

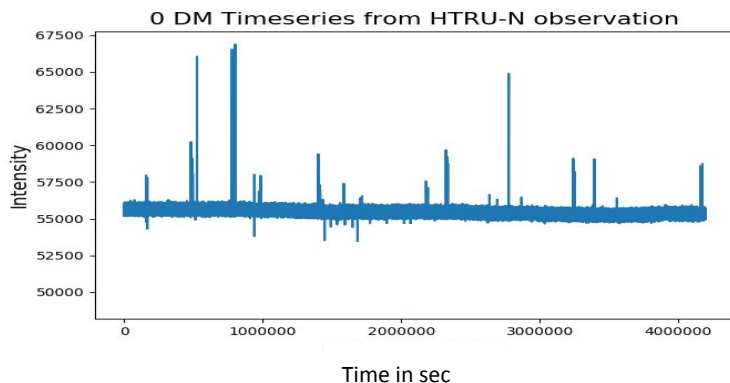
Multibeam Time domain technique for RFI mitigation.

Shalini Sengupta

Advisor: David Champion.

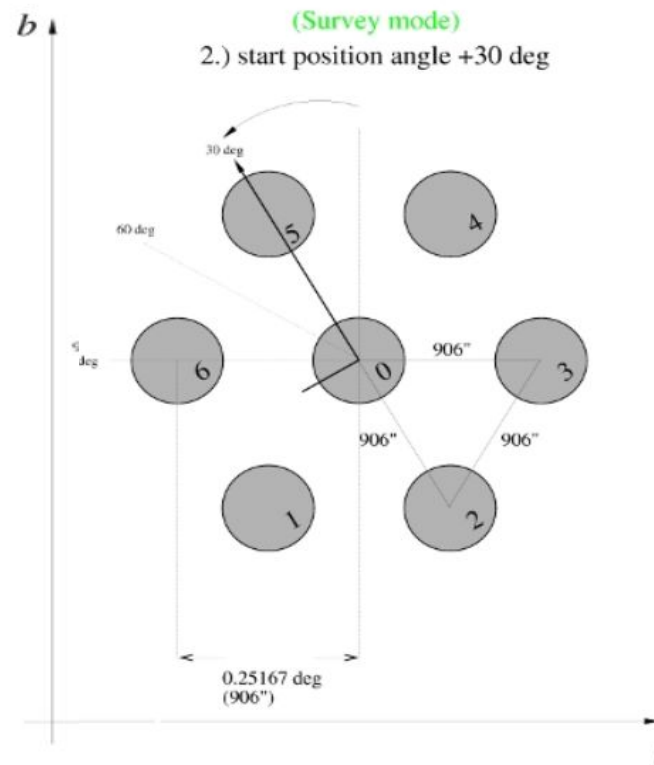
FPRA group meeting talk : 23.03.2021

Key Ideas:



- **RFI appears in multiple beams.**
- Assuming **same time of incidence of RFI** entering the **multibeam receivers**, a **spatial filtering** system is applied.
- **Sample by sample comparison** is done for 0 DM timeseries of each of the 7 beams to flag samples **affected by RFI in ≥ 4 beams**.

Credit: R.P. Eatough



7 beam map of 21 cm receiver at Effelsberg.

Challenges:

- The **7 beam servers at Effelsberg do not start at the same time.**
- **Simultaneous occurrence of RFI in multiple beams.**

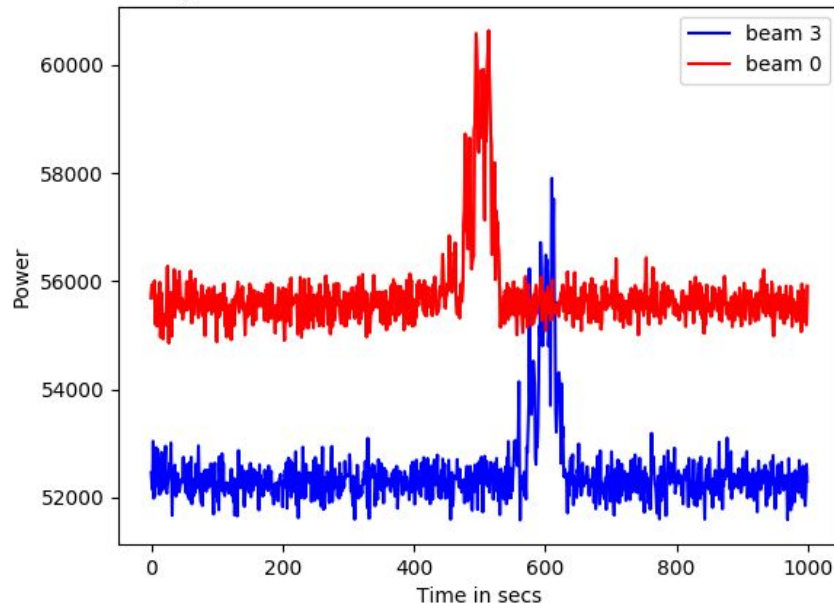


Strong cross correlation between the 0 DM timeseries of different beams.



Based on **lead/lag values** from cross correlation, **absolute reference for comparing** time samples between beams for RFI mitigation is decided.

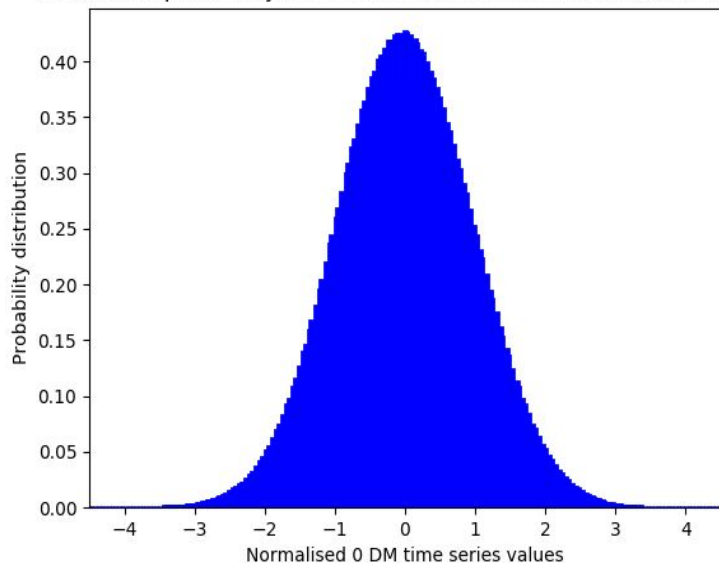
Using RFI to cross correlate timeseries of different beams



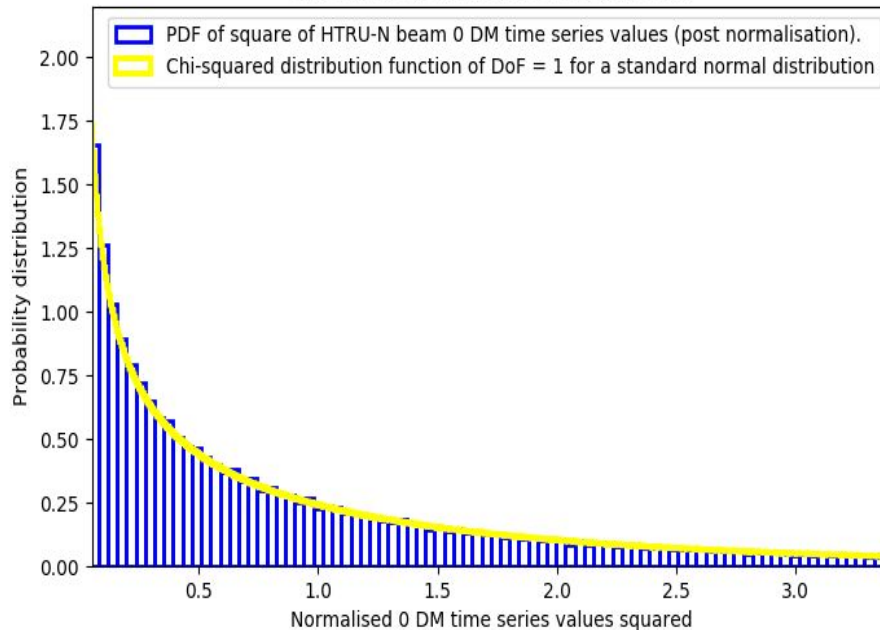
- 7C_2 combinations of correlations performed to get mutual delays.

Probability distribution to decide thresholds

Normalised probability distribution of 0 DM series of a HTRU-N beam.



Chi-squared distribution comparison.



Thresholding and Implementation

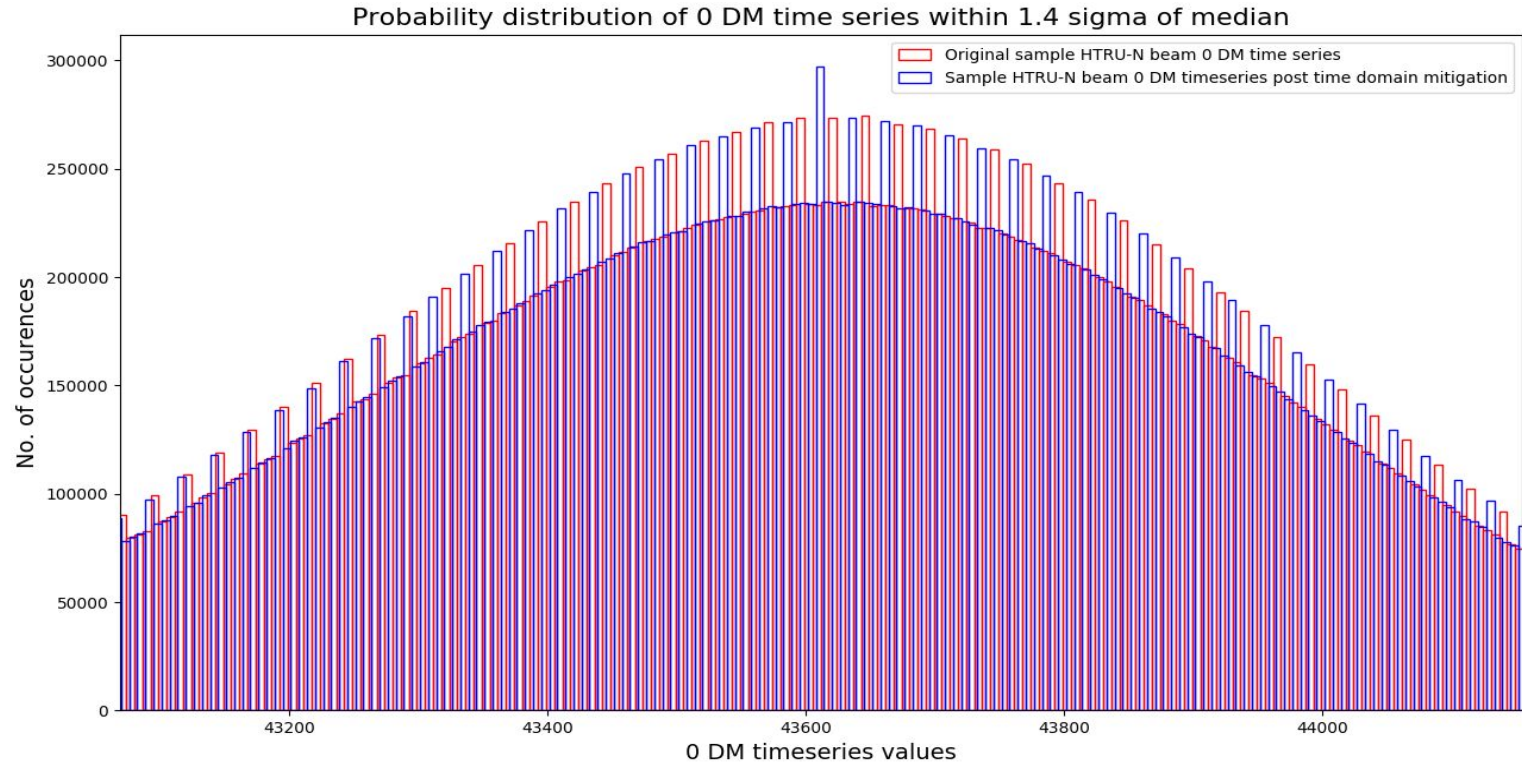
- Assuming **Gaussian** distribution for each beam, the **cumulative probability distribution** is :

$$\frac{1}{2} \left[1 + \operatorname{erf} \left(\frac{x - \mu}{\sqrt{2\sigma^2}} \right) \right]$$

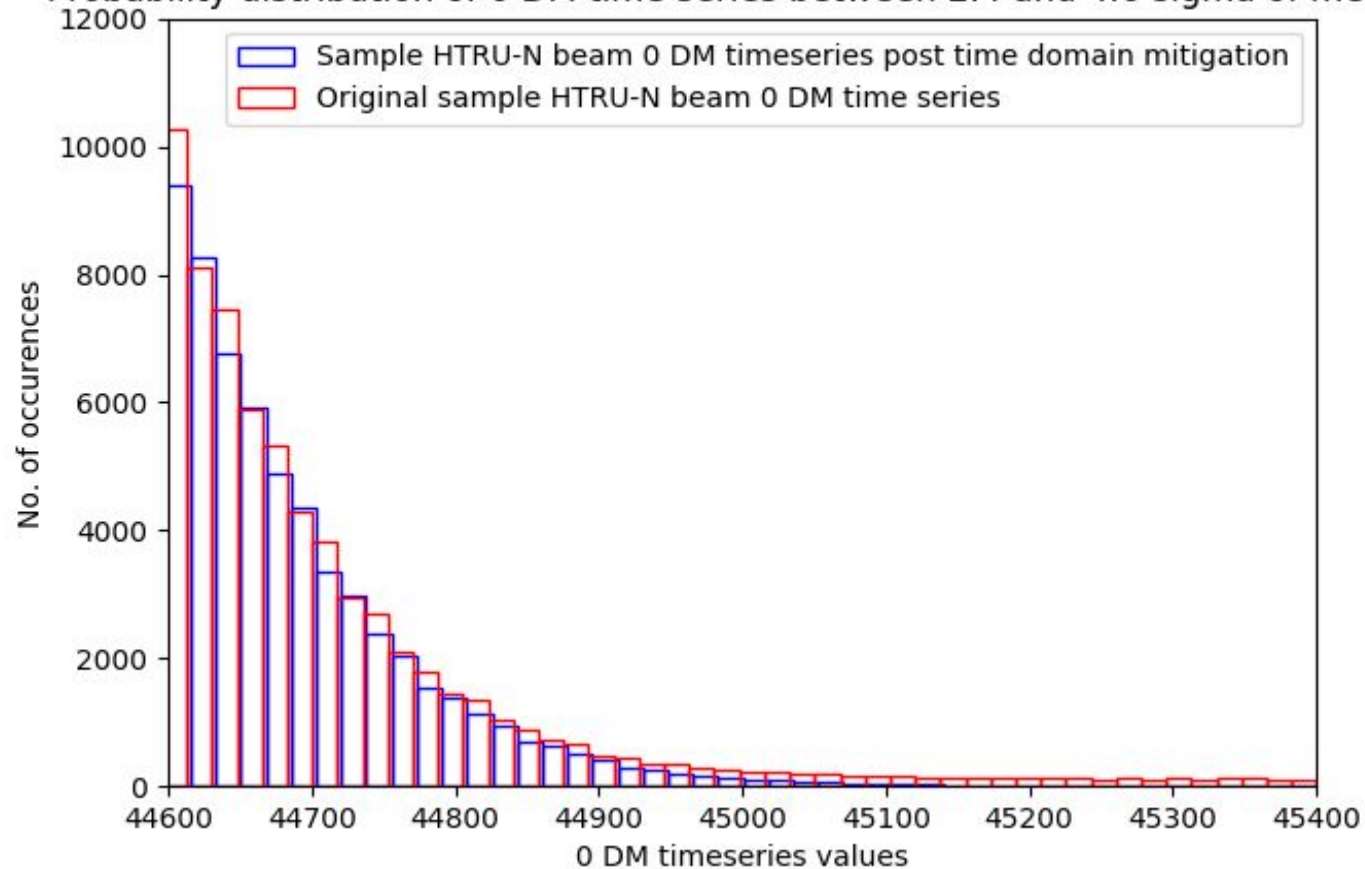
- Using 1 - **error function**, the probability that a particular **bin exceeds the threshold in n beams simultaneously** is 1, threshold for flagging is decided (**false alarm**).
- The **no. of simultaneous beams**, n takes values **4, 5, 6, 7**. Lowest threshold is for 7 beams.
- With **mutual delays** calculated respective to a **reference beam**, **time bins exceeding respective thresholds** in 4 or 5 or 6 or 7 beams **simultaneously** are flagged.

- To account for the non-transitive property of correlation, the reference beam is **rotated** from the **0th to 6th beam** taking care of the **dynamic RFI environment** between the beams.
- A **beam specific list** of time bins having **outliers** is prepared.
- For each outlying time bin, the values of the 512 frequency channels are **replaced with median distribution of noise** from **neighbouring 'good' bins** in the original filterbank file.
- On average **0.05 - 0.09 %** of time bins (having in total $2^{**}25$ time bins) are **flagged** this way.

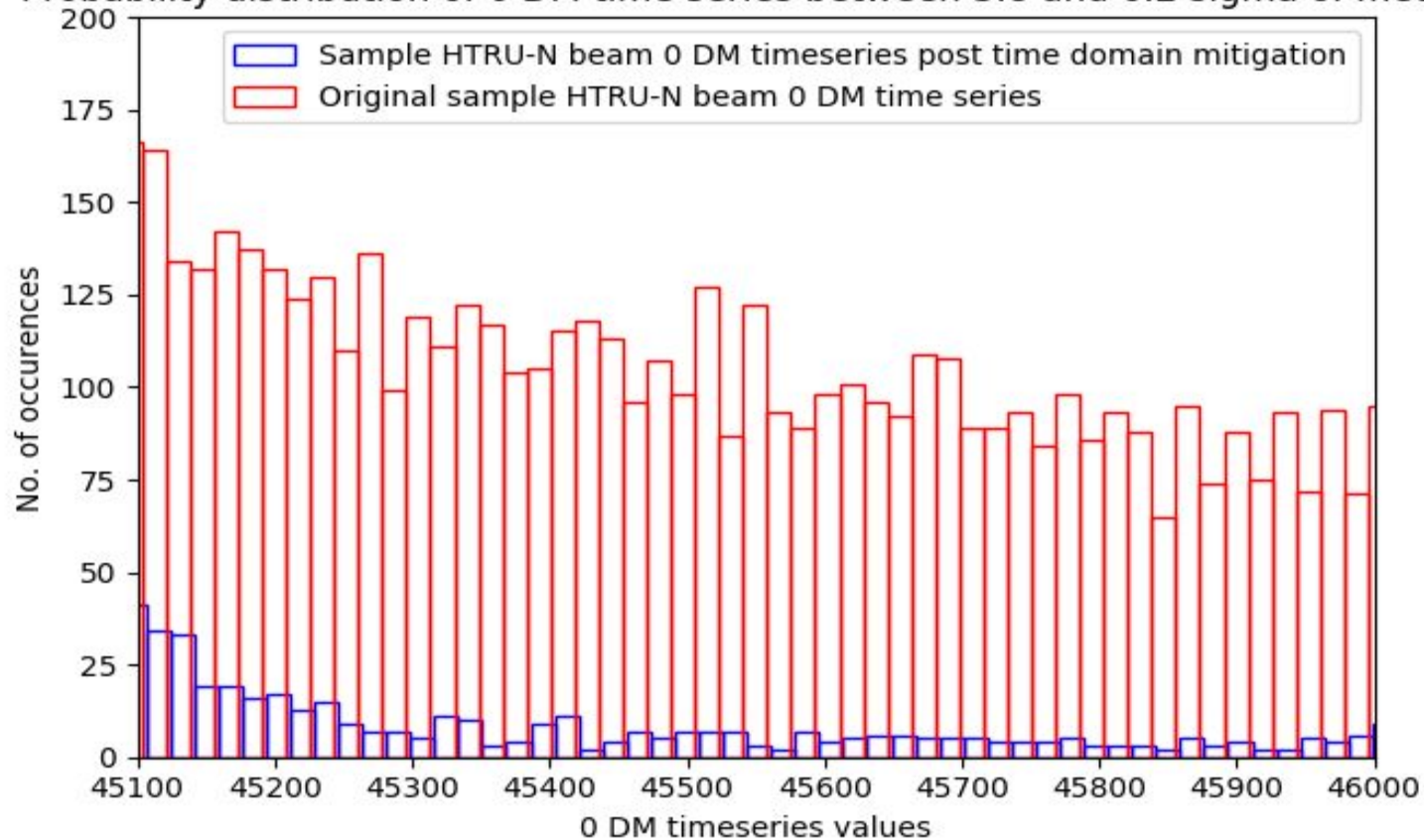
Results and Discussions:



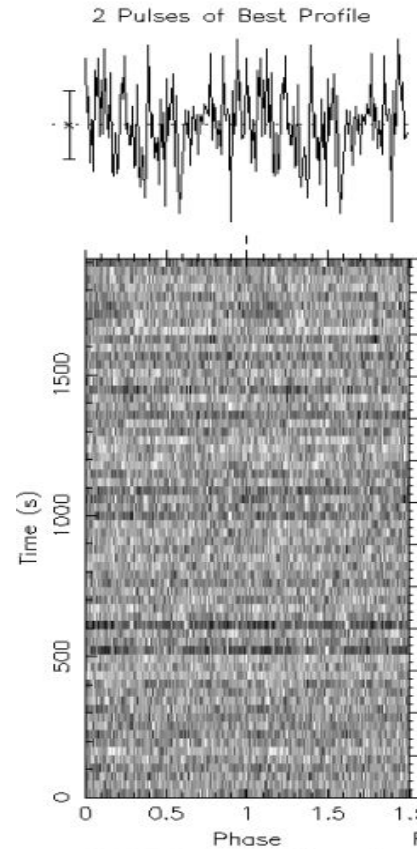
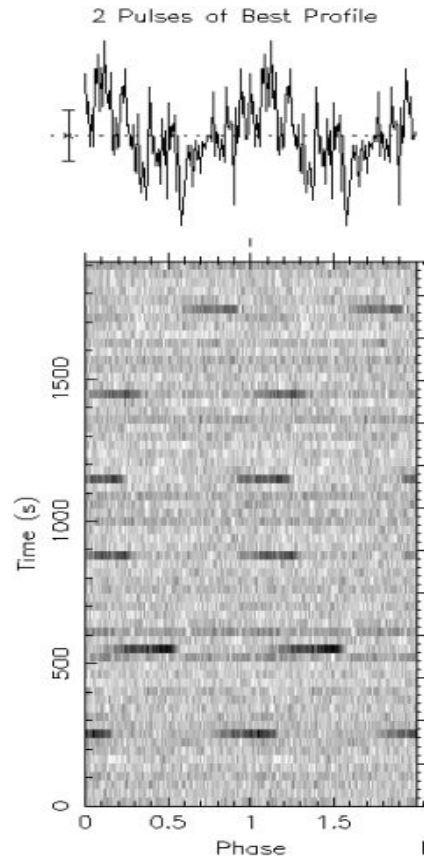
Probability distribution of 0 DM time series between 2.4 and 4.6 sigma of median



Probability distribution of 0 DM time series between 3.8 and 6.2 sigma of median



- Sample time-phase plot pre and post zap. .



● Improvements in Search pipeline:

- ❖ The **no. of fourier bins zapped** from **multibeam fourier domain RFI** mitigation **goes down by 50-75%** on average.
- ❖ **Improved spectral significance** resulting in **going up the candidate list** in the search for DMs near the known pulsar candidate. **More DM detections.**
- ❖ **Improved sifting** of candidates (more folds of desired candidate).
- ❖ Leading to **detection** of test pulsars **in the segmented filterbank's sifted candidate** list which were not appearing before!

CONCLUSION:

- ❖ Among **observing frequency domain** mitigation, **fourier domain mitigation**, and **time domain mitigation**, latter has given the most improvement to the search pipeline.
- ❖ **Currently** being used for **HTRU-N**. Will soon be implementing this for the **L-band survey** for **MeerKAT**.

THANK YOU.