

Universität Bielefeld



The German
Long Wavelength
Consortium



IISM studies with low-frequency pulsar observations using GLOW

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GLOW



Pulsar observing campaign

- Weekly observations with the 6 German stations of LOFAR
 - HBAs ($\sim 110\text{-}240$ MHz)
 - ~ 137 pulsars (~ 30 bi-weekly)
 - >6 years of time span
 - >80 TB of “folded” pulsar data
 - Several “special modes” of observation (high frequency resolution, single pulses, etc.)
 - Especially useful for studies of magnetoionic media



Copyright: M. Biermann

GLOW single station science

People:

- * J. Verbiest, J. Donner, M.A. Krishnakumar, A. Bak Nielsen, C. Tiburzi, S. Osłowski, N. Porayko, O. Wucknitz, R. Main, L. Künkel, Z. Wu, P. Bergjann,

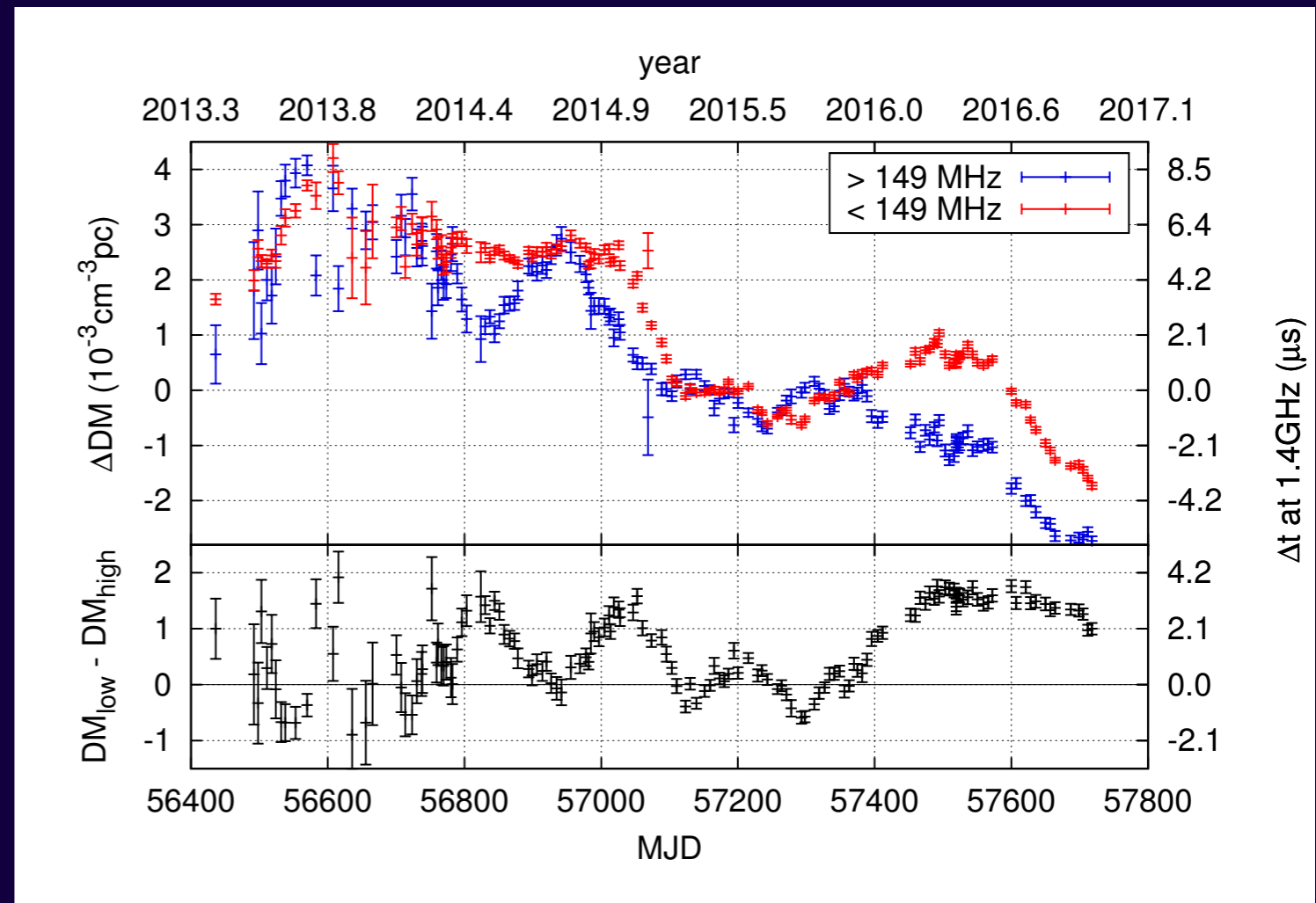
Projects:

- * Dispersion measure
- * Scintillation time series
- * Scintillation arcs
- * Scatter-broadening and DM correlation
- * Solar wind

See C. Tiburzi Talk

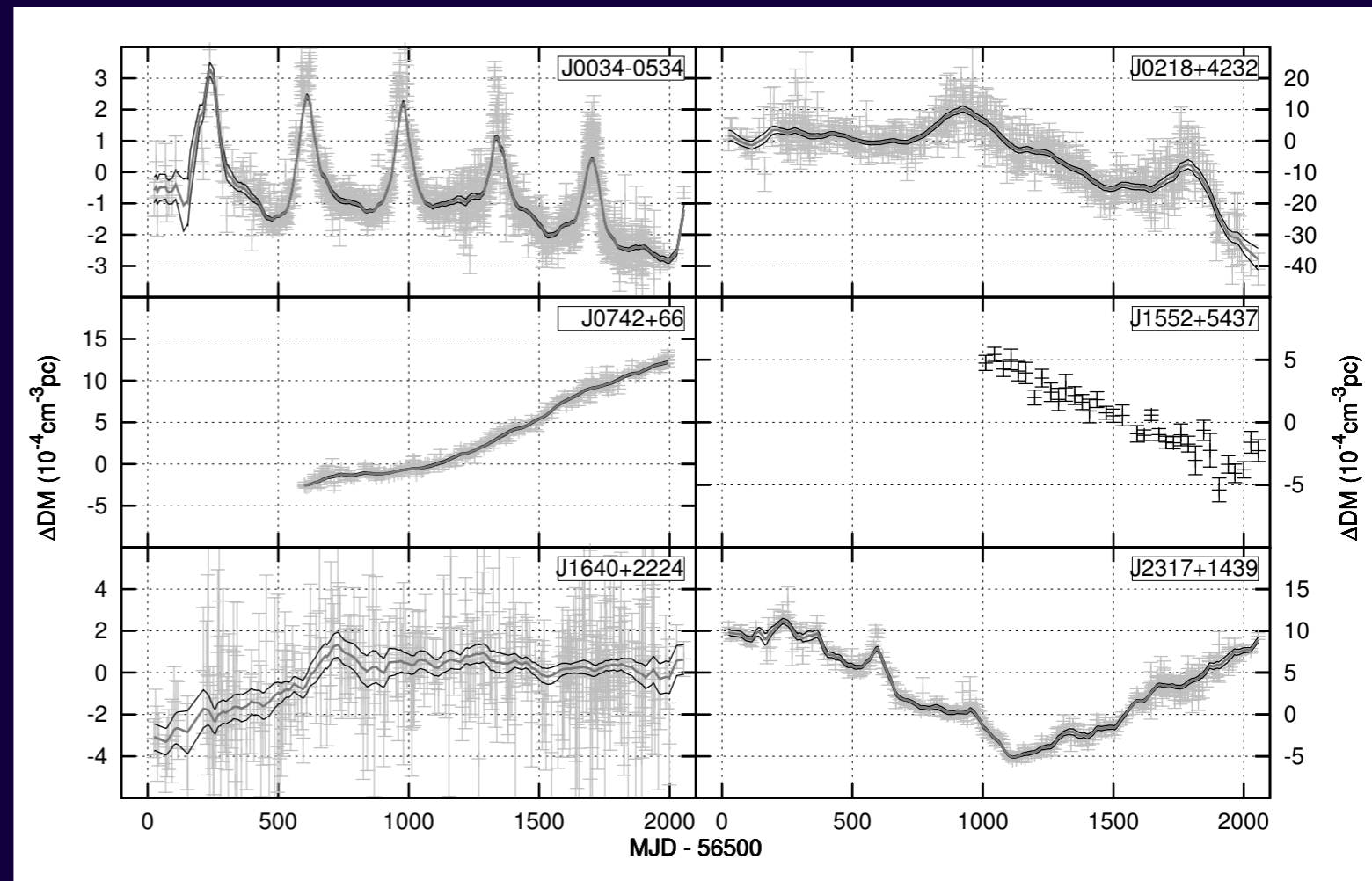
Chromatic dispersion measure

- * DM usually not assumed to be frequency dependent
- * DM integrated electron density
- * PSR J2219+4754
- * DM time series measured at upper and lower half of LOFAR band
- * DM variations in frequency
- * Lower frequency smoother
 - * Goes through larger volume of IISM
- * Need to understand chromatic DM to correct for DM when timing



DM of Millisecond Pulsars

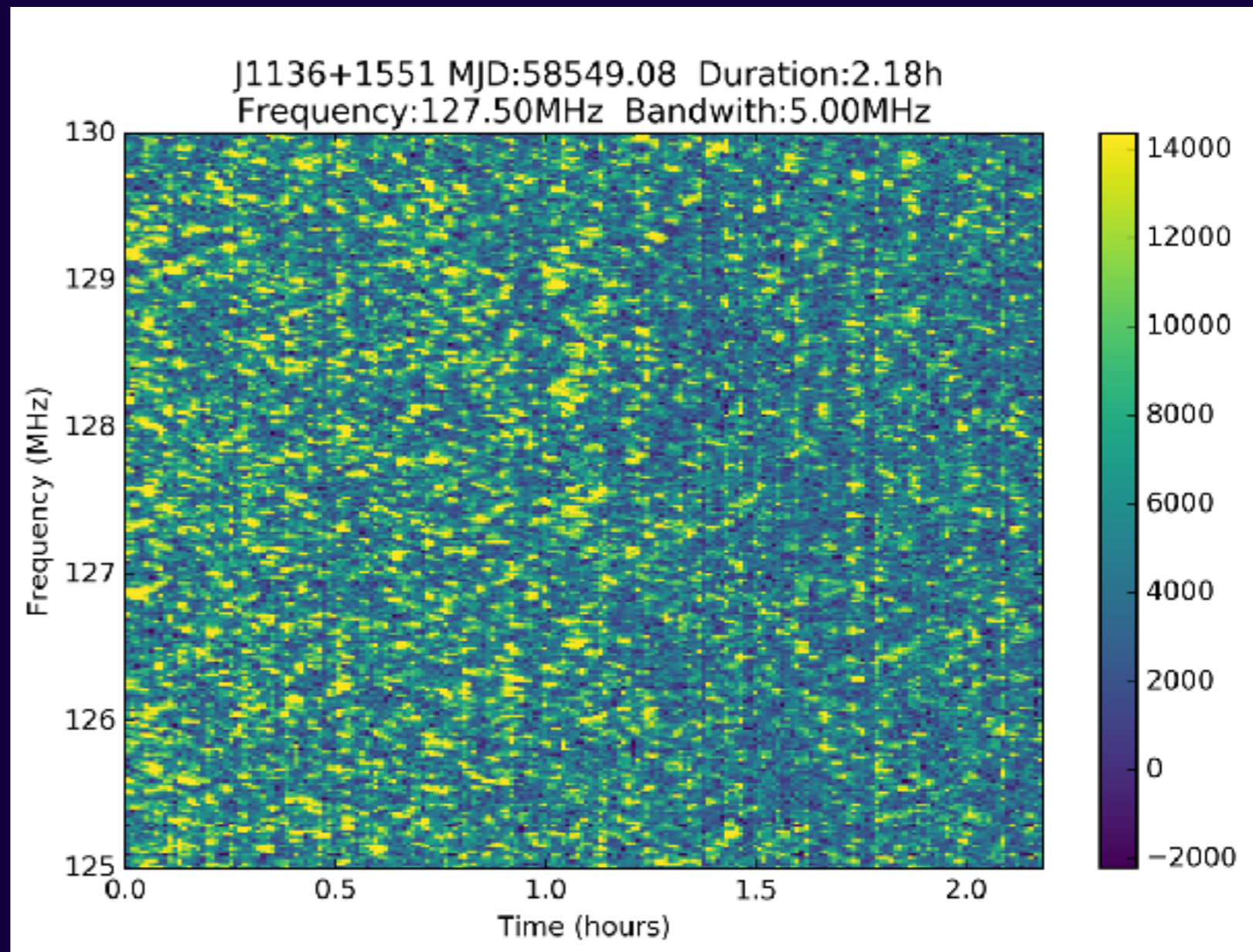
- * MSP DM project
- * LOFAR core + GLOW
- * Average DM of MSPs
- * Features/properties:
 - * Solar wind (J0034-0534 & J2317+1439)
 - * IISM (J0218, J0742, J1552, J2317 (core))
- * J1640+2224 very few variations, still DM variation
- * DM variations are on a variety of scales and shapes
- * Object: Use highly precise DM measurements to improve timing of EPTA pulsars



Donner, J. et al, in prep

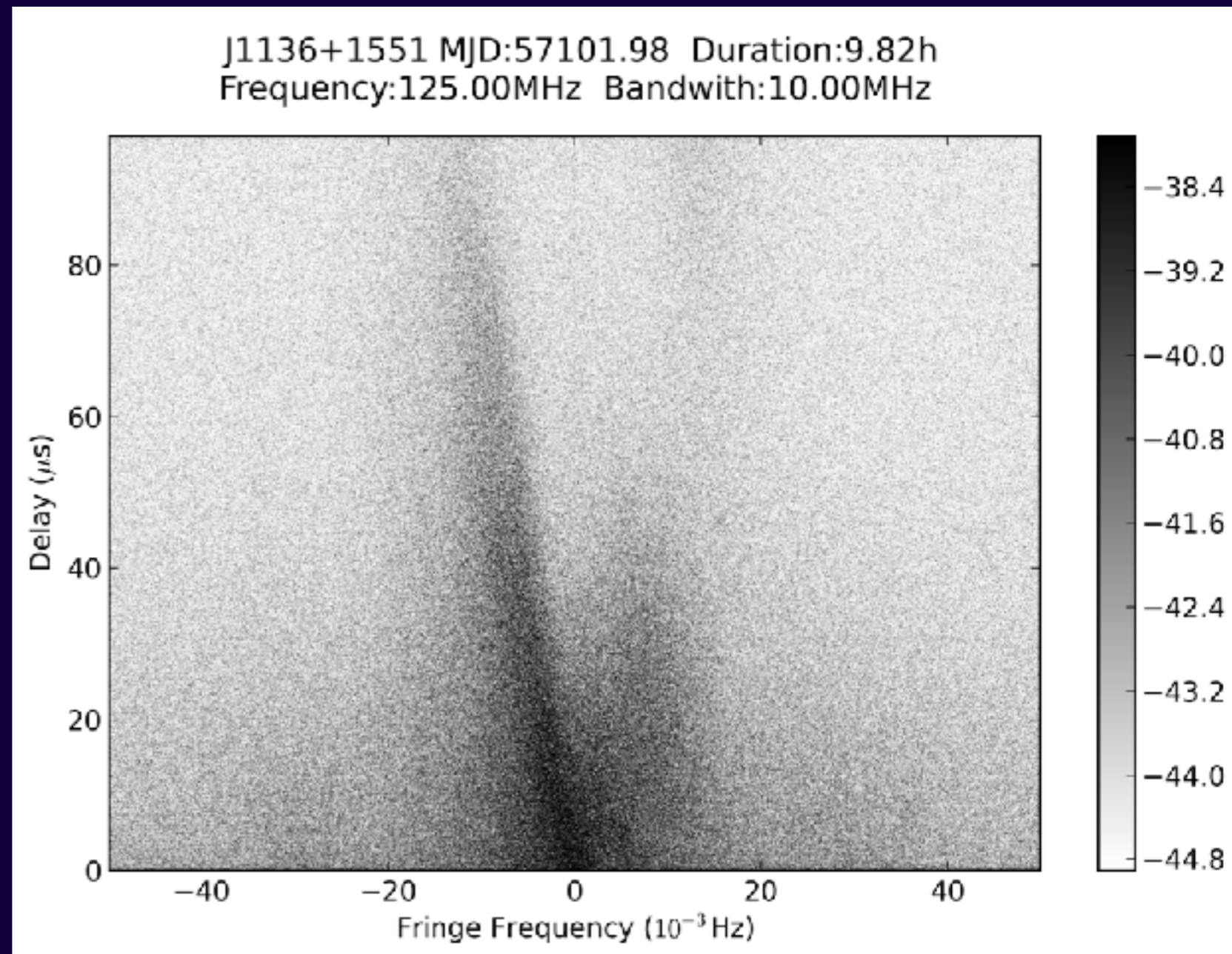
Scintillation arcs

- * Dynamic Spectra
- * Diffractive scintillation pattern
- * LOFAR data shows very detailed scintillation pattern



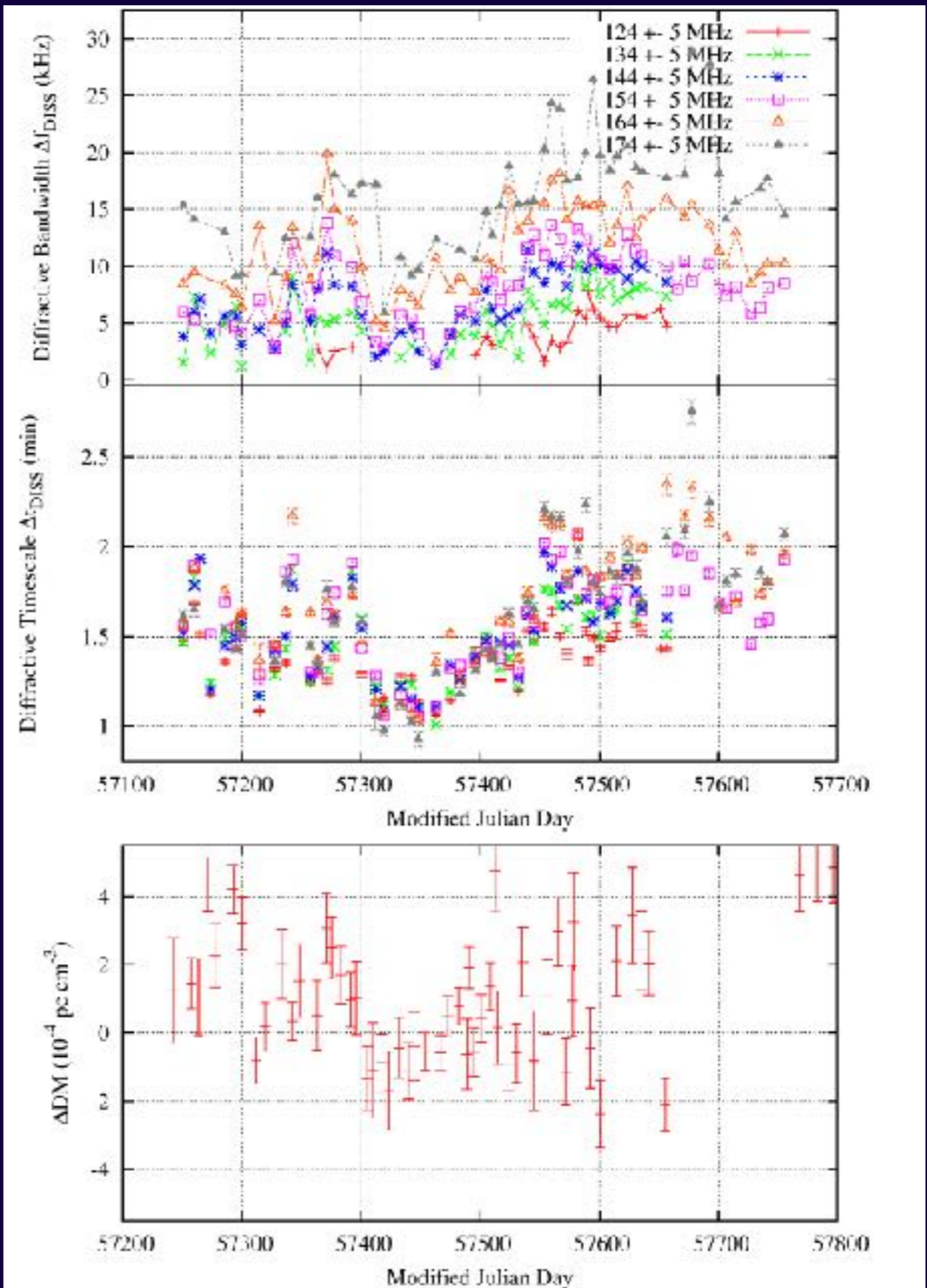
Scintillation arcs

- * 2D fourier transform of dynamic spectrum - Scint. Arcs
- * Scint. Arcs discovered in 1986, not until 2000s origin known
- * Representation of doppler shifted and reflected pulse signal
- * Reflected through filament in IISM
- * Arcs fuzzy in LOFAR - scattering disc
- * Information about the physics of the scattering screen/IISM structure
- * Not seen for MSPs



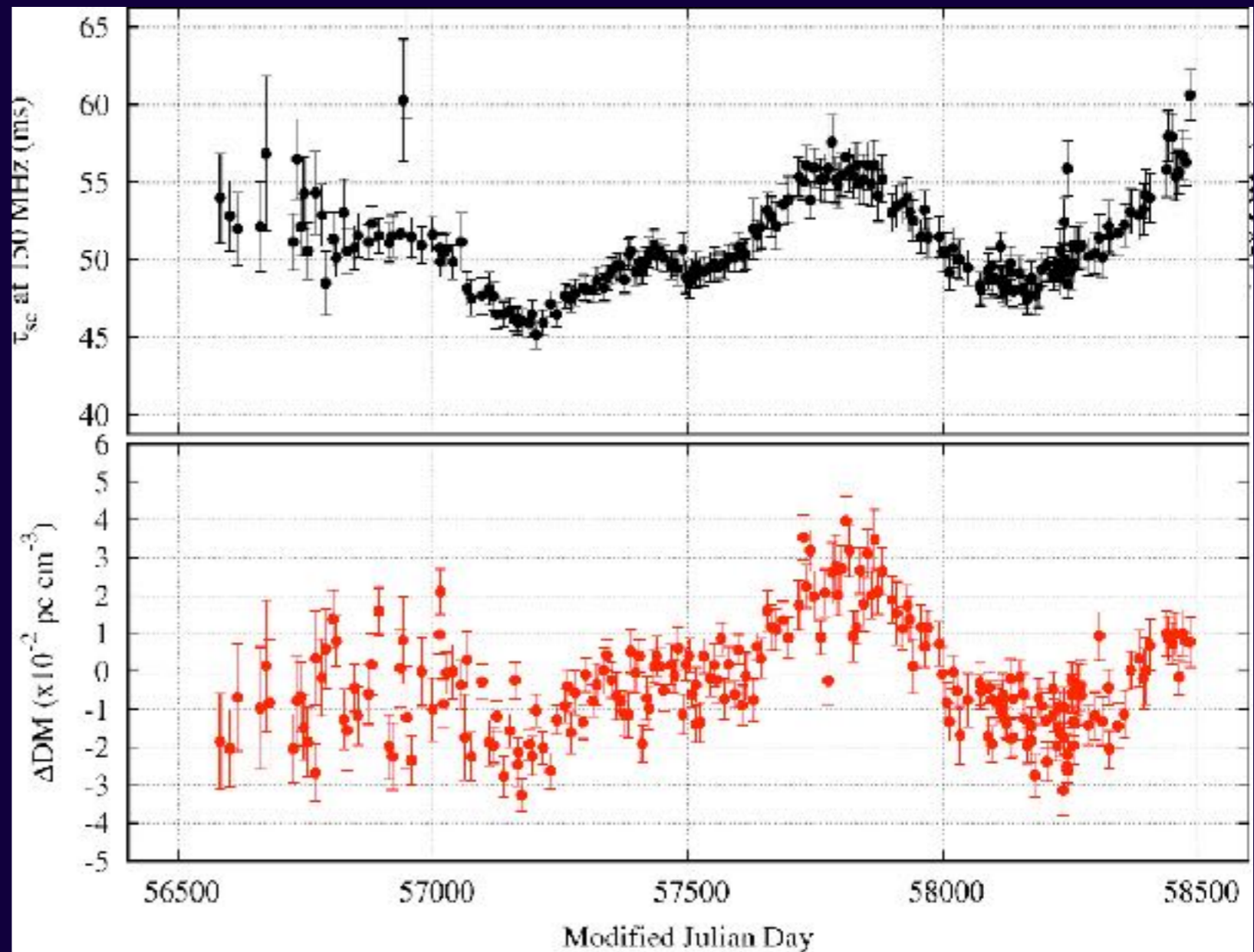
Scintillation time series

- * Clear correlation between DM and scintillation parameters
 - * Only seen in one pulsar
 - * Checking claim from literature
- * Scintillation parameters for J0837+0610 (top plots)
- * DM off-set by 100 days
- * Not clear why this correlation is present
- * Observations between 08/05-2015 to 24/09-2016



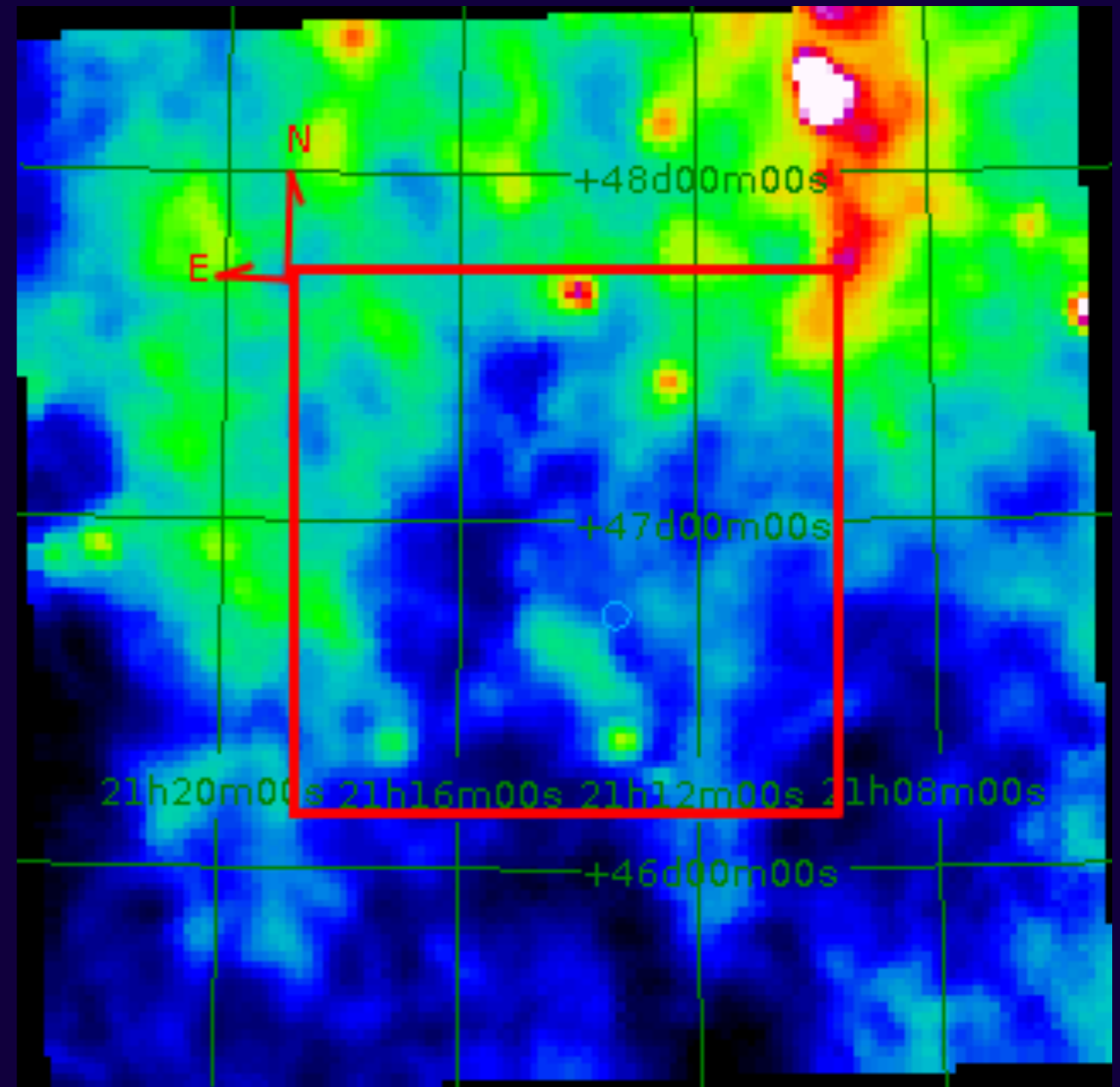
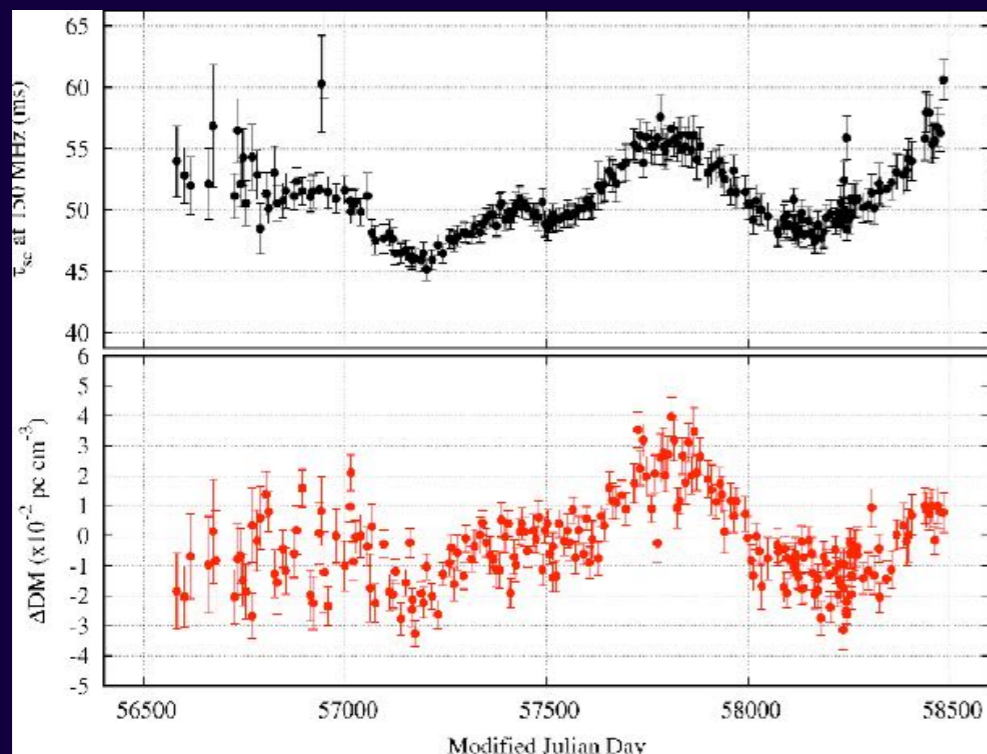
Scatter broadening - DM correlation

- * Scatter-broadening and DM variations
- * PSR J2113+4644
- * Strongly correlated variation
- * Scatter-broadening:
 - * Broadening of pulse signal with frequency
 - * Fitting a Gaussian + exponential decay function to HBA band
- * DM for each observation



Scatter broadening - DM correlation

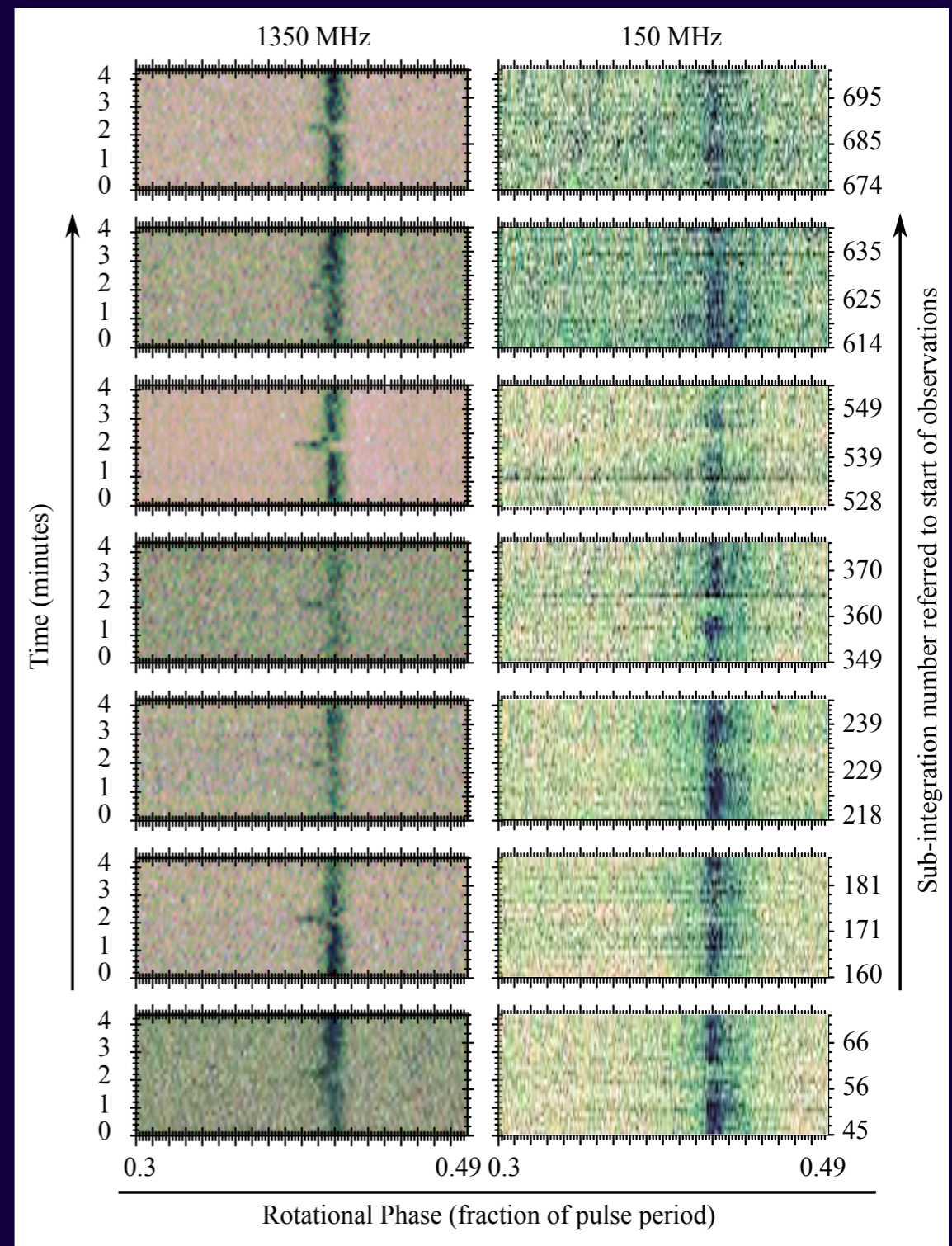
- * In line of sight of North America and Pelican nebulae ($d \sim 700 \text{ pc}$)
- * Pulsar PX distance is 4 kpc
- * Nebulae is ionised by O-type star and is strongly magnetised
- * Cause variations seen in DM
- * WISE infrared image



Krishnakumar M.A., initial results

Recent papers from GLOW

- * Shaifullah et al. 2018 (Multi frequency behaviour of “Swooshing” pulsar, PSR J0922+0638.)
- * Porayko et al. 2019 (ionospheric rotation measure)
- * Donner et al. 2019 (chromatic dispersion measure)
- * Tiburzi et al. 2019 (Solar wind)





Thank you!

Extra - scatter broad. - DM corr.

