This talk contains jokes !

30 years of high-mass star formation

by Cesa & mosca

(mm interferometers & maser VLBI)

EUROPEAN VLBI NETWORK
Consortium for Very Long Baseline Interferometry in Europe

closest collaborators:

Maite Beltrán

Alberto Sanna

Ciriaco Goddi

Fabrizio Massi

HM SF Open Problems and Talk Outline

Low-mass (~1 $M_\odot$) SF: disk-jets well characterized by observations.

In high-mass (> 8 $M_\odot$), prior of ALMA/JVLA observations:

A few (claims of) disks towards OB-type YSOs

A few thermal jets towards high-mass YSOs (VLA, rms ~ 0.3 mJy)

IRAS 20126+4104: an (almost) unique disk-jet system in HMYSO.

HM SF Open Problems and Talk Outline

Low-mass (~1 $M_\odot$) SF: disk-jets well characterized by observations.

In high-mass (> 8 $M_\odot$), prior of ALMA/JVLA observations:

A few (claims of) disks towards OB-type YSOs

A few thermal jets towards high-mass YSOs (VLA, rms ~ 0.3 mJy)

IRAS 20126+4104: an (almost) unique disk-jet system in HMYSO.

Peculiar for high-mass SF:

Impact of radiation pressure and photoionization (thermal pressure from ionized gas) on the accretion/ejection.

The onset of the ionization: hyper-compact (HC) HII region.

The HC HII region inside core A1 in the SFR G24.78+0.08.

Cesa in Firenze In the shadows of the towers…..

mosca in Siena

Firenze and Siena: bitter enemies in the Middle Age

Montaperti 1260

Lo strazio e 'l grande scempio

che fece l'Arbia colorata in rosso,

tal orazion fa far nel nostro tempio». *Inf.* X, 85-88

Firenze and Siena: bitter enemies in the Middle Age

Montaperti 1260

Lo strazio e 'l grande scempio

che fece l'Arbia colorata in rosso,

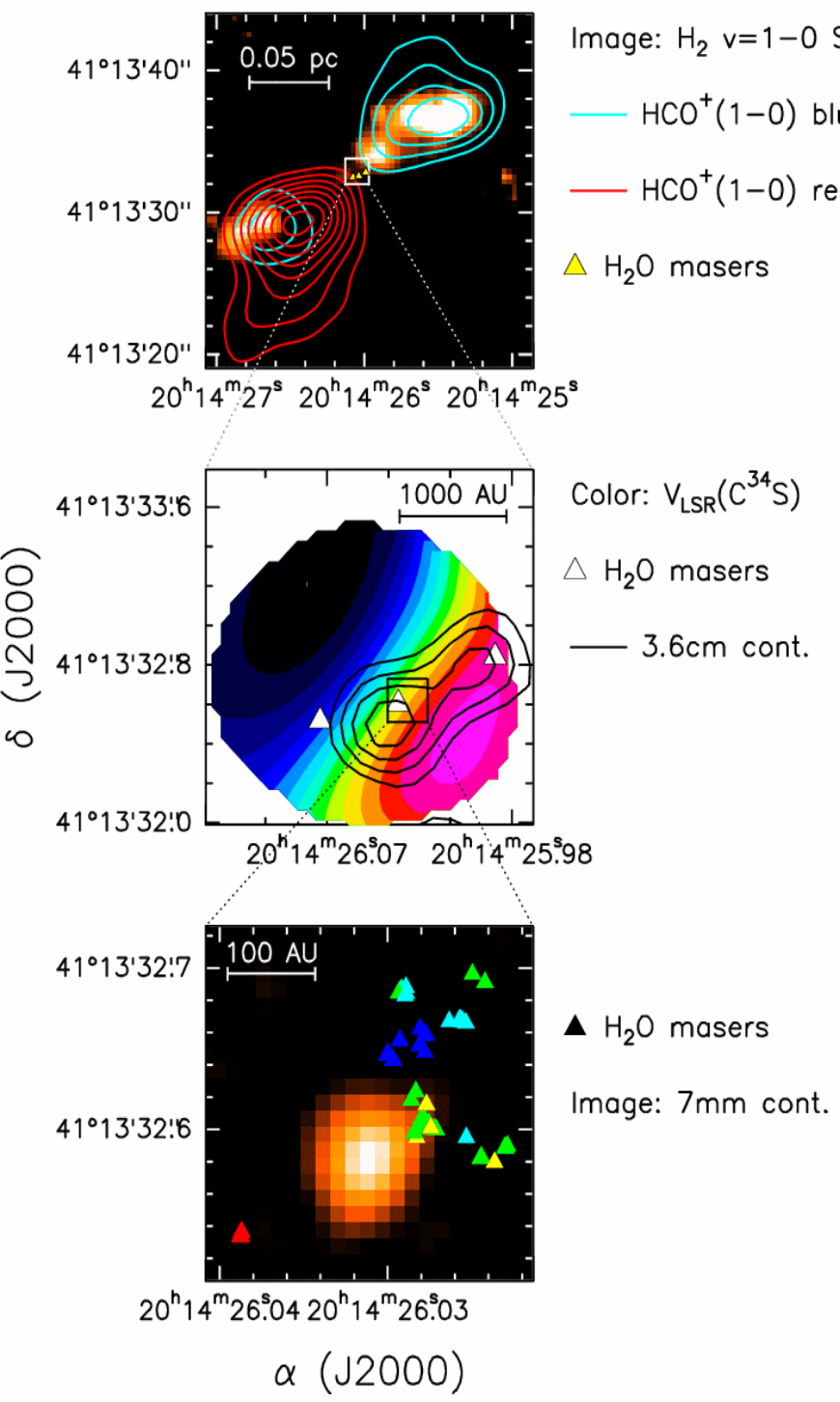
tal orazion fa far nel nostro tempio». *Inf.* X, 85-88

San Romano 1432

Trittico di Paolo Uccello:

"Disarcionamento di Bernardino della Carda"

(Uffizi, Firenze)



IRAS 20126+4104 $M_* \sim 12\ M_\odot$ d = 1.64 ± 0.05 kpc

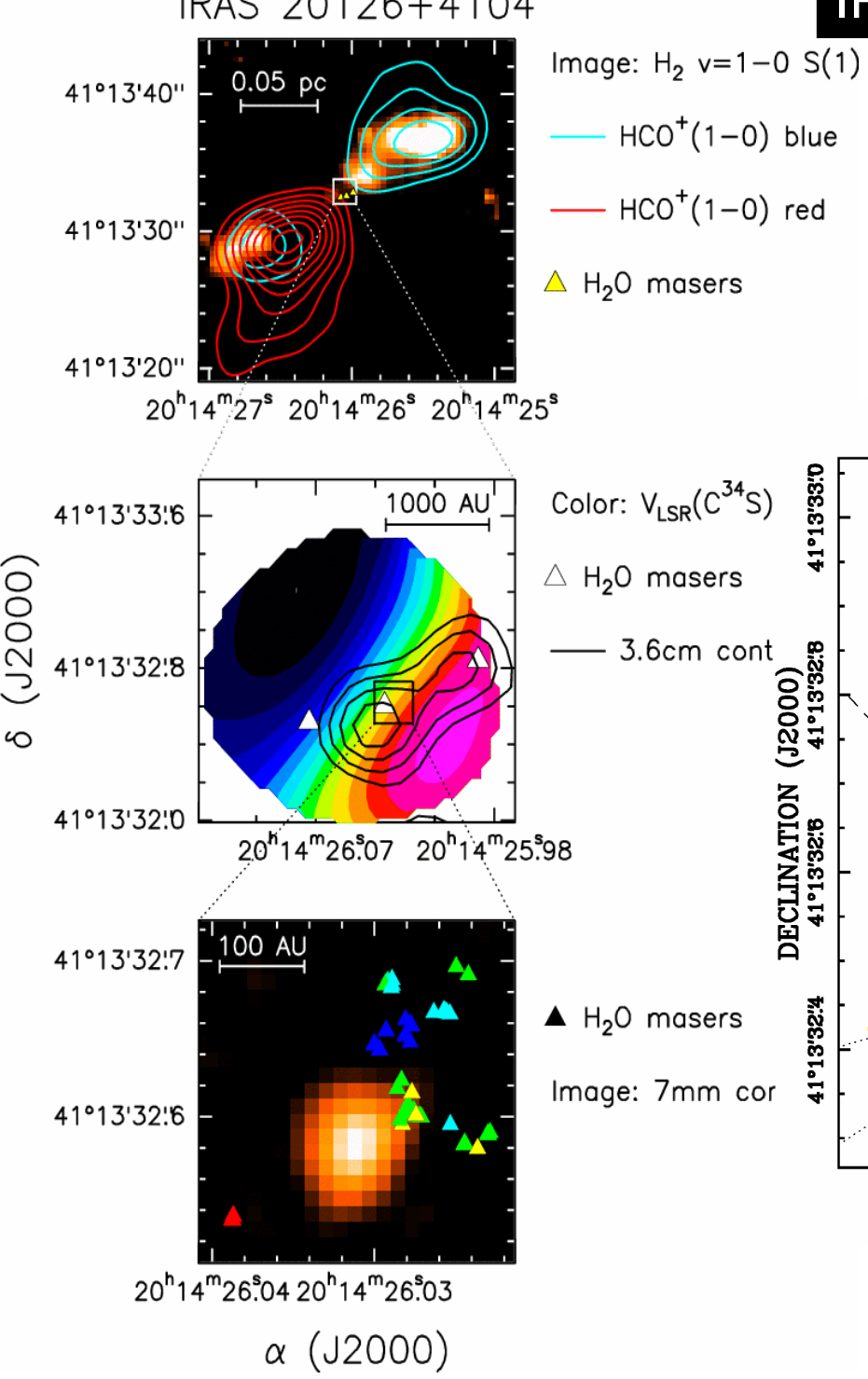
Cesaroni et al.

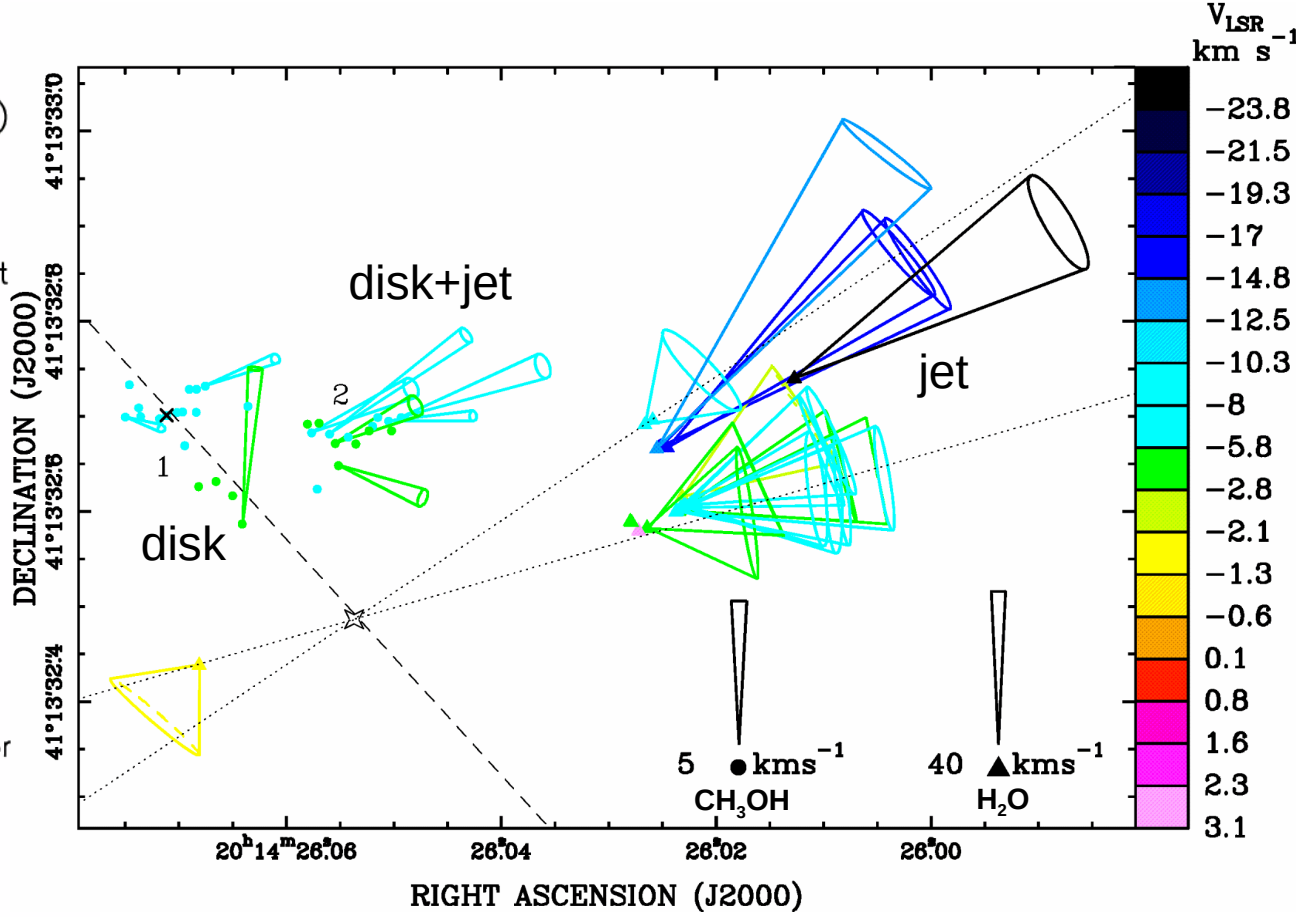
Hofner et al.

Moscadelli et al.

IRAS 20126+4104 $M_* \sim 12\ M_\odot$ d = 1.64 ± 0.05 kpc

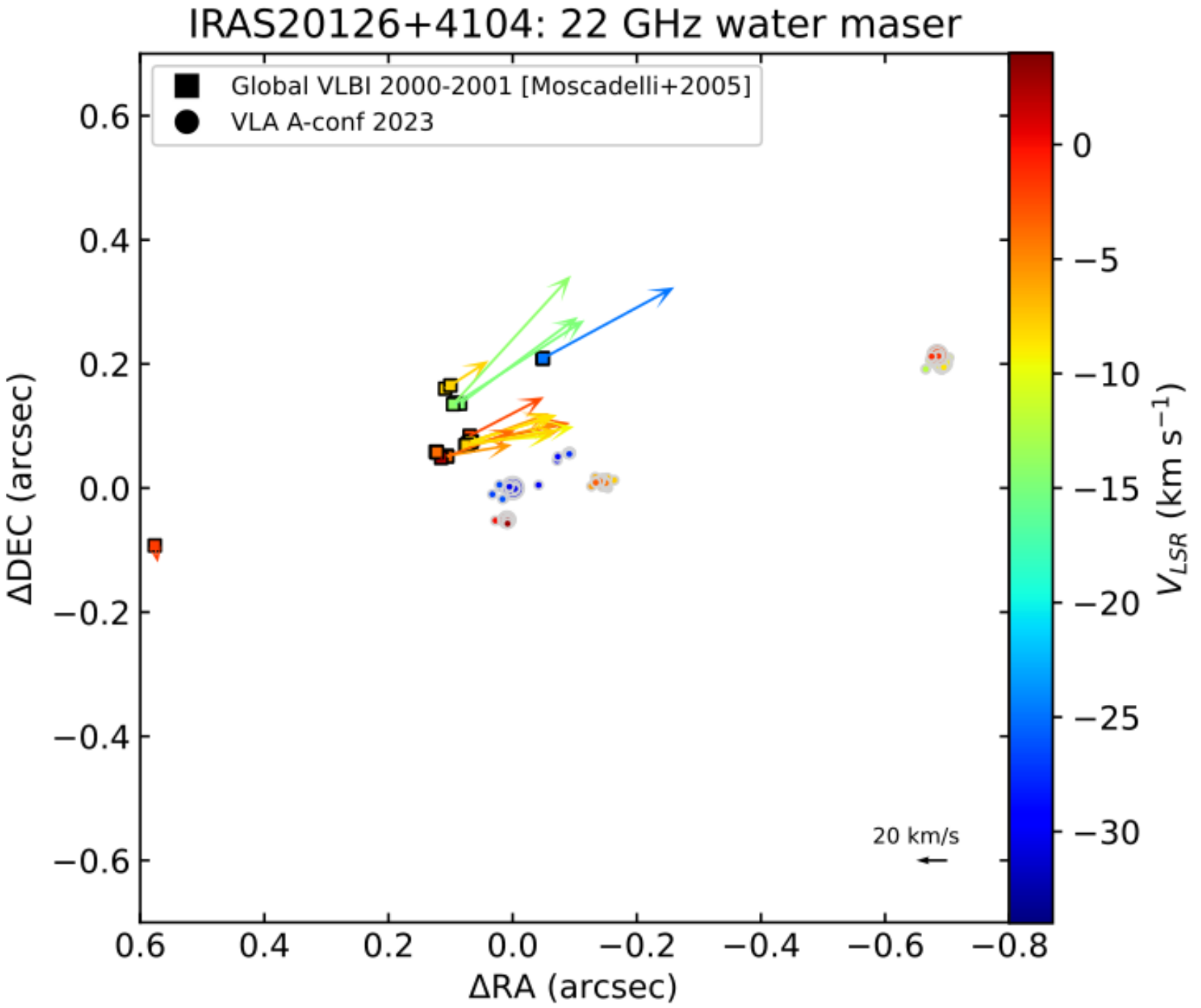
Cesaroni et al.
Hofner et al.
Moscadelli et al.



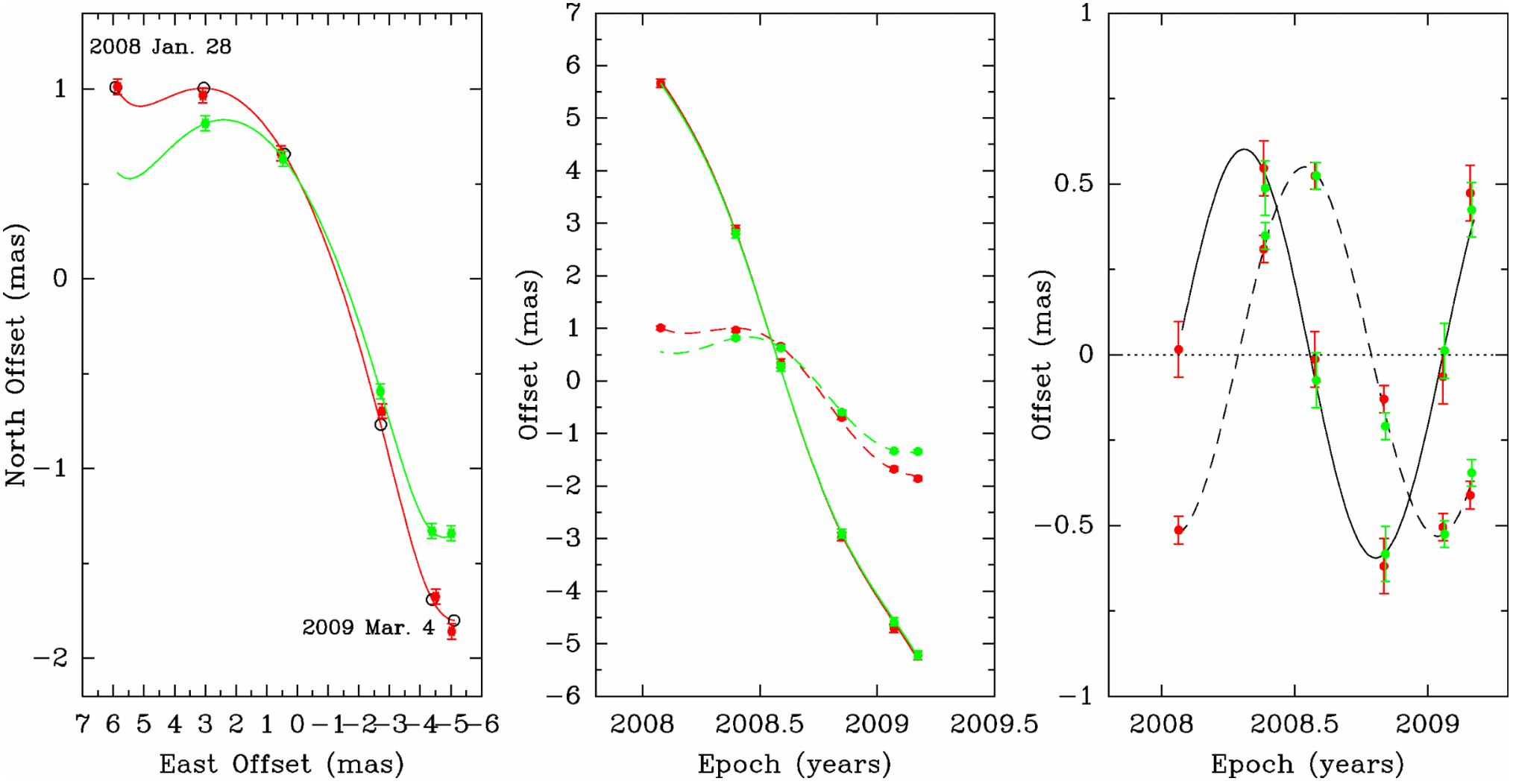


Moscadelli et al. (2011)

Hints at jet rotation

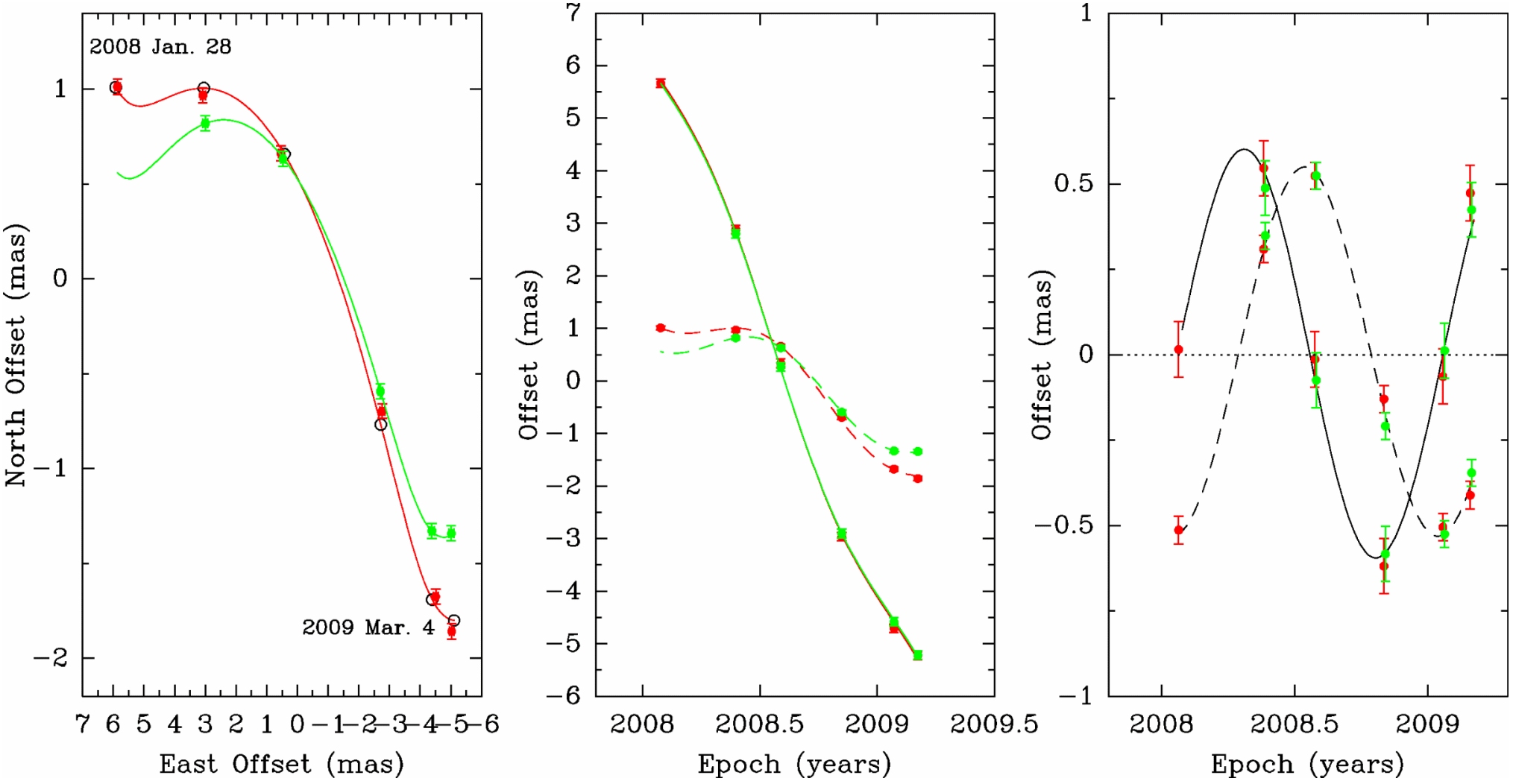


22 GHz maser parallax in IRAS 20126+4104



22 GHz maser parallax in IRAS 20126+4104

π = 0.61±0.02 mas → d = 1.64±0.05 kpc



April 17, 1555:

The (glorious) Republic of Siena and the French forces of Biagio di Montluc,
after a long siege – from January 1554,
surrendered to the army of Carlo V (Spain) & Cosimo I de' Medici (Firenze).
Because of the heroic defense, Carlo V accorded the honours of war and
the possibility to leave the town to those we wished to do that.
Hundreds of families together with Biagio di Montluc and the remnant of the army
left Siena and went to Montalcino. The "Republic of Siena in Montalcino"
kept on fighting till 1559, when the treaty of Cateau-Cambrésis stated the end
of the war between Spain and French in Italy with the victory of Spain.

"(*Lo Stato di Siena) è mio et a me s'appartiene in tutto*"

(Cosimo I de' Medici after the signature of the treaty of Cateau-Cambrésis)

April 17, 1555:

The (glorious) Republic of Siena and the French forces of Biagio di Montluc,
after a long siege – from January 1554,
surrendered to the army of Carlo V (Spain) & Cosimo I de' Medici (Firenze).
Because of the heroic defense, Carlo V accorded the honours of war and
the possibility to leave the town to those we wished to do that.
Hundreds of families together with Biagio di Montluc and the remnant of the army
left Siena and went to Montalcino. The "Republic of Siena in Montalcino"
kept on fighting till 1559, when the treaty of Cateau-Cambrésis stated the end
of the war between Spain and French in Italy with the victory of Spain.

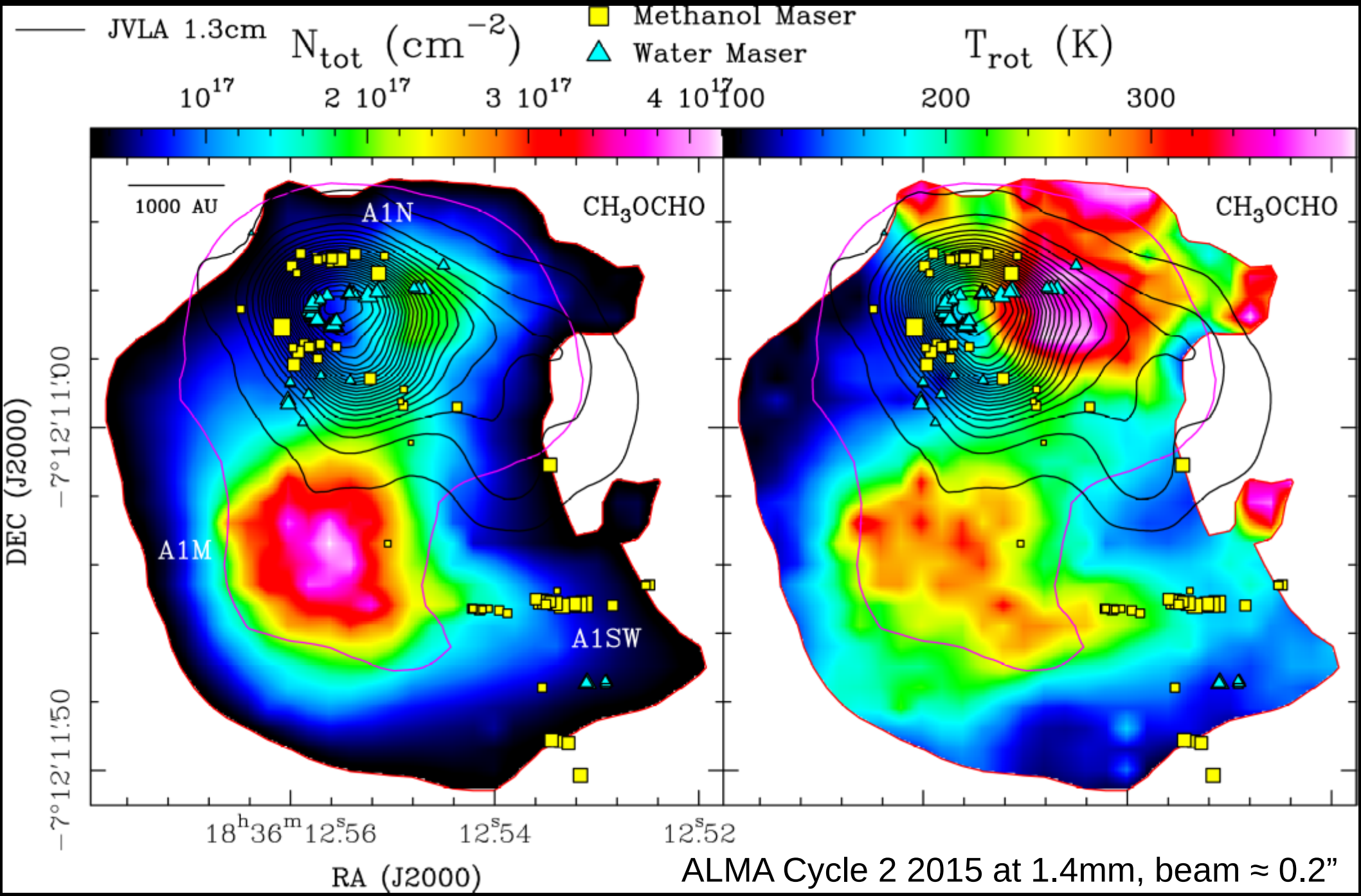
"(Lo Stato di Siena) è mio et a me s'appartiene in tutto"

(Cosimo I de' Medici after the signature of the treaty of Cateau-Cambrésis)

Summer 2016:

mosca ,after a long siege, surrendered to Maite Beltrán and Cesa
and accepted to take part to the data reduction and analysis of
mm interferometric data,
(specifically, the ALMA Cycle 2 observations of the source G24.78+0.08).
Because of the strenuous resistance, the honours of war were accorded,
and mosca was allowed to reduce and analyze the corresponding
maser VLBI data, too.

Core A1 in the high-mass SFR G24.78+0.08

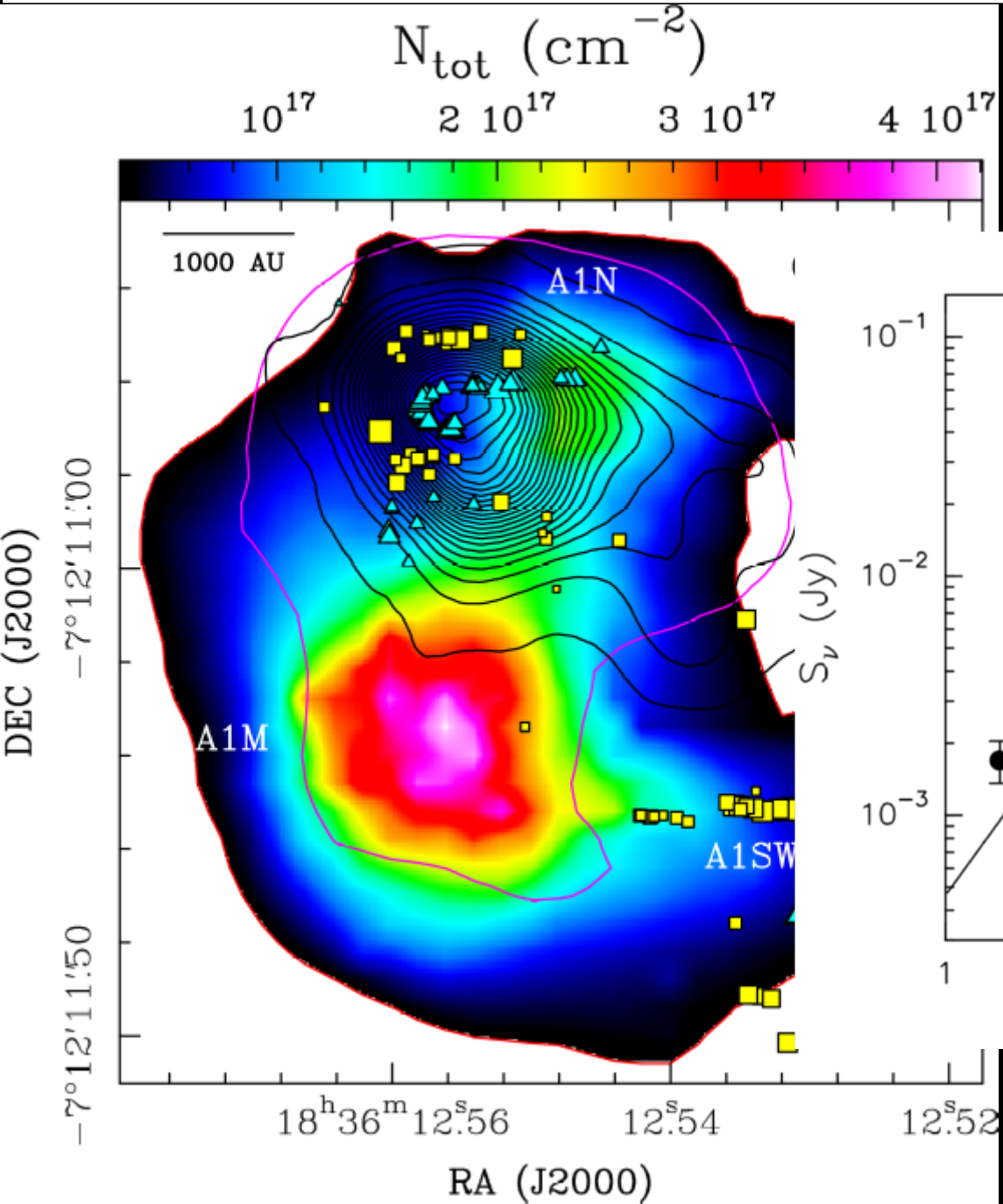


ALMA Cycle 2 2015 at 1.4mm, beam ≈ 0.2”

(Moscadelli et al. 2018)

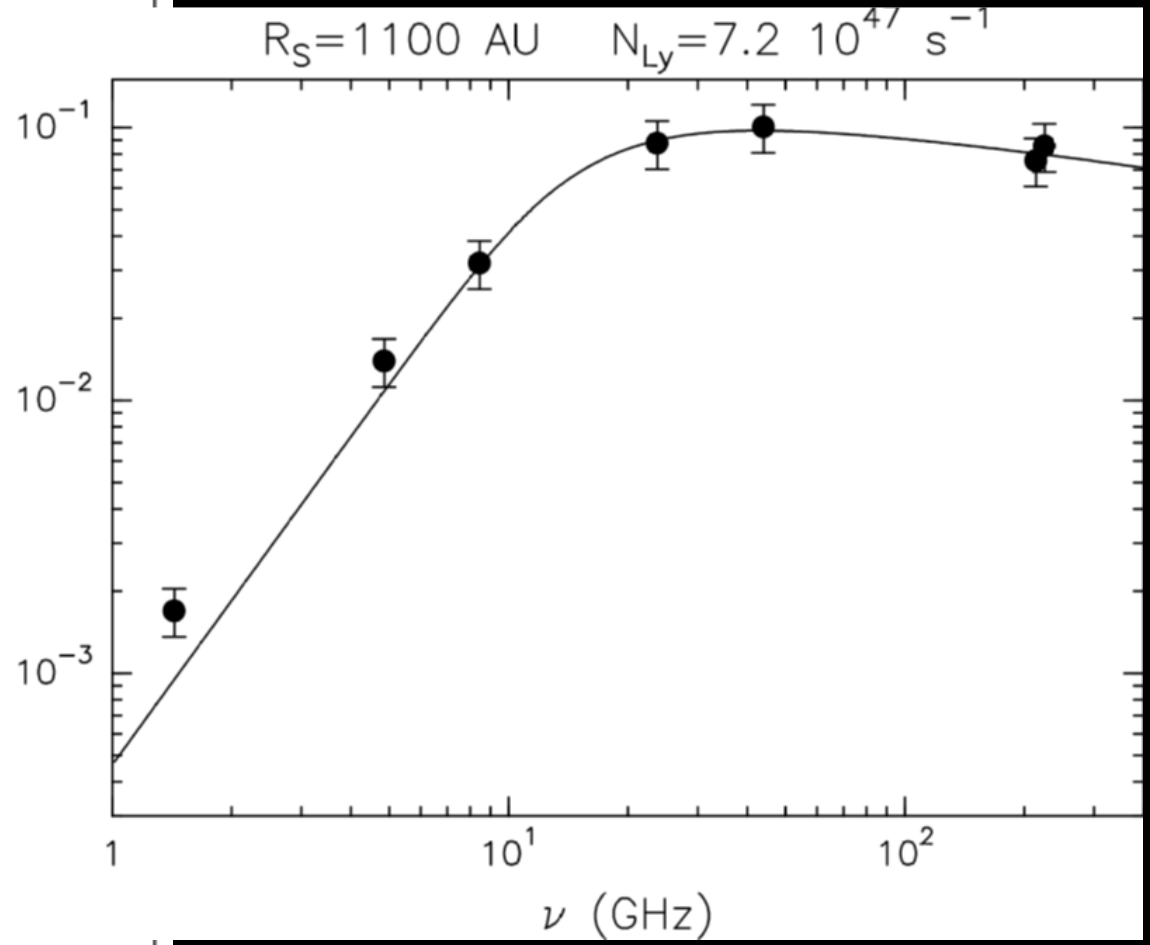
Core A1 in the high-mass SFR G24.78+0.08

—— : JVLA 1.3 cm ; ■ : meth. maser ; ▲ : water maser



FREE-FREE EMISSION:

ZAMS TYPE O9.5, M ≈ 20$M_\odot$



ALMA Cycle 2 2015 at 1.4mm, beam ≈ 0.2”

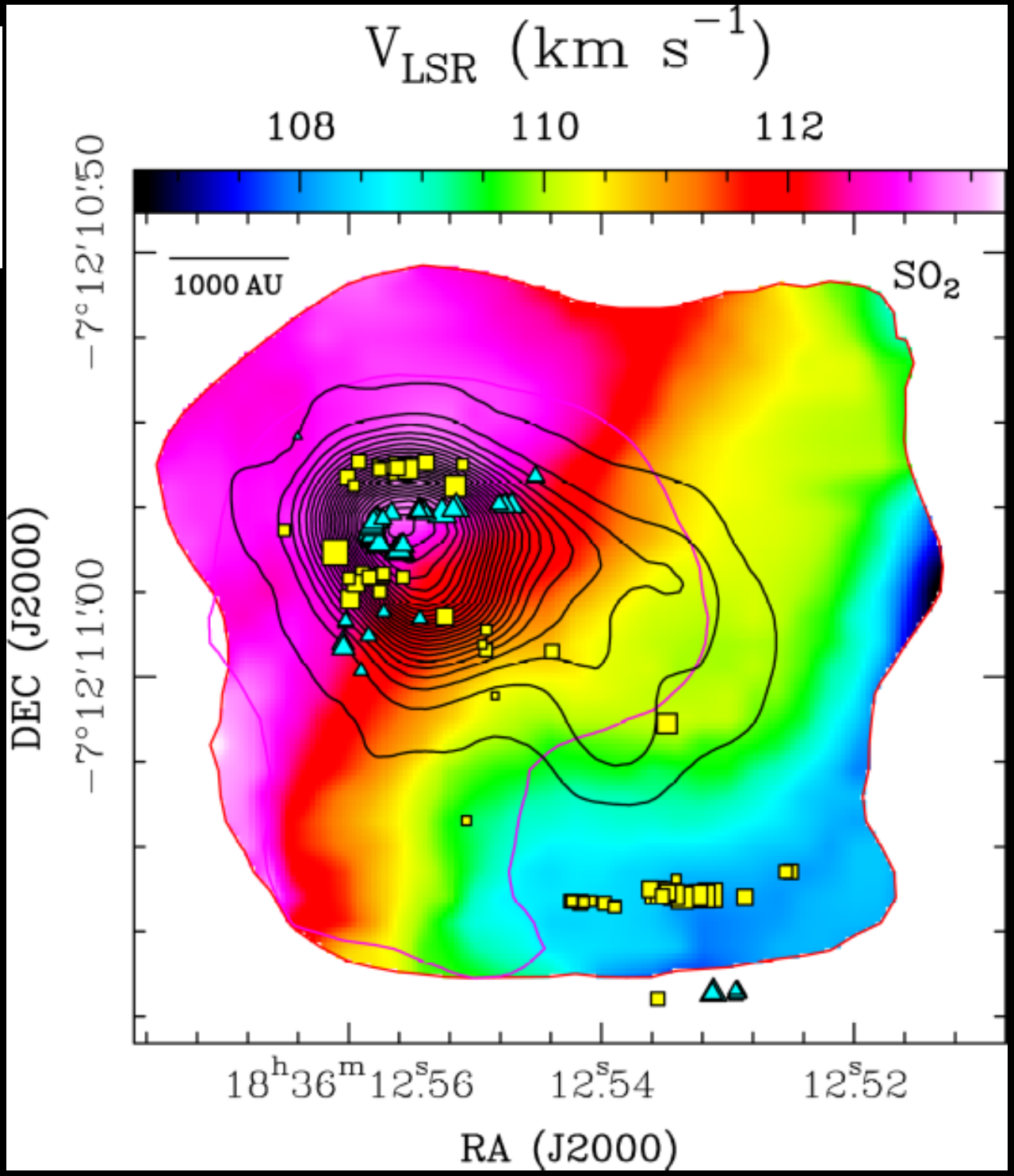
(Moscadelli et al. 2018)

Core A1 in the high-mass SFR G24.78+0.08

— : JVLA 1.3 cm ;

■ : meth. maser ;

▲ : water maser

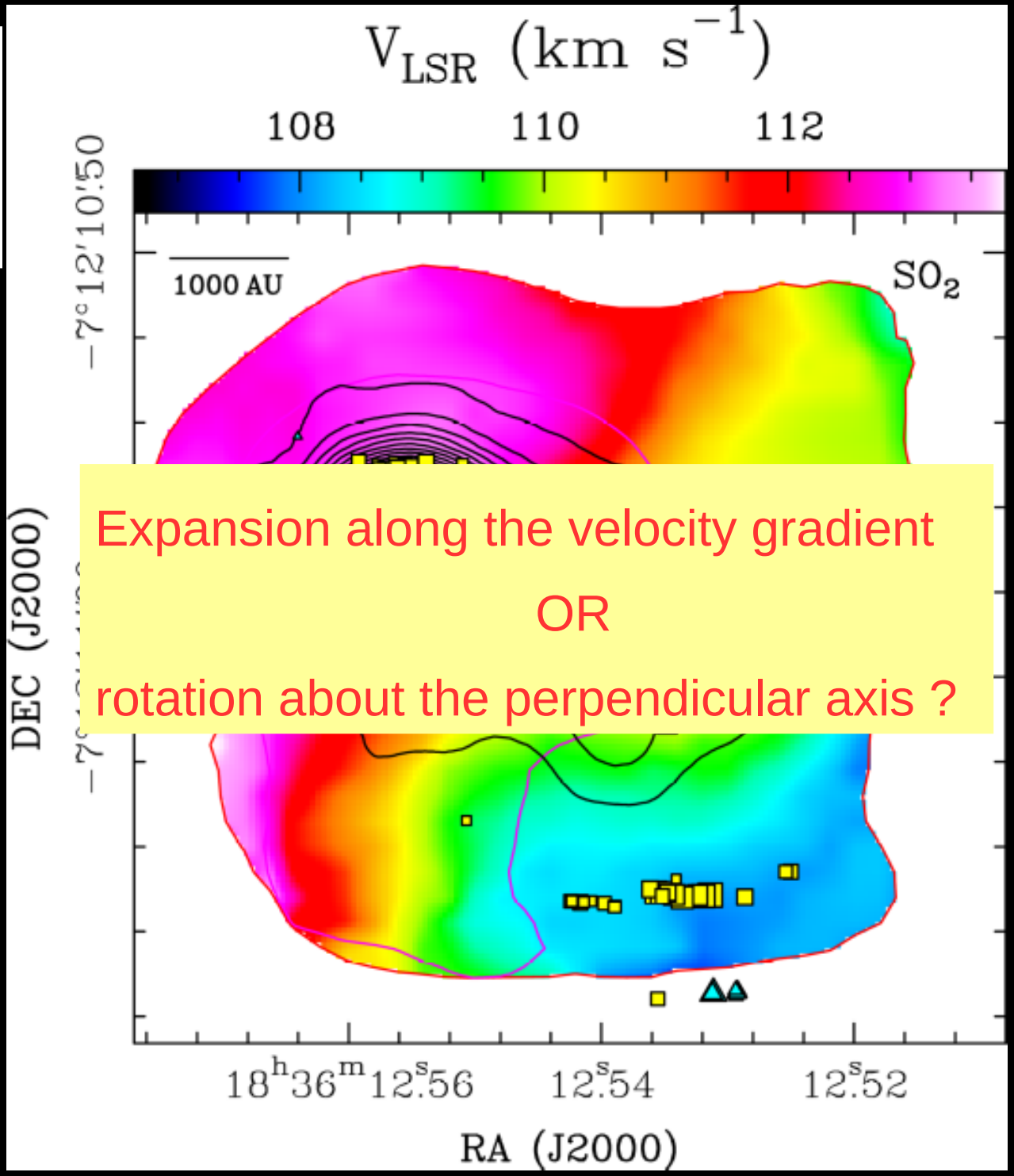


Core A1 in the high-mass SFR G24.78+0.08

—— : JVLA 1.3 cm ;

■ : meth. maser ;

▲ : water maser

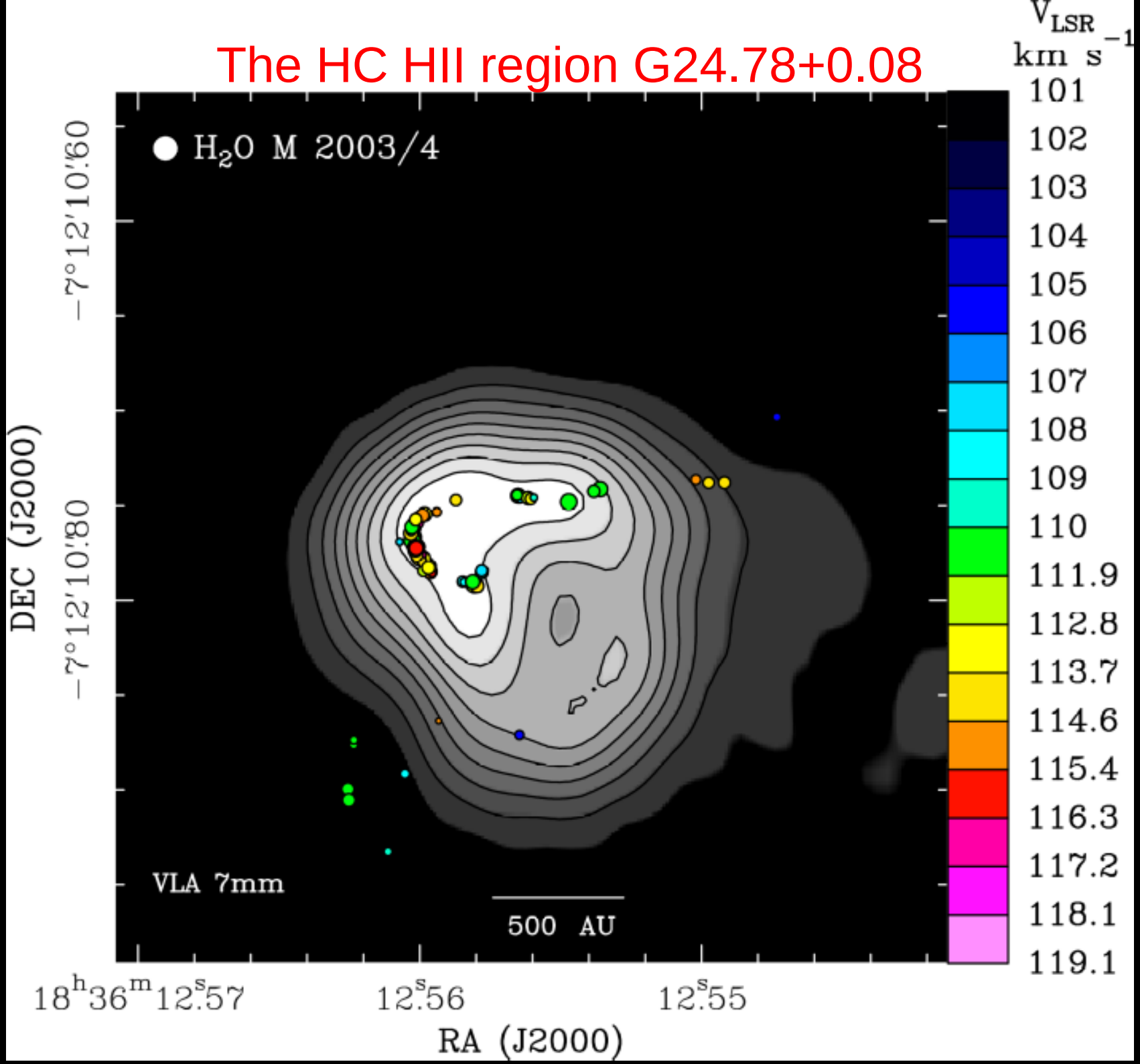


Expansion along the velocity gradient

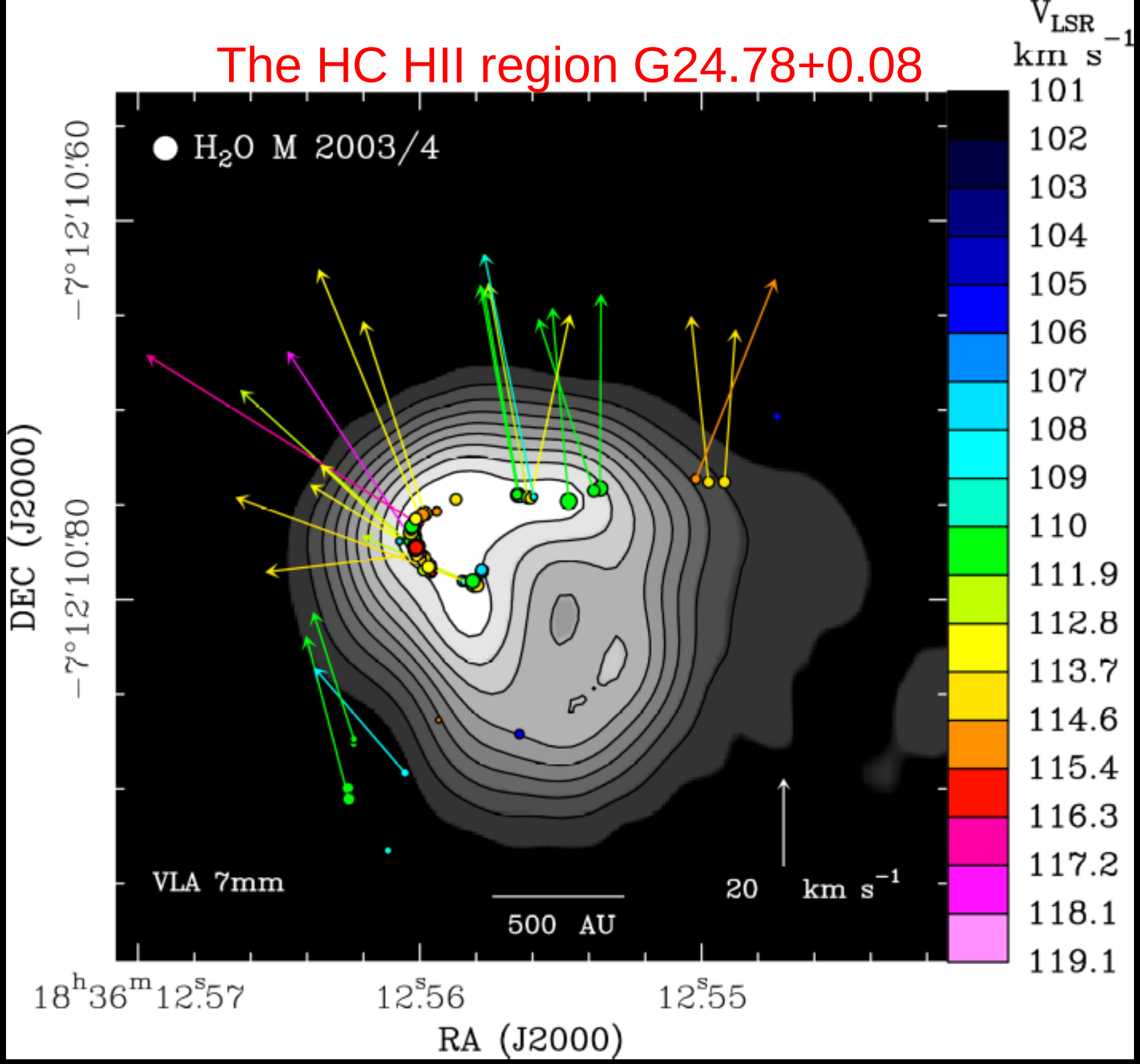
OR

rotation about the perpendicular axis ?

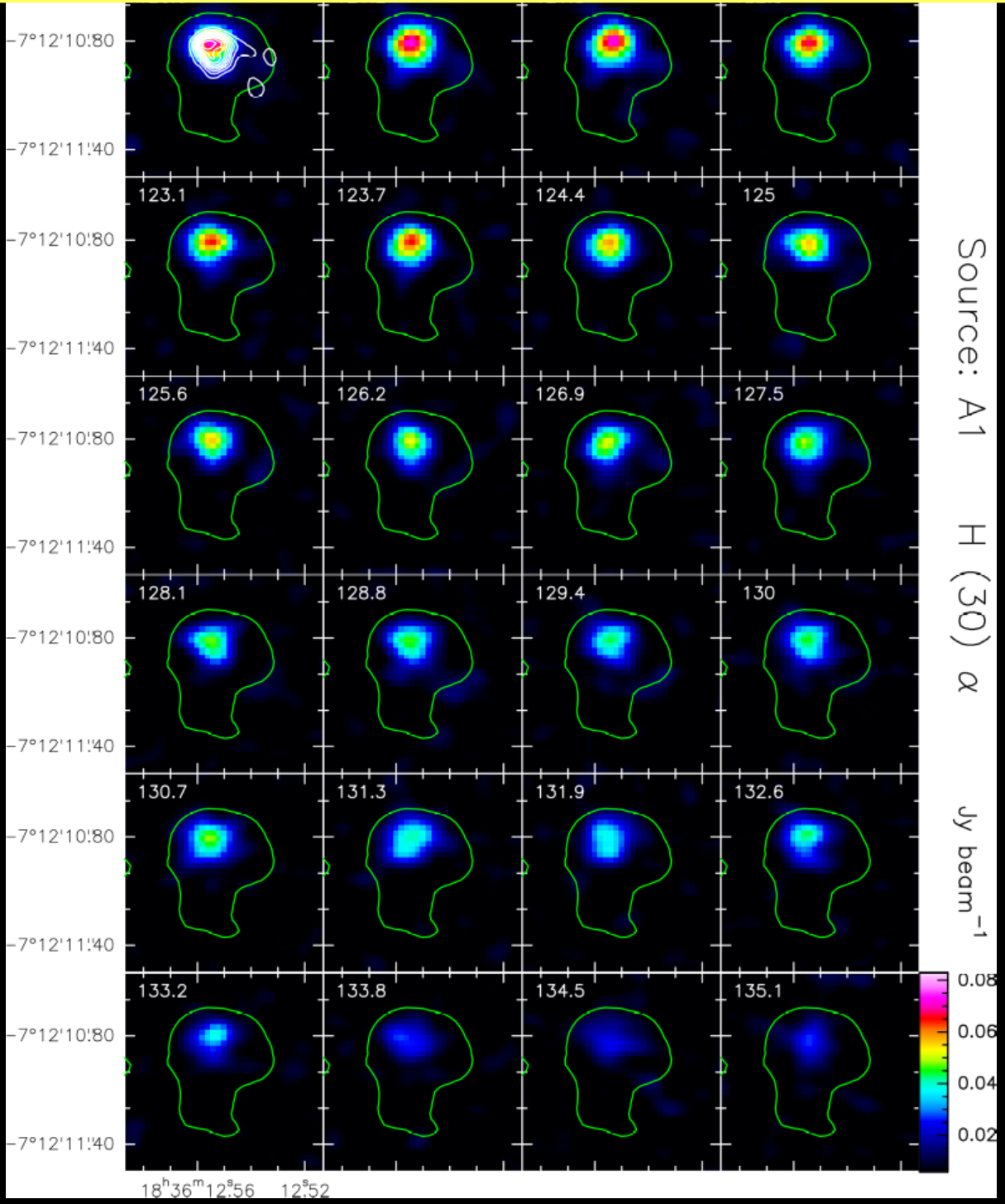
The HC HII region G24.78+0.08



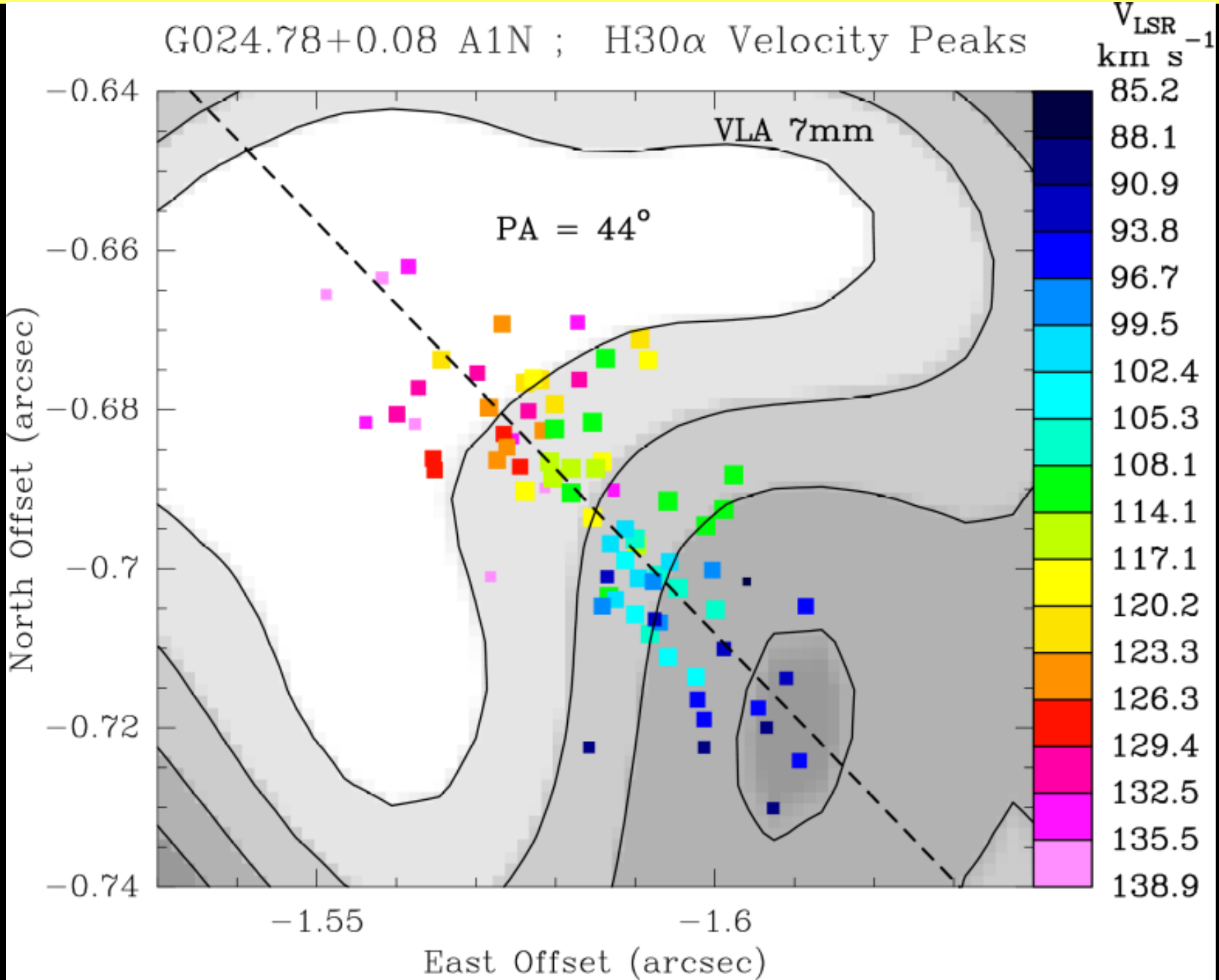
The HC HII region G24.78+0.08

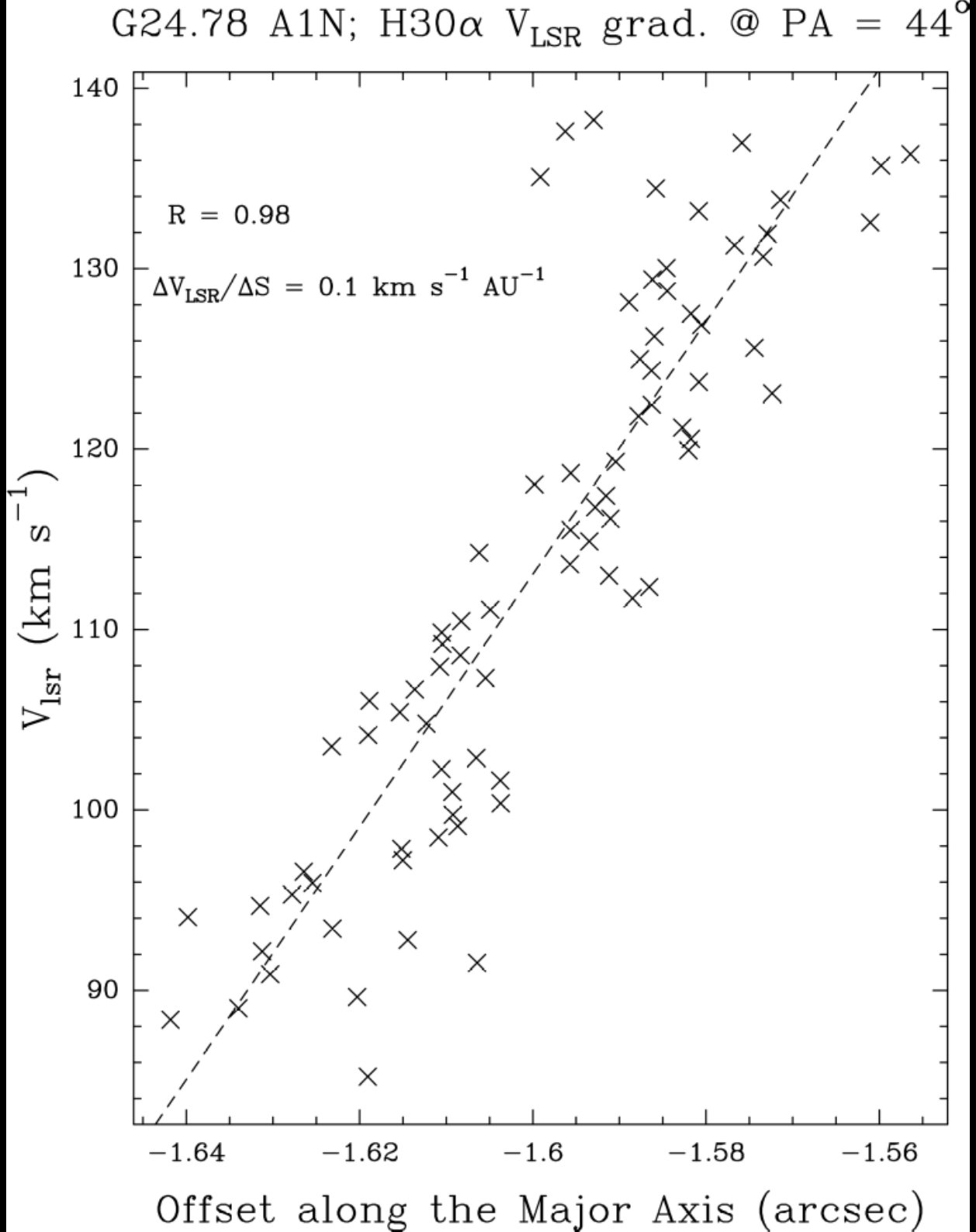


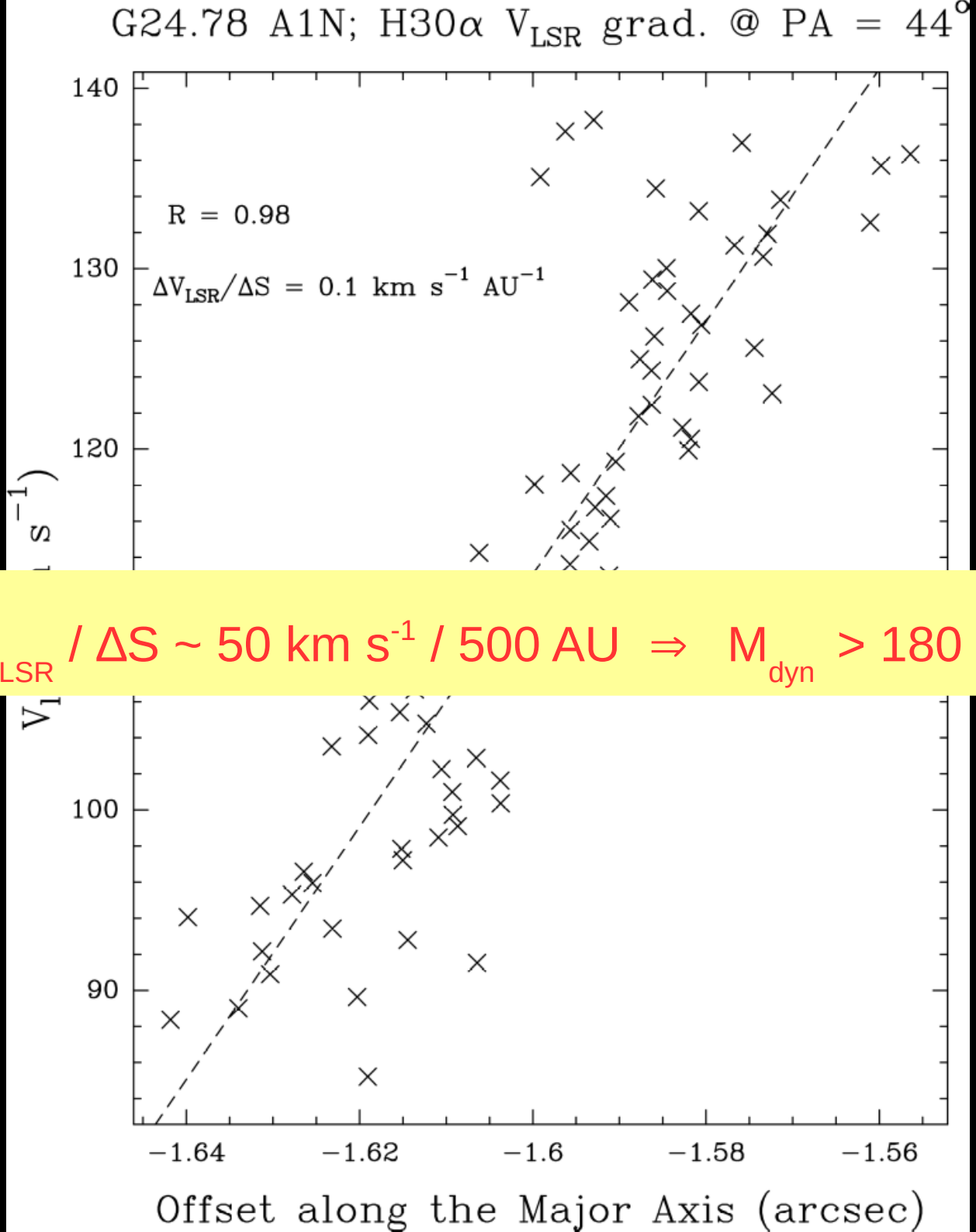
ALMA @ 1.4mm: H30α channel maps towards core A1



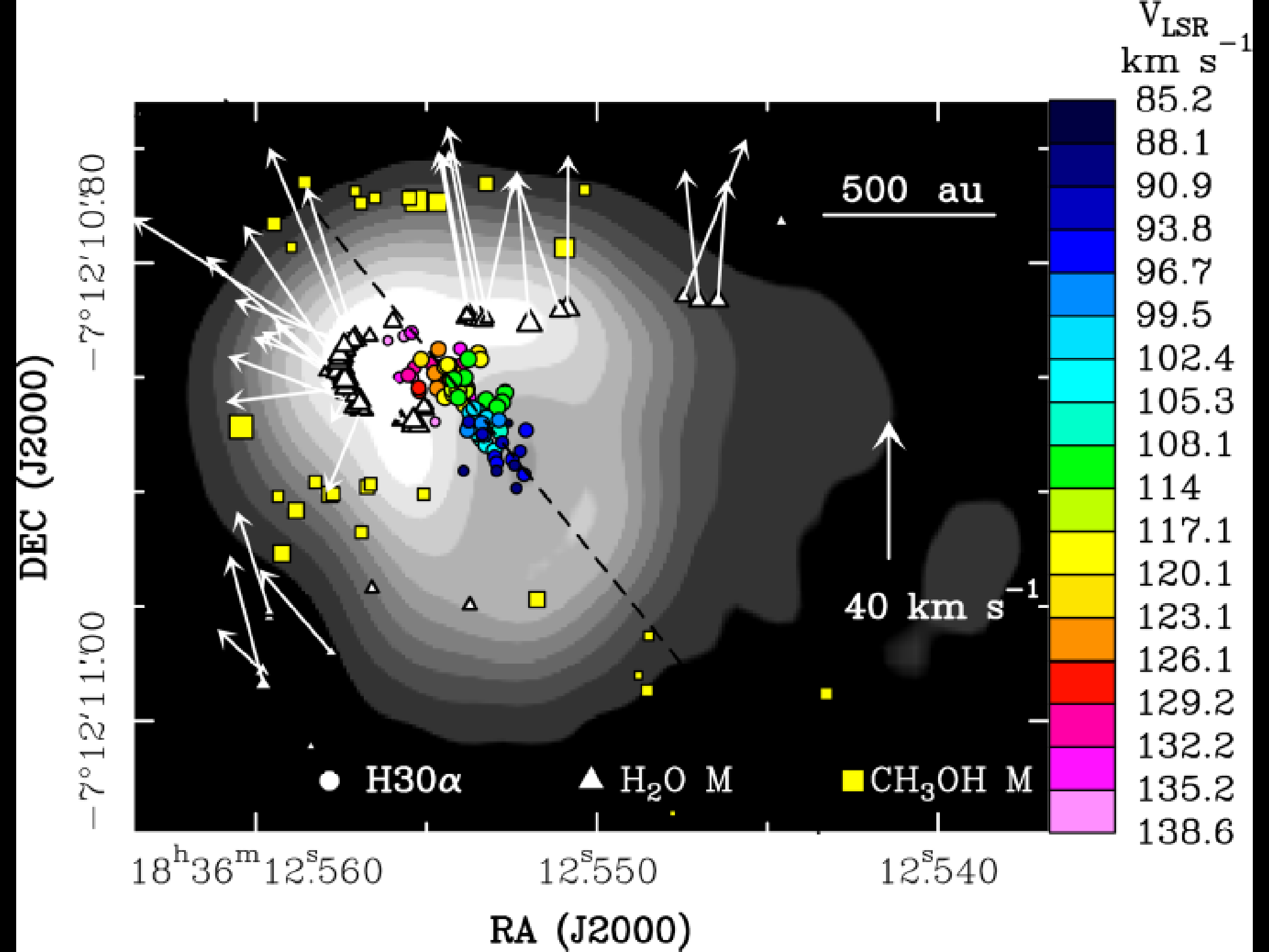
ALMA @ 1.4mm: H30 α Vel. Grad. towards A1N HCHII

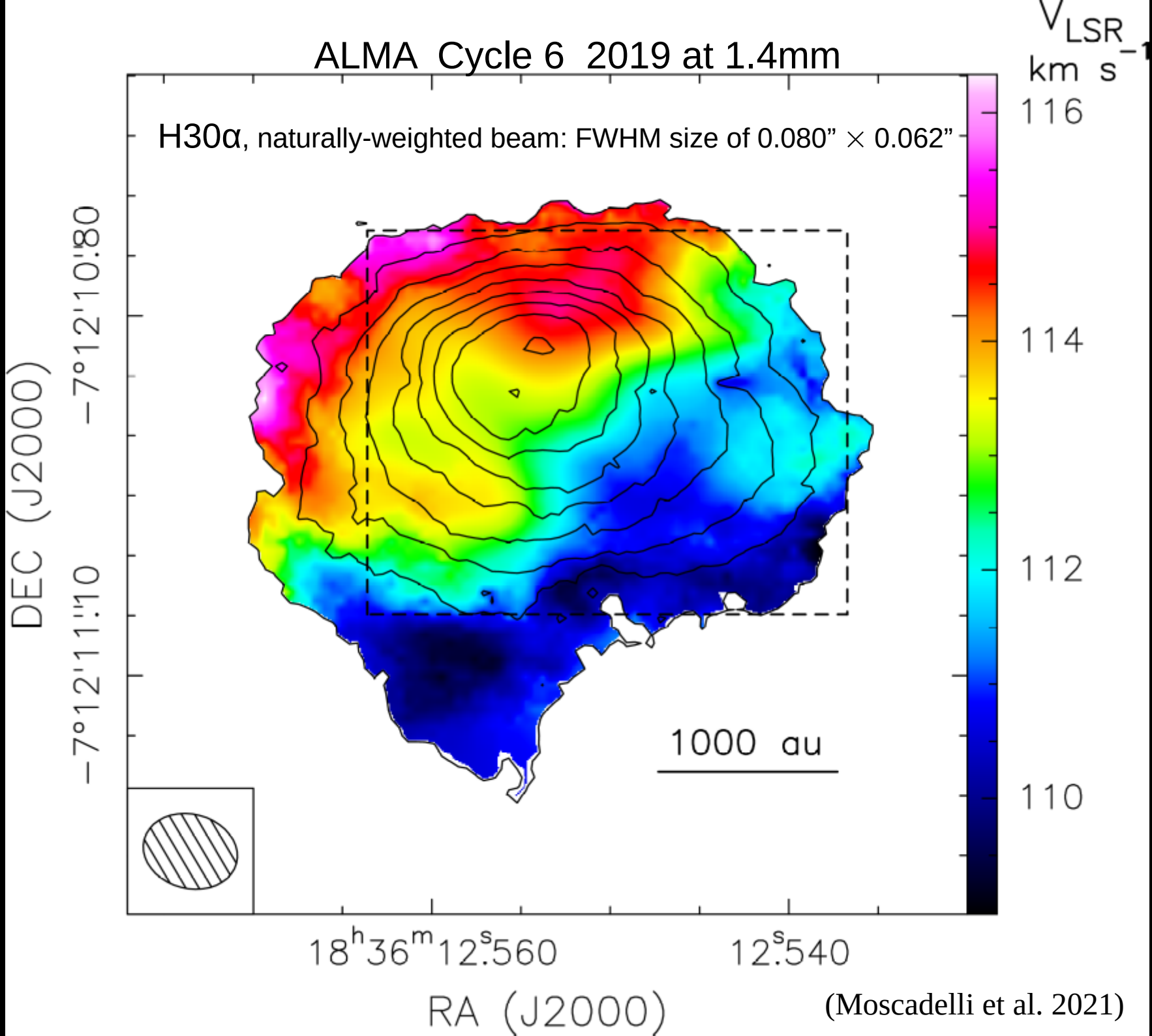



G24.78 A1N; H30α V_LSR grad. @ PA = 44°
R = 0.98
ΔV_LSR/ΔS = 0.1 km s^-1 AU^-1
V_lsr (km s^-1)
140
130
120
110
100
90
−1.64
−1.62
−1.6
−1.58
−1.56
Offset along the Major Axis (arcsec)



$\Delta V_{LSR} / \Delta S \sim 50$ km s^{-1} / 500 AU $\Rightarrow$ $M_{dyn} > 180\ M_{\odot}$

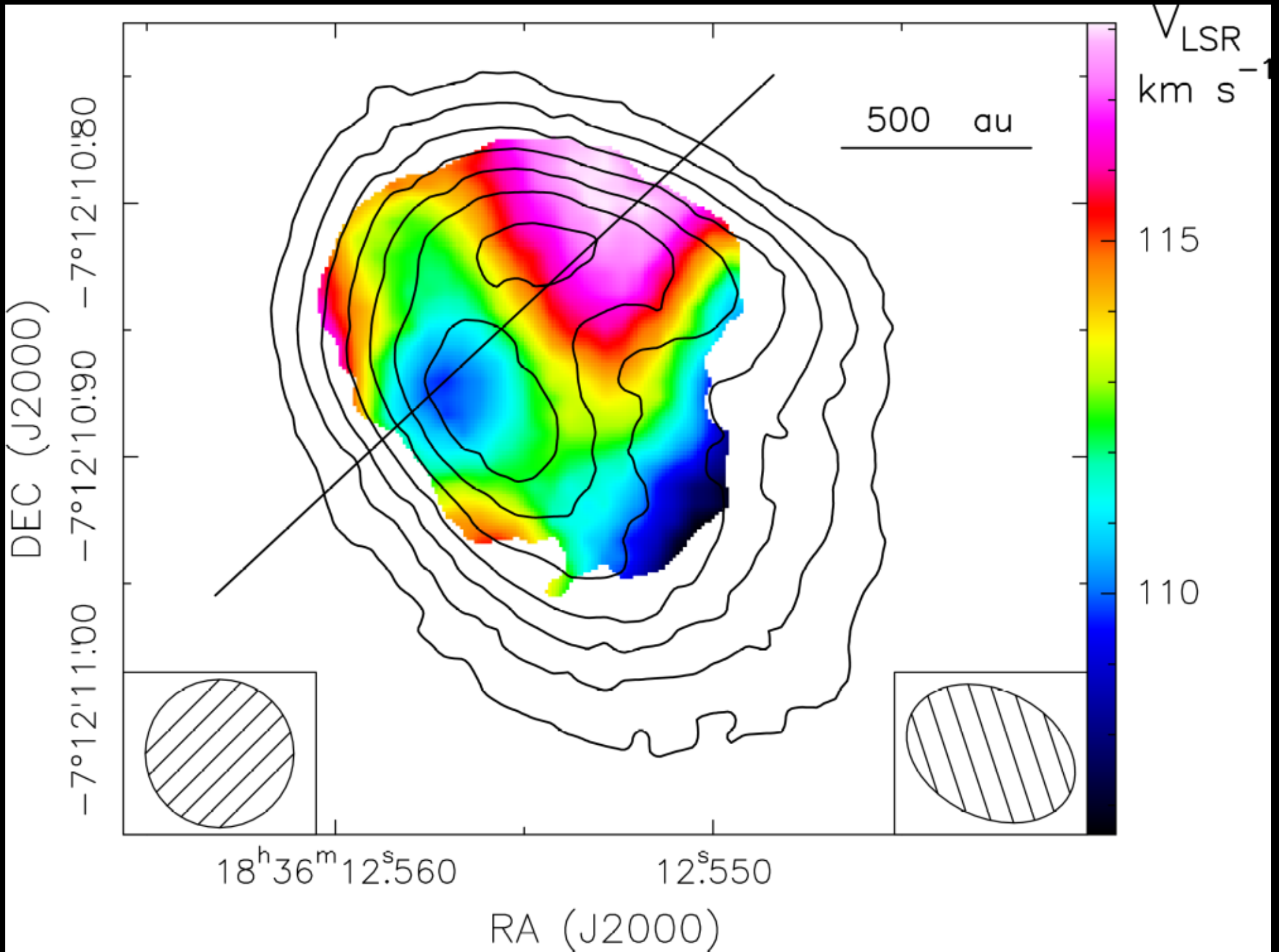

500 au
40 km s^{-1}
H30α
H_2O M
CH_3OH M
V_{LSR}
km s^{-1}
85.2
88.1
90.9
93.8
96.7
99.5
102.4
105.3
108.1
114
117.1
120.1
123.1
126.1
129.2
132.2
135.2
138.6
DEC (J2000)
−7°12′10.″80
−7°12′11.″00
18^{h}36^{m}12^s.560
12^s.550
12^s.540
RA (J2000)

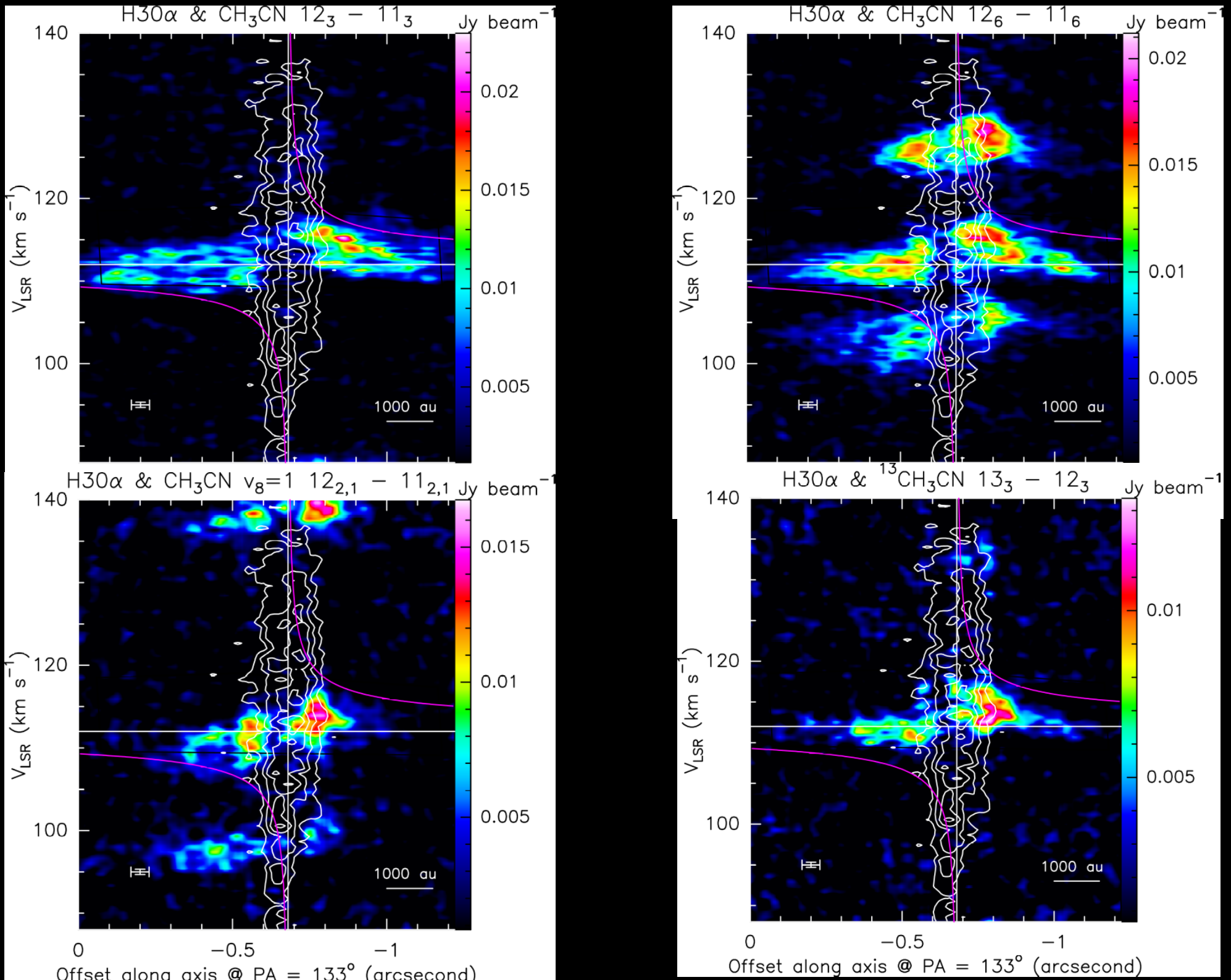


(Moscadelli et al. 2021)

Color map: H30α, Briggs robust=0.5 beam: FWHM size of 0.058”

Black contours: 1.4 mm ALMA continuum




H30α & CH3CN 12_3 – 11_3
H30α & CH3CN 12_6 – 11_6
H30α & CH3CN v8=1 12_2,1 – 11_2,1
H30α & 13CH3CN 13_3 – 12_3
Jy beam−1
VLSR (km s−1)
140
120
100
0.02
0.015
0.01
0.005
1000 au
0
−0.5
−1
Offset along axis @ PA = 133° (arcsecond)

CONCLUSIONS

1) In G24.78+0.08, 22 GHz water maser 3D motion helps distinguish between molecular core (A1) expansion and rotation. A strong case for a massive ionized star surrounded by an outer molecular and inner ionized disk, which is likely still actively accreting from its parental core.

CONCLUSIONS

1) In G24.78+0.08, 22 GHz water maser 3D motion helps distinguish between molecular core (A1) expansion and rotation. A strong case for a massive ionized star surrounded by an outer molecular and inner ionized disk, which is likely still actively accreting from its parental core.

2) In IRAS 20126+4104, 6.7 GHz methanol and 22 GHz water masers trace the disk-jet system at scales of 10-100 au. In particular, the water masers trace a fast collimated jet, with hints at rotation. Accurate distance from water maser trigonometric parallax.

CONCLUSIONS

1) In G24.78+0.08, 22 GHz water maser 3D motion helps distinguish between molecular core (A1) expansion and rotation. A strong case for a massive ionized star surrounded by an outer molecular and inner ionized disk, which is likely still actively accreting from its parental core.

2) In IRAS 20126+4104, 6.7 GHz methanol and 22 GHz water masers trace the disk-jet system at scales of 10-100 au. In particular, the water masers trace a fast collimated jet, with hints at rotation. Accurate distance from water maser trigonometric parallax.

3) A very detailed view of high-mass (embedded) YSOs can be obtained combining JVLA + ALMA (continuum / line, 0.05”-10”) thermal data with multi-epoch VLBI (milli-arcsec) maser observations.

Palio in Siena: suddenly the Middle Age “resurrects”

Nicchio

Contrade; the quarters of Siena

Palio in Siena: suddenly the Middle Age “resurrects”

Nicchio

Contrade;

the quarters

of Siena

Cesa: the new jockey (“fantino”) of Nicchio

Overwhelmed by emotion, I warmly thank Riccardo for his friendship, generous contribution to our research and sense of humor that made everyday work more joyful.