

# Filamentary Accretion Flows in the IRDC M17 SWex

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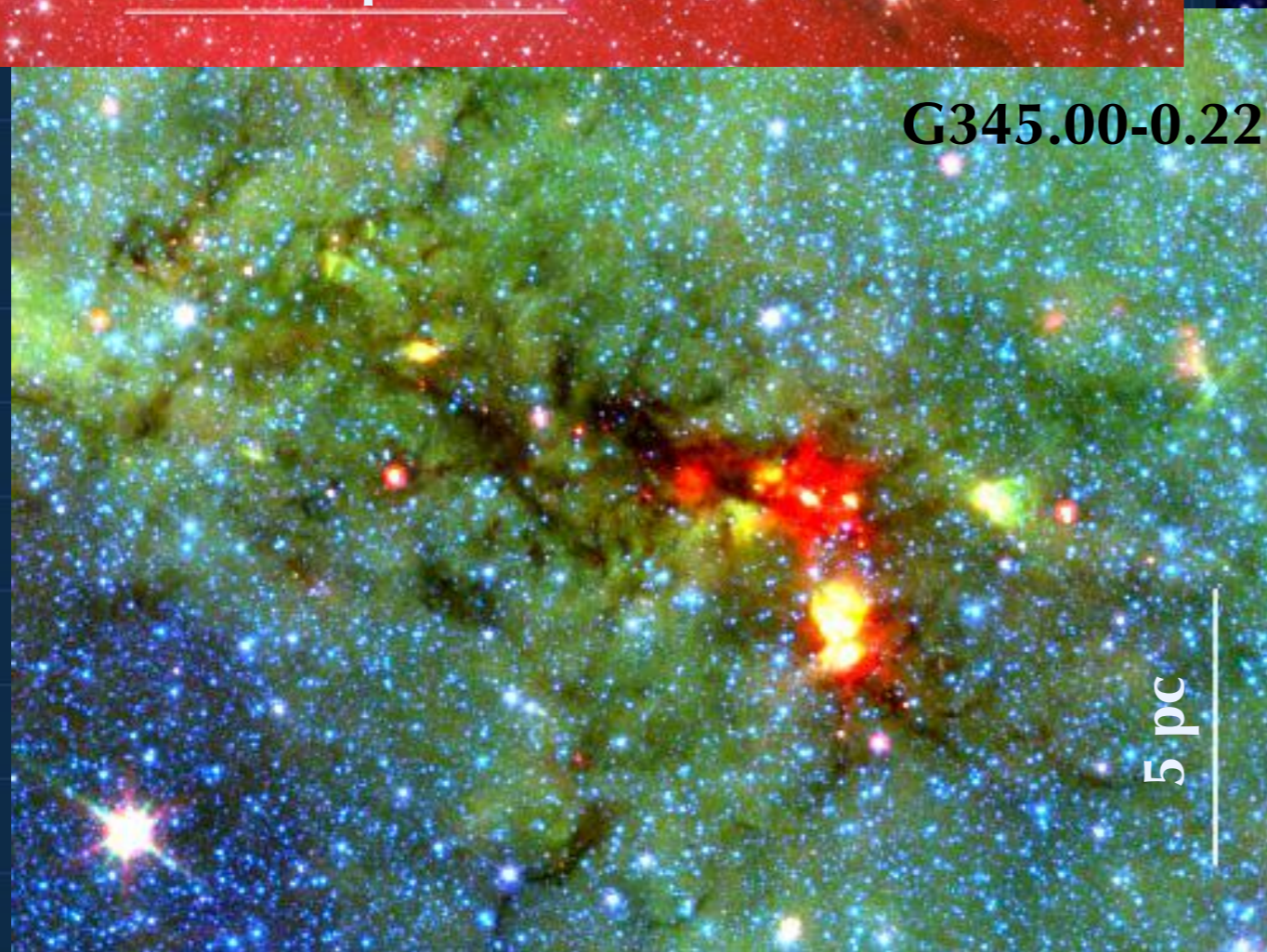
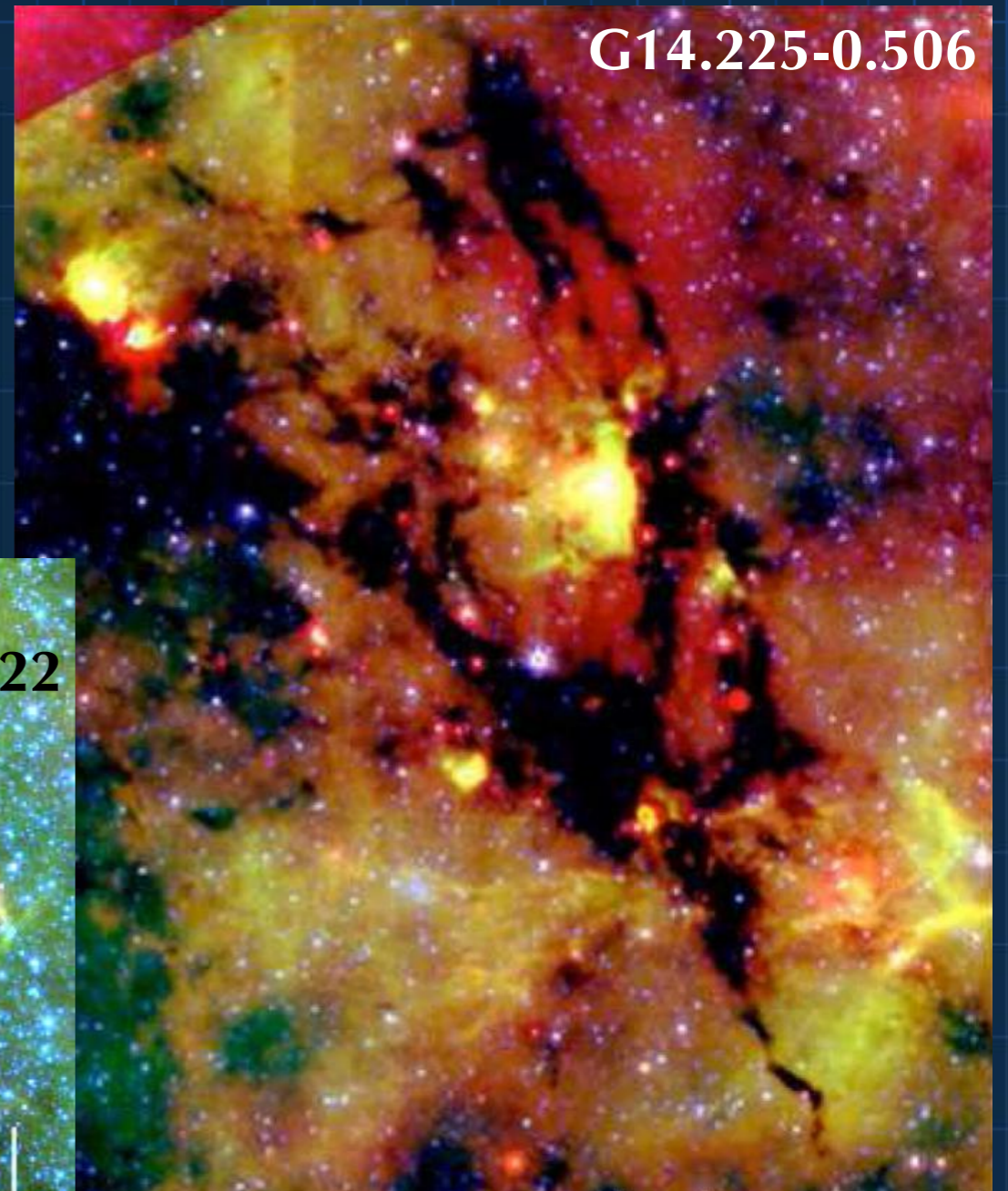
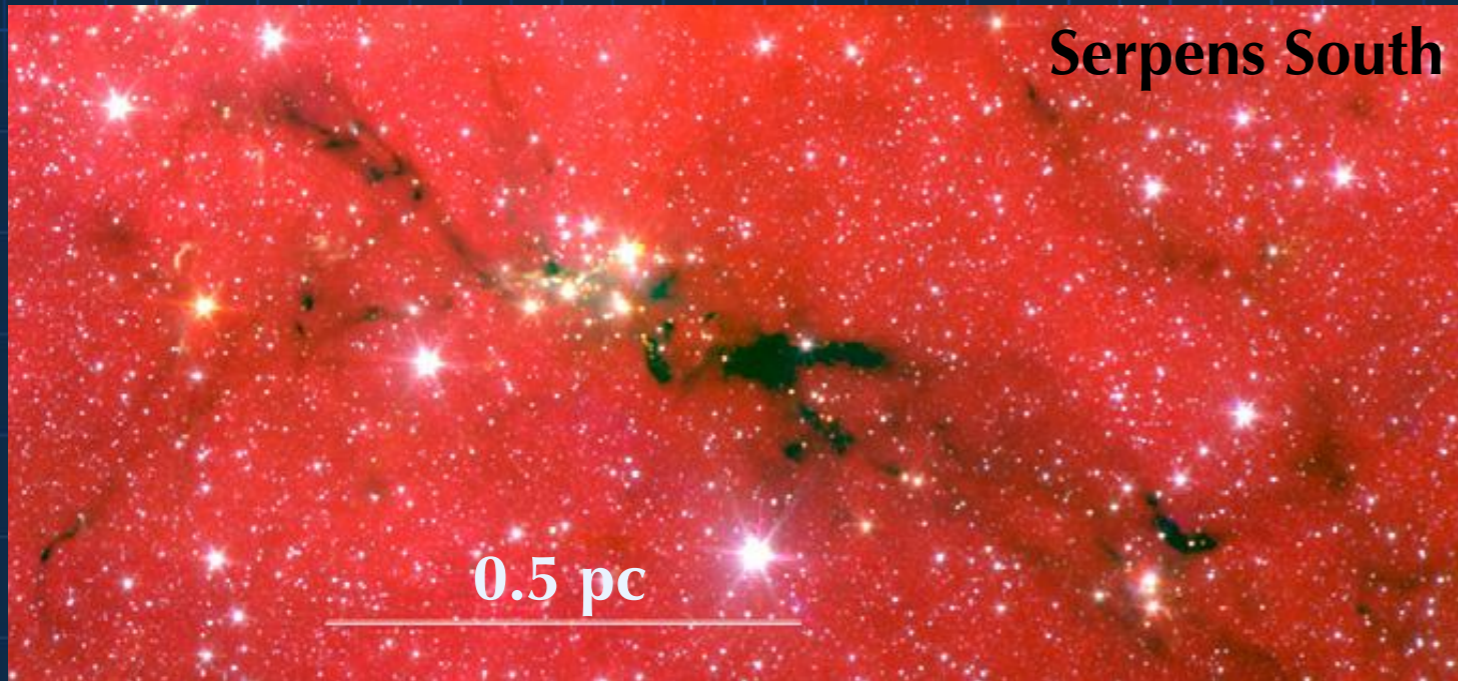
Fumitaka Nakamura, Qizhou Zhang, Gemma Busquet, Patricio Sanhueza,  
Satoshi Ohashi, Ania Palau, Ken Tatematsu

August 7, 2017

Star Formation in Different Environment @ Qui Nhon, Vietnam



# Hubs and Filaments

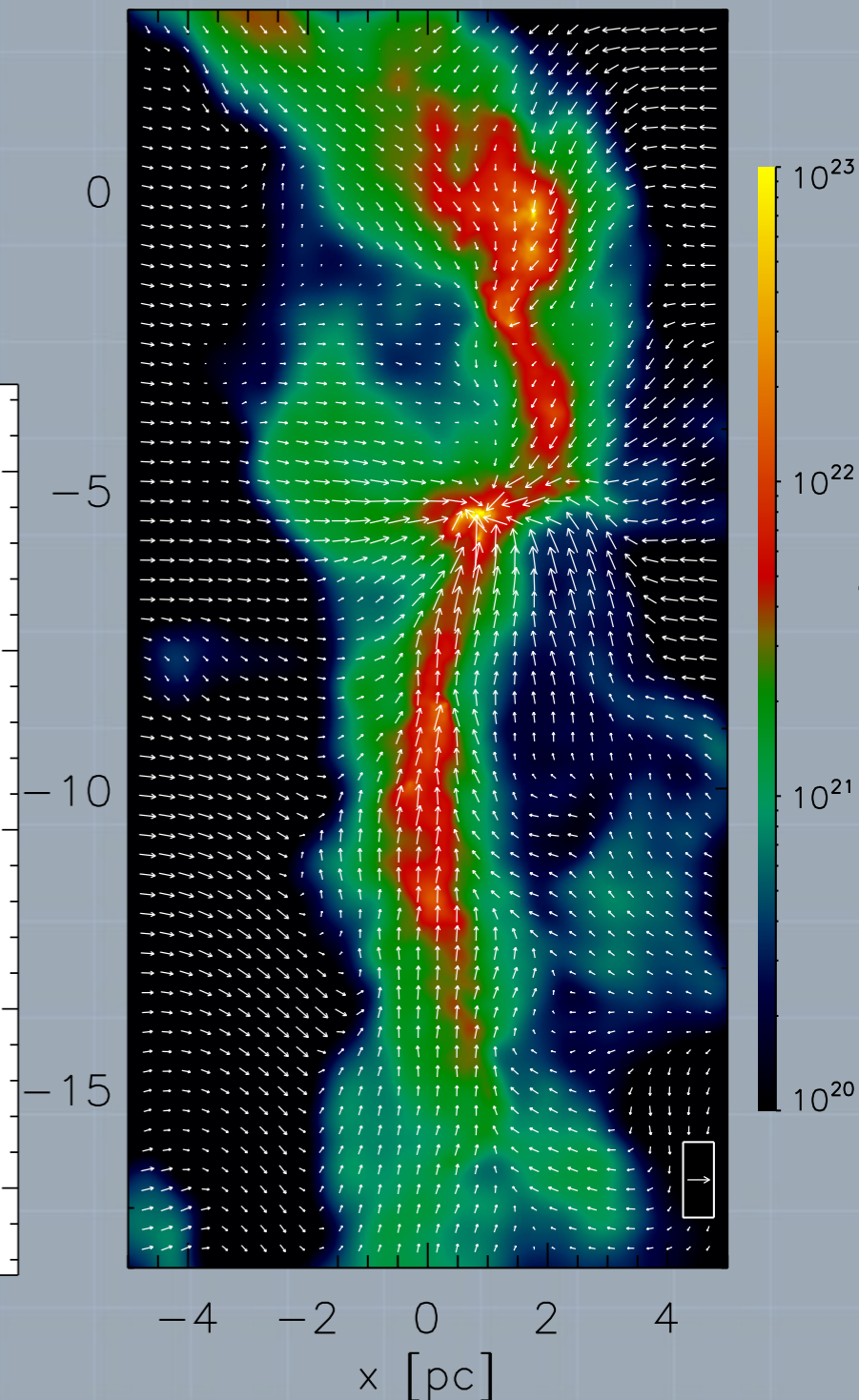
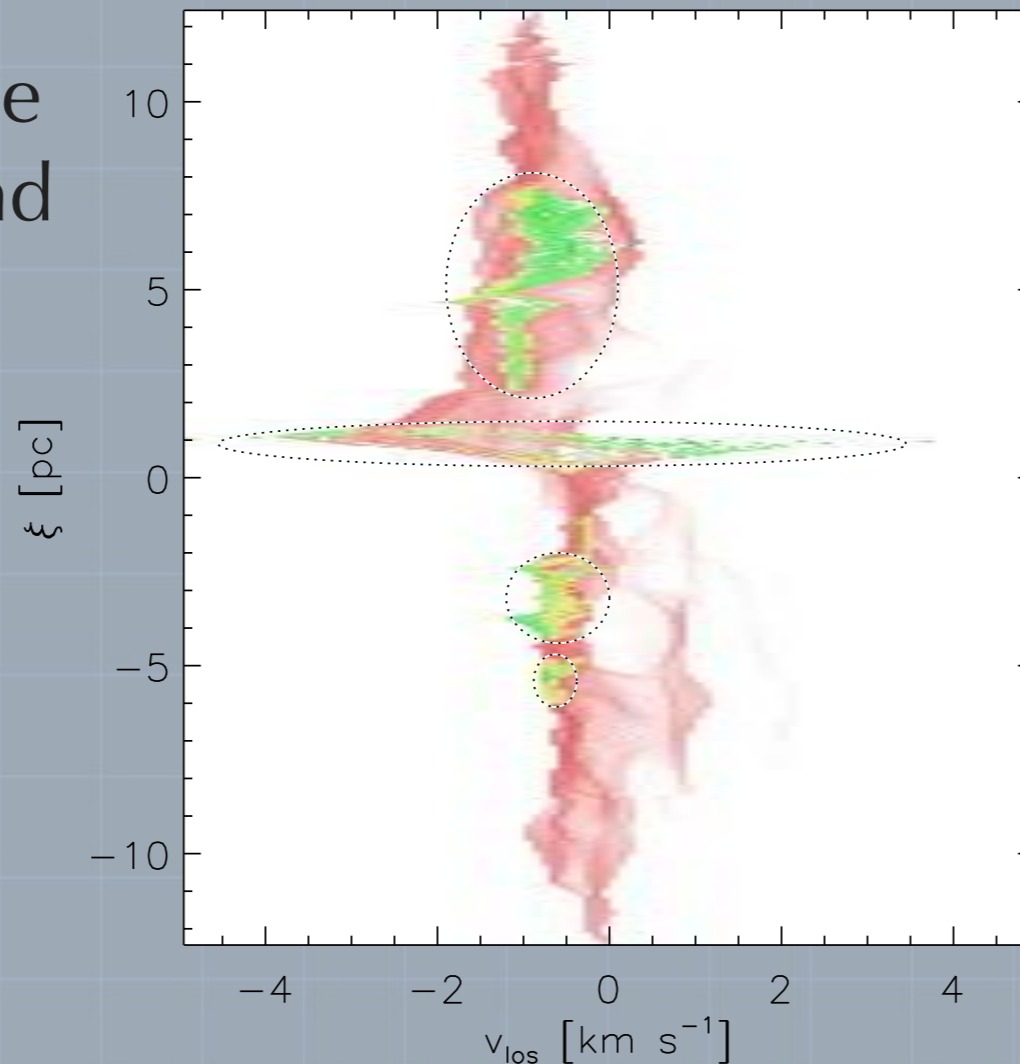


Myers 2009, Busquet et al. 2013,  
See also Andre et al. 2010,  
Arzoumanian et al. 2011, etc.

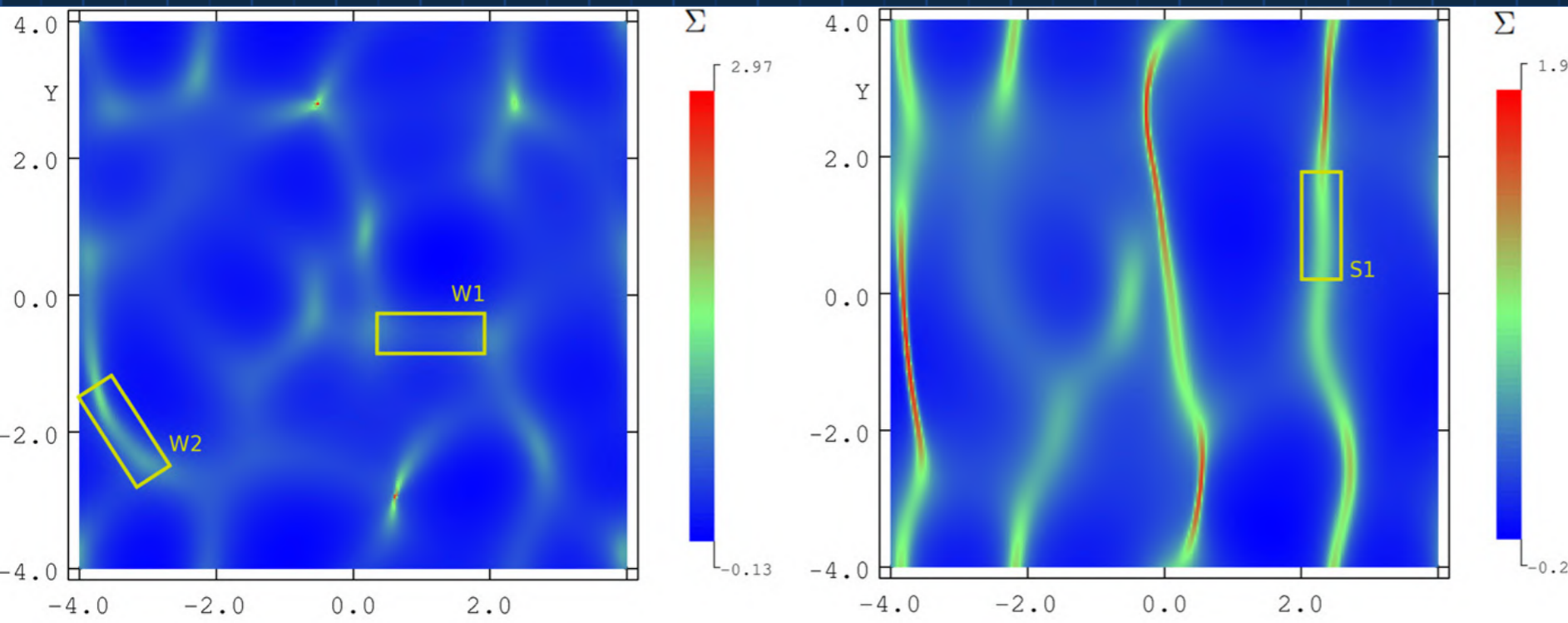


# Filamentary Molecular Clouds

- Natural product of colliding flows in the WNM (Gómez & Vázquez-Semadeni 2014)
- Long-lived flow
- Accrete from the environment and onto clumps



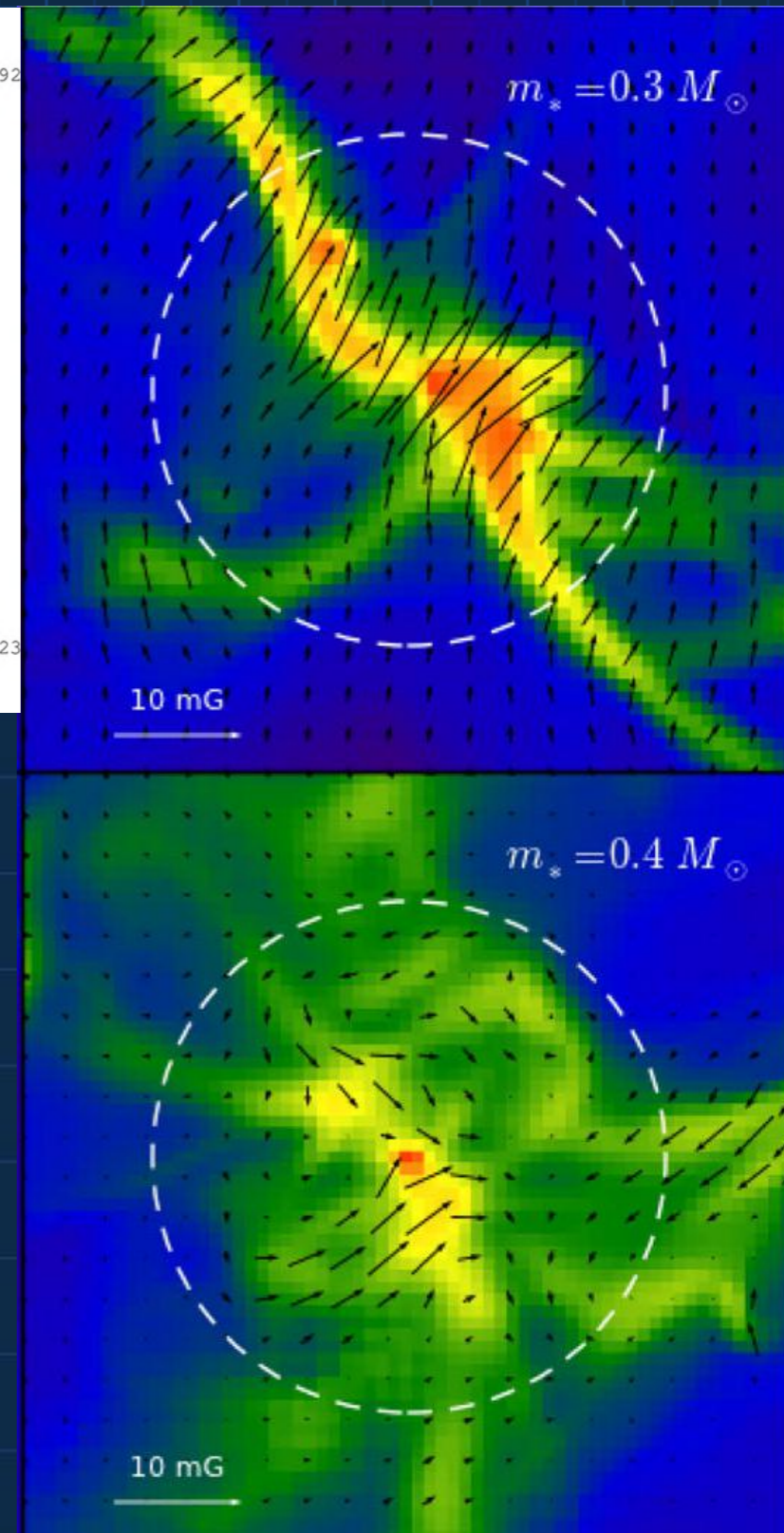
# Configuration of Filaments



Van Loo, Keto, & Zhang 2014

- Competing effects between turbulence and magnetic field
- Parallel filaments (strong B)  
Spiderweb-like filaments (weak B)

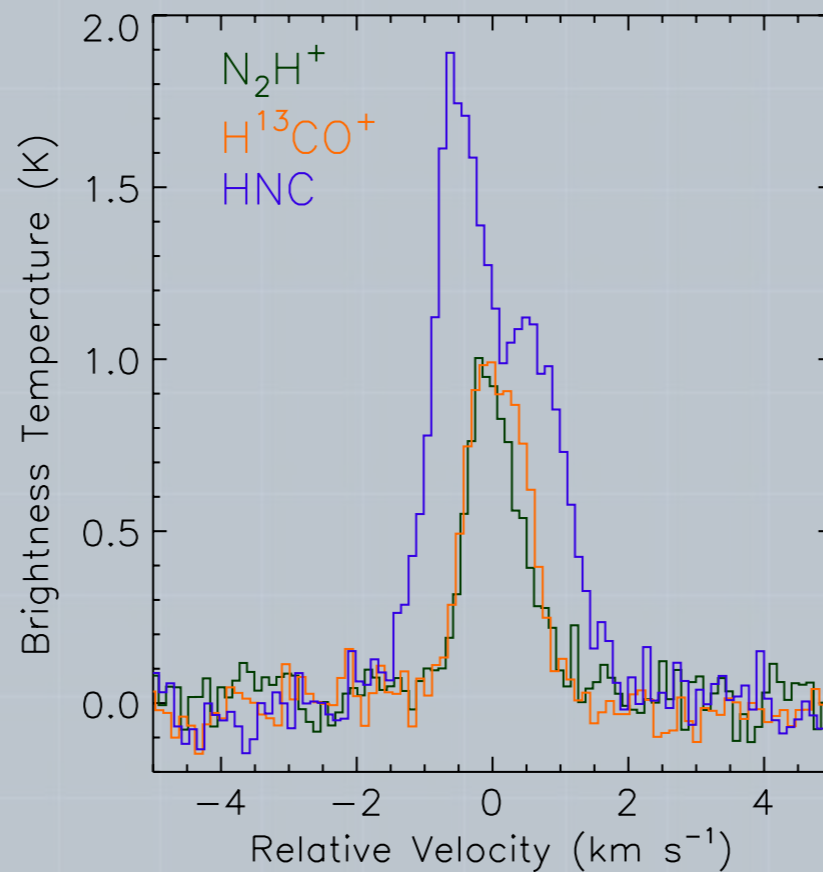
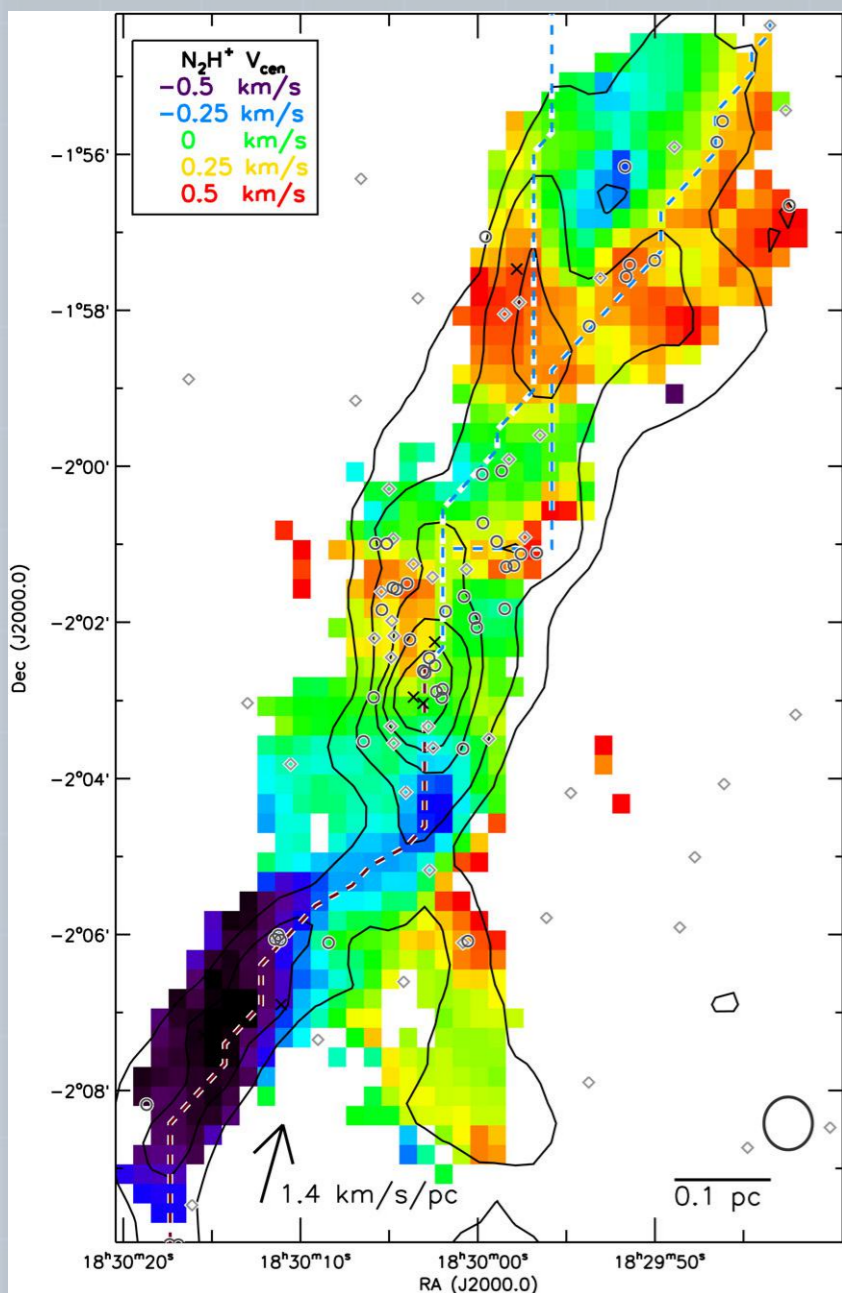
Myers et al. 2014; Chen, King, & Li 2016



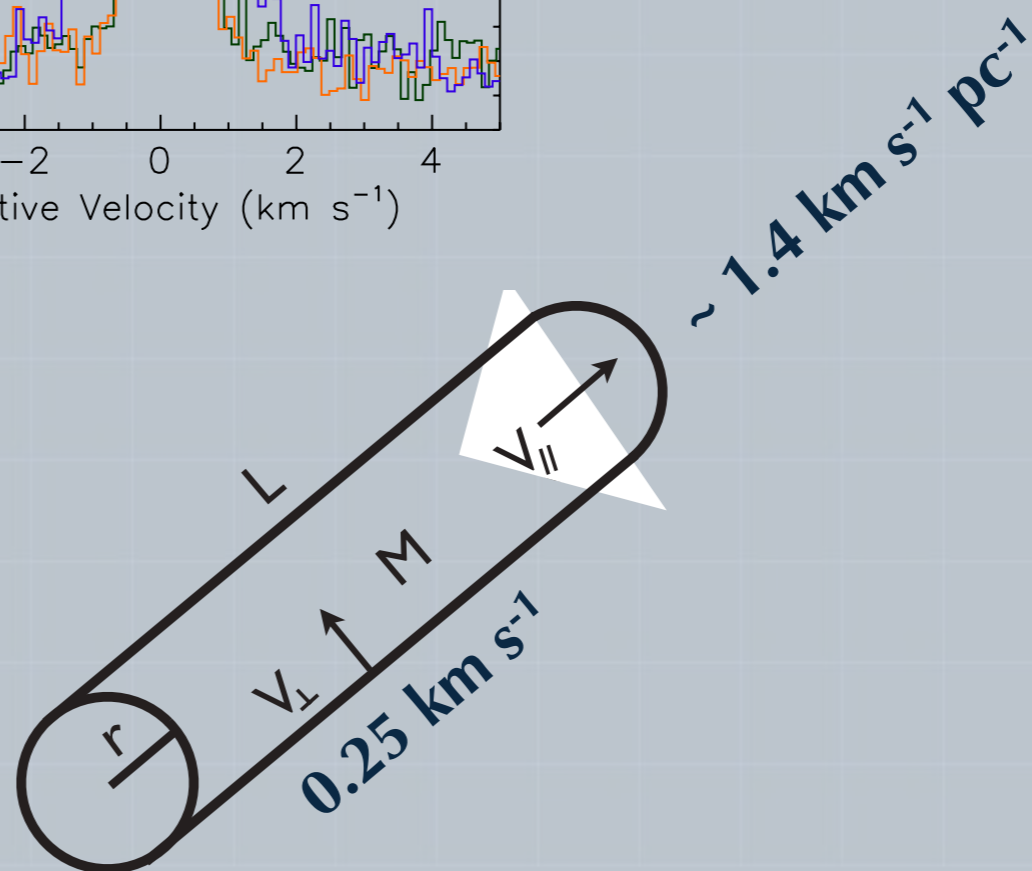


# Accretion along and onto Filaments in Serpens South

Kirk et al. 2013



- Inflow along filament  
~ 30  $M_{\odot} \text{ Myr}^{-1}$
- Radial contraction onto filament  
~ 130  $M_{\odot} \text{ Myr}^{-1}$

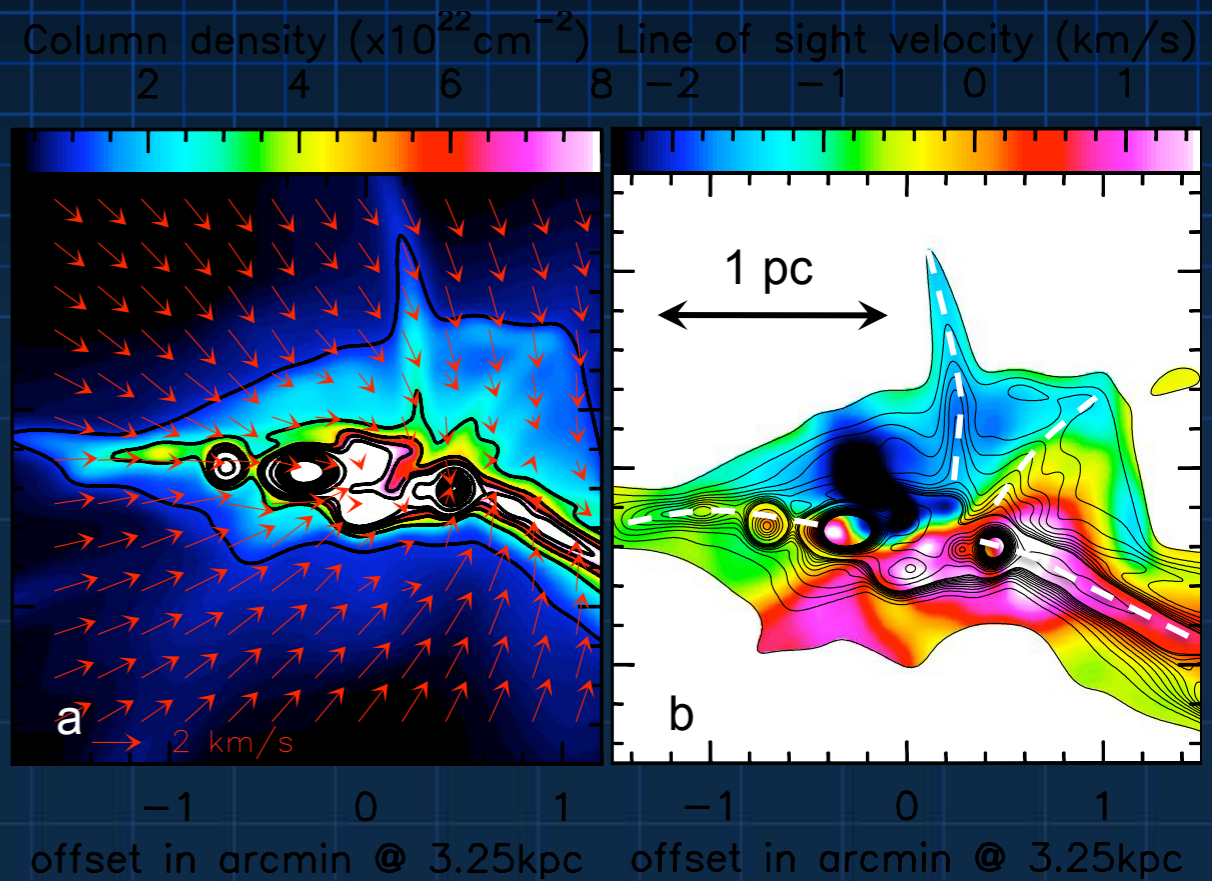


# Filamentary Accretion Flows

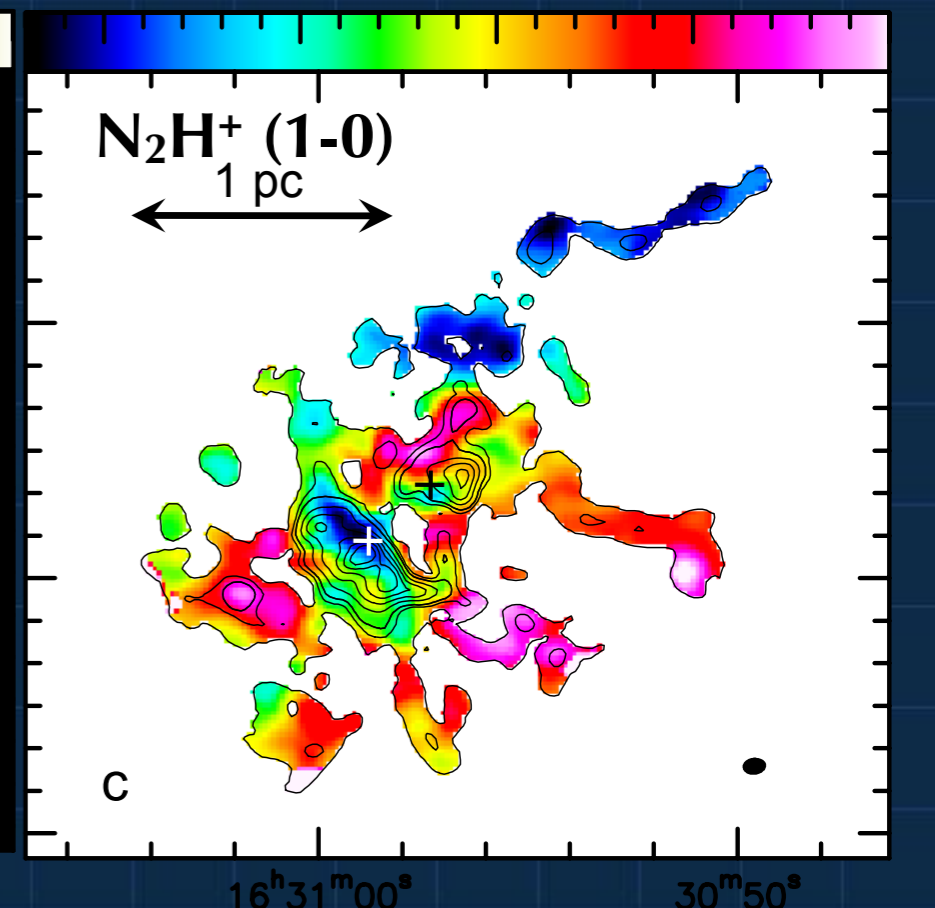
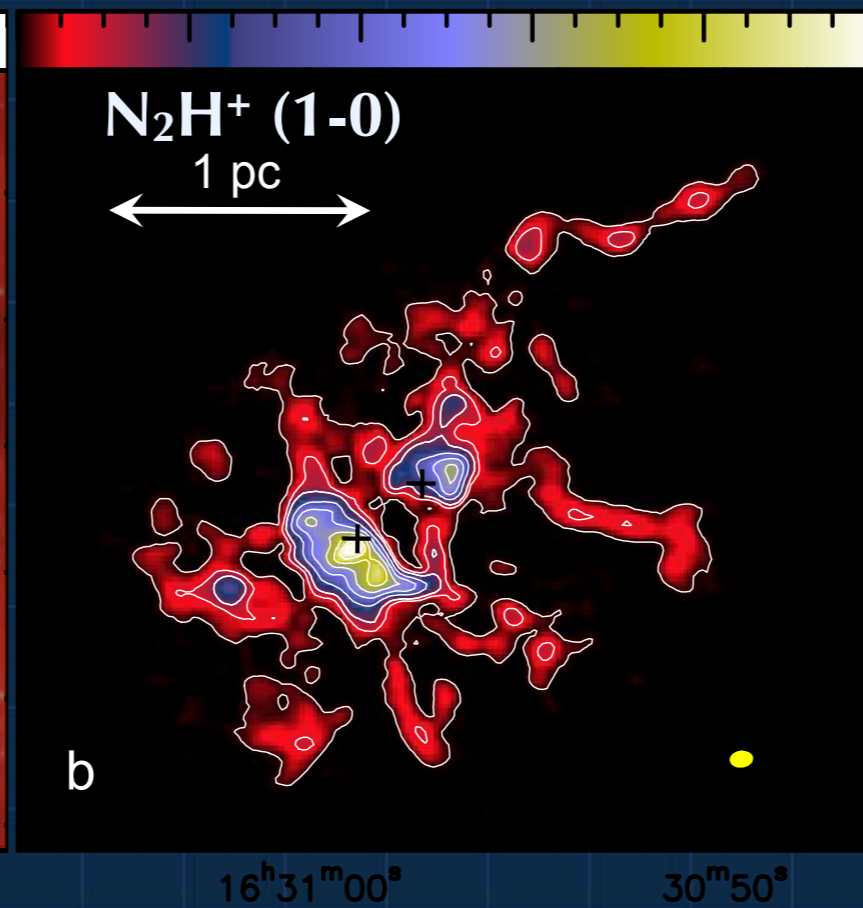
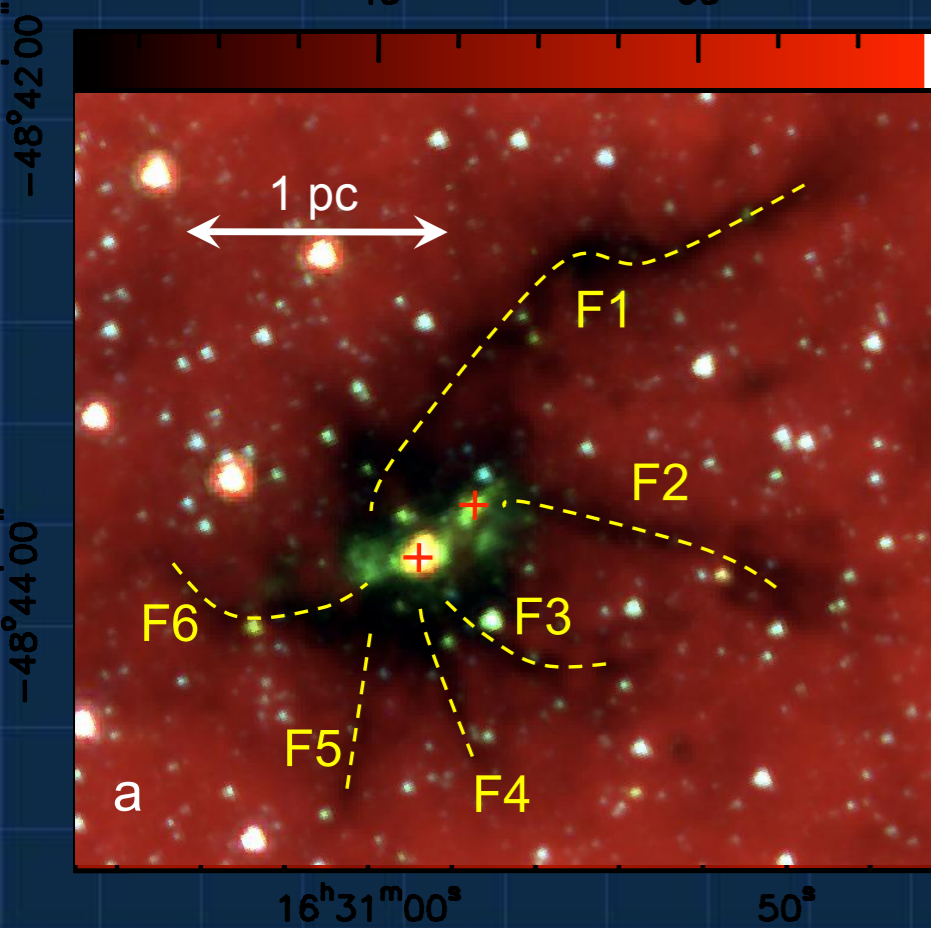
○ Accretion rate  $\sim 2 \times 10^{-3} M_{\odot} \text{ yr}^{-1}$

○  $\sim 20\%$  by filaments

## SDC 335 (ALMA+Mopra)

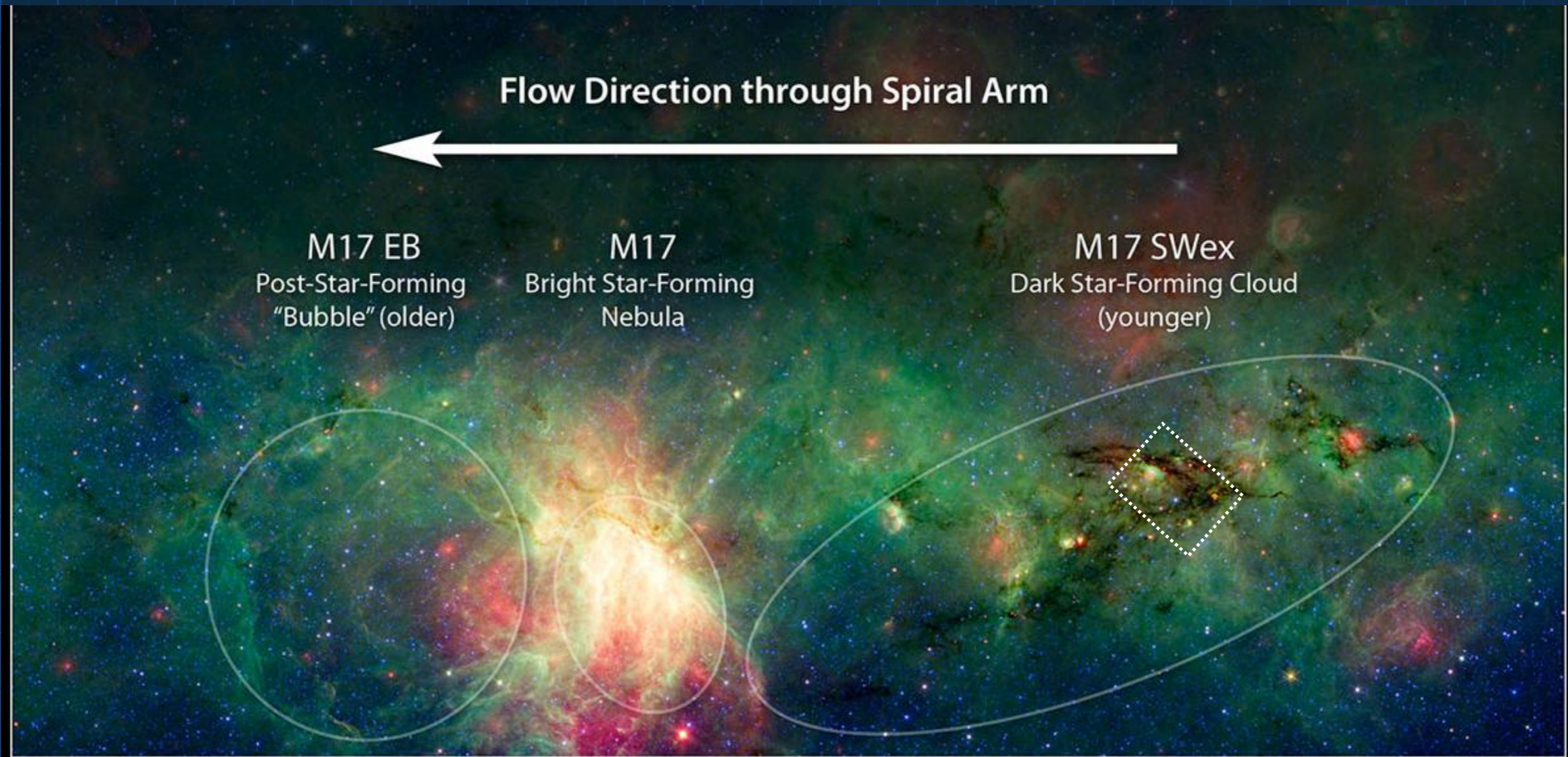


Peretto et al. 2013





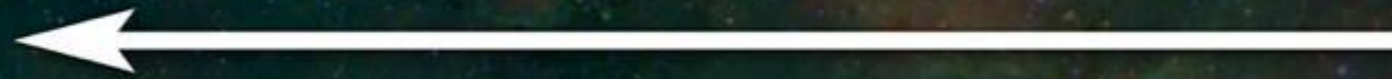
# Environment of G14.225-0.506





# Environment of G14.225-0.506

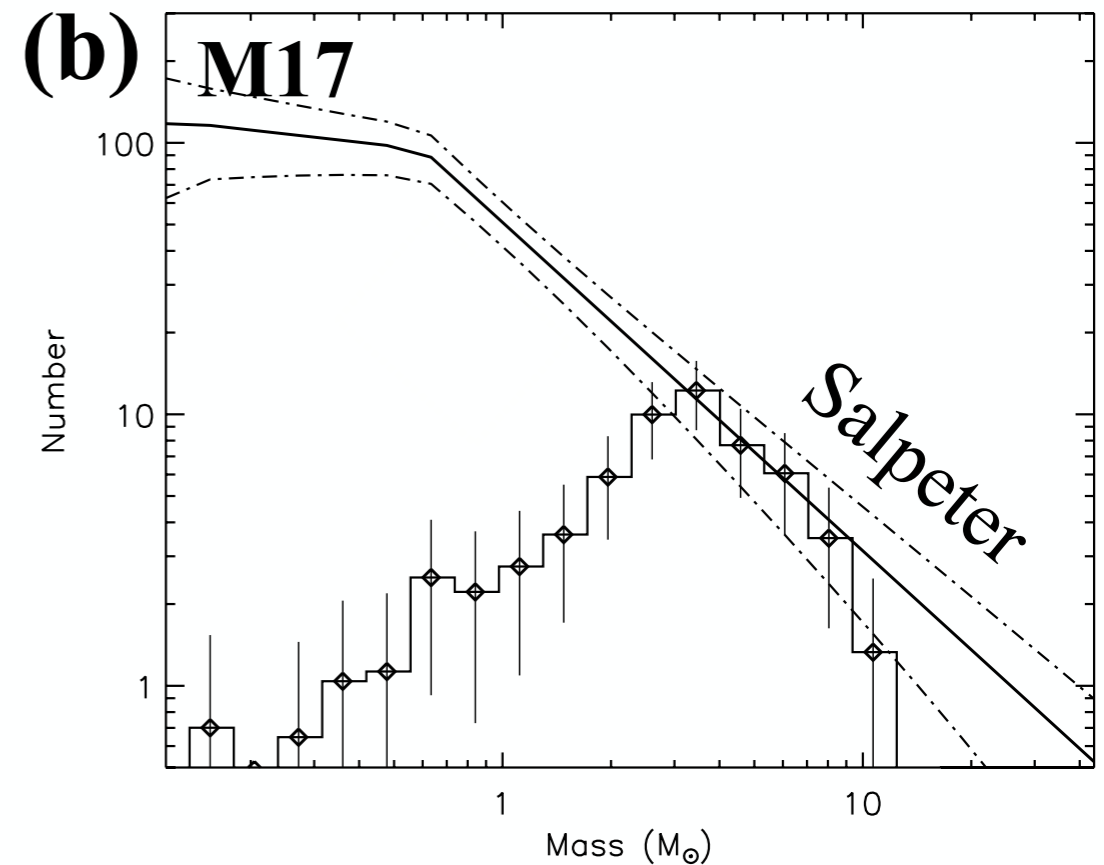
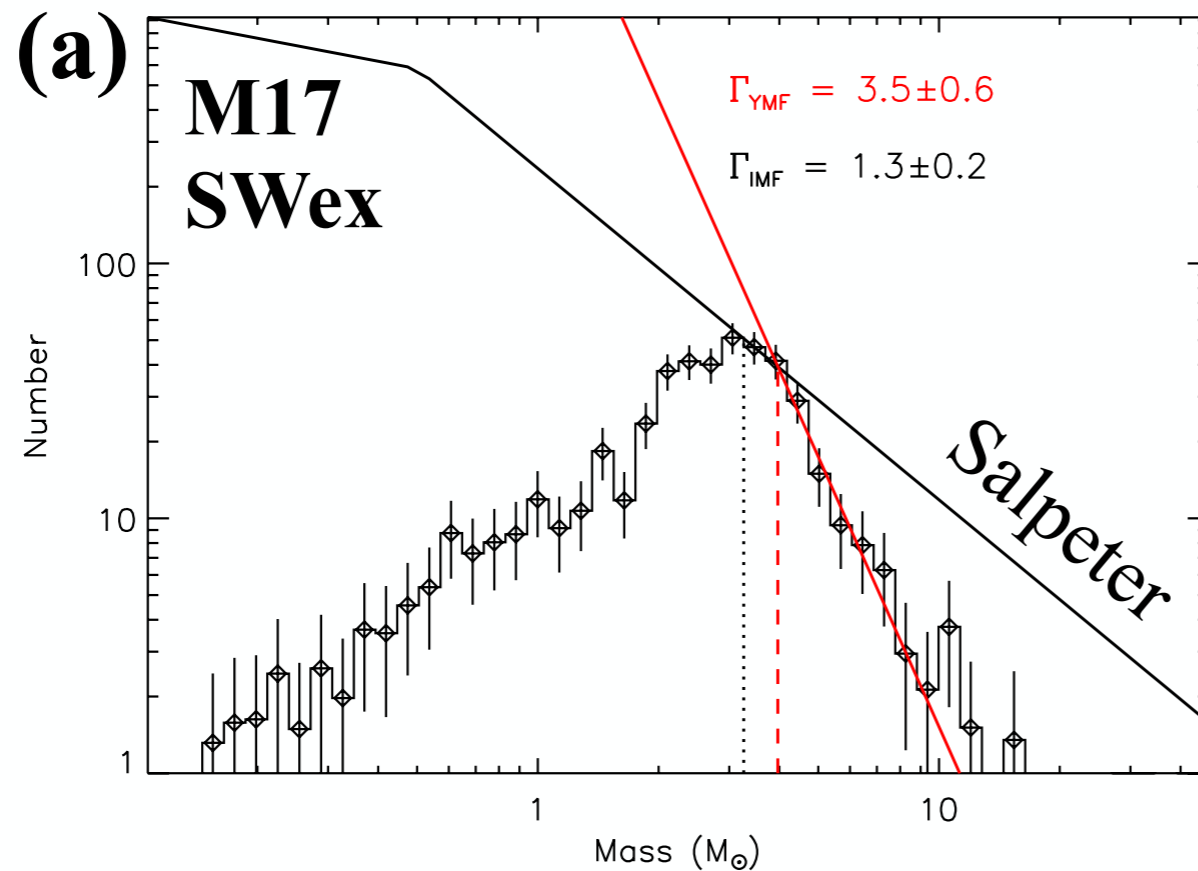
Flow Direction through Spiral Arm



M17 EB

M17

M17 SWex



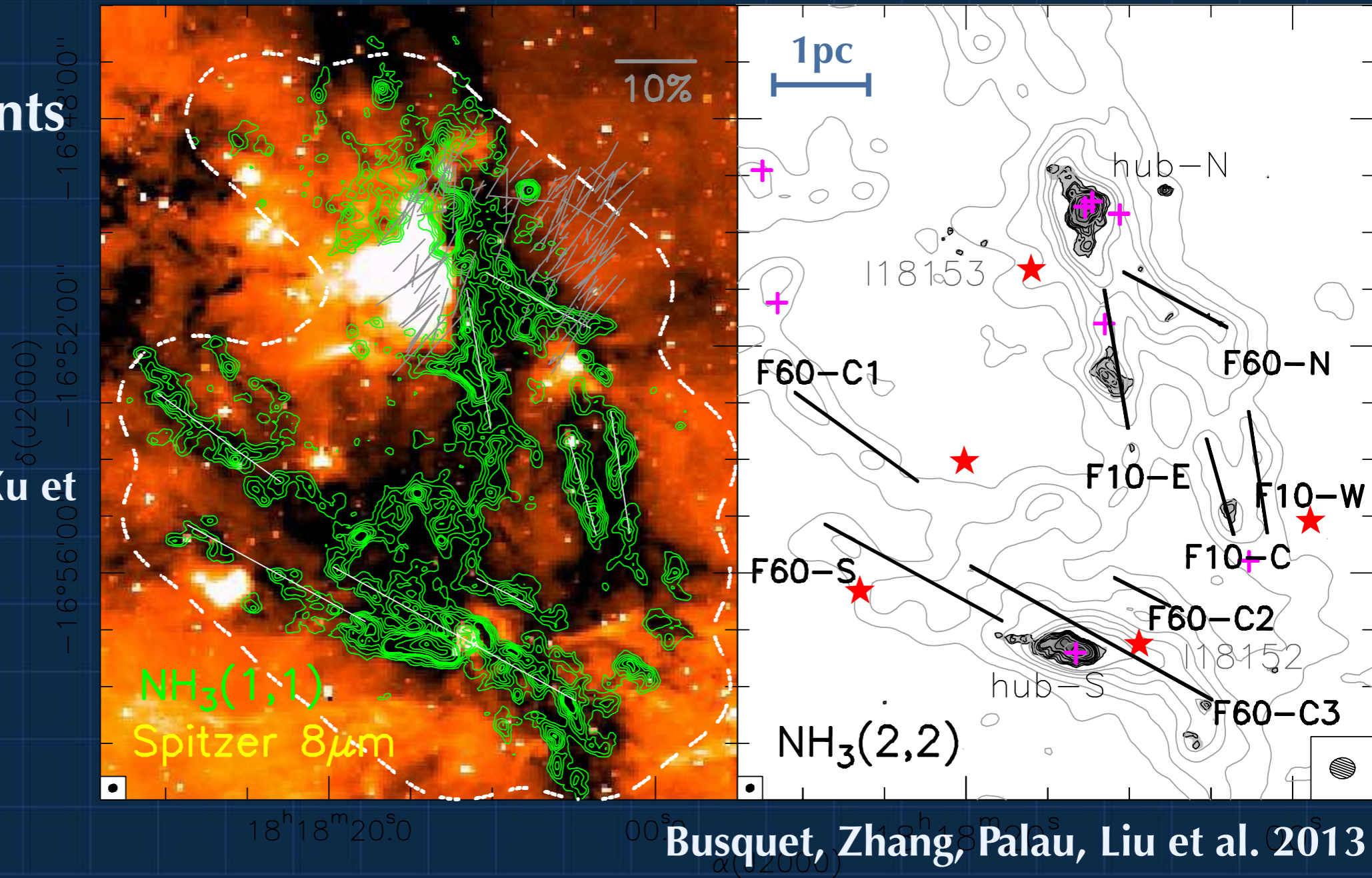
Povich & Whitney 2010; Povich et al. 2009

Spiral Arm



# Filamentary Networks

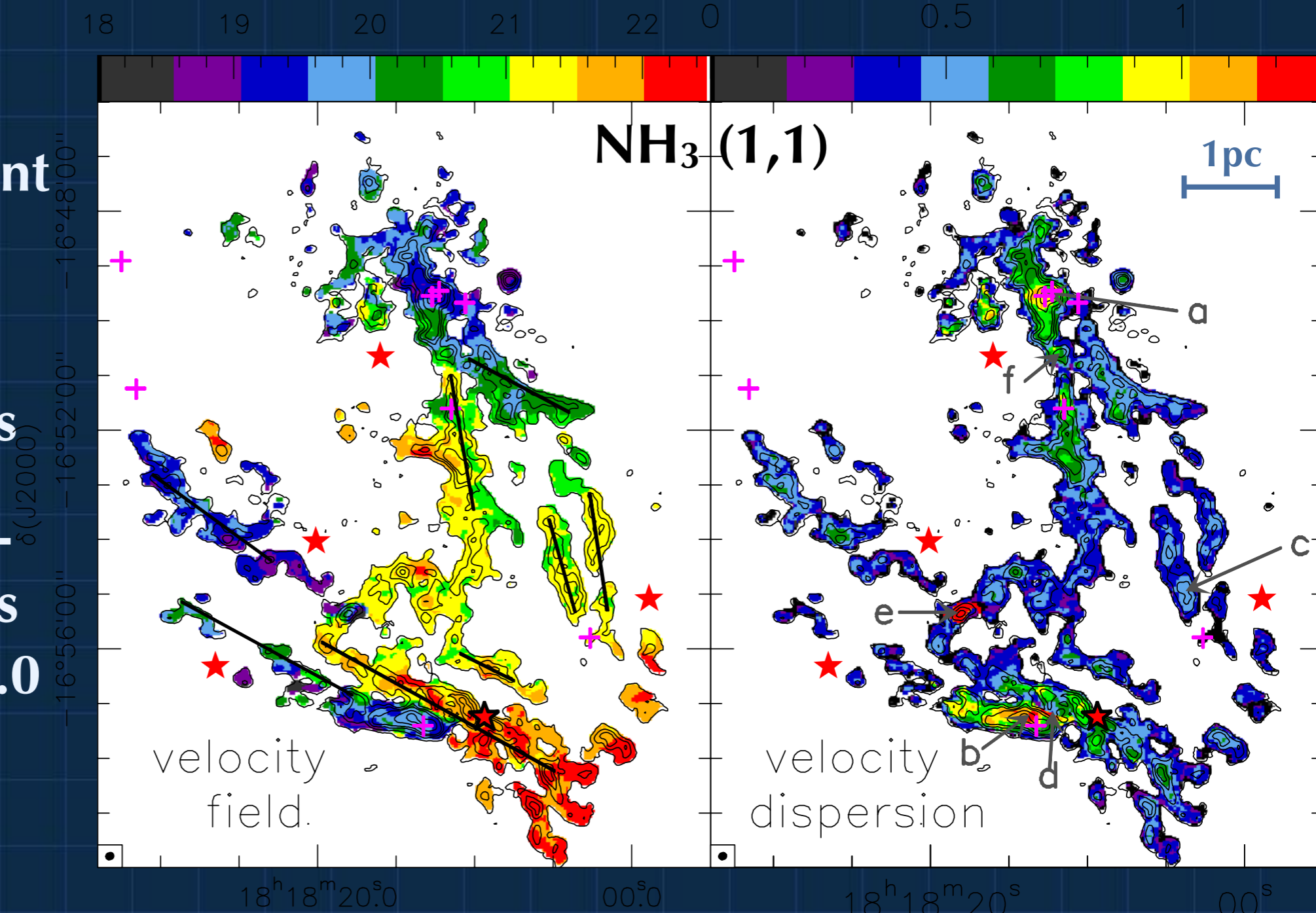
- A network of parallel filaments
- $T_{\text{gas}} \sim 10\text{-}18\text{ K}$
- Beam  $\sim 8''$  ( $\sim 0.08\text{ pc}$ ) at  $d = 1.98\text{ kpc}$  (Xu et al. 2011, Wu et al. 2014)





# Filamentary Networks

- Velocity coherent
- Larger velocity dispersion at converging hubs
- Supersonic non-thermal motions  
 $\sigma_{NT}/c_s \sim 2.3 - 5.0$



Busquet, Zhang, Palau, Liu et al. 2013



# ALMA Mosaic Observations

- Two mosaic fields in Band 3

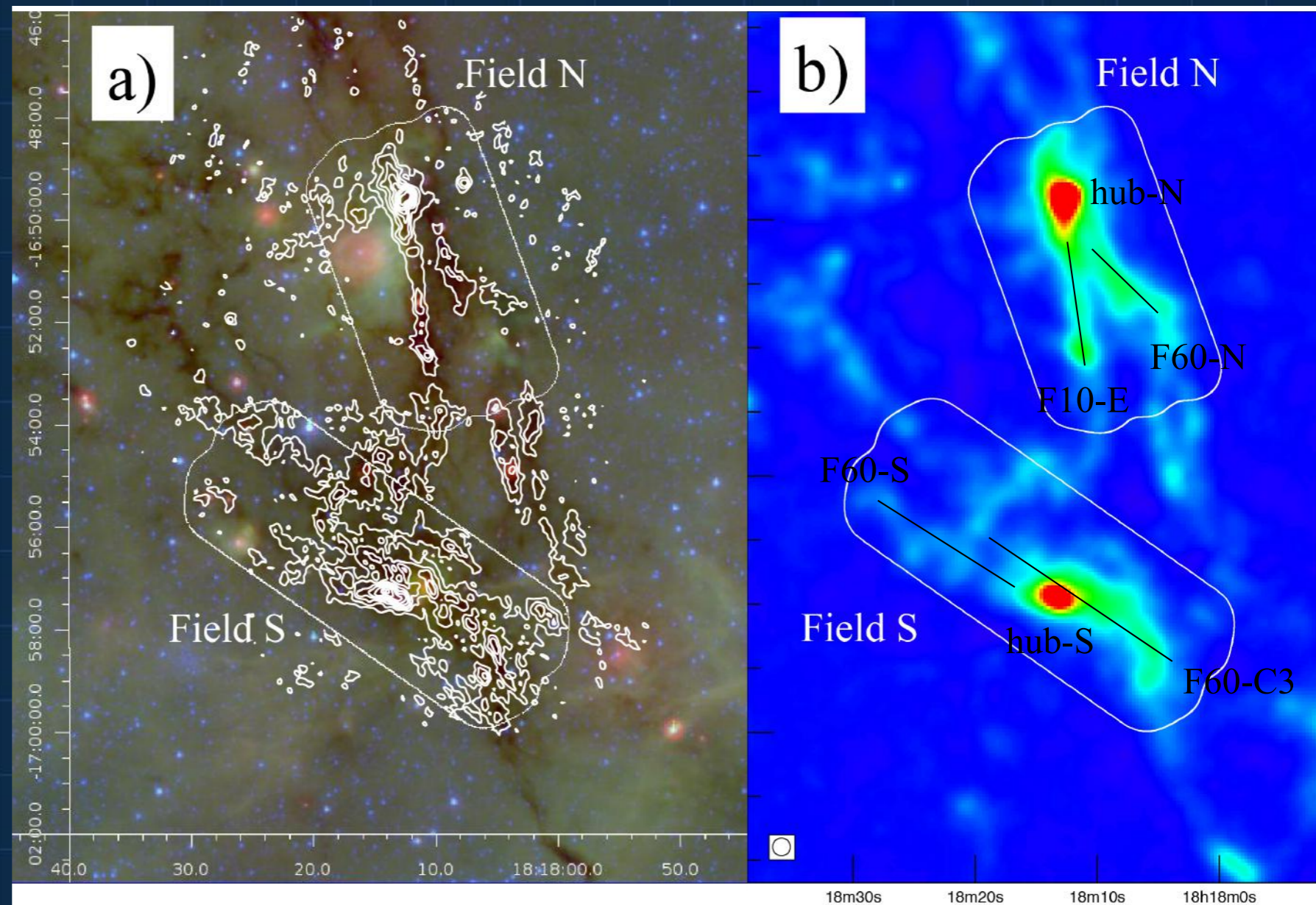
- Beam  $\sim 3''$  ( $\sim 0.03$  pc)

- 12m + ACA + TP

- $\text{N}_2\text{H}^+$  (1-0), HNC (1-0)

- Spectral resolution of 0.2 km/s

- TP data delivered

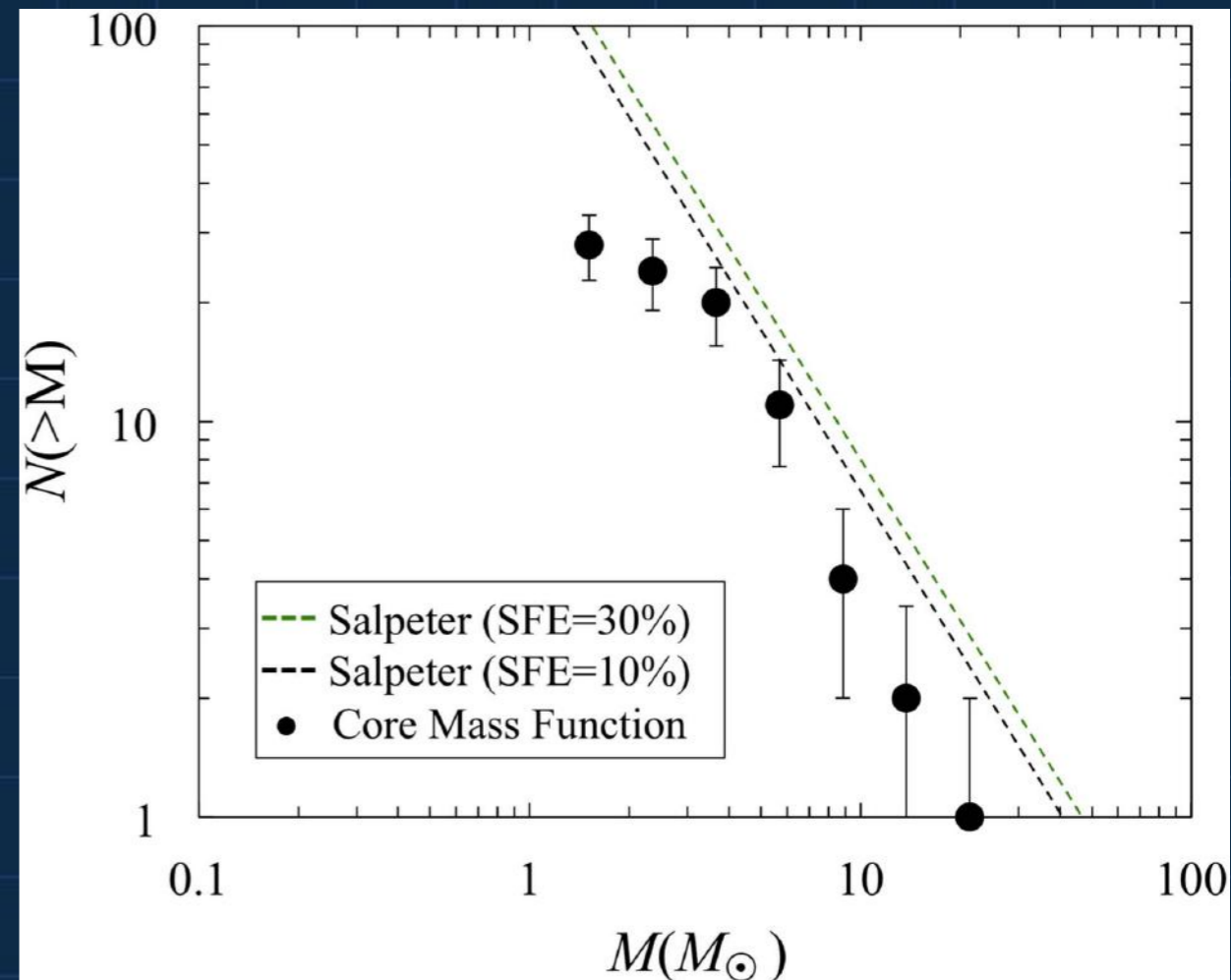
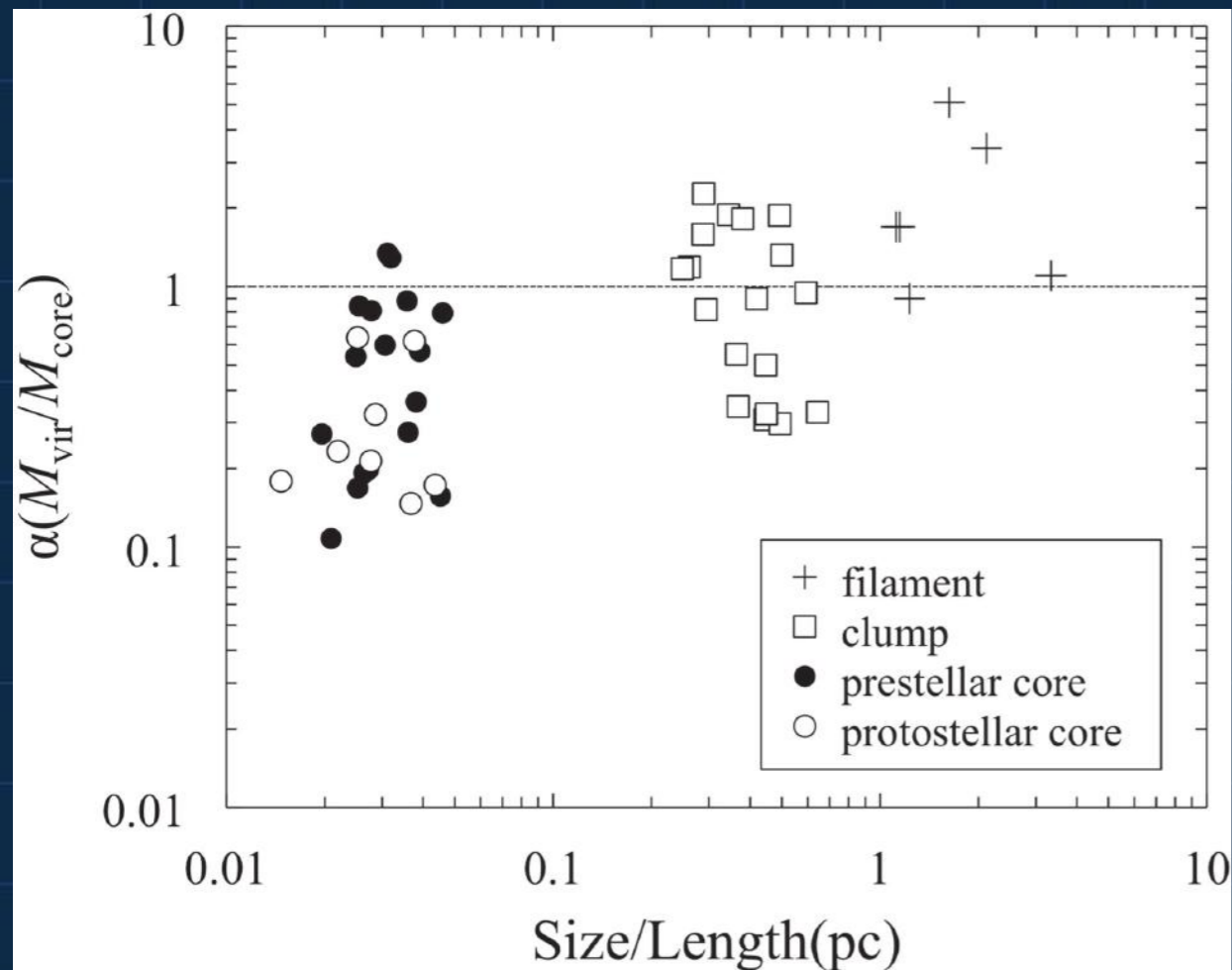




# Core Properties

- Decreasing virial parameter from filaments to clumps to cores
- Lack of massive cores ( $M_{\text{core}} < 22 M_{\odot}$ )

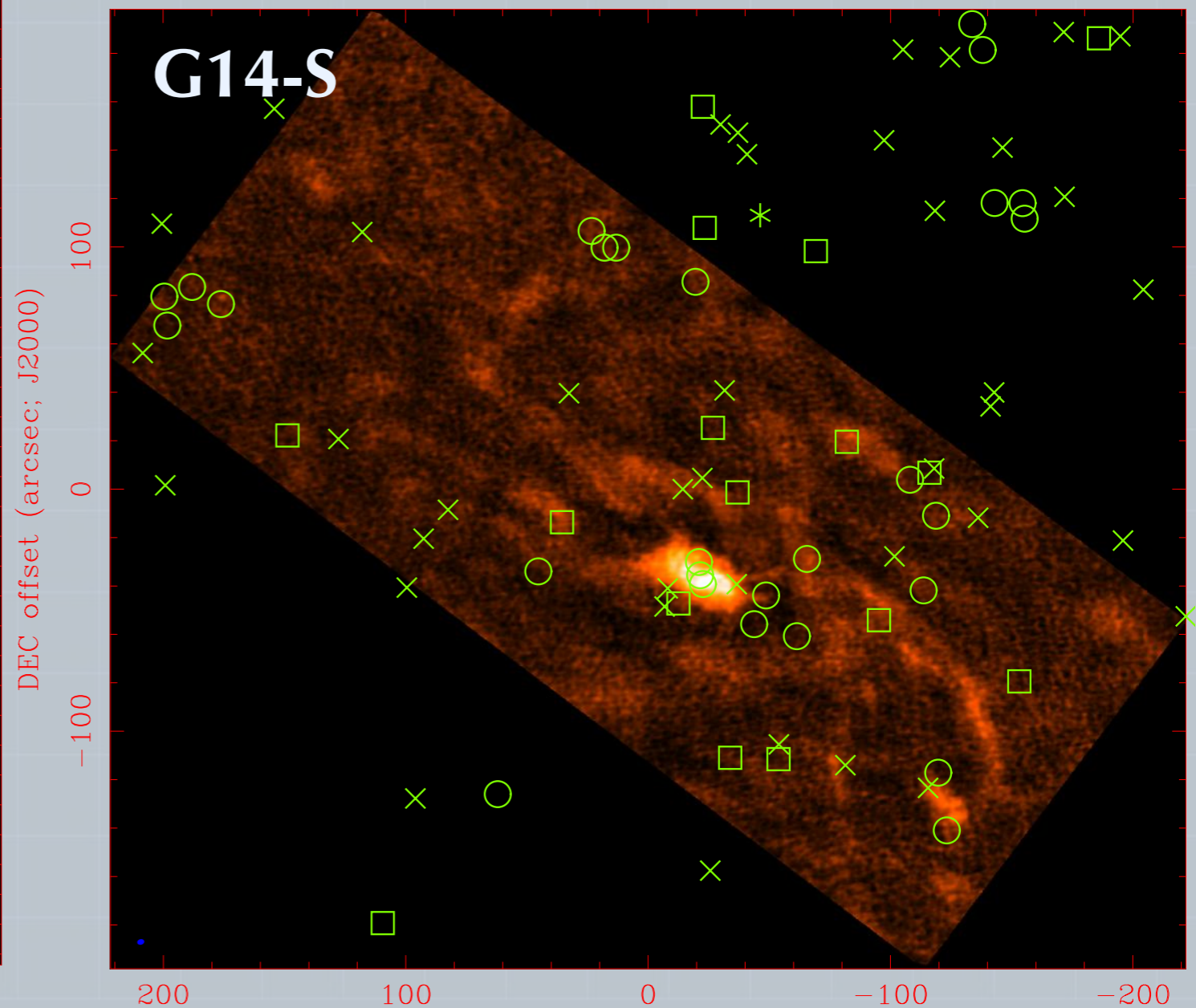
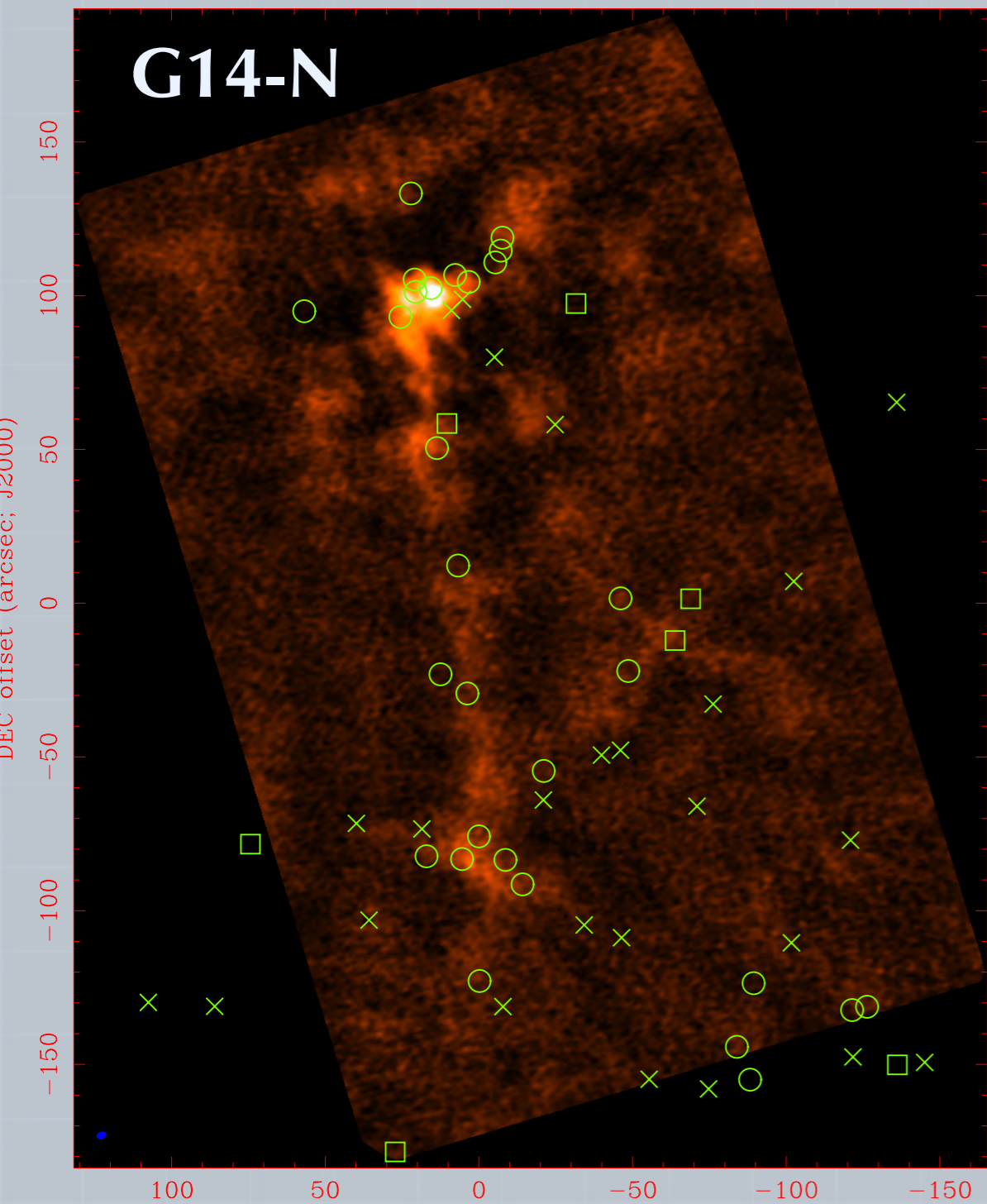
Ohashi, Sanhueza, Chen et al. 2016, ApJ, 833, 209





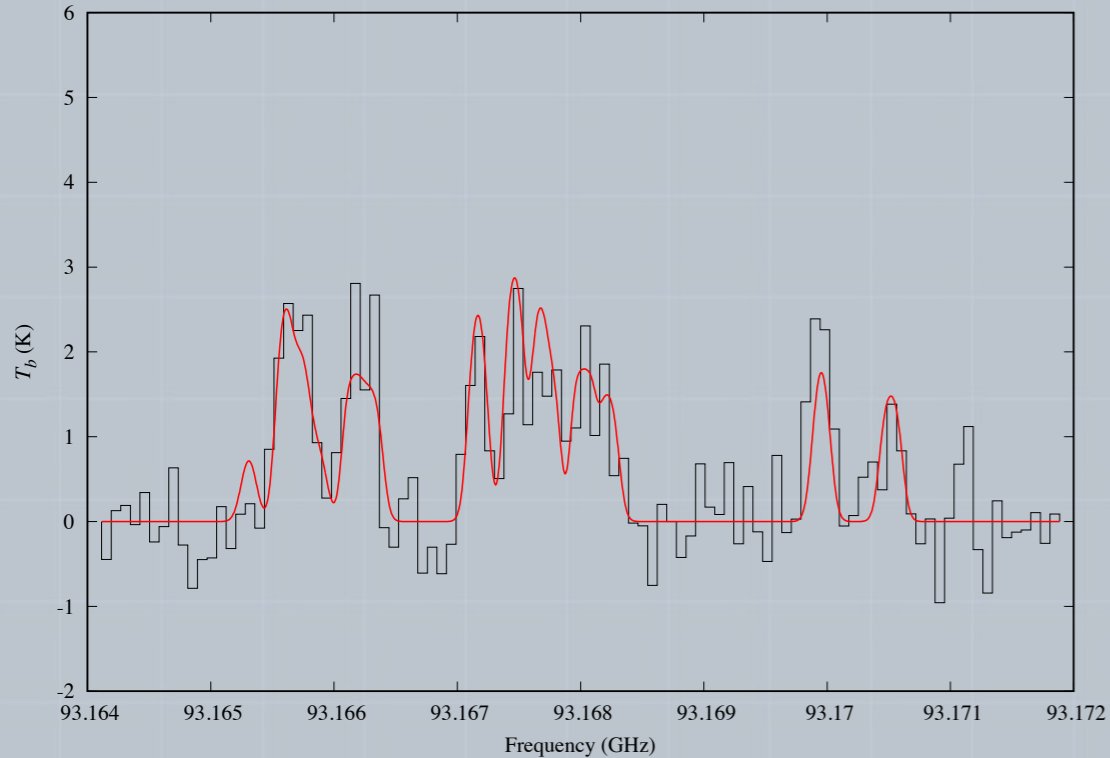
# G14.2 N<sub>2</sub>H<sup>+</sup> (1-0) Maps

- Trace hubs and filaments well
- Need Total Power data for short spacing

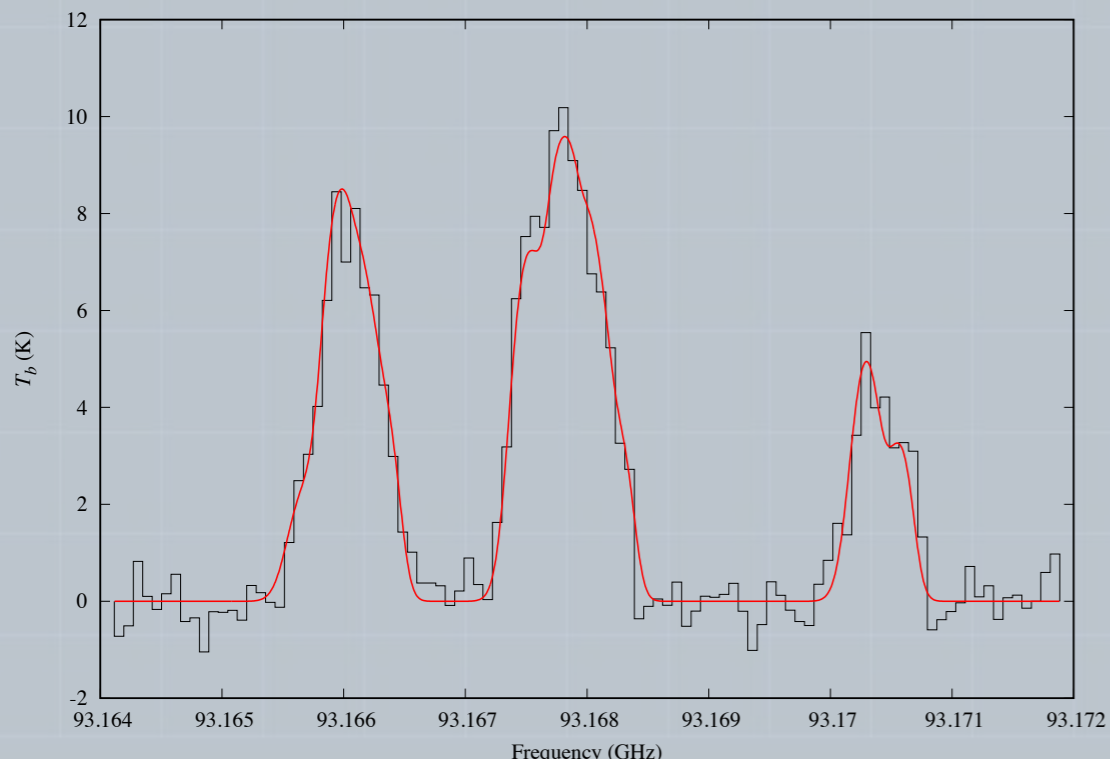




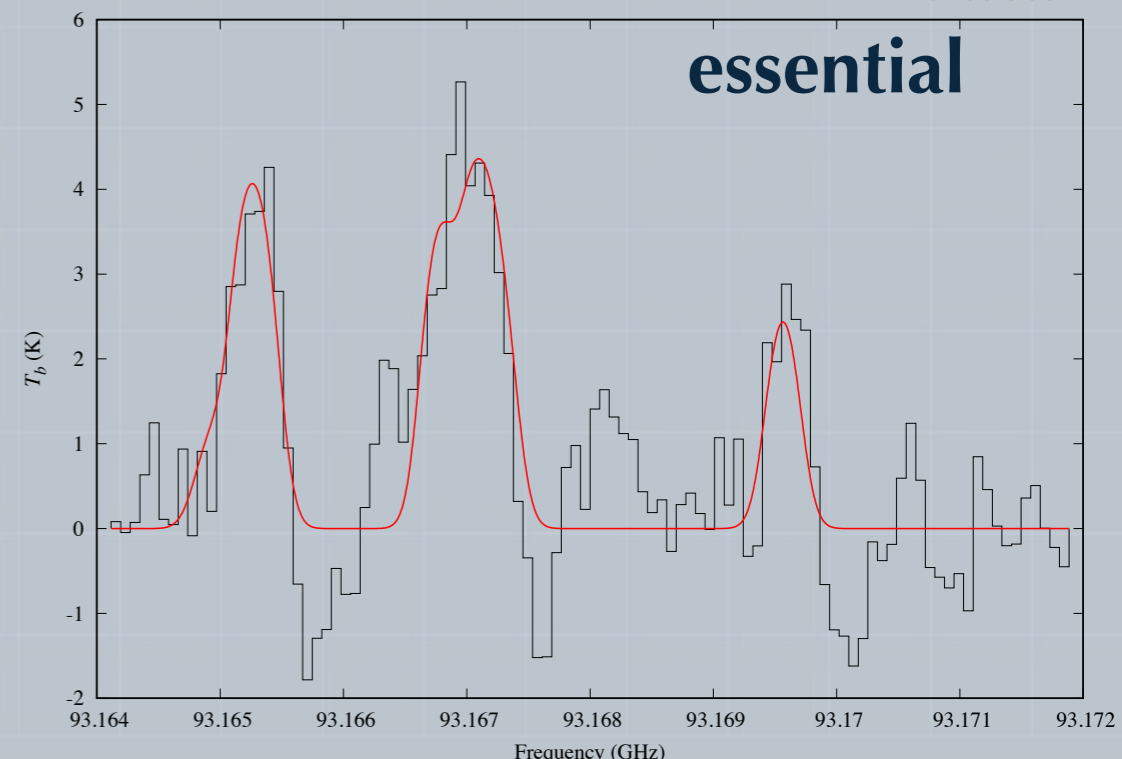
# Example Spectral Fits



- Extract kinematics pixel by pixel
- Isothermal along LOS, LTE
- Fit 7 HFS and large optical depth
- Extract  $\sim 28,000$  pixels



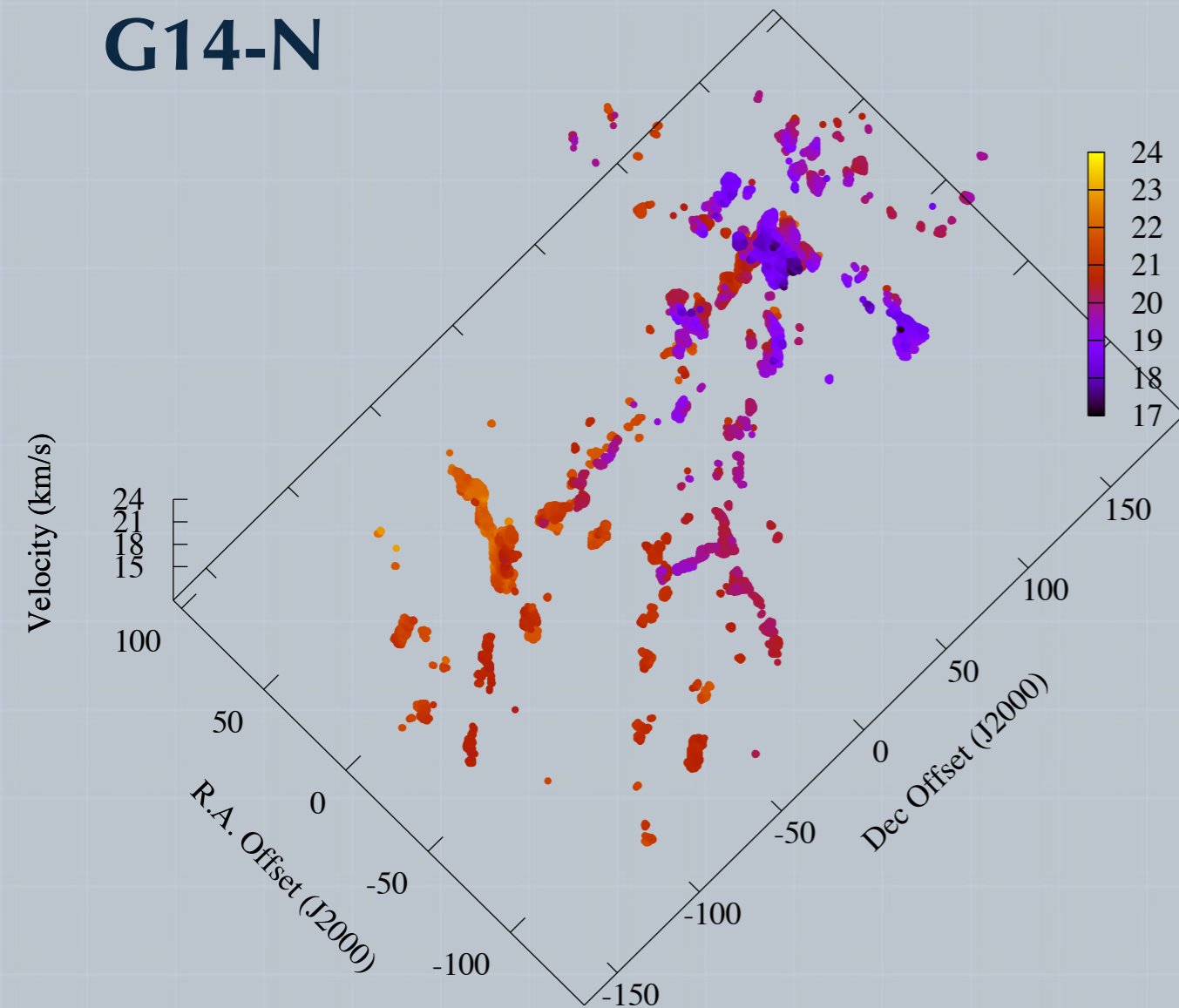
**ALMA TP data  
essential**



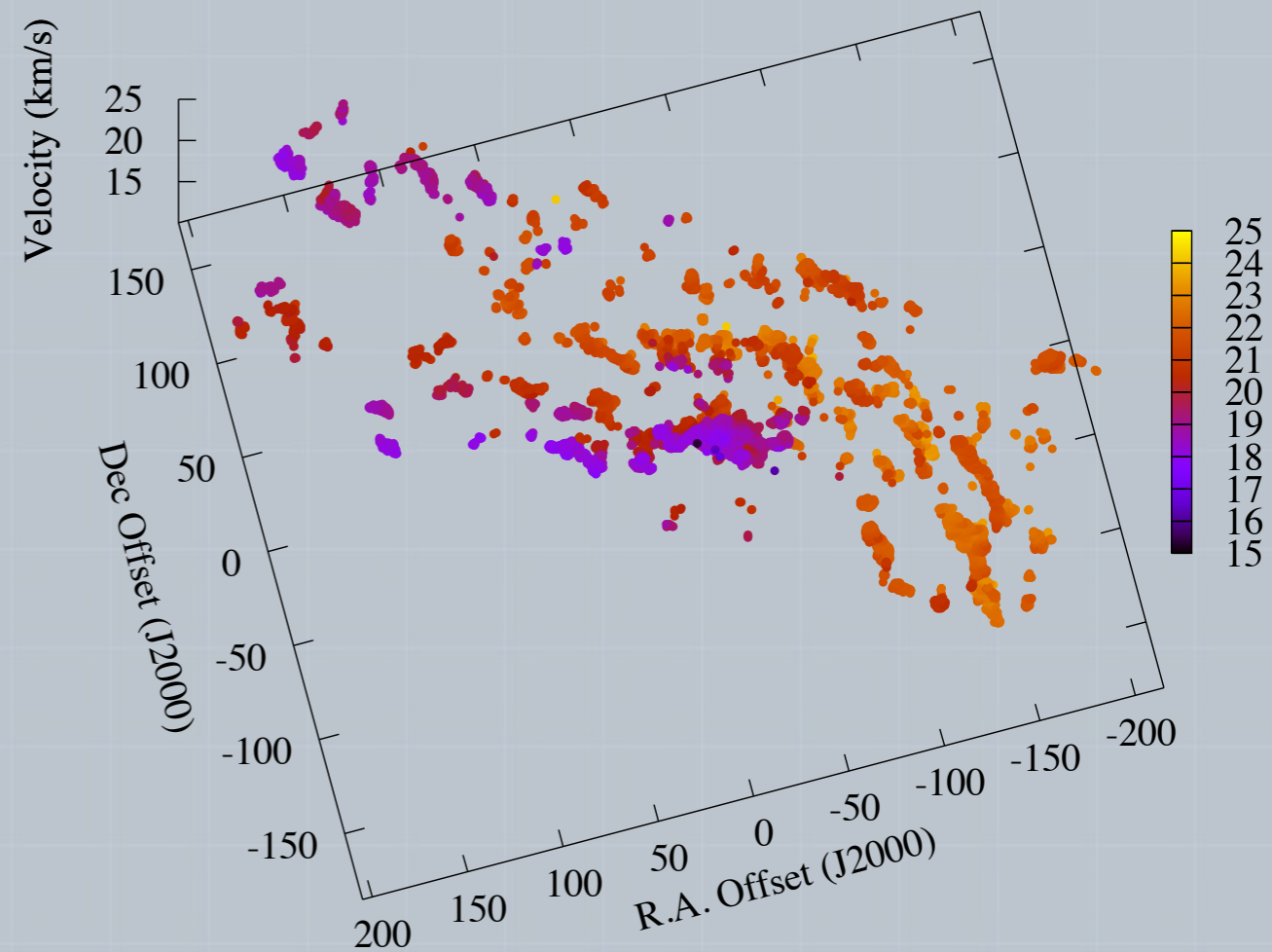


# Large-scale Kinematics

## G14-N



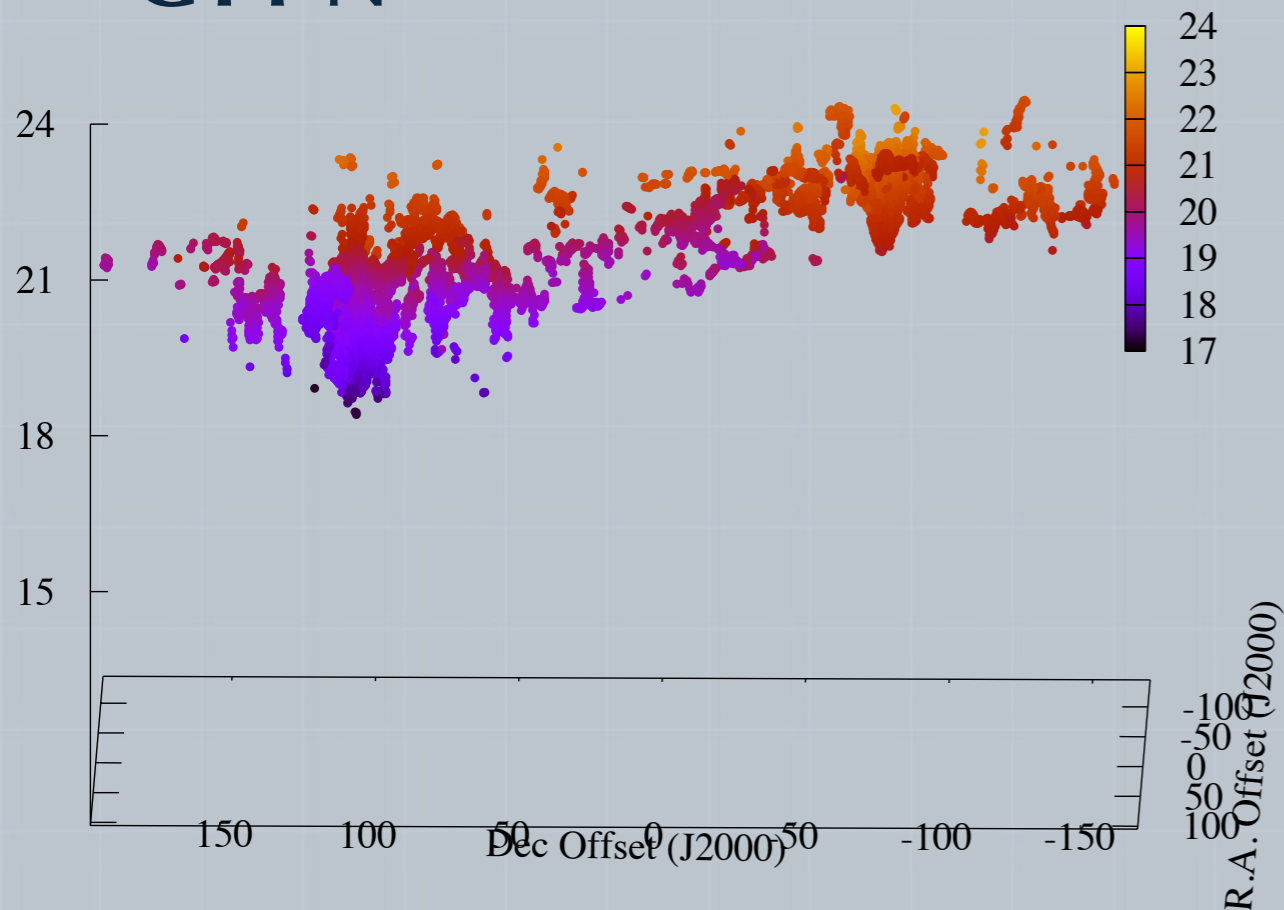
## G14-S



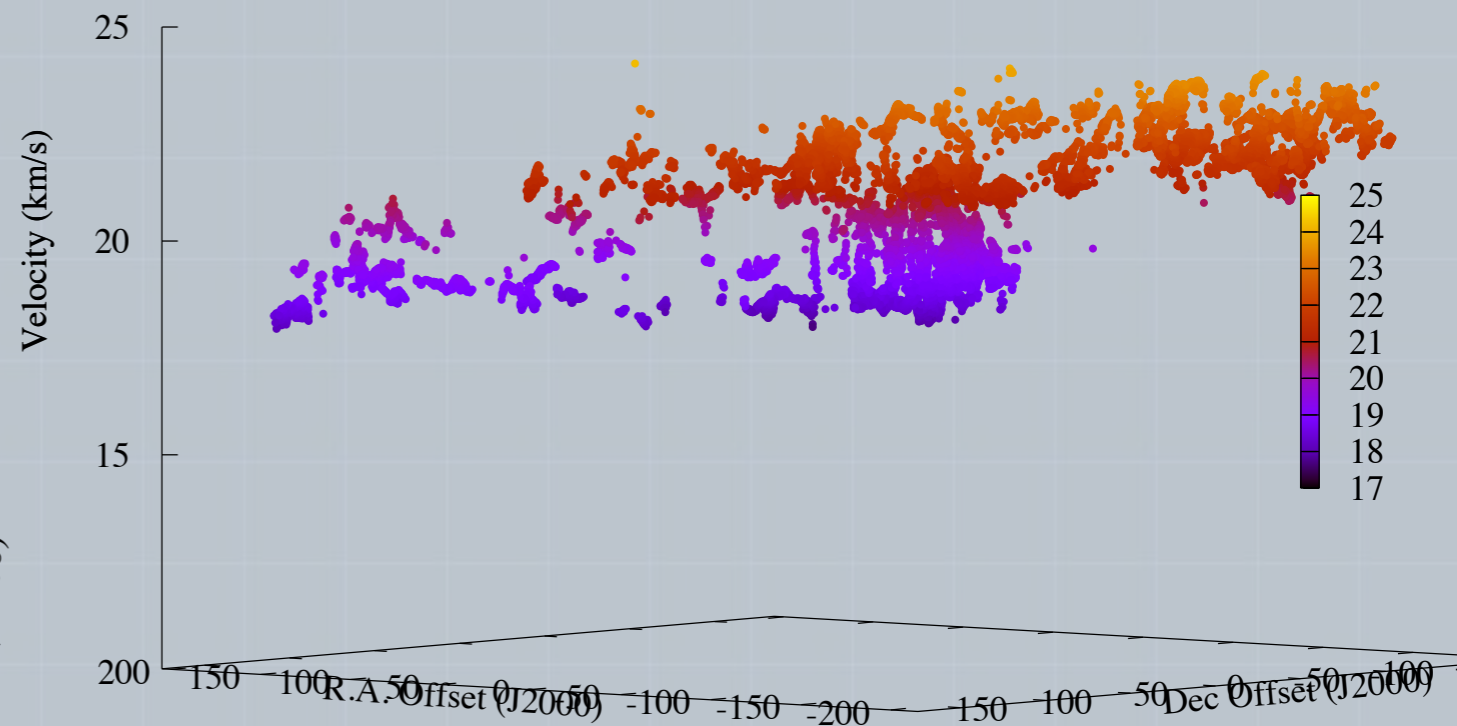
# Slow Inflow along Filaments

- Slow inflow along the filaments with multiple velocity components of short “ribbon-like” sub-filaments (Hacar et al. 2013)
- Hubs show multiple velocity components, not yet virialized

## G14-N



## G14-S





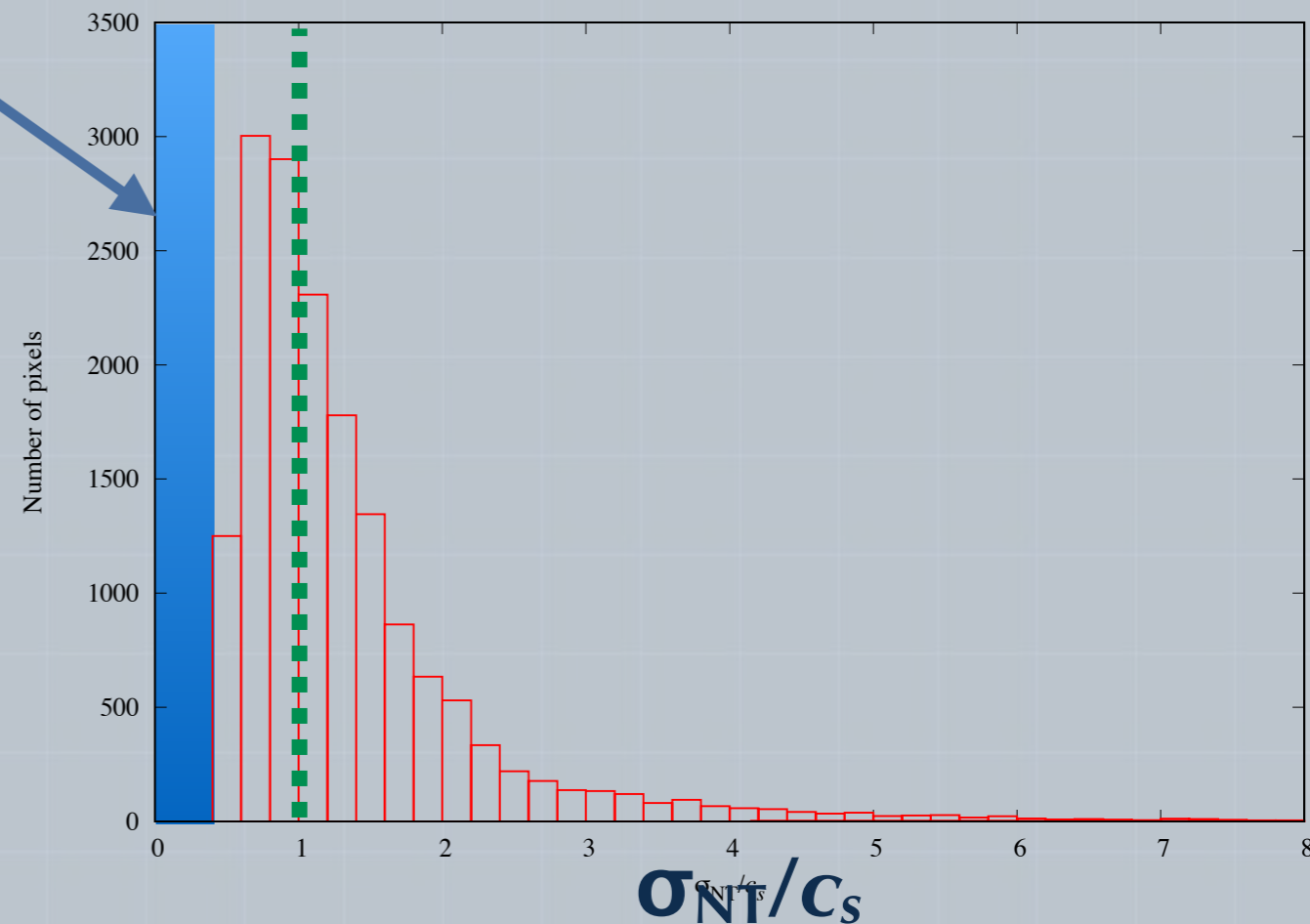
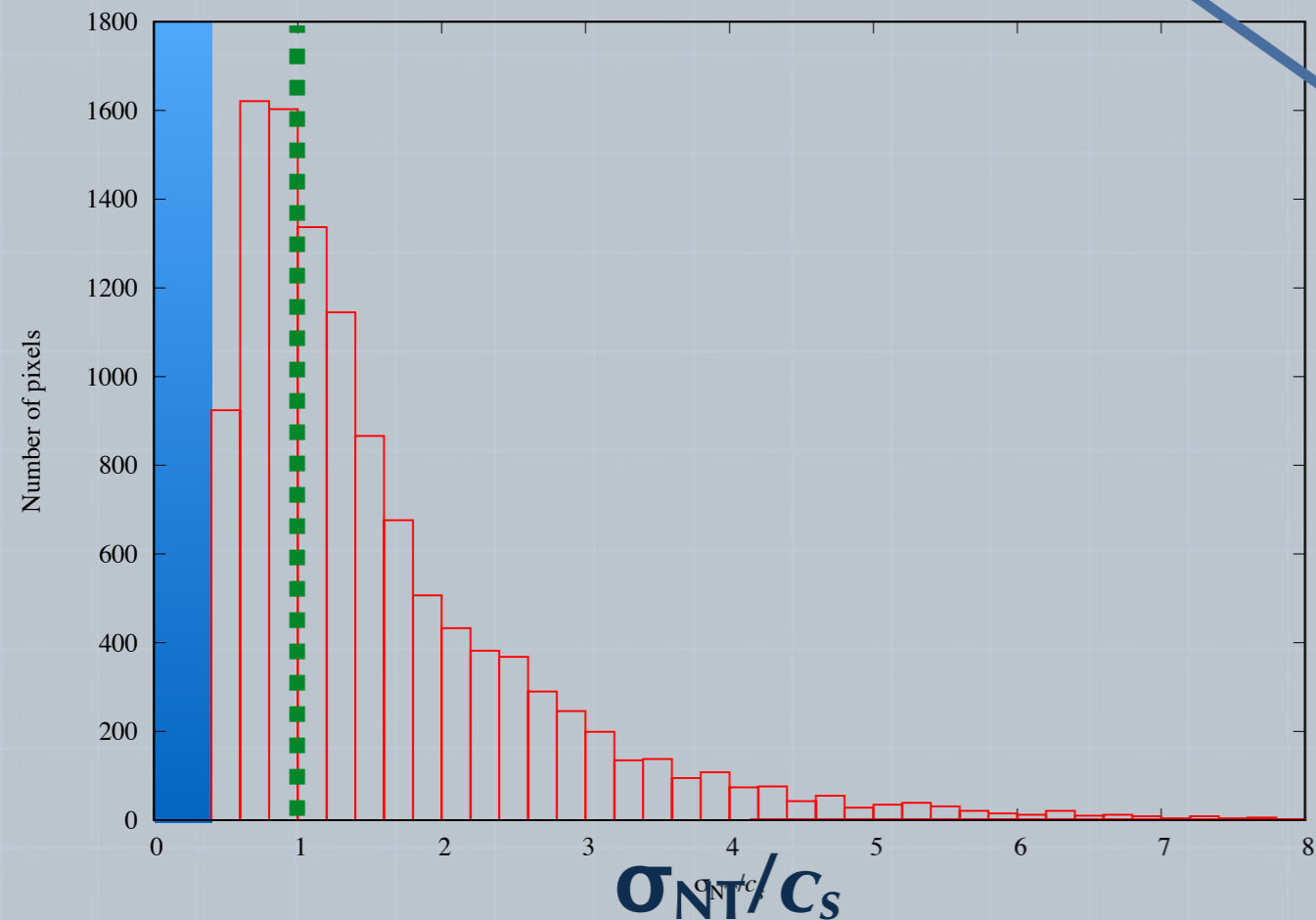
# Transonic Subfilaments

- Unlike  $\text{NH}_3$ , non-thermal line width of  $\text{N}_2\text{H}^+$  in filaments are generally transonic/subsonic,  $\sigma_{\text{NT}}/c_s \sim 1$

G14-N

Null zone due to spectral resolution

G14-S



# Summary

- **ALMA observations of  $\text{N}_2\text{H}^+$  (1-0) and HNC (1-0) in the filamentary IRDC G14.225-0.506**
- **Kinematics of  $\text{N}_2\text{H}^+$  show transonic sub-filaments and a slow inflow along filaments toward hubs, where virialization is not yet established**
- **Combine ALMA TP data in progress**
  - Investigating various algorithms in miriad and casa
  - More 12m and ACA data on the way
  - Stay tuned ...