Molecular line analysis to study the kinematics of the binary protostellar system L1551 IRS5

🔥 최강 Team 5 🔥

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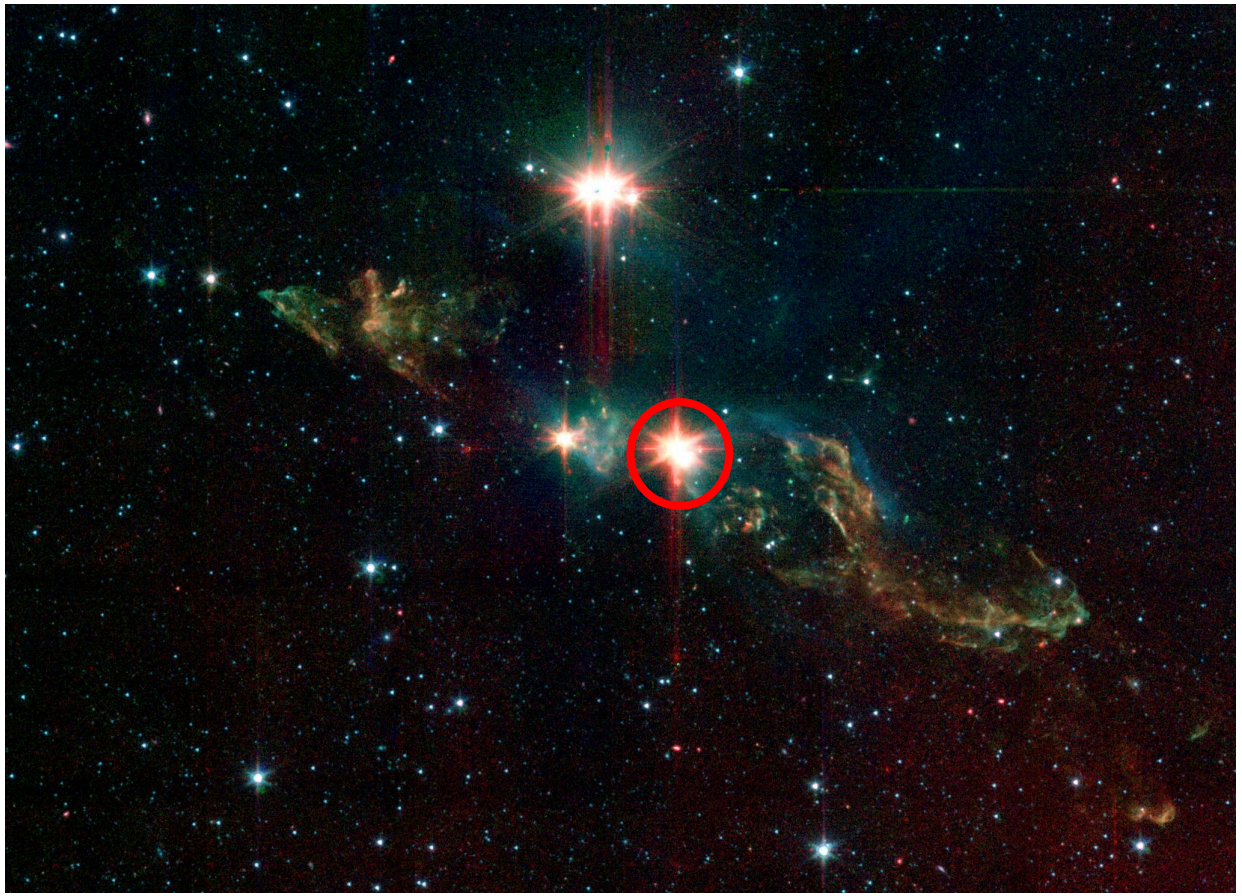
L1551 IRS5

L1551 IRS5 is a protostellar envelope surrounding a binary protostar system at a distance of 147 ± 5 pc. It consists of a 0.8 $M_\odot$ primary (N component) and a 0.3 $M_\odot$ secondary (S component). The separation of the binary is 50 AU.

Distance	147 pc
Right Ascension	$04^h\ 31^m\ 34.077^s$
Declination	18° 08′ 04.90″



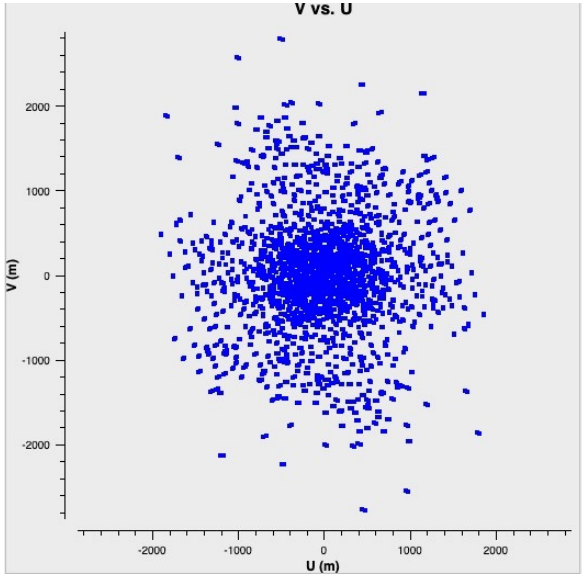
https://en.wikipedia.org/wiki/L1551_IRS_5

Archive data

ALMA Science Archive data 2016.1.00209.S

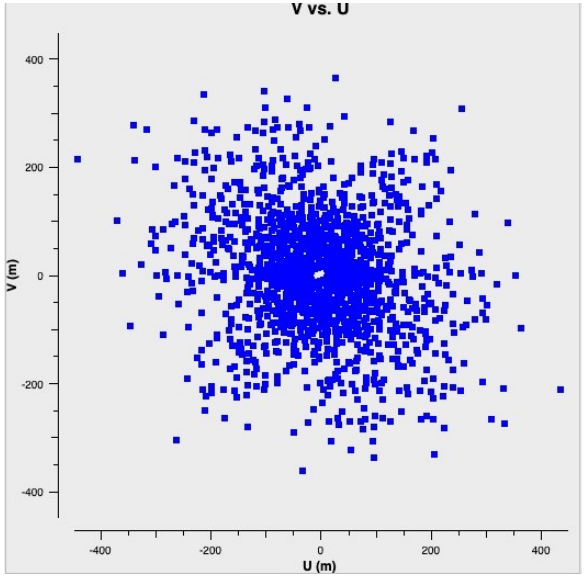
Project code	ALMA source name	RA	Dec	Band	Cont. sens.	Frequency support	↑ Release date	Publications	Ang. res.	Min. vel. res.
2016.1.	L1551	h:m:s	d:m:s		mJy/beam				arcsec	km/s
2016.1.00209.S	L1551_IRS_5	04:31:34.077	+18:08:04.900	6	0.2495	215.896..233.197 GHz	2018-03-07	4	23.408	0.040
2016.1.00209.S	L1551_IRS_5	04:31:34.077	+18:08:04.900	6	0.5760	215.896..233.198 GHz	2018-04-12	4	5.976	0.040
2016.1.00209.S	L1551_IRS_5	04:31:34.077	+18:08:04.900	6	0.0289	215.959..233.135 GHz	2018-08-07	4	0.137	0.040
2016.1.00209.S	L1551_IRS_5	04:31:34.077	+18:08:04.900	6	0.0632	215.958..233.136 GHz	2019-04-25	4	0.776	0.040

TM1



2000m

TM2



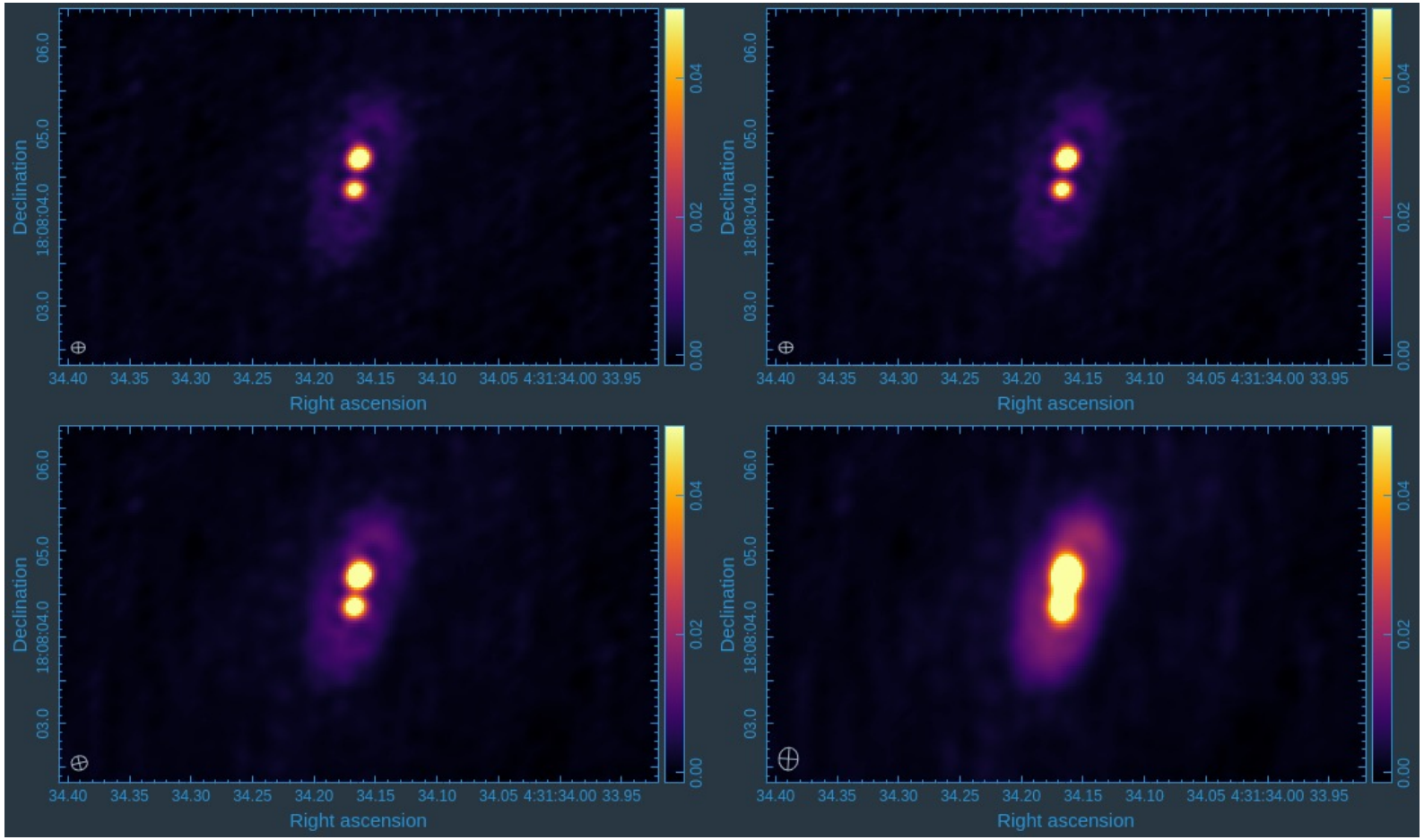
400m

Weighting

Compare the uniform weighting and natural weighting

robust = -2.0 (uniform)

beamsize = 0.15”



robust = -0.5

beamsize = 0.16”

robust = 0.5

beamsize = 0.18”

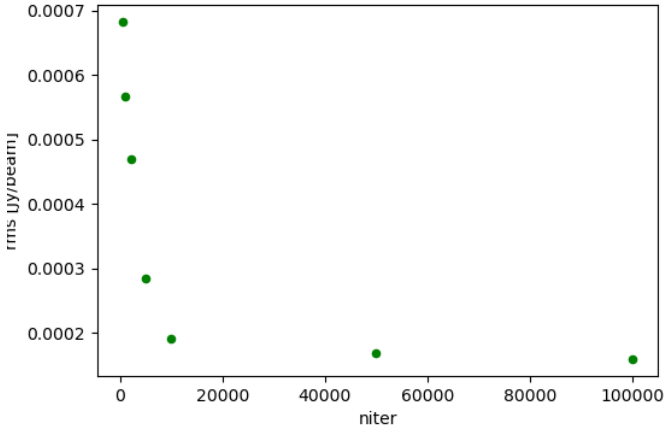
robust = 2.0 (natural)

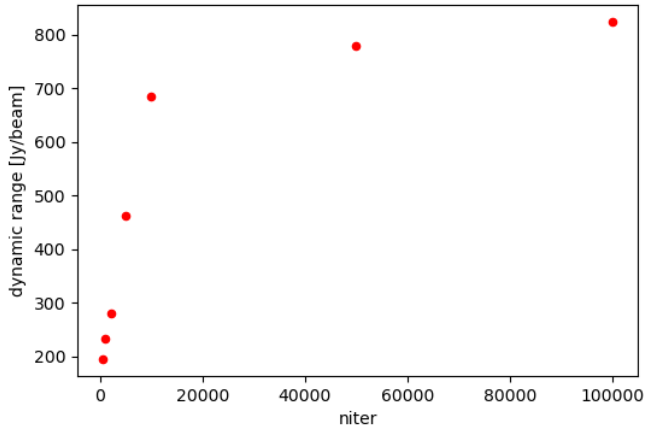
beamsize = 0.26”

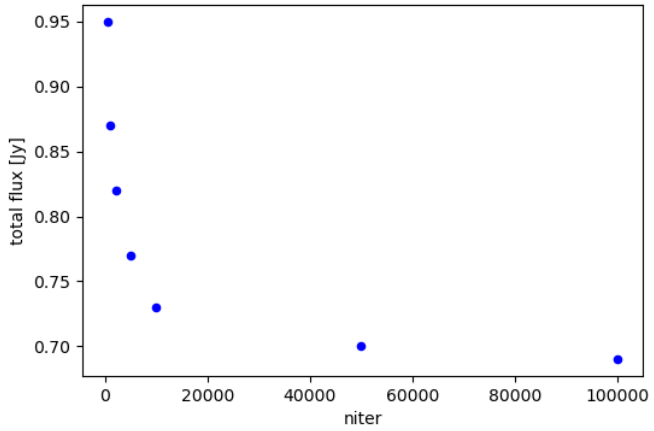
Iteration Number

Compare the continuum cleaning images of different iteration numbers

niter	max [Jy/beam]	rms [Jy/beam]	dynamic range (=max/rms)	total flux [Jy]
500	1.33E-01	6.83E-04	1.95E+02	9.50E-01
1000	1.32E-01	5.67E-04	2.33E+02	8.70E-01
2000	1.32E-01	4.69E-04	2.81E+02	8.20E-01
5000	1.32E-01	2.85E-04	4.62E+02	7.70E-01
10000	1.32E-01	1.92E-04	6.86E+02	7.30E-01
50000	1.31E-01	1.69E-04	7.80E+02	7.00E-01
100000	1.32E-01	1.60E-04	8.25E+02	6.90E-01

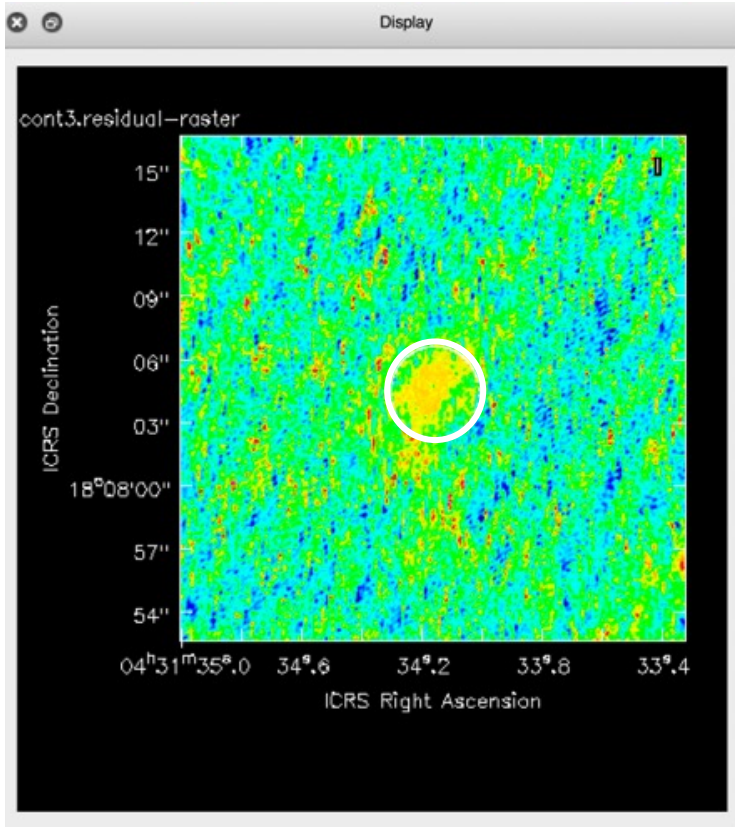




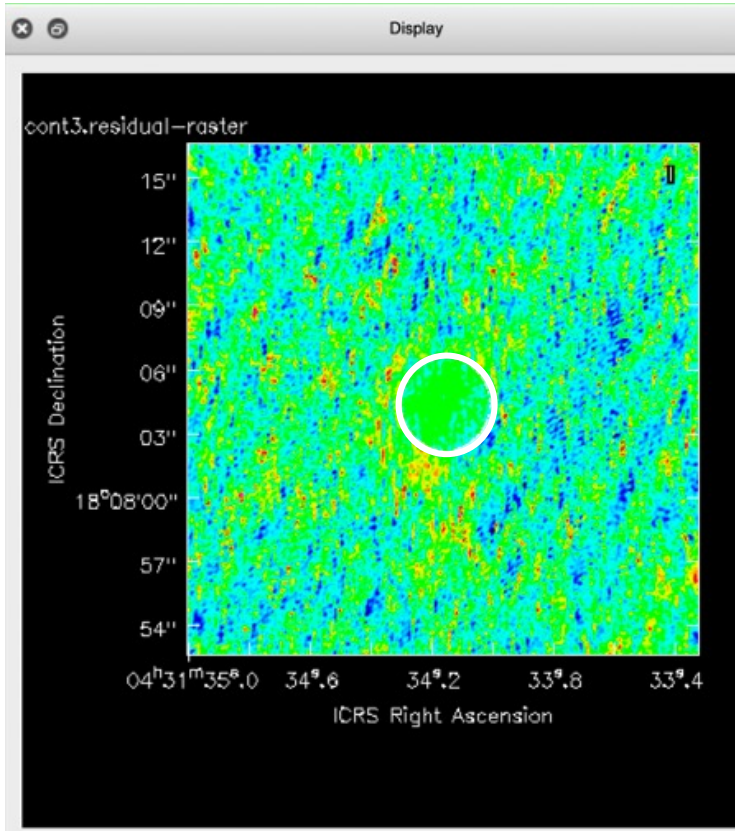


Iteration Number

Find the proper iteration number using interactive mode



niter = 100

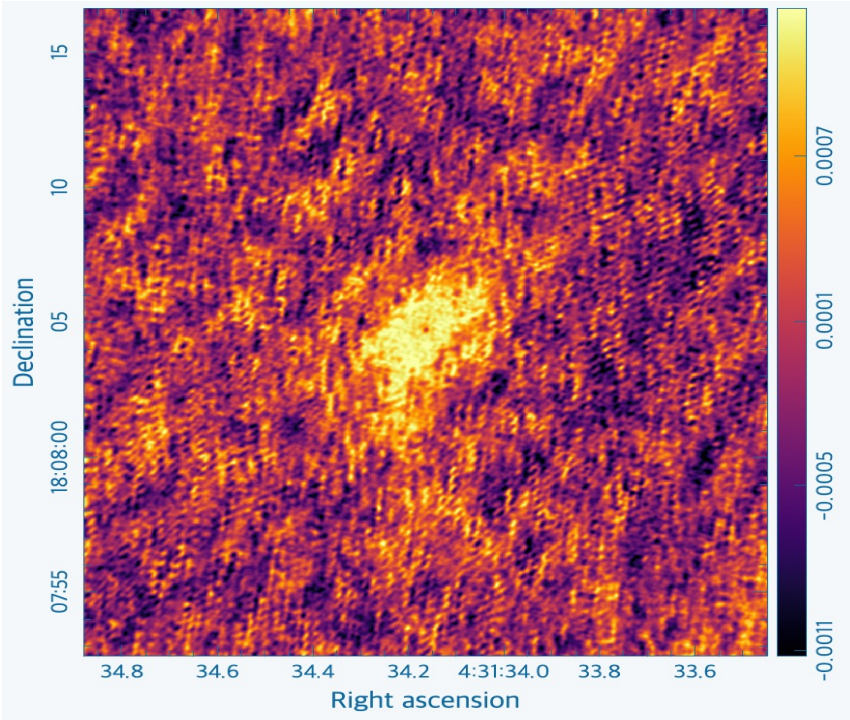


niter = 2000

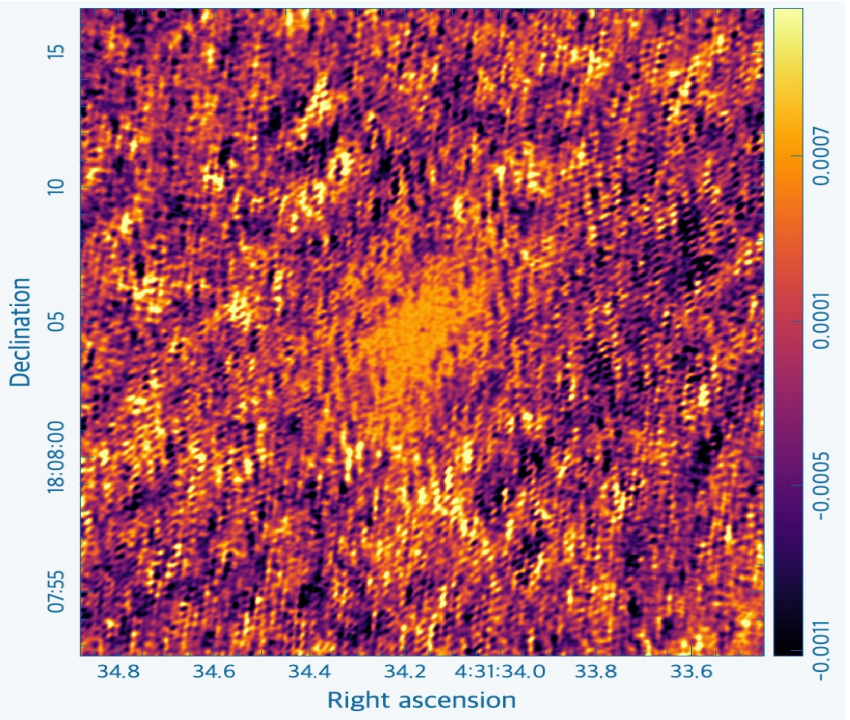
Masking

Compare the residual images with or without masking

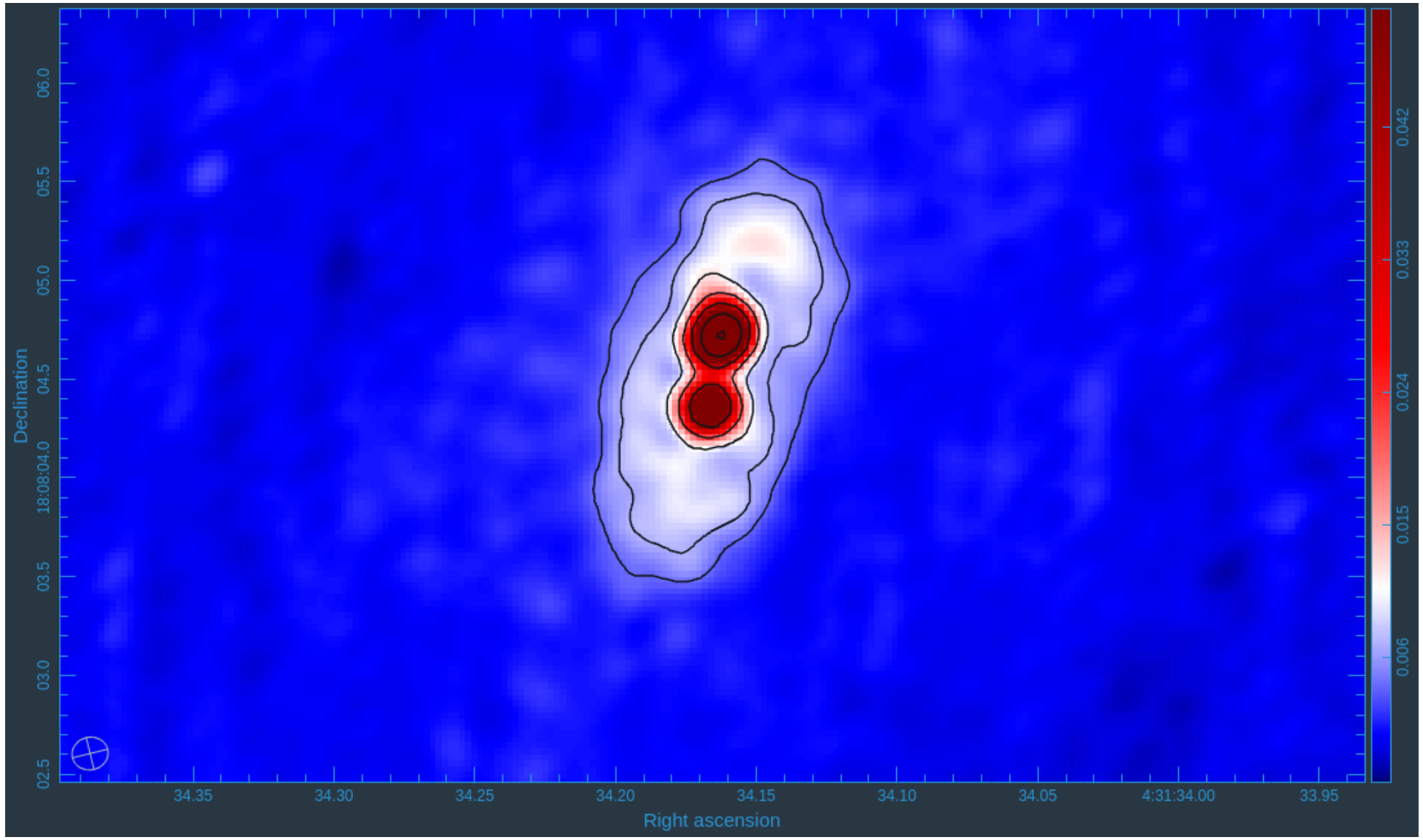
dynamic range : 325
(no masking)



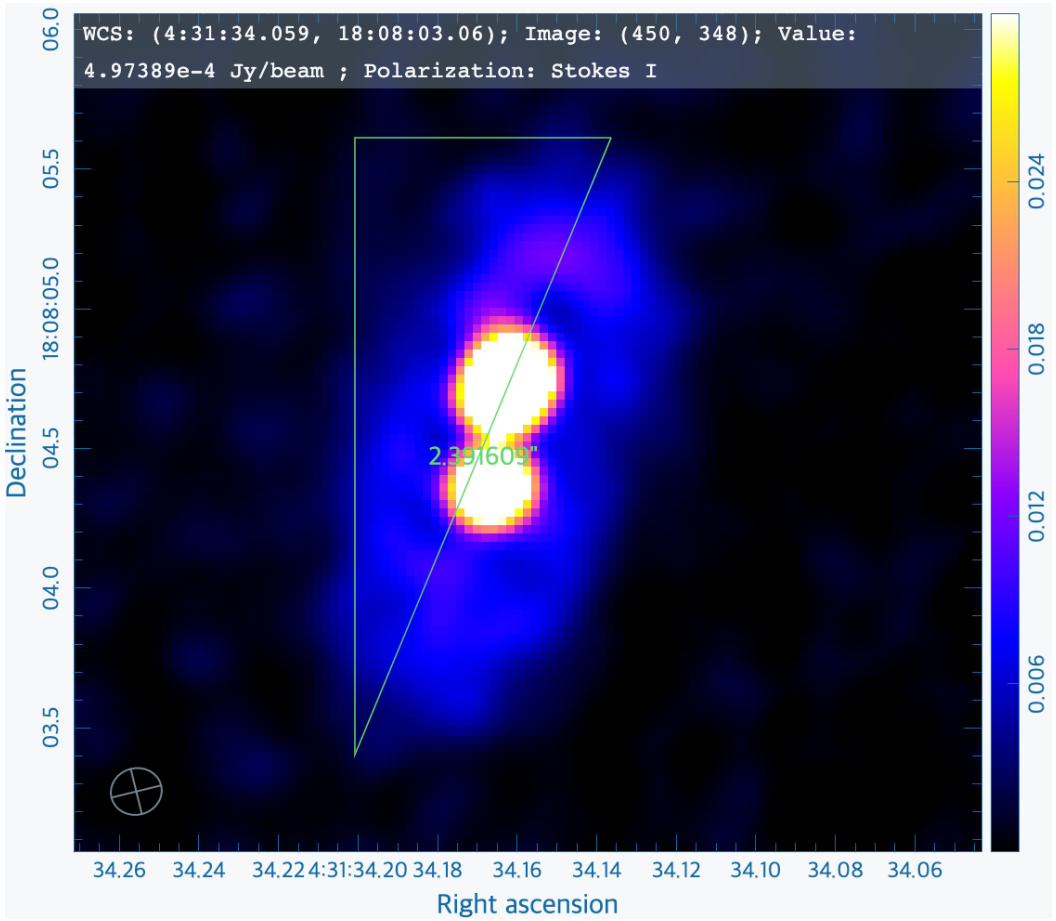
dynamic range : 260
(masking)



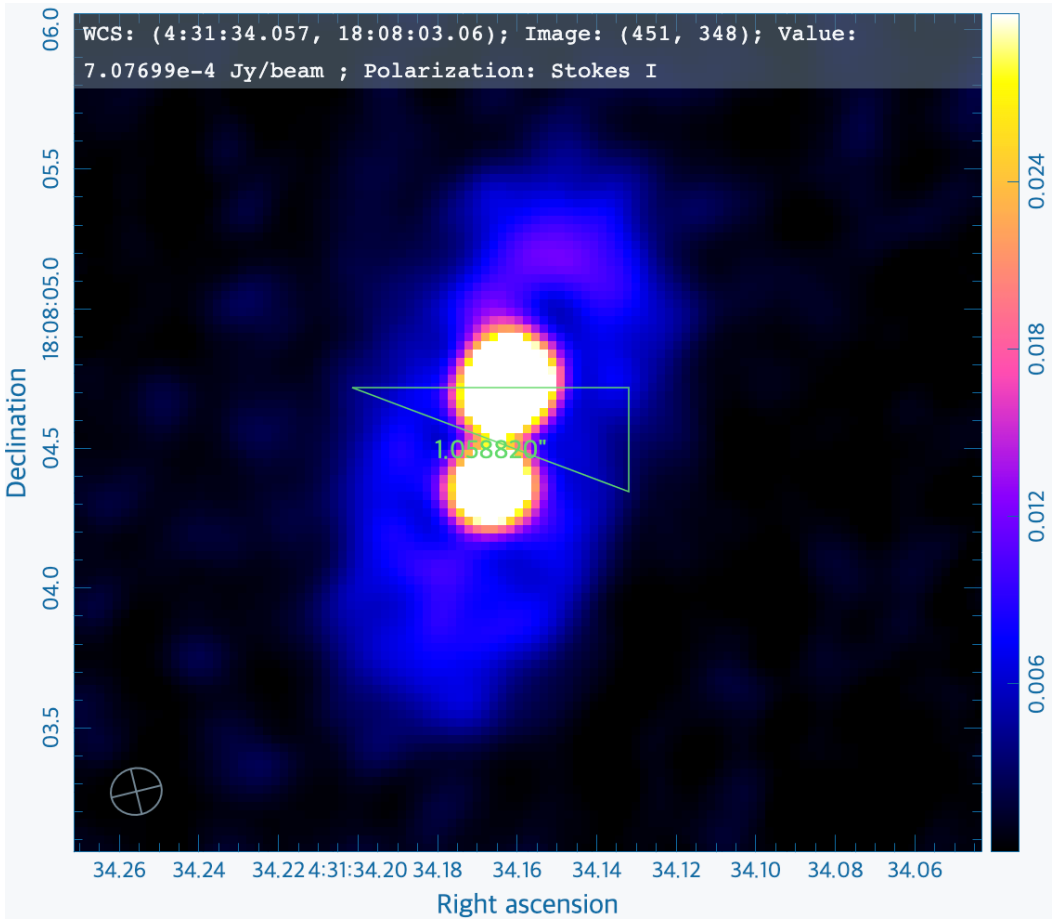
Continuum image of L1551 IRS5



Continuum image of L1551 IRS5



2.391”

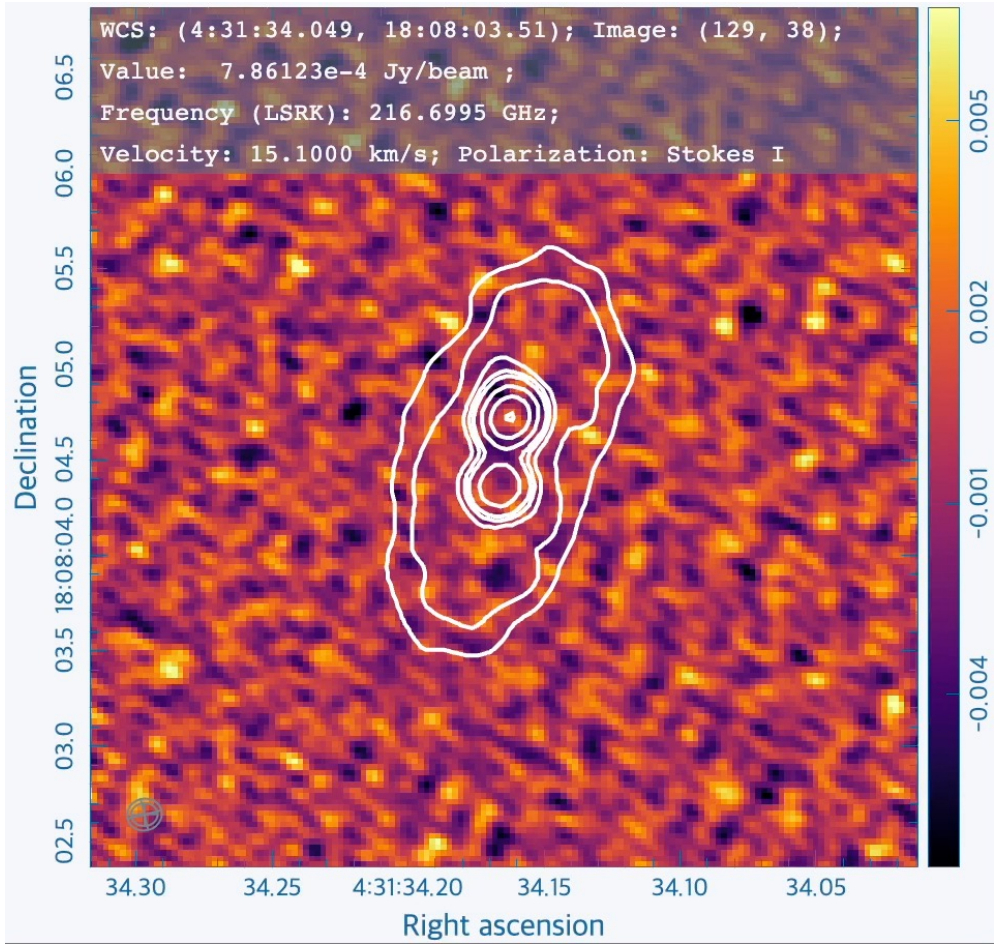


1.058”

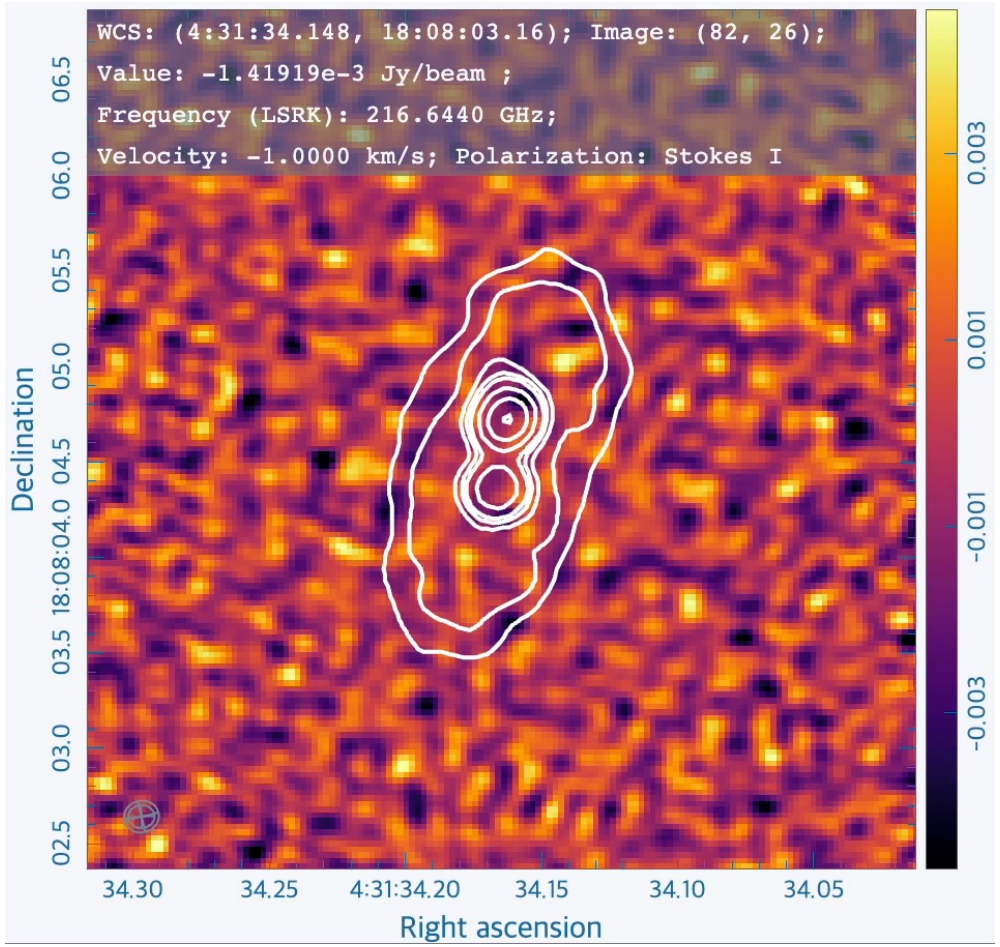
Maximum recoverable scale : 8.813”

Spectral cubes

The number of channel: 25
Width of the each channel : 0.7km/s



H2S

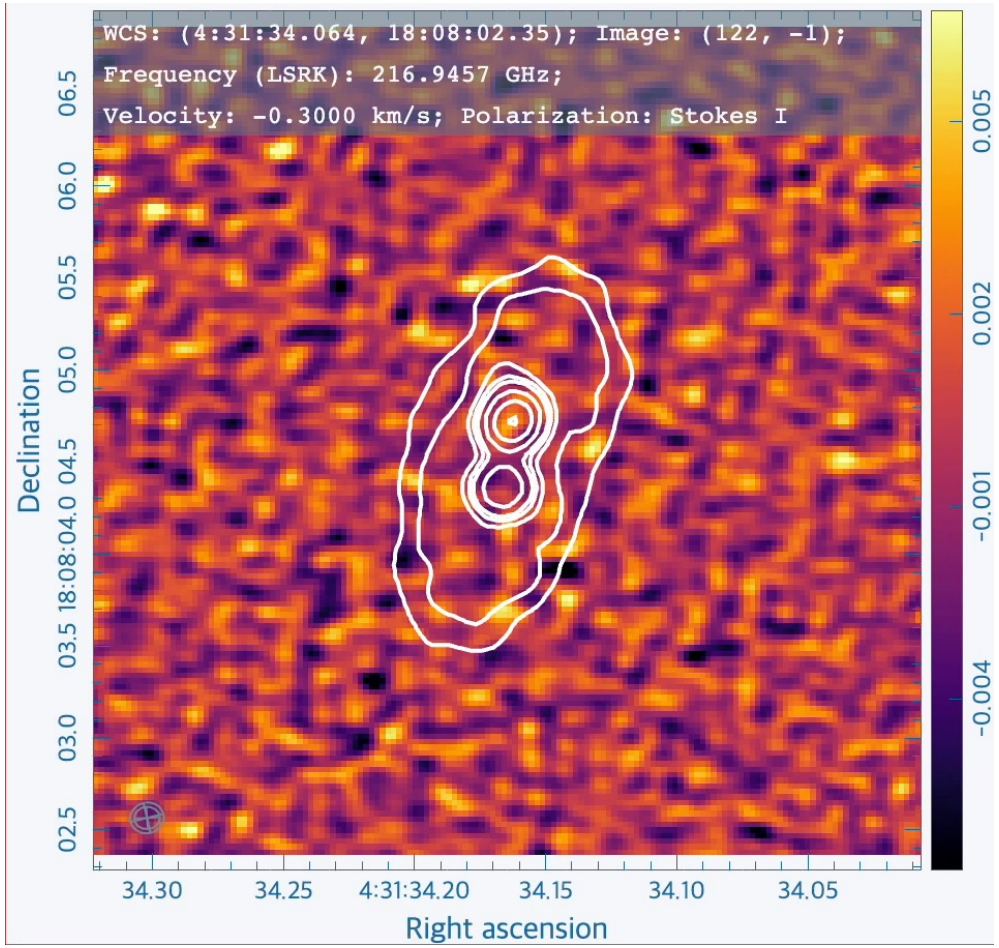


SO2

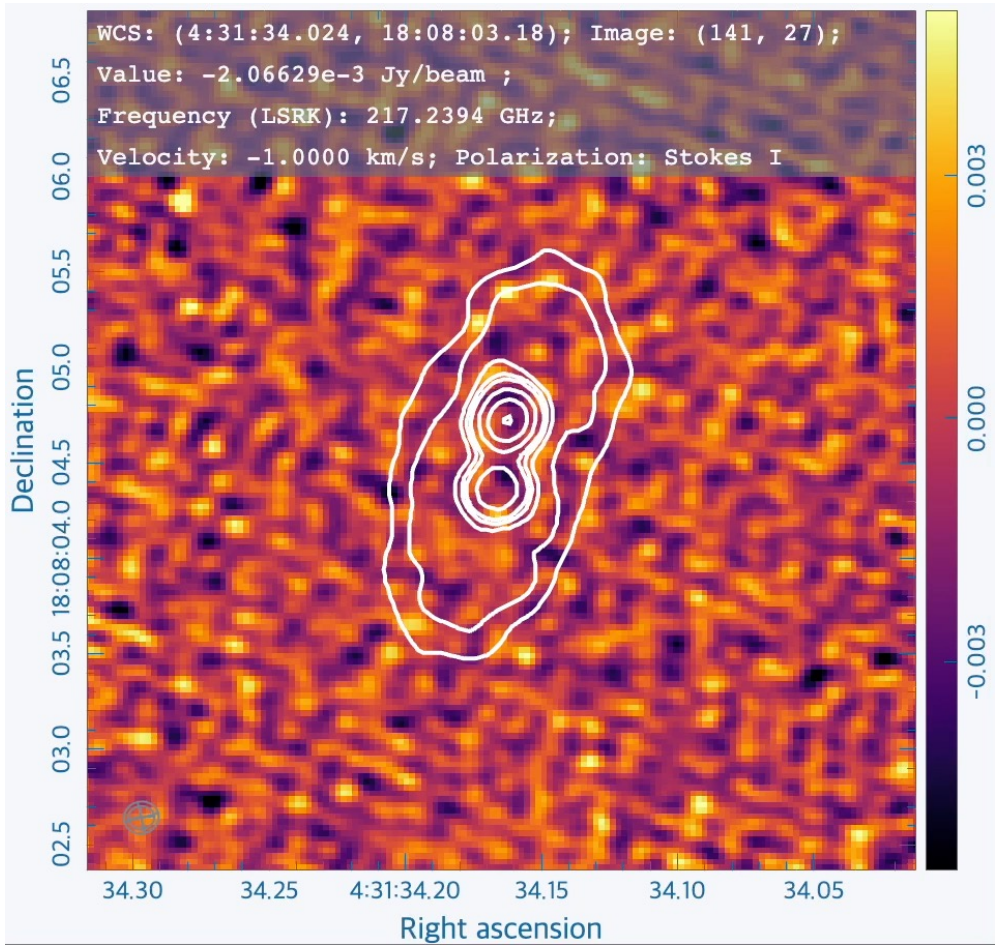
Spectral cubes

The number of channel: 25

Width of the each channel : $0.7\mathrm{km/s}$



CH3OH

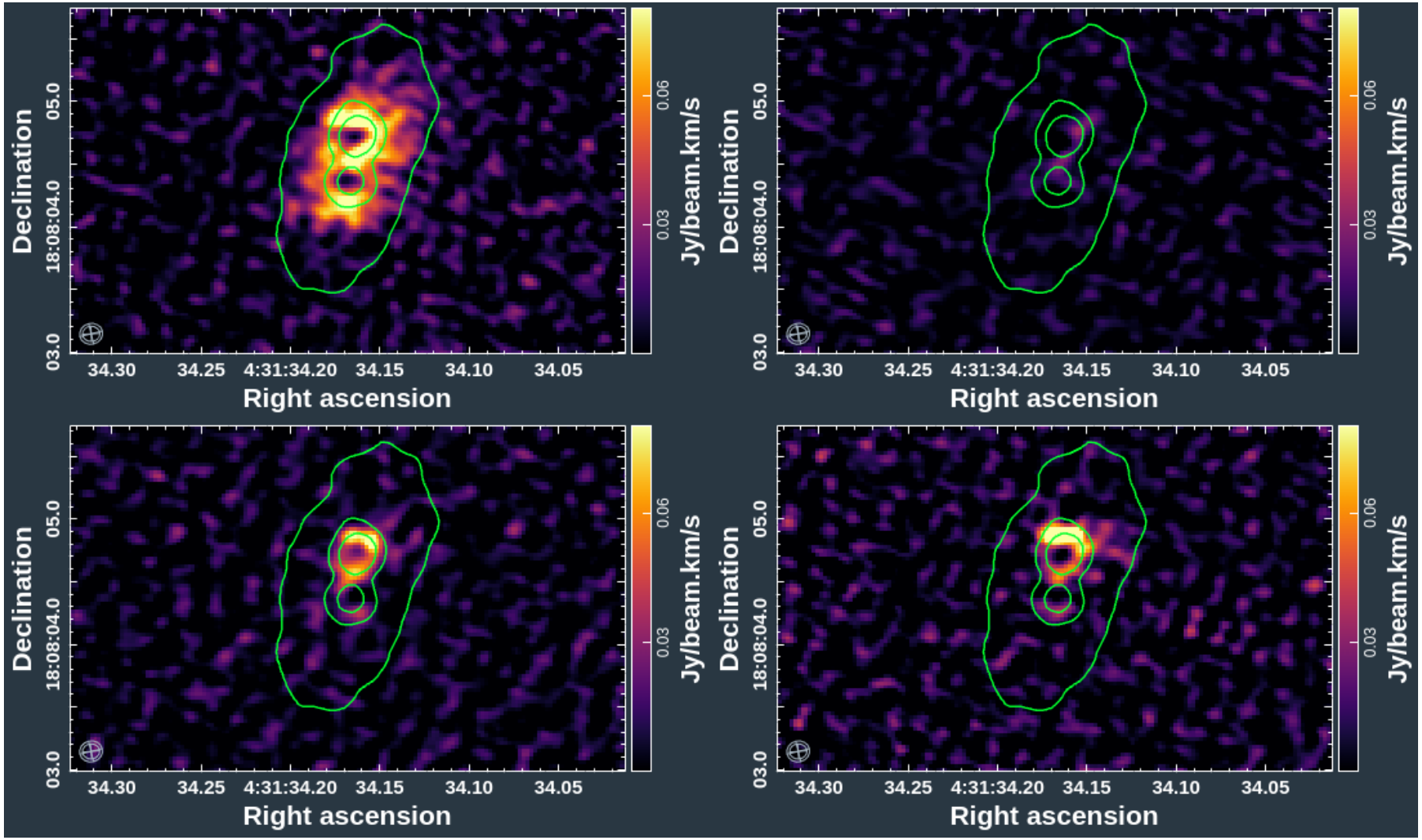


DCN

Moment 0 (integrated intensity) map

Range of integration: $1\mathrm{km/s} - 11\mathrm{km/s}$ [system velocity $\approx 6\mathrm{km/s}$]
Masking range > 3σ

H2S



SO2

DCN

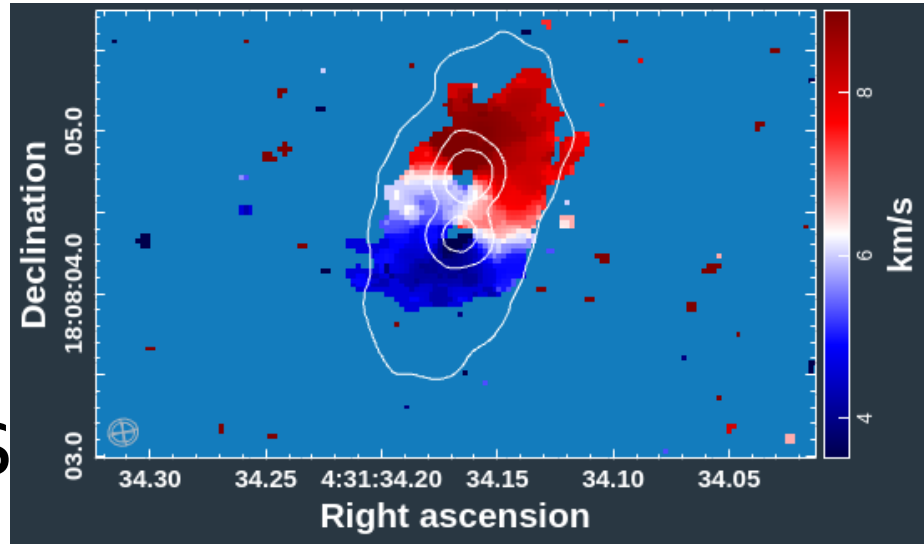
CH3OH

Moment 1 (velocity) map

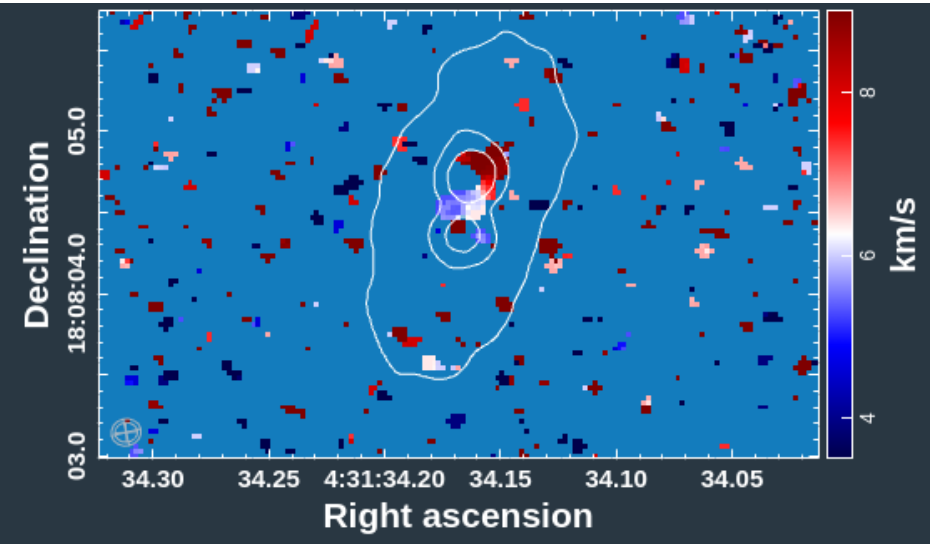
Range of integration: $1\mathrm{km/s} - 11\mathrm{km/s}$ [system velocity $\approx 6\mathrm{km/s}$

Masking range > 3σ

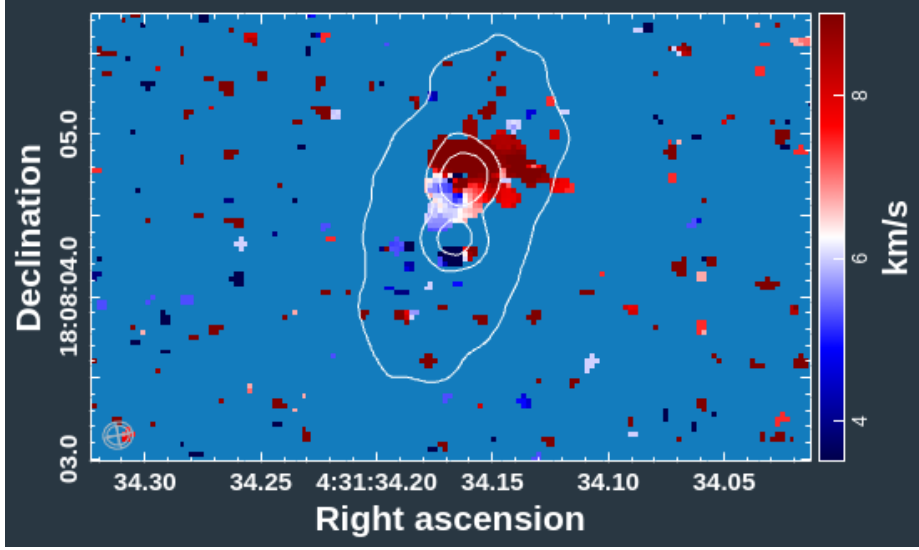
H2S



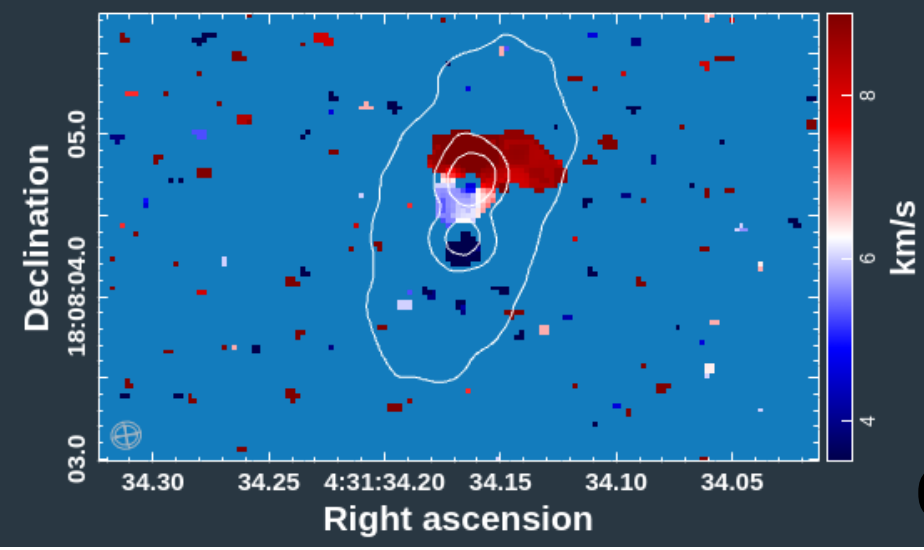
SO2



DCN



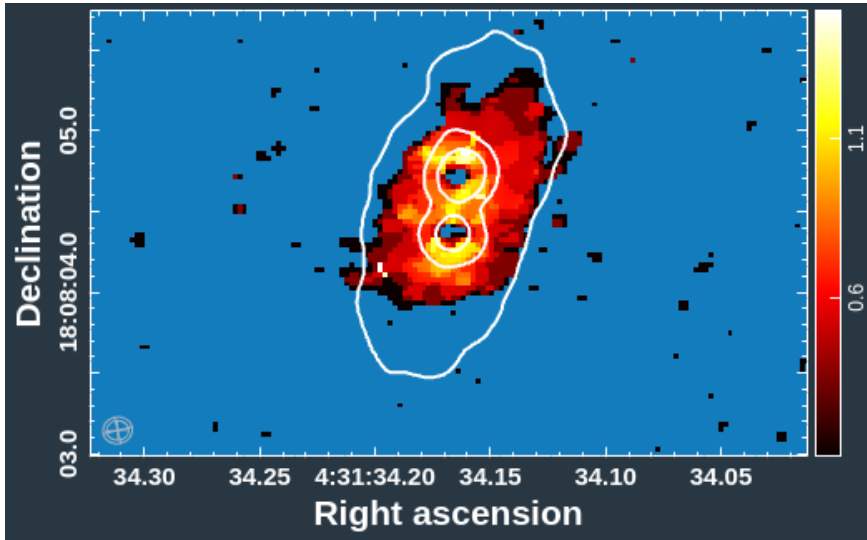
CH3OH



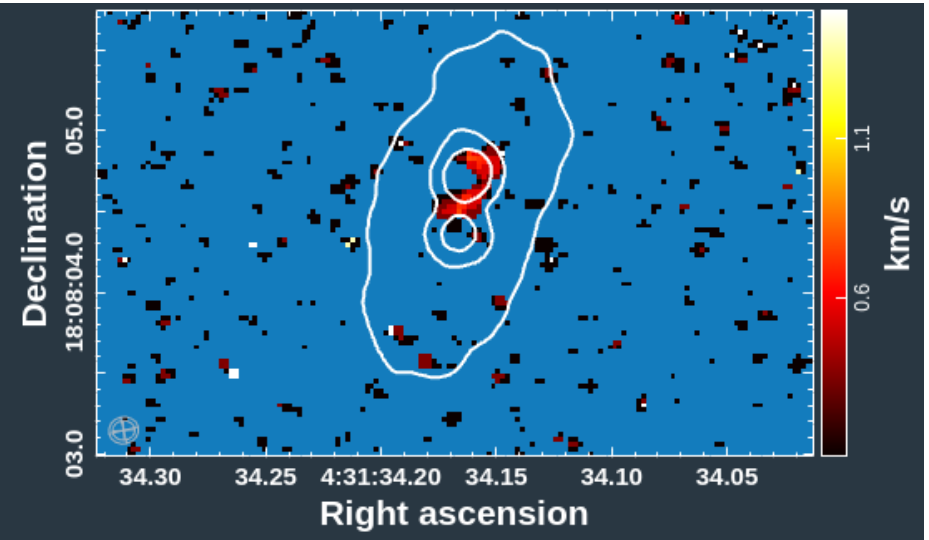
Moment 2 (velocity dispersion) map

Range of integration: $1\mathrm{km/s} - 11\mathrm{km/s}$ [system velocity $\approx 6\mathrm{km/s}$]
Masking range > 3σ

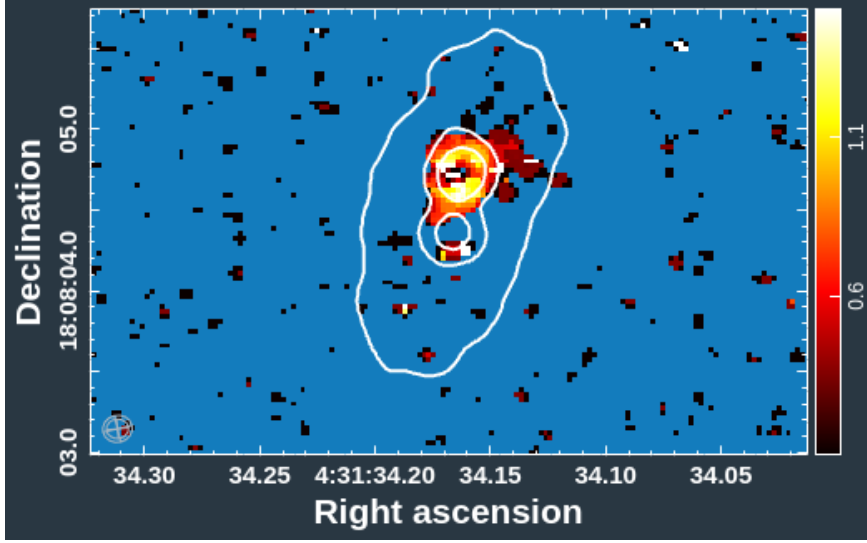
H2S



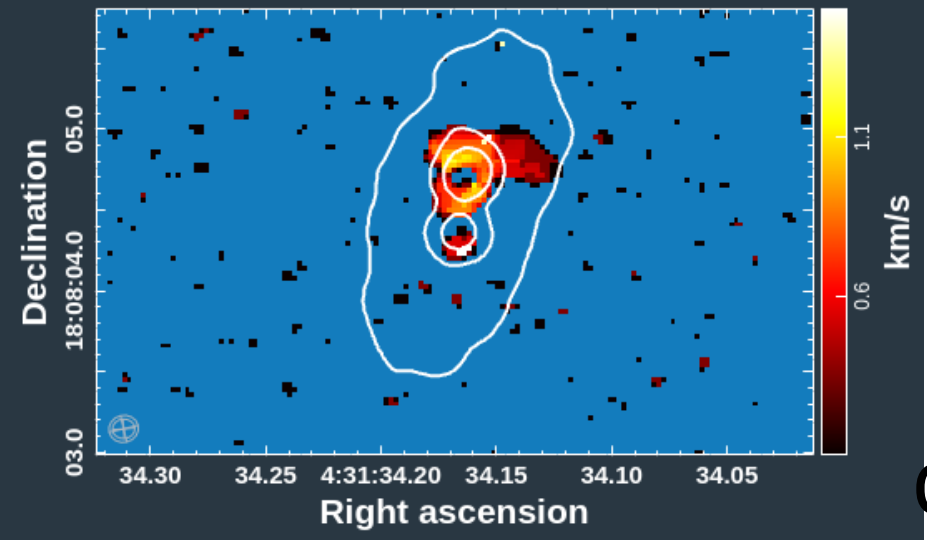
SO2



DCN



CH3OH



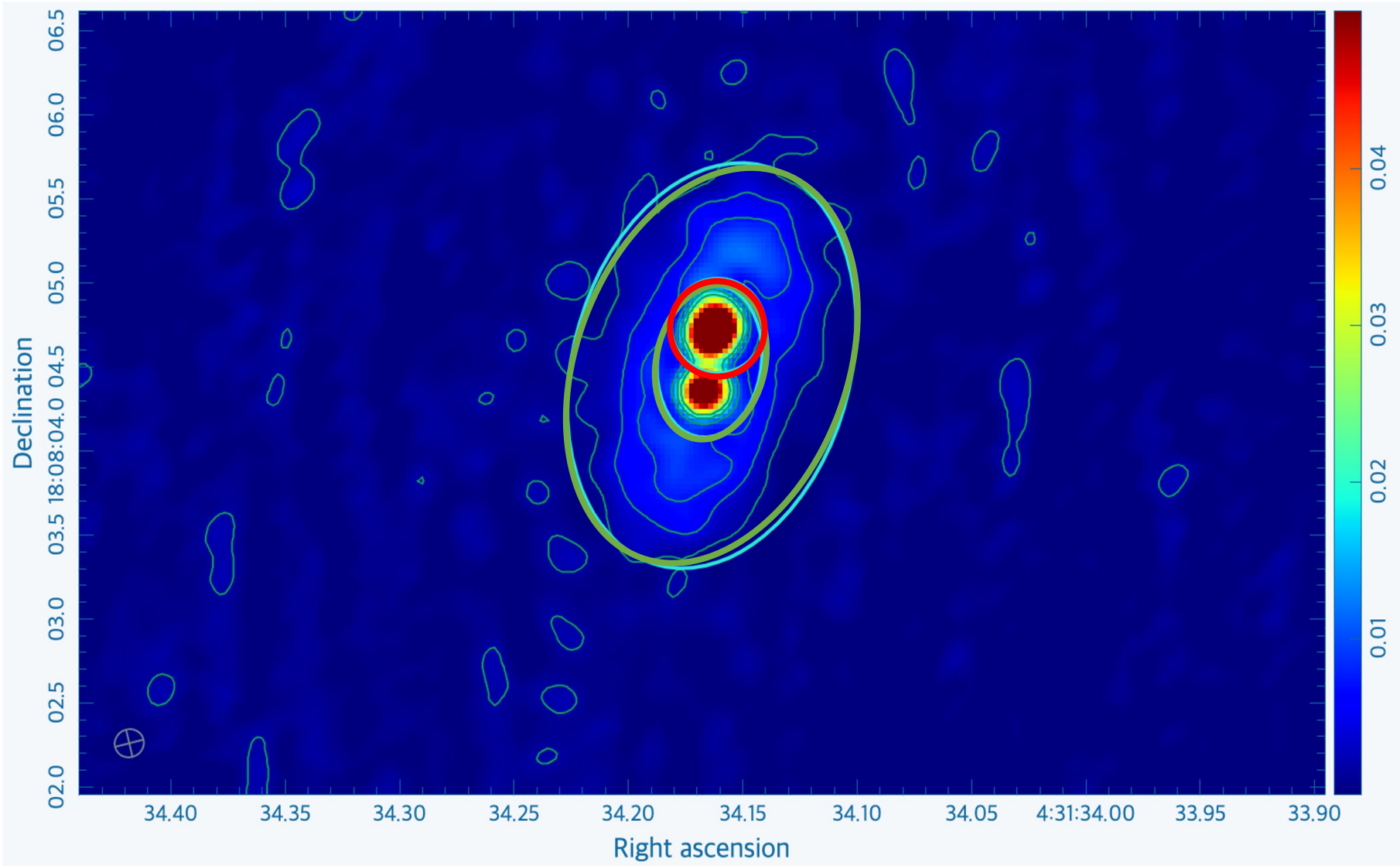
Dust mass estimation

- Dust mass of specific regions could be estimated from continuum flux density

$$M_{\rm dust} = \frac{f\ d^2}{\kappa\ B_\nu(T_{\rm dust})},$$

Northern compact region
T_dust = 160K
M_tot = 5.1 x 10^{-3} M_sun

Circumbinary disk
T_dust = 80K
M_dust = 1.4 x 10^{-2} M_sun



Miera+2019

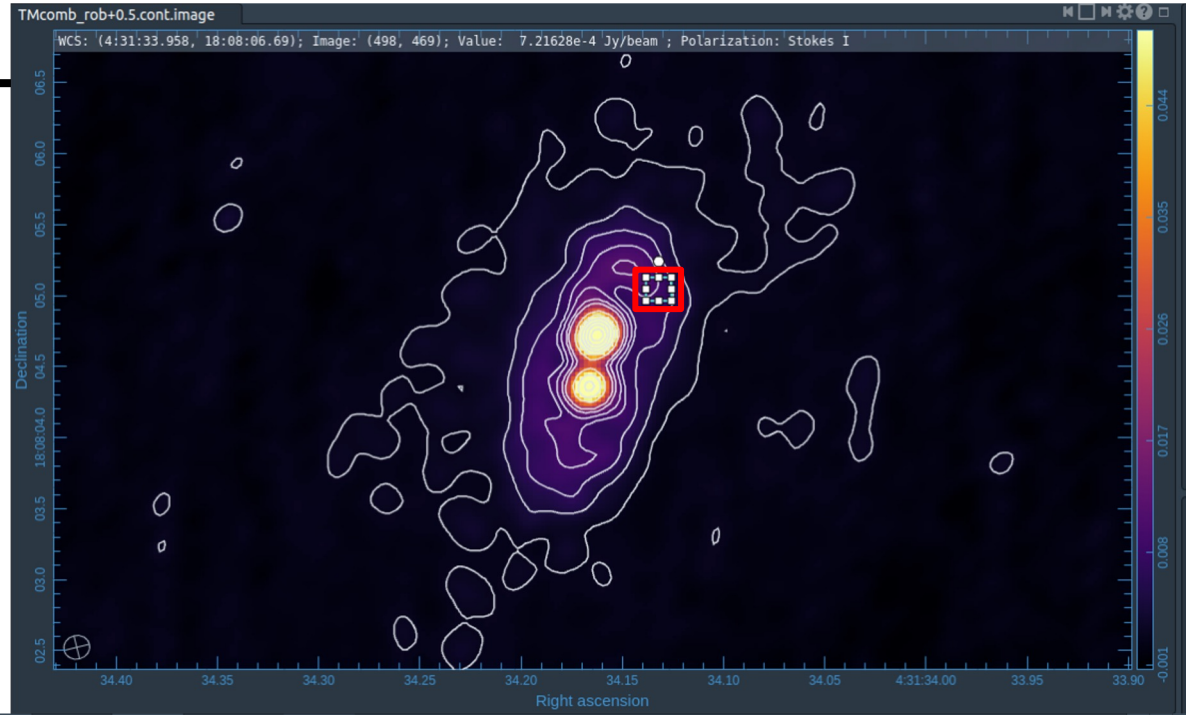
Gas temperature estimation

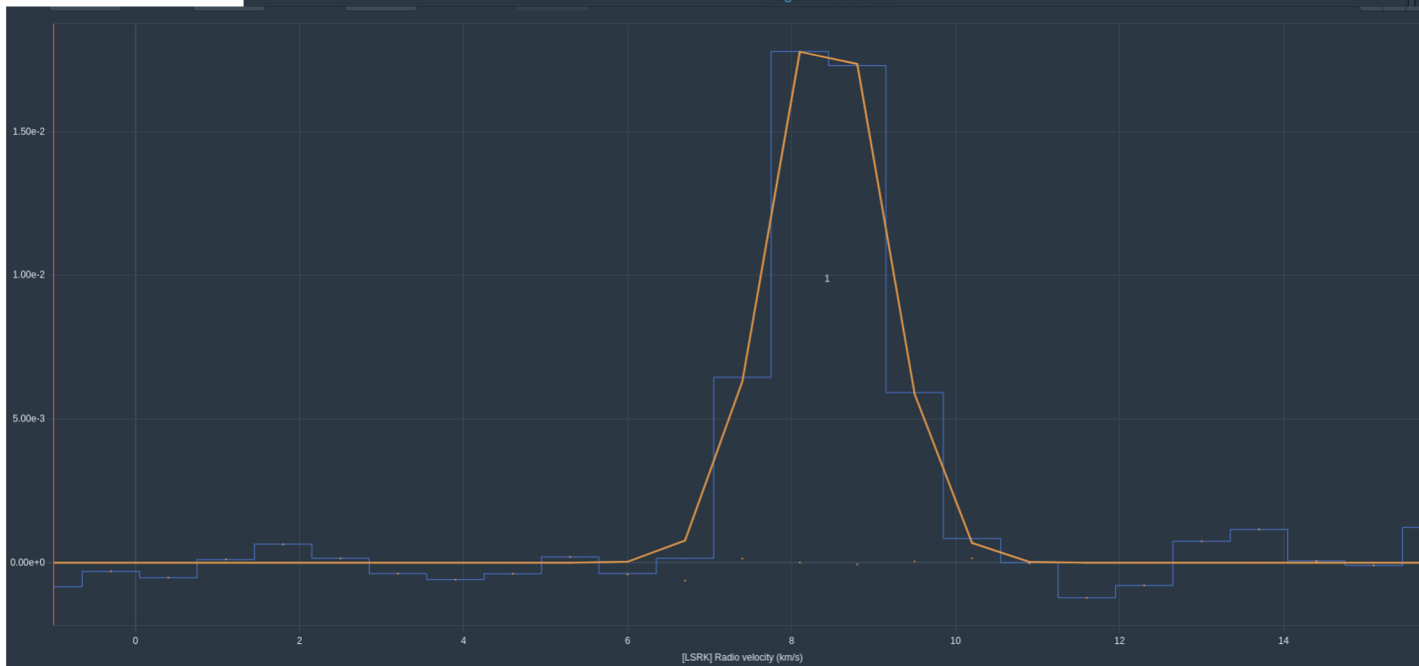
- Line gaussian fitting of selected region

- Temperature could be estimated by

$$C_{rms} = \sqrt{\frac{3RT}{M}}$$

and we got T < 910K (upper limit), which is deviated from previous one. (T~80K)

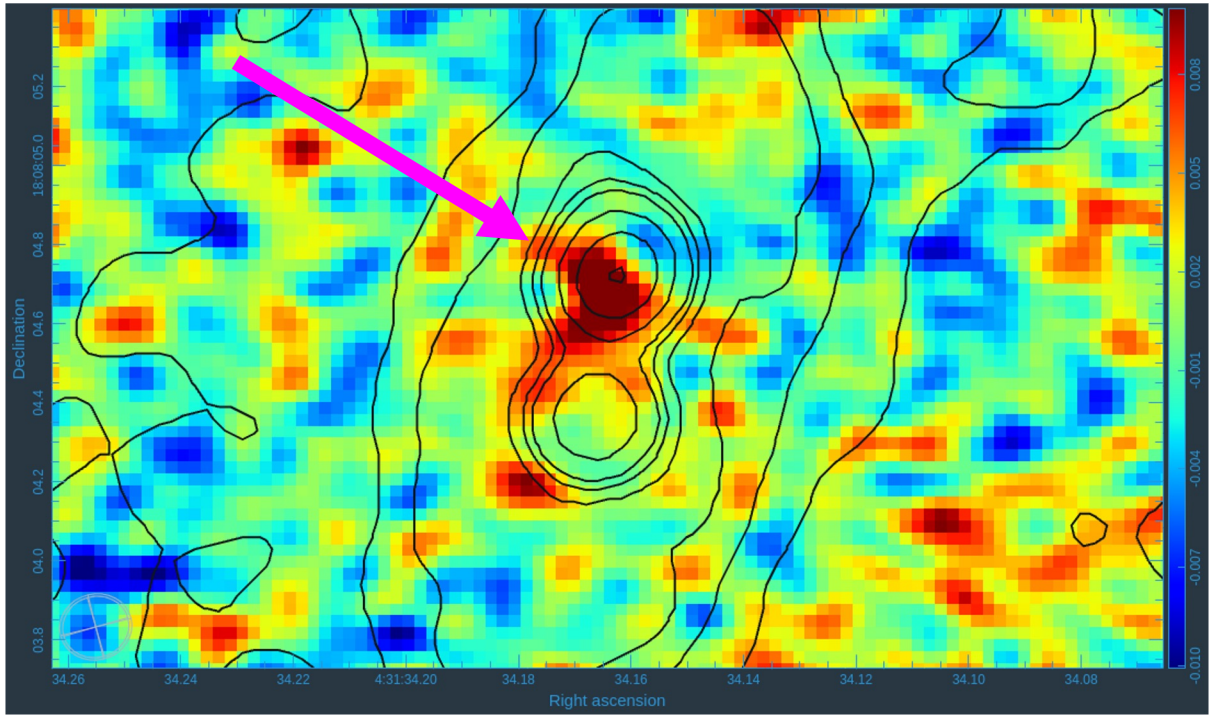




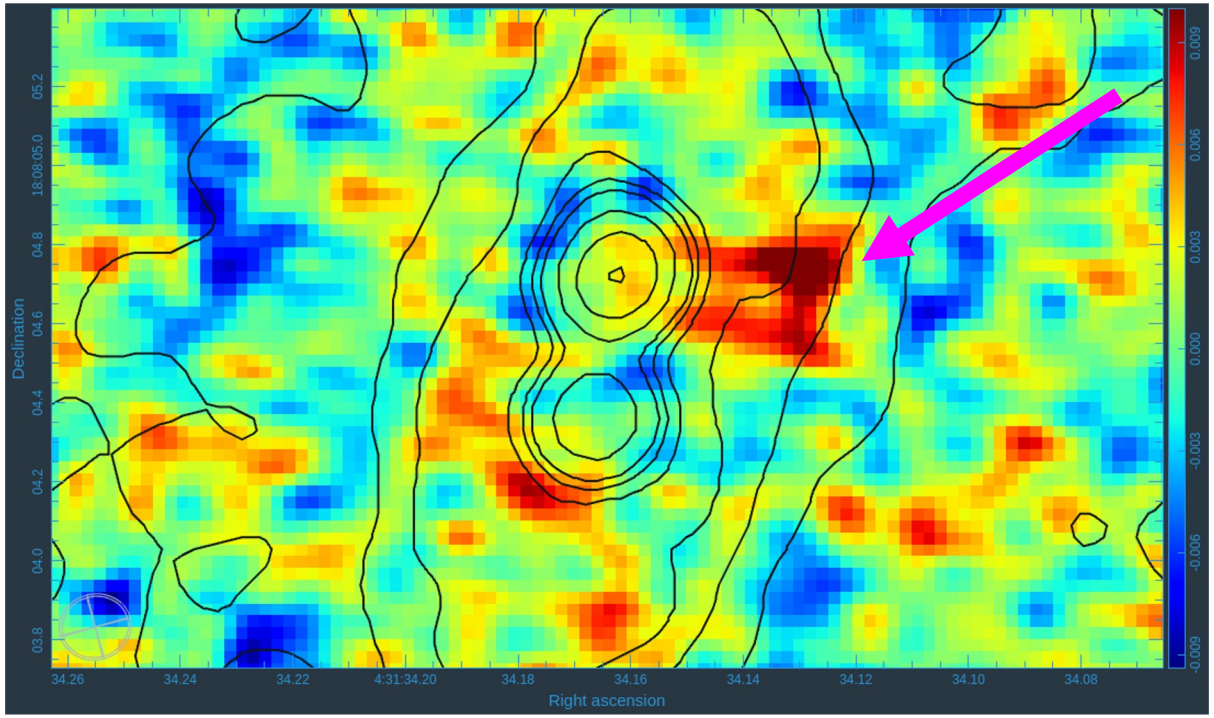
SiO moment-zero (integrated intensity) map

- Very weak compared to other lines
- Divided dominant velocity components into blue & redshift (rest velocity ~ 6.5km)

2 ~ 5 km/s (blue-shifted)

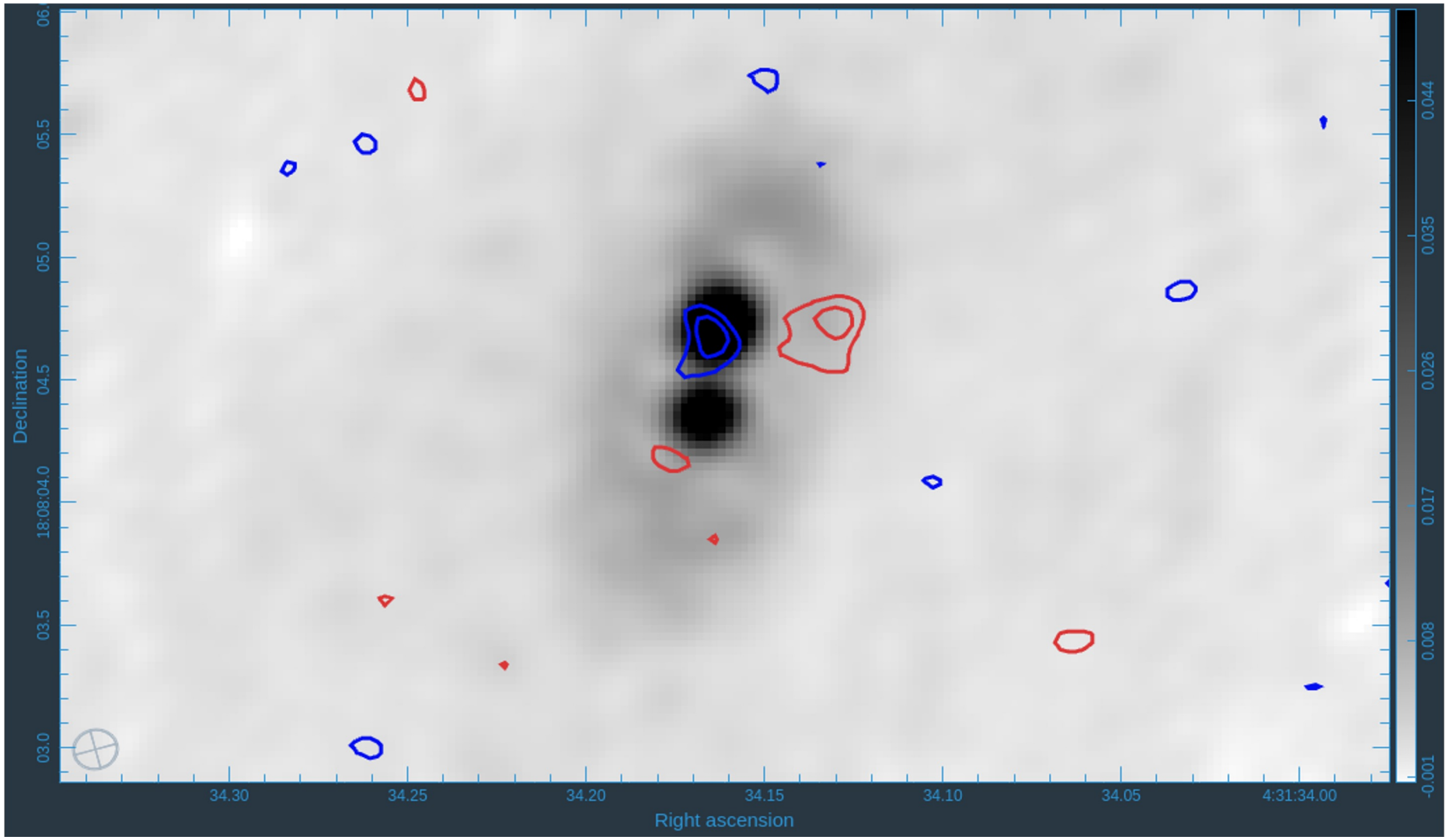


6 ~ 9 km/s (red-shifted)



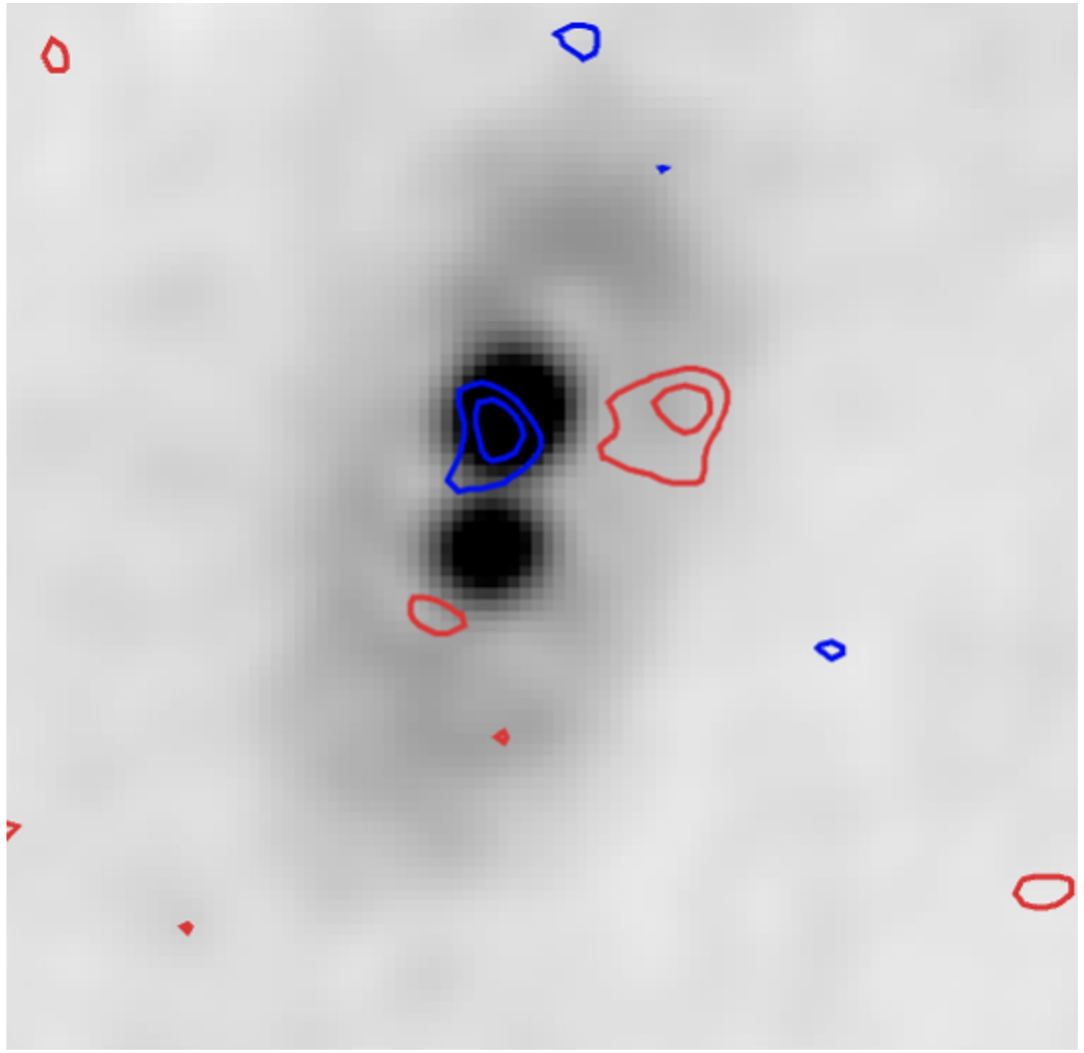
SiO moment-zero (integrated intensity) map

Overlapping two velocity components, outflow along opposite direction could be seen.



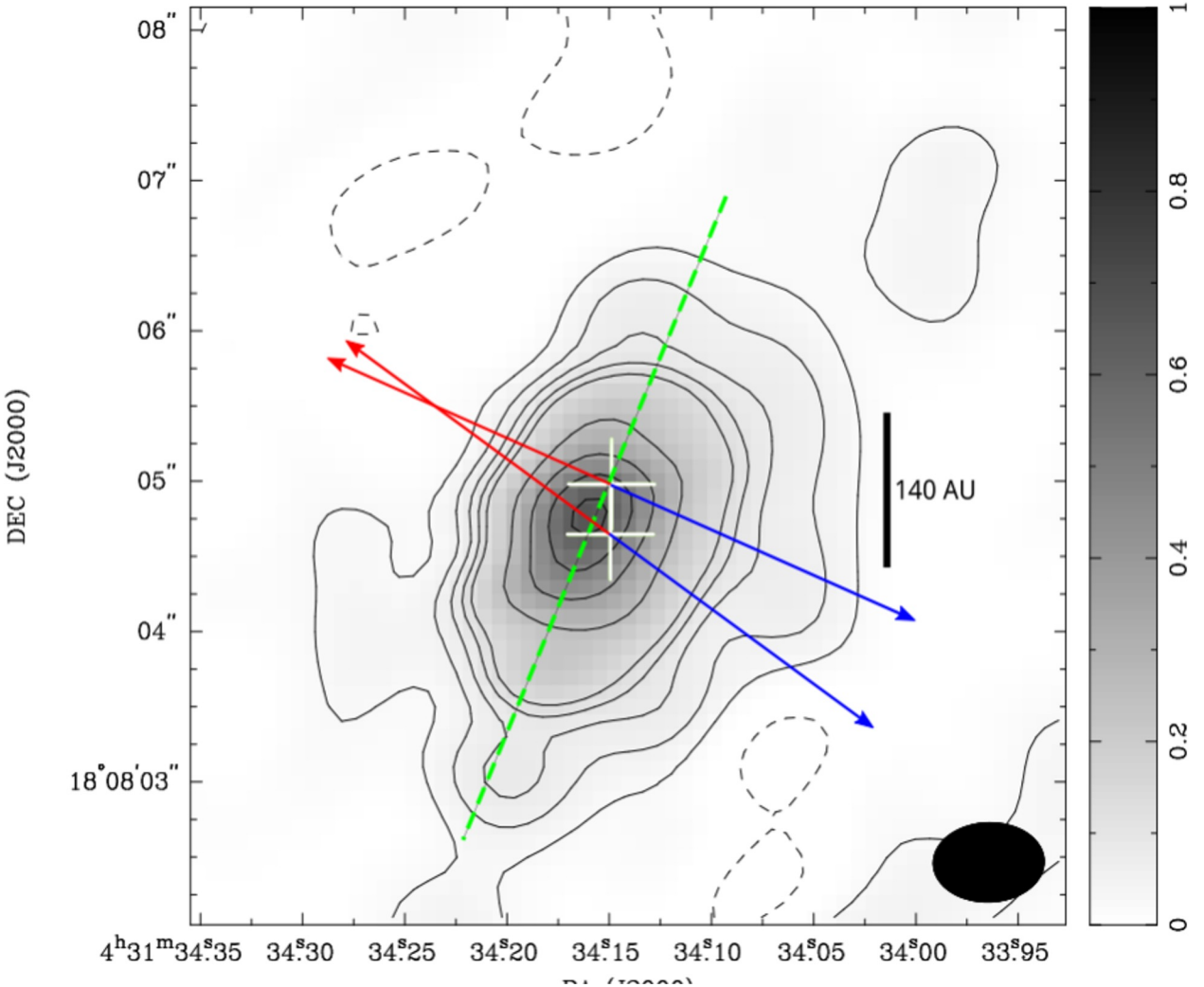
SiO moment-zero (integrated intensity) map

SiO moment-zero



CO gas outflow

Chou+2014



PV diagram

H2S

SO2

DCN

CH3OH