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The VLBA Fast Radio Transient Experiment: Progress and Early Results

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Abstract. Motivated by recent discoveries of isolated, dispersed radio pulses of possible extragalactic origin, we are performing a commensal search for short-duration (ms) continuum radio pulses using the Very Long Baseline Array (VLBA). The geographically separated antennæ of the VLBA make the system robust to local RFI and allow events to be verified and localised on the sky with milli-arcsec accuracy. We report sky coverage and detection limits from the experiment to date.

Keywords. radio continuum: general – methods: data analysis

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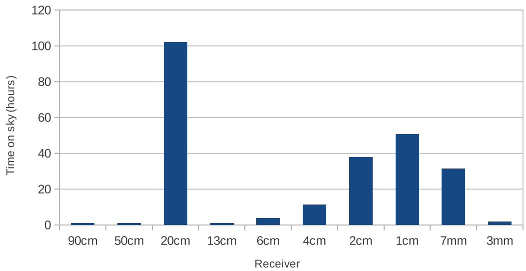
1. Introduction

Recent discoveries of isolated, dispersed pulses of radio emission in pulsar surveys (Lorimer *et al.* 2007; Burke-Spolaor *et al.* 2011; Keane *et al.* 2011) hint at the possibility of a population of extragalactic sources of fast transient radio emission. The possible sources of that emission are somewhat speculative, but include some exotic objects and physics such as annihilating black holes, and merger events generating gravitational waves (see Macquart *et al.* 2010).

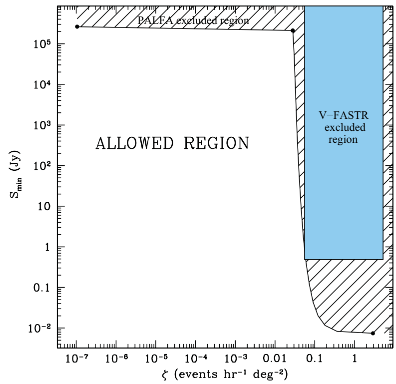
The isolated radio bursts discovered to date have been found with the Parkes radio telescope, which is a large single dish. Big dishes have great sensitivity but poor resolution, making the localisation of an event on the sky, and hence follow-up, difficult. In addition, single dishes cannot easily distinguish between genuine astronomical events and the terrestrial radio-frequency interference (RFI) that mimics the frequency-swept "chirp" expected, owing to the dispersion of radio waves in the ionised interstellar medium.

To overcome these issues when searching for fast radio transients, we are conducting the V-FASTR experiment (Wayth *et al.* 2011). V-FASTR is a commensal search for fast transients that uses the Very Long Baseline Array (VLBA)—a long-baseline interferometer with baseline lengths ranging from hundreds to thousands of kilometres. Data from the VLBA are correlated with the DiFX-2 software correlator (Deller *et al.* 2011), which can generate short integration time ($\sim$1 ms) spectrometer data from each antenna during the correlation.

The spectrometer data are fed into a real-time detection pipeline that uses sophisticated statistical and machine-learning techniques (Thompson *et al.* 2011) to evaluate the data quality from each antenna and to excise RFI events. V-FASTR has several advantages over single-dish searches, including the ability to distinguish easily RFI that is local



(a) V-FASTR time on sky per VLBA receiver to end of 2011 August.



(b) Event rate limits for V-FASTR compared to PALFA. Figure adapted from Deneva et al. (2009).

Figure 1: Figure adapted from Deneva *et al.* (2009).

to one antenna, and in being able to follow-up candidate events by imaging with VLBI (milli-arcsec) resolution.

2. Results to Date

V-FASTR has been in full-time commensal operation since the deployment of DiFX-2 on the VLBA correlator in mid-2011. Fig. 1 shows the time spent on the sky per VLBA receiver for data processed to the end of 2011 August. For that observing period on the 20-cm receiver, the 5σ detection limit is 0.42 Jy for 10-ms integrations and 64 MHz bandwidth. The upper limit on event rates at that sensitivity in the 20-cm band is 0.06 events hr^{-1} deg^{-2}.

In Fig. 1 we plot the limit on event rates for the 20-cm receiver, assuming isotropically distributed sources, and compare them to the results from the PALFA survey (Deneva *et al.* 2009). V-FASTR is rapidly accumulating hours on the sky. More hours on the sky will push the limit in Fig. 1 to the left, overtaking the PALFA limit in some regions of parameter space. The VLBA is also undergoing an upgrade for broad-band digital backends that will increase the system sensitivity by a factor of a few. That upgrade will push the limit in Fig. 1 down, thereby placing even stricter limits on parameter space.

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