Study of Interstellar Medium below 100 MHz using the LWA

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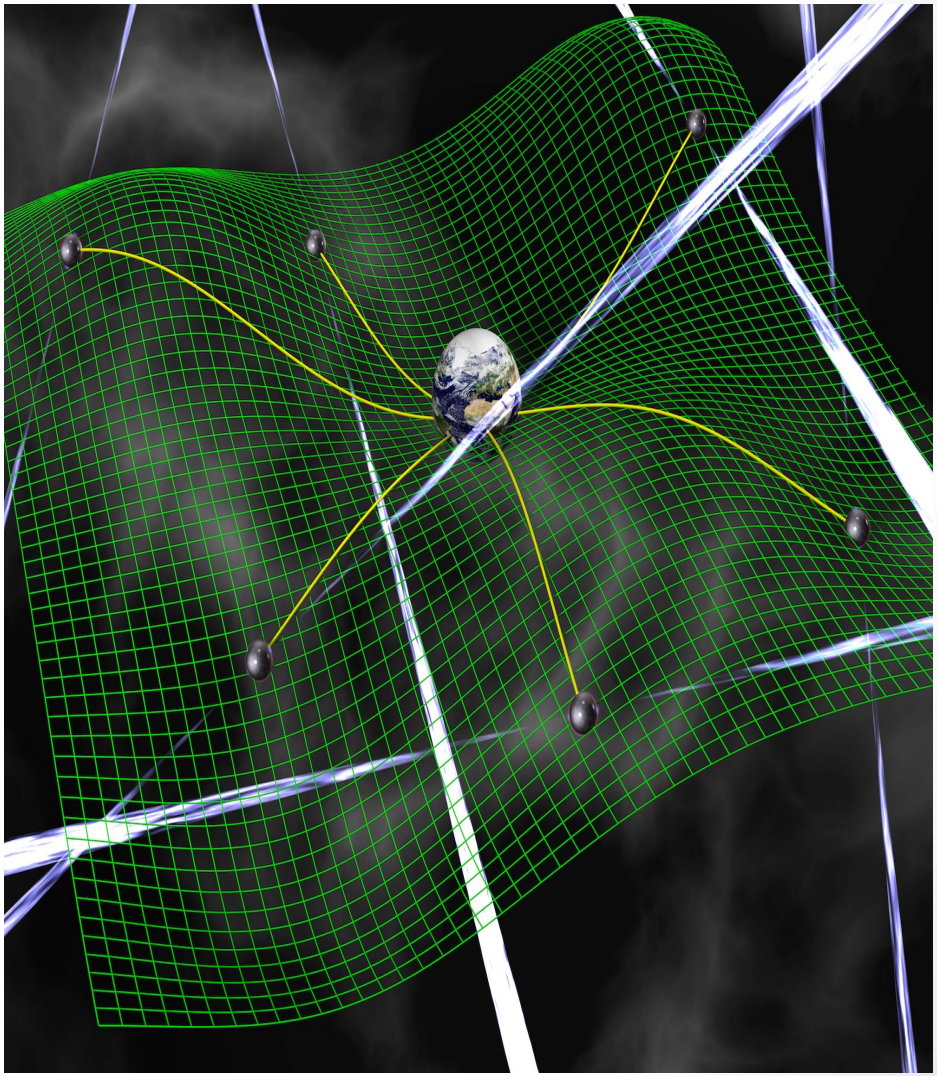
BACKGROUND

- Supermassive black hole binaries (SMBHB) emit from nano to micro Hz.
- Relevance to Gravitational waves
- Pulsar timing
- Low Frequencies



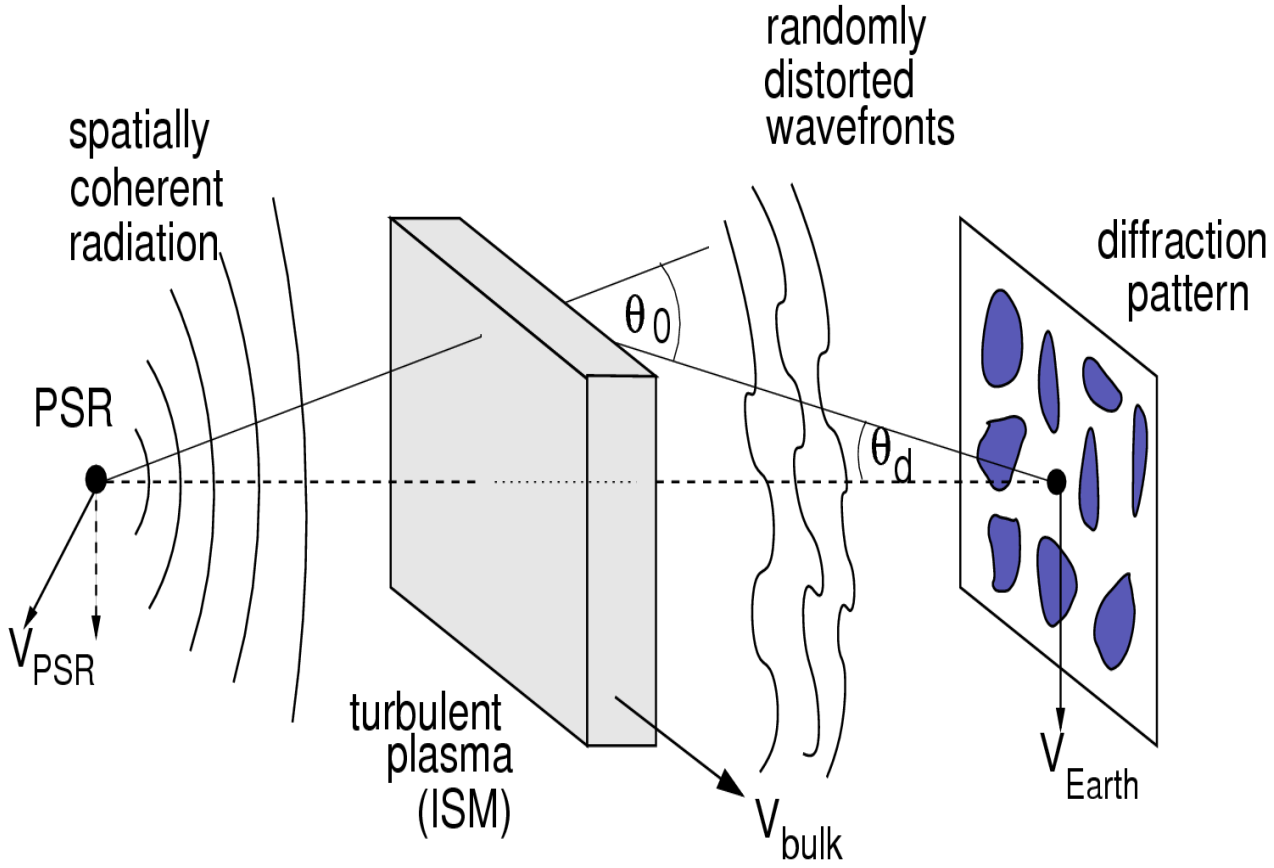
PULSARS

- Rotating Neutron Stars
- Highly dense
- Misaligned Rotation and Magnetic axis
- Beamed emission
- Highly periodic ranges from milliseconds to 24 seconds

ISM EFFECTS

- Dispersion
- Scattering
- Scintillation
- Angular Broadening

Thin Screen Model



Cordes (2002)

ISM EFFECTS

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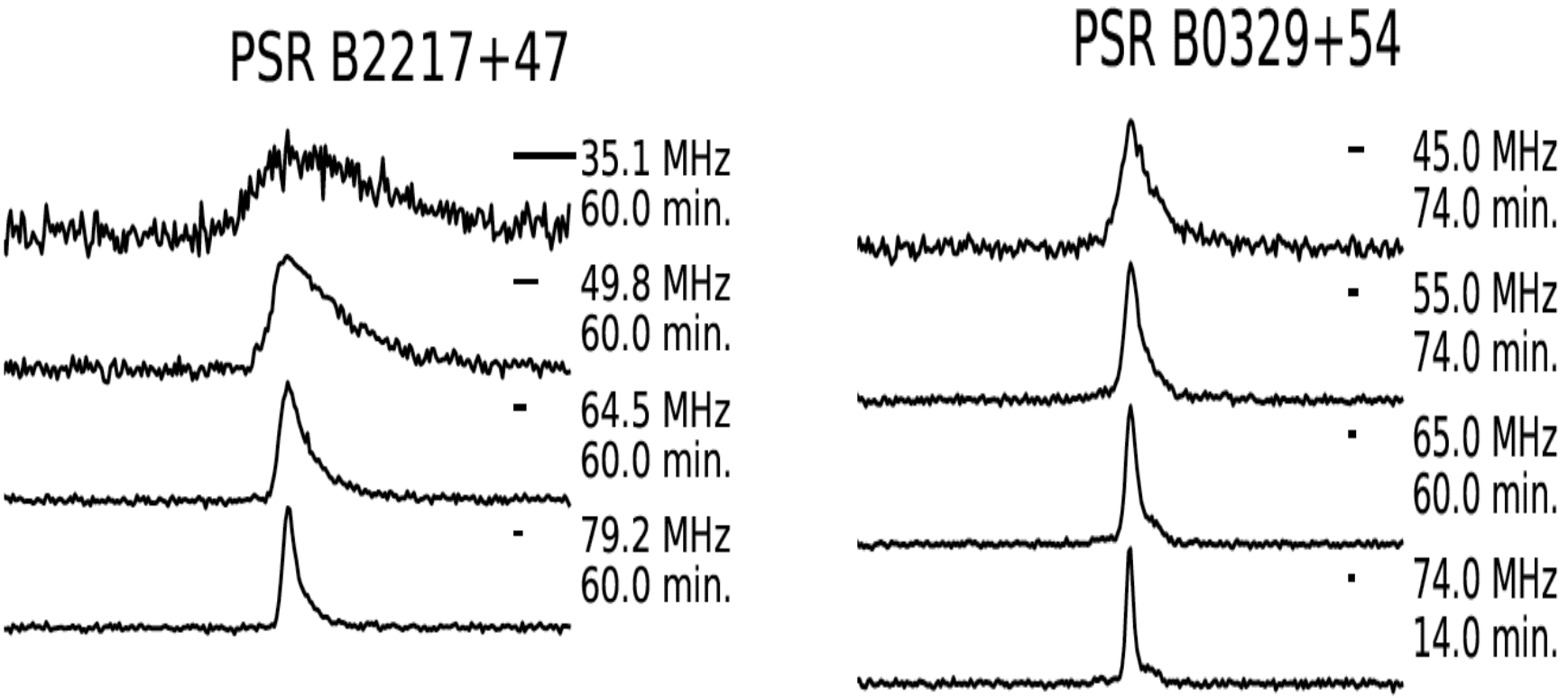
Scattering – Pulse Broadening



Stovall et al 2014

Scattering Model

Pulse Model

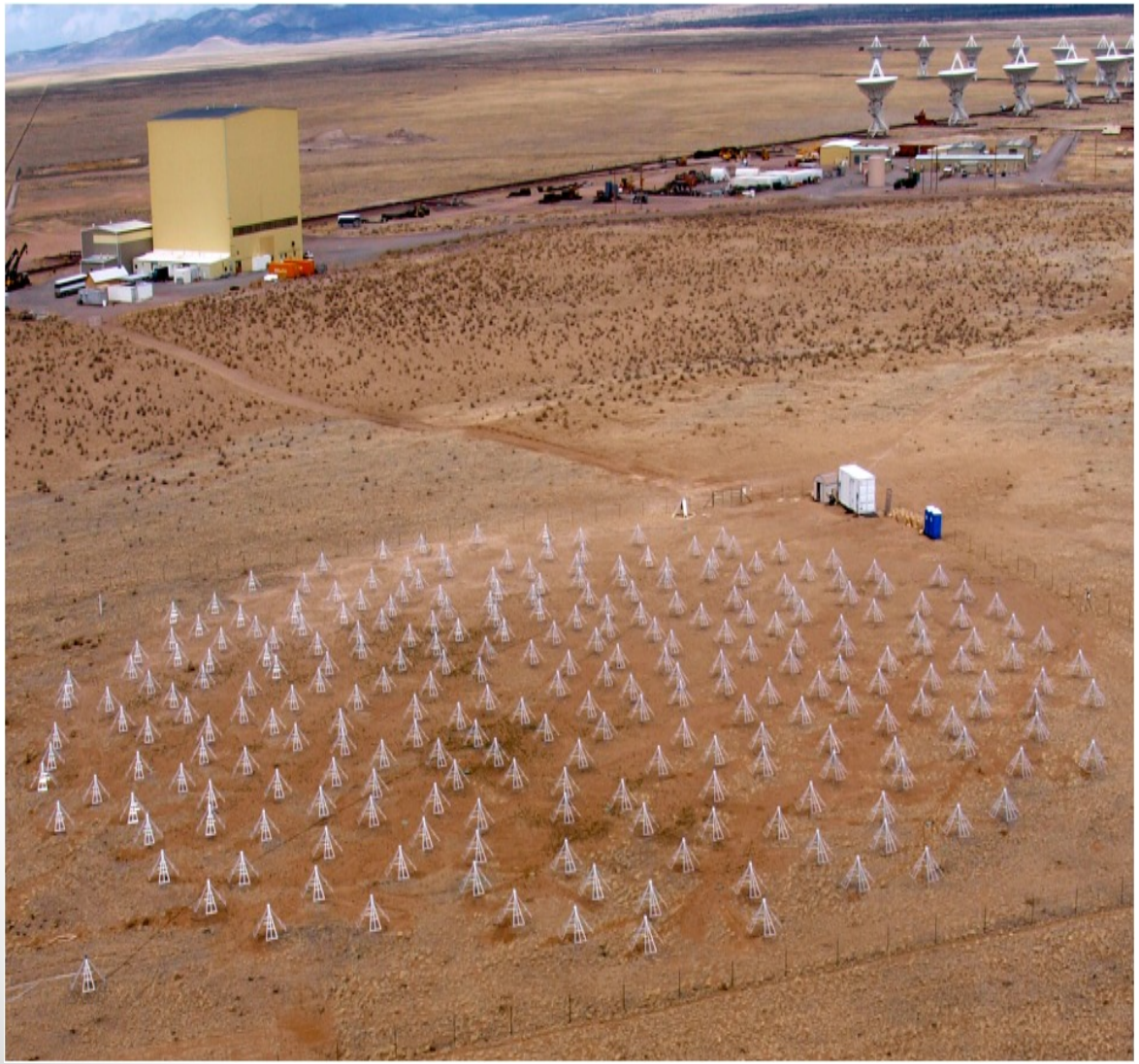
$$P(t) = P_i(t) * s(t) * D(t) * I(t)$$

Scattering Function

$$s(t) = exp(-t/\tau_{sc})$$

(Krishankumar et al. 2015)

Long Wavelength Array-1



- 10 – 88 MHz
- 256 dipoles
- 4 beams, 2 per tuning
- Each tuning Bandwidth - 19.6 MHz
- 4 Frequency bands – 35.1, 49.8, 64.5, & 79.2 MHz
- Dual Polarization
- Online Pulsar Archive

Pulse Fitting Model

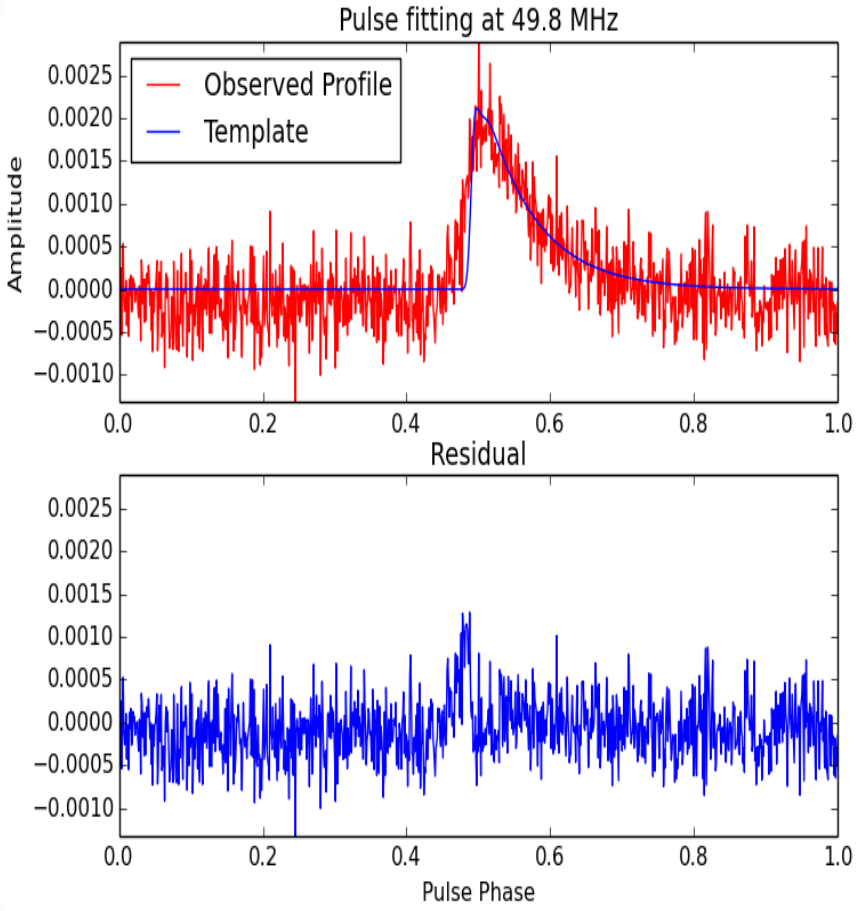
Intrinsic Profile Model (IPM)

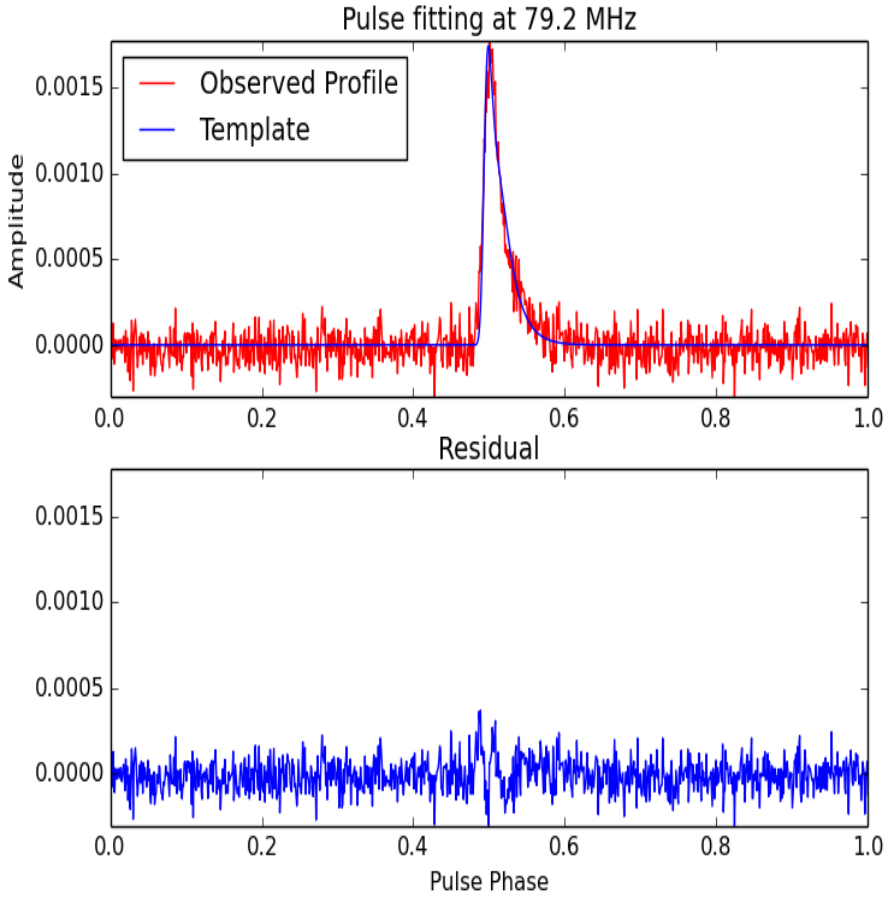
- Average profiles ranging from 100 – 600 MHz from EPN. May include 79.2 MHz
- Sum of Gaussians to model each profile
- Obtain frequency dependency for component width and Separation

Scattering Time:

- Convolve IPM with an exponential function
- Chi-square fitting algorithm while fitting the template to the observed pulse profile.

Model Fitting





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Scattering Spectral Index

Scaling Relations:

$$\tau \propto \nu^{\alpha} DM^{\beta}$$

Circularly Symmetric Gaussian Distribution:

α = -4, β = 2

Kolmogorov Electron Density:

α = -4.4, β = 2.2

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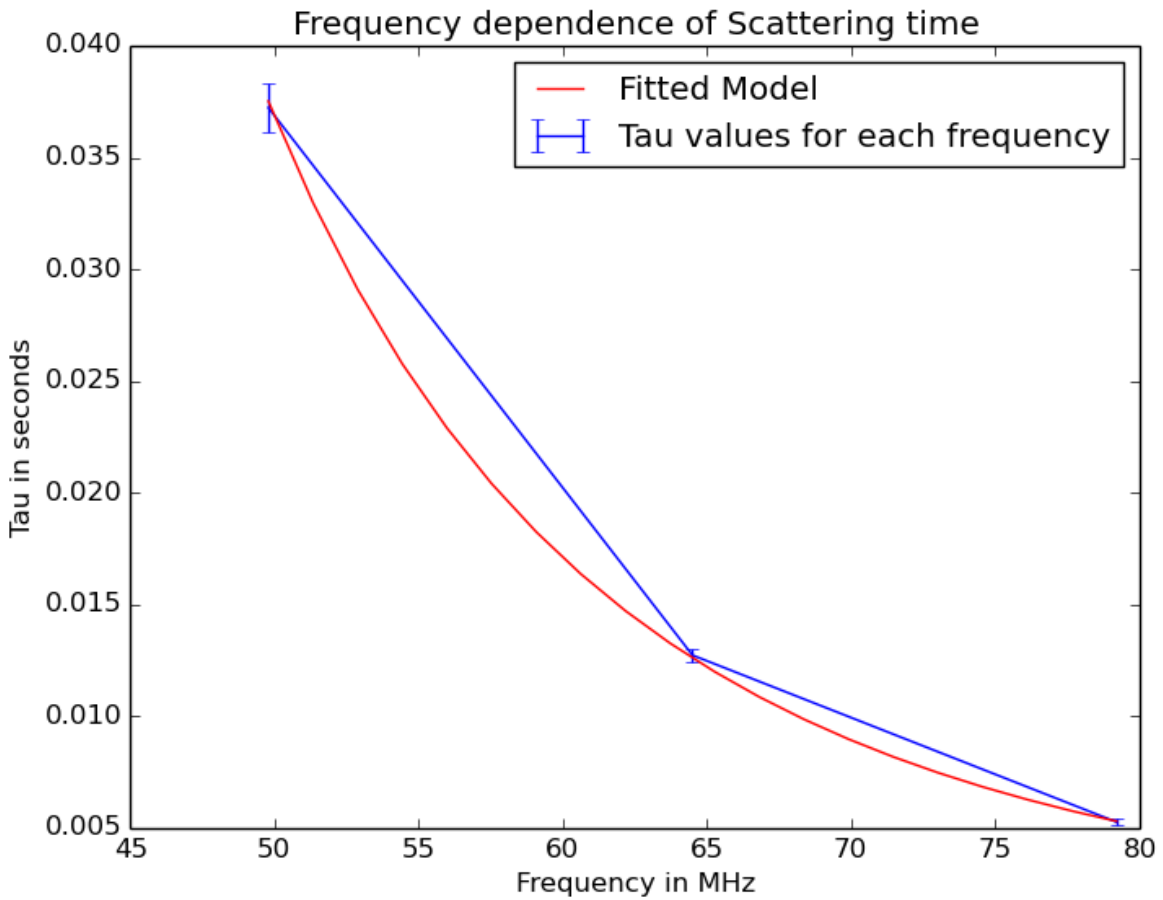

α-value = -4.21 +/- 0.05

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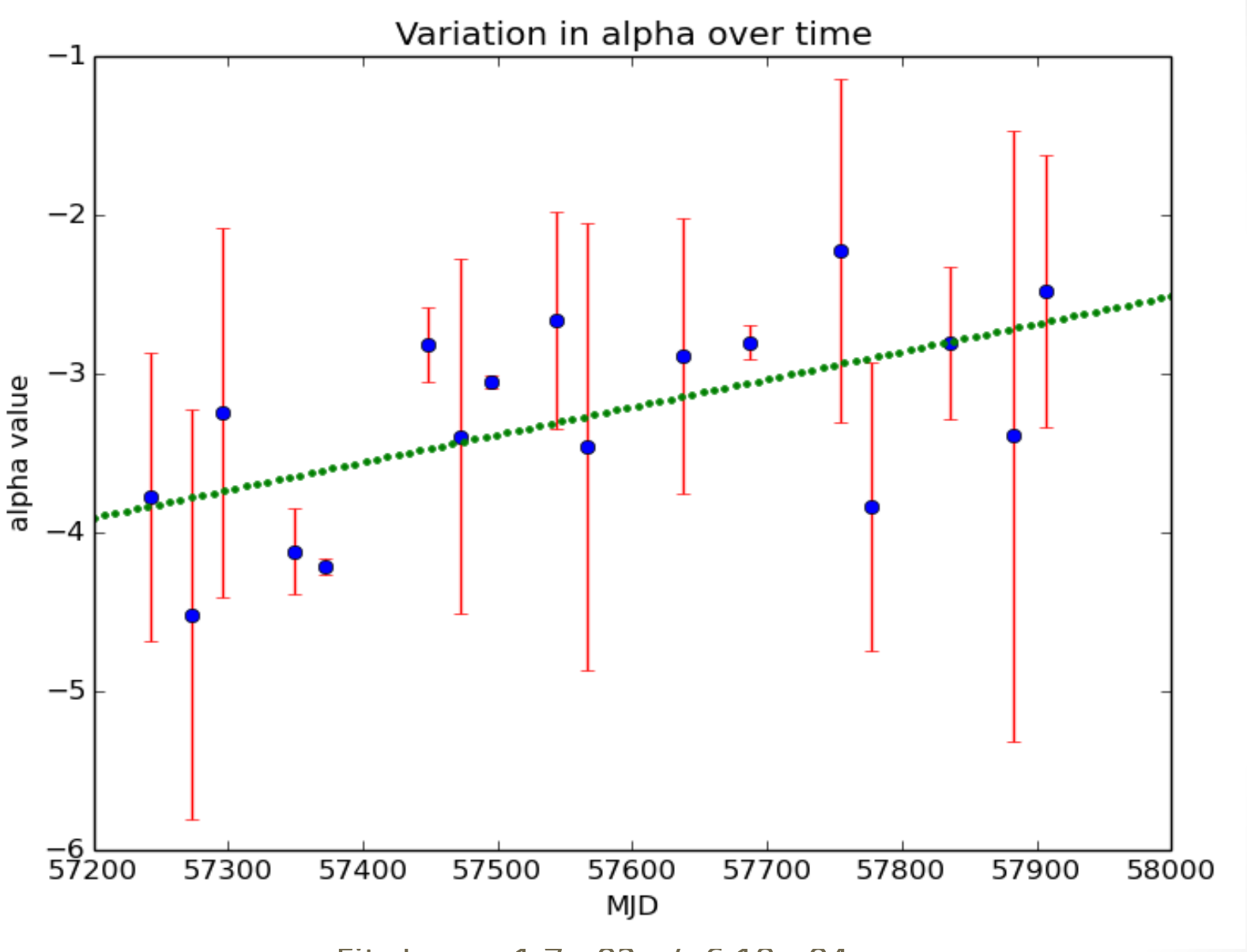

Fit slope = 1.7e-03 +/- 6.18e-04

Mean Value = -3.39 +/-0.79

Summary

- Previous observations – alpha-value> -4.
- Time variation in alpha has been studied for the first time.
- This combined with variation in DM will enable us to better model the scattering.
- Apply this procedure for about 10 pulsars.

Questions?