Core mass distribution in the W43-MM1 protocluster

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With F. Louvet, K. Marsh, V. Könyves, S. Bontemps, T. Csengeri, E. Chapillon, A. Maury et al.

GENESIS meeting

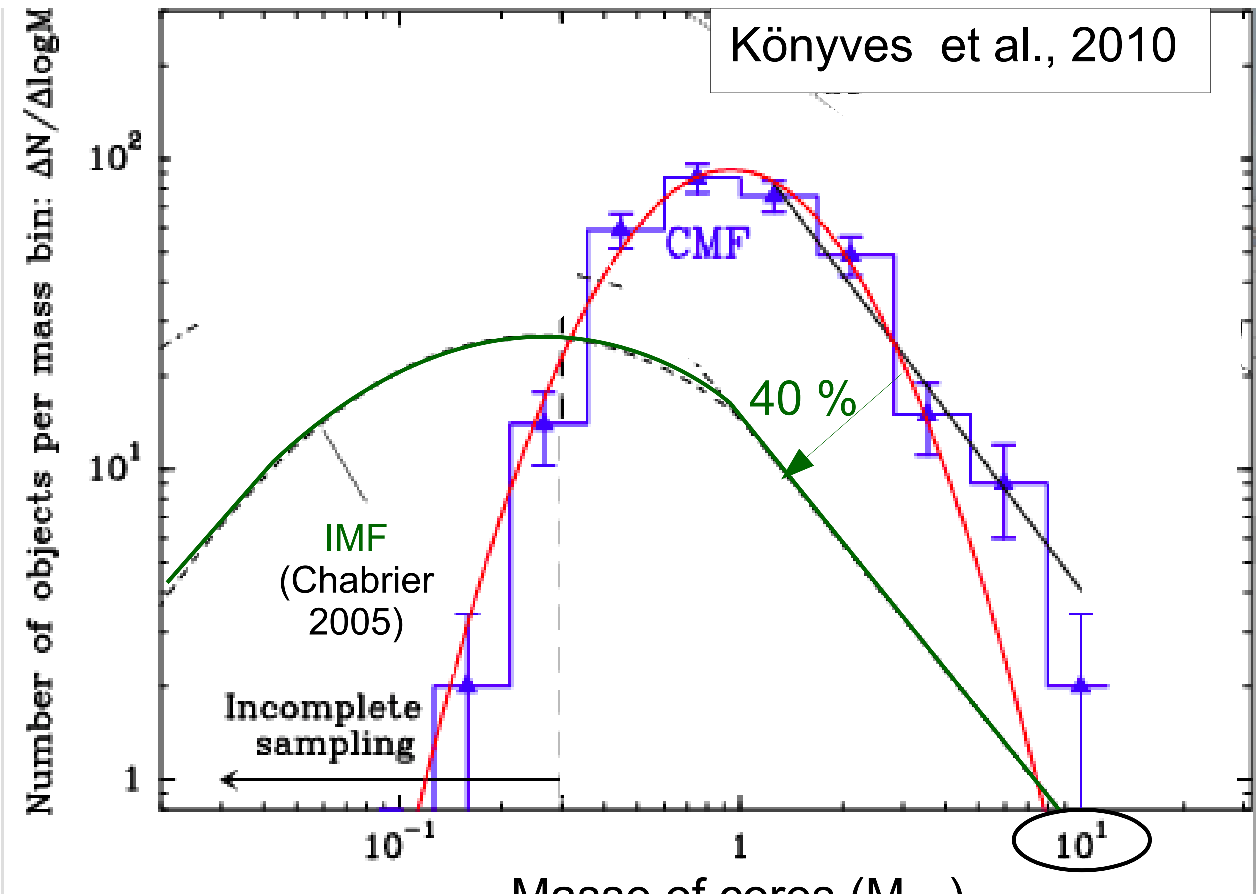
Overview

1) Introduction and data analysis

2) Mass calculation and CMF

Origin of stars' mass

IMF = mass distribution of stars on the main sequence
CMF = mass distribution of cores



For M_{core} = 0.5 – 10 M_{sun} :

CMF/IMF comparison

(e.g. Motte+98, Alves+07, Enoch+08, Könyves+15, ...):

$$IMF = \epsilon_{core} \, . \, CMF$$

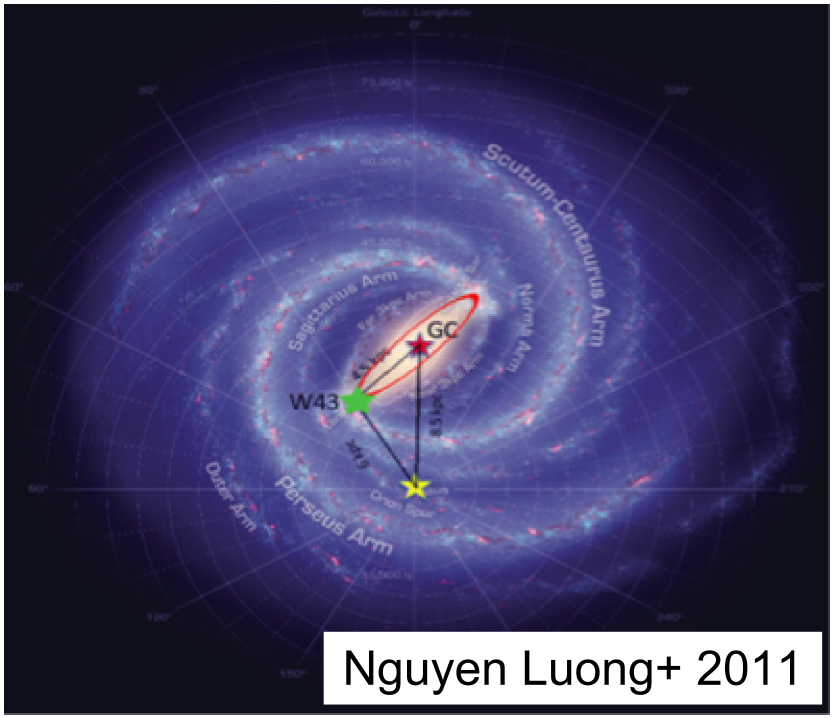
$$\text{with} \quad \epsilon_{core} \sim 0.4$$

→ Stars mass set by cores fragmentation

Open question: What is the IMF origin for massive stars ($M_* > 8\ M_{sun}$)?

→ need to observe massive cores ($M_{core} > 20\ M_{sun}$)

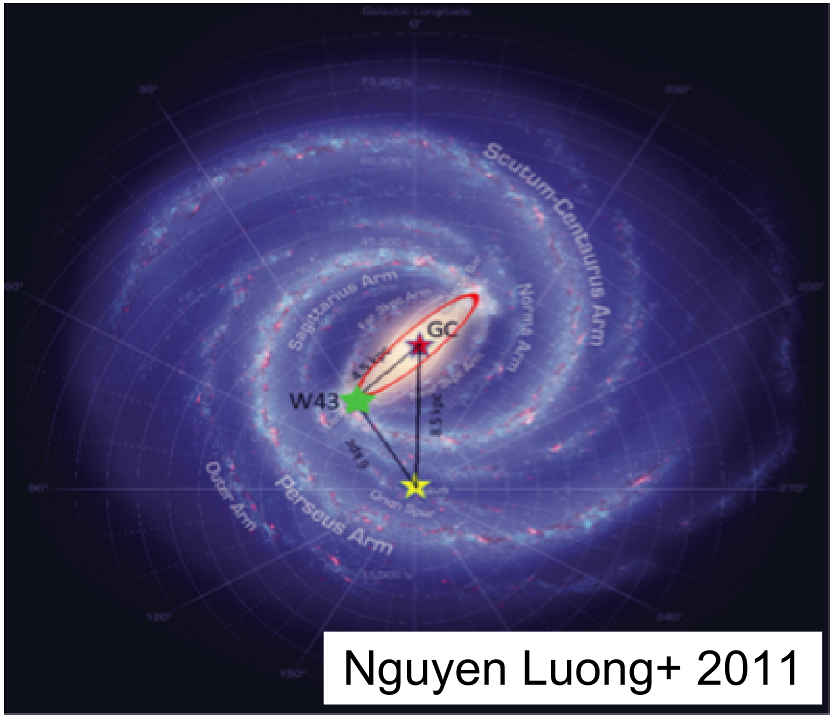
W43-MM1: a mini-starburst region



Nguyen Luong+ 2011

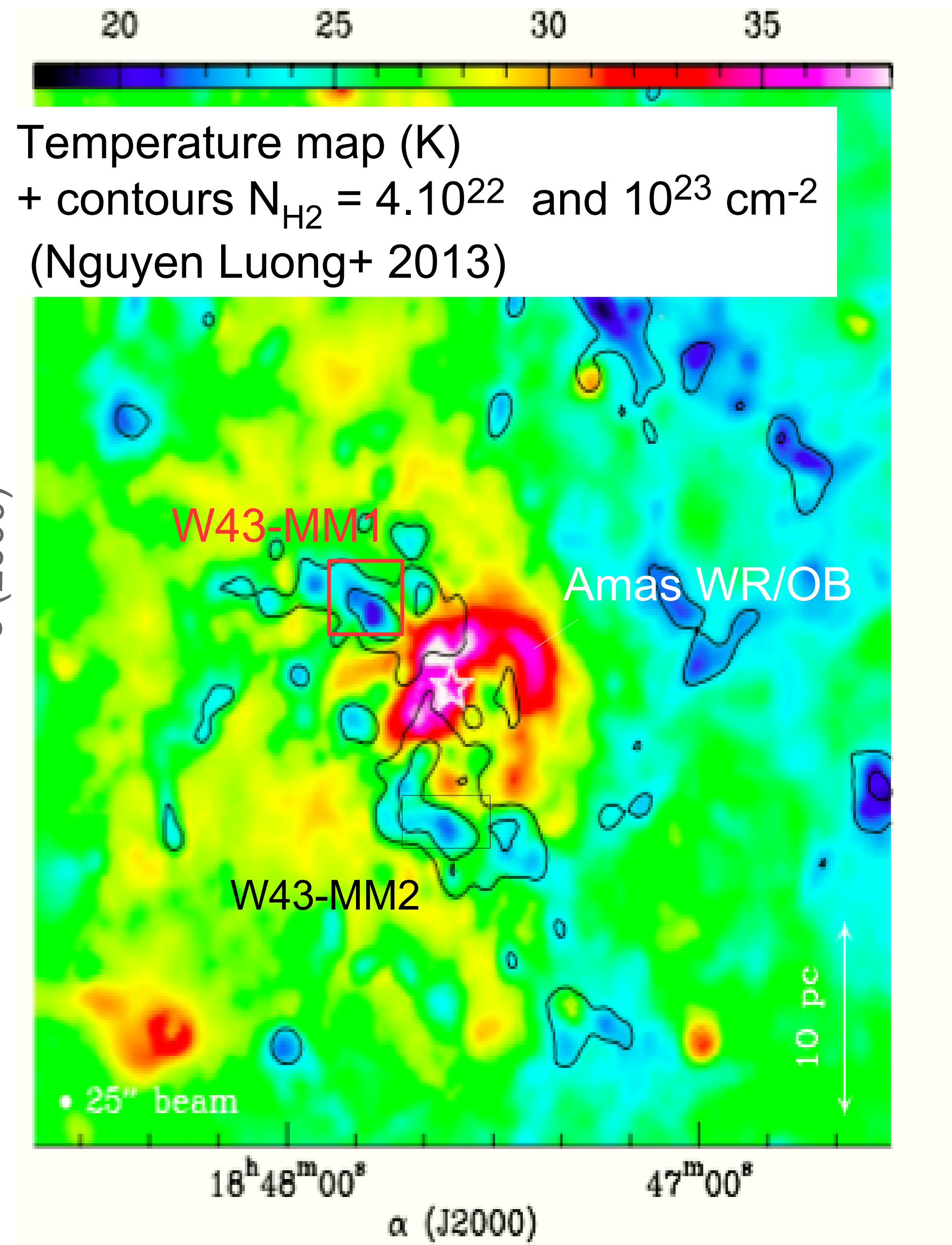
- d = 5.5 kpc
- SFE ~ 25 % in 10^6 years
  (~ 0.25 M_{sun} / yr, Motte+ 2003)

W43-MM1: a mini-starburst region



- d = 5.5 kpc
- SFE ~ 25 % in 10^6 years
  (~ 0.25 M_{sun} / yr, Motte+ 2003)

- Densest and coldest cloud in the galaxy
  (Csengeri et al. 2017)



Data set presentation

ALMA: a network of 66 antennas forming the largest sub-(mm) interferometer

- Project Cycle 2 and 3, 8h and 6h (+ 22h and 17h ACA), PI Motte
- 3 configurations:
  12m compact and extended, 7m (ACA)

- Mosaic: 33 fields (12m) , 1.4 pc x 2.1 pc
- Spatial resolution to identify cores:
  0.5'' ~ 2000 AU (0.01 pc)

- Spectro-imaging at λ = 1.3 mm (216-233 GHz): 7 lines bands + 1 continuum band

SpwID	Name	Tracer	Chan. Width (kHz / km.s^{-1})	CtrFreq (GHz)	Total BW (MHz)
1	SiO(5-4)	Outflows / shocks	244 / 0.3	217.1	234
5	CO(2-1)	Outflows	977 / 1.2	230.5	469
6	^{13}CS(5-4)	Density	244 / 0.3	231.2	469
7	continuum	Dust thermal emission	977 / 1.3	233.4	1875

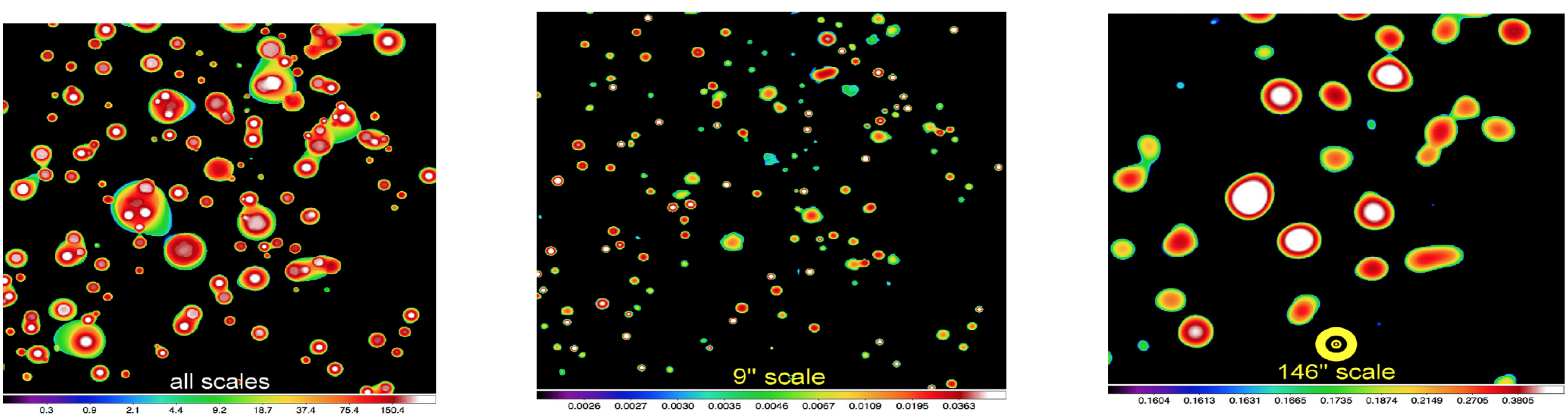
Pre- and proto-stellar cores extraction

Detection and characterization of compact sources with a multi-resolution program (<u>getsources</u>, *Men'shchikov et al. 2012*)

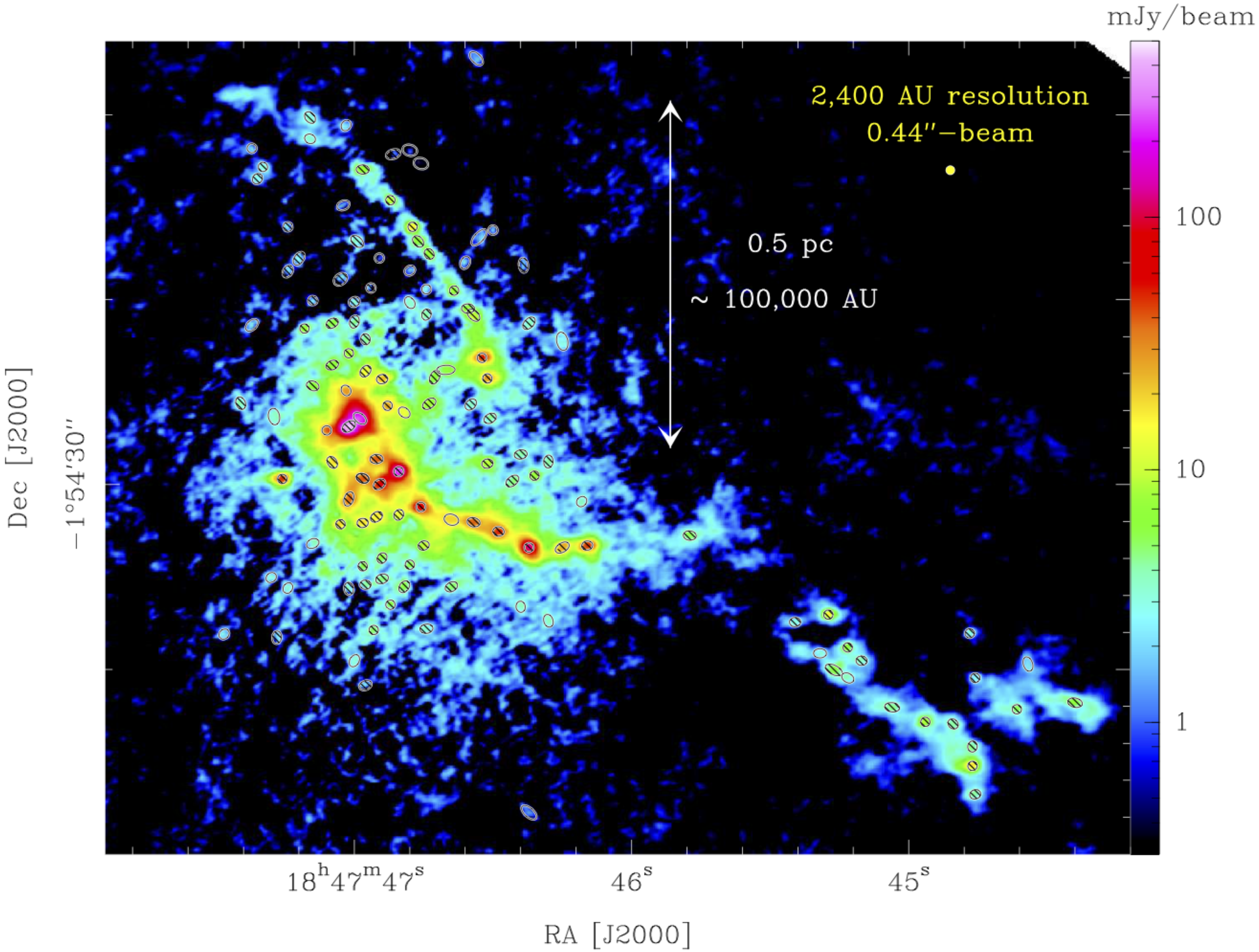
- On 12m selfcalibrated map $\rightarrow$ 174 sources detected
- 2 post selection criteria (size and ellipticity) + visual inspection

⇨ 131 cores (including 94 very reliable cores)

Separation of cloud emission at different spatial scales



Continuum map



Overview

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Estimate cores mass

Mass calculation from dust thermal emission:

distance

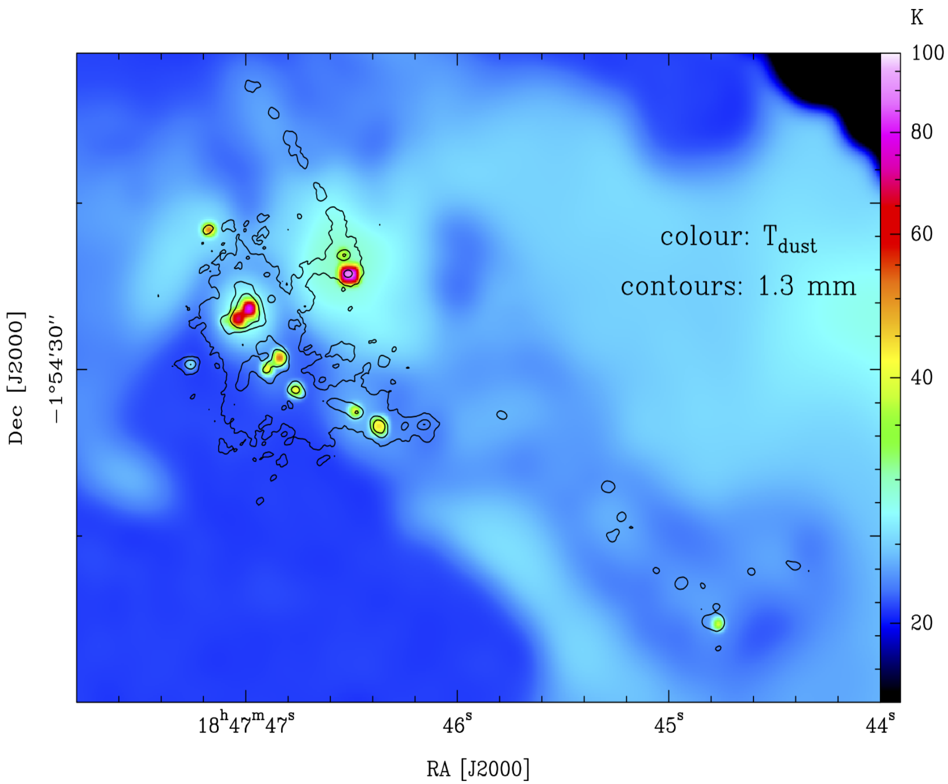
Beam solid angle

$$M_{core} = \frac{-S_\lambda^i . d^2}{\kappa_\lambda . B_\lambda(T_d)} . \frac{\Omega_b B_\lambda(T_d)}{S_\lambda^p} \ln\left(1 - \frac{S_\lambda^p}{\Omega_b B_\lambda(T_d)}\right)$$

dust emissivity

Planck function

With S^p : peak flux
S^i : integrated flux



T_d : dust temperature

heating model:

- based on 2.5 " PPMAP (Marsh+2015) temperature map
- local heating : luminosities estimated from the strength of hot core lines

Core mass from 2 to 100 M_{sun}

Ref : T_d map and equation in Motte *et al.* subm.

CMF of W43-MM1 proto-cluster

Cumulative form

→ CMF for cores forming up to 50 M_{sun} !

→ excess of massive cores : CMF not similar to IMF

CMF of W43-MM1 proto-cluster

Tests and improvements

Table 2: Tests performed to evaluate the uncertainty of the reference CMF fit of Fig. 2b.

	Mass range	γ
Reference cumulative CMF of all cores extracted by *getsources*[21]	$>2\,M_\odot$	$\mathbf{-0.95 \pm 0.02}$
low-mass regime	$2-20\,M_\odot$	-0.86 ± 0.03
high-mass regime	$>20\,M_\odot$	-1.08 ± 0.06
with a lower completeness level	$>12\,M_\odot$	-1.07 ± 0.04
CMF of the 94 most robust cores	$>2\,M_\odot$	-0.90 ± 0.01
CMF with core masses estimated in the optical thin approximation	$>2\,M_\odot$	-1.02 ± 0.03
with a single uniform temperature	$>2\,M_\odot$	-0.80 ± 0.06
Differential CMF with all cores and default assumptions	$>2\,M_\odot$	-0.83 ± 0.08
CMF built from cores extracted in a classic-cleaned image	$>2\,M_\odot$	-1.05 ± 0.03
with MRE-GaussClumps[29]	$>2\,M_\odot$	-1.08 ± 0.02

Notes: CMFs are fitted by power-laws of the form $N(>\log(M)) \propto M^{\gamma}$, except for the differential CMF where the power-law is $dN/d\log(M) \propto M^{\gamma}$.

[29] : extraction from T. Csengeri

+ Monte Carlo simulation with S. Bontemps to propagate uncertainties on mass

+ Tests on completeness level with S. Men’shchikov

Conclusions and future work

- A massive protocluster studied at high resolution with ALMA:

➢ First measure of CMF in high mass area (Motte *et al.* subm)

→ top-heavy CMF or evolution with time ?

➢ To be reproduced/confirmed with ALMA LP …

- Collaboration with Molet *et al.* (Bordeaux) on lines survey
→ chemical enrichment of the protostars

- Collaboration with Louvet & Gusdorf on SiO shocks
→ link with filaments formation