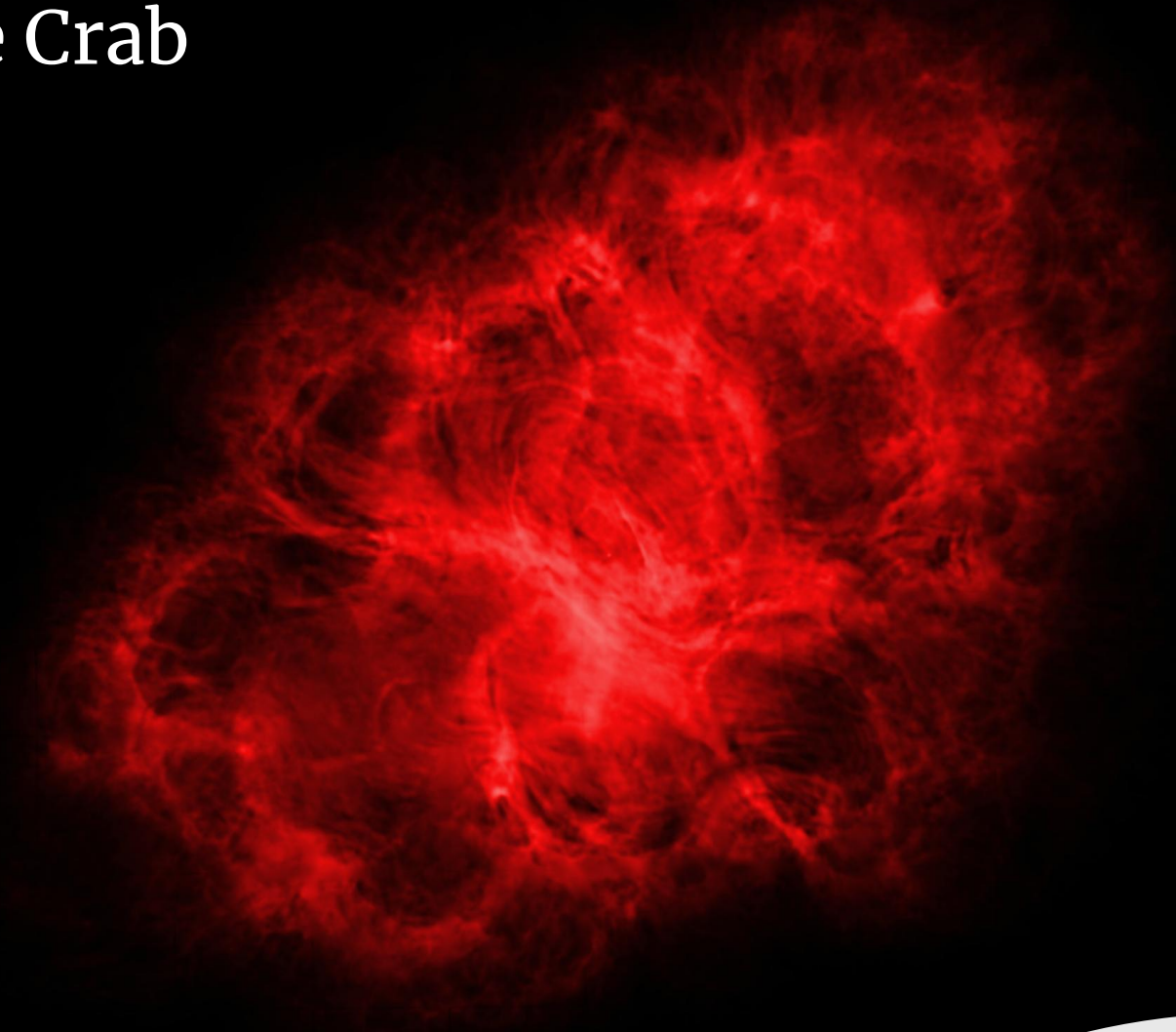
Multifrequency study of the energy distribution of the Crab single pulses



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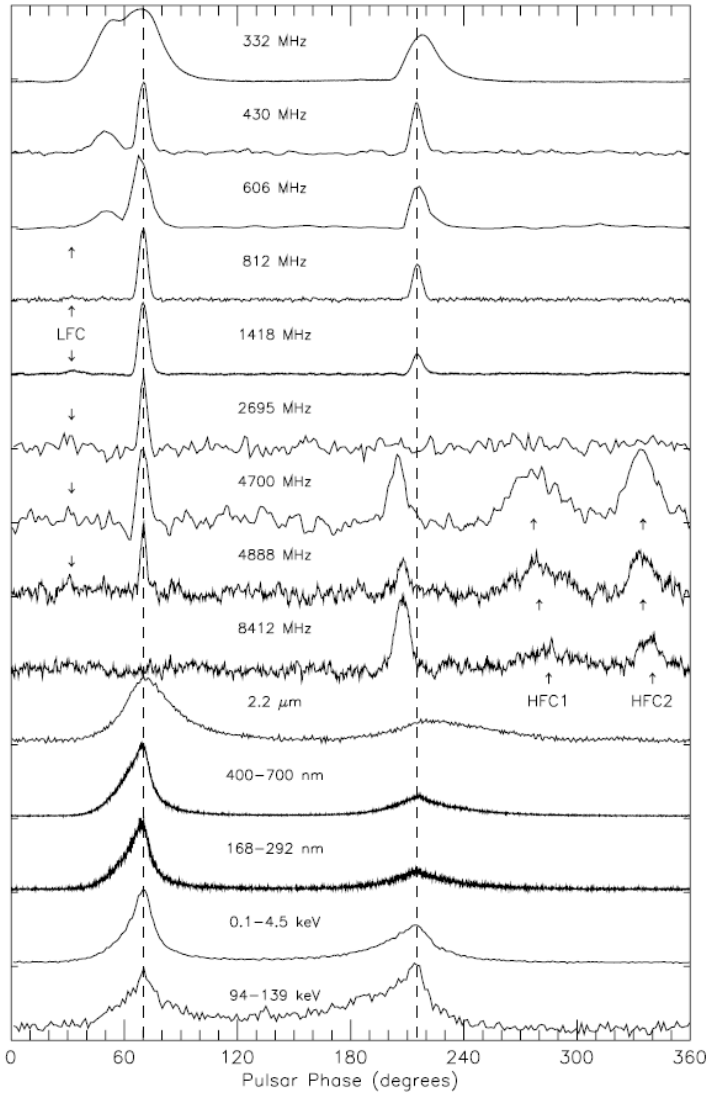
Crab Pulsar

- It is the youngest rotation-powered neutron star and it has a pulsar wind nebula.
- It has a period of 33 ms.
- It emits giant pulses (GPs, only ~20 pulsars out of ~ 3000 are known to emit GPs, Kazantsev & Potapov 2018).

Crab GPs:

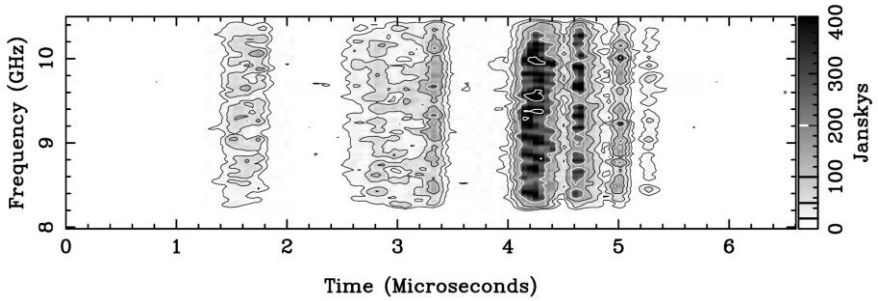
- they are observable from low radio frequencies ($\nu \sim 20$ MHz) to optical and X-ray bands (Sallmen et al. 1999) ;
- fluence can be up to two orders of magnitude ($\sim 10^2$) higher than regular pulses;
- they can exhibit nanosecond intrinsic structure (microbursts and nanoshots, Hankins & Eilek 2007);
- they are not detected every rotation;
- the fluence cumulative distribution follows a power law (Popov & Stappers 2007).



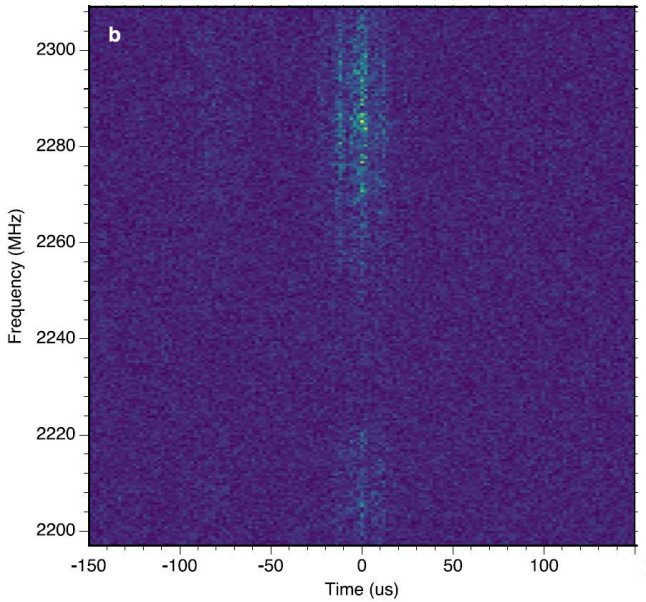
Moffett & Hankins (1996)

Giant pulses and FRBs

Hankins & Eilek (2007); Crab

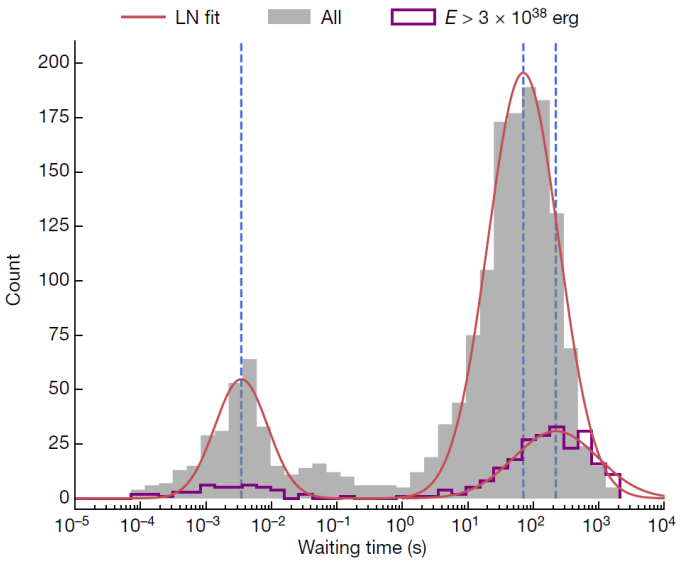


Majid et al. (2021); FRB 20200120E



Link with FRBs:

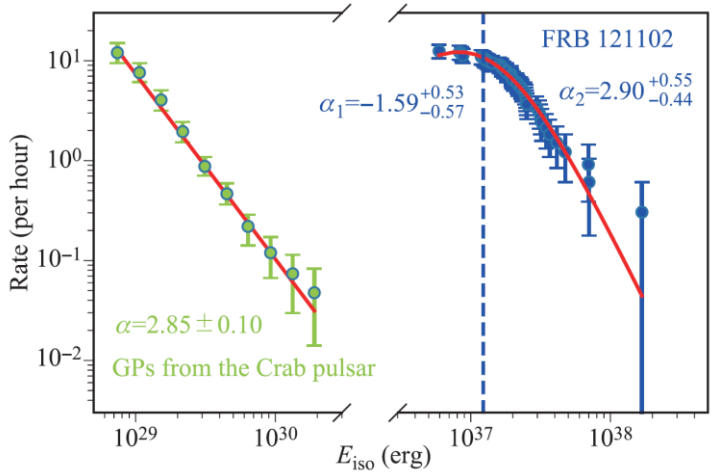
- the energy distribution of FRB121102 has the same slope of as that of the Crab GPs (α =2.9 at >130 Jy ms, Lyu et al. 2021);
- in some cases they exhibit the same intrinsic nanosecond structure (Majid et al. 2021).



Li et al. (2021); from hyperactive FRB source

Goals of this work:

- Investigate the energy and time distributions to compare optical and radio emission;
- Compare the waiting time distribution with that of FRBs and see if it is possible to determine whether trends in the emission mechanisms can be identified.

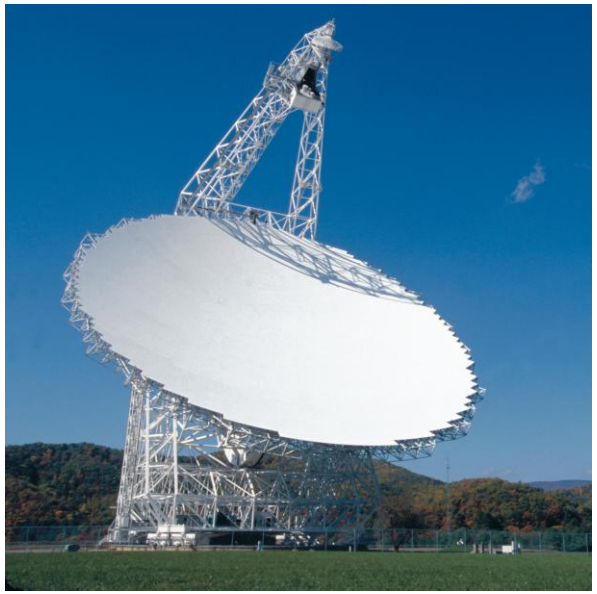


Lyu et al. (2021)

Observations

Green Bank telescope:

- on source time: 245 minutes;
- frequencies: 1100-1900 MHz;
- sampling time: 10.24 μs;
- 1 sigma fluence = 0.01 Jy ms.



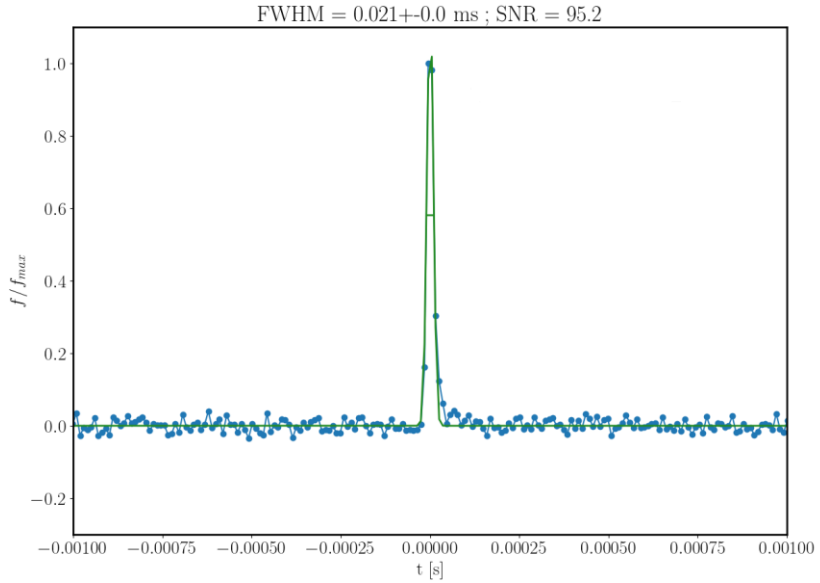
Northern Cross:

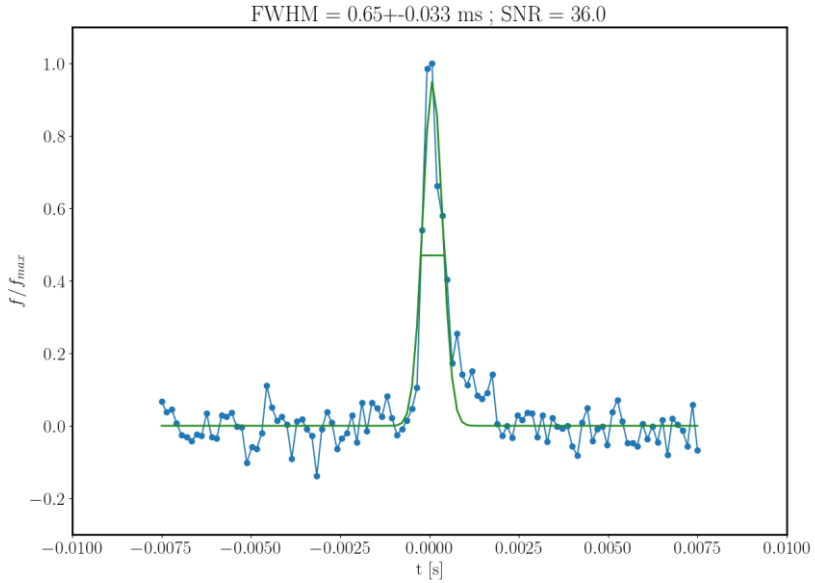
- on source time: 139 minutes;
- frequencies : 400-416 MHz;
- sampling time: 138.24 μs;
- 1 sigma fluence = 1.24 Jy ms.

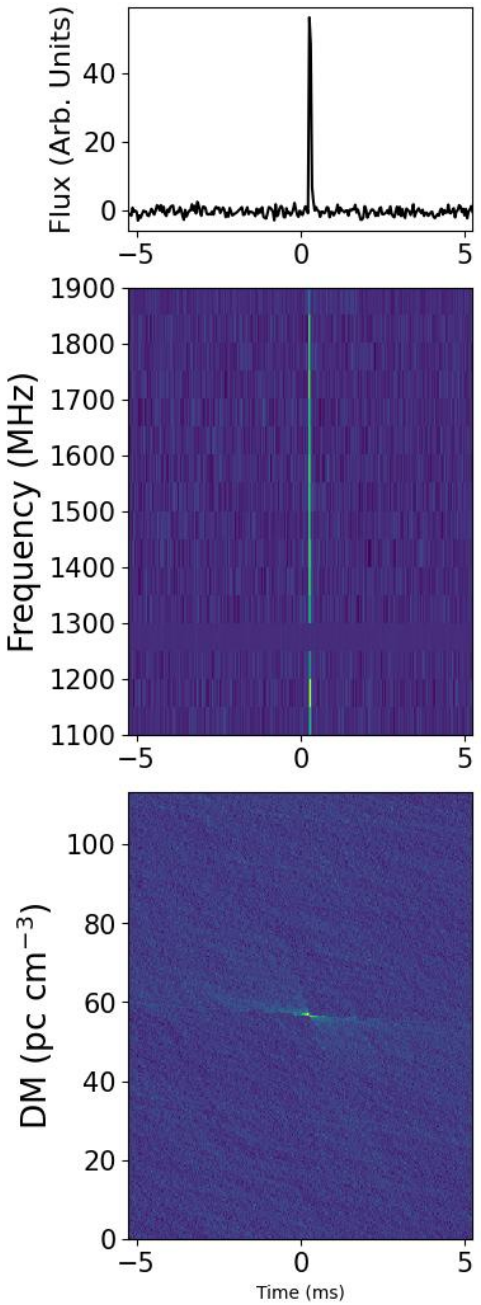
Pulse Search

Procedure:

- search for candidates with HEIMDALL (DM range: 37-77 ; SNR threshold 6.5);
- classify candidate with FETCH;
- fit a Gaussian profile to the de-dispersed spectrum (DM = 56.71) integrated over all frequencies;
- automatic fit of the burst profile;
- compute the flux density and the width.

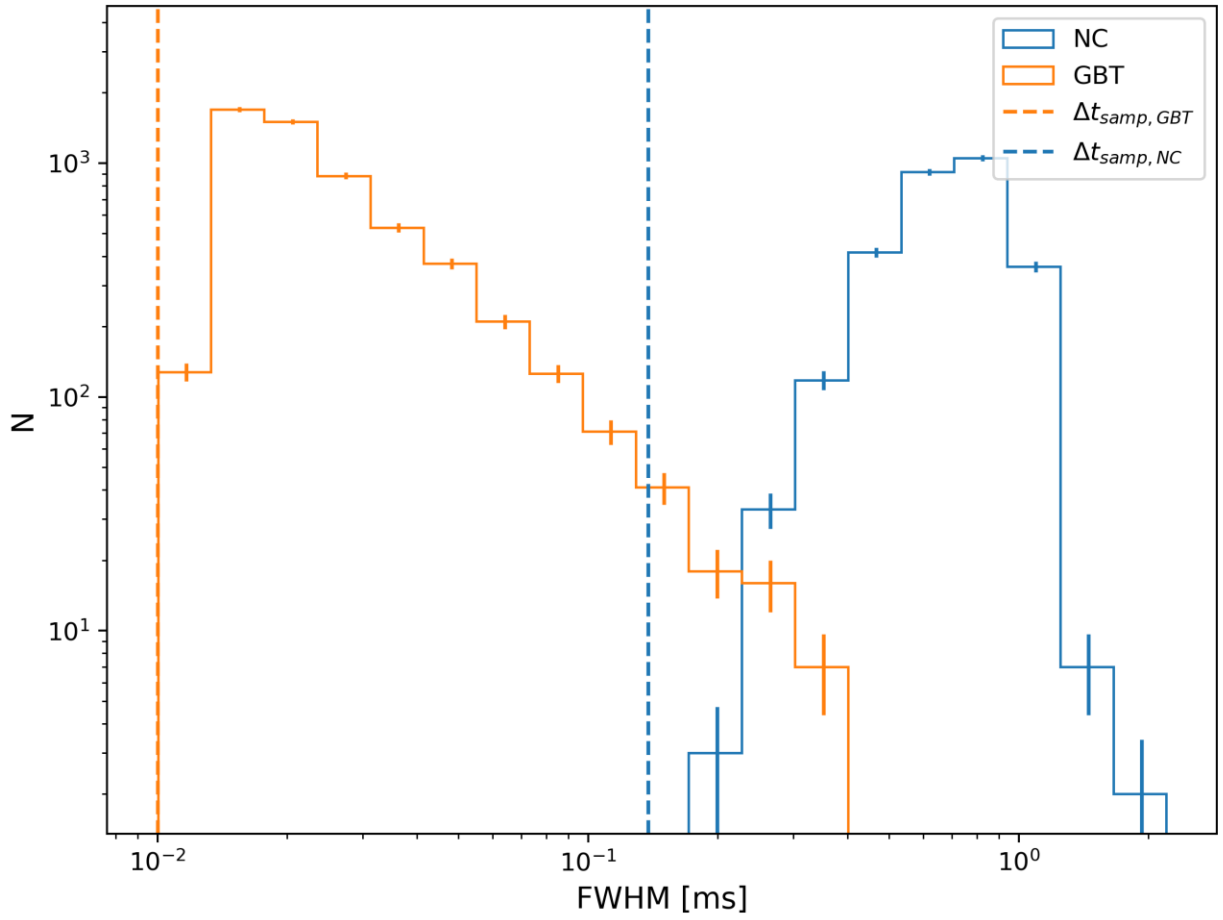






Preliminary results: width distributions

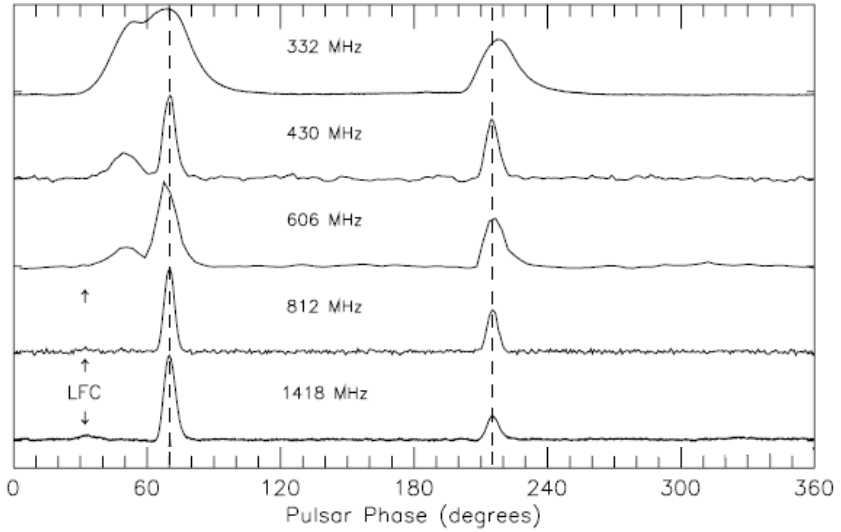
- The FWHM at high ν is smaller consostent with Radius-to-Frequency Mapping;
- The width distribution at 1.4 GHz is truncated due to limitations in time resolution (~ 10 μs);
- At 1.4 GHz the FWHM distribution is expected to peak at lower values (Karuppusami et al. 2010, Bhat et al. 2008).



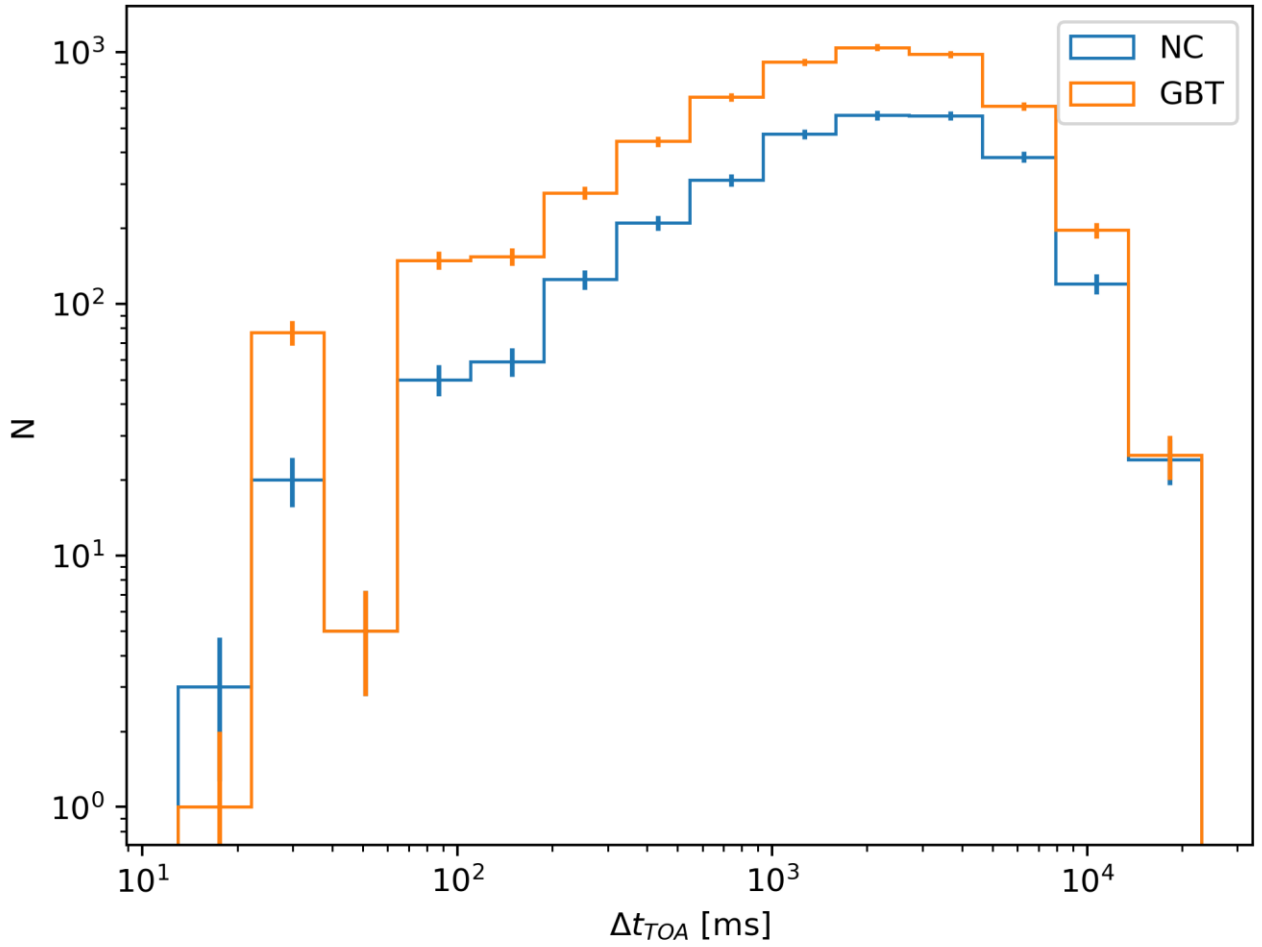
Preliminary results: waiting times distributions

The waiting time is defined as the difference between two consecutive pulses.

- Few consecutive interpulses and main pulses are observed (separated by ~ 14 ms).
- Frequent GPs occur each rotation (at 33 ms, they can appear as either main pulse or interpulse).

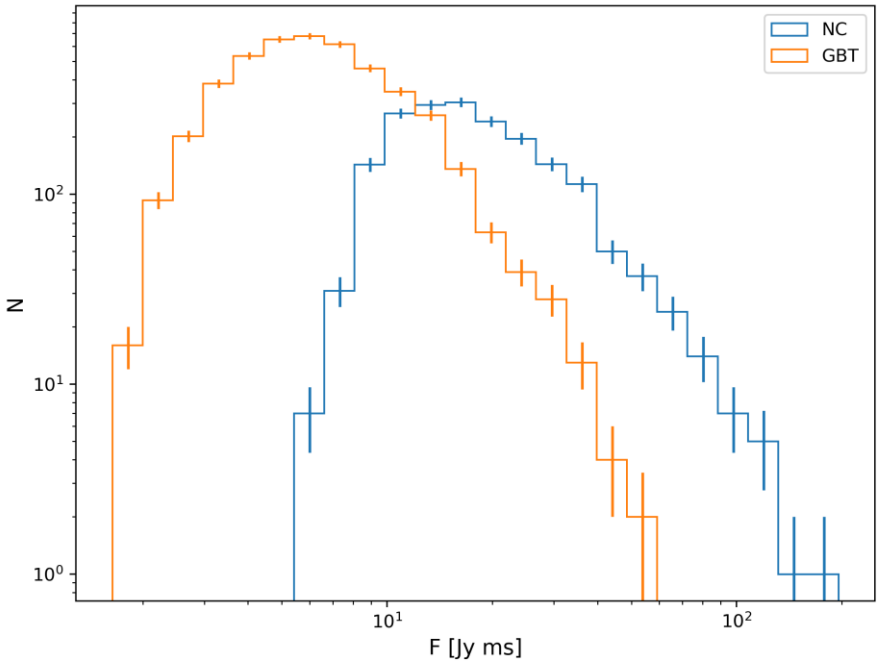


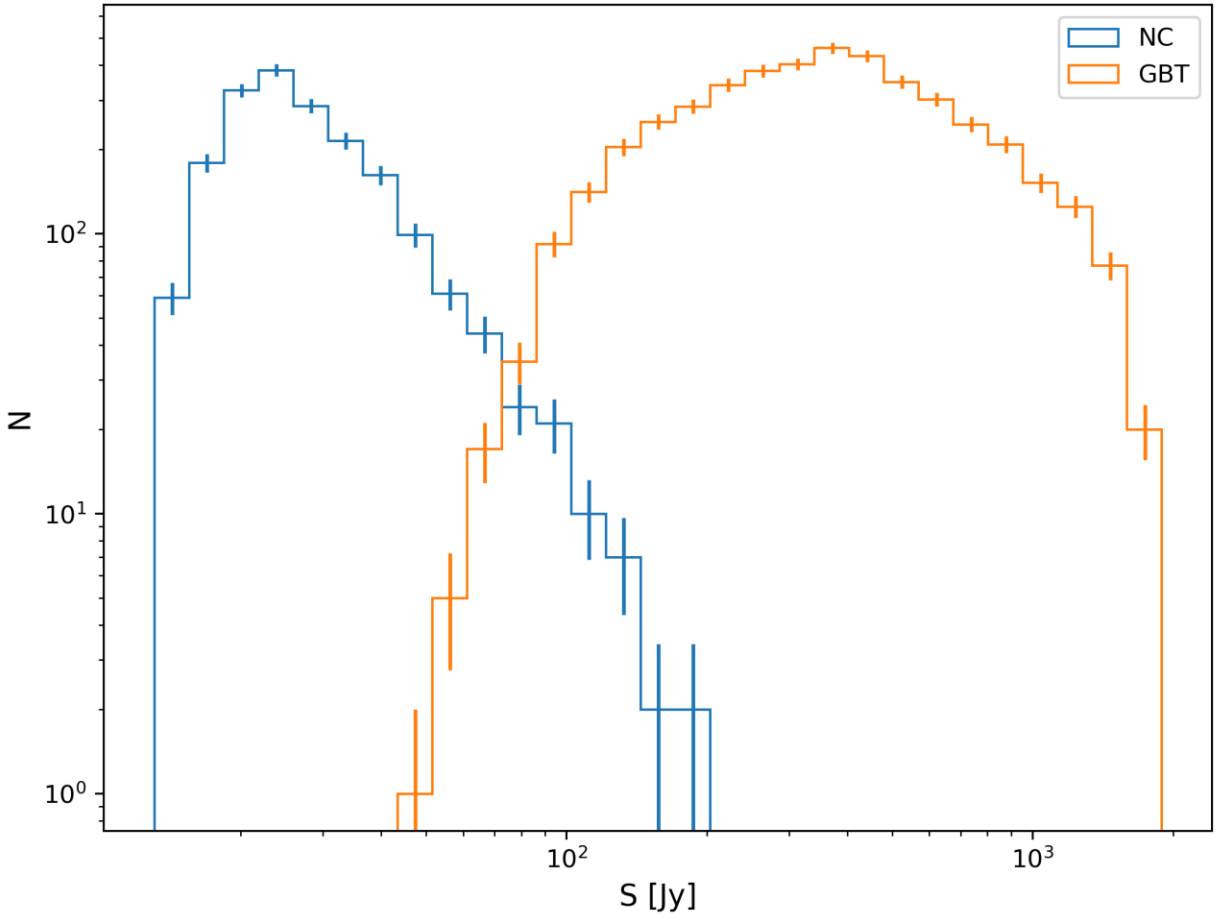
Moffett & Hankins (1996)



Preliminary results: flux and fluence distributions

- Flux limit GBT: 13.7 Jy (10 sigma, 1400 GHz).
- Flux limit NC: 12.4 Jy (8 sigma, 408 MHz).





Future work

- These observations will provide an energy ratio (optical vs. radio) for the Crab pulsar, enabeling a comparison with observations carried out for FRBs.

- Additional observations from GBT (at 800 and 1400 MHz) and from Noto (at 2300 MHz, simultaneously with the NC) will help characterise the spectral properties single/giant pulses and allow a comparison with FRBs.

- By studying the waiting times distribution, we aim to determine whether the periodicity of the Crab could be recovered from it. This approach could be used to reveal potential periodicities in hyperactive repeaters.

Double pulses