The importance of low frequency observations for the understanding of the GPS pulsars spectra

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*as part of the project **LC9_004**:*

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The Gigahertz-peaked spectra effect in radio pulsars

Kijak et al. 2018:
25 confirmed gigahertz-peaked spectrum (GPS) pulsars (18 assosiated with SNR, PWN or H II).

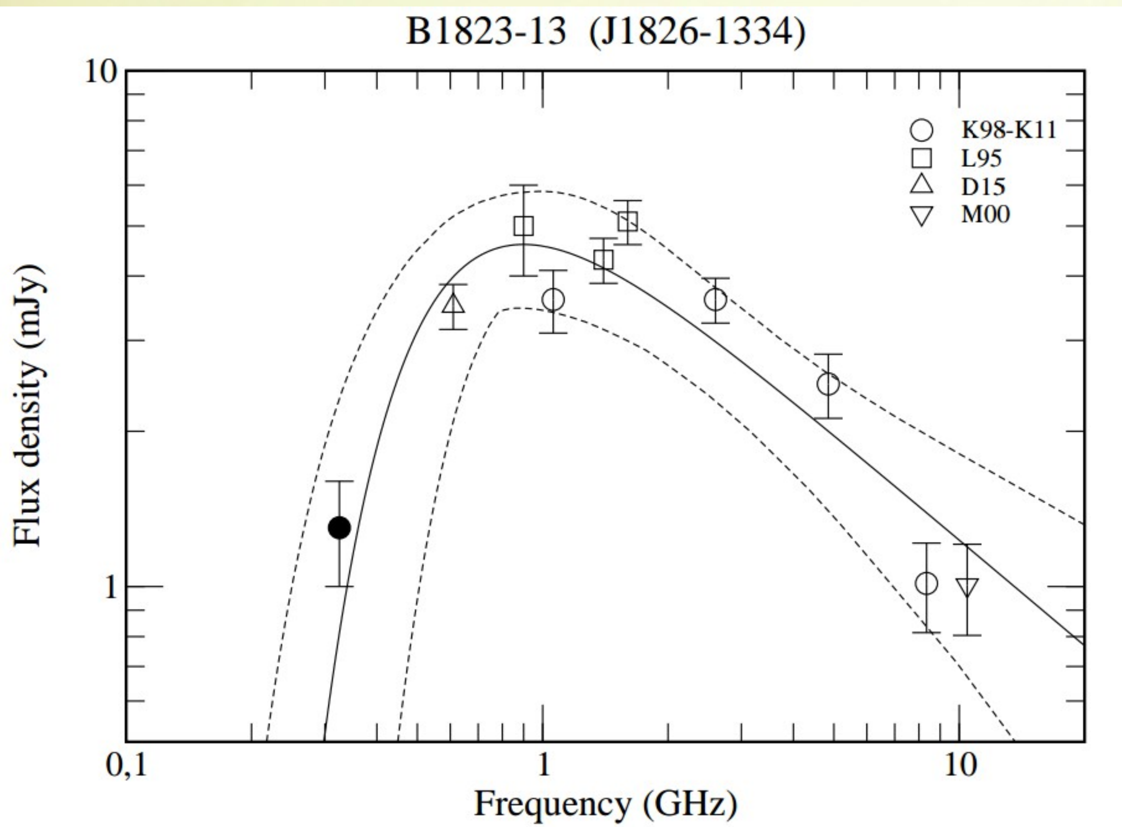

Figure 1: Example of the GPS pulsar (Kijak et al. 2017).

Allen et al. 2013:

identified 1 new GPS pulsar.

Jankowski et al. 2018:
identified 3 new GPS pulsars.

There is considerable evidence that an external mechanism is responsible for the spectral turnovers. The most compelling possibility is the thermal free-free absorption taking place in pulsar environments.

(see Lewandowski et al. 2015, Rajwade, Lorimer & Anderson 2016, Basu et al. 2016 and Kijak et al. 2017).

J1740+1000: the young pulsar far from the galactic plane

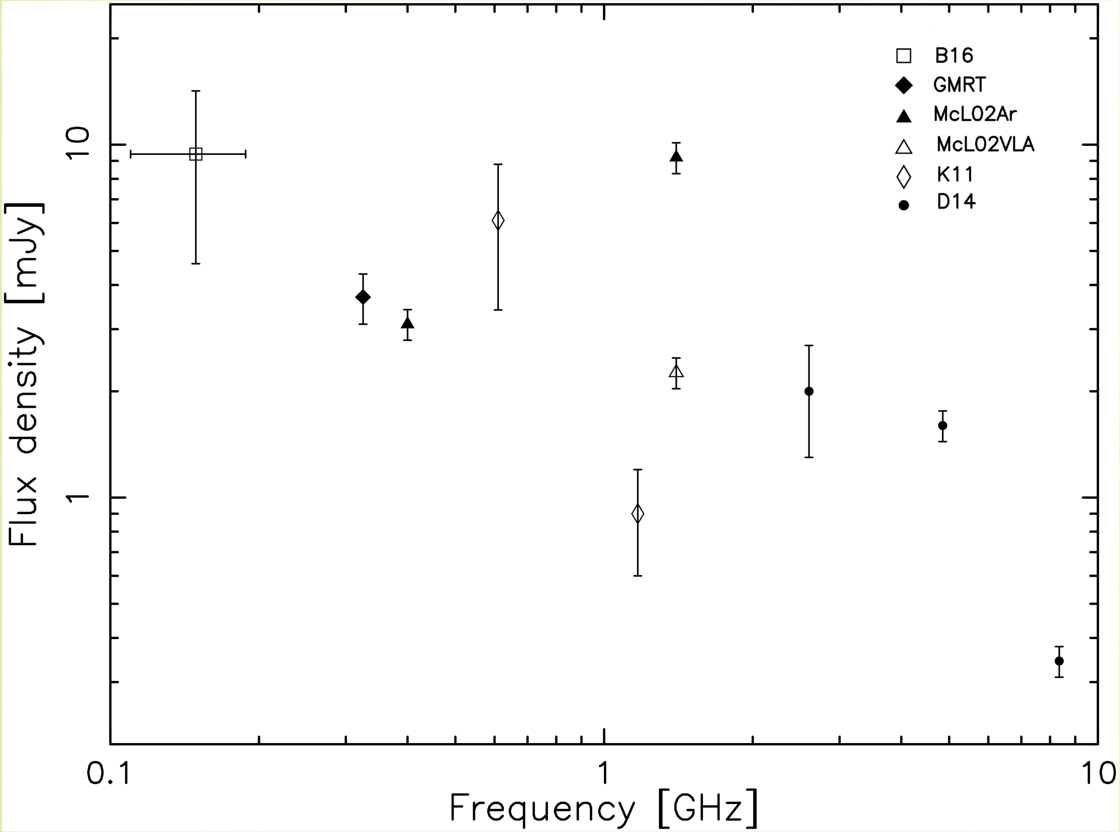

Figure 2: The PSR J1740+1000 spectrum with all measurements available in 2017. The points come from: Bilous et al. (2016), Kijak et al. (2011), McLaughlin et al. (2002) and Dembska et al. (2014).

Age ~11 thousand years
Period ~0.15 s
Distance: 1.23 kpc
Distance from the Galactic plane: 0.43 kpc

The line of sight to PSR J1740+1000 passes through the North Polar Spur (Loop I) and the Gould Belt, an expanding disk of gas and young stars.
(McLauglin et al. 2002)

Most likely it has the pulsar wind nebula (PWN) with a long tail.
(Kargaltsev et al., 2008; Kargaltsev & Pavlov, 2010)

J1740+1000: GMRT and GBT observations

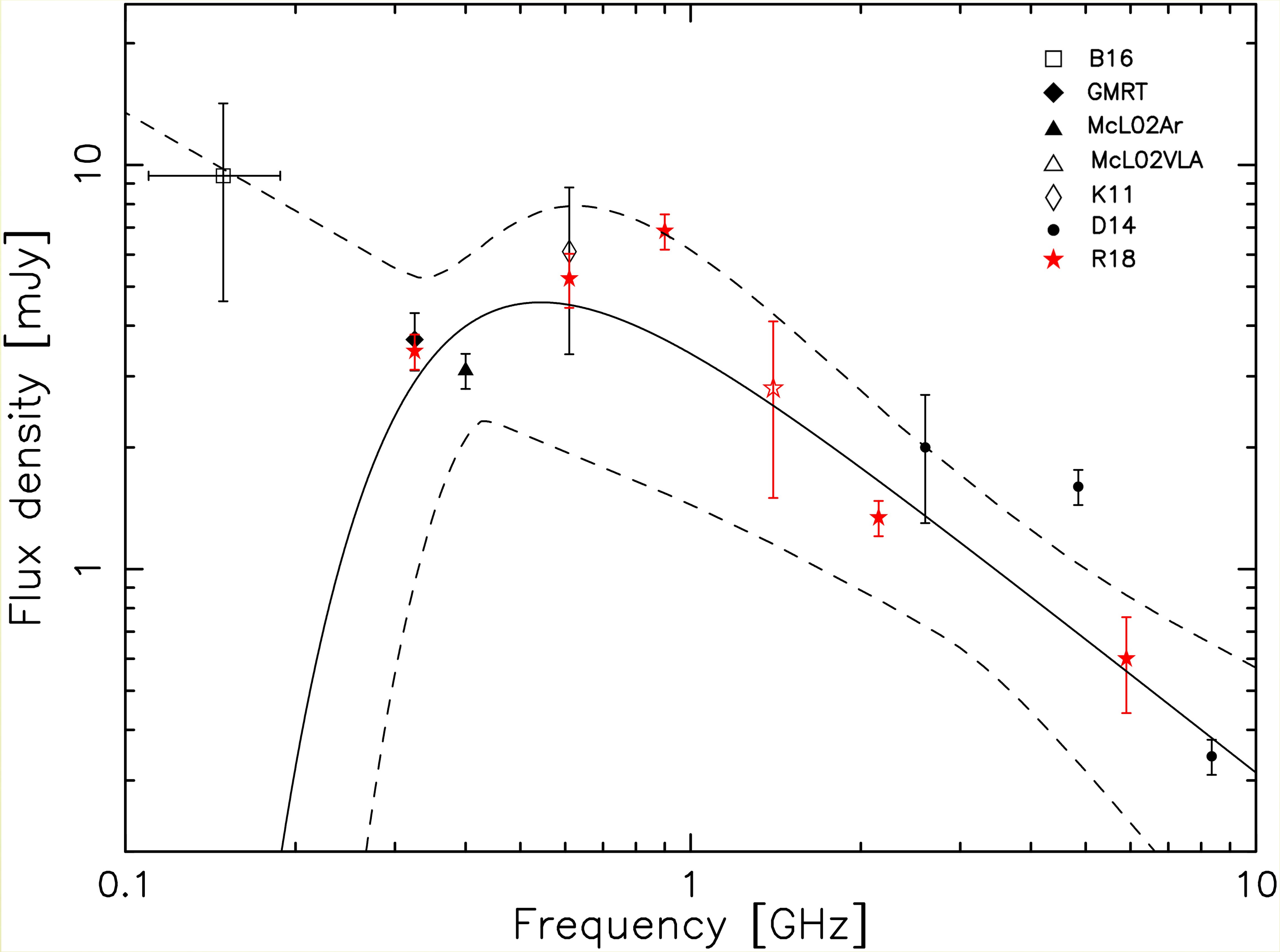

Figure 3: The PSR J1740+1000 spectrum with fitted free-free thermal absorption model for all measurements available in 2018. Additional fluxes were obtained from GMRT and GBT observations (in collaboration with K. Rajwade and D. Lorimer). (Rozko et al. 2018)

LC9_004 project: *Low frequency study of J1740+1000 using the interferometric imaging method*

- 9 hours of HBA observations that were co-observed with the LOFAR Tier I survey:
  - ~4 hour scan in December 12, 2017
  - ~4 hour scan in February 1, 2018
- Calibration process:
  - Standard facet calibration (Prefactor and factor)
  - DR2 pipeline (DDFacet and killMS)
- Flux measurements were determined using AIPS and CASA.
- We checked flux scaling using radio sources from TGSS for comparison.

PSR J1740+1000 radio map

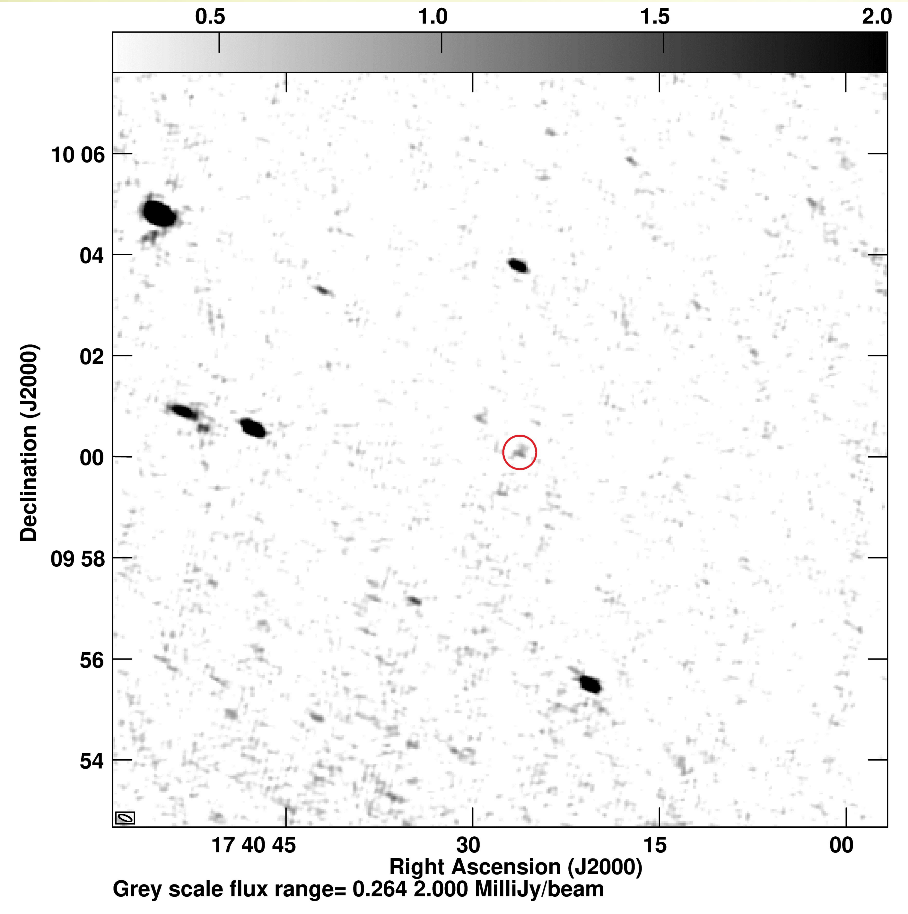

Figure 4: The fragment of a radio map obtained as the result of FACTOR pipeline. The PSR J1740+1000 is inside the red circle. The angular resolution of map is 16.5''x6.2'' and RMS ~250 µJy/beam.

Pulsar flux: 2.85 +/- 0.98 mJy.

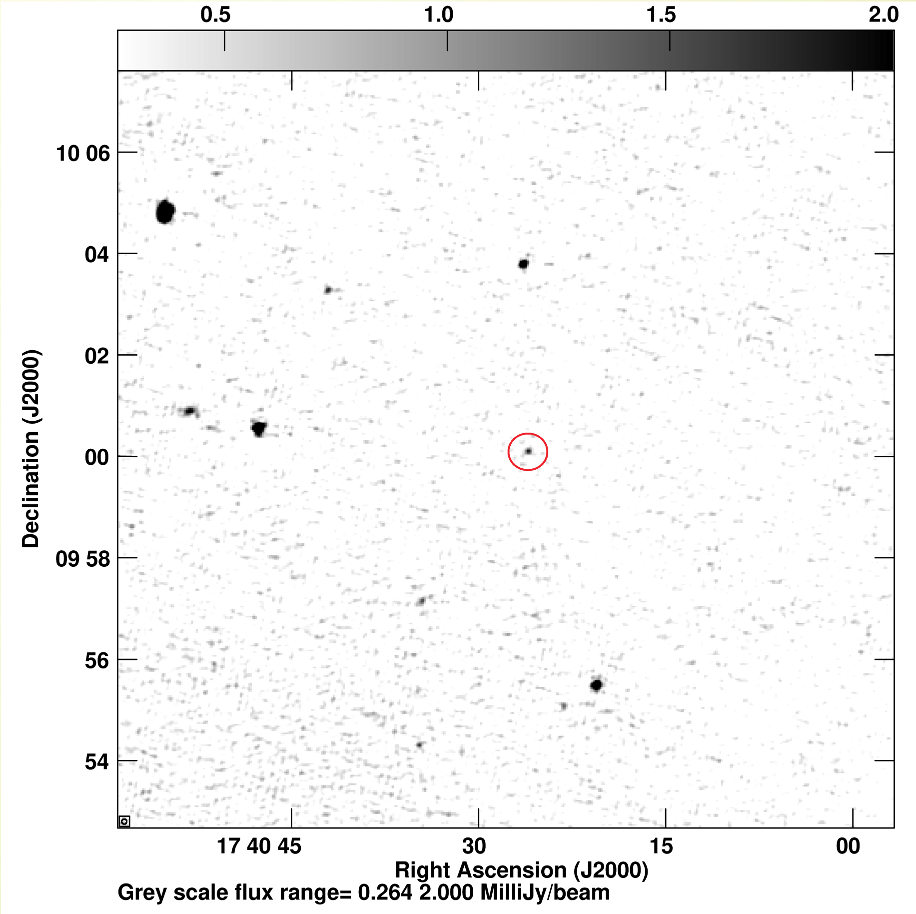

Figure 5: The fragment of a radio map obtained as the result of DR2 pipeline. The PSR J1740+1000 is inside the red circle. The angular resolution of map is 3.2''x5.5'' and RMS ~190 µJy/beam.

Pulsar flux: 3.42 +/- 1.65 mJy.

(Rozko et al. 2019, in preparation)

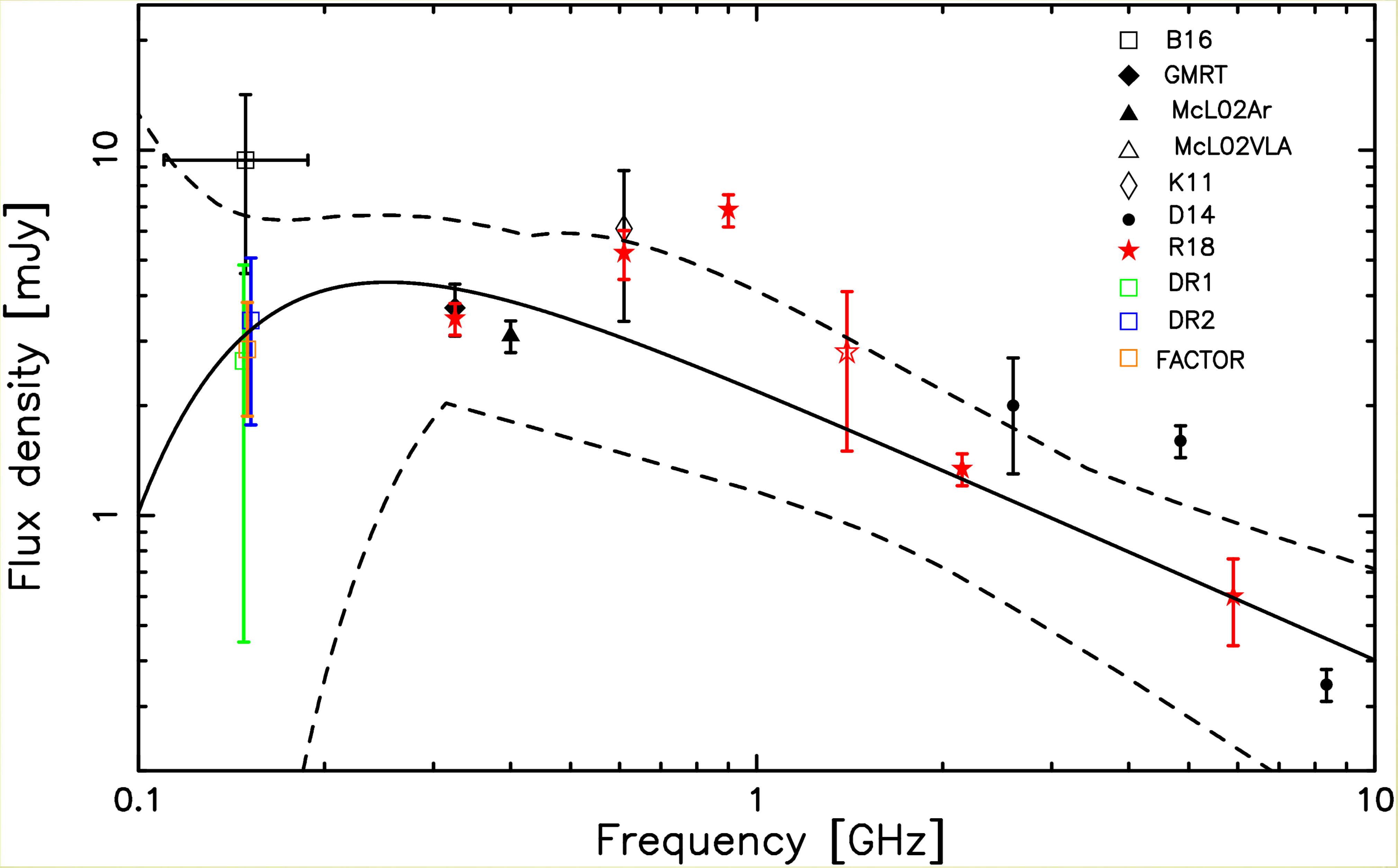

Figure 7: J1740+1000 spectrum with thermal absorption model using the Levenberg-Marquard algorithm and the minimum chi square method. Fit and 1σ envelopes.

(Rozko et al. 2019, in preparation)

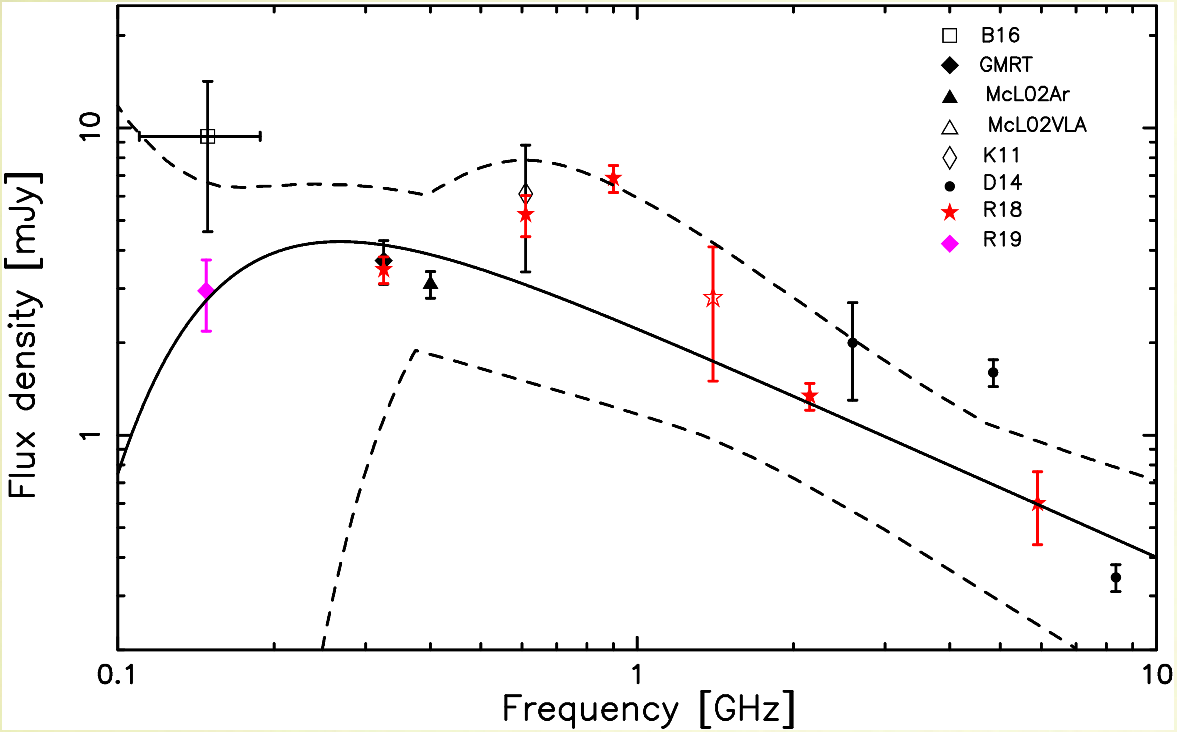

Figure 7: J1740+1000 spectrum with thermal absorption model using the Levenberg-Marquard algorithm and the minimum chi square method. Fit and 1σ envelopes.

(Rozko et al. 2019, in preparation)

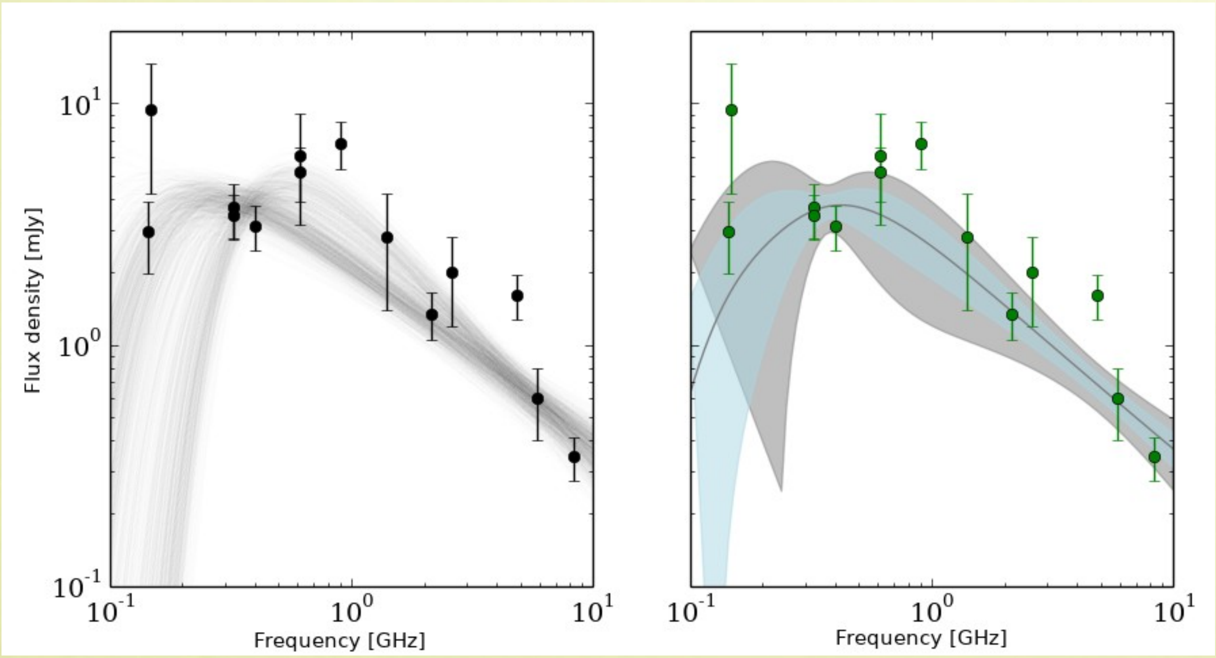

Figure 8: J1740+1000 spectrum with thermal absorption model fitted using Monte Carlo (MCMC) Bayesian approach. Fit and 2σ envelopes.

(Rozko et al. 2019, in preparation)

Summary

The future work:

Continue to investigate different spectral models e.g. self-absorption model in the pulsar magnetosphere and synchrotron absorption in the pulsar environment.

Conlusion:

The low frequency observations could be crucial for understanding spectral behaviour of some GPS pulsars.
PSR J1740+1000 is located at a relatively large distance from the Galactic plane and has a very low DM (24 pc cm ^{3}), but it has a very interesting environment such as PWN, which makes it very unique – both amongst the GPS pulsars as well as in the general pulsar population.

Thanks for your attention!