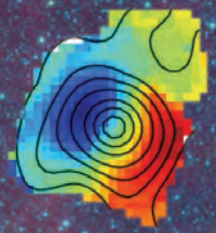

CH_3CN (13 - 12) velocities
Contours: 1.2mm continuum

An ALMA view of high-mass star formation in AFGL 4176

Katharine Johnston
University of Leeds, MPIA

Collaborators: *Henrik Beuther, Paul Boley, Eric Keto, Rolf Kuiper, Hendrik Linz, Tom Robitaille & Roy van Boekel*

Outline

UNIVERSITY OF LEEDS

Background and Observations

Kinematics and temperatures from CH_3CN

Dust structure from 1.2mm continuum

Outflow seen in ^{12}CO and $C^{34}S$?

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AFGL 4176: Background and Observations

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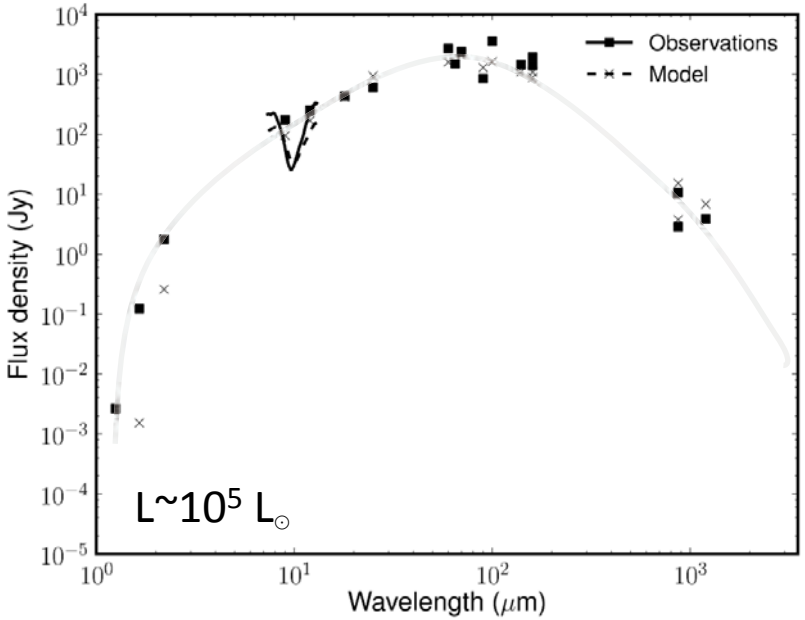
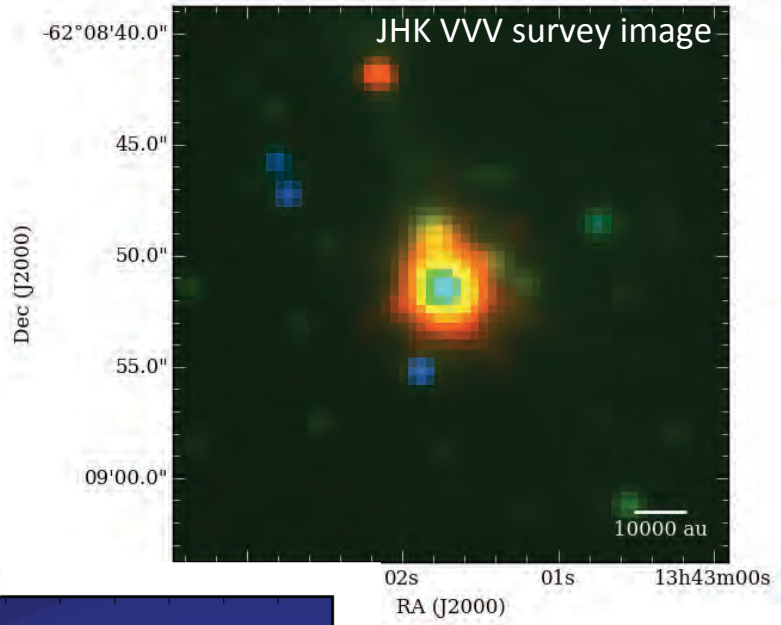
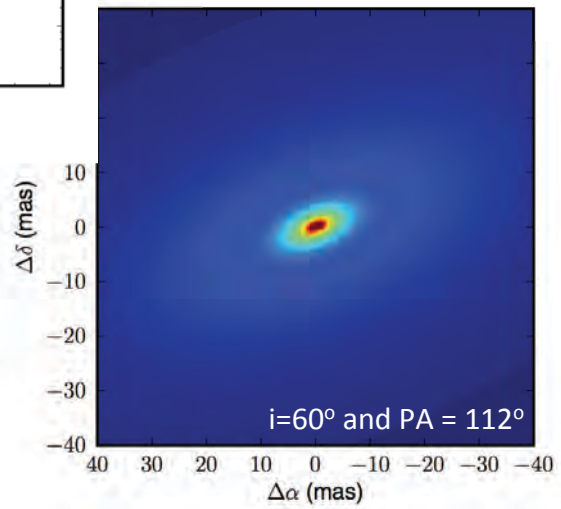
SED Modelling (Boley et al. 2012)







Mid-IR interferometry
(Boley et al. 2012, 2013a)

Model: extended 1D gaussian plus 2D disk-like component

AFGL 4176: Background and Observations

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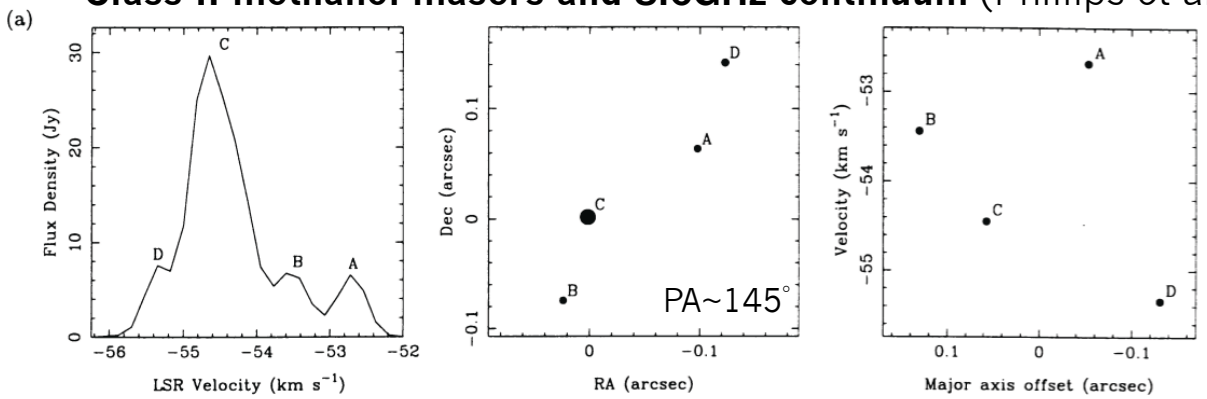
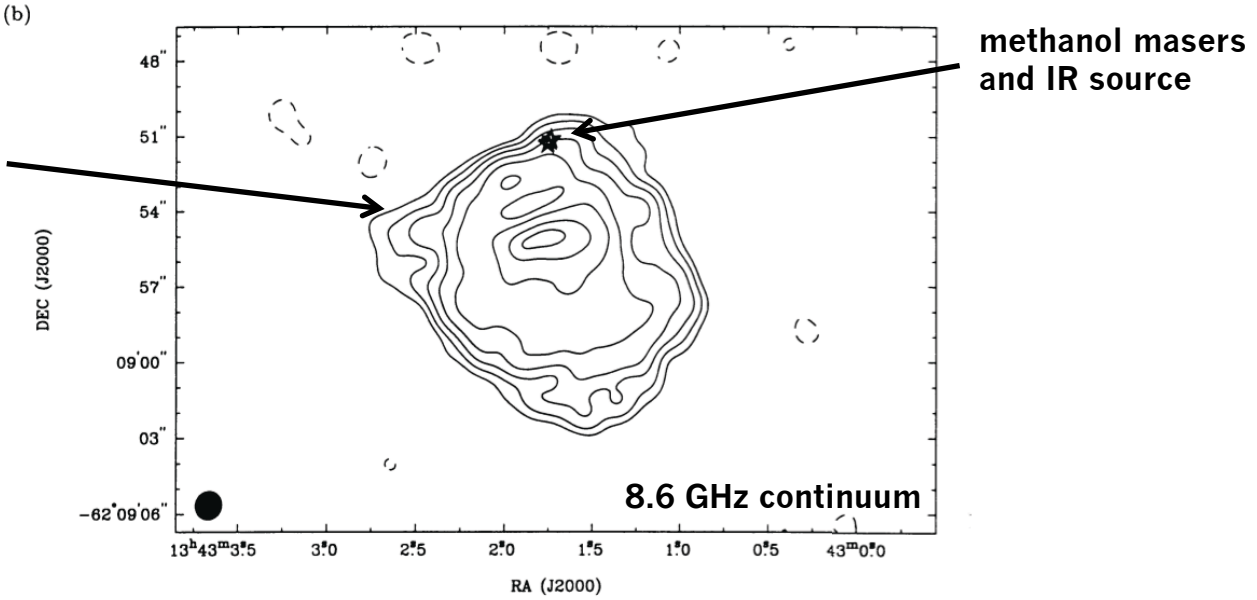
Class II methanol masers and 8.6GHz continuum (Phillips et al. 1998)



Compact but optically thin HII region: O8.5 star

(Ellingsen et al. 2005, Shabala et al. 2006)



Kinematics of the gas with ATCA

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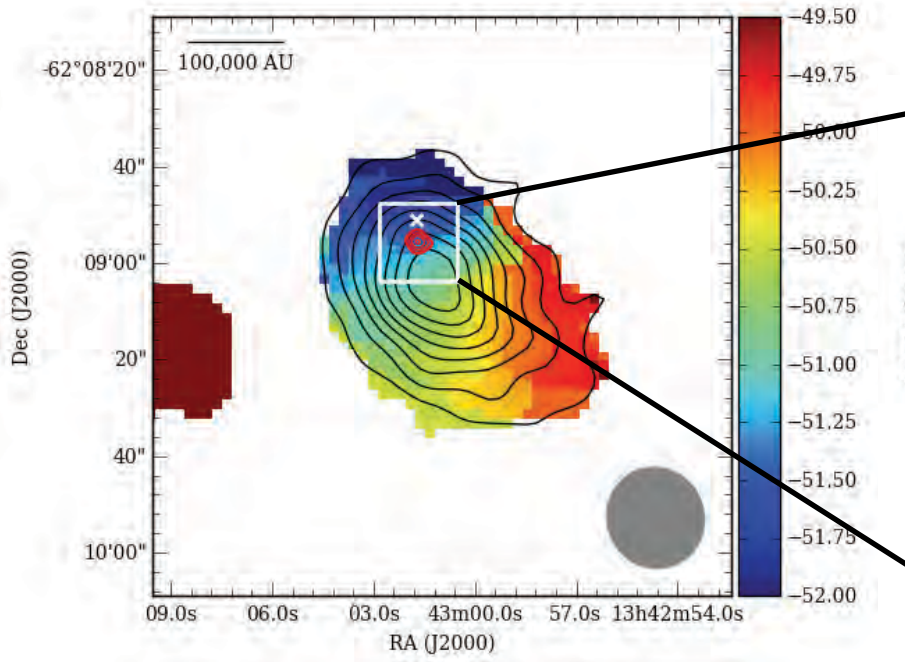
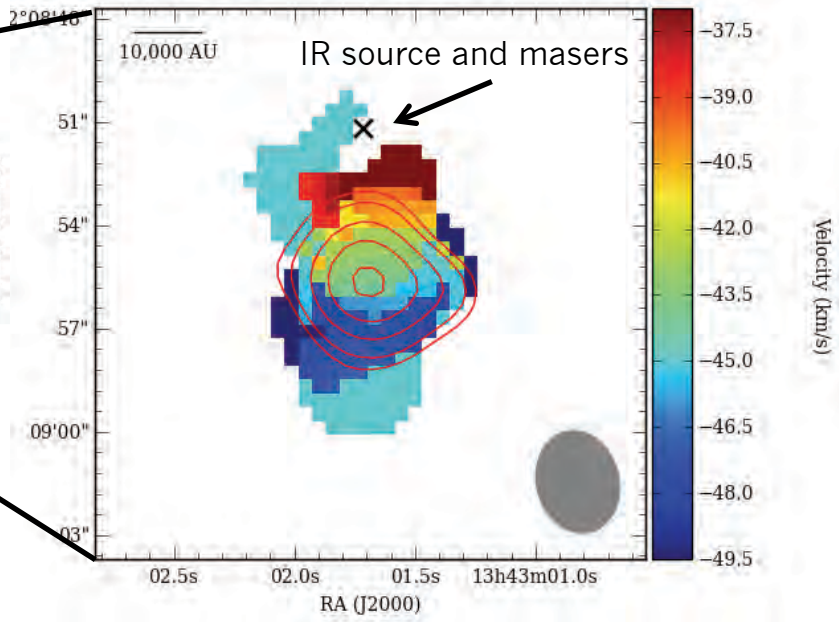
First moment map of $NH_3(1,1)$



H68α first moment map

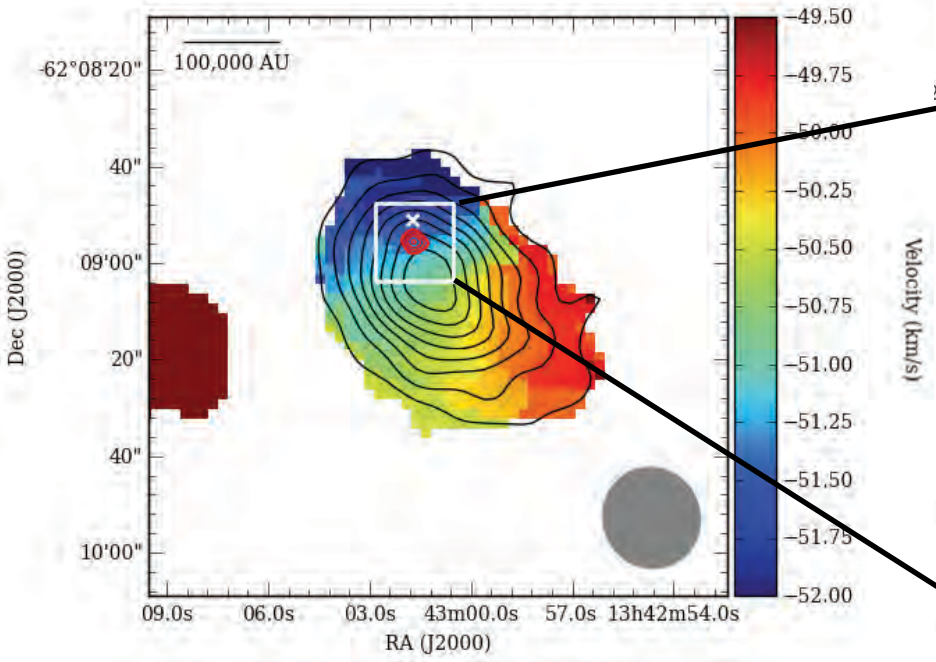


- **Black contours**: integrated NH_3 (1,1) emission
- Red contours: integrated emission from the radio recombination line H68α

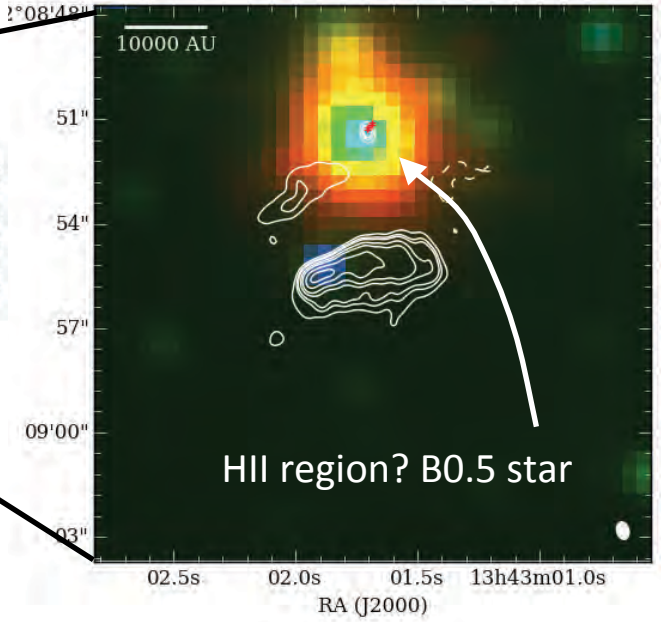
Kinematics of the gas with ATCA

UNIVERSITY OF LEEDS

First moment map of $NH_3(1,1)$



JHK VVV, contours: 1.2cm continuum



- **Black contours**: integrated NH_3 (1,1) emission
- Red contours: integrated emission from the radio recombination line H68α

ALMA Observations

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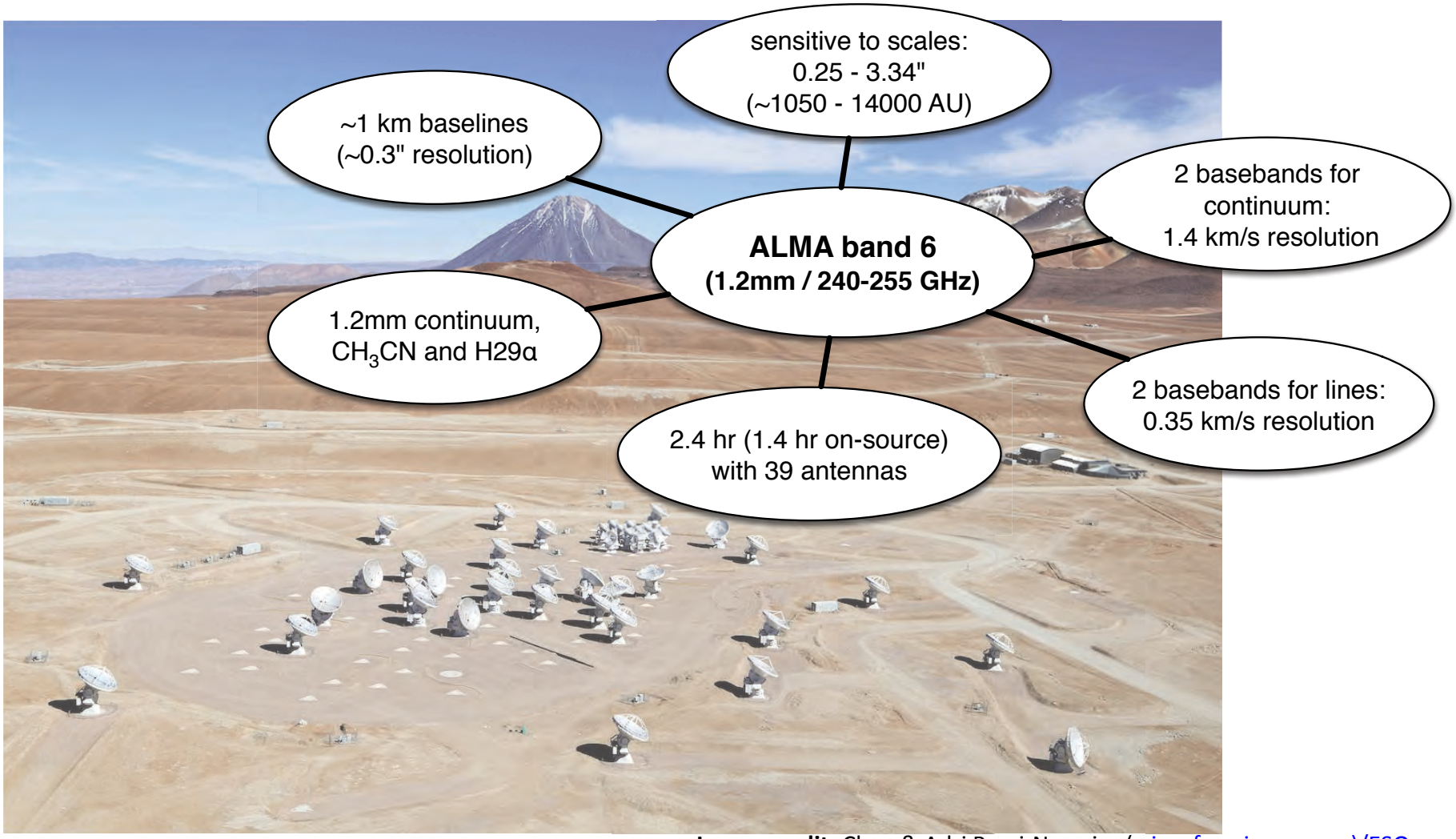

Image credit: Clem & Adri Bacri-Normier (wingsforscience.com)/ESO

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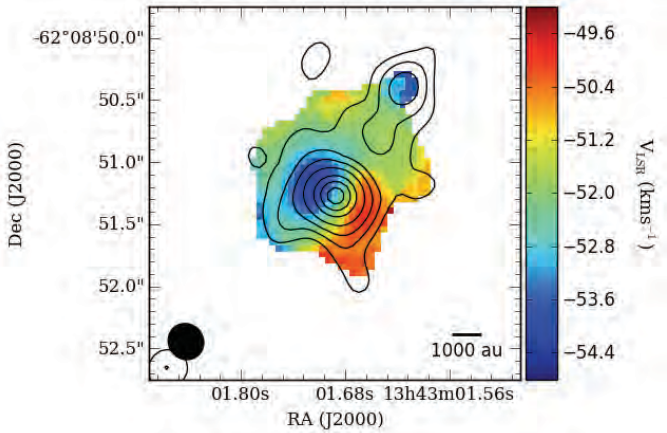
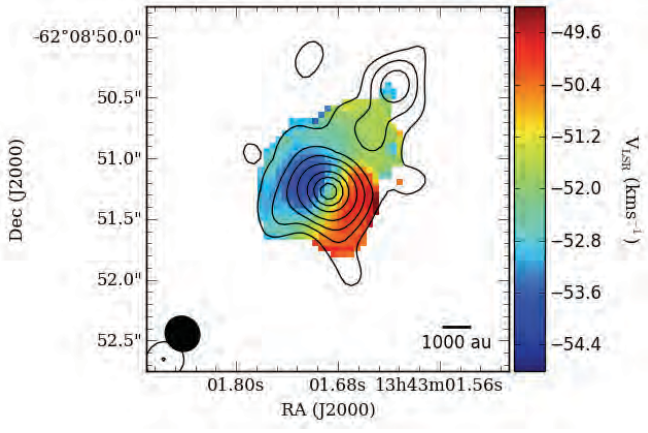
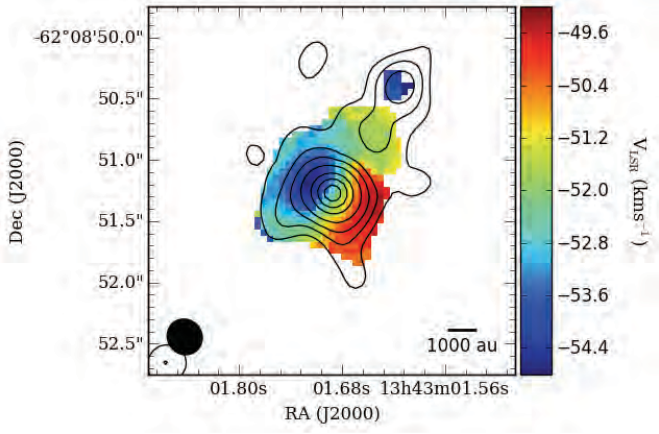
CH_3CN 13(2)-12(2)



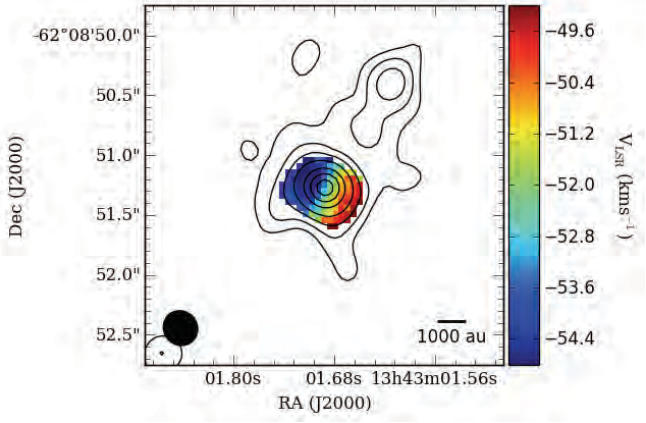
CH_3CN 13(4)-12(4)



CH_3CN 13(6)-12(6)



CH_3CN 13(8)-12(8)



Contours: continuum
Resolution: 0.30 x 0.28” or 1260 x 1180 AU

Keplerian-like kinematics from CH_3CN

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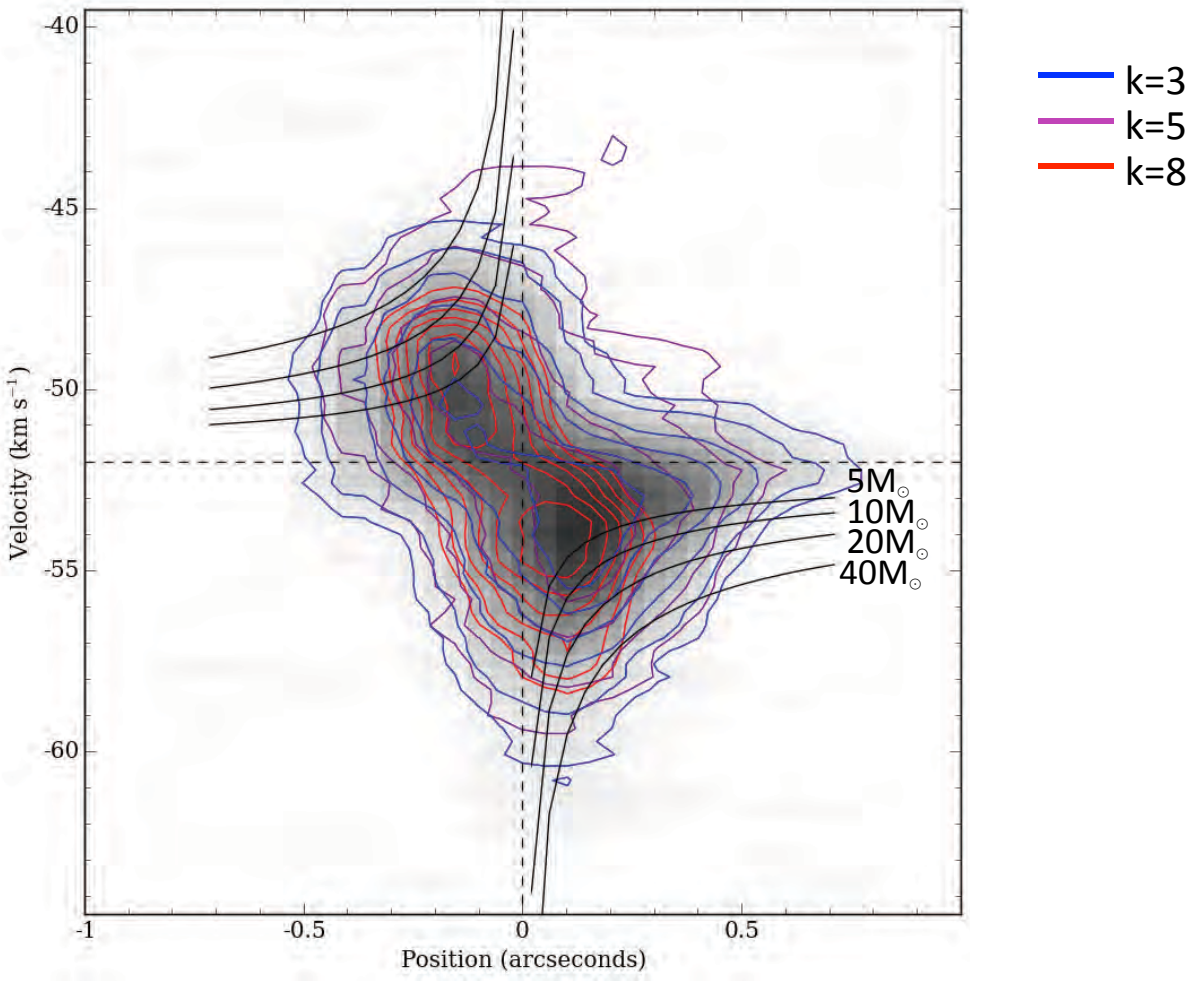

Temperatures and densities from CH_3CN

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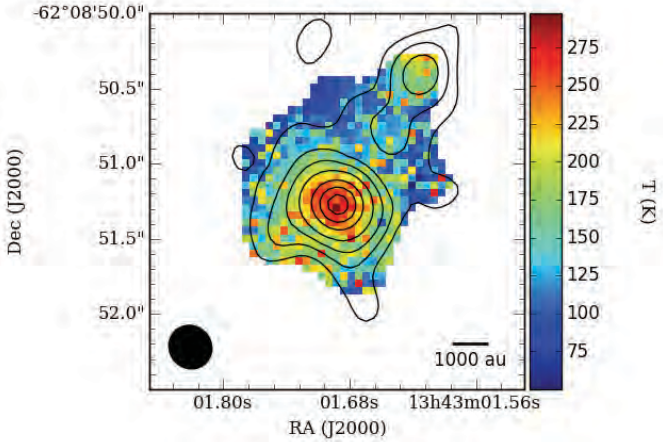
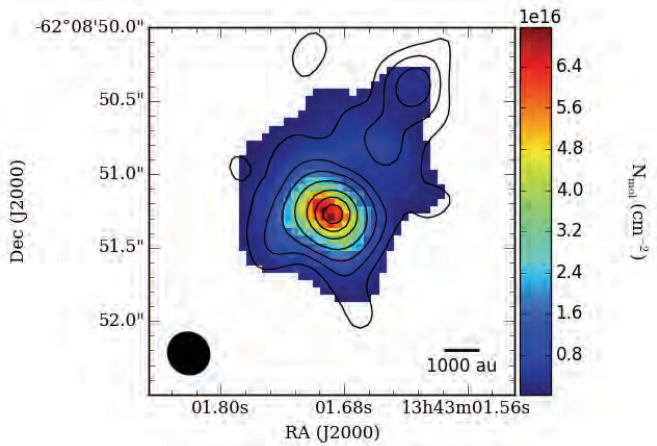
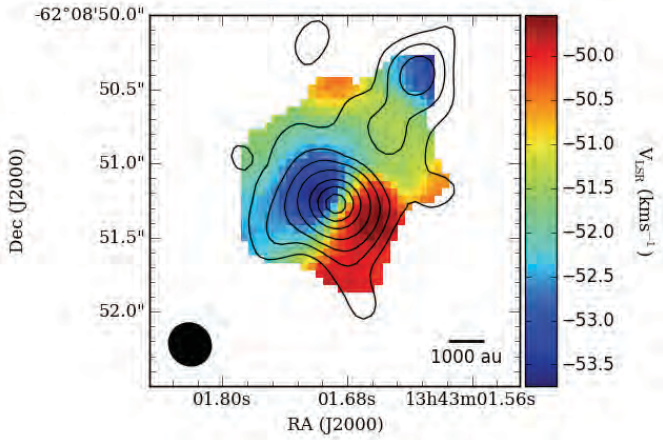
Fitting of CH_3CN and $CH_3{}^{13}CN$ using CASSIS LTE models



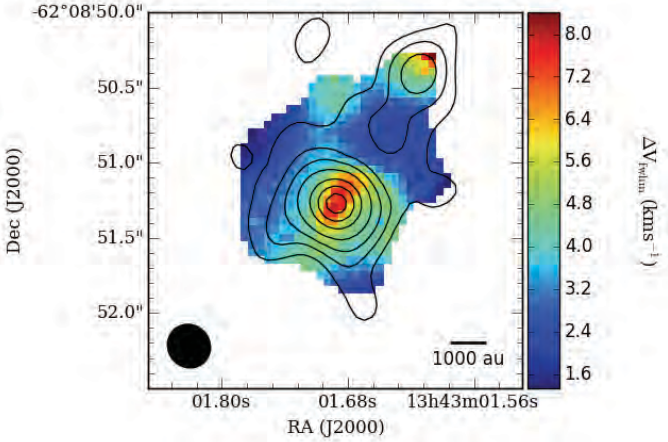
Temperature (~150 to 300 K)



Column density (M_{tot} ~ $1M_{\odot}$)



Velocity



Linewidth

Outline

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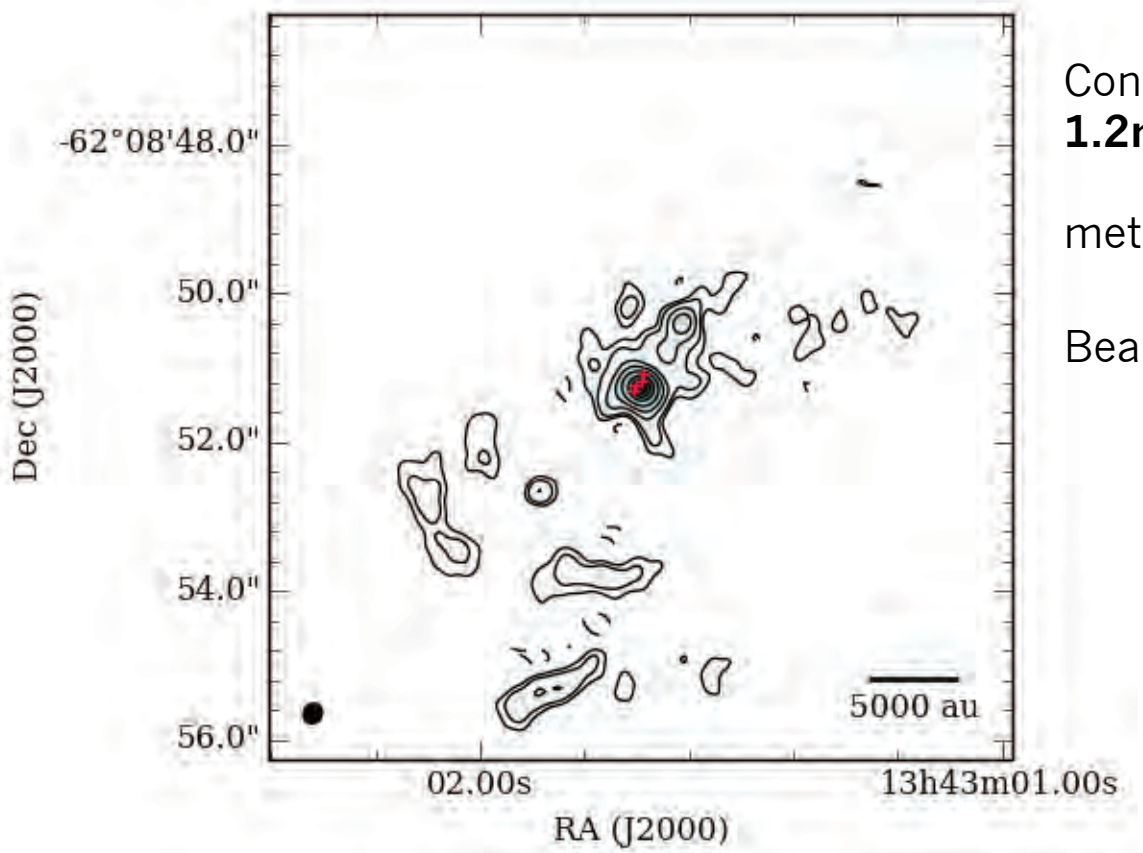
Dust structure from 1.2mm continuum



Contours and greyscale:
1.2mm continuum

methanol masers shown by +

Beam: 0.24 x 0.28”, PA~-30°

Dust structure from 1.2mm continuum

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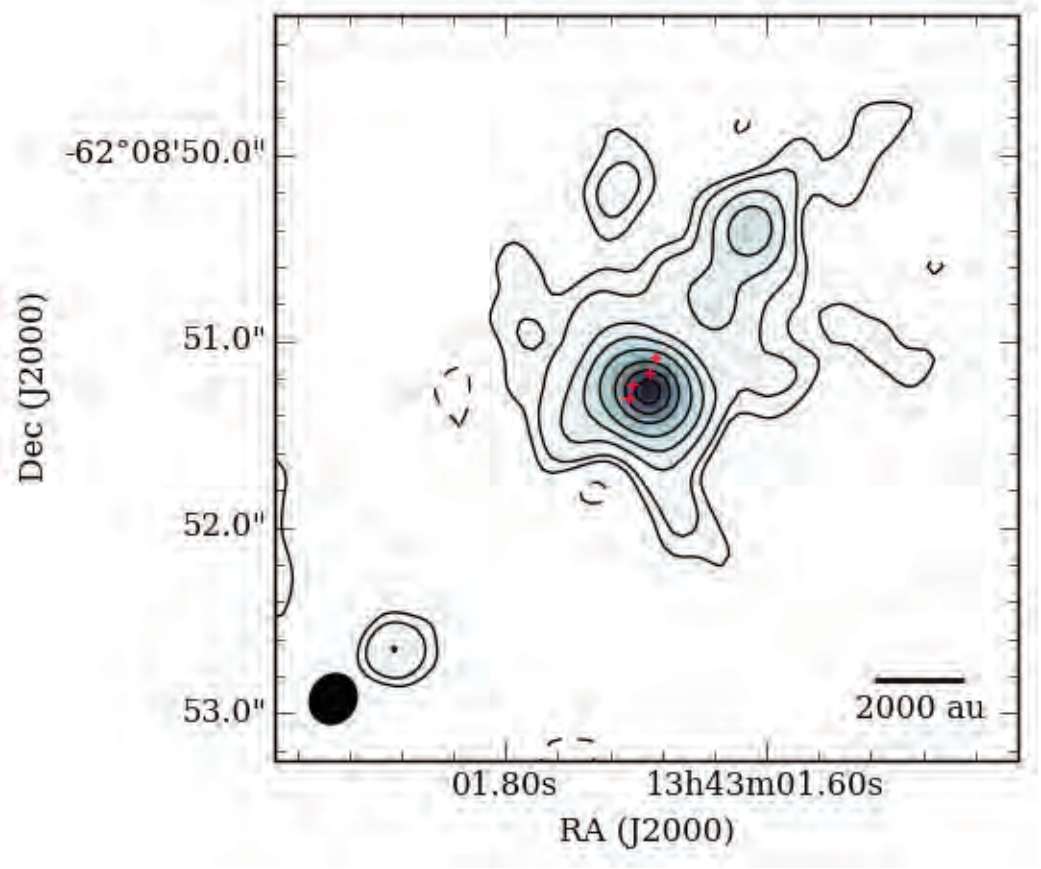

Contours and greyscale: 1.2mm continuum
methanol masers shown by +
Beam: 0.24 x 0.28", PA~-30°

Main source uv-fitting:

Gaussian fit (deconvolved):
0.232 x 0.130", PA=60.6°
974 x 544 AU (d=4.2 kpc)

M_{gas} (T=50K) = 10.3 $M_{\odot}$

IF is disk:
Inclination = 56.1°
Radius = **487 AU**

Dust structure from 1.2mm continuum

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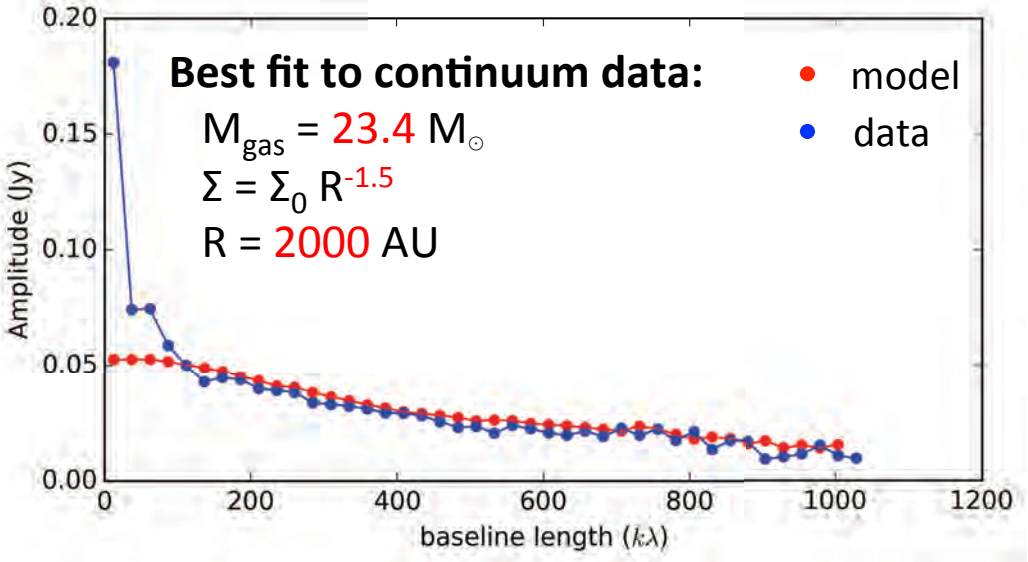
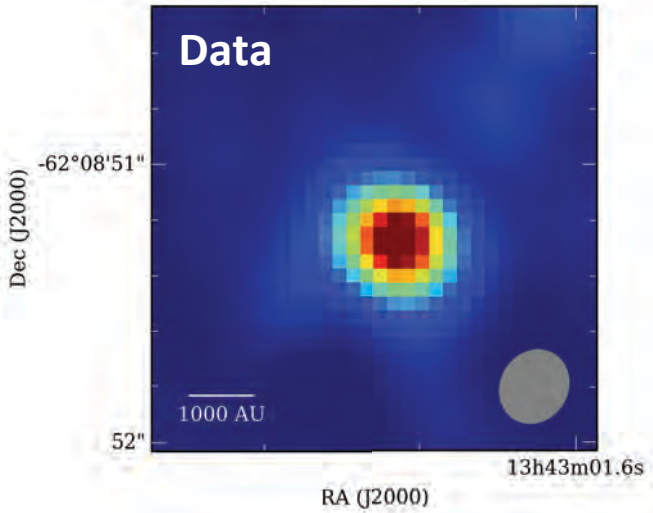
Initial modelling of continuum using Hyperion dust code (Robitaille+2011)

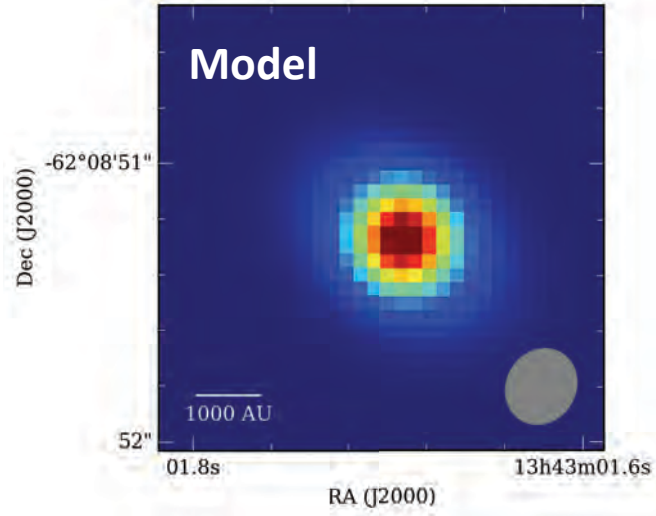
Fit uv-data with grid of flared disk models

Assumed B0 star for stellar parameters:
$L=3x10^4\ L_\odot$, $M=17.5\ M_\odot$, $T=3x10^4$ K and $R=7.4\ R_\odot$

Disk flaring power fixed at 1.25
Disk scale-height fixed at 7 AU at 100 AU
Disk inclination fixed at 56°







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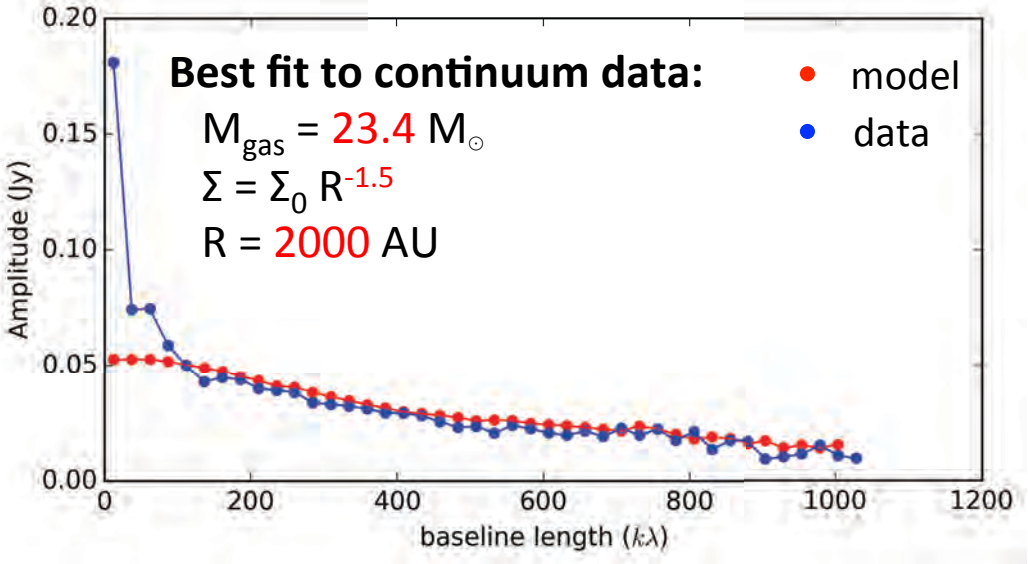

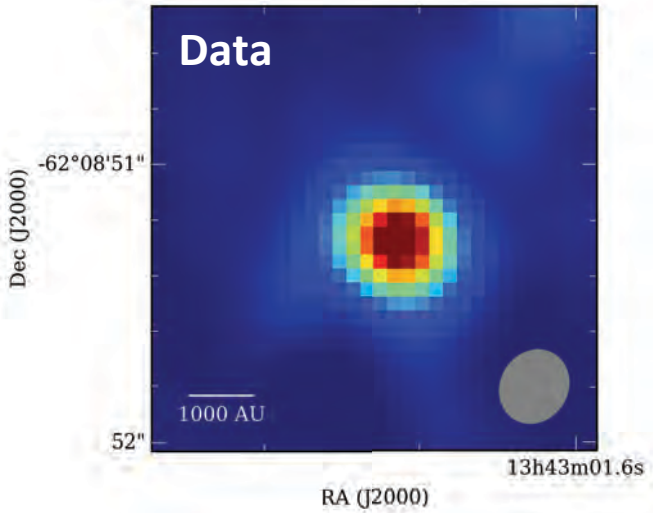

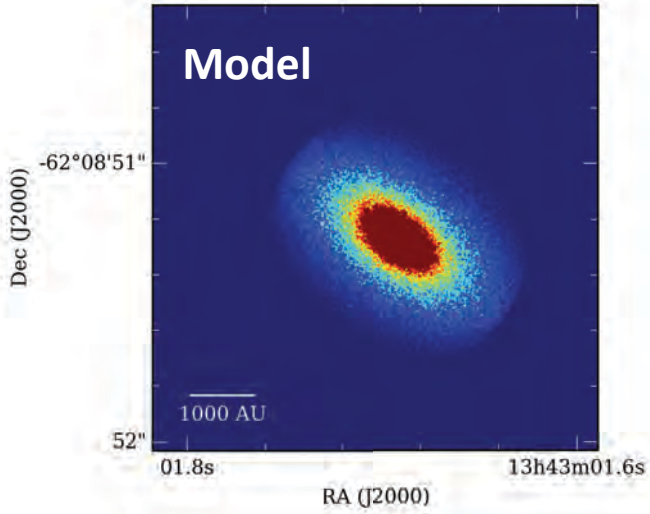

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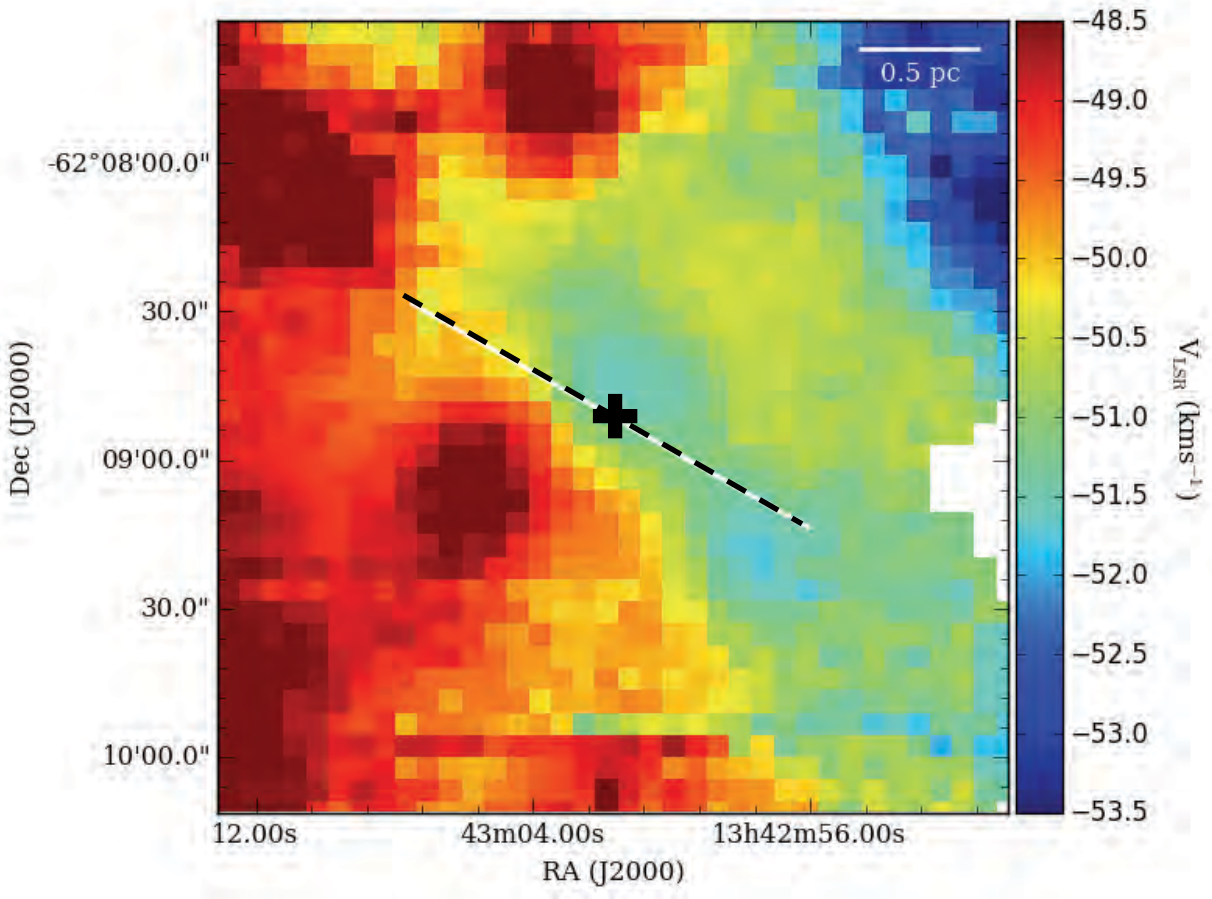
^{12}CO (3-2) with APEX



Outflow seen in ^{12}CO and $C^{34}S$?

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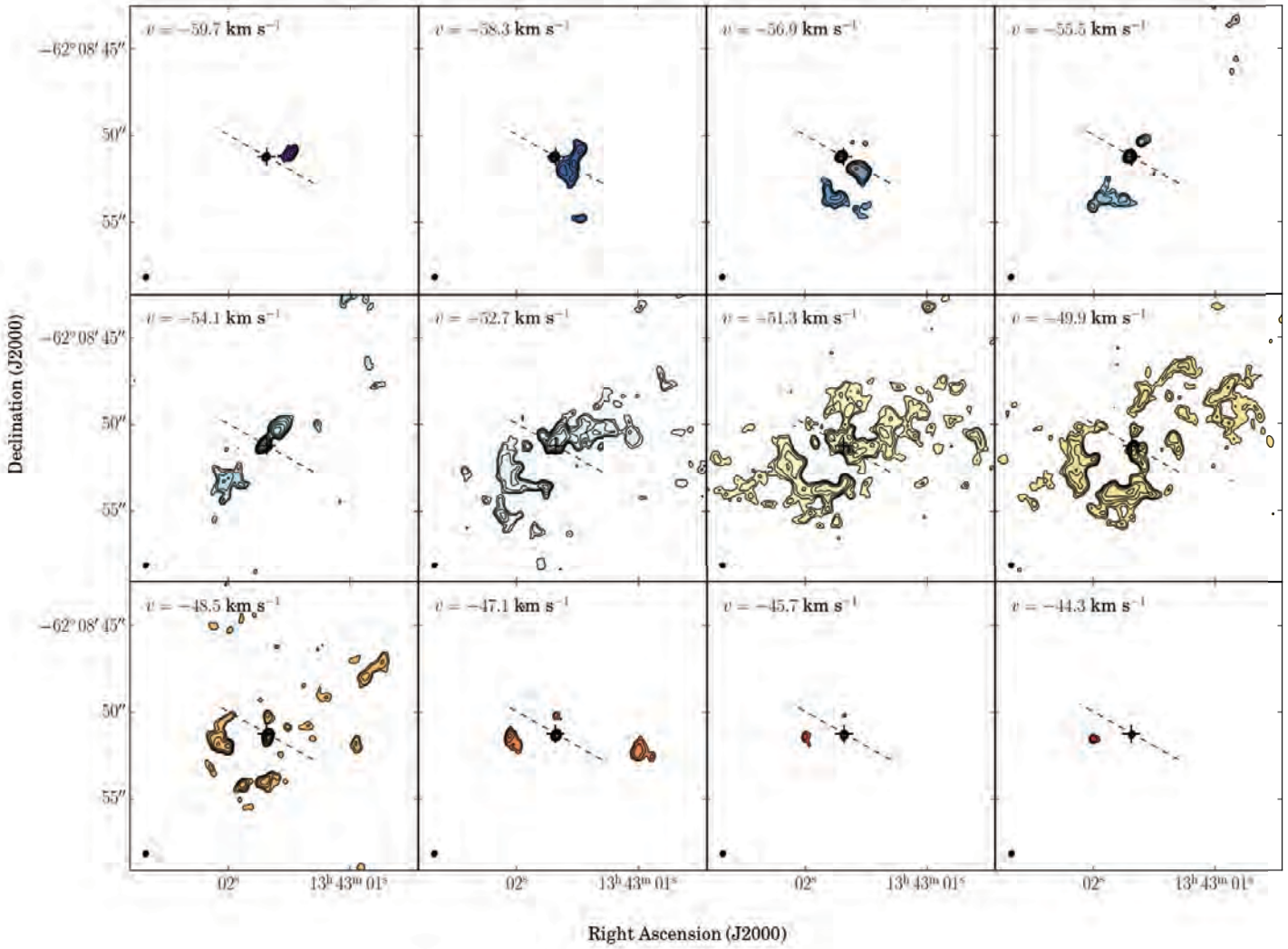
$C^{34}S$ (5-4) with ALMA



Outflow seen in ^{12}CO and $C^{34}S$?

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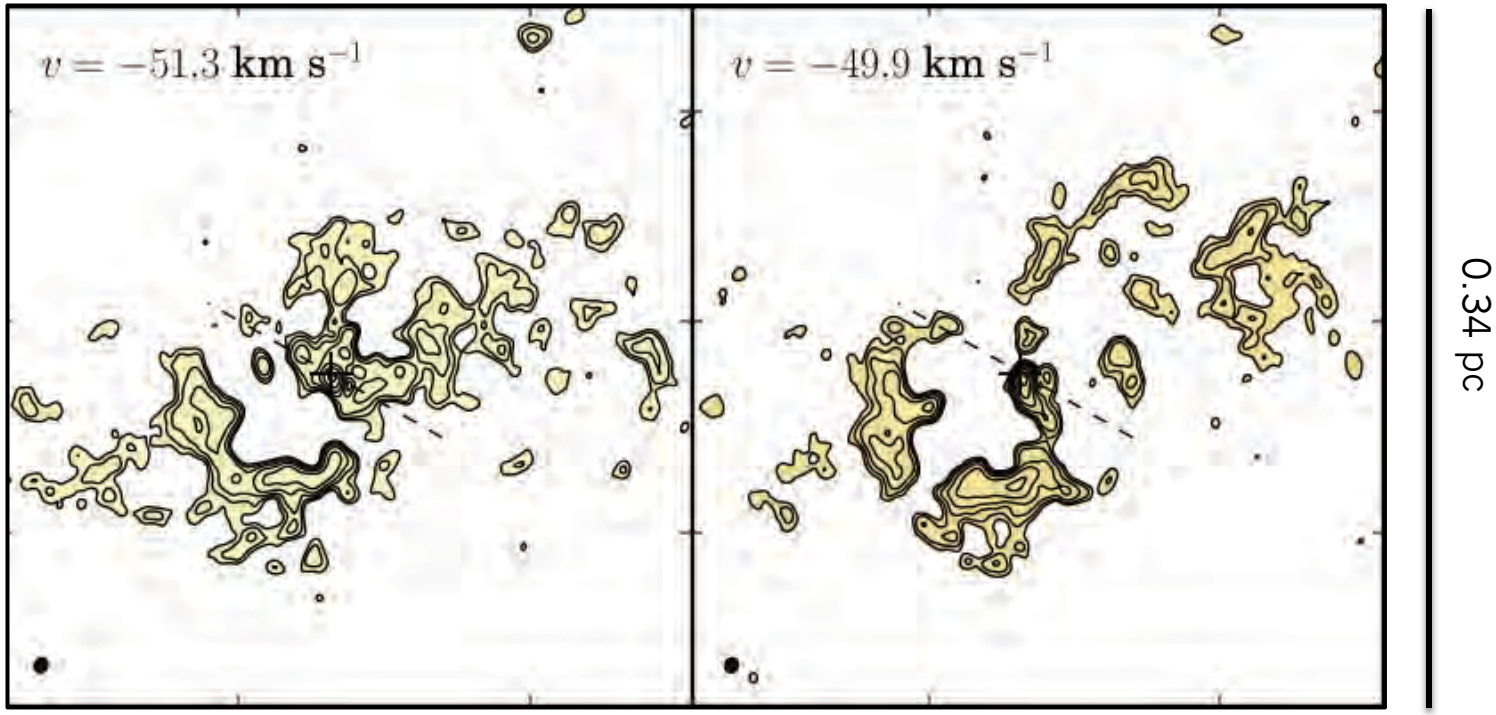
$C^{34}S$ (5-4) with ALMA



Beam: 0.35 x 0.30”, PA~-31°

Outflow seen in ^{12}CO and $C^{34}S$?

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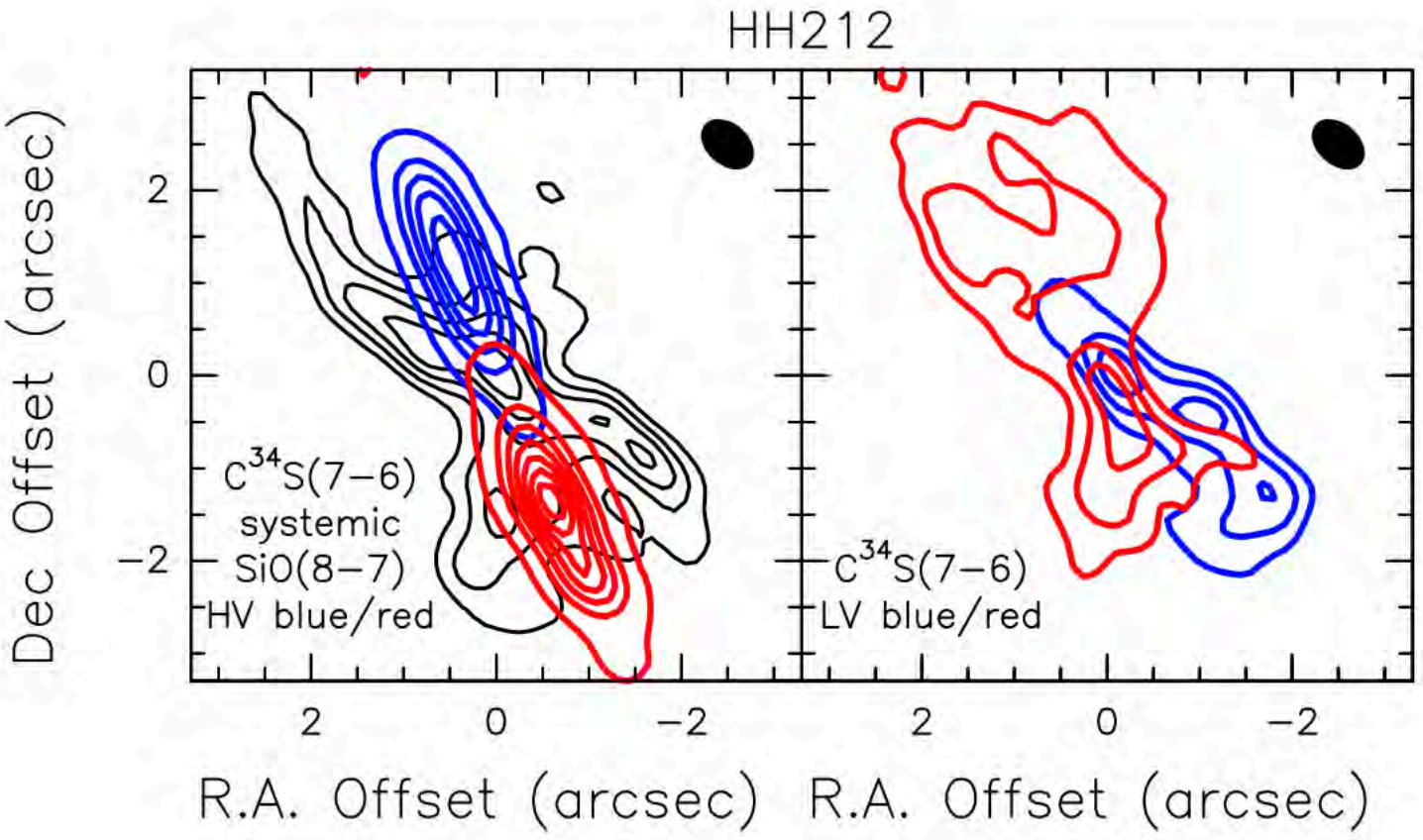

Codella et al. 2014

Conclusions: AFGL 4176

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Kinematics and temperatures from CH_3CN

- **Keplerian-like kinematics!**
- **Temperatures of 150 to 300 K**

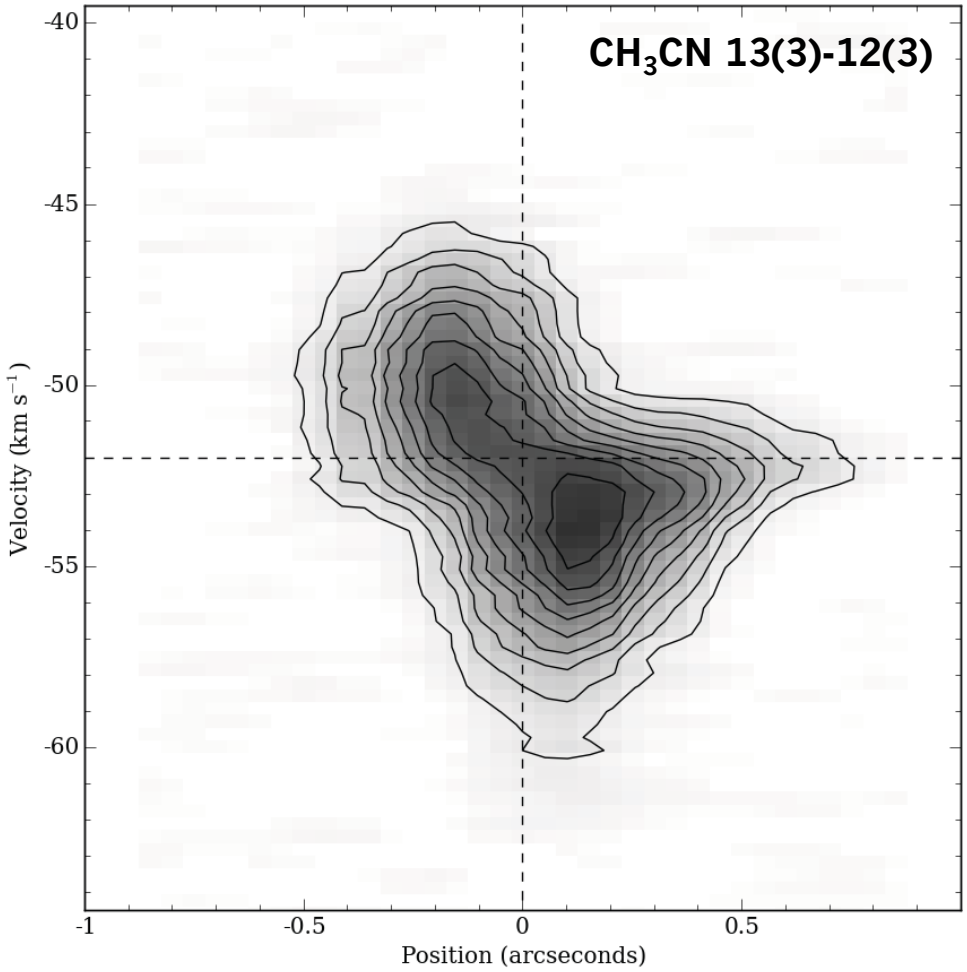
Dust structure from 1.2mm continuum

- **970 x 540 AU main source (or ~500 AU radius)**
- **UV data fit well by flared disk model**
- **Best-fitting disk mass is large…**

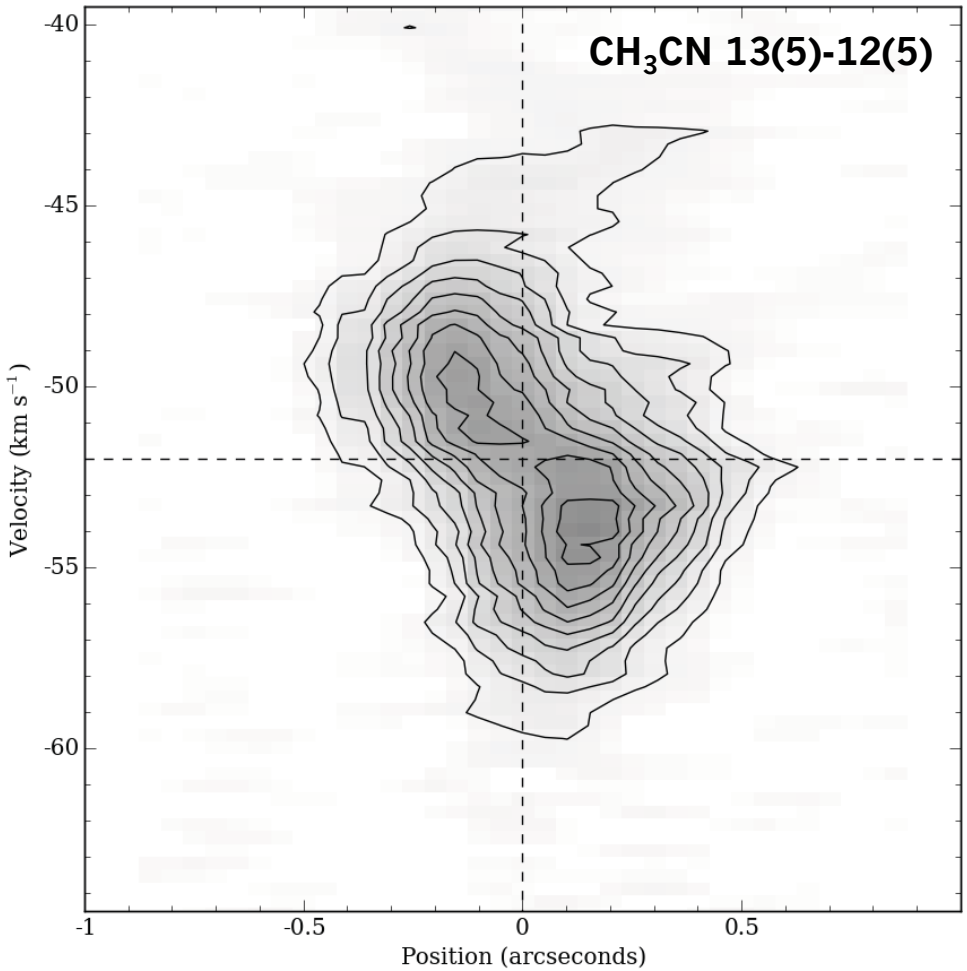
Outflow seen in ^{12}CO and $C^{34}S$?

- **Large-scale outflow in ^{12}CO (3-2) ?**
- **Dense gas in the cavity walls with $C^{34}S$ (5-4)**

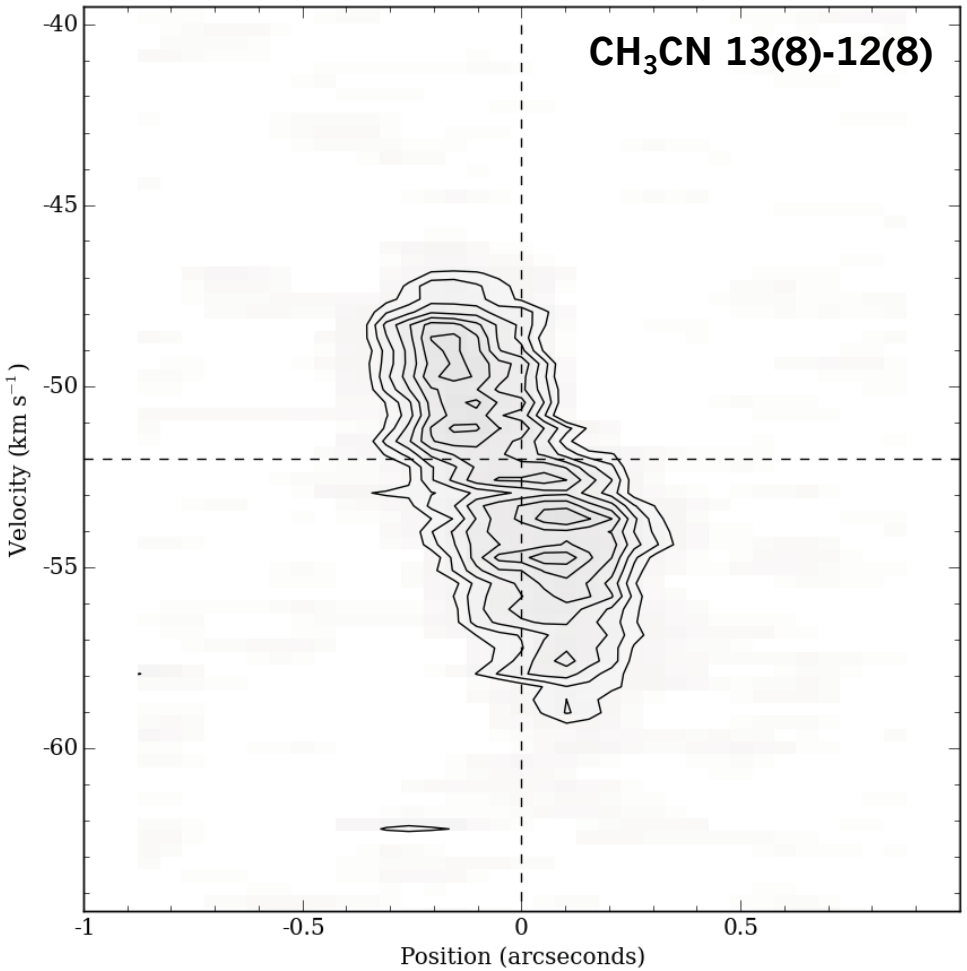
Keplerian kinematics from CH_3CN?



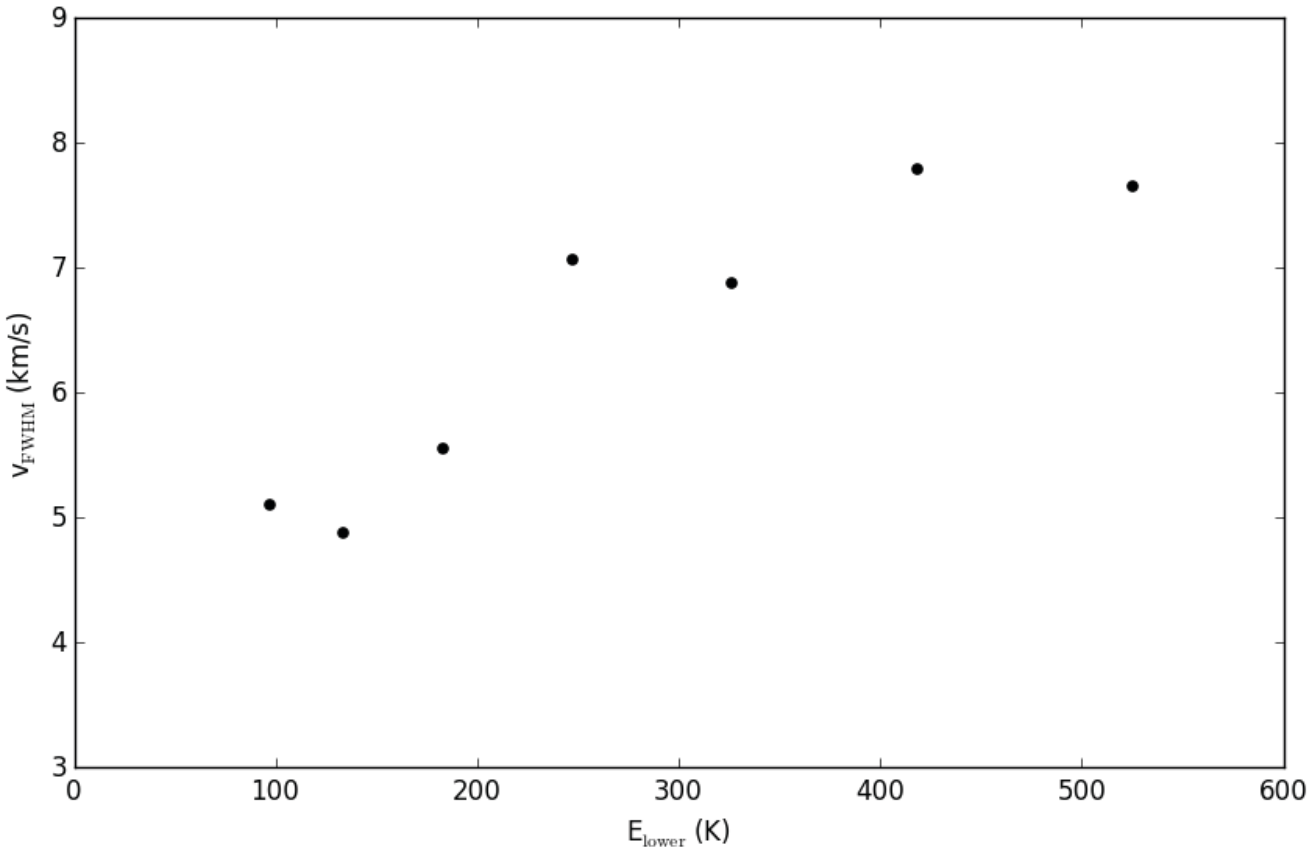
Keplerian kinematics from CH_3CN?



Keplerian kinematics from CH_3CN?



CH_3CN linewidths



Parameter space

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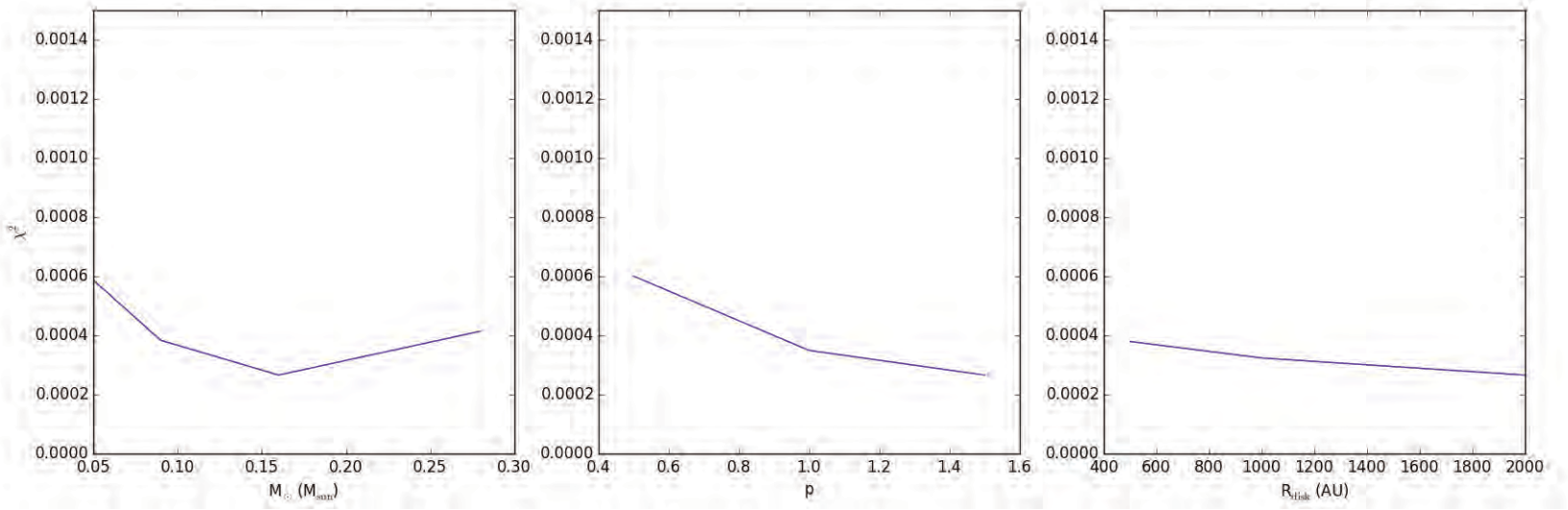

Outflow seen in ^{12}CO and $C^{34}S$?

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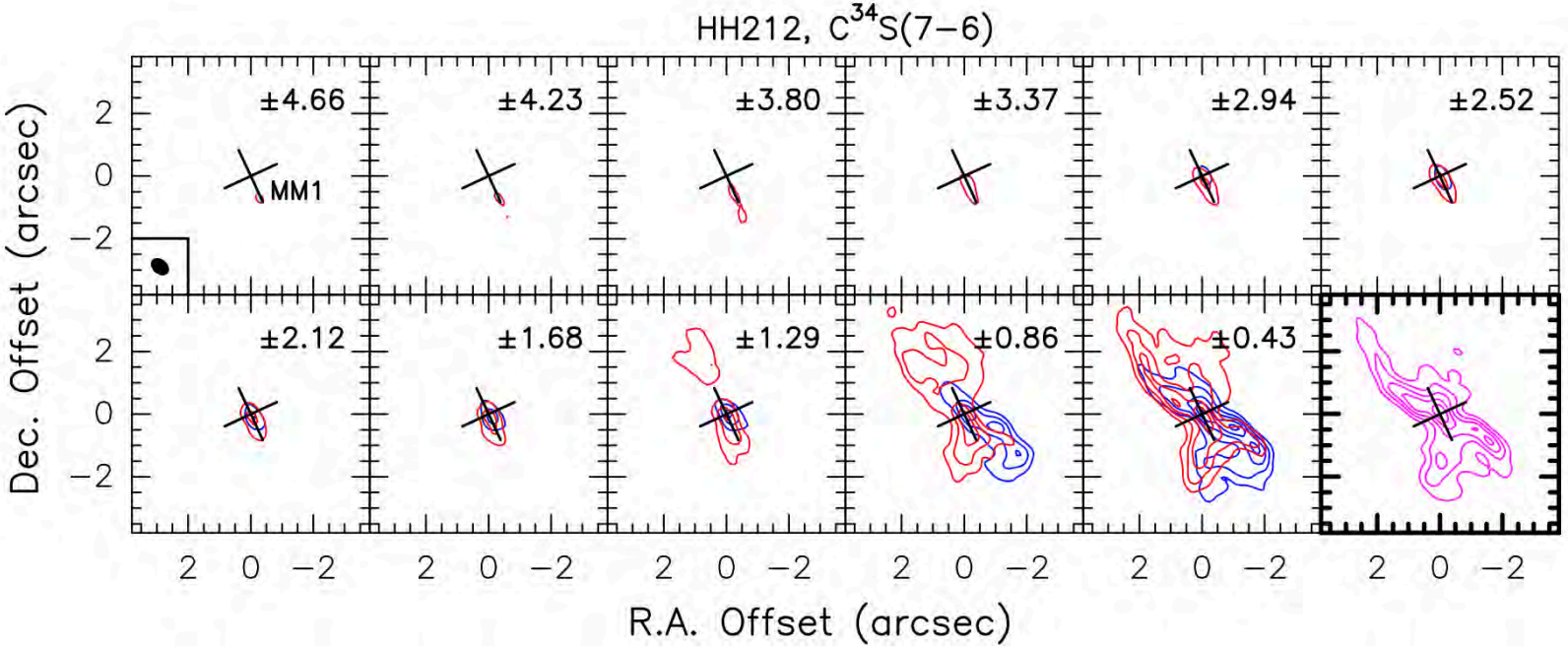

Codella et al. 2014