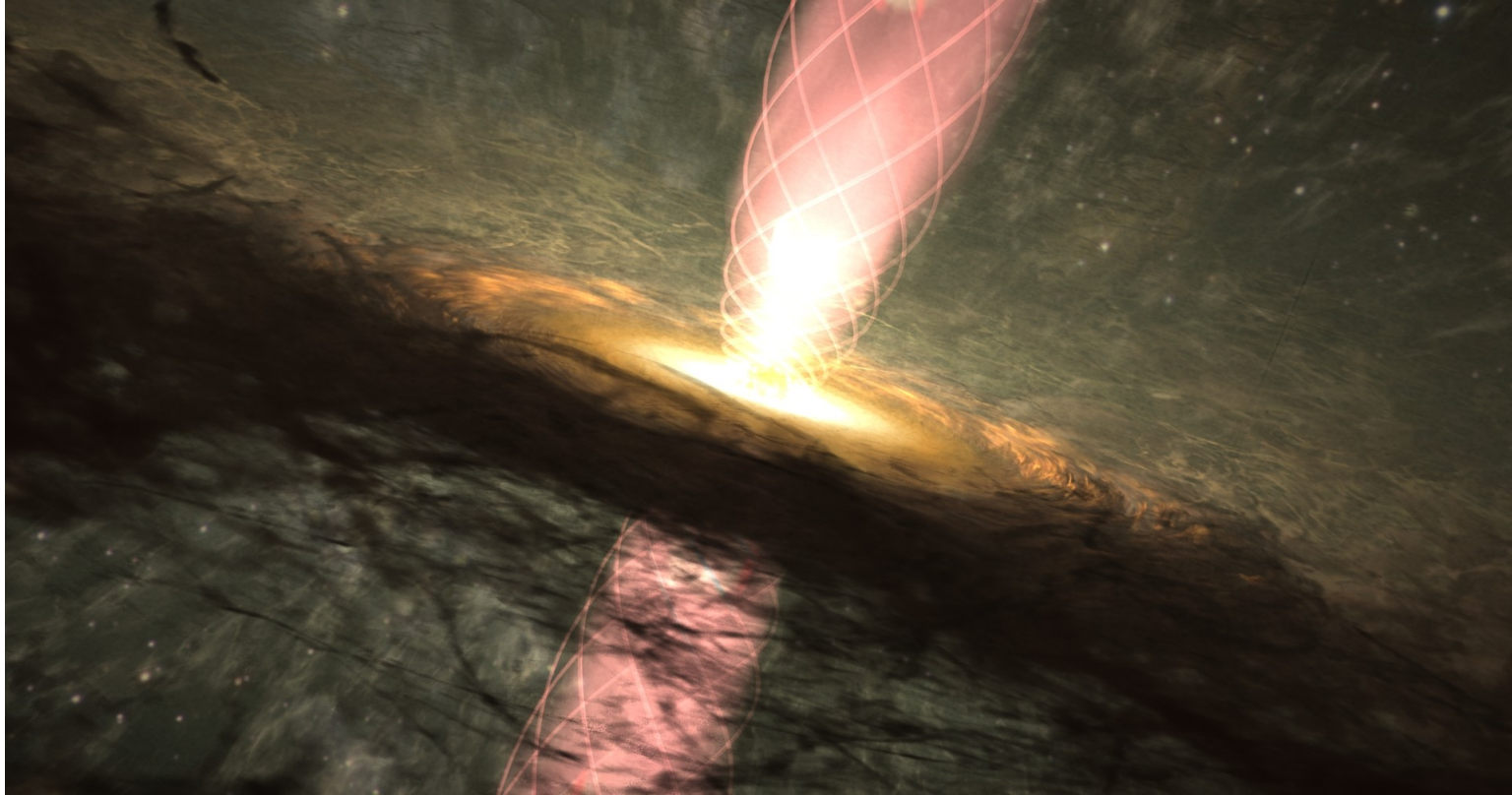


# Discovery of Synchrotron Emission from a YSO Jet



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Josep Martí (U. Jaén), José M. Torrelles (IEEC), Mayra Osorio (IAA)

# Jet Formation and collimation

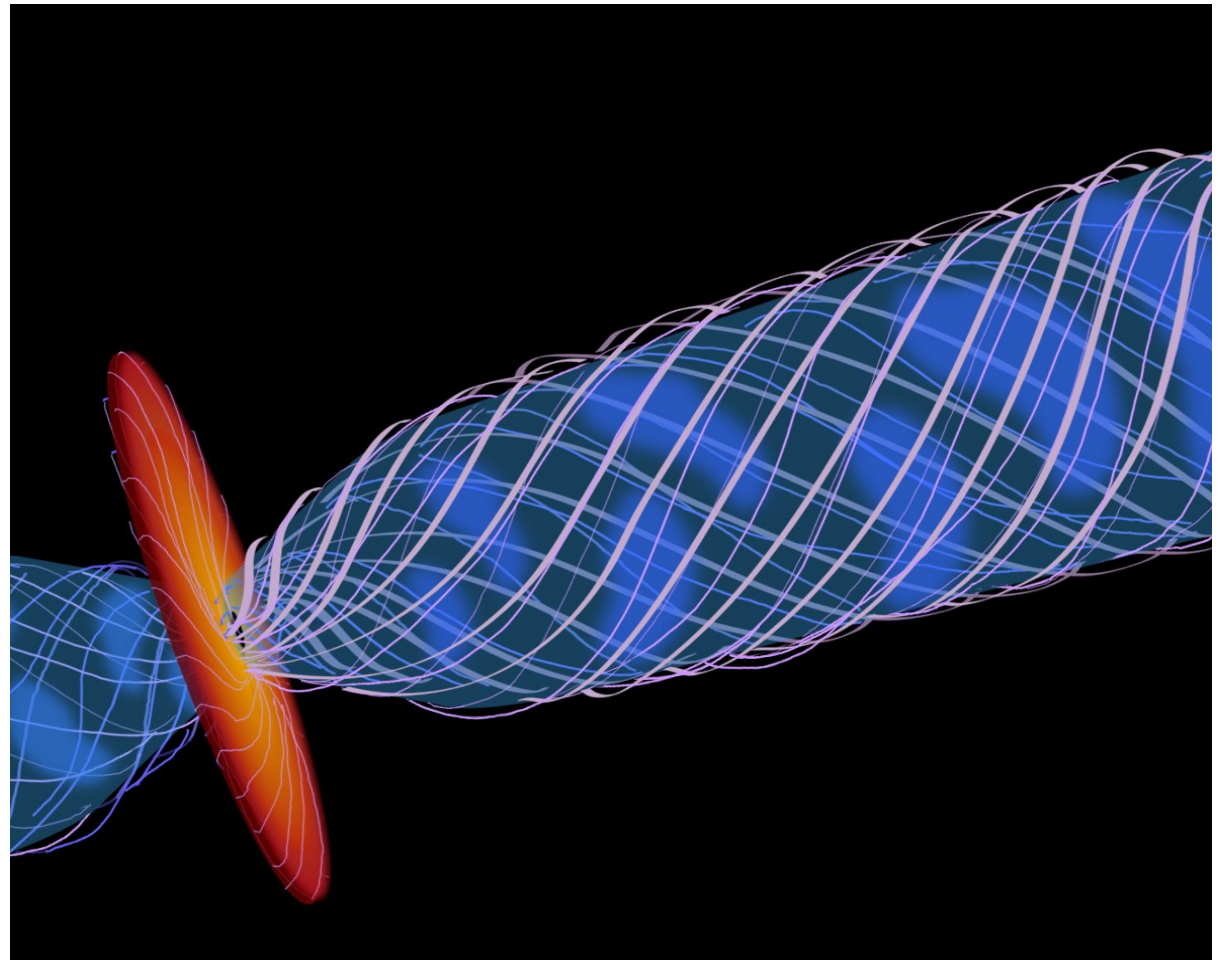
Fundamental ingredients  $\rightarrow$  Accretion disk + Magnetic field

Rotation + accretion  $\rightarrow$  B is twisted in the disk

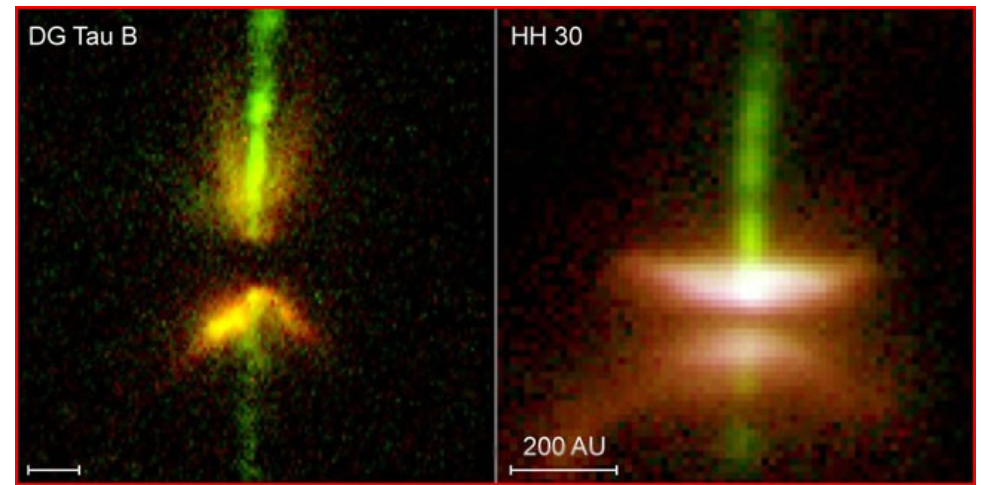
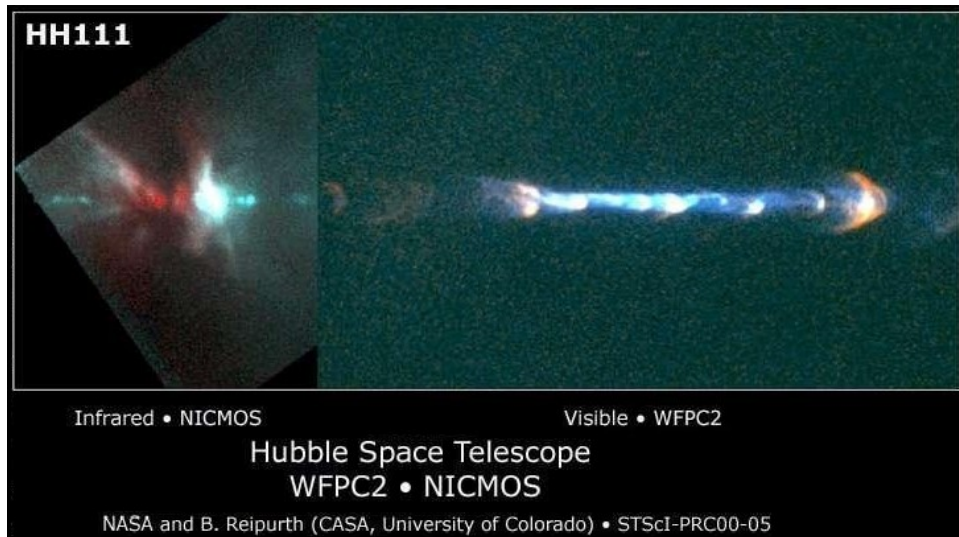
Large distances  $\rightarrow$  helical B  $\rightarrow$  confines the material

Similar mechanism for  
all kind of jets:

- AGNs
- Microquasars
- PNe
- YSOs
- ...



# YSO Jets



Fantastic targets because of number, nearby and lot of information can be obtained from observations

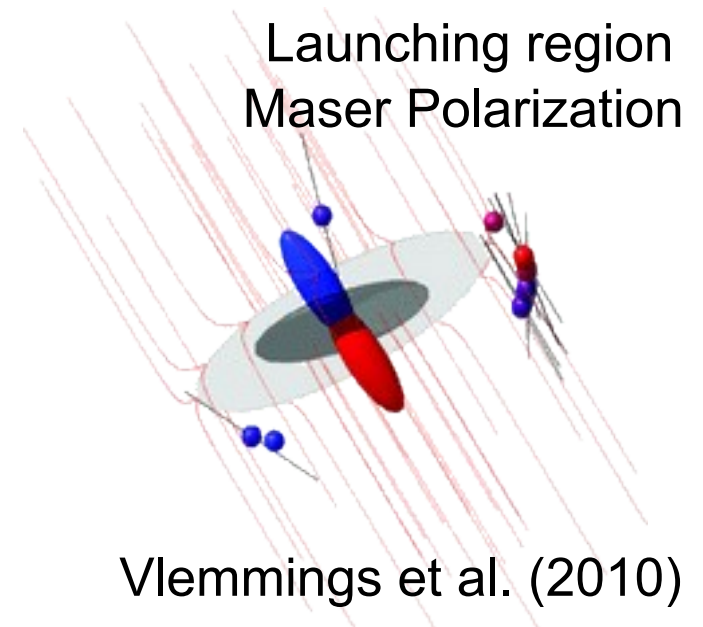
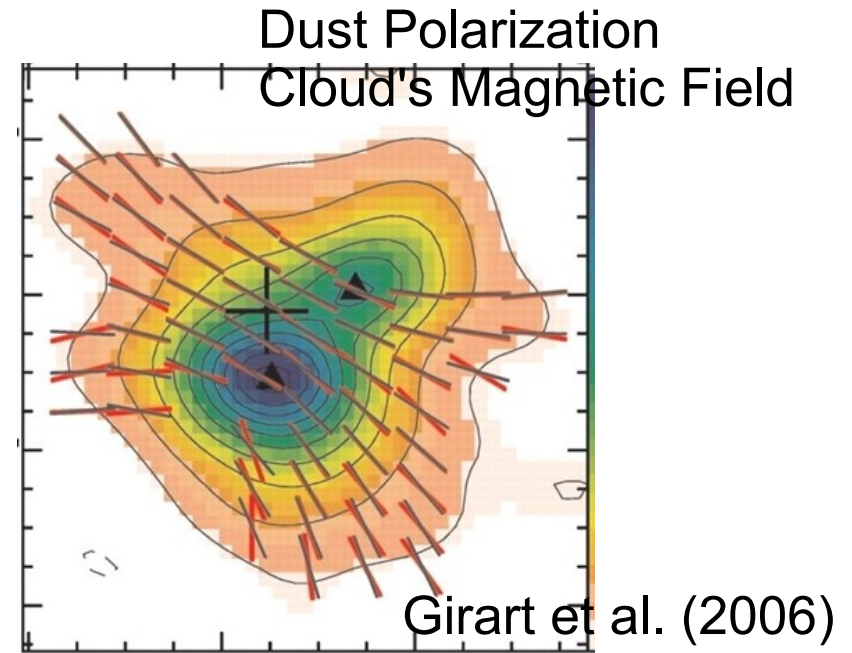
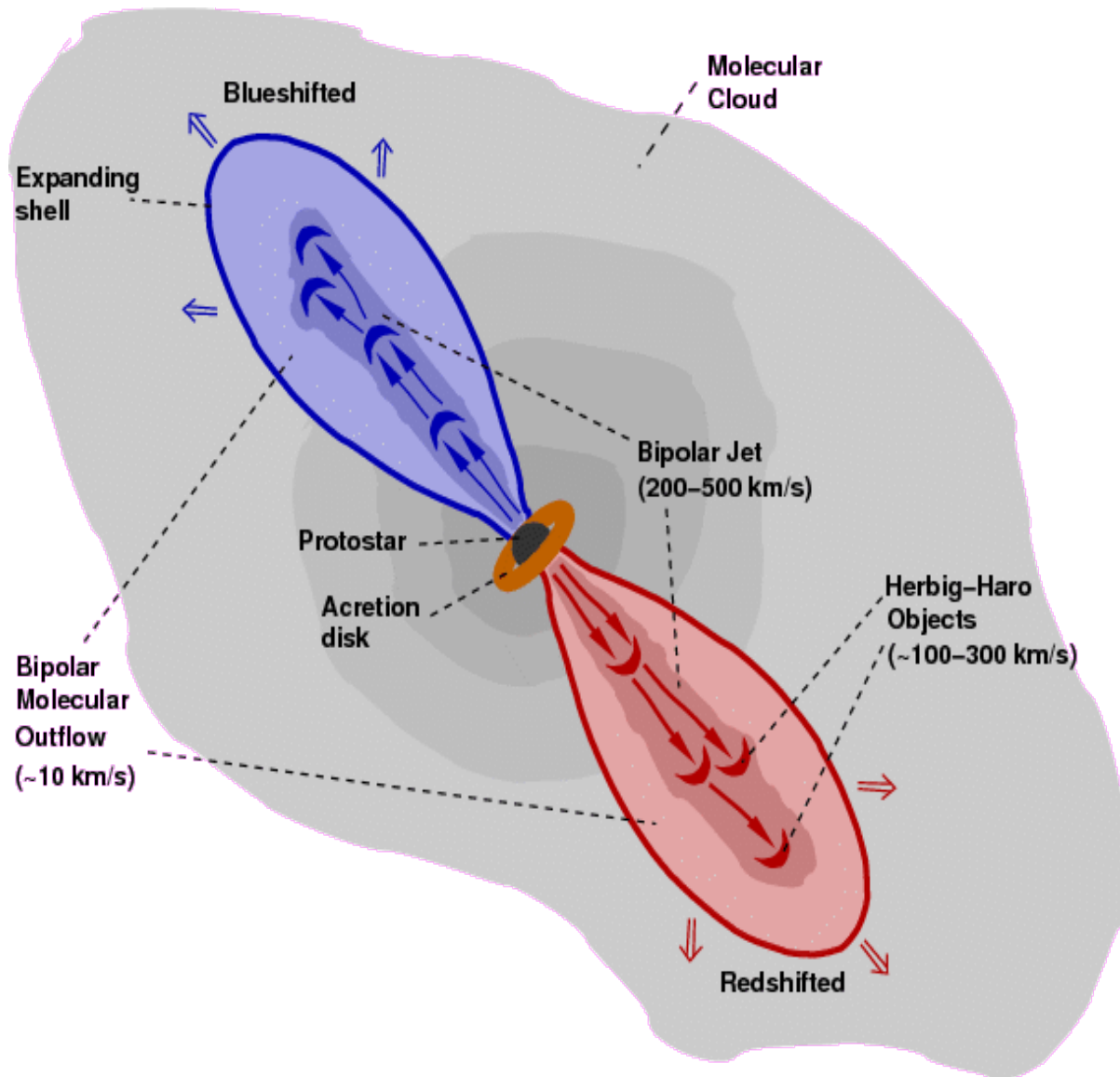
Optical & IR → Temperature, density, mass

Radio → ionized gas, base of the jet

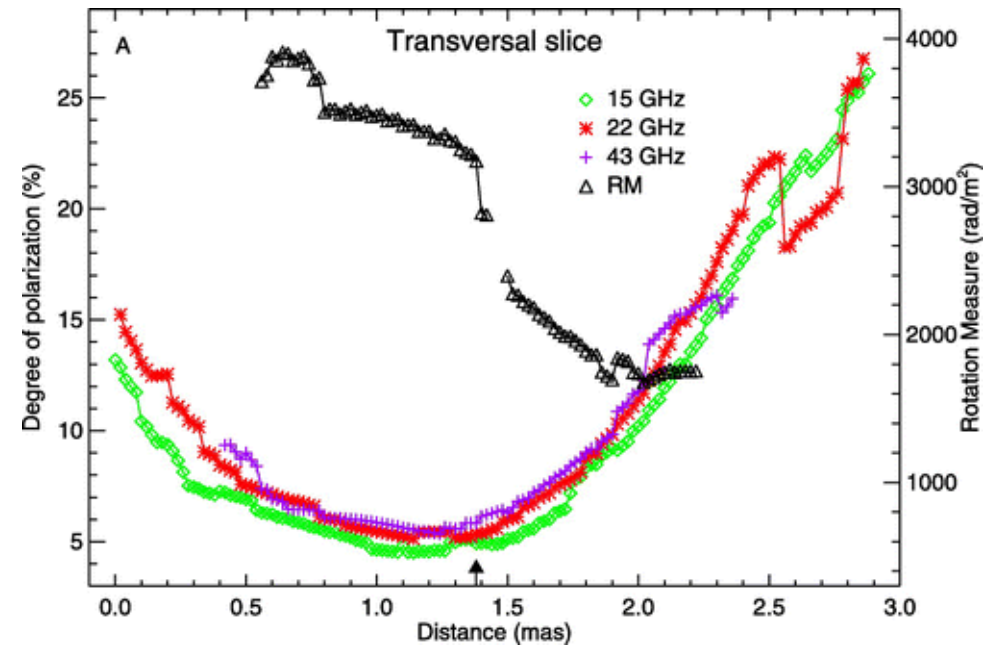
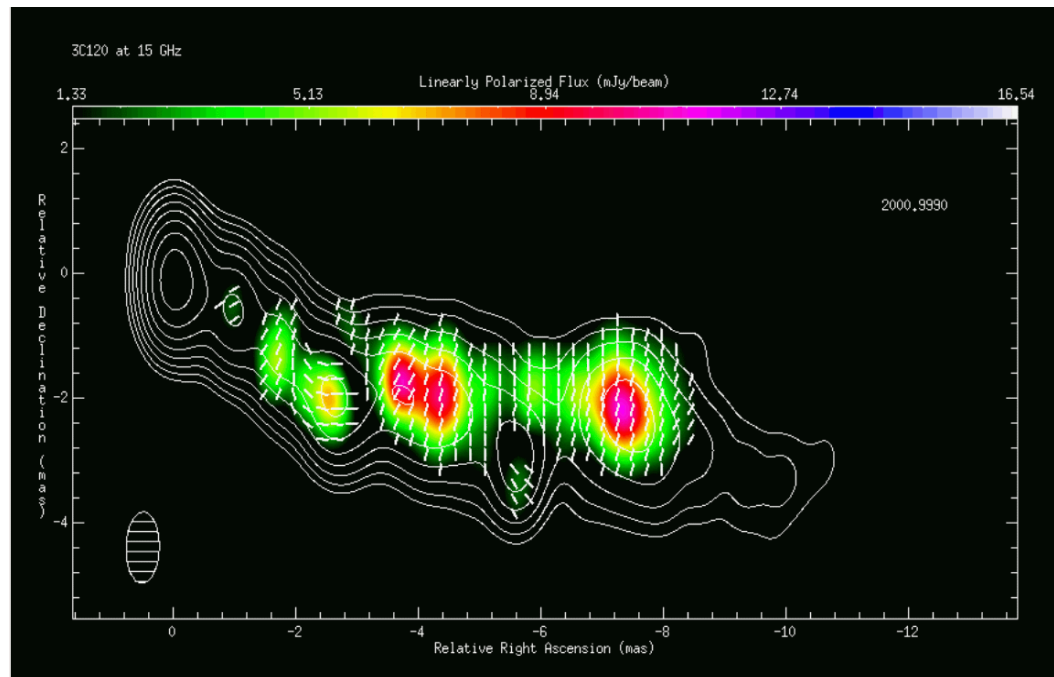
mm/submm → Disk, outflow

But magnetic field difficult to “observe”

# Magnetic Fields in YSO Jets



# Synchrotron Emission from relativistic jets



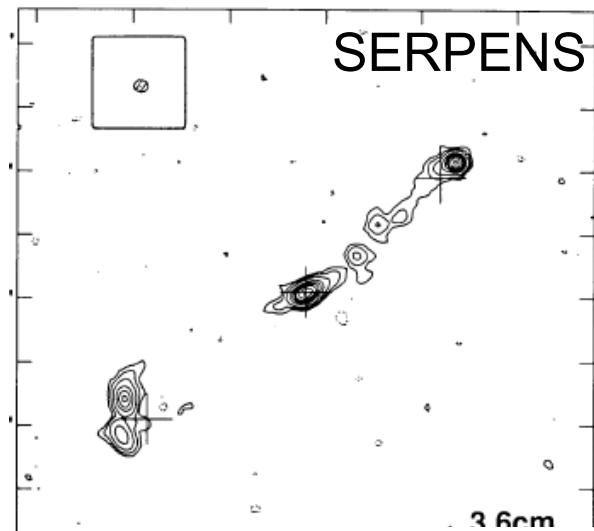
Magnetic fields in relativistic jets can be “easily” studied through their synchrotron emission at radio wavelengths

Intensity of radio emission → Intensity of **B**

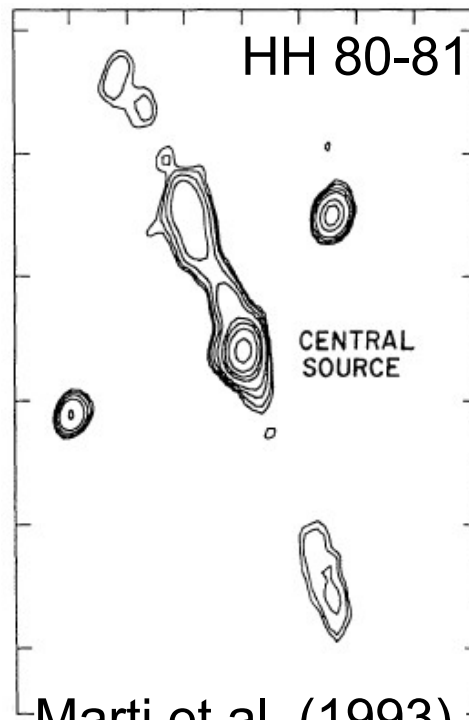
Linear Polarization → Direction of **B**

Pol. Deg and Faraday Rotation → 3D structure of **B**

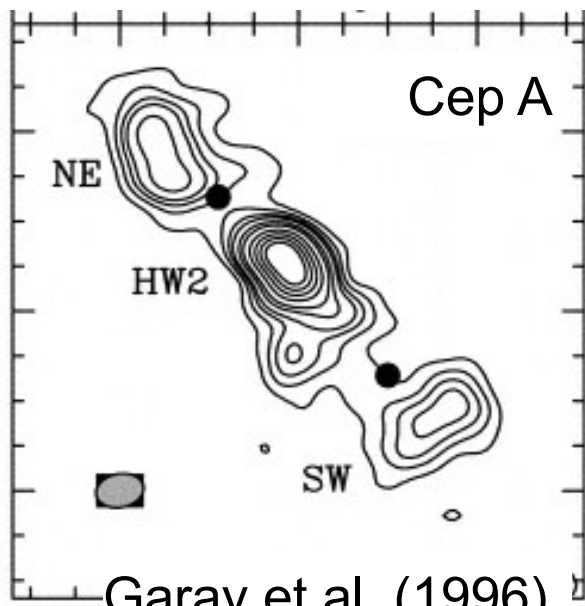
# Synchrotron Emission in YSO Jets???



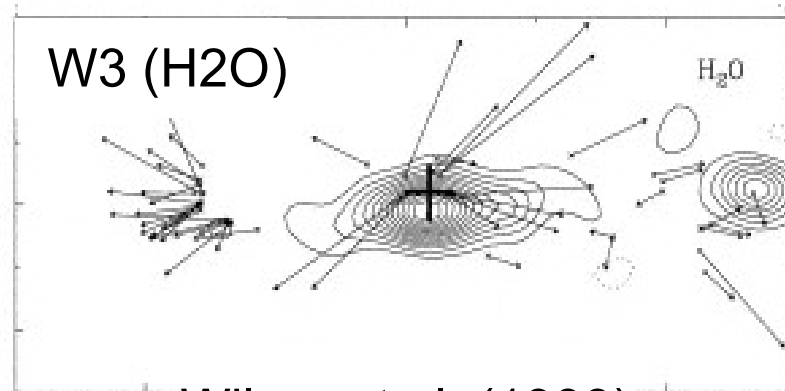
Rodriguez et al. (1989)



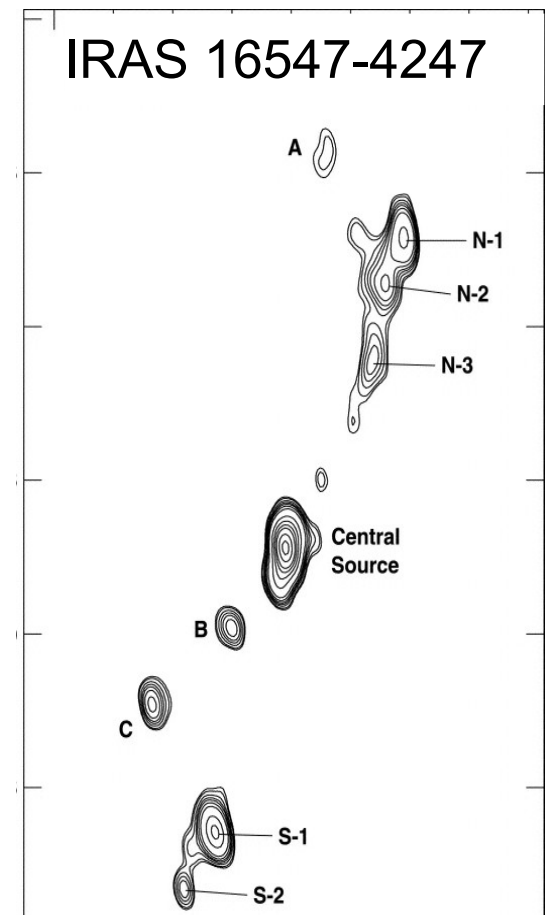
Marti et al. (1993)



Garay et al. (1996)

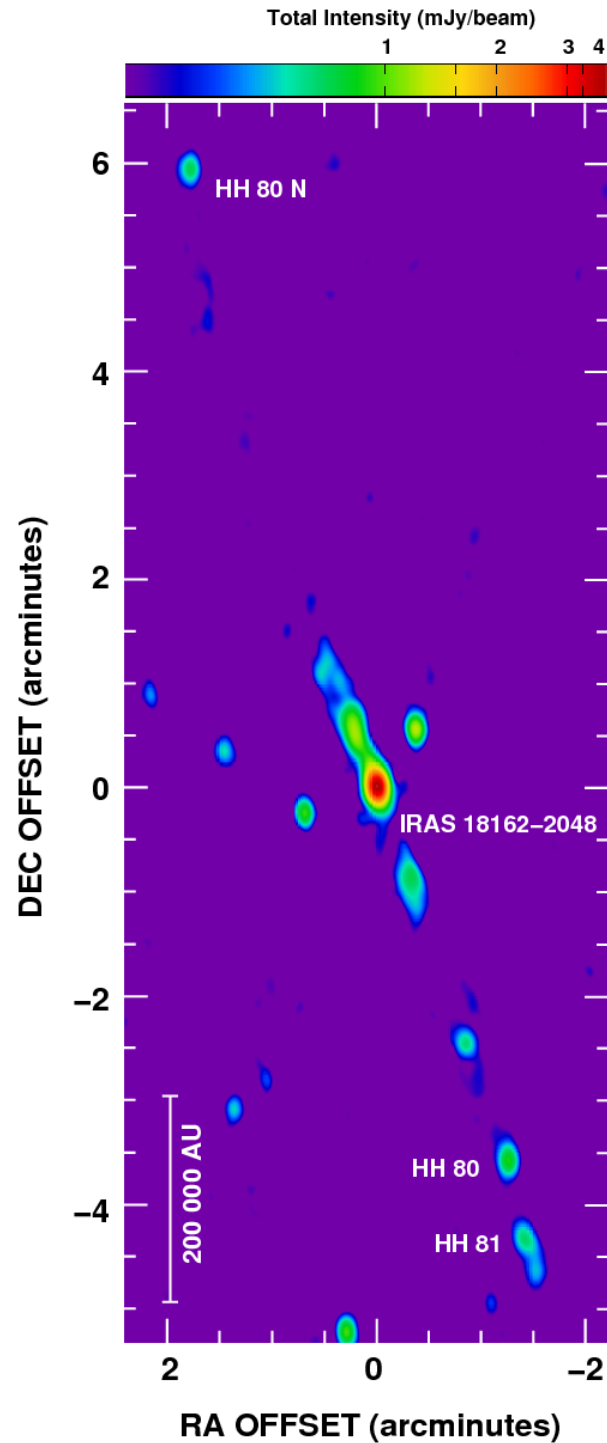


Wilner et al. (1999)



Rodriguez et al. (2005)

# HH 80-81



Distance: 1.7 kpc

IRAS 18162-2048 ; 17,000 L (B0; 10 M )

HH 80, HH 81, HH 80 N (Martí et al. 1993)

Largest ( $\sim 5.3$  pc) and most collimated ( $< 1^\circ$ )  
YSO radio jet known

# HH 80-81

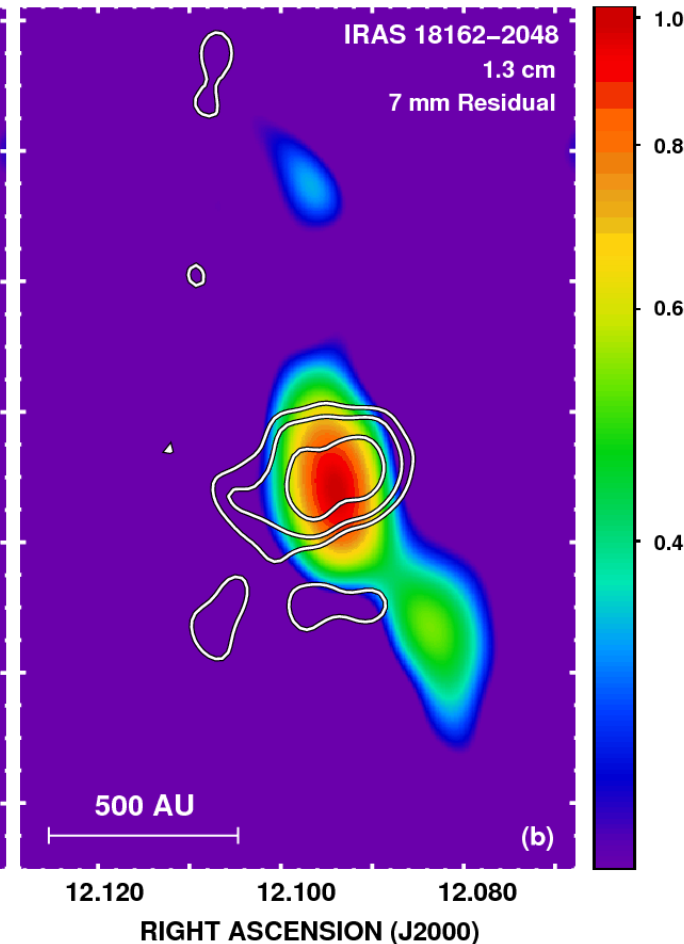
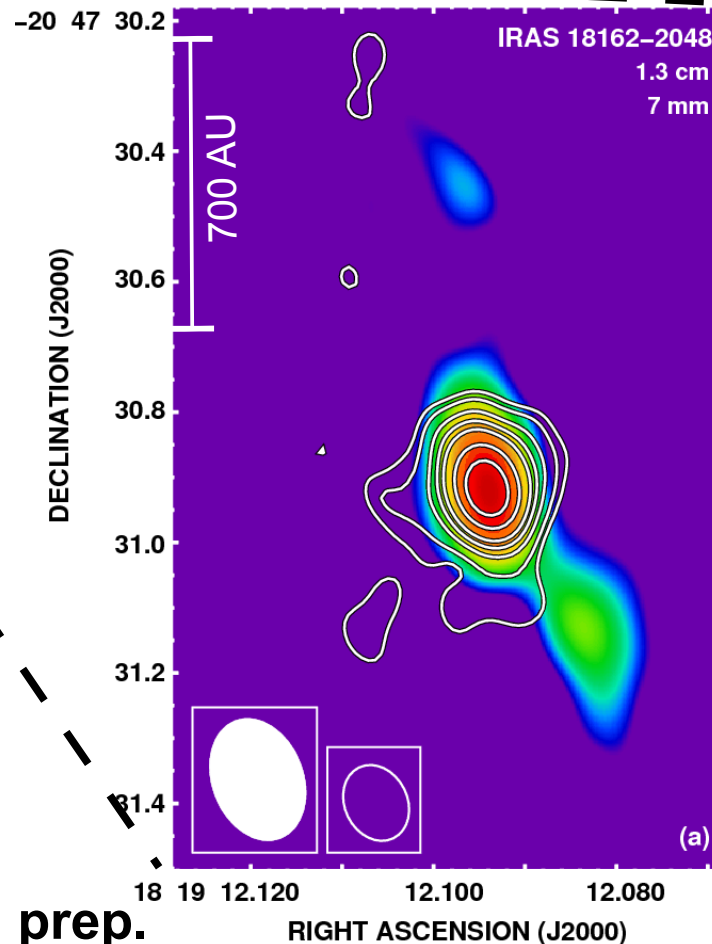
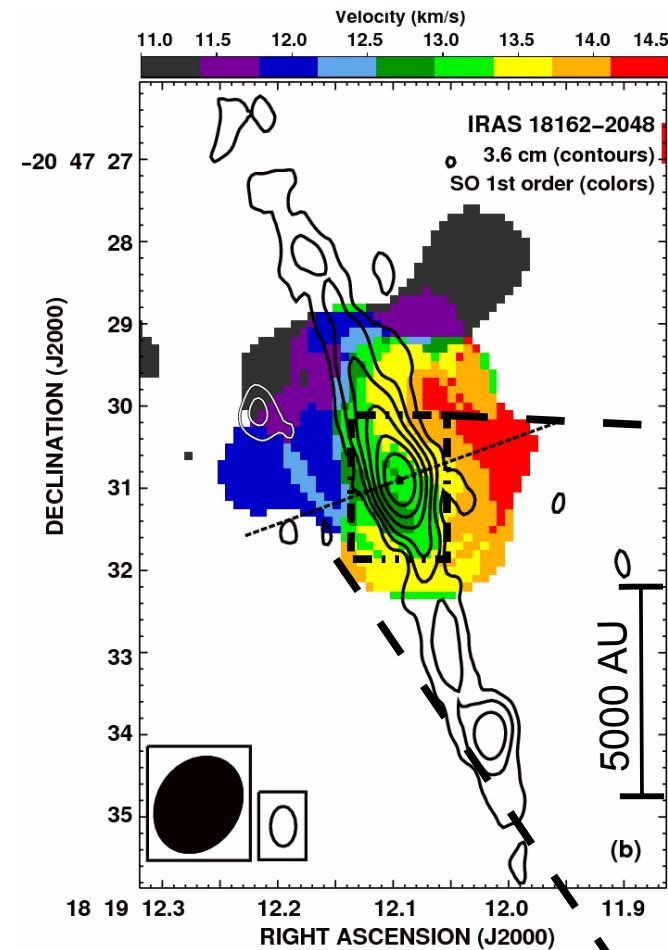
## SMA & VLA Observations

Radius  $\sim 200$  AU

Disk

Mass  $\sim 4\text{--}7$  Msun

Accretion rate  $\sim 10^{-4}$  Msun/yr



# HH 80-81

Martí et al. (1993)

**Central source: Thermal free-free emission  
and dust from the disk**

**HHs and knots in the radio jet: non-thermal**

**Which is the emission mechanism?**

**If synchrotron  $\rightarrow$  magnetic field + relativistic electrons**

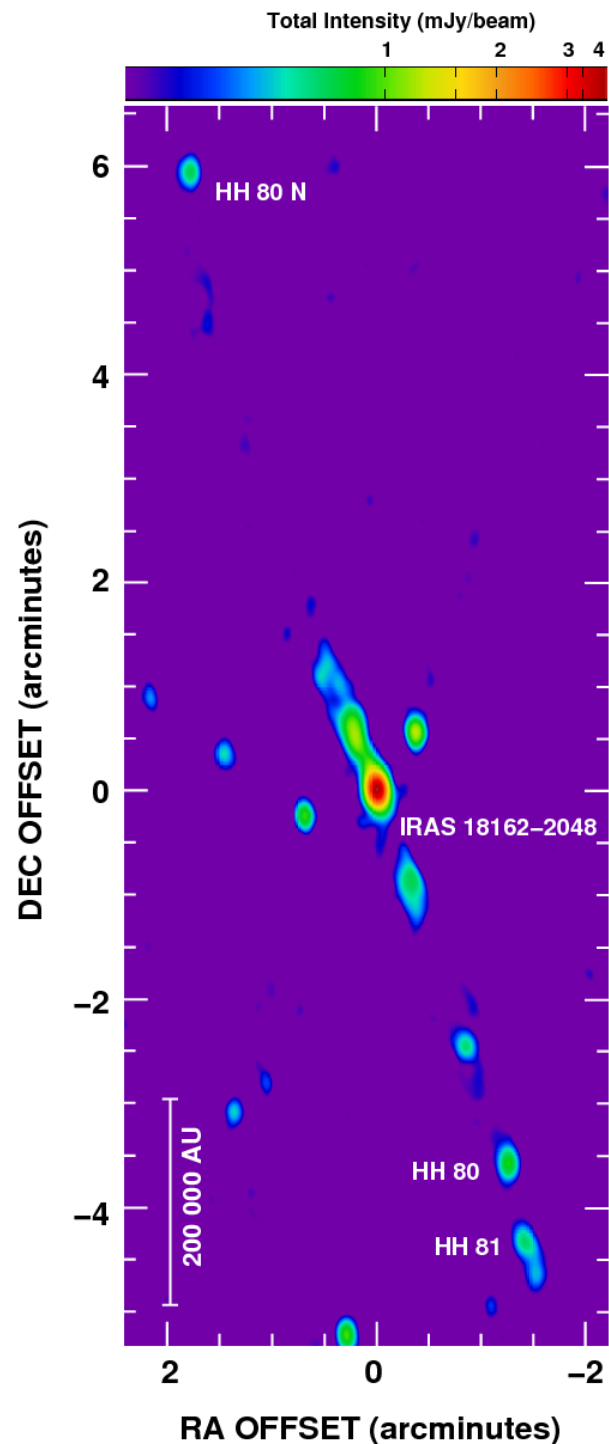
**electron acceleration  $\rightarrow$  strong shocks (Fermi  
mechanism)**

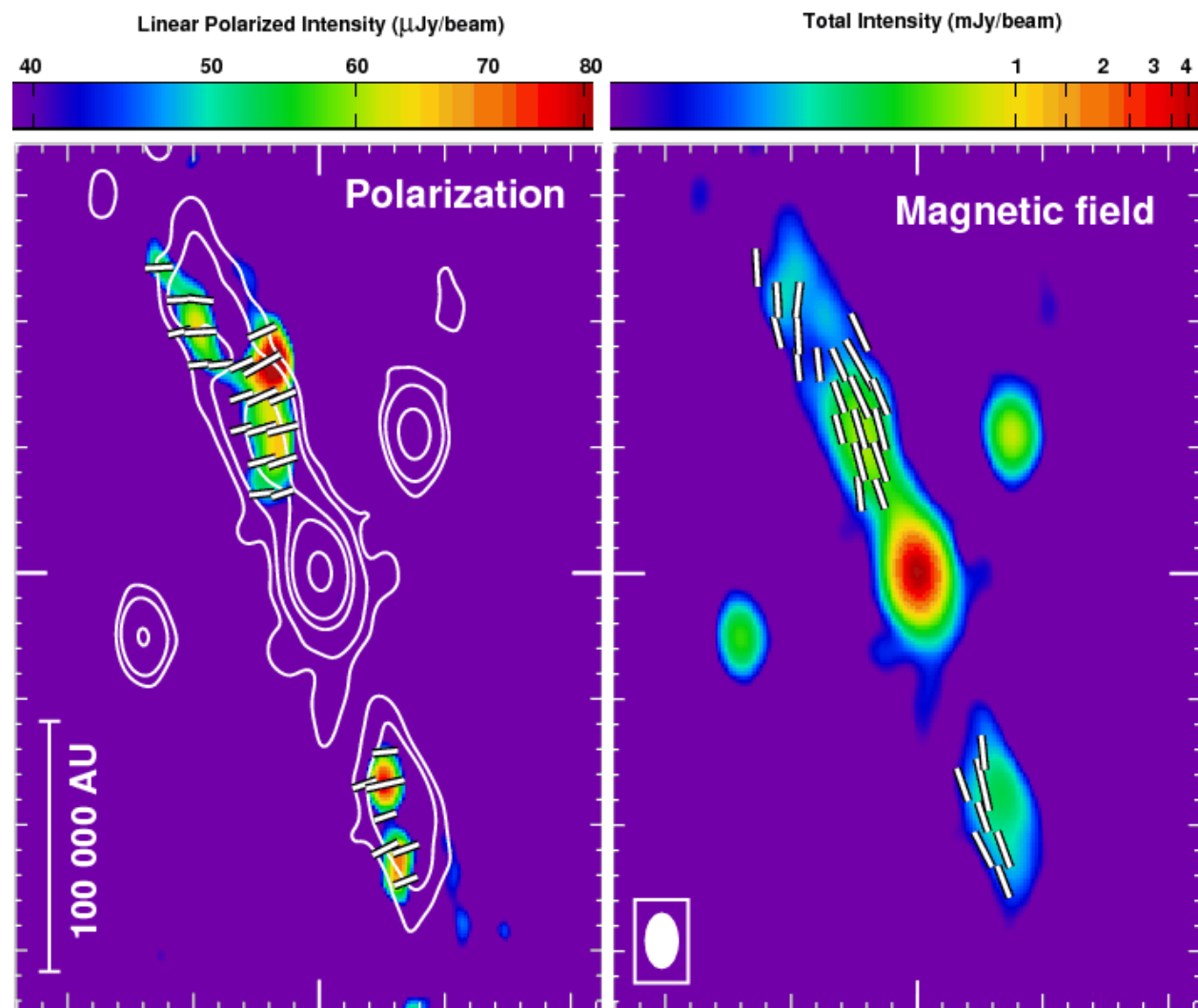
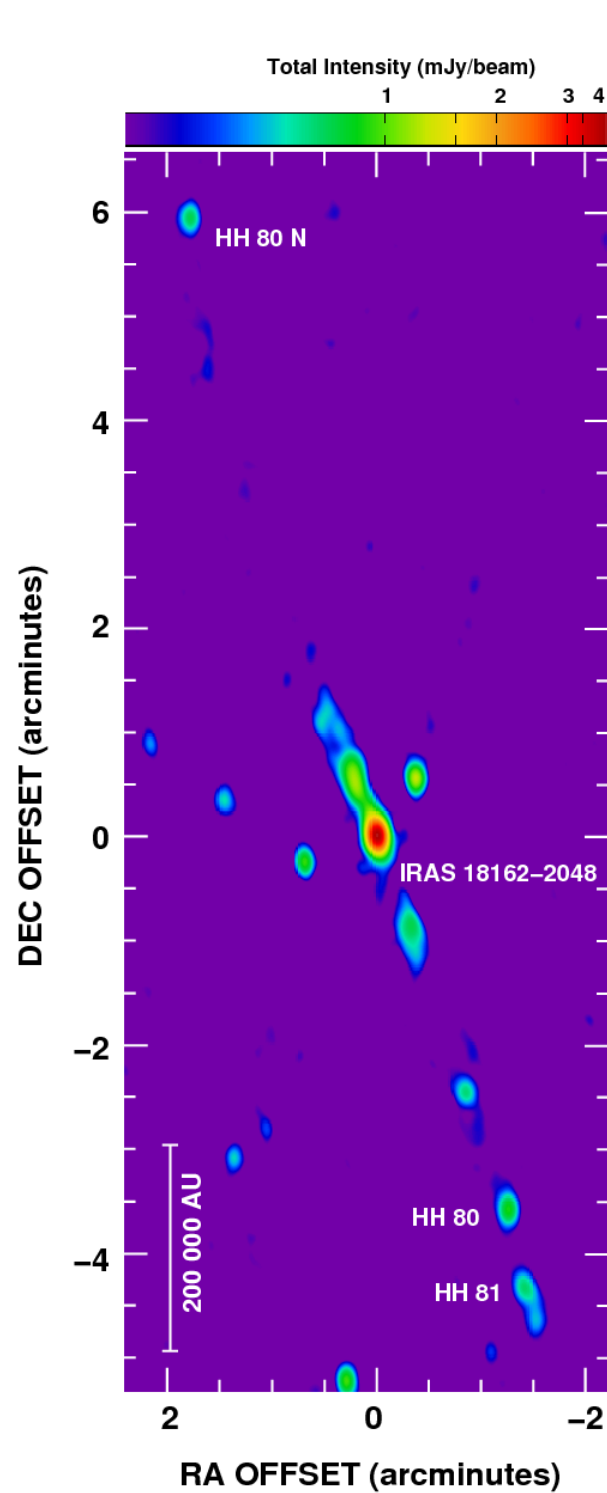
**POSSIBILITY TO STUDY THE MAGNETIC FIELD IN  
THE JET THROUGH LINEAR POLARIZATION!!!**

**...but weak  $\rightarrow$  very high sensitivity required**

**So, we observed with the VLA at 6 cm during 12 hours**

**We reached a rms noise of  $\sim 10$  microJy/beam**

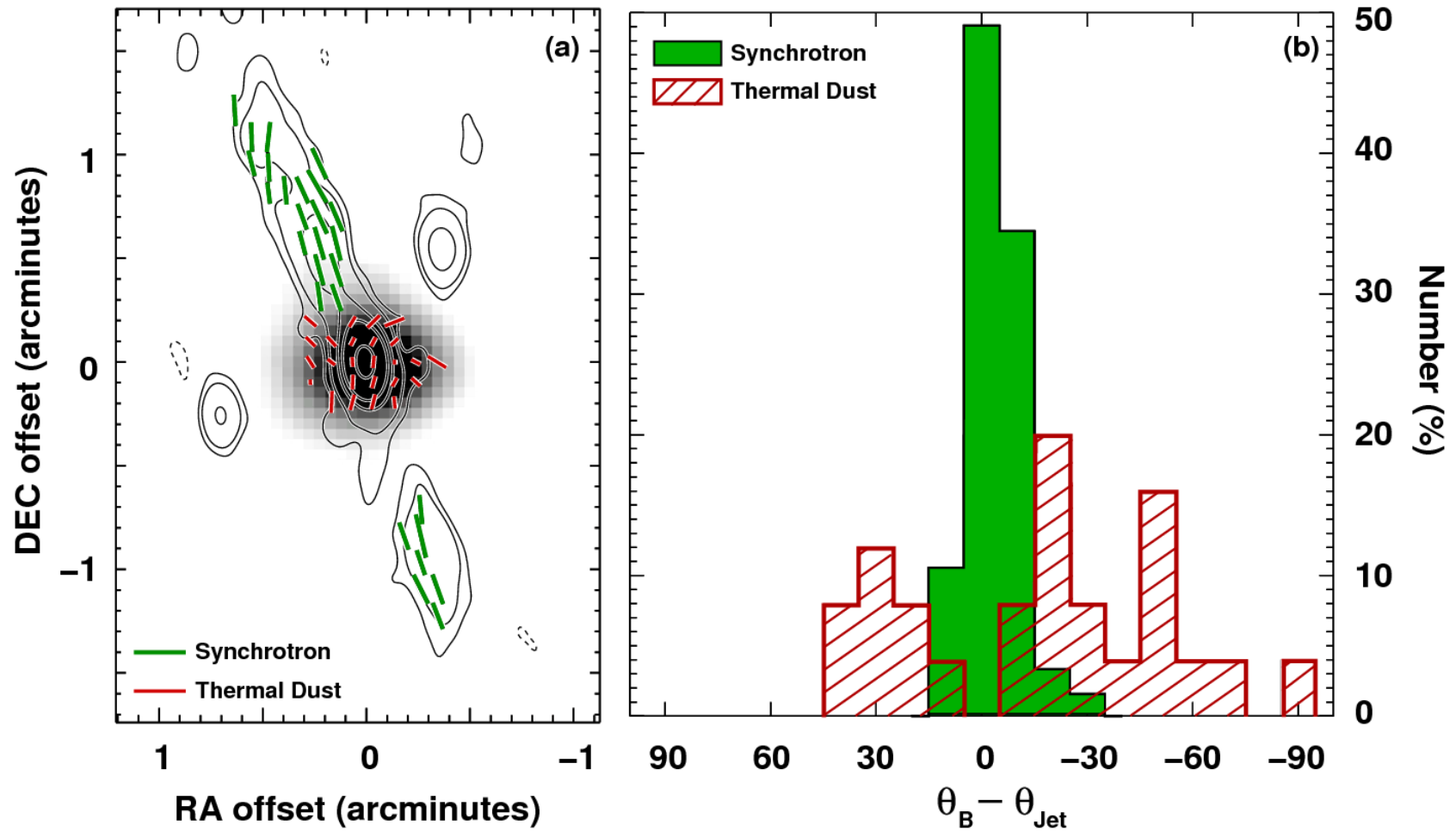




**Magnetic field appears parallel to the jet axis**

**We estimate magnetic field strength 0.2 mG**

**Carrasco-González et al. (2010)**

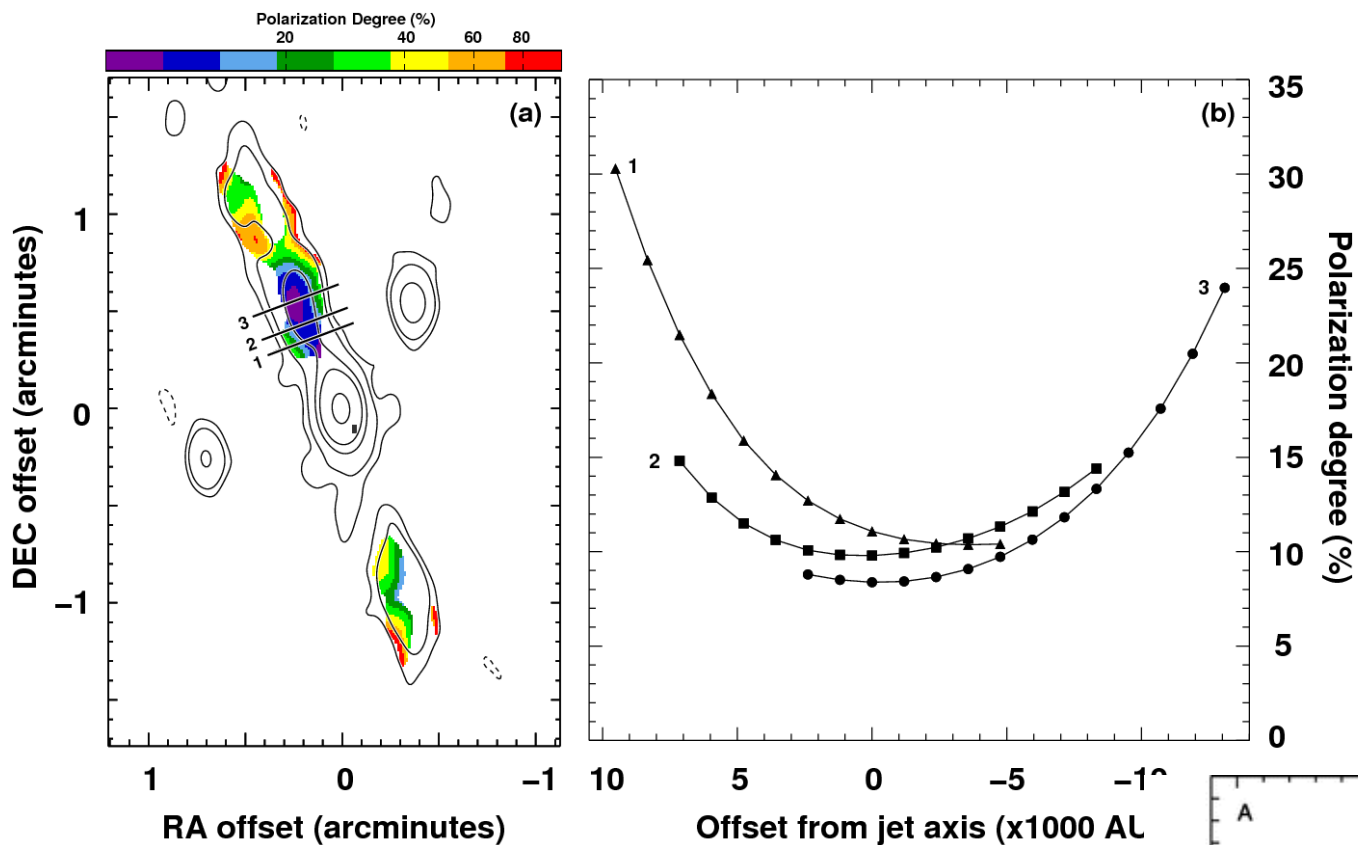


Polarized dust emission direction shows considerable scatter with respect to the jet direction (Curran et al. 2007) → envelope/disk

Magnetic field traced by synchrotron emission is intrinsic to the jet

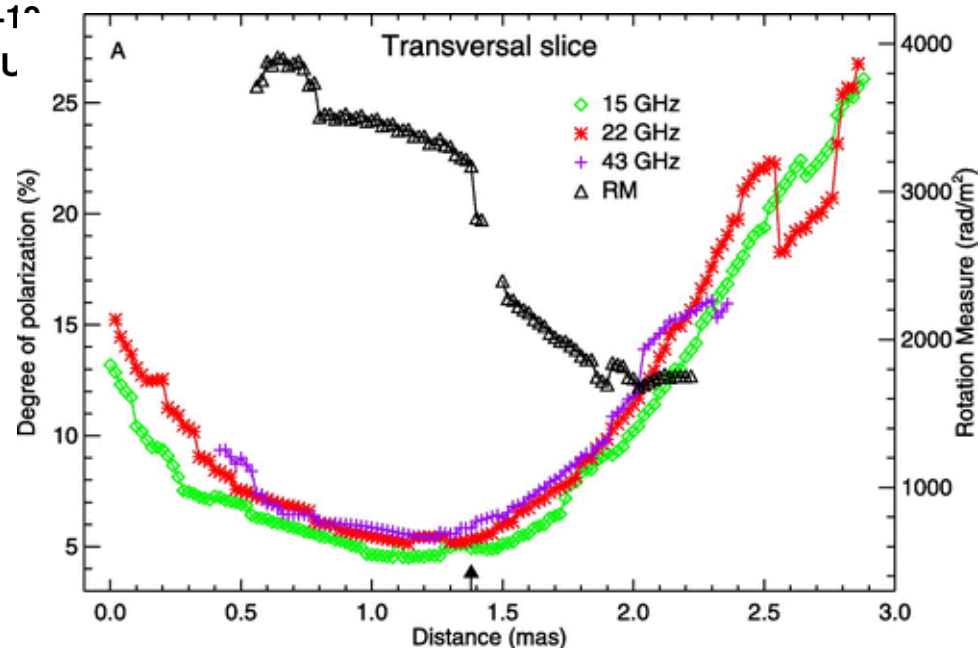
We measure similar values for the magnetic field strength at 0.5 pc from the star

The jet is removing magnetic field from the disk

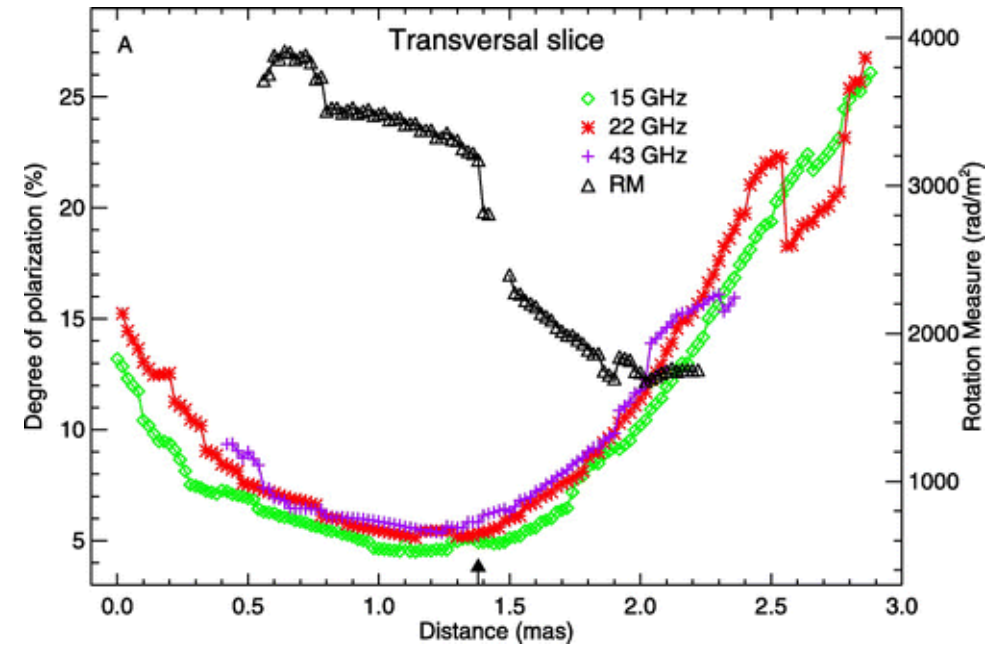
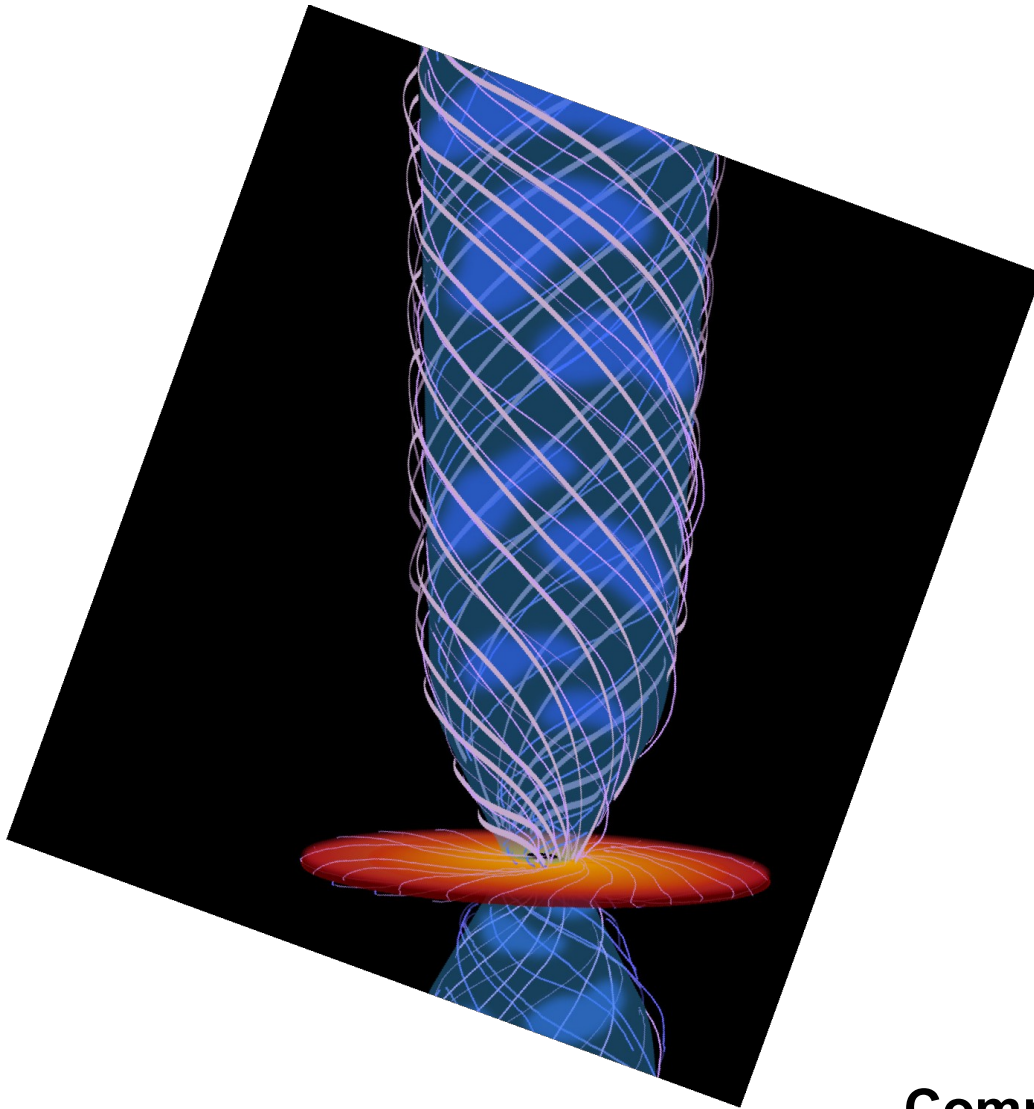


**Polarization degree increases towards the edges of the jet**

**Similar to what is commonly found in extragalactic jets and what we would expect to observe in a helical magnetic field (e.g. Lyutikov et al. 2005)**



Gómez et al. (2008)



**Compatible with helical magnetic field.**

**But need of Farady Rotation measurements.**



## Expanded Very Large Array

Higher Sensitivity

Observations of a sample of  
protostellar jets

Using this technique and  
combining with others (optical/IR)  
we can obtain full description of  
jets



## ALMA

High angular resolution and sensitivity  
at (sub)mm wavelengths

Disk's magnetic field