Multi-frequency characterisation of Crab Giant Pulses

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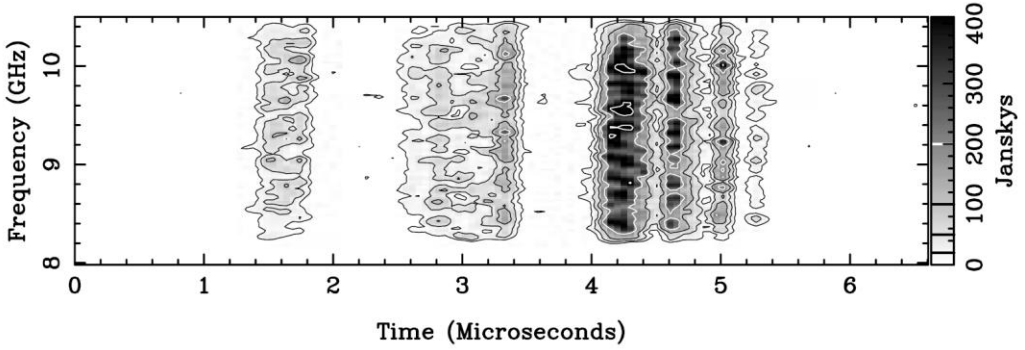
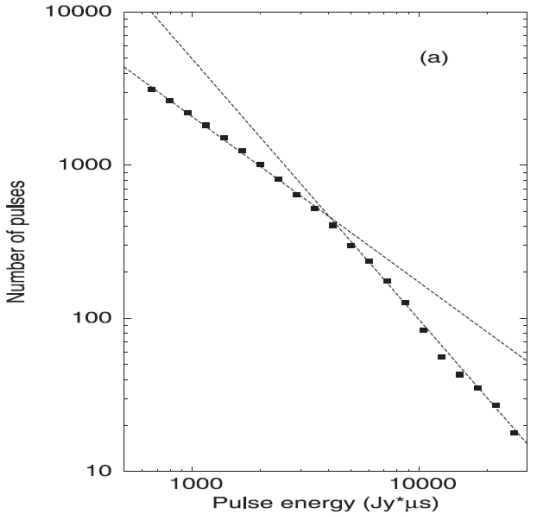
Crab Pulsar

- Youngest rotation-powered neutron star (period of 33.8 ms).
- It shows giant pulses (GPs).
- GPs divided in Main Pulses (MPs) and an Interpulse (IPs).

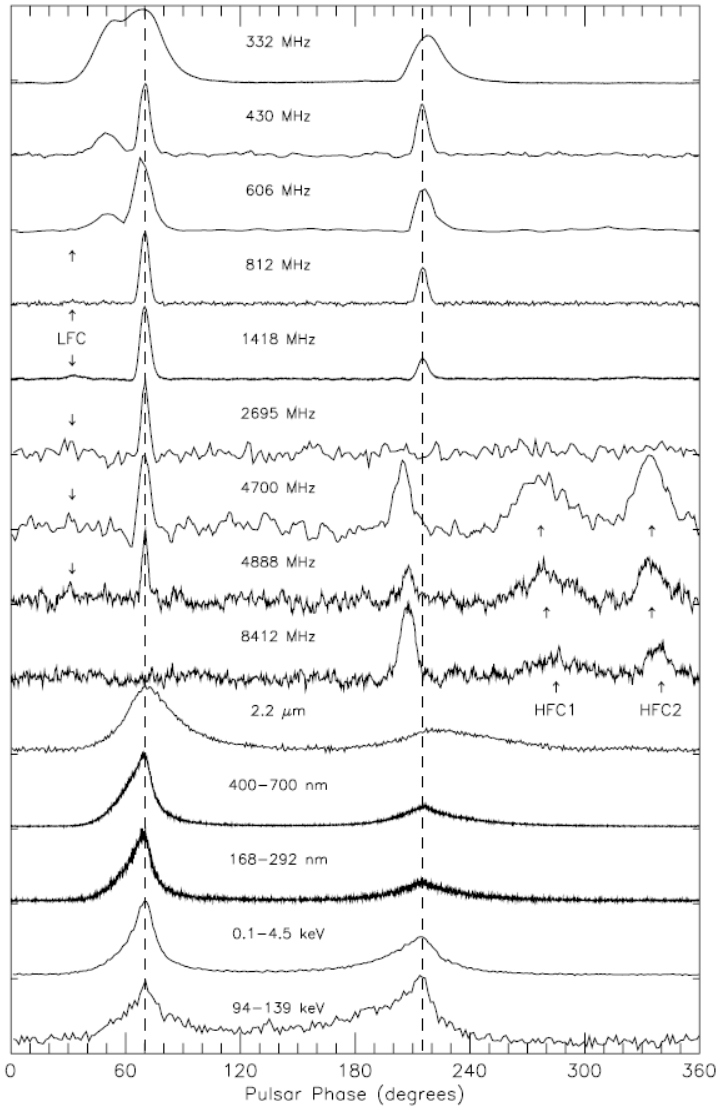
Crab GPs:
- They exhibit ns intrinsic structure (microbursts and nanoshots).
- Energy power law distribution.



Hankins & Eilek (2007); giant MP @8 GHz



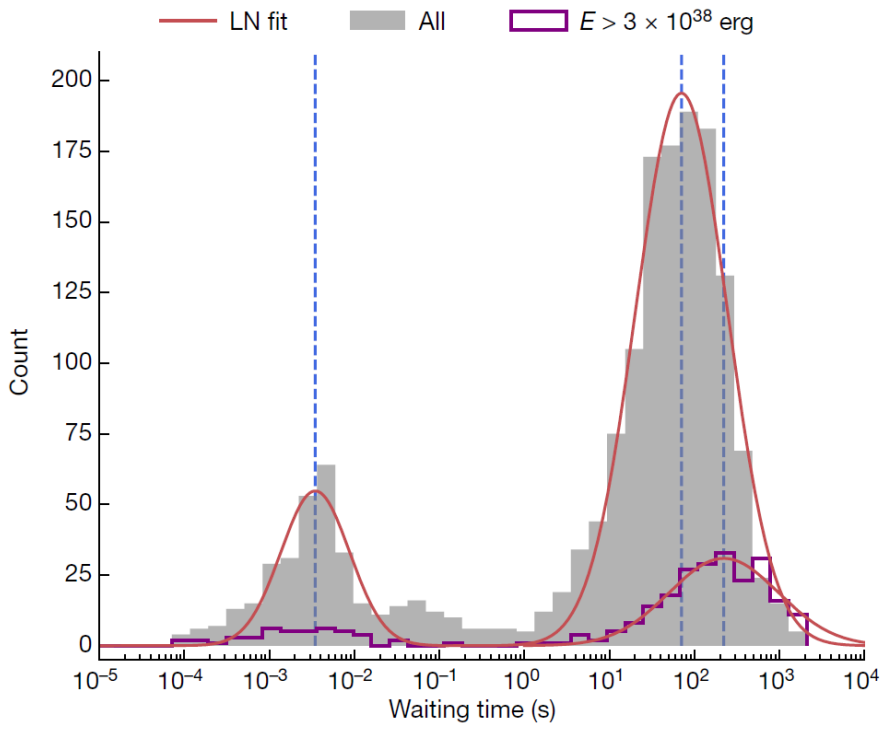
Popov & Stappers (2007); MPs



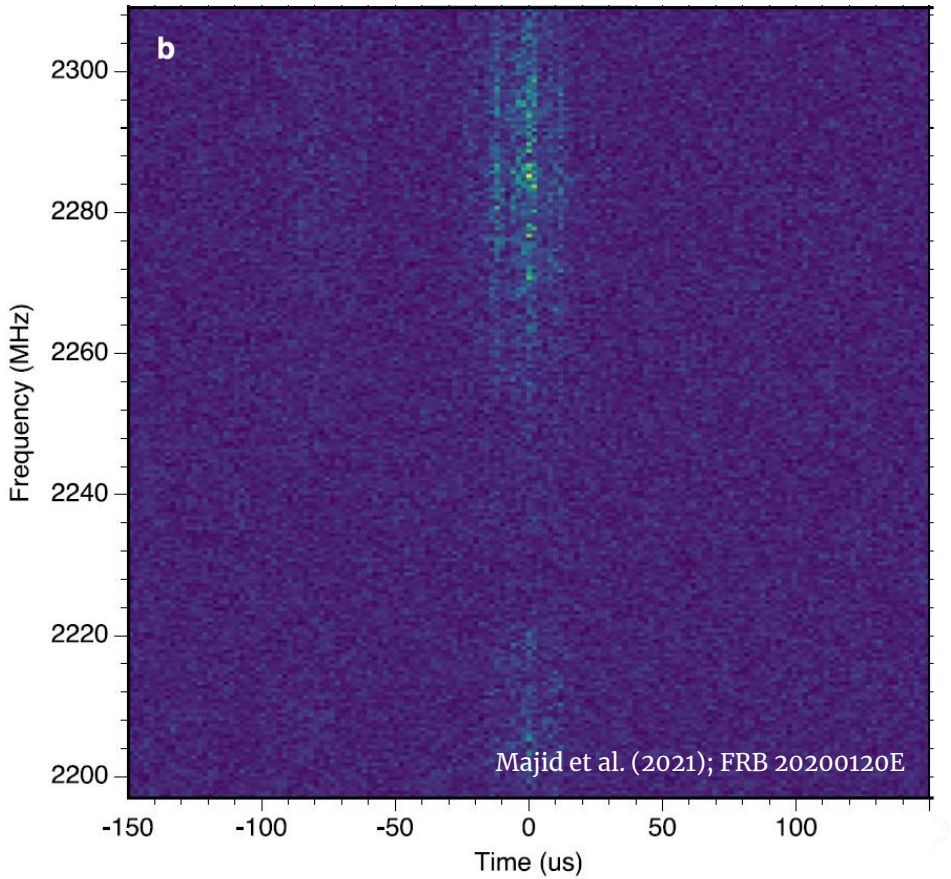
Moffett & Hankins (1996)

Fast radio bursts

- Divided in one-off and repeaters.
- PRS associated with repeaters + 2 bursts from SGR 1935+2154.
- Nanoshots from FBR20200120E (Majid et al. 2021).
- Bimodal waiting time distribution in FRB20121102 and FRB20240114A.



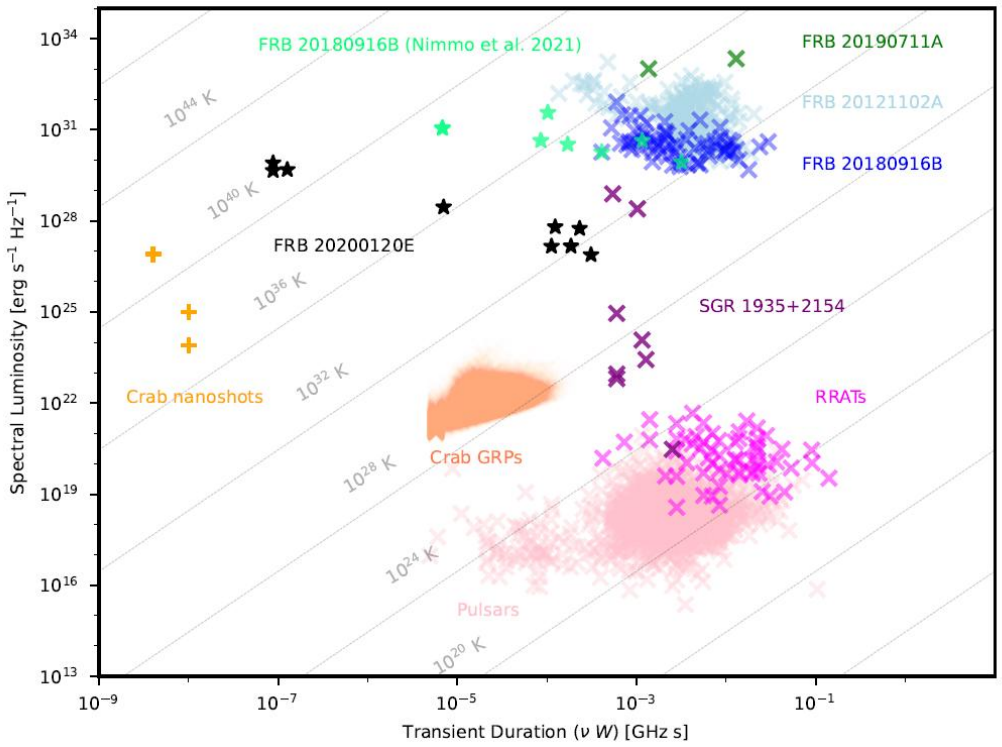
Li et al. (2021), FBR 121102



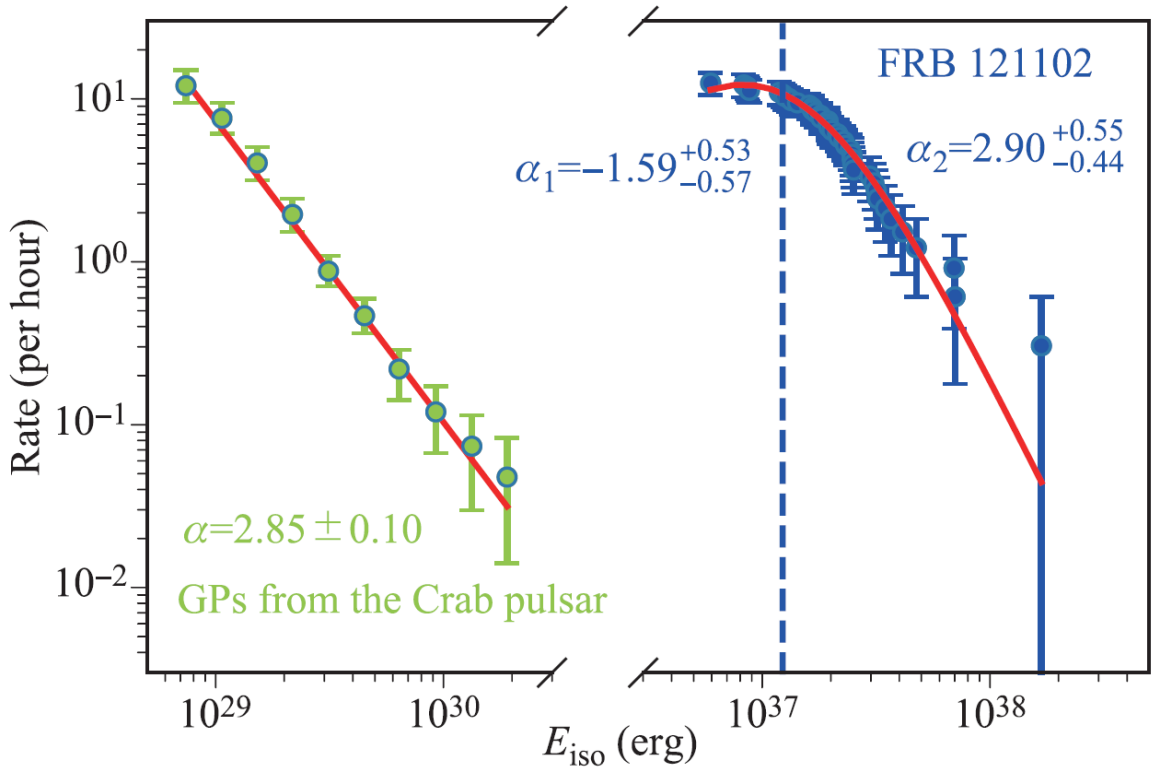
Giant pulses and FRBs

Link with FRBs:

- FRB121102 spectral index resembles that of the GPs;
- FRB 20200120E exhibits nanoshots as the GPs.



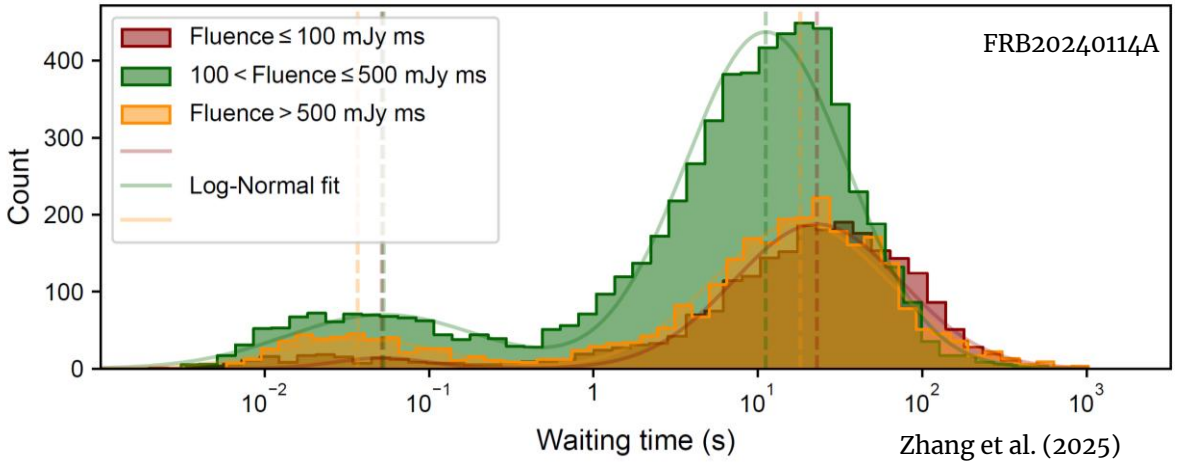
Nimmo et al. (2022)



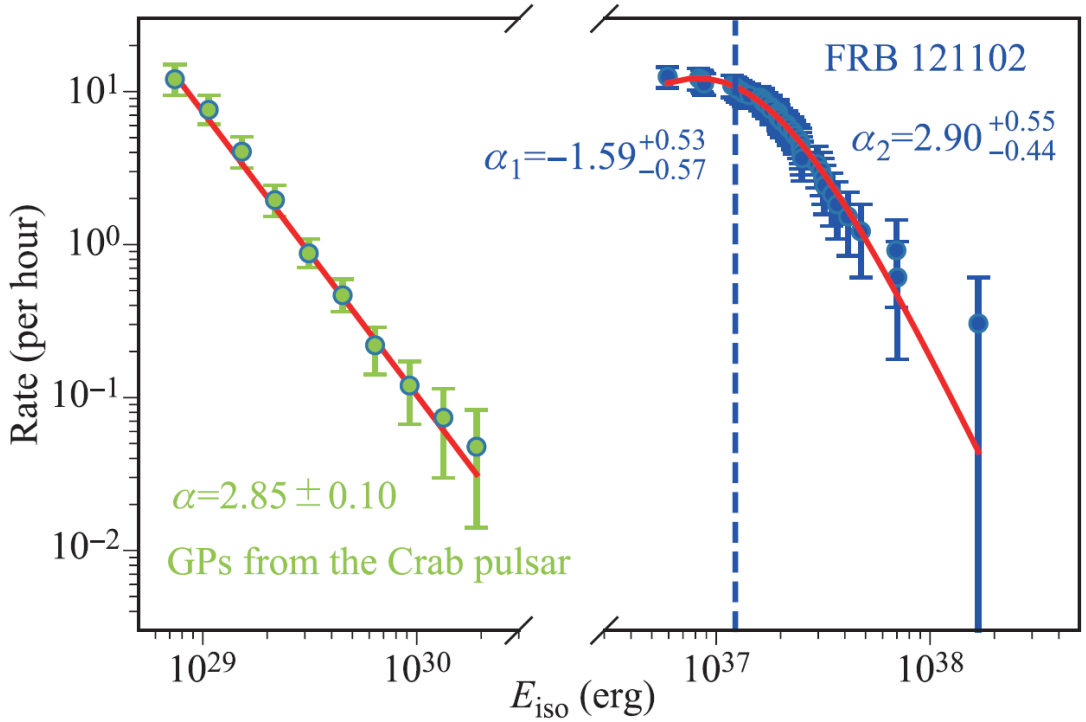
Lyu et al. (2021); F>130 Jy ms

Goals of the project

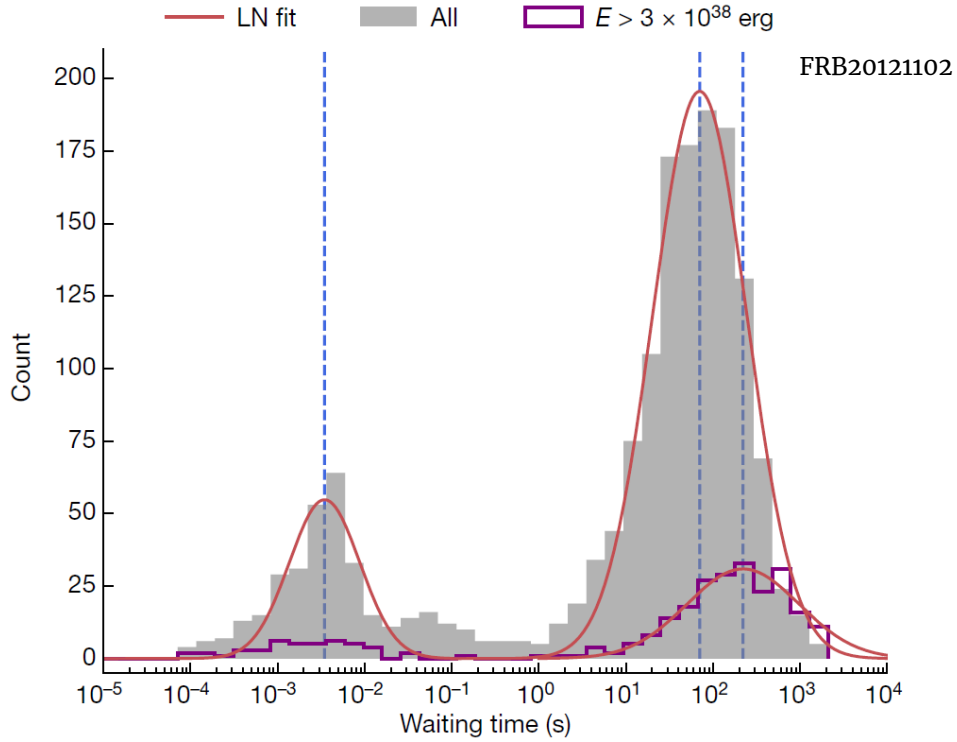
- Compare the energy distributions with repeating FRBs ones.
- Comparison of the optical to radio energy ratio with the repeating FRBs (future).
- Compare the GPs waiting time distribution with the repeating FRBs ones.



Zhang et al. (2025)



Lyu et al. (2021)



Li et al. (2021)

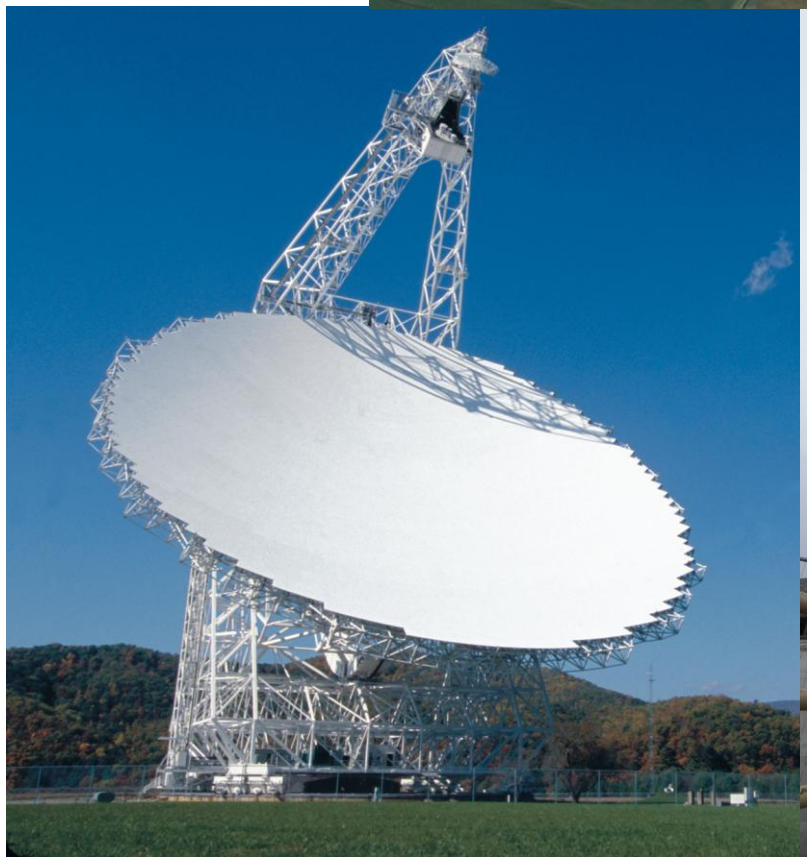
Observations

Green Bank telescope (GBT):

- 12.3 h;
- frequencies: 720-920 MHz and 1100-1900 MHz (5.1 h and 7.2 h respectively);
- time resolution: 10.24 μs.

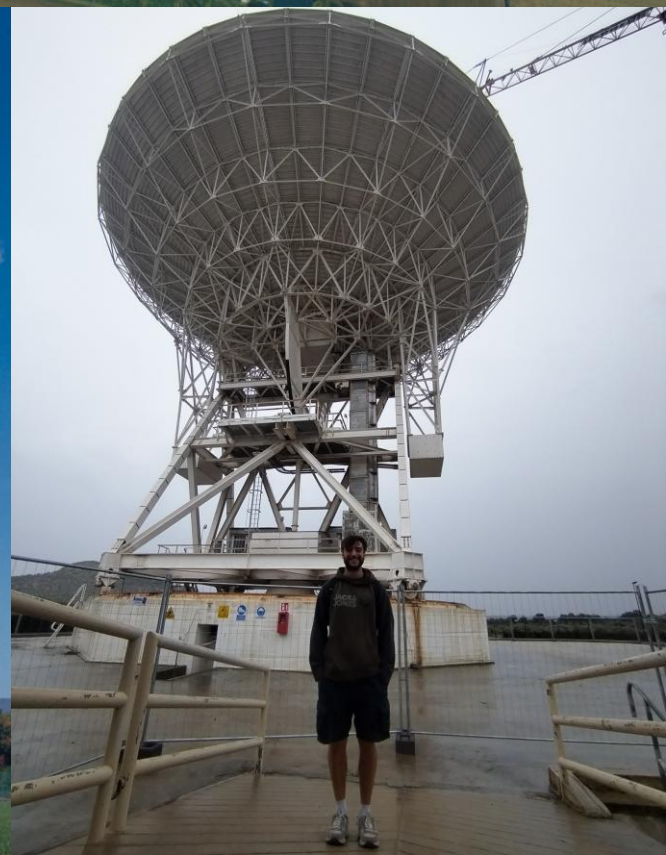
Northern Cross (NC):

- 2.3 h;
- frequencies : 400-416 MHz;
- time resolution : 138.24 μs.



Noto radio telescope:

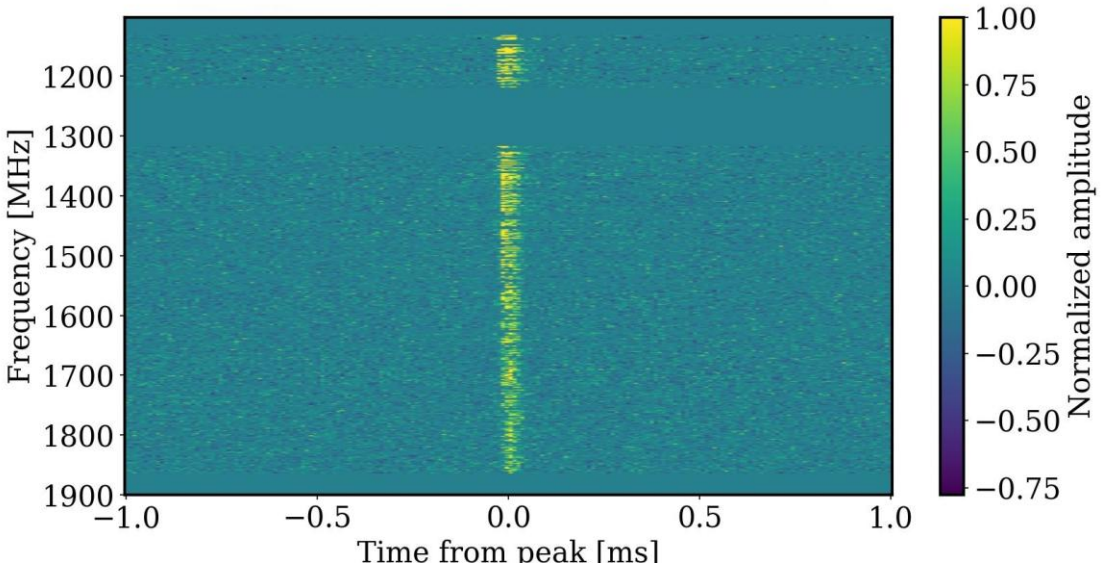
- 2.2 h;
- frequencies : 1349-1605 MHz;
- time resolution : 4.0 μs.

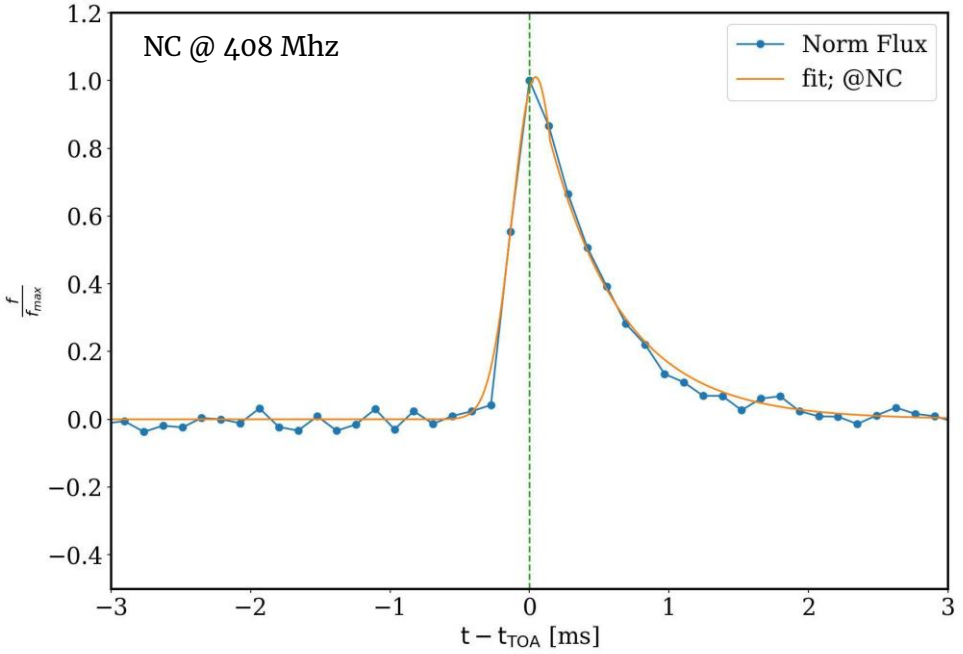


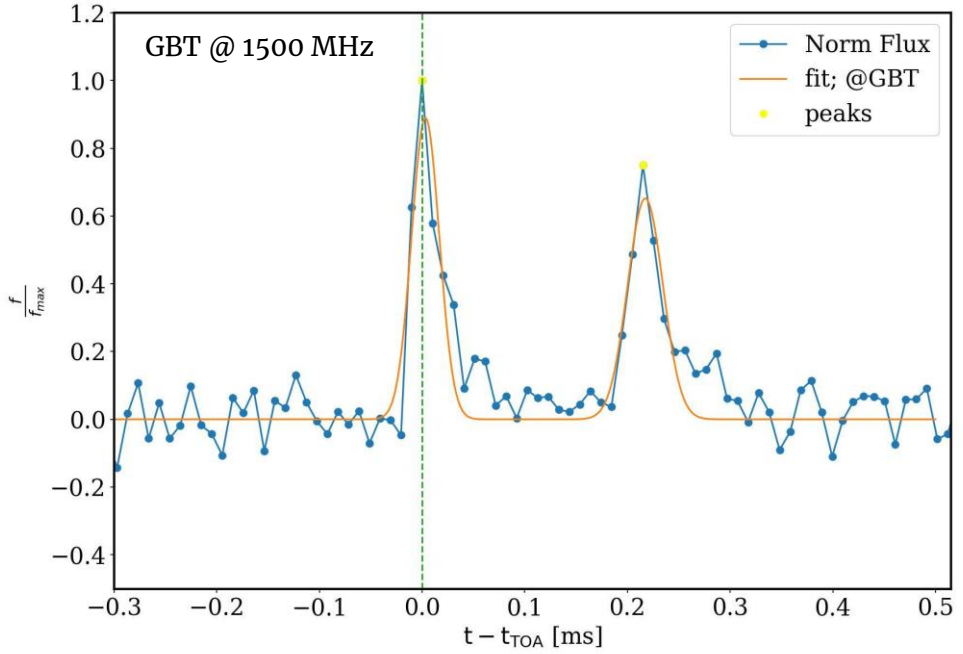
Pulse Search

Procedure:

- Candidates - HEIMDALL (SNR threshold 6.5);
- Classification - FETCH;
- Fit a Gaussian profile for each single pulse;
- Pulses with SNR > 9 are selected to be GPs;
- Compute the flux density and the width.



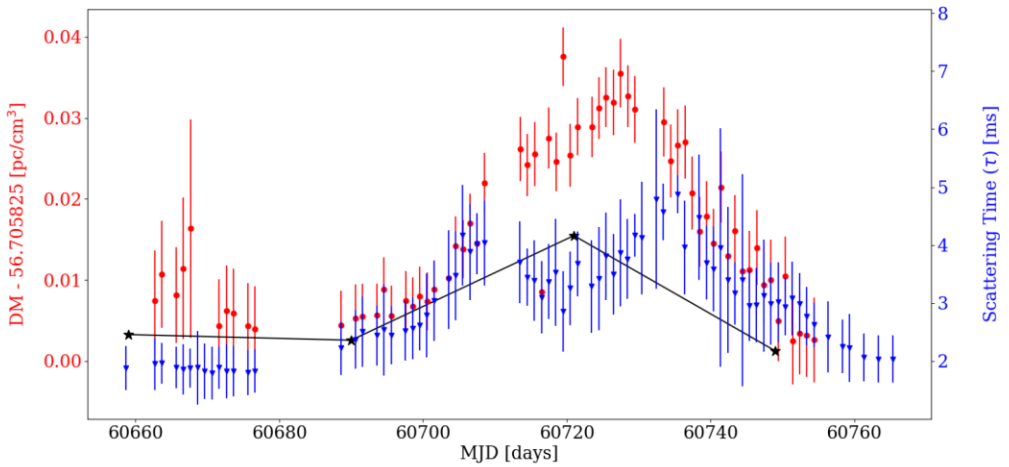




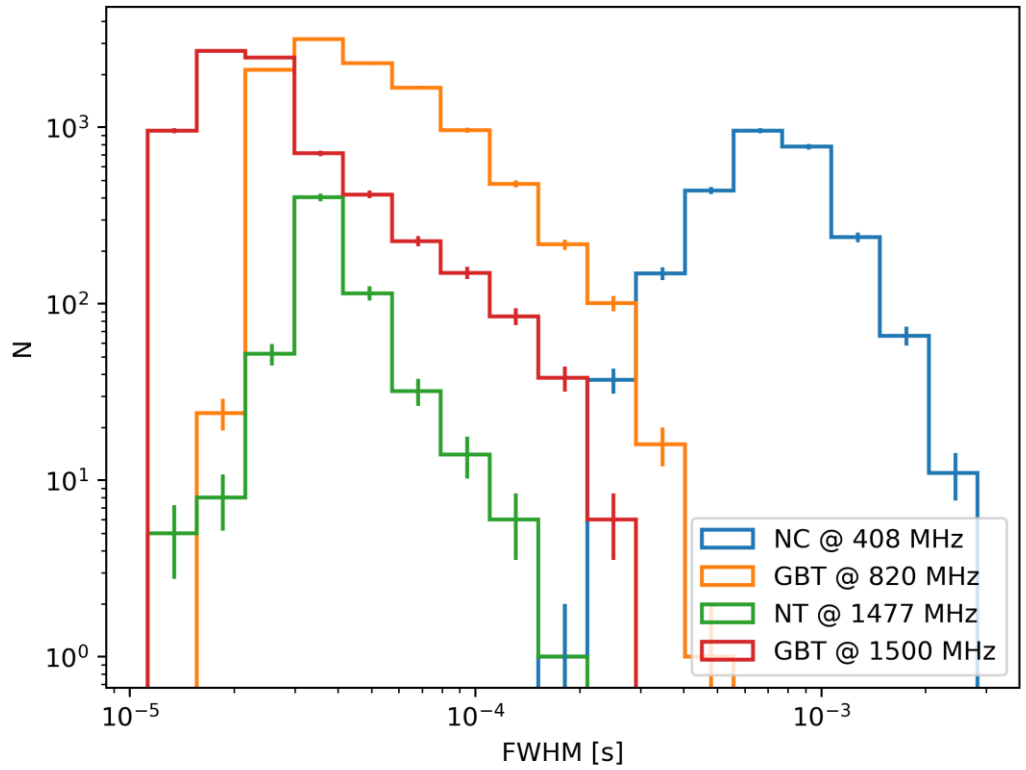
GPs widths and scattering distribution

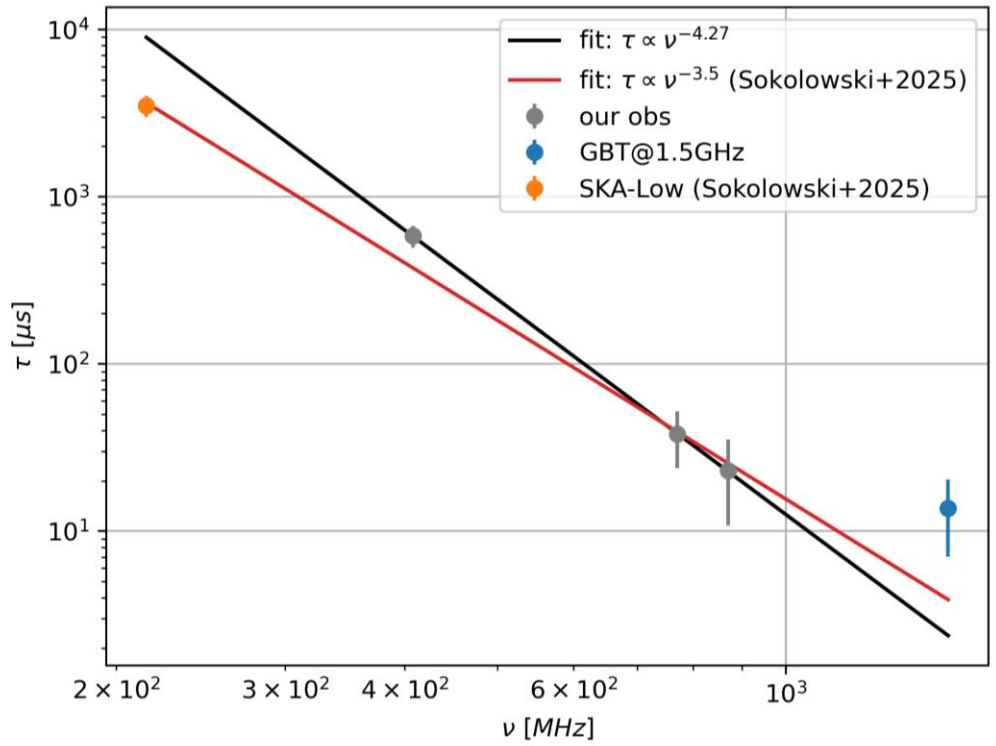
Width distribution:

- The peak of the width distribution decreases with increasing frequency;
- FWHM peaks at < 1 μs @ 1.5 GHz (Bhat et al. 2008);
- Average scattering time 5 μs (@ 1.7 GHz) reported in Lin et al. (2023b).



Sokolowski et al. (2025)

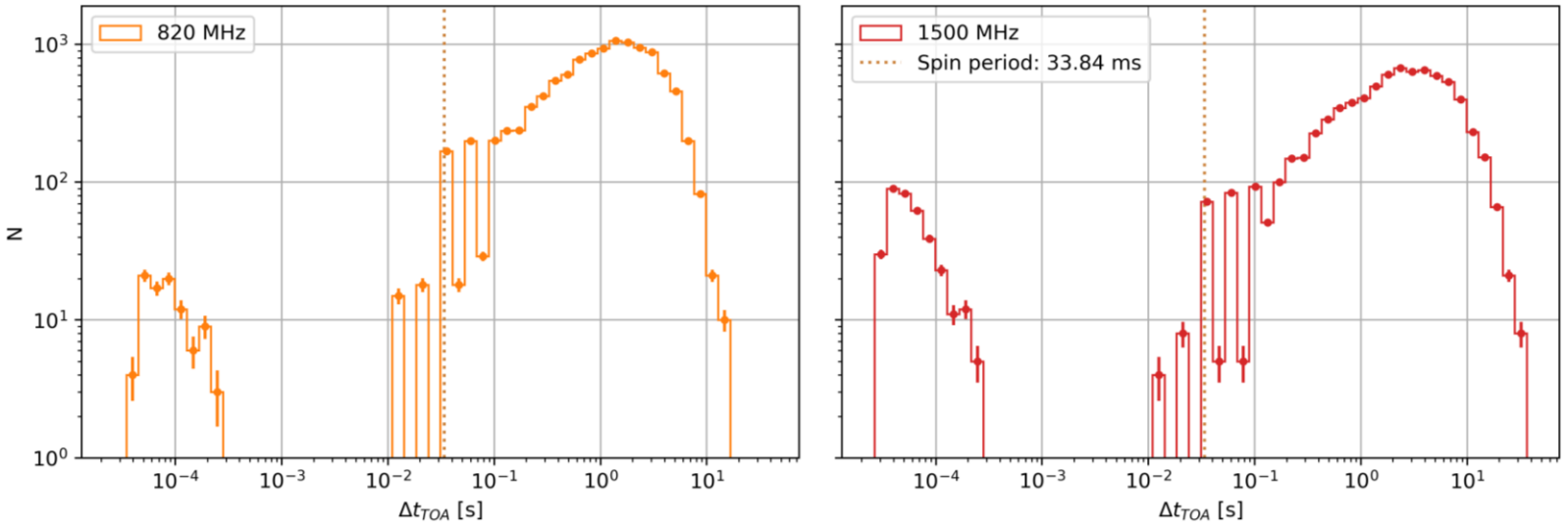


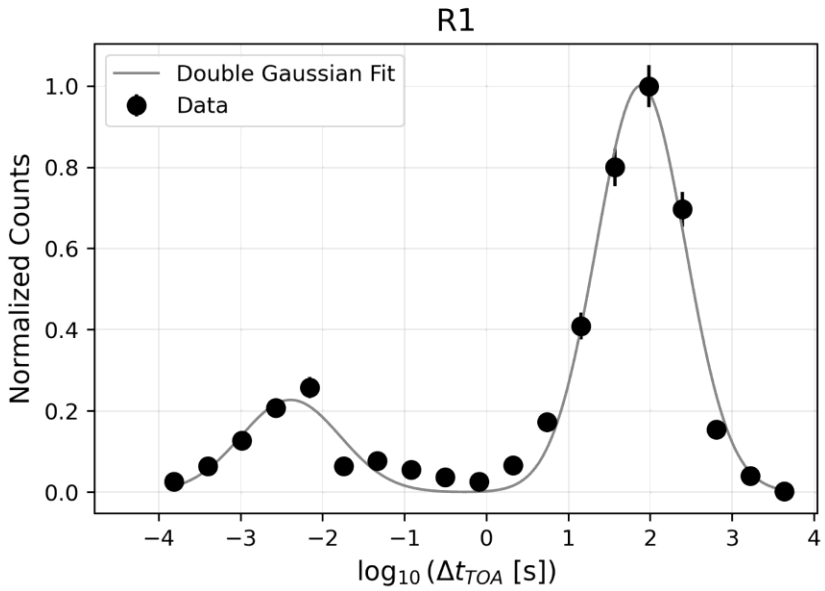


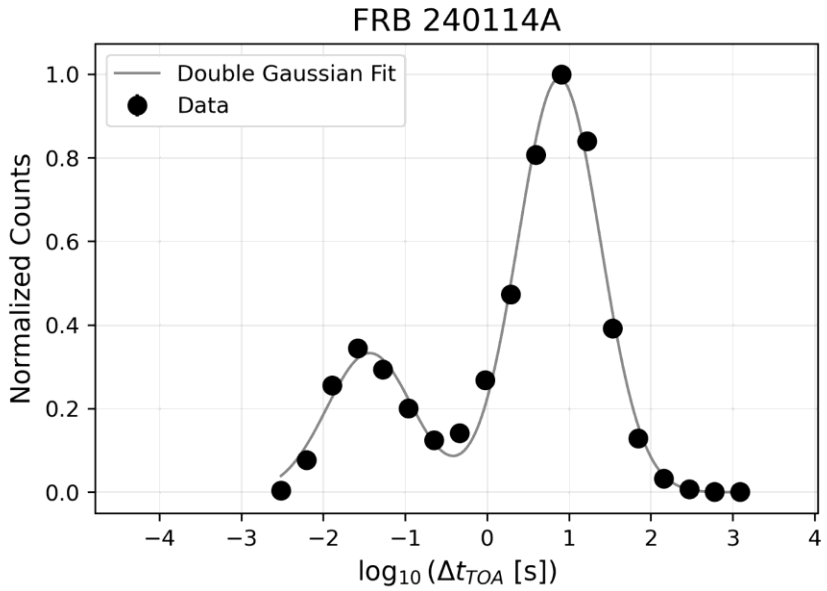
Waiting time distributions

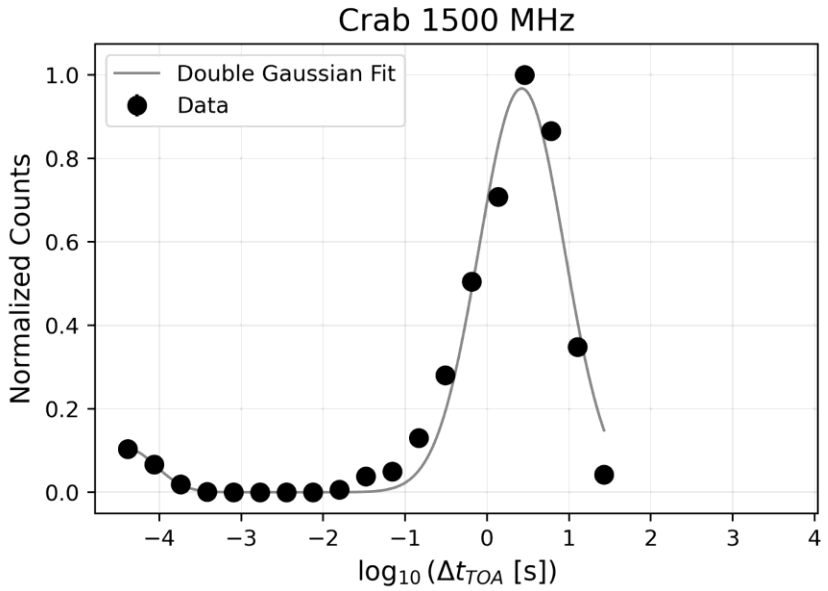
Waiting time: time difference between two consecutive pulses.

- Bimodal distribution for FRBs.
- Two separate distribution for Crab GPs.



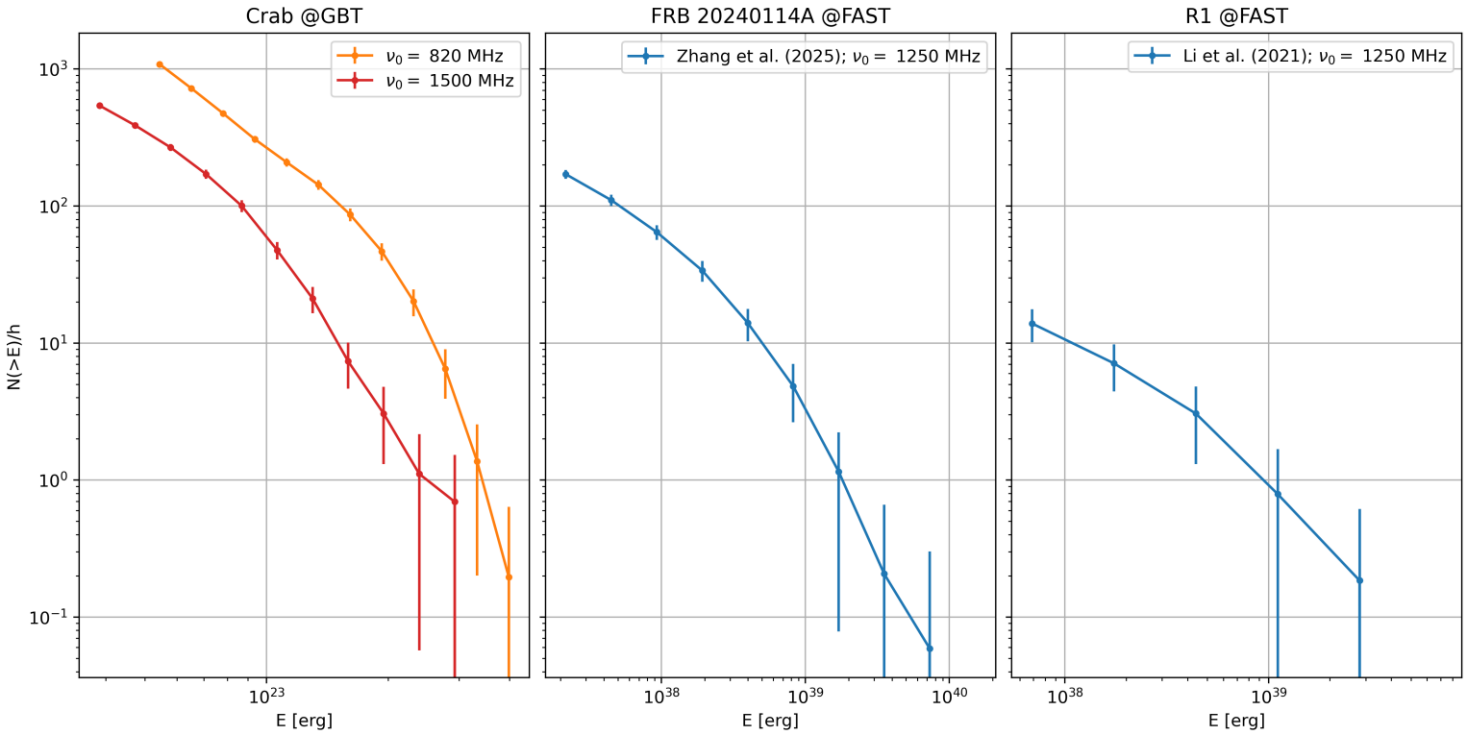


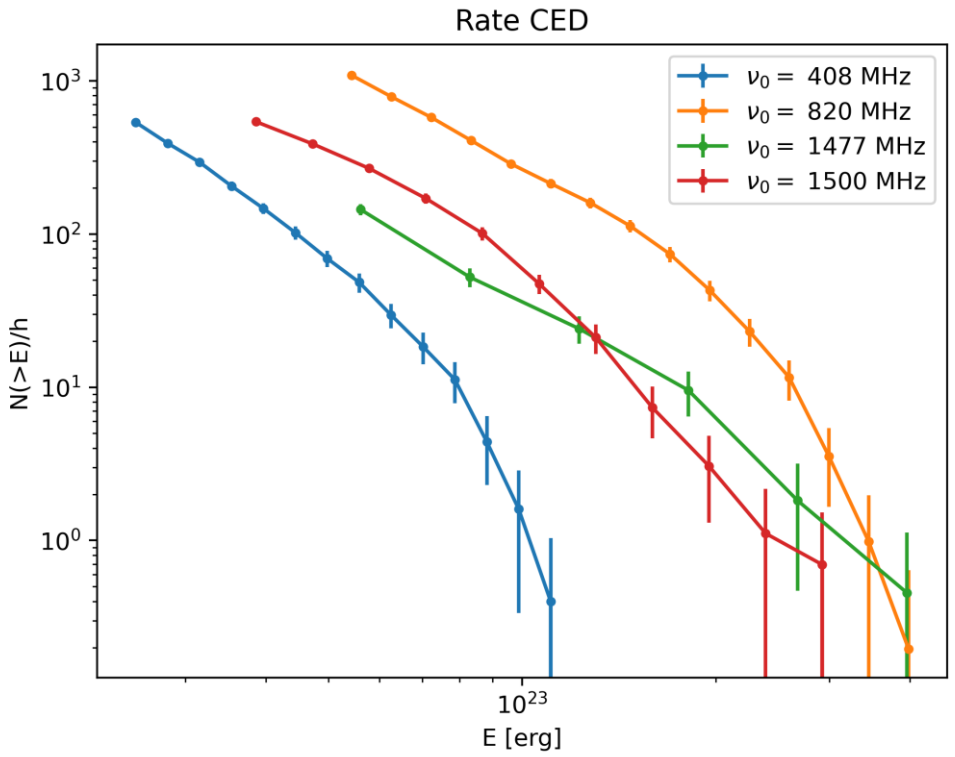


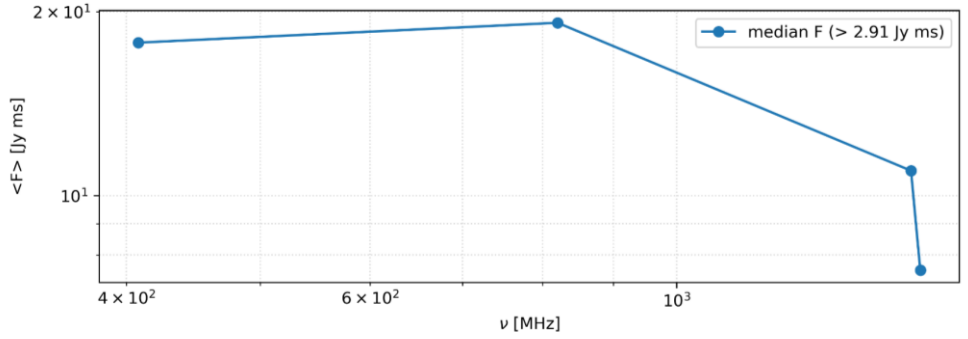


Energy distributions of GPs

- Broken power law for GPs.
- Similar distribution between GPs and FRB14A bursts.



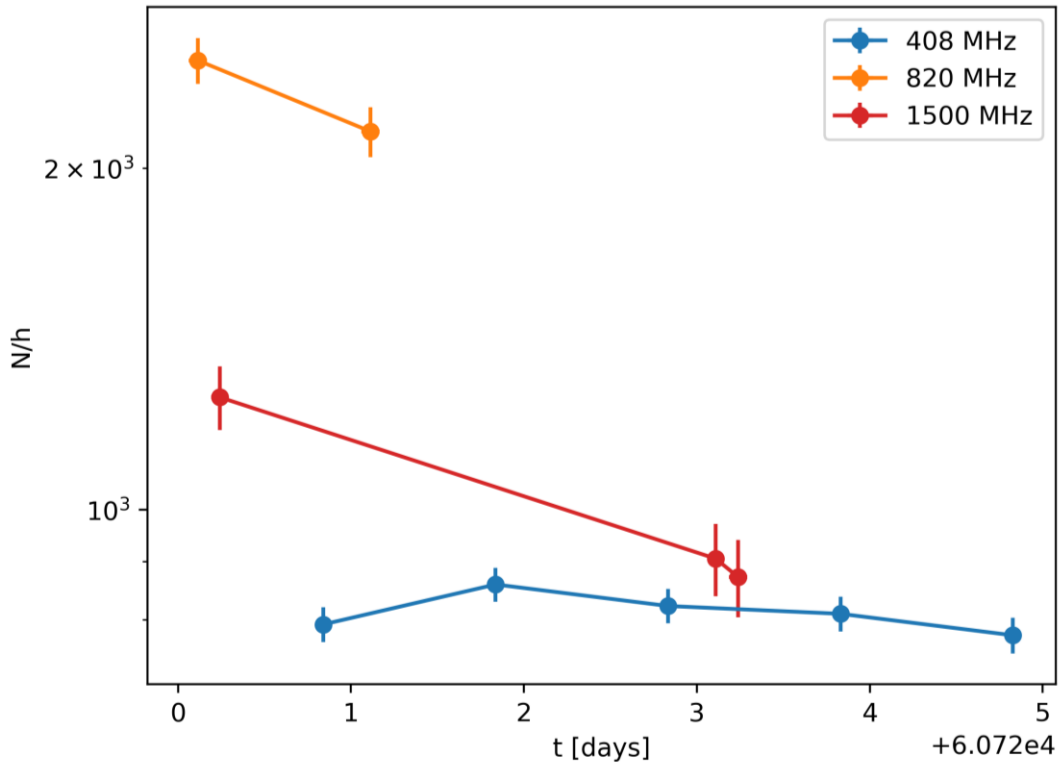


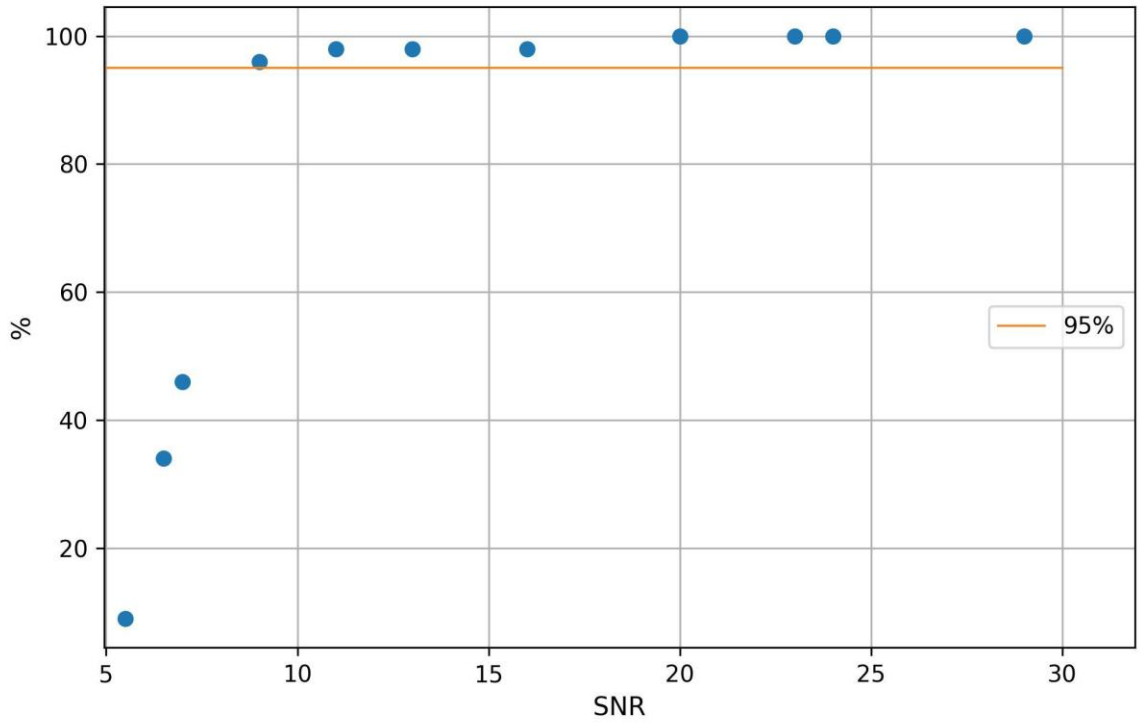


Conclusions and future works

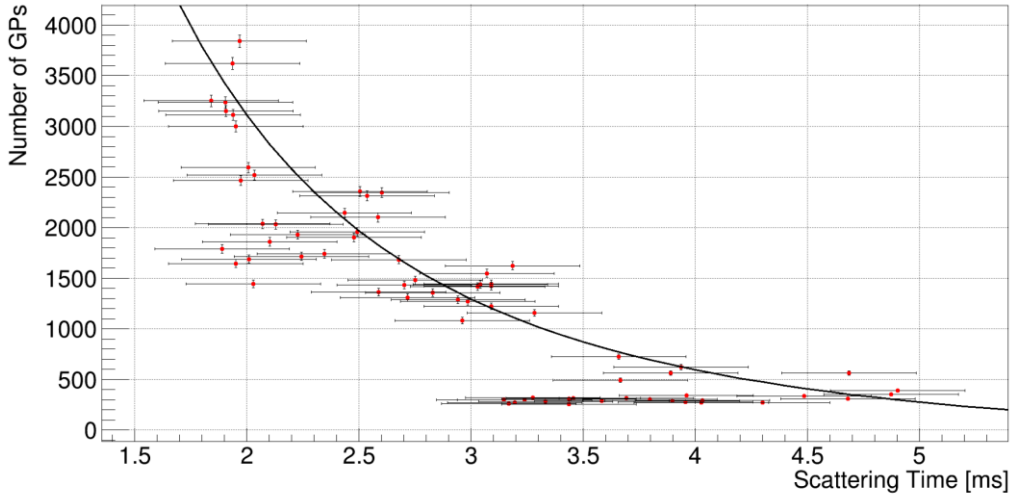
- The cumulative energy distributions show a broken power law.
- The waiting time distributions seem to have common features with the repeating FRBs.
- In the feature we will carry out simultaneous optical observations.
- This study will provide comparison for higher sensitivity SKA observations of faint FRBs.

Appendix - Useful (?) figures

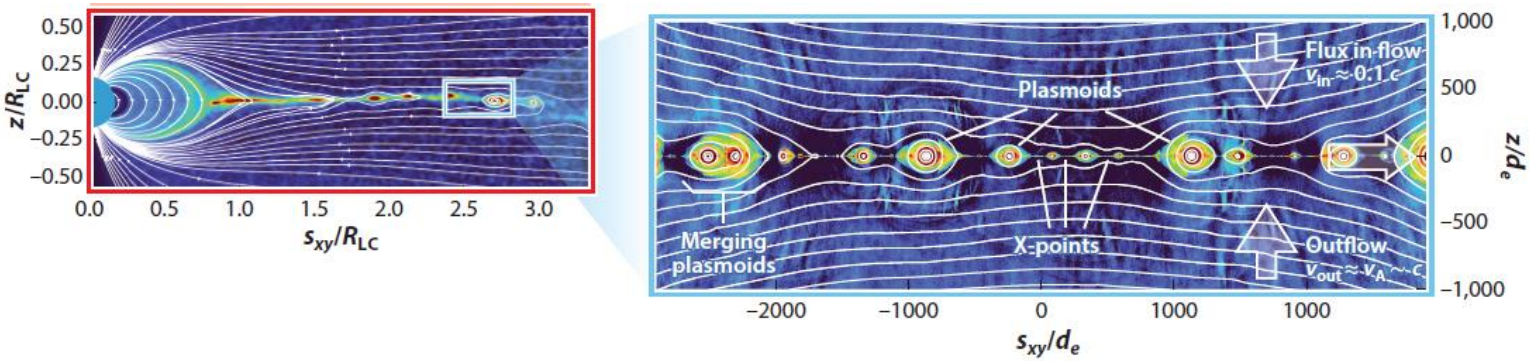




Appendix - Useful (?) figures



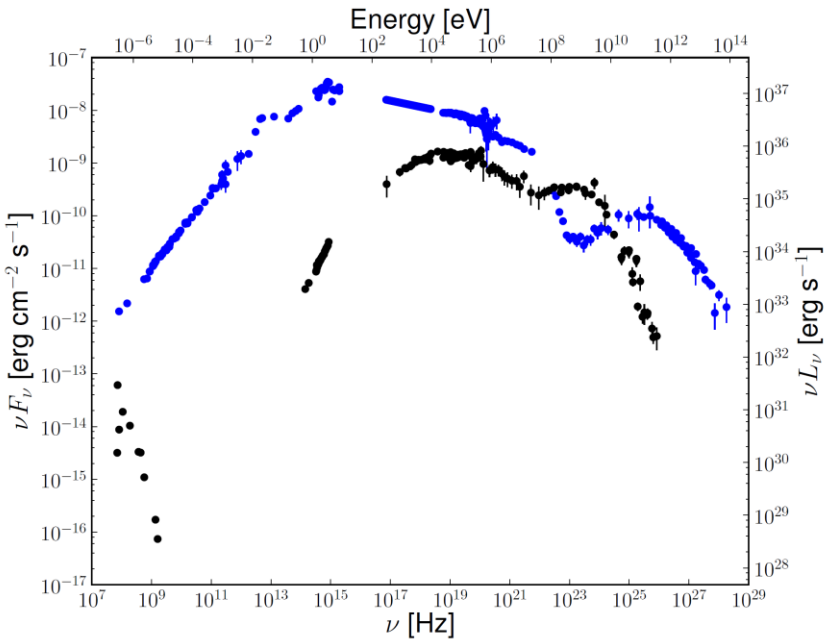
Sokolowski et al. (2025)



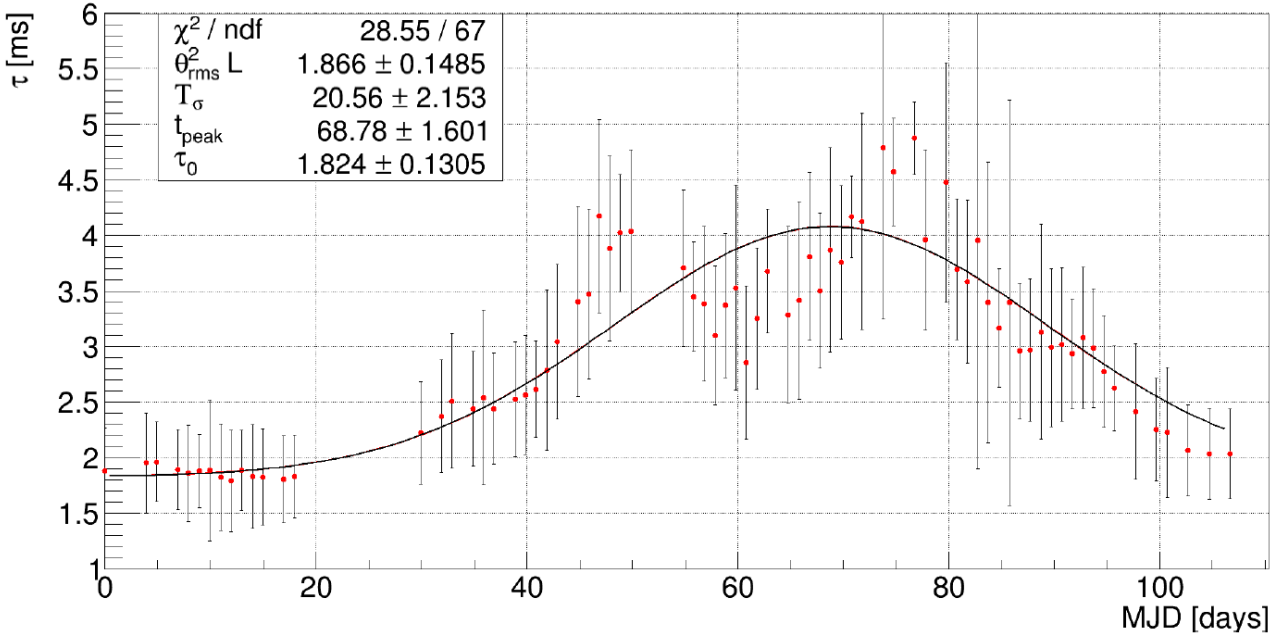
Philippov et al. (2020)

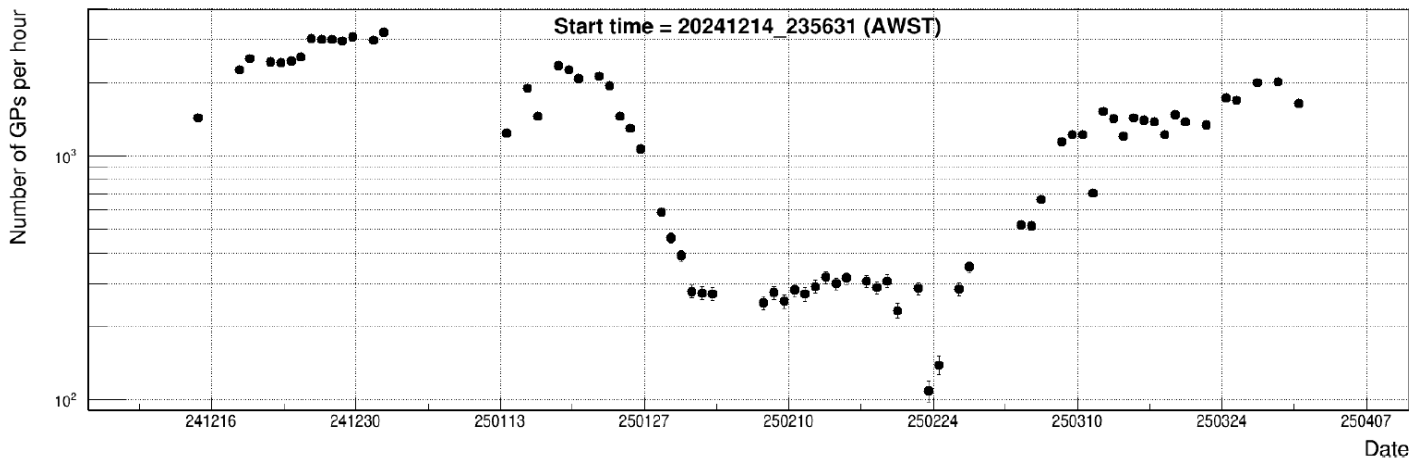
Appendix – Observations biases

- Observations conducted between: 14/02/2025 – 18/02/2025;
- there are evidence of a plasma blob passing through the line of sight;
- decrease of GPs during our observations coincident with the one of Sokolowski et al. (2025);
- the minimum observable energy influenced by the Crab nebula.



Bühler & Blandfor (2014)

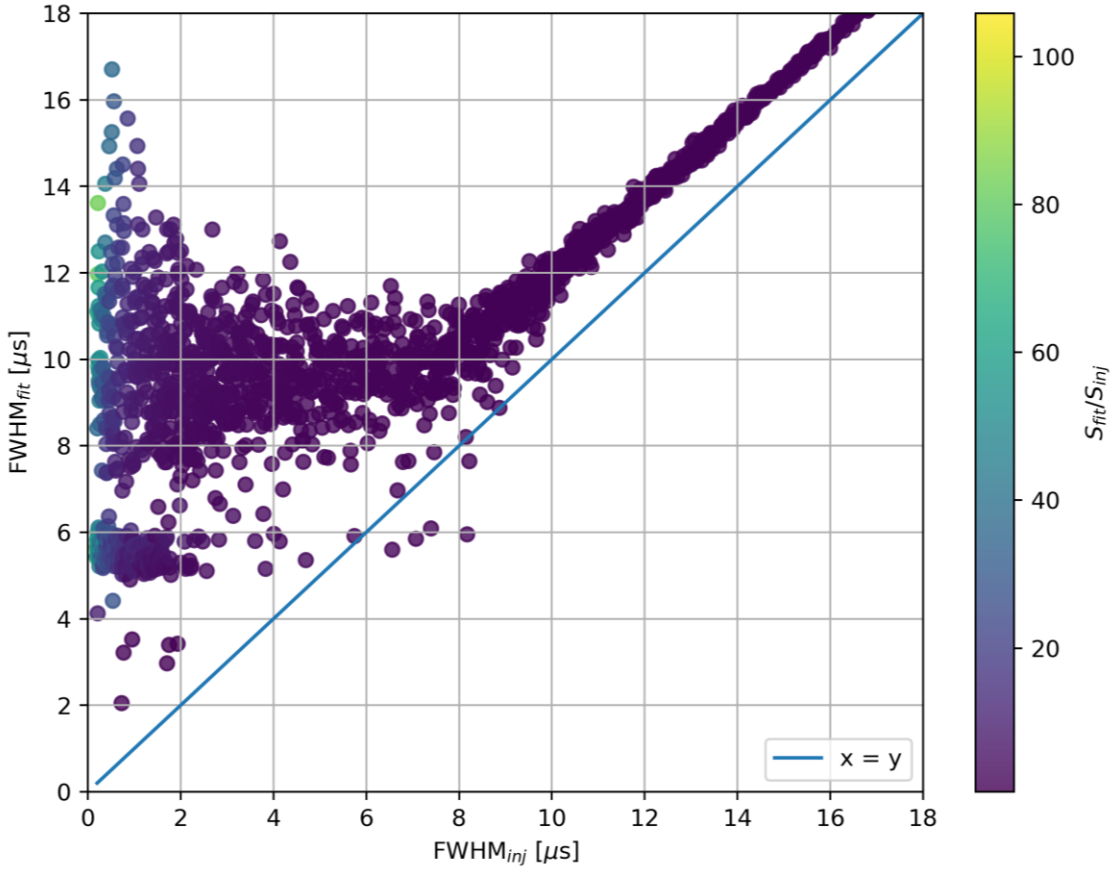


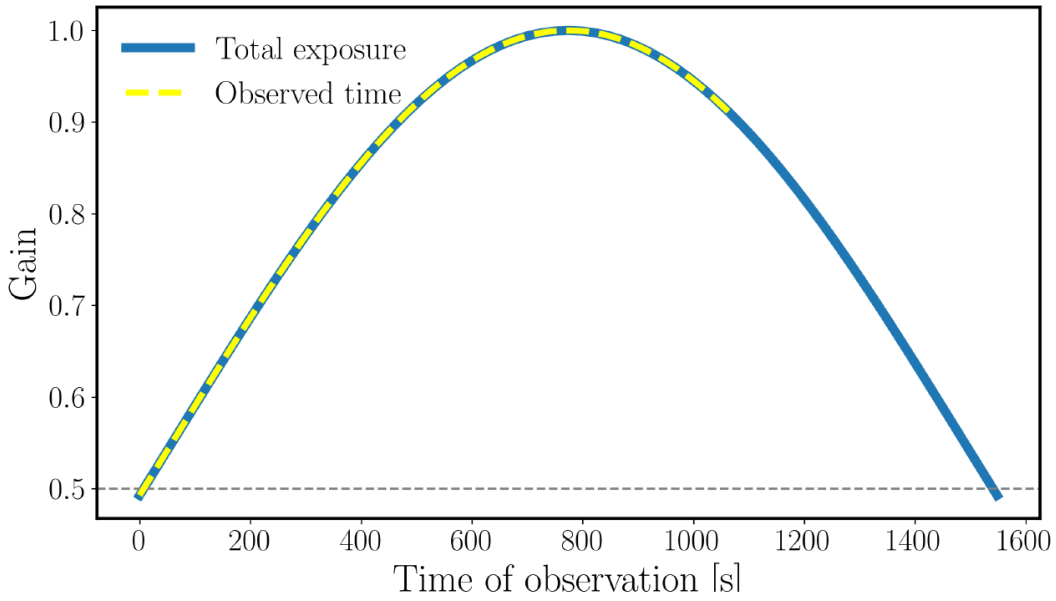


Sokolowski et al. (2025)

Appendix - Instrumental effects

- GBT resolution ~ 10 μs vs. peak of whidths distribution < 1 μs (Bhat et al. 2008);
- NC gain changes during the transit.





Geminardi et al. (2025)