Searching for Faraday Complexity in the ATCA Beta Test Fields

A Brief Overview & Preliminary Results

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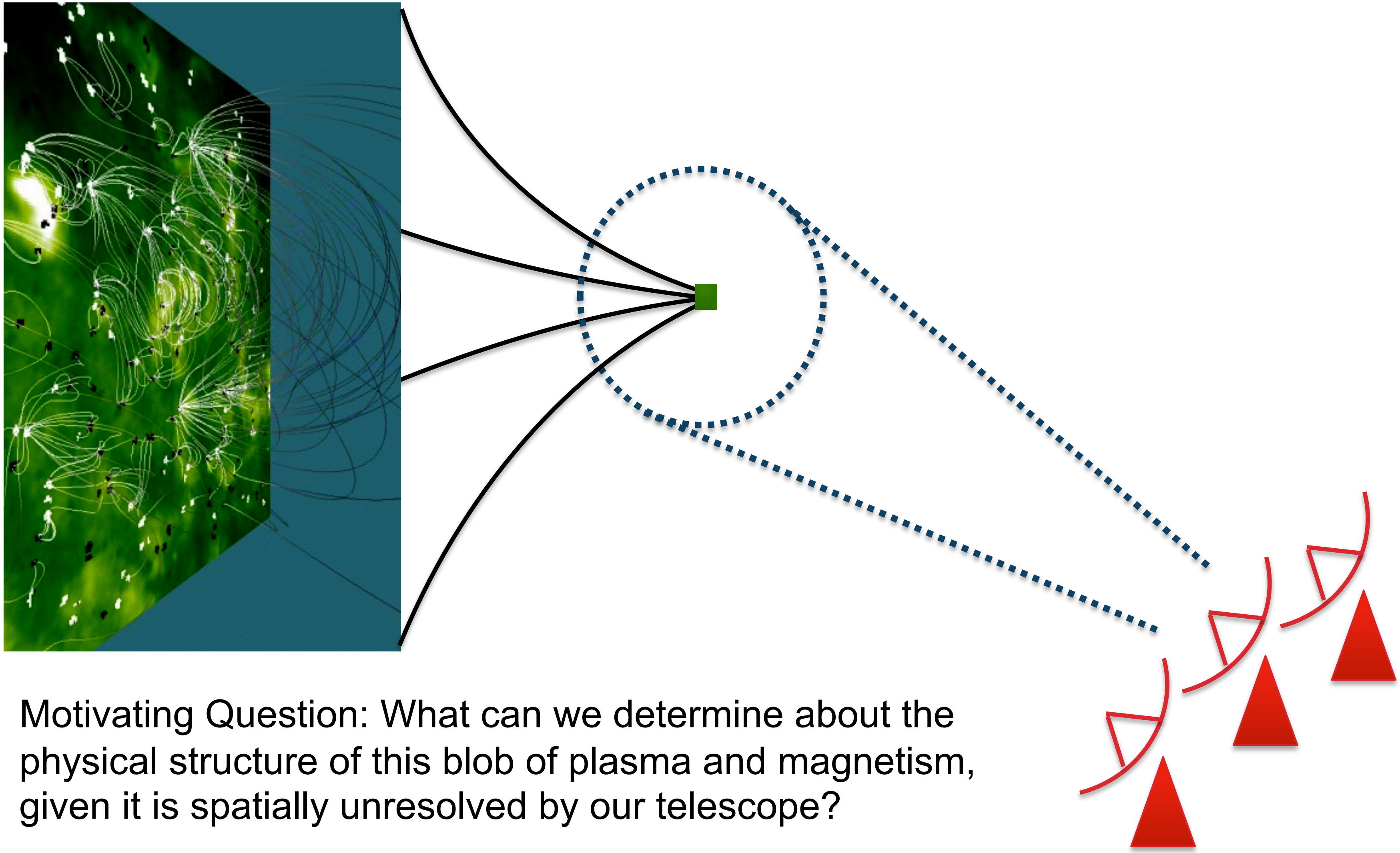
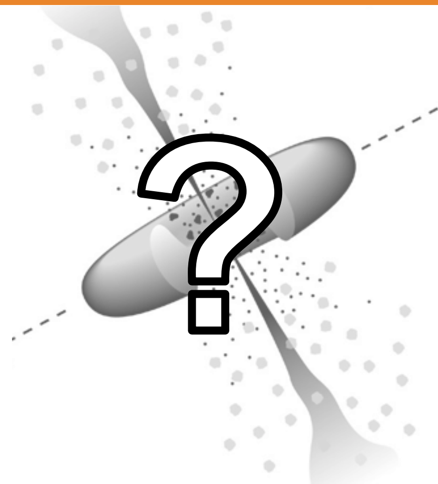
Motivation: Dodging The Spatial Resolution Constraint

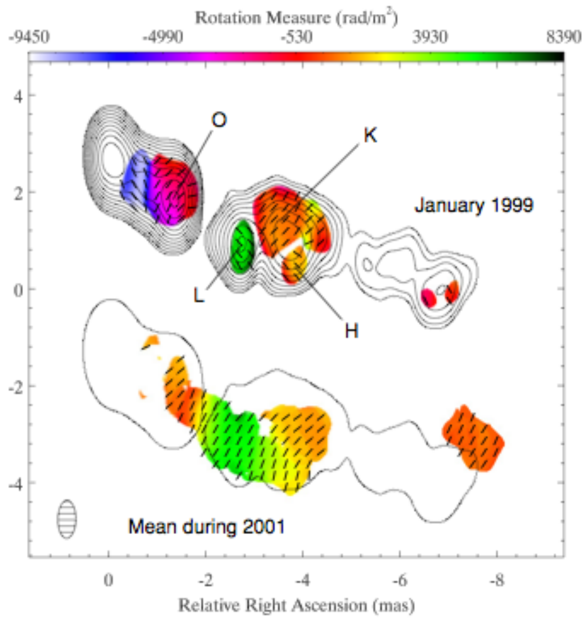


Motivating Question: What can we determine about the physical structure of this blob of plasma and magnetism, given it is spatially unresolved by our telescope?

One Application: AGN Science



› Magnetic processes dominate AGN phenomenology
- behaviour of accretion disks
- jet launching and collimation
- particle acceleration
- cluster B field seeding



(Gomez et al. 2011)

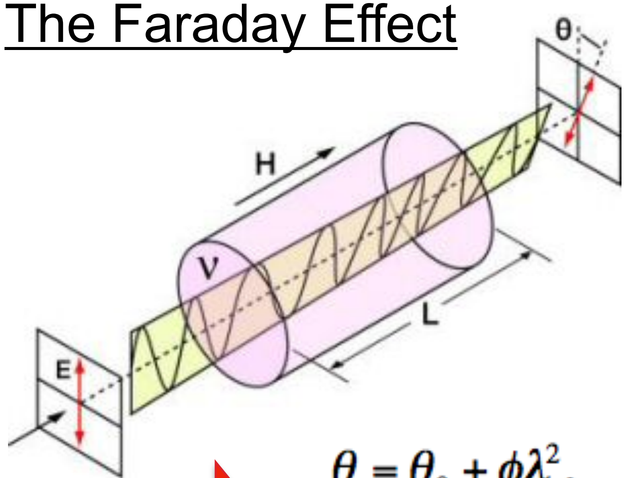
› Typically studied with VLBI
- Highly effective but limited - poor survey capability & small bandwidth coverage

› Imagine we had a ‘super-resolution’ technique for studying B fields > a complimentary approach to studying critical AGN processes.

>> RM Synthesis gives us that capability.

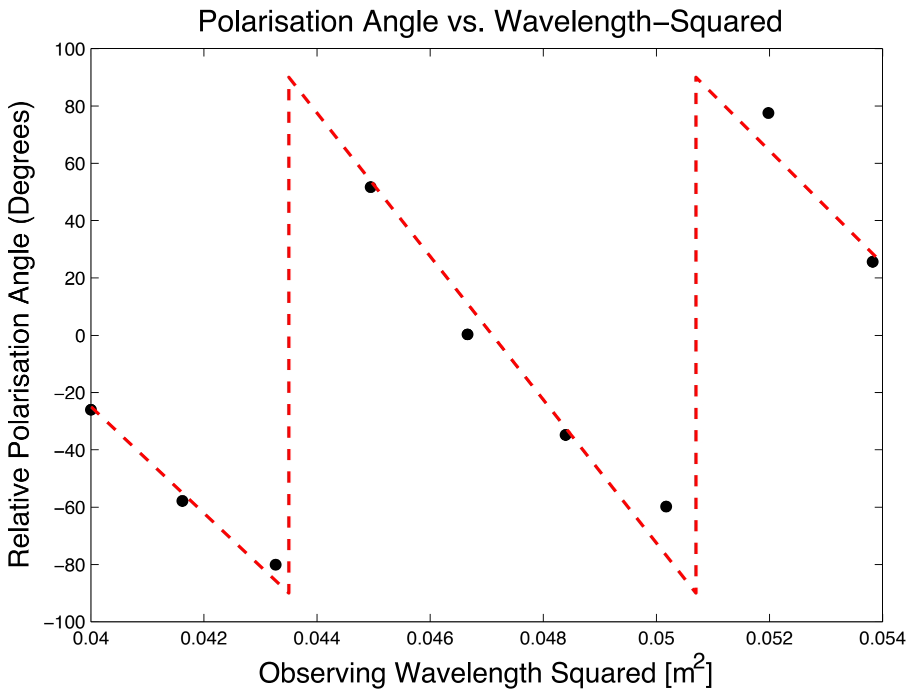
Refresher: Faraday Effect

The Faraday Effect



$$\theta = \theta_0 + \phi\lambda^2, \qquad (1)$$

$$\phi \propto \int_{source}^{telescope} n_e B.dl \qquad (2)$$

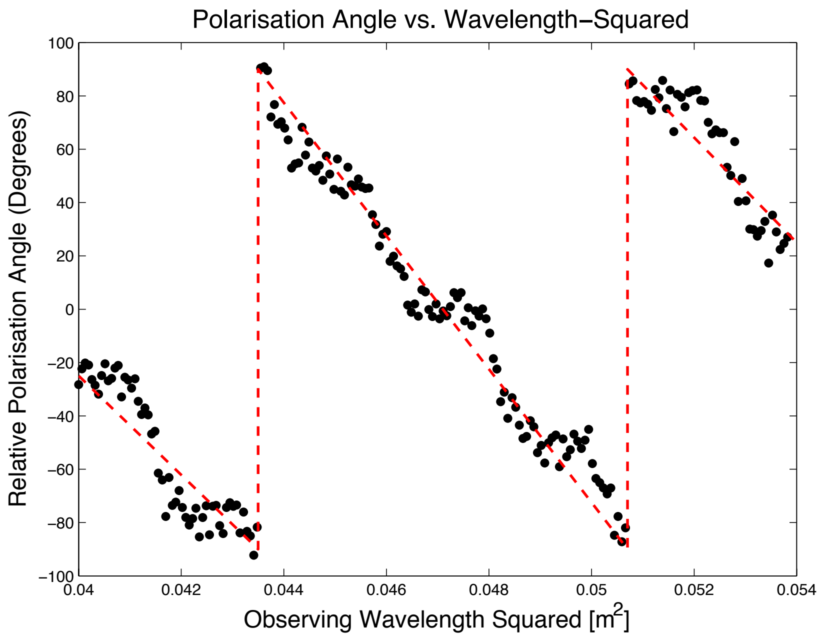


- The *Faraday Effect* > Polarisation angle of EM radiation rotated as a linear function of wavelength-squared (Eqn. 1)

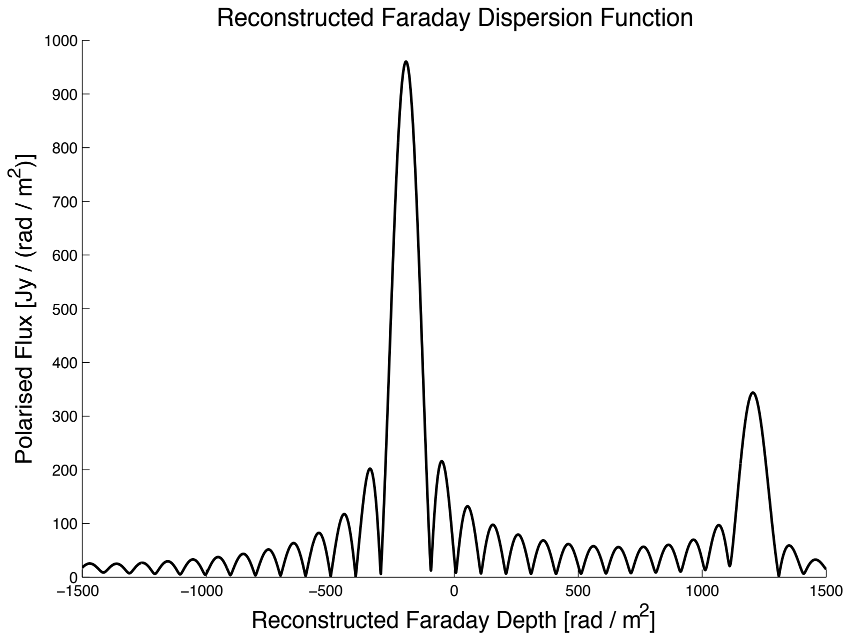
- Characterised by the 'Rotation Measure', or 'Faraday Depth' > Measure of the 'depth' of magnetic field from which radiation has emanated.

Refresher: RM Synthesis

RM Synthesis



Fourier Transform



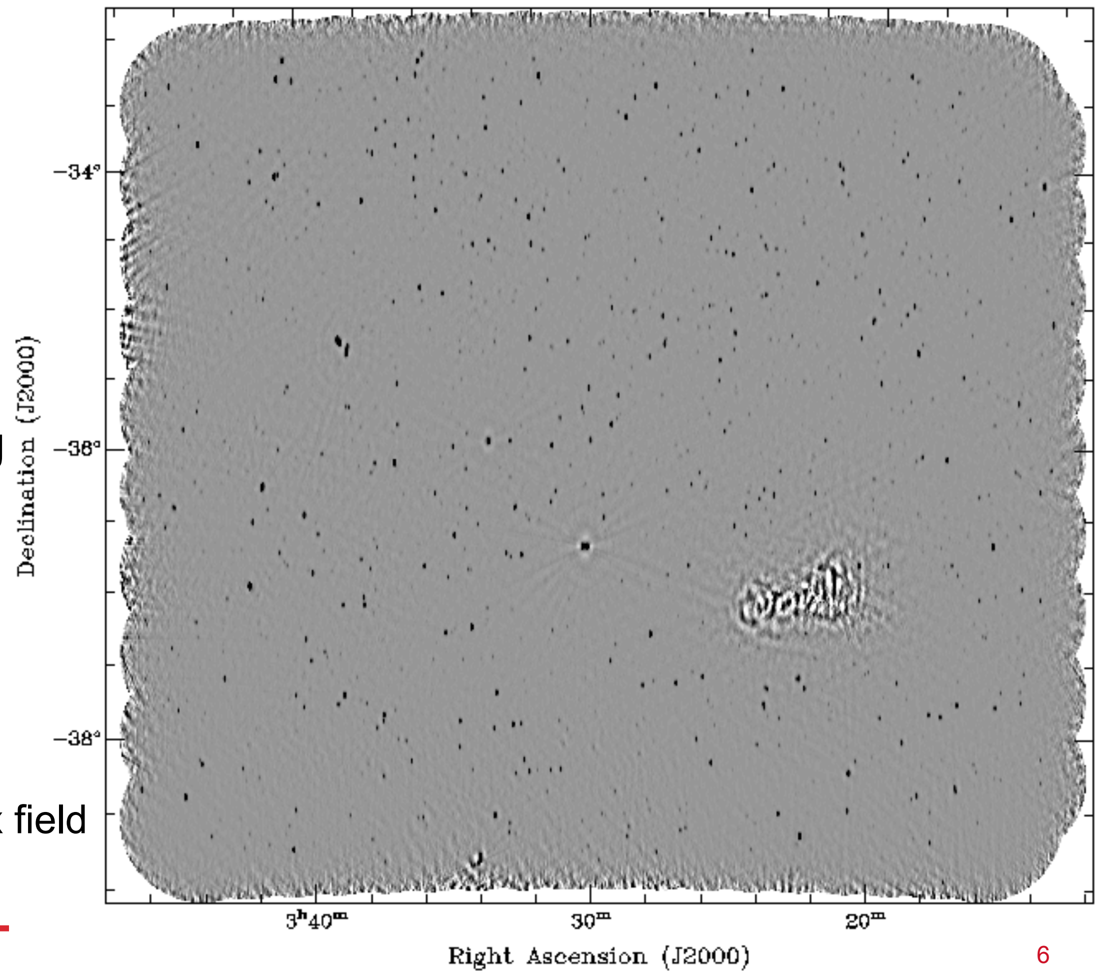
- Gives ‘Faraday Dispersion Function’ – the intensity of polarised emission emanating from each Faraday Depth.

- Resolves emission spectrally rather than spatially!

ATCA Beta Test Fields

› Two 30 degree^2 mosaiced fields located in Circinus & Fornax observed with ATCA. My work currently focuses on Fornax field only.

- ~340 pointings; 1.1 - 3.1 GHz; 1500m & 750m ATCA configs
- Sensitivity ~ 150 uJy for mosaiced 512 MHz MFS image
- ~1250 sources detected to 10sig in Stokes I
- ~20% significantly polarised

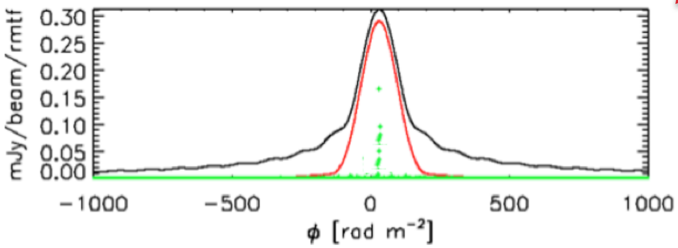


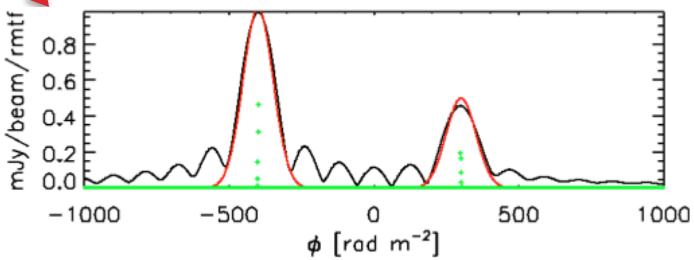
512MHz MFS mosaic of ATCA beta Fornax field

Image credit: Thomas Franzen (CASS)

ATCA Beta Test Fields

1) Imaging: linear mosaics of 8 MHz MFS images through entire band.
2) Source finding (T. Franzen)
3) Stokes I, Q, U, QU_{noise} extraction across full band (5x5 boxed extraction)
4) RM synthesis & rmclean using Q/I and U/I (decouples SI effects)
5) Sources classified as simple or complex/structured based on second moment ('spread') of clean-component distribution in Faraday Depth space (algorithm: S. Brown)





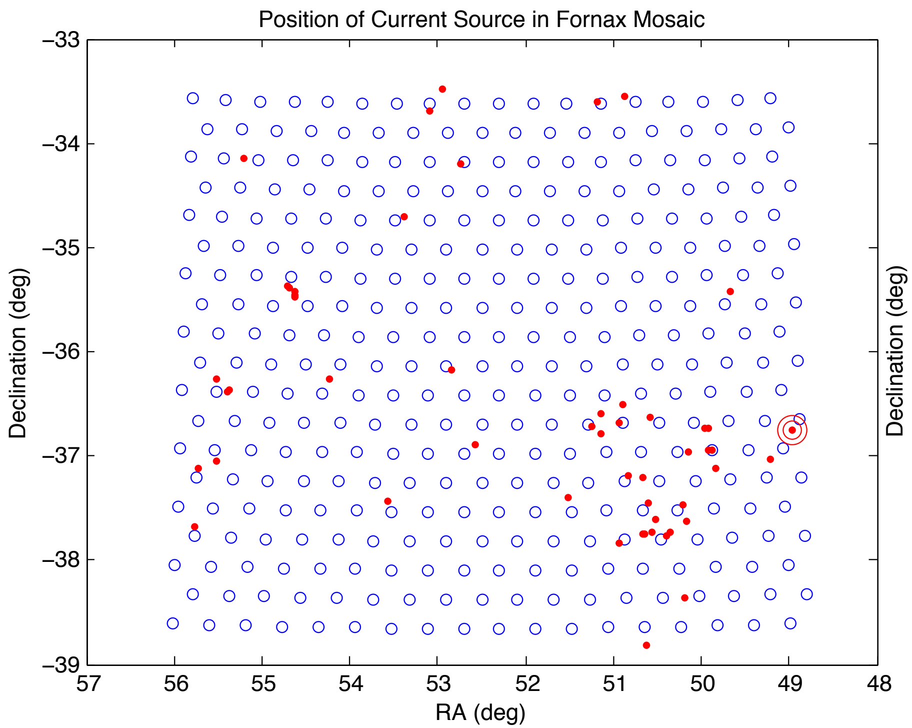
Figures adapted from POSSUM memo by Shea Brown

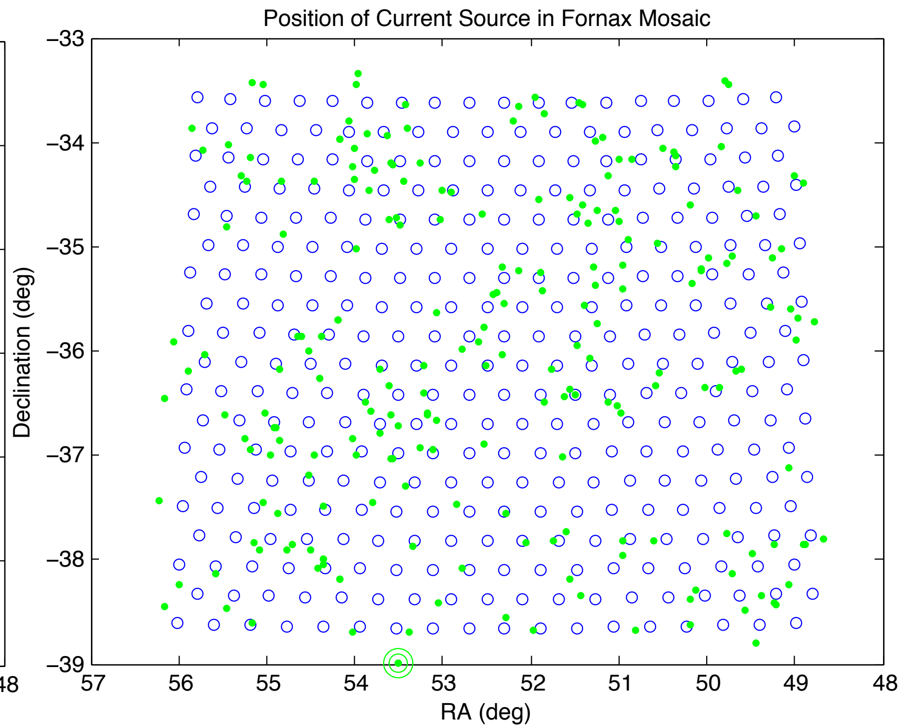
Off-axis instrumental pol a major concern > several checks performed to date with available data, but more characterisation work to do.

Preliminary Results: Prevalence of Faraday Complexity

Initial breakdown of Faraday structure classifications (probably too simplistic):

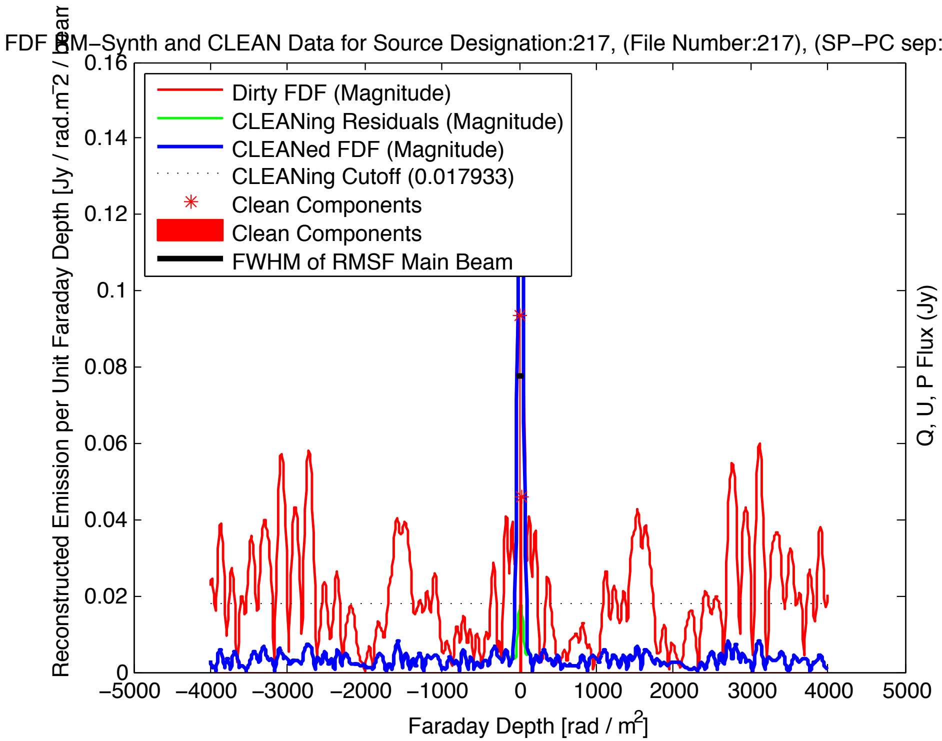
- 77% effectively unpolarised
- ~18% polarised with simple Faraday structure (to first order)
- ~5% polarised with complexity apparent in Faraday structure

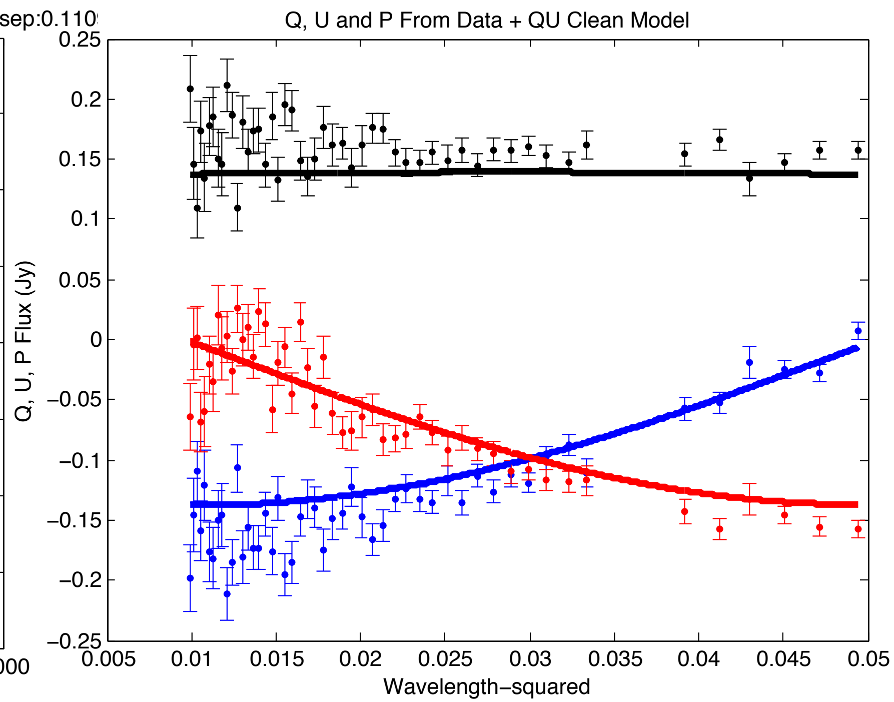




Example: A ‘Simple’ Source

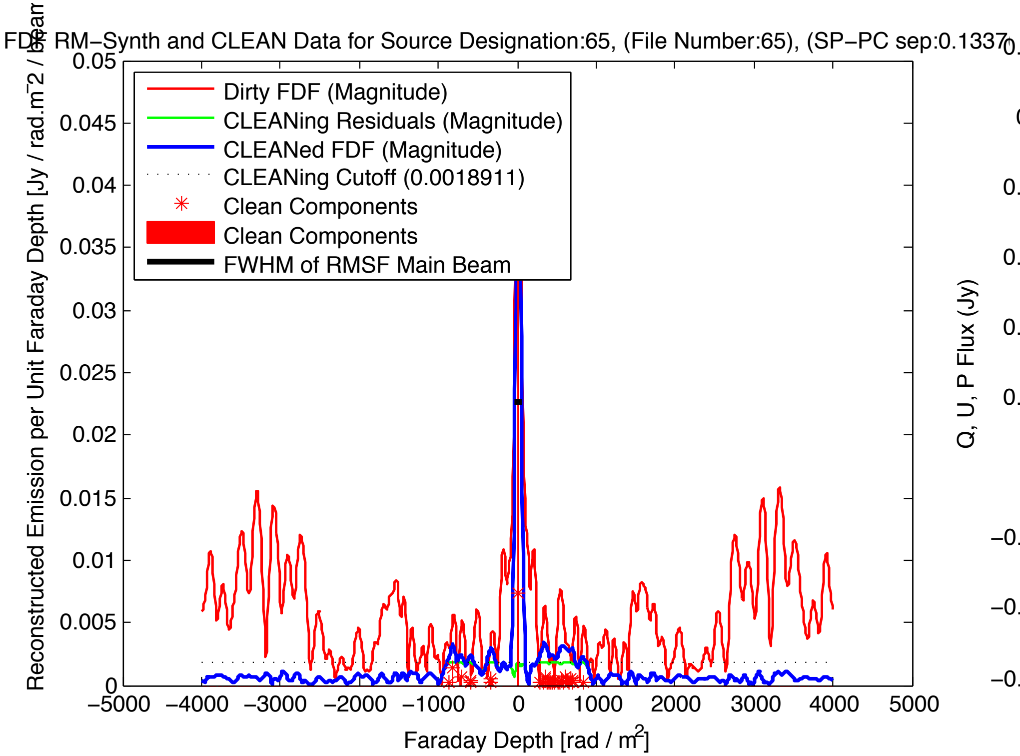
Example of a source classified as ‘simple’:

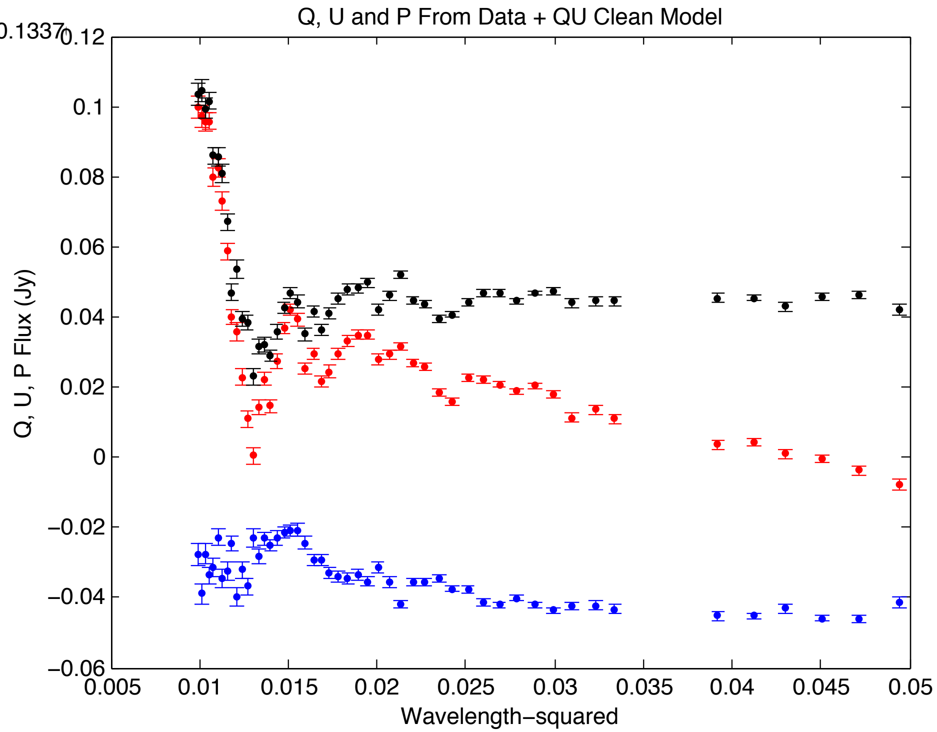




Example: A Complex Source

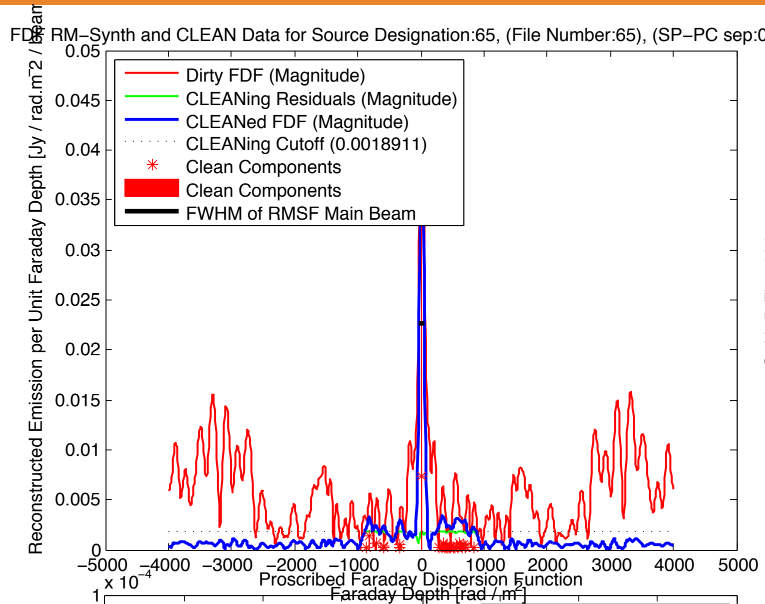
Example of a source classified as complex:

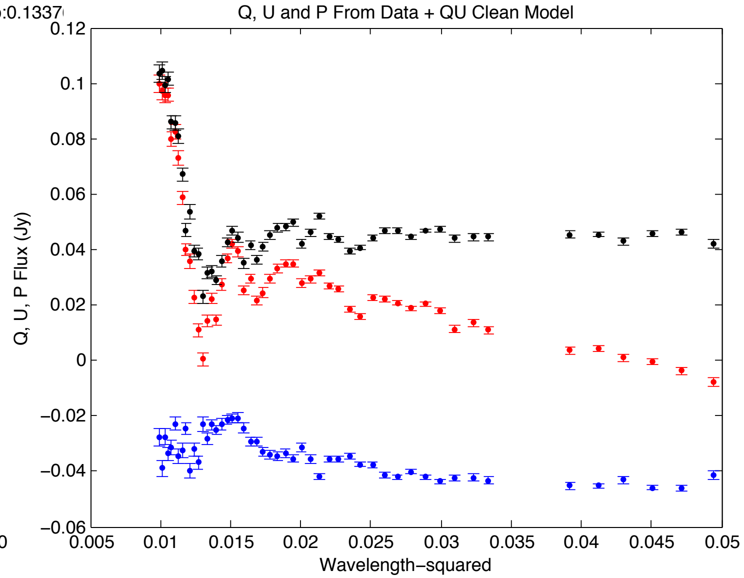




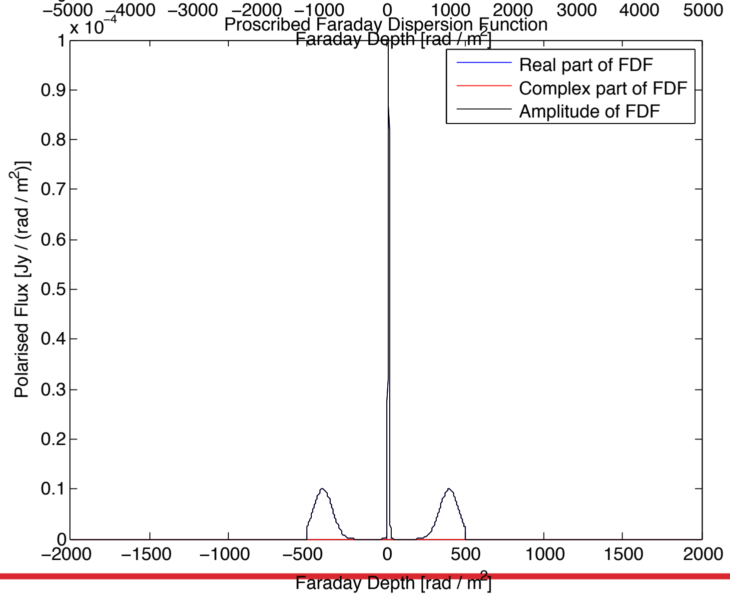
Example: A Complex Source

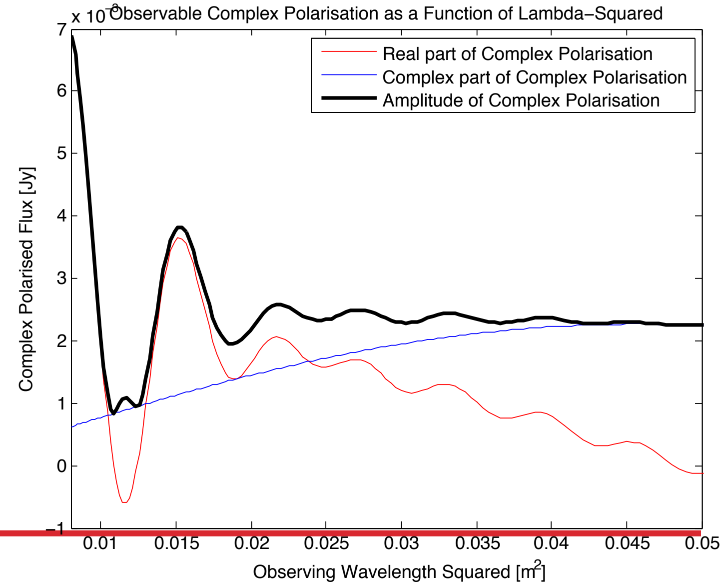
Data





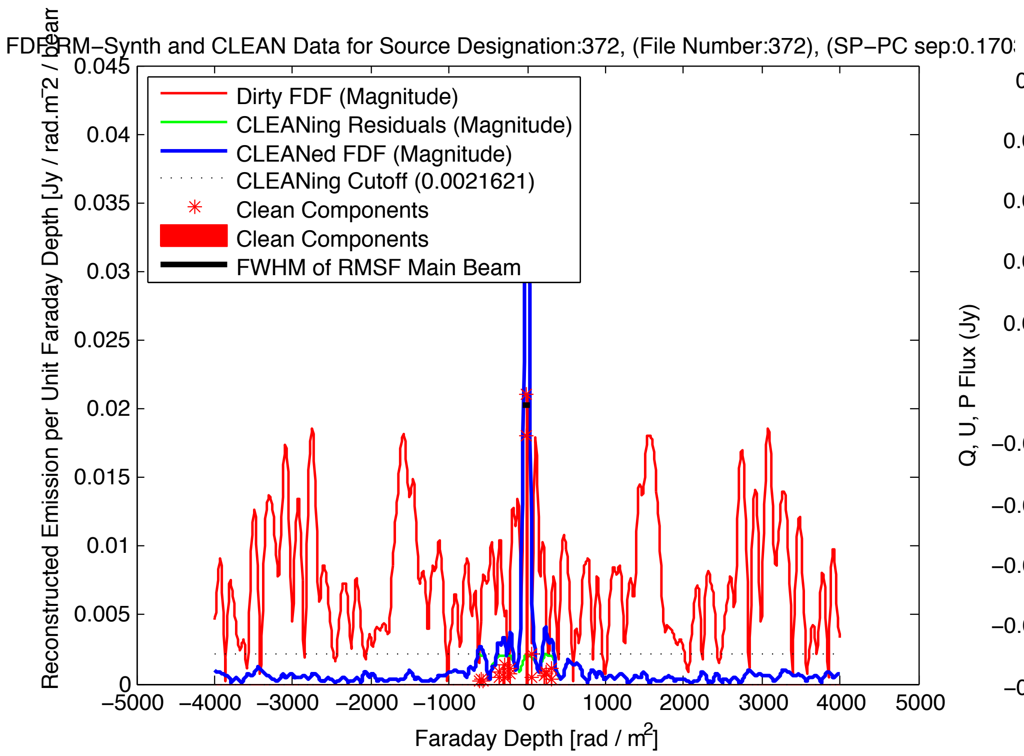
Toy Model

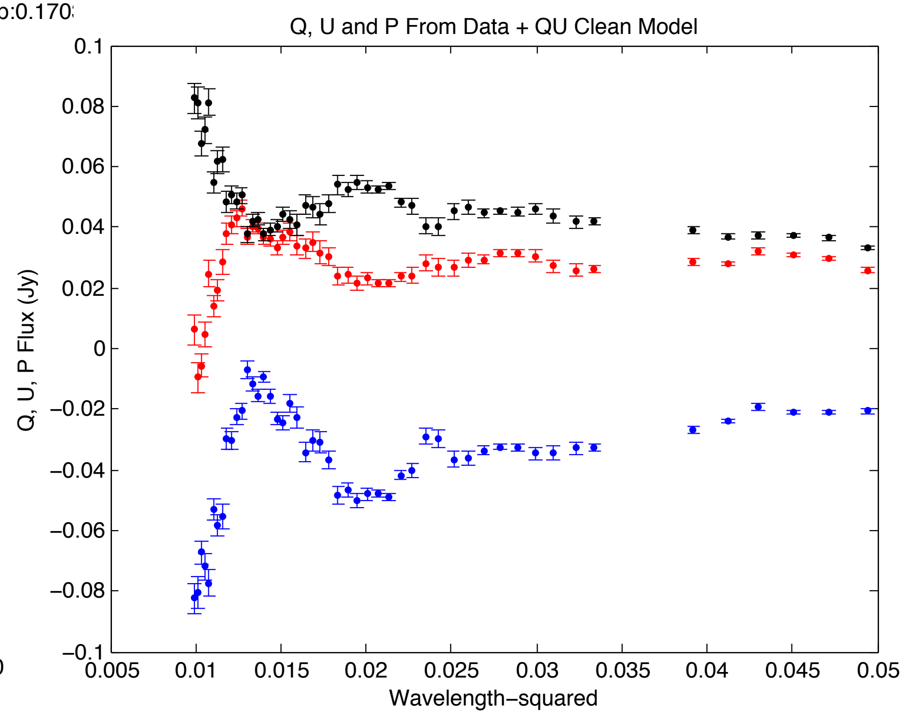




Example: Another Complex Source

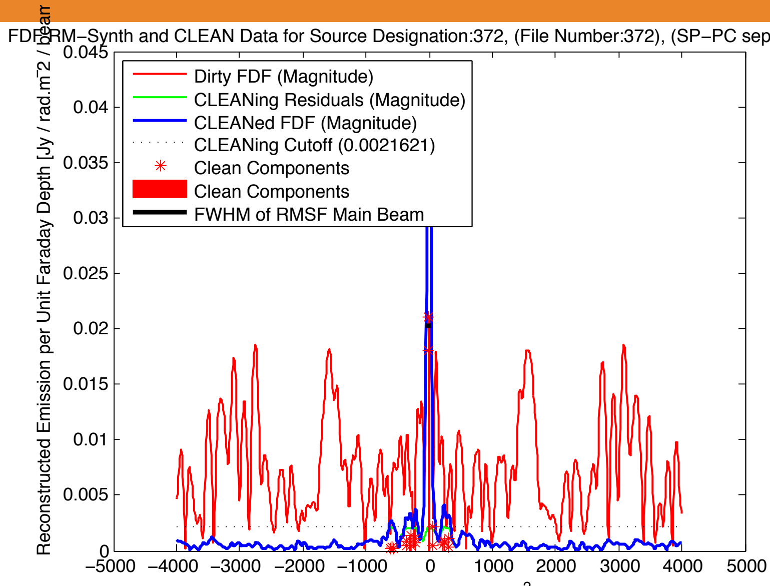
Another example of a source classified as complex:

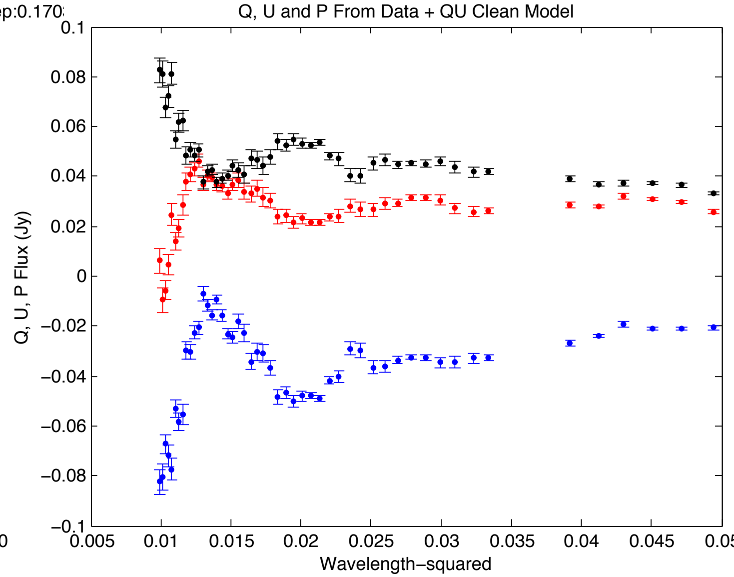




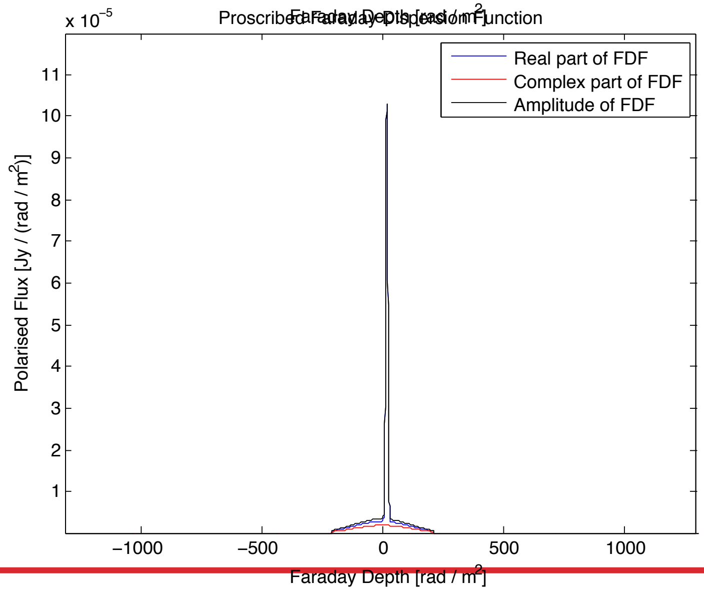
Example: Another Complex Source

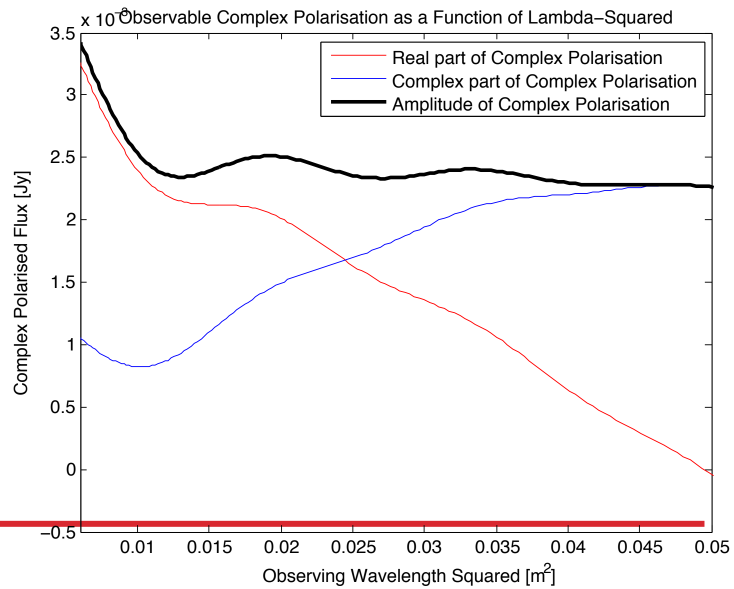
Data



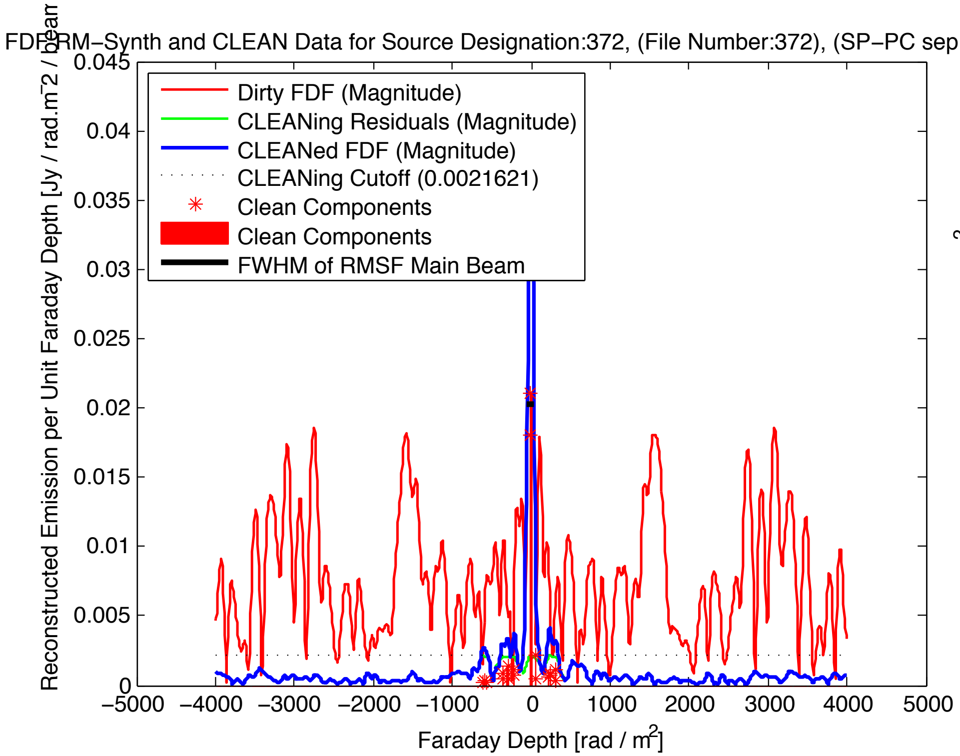


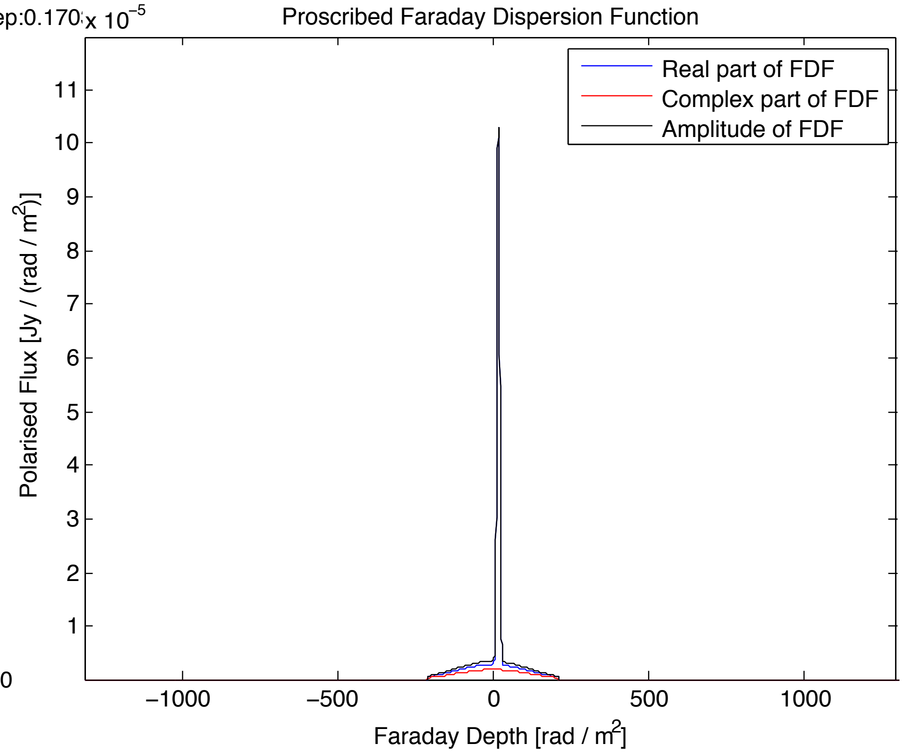
Toy Model



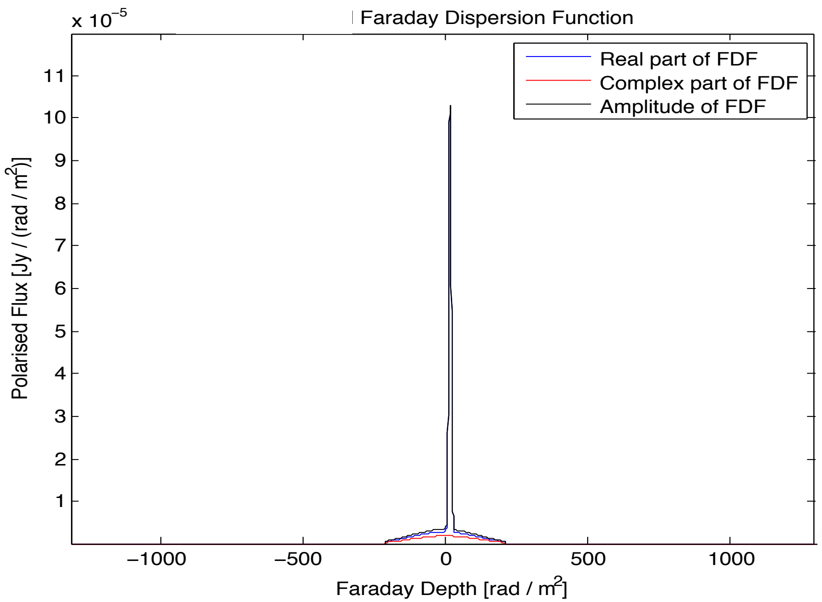


How do we Interpret Complex FDFs?

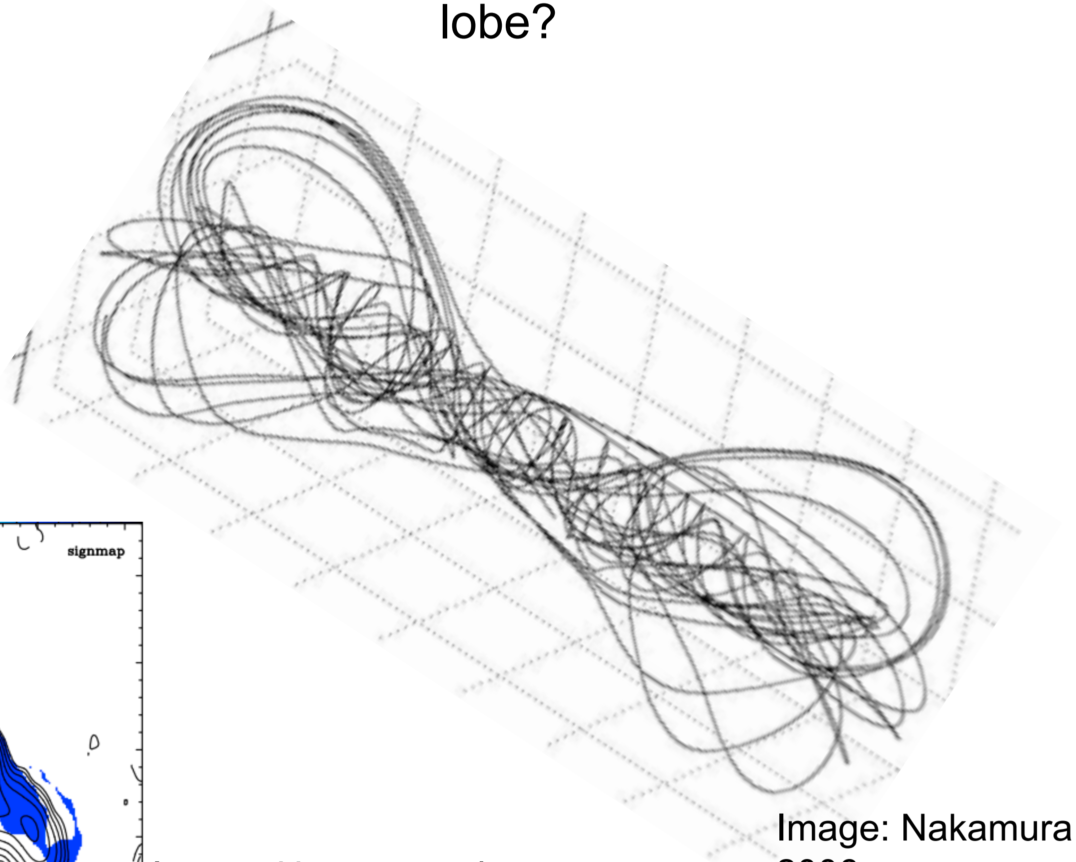




Speculative Interpretation of Example



Emission from within helical magnetic sheath + lobe?



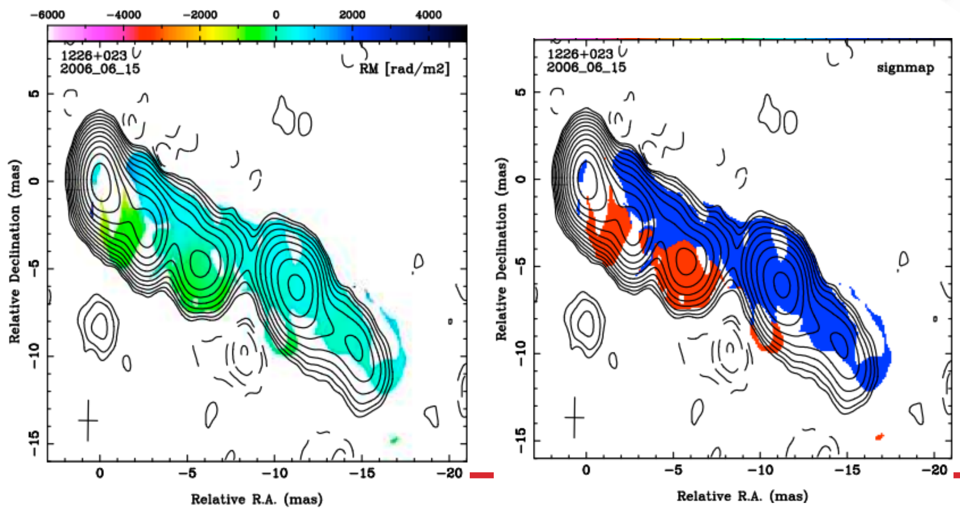
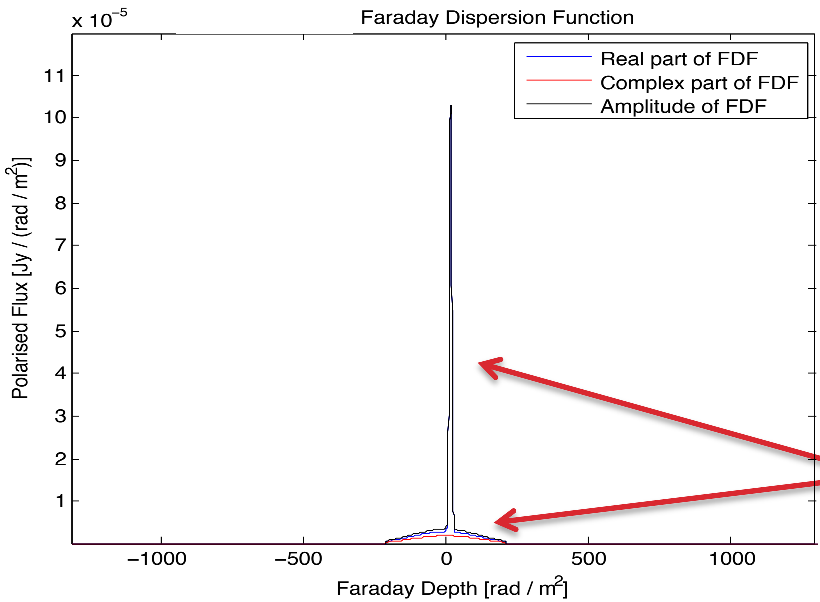
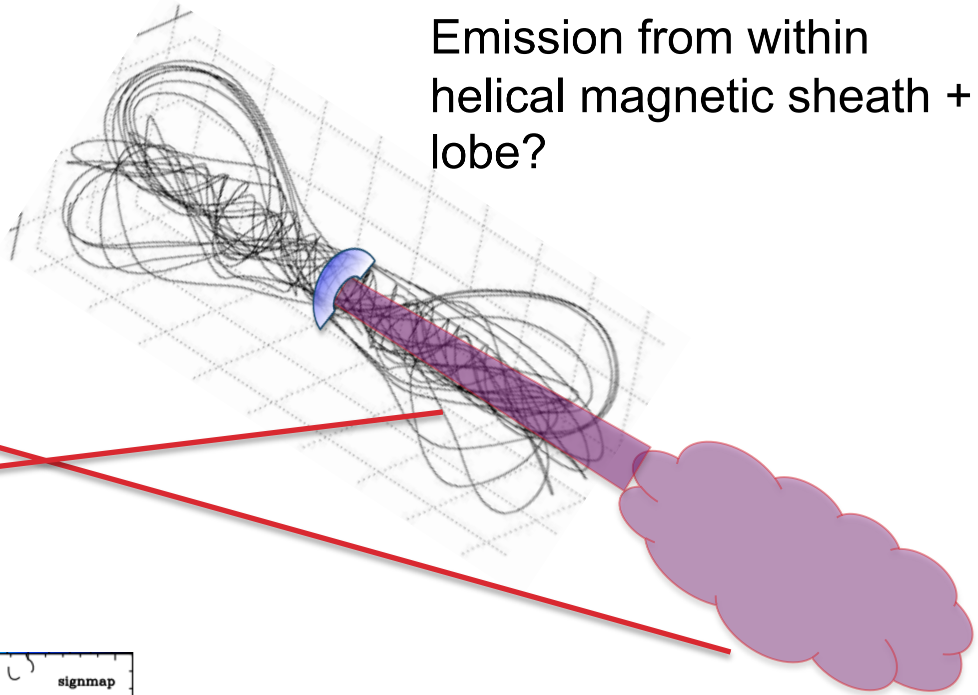


Image: Hovatta et al. (2012)

Image: Nakamura 2006

Just One Possibility for Interpretation of an Example…





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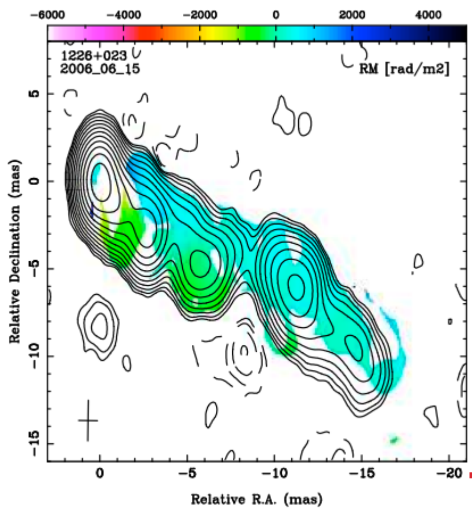


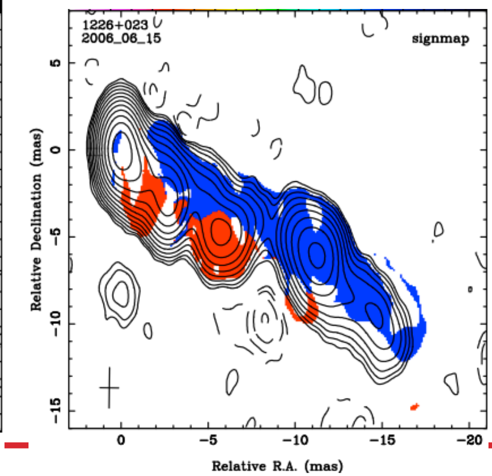
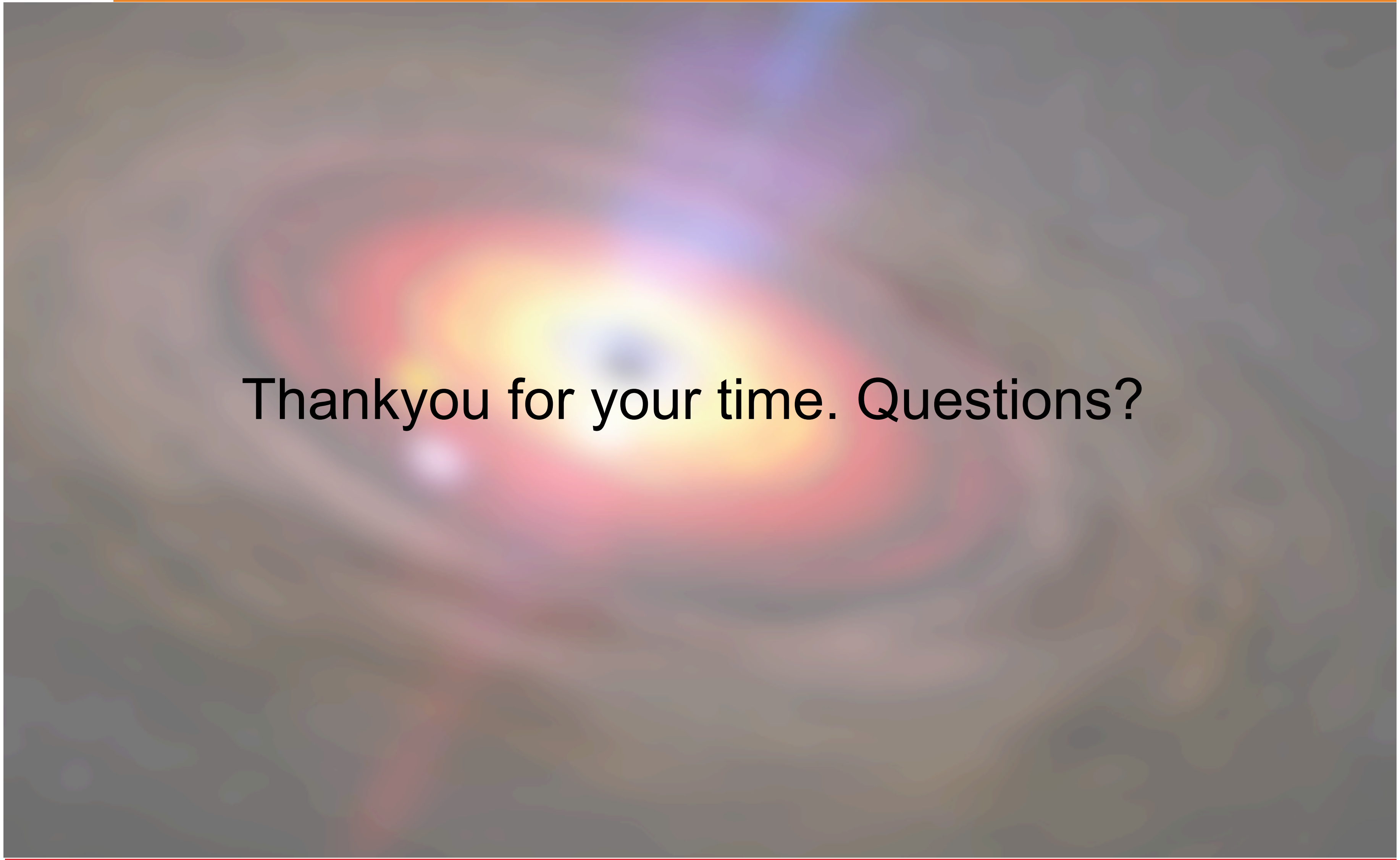


Image: Hovatta et al. (2012)

The Path Ahead…

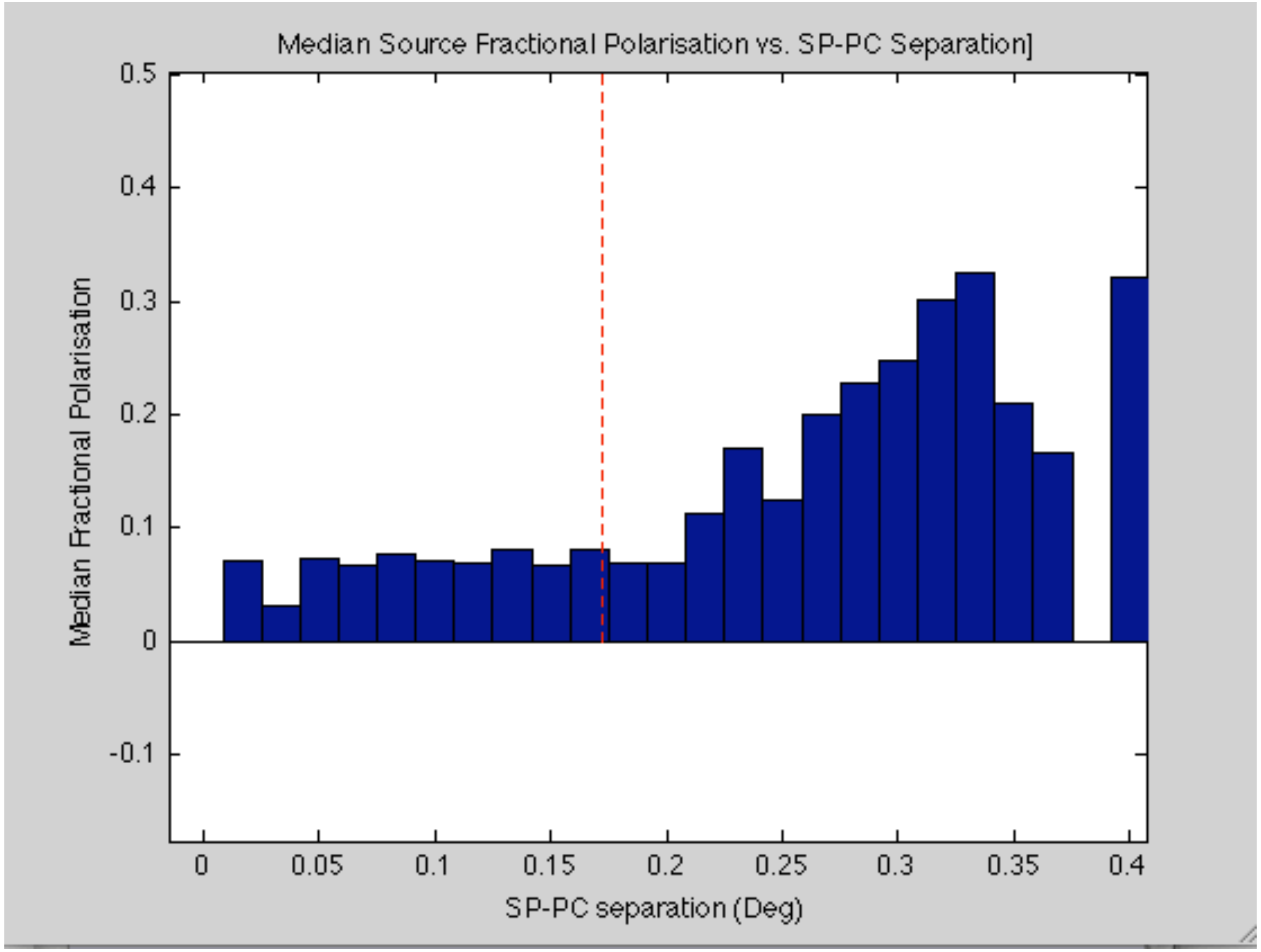
- Further checks of off-axis instrumental polarisation effects
- Further analysis of data to shore up Faraday simple/complex classifications
- Attempt to identify different types of FDF complexity
- Spectral index of sources – where is the emission coming from?
- Attempts to model Q and U behaviour with constructed FDFs and/or analytic models of spectropolarimetric behaviour
- More observations! Targeted radio observations of ~30 individual complex objects, 1-9 GHz (not drawn from Beta obs at this stage). Multi-wavelength obs.

Thankyou



Thankyou for your time. Questions?

Median Fractional Pol vs. Dist. From Pointing Centre



Fractional Pol vs. Dist. From Pointing Centre