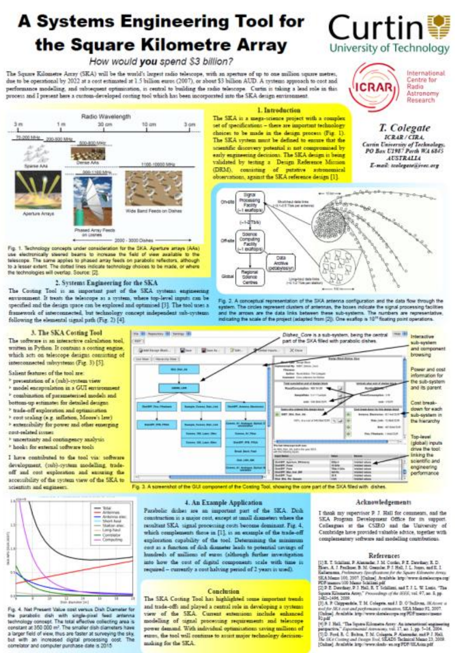
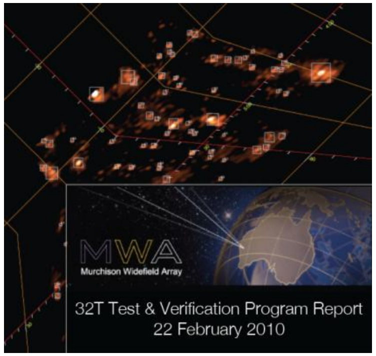
PrepSKA Program Work

WP2.1.6 Electromagnetic compatibility
WP2.1.7 SKA cost analysis
WP2.3.1 Wide FoV Aperture Array - AAVP
(AA-lo work package co-lead)
WP2.3.2 AAVP signal processing
WP2.6.2 Computing h/w architecture
WP2.6.5 Data products, storage, distrib^{n}
WP3.5 SKA configuration
WP5 Procurement (incl. Phil Crosby)
+ SESC, IEAC, SWG, PITF, …





Progress

- *Started ICRAR – 1 September, 2009*
- *€50M venture; 40+ research staff*
- *Budgets and programs in place*
- *More than 200 person-months for PrepSKA*
- *Hired round-1 EMC, AAVP, data archive personnel*
- *AAVP collaboration agreement close to signing*
- *Steady progress on SKACost*
    - *T. Colegate deployed to SPDO*

ICRAR International Centre for Radio Astronomy Research

Curtin University of Technology

The University of Western Australia
Achieving International Excellence

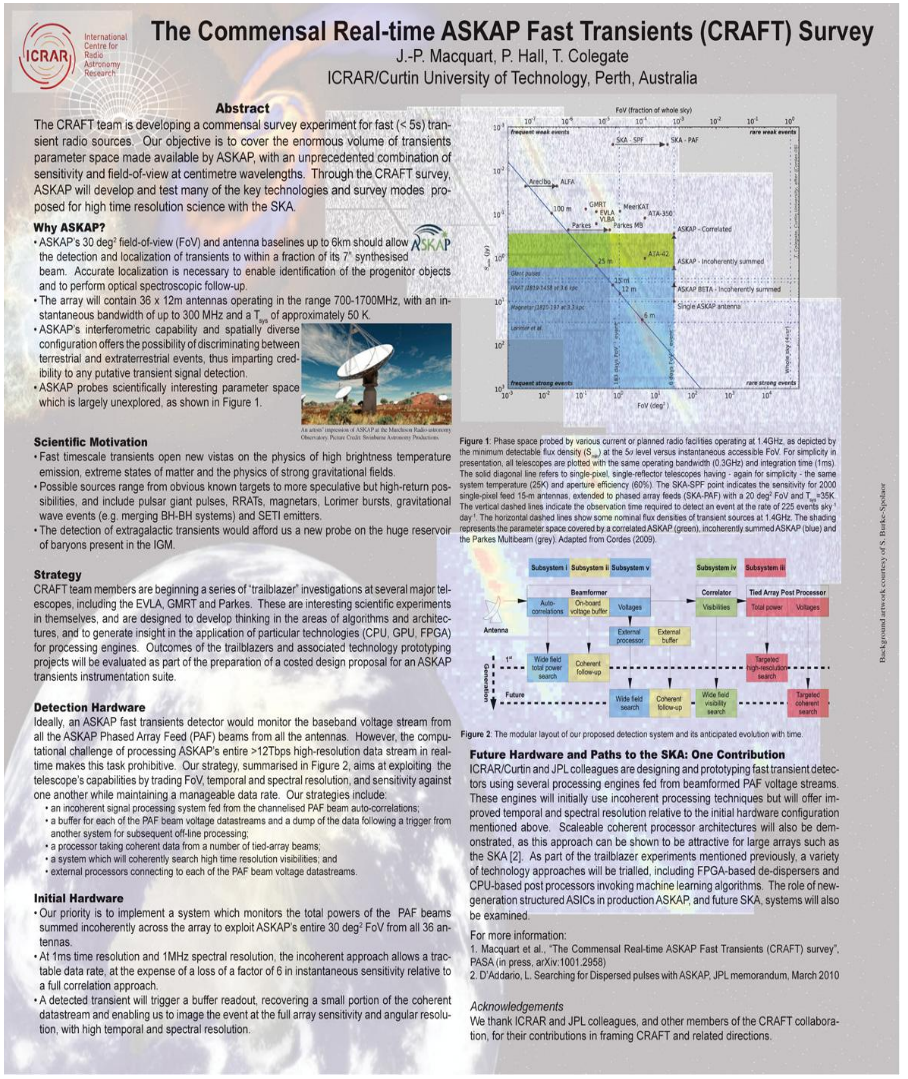
ICRAR is a partnership between Curtin University of Technology and The University of Western Australia

Peter Hall
ICRAR
Peter.Hall@icrar.org

www.icrar.org

ICRAR at SKA2010

- *Lister Staveley-Smith, ASKAP Wallaby SSP (Mon pm)*
- *J-P Macquart et al., ASKAP CRAFT SSP (poster + 1200 – 1330 mtg Tues)*
- *P Hall et al., PITF (Wed am)*
- *T. Colegate et al.: New improved SKAcost (Wed pm)*
- *S. Tingay, Long baseline science (Thurs pm)*



The Commensal Real-time ASKAP Fast Transients (CRAFT) Survey

J.-P. Macquart, P. Hall, T. Colegate
ICRAR/Curtin University of Technology, Perth, Australia

Abstract

The CRAFT team is developing a commensal survey experiment for fast (< 5s) transient radio sources. Our objective is to cover the enormous volume of transients parameter space made available by ASKAP, with an unprecedented combination of sensitivity and field-of-view at centimetre wavelengths. Through the CRAFT survey, ASKAP will develop and test many of the key technologies and survey modes proposed for high time resolution science with the SKA.

Why ASKAP?
- ASKAP's 30 deg^2 field-of-view (FoV) and antenna baselines up to 6km should allow the detection and localization of transients to within a fraction of its 7" synthesised beam. Accurate localization is necessary to enable identification of the progenitor objects and to perform optical spectroscopic follow-up.
- The array will contain 36 x 12m antennas operating in the range 700-1700MHz, with an instantaneous bandwidth of up to 300 MHz and a T_{sys} of approximately 50 K.
- ASKAP's interferometric capability and spatially diverse configuration offers the possibility of discriminating between terrestrial and extraterrestrial events, thus imparting credibility to any putative transient signal detection.
- ASKAP probes scientifically interesting parameter space which is largely unexplored, as shown in Figure 1.

An artists' impression of ASKAP at the Murchison Radio-astronomy Observatory. Picture Credit: Swinburne Astronomy Productions.

Scientific Motivation
- Fast timescale transients open new vistas on the physics of high brightness temperature emission, extreme states of matter and the physics of strong gravitational fields.
- Possible sources range from obvious known targets to more speculative but high-return possibilities, and include pulsar giant pulses, RRATs, magnetars, Lorimer bursts, gravitational wave events (e.g. merging BH-BH systems) and SETI emitters.
- The detection of extragalactic transients would afford us a new probe on the huge reservoir of baryons present in the IGM.

Strategy

CRAFT team members are beginning a series of "trailblazer" investigations at several major telescopes, including the EVLA, GMRT and Parkes. These are interesting scientific experiments in themselves, and are designed to develop thinking in the areas of algorithms and architectures, and to generate insight in the application of particular technologies (CPU, GPU, FPGA) for processing engines. Outcomes of the trailblazers and associated technology prototyping projects will be evaluated as part of the preparation of a costed design proposal for an ASKAP transients instrumentation suite.

Detection Hardware

Ideally, an ASKAP fast transients detector would monitor the baseband voltage stream from all the ASKAP Phased Array Feed (PAF) beams from all the antennas. However, the computational challenge of processing ASKAP's entire >12Tbps high-resolution data stream in real-time makes this task prohibitive. Our strategy, summarised in Figure 2, aims at exploiting the telescope's capabilities by trading FoV, temporal and spectral resolution, and sensitivity against one another while maintaining a manageable data rate. Our strategies include:
- an incoherent signal processing system fed from the channelised PAF beam auto-correlations;
- a buffer for each of the PAF beam voltage datastreams and a dump of the data following a trigger from another system for subsequent off-line processing;
- a processor taking coherent data from a number of tied-array beams;
- a system which will coherently search high time resolution visibilities; and
- external processors connecting to each of the PAF beam voltage datastreams.

Initial Hardware
- Our priority is to implement a system which monitors the total powers of the PAF beams summed incoherently across the array to exploit ASKAP's entire 30 deg^2 FoV from all 36 antennas.
- At 1ms time resolution and 1MHz spectral resolution, the incoherent approach allows a tractable data rate, at the expense of a loss of a factor of 6 in instantaneous sensitivity relative to a full correlation approach.
- A detected transient will trigger a buffer readout, recovering a small portion of the coherent datastream and enabling us to image the event at the full array sensitivity and angular resolution, with high temporal and spectral resolution.

Figure 1: Phase space probed by various current or planned radio facilities operating at 1.4GHz, as depicted by the minimum detectable flux density (S_{min}) at the 5σ level versus instantaneous accessible FoV. For simplicity in presentation, all telescopes are plotted with the same operating bandwidth (0.3GHz) and integration time (1ms). The solid diagonal line refers to single-pixel, single-reflector telescopes having - again for simplicity - the same system temperature (25K) and aperture efficiency (60%). The SKA-SPF point indicates the sensitivity for 2000 single-pixel feed 15-m antennas, extended to phased array feeds (SKA-PAF) with a 20 deg^2 FoV and T_{sys}=35K. The vertical dashed lines indicate the observation time required to detect an event at the rate of 225 events sky^{-1} day^{-1}. The horizontal dashed lines show some nominal flux densities of transient sources at 1.4GHz. The shading represents the parameter space covered by a correlated ASKAP (green), incoherently summed ASKAP (blue) and the Parkes Multibeam (grey). Adapted from Cordes (2009).

Figure 2: The modular layout of our proposed detection system and its anticipated evolution with time.

Future Hardware and Paths to the SKA: One Contribution

ICRAR/Curtin and JPL colleagues are designing and prototyping fast transient detectors using several processing engines fed from beamformed PAF voltage streams. These engines will initially use incoherent processing techniques but will offer improved temporal and spectral resolution relative to the initial hardware configuration mentioned above. Scaleable coherent processor architectures will also be demonstrated, as this approach can be shown to be attractive for large arrays such as the SKA [2]. As part of the trailblazer experiments mentioned previously, a variety of technology approaches will be trialled, including FPGA-based de-dispersers and CPU-based post processors invoking machine learning algorithms. The role of new-generation structured ASICs in production ASKAP, and future SKA, systems will also be examined.

For more information:

1. Macquart et al., "The Commensal Real-time ASKAP Fast Transients (CRAFT) survey", PASA (in press, arXiv:1001.2958)
2. D'Addario, L. Searching for Dispersed pulses with ASKAP, JPL memorandum, March 2010

Acknowledgements

We thank ICRAR and JPL colleagues, and other members of the CRAFT collaboration, for their contributions in framing CRAFT and related directions.

Background artwork courtesy of S. Burke-Spolaor