The physical and chemical state of cold dust cores mapped with Herschel

Aims of the study

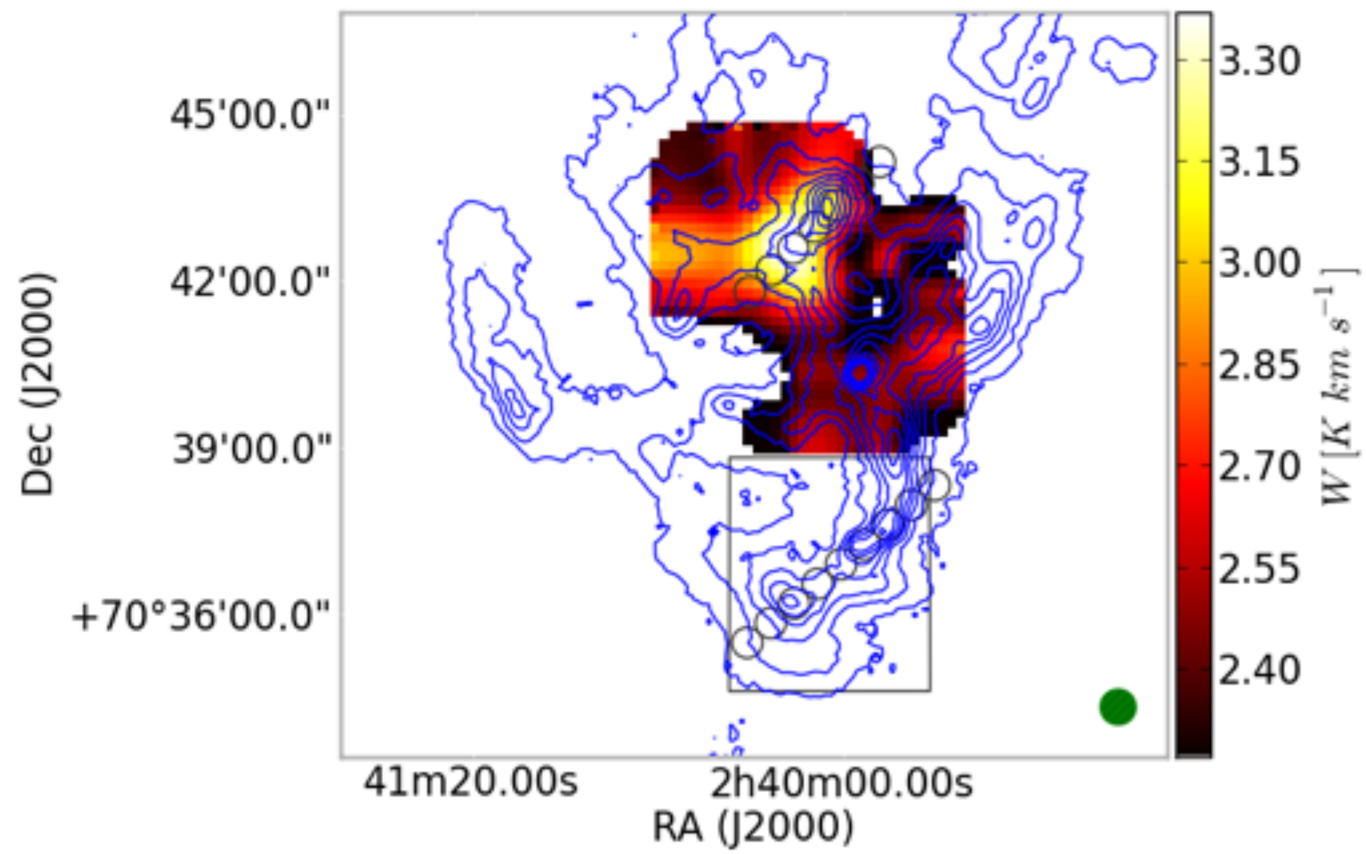
- Examine the physical properties of the selected fields from molecular lines
- Compare the molecular line observations with dust continuum observations, especially the derived column density
- Compare the dust and molecular line observations with theoretical models

Observations

- Based on observations: Planck all-sky survey & Herschel
- Observations done: February & March 2012
- Telescope: OSO 20-m telescope
    - mm- and cm-wave antenna: observations @ 86 GHz (~3.5 mm)
    - diameter: 20.1 m
- Frequency switching used in all observations
- problems: bad weather, N_2H^+

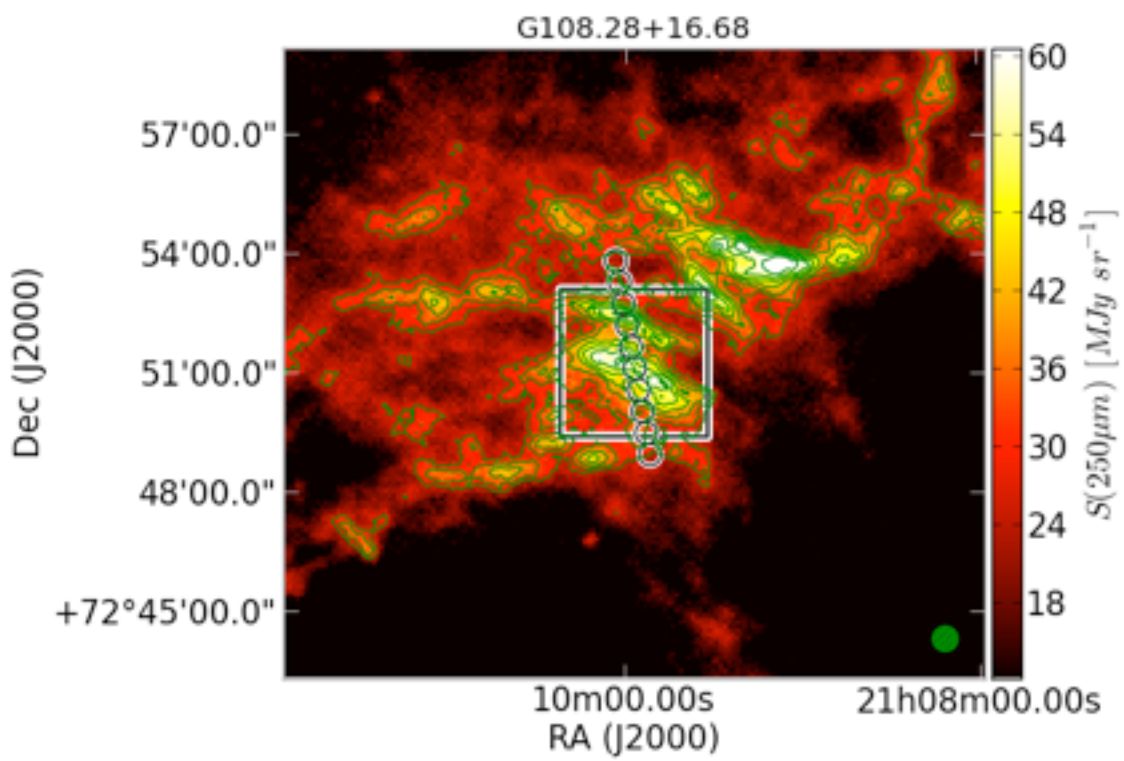
Target fields

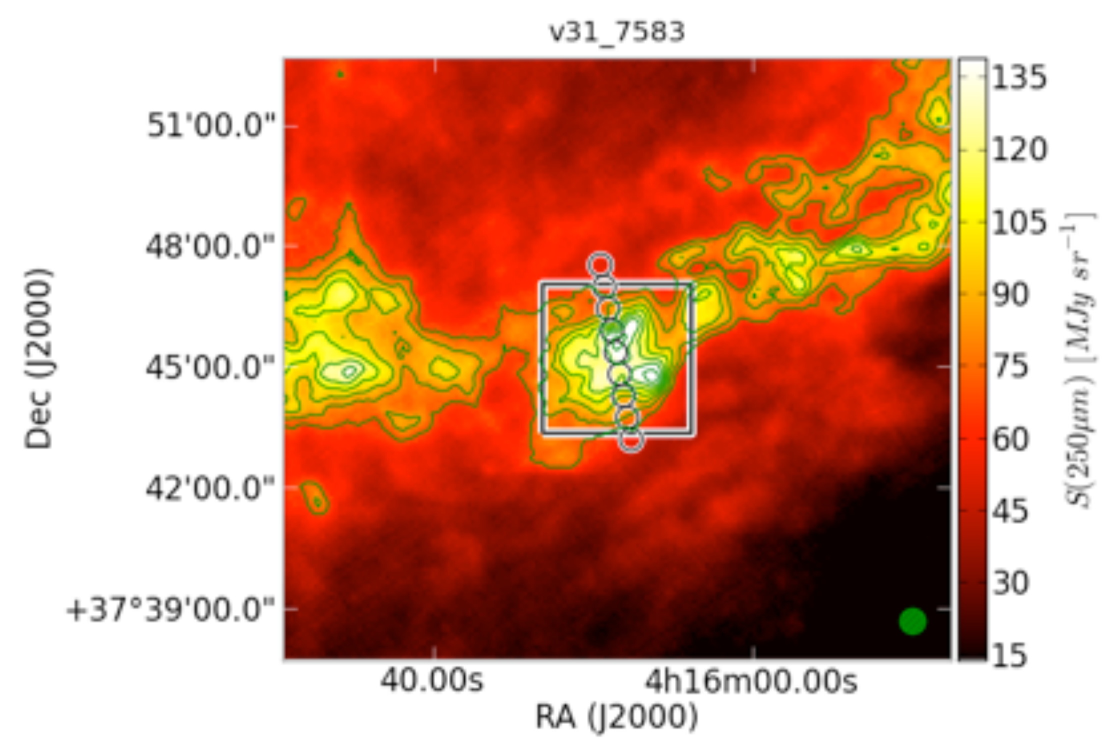
- G131.65+9.75:
    - distinct cometary shape
    - distance ~400 pc
    - Partly mapped in Onsala 2010



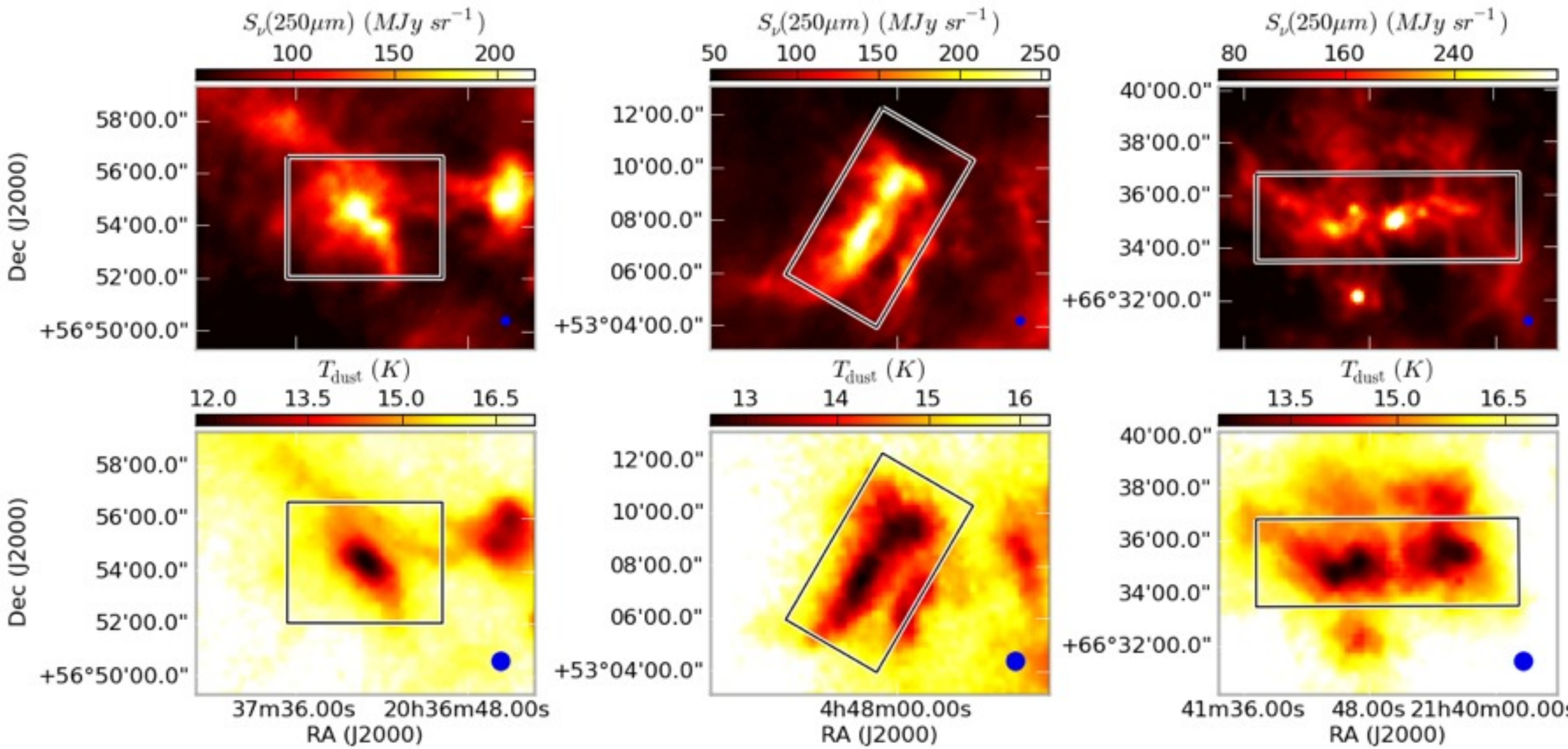
- G108.28+16.68:
  - likely associated with Cepheus complex
  - Herschel maps: possible shock front, column density drops towards south
  - distance ~450 pc

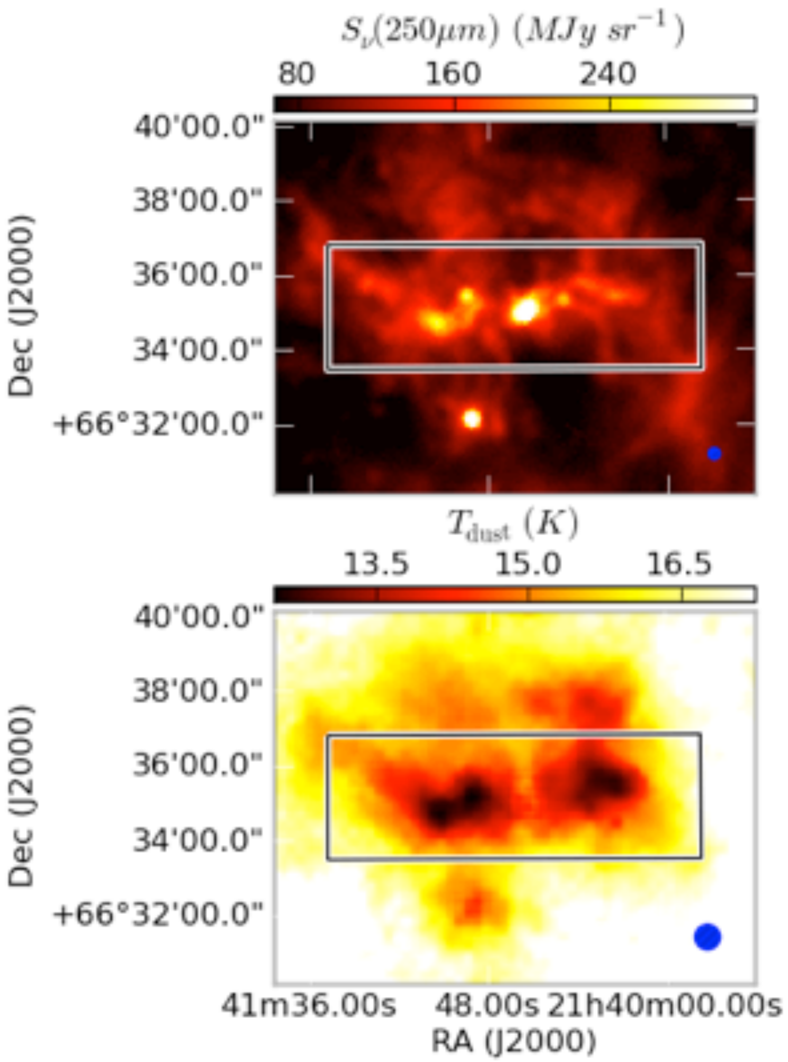
- G161.55-9.30:
  - near Perseus OB2 CO complex
  - distance ~350 pc
  - part of a long filament (Herschel: breaks in number of clumps)

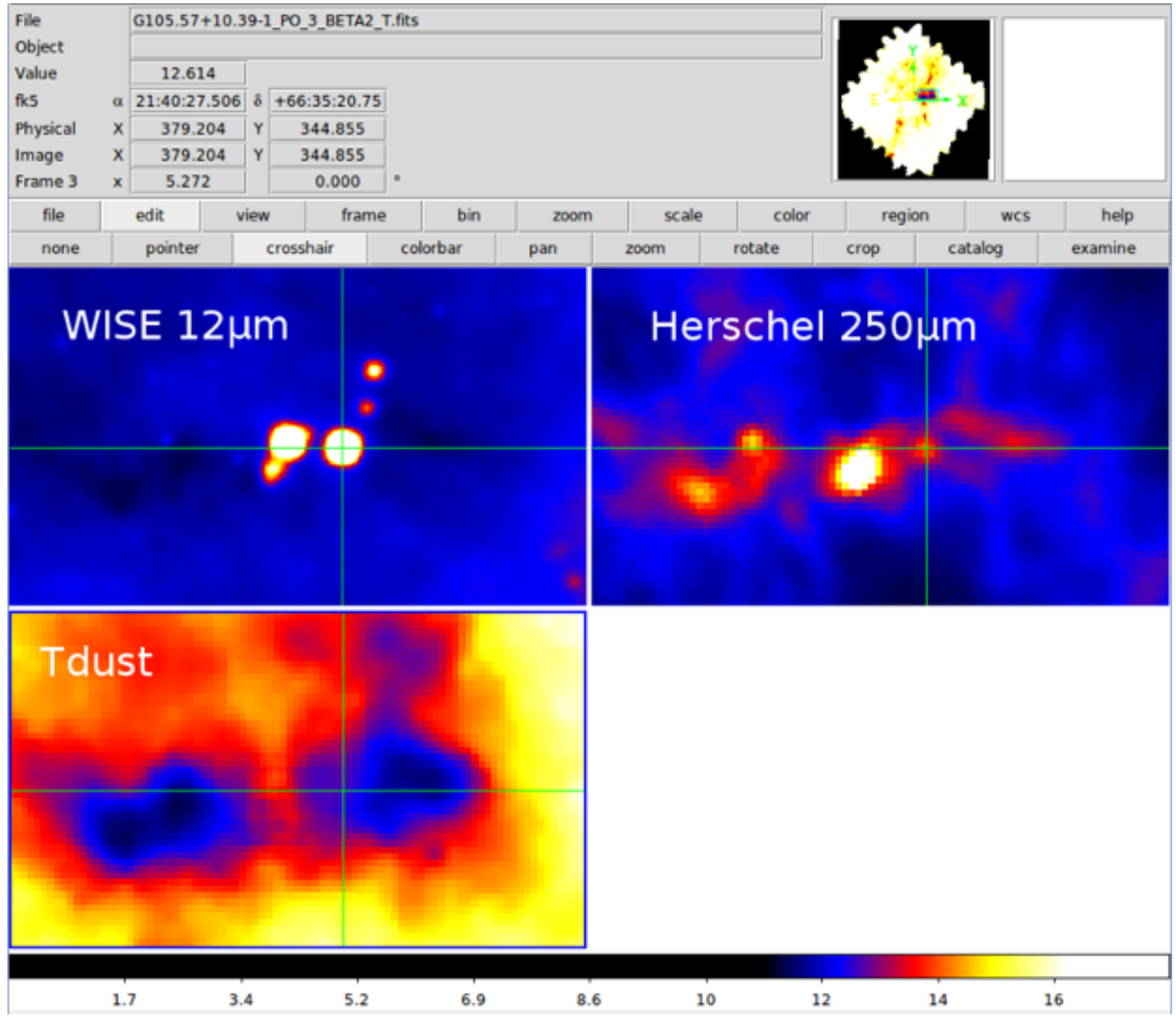




G93.21+9.55 G154.08+5.23 G105.57+10.39

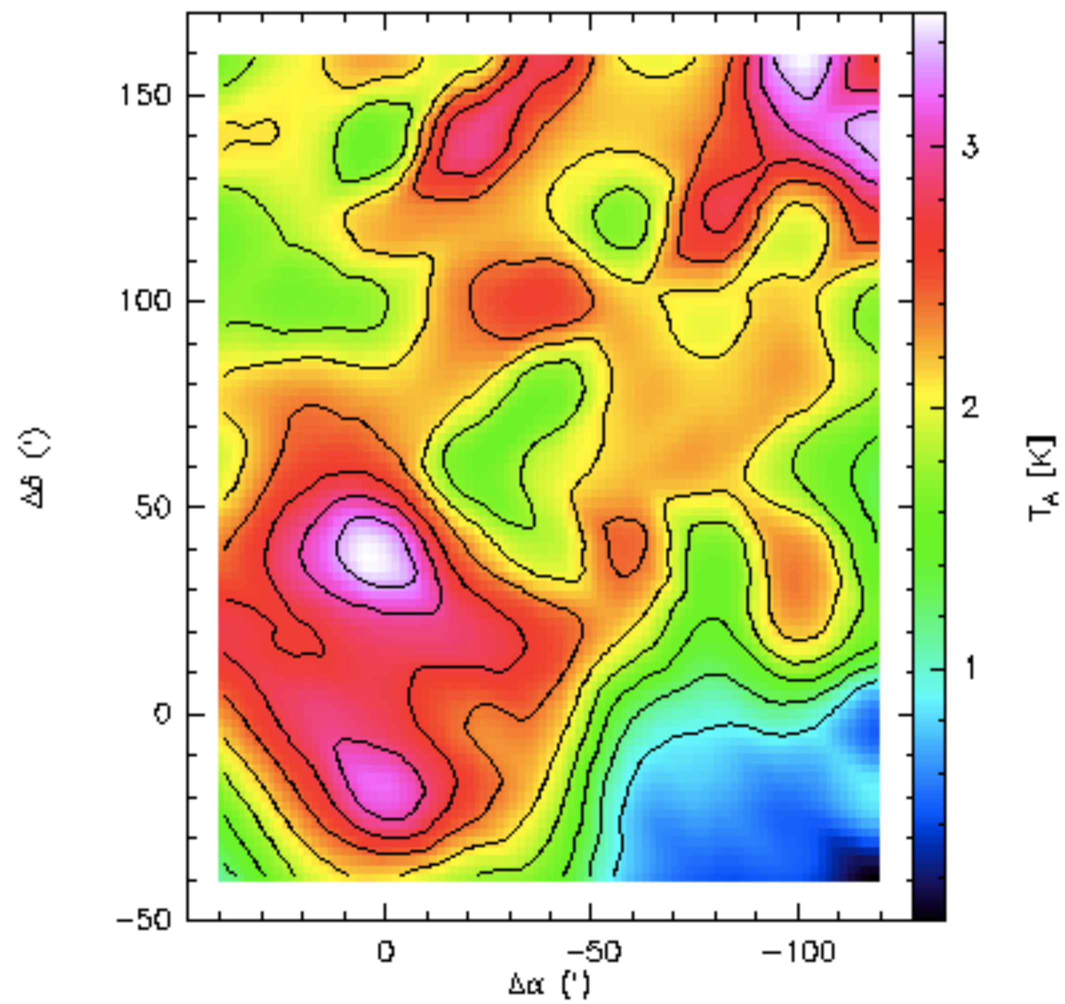



$S_\nu(250\mu m)$ $(MJy\ sr^{-1})$
80 160 240
T_{dust} (K)
13.5 15.0 16.5
40'00.0"
38'00.0"
36'00.0"
34'00.0"
+66°32'00.0"
Dec (J2000)
41m36.00s 48.00s 21h40m00.00s
RA (J2000)

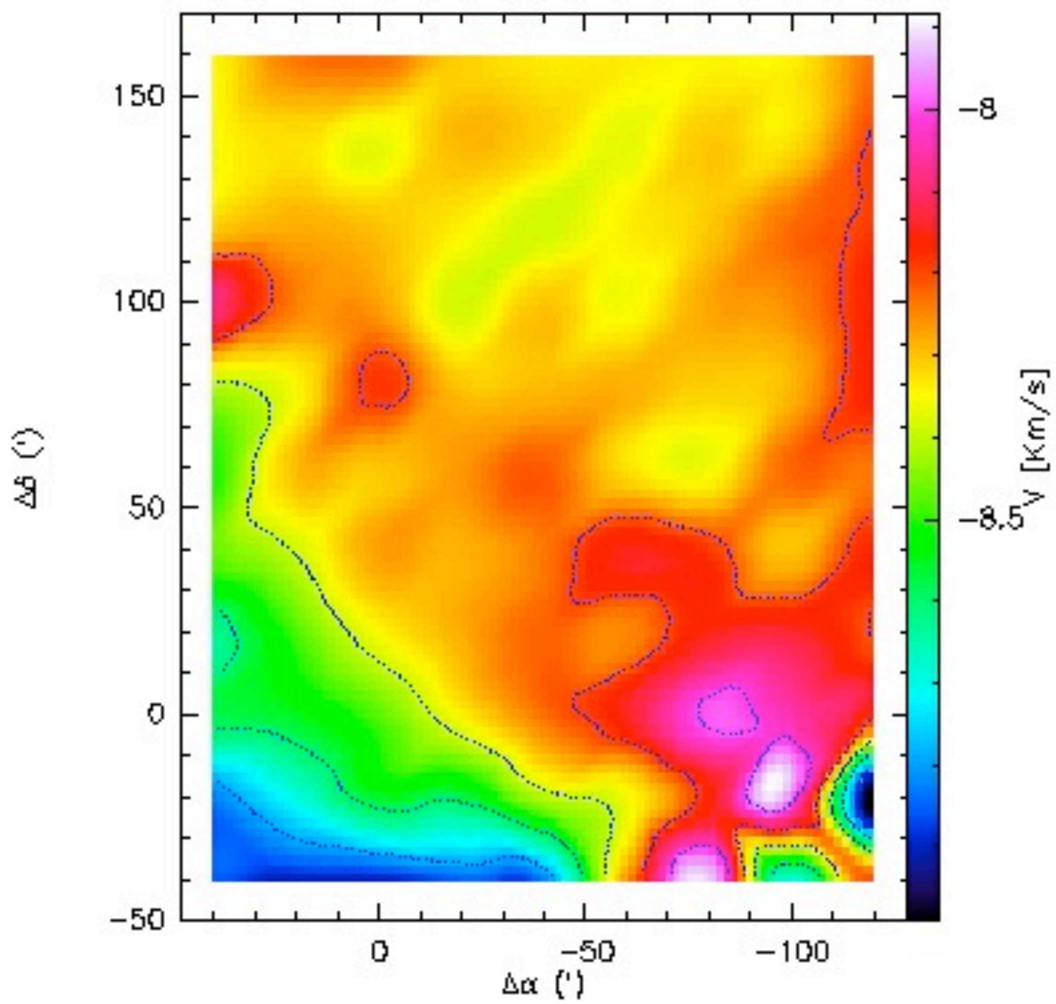

File G105.57+10.39-1_PO_3_BETA2_T.fits
Object
Value 12.614
fk5 α 21:40:27.506 δ +66:35:20.75
Physical X 379.204 Y 344.855
Image X 379.204 Y 344.855
Frame 3 x 5.272 0.000 °
file edit view frame bin zoom scale color region wcs help
none pointer crosshair colorbar pan zoom rotate crop catalog examine
WISE 12μm
Herschel 250μm
Tdust
1.7 3.4 5.2 6.9 8.6 10 12 14 16

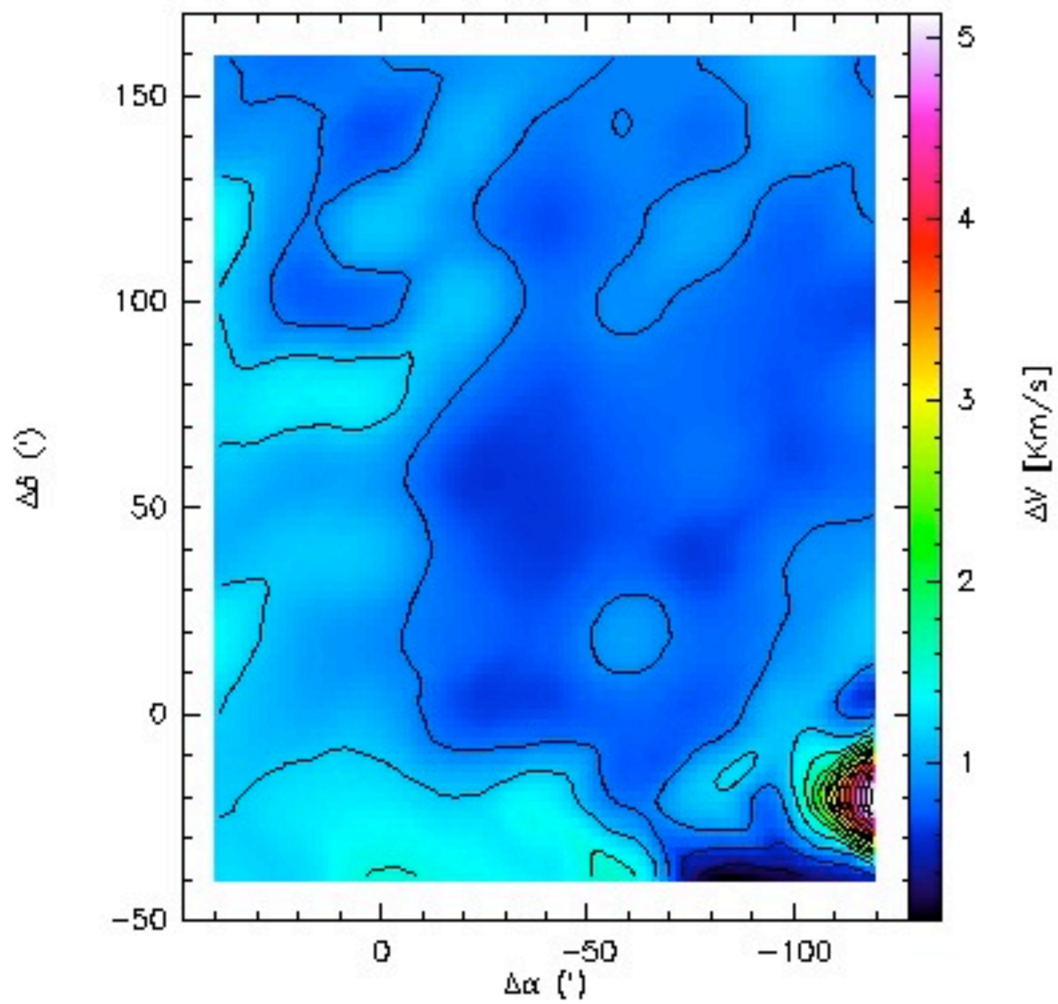
maps: G131.65+9.75

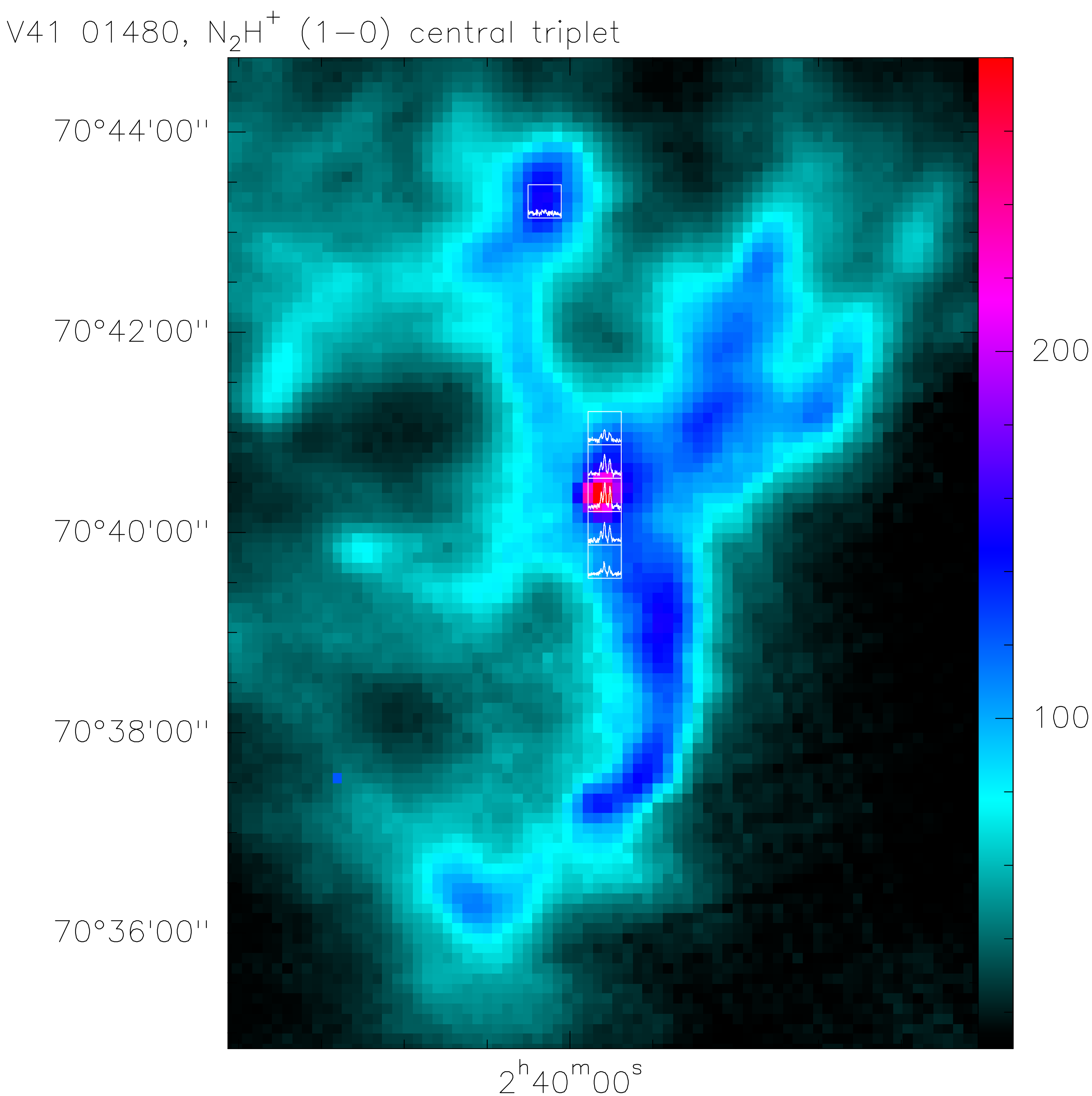
- Position (0, 0): 2h40m11.2s, 70°36'09.5"
- Velocity gradient
- Stable field: no turbulence
- Potential point source in Herschel data



maps: G131.65+9.75



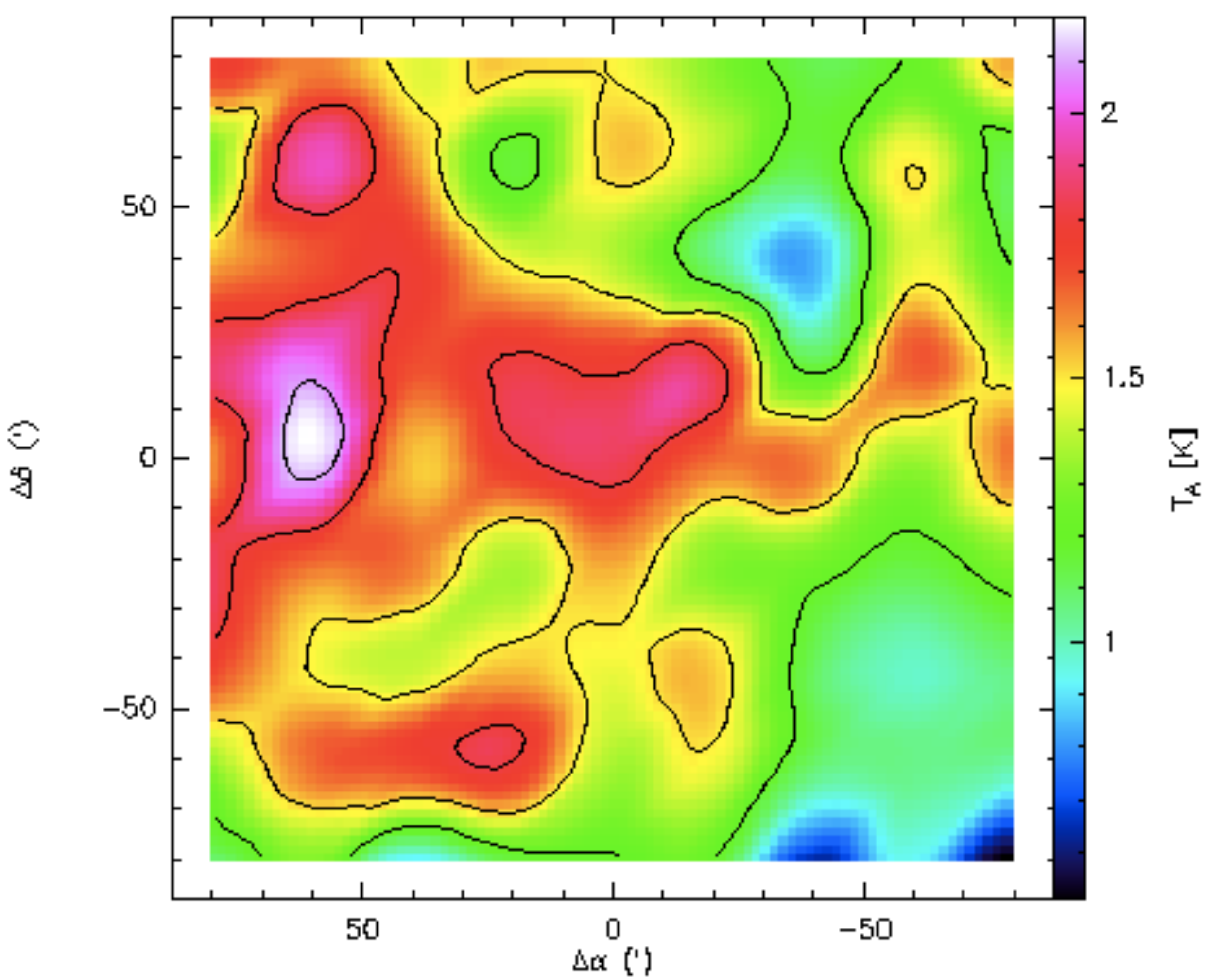


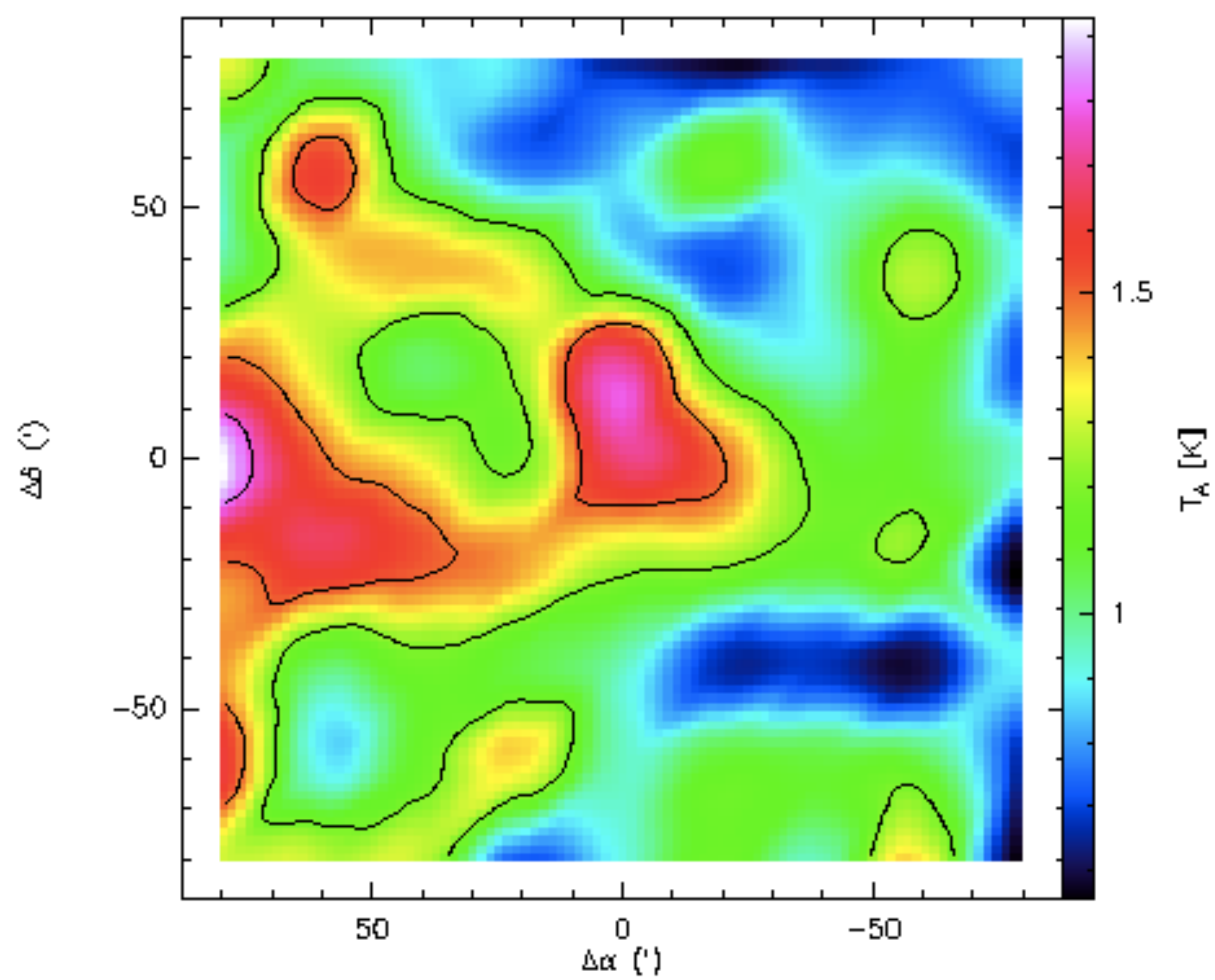


V41 01480, N_2H^+ (1−0) central triplet
70°44'00''
70°42'00''
70°40'00''
70°38'00''
70°36'00''
$2^h40^m00^s$
200
100

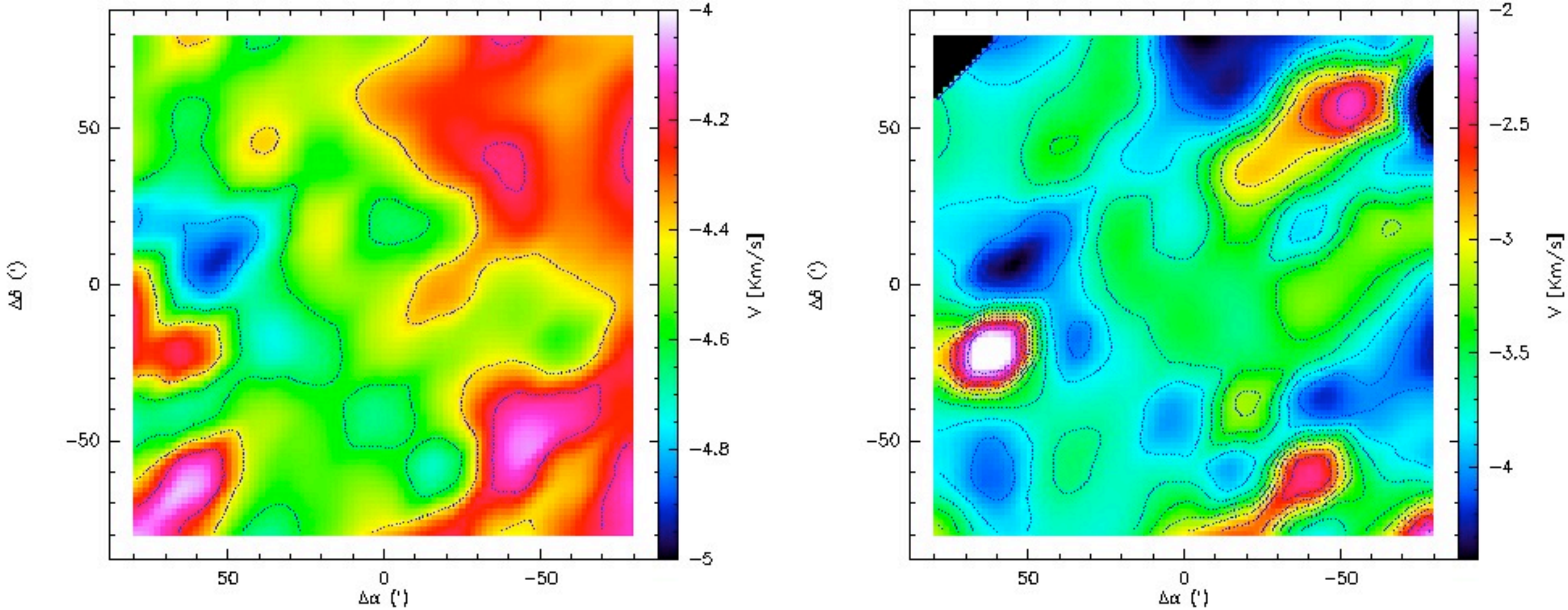
maps: G108.28+16.68

- Position (0, 0): 21h09m08.6s, 72°53’43.2”

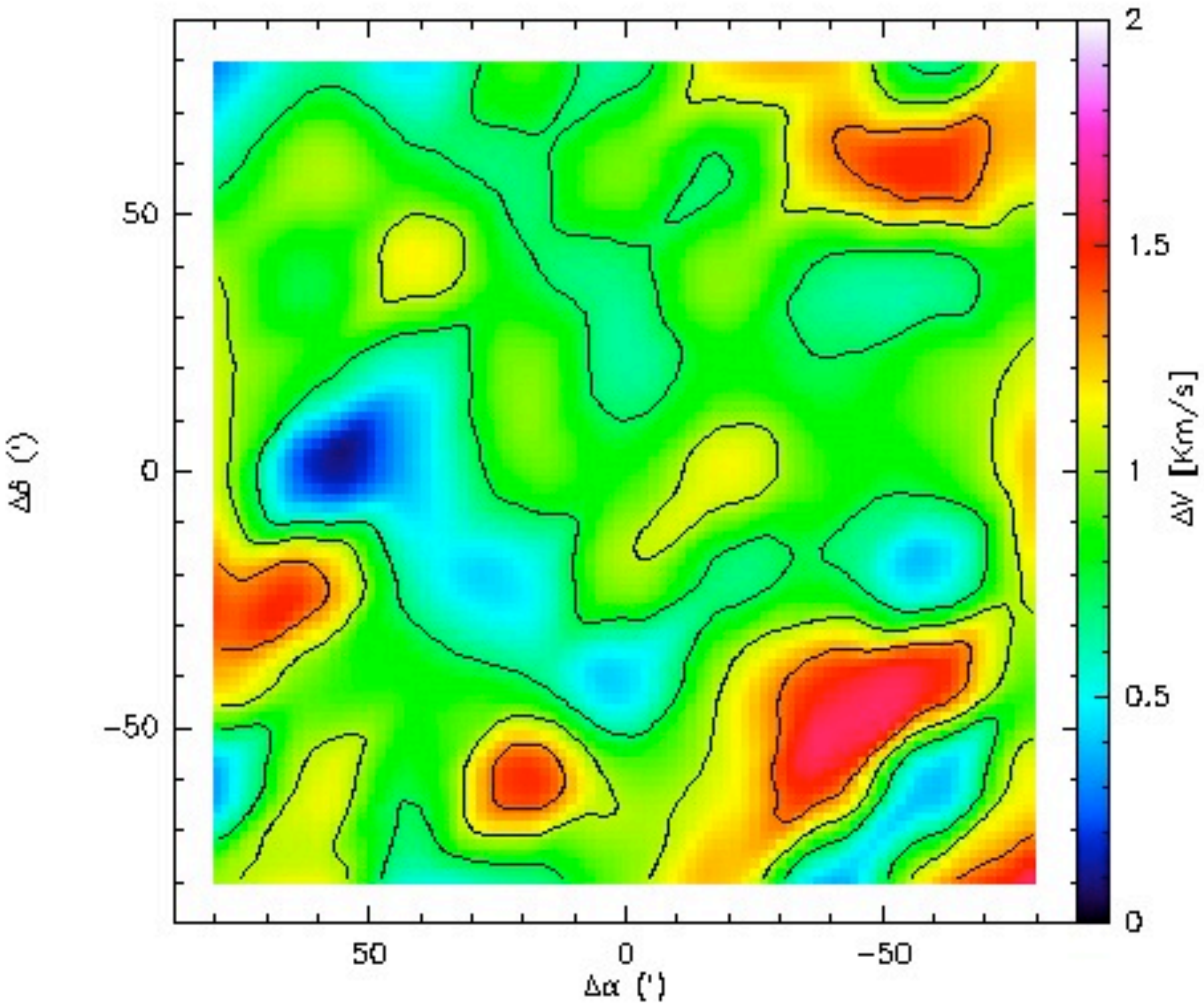


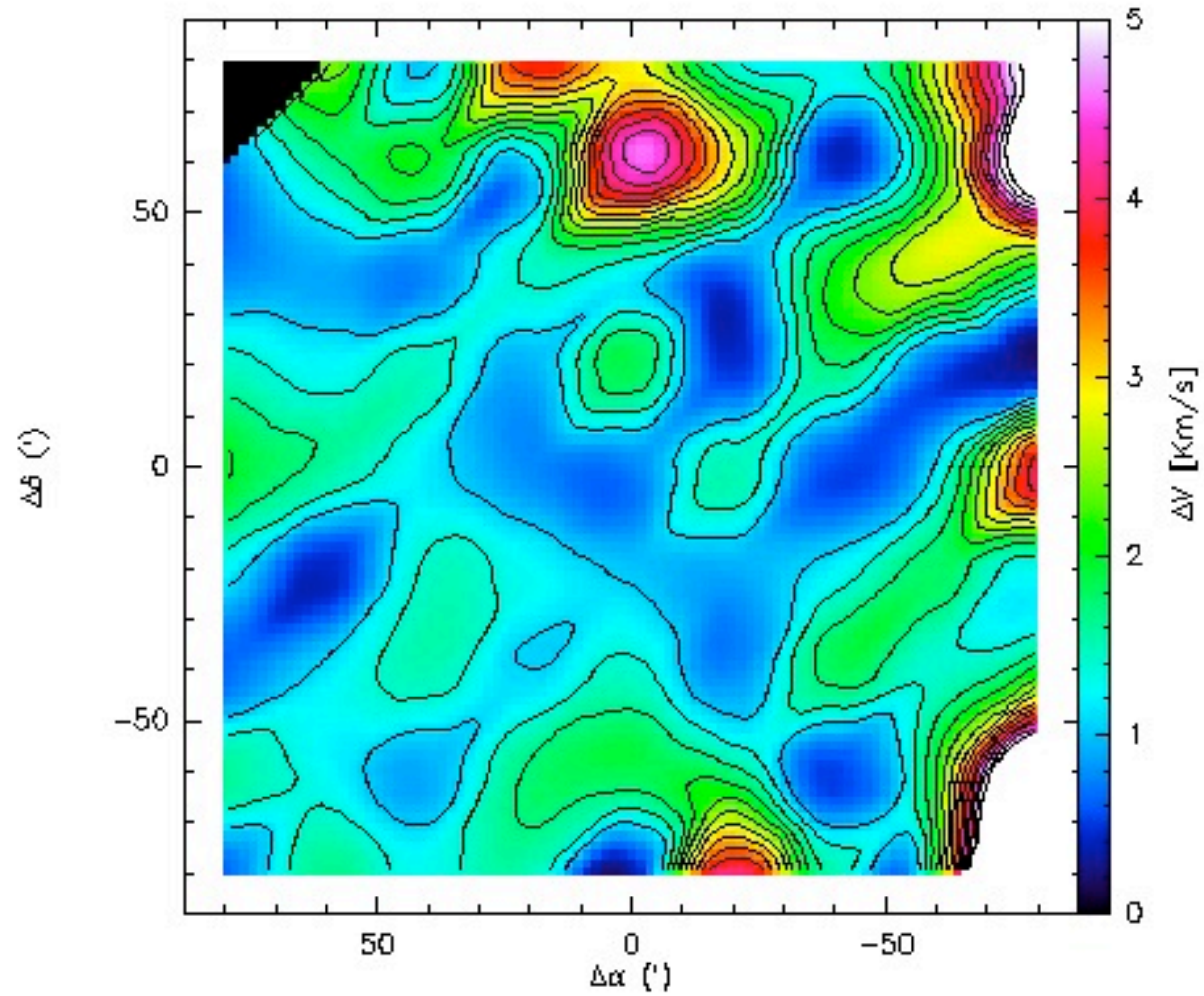


maps: G108.28+16.68



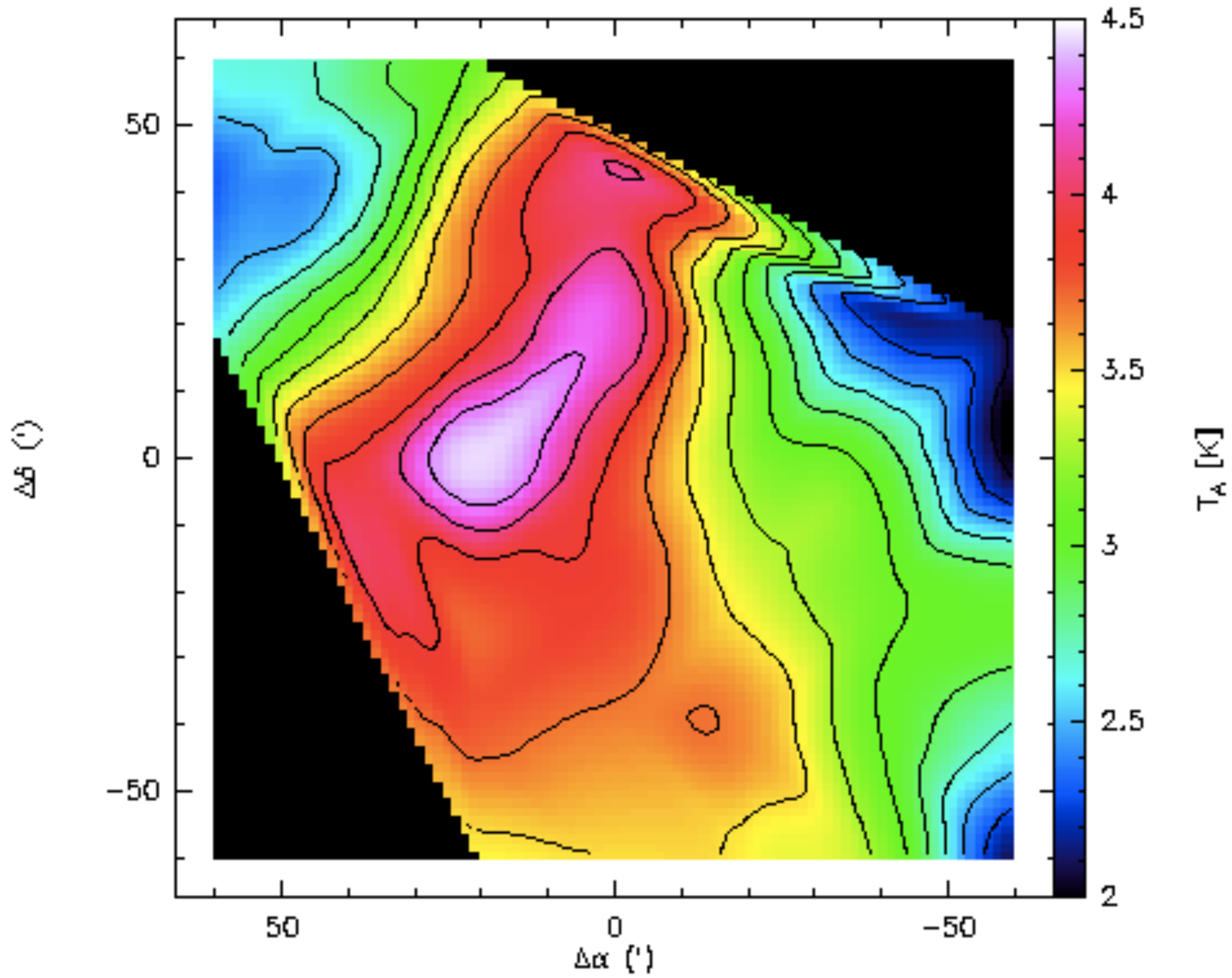
maps: G108.28+16.68



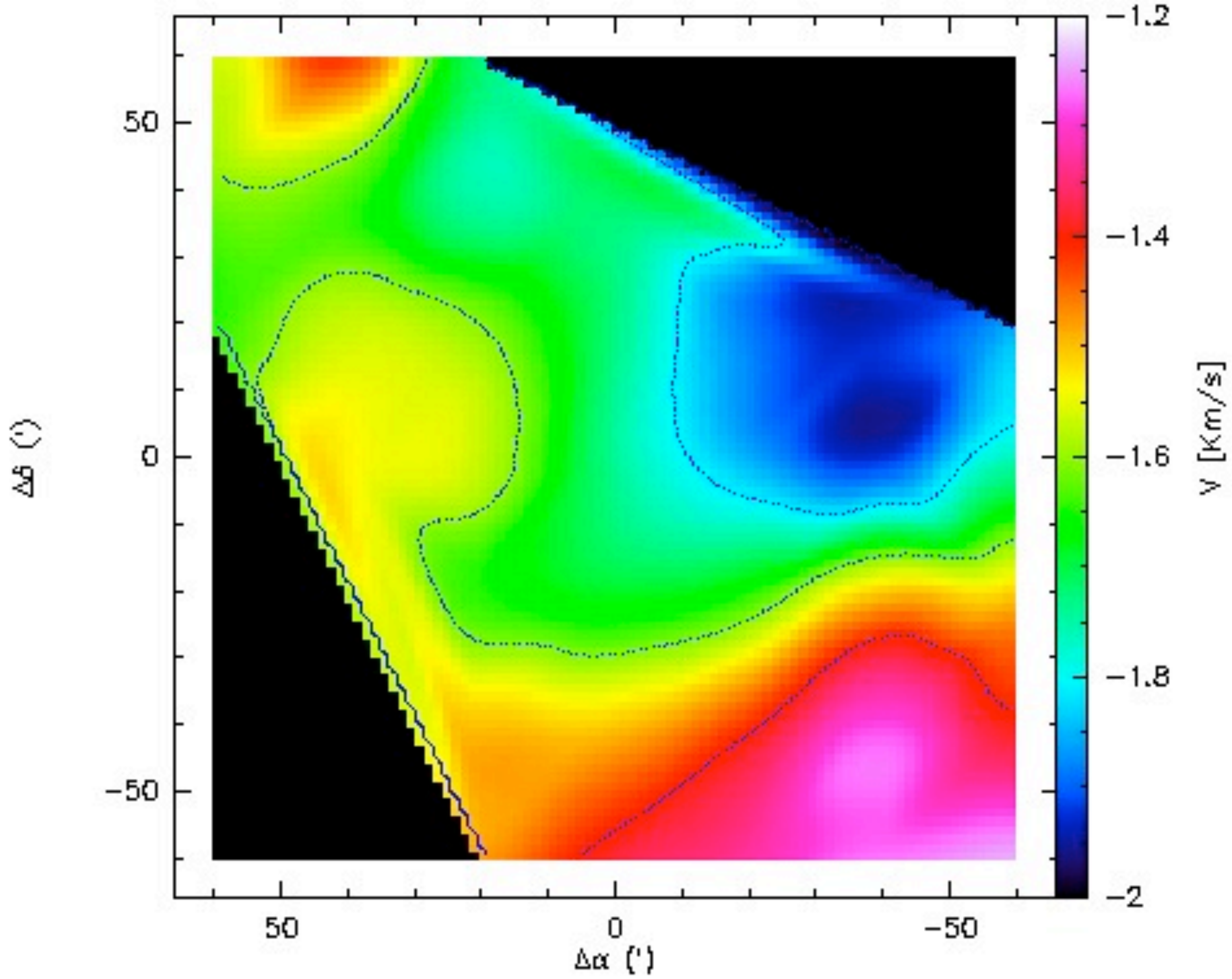


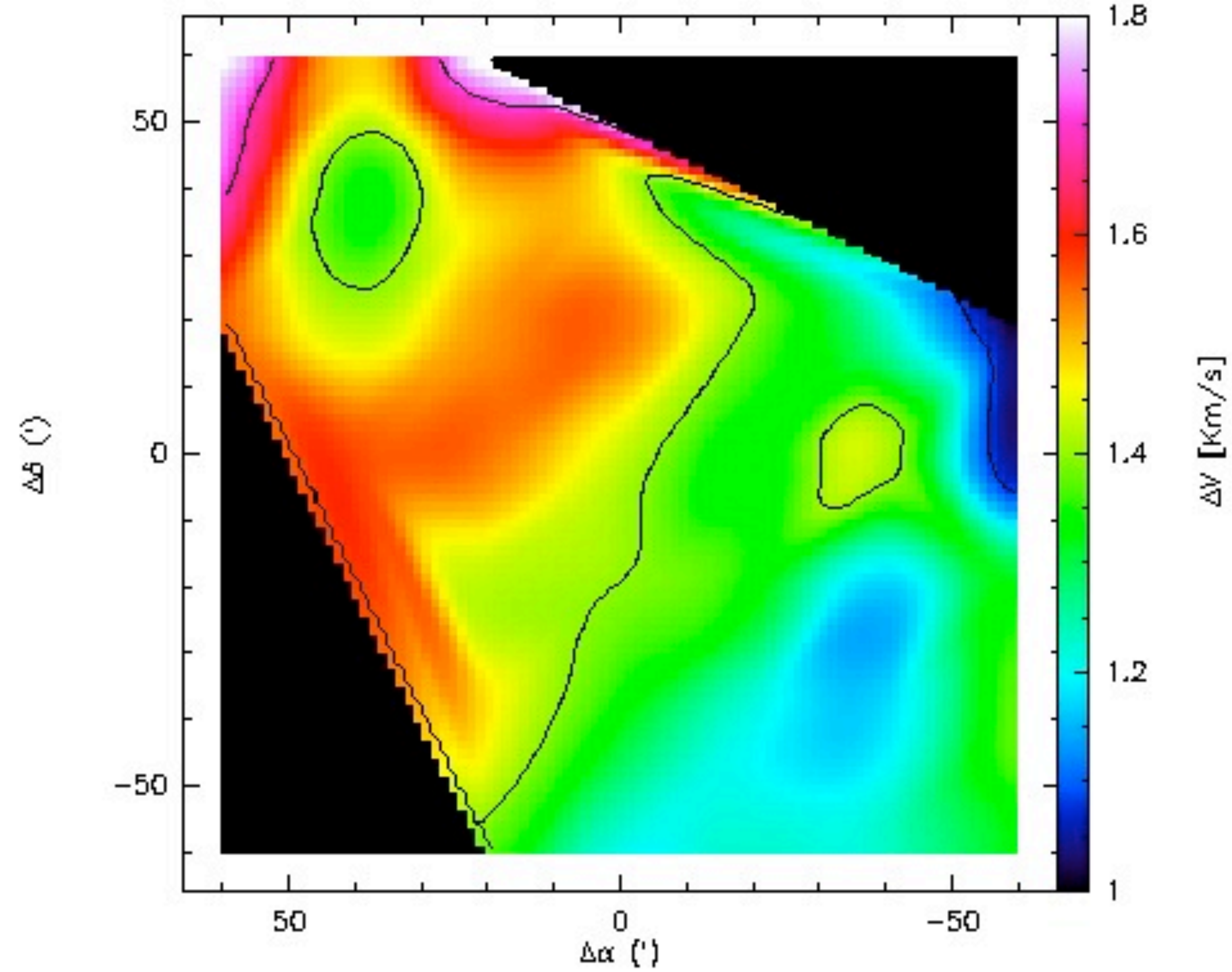
maps: G161.55-9.30

- Position (0, 0): 4h16m15.3s, 37°45’35.0”
- Possible protostar: not visible in Herschel data



maps: G161.55-9.30





Column density

(Myers et al. 1983)

- Basic assumptions:

1. The product of beam efficiency η_b and filling factor Φ is equal for the $C^{18}O$ and ^{13}CO line.
2. The excitation temperature T_{18} of the $C^{18}O$ line is equal to the excitation temperature T_{13} of the ^{13}CO line.
3. Where the ^{13}CO and $C^{18}O$ line peaks are formed, the density of ^{13}CO in the J = 1 state is greater than the density of $C^{18}O$ in the J = 1 state by the ratio of terrestrial abundances: 5.5.
4. In each cloud the ^{13}CO and $C^{18}O$ molecules emitting the observed lines have the same ”velocity gradient” (linewidth/line-of-sight extent of emitting gas).

Column density

(Myers et al. 1983)

- relationship of the optical depths (assumptions + definition of optical depth; $J(T) = T_0[\exp(T_0/T) - 1]^{-1}$; $T_0 = 5.27$ K for $C^{18}O$ and 5.29 K for ^{13}CO):

$$\tau_{13} = \tau_{18} \frac{n_{13}(J=1)}{n_{18}(J=1)} \frac{L_{13}}{L_{18}} \frac{\Delta V_{18}}{\Delta V_{13}} \frac{J(T_{18})}{J(T_{13})}$$

- the ratio of line intensities (assumptions + eq. of radiative transfer):

$$\frac{(T_A^*)_{13}}{(T_A^*)_{18}} = \frac{1 - exp(-5.5\tau_{18})}{1 - exp(-\tau_{18})}$$

Column density

(Myers et al. 1983)

- excitation temperature for $C^{18}O$ (T_b = 2.7 K and $\eta_b\Phi$ = 0.9):

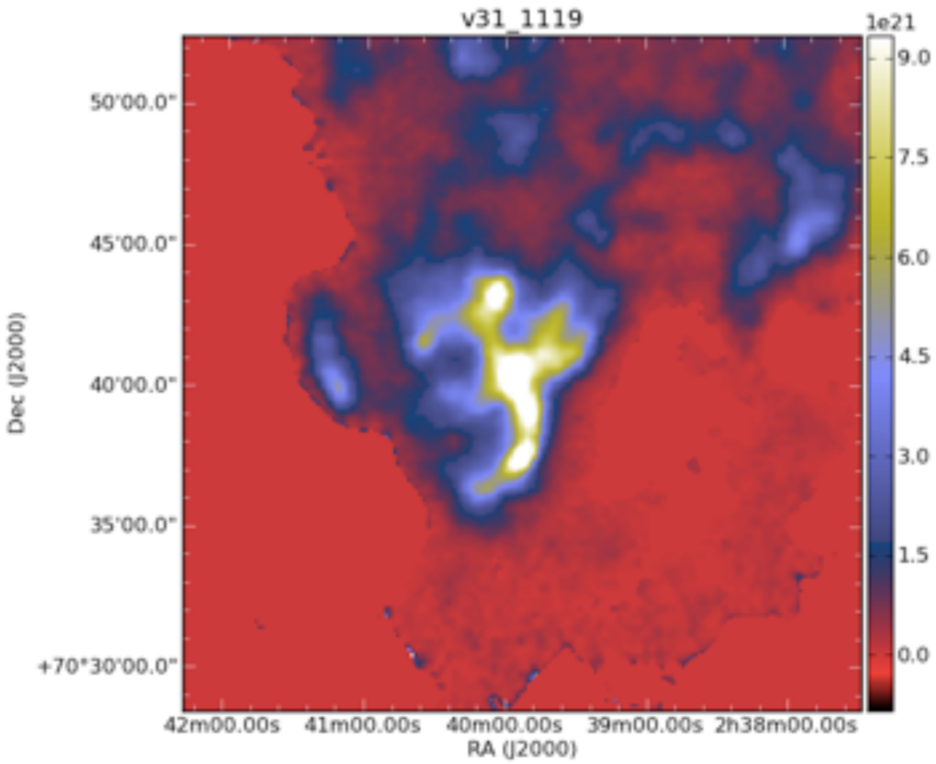
$$T_{18} = T_0\left\{ln\left[1 + \frac{T_0}{J(T_b) + (T_A^*)_{18}/\eta_b\Phi(1 - e^{-\tau_{18}})}\right]\right\}$$

- column density for $C^{18}O$ in the J = 1 state (Gaussian shape):

$$N_{18}(J=1) = 3.86 \times 10^{14}\tau_{18}J(T_{18})\Delta v_{18}cm^{-2}$$

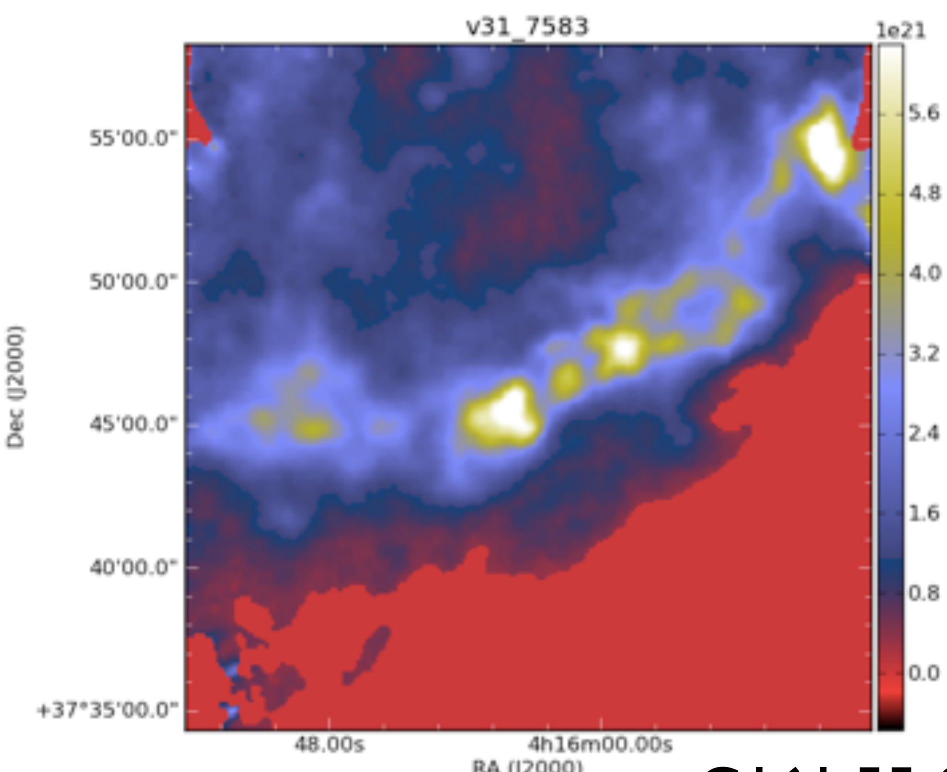
- total column density: $N_{18}(J=1)$ multiplied by classical partition function ratio ($f_1^{-1} = \frac{\Sigma_{J=0}^{J_{max}}(2J+1)exp[-hBJ(J+1)/kT_{18}]}{3exp[-2hB/kT_{18}]}$)

Dust column density

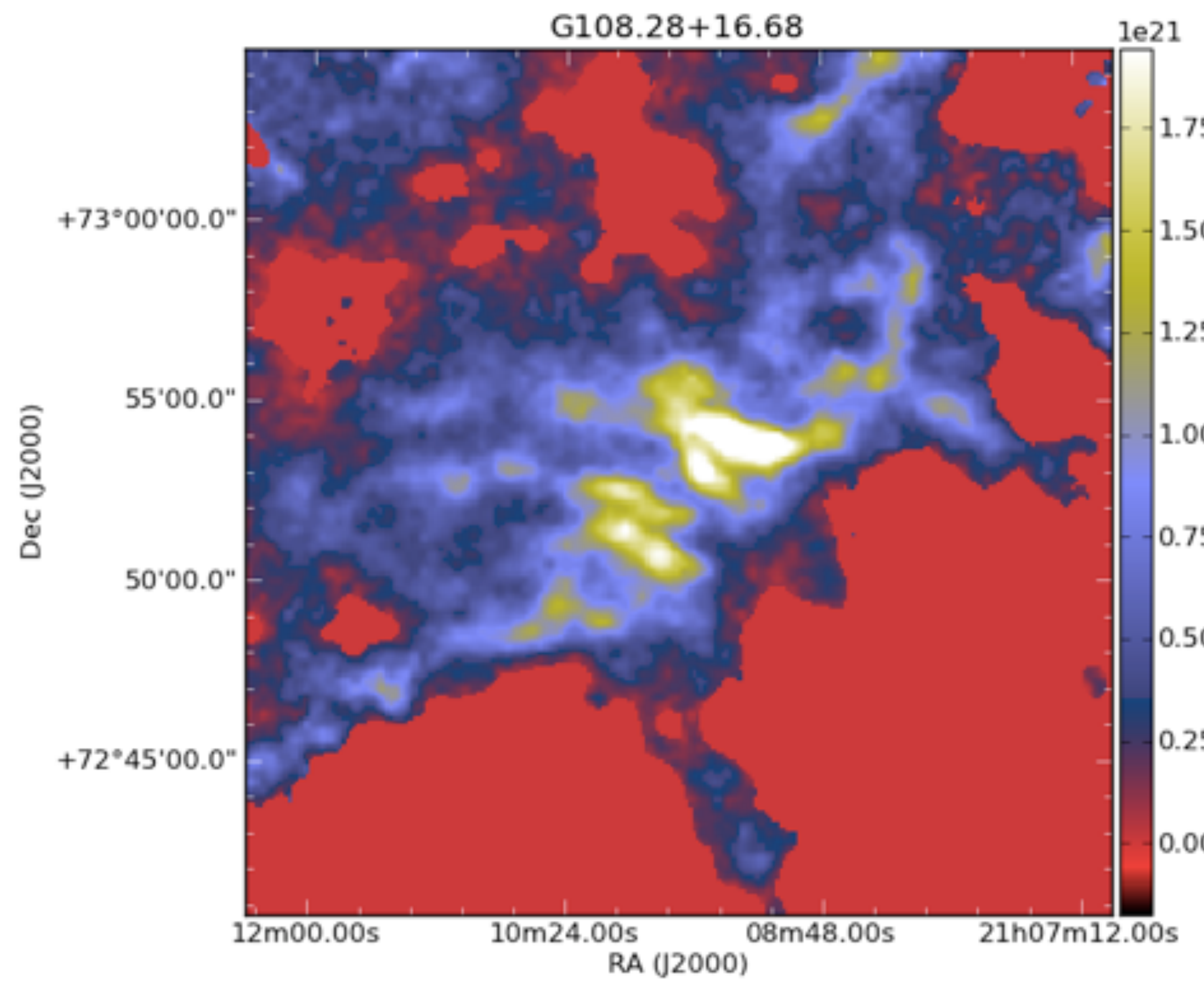


G131.65+9.75

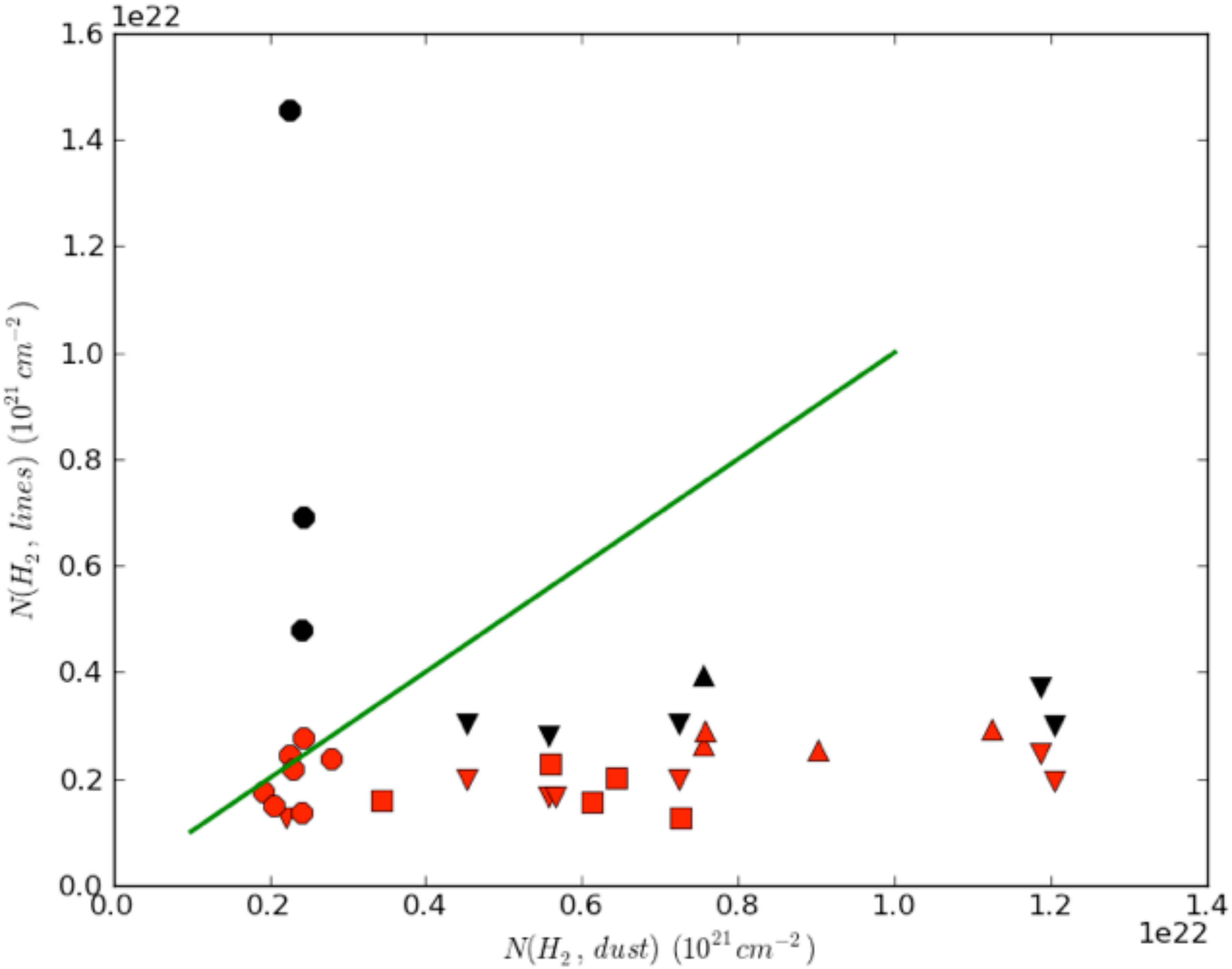
$$N(H_2) = \frac{I_\nu}{B_\nu(T)\kappa_\nu}$$



G161.55-9.30



Column densities compared to dust



Estimates on core mass and density

- G131.65+9.75:
  - south (core r: 0.3' , dist: 400.0 pc):
    - calculated: mass 0.258 $M_\odot$, average density 1.404×10^4
    - estimated (T_{ex}=10K): mass 0.170 $M_\odot$, average density 9.270×10^3
  - north (core r: 0.3' , dist: 400.0 pc): estimated: mass 0.249 $M_\odot$, average density 1.358×10^4
- G108.28+16.68:

  (core r: 0.9' , dist: 450.0 pc) estimated: mass 2.312 $M_\odot$, average density 3.279×10^3
- G161.55-9.30:

  (core r: 1.0' , dist: 350.0 pc) estimated: mass 0.908 $M_\odot$, average density1.995×10^3

Summary

- Past Planck and Herschel data as a background
- Selected fields seem to be quite different
- Column densities compared to dust seem different
- Mass and density: order of magnitude seems correct