



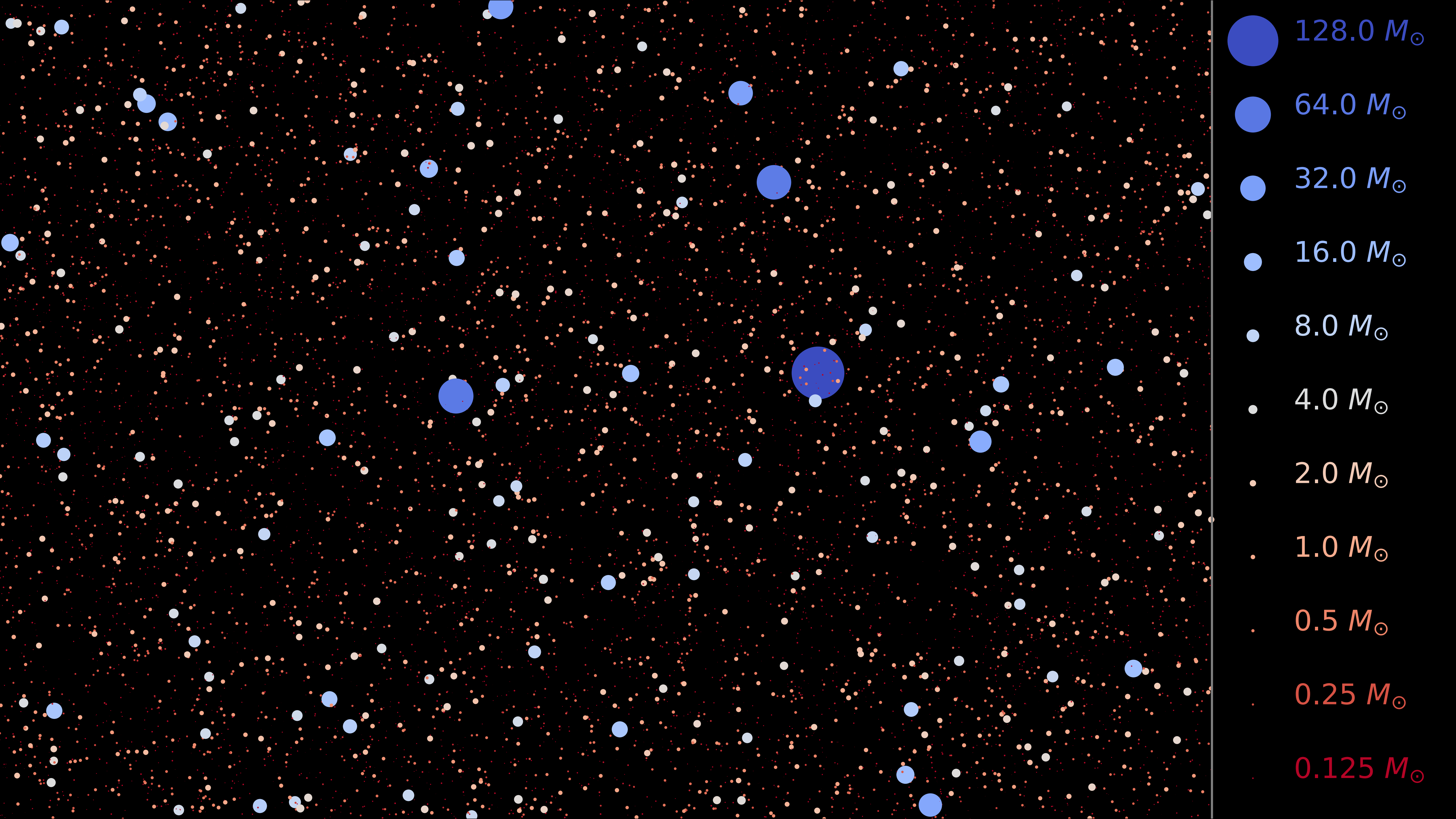
# Striking resemblance between **IMF** and the mass spectrum of **sub-pc clumps**

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**Colaborators:** Keping Qiu (Nanjing University), Qizhou Zhang (Center for Astrophysics | Harvard & Smithsonian)

Dec 2, 2020

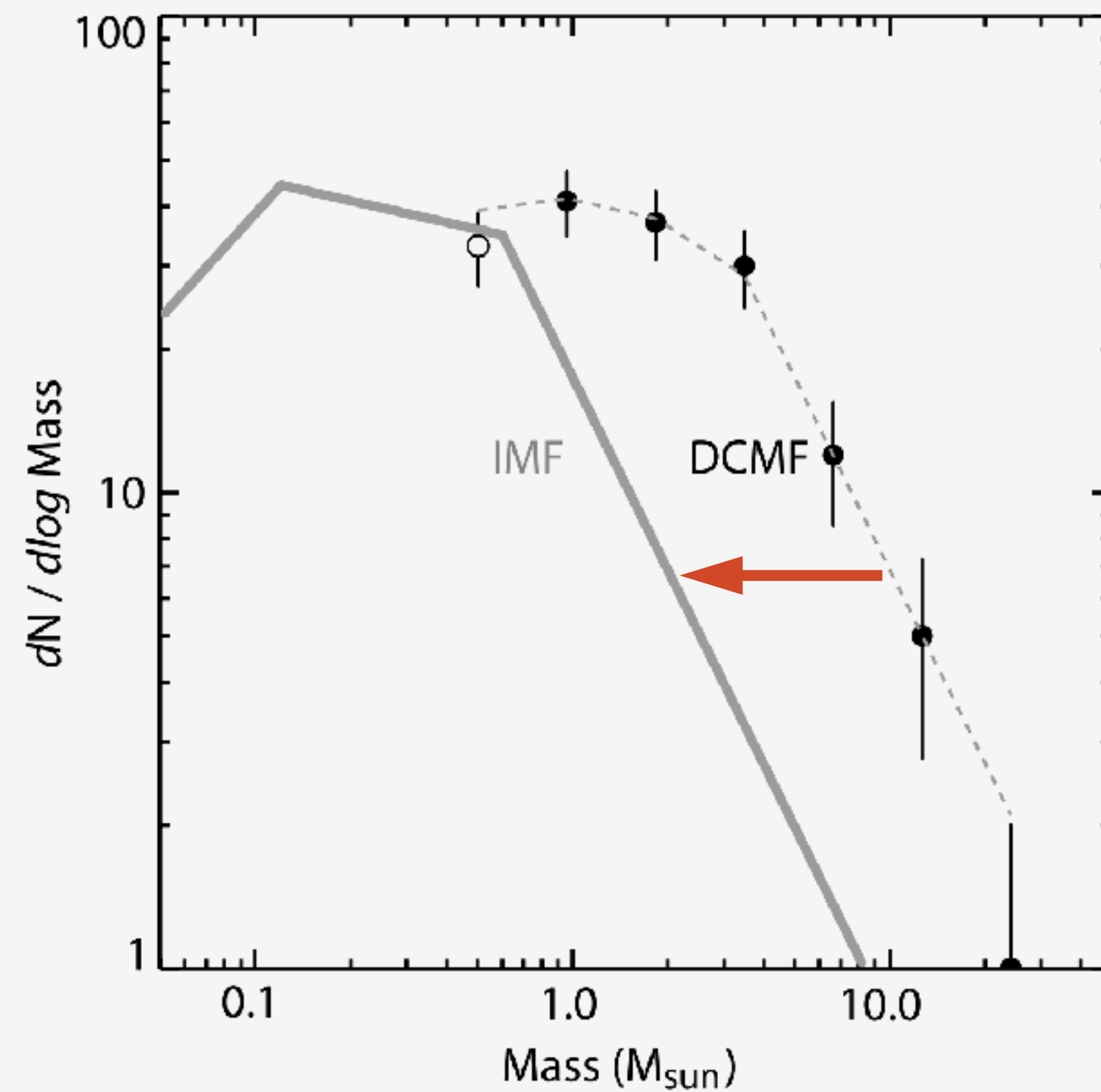
**(Please contact the speaker first before using the figures in the slides since some data may have not been published)**



- 128.0  $M_{\odot}$
- 64.0  $M_{\odot}$
- 32.0  $M_{\odot}$
- 16.0  $M_{\odot}$
- 8.0  $M_{\odot}$
- 4.0  $M_{\odot}$
- 2.0  $M_{\odot}$
- 1.0  $M_{\odot}$
- 0.5  $M_{\odot}$
- 0.25  $M_{\odot}$
- 0.125  $M_{\odot}$

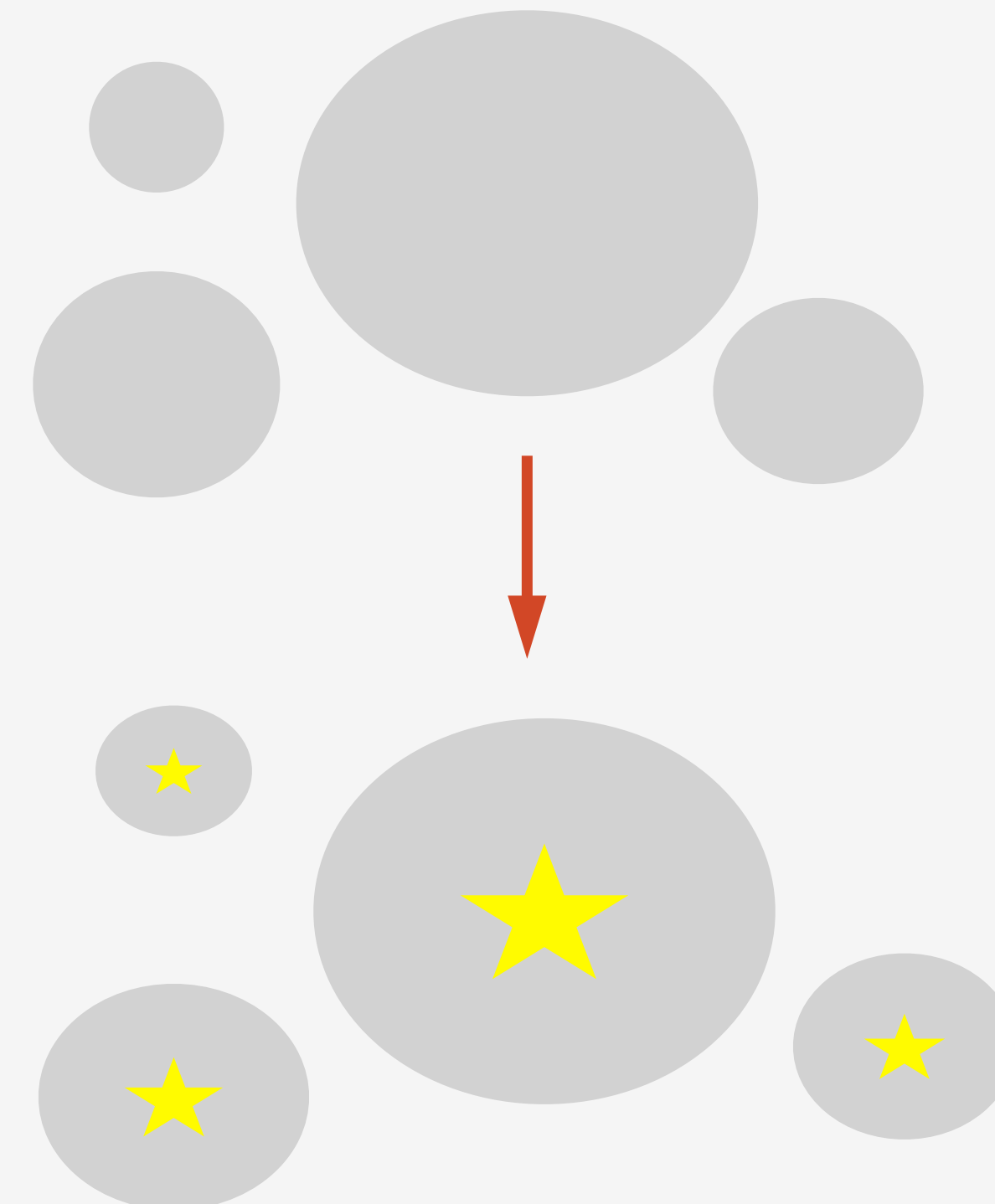
# Background

## 1. Core mass function (CMF) resembles IMF



Alves et al. (2007)

## Cores (0.01–0.1 pc)



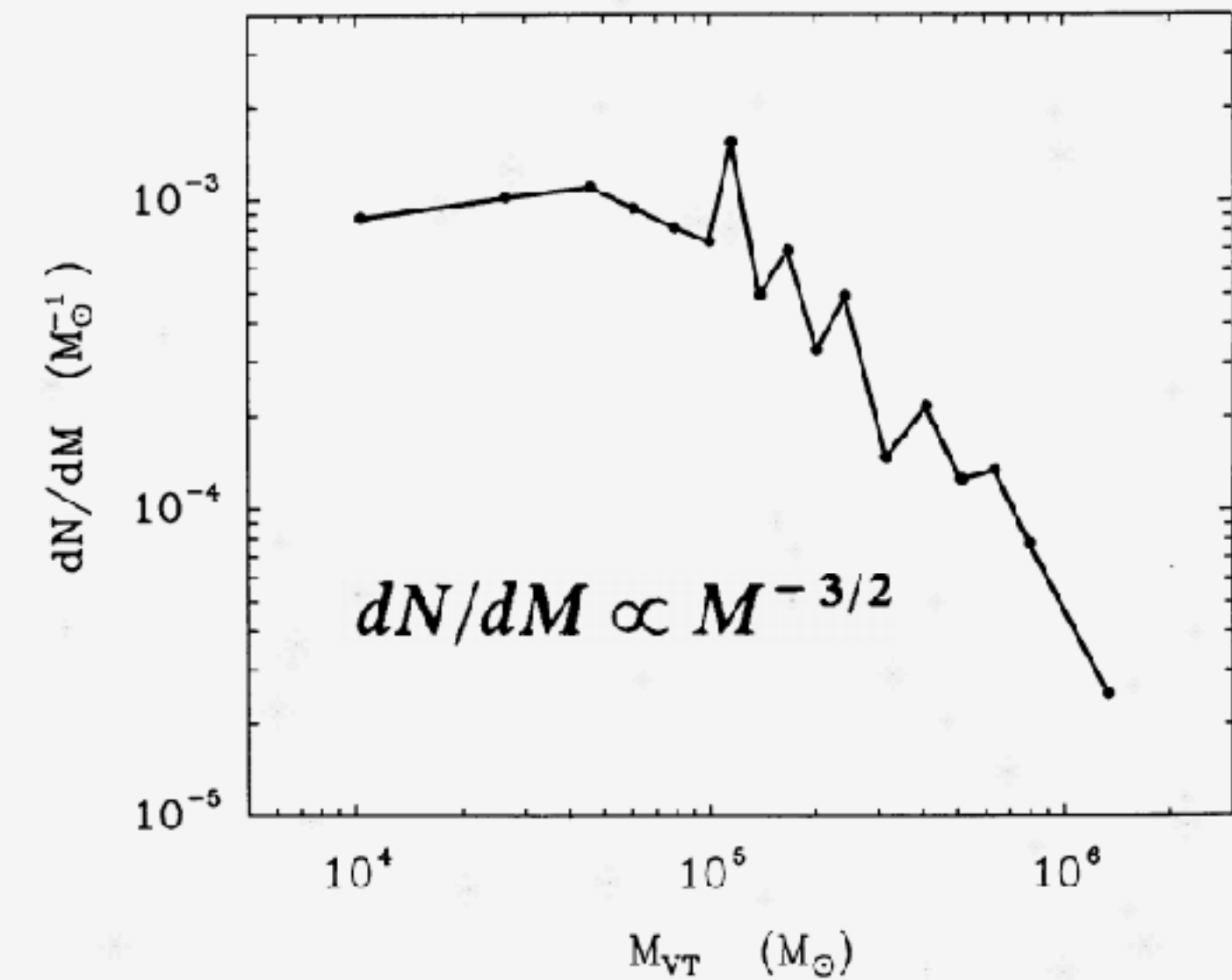
**Self-similar** core-to-star  
mass mapping

# Background

## 2. Cloud mass function does *not* resemble IMF

Solomon et al. (1987); Williams & McKee (1997);

Roman-Duval et al. (2010); ...



*A matter of scale*



*Key question: what is the scale where the IMF shape come into play?*

# Background

## 3. Clump mass function ? IMF

- Samples not statistically significant enough

Larger mapping areas & larger sample sizes needed.

Region Name	$\alpha_{\text{high}}$
NGC 7538	$-1.8 \pm 0.6$
W43	$-2.0 \pm 0.6$
RCW 106	$-2.1 \pm 0.3$

Micheal Reid & Christine Wilson (2006)

# Generating a large-sample CIMF

**Target selection**

**Column density map**

**Clumps catalog**

**Comparison with IMF**

## Target requirements

- near ← 1.4 kpc
- large ← 200 pc x 100 pc,  $3 \times 10^6 M_{\odot}$
- all-inclusive ← low/high-mass star formation

Introducing... **Cygnus X!**

# Generating a large-sample CIMF

Planck 350  $\mu\text{m}$

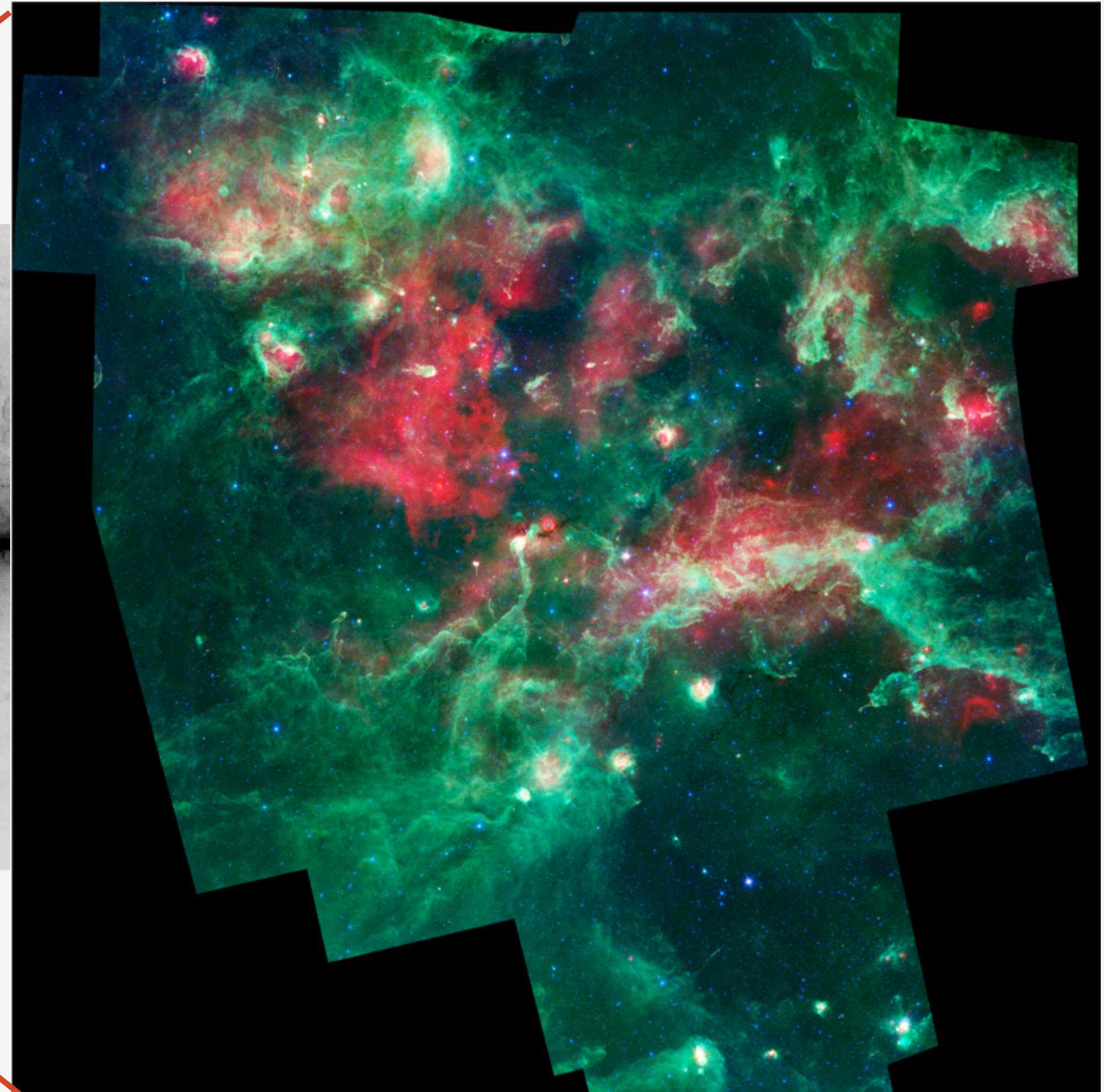
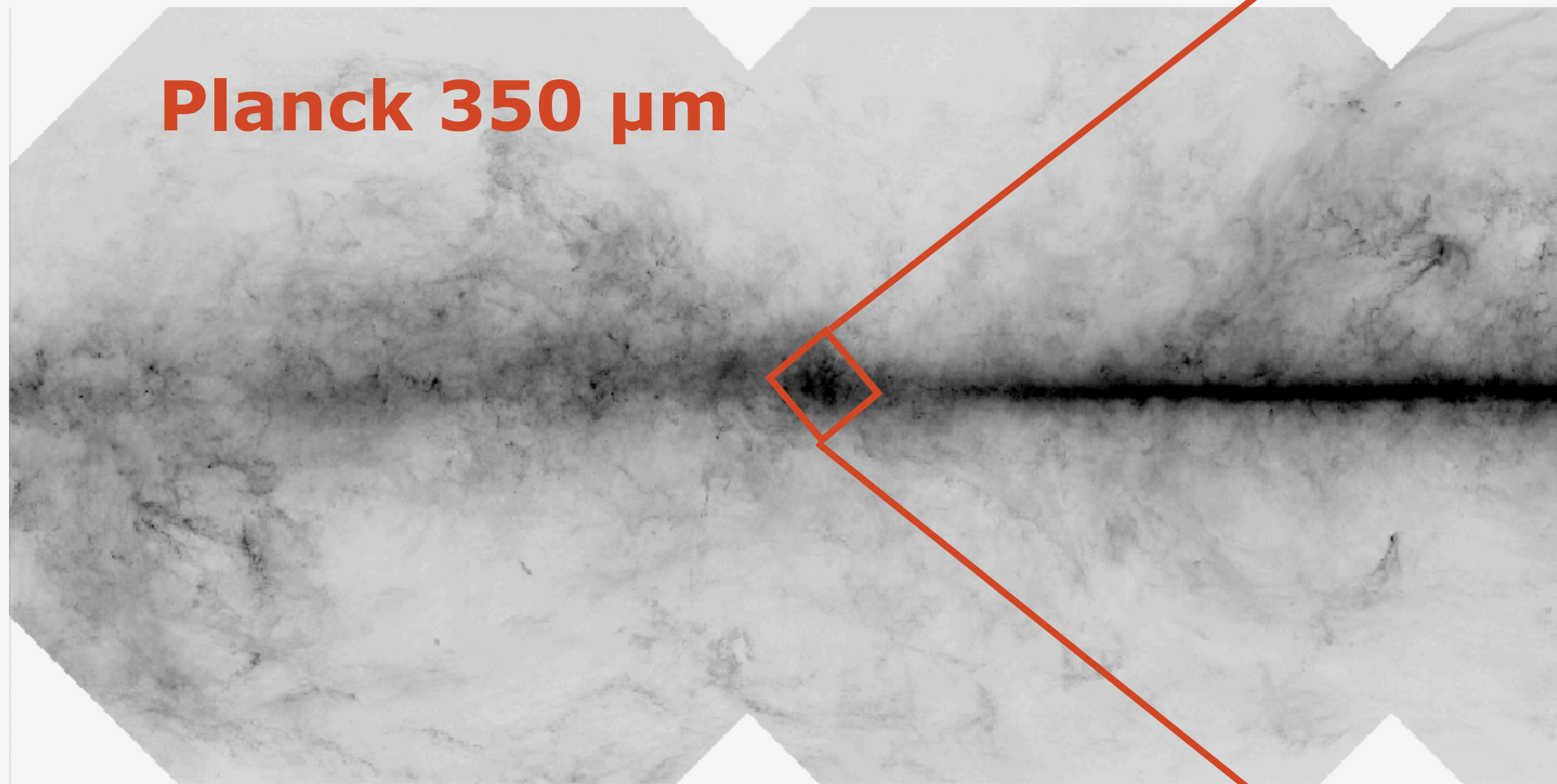


Image Credit: Spitzer Cyg X Legacy Survey (PI: J. Hora)

# Generating a large-sample CIMF

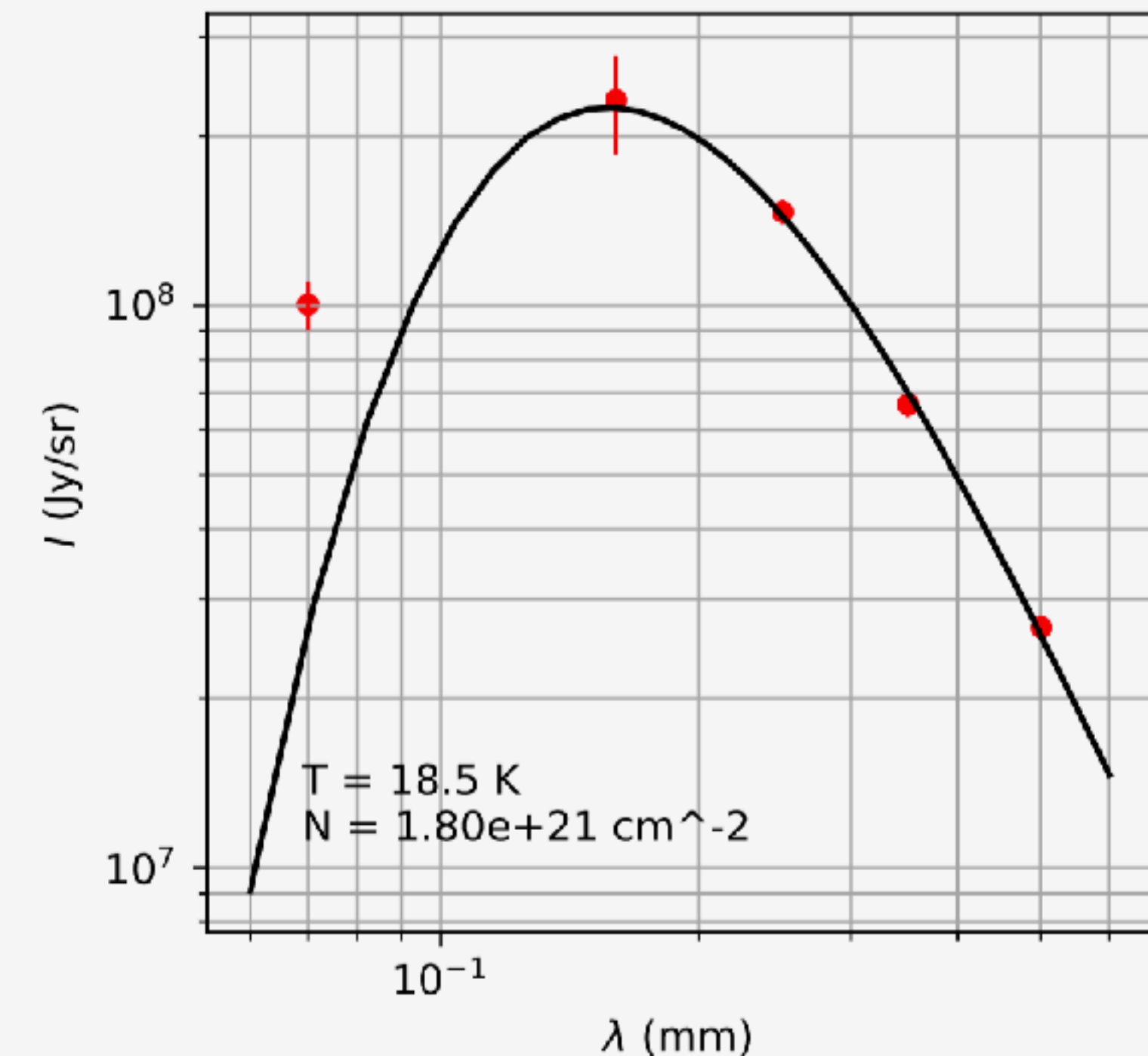
Target selection

Column density map

Clumps catalog

Comparison with IMF

- Herschel 160, 250, 350, 500  $\mu\text{m}$
- Pixel-by-pixel SED fitting
- 200pc x 100pc, beam=20" 0.15pc@1.4 kpc
- $N_{\text{H}_2} \sim 10^{21-24} \text{ cm}^{-2}$





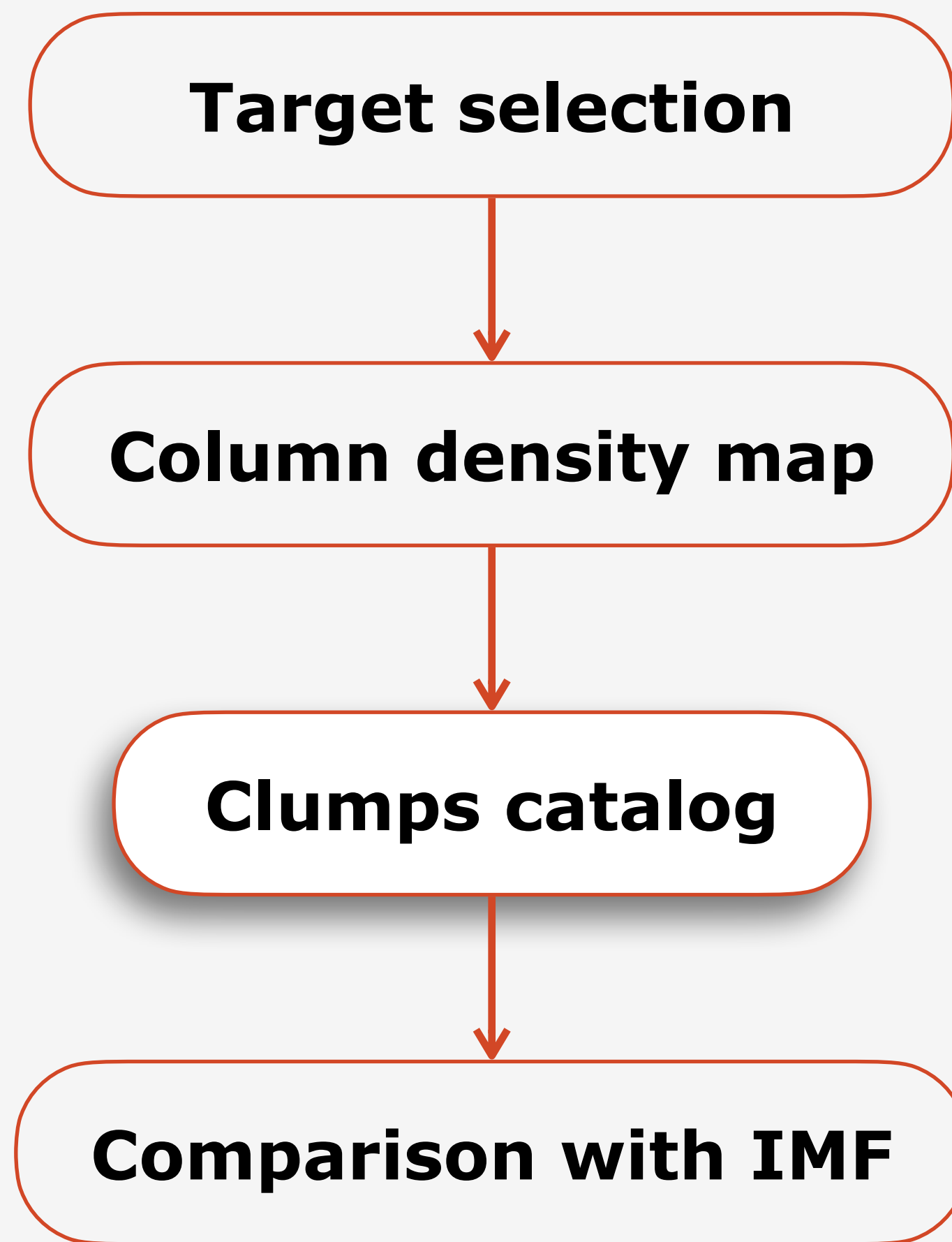


20 pc

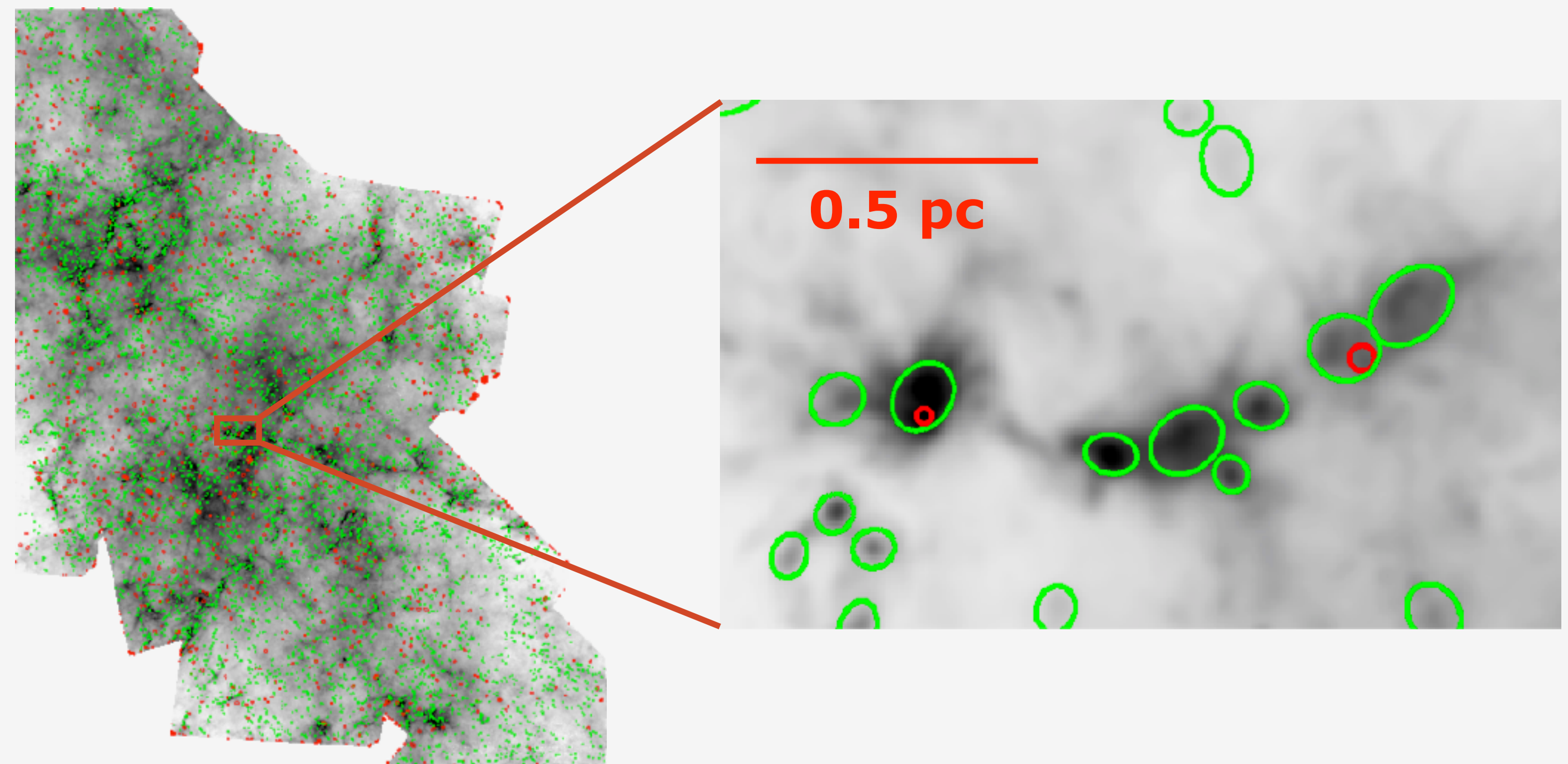
W75N

DR21

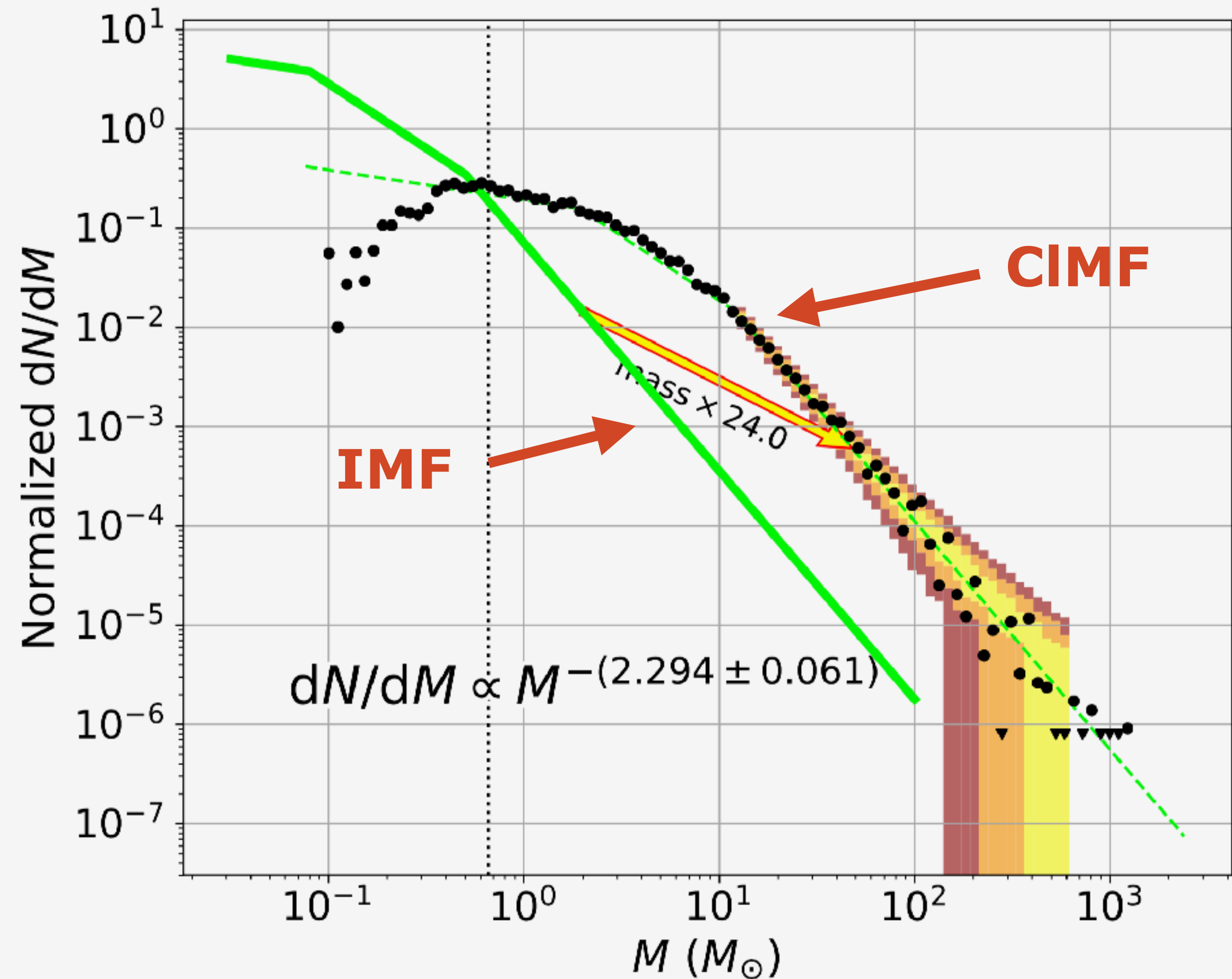
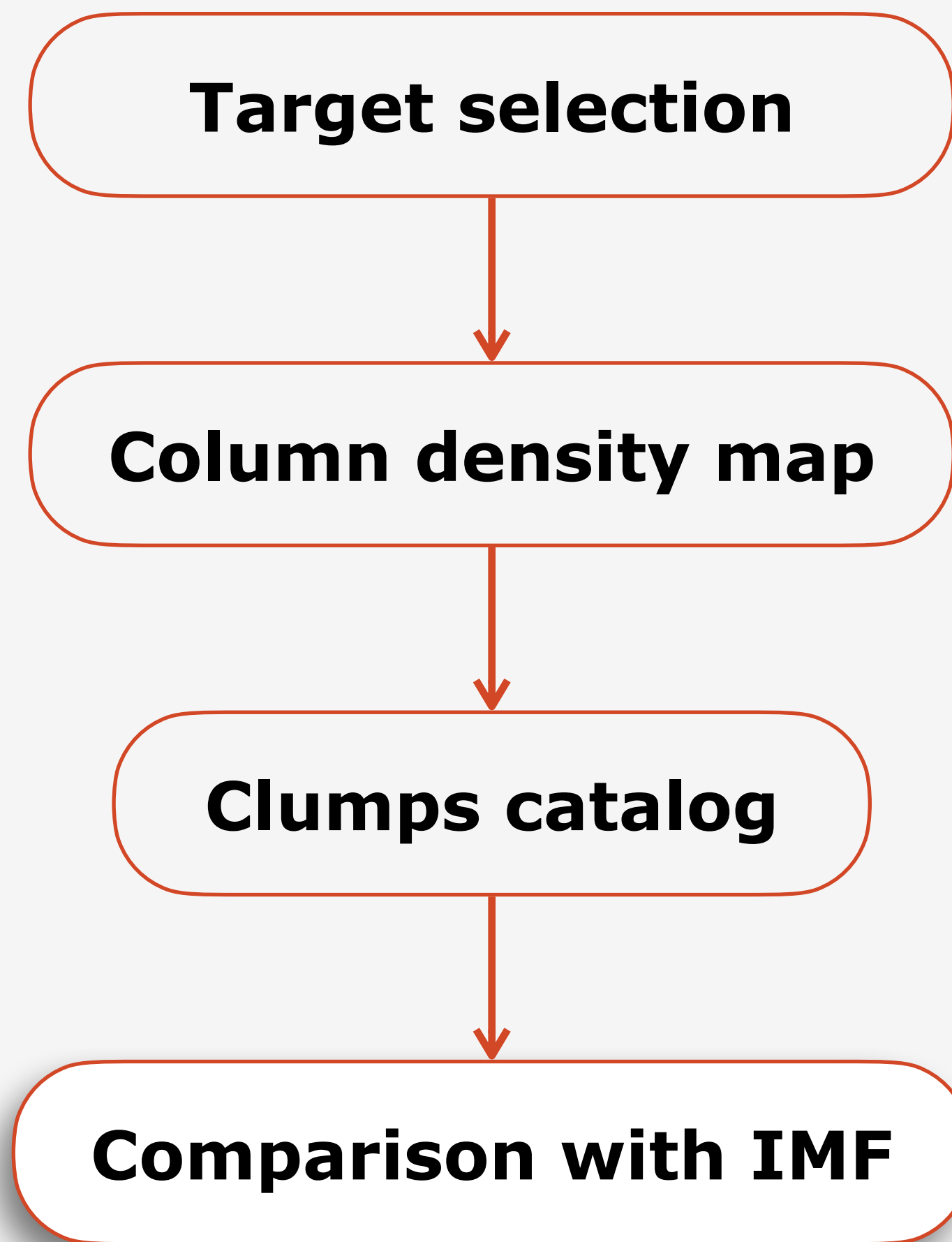
# Generating a large-sample CIMF



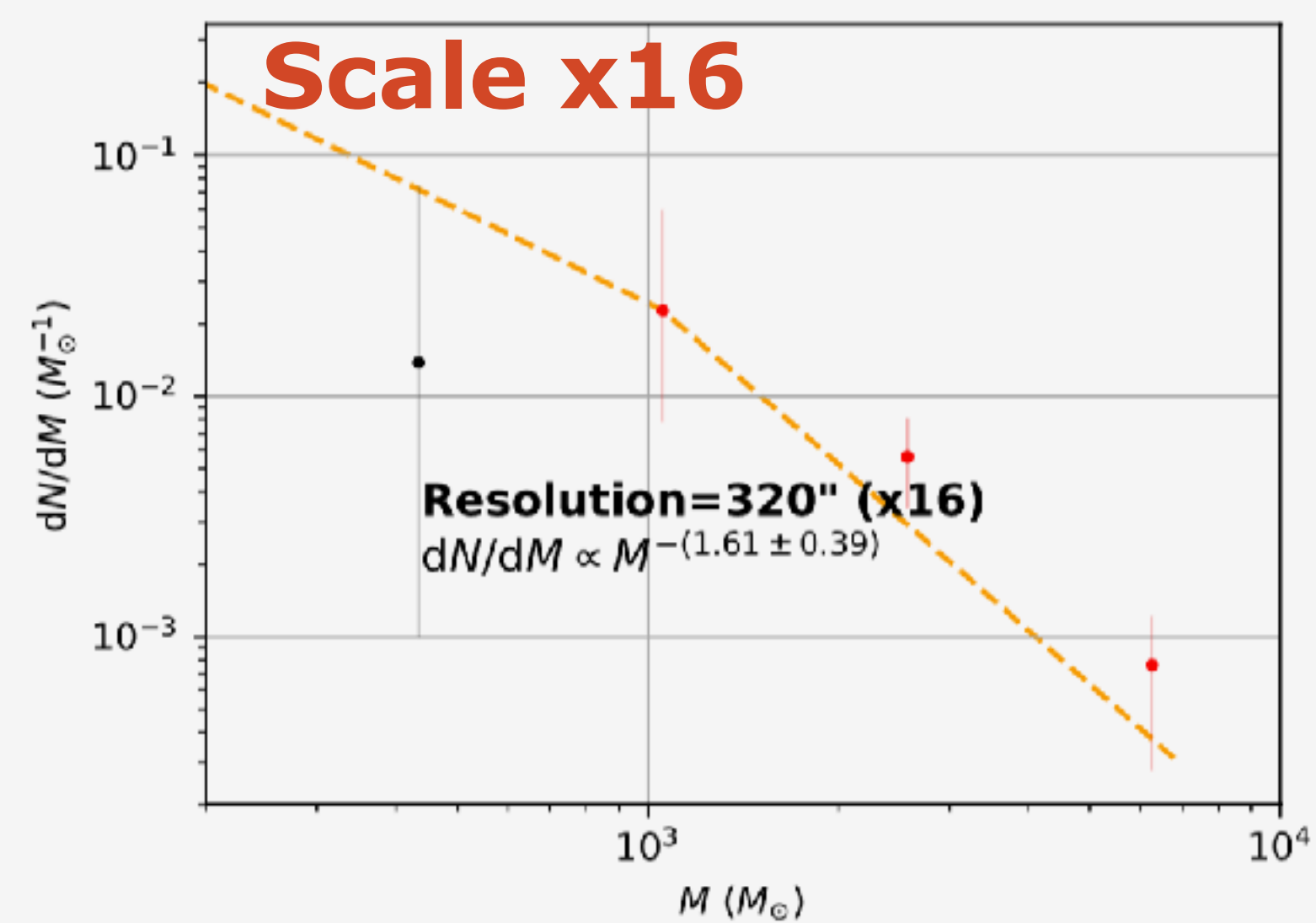
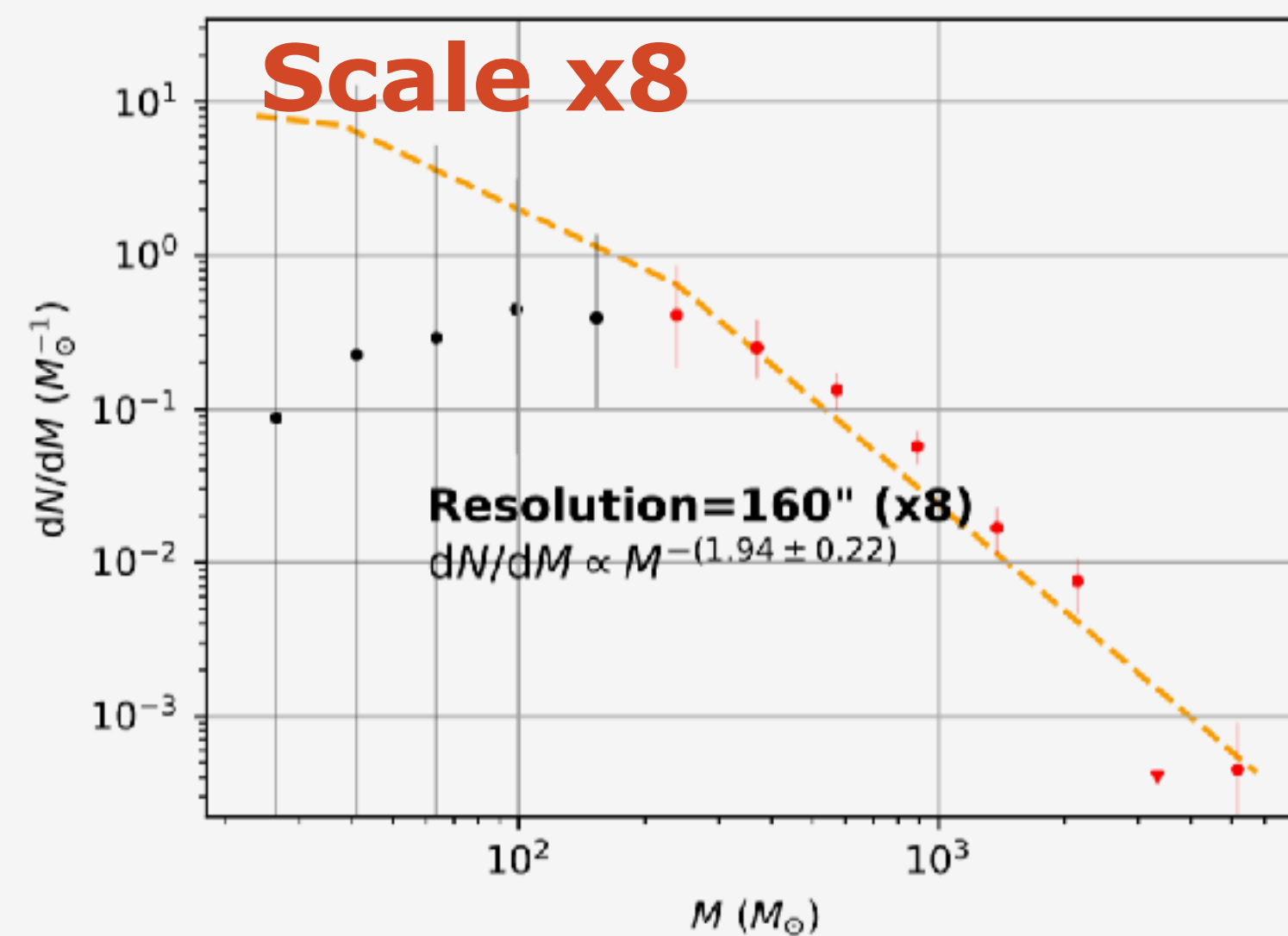
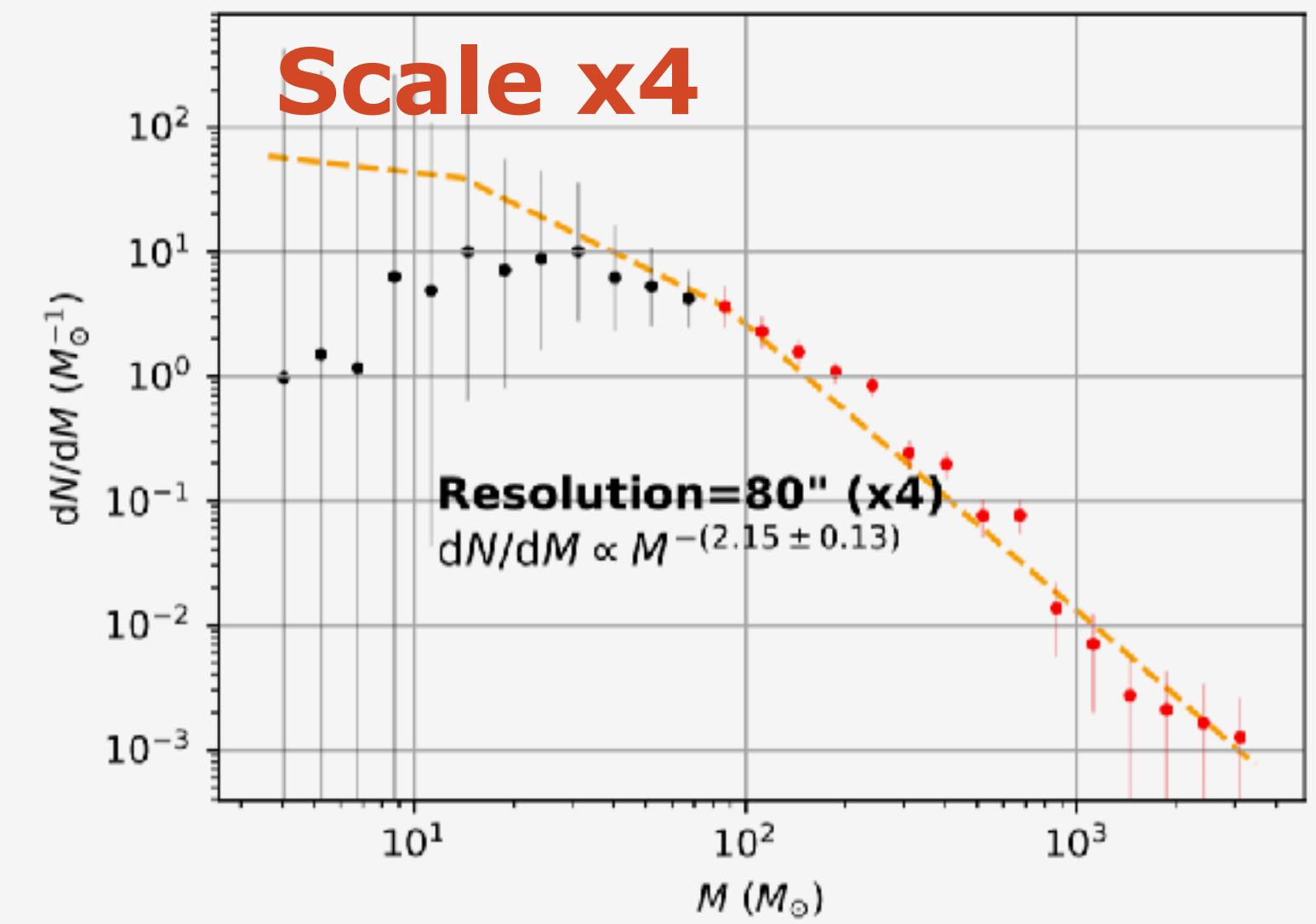
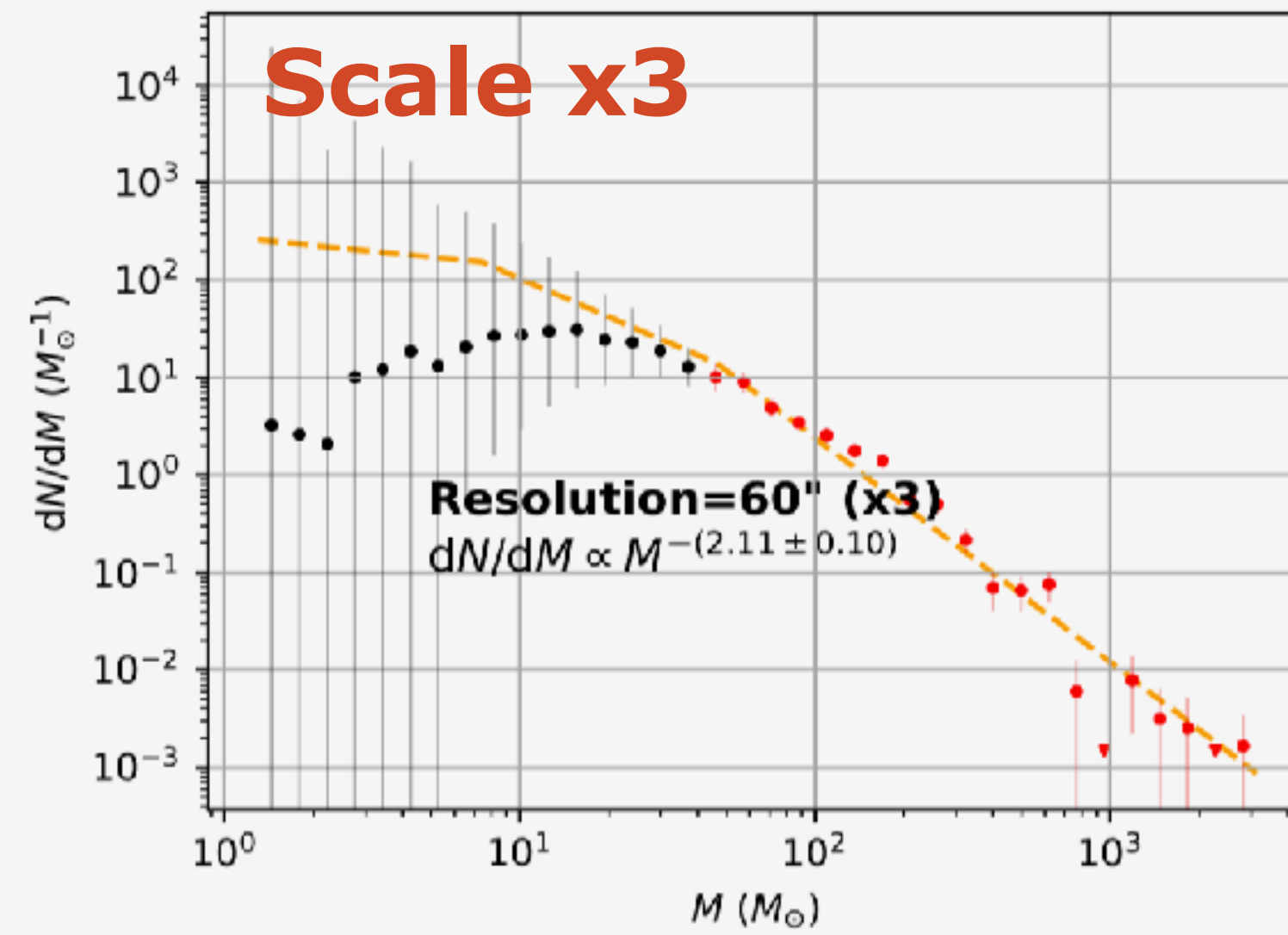
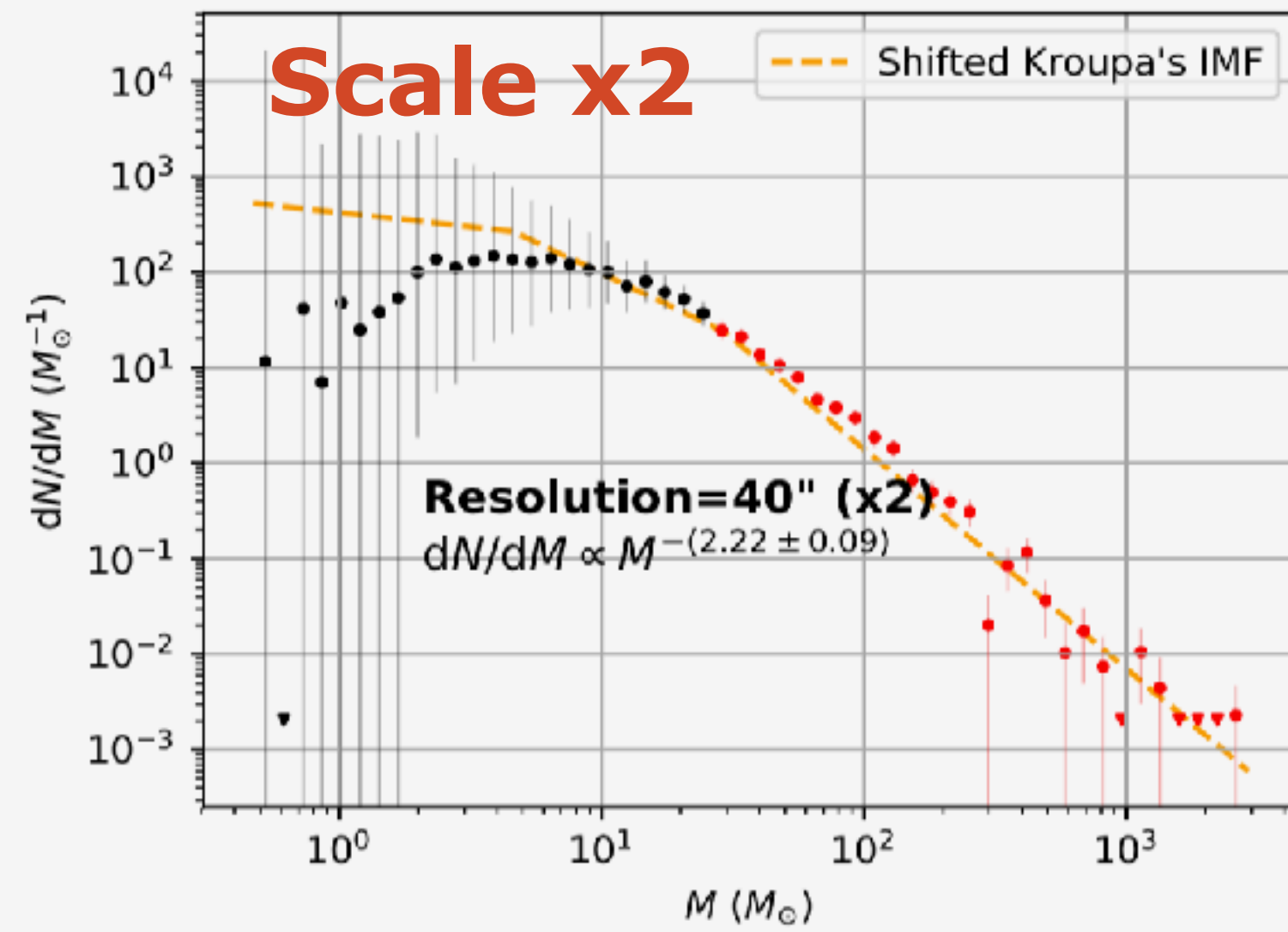
- *Getsources* algorithm (Men'shchikov et al. 2012)
- **8,431** clumps, 90% complete for  $M > 11 M_{\odot}$  (MC)
- $0.1\text{--}1300 M_{\odot}$  ( $3 M_{\odot}$ ),  $0.14\text{--}0.57$  pc ( $0.28$  pc)



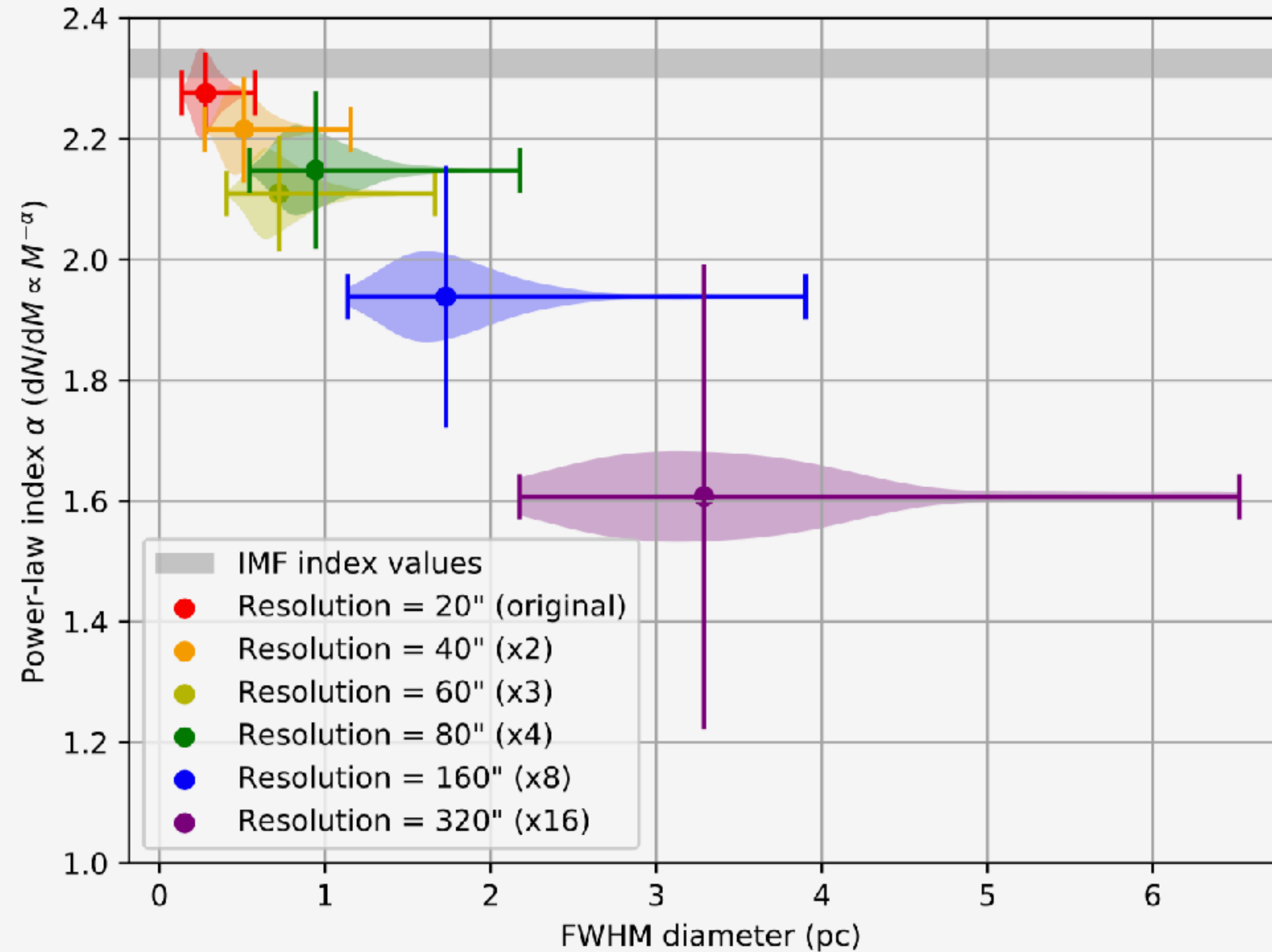
# Generating a large-sample CIMF



# On even larger (~pc) scales...

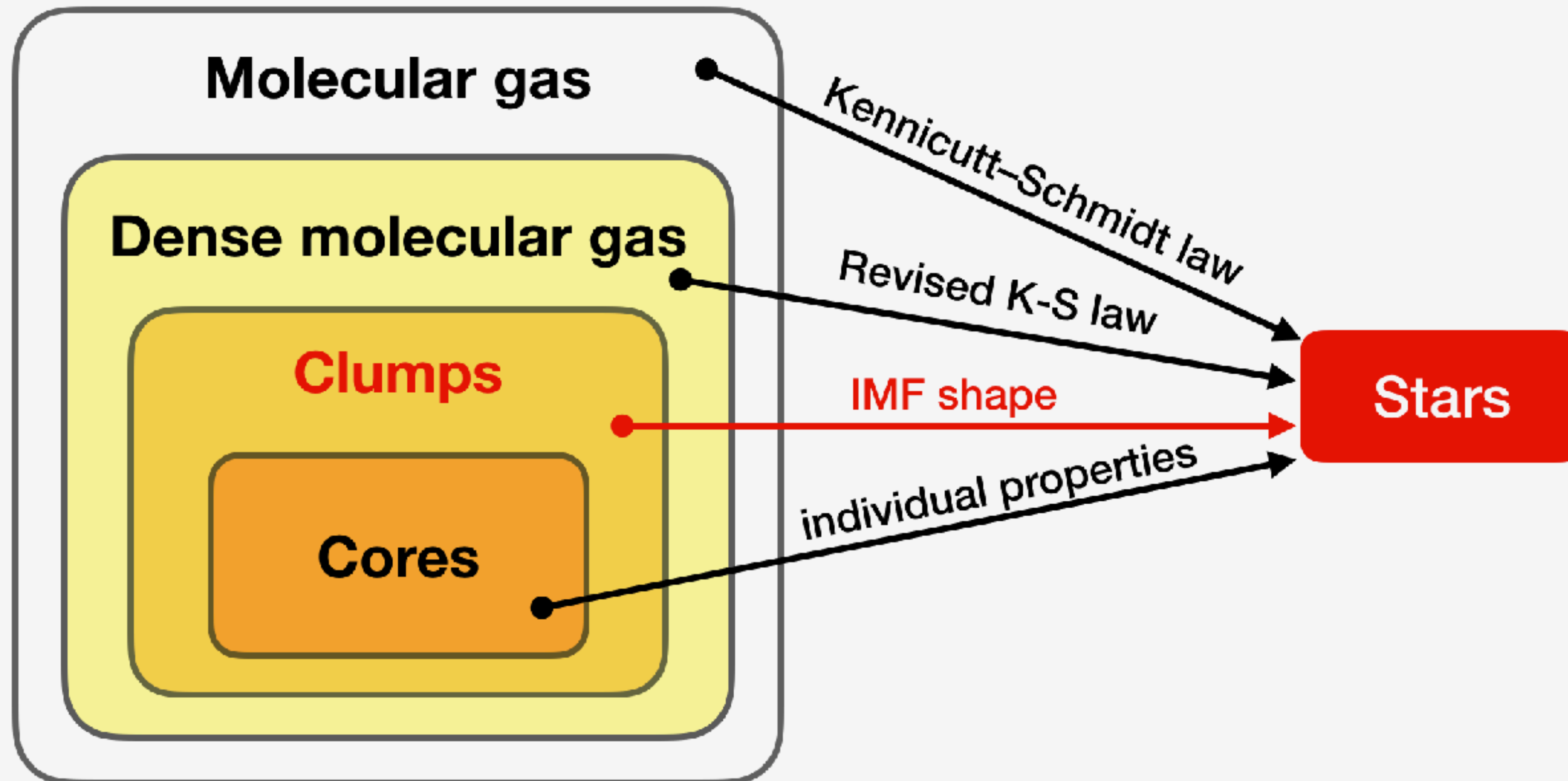


# On even larger (~pc) scales...



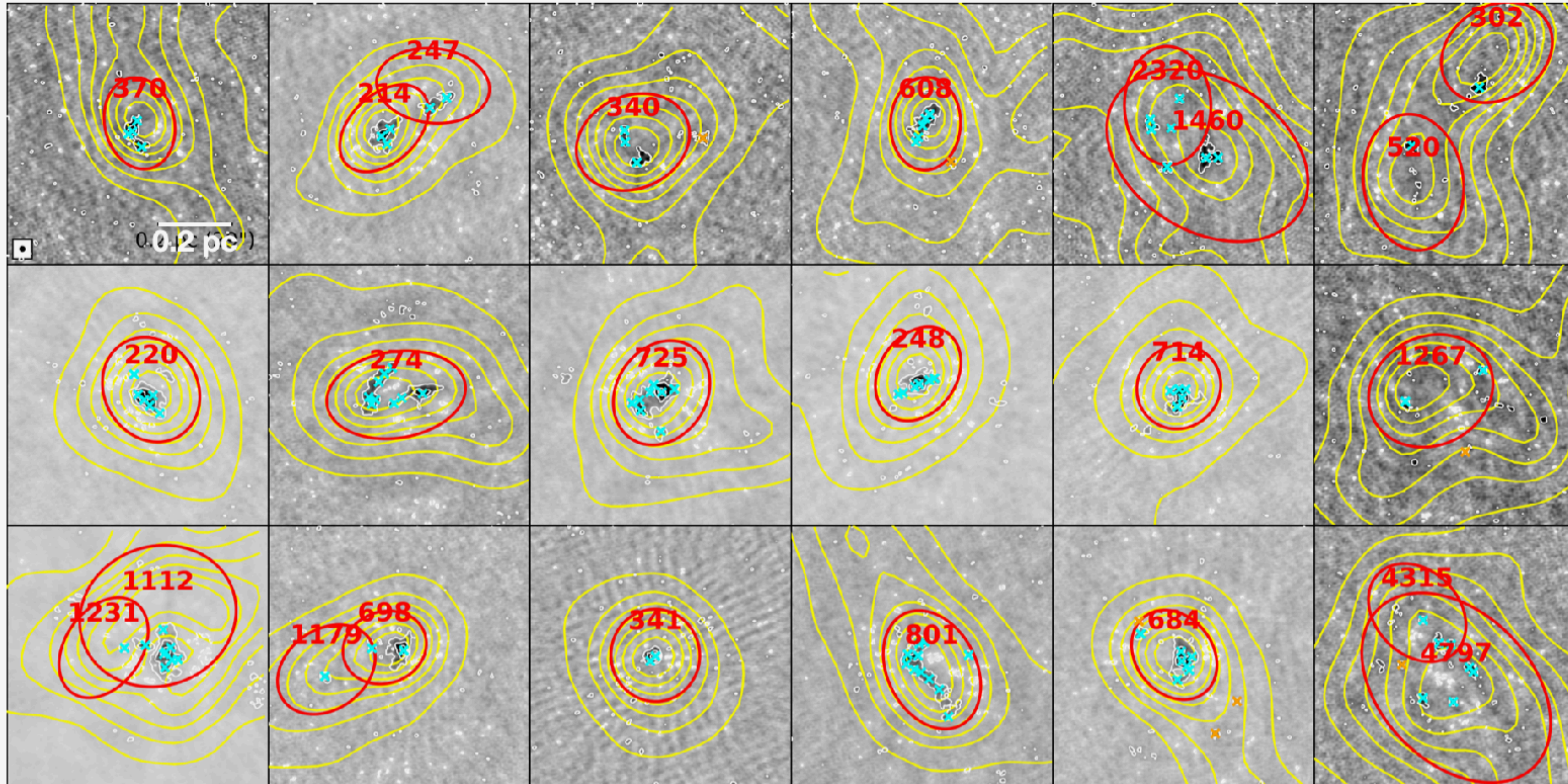
# The big picture

## Hierarchical ISM and relation to star formation



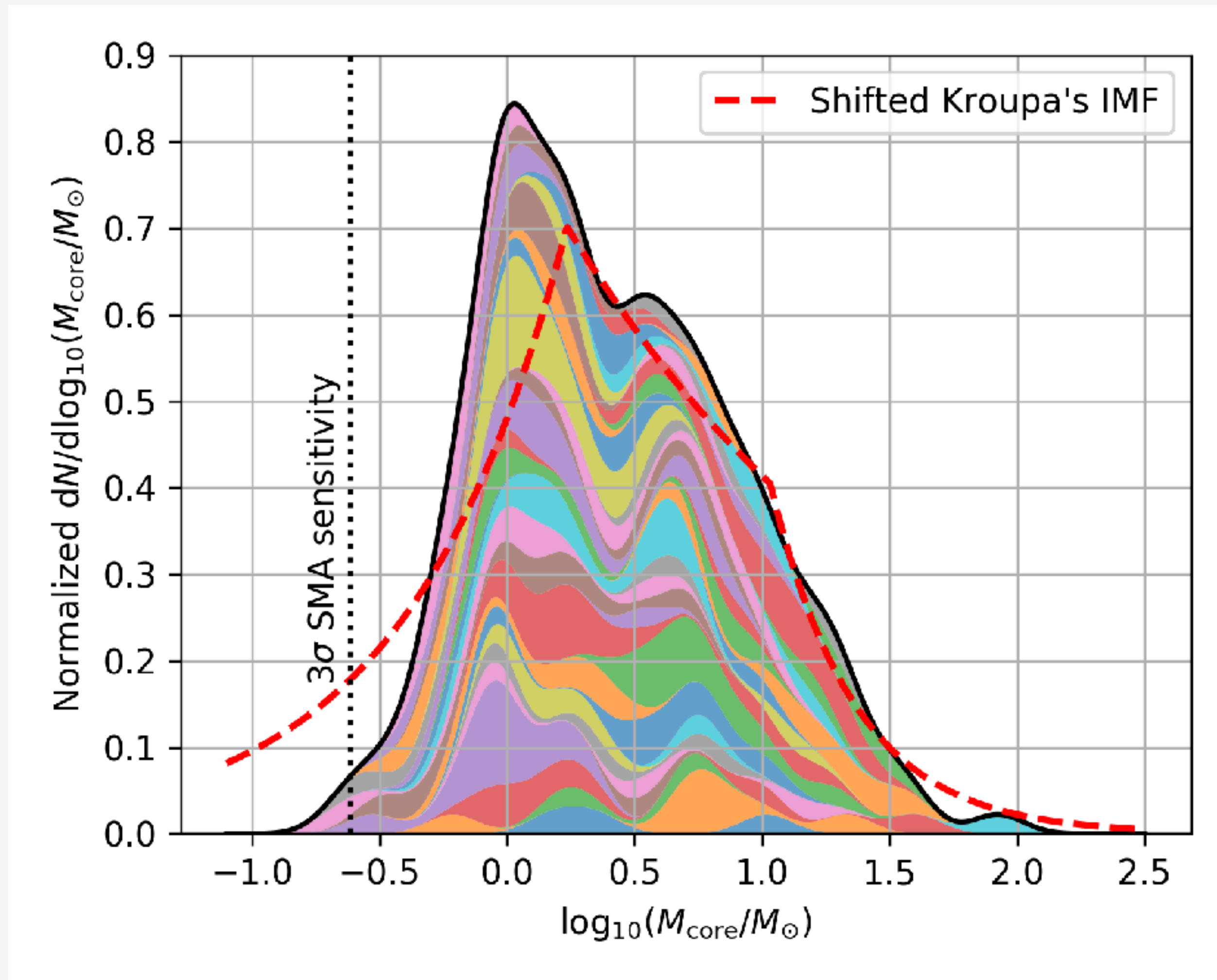
# Substructures of clumps on $\sim 0.01$ pc scales

## 1. SMA 1.3 mm, 48 clumps with 180 cores



# Substructures of clumps on $\sim 0.01$ pc scales

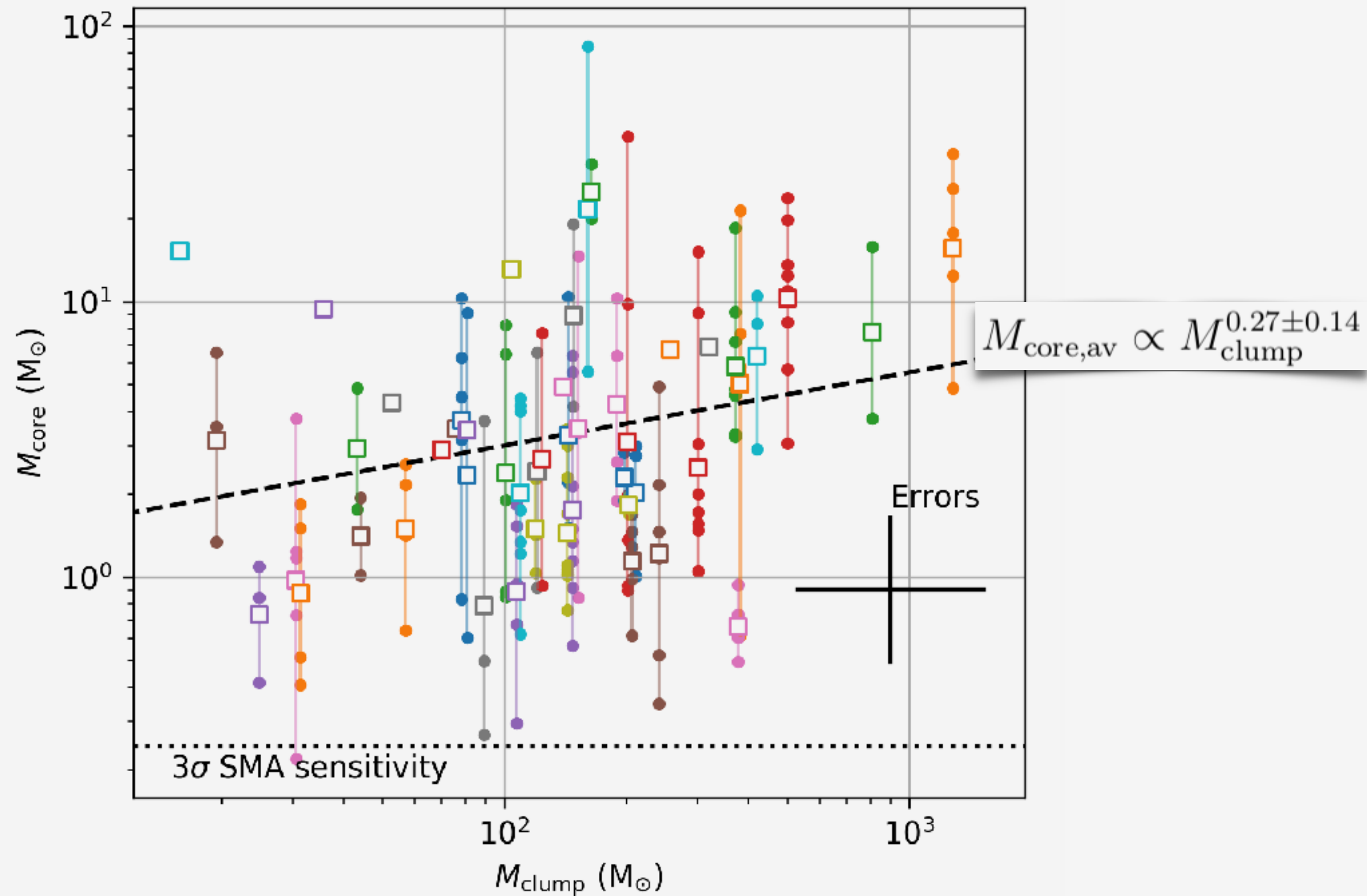
## 2. Clump fragmentation & core mass function @0.01 pc scale



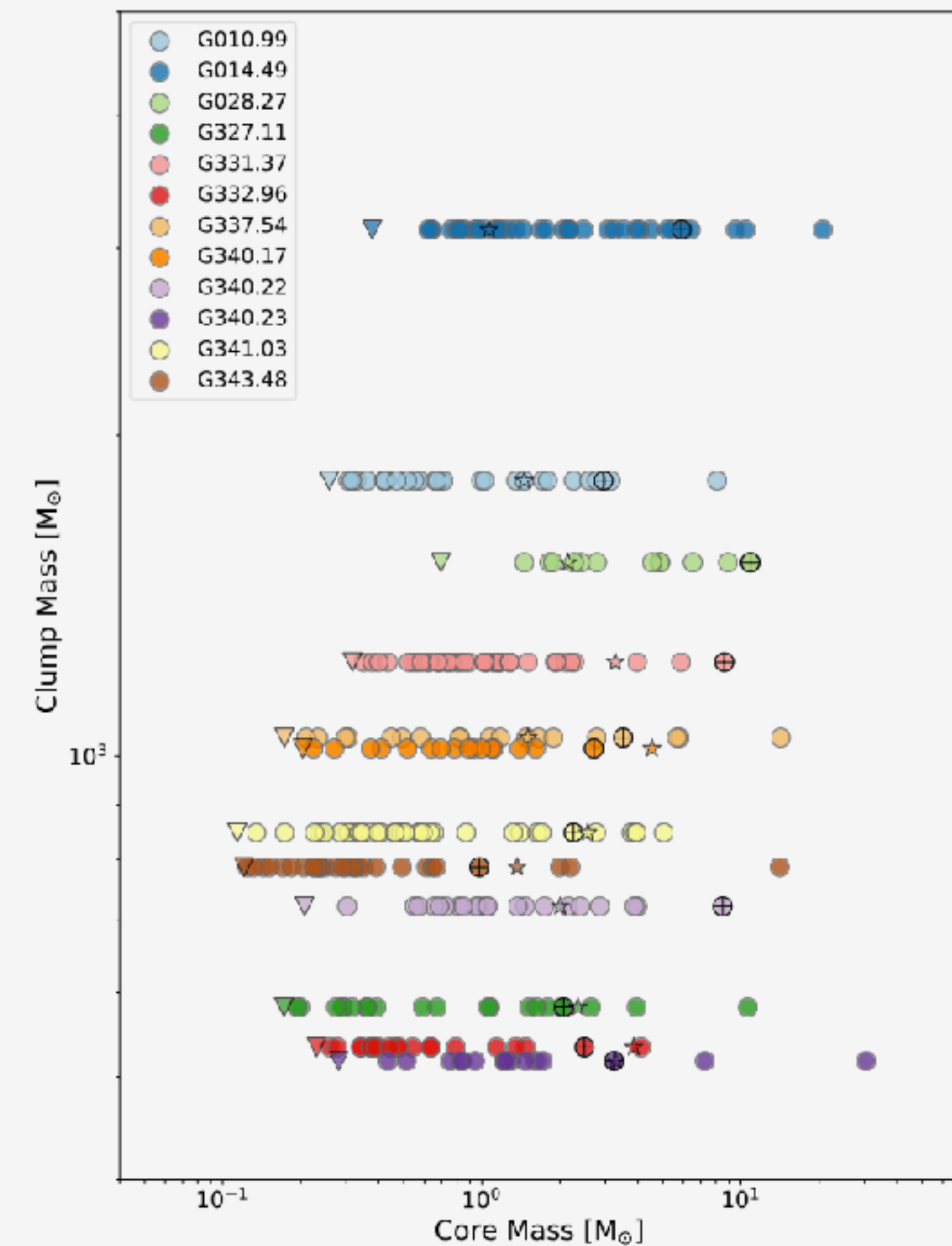


# Substructures of clumps on $\sim 0.01$ pc scales

## 2. Clump fragmentation & core mass function @0.01 pc scale

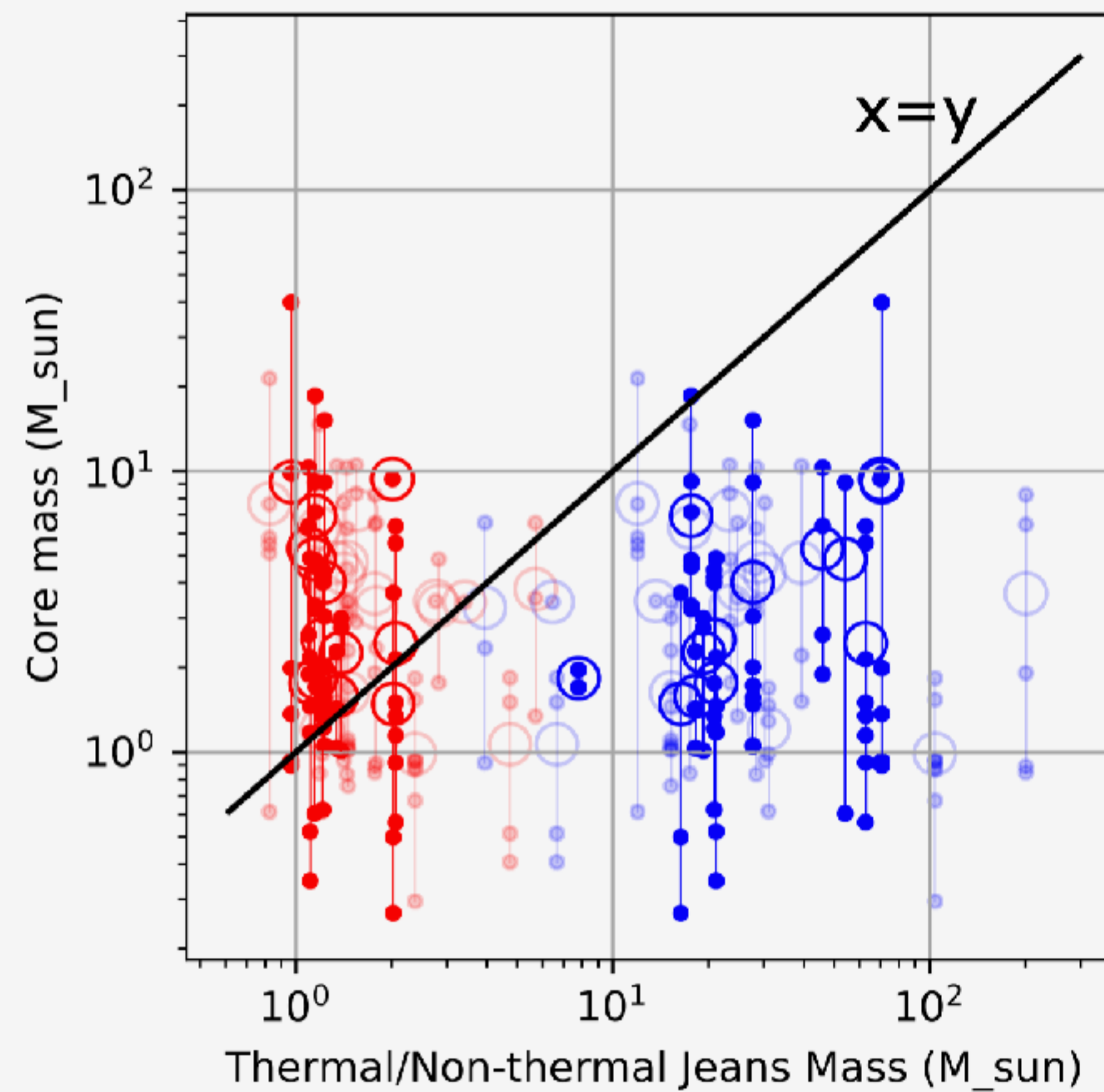
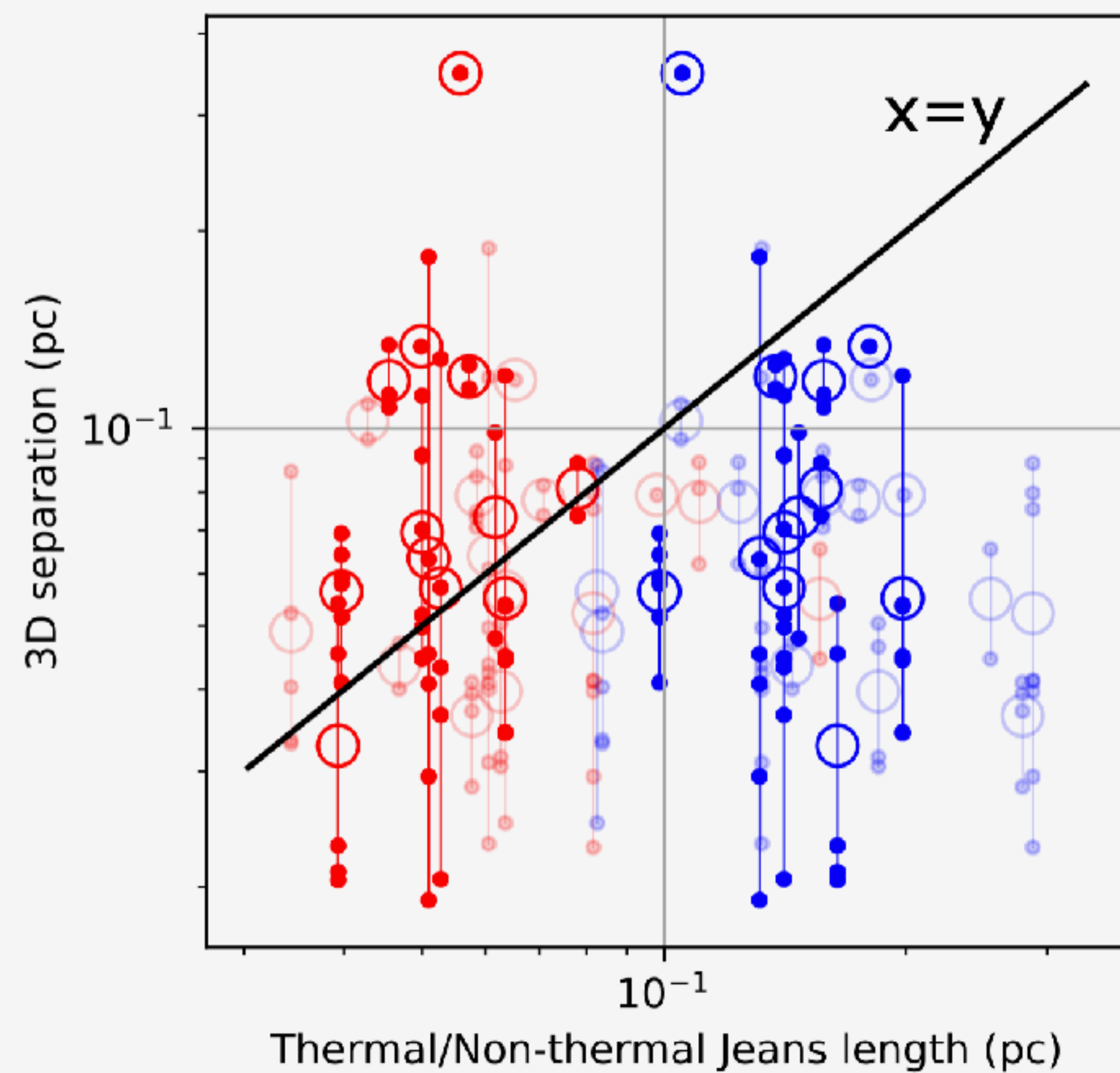


Sanhueza et al.



# Substructures of clumps on $\sim 0.01$ pc scales

## 2. Clump fragmentation & core mass function @0.01 pc scale



**Thermal Jeans defeats turbulent Jeans**

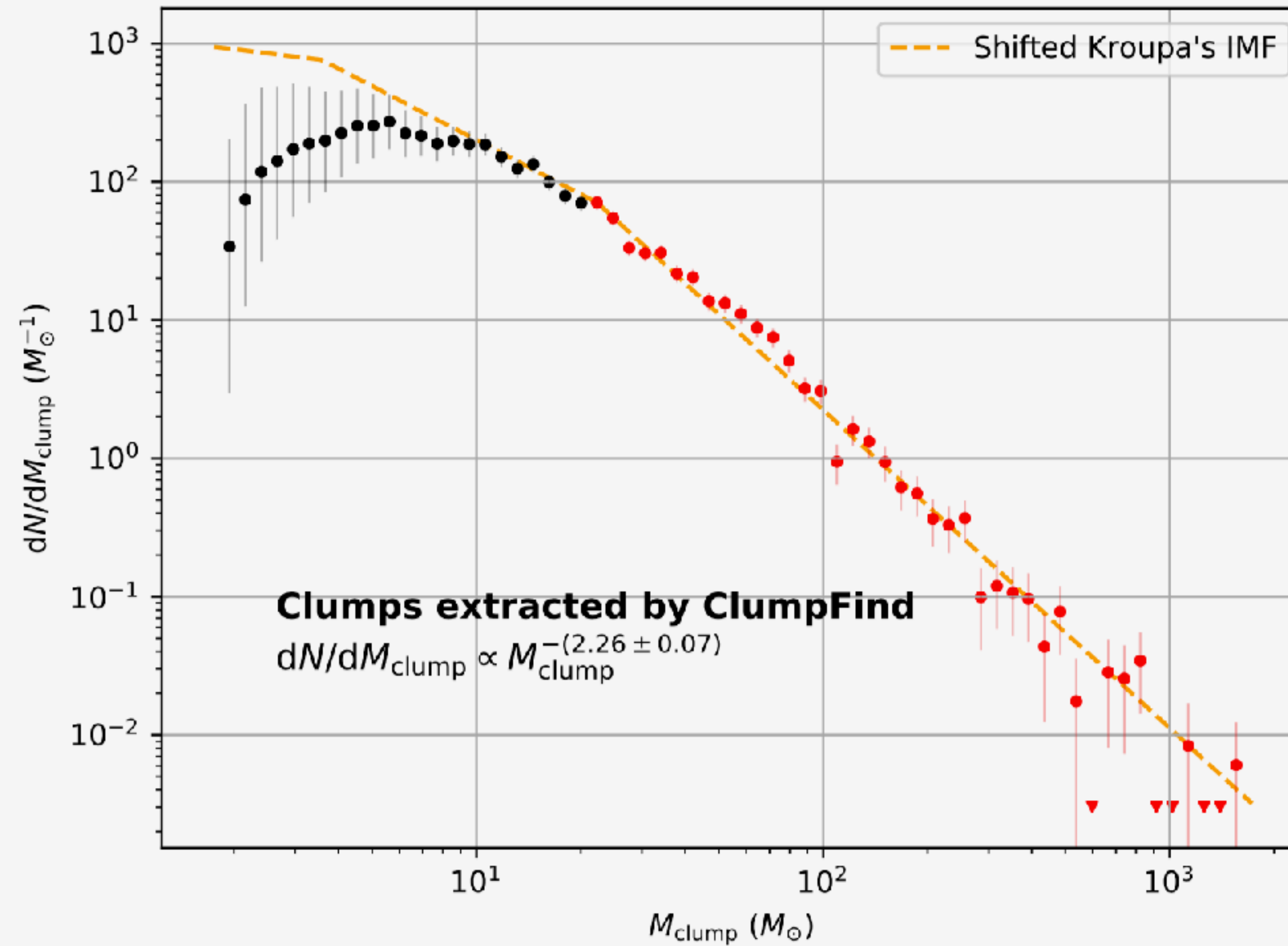
# Take-home messages

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1. Not only **cores (0.01–0.1 pc)**, but also **clumps (0.1–1 pc)** have mass functions **similar to the IMF**, revealed by an unprecedentedly large-sample survey.
2. Over the clump scales, such resemblance **fades away**, indicating the unique role of clumps.
3. Clump fragmentation is **not self-similar**. **No good correlation** between clump mass & core mass (and others). Yet thermal **Jeans prevails** the sub-pc fragmentation.
4. In a big picture: interstellar medium on **different scales** determines the star formation in different ways.

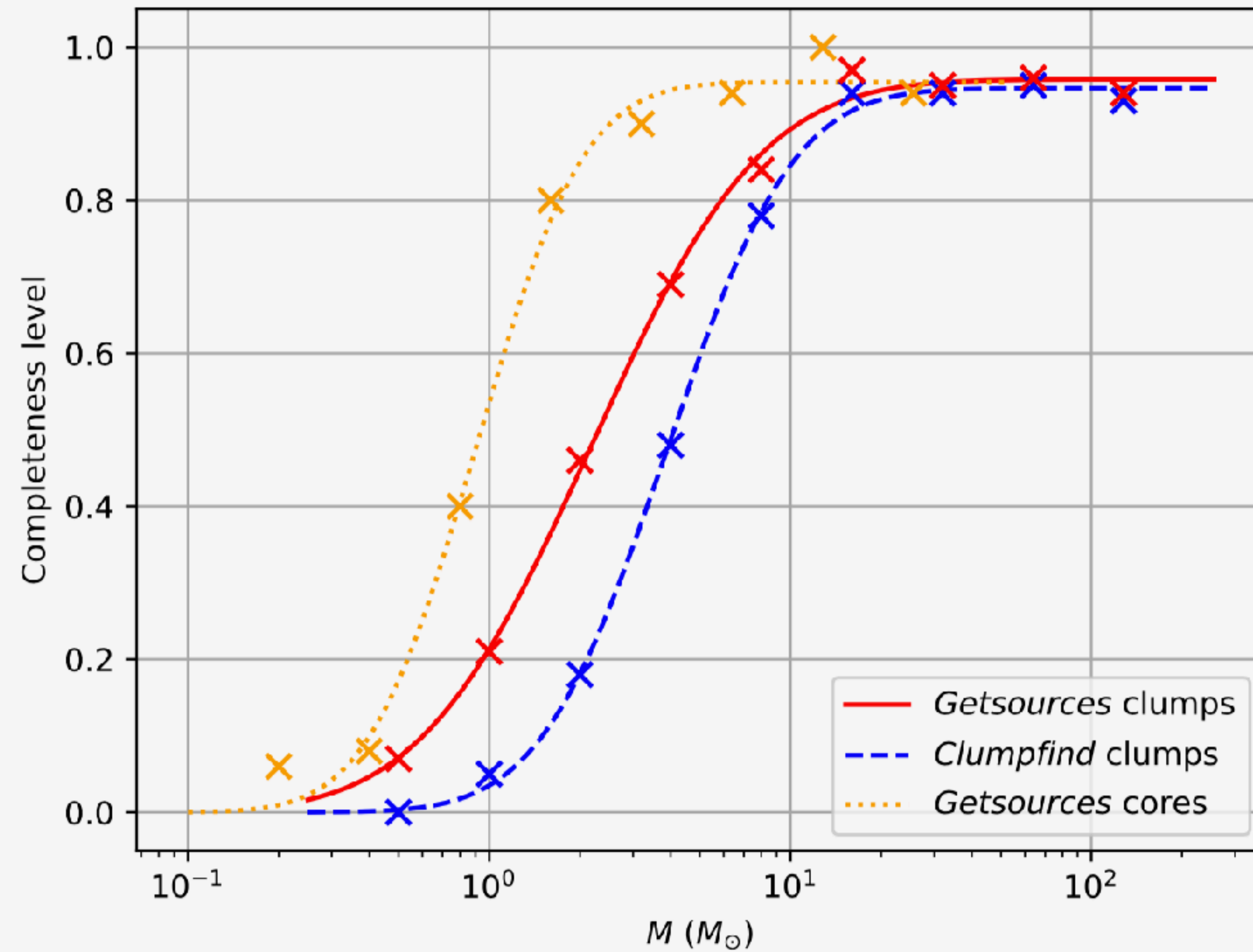
# Supplementary

## 1. Another algorithm to derive CIMF: clumpfind



# Supplementary

## 2. Completeness of the clump/core samples



# Supplementary

## 3. SF activities of the clumps: SMA CO 2-1

