Evidence for internal rotation in the jet of the quasar NRAO150

Outline

Jet wobbling
General properties of NRAO150

New multi-epoch 8, 15, 22, and 43 GHZ VLBA, as well as 86 GHz with GMVA

Discussion
New model to explain most internal jet wobbling

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in collaboration with
Iván Agudo, Jose L. Gómez, Thomas P. Krichbaum

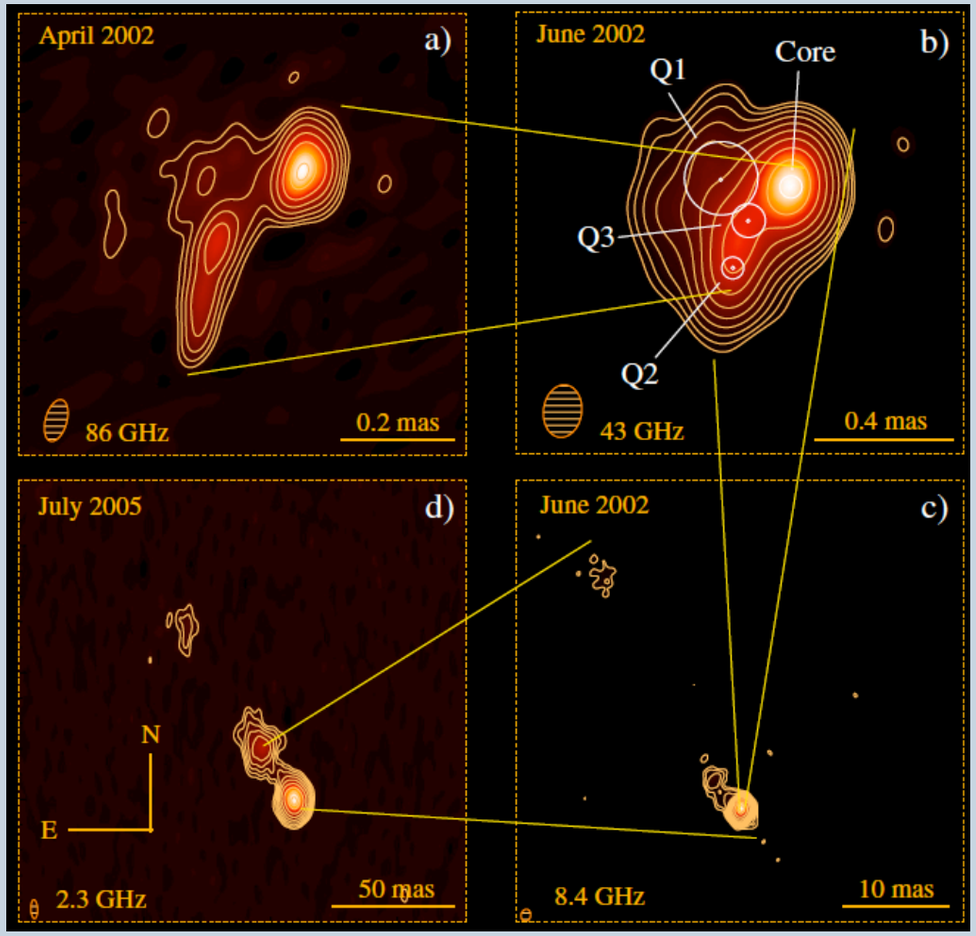
General properties of NRAO150

Intense radio-mm source, identified as a quasar at redshift z = 1.52. (Acosta-Pulido et al. 2010)

At radio wavelengths NRAO 150 displays a compact and brilliant region plus a one-sided jet extending up to 80 mas.

Misalignment between jet position angle at sub-mas and larger scales by >100◦.

This suggests a bent structure of the inner jet oriented within a **very small angle to the line of sight**.



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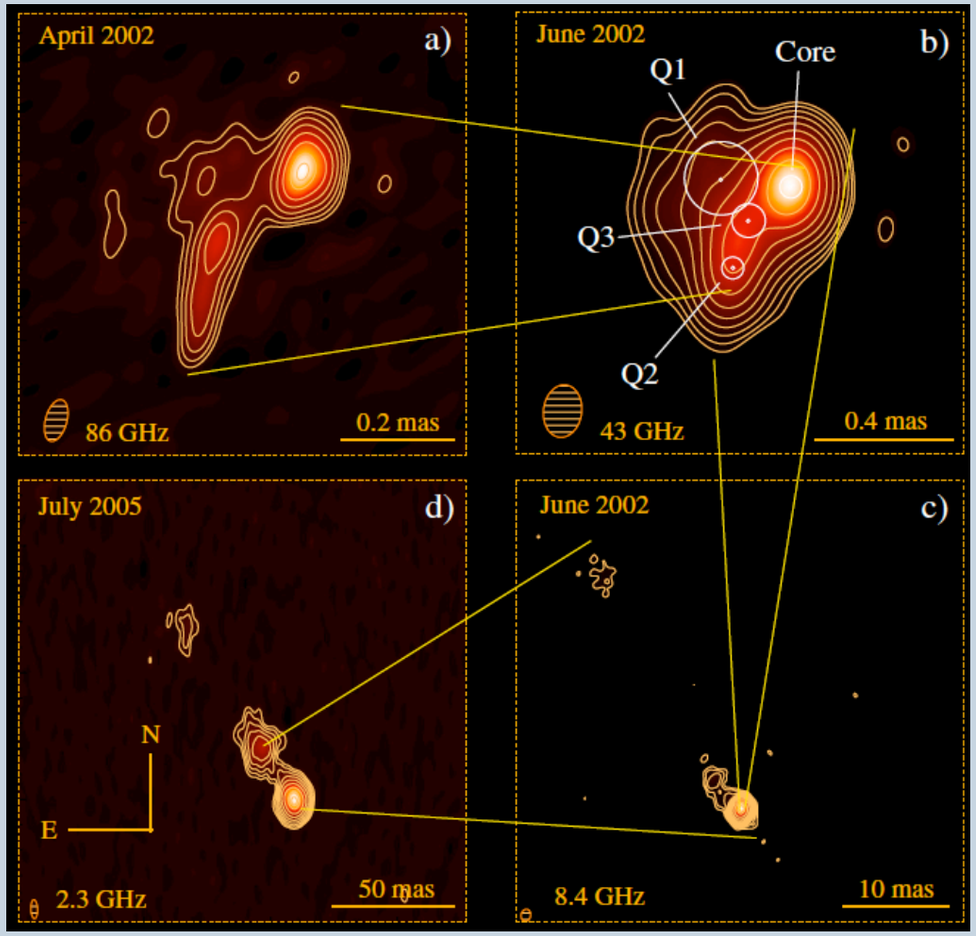

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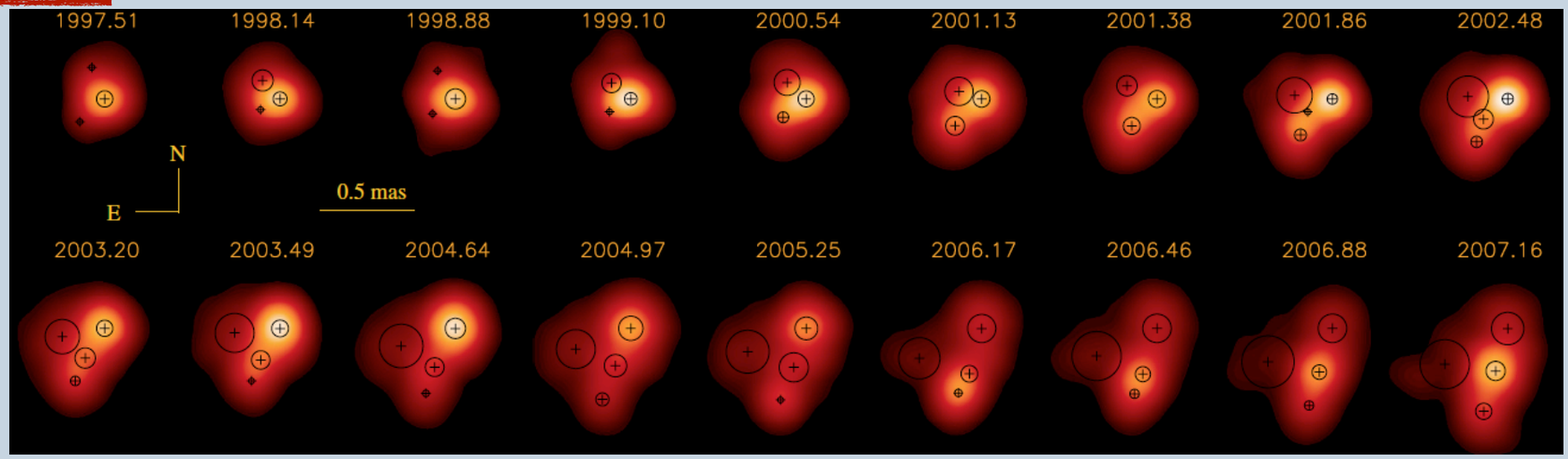
43 GHz



Total intensity VLBA NRAO150 images from 1997 to 2007 at 43 GHz. Reproduced from Agudo et al. 2007.

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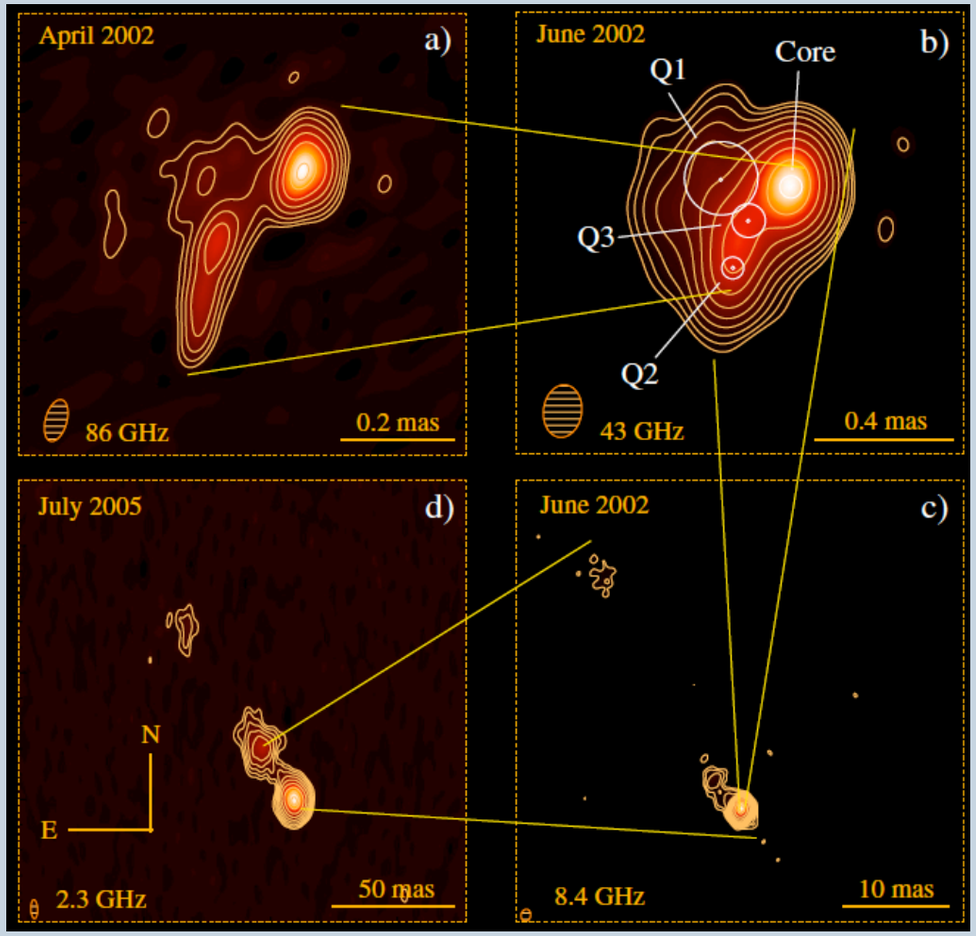

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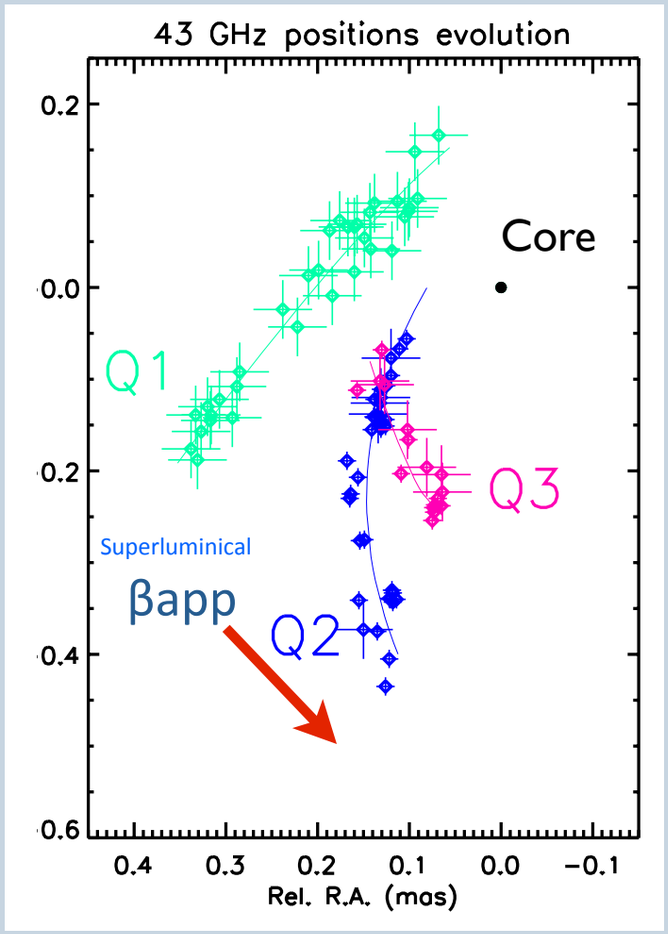

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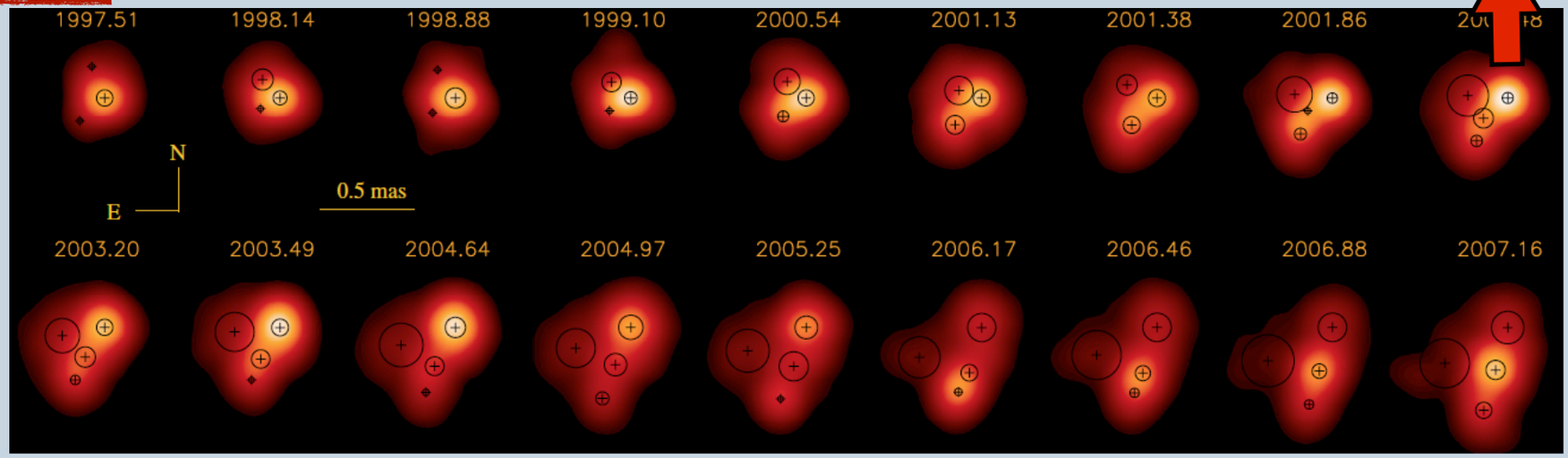
Core



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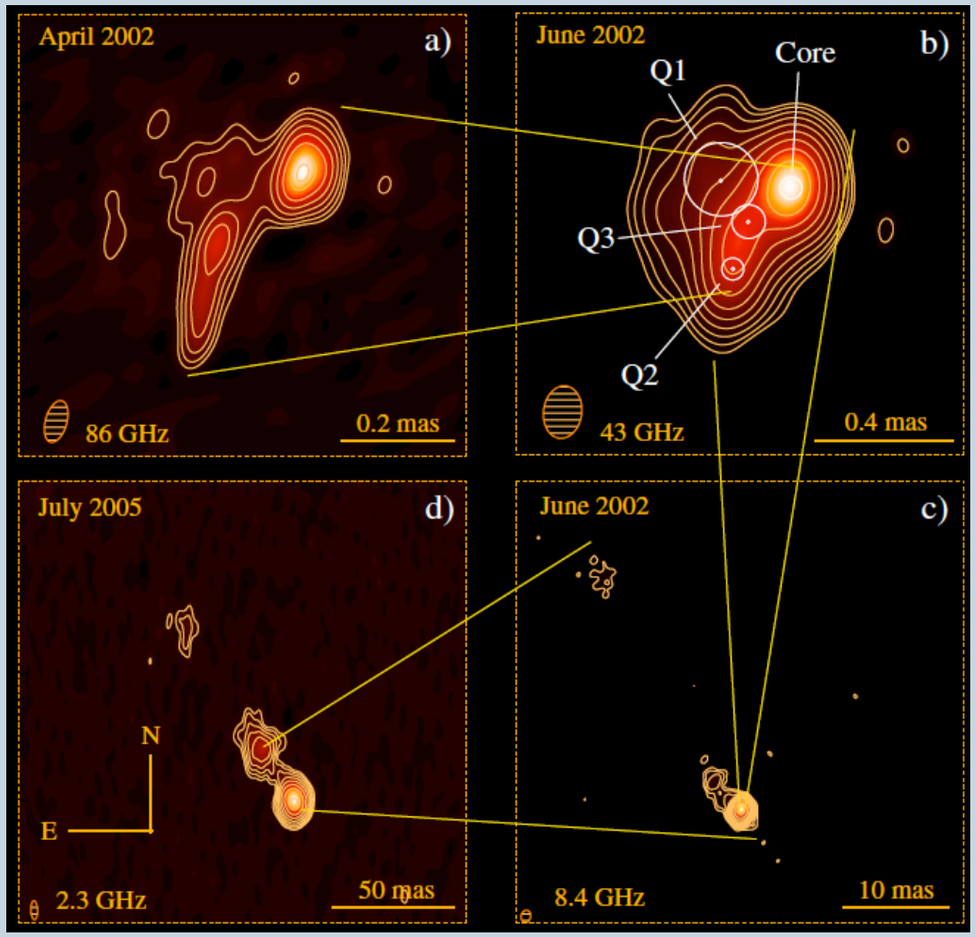

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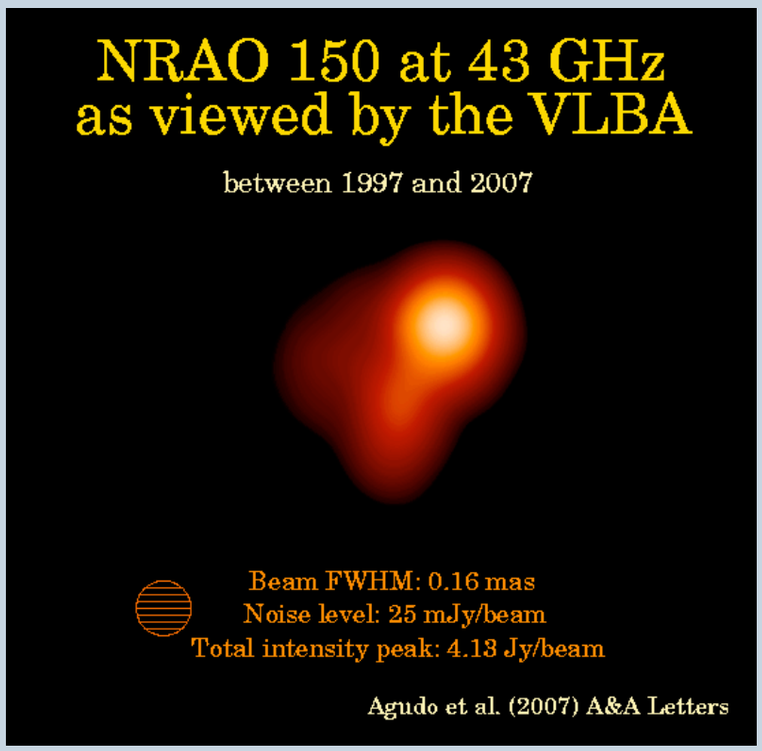

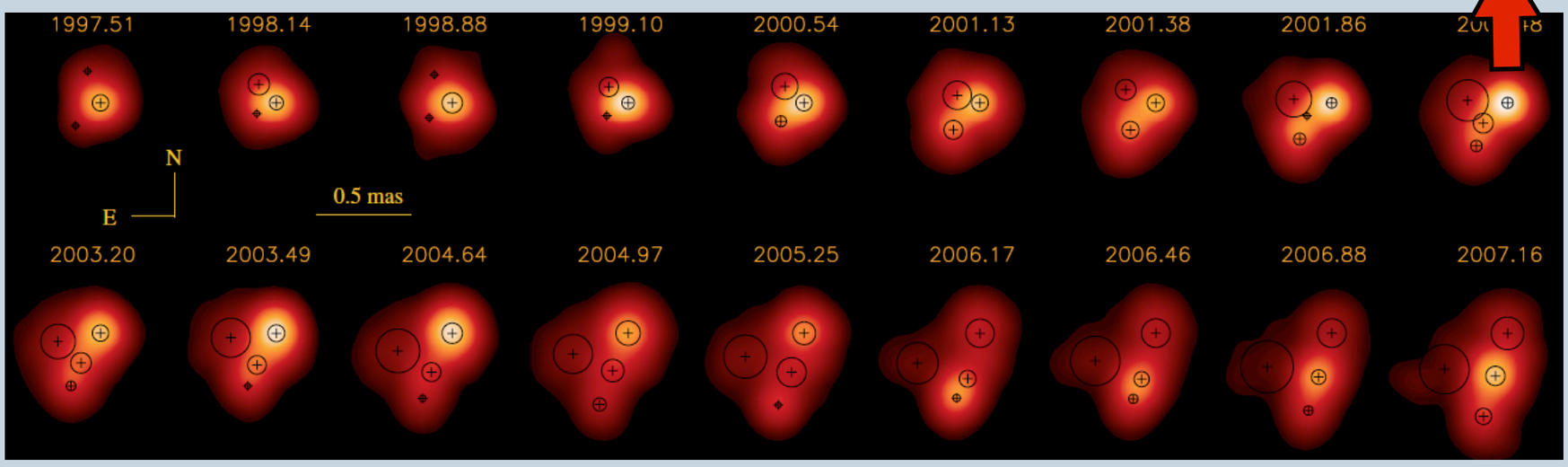

Total intensity VLBA NRAO150 images from 1997 to 2007 at 43 GHz. Reproduced from Agudo et al. 2007.

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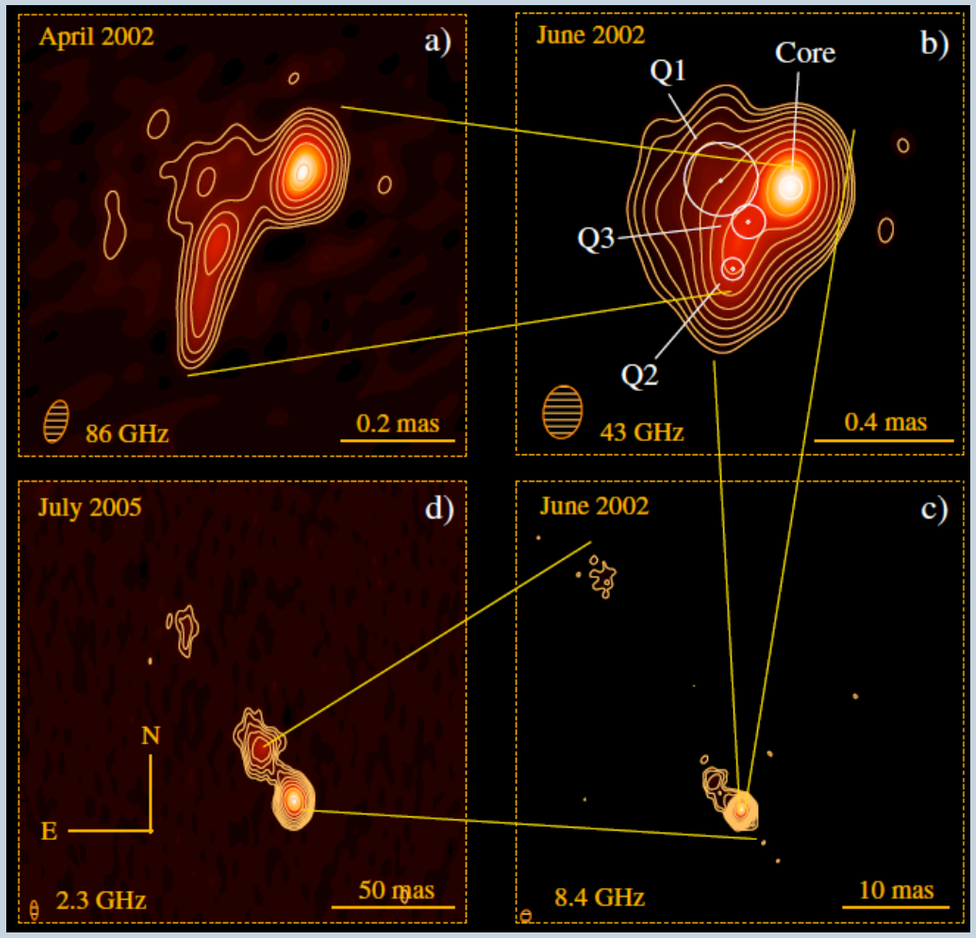

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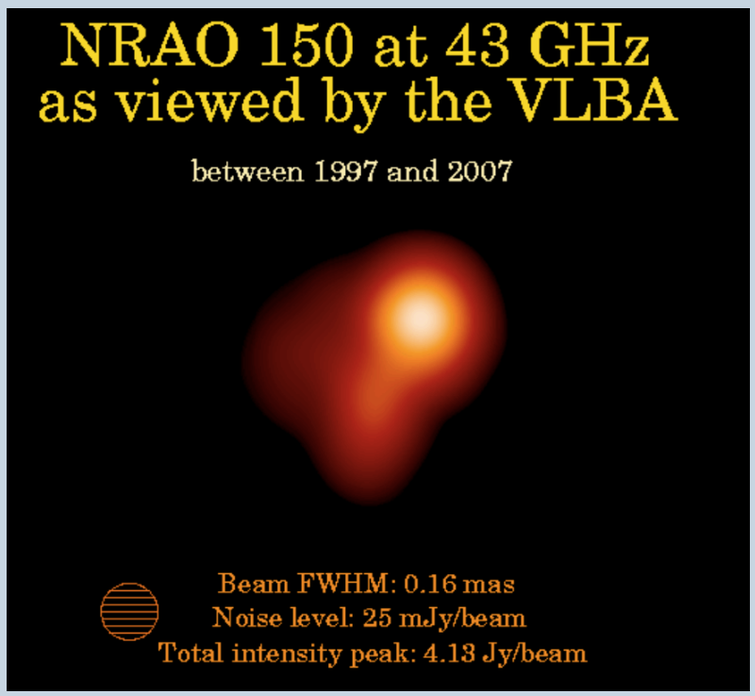


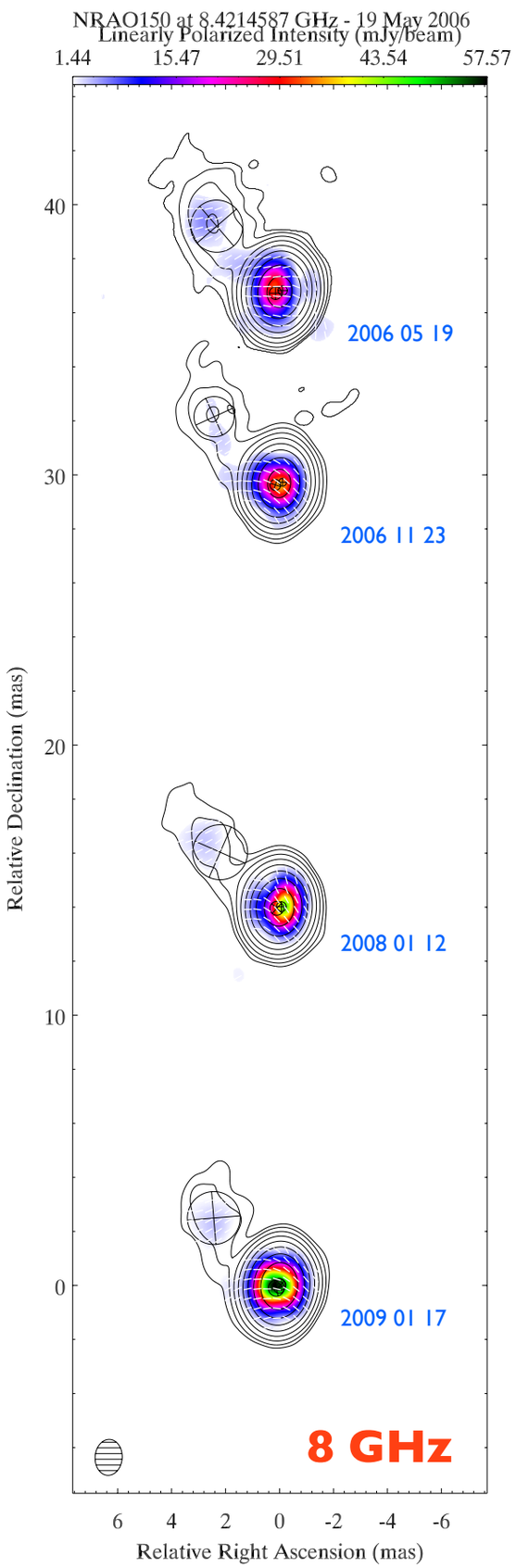
Jet Wobbling

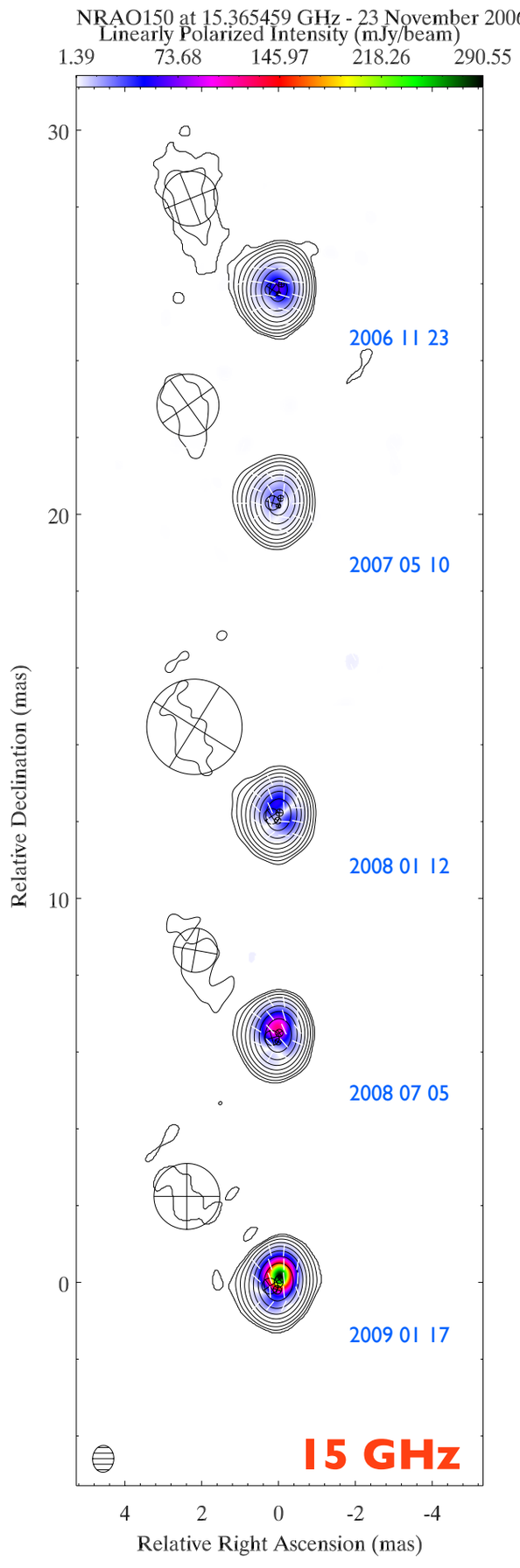
rotation in the plain of the sky of the innermost jet position angle of the jet.

Counter-clock-wise jet wobbling at

7º/yr -11º/yr

VLBA Data


NRAO150 at 8.4214587 GHz - 19 May 2006
Linearly Polarized Intensity (mJy/beam)
1.44 15.47 29.51 43.54 57.57
2006 05 19
2006 11 23
2008 01 12
2009 01 17
8 GHz
Relative Declination (mas)
Relative Right Ascension (mas)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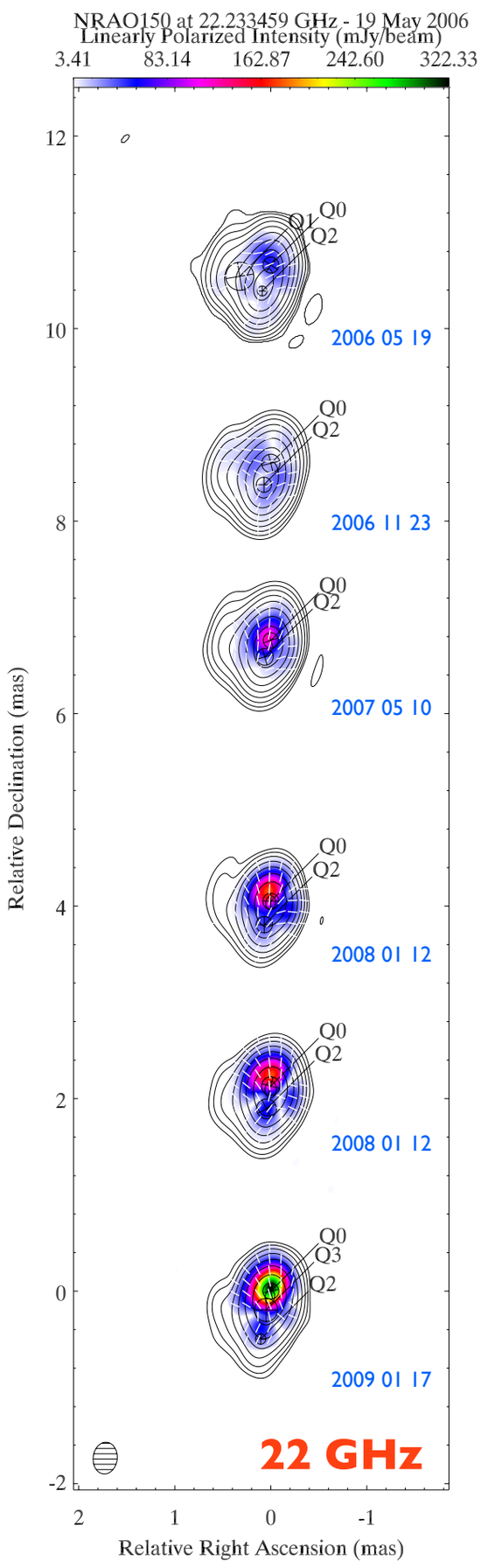
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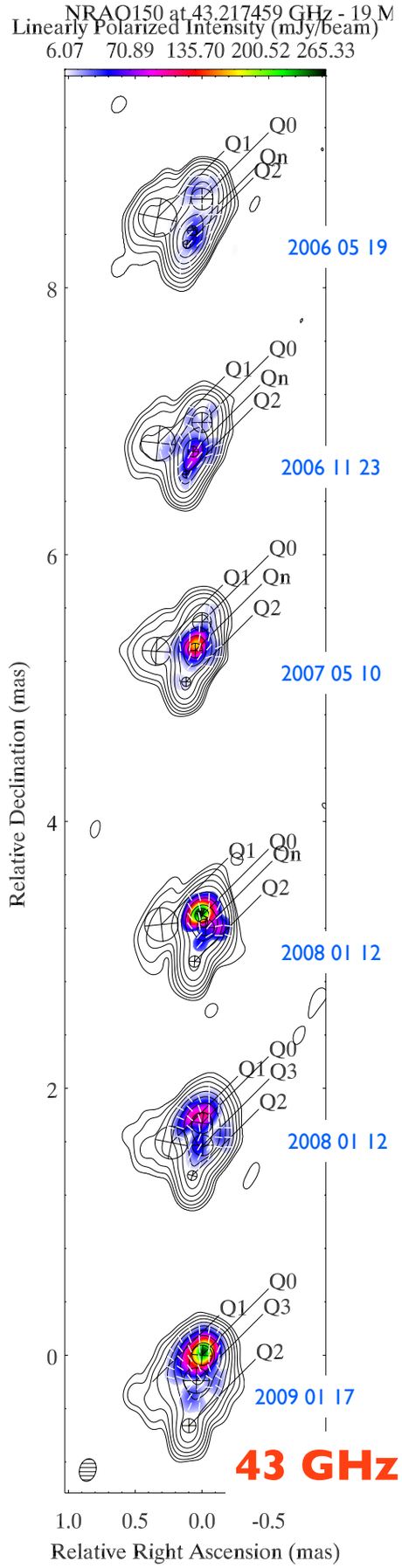
NRAO150 at 43.217459 GHz - 19 M
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6.07 70.89 135.70 200.52 265.33
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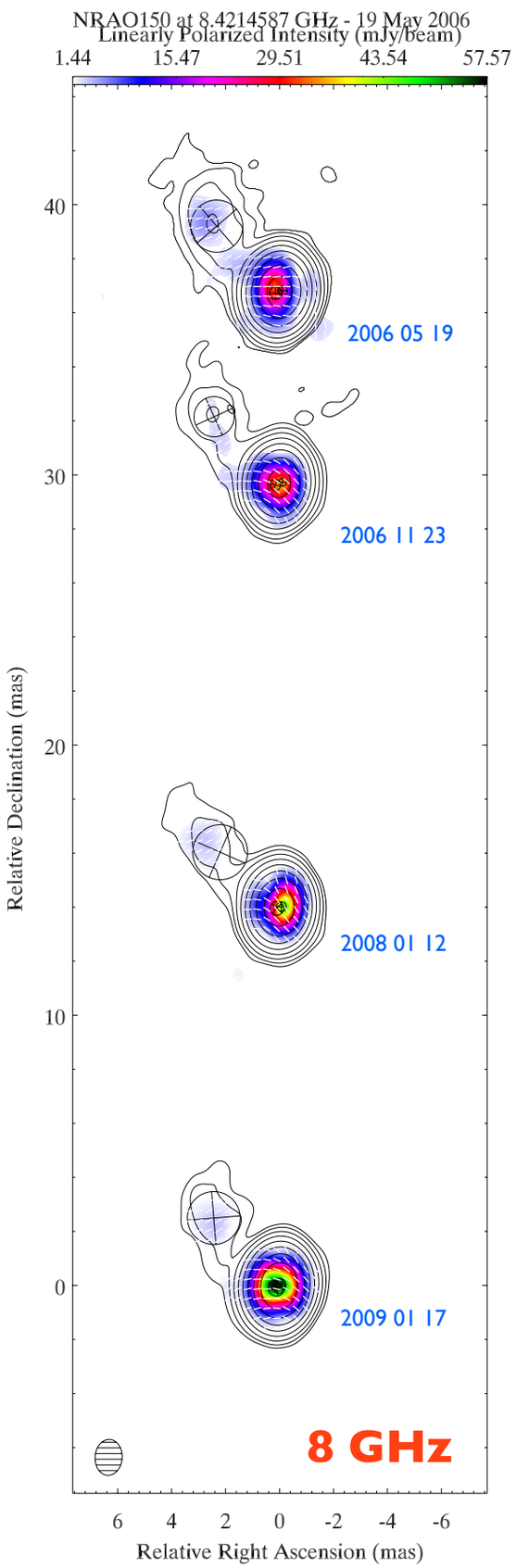
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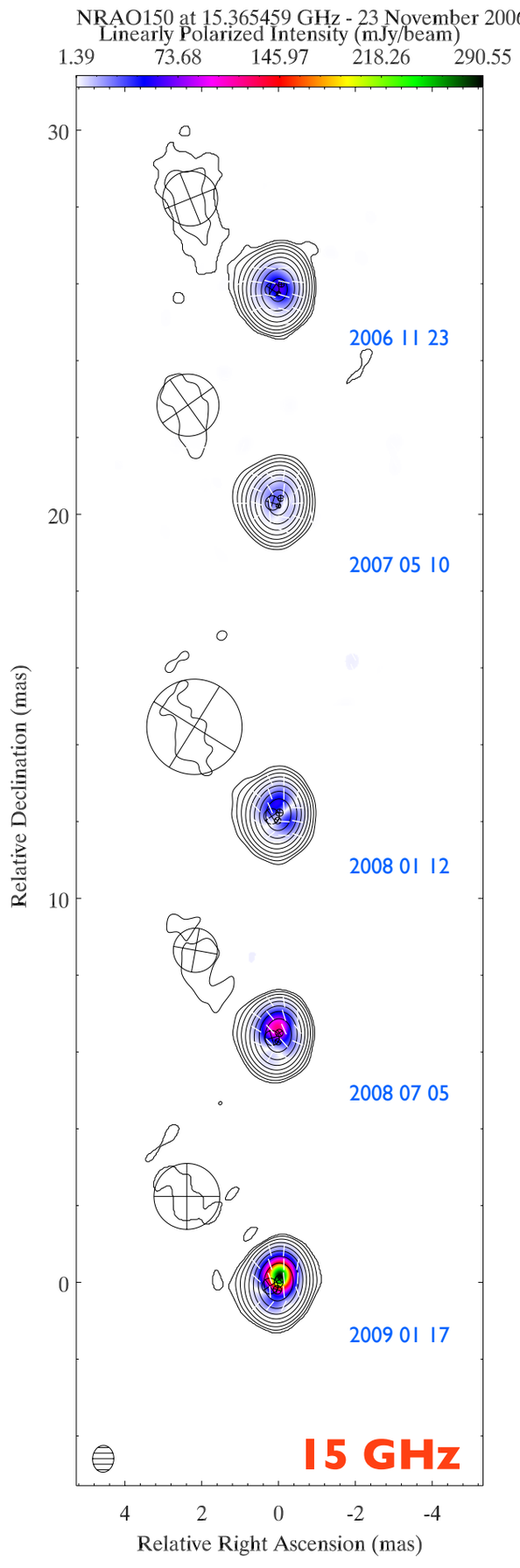
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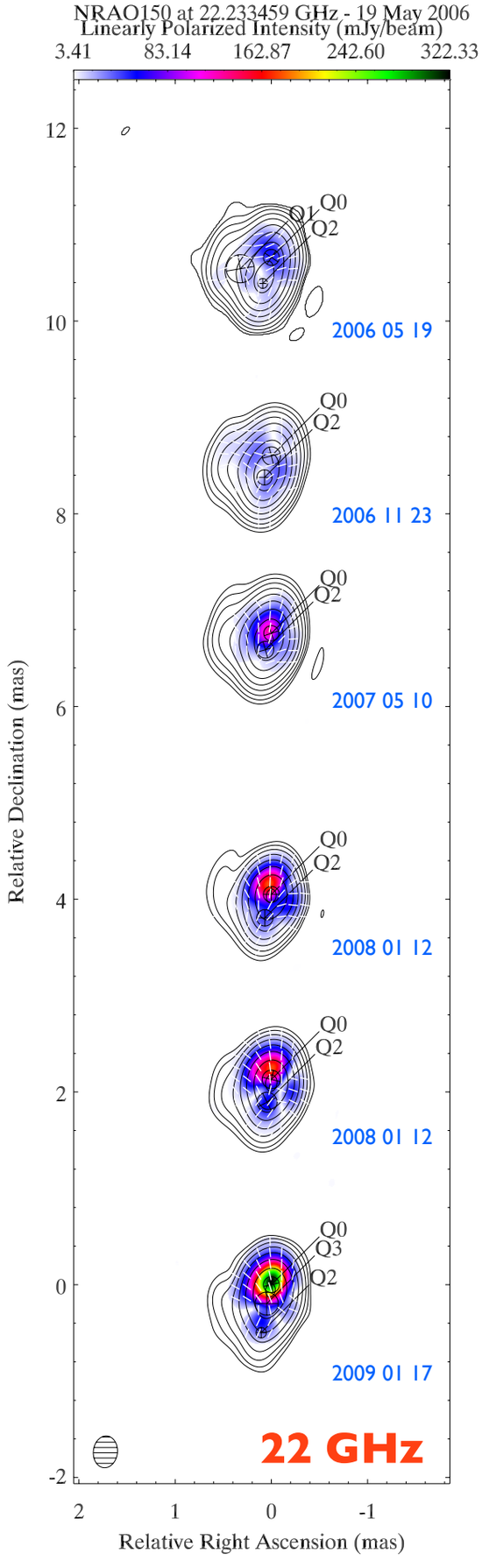
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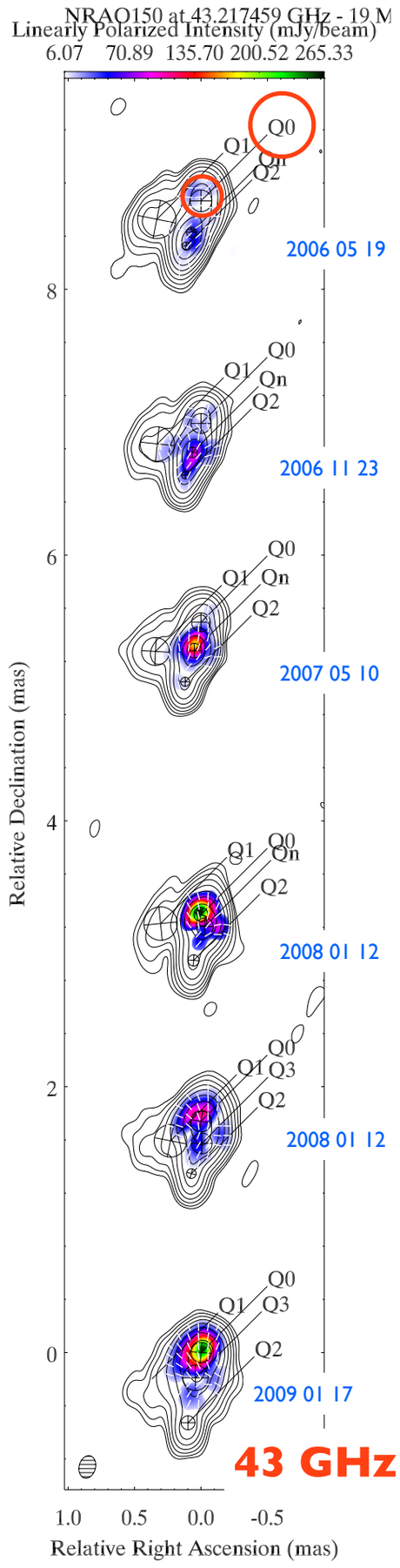
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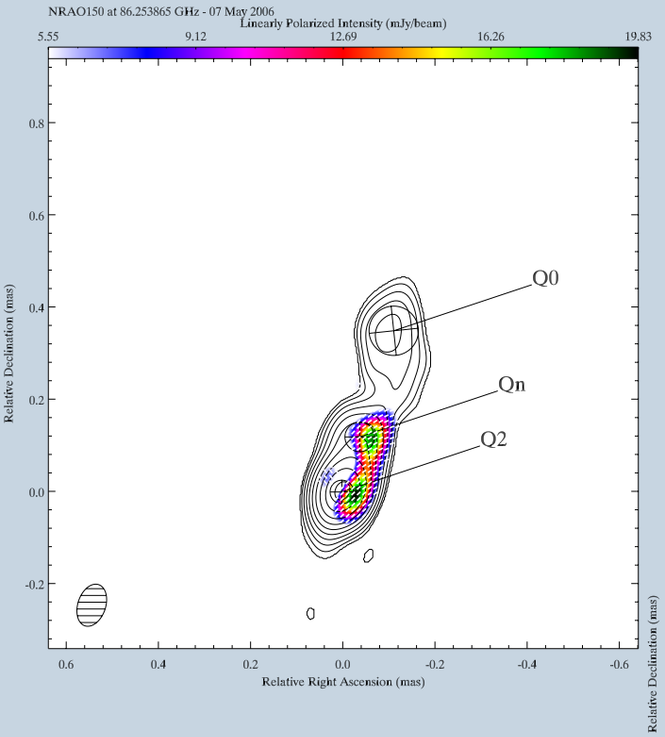
86 GHz Global mm VLBI Array Data



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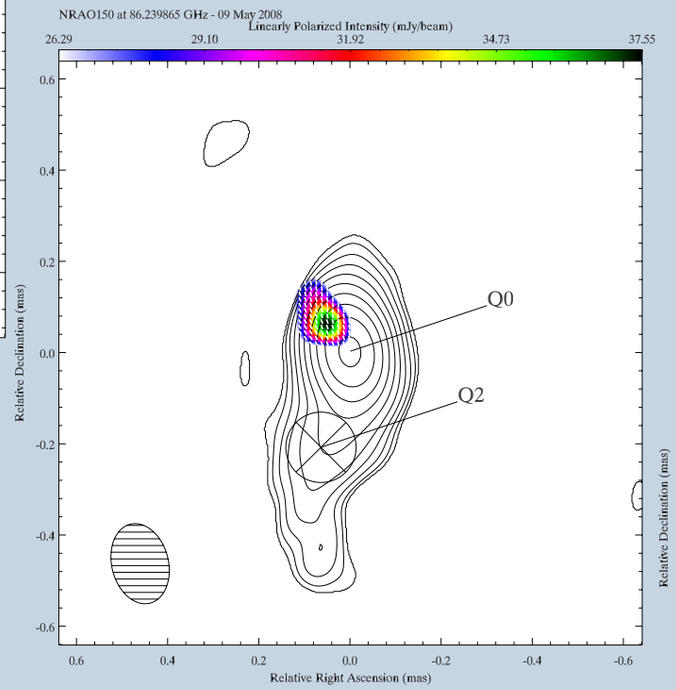

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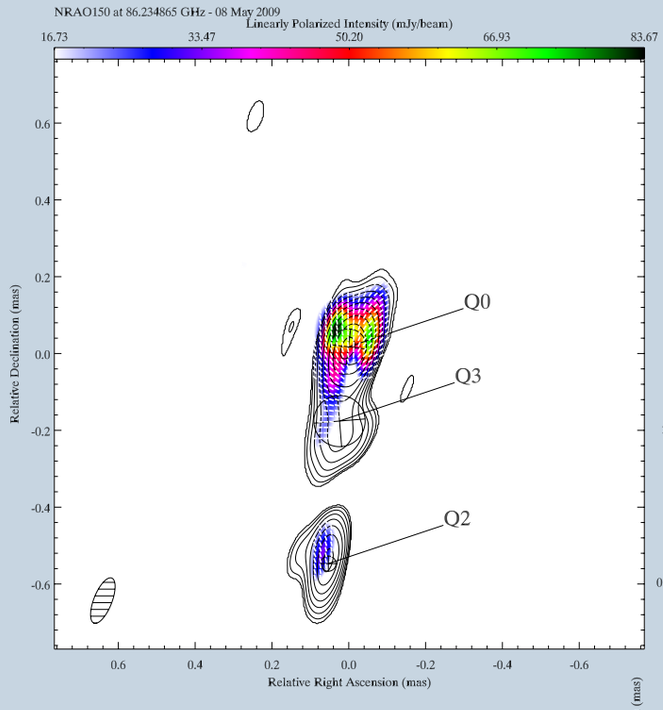

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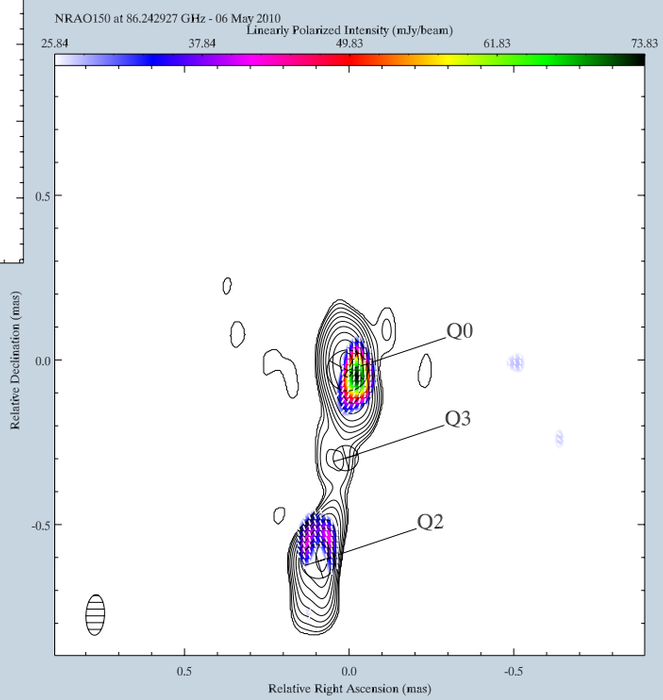

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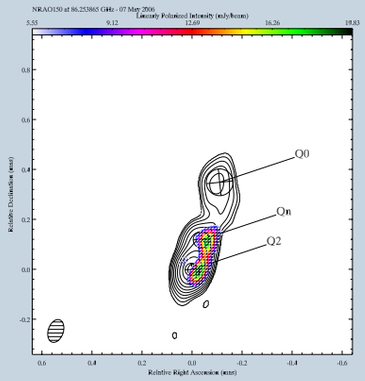

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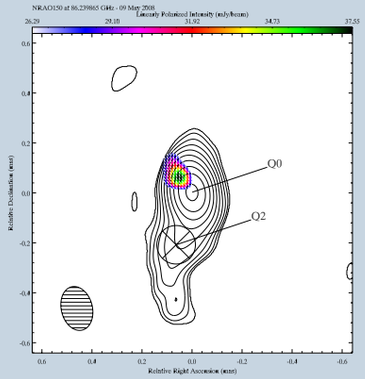

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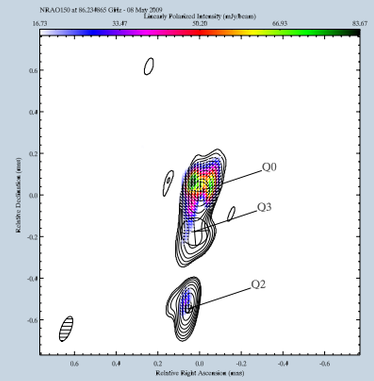

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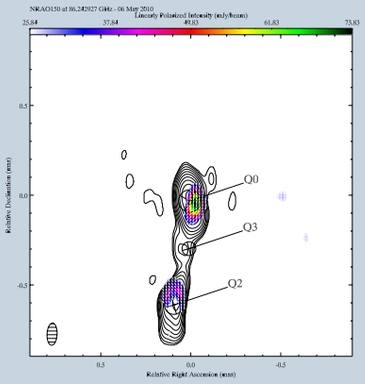

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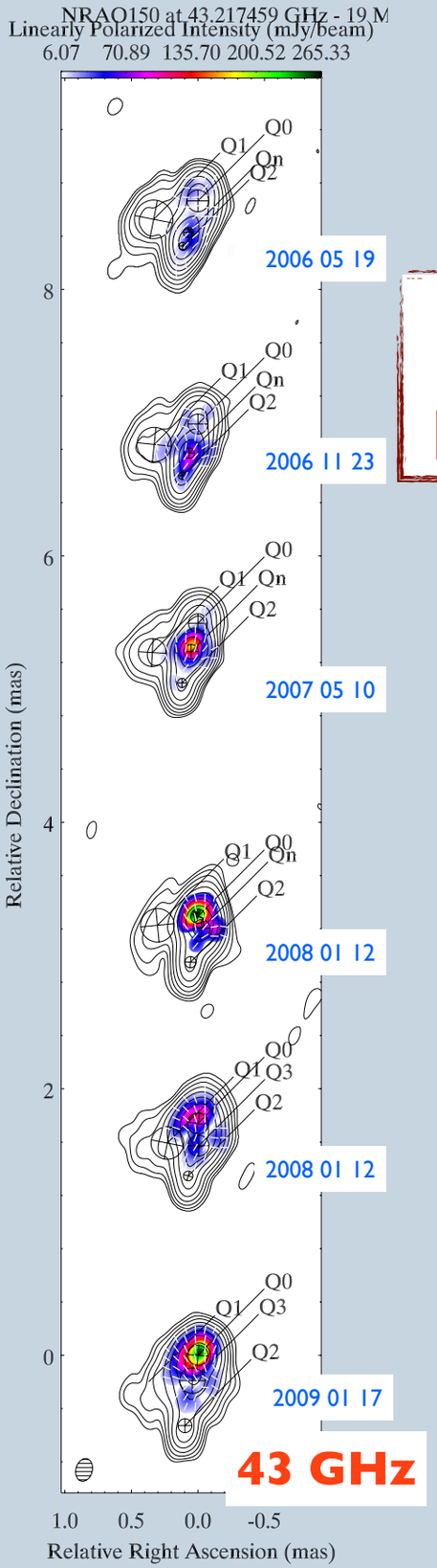

The wobbling is periodic or not?!!

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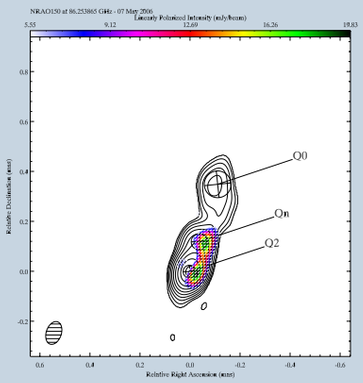

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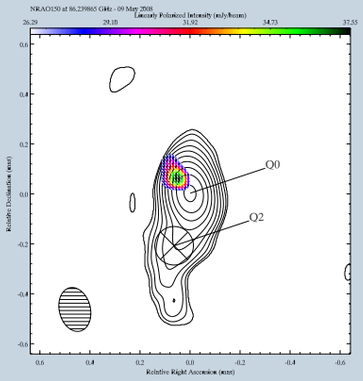

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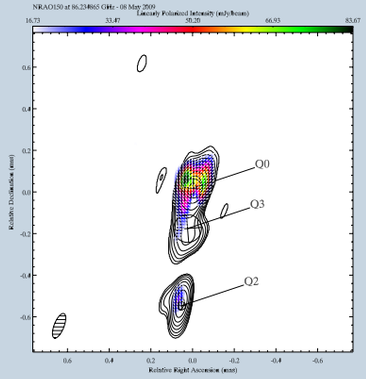

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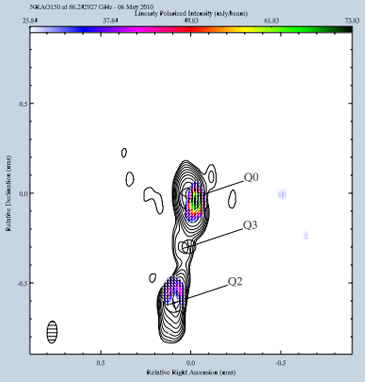

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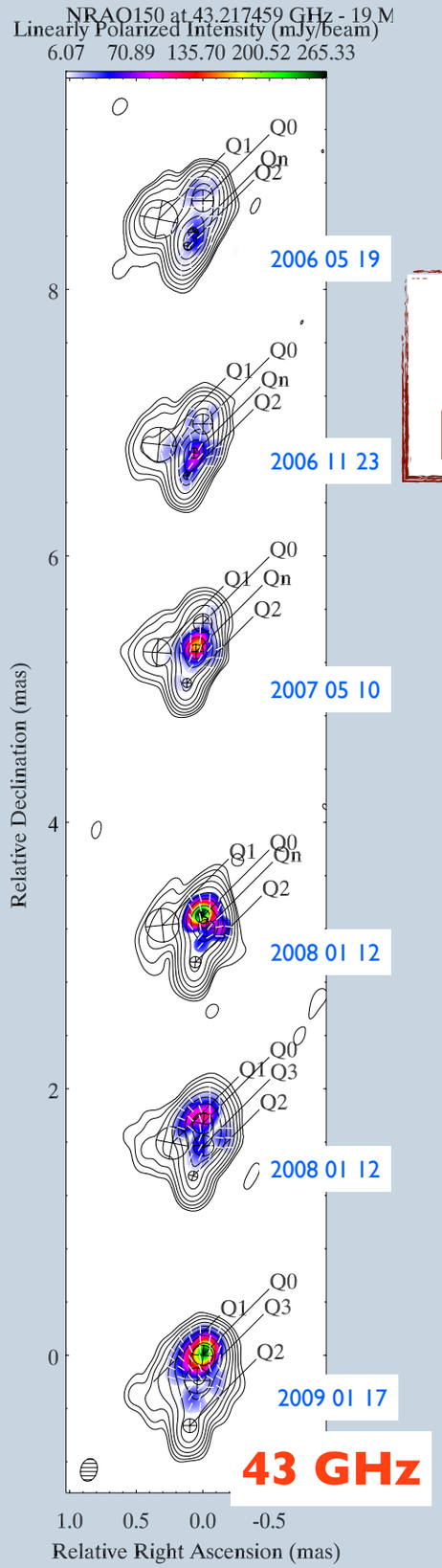

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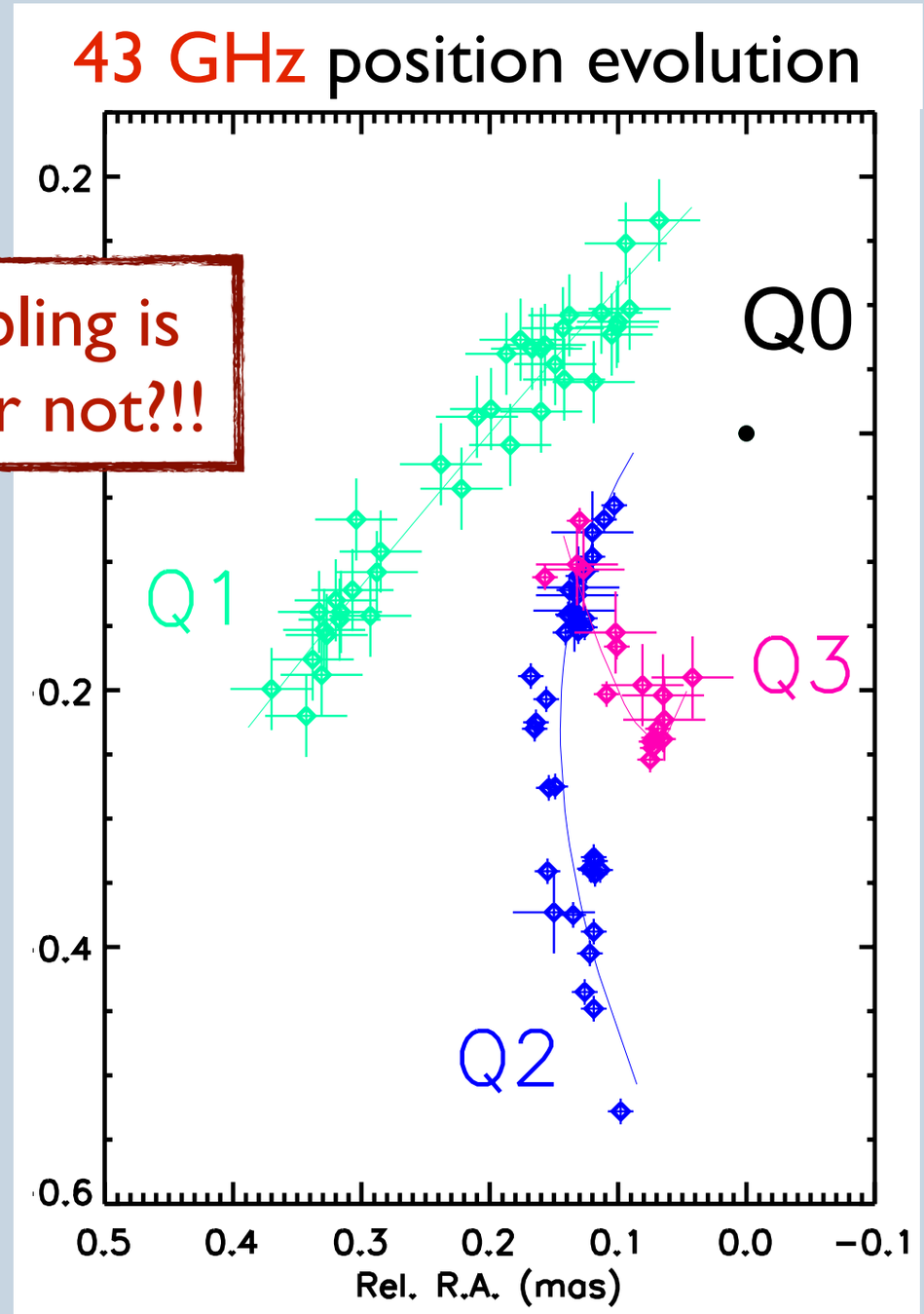

We confirm the clock wise rotation of jet position angle

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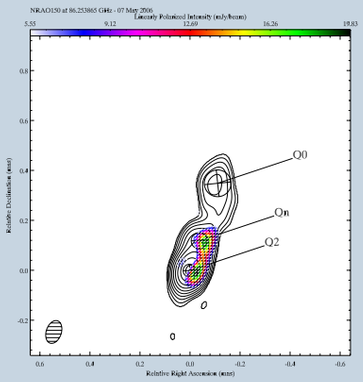

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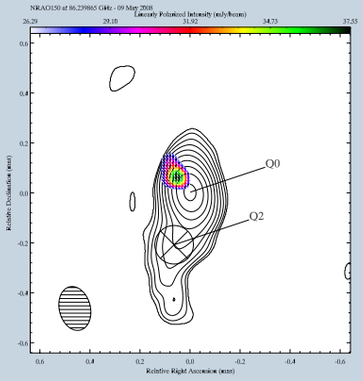

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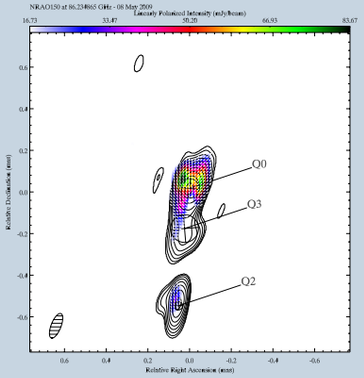

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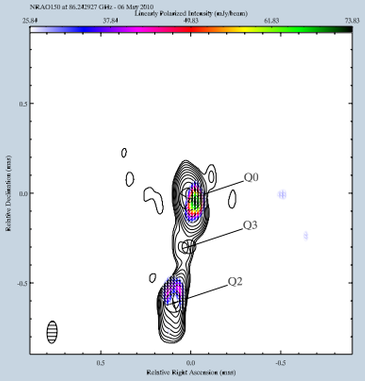

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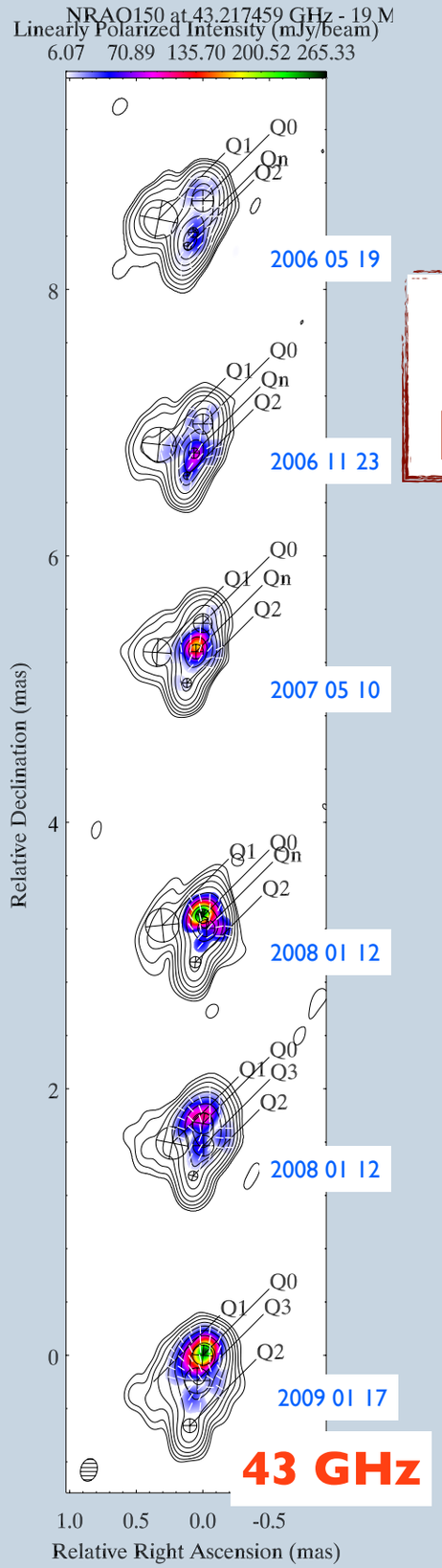

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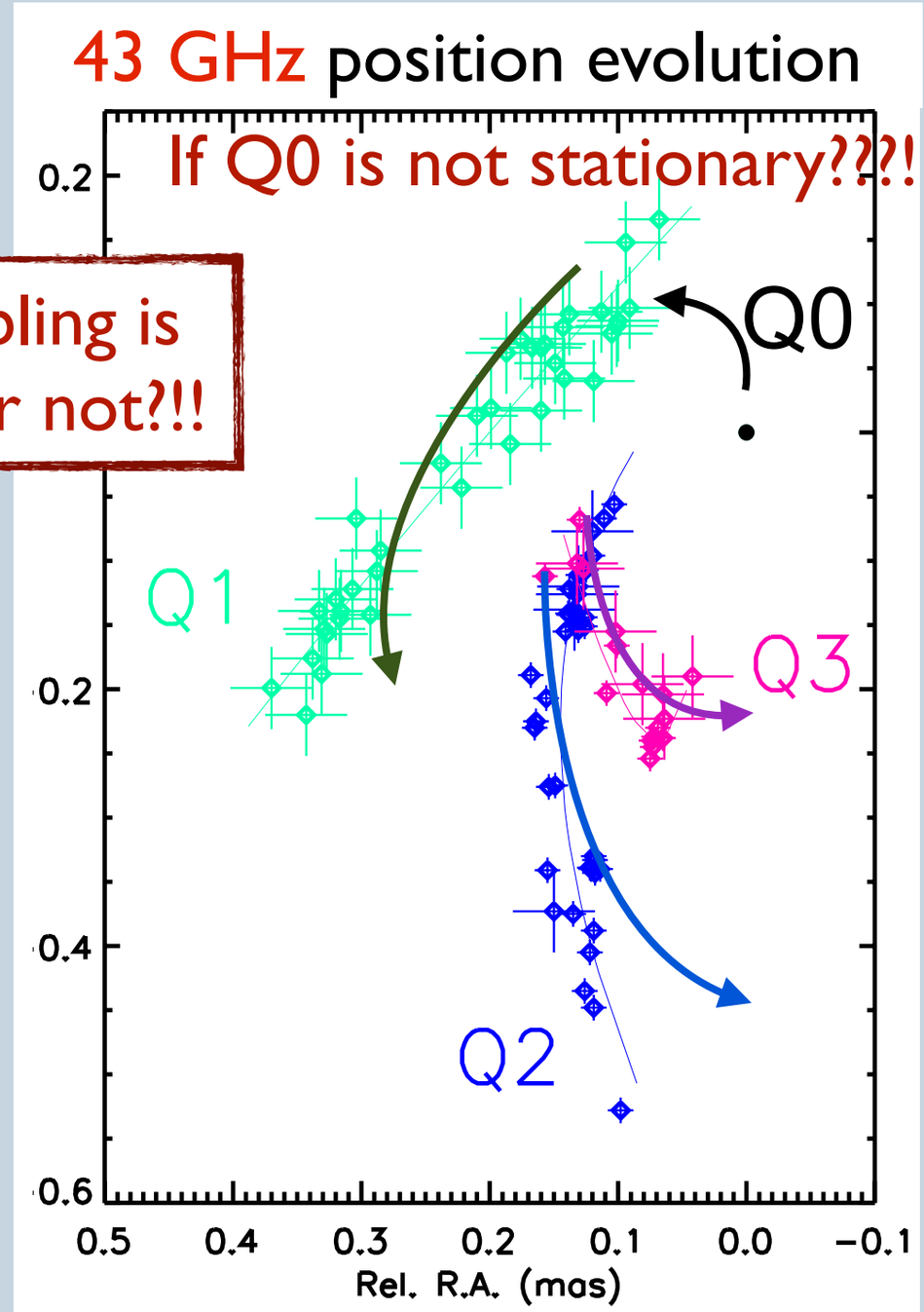

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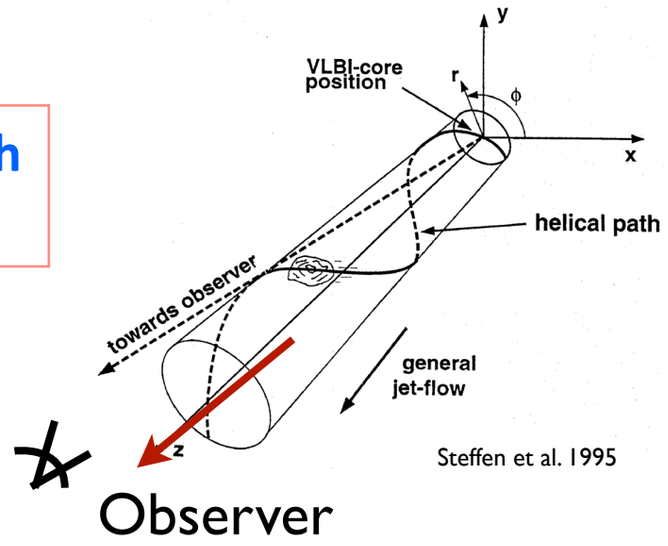
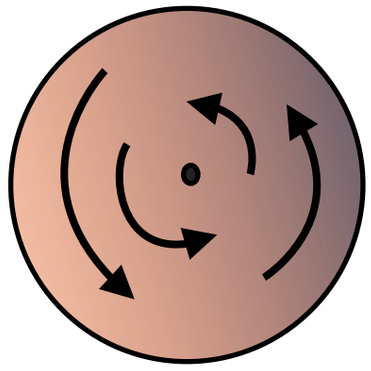
New model to explain most internal jet swing

We assume the jet point at us with a very small angle to the line of sight.

This idea is consistent with previous observations.





We assume the rotation observed is produced by the material following helical trajectories.

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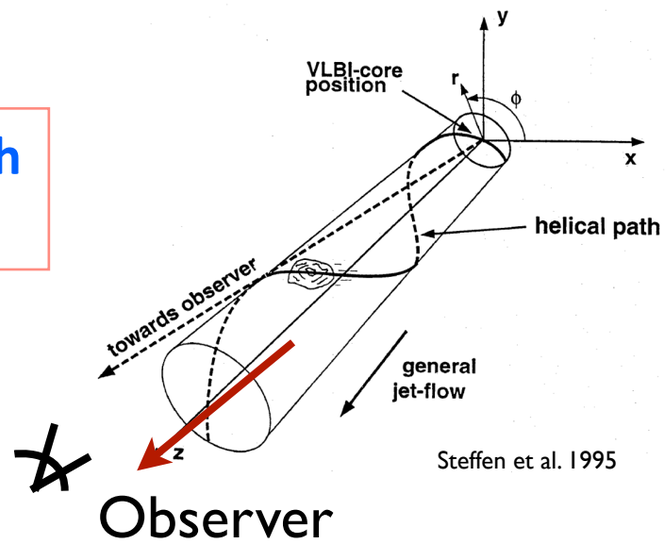

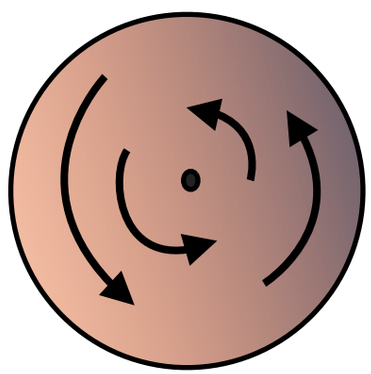

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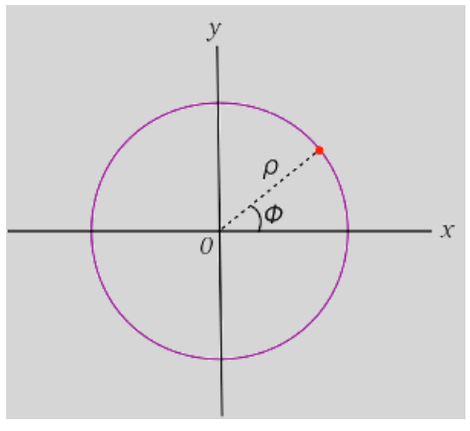
A simple model

Each component describes a circular motion

$$r = cte$$

$$\omega = cte$$

$$\phi = \frac{\omega}{t}$$



→ We can't fit all components

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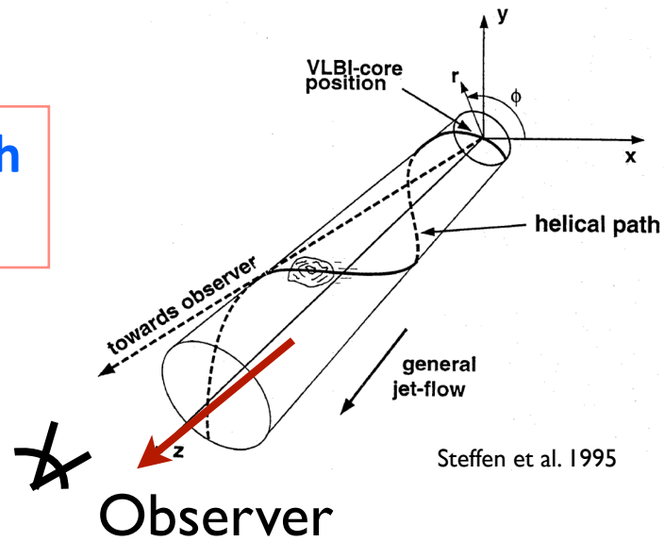
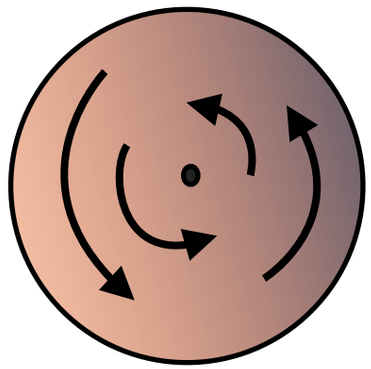
→ This idea is consistent with previous observations.





We assume the rotation observed is produced by the material following helical trajectories.

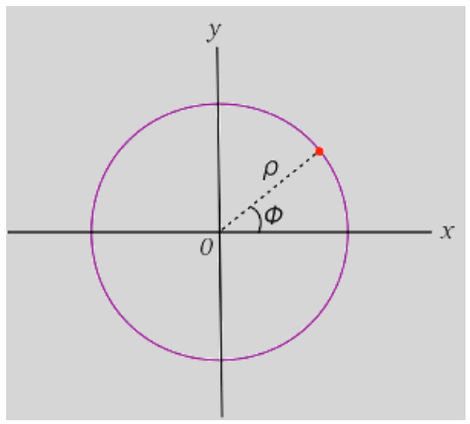
A simple model

Each component describes a circular motion

$$r = cte$$

$$\omega = cte$$

$$\phi = \frac{\omega}{t}$$



→ We can't fit all components

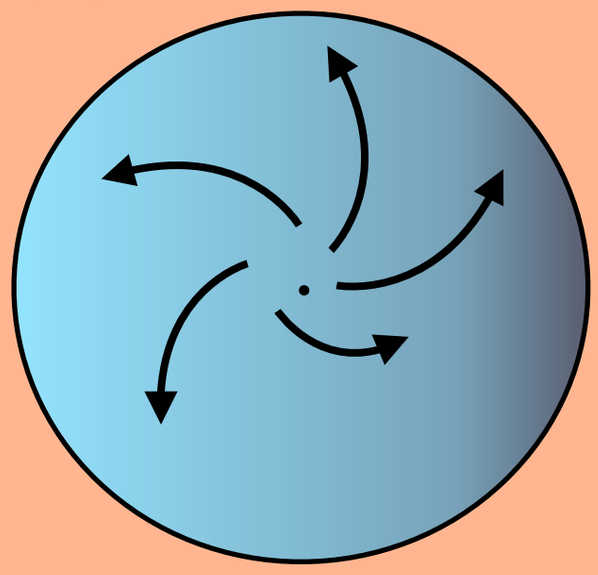
Improved model

$$r_{(t)} = r_0 + v_r \cdot t$$

cartesian coordinates

$$x_{(t)} = r_{(t)} \cdot \cos(\phi_0 + \omega \cdot t)$$

$$y_{(t)} = r_{(t)} \cdot sen(\phi_0 + \omega \cdot t)$$

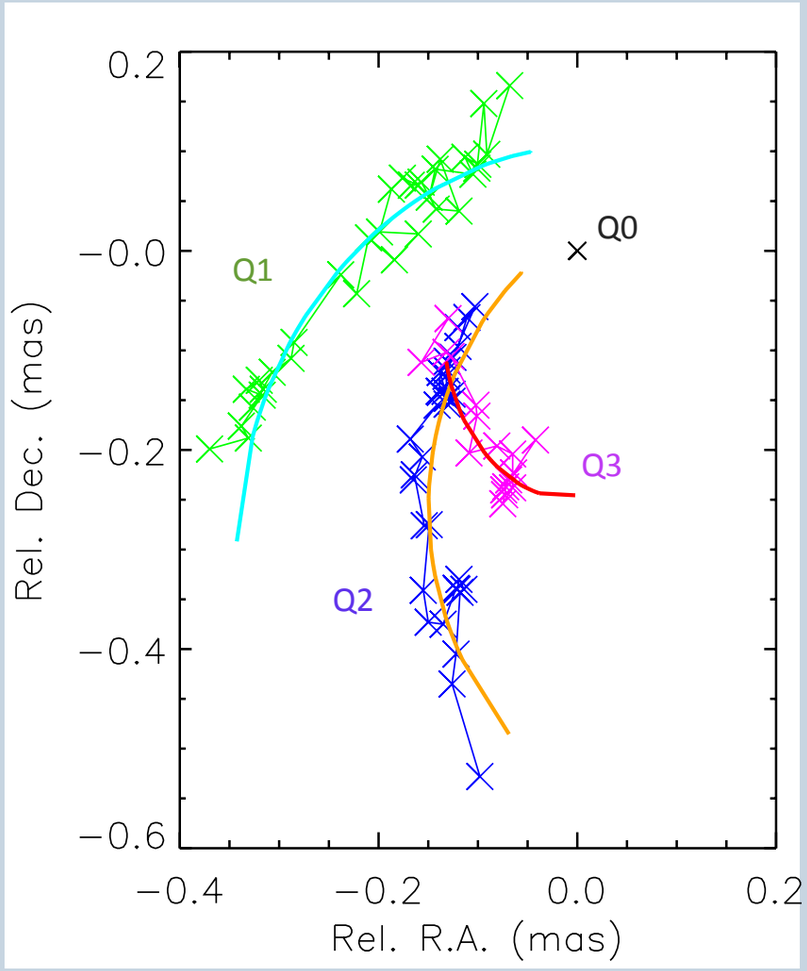


Parameters to fit $\{ r_0 \quad \omega \quad v_r \quad \phi_0$

Chi square Fitting

Results of fit

Best Fit of Data



Best fit

Q0
$v_r = 1.1$ c
$\omega = 0.57$ deg/year

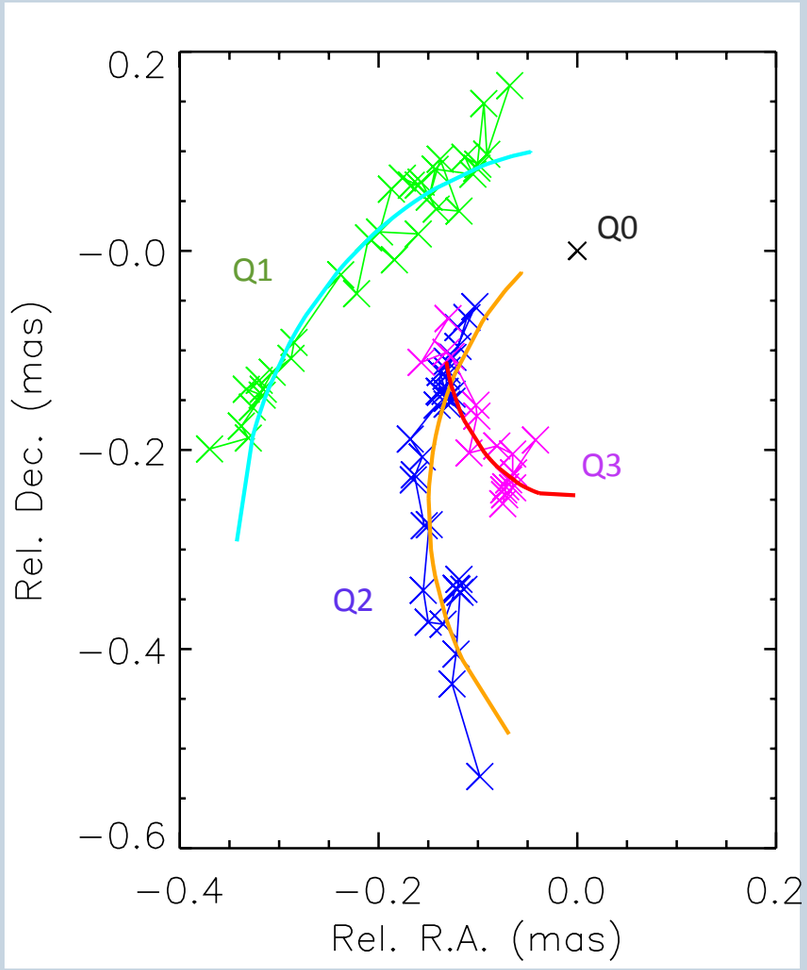
Q1
$v_r = 1.1$ c
$\omega = 7.809$ deg/year

Q2
$v_r = 1.5$ c
$\omega = 6.099$ deg/year

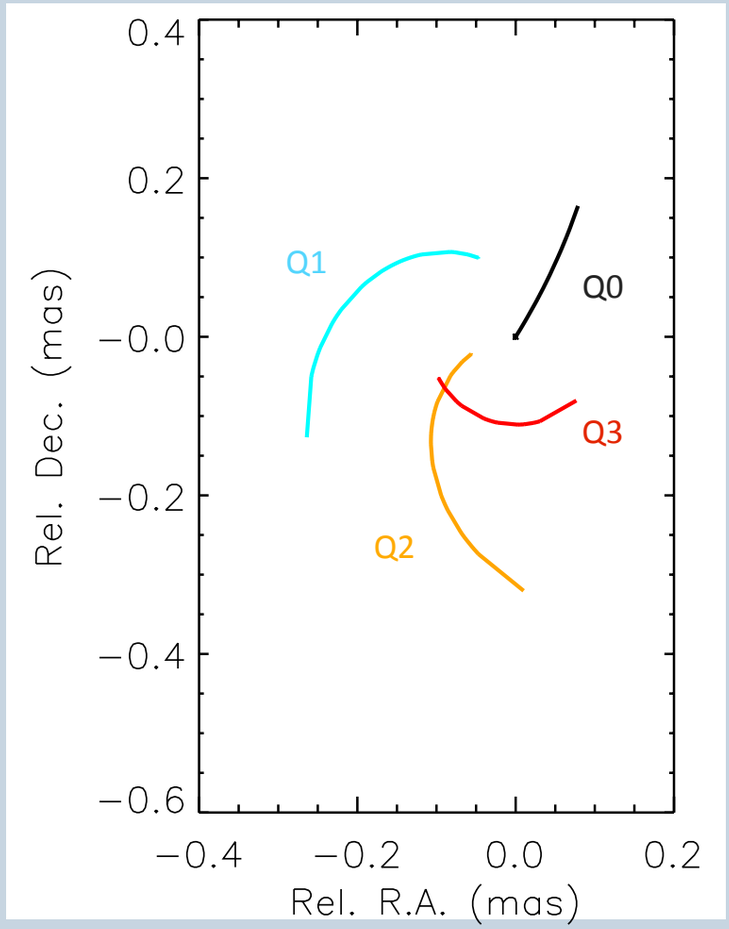
Q3
$v_r = 0.007$ c
$\omega = 14.649$ deg/year

Results of fit

Best Fit of Data



Real movements of components



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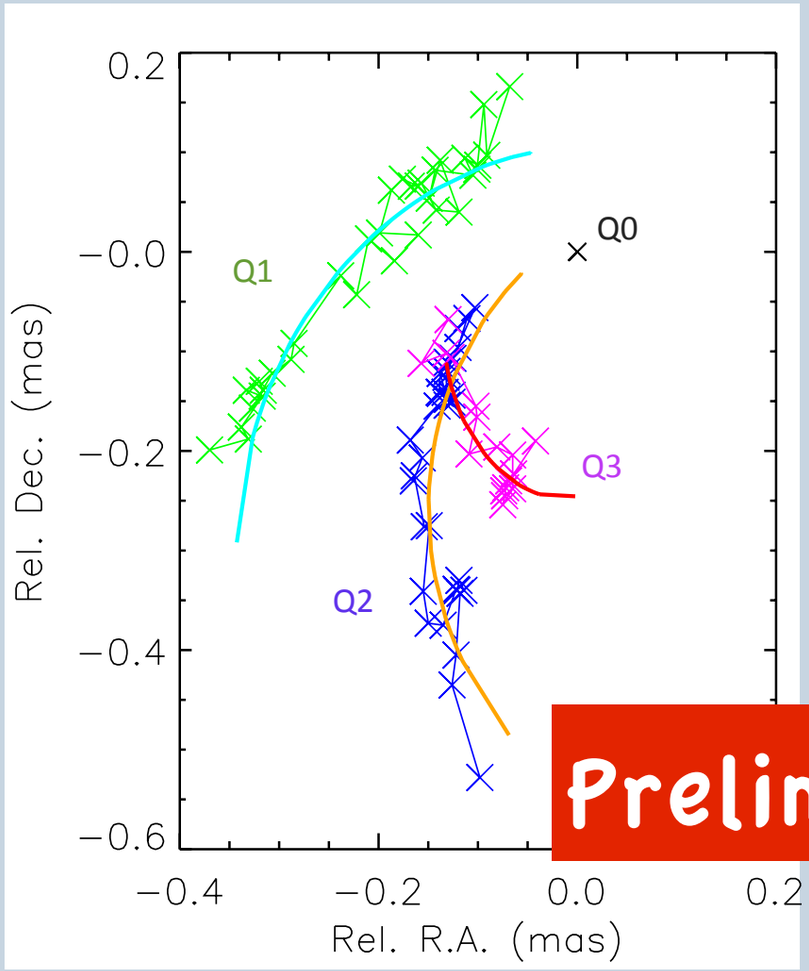
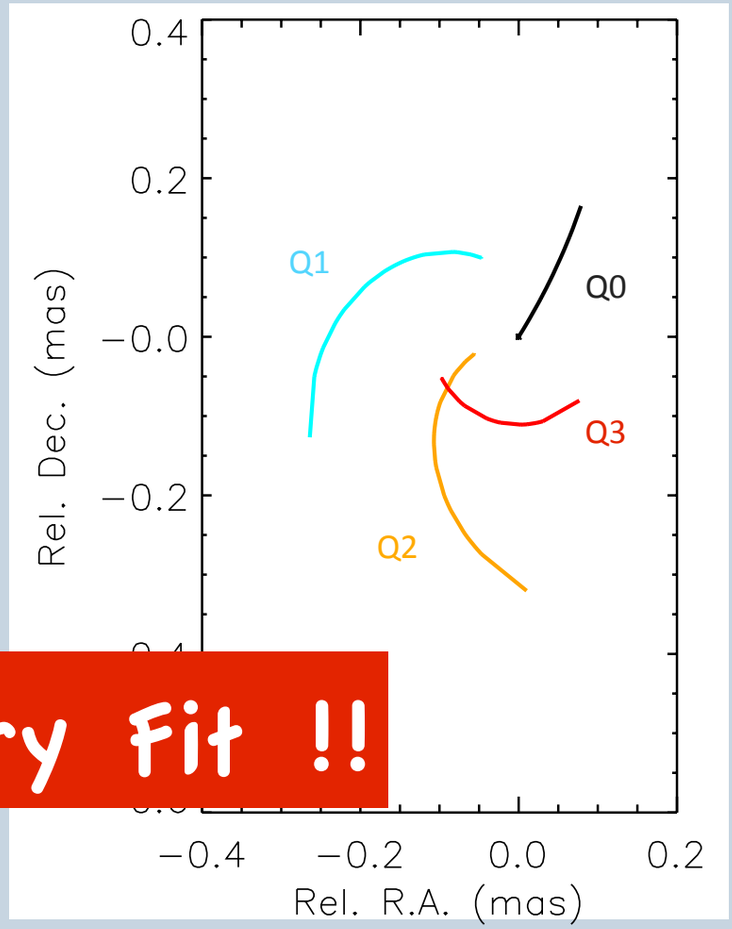
Results of fit

Best Fit of Data



Real movements of components



Preliminary Fit !!

Best fit

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Q1
v_r = 1.1 c
ω = 7.809 deg/year

Q2
v_r = 1.5 c
ω = 6.099 deg/year

Q3
v_r = 0.007 c
ω = 14.649 deg/year

Future work

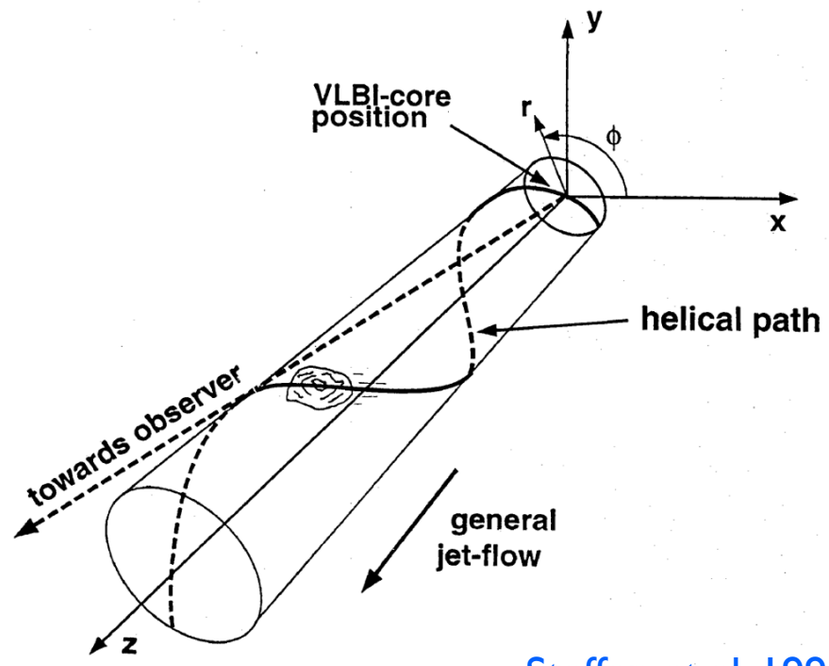
↳ Helical Model by Steffen et al. 1995

$$E_{kin} = const$$

$$L_z = const$$

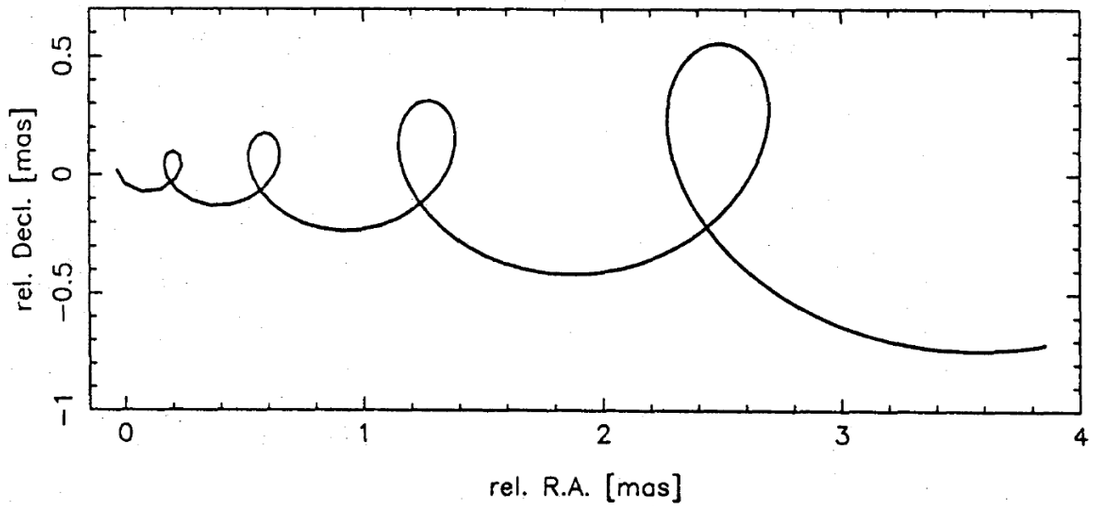
$$p_z = const$$

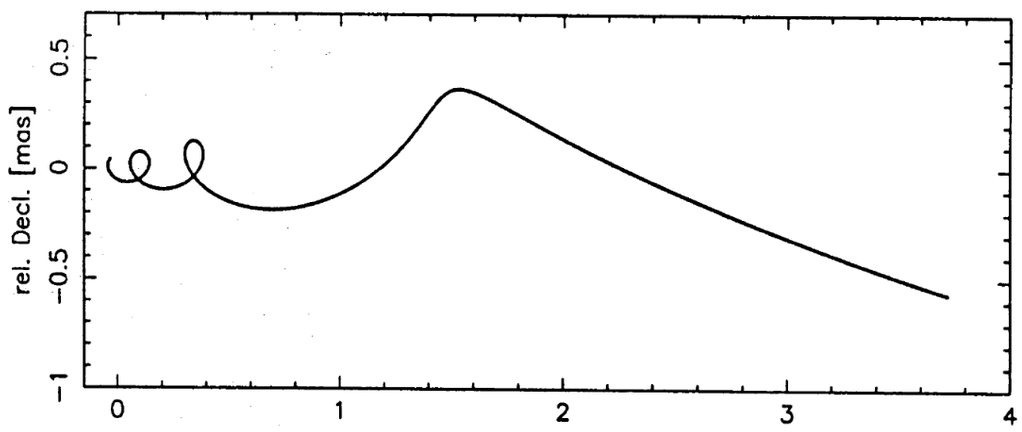
$$\psi = const$$



Steffen et al. 1995

predict this typical trajectories





Summary

- New multi epoch VLBA images at 8, 15, 22 and 43 GHz.
- GMVA images at 86 GHz with polarization.
- We confirm the clock wise rotation of jet position angle observed in previous works.
- A new model to explain the jet wobbling in NRAO150.

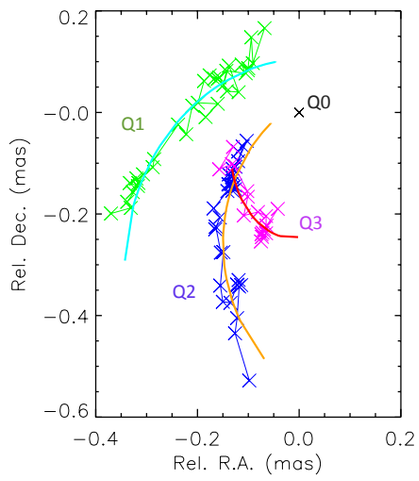
Future work: To apply the helical model (Steffen et al 1995) to fit data.

Main Conclusion

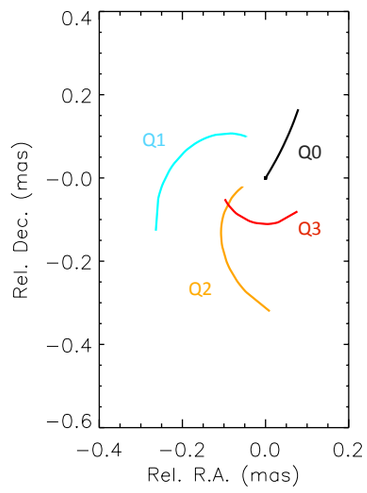
We propose the Jet wobbling is produced by the material following helical trajectories.

This model is an alternative model to explain the jet wobbling in NRAO150 as an internal rotation of material.

Best fit



Real trajectories



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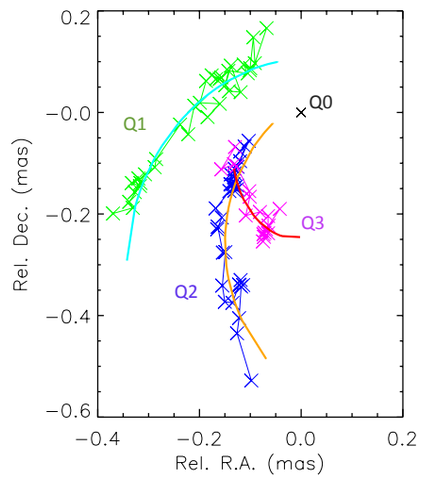

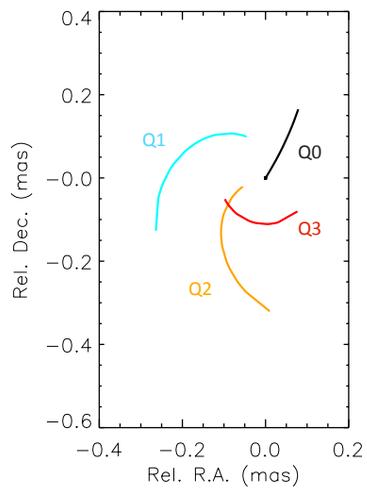

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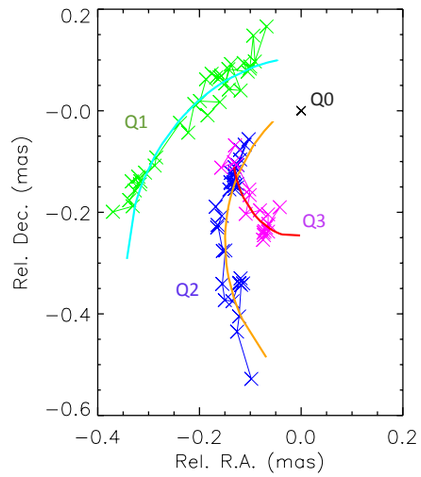

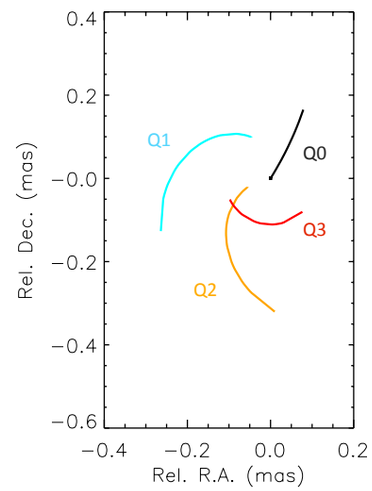

Thank You!!!