HOPS 186

Young Stellar Object Outflow

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INTRODUCTION

What is HOPS?

Herschel Orion Protostar Survey (HOPS) is a program to characterize hundreds of protostars in the Orion Molecular Clouds

Young Stellar Object

infalling envelope which absorbs and reprocesses

⇒ most of the luminosity from the central protostar.

In the initial phases,

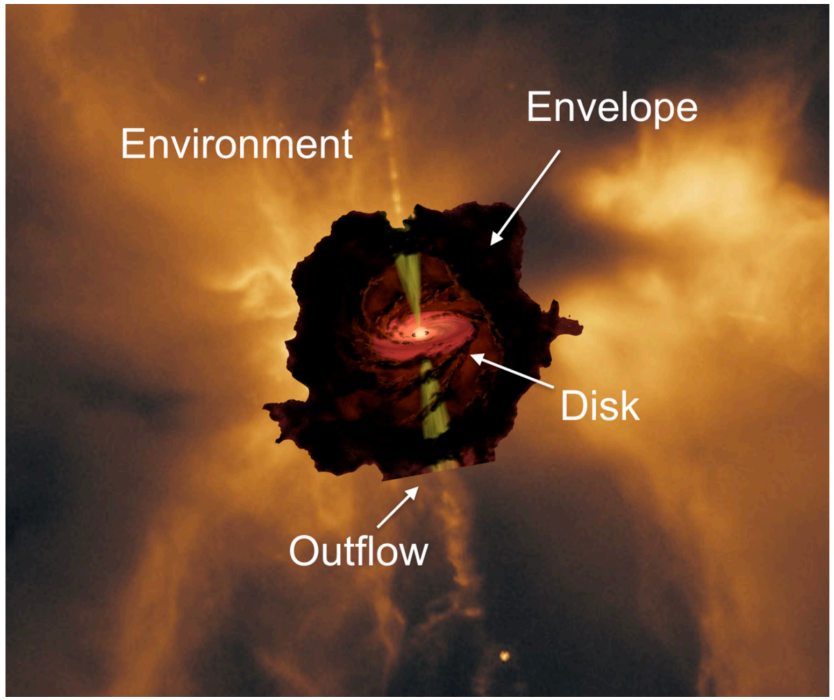
⇒ the **envelope dominates** the mass

In the later phases

⇒ most of the mass is already **accreted onto the star**.

Even in these later phases

⇒ the mass of the envelope exceeds that of the circumstellar disks surrounding the central protostar



(credit : Joseph J. Booker et al. 2017)

OBSERVATION DATA

BASIC PROPERTIES

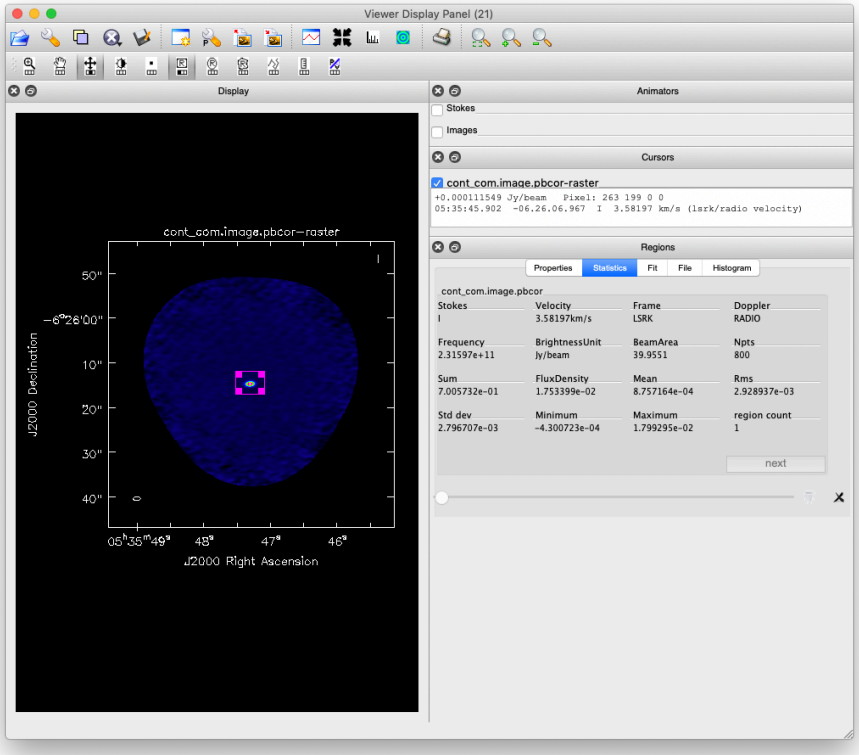
In this project, we combined 12m and 7m observation data.

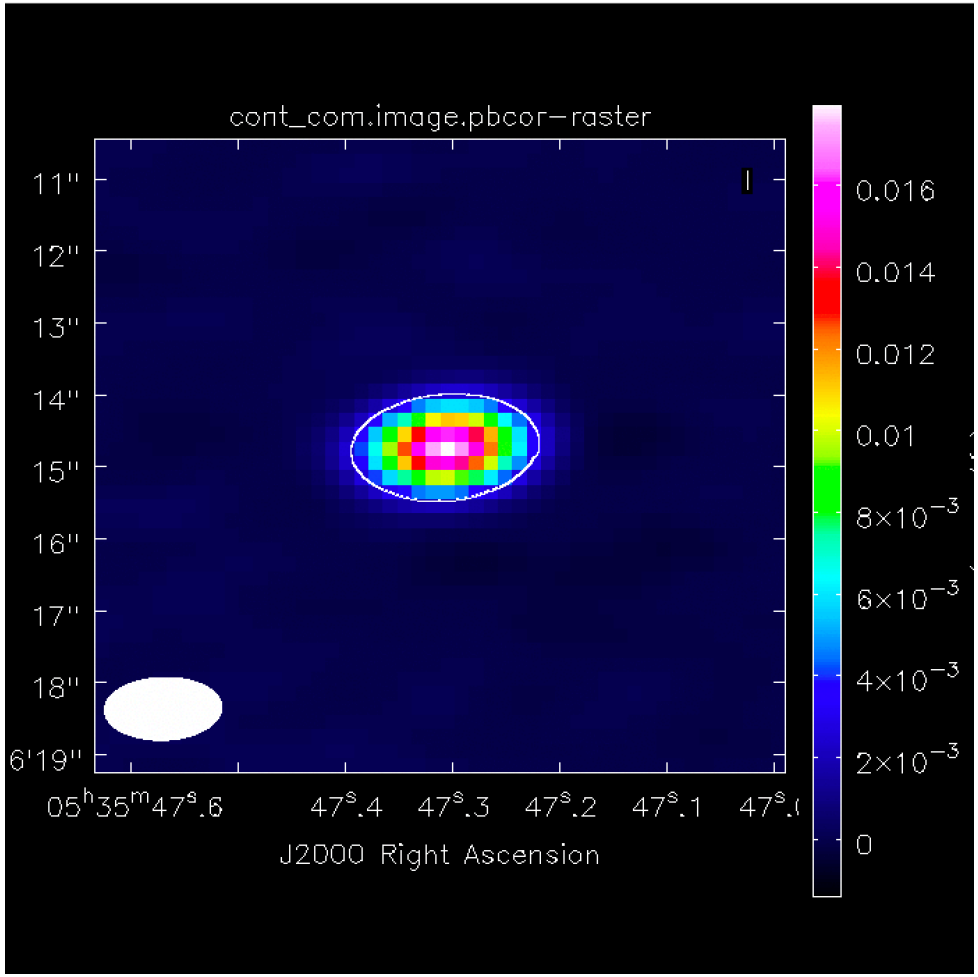
Line data : 12CO, 13CO, C18O (rest freq. = 230.538GHz, 220.398GHz, 219.560GHz)
Continuum data

ALMA Band 6 - λ = 1.3 mm

Combined	12CO	13CO	C18O	CONT
central freq.	230.511GHz	220.373 GHz	219.535 GHz	231.573GHz
Channel width	15.259kHz	15.259kHz	15.259kHz	15625kHz
Vel. resol	19.8 m/s	20.7 m/s	20.8 m/s	-
lambda	1.301 mm	1.36 mm	1.36 mm	1.301 mm
UVdis	250	250	250	-
Synthesis BEAM(resolution)	1.073	1.073	1.073	-
Primary (FOV)	22.3	22.3	22.3	-
Spw	0 - 6	0 - 6	0 - 6	0 - 6

CONTINUUM





	Flux Density
Continuum	0.001799 Jy

CONTINUUM

Disk Mass

$$M_{disk} = 0.06\, M_{\odot} \frac{F_{\lambda}}{1Jy} \left(\frac{d}{100\ pc} \right)^2 \frac{50\,K}{<T>} \frac{0.01\ cm^2 g^{-1}}{\kappa_{1.3mm}}$$

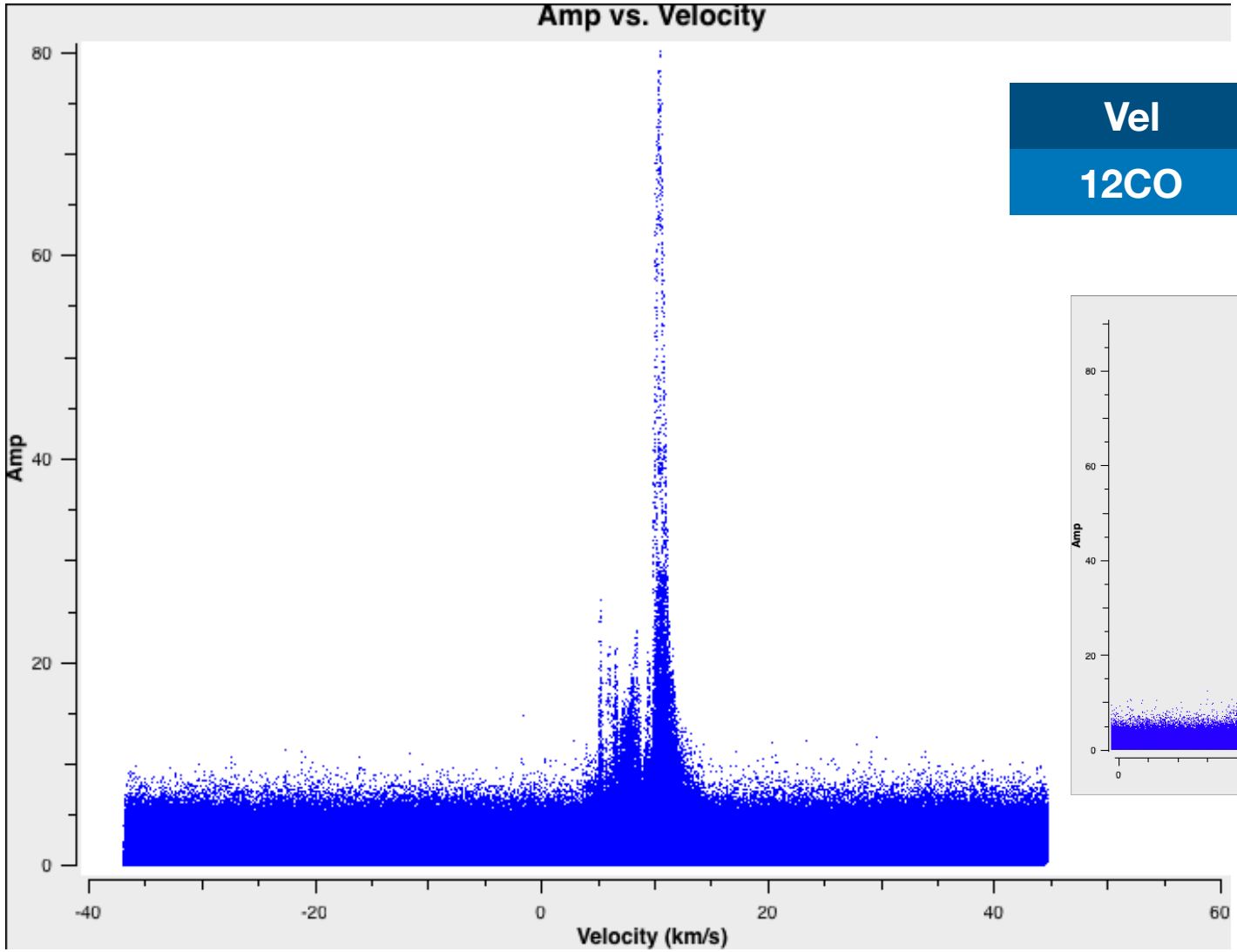
$$where\ ,\ d = 420\,pc,\ \ <T> = 30K,\ \ \kappa_{1.3mm} = 0.01$$ (W. F. THI et al, 2001.)

From our result, the flux is measured as **0.018 Jy**

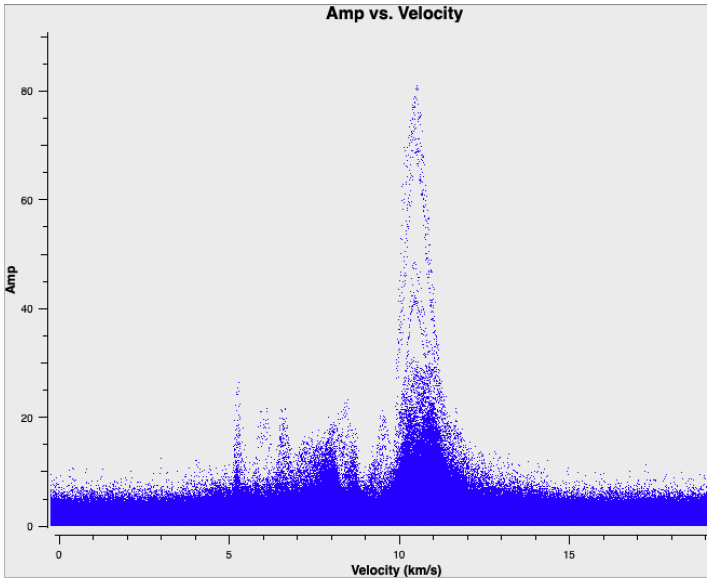
$$M_{disk} = 0.06\, M_{\odot} \frac{0.018Jy}{1Jy} \left(\frac{420\ pc}{100\ pc} \right)^2 \frac{50\,K}{30\ K} \frac{0.01\ cm^2 g^{-1}}{0.01\ cm^2 g^{-1}} = 3.17 \times 10^{-2} M_{\odot}$$

The disk Mass = (Gas + Dust) Mass = $\mathbf{3.17 \times 10^{-2} M_{\odot}}$

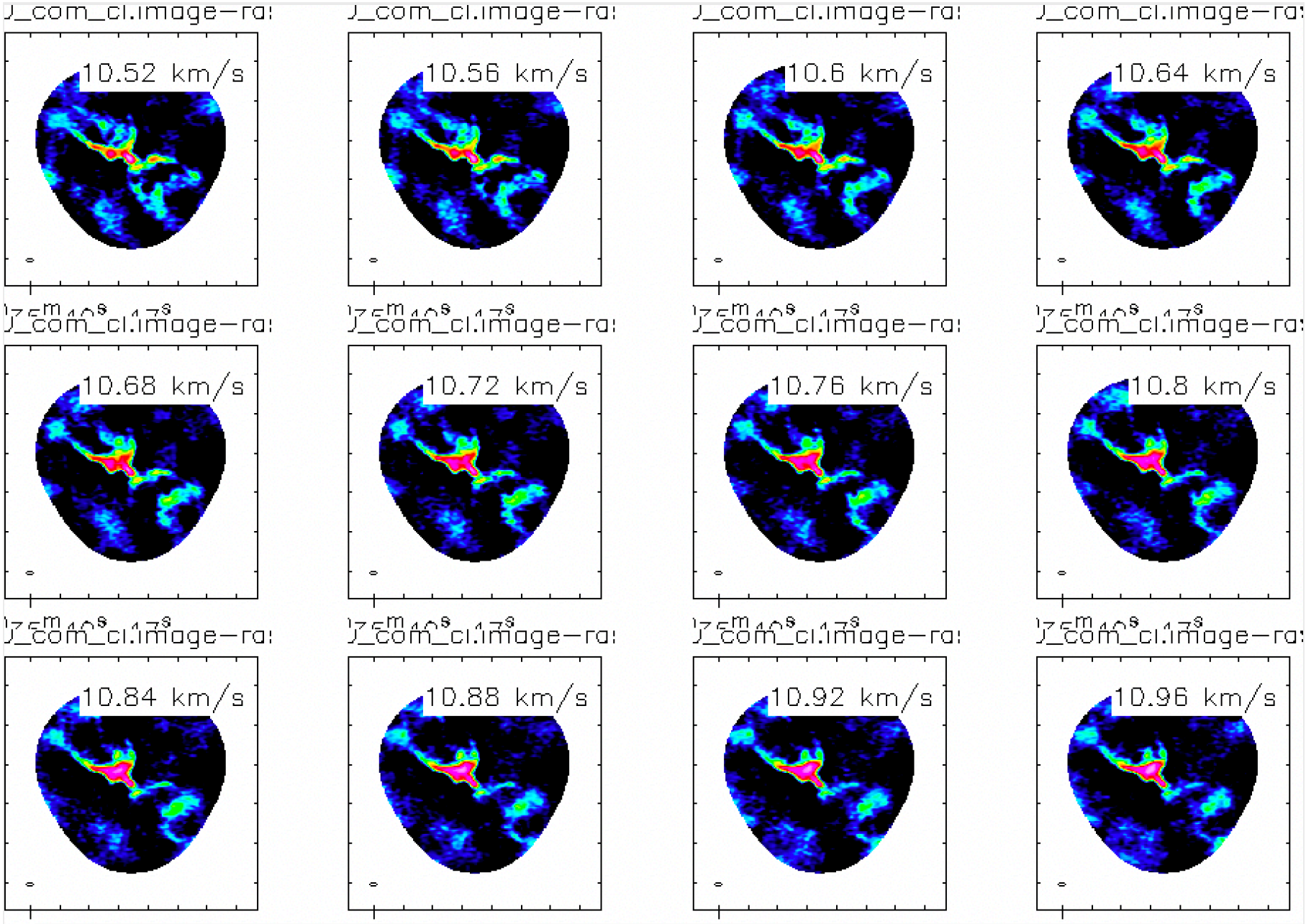
12CO LINE



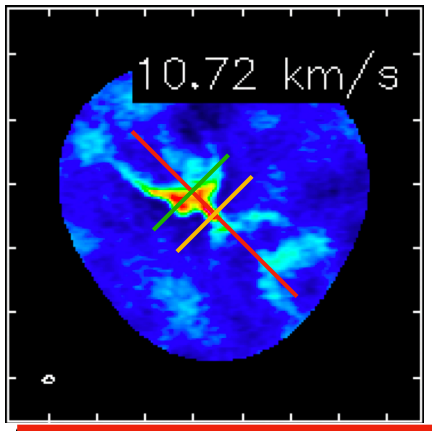
Vel	Start	End
12CO	3	15



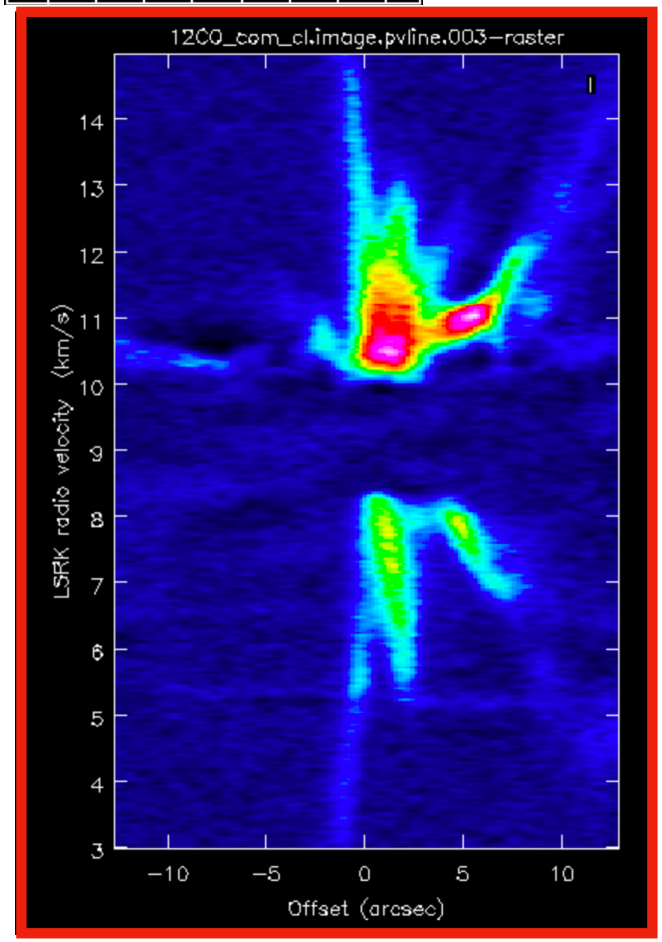
CHANNEL MAP

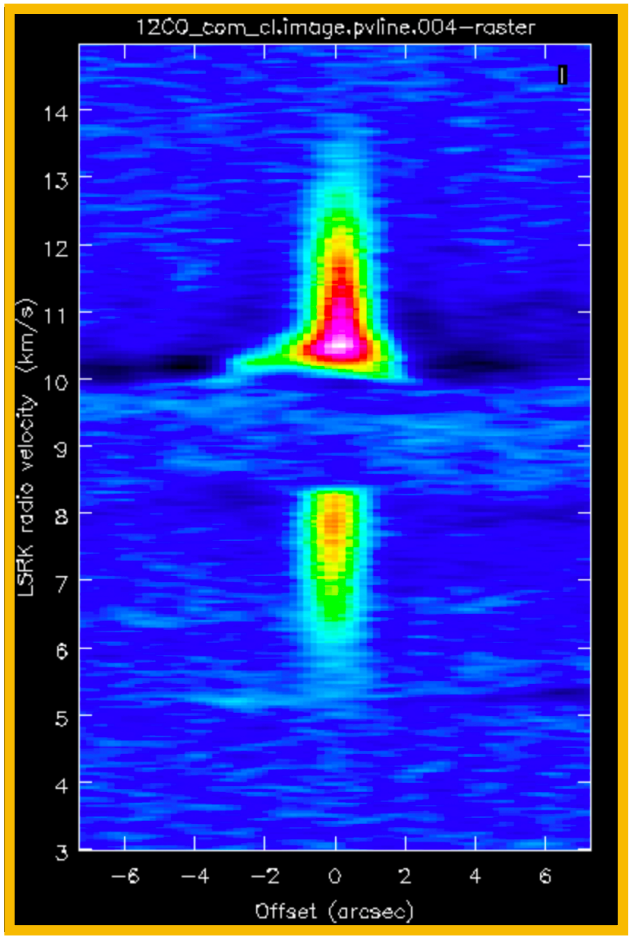

10.52 km/s
10.56 km/s
10.6 km/s
10.64 km/s
10.68 km/s
10.72 km/s
10.76 km/s
10.8 km/s
10.84 km/s
10.88 km/s
10.92 km/s
10.96 km/s

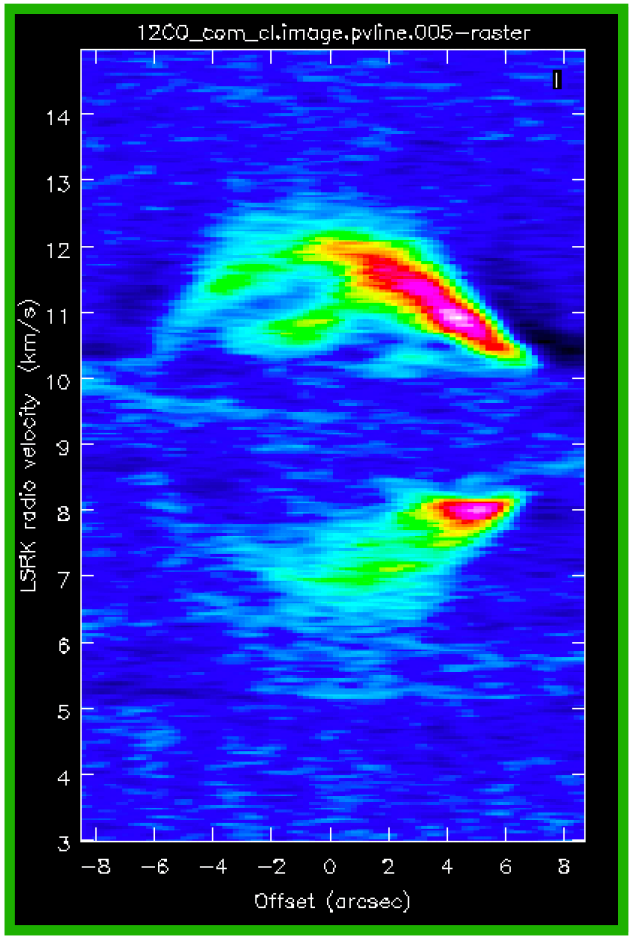
PV DIAGRAM



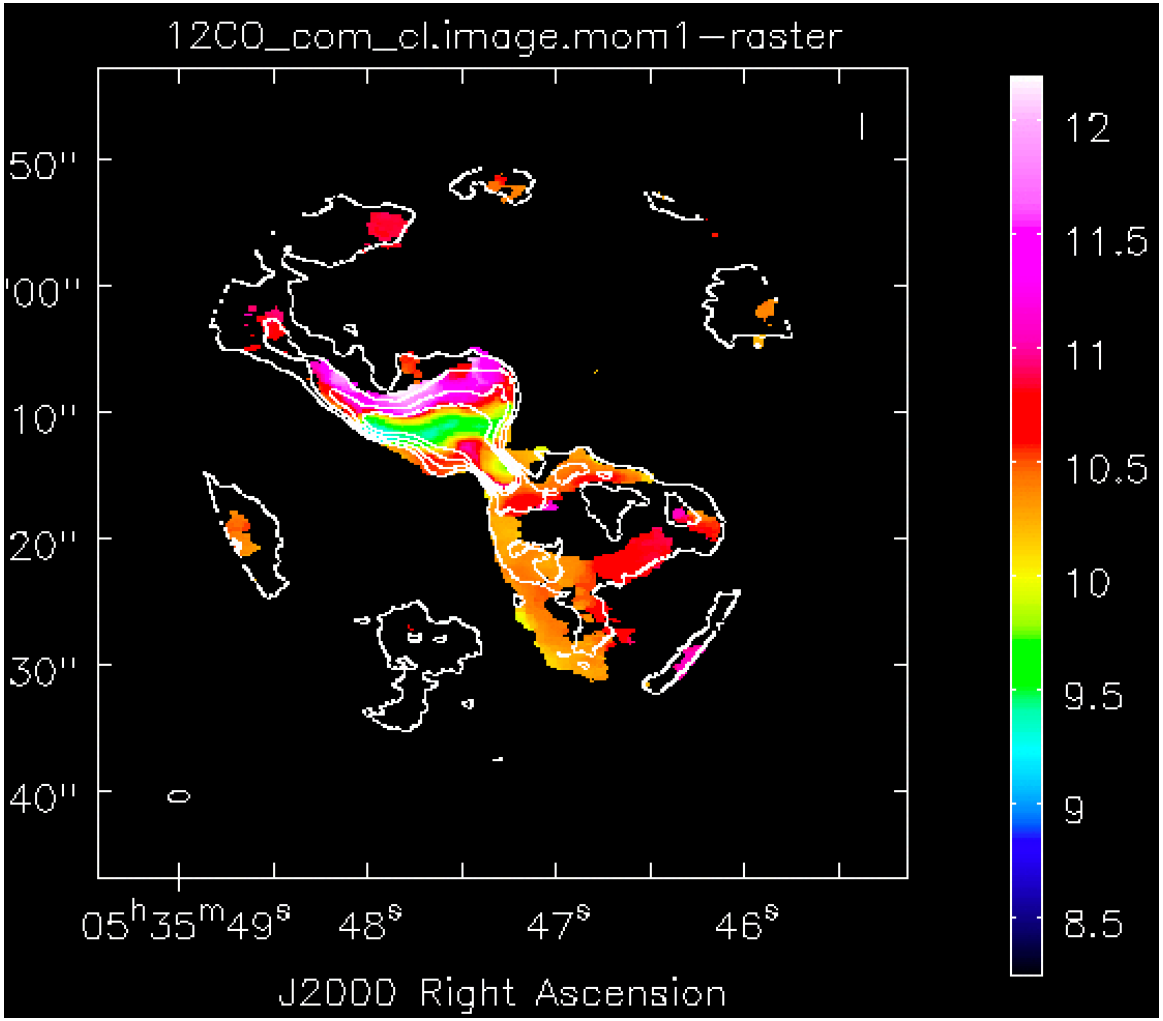
OUTFLOW + LOBE

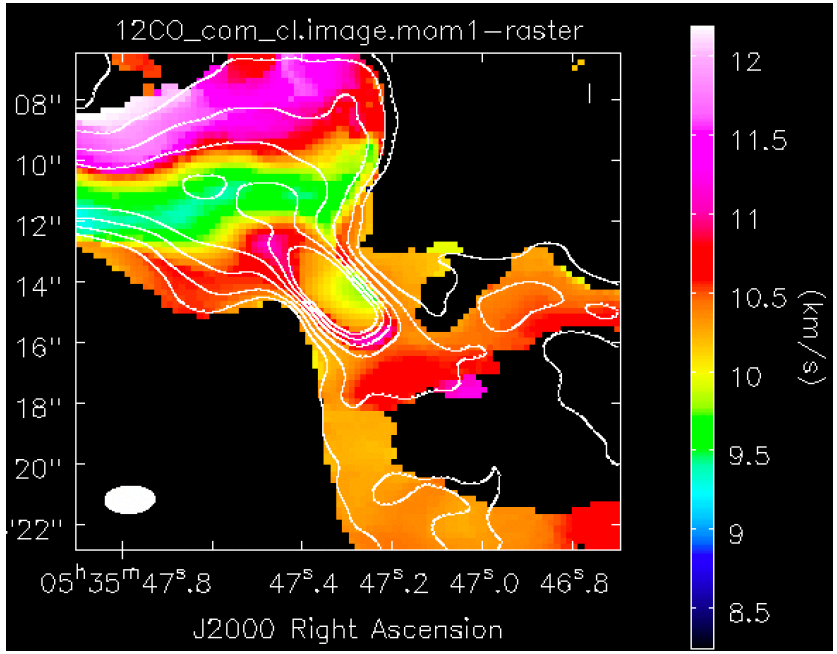






MOMENT MAP





Systemic velocity ~ 9.2 m/s

```
immoments(imagename='12CO_com_cl.image',moments=[1],
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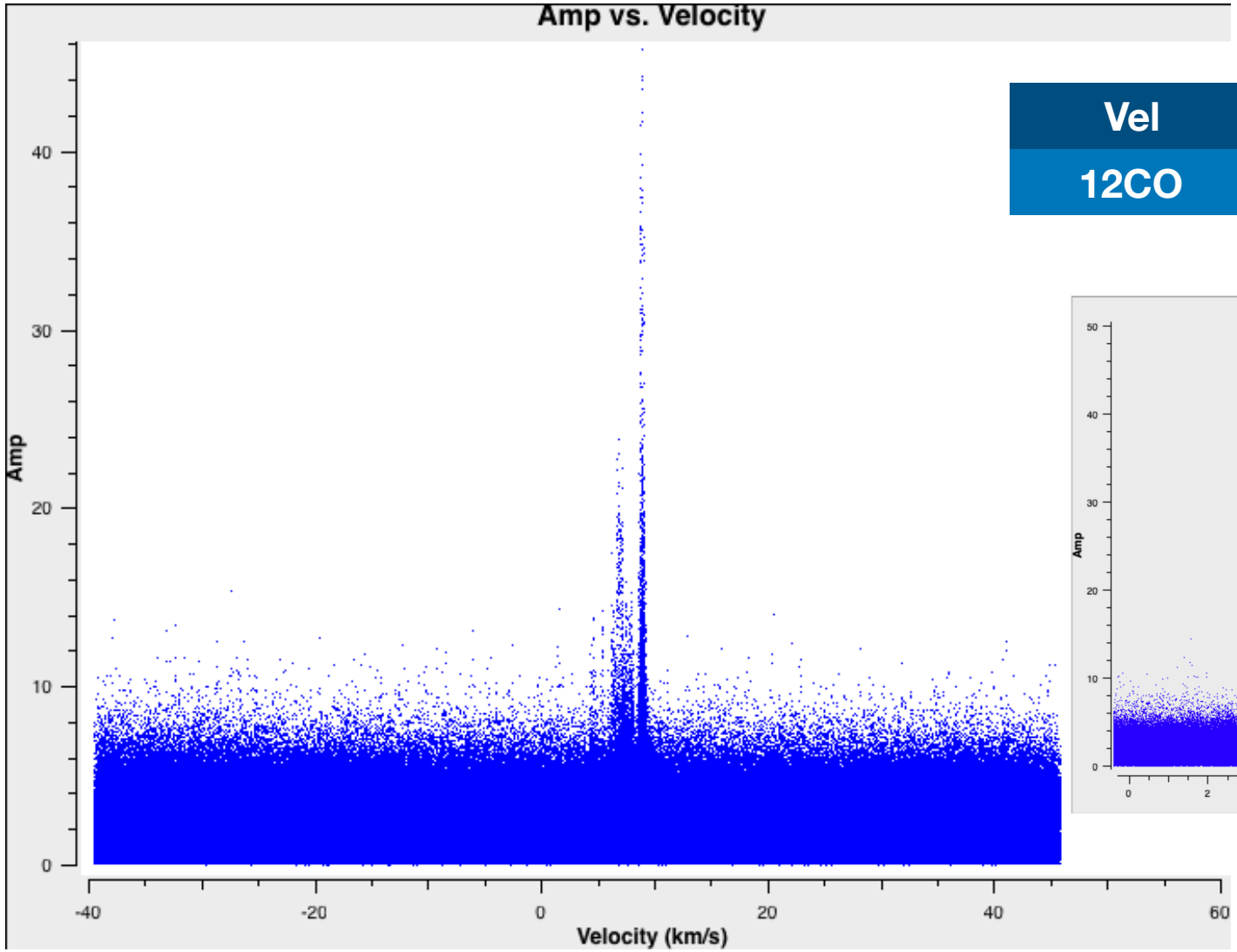
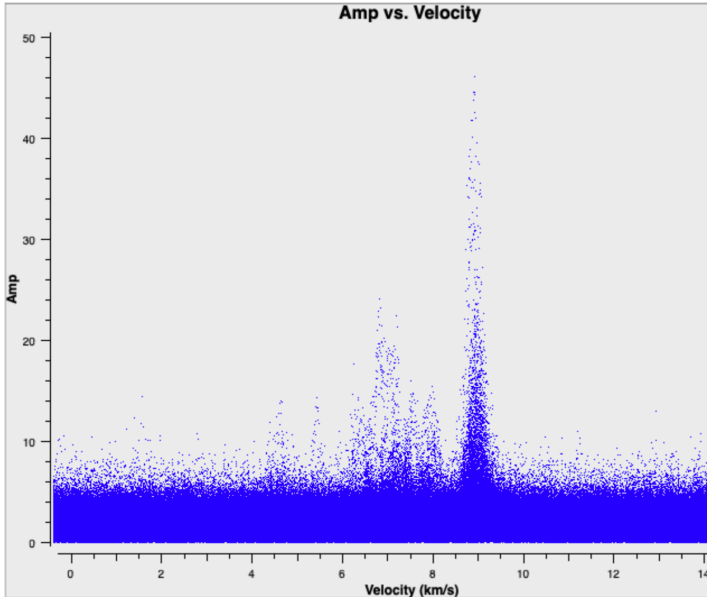
          chans='100~230',includepix=[0.16,100]) 8sig
```

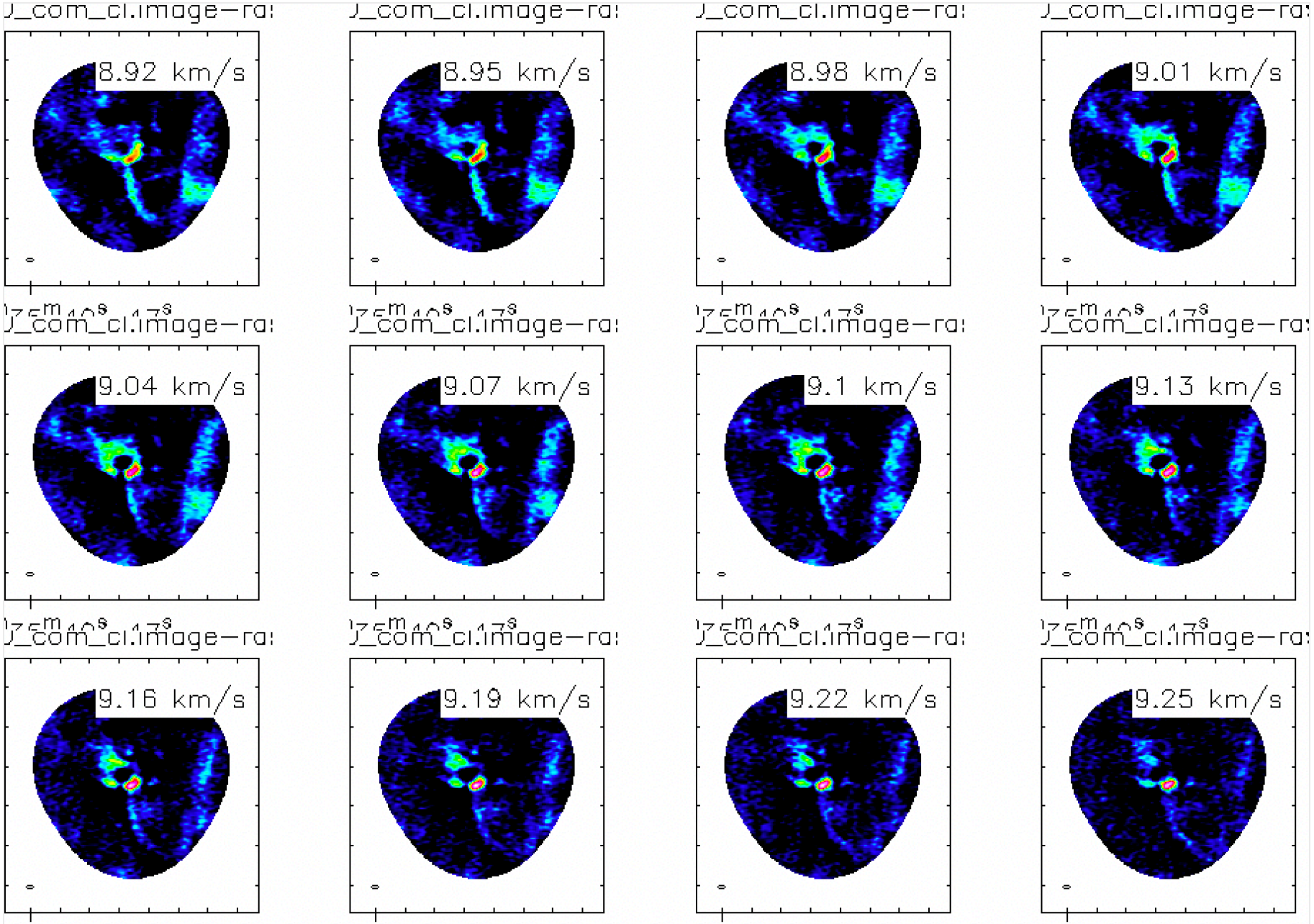
13CO LINE



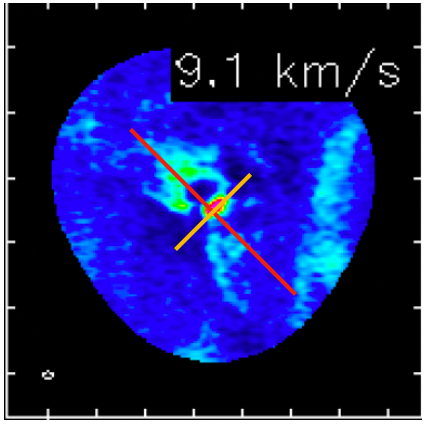
Vel	Start	End
12CO	4	10.5



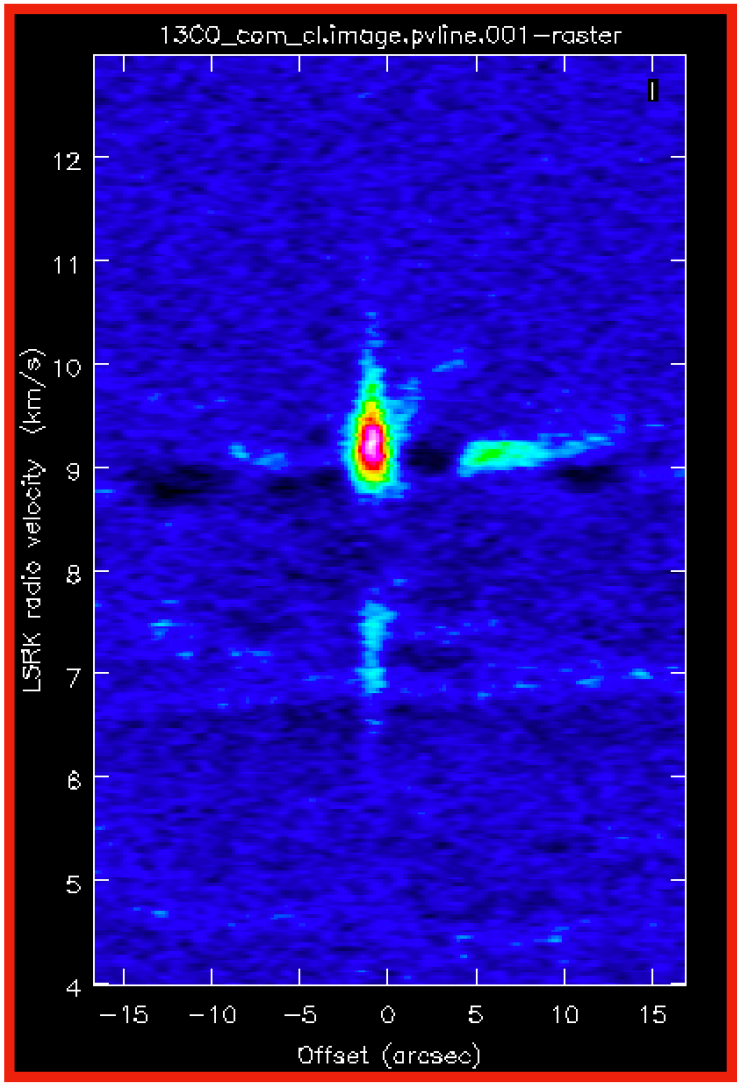
CHANNEL MAP

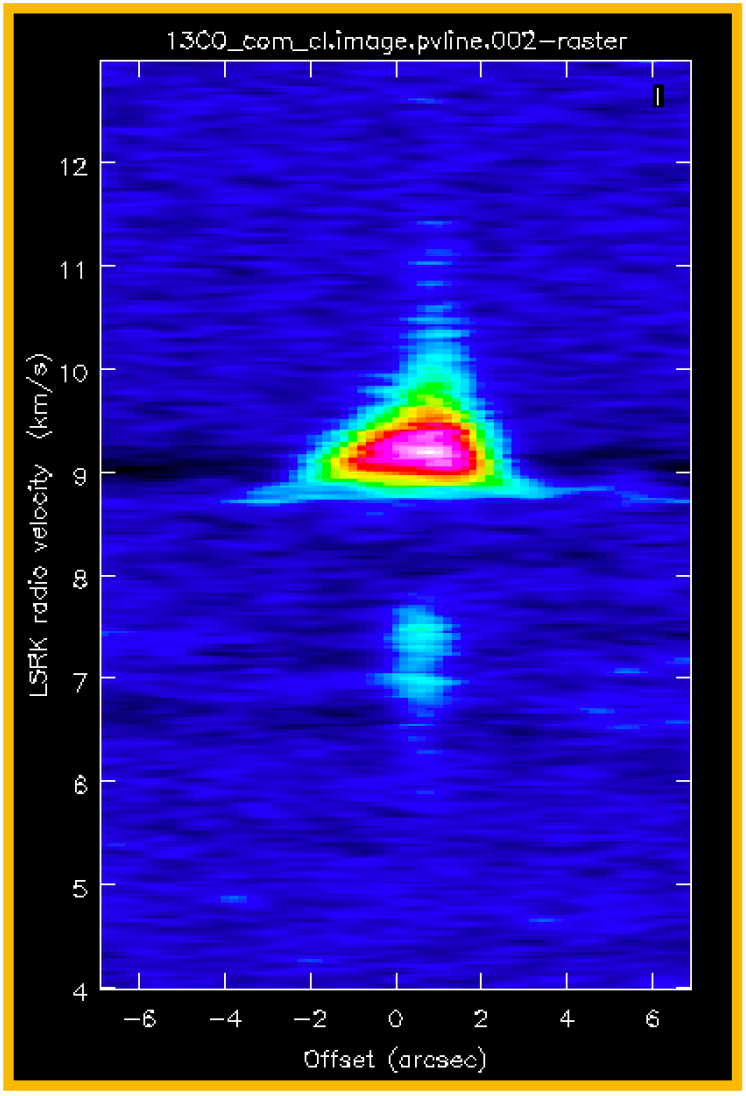

8.92 km/s
8.95 km/s
8.98 km/s
9.01 km/s
9.04 km/s
9.07 km/s
9.1 km/s
9.13 km/s
9.16 km/s
9.19 km/s
9.22 km/s
9.25 km/s

PV DIAGRAM

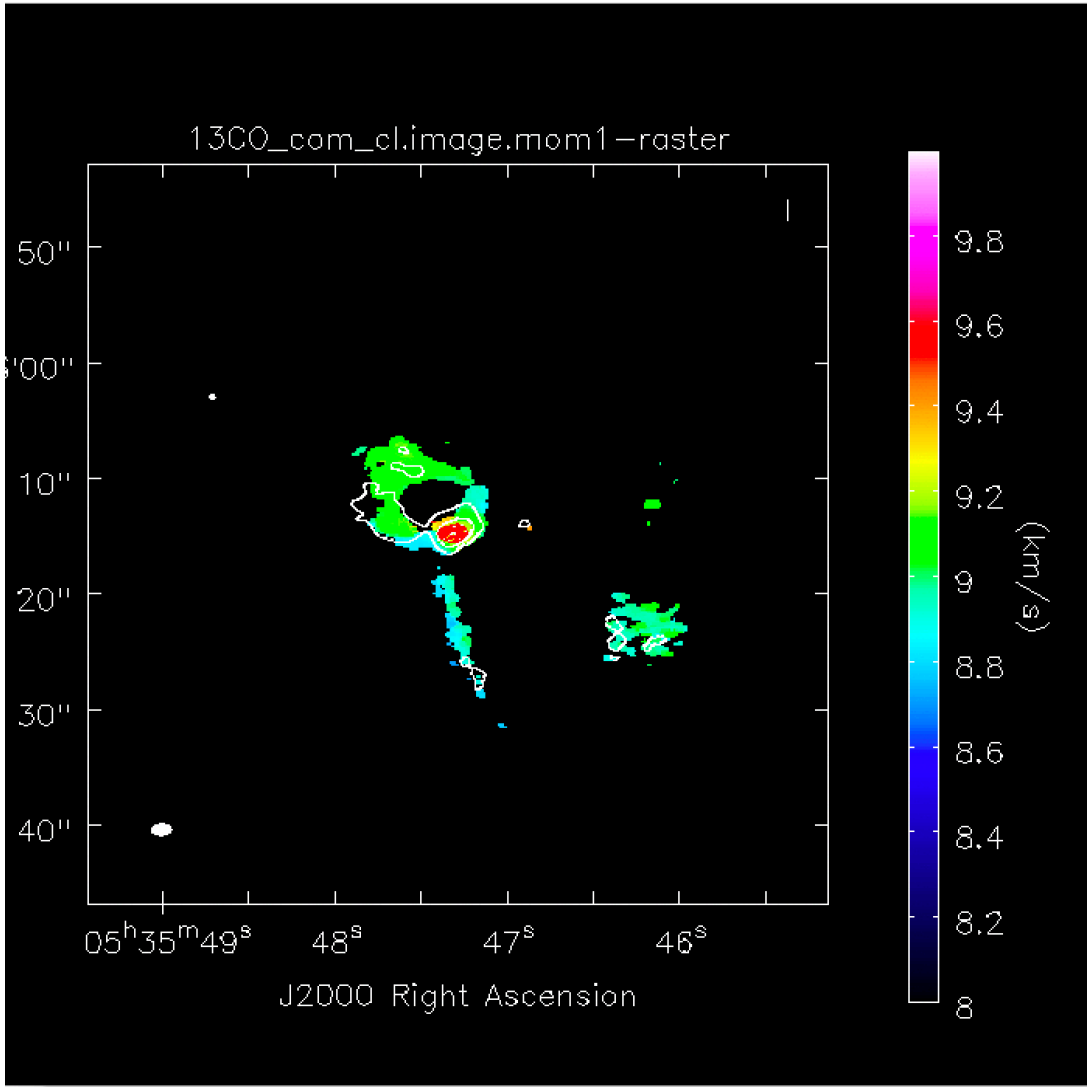


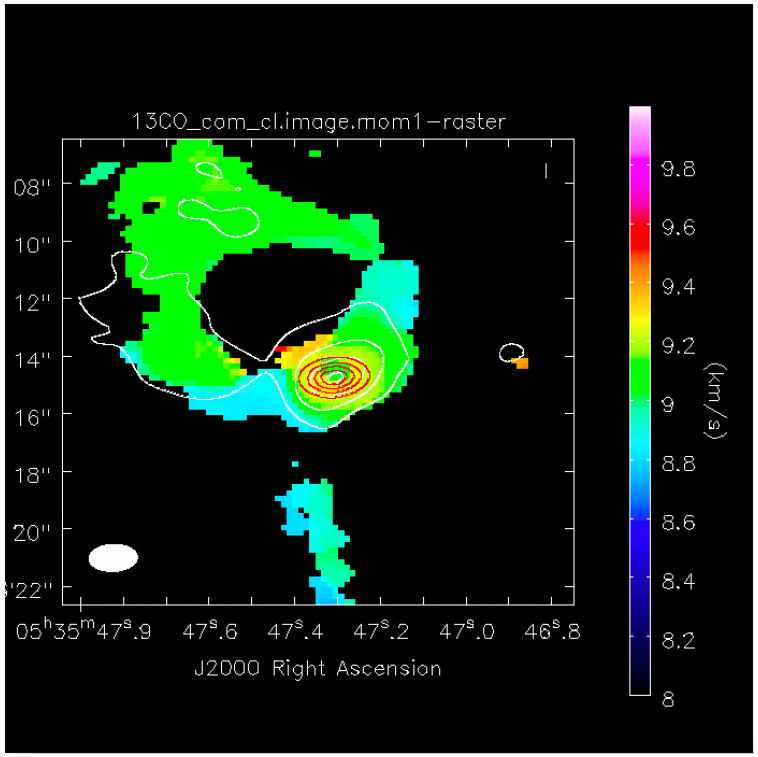
OUTFLOW
Near
Launching Part





MOMENT MAP





Systemic velocity ~ 9.2 m/s

```
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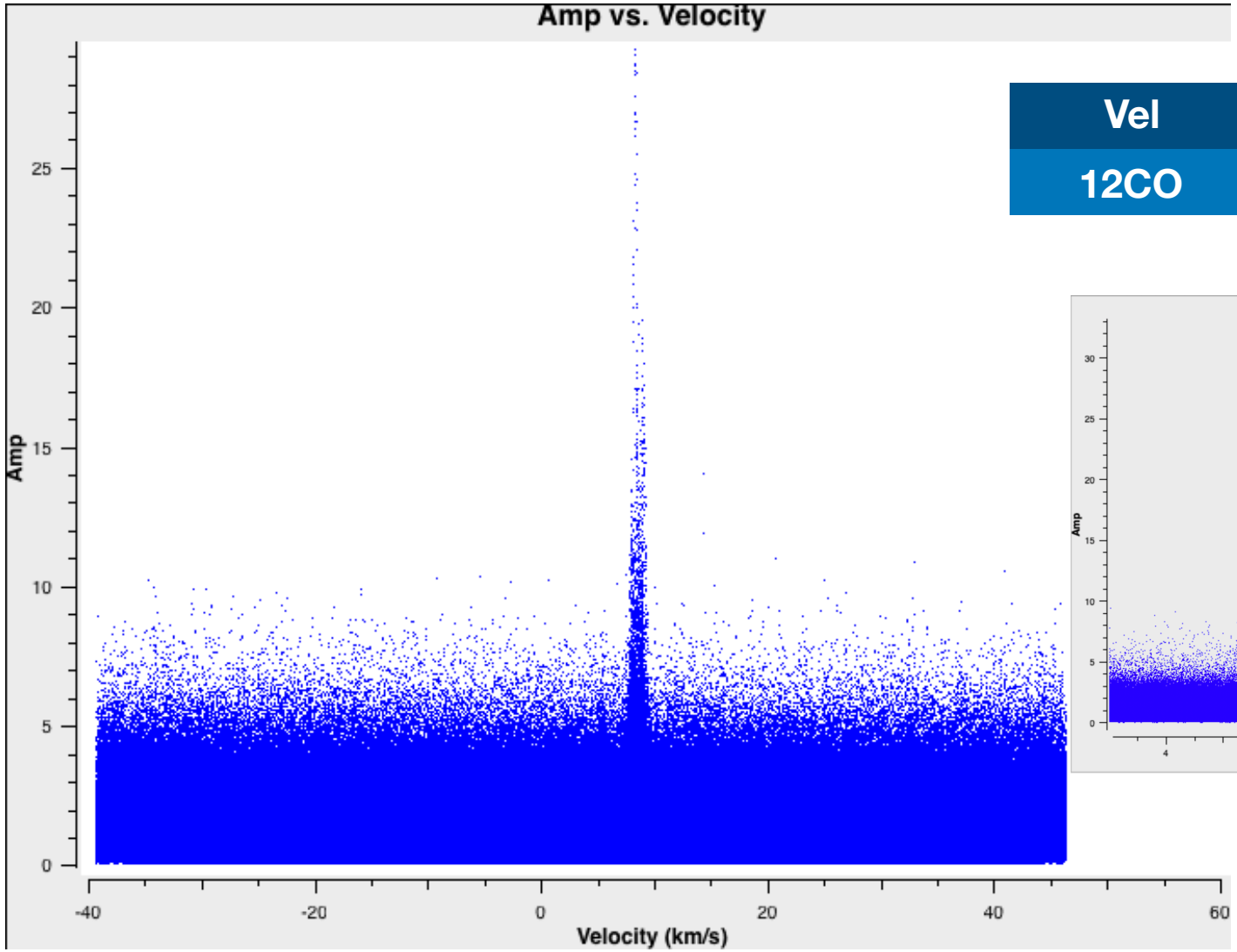
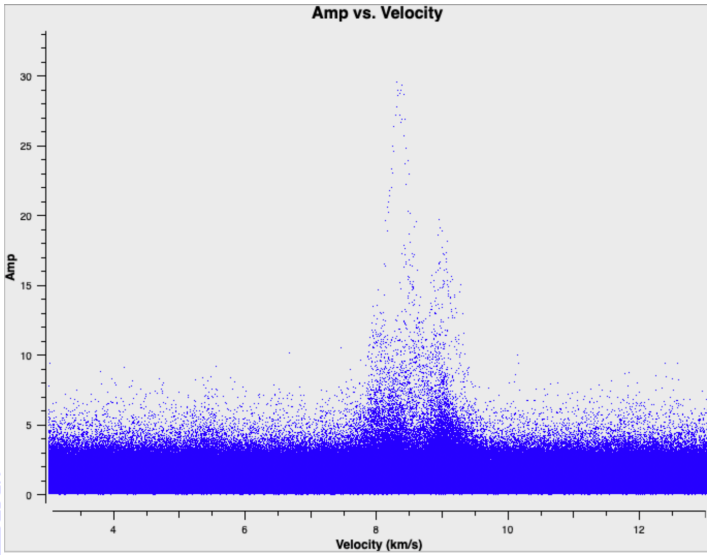
```

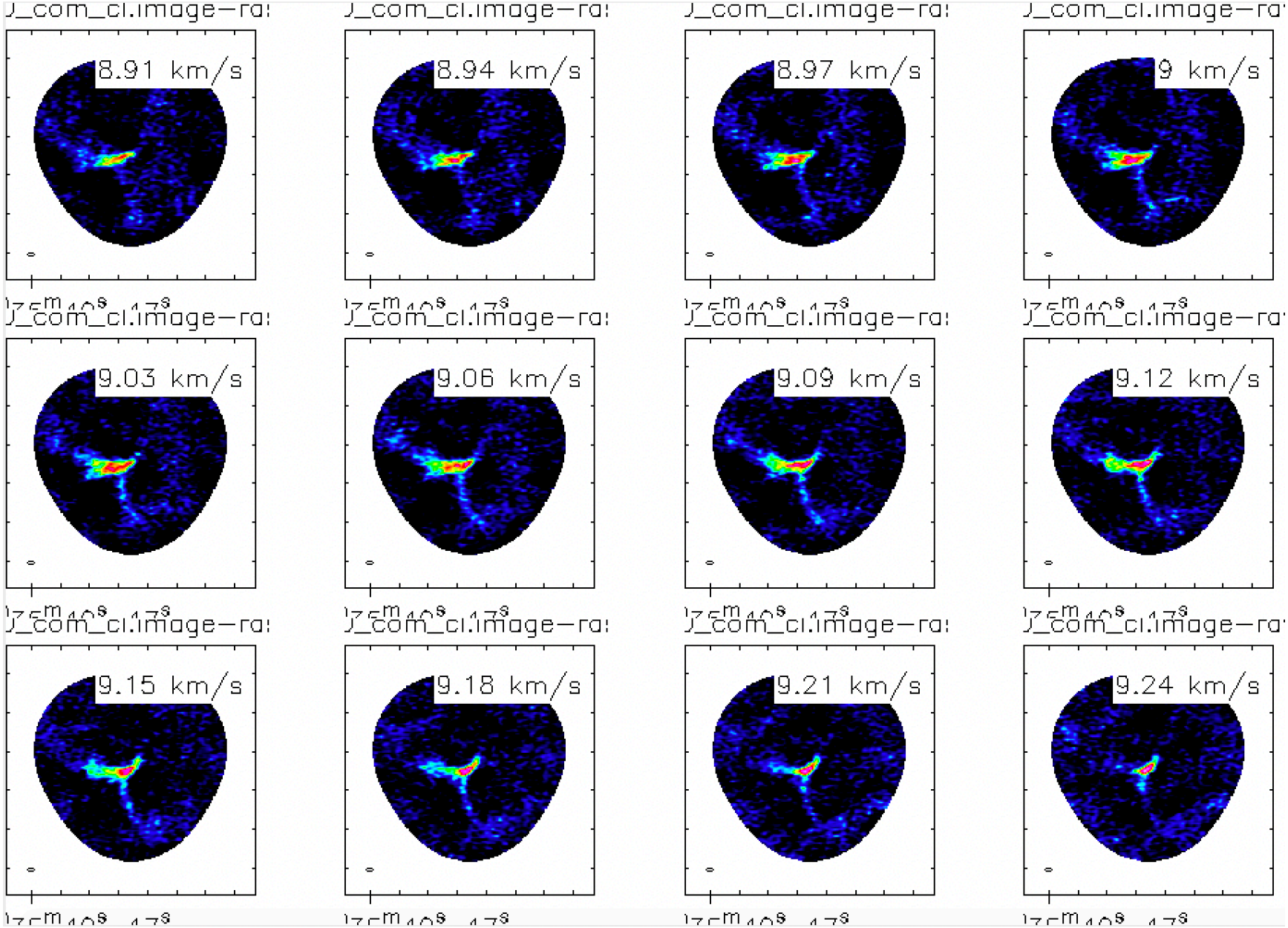
C18O LINE



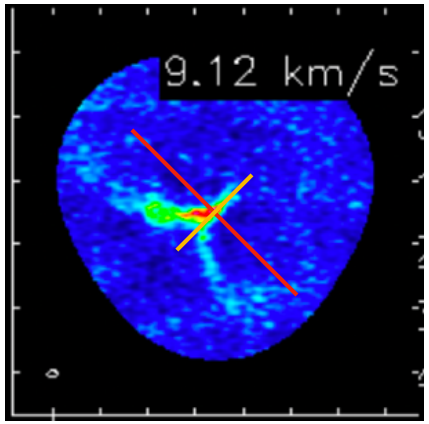
Vel	Start	End
12CO	6	12



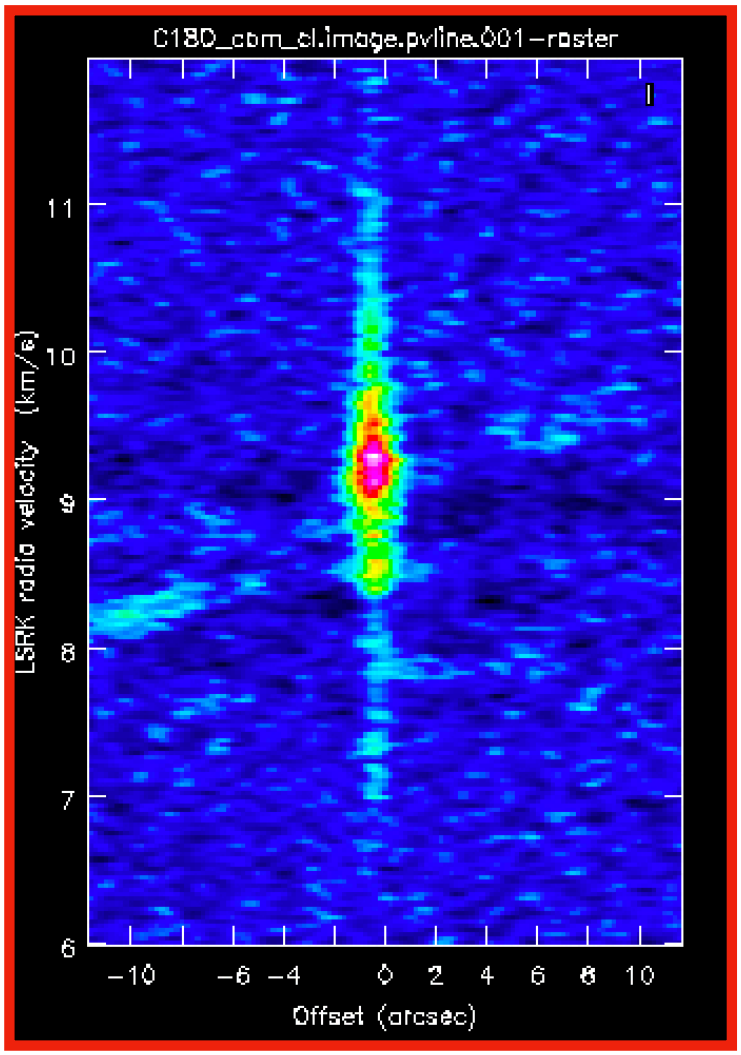
CHANNEL MAP

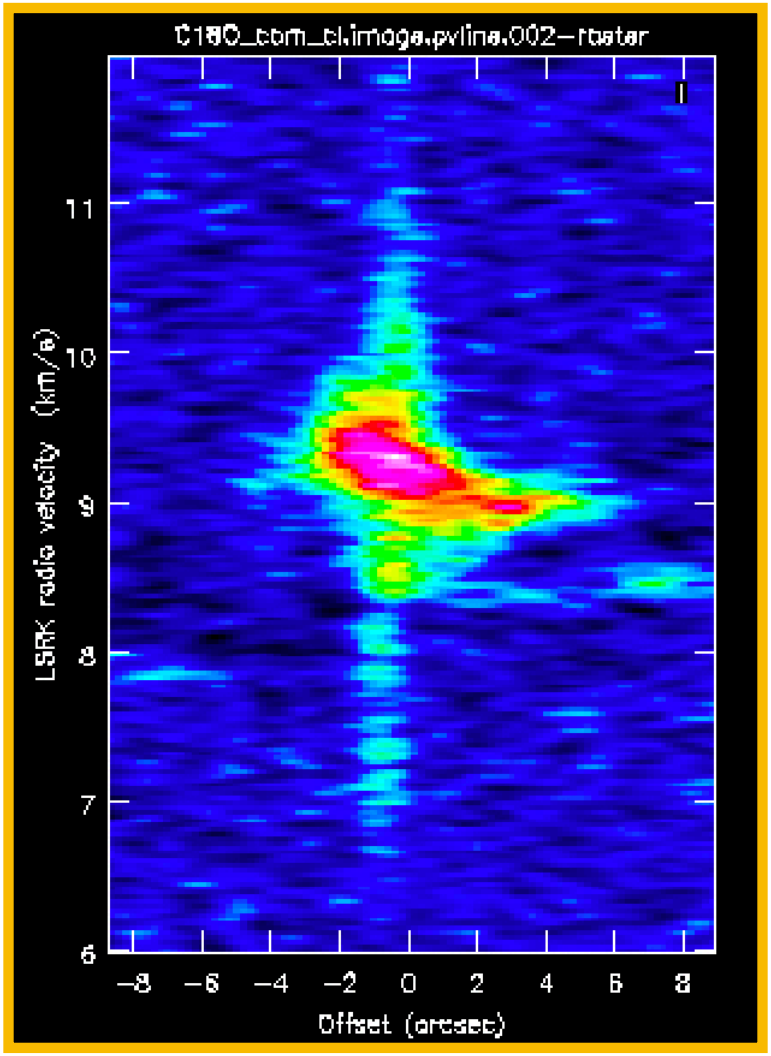

8.91 km/s
8.94 km/s
8.97 km/s
9 km/s
9.03 km/s
9.06 km/s
9.09 km/s
9.12 km/s
9.15 km/s
9.18 km/s
9.21 km/s
9.24 km/s

PV DIAGRAM

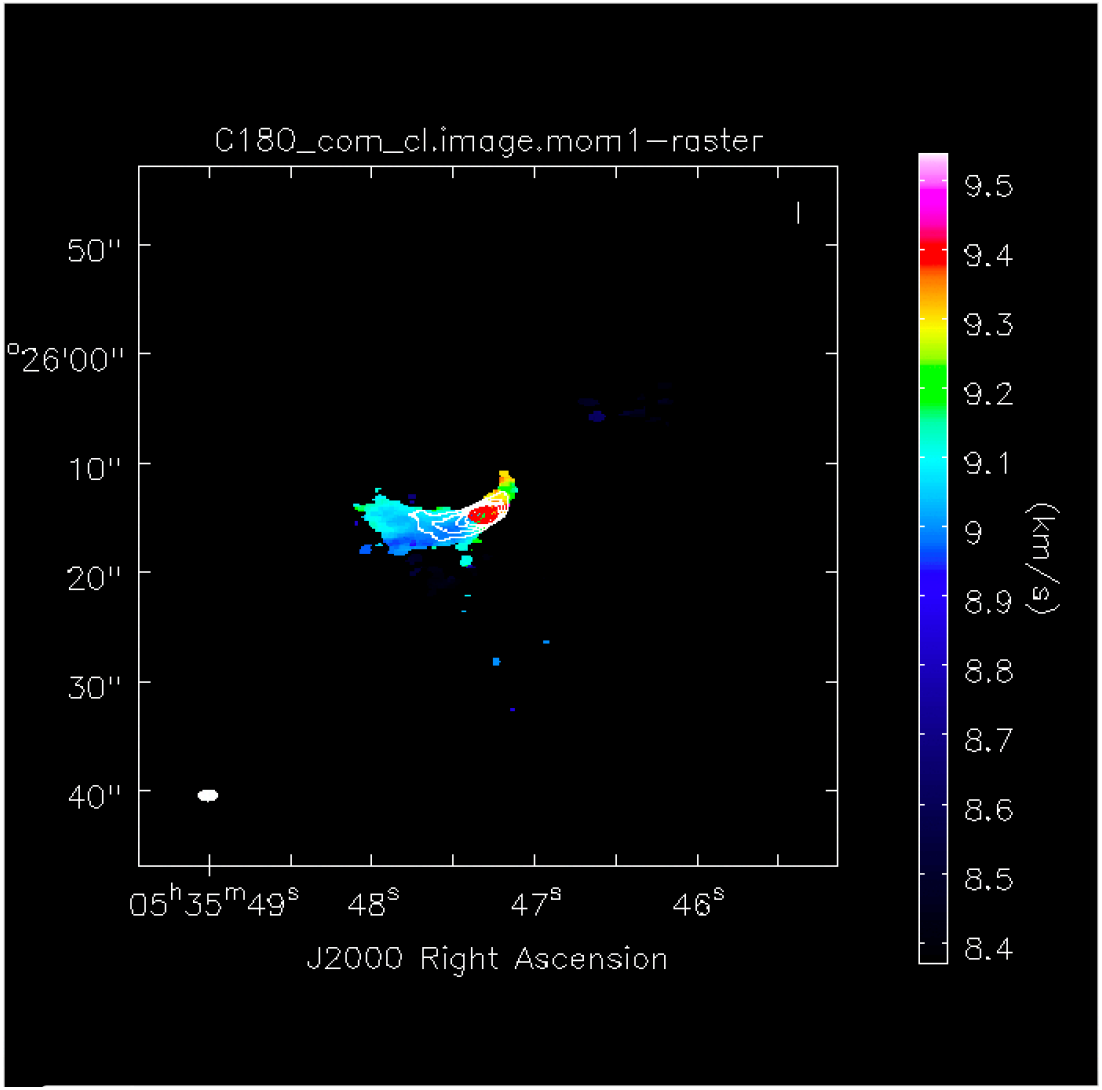


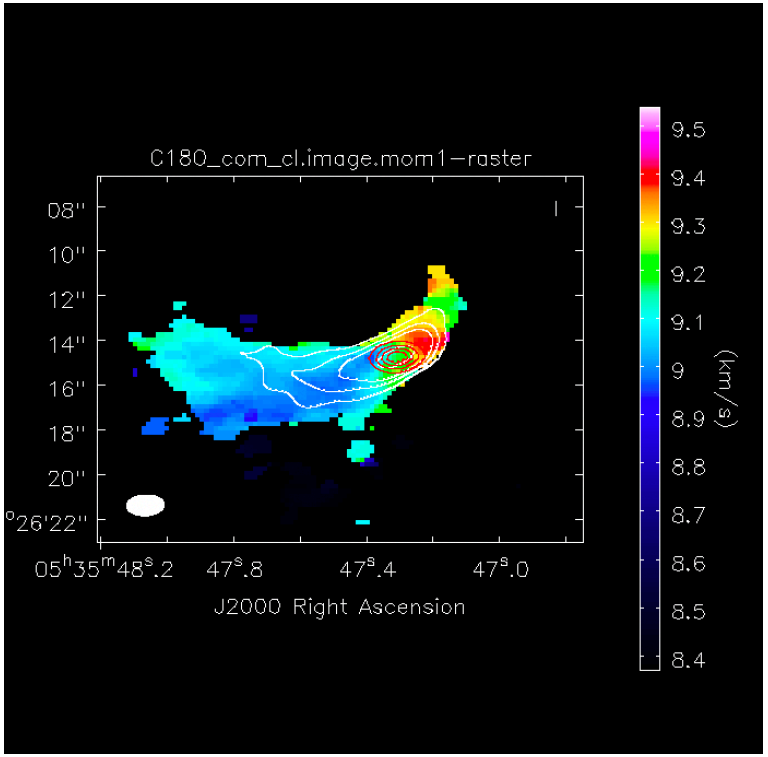
Perpendicular direction velocity flow





MOMENT MAP





Systemic velocity ~ 9.2 m/s

```
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          outfile='C18O_com_cl.image.mom1',
          chans='79~132',includepix=[0.08,100]) 5sig
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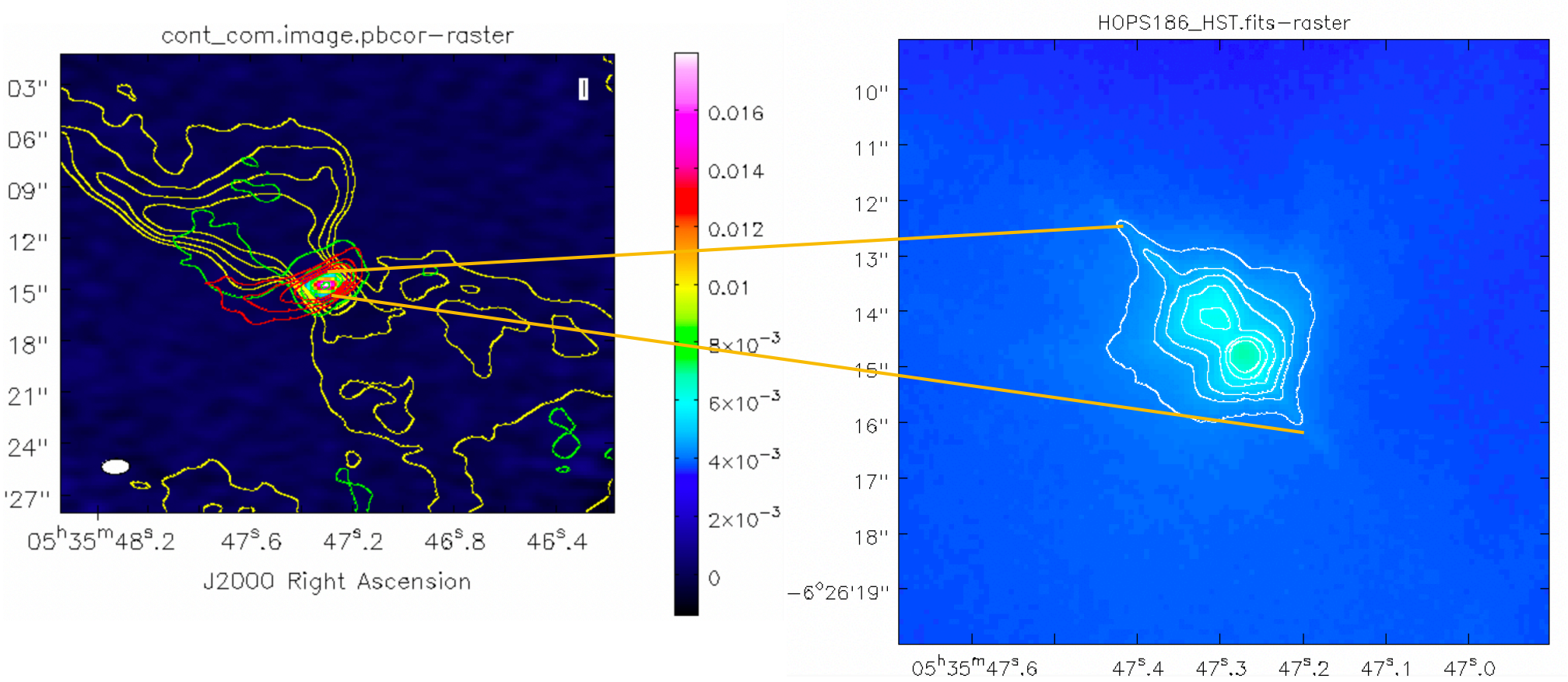
RESULT



Yellow, green, and red contours denote 12CO, 13CO, and C18O line respectively.

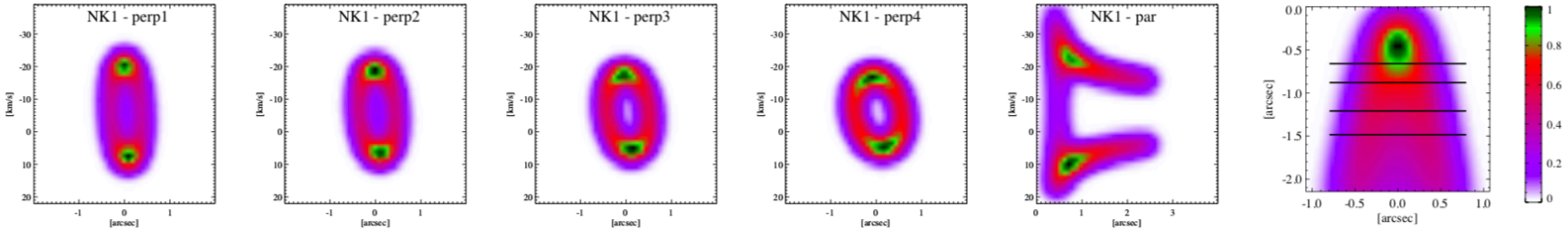
model	description
A	bow shock
B	rotating bow shock
C	bow shock + jet precession
D	bow shock + jet precession + velocity shear
E	rotating bow shock + jet precession + velocity shear

IMPROVEMENT

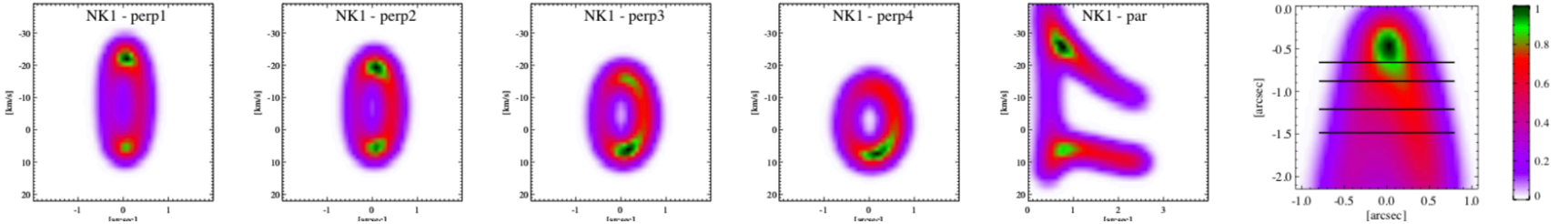
Outflow Rotation?

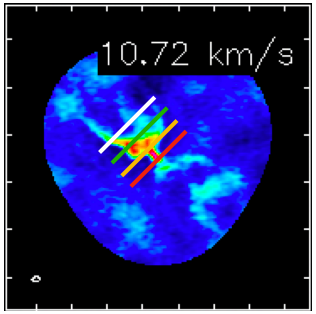
(S. Correia et al, 2009.)

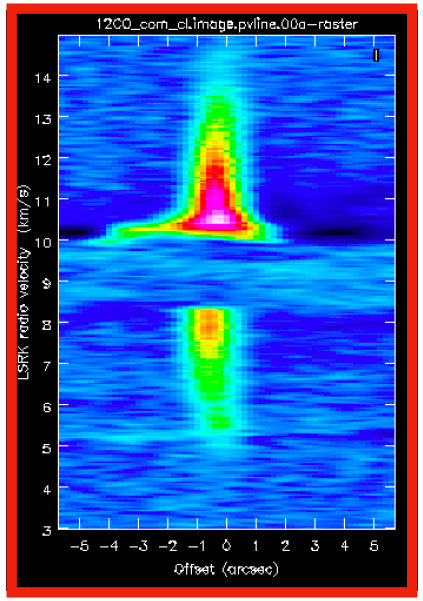
B

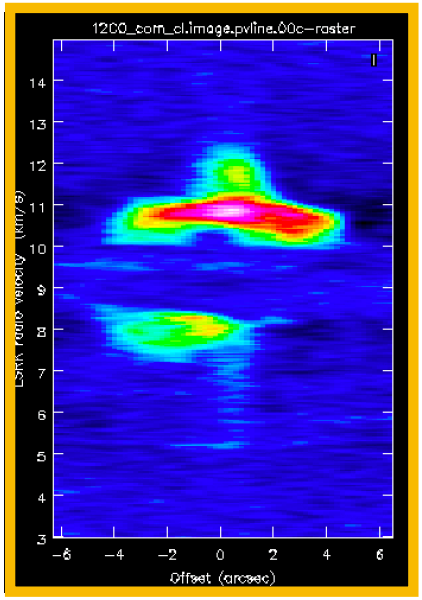


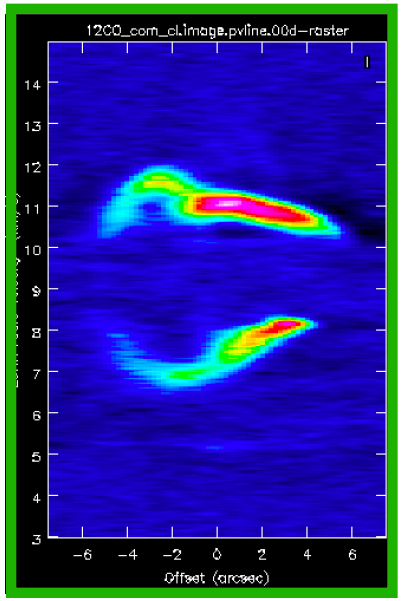
C

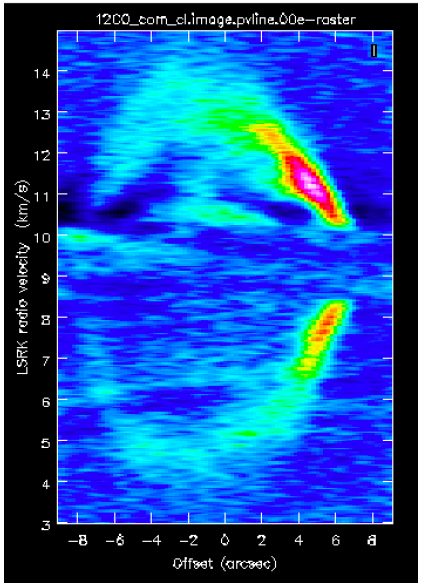












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A	bow shock
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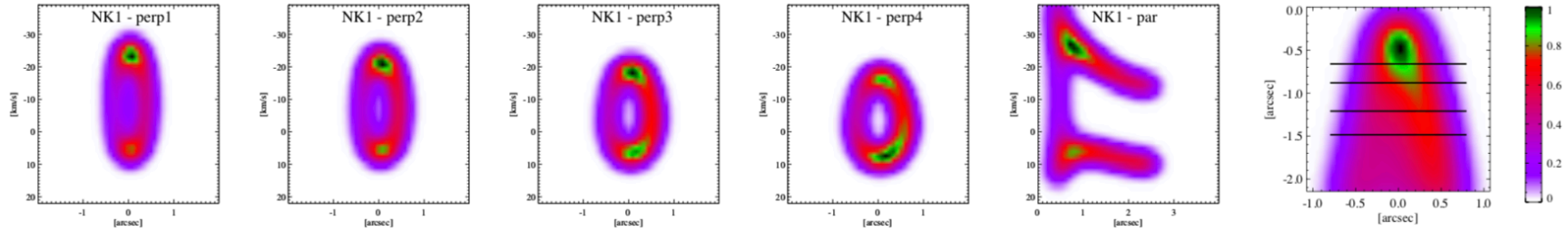
IMPROVEMENT

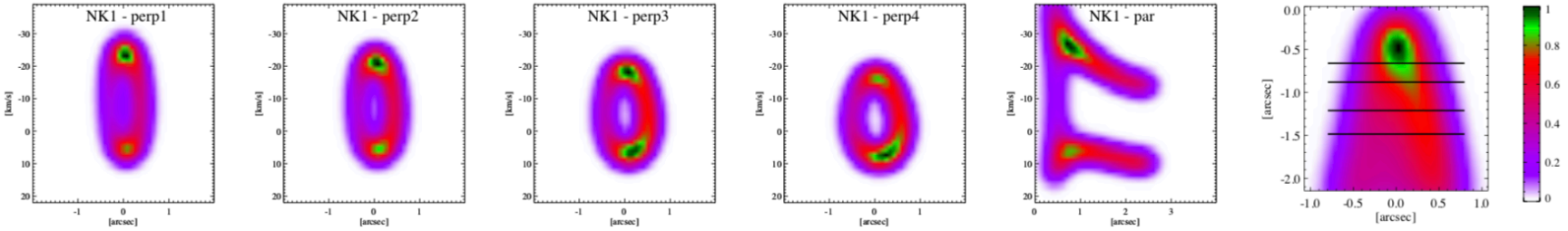
Outflow Rotation?

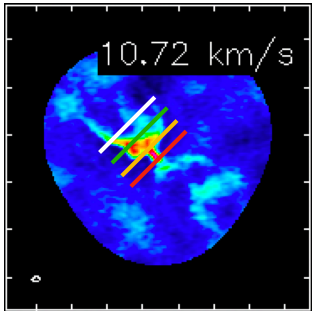
(S. Correia et al, 2009.)

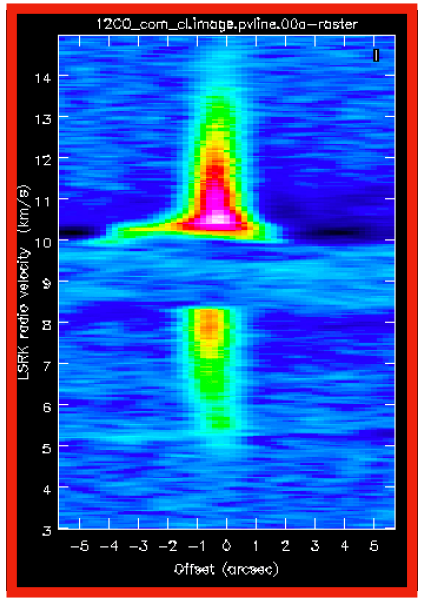
D

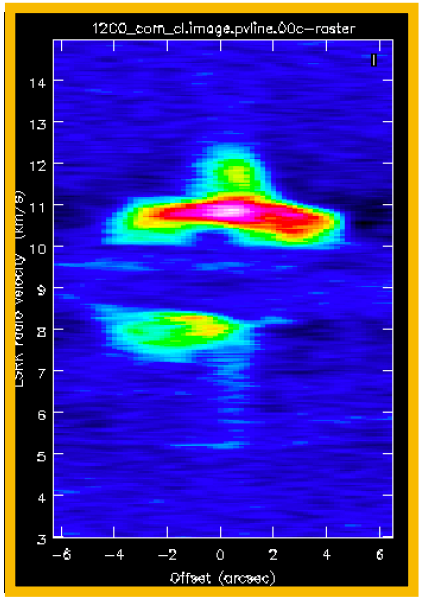


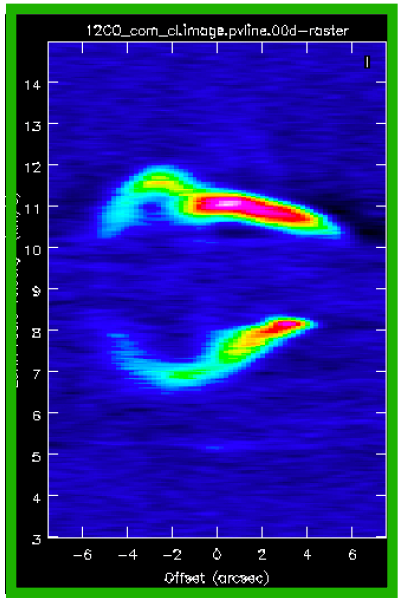
E

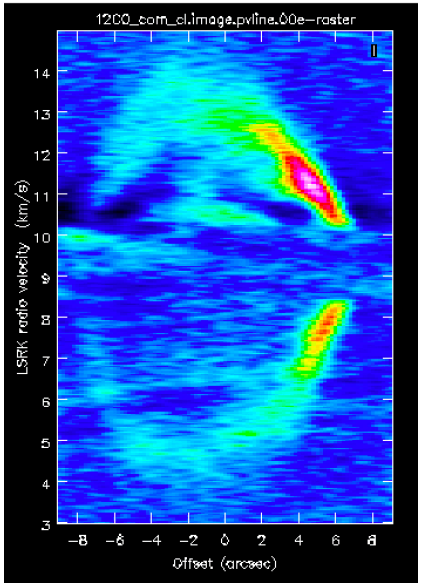












SUMMARY

1. **HOPS 186 data reduction with CASA**

2. **Outflow lobe and bipolar jet component**

3. **12CO, 13CO shows outflow structure**

4. **C18O traces central region**

(outflow + perpendicular direction velocity flow)

5. Outflow Rotation?