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ALMA Regional Centre || Allegro

ALMA SV Data:

The IRAS 16293 Controversy

Kristensen, Klaassen, Mottram, Schmalzl & Hogerheijde 2013
(K km/s/h)

Pamela Klaassen
Feb 8, 2013

Outline

- ALMA Science Verification
- IRAS 16293-2422
  - ALMA Observations
    - And the controversy surrounding them

Encore:
The radiative transfer arguments that show the robustness of our arguments

Science Verification

Science Verification Data — Welcome to the Science Portal at ESO

almascience.eso.org/alma-data/science-verification

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ALMA

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Call for Proposals

ALMA Data

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Cycle 0 Status

Science Verification

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- EU ARC
- NA ARC
- EA ARC

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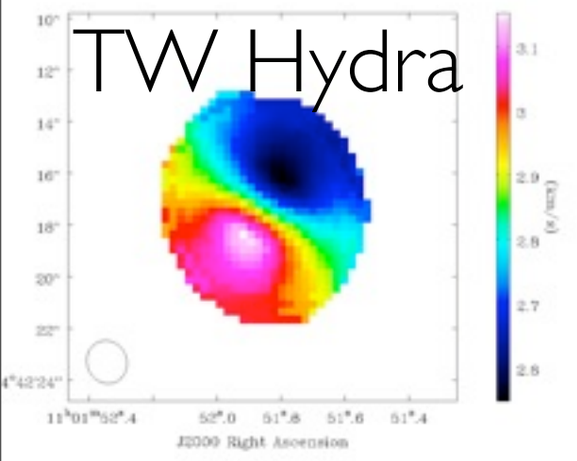
Science Verification Data

almascience.eso.org/alma-data/science-verification

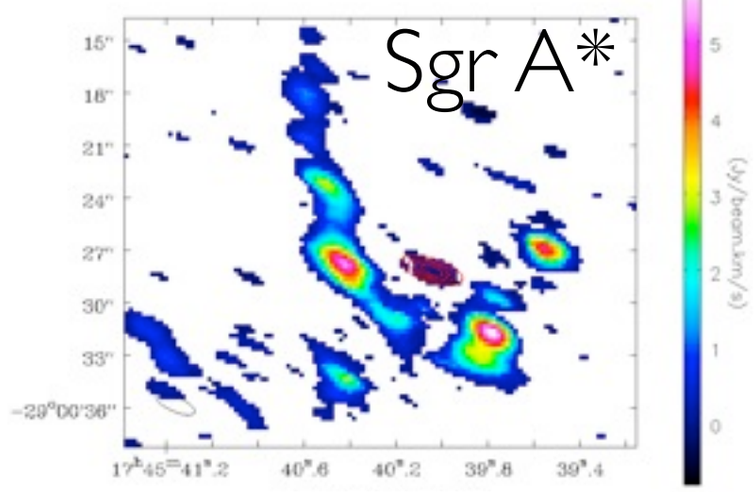
- Making sure the array is working properly
  - When it is, the data are released to the public

Science Verification

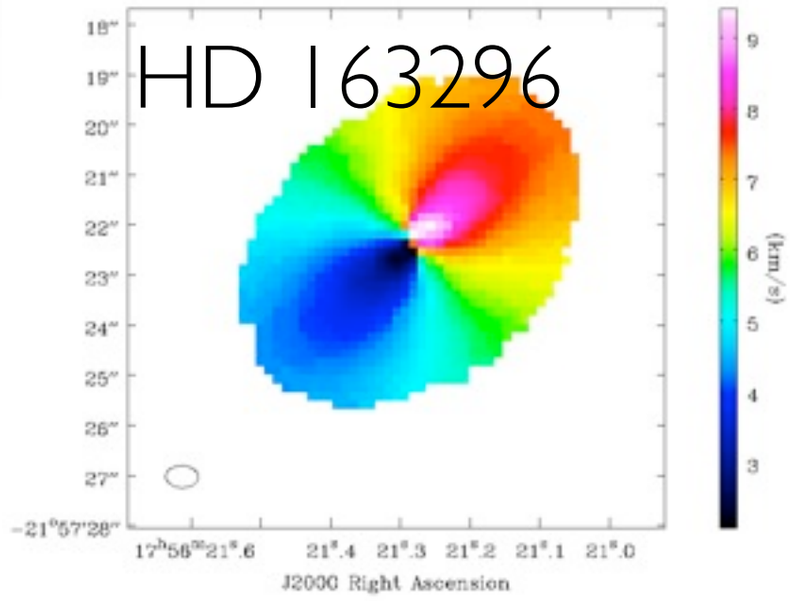
TW Hydra



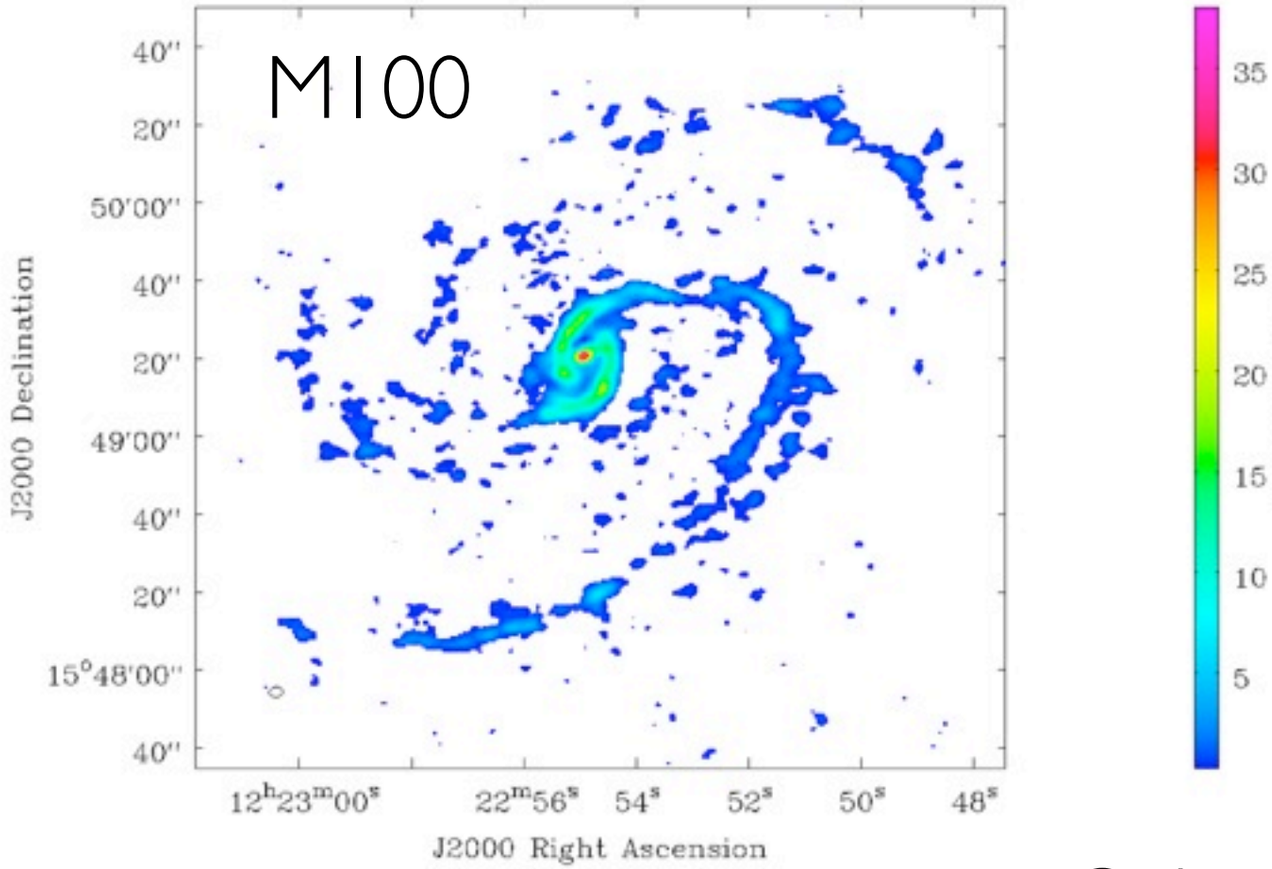
Sgr A*



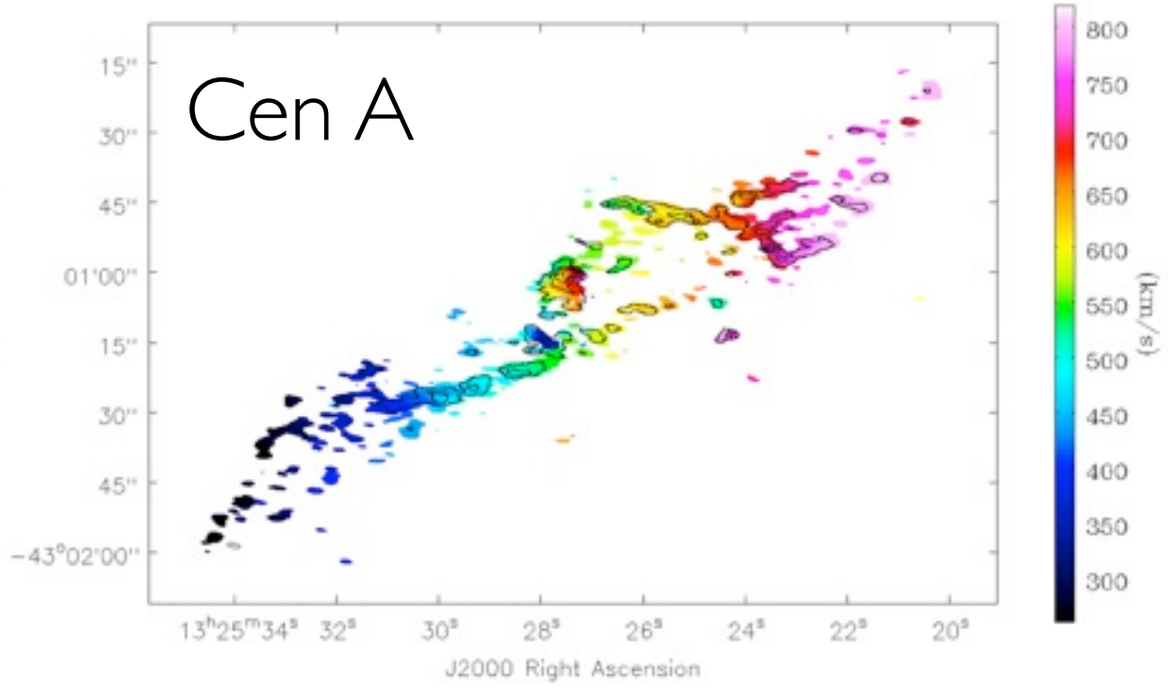
HD 163296



M100



Cen A

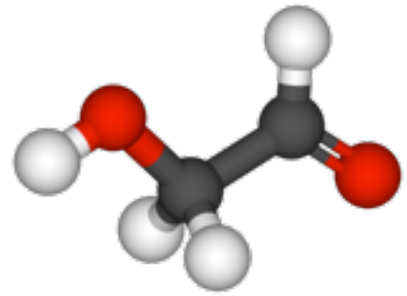


Orion KL

And of course.. IRAS 16293

Band 6 (230 GHz) and Band 9 (690 GHz) data

- Pineda et al. 2012 - Infall onto source B
- Jorgensen et al. 2012 - Glycoaldehyde!



- Loinard et al. 2012 - Outflows
- Persson et al. 2013 - Deuterium Fractionation
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- Zapata et al. 2013 - infall onto a disk

.... List probably incomplete

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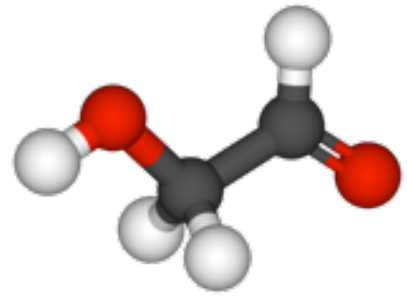

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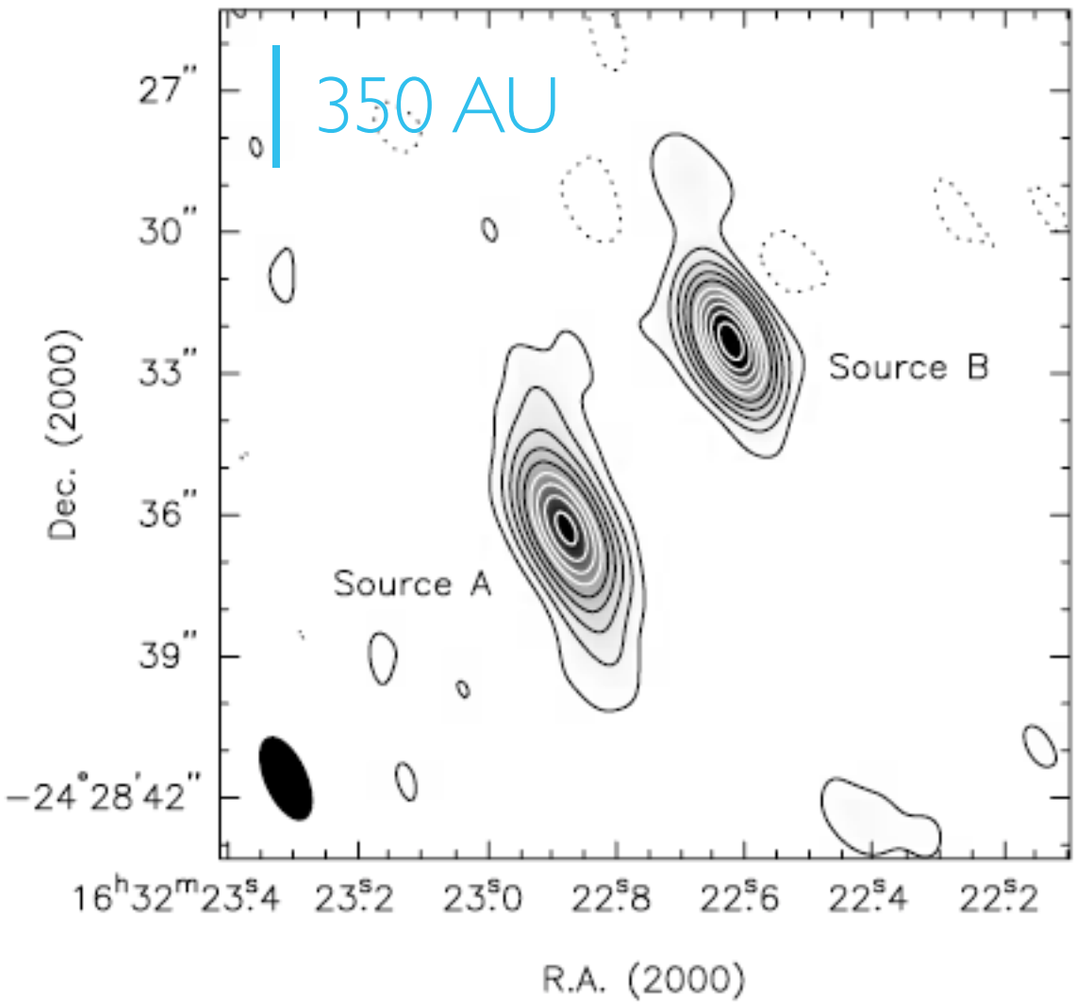
IRAS 16293-2422

In ρ Ophichus ~ 120 pc



- First:
  - Protobinary
  - Detection of infall

Chandler et al. 2005

IRAS 16293-2422

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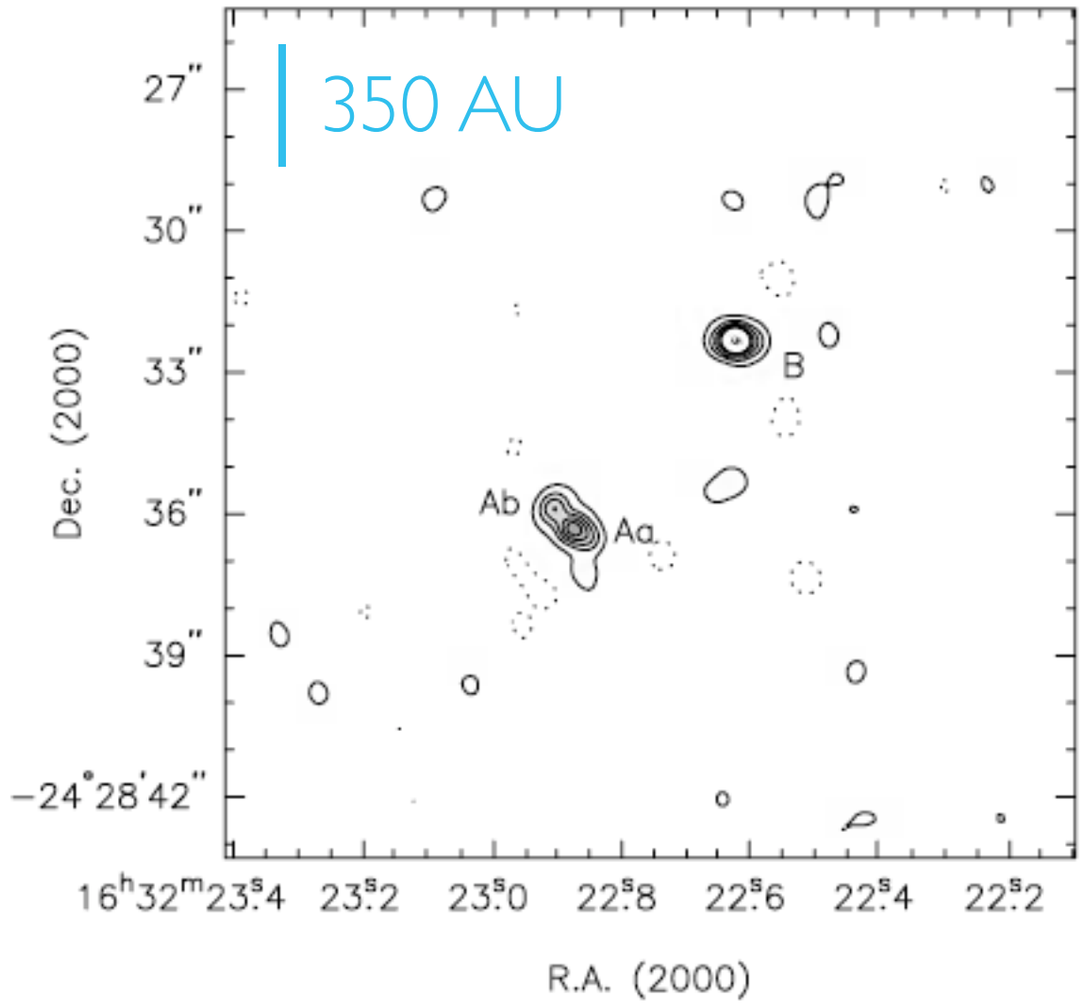

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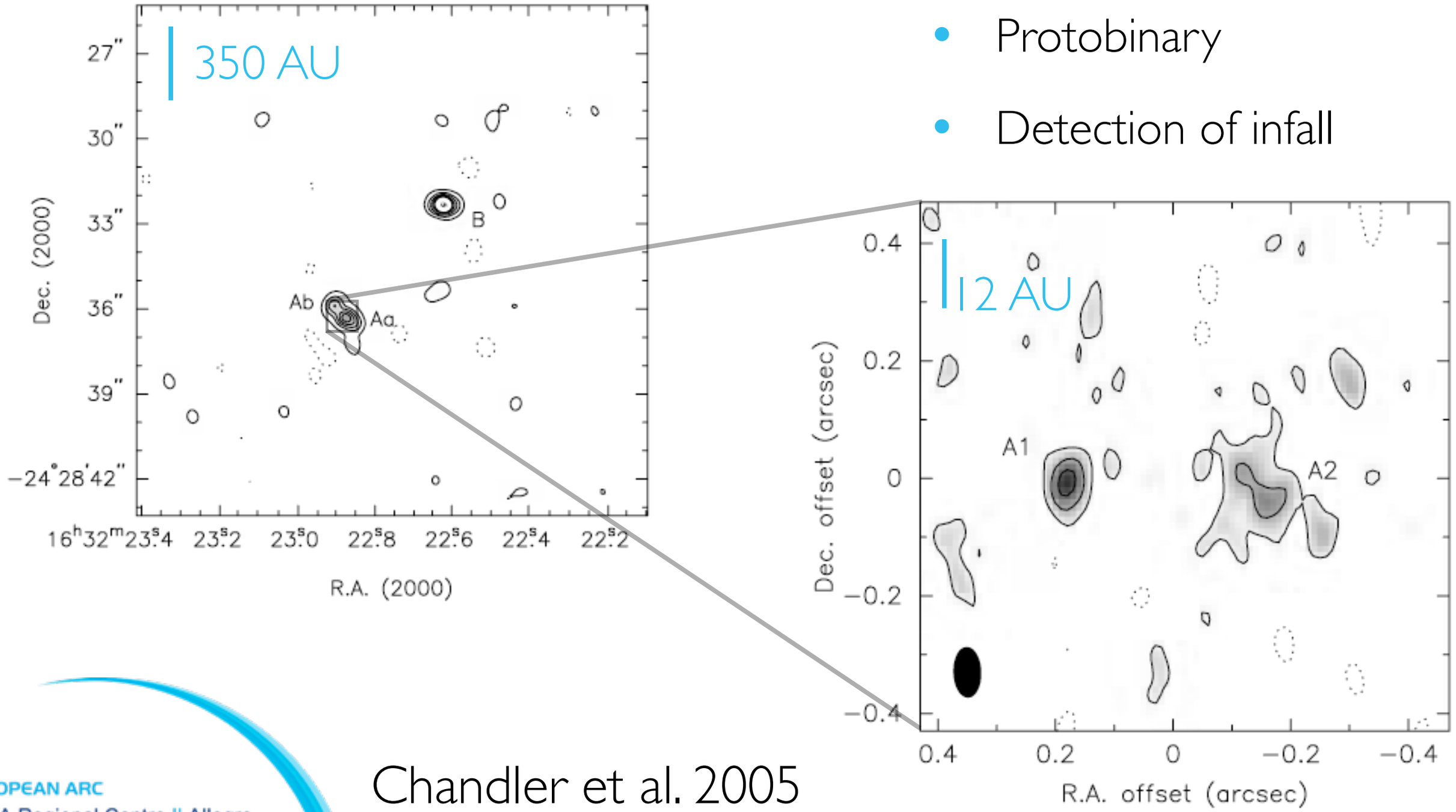
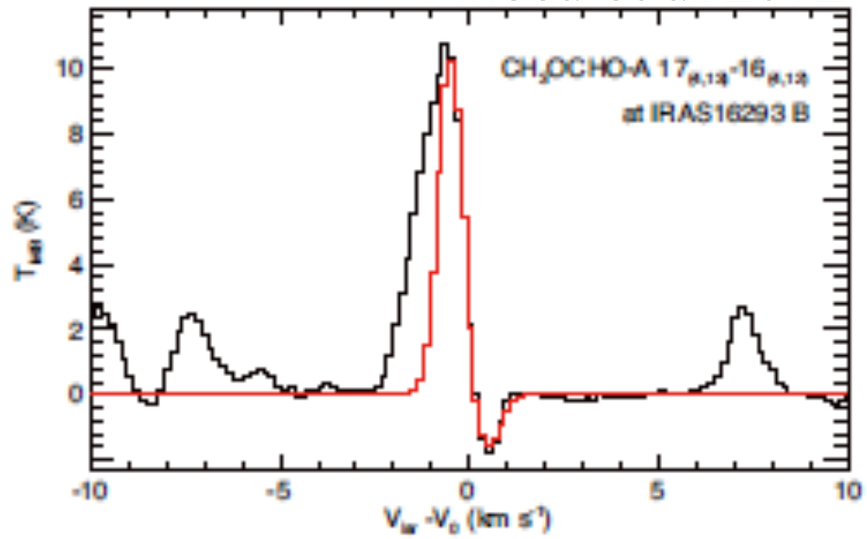


Chandler et al. 2005

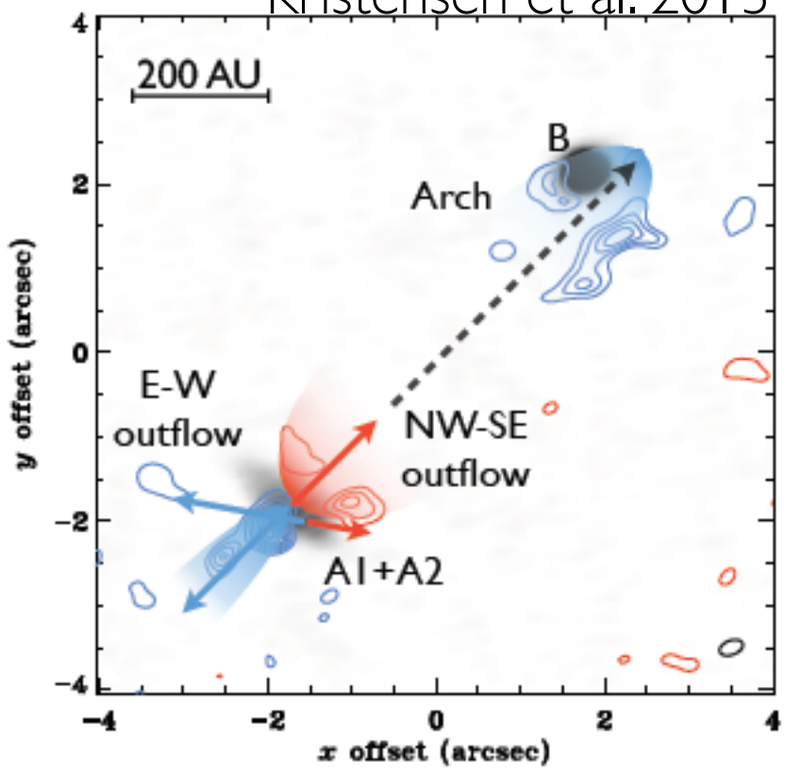
IRAS 16293

- Focus on the gas dynamics
- Infall
- Outflow
- and the controversy..

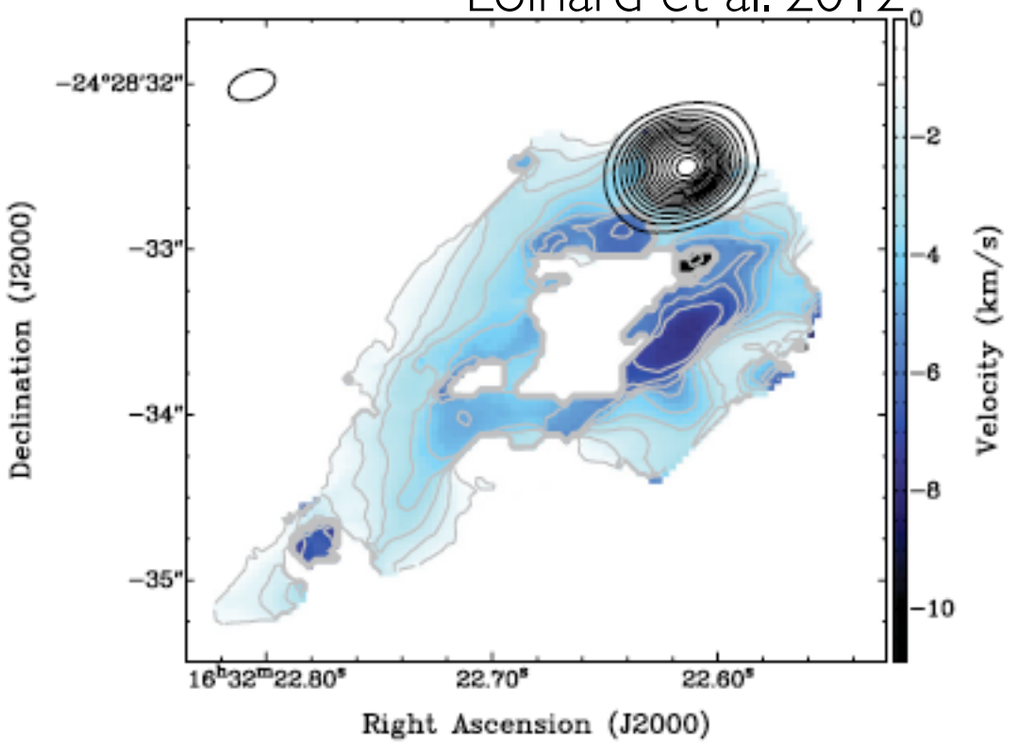
Pineda et al. 2012



Kristensen et al. 2013



Loinard et al. 2012



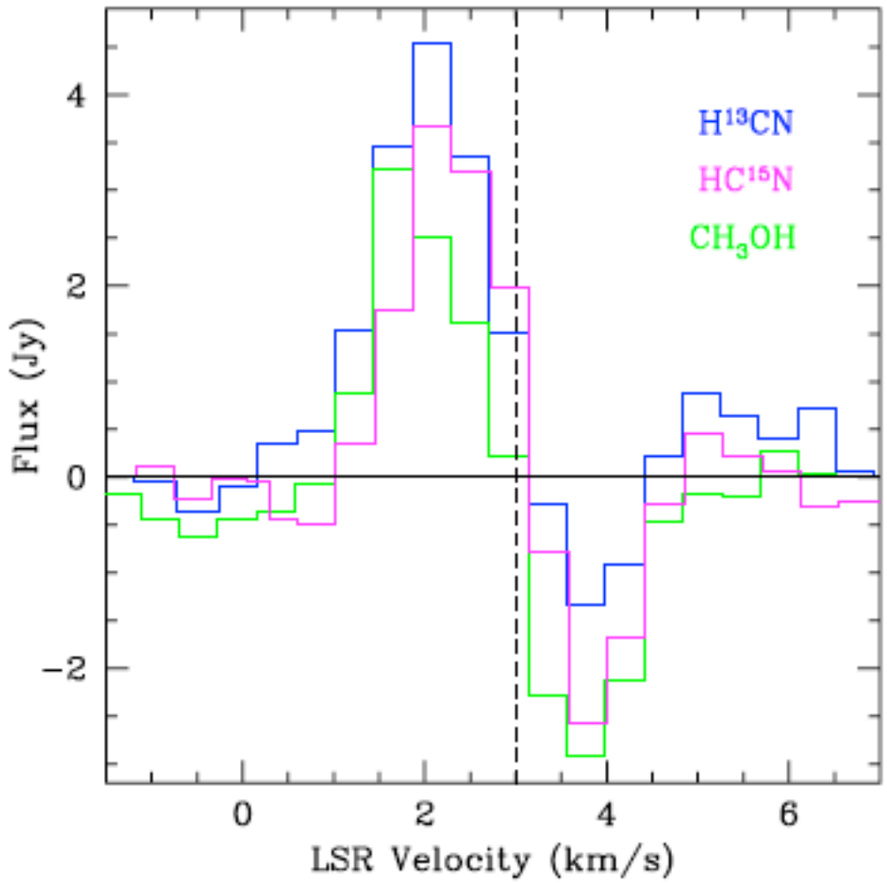
Infall

- Inverse P-cygni profiles show infall onto Source B
  - In multiple gas tracers

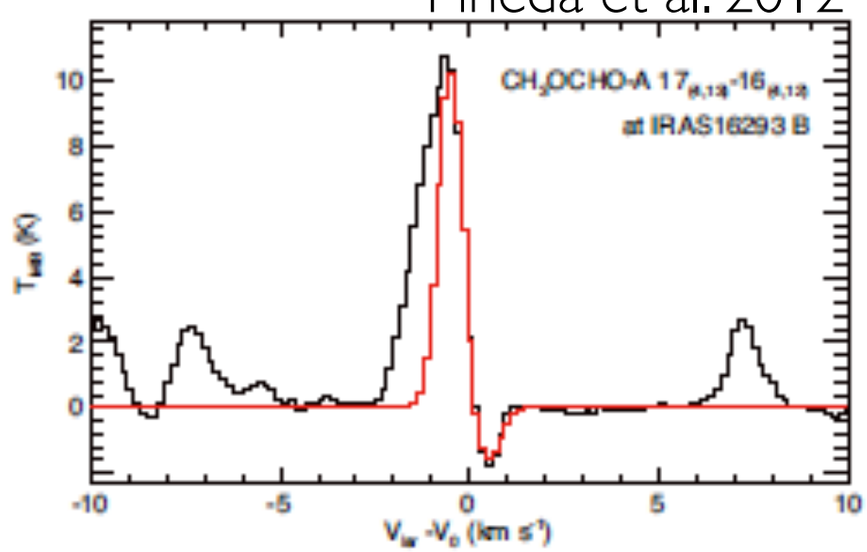
High excitation tracers: 0.7 km/s
Low excitation tracers: 0.5 km/s

Faster infall closer to the source center

Zapata et al. 2013



Pineda et al. 2012



The Controversy

XKCD

Outflow

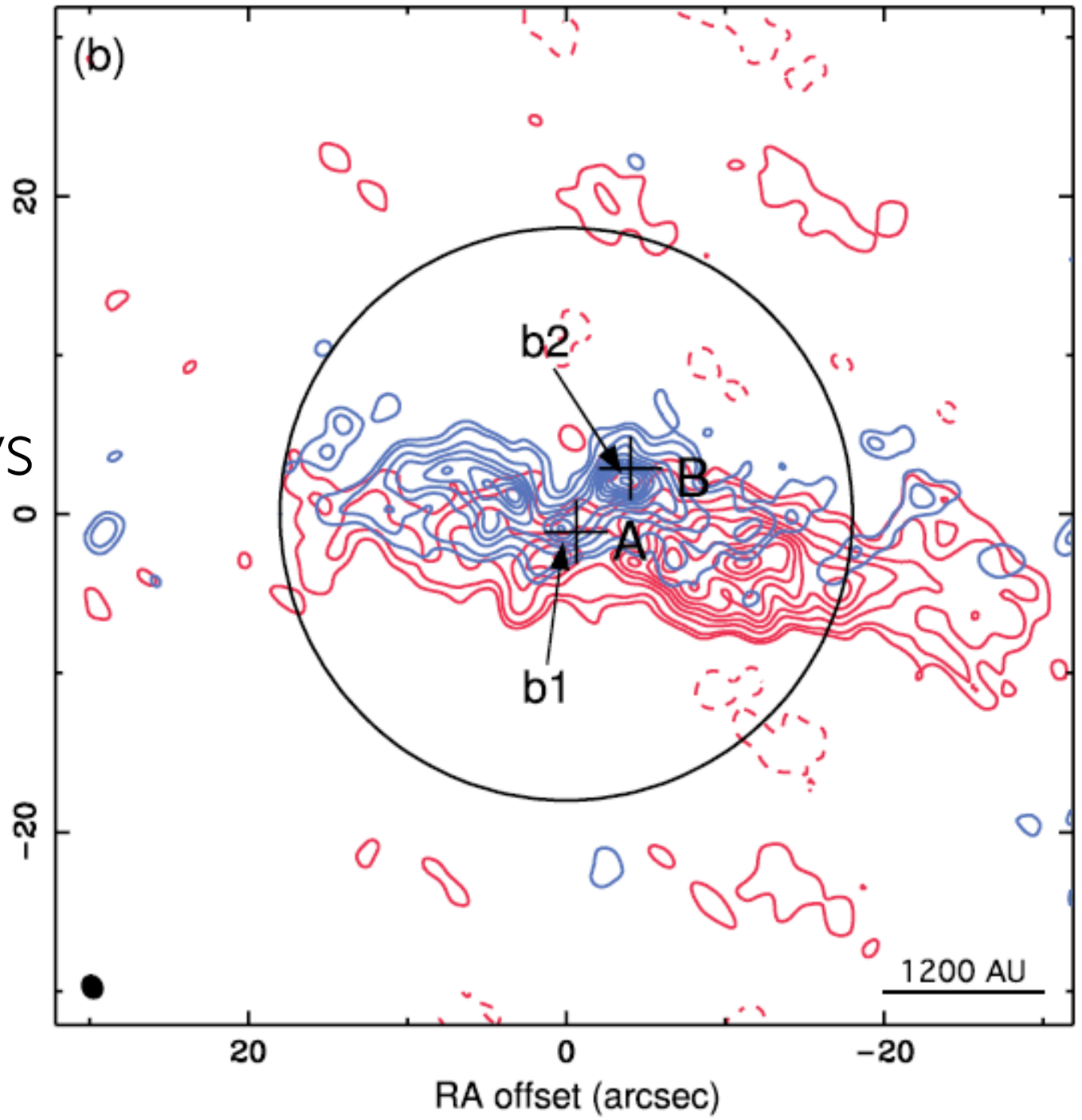
Here's where things get interesting...

Outflow

Here's where things get interesting...

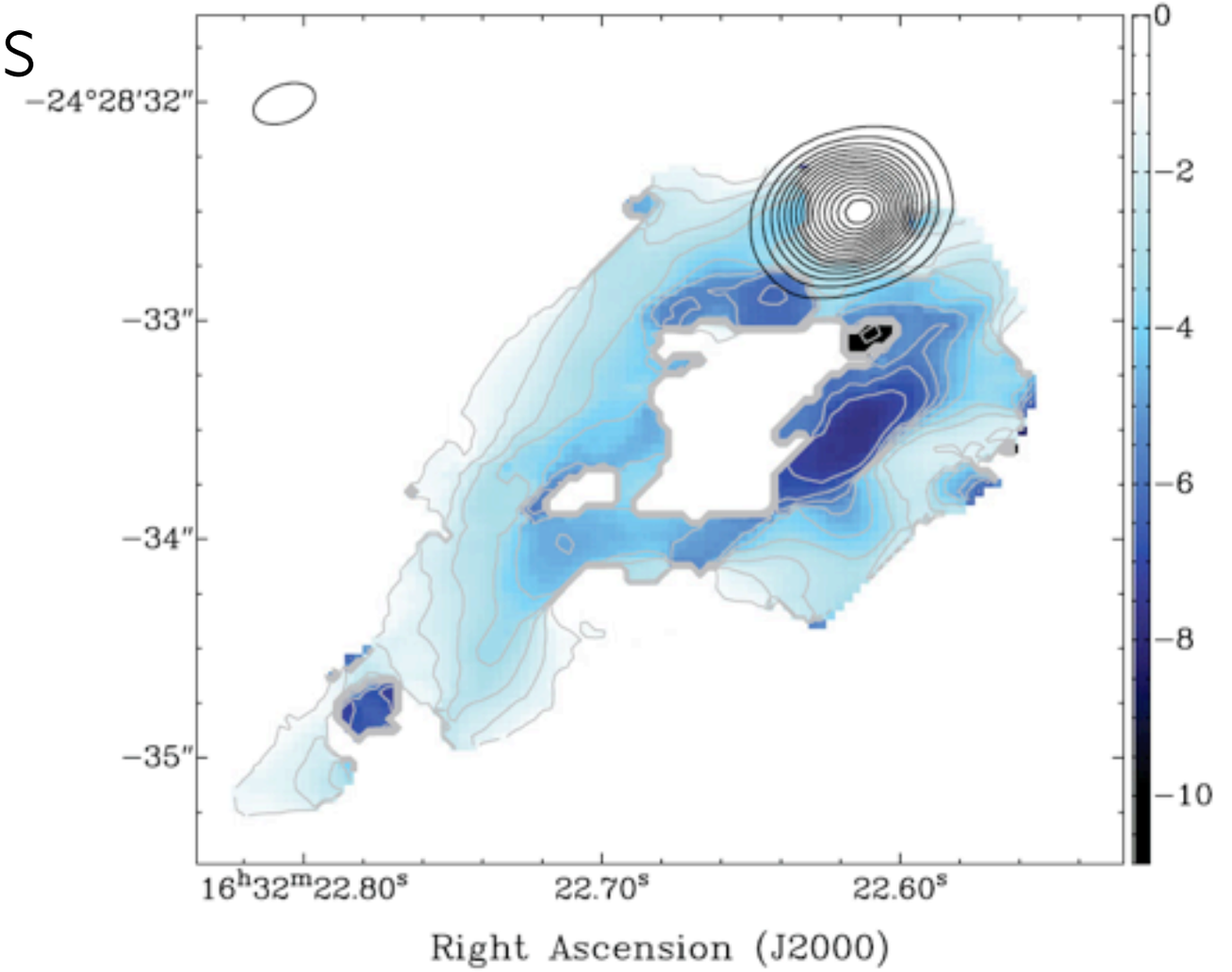
- Previous observations couldn't resolve the outflow well
- Some suggest 2 outflows
  - one from Source A
  - one from Source B

Yeh et al. 2008



Loinard et al. 2012

- ALMA Band 9 observations
- There is a blue shifted outflow from Source B
- There is a bipolar outflow from Source A2



A2

Loinard et al. 2012

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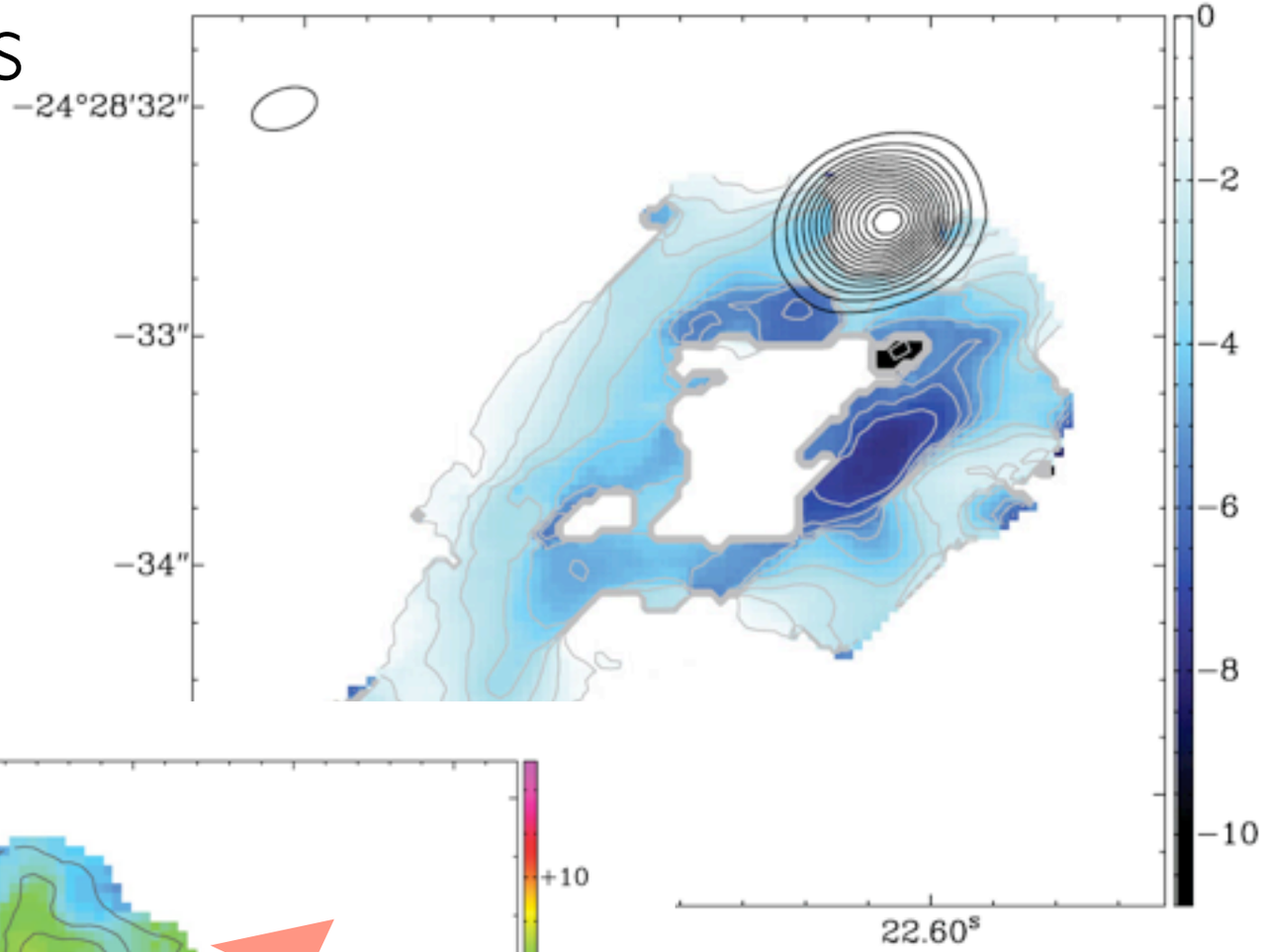
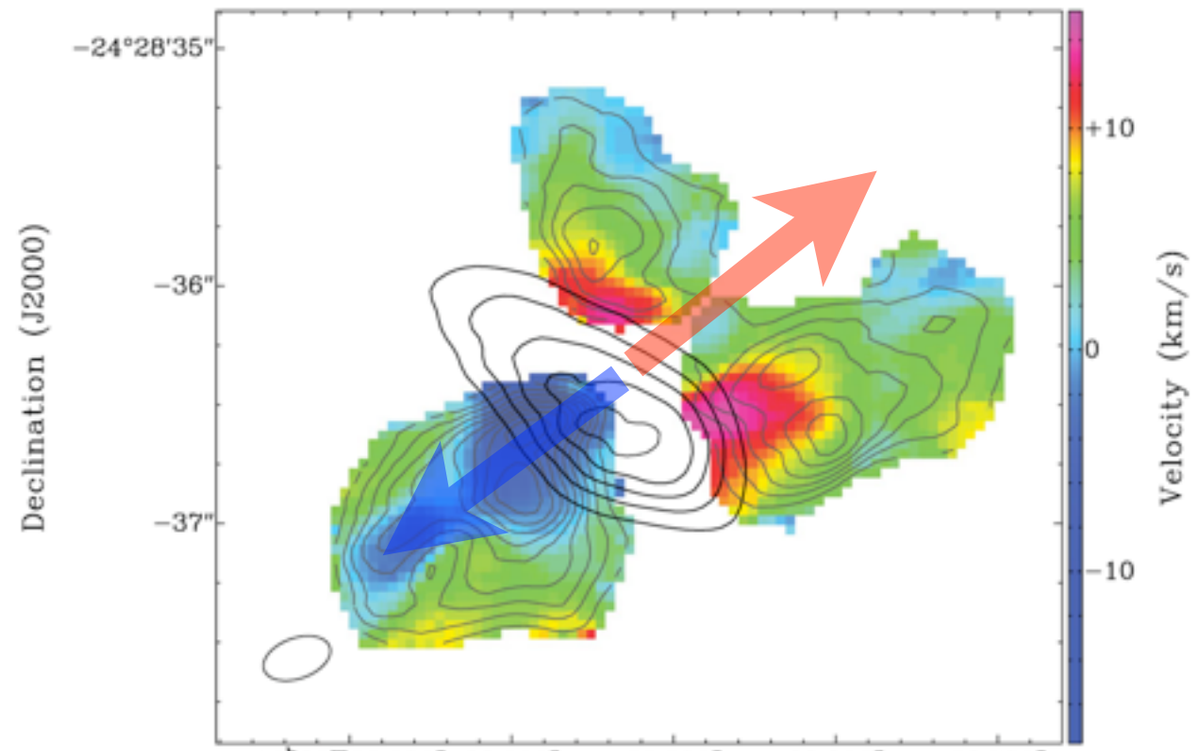
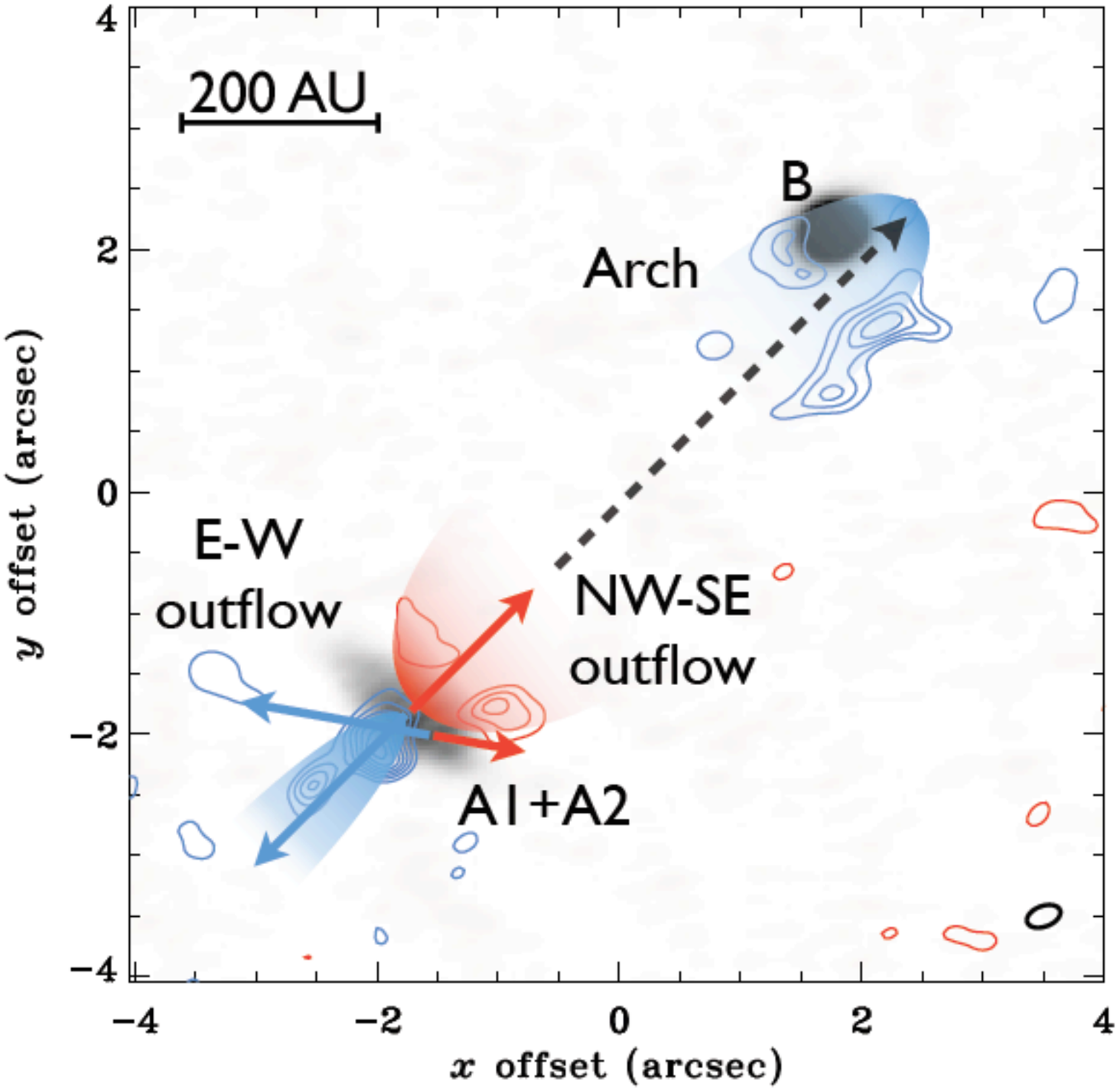


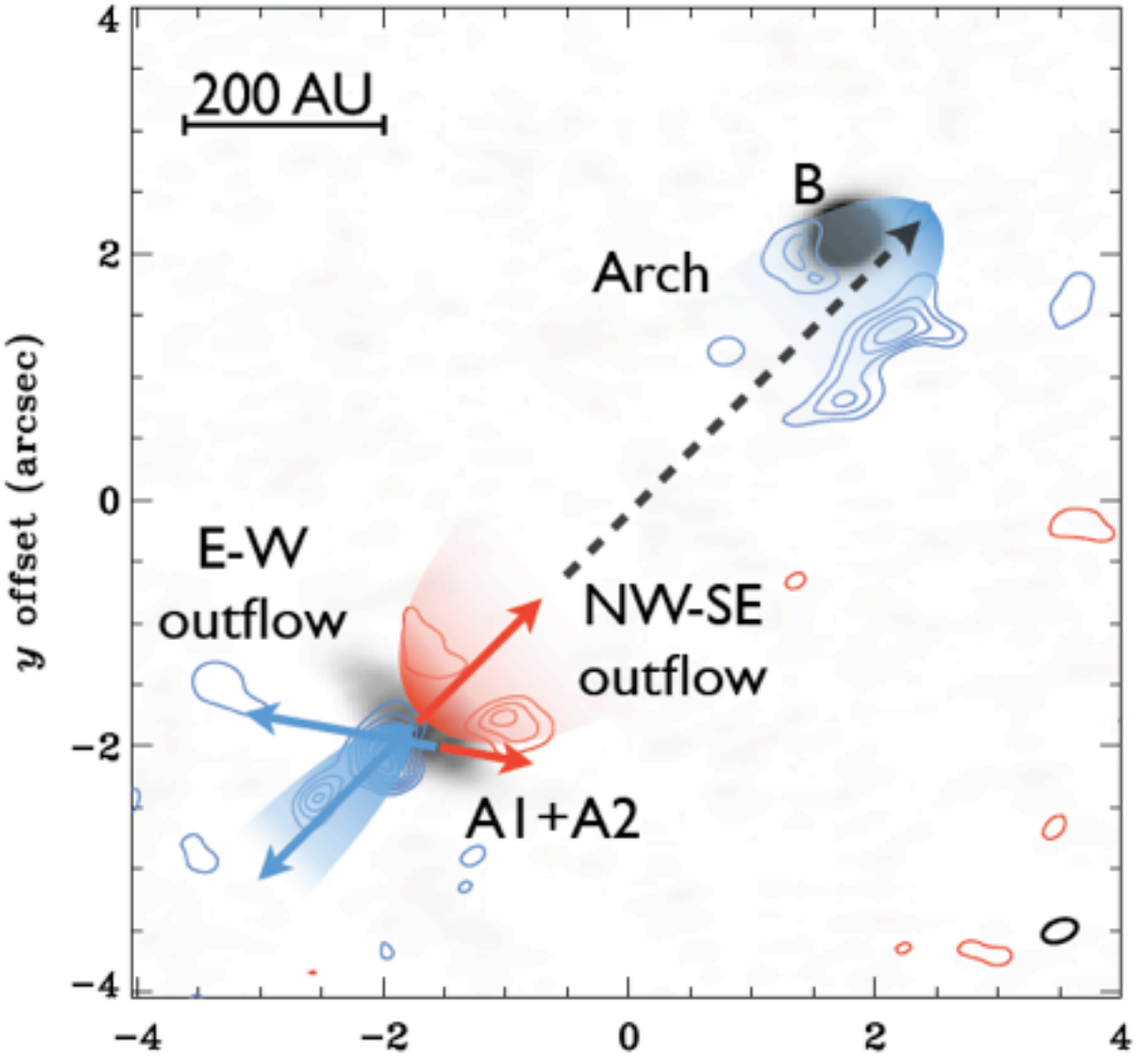


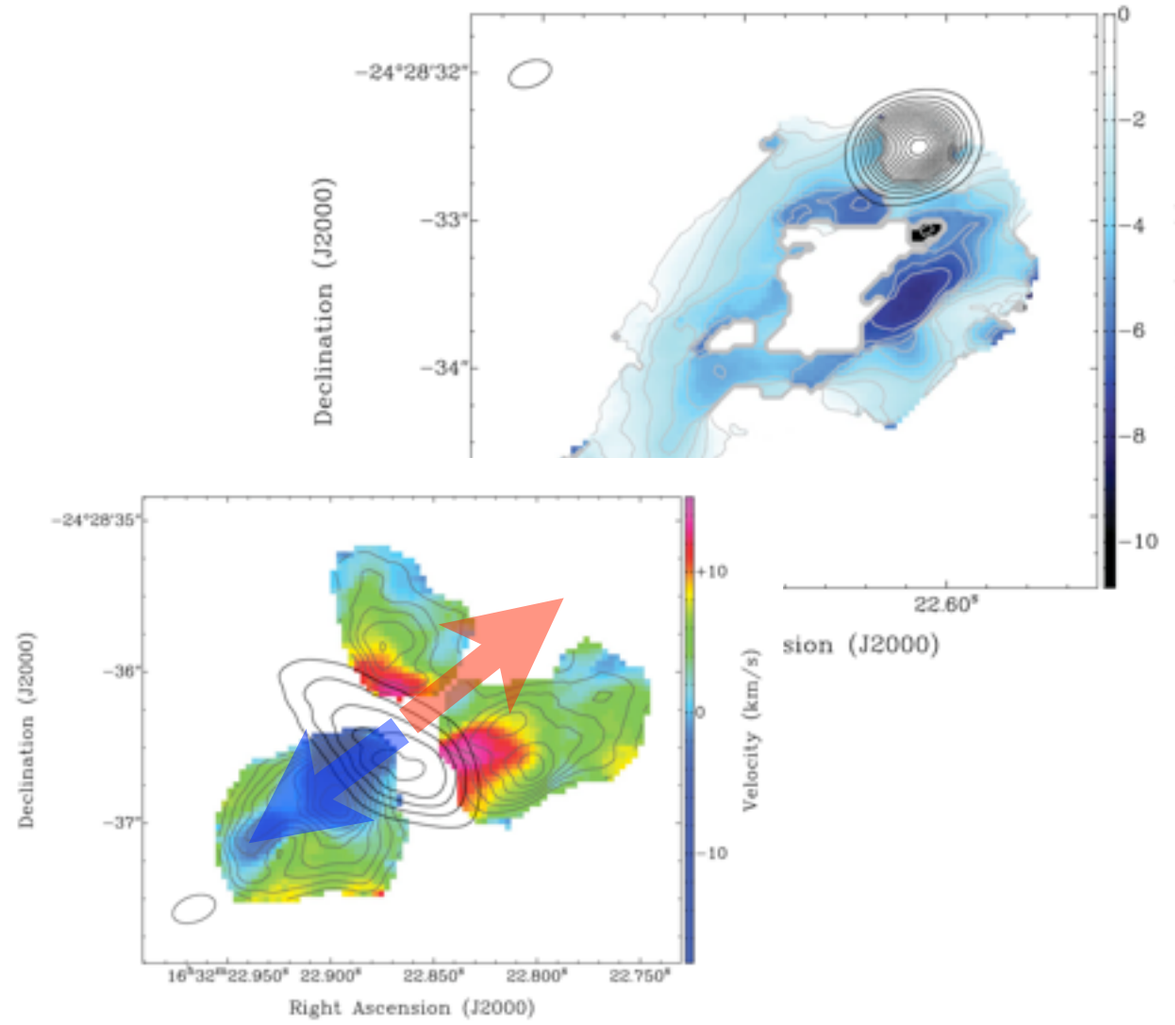
Kristensen et al. 2013

- But no, it's all one outflow!
- The single outflow is near the plane of the sky, and it's precessing in and out



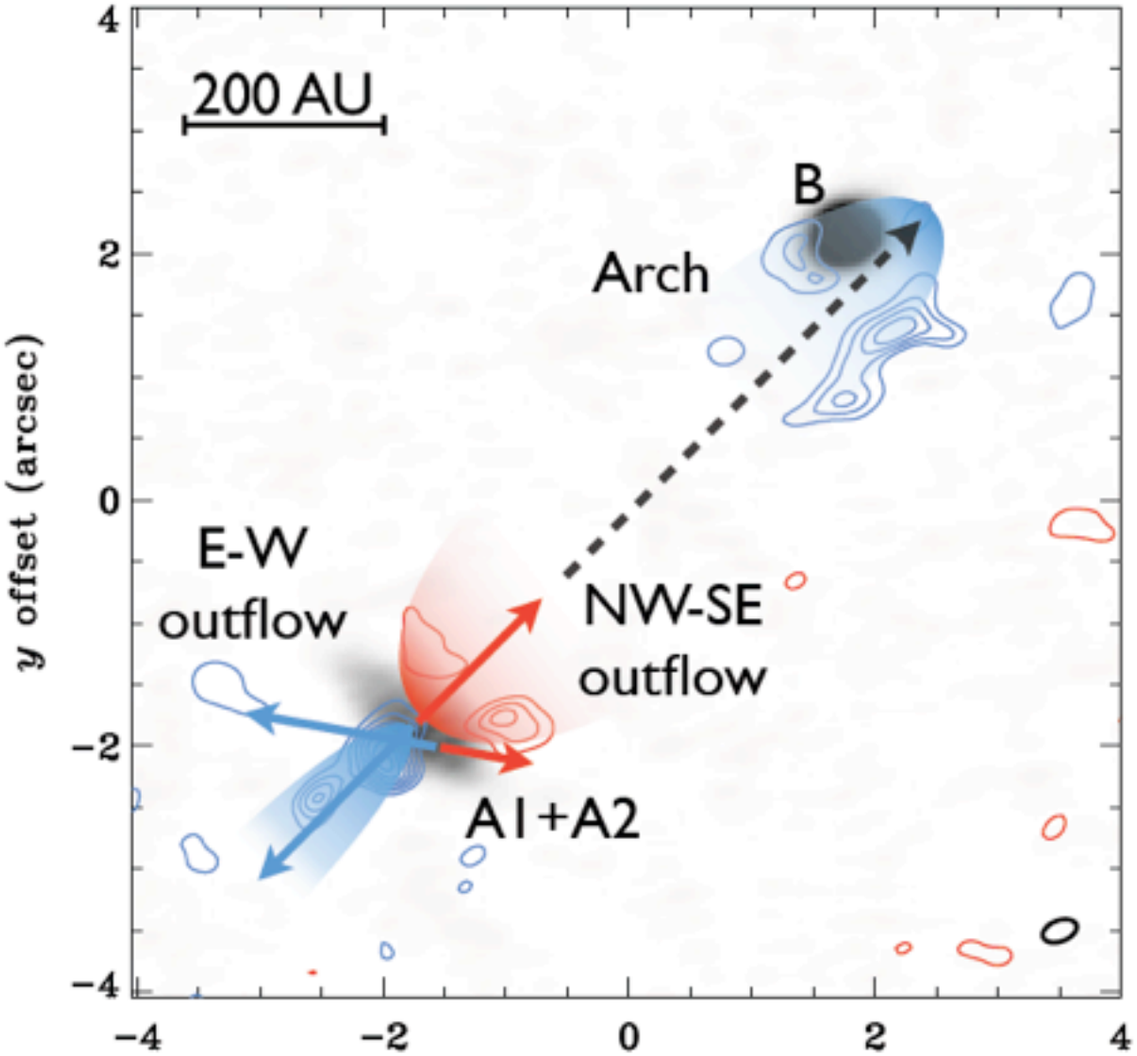
The Outflow(s)

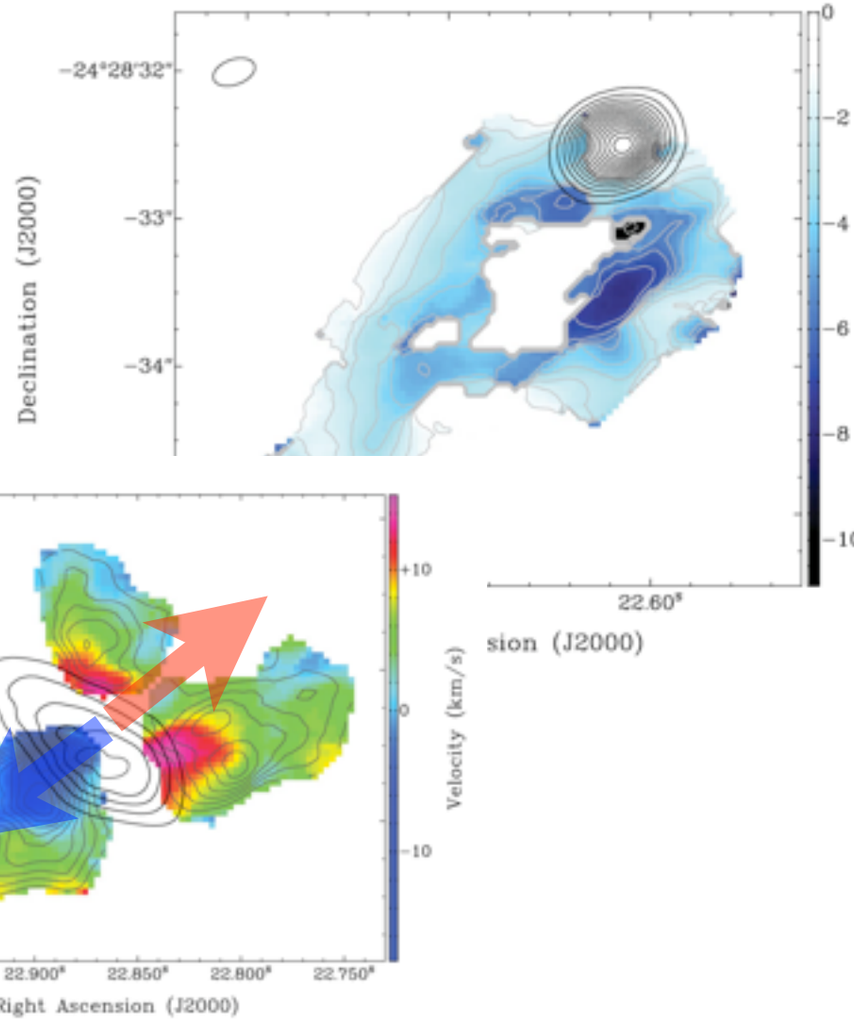




The Outflow(s)

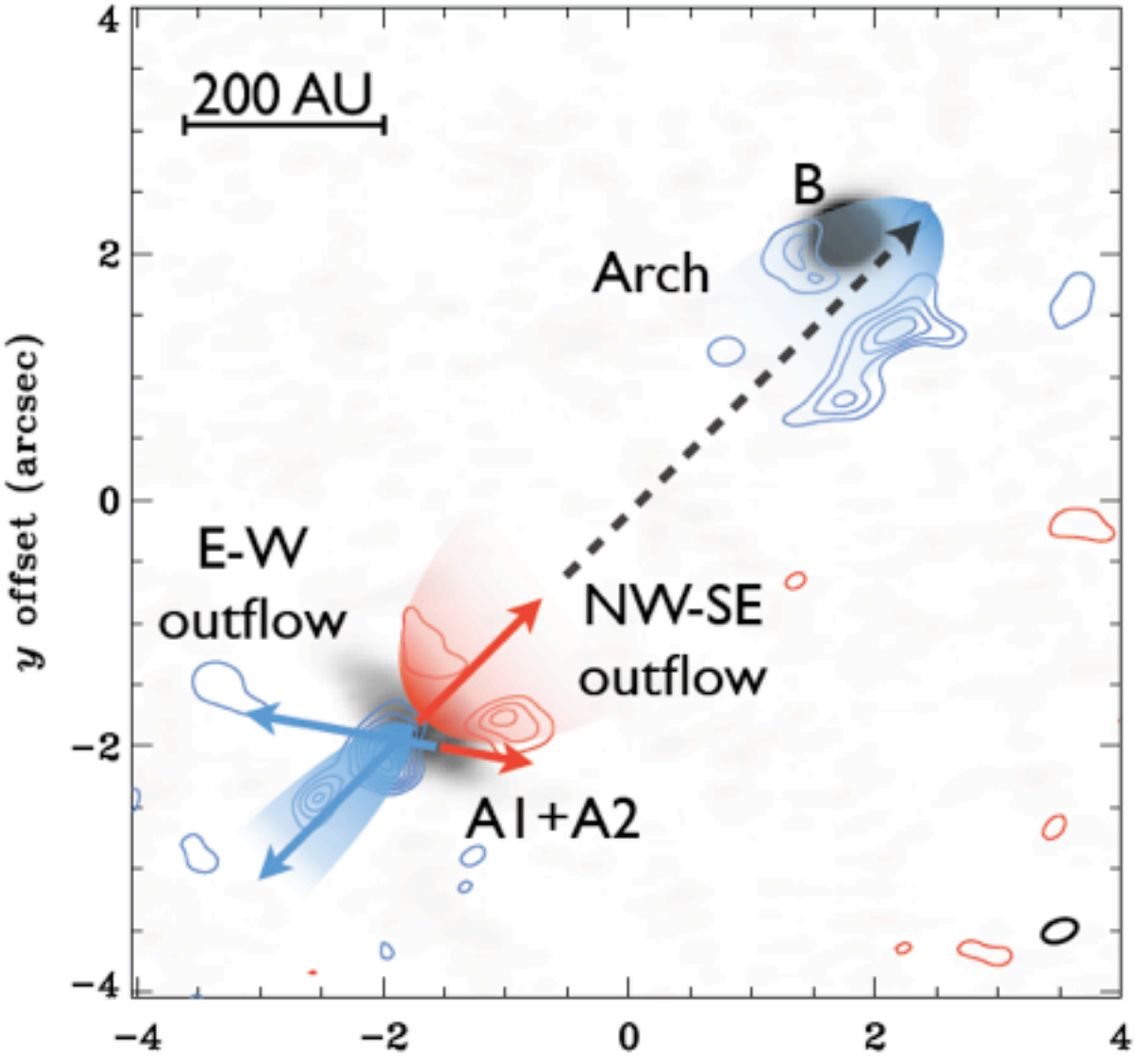
- Just because our figure is prettier, doesn't mean our interpretation is more robust.

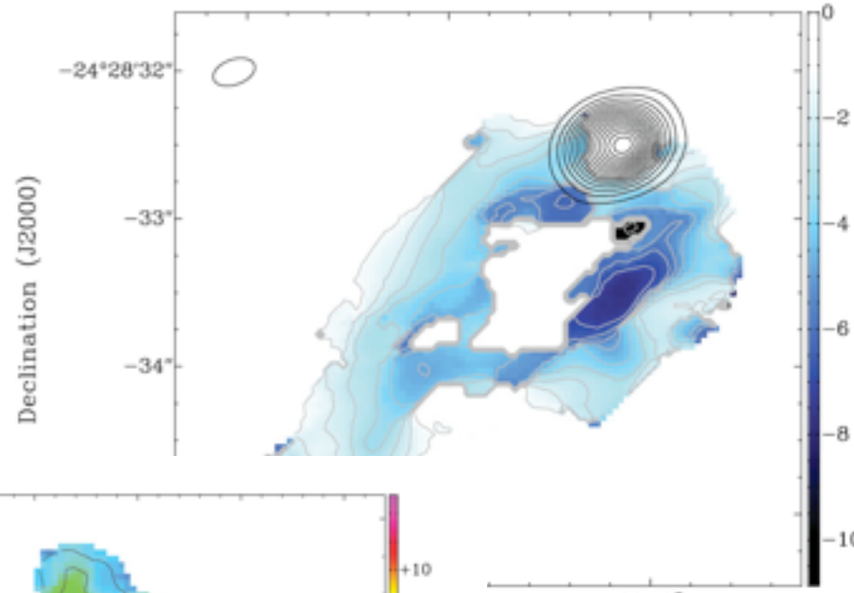


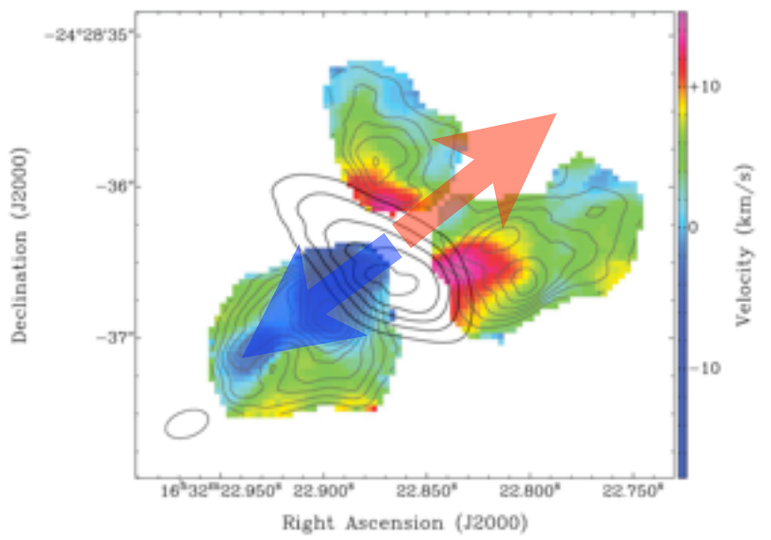


The Outflow(s)

- Just because our figure is prettier, doesn't mean our interpretation is more robust.
  - It's our more in-depth analysis that does it

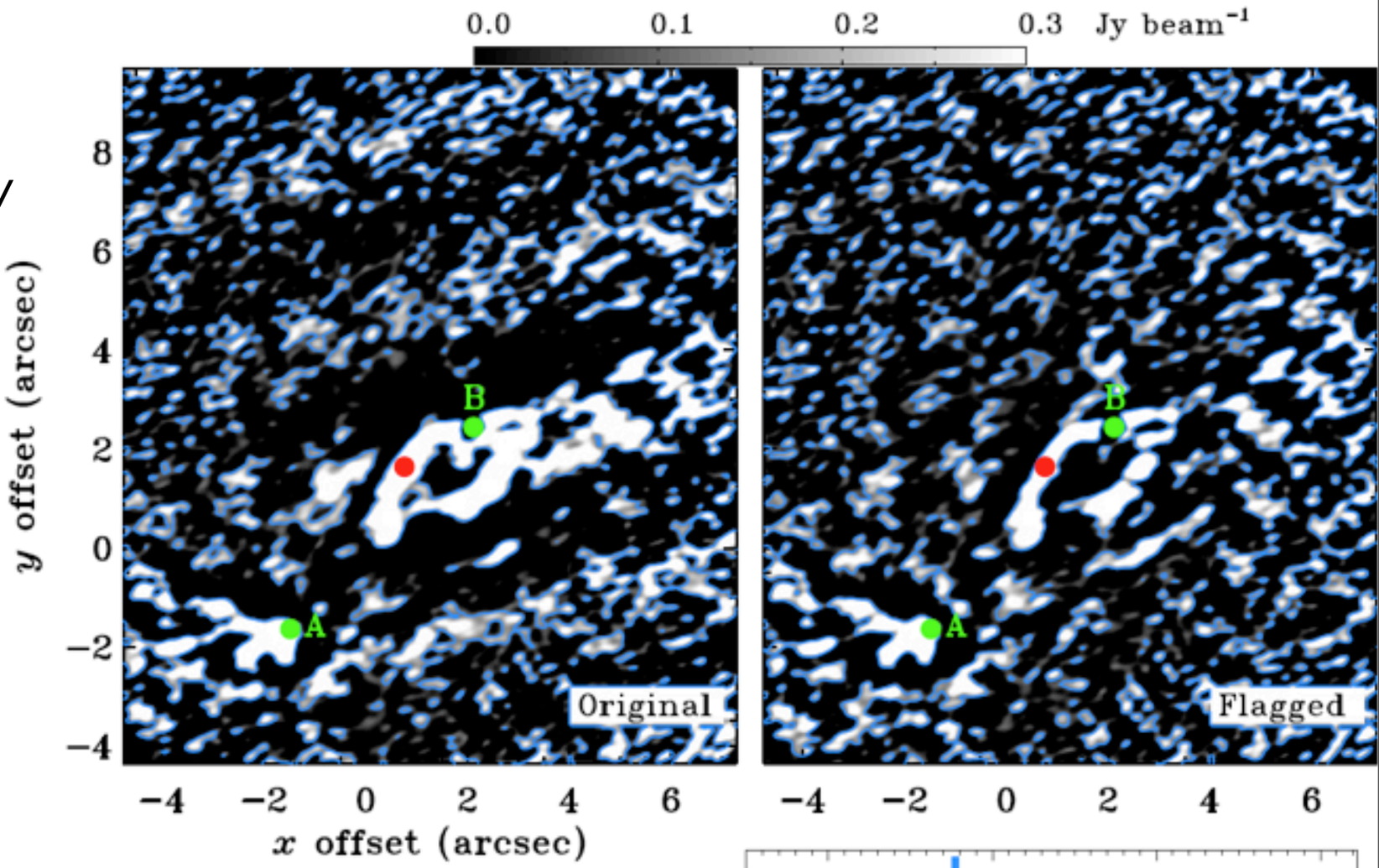


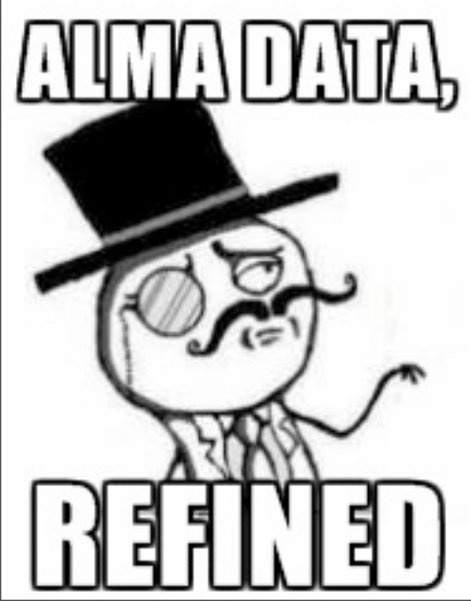




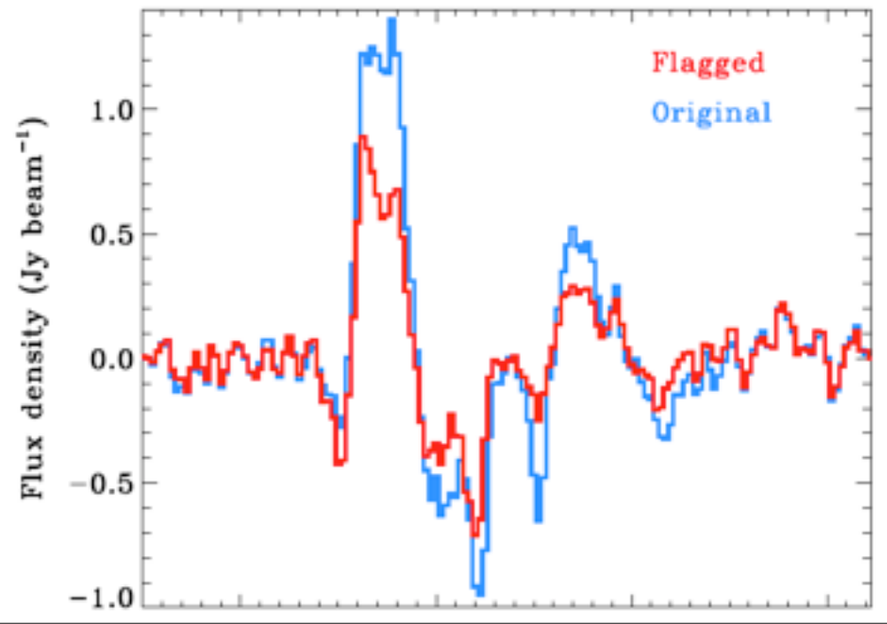
Our Refined Reduction

- Went systematically through the data
- Found data that needed to be flagged (due to poor sampling)





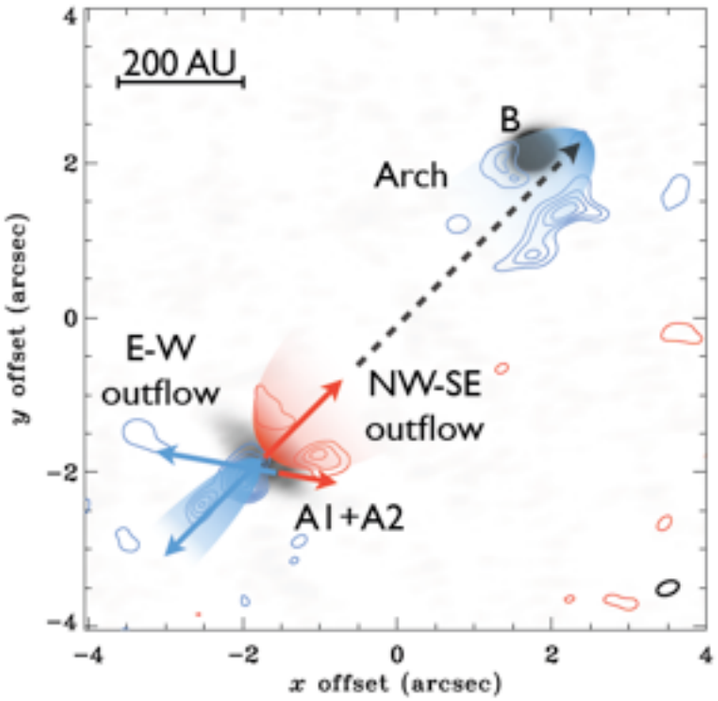
There is a lot of large scale structure that was filtered out by the interferometer



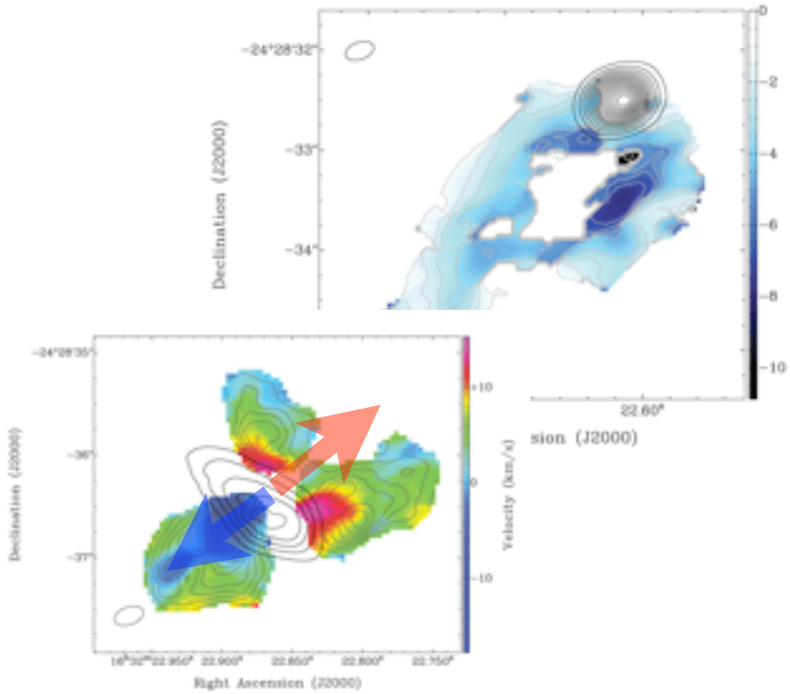
The Outflow(s)

- The outflow has large line widths
  - Consistent with Source A
- It extends further than Source B
- Suggesting it's passing by, not powered by B

We're filtering out the large scale outflow(s)



Ask me later, I can go into radiative transfer arguments as well (in the *Encore*)



Conclusions

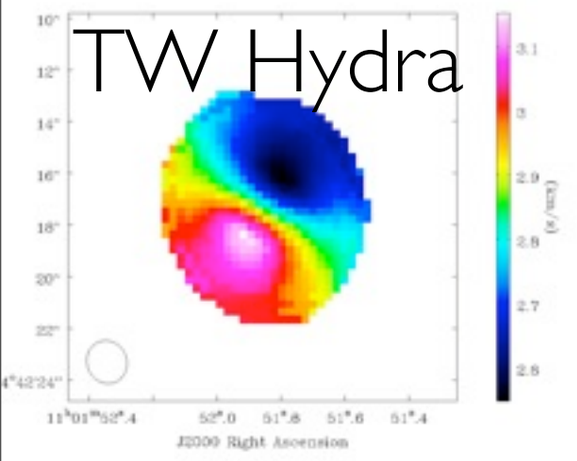
- There's a lot that can be done with ALMA SV data!
  - (but we still need more data!)

- The great increase in sensitivity means we're already getting confused about the physics
  - But, with careful analysis, the underlying processes become clear

Lets see what the future brings!

Science Verification

TW Hydra



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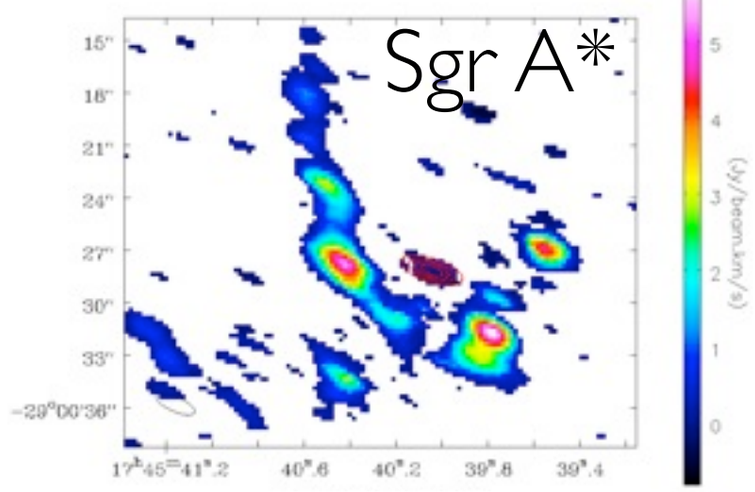

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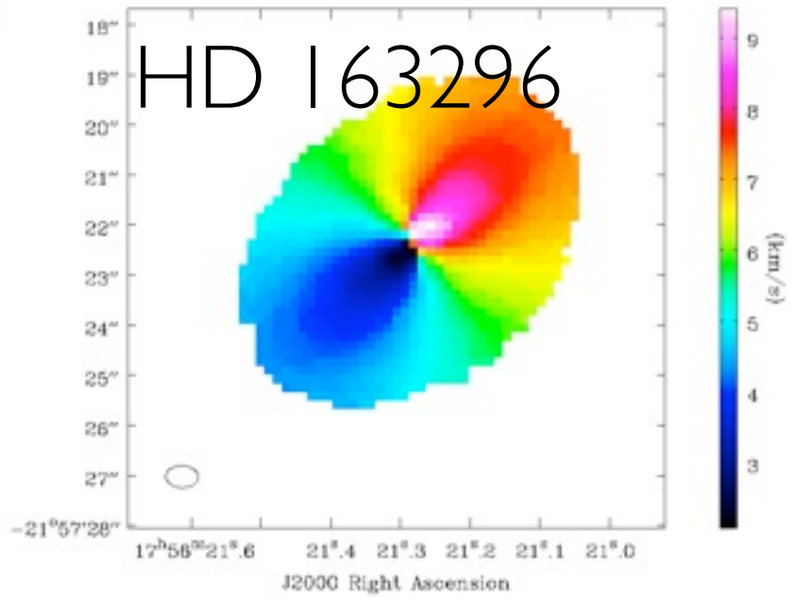

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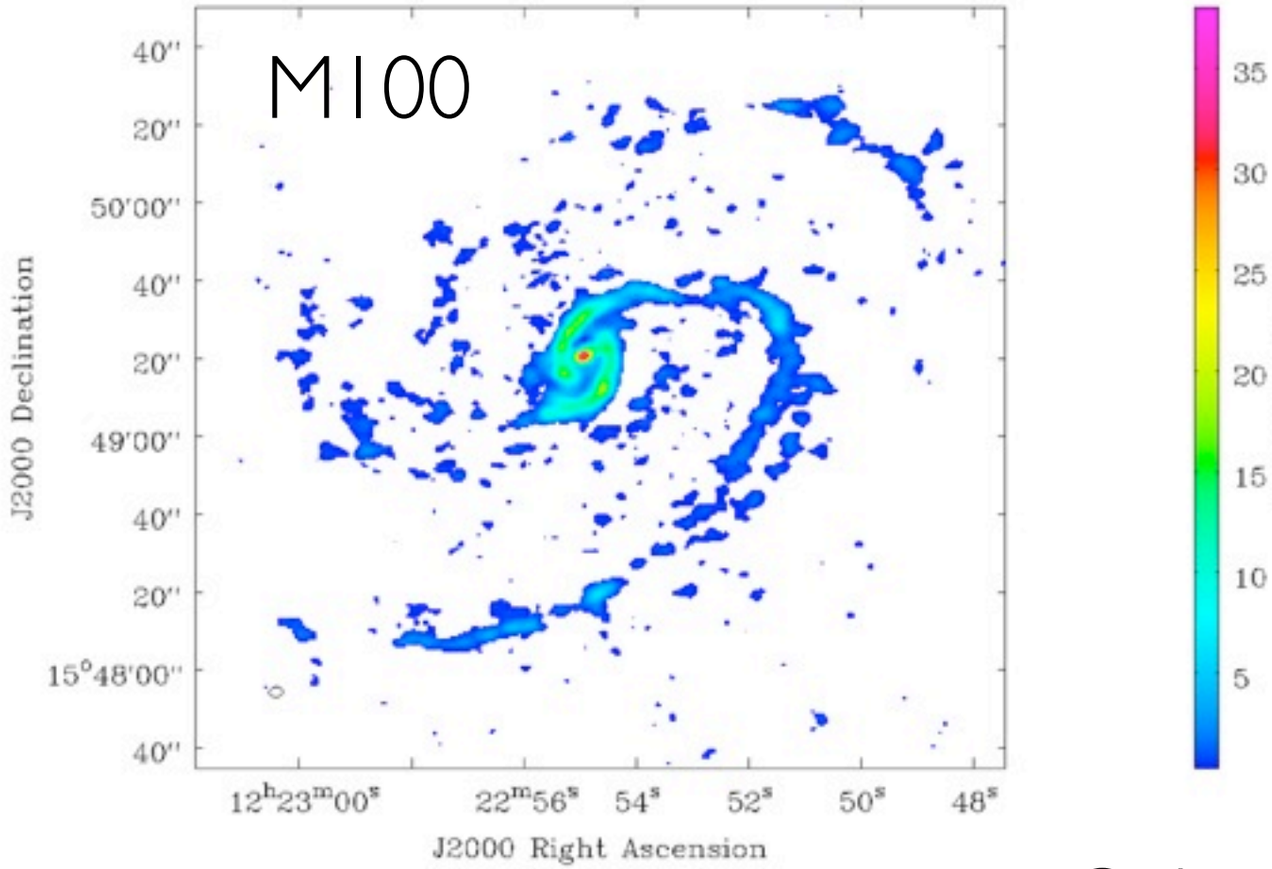

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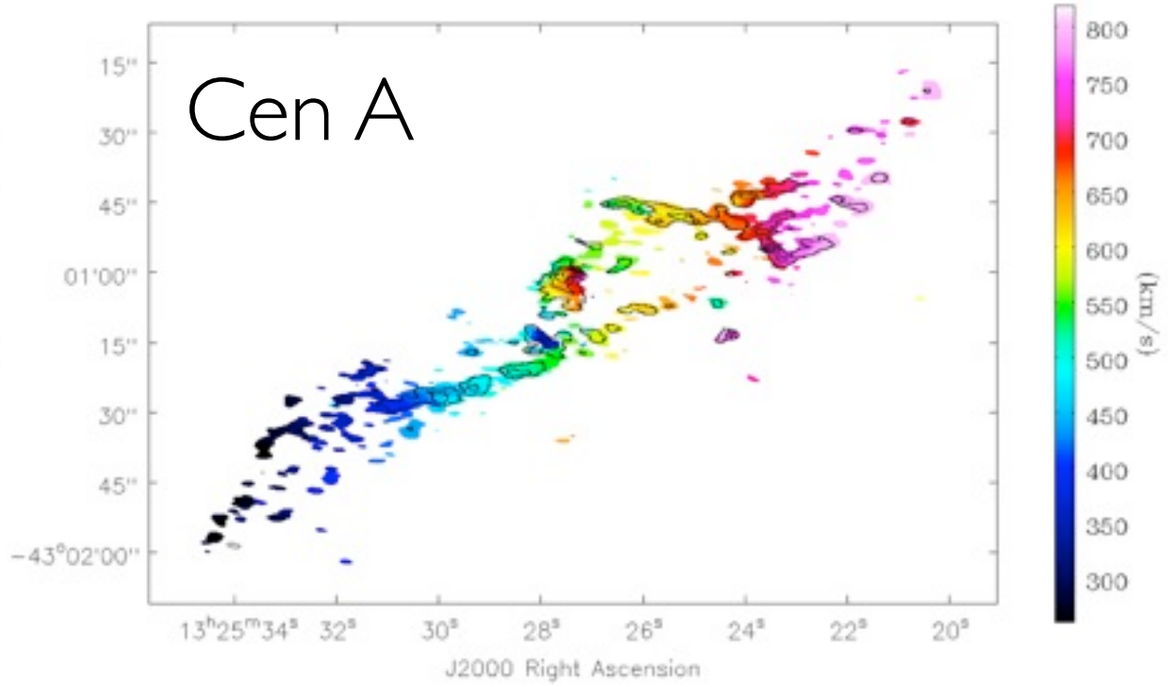
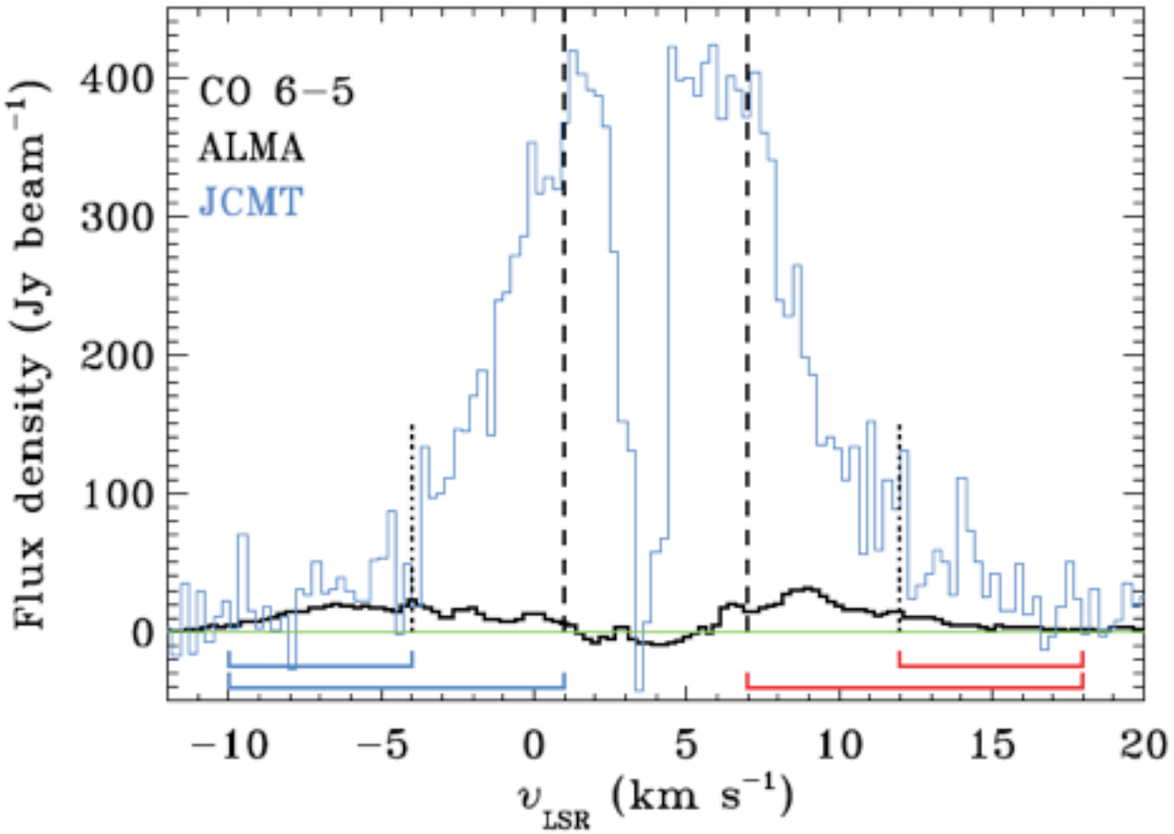
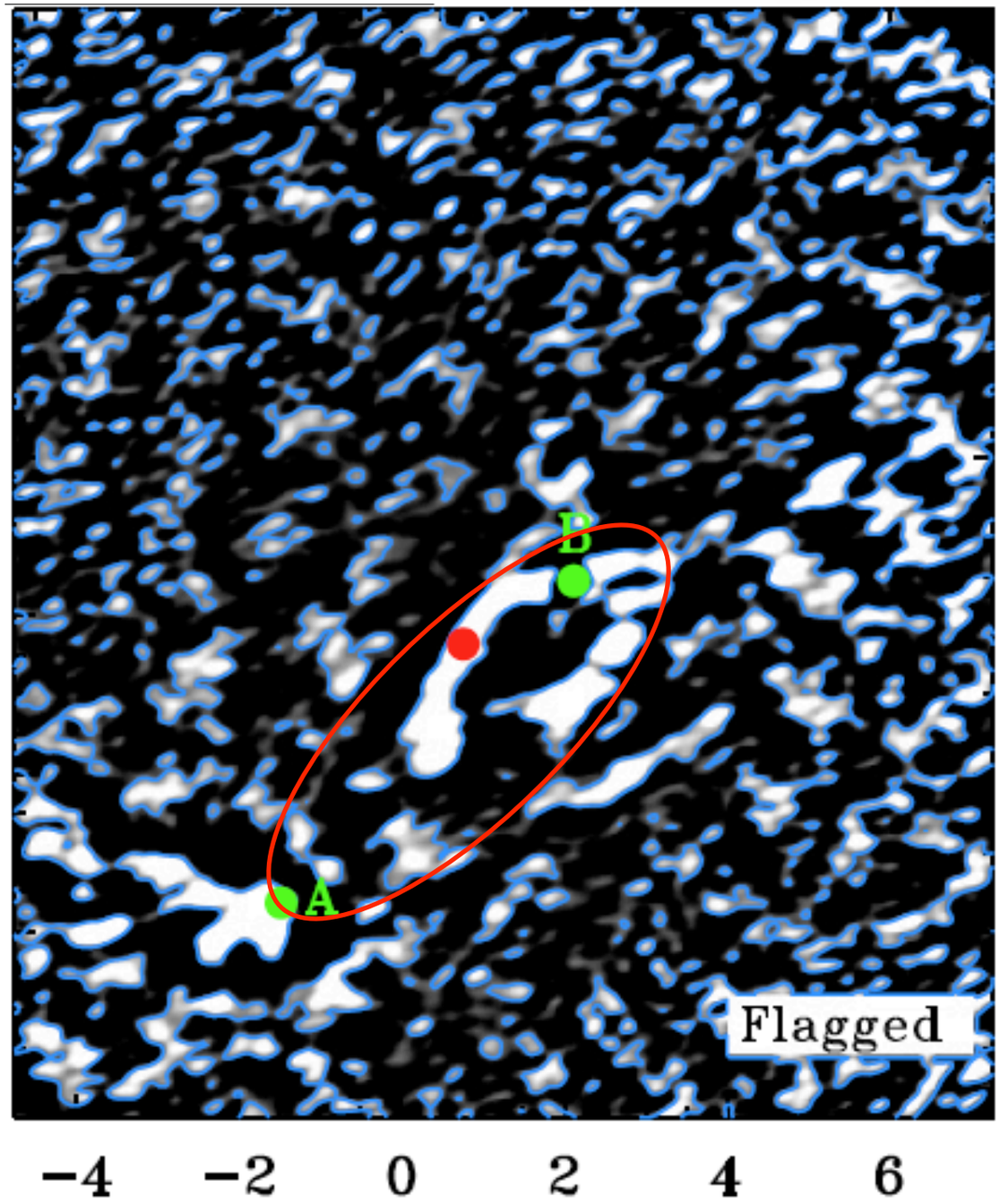


Orion KL

The Analysis

- About 95% of the emission is filtered out
- But, at -3 km/s, look at the structure of the CO gas!



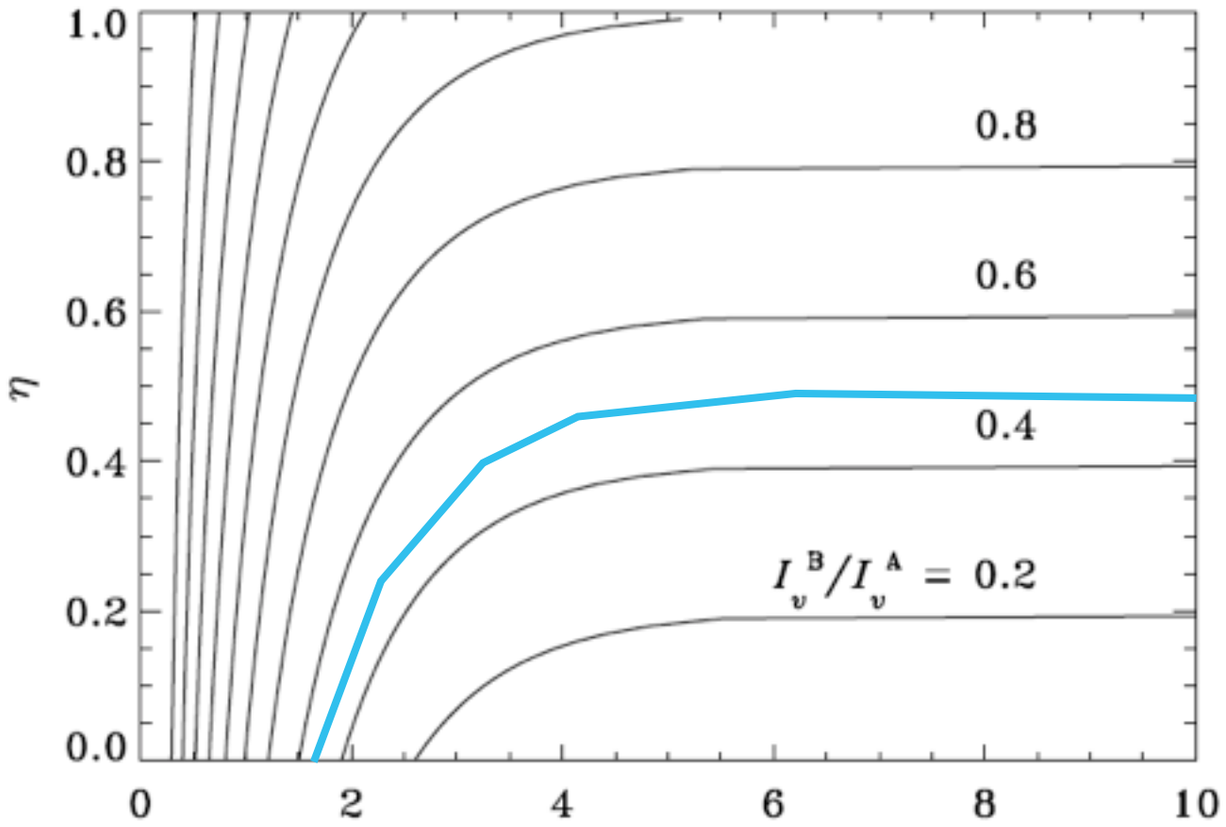


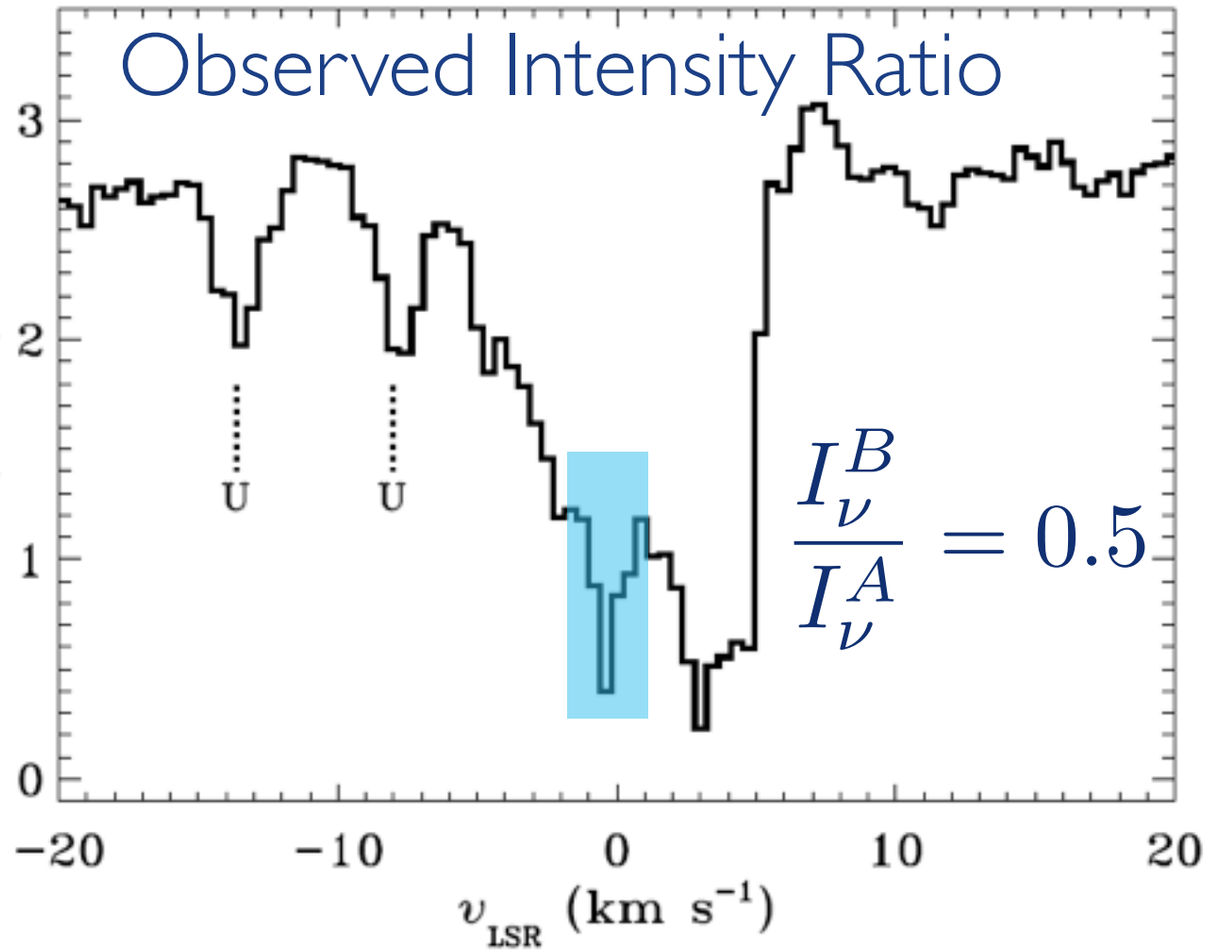
It extends further than ***B***

Looking at the Physics

- We can't conclude on morphology alone
- Use the fact that the interferometer is a filter to our advantage

η, Fraction of recovered flux (relative to Source A)





For any **τ**, **η** is <0.5

Looking at the Physics

- The fraction of recovered flux at B is less than at A
- This means the structures towards B are larger than those towards A

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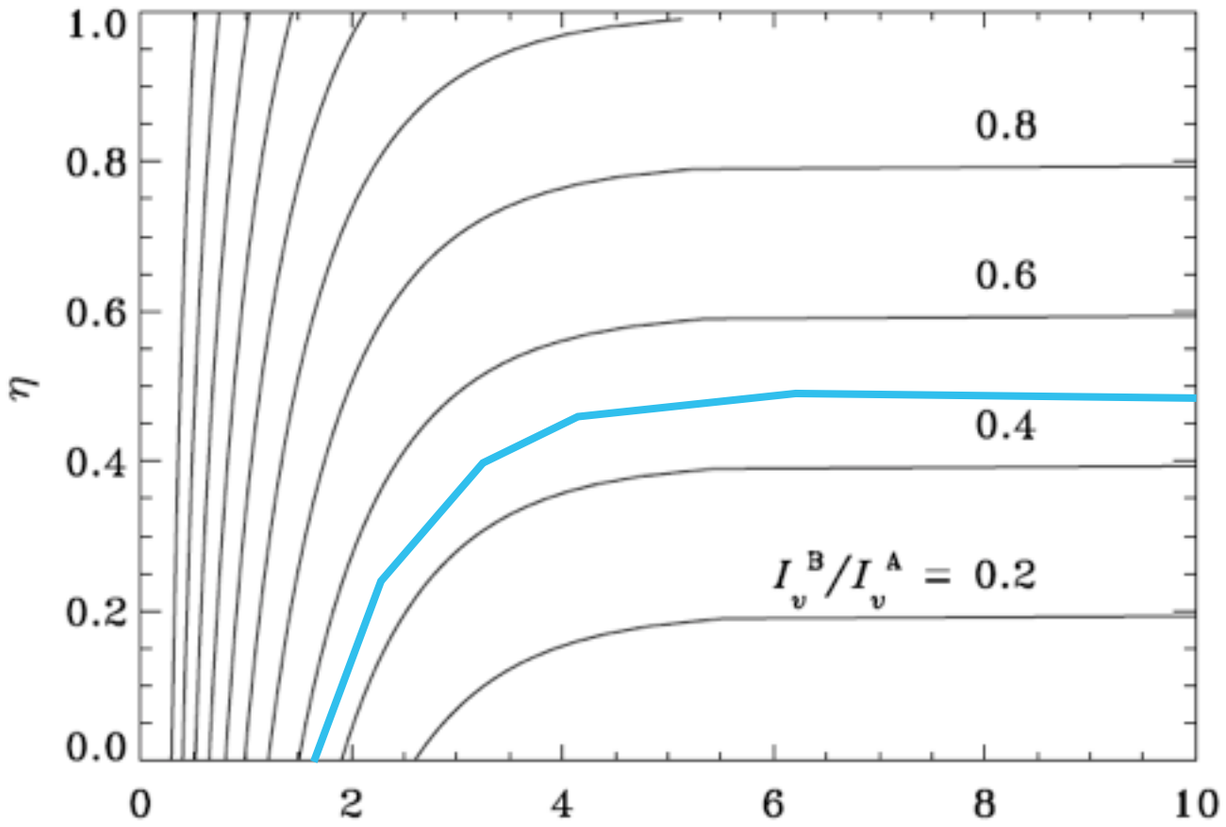

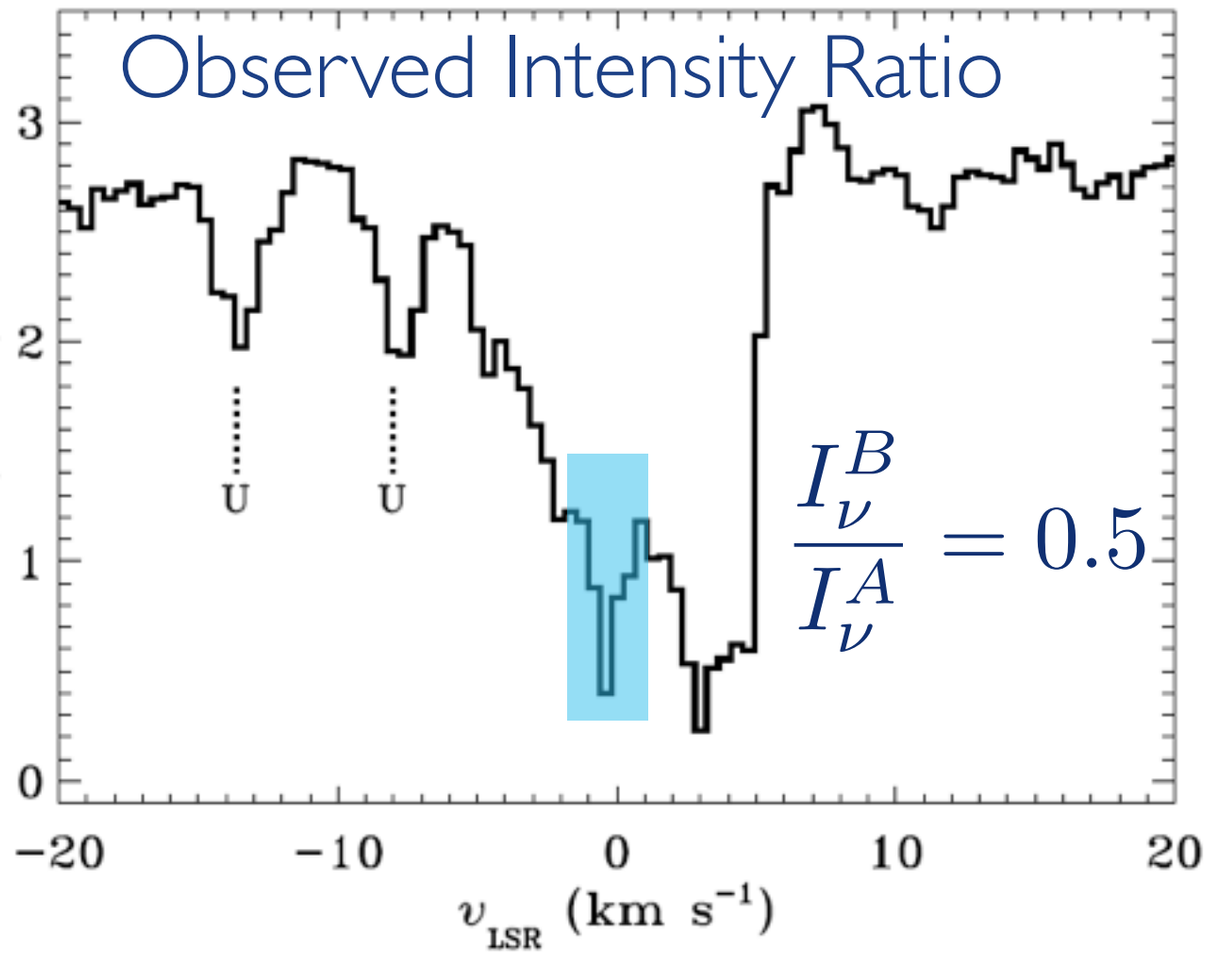

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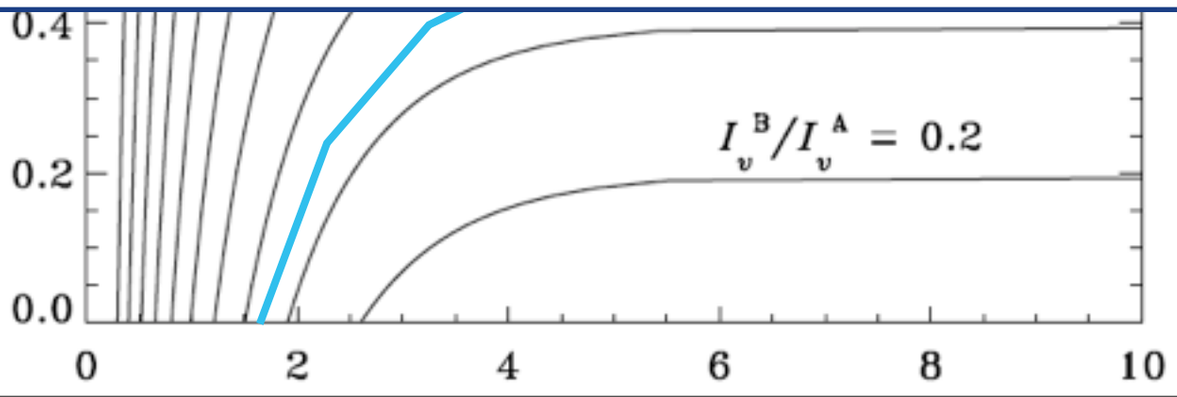
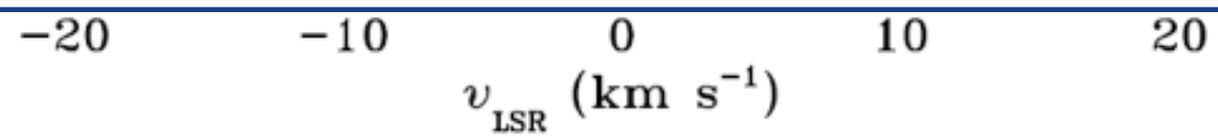
If the outflow powering mechanism would be the same in A and B:

There is too much large scale emission towards B for it to be powering the outflow





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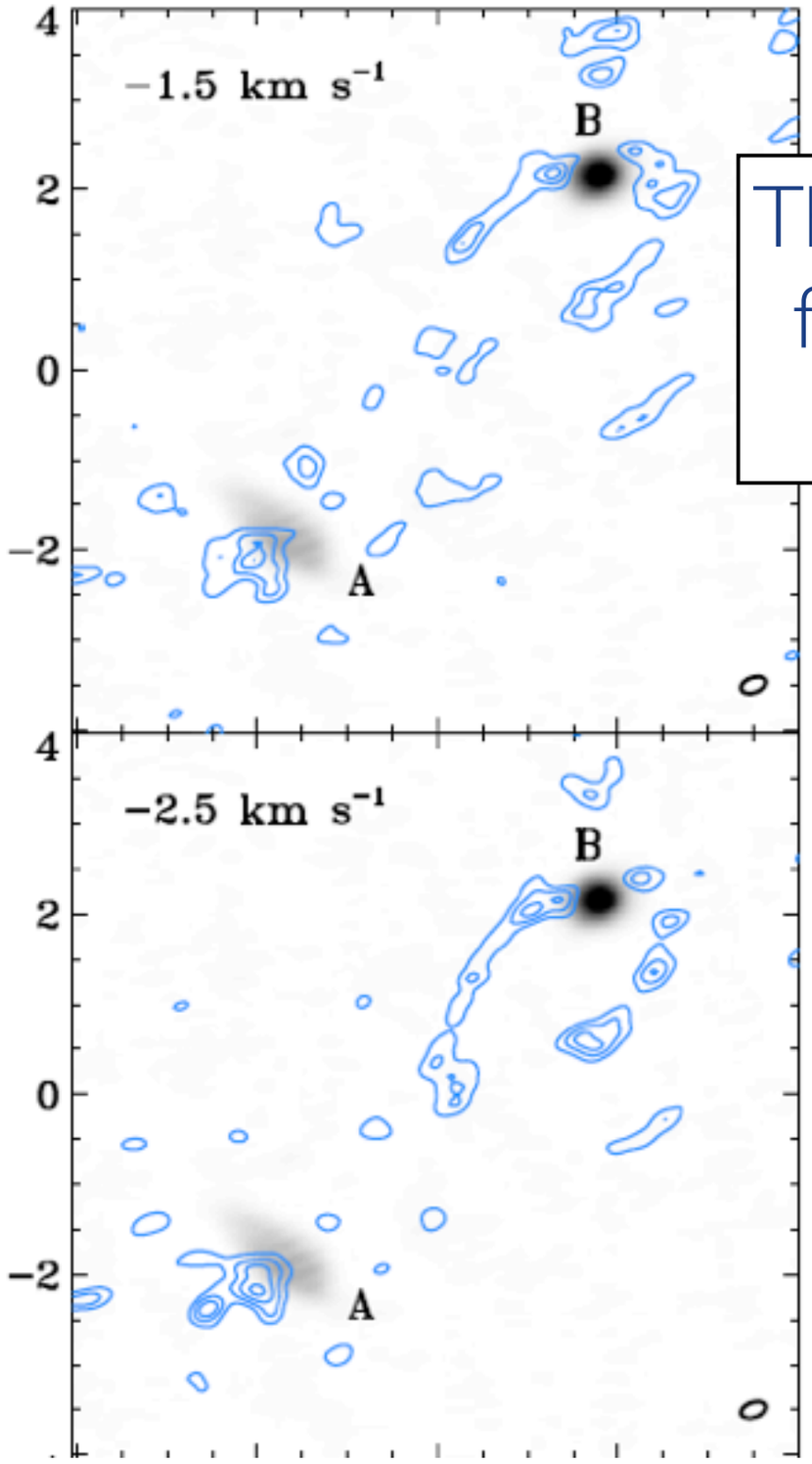
The Channel Maps



The end of the outflow is offset from Source B for a few km/s (not just a channel or two)