

Wideband timing of Parkes Pulsar Timing Array UWL data

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1. Introduction

Pulsar timing array (PTA) experiments provide extraordinary means to study a wide range of physical phenomena across nearly all branches of physics and astronomy. In particular, analysis of variations in pulse times of arrival (ToAs) can be used in searches for nHz gravitational waves generated by, e.g. super-massive black hole binary inspirals or cosmic strings. However, as such processes may have a very subtle effect on our measurements, an increase of the precision is a vital element of current PTA efforts.

Ways to increase PTA sensitivity:

- Observe more pulsars
- Observe more frequently
- Upgrade telescopes/receivers

2. UWL receiver

Based on the radiometer equation:

$$\frac{T_{sys}}{A_{eff} t_{obs} f} \quad (1)$$

ToA measurement precision can be increased by:

- lowering down systems temperature T_{sys} ,
 - increasing the aperture A_{eff} ,
 - increasing time of observations t_{obs}
- or
- increasing the bandwidth of observations

Since 2018 the Parkes Radio Telescope (Murriyang) has been carrying out observations using ultra-wide bandwidth receiver (UWL) simultaneously covering **frequency range of 704 - 4032 MHz** (Hobbs et al. 2020).

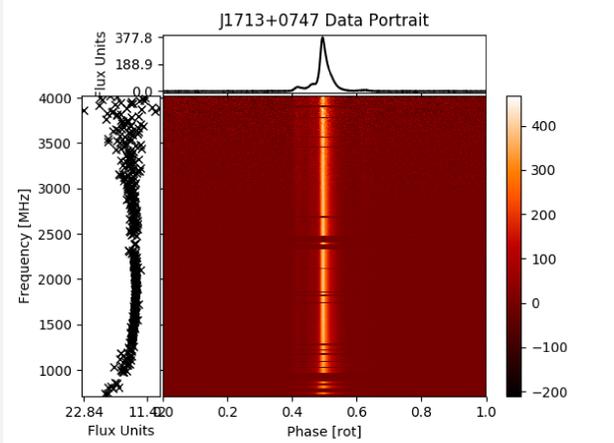
5. References

[1] Hobbs G. et al., PASA, 37, e012 (2020)

[2] Pennucci T. T. et al., ApJ, 790, 16 (2014)

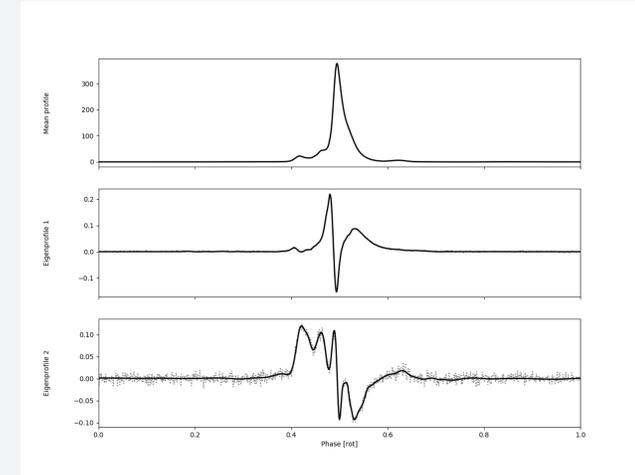
[3] Kerr M. et al., PASA, 37, e020, (2020)

3. Wideband timing with Pulse Portraiture

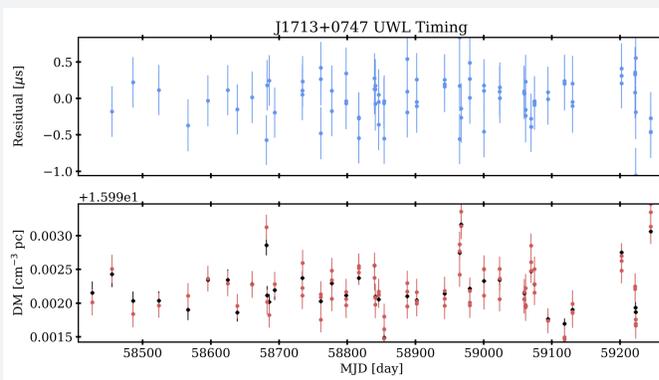
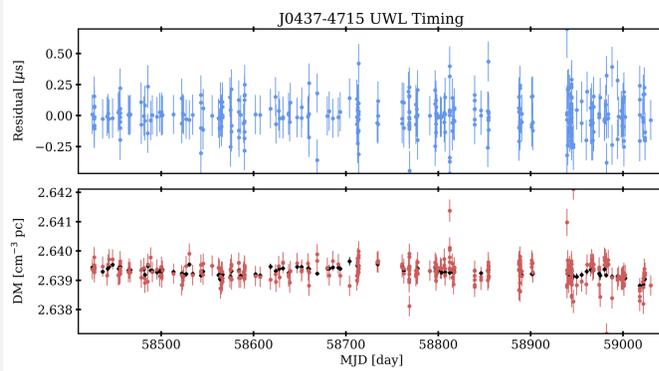


What's different compared to standard techniques?

- 2-D profile template maintaining frequency resolution
- Modelling frequency evolution of the pulse profile
- One measurement of ToA and dispersion measure (DM) per whole band



4. Results



Pulsar	ToA error		RMS	
	UWL	DR 2	UWL	DR 2
J0437-4715	0.007	0.057	0.133	0.59
J1713+0747	0.073	0.403	0.289	0.32
J1909-3744	0.034	0.52	0.181	0.240
J2241-5236	0.009	0.37	0.299	0.26
J1022+1001	0.407	1.5	0.85	1.62
J1744-1134	0.152	0.57	0.504	0.46

Table 1. ToA errors and RMS for 6 of 38 pulsars observed with UWL. DR 2 values are averaged across 3 bands.

Applying Pulse Portraiture (Pennucci et al. 2014) analysis to UWL datasets resulted in **increased precision by a factor of few** (ToA errors) with respect to PPTA DR2 (Kerr et al. 2020) which was obtained with standard timing techniques and observations in 3 separate bands.

Plots in this section show residuals and DM measurements for our 4 best pulsars. We are currently working on improved noise analysis and timing solutions for all 38 pulsars observed with UWL since 2018.

