# Polarization monitoring of the lens system JVAS B0218+357

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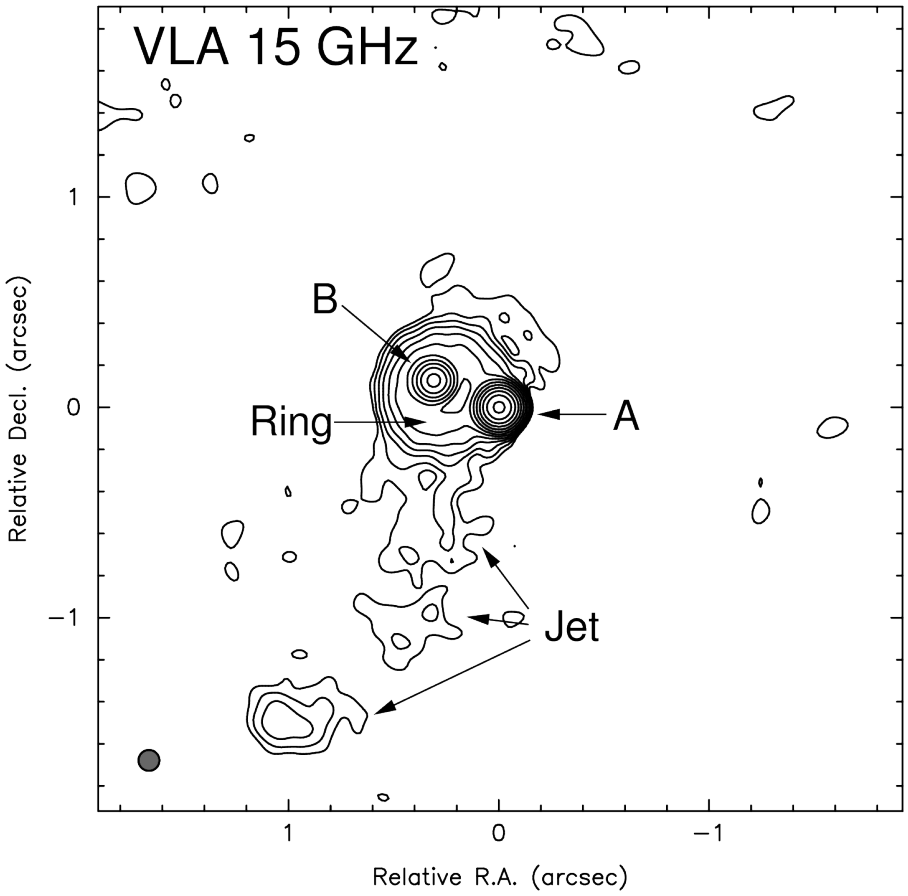
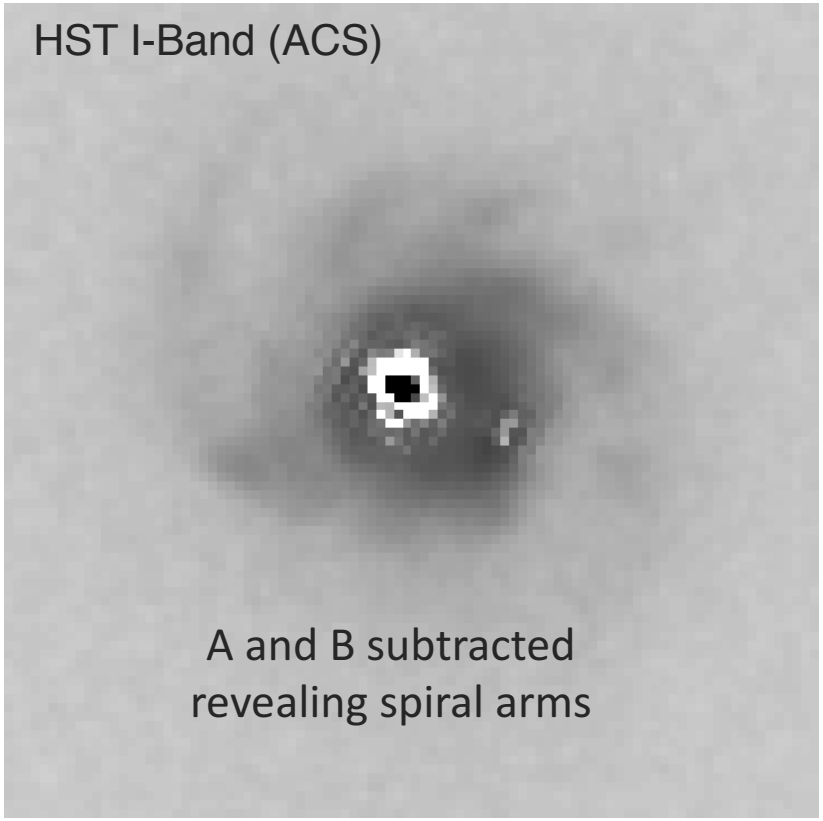
# JVAS B0218+357



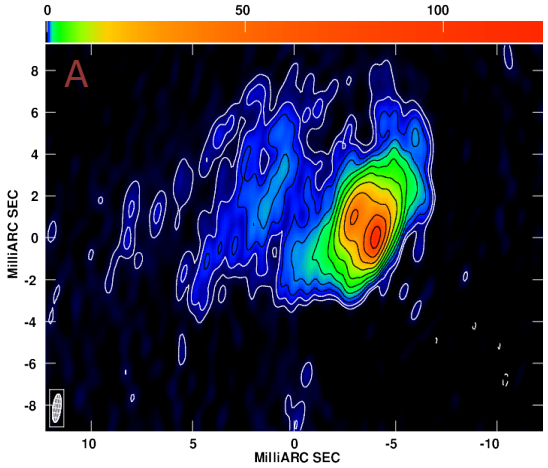

Biggs et al. 1999

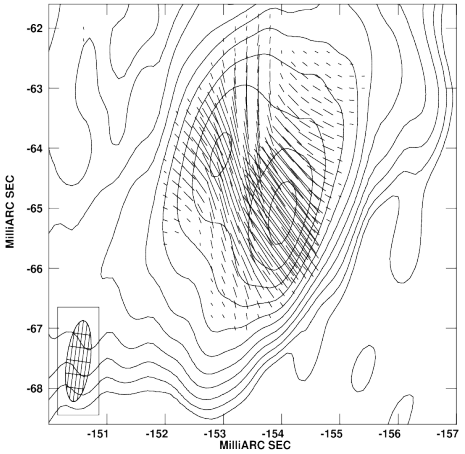


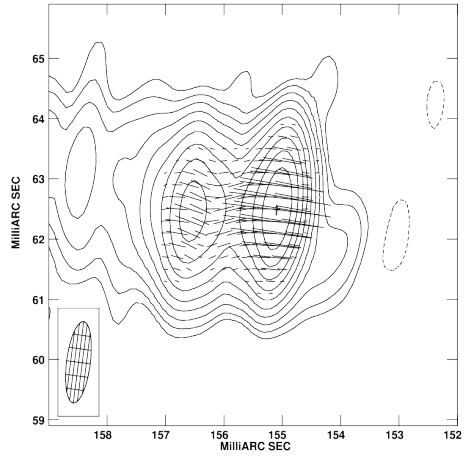

York et al. 2005

# Polarization properties

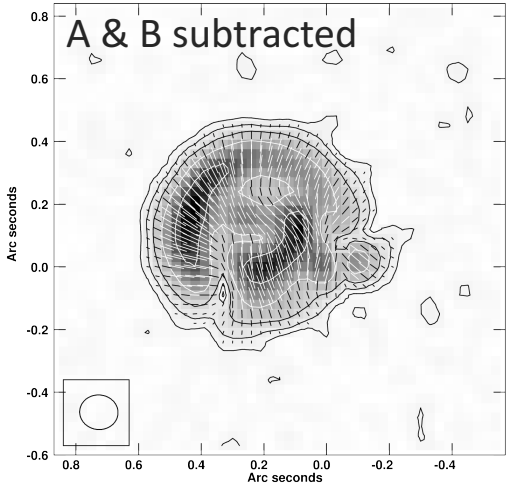
## 8.4-GHz Global VLBI

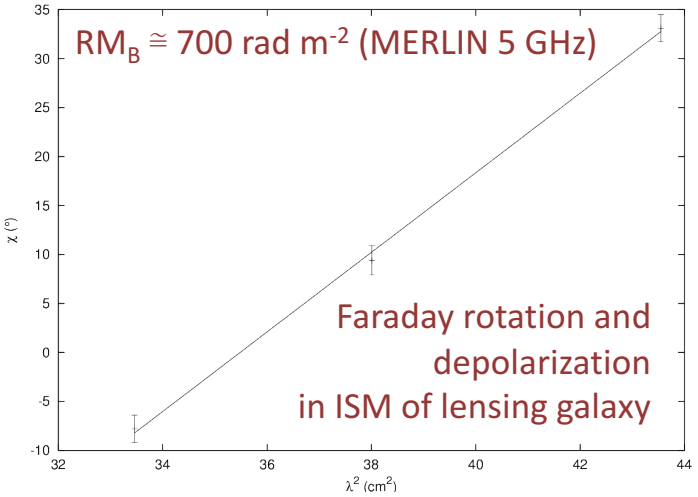


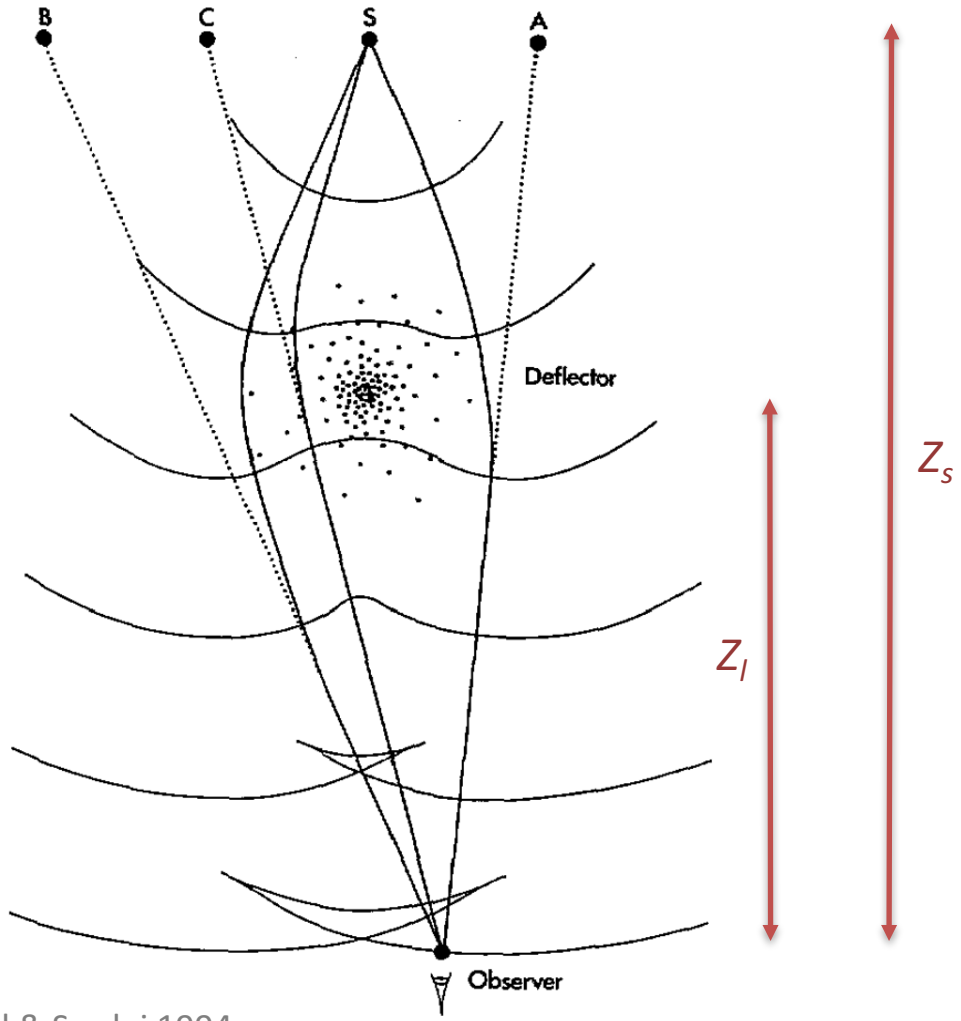

## 15-GHz VLA Polarized Intensity



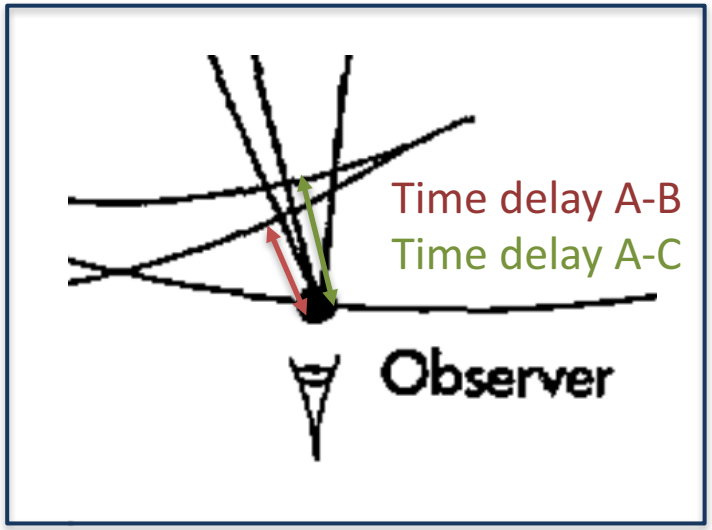




Biggs et al. 2003

# $H_0$ via lens time delays

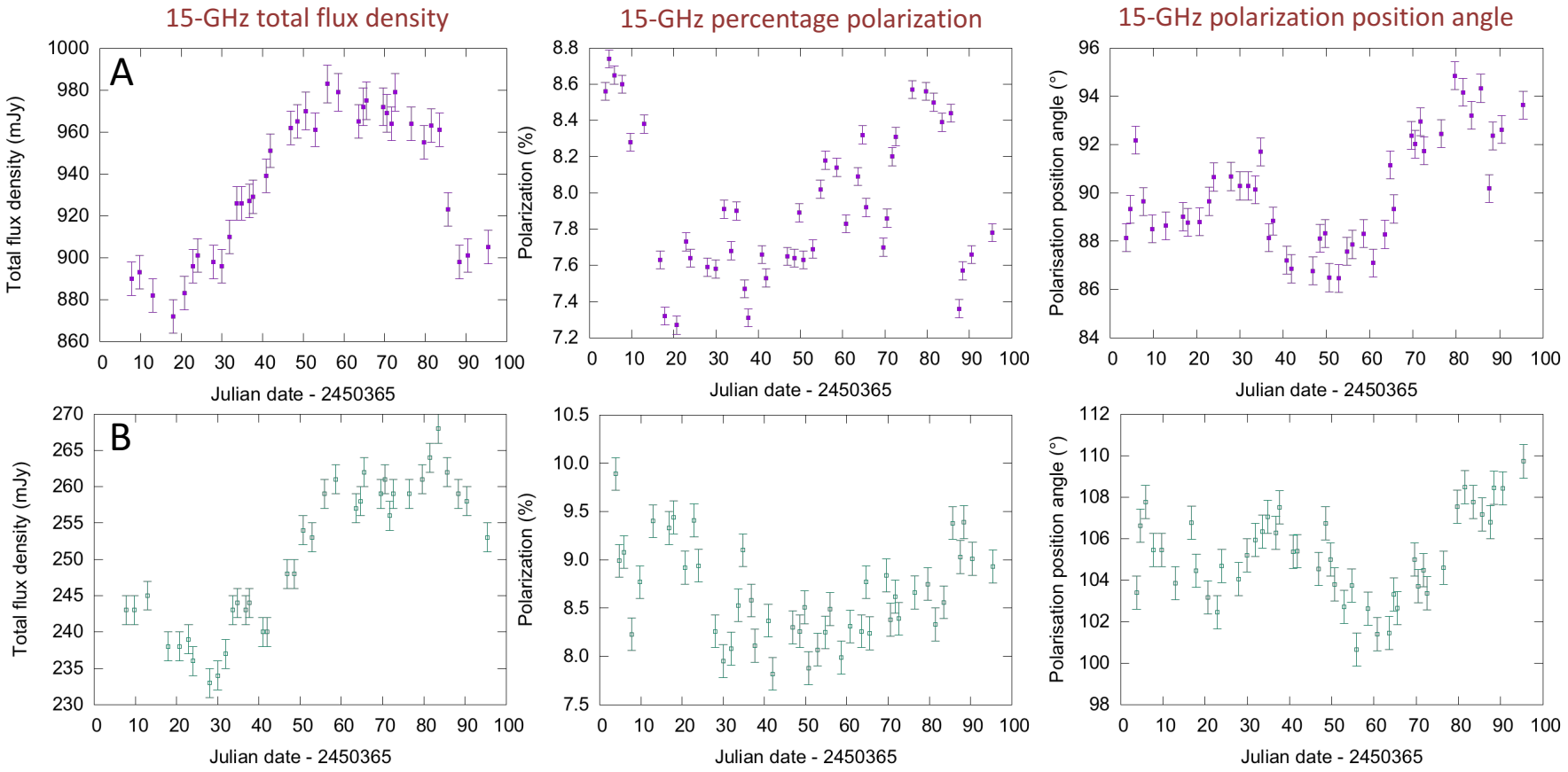



Refsdal & Surdej 1994




Comparison of modelled and measured time delays gives $H_0$

# VLA monitoring 1996/97



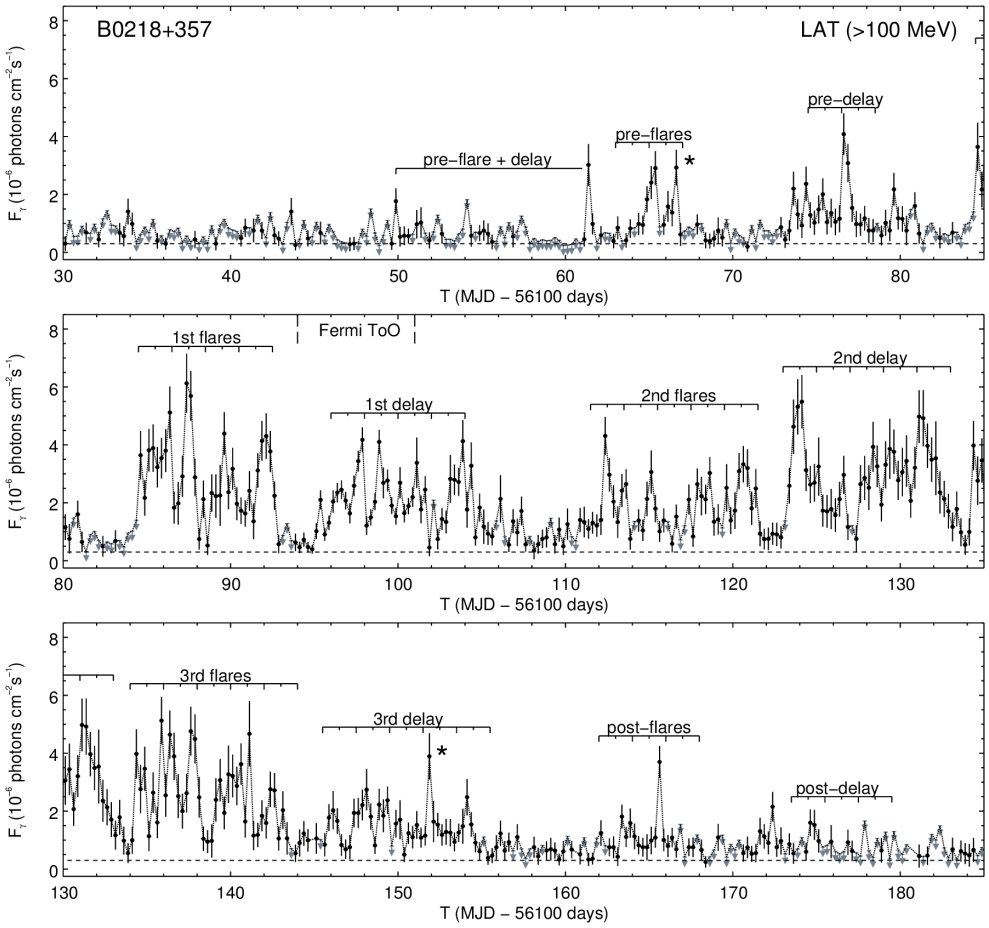

Biggs et al. 1999

Time delay = 10.5 ± 0.4 d (95% confidence)

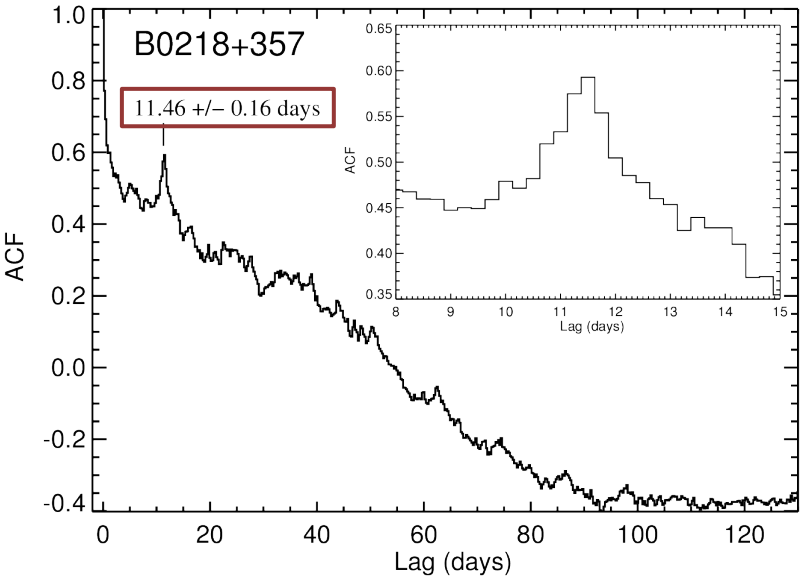
Cohen et al. (2000) found 10.1 ± 1.6 d from simultaneous monitoring (total flux density only)

# Gamma-ray monitoring

Fermi $\gamma$-ray flux versus time (A and B unresolved)




Auto-correlation




Cheung et al. 2014

Positional offset between radio- and $\gamma$-ray-emitting regions? (Barnacka et al. 2015)

Or is the radio delay wrong?

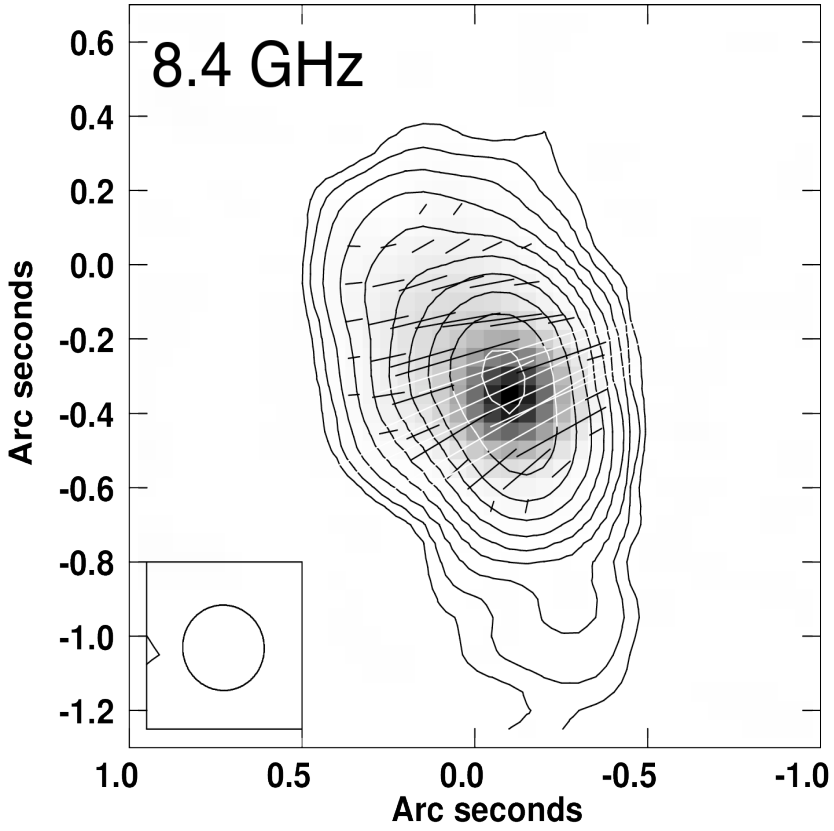
# Reanalysis of radio monitoring data

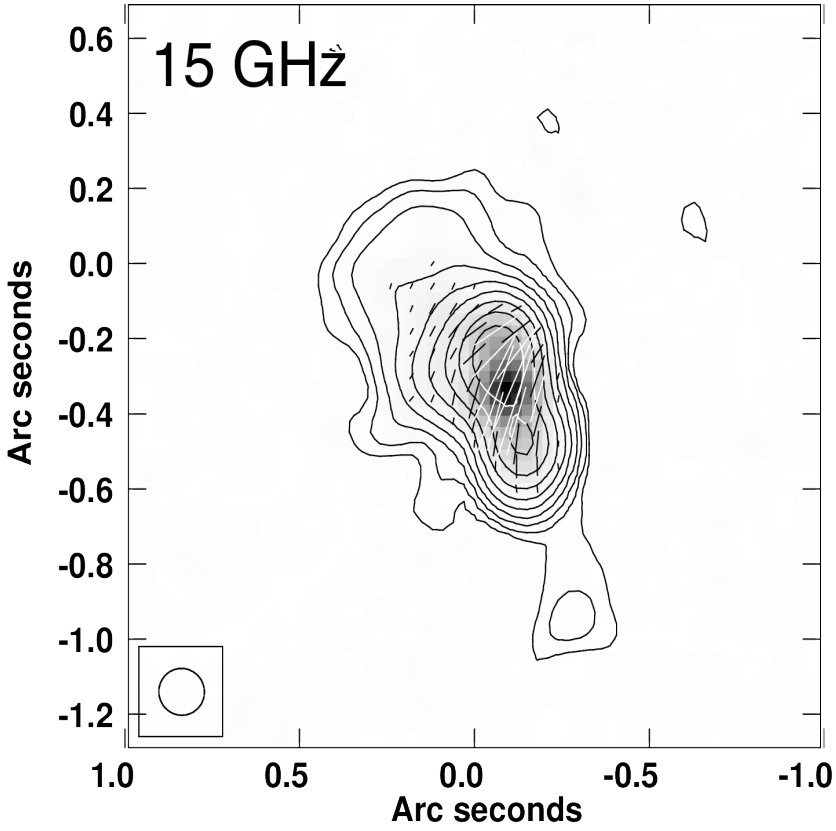
- The data
  - VLA A configuration
  - 106 epochs in total
  - 3 Frequencies (15, 8.4 and 5 GHz*)
  - Polarization leakage calibrator was 3C84
  - PPA calibrators were 3C119 (Biggs) and 3C48 (Cohen)
  - Calibration in AIPS ; *u,v* modelfitting in Difmap
- Data-reduction improvements
  - Ring models in Stokes I, Q and U
    - Essential for accurate polarization measurements at 8.4 GHz
  - Recognition of polarization systematic offsets
  - Absolute flux and PPA calibration

*Cohen et al. did not observe at 5 GHz

# 3C48 as a PPA calibrator

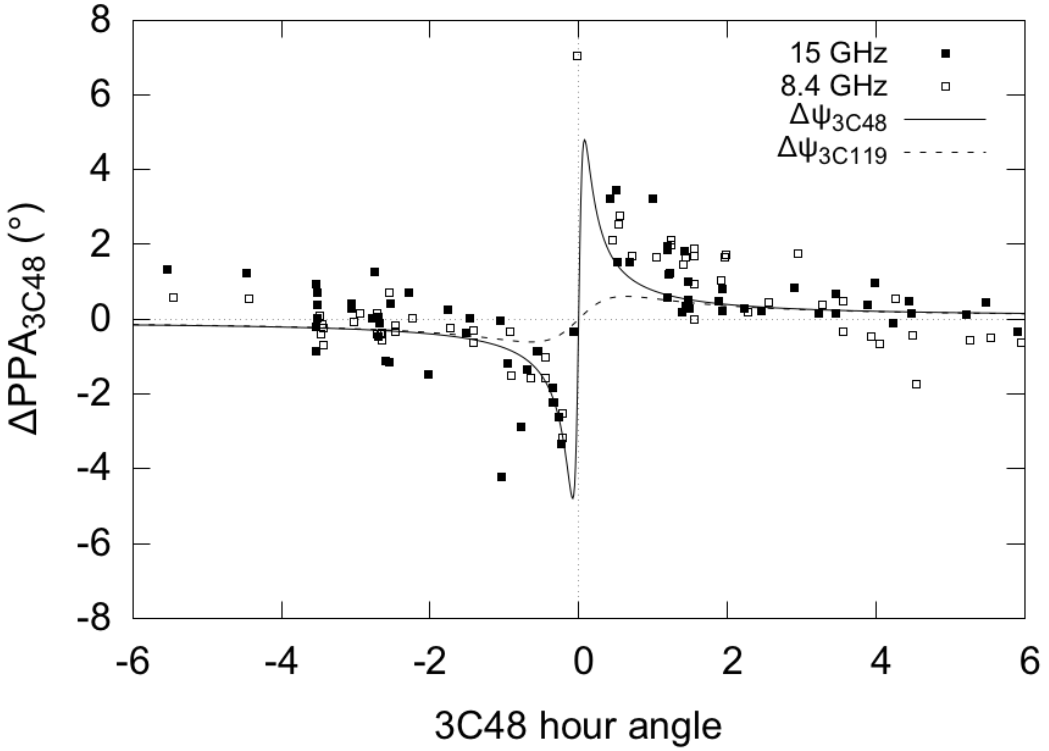
Automated maps measure PPA at peak of polarized flux



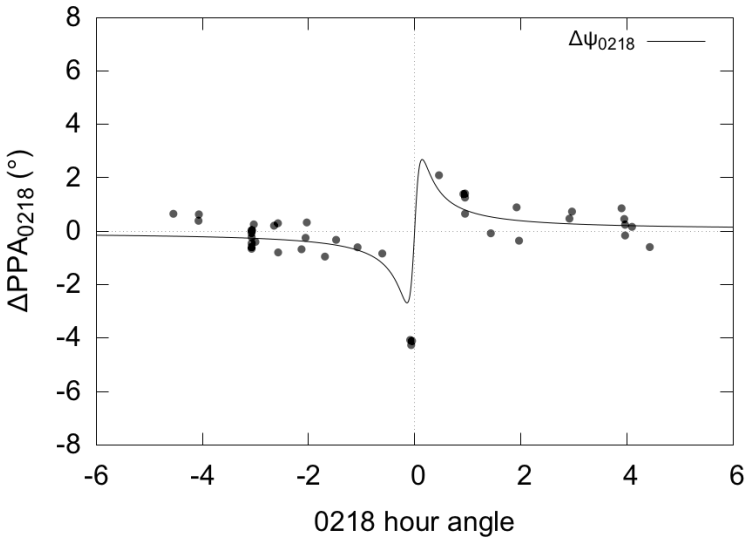



# HA-based PPA offset

Comparison of 3C119 and 3C48 R-L phase corrections (CLCOR)



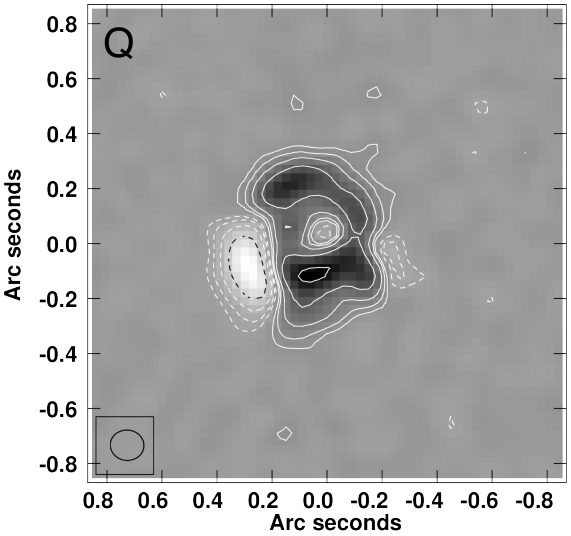

Same effect visible in 0218+357
(3C119 cal'd data − 3rd-order polynomial)

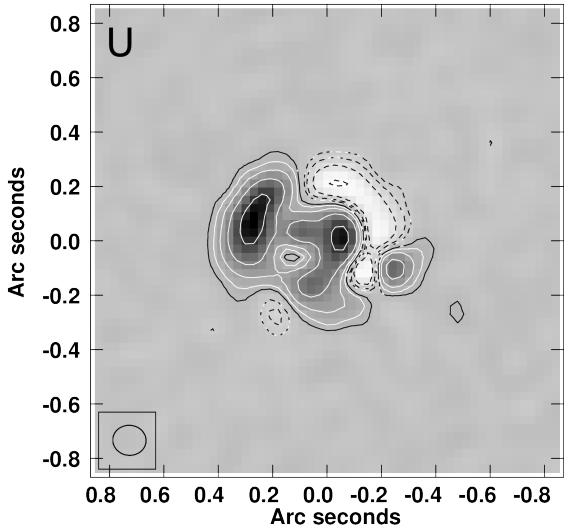



Systematic offset is equivalent to the error in parallactic angle (Δψ)
corresponding to a 10′ latitude error

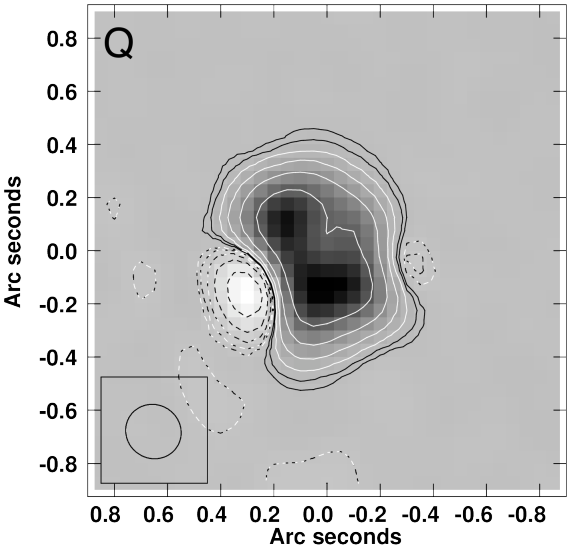
# Maps of ring polarized emission

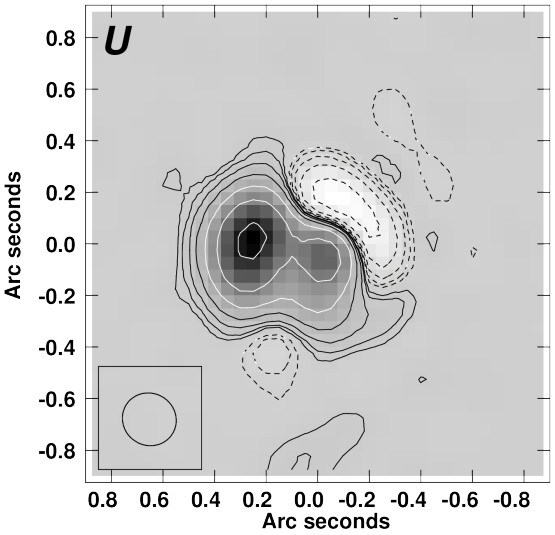
15 GHz



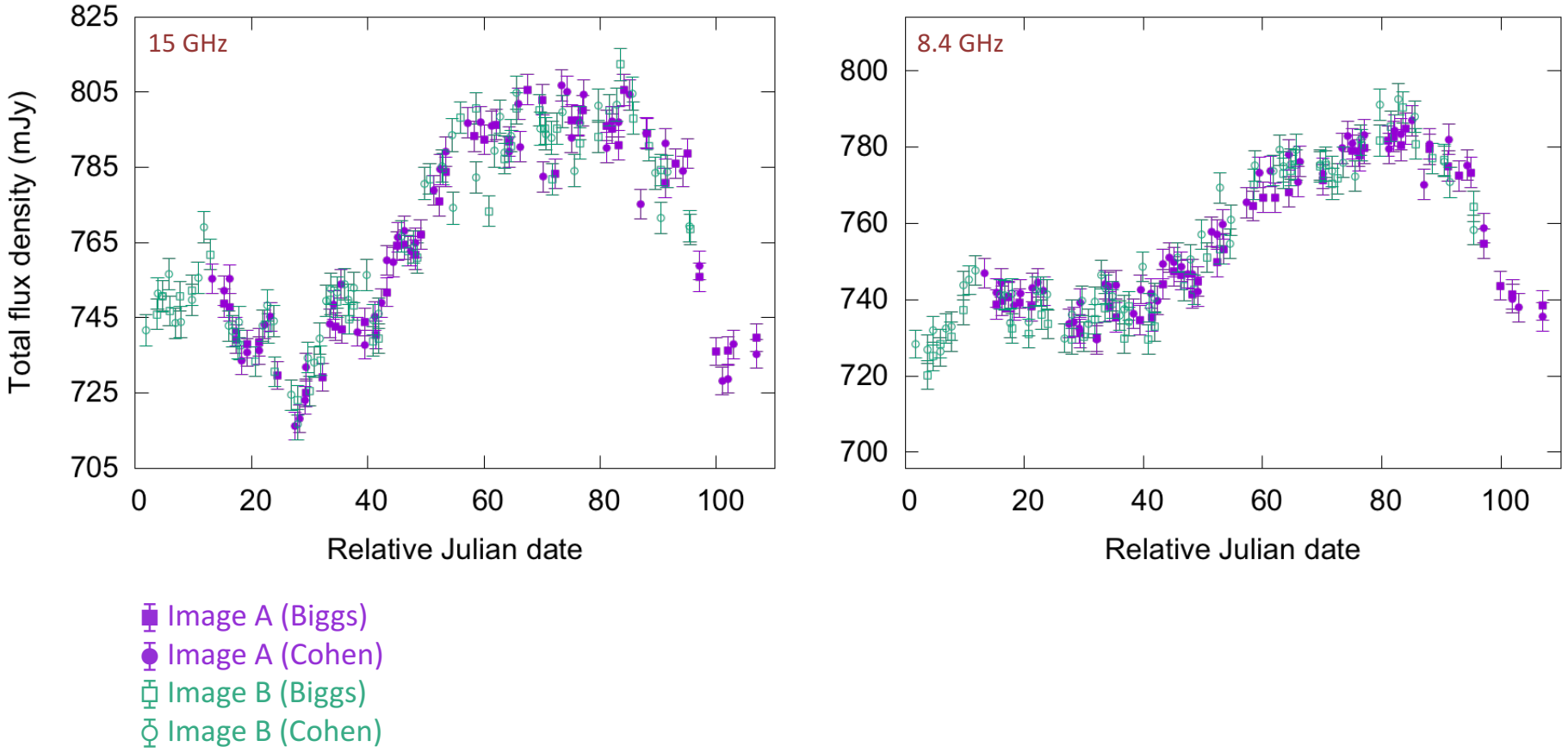

8.4 GHz



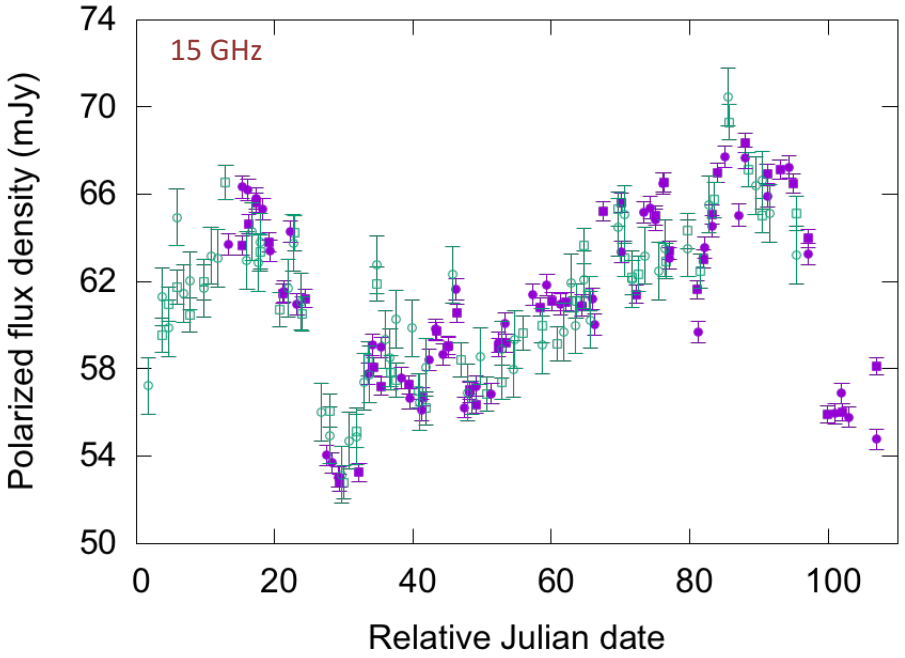
# Combined variability curves

Total flux density (delay and flux ratio removed)



# Combined variability curves

Polarized flux density (delay and flux ratio removed)



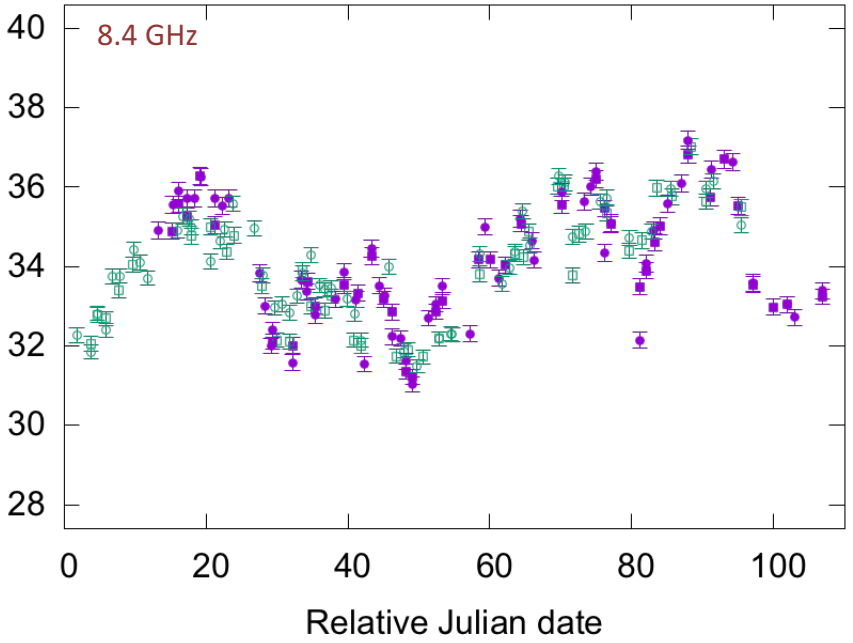
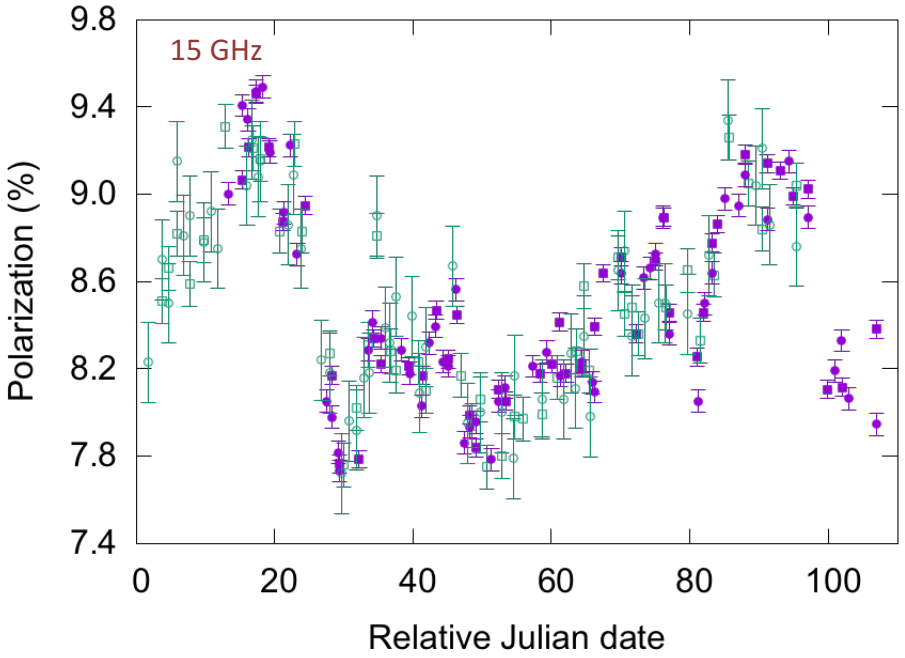




Image A (Biggs)
Image A (Cohen)
Image B (Biggs)
Image B (Cohen)

# Combined variability curves

Percentage polarization (delay and depolarization removed)



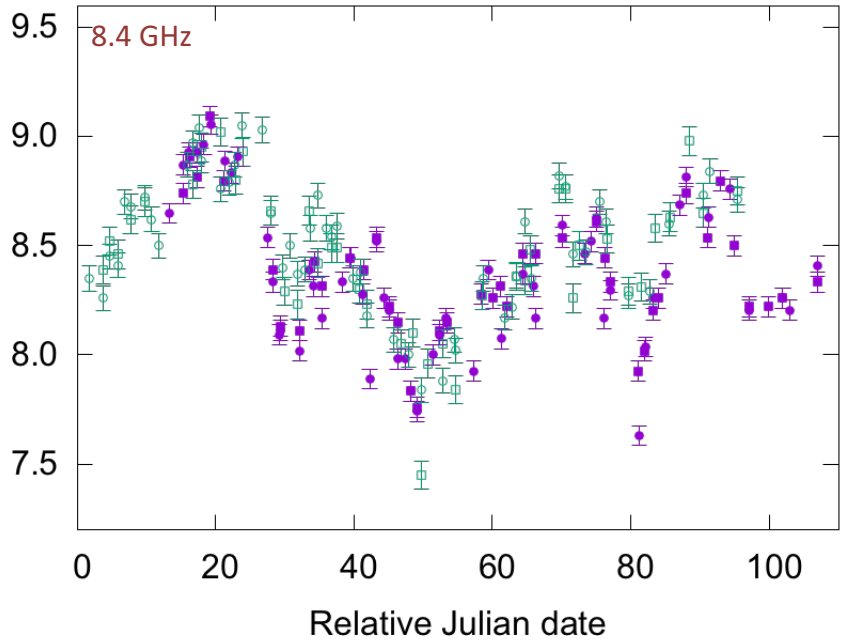
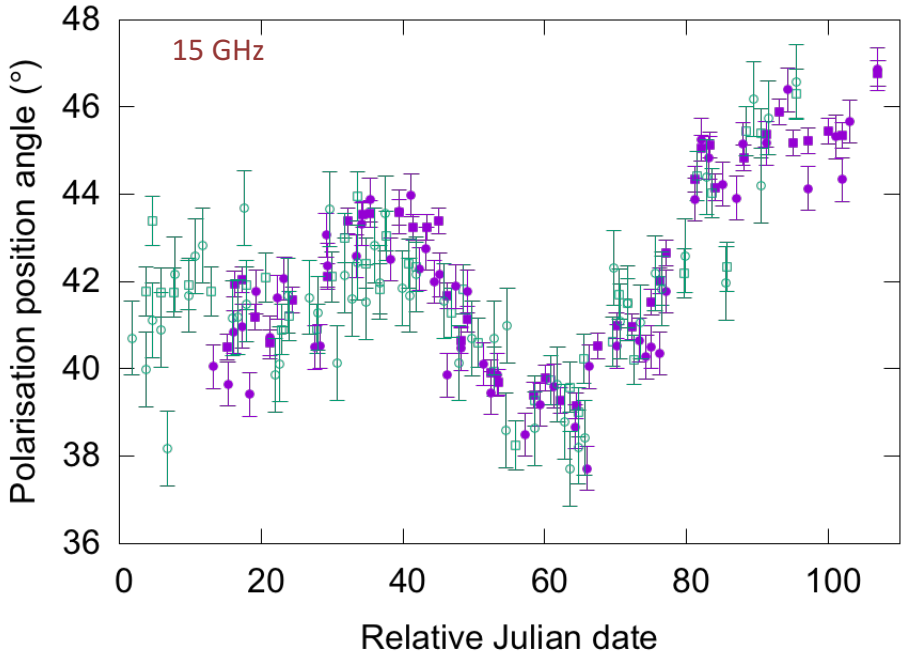




Image A (Biggs)
Image A (Cohen)
Image B (Biggs)
Image B (Cohen)

# Combined variability curves

EVPA (delay and Faraday rotation removed)



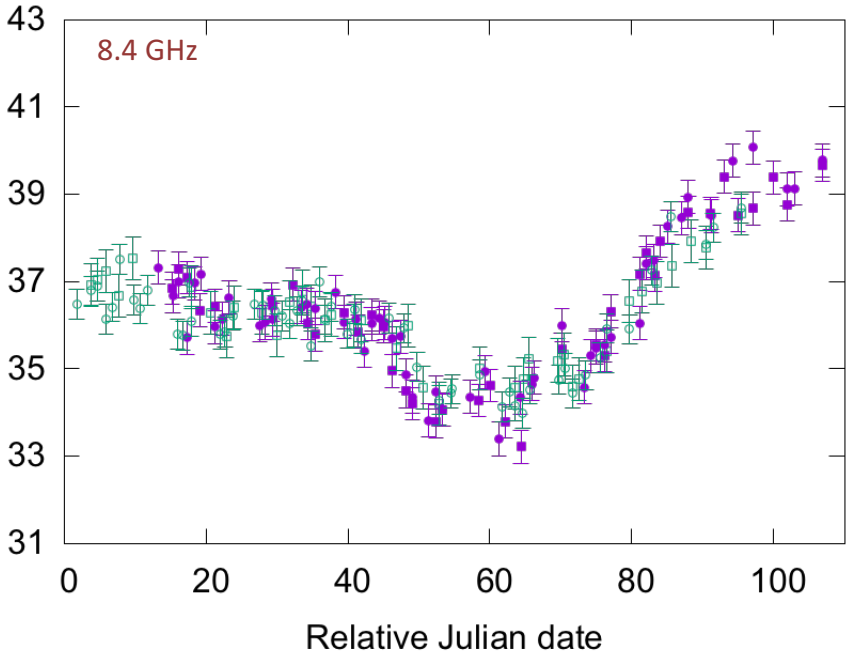
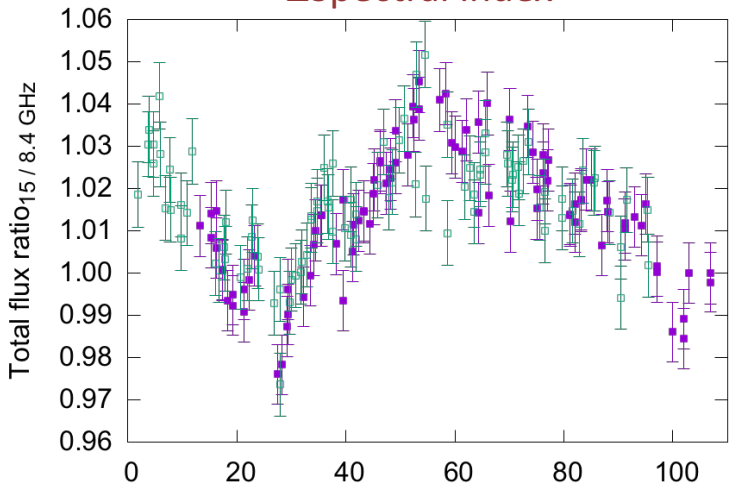



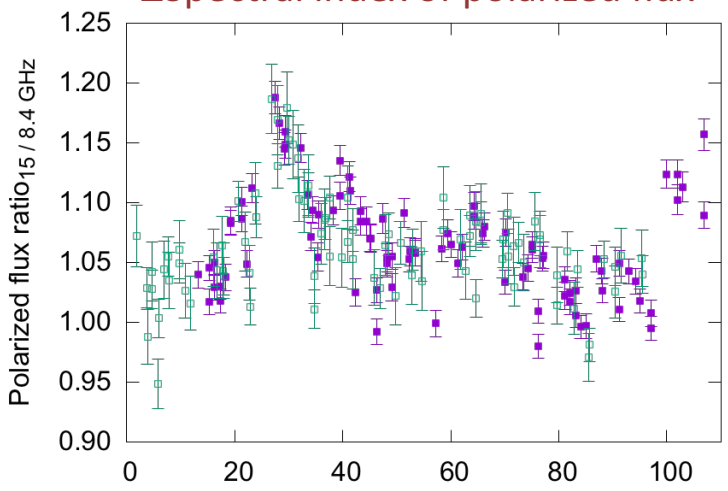

Image A (Biggs)
Image A (Cohen)
Image B (Biggs)
Image B (Cohen)

# Ratio/difference curves

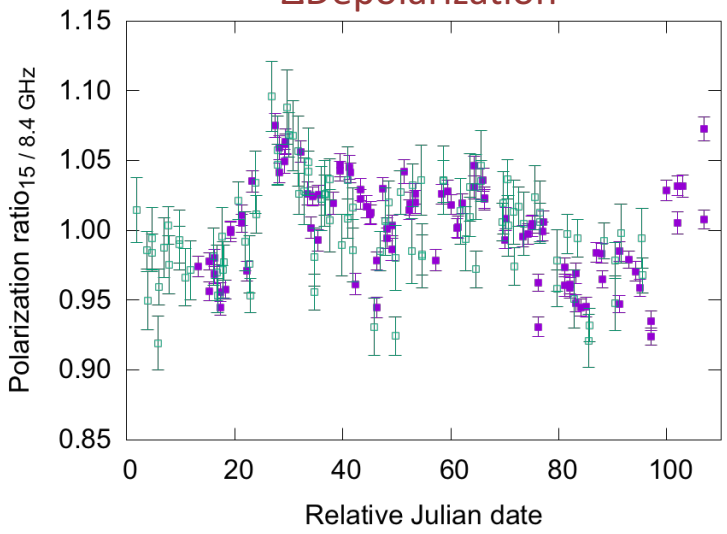
ΔSpectral index



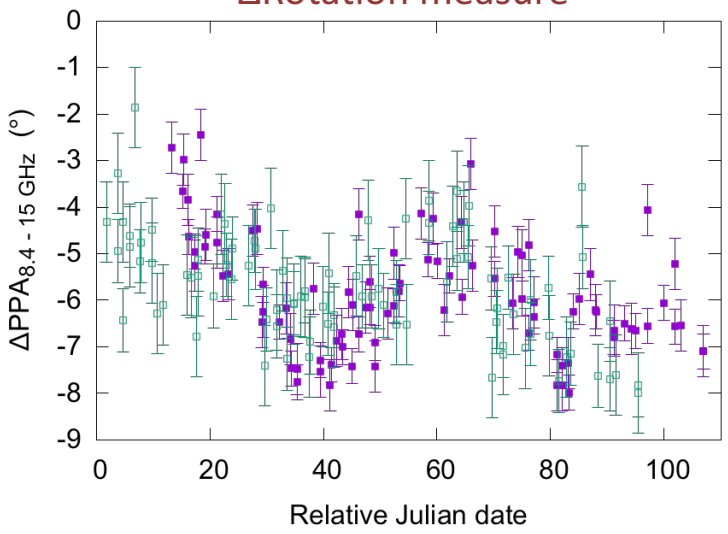

ΔSpectral index of polarized flux



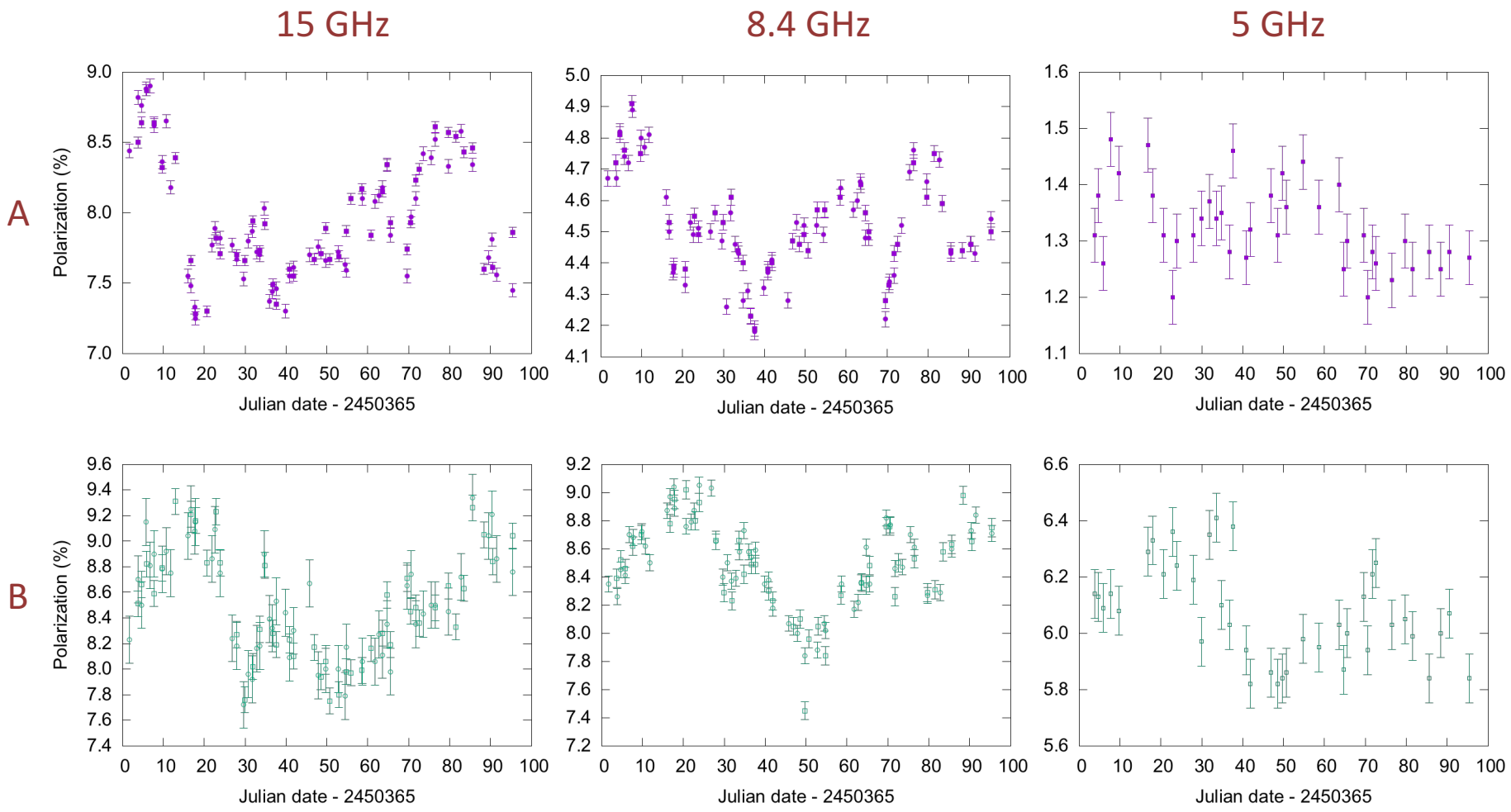

ΔDepolarization



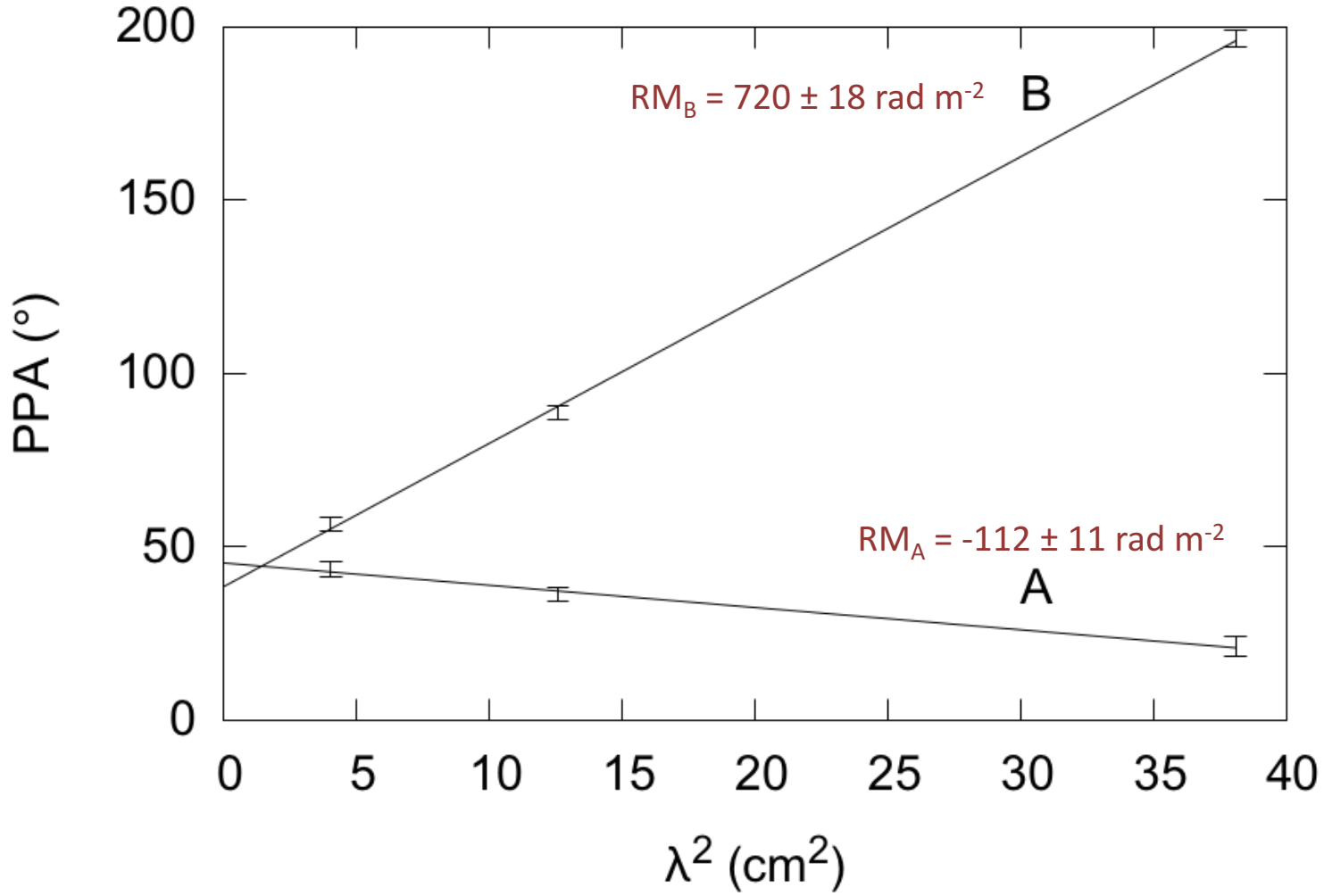

ΔRotation measure



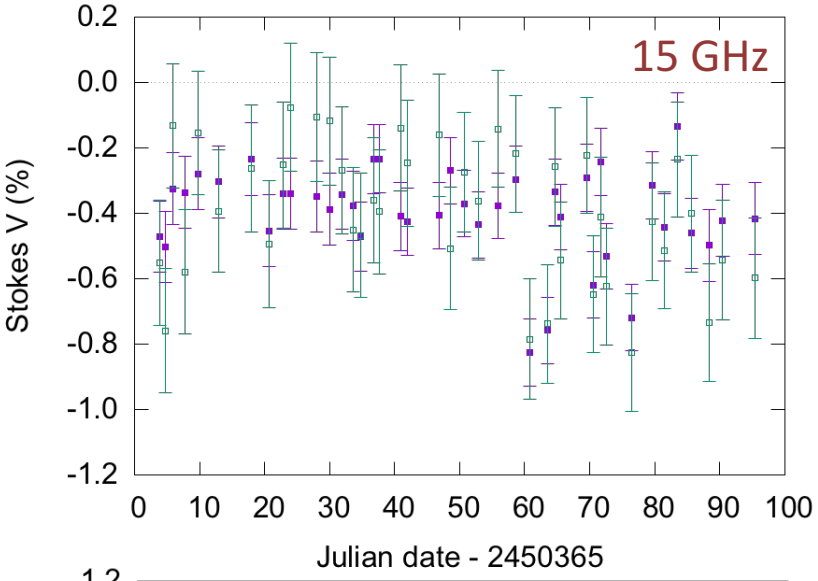
# Depolarization

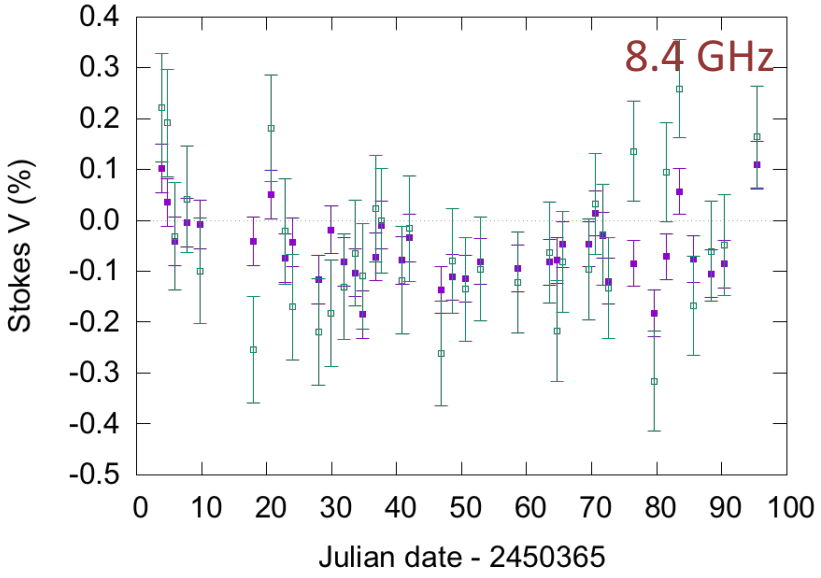


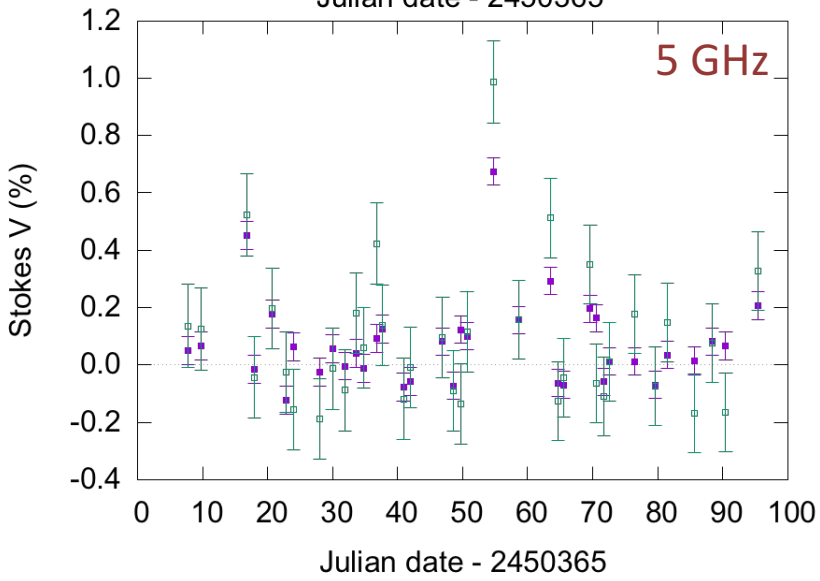
# Faraday rotation



# Circular polarization

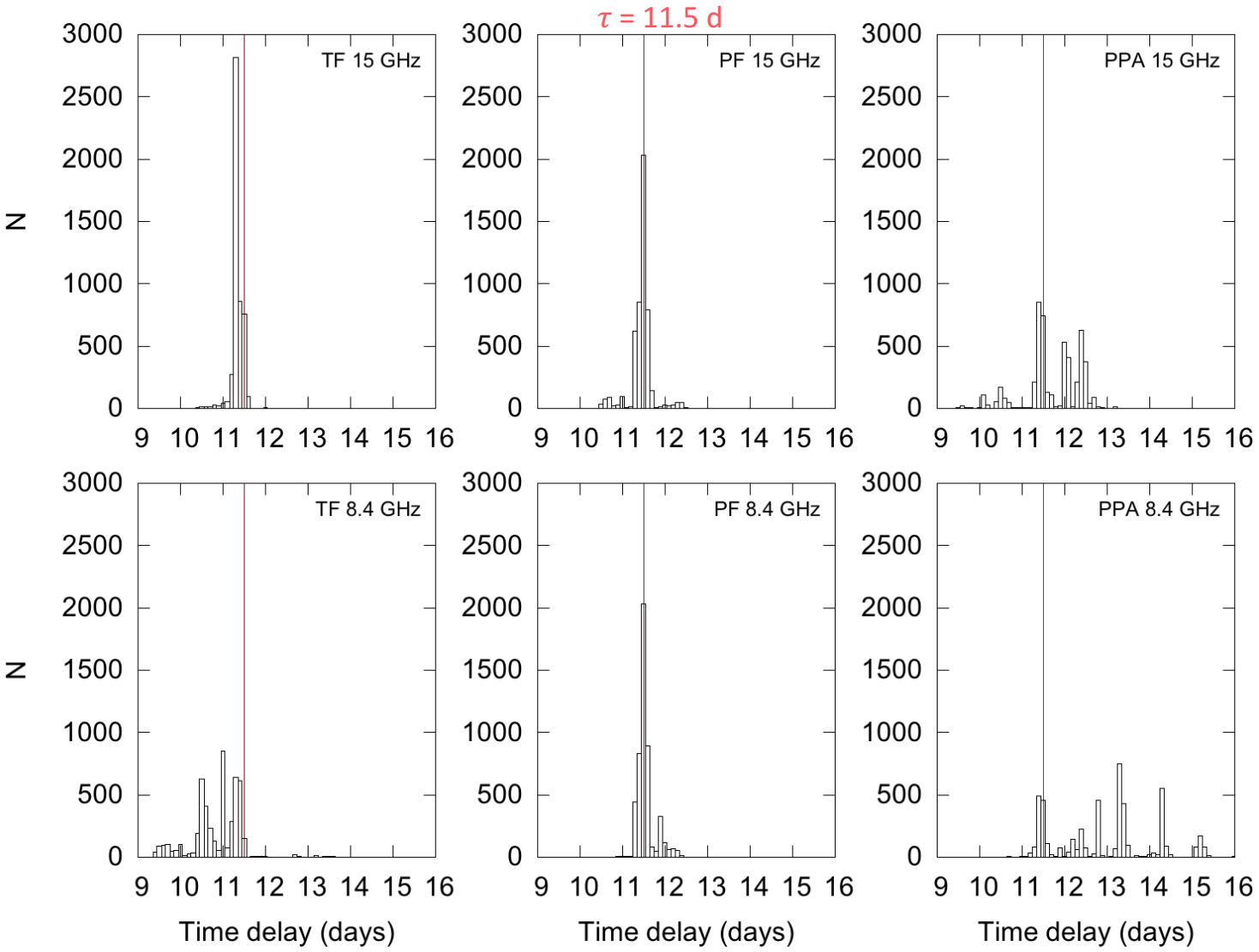


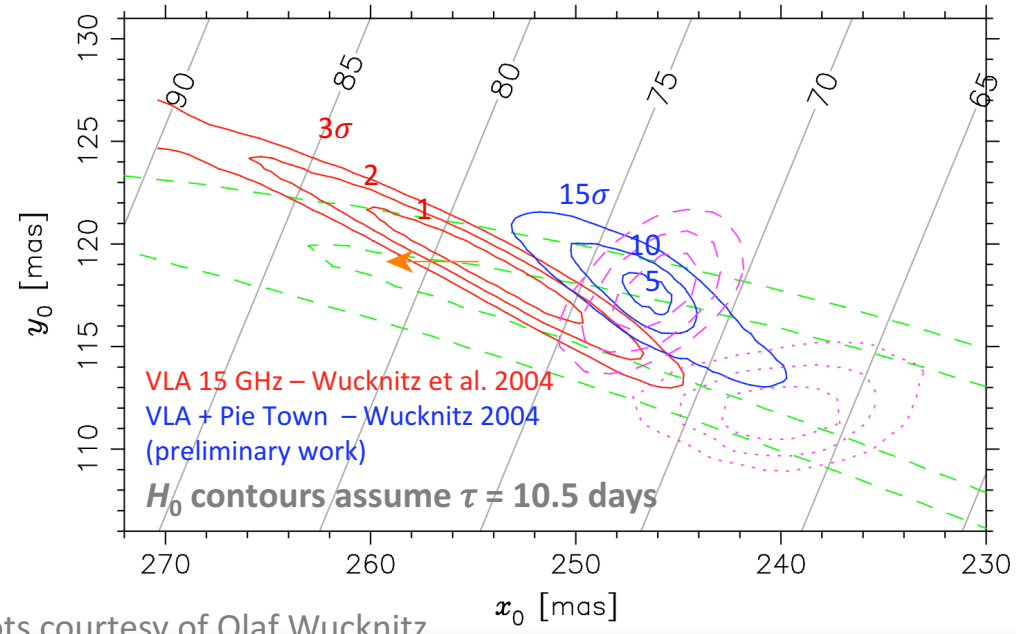

$m_c$ almost certainly due to use of 3C84 as the gain calibrator
i.e. plots show $-m_c$ (3C84)

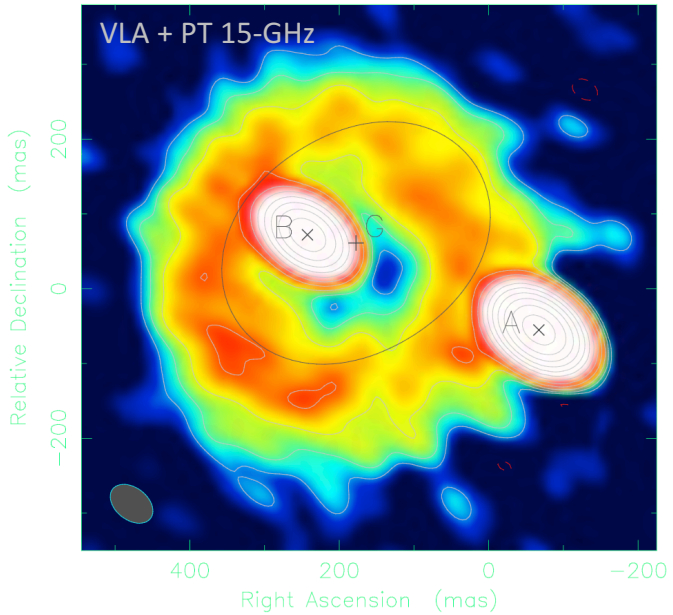
# Time-delay analysis



# What does this mean for $H_0$?

Main uncertainty on $H_0$ is the centre of the lensing galaxy which is constrained by the Einstein ring




Plots courtesy of Olaf Wucknitz

For $\tau$ = 11.5 days, $H_0 \cong 67 \pm 5$ km s$^{-1}$ Mpc$^{-1}$ ($2\sigma$)

$H_0$ increases if mass profile is steeper than isothermal

# Summary

- We have reanalysed VLA monitoring data for B0218+357
- Total of ≅100 epochs at 15 and 8.4 GHz over ≅100 days
- EVPA offsets due to near-zenith observing can be corrected
- Polarized-flux variability is particularly high
- Time delay is consistent with $\gamma$-ray value (11.5 days)
- Current modelling suggests $H_0 \cong 70$ km $s^{-1}$ $Mpc^{-1}$
- Combined variability curves sampled at 2 epochs per day