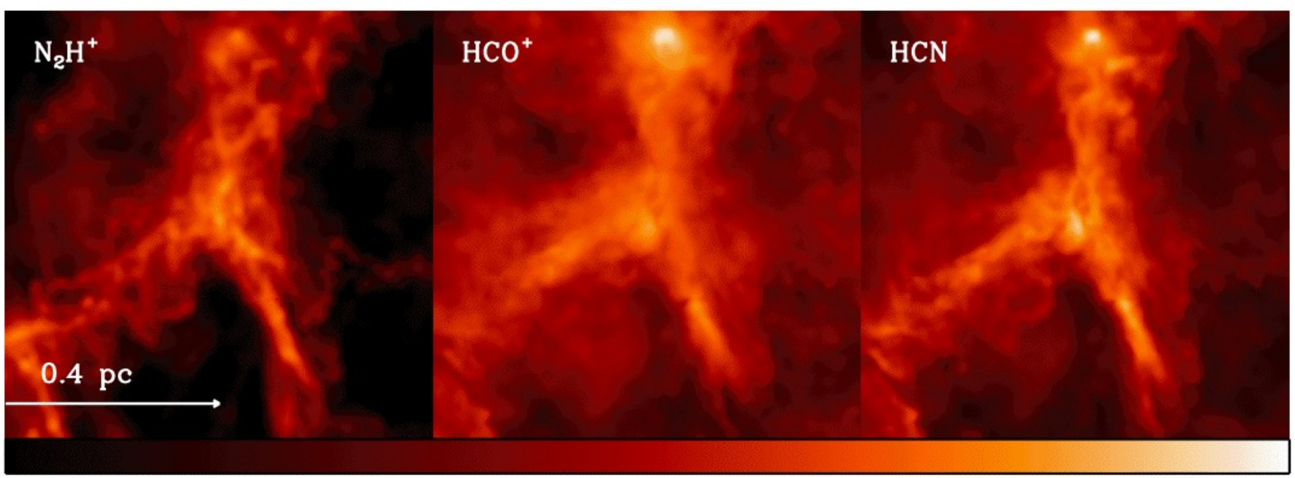
Signatures of Massive Star Formation

Rowan Smith

ZAH/ITA University of Heidelberg

ARI ITA LSW

Ian Bonnell, Henrik Beuther, Adam Ginsburg, Rahul Shetty, Ralf Klessen, Amelia Stutz



Summary

1. Massive Stars are formed from the large scale collapse of a protocluster.
2. There is an extremely sharp velocity gradient across the central object.
3. Typically exhibit a blue skewed profile in optically thick lines that increases in width and intensity with time.
4. Frequently exhibit non-gaussian profiles in the optically thin lines.

Motivation

1

Massive Star Observations

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

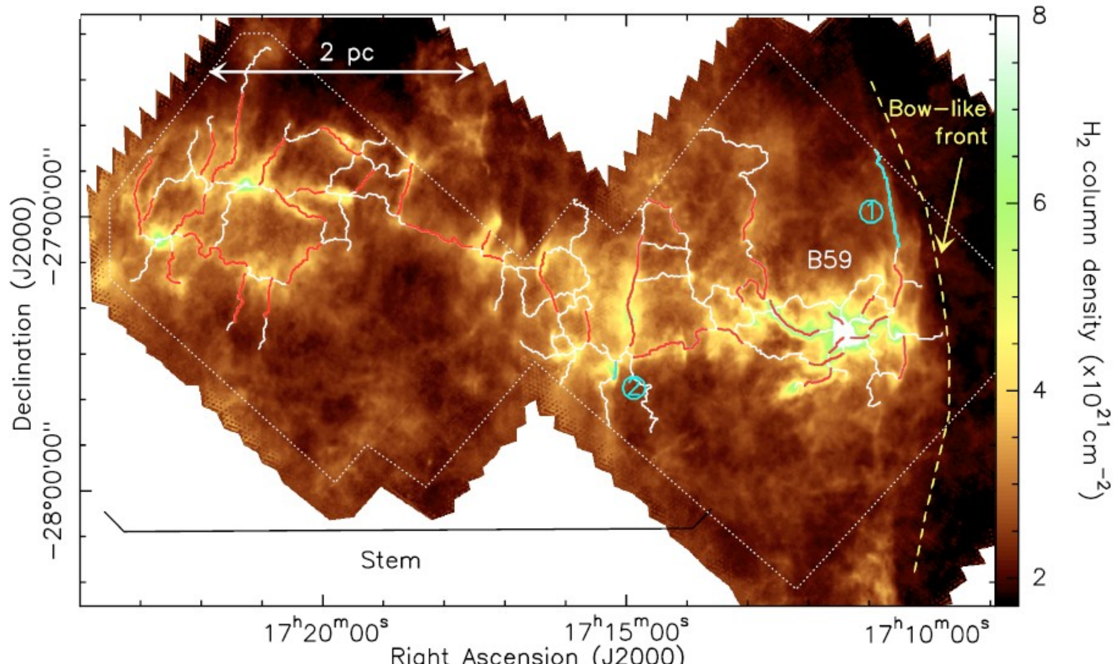
Massive stars usually form at the centre of dense star forming clumps.

Pre-stellar massive cores either extremely short lived or don't exist

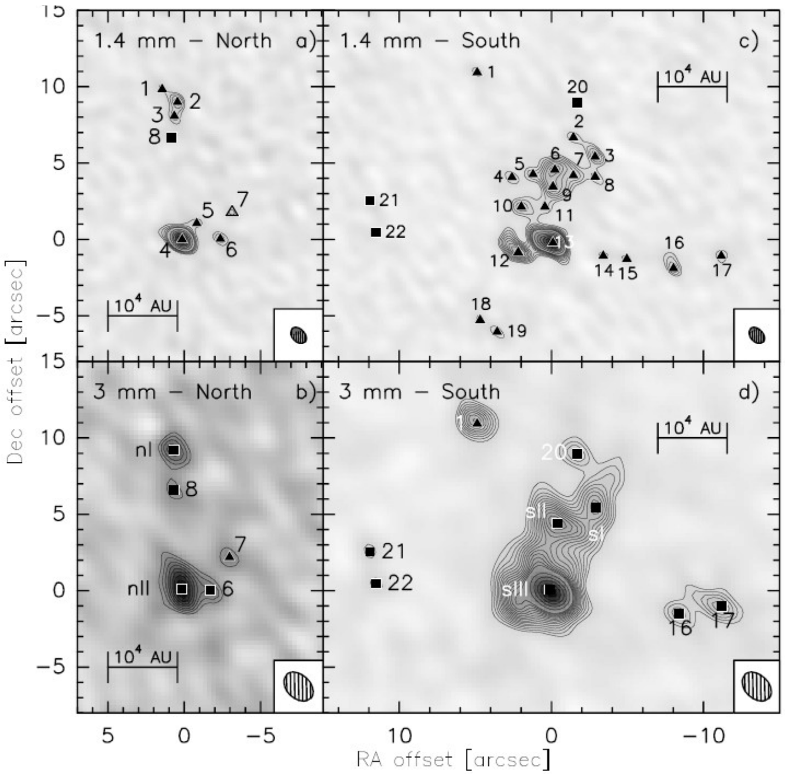
Motte et. al. 2007

Star forming clumps form at the hub points of filaments.

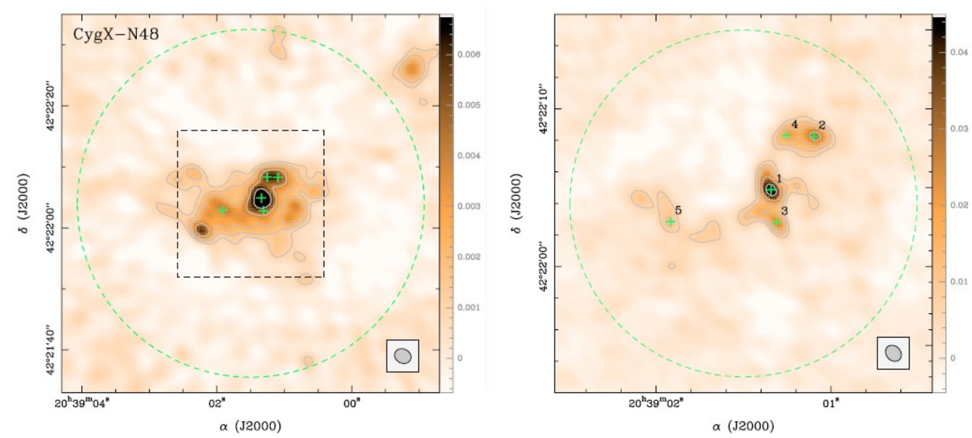
Peretto et. al. 2012, Myers 2009, Schneider et. al. 2012



Massive Star Observations



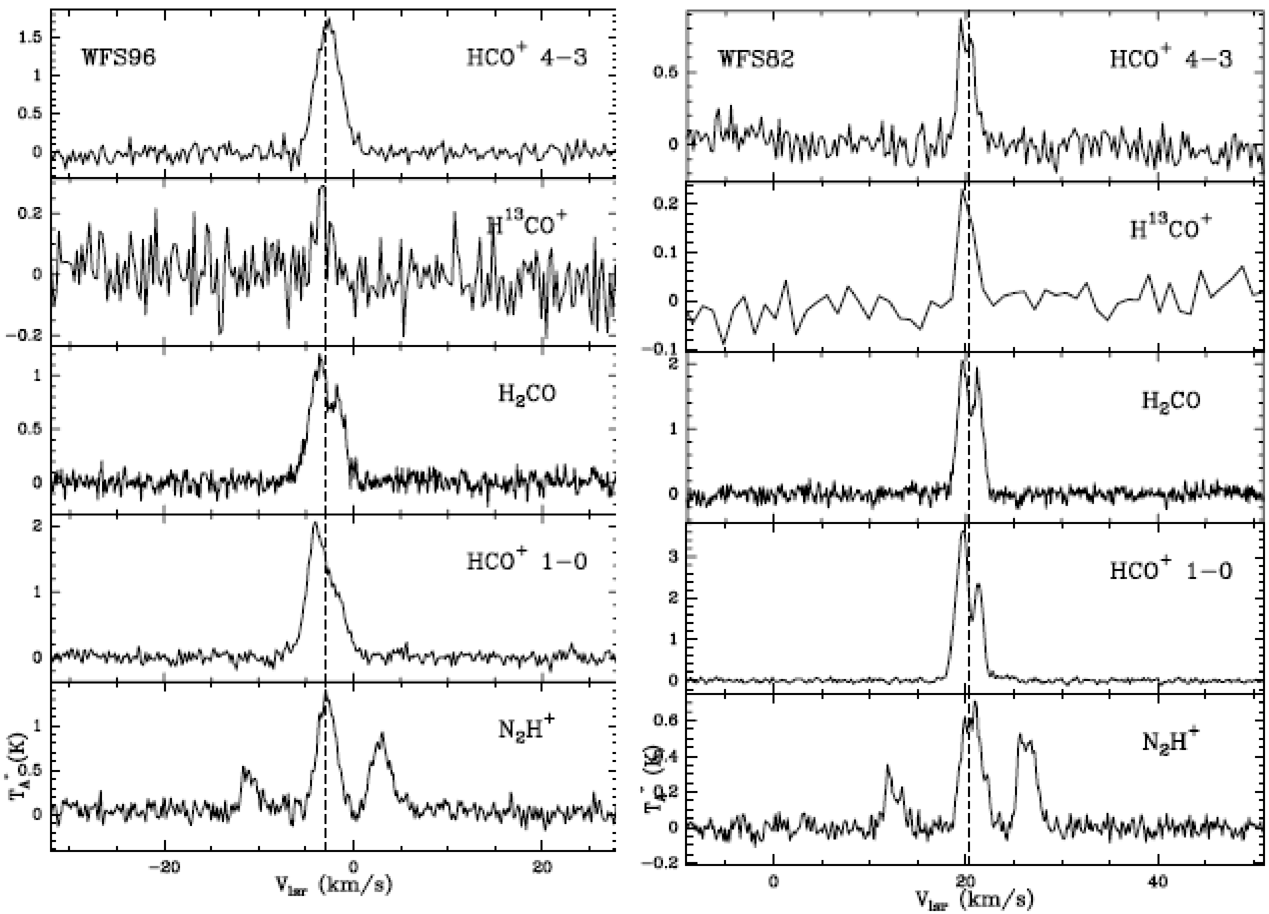
Rodon et. al. 2012



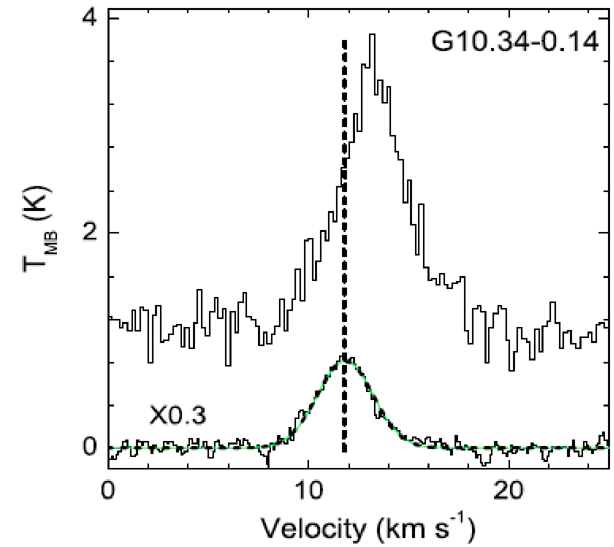
Bontemps et. al. 2012

Interferometry observations usually reveal substructure.

Massive Star Observations



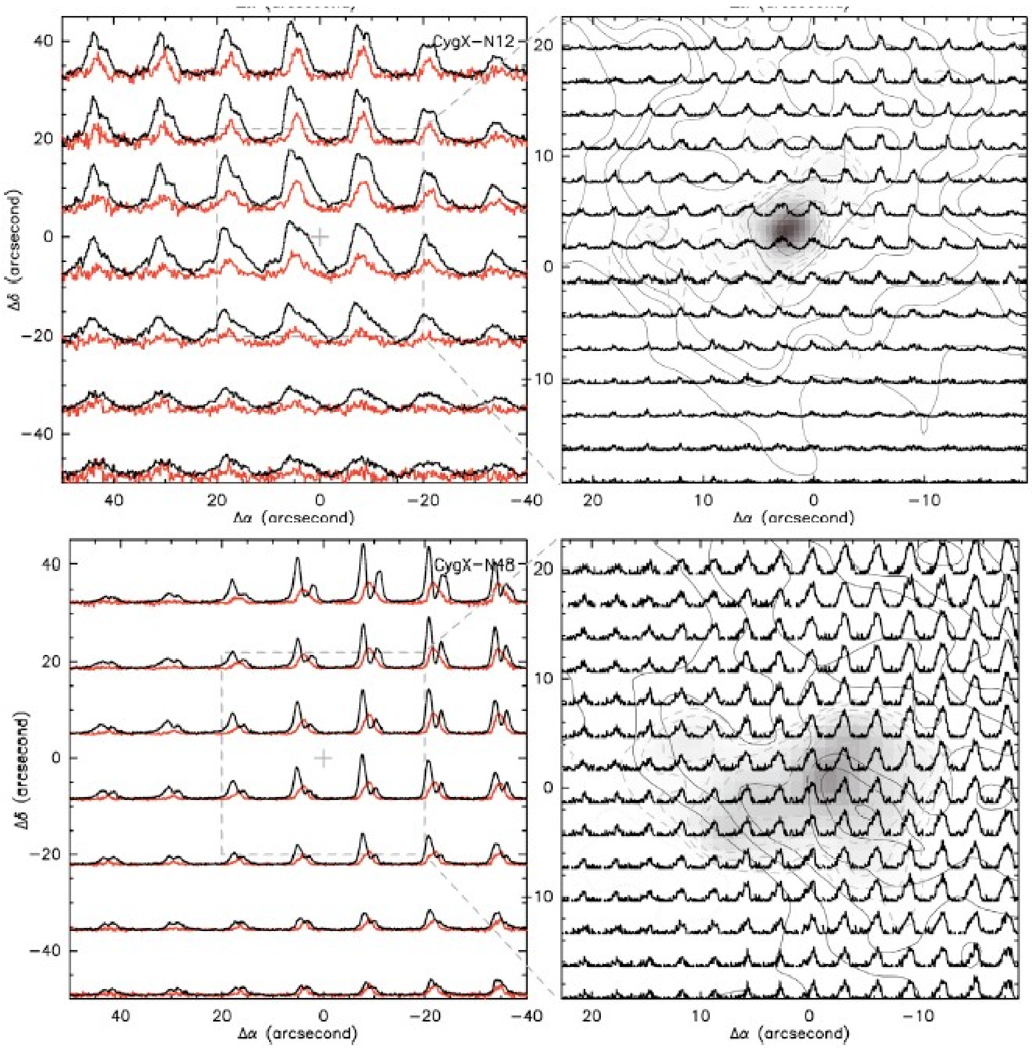
Fuller et. al. 2005

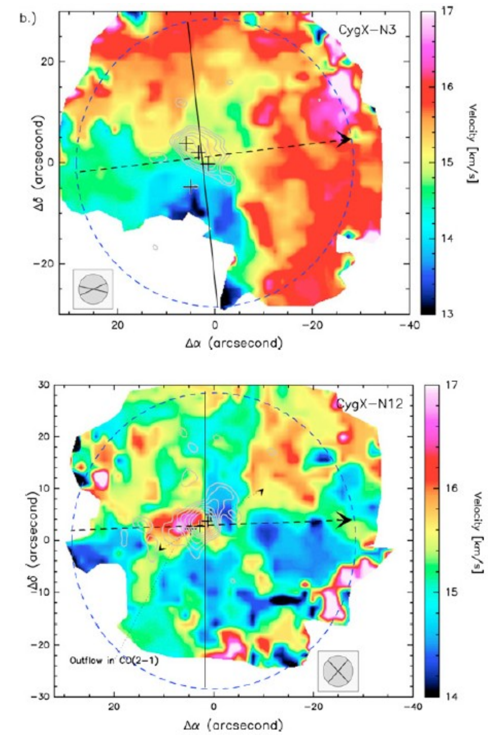


Chen et. al. 2010

Generally blue shifted profiles- although red shifted profiles are also observed.

Massive Star Observations





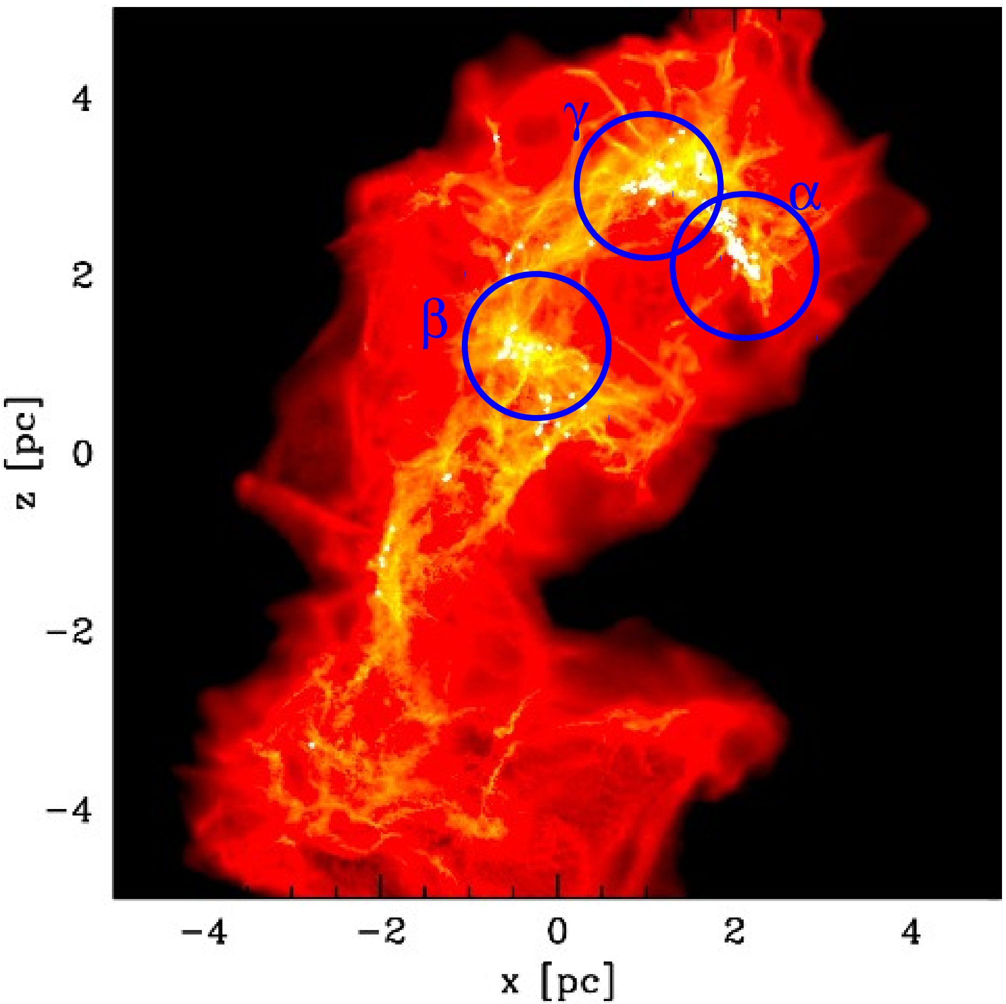
Csengeri et. al. 2011

Infall motions usually persist across large regions, however there are also complex motions in the core.

The Method

2

Clump Selection



- From the global simulation three **clumps** are arbitrarily assigned.

- Each forms a star cluster and has a massive star at its centre.

Radiative Transfer

1) Gas densities, temperature and velocities from the original simulation

2) Assume abundance ratio relative to H_2

- N_2H^+ $A=10^{-10}$
- HCO^+ $A=5\times10^{-9}$

3) Use the radiative transfer code RADMC-3D *(Dullemond et. al 2012)*

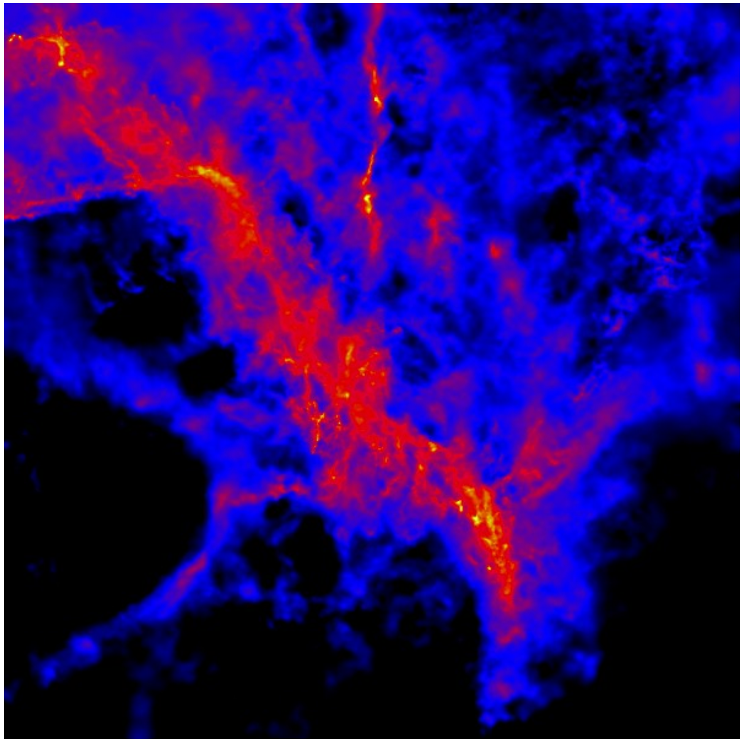
- Lines mode
- LVG approximation
- Doppler catching

4) Sample over a gaussian beam

Assembly

3

Time Evolution

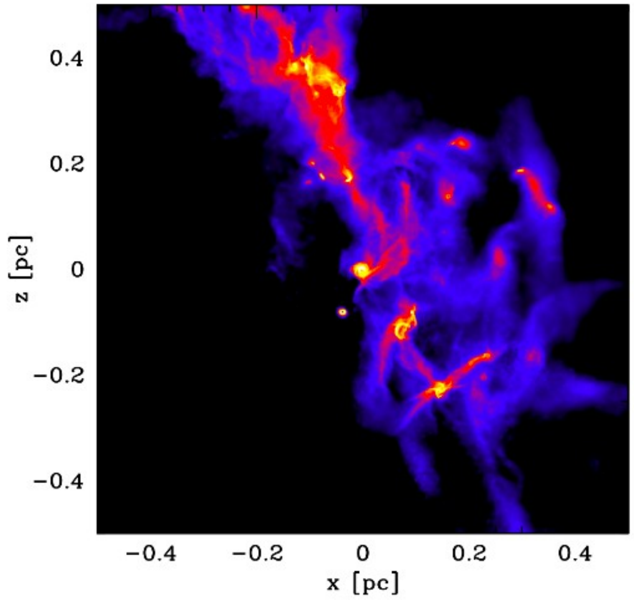


column density
blue: 0.05 gcm^{-2} yellow: 5 gcm^{-2}

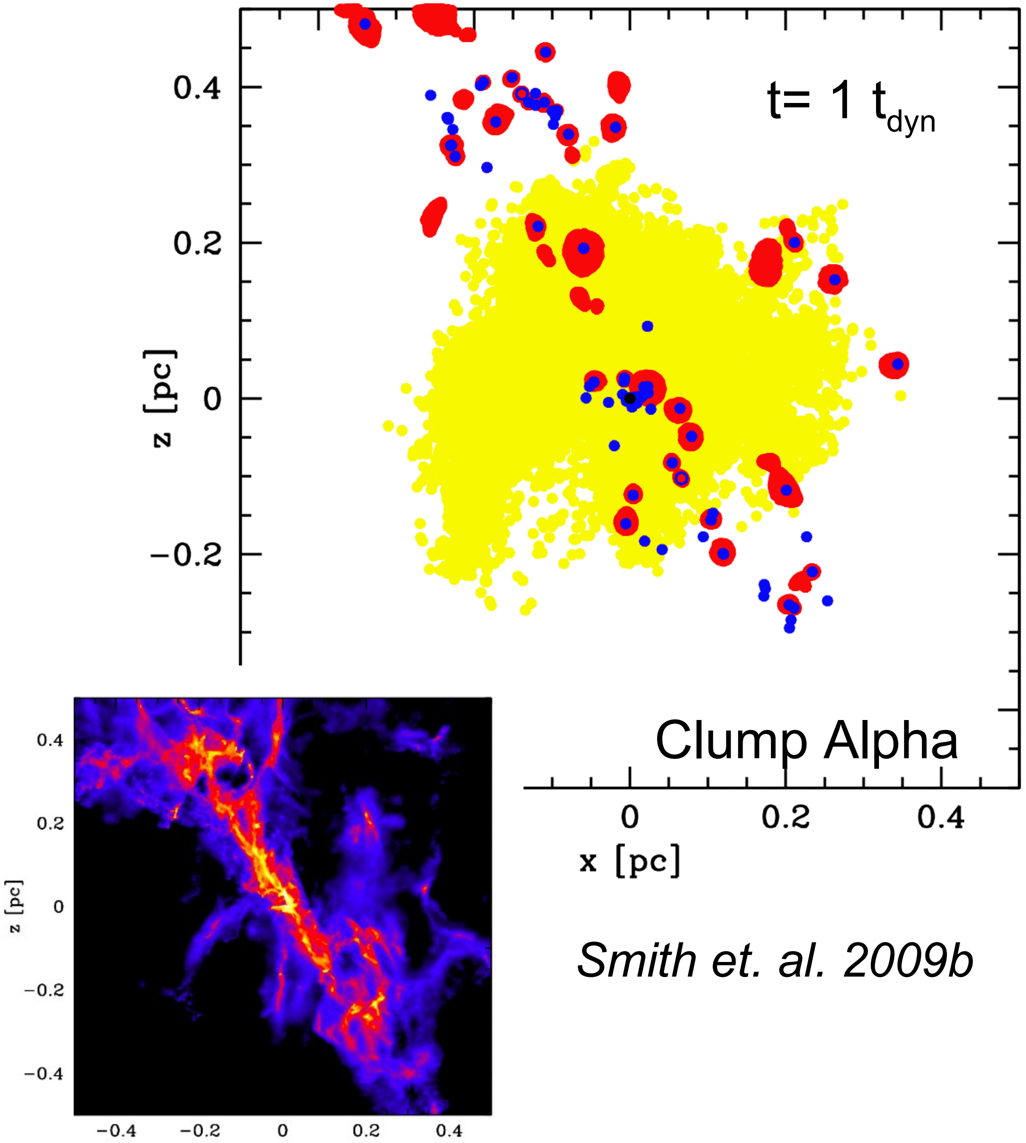
Filament collapsing along its axis

- evolves to a more compact state with less sub-structure

2.4 x 10^5 yrs



Fate



Smith et. al. 2009b

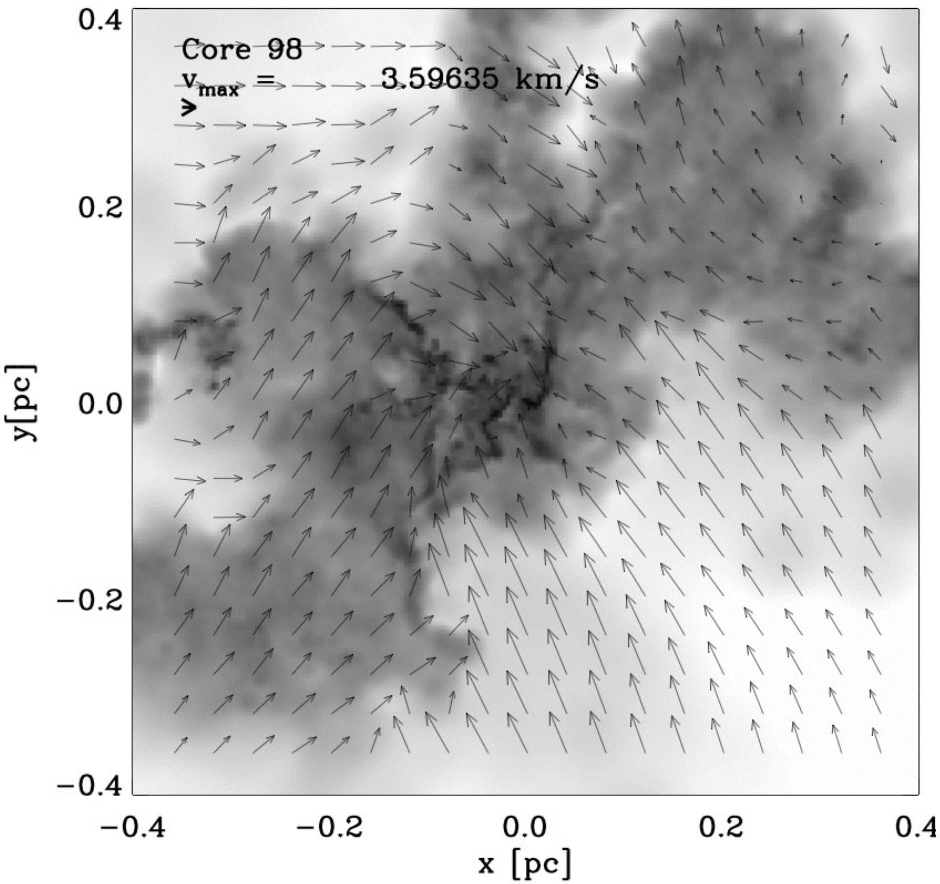
Red = p-cores

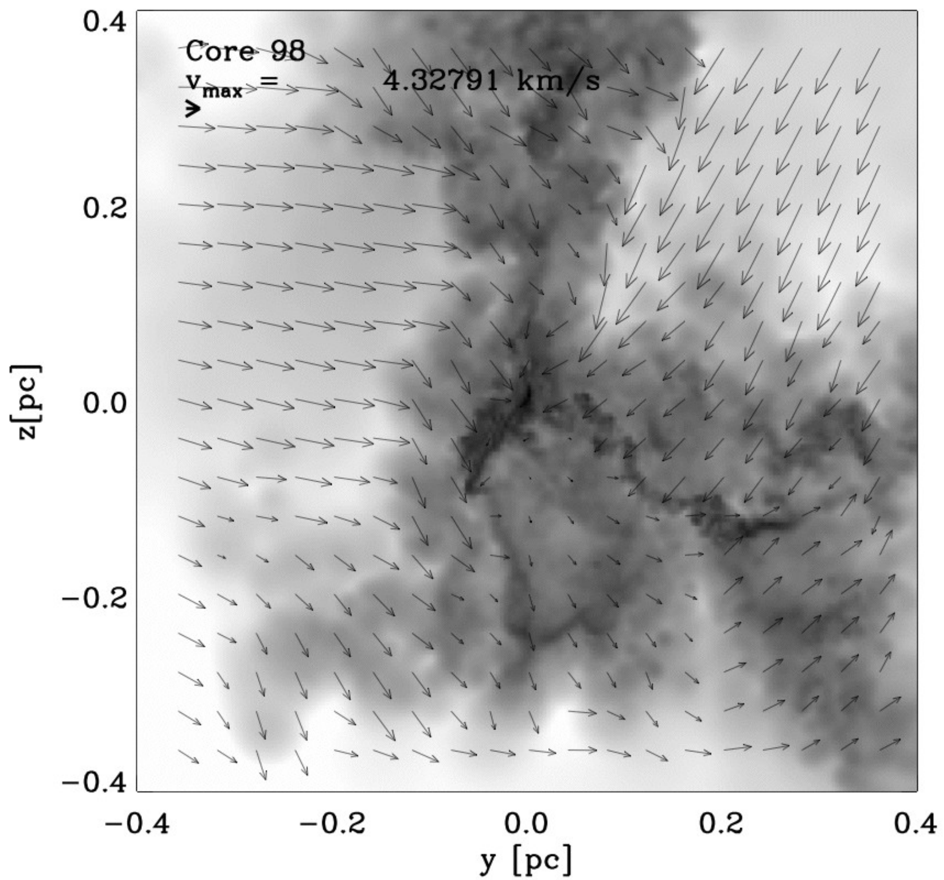
Solid blue = sinks

Hollow blue= pre-stellar

Yellow = mass which will be accreted by the most massive sink within 0.25 t_{dyn}

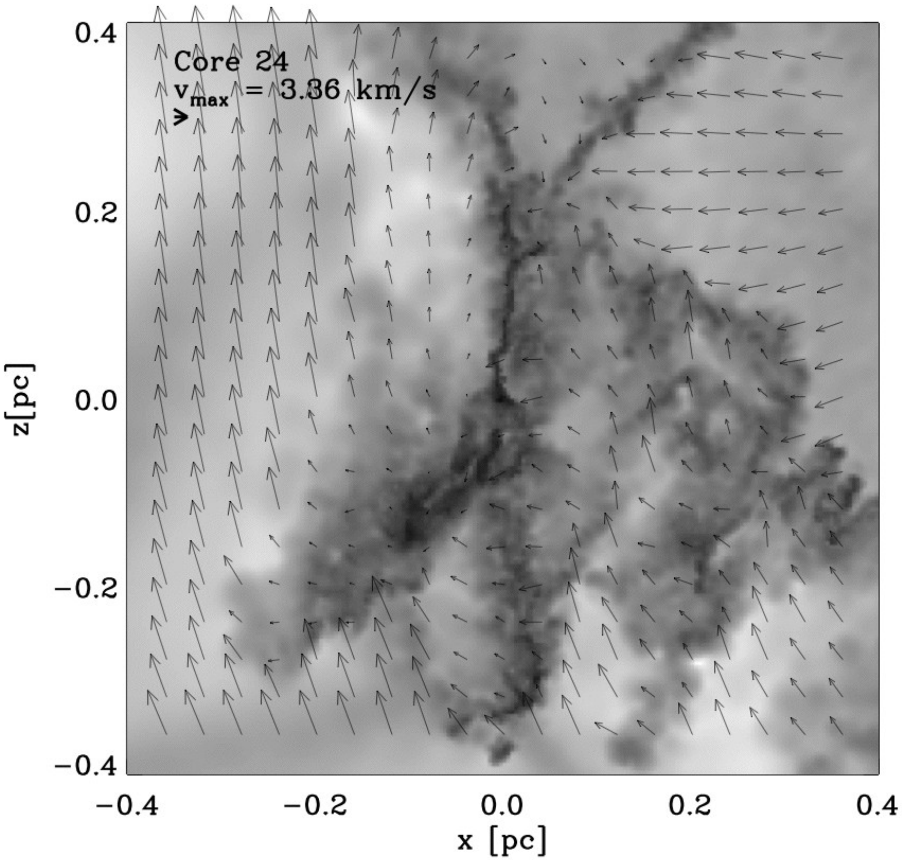
Velocity Fields

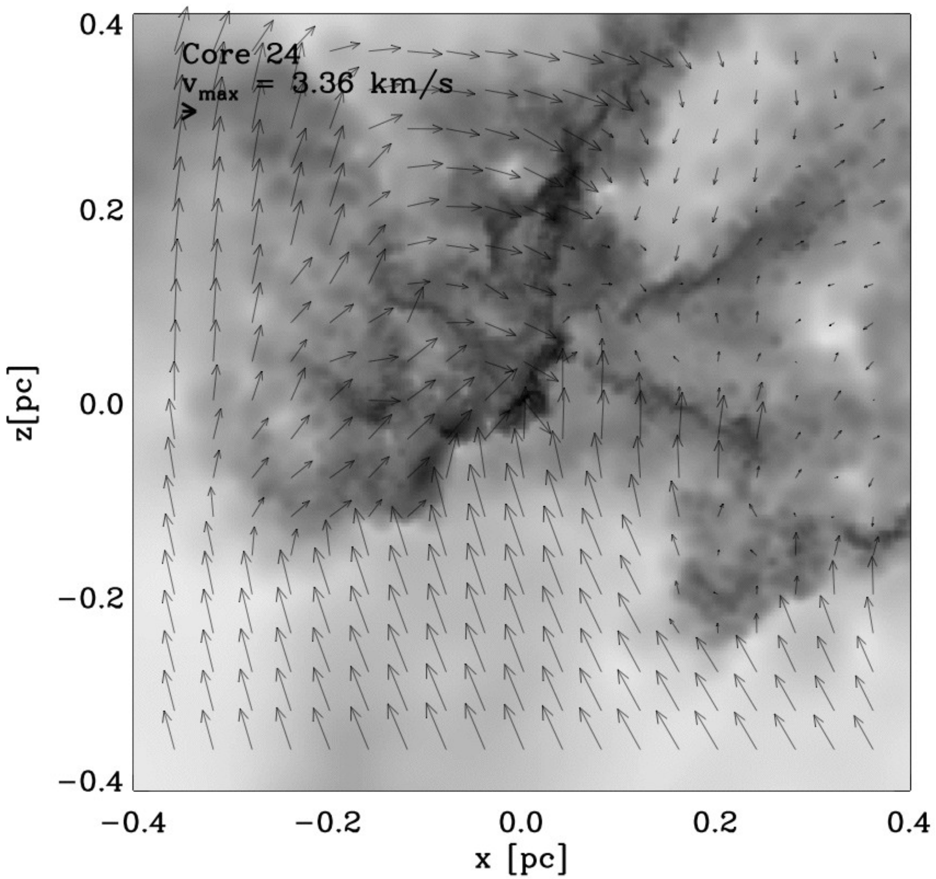




Massive stars formed where filament converge, and there is a large scale collapse across the region.

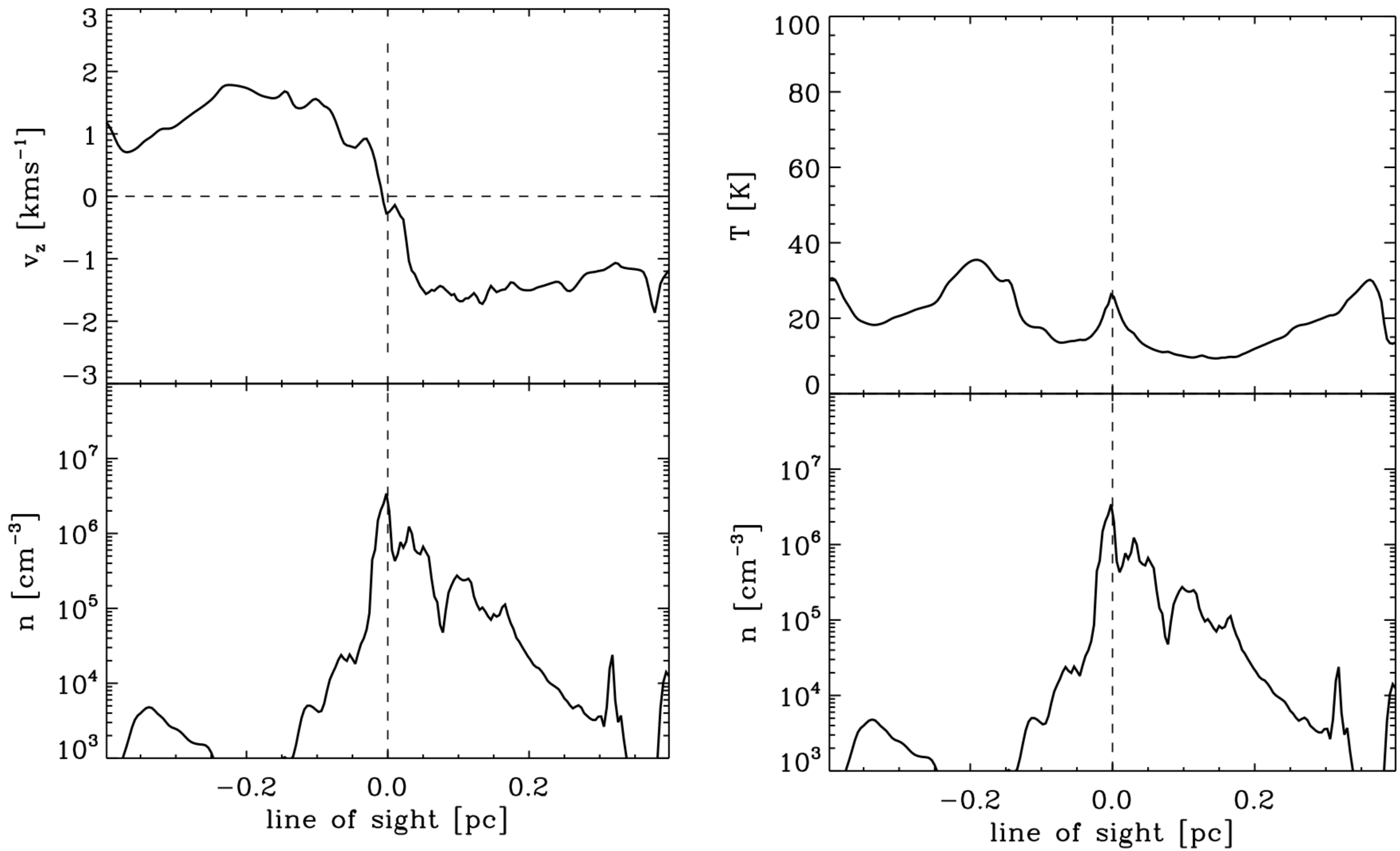
Velocity Field





The velocity fields evolve with time.

Temperatures and Velocities



Line Profiles

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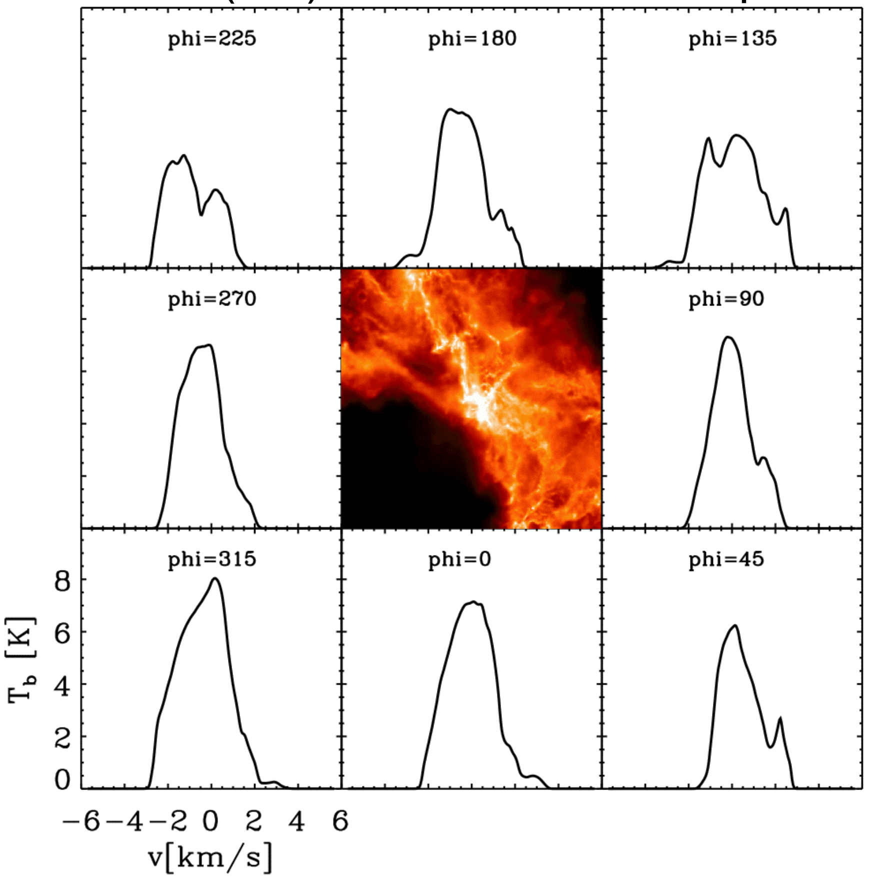
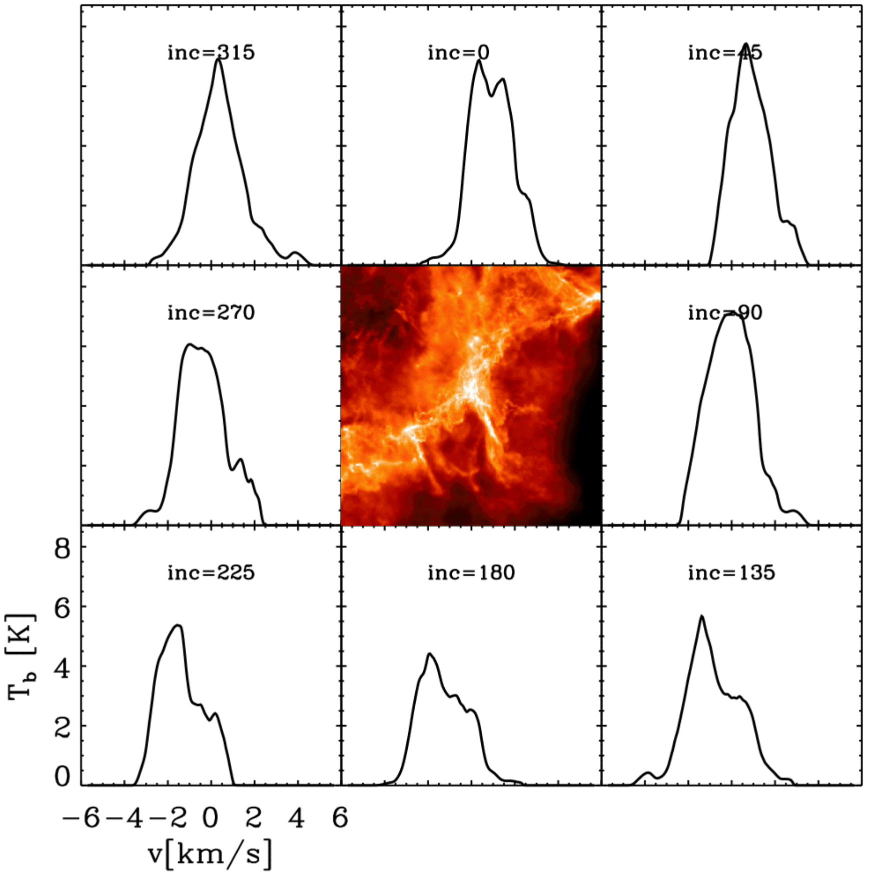
Thick Profiles

HCO⁺ (1-0) observed over 0.06pc HWFM beam



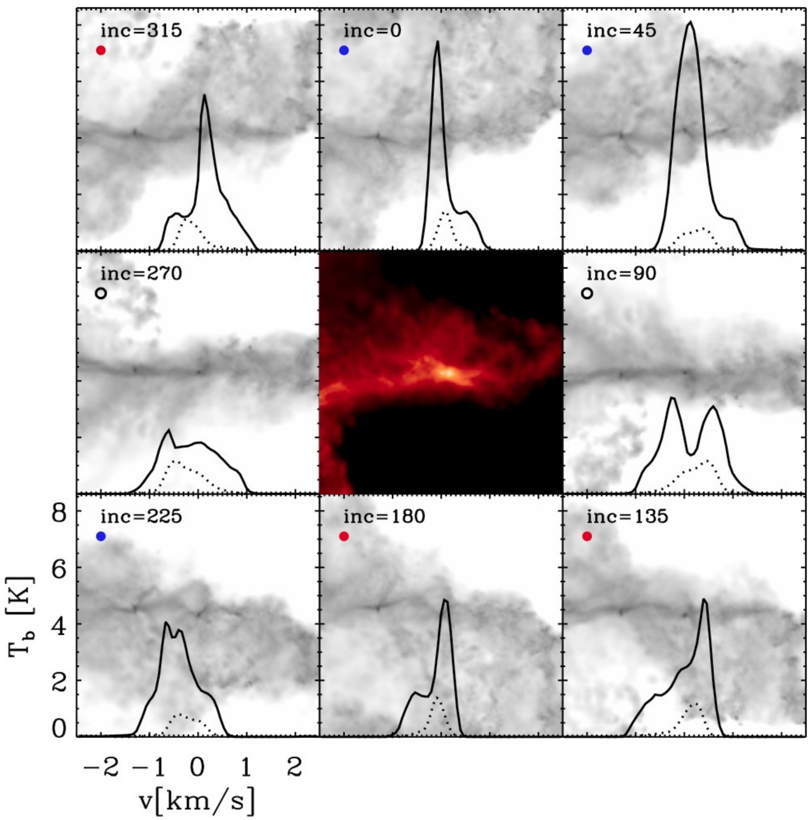


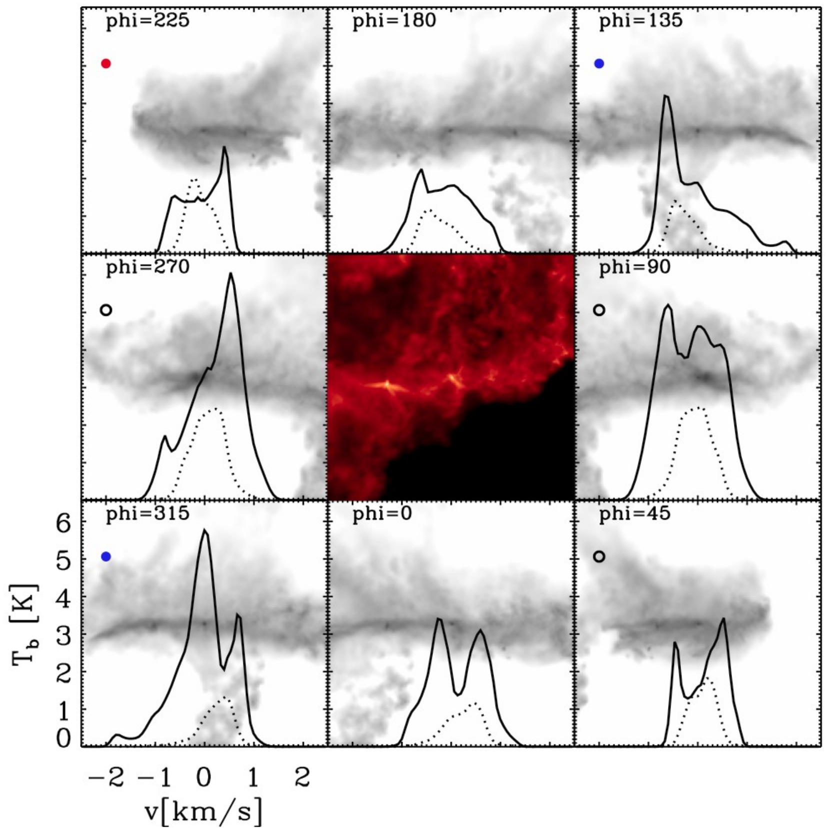
Unlike lower mass cores there are blue shifted profiles from all directions.

Lower Mass profiles

Line profiles are highly dependent on viewing angle.

Profiles, contain blue, red and ambiguous asymmetries.

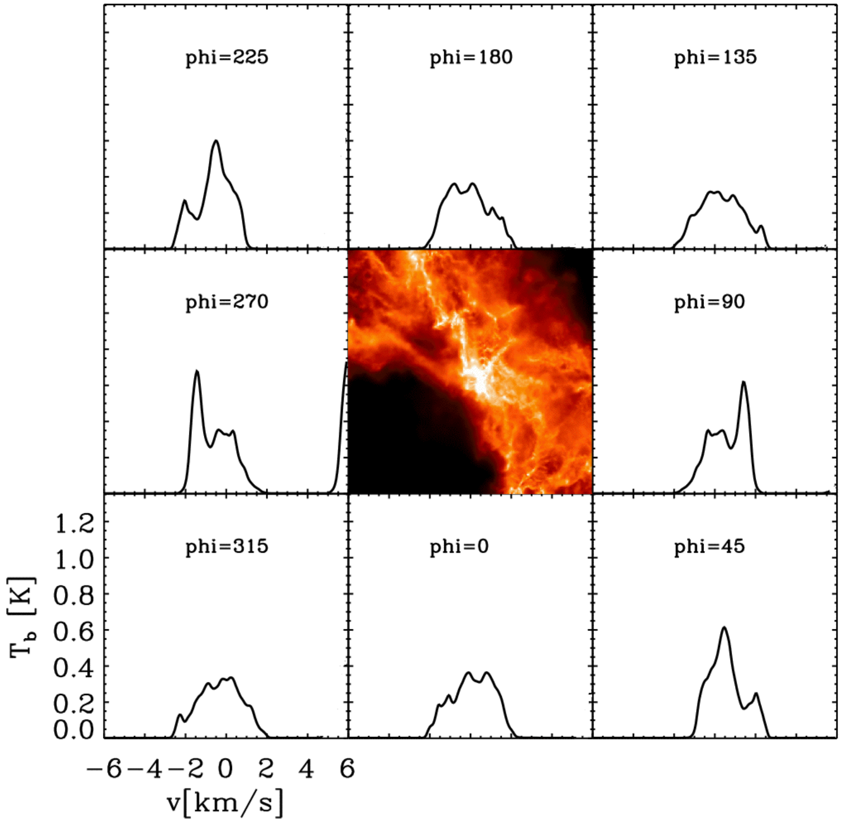


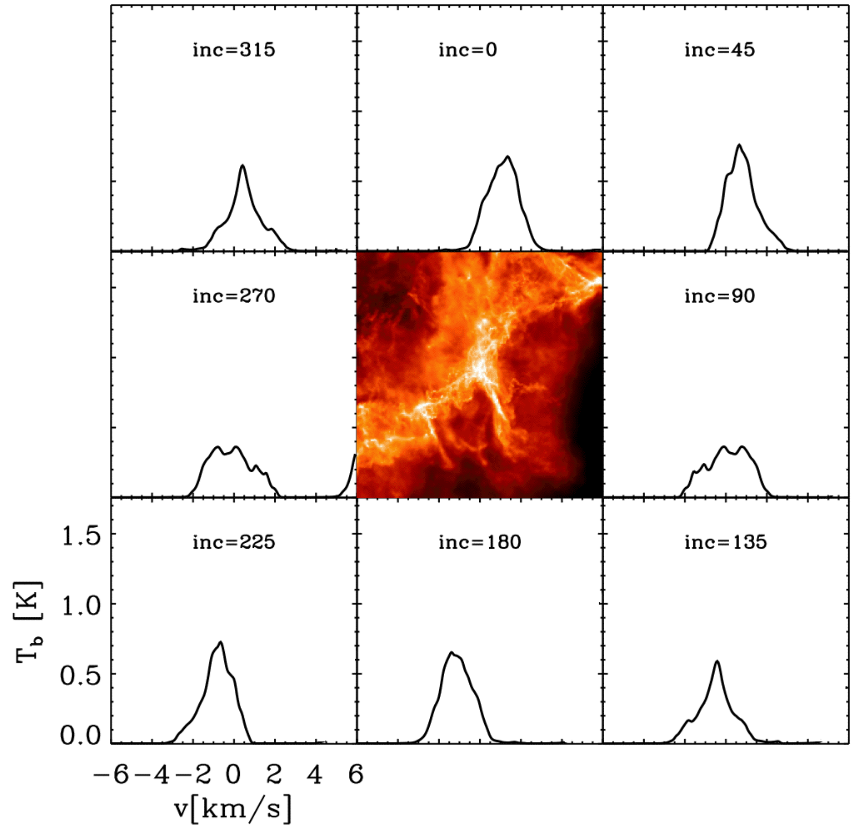


Smith et. al. 2012

Thin Profiles

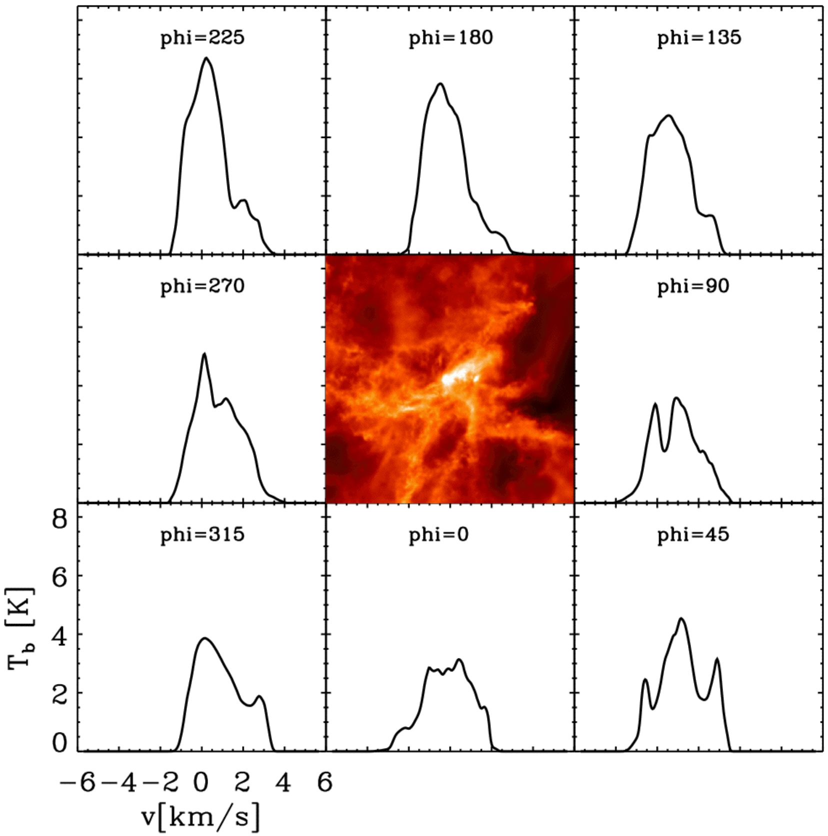
N_2H^+ (1-0) isolated hyperfine component observed over 0.06pc HWFM beam

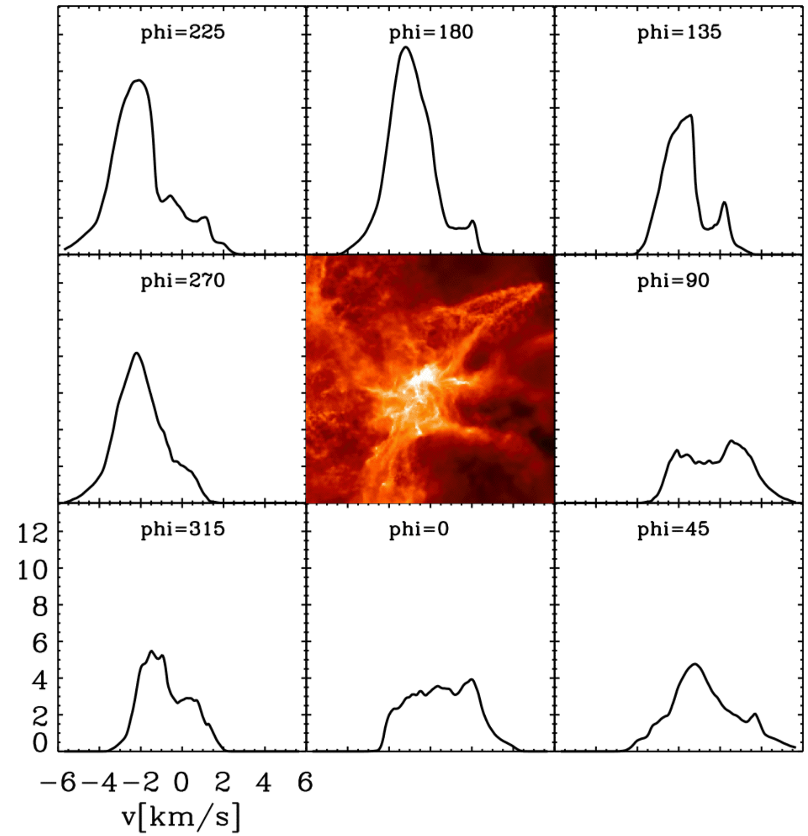




Multiple components in the optically thin lines.

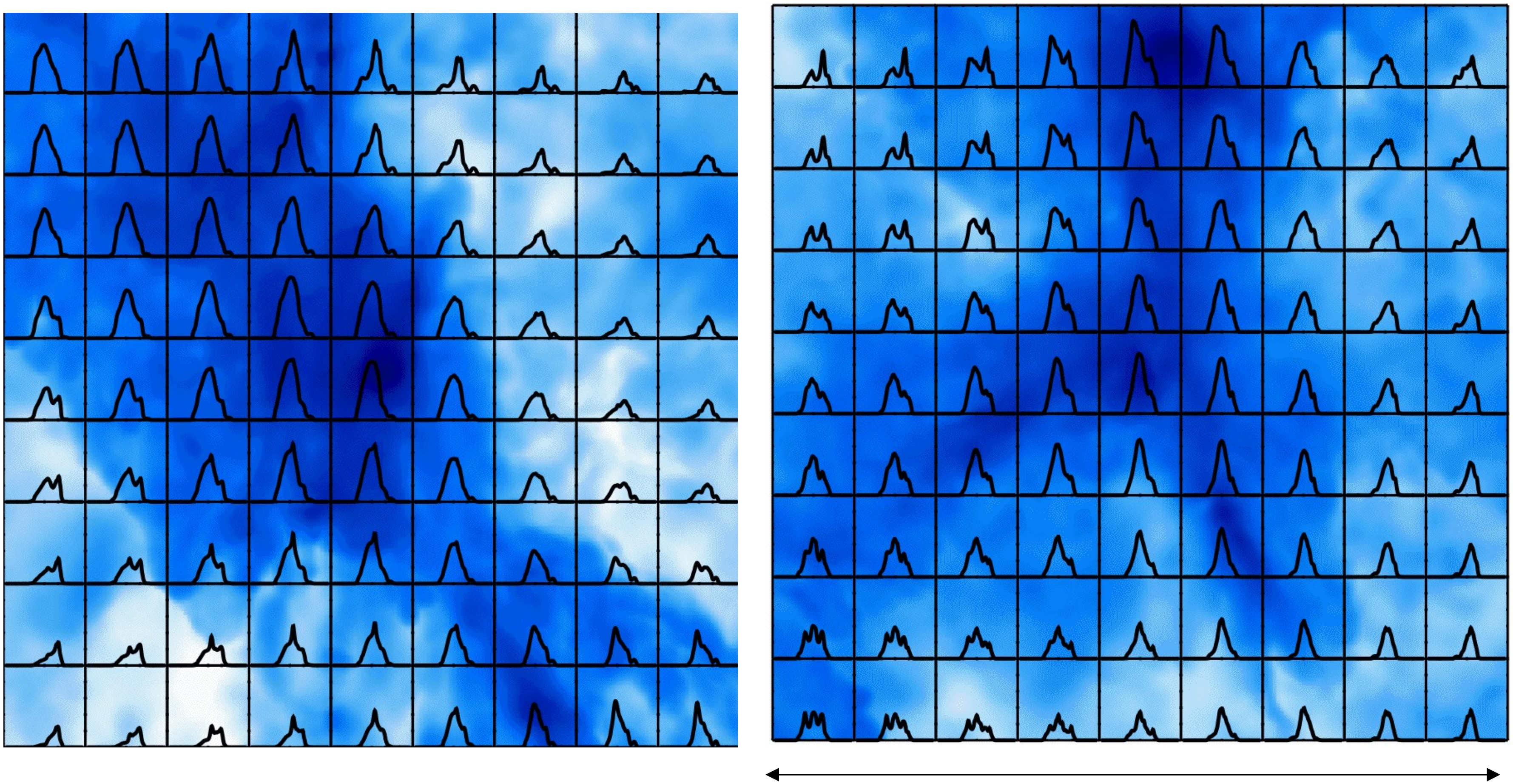
Time Evolution





Profiles tend to get brighter and span a wider velocity range as the region evolves.

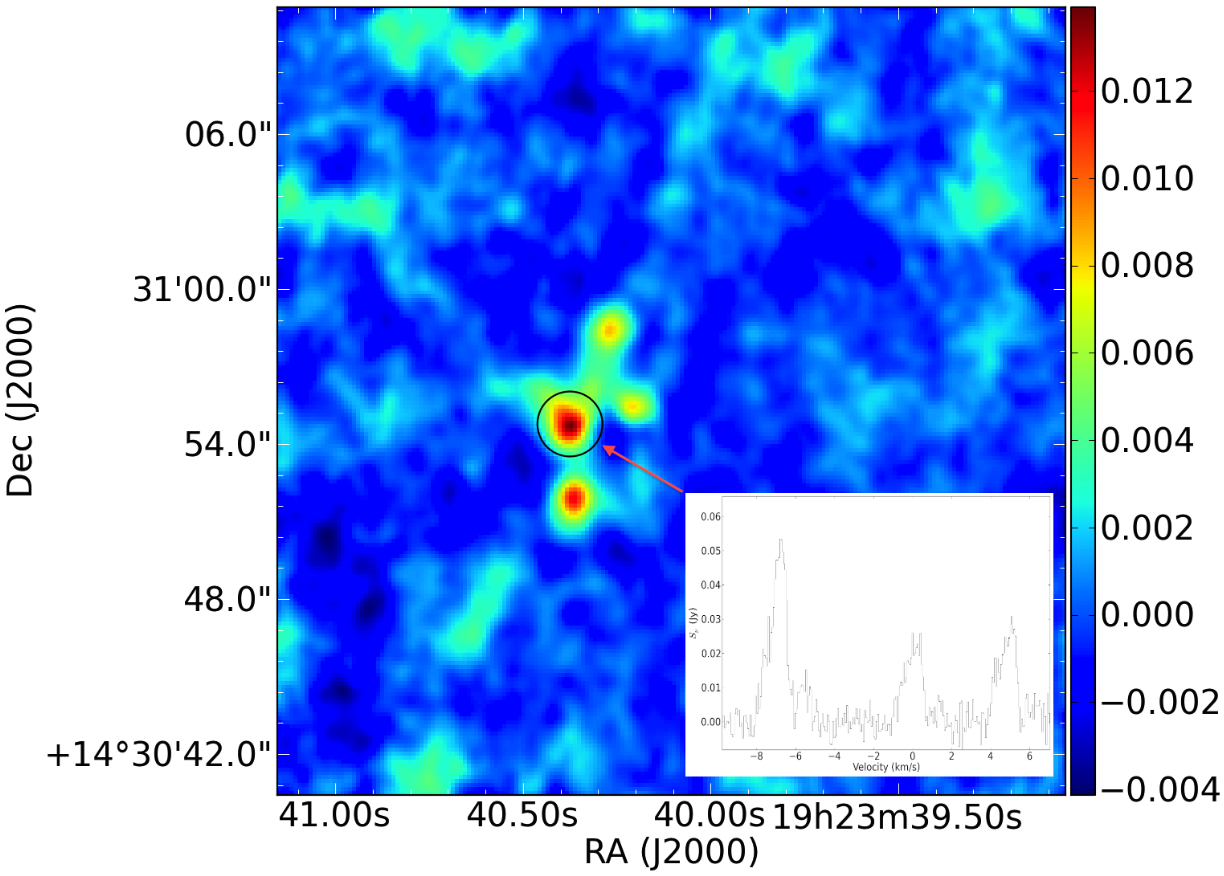
Line Maps



0.8 pc

Collapse motions across the majority of the dense gas.

ALMA



Predicted observation at distance of W51 (d=5.4kpc) in HCN(1-0)

Conclusions

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Conclusions

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