ALOHA: Exploring the Infrared Dark Clouds with JCMT

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- Data Summary

  science goal: high-sensitivity images — more complete gas distribution in nearby IRDCs

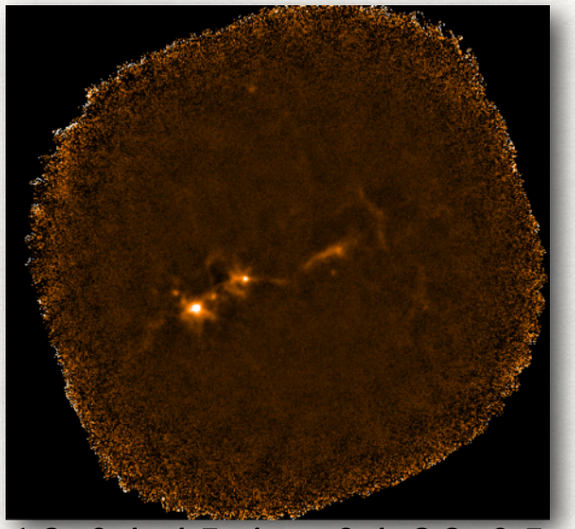
  data product: sensitive 850 μm images towards the nearby (D<2.5 kpc) IRDCs)

  Scuba 450/850 μm OTF mapping (PONG)

  total FoV : diameter = 20 arcmin (with noisy edge excluded)

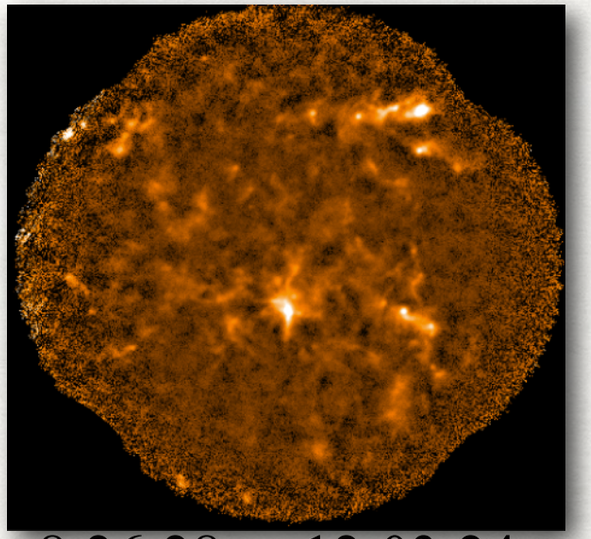
  expected t_{int} = 6 hours $\Longrightarrow$ rms = 4 mJy /beam (850 μm)

- Observed regions:



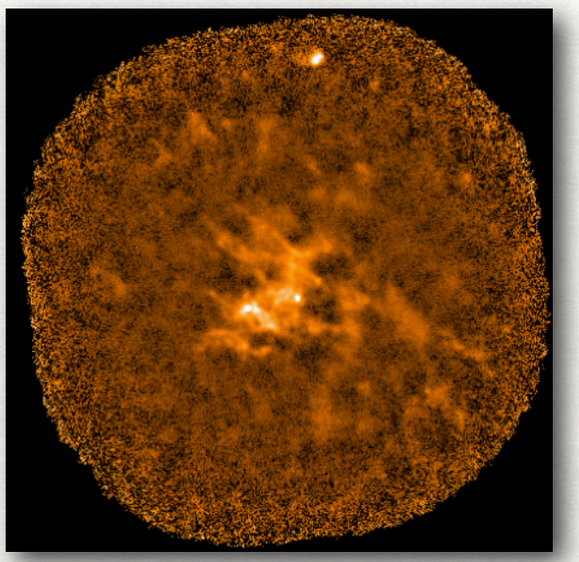
19:04:45.4 +04:23:05

SDC38_c1
t_{int} = 6 hours
(complete)
rms = 3.5 mJy
isolated cores
filament



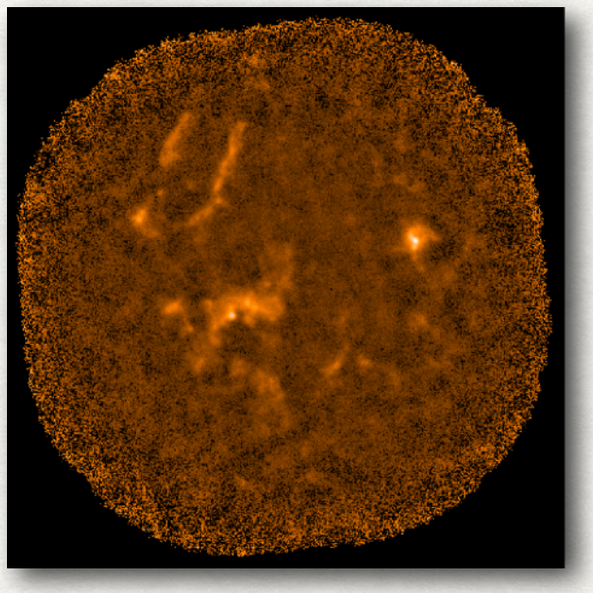
8:26:28 -12:03:24

M19.37
t_{int} = 9 hours
(complete)
rms = 1.5 mJy
dense central core with
possible convergent filaments



18:56:49.6 +01:23:11

SDC35_c3
t_{int} = 5 hours
rms = 3.5 mJy
clustered cores
and filament



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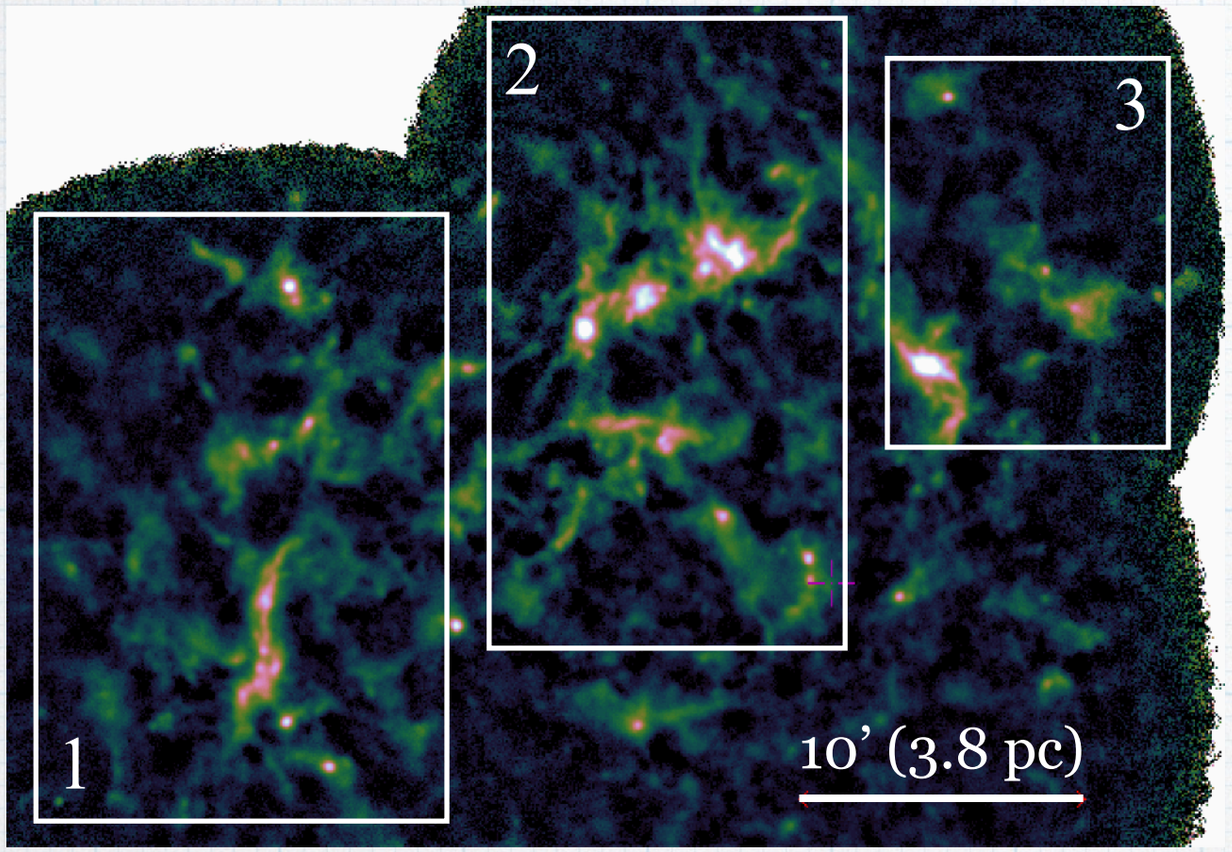
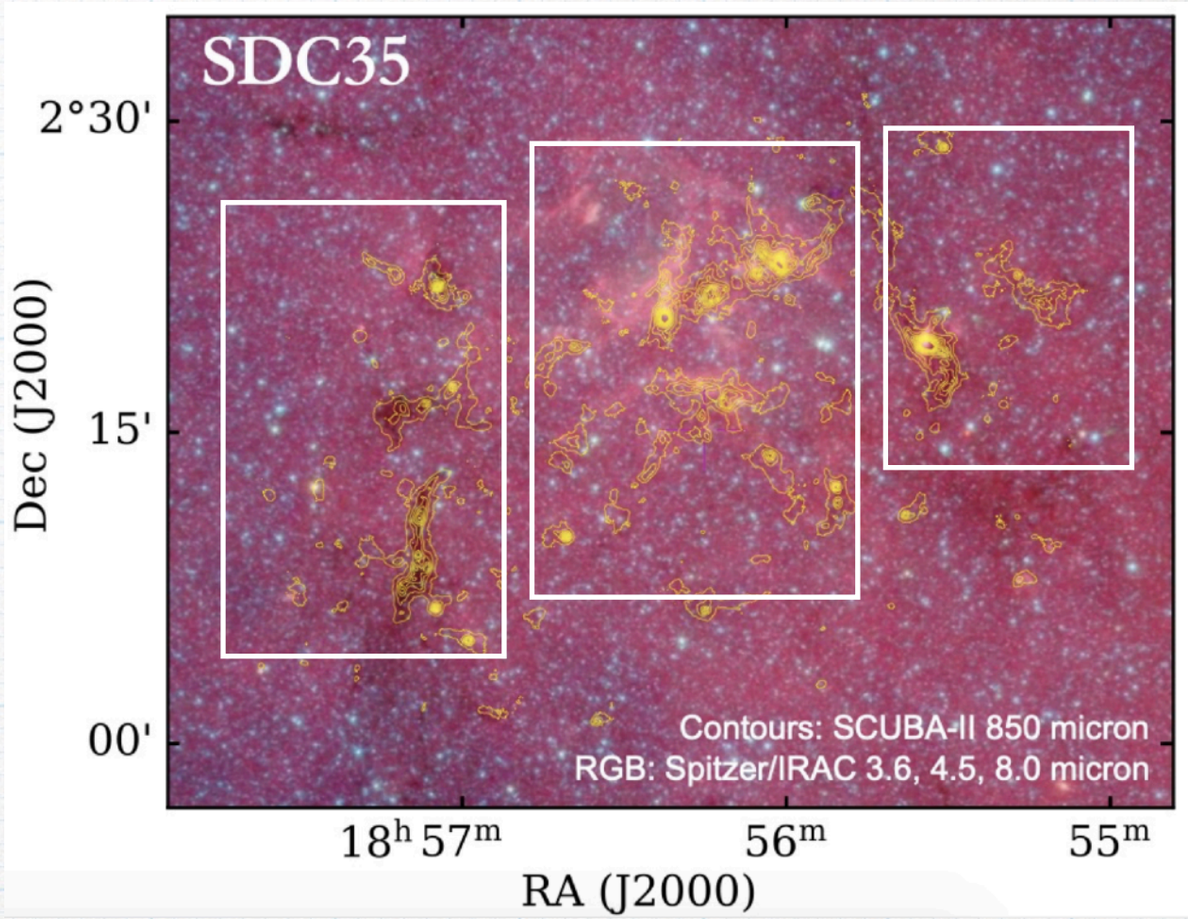
M37
t_{int} = 7 hours
rms = 3 mJy
isolated cores
and filaments

Observed regions： SDC35 (3-area mosaic)

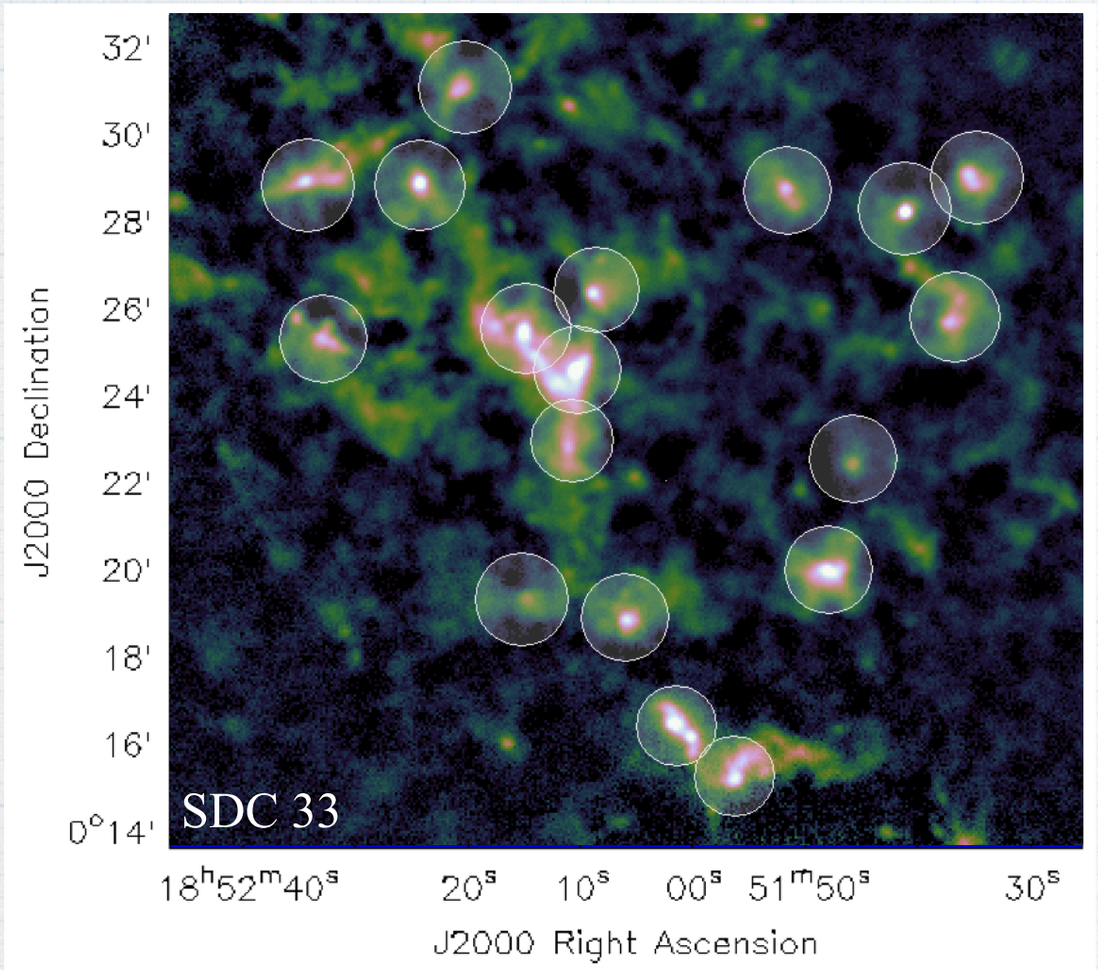


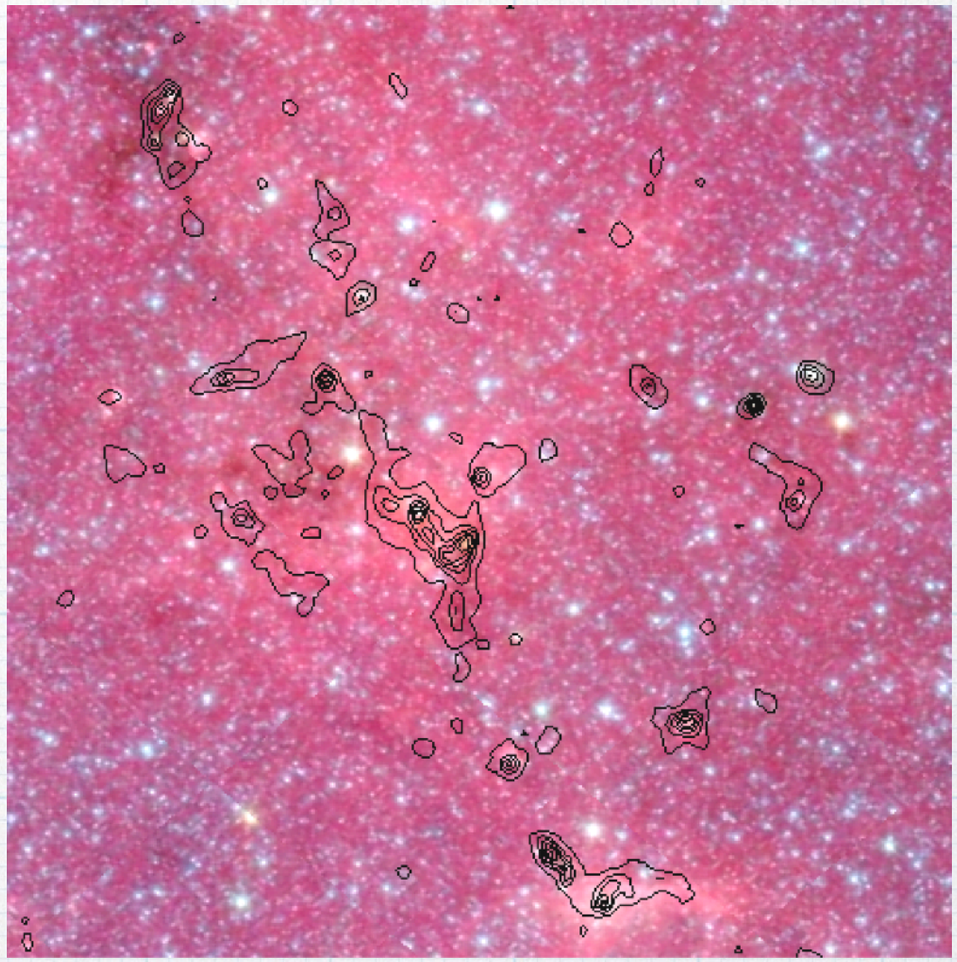


SDC35_mosaic
t_{int} = 5 hours
rms = 4 mJy

- Feature: clustered cores in 3 discrete assemblies:
  Region 1: infrared dark cloud, free of YSOs
  Region 2: bright protostellar cluster
  Region 3: IR-dark, a few IR sources
-

Observed regions: SDC-33(3-area mosaic)





SDC33 mosaic

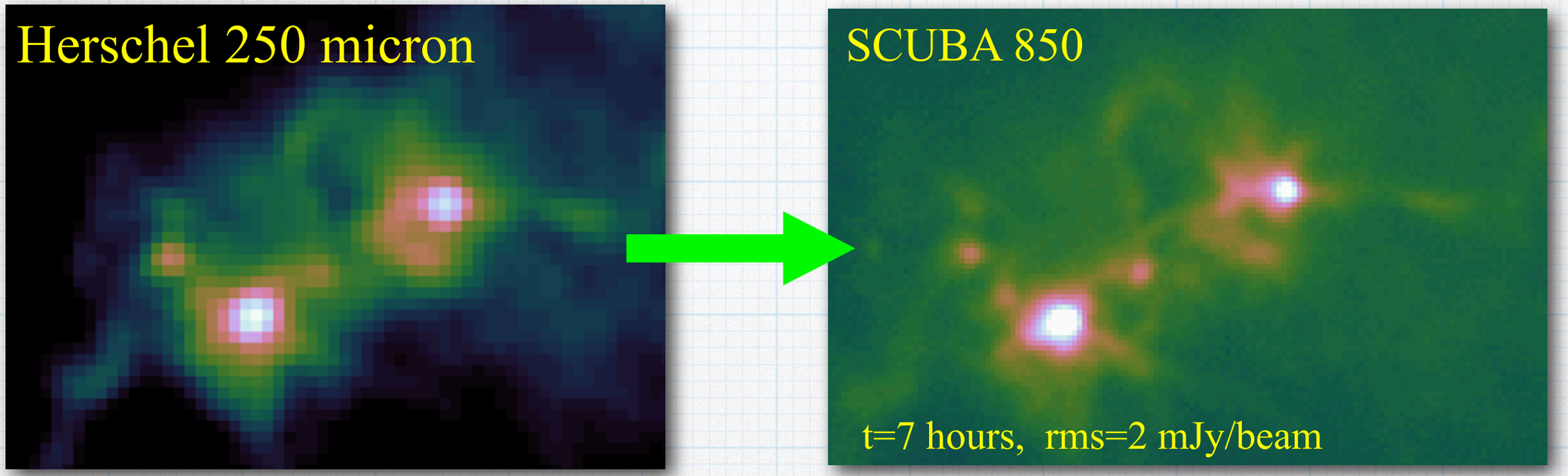
t_{int} = 3-4 hours

rms = 4 mJy (diffuse emission)

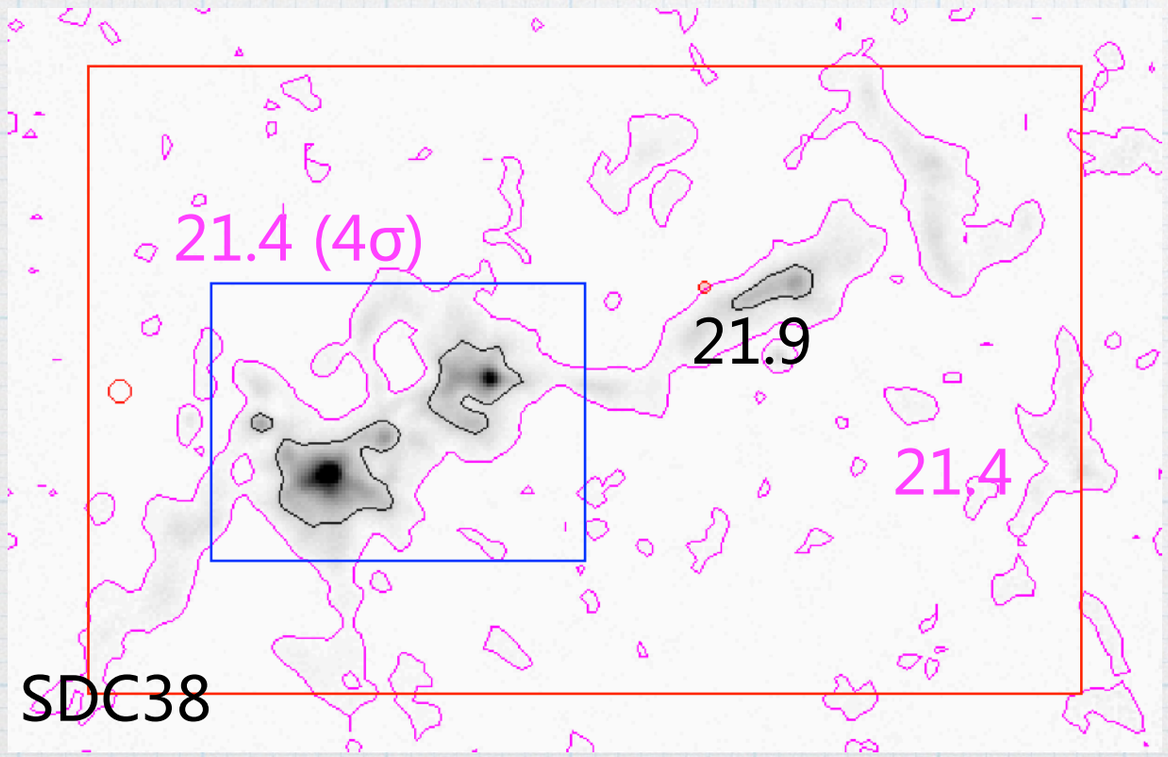
- Feature: IR bright center surrounded by some IR-dark cores.

Observational Results: image quality

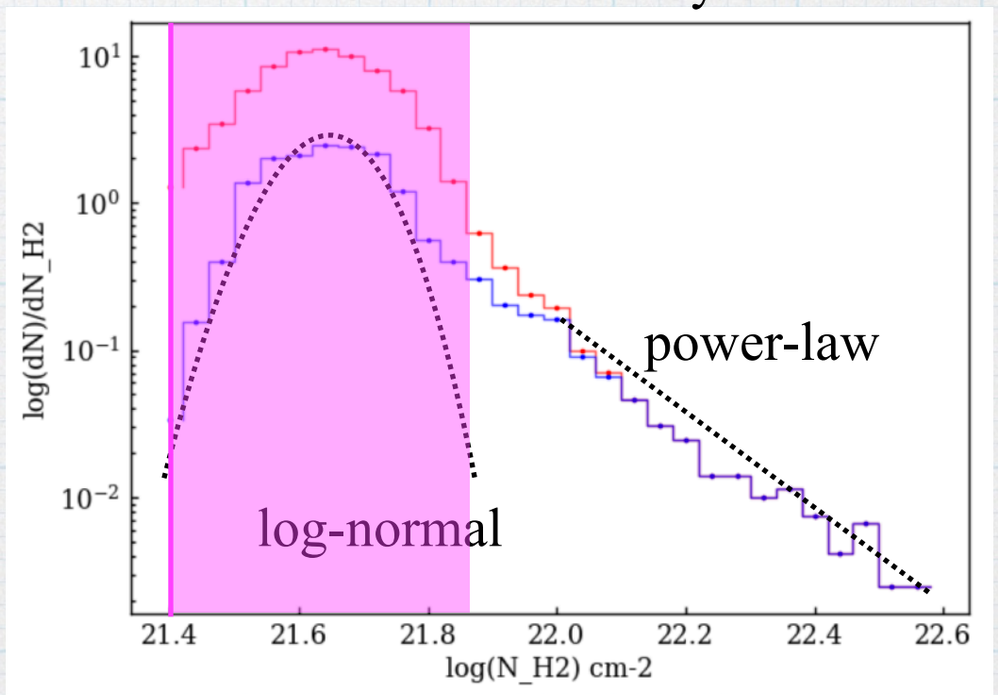
- better resolution and sensitivity than Herschel



- more complete sampling of the extended gas components

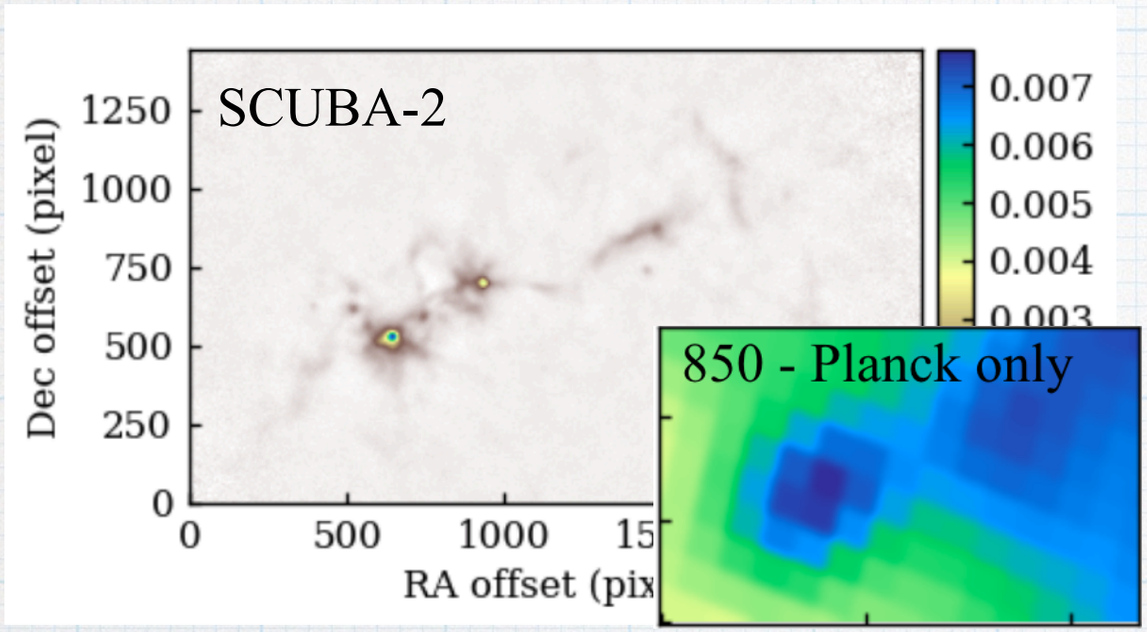


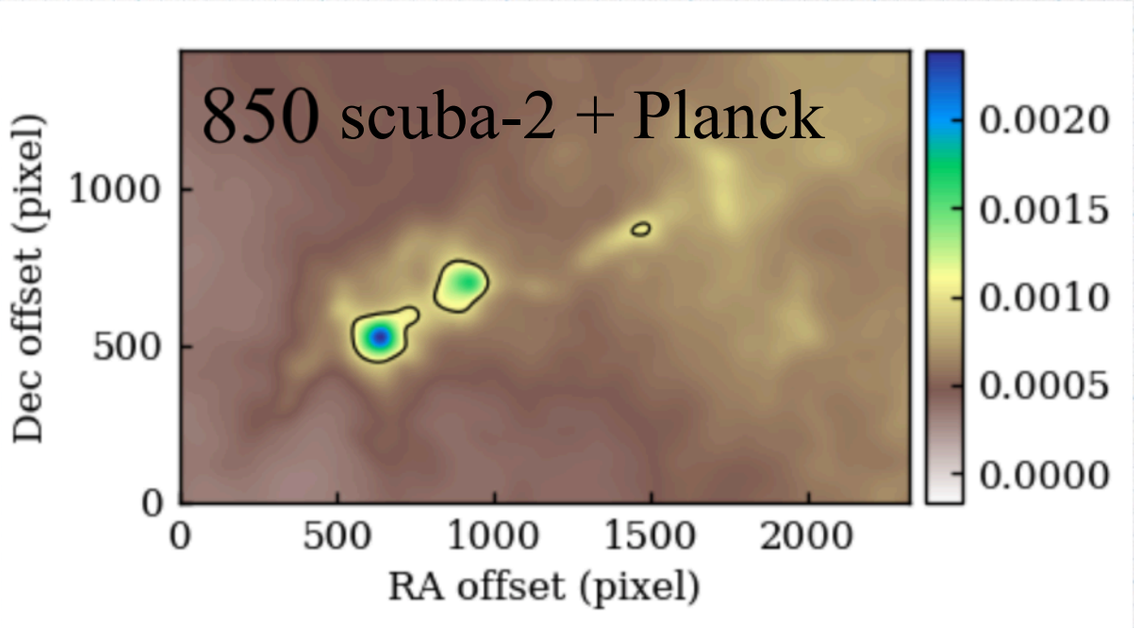
1.5x10^21 cm-2 = 4σ 8 mJy/beam



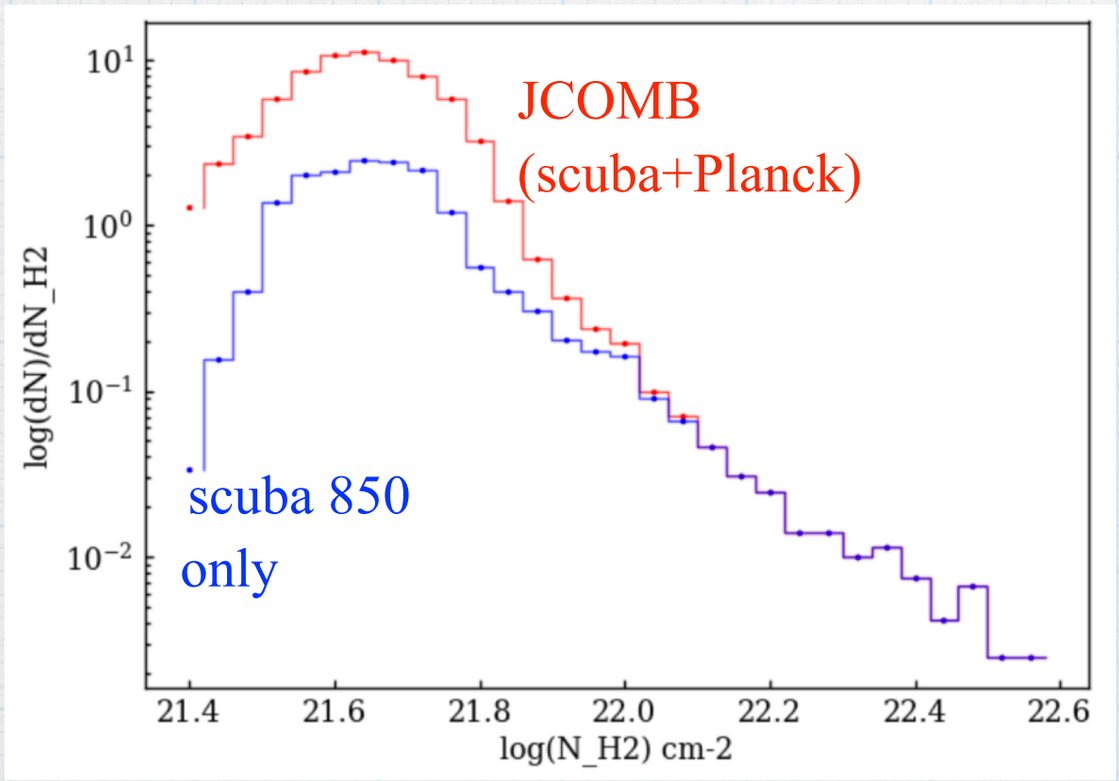
JCOMB method - further improve image quality (Jiao et al. to be published)

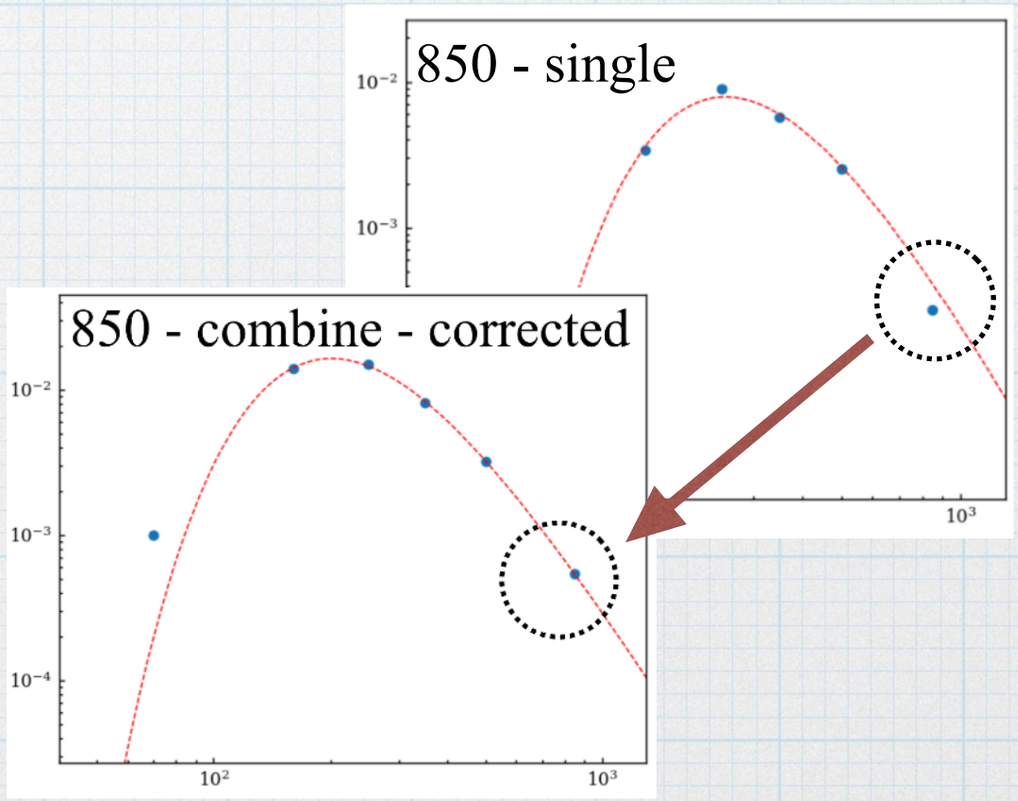
- recover the more complete sampling of the extended gas components



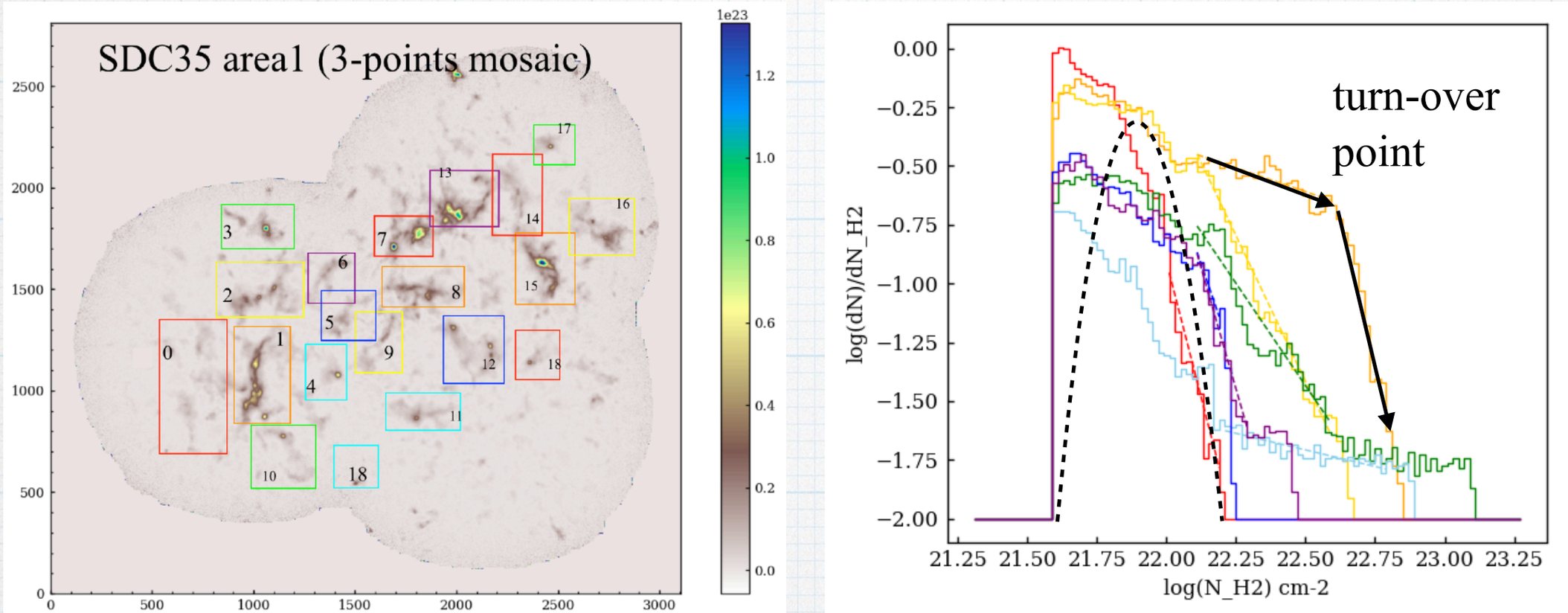


- JCOMB: notably improved accuracy in NPDF and SED fitting

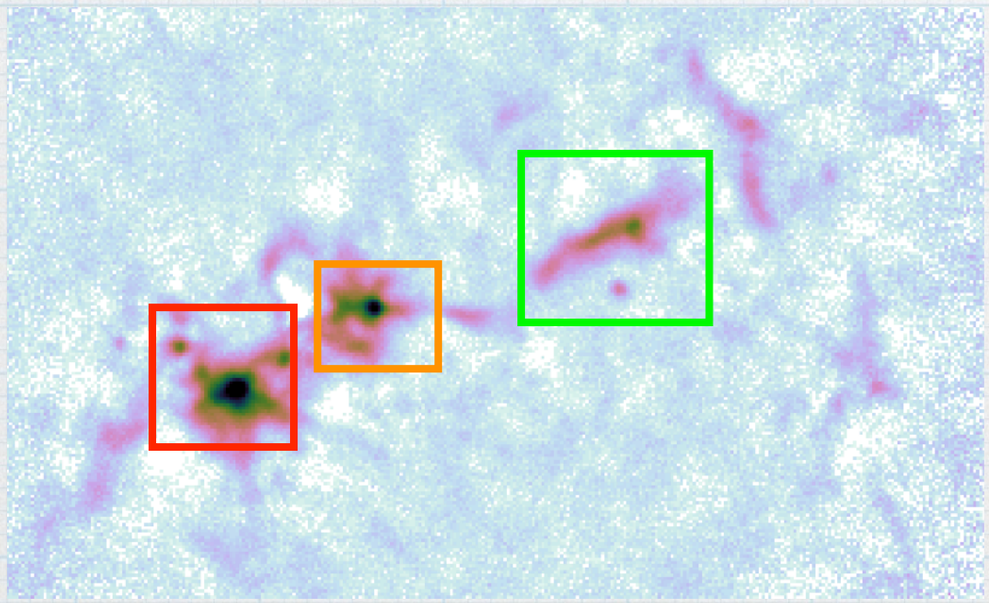


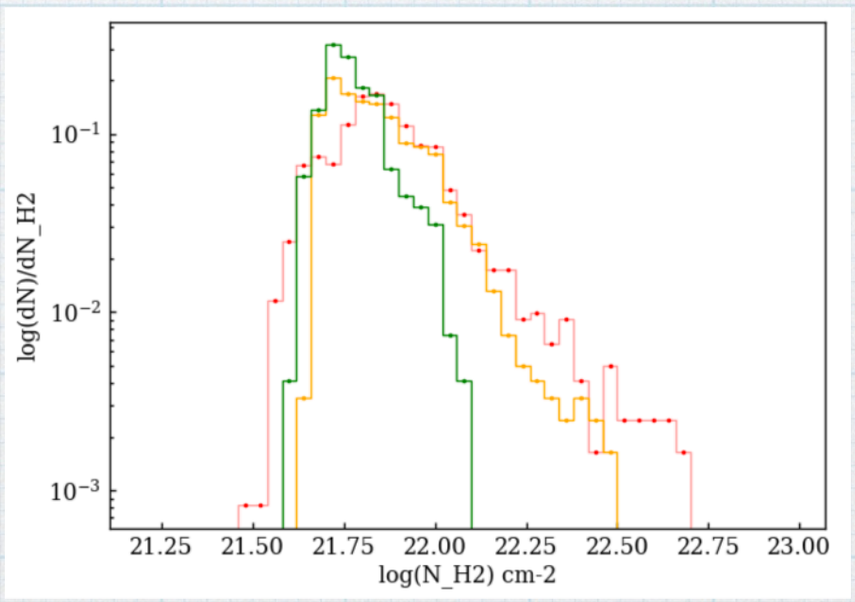


Results: column density distribution (NPDF)

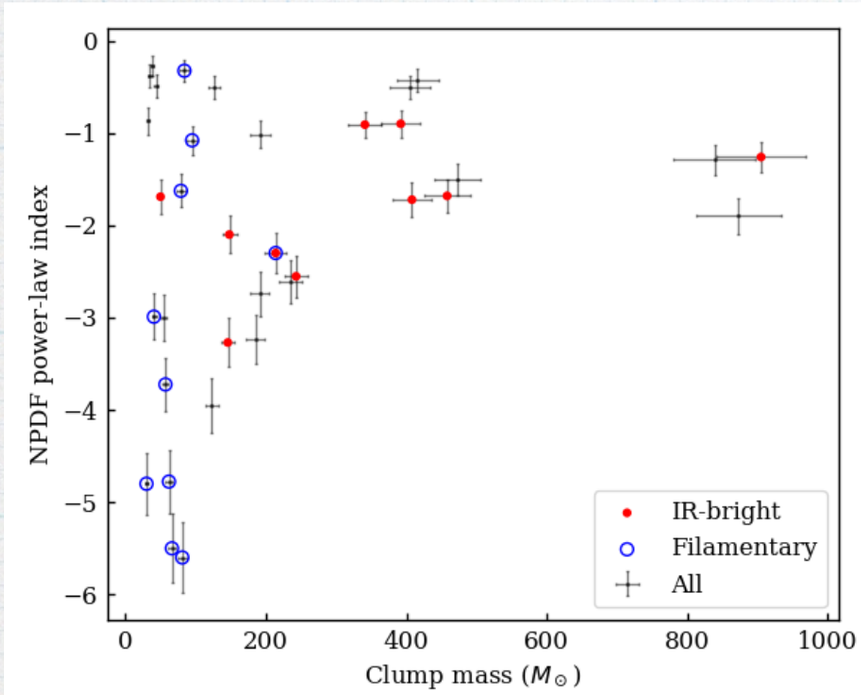


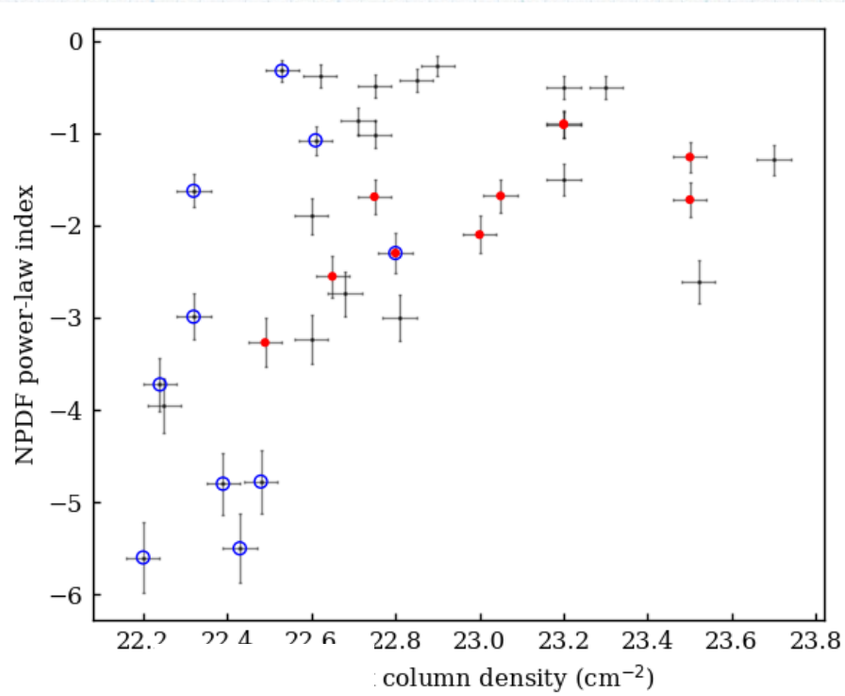
- for individual clumps, power-law tails usually not single power-law.
  —— dense cores more compact than surrounding G-bound components



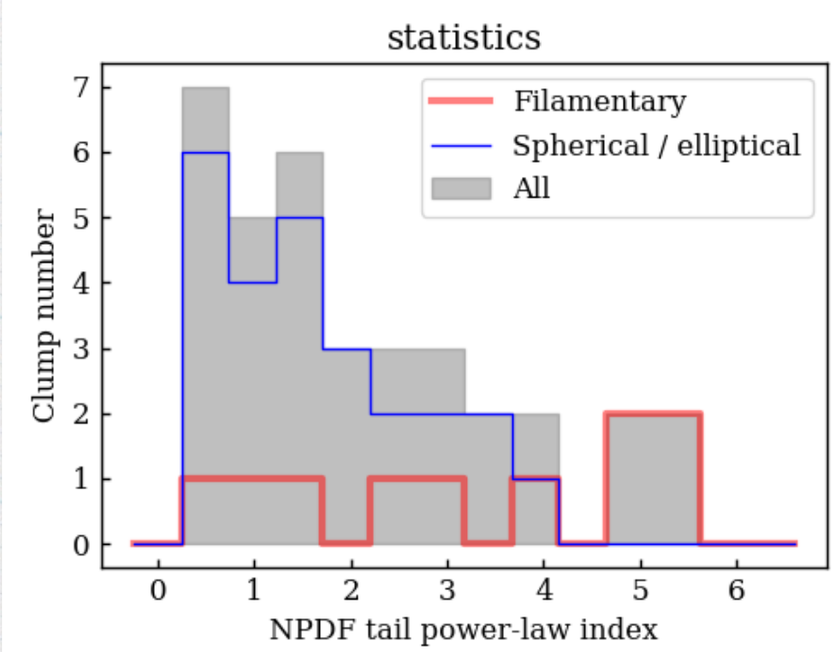


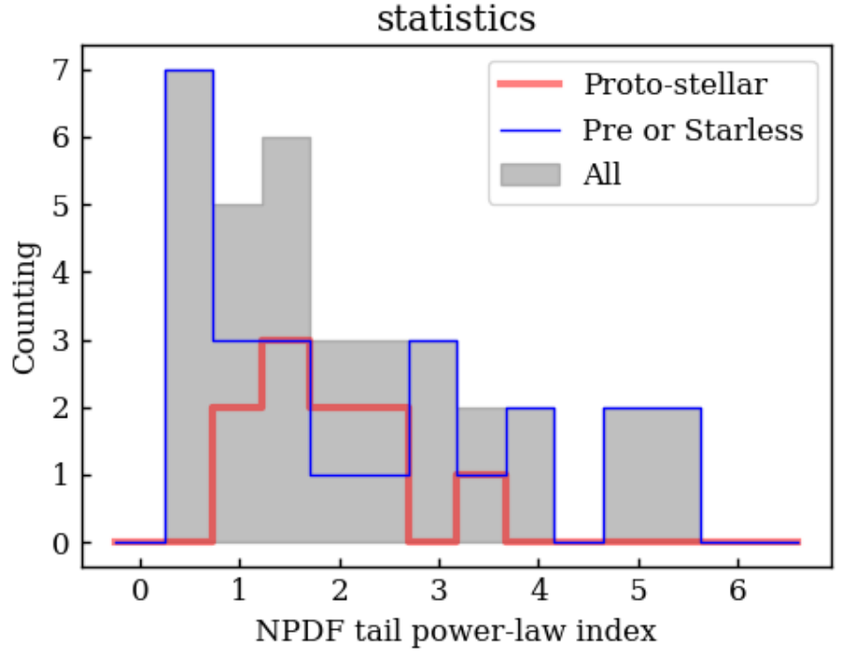
- NPDF: statistical relation with physical parameters





Converging to p=1.5 towards massive cores ?

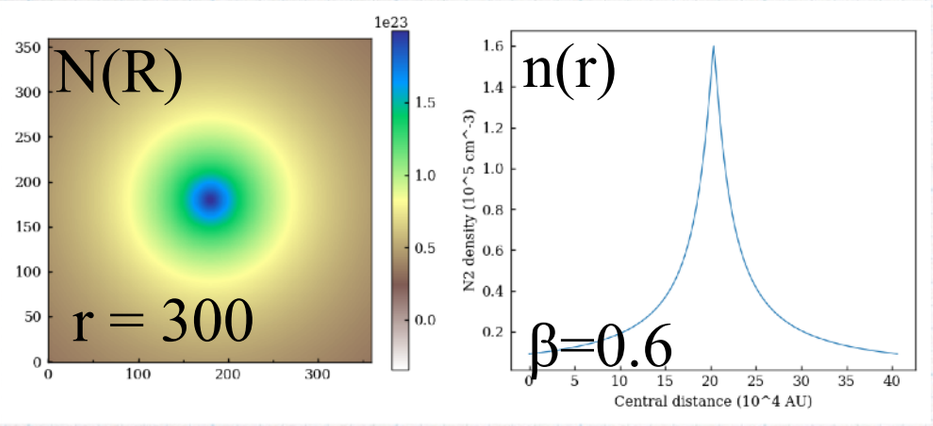


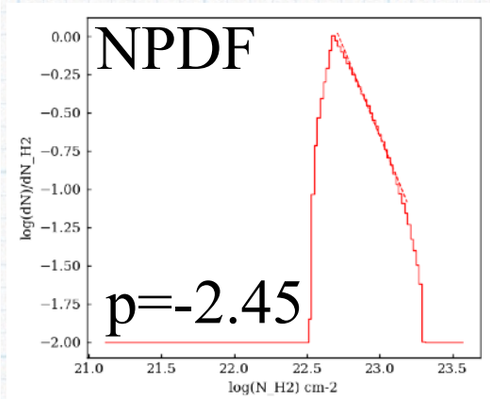


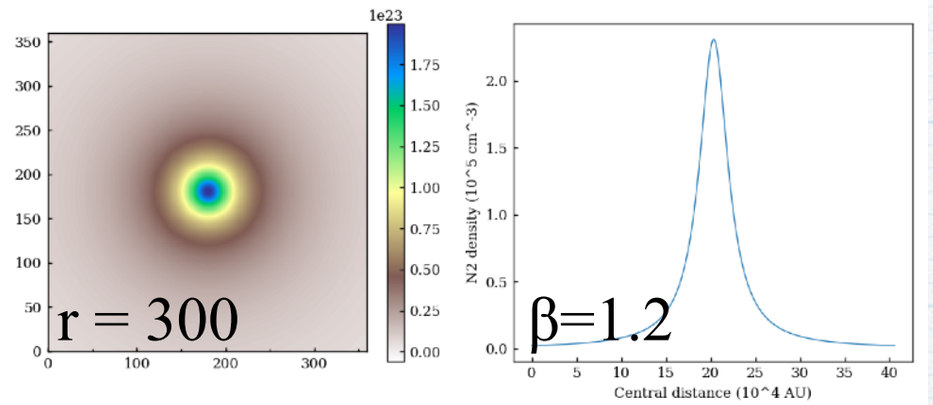
evident differences:
Filaments - Spherical
pre-stellar - protostellar
(more flattened NPDF)

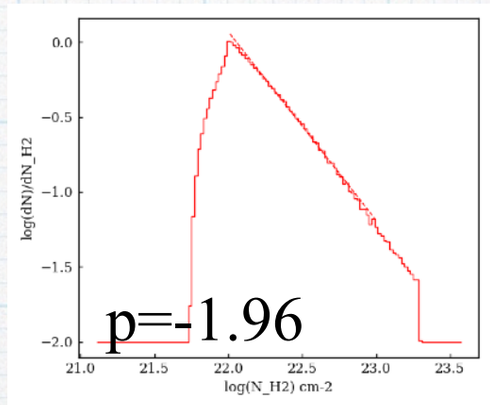
→ improve the previous NPDF diagnosis for IRDC evolutionary states

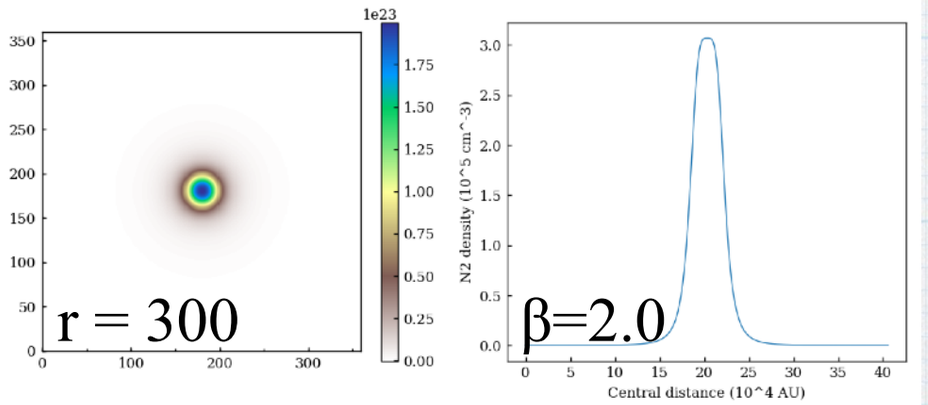
- Theoretical study to facilitate the NPDF observations

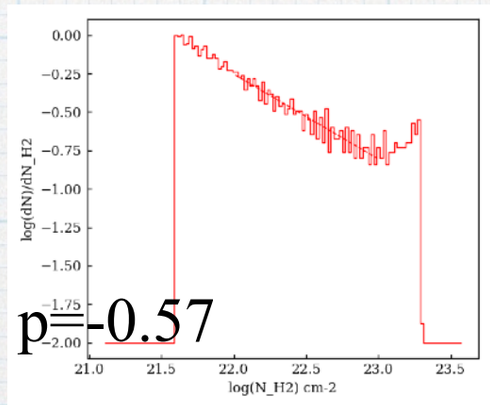


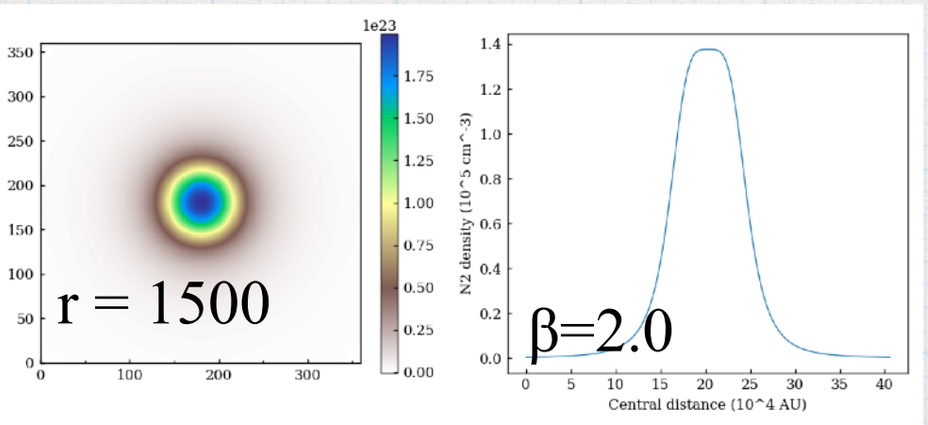


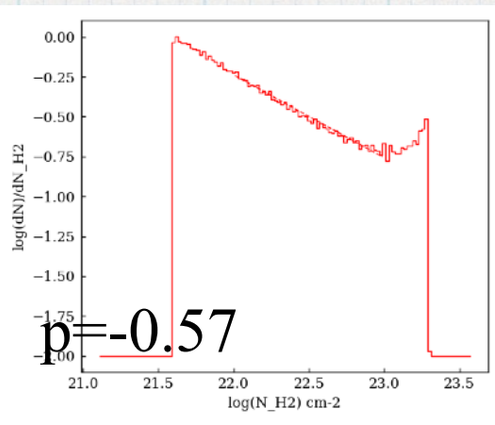








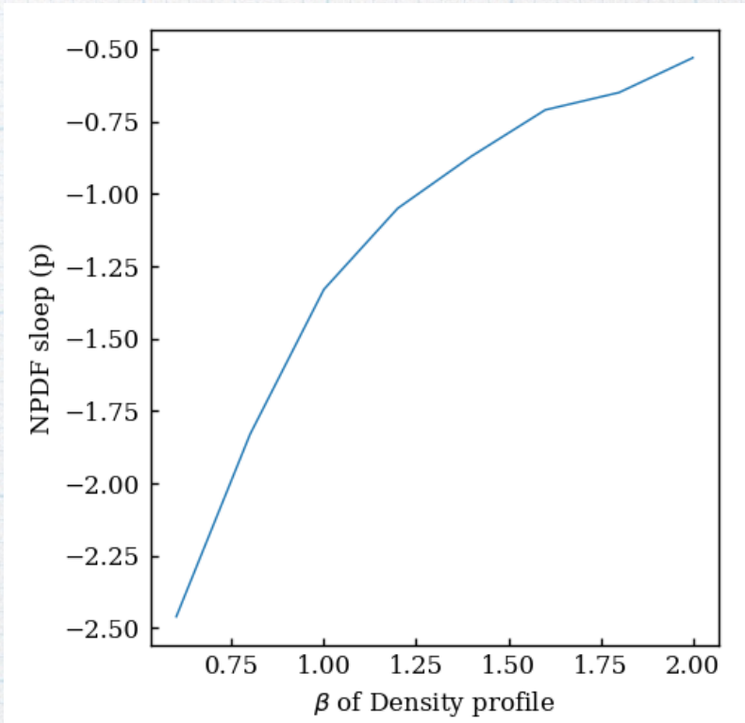




Density profile:

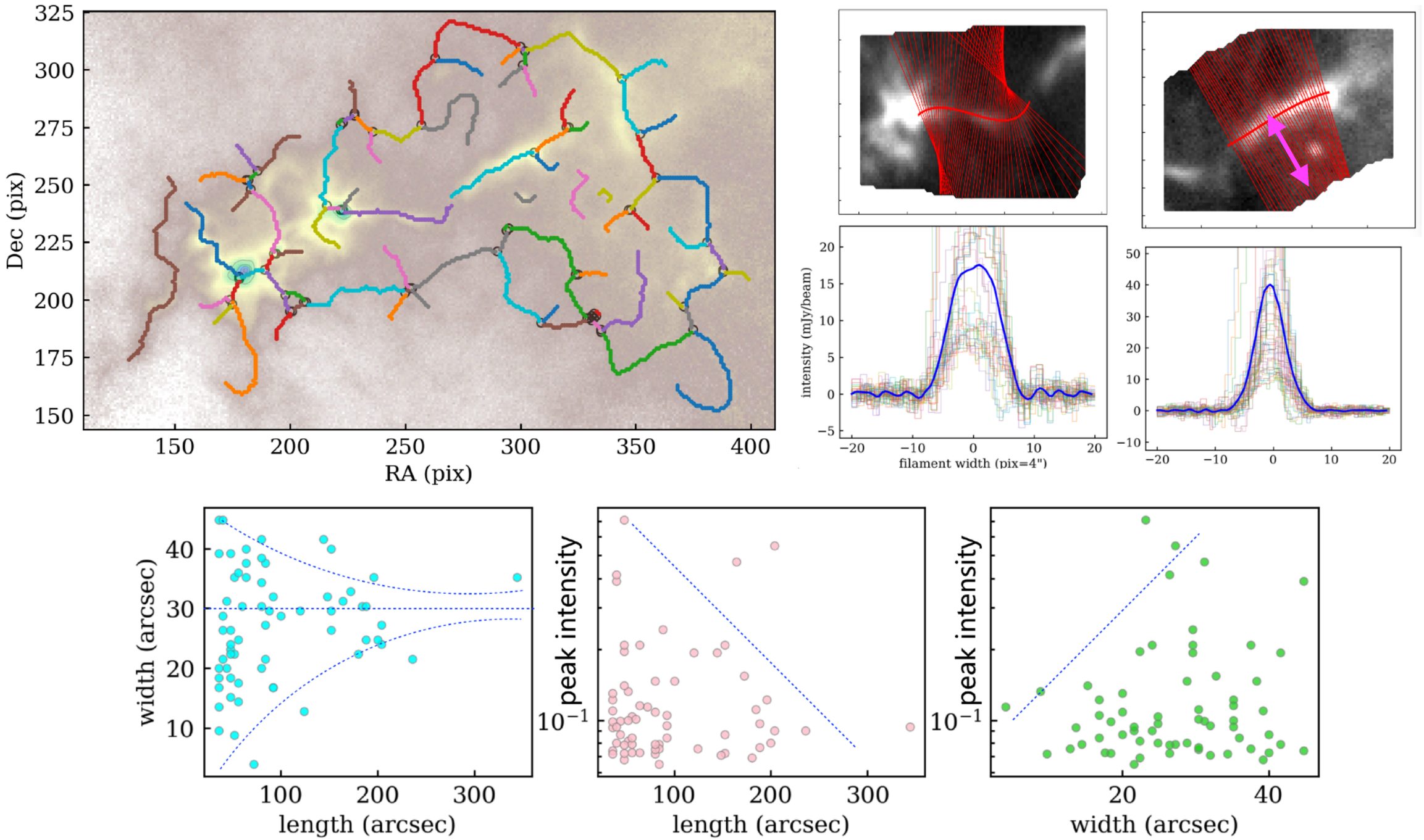
$$n(r) = \frac{n_0}{(r/r_0)^{\beta} + 1}$$

- NPDF-slope increases with β
  ⇒ One can use NPDF to derive β



- When β=const, NPDF-slope does not change with r0

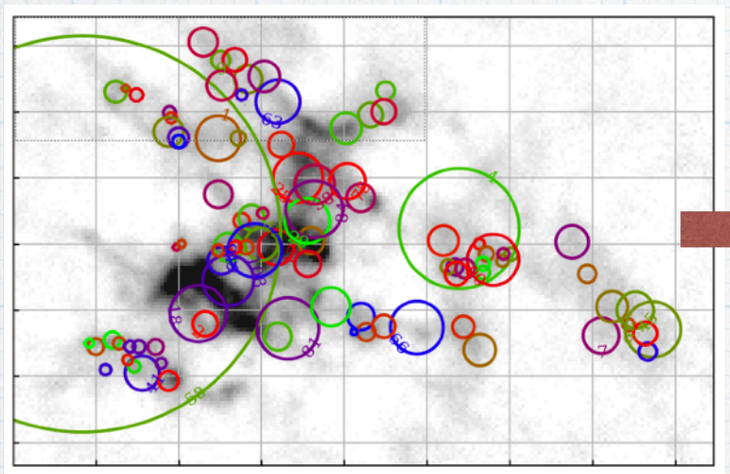
- Filaments: more detailed N(H2) profile sampling over filament width.



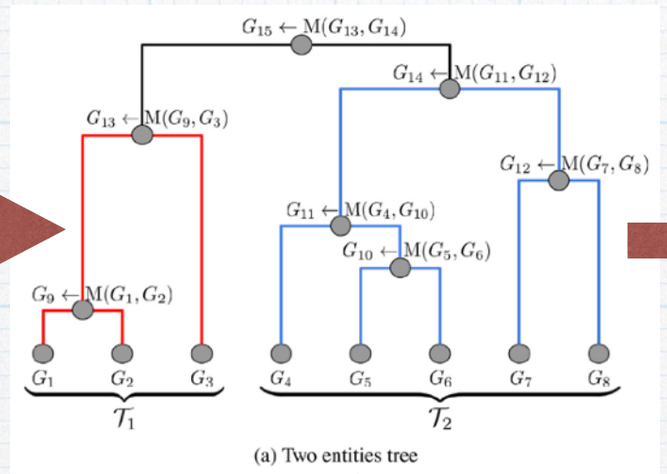
- long branches tend to have average width of ~30 arcsec (0.24 pc = 2×0.13 pc)
- long ones have lower intensities (more intersections around cores - short ones)
  —— long branch does not have as many dense cores along its path
- wider ones have higher intensities. (same explanation)

Current results: cores

- HDMC algorithm: (Villanueva et al. 2019)
  major feature: resolving the overlapped cores, accurately delineate irregular cores

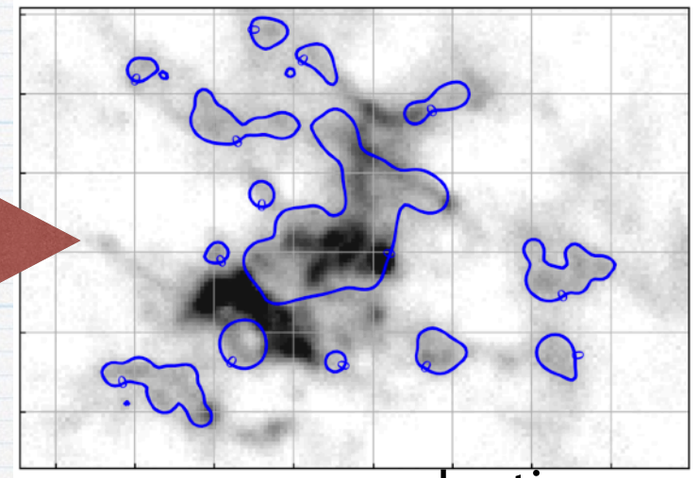


components analysis



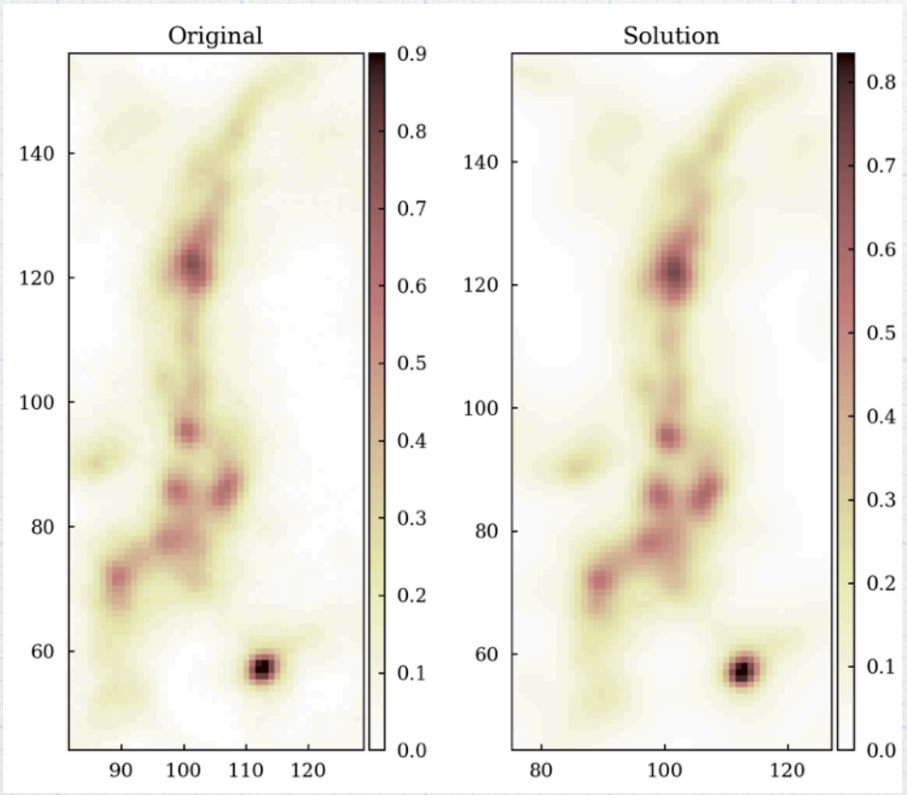
(a) Two entities tree

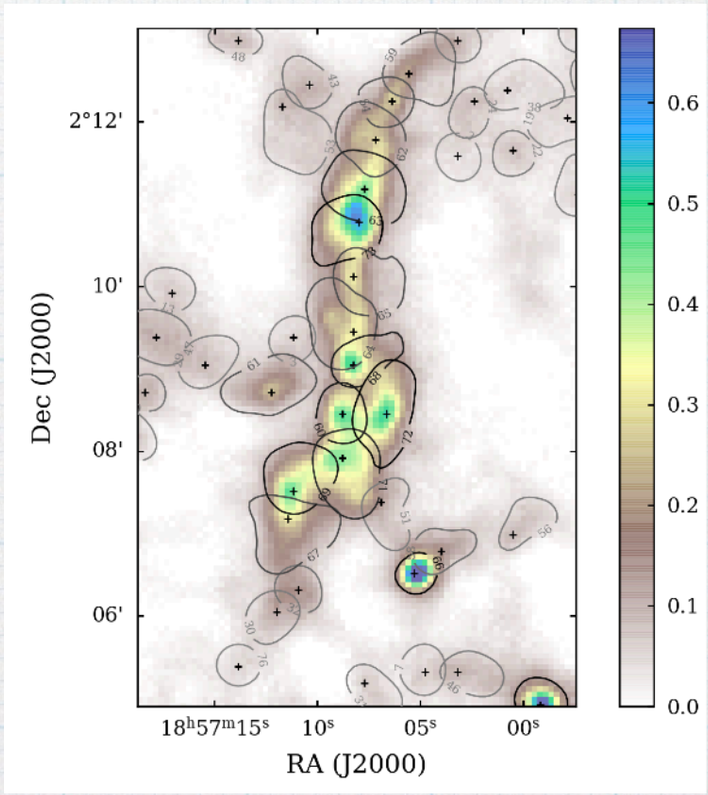
components merge



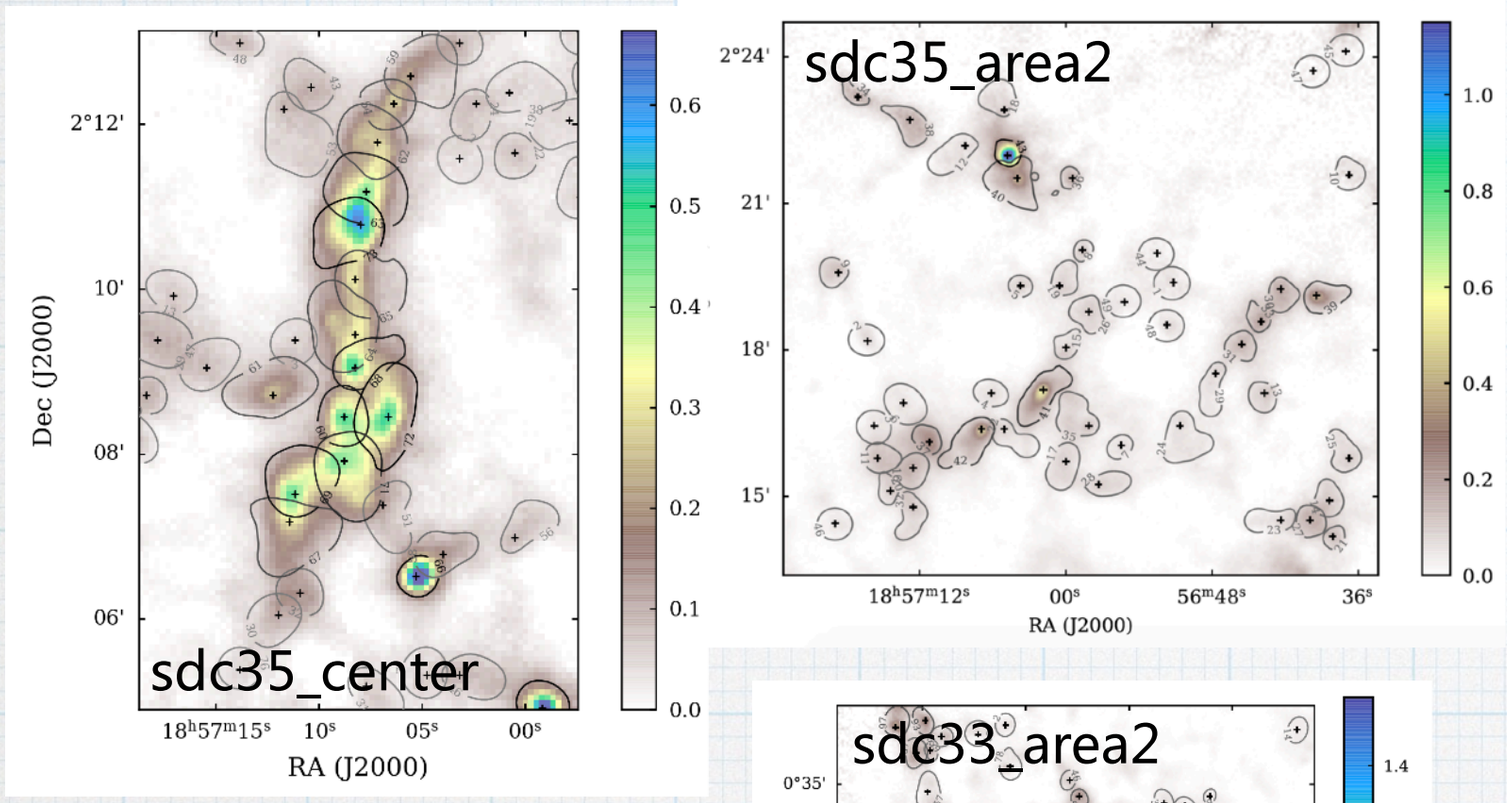
cores reproduction

- improvement (constraint on components distribution, core size, separation)





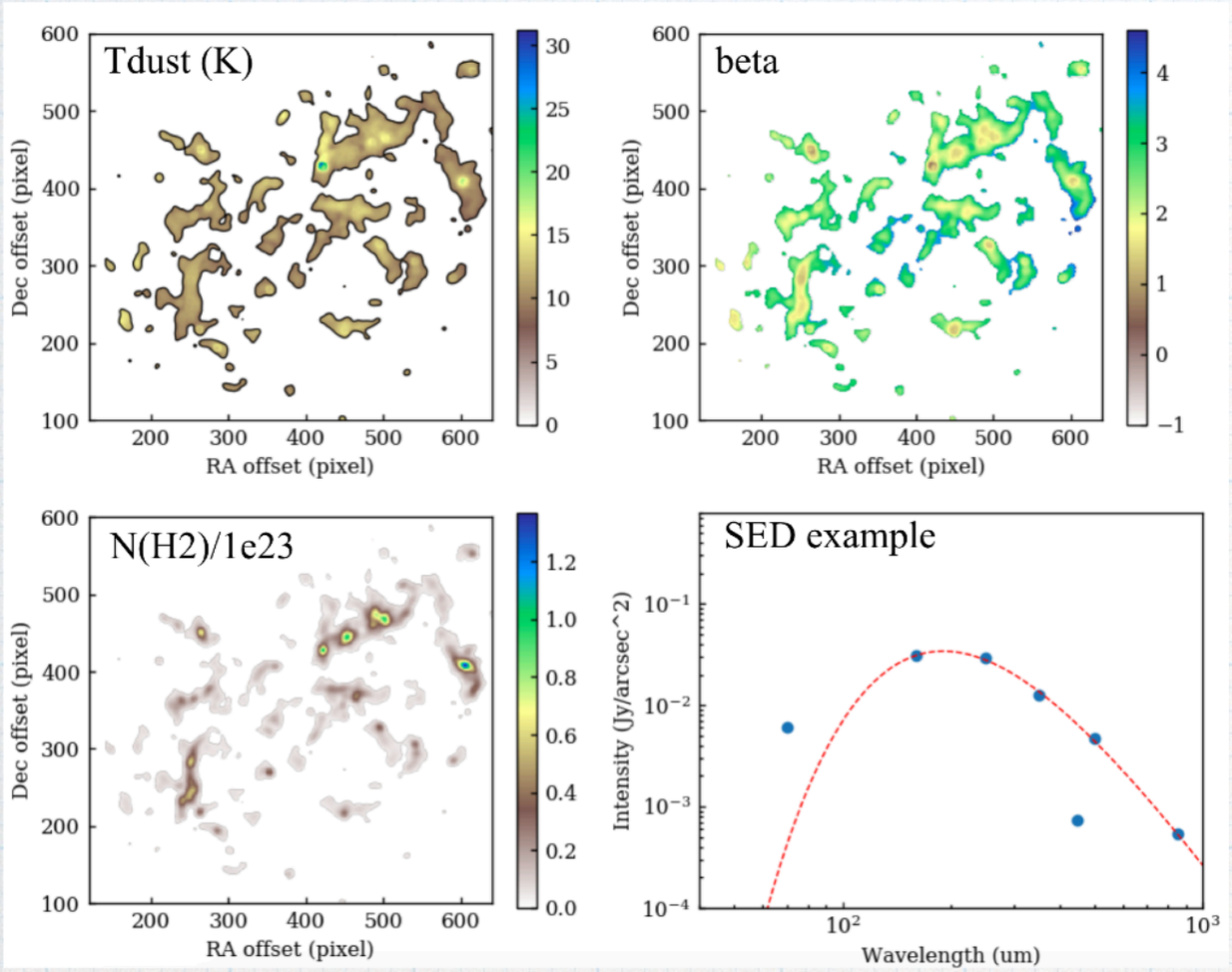
- Core catalogue:

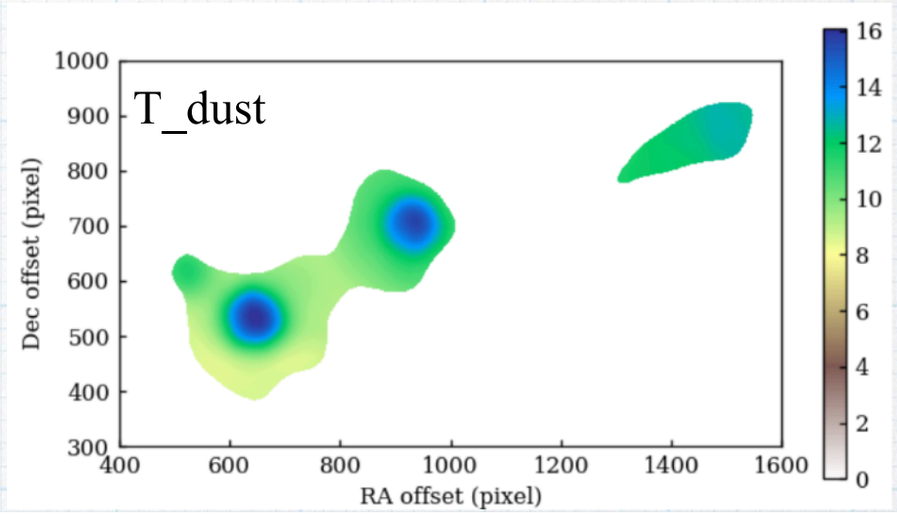


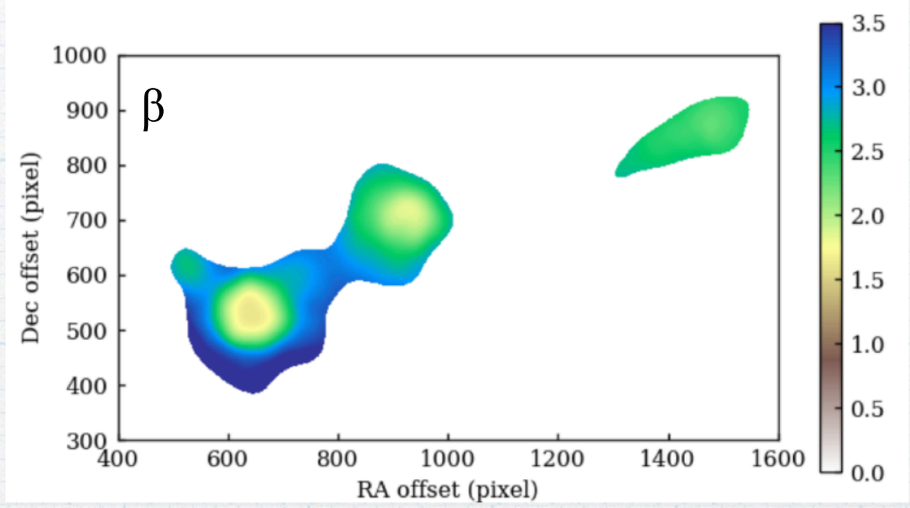
Number	Mass ($M_\odot$)	NPDF Index (no unit)	Peak $N(H_2)$ (log cm^{-2})	Morphology	Starless
SDC_38					
0	216(8)	-1.49(0.05)	23.0	Spherical	YSO
1	86(6)	-1.84(0.17)	22.81	Spherical	starless/pre
2	21(3)	-3.13(0.39)	22.39	Filamentary	starless/pre
M37					
0	19(2)	-0.81(0.20)	22.71	Spherical	starless/pre
1	18(3)	-1.86(0.85)	22.32	Filamentary	starless/pre
2	27(5)	-2.04(0.07)	22.43	Filamentary	starless/pre
3	8(2)	-4.37(0.48)	22.49	Spherical	YSO
4	24(2)	-1.28(0.35)	22.75	Spherical	YSO
M19					
0	678(31	-1.19(0.01)	23.5	Spherical	YSO
1	333(12	-1.16(0.04)	23.2	Spherical	starless/pre
2	737(28	-1.24(0.01)	23.7	Spherical	starless/pre
SDC_35c3					
0	166(12)	-2.25(0.00)	23.2	Spherical	YSO
1	195(11)	-0.89(0.27)	22.8	Filamentary	YSO
2	226(23)	-2.63(0.66)	22.6	Spherical	starless/pre
SDC_35c1					
0	4(2)	-4.98(0.55)	22.2	Filamentary	starless/pre
1	341(12)	-0.41(0.03)	22.85	Spherical	starless/pre
2	101(11)	-2.58(0.13)	22.68	Spherical	starless/pre
3	86(6)	-1.83(0.05)	23.3	Spherical	starless/pre
4	23(1)	-0.33(0.05)	22.9	Spherical	starless/pre
5	19(4)	-3.55(0.78)	22.24	Filamentary	starless/pre
6	25(5)	-4.36(0.70)	22.48	Filamentary	starless/pre
7	285(12)	-0.87(0.16)	23.2	Spherical	YSO
8	137(14)	-2.42(0.16)	22.65	Spherical	YSO
9	16(4)	-3.17(0.00)	22.32	Filamentary	starless/pre
10	14(1)	-0.40(0.05)	22.53	Filamentary	starless/pre
11	24(3)	-0.86(0.33)	22.61	Filamentary	starless/pre
12	60(8)	-0.89(0.22)	22.75	Spherical	starless/pre
13	381(16)	-1.59(0.01)	23.05	Spherical	YSO
14	16(6)	-4.89(0.12)	22.25	Spherical	starless/pre
15	319(13)	-1.61(0.03)	23.5	Spherical	YSO
16	89(11)	-2.96(0.10)	22.6	Spherical	starless/pre
17	19(3)	-0.36(0.16)	22.75	Spherical	starless/pre
18	11(1)	-0.28(0.26)	22.62	Spherical	starless/pre

- a more complete core list towards nearby IRDCs including >500 cores:
  - physical parameters

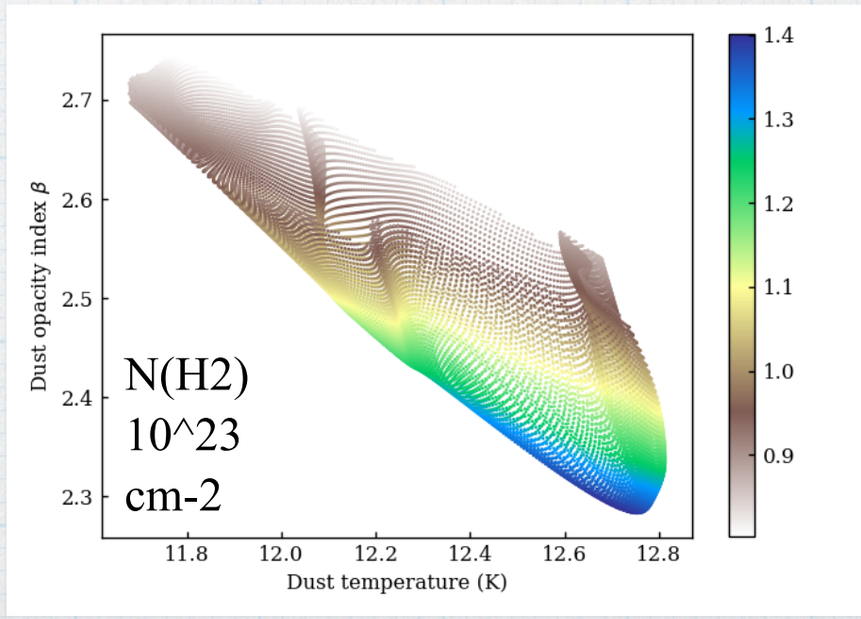
- joint study with Herschel images - temperature and dust properties





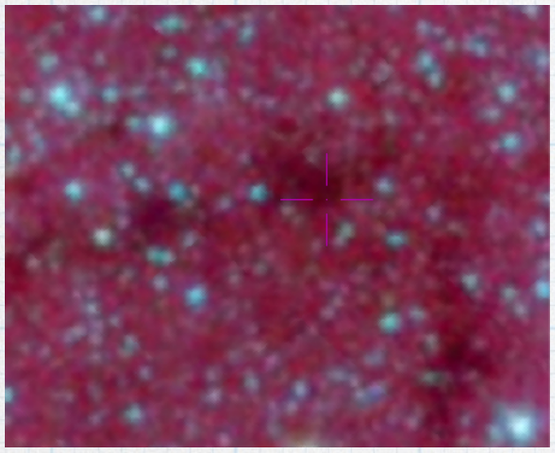


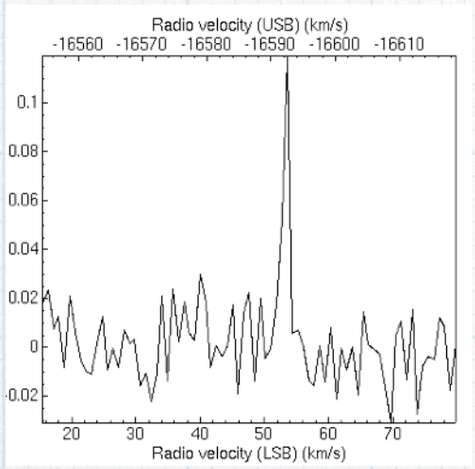
- temperatures only moderately increasing towards protostellar cores ($\Delta T<10$ K)
  — IRDC cores not sufficiently heated
- correlation between β and Tdust and N_{tot}
  — dust properties affected by temperature and density



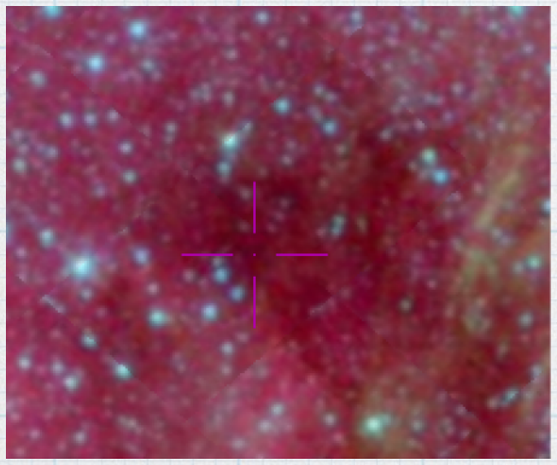
ongoing studies - molecular lines

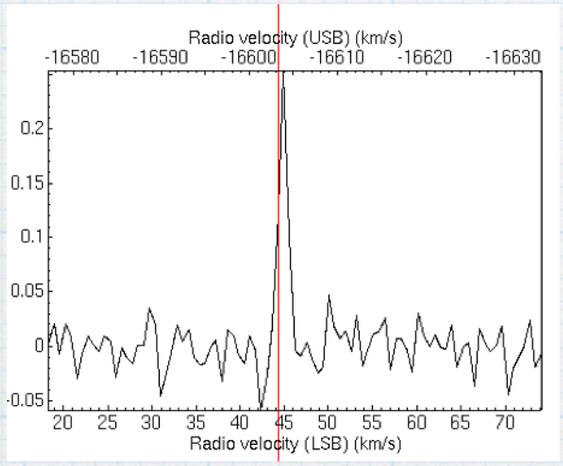
SDC35_2 | 18:58:39.3 +03:16:11 | 54
pmo-13co=2.6K, filament center, very dark.



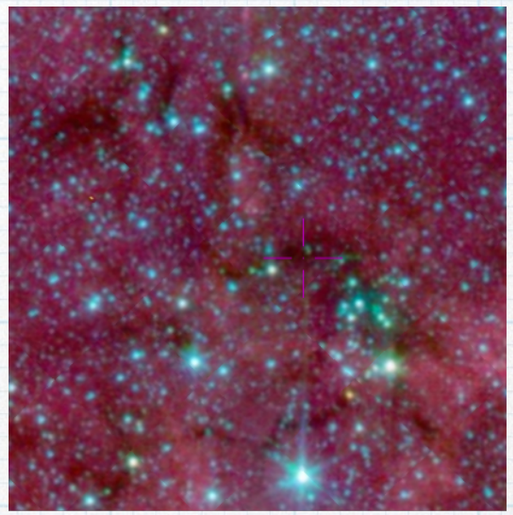


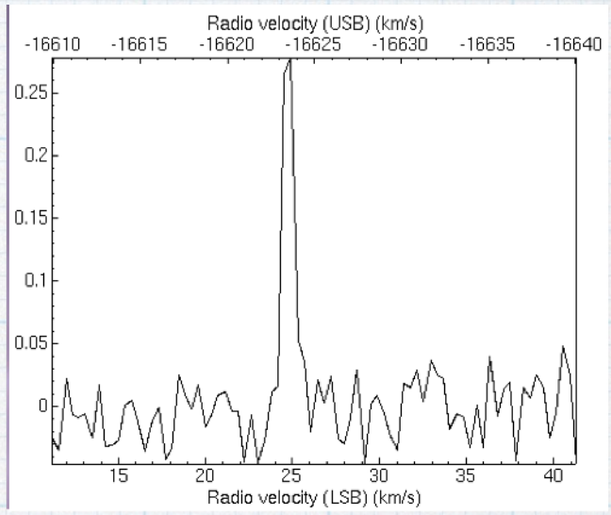
SDC35_3 | 18:56:49.6 +01:23:11
dark extended.



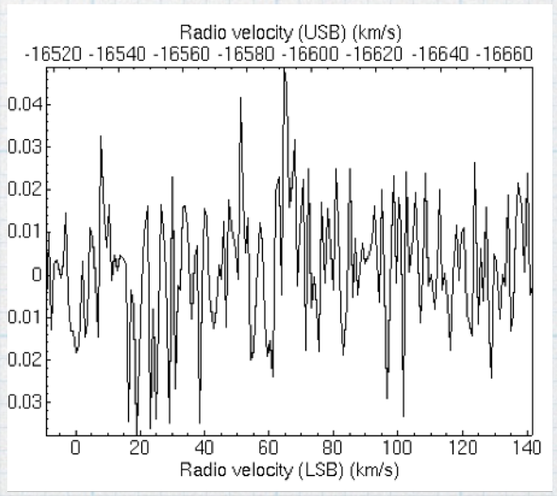


PF_12 19:29:37.4 +18:01:41
compact filament IRDC



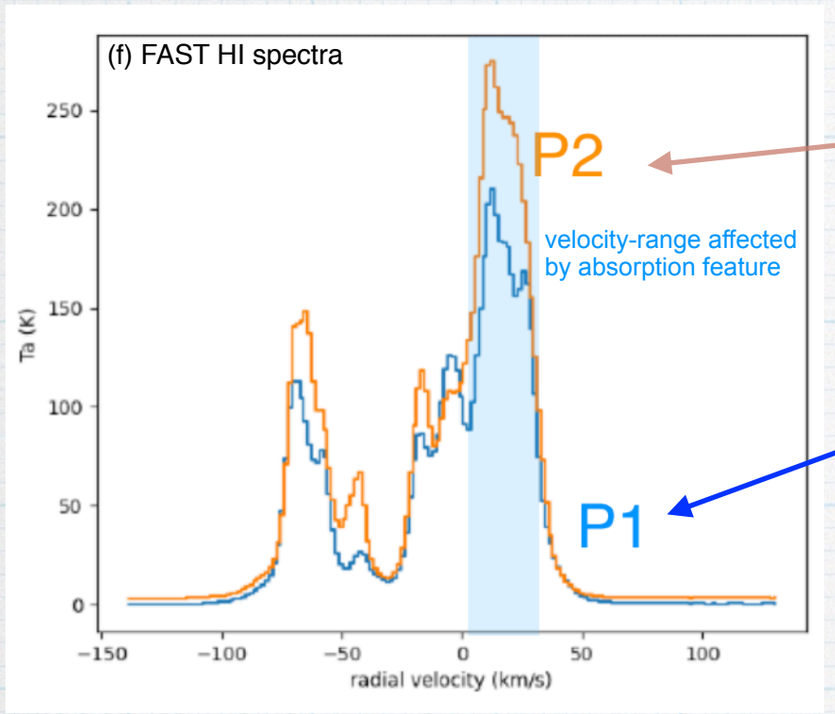


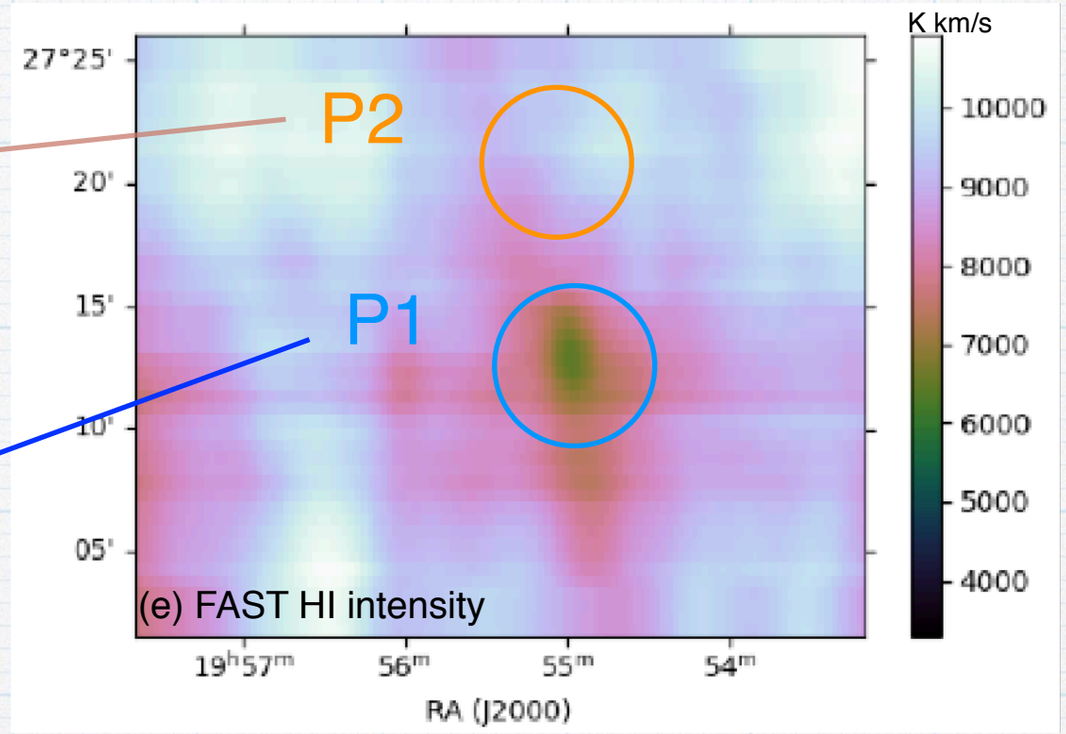
PF_02 | 19:23:43.2 +14:30:27
pmo-13co=5.5K, HII background

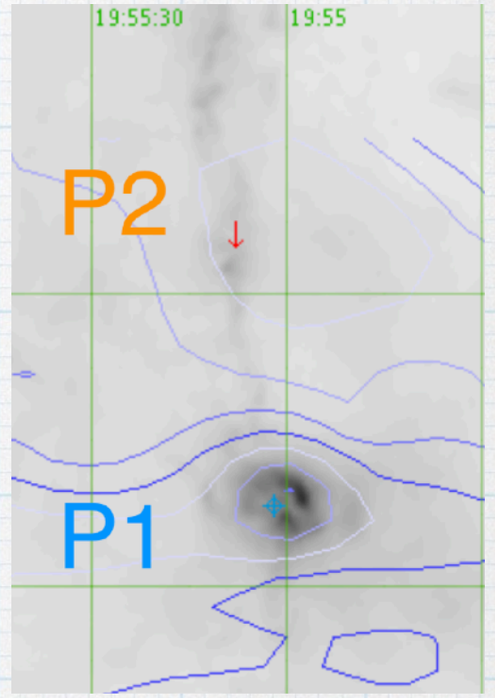


- JCMT R21AP006: DCO+ (2-1) observation:
  Uu receiver, t_int=10 min, rms=10 mJy/chan (0.5 km/s)
  4 out of 6 DCO+ detections - Good tracer for cloud dense gas in IRDCs

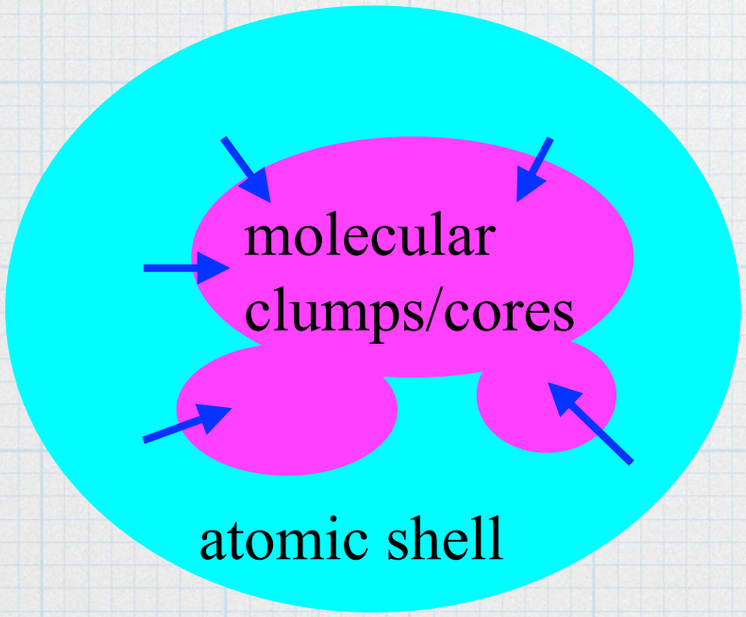
ongoing studies - HI observation with FAST telescope

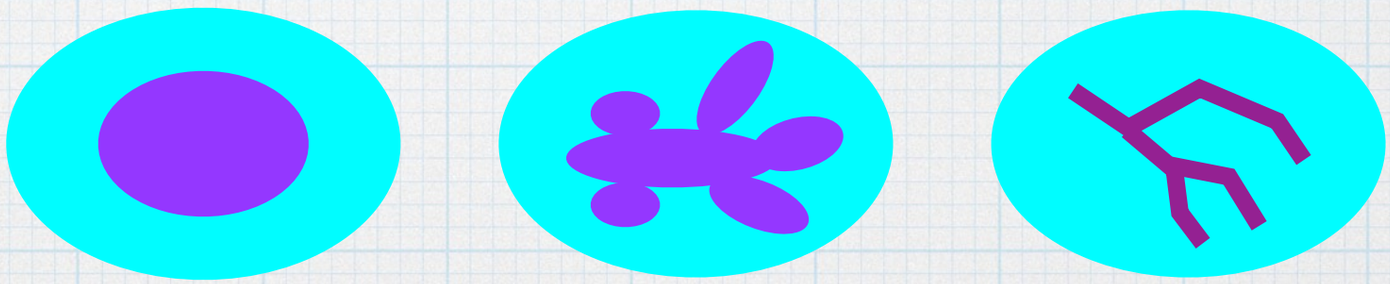






- absorption features can be identified from images.
- science objectives: HI envelope — correlation with internal dust structures.





- Key ingredient to determine these scenarios:
  total shell mass, pressure, density profile, etc.

Summary

1. sample: nearby IRDCs — high-sensitivity 850-um images (2-5 mJy/beam)
 - large sample of dense cores (> 500 objects), and filaments based on improved methods (filfinder and HDMC)
 - complete NPDF sampling covering the lognormal components.
2. Physical properties:
   - massive cores (>50 objects with M>10 Msun)
   - temperature, dust opacity and masses would have potential relations.
   - mass assembly could be characterized by NPDF

Subsequent studies:

- molecular lines: turbulence level, gravitational instabilities, importance of B-field?
- HI 21-cm: cold dense gas assembly - molecular gas formation.
- …

Welcome people to join the study,

Welcome to use the data,

Welcome to share the data, methods, and ideas