VAST - a real-time pipeline for detecting radio transients and variables on the Australian SKA Pathfinder (ASKAP) telescope.

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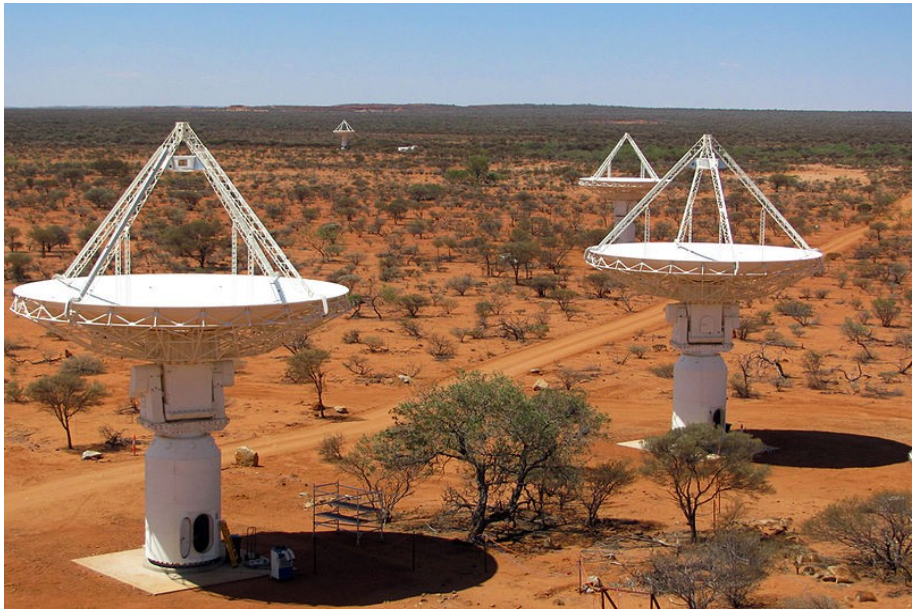
Presentation Overview

- The Australian Square Kilometre Array Pathfinder (ASKAP) radio telescope
- The Variable and Slow Transient (VAST) project:
  - Survey and project overview
  - Pipeline overview
  - Capacity challenges
  - Prototype pipeline

ASKAP: Australian SKA Pathfinder

- 36 dish radio interferometer
- Very fast survey speed: can image the entire visible sky in two nights – current telescopes take years!
- Located in the desert in Western Australia
- Radio quiet site
- First science in 2013

Credit: John Sarkissian, CSIRO

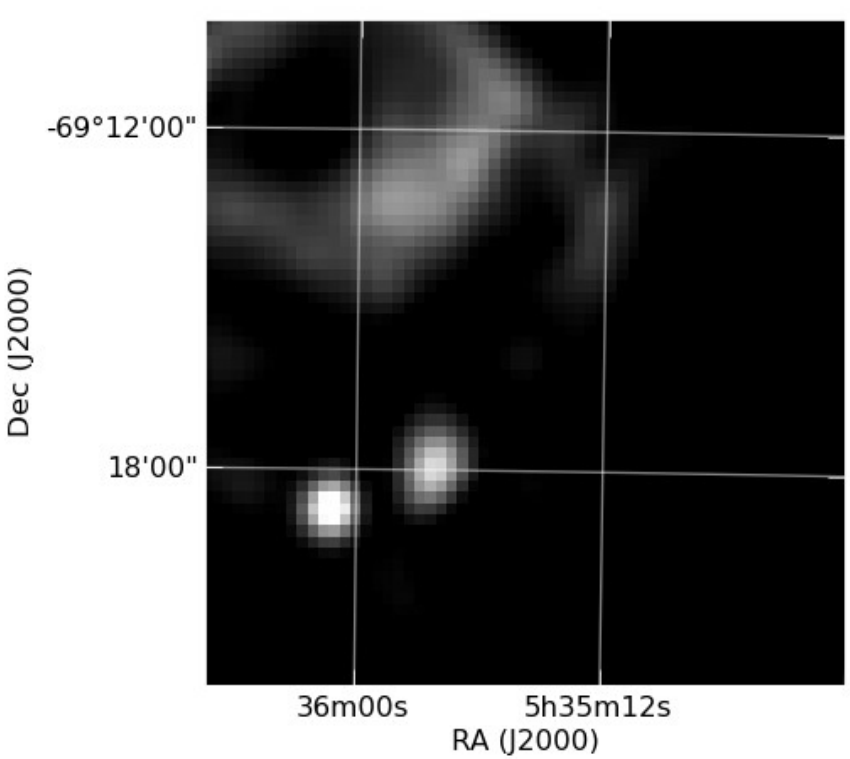


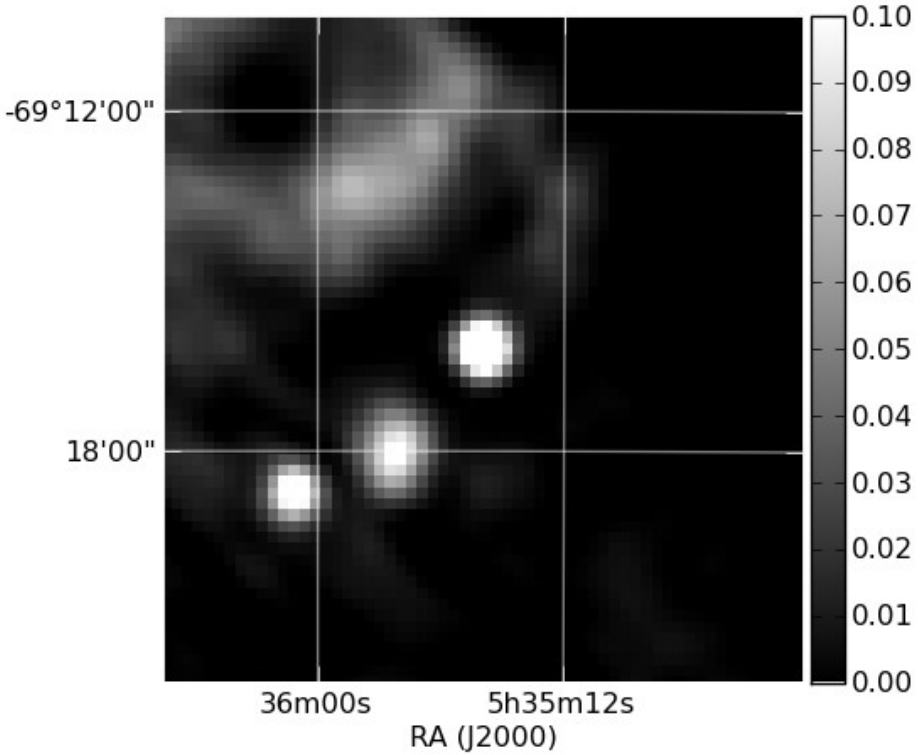
Credit: Ant Schinckel, CSIRO

VAST Survey Overview

- Goals:
  - Detect variable and transient phenomena at radio wavelengths
  - Achieve an unprecedented combination of sky area, sensitivity and time sampling
  - Automatic classification of sources
  - Automatic triggering of events to the community e.g. VOEvent
- All in near real-time
- Several survey regimes, including looking at most of the southern sky every night for 2 years
- “Slow” transients means changes over 5 seconds or more

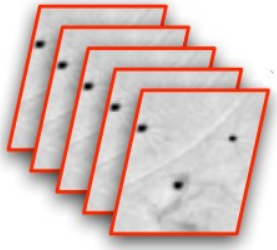
Spot the difference?



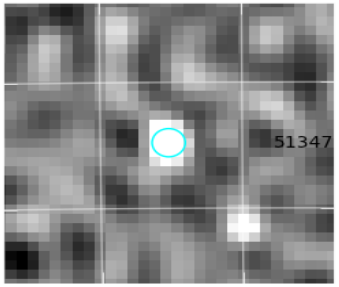


SN 1987A, Molonglo Observatory Synthesis Telescope (MOST)

VAST Pipeline Functionality

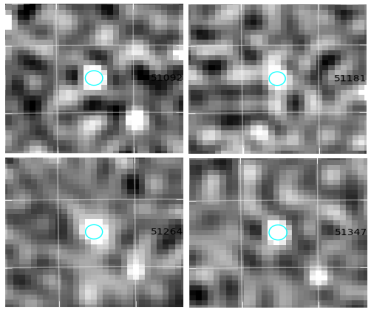


Images

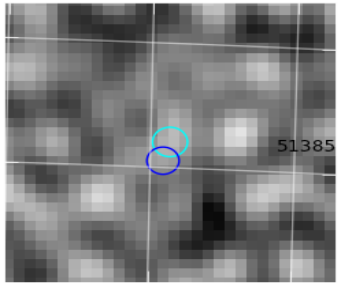


Source Finding

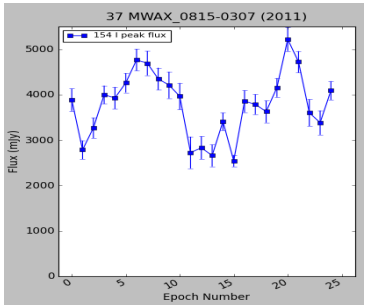
id	ra	dec	peak_flux
45698	140.086018813898	-0.0264923531020644	5116.71727867957
45699	133.491353124597	-14.4742190036336	5149.13446702225
45700	126.845471363379	-20.4499560344826	4238.0402273483
45701	140.59682119768	-14.4677999721053	3494.67636798833
45702	122.287433196622	-10.4284867170353	2305.83548545837
45703	123.92024884036	-3.10268649418916	2216.57492940524
45704	129.320666998052	-19.7999061246862	2525.59456548082
45705	129.96297145562	-12.2740590816346	1658.29703423204
45706	134.331703871591	-21.287983405128	1653.28886399535
45707	135.48608235753	-14.2323400686431	1022.21738233811



Source Association

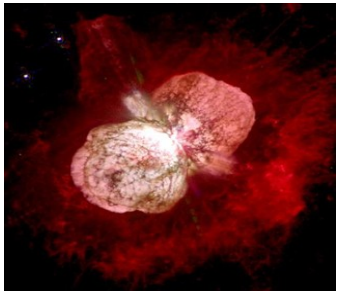


Source Monitoring



Light Curve Creation

Image: Jon Morse/NASA



Transient Detection & Classification

Image: usvao.org

VOEvent

VAST Collaboration

- A collaboration with diverse scientific interests.
- Led by Tara Murphy (The University of Sydney) and Shami Chatterjee (Cornell University)
- http://www.physics.usyd.edu.au/sifa/vast

Hayley Bignall[1], Geoffrey Bower[2], Joshua Bloom[2], Jess Broderick[3], *Edwin Budding[4], Robert Cameron[5], David Champion[6], Shami Chatterjee[7], *Stéphane Corbel[8], James Cordes[7], David Coward[9], *Steve Croft[2], James Curran[10], Avinash Deshpande[11], George Djorgovski[12], Richard Dodson[9], Philip Edwards[13], Simon Ellingsen[14], Alan Fekete[10], Rob Fender[3], Dale Frail[15], Bryan Gaensler[10], Duncan Galloway[16], Matthew Graham[12], Anne Green[10], Lincoln Greenhill[17], *Paul Hancock[10], George Hobbs[13], Richard Hunstead[10], *Scott Hyman[18], Simon Johnston[13], Glenn Jones[12], *Atish Kamble[19], David Kaplan[19], Aris Karastergiou[20], *Slava Kitaeff[21], Michael Kramer[6], *Casey Law[2], Joseph Lazio[23,36], Jim Lovell[14], Jean-Pierre Macquart[1], Ashish Mahabal[12], Walid Majid[23], Maura McLaughlin[24], Andrew Melatos[25], Tara Murphy[10], Ray Norris[13], *Roopesh Ojha[22], Steve Ord[17], Sabyasachi Pal[9], Michele Pestalozzi[35], Andrea Possenti[27], Peter Quinn[9], Nanda Rea[28], Cormac Reynolds [1], Roger Romani[5], Stuart Ryder[29], Elaine Sadler[10], Brian Schmidt[30], Bruce Slee[13], Ingrid Stairs[31], Ben Stappers[32], Lister Staveley-Smith[9], Jamie Stevens[13], *David Thompson[23], Steven Tingay[1], Ulf Torkelsson[26], Tasso Tzioumis[13], Marten van Kerkwijk[33], *Kiri Wagstaff[23], Mark Walker[34], Randall Wayth[1], Linqing Wen[9], Matthew Whiting[13], *Peter Williams[2], Roy Williams[12] and others...

Source Finding in VAST

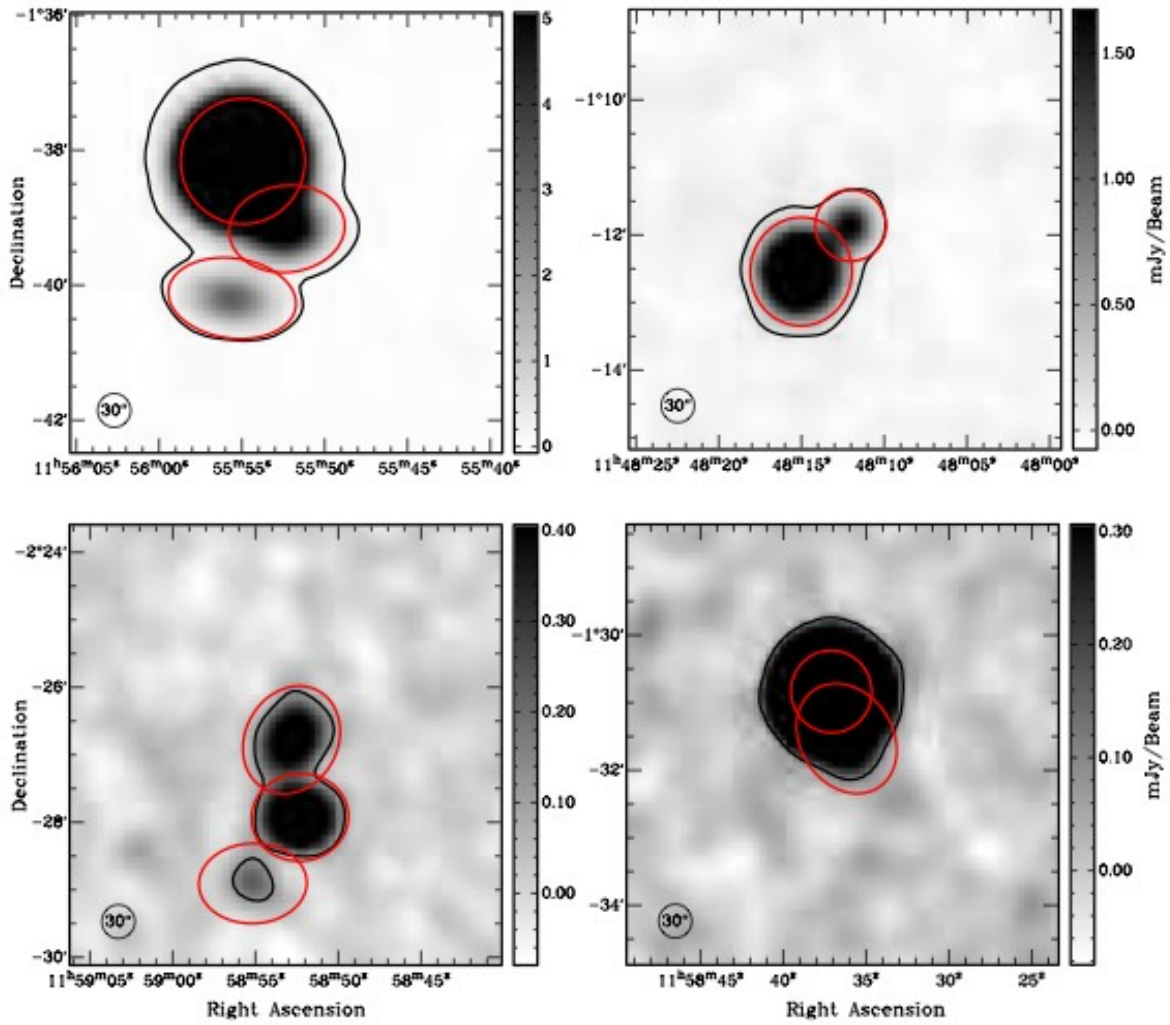
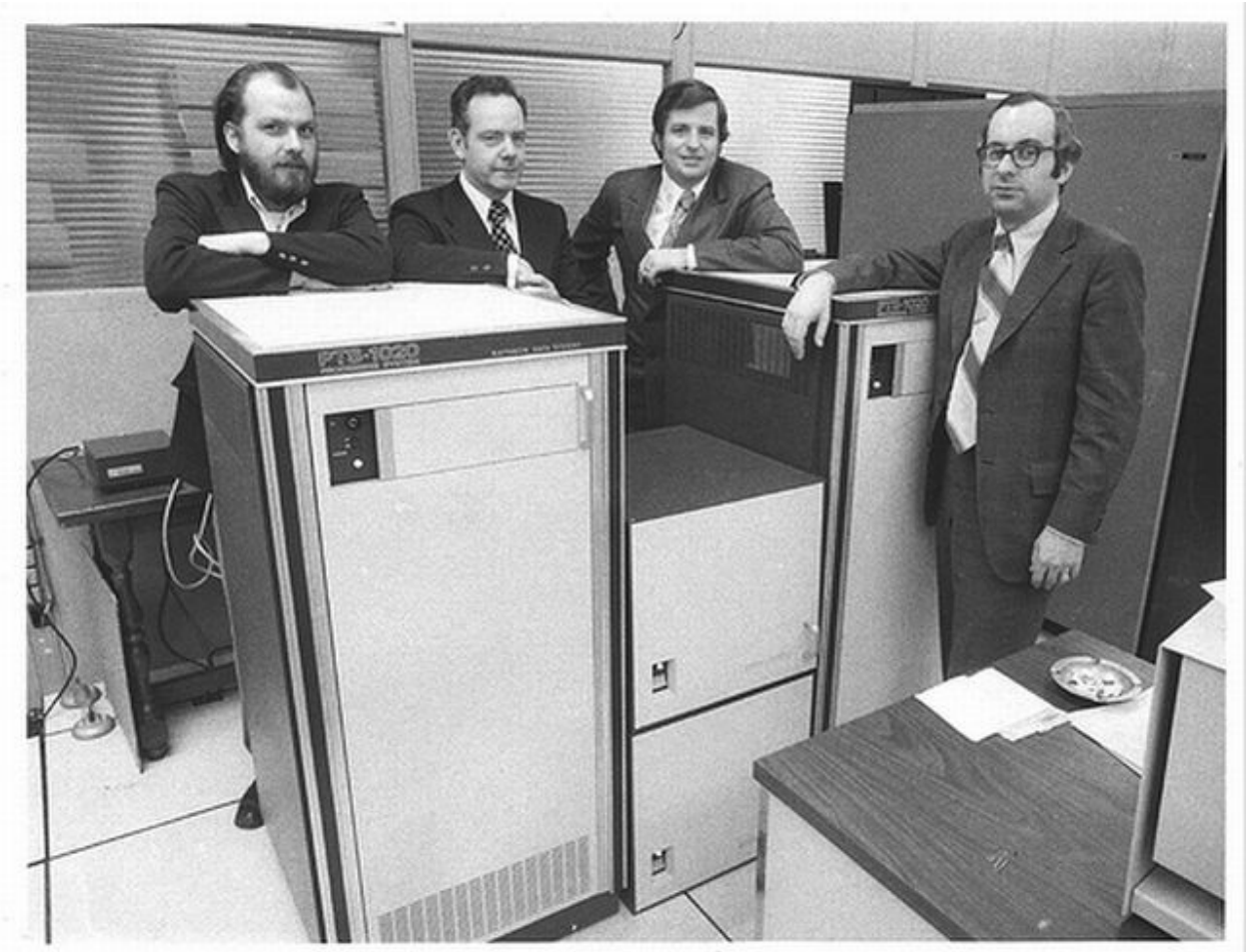


Image ref: Paul Hancock

VAST Capacity Challenges

- Input rate:
  - 1 x ~8GB image cube every 5s (60TB / day)
  - 1 x larger, more sensitive image cube e.g. every 1 hour
- ~20,000 Gaussian fits per second
- ~20,000 measurements stored per second
- ~5,000 cone search queries per second
- ~5,000 light curve changes per second to analyse
- ~720 million measurements stored per 10 hour observation
- We need a big computer!

A big computer?



Credit: http://www.ronmartin.net

ASKAP Computer

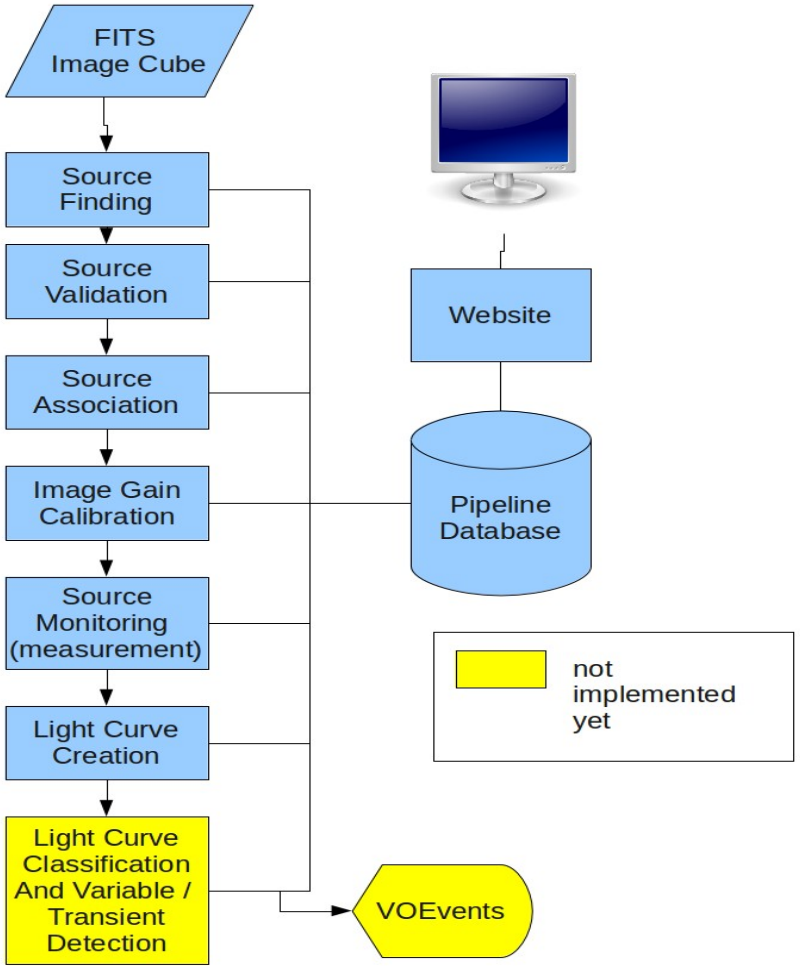
- A petascale computing cluster at the Pawsey Supercomputing Centre in Perth, Western Australia
- Will be one of the most powerful supercomputers globally
- This cluster will run the telescope imaging etc. and the science pipelines including VAST

Credit: iVEC

VAST Pipeline Prototype

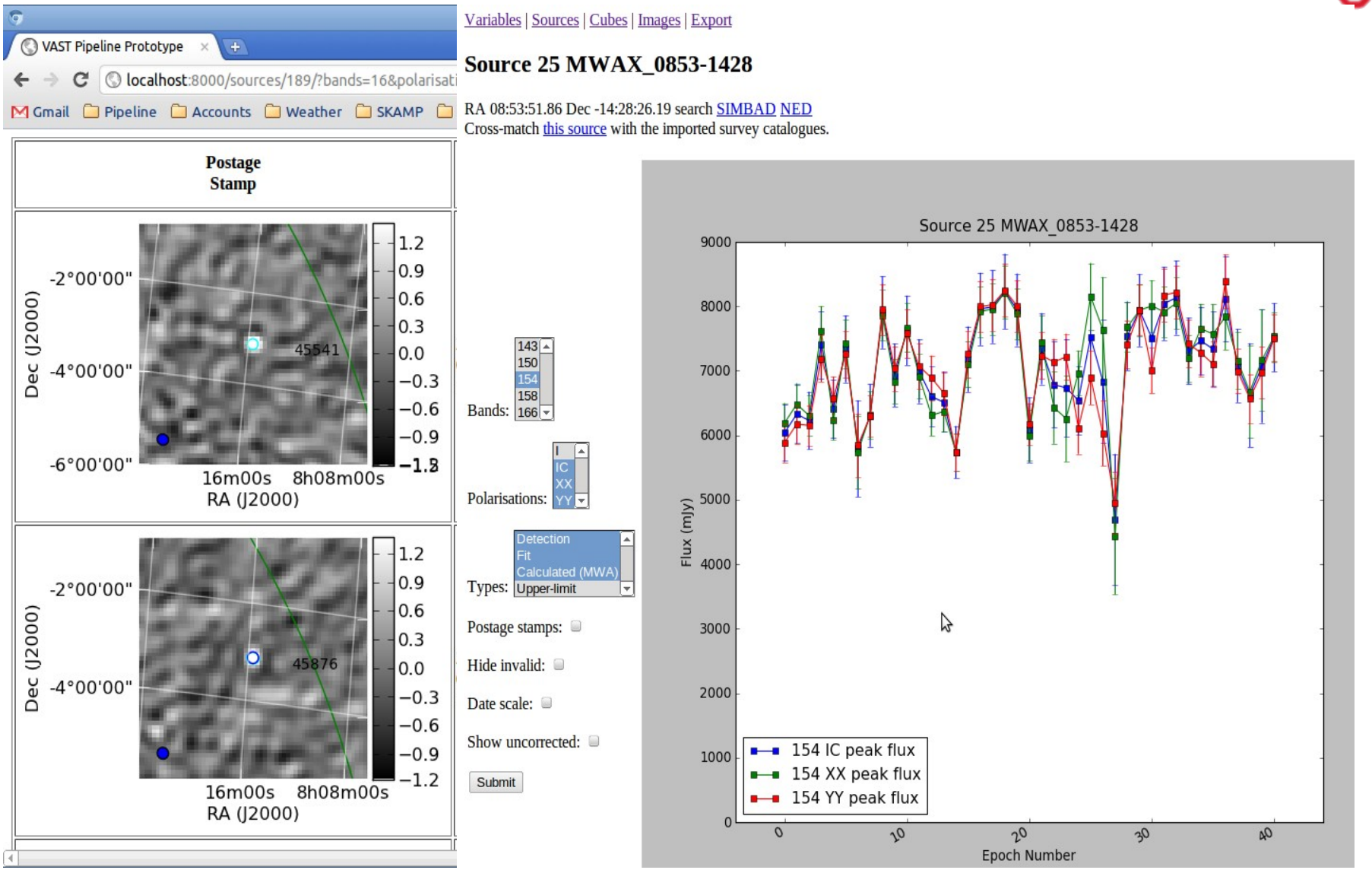
- The VAST collaboration is developing a prototype pipeline
- Goals:
  - Develop the functional requirements for the real pipeline
  - Discover and address the issues facing the VAST survey
  - Do transient detection on data from other telescopes:
    - ASKAP BETA (ASKAP with 6 or 12 dishes)
    - Murchison Widefield Array (MWA)
    - Australia Telescope Compact Array (ATCA)
    - Very Large Array (VLA) (archival)
    - SKA Molonglo Prototype (SKAMP)

VAST Pipeline Prototype



- Pipeline is fully automatic
- Dynamic website to view results
- Handles FITS images from any radio telescope (with minor adjustments, in theory...)
- Implemented in Python
- PostgreSQL database with Q3C for coordinate searches
- Django for dynamic website
- Libraries: aplpy, pyfits, pywcs, matplotlib, mpfit
- Capacity: ~20 source measurements per second. 1000 times too slow... but it's a prototype!

VAST Prototype Screenshots



Summary

- ASKAP is a radio telescope with unprecedented survey speed being built in Western Australia
- The VAST survey will detect radio transients and variables using ASKAP
- VAST will use a near real-time pipeline on a large computing cluster and will face significant capacity challenges
- A prototype pipeline exists and is under continuing development. It can be used on data from any radio telescope