Gravity drives the evolution of infrared dark hubs: JVLA observations of SDC13

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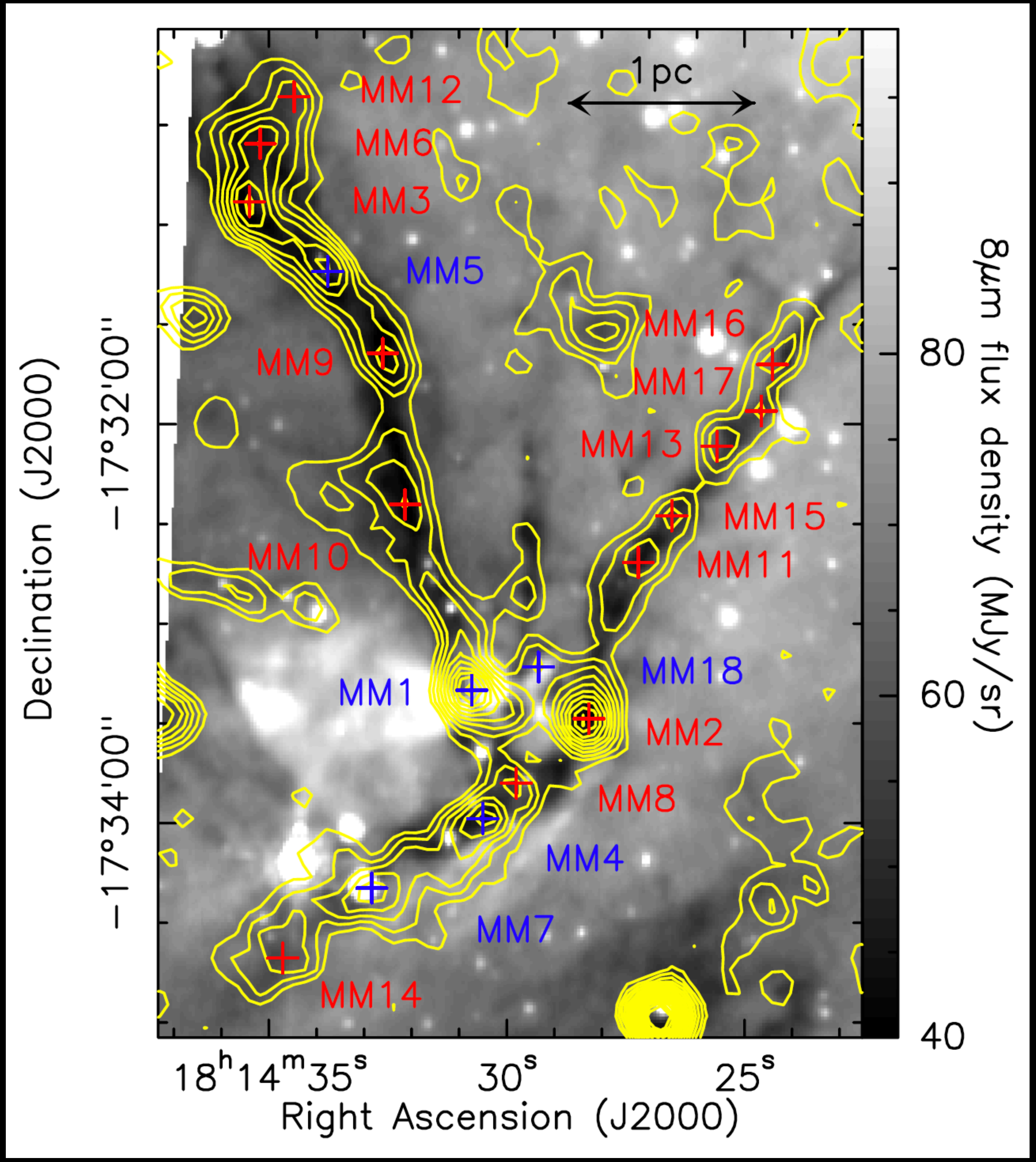
Infrared dark clouds are:
• Cold (T < 20K)
• Dense (n > $10^5 cm^{-3}$)
SDC13:
• $1000M_\odot$ of mass
• 3.6kpc distant in the Galactic plane
• Hub-filament system, with 4 spatially converging filaments
Image:
R 70µm HIGAL
G 24µm MIPSGAL
B 8µm GLIMPSE

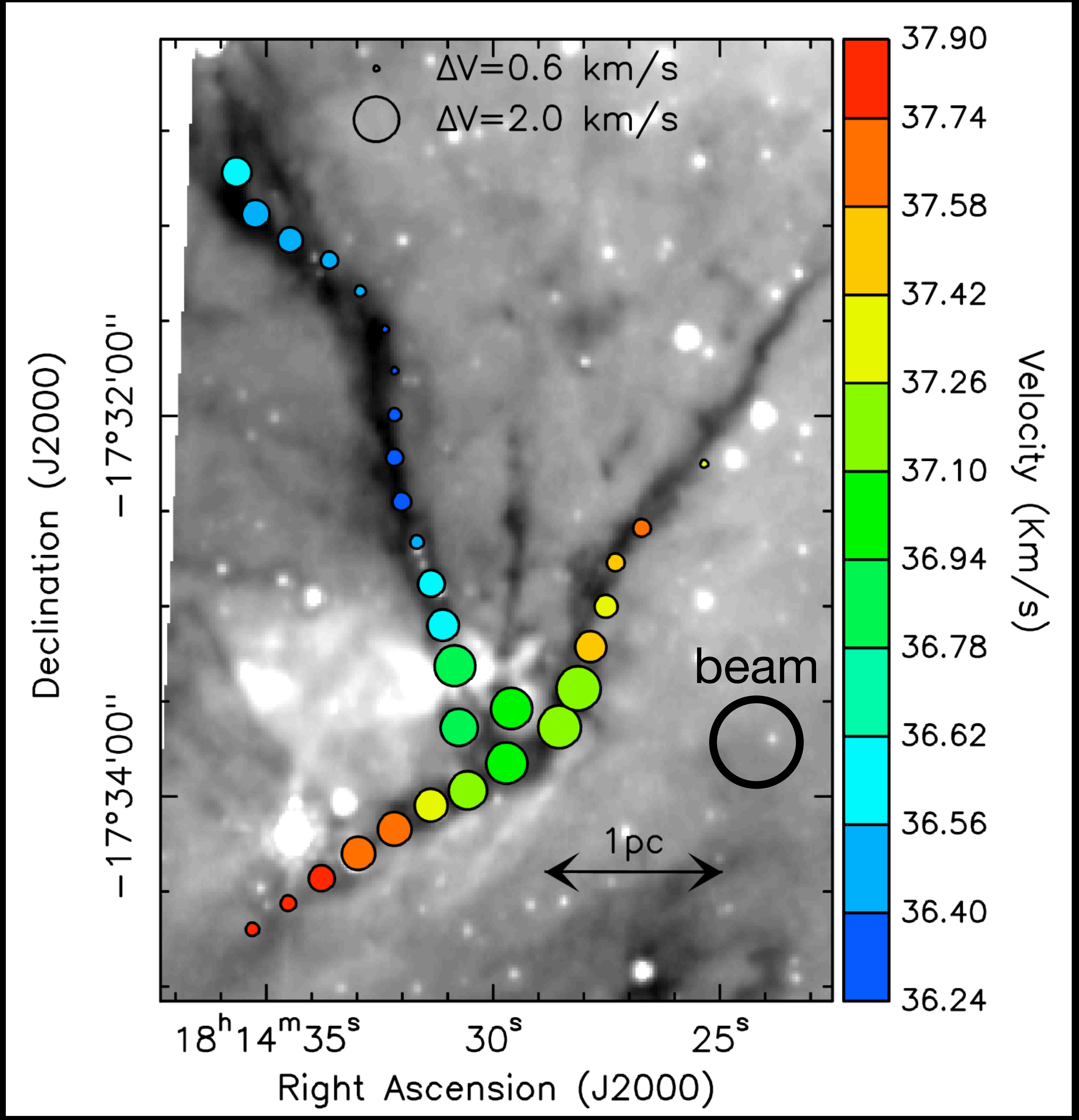
Previous work

18 compact mm sources



+ Starless + Protostellar

N_2H^+(1-0) centroid velocity

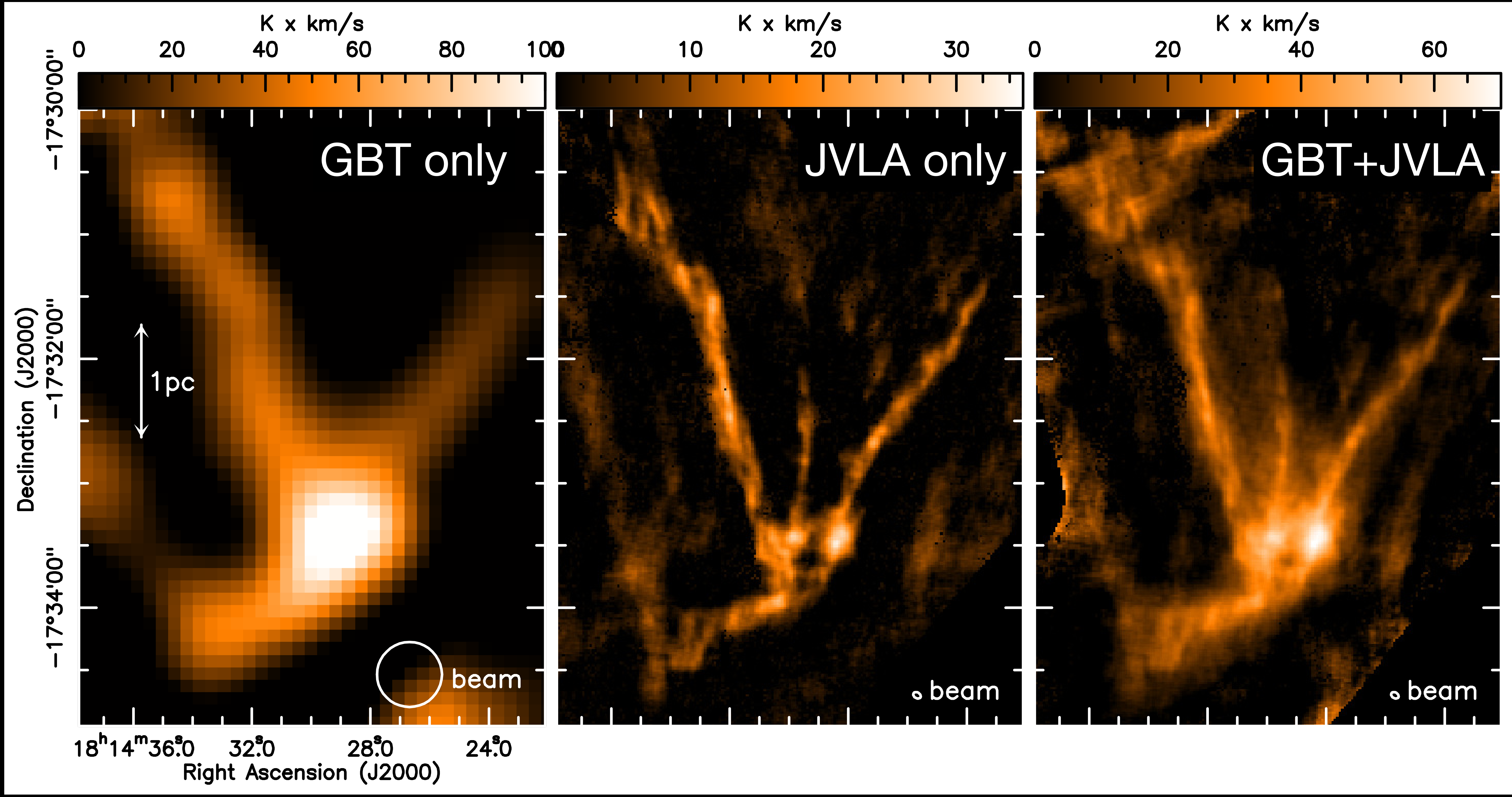


Ordered velocity structure

Peretto et al. (2014), A&A, 561, 83

New data: combining GBT and JVLA data

Integrated intensity maps of $NH_3(1,1)$

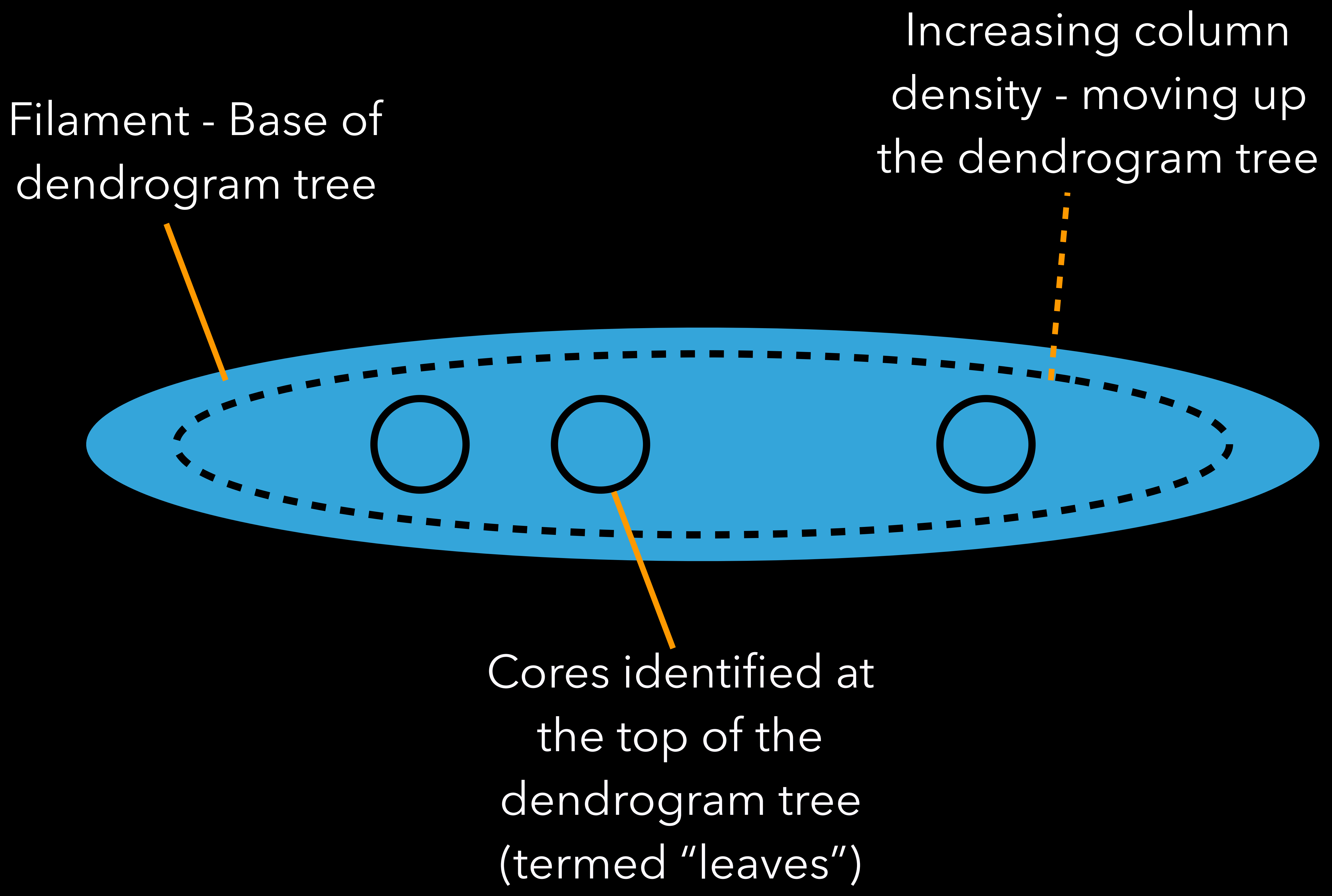


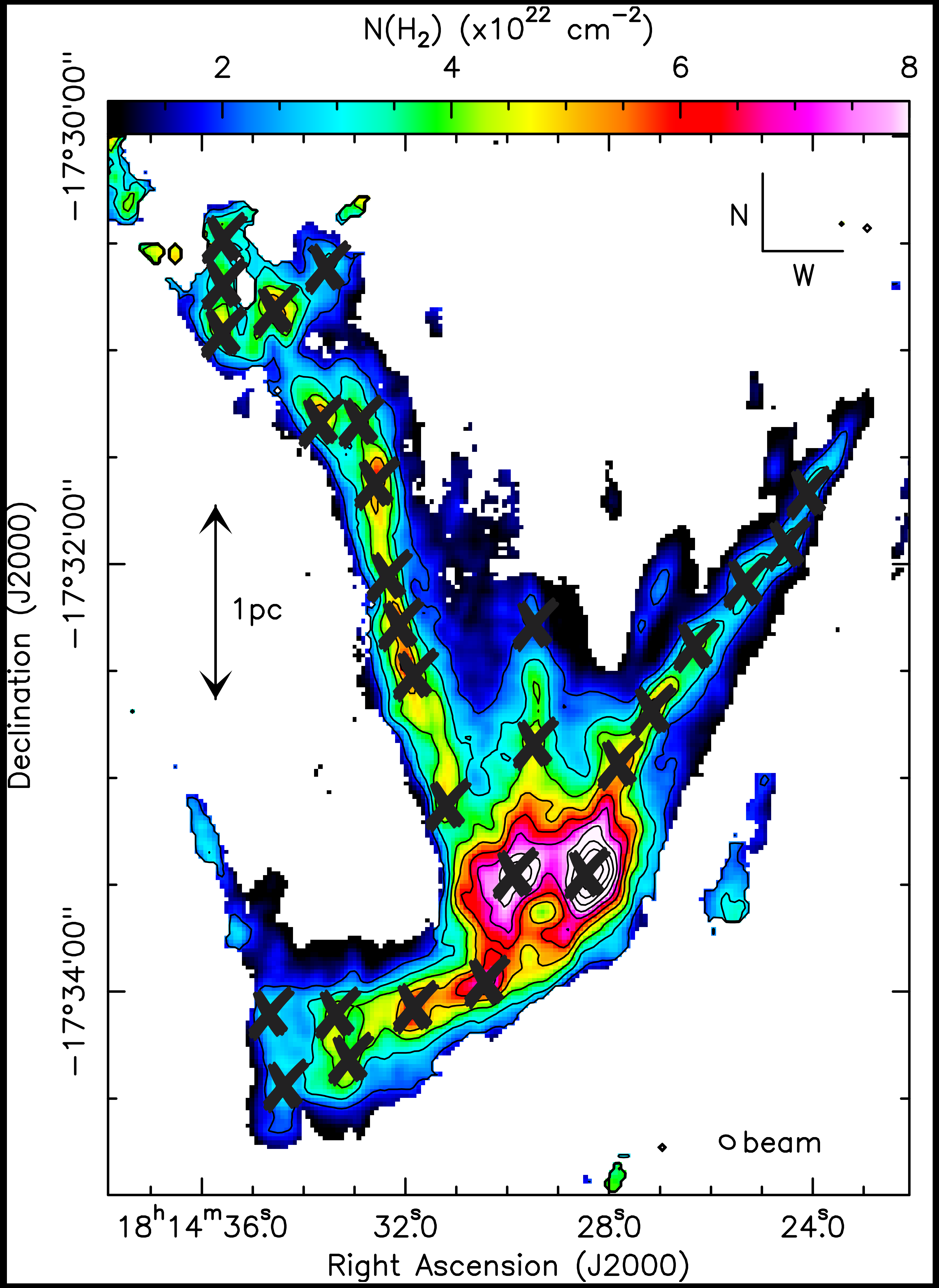
- Resolution of ~4″, ~0.07pc
- Able to resolve mean core sizes of ~0.1pc

Williams et al. (2018), A&A, 613, 11   arXiv:1801.07253

Fragmentation

- Dendrogram analysis used to identify structures:





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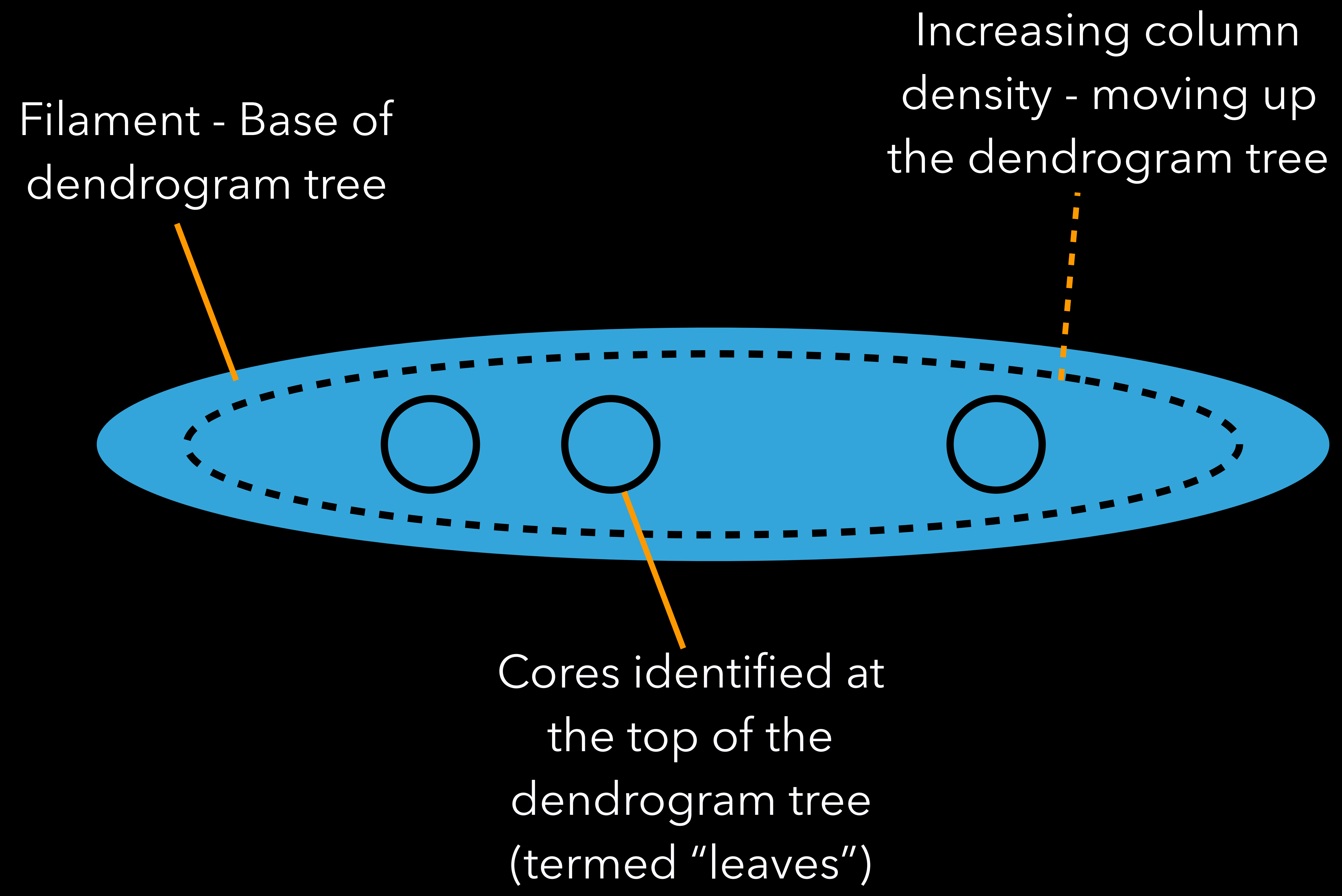
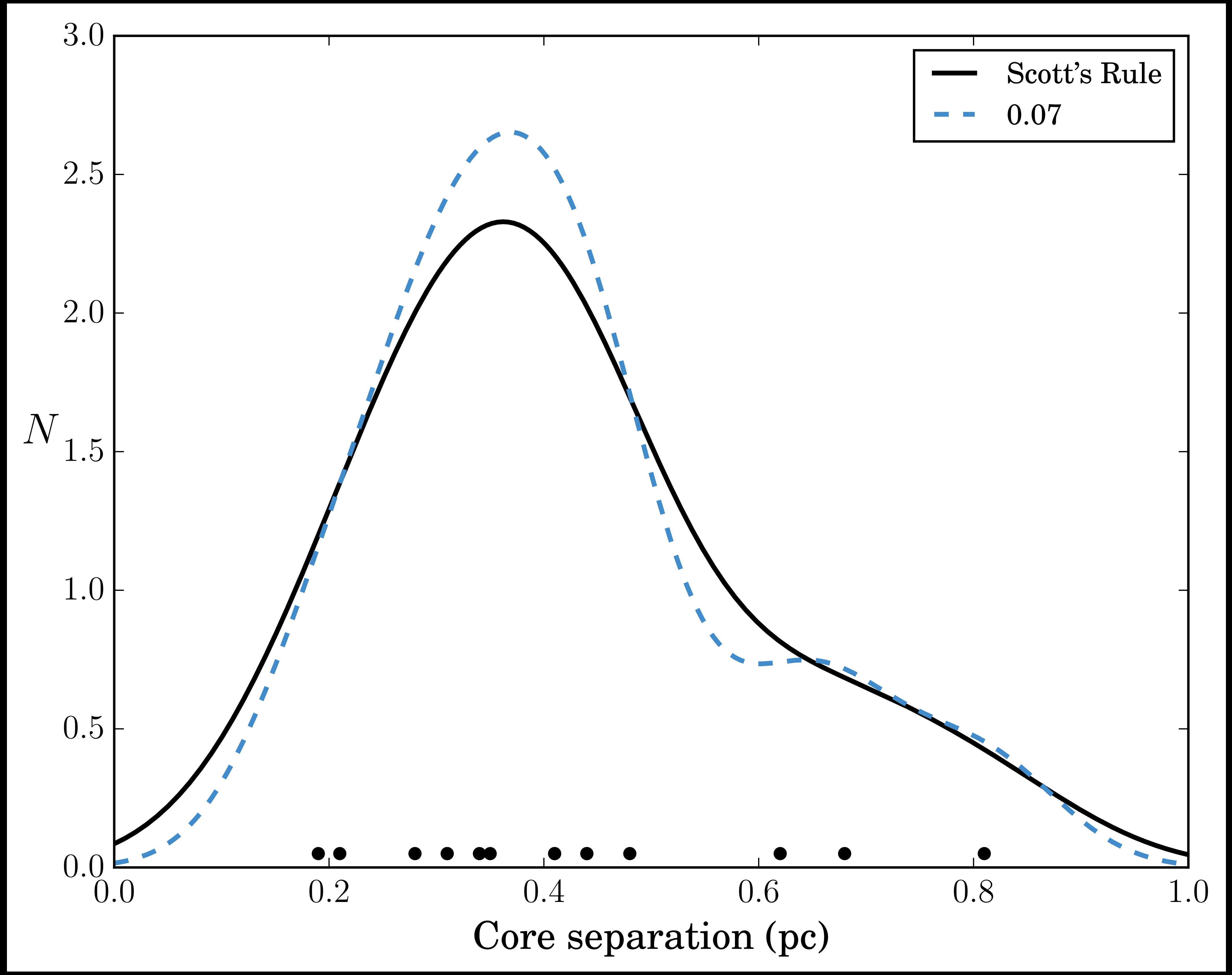
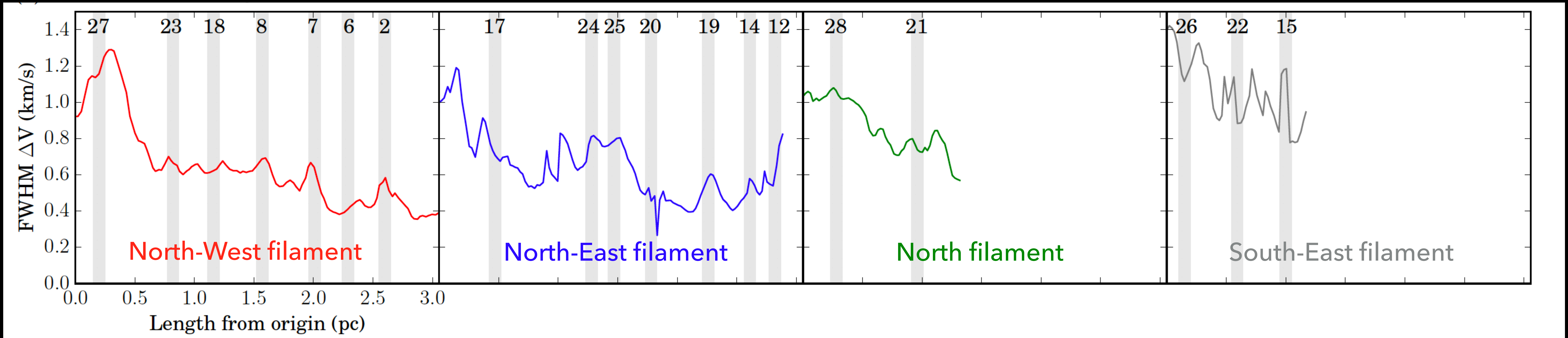




Regular core separation of 0.37 ± 0.17 pc

Velocity width

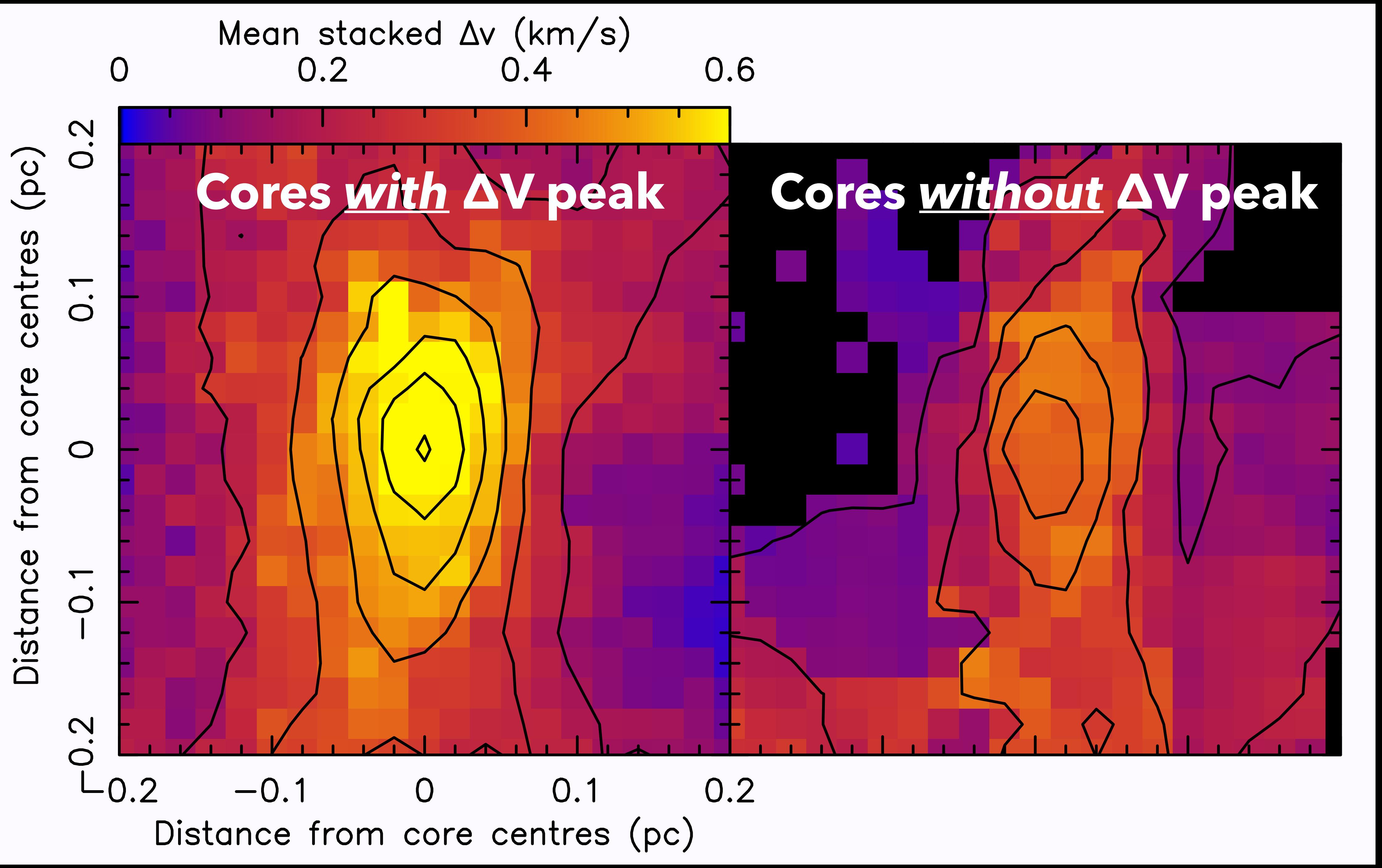
Velocity width profiles along the spines of all four filaments



- Velocity width peaks at the position of two-thirds of starless cores

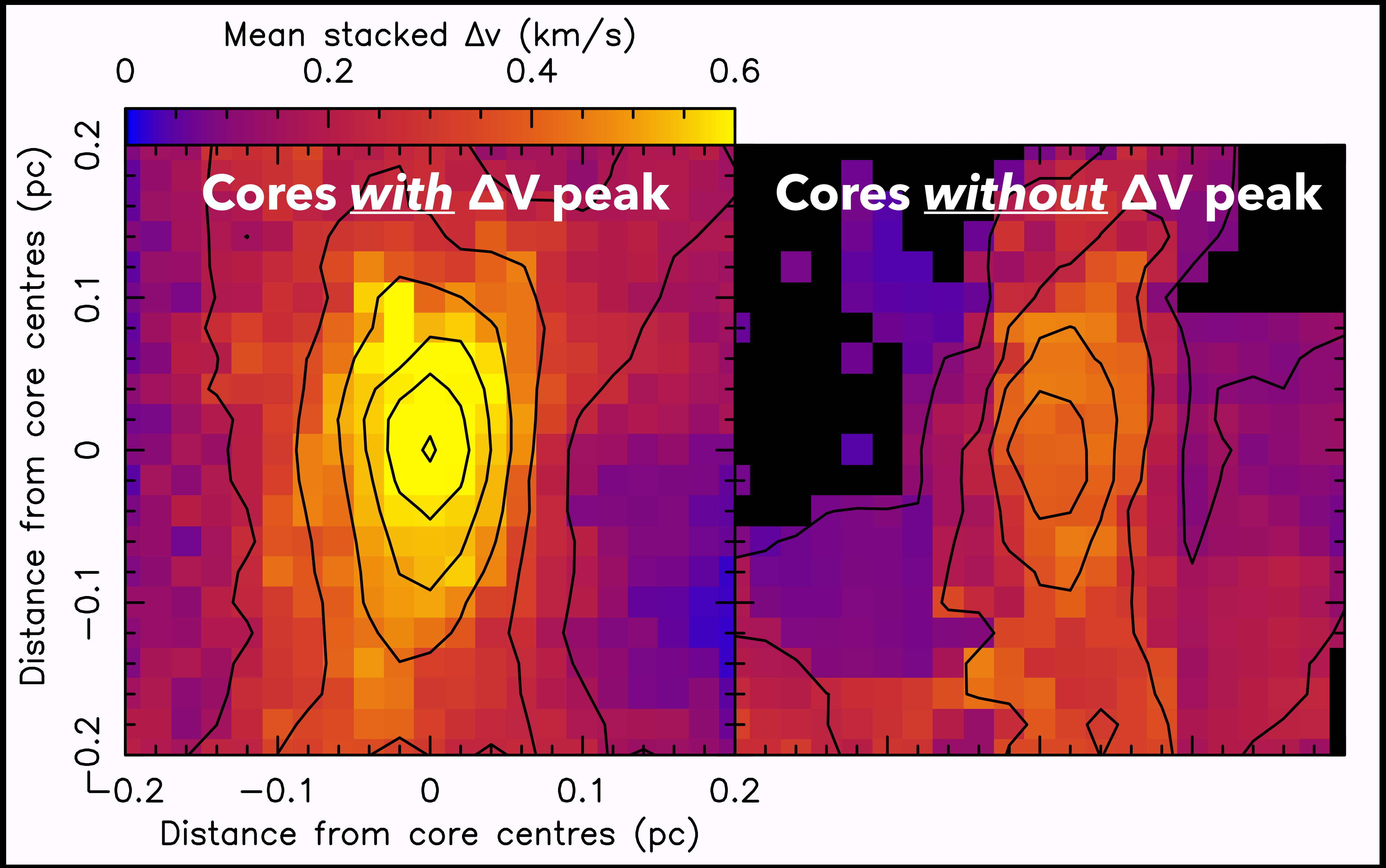
Velocity width

Mean velocity width of the cores

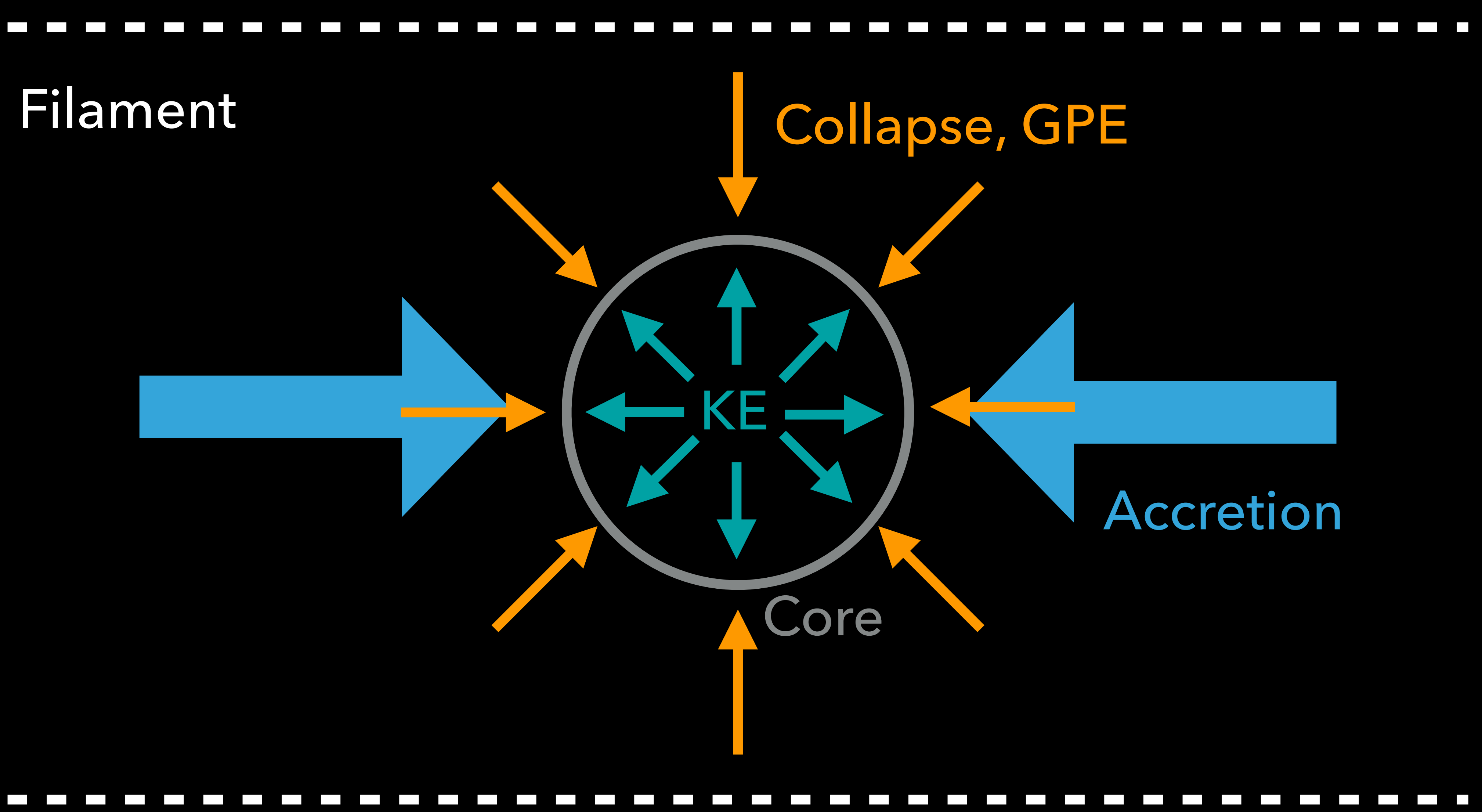


Velocity width

Mean velocity width of the cores



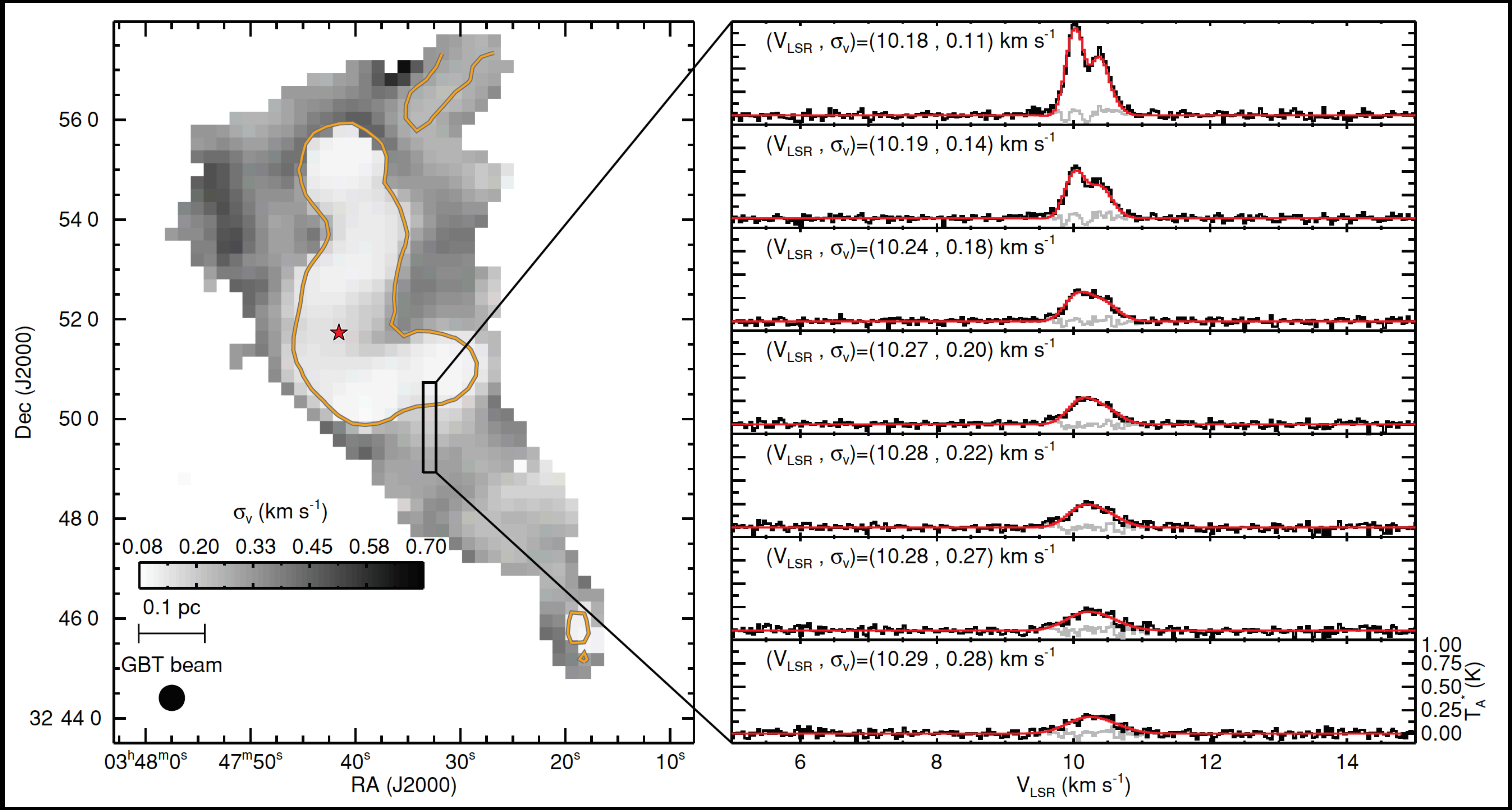
Interpretation:



Extra “turbulent” support of cores, allowing for the assembly of super-Jeans cores

Velocity width

B5 prestellar core in Perseus - Pineda et al. (2010)



Velocity width narrows at the position of this low mass, nearby core

Virial analysis

Given the virial equation:

$$\alpha_{vir} = 2\frac{E_k}{E_g}$$

- $\alpha_{vir} > 2$, unbound
- $\alpha_{vir} < 2$, gravitationally bound
- $\alpha_{vir} \sim 1$, hydrostatic equilibrium
- $\alpha_{vir} < 1$, gravitationally unstable

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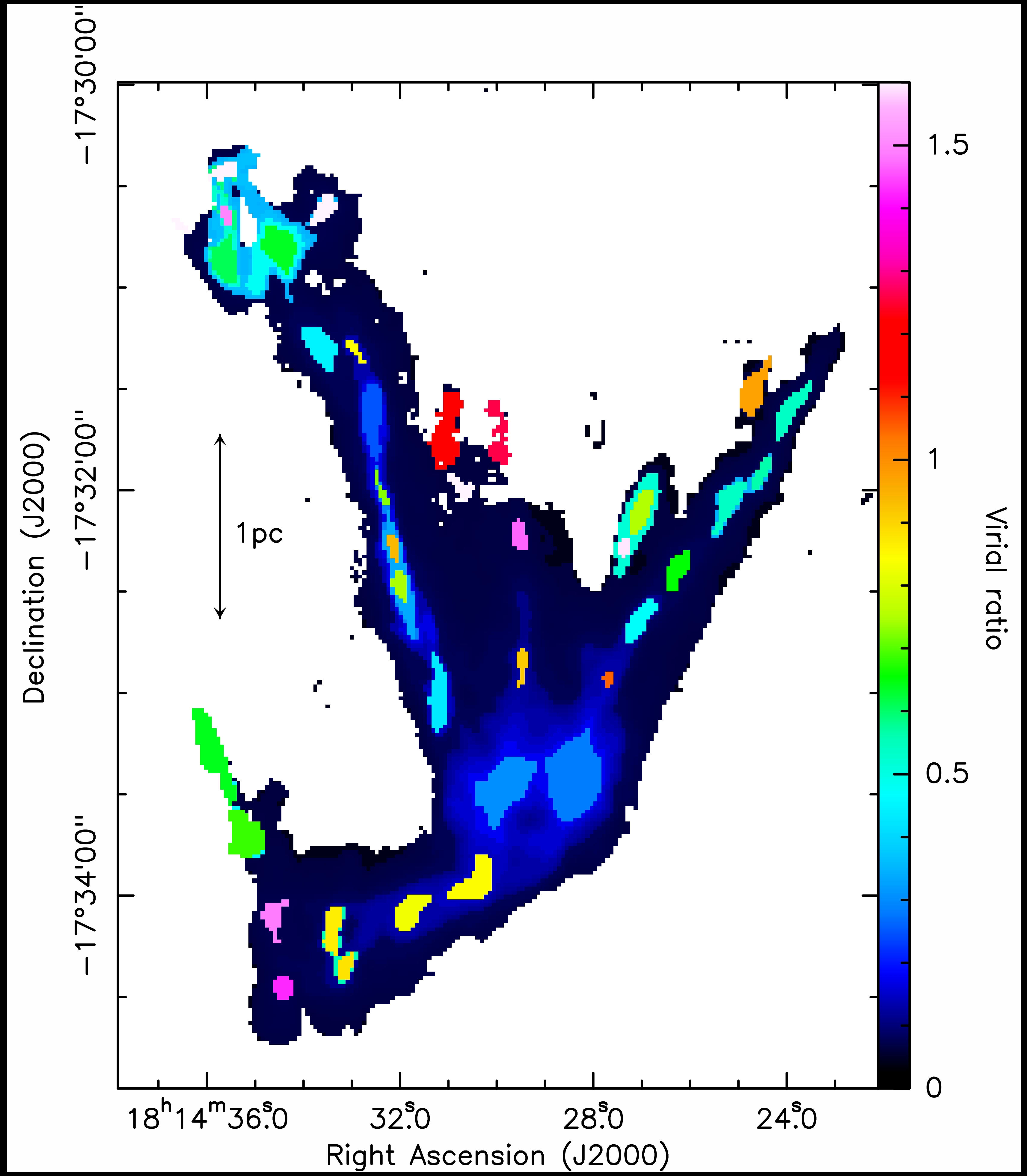
- SDC13 appears gravitationally unstable on all scales
- Increase of virial ratio on small, core scales

Map of the virial parameter



Conversion of GPE to KE

Kinetic energy, E_k:

$$E_k = E_{k,0} + \Delta E_k$$

Fractional increase in kinetic energy:

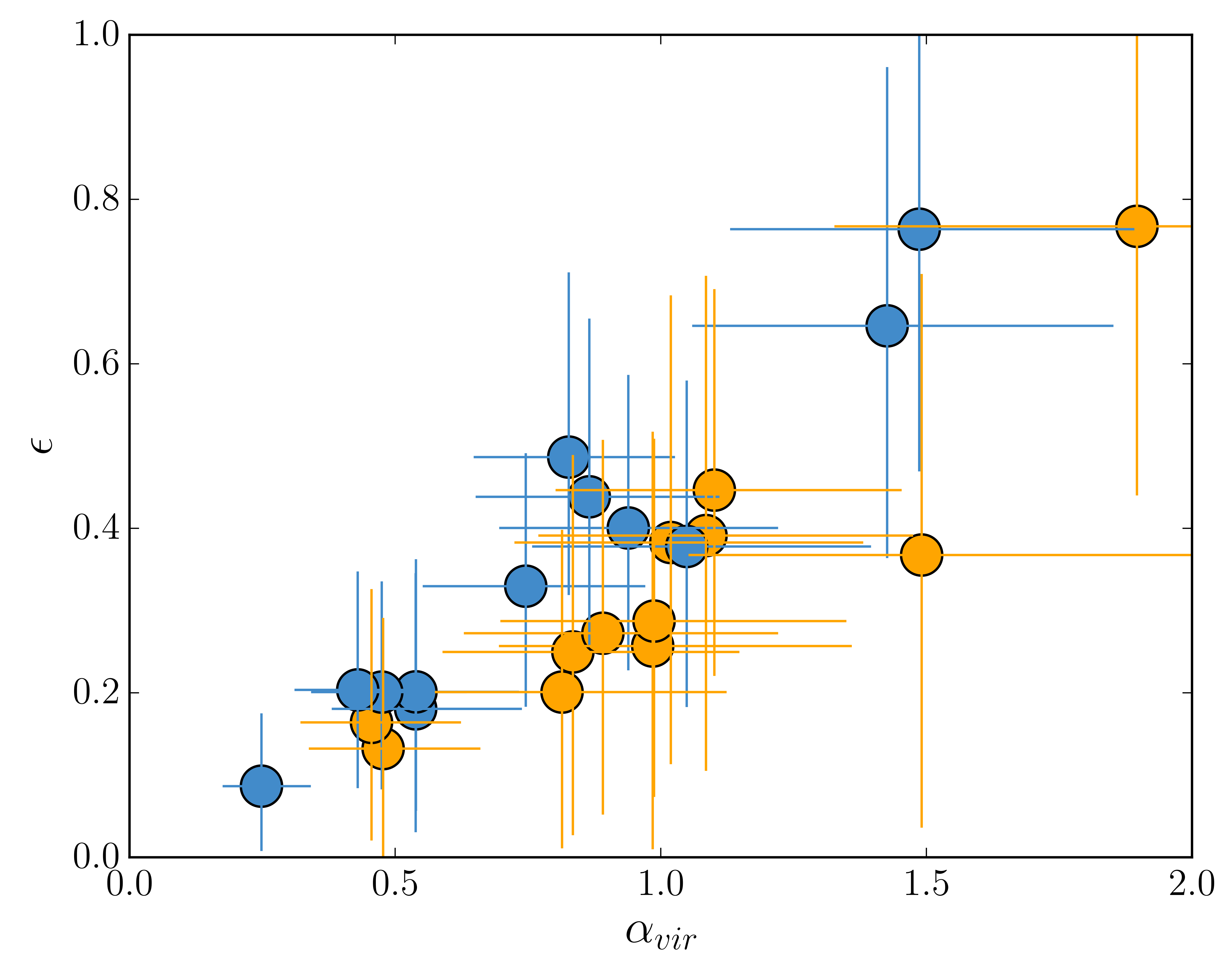
$$\Delta E_k = \epsilon\left(E_g - E_{g,0}\right)$$

Given the virial equation:

$$\alpha_{vir} = 2\frac{E_k}{E_g}$$

Substituting and rearranging gives:

$$\alpha_{vir} = 2\frac{E_{k,0}}{|E_g|} + 2\epsilon\left(1 - \frac{|E_{g,0}|}{|E_g|}\right)$$



● = JVLA+GBT data, ● = JVLA only data.

ϵ_{mean} **= 35%**

Conclusions

- A new high-angular/spectral resolution study
- Regularly spaced cores, fragmented along the filaments
- Velocity width broadens at the positions of starless cores
- SDC13 is gravitationally unstable on all scales
- Conversion of GPE into KE is on average 35% efficient in cores

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