



# The Search for a Repeating Fast Radio Burst

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## ABSTRACT

When FRB 121102 was detected, it was expected to be a one-off event just as previously discovered FRBs. However, years later, repeat bursts were found causing experts and theorists to wonder if all FRBs repeat. Now, using data taken with the ALFA multi-beam receiver at the Arecibo Observatory we present approximately 41 hours of follow up observations and analysis on FRB 110523. We utilized PRESTO's (PulsaR Exploration and Search Toolkit)<sup>1</sup> single pulse search tool to analyze the data and search for any repeat bursts. Here we report a marginal burst detected in a single beam at a similar DM as the previously measured value for FRB 110523, supporting the idea that there is a population of repeating FRBs.

## INTRODUCTION

### What is a Fast Radio Burst (FRB)?

- Short duration, intense burst of radio energy
- Excess dispersion measure (Figure 1)
- Appear to be one-off events
  - Suggests cataclysmic event

### FRB 121102

- First FRB known to repeat<sup>2,3,4,5</sup>
- Suggests a non-cataclysmic event
- Able to localize the burst and was found to be in galaxy 3 billion light years away

Figure 1

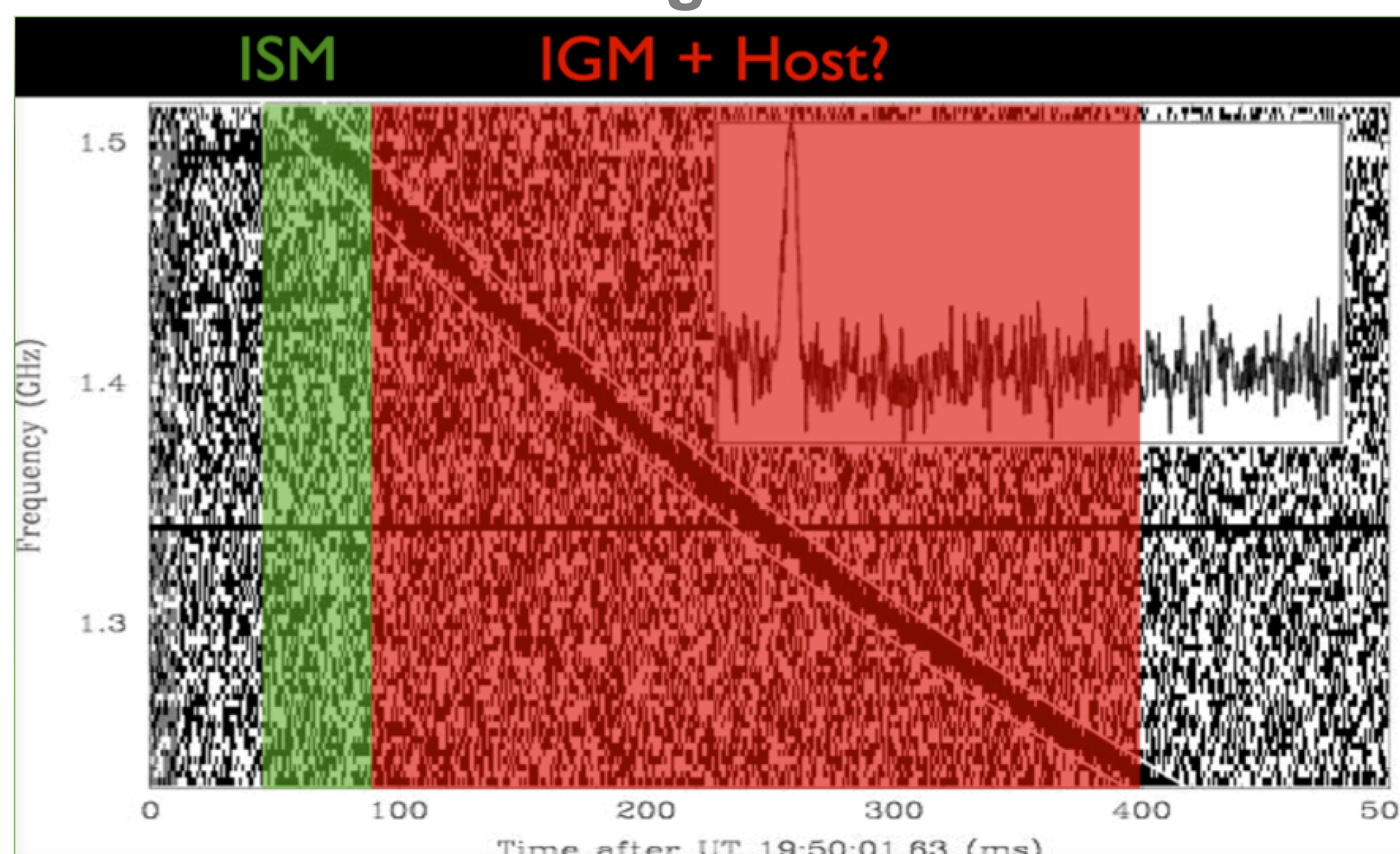


Figure 1 The dispersion for the first Fast Radio Burst

The green portion is the amount of dispersion that can be credited to the interstellar medium. The red portion is the amount excess dispersion (likely from the intergalactic medium, the host galaxy, or some combination of the two). Concluding that Fast Radio Bursts are extragalactic.<sup>6</sup>

## FRB 110523

- First reported in 2015, found in archival data taken in 2011 by the Green Bank Telescope at 820 MHz.
- The burst detected was linearly polarized, allowing for a rotation measure to be determined.
- Dispersion Measure of  $623.30 \text{ pc cm}^{-3}$ .
  - Only  $45 \text{ pc cm}^{-3}$  of the  $623.30 \text{ pc cm}^{-3}$  dispersion measure can be contributed to the Milky Way galaxy.
  - Suggests that FRB 110523 is of extragalactic origin.
- Burst estimate that it is at a distance of 6 billion light years.<sup>7</sup>

### Similarities to FRB 121102

- FRB 121102 is also polarized.
- The polarization and Rotation Measure are integral components pertaining to the environment and cause of FRB 121102.
- Repeat Bursts from FRB 110523 are also possible

## METHODS

### Observations

- 41 days of observations of approximately one hour each
  - Taken at Arecibo
- ALFA (Arecibo L-Band Feed Array) seven beams
- Three different pointings were used to grid the area

### Data Analysis

- Complete with PRESTO
  1. RFI search
  2. Create mask for data files based off RFI
  3. Create de-dispersion plan and implement the plan for a DM range of  $600\text{--}700 \text{ pc cm}^{-3}$
  4. Single Pulse Search
- The Single Pulse Search plots (Figure 2) were visually inspected for:
  - Broad band events peaking at dispersion measure similar to that previously measured for FRB 110523
  - Detected in a confined region of the ALFA receiver

## RESULTS

- One potential candidate was found.
- Has a dispersion measure of approximately 624, similar to the dispersion measure of the previously detected burst.
- Detected in one beam of the ALFA receiver.
- Has a SNR of approximately 7.2.

Figure 2

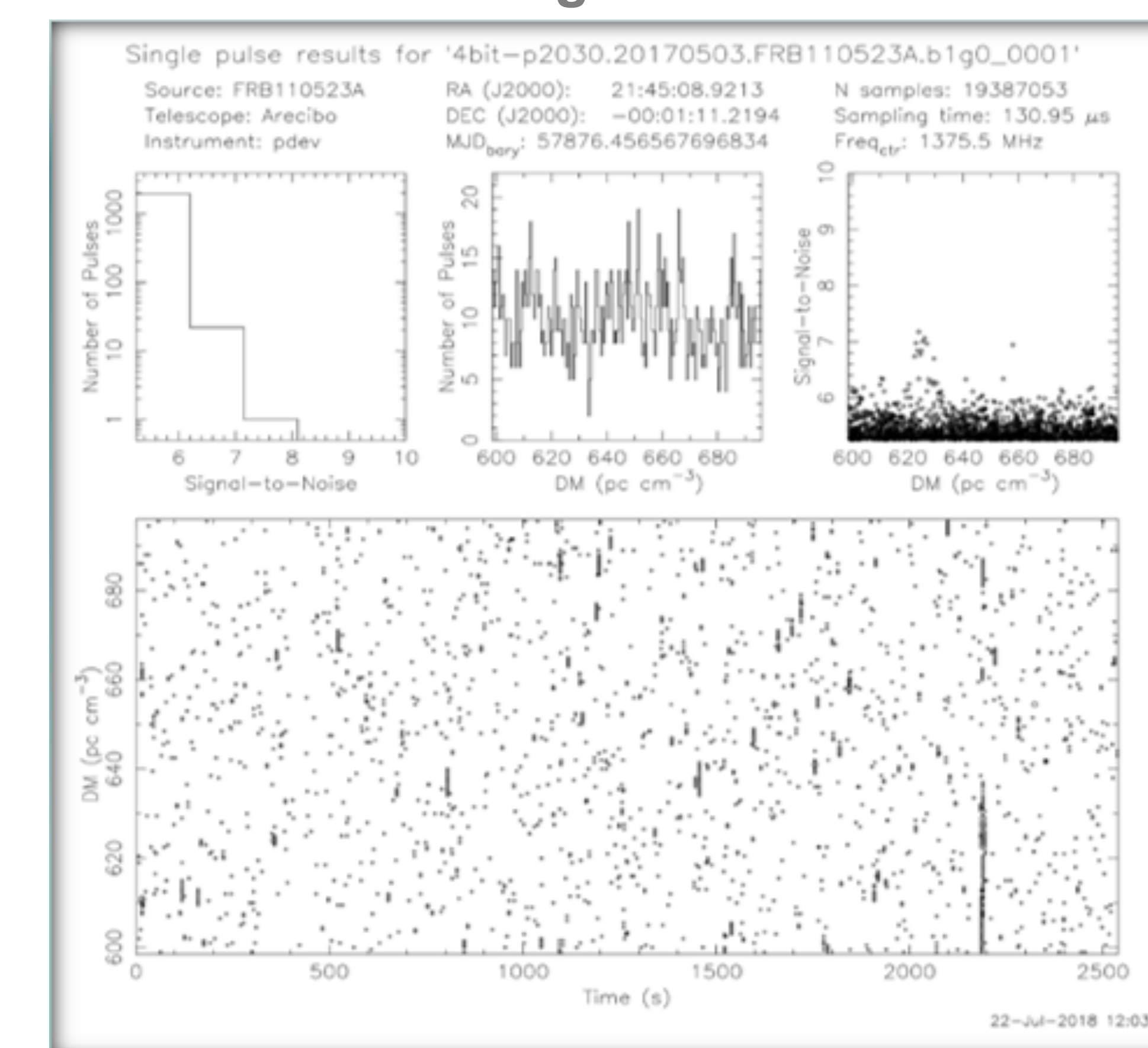
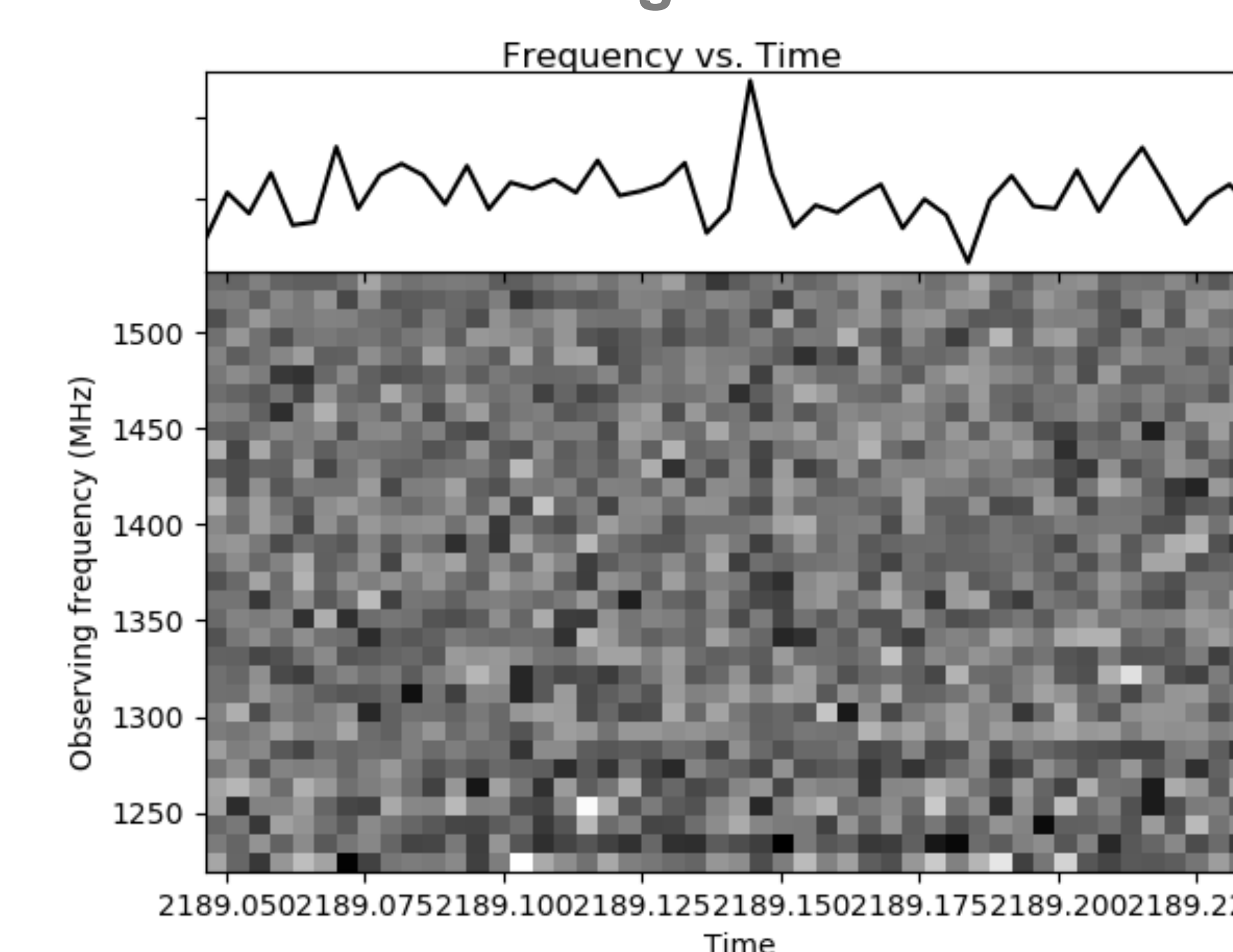


Figure 2: Single Pulse Search plot from PRESTO. Top right plot - Signal-to-Noise vs. DM: there is a visible peak at a Signal-to-Noise of approximately 7.2, which could signal the detection of an FRB. Bottom plot shows a stronger signal at a particular time, corresponding to the peak shown in figure 3.

Figure 3



The dynamic spectrum for the discovered pulse which shows a slightly stronger peak. Being darker across a large range of frequencies suggests that this detection is broadband. With this event only occurring in a single beam, it implies that this is an additional burst from FRB 110523.

## CONCLUSIONS/SIGNIFICANCE

- Approximately 41 hours of follow up observations on FRB 110523, each hour utilizing the seven beams on ALFA, were taken.
- One marginal detection
- Further follow up is needed on FRB 110523 as well as other FRBs to determine if all FRBs cause repeat events or if there are two separate classes of FRBs.

## FUTURE DIRECTIONS

- 66 total hours of observation on FRB 110523 thus far
- Future observations with the intent of looking for repeat bursts
- If a repeat burst is detected we could:
  - Localize the burst using radio interferometry
  - Study properties of the burst such as polarization, pulse structure and spectrum
  - Have a direct comparison to FRB 121102 to better determine what causes repeat FRBs vs single burst FRBs.

## REFERENCES

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