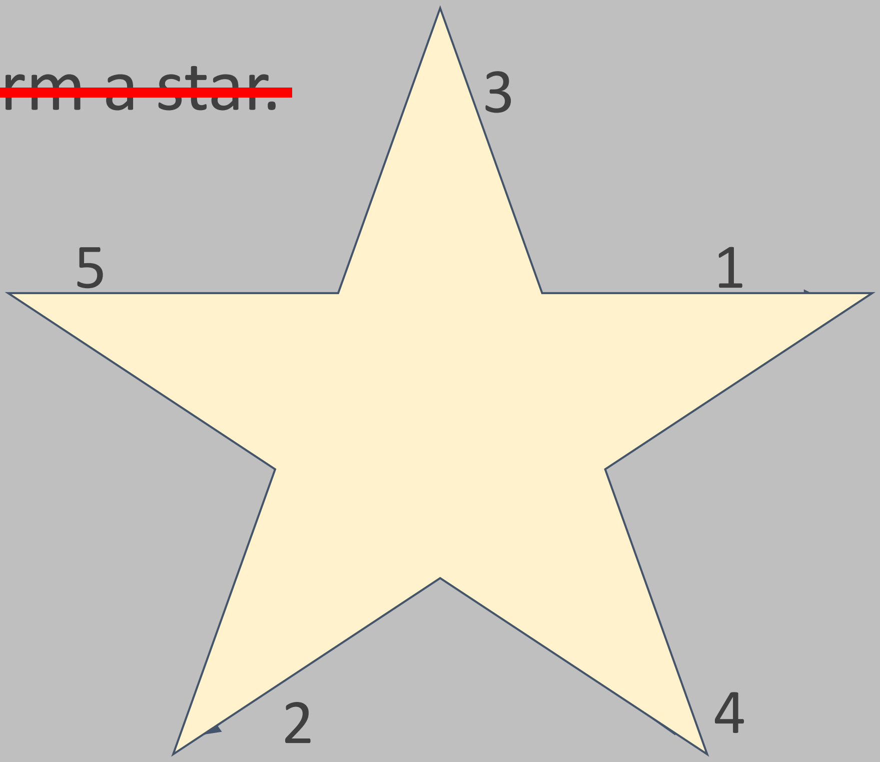
Pre- + protostellar cores in Sagittarius B2

Nazar Budaiev

Star formation

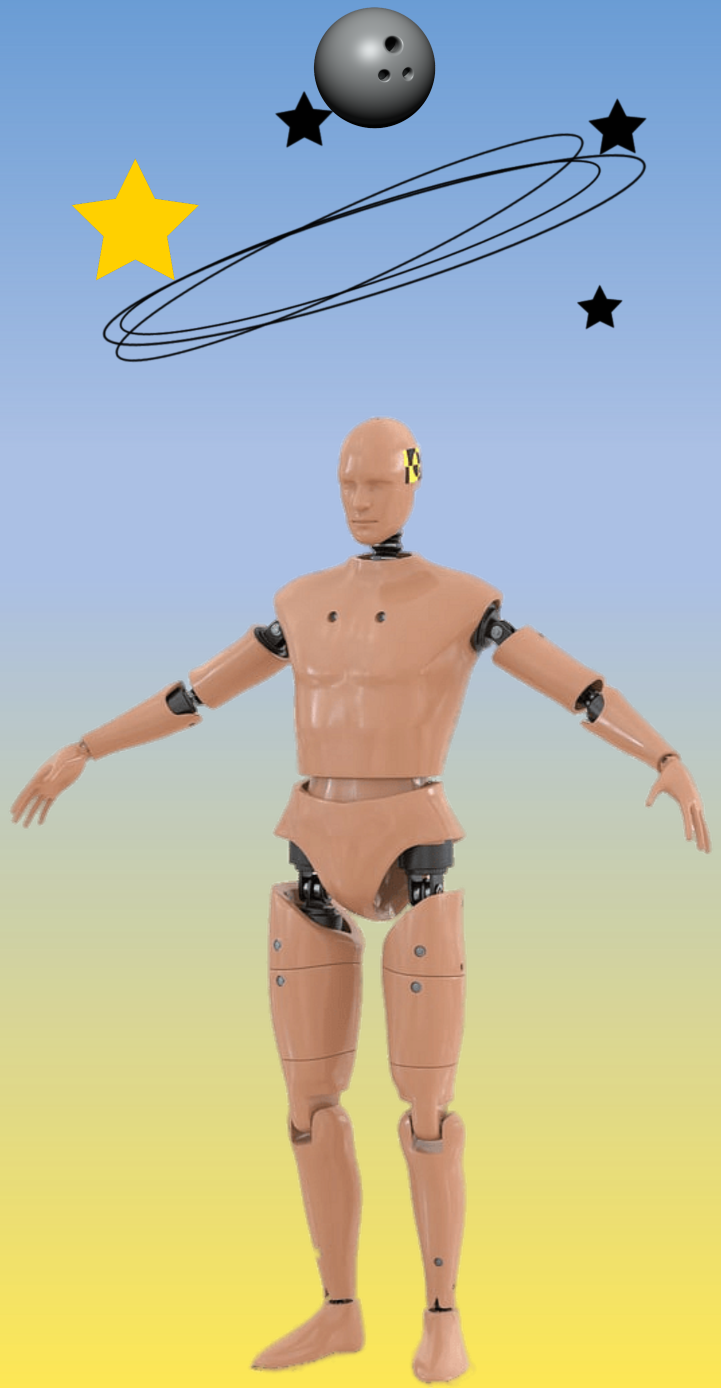
Previously…

~~There are 5 steps to form a star.~~



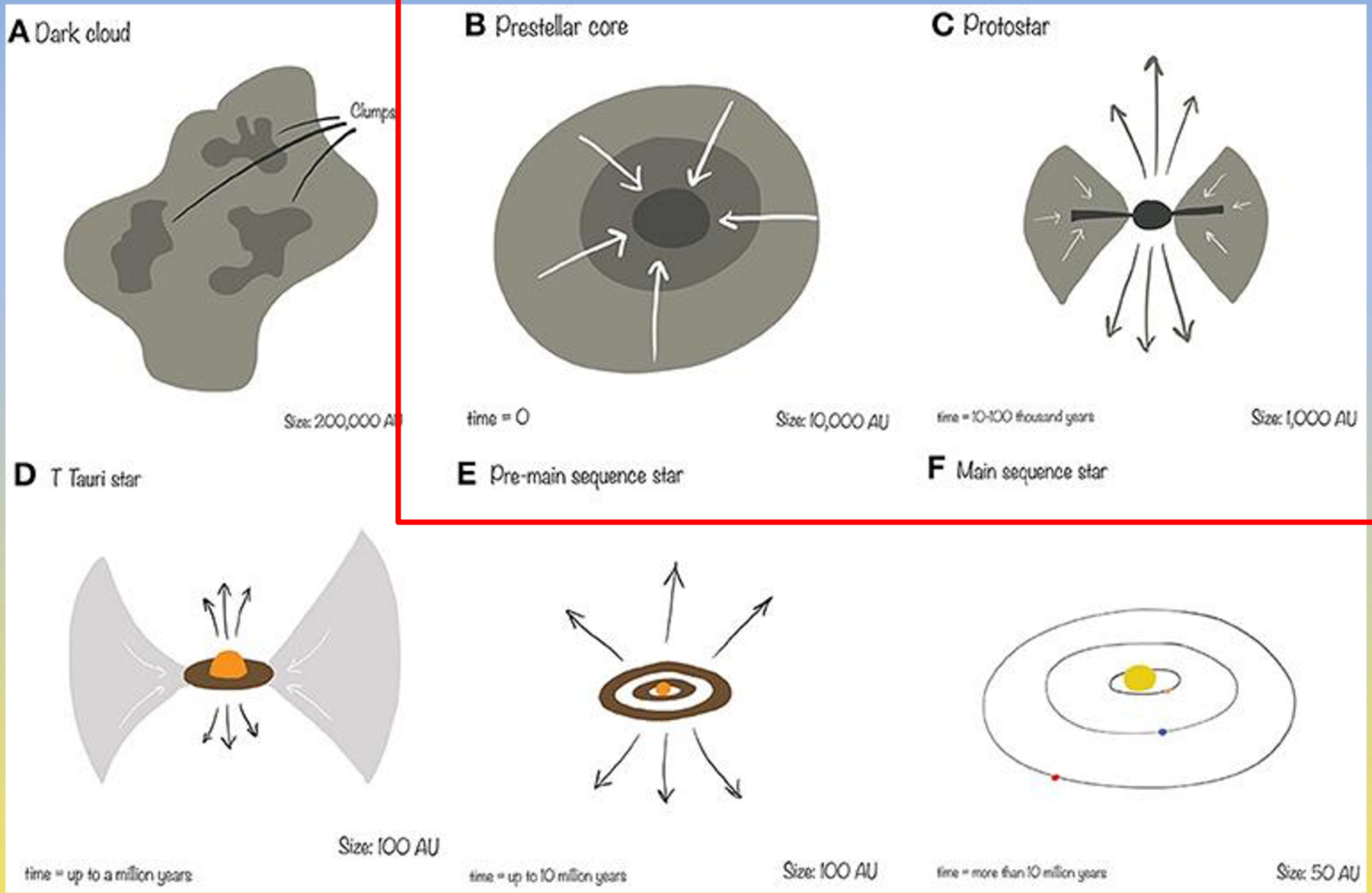
Star formation

- There are 4 steps to form a star:

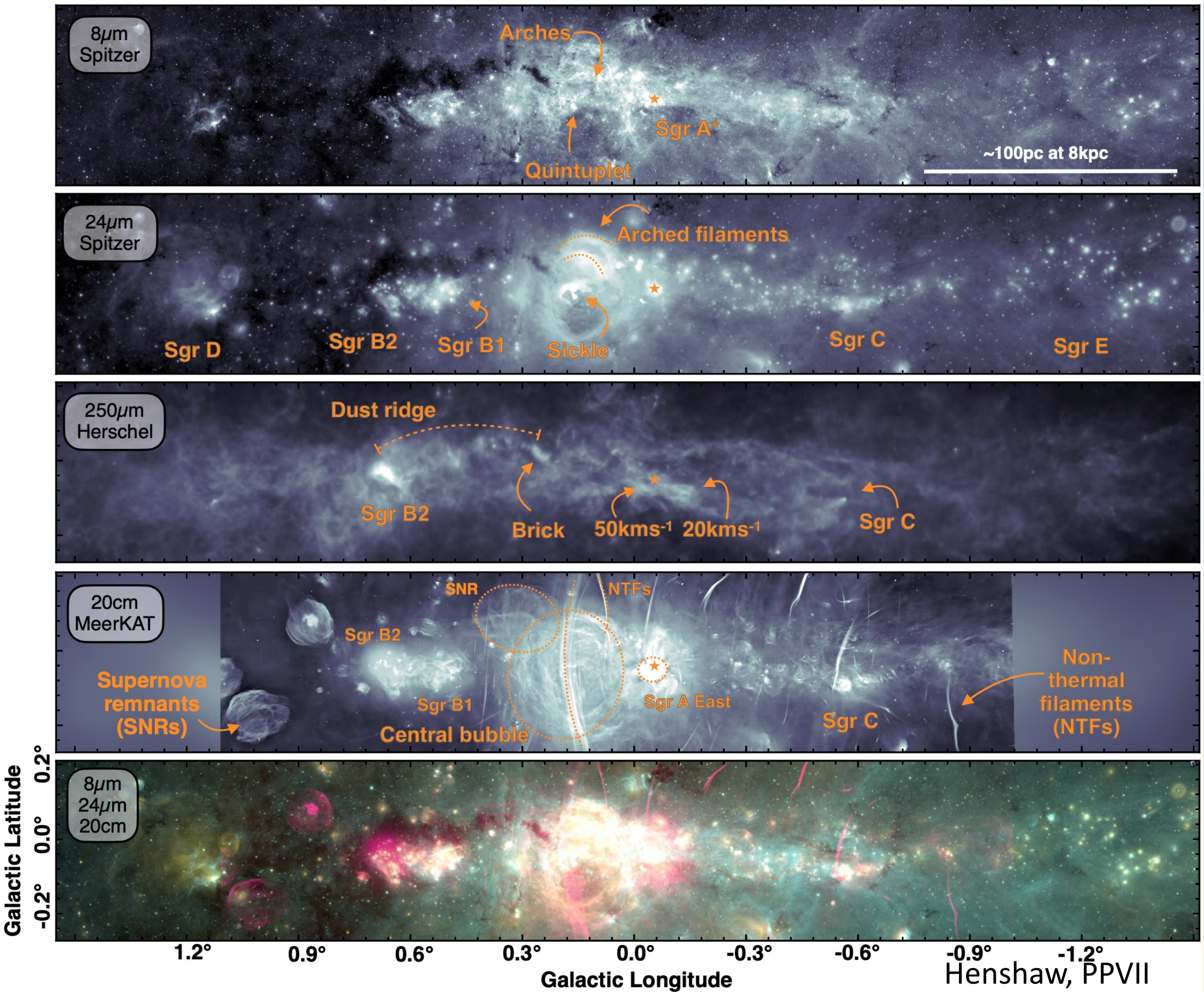


Star formation

Young Stellar Object (YSO)

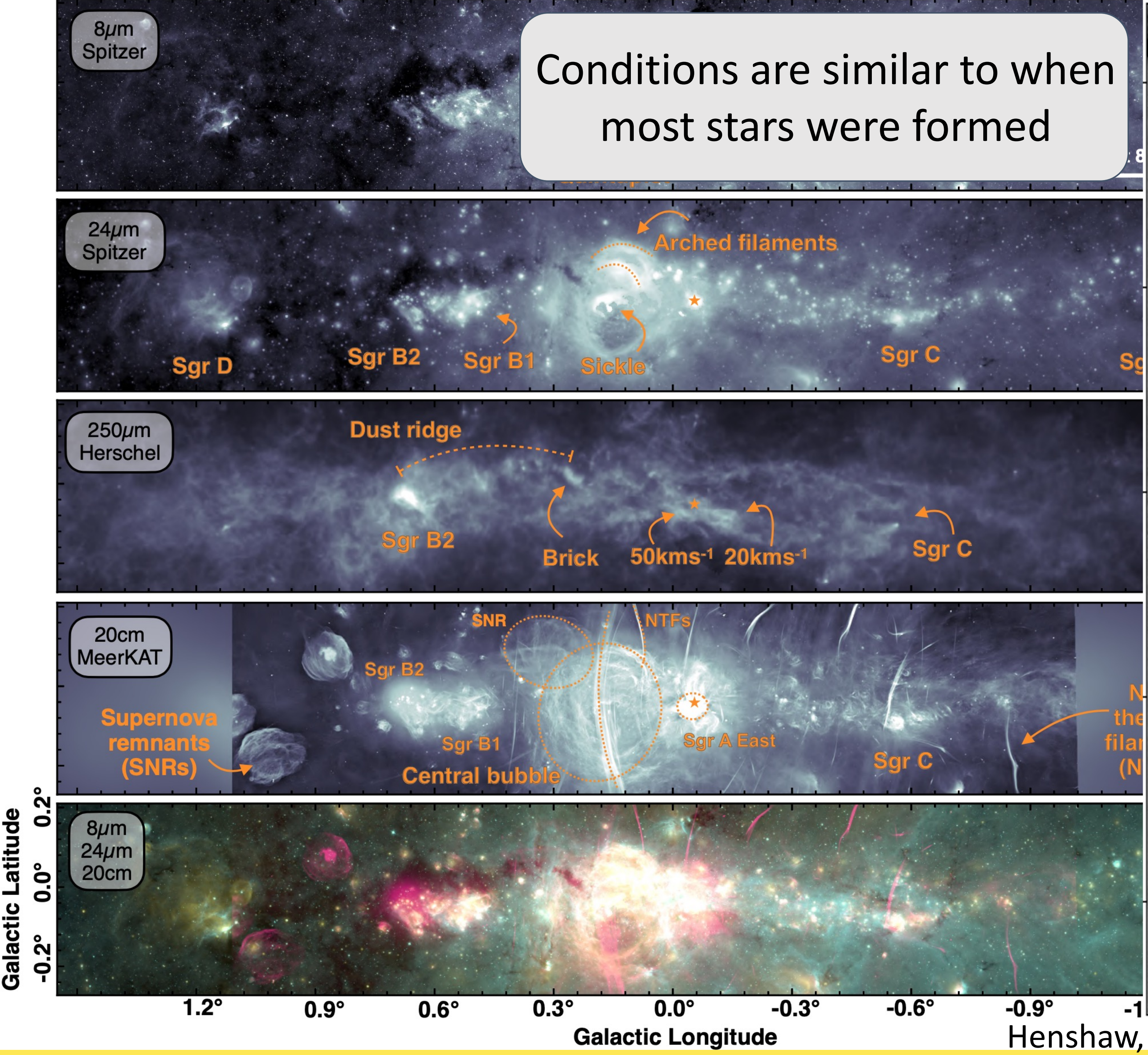


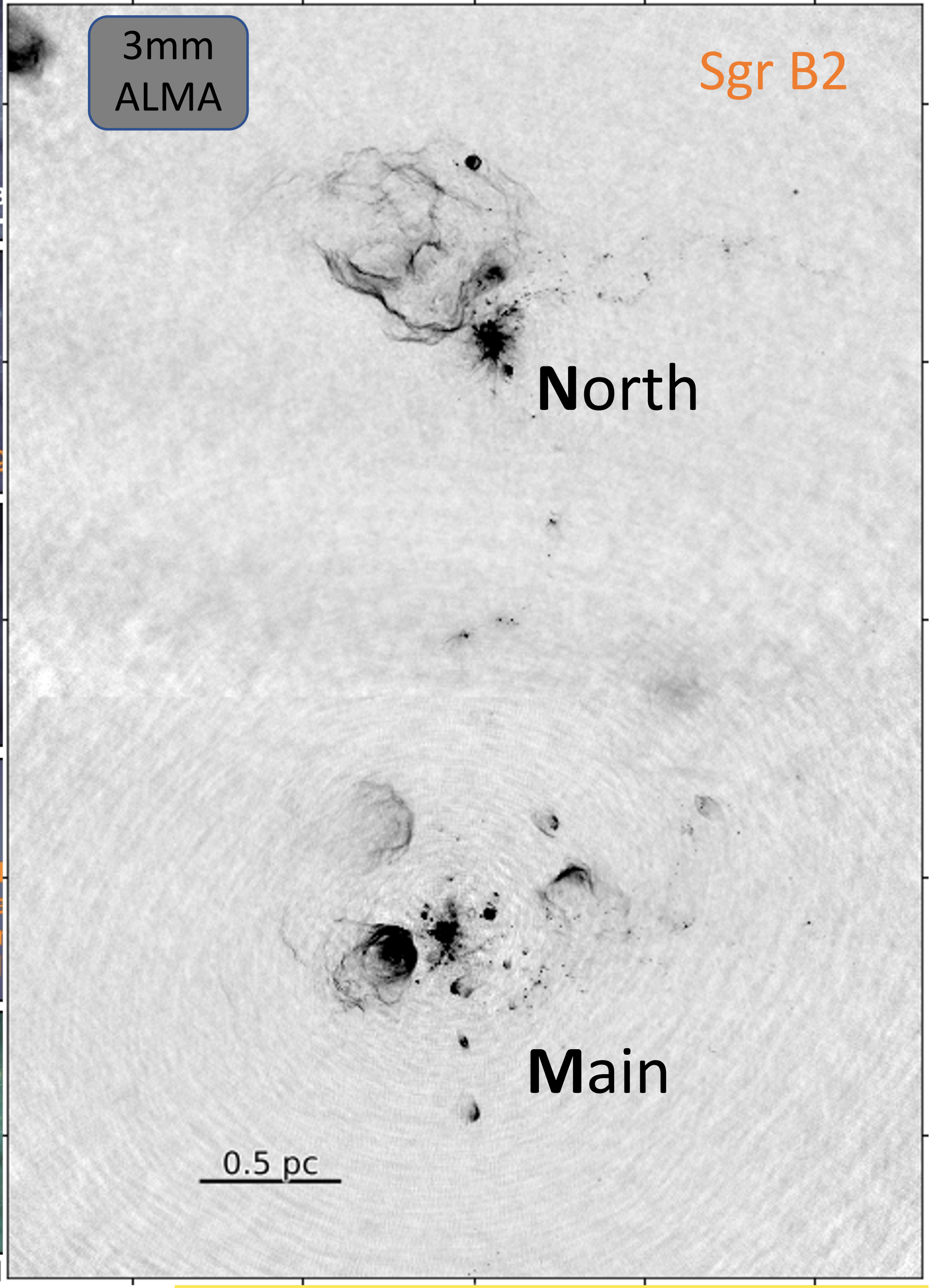
Christensen M. (2019)



Henshaw, PPVII

Conditions are similar to when most stars were formed





Henshaw, PPVII

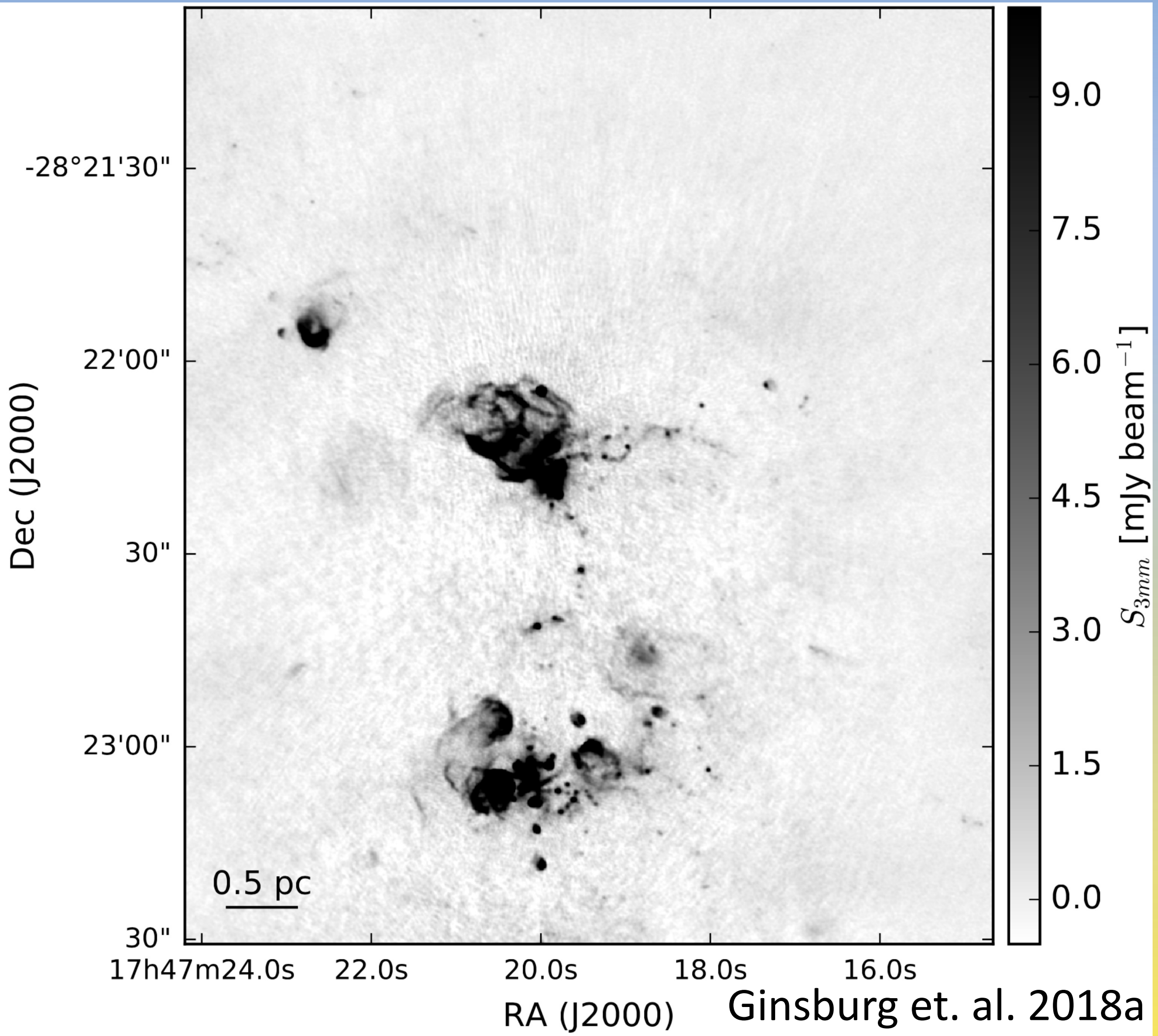
Motivation

There is evidence of more massive stars in clusters near the center of the Galaxy (Hosek et al. 2019)

If only we could look back at how they were formed...

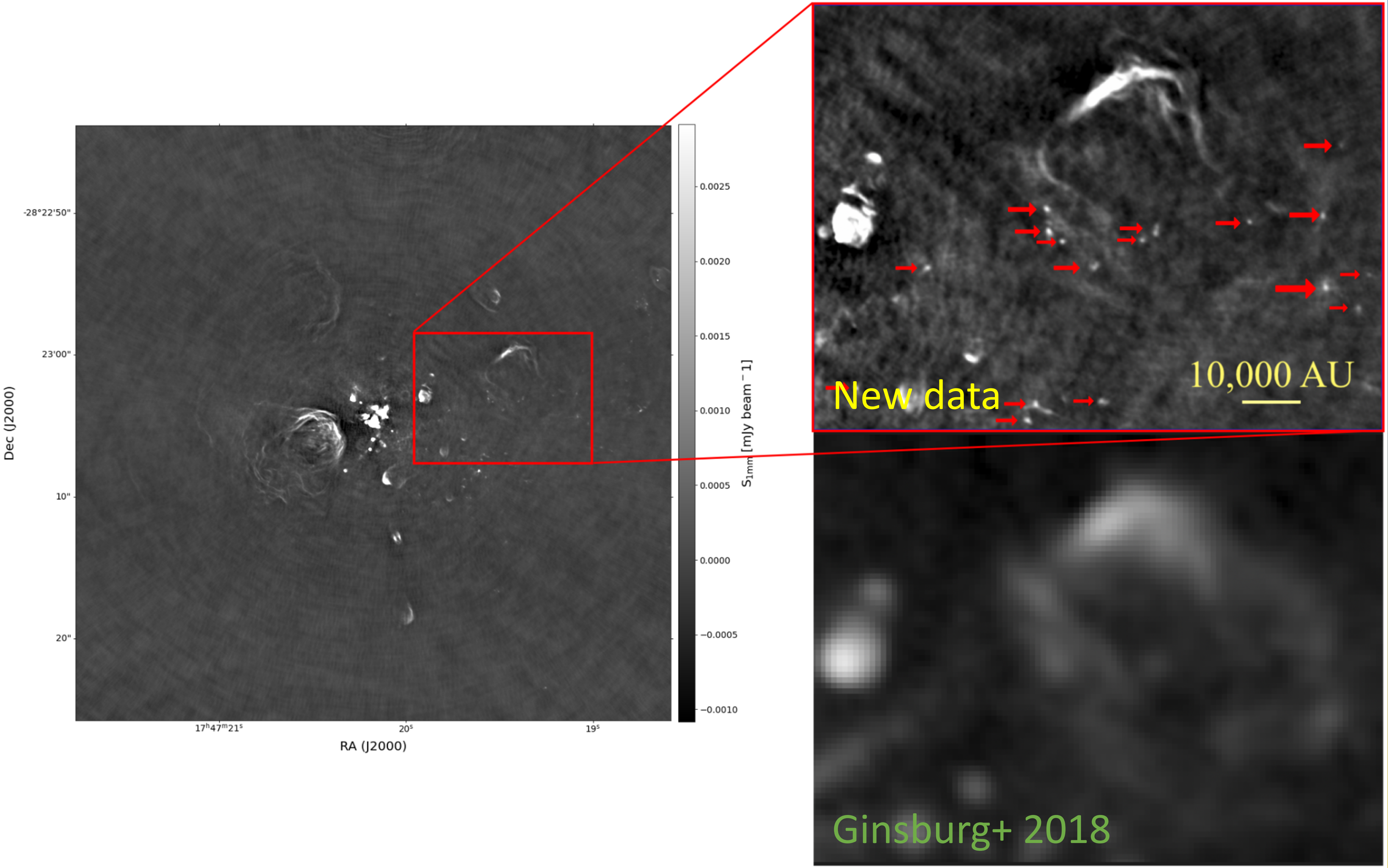
We can! (kind of) -> Sagittarius B2

This has been done before:



Ginsburg et. al. 2018a

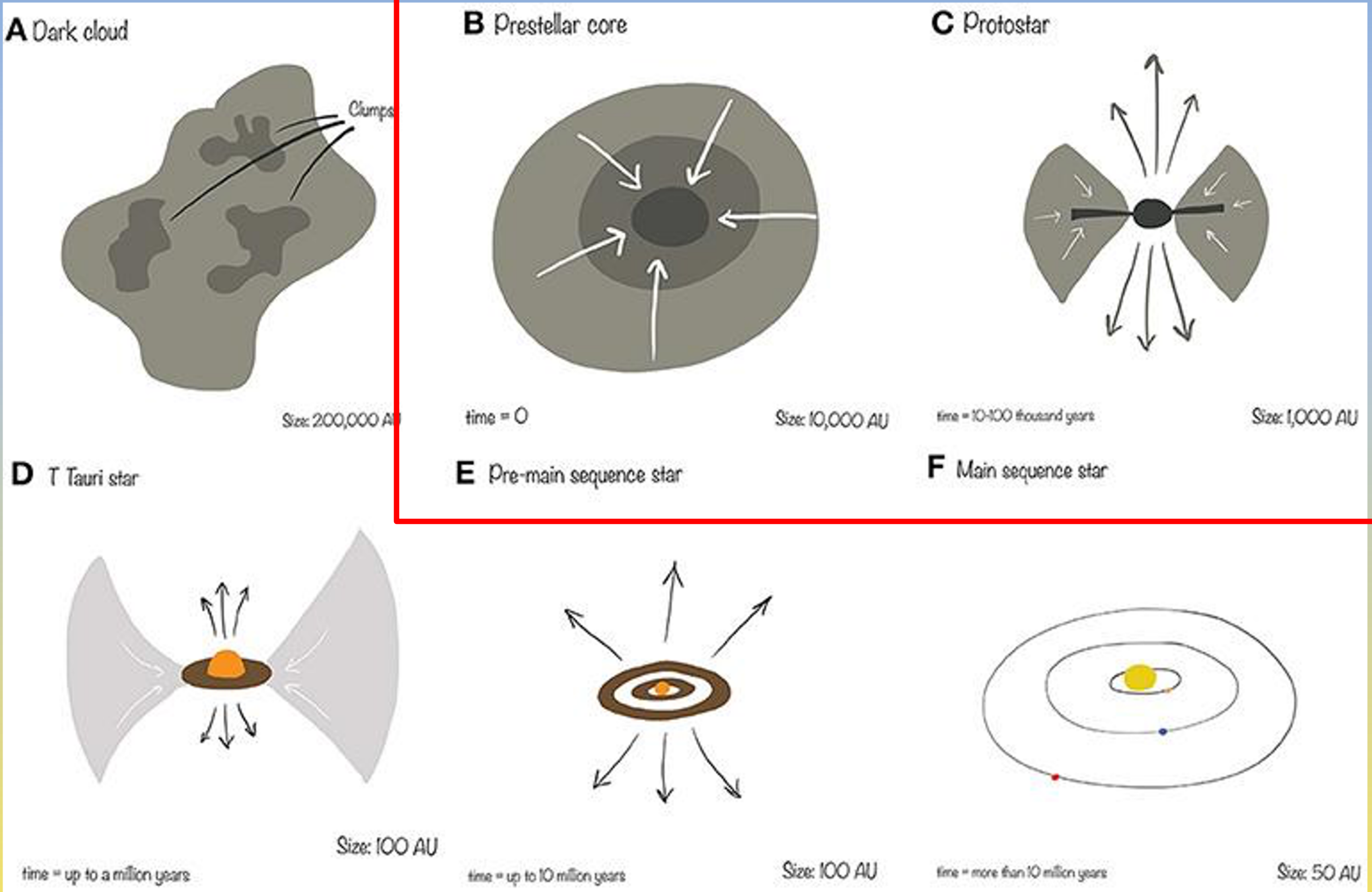
SgrB2 M (Main)



-28°22'50"
23'00"
10"
20"
Dec (J2000)
17h47m21s
20s
19s
RA (J2000)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
−0.0005
−0.0010
S1mm [mJy beam^-1]
10,000 AU
New data
Ginsburg+ 2018

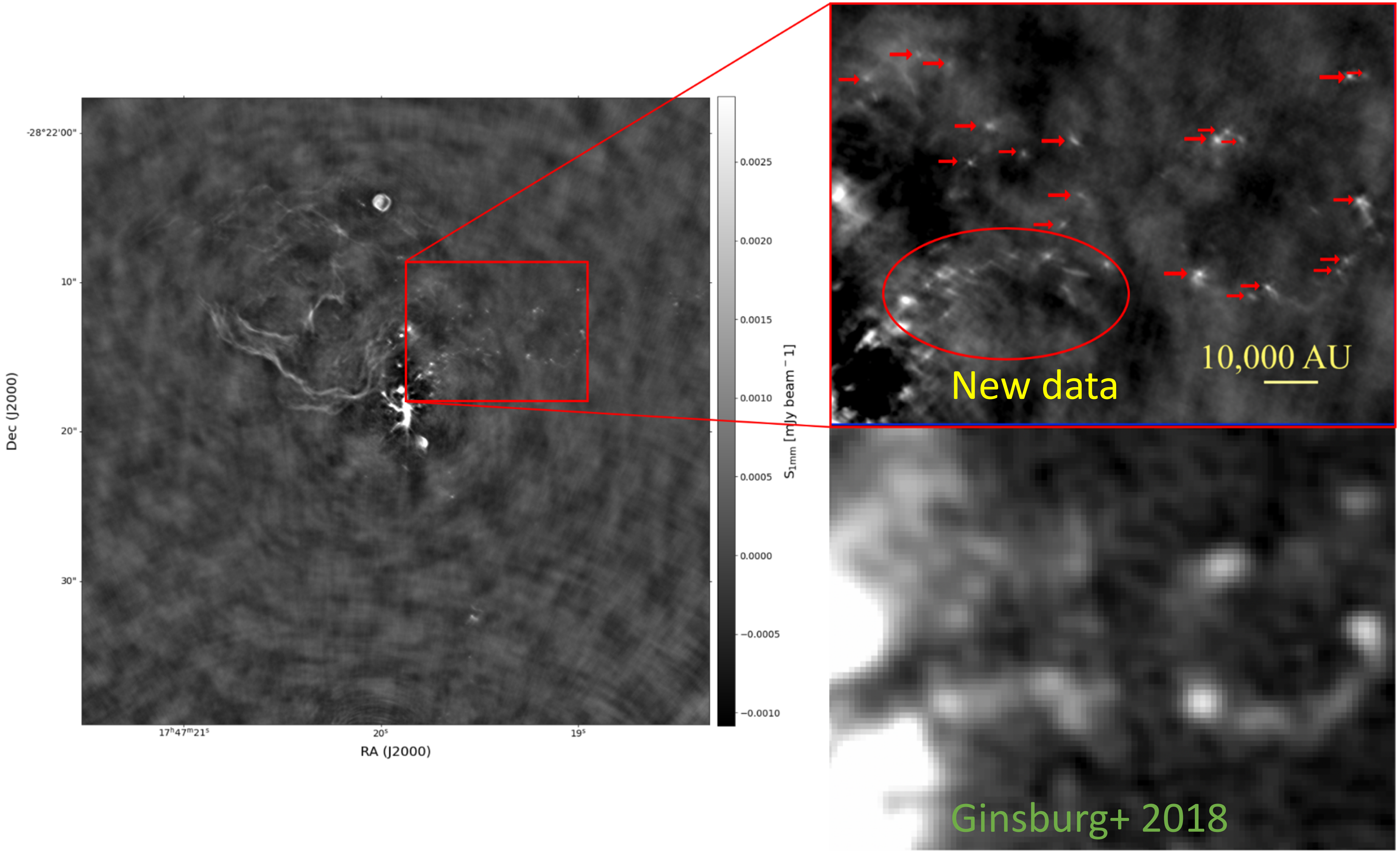
Star formation

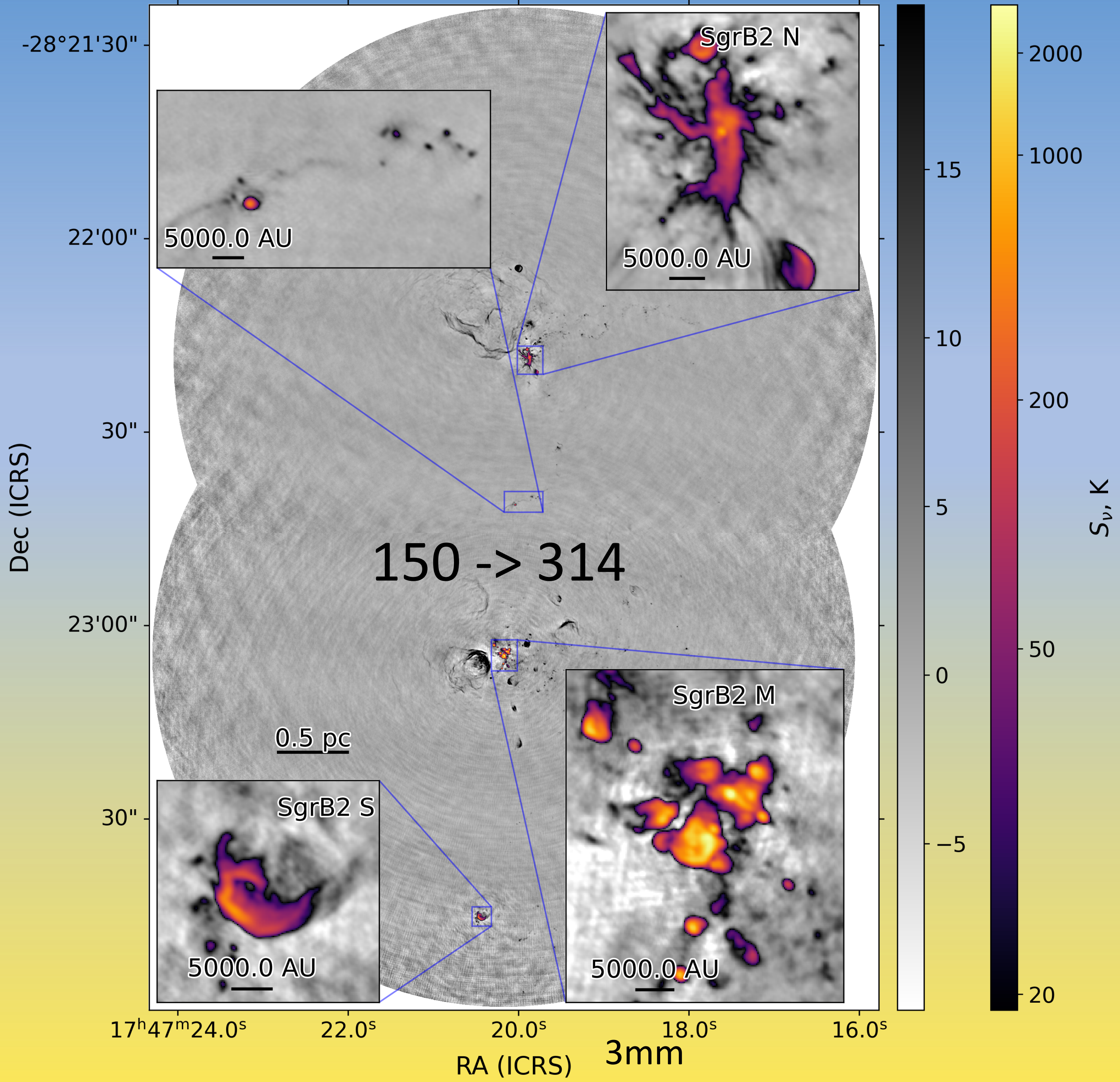
Young Stellar Object (YSO)



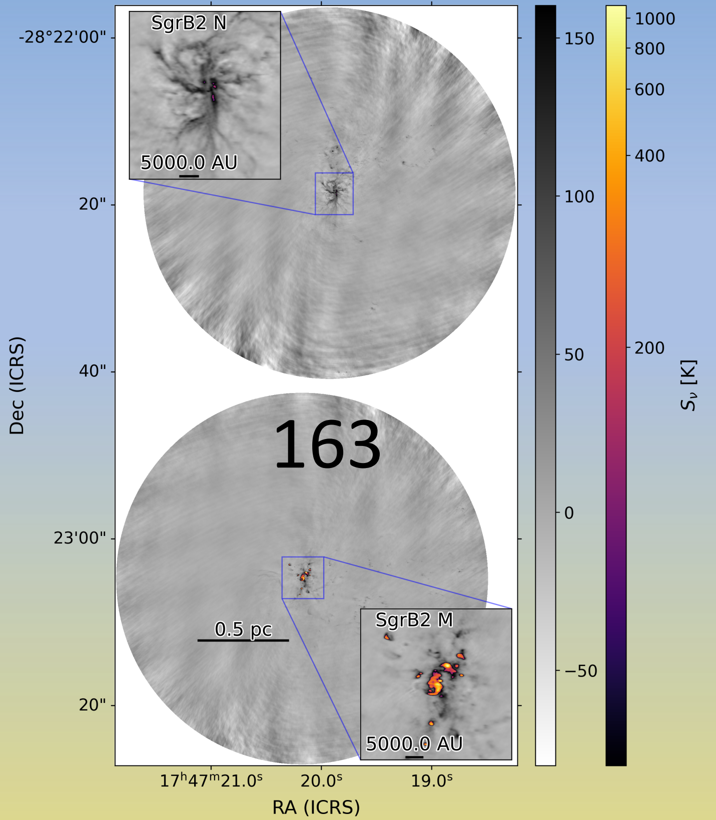
Christensen M. (2019)

SgrB2 N (North)





3mm
ALMA

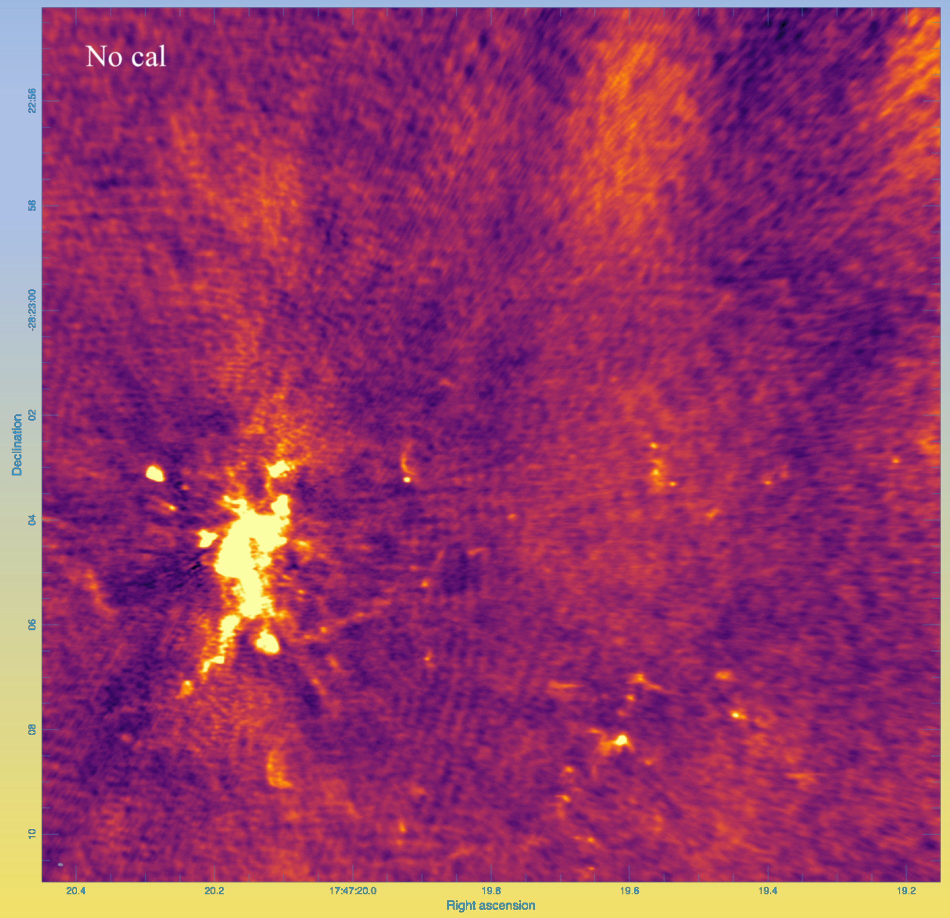


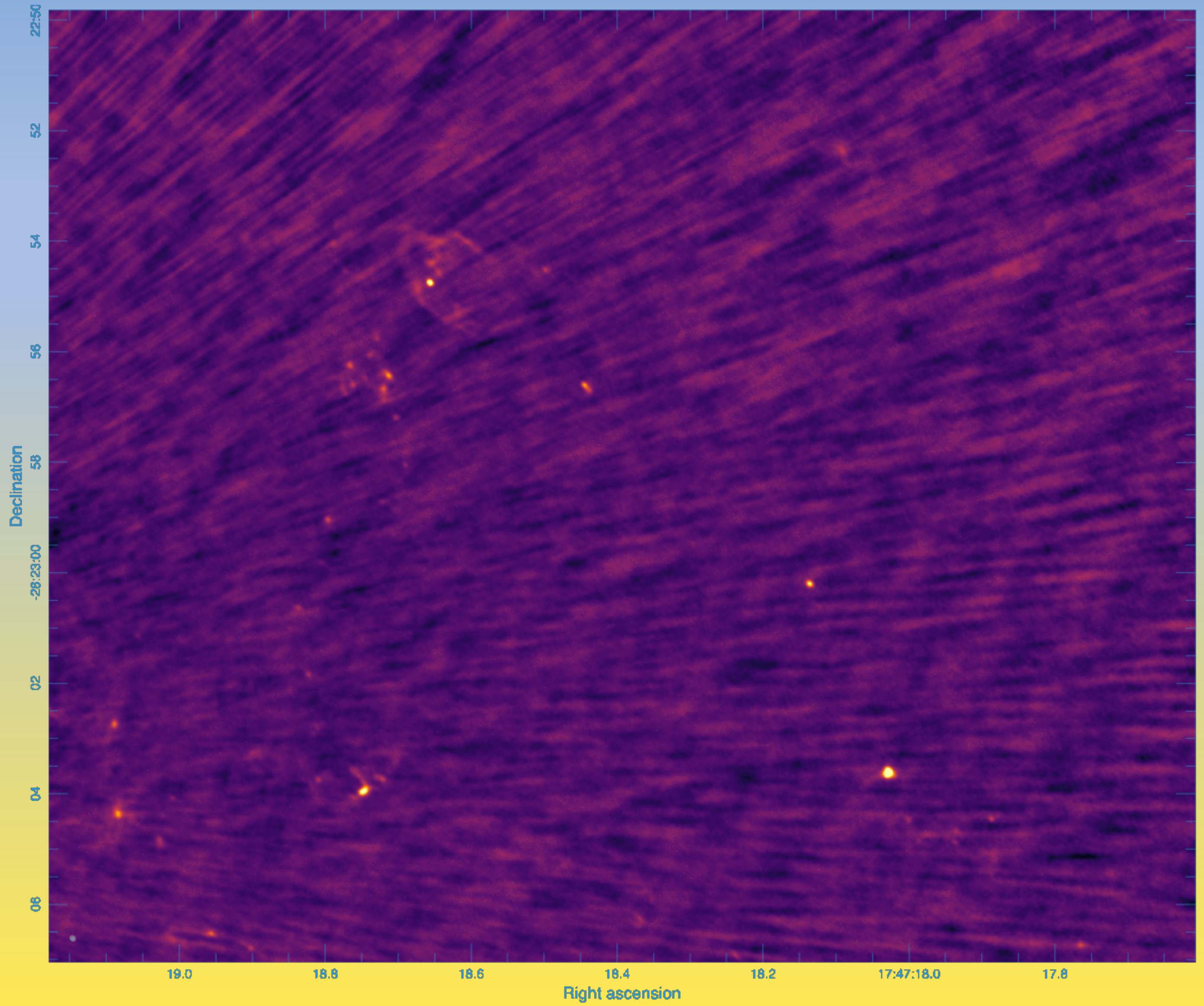
1mm
ALMA

Data processing

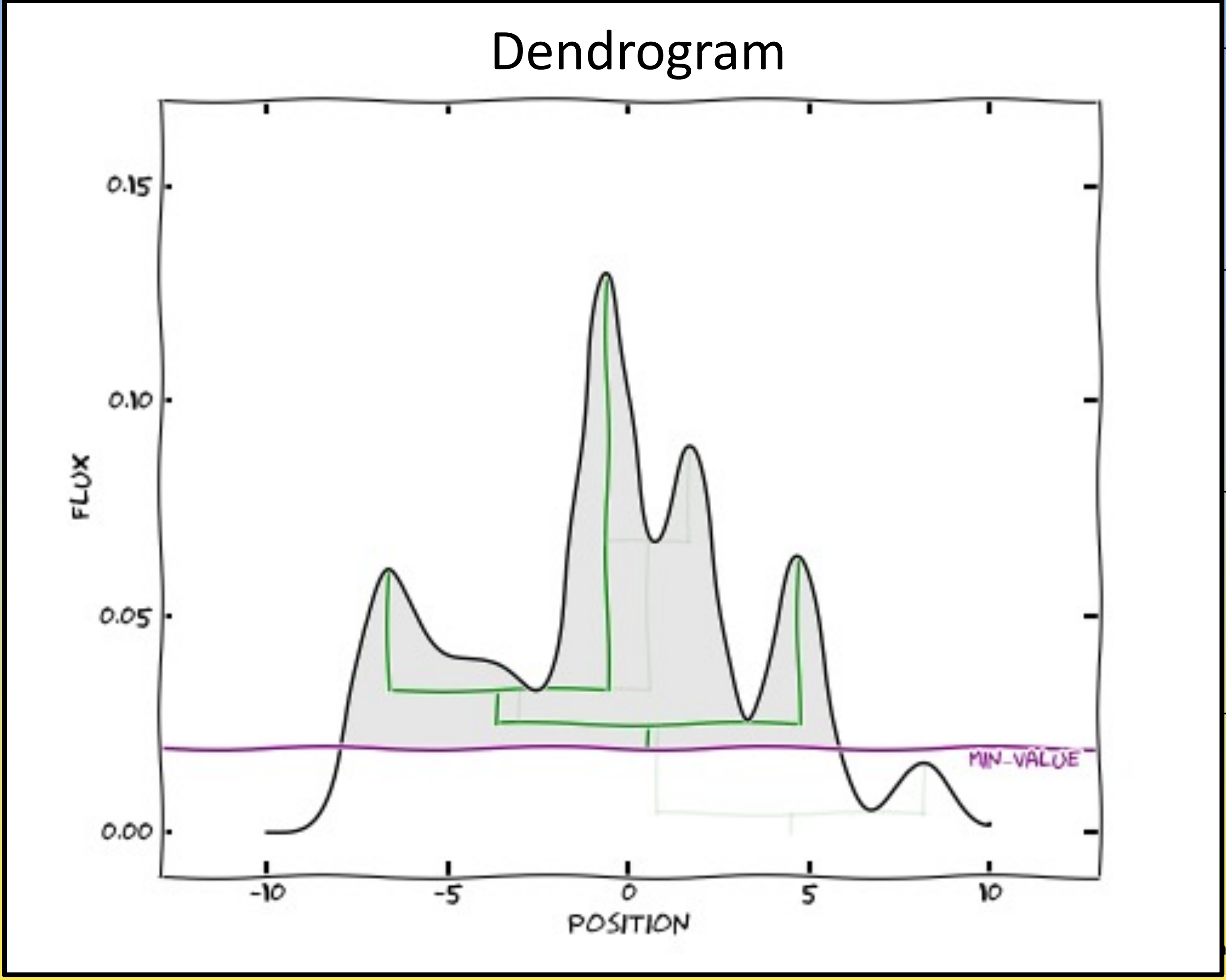
- Data reduction: self-calibration and cleaning
- Source extraction: dendrograms
- Photometry: dendrogram leaf contours
- Data analysis

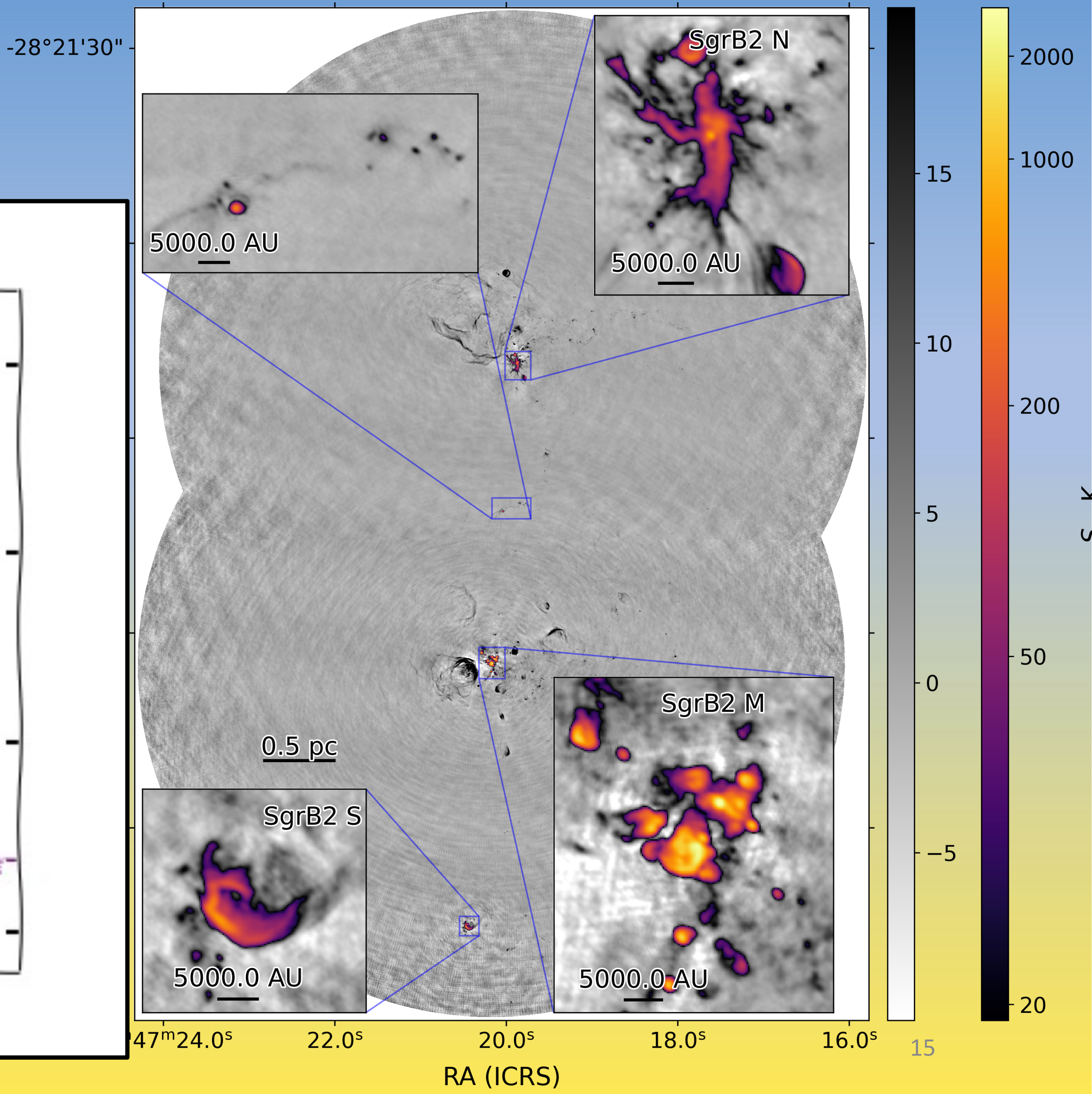
Self-calibration and cleaning



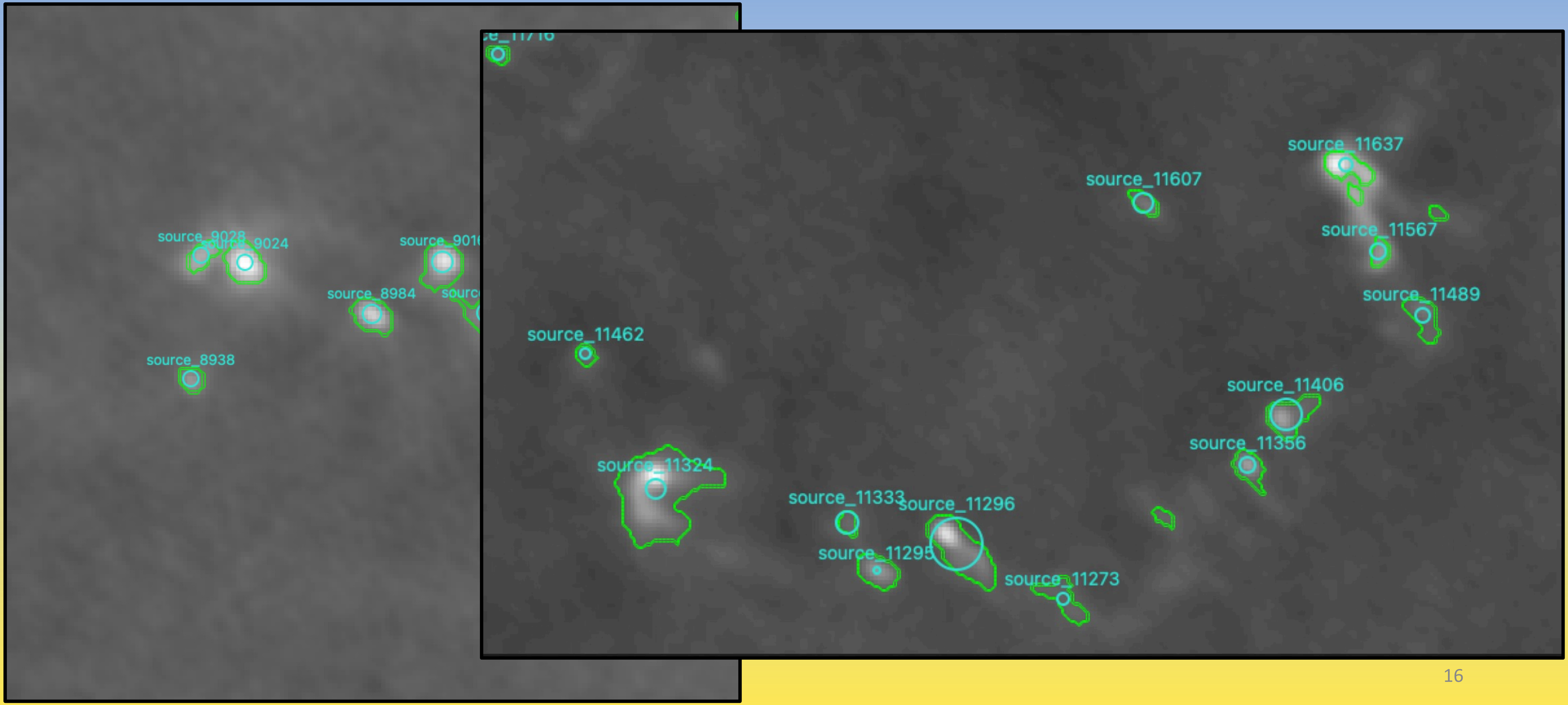


Source extraction



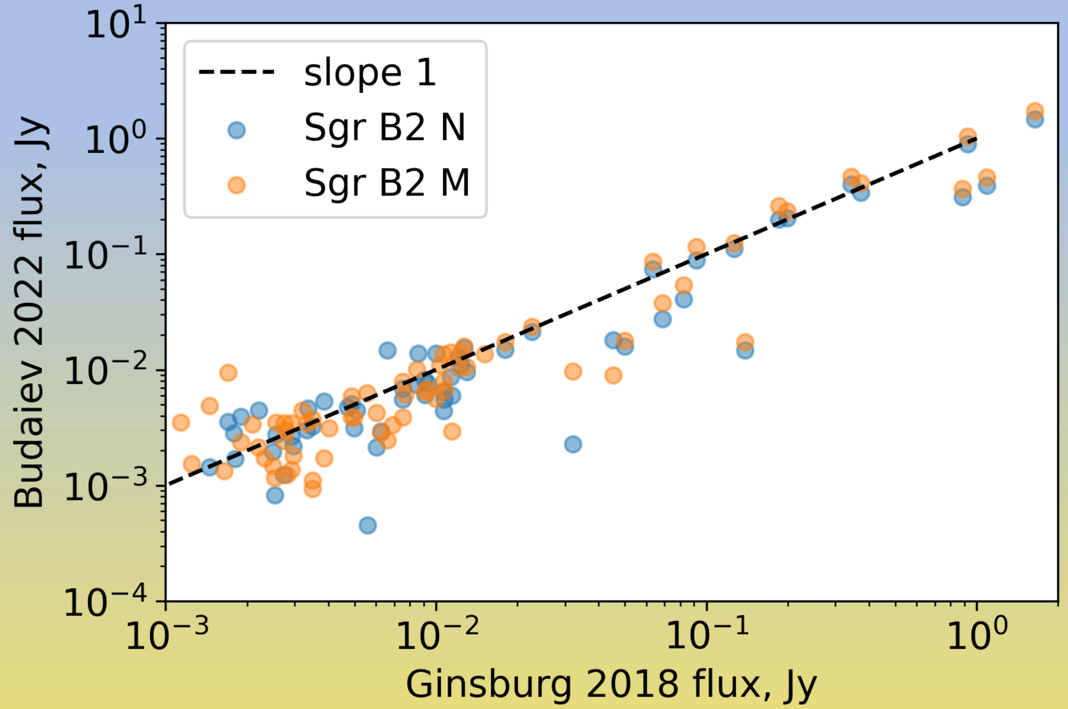


Photometry: dendrogram leaves



Comparing with previous data: photometry

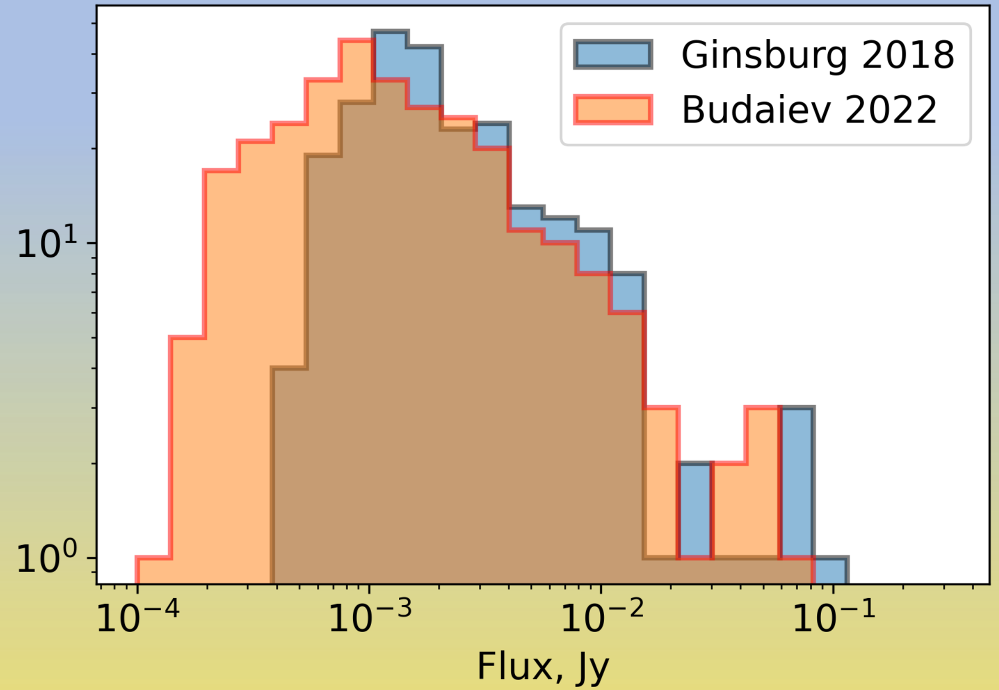
- Total flux within a beam-sized aperture
- Shortest baseline is now longer -> some flux is resolved out



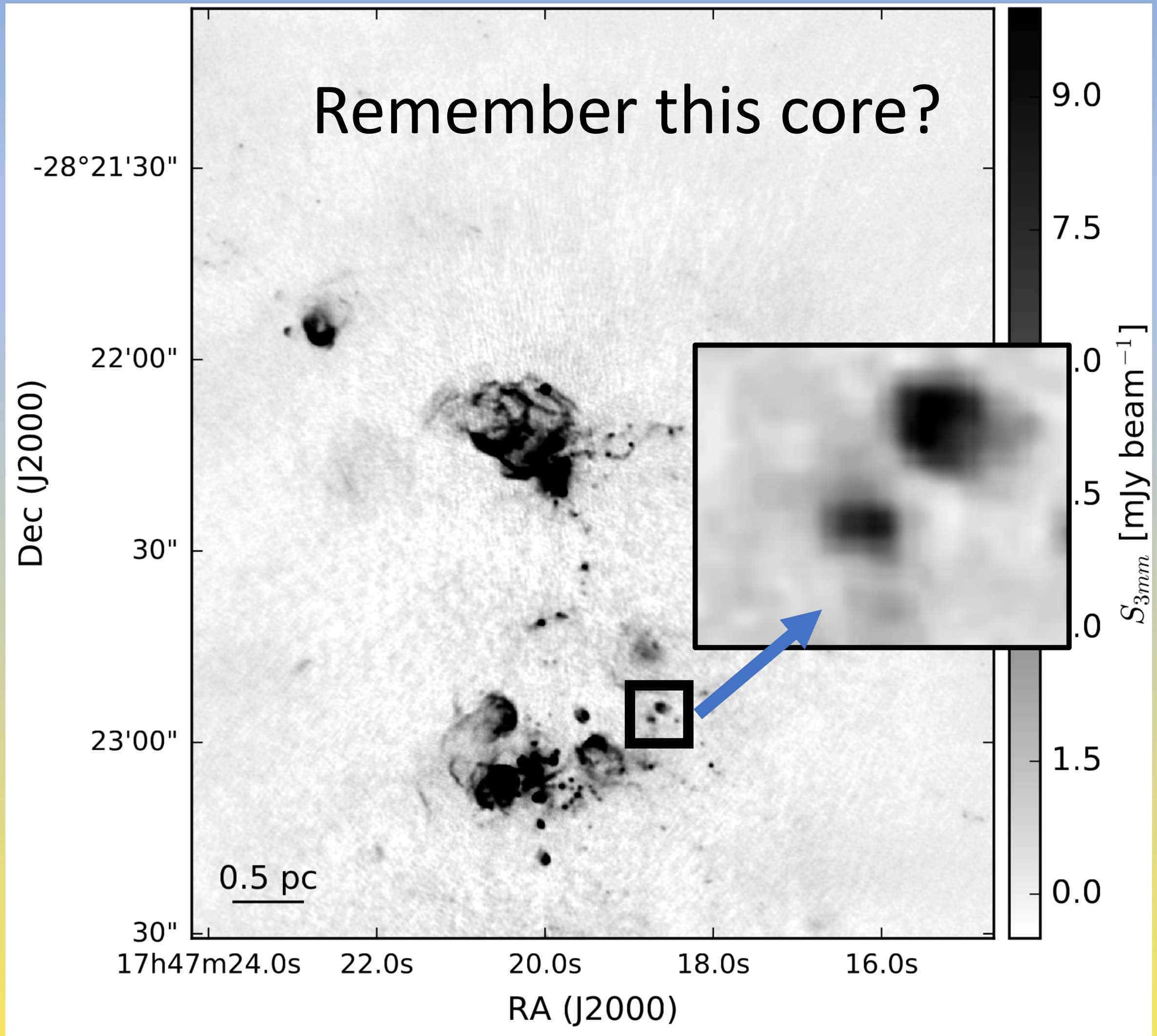
Comparing with previous data: source flux

- Full Sgr B2 cloud for Ginsburg 2018a vs N and M pointings in the new data

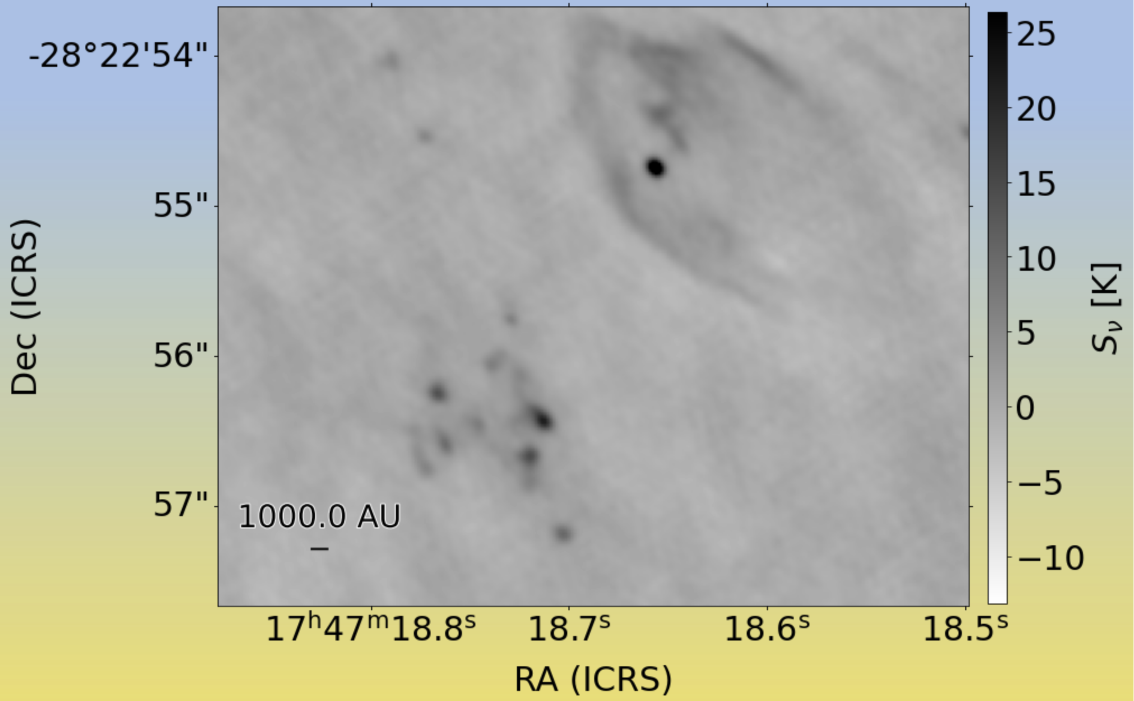
- Similar slope
- More fainter sources
- Similar turnover point



Comparing with previous data: visual



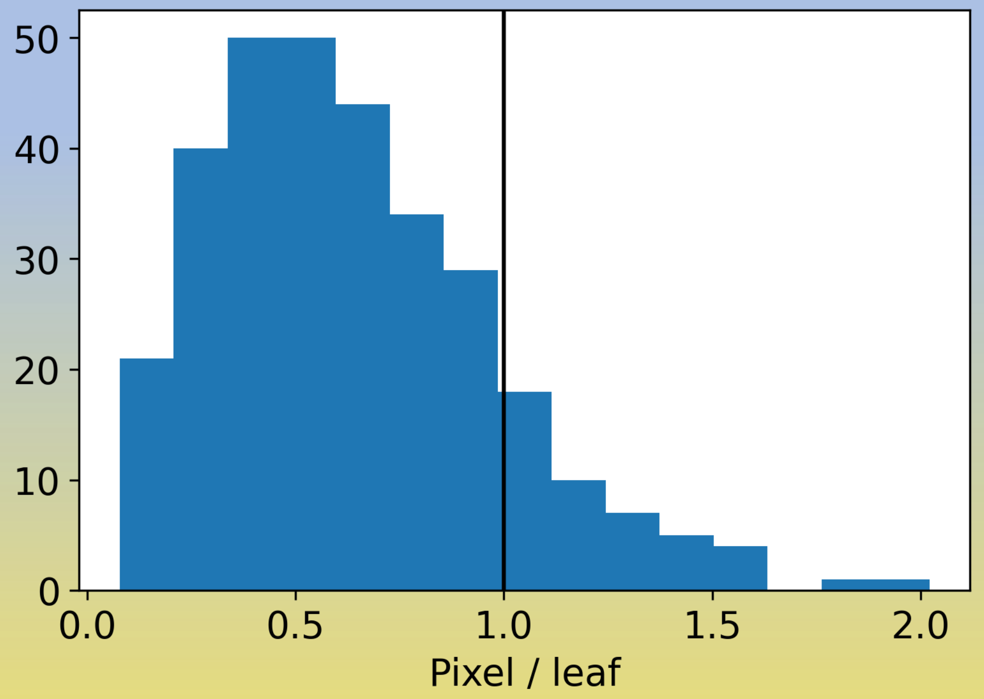
This is them now



Feel old yet?

Are our sources resolved?

- Most of them are resolved



Brightest pixel within a leaf

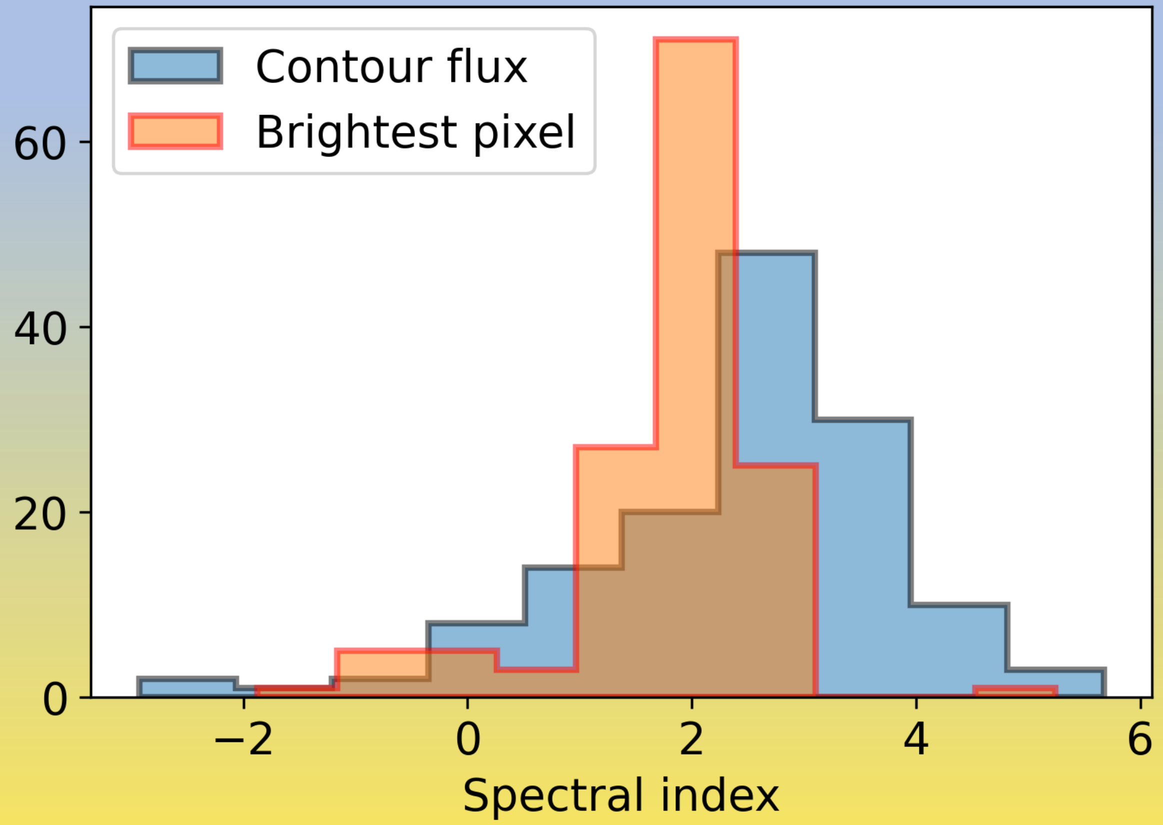
Total flux within a leaf

Spectral indexes / indices tell me in the comments below

How much does flux change with frequency? $S_\nu \propto \nu^\alpha$

$$\alpha = \frac{\log\left(\frac{S_{100GHz}}{S_{225GHz}}\right)}{\log\left(\frac{100GHz}{225GHz}\right)}$$

Most sources are optically thick

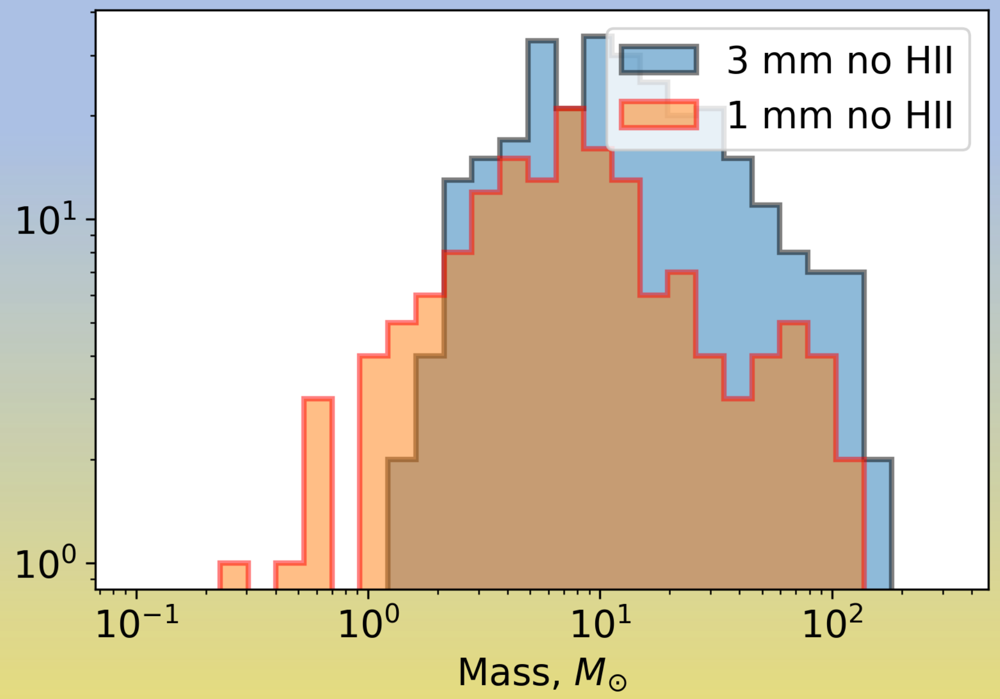


Source masses

- Ginsburg et. al. 2018a uses an **optically thin dust** assumption to get source masses.
- Other assumptions:
  - Temperature. 20K? 50K? 100K? Uniform?
  - Dust opacity index. Extrapolate from dust grain models?
  - Distance of 8.4 kpc?
- Is there even a point?

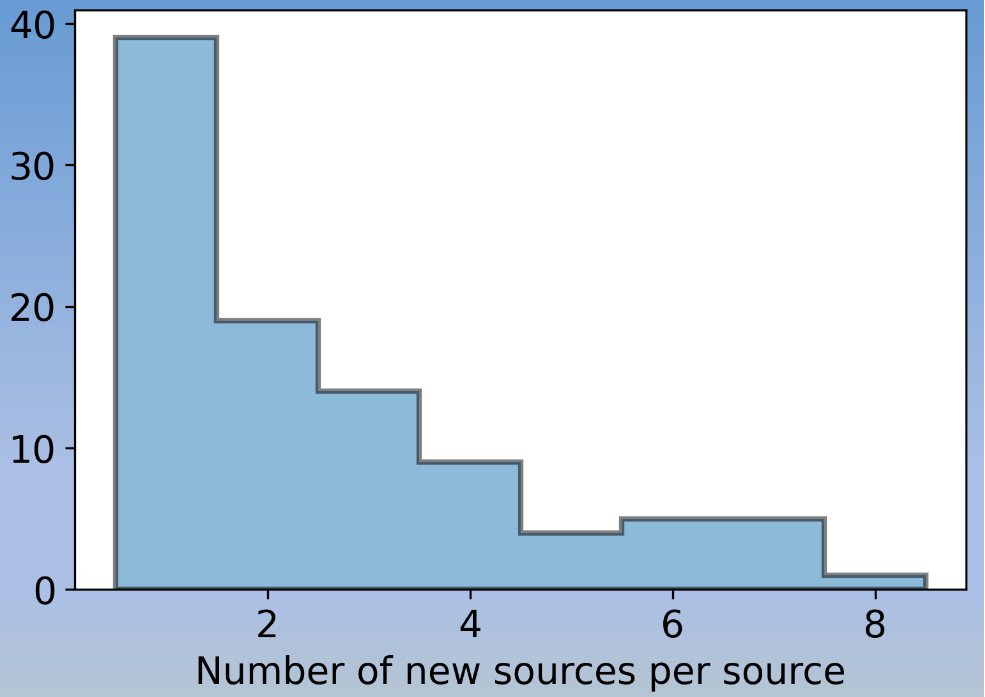
Source masses

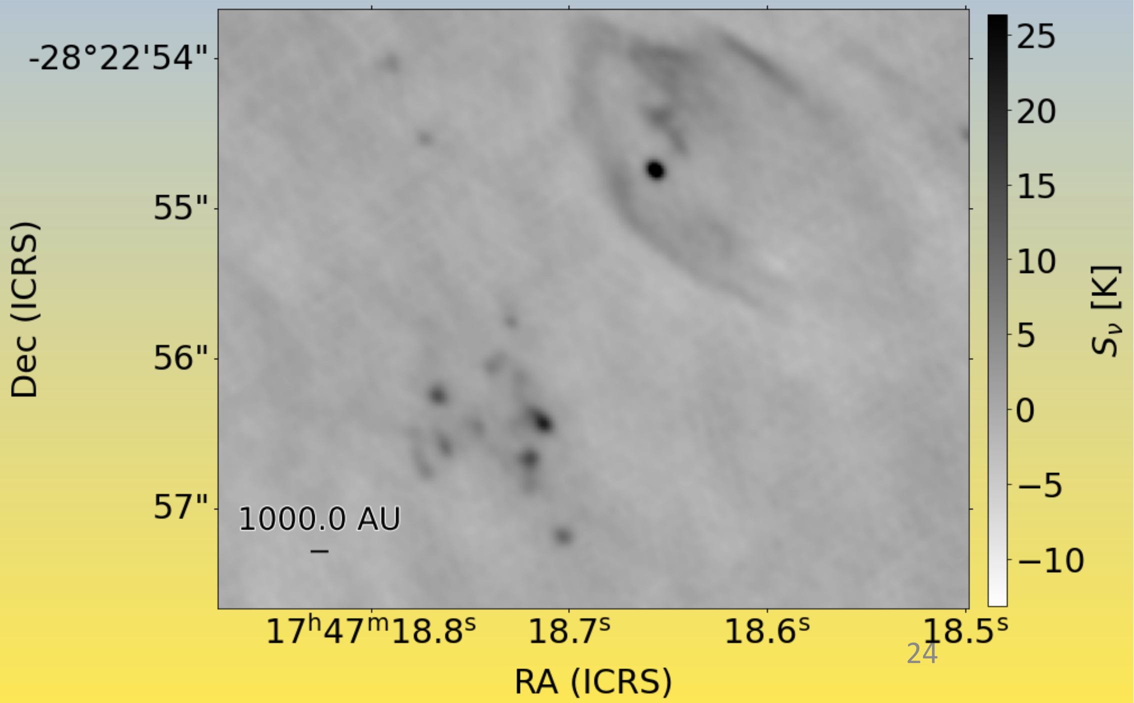
- Assumed uniform temperature of 50K
- Remove HII regions from the sample
- We can get a lower-mass limit for the cores
- Infer total mass, compare with previous results
- Schmiedeke et. al. 2016: ~25,000 Msun
- 3mm: ~85,000 Msun, 1mm: ~18,000 Msun



Cluster Formation Efficiency

- Ginsburg et. al. 2018b measured the Cluster Formation Efficiency to be ~ 35%
- > 50% of the sources are fragmented
- More stars form in bound clusters.





Future work

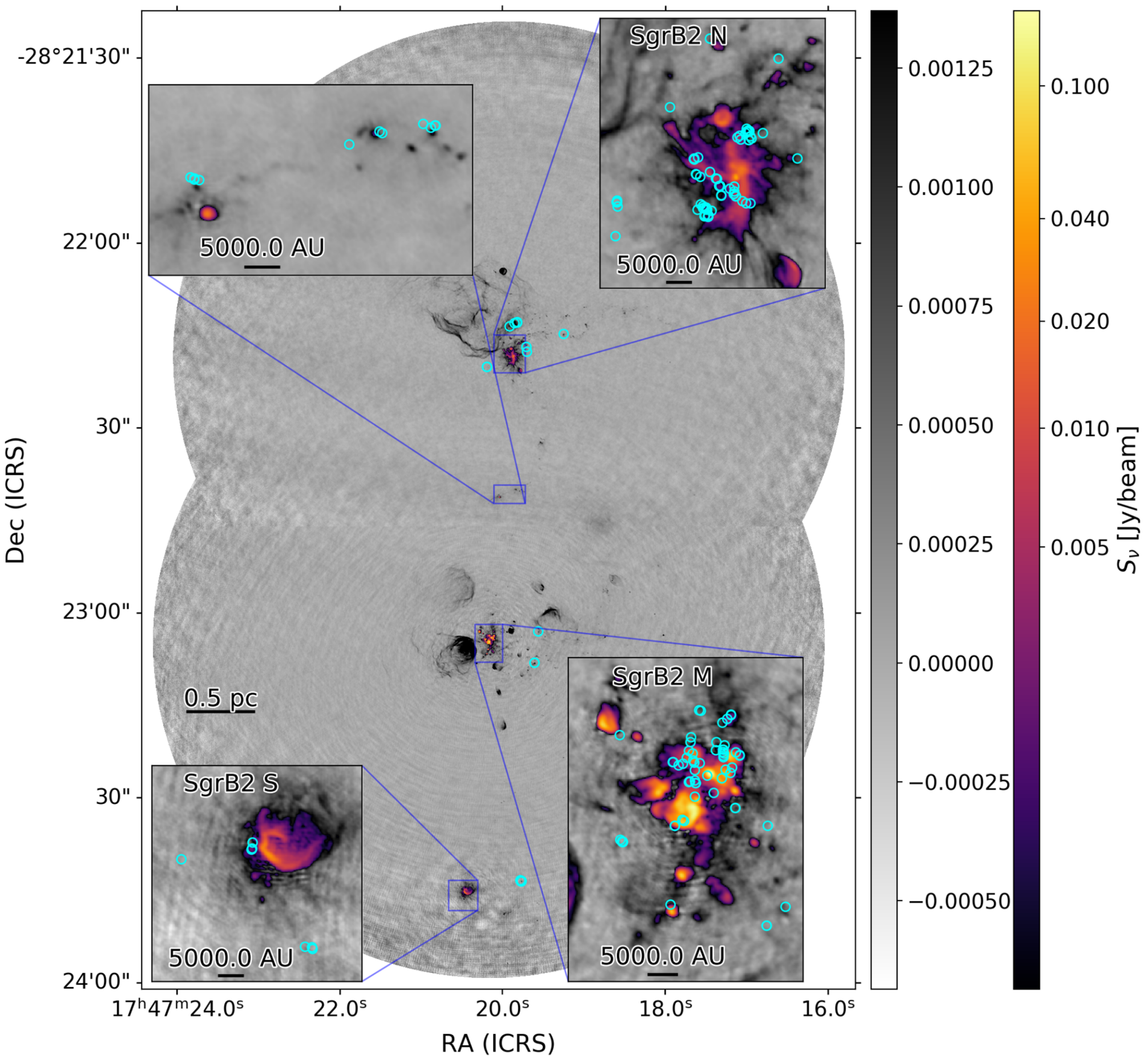
- Address some issues with how the data was processed
- Re-calculate total Star Formation Rate
- Re-calculate the Cluster Formation Efficiency for the cloud
- Use recent VLA data to create H2O maser catalog of SgrB2
- Measure proper motions of the cores with follow-up observations

Summary

- Young star clusters in the CMZ have more massive stars than expected
- Sagittarius B2 forms a lot of stars in conditions similar to cosmic noon

- We found 314 sources at 3mm and 163 at 1mm, most are resolved and optically thick
- We measured the lower-mass limit for the cores; the inferred stellar mass matches previous observations

Backup



H2O masers (McGrath 2004)