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A Real-time Automated Trigger for Solar Radio Burst Detection from Yamagawa Spectrograph

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The observing time of the cutting-edge radio interferometers tends to be heavily oversubscribed. This, coupled with the fact that solar activity is inherently unpredictable leads to solar observing proposals typically being granted rather limited observing time. There are, of course, dedicated solar monitoring radio telescopes, but their data quality, and hence the resulting science, pales in comparison with what is possible with the best-in-class instruments. A robust and reliable automated near-real time observing trigger can change this situation dramatically. By enabling one to use precious observing time only when some solar activity is known to have just taken place, such a system can vastly increase the efficiency of limited available observing time to capture instances of solar activity. With observatories like the Square Kilometre Array Observatory (SKAO) on the horizon, the need for such a system is even more imperative. We present such a system which we have developed for the low frequency precursor of the SKAO, the Murchison Widefield Array (MWA) based on near-real time data from the Yamagawa spectrograph.

The ability to conduct robust and efficient triggered observations requires (1) near-real time access to appropriate data which provides the raw data on the basis of which a trigger can be generated; (2) algorithms and software tools needed to ingest these data and process them to provide a boolean trigger; (3) the framework required for this trigger to be communicated to the telescope under consideration and finally (4) the actual scheduling of observations and the acquisition of data. Here we focus on the first two of the aspects mentioned here, the others have already been implemented at the MWA in a different context, and have been adapted for our use.

Our solar observing trigger is derived from the data from the Yamagawa heliospectrograph which is located at a similar longitude as the MWA and observes the Sun daily from rise to set in the band from 70 MHz to 9 GHz. Generating an observing trigger poses an interesting and challenging problem. Not only does one have to reliably detect and reject any radio frequency interference (RFI) which is inevitably present, one does not have the luxury of allowing the solar radio event to play out before raising the trigger and successive triggers also need to account for the earlier ones. Additionally, these data are available with a latency of 3 minutes and the necessary processing needs to be sufficiently computationally lean that it can return a decision without much additional delay. We have devised, implemented and tested algorithms to identify and remove the RFI and do an effective ‘de-noising’ of the data to improve the contrast with which features of interest can be detected. We have also developed heuristics for optimally tuning our observations for different classes of long lived (>3 min) active emissions (e.g. type II solar radio bursts which can last for about 10 min and type I noise storms which can continue for hours or even days). We note that much of the event data lost due to the 3 minute latency from Yamagawa can be recovered using the 3 minute data buffer available at the MWA, which was designed exactly to meet such needs. These triggers have been tested and tuned using the archival Yamagawa data, end-to-end tests of triggered observations have successfully been carried out at the MWA. Very recently this real time triggering has been operationalized at the MWA, a very timely development in view of the approaching solar maxima.