A high time resolution digital backend system for pulsar observations at the Ghana Radio Astronomy Observatory - putting the UK and Africa together at the leading edge of astronomy.

Pulsar Observations in Ghana

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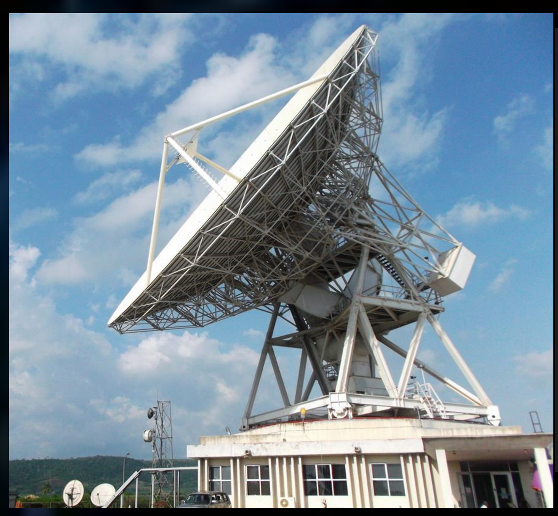
1. Abstract : In August 2017 a new radio telescope at the Ghana Radio Astronomy Observatory (GRAO), was officially inaugurated in Kuntunse, Ghana. The GRAO is a former satellite communications Earth station and is now the first operational station in the African VLBI Network (AVN). Once it was recognised that the GRAO could also be used to study pulsars, and with support from the UK's STFC / Newton Fund, the Jodrell Bank Centre for Astrophysics proposed to develop a pulsar timing system for the new telescope. We present some of the pulsar timing system design findings below together with an outline of the first pulsar detection at Kuntunse.



2. The telescope at Kuntunse : was originally a telecommunications satellite Earth station, donated by Vodafone to the government of Ghana. The telescope is a fully steerable, 32meter Cassegrain design single dish antenna mounted on the roof of the main building. A four-mirror wave guide connects the dish to a room temperature receiver located in the main building. Currently capable of observing at 5GHz and 6.7GHz, an L-Band receiver is planned for the future.

Once fully commissioned the GRAO will enable local users to undertake an independent scientific program and participate in international studies.

The new pulsar timing system will be installed at the GRAO in April 2018.

3. Hebe : is a new Pulsar Timing System based on a dual 8-core CPU workstation with two Maxwell class Titan X GPUs and 32 TB disks. HebeControl is a fully automated supervisory program that controls pulsar data recording. Hebe is also designed to be capable of commensal observations, for example, real time FRB searching during pulsar observations. When not observing pulsars Hebe is a flexible general purpose workstation.

To select a suitable GPU for Hebe over 32,000 processing trials were conducted on a range of devices. The trials featured various combinations of bandwidth, frequency, output filterbank channels and dispersion measure and the results indicated two GPUs were required to achieve real time processing of the incoming data. The testing routine used DSPSR and was based on the methodology described in 'van Straten and Bailes PASA Vol 28 issue 1 2010'.

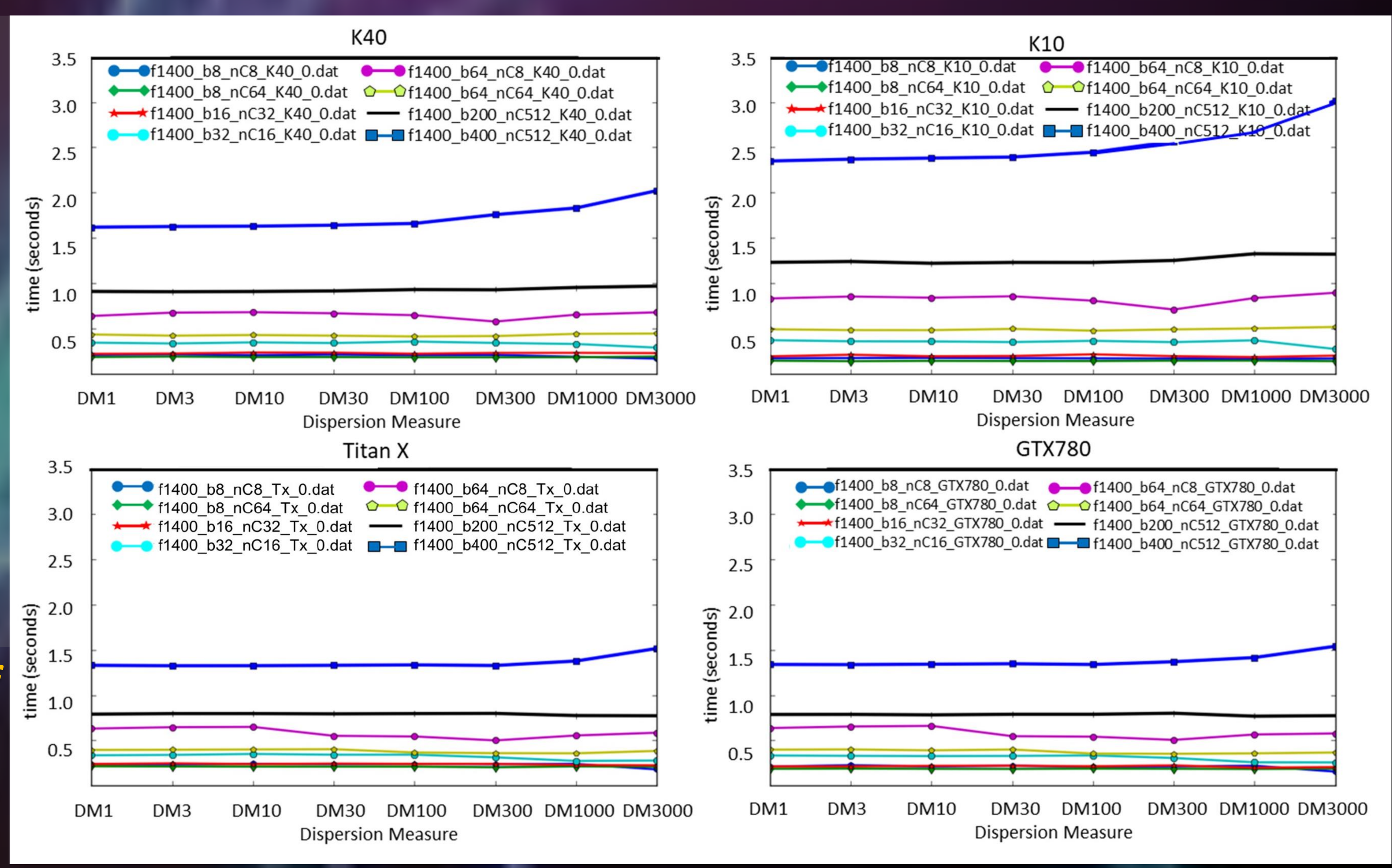
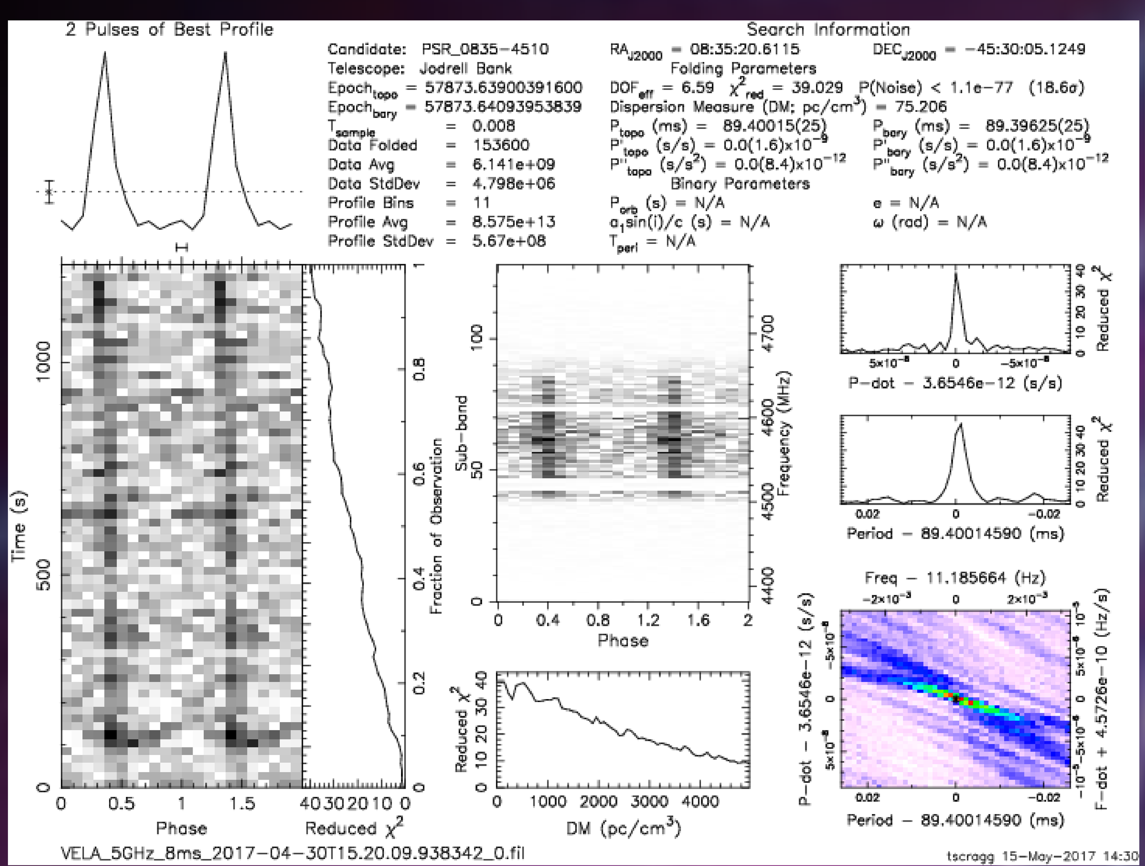


Figure 1: Benchmark results for four commercial GPUs, for a sample of eight combinations of input bandwidth and output filterbank channels at a centre frequency of 1400 MHz. The vertical axis is the time taken to process one second of data (averaged over six trials) and the horizontal axis is the length of the calculation based on a target dispersion measure

4. Interface testing: The GRAO's receiver and digitiser backend systems were developed by the team in SKA-SA and features dual 10GE data links to Hebe. The interface is based on the SPEAD data transfer protocol together with IP based messages for timing, command and control. To develop and test the interface SKA-SA developed and configured a test system in their office in Cape Town. Comprised of a backend system linked to a Hebe emulator and, accessed remotely by the team in Manchester, we jointly developed and tested the operation of the interface. Spread over many months this joint development saved much work on site and provides for greater confidence in the operation of the telescope.



5. First pulsar detection : During a pre-commissioning visit to Kuntunse we observed Vela (PSR J0835-4510) at 5GHz, using the available spectral receiver, and then processed the recorded data at Jodrell Bank using Hebe. The integration time was short, at 98s and the time resolution low at 3ms, but the PRESTO plot clearly shows the detection of pulses from Vela.

Figure 2: Detection of Vela at Kuntunse, 30th April 2017. *(PRESTO http://www.cv.nrao.edu/~sransom/presto/)*

Figure 3: Left to right Eugene Okwei, James Chibueze, Ben Stappers, T L Venkatasubramani

6. Team Photo: some of the team working on the GRAO and development of the PTS, Sunday 30th April 2017, Accra.

7. Science : A number of pulsar science goals can be suggested for the GRAO.

Very few pulsars have been observed in the 5 – 7 GHz band and the GRAO could be used to study the evolution and variability of the pulse profile and derive a spectral index for known pulsars. With repetitive scans the GRAO may also be used to find new intermittent pulsars missed by other search programmes. The GRAO could also participate in the long term timing of pulsars in both the C & L bands.

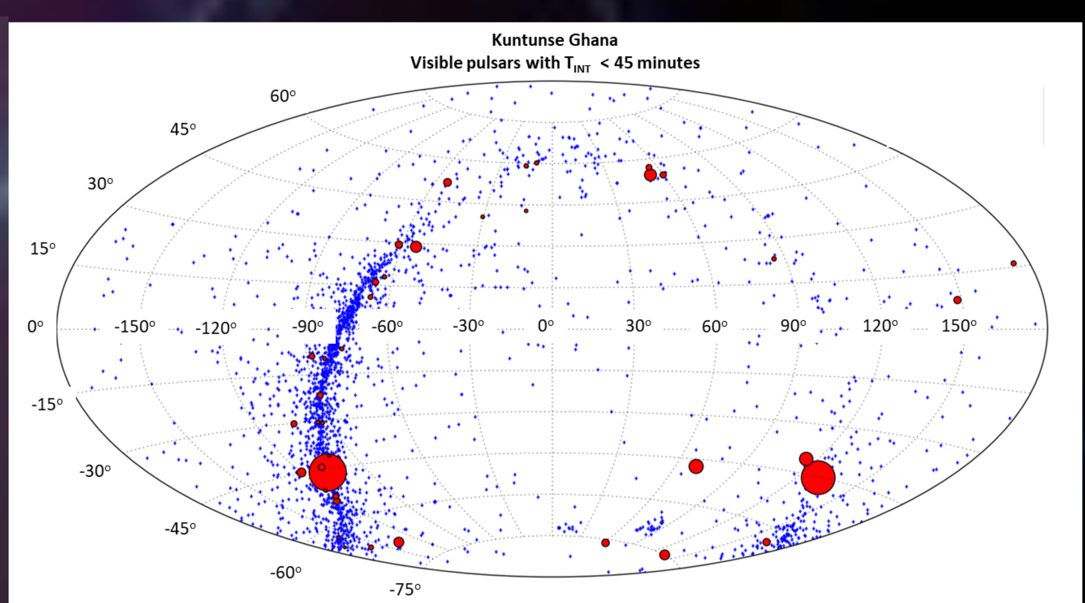


Figure 4: Proposed pulsar census, the red circles in the Aitoff projection of the sky in ecliptic coordinates are 20 of the brightest pulsars potentially observable by Kuntunse at 5GHz (size ∝ flux). The blue crosses are the locations of all the pulsars so far listed in the ATNF Catalogue. *(Manchester, R. N., Hobbs, G.B., Teoh, A. & Hobbs, M., AJ, 129, 1993-2006 (2005), http://www.atnf.csiro.au/people/pulsar/psrcat/)*

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