National Centre for Radio Astrophysics
Tata Institute of Fundamental Research

Semester Project

A real-time Beamformer Data Monitoring Tool at the GMRT

Garvit Agarwal
BS-MS IISER Pune

Project Guide – Prof. Yashwant Gupta, NCRA, Pune

IISER Internal Guide – Dr. Ramana Athreya

Acknowledgments

First of all, I would like to express immense gratitude to Prof. Yashwant Gupta for giving me this opportunity and guiding me throughout this project with patience. Thanks also to Dr. Ramana Athreya for agreeing to be my internal guide for this semester project at IISER Pune. This project will serve as a great starting point for my future endeavors in astronomy.

Furthermore, the project required a lot of help and communication with the control room staff at the GMRT, so I am grateful for their cooperation. I especially thank Sanjay Kudale sir for his immense help with various aspects which enabled me to work on the beamformer data monitoring tool.

Introduction

- Initial weeks were spent on covering basics -

    - Writing my own code for folding and other analyses routines.

    - On-pulse and off-pulse energy statistics in pulsar data.

    - GMRT Pulsar Tool (gptool) and how it performs folding, dedispersion and RFI filtering on the pulsar data.

    - Learnt how to use shared-memory for inter-process communication.

    - Explored an interesting inter-pulse emission in B1642-03.

- With this background, I worked on a single-pulse analysis tool for pulsars and a real-time beamformer monitoring tool for GMRT.

Single-pulse Analysis tool for Pulsars

- Developed by past students. Various options for detailed analysis of individual pulses.

- Eg finding null pulses, energy histograms, autocorrelation of a pulse etc.

- 2 different codes- for single and dual frequency analysis with slightly different set of features.

```
Instructions:
Use 'n' to go to next pulse
Use 'b' to go the earlier pulse
Use 'p <start phase> <end phase>' to set a phase range (Default is full period)
Use 's <phase shift>' to shift phase window (Phase shift should remain between 0
Use 'f' to show folded profile
Use 'h' to hide folded profile
Use 'i <Integration>' to integrate profile
Use 'g <Pulse Number>' to get profile for a specified pulse number
Use 'l' to check for pulse nulling
Use 'u' to find all null pulses
Use 'a <Time lag>' to get autocorrelation plot for the current pulse, integration
ange
Use 'c <MinSNR>' to get list of pulse numbers above a given threshold
Use 't <MinSNR>' to get list of pulse numbers with peak above a given SNR
Use 'v <Time lag(ms)> to get the average ACF for the strongest pulses
Use 'y' to view the ADP for the specified window
Use 'k' to get instructions
Use 'q' to terminate program
Use 'w' to see on-pulse and off pulse energy histograms
Use 'x' to see grayscale plot of on-pulse energy as a function of pulse number
Folding profile. Please wait.

Default integration is 1 samples
```
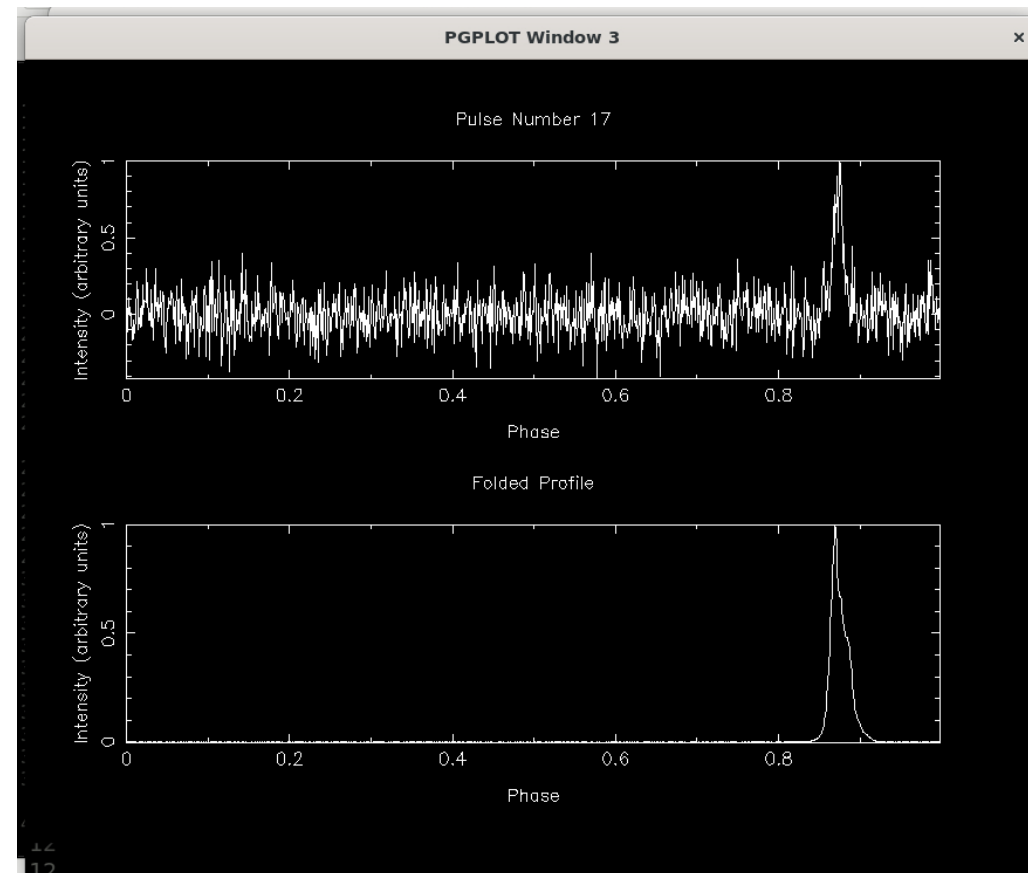
Single-pulse Analysis tool for Pulsars

My work involved -

- Comparing the 2 codes' features and understanding them.

- Fixing flaws in various features and adding some more functionality.

- Making the user experience more sensible.

- Adding a feature myself for changing current pulsar without exiting the tool.

- Ongoing task – consolidate the features of both codes into a single tool for both dual and single frequency analysis.

Real-time beamformer data monitoring tool

- The monitoring tool uses the GMRT Pulsar Tool (gptool) .

- Gptool requires a 'gptool.in' file to run. The file contains various observation parameters.

- Gptool can attach to the real-time incoming data and do folding, dedispersion etc.


```
#****Spectral line RFI mitigation options****#
200            : Number of channels to flag at band beginning
200            : Number of channels to flag at band end
1              : Frequency flagging options (0-> no flagging, 1-> real time
calculation)
1              : Bandshape to use for frequency flagging (1-> normalized bandshape,
2-> mean-to-rms bandshape, 3-> Both)
3.5            : Threshold for frequency flagging (in units of RMS deviation)
------------------------------------------------------------------
#****Time domain impulsive RFI mitigation options****#
0              : Time flagging options        (0-> no flagging, 1-> real time
calculation)
1              : Data normalization before filtering (0-> no, 1-> yes)
1              : Time flagging algorithm      (1-> histogram based, 2-> MAD based)
100            : Threshold for time flagging (in units of RMS deviation)
------------------------------------------------------------------
#****Other options****#
50             : Smoothing window size for bandshape normalization (in number of
channels)
1              : Normalization procedure (1-> cumulative smooth bandshape, 2->
externally supplied bandshape.dat)
0              : Replace by median values (0-> Ignore flagged samples, 1-> Replace
flagged samples by window median, 2-> Replace by smooth bandshape)
------------------------------------------------------------------
```

gptool.in
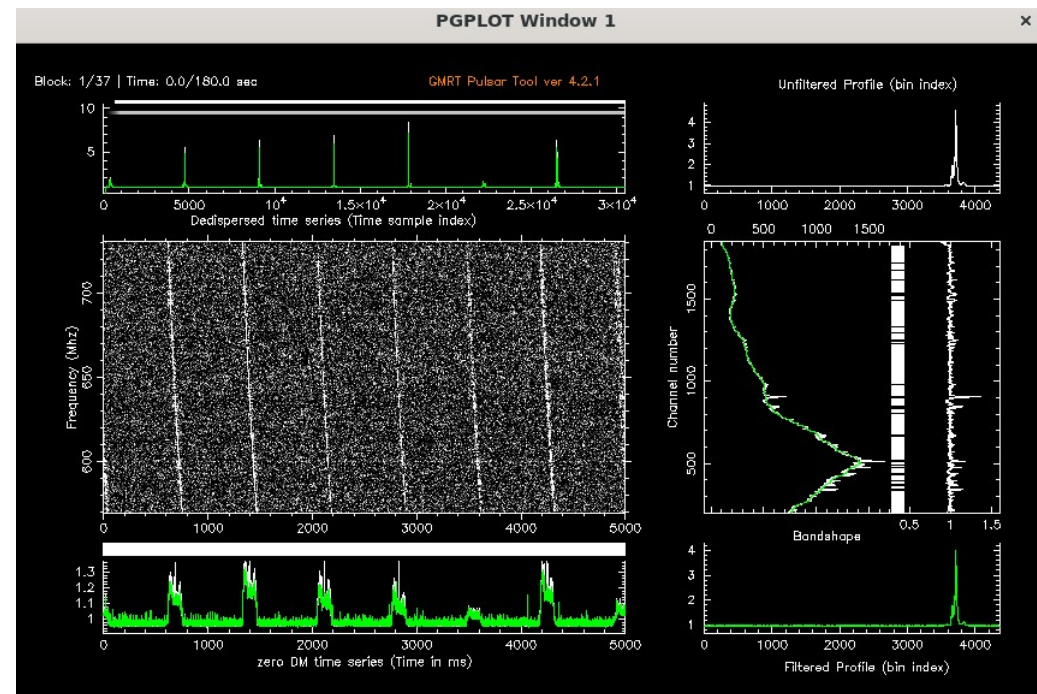
<u>Real-time beamformer data monitoring tool</u>

The monitoring tool currently has the following capabilities -

- Detect whether there is an ongoing observation or not.

- Retrieve current observation parameters and put them in gptool.in

- Detect whether the source name is a standard pulsar name or not.

- Let gptool process the real-time data until observation is stopped.

- More features and refinements are in progress.

Real-time beamformer data monitoring tool

Applications and use of this monitoring tool

- For continuous monitoring of the beamformer data. Eg by choosing the right 'period' in gptool.in, strength of powerline RFI can be monitored.

- For checking the data quality during pulsar observation.

- Can also be used for checking the performance of individual antennas in an automated way.

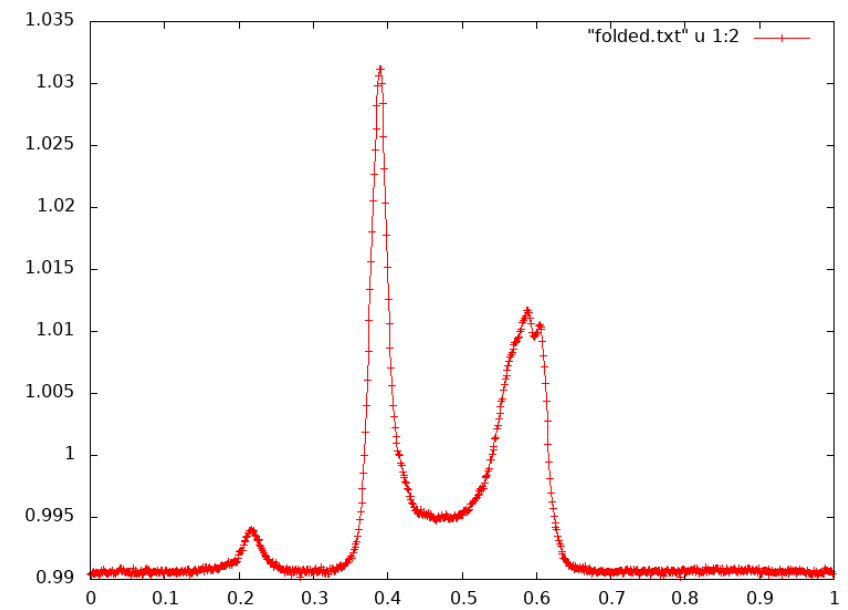- Use a GUI and a web-based platform to allow remote users to use the tool.
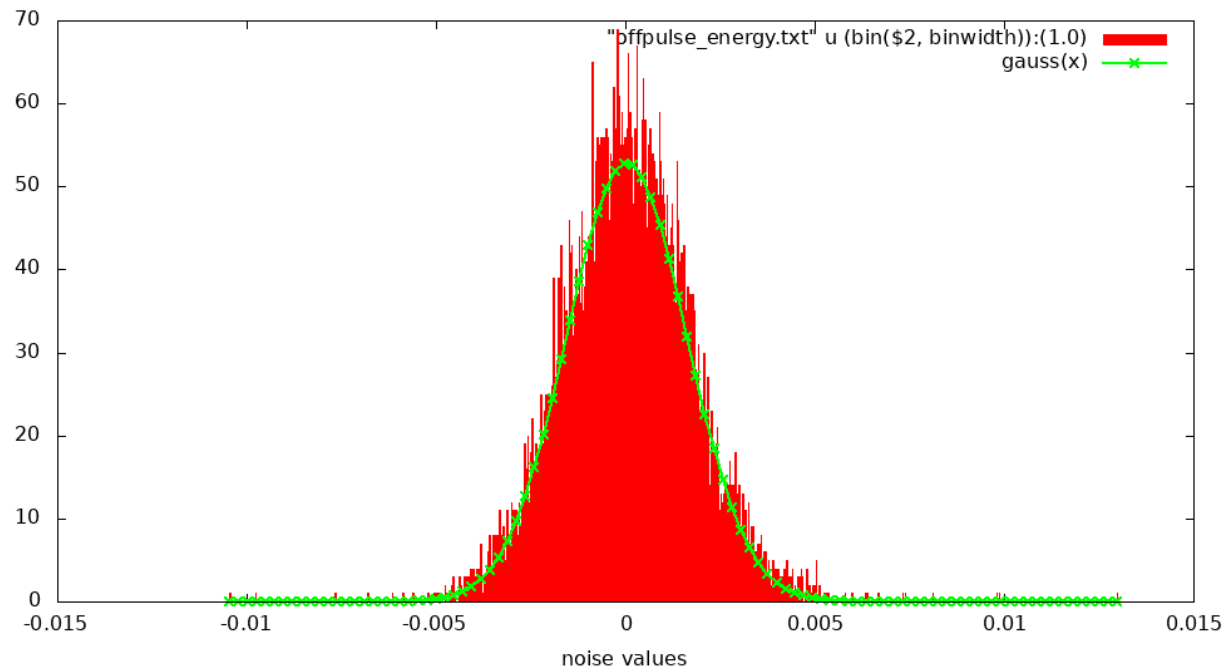
And more..

THANK YOU

Pulse energy - ../../J2145-0750_msp/stacked_profiles/pulses.bin
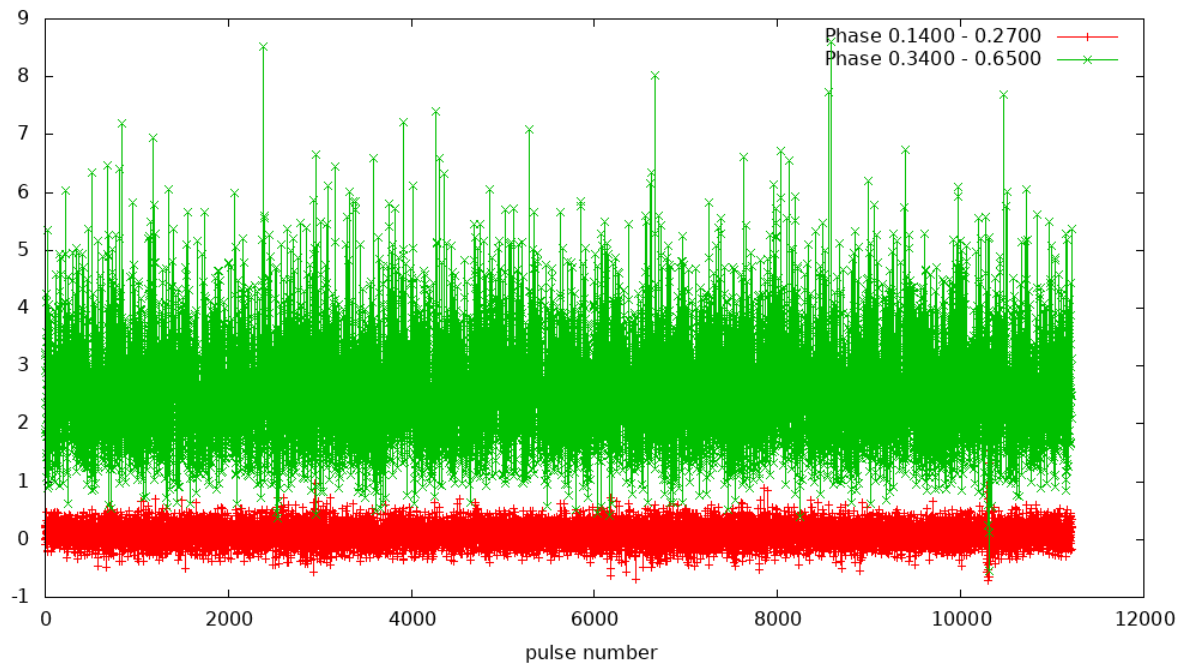
Folded - ../../gptool_results/J2145-0750_msp/fullDM_filtered.gpt