Parkes Fast Radio Burst National Facility detection mode

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Summary

We propose to operate the Parkes Fast Radio Burst (FRB) real-time detection system at all times that the Multi-beam receiver is on focus. This includes not only during tracked observations but also during wind stows and, in the ideal scenario, also during slewing. This maximises the FRB-discovery rate of Parkes, which, complementary to the Australian Square Kilometre Pathfinder, is sensitive to the most-distant high-dispersion measure FRBs with the most utility for cosmological studies.

History and context

The first FRB was detected by Lorimer et al. (2007) in a search of archival data recorded in 2001, from the analogue filterbanks that performed the Parkes Multi-beam Pulsar Survey (and several other smaller surveys). This discovery was momentous, leading to the high-latitude component of the High Time Resolution Universe survey (HTRU, Keith et al. 2010) to specifically search for more FRBs. By 2013, with the advent of the FRB discoveries of Thornton et al. (2013), the FRB search system was evolving towards being 'real time' – it now consists of the 'Heimdall' software suite and the Berkeley-Parkes-Swinburne Recorder/HI-Pulsar (BPSR/HIPSR) digital signal processing system (Price et al. 2016). Following the conclusion of HTRU, real-time FRB searches have been performed as part of the SUPERB(x) program (Keane et al. 2018).

By 2017 the FRB search system had become very easy to use in parallel to any other Multi-beam observations. At this time, the Parkes Pulsar Timing Array (PPTA) approached the Parkes System Scientist (Green) to enquire whether the team could also run this software with their program. Following consultation with the SUPERB Principal Investigator (Keane) they adopted the software usage and from the 2017 October semester have run it, with the alert system going only to select PPTA members.

The Breakthrough Listen (BL) team also initiated use of the system during their Multi-beam observations in the 2017 October semester, but with a modified version of the existing SUPERB alert system, and with SUPERB team support. Both the PPTA and BL programs have successfully detected FRBs in this mode. Most recently the FAST team have also initiated use of the system.

Parkes receiver development is building towards a cryogenically cooled Phased Array Feed (cryo-PAF), and it is envisaged that a continuously-running commensal FRB search, such as the one proposed here, will be the default mode of operation for the cryo-PAF.

Proposal

The proposal is to make it an Australia Telescope National Facility Parkes policy to run BPSR/HIPSR and the FRB detection software whenever the multi-beam is on focus. The FRB candidate events generated would be emailed out as per the SUPERB/PPTA/BL/FAST set up to an email exploder list consisting of national and international members experienced in FRB validation (the membership of this list will be open and inclusive, but subject to some initial training in what needs to be done, in order to avoid false positives).

The FRB search system software produces detection alerts which would be sent in a VOEvent format. When an event is detected, responsibility falls on the on-call member(s) of this FRB validation team to validate the detection (in case of a false positive) and then react accordingly, e.g. ensuring calibration observations are undertaken as soon as possible, tracking for repeat bursts, triggering radio and multi-wavelength/multi-messenger follow-up, and coordinating an Astronomers Telegram (ATEL). There would be no obligation on the current observer to interrupt their observations for calibration, but it would only take a few minutes to do so. If the current observer is unable to voluntarily initiate a calibration observation, the FRB team members could trigger a Target-of-Opportunity (ToO) request for this observation.

The intention would be for events to be validated (with a corresponding validated VOEvent put out) and for the ATEL to be put out within one hour of the event (a pro-forma will be written as a template) and the data would be made publicly available within 24 hrs.

This proposal essentially means that Parkes will search for FRBs using the Multi-beam for all the time that it can, maximising the scientific return in this field (the number of FRBs scales linearly with the observing time). It effectively combines the existing commensal searches of BL, PPTA and FAST and broadens the scope. The counter-point is that future FRB-only detection proposals would effectively be excluded as the capability will always be there, however the data will be provided through this scheme.

The proposal can be extended to include the Australia Telescope Compact Array as a triggered follow-up instrument, although this would require an associated NAPA proposal to be submitted each semester, and appropriate scientific justification to be made. The authorship could be the FRB team.

Summary Sequence

1. Heimdall/BPSR continually running
2. Detection made and event email sent to experienced users (the Parkes FRB Team, PFT)
3. Event validated by experienced users (PFT)
4. VOEvent generated
5. ATEL produced and data made available

6. Data (transient buffer, detection and cals) archived in DAP and accessible through system

What's needed

- Either automatically run BPSR when Multi-beam is on focus, or ask all observers to enable when observing.
- Enable BPSR to run during slewing as well, requiring the position data acquisition to be developed.
- Set up a new FRB detection team, with an email exploder whose membership vet events and initiate follow-up activities.
- Set up software to publicly release (un-validated and, up to one hour later,) validated FRB VOEevent (not currently a part of the BPSR software alerts).
- Enable a method to make data products available publicly as soon as possible.
- Enable capture of meta data for positions when taking data during slews.
- Further technical support for the BPSR software beyond the current single point of contact (who exists outside of the CSIRO Australia Telescope National Facility): either in the form of training for existing personnel or the addition of appropriate skilled full time equivalent.
- Single observation time needs to be limited so as not to overwhelm the transient detection software.
- A single project code that applies to the Heimdall/BPSR processed data to enable prompt archiving and data accessibility (e.g. 'PFRB').
- Appropriate scheduling of Multi-beam observing such the data rate and storage needs can be coped with (estimates are 50MB/s by default rate, ~4-5TB per day, current capacity 40TB).

Questions

- What acknowledgements are required for the FRBs and resultant publications – FRB data will be public within 24 hrs in the proposed model, but policies may be required around analysis and publications? (will a standard ATNF and FRB team acknowledgement suffice? Who owns the FRBs? Those that do the analysis/write the paper? What policies are there for publications? We propose that the FRB is considered 'published by ATNF' at the point of issue of the ATEL and thence the data public.
- What method would be used for level setting continual power level adjustment?
- (to be addressed through existing system characterisation projects, e.g. P737) Will having all beams on for projects only requiring the central beam of the Multi-beam affect the Tsys of the central beam.
- Could the data of single pulse detections from pulsars in the beams be recorded/utilised.
- Allow projects to 'opt-out'?