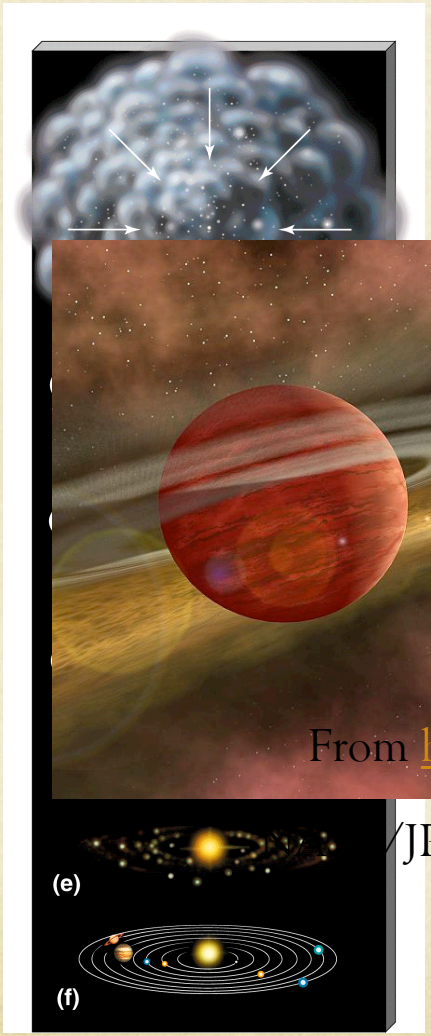
Modeling Spectro-astrometric Observations of CO in Circumstellar Disks

Matt Troutman - Clemson University
Sagan/Michelson Fellows Symposium
November 12, 2009

Planet Formation



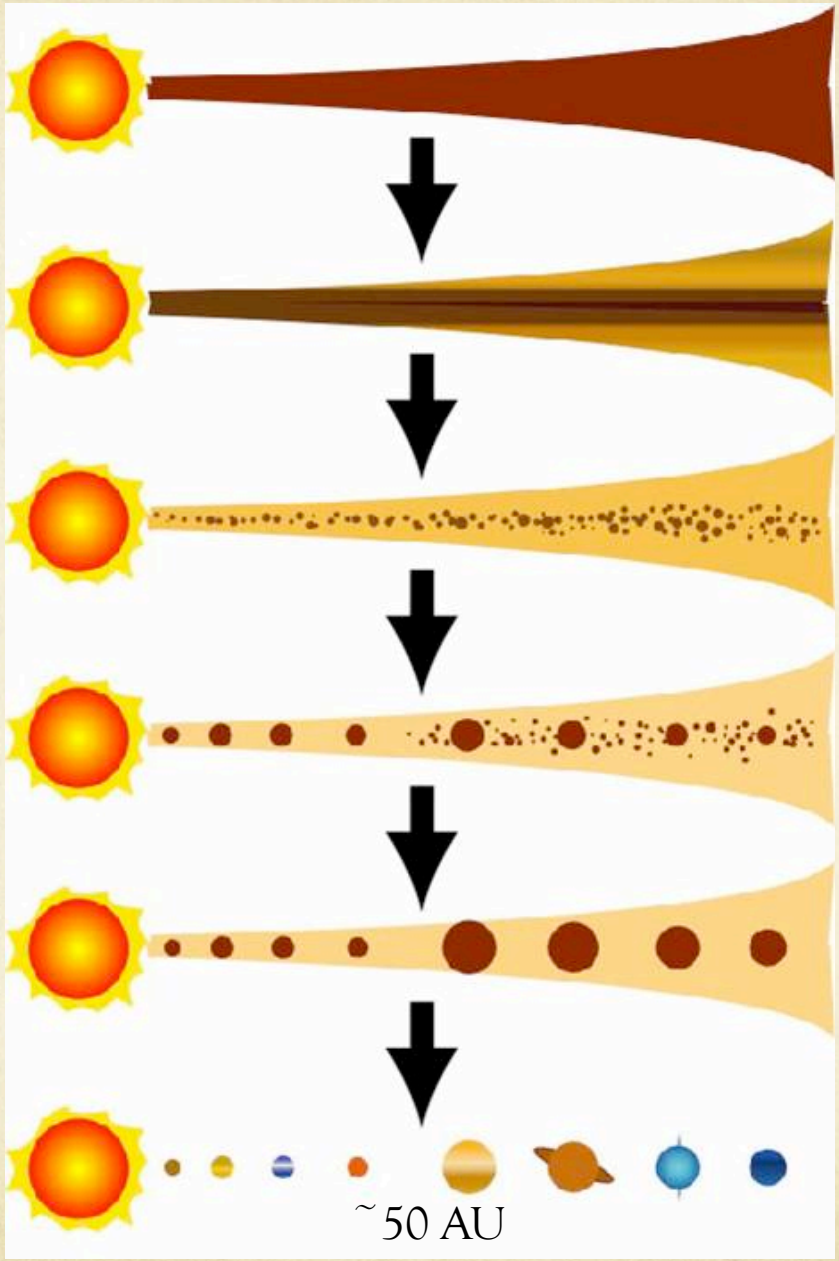
From astro.psu.edu

From http://www.star.qmw.ac.uk/~masset/intertmr.html

/JPL-C

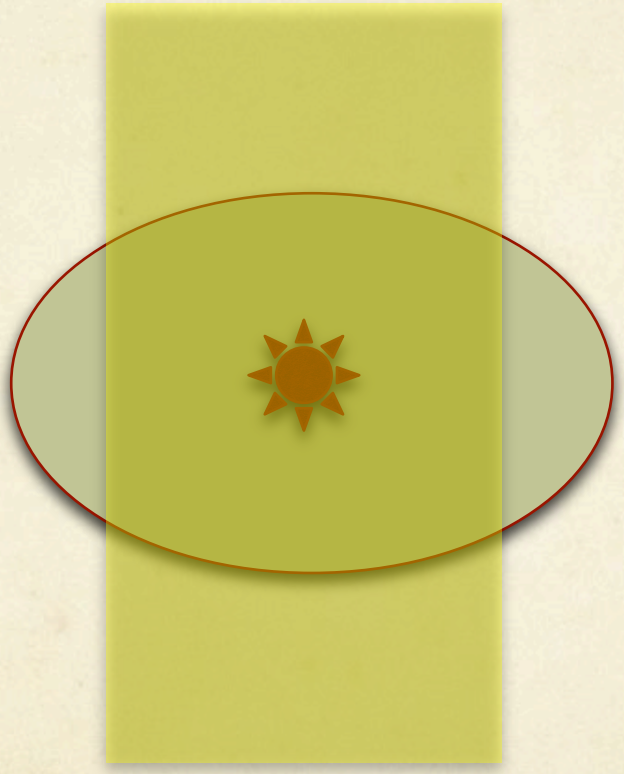
NASA/ESA and A.

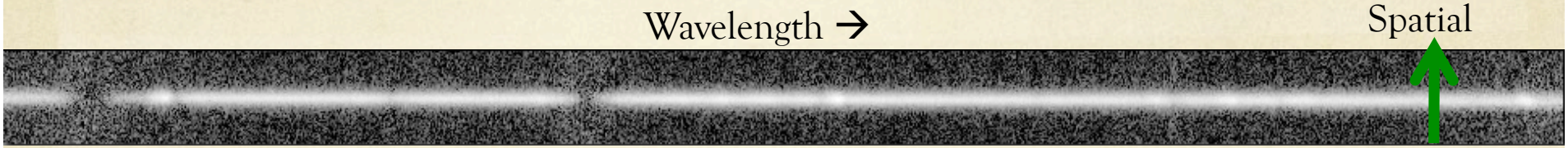
From lpl.arizona.edu



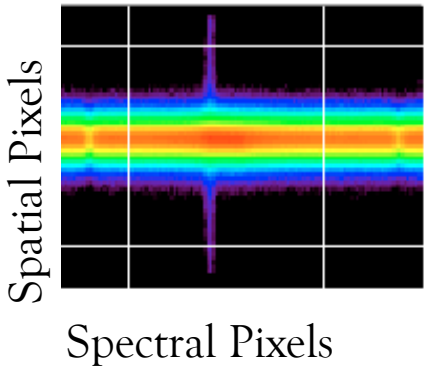
From planet.sci.kobe-u.ac.jp

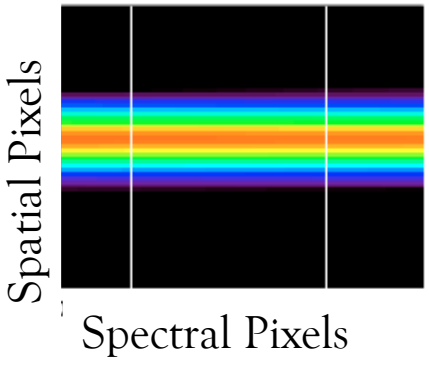
Observing





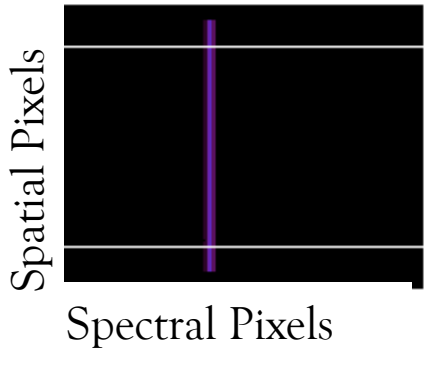
Raw Data→

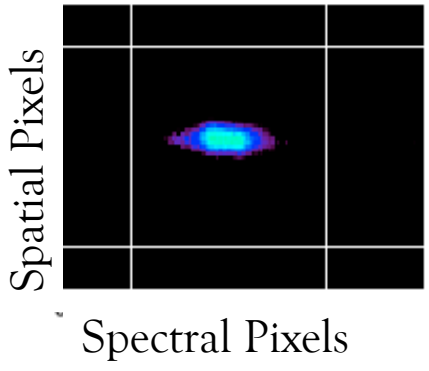




←Continuum

Sky Line→



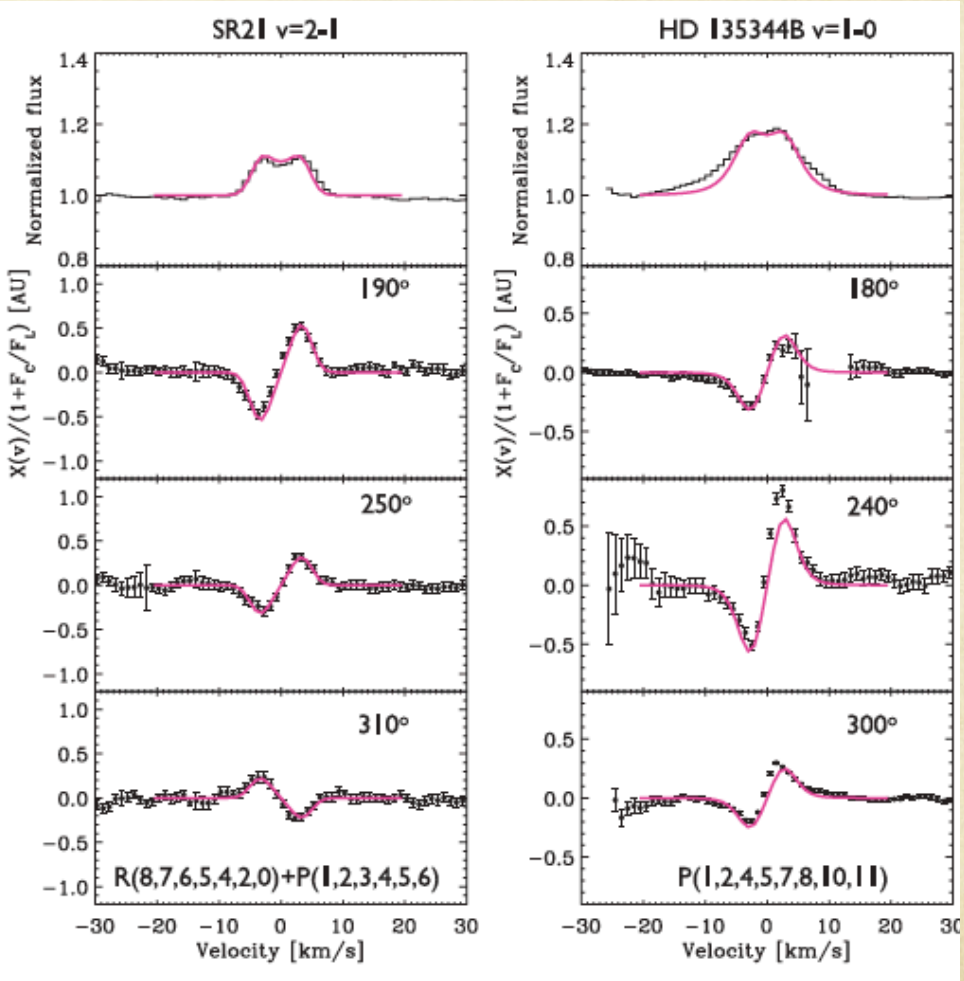


←Signal

Acke & van den Ancker (2006)

Spectro-astrometry

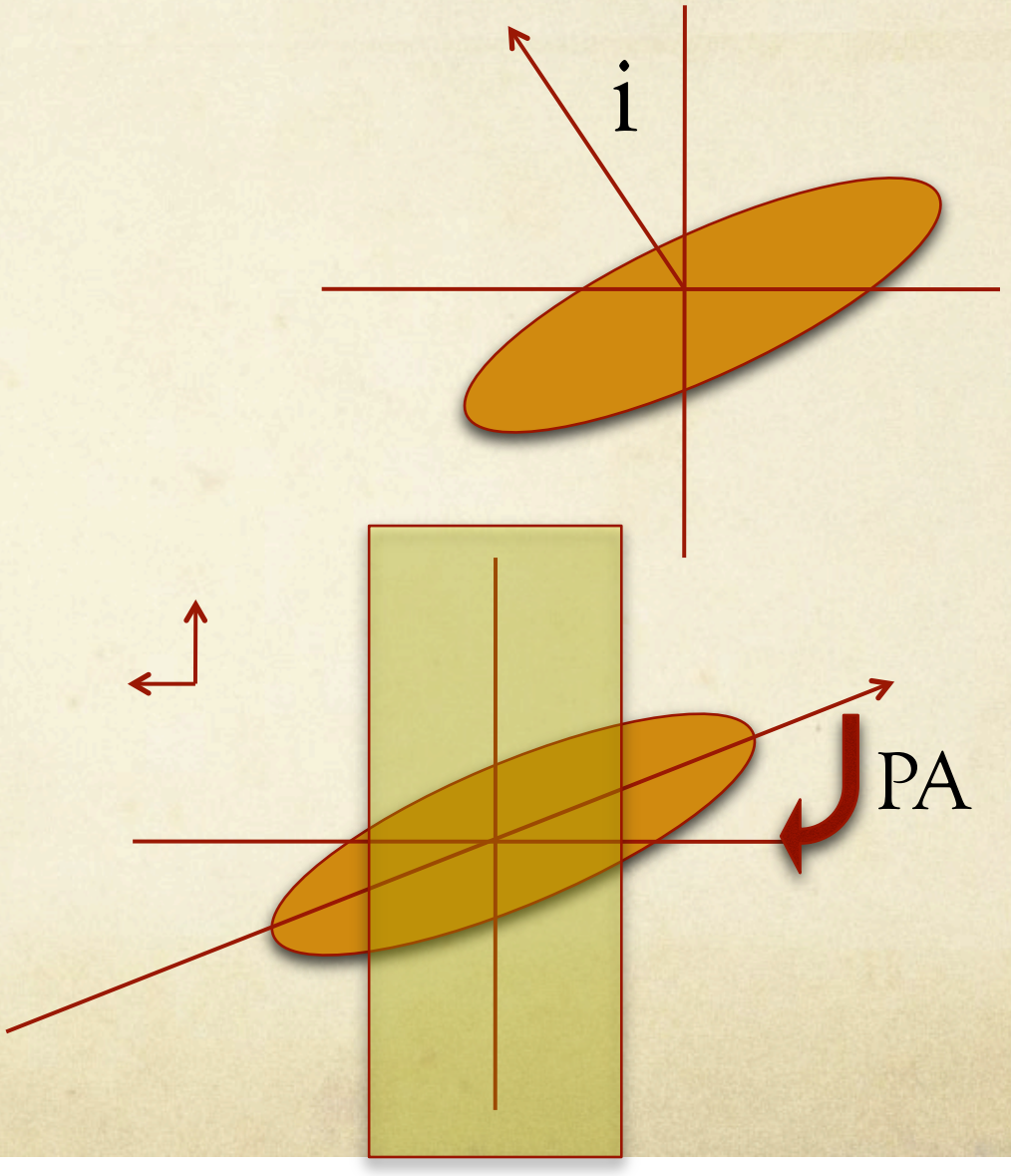
- If spatially extended, can find spatial and velocity information about extended object
- Used to observe BD companions, jets, binaries, etc.
- Can also be used for circumstellar disks



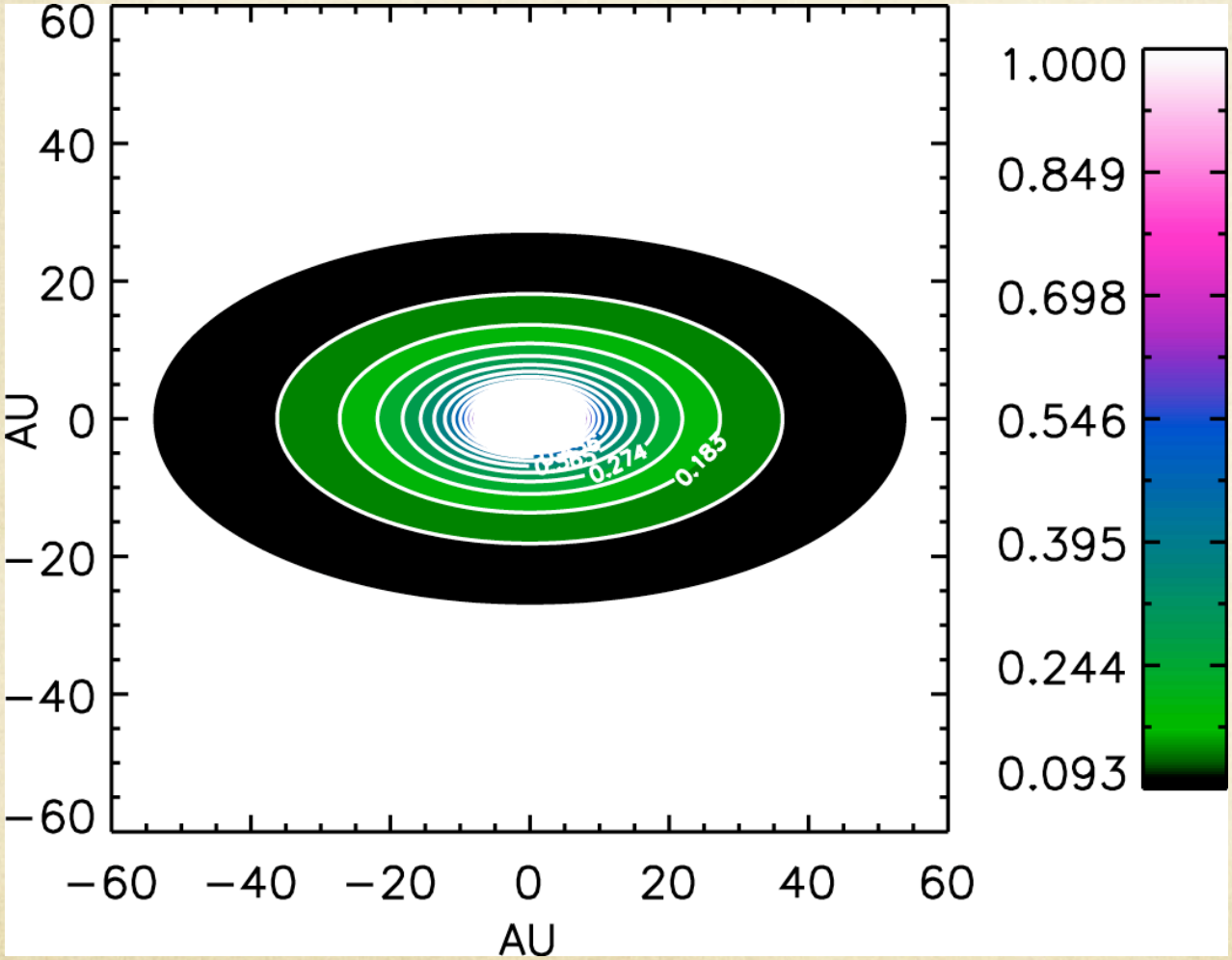
Pontoppidan et al. (2008)

Parameters

- Disk size
- Inclination - i
- Position angle - PA
- Distance
- Mass of star
- Disk flux
- Slit size



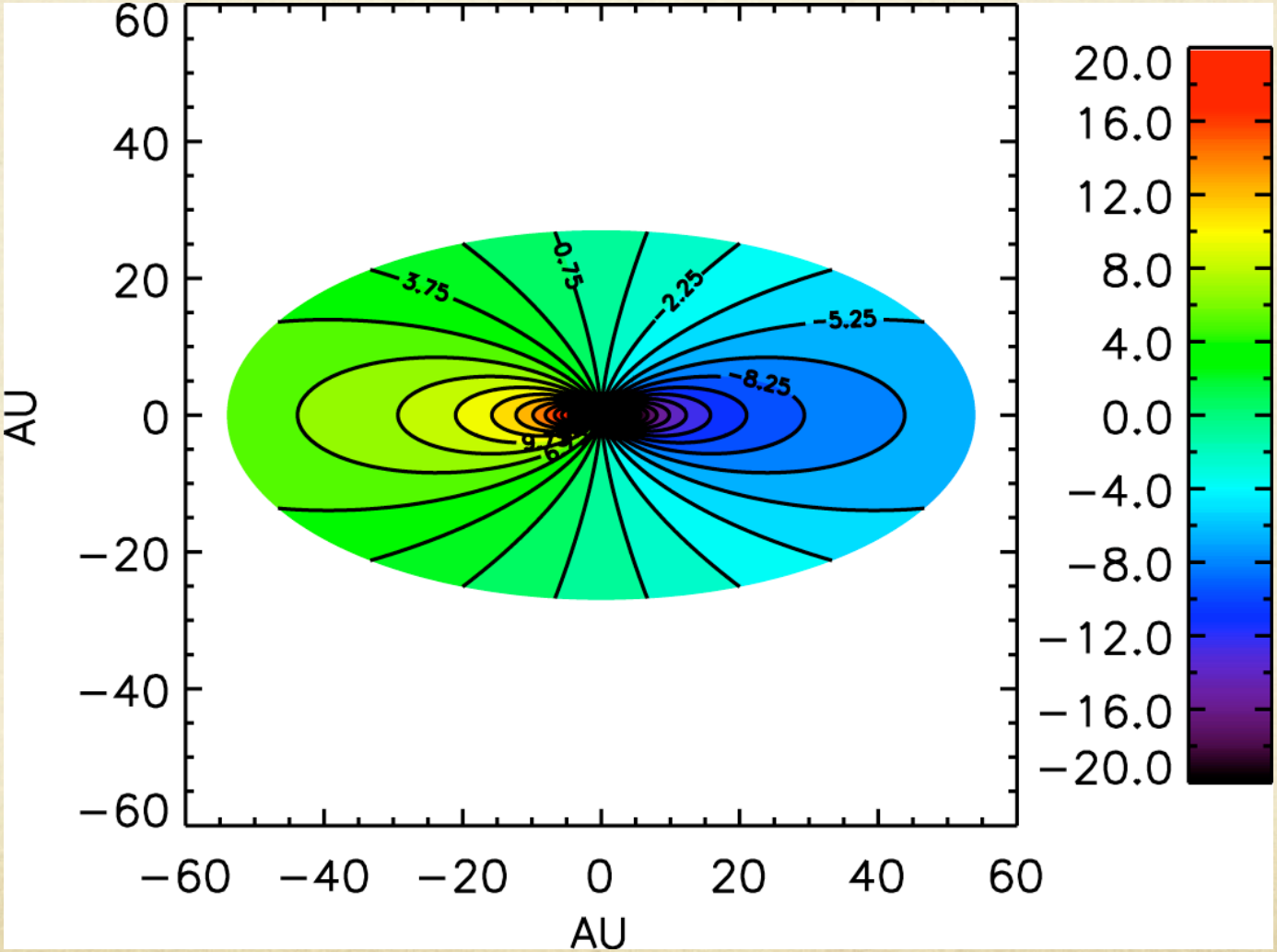
Disk Flux



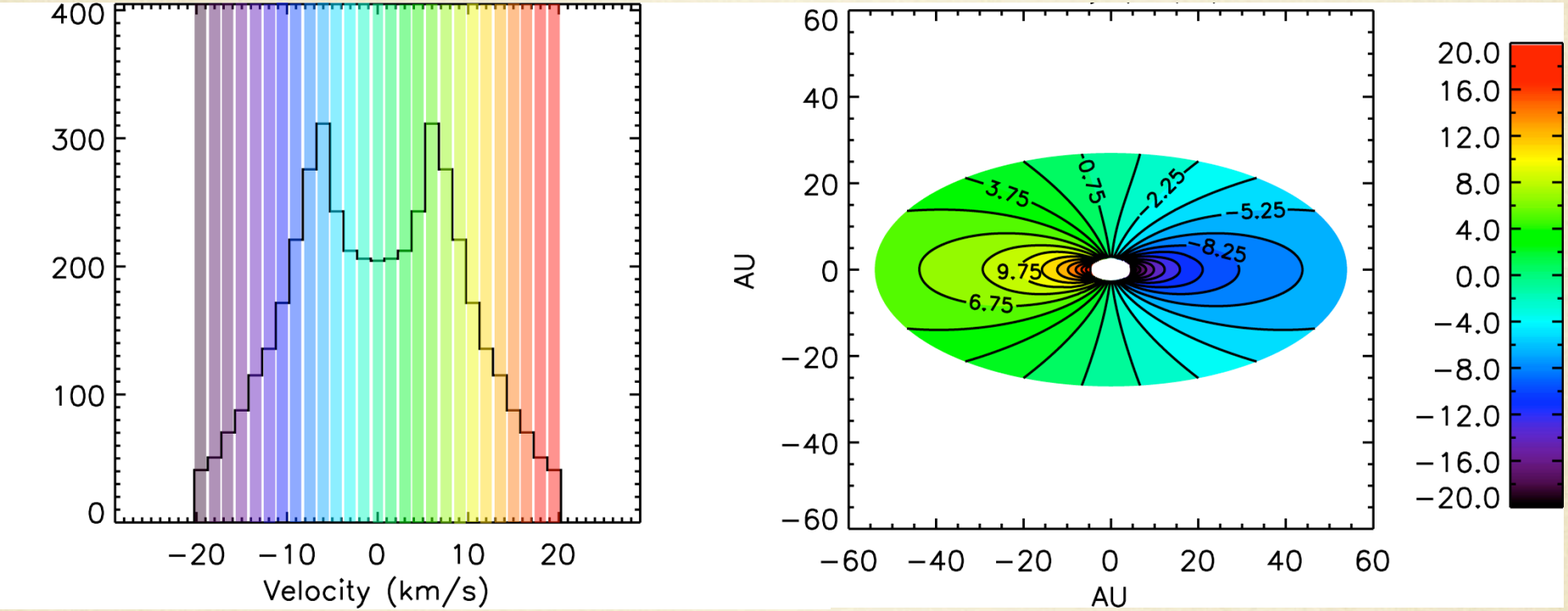
F(r)=Flux from fluorescence model

F≈1/r

Disk Velocity Field

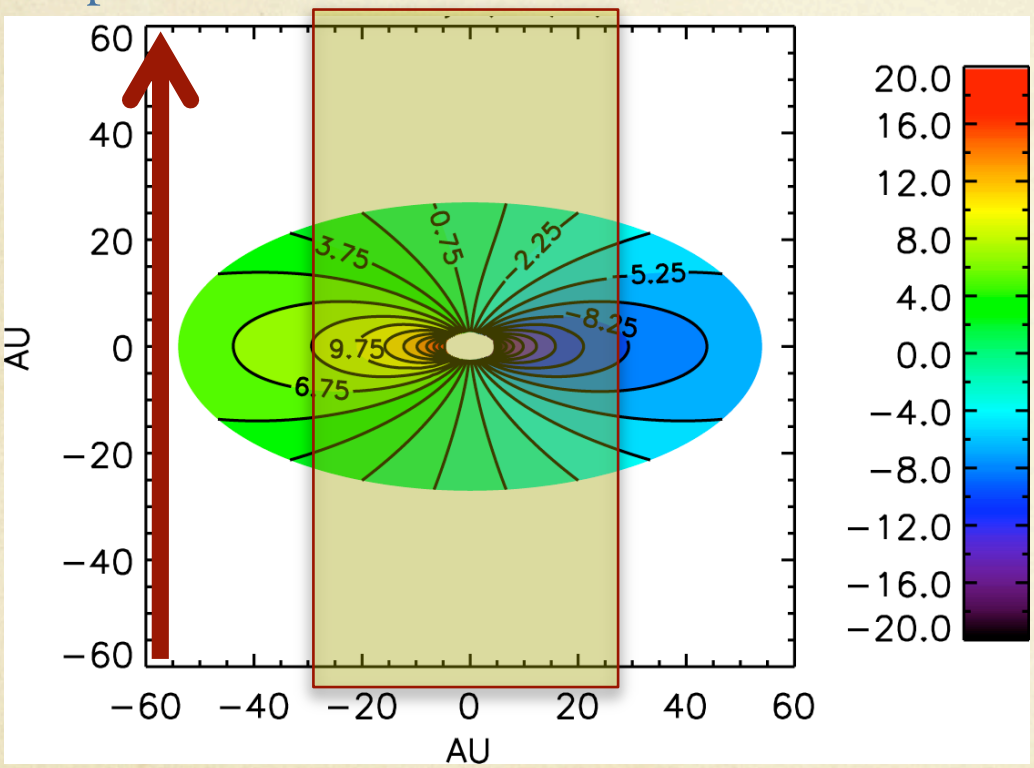


Connecting to Flux



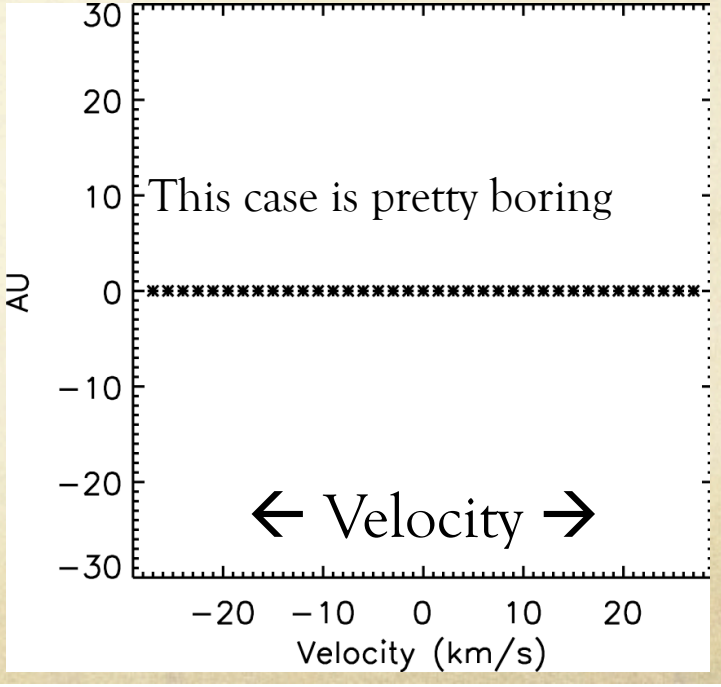
Connecting to SA Signal

Spatial

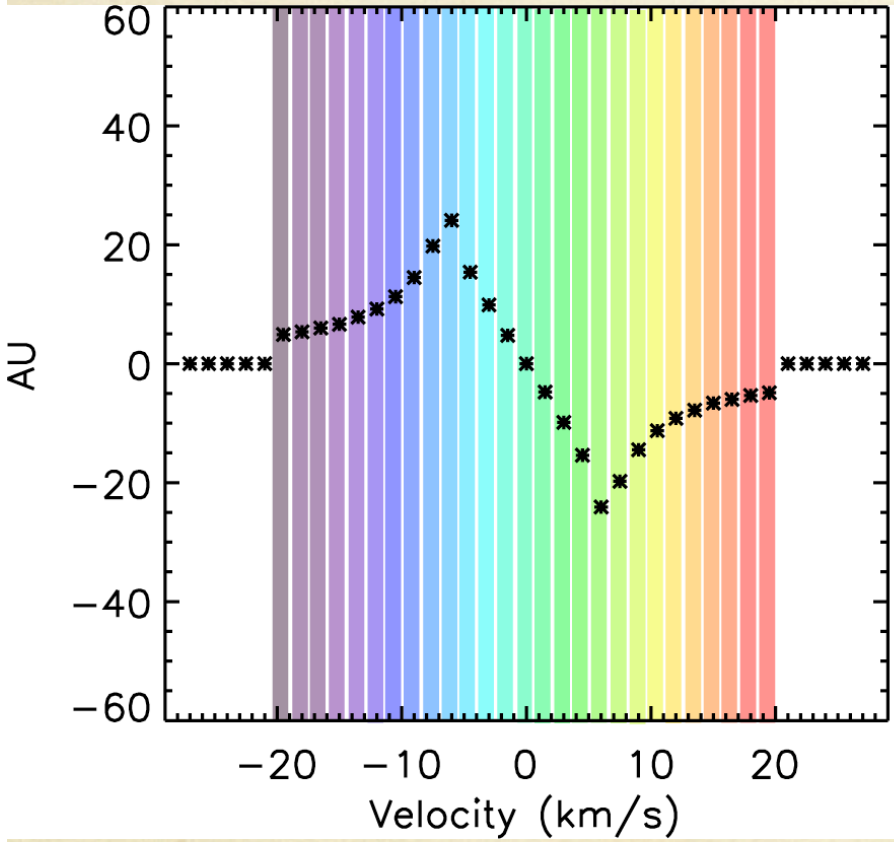


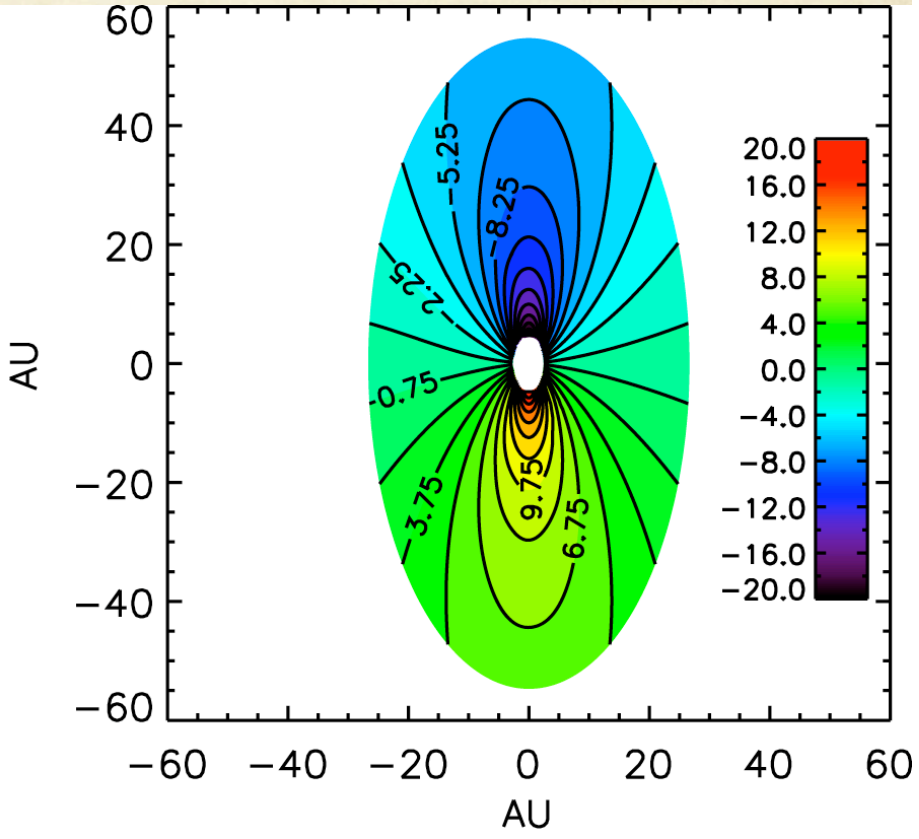
Signal is taking "COM" of the flux from the disk for a specific velocity:

$$\frac{\sum F_i \times y}{\sum F_i}$$

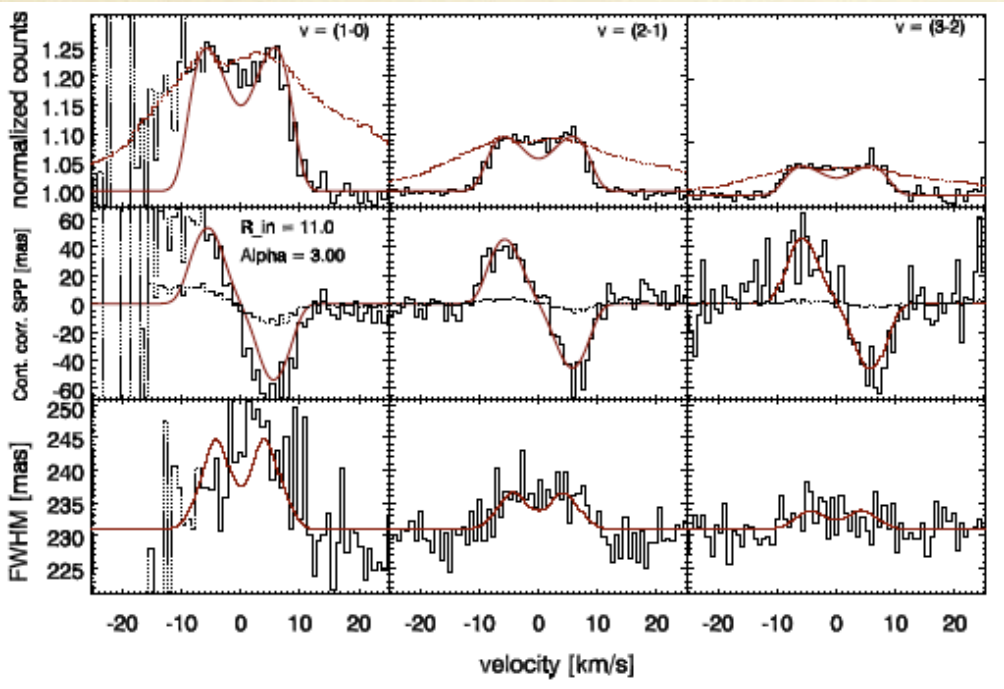


Velocity and Spectro-astrometry

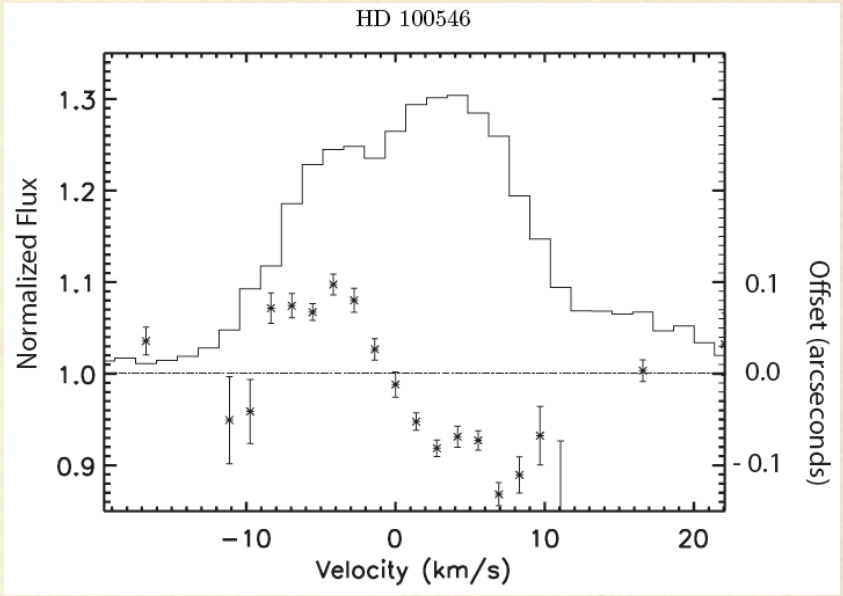




Example Data



van der Plas et al. (2009)

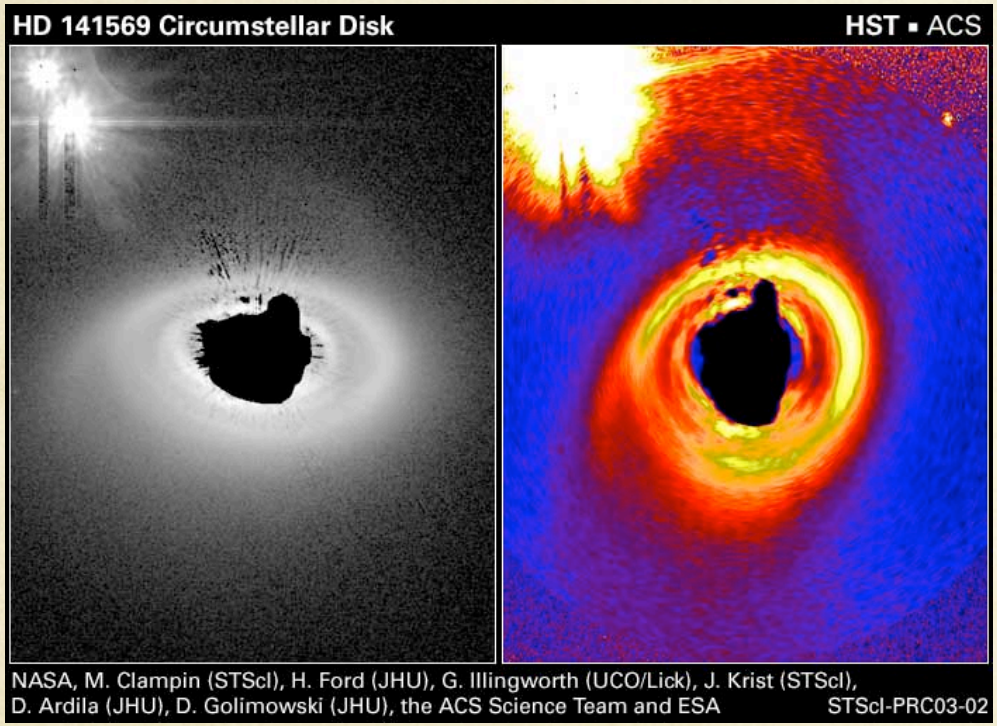


Brittain et al. (2009)

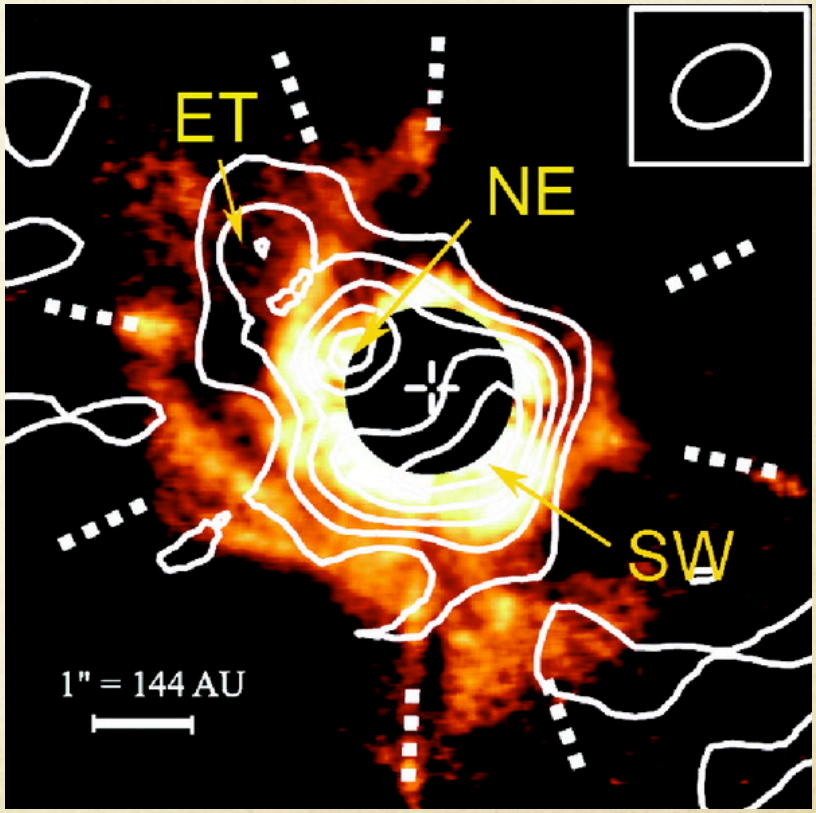
So Why is this important?

- Measure of velocity field independent of Keplerian assumption
- Can independently measure:
  - inclination
  - position angle
  - stellar mass
- Also…

Other Effects

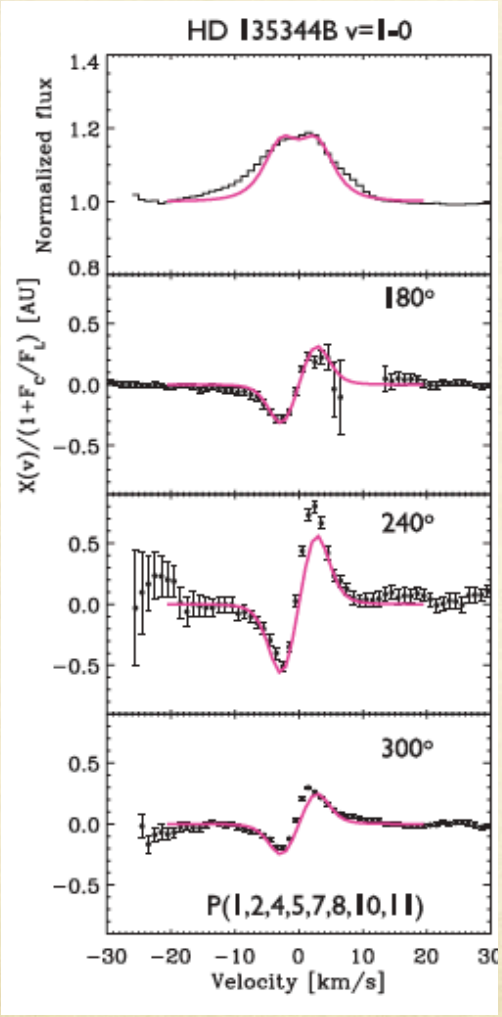


AB Aur

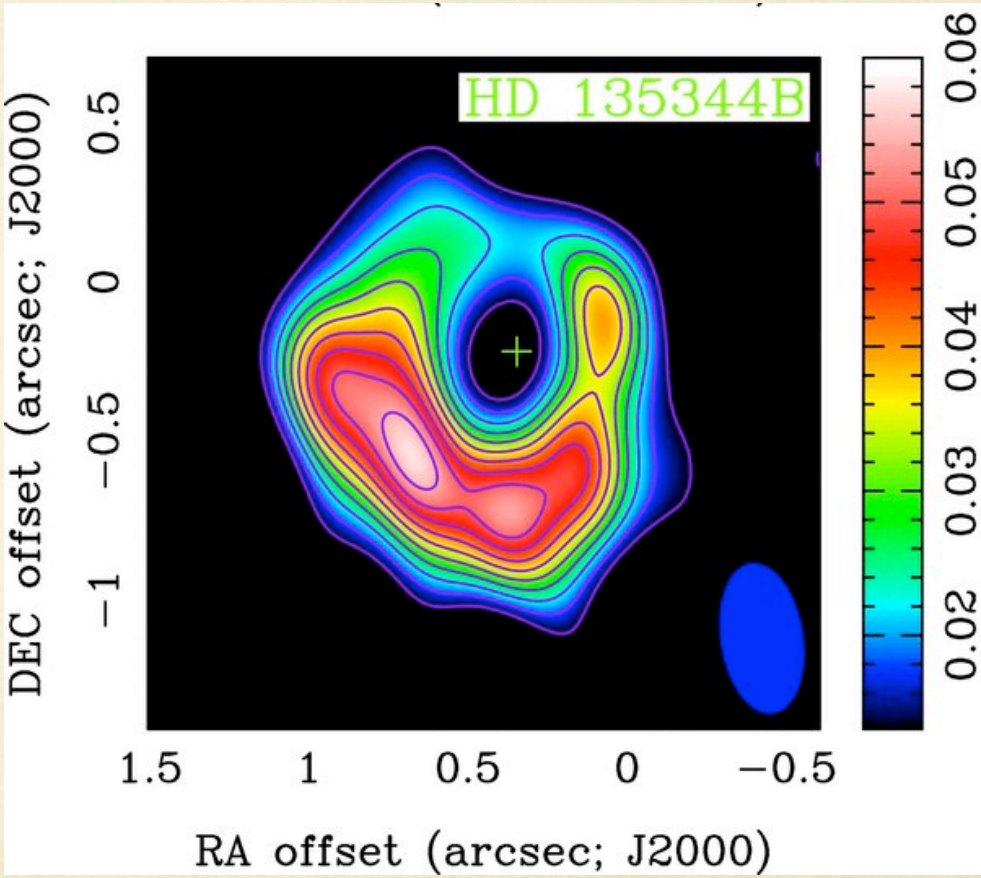


Lin et al. (2006)

Evidence for Asymmetry?



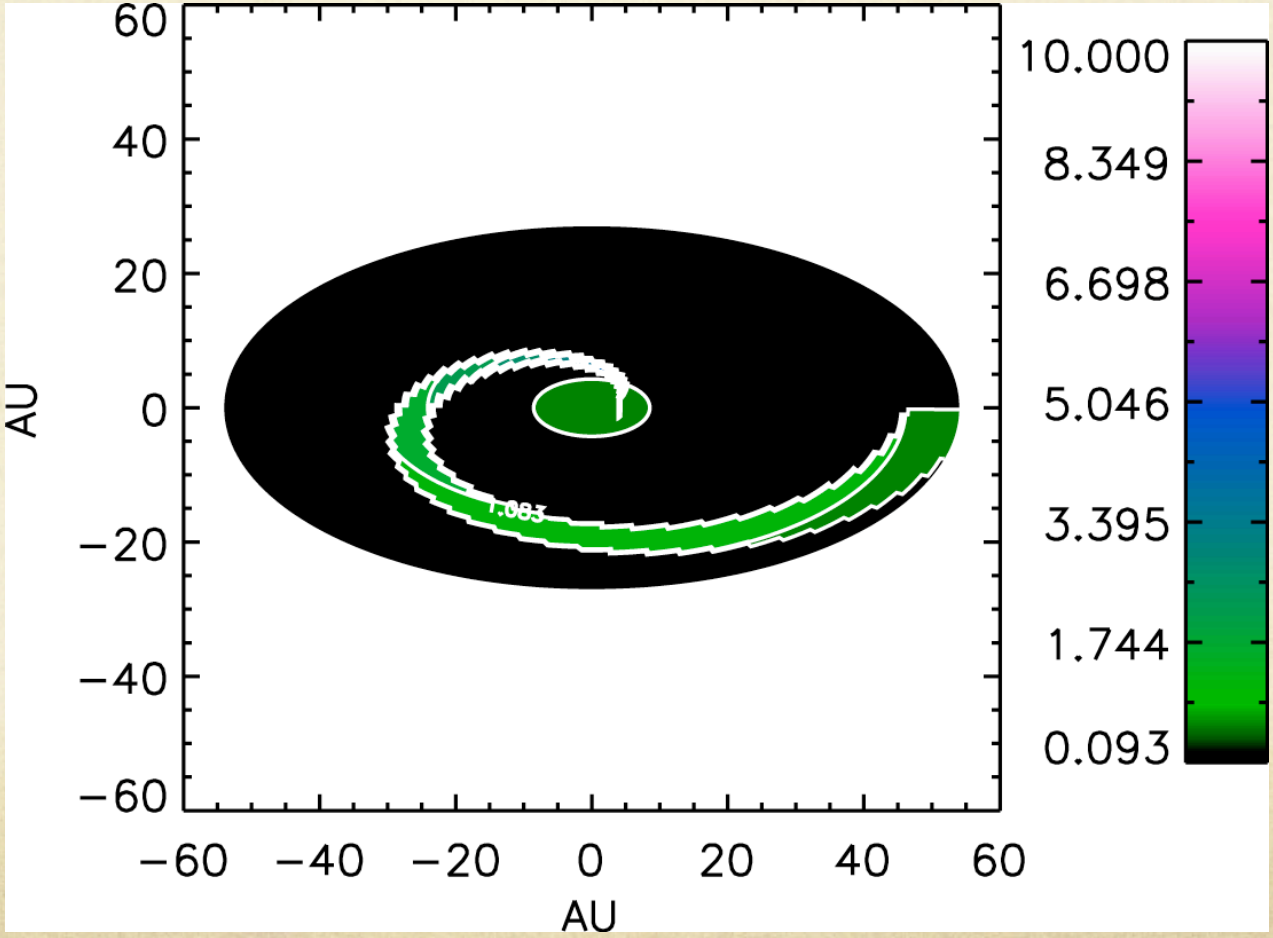
Pontoppidan et al. (2008)



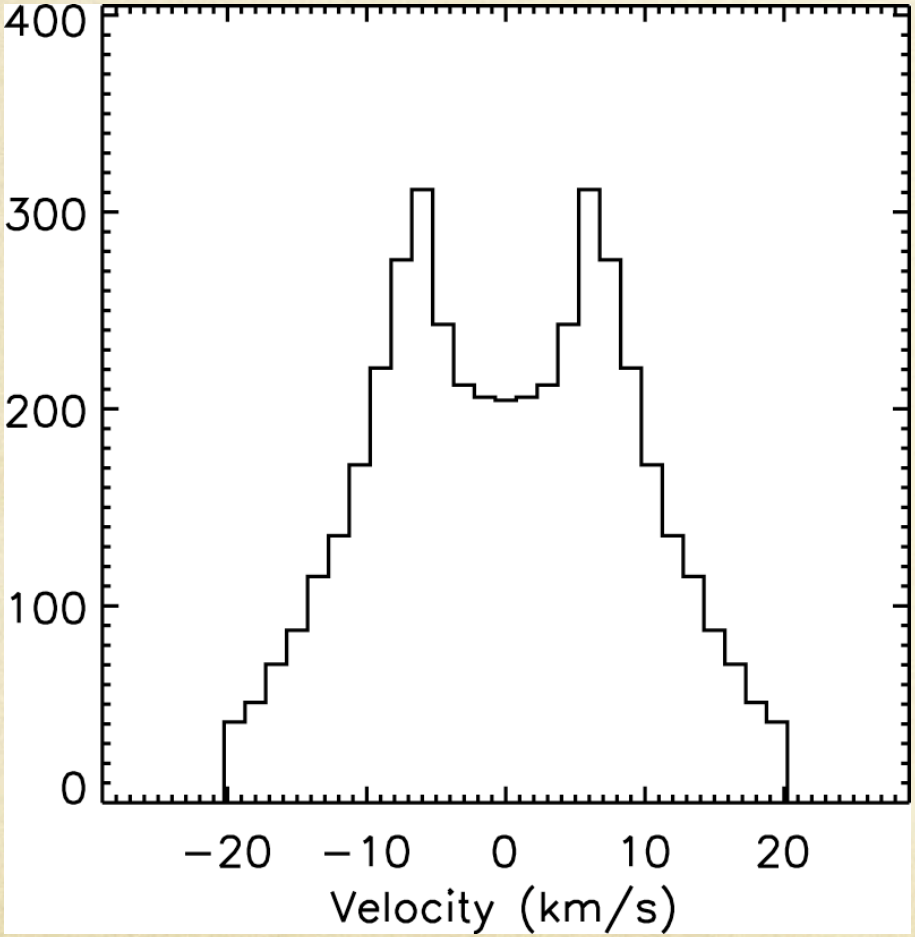
Brown et al. (2009)

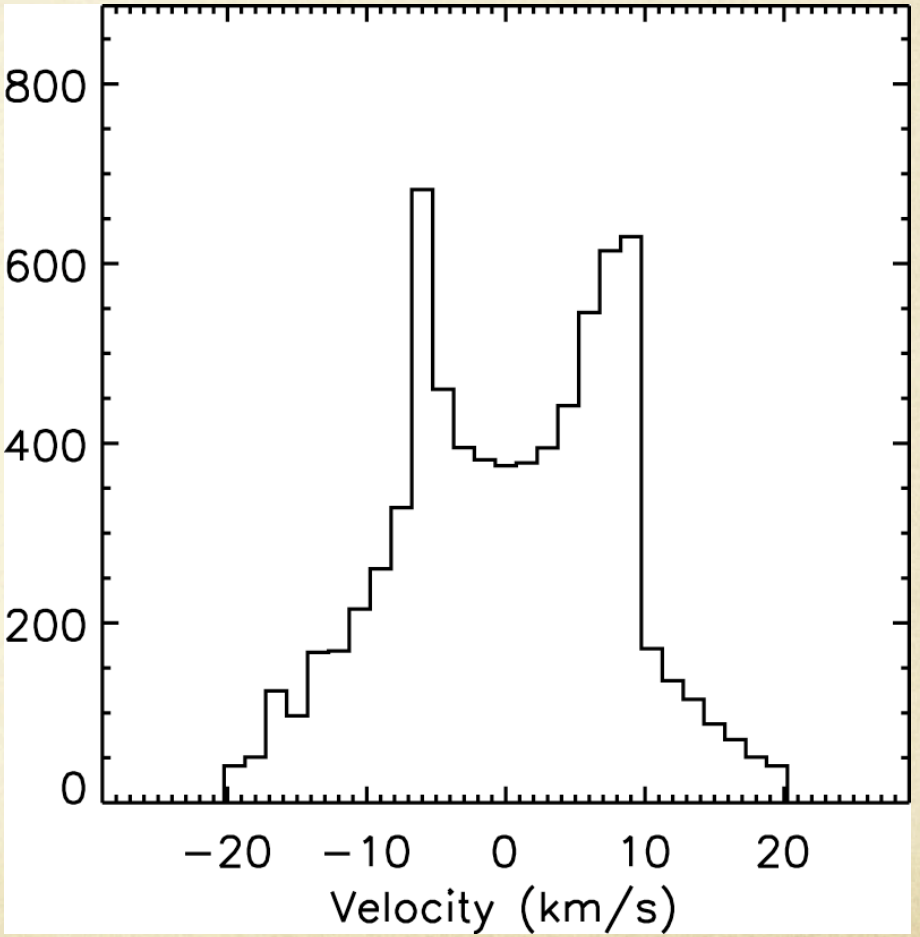
Adding a Spiral Arm

- F(s)=10 F(ns)
- r=7 θ



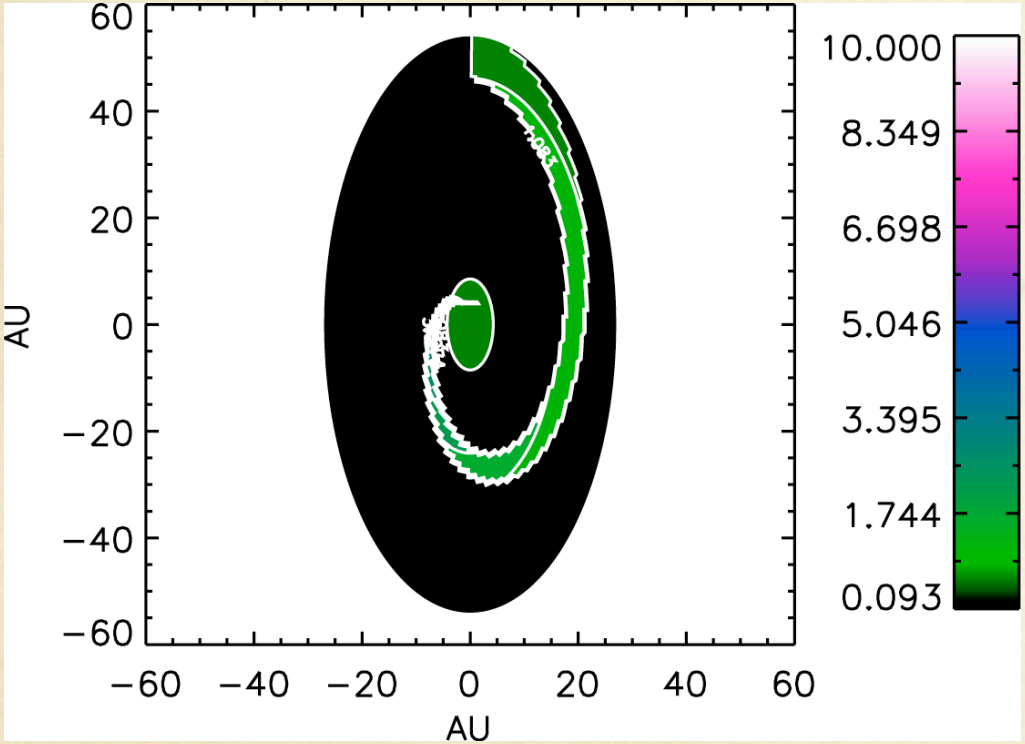
Flux Comparison

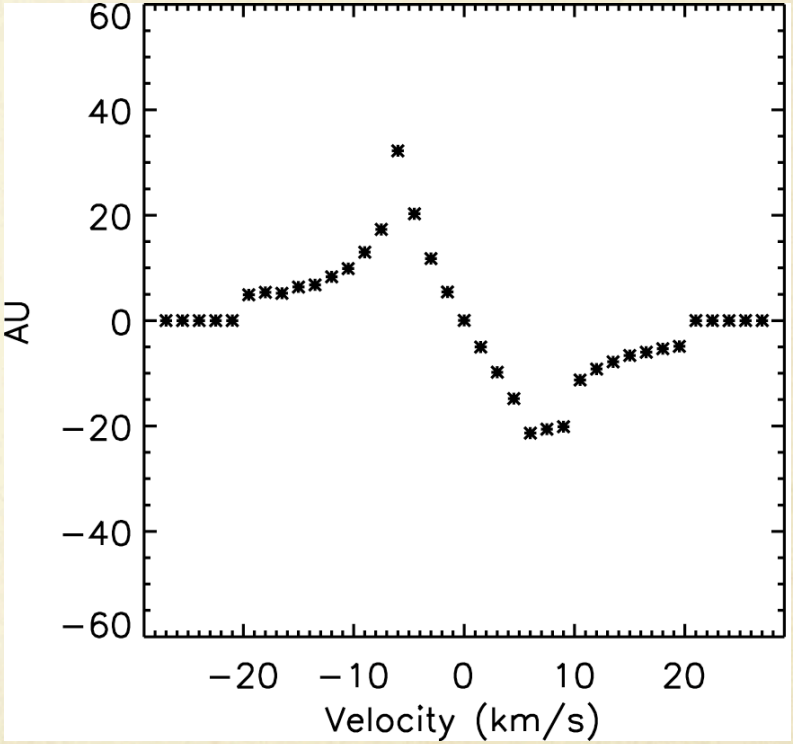




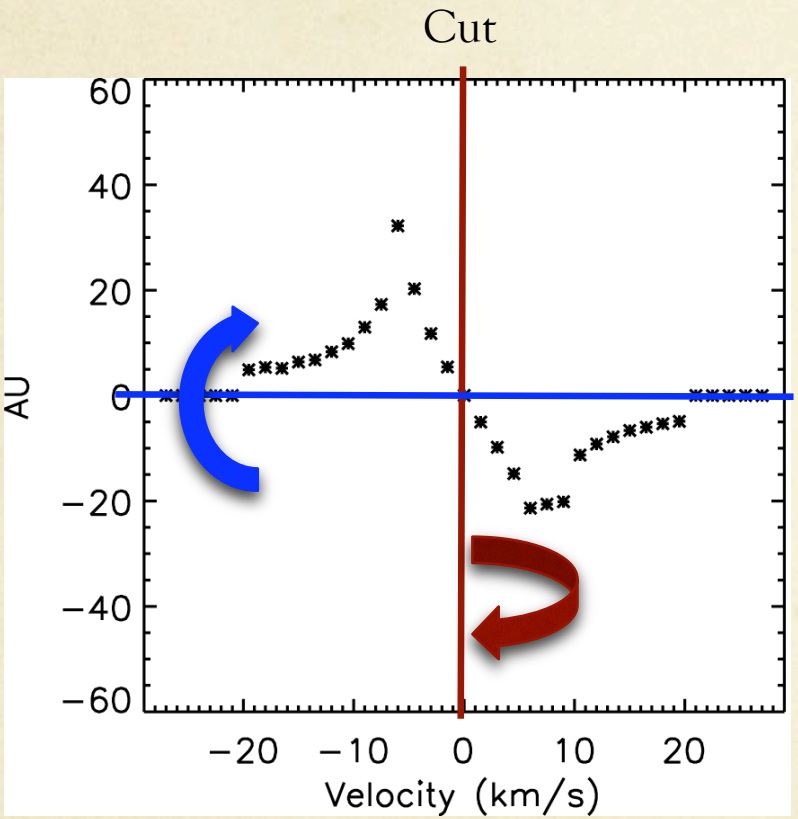
May not see this in flux signal!!

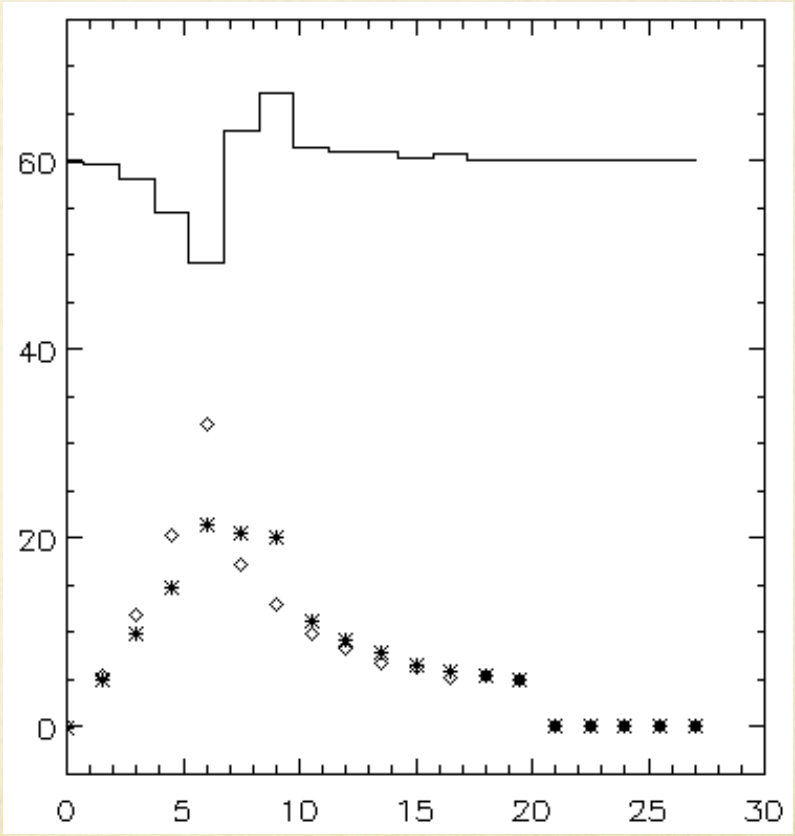
Spectro-astrometric Signal



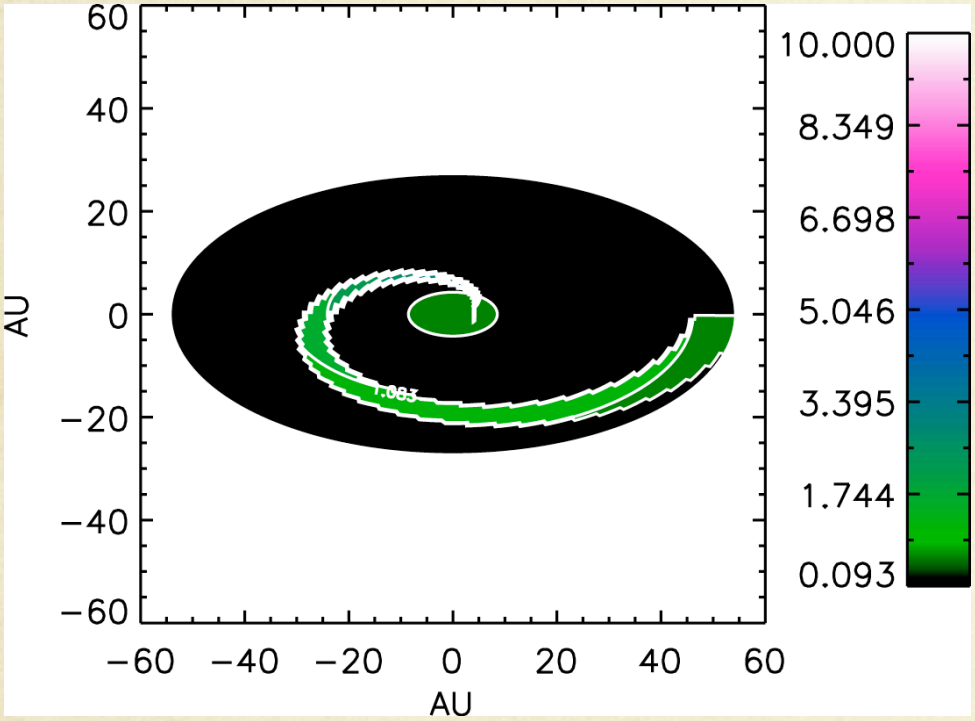


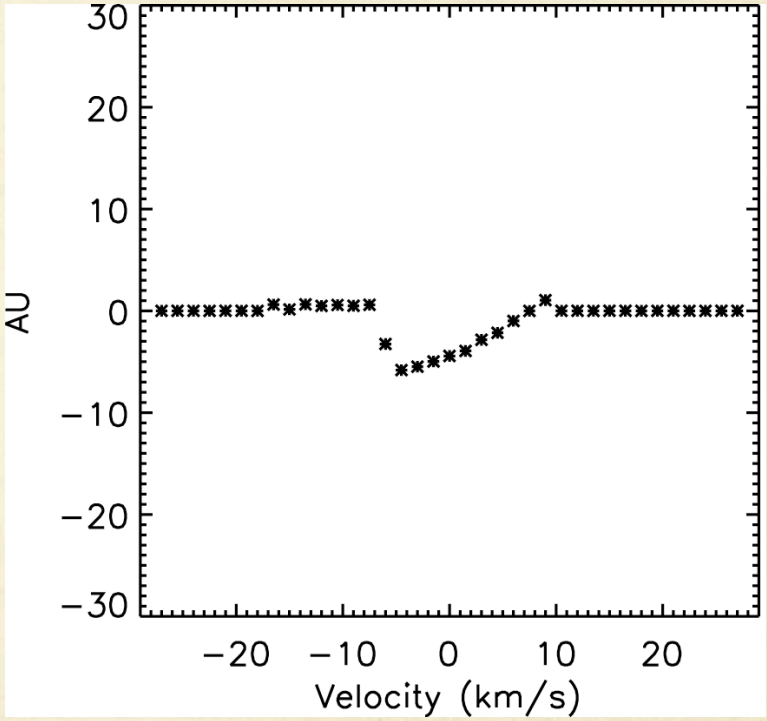
Technique for Comparison





Spectro-astrometric Signal





Still observable with “non-optimal” PA

Summary

- Spectro-astrometry is an extremely unique way to gain high spatial resolution from the disk, and find structures that cannot be probed with other techniques.