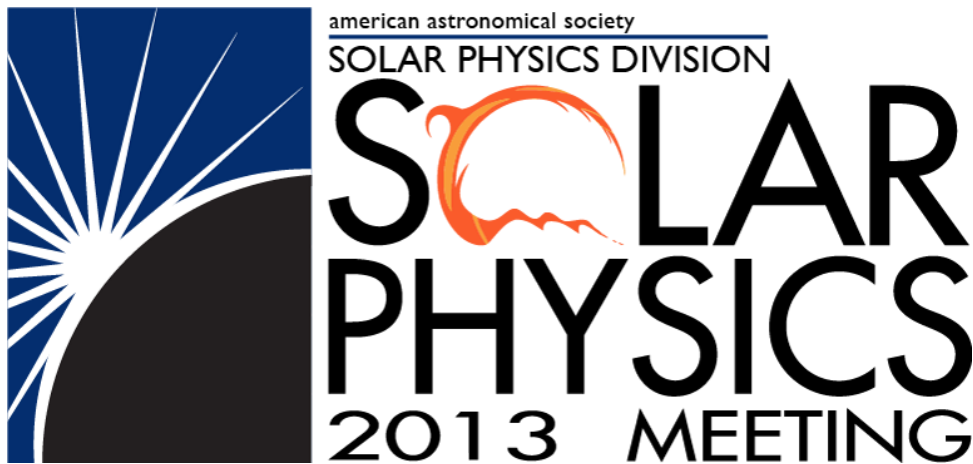


# Measurements of Faraday Rotation Through the Solar Corona at 4.6 Solar Radii

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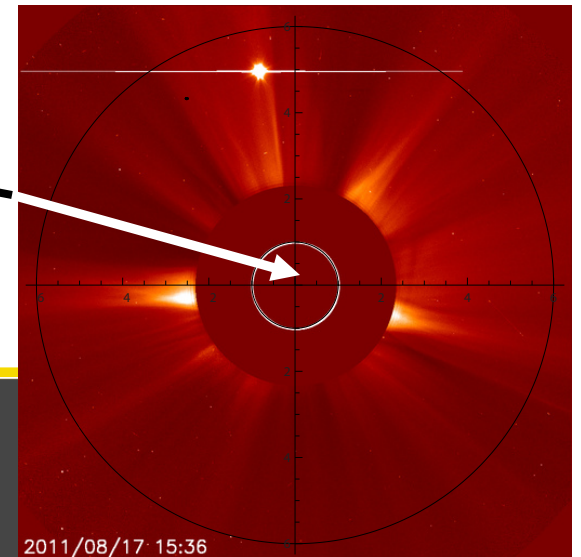
# Why Study the Coronal B?

1. Great example of a Magnetic Field in an astrophysical plasma
2. Techniques used here can be used to study ISM, SNR, etc.
3. LOTS of data for this object
4. Interesting mysteries to unravel:
  - What mechanism(s) heat the corona?
  - What mechanism(s) accelerate the solar wind?

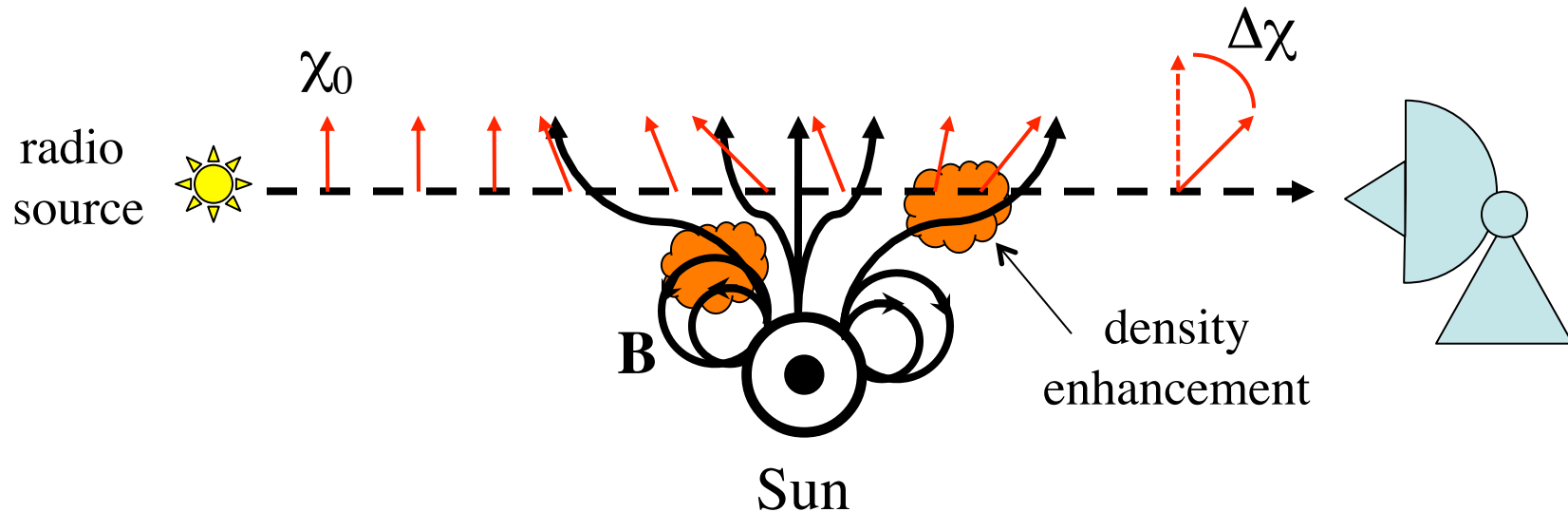
## Measuring the Coronal B

Assessing theories requires measurement ...

- Photosphere: Zeeman splitting
- Outer Corona: magnetometer measurements
  - *Helios* approached  $\sim 62 R_{\odot}$



# Faraday Rotation (FR) @ 2 - 15R<sub>⊙</sub>



- $\chi$  : polarization position angle
- $\chi_0$  : intrinsic polarization angle
- $RM$  : rotation measure [rad/m<sup>2</sup>]
- $\lambda$  : wavelength

$$\Delta\chi \equiv \chi - \chi_0 = \left[ \left( \frac{e^3}{2\pi m_e^2 c^4} \right) \int_{LOS} n_e \vec{B} \cdot \vec{ds} \right] \lambda^2$$

$$= [RM] \lambda^2$$

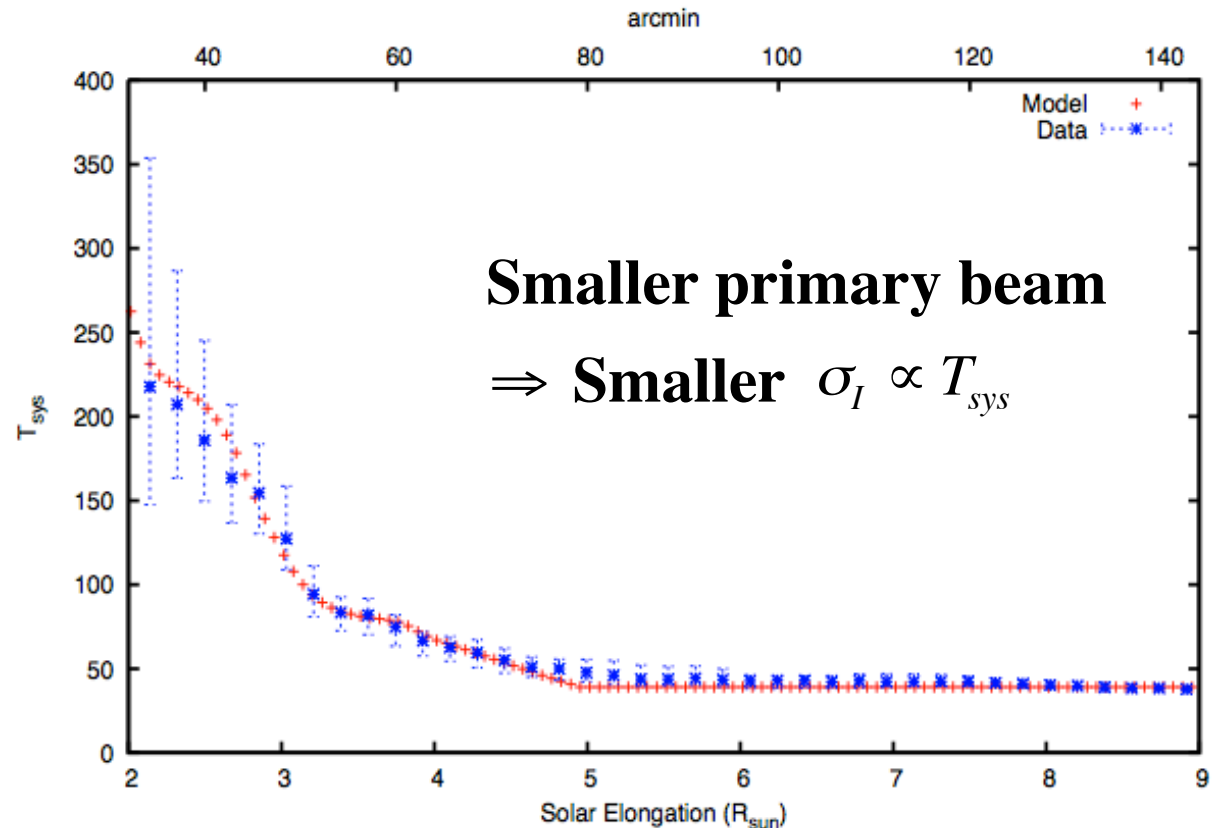
Note: symmetry can give  $\int n_e \vec{B} \cdot \vec{ds} \approx 0$

# Purpose: To Boldly Go ...

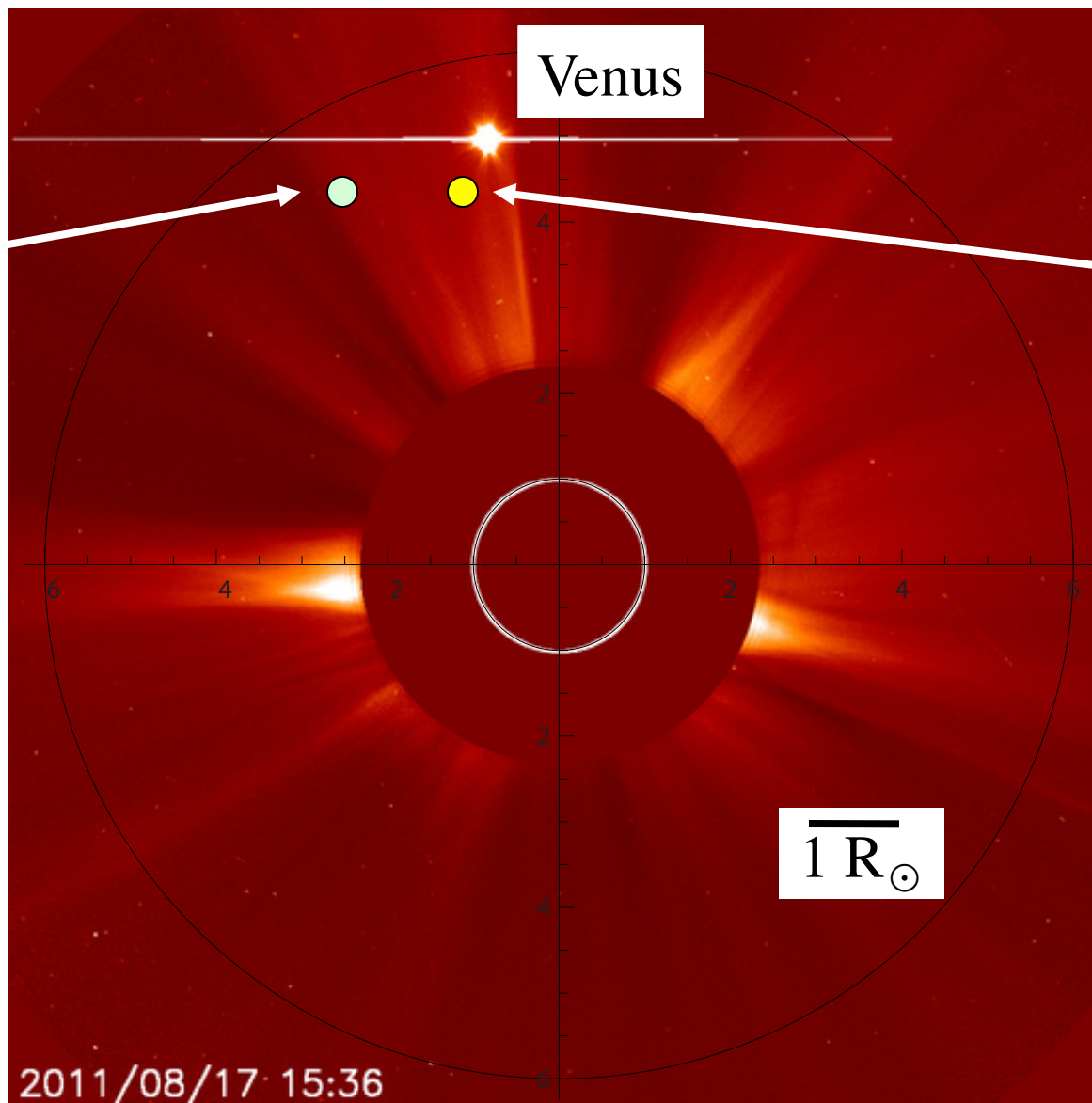
1) Measure Faraday Rotation of a background extragalactic radio source through the corona:  $\Delta\chi = [RM]\lambda^2$

2) Observations made with the VLA @ 5.0 & 6.0 GHz in August, 2011

3) Observations made between **4.6 – 5.0  $R_{\odot}$**  above the north limb



**3C228  
First Scan  
5.0 R<sub>☉</sub>**



**3C228  
Final Scan  
4.6 R<sub>☉</sub>**

# Radio Galaxy 3C228

- 2 strongly polarized components 46'' apart
- $m_{\text{north}} \sim 14\%$  @ 5.0 GHz
- $m_{\text{south}} \sim 8\%$  @ 5.0 GHz

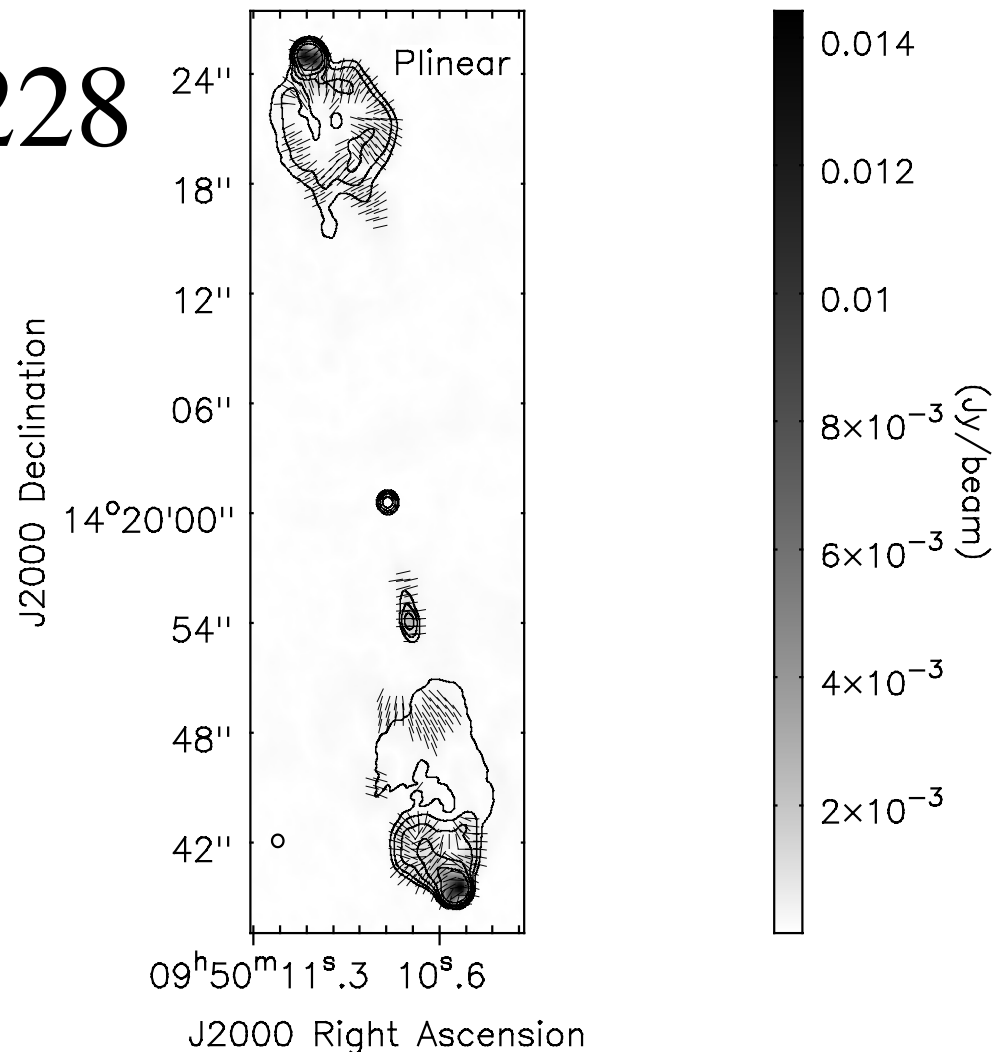
5.0 GHz reference observations

Contours:

$-5\sigma_I, 5\sigma_I, 10\sigma_I, 20\sigma_I, 40\sigma_I, 100\sigma_I$

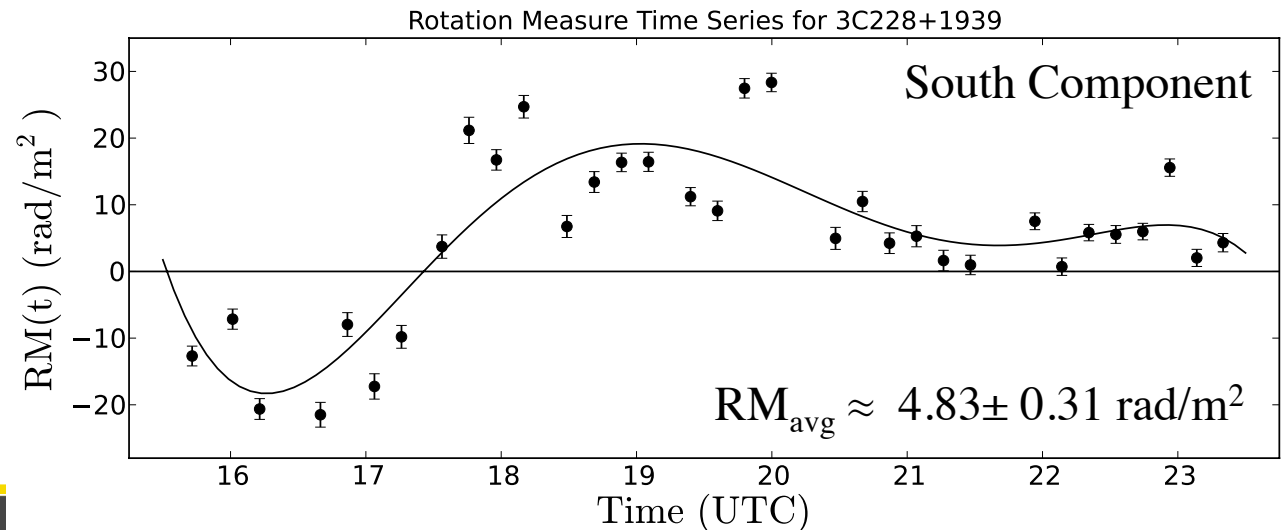
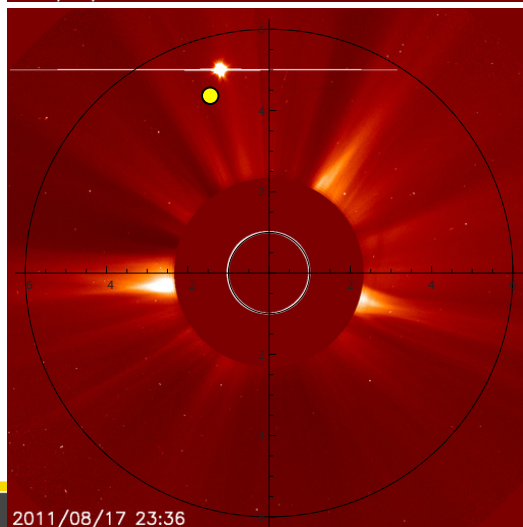
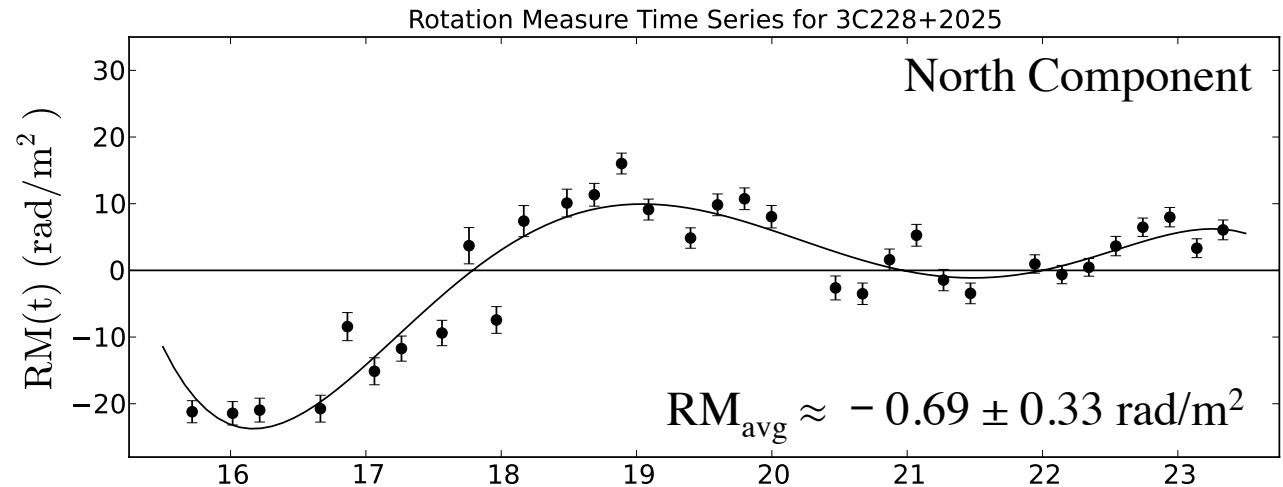
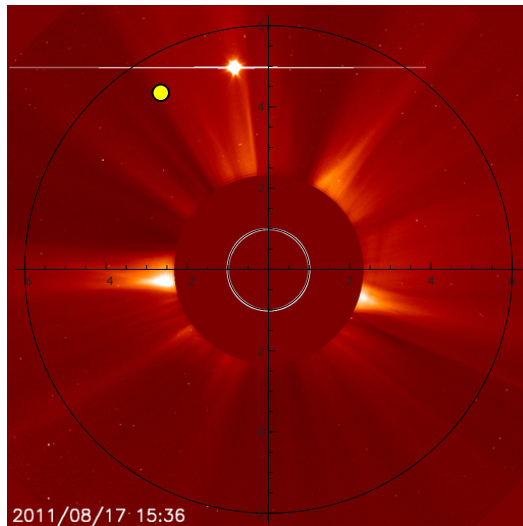
Line orientation gives  $\chi_0$

FWHM is 0.68''



# Slowly Varying RM(t)

$$\Delta\chi \equiv \chi - \chi_0 = [RM]\lambda^2$$



# Other Information about B . . .

- 1) Subtracting RM(t) time series for two lines of sight from each other

$$\Delta RM^i = RM_{North}^i - RM_{South}^i$$

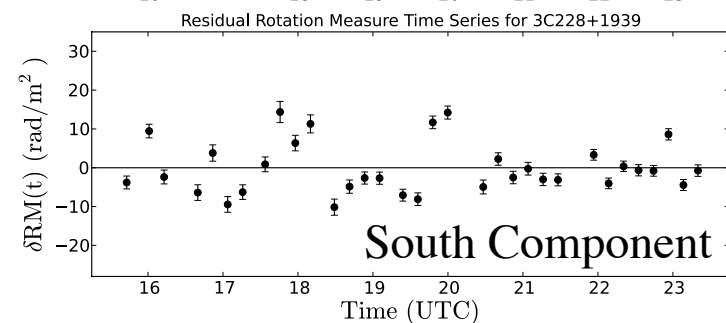
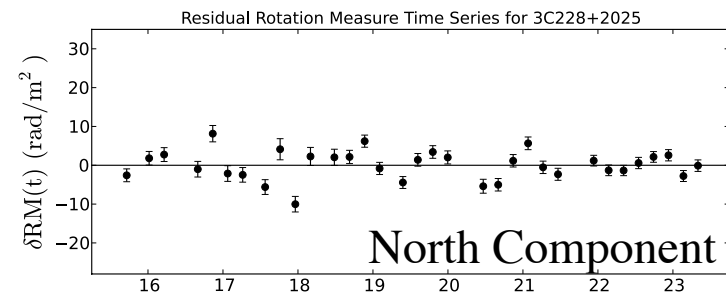
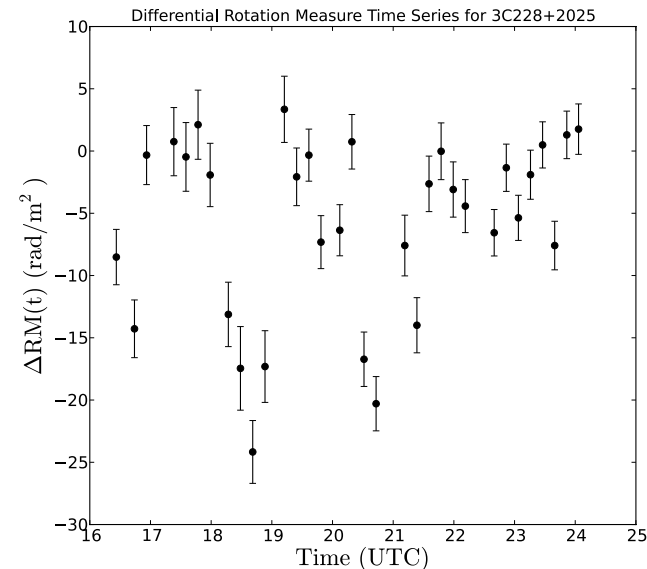
can provide info/limits on the coronal currents detected by FR.  
[Spangler, ApJ **670** (2007) 841]

- 2) Subtracting the slowly varying polynomial from RM(t)

$$\delta RM^i = RM^i - RM_{Fit}^i$$

can provide info/limits on the fluctuations in the corona  
(e.g., Alfvén wave amplitudes).

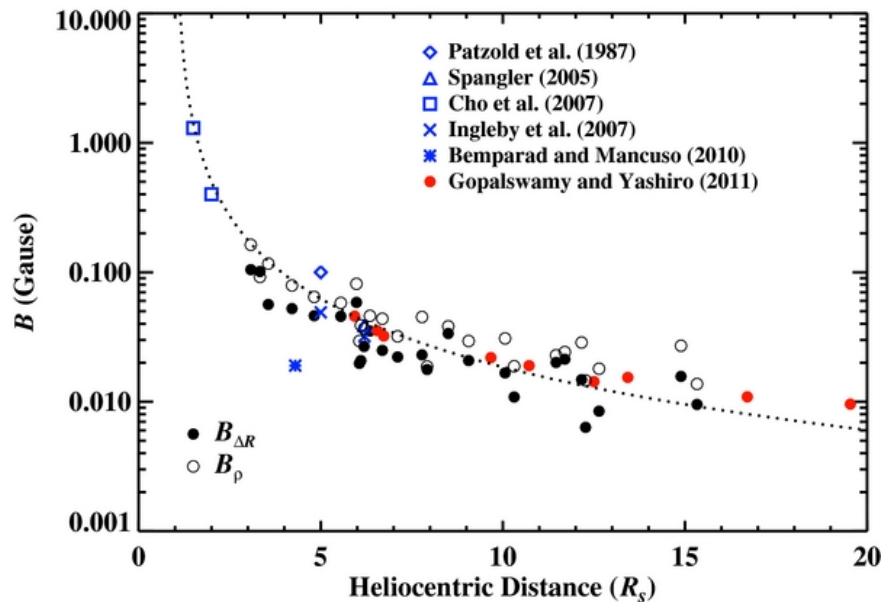
[Mancuso & Spangler, ApJ **539** (2000) 480]



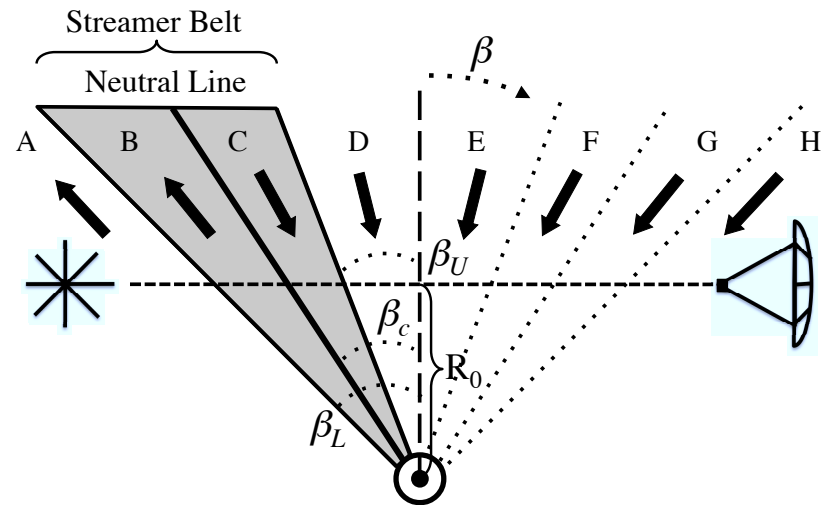


# Summary

- 1) 5.0 & 6.0 GHz @ 4.6 – 5.0  $R_{\odot}$
- 2) RM for full session & RM(t)
  - Approaching northern solar pole
  - Current Sheet necessary in modeling



[fig. 8 in Kim et al., ApJ 746 (2012) 118]



- 3) Consistent with previous work:

$$\vec{B} = \left[ B_{dipole} r^{-3} + B_{IPM} r^{-2} \right] \vec{e}_r$$

Further Reading ...

Submitted to ApJ

arXiv: 1307.1727