FRB 121102: VERY LARGE ARRAY BURST PROPERTIES AND IMPLICATIONS FOR OVERALL FRB POPULATION

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ABSTRACT

The highly-dispersed, millisecond radio transients known as Fast Radio Bursts have recently emerged as a new class...

The discovery of repeating bursts from FRB121102 has shown that at least some FRBs are not cataclysmic and opened potential for studying a homogenous sample of bursts... Our recent coordinated campaign with the Very Large Array and Arecibo Observatory has made the first direct, arcsecond-scale localization of an FRB and unambiguously associated it with counterparts in other observations. This campaign detected nine bursts at the VLA from 2.5 to 3.5 GHz and many more at Arecibo, GBT, and Effelsberg. The coordination of these observations allow us to refine our picture of the physical processes in FRB121102.

With so many bursts, we can make the first reliable measures of burst flux distribution and temporal statistics...

The connection of FRB121102 to the overall population...

1. INTRODUCTION

The discovery of Fast Radio Bursts, a new class of millisecond-duration, highly-dispersed radio transients, has opened a whole new playground in astrophysics.

- FRBs, extreme brightness, emission physics

- Extragalactic counterpart and potential utility as probes

- Repeating FRB as good target

- Potential to infer properties of FRB population

2. OBSERVATIONS

2.1. realfast

All observations in August and Septmeber were searched in quasi real-time by a prototype version of *realfast*. *realfast* is a real-time, fast imaging transient search system. The current, prototype runs on existing hardware of the VLA correlator backend, while the future *realfast* will run on a dedicated GPU cluster. The transient search pipeline software is called "rtpipe"[2] and is mostly written in Python.

Burst detections and localizations were made within hours of data being recorded.

2.2. Arecibo

2.3. Effelsberg

last two bursts (with bad filter in place)

2.4. AMI

3. RESULTS

3.1. VLA Detections

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[2] See `https://github.com/caseyjlaw/rtpipe`

Figure 1 shows the spectrograms of all nine bursts detected by *realfast*.

Computational notebooks to reproduce the transient detection and localization can be found at `https://github.com/caseyjlaw/FRB121102`. VLA data are available at `https://doi.org/10.7910/DVN/TLDKXG`.

3.2. Multi-Telescope Burst Spectra

3.3. VLA Spectra

After detection, we refined the analysis of each burst offline. We used a fine dispersion grid to find the best-fit DM for each burst.

Table? 57623 (DM= 561 pc cm^{-3}) 57633, Scan 7 (DM= 554 pc cm^{-3}) 57633, Scan 13 (DM= 559 pc cm^{-3}) 57638 (DM= 554 pc cm^{-3}) 57643 (DM= 559 pc cm^{-3}) 57645 (DM= 572 pc cm^{-3}) 57646 (DM= 573 pc cm^{-3}) 57648 (DM= 559 pc cm^{-3}) 57649 (DM= 552 pc cm^{-3}).

Dispersion measure changes between bursts significant?

Burst spectra are shown in Figure 2...

The VLA S-band recievers natively measure circular polarization, although observations did not include polarization calibration procedures. Crude constraints on circular polarization are possible by comparing the burst intensity in right and left-hand polarized data products. The apparent circular polarization fraction ($(RR - LL)/(RR + LL)$) for the most significant bursts are all less than 3%. FRB121102 was located 2.3 arcmin away from pointing center, where systematic effects have been measured as large as 3% (Perley et al 2016, VLA memo). We conclude that the S-band bursts seen by the VLA have a circular polarization of less than 3%.

3.4. Brightness Distribution

The bursts seen by the VLA range in significance from 10 to 150σ. Offline analysis for flux scale...

Figure 3 shows the flux distribution of the nine VLA bursts. Flatness...
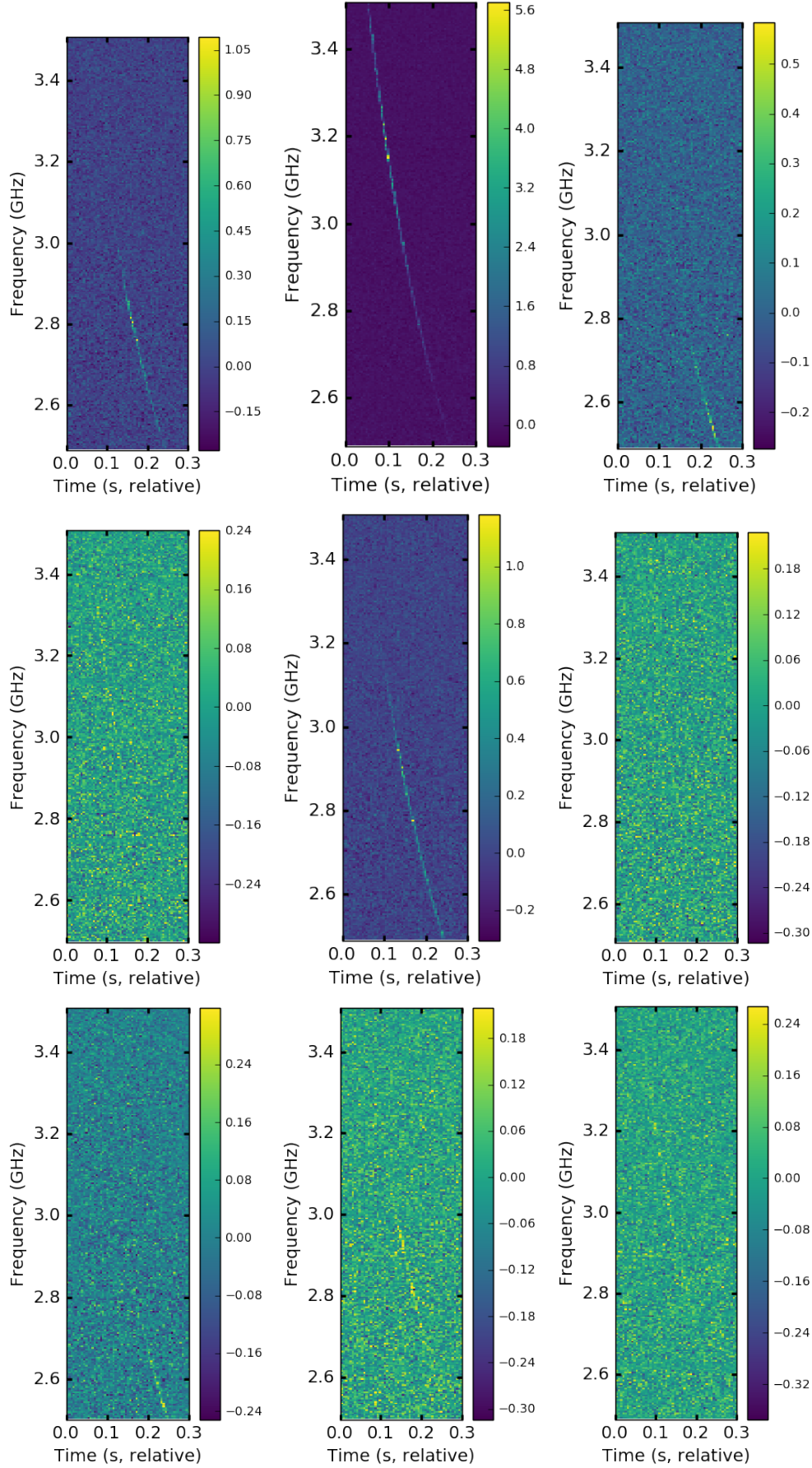
Law et al.

FIG. 1.— Spectrograms (time vs frequency intensity maps) for all nine VLA bursts. Note that bursts are detected in 5 ms images generated from dedispersed visibilities. **NOT SURE WHY ONE FIG LARGER**

Doubts were cast on the first FRB detection ("Lorimer burst") due to its unusually high brightness. The lack of lower-significance detections suggested that this burst was unlikely to be part of any astrophysical population...

3.5. *Temporal Statistics*

Burst detections were made very inhomogenously though the roughly 60 hours of observing toward FRB 121102. In the first ~ 8 hours of observing at L-band and the first ~ 25 hours observing at S-band no bursts were detected. Finally, in the last ~ 27 hours of S-band observing, all nine bursts were detected. Data quality are relatively high and RFI did not significantly impact sensitivity, so the inhomogeneous burst distribution not an observational artifact.

Connor et al. (2016)

4. DISCUSSION

4.1. *Connection to Overall FRB Population*

Flat luminosity distribution of FRB121102 and overall population

Does local (100 Mpc) population with flat luminosity distribution reproduce observed properties? Imagine also how log N/log S cut-offs and scattering biases the intrinsic into the observed distribution (Macquart and Johnston)

Discussion of "red spectrum" and Connor & Pen. Bursts predict bursts therefore repetition constraints of other FRBs are likely weaker than claimed...

Intrinsic versus refractive scintillation

Constraints on repetition assuming "red spectrum" for whole population. Simulation using observed burst temporal statistics...

4.2. *Emission Physics and Burst Energetics*

4.3. *Observing Strategies*

Targeting known FRBs is optimal

Wide, low-sensitivity searches are best way to conduct a blind search

5. CONCLUSIONS

REFERENCES

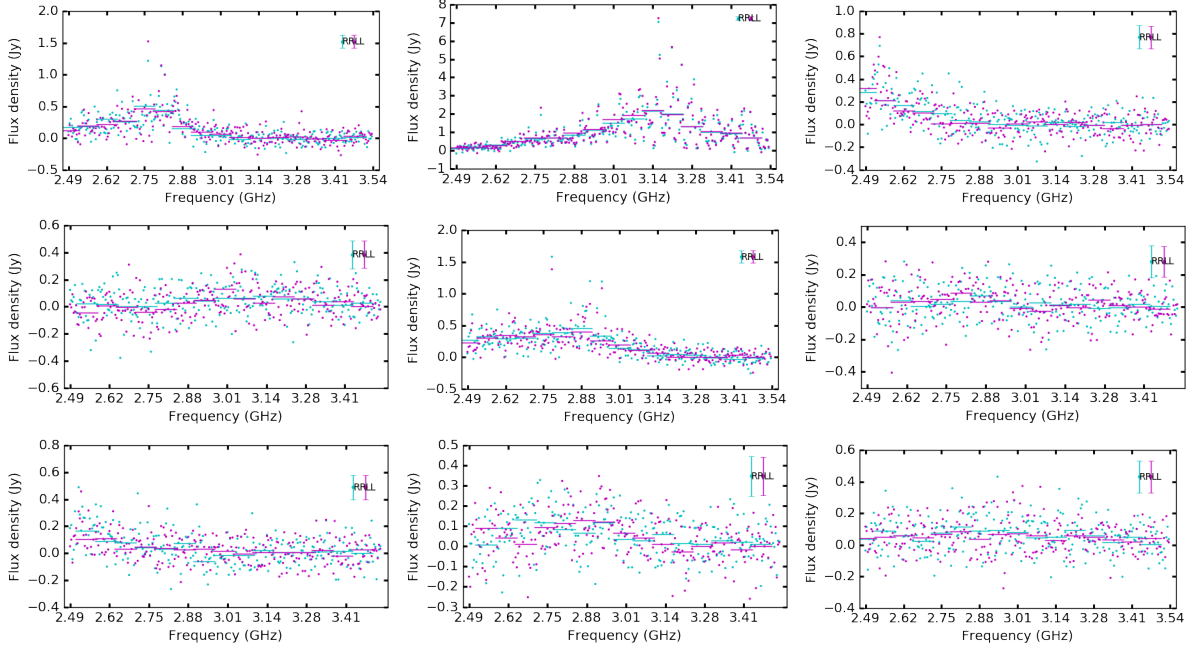Connor, L., Pen, U.-L., & Oppermann, N. 2016, MNRAS, 458, L89

Fig. 2.— Spectra of nine bursts seen by the VLA from 2.5 to 3.5 GHz. **LABELS ALL SAME FREQ. SOME SHOULD START HIGHER FOR DROPPED CHANNELS**
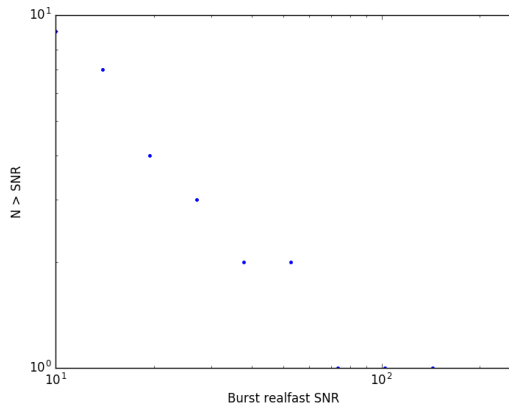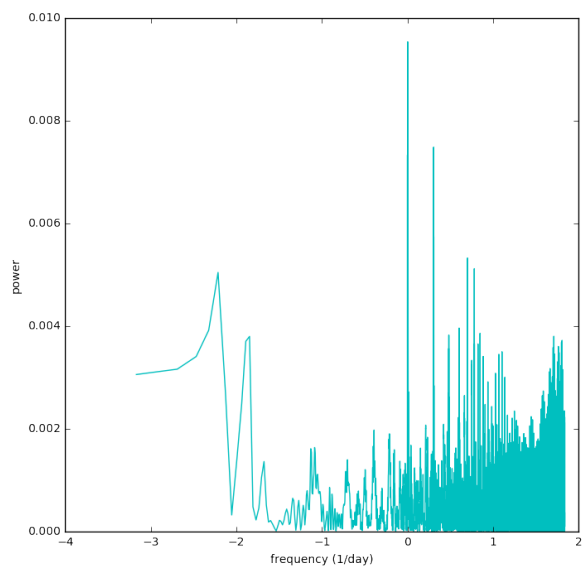

Fig. 3.— Log N – Log SNR distribution of real-time detections of FRB 121102.

Fig. 4.— Lomb-Scargle periodogram.