

# Faraday rotation and degree of polarization gradients in 3C120: Jet interaction and a helical field?

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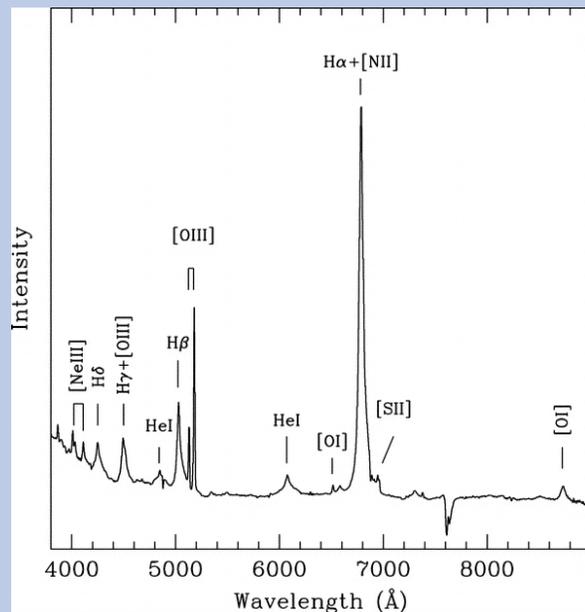
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Boston University, Boston, USA

## 3C120

It is an unusual active galaxy, classified as both, **Seyfert 1** and **broad line radio galaxy**.

- Complex optical morphology, possibly the result of a merger (Moles et al. 1988, García-Lorenzo et al. 2005)



Optical spectrum (García-Lorenzo et al. 2005)

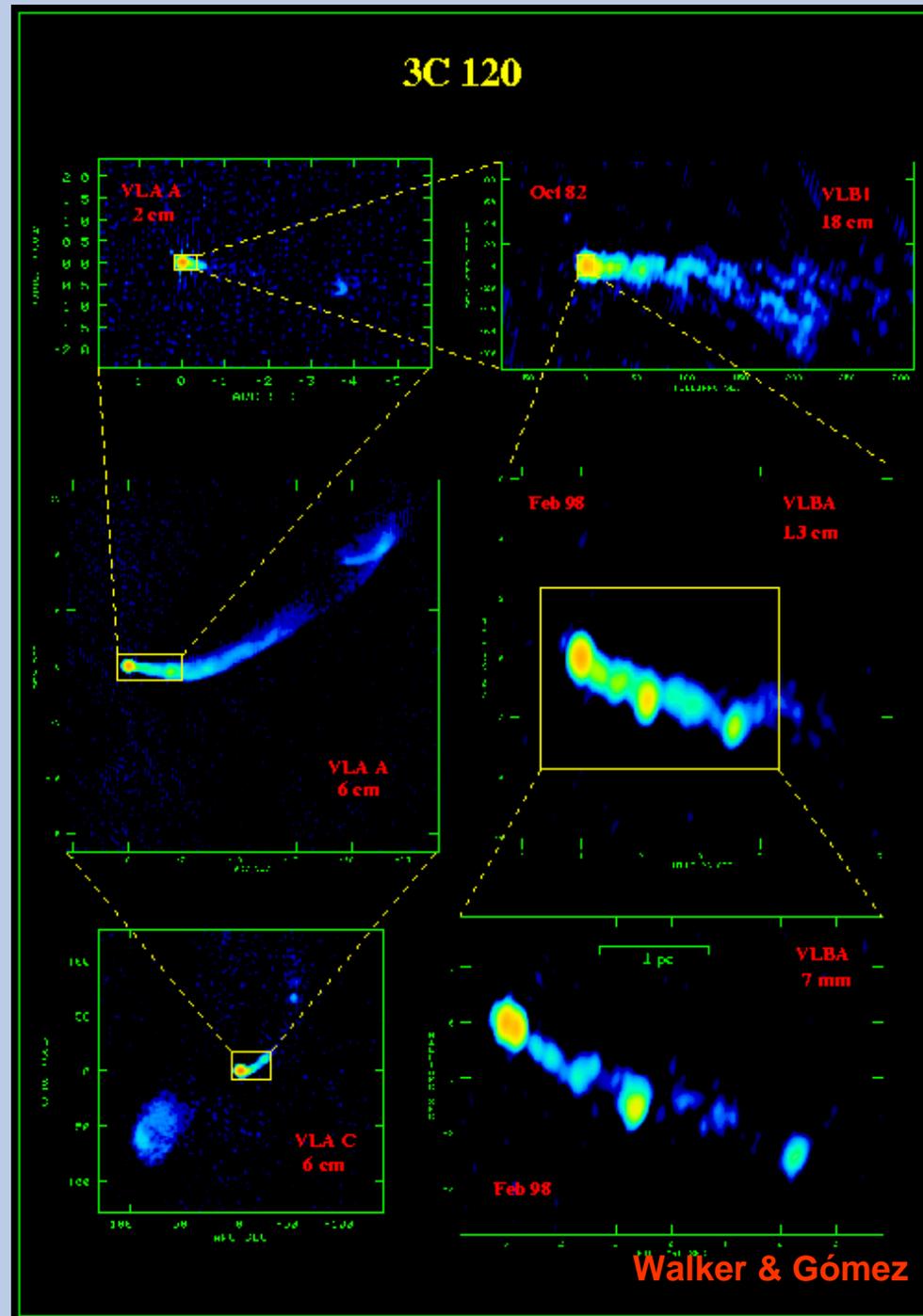
HST image + VLA image by Walker et al.

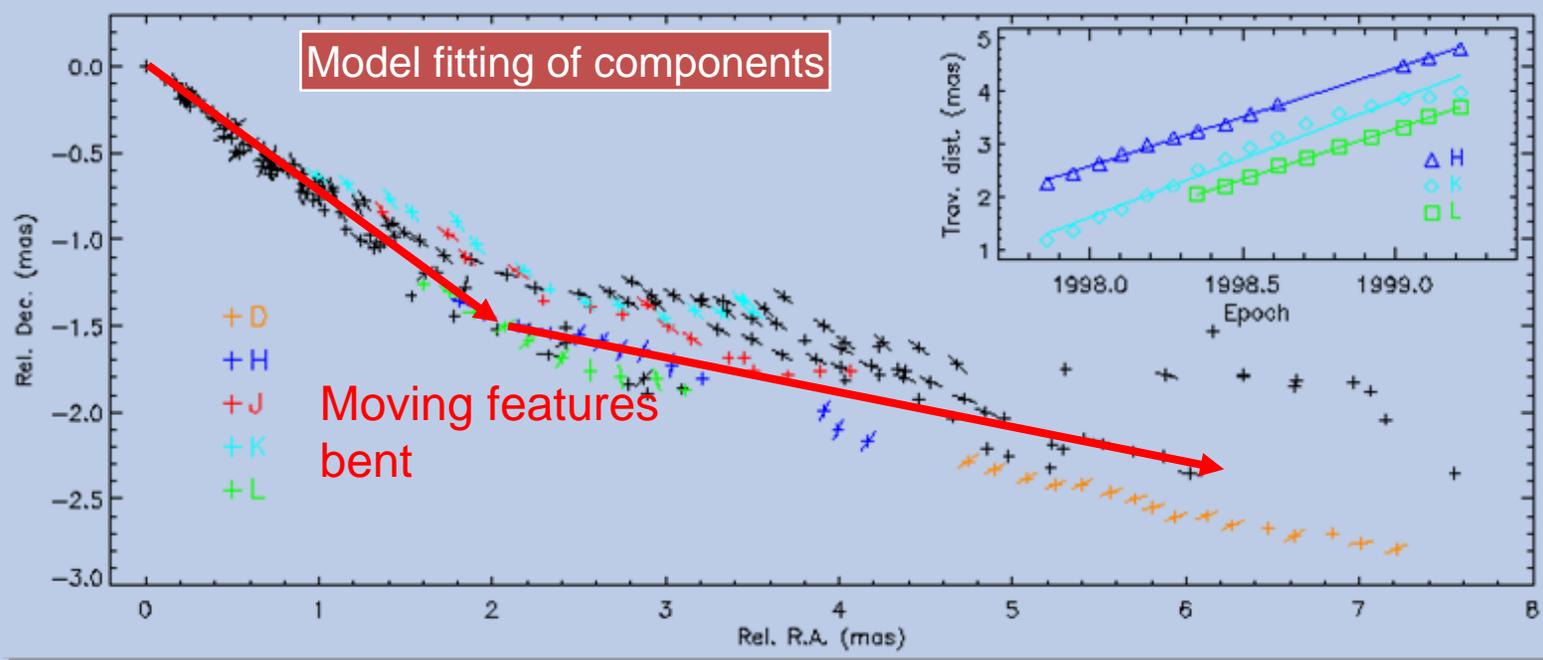


- Prominent one sided jet observed in radio (Walker et al., Gómez et al., Marscher, et al.)

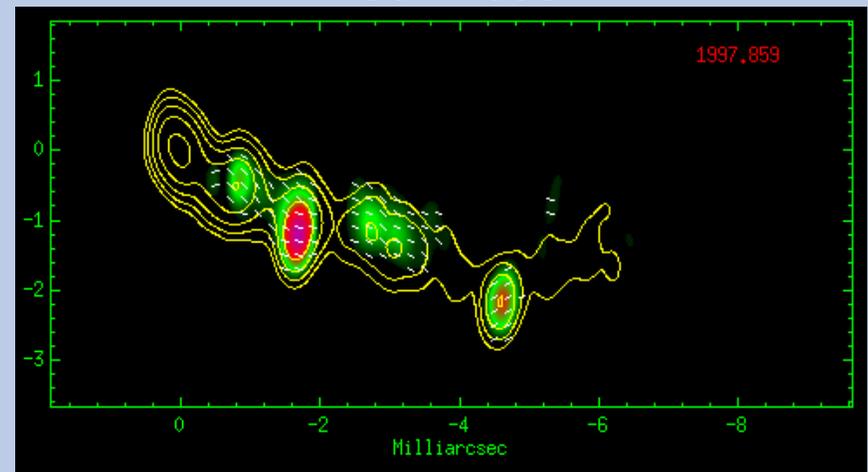
**3C120**

- Prominent radio jet from pc to kpc
- One of the first sources in which superluminal motions (5-6 c) were found
- Very active jet, with multiple components and very rich structure even at the shortest wavelengths
- One of the closest superluminals. At  $z=0.033$  ( $\sim 125$  Mpc), the VLBA at 7 mm provides a linear resolution of  $0.07\text{pc}$  ( $\sim 10^4 R_s$ )
- One of the best sources for studying the inner jet properties in superluminals



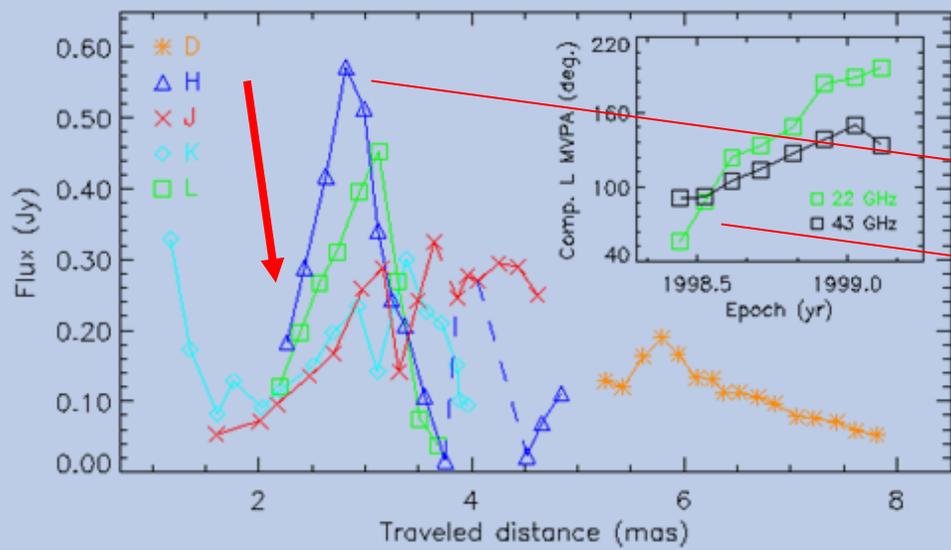
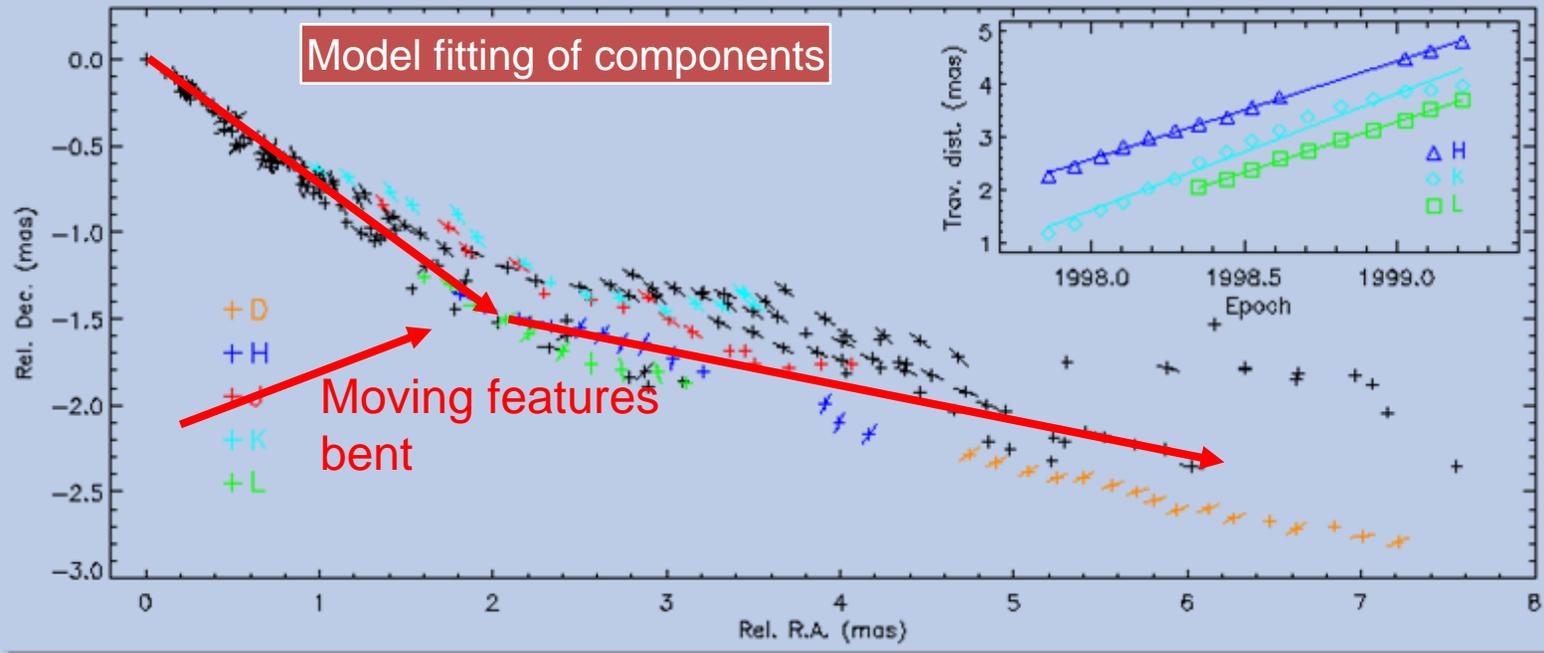


1997-1999



Gómez et al. (2000)

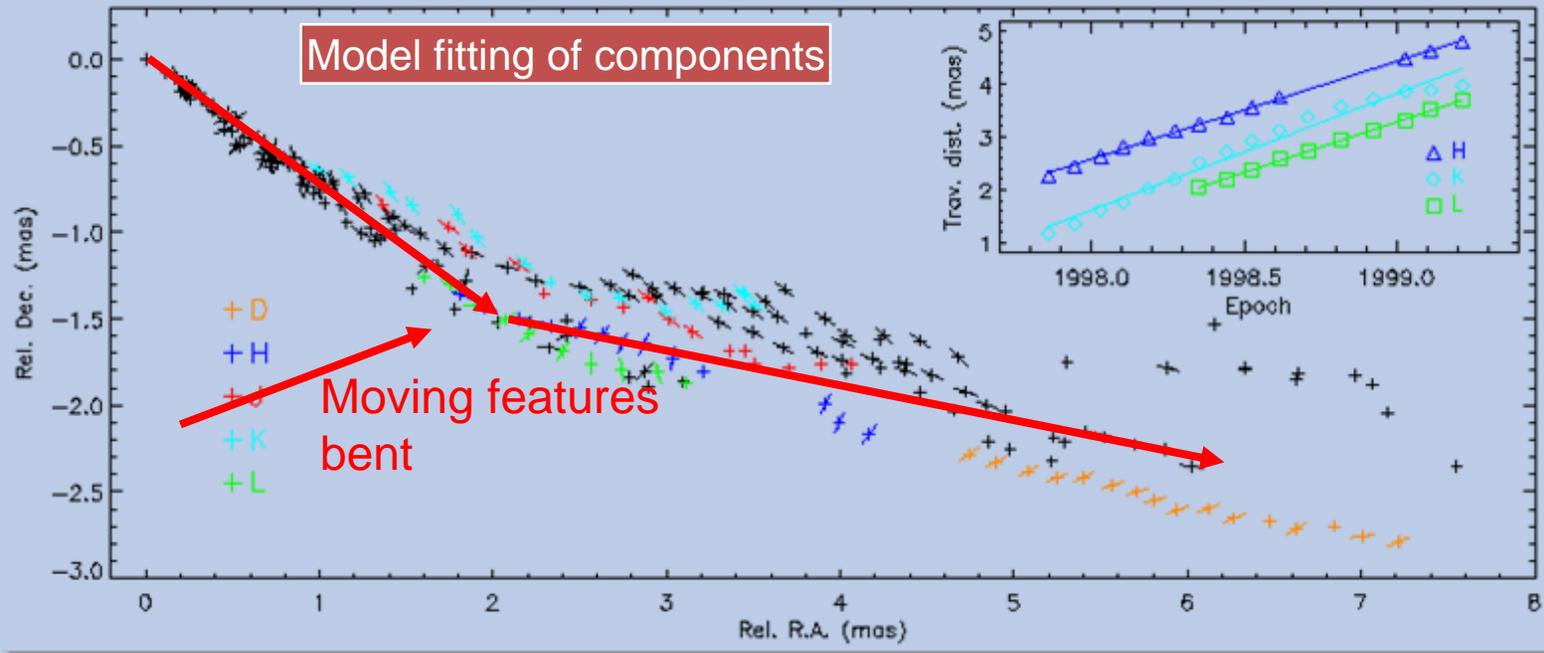
Gómez et al. (2000)



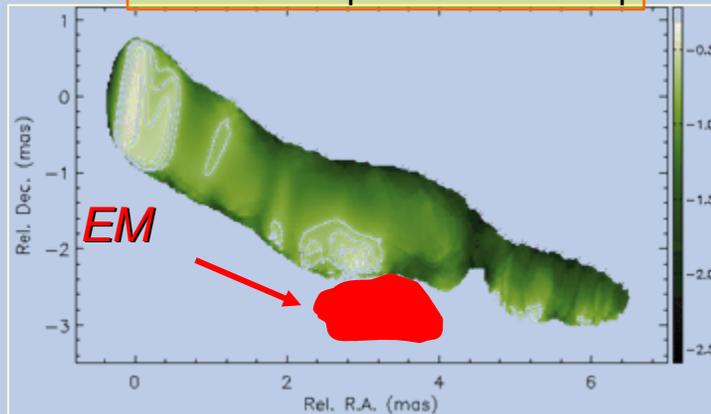
Arrows mark the position at which southern components start:

- ✓ Flaring in total and pol. flux
- ✓ Differential rotation of the EVPAs at 22 and 43 GHz.

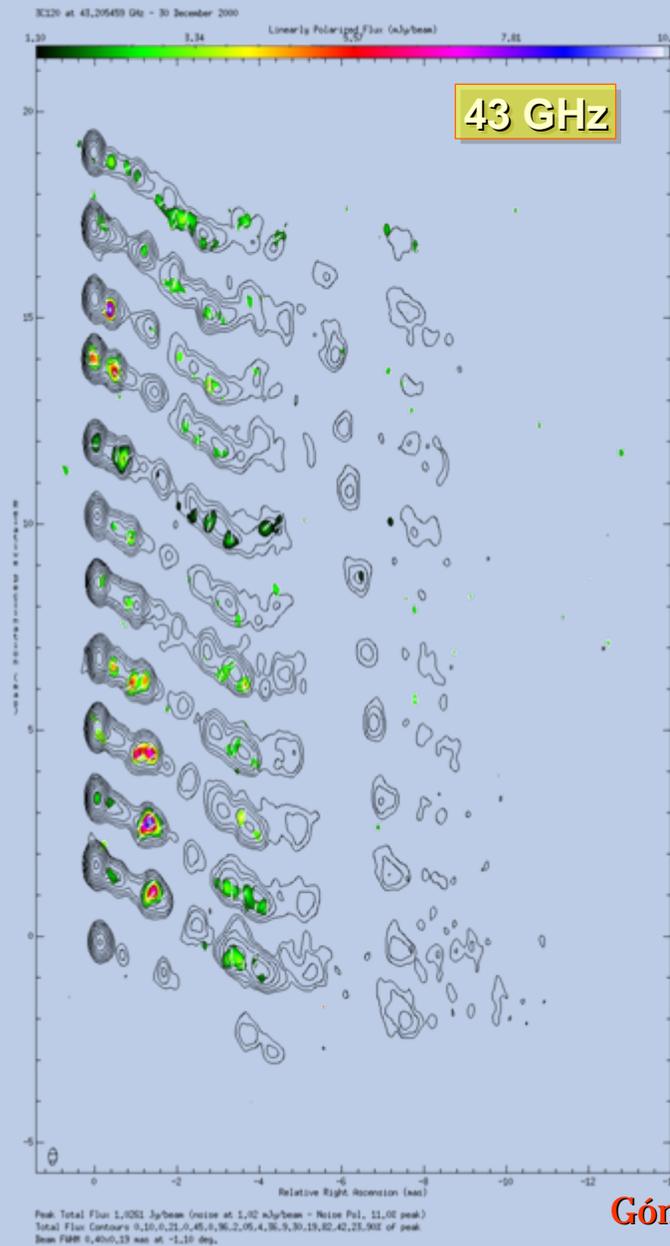
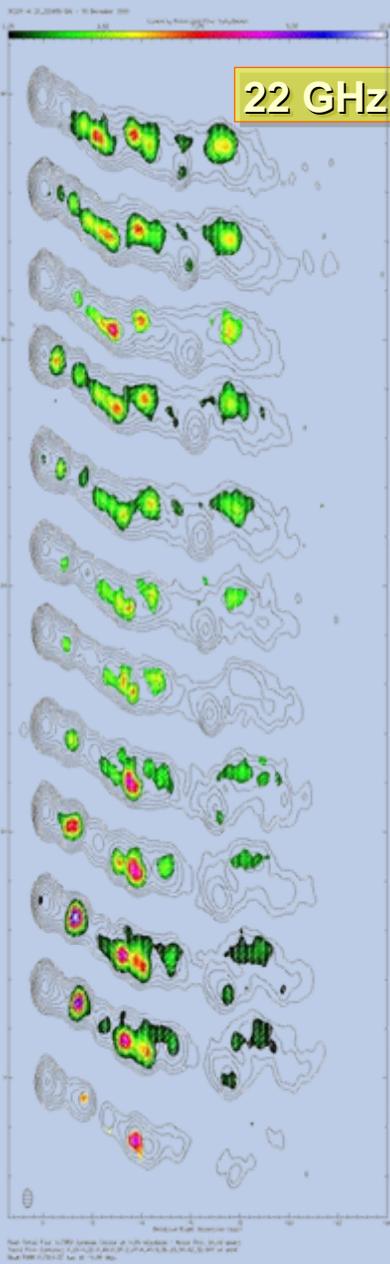
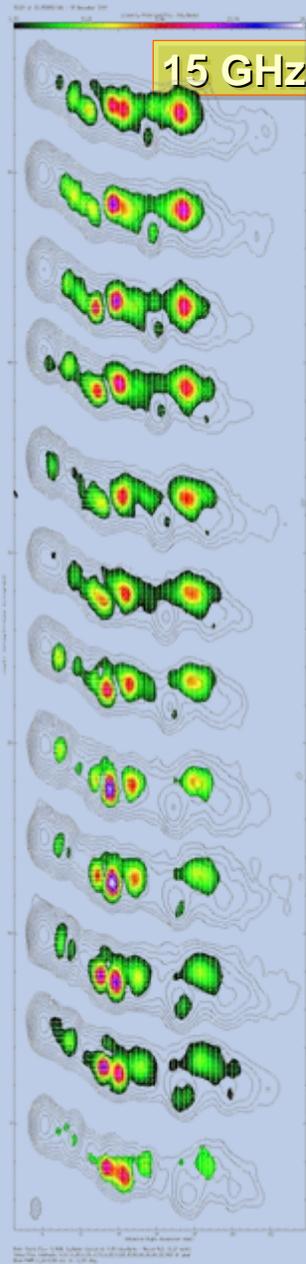
Gómez et al. (2000)



22-43 GHz Spectral index map



Evidence for the interaction with an ext med (cloud) of properties intermediate of those of the BLR and NLR



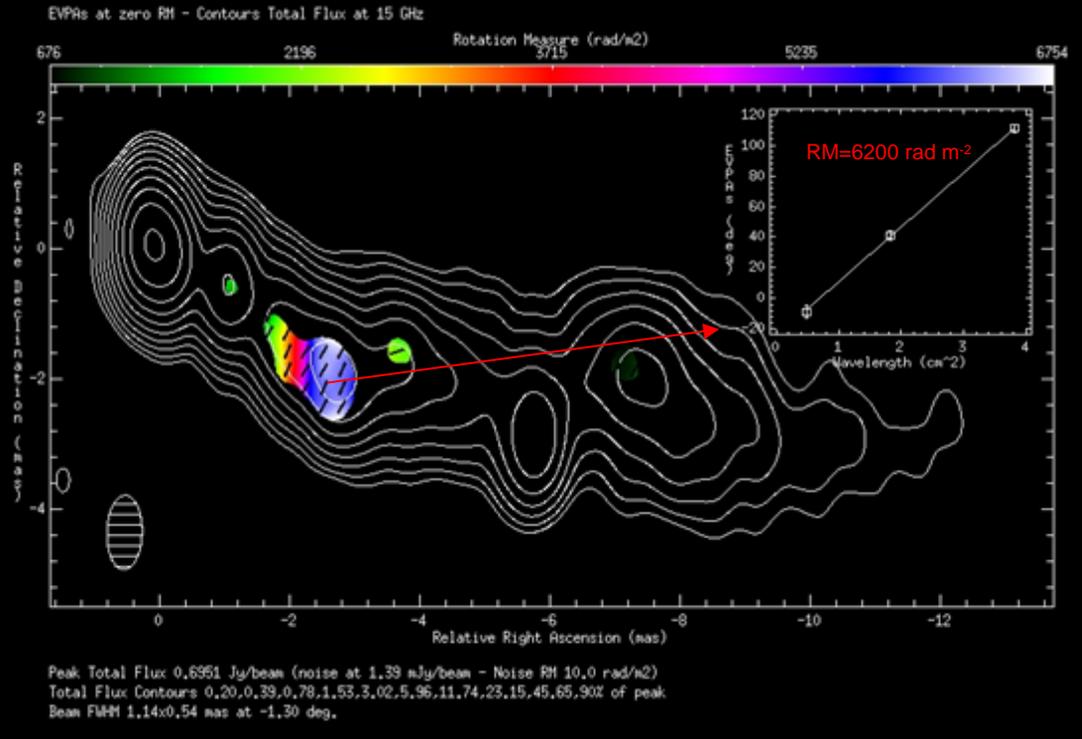
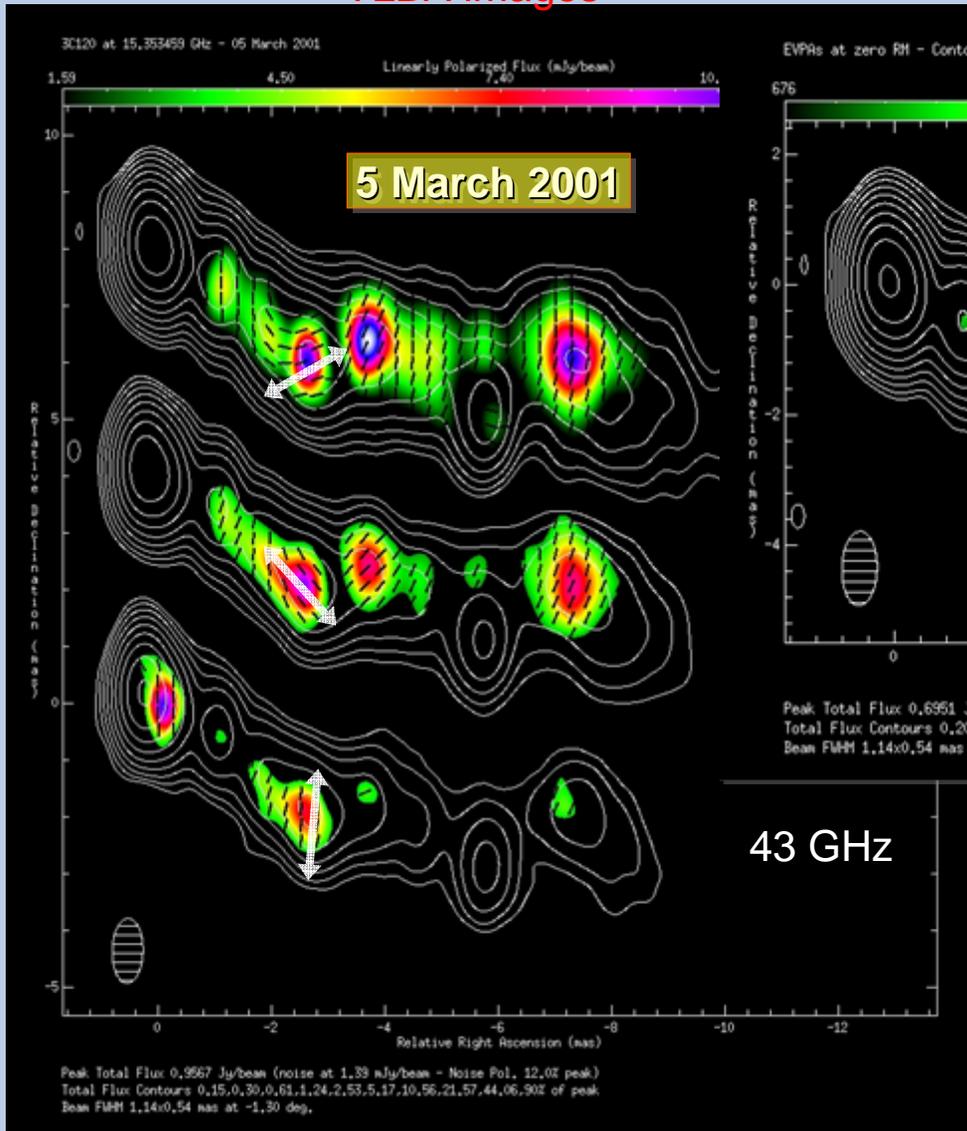
12 monthly polarimetric VLBA images

During 2001

# 3C120 Gradients in Faraday rotation and deg. of pol.

VLBA images

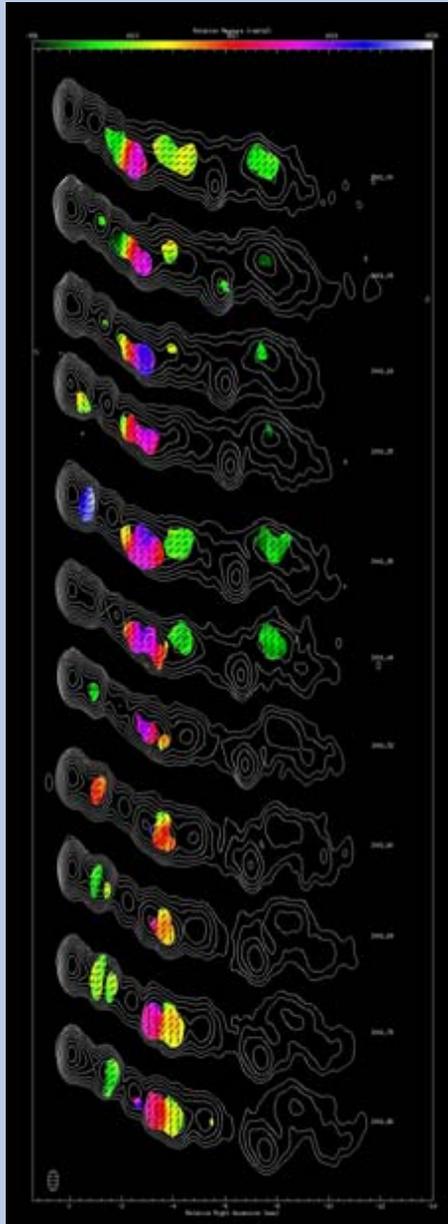
Rotation measure map



Excellent fit to a  $\lambda^2$  law,  
with a *RM* of 6200 rad m<sup>-2</sup>  
at the location of the  
flaring of components.

# 3C120 Gradients in Faraday rotation and deg. of pol.

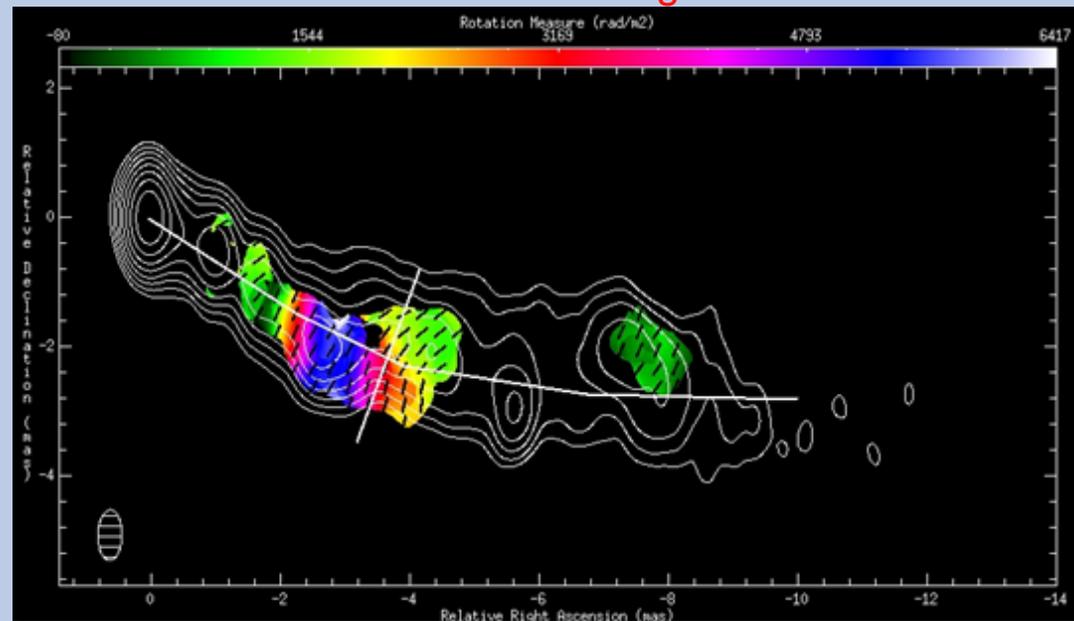
Rotation measure across time



## Rotation Measure in 3C120

- Confirmed rotation measure across epochs
- Varies with time
- Localized at a particular jet region, mapped by the passing of superluminal components

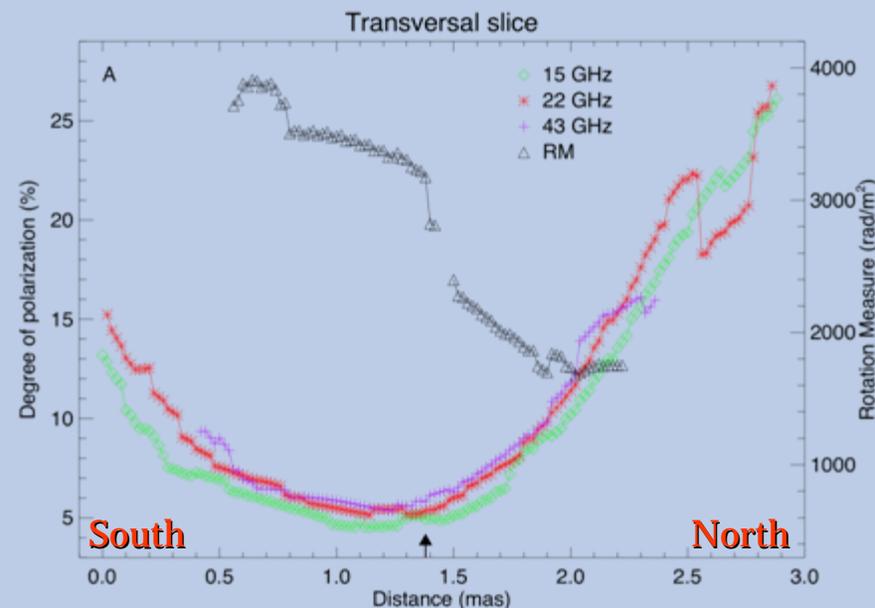
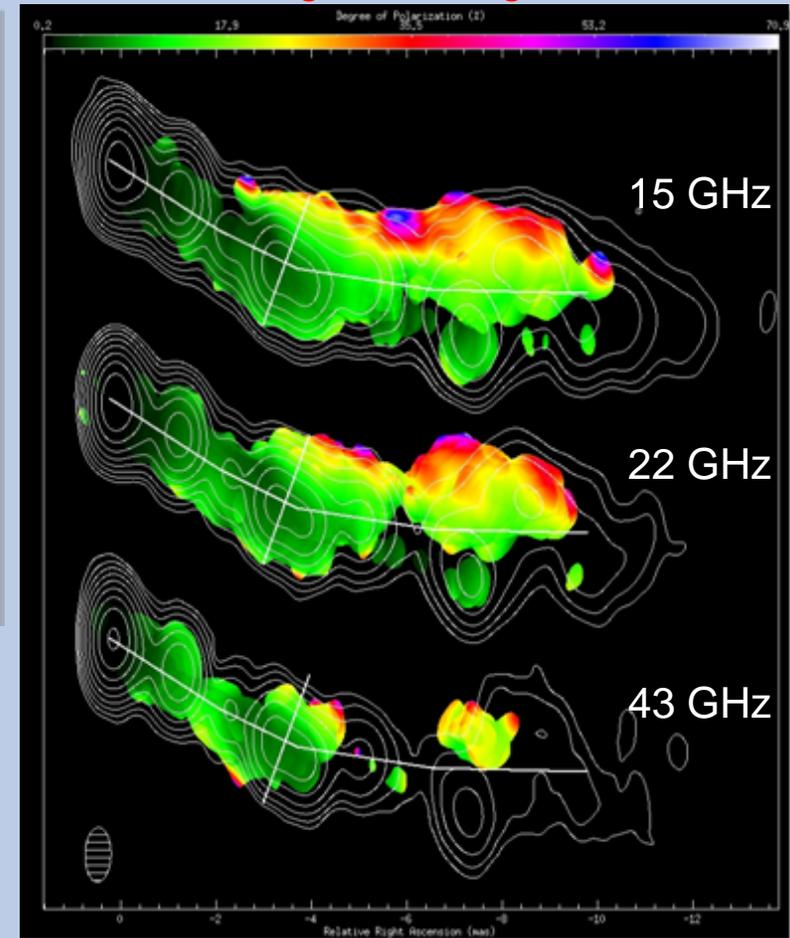
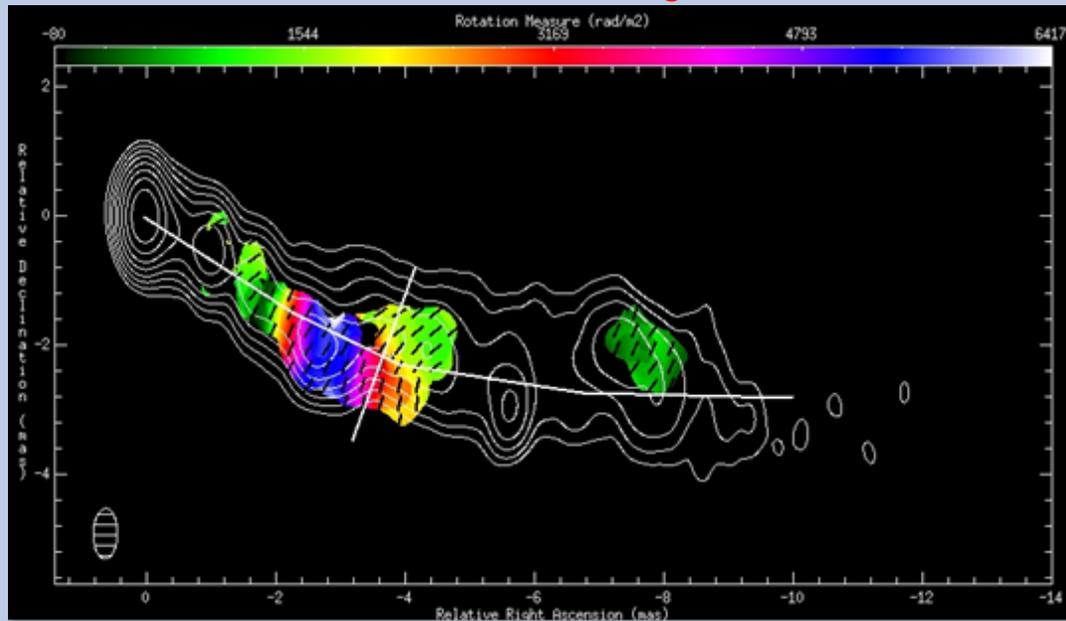
Rotation measure averaged across time



# 3C120 Gradients in Faraday rotation and deg. of pol.

Rotation measure averaged across time

Polarization degree averaged across time

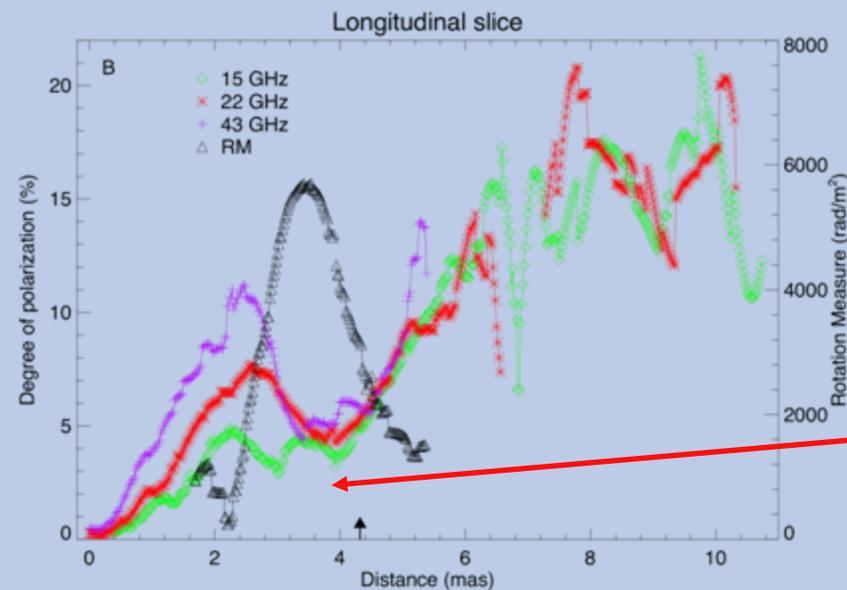
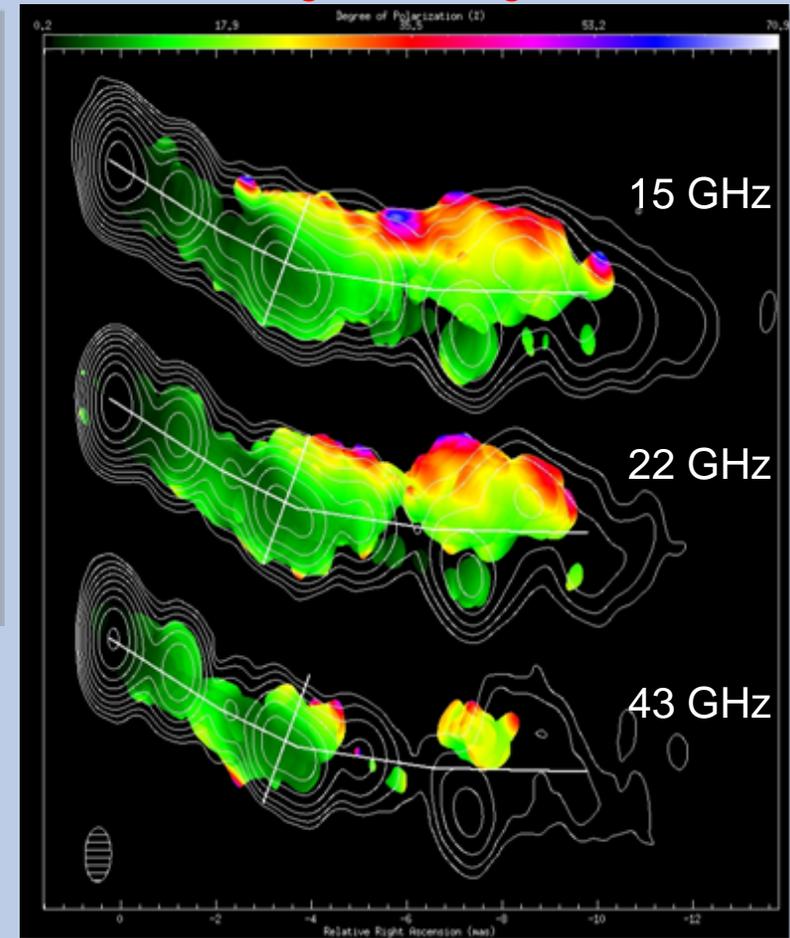
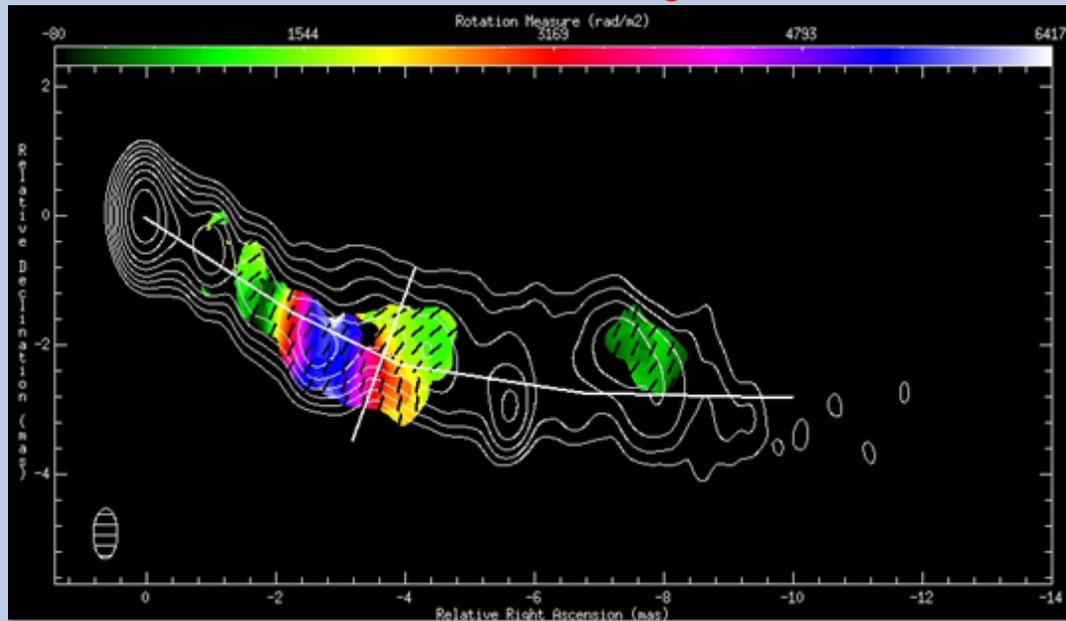


- Transverse gradients in pol deg at 3 freqs.
- Clear transverse gradient in Faraday rotation
- So high Faraday rotation requires external screen

# 3C120 Gradients in Faraday rotation and deg. of pol.

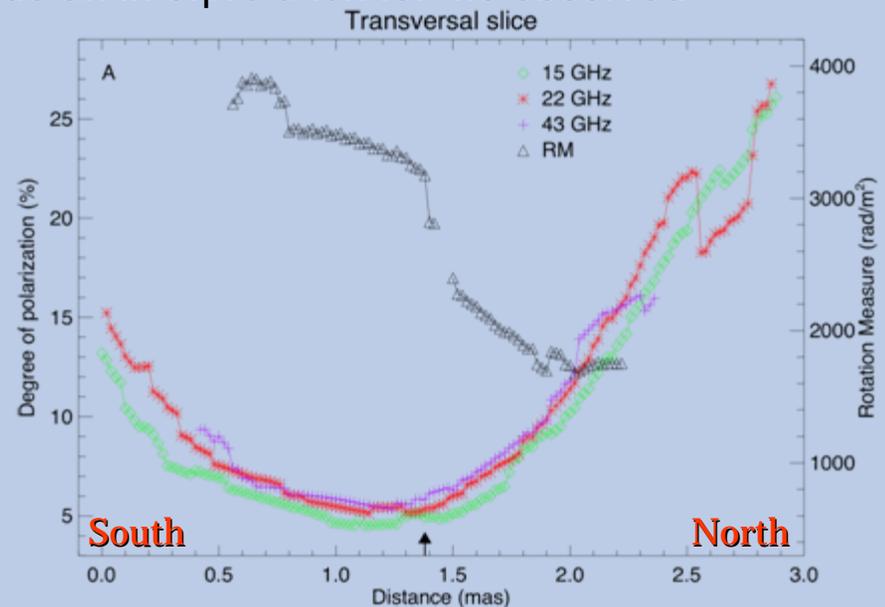
Rotation measure averaged across time

Polarization degree averaged across time



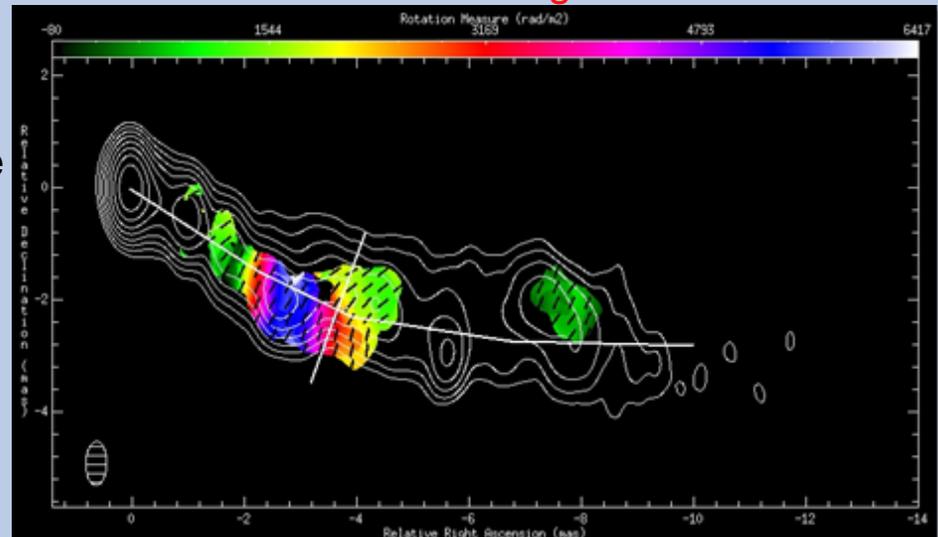
- Polarization degree has a clear dependence with RM, suggesting that the decay is produced by Faraday depolarization.

- Helical magnetic fields in the jets may appear naturally through the rotation of the accretion disk, and may have an role in the formation and collimation of jets
- Gradients in Faraday rotation across the jet may be indicative of helical magnetic fields wrapping the jet (Blandford 1993)
- Our observations provide information to the debate about whereas helical magnetic fields are present in the inner jets or not
- Asymmetry in polarization degree is also consistent with the presence of a helical magnetic field
- A two-fluid model, with an internal emitting jet and a sheath of thermal electrons, both immersed in a helical magnetic field, could provide an interpretation for the observed transverse profiles of pol deg and RM.



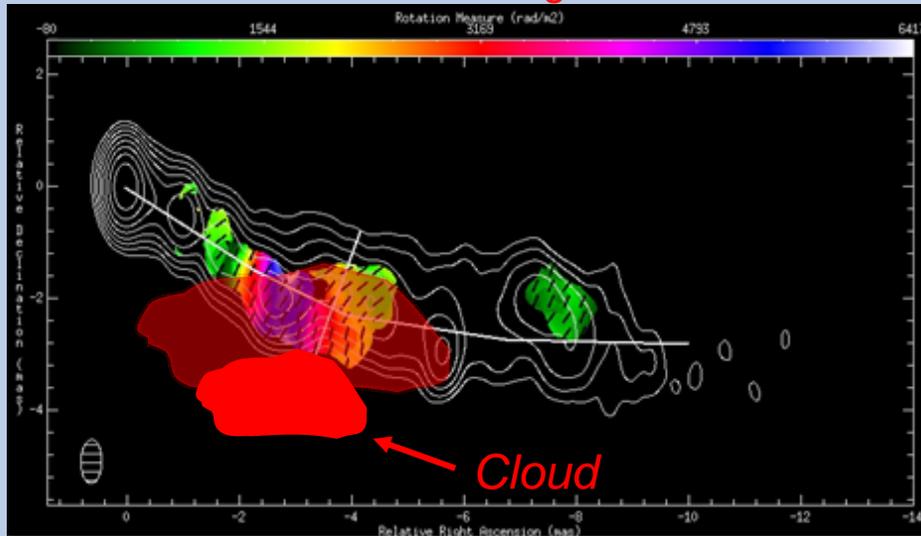
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- The RM-corrected EVPAs, predominantly perpendicular to the jet axis, require a dominant poloidal (as measured in the frame of the jet fluid) magnetic field in the emitting region (Lyutikov et al. 2005).

Rotation measure averaged across time

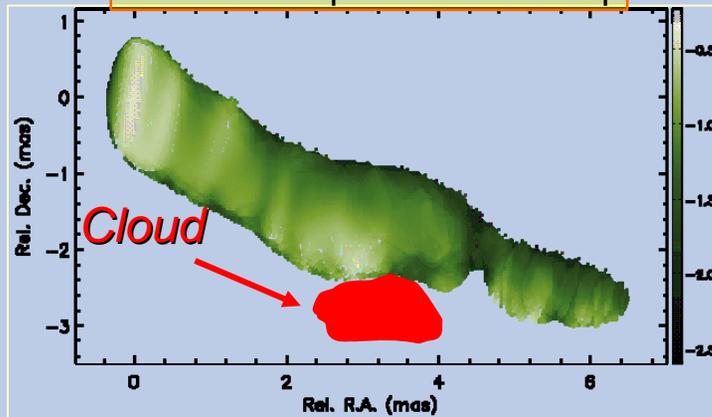


- A helical magnetic field in a sheath around the jet may explain some of the phenomenology
- **BUT NOT ALL!** Helical magnetic field is not able to explain the Faraday rotation gradient at a particular location in the jet

### Rotation measure averaged across time



### 22-43 GHz Spectral index map



- **However**, a cloud or a dense ionized external medium interacting with the jet explains, for this particular region:
  - Gradient of Faraday rotation to the South
  - Gradient of depolarization to the South
  - Bend of the jet
  - Flaring of jet features when approaching the region (interaction produces a region of jet enhanced pressure)
  - Enhanced spectral index (through free-free absorption by the cloud)

- Jet external medium interaction explains all the observed phenomenology in the jet of 3C120
- A helical magnetic field in a two-fluid jet model can be accommodated within this scenario, but by itself cannot explain the existence of the localized Faraday rotation region
- Other sources showing transverse structure also fail to show clear evidence of a helical magnetic field (see Zavala & Taylor 2005)
- Even when helical magnetic fields are supported by reasonable and elaborated theoretical and numerical models
- Real jets seem to conspire to “hide” them.