Helical Magnetic Fields and Jet Formation: The Case of 3C120

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Boston University

Jet formation and helical magnetic fields

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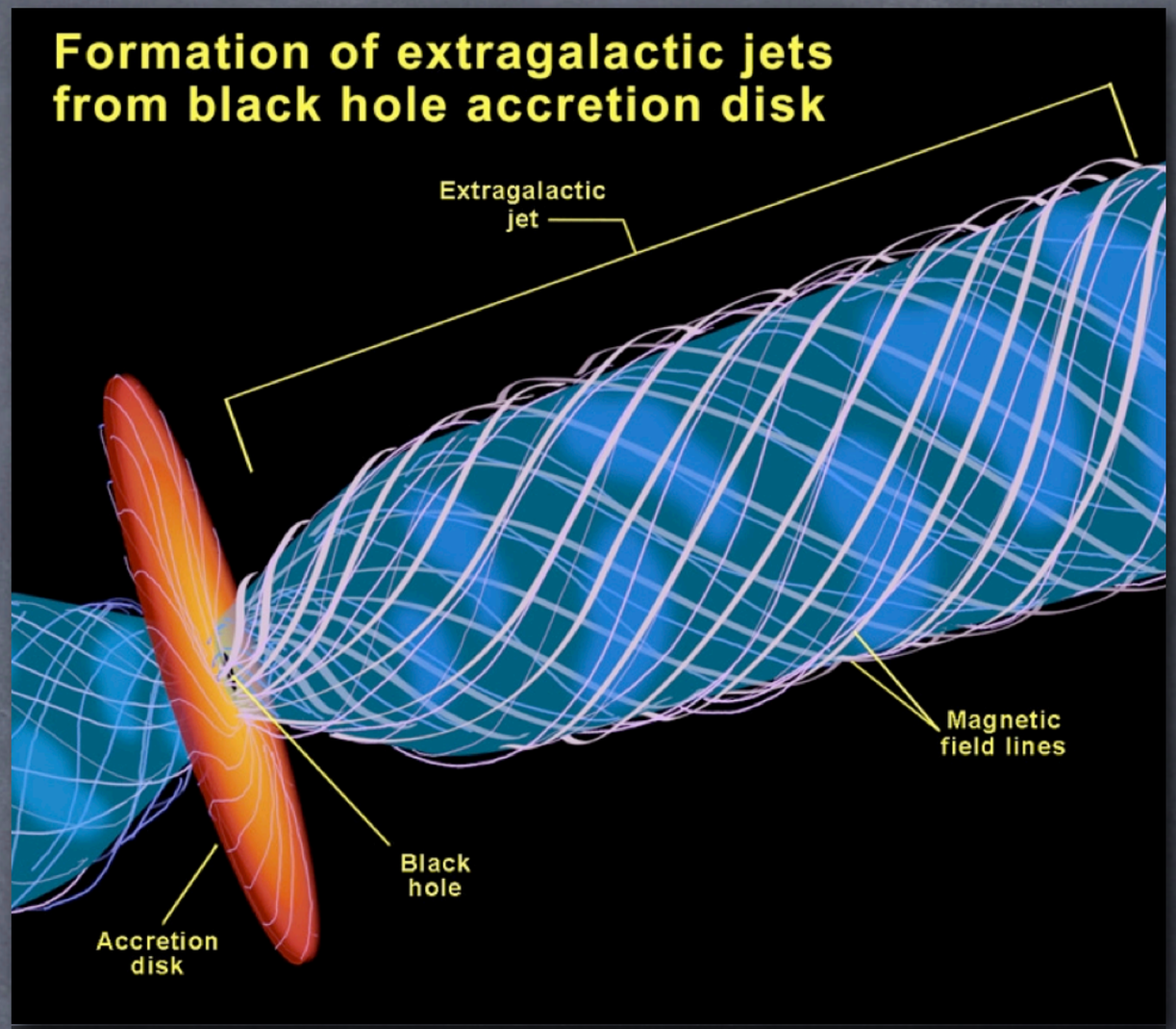
How can we observe these helical fields?

A. Within the ACZ, through multi-wavelength observations



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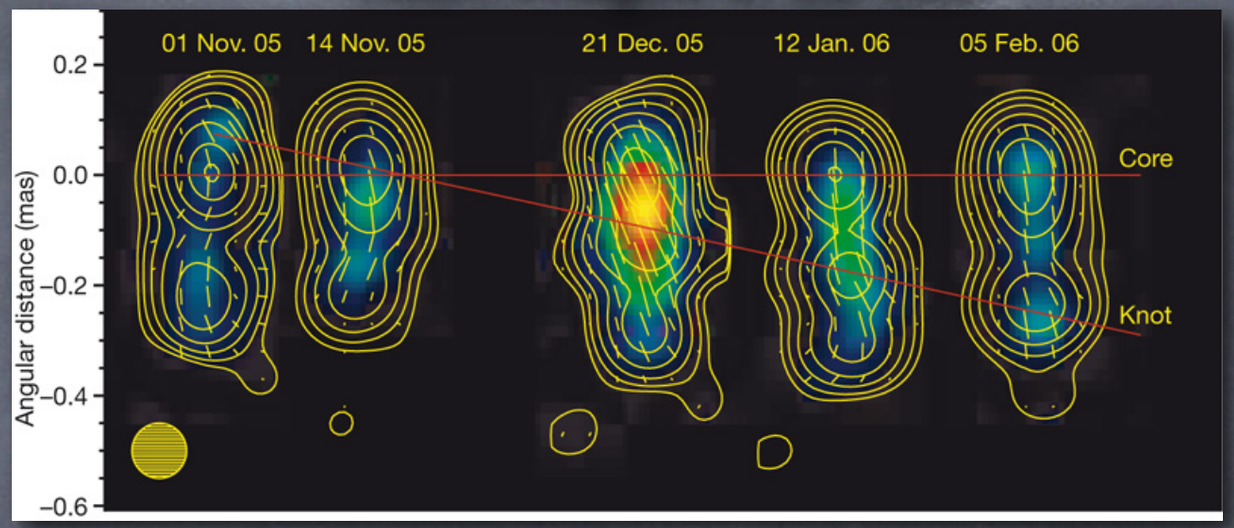

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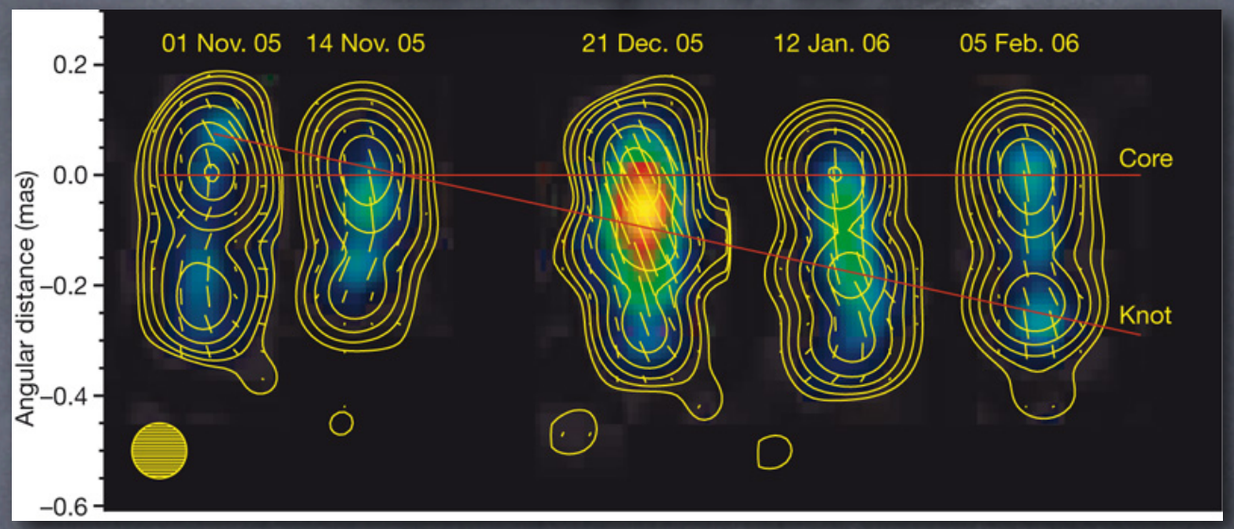

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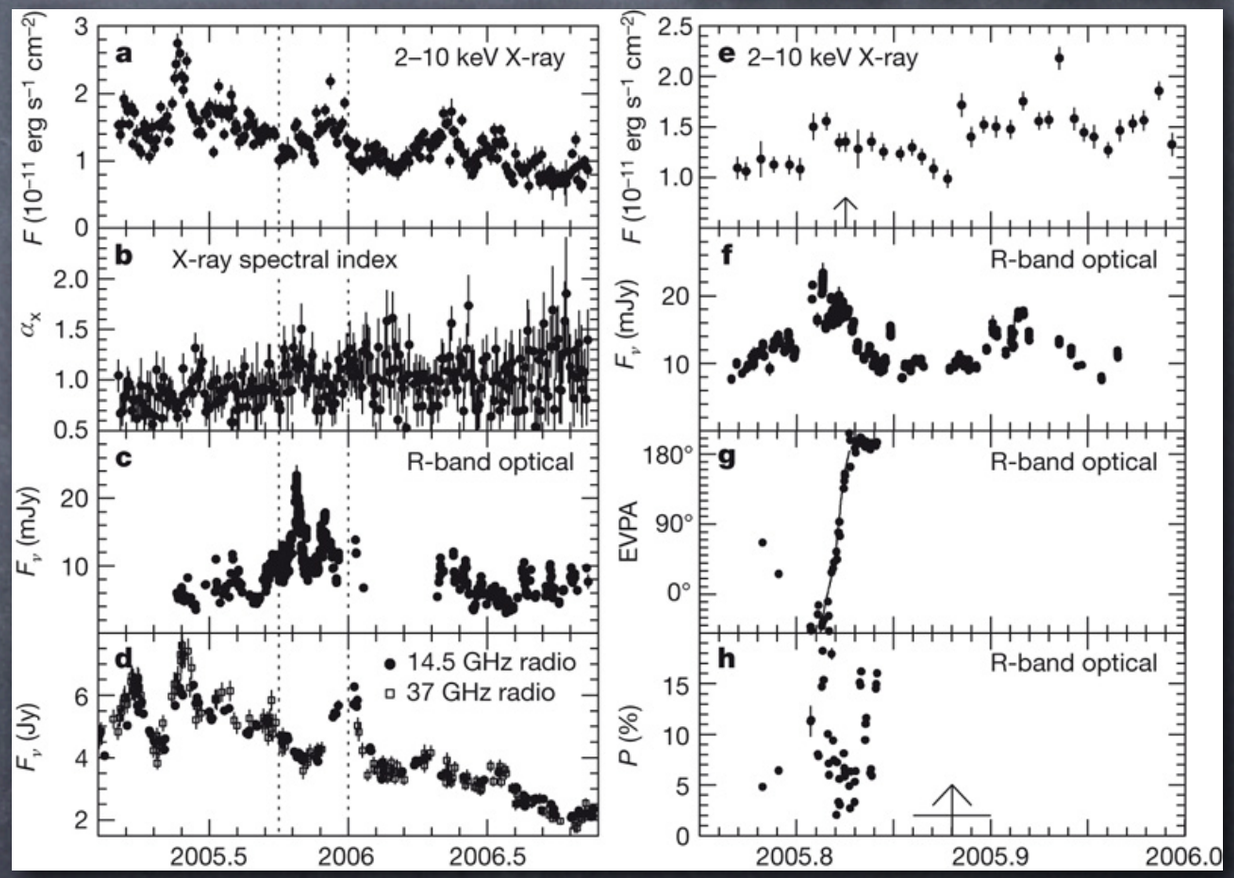

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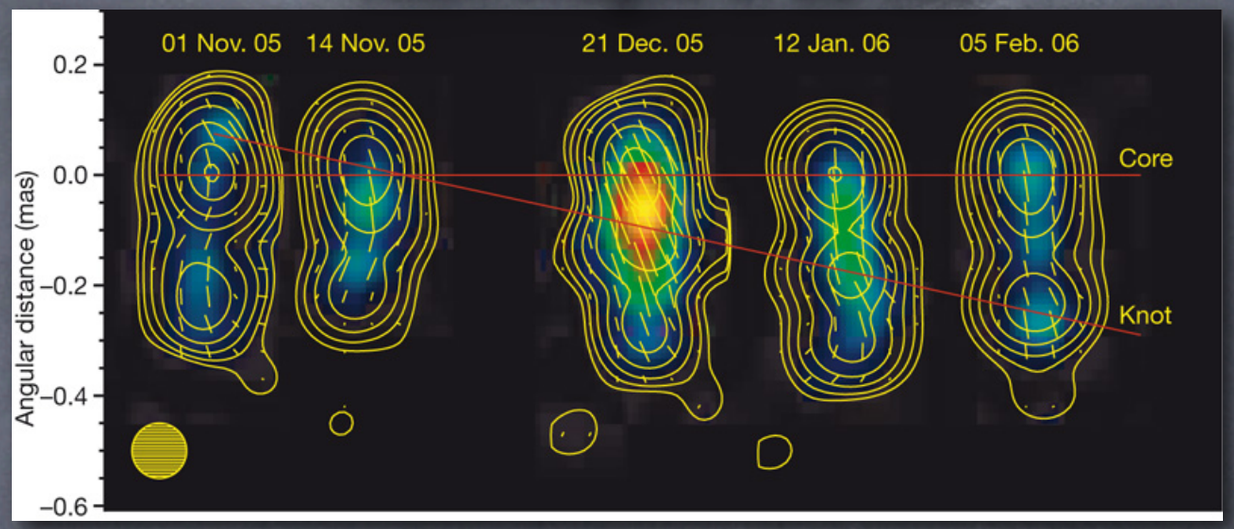

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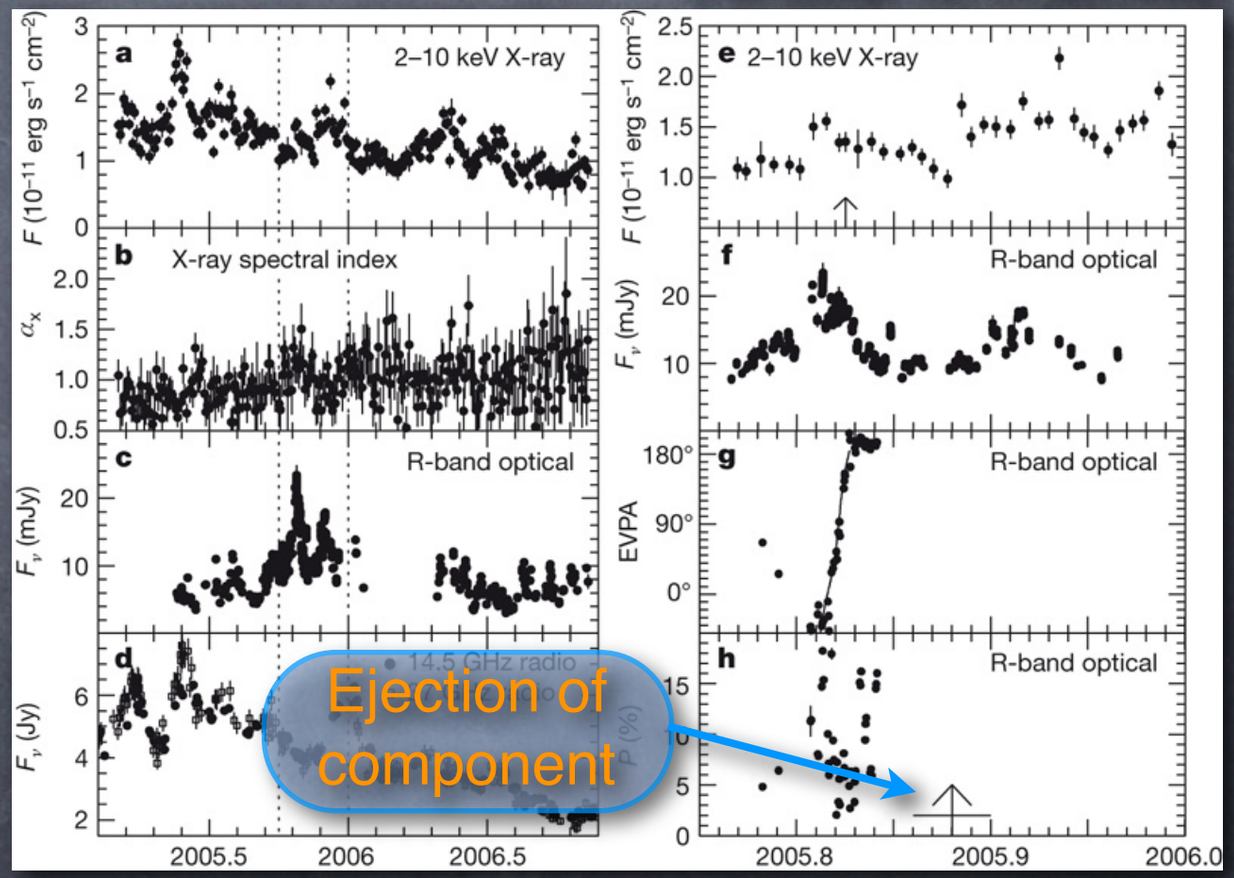

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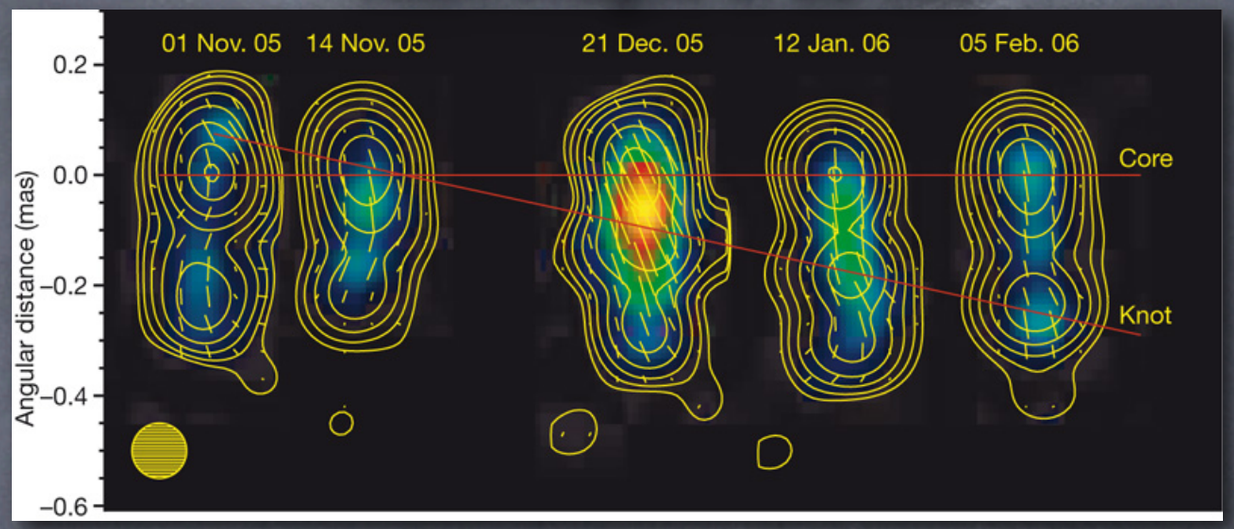

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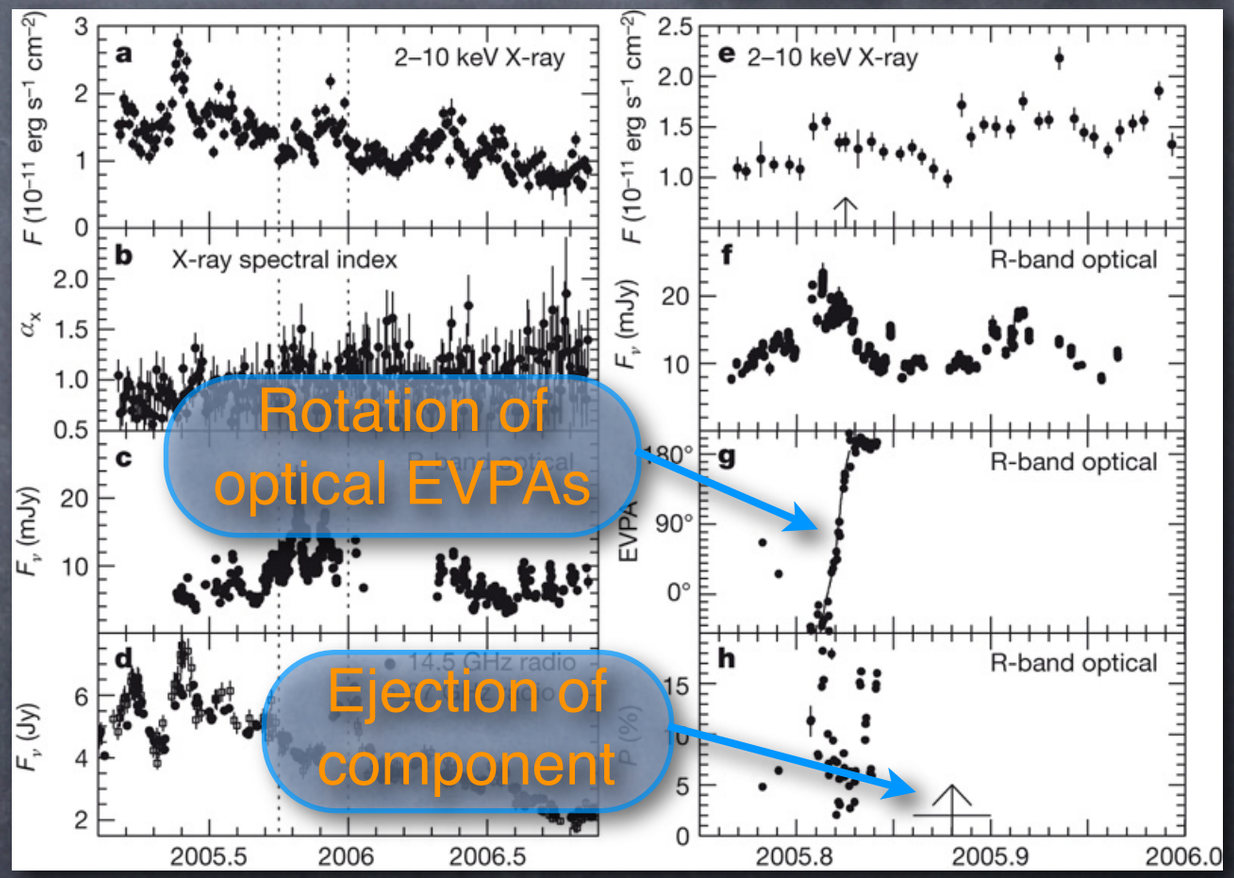

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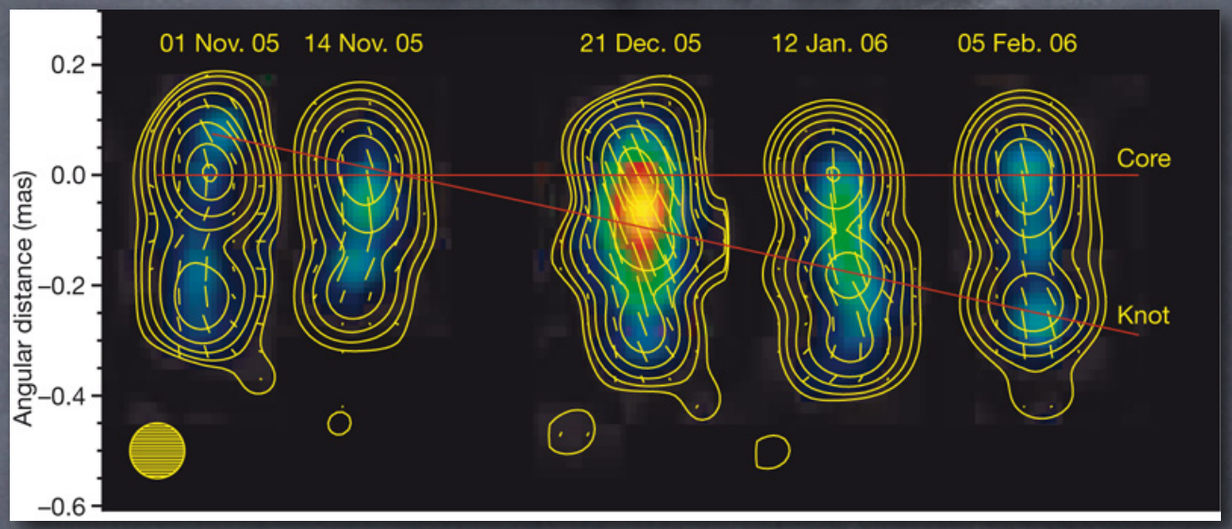

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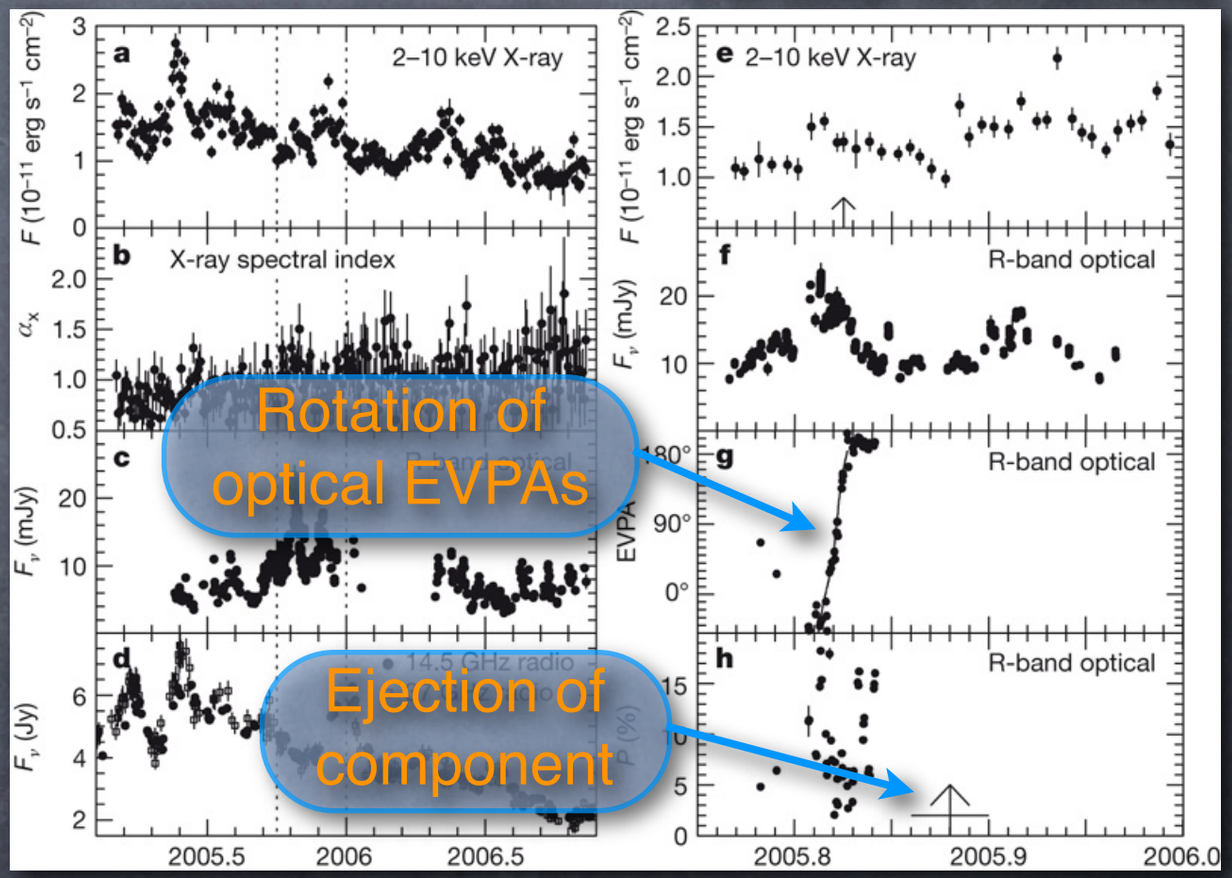

Further evidence in 1510-089 (Marscher et al., submitted), and 3C454.3 (Jorstad et al., in preparation)

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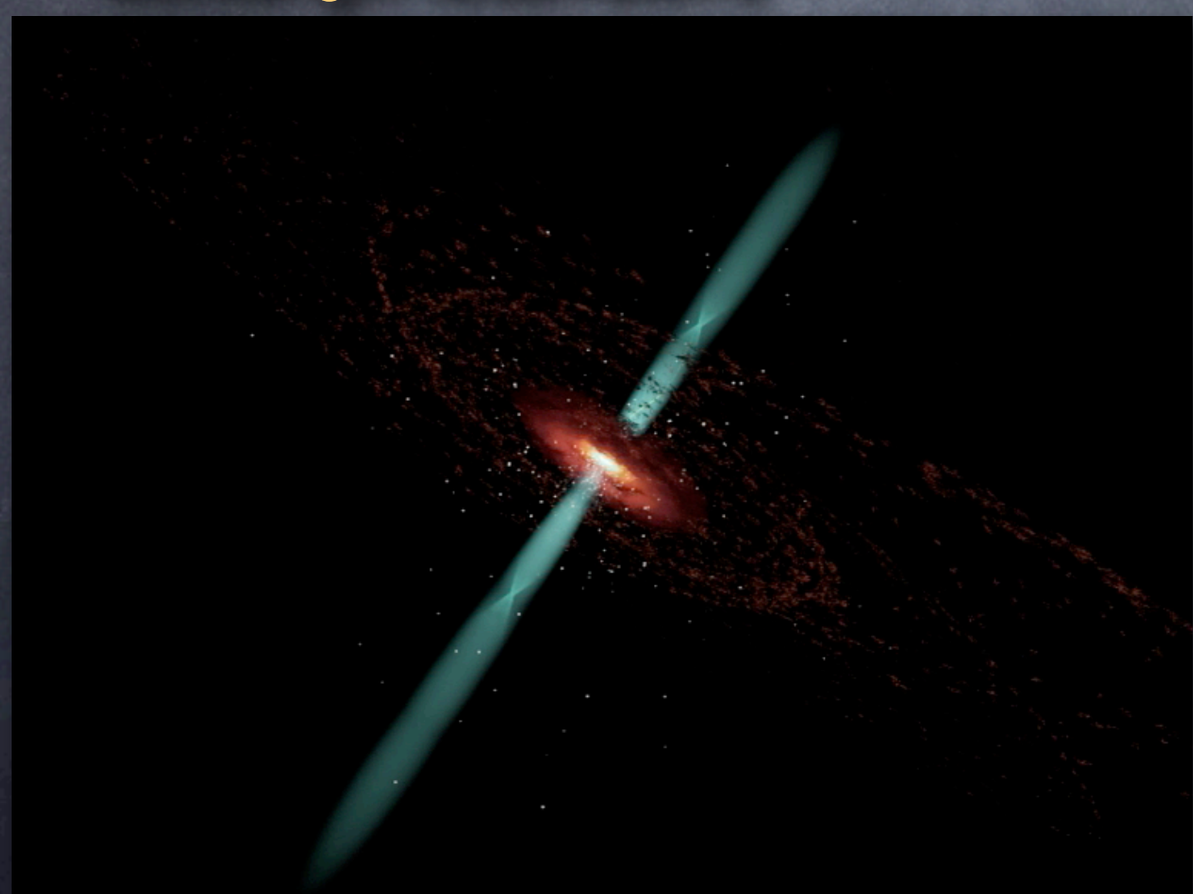

Animation by W. Steffen (UNAM & Cosmovision)

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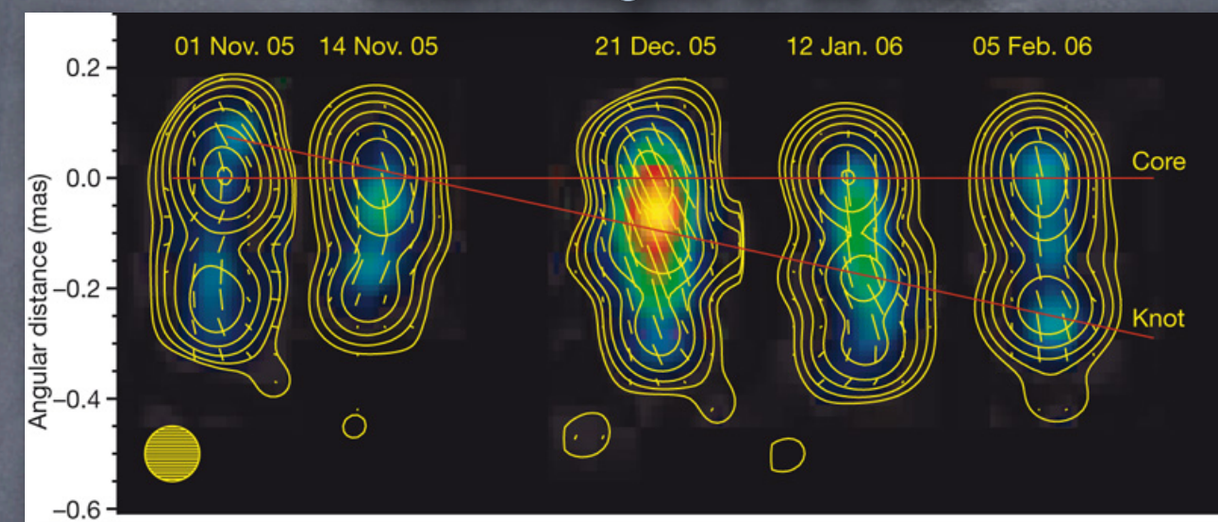

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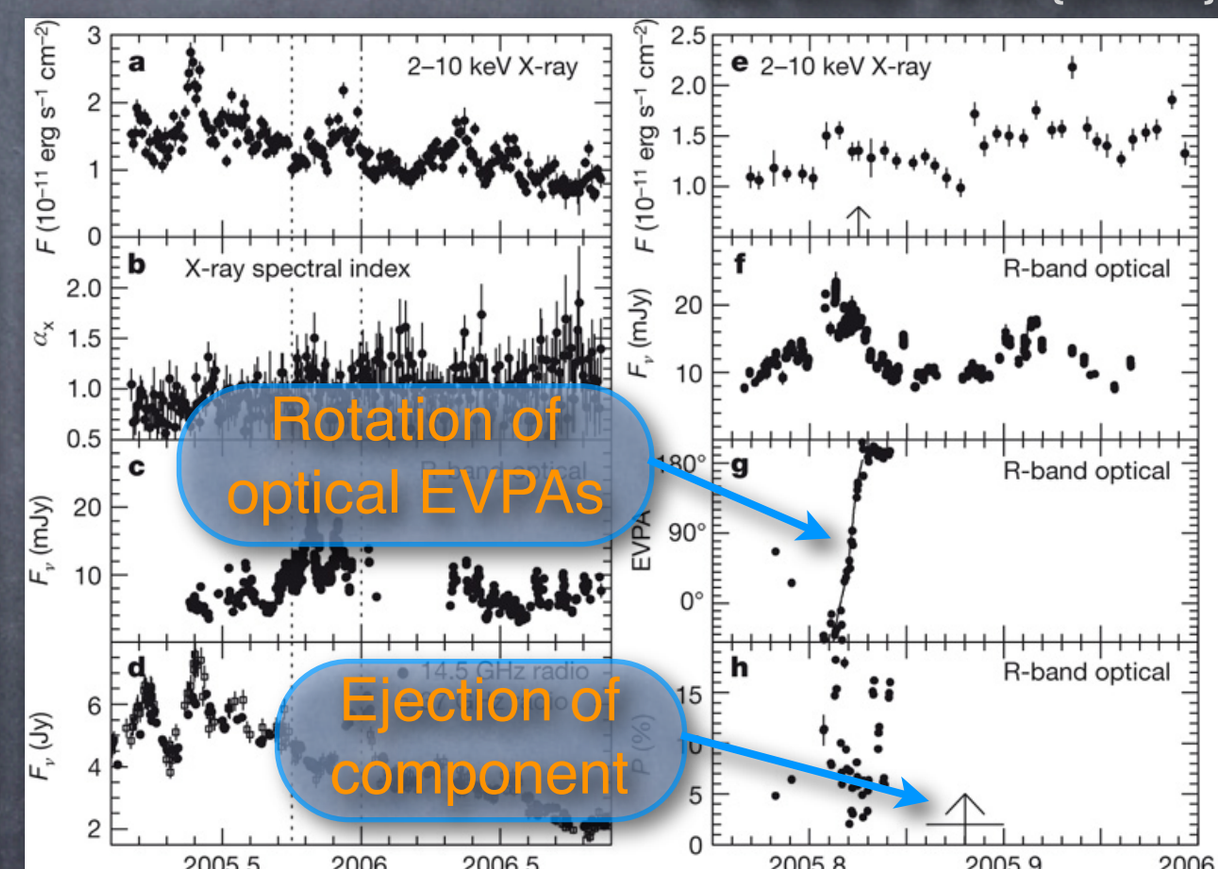

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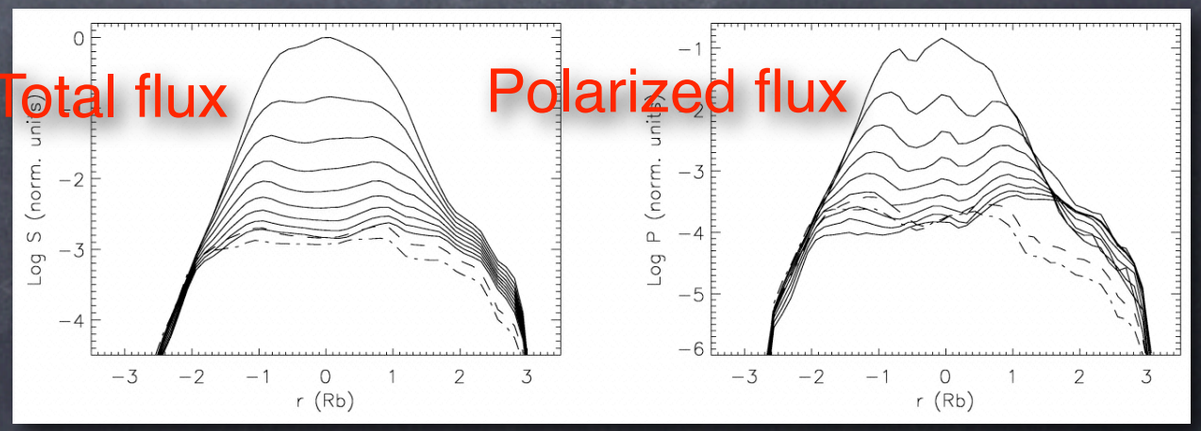
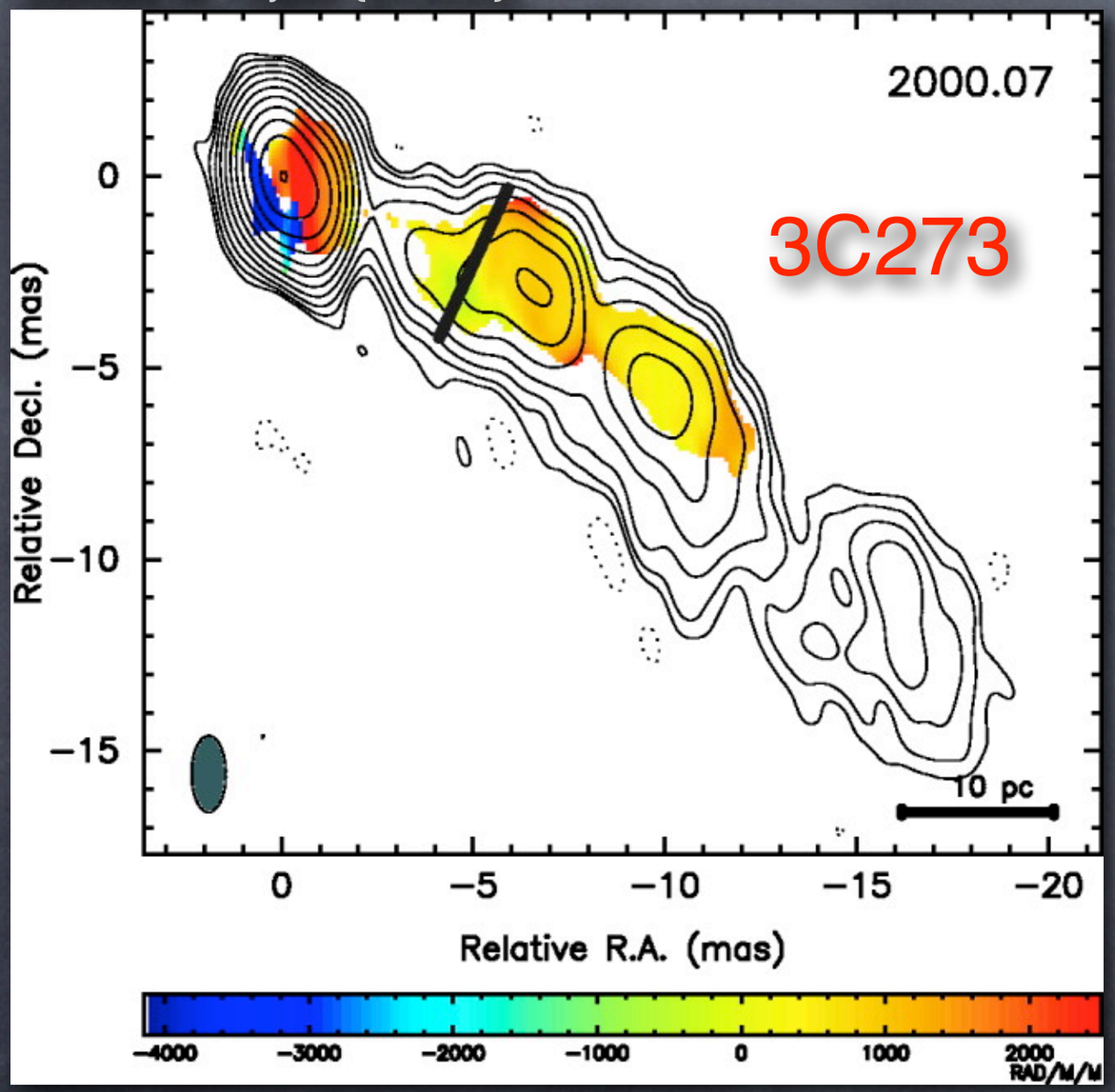


Aloy et al. (2000)

Jet formation and helical magnetic fields

Zavala & Taylor (2005)



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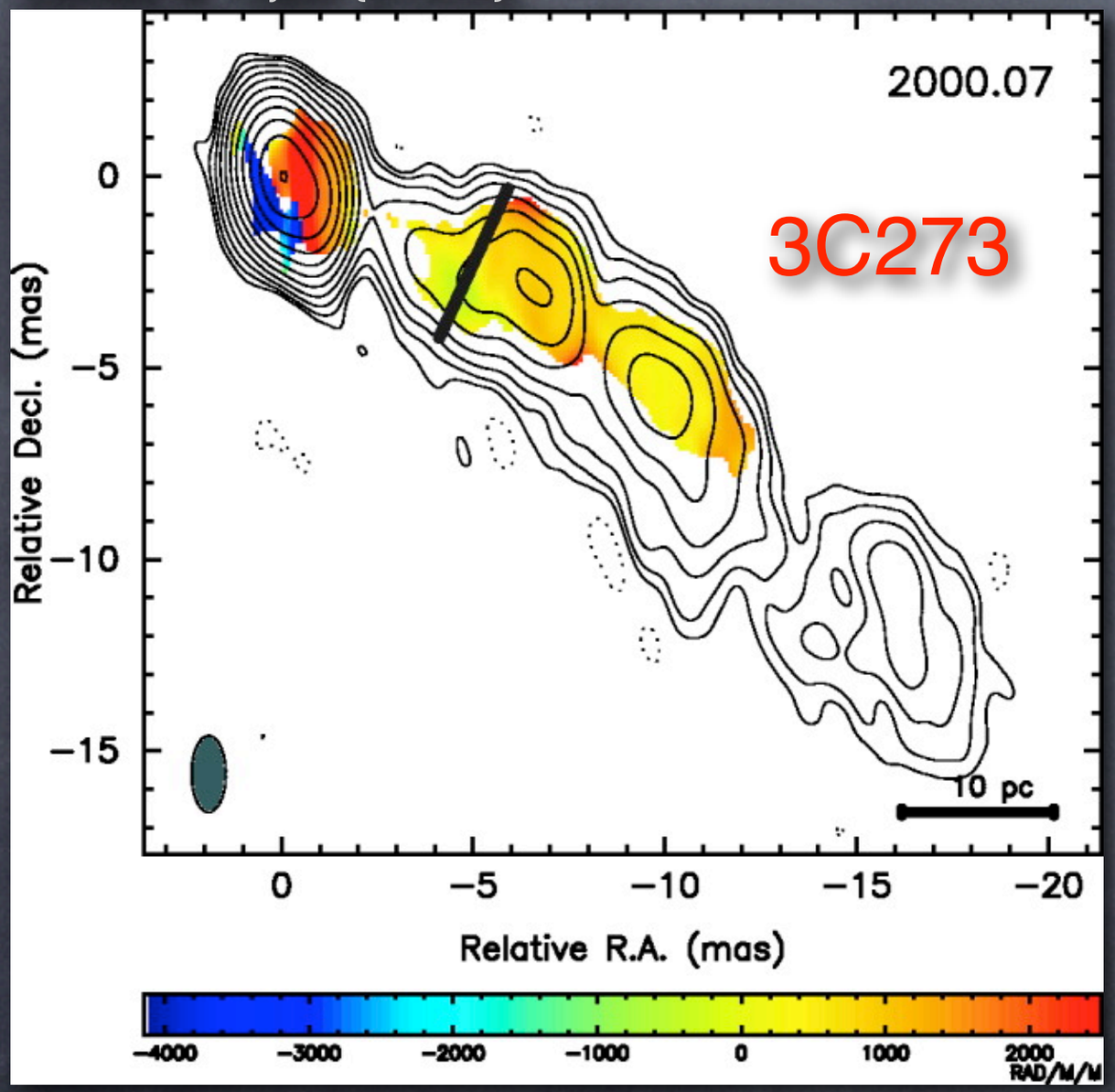

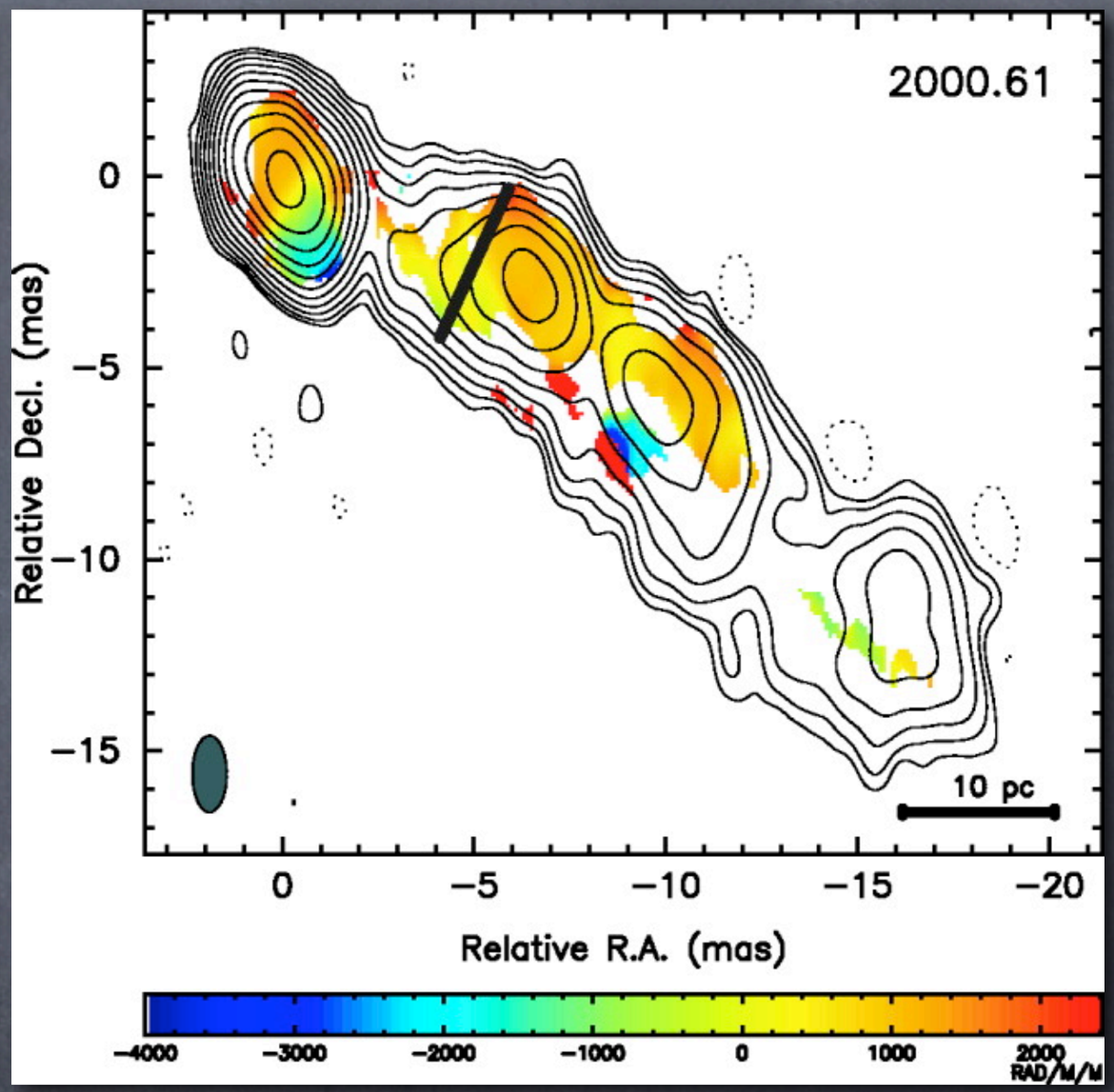

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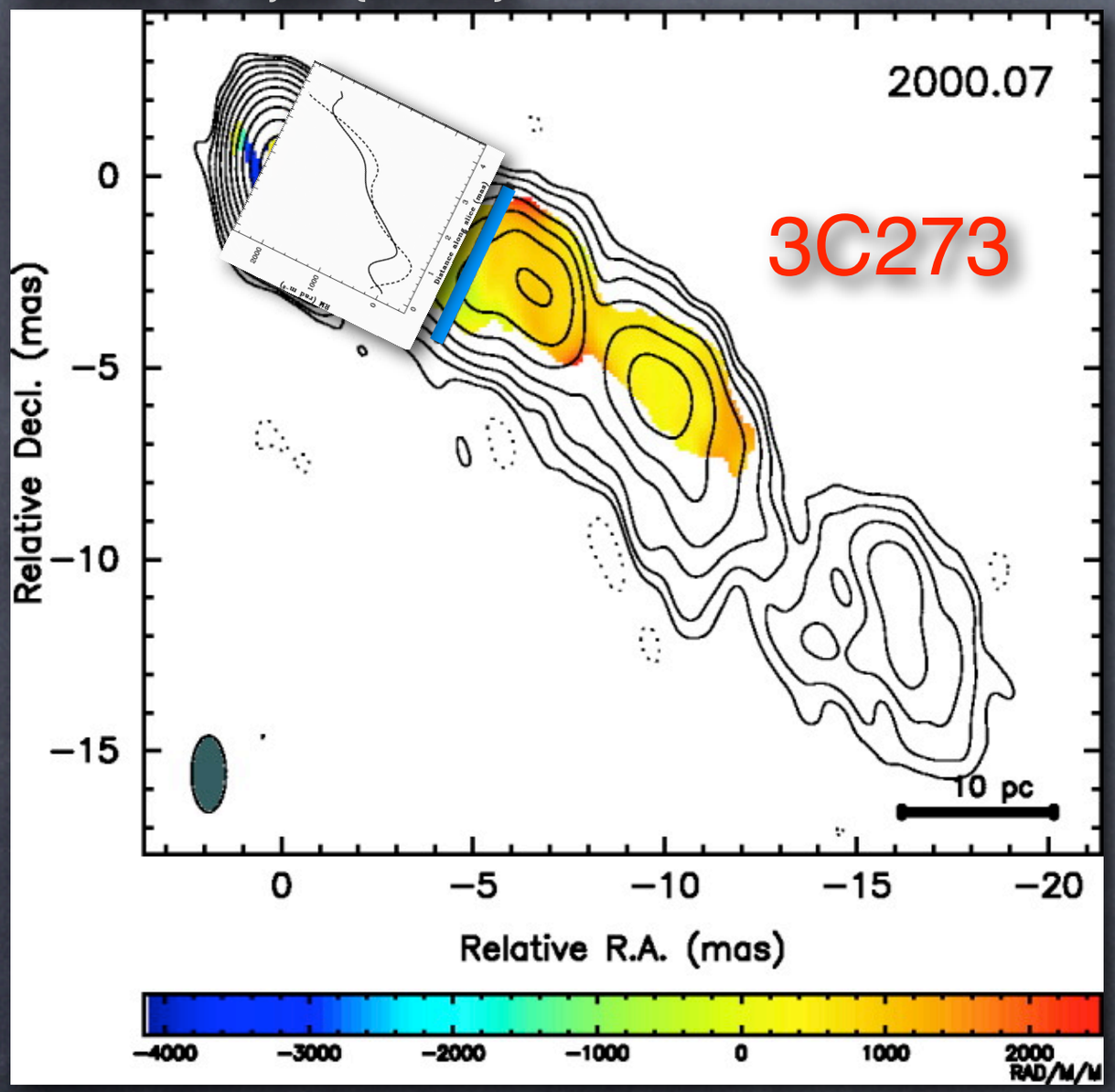

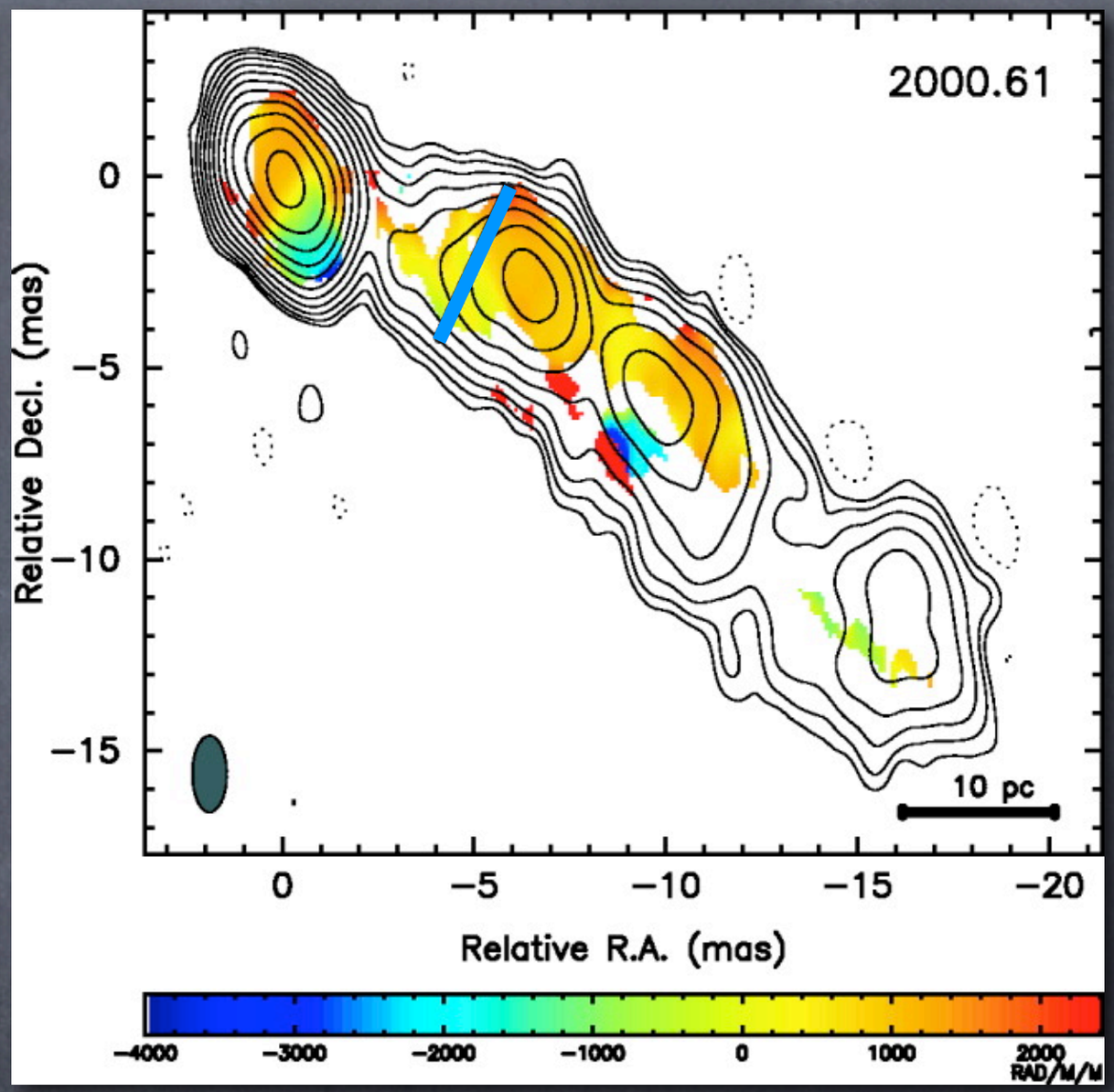

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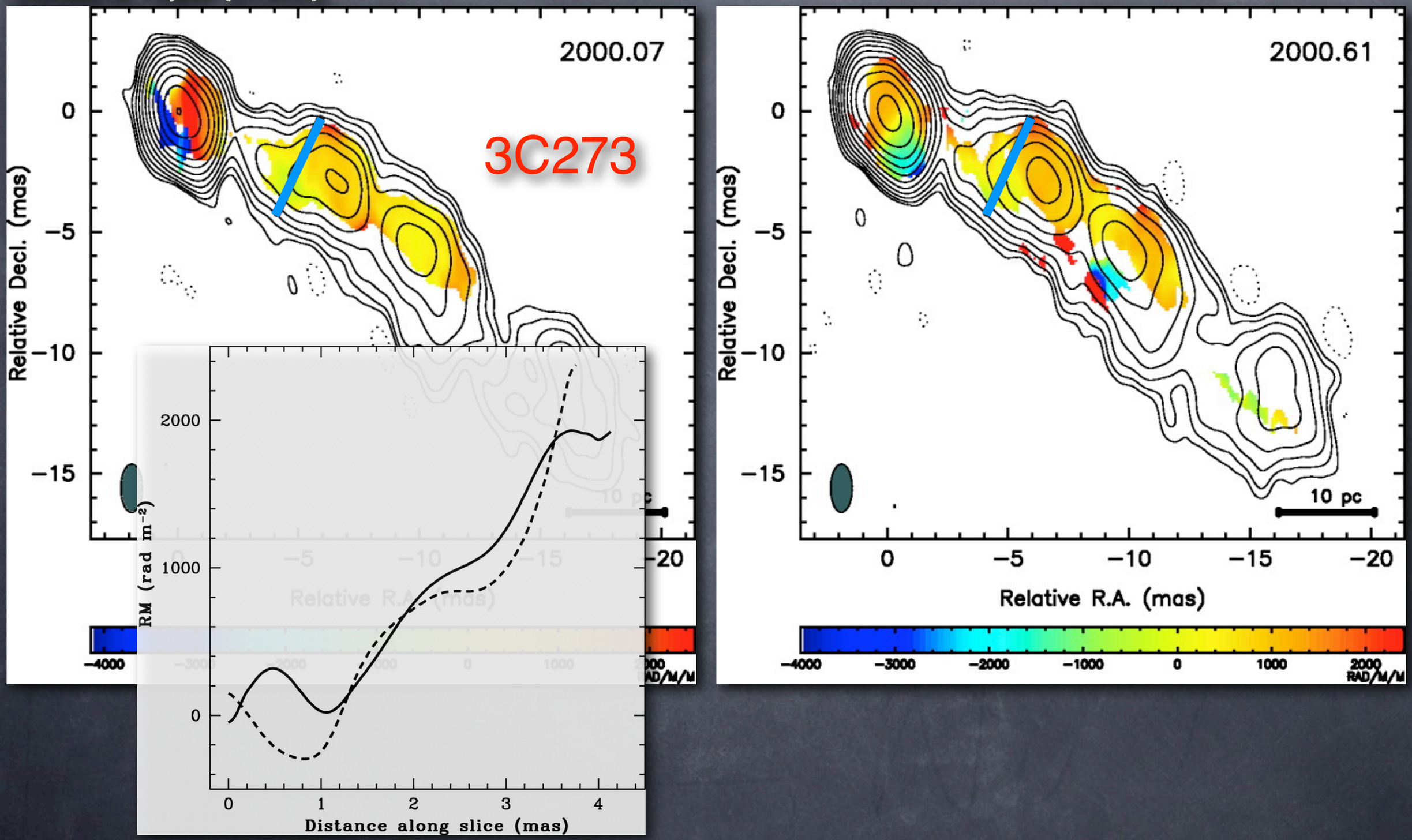

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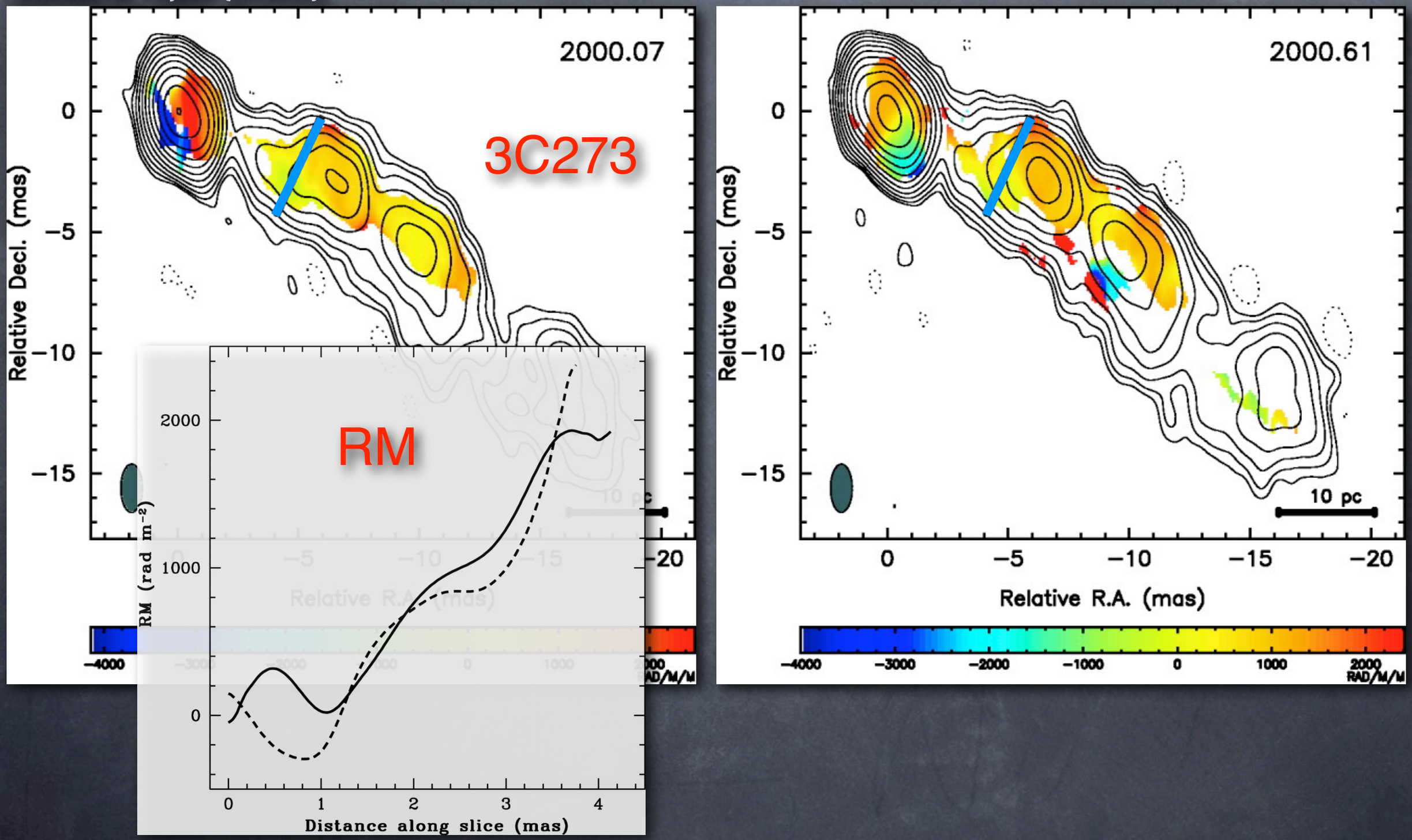

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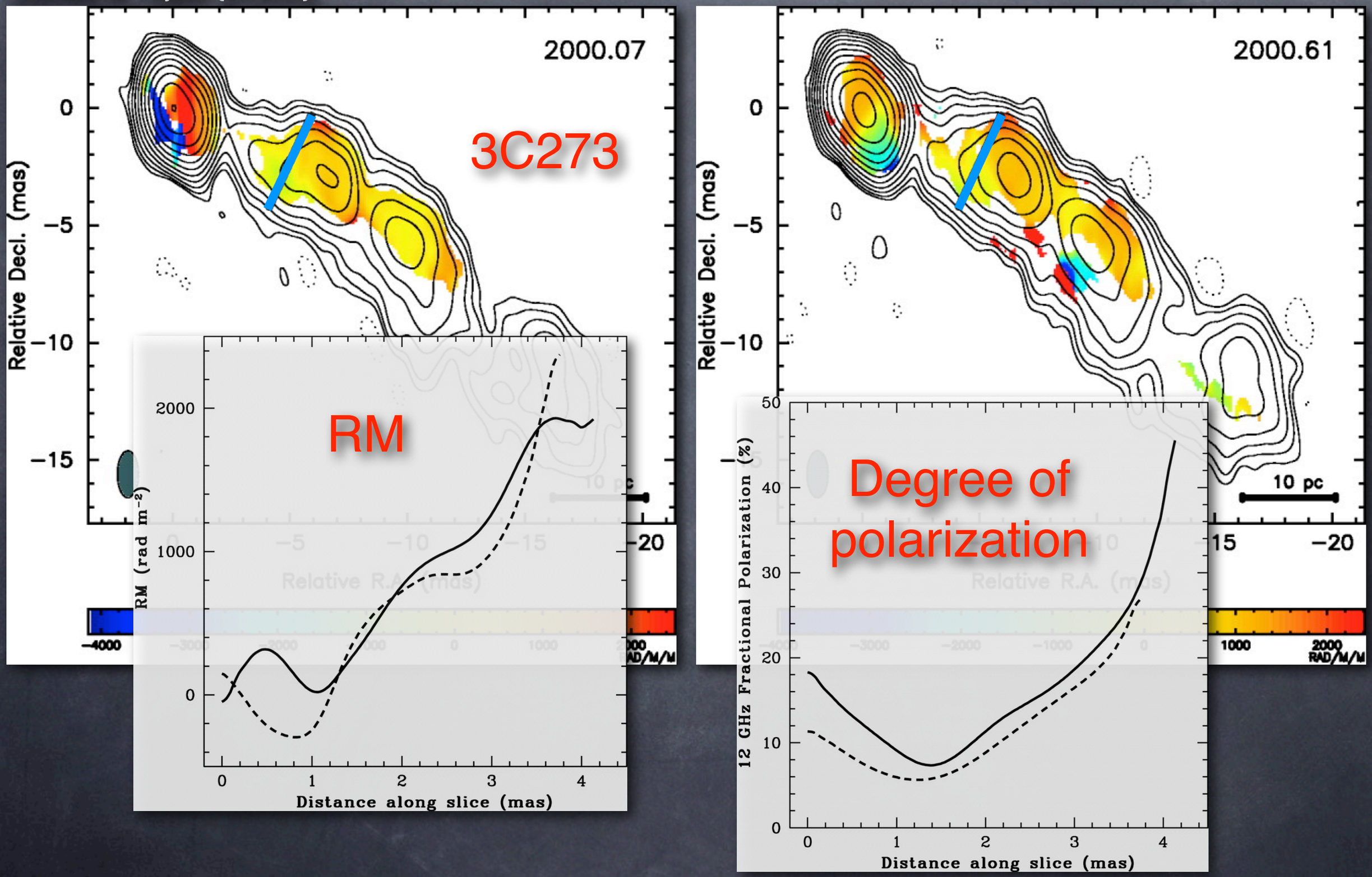

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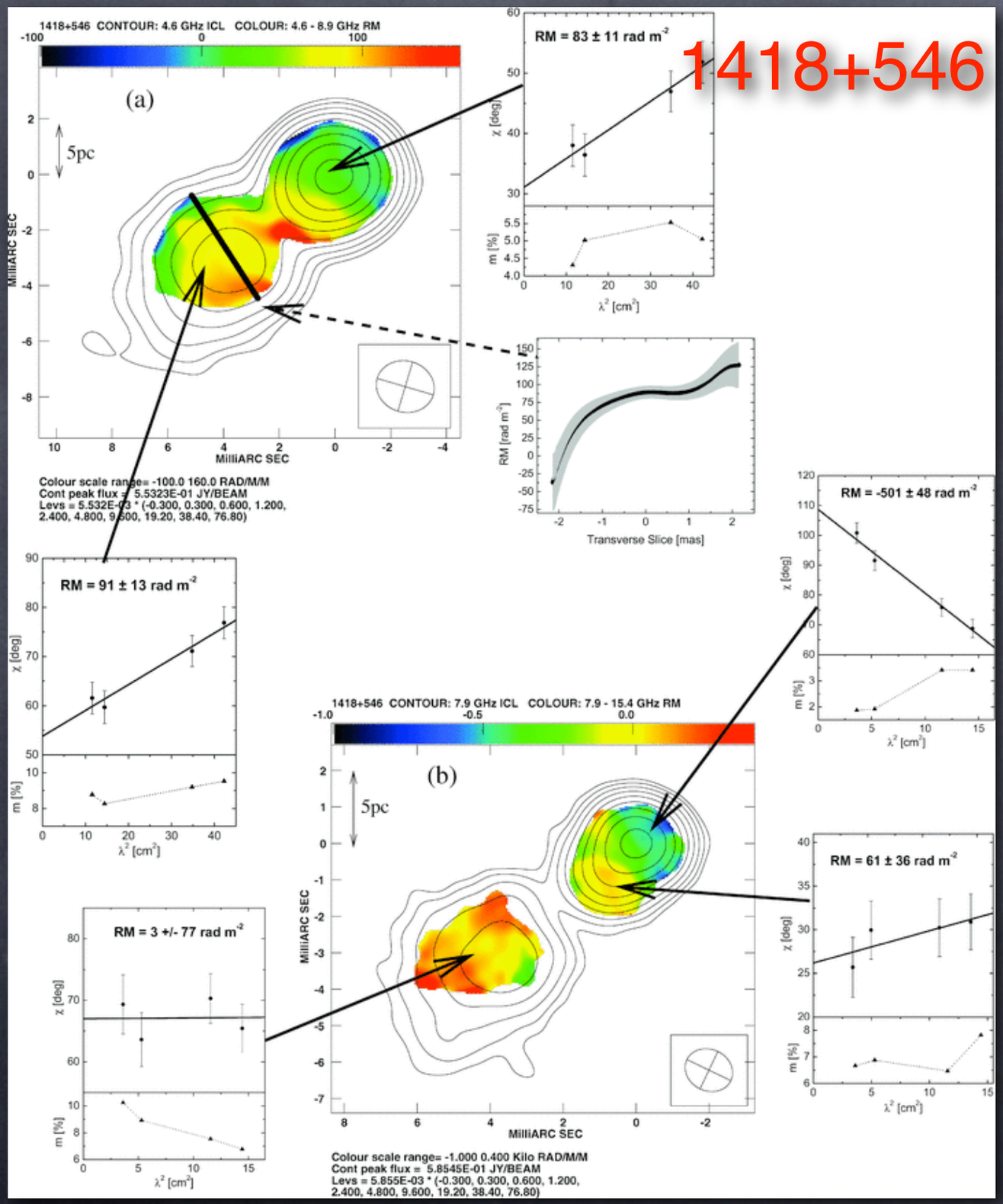

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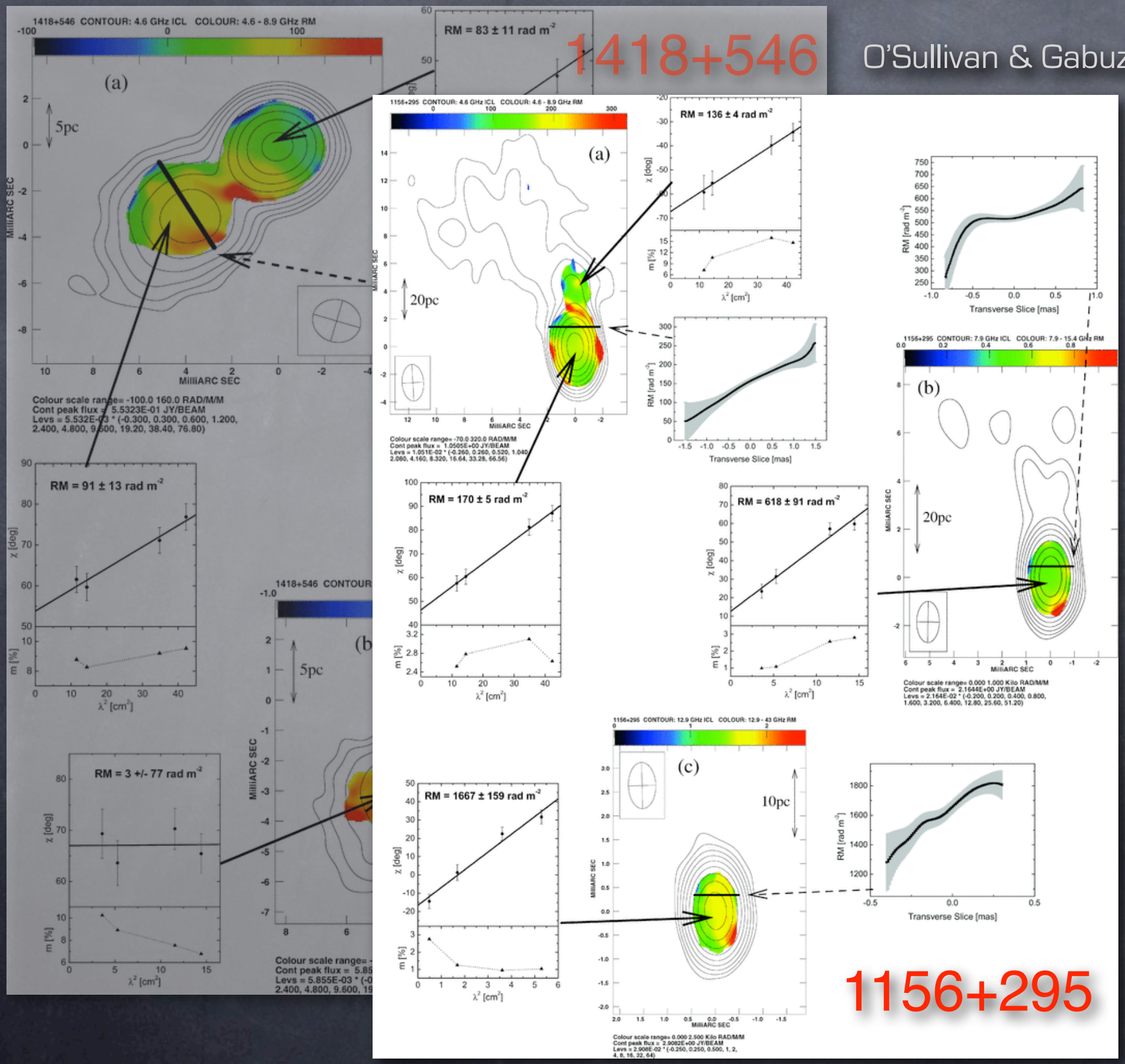

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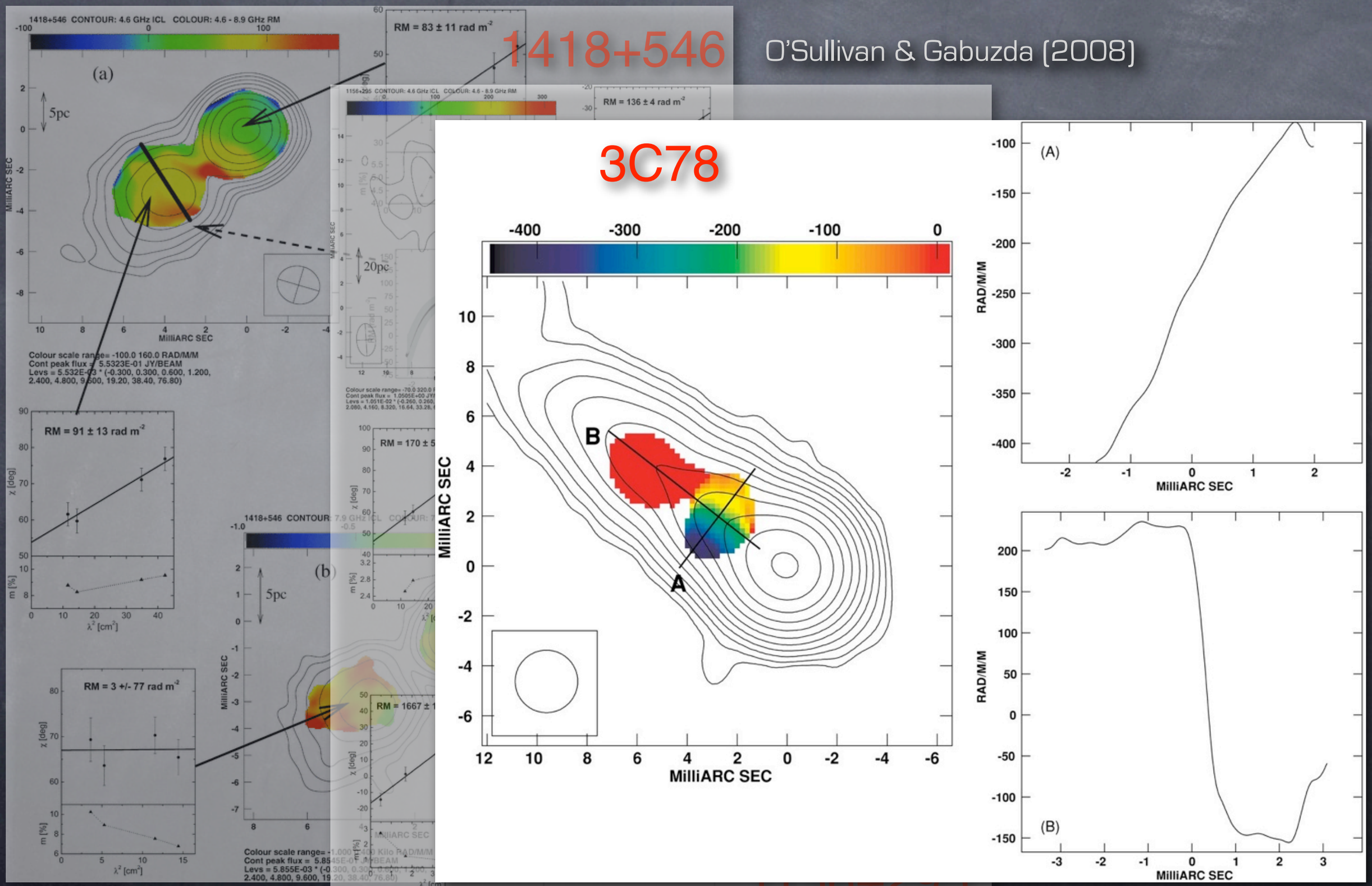

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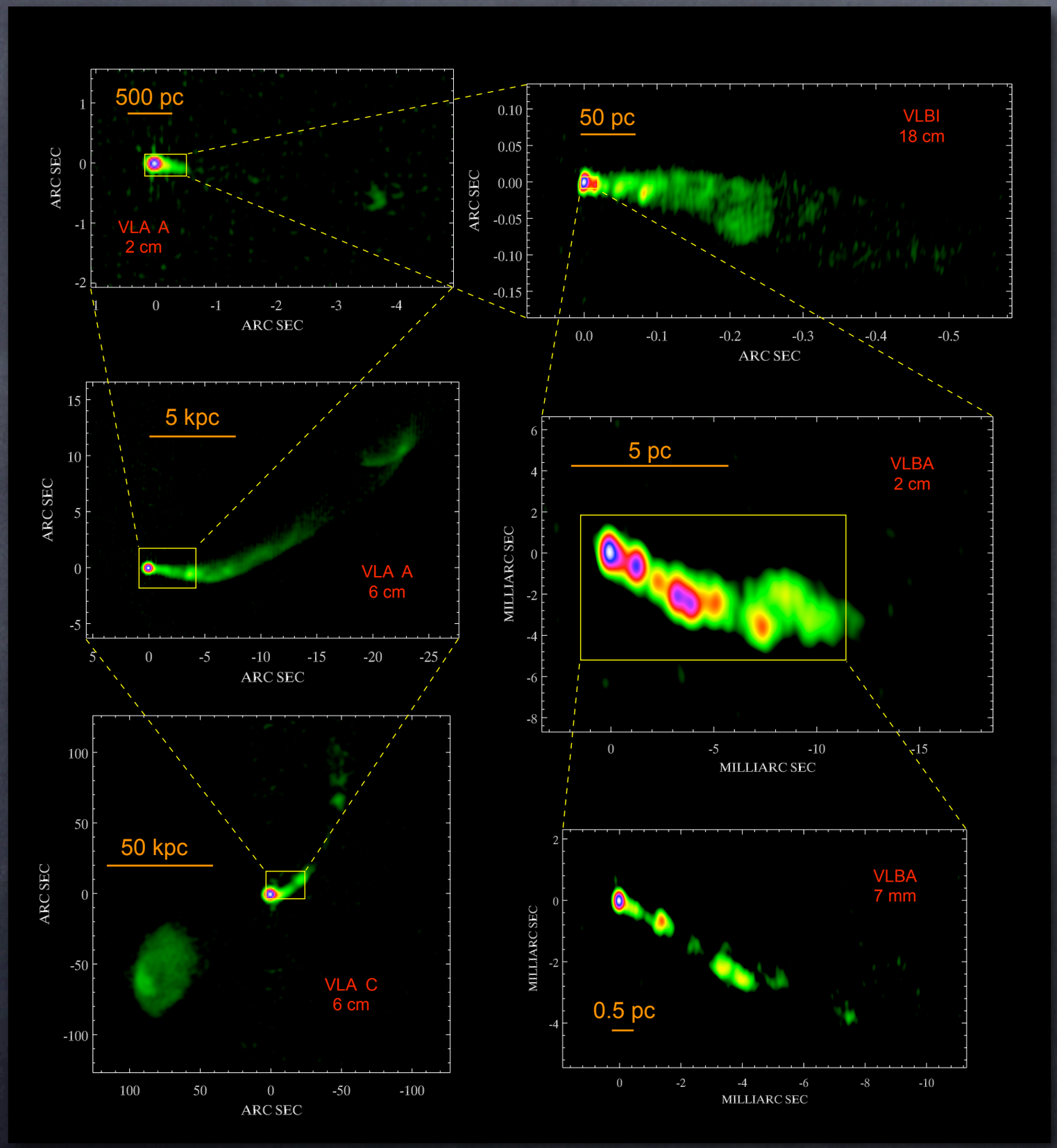

3C120 as a prototype jet

- Prominent radio jet from pc to Kpc scales
- Very active, with multiple components, even at the highest frequencies
- At z=0.033 the VLBA provides a linear resolution up to 0.07 pc (~10^4 R_s)

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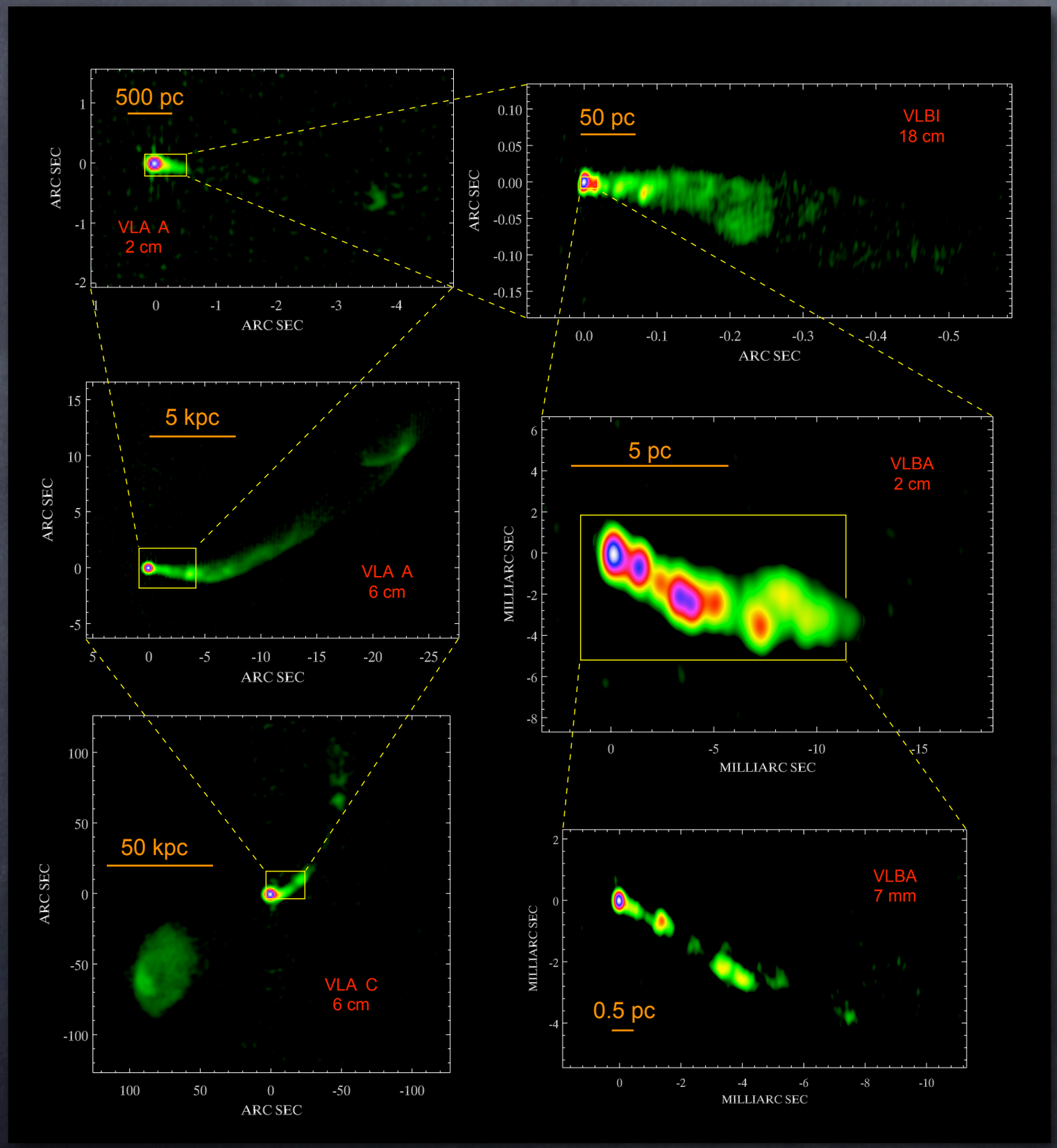

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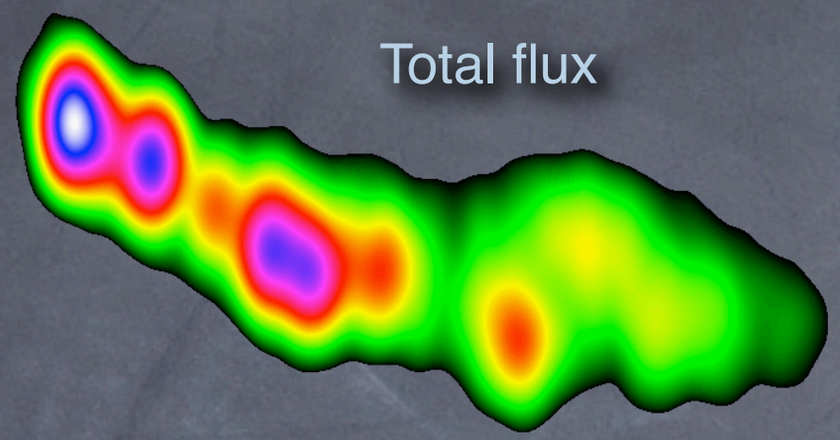

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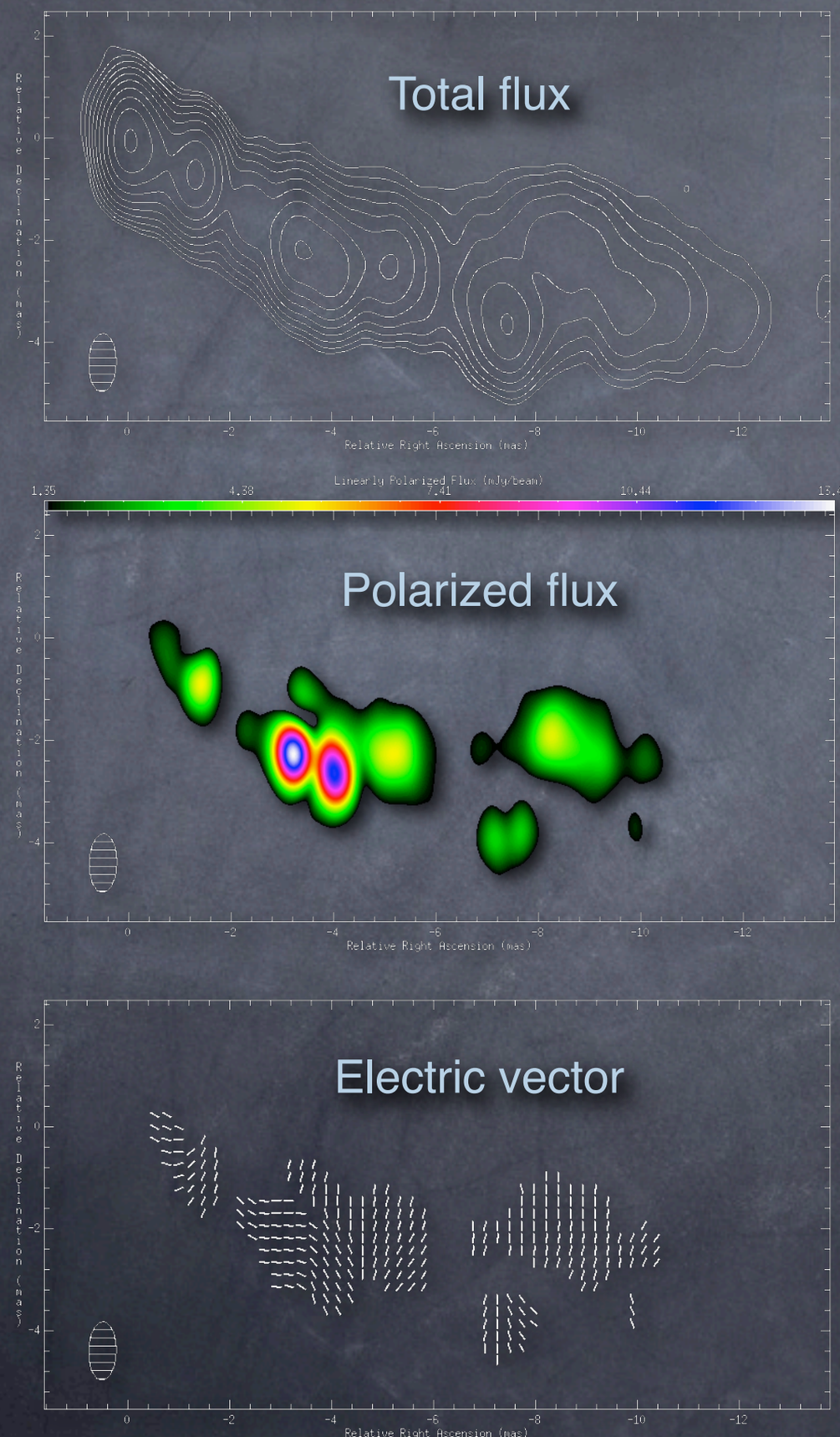

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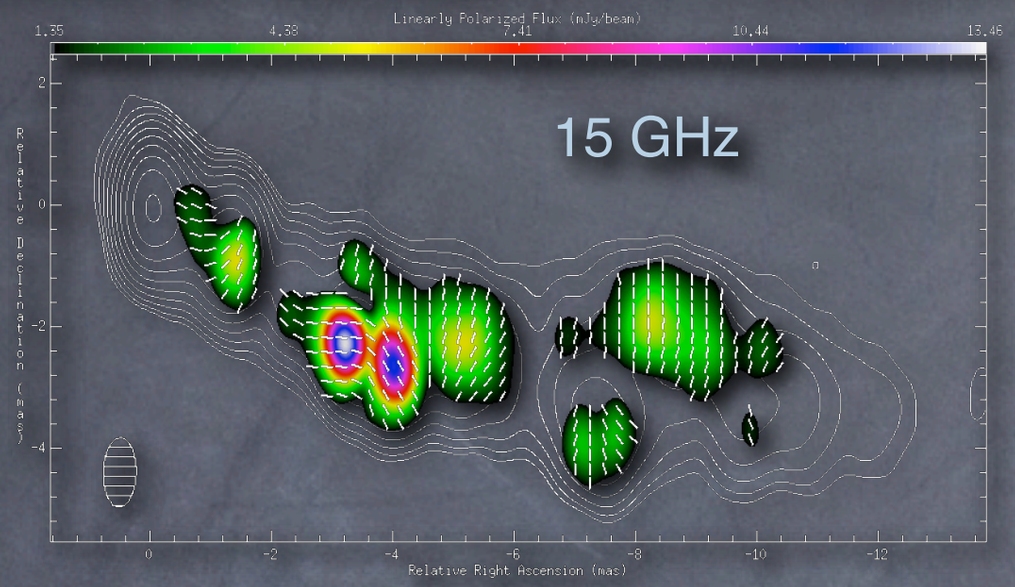

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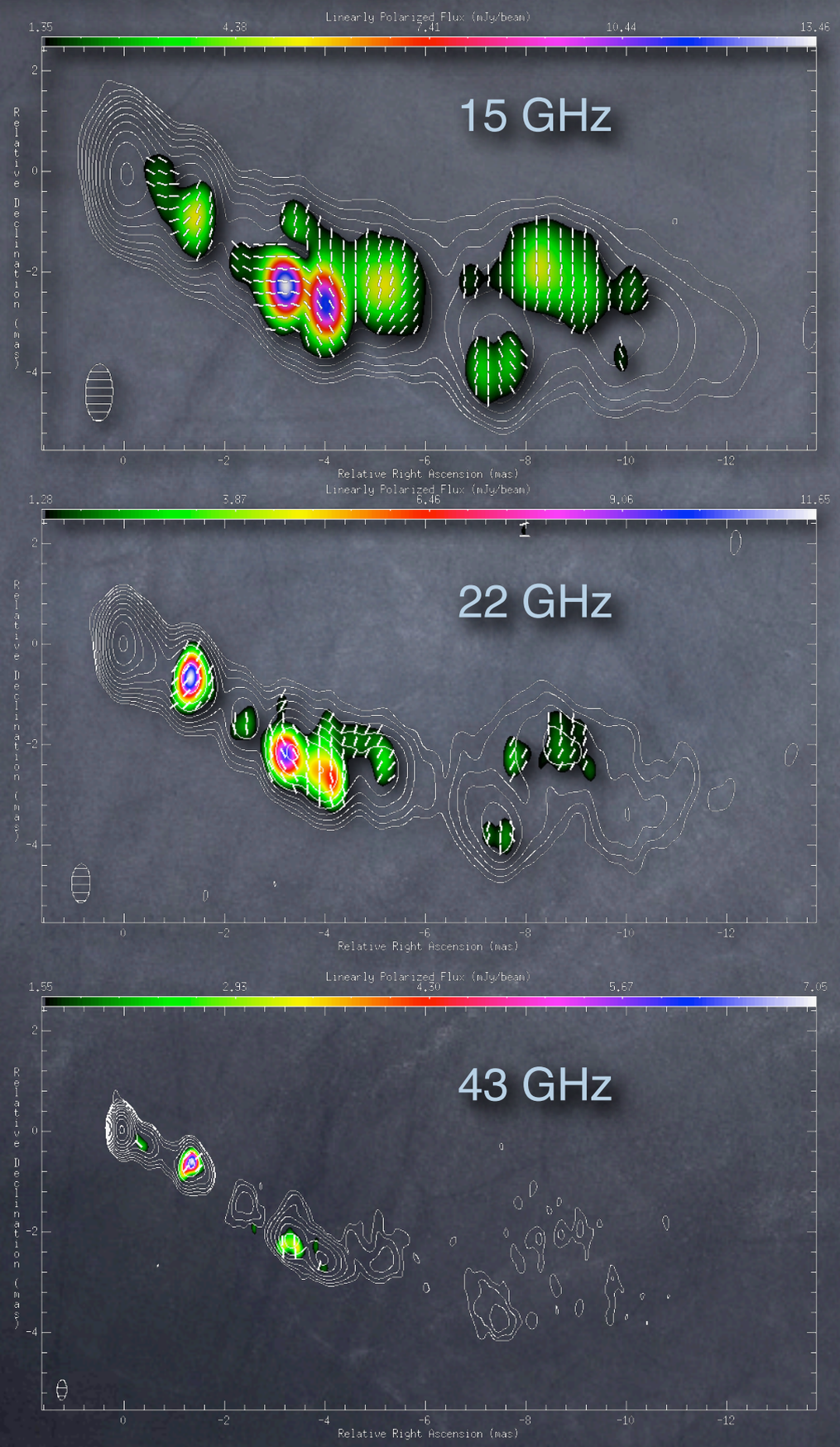

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Gómez et al. (2000, 2001, 2008)

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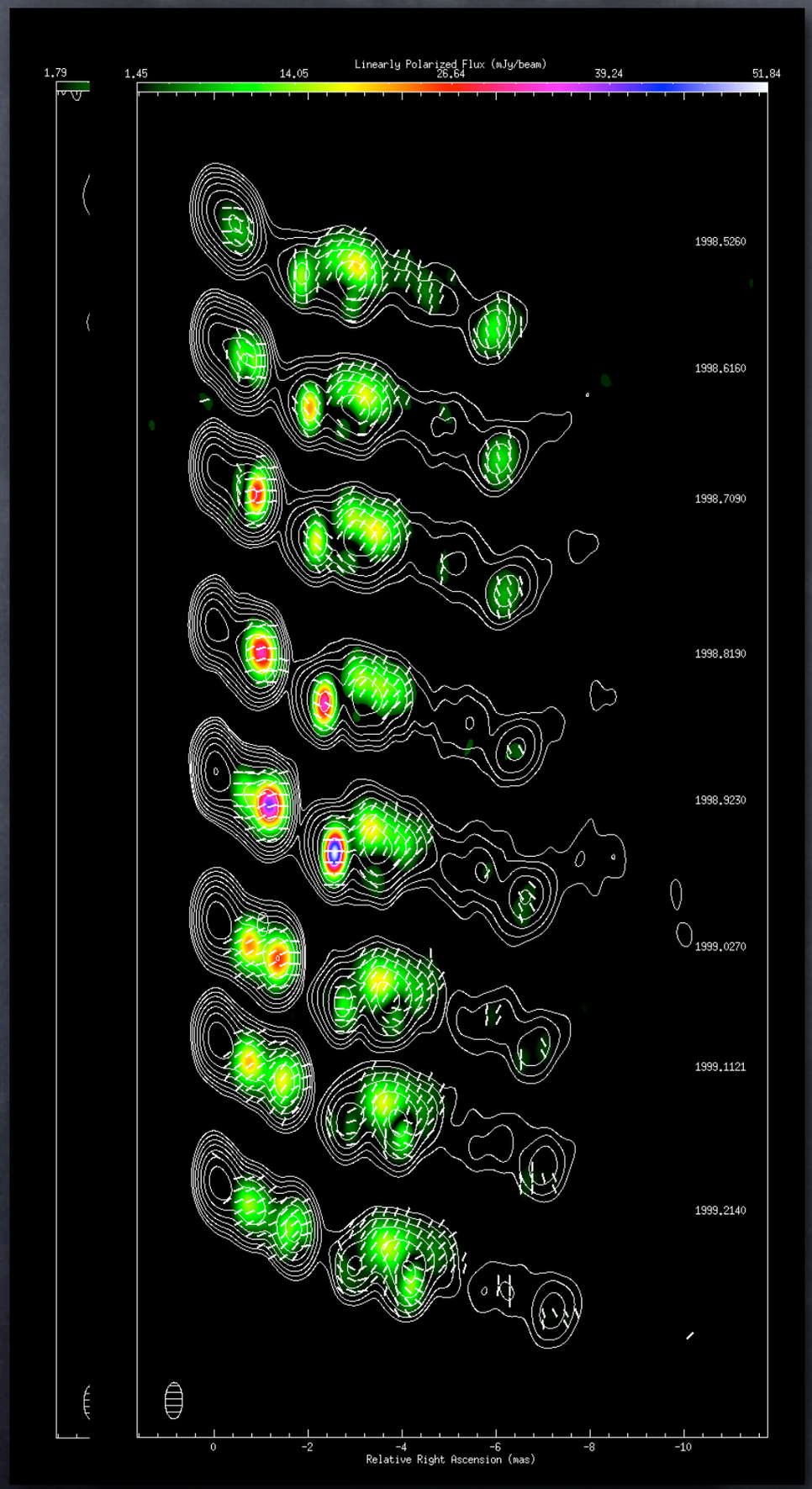

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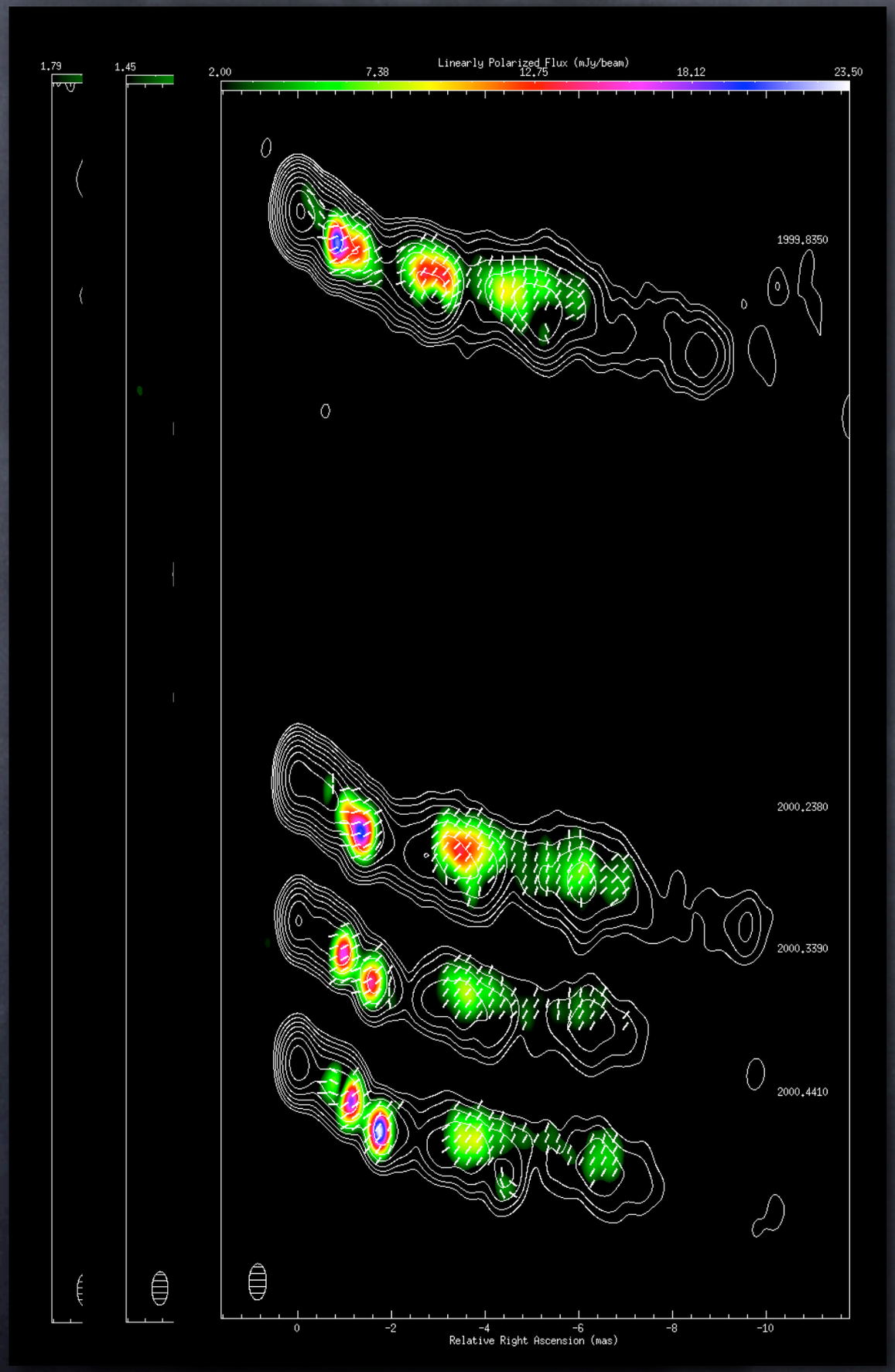

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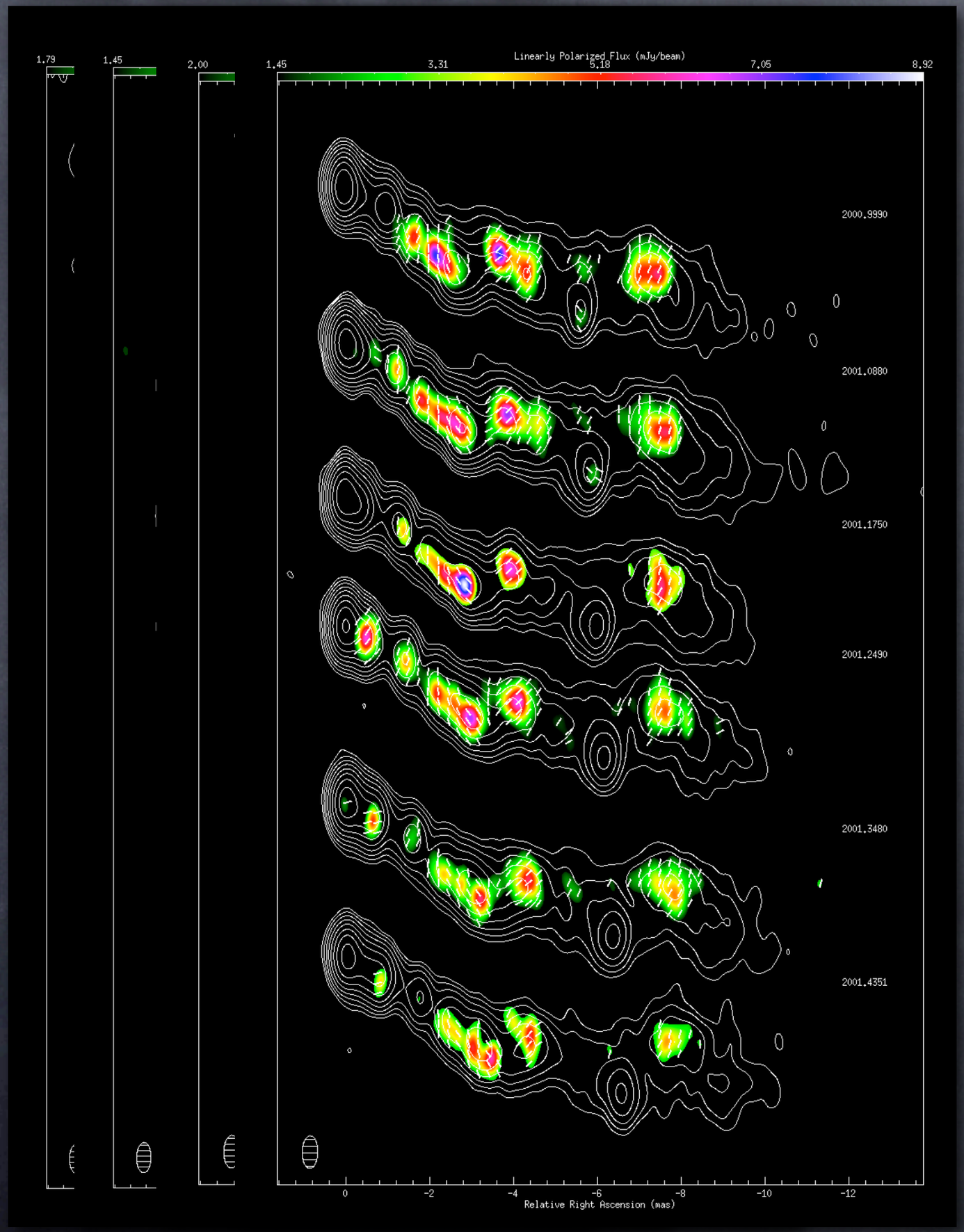

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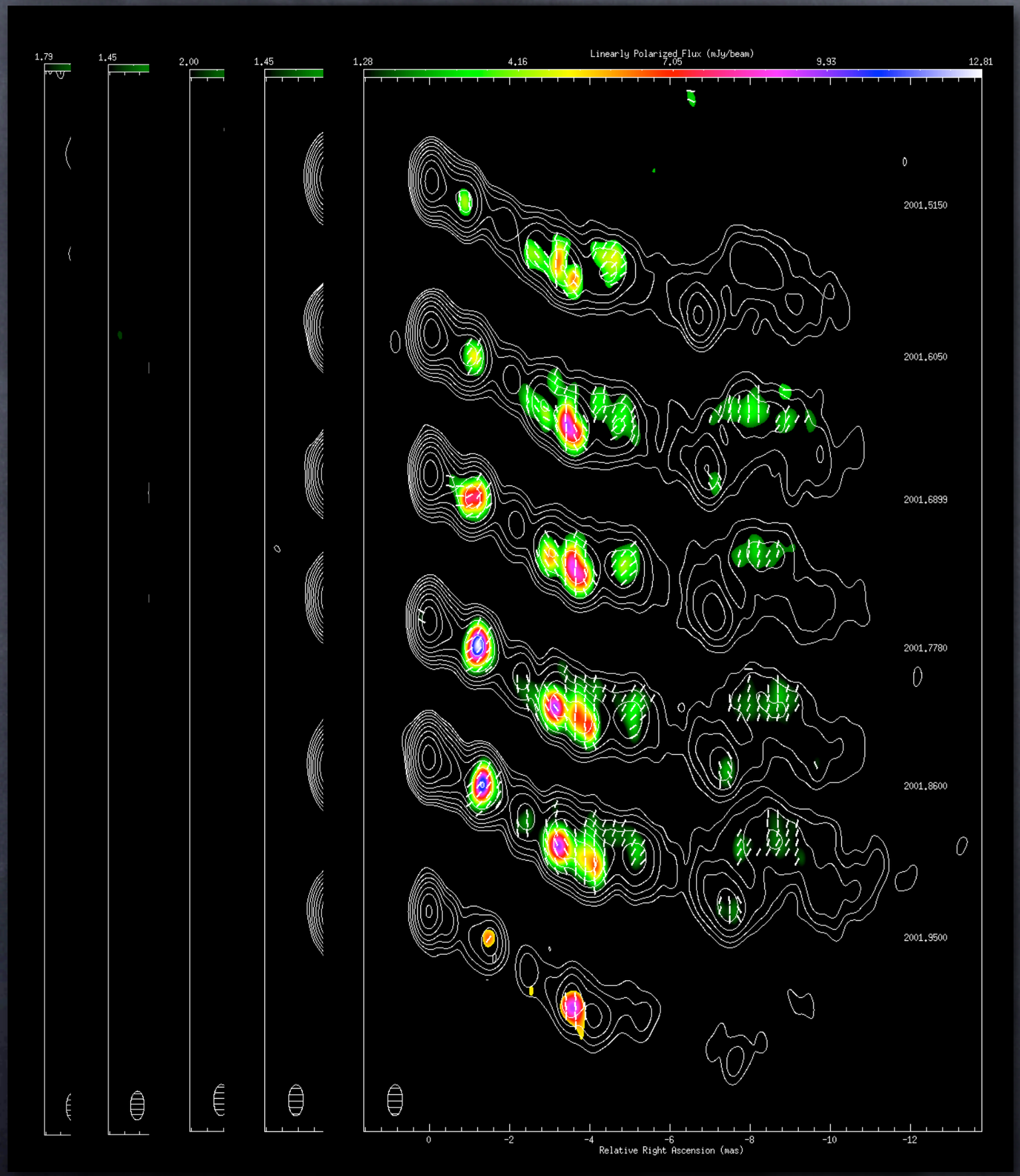

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This allows to obtain a movie of the emission in 3C120.

22 GHz

43 GHz

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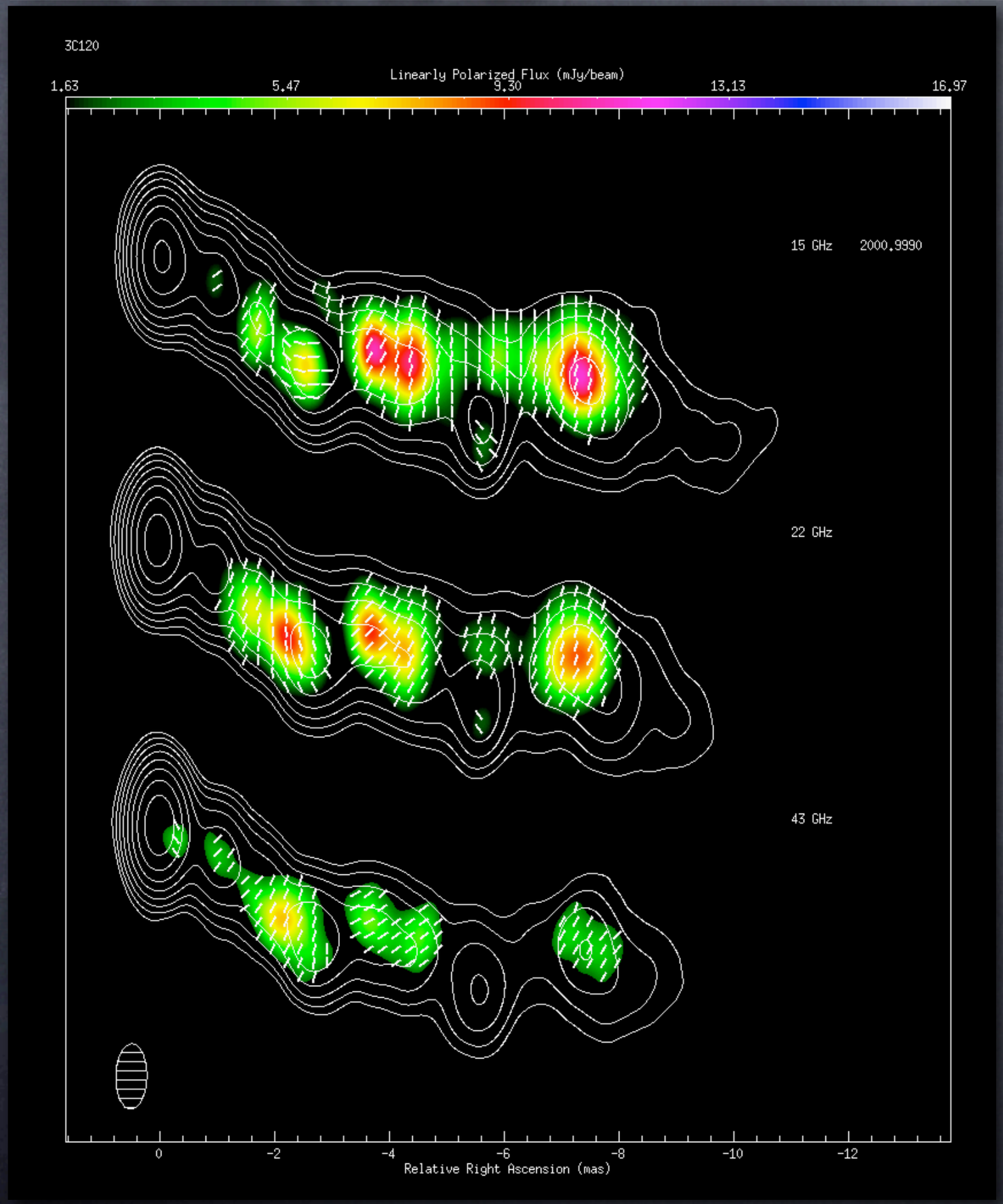

This allows to obtain a movie of the emission in 3C120.

Superluminal components map the jet polarization as they travel downstream.

The case of 3C120

By combining the information from all the epochs it is possible to reveal the full jet RM structure.

Bars indicate the EVPA at zero RM

Rotation Measure map

The case of 3C120

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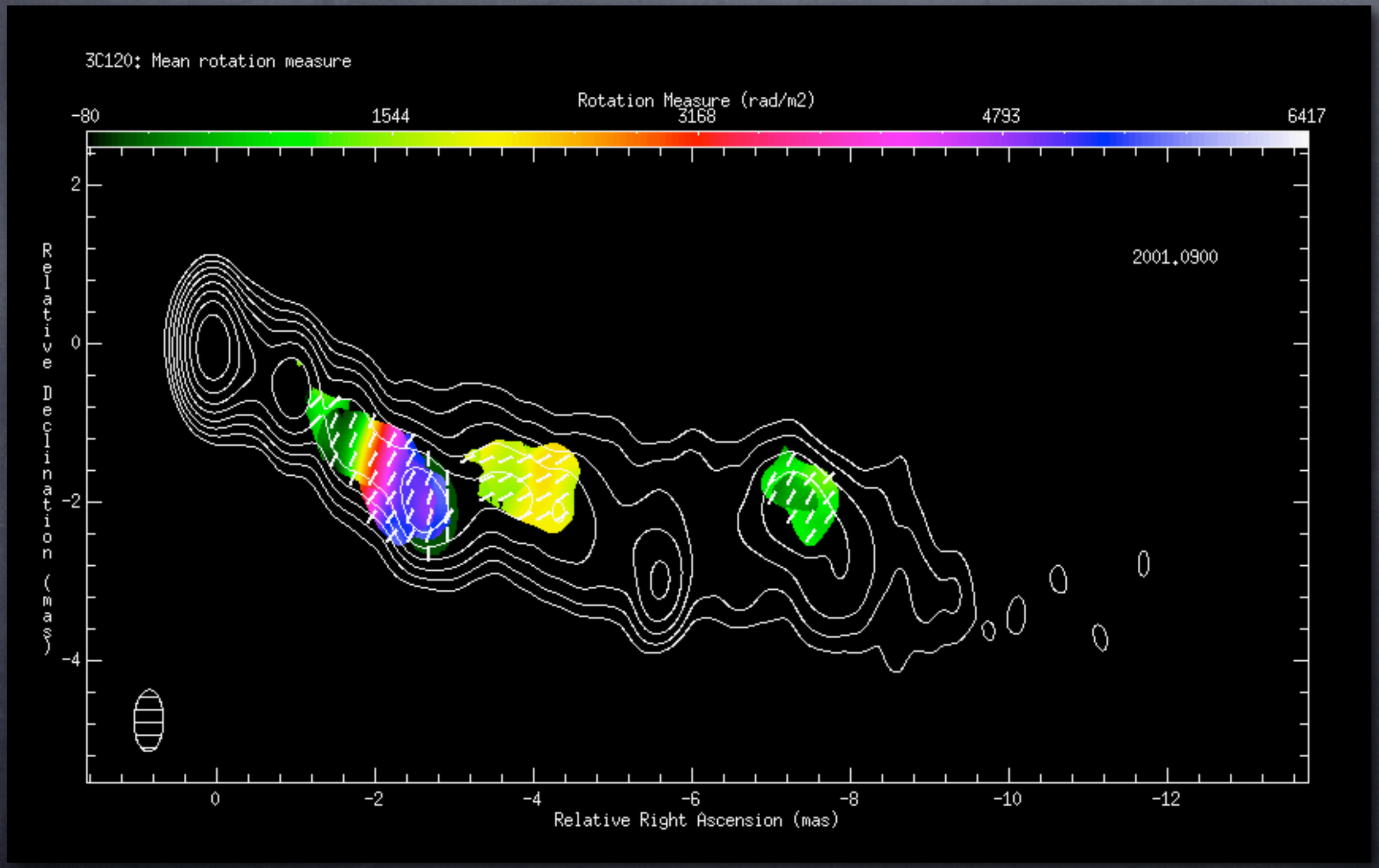

The case of 3C120

Degree of polarization

15 GHz

22 GHz

43 GHz

We can also combine the information at each frequency to obtain a map of the degree of polarization for the full jet

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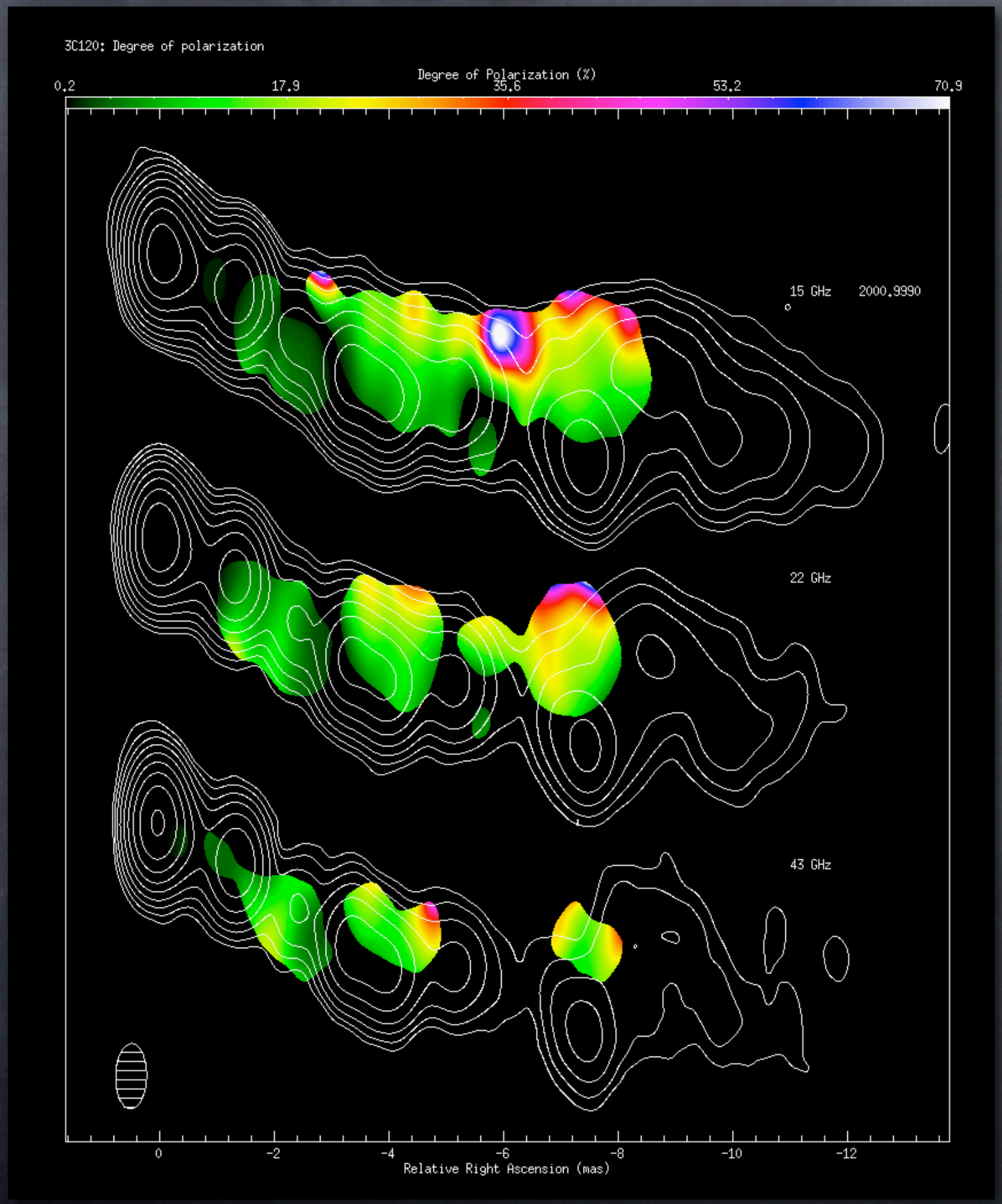

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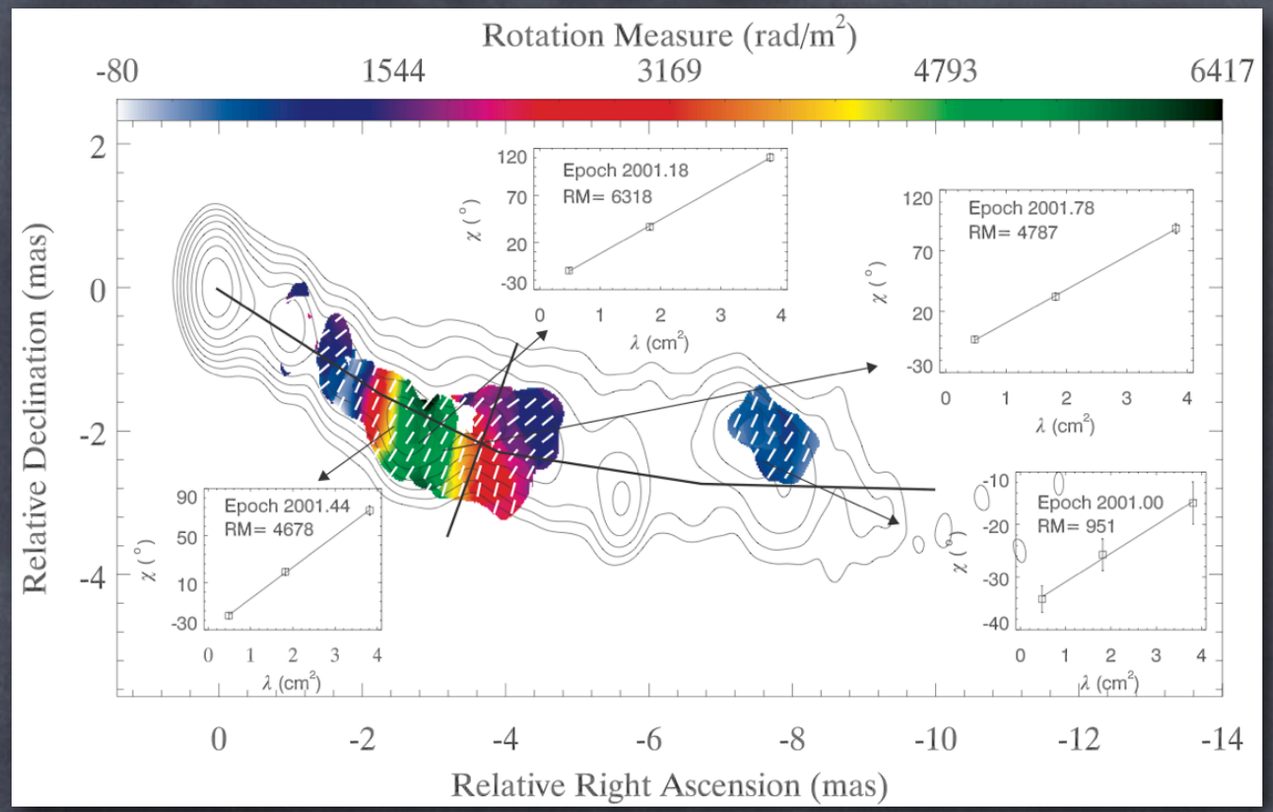
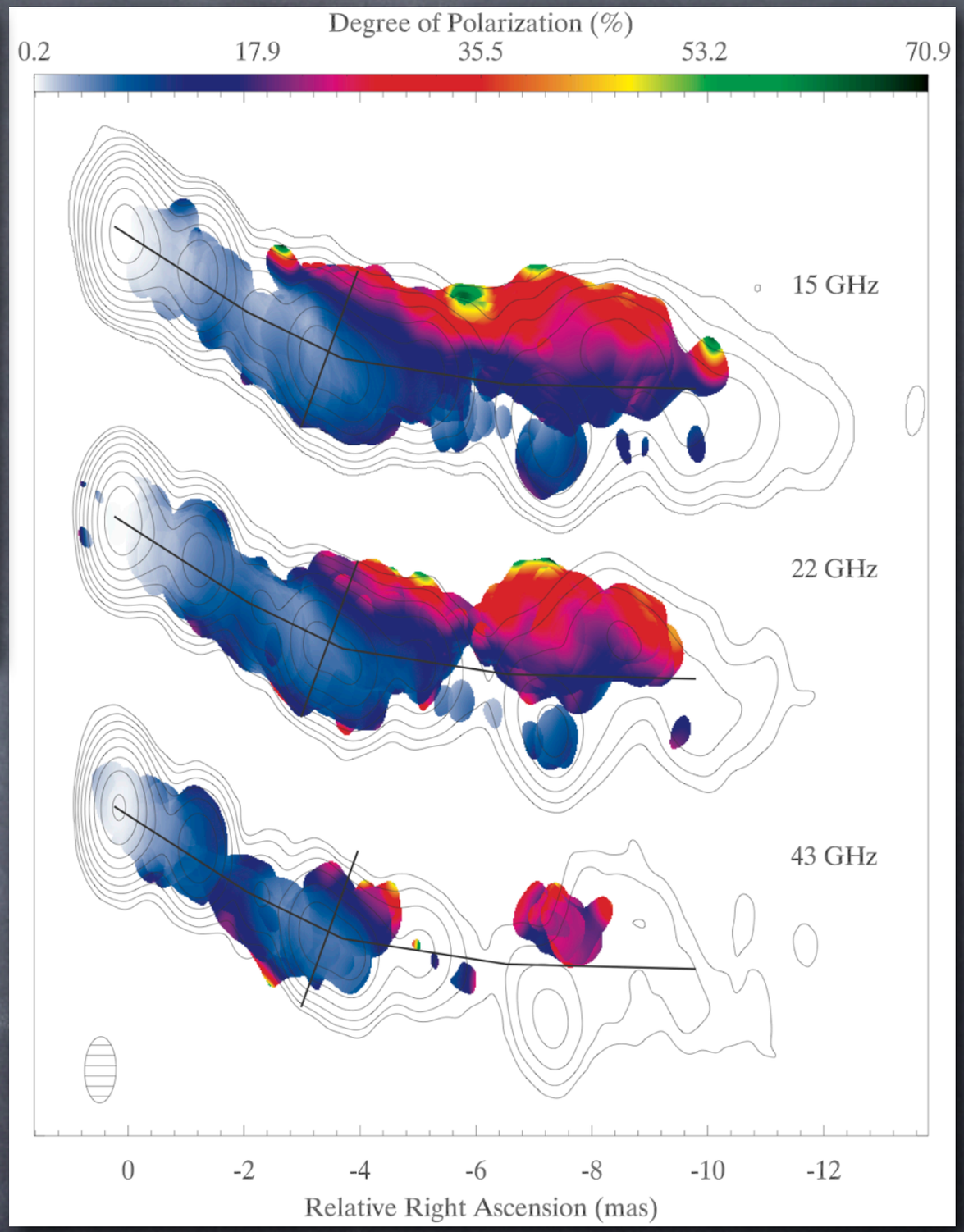
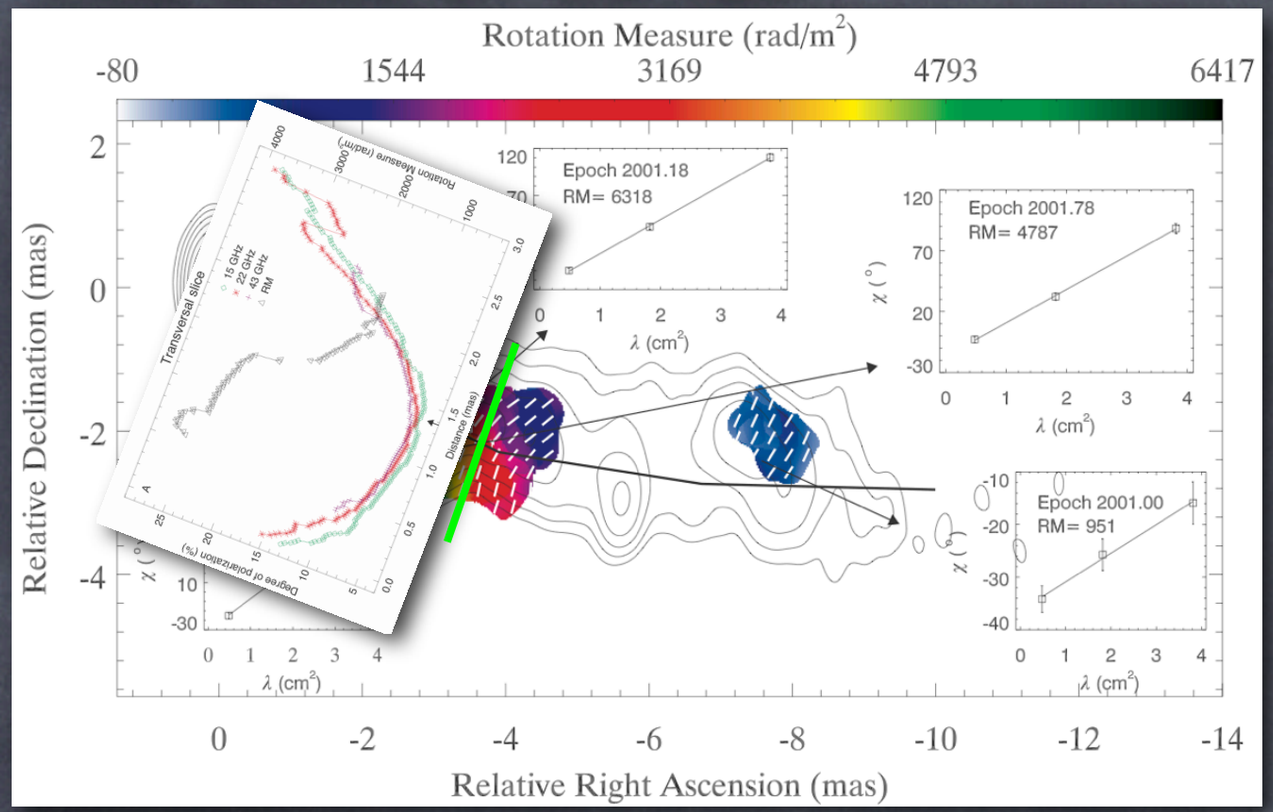
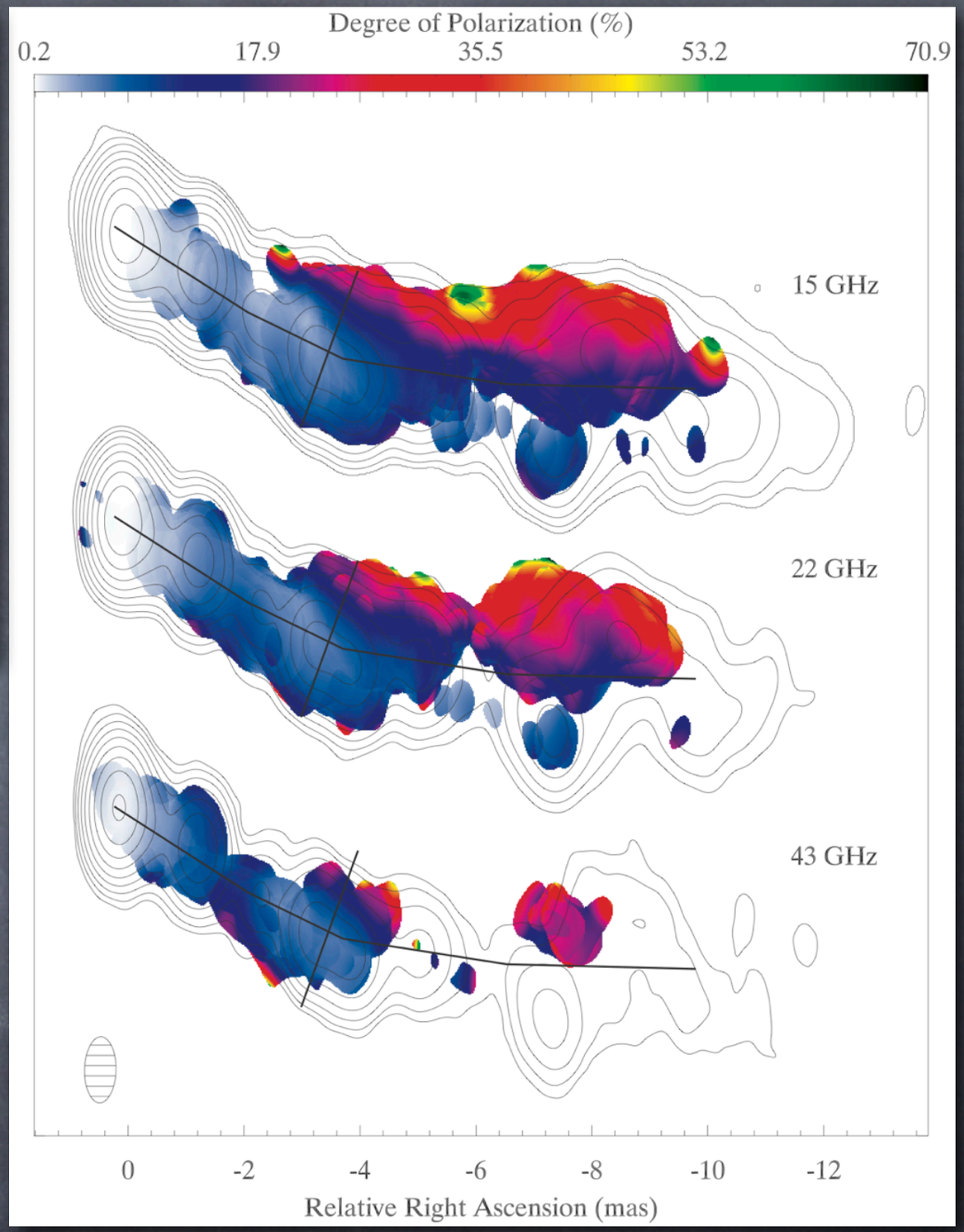




Gómez et al. (2008)

The case of 3C120





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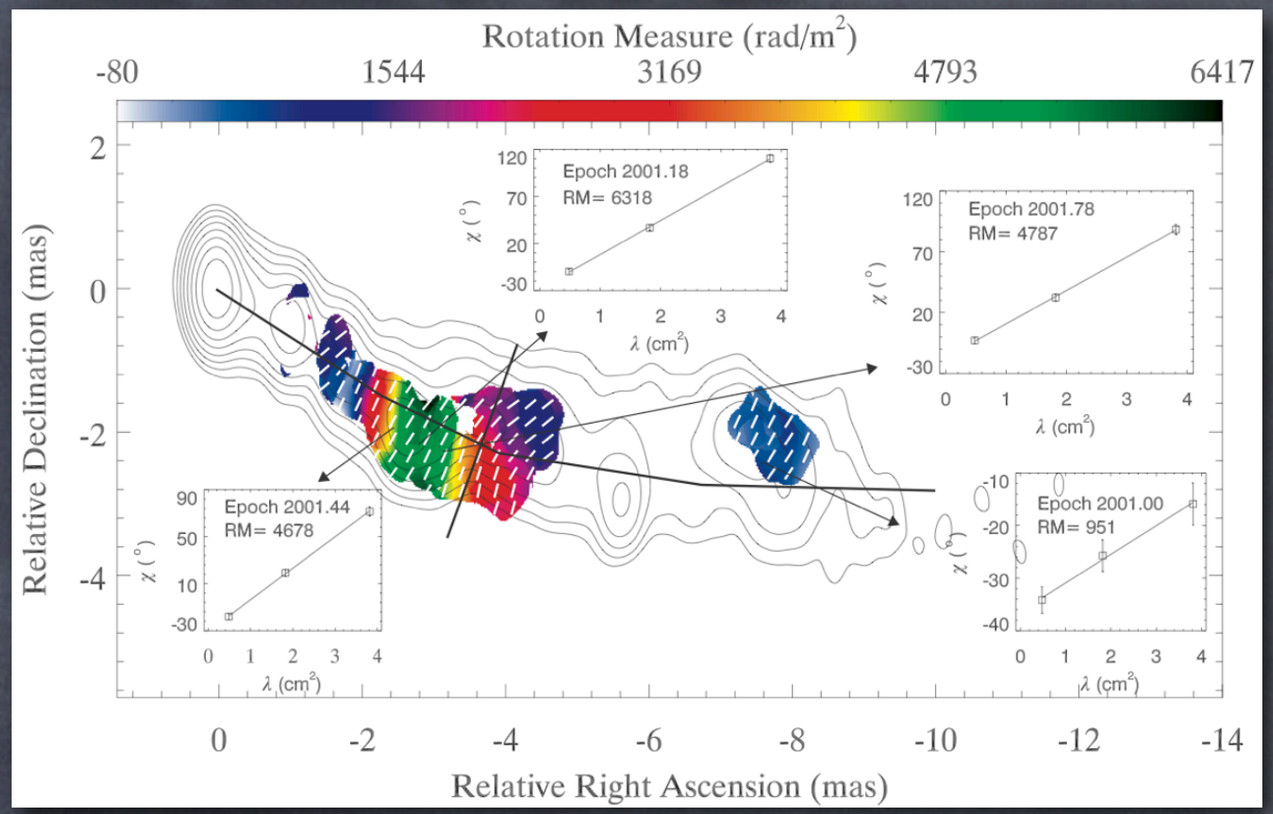

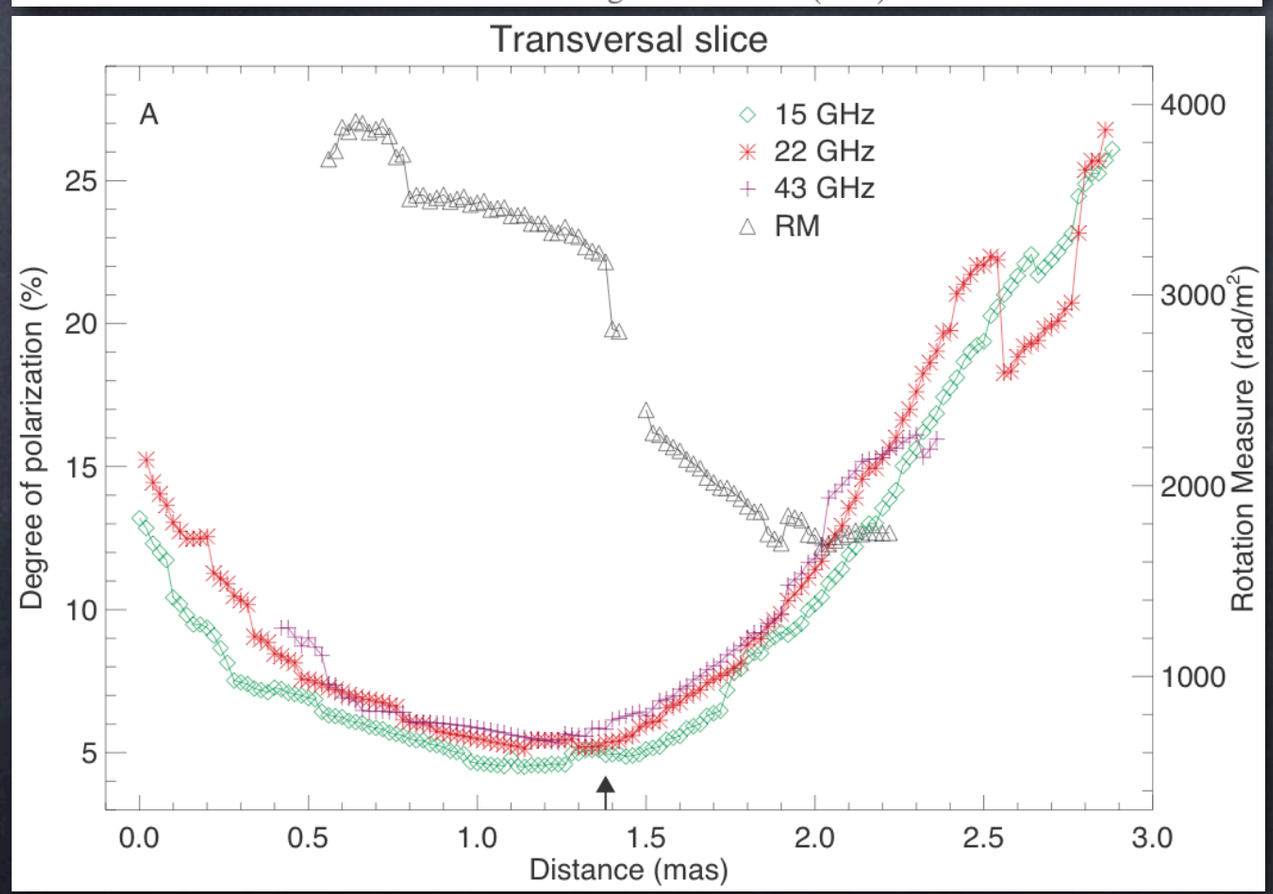

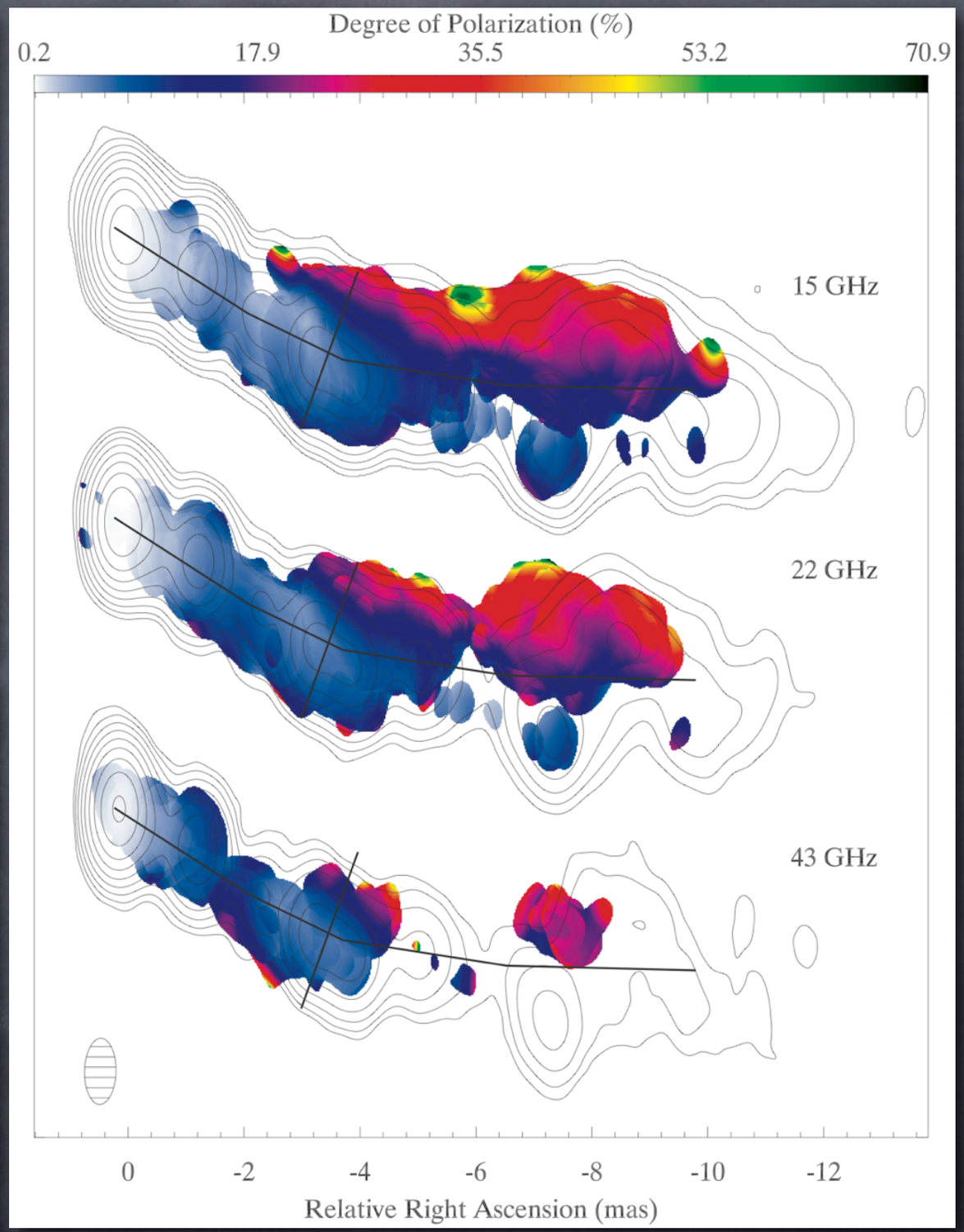

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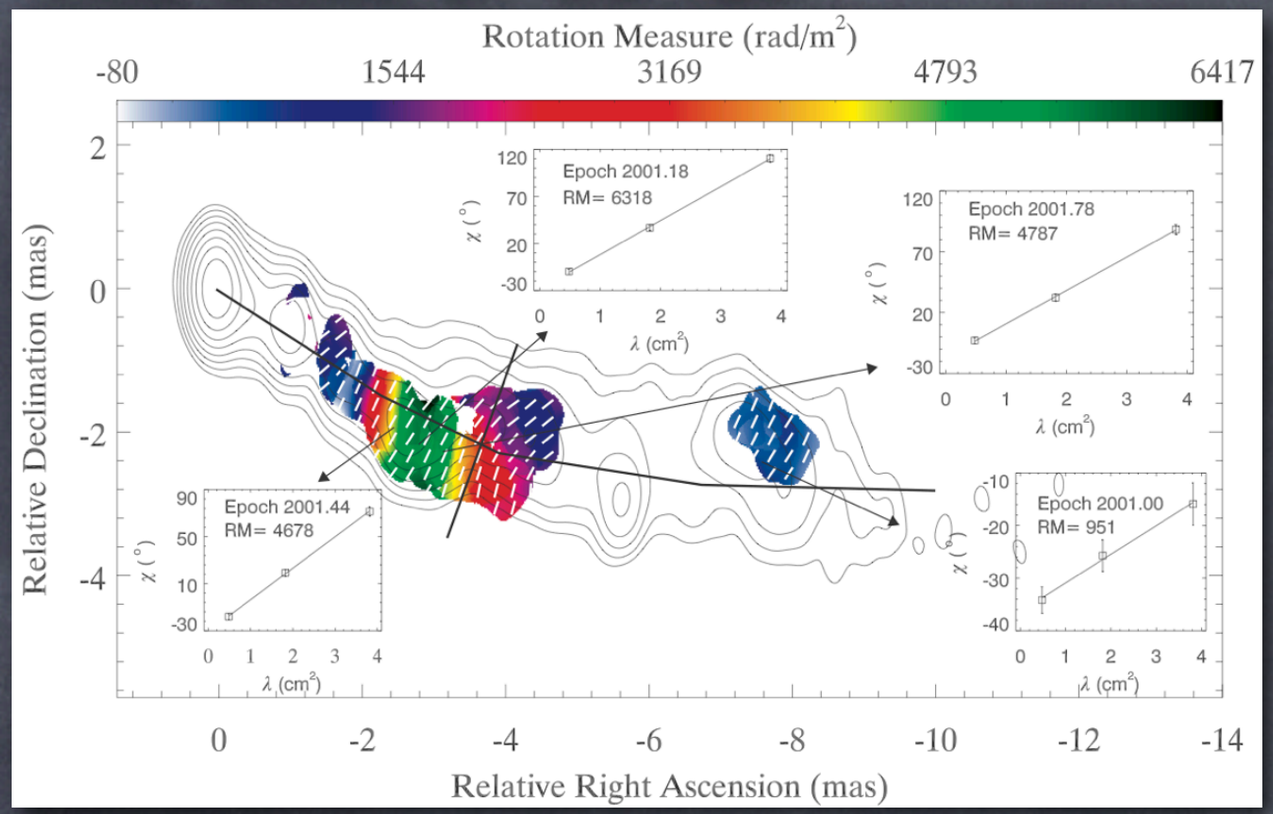
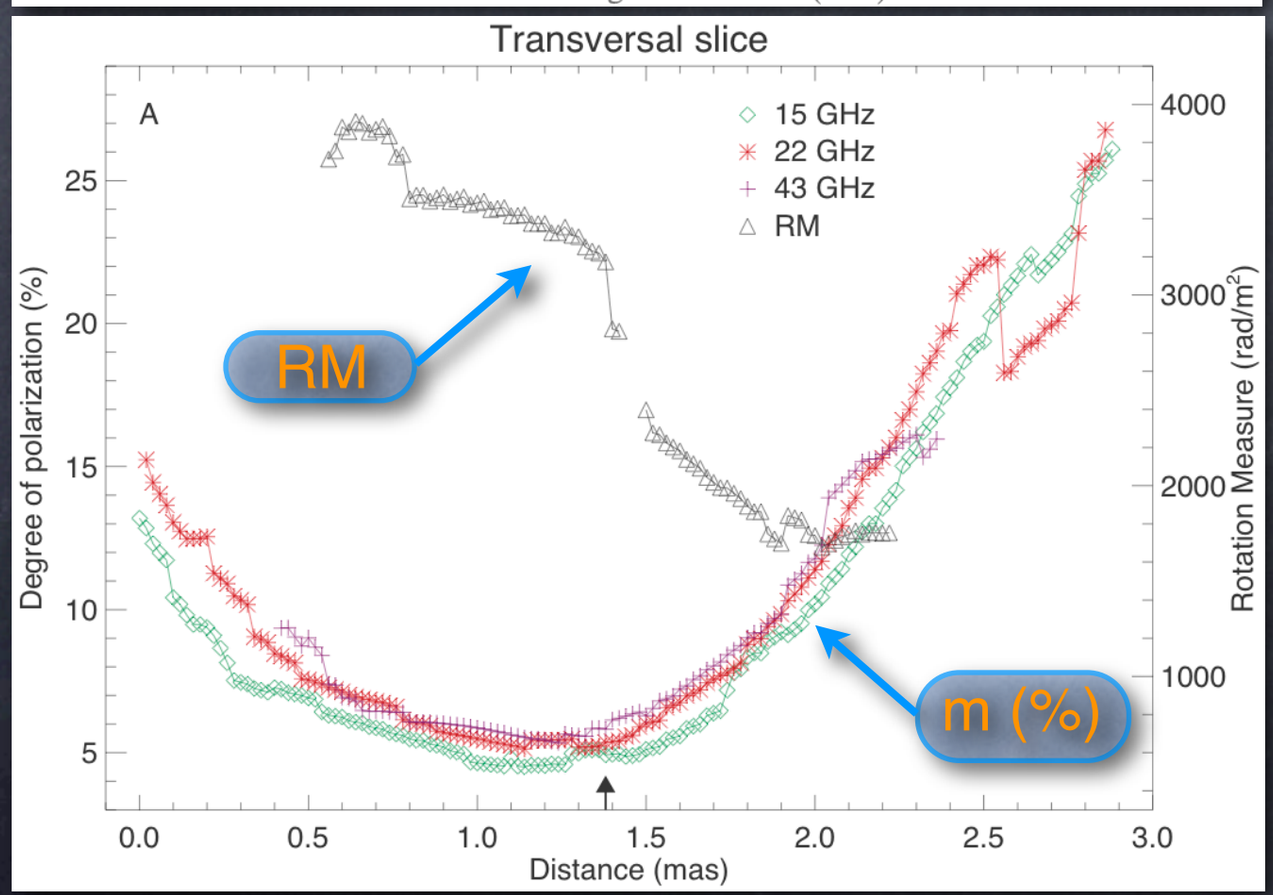
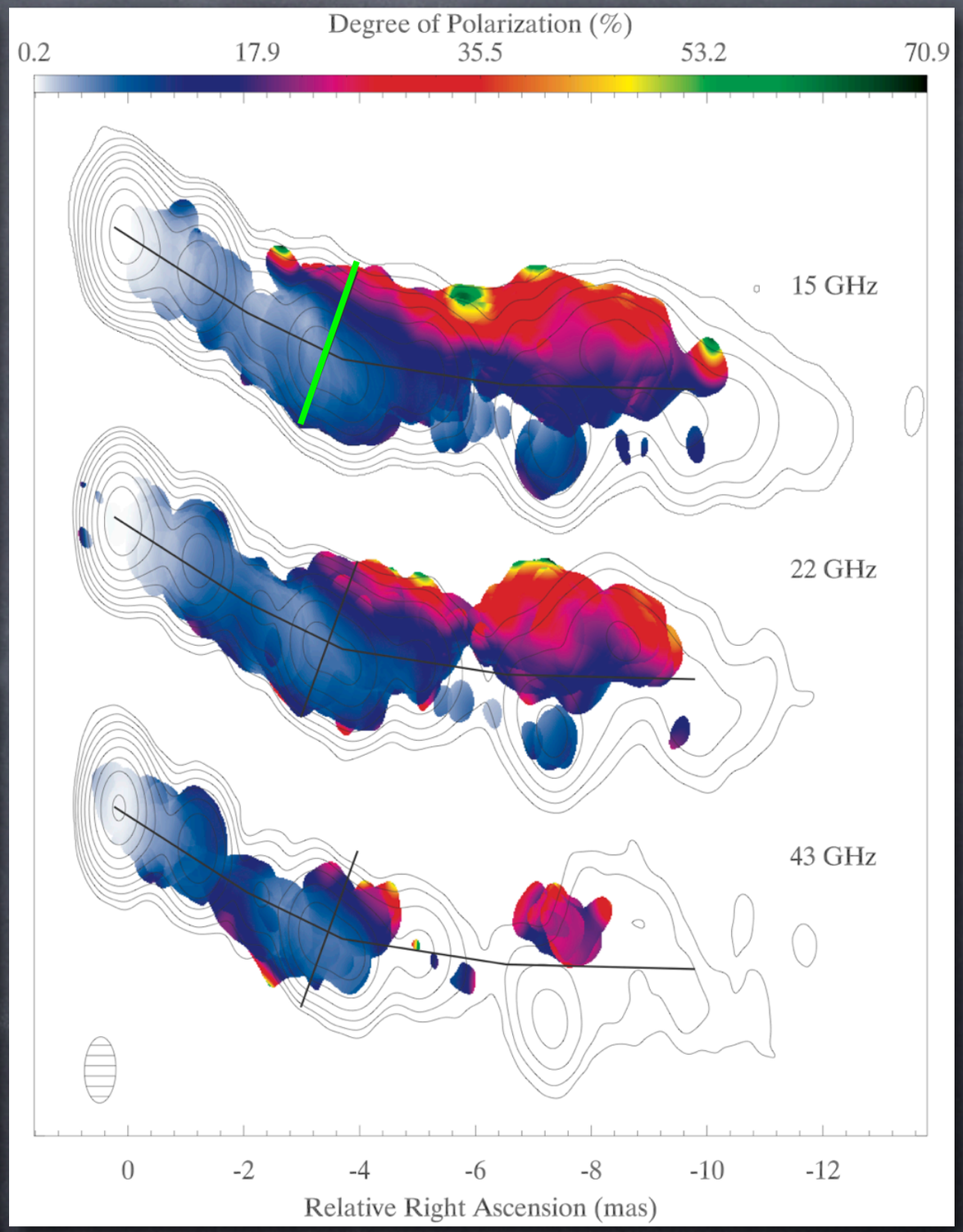
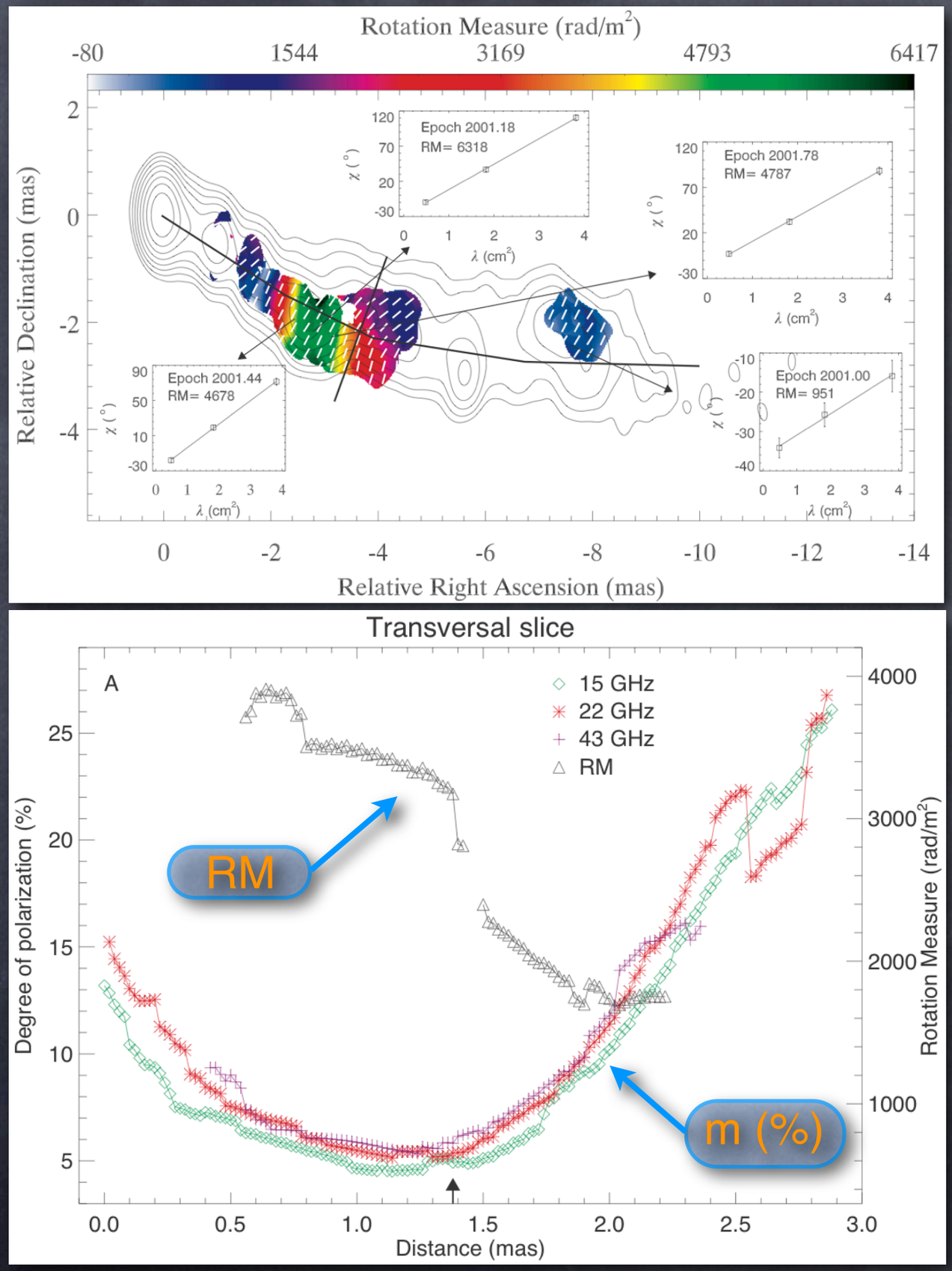






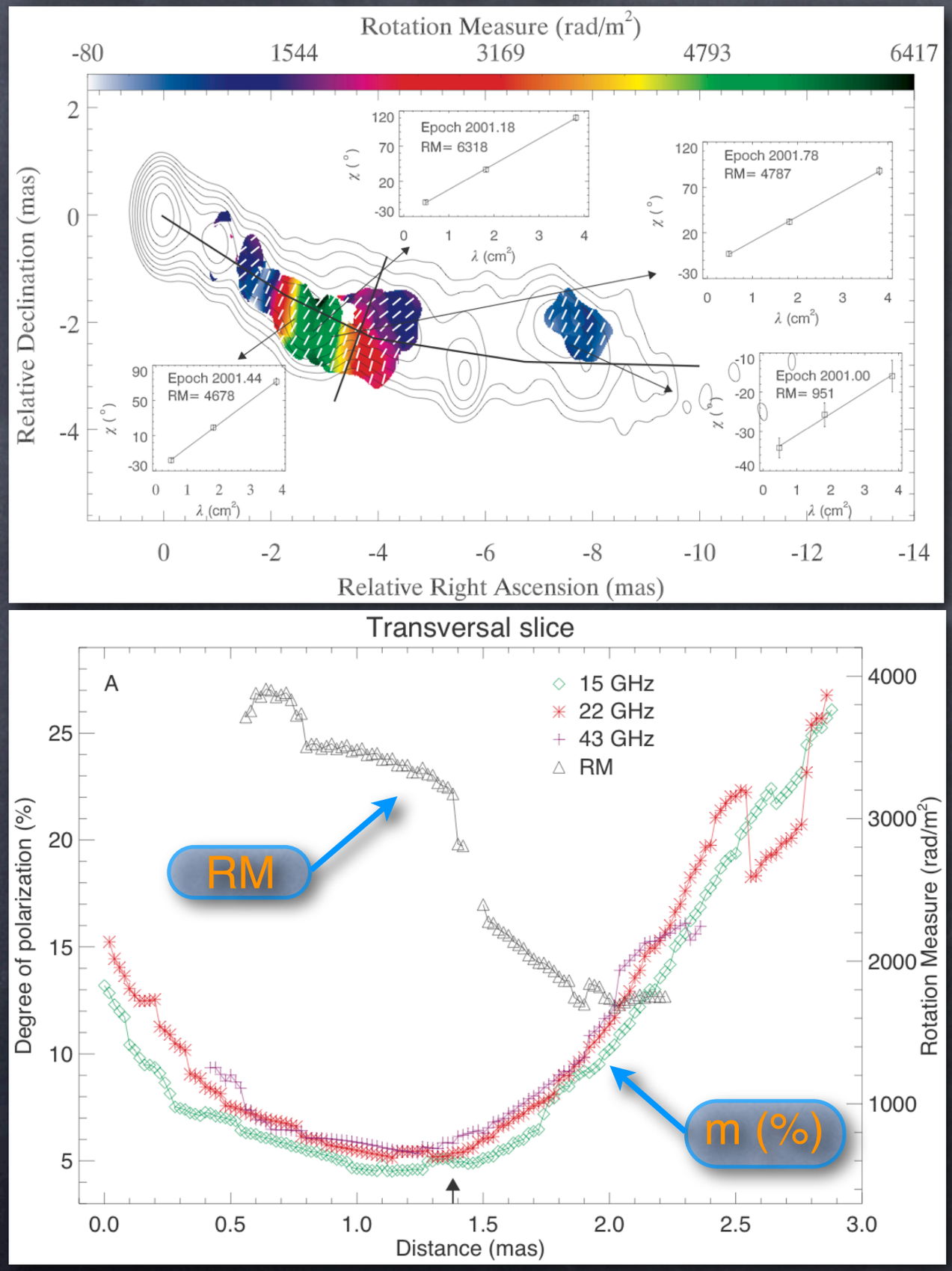
Gómez et al. (2008)

The case of 3C120



Gómez et al. (2008)

The case of 3C120



- Stratification in RM and degree of polarization across the jet as expected for the case of a helical magnetic field.

Gómez et al. (2008)

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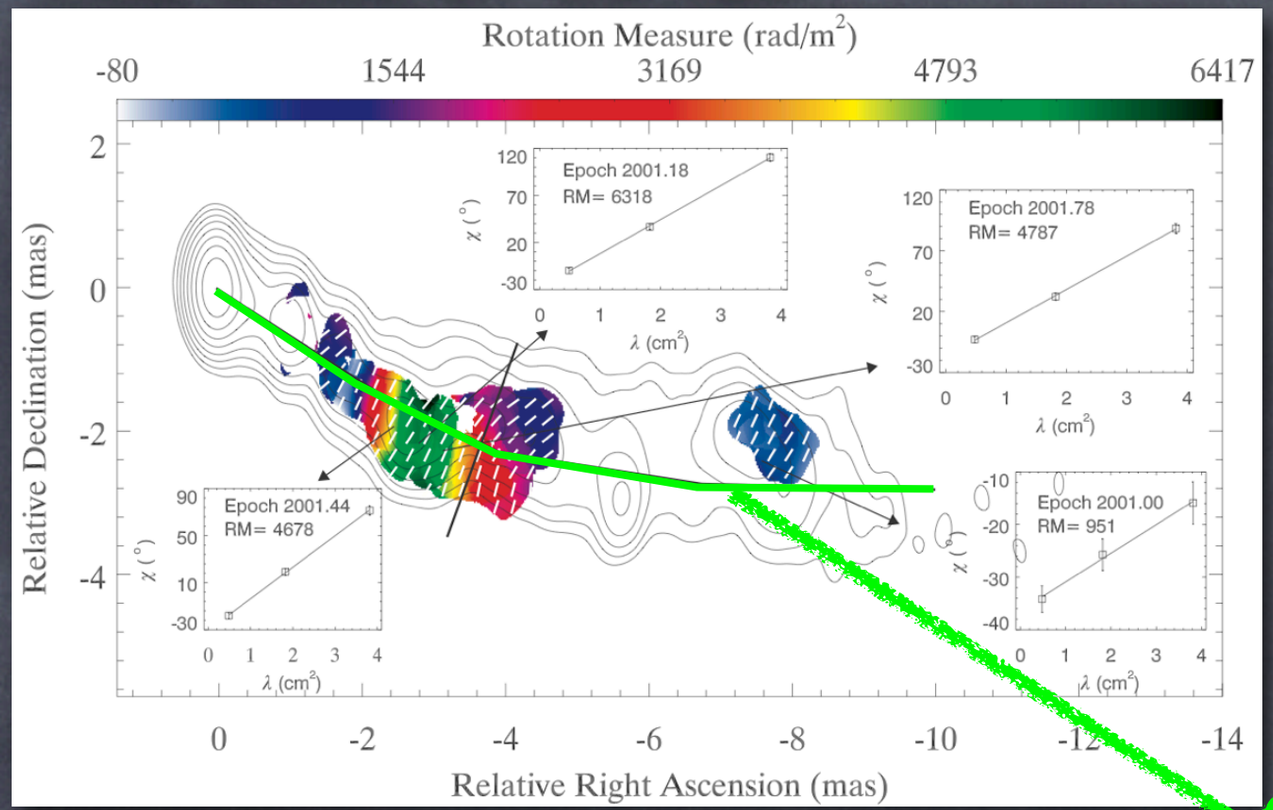
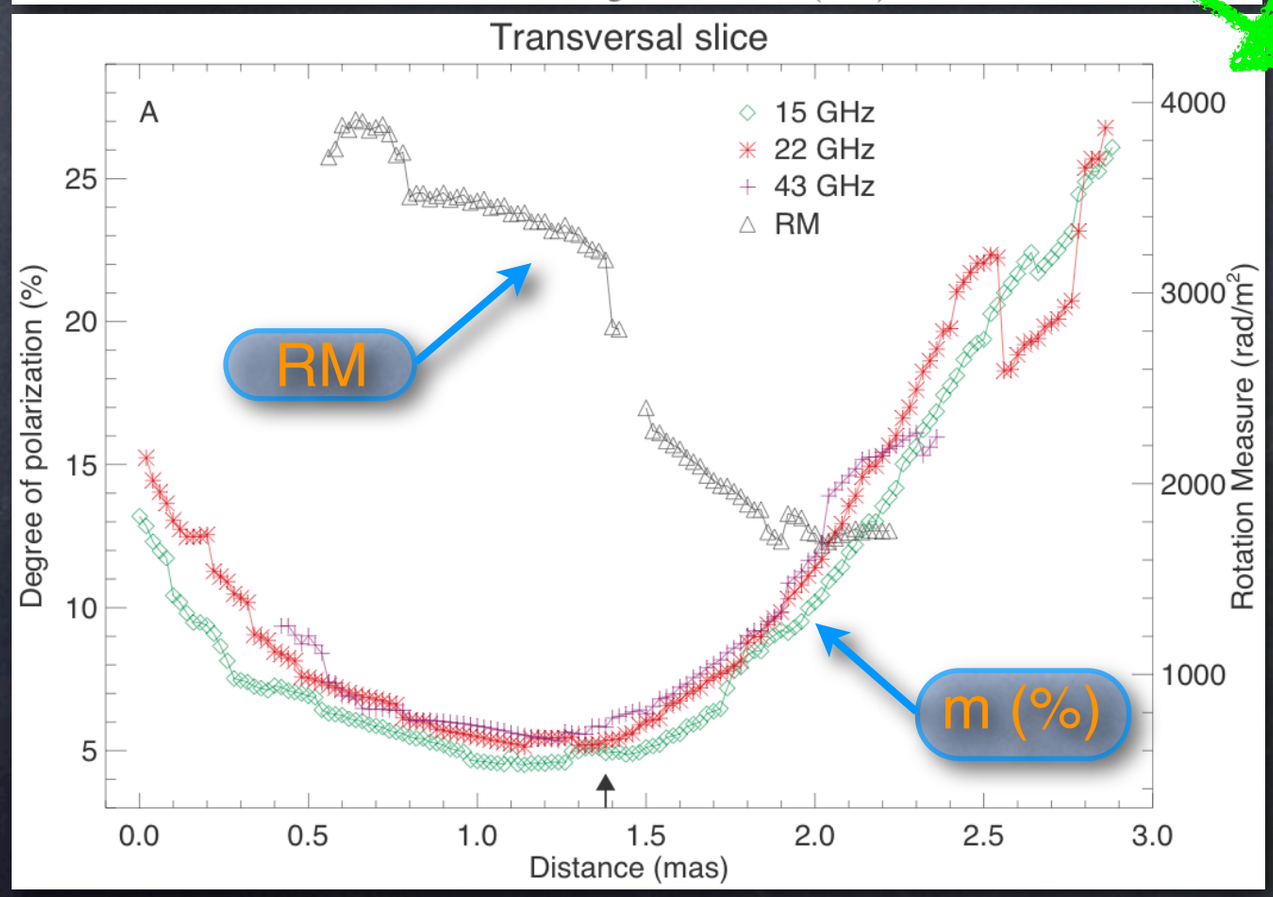
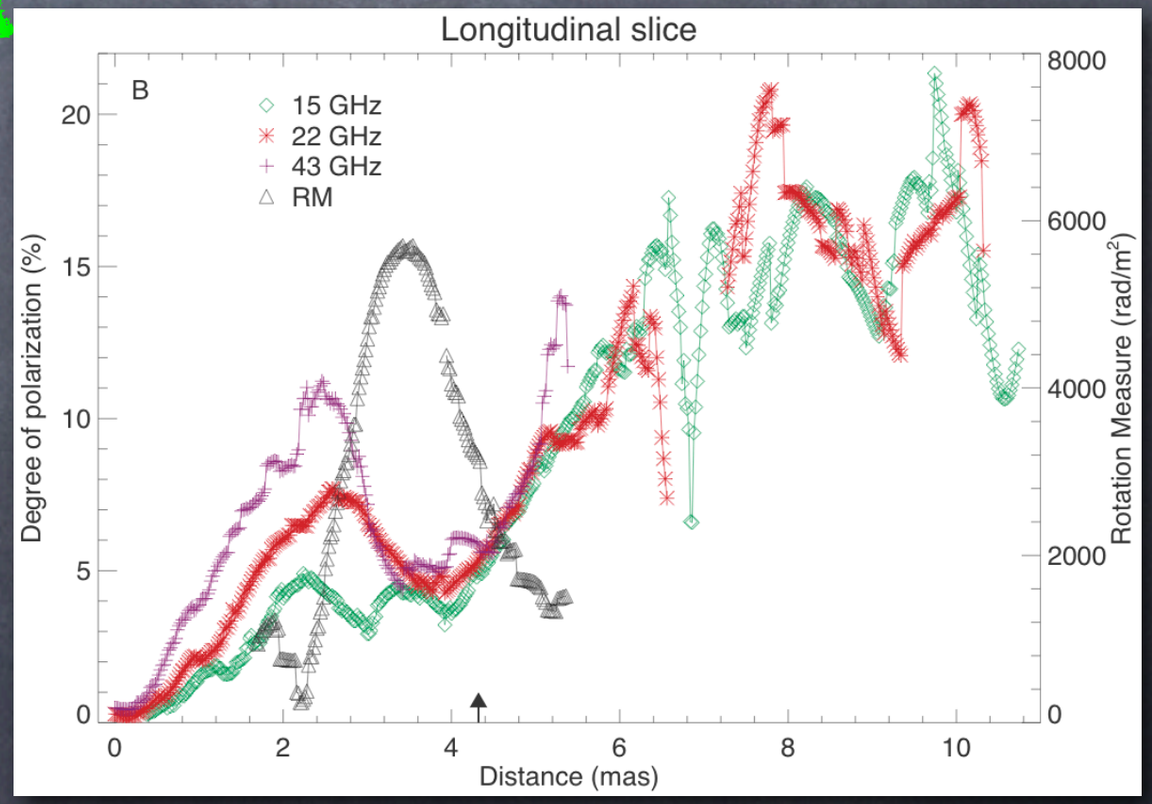


- Stratification in RM and degree of polarization across the jet as expected for the case of a helical magnetic field.
- Localized region of enhanced RM. Interpreted as the result of the interaction between the jet and the external medium.





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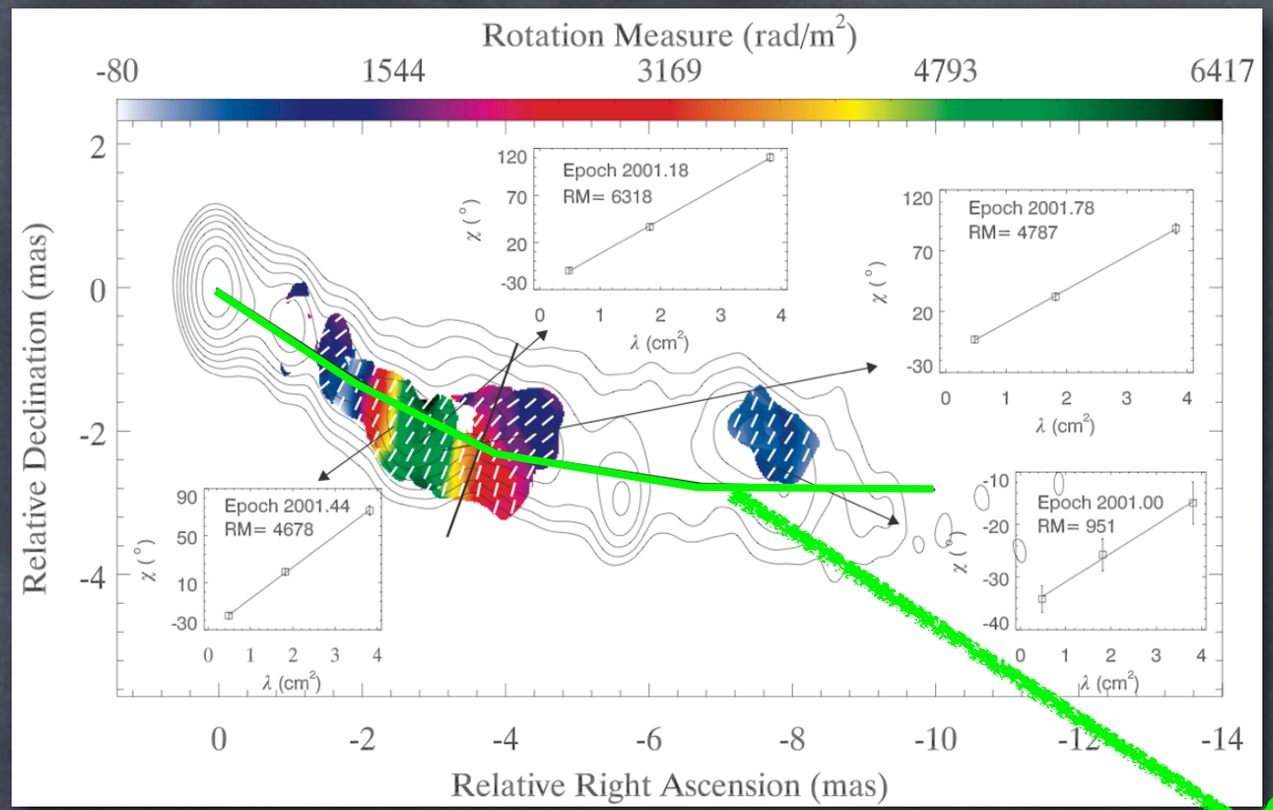
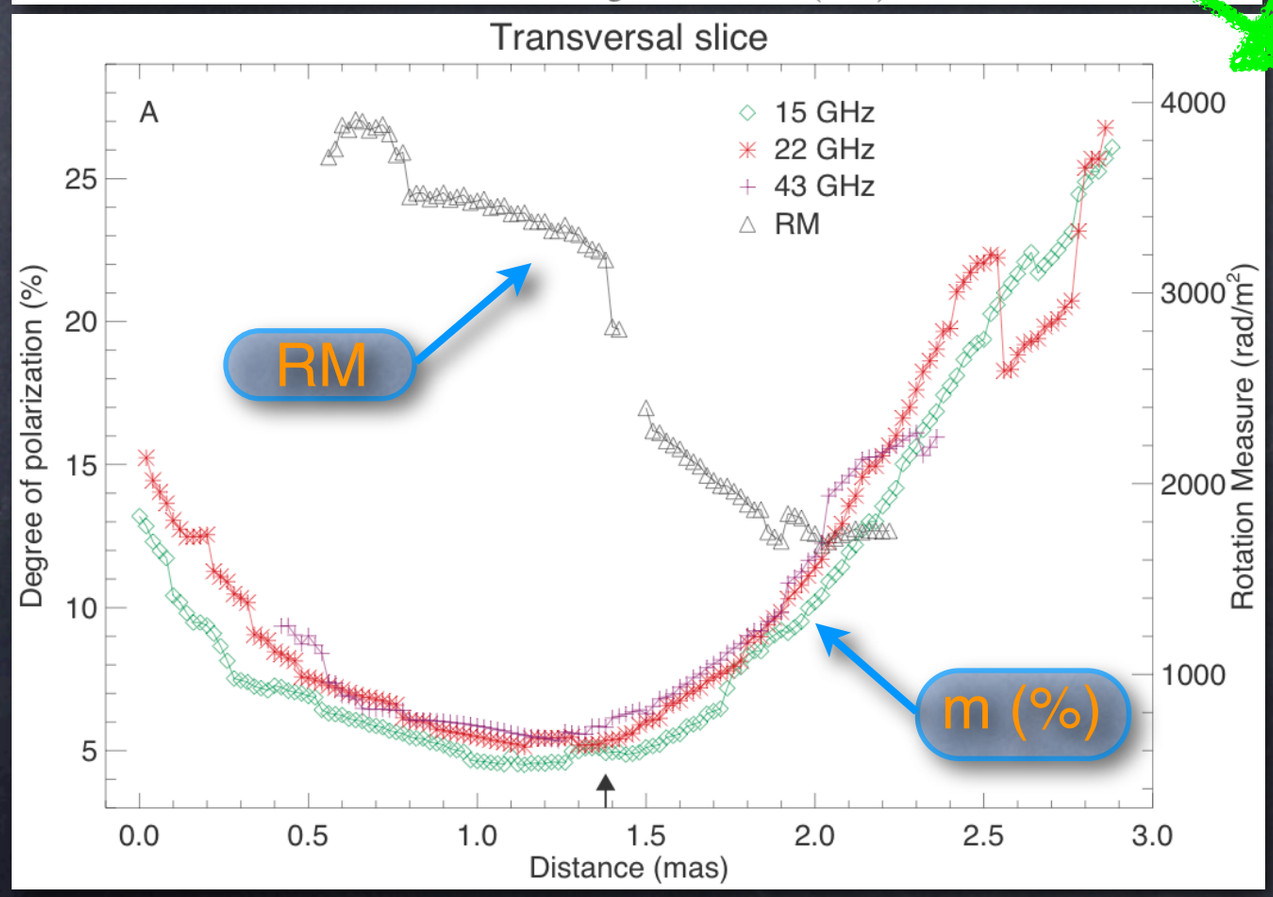
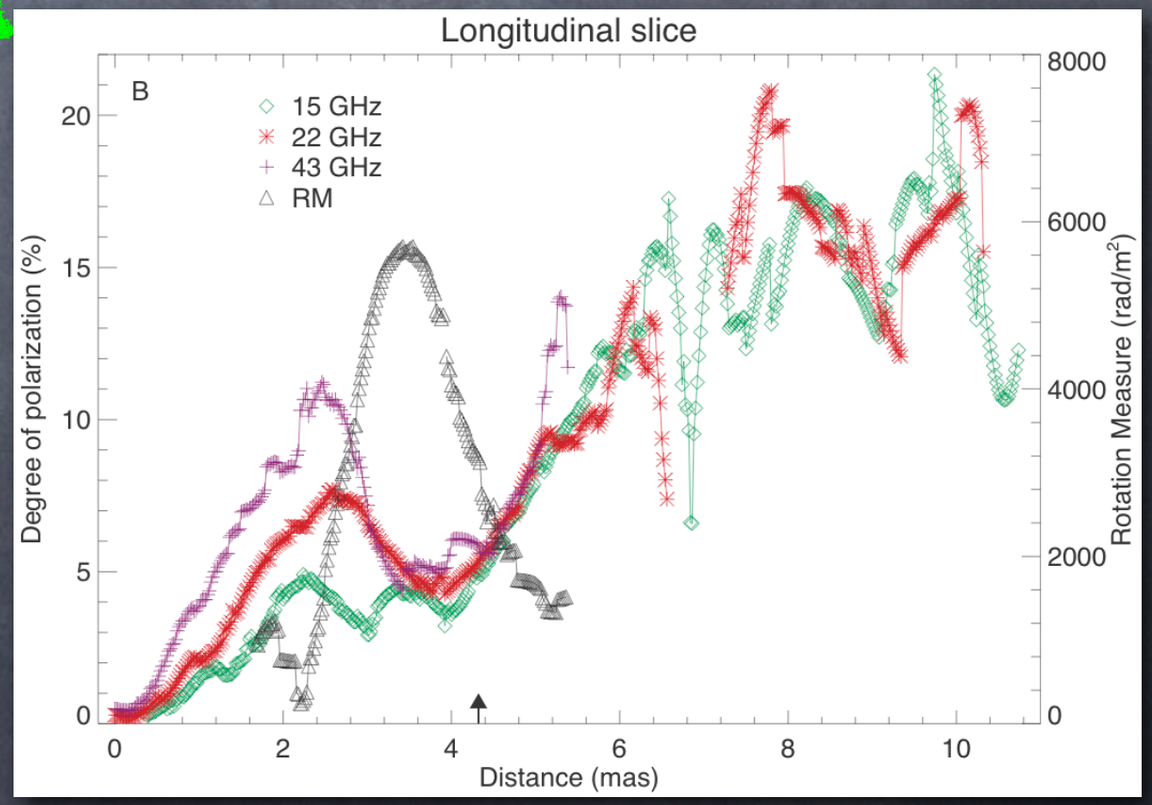


- Stratification in RM and degree of polarization across the jet as expected for the case of a helical magnetic field.
- Localized region of enhanced RM. Interpreted as the result of the interaction between the jet and the external medium.
- The data are consistent with a helical field in a two-fluid jet model, consisting of an inner, emitting jet and a sheath containing nonrelativistic electrons





Gómez et al. (2008)

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- First clear observational evidences are being obtained from:
  - Multi-wavelength studies of the ACZ (BL Lac)
  - Jet stratification in RM and degree of polarization beyond the VLBI core
- Detailed VLBA multi-frequency monitoring of 3C120:
  - It is possible to combine data from multiple epoch to reveal the full jet structure in rotation measure and degree of polarization
  - Clear stratification suggests a helical two-fluid model
  - Evidence for the jet interaction with the external medium
  - Further analysis to look for possible *internal* Faraday rotation, from which to estimate the electrons minimum energy