Chemical structure in NGC 3603

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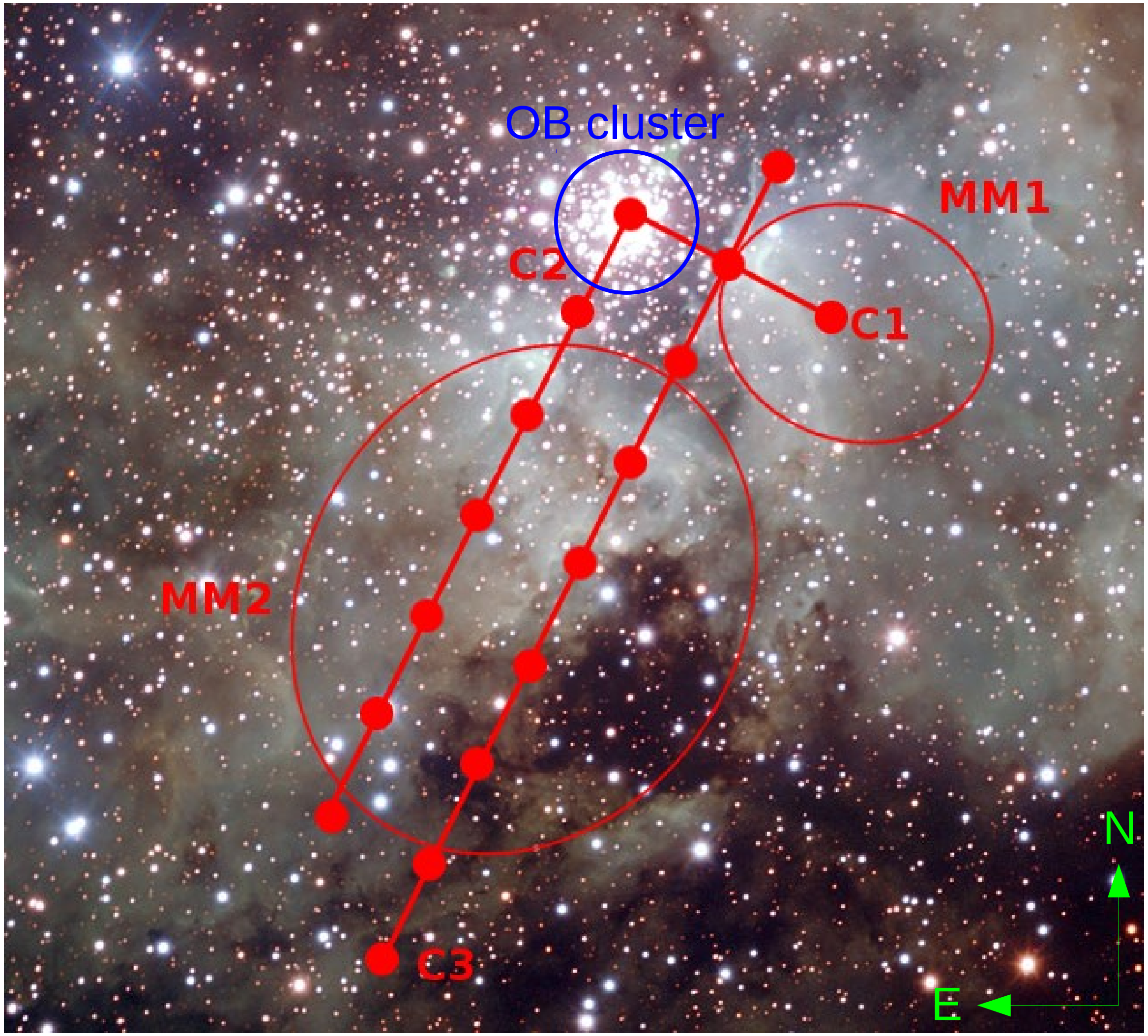
Outline

- Basic information about the source
- Observations, data analyzes
  - HIFI
  - PACS
- Results (few examples)
- Summary
- Future works

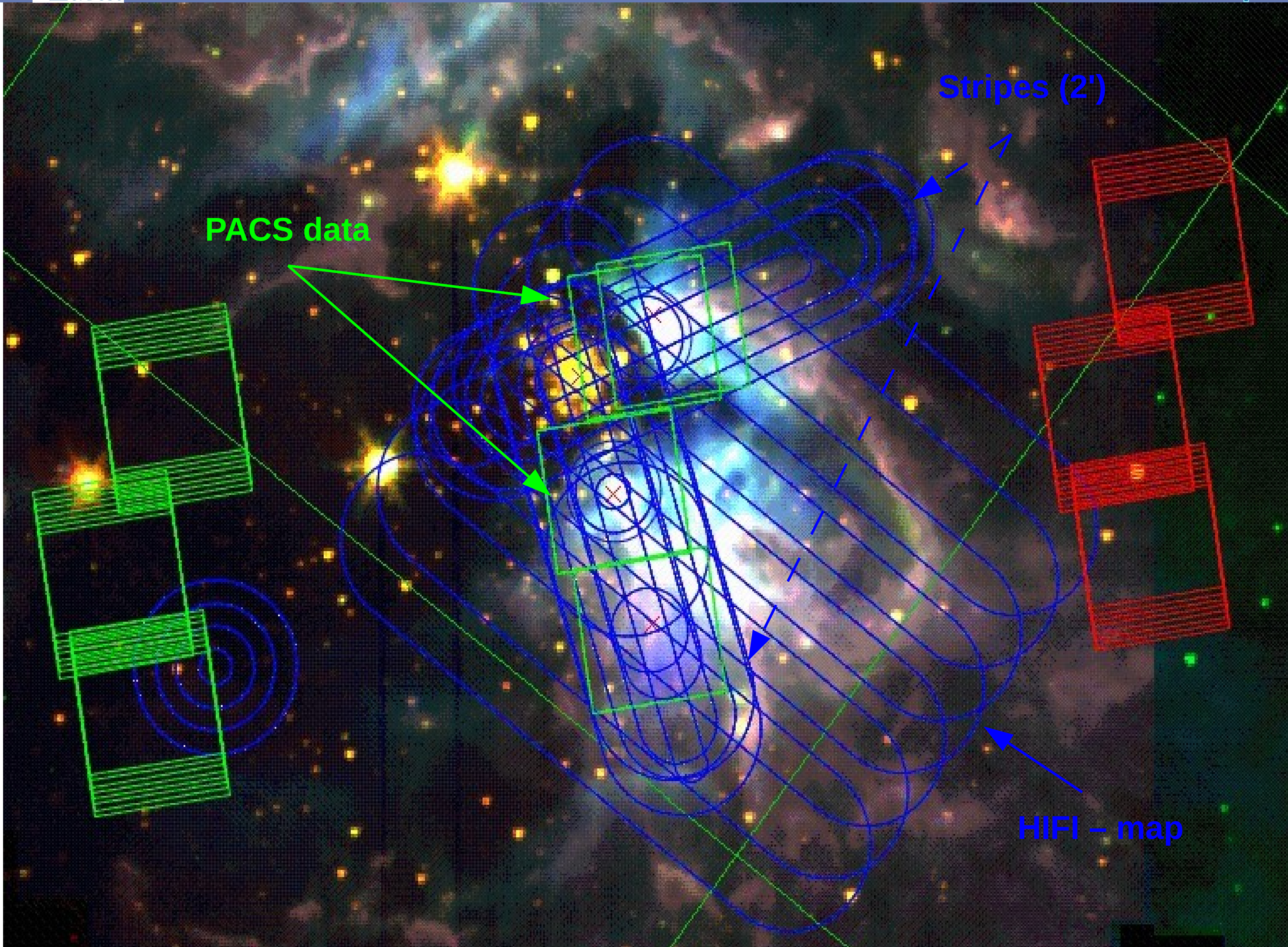
NGC 3603

- *Location:* in Carina spiral arm in the southern hemisphere
- *Coordinates (ep. 2000):* $\alpha = 11^h\ 15^m\ 9.1^s$; $\delta = -61°\ 16'\ 17''$
- *Distance:* ~7 – 8 kpc
- *Luminosity:* $L_{bol} > 10^7\ L_{Sun}$ → 100 times more luminous than Orion Nebula
- *UV-field:* $X \sim 10^6$ Draine
- *Central cluster:* massive ($M_{total} > 4000\ M_{sun}$) and young ($\sim 2.5 \times 10^6$ y) cluster with dozen O-type stars
- *Two clumps:*
  - **MM1** → $M_{vir} < 0.7 \times 10^3\ M_{Sun}$; $\langle N(H_2) \rangle > 10^{23}$ cm^{-2}
  - **MM2** → $M_{vir} = 1.5 \times 10^3\ M_{Sun}$; $\langle N(H_2) \rangle = 0.4 \times 10^{23}$ cm^{-2}



Three cuts:
C1: 3 positions toward MM1
C2: 7 positions toward MM2
C3: 9 positions toward MM2

Observation plan



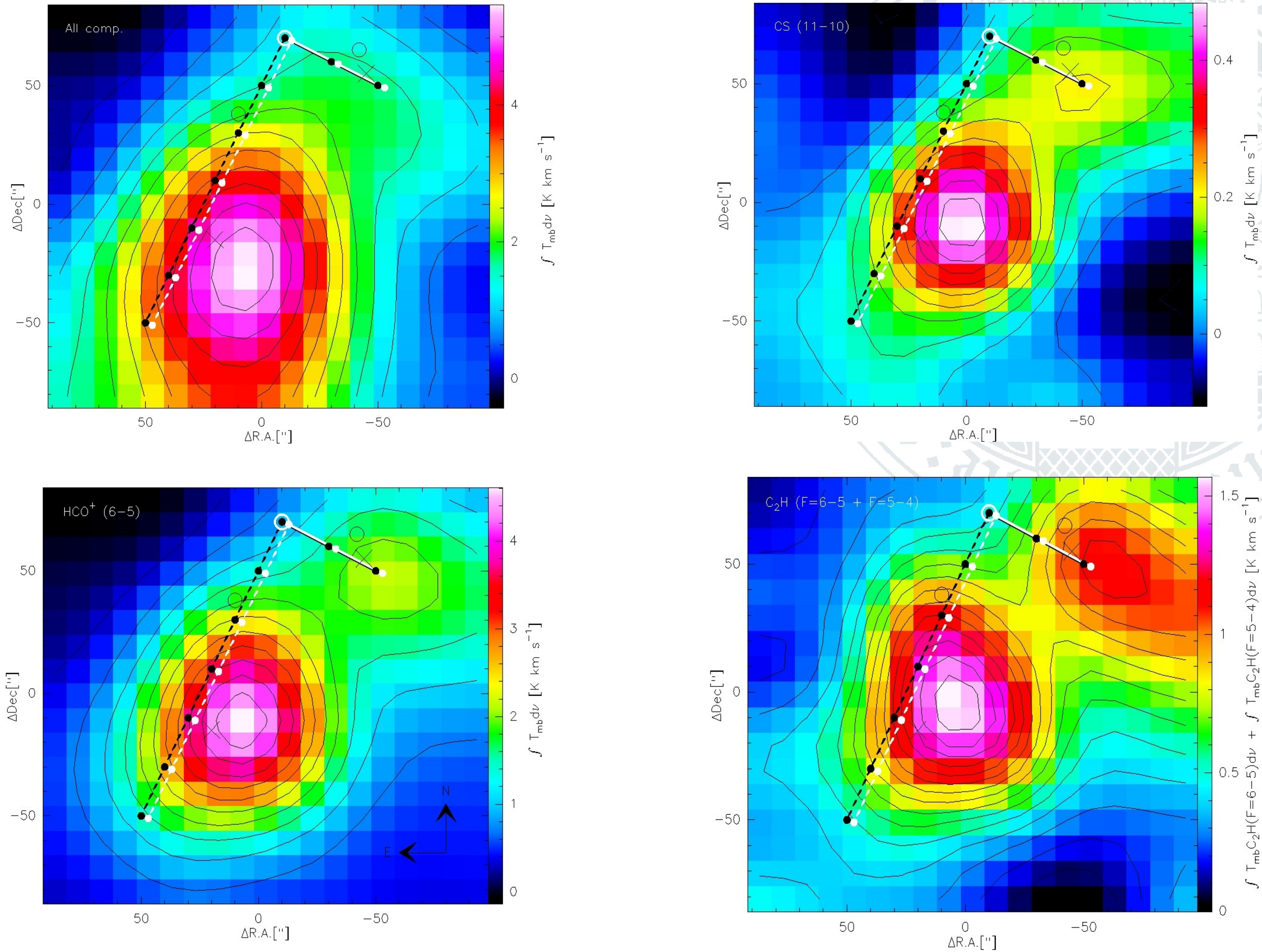
Observed molecules in NGC 3603 I. (HIFI)

Obs. type	Obsid	Molecule	Transition	Frequency [GHz]	Beam ["]	Δv [km/s]
OTF map	1342201692	CH	$N_J = 1_{3/2} - 1_{1/2}$, F = 2 – 1	536.761	43.5	0.7
				536.782		
				536.796		
		C_2H	$N_J = 6_{13/2} - 5_{11/2}$, F = 6 – 5	523.972		
			$N_J = 6_{11/2} - 5_{9/2}$, F = 5 – 4	524.034		
		HCO^+	J = 6 – 5	538.689		
		CS	J = 11 – 10	535.062		
Cuts	1342201675	o–H_2O	$1_{10} - 1_{01}$	556.936	37.7	0.7
		NH_3	$1_{00} - 0_{00}$	572.498		
	1342201676	o–H_2O	$1_{10} - 1_{01}$	556.936		
		NH_3	$1_{00} - 0_{00}$	572.498		
	1342201750	^{12}CO	J = 9 – 8	1036.912	22.5	2.91
	1342201752	^{12}CO				
	1342201809	^{13}CO	J = 10 – 9	1101.350	20.8	0.7
	1342201810	^{13}CO				
	1342201818	$^{12}C^+$	$^2P_{3/2} - {}^2P_{1/2}$	1900.537	12.2	
	1342201819	$^{12}C^+$				

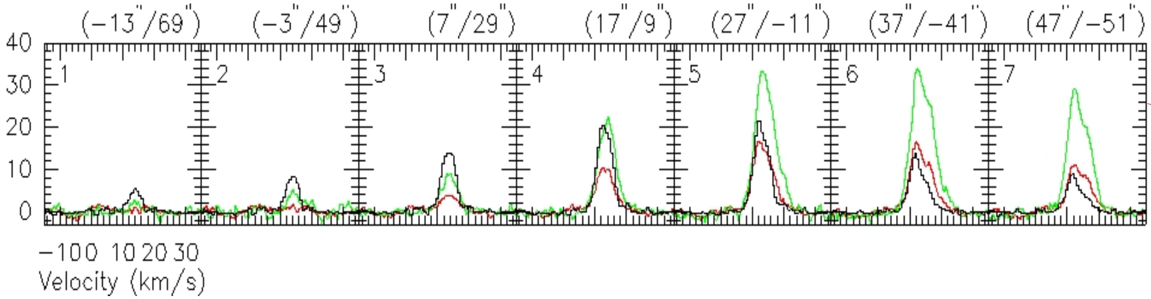
Observed molecules in NGC 3603 II. (HIFI)

Obs. type	Obsid	Molecules	Transition	Frequency [GHz]	Beam ["]	Δv [km/s]
Point	1342223427	NH	N = 1 – 0, J = 2 – 1	974.450	22.5	0.7
		H_2O	$2_{02} - 1_{11}$	987.927		
		$C^{18}O$	J = 8 – 7	987.560		
	1342223428	NH	N = 1 – 0, J = 2 – 1	974.450		
		OH^+	J = 1 – 0, F = 5/2 – 3/2	971.800		
	1342223429	NH	N = 1 – 0, J = 2 – 1	974.450		
		H_2O	$2_{02} - 1_{11}$	987.927		
		$C^{18}O$	J = 8 – 7	987.560		
	1342223430	NH	N = 1 – 0, J = 2 – 1	974.450		
		H_2O	$2_{02} - 1_{11}$	987.927		
		$C^{18}O$	J = 8 – 7	987.560		
	1342225899	NH	N = 1 – 0, J = 2 – 1	974.450		
		OH^+	J = 1 – 0, F = 5/2 – 3/2	971.800		
	1342225900	NH	N = 1 – 0, J = 2 – 1	974.450		
		OH^+	J = 1 – 0, F = 5/2 – 3/2	971.800		

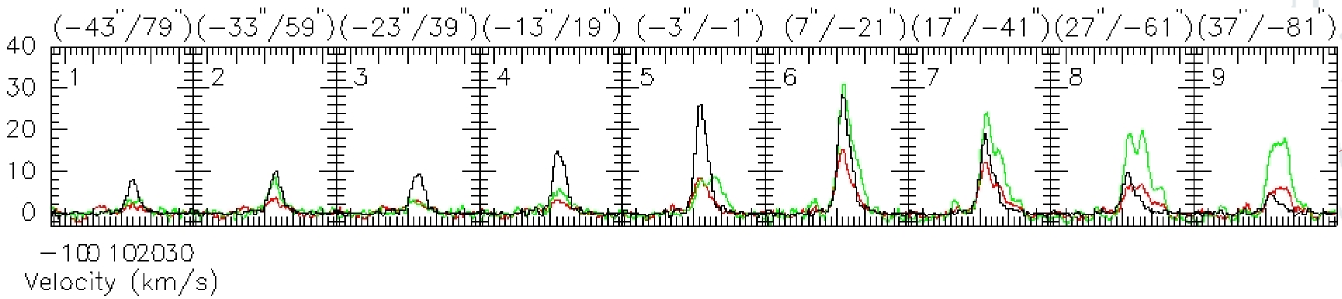
Integrated intensity maps (HIFI)



Investigation of the spectra along the cuts I. (HIFI)

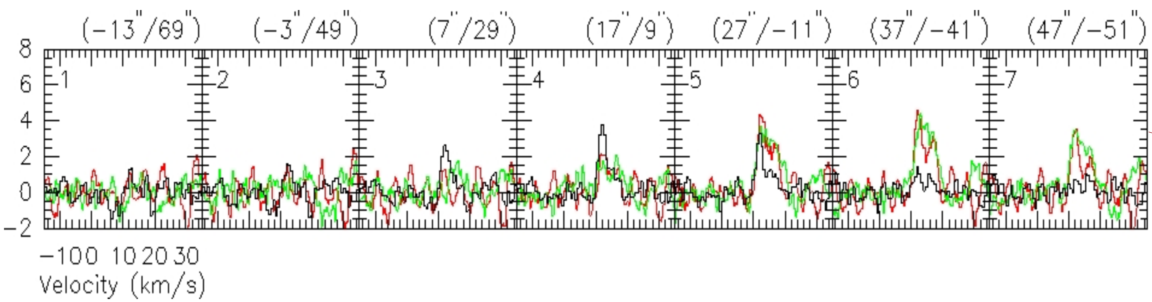


C2

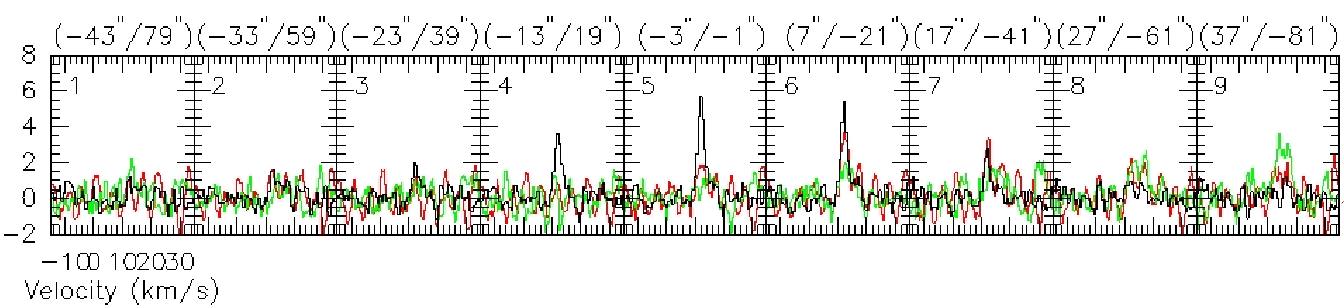


C3

HCO$^+$ (6 – 5) (scaled up by 36)
CO (4 – 3)
CO (7 – 6)



C2



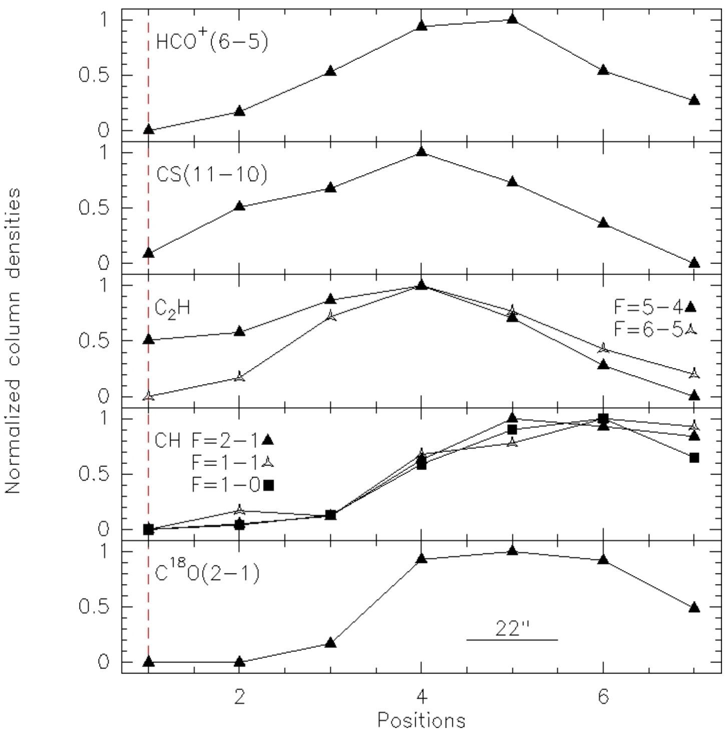
C3

CS (11 – 10) (scaled up by 50)
[CI] ($^3P_1$ – $^3P_0$)
[CI] ($^3P_2$ – $^3P_1$)

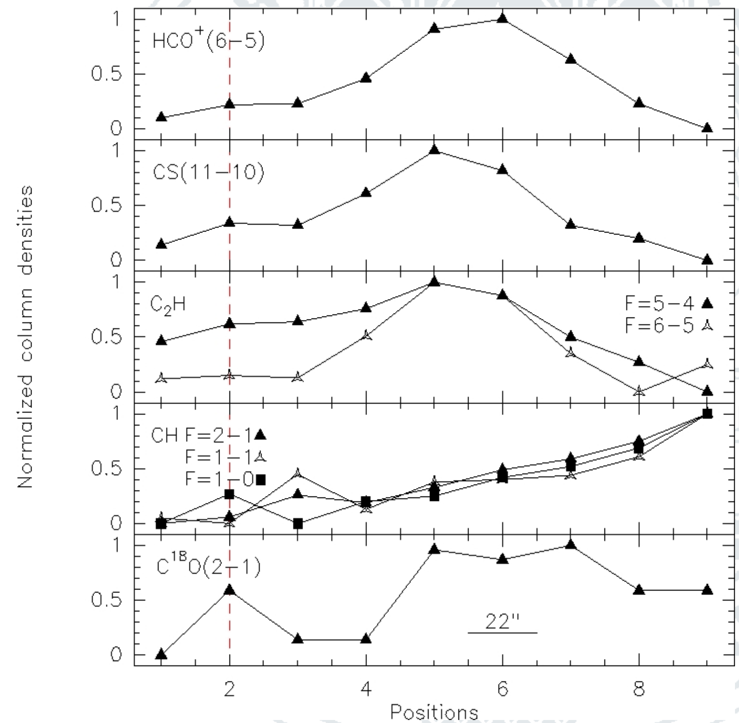
Investigation of the spectra along the cuts II. (HIFI)

Column densities

C2

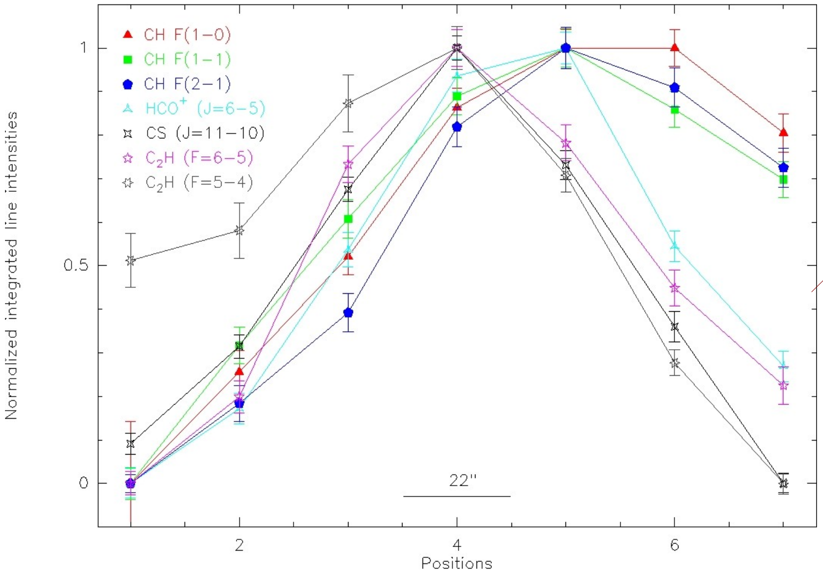


C3

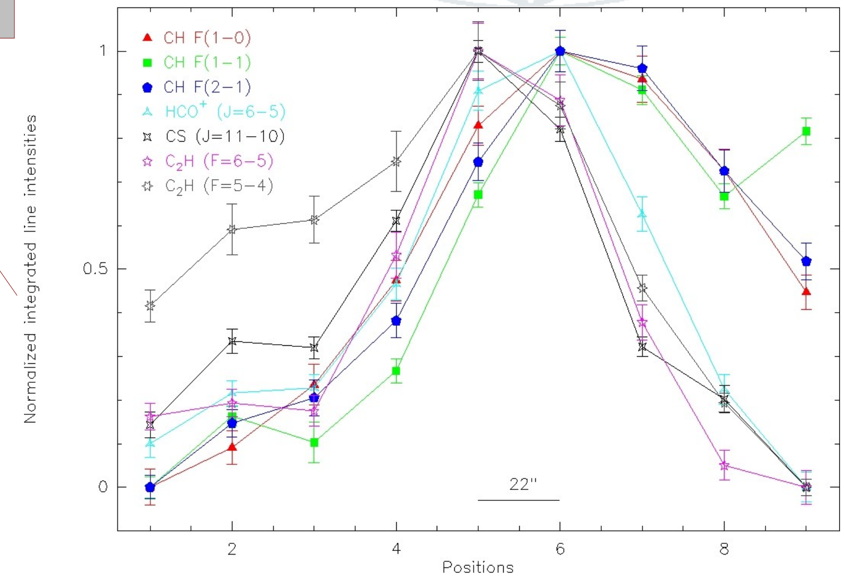


Int. intensities

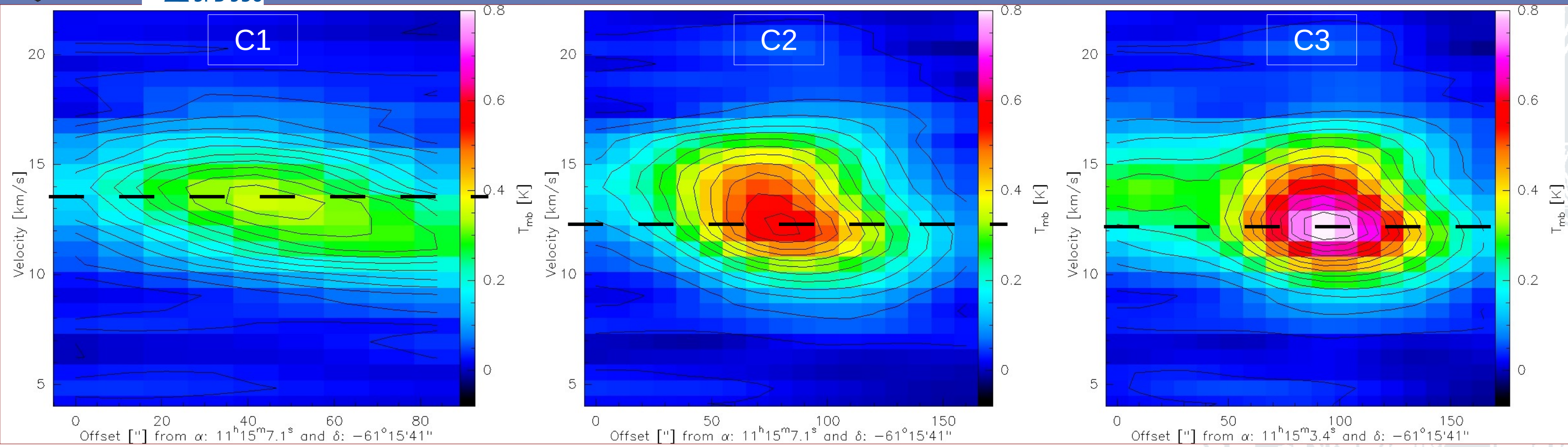
C2



C3

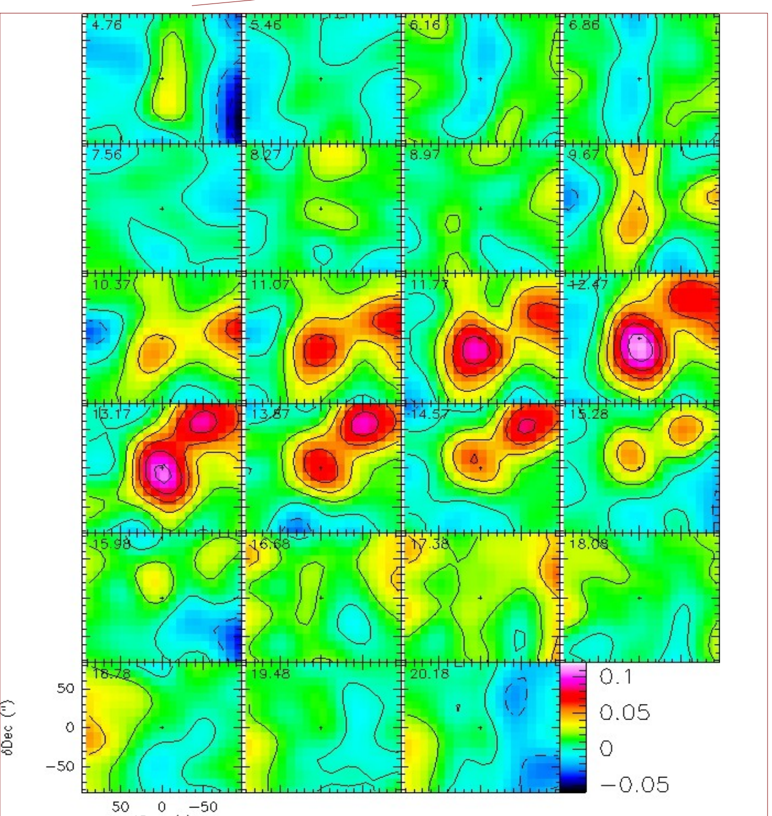


Signs of gas movements in the clumps

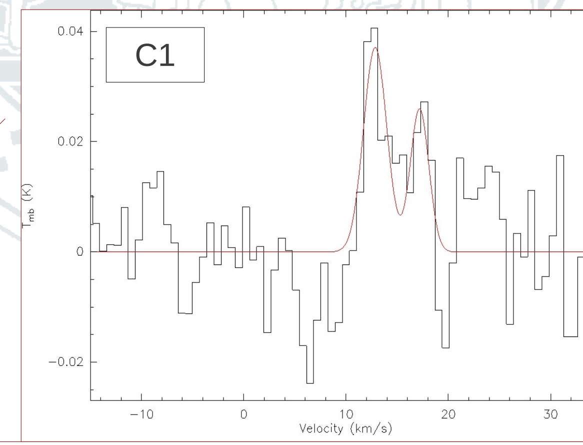


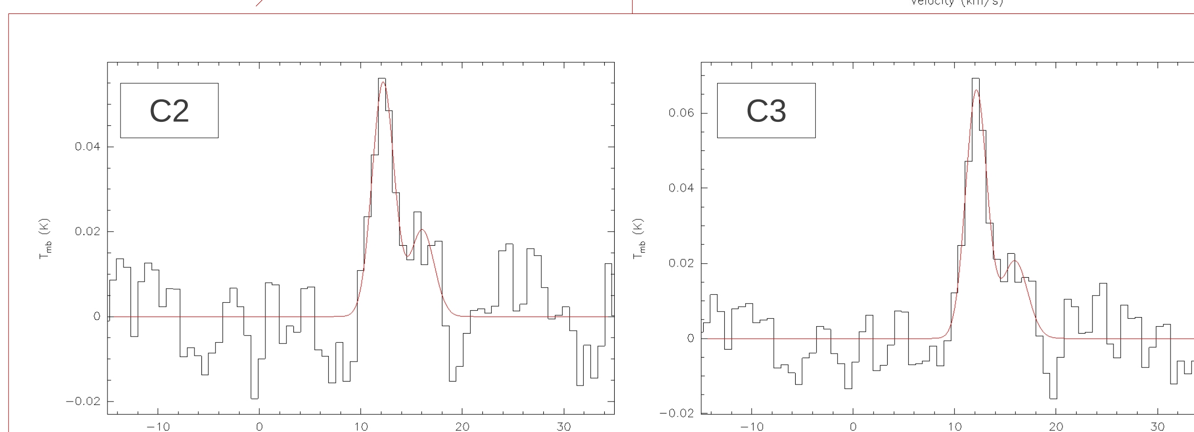
PV-diagram (HCO^+)
Velocity shifts between the clumps

Channel map of CCH (5–4)
Strong intensity fluctuations between MM1 and MM2

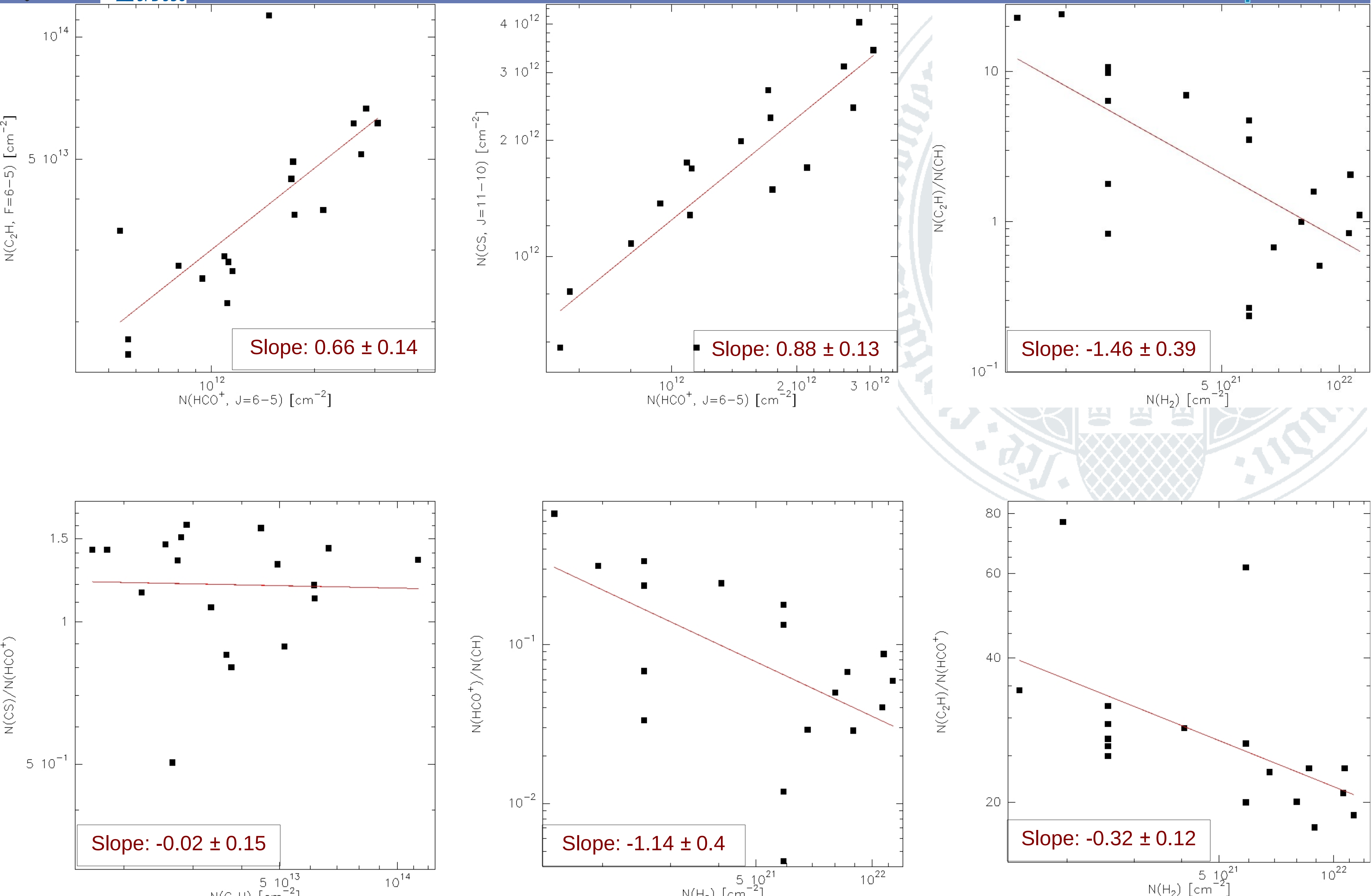


Averaged spectra of CS
Second component appears





Chemistry (HIFI)



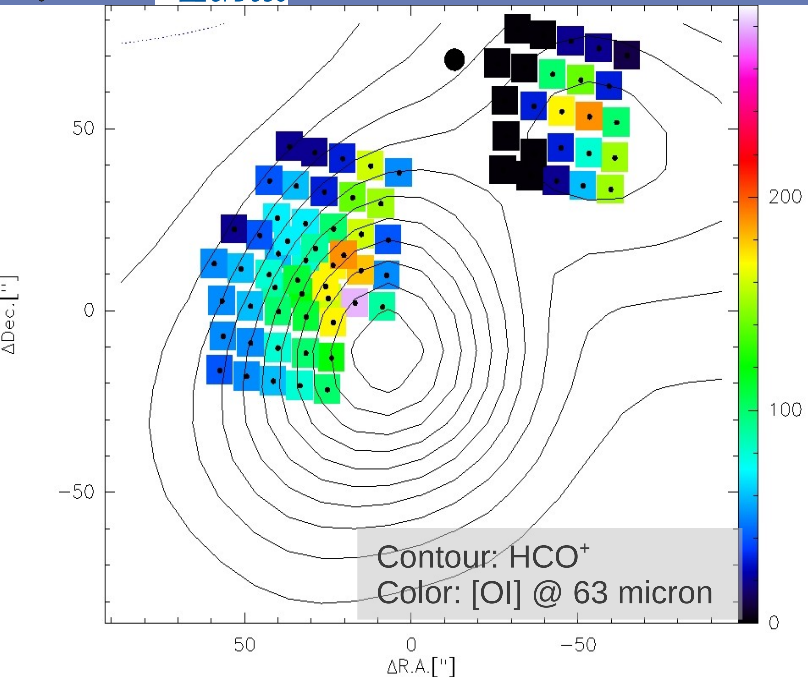
Observed species I. (PACS)

Obs. type	Obsid.	Side	Molecules	Transition	λ [micron]
Line spectr.	1342214681	Blue	[NIII]	$^2P_{3/2} - {}^2P_{1/2}$	57.343
			[OI]	$^3P_1 - {}^3P_2$	63.184
	1342214684		[NIII]	$^2P_{3/2} - {}^2P_{1/2}$	57.343
			[OI]	$^3P_1 - {}^3P_2$	
	1342214687		[OI]	$^3P_1 - {}^3P_2$	63.184
Range spectr.	1342214682	Blue	[OI]	$^3P_1 - {}^3P_2$	
			^{12}CO	J = 36 – 35	72.850
			[OIII]	$^3P_0 - {}^3P_1$	88.356
		Red	[OI]	$^3P_1 - {}^3P_0$	145.535
			[CII]	$^3P_{1/2} - {}^3P_{3/2}$	157.741
			^{12}CO	J = 16 – 15	162.820
				J = 15 – 14	173.630
				J = 14 – 13	186.010
				J = 13 – 12	200.270
	1342214685	Blue	[OI]	$^3P_1 - {}^3P_2$	63.184
			^{12}CO	J = 36 – 35	72.850
			[OIII]	$^3P_0 - {}^3P_1$	88.356

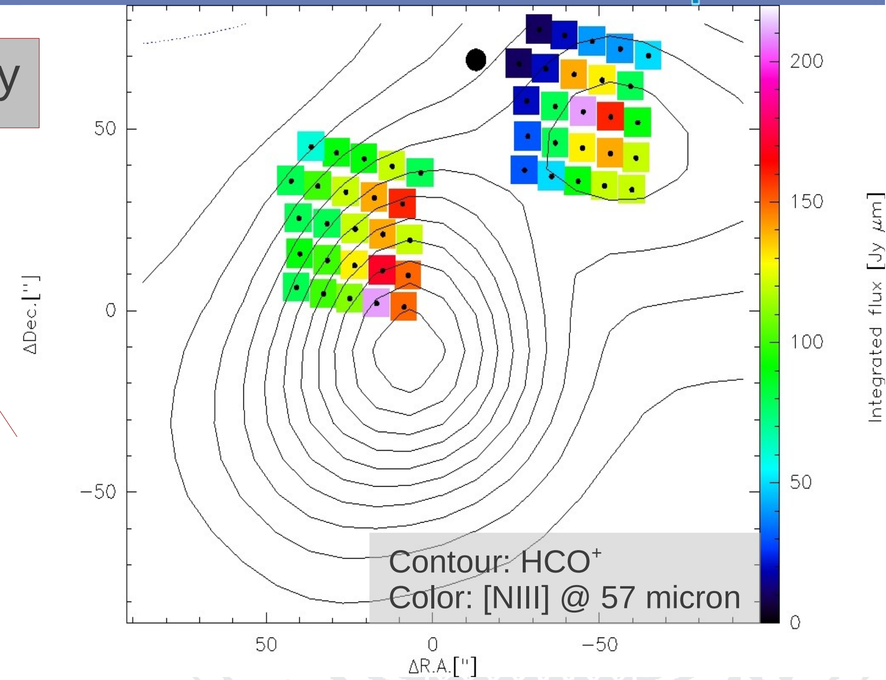
Observed species II. (PACS)

Obs. type	Obsid.	Side	Molecules	Transition	λ [micron]
Range spectr.	1342214685	Red	[OI]	$^3P_1 - ^3P_0$	145.535
			[CII]	$^3P_{1/2} - ^3P_{3/2}$	157.741
			^{12}CO	J = 16 – 15	162.820
				J = 15 – 14	173.630
				J = 14 – 13	186.010
				J = 13 – 12	200.270
	1342214688	Blue	[OI]	J = 36 – 35	63.184
			^{12}CO	$^3P_0 - ^3P_1$	72.850
			[OIII]	$^3P_1 - ^3P_0$	88.356
		Red	?	?	122.500
			[NII]	$^3P_2 - ^3P_1$	121.898
			[OI]	$^3P_1 - ^3P_0$	145.535
			[CII]	$^3P_{1/2} - ^3P_{3/2}$	157.741
			^{12}CO	J = 16 – 15	162.820
				J = 15 – 14	173.630
				J = 14 – 13	186.010
				J = 13 – 12	200.270

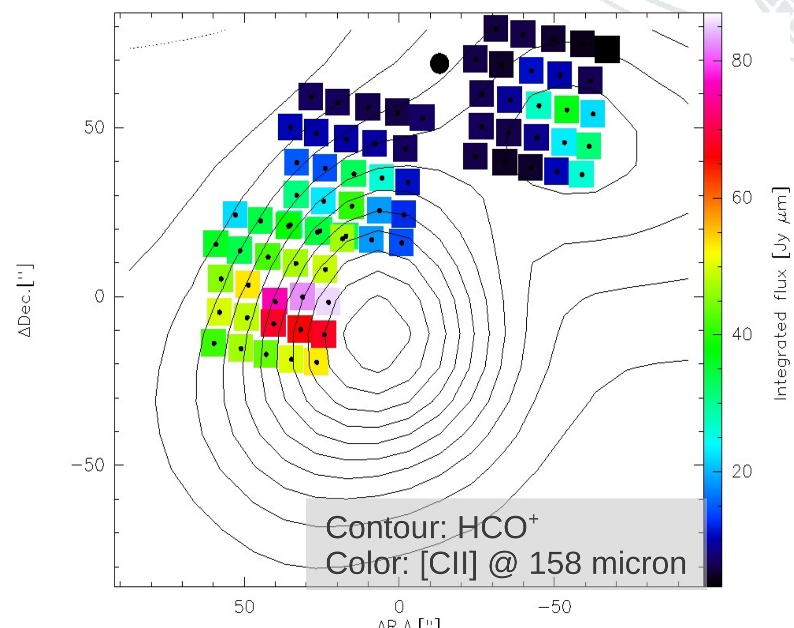
Cooling lines



Line spectroscopy



Range spectroscopy



- There is a cavity around the central cluster where the molecular hydrogen has been blown away farther into the clumps
- The diffuse gas tracer CH is more widely distributed and extended to the south (relative to the OB cluster). CH also has a good correlation with [CI] (from Röllig et al. (2011)), hence we might see the formation path of carbon via CH + H ---> C + H_2
- The gas probably excited by radiative heating rather than by collisions in the deeper part of the clouds
- The dense gas tracers (CS and HCO^+) are well correlated and the main source of HCO^+ may be the reactions between CH and O, and CO and H^+_3
- The macro- and microscopic gas movements scenario could supported by CS, CCH
- We found correlations between few observed molecules...
- We used $C^{18}O$ data (from Nürnberger et al. (2002)) to calculate the hydrogen column density in MM1 and MM2

Future works

·Finish the analysis of the small amount of remaining data (mainly PACS)

·Continue to work on the HIFI map paper

·Do modeling of few species (e.g. 12CO, [CII])

·Possibly another paper about the rest data (point, cut, PACS observation, plus modeling part)

Thank you for your attention!