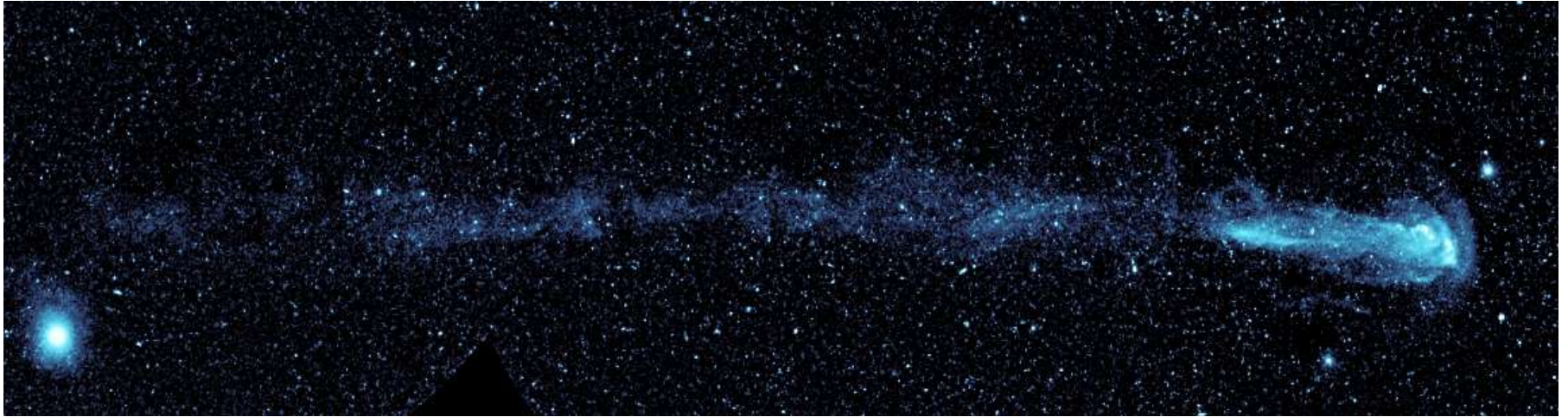




Evolved Stars



Ken Young



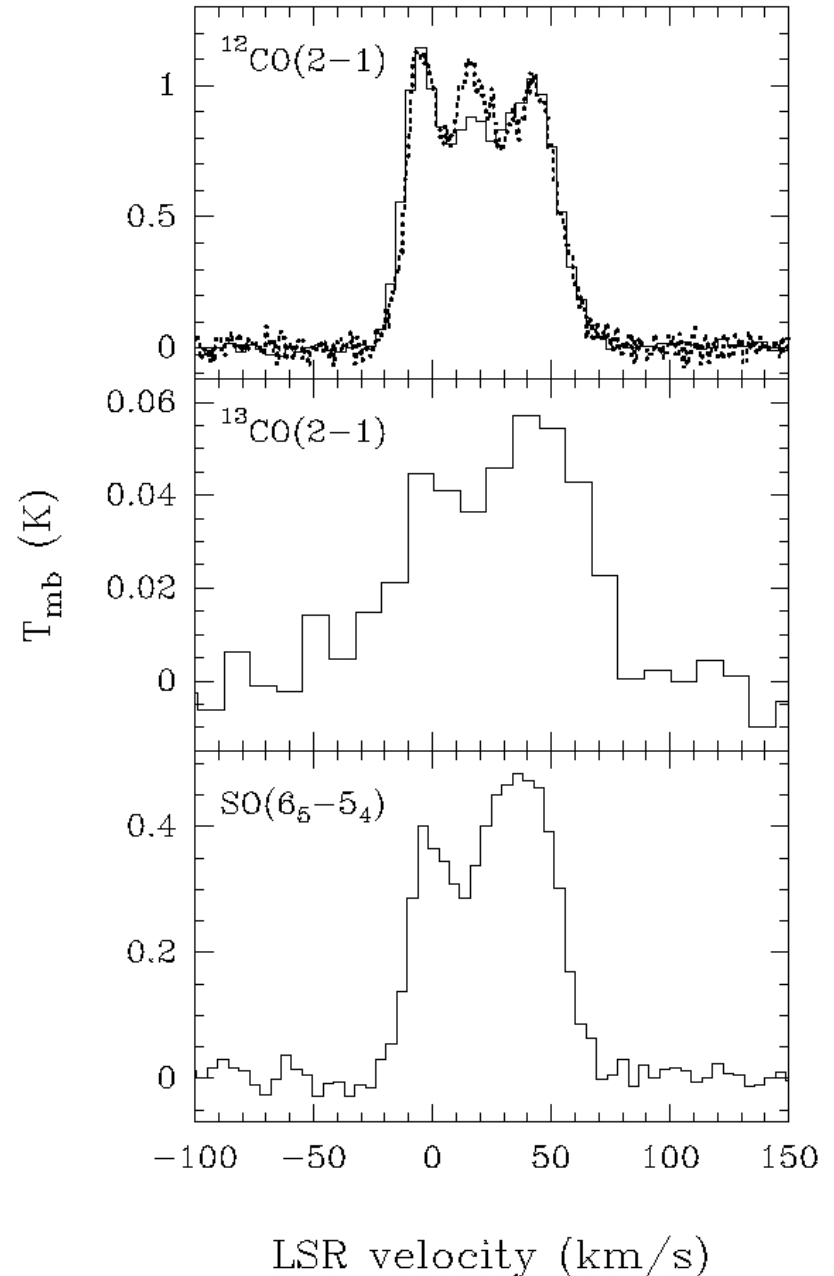
Supergiants, AGB Stars & (proto)PNe

- Seven published papers in 2006 → 2007
 - One on supergiant VY CMa (too massive for AGB)
 - Three on AGB Stars
 - Two on Protoplanetary Nebulae
 - One on a Planetary Nebula
- At least six more papers have been submitted, or are in preparation.
- Ongoing Survey of IRC+10216



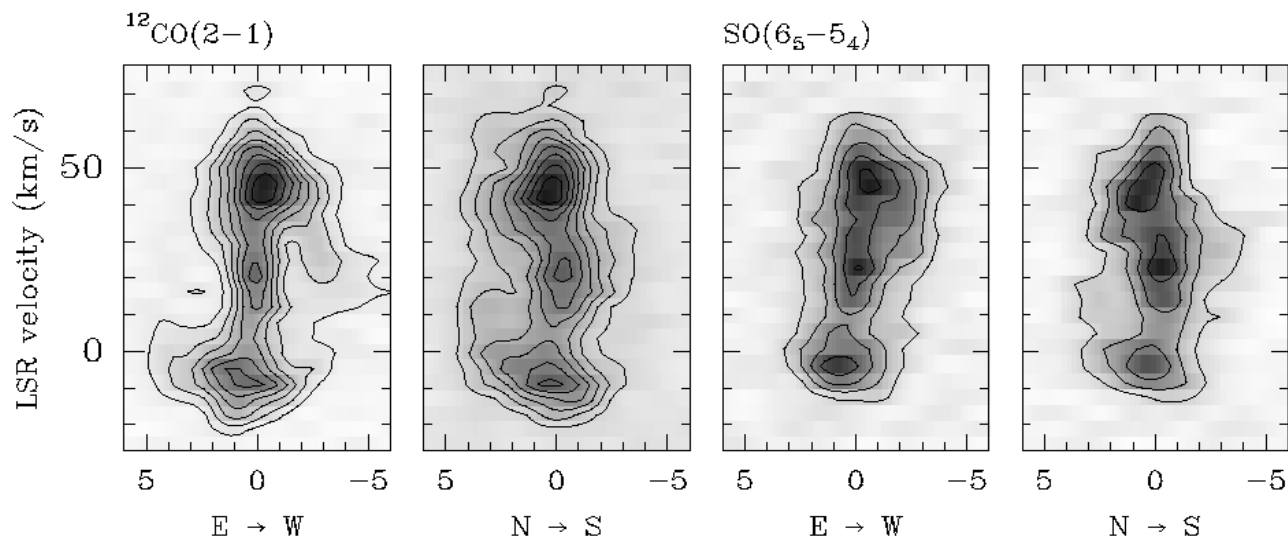
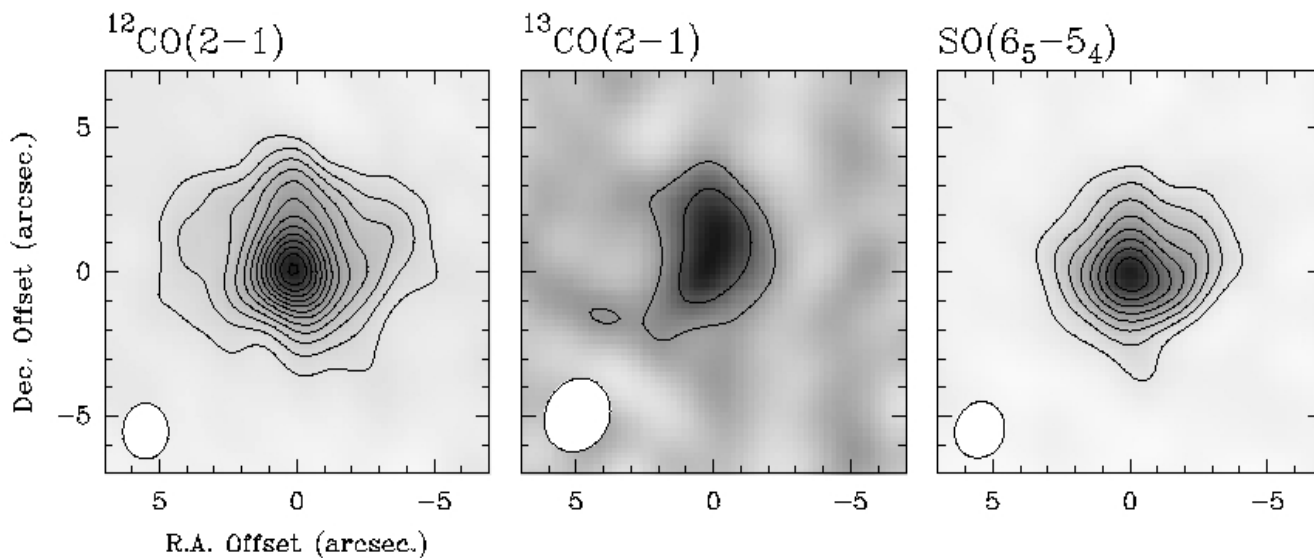
VY CMa

- Muller *et al.* 2007 in press
- Two tracks: compact and extended
- CO(2-1), $^{13}\text{CO}(2-1)$, SO(6_5-5_4) and continuum
- Continuum unresolved, all three lines resolved
- 80% of single dish flux recovered





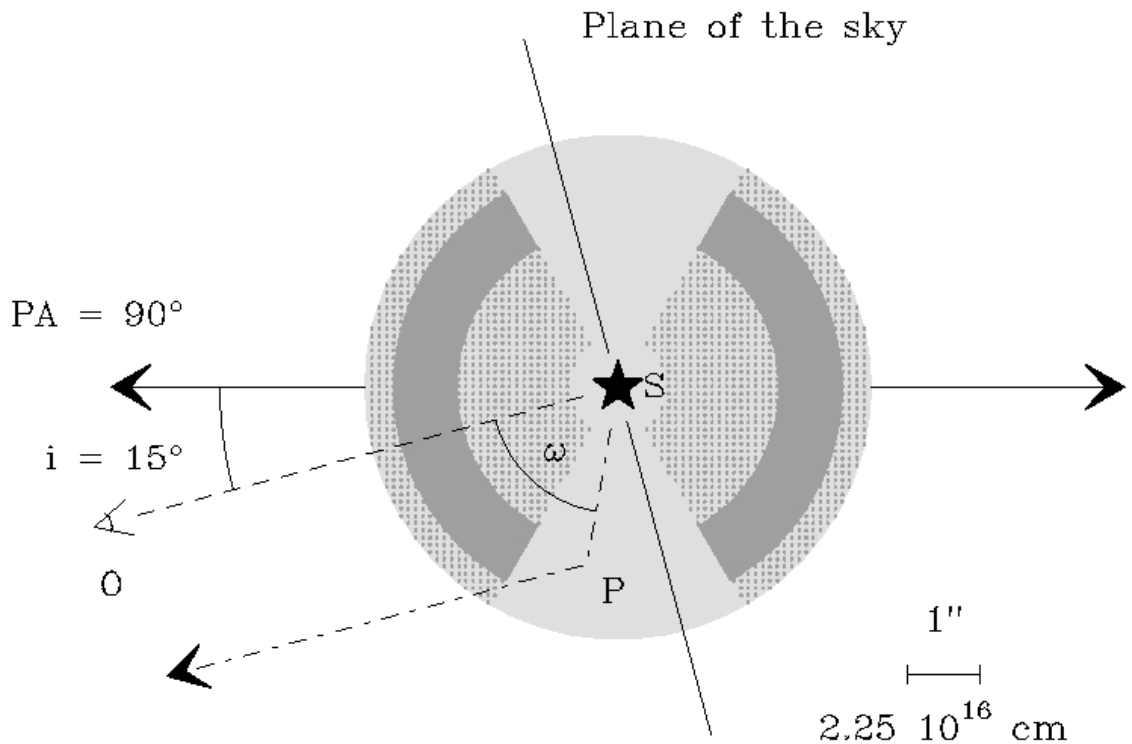
VY CMa





VY CMa

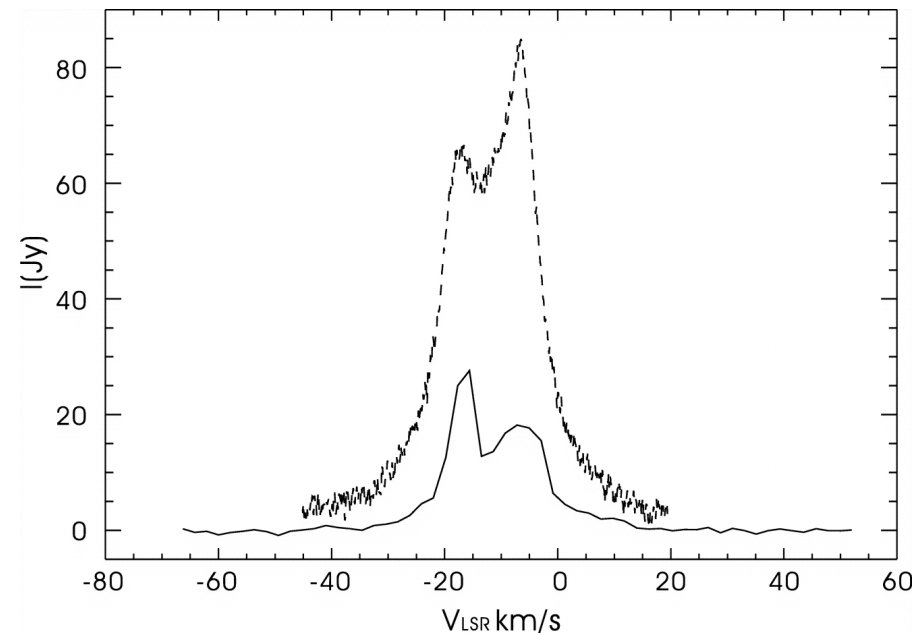
- High velocity bipolar flow with large opening angle
- Enhanced mass loss 350→500 years ago





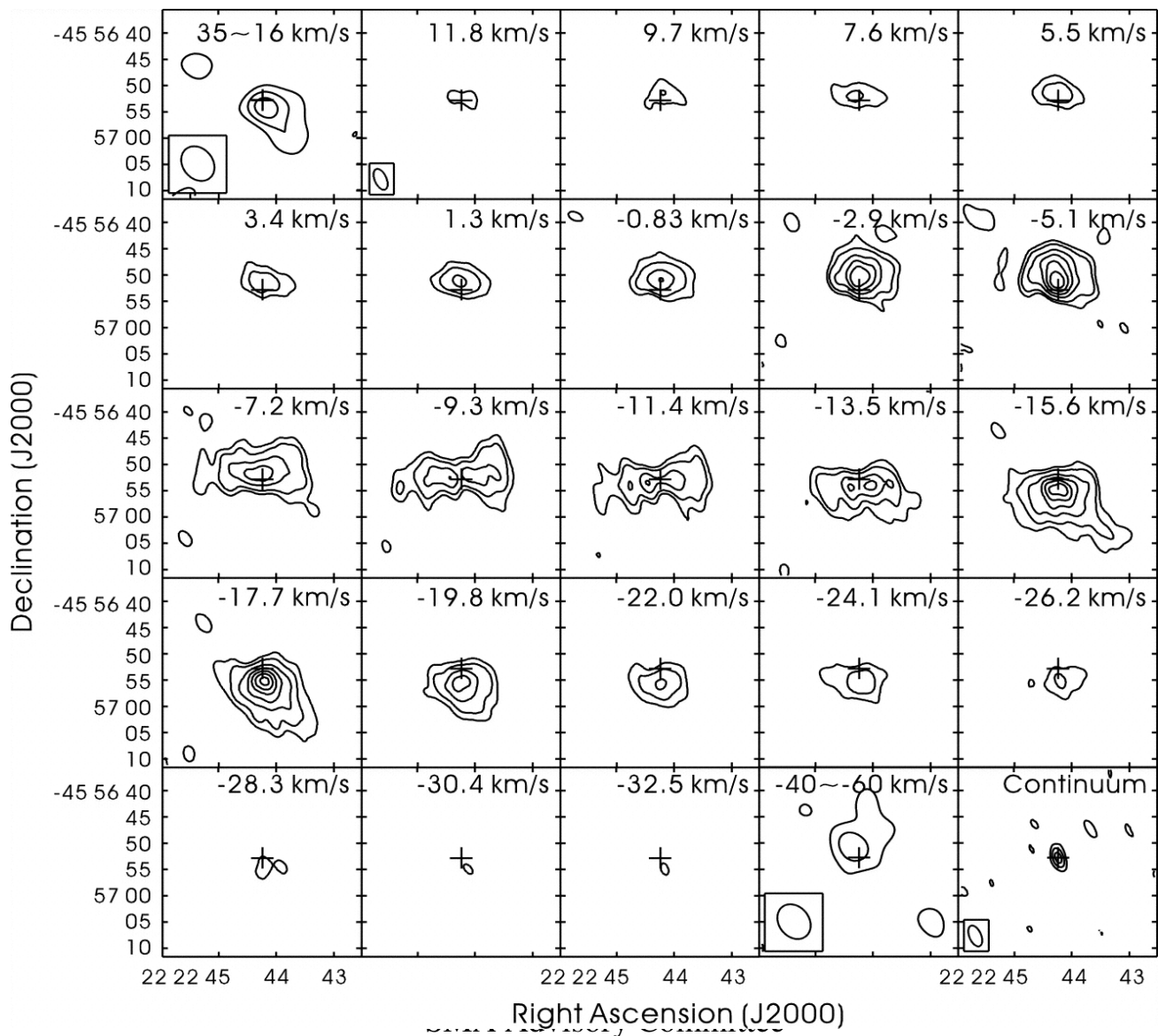
π^1 Gruis

- Prototype S Star
 - AGB Star, still red giant
 - Very peculiar single dish spectrum
 - Very far south (-46°)
- Chiu *et al.* 2006, ApJ 645
 - compact array, tuned for CO(2-1), $^{13}\text{CO}(2-1)$, C $^{18}\text{O}(2-1)$
 - CO(2-1) and continuum detected
 - Continuum consistent with photosphere
 - $\sim 1/3$ of CSO CO(2-1) flux recovered





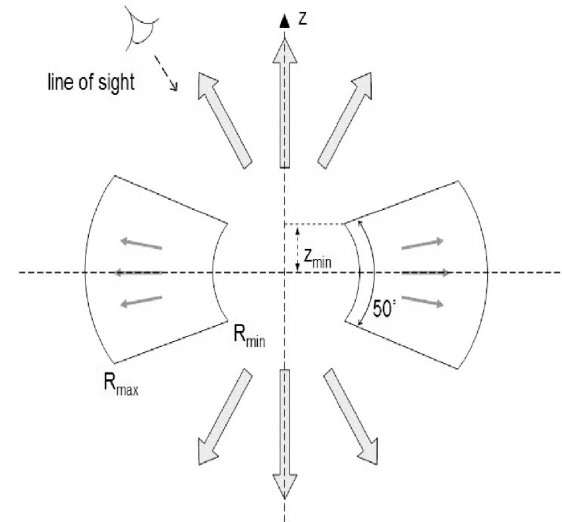
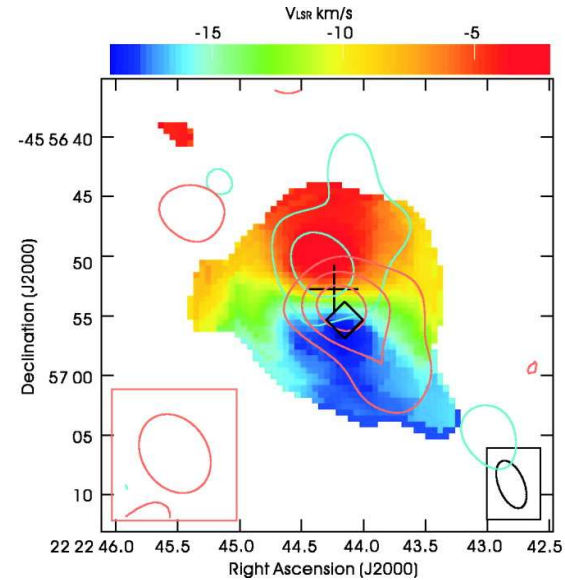
π^1 Gruis





π^1 Gruis

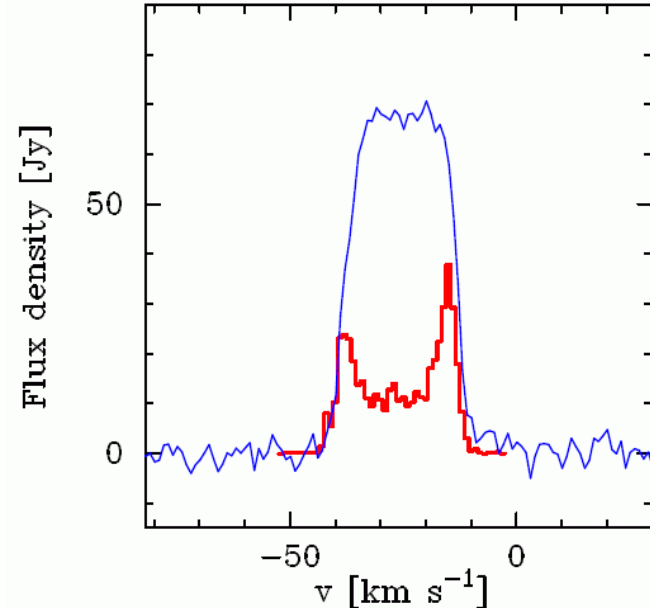
- Modelled by flared disk with 200 AU central cavity and high velocity bipolar flow
- Similar to V Hya





SiO in IRC+10°216

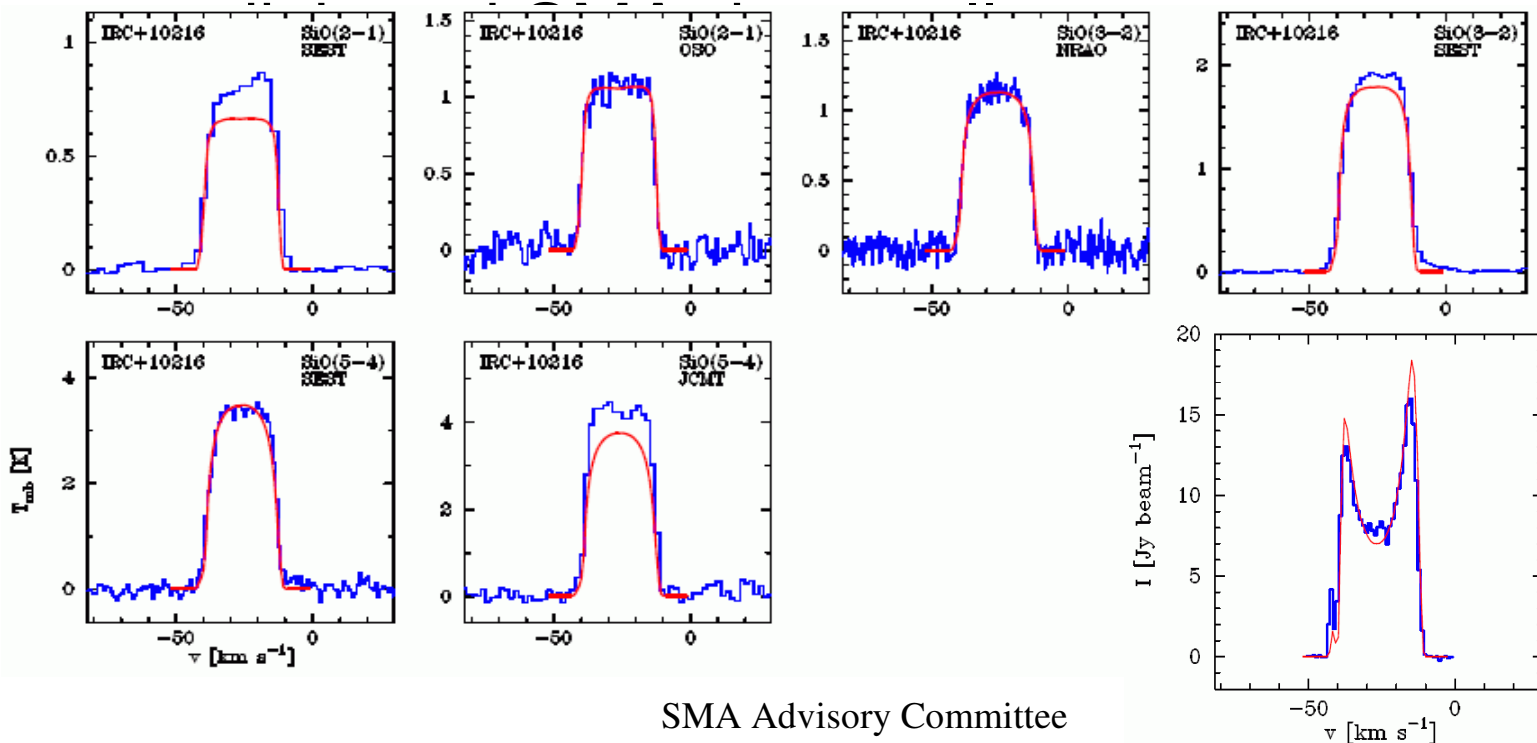
- Schöier *et al.* 2007
- LTE models of SiO abundance give too much SiO in M stars, and ~ 100 times too little in C stars
- One compact track of SiO(5-4) in very good weather
- Most of the SiO(5-4) flux seen at SEST was filtered out by interferometer





SiO in IRC+10°216

- A two component model, with no SiO closer than 3 stellar radii, high abundance at intermediate distances, and low abundance at large radii (depletion onto dust) fits both single





H¹³CN(8-7) in IRC+10°216

- Schöier *et al.* 2007, in press
- Mapped 690.552 GHz transition in compact configuration.
- Most of the flux seen with the CSO (11 years ago!) was seen by the SMA, but the line was resolved by the SMA.
- Simple LTE model, with no depletion to grains and destruction by UV at 4×10^{14} cm fits CSO and SMA data well



300 → 355 GHz Survey

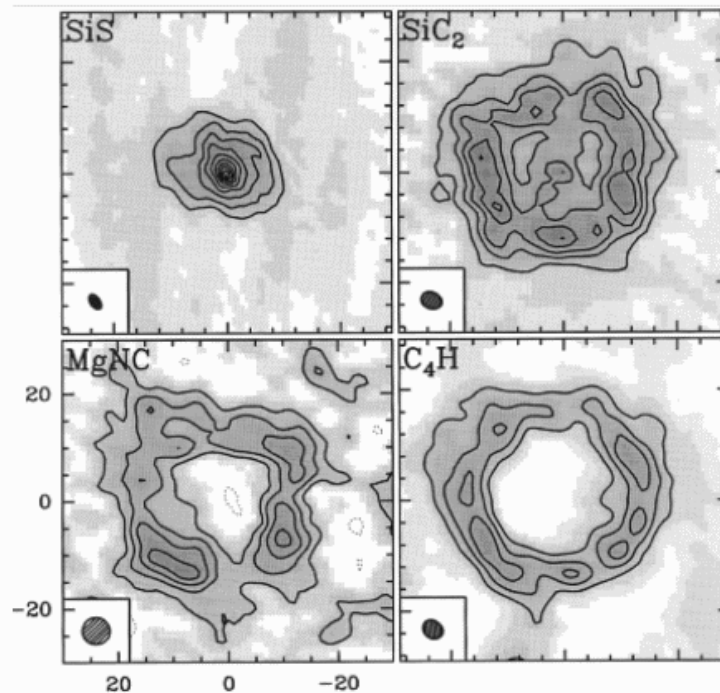
- Patel + 9 co-investigators – legacy project
- Unbiased survey, should be several times more sensitive than Groesbeck et al (1994), because of larger bandwidth, more collecting area
- Will map the transitions, the large majority are resolved
- Will follow up with single dish observations
- Six tracks done to far, ~ 1/3 done



300 → 355 GHz Survey

- Some shells comparable in size to larger single dish antennas' beams

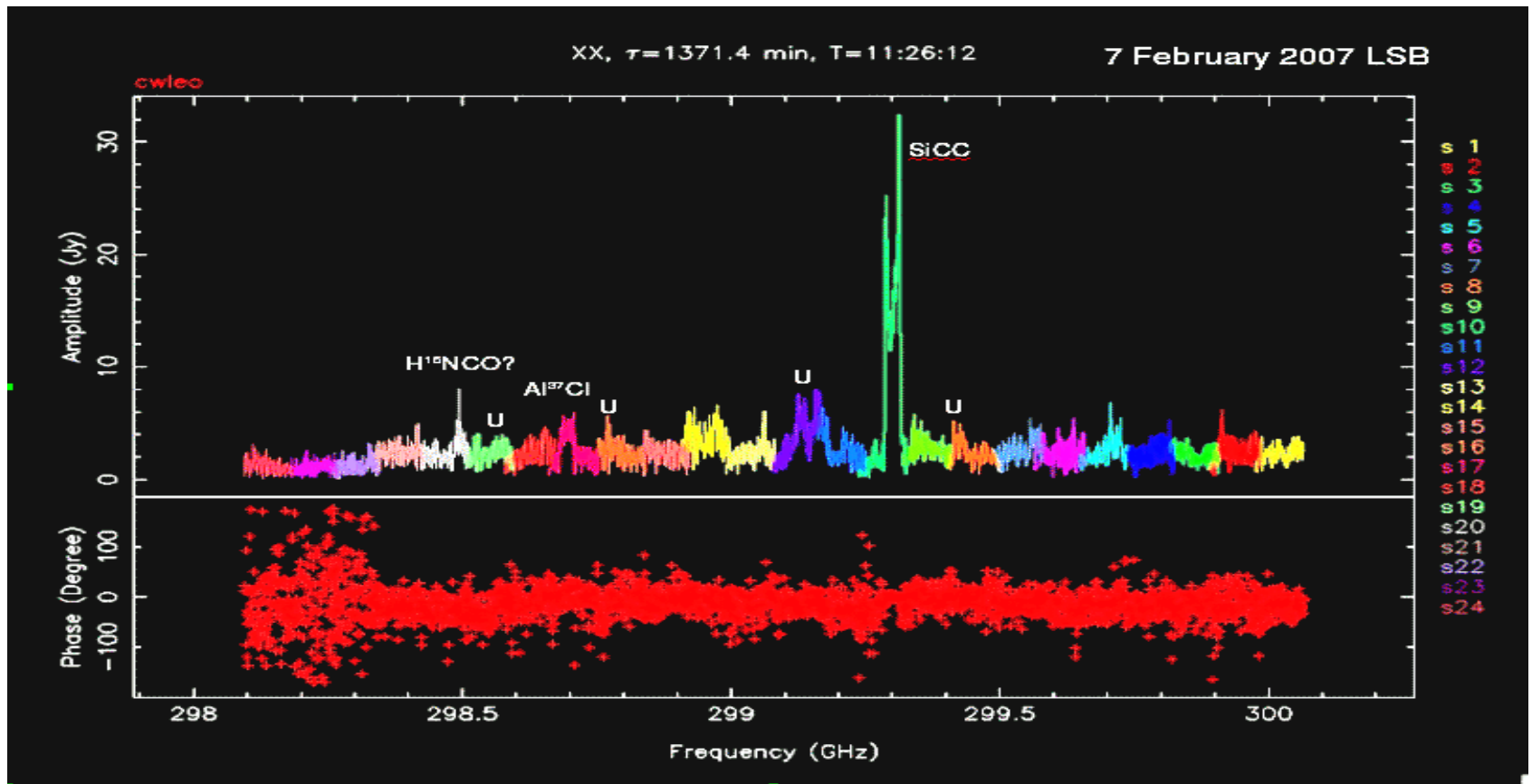
PdBI 3mm observations of IRC+10216





300 → 355 GHz Survey

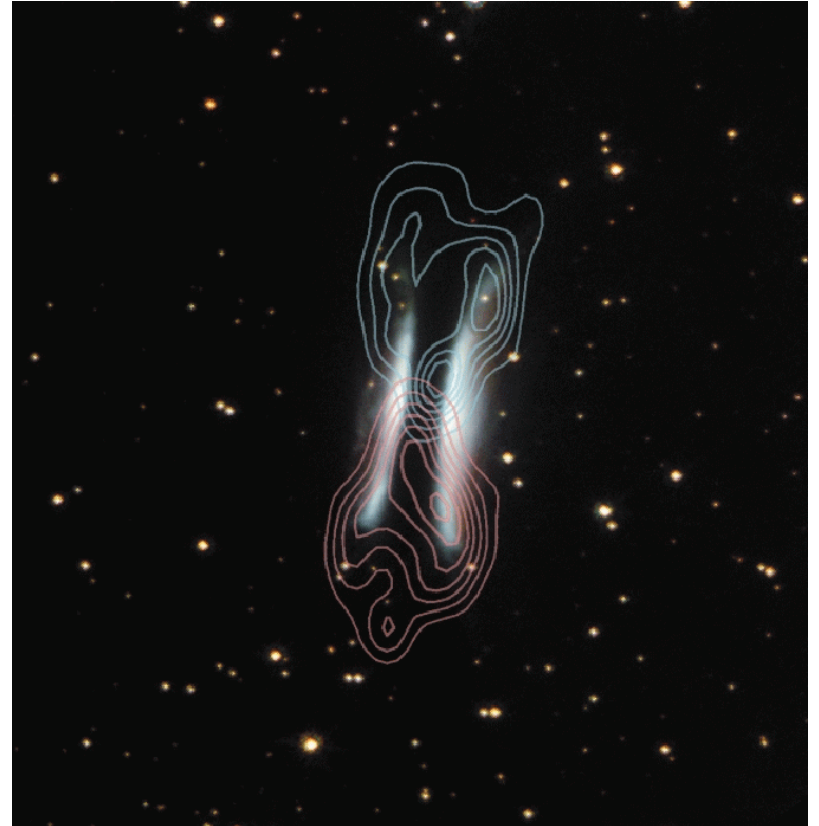
- Typically ~8 lines per tuning seen, 1/4 are U lines. Careful processing should show more.





Gomez's Hamburger

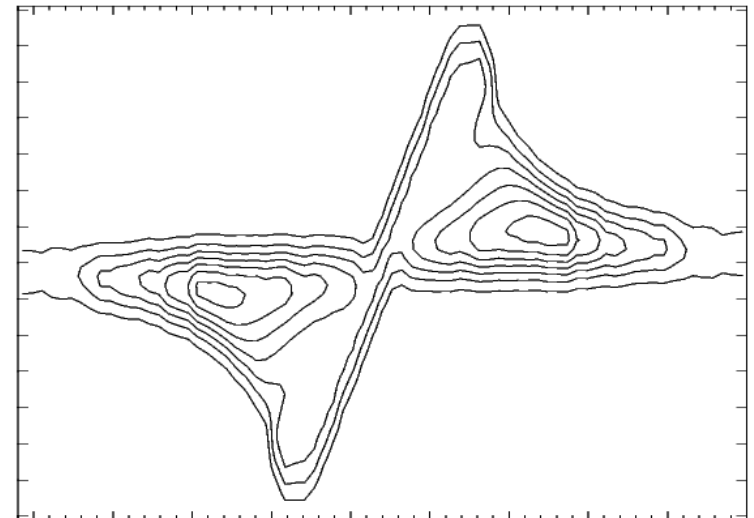
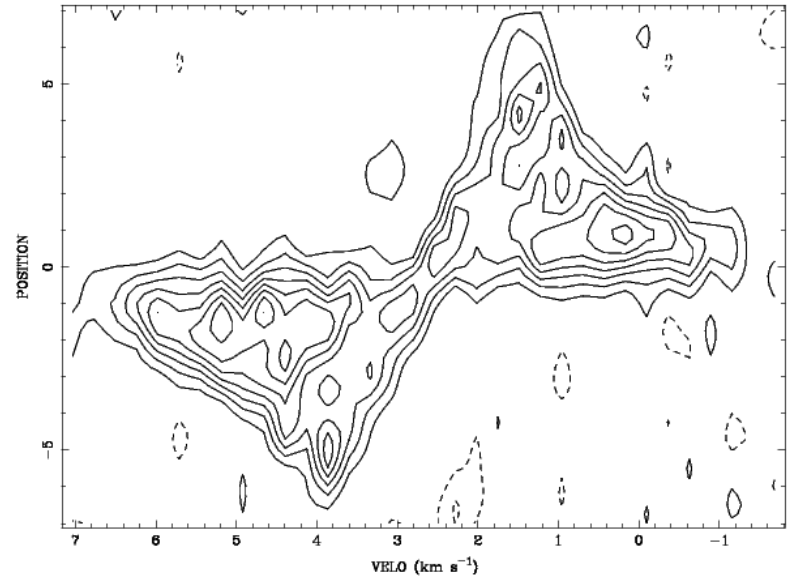
- Bujarrabal et al. in prep
- Relatively unstudied source, only six SIMBAD references.
- Observed in compact CO(1-2), $^{13}\text{CO}(2-1)$, CO(3-2), CO(6-5). Detected all but CO(6-5), and got good 690 GHz continuum map.





Gomez's Hamburger

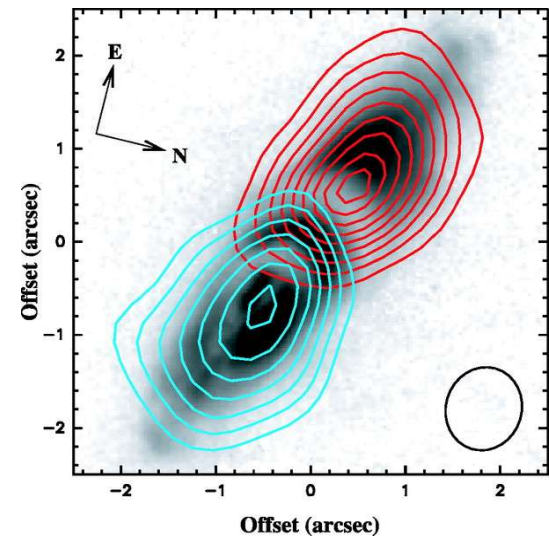
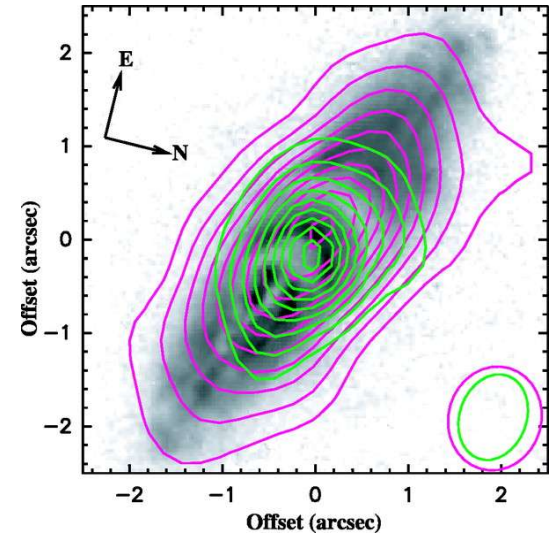
- CO(2-1) data shows temperature increase at disk edge, perhaps from stellar heating
- $^{13}\text{CO}(2-1)$ shows density gradient away from disk plane
- Very well fit by flared keplerian disk, with no bipolar wind





IRAS 22036+5306

- Sahai *et al.* 2006
- Is a bipolar PPNe with knotty jets
- CO(3-2) and continuum, compact and extended
- Total velocity extent of CO(3-2) ~ 500 km/sec





IRAS 22036+5306

- The large scalar momentum of the high velocity wind, and the low dynamic age (~ 25 yr) means radiation pressure too weak by $\sim 10^3$ to have accelerated this wind
- When the 850μ flux is combined with OVRO, IRAS, ISO and MSX data, the SED indicates the presence of a large mass ($\sim 0.03 M_{\odot}$) of cold, large (~ 1 mm) grains



Helix Nebula

- Nearest (130 pc) undisrupted PNe
- Far too large to map with SMA – only one CO(2-1) and $^{13}\text{CO}(2-1)$ field observed
- Our resolution comparable to IR images
- Many filaments seen, some with no lost flux when compared with CSO spectrum.
- Filament masses larger than cometary knots
- Some possible bow shocks seen



Helix Nebula

