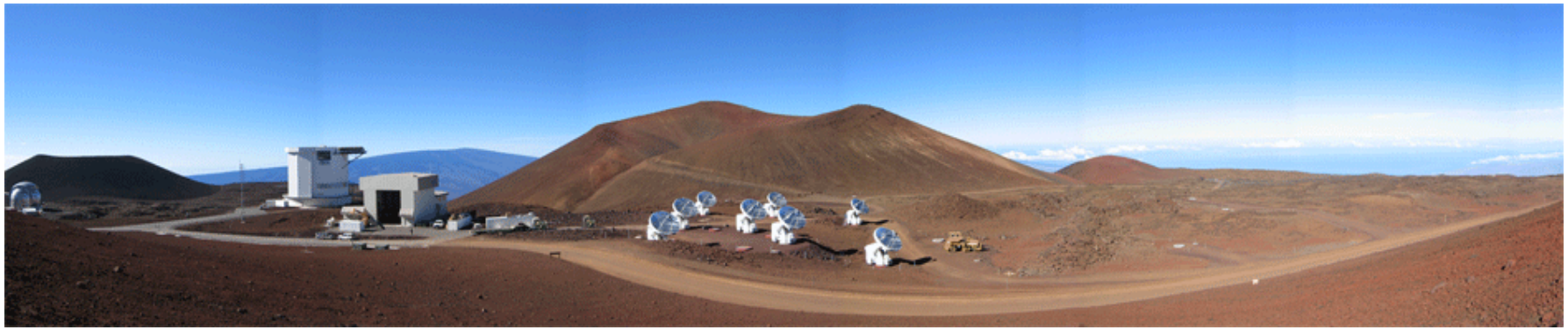


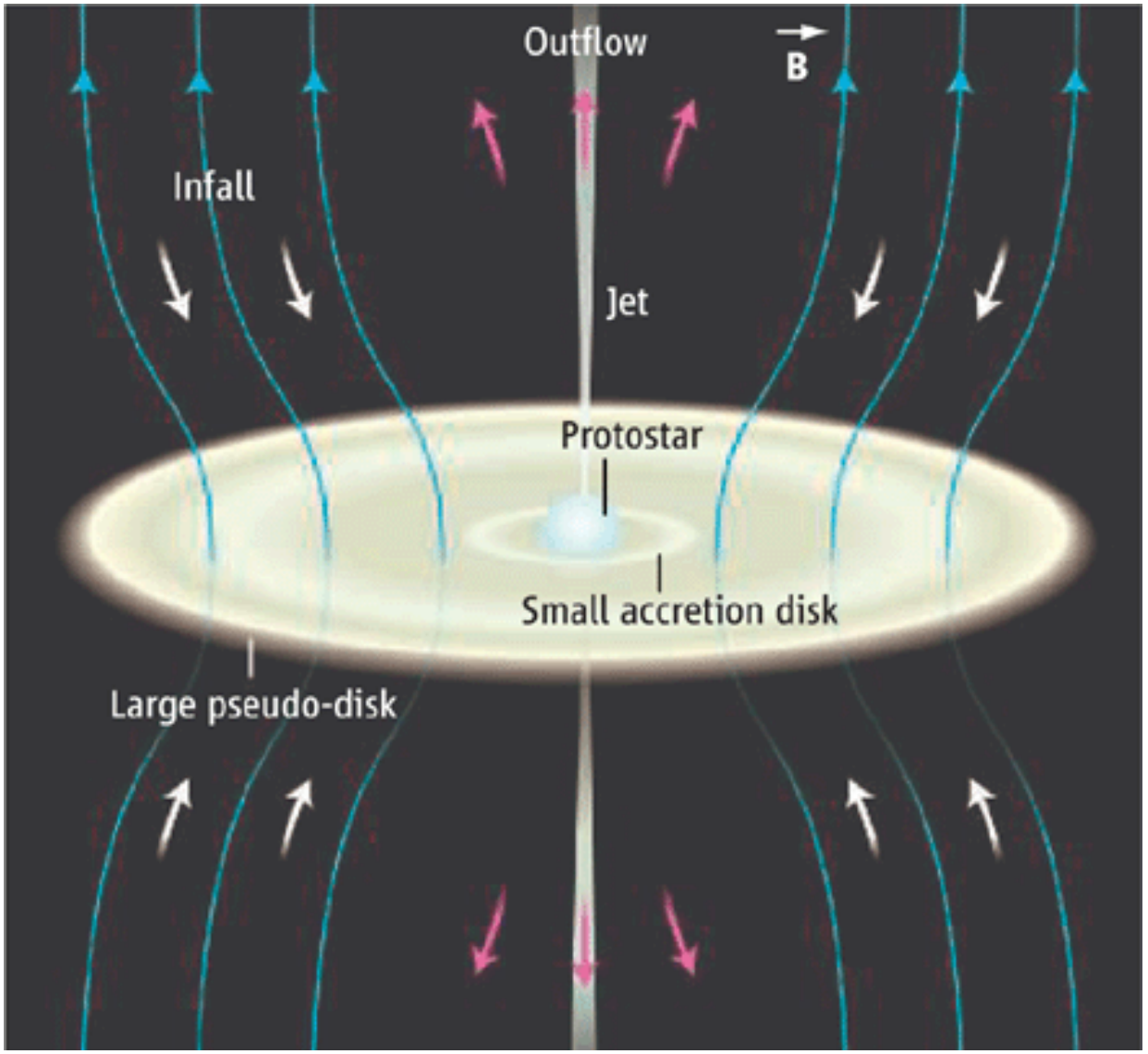
Polarimetry with the SMA

Do magnetic fields play a role in the star formation process?

R. Rao, J.M. Girart, D.P. Marrone & others…

Science

- Role of magnetic fields - cloud support, ambipolar diffusion, angular momentum, fragmentation, turbulence, accretion
- Grain properties (sizes and shapes) and alignment mechanisms (classical DG + modifications, radiative torques)



Crutcher (2006), Science, 313, 771

Dust Polarimetry

- First observed in optical absorption by Hall (1949) and Hiltner (1949)
- Must be polarized in emission as well
- Cold dust emits mainly at far-IR, submm, and mm
- Advantages of emission polarimetry - a) Emission is optically thin, b) No contamination from scattering, absorption etc.
- BUT, cannot directly give strength of B
- Early work on KAO (far-IR), submm (CSO, JCMT), mm (NRAO 12m)
- SCUBA and Hertz

Advantages of Submm Polarimetry

- Single dish measurements (CSO,JCMT) - resolution (10”) is low but good sensitivity
- Interferometer array observations (OVRO, BIMA) improve resolution but inadequate sensitivity but CARMA will be useful.
- **SMA is good - Improves resolution AND sensitivity**

SMA Polarization Hardware

Marrone 2006 Ph.D. Thesis

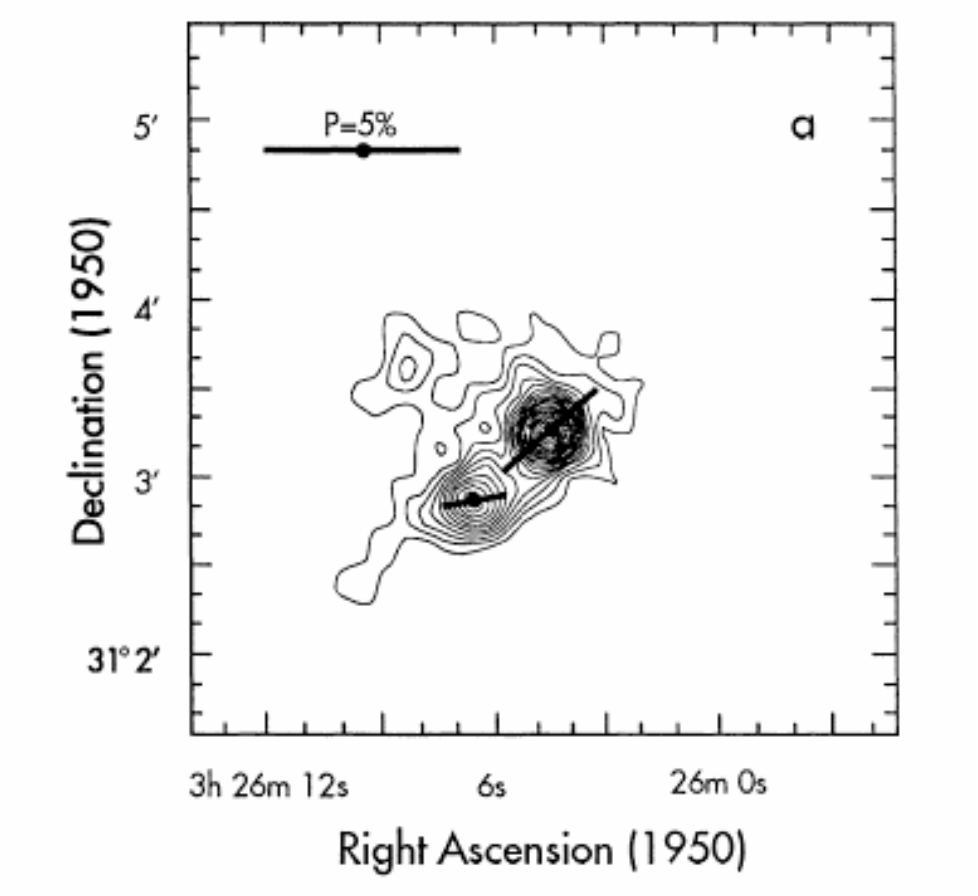
- SMA receivers are currently single polarization X,Y
- QWP converts linear to circular pol. X,Y => L,R
- Time multiplex using Walsh switching
- Average to get quasi-simultaneous dual-pol
- Future dual pol receiver conversion is in progress

NGC 1333 IRAS 4A/B (JCMT)

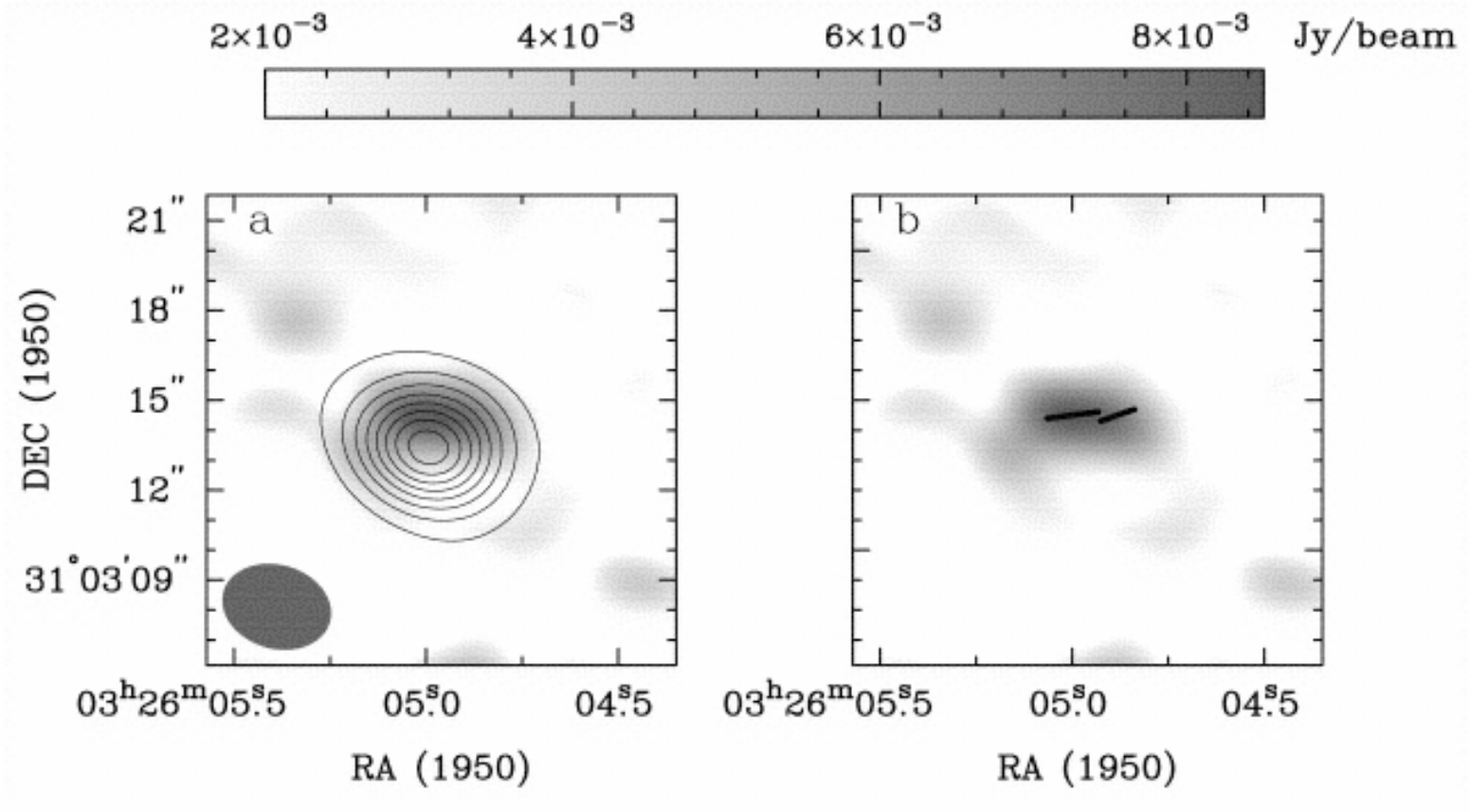
Low mass
Class0 protostar
in Perseus cloud (300AU)

Minchin, Sandell
and Murray 1995

JCMT 800 micron
14 arcsec

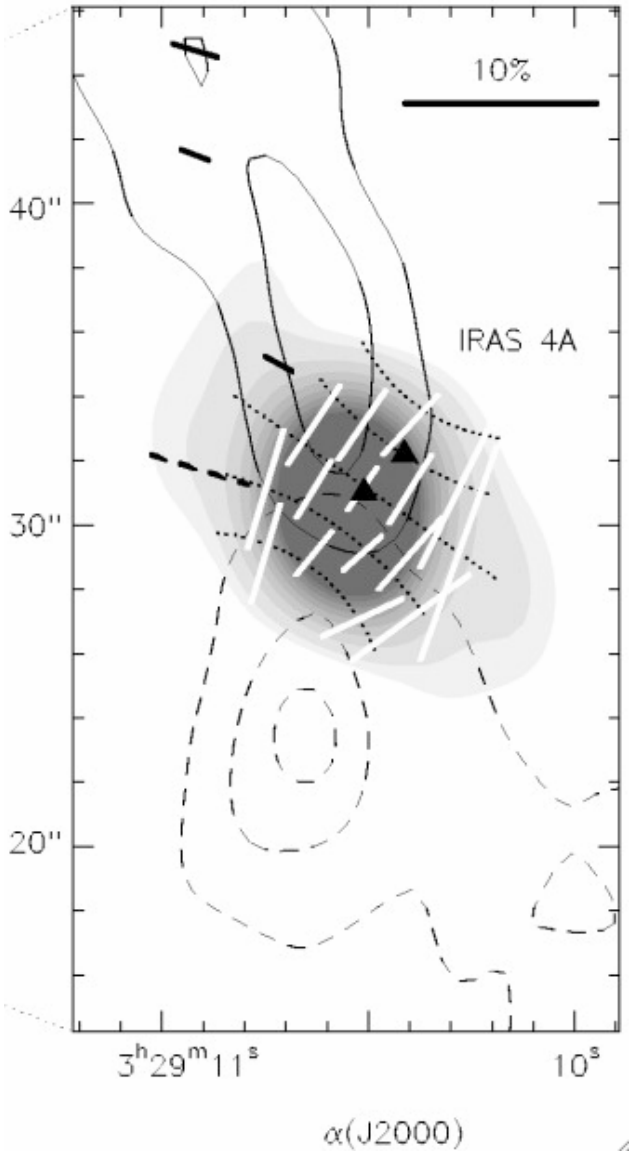


NGC 1333 IRAS 4A (OVRO)



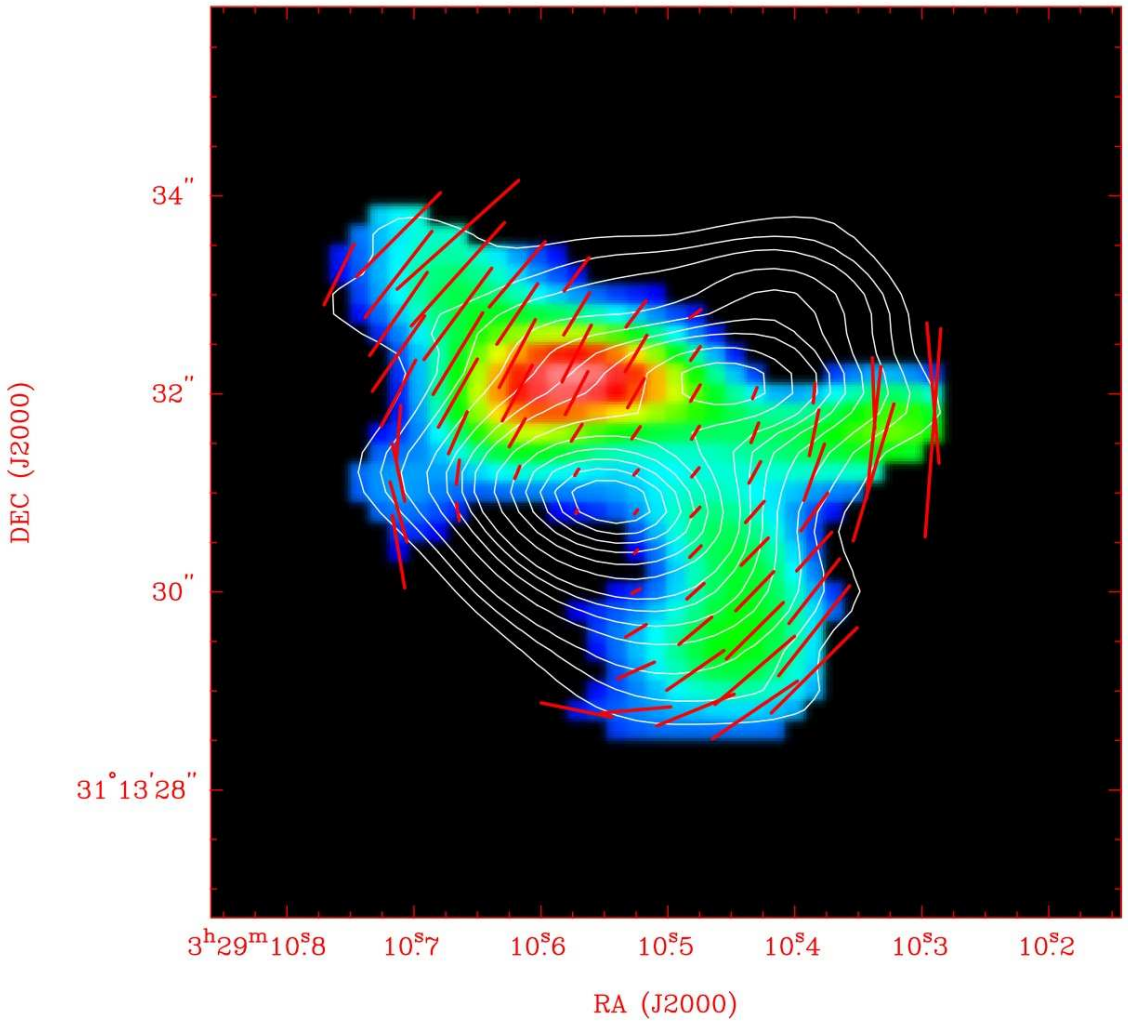
Akeson & Carlstrom 1997
OVRO 86.2 GHz

NGC 1333 IRAS 4A (BIMA)

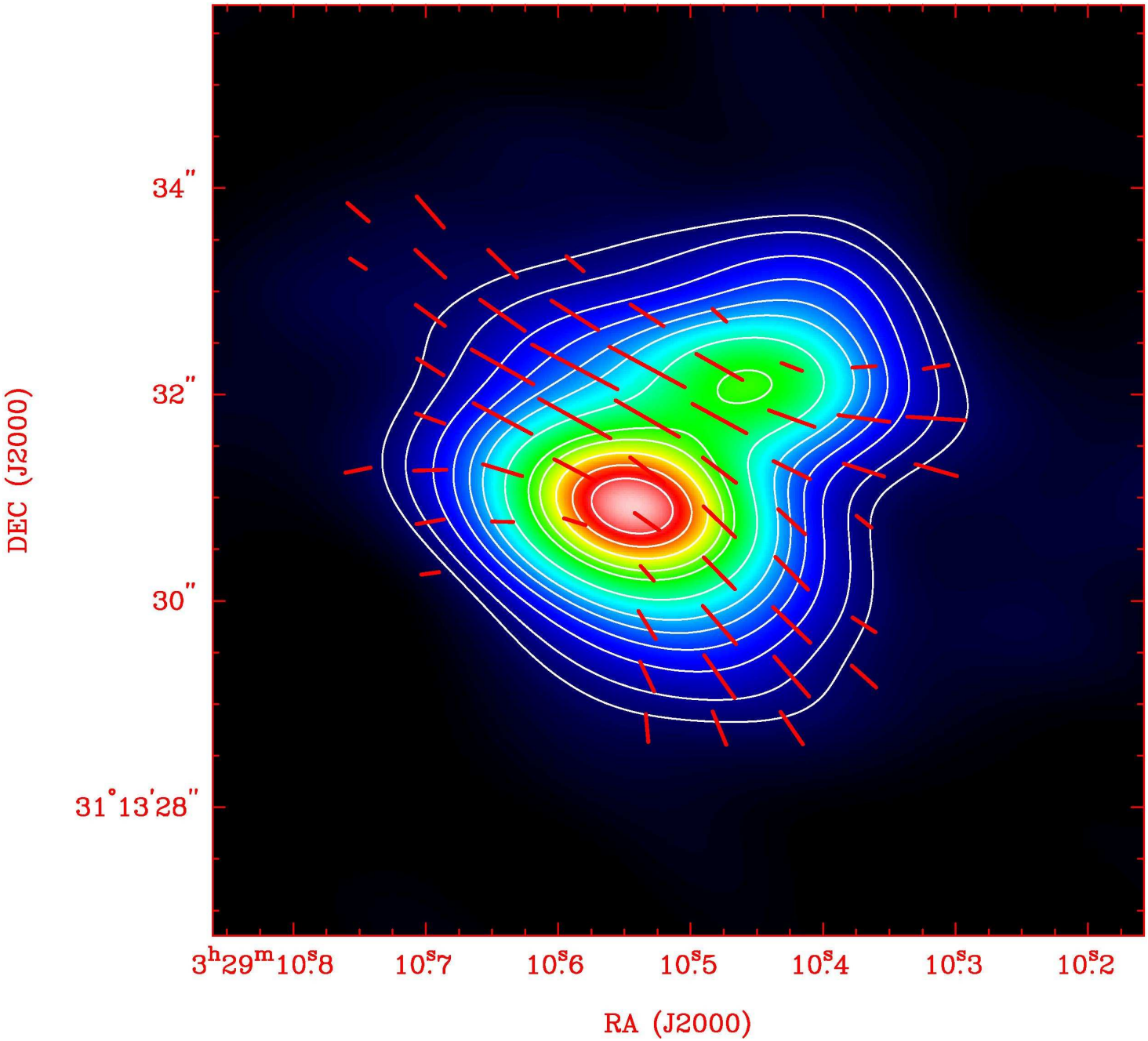


Girart, Crutcher, & Rao 1999
BIMA at 230 GHz
Beam ~4”x2”

NGC 1333 IRAS 4A (SMA)



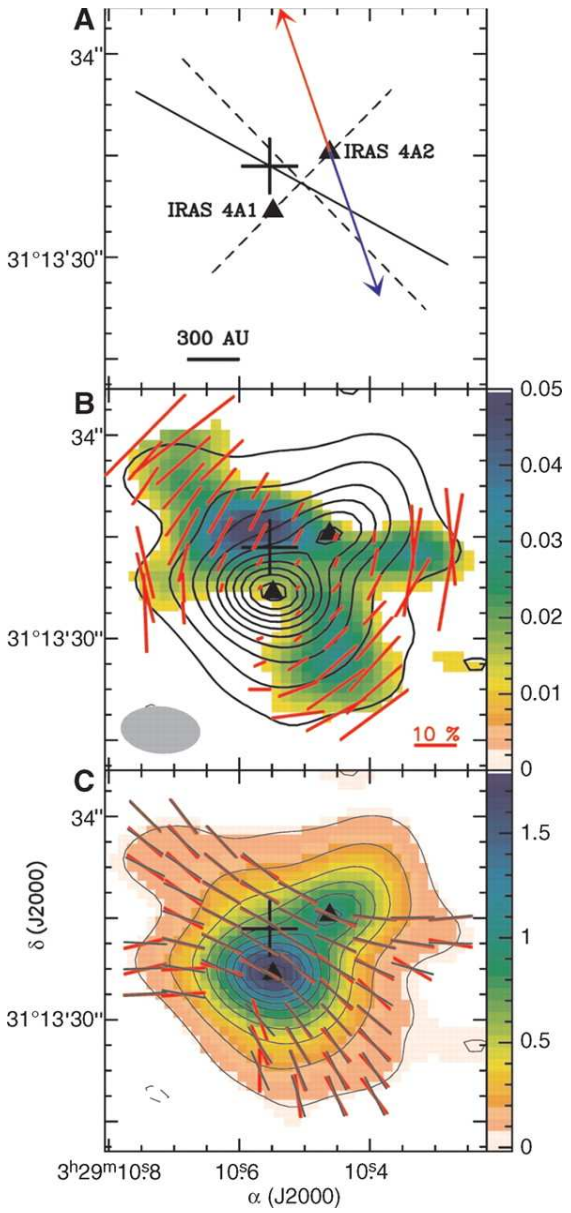
Girart, Rao, & Marrone (2006), Science, 313, 812


34″
32″
30″
31°13′28″
DEC (J2000)
3h29m10.s8
10.s7
10.s6
10.s5
10.s4
10.s3
10.s2
RA (J2000)

- Detect 4A1 and 4A2 with separation ~1.8”
- Total flux ~ 6.2 Jy
- Dust mass 1.2 M_sun

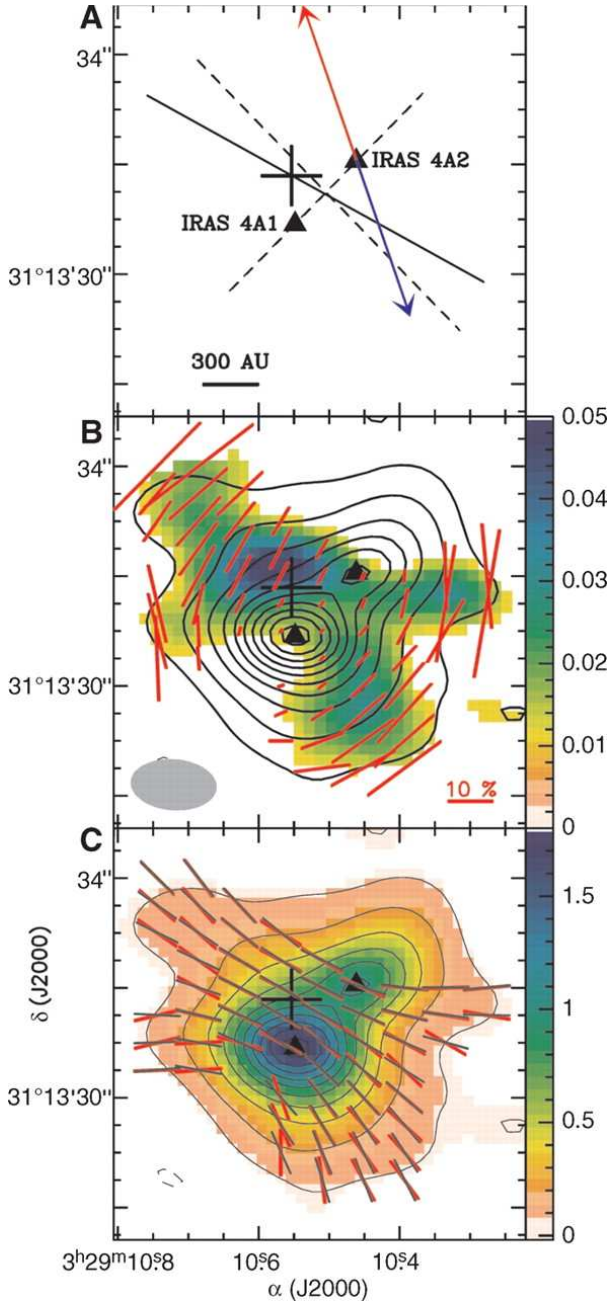
Distance uncertainty 220-350pc

Freq=345 GHz, Beam=1.6x1



B-Fields in IRAS4A

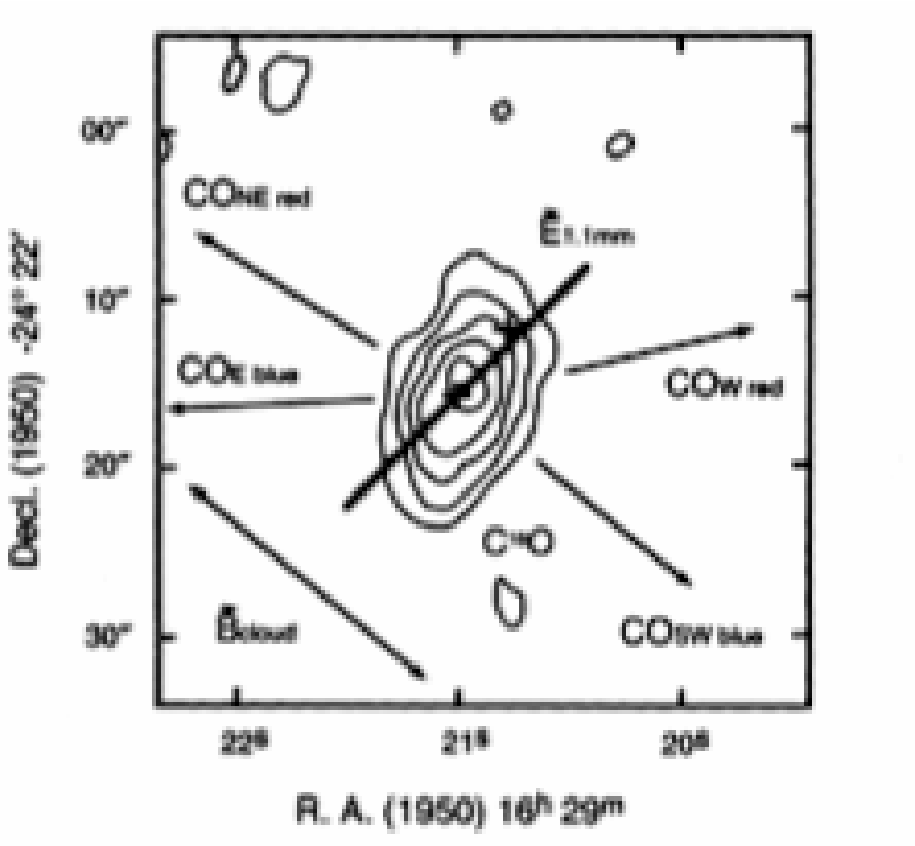
- Predicted hourglass pinch is clearly seen
- Fit parabolic curves to B-field position angles (PA)
- Estimate strength of B-field from PA residuals and velocity dispersion (Chandrasekhar-Fermi method)
- B ~ 5mG
- Axes misalignment between cloud/B-field/outflow
- Fragmentation?



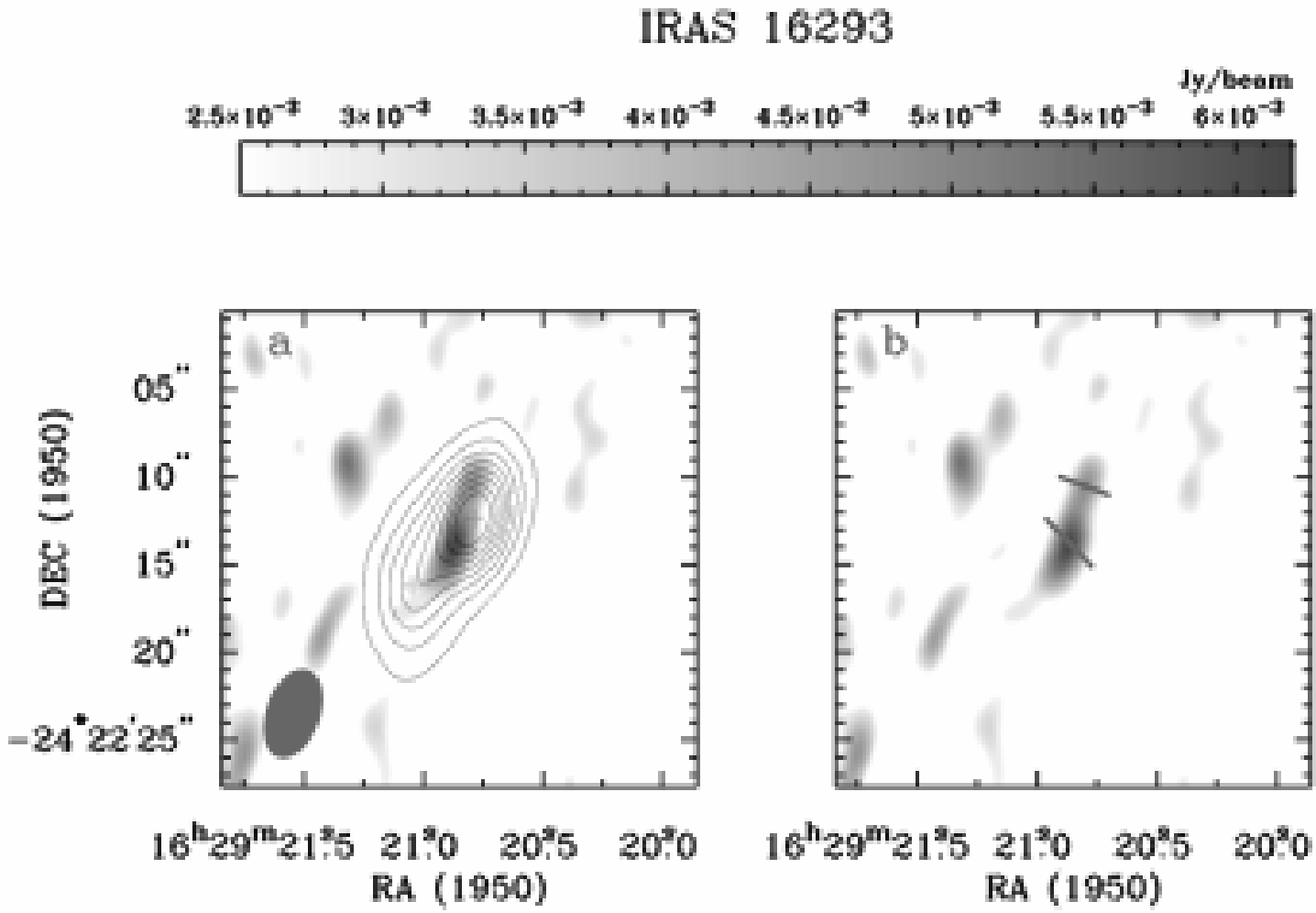
IRAS 16293 (JCMT)

- Class0 protostar in Ophiuchus (160 pc)

Tamura et al. 1995
JCMT
1.1 mm
Beam 19”

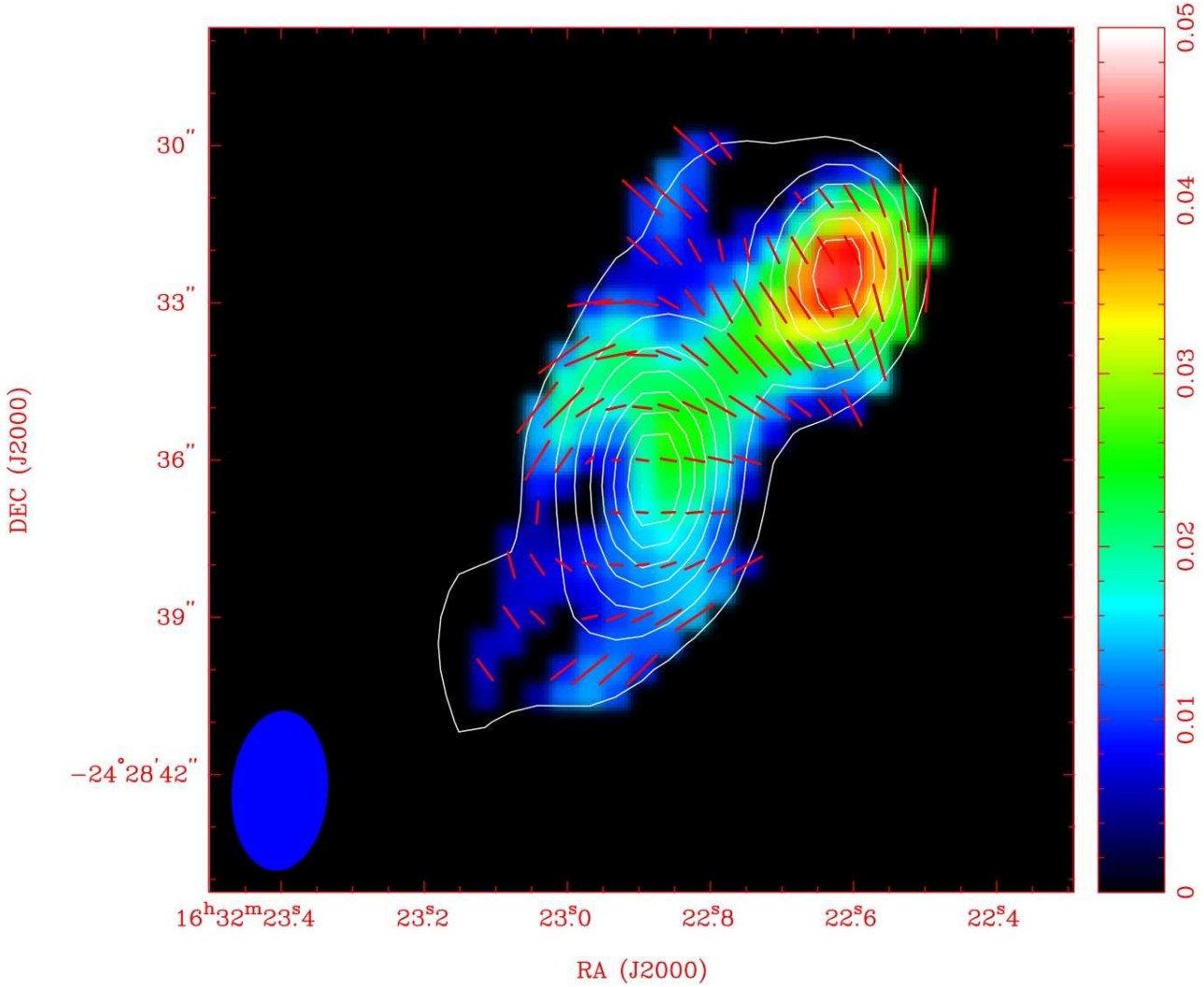


IRAS 16293 (OVRO)

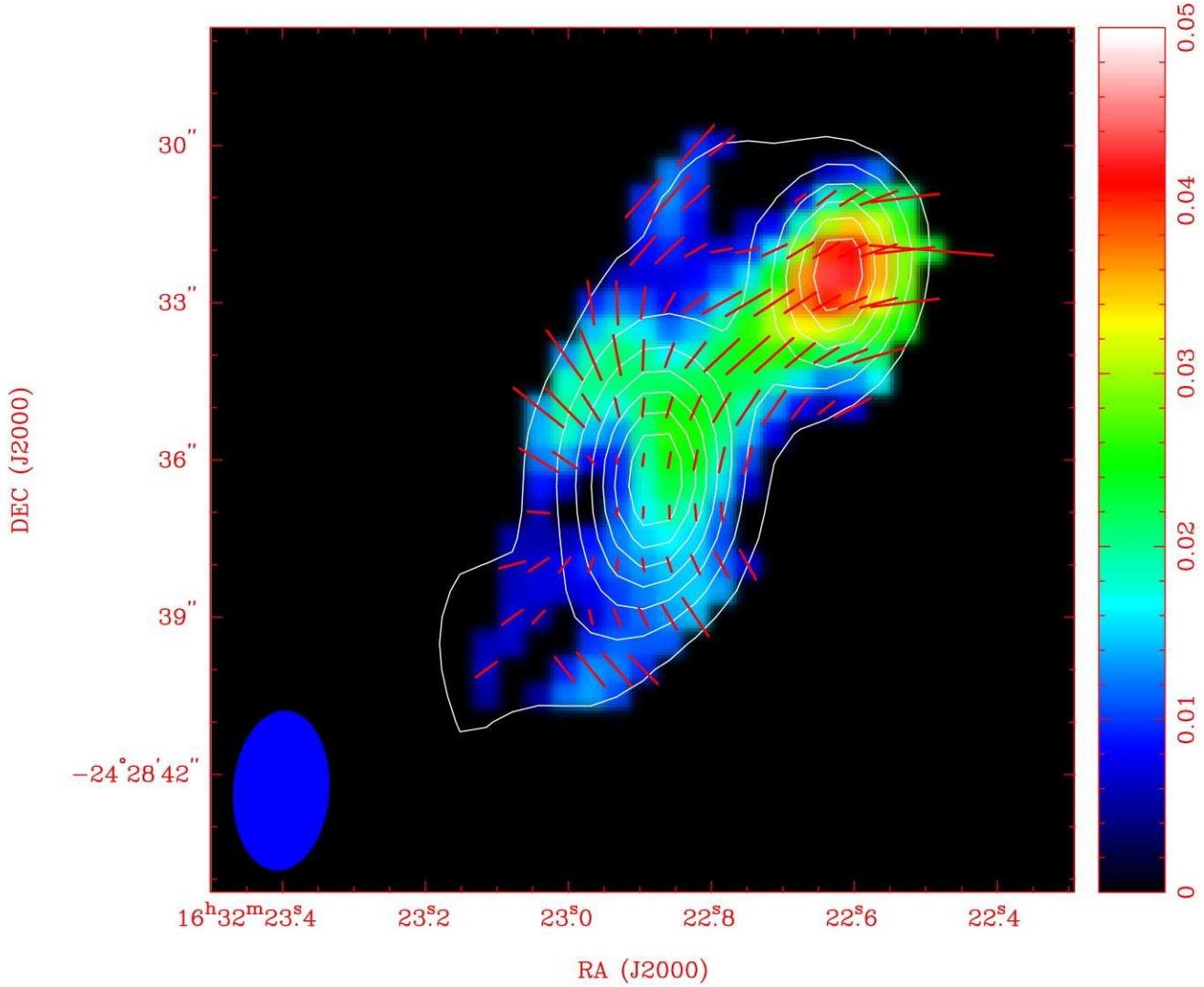


Akeson & Carlstrom 1997 OVRO 105.6 GHz

IRAS16293: Polarization



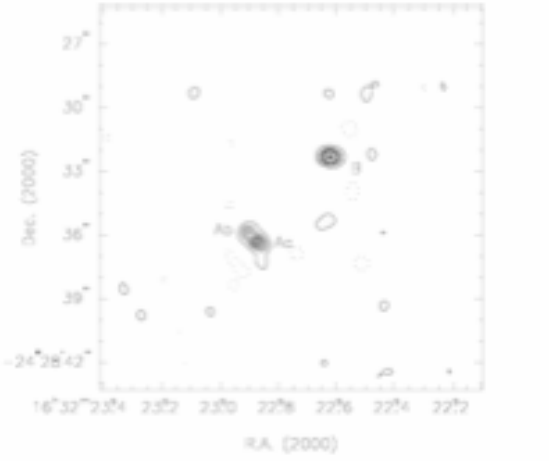
IRAS16293: Magnetic Field

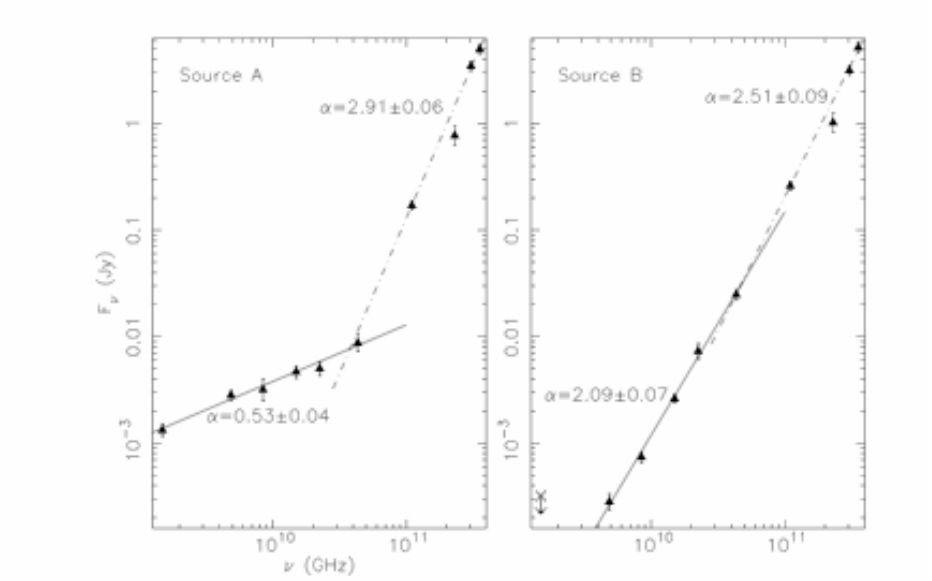


IRAS16293: A and B

- Source A shows multiplicity
- A and B have different spectral indices
- Molecular outflows seem to be associated with Source A
- A and B thus appear to be at different evolutionary stages
- The magnetic field information shows that A is certainly more evolved
- Further analysis is still ongoing…

Chandler et al. 2005





ALMA will be fantastic!!

- Provide 1) sub-arcsec resolution, 2) high dynamic range, and 3) sensitivity will map the field with unprecedented detail from large scales to small

Starless Cores ---> Envelopes --->Disks

Thanks!