Pulsar Observations – Kiel-Roenne - 2024

Long Term Observation of PSR – B0329+54
Roemer-Delay and Some Further Astrometric Considerations

Hermann Fenger-Vegeler

9m Dish - Kiel-Roenne

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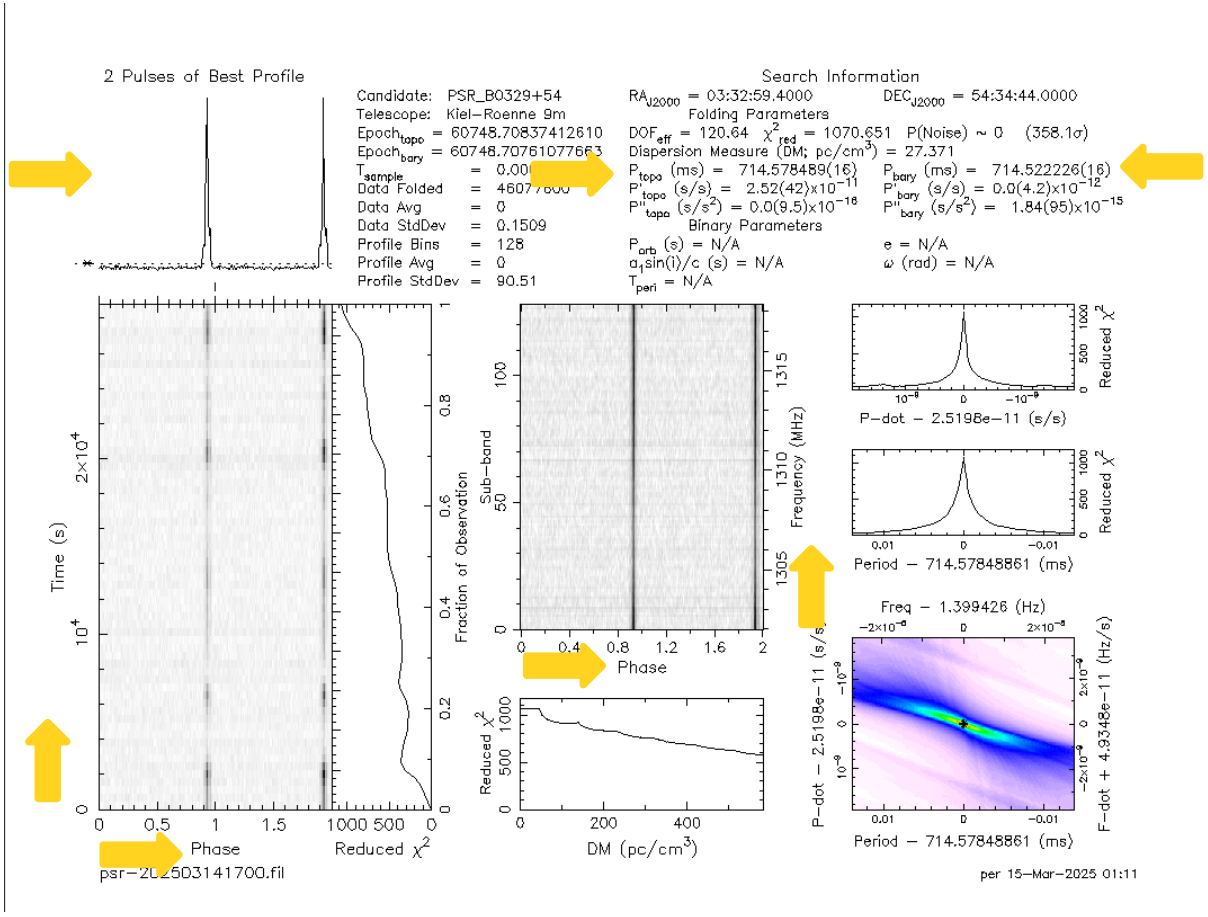
- LNA : Unique Piece : 1300 MHz – 300 MHz BW
- Receiver - Hardware :
  - SDR Ettus USRP B205mini
  - AMD Ryzen
- Software :
  - Ubuntu 22.04.
  - GNURadio
  - Presto incl. Tempo

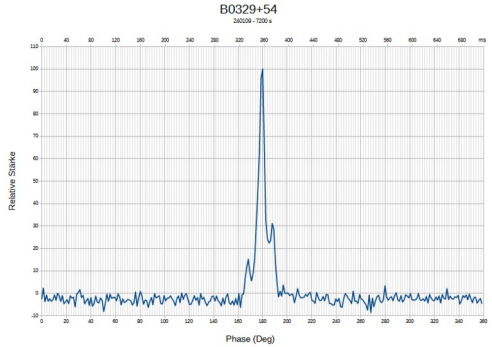
9m Dish - Kiel-Roenne

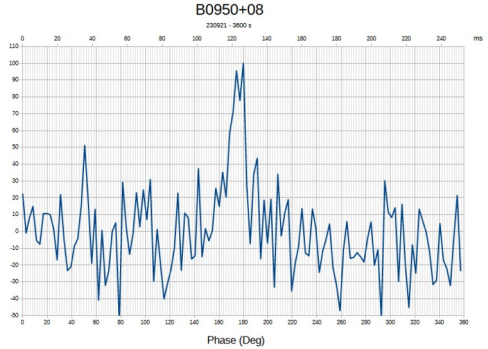
- Measurements at 1310 MHz – 16 MHz Bandwidth
- FWHM : < 2 ^{o}
- Aeff : 37 m^2
- Gain : 0.0135 K / Jy
- Tsys : ca. 60 K
- SEFD : 4450 Jy

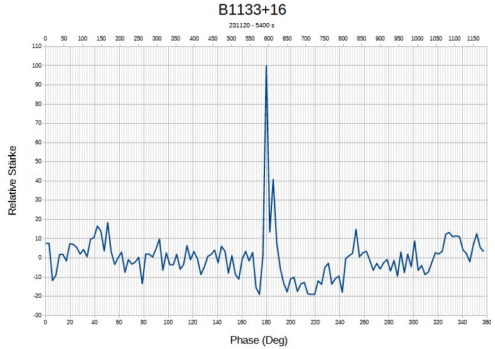
Presto Plot - PSR B0329+54

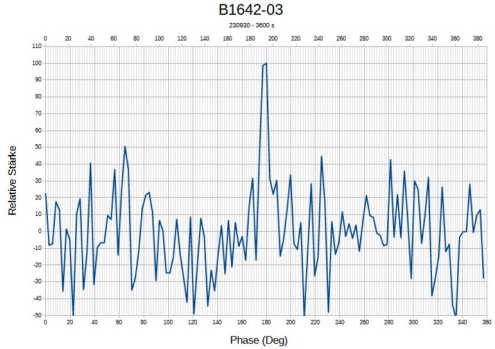


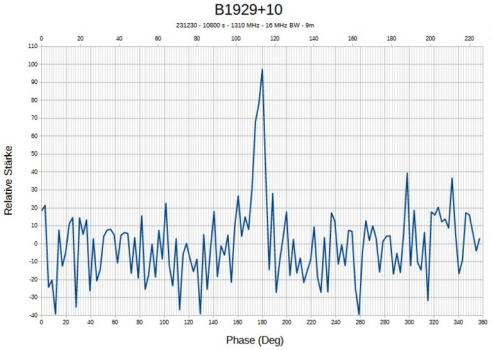
Pulsar Zoo 2024

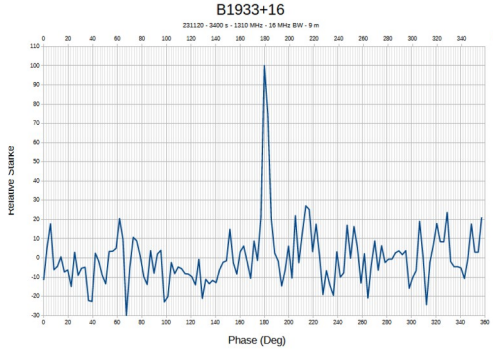


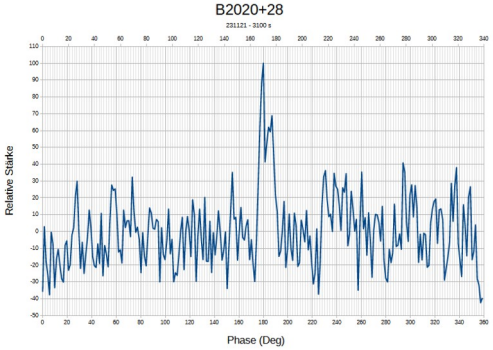


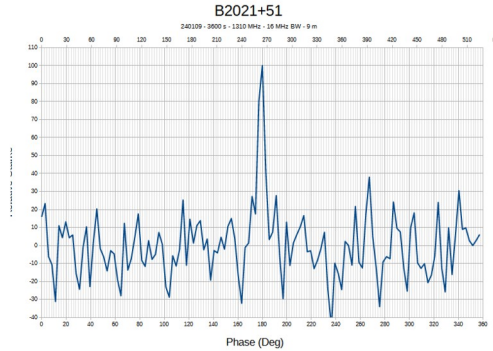












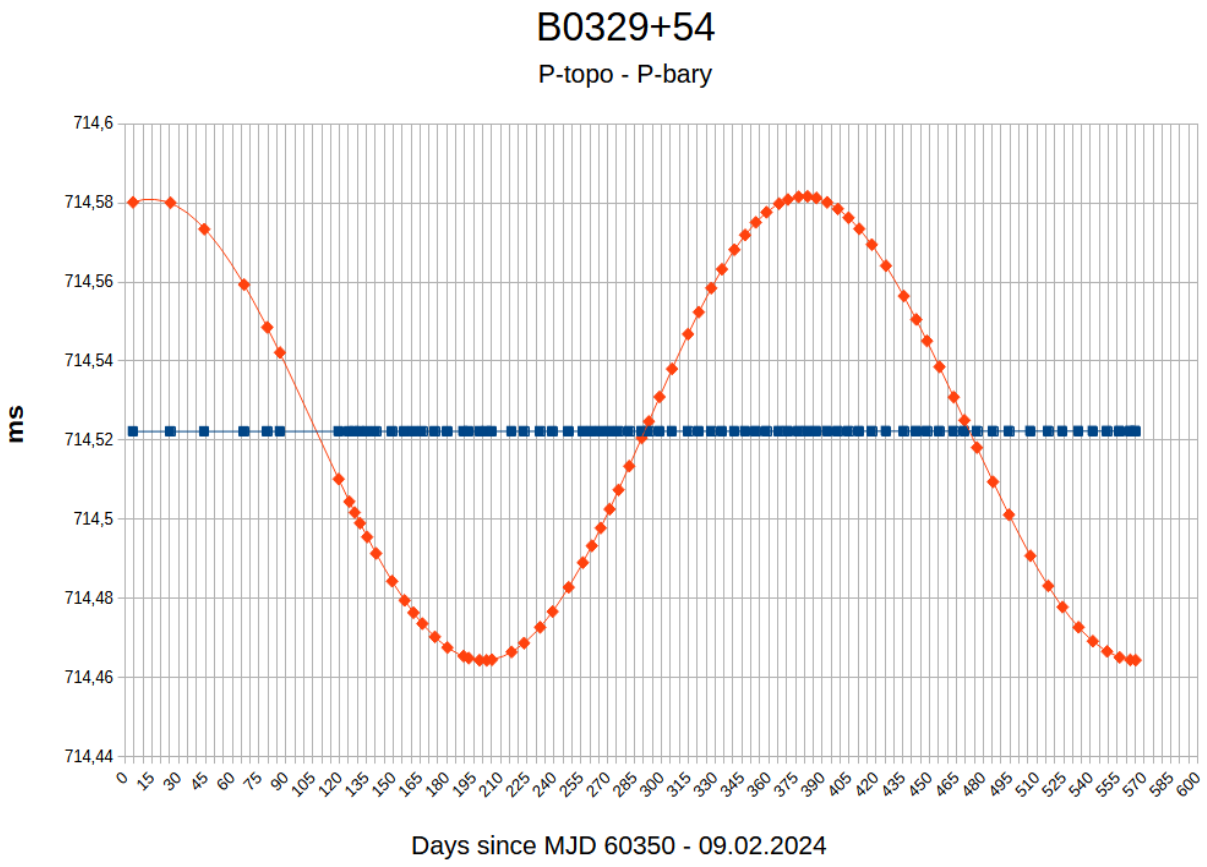
Long-Term-Observation -LTO- of PSR-B0329+54

- Motivation
  - Observing the temporal changes of the periods
  - Questions about astrometric applications of pulsar data
  - Questions about the interstellar medium - scintillation and intensity fluctuations of a pulsar - dynamic spectrum

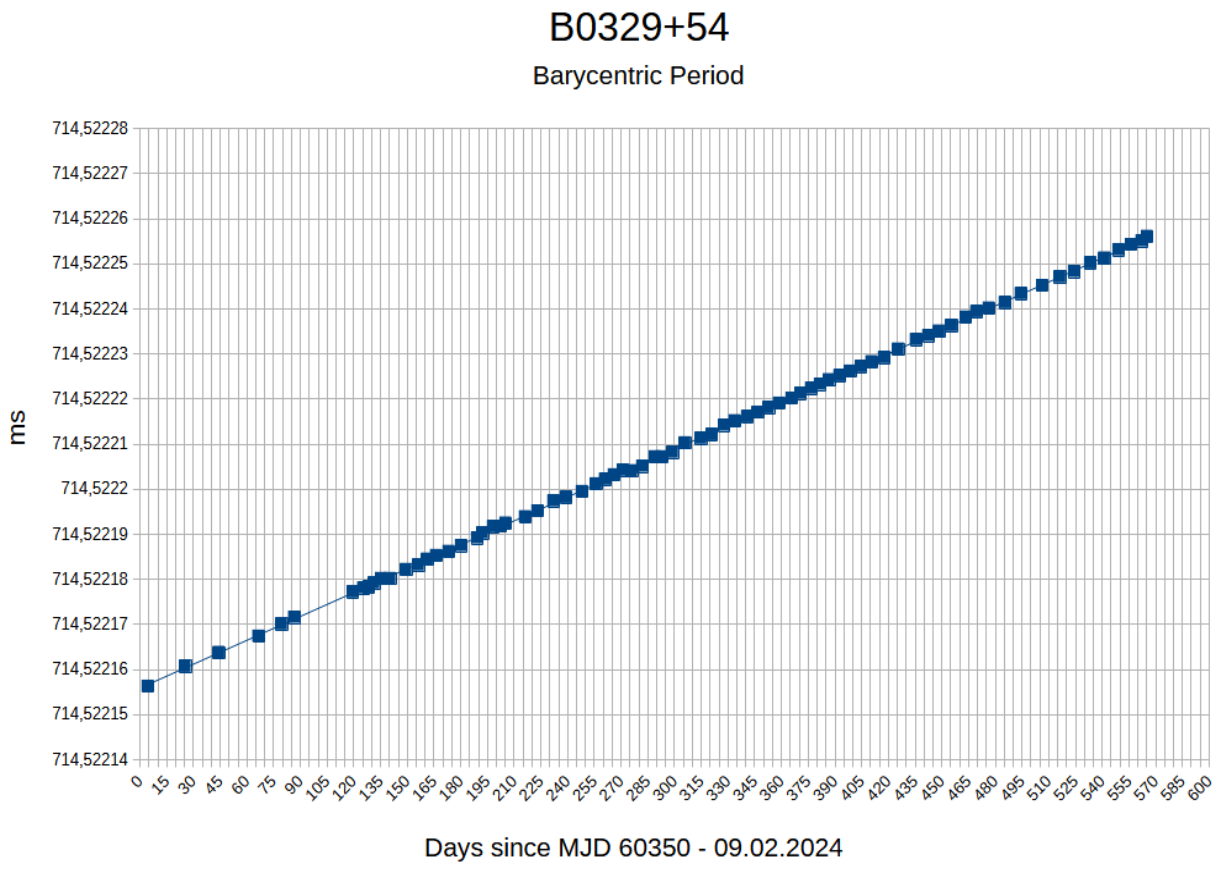
LTO – PSR B0329+54

- Start of observations June 2024
  - Nearly all measurements were carried out over 8 hours
  - More than 70 observations corresponding to 560 hours of observation and approximately 1500 GB of data.

LTO – PSR B0329+54



LTO – PSR B0329+54



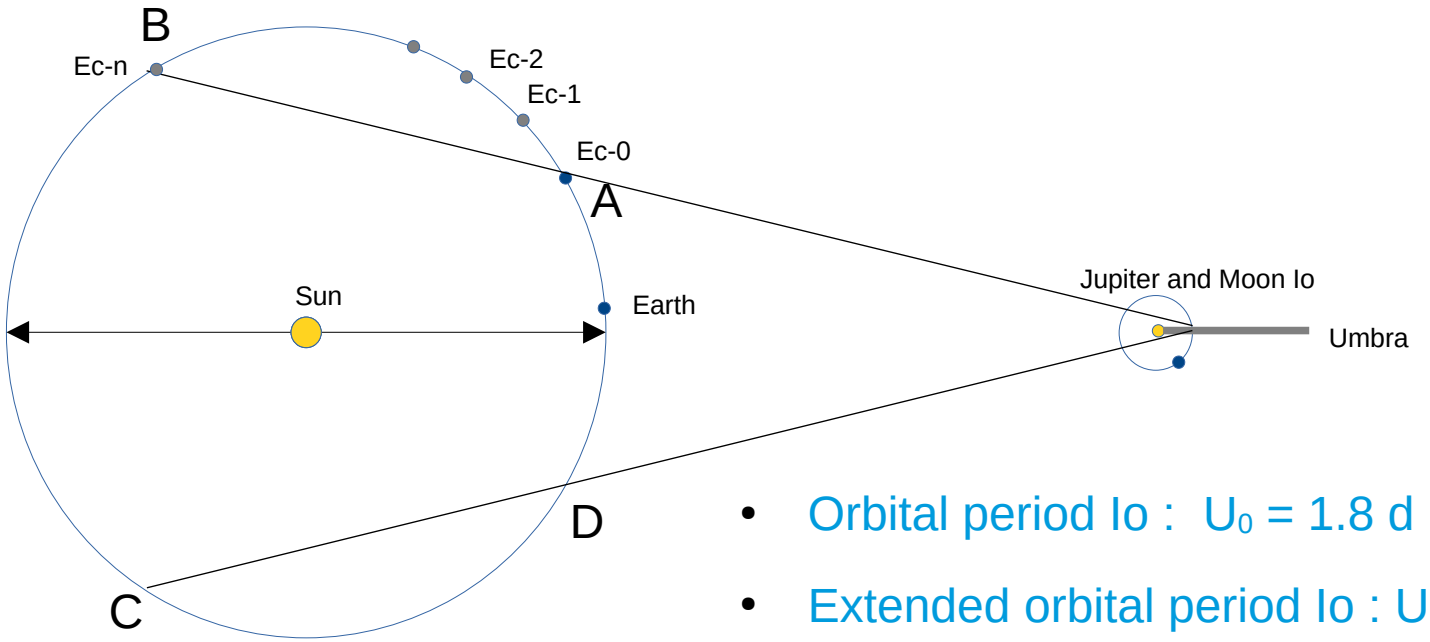
Roemer - Delay

Signal Propagation Time

- First determination of the speed of light by Ole Roemer 1676
- 1610 - Galileo Galilei discovers the moons I – IV of Jupiter
- 1668 – First eclipse tables were calculated by Giovanni Cassini [14]
- 1676 – Ole Roemer recognizes that periodic deviations in eclipse data are due to the Earth's movement around the Sun and thus to a finite speed of light.
- Roemer calculated the time it takes for light to travel 1 AU to be 11 minutes. [13]
- 1678 - Christiaan Huygens determined the speed of light to be :

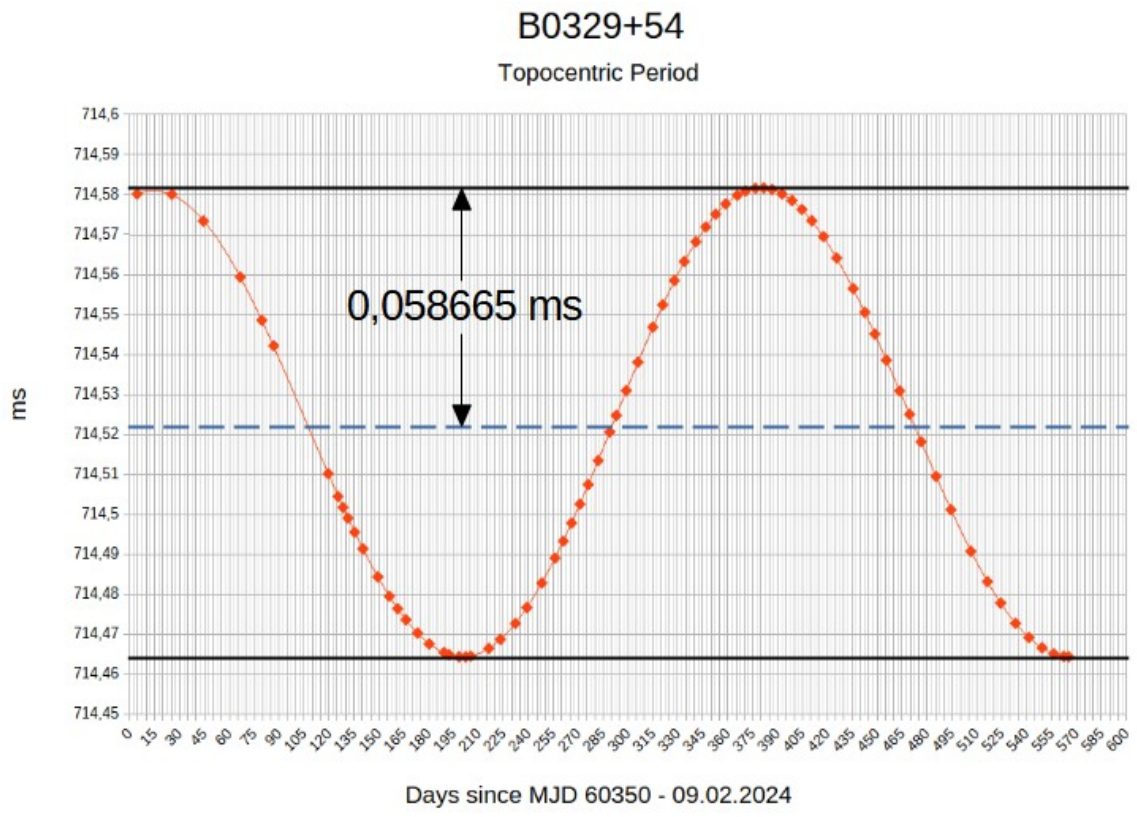
$$c = 212{,}000 \text{ km/s}$$

Roemer Delay and the Speed of Light



- Orbital period Io : $U_0 = 1.8$ d
- Extended orbital period Io : $U_n = U_0 + dt_n$
- Total delay dt = Sum(dt_n)
- $c = \overline{AB} / dt$

LTO – PSR B0329+54



LTO – PSR B0329+54 - Results

- Signal propagation time for 1 AU measured :

$$dt = sum(dtn) = mean(A) * f * year / 4 :$$

$$dt = 412.4\ s +/- 1\ s$$

- Signal propagation time for 1 AU corrected :

$$dt_C = dt / \cos(\beta)$$

$$dt_C = 498.97\ s$$

- Speed of light $c = \overline{AB} * \cos(\beta) / dt$:

$$c = 299{,}813{,}356\ m / s$$

- Ecliptical latitude - β - of the Pulsar :

$$34.26\ deg +/- 0.03$$

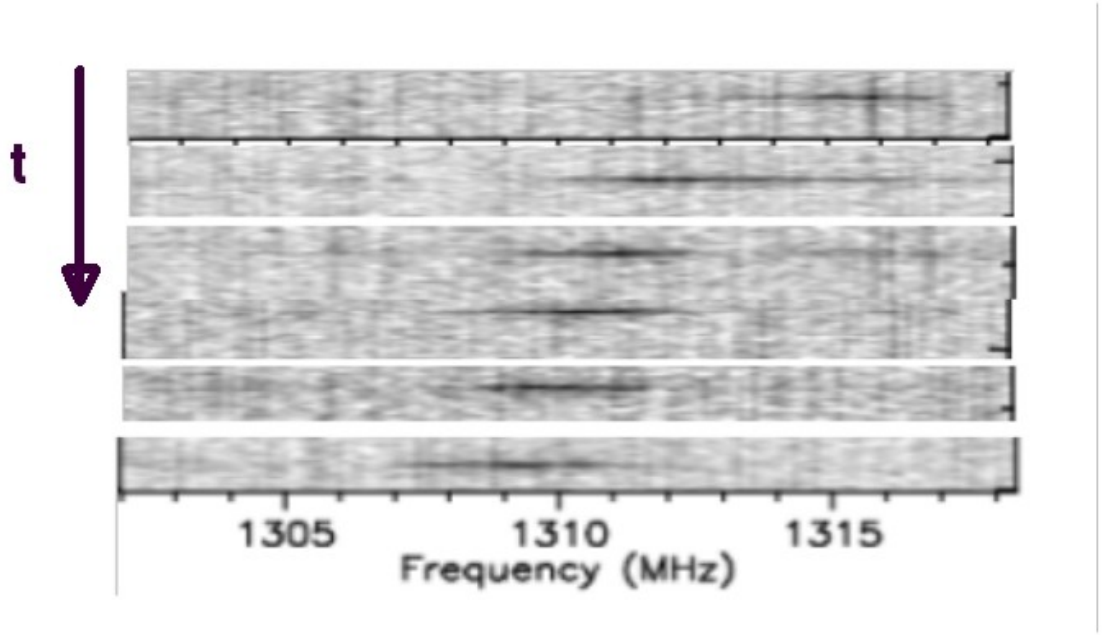
- Astronomical Unit - AU :

$$149{,}597{,}953{,}504\ m$$

LTO – PSR B0329+54 - Results

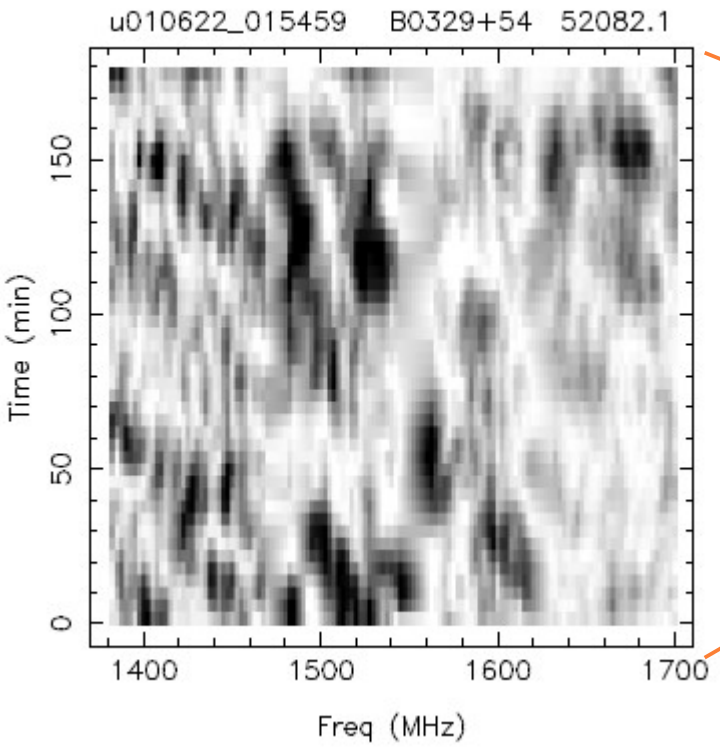
- Relative velocity – Earth - Pulsar :
  Max.: measured 24,919 m/s (+/- 150 m/s)
  Min. : measured 24,311 m/s (+/- 150 m/s)
- Earth orbital speed :
  Max.: 30,330 m/s (+/- 150 m/s)
  Min. : 29,234 m/s (+/- 150 m/s
- Linear eccentricity – Earth orbit :
  Measured : e = 2,809,205,993 m
  Deviation : de = 255,469,723 := 0.85 Ls

PSR B0329+54 – Frequency Drift within 25 min



Scintillation and Frequency Drift

- The Signal of Pulsars have varying intensities at different frequencies over time .
  - Wang, Manchester et al - MNRAS 2018 [12]



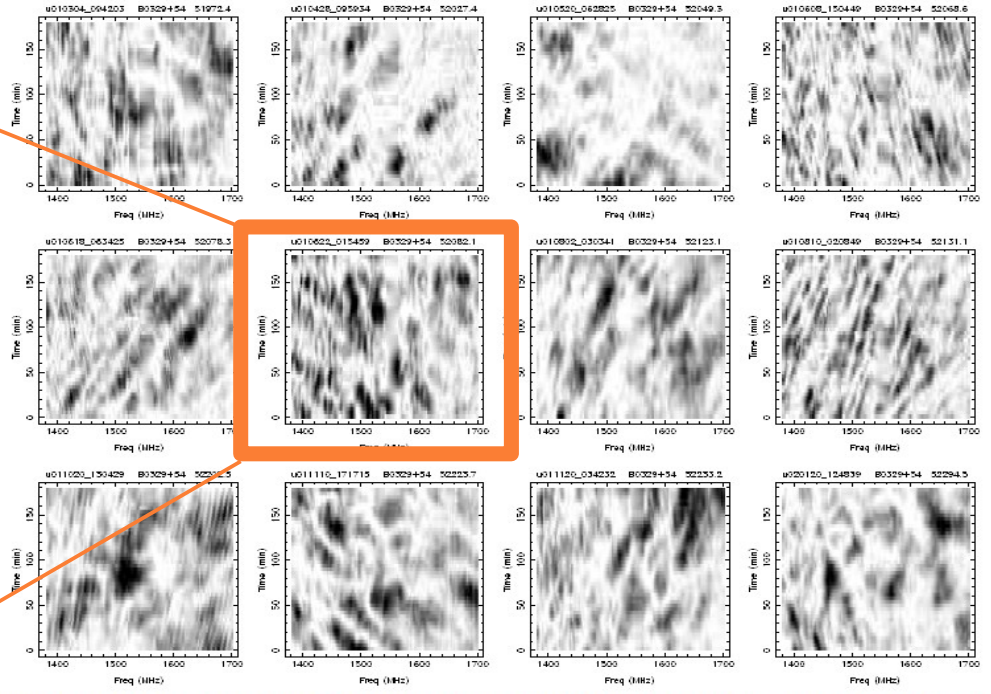
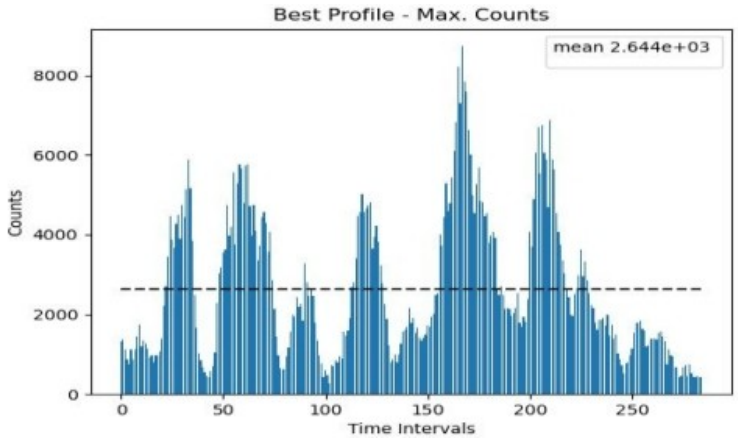
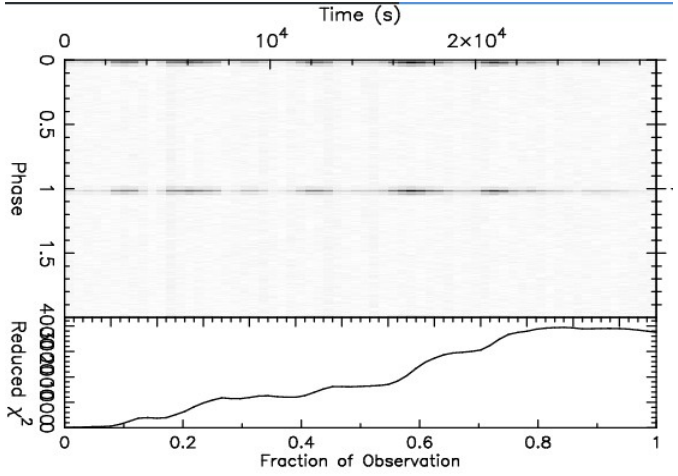


Figure 1. Dynamic spectra for PSR B0329+54 at center frequency 1540 MHz, with frequency and time resolution of 2.5 MHz and 4 min respectively. Intensity is represented by a linear greyscale between 1% (white) and 85% (black) of the maximum.

Intensity Fluctuations – PSR B0329+54





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A Big Thank You

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