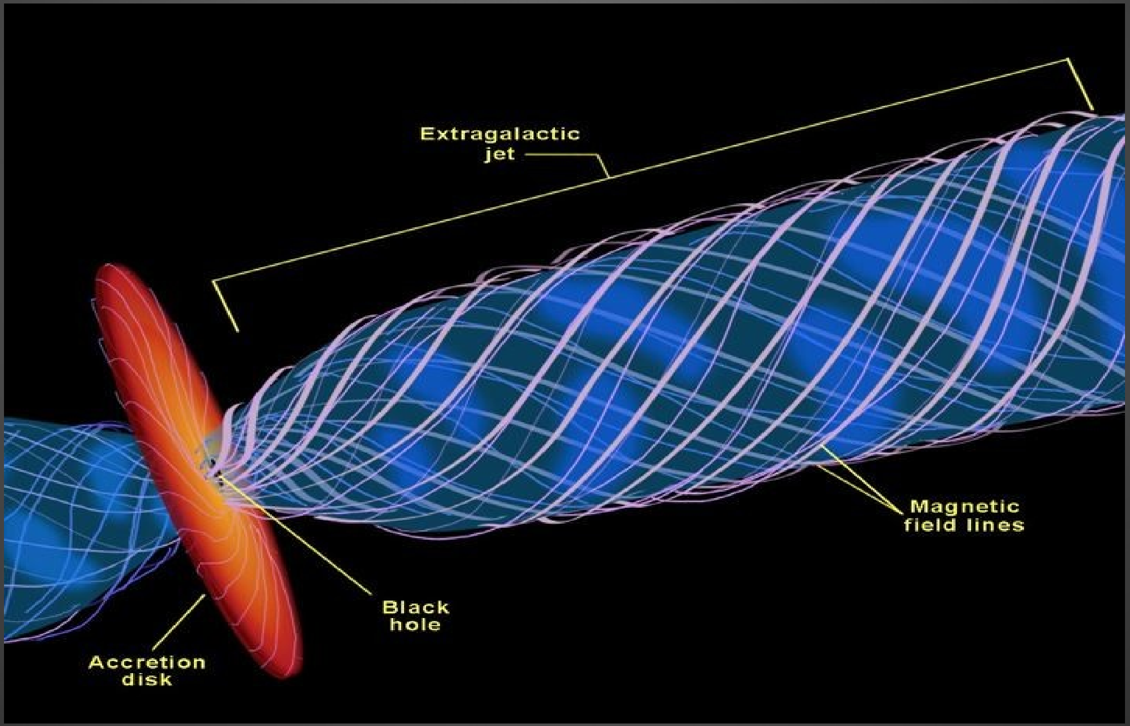
Gleaning Secrets from Transverse Profiles of AGN

Eoin Murphy

YERAC 2010, Madrid



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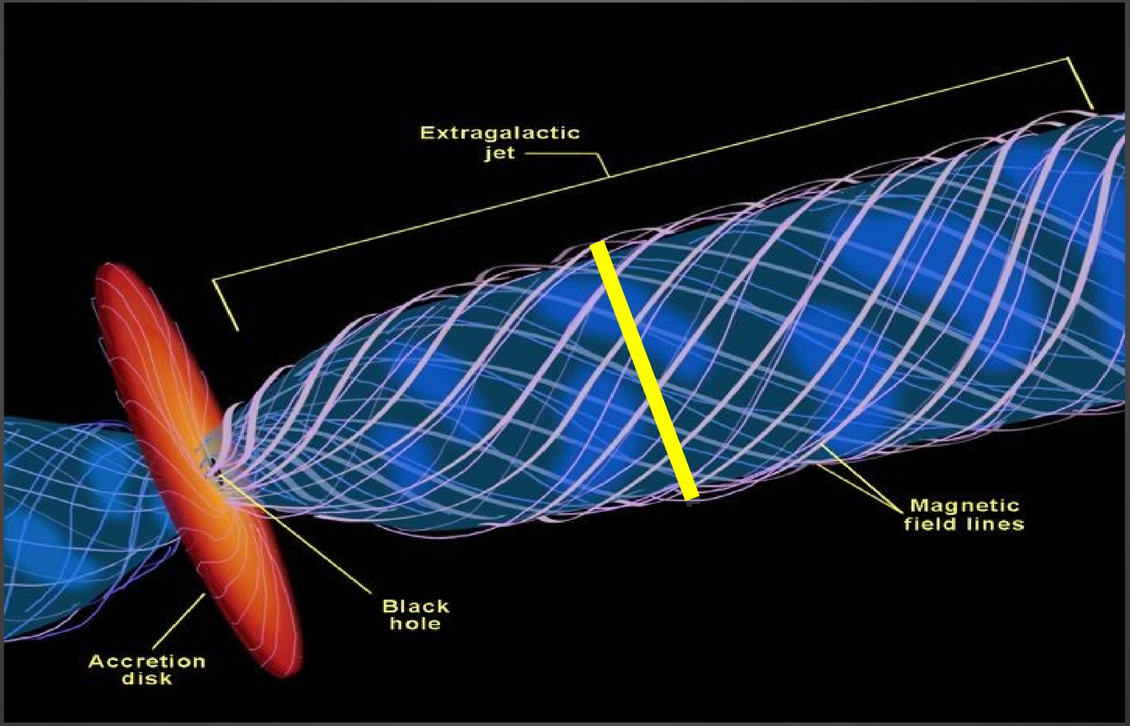

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Evidence for Helical Magnetic Fields

There are primarily 3 different observations that support Helical Magnetic Fields.

- Systematic Faraday Rotation Measures gradients across jets
- Characteristic variations of intensity and polarization across jets
- Magnetic field angle orientation changing from longitudinal to transverse within a given jet profile.

Evidence for Helical Magnetic Fields

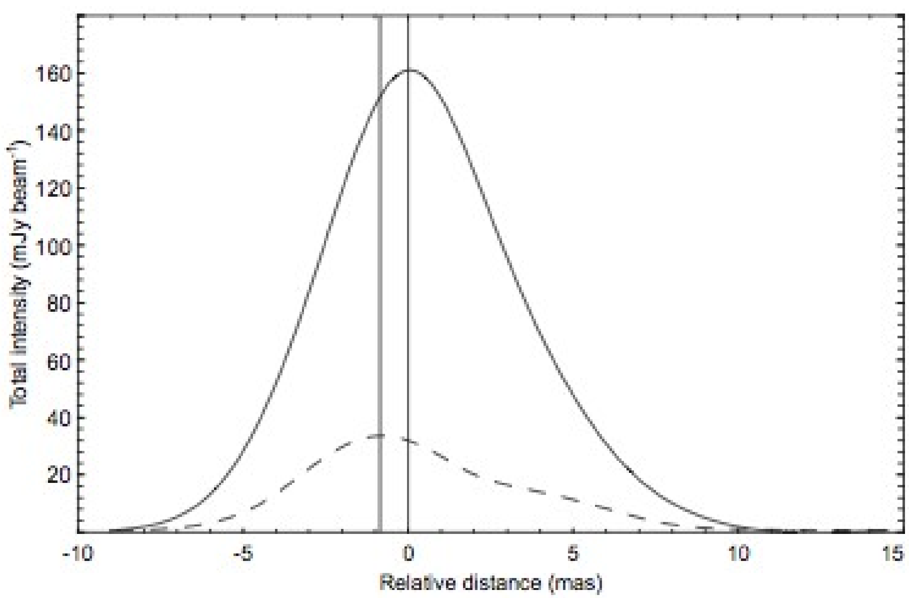

Figure 2. 1.6 GHz total and polarized intensity transverse profile of the jet in 3C 380, 16 mas away from the core. The convolution beam is ∼ 4 mas. Solid line corresponds to total intensity, dashed line corresponds to polarized intensity.

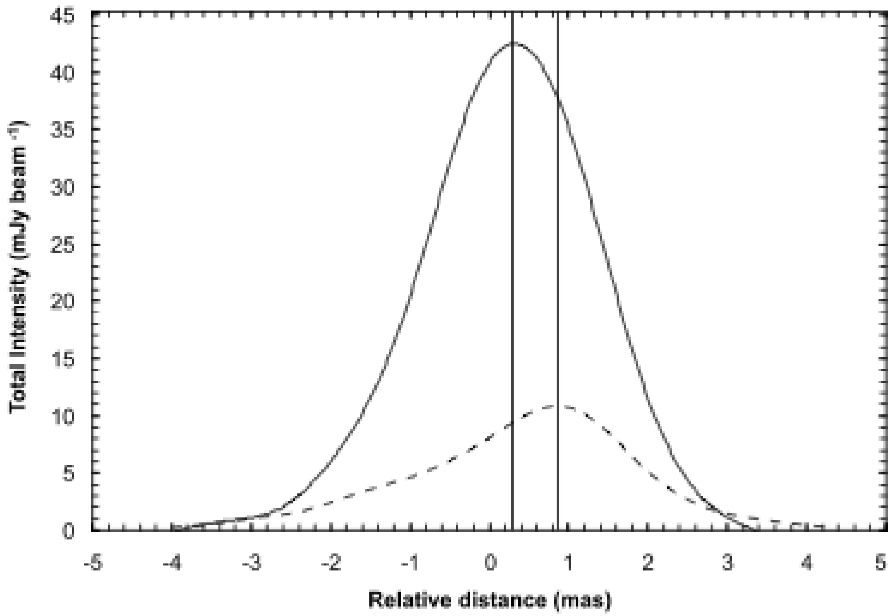

Figure 1. 8 GHz total and polarized intensity transverse profile of the jet in 4C 71.07 (epoch 1997.89), 6 mas away from the core. The convolution beam is ∼ 1.5 mas. Solid line corresponds to total intensity, dashed line corresponds to polarized intensity.

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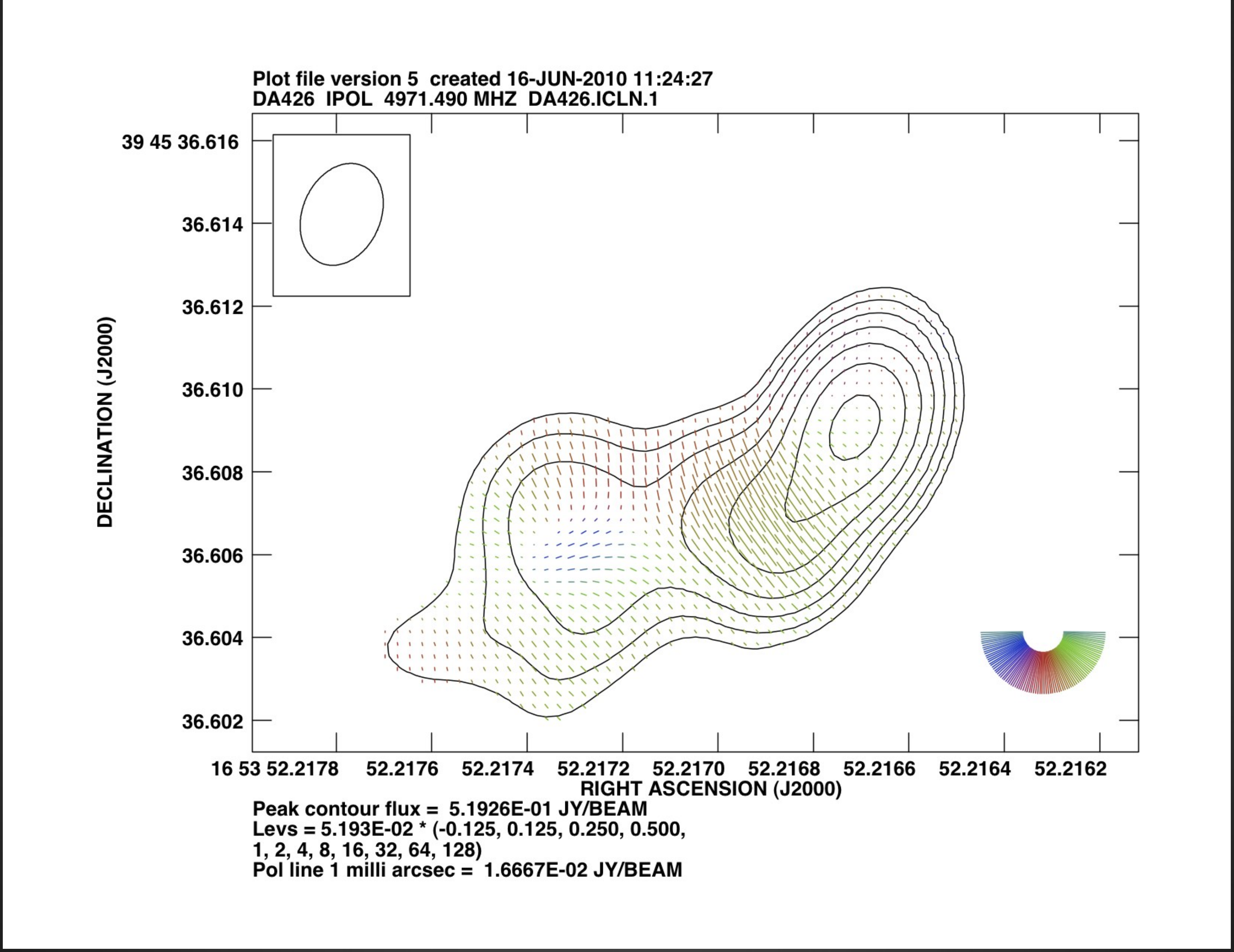
Evidence for Helical Magnetic Fields



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Helical Magnetic Fields Models

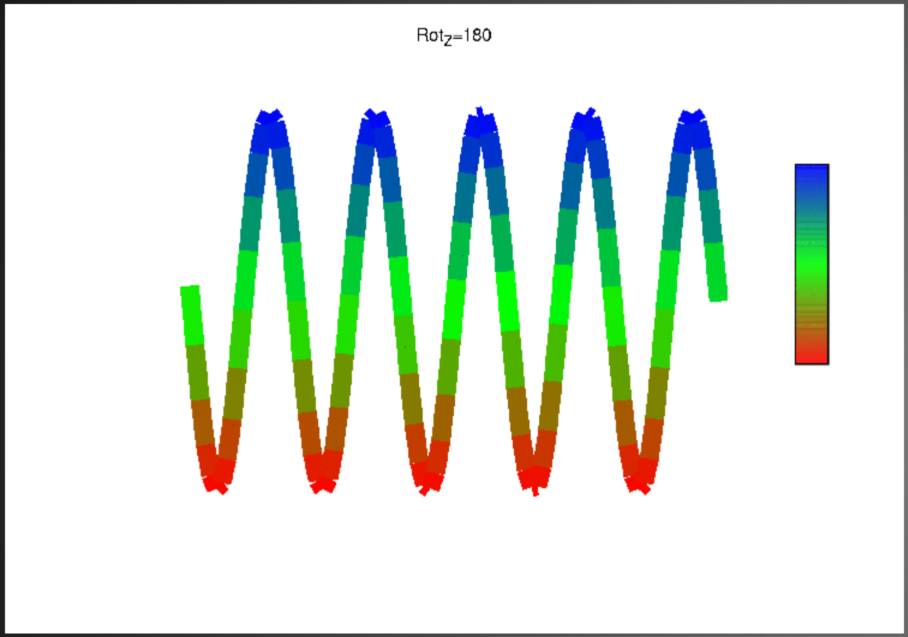
In the simplest case, a helical field model can be described using 2 parameters:

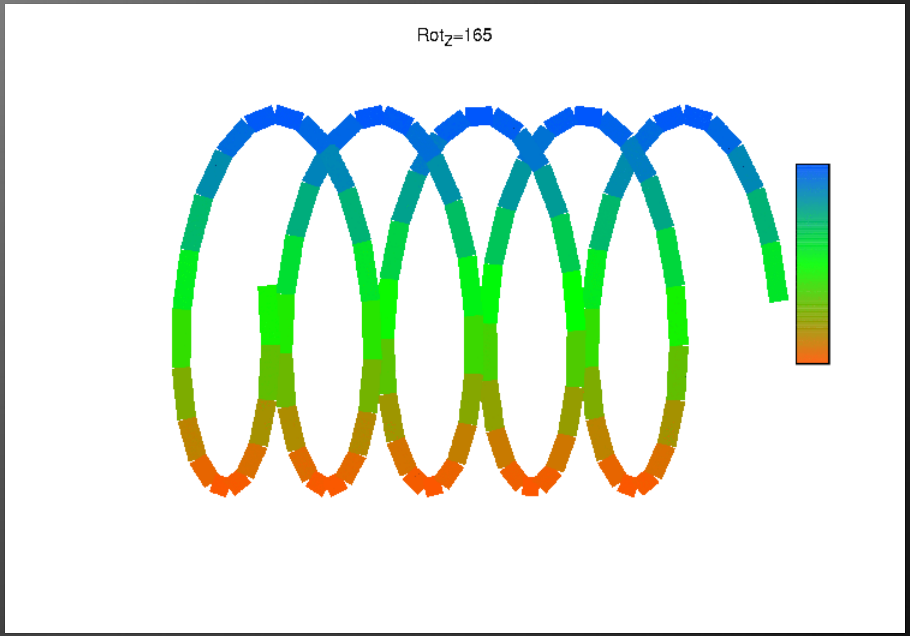
- The line of sight (viewing) angle delta (δ)
- The helical pitch angle gamma (γ)

After considering various models proposed by Laing (1981), Papageorgio (2005) showed that the best agreement was given by a model with a constant pitch angle and uniform flux density threading a cylindrical jet.

Helical Magnetic Fields Models

Changing the Line of Sight Angle, δ, changes what we expect to see.





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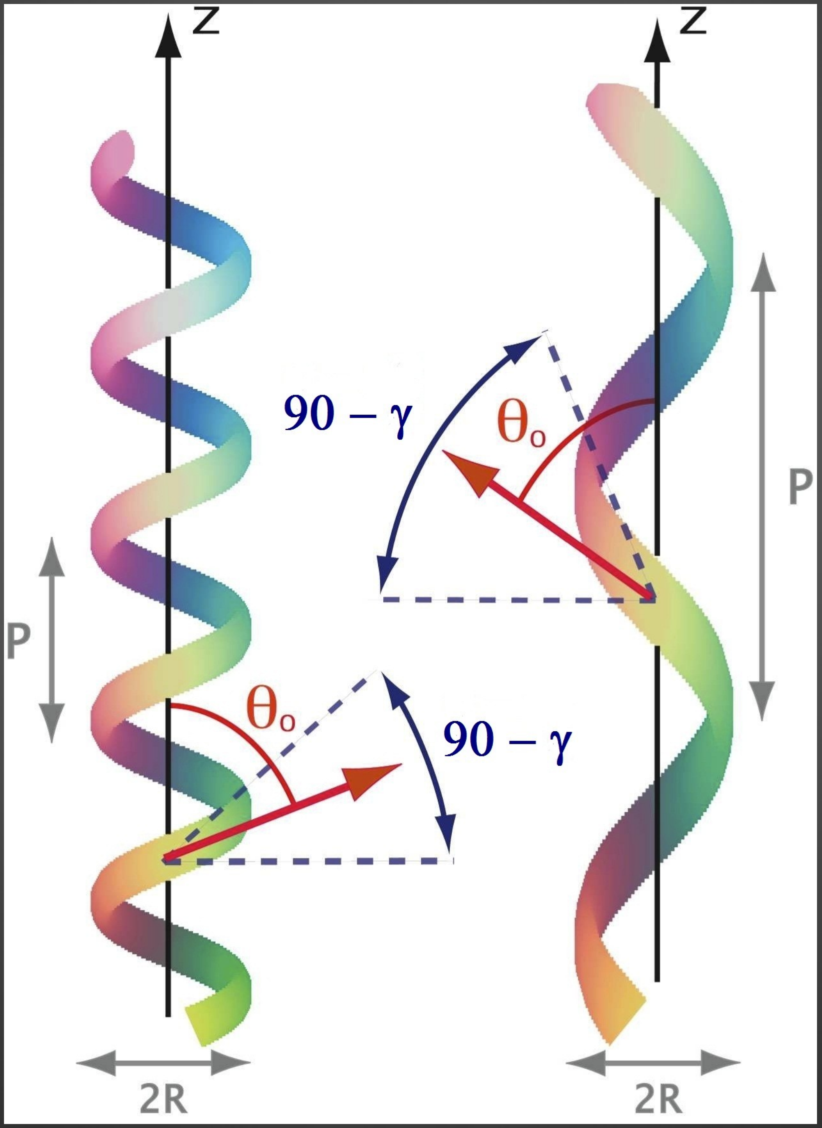
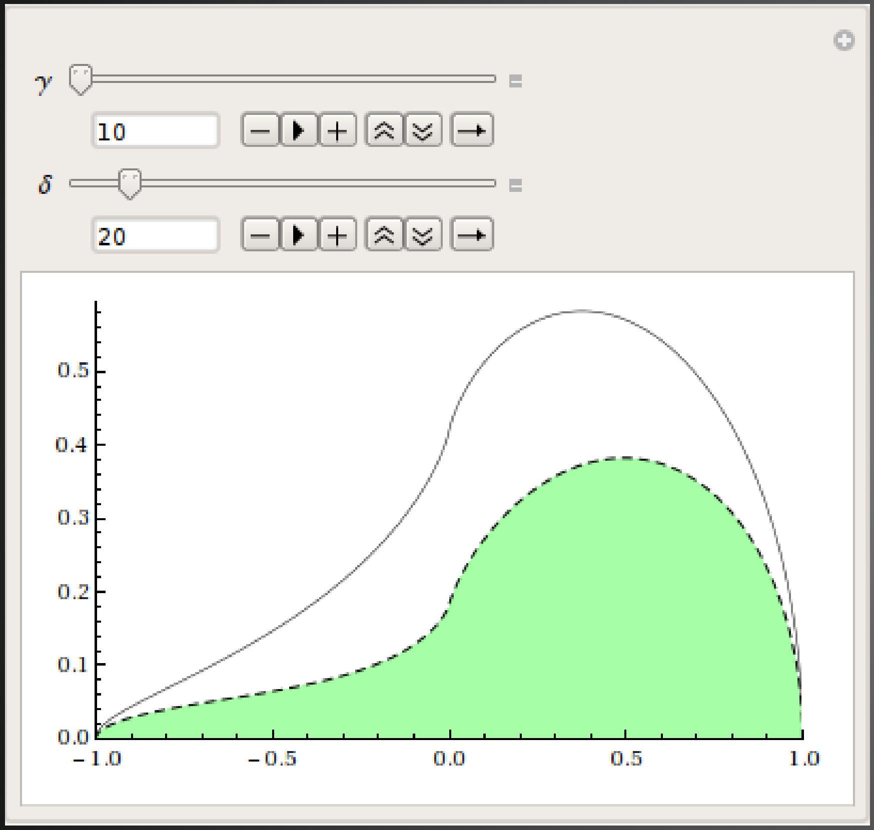
Helical Magnetic Fields Models

Likewise, changing the Helical Pitch Angle, γ, changes what we expect to see.



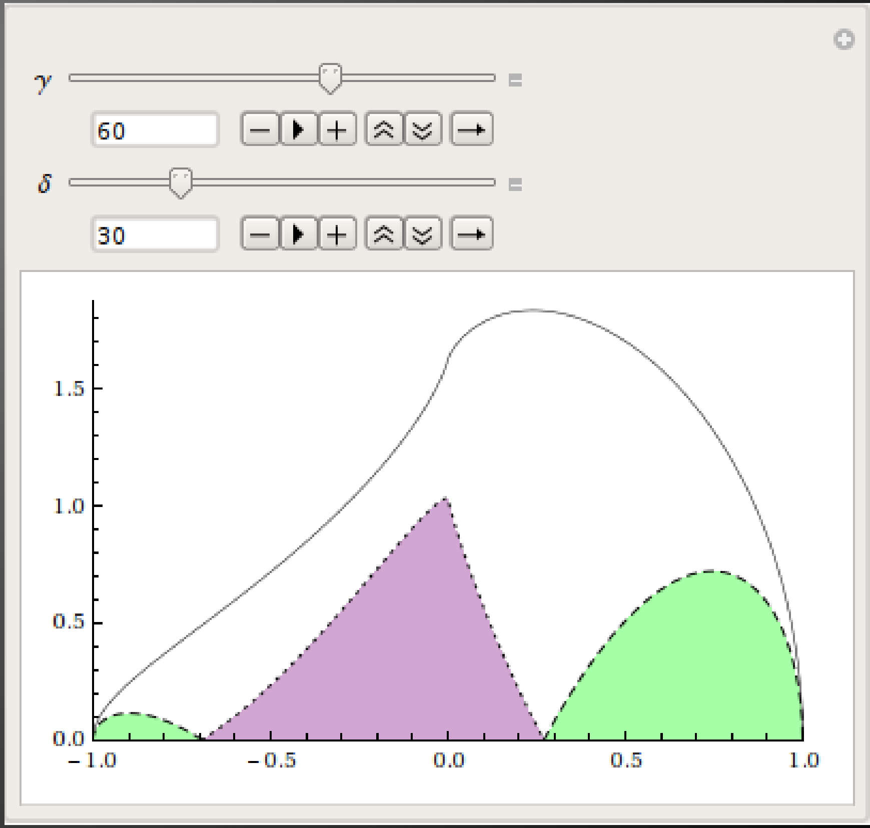
Helical Magnetic Fields Models

Using this model transverse profiles (slices) can be generated.



Green : Longitudinal MVPA

Purple: Transverse MVPA



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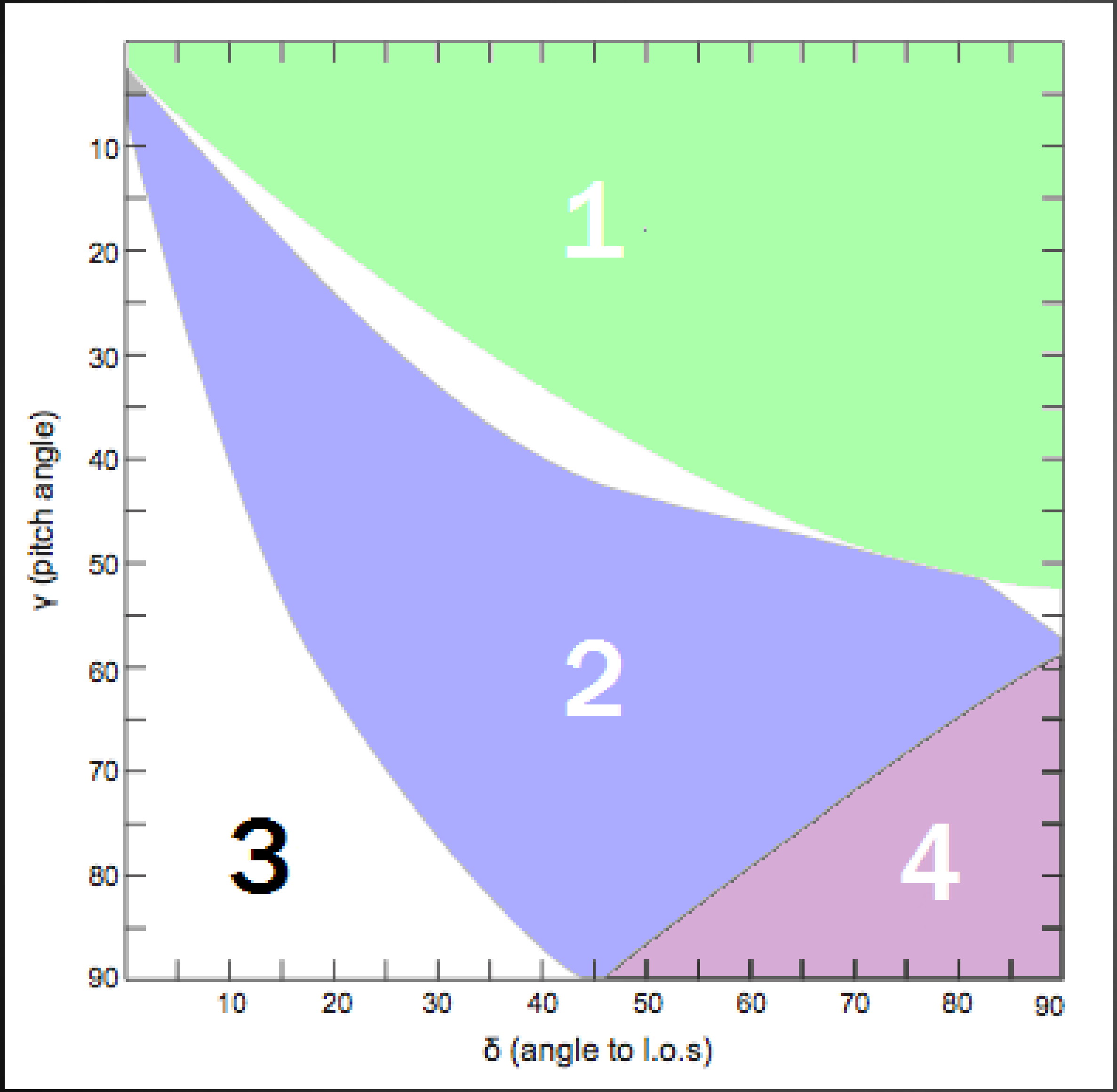
Helical Magnetic Field Models



1. Longitudinal all across the jet.
2. Longitudinal on one side and Transverse on the other side.
3. Longitudinal at the edges and Transverse at the centre.
4. Transverse all across.

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Degree of Entanglement

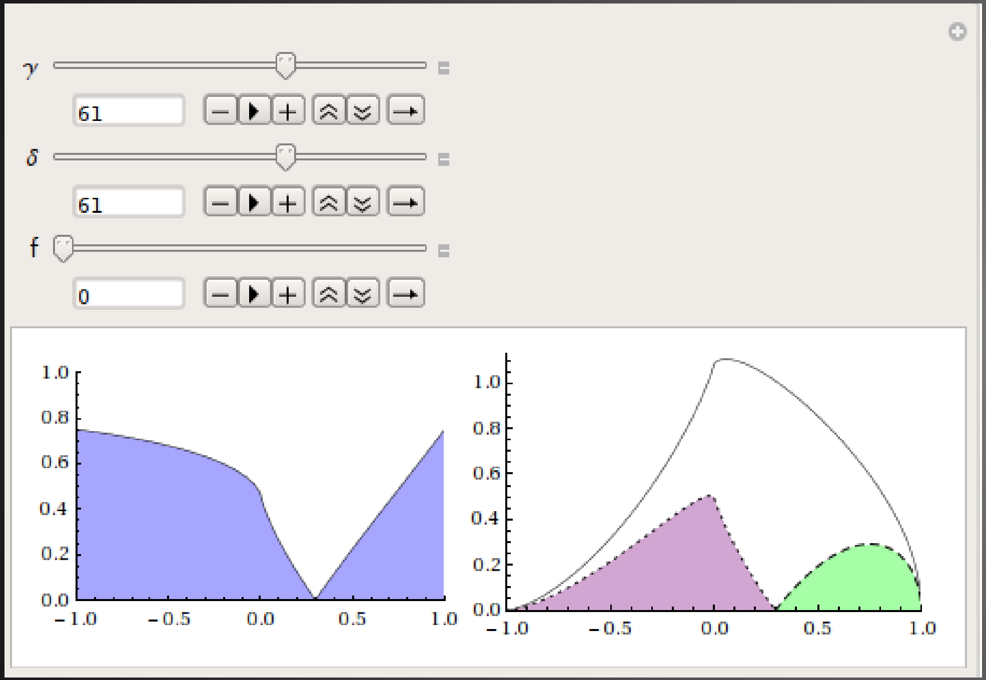
Comparisons between this model and observations showed that the model produced a much higher percentage polarization than was observed.

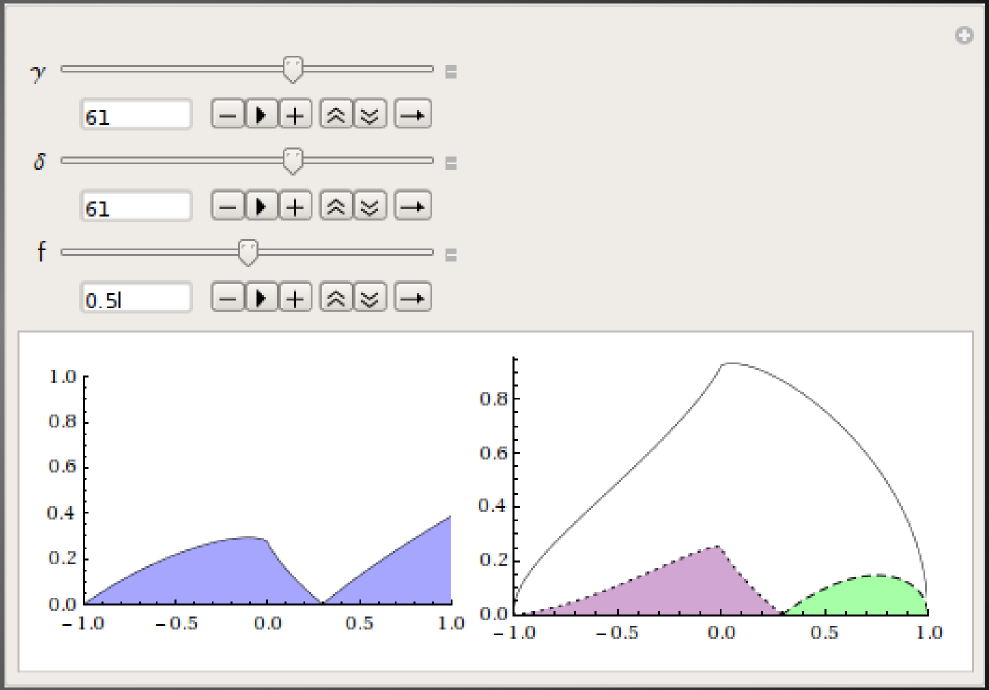
In order to reduce the percentage polarization of the model a third parameter is introduced, the degree of entanglement, f.

$$f = \frac{\langle B_T^{\ 2} \rangle}{\langle B_H^{\ 2} \rangle + \langle B_T^{\ 2} \rangle}$$

Increasing f also decreases asymmetries in the model profiles.

Degree of Entanglement





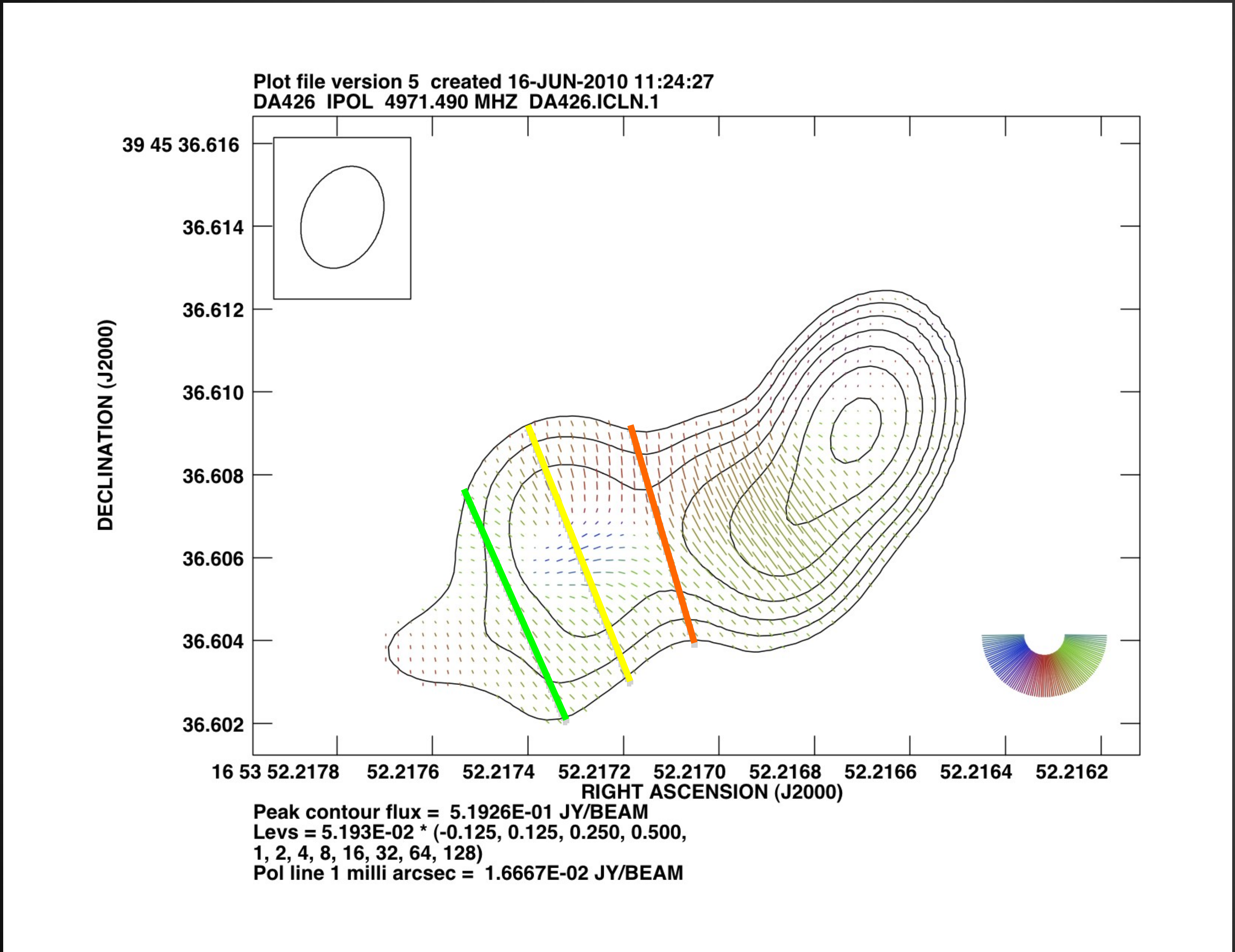
Method of Comparison

I have written a program which generated a database of profiles based on a specified beam width and then compares this entire database to the observed profile in order to find a best fit. This entire process takes less than 5 minutes.

In order to compare the observed profiles to the model profiles the model profiles are scaled such that the maximum Total Intensity is equal for both profiles.

Not only does this method allow one to quickly compare multiple profiles for a source but it provides an objective way to fit profiles

Markarian 501



lice 1

lice 2

lice 3

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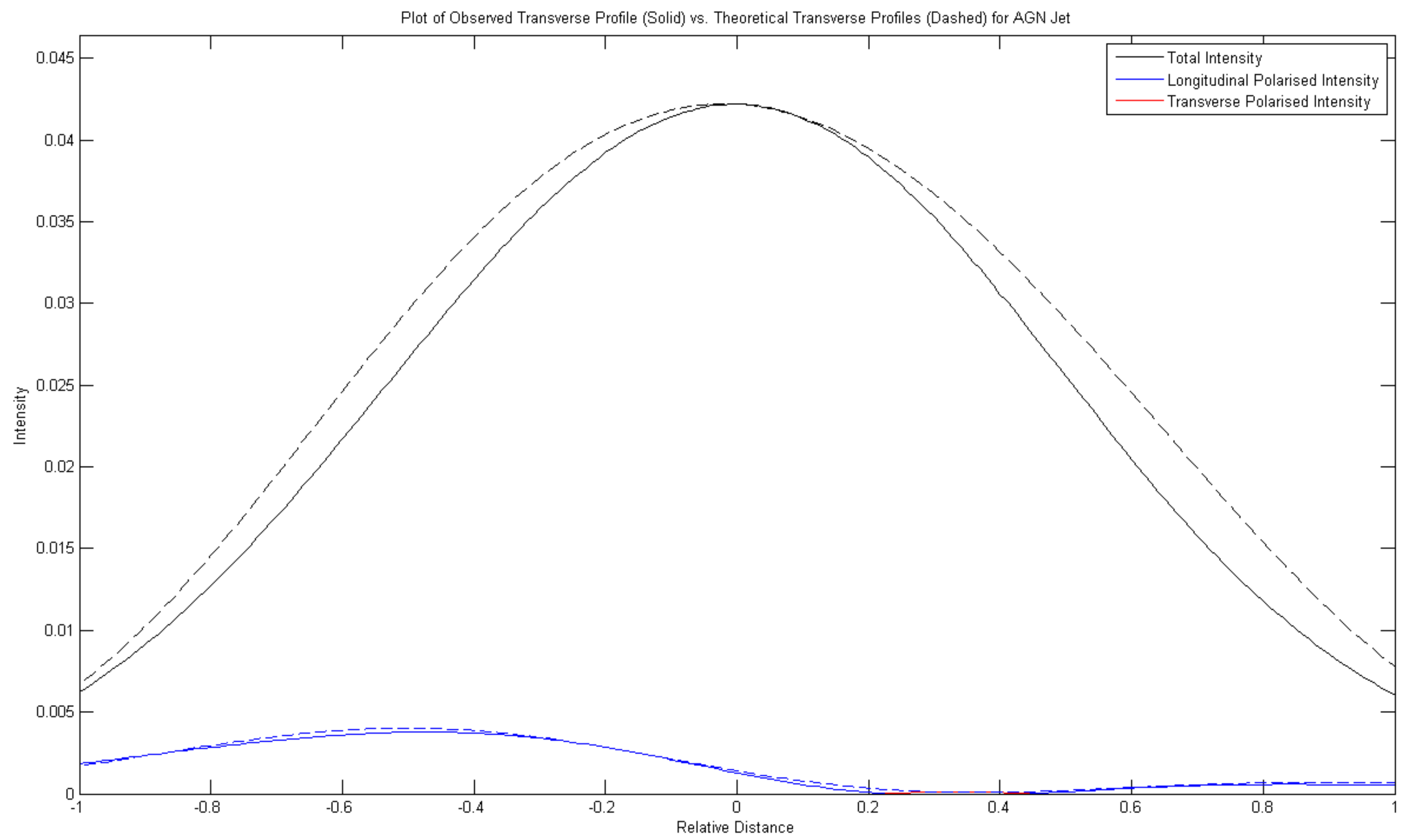
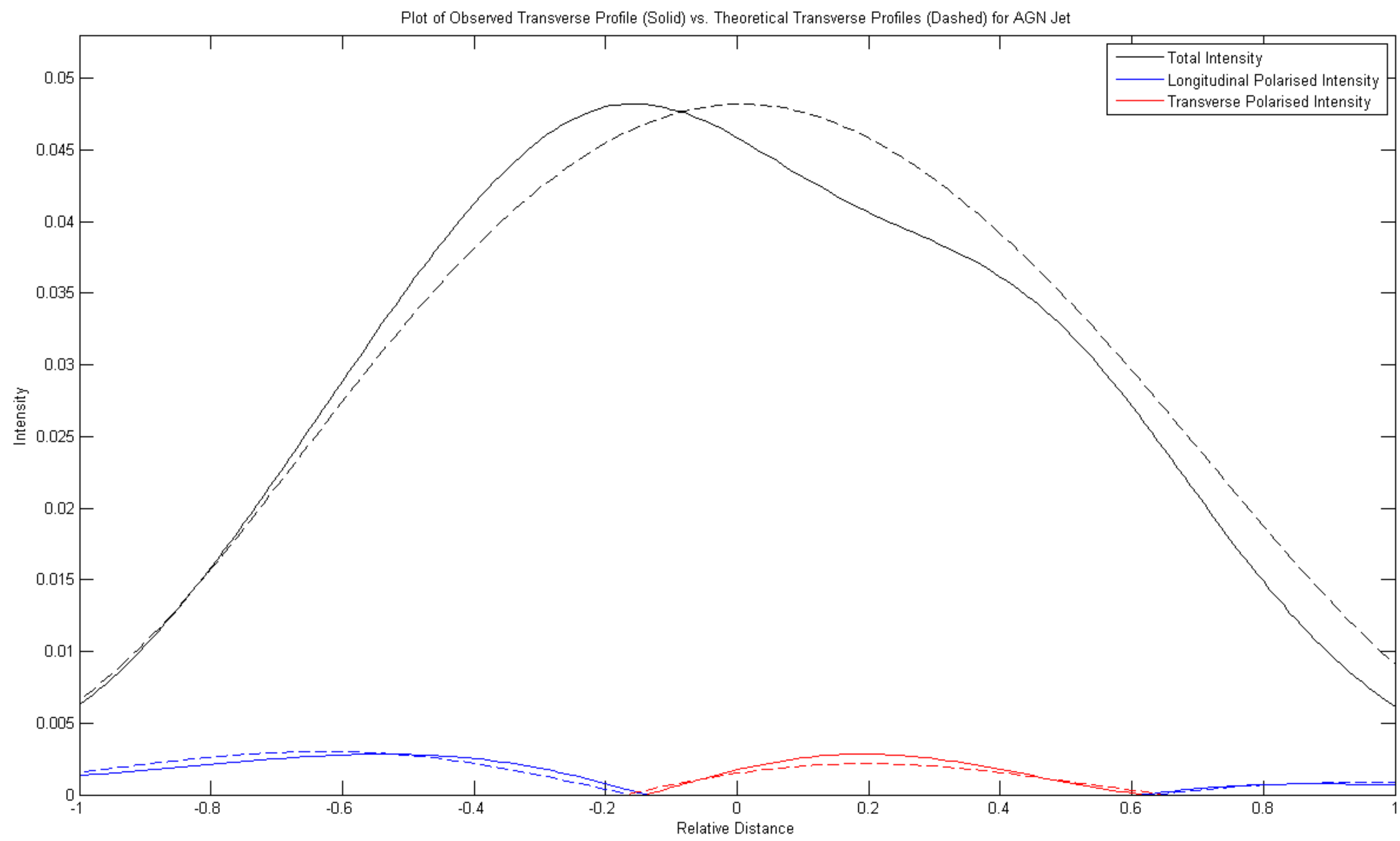
Slice 1



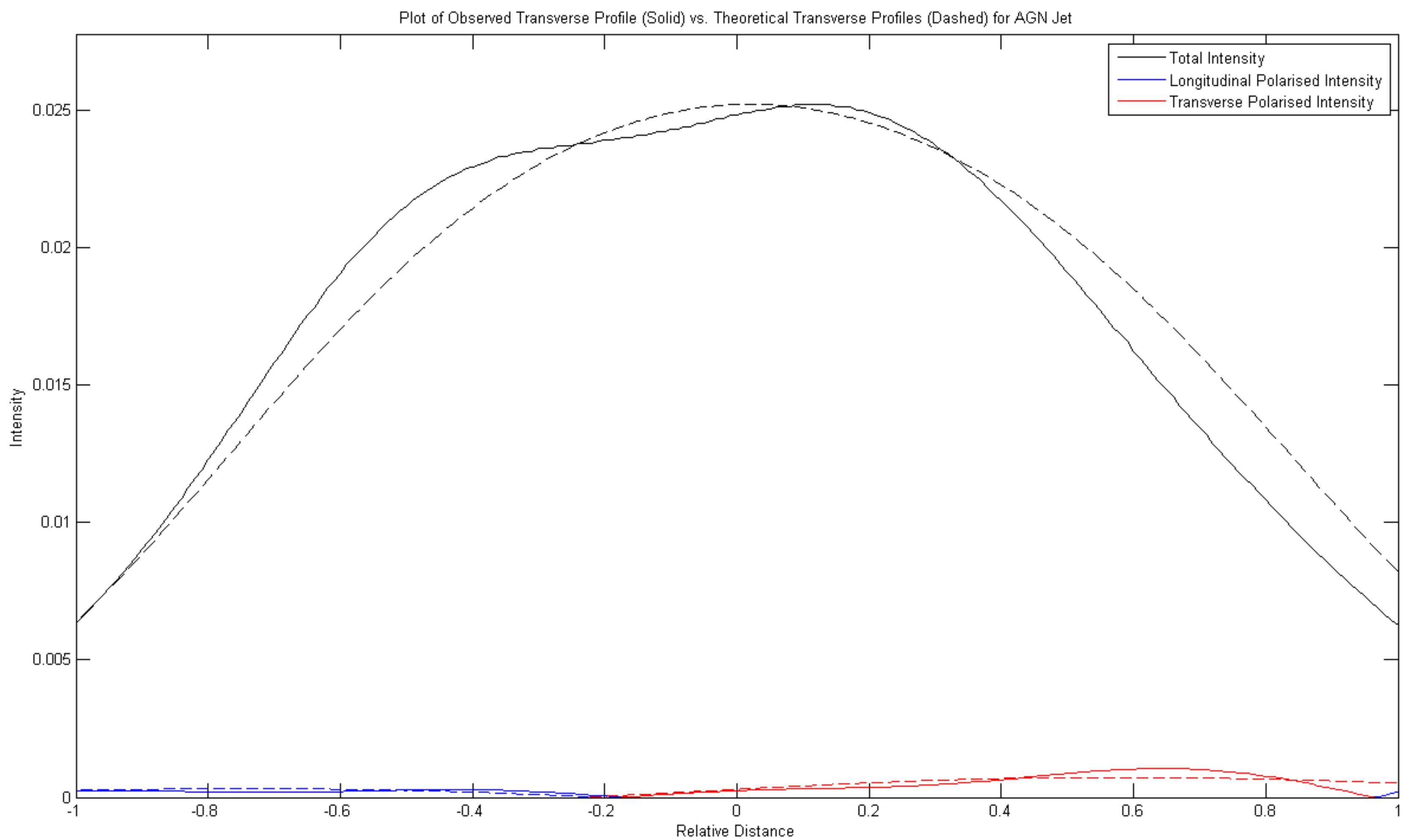
Slice	γ	δ	f
Slice 1	49 Degrees	78 Degrees	.4

Slice 2



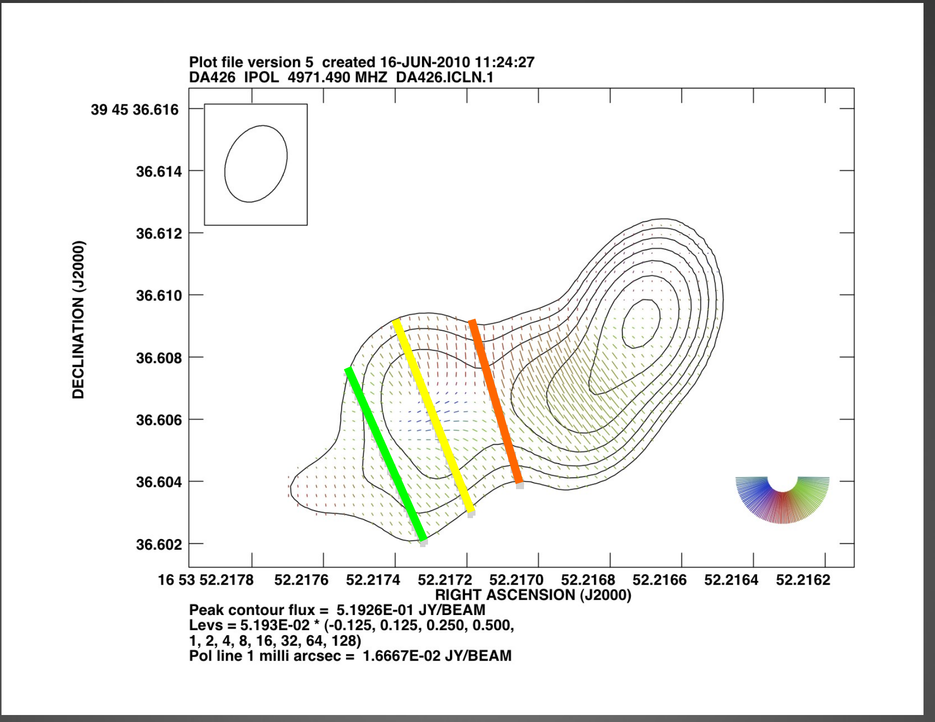
Slice	γ	δ	f
Slice 2	53 Degrees	80 Degrees	.4

Slice 3



Slice	γ	δ	f
Slice 3	58 Degrees	78 Degrees	.8

Markarian 501



Slice	γ	δ	f
Slice 1	49 Degrees	78 Degrees	.4
Slice 2	53 Degrees	80 Degrees	.4
Slice 3	58 Degrees	78 Degrees	.8

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Rotation Measure Gradients

Faraday Rotation occurs when an electromagnetic wave propagates through a charged plasma threaded by a Magnetic Field.

$$\chi = \chi_0 + RM\lambda^2$$

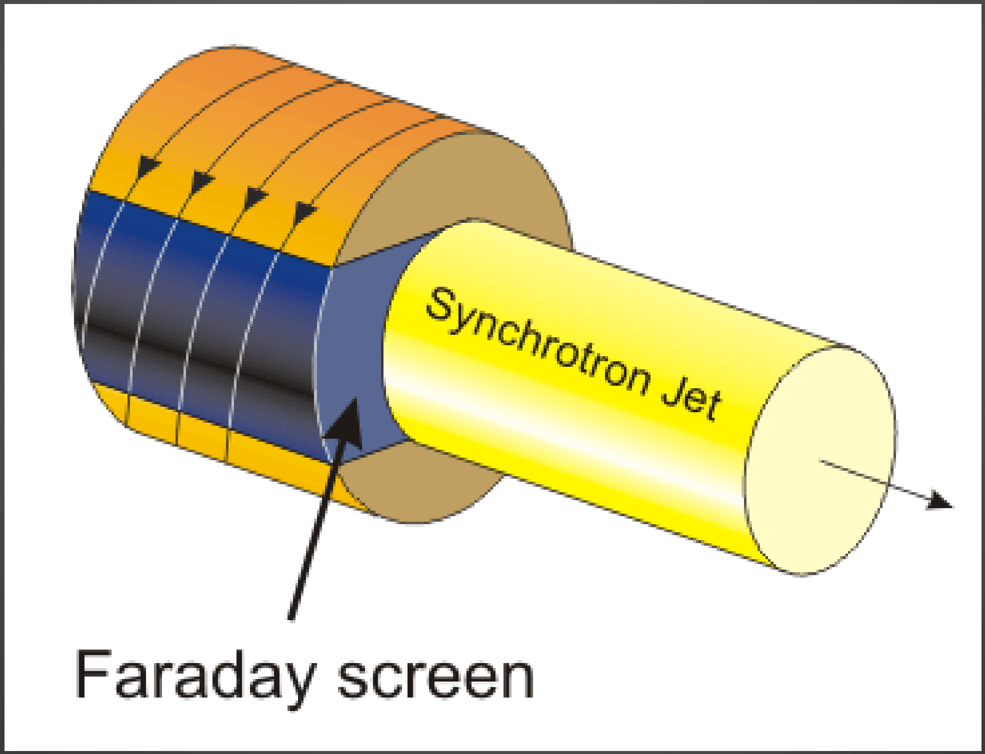
$$RM = \frac{e^3}{8\pi\varepsilon_0 m_e^2 c^3}\int n_e B \bullet dl$$

As B • dl changes across a Helical Magnetic Field we would expect the Rotation Measure to change if a Helical Magnetic Field thread the jet.

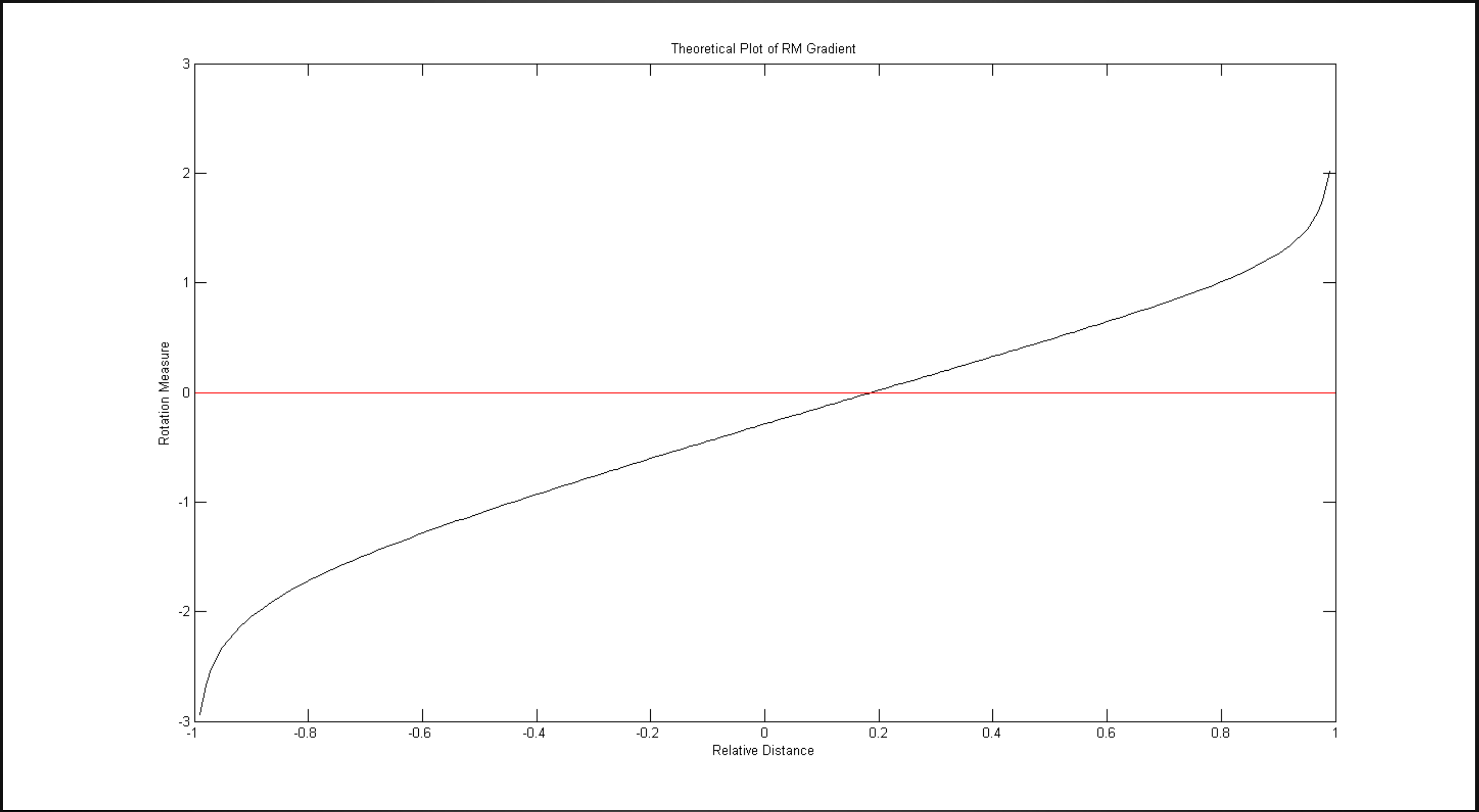
Rotation Measure Gradients are seen across many jets (see talk by Dr. Mehreen Mahmud)

Rotation Measure Gradients

I have modeled my Rotation Measure gradients as shown below



Rotation Measure Gradients



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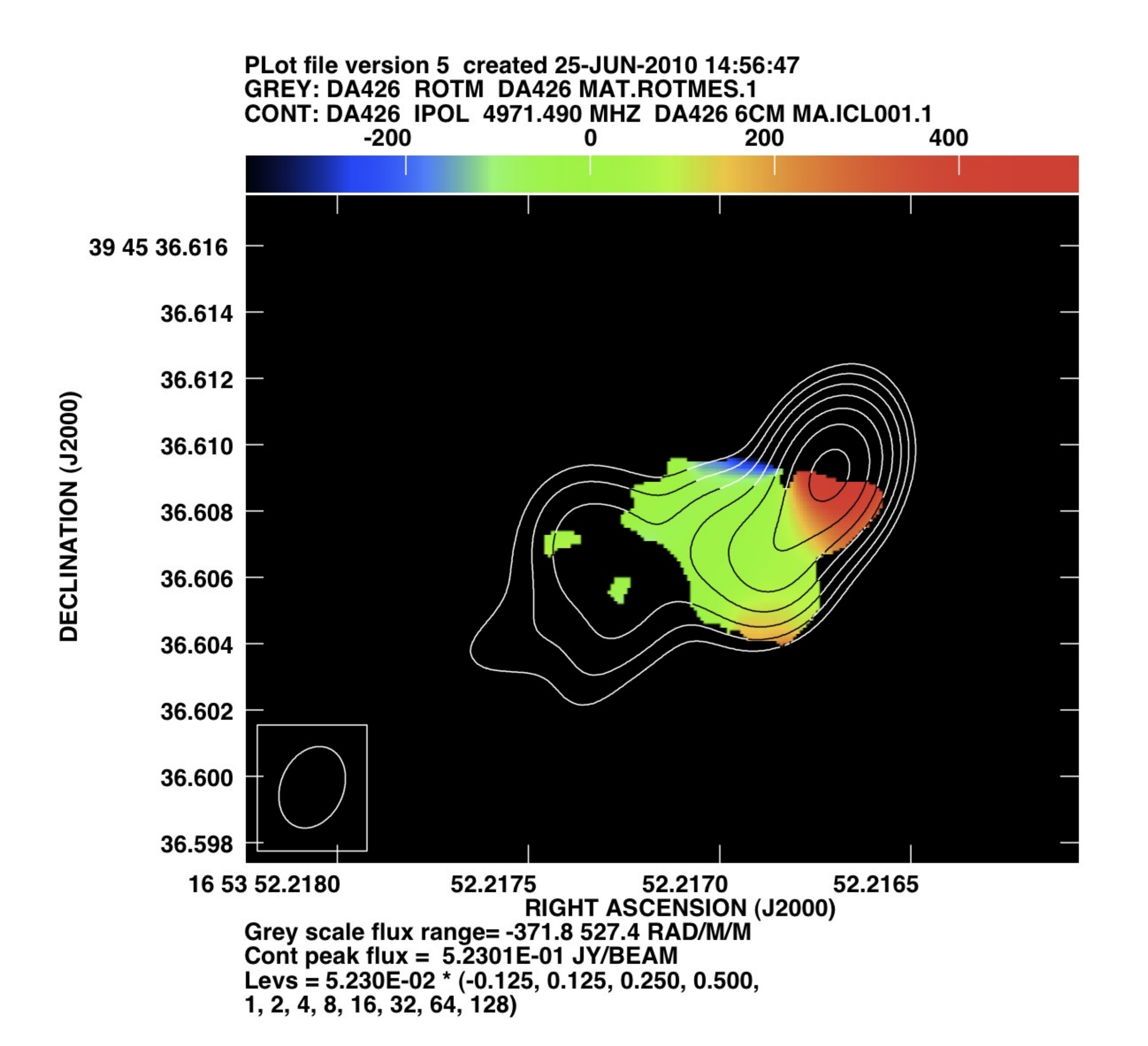
Rotation Measure Gradients



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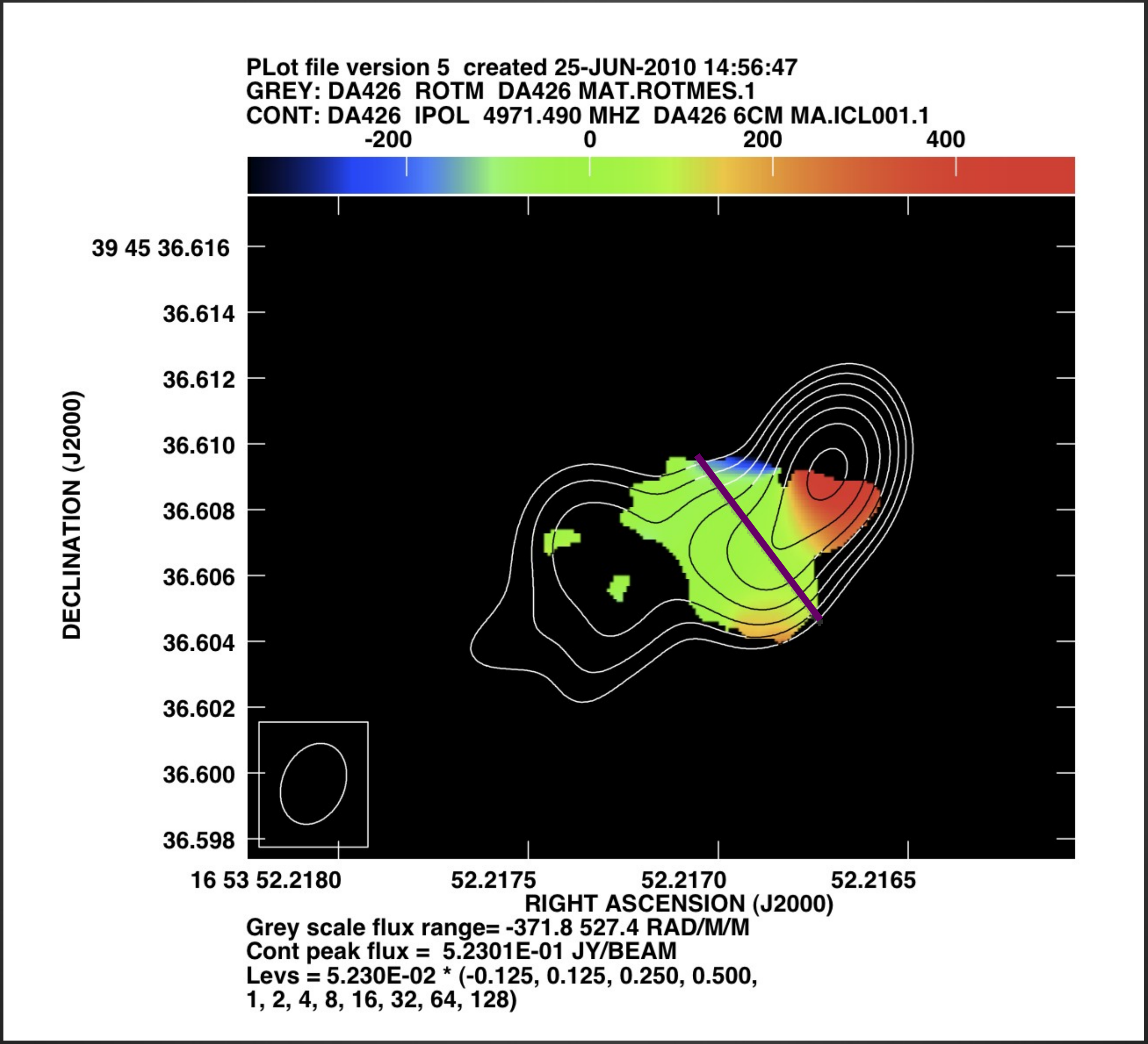
Rotation Measure Gradients



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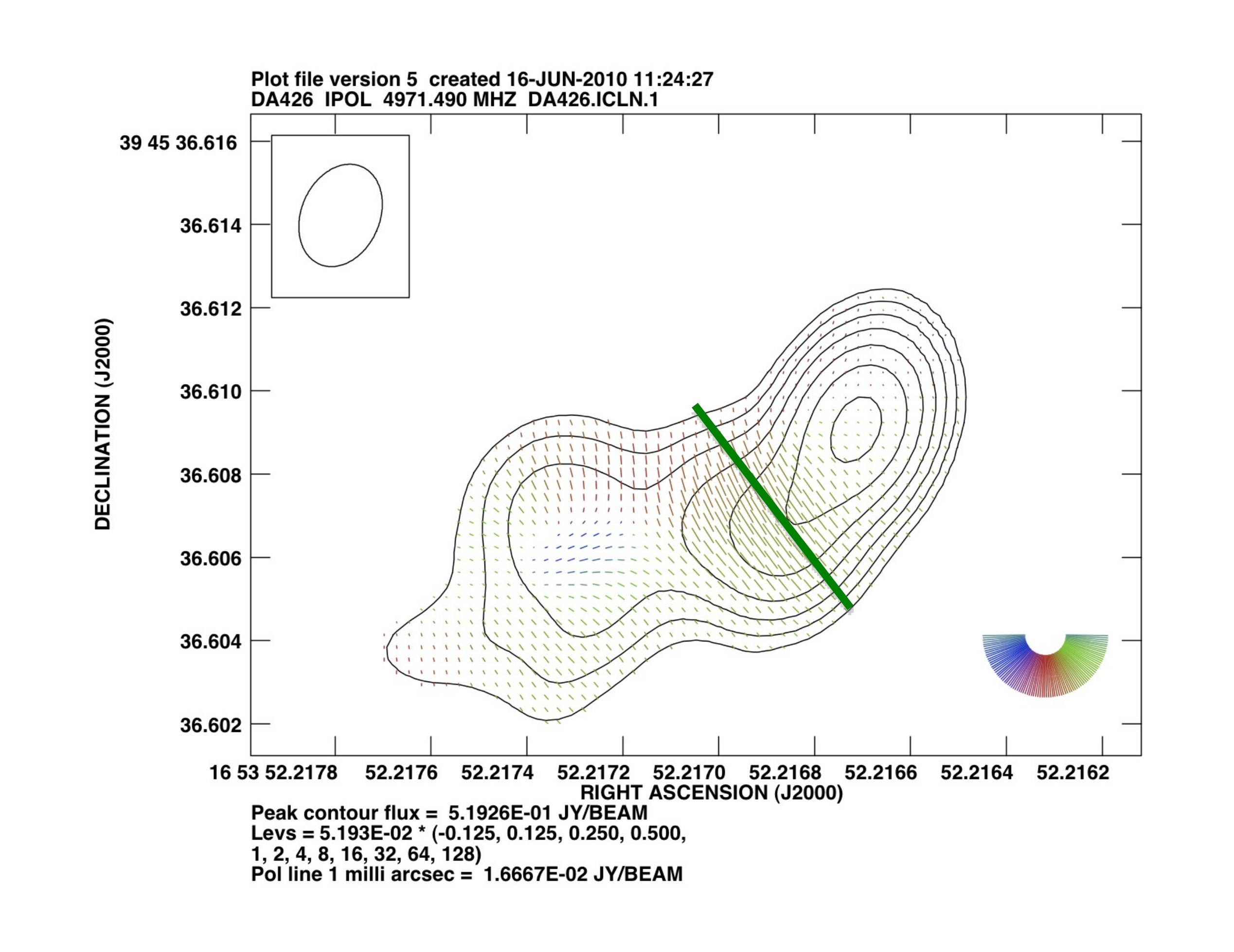
Rotation Measure Gradients

These theoretical Rotation Measure Gradients have been preliminarily applied to observed rotation measure gradients in Markarian 501.



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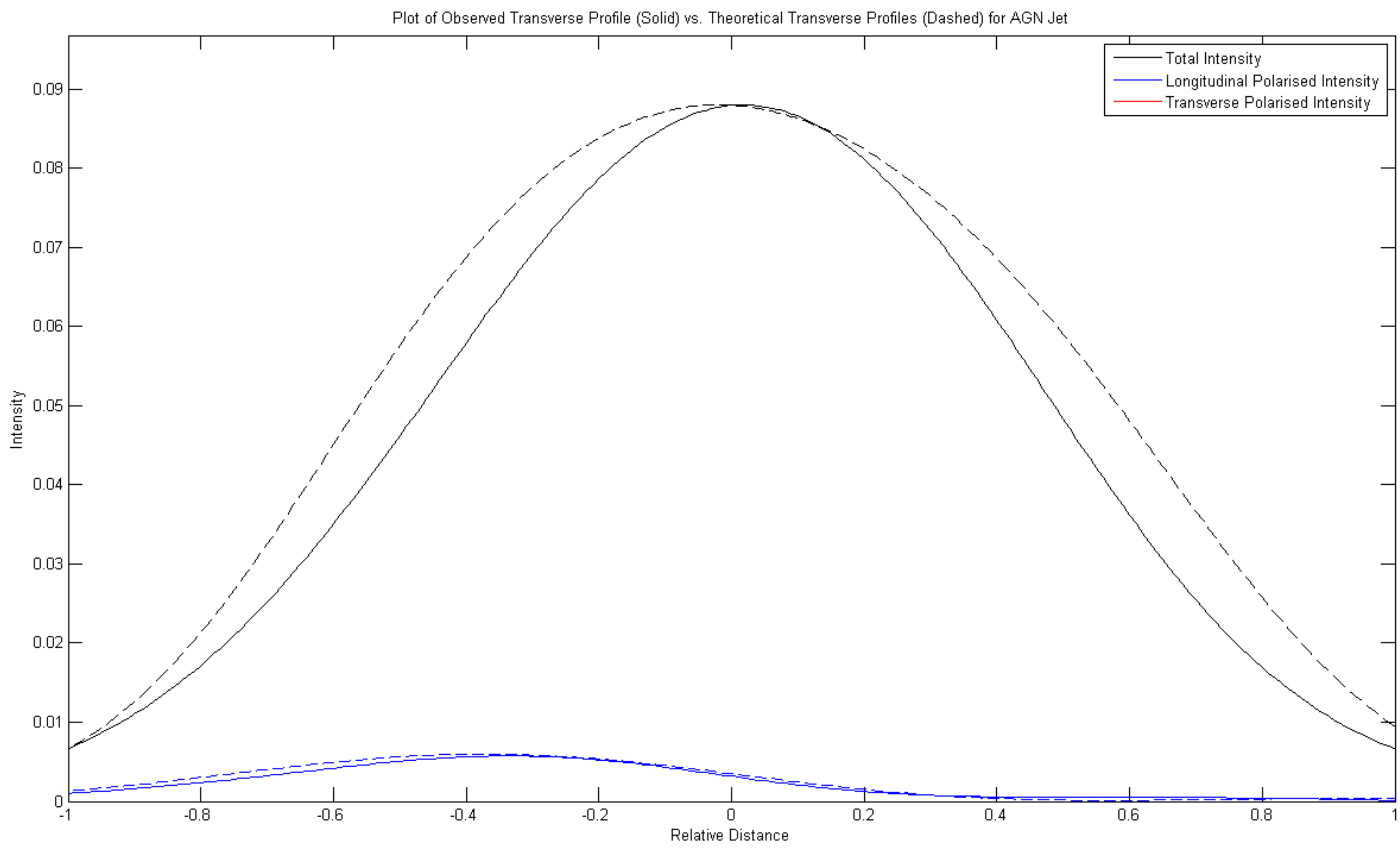
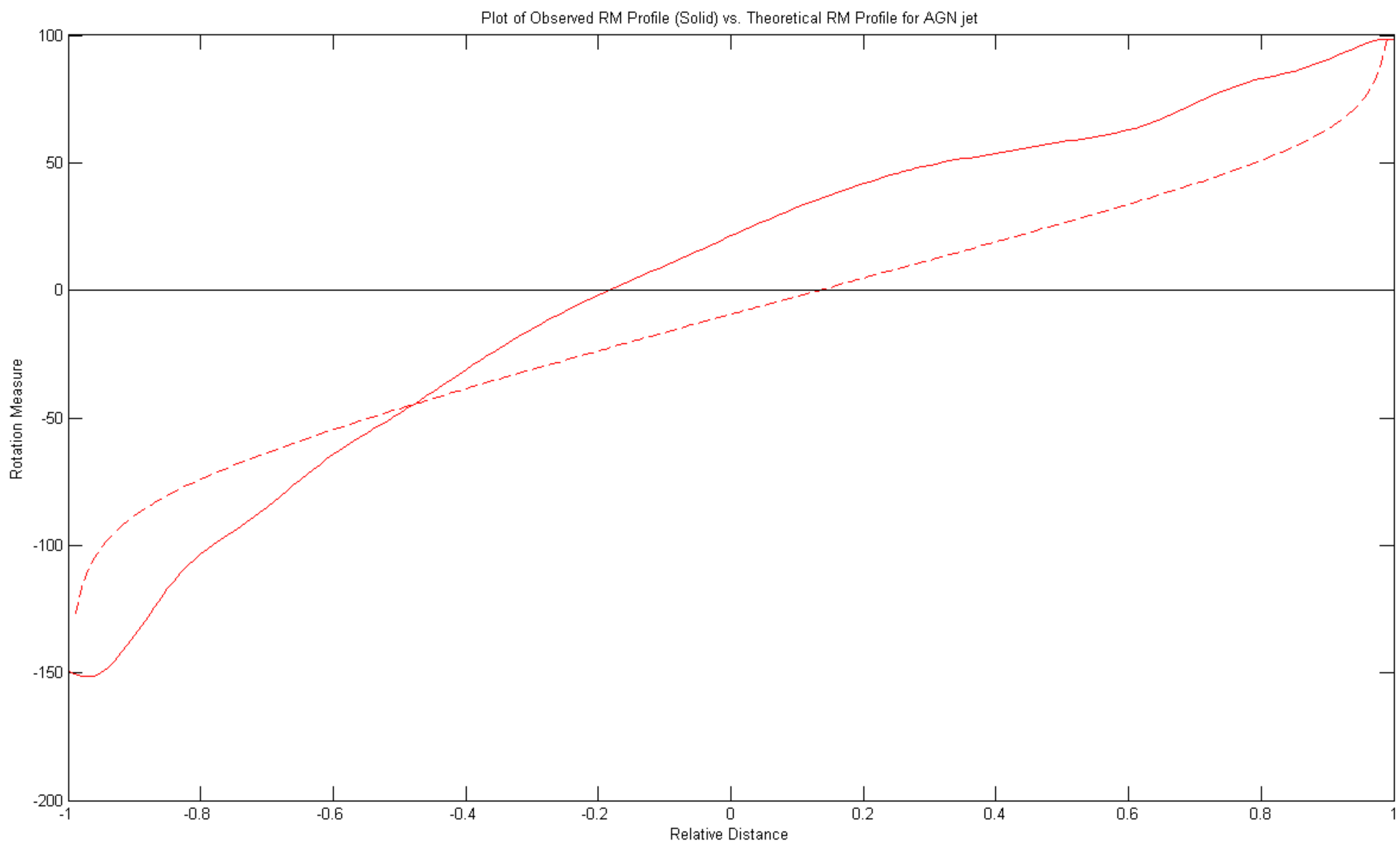
RM Slice



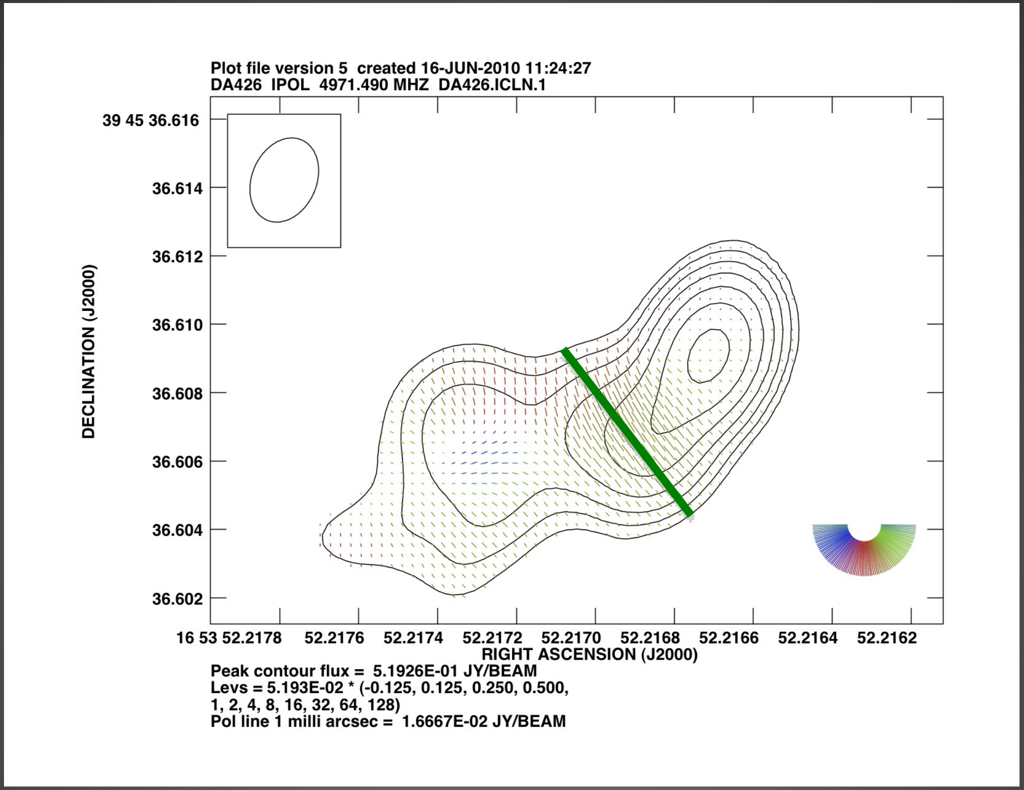
Slice	γ	δ	f
Slice 1	45 Degrees	68 Degrees	.7

RM Slice



Slice	γ	δ
RM Slice	44 Degrees	73 Degrees

Markarian 501



Slice	γ	δ
Pol Comp.	45 Degrees	68 Degrees
RM Comp.	44 Degrees	73 Degrees

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Future Work

Apply this method to different frequency maps of MK501

Apply this method to different sources.

Devise a way of maximising the chances that the taken profile are perpendicular to the direction of the jet.

Improve the model!

Any Questions?