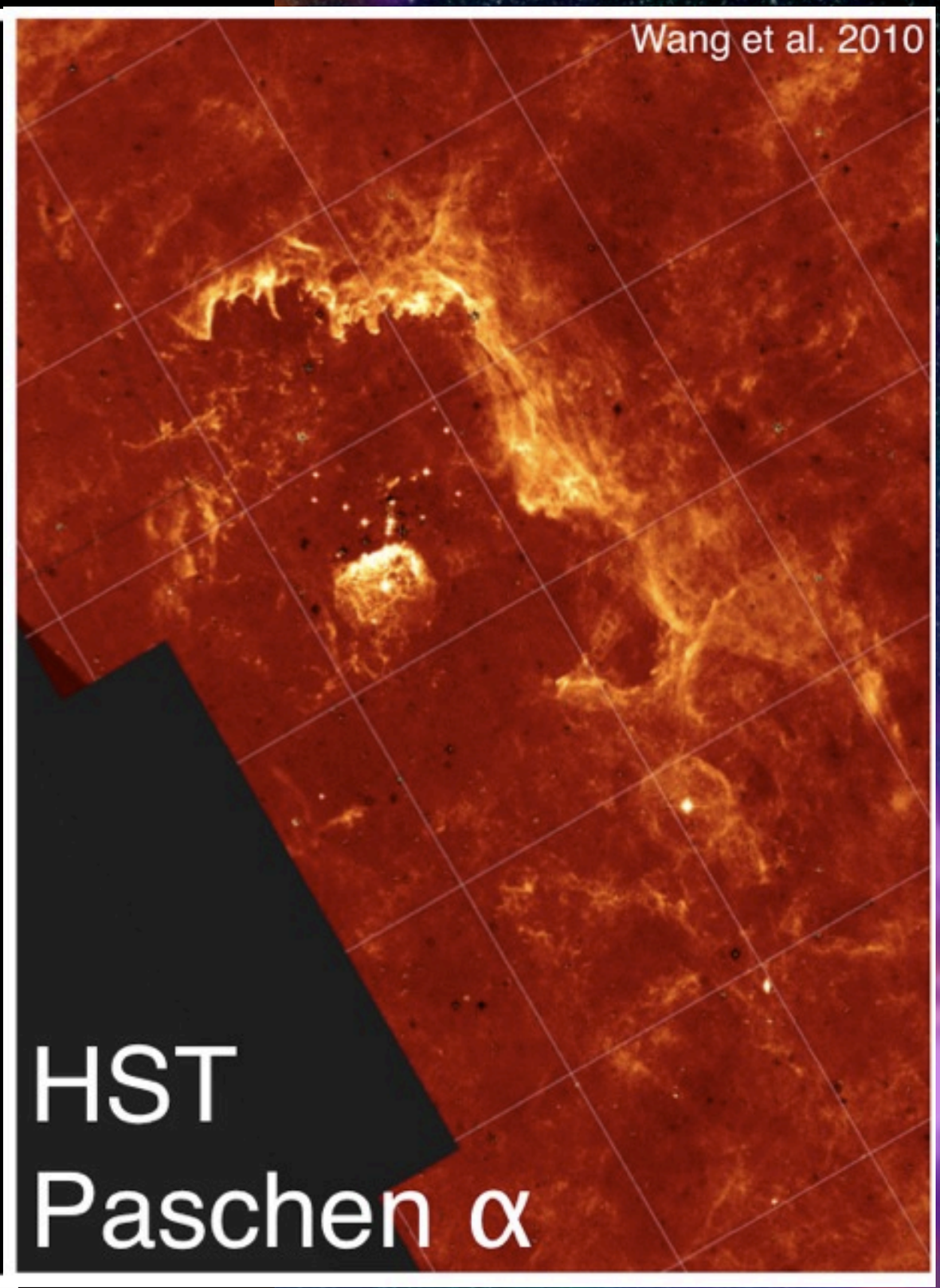
Sensitive high-frequency continuum: **Sickle**



Lang+ in prep.

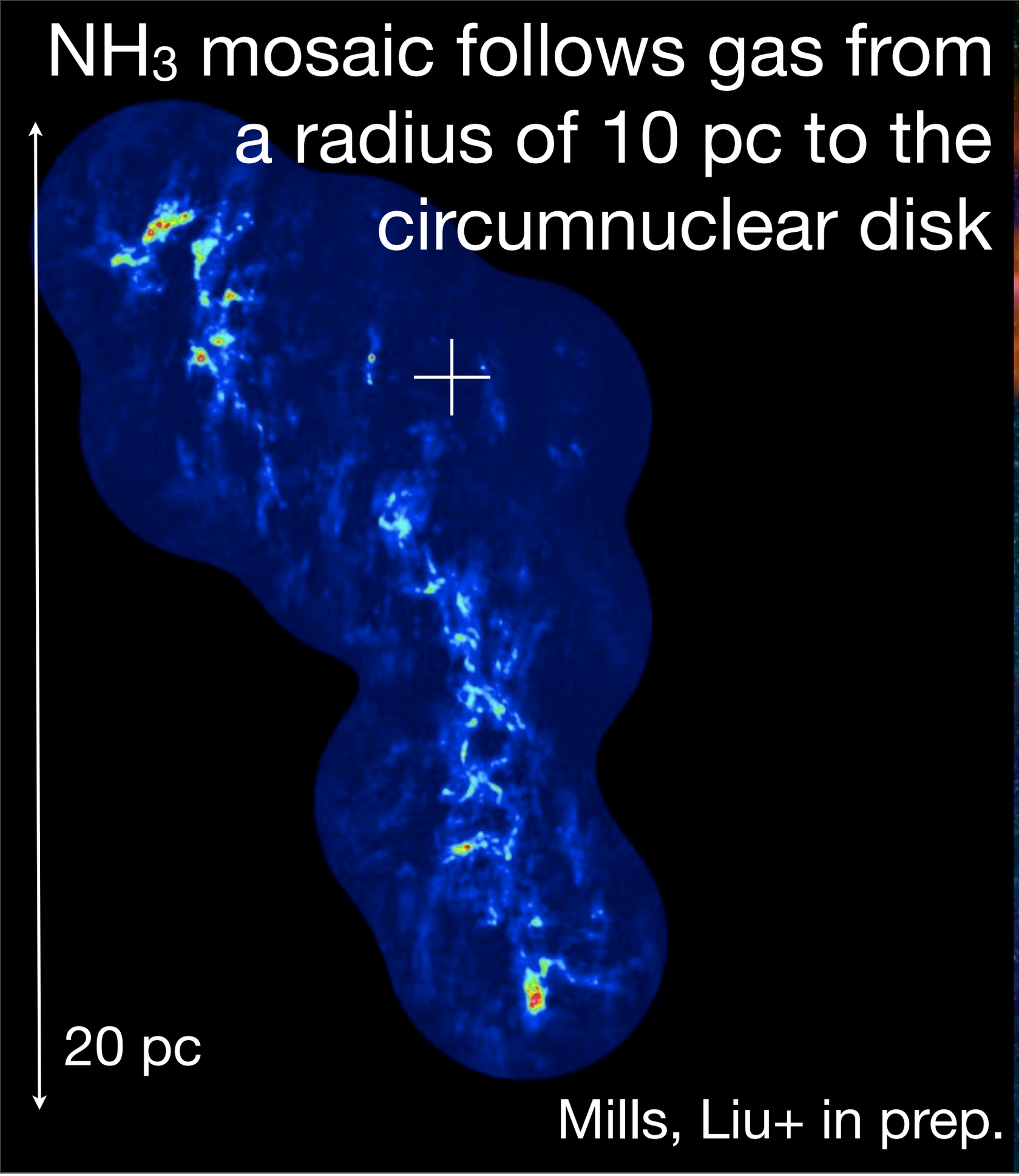
Sensitive high-frequency continuum: **Sickle**



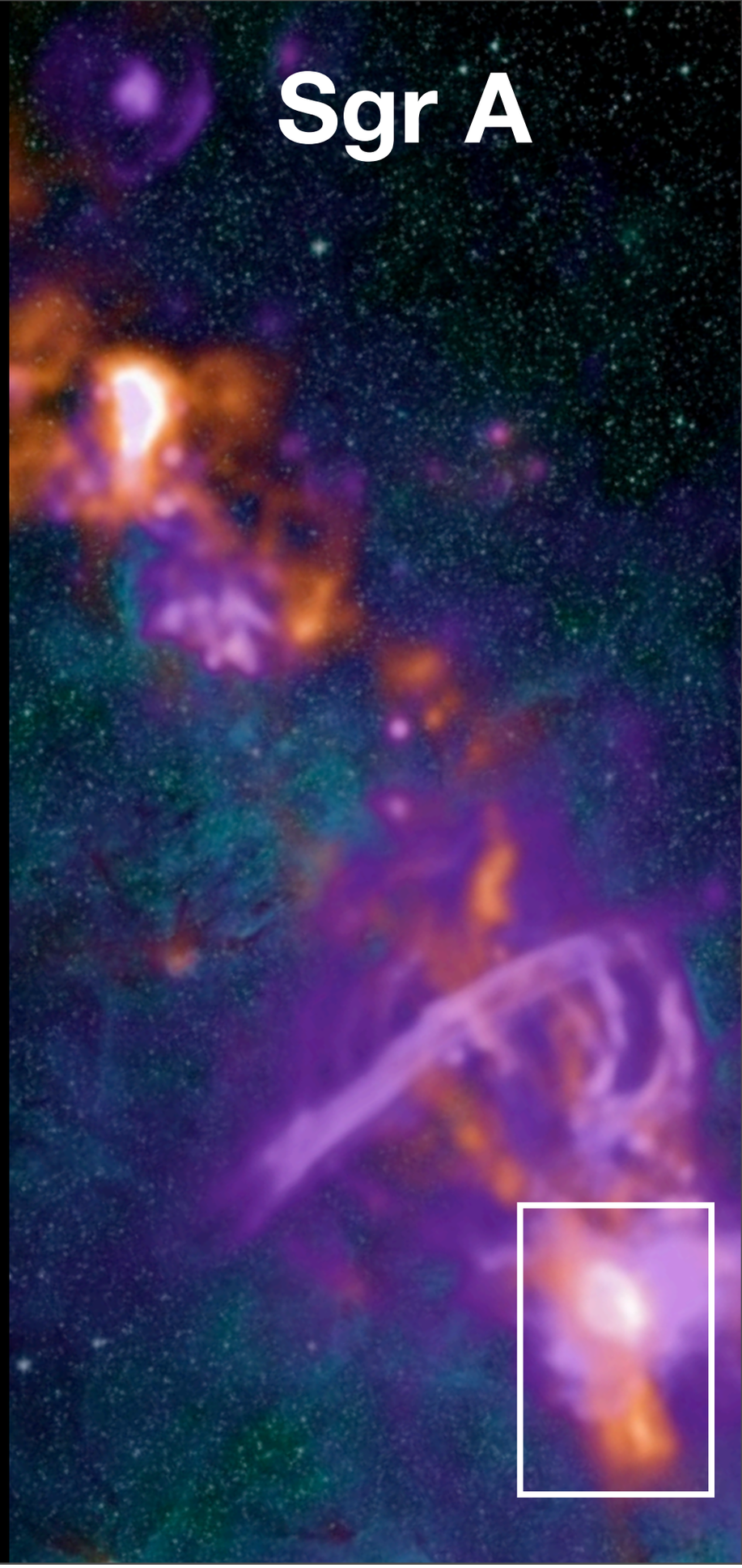


Lang+ in prep.

NH_3 mosaic follows gas from a radius of 10 pc to the circumnuclear disk



Mills, Liu+ in prep.



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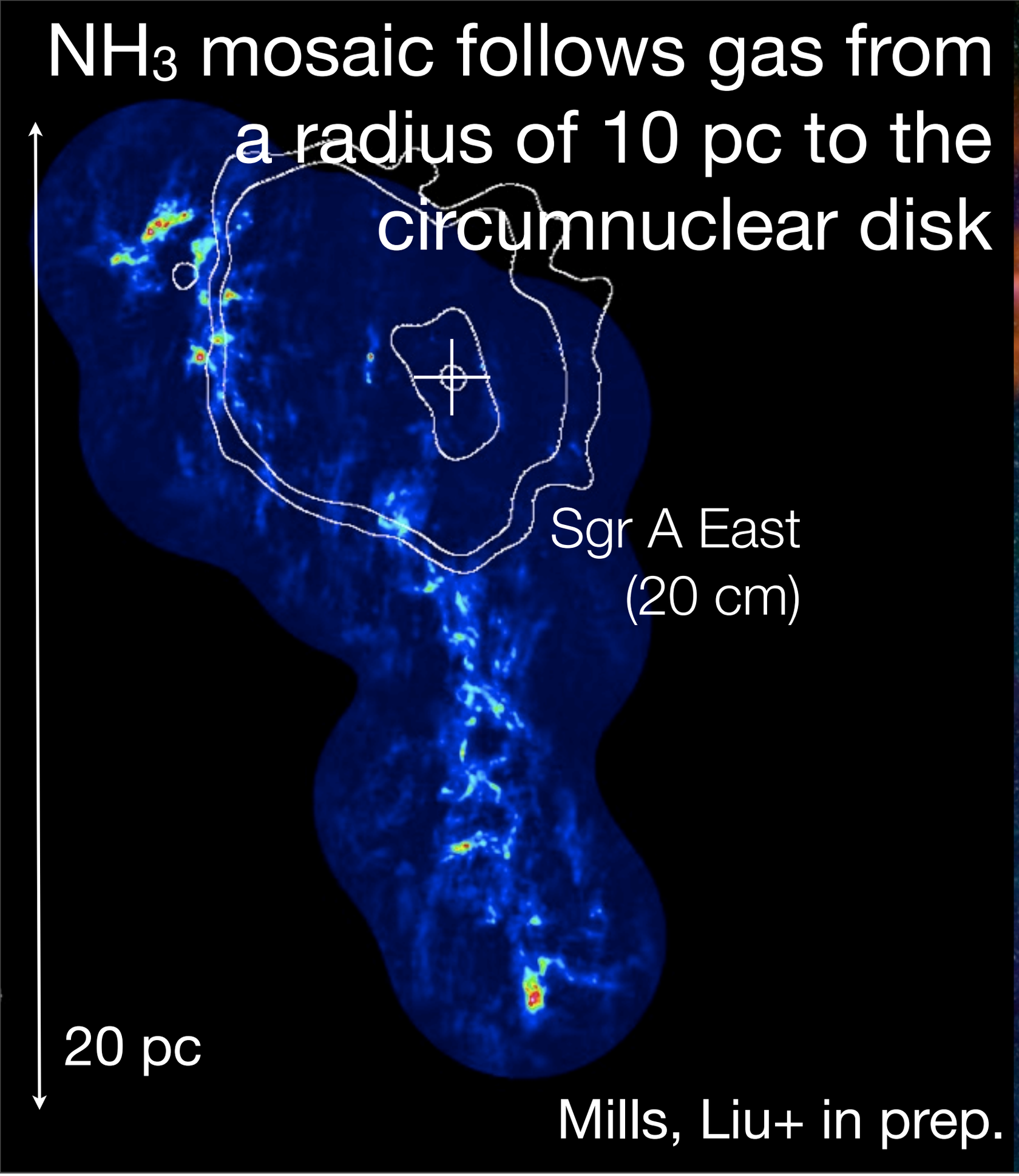
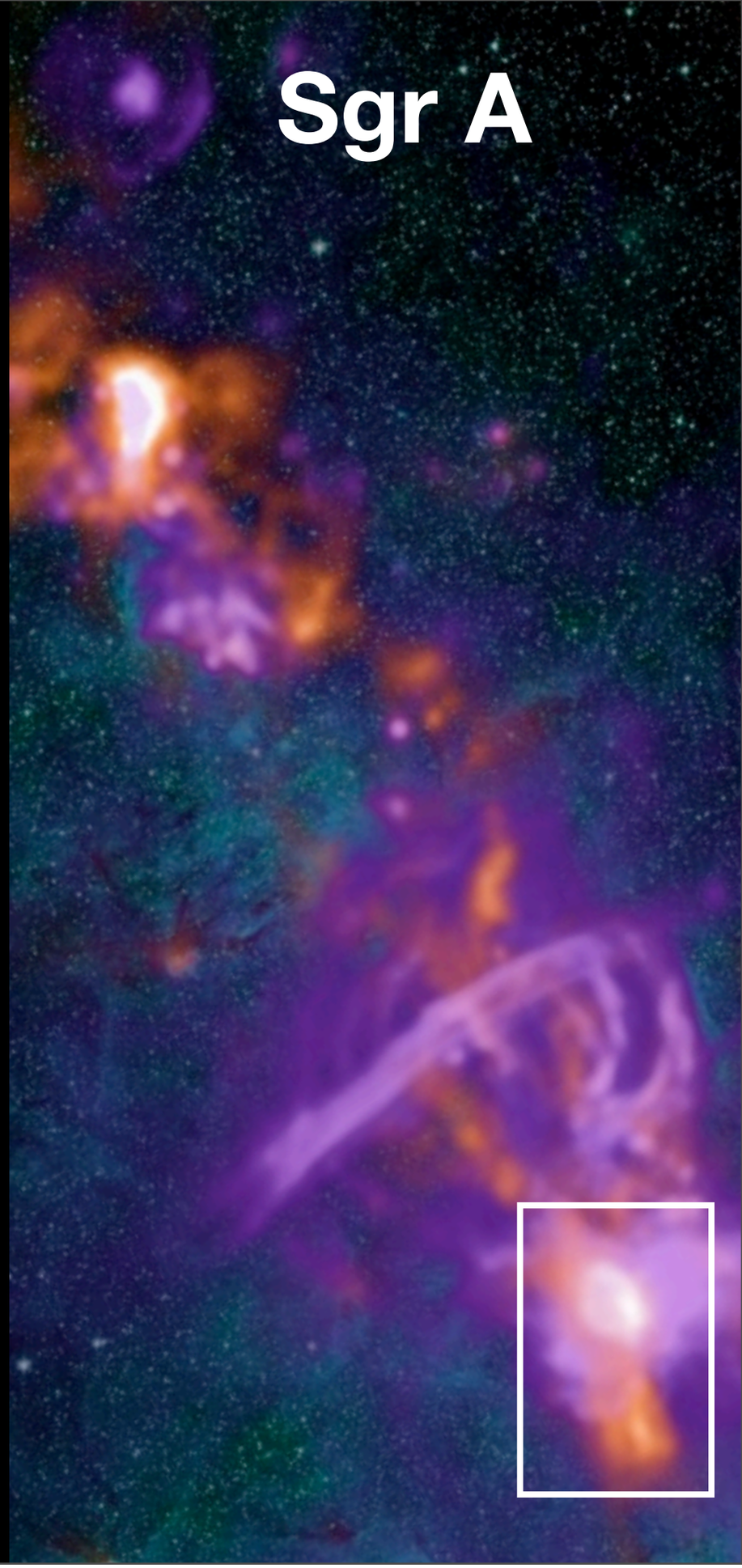
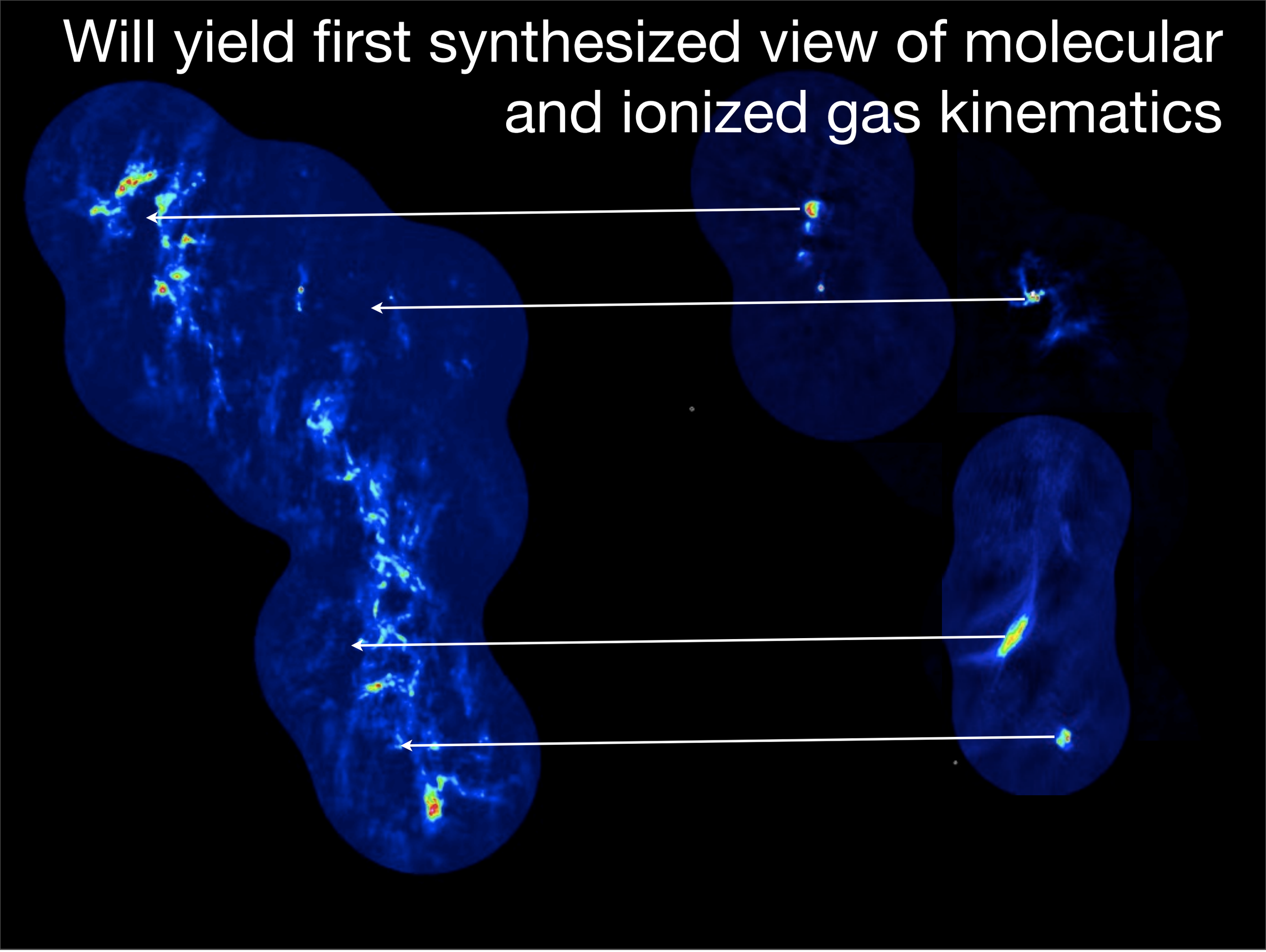


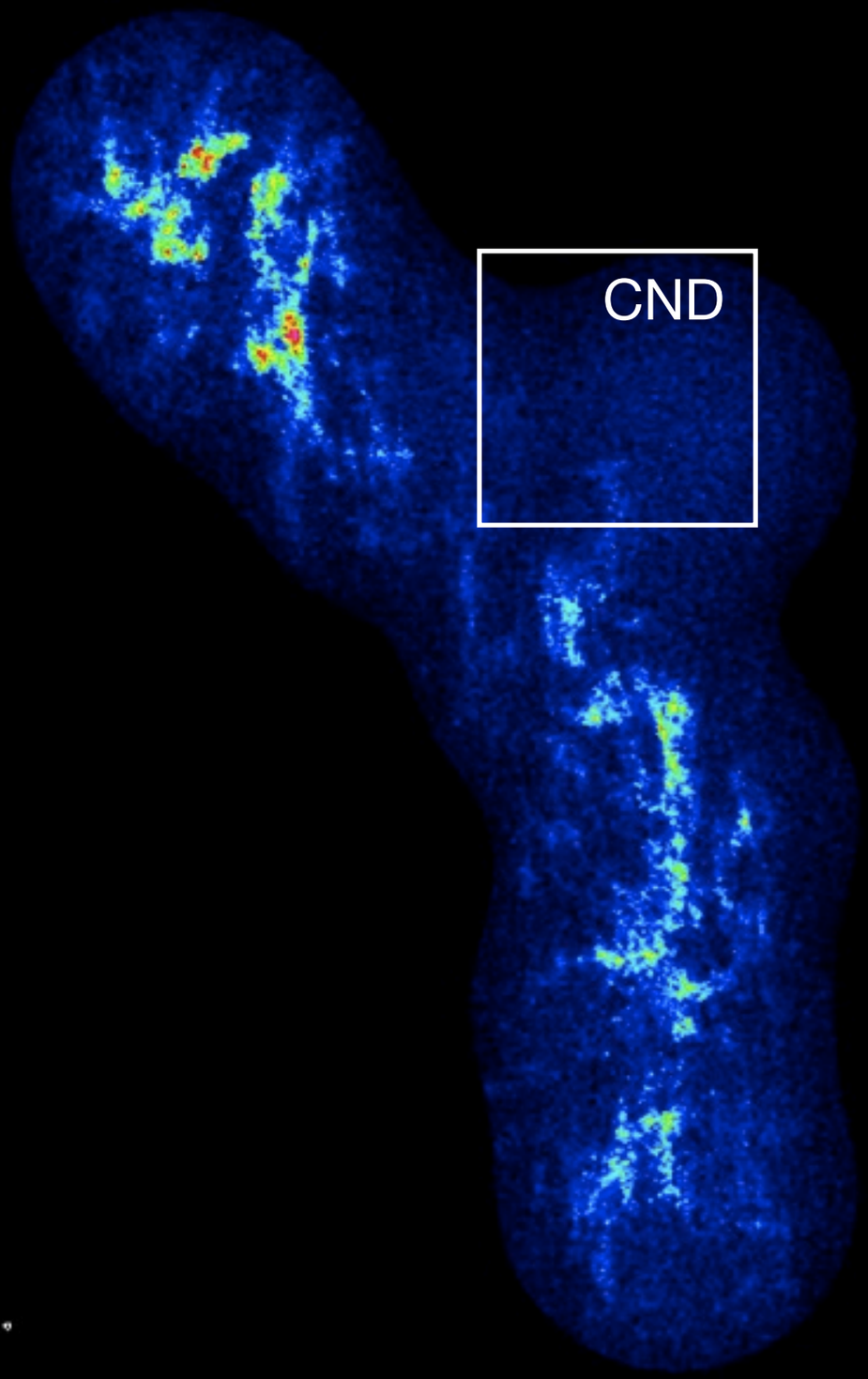
Mills, Liu+ in prep.



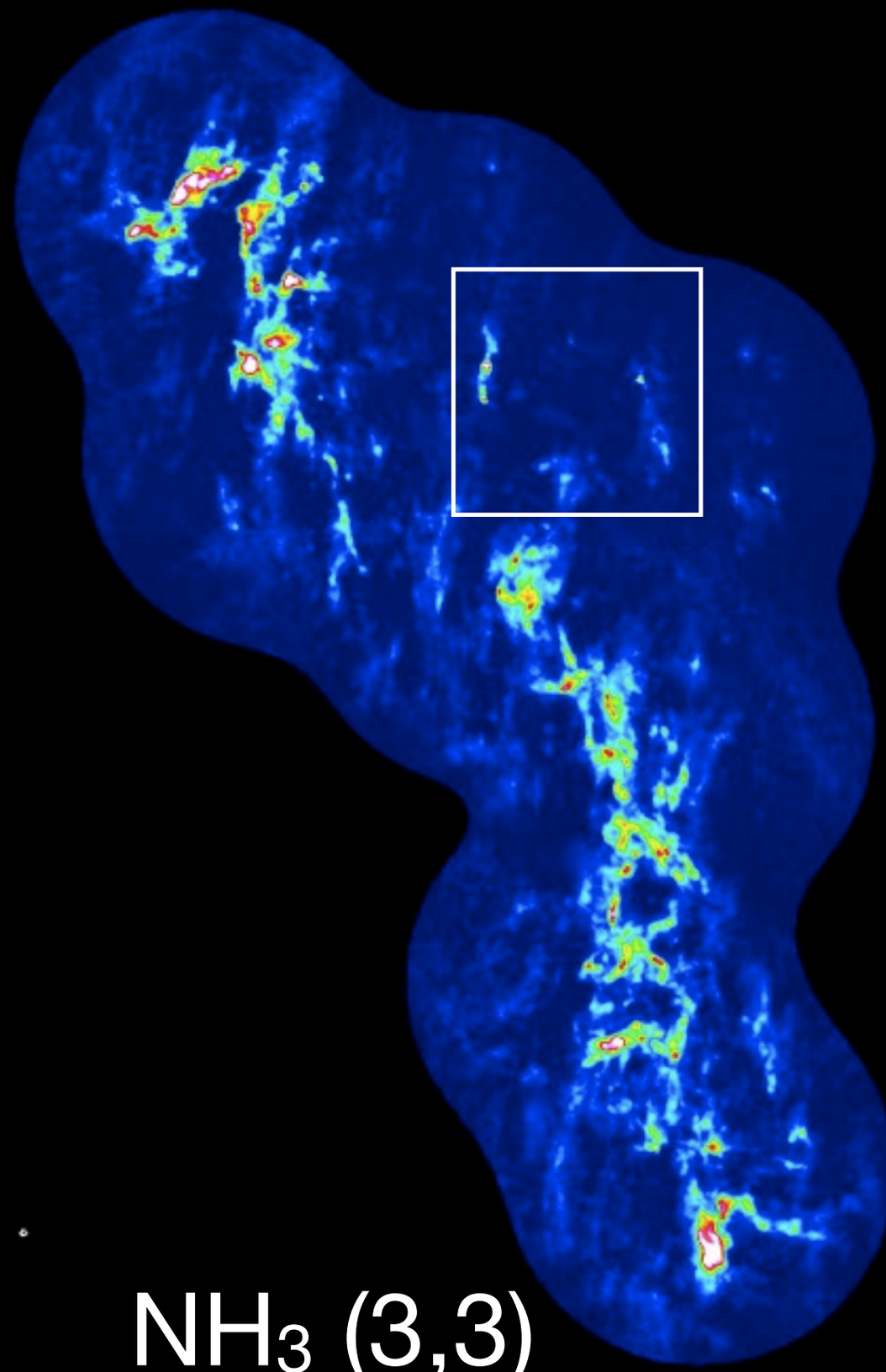
Will yield first synthesized view of molecular and ionized gas kinematics



Data also indicate differences in chemistry

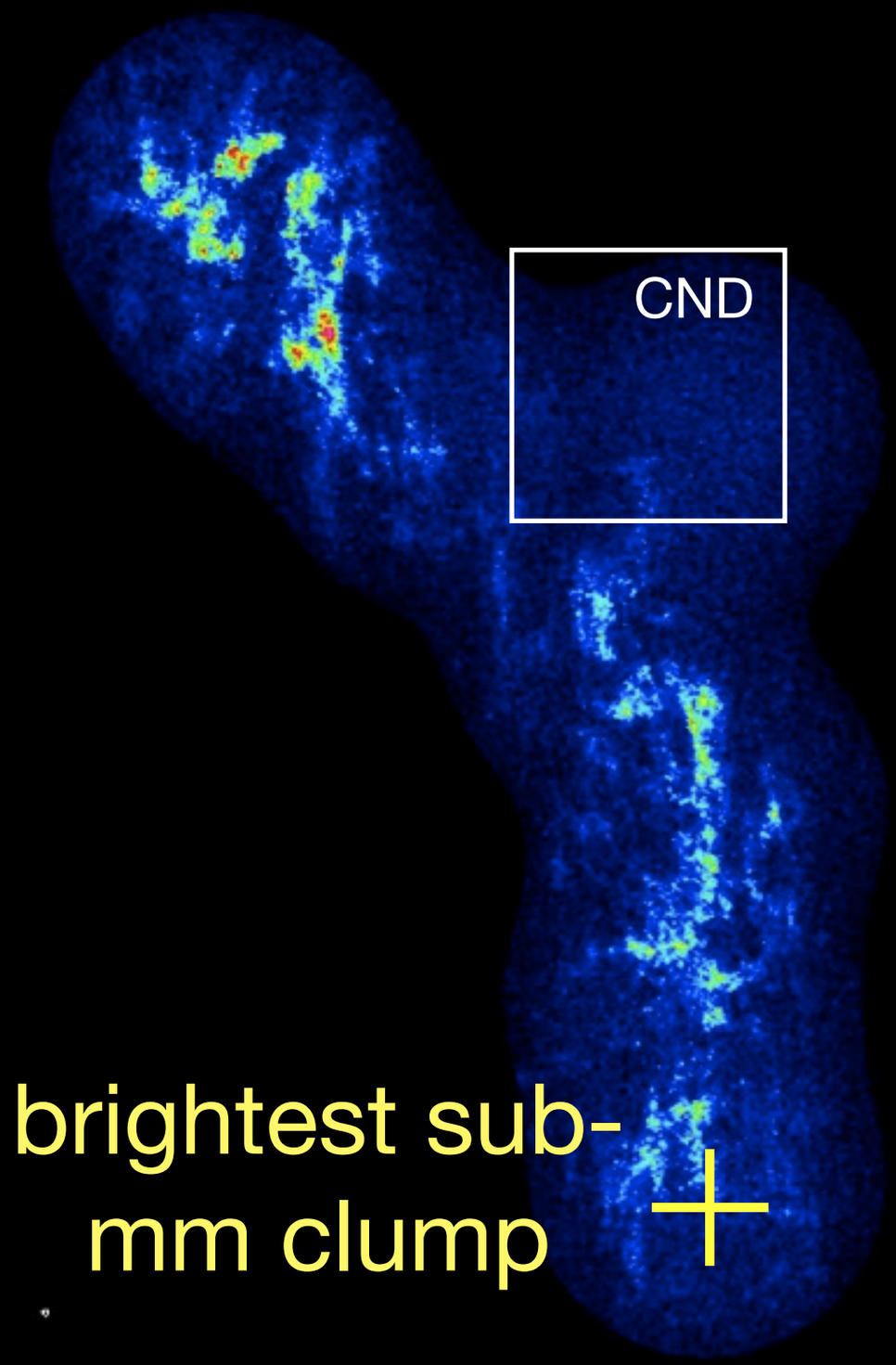


HC_3N (3-2)

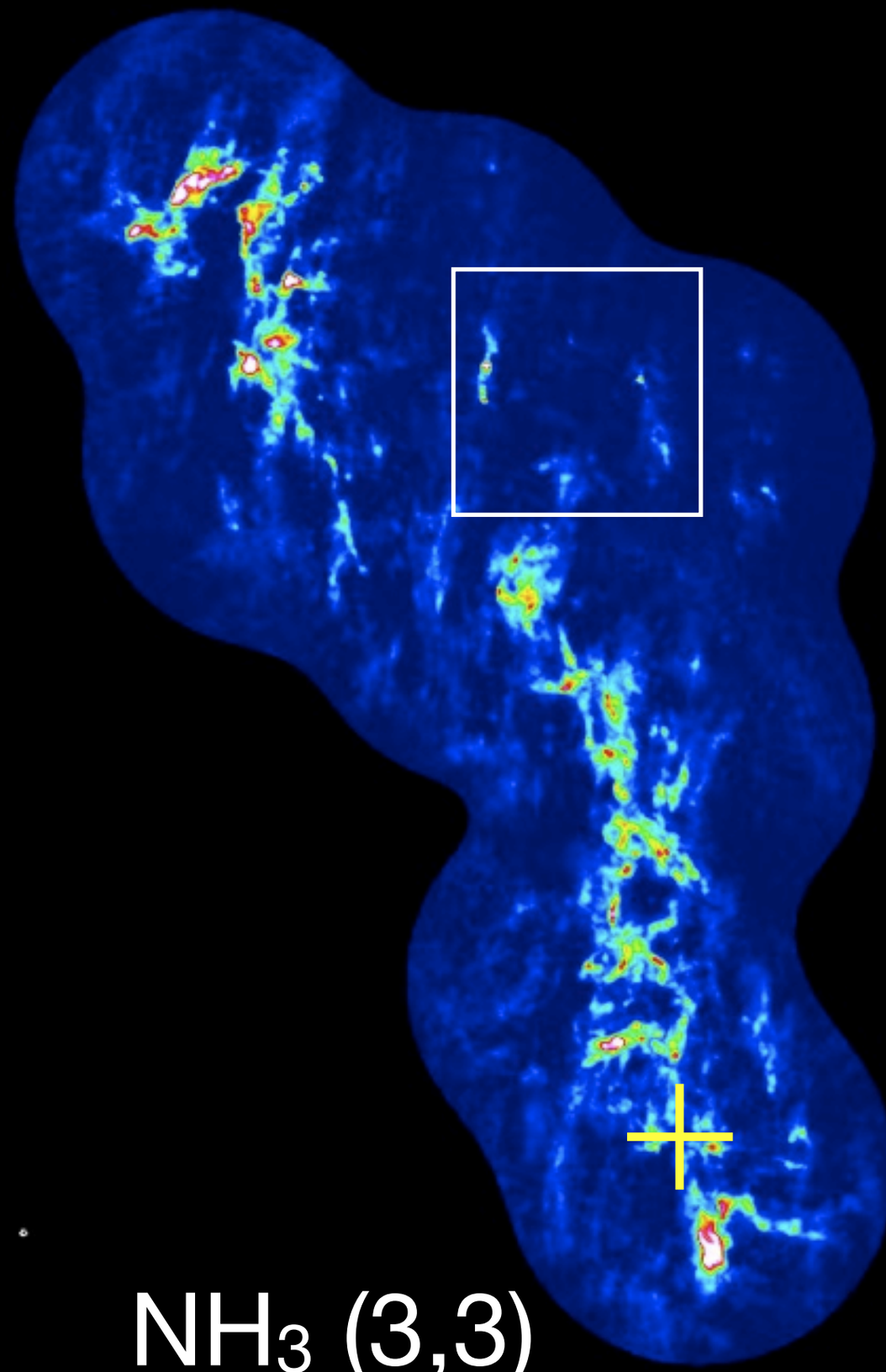


NH_3 (3,3)

Data also indicate differences in chemistry

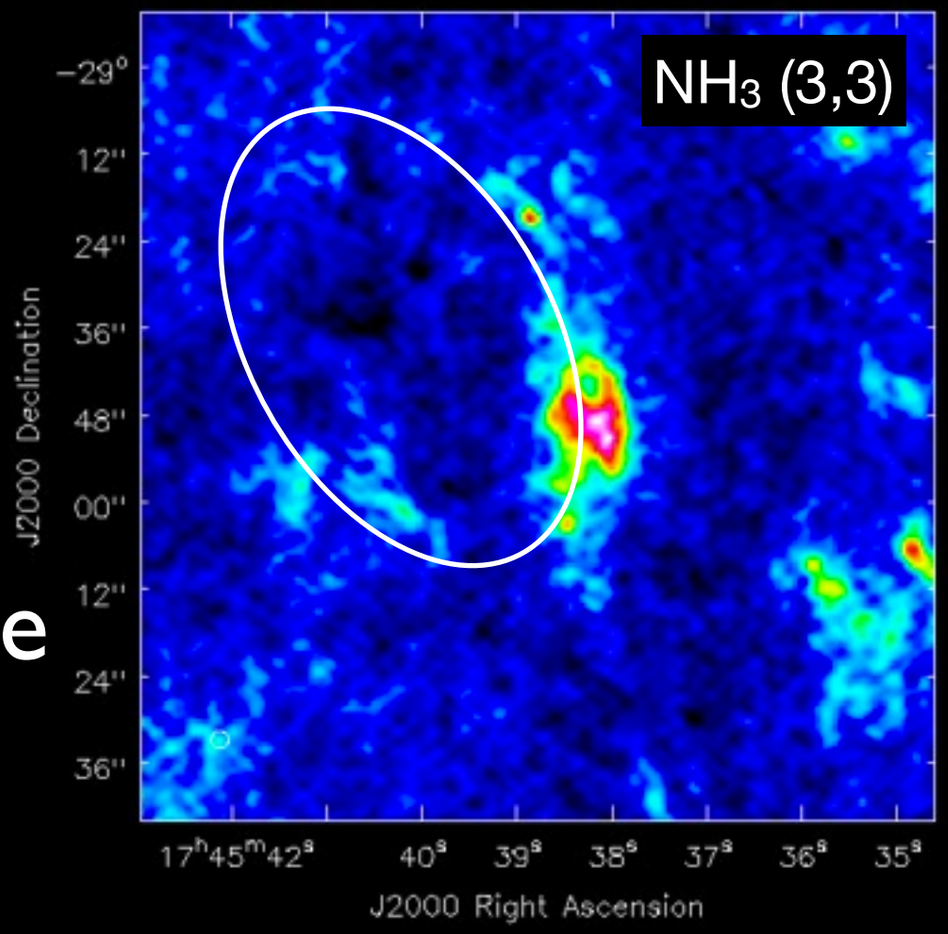


HC_3N (3-2)

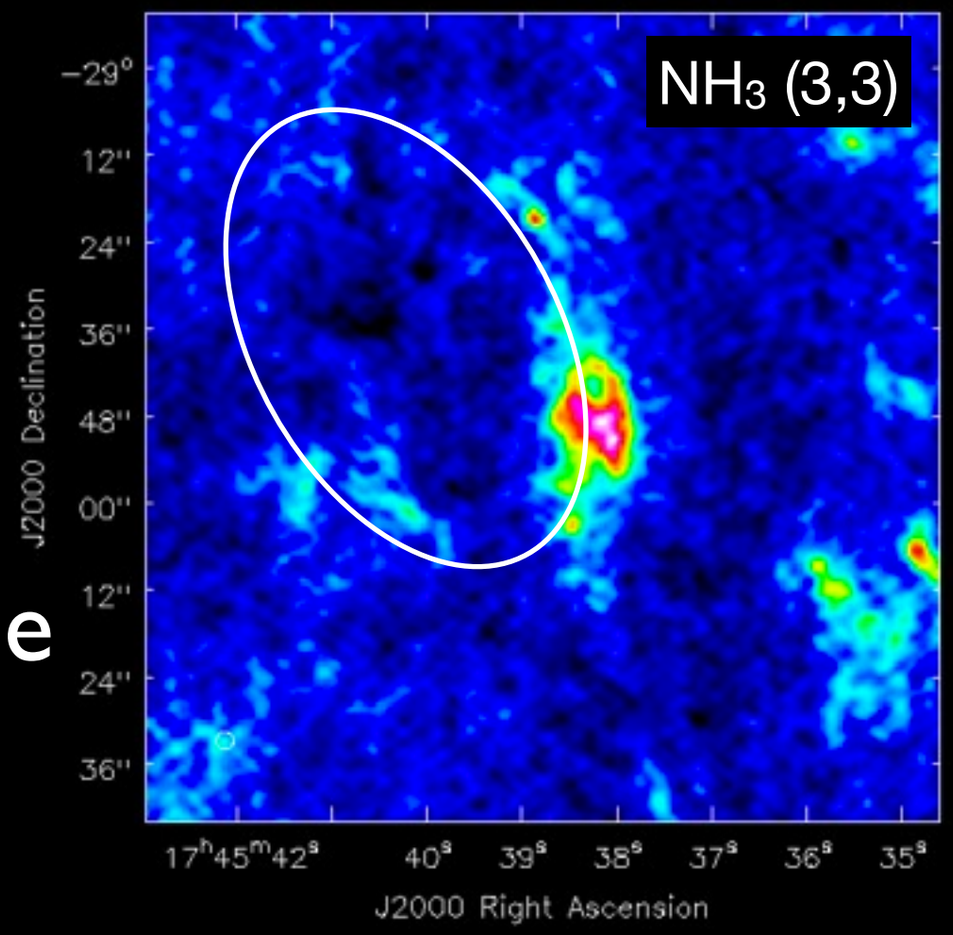


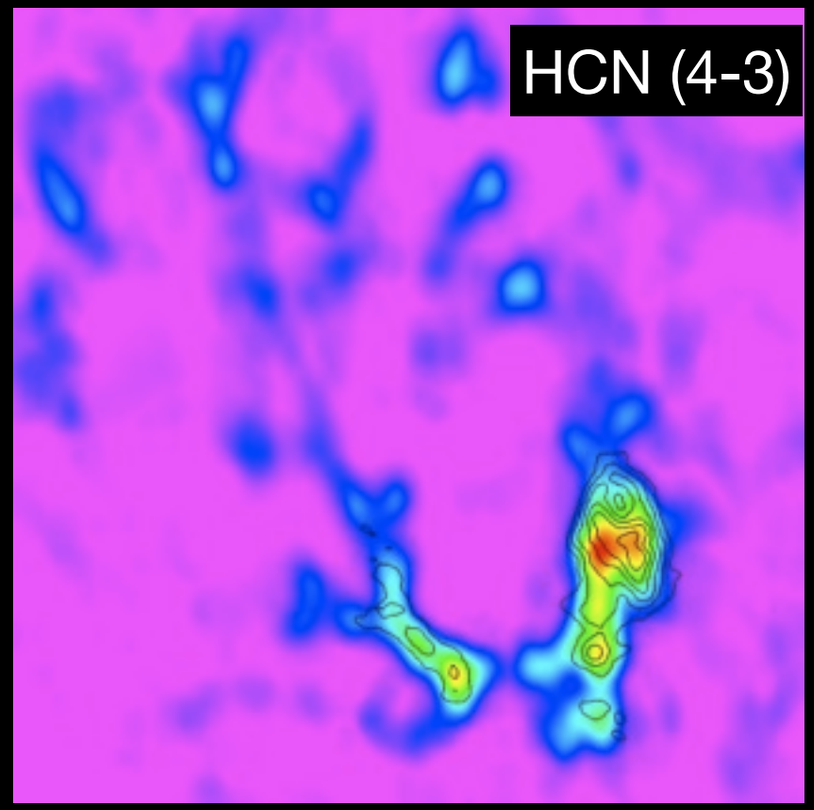
NH_3 (3,3)

Highest resolution image of molecular emission in the CND



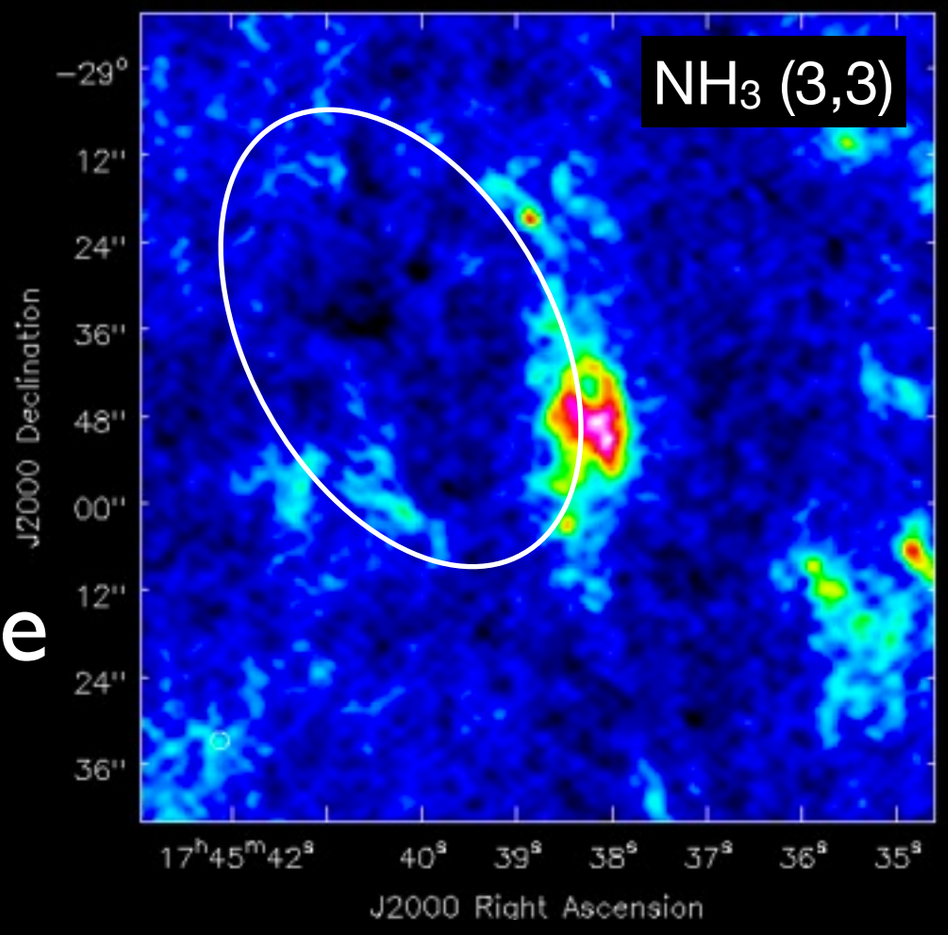
Highest resolution image of molecular emission in the CND

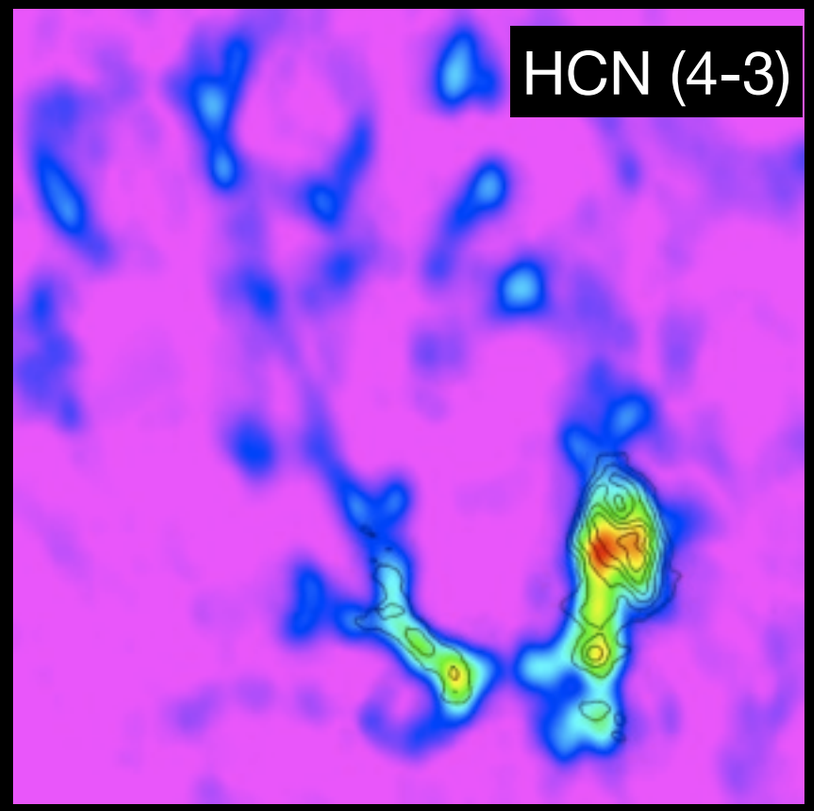




Montero-Castano+ 2009.

Highest resolution image of molecular emission in the CND





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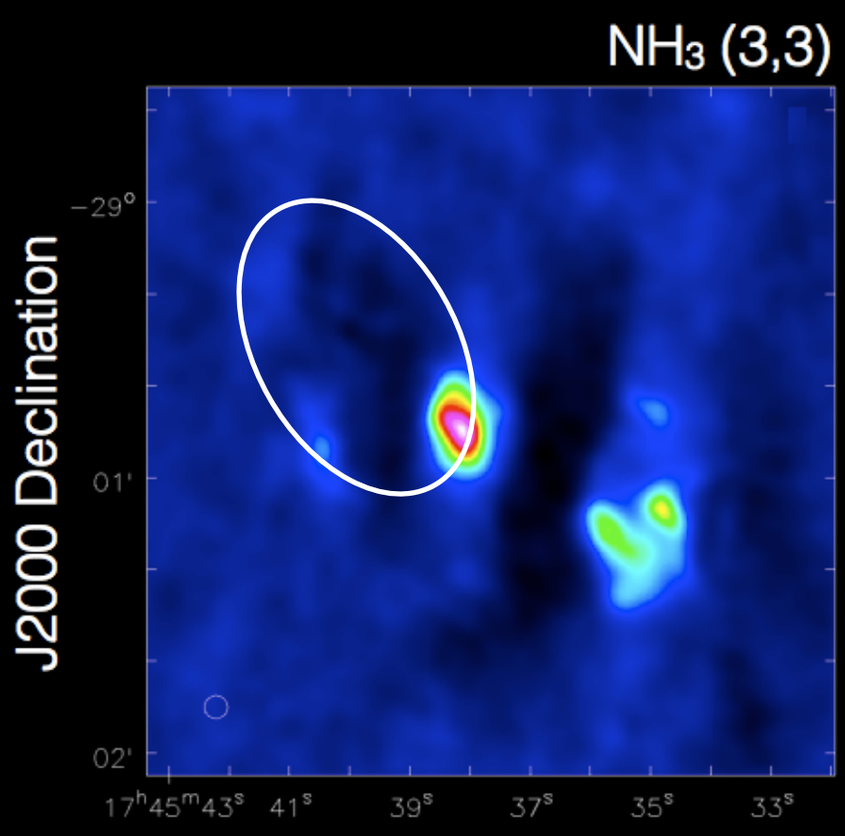
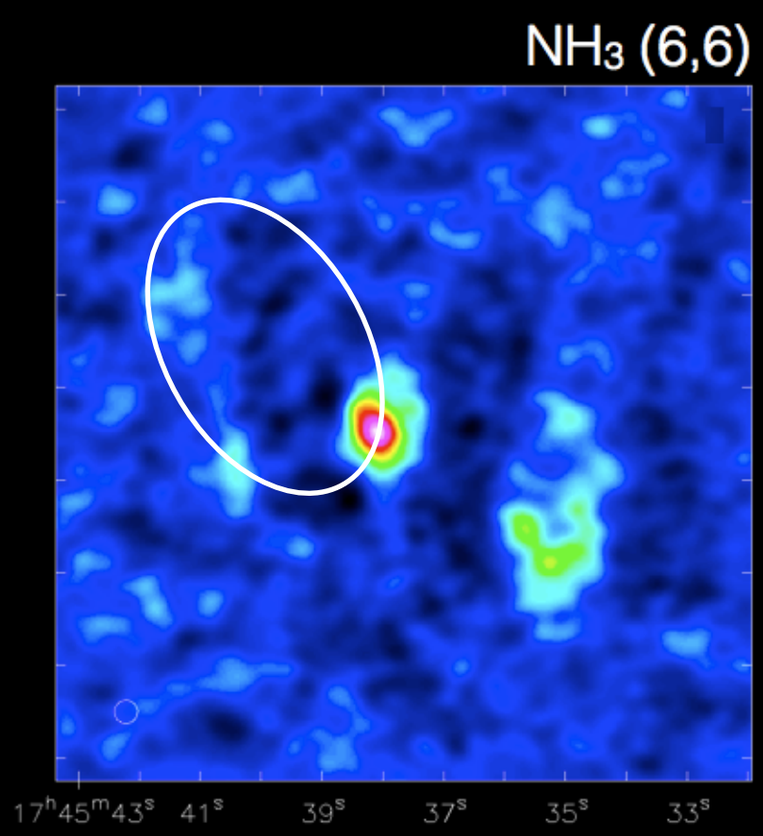
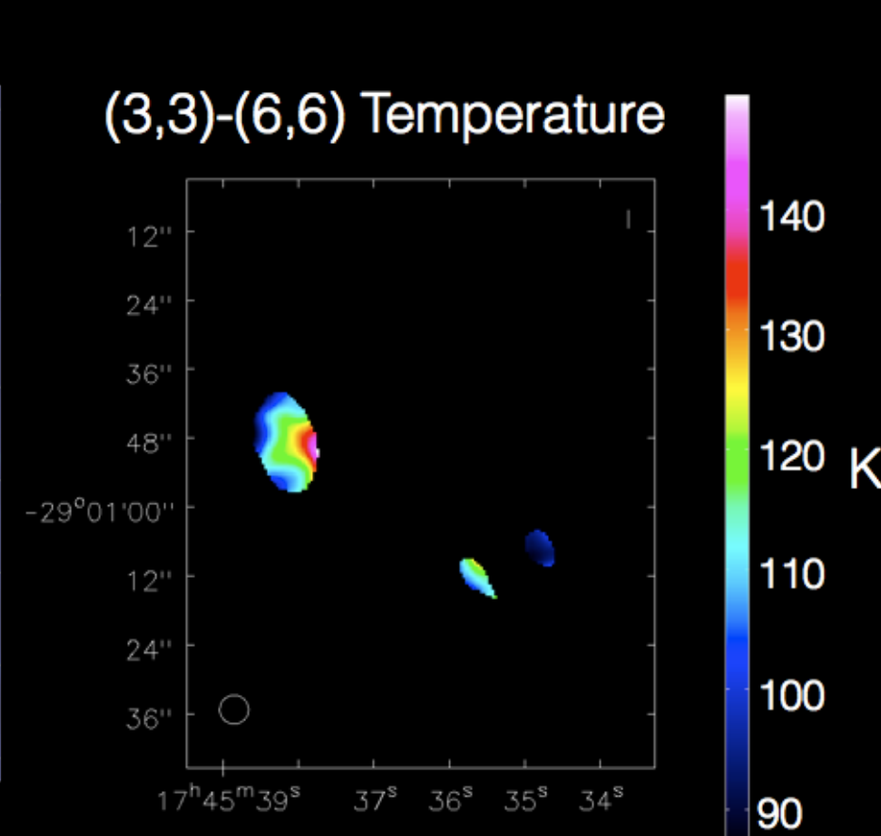
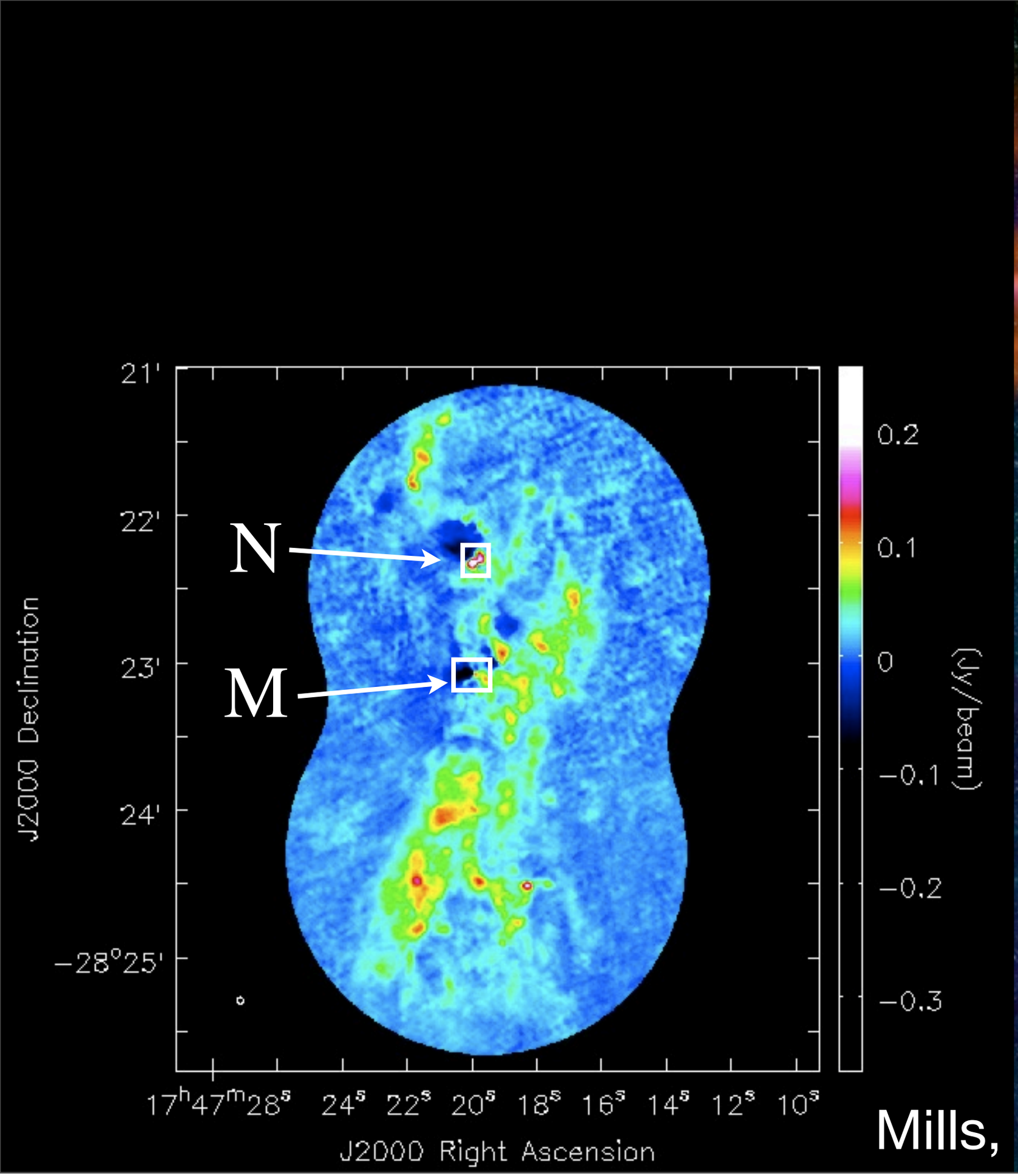
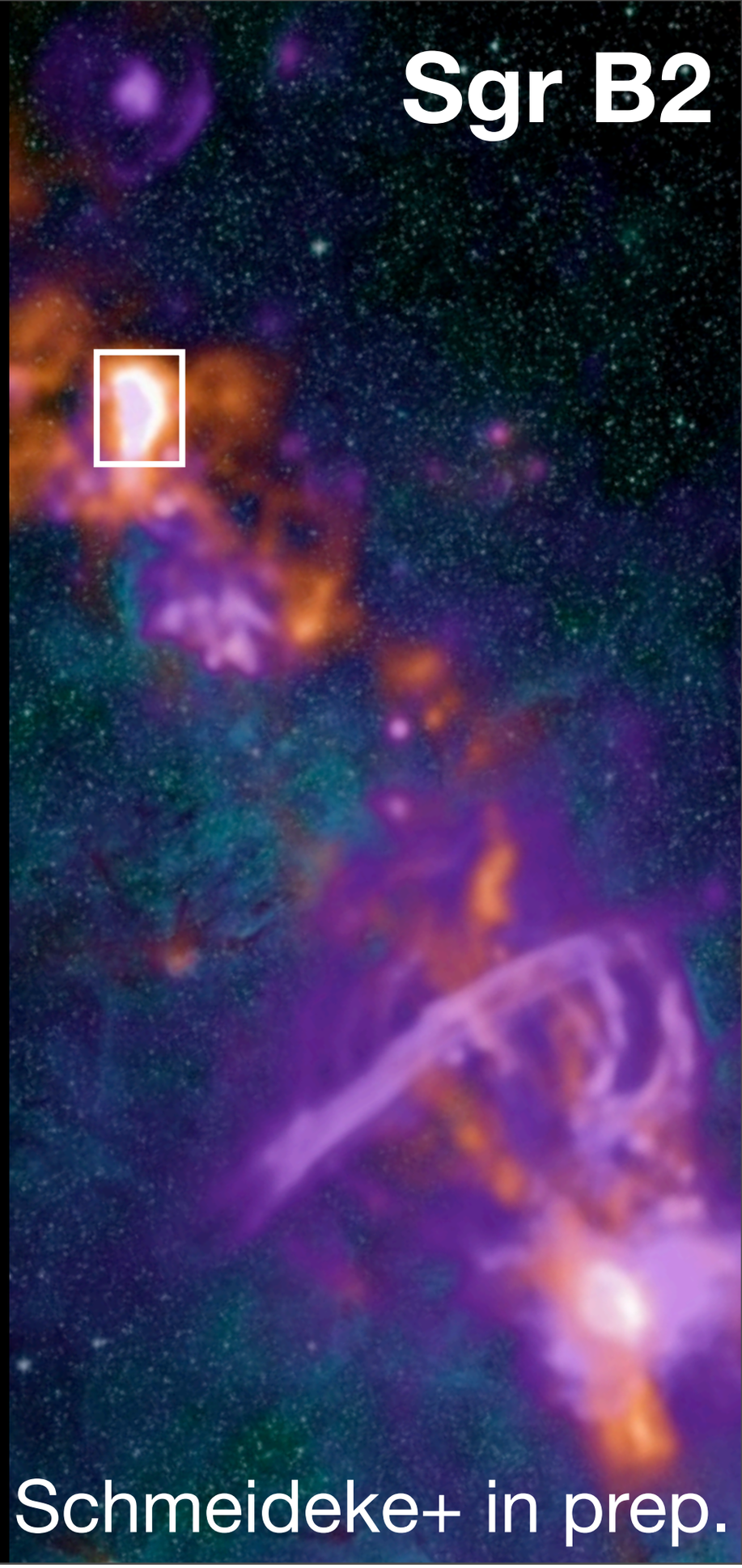




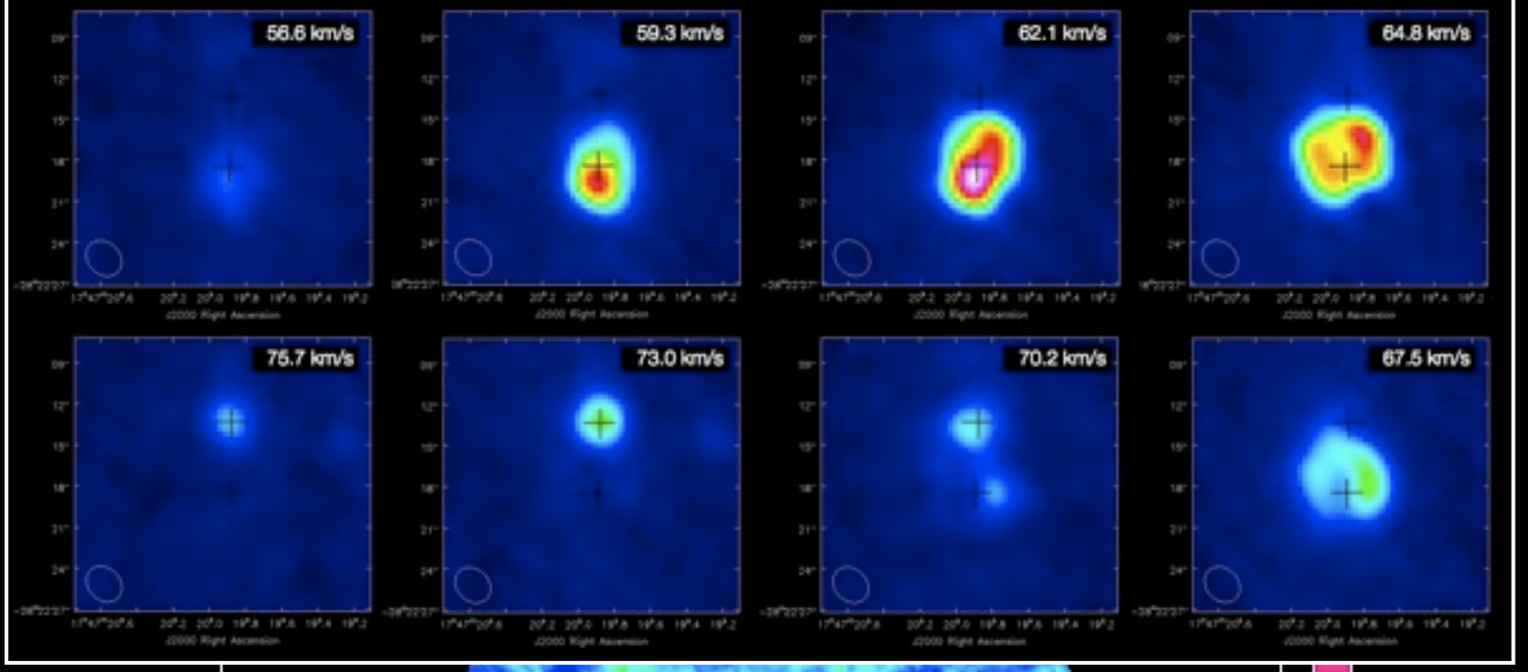


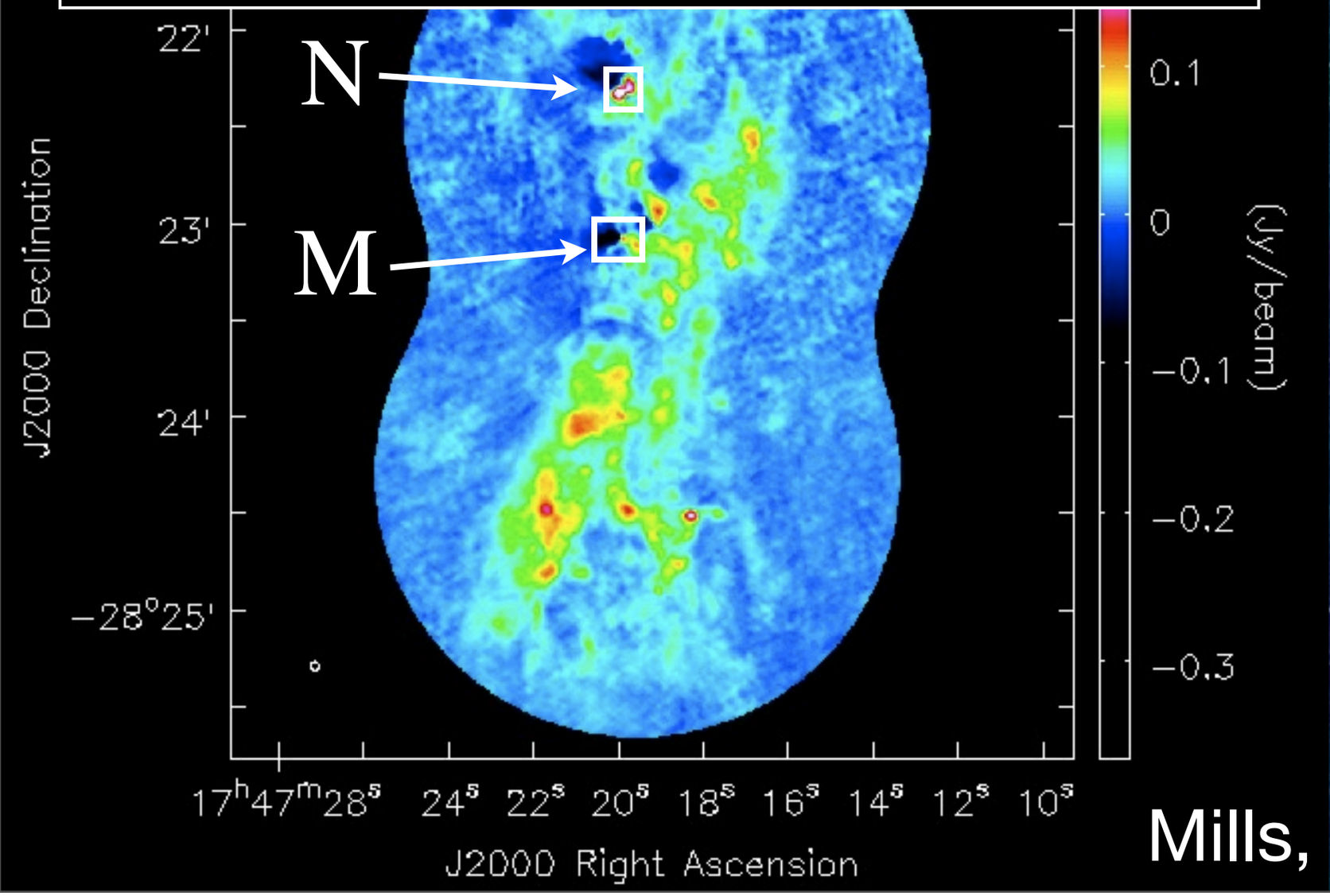
J2000 Right Ascension

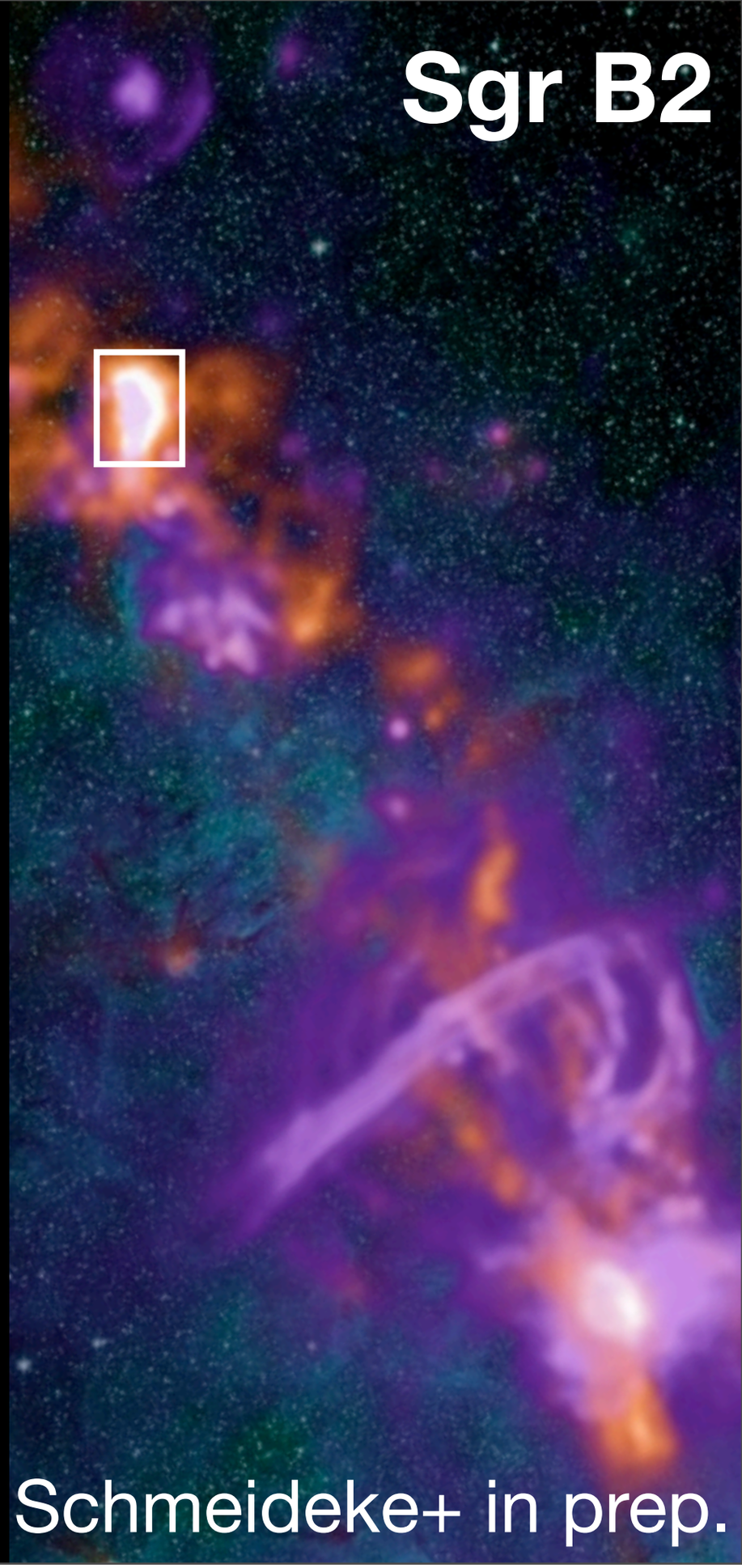

21'
22'
23'
24'
−28°25'
N
M
J2000 Declination
0.2
0.1
0
−0.1
−0.2
−0.3
(Jy/beam)
17h47m28s
24s
22s
20s
18s
16s
14s
12s
10s
J2000 Right Ascension


Sgr B2
Mills, Schmeideke+ in prep.

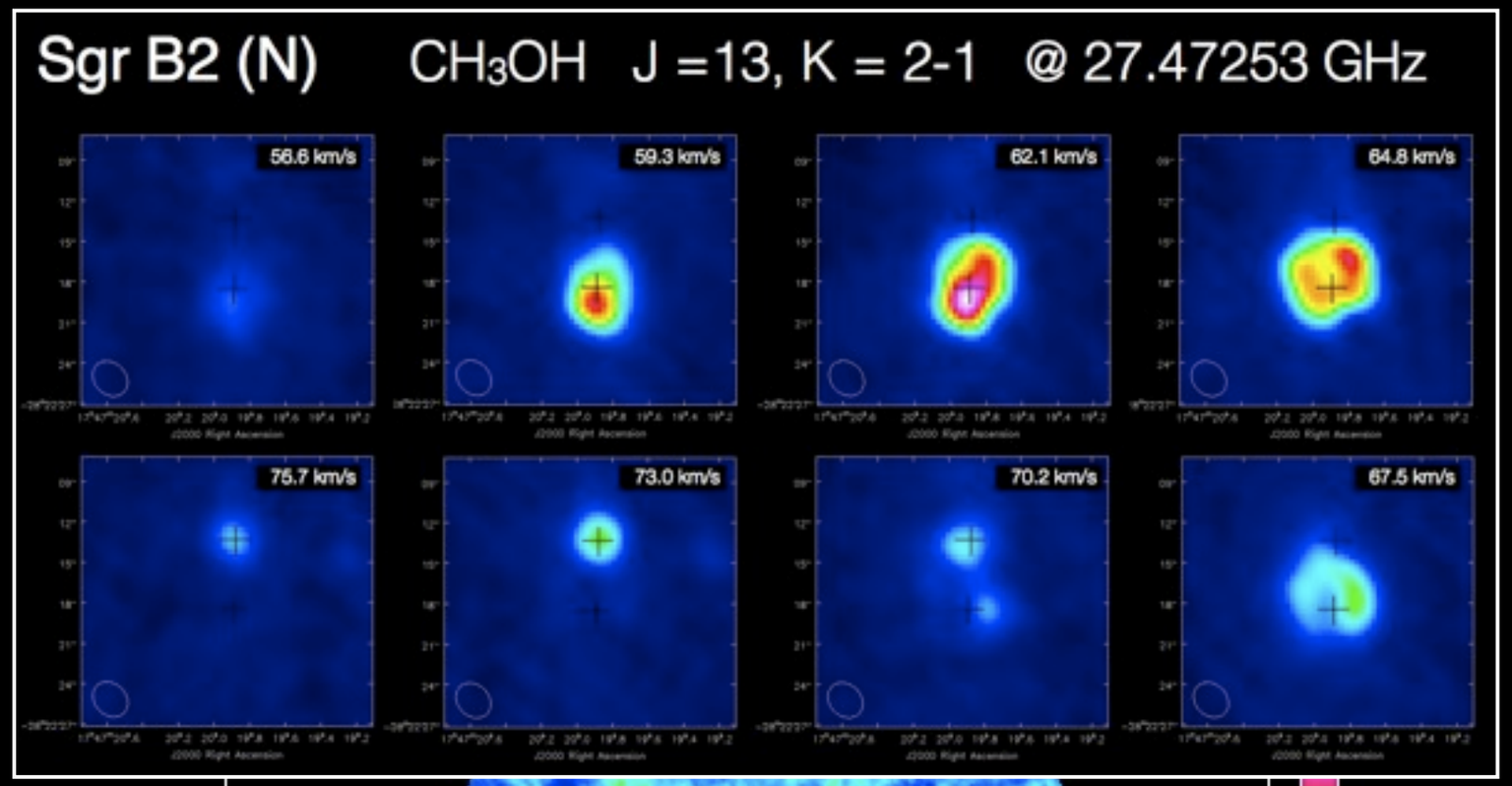
Sgr B2 (N) CH_3OH J =13, K = 2-1 @ 27.47253 GHz

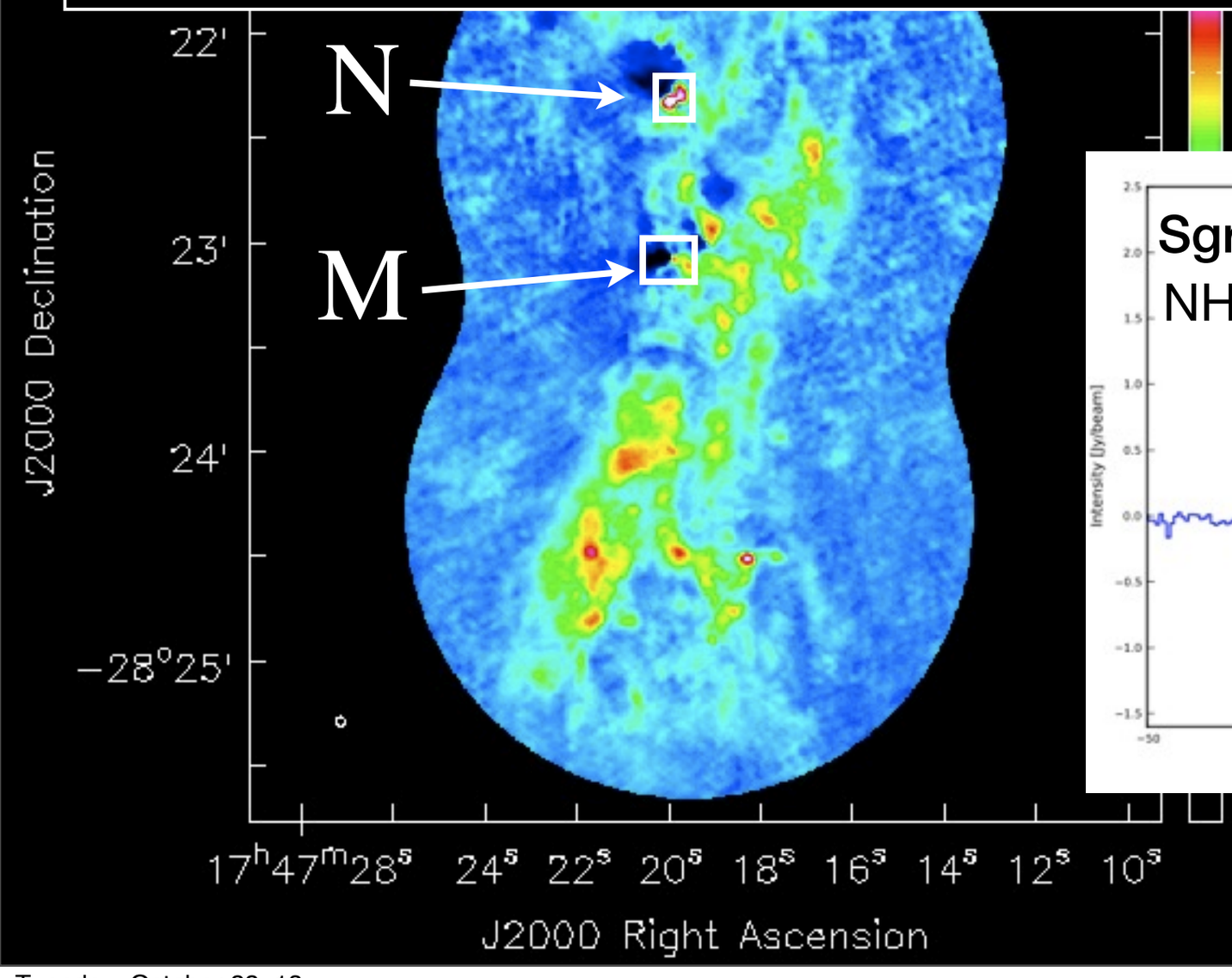


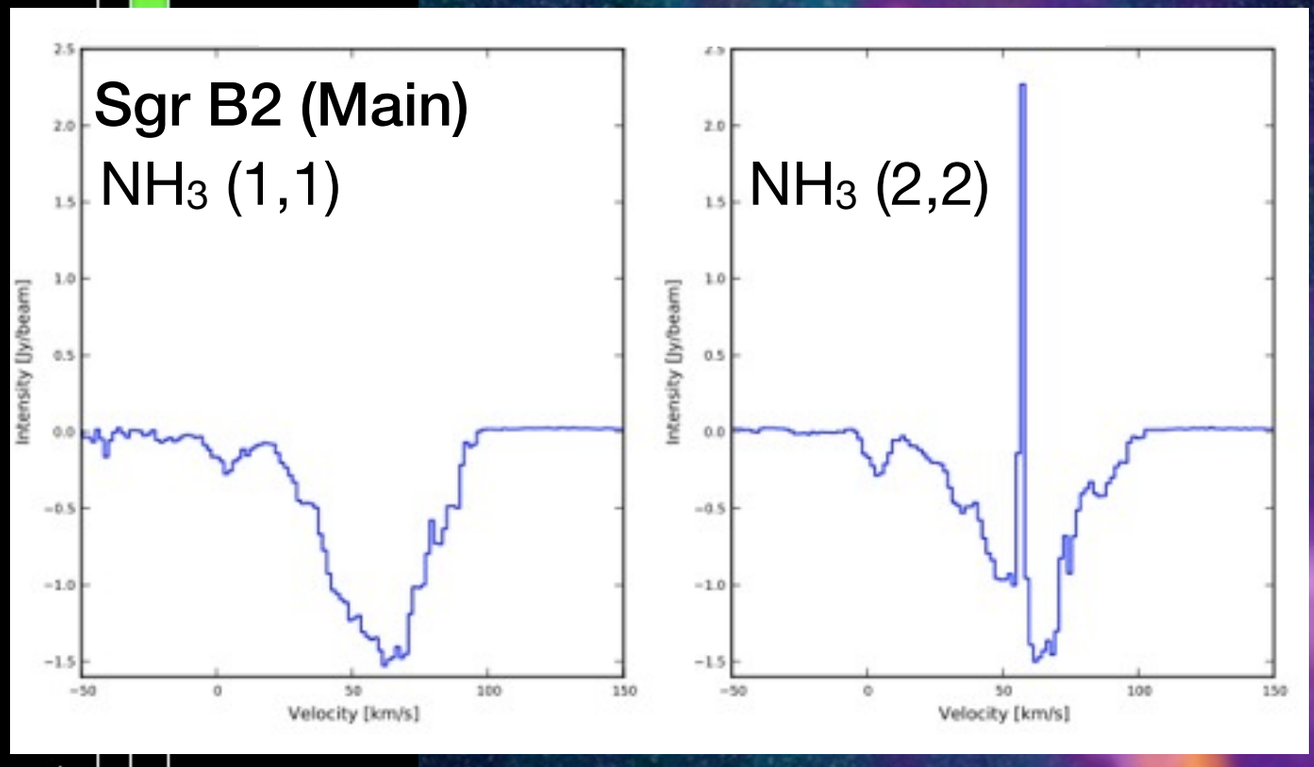




Sgr B2

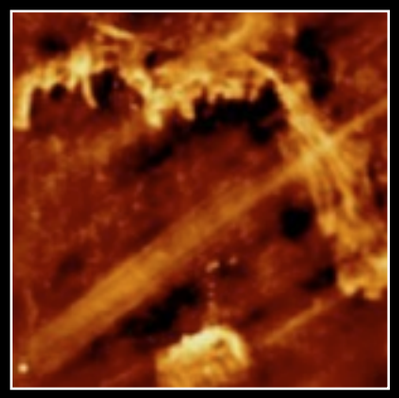






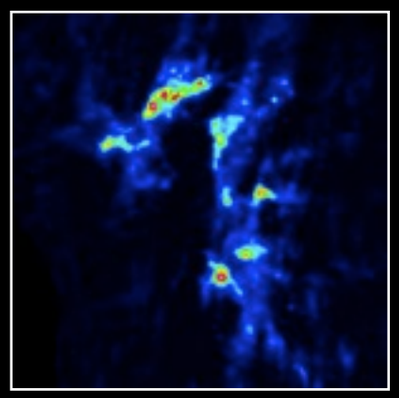
Mills, Schmeideke+ in prep.

Summary

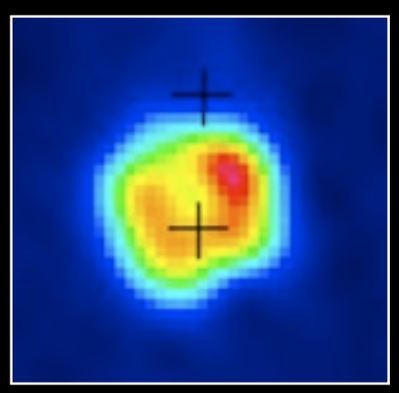


Sensitive continuum data are allowing us to characterize new features

(See also P73, Lang+)



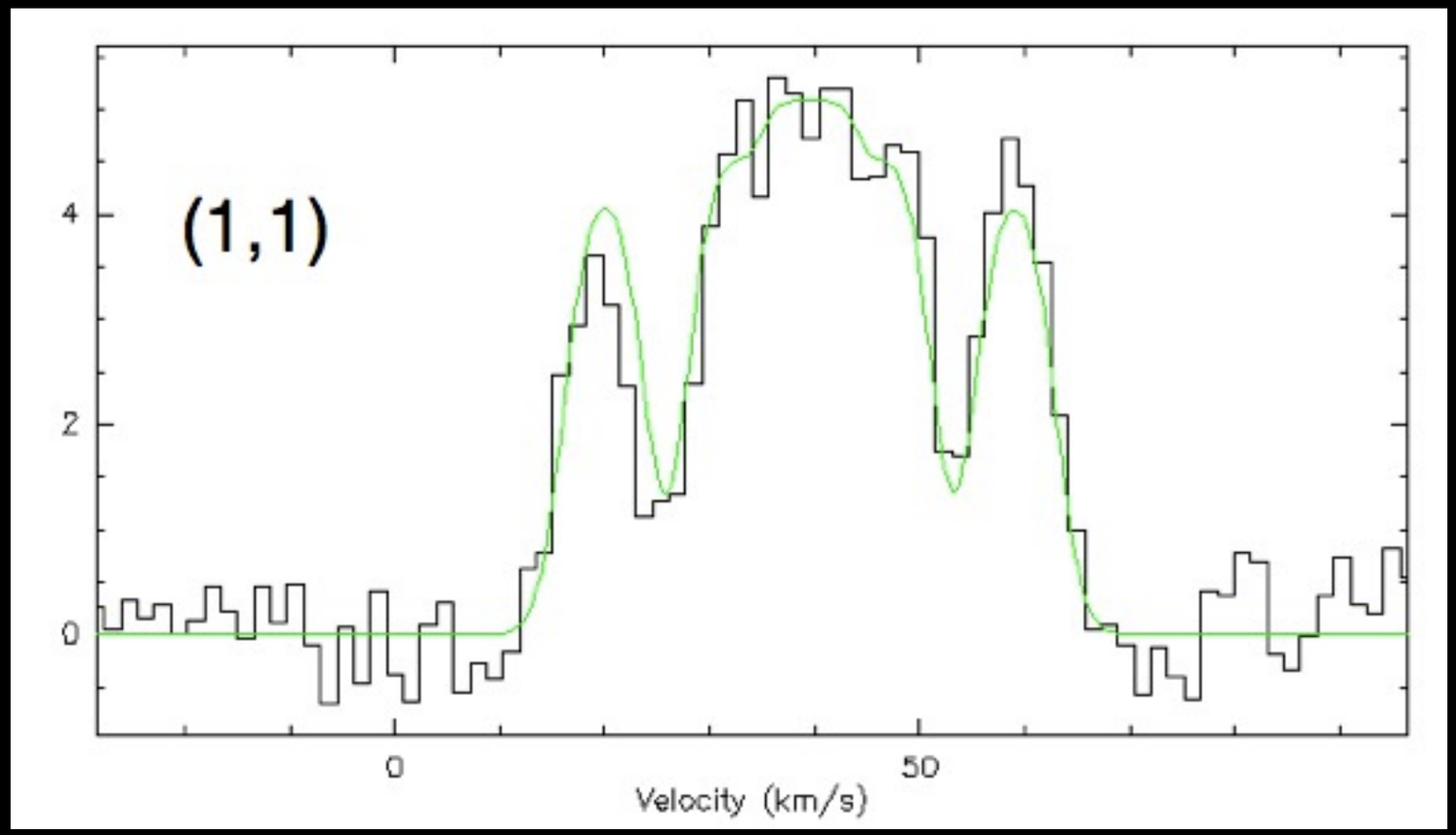
Complementary continuum, recombline, and molecular data will allow us to follow the gas from a radius of 10 pc to the black hole.



Opportunity to compare properties of the larger Sgr B2 cloud to more quiescent GC clouds

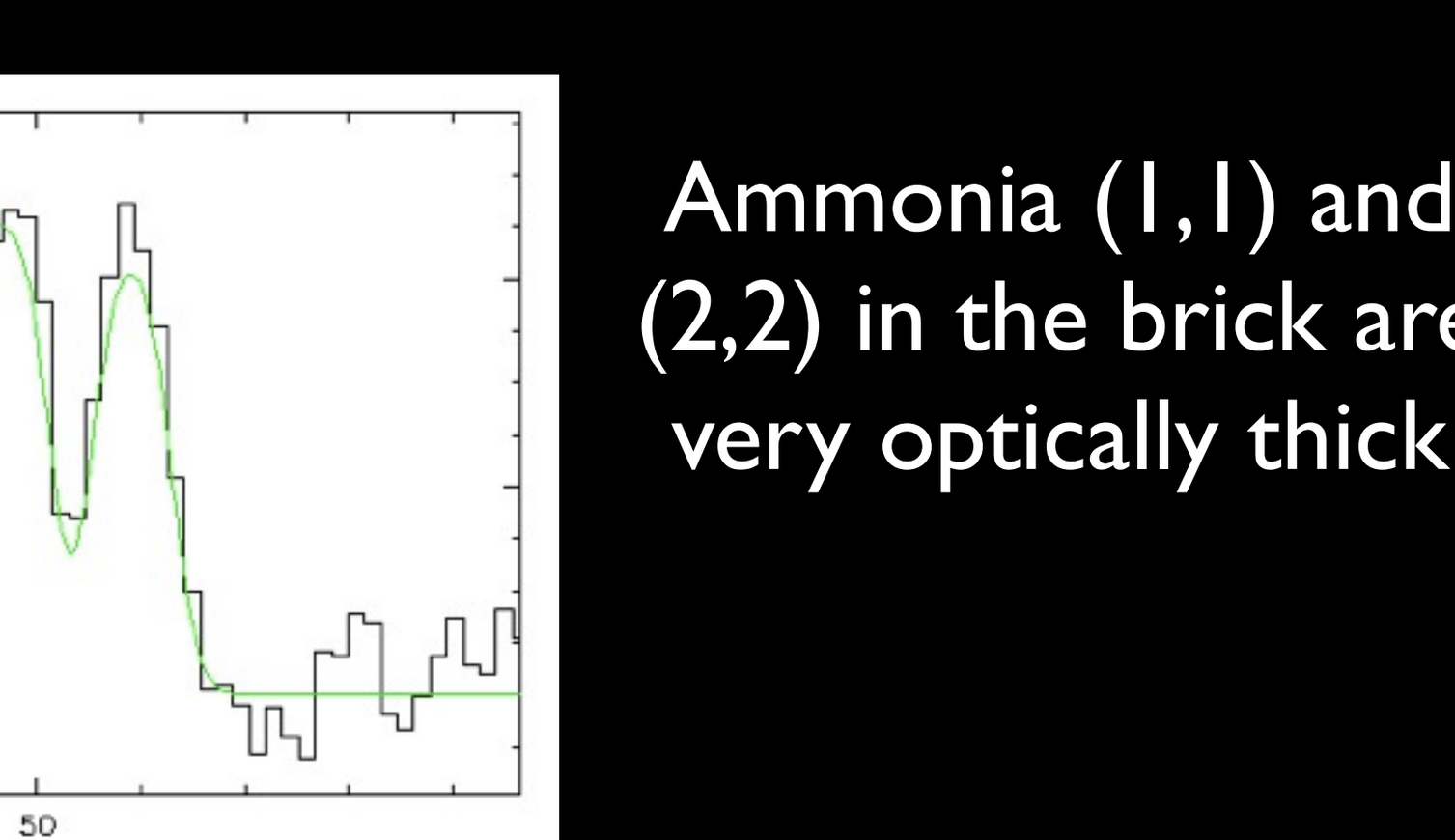
(See also P22, Corby+)

EXTRAS

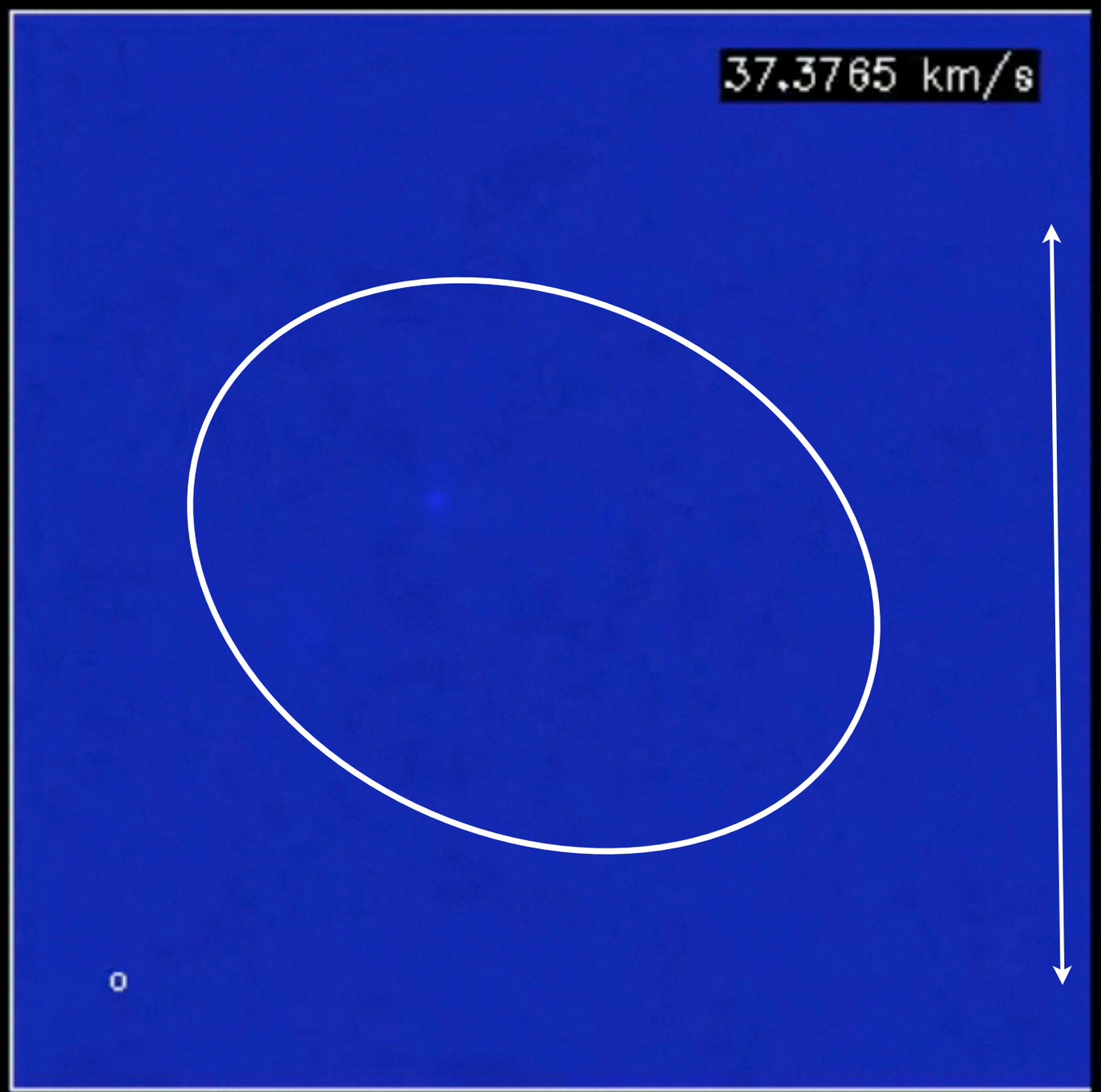


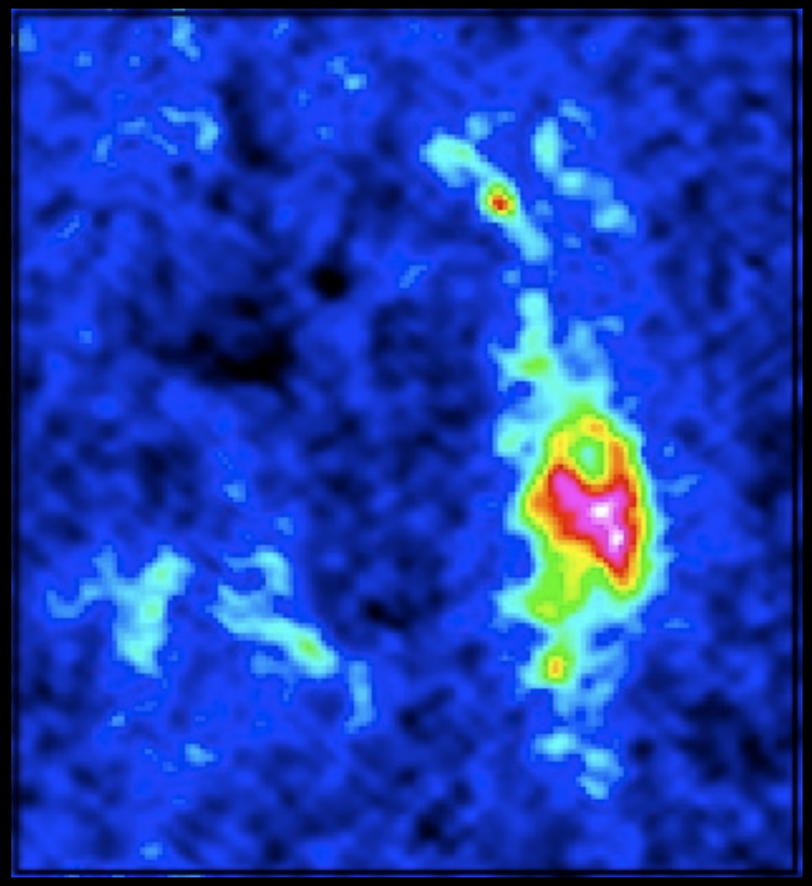
Ammonia (1,1) and (2,2) in the brick are very optically thick

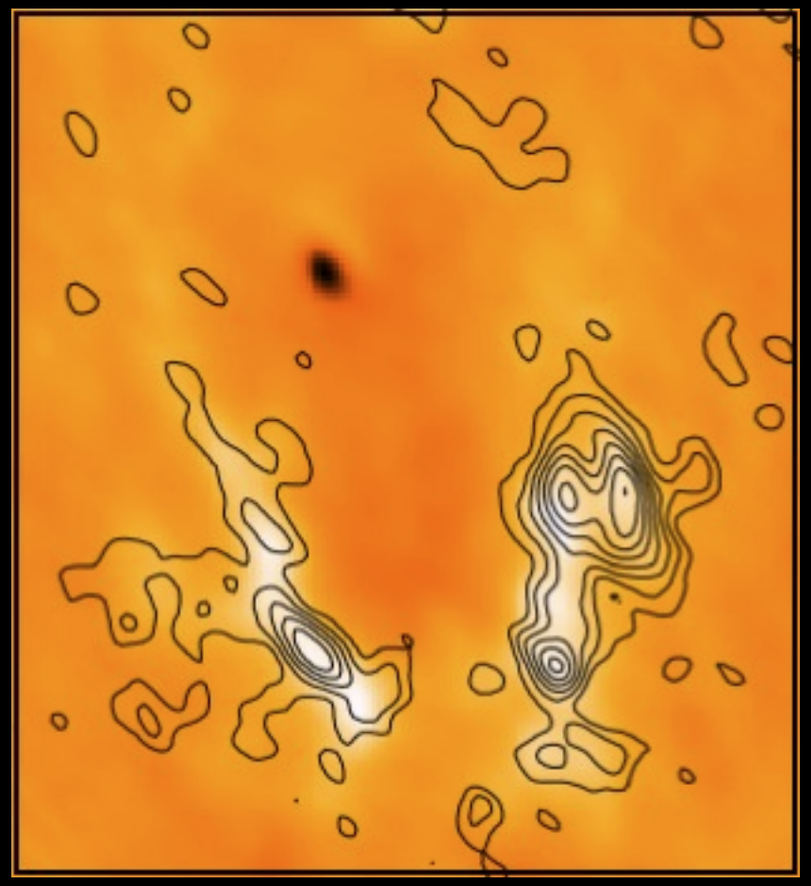
Typical tau ranges from 2 up to more than 7 (shown here)



36 GHz Methanol masers are in every field we surveyed







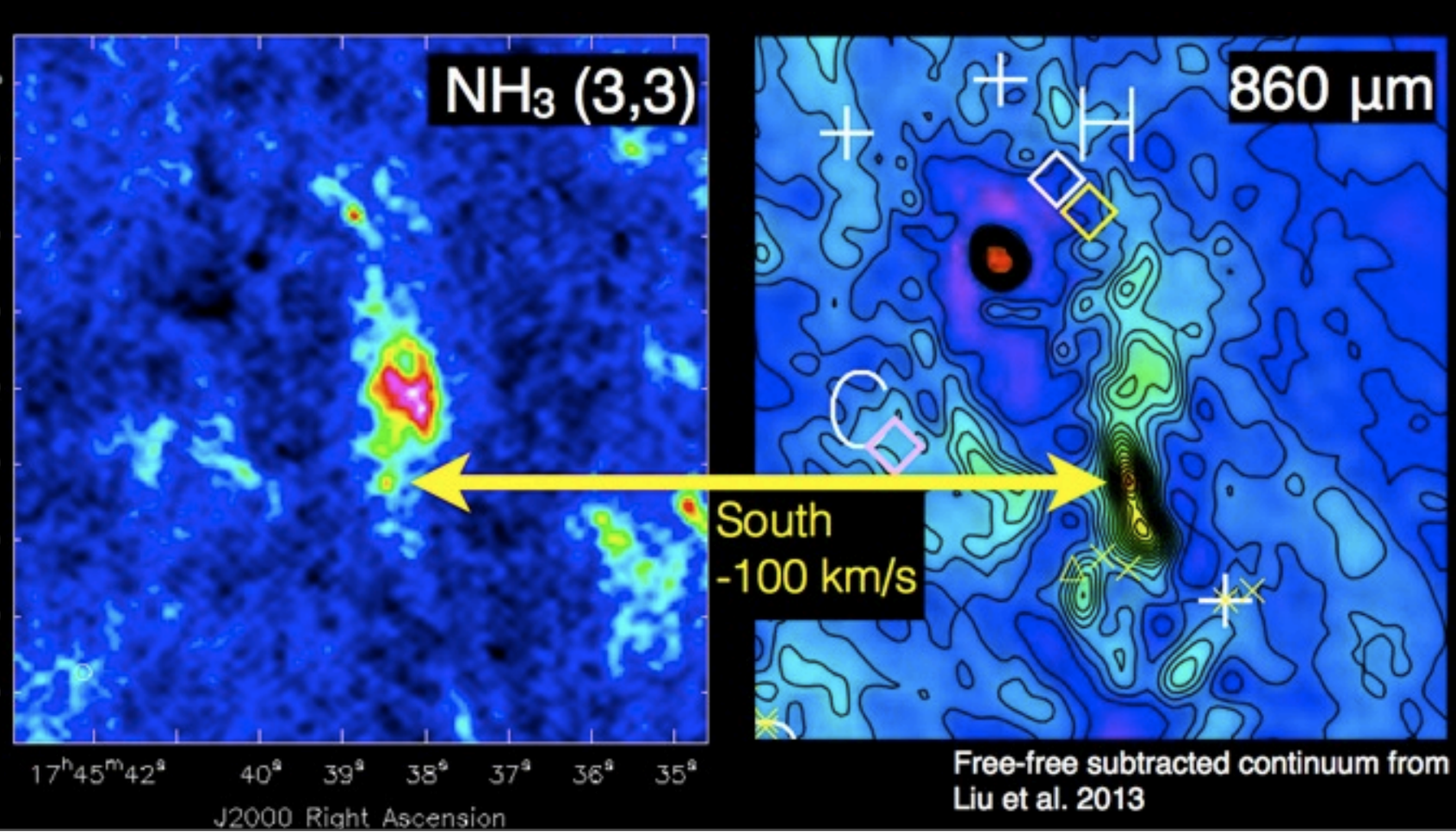
Ammonia as a shock tracer?

Well correlated with SiO, CH_3OH-- but NOT with dense gas tracer HC_3N

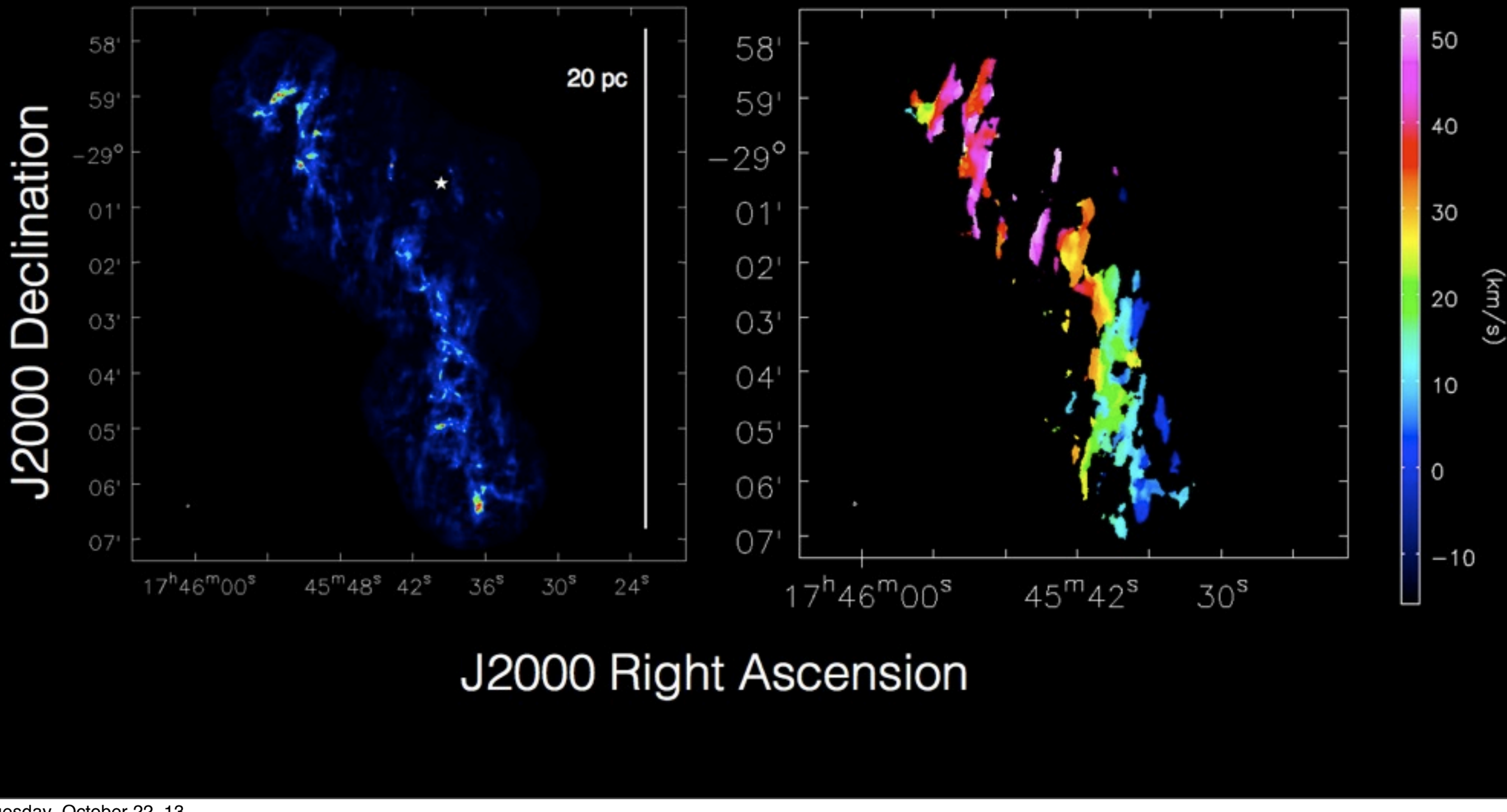
South clump:
σ ~30 km/s

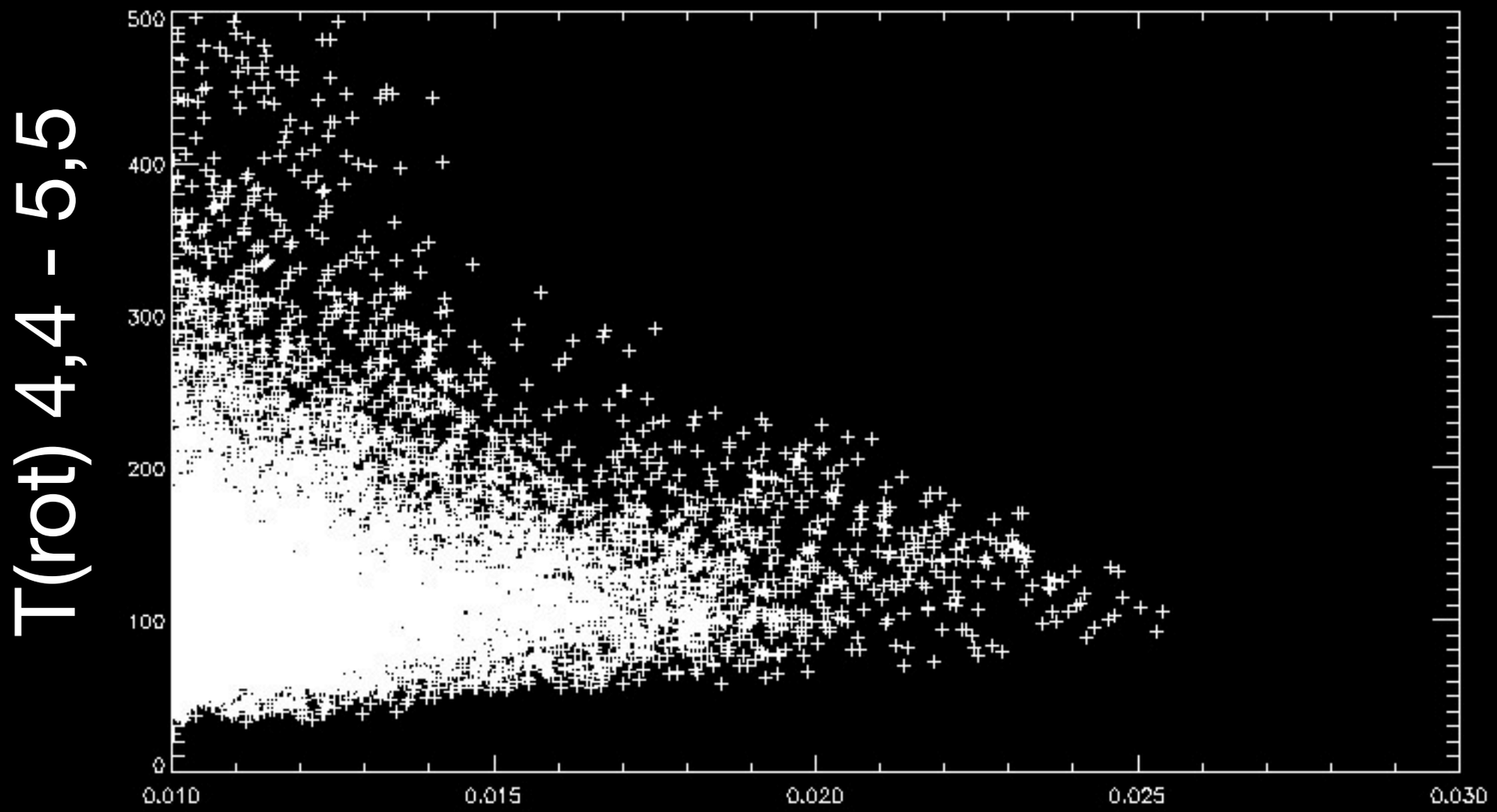
Strongest dust continuum source

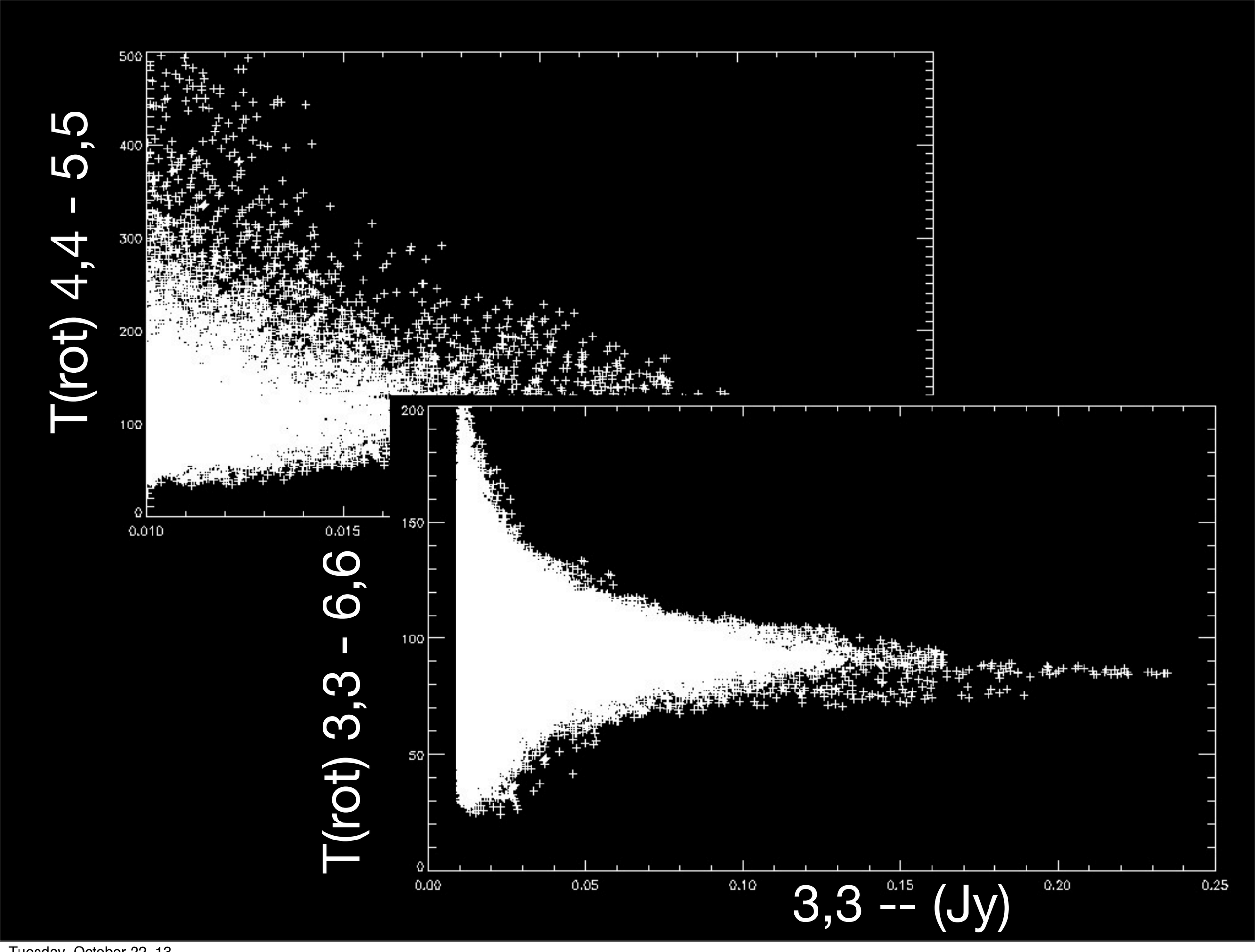
HCN suggests $n > 10^6$



Kinematics of gas near Sgr A--
strong velocity gradients




T(rot) 4,4 - 5,5
500
400
300
200
100
0
0.010
0.015
0.020
0.025
0.030
4,4 -- (Jy)


T(rot) 4,4 - 5,5
500
400
300
200
100
0
0.010
0.015
T(rot) 3,3 - 6,6
200
150
100
50
0
0.00
0.05
0.10
0.15
0.20
0.25
3,3 -- (Jy)