Core mass function and gas kinematics in the protocluster G286.21+0.17 revealed by ALMA

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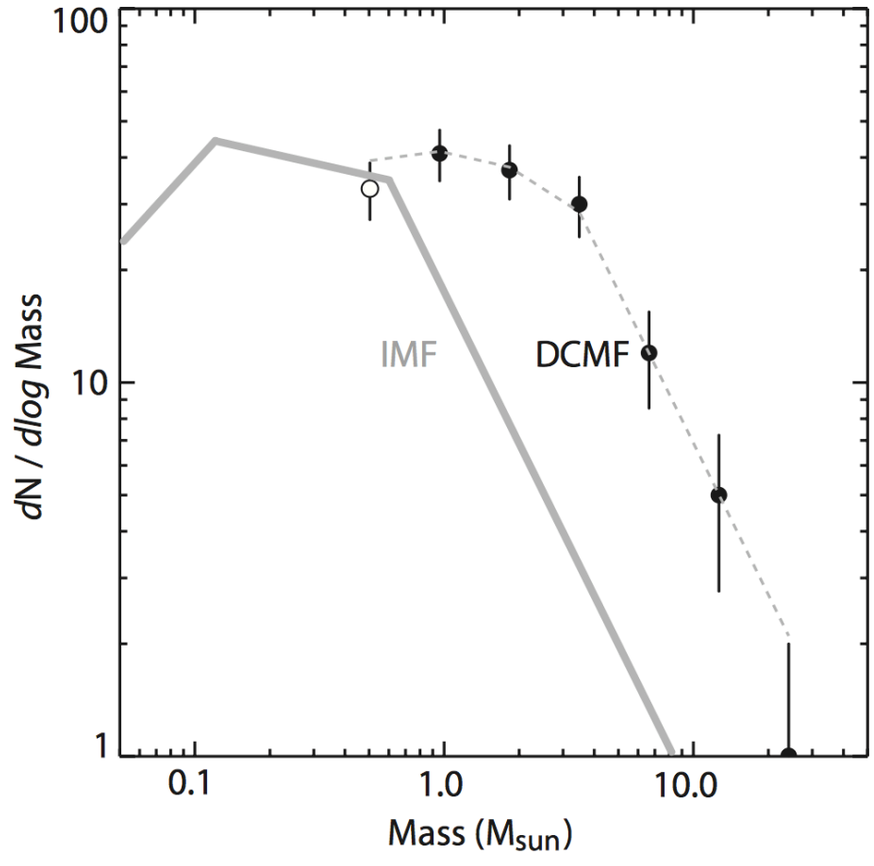
Cluster formation

- Most stars tend to form together in clusters (Lada & Lada 2003)
- Time scale, star formation efficiency…?
  - "Slow" cluster formation (Tan et al. 2006; Nakamura & Li 2007)
  - "Fast" cluster formation (Elmegreen 2000, 2007; Hartmann & Burkert 2007)



Alves et al. 2007

- CMF: precursor of IMF?
  - Submillimeter continuum/ near-IR extinction map
  - nearby low mass clouds: a log-normal CMF with a Salpeter-like high mass slope, which overall resembles the stellar IMF(Motte et al. 1998; Tests & Sargent 1998; Johnstone et al. 2000; Alves et al. 2007)
  - CMF in massive star formation regions (Rodon et al. 2012; Ohashi et al. 2016; Kainulainen et al. 2017; Motte et al. 2018; Liu et al. 2018)

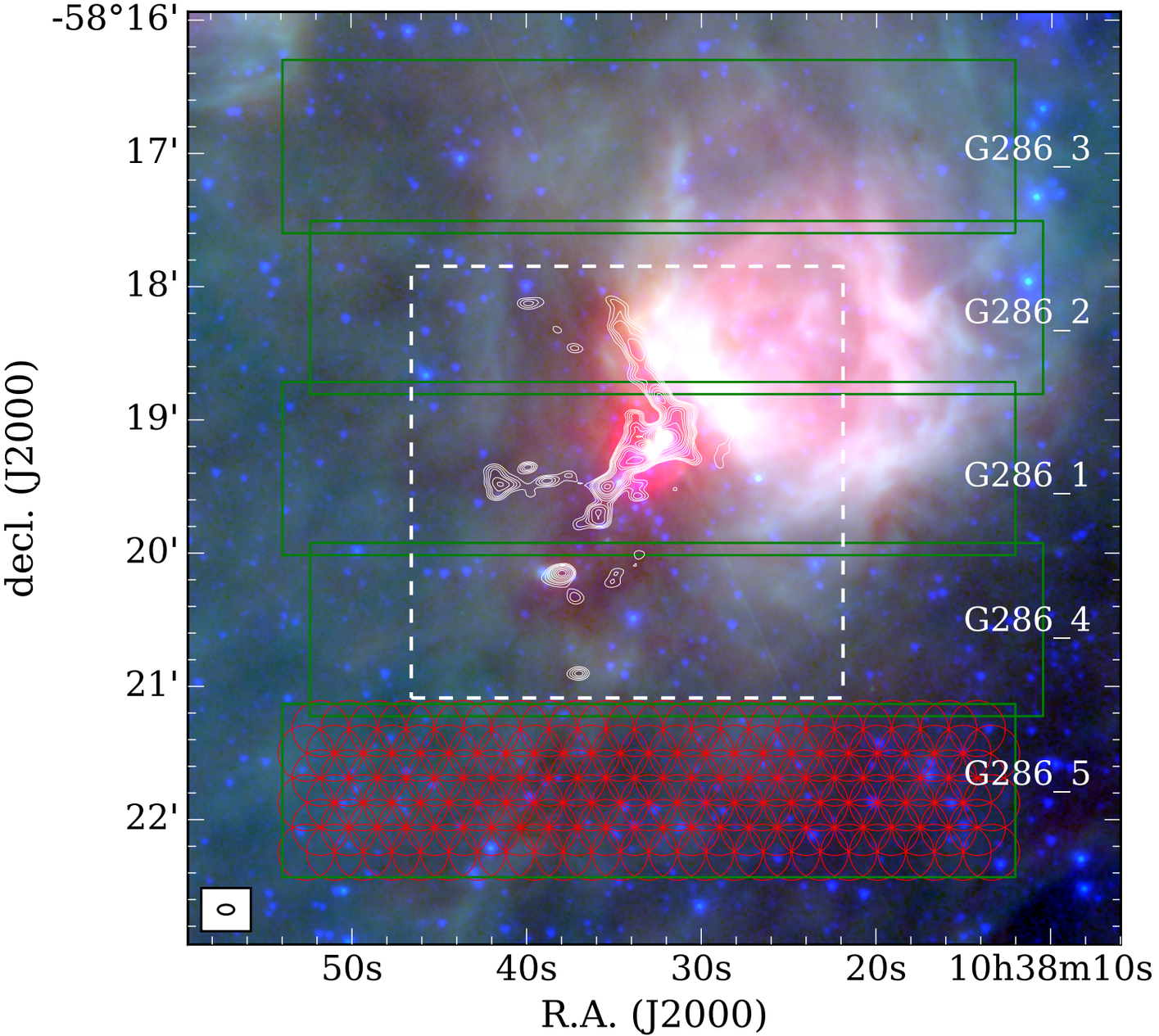
- G286.21+0.17
  - ~ 2000 M⊙ at a distance of 2.5 kpc, with a large global mass infall rate.
  - the most massive and densest of the gas clumps in the sample of 300 HCO^+ clumps (Barnes et al. 2010, 2011)

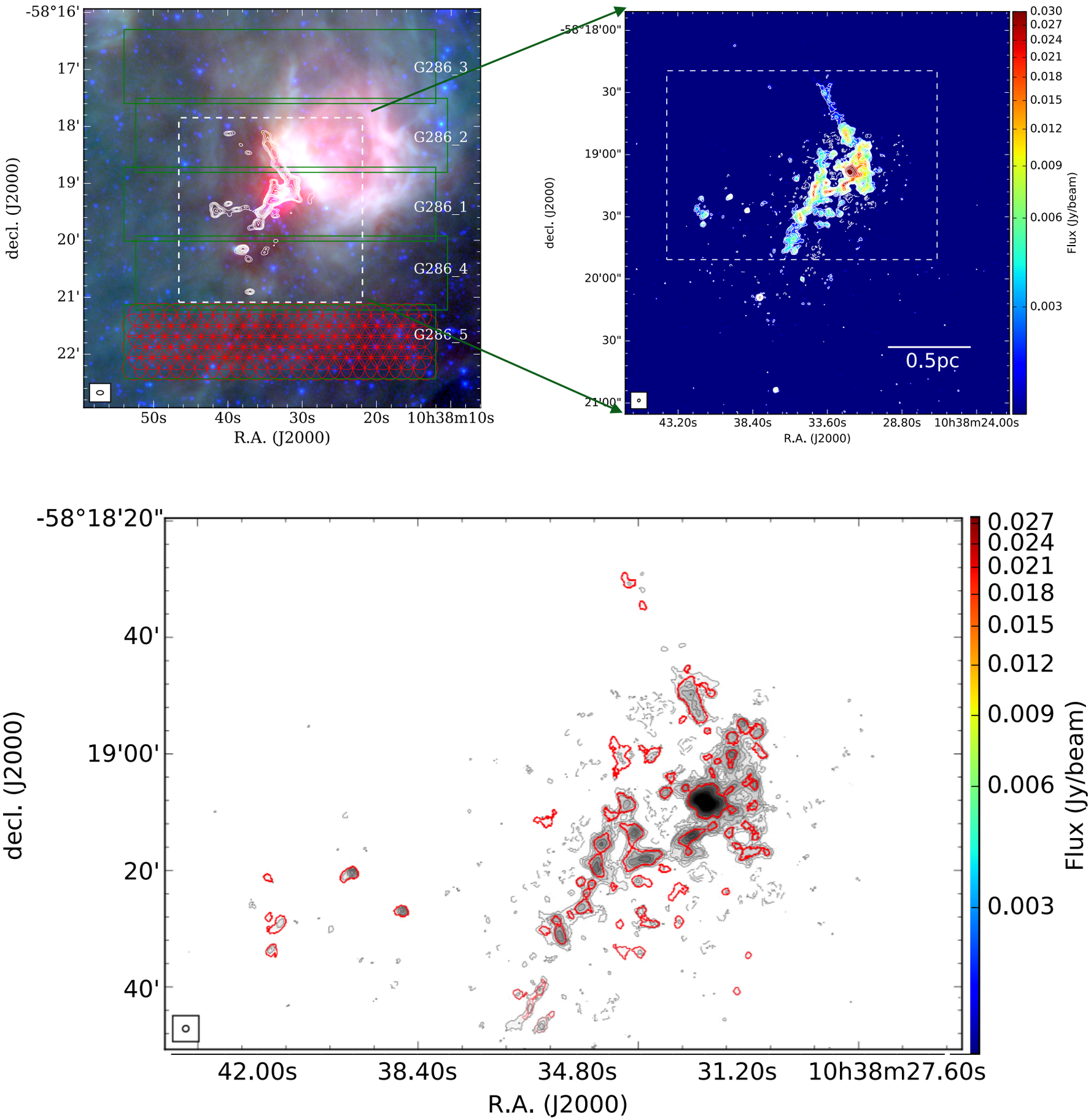
ALMA cycle 3 observations

- compact configuration(1.5”)
- Band 6

  1.3mm continuum

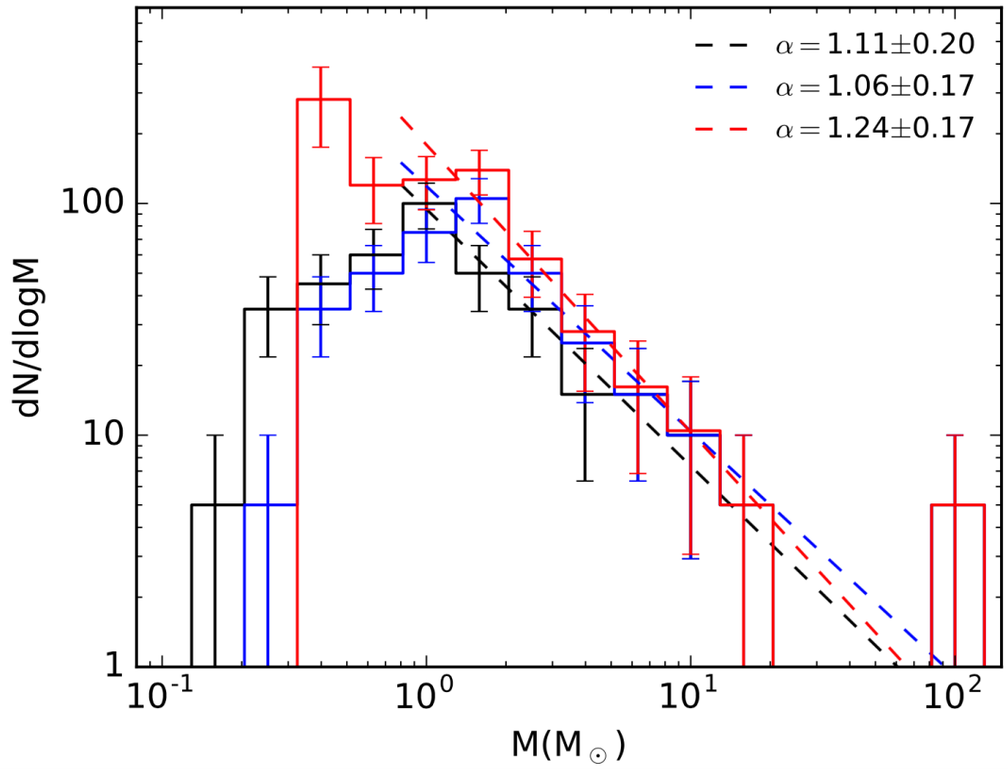
  N_2D^+, $C^{18}O$, DCO+, DCN, SiO, CH_3OH…
- 750 pointings in total
- extra uv coverage due to antenna moving

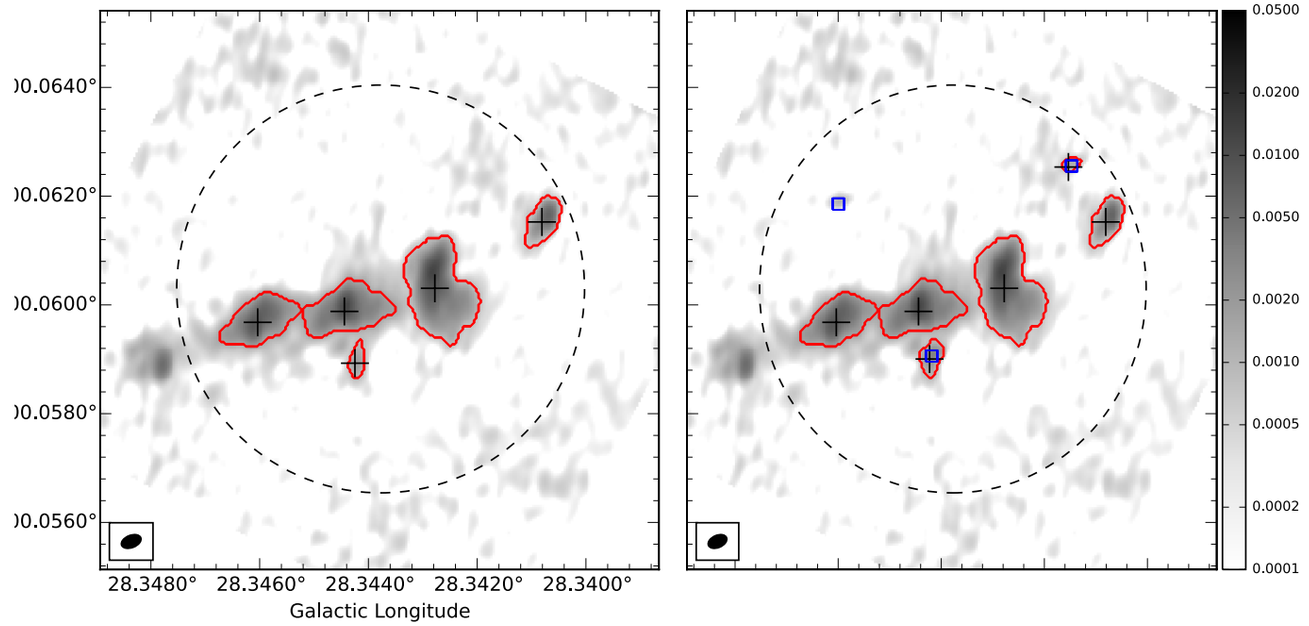



-58°16'
17'
18'
19'
20'
21'
22'
decl. (J2000)
G286_3
G286_2
G286_1
G286_4
G286_5
50s
40s
30s
20s
10h38m10s
R.A. (J2000)
-58°18'00"
30"
19'00"
30"
20'00"
30"
21'00"
decl. (J2000)
0.5pc
43.20s
38.40s
33.60s
28.80s
10h38m24.00s
R.A. (J2000)
0.030
0.027
0.024
0.021
0.018
0.015
0.012
0.009
0.006
0.003
Flux (Jy/beam)
-58°18'20"
40'
19'00'
20'
40'
decl. (J2000)
42.00s
38.40s
34.80s
31.20s
10h38m27.60s
R.A. (J2000)
0.027
0.024
0.021
0.018
0.015
0.012
0.009
0.006
0.003
Flux (Jy/beam)

Build the Core mass function

- Assuming optical thin thermal dust emission (kappa = 0.899 $cm^2\ g^{-1}$; gas/dust = 141)
- A uniform temperature of 20K (Zhang & Tan 2015).



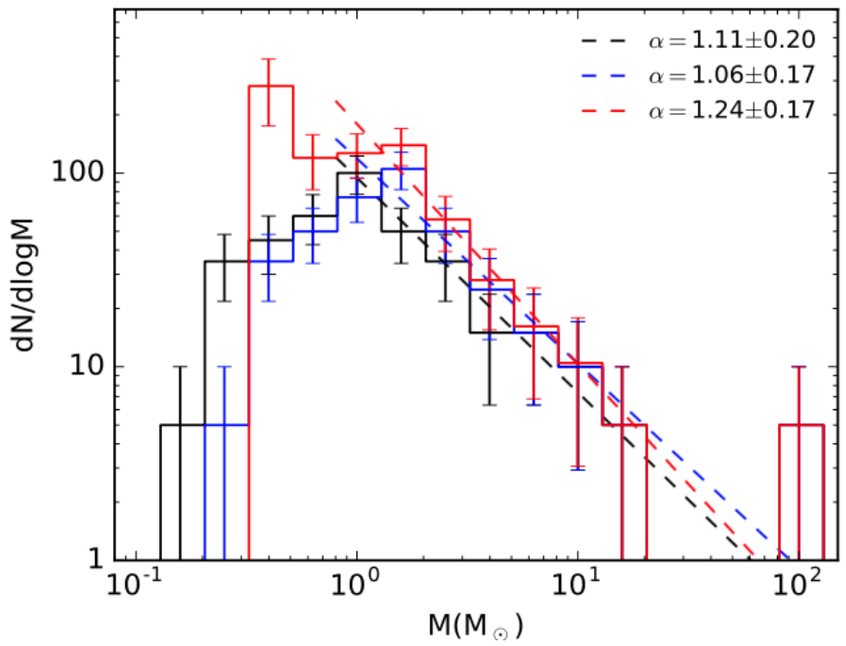


- flux correction: flux extending out of the 4sigma boundary not accounted
- number correction: low S/N cores missed due to noise fluctuation

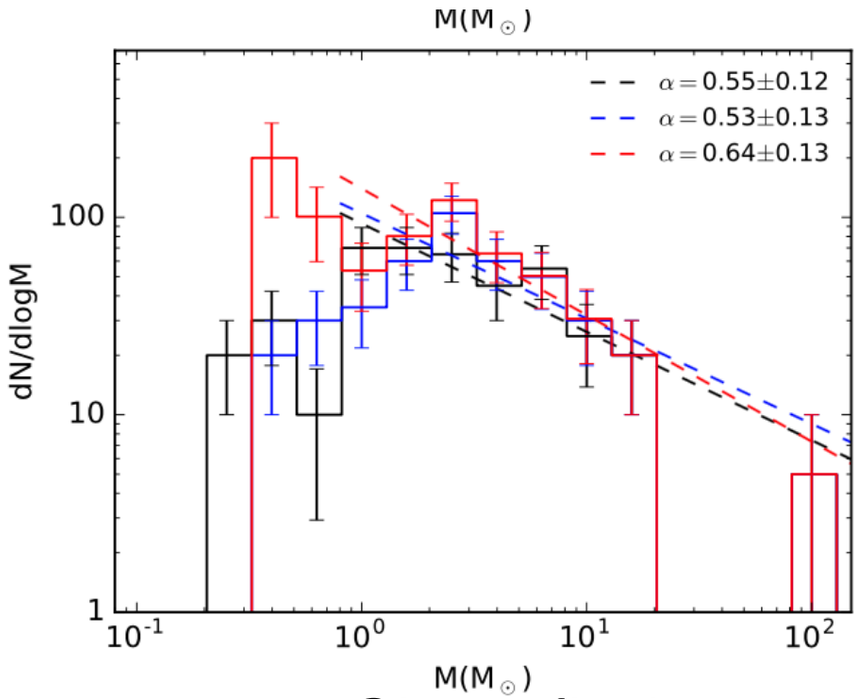
==> core insertion experiment

Robustness of the Core mass function

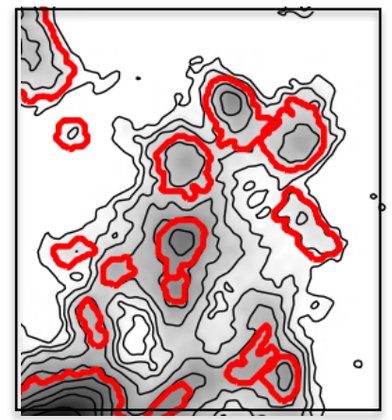
- different algorithms

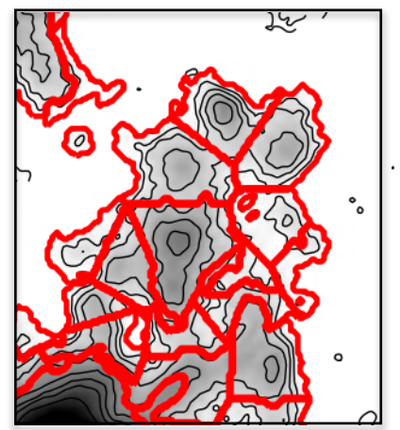


Dendrogram



Clumpfind



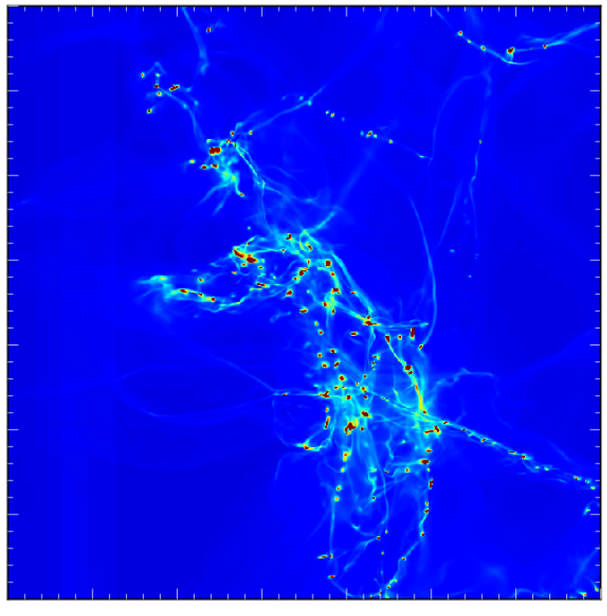


- include ACA data or use 12m data only?
- varying the spatial resolution

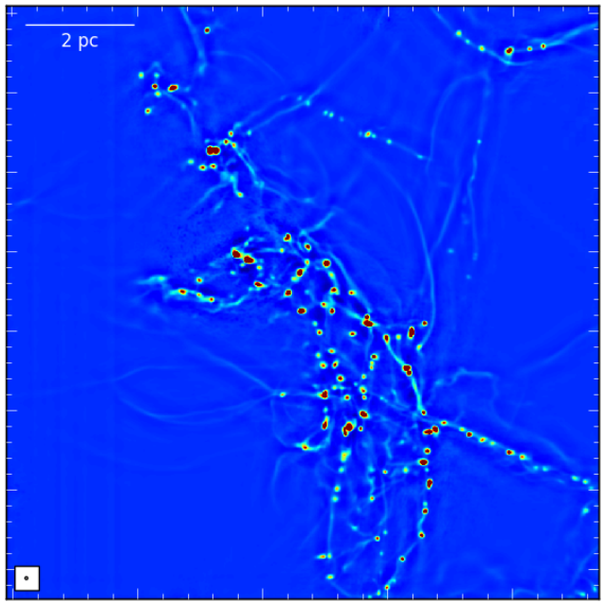
- what is the definition of a core?

==> test the core definition(identification/ characterization) from 3D MHD simulations

3D MHD Simulation

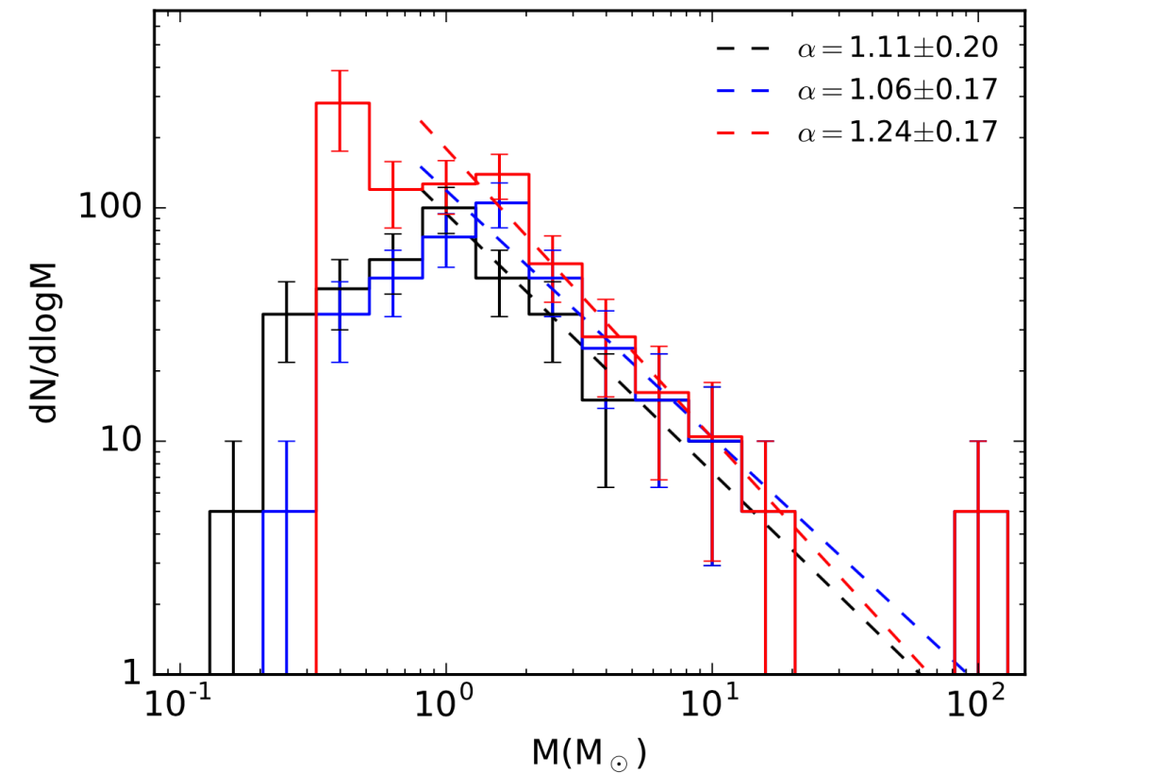


Synthetic observation

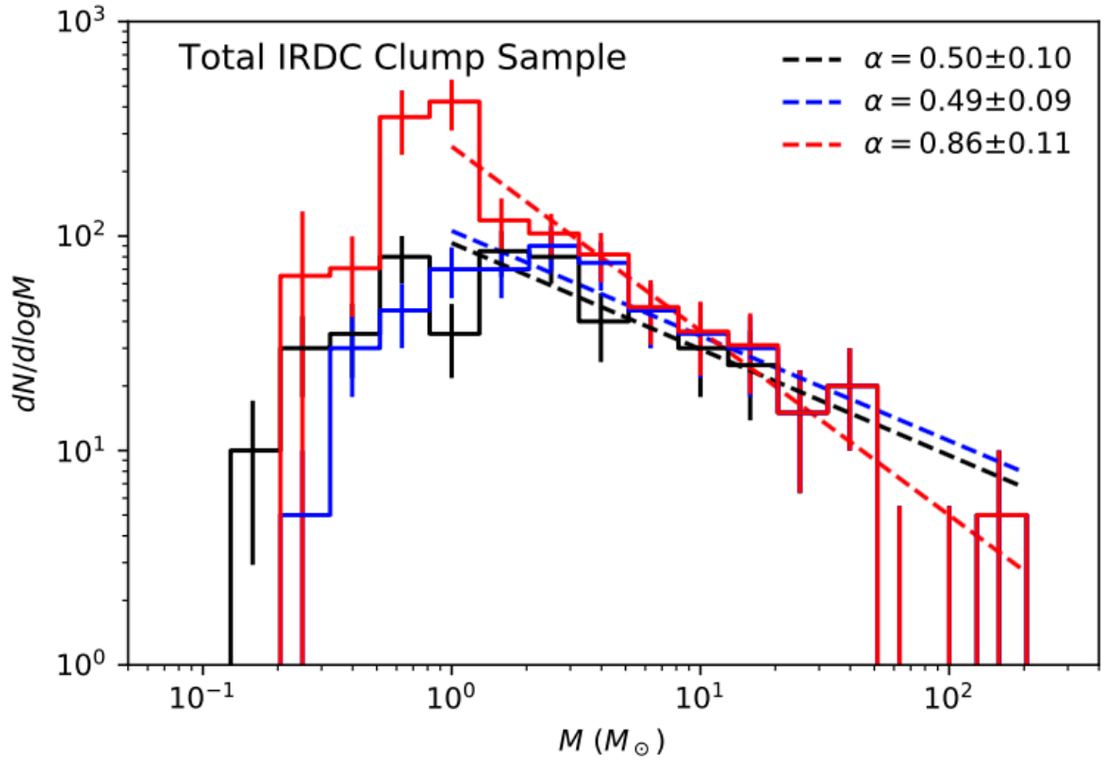


Wu et al. 2016, Christie et al. 2017

CMF in different environments



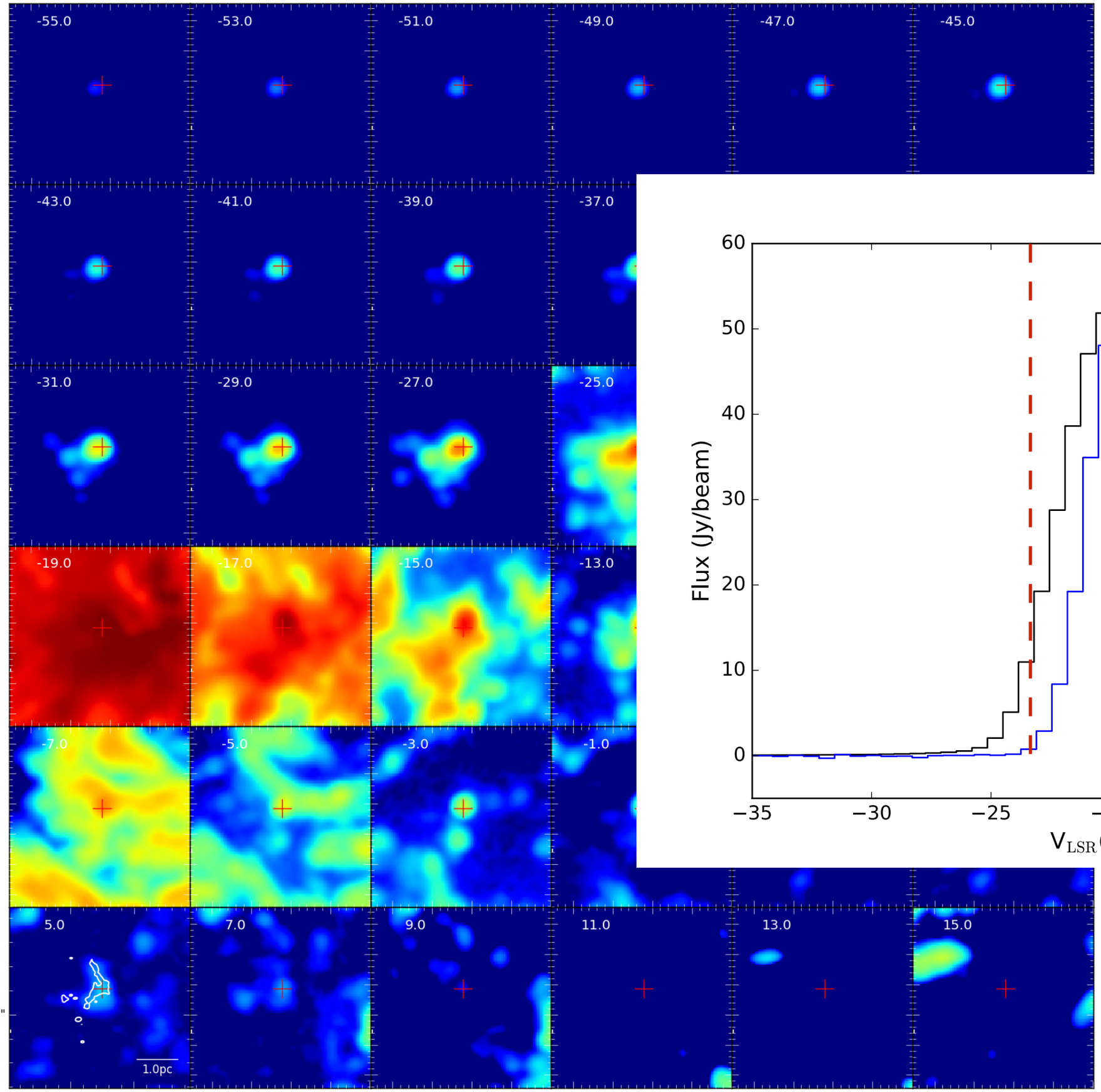
G286 protocluster



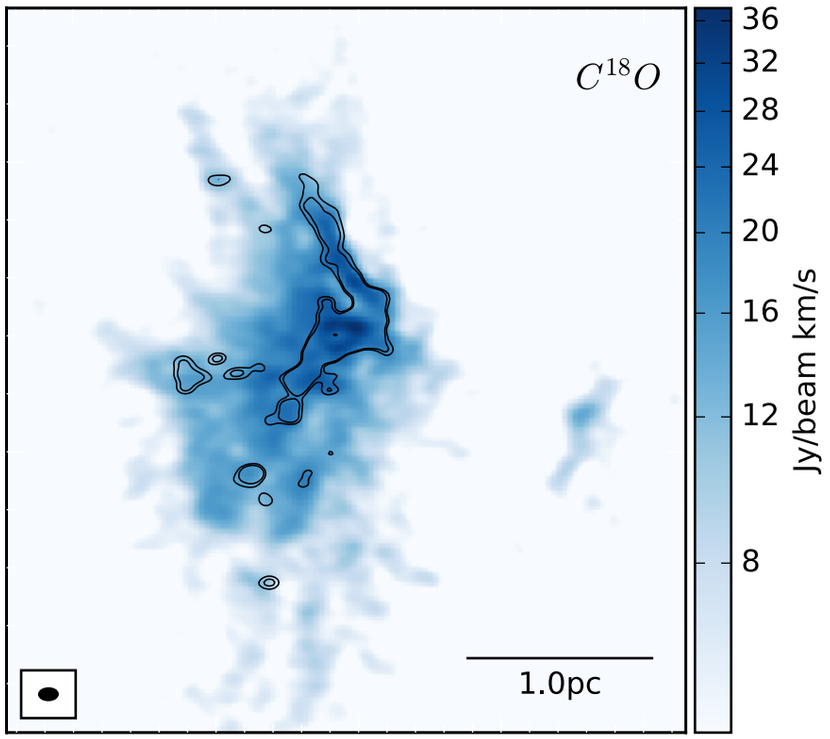
32 dense clumps in seven infrared dark clouds (IRDCs) (Liu et al. 2018)

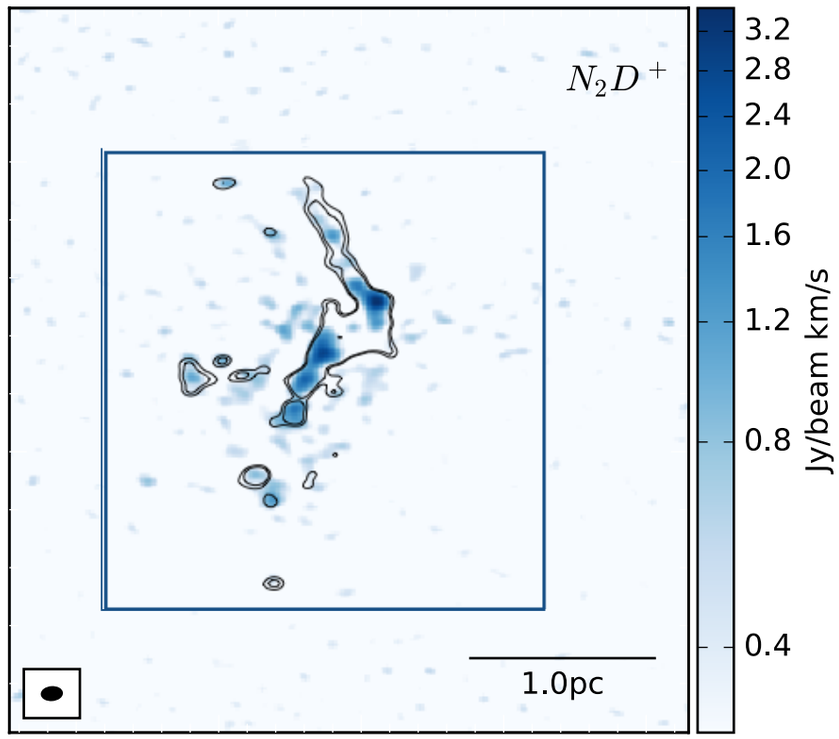
- The CMF in high pressure, early-stage environments of IRDC clumps may be top-heavy compared to that in the more evolved, global environment of the G286 protoclusters.

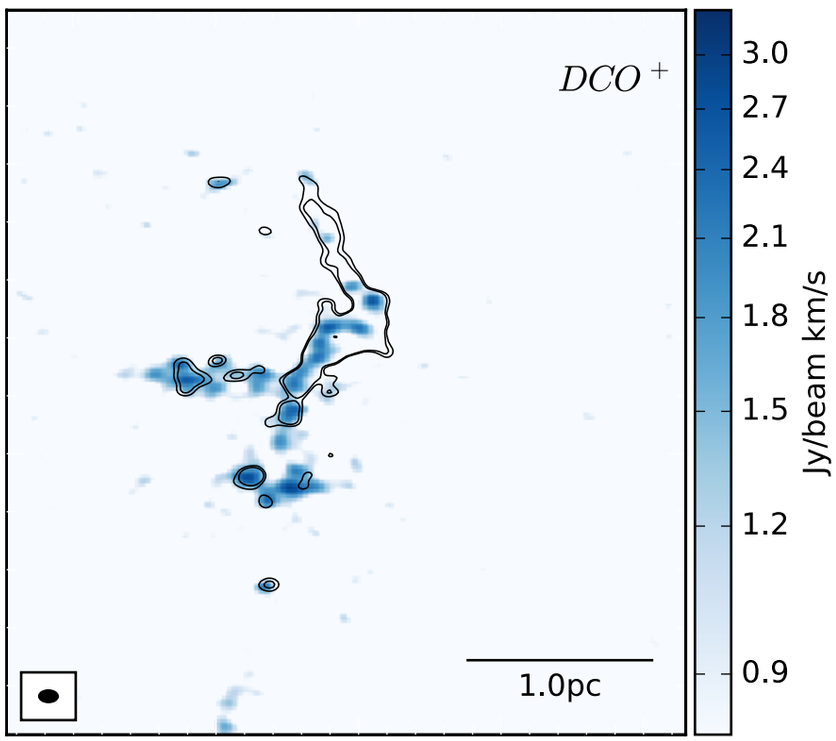
G286: large scale CO emission

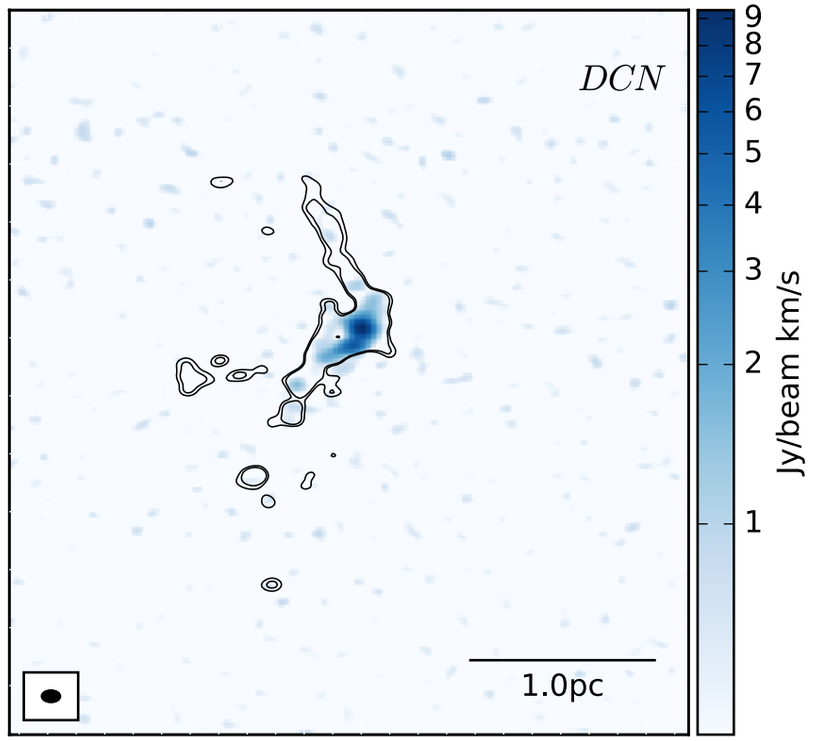


Integrated spectral line emission (ACA+TP)

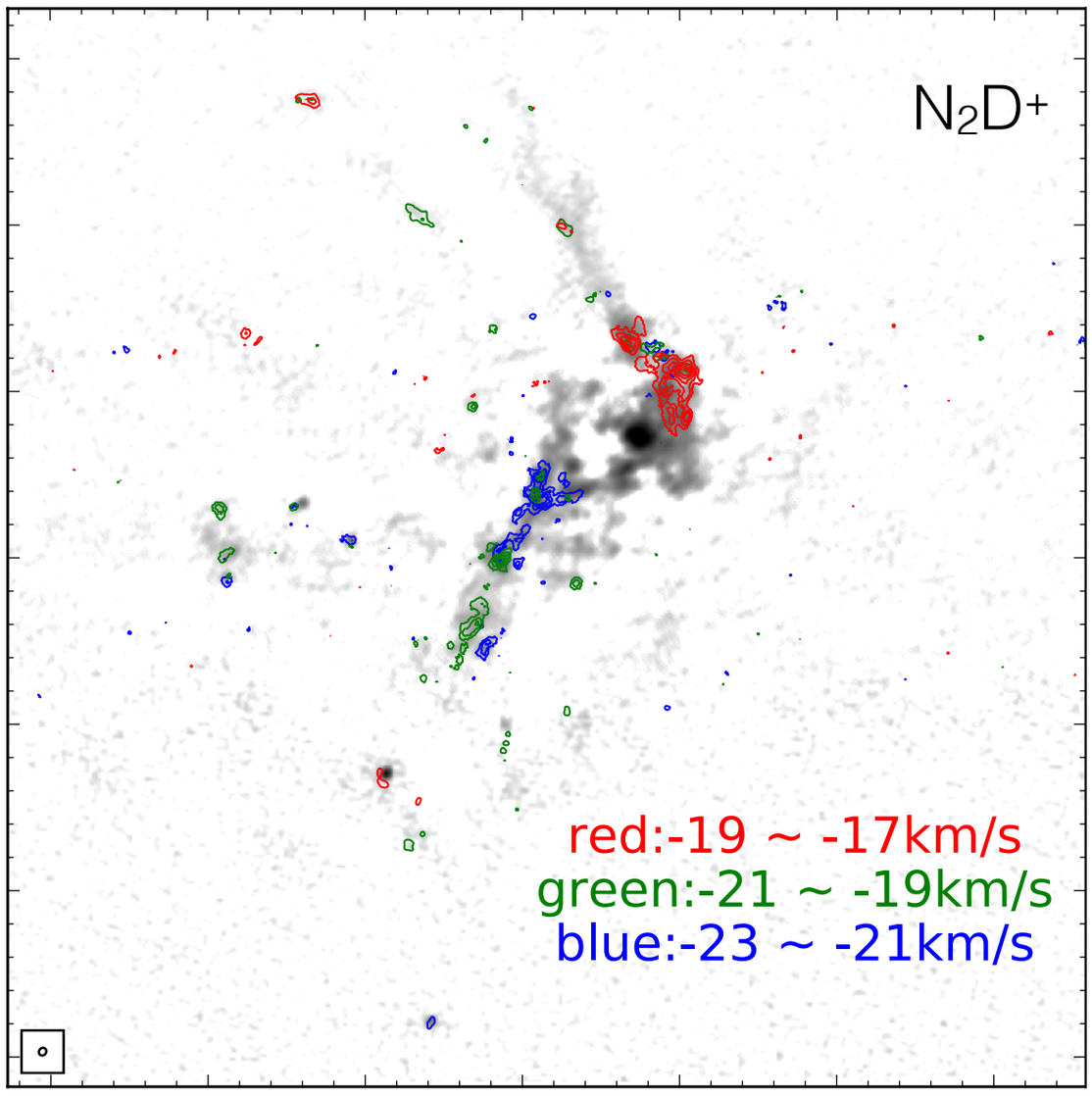


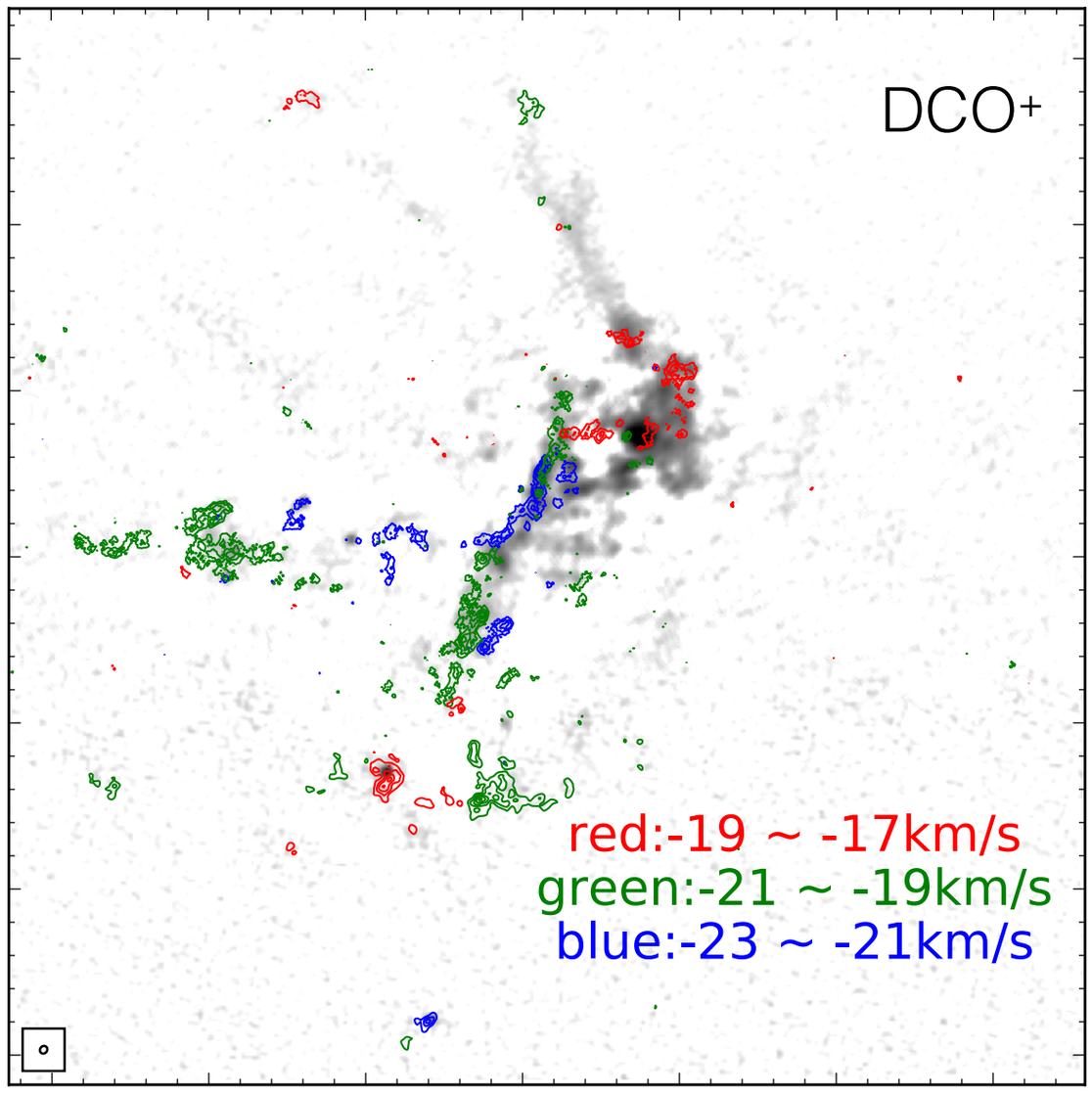




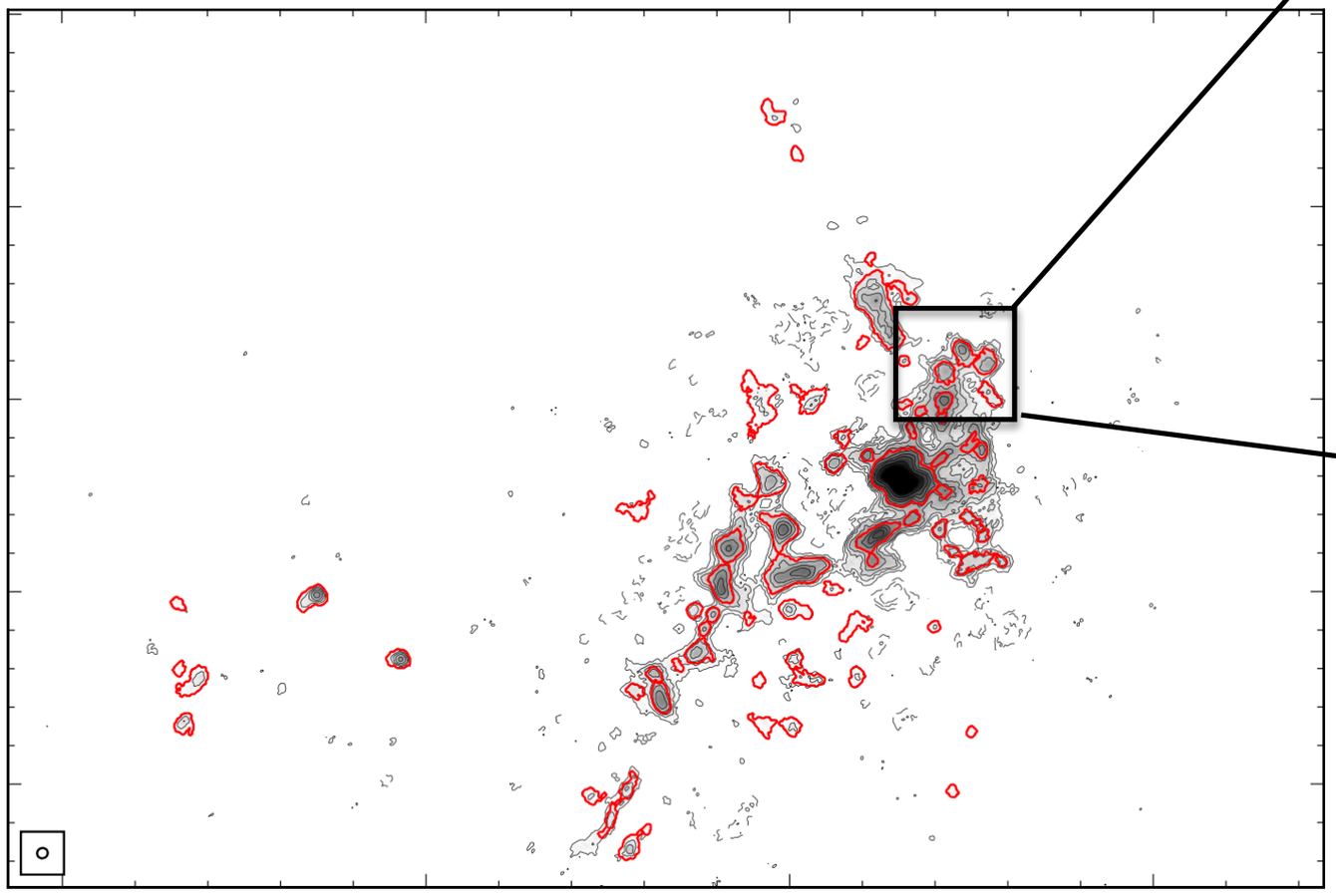


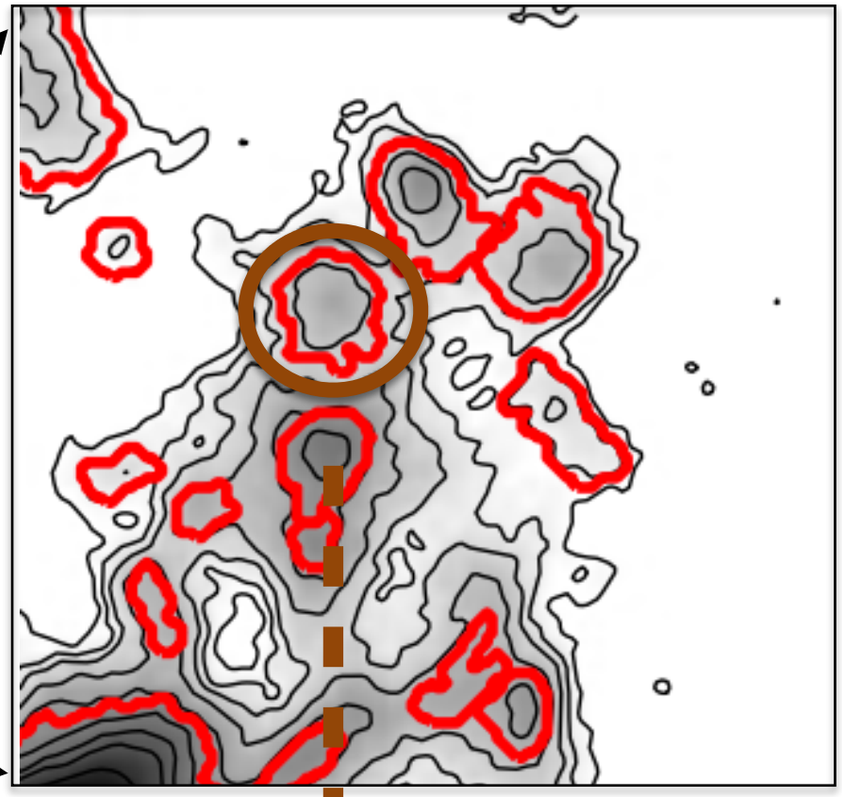
Integrated spectral line emission (12m+ACA+TP)

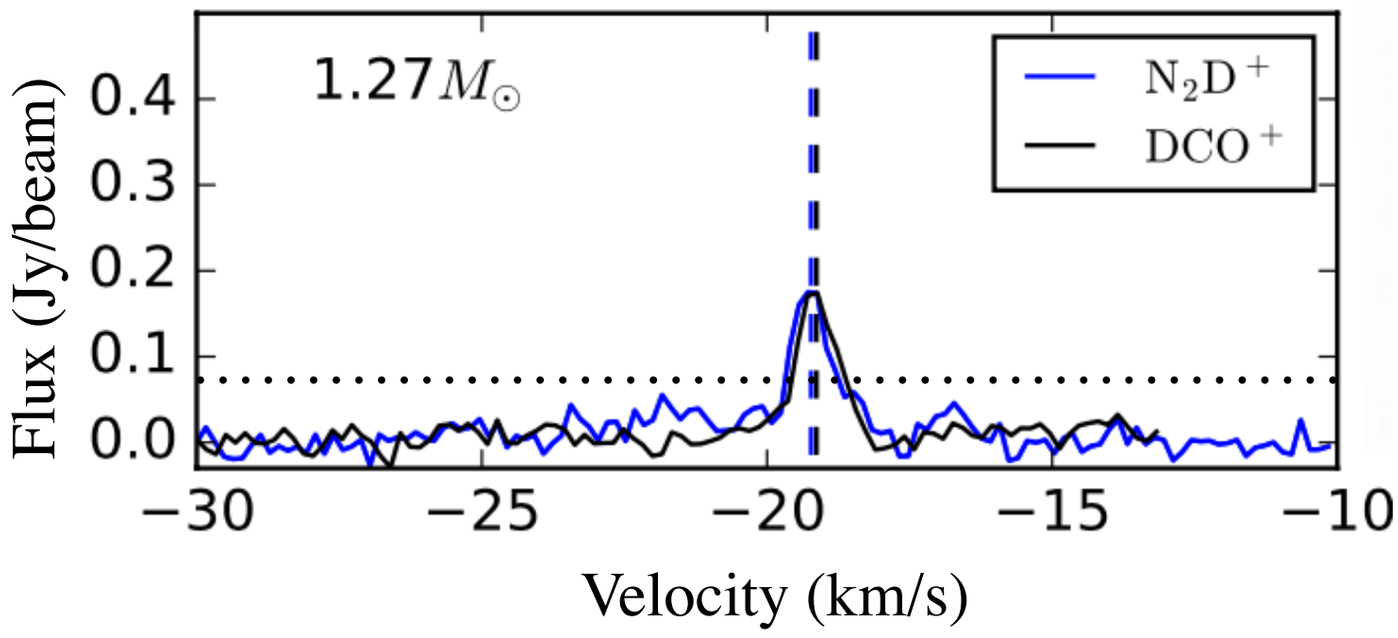


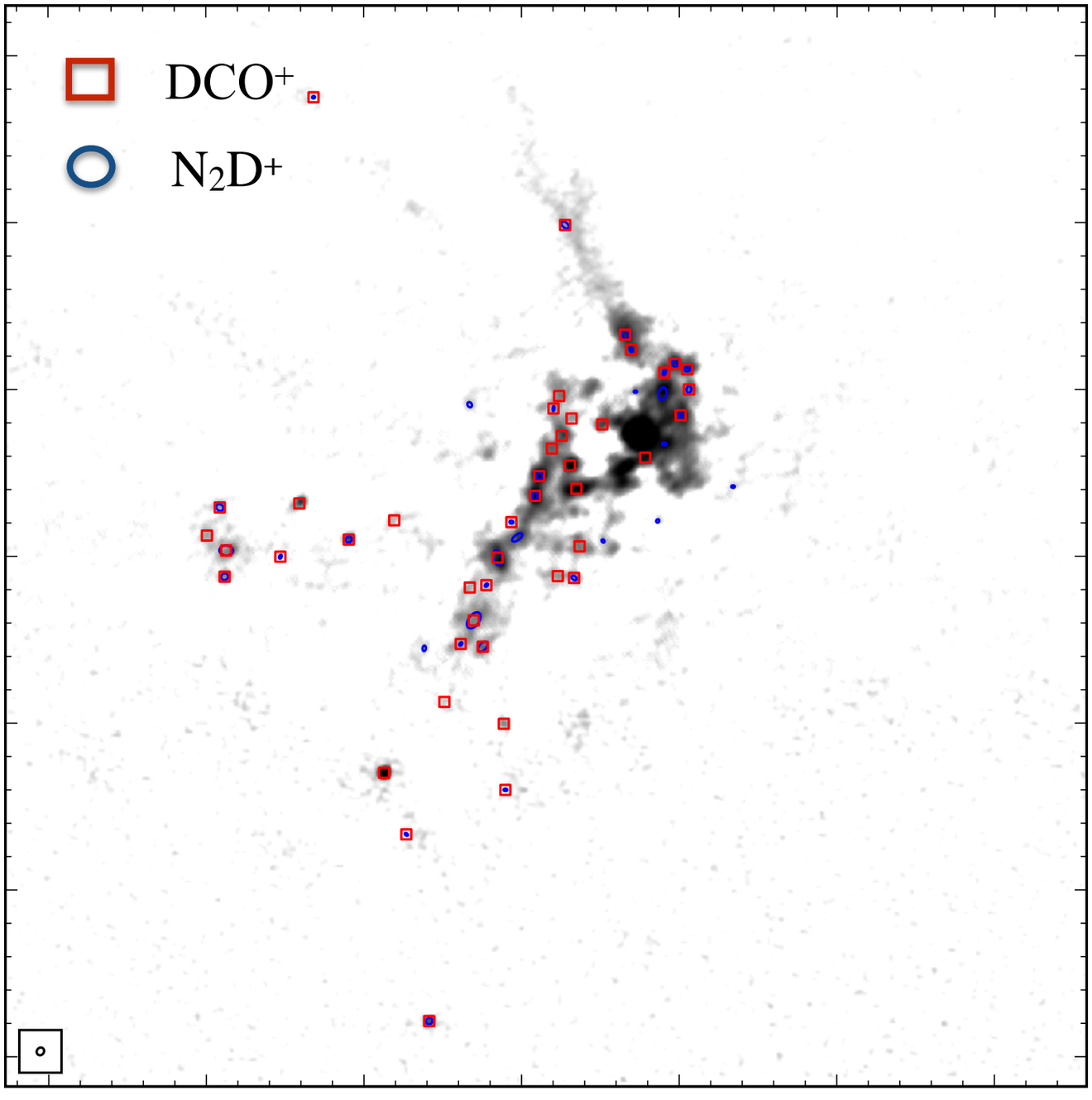


Core velocity determination

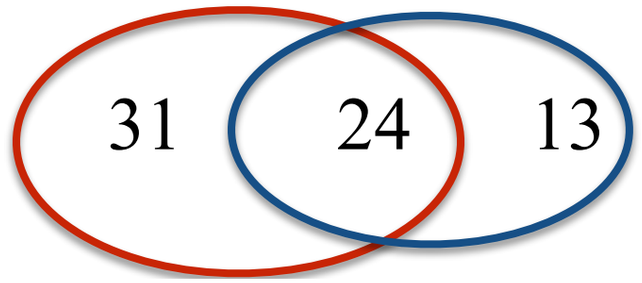


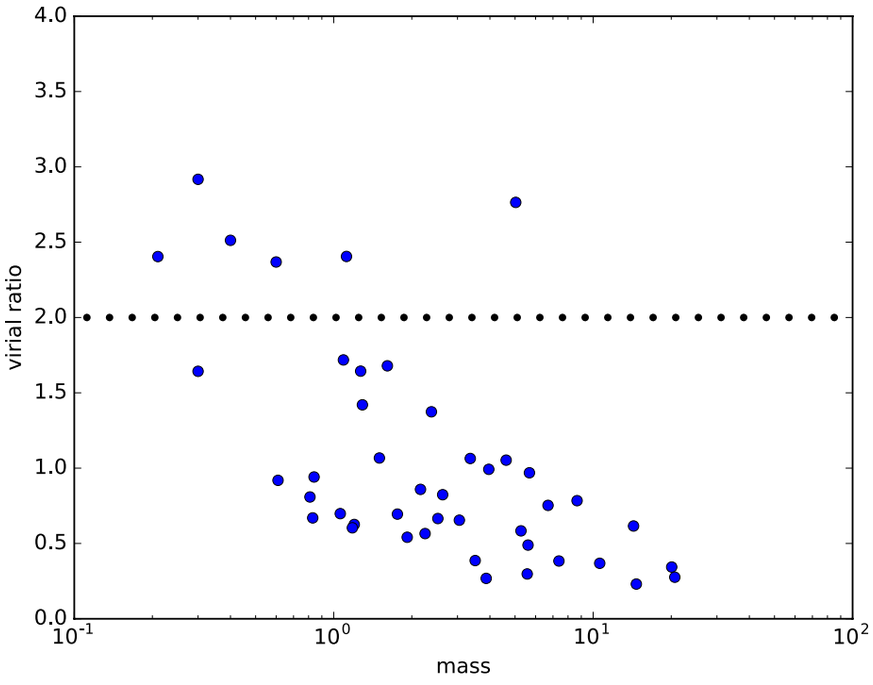


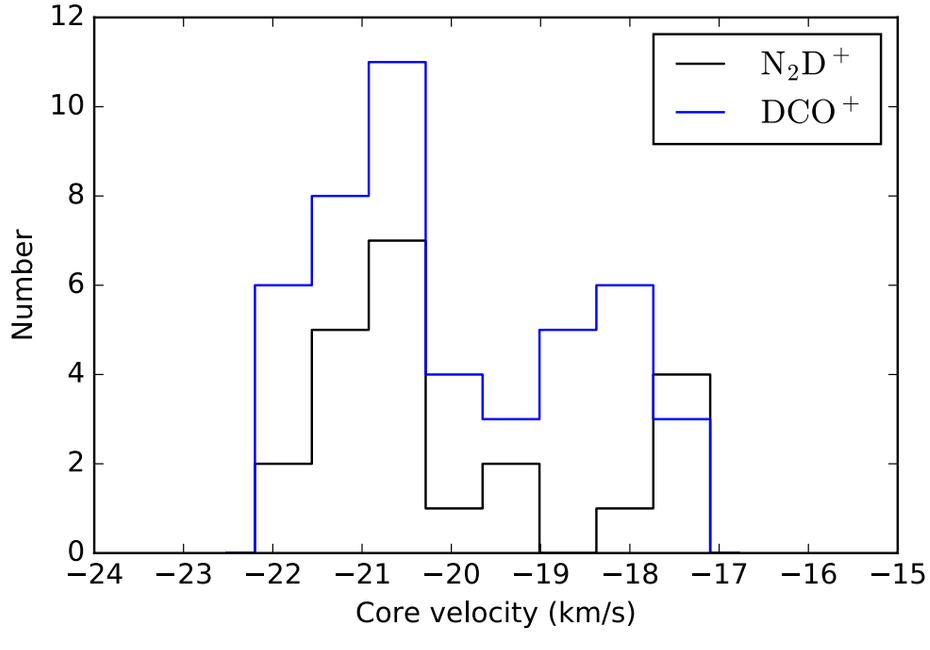




Detection statistics:







In comparison:

- Total mass of 1820 ± 540 M⊙ from SED fitting at an aperture of ~ 120” (Ma et al. in prep.)
- Required velocity dispersion for viral equilibrium: 2.34 ± 0.46 km/s

Core-to-core velocity dispersion: 1.53 ± 0.13 km/s

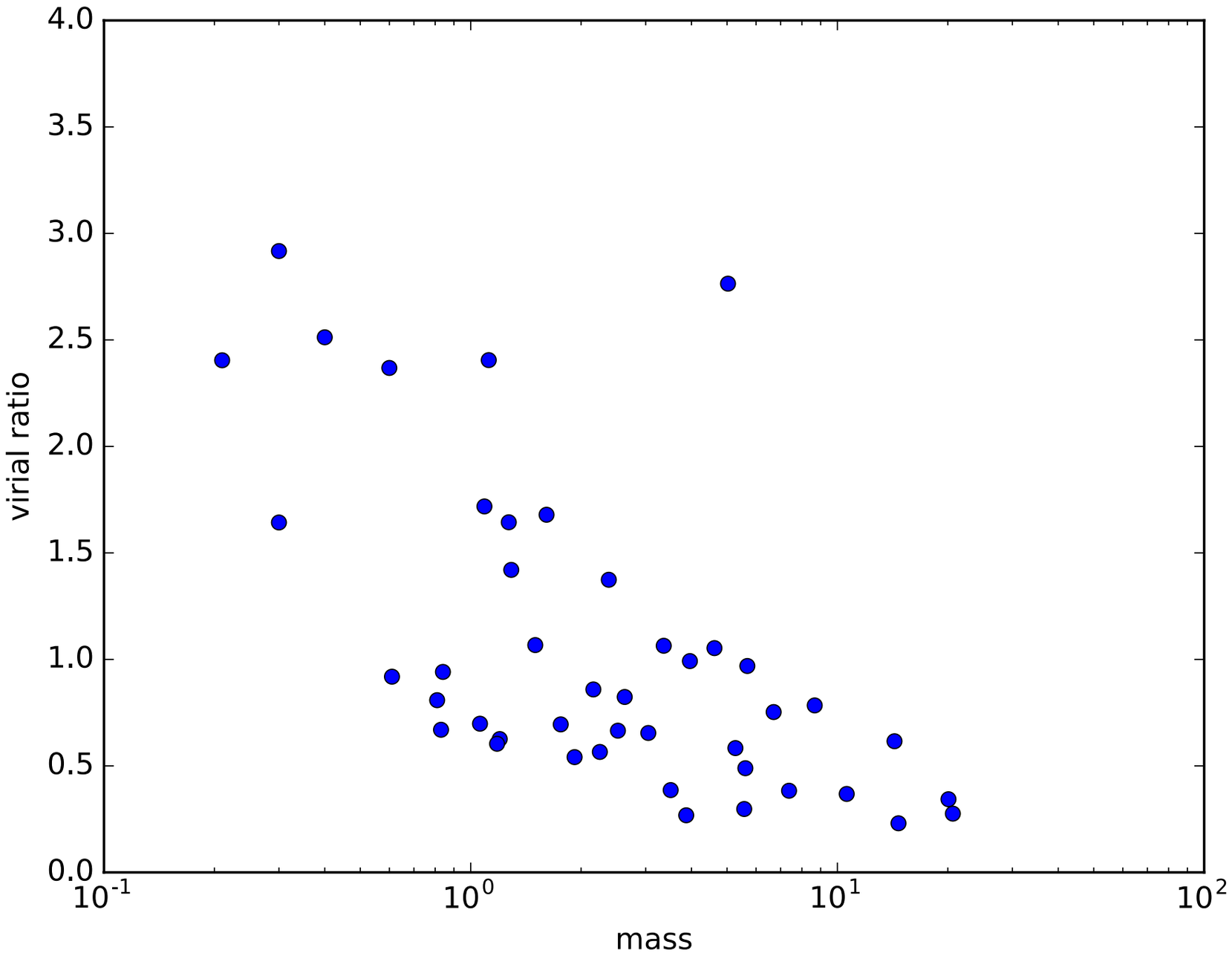
Summary

- The fiducial dendrogram-identified CMF in G286 can be fit with a power law slightly shallower than, but still consistent with, the index of the Salpeter stellar initial mass function of 1.35. Clumpfind gives a shallower high mass slope.

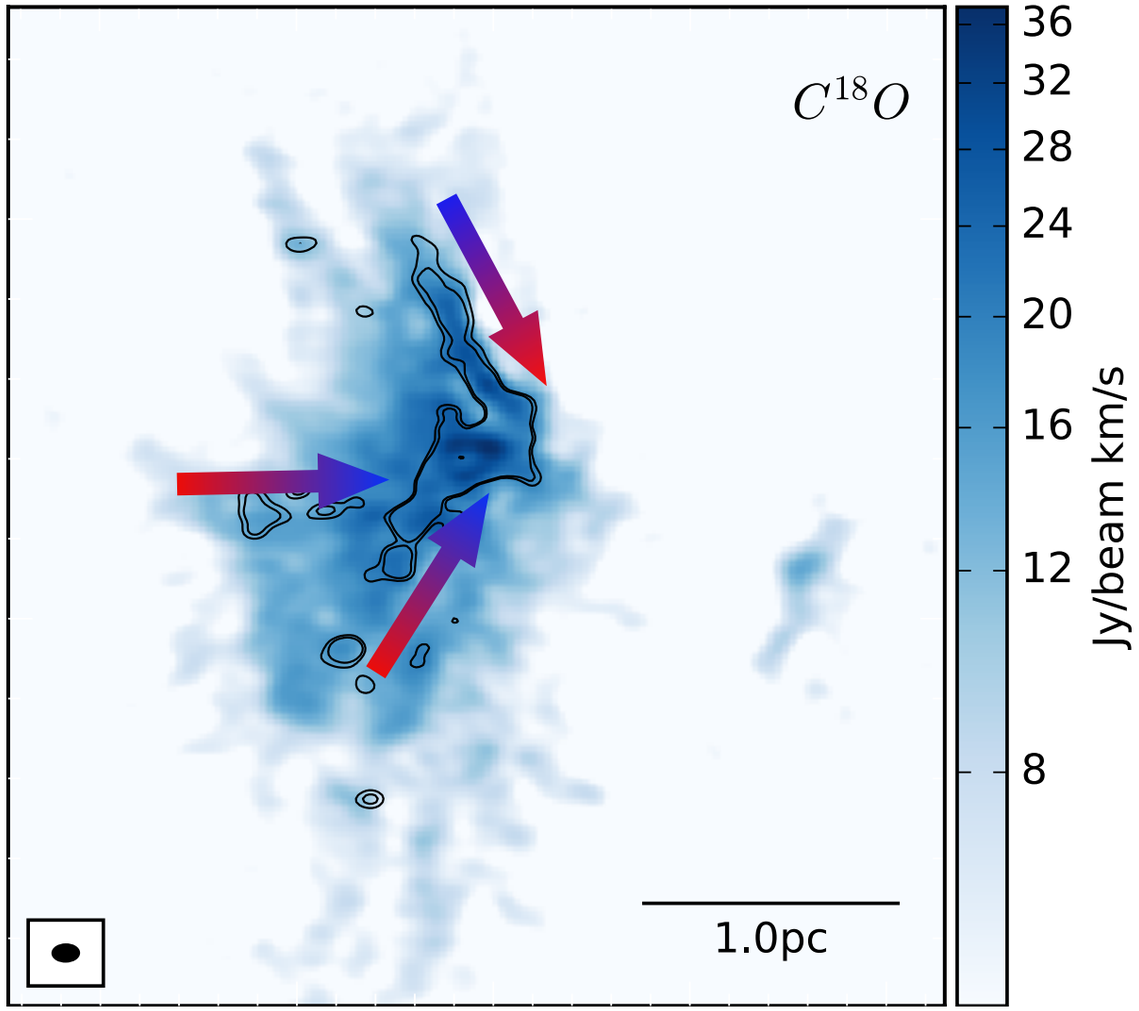
- The CMF in high pressure, early-stage environments of IRDC clumps may be top-heavy compared to that in the more evolved, global environment of the G286 protoclusters.

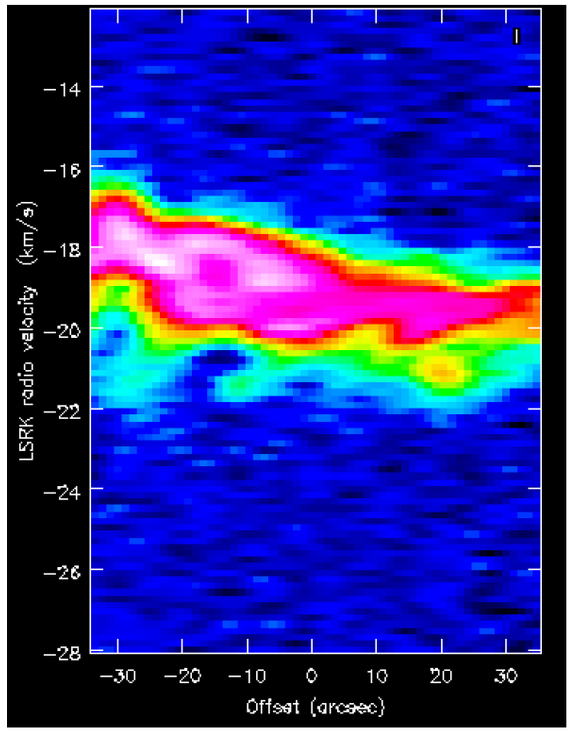
- We measure the core velocity with N_2D^+ and DCO^+ spectral lines for the continuum-identified core sample. The core-to-core velocity dispersion is smaller than that required for viral equilibrium, possibly indicating support from large-scale magnetic field.

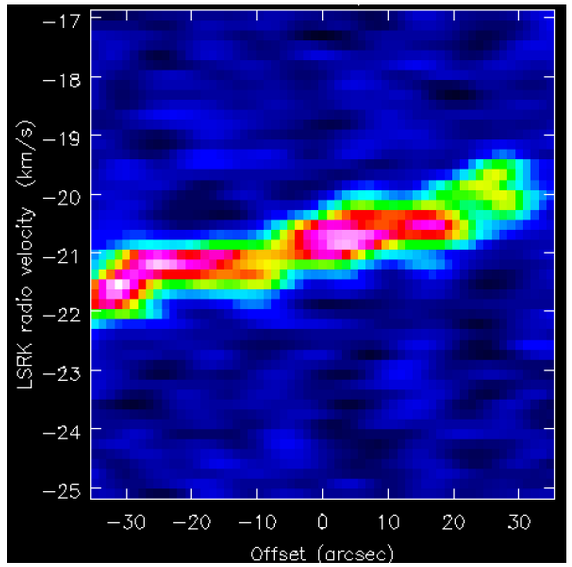
- The core velocity is largely dependent on the large scale velocity gradient along the filament.

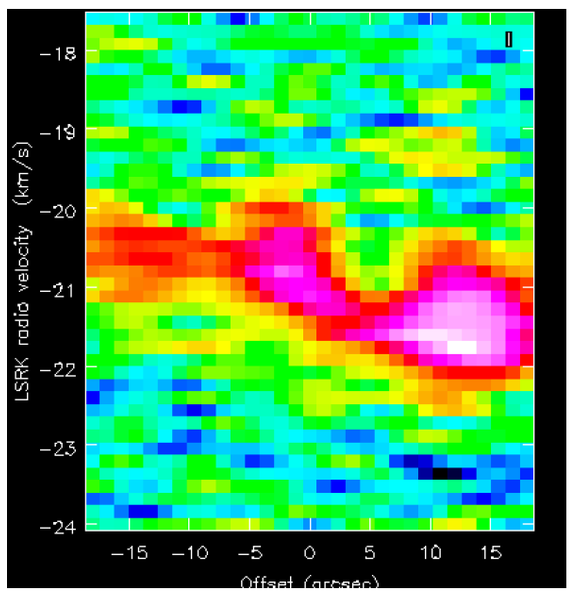

4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
virial ratio
10^{-1}
10^{0}
10^{1}
10^{2}
mass

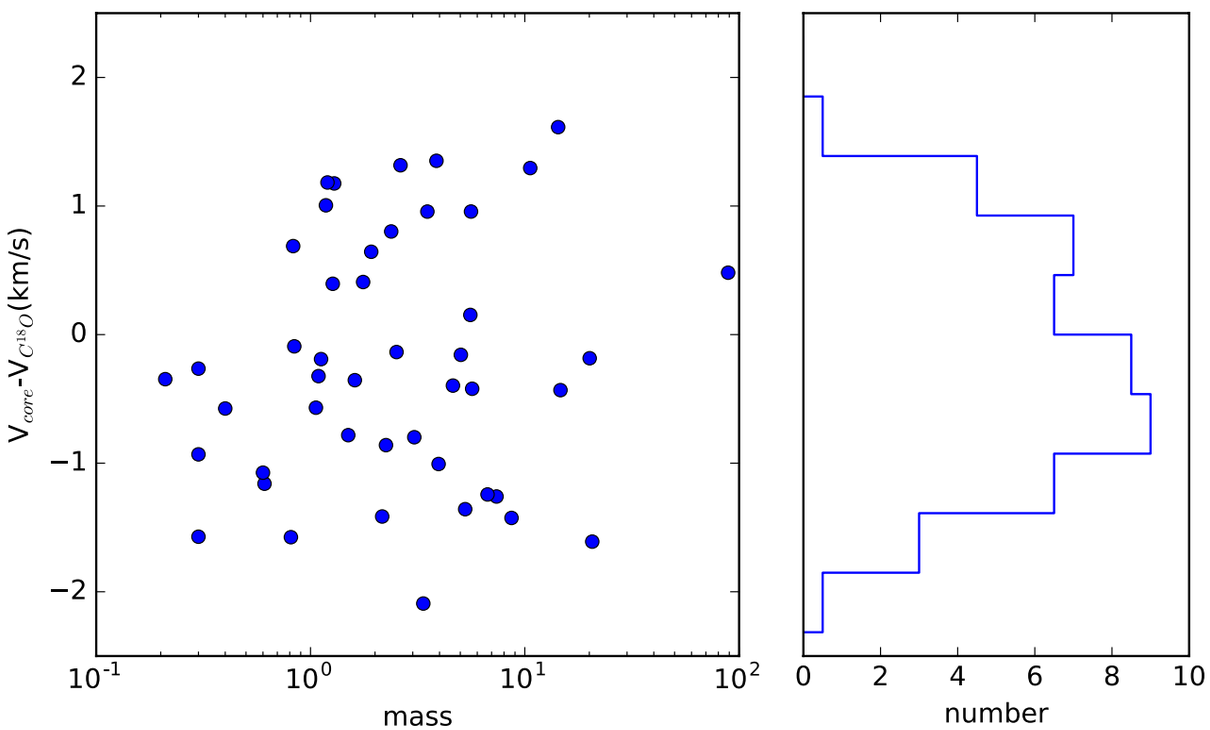
Core velocity v.s. large scale velocity gradient











A massive multiple system in formation