# Magnetized Molecular Cloud Formation and Dynamics

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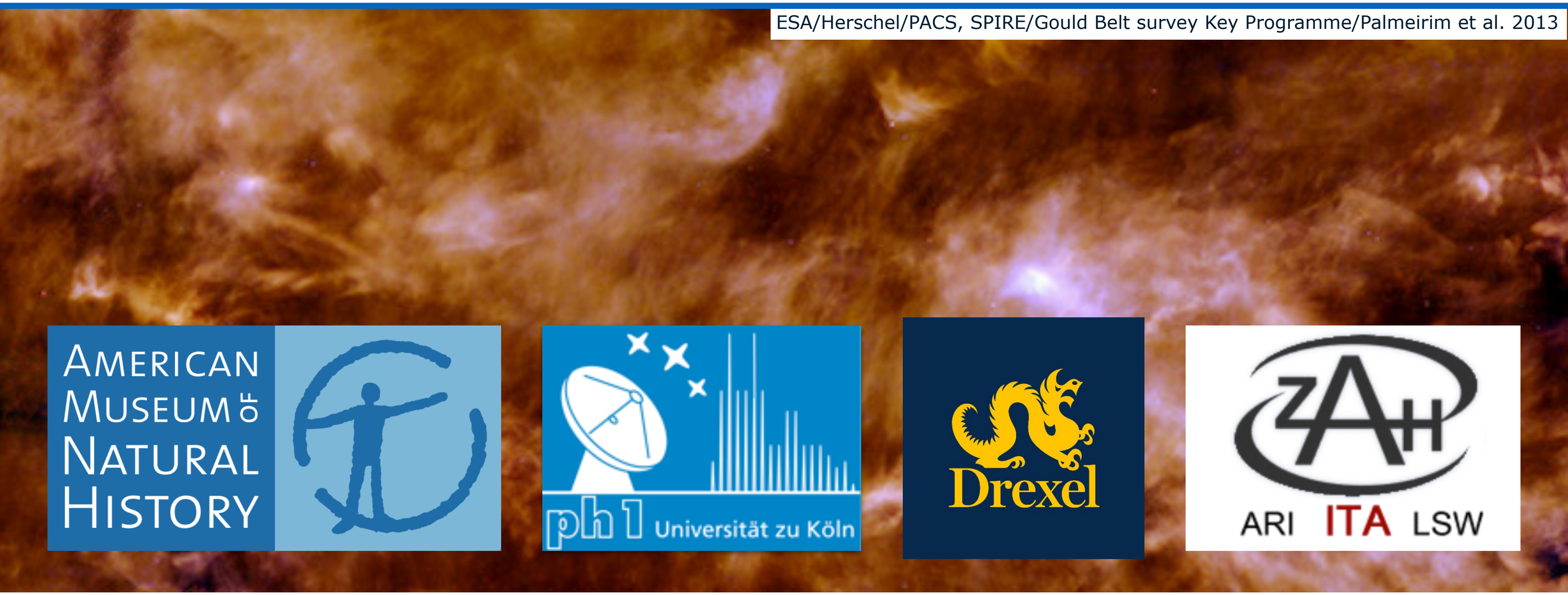
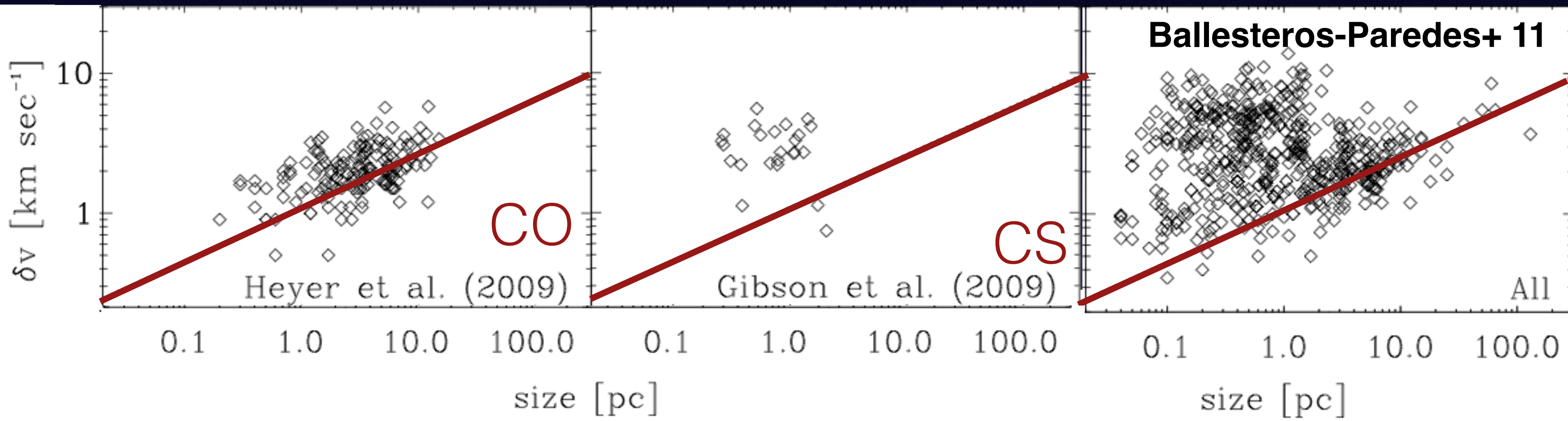
Joshua E. Wall    Stephen McMillan    Ralf S. Klessen




ESA/Herschel/PACS, SPIRE/Gould Belt survey Key Programme/Palmeirim et al. 2013

Larson's size-velocity relation
has been argued to result from turbulent driving.




But, it only applies
to a narrow range of column densities.

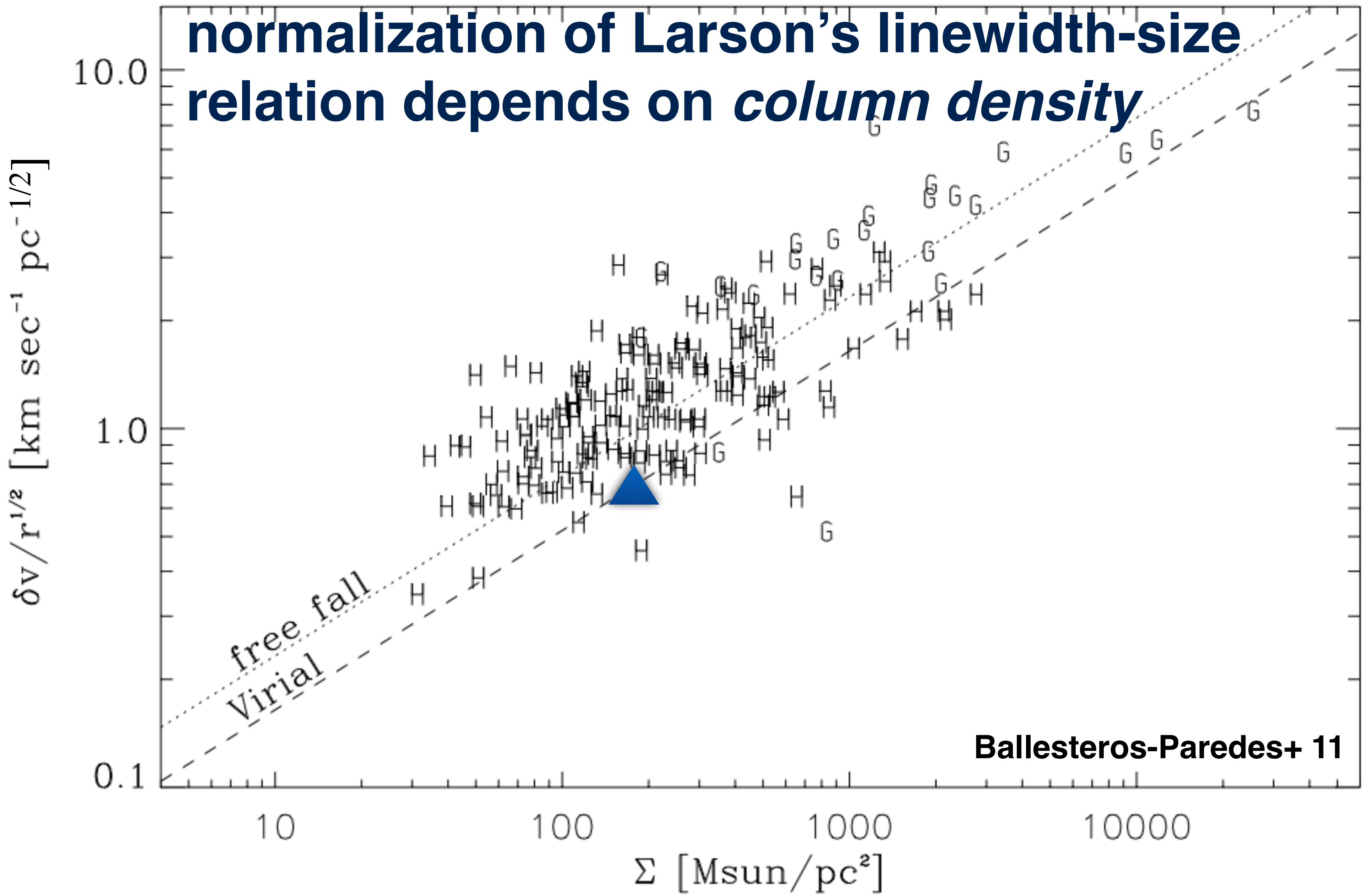
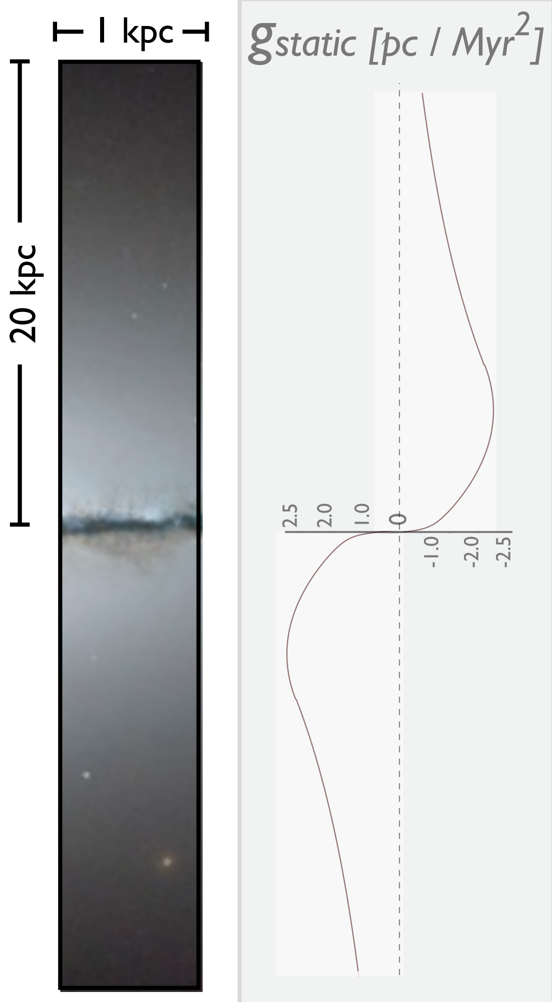
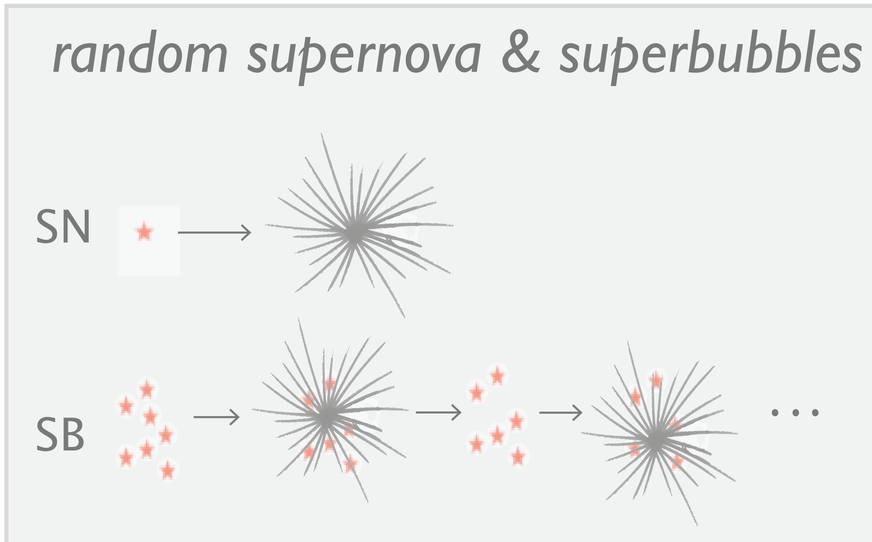


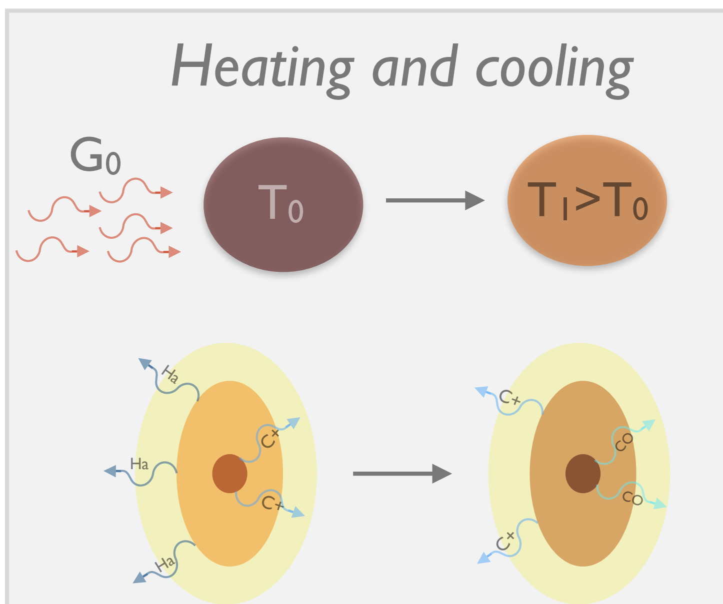

**Figure 2.** Heyer's relation ($\delta v/r^{1/2}$ versus surface density $\Sigma$) for the clouds reported in Heyer et al. (2009) and Gibson et al. (2009). Note that the massive

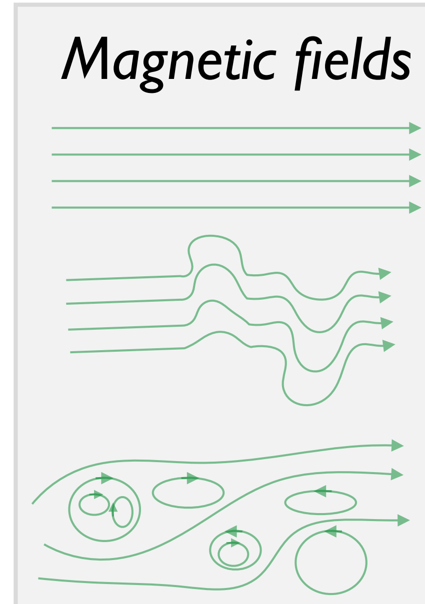
# Modeling the turbulent ISM with Flash

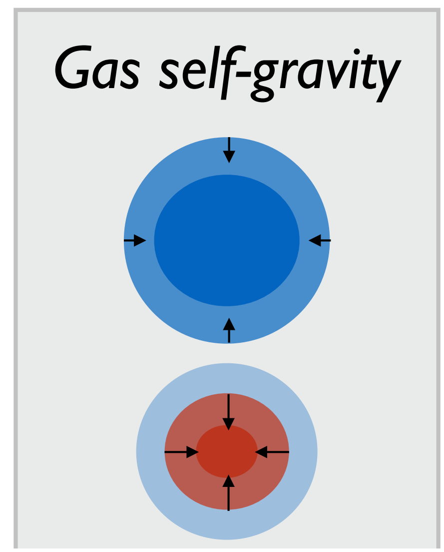



Ibáñez-Mejía + 16



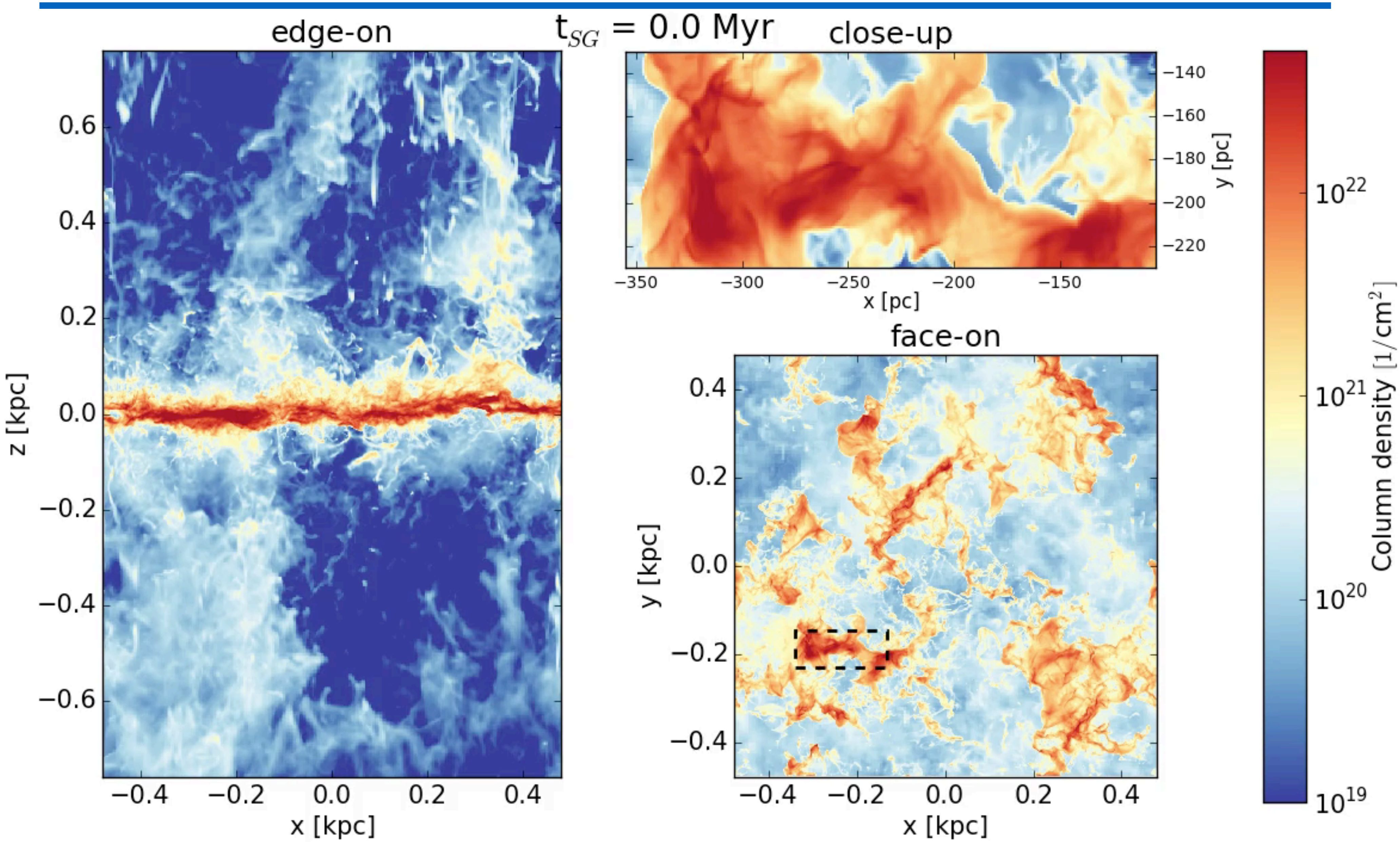



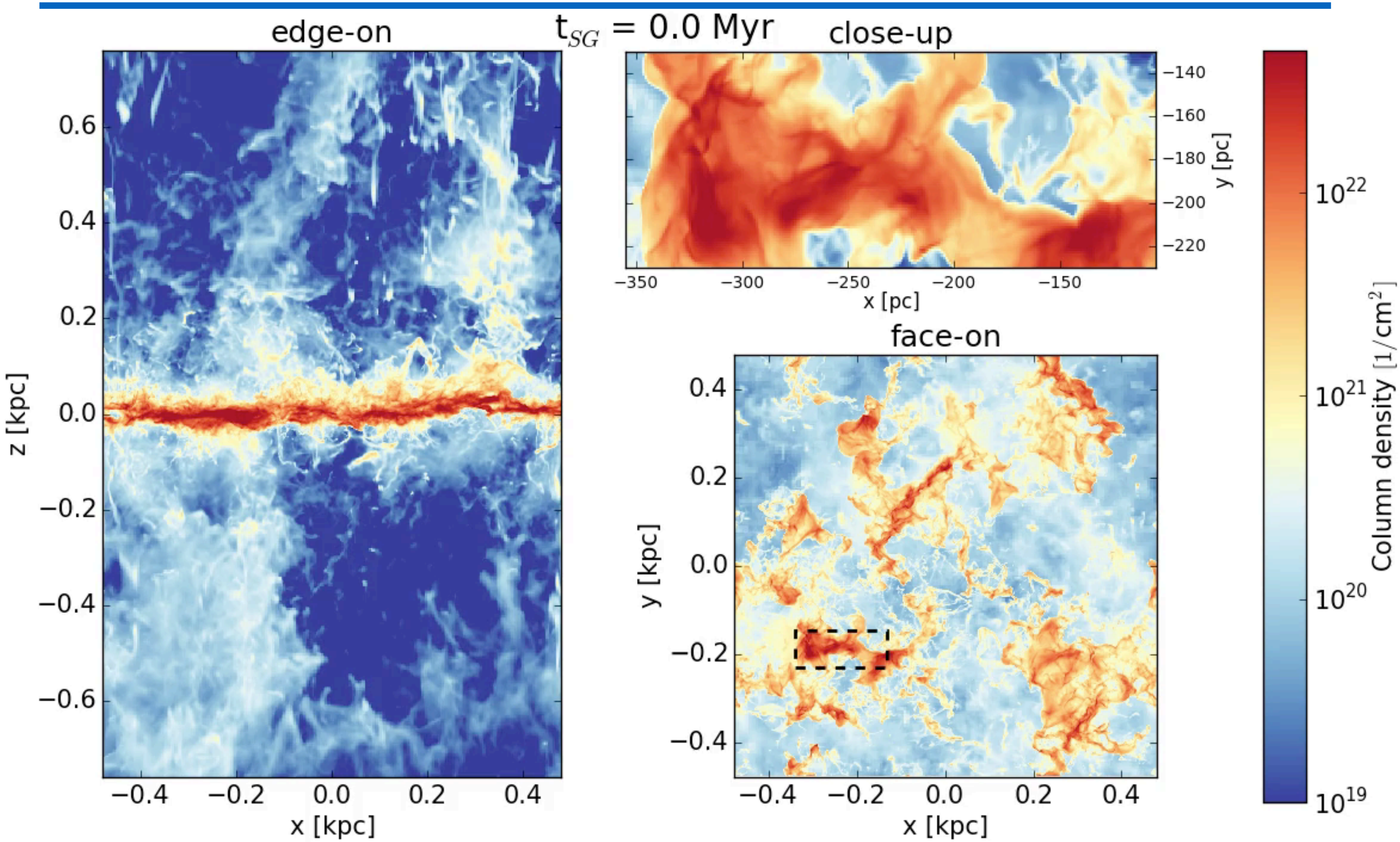

Included at late times

# Modeling the turbulent ISM with Flash

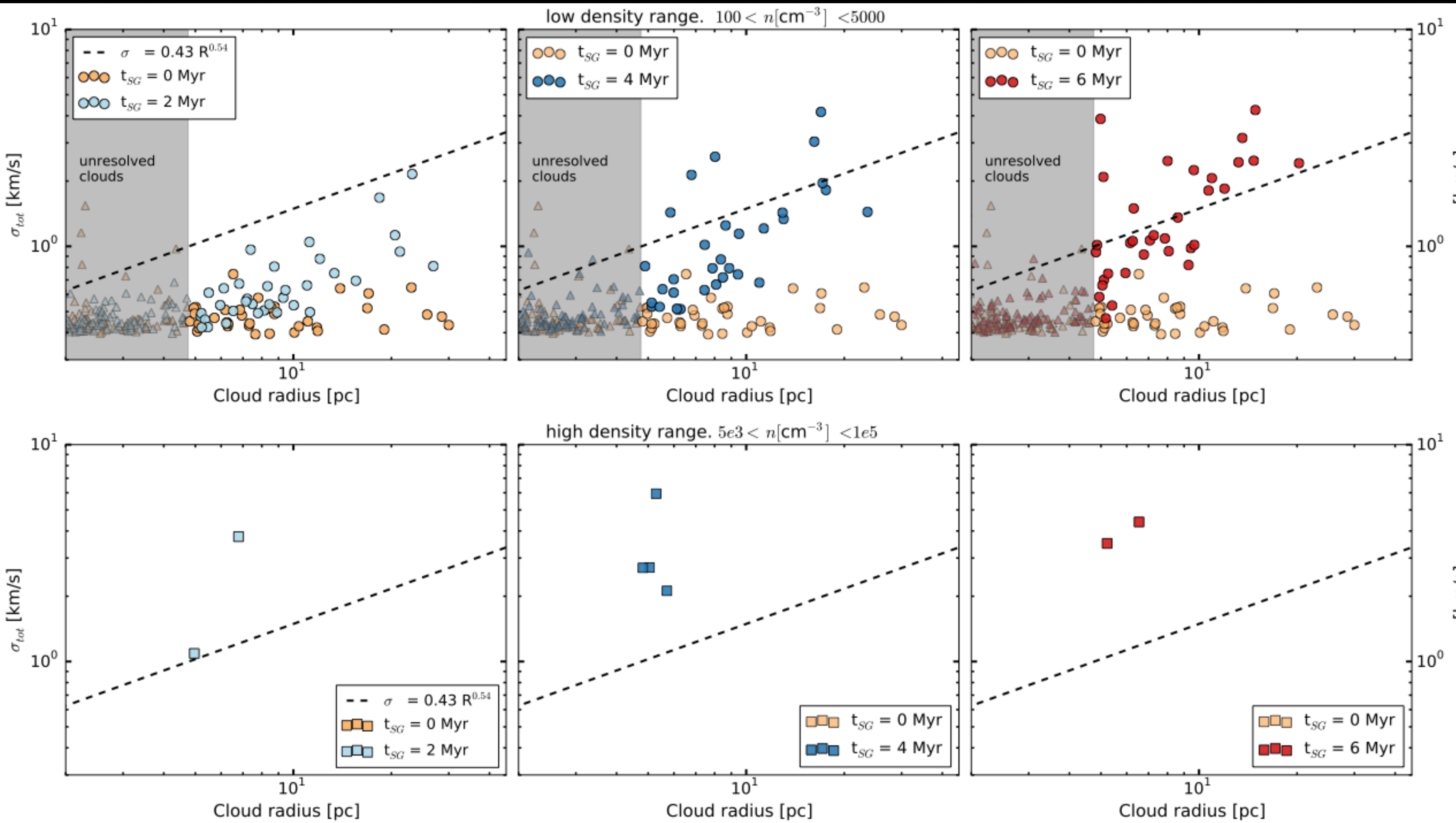



Ibáñez-Mejía et al. 2016

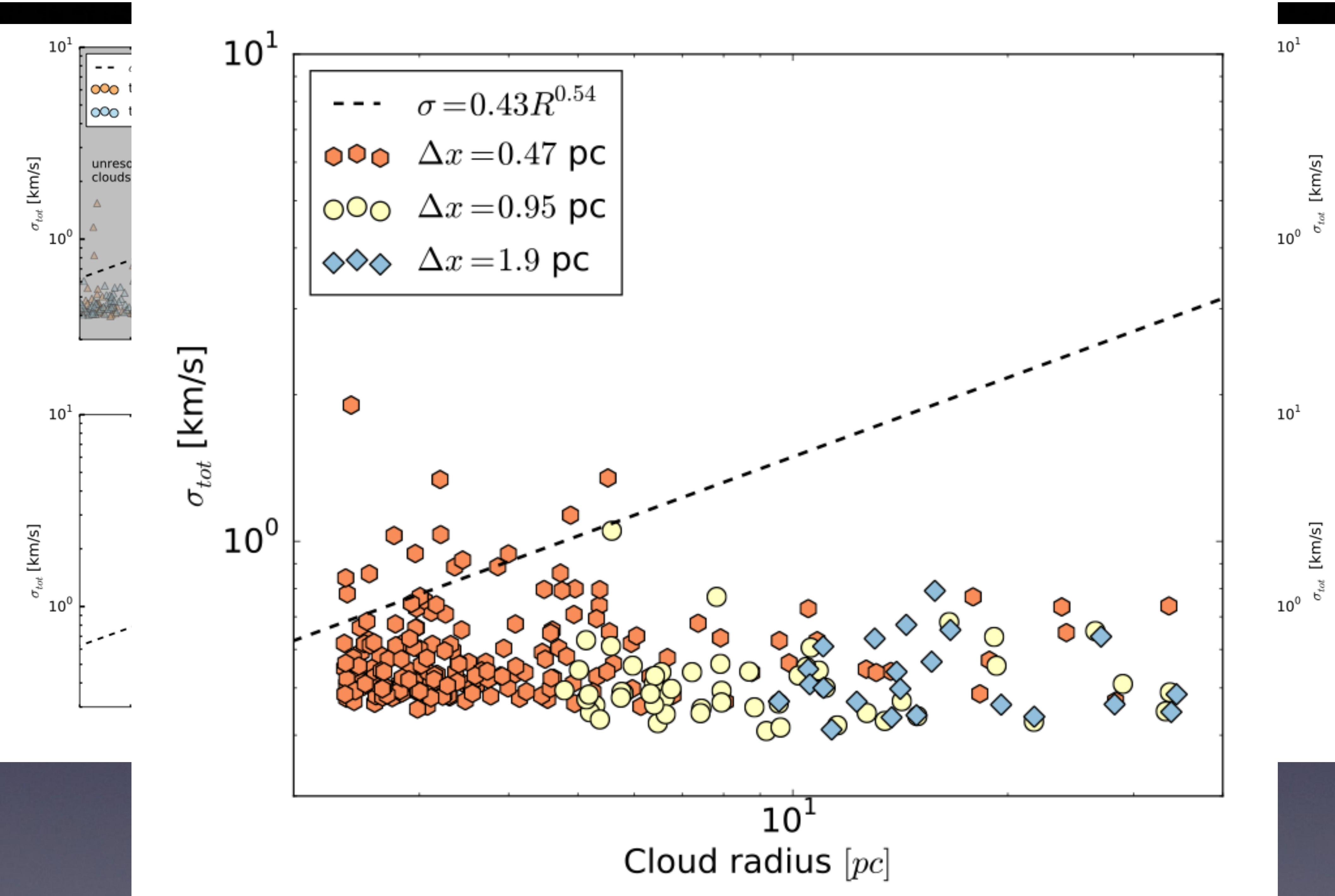
# Modeling the turbulent ISM with Flash




Ibáñez-Mejía et al. 2016

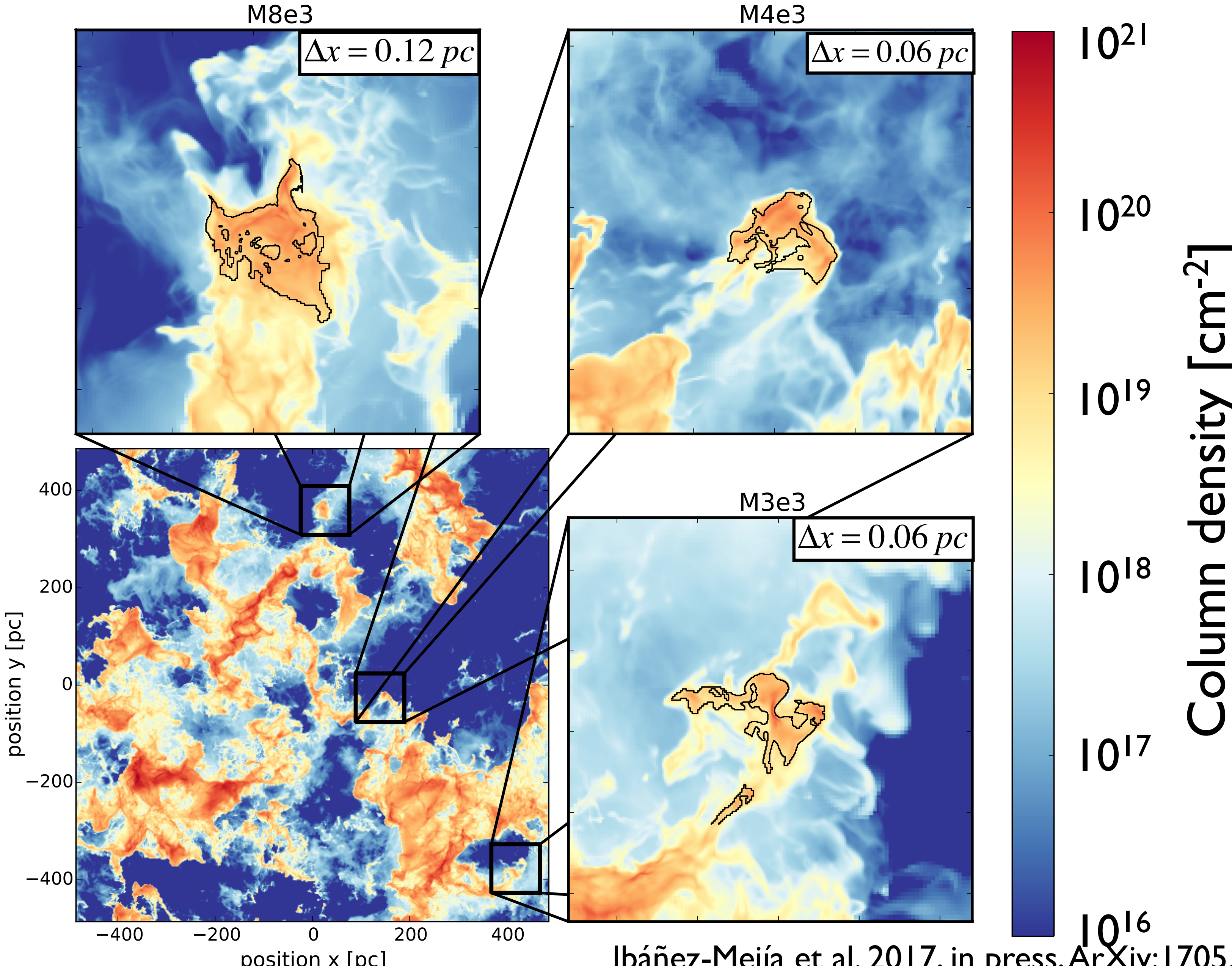



Ibáñez-Mejía + 16



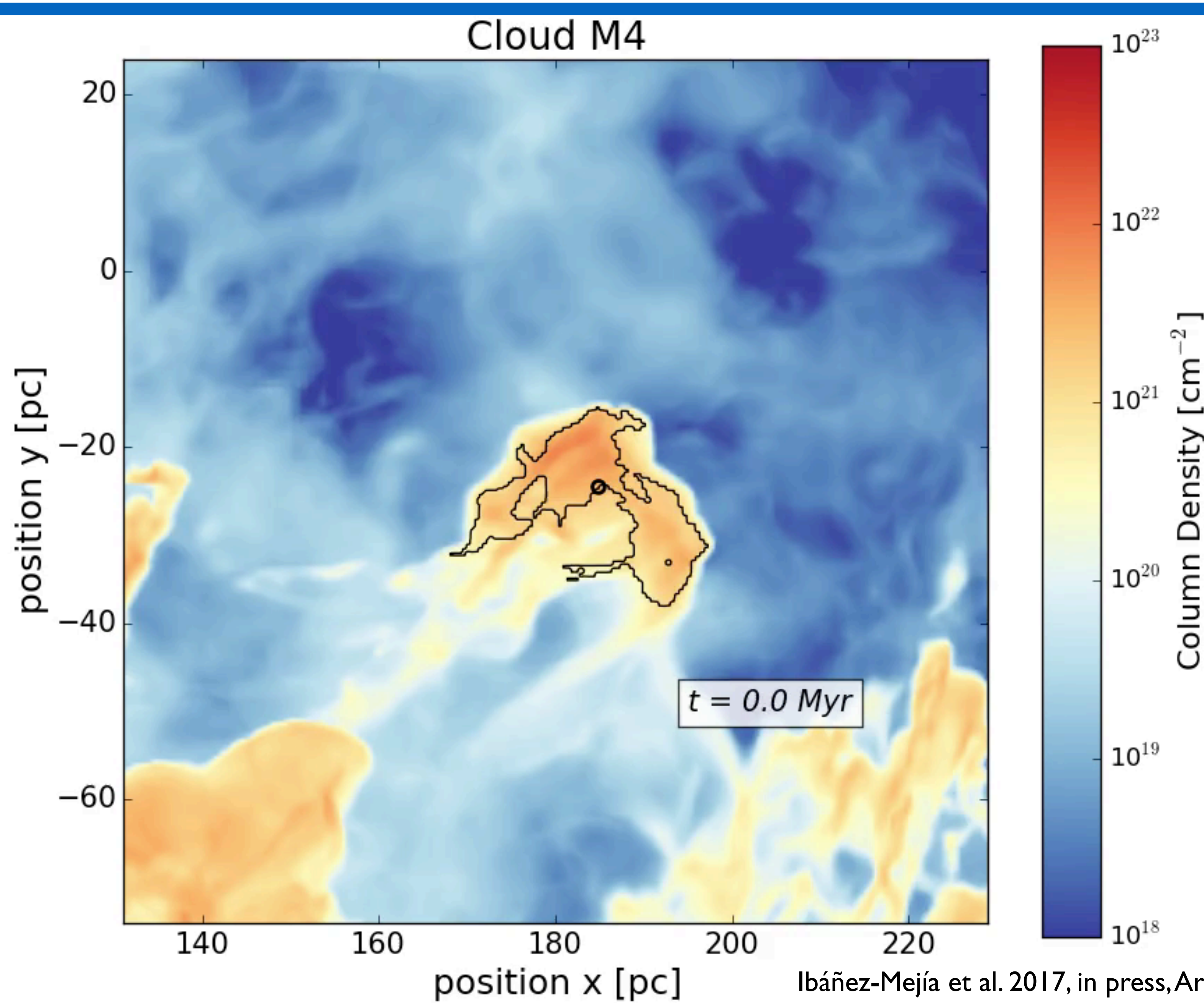

Ibáñez-Mejía + 16

# Zooming-in to collapsing clouds




Ibáñez-Mejía et al. 2017, in press, ArXiv:1705.01779

# Evolution and collapse of a dense cloud

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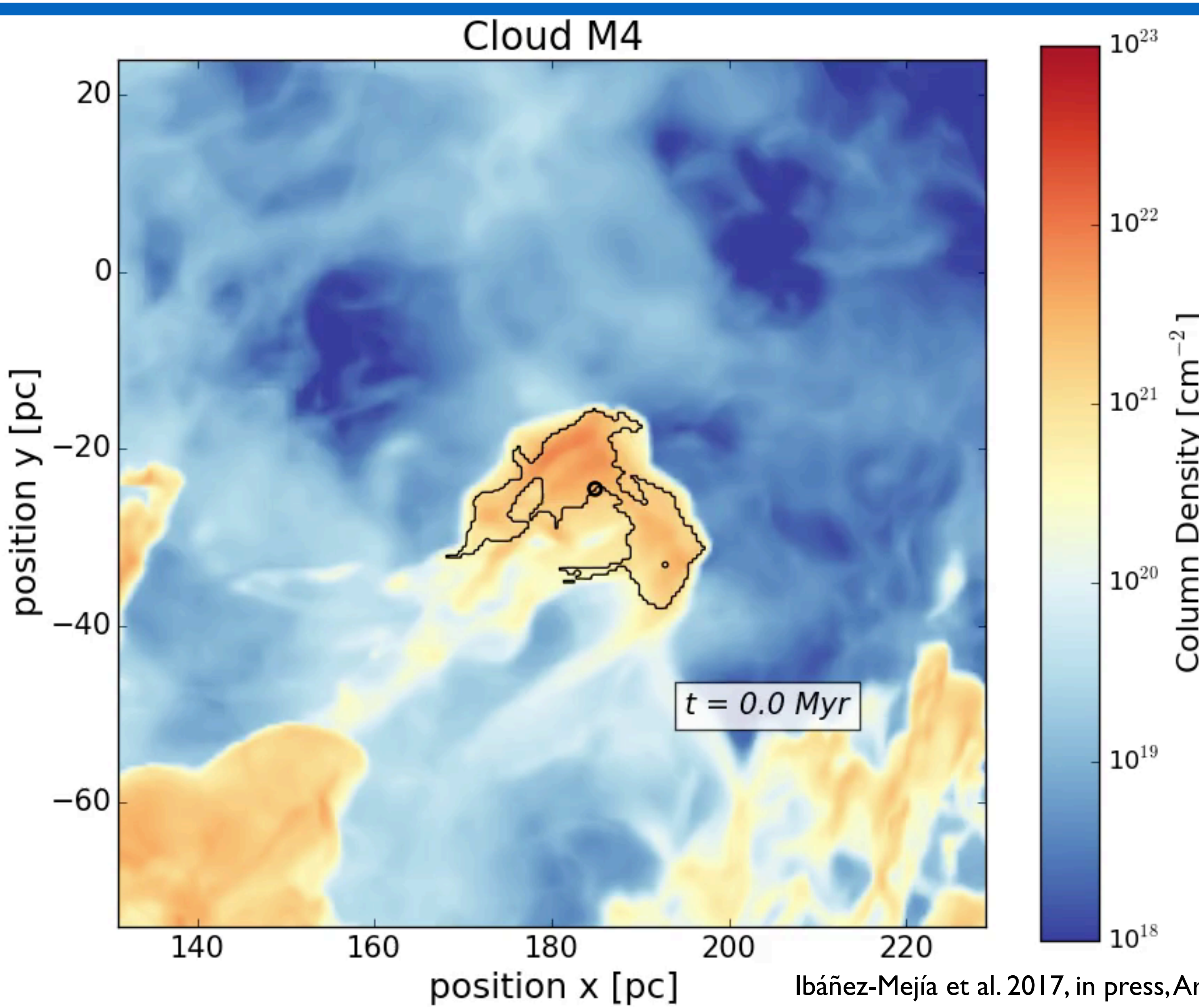
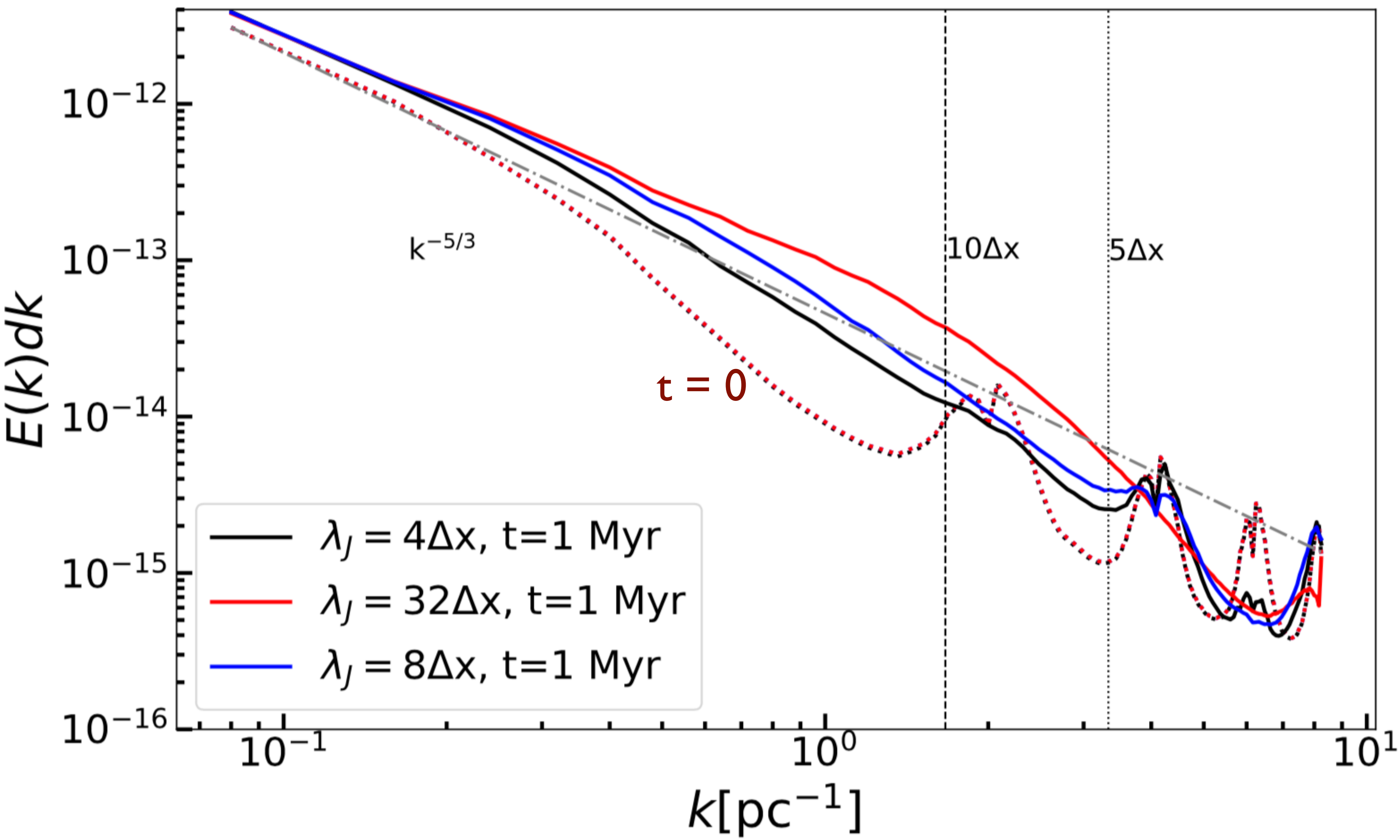
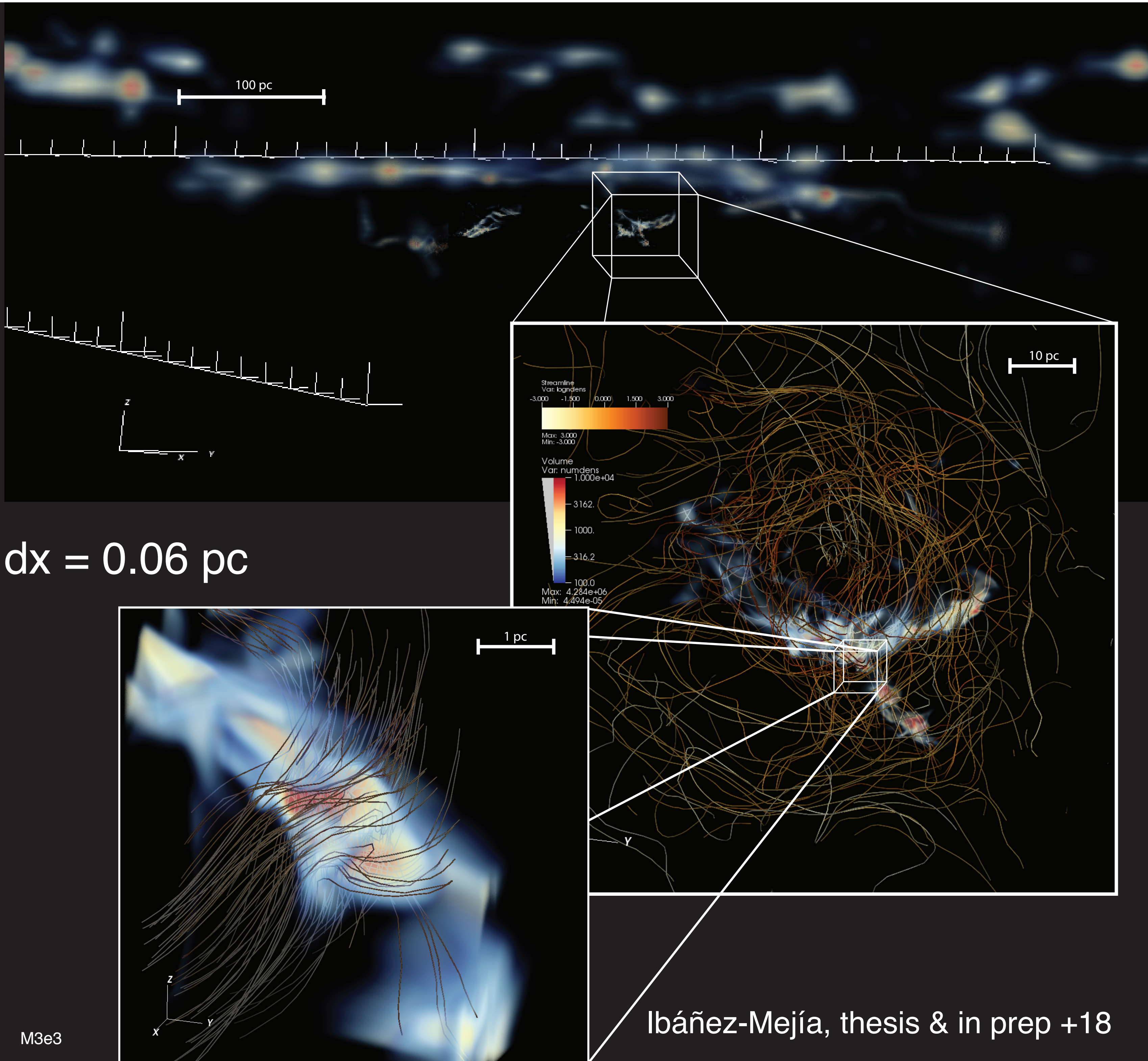



Ibáñez-Mejía et al. 2017, in press, ArXiv:1705.01779

# Resolution study of energy: acceptable 25% variation




Ibáñez-Mejía et al. 2017, in press, ArXiv:1705.01779

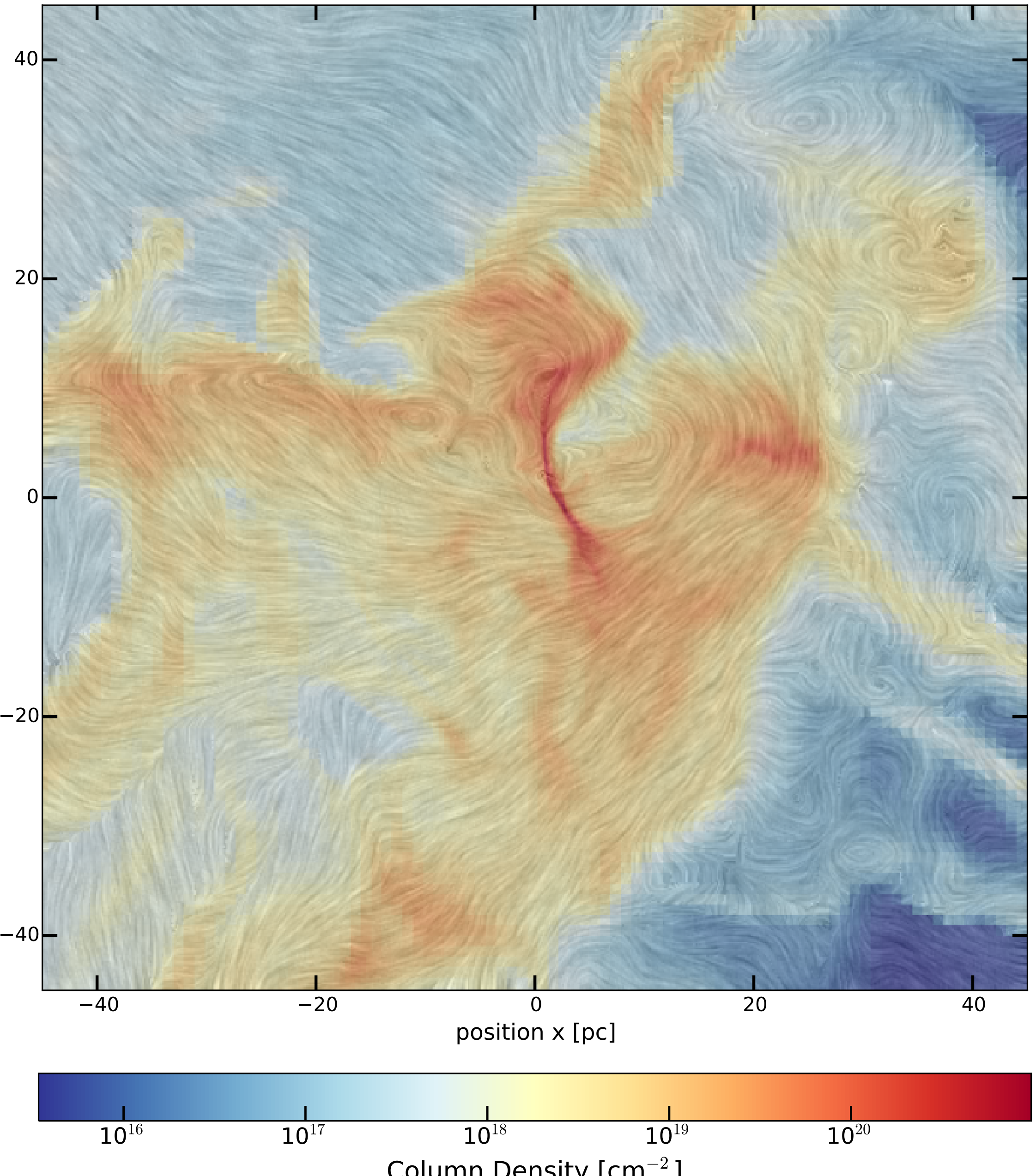


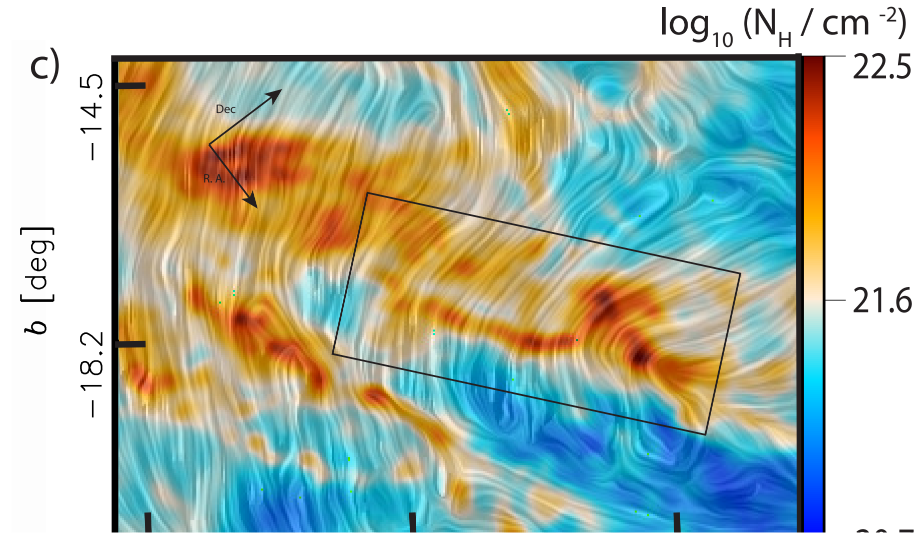

dx = 0.06 pc

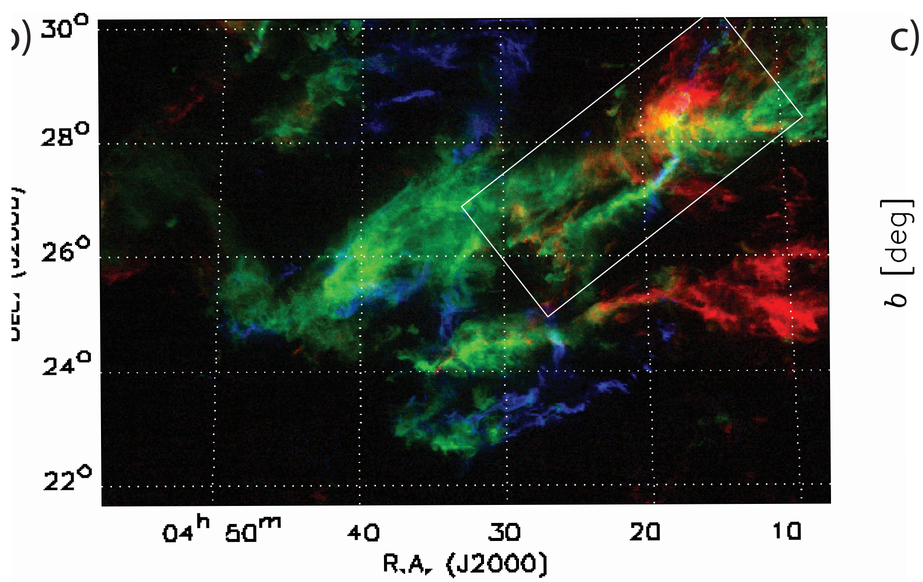
M3e3

Ibáñez-Mejía, thesis & in prep +18

# Field angle varies

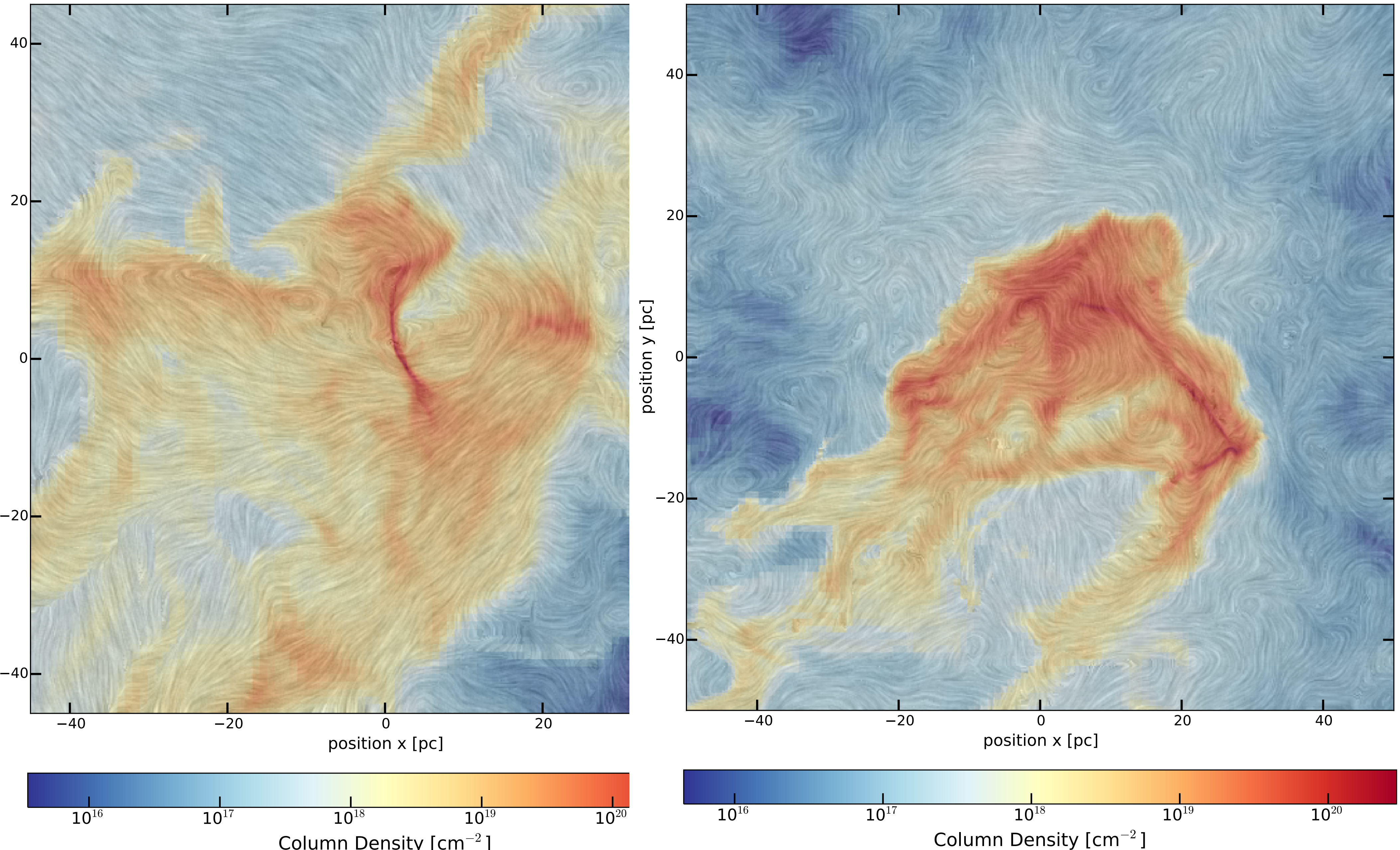


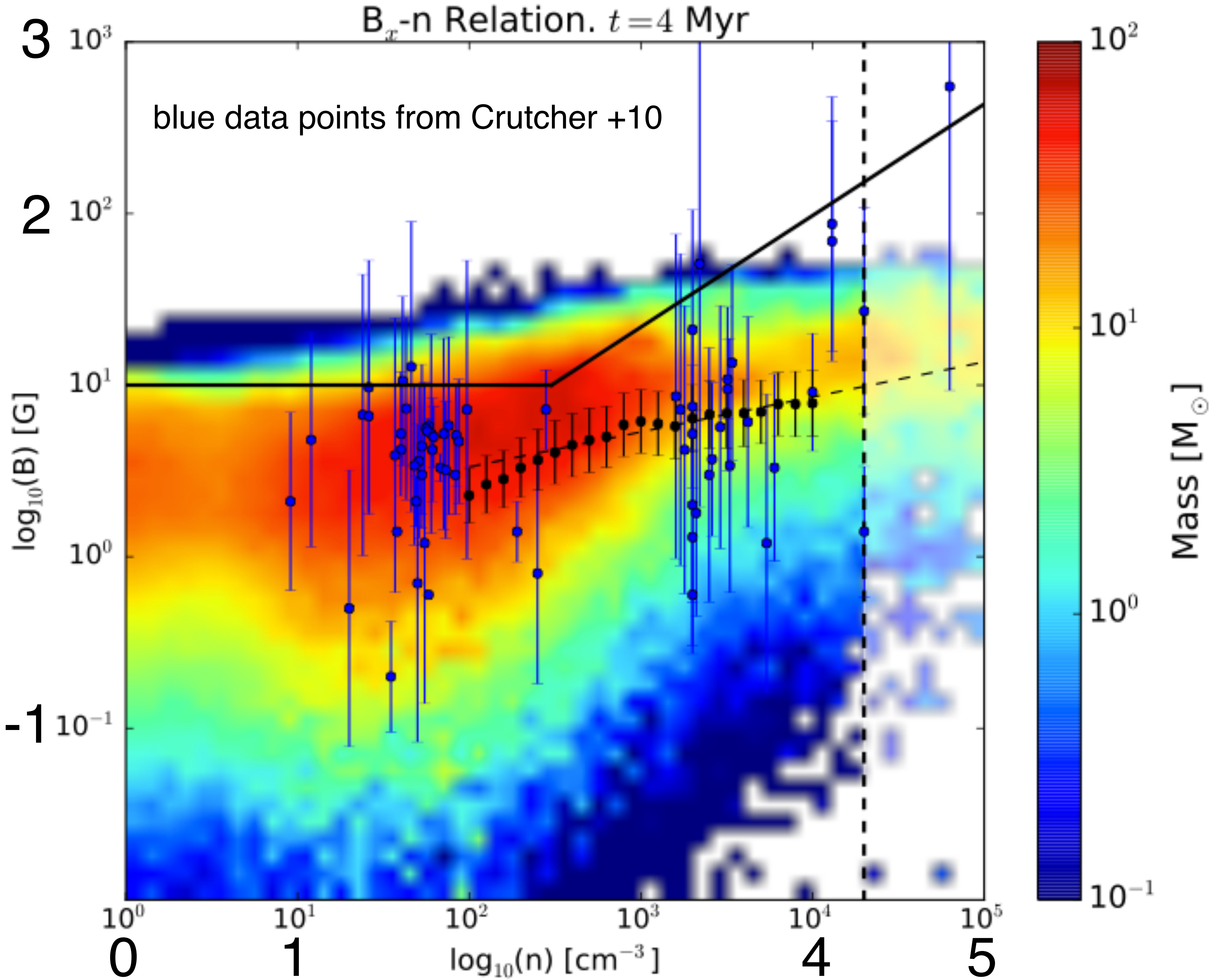




Ibáñez-Mejía et al. 2018, in prep; Palmeirim et al. 2013, Narayanan et al., 2008, Ade et al. 2016. Planck XXXIII 2016

# Field angle varies

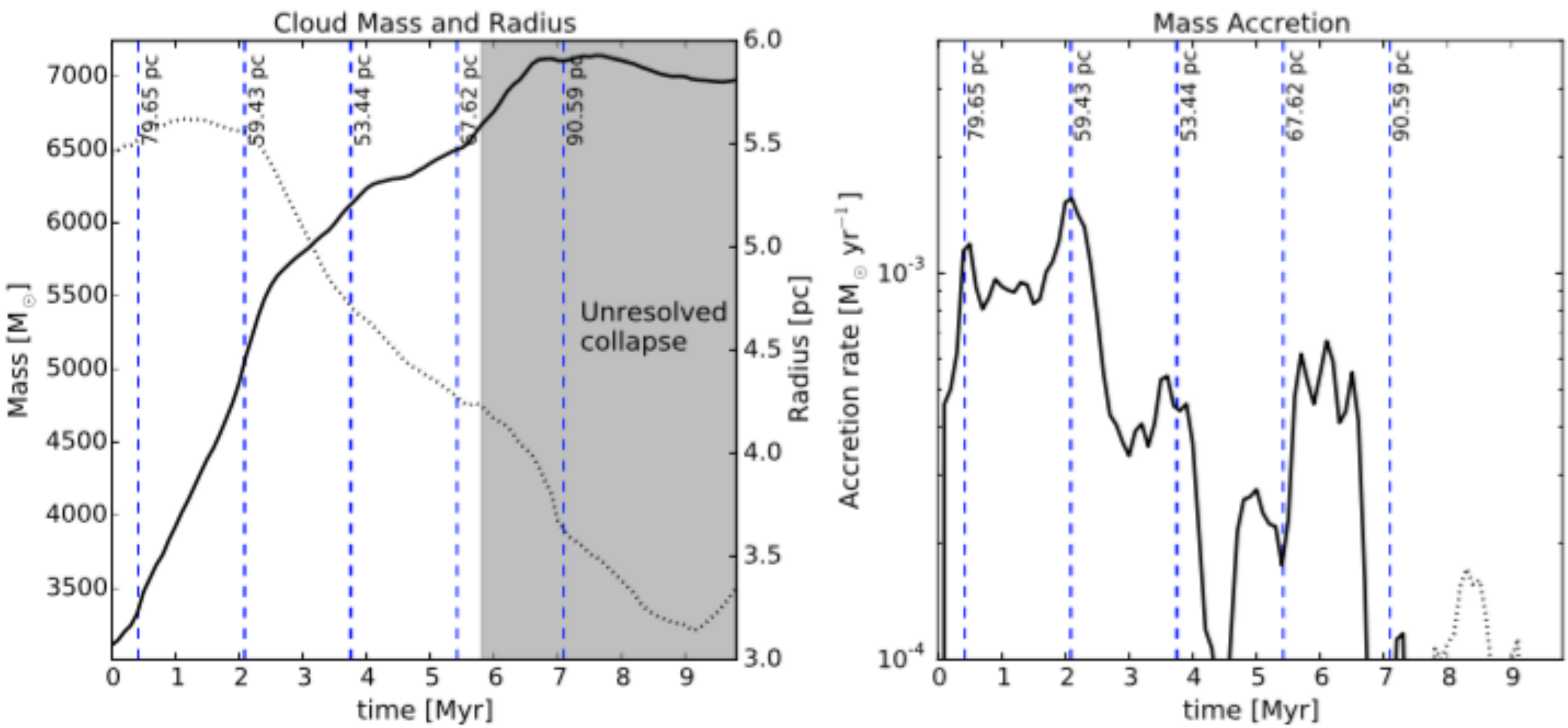



Ibáñez-Mejía et al. 2018, in prep;



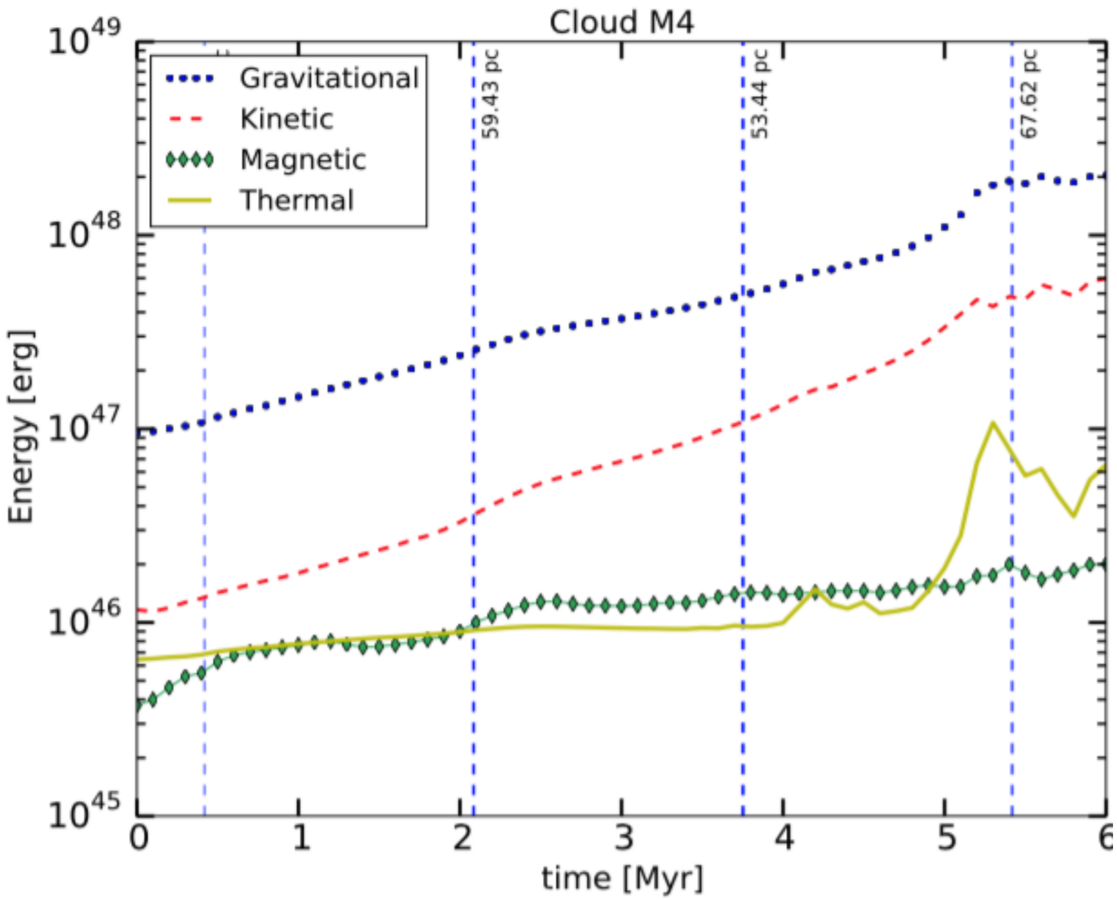
Ibáñez-Mejía, thesis, in prep +18

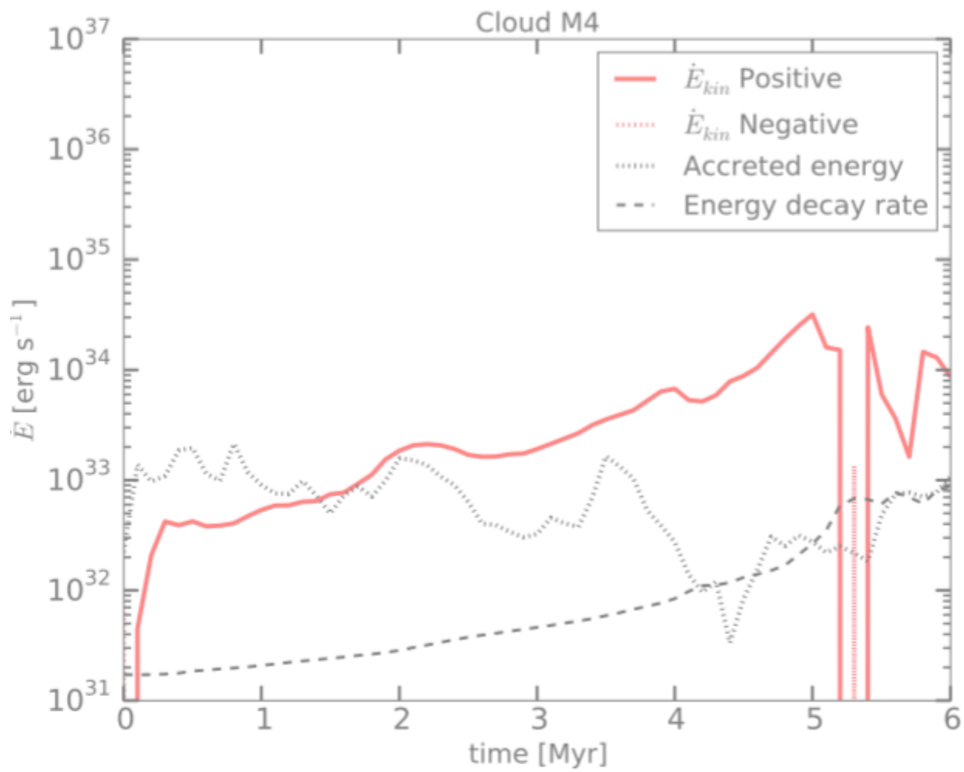
# Dense clouds collapse quickly while accreting.




Ibáñez-Mejía et al. 2017, in press, ArXiv:1705.01779

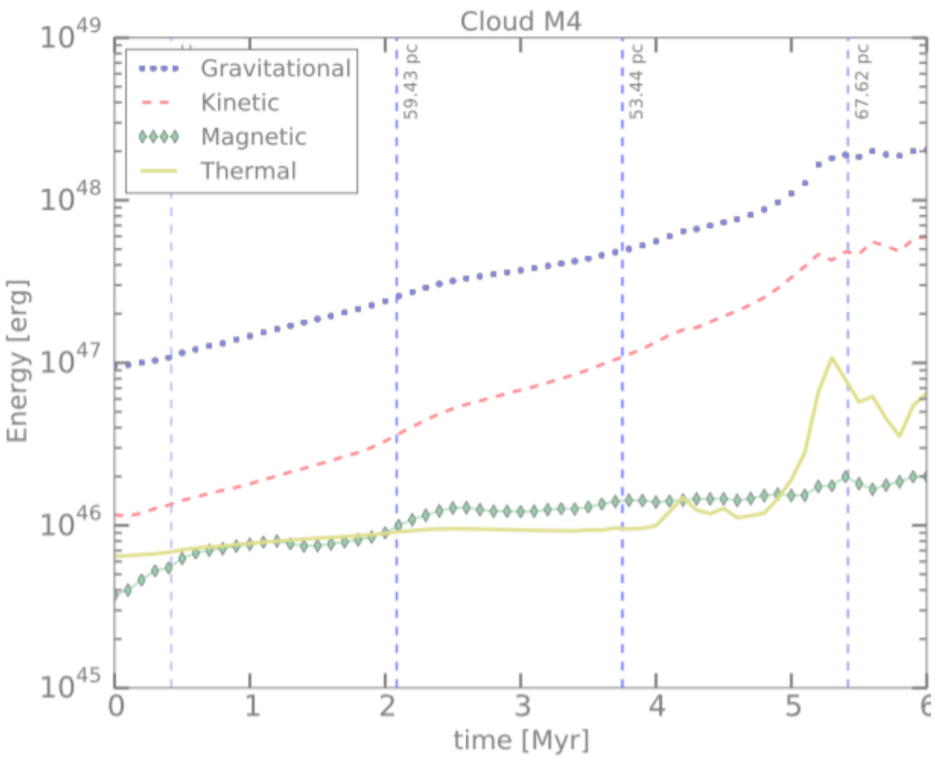
# Gravitational energy dominates cloud evolution.

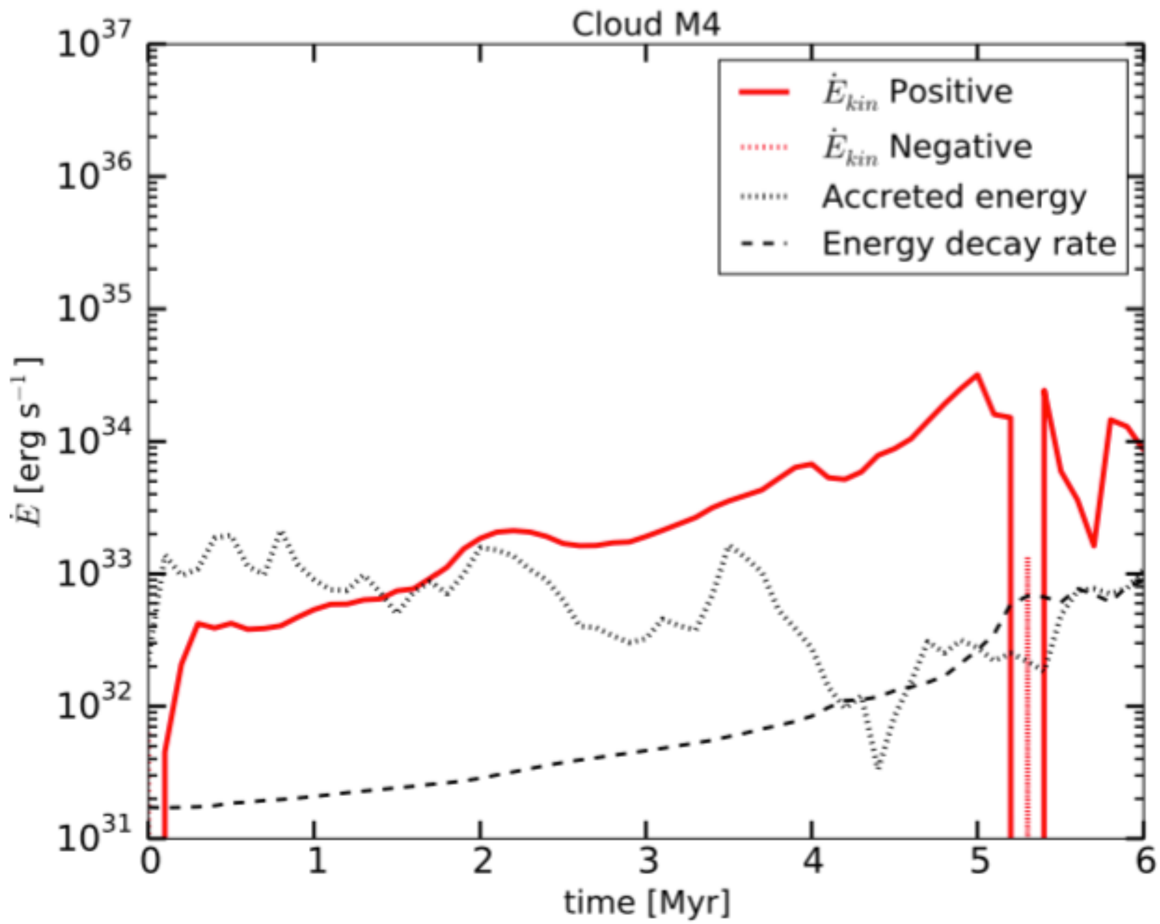



Ibáñez-Mejía et al. 2017, in press, ArXiv:1705.01779

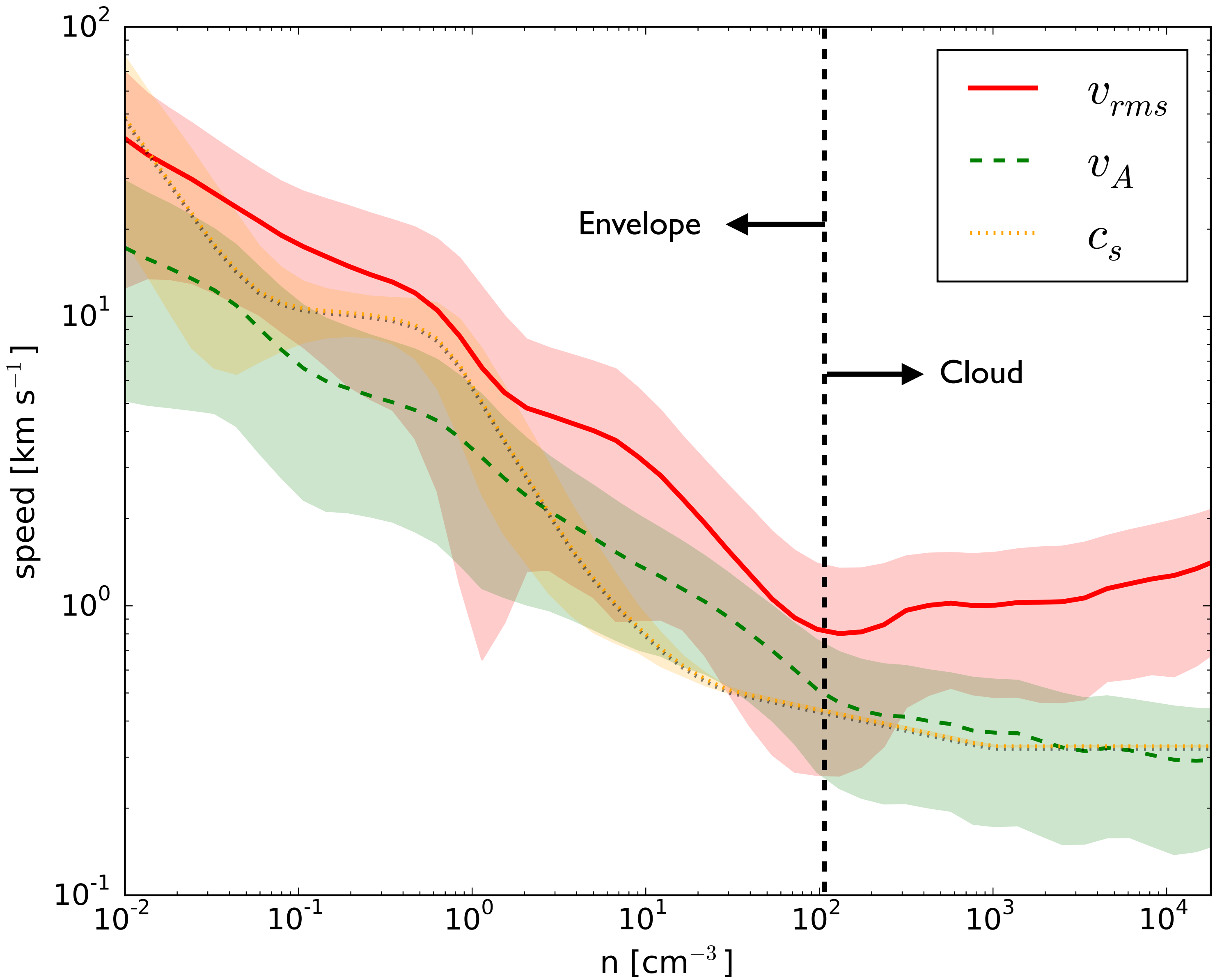
# Contraction dominates over accretion for KE.



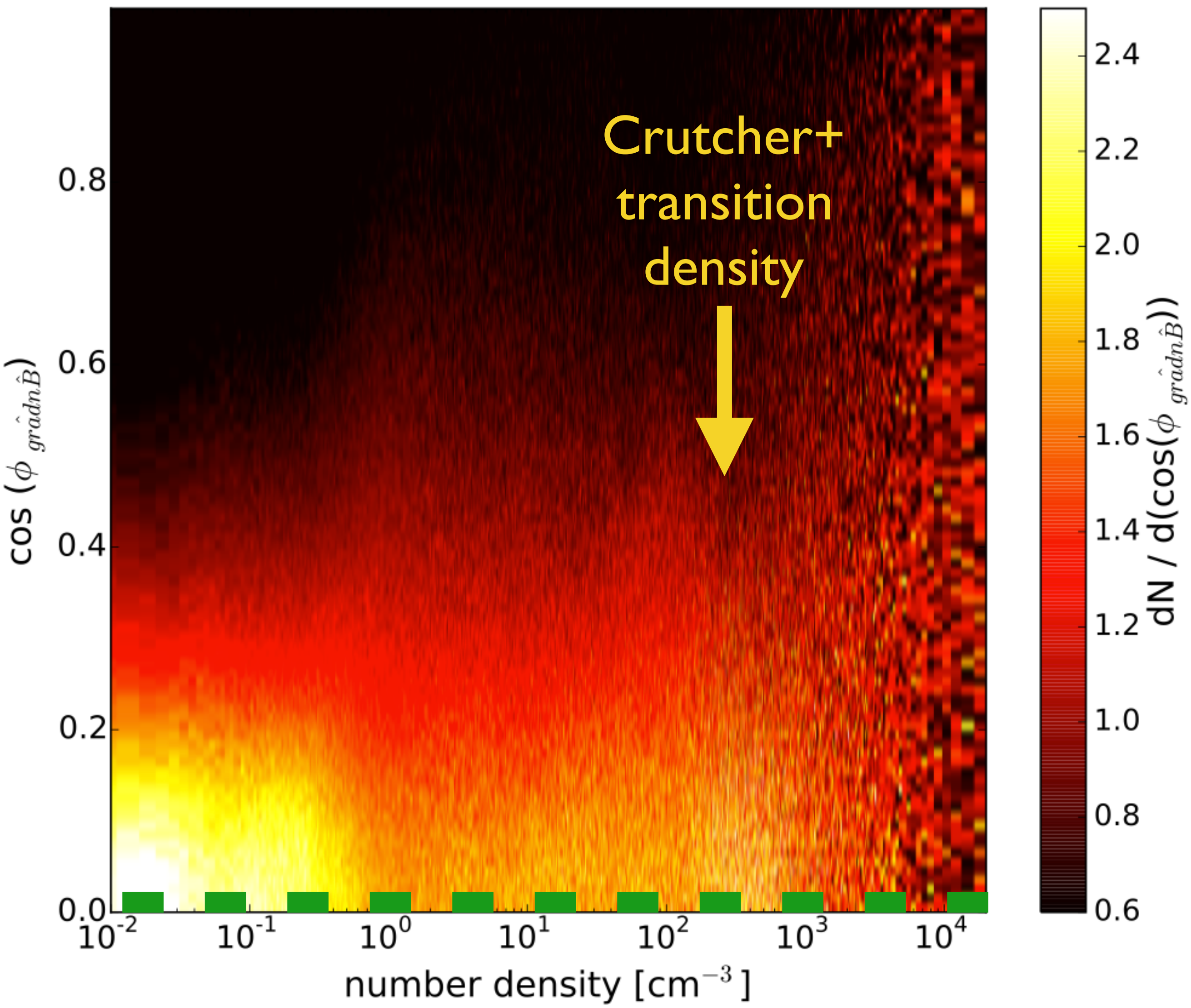

Ibáñez-Mejía et al. 2017, in press, ArXiv:1705.01779

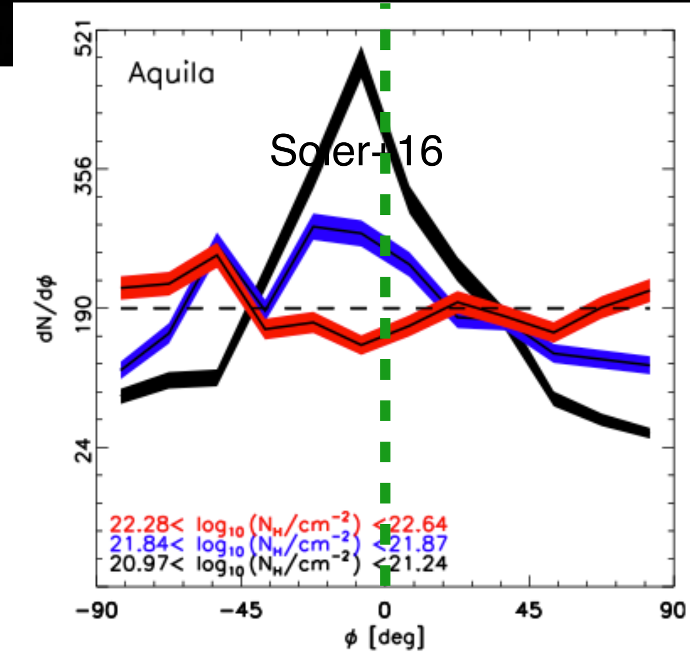
# Trans-Alfvénic envelope, super-Alfvénic core

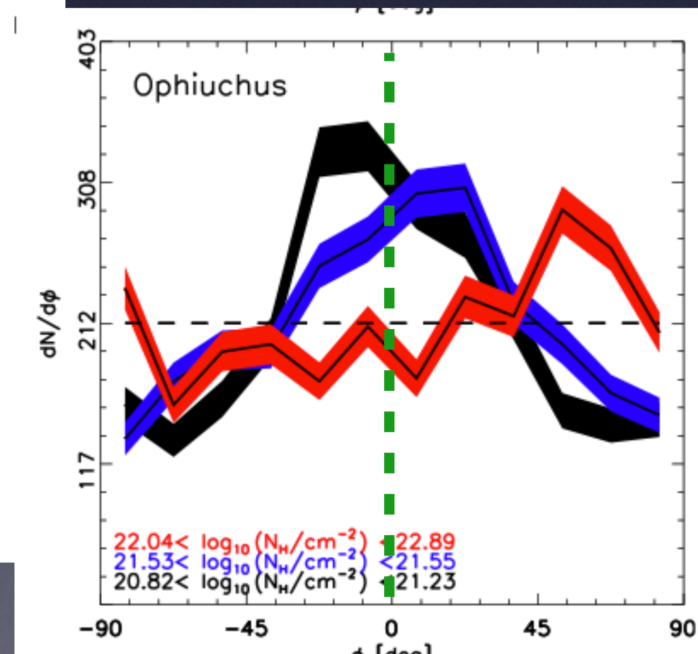



Ibáñez-Mejía et al. 2018, in prep

Histogram of relative orientations (HRO) between magnetic field and density *gradient* shows moderate alignment in envelope, none in core with $n > 10^3$ cm$^{-3}$.



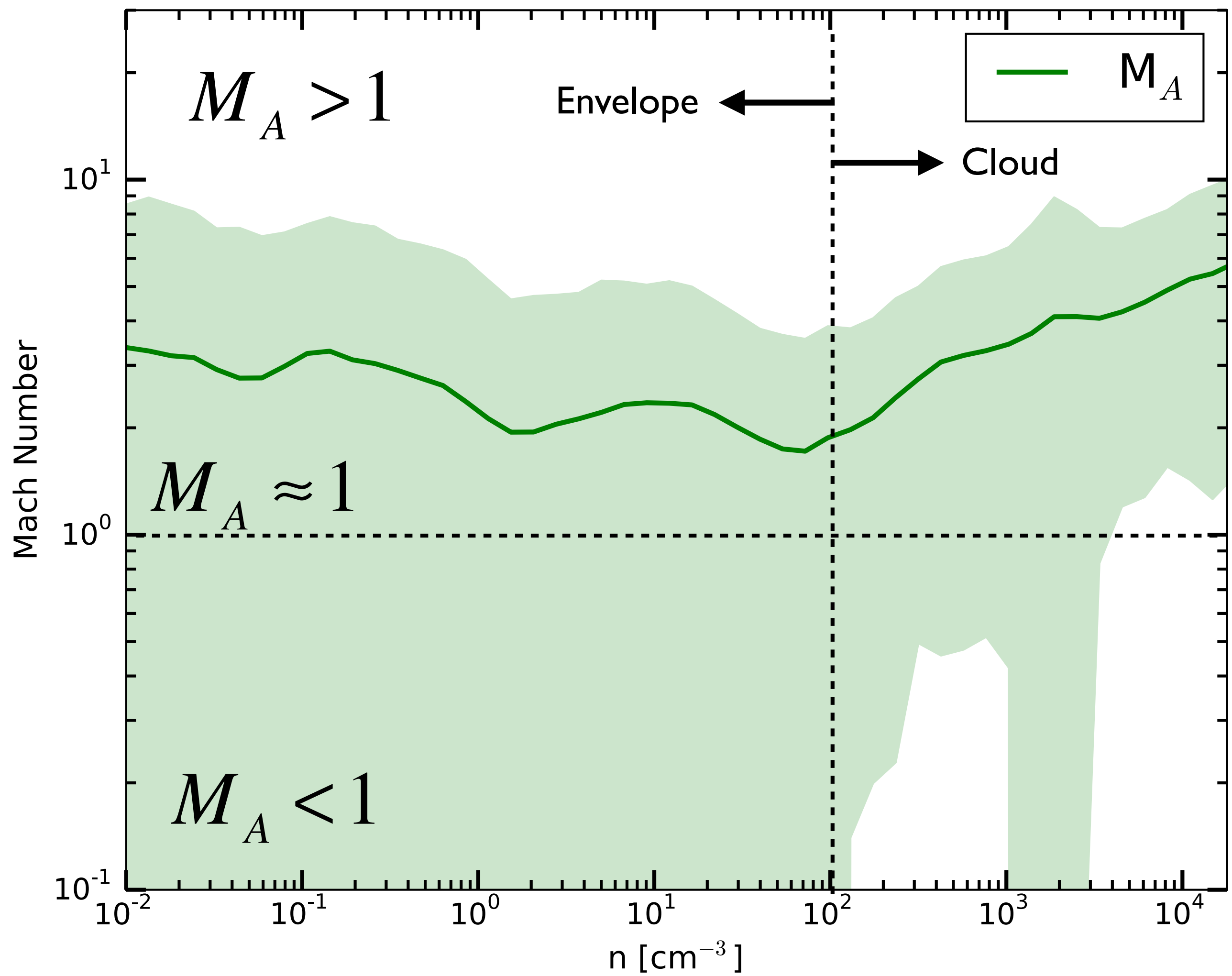




Ibáñez-Mejía, thesis & in prep +18

# Alfvénic Mach number inside and around a cloud

- Nearby SN feedback maintains the diffuse ISM super-Alfvénic.
- Cloud envelopes are mostly trans-Alfvénic to mildly super-Alfvénic.
- gravitational contraction drives fast, super-Alfvénic, motions inside the cloud

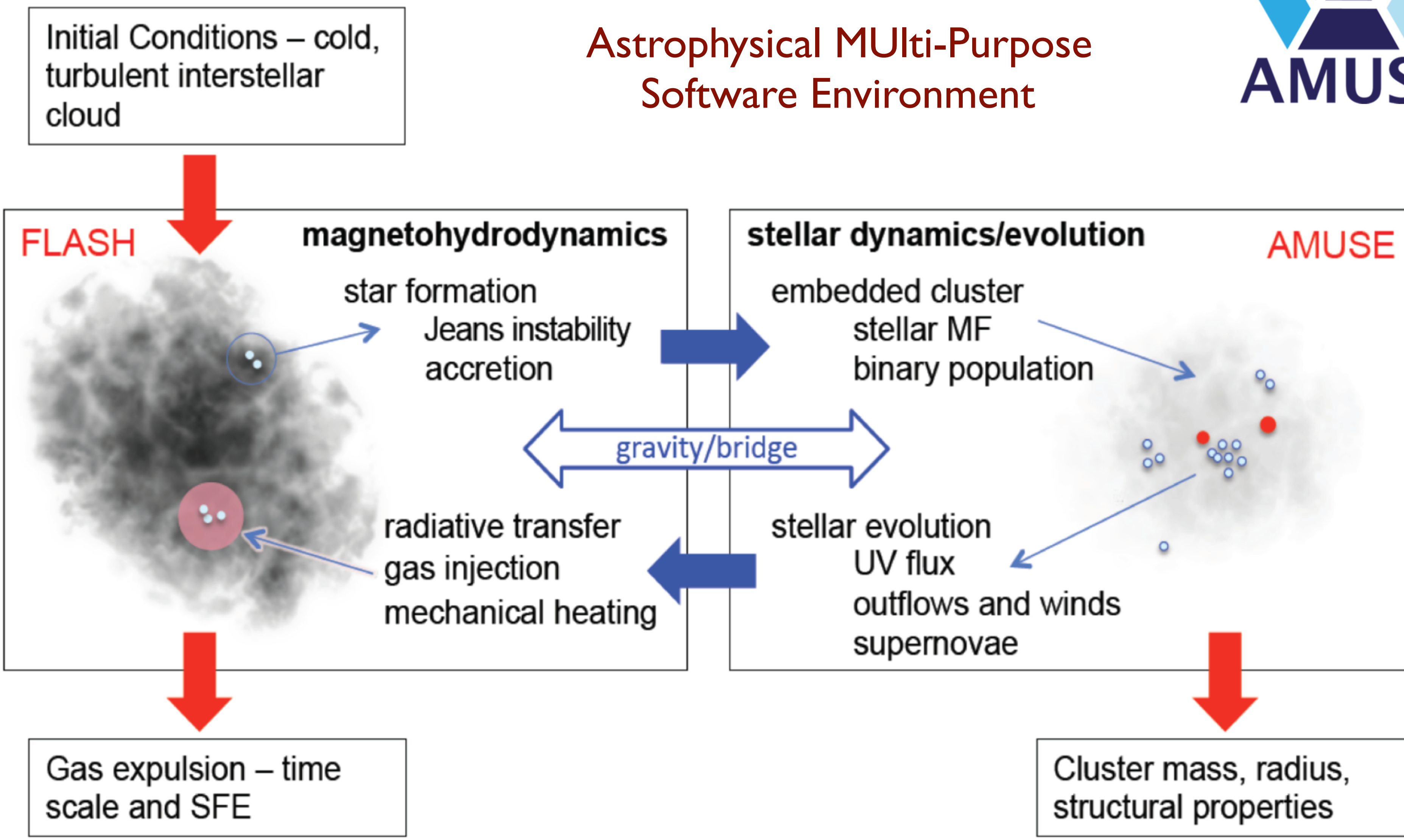



Ibáñez-Mejía et al. 2018, in prep

# Coupling between AMUSE and Flash

Astrophysical MUlti-Purpose
Software Environment

AMUSE

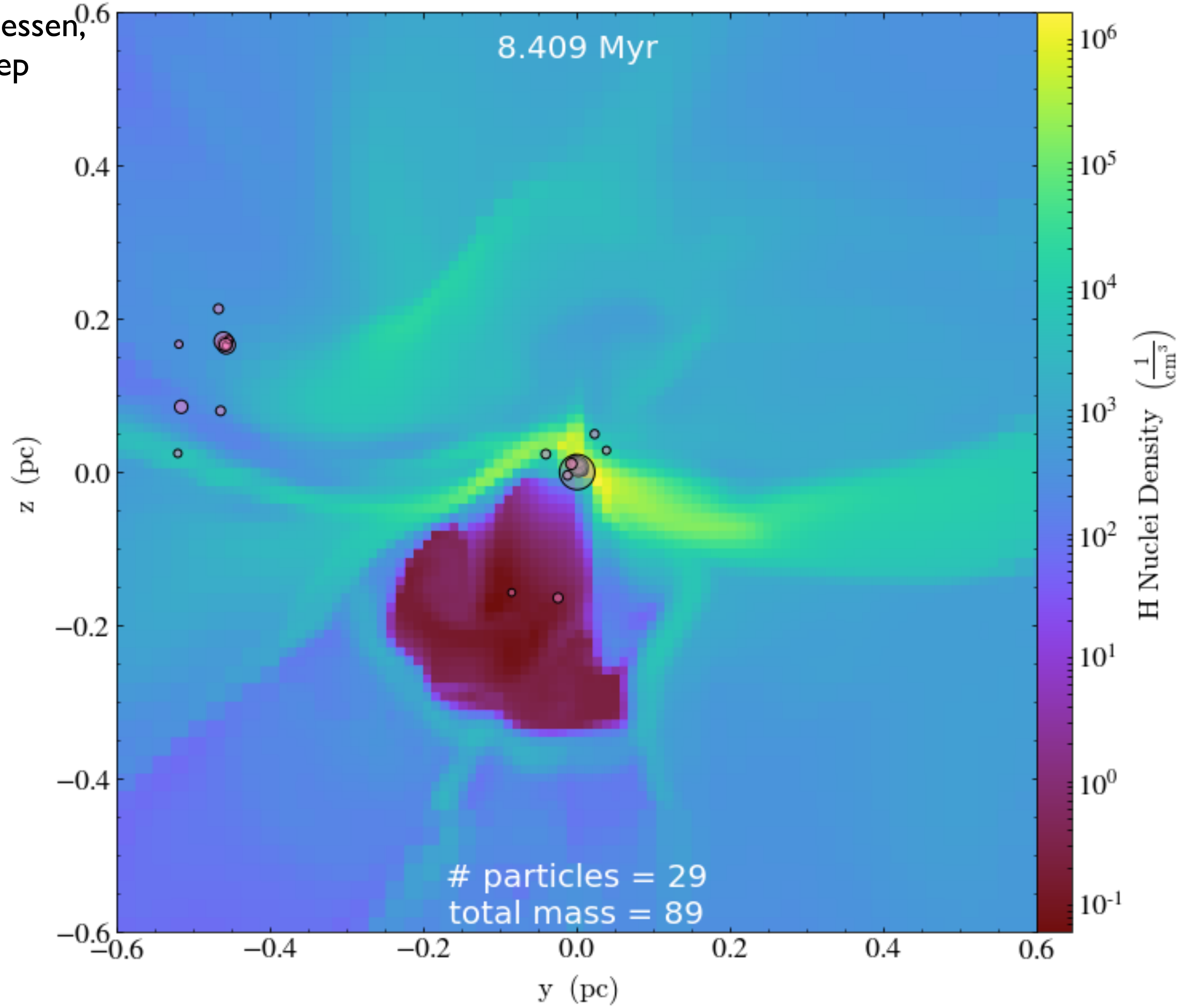



Wall, M-MML, McMillan, Klessen, Portegies-Zwart, in prep

Wall, M-MML, McMillan, Klessen, Portegies-Zwart, in prep

2400 AU
resolution

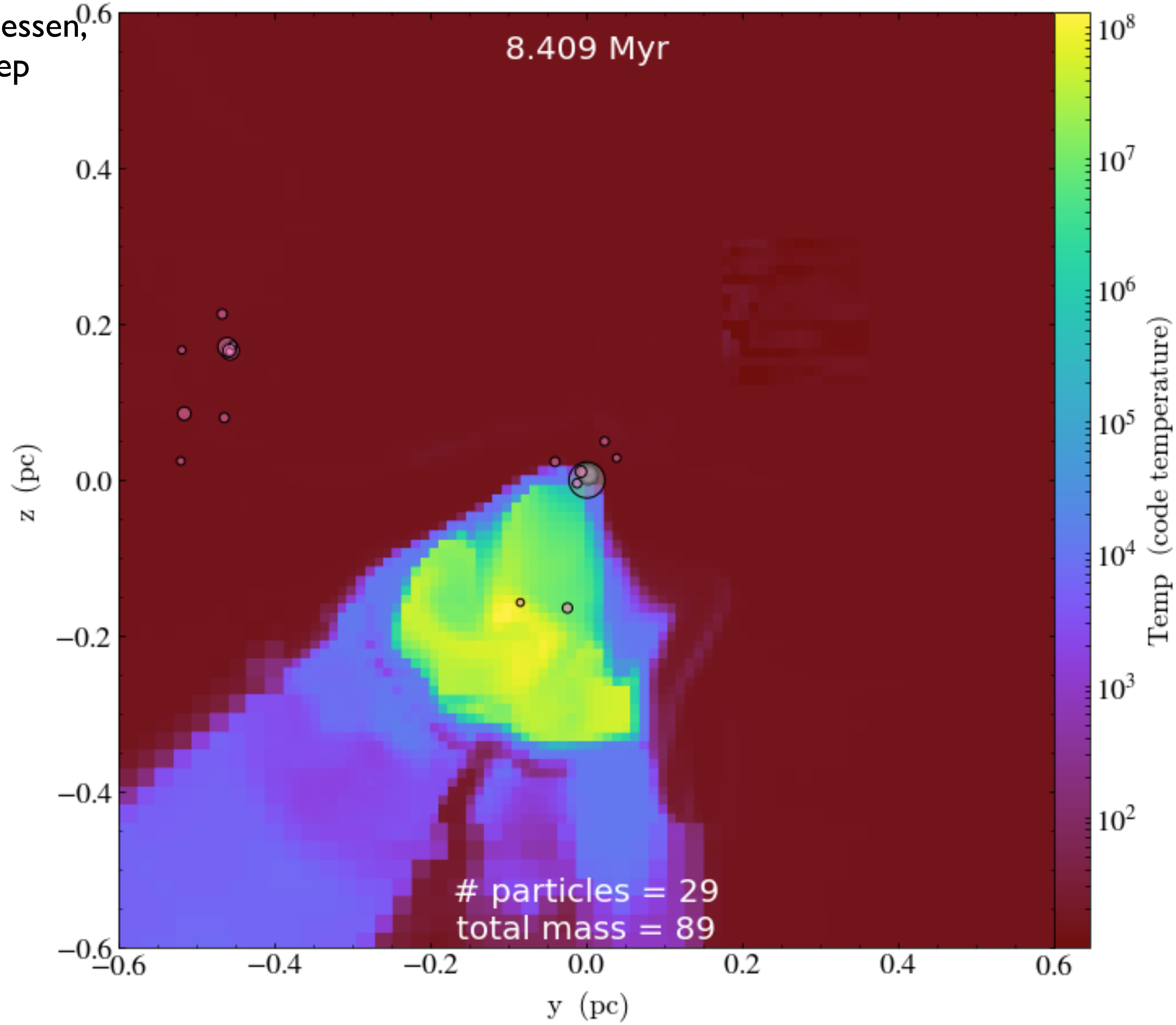
$10^4\ M_\odot$
test cloud



Wall, M-MML, McMillan, Klessen, Portegies-Zwart, in prep

2400 AU resolution

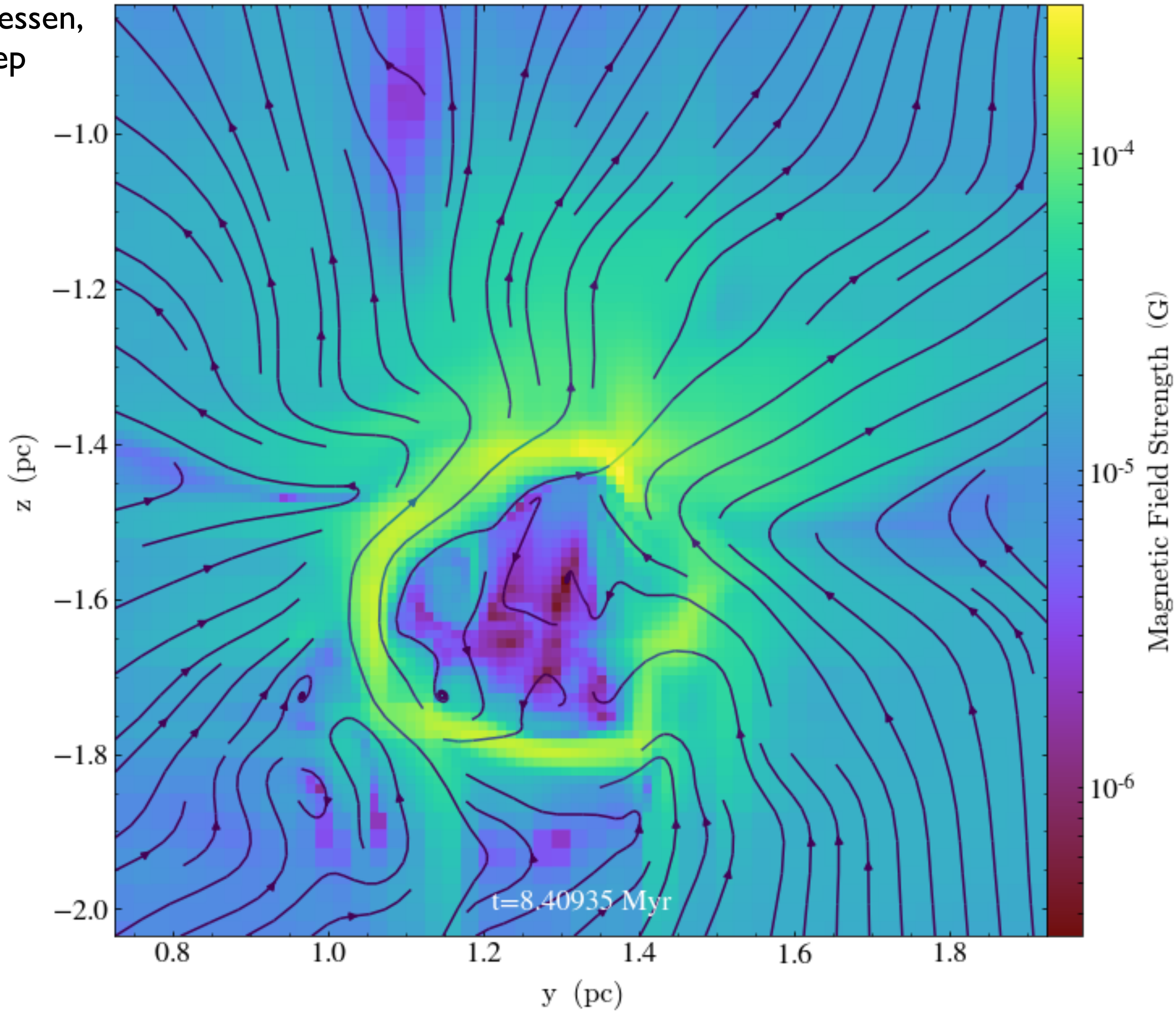
$10^4$ M$_\odot$ test cloud



Wall, M-MML, McMillan, Klessen, Portegies-Zwart, in prep

2400 AU resolution

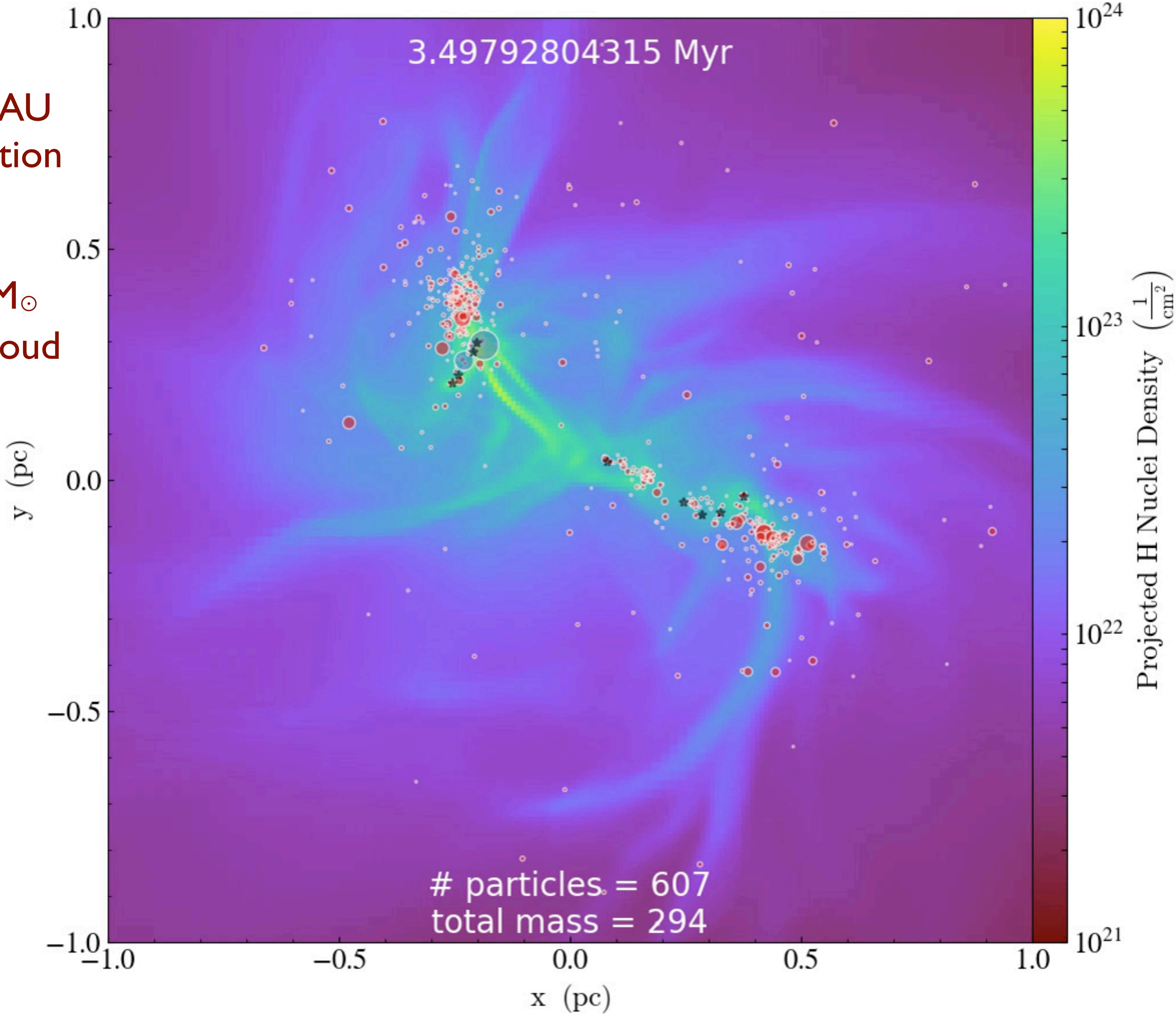
$10^4$ M$_\odot$ test cloud



Wall, M-MML, McMillan, Klessen, Portegies-Zwart, in prep

2000 AU resolution

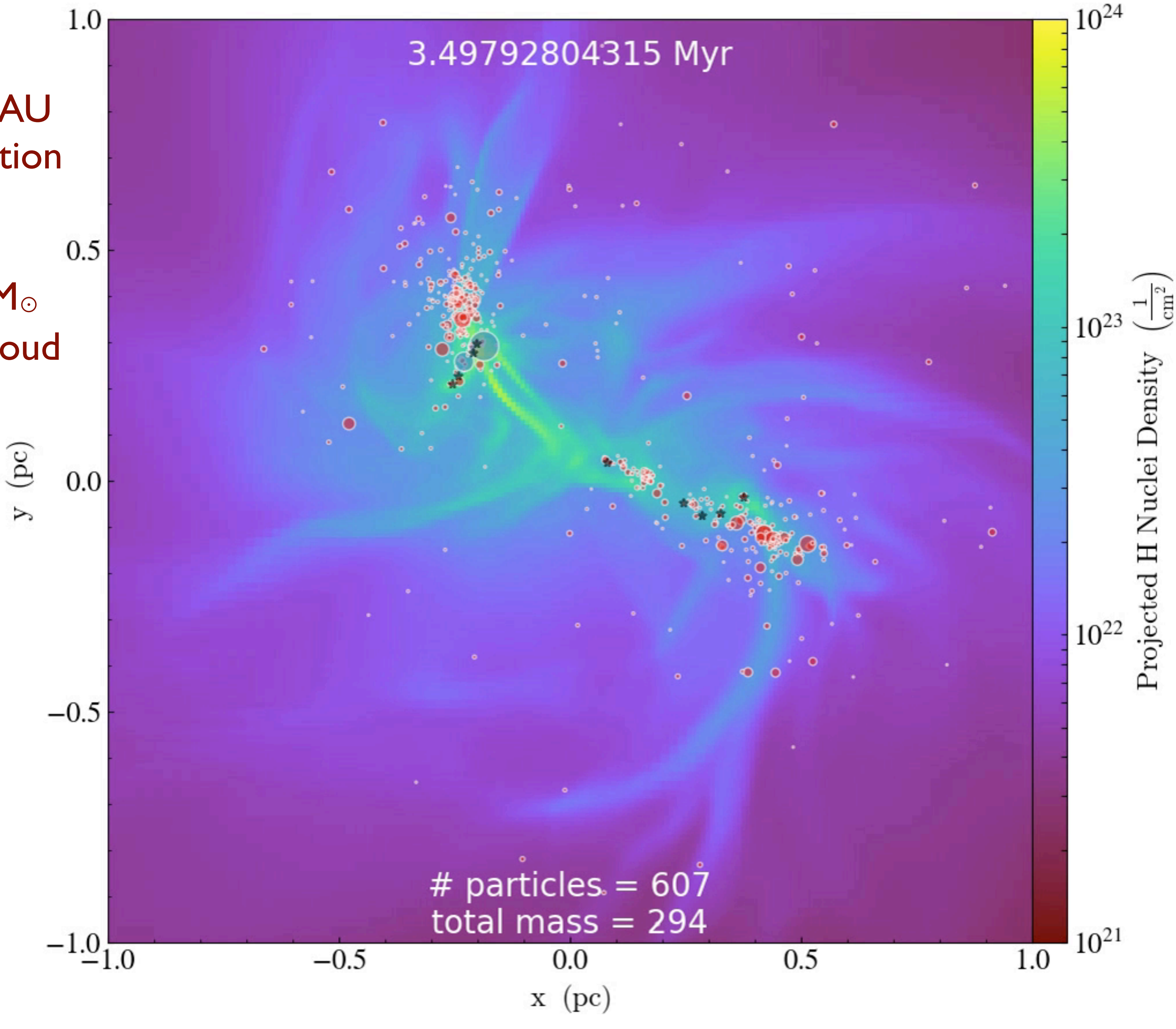
$10^3$ M$_\odot$ test cloud



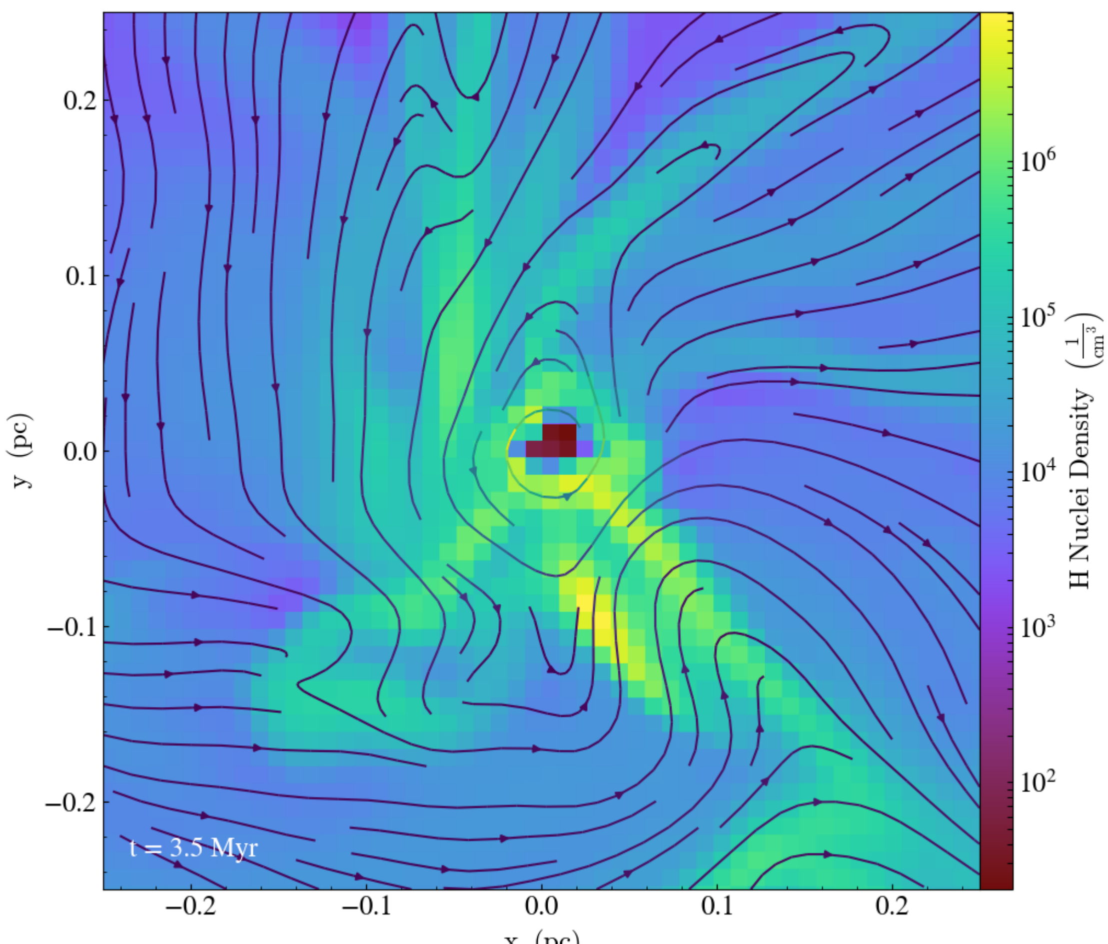
Wall, M-MML, McMillan, Klessen, Portegies-Zwart, in prep

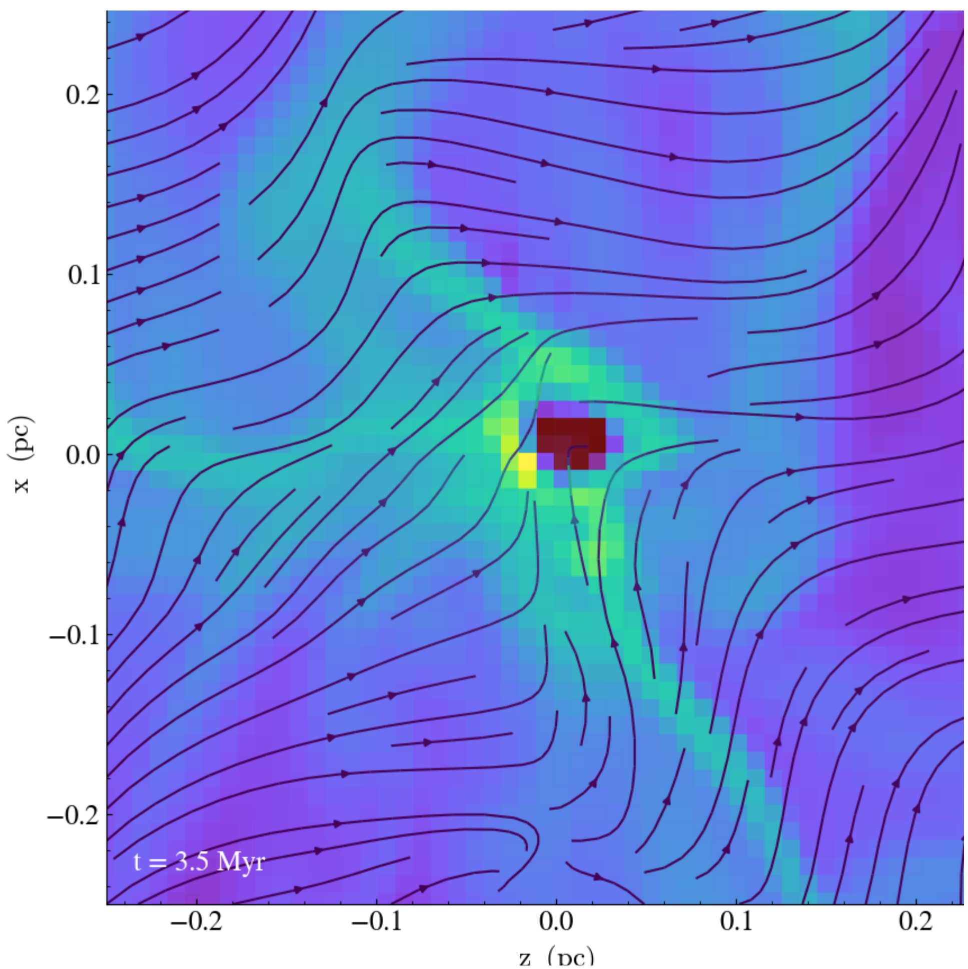
2000 AU resolution

$10^3\ M_\odot$ test cloud



Wall, M-MML, McMillan, Klessen,
Portegies-Zwart, in prep



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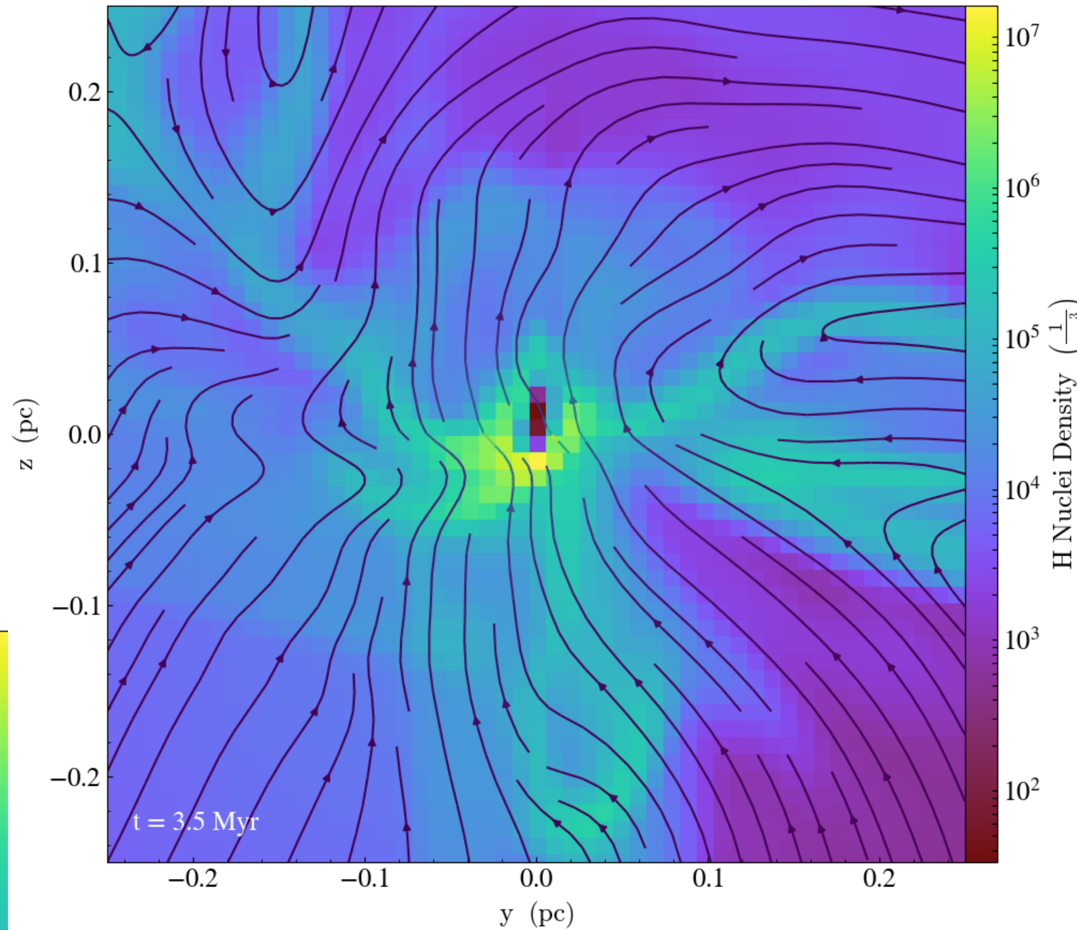


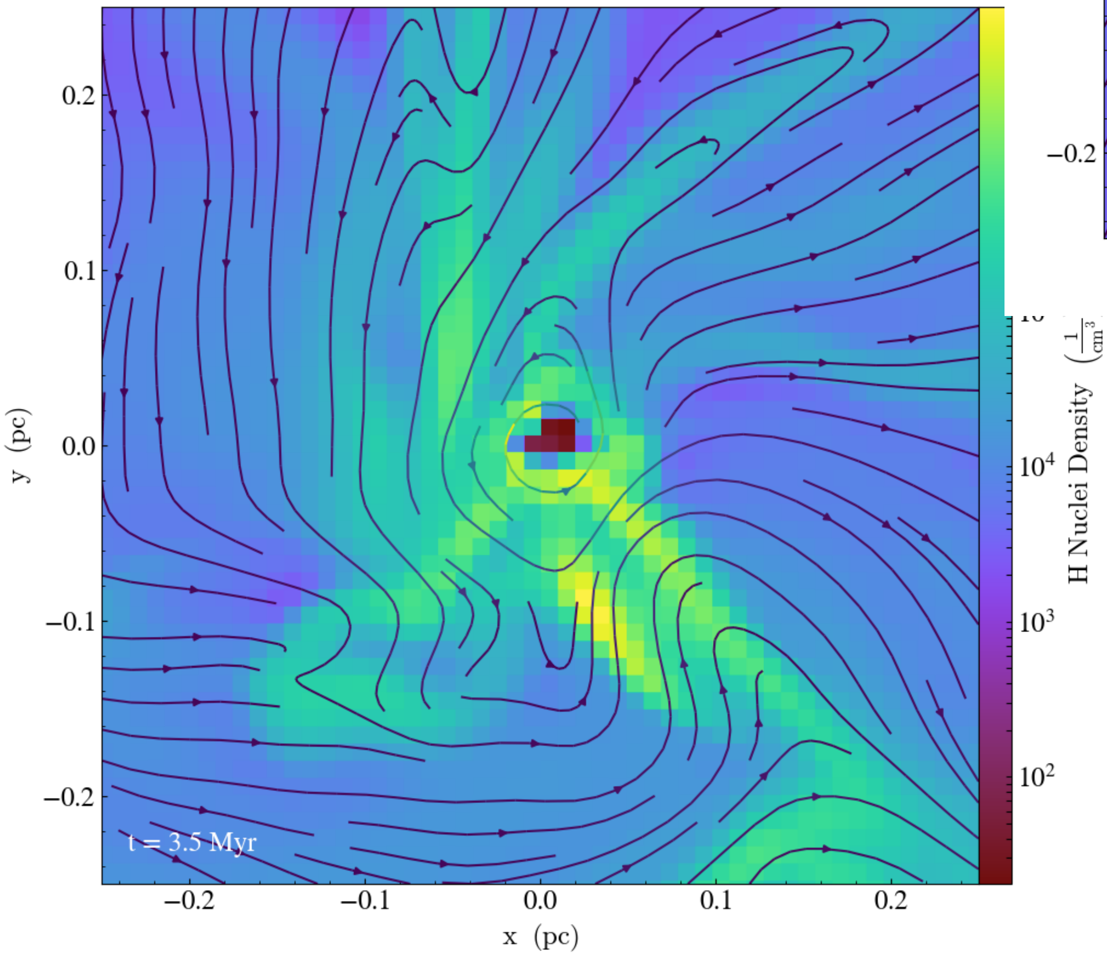


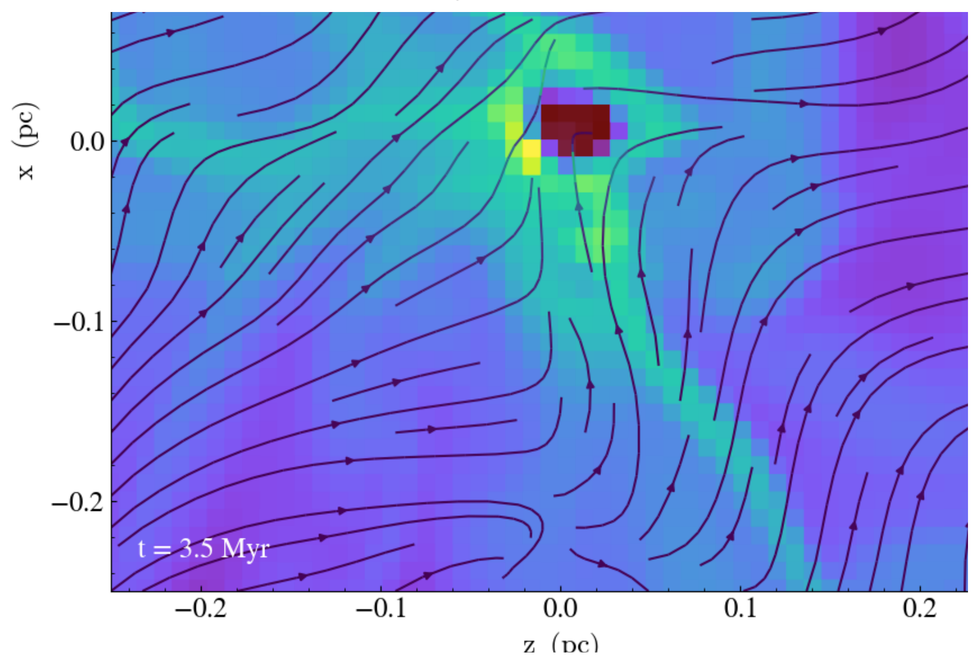

# Conclusions

- In the absence of star formation and internal feedback, **gravitational contraction** seems to be the **main driver of non-thermal motions** inside dense clouds.

- **Nearby SN** explosions **both** compress the clouds' envelopes, **increasing mass accretion rates**, *and* **erode the surface** and fragment the cloud.

- Gas **flows around clouds** are predominantly **trans-Alfvénic**, so magnetic fields play an active role regulating mass accretion rates.

- Magnetic fields inside dense clouds seem unable to prevent collapse. **Hierarchical gravitational contraction** drives **super-Alfvénic internal motions.**

- **HII region expansion** carries the field with it, but angle of observation matters.