Transient Signal Detections with the Breakthrough Listen Digital Instrument

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The Goal: Building a Semi-Automated Pipeline for Transient Signal Analysis

1. Automation of Extraction, Dedispersion, Calibration, and Fitting of Raw Data

Already exists: Stage 1

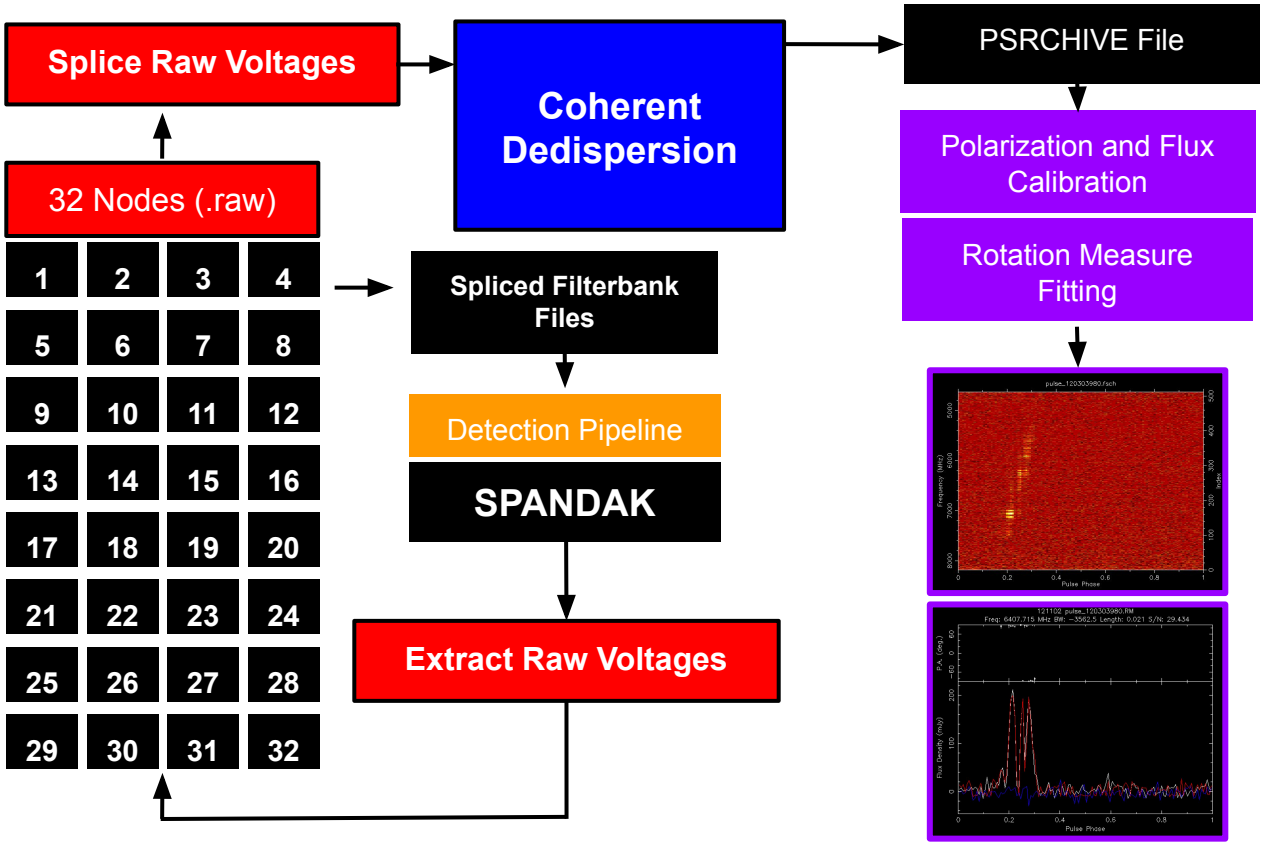
New Pipeline! Stage 2

Stage 3

Stage 4

2. Test observations of FRB121102 and FRB180916.J0158+65 made by the GBT.

*Each node holds 187.5 MHz of the band.



Test 1: FRB121102

- First Repeater
- Observed at C-Band
- Rotation measures and polarization angles match Gajjar et al. 2018, which we retrieved as a sanity check.
- Attempted to retrieve further bursts from FRB121102 by subbanding the full band to improve S/N.
    - Aim to retrieve a fraction of those reported in Zhang et al. 2018 using ML techniques. So far these bursts appear too dim.

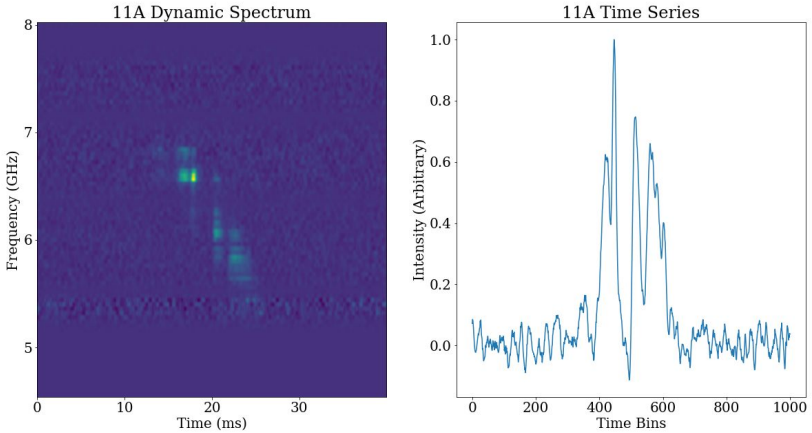


Table 1. FRB121102 Observations with GBT (C-Band)

Burst	MJD (57991+)	$DM_{S/N}$ $(pccm^{-3})$	RM_{obs} $(radm^{-2})$	PA_{∞}^{mean}(deg)	SNR	$\Delta\nu$ (GHz)
11A	0.409904044	565	93504 ±95	60 ±5	23.6	2
...	...	...	...	...	...	...

Test 2: FRB180916 (R3)

- Third Repeater
- Periodicity of 16 days
- We performed a preliminary analysis of R3 GBT observations in an **as of yet unreported band (first detection at such high frequencies)**, and drift rates appear consistent with those reported for repeating sources!

2 Distinct Morphologies

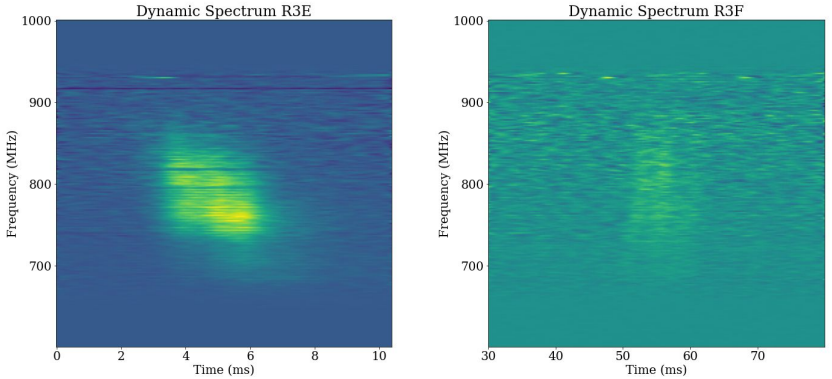


Table 2. FRB180916.J0158+65 Observations with GBT (600-1000 MHz)

Burst	Full Band TOA (s)	Lower Sub-Band TOA (s)	$DM_{S/N}$ $(pccm^{-3})$	SNR	$\Delta\nu$ (MHz)
A	...	117.953	350.1 ± 0.2	7.13	70
B	2486.015	...	349.6 ± 0.2	68.1	225
C	...	2964.55	350.1 ± 0.2	7.02	60
D	...	3867.274	350.1 ± 0.2	9.57	80
E	4179.185	...	348.9 ± 0.2	168	200
F	4239.185	...	350.4 ± 0.2	16.4	175
G	5149.36	...	349.6 ± 0.2	24.2	185

Pipeline Continued...

Example: FRB180916 E Burst

Further Data Analysis

Conversion to Numpy Array

Drift Rate Analysis (2D ACF)

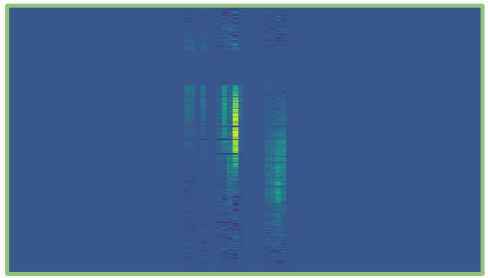
Step 2: Intensity Analysis Branch:

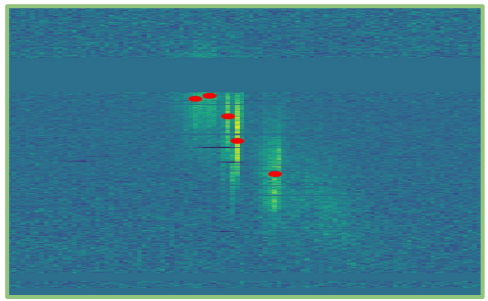
Sub-Burst Analysis

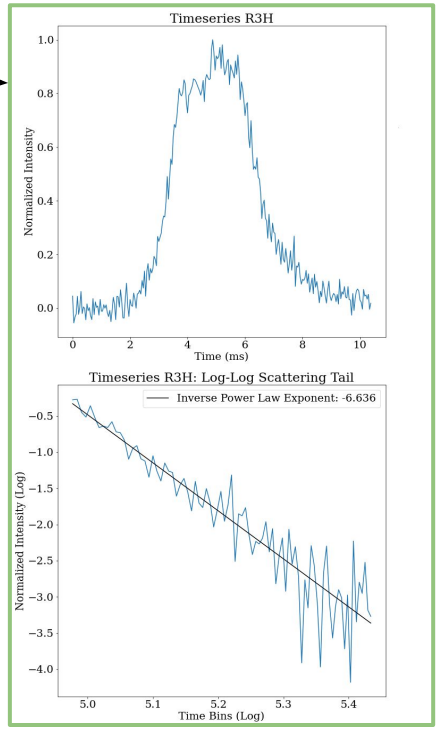
Scattering Tail Analysis

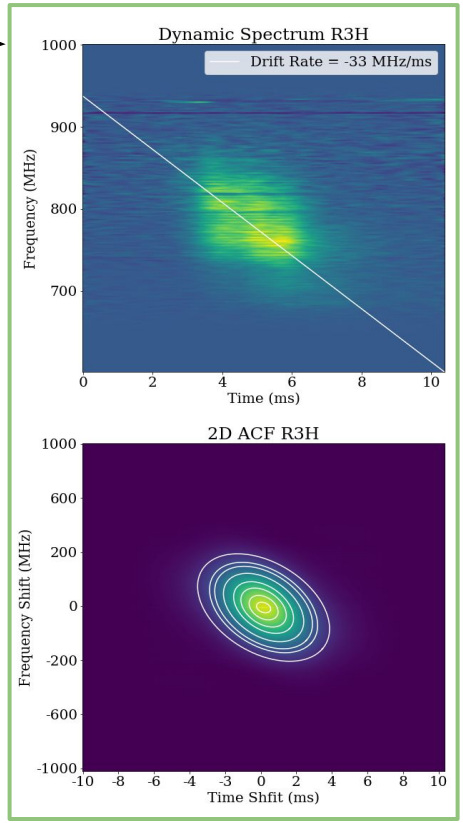
Stage 5

A range of data analysis utilities which can be employed to characterize transient signal intensity data. A few utilities are shown here.









Future Work

- Collaborating with CHIME (Canadian Hydrogen Intensity Mapping Experiment)
- Collaborating with the GMRT (Giant Metrewave Radio Telescope) on R3 follow-up

Proposals:

- Proposal has been accepted to observe R3 at C-band with the GBT (2020B Semester)
- Proposal has been submitted to do further CHIME follow-up observations on repeaters at C-band

Papers in production:

- Observations of FRB180916.J0158+65 with CHIME and GMRT
- Polarization, Flux and Rotation Measure Distributions for FRB121102 at C-Band

CHIME (BC, Canada)

GMRT (Khodad, India)