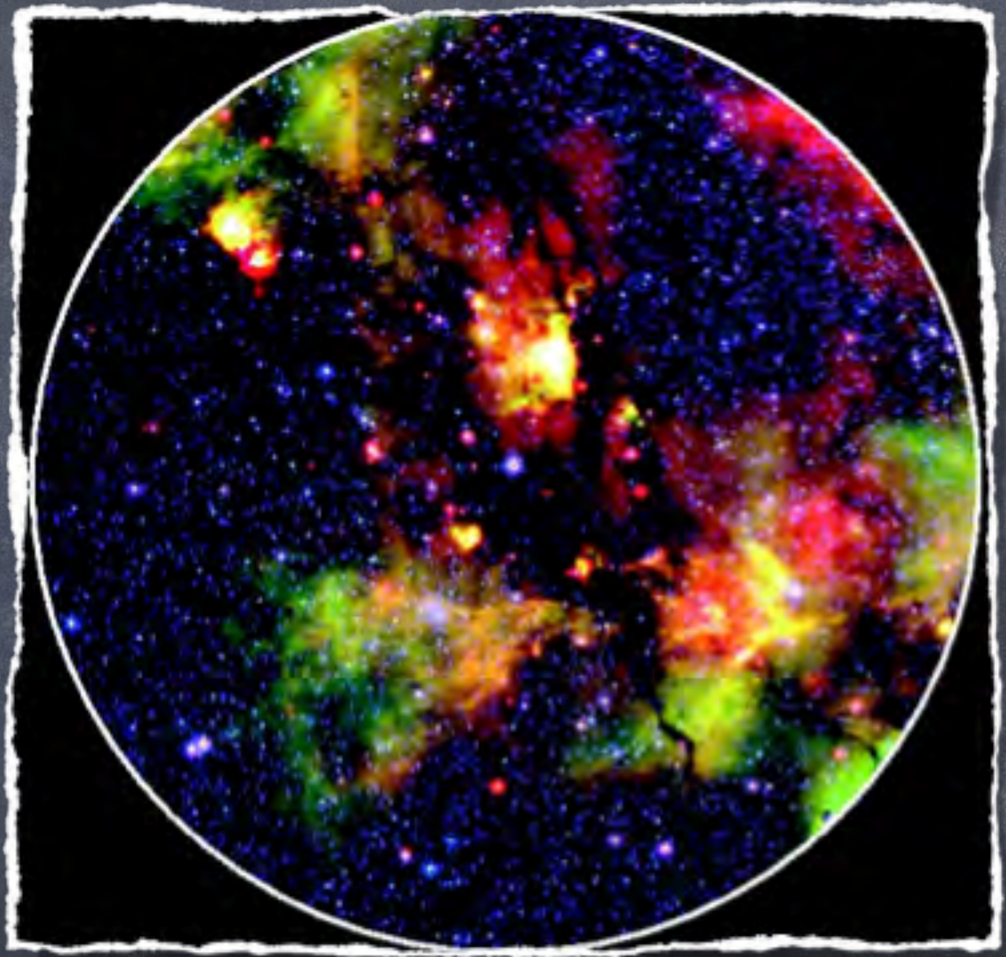
Fragmentation in the IRDC G14.225-0.506



Gemma Busquet (IAA-CSIC)

R. Estalella, A. Palau, H. Baobab Liu, Q Zhang, J.M. Girart, G. Anglada, I. de Gregorio-Monsalvo, T. Pillai, P.T.P Ho

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Introduction

- Highly inhomogeneous structure

clouds

↓

filaments

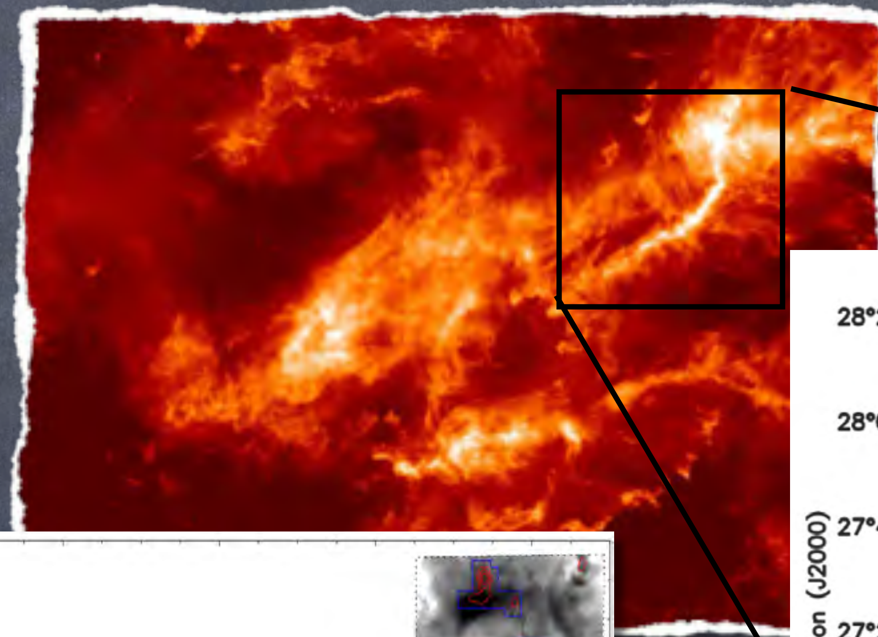
↓

clumps

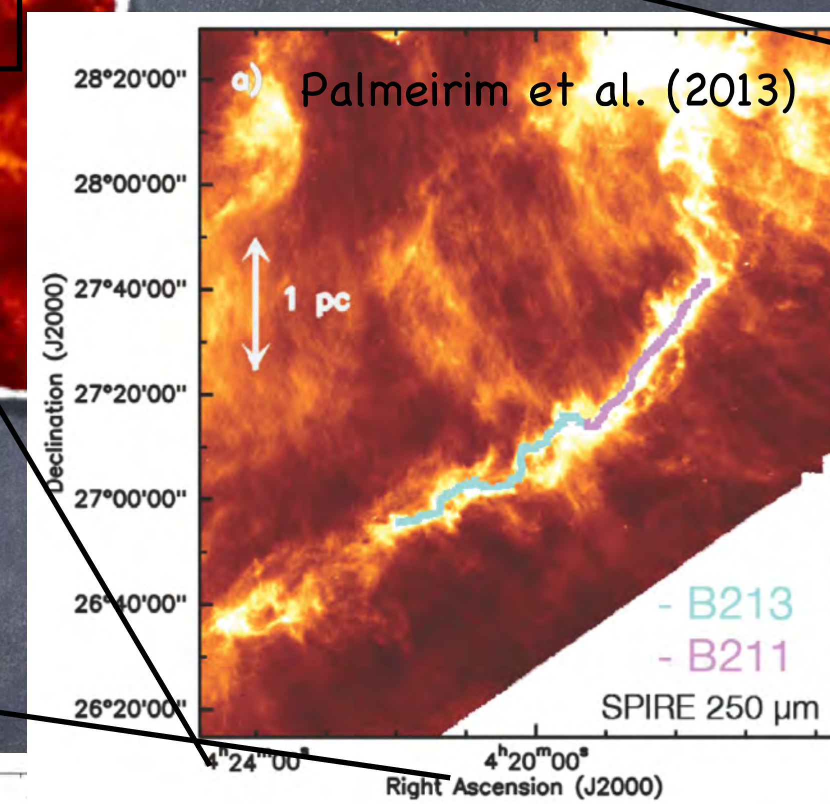
↓

dense cores

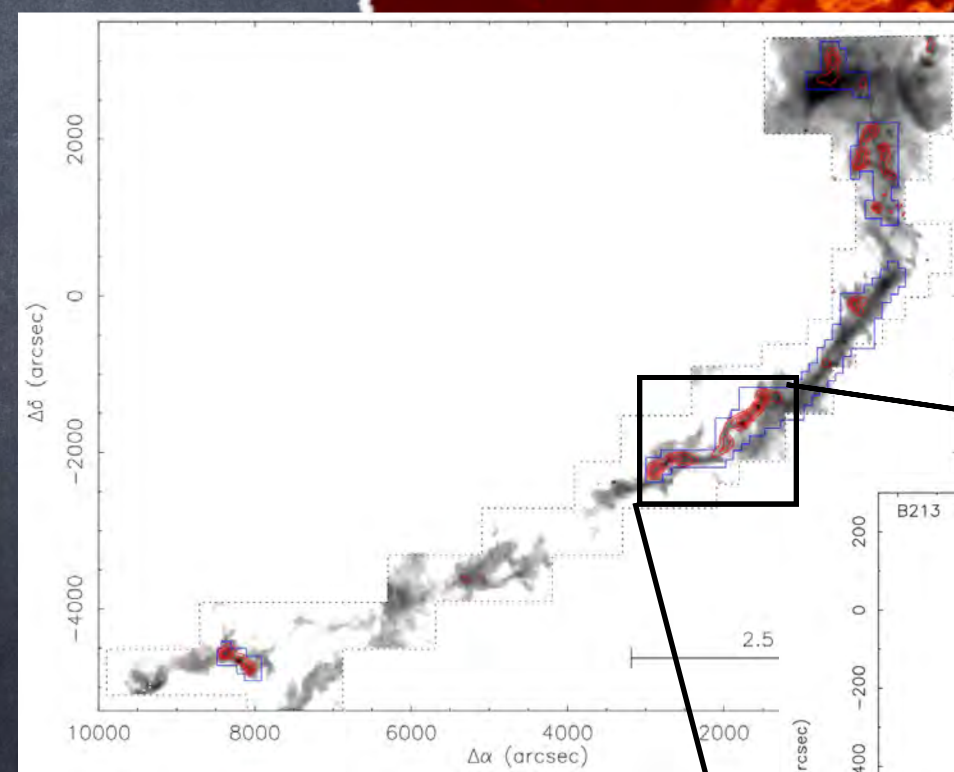
several pc



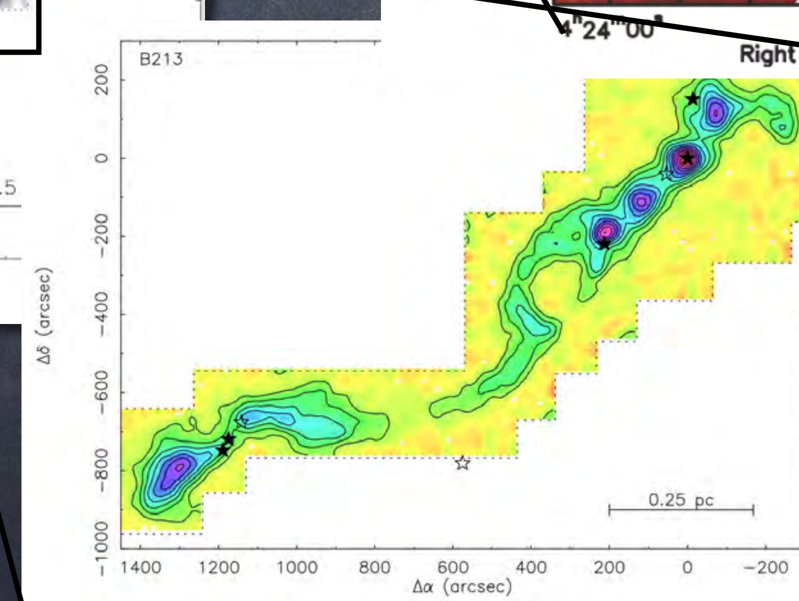
Goldsmith et al. (2008)



Palmeirim et al. (2013)



Tafalla & Hacar (2014)

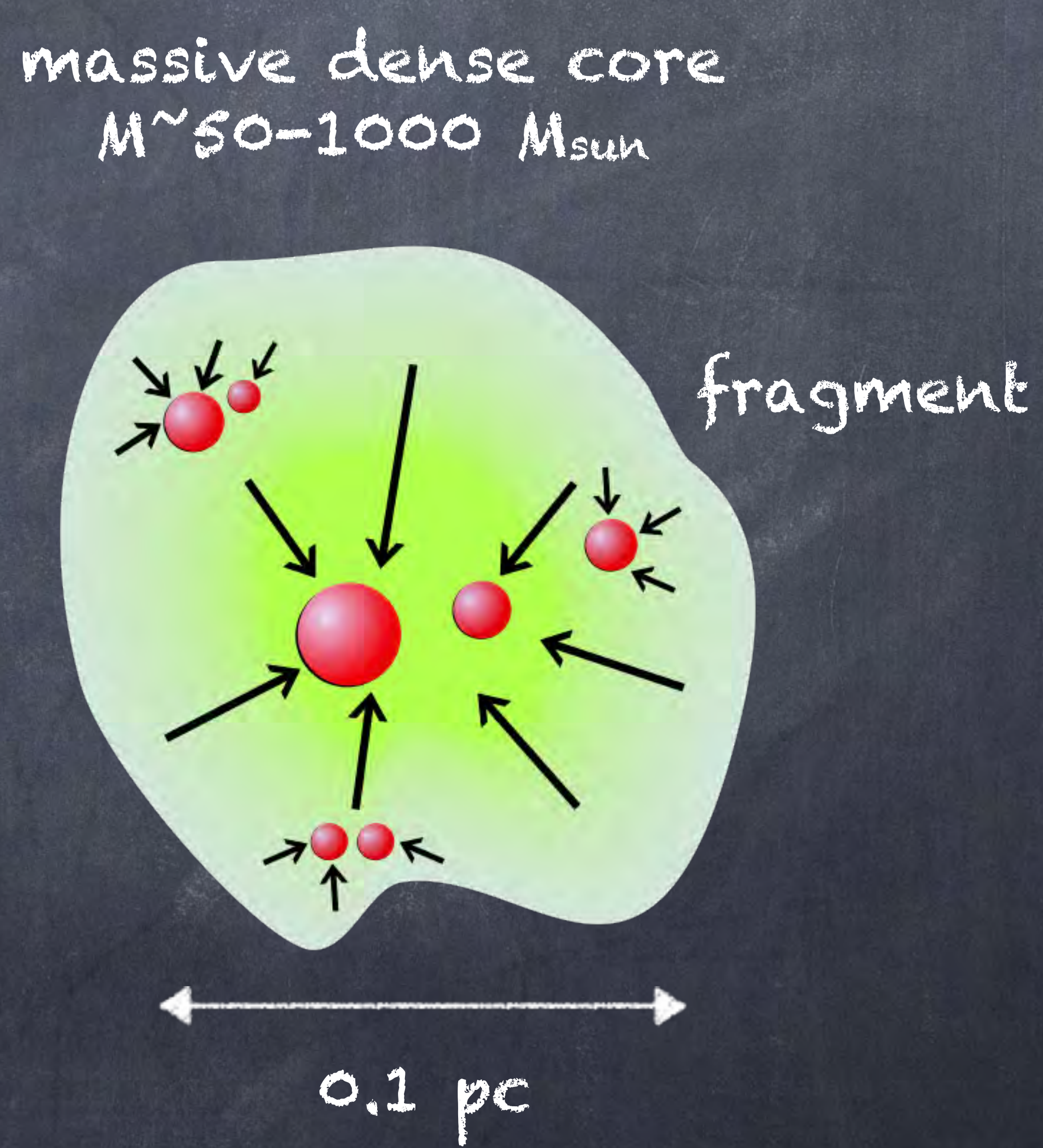


0.03 pc - 0.2 pc

High degree of cloud fragmentation in the star formation process

Observationally:

- number of condensations is typically smaller than the predicted from pure thermal Jeans fragmentation



- ✓ Gravity
- ✓ Turbulence
- ✓ Magnetic fields
- ✓ Angular momentum
- ✓ Stellar feedback

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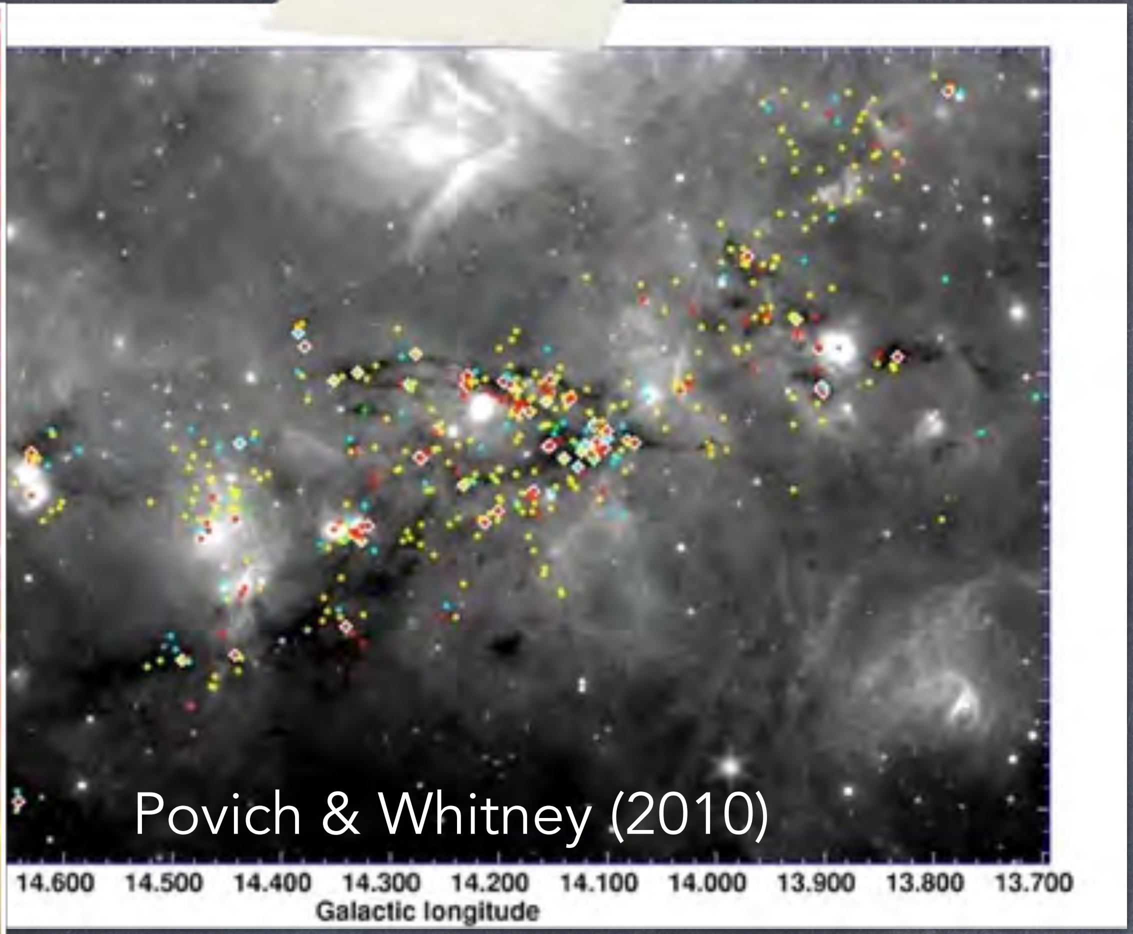
The IRDC G14.225-0.506 (or M17 SWex)



d~1.98 kpc
(Xu et al. 2011)

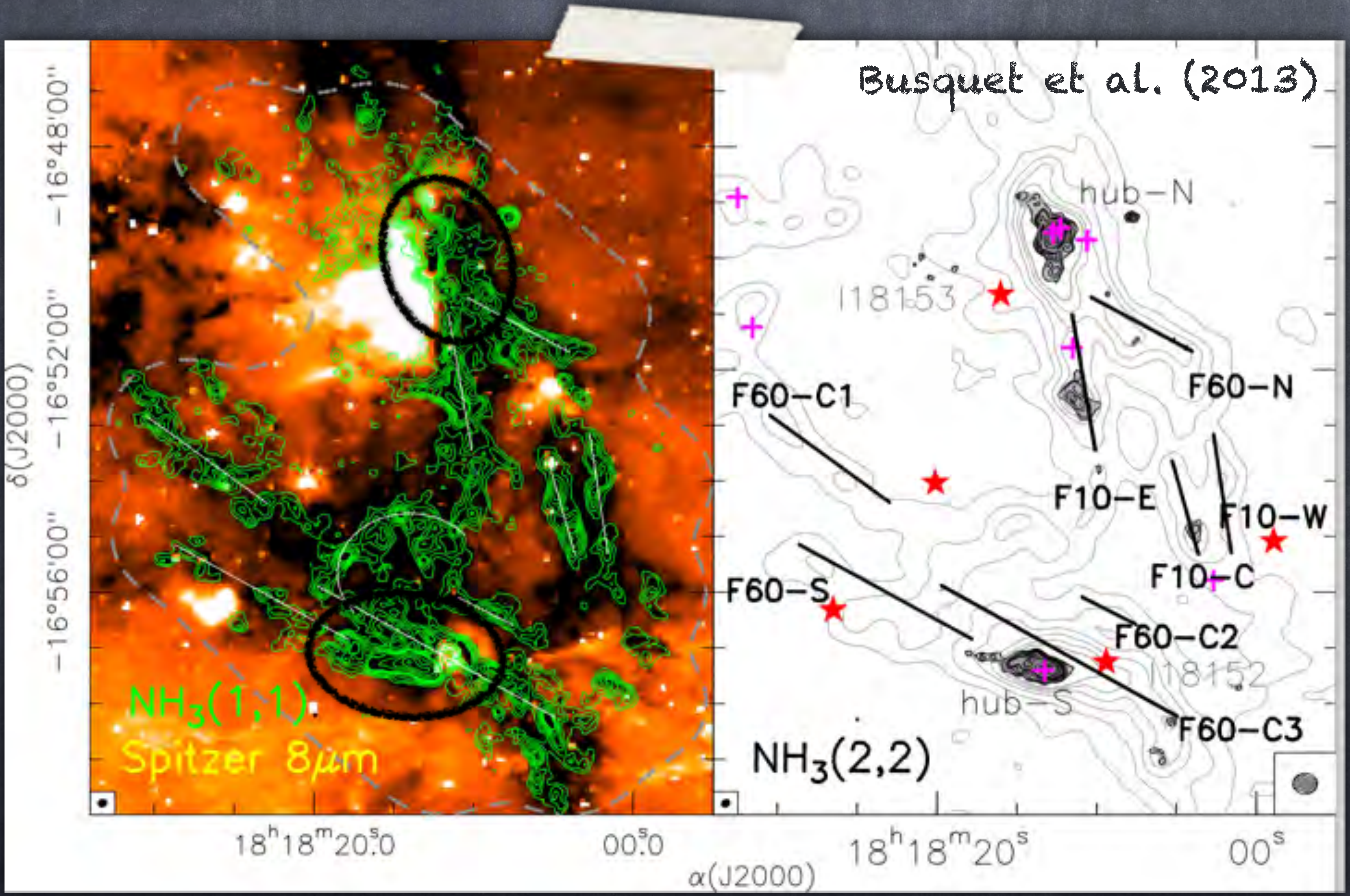
Star formation activity

- Several intermediate-massYSOs identified using Spitzer data (Povich & Whitney 2010): Stage 0/I Stage II Stage III ambiguous

- H_2O maser emission (Wang et al. (2006)

NH$_3$ (VLA + Effelsberg): Network of 8 filaments and 2 Hubs

Cores embedded within filaments with a mean separation ~0.33 pc



Hubs are warmer, H$_2$O maser and IR sources, larger line widths, and M$_{line}$ → main sites of stellar activity within the cloud

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Observations

- Large scale view of Hubs (0.1-0.2 pc)

APEX-LABOCA @870μm

CSO-SHARC II @350μm

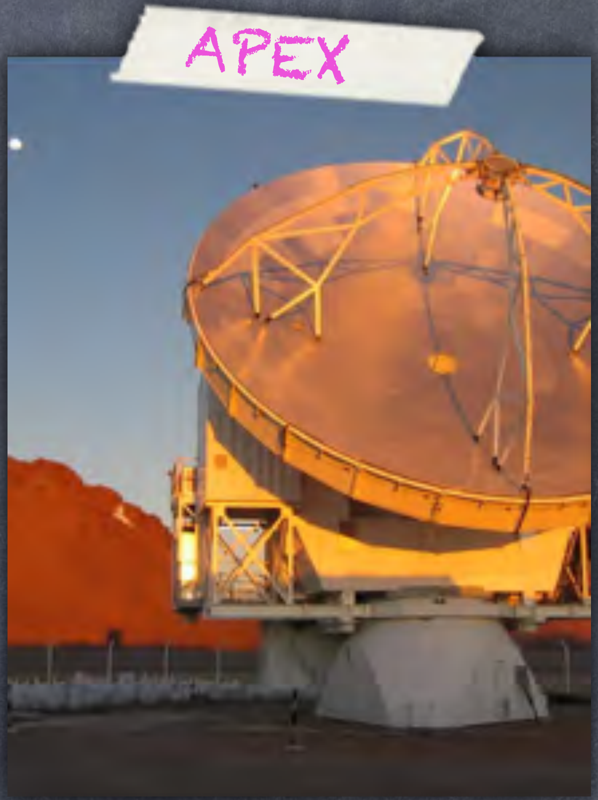
- SMA mosaic at 1.3 mm

configurations: compact + extended

(+ very extended for hub-N)

beam~1.5" ~3000 AU~0.01 pc

M_{sens}~0.3 M_{sun}



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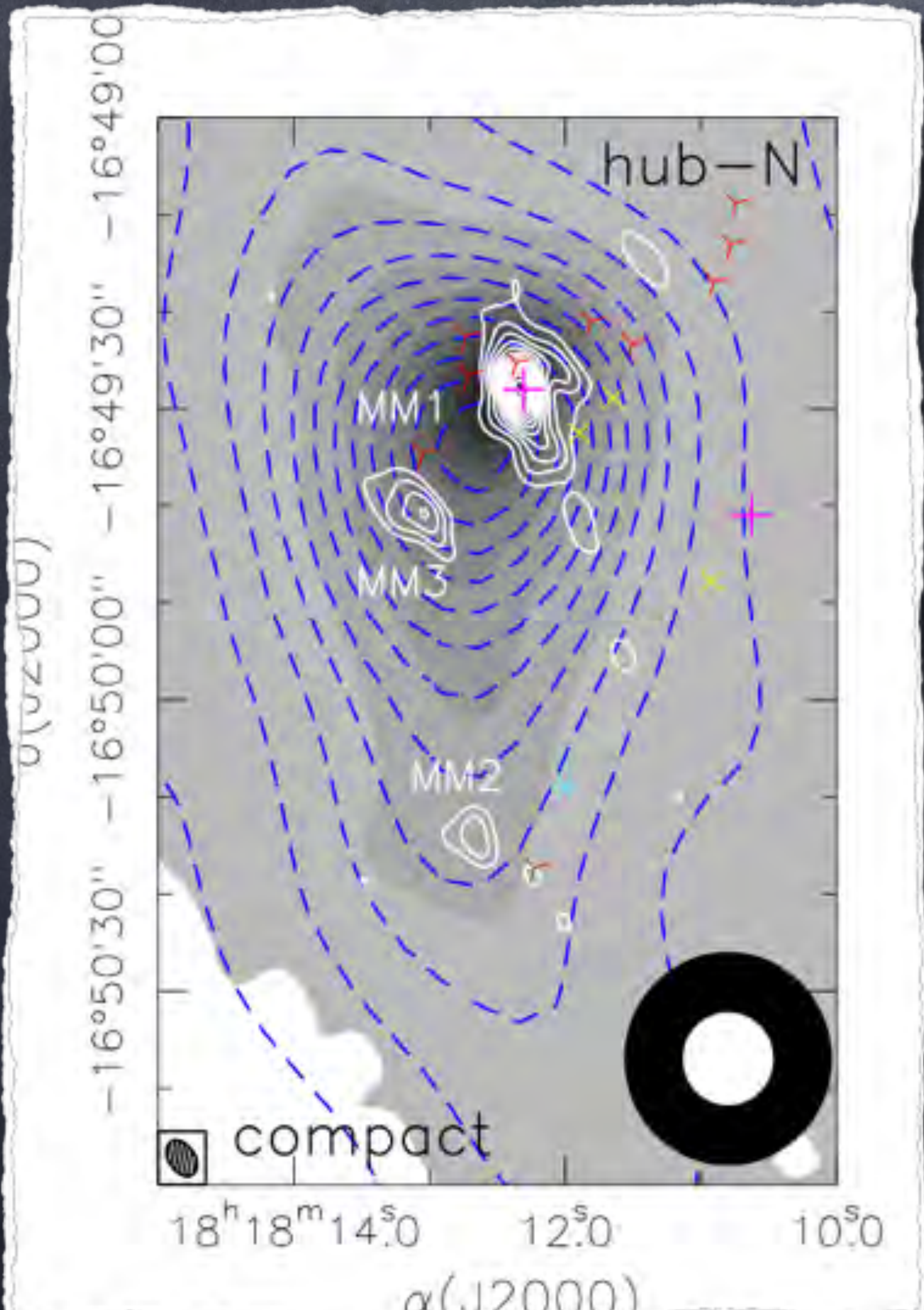
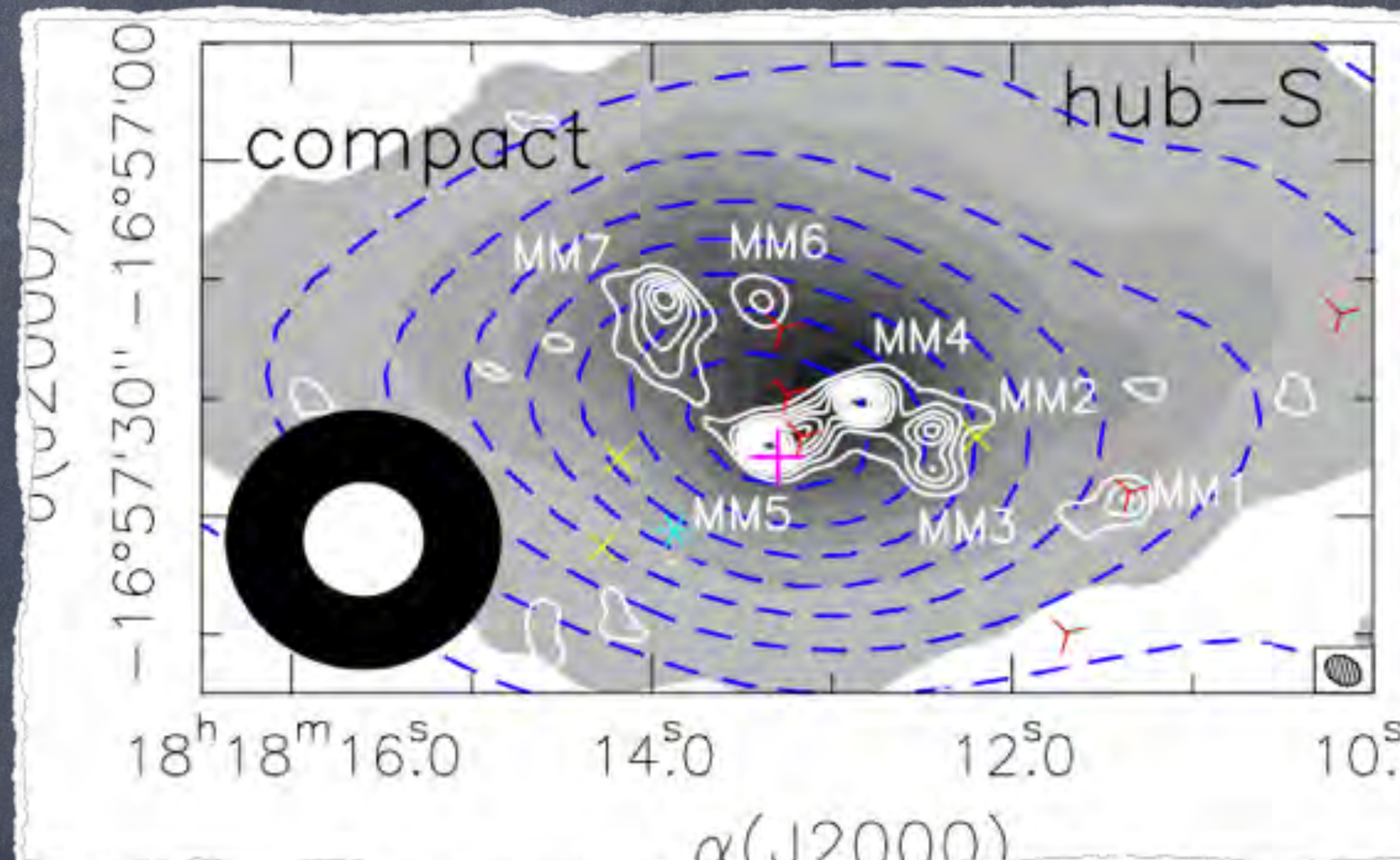
Results: Large scale view

(from 0.5 pc to 0.05 pc)





Number of condensations:

hub-N = 3

hub-S = 7

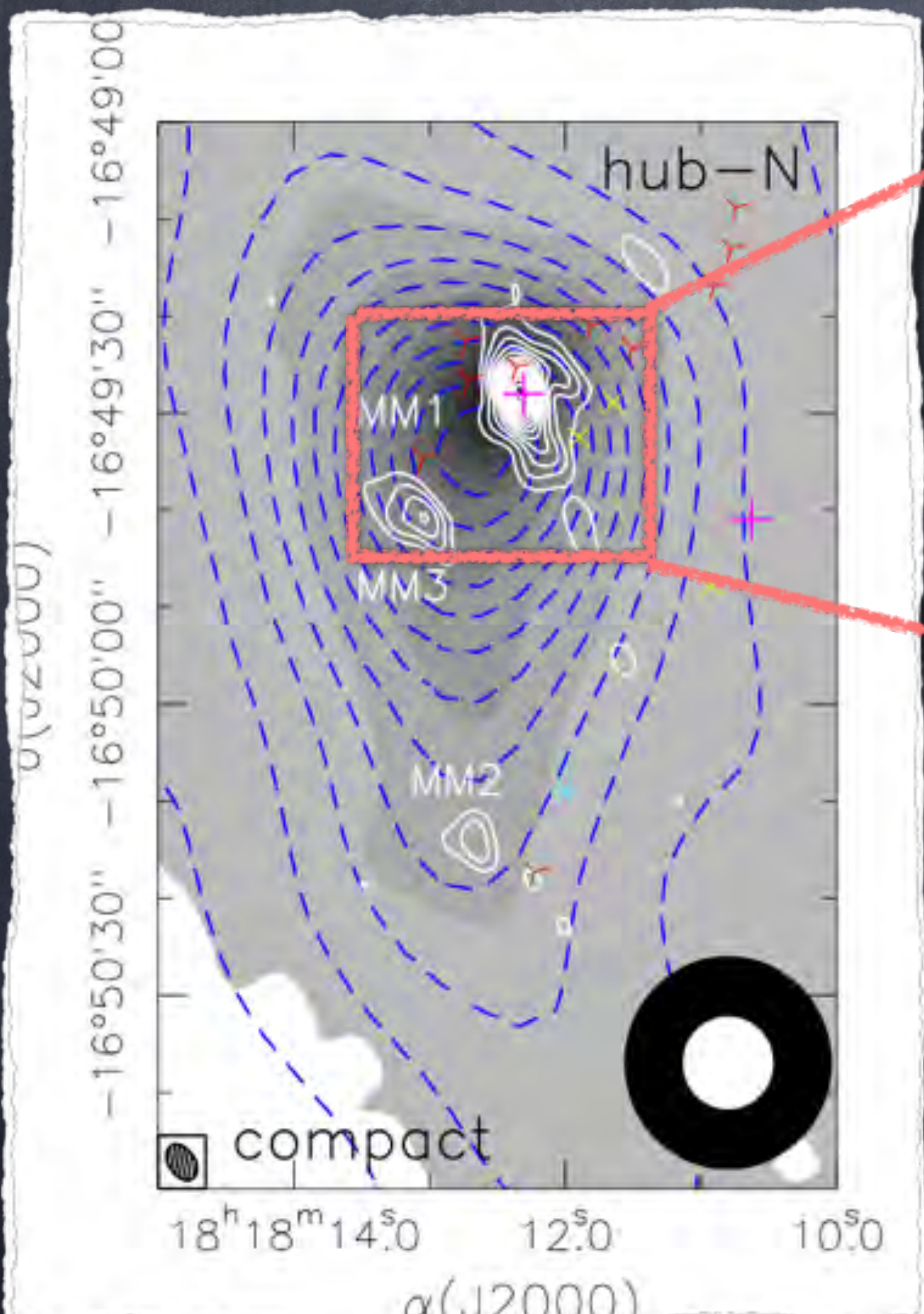
grey scale: CSO @350

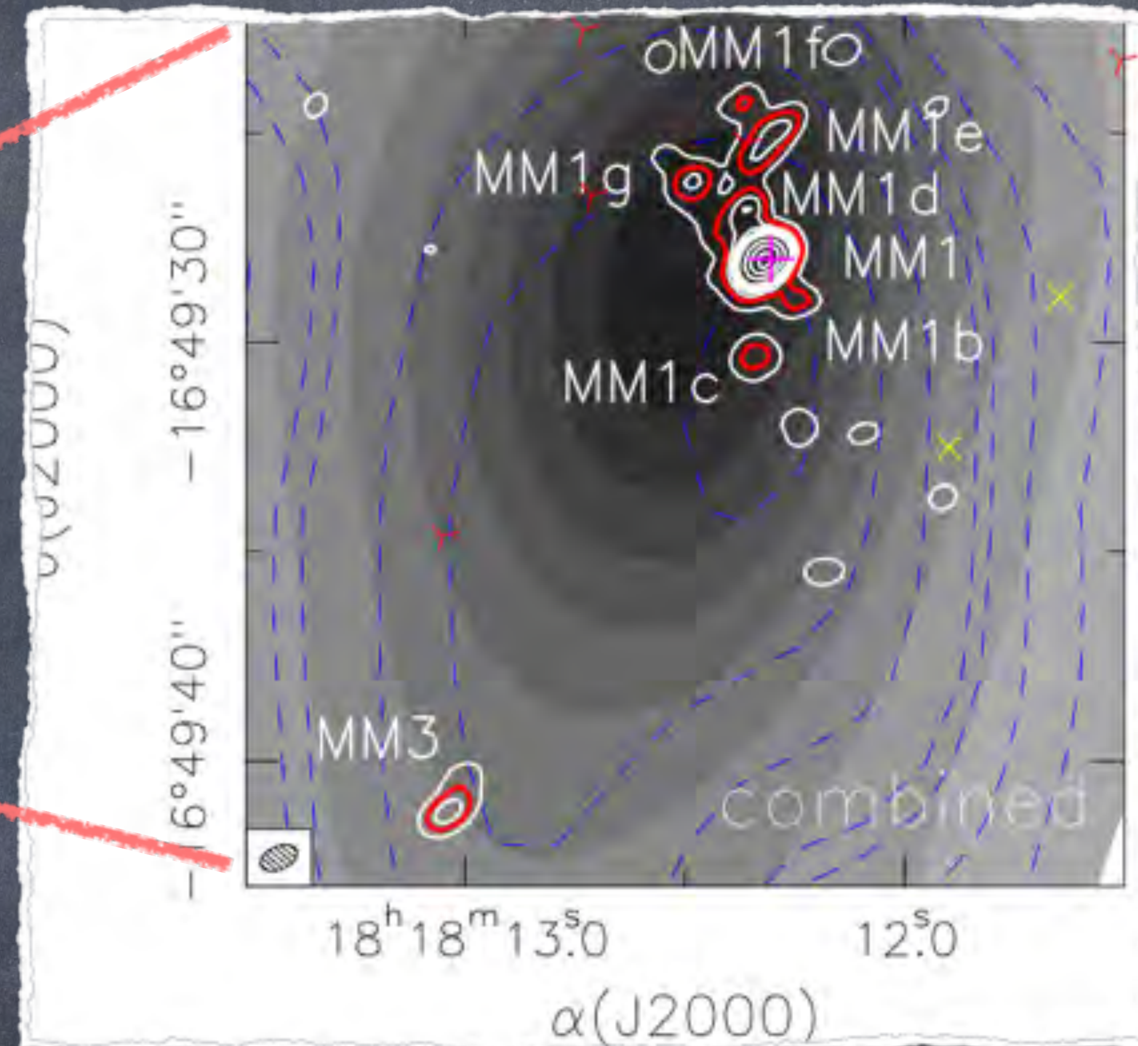
blue contours: LABOCA @870

Results: small scale

(down to 0.01 pc)

red contour: 6σ level





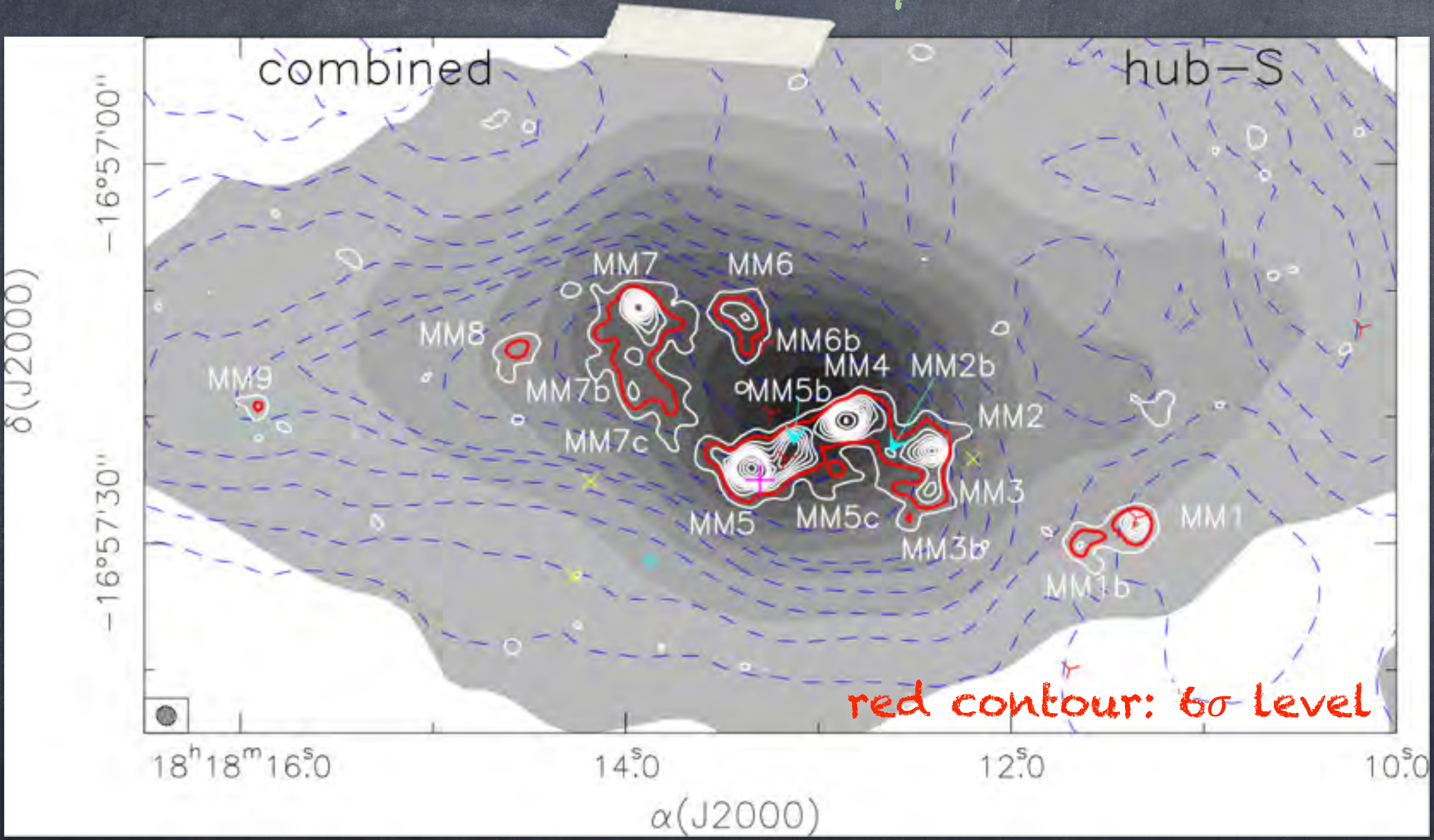
umber of condensations: hub-N = 9

11 breaks up into 7 condensations

Masses ~ 0.9 to 15 Msun

Results: small scale

(down to 0.01 pc)



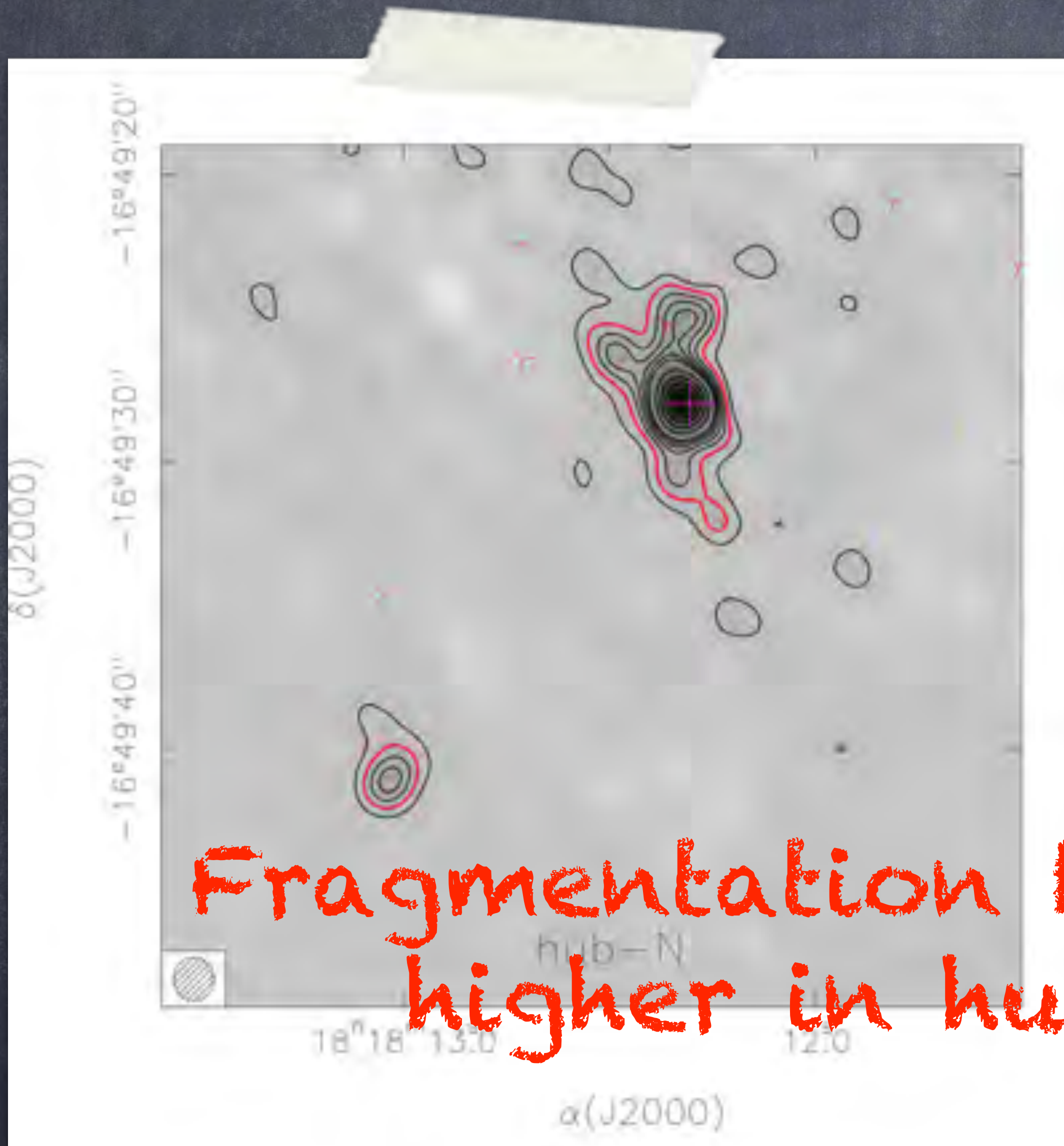
Number of condensations:

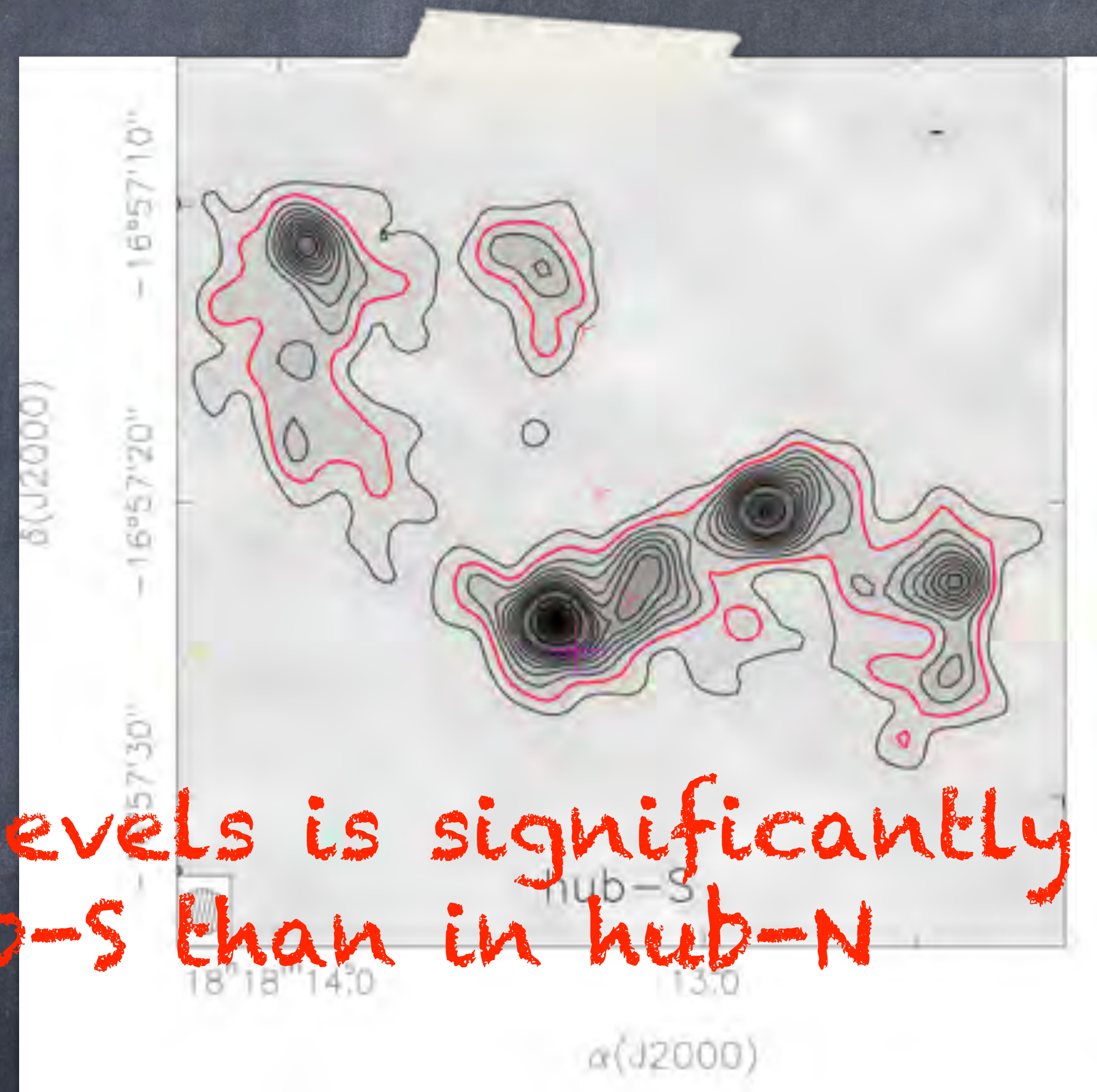
hub-S = 17

Masses~0.7 to 18 Msun

Fragmentation level

- Imaging with the same uv-range; convolution to the same beam (





Fragmentation levels is significantly higher in hub-S than in hub-N

Number of condensations:

hub-N=5

hub-S = 13

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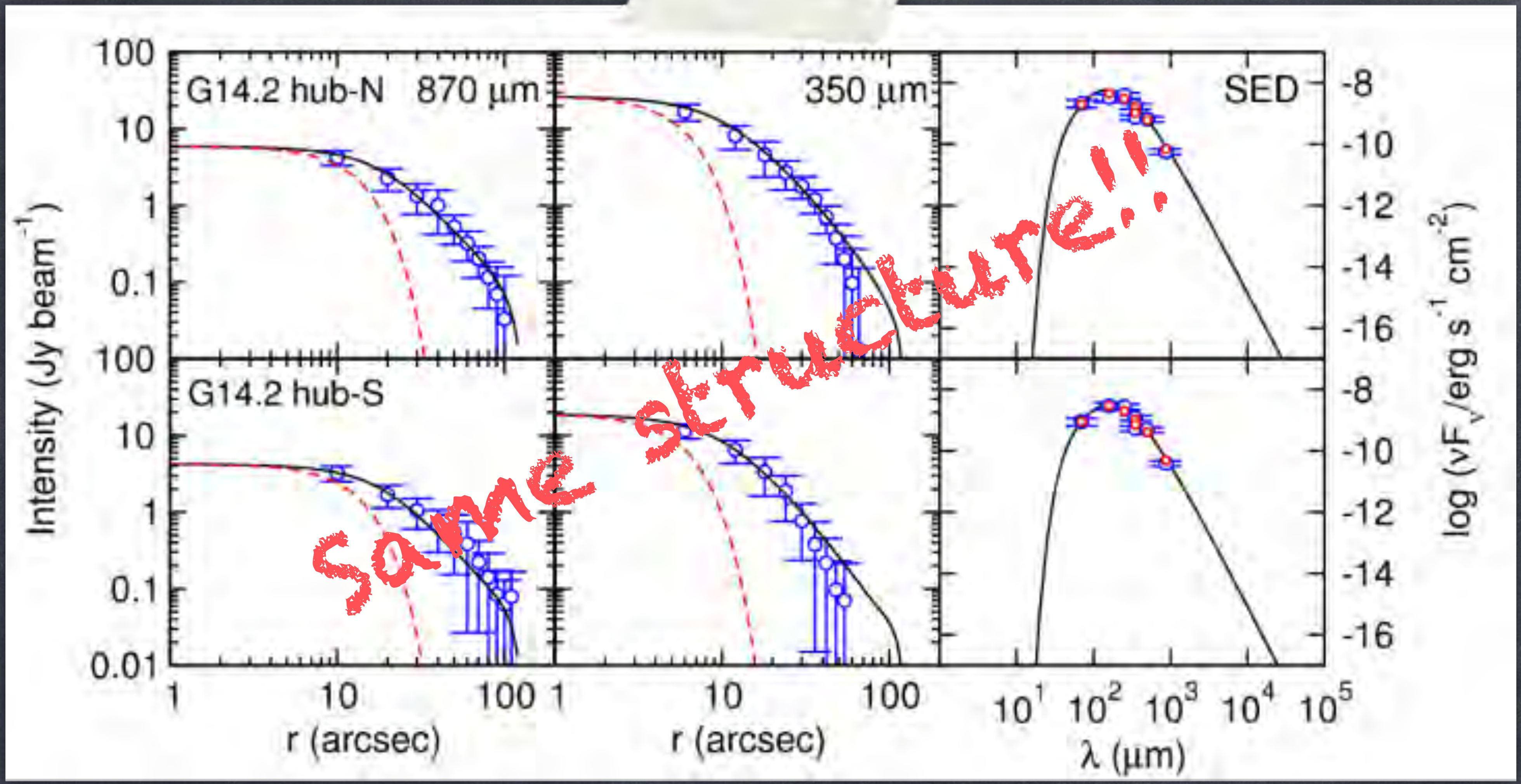
Model density and Temperature profile

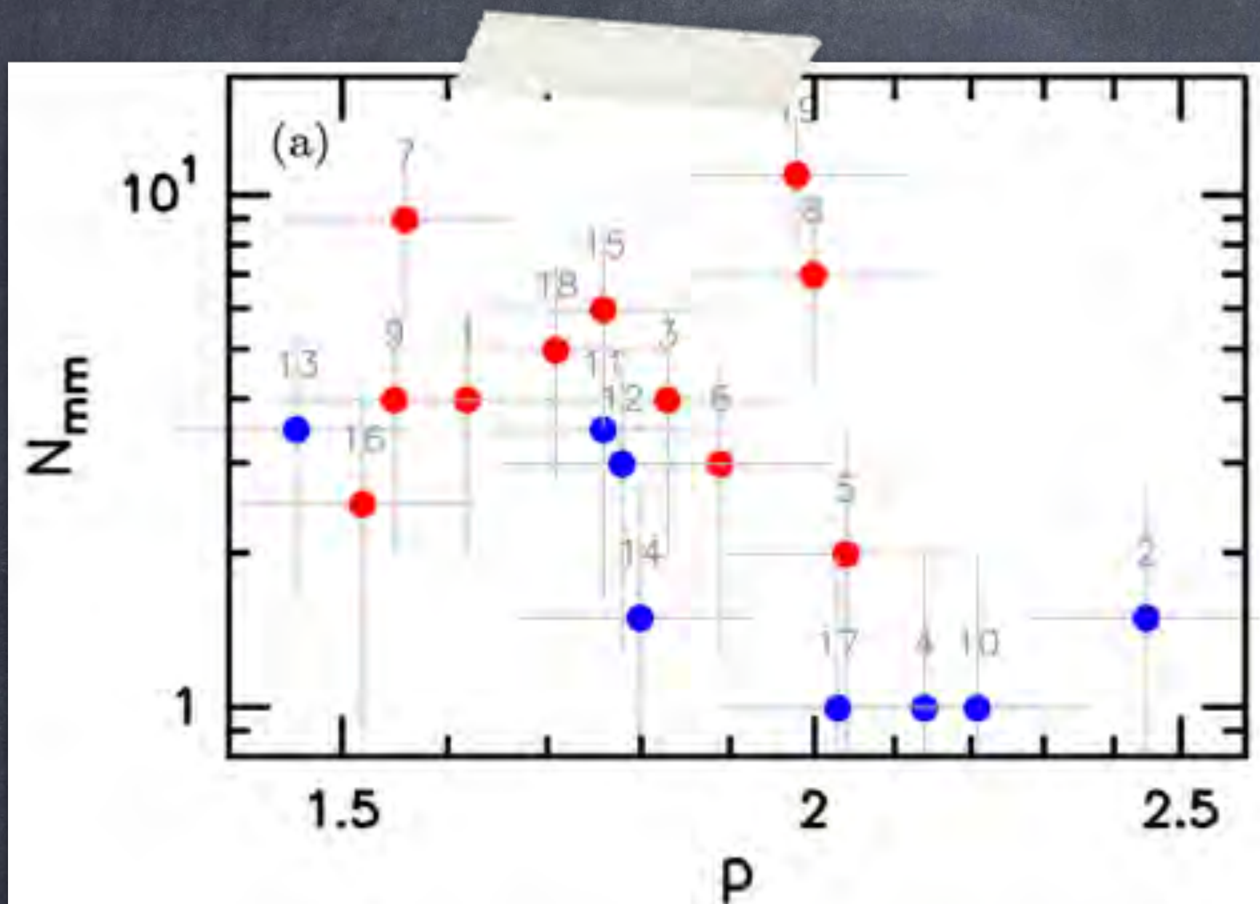


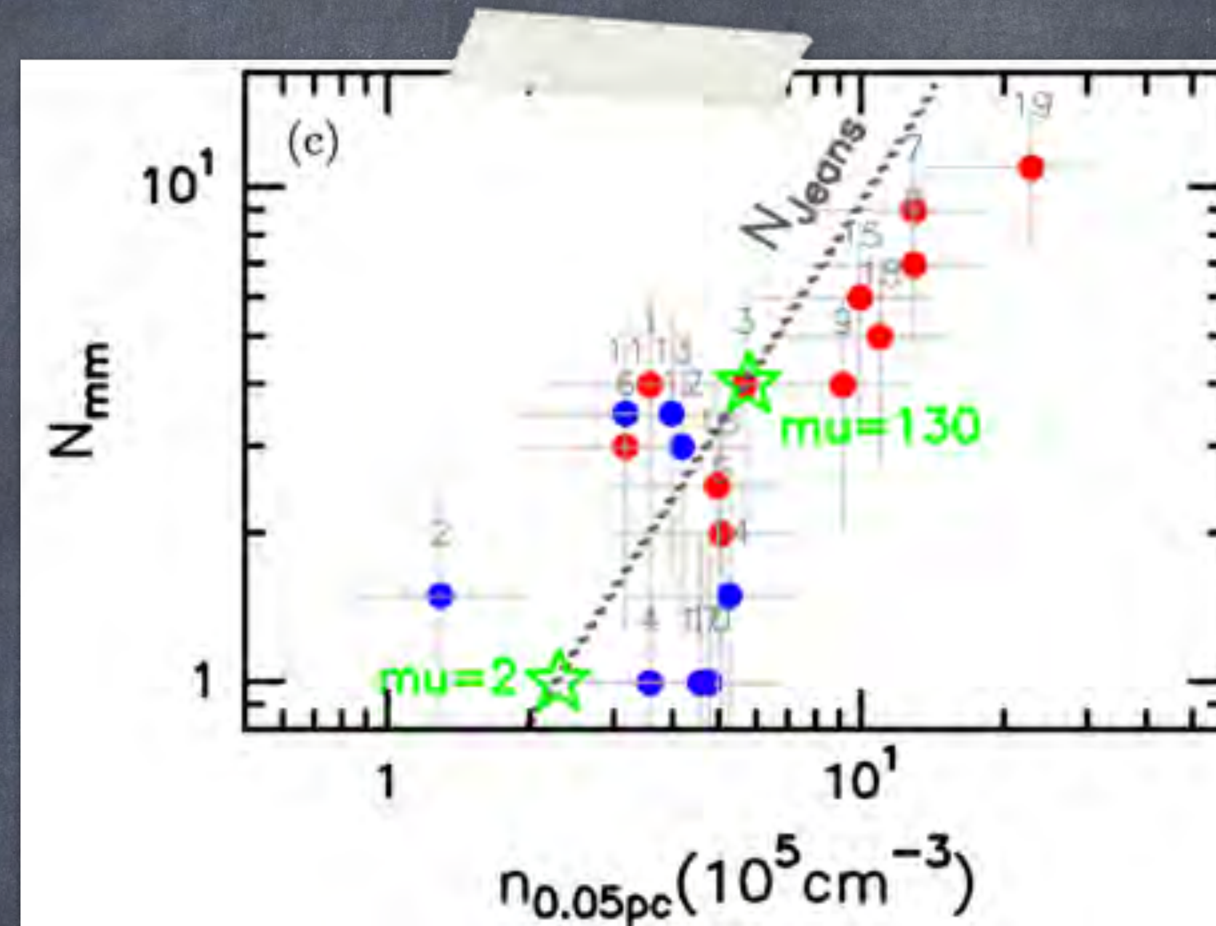
5

13 fragments

	β	T_0 (K)	ρ_0 (10^{-15} g cm^{-3})	r_c/r_0	ρ_c (10^{-18} g cm^{-3})	p
Hub-N	1.81	51±2	1.3±0.2	21±4	1.4±0.6	2.24
Hub-S	1.89	45±2	1.0±0.2	20±3	1.2±0.5	2.24

- Density structure based on a sample of 19 massive dense cores (Palau et al. 2014)

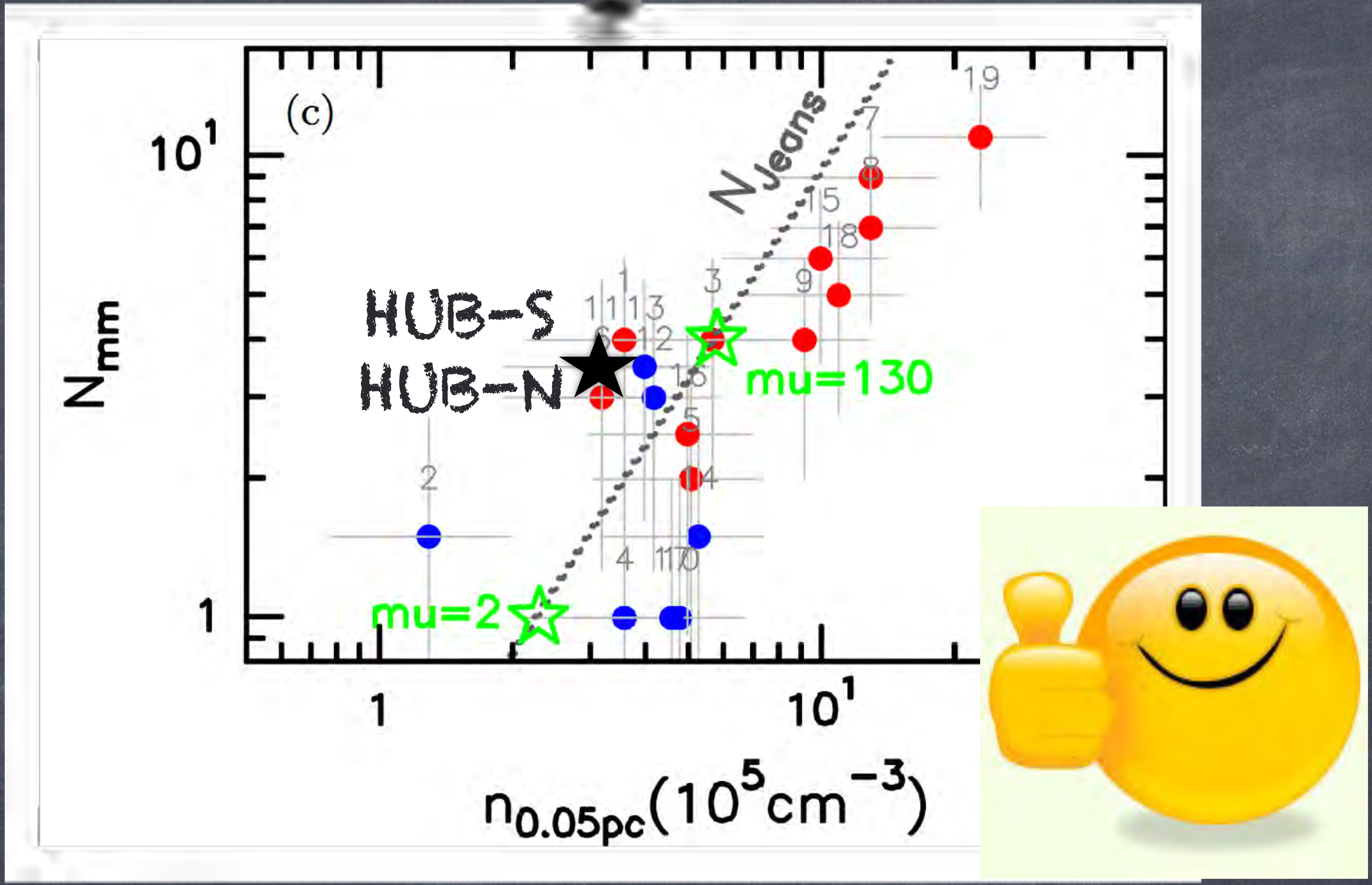




Weak trend of fragmentation level and density power law

Fragmentation increases with density as a combination of flat density profile and high central density

resolution
1000 AU



- At smaller scales (FoV~0.1pc) we count 3-4 fragments in each hub.

n the fragmentation level are seen at scal

General properties of Hubs

- Derived from the best-fit model: CFE~0.5-30%

	M (Msun)	Lbol (Lsun)	$M_{0.15pc}$ (Msun)	$n_{0.15pc}$ (10^5 cm^{-3})	$T_{0.15pc}$ (K)	M^{th}_{Jeans} (Msun)	N_{Jeans}
hub-N	979±329	995	126	1.3	18	1.31	5-29
hub-S	717±250	531	105	1.1	17	1.21	4-26

- Derived using NH_3 emission (Busquet et al. 2013)

	σ_{n-th} (km/s)	M^{tot}_{Jeans}(Msun)	N_{Jeans}
hub-N	0.96	28	1
hub-S	1.01	32	1

CFE~30%

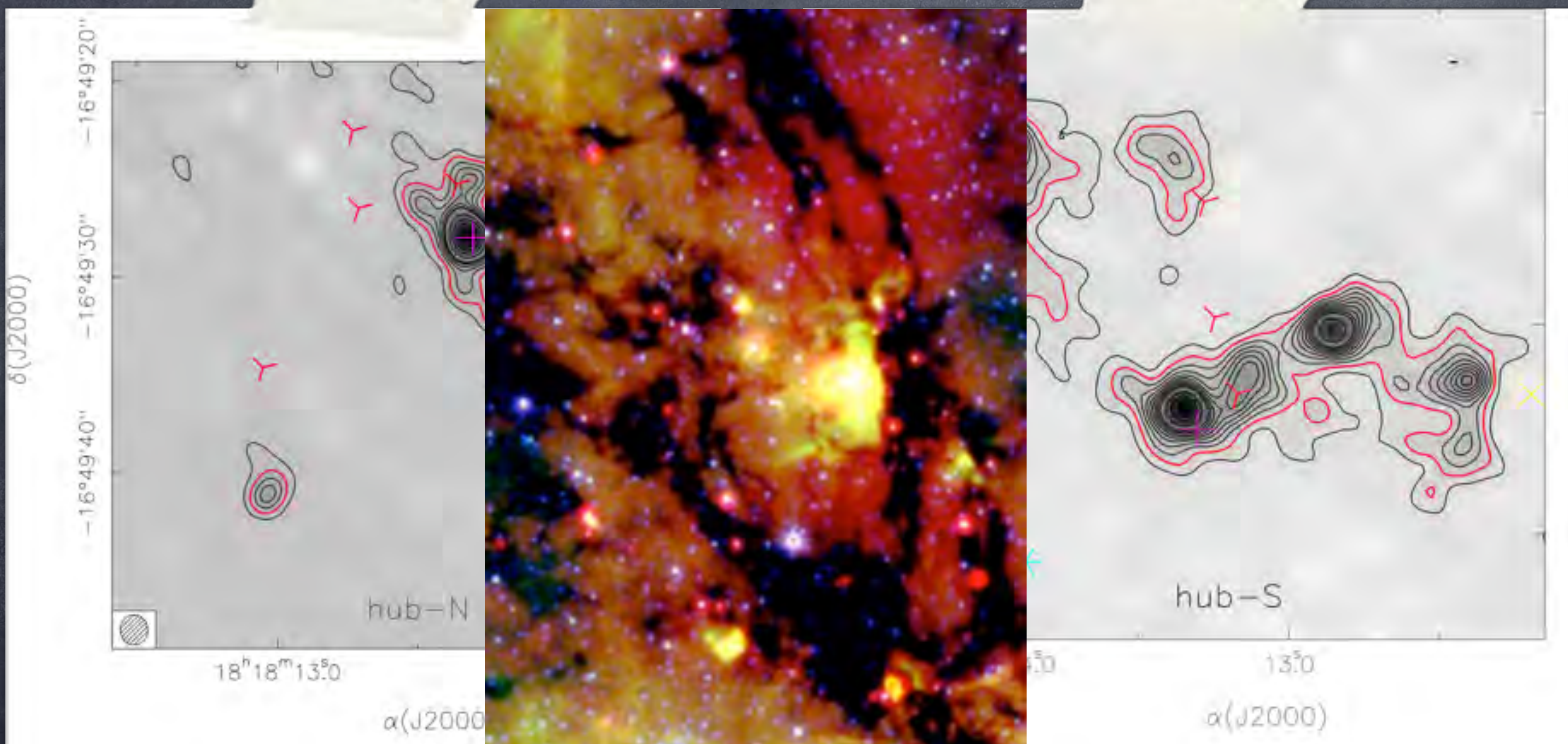
"Pure" thermal Jeans fragmentation works!

General properties of Hubs

- Using NH_3 emission (Busquet et al. 2013)
  - ✓ Rotational-to-gravitational energy: $\beta_{rot} = 14$
  - ✓ Turbulence to thermal energy (Mach number): M=3-7
- Using near-IR polarization measurements (Santos et al. in prep.)
  - ✓ Turbulence with respect magnetic field (Alfvén Mach number): M_A=1-1.2 using B_{tot}=0.4-0.5 mG
  - ✓ Mass-to-flux ratio $(M/\phi_B)(M/\phi_B)_{cr}$=1.5-2.2

Same physical conditions!

Core evolution and stellar feedback



Nmm=5
NIR/Nmm=1.4

Nmm=13
NIR/Nmm=0.4

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Conclusions

- We found significant differences in the fragmentation level
- The density and temperature structure appear to be exactly the same in both hubs
- Both hubs present similar physical conditions (Mach number, βrot, magnetic field, etc)
- Core evolution, stellar feedback, and possibly magnetic field, could explain the high level of fragmentation observed in hub-S than in hub-N.

THANK YOU!!