Probing the Initial Conditions of Massive Star Formation with JCMT

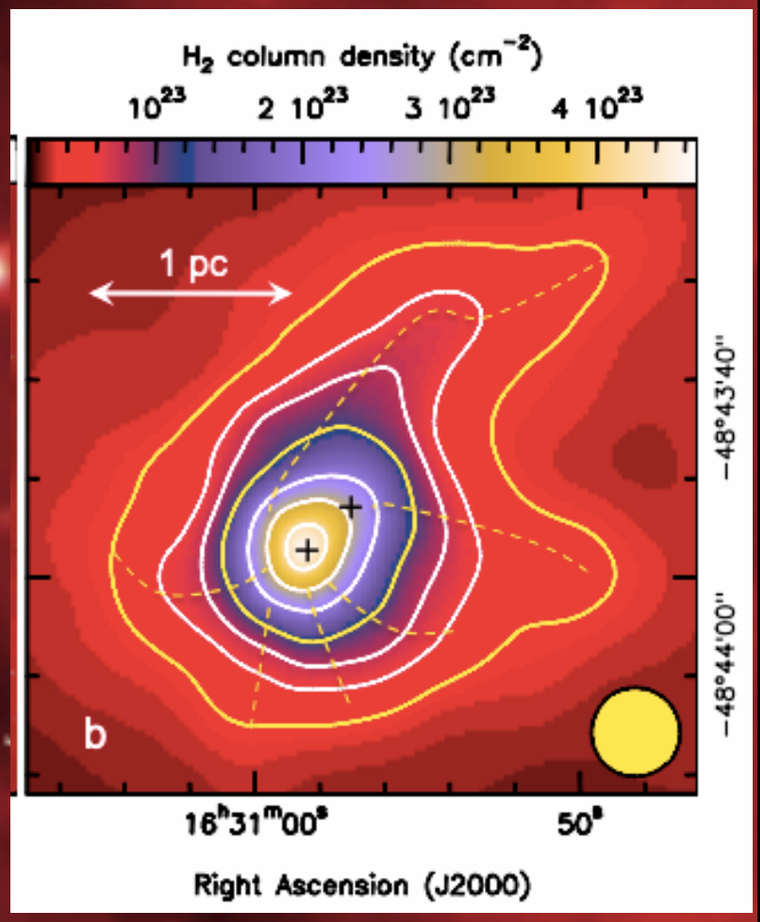
XIE Jinjin（NAOC）
Di Li（NAOC）, Gary Fuller（Univ. of Manchester）
Nicolas Peretto（Cardiff University）
Rowan Smith（Univ. of Manchester）
Zhiyuan Ren（NAOC）, Sihan Jiao（NAOC）

JCMT User Meeting, Taipei, Nov, 2019

IRDC (Infrared Dark Cloud) —

Cold & Dense

The Initial Condition of Star Formation



First Detection: Pérault et al (1996) with ISO
Typical Distance: 4 kpc

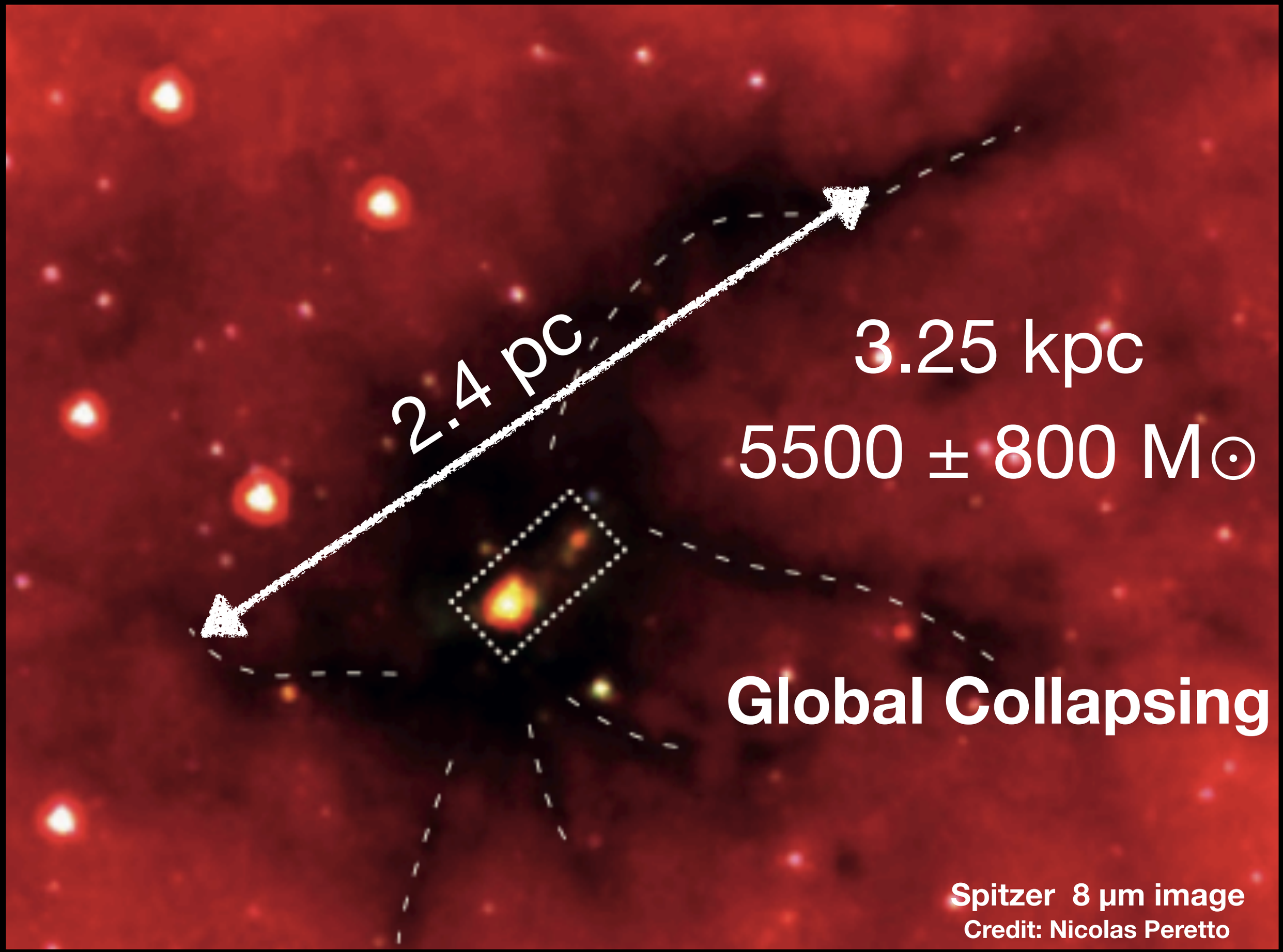
Peak Column Density: 3×10^{22} cm^{-2}

Temperature: <30 K

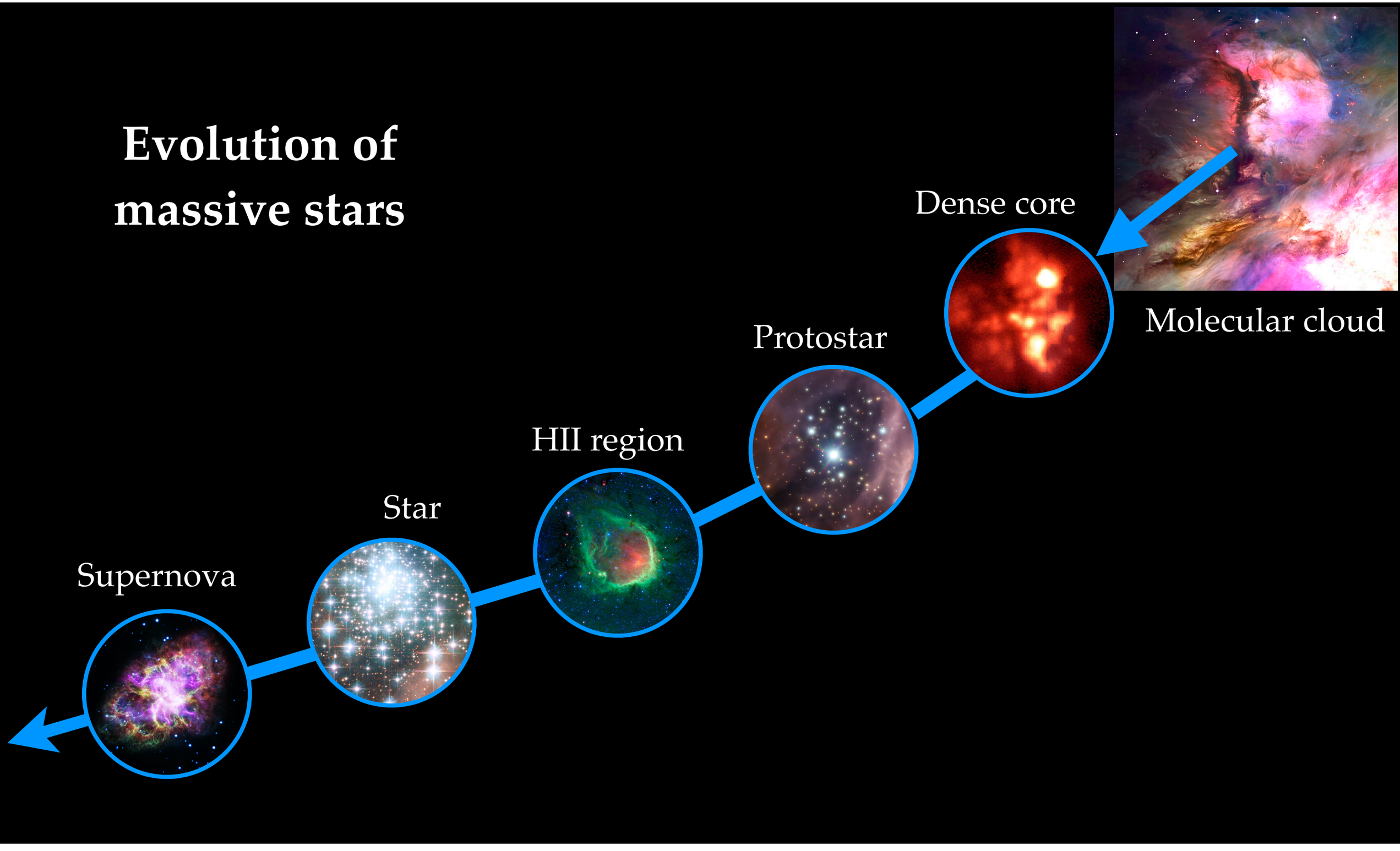
Many of them are massive!

Spitzer 8 μm image
Credit: Nicolas Peretto

One Massive IRDC SDC335



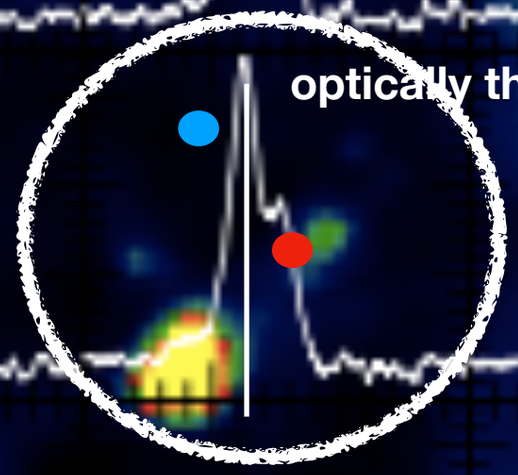
Evolution of massive stars



Credit: Shanghuo Li

A collapsing core
creates excitation temperature gradient.

Observing in optically thick molecular lines
— Blue-shifted asymmetric line profile



T_a^*(K)
3
2
1
0
−60 −50 −40 −30
Velocity (km/s)

Diagnostic feature of gas infalling

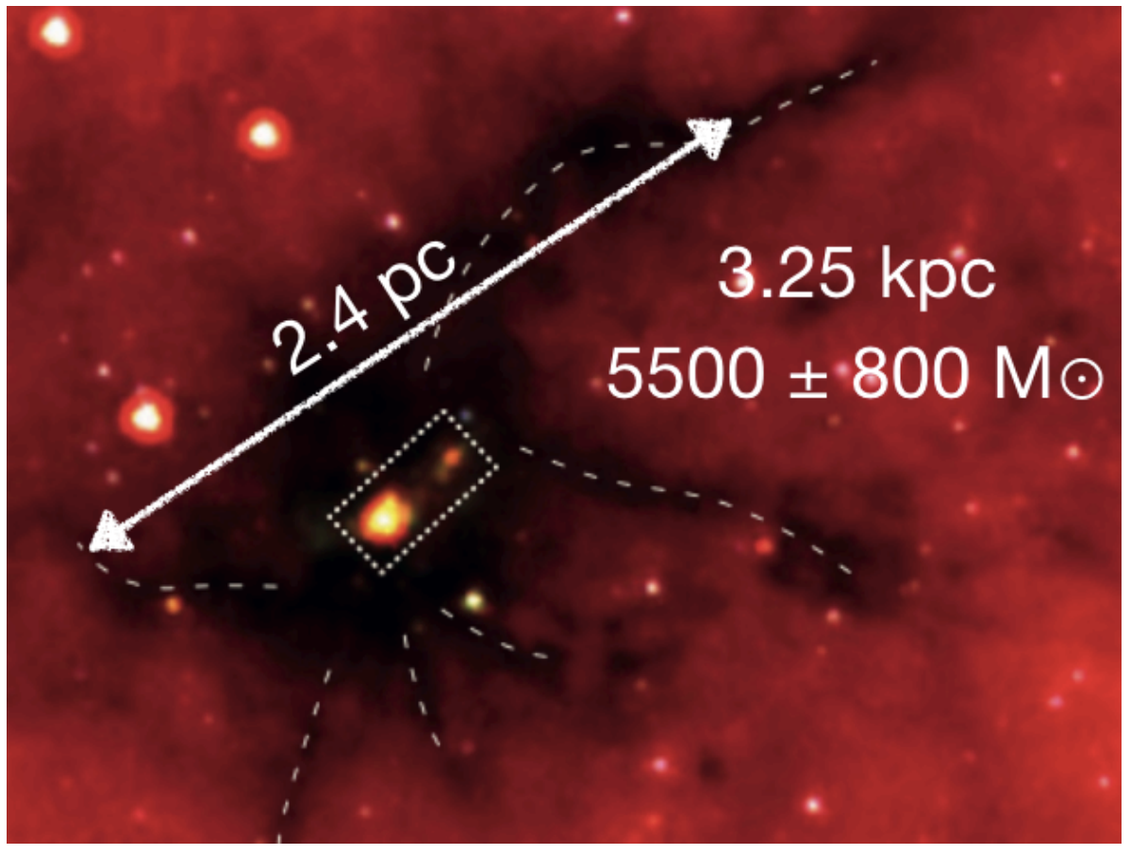
HCO^+(1—0) Mopra 22 m (Peretto et al. 2013)

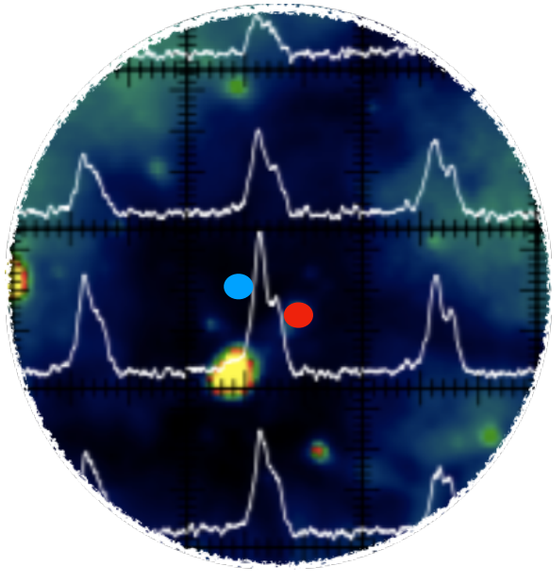
state-of-art RT model RADMC-3D

Input Parametres:

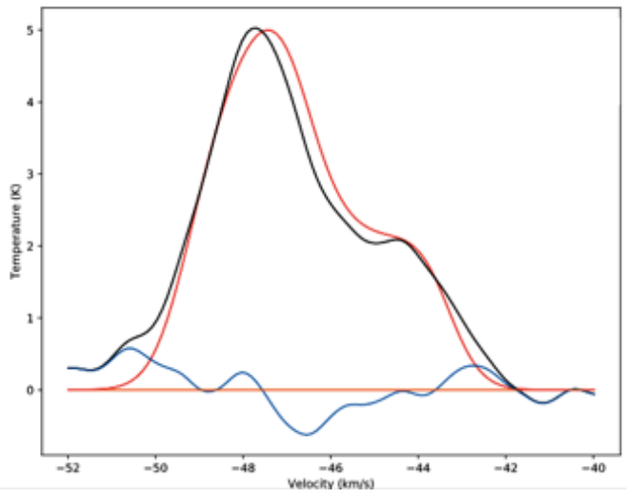
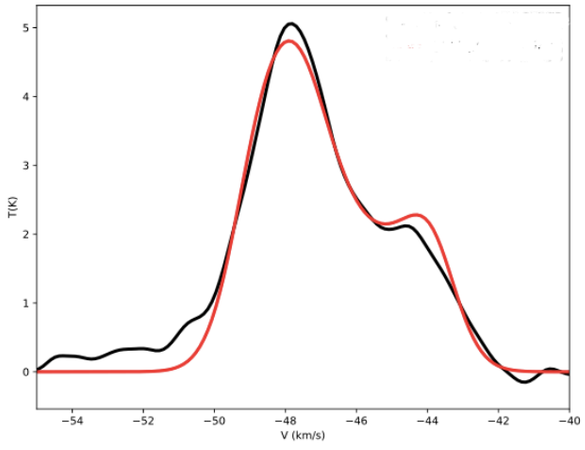
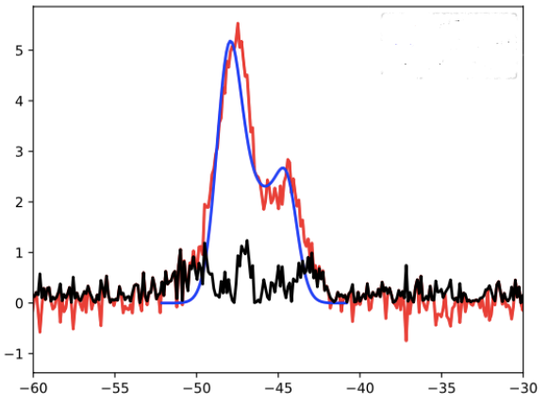
- **R — cloud size;**
- **X —molecular abundance;**
- **molecule properties (LAMDA)**
- **Vin — infall velocity (structure);**
- **σ — turbulence velocity;**
- **Tgas — gas temperature;**
- **m — mass;**
- **ρ —density profile;**
- **Tdust — dust temperature.**

RADMC-3D (Dullemond et al. in prep)



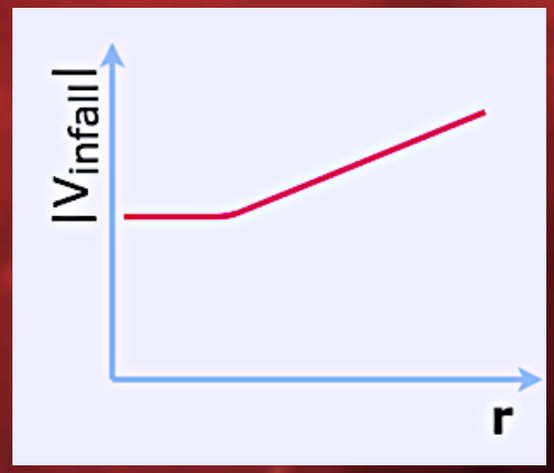


model to HCO^+ (1–0)

	RADMC-3D (Dullemond et al. in prep)	Analytical (HILL) (De Vries & Myers 2005)	RATRAN (Peretto et al. 2013)
complexity	3D	1D	1D
Vin	1.6 km/s	0.7 km/s	0.7 km/s
Vturb	1.3 km/s	1.2 km/s	1.0 km/s
Vin(r)	increasing	decreasing	constant (assumption)
central prixel			 They only fitted the central pixel.

Xie et al. in prep

Current Conclusion

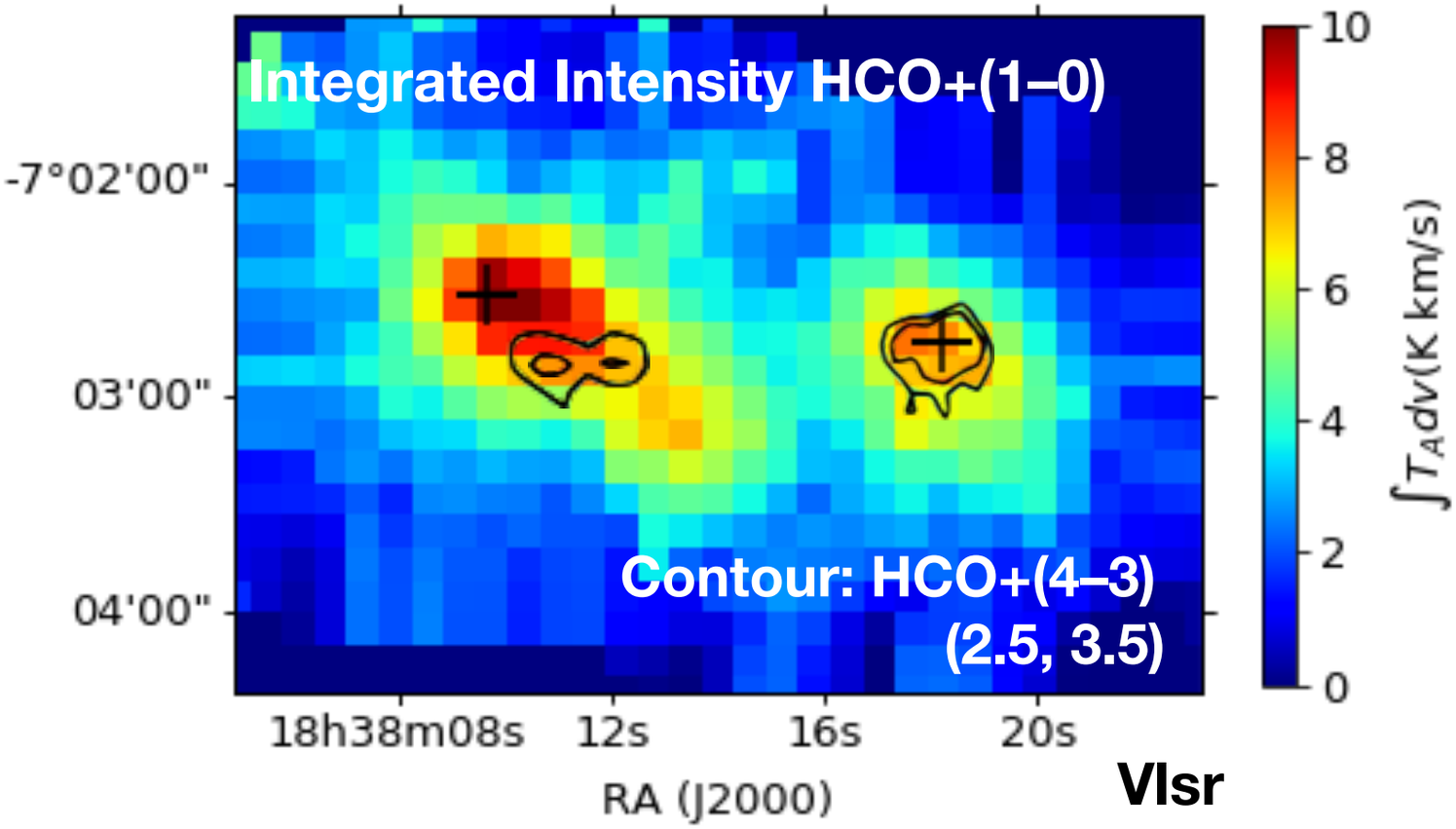


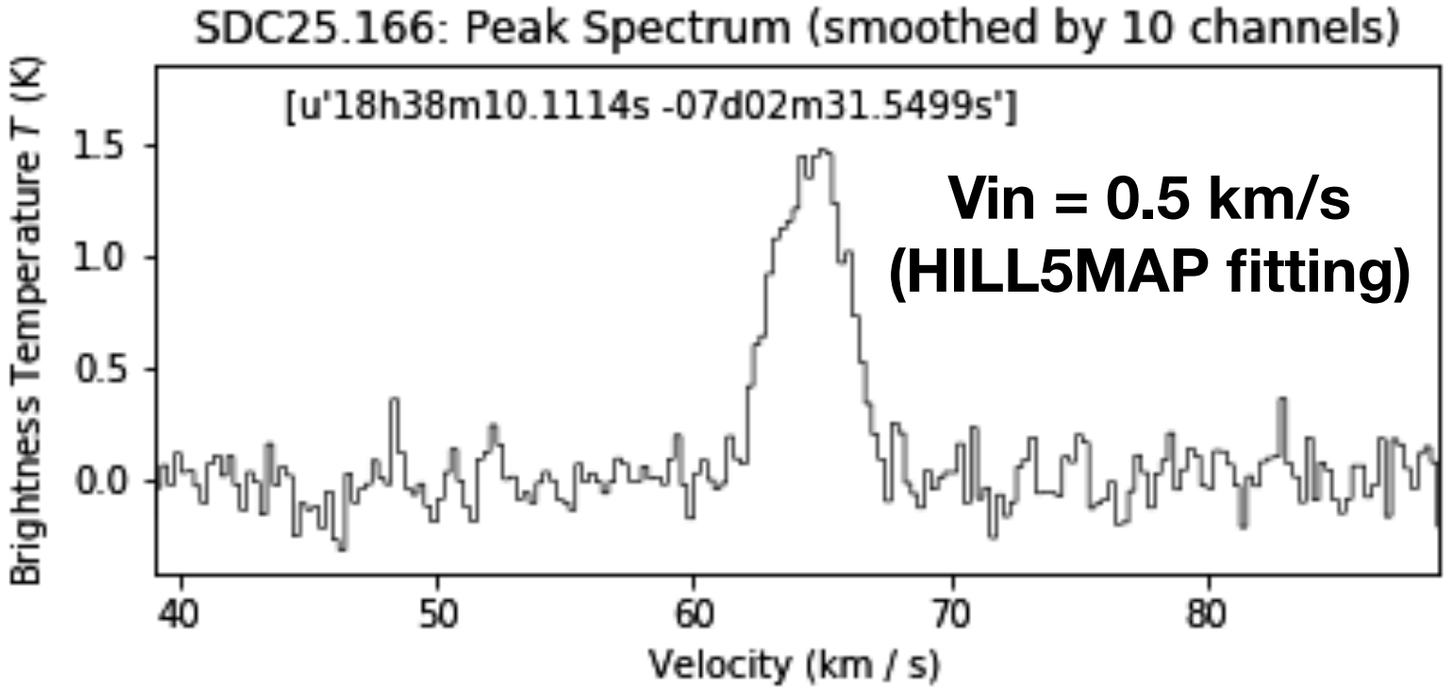
Vin = 1.6 km/s

Whether this velocity structure holds true for other massive star forming clouds?

Observations

Infall Candidate SDC25.166 (Massive IRDC)





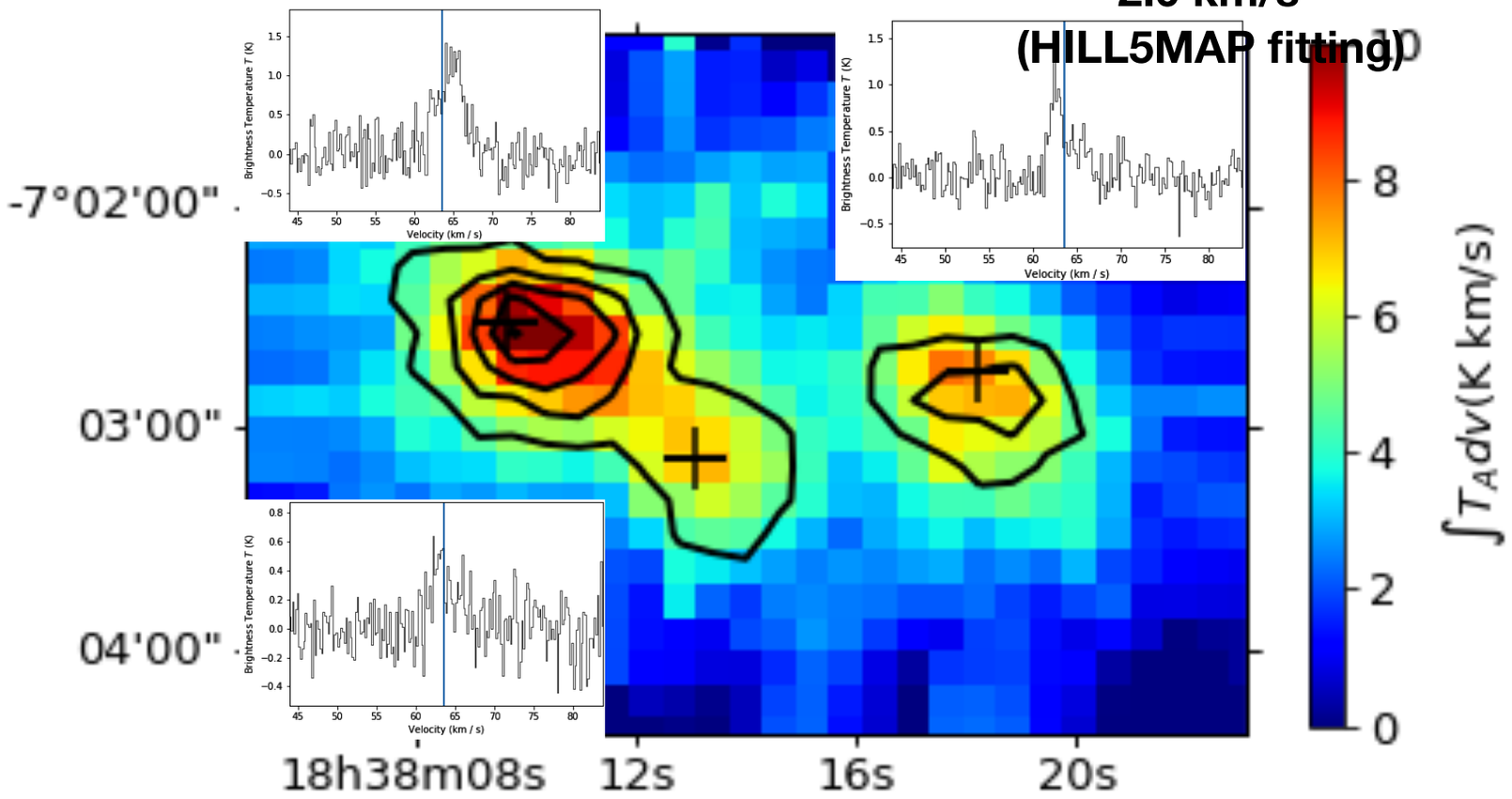
JCMT HARP

Xie et al. in prep

Infall Candidate SDC25.166 (Massive IRDC)

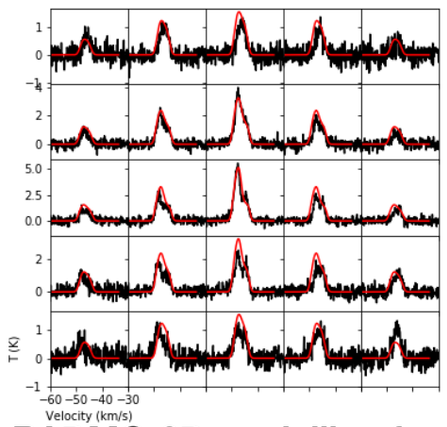
JCMT RxA

HCO+ (3–2) single-point observation



Vin = 1.45 km/s
(HILL5MAP fitting)

To fully constrain the infall velocity across the cloud



RADMC-3D modelling for SDC335

We need mapping with Namakanui!

(JCMT website)

Xie et al. in prep

Basic Parametres of IRDC

- **m — mass;**
- **ρ —density profile;**
- **Tdust — dust temperature;**

Interstellar Dust

- **R — cloud size;**
- **Vin — infall velocity (structure);**
- **σ — turbulence velocity;**
- **Tgas — gas temperature;**

line survey

There is no JCMT/SCUBA-2 survey towards IRDCs yet!

Herschel

SCUBA-2

36”
500 μm

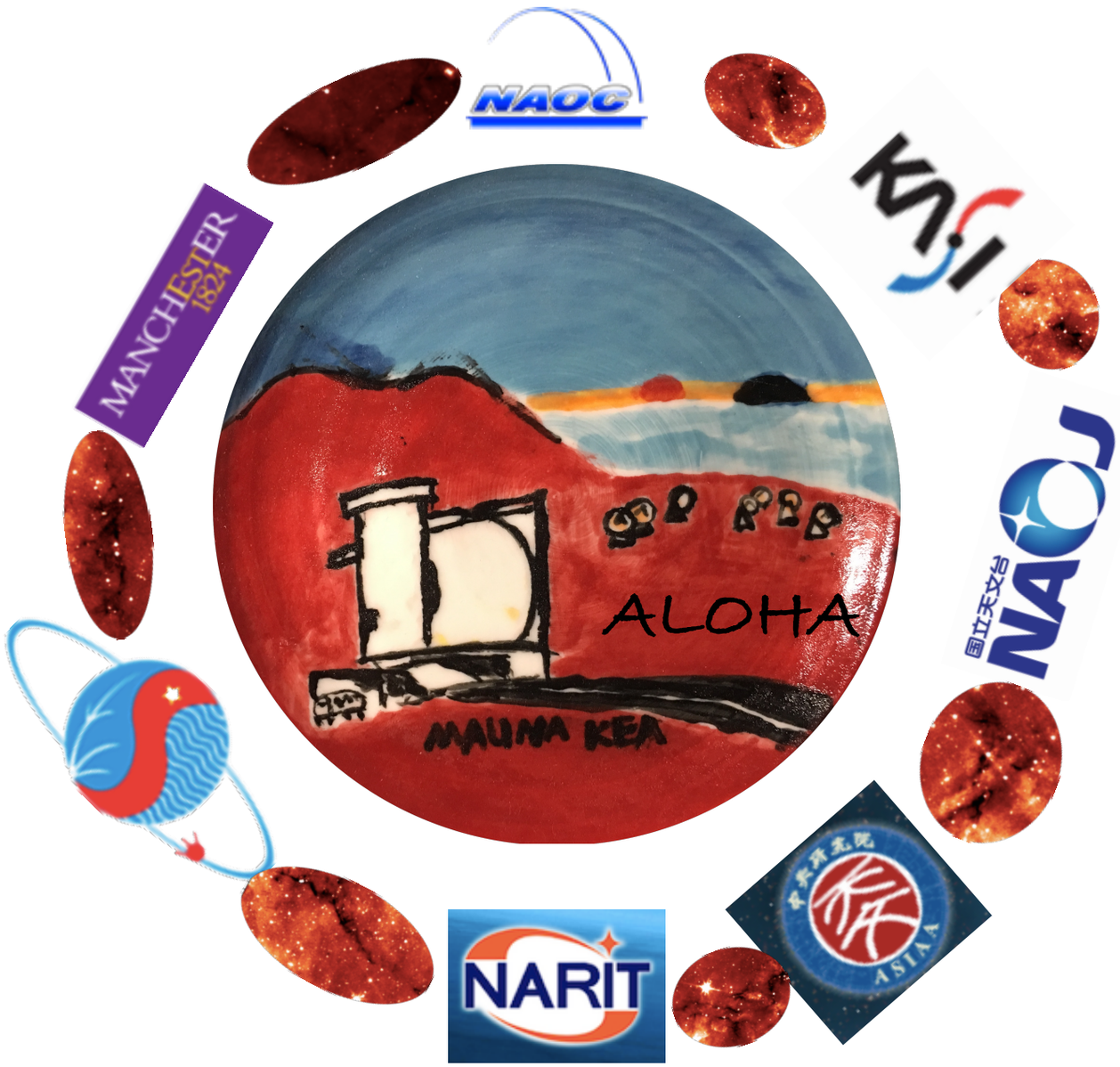
higher resolution 14”
longer wavelength 850 μm

To cover Rayleigh Jeans tail from the peak to better constrain the density and temperature.

Proposed Large Program

ALOHA IRDC

A Lei Of the Habitat and Assembly of Infrared Dark Clouds



Lei

Proposed Large Program

ALOHA IRDC

A Lei Of the Habitat and Assembly of Infrared Dark Clouds

Coordinators:

Di Li

XIE Jinjin

Gary Fuller

Pham Ngoc Diep

Kee-Tae Kim

Ken’ichi Tatematsu

Hauyu Baobab Liu

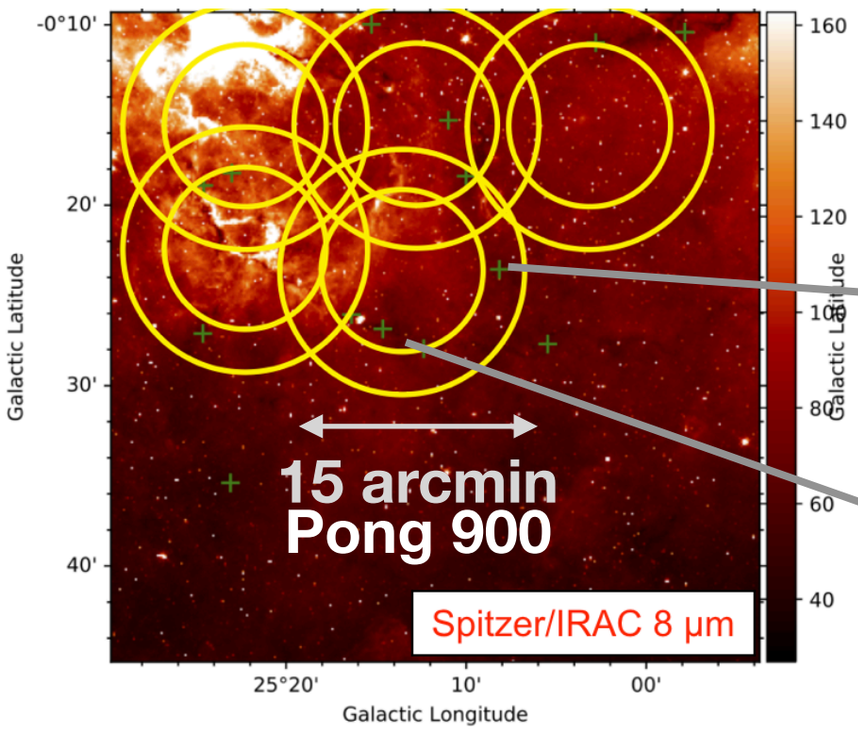
Busaba Kramer

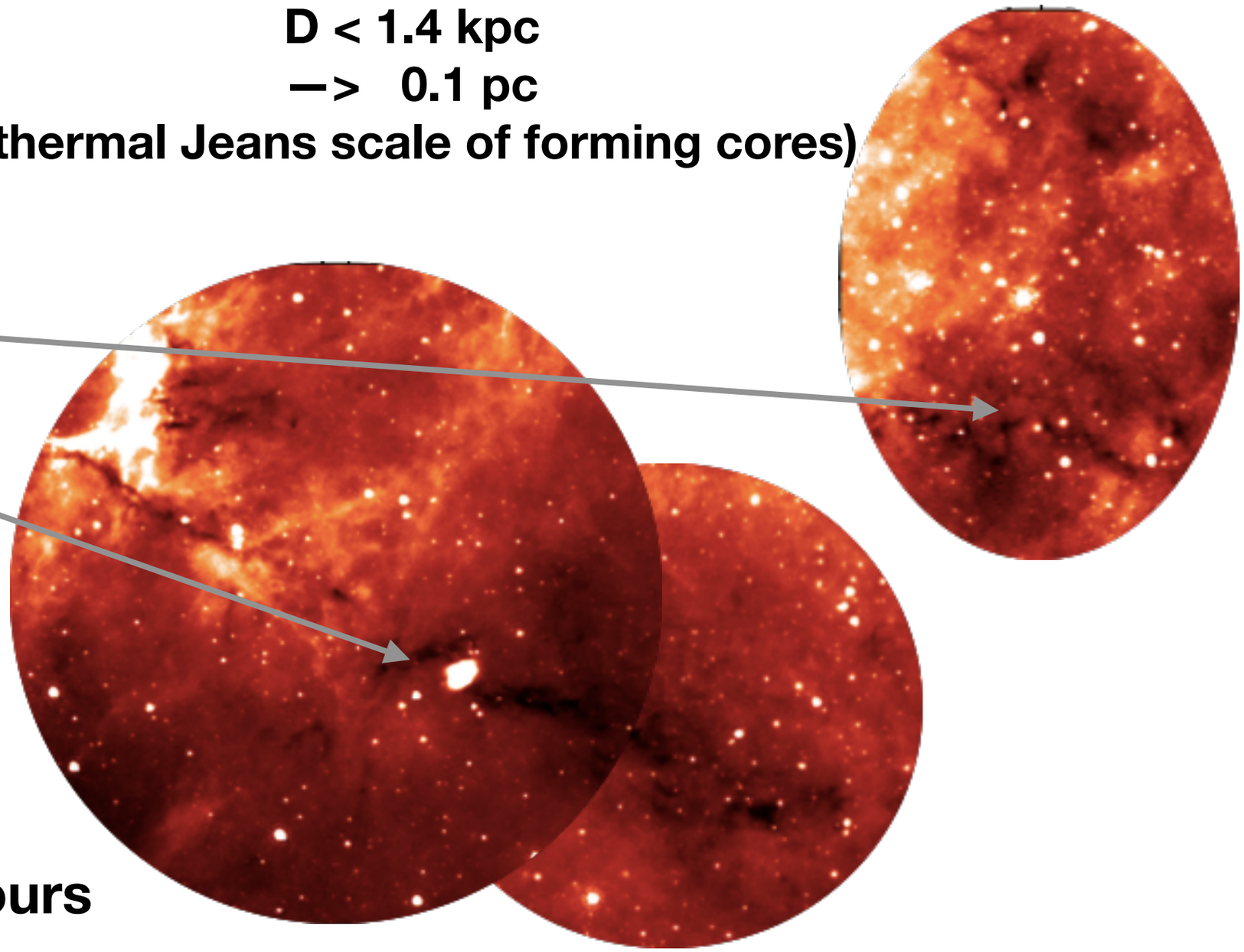
Mark Rawlings

Selection & Mapping on

The Habitat & Assembly

D < 1.4 kpc
—> 0.1 pc
(thermal Jeans scale of forming cores)



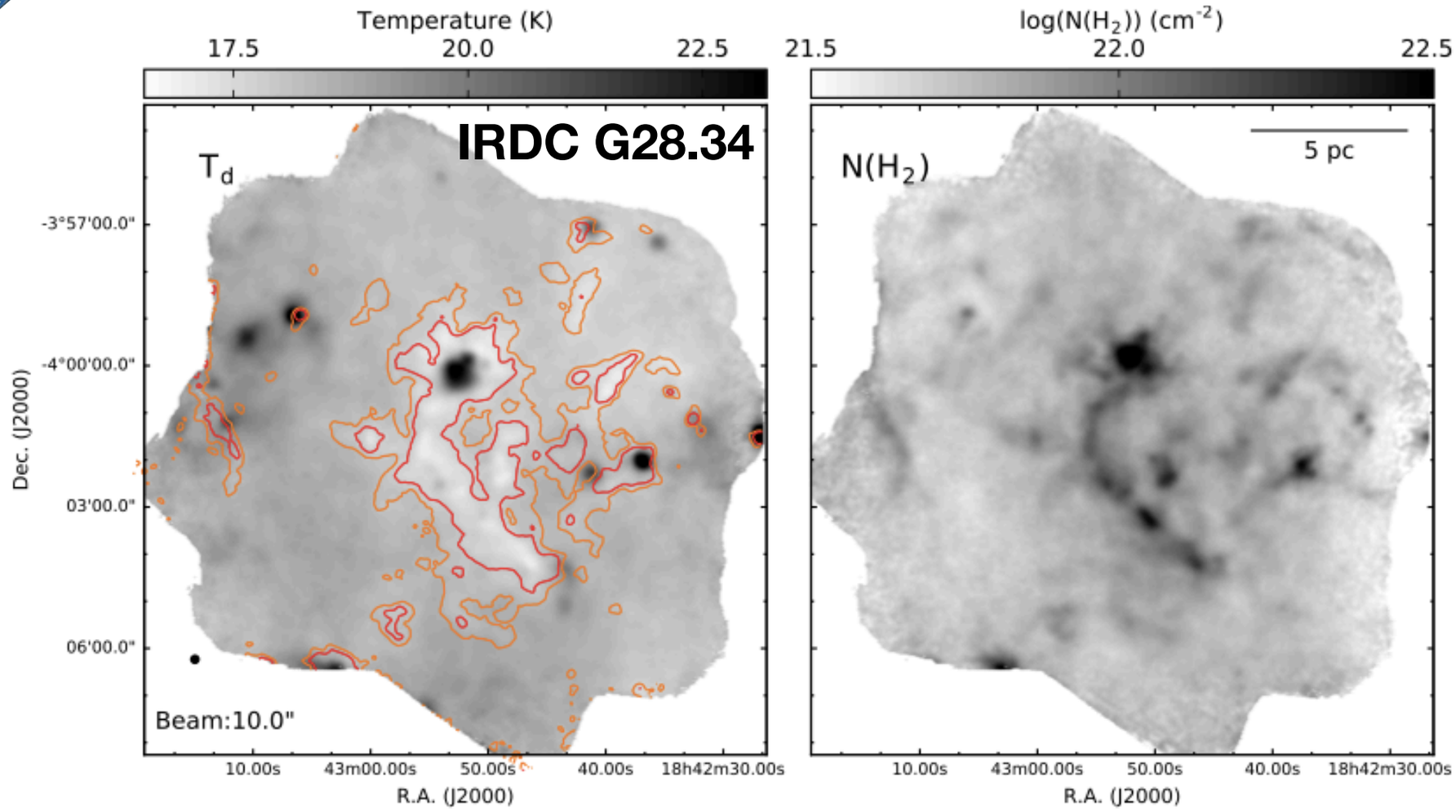


50 Pong mappings

Weather Request: Band 3
Each Pong mapping: 10 hours

Total mapping time: 520 Hours

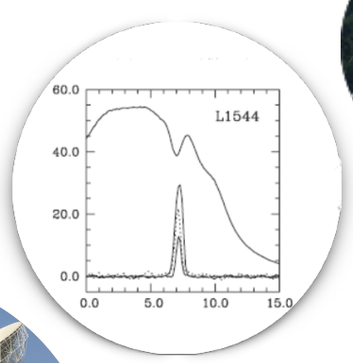
Innovative Analysis Tool — J-Comb

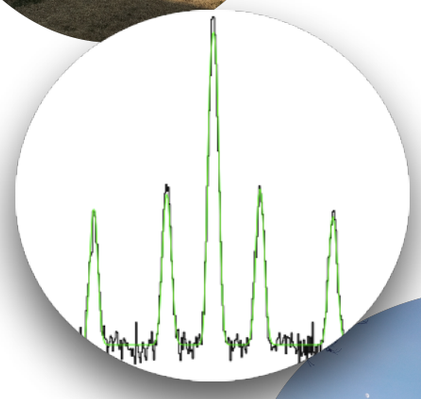


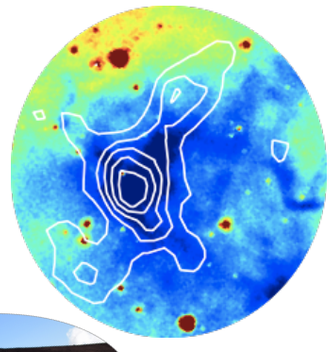
Lin et al. 2017

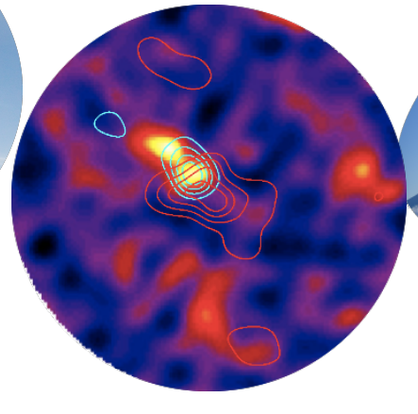
Optimise the observation data with the combination of Herschel data To derive the column density and dust temperature.

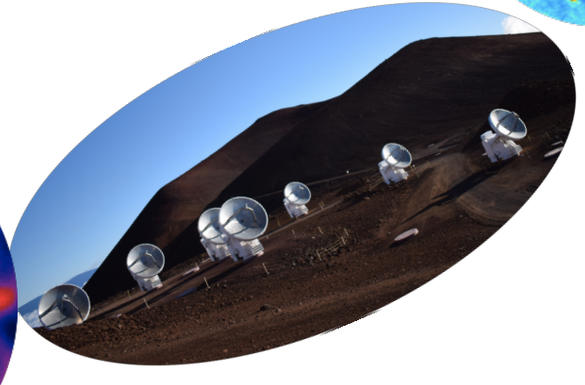
Coordinating Multi-wavelength Observations











ALOHA IRDCs