Baseband Polarimetry of MSPs using FAST

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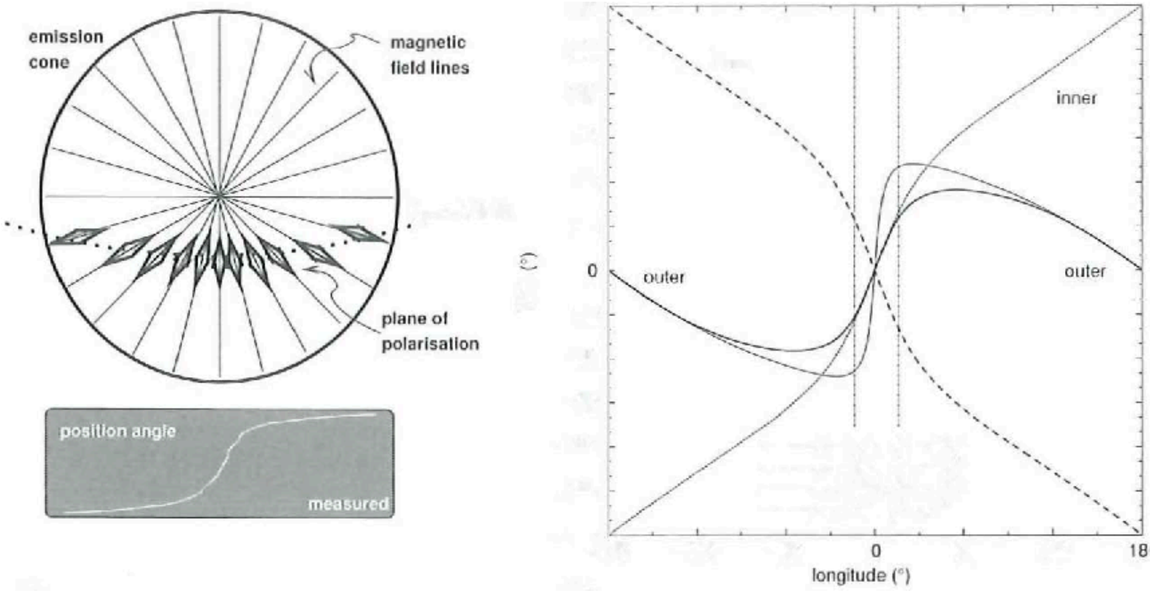
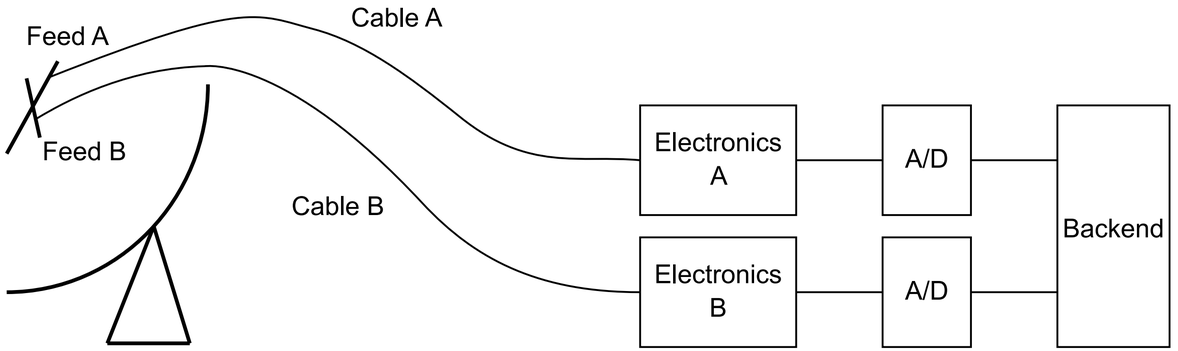
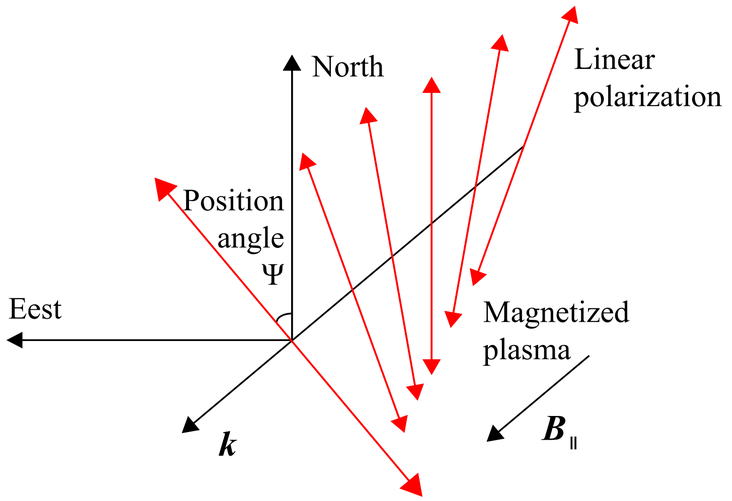
Why polarimetry?

- Pulsar magnetosphere
  RVM (BCW) for some normal pulsars
  more complicated for MSPs
- Interstellar magnetic field (RM)
- Pulsar timing
  Total intensity is not Lorentz invariant in
  radio polarimetry



RVM (figure in Handbook, Lorimer & Kramer)

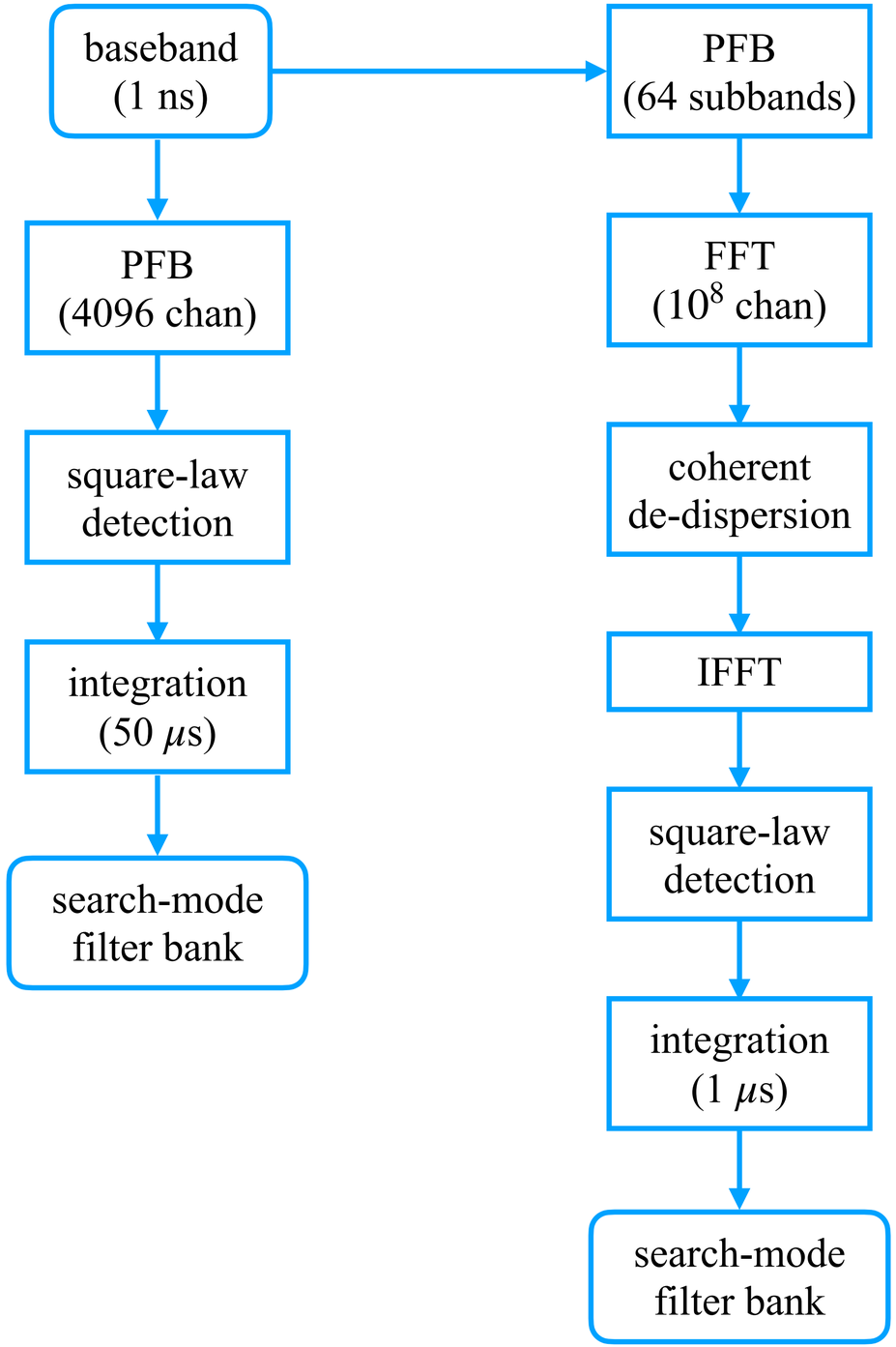




Faraday rotation

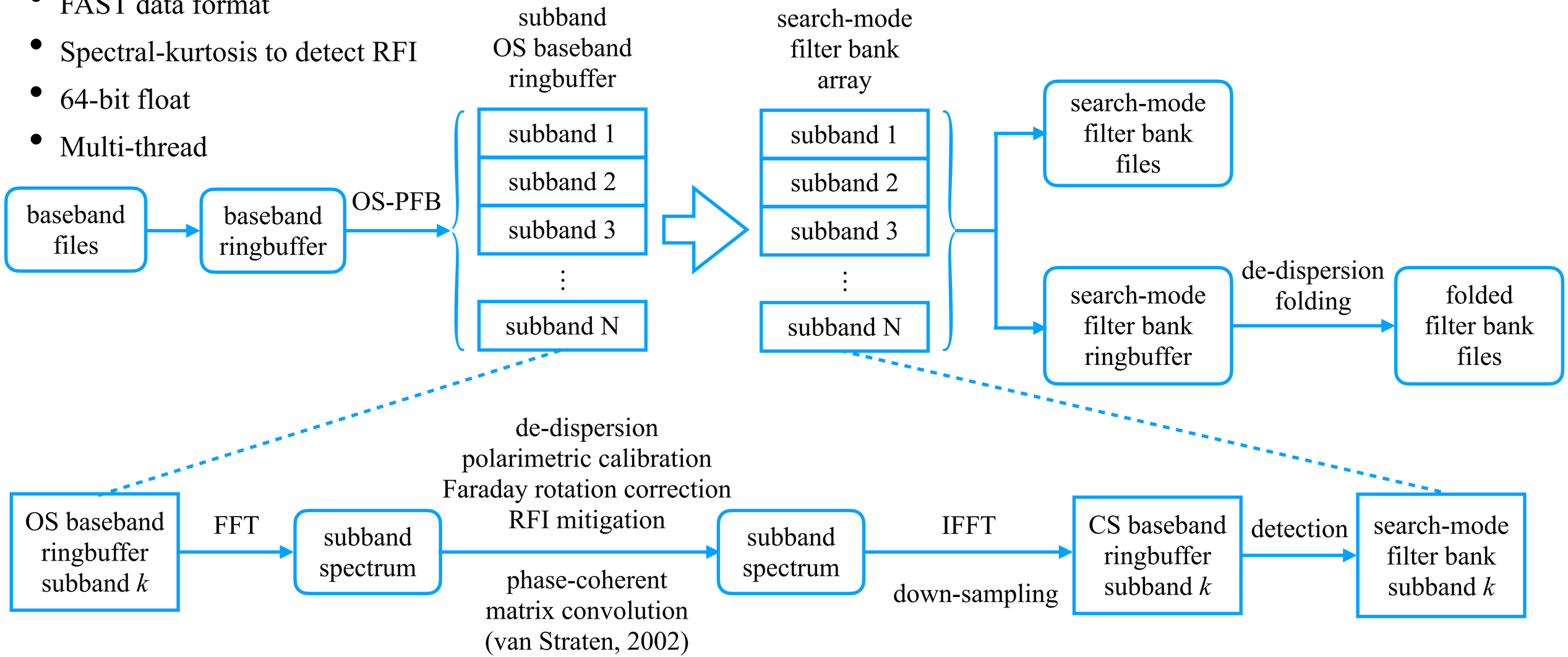
Why baseband?

- High time resolution
  short structures in profiles
  improve timing accuracy
- High spectral resolution
  polarimetric calibration
  de-dispersion
  Faraday rotation
  narrow-band RFI
- Uncertainty principle
  channelization + baseband synthesis



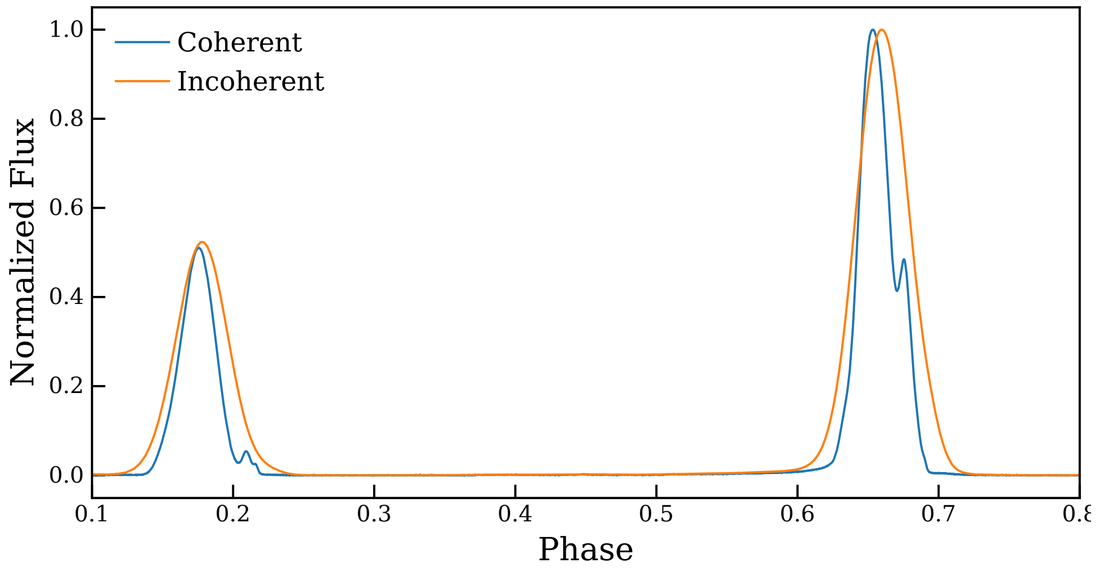
A new software

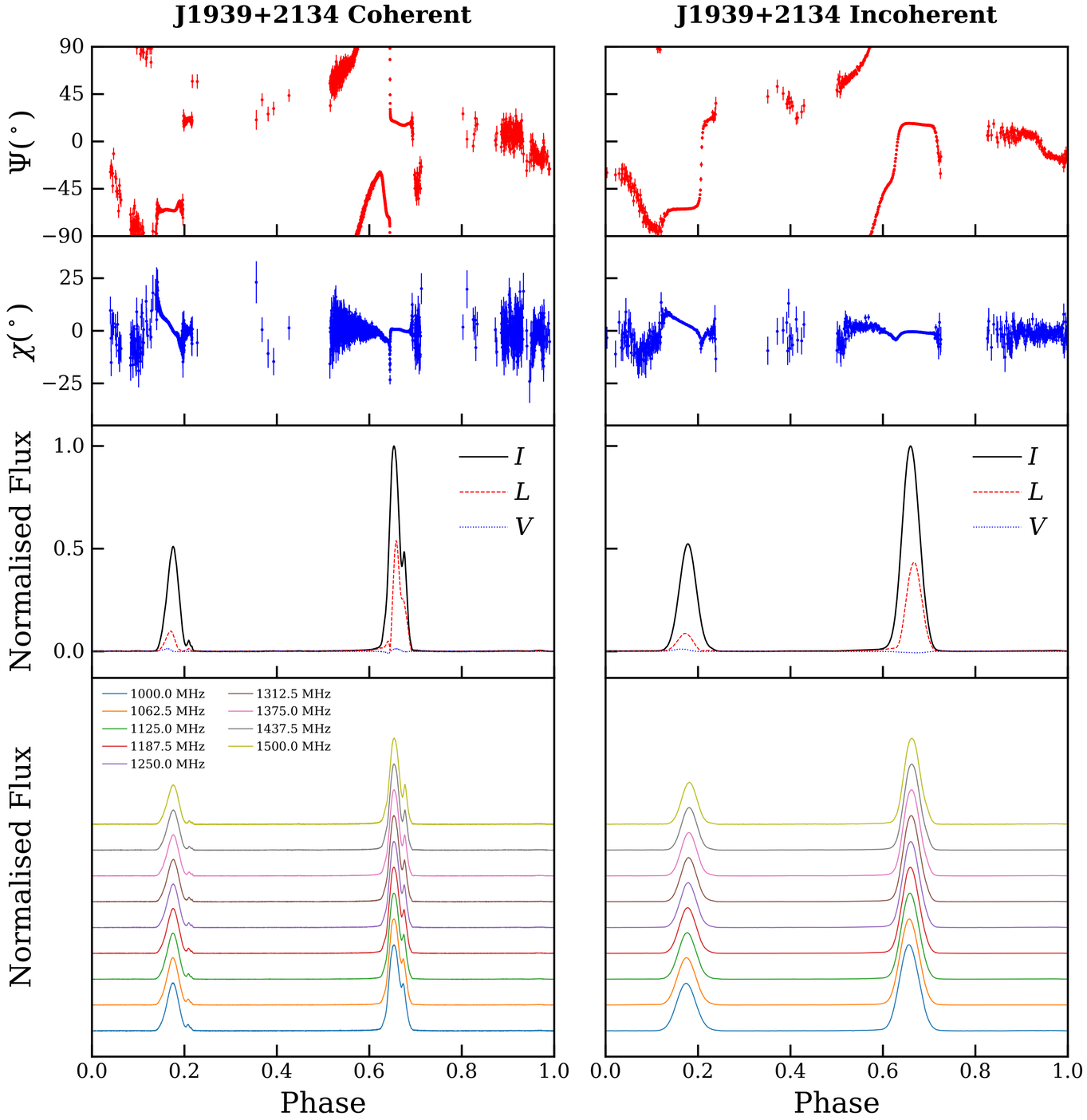
- Off-line
- Python + Cython + FFTW3
- FAST data format
- Spectral-kurtosis to detect RFI
- 64-bit float
- Multi-thread



Test: B1937+21

- Coherent pipeline
  new software
- Incoherent pipeline
  psr backend + dspsr
- Short structures in profile

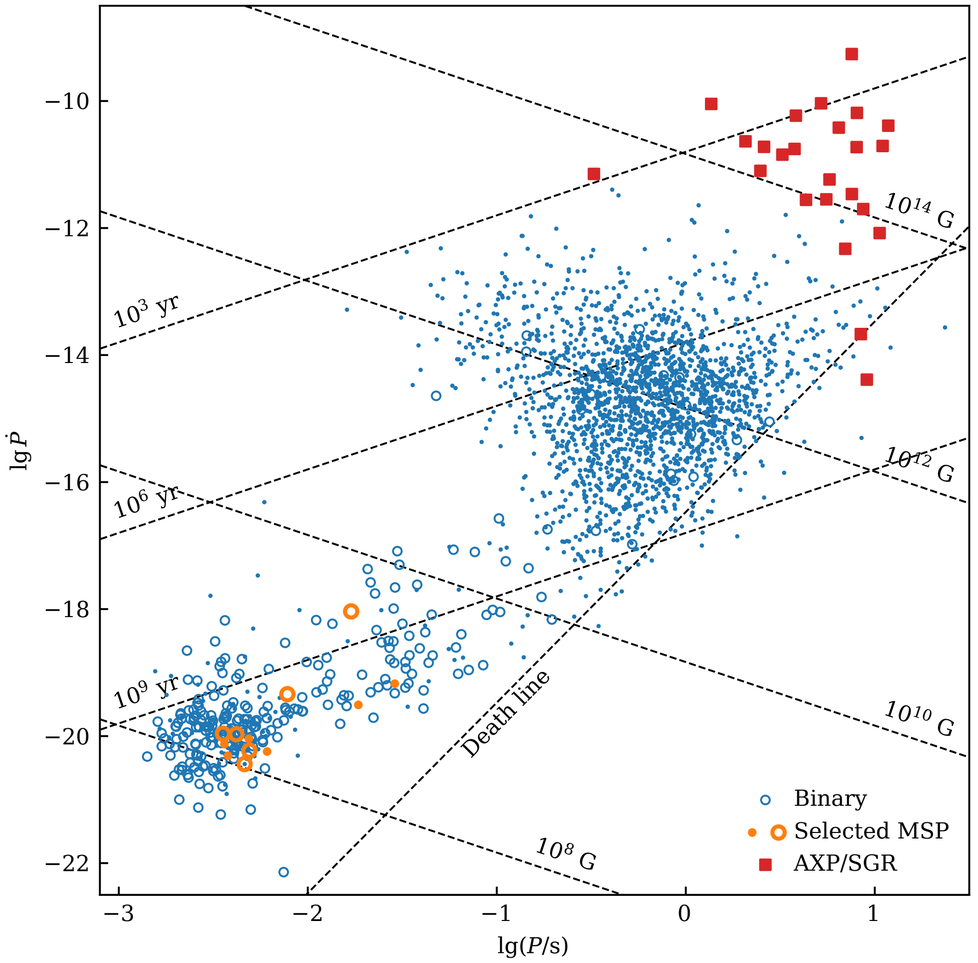




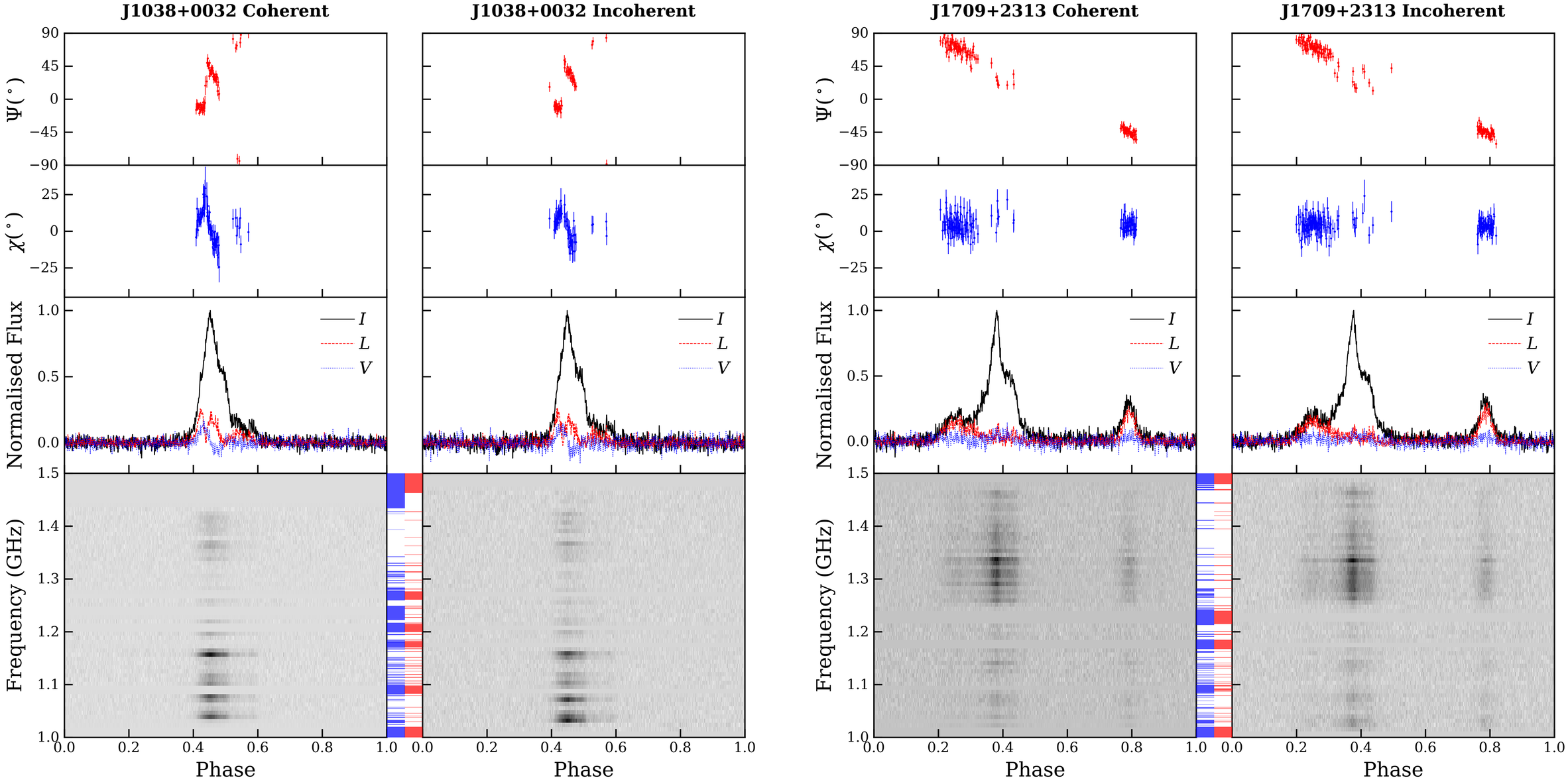
Source selection

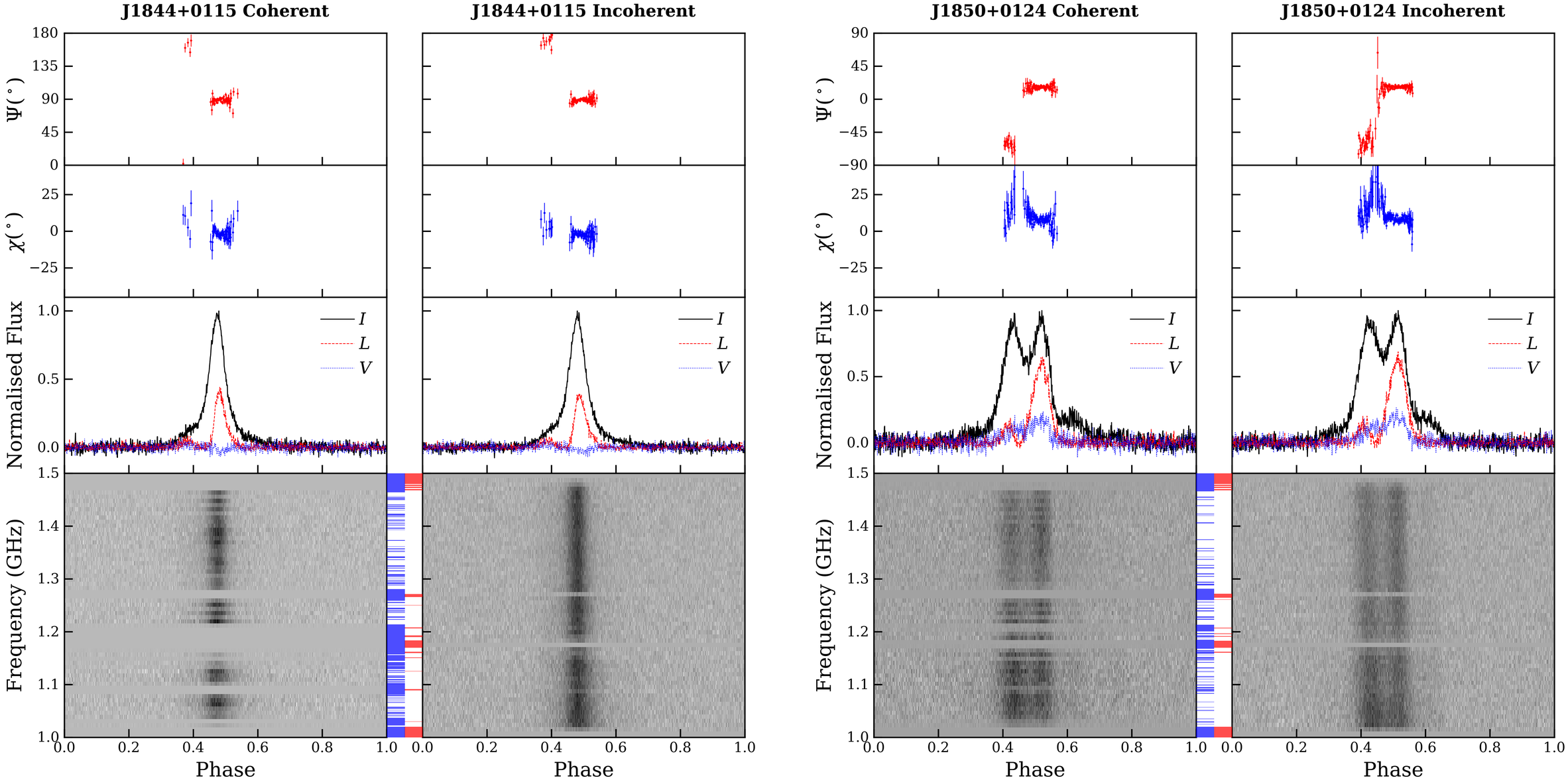
- Small zenith angle (< 26.4°)
- Not in PTAs
- Not in pulsar polarimetry literature
- S/N

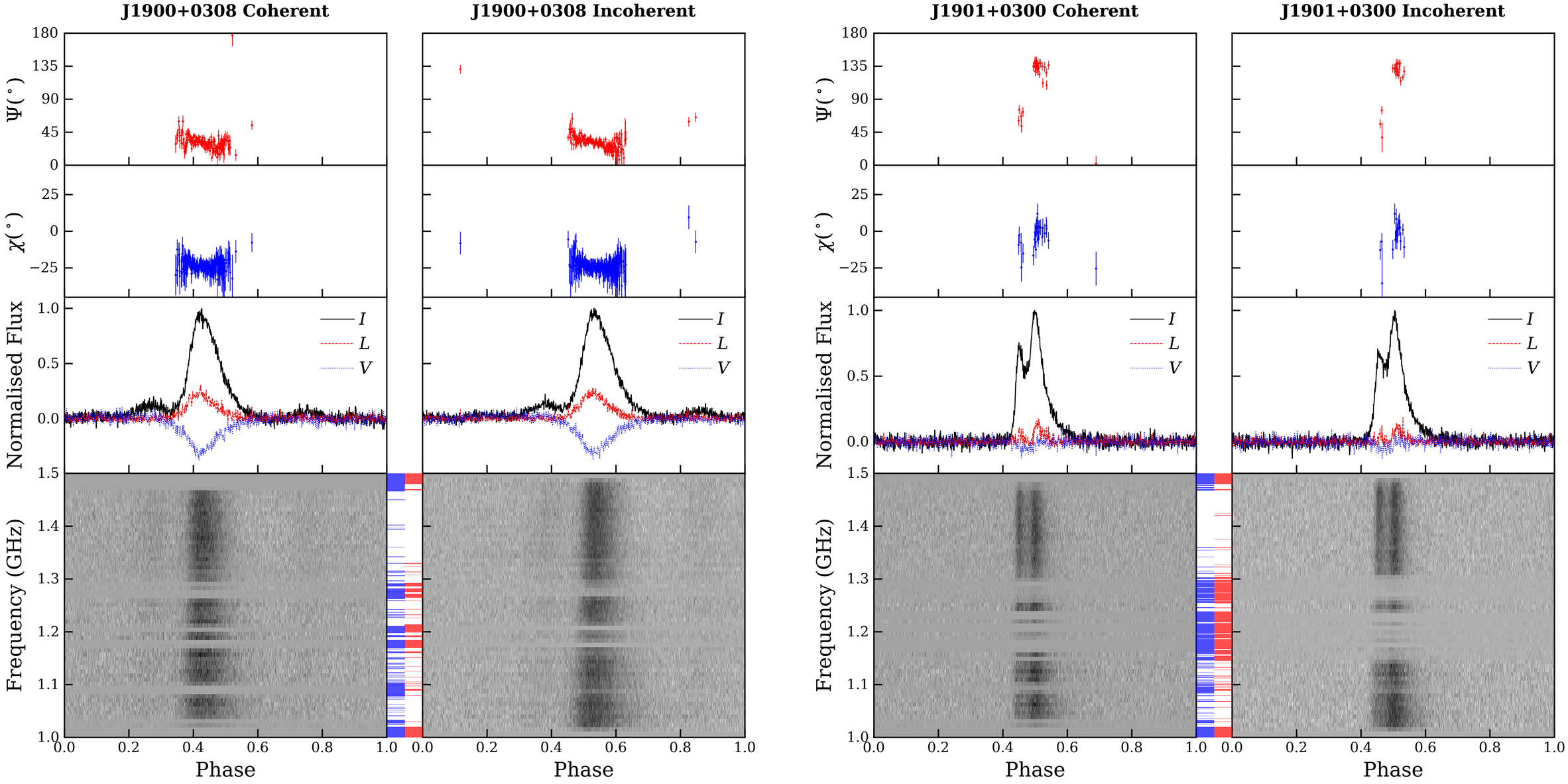
- 8h allocated in 2020

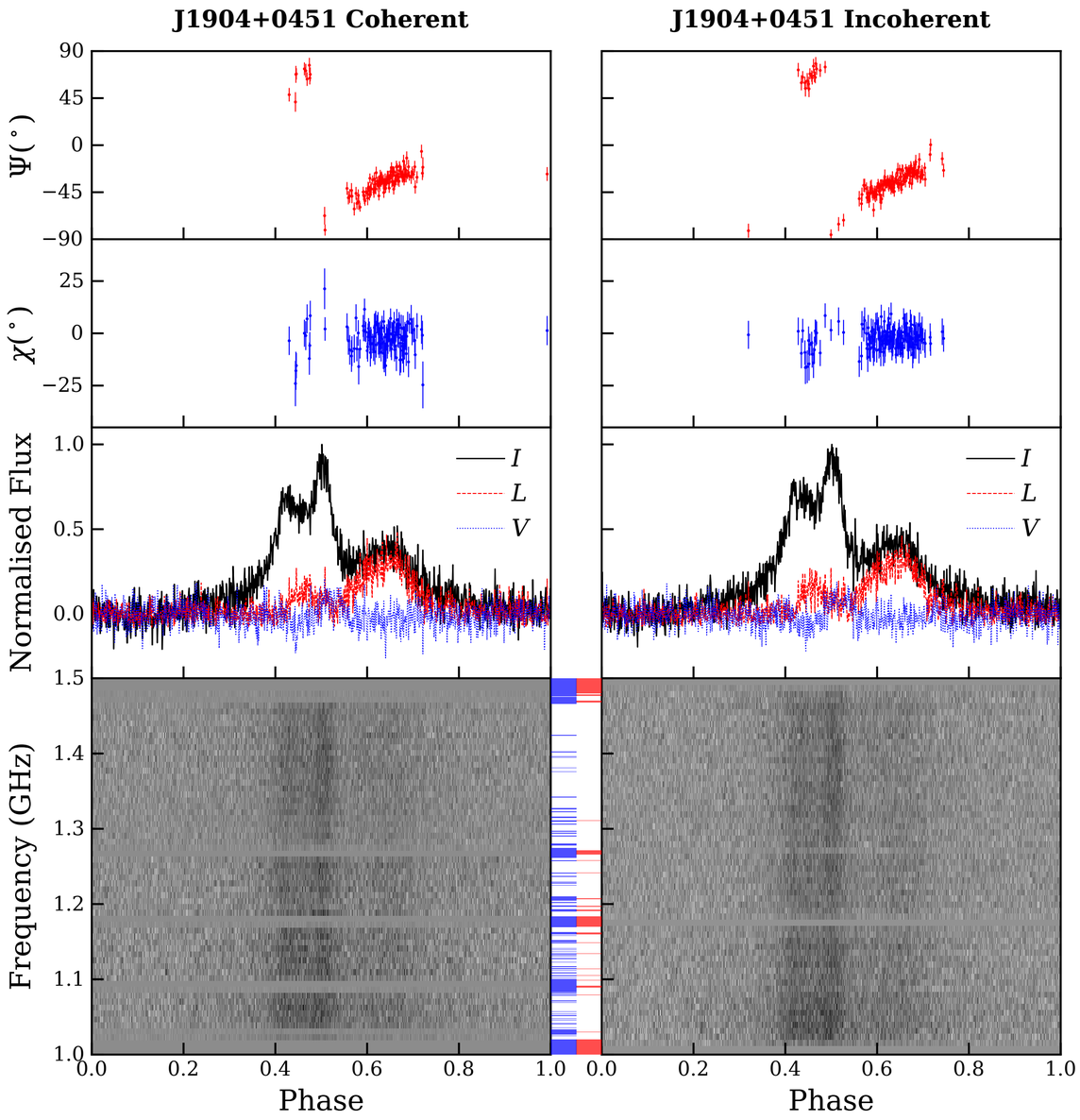


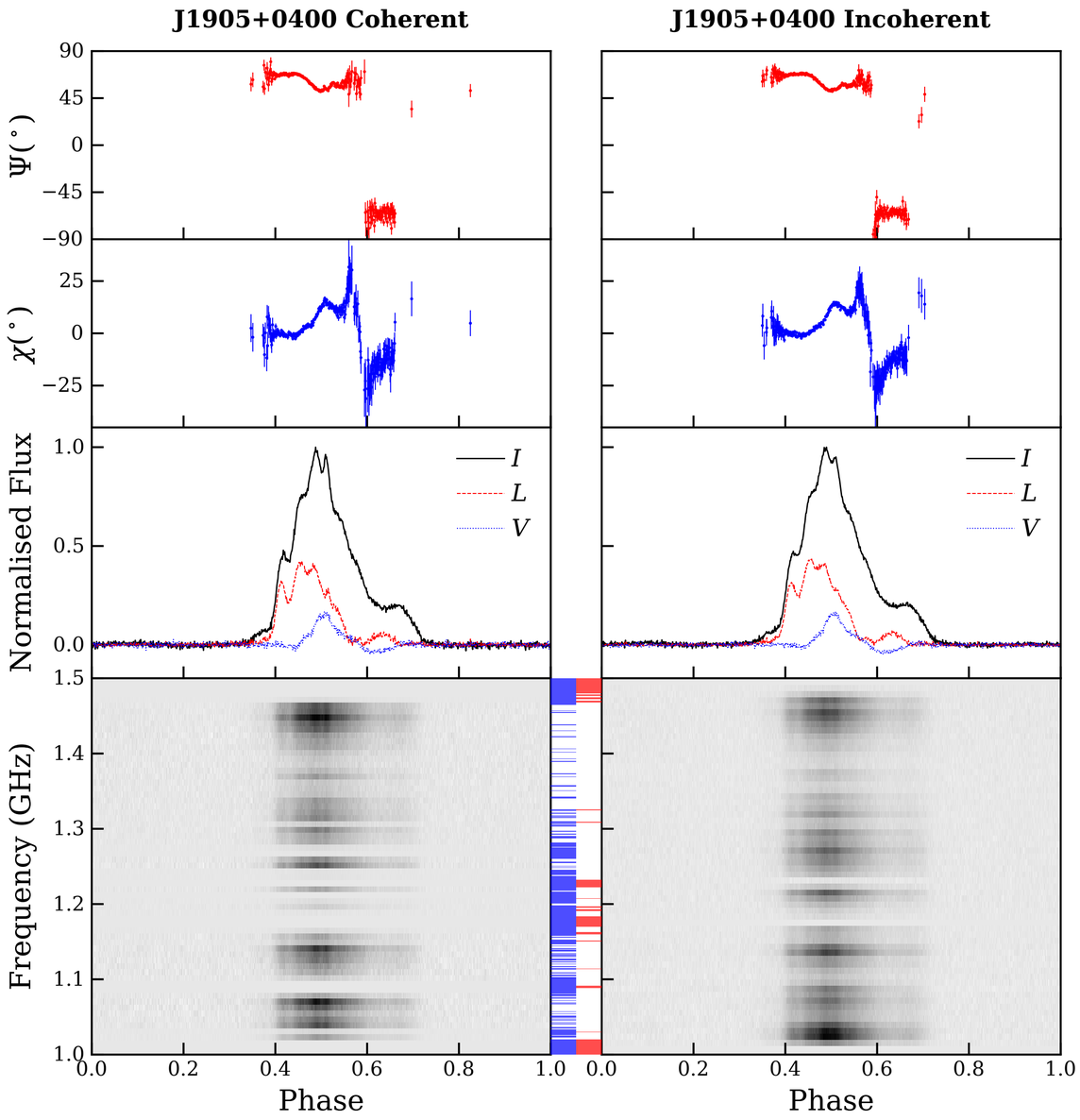
Source name	Obs length (min)
J1038+0032	22
J1709+2313	22
J1844+0115	40
J1850+0124	22
J1900+0308	40
J1901+0300	30
J1904+0451	30
J1905+0400	60
J1914+0659	22
J1944+2236	40
J1946+2052	90
J1955+2527	22


J1038+0032 Coherent
J1038+0032 Incoherent
J1709+2313 Coherent
J1709+2313 Incoherent
Ψ(°)
χ(°)
Normalised Flux
Frequency (GHz)
Phase
I
L
V

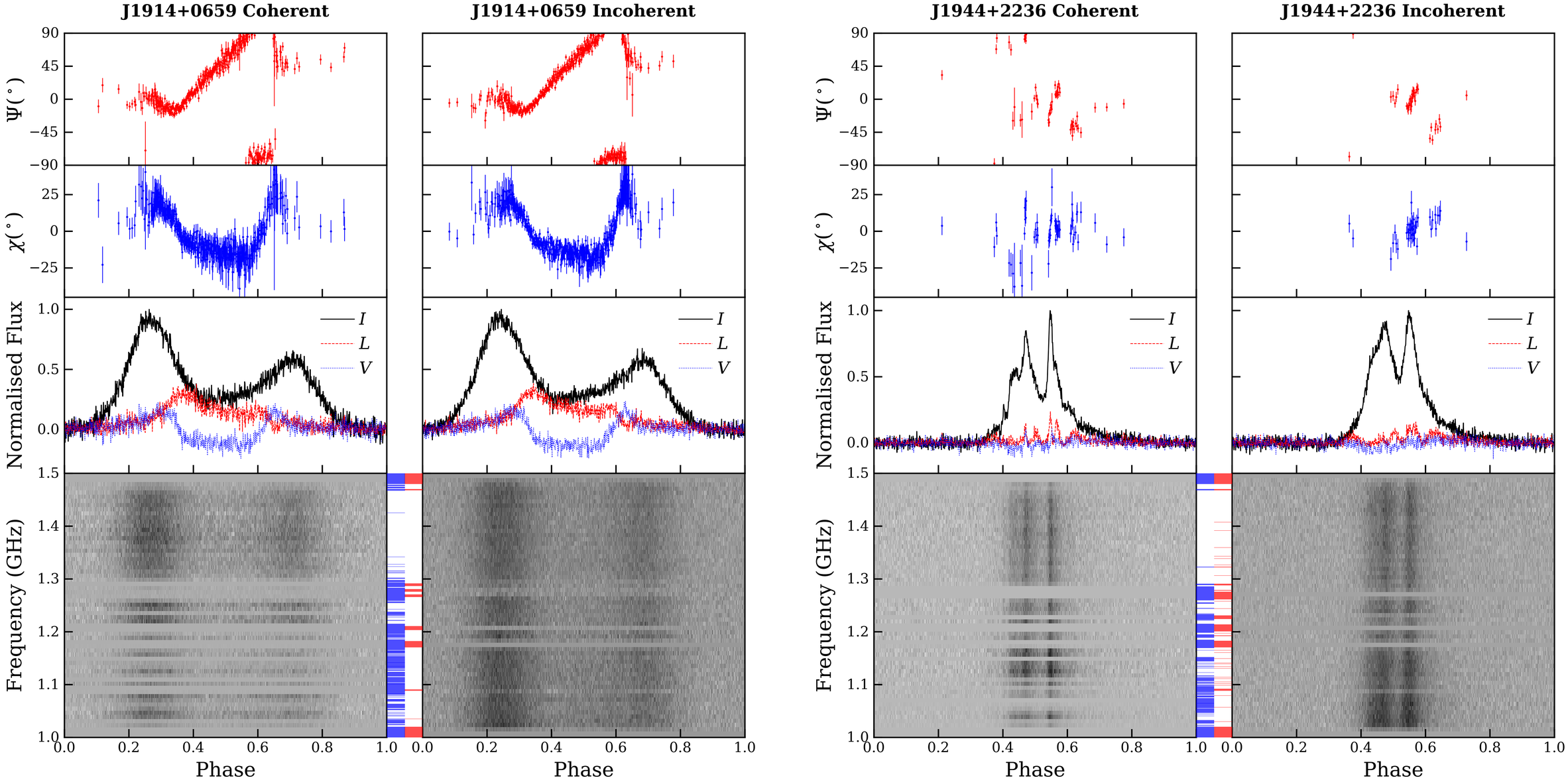

J1844+0115 Coherent
J1844+0115 Incoherent
J1850+0124 Coherent
J1850+0124 Incoherent
Ψ(°)
χ(°)
Normalised Flux
Frequency (GHz)
Phase
I
L
V


J1900+0308 Coherent
J1900+0308 Incoherent
J1901+0300 Coherent
J1901+0300 Incoherent
Ψ(°)
χ(°)
Normalised Flux
Frequency (GHz)
Phase
I
L
V

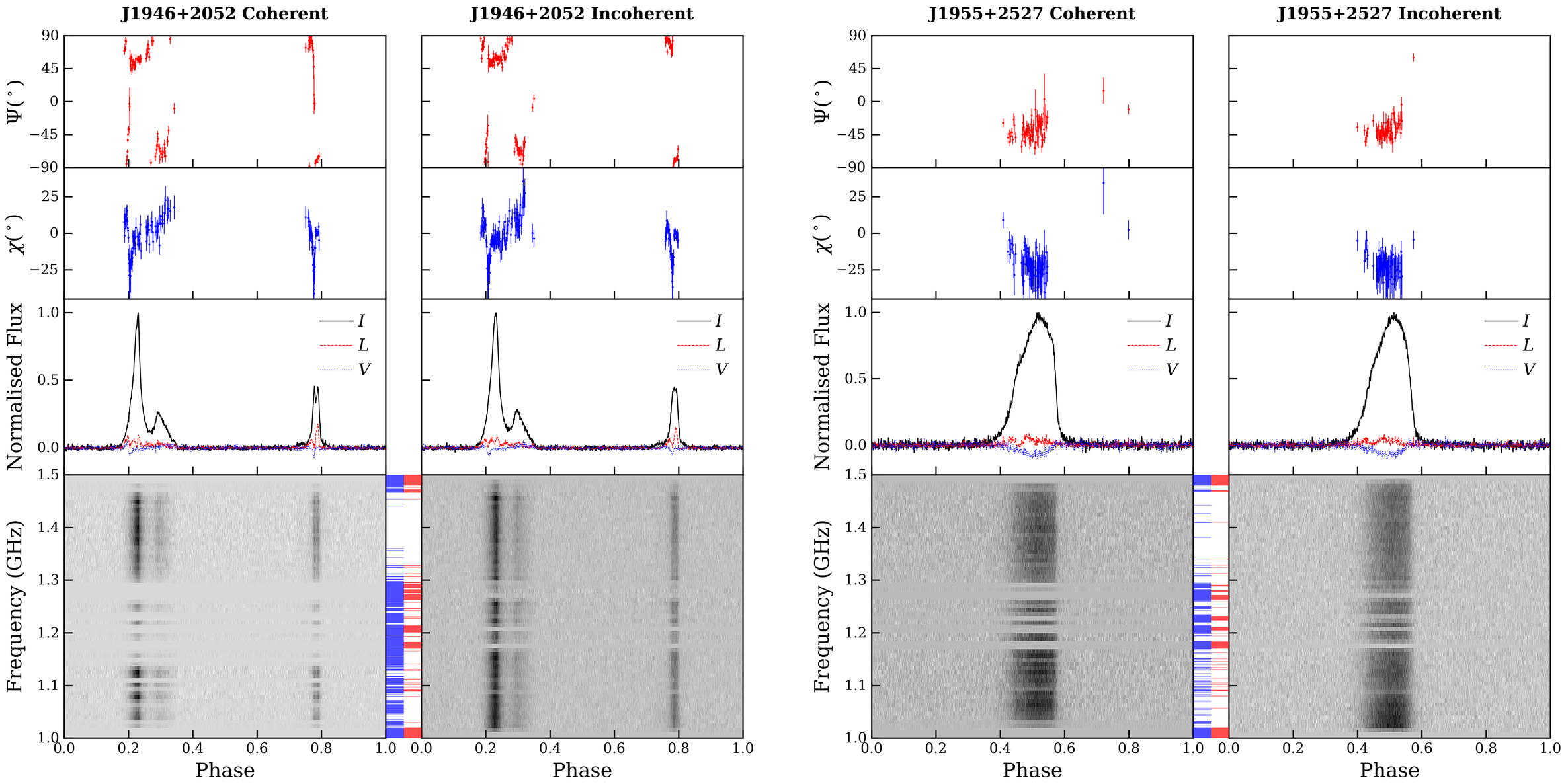




short sturcture



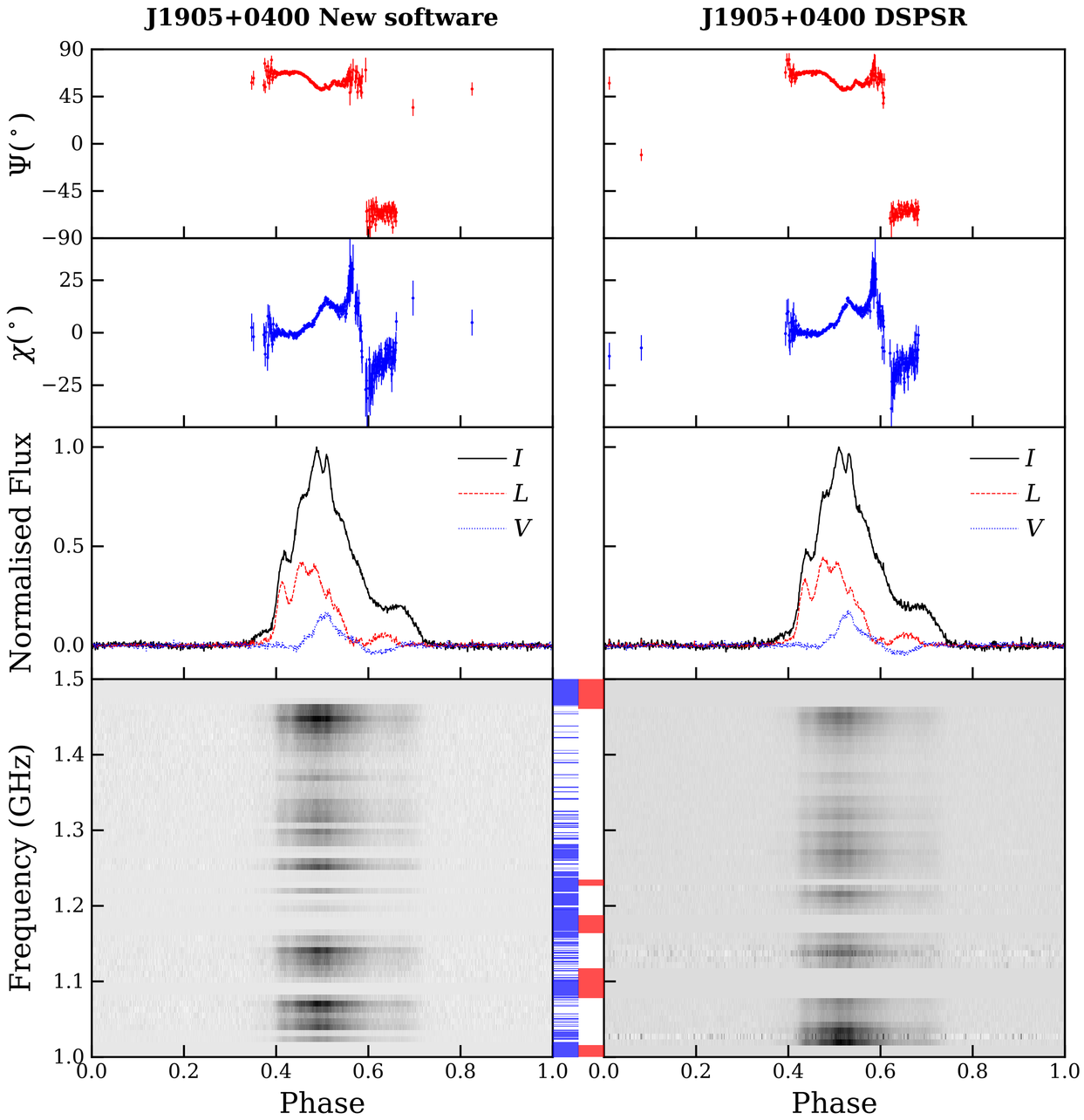
short sturcture



short sturcture

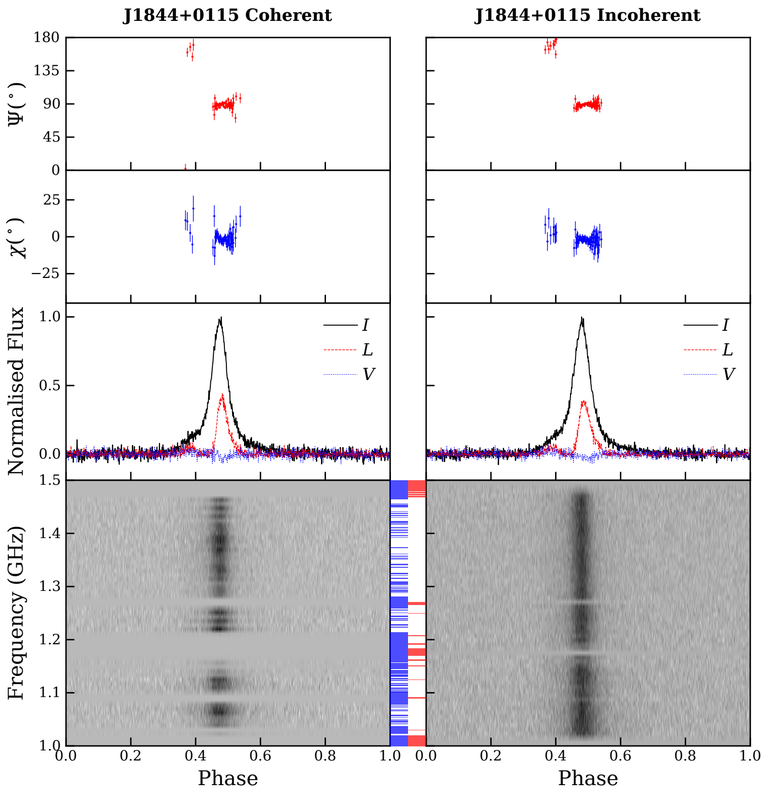
Compare with DSPSR coherent de-dispersion

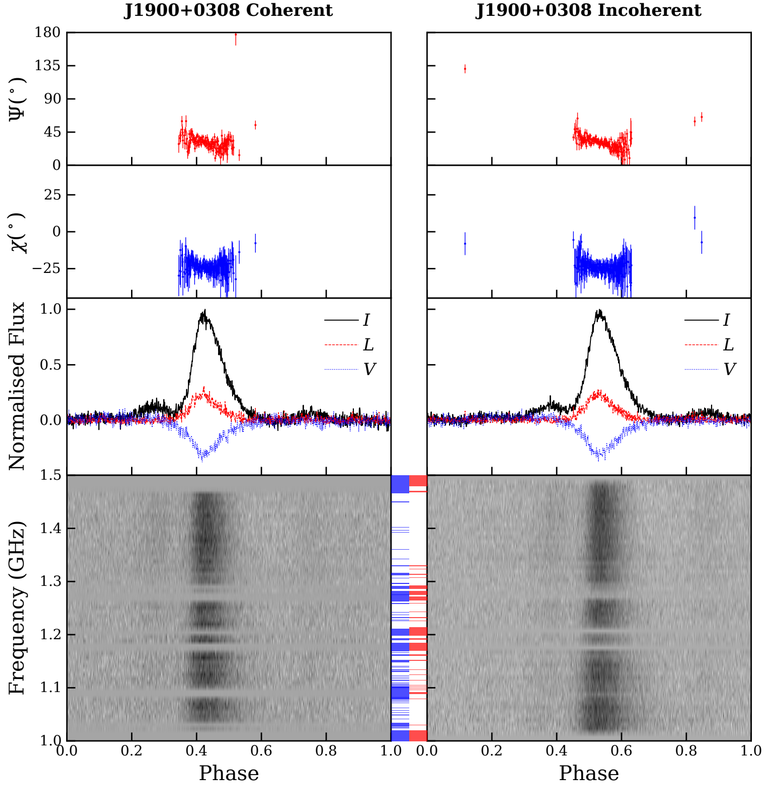
- DSPSR:
  conversion to DADA files
  coherent de-dispersion
  spectral kurtosis RFI zapping
  Incoherent polarimetric calibration
  Incoherent correction for Faraday rotation



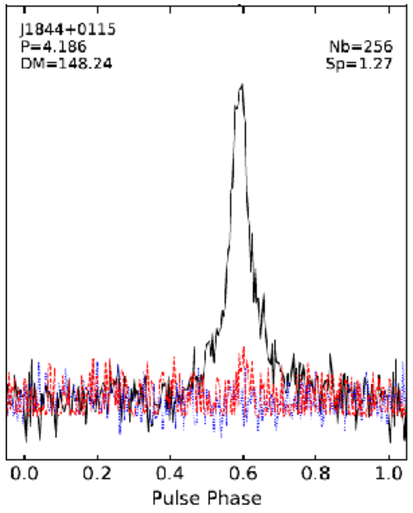
Compare with MeerKAT polarimetry results

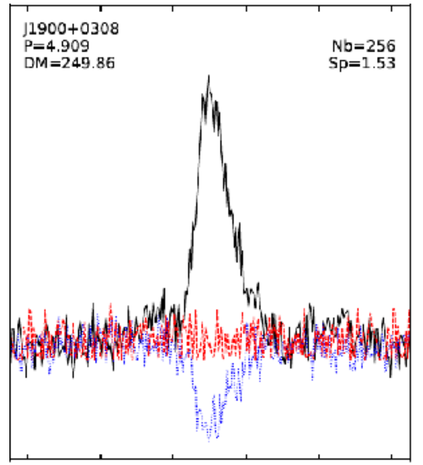
FAST (1-1.5 GHz)





MeerKAT (1-1.7 GHz)
(Spiewak et al. 2022)





Summary

- A new software for baseband data processing
  Coherent de-dispersion, polarimetric calibration, Faraday rotation correction, RFI mitigation
  Python + Cython + FFTW3, multi-thread
- Polarization profiles of 12 MSPs
  short structures: J1905+0400, J1944+2236, J1946+2052
  diverse degrees of polarization & PA curves

Thanks!