Gravity drives the evolution of infrared dark hubs

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Adam Avison, Ana Duarte-Cabral, Gary Fuller.

Williams, Peretto et al. 2017, A&A, submitted

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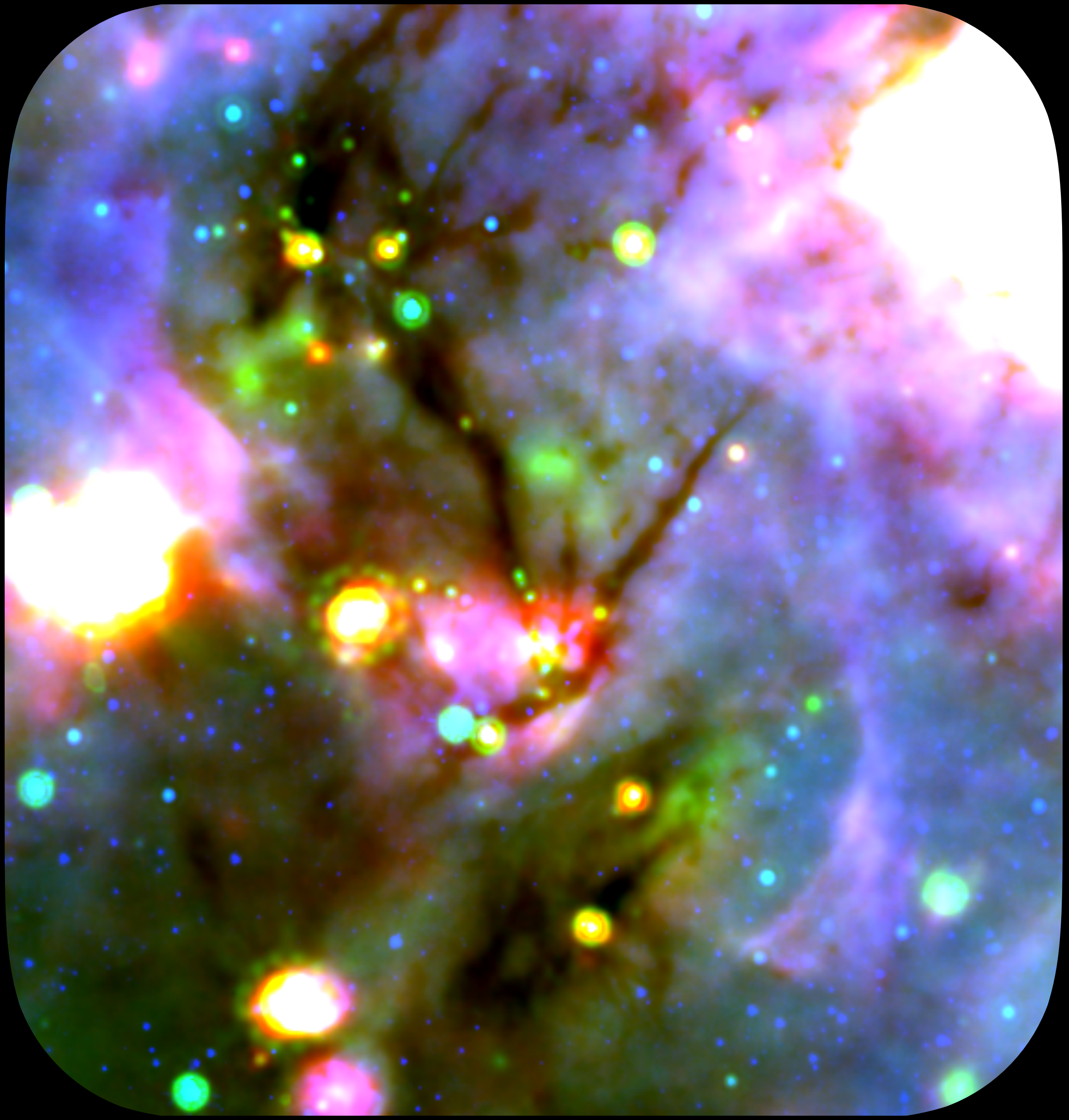
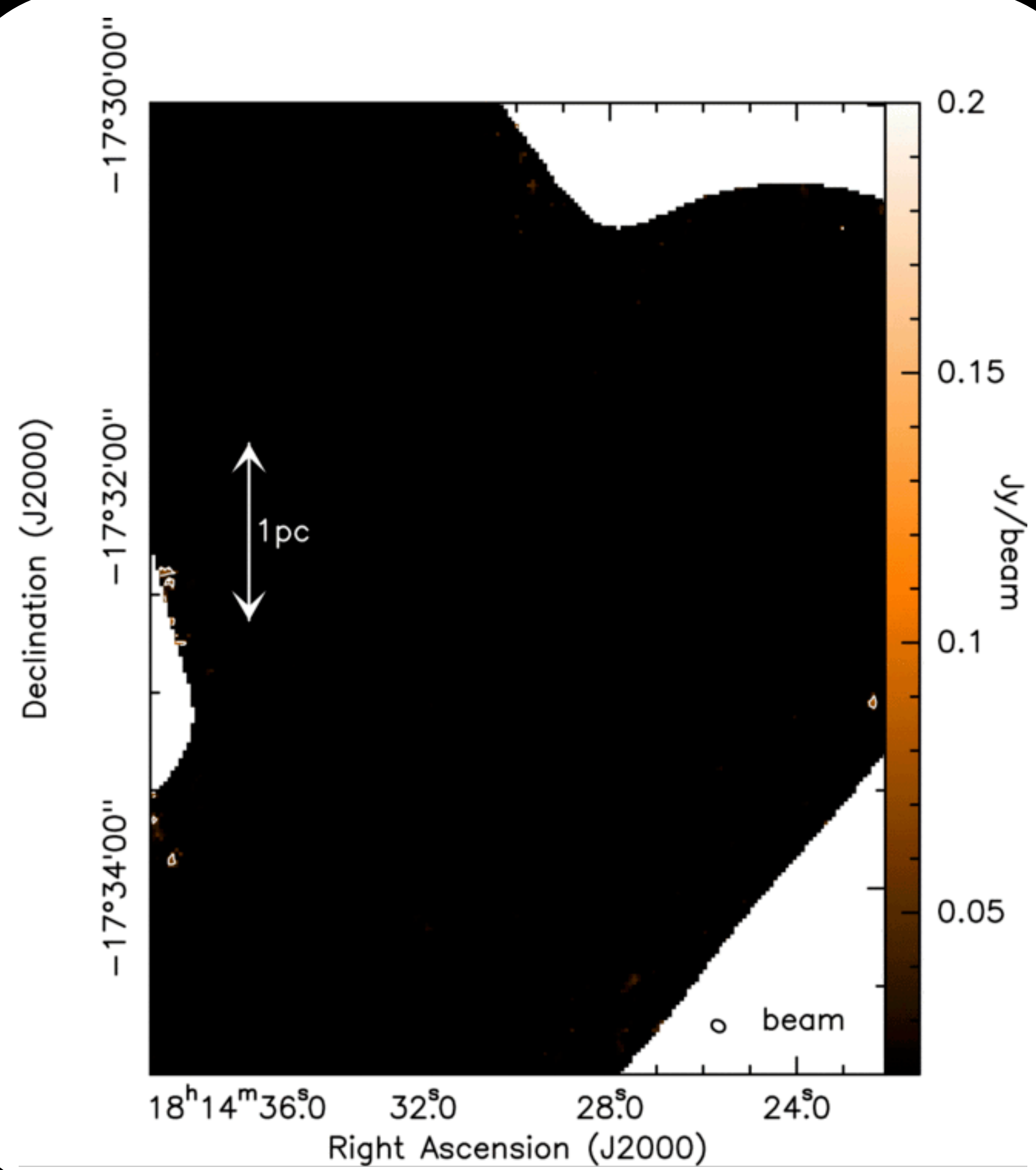
@gwenows

The SDC13 hub



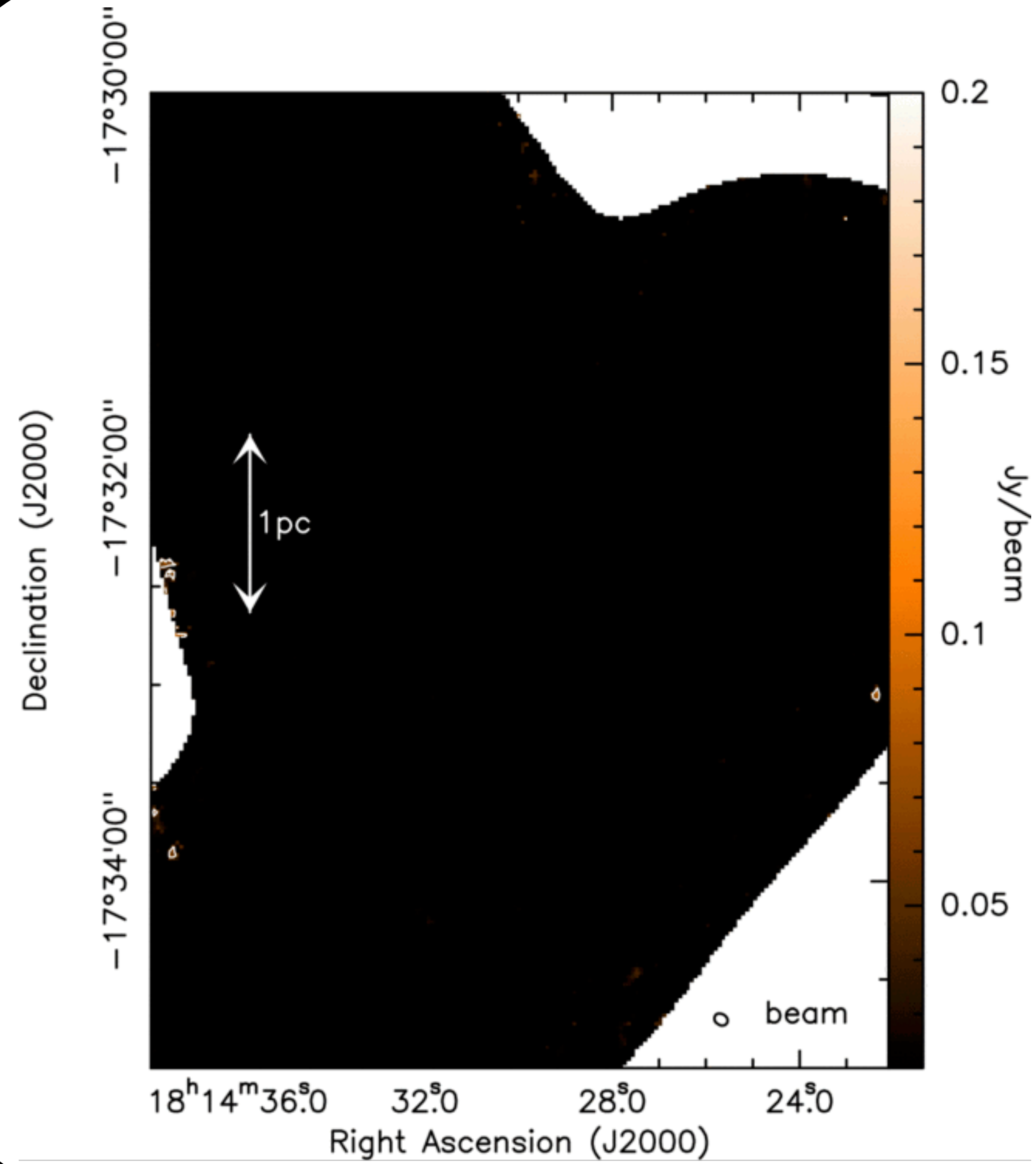
Three colour image
R 70μm HIGAL
G 24μm MIPSGAL
B 8μm GLIMPSE

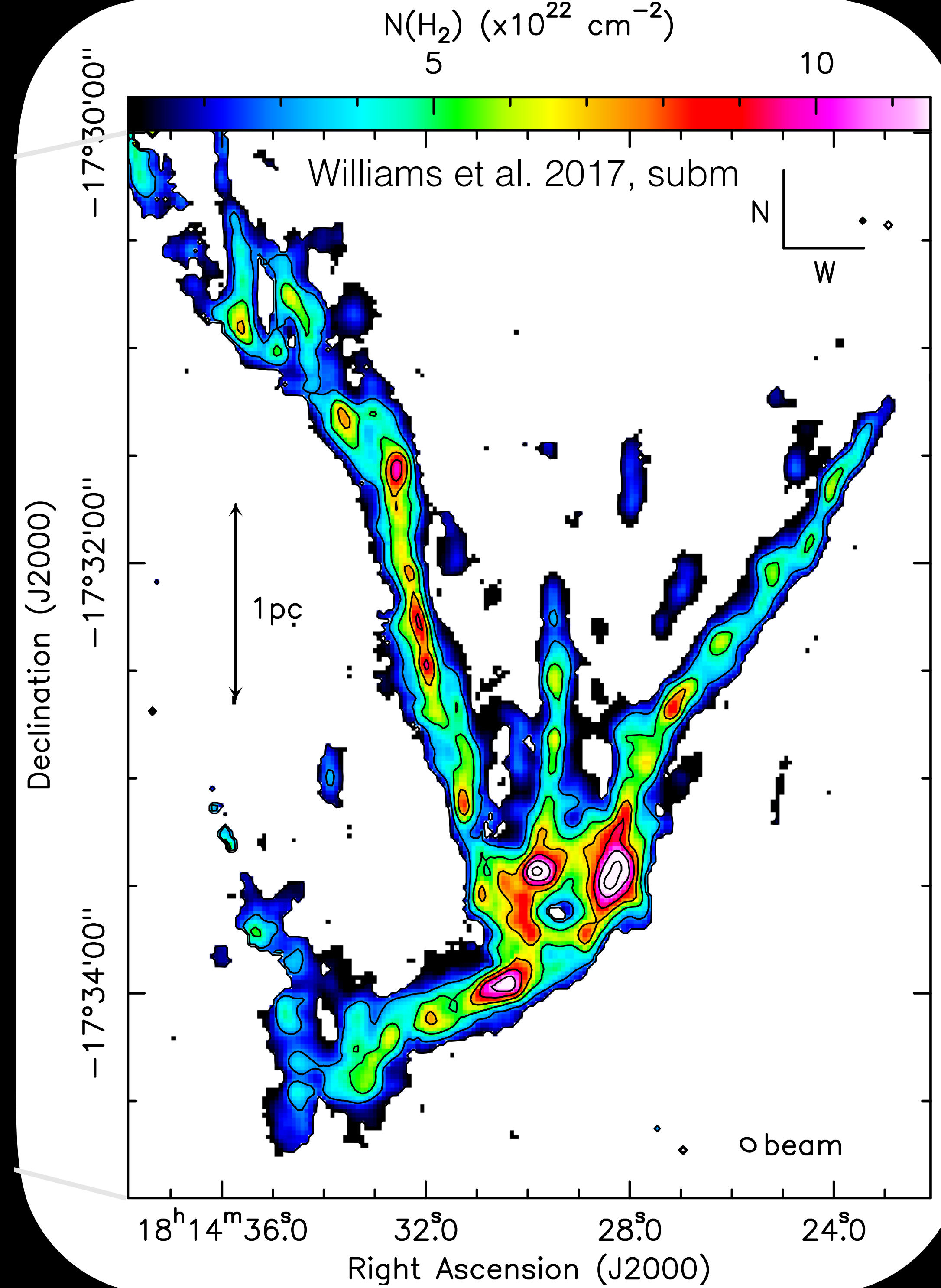
The SDC13 hub



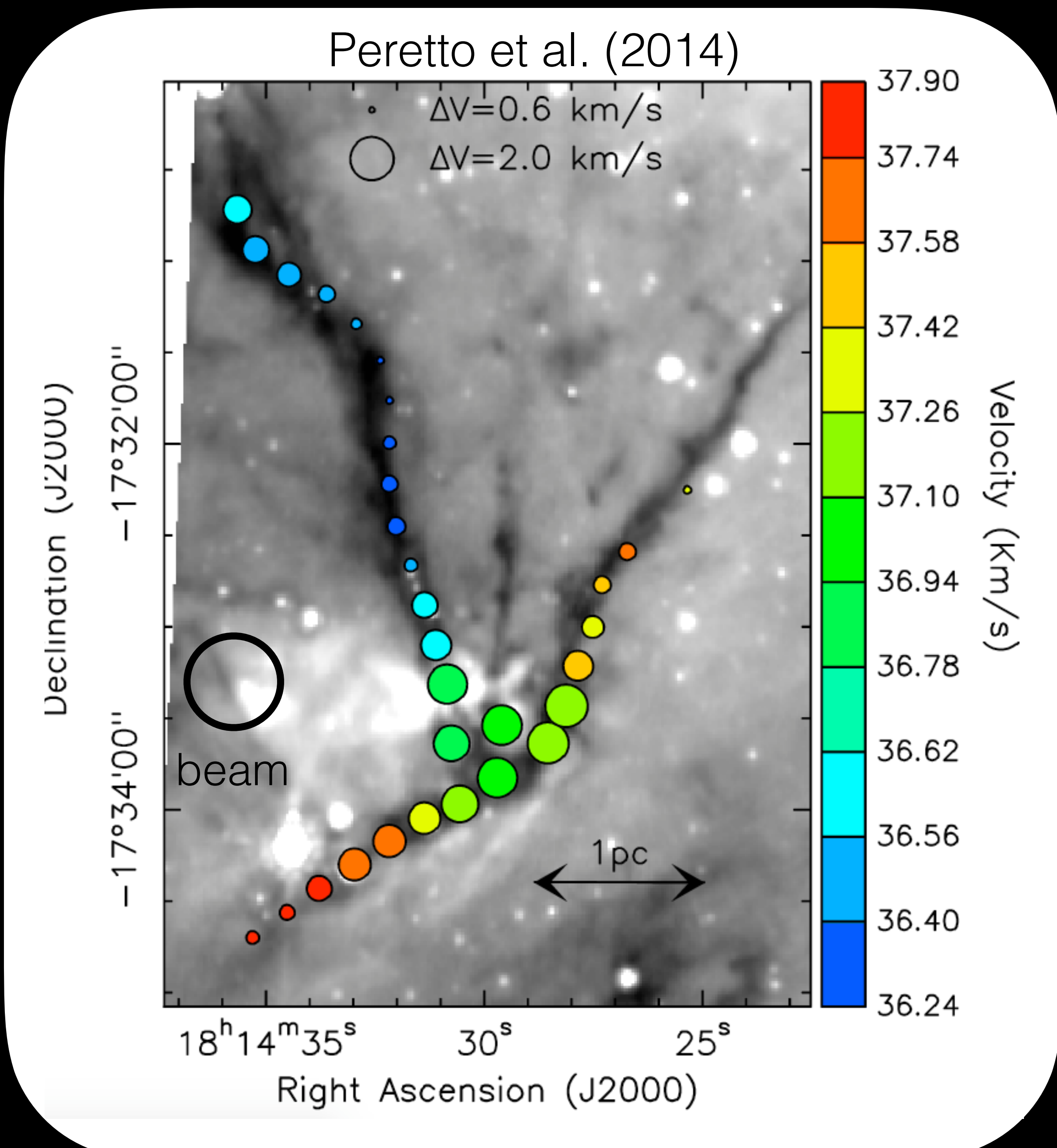
- $NH_3(1,1)$ and $NH_3(2,2)$
- New, combined data set from the JVLA interferometer and GBT single-dish
- 7 times better angular resolution than old data
  - ~4'', 0.07pc scales

The SDC13 hub



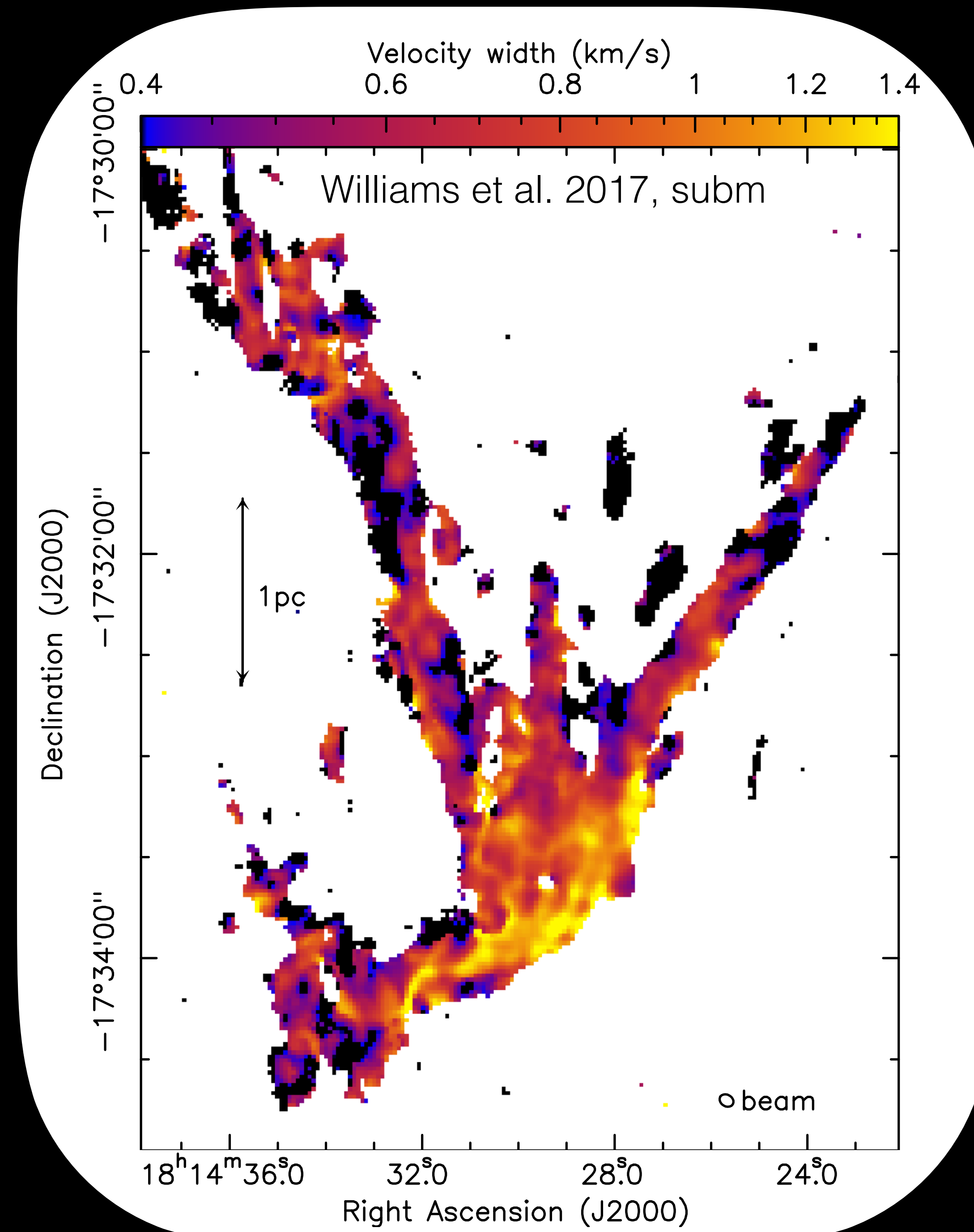


Velocity width



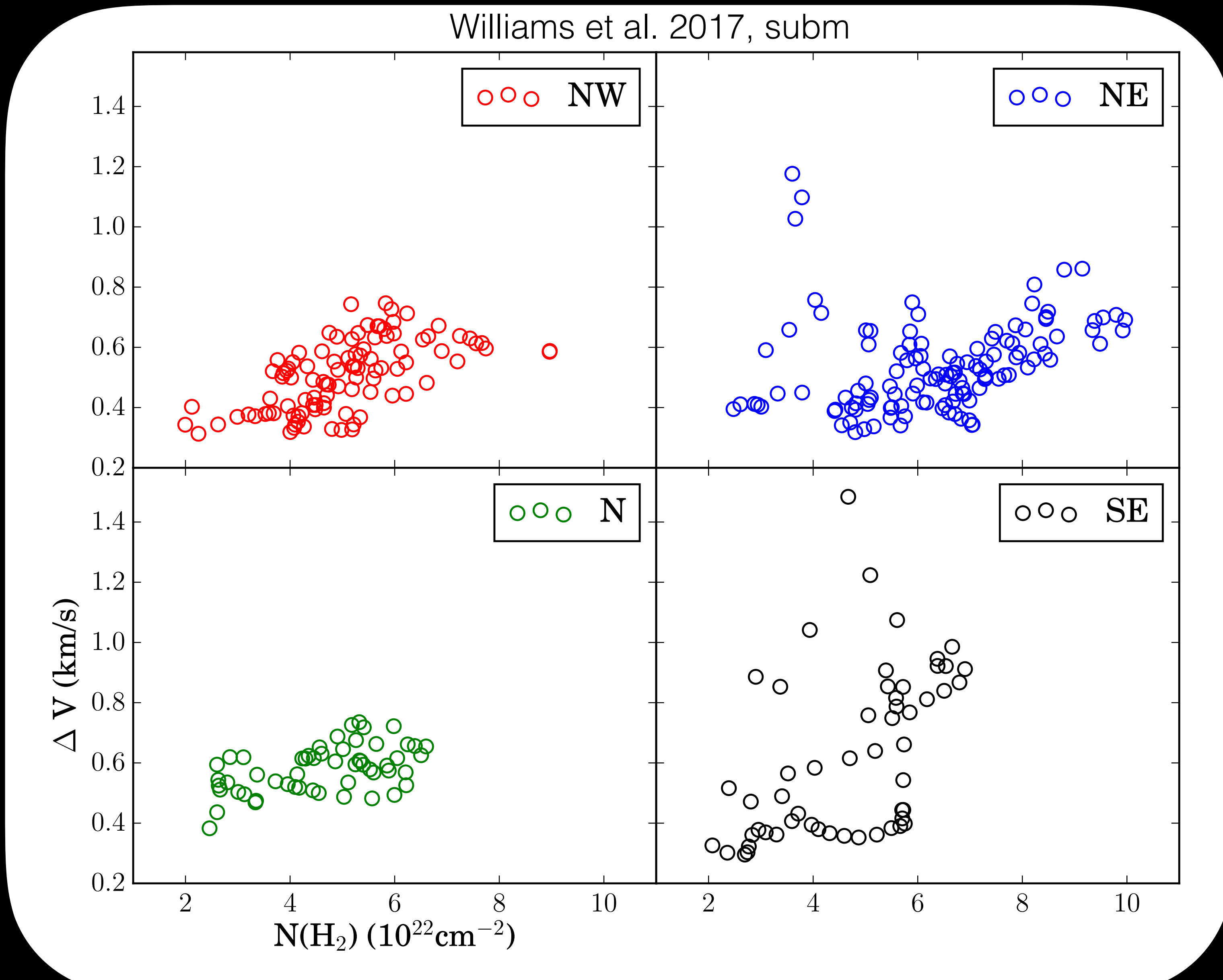
IRAM 30m $N_2H^+(1,0)$ emission

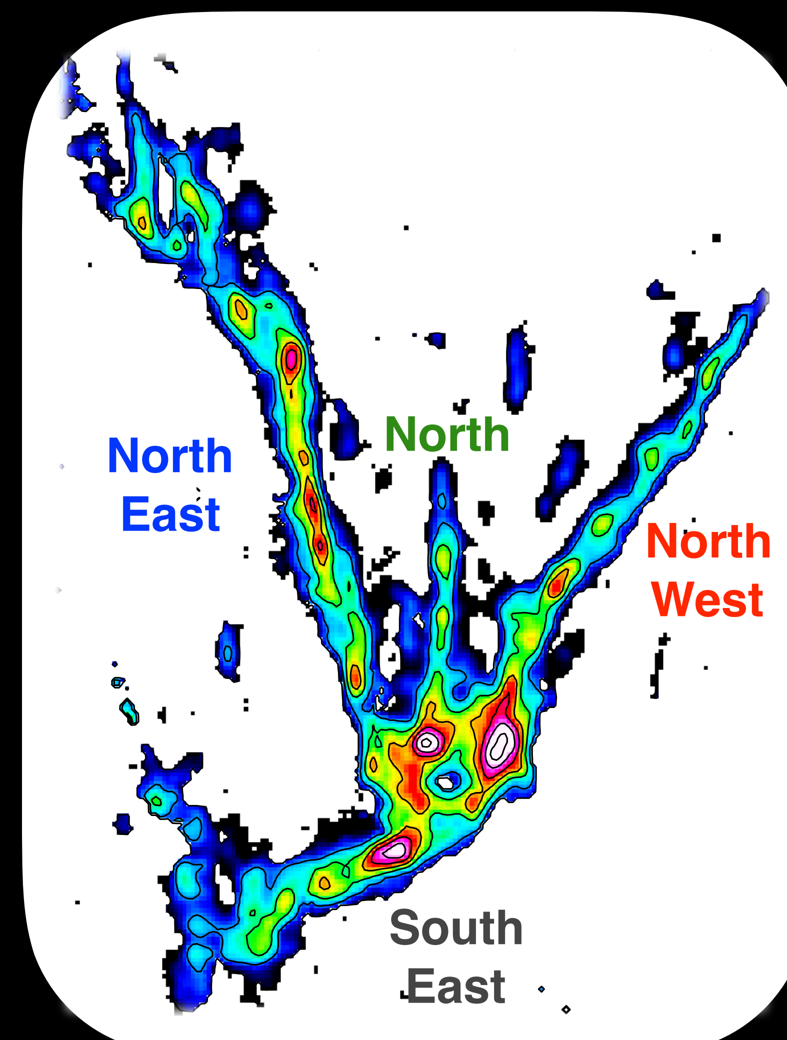
Greyscale: Spitzer 8μm image



JVLA+GBT combined $NH_3(1,1)$ velocity width

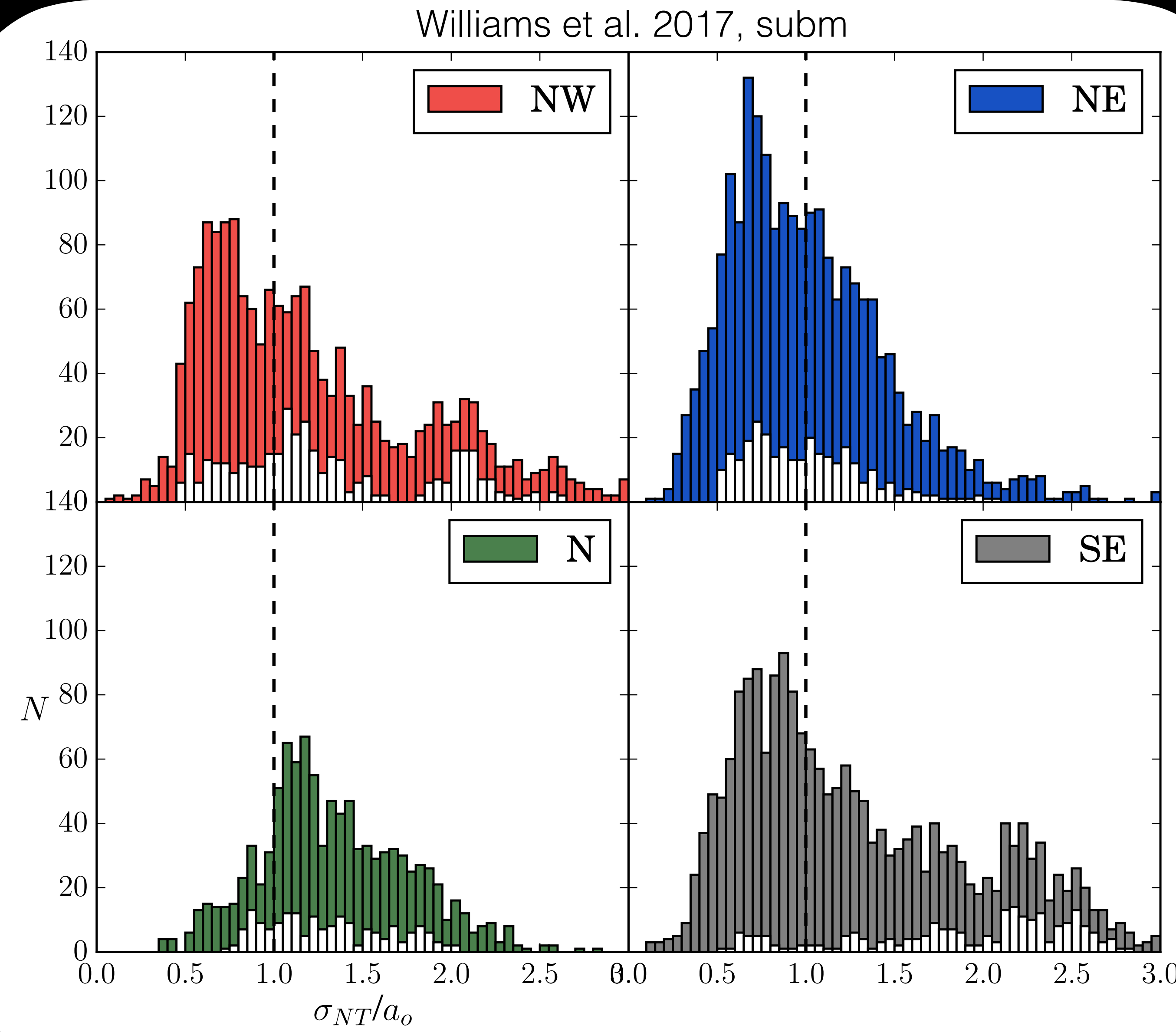
Velocity width broadening

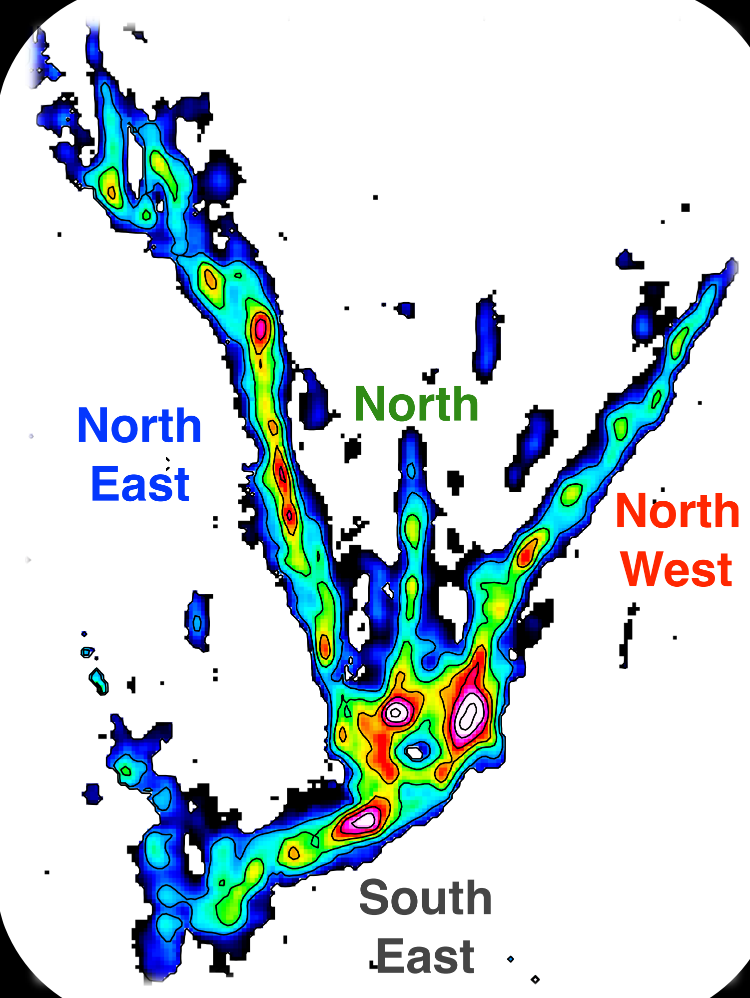




Velocity width is seen to increase with column density along the filament spines.

Velocity width broadening

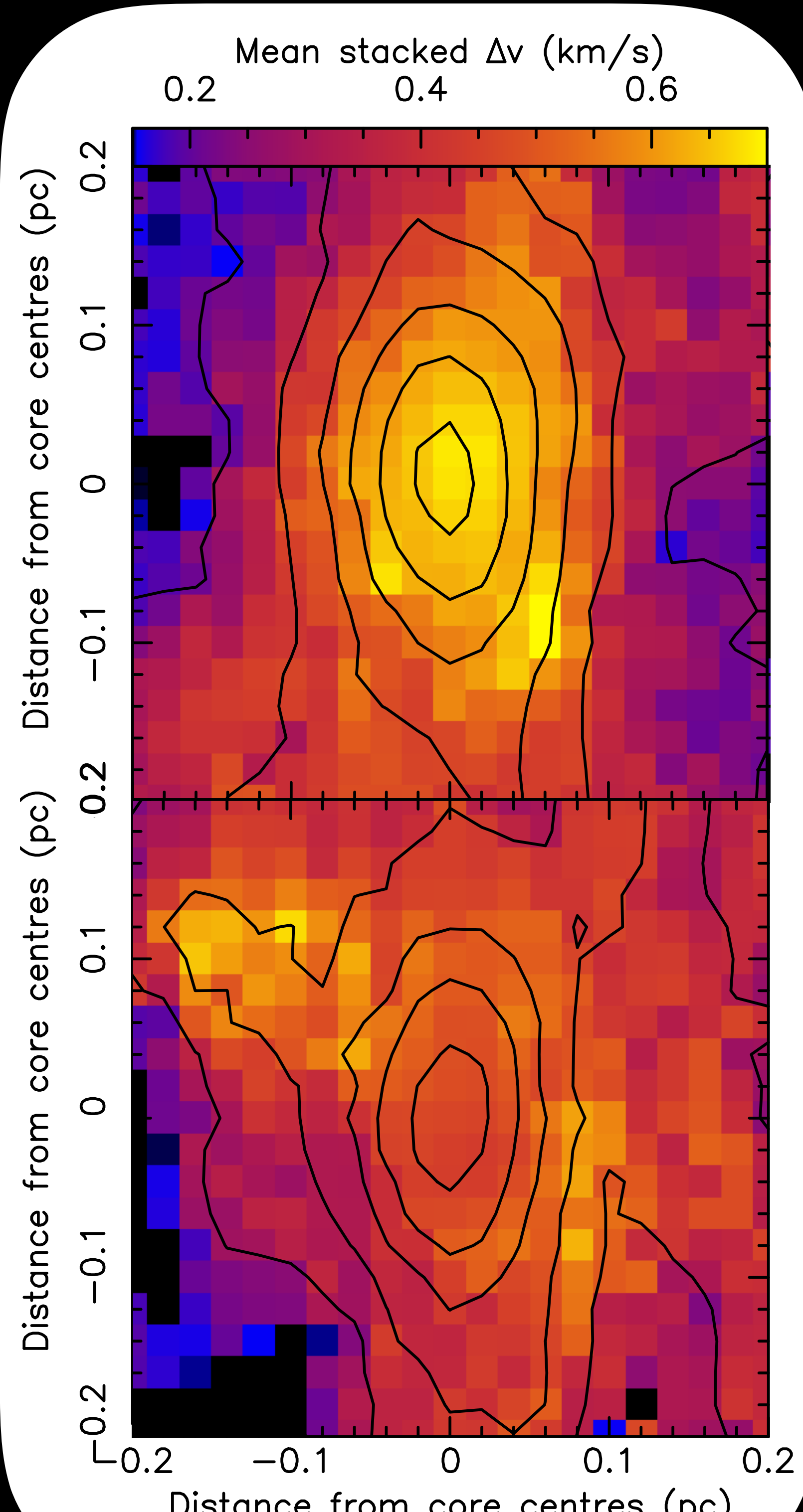




$$\sigma_{NT} = \sqrt{\frac{\Delta V_{obs}^2}{8 \ln 2} - \frac{k_b T}{m_{NH_3}}}$$

Supersonic behaviour seen to correspond well the with the positions of 68% of cores (white histograms).

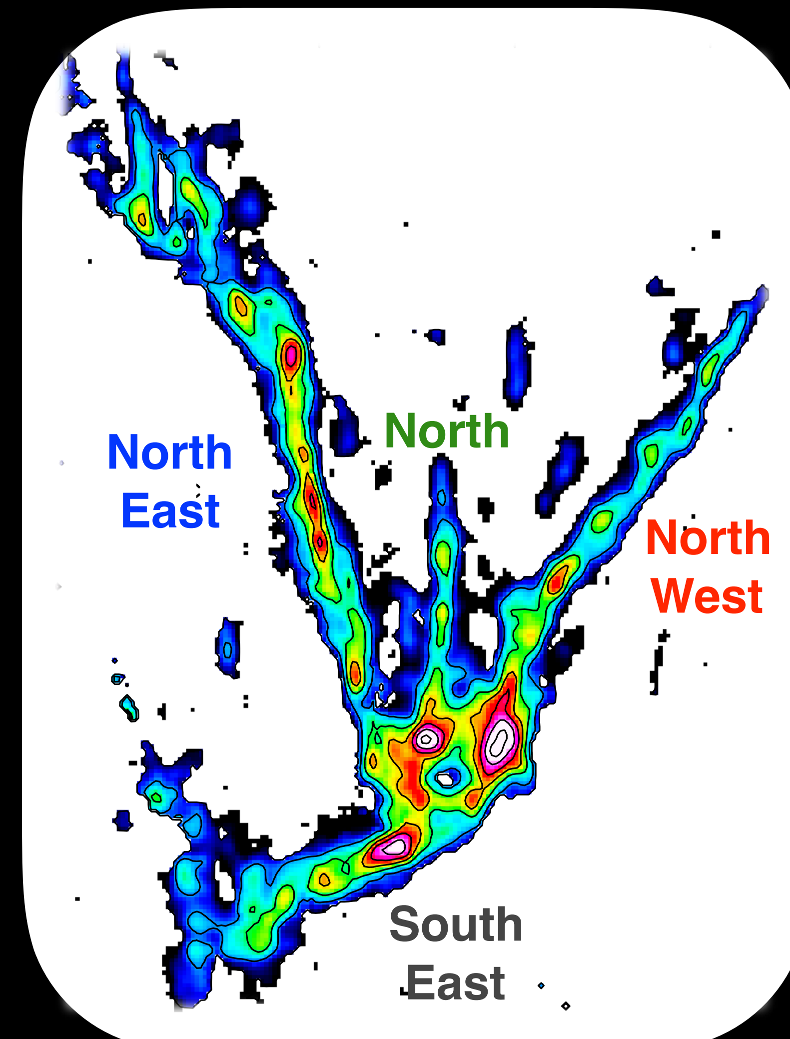
Velocity width broadening



Williams et al. 2017, subm

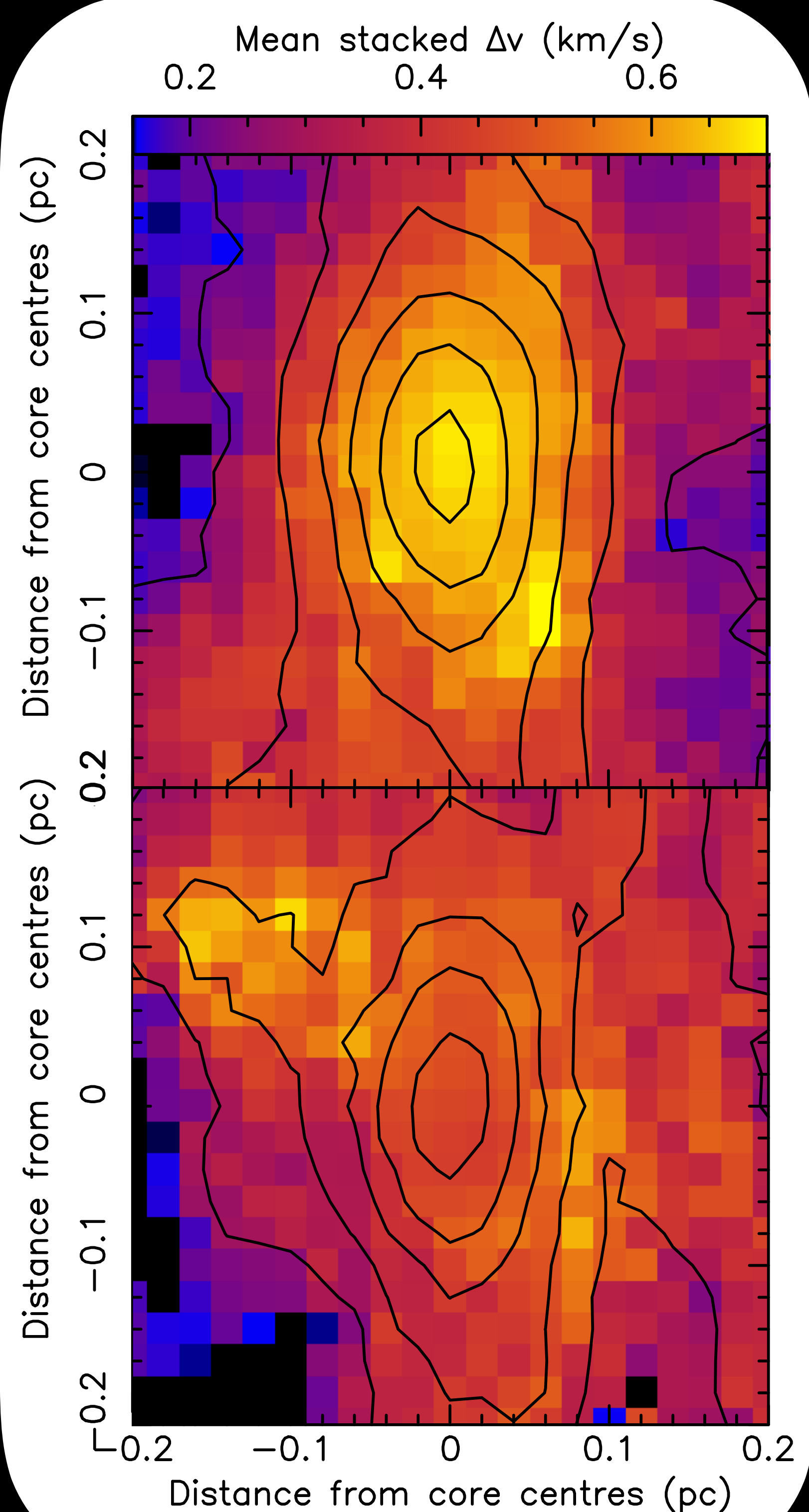
Starless cores <u>*WITH*</u> ΔV peaks

Starless cores <u>*WITHOUT*</u> ΔV peaks



On average, ΔV peaks are 1.5x broader than non-peaked cores.

Velocity width broadening

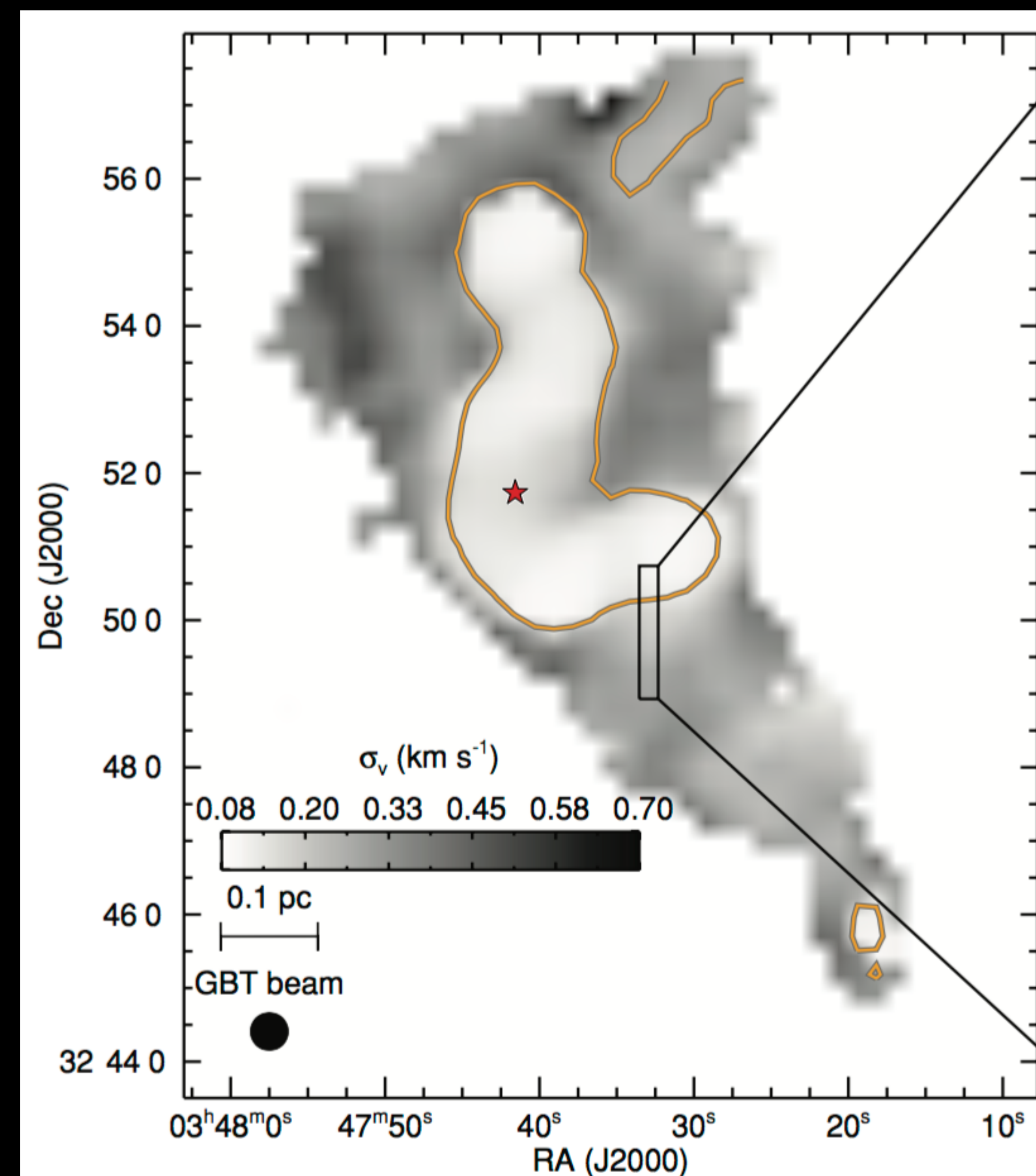


Williams et al. 2017, subm

Starless cores <ins>*WITH*</ins> ΔV peaks

Starless cores <ins>*WITHOUT*</ins> ΔV peaks

B5 region of Perseus
Pineda et al. (2010)



Troughs in ΔV interpreted as dissipation of turbulence

Velocity width broadening

- Transonic filaments expected out of turbulent ISM — supersonic shocks create stagnation regions where turbulent energy is dissipated

- SDC13, with mostly transonic filaments, seems to represent such a post-shock region

- Supersonic nature of SDC13 cores then purely generated by gravity, representing accumulation of material, converting GPE into KE in the process

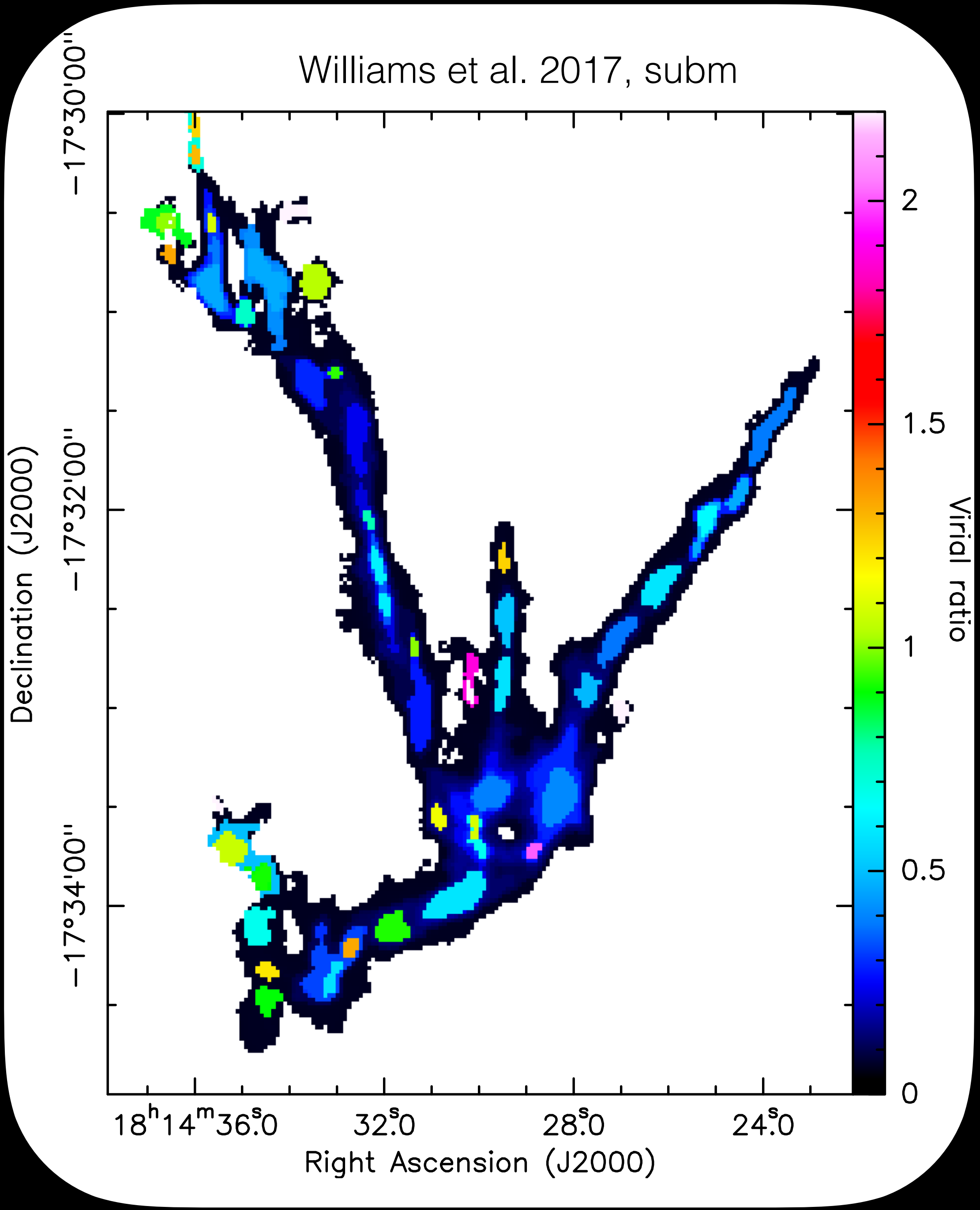
Velocity width broadening

- Truly starless cores are central to core accretion models of massive star formation
- Other sources of ΔV peaks in the "starless cores":
  - Deeply embedded protostars
  - Already sub-fragmented into core systems
- My accepted ALMA Cycle 5 proposal will settle the issue

Evolution of the virial ratio

$$\alpha_{vir} = \frac{5a_{eff}^2 R}{GM}$$

Virial ratio evolves from very sub-virial in the larger filament, towards less sub-virial/virial at the cores.



A conclusion also reached by Peretto et al. (2017) in prep

Evolution of the virial ratio

$$\alpha_{vir} = \frac{5a_{eff}^2 R}{\mathrm{G}M}$$

can be analytically described by,

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

where ε is the energy conversion efficiency.

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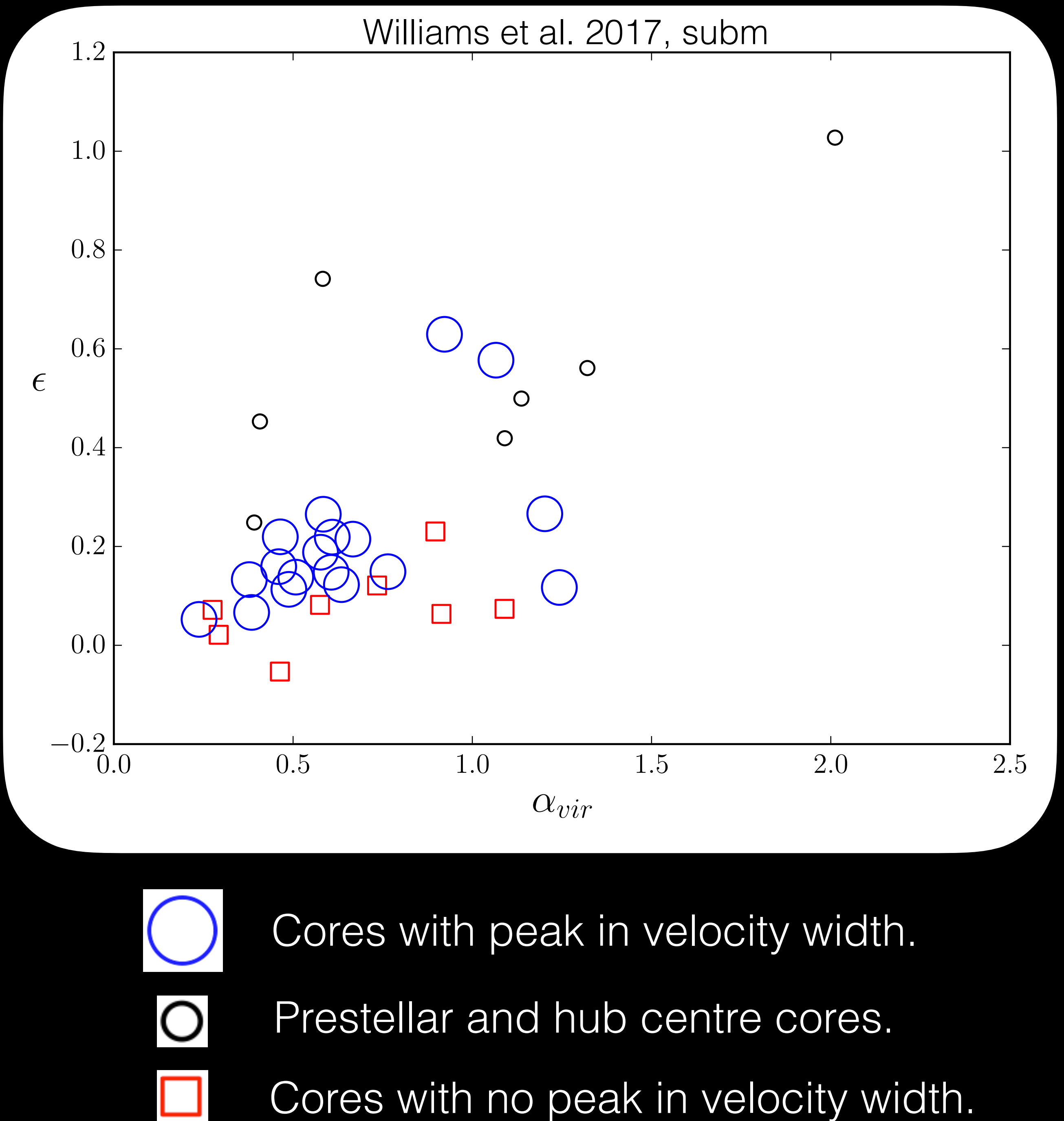
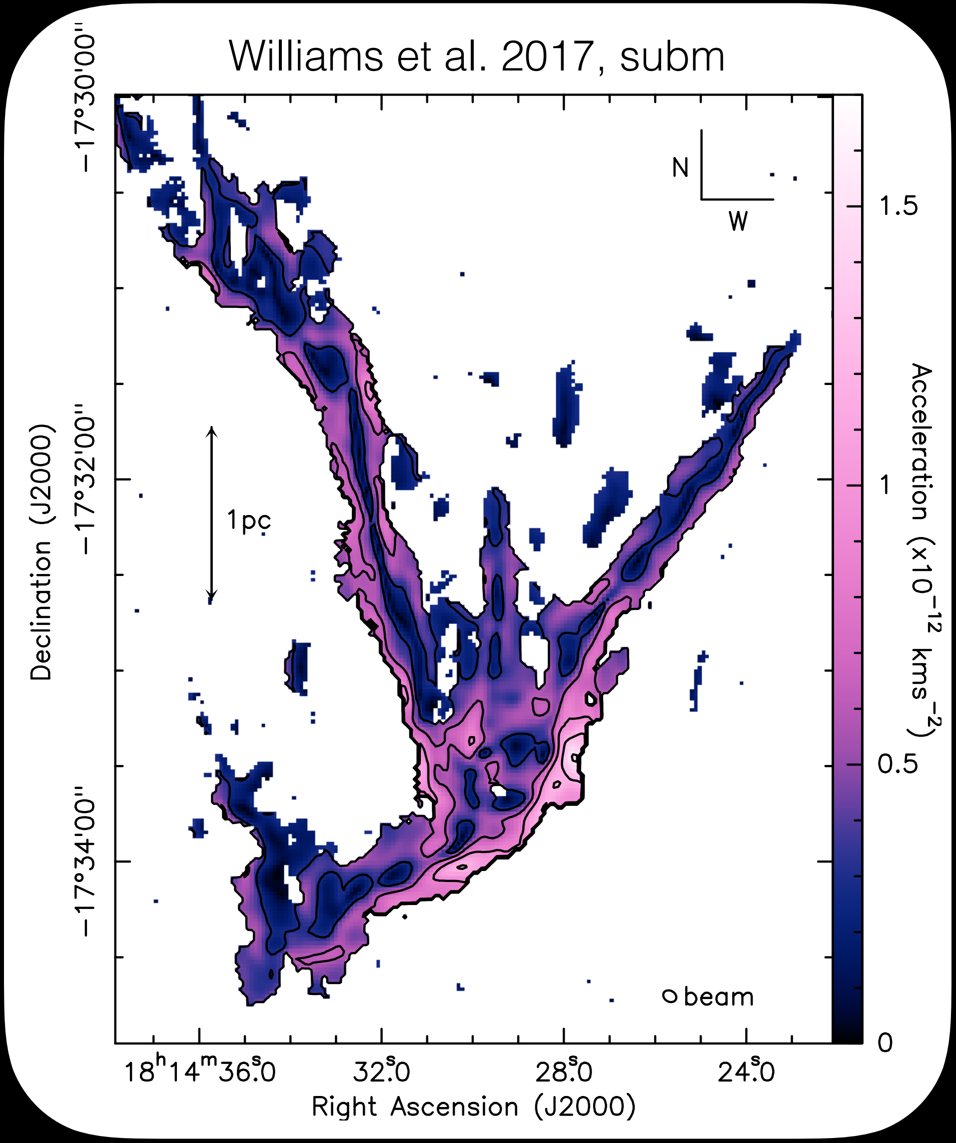
Average ε ~ 20%



Gravitational acceleration

$$|\boldsymbol{a}_j| = \left| \sum_{i \neq j} \frac{Gm_i}{r_{i,j}^3} \boldsymbol{r}_{i,j} \right|$$

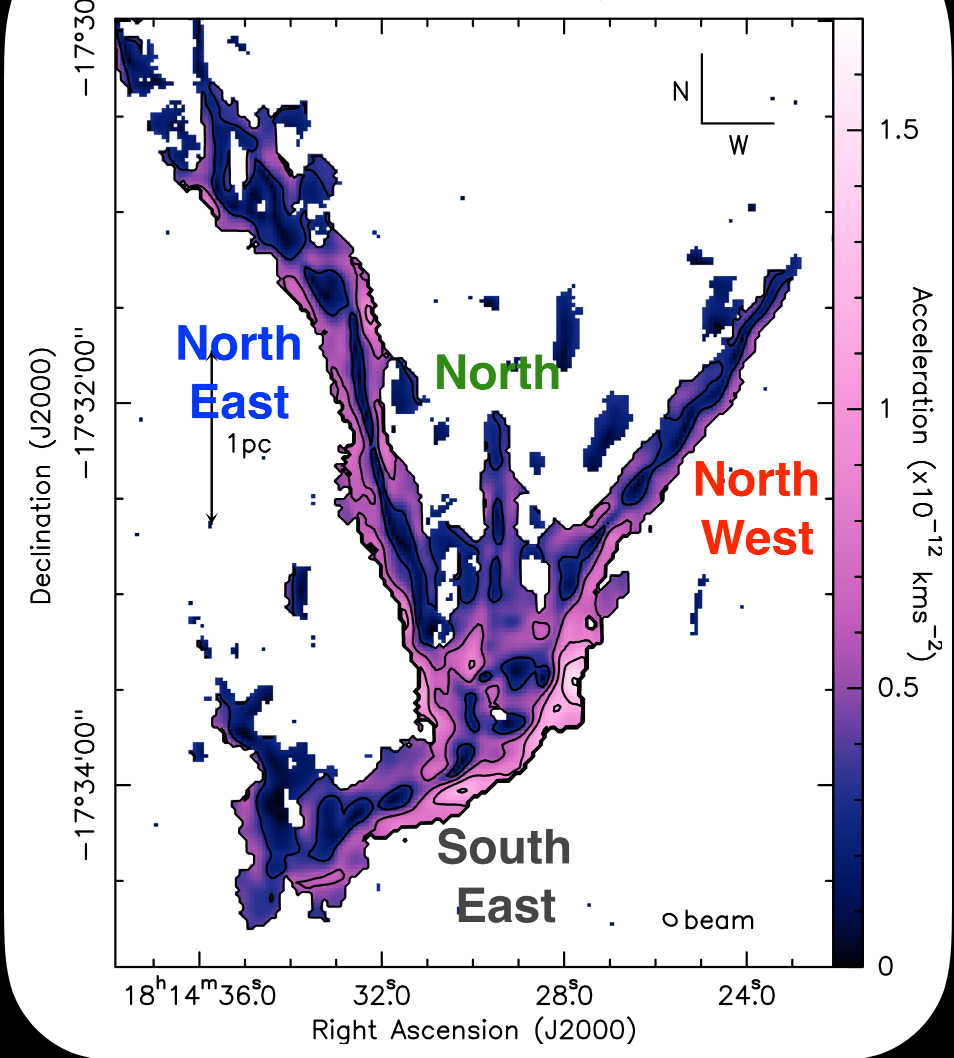


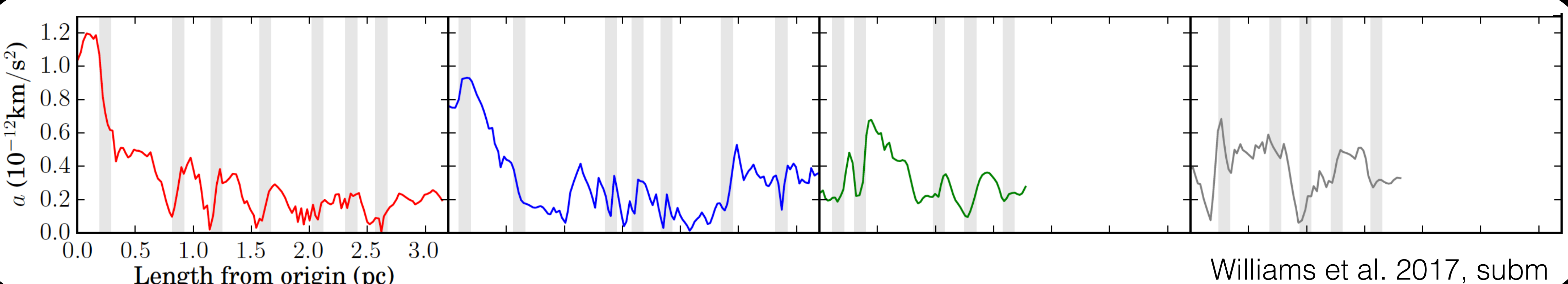
Gravitational acceleration

$$|\boldsymbol{a}_j| = \left| \sum_{i \neq j} \frac{G m_i}{r_{i,j}^3} \boldsymbol{r}_{i,j} \right|$$

- Acceleration increases towards hub centre
- Largest acceleration gradients at the centre of the hub

Williams et al. 2017, subm





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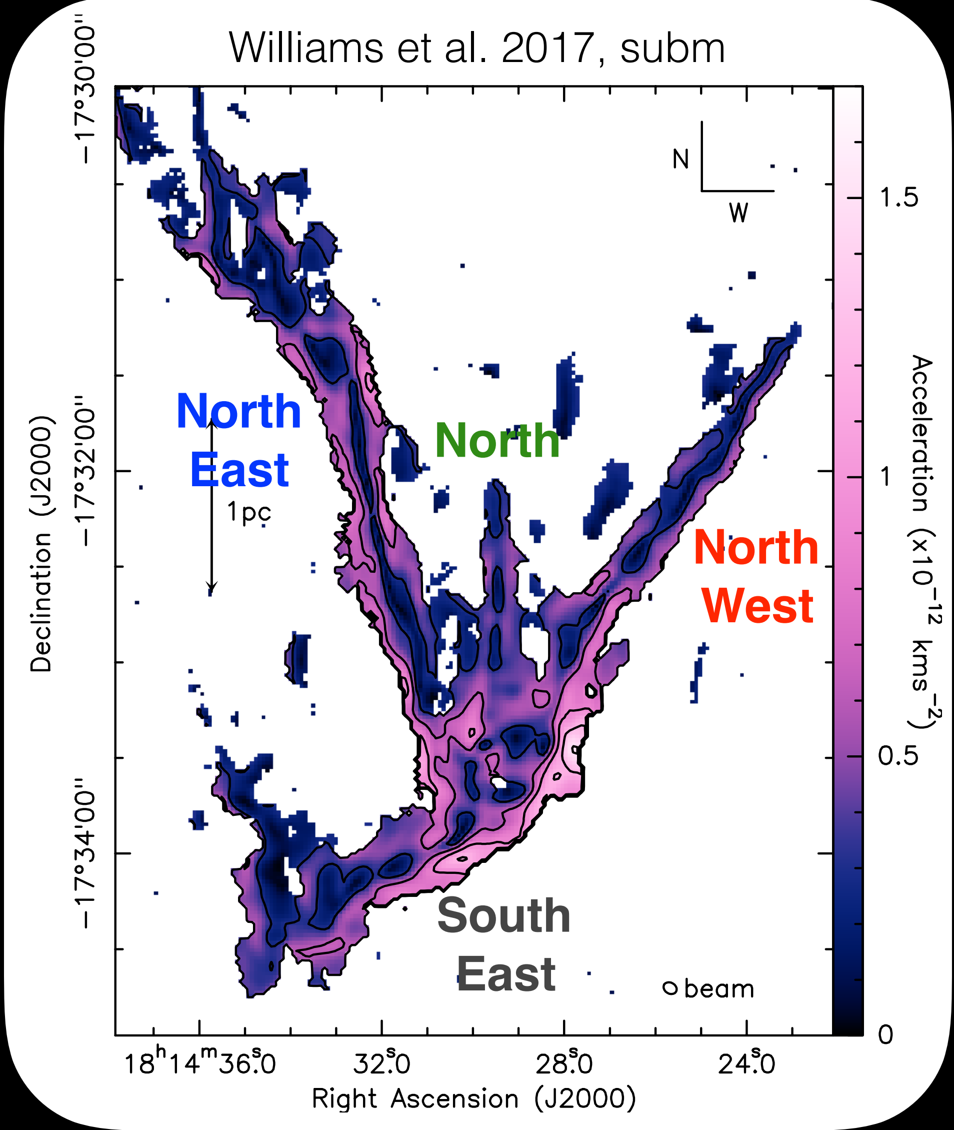
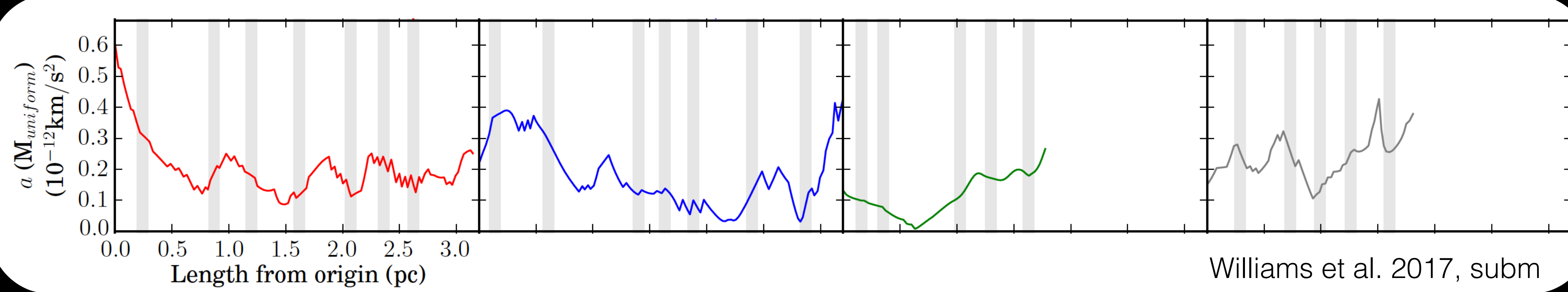
Gravitational acceleration

$$|\boldsymbol{a}_j| = \left| \sum_{i \neq j} \frac{G m_i}{r_{i,j}^3} \boldsymbol{r}_{i,j} \right|$$

- Large scale oscillations in acceleration prevail with the removal of density fluctuations
- Hub morphology is the main driver of the SDC13 kinematics





Williams et al. 2017, subm

Conclusions

- Velocity width of NH_3 increases towards 68% of starless cores in SDC13
  - represents the conversion of GPE into KE during accretion
- Acceleration gradients largest at hub centre, coinciding with the largest starless core
  - Hub morphology is the main driver of SDC13 kinematics

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