A Class I protostar with a high streamer mass infall rate

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GAPS, RINGS, SPIRALS, AND VORTICES: STRUCTURE FORMATION IN PLANET-FORMING DISKS MIAPP CONFERENCE
29.10.2021

Will the streamer deliver a significant amount of mass to the disk?

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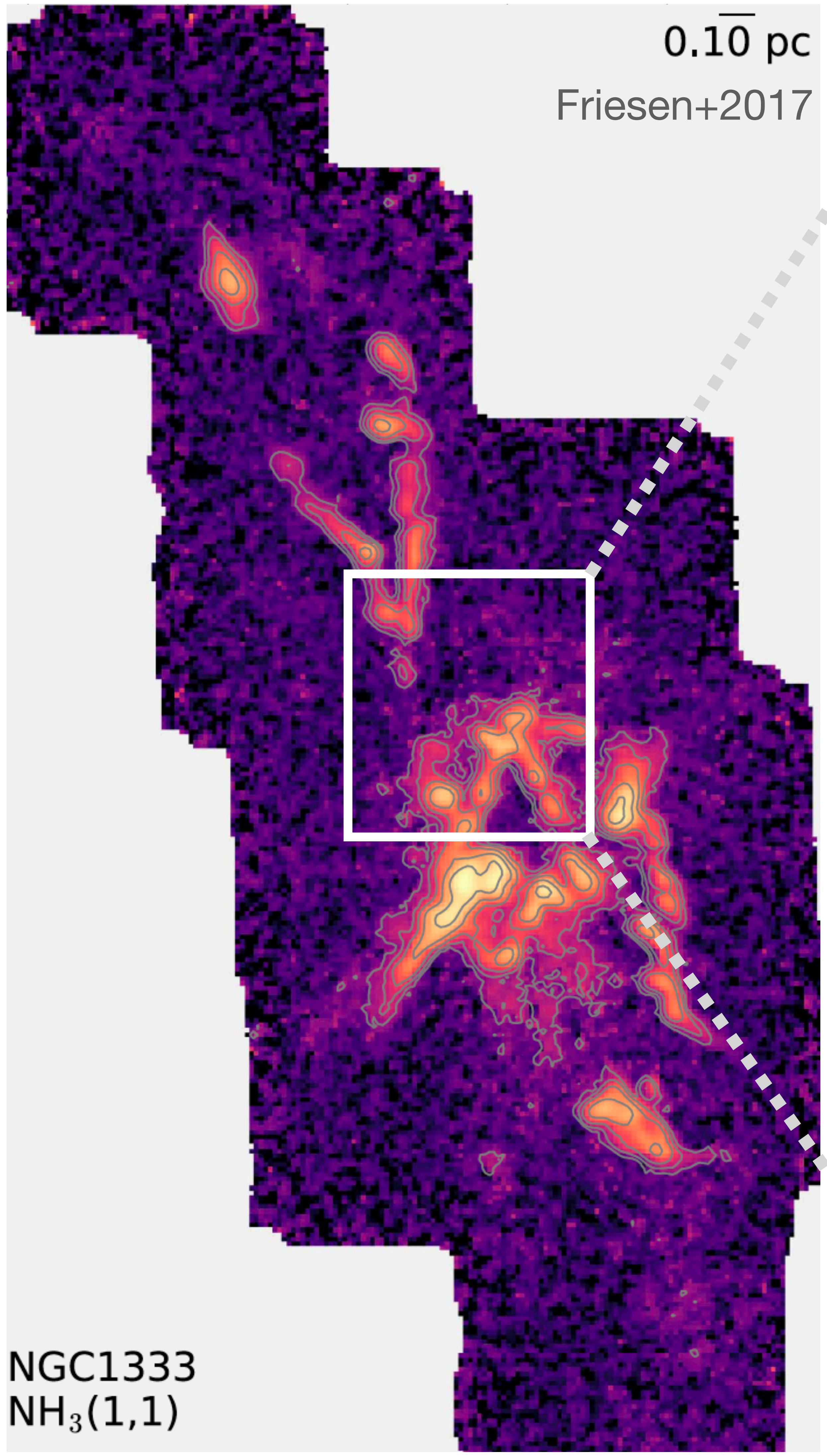
Yes.

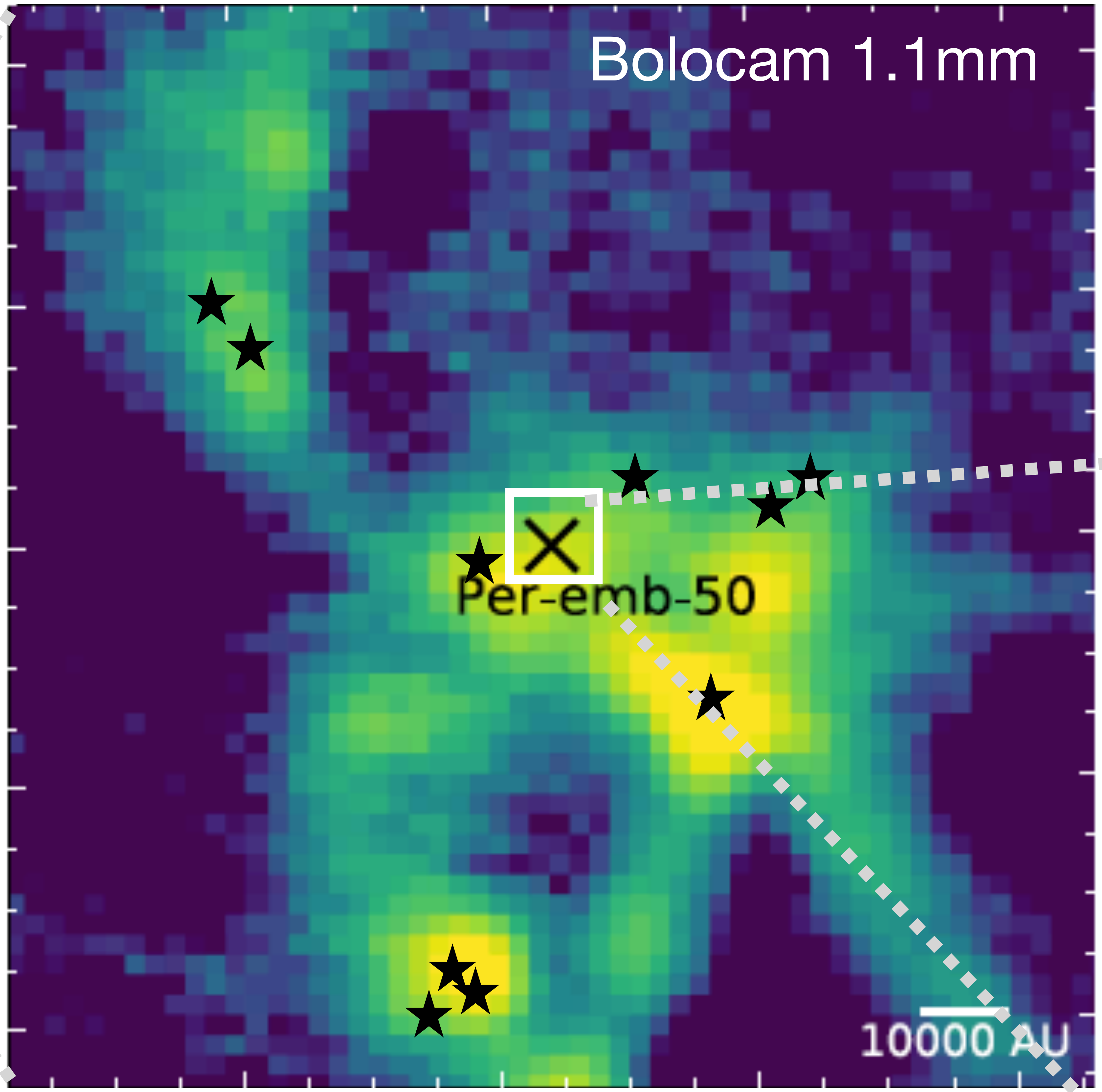
Will I show you how the streamer affects the protoplanetary disk?

… no.

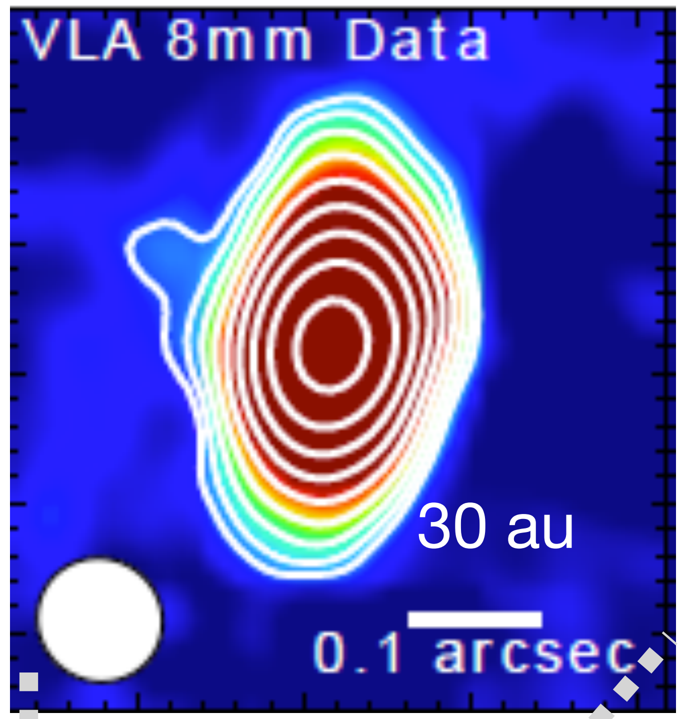
How do you know you found a streamer?

Step 1: find asymmetric gas emission

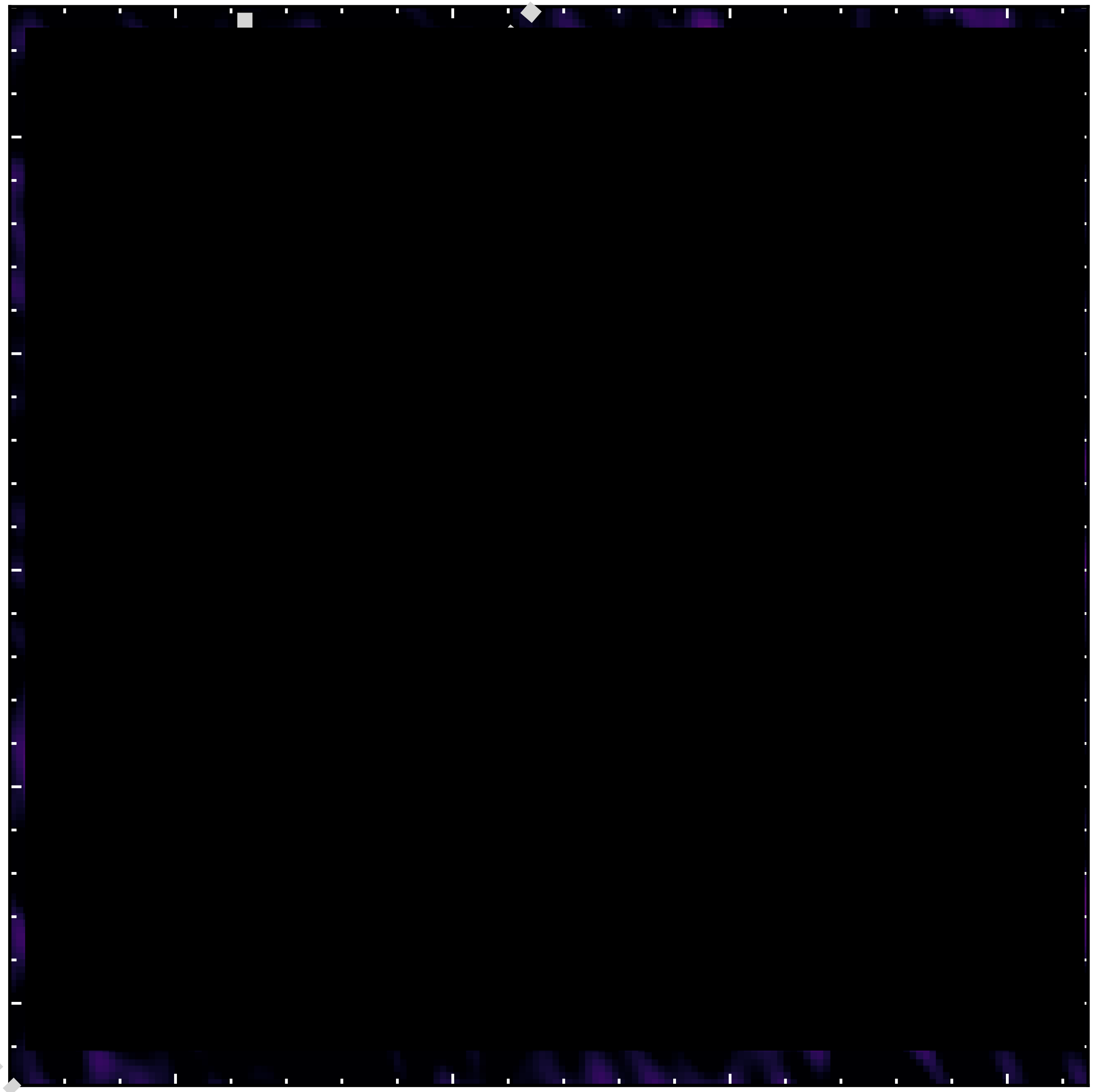




Agurto-Gangas+2019, Enoch+2006



Segura-Cox+2018



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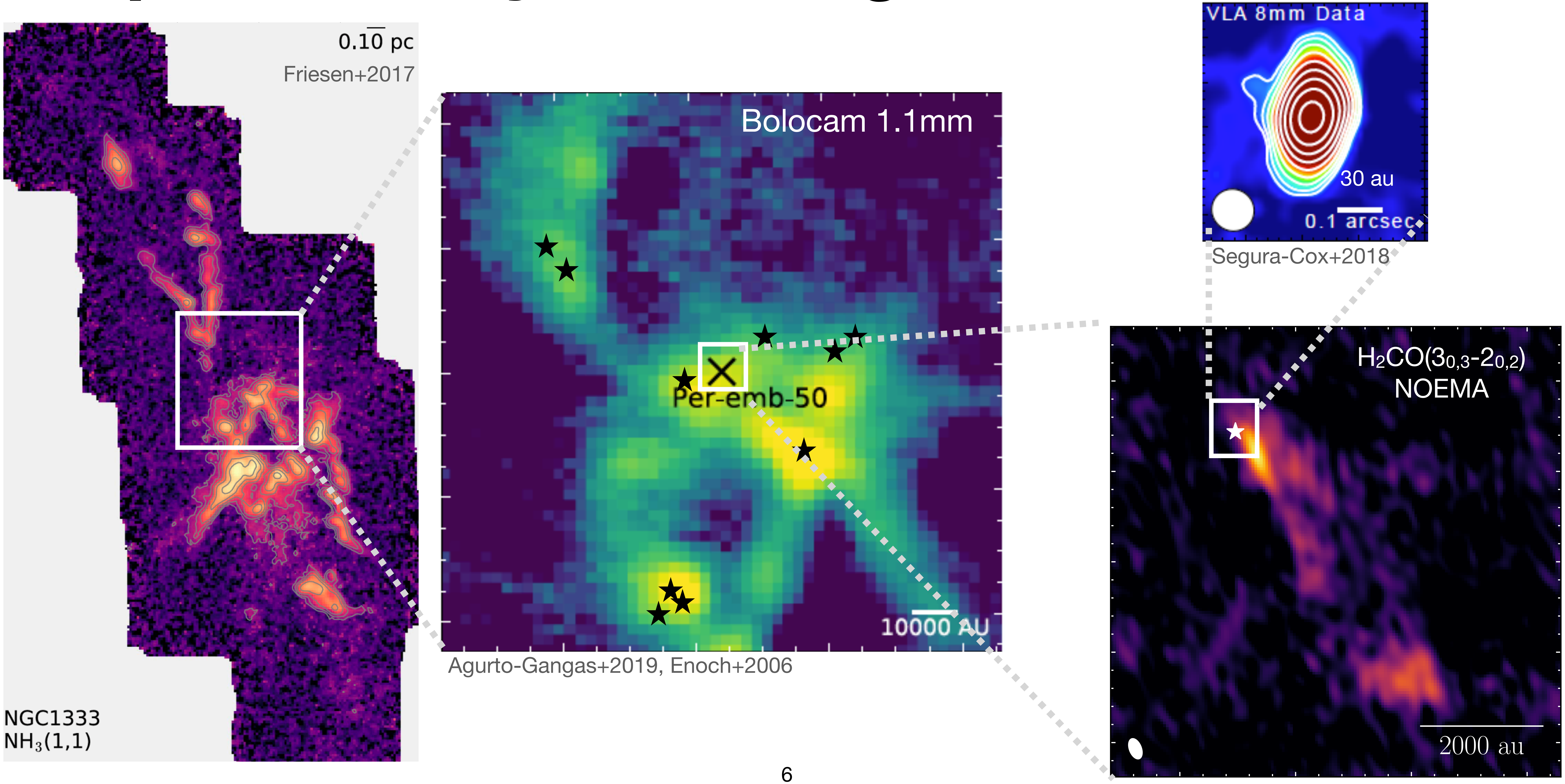
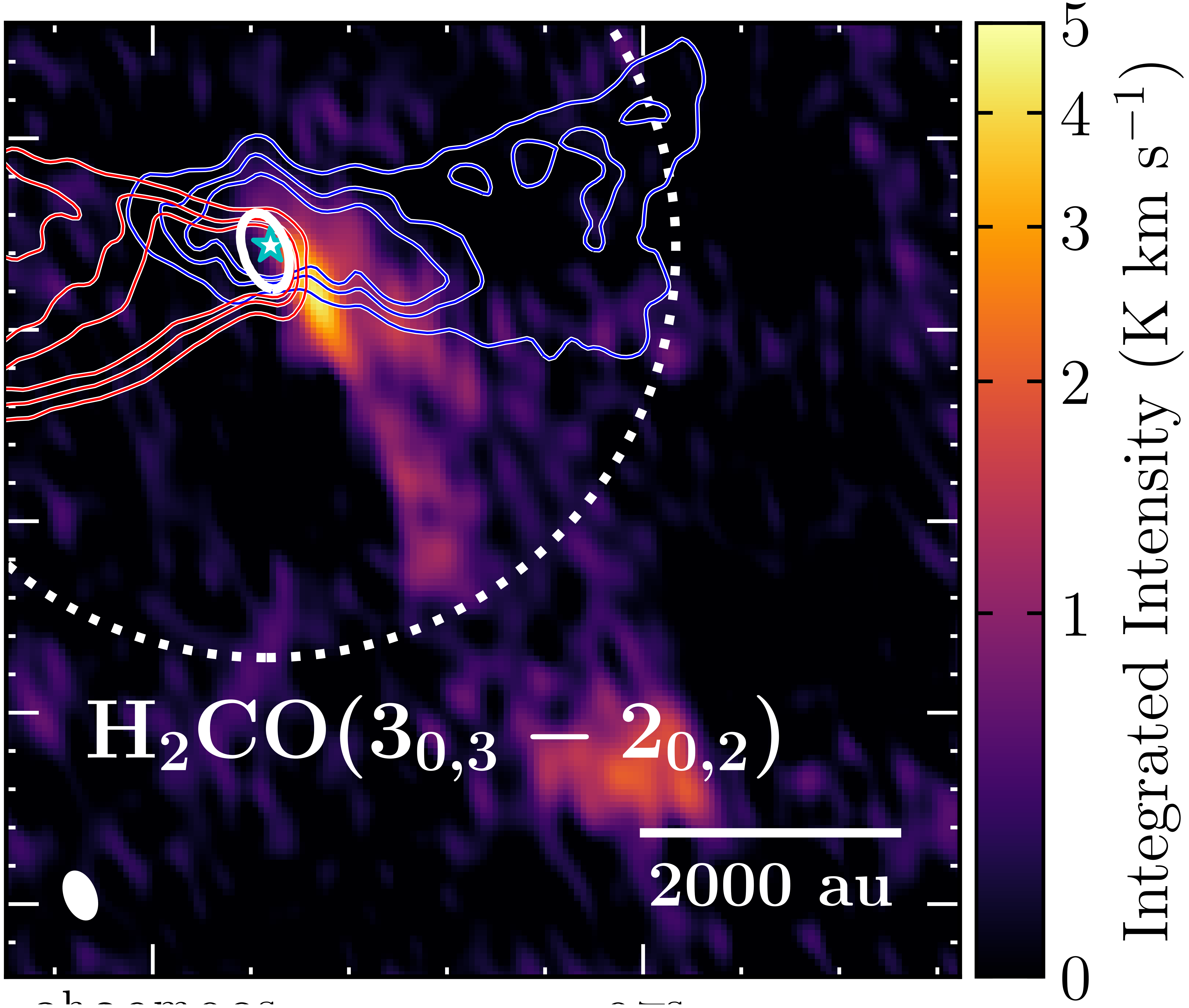


Step 2: check that its not part of the outflow

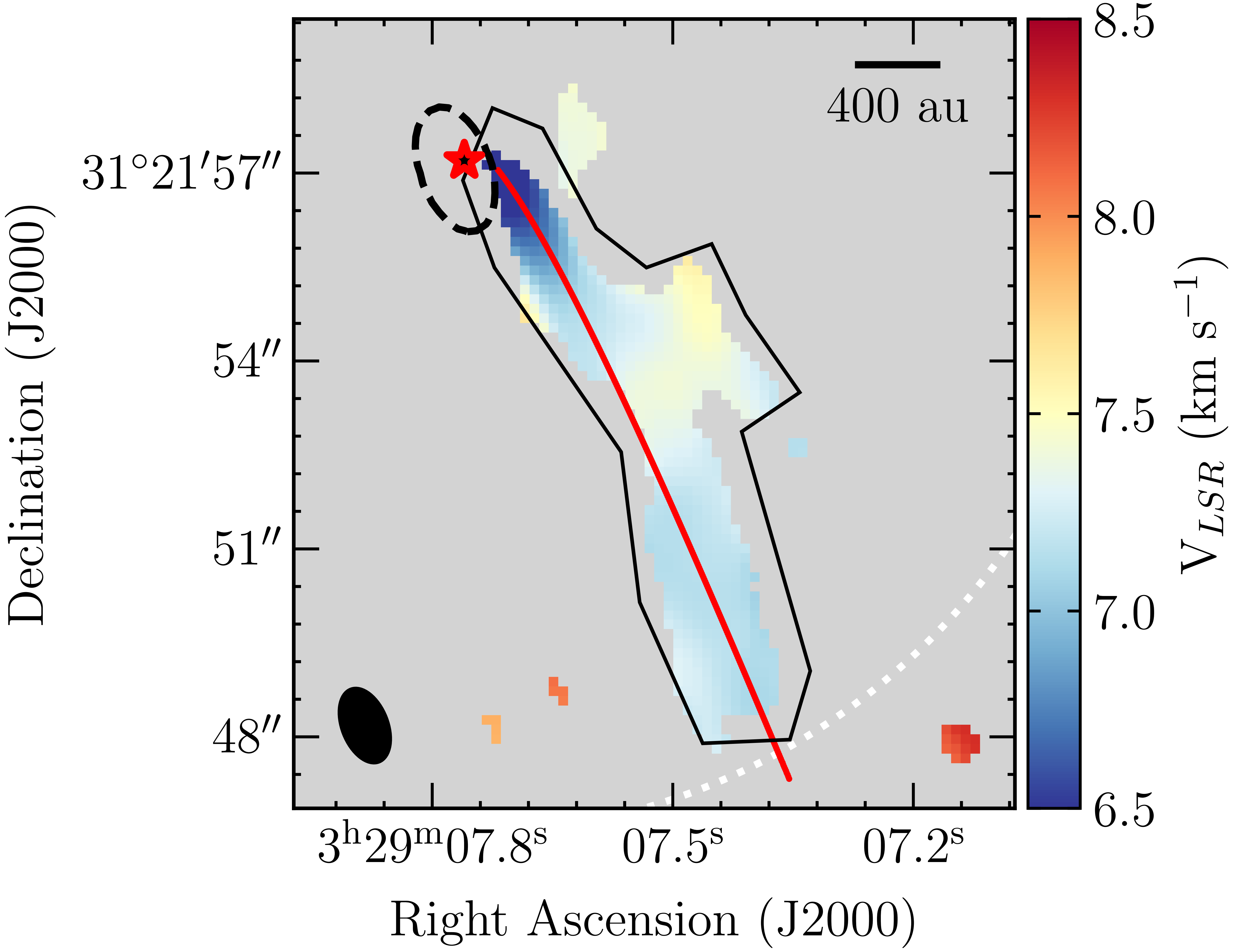


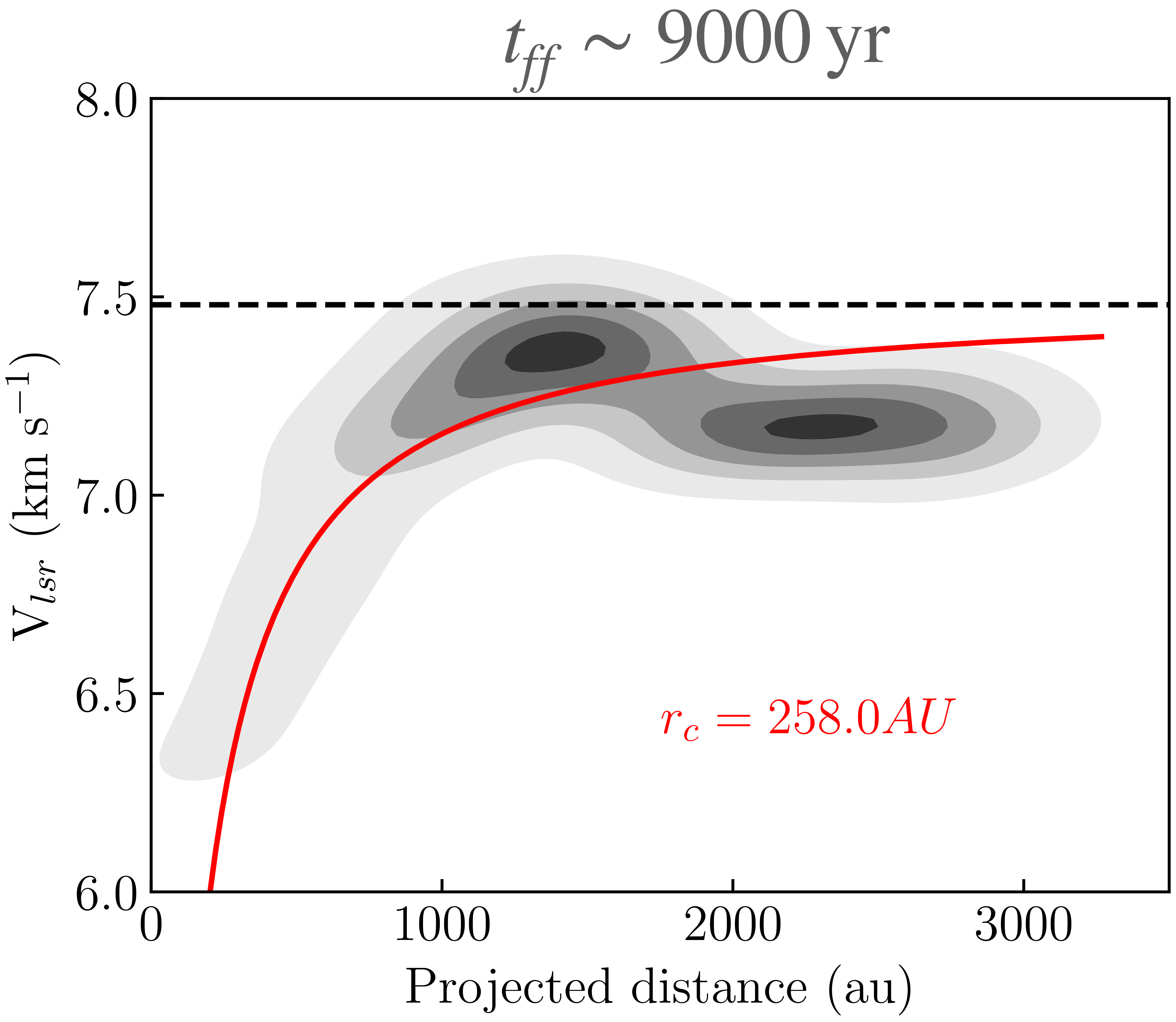
- CO(2-1) blueshifted
- CO(2-1) redshifted
- Continuum 1 mm

This may not be the full length of the streamer

Step 3: attempt to model it!

Streamer is free falling





Analytical solution of Mendoza+2009

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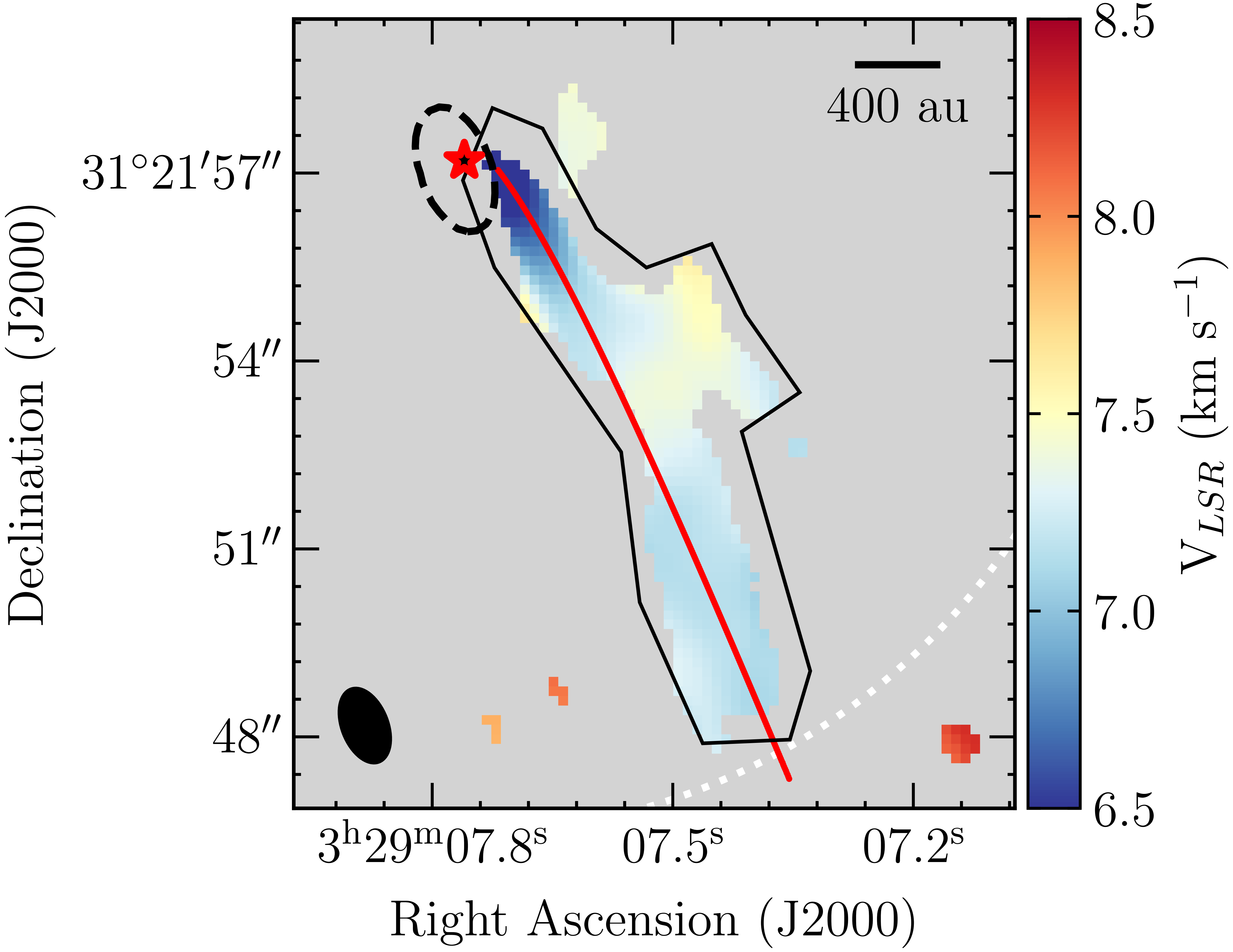
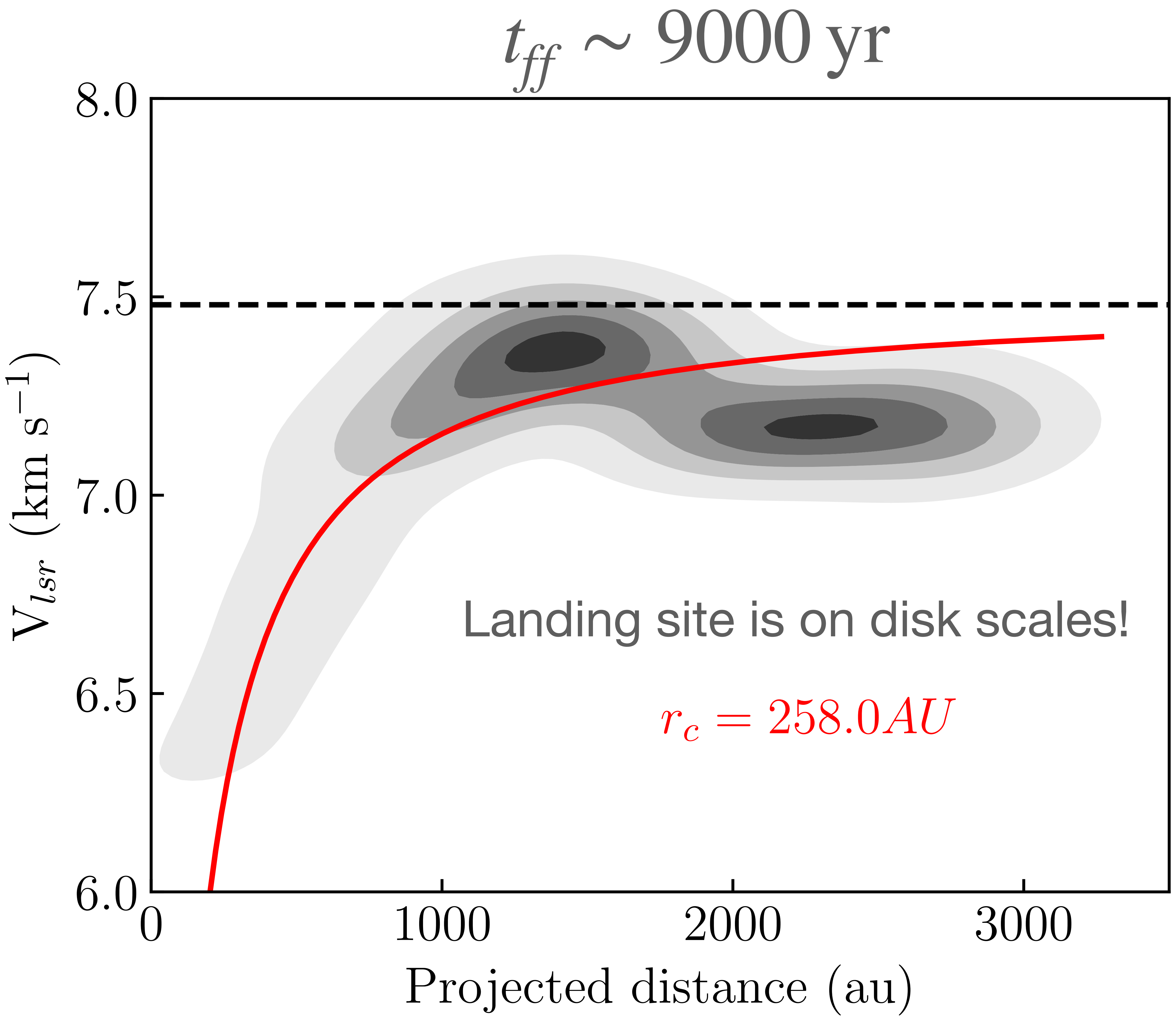
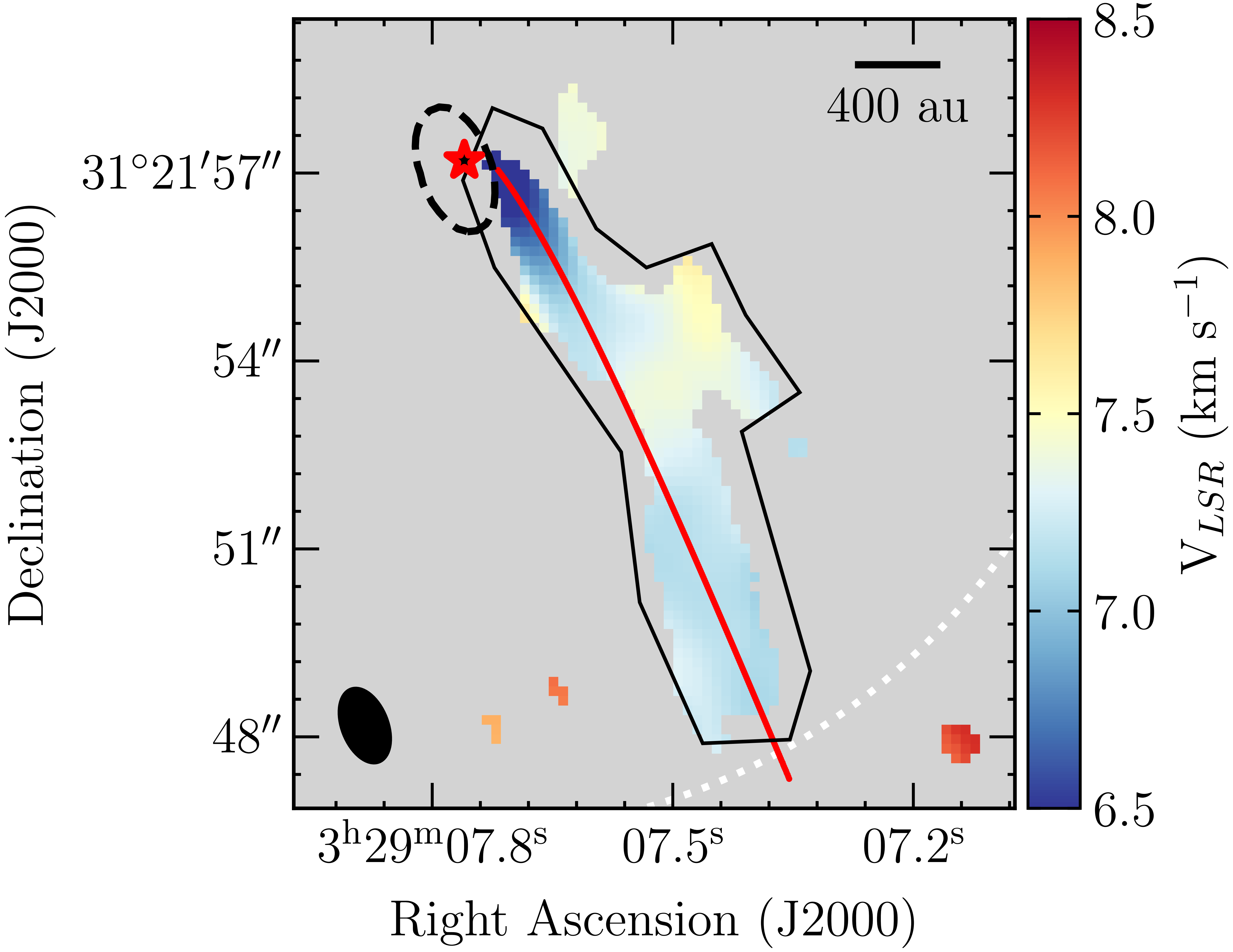


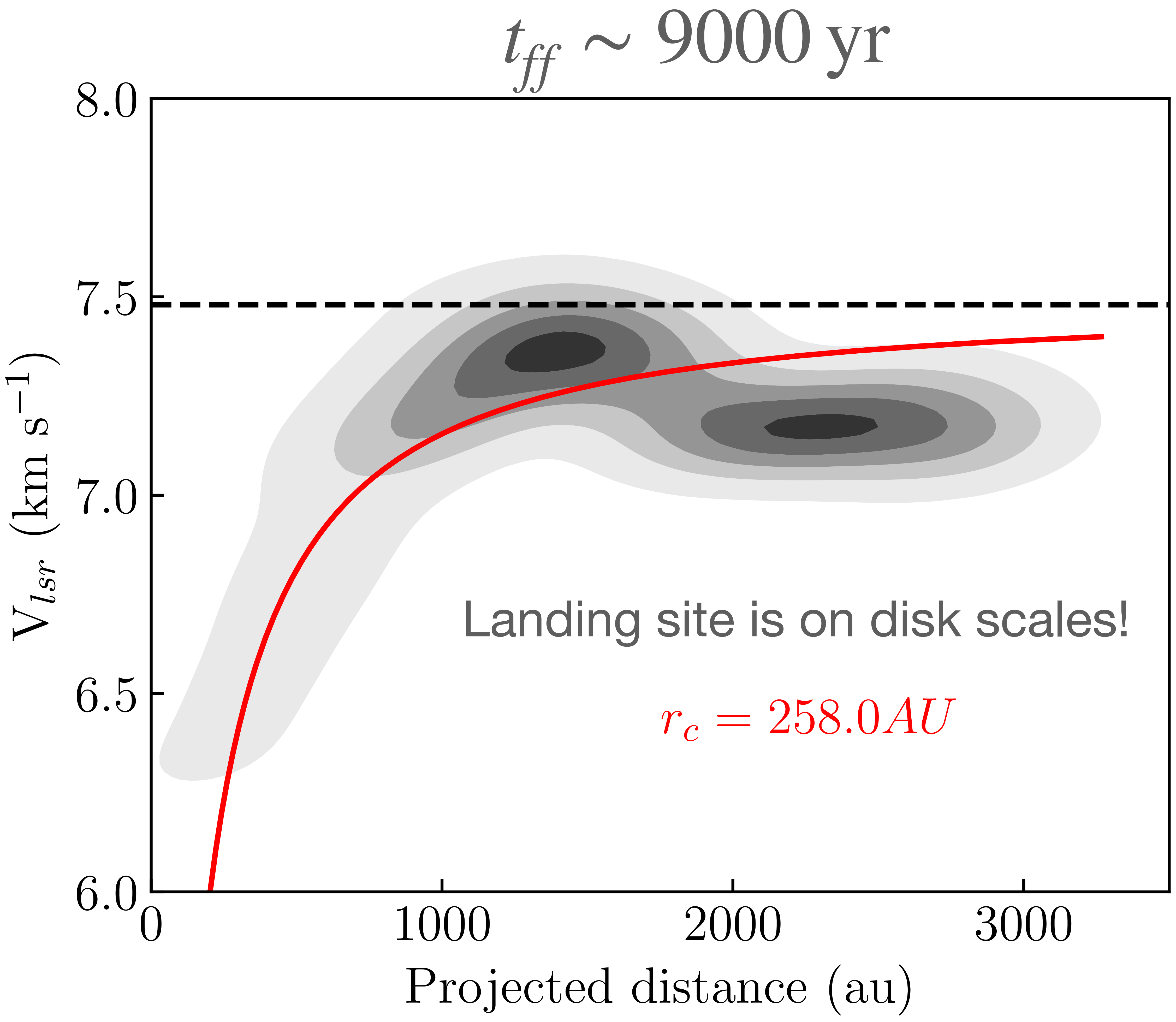


Analytical solution of Mendoza+2009

Step 3: attempt to model it!

Streamer is free falling … so how much mass does it deliver?



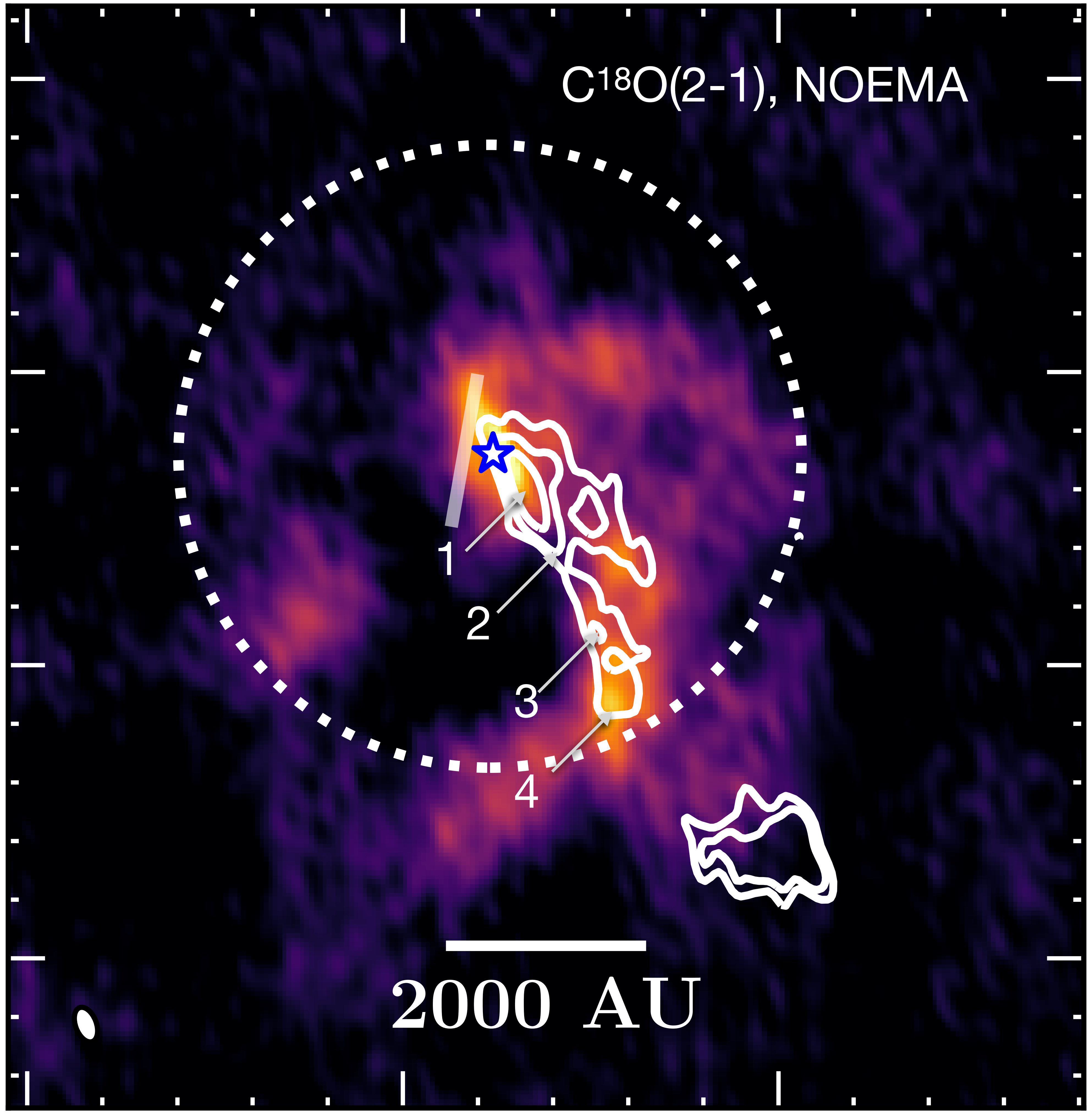


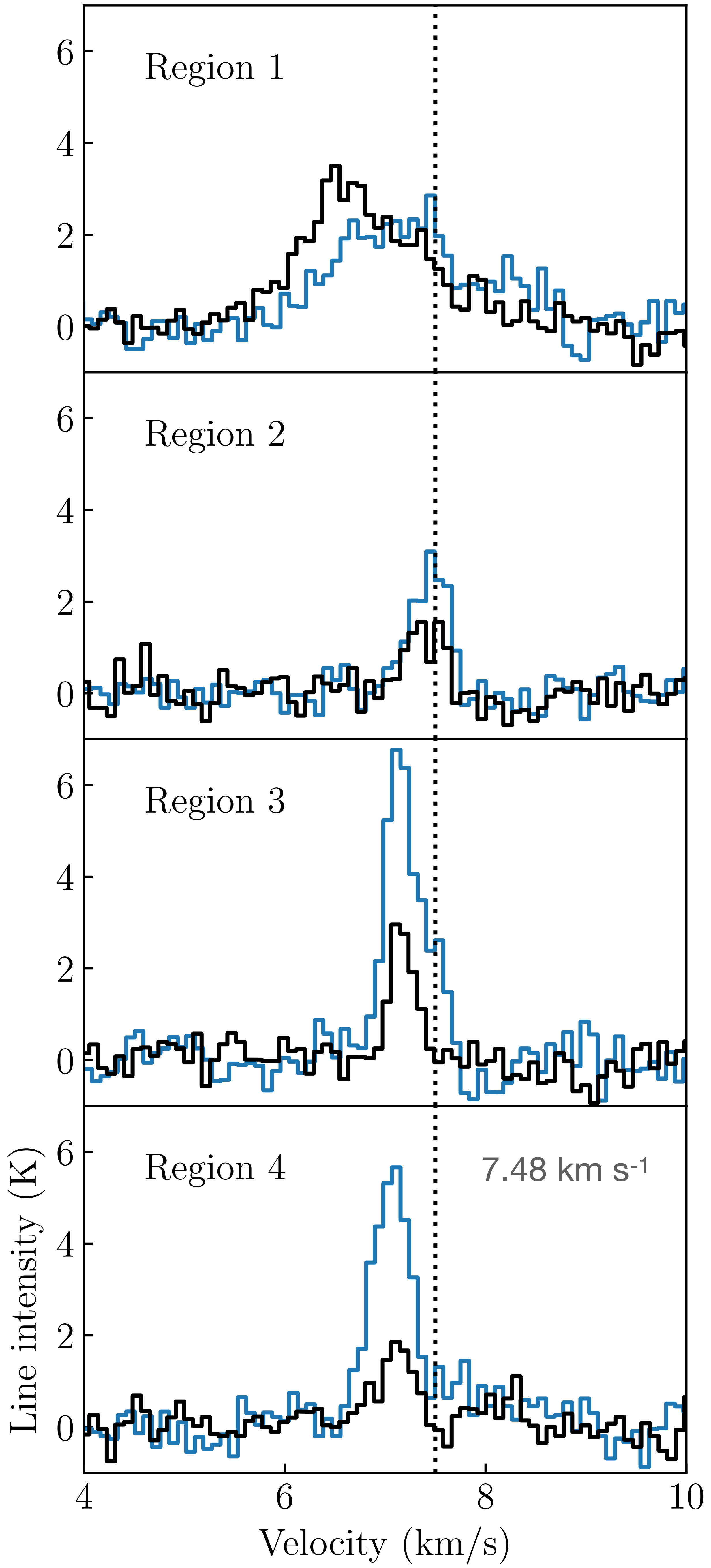
Analytical solution of Mendoza+2009

Streamer is also traced by $C^{18}O$

$N_{C^{18}O} \sim 0.8 - 4 \times 10^{15}\,\mathrm{cm}^{-2}$

$M_{in} > 1.2 \times 10^{-2}\,\mathrm{M}_\odot$





Valdivia-Mena+in prep

$C^{18}O$(2-1) (image)

$H_2CO(3_{0,3}-2_{0,2})$ (contours)

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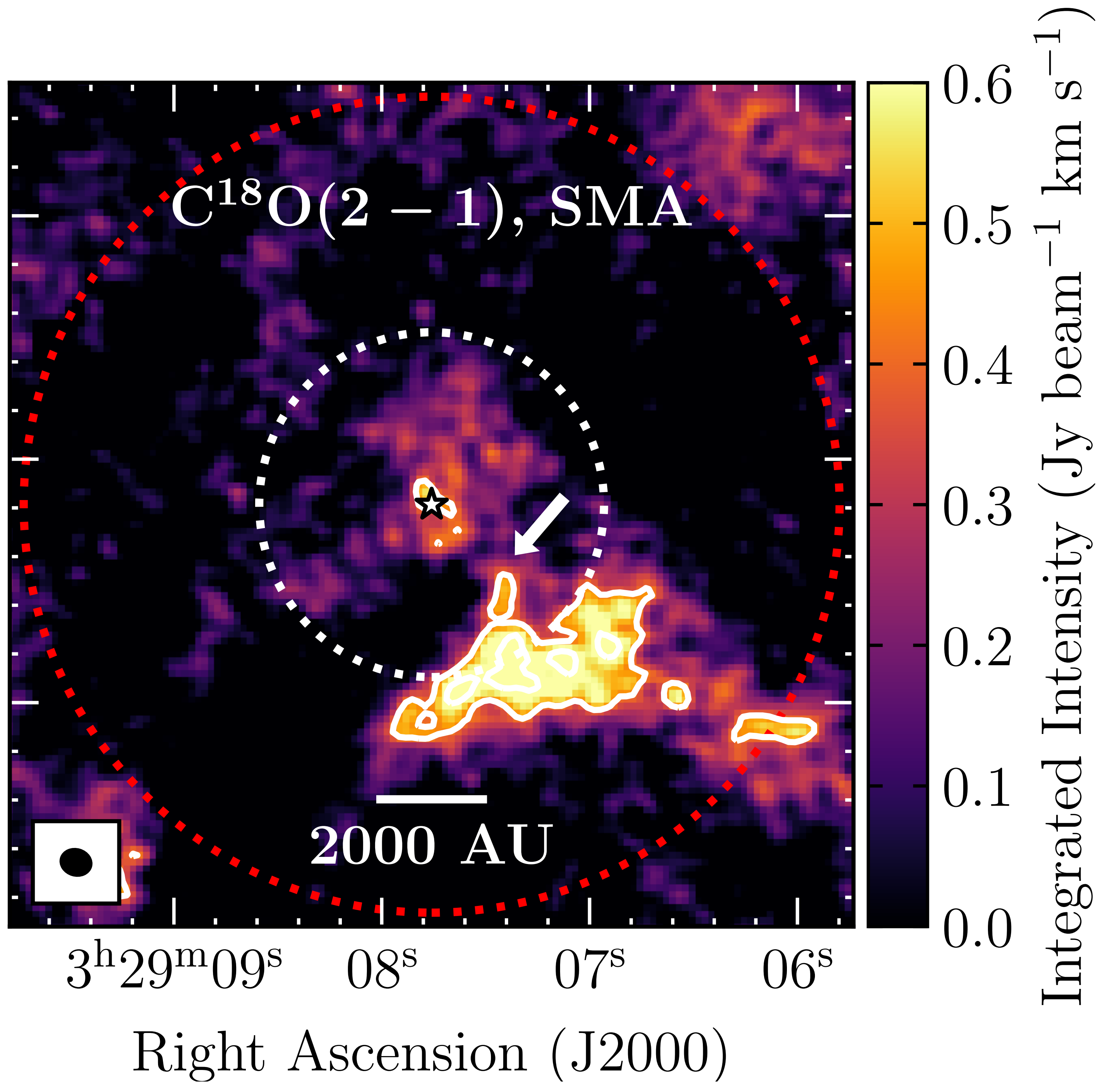
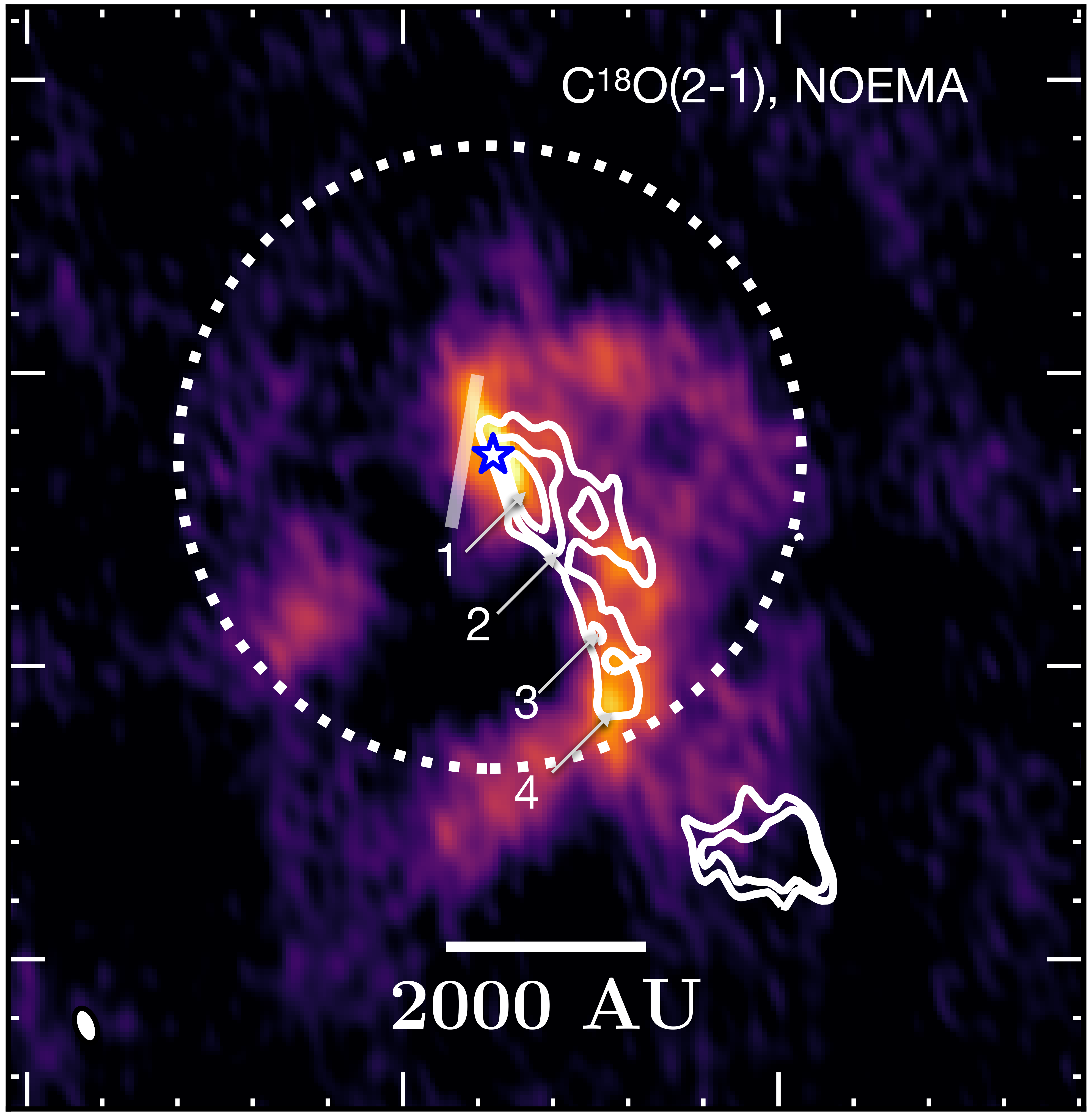
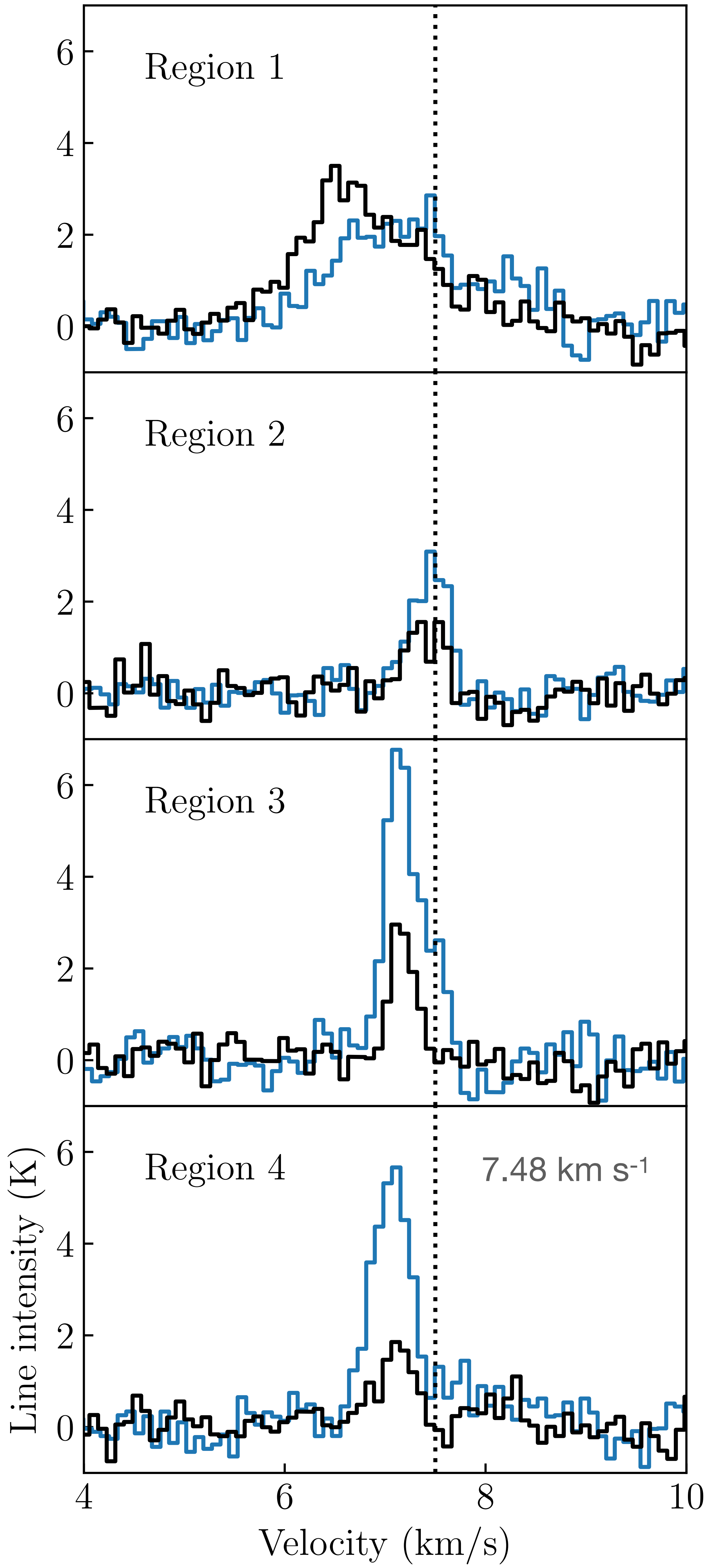




Valdivia-Mena+in prep



$C^{18}O$(2-1) (image)

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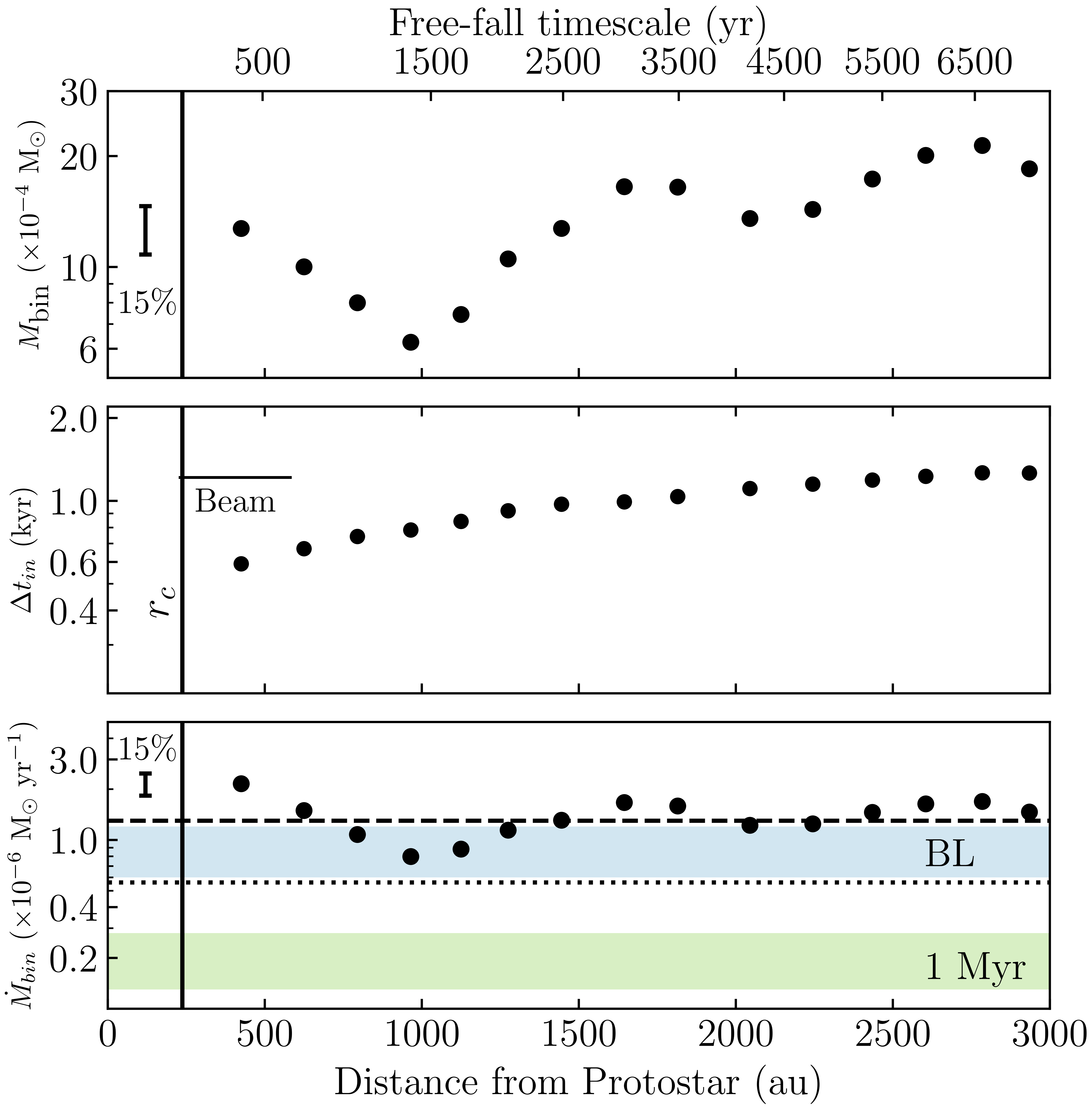
Infall rate dominates over accretion rate



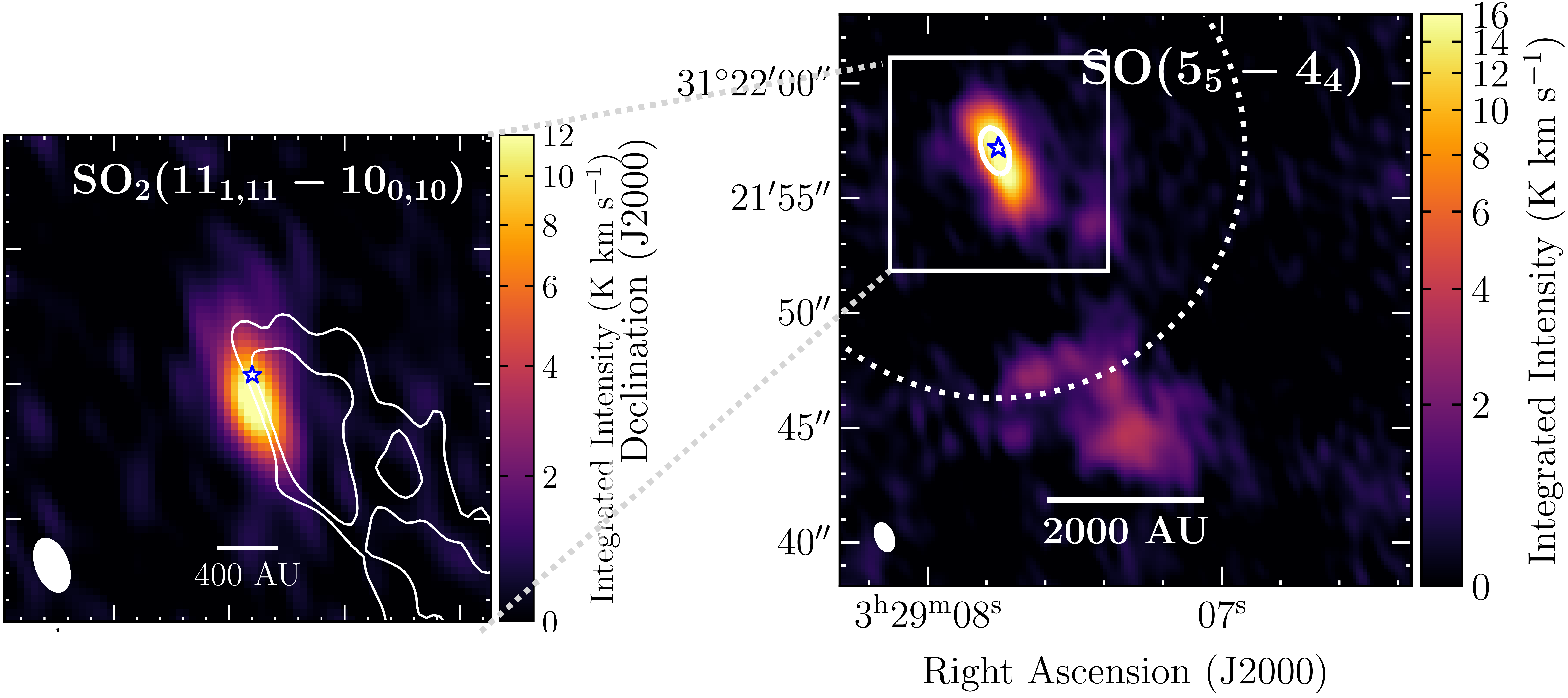
$$\dot{M} = (1.3 - 2.8) \times 10^{-7}\,\mathrm{M_\odot yr^{-1}}$$

Fiorellino+ 2021

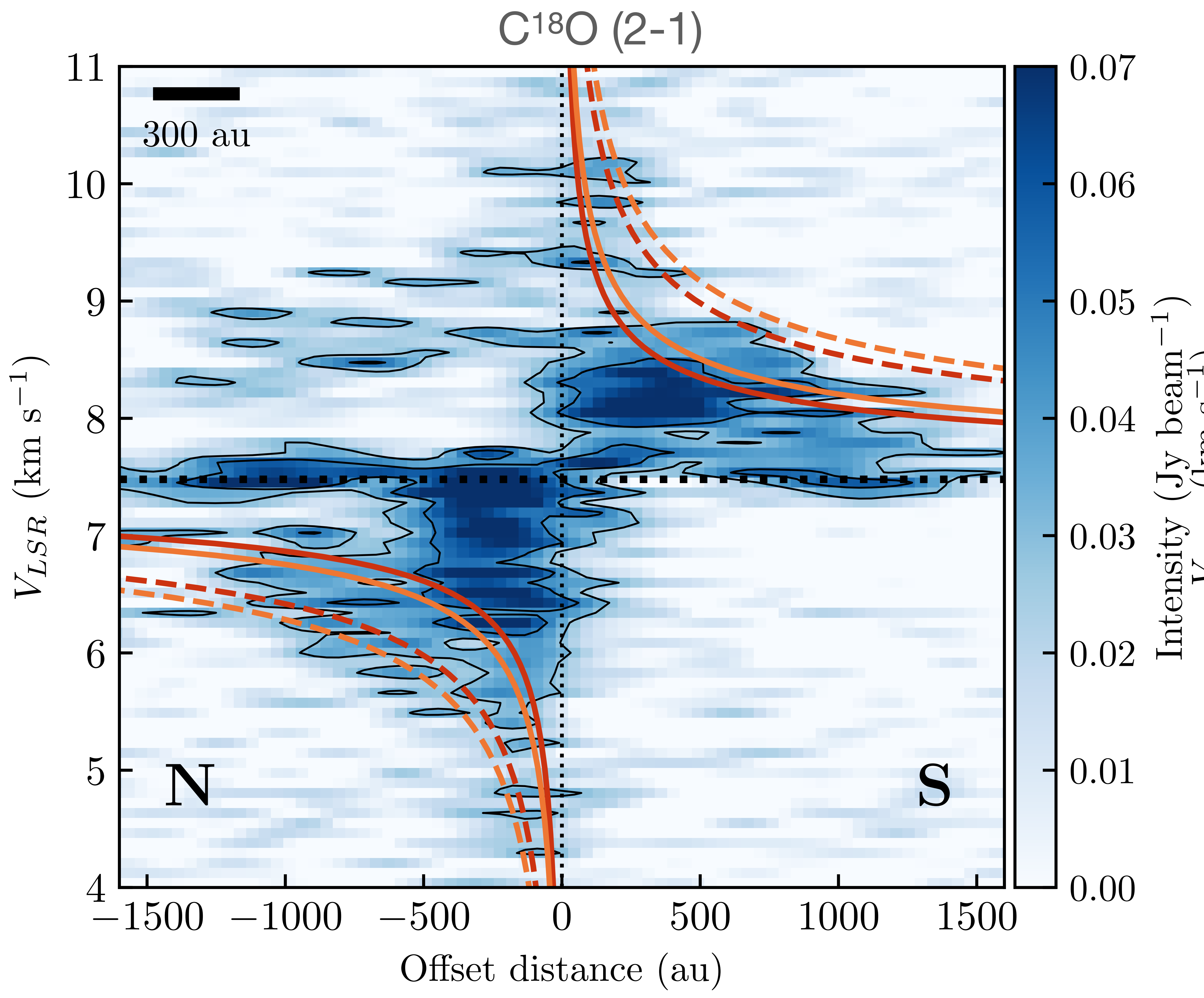
$$\langle \dot{M}_{in} \rangle = 1.3 \times 10^{-6}\,\mathrm{M_\odot yr^{-1}}$$

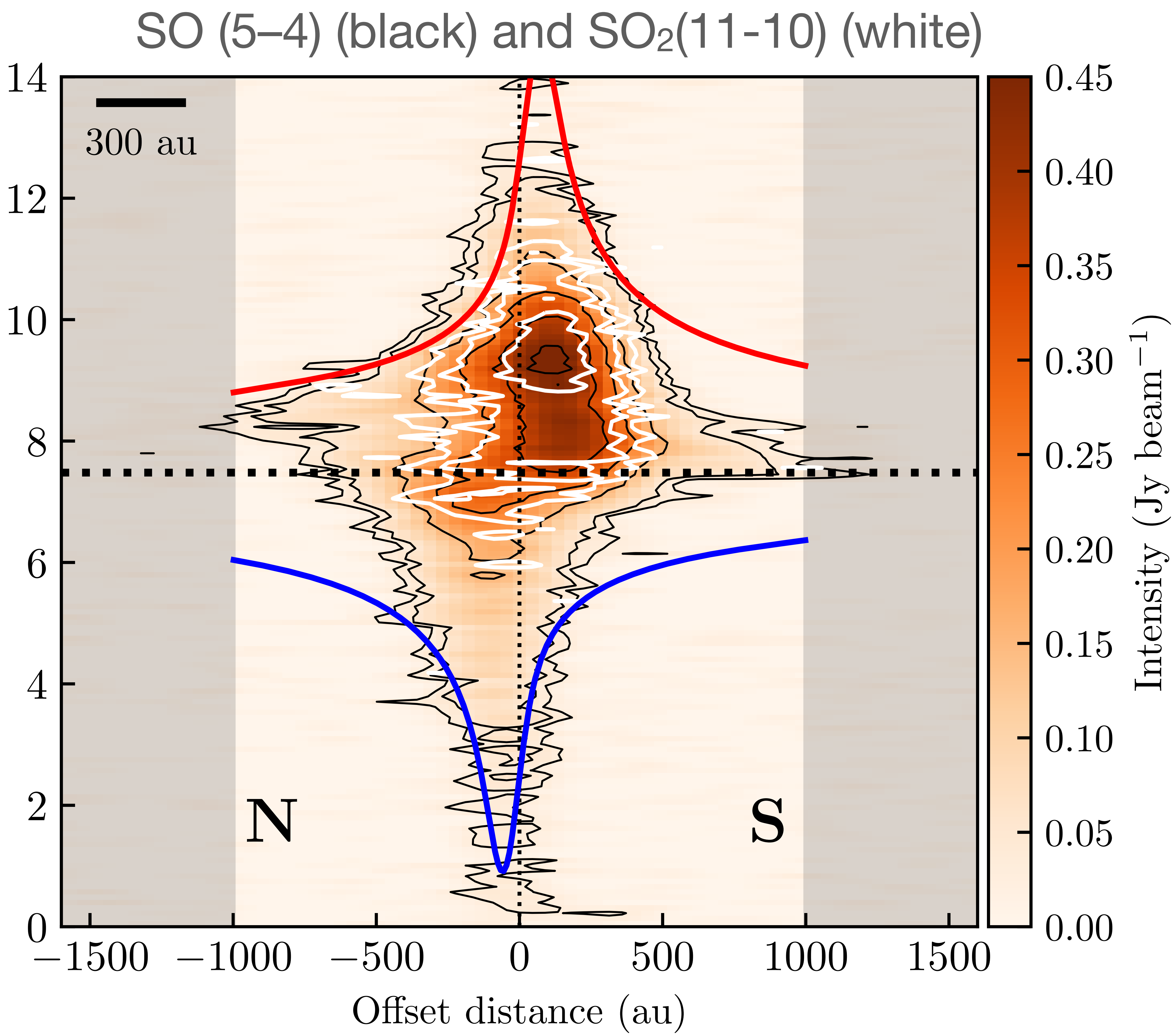
- Mass might be accumulating in the disk
- Gas replenishment from outside the core
- Late infall can cause accretion burst

SO and SO_2 trace the inner envelope and gas disk



SO shows the envelope is asymmetric

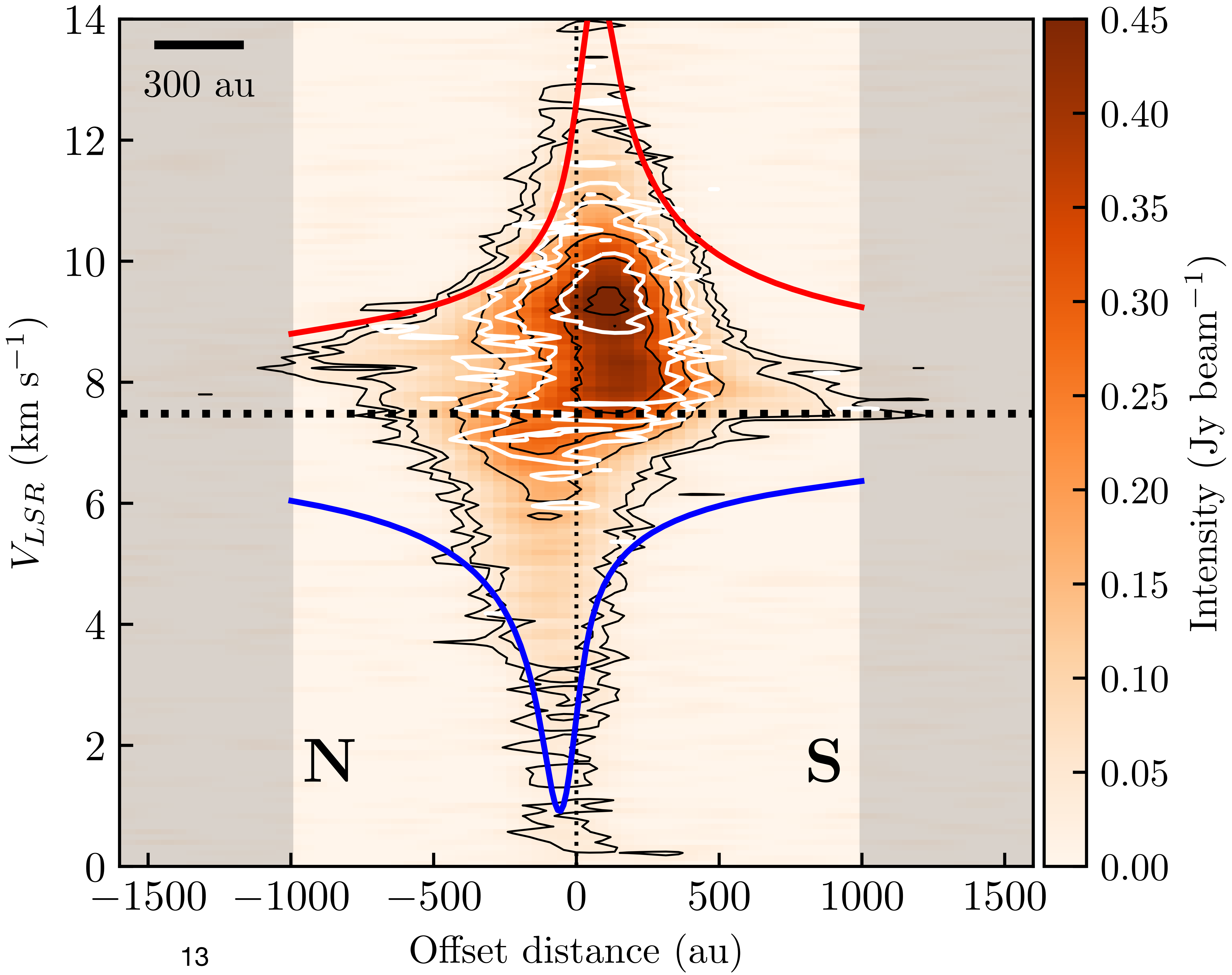




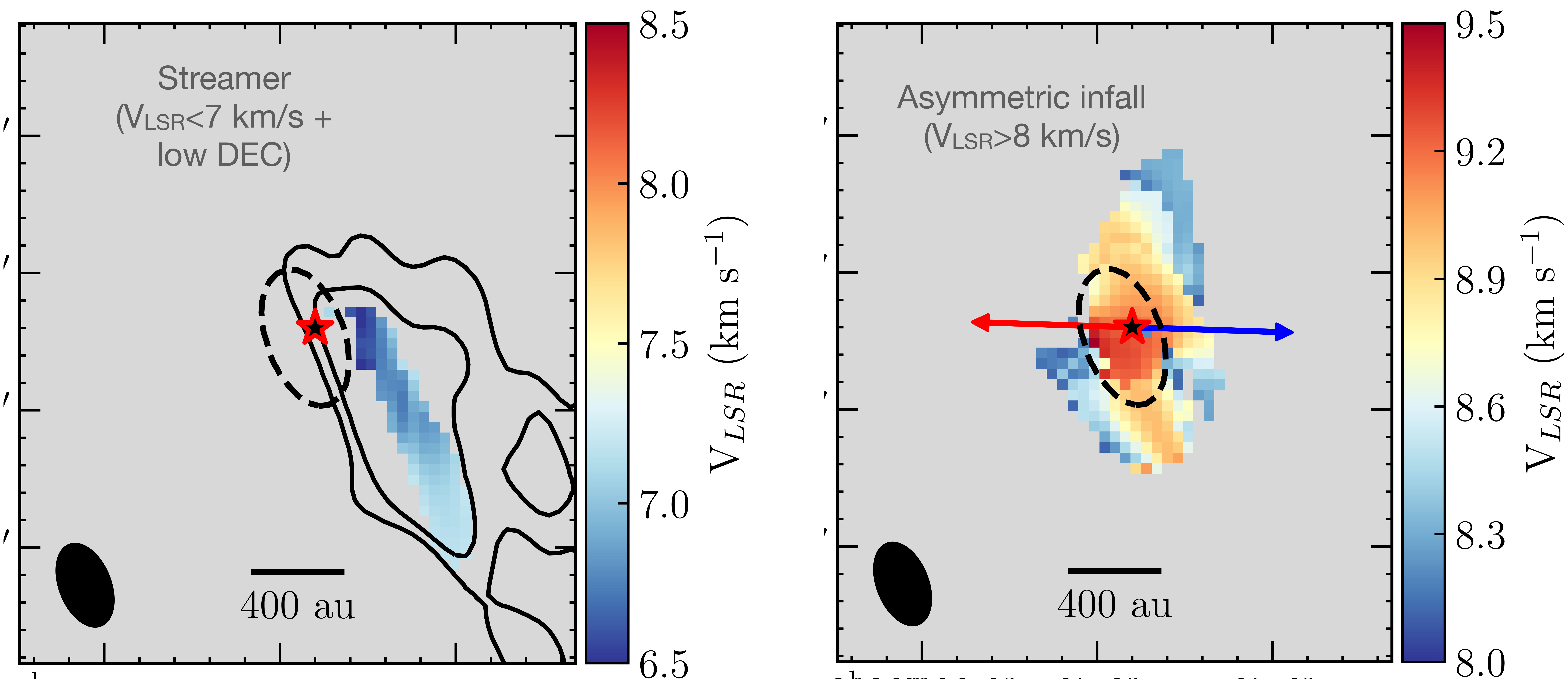
SO shows the envelope is asymmetric

- Sakai et al. (2014) toy model of rotation + infall
- Red. and blueshifted sides need different sets of parameters

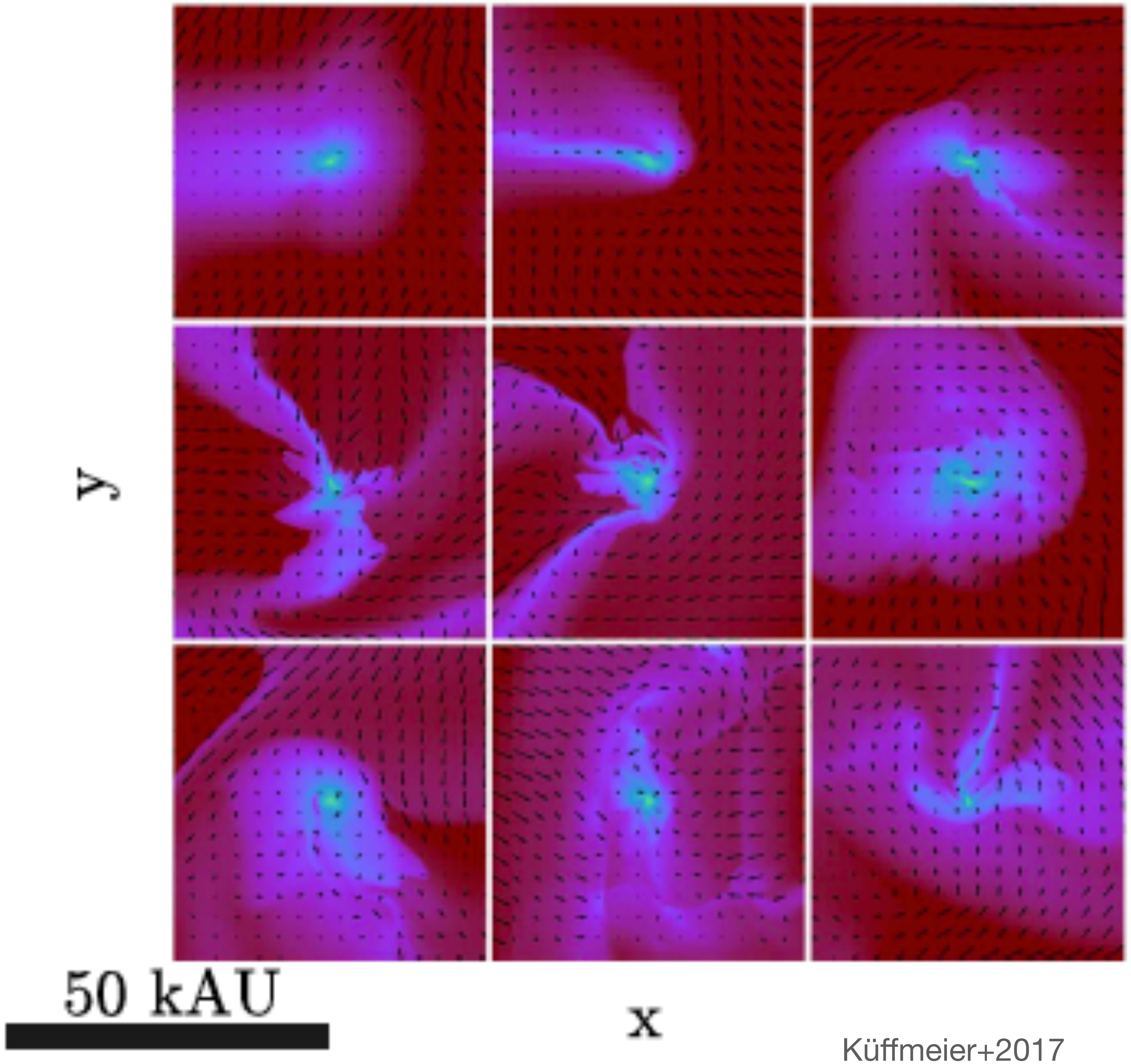
SO (5–4) (black) and SO_2(11-10) (white)



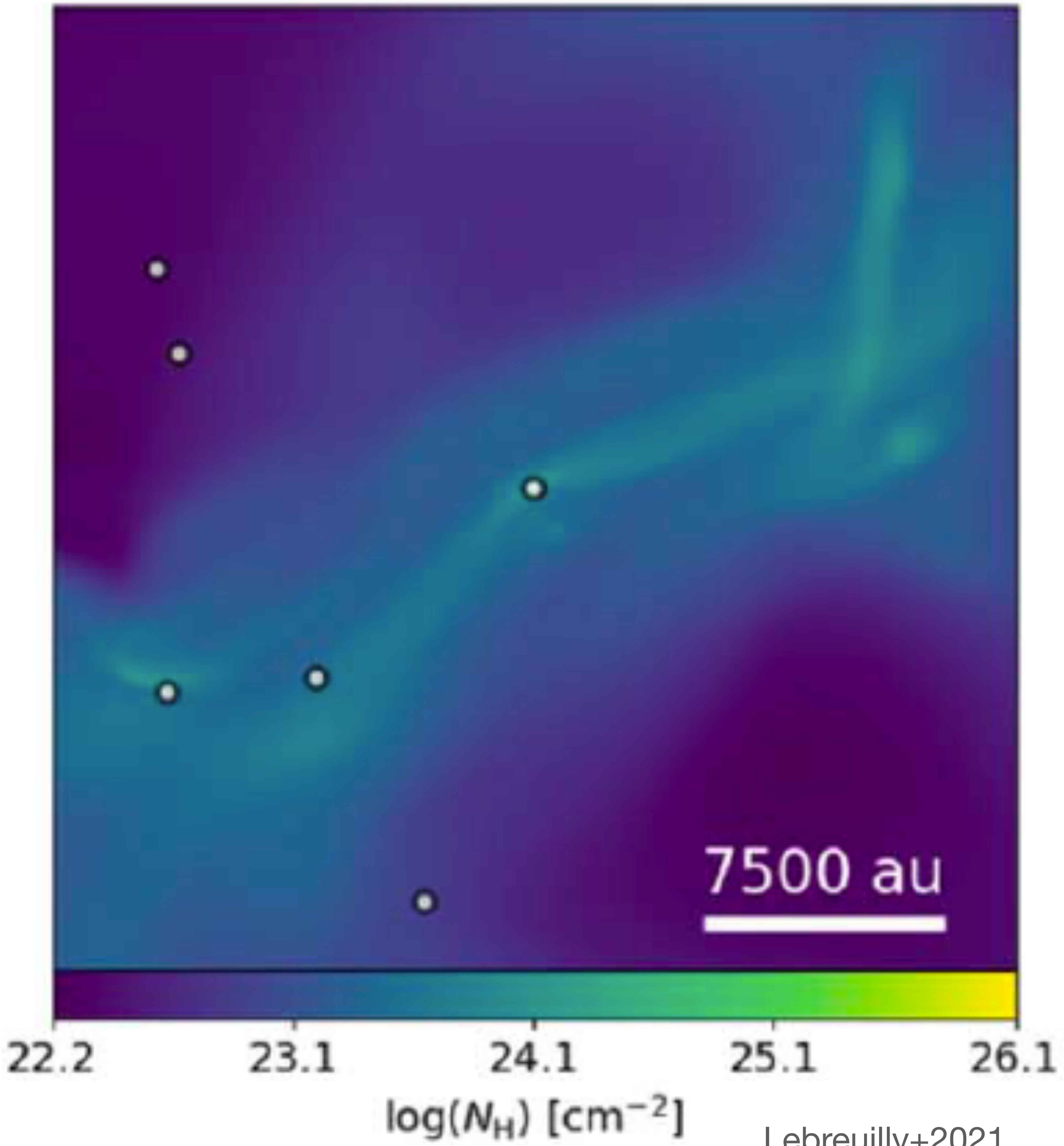
Gaussian decomposition returns 4 distinct components!



The asymmetries are expected from the environment



Küffmeier+2017



Lebreuilly+2021

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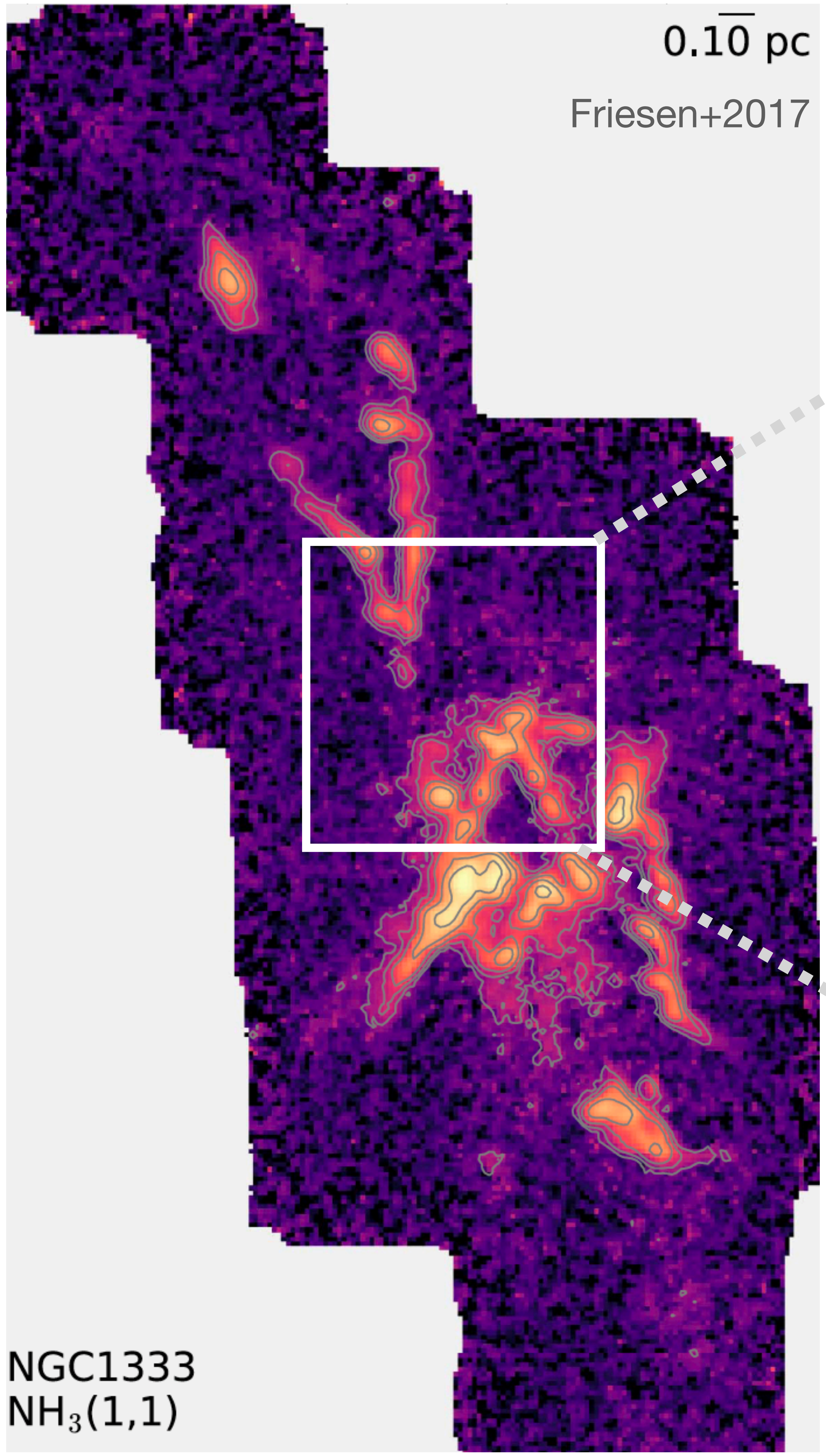

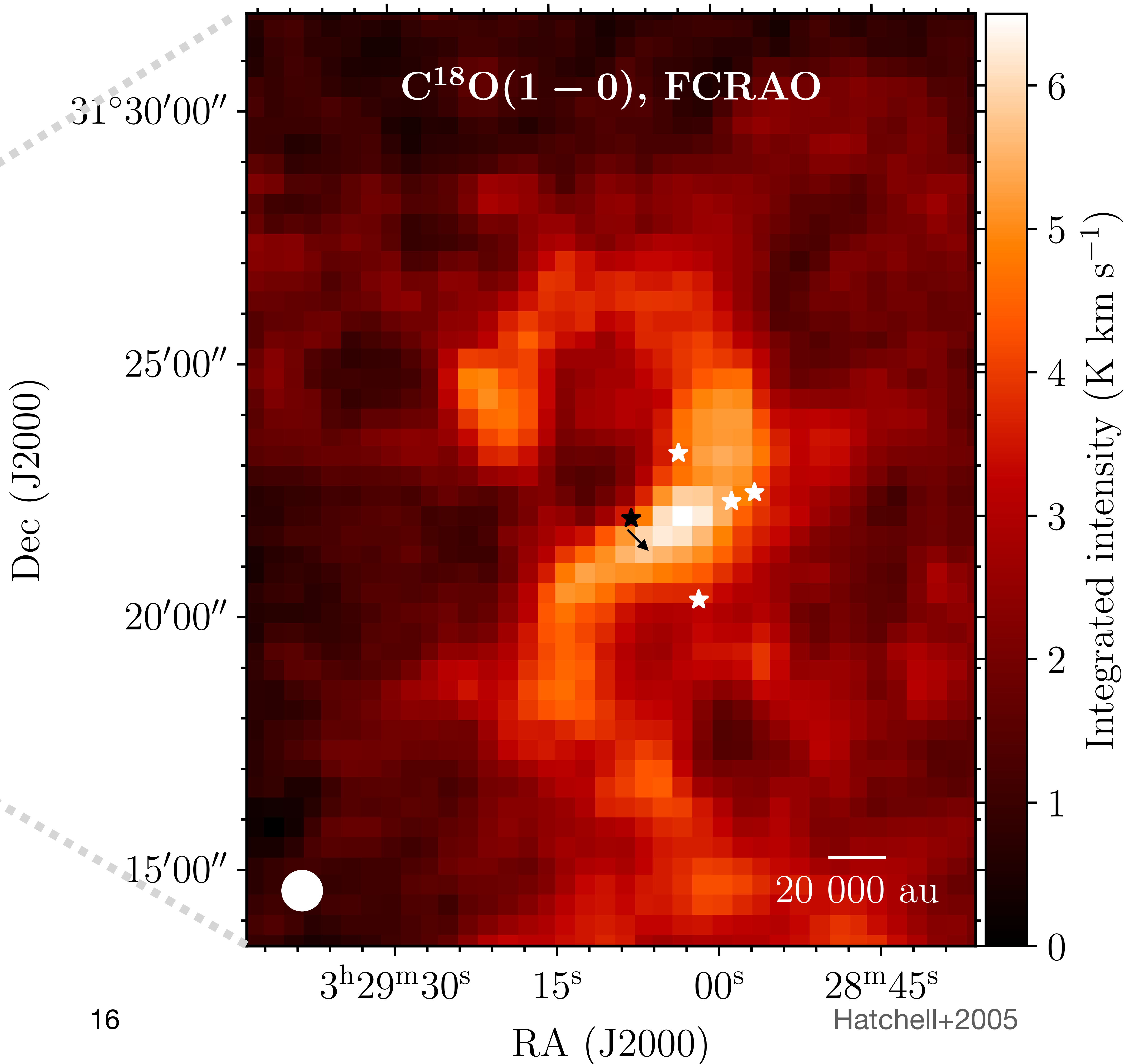

Summary

- Mass infall rate is higher the protostellar accretion rate
- SO shows the complex kinematics of the inner envelope + probes the entrance of the streamer
- **Mass for the protostar's growth can come from outside the natal core**