ALMA “real life” example

The story of G17 - a massive proto-star

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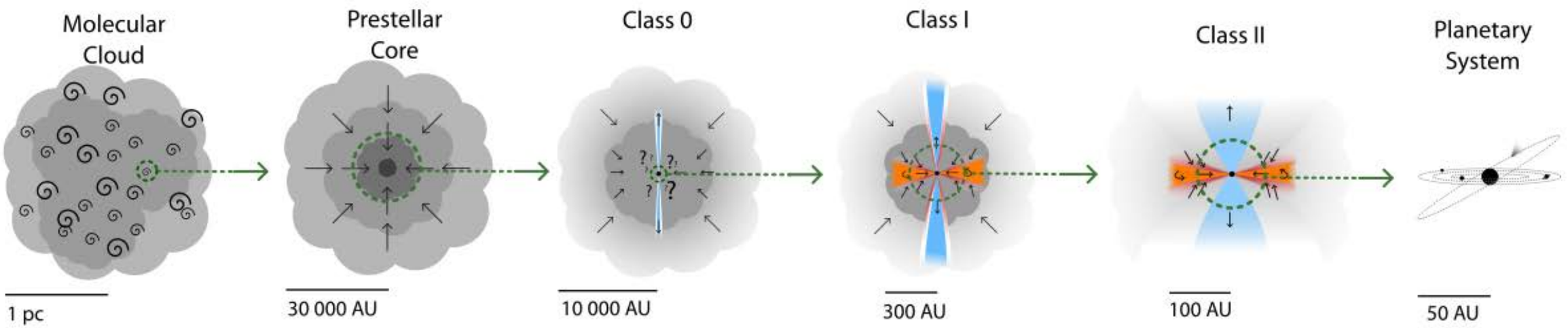
Spanish **ALMA** Days
La Laguna, Tenerife, Spain
18-20 February

Where it began

- **Me** - many many years ago…a PhD studying massive star forming regions with mm-interformetry… to postdoc with limited science time
- **Key Collaborators** - experts in the field for decades, looking to “see” how massive stars form - association via supervisors
- **The idea** - are there disks around high mass ‘proto’- stars, like (we thought) there are around **low mass** protostars (pre-ALMA)



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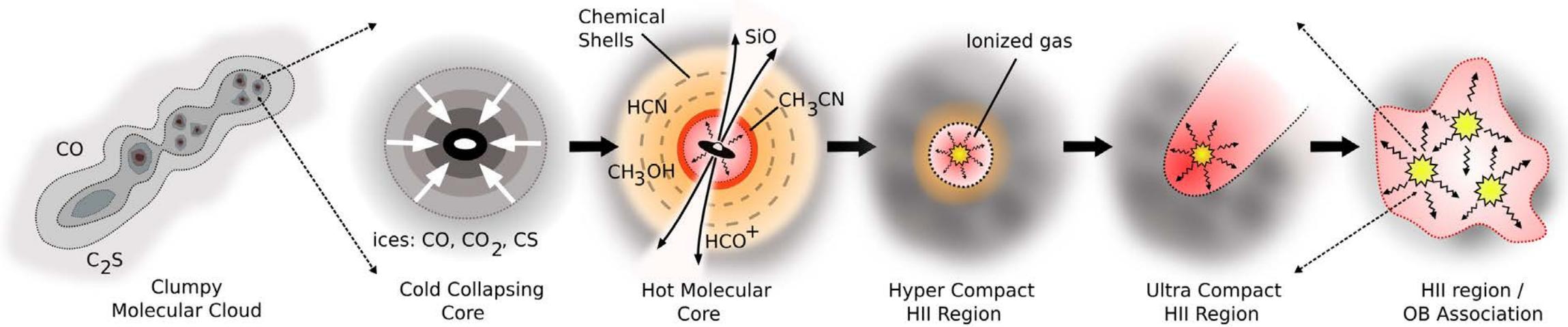

Credits: C. Purcell

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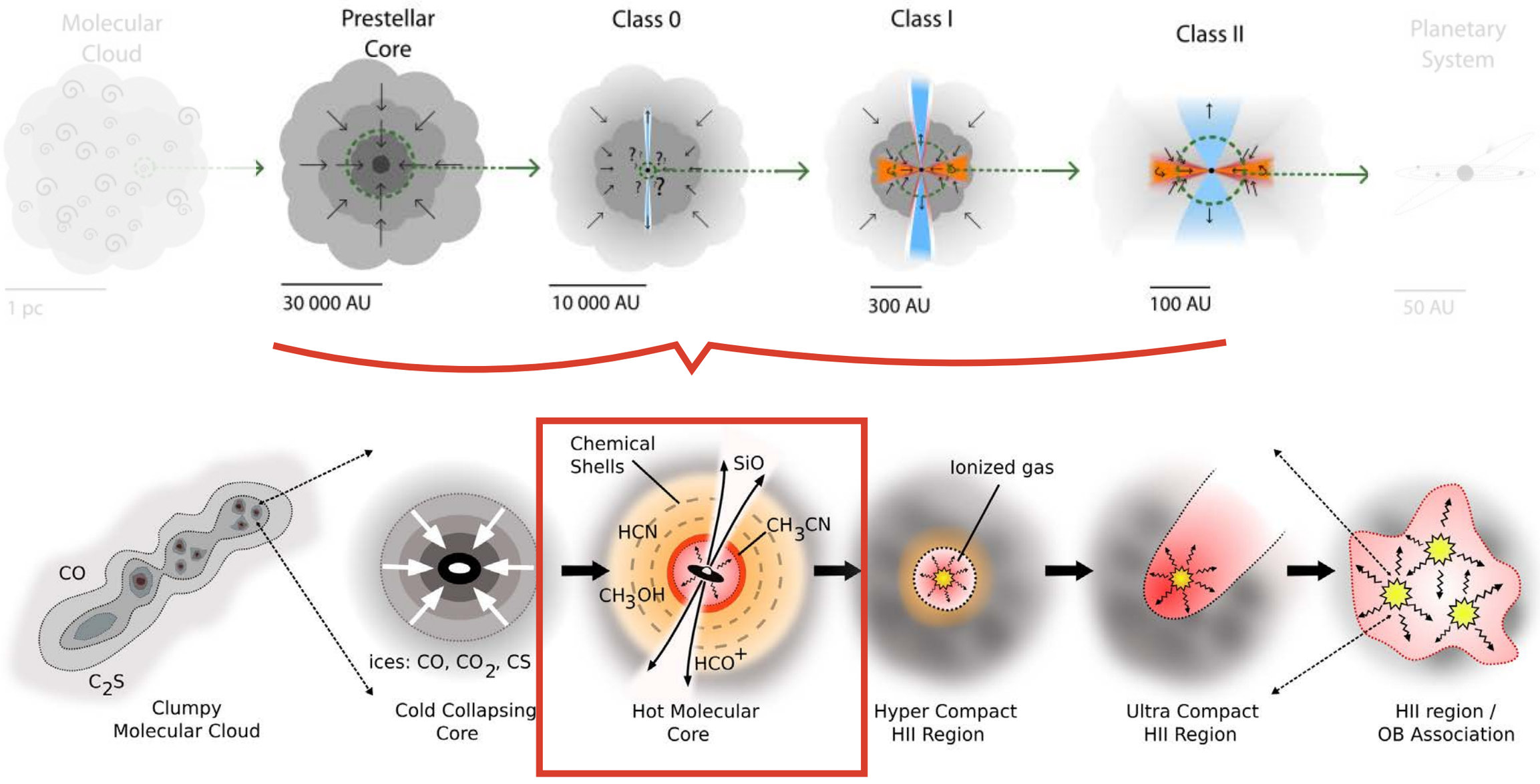

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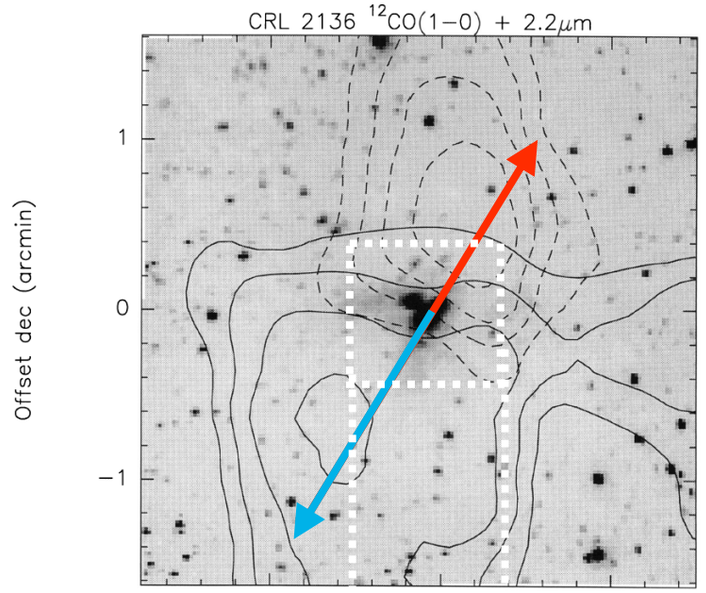
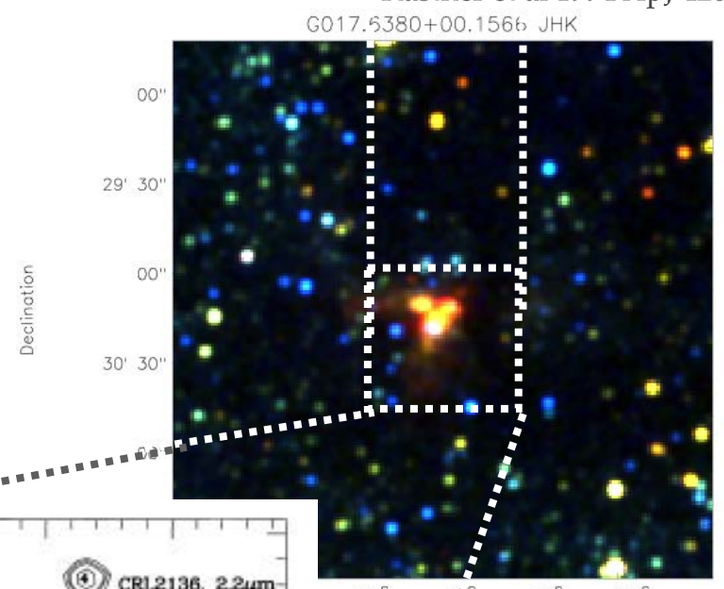
plus, high-mass regions are 10x more distant

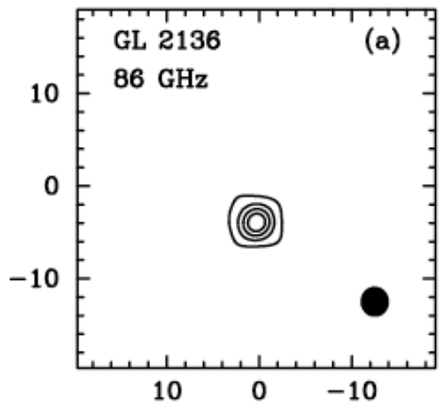
Setting the scene

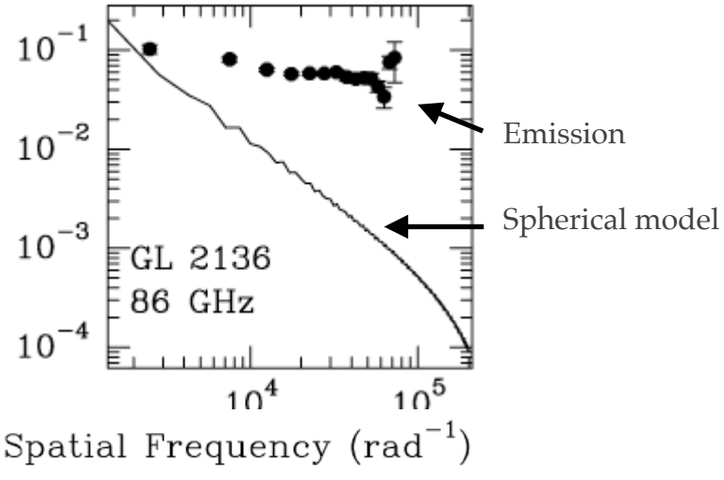
- **G17** - relatively nearby ~2.2kpc, Luminous ~10^5Lo, IR bright - not totally enshrouded, should be an **O-type** ‘proto’ star(s)
- **Lots of previous observations** - CO molecular outflow and IR reflection nebula (scattered light from an outflow cavity)
- **Compact** - mm and radio emission at <10000AU scales - ***could there be a ‘disk’***



Kastner et al 1994 ApJ 426 695







van der Tak et al. et al. 2000 ApJ 537 283

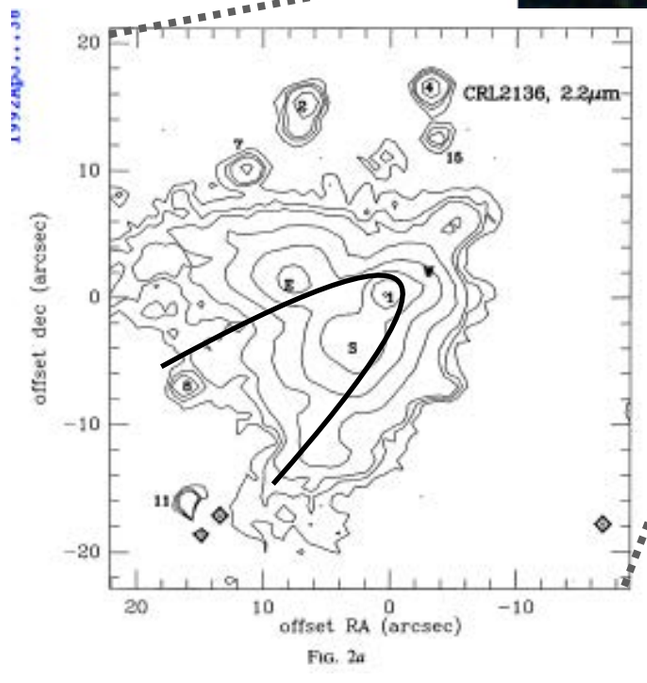


Fig. 2a

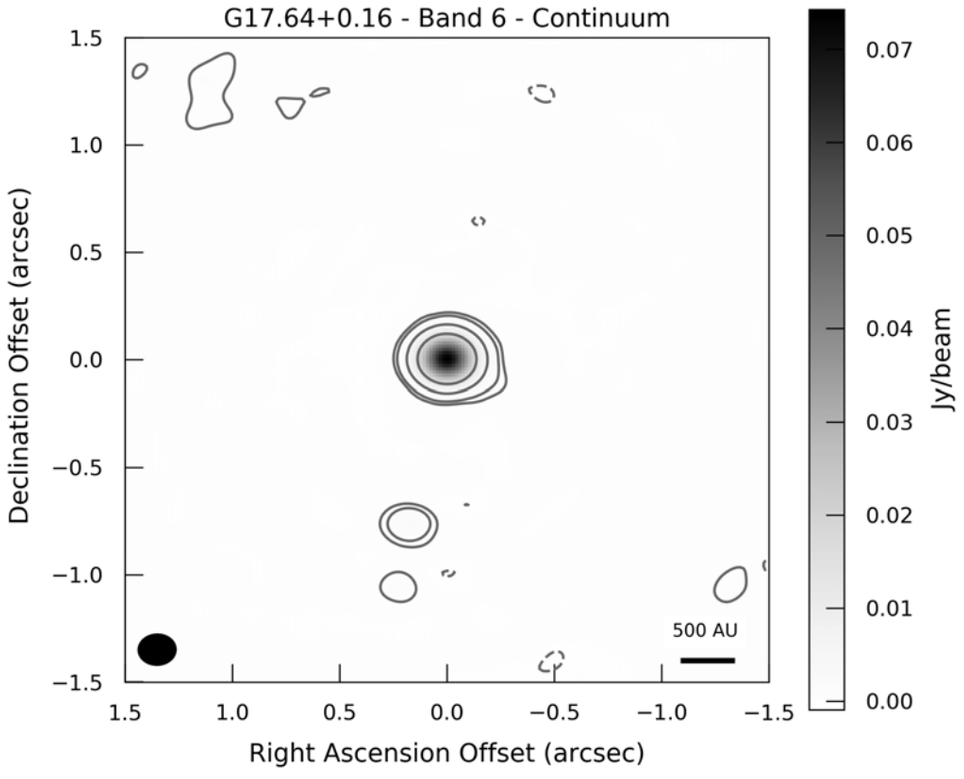
Kastner et al. 1992 ApJ 389 357, Holbrook & Temi 1998 ApJ 496 280

Useful Lesson:

- **ARCHIVE** - ***you*** are not starting from scratch, there will be ideas, papers and data available - ***especially now with ALMA***

Our first ALMA view

- **The proposal** - written by the ‘leads’, to focus on 6 highest luminosity candidates
- **Effort** - extra processing of the data, self-calibration, and a lot of analysis. I lead the G17 team



Oh…there is not really any structure….even at 500 au scales…

But let’s not be disappointed, what else do we have???

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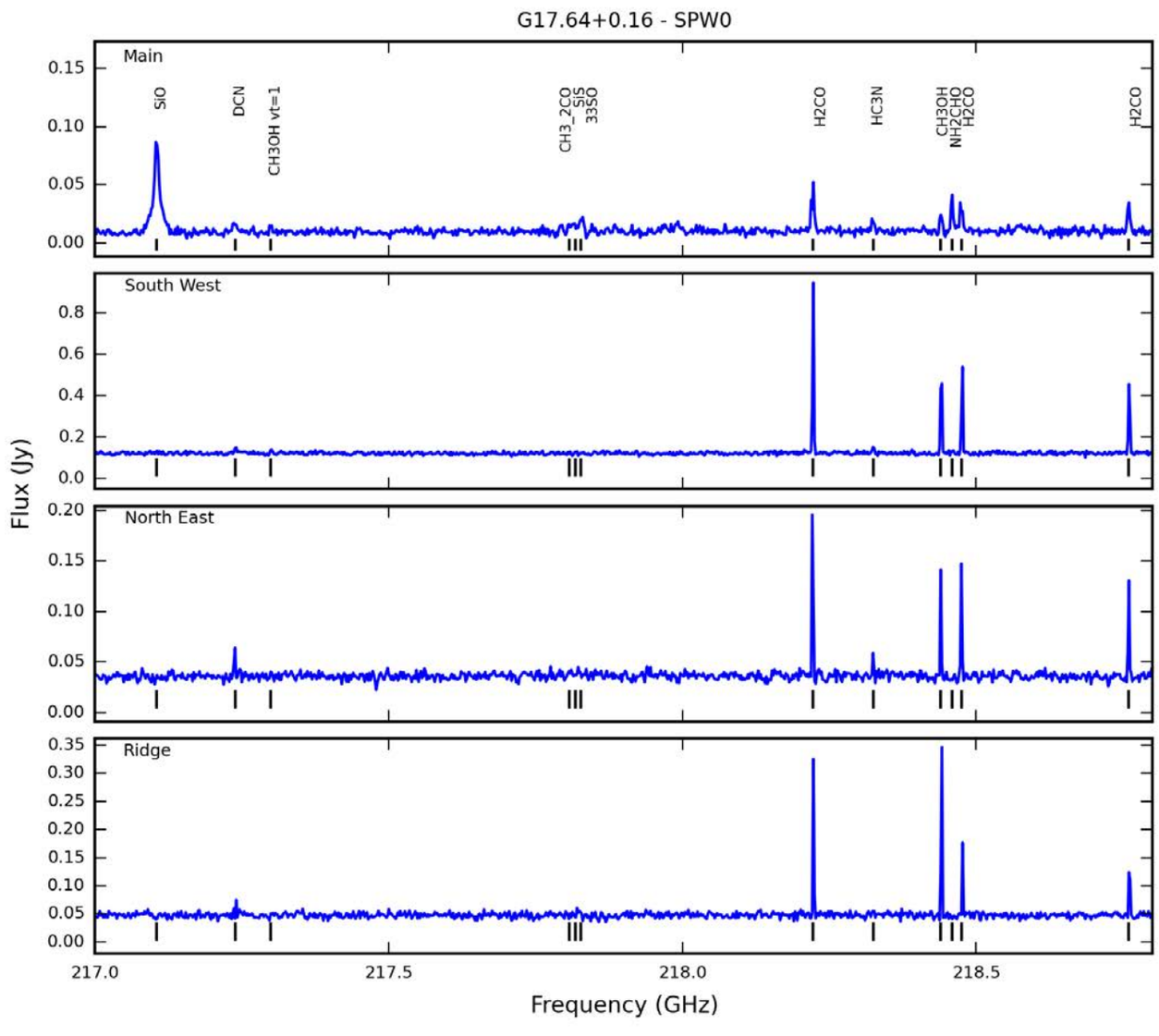

there are a reasonable number of emission lines….lets investigate

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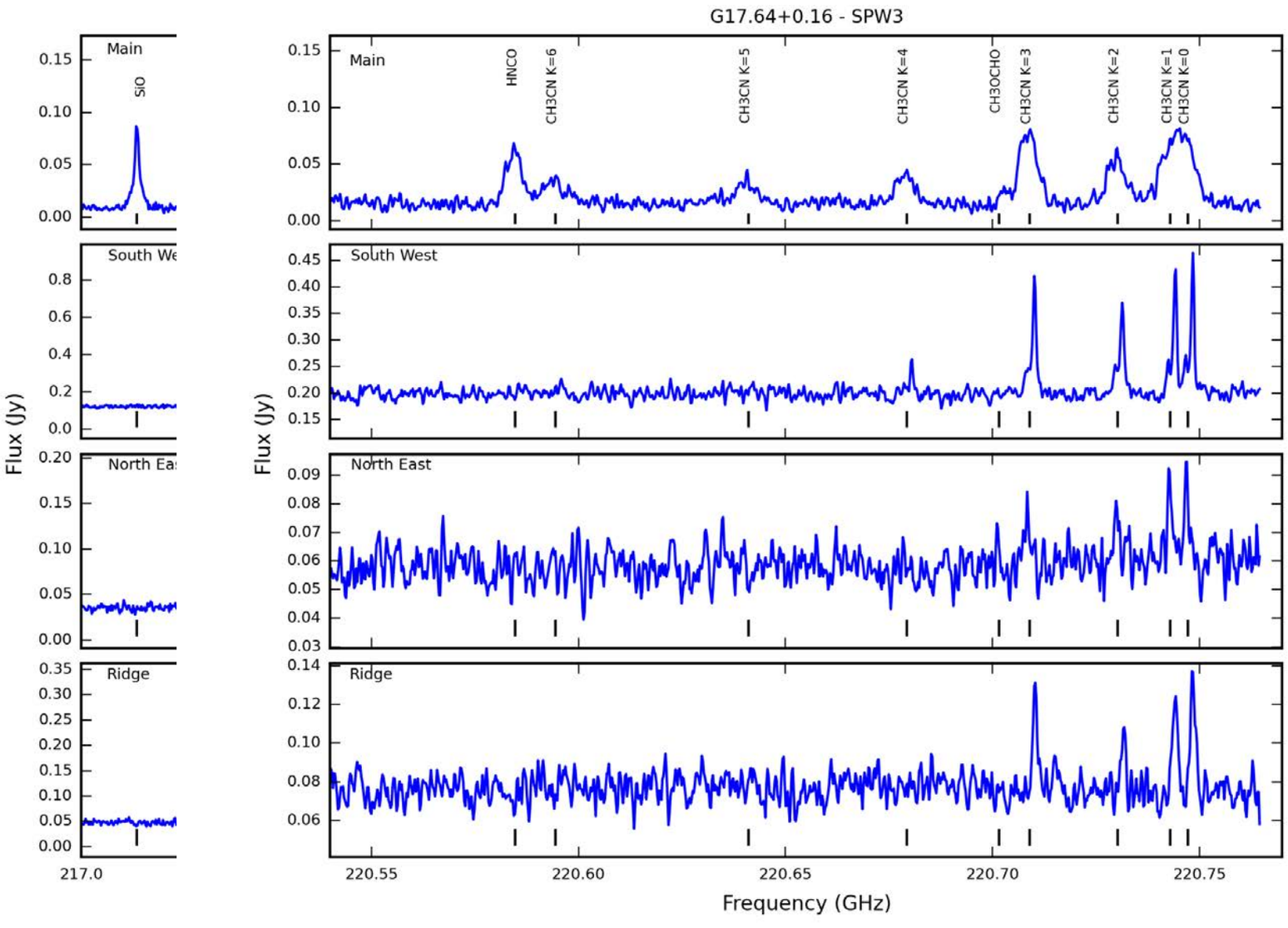

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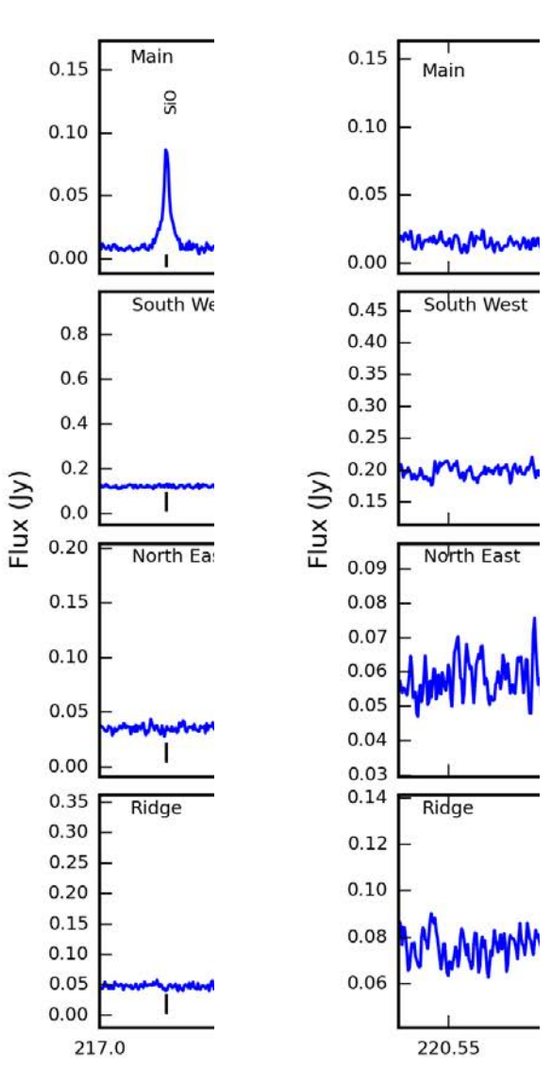

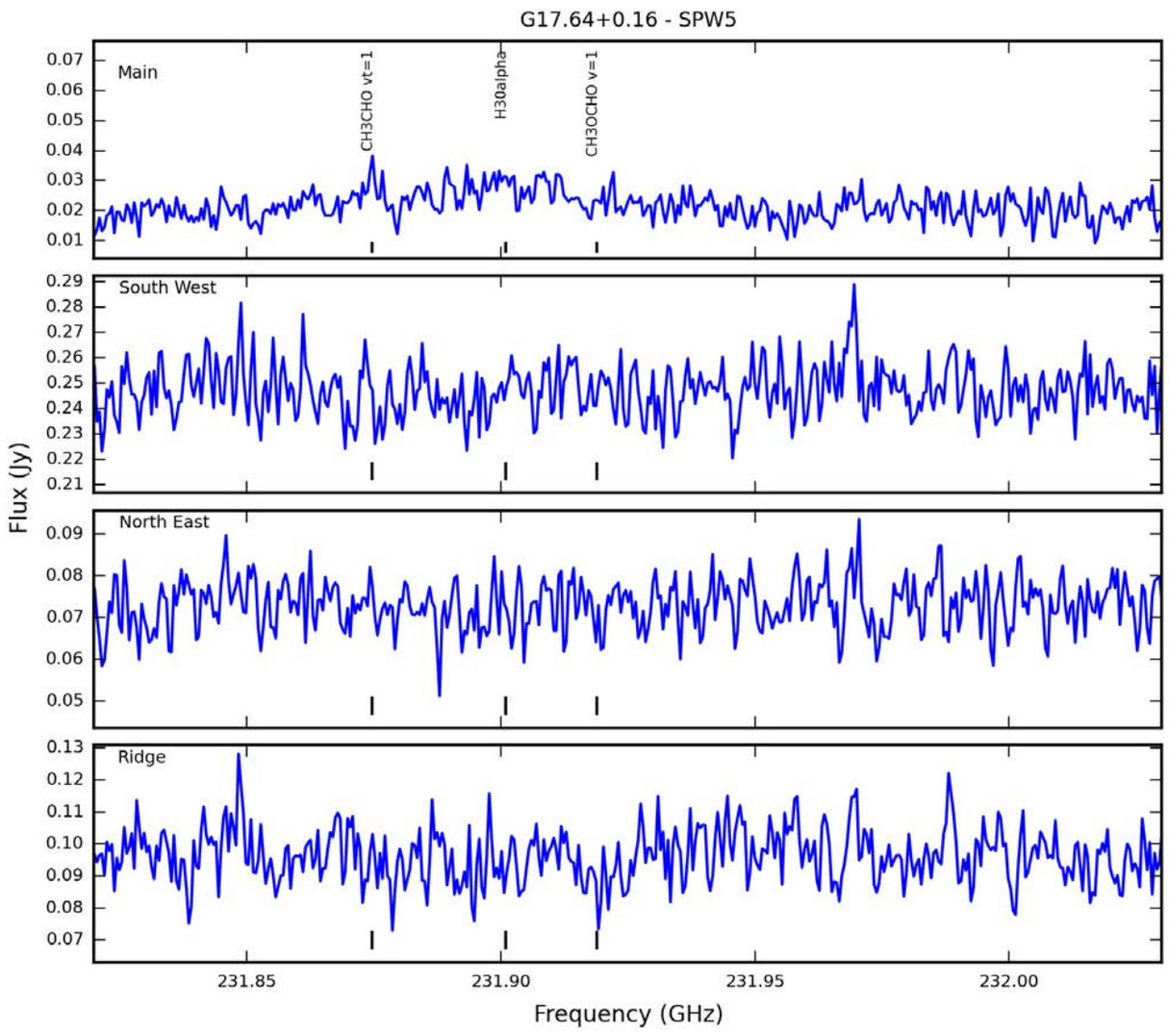

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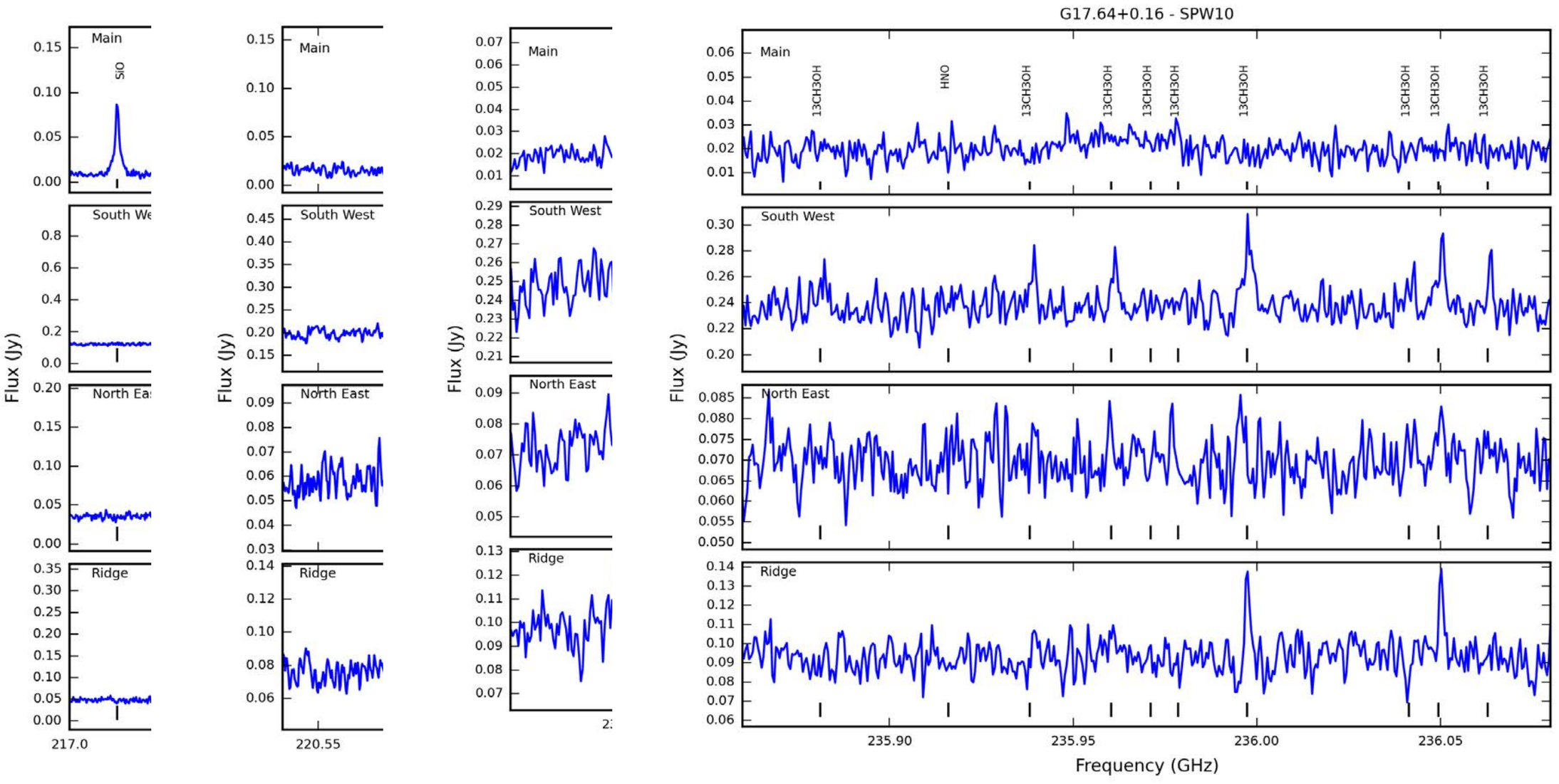

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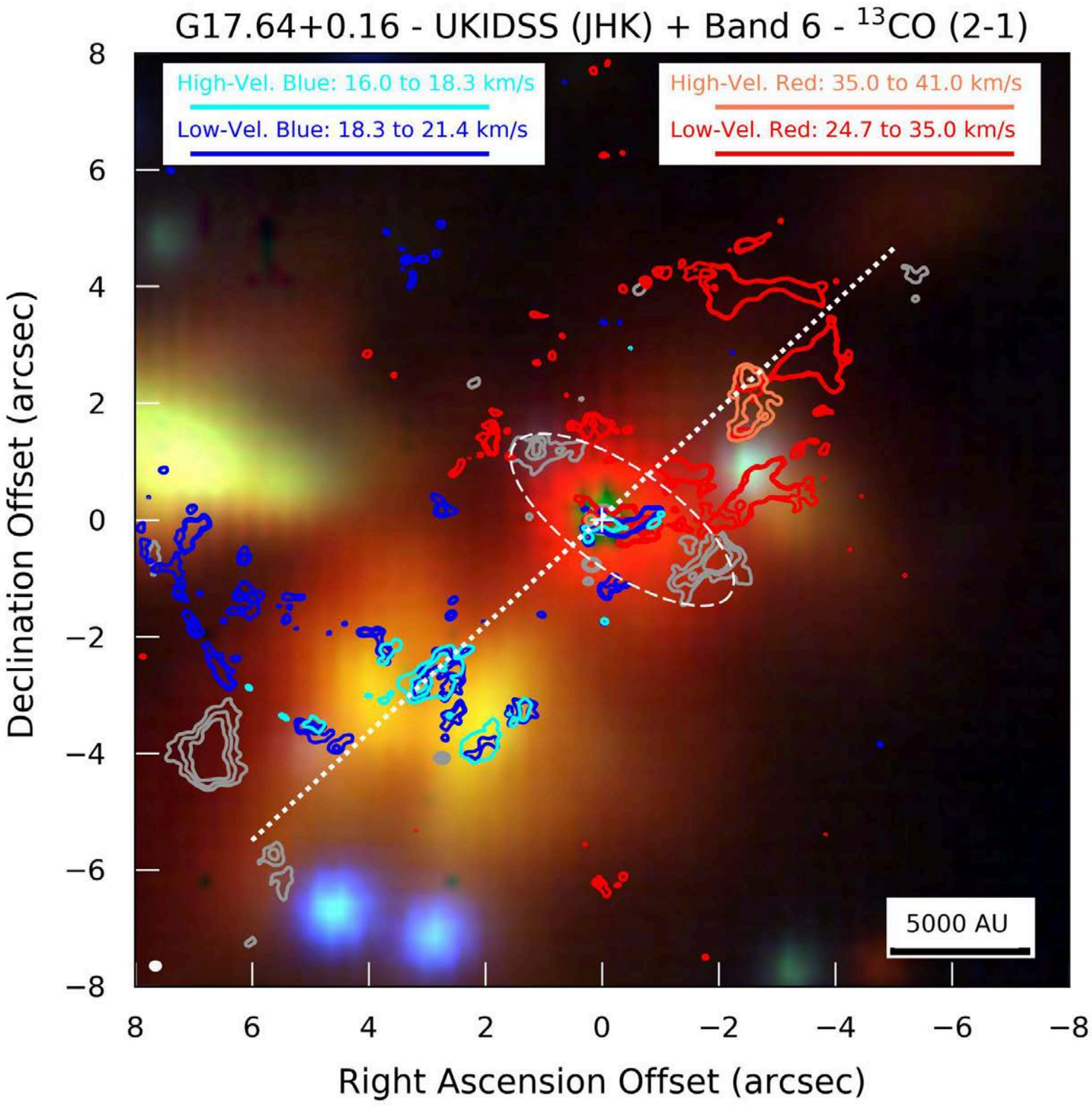
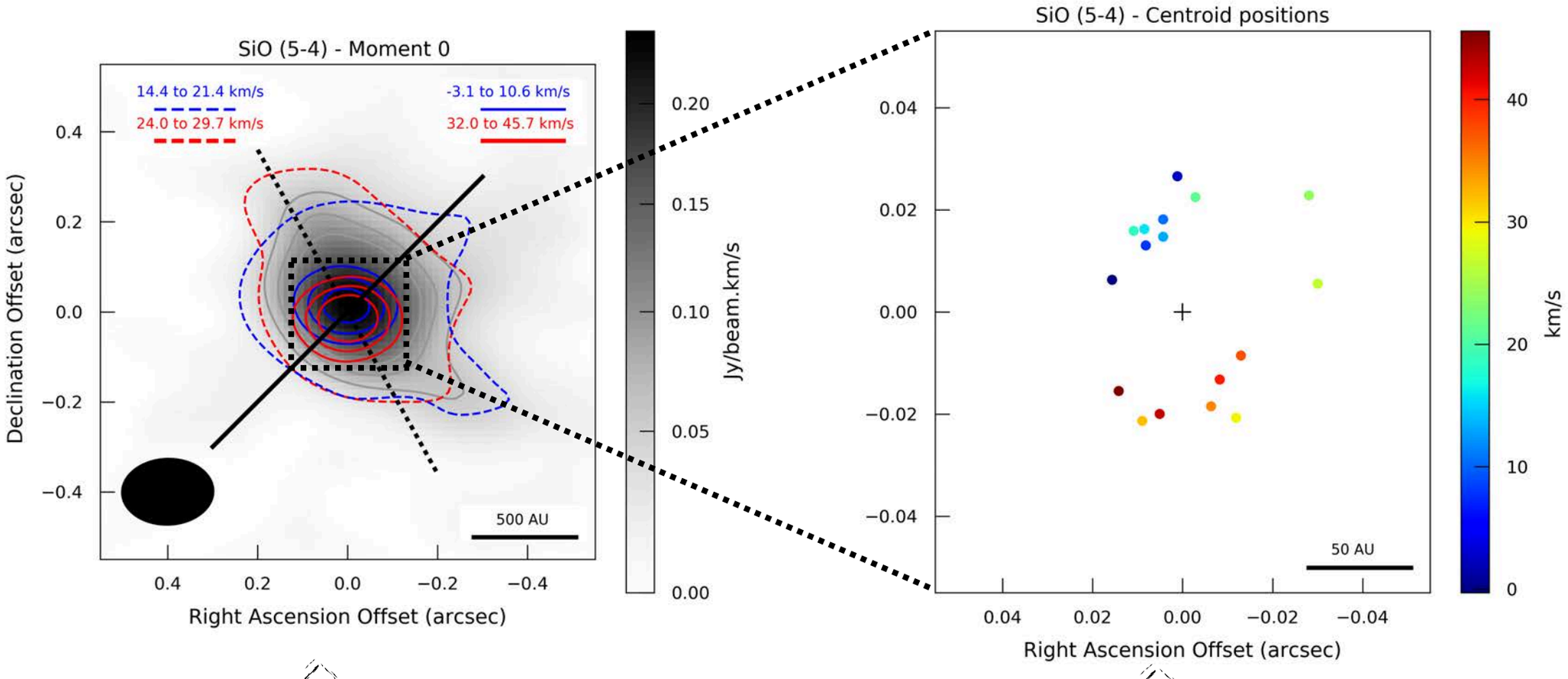


- **Large scale** - the single 12m array resolved out much of the CO outflow, but we see evidence of a bubble and a ridge that appear to delineate the outflow extent

grey is continuum, colour is Blue- or Red-shifted CO

Our first ALMA view

- **Any disk?** - the SiO line was interestingly spatially compact, usually associated with shocks and large scale jets, but here the ‘hint’ of a velocity gradient is *perpendicular* to the large scale CO outflow



possible elongation??

centroids show an offset at <50 AU - rotation???

Useful Lesson:

- **WORK** - it goes without saying ***you*** have to investigate the data and do the analysis. Use any support networks/tools available to you

What was next

- **My proposal** - zoom in to the ‘disk’, plenty of evidence, *can we really see it?* **Selling point:** This would be one of only a handful of O-type ‘proto’ stars that might have a disk
- **Strategy**:
  - **Explain** the history, one of a few sources
  - **Describe** current findings, dust emission is compact, has molecular lines, models w.r.t other observations predict there *should* be a disk, outflow evidence is clear
  - **Make a clear goal** - focus on continuum to really spatially resolve the disk

Setup the OT and write the proposal

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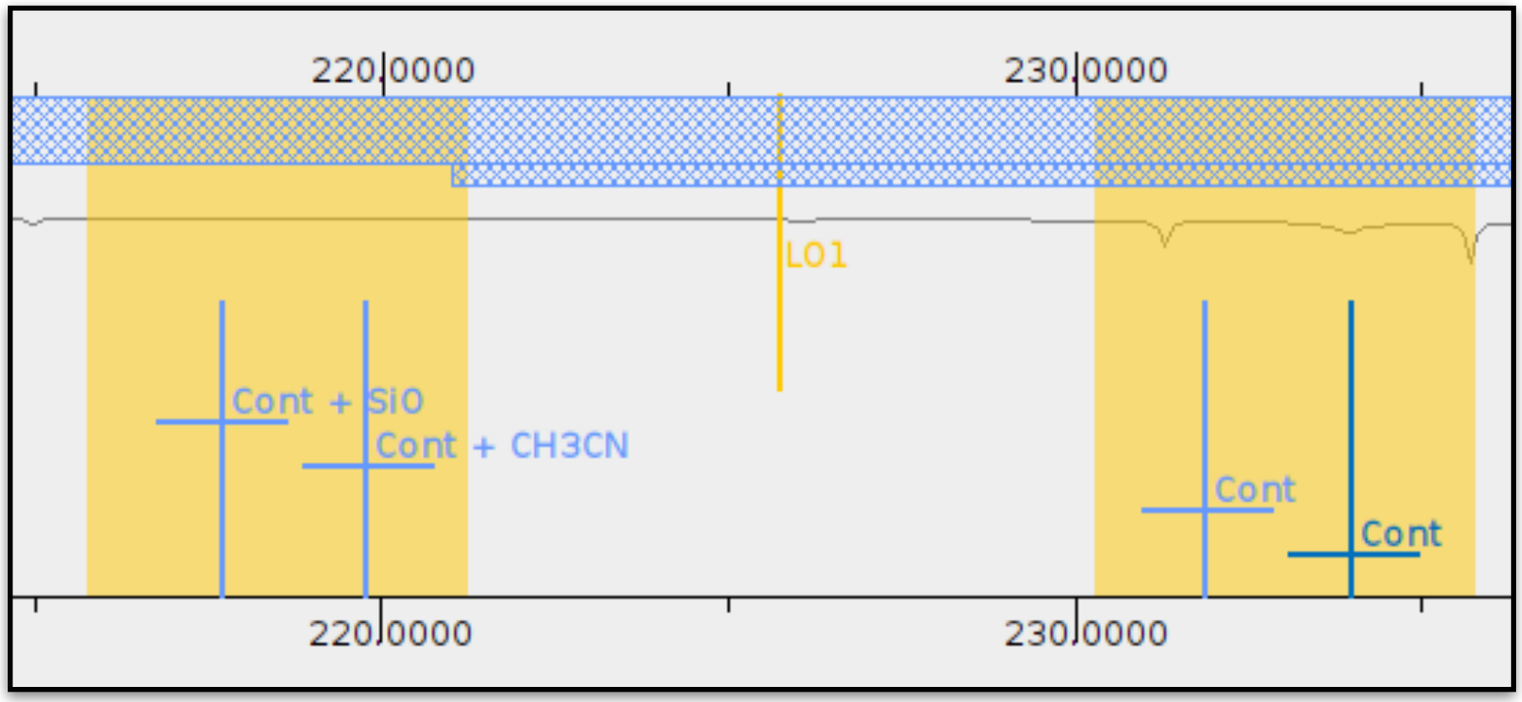

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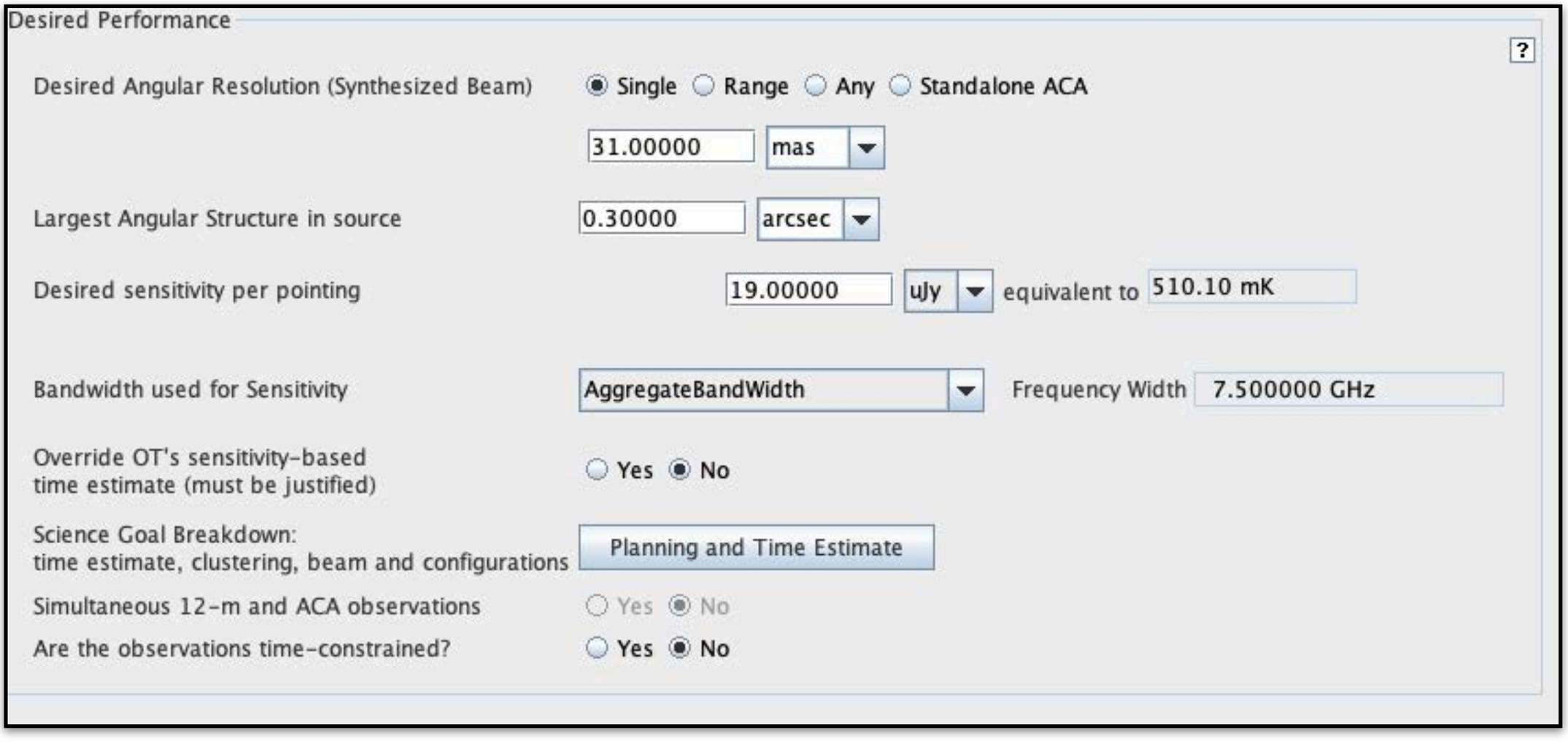
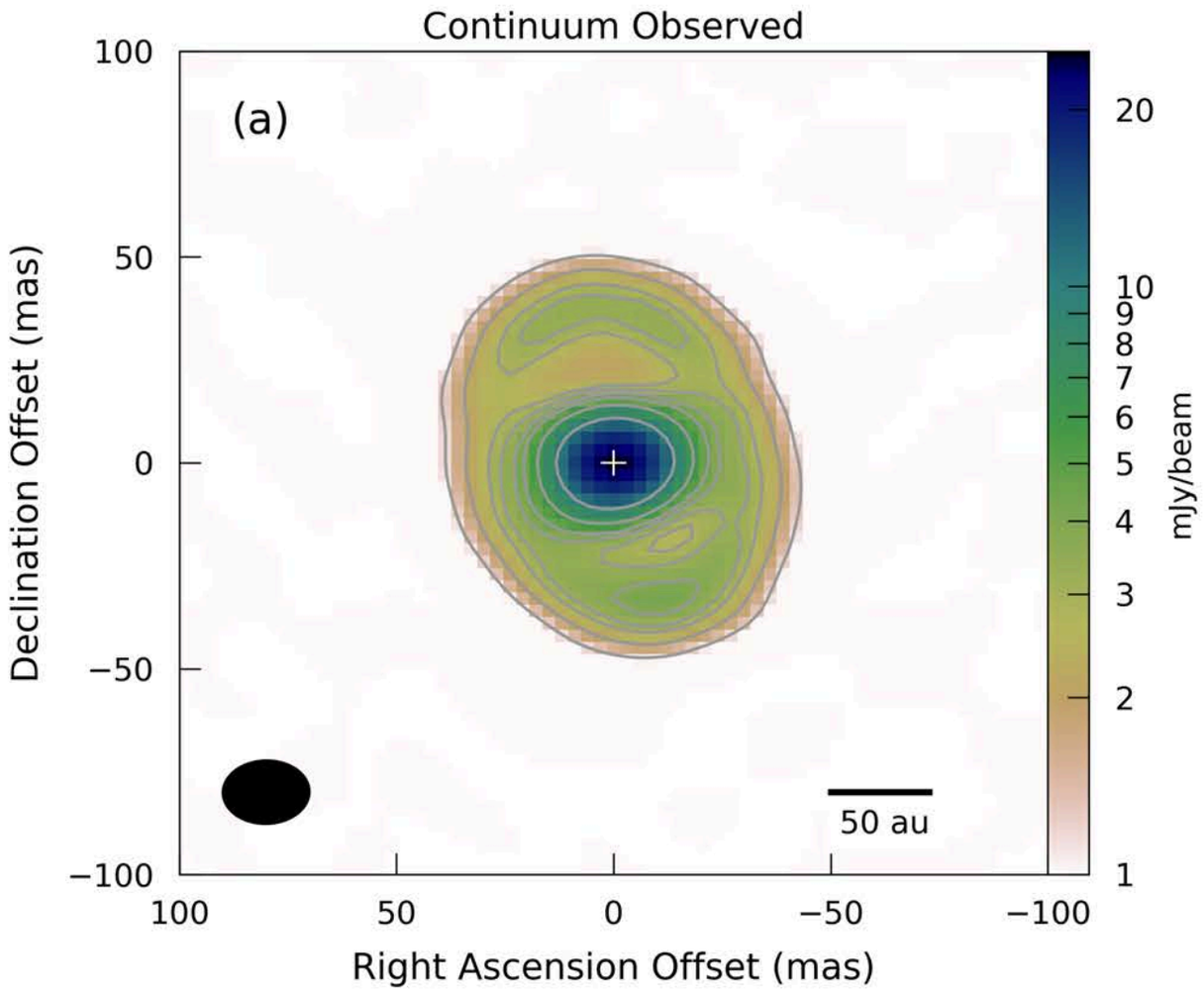


0.031 arcsec x 2200pc = 60 AU ‘physical’ resolution

Success

- **Awarded time** - data came in from Long-baseline observations as requested - 10x better angular resolution than before



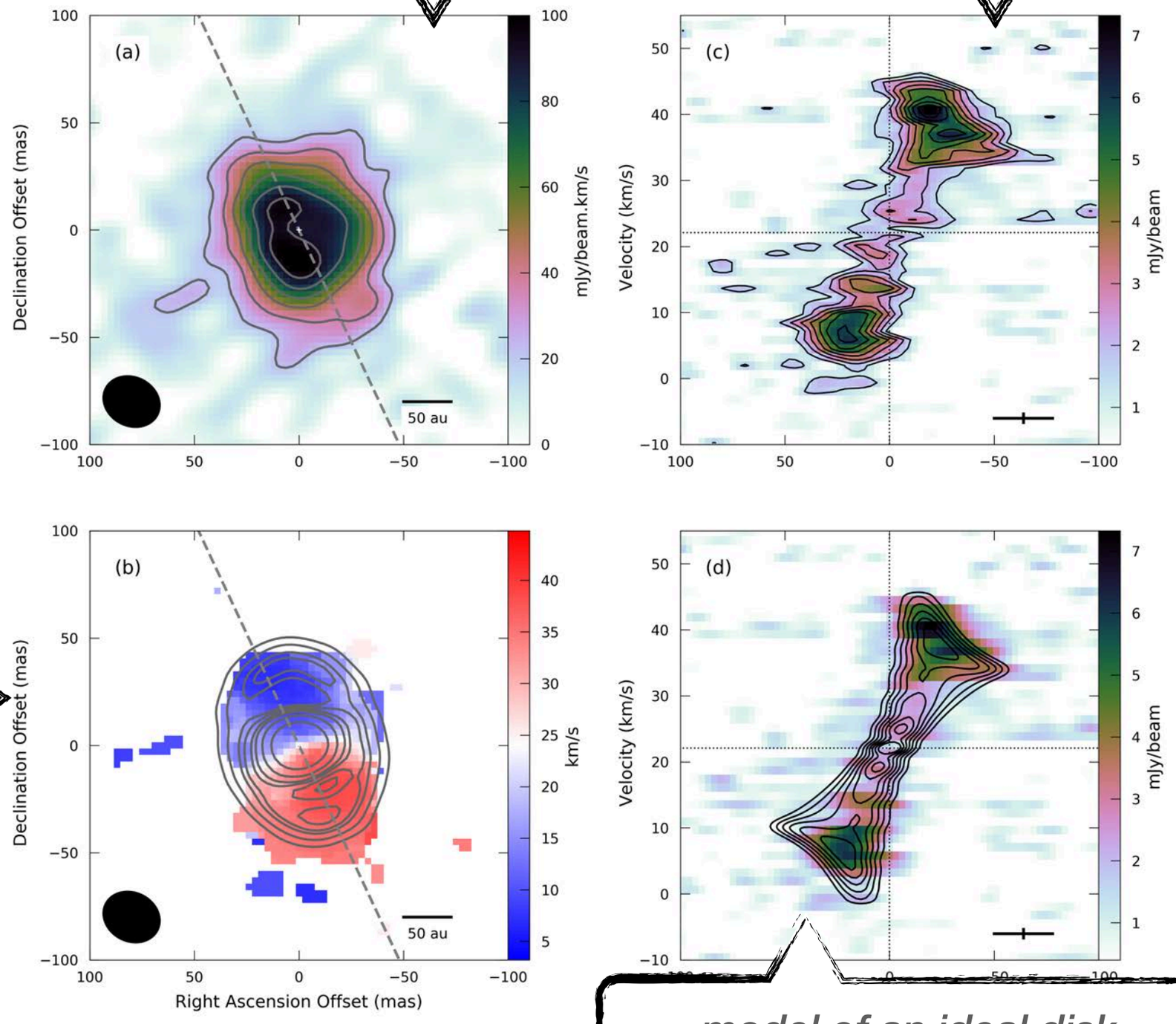
*YES - we resolved the emission from the dust continuum - there is a **disk***
(technically an elongated structure at this point without proof of rotation)

Success

- **Luck** - emission from other molecules we didn't expect was detected - **~232 GHz water line in Band 6**

moment 0 average matches the disk

PV diagram has pattern of rotation



*Moment 1 map shows blue-red shift -**rotation**, perpendicular to the large scale outflow*

model of an ideal disk indicative of ~40Mo protostar

Useful Lesson

- **EXPECTATIONS** - we got ‘lucky’ with these data, but since asking for more time - there was no success the last couple of cycles *(pushing to higher angular resolution with higher frequencies)*

- stay positive and persevere *<u>but</u>* also look to the **archive - 10 years of ALMA data**

THANK YOU - any questions ???