



Current developments with the LBA

Chris Phillips, Phil Edwards,
Cormac Reynolds
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Australia's National Science Agency



I would like to begin by acknowledging the Traditional Owners of the land on which our telescopes are located and pay my respect to their Elders past and present.

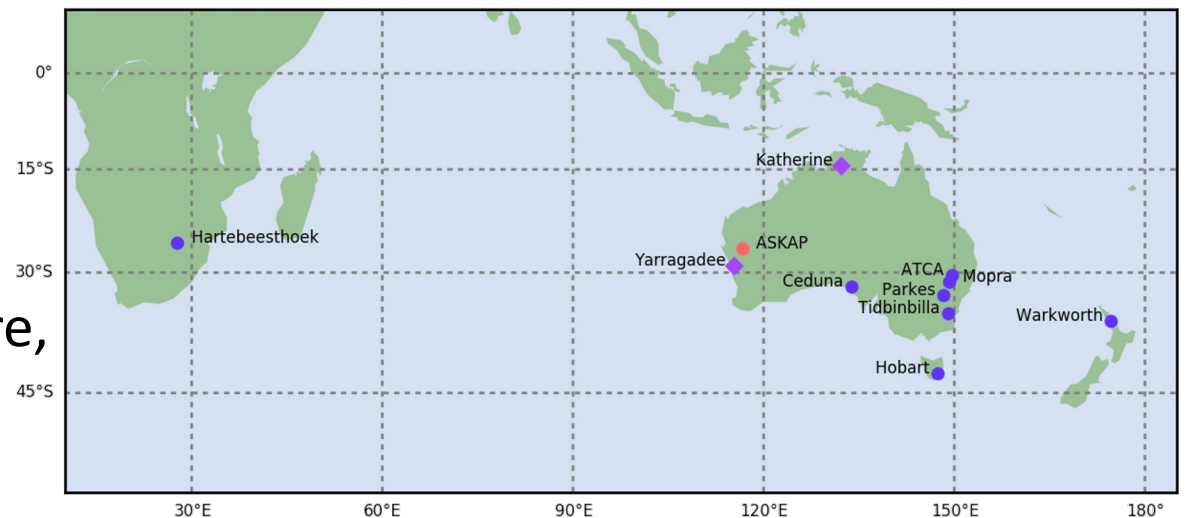


Vanessa Kelly, VLBI, 2019



The Long Baseline Array (LBA)

- Partnership between CSIRO, UTAS, Warkworth Obs. and SARA0
 - Ad hoc Asian telescope involvement, some joint EVN observations
 - Open sky policy
 - Proposals mid-June & mid-Dec
- Wide range of Galactic and extragalactic science
 - Pulsars, masers, Galactic structure, stars, gamma-ray binaries, AGN, SNR, radio stars, radio galaxies
 - Astrometry pivotal
 - Southern skies



<https://www.atnf.csiro.au/vlbi/>



LBA – Current Tech Specs



~ 30 days VLBI, 2-4 sessions

Max rate 1 Gbps (128 MHz)

- Increasing to 4 Gbps in 2025

1.4 - 25 GHz

- ATCA, Mopra 43 & 86 GHz, Parkes 700-3500 MHz

Correlation using DiFX

Setonix supercomputer @Pawsey centre

- #14 on TOP500 supercomputers 2022
- eTransfer *only*

Murriyang (Parkes)

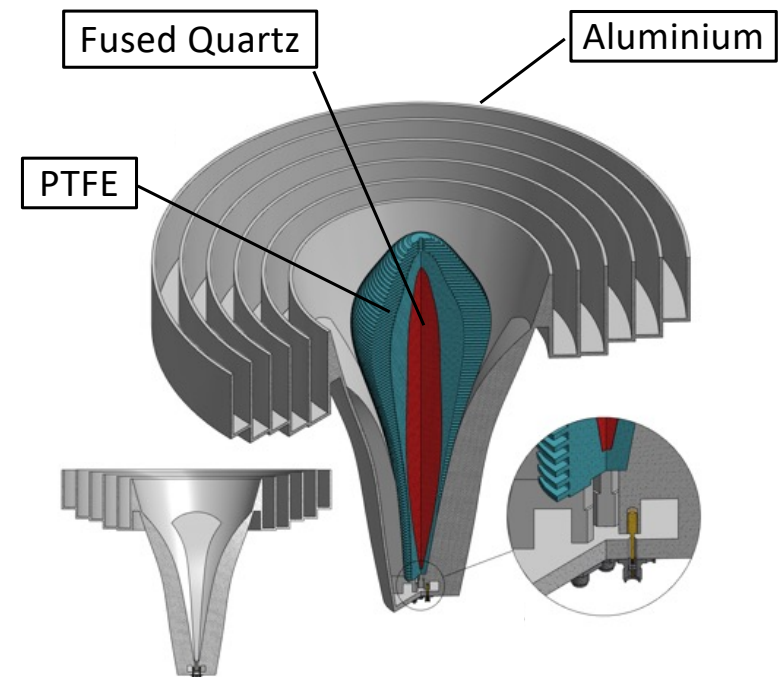
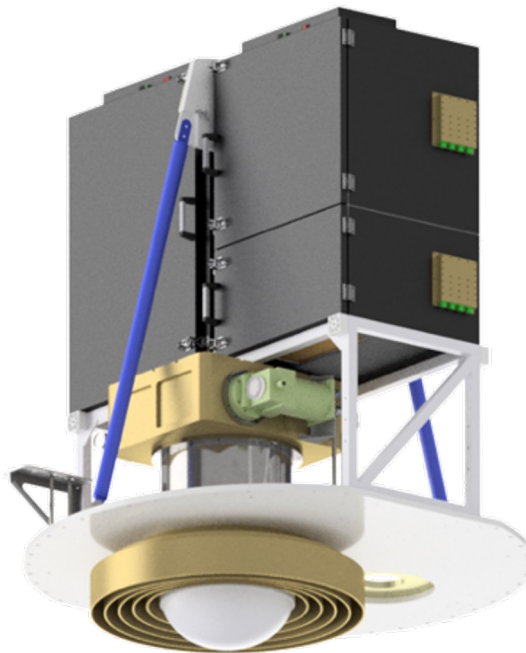
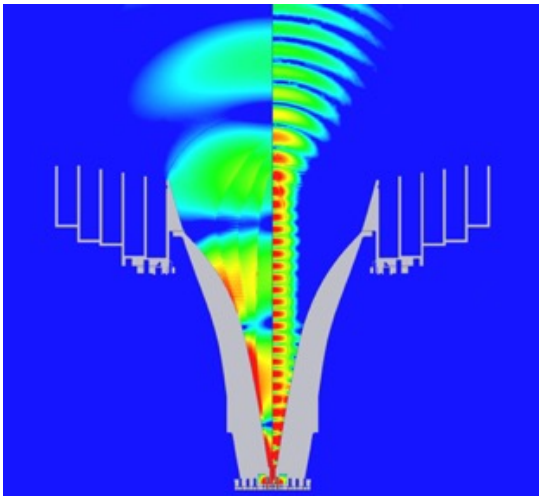
Murriyang

- Murriyang, Parkes 64m telescope
- 700 MHz – 27 GHz
- 700-4200 MHz "Ultrawideband Low" Rx (UWL)
- Commissioning cryogenically cooled PAF
- 8 & 22 GHz single pixel feed
 - Limited availability
- 6.7 & 4.8 GHz Rx essentially not available
- Ultra wideband high (UWH) project started (2026-2027 completion)

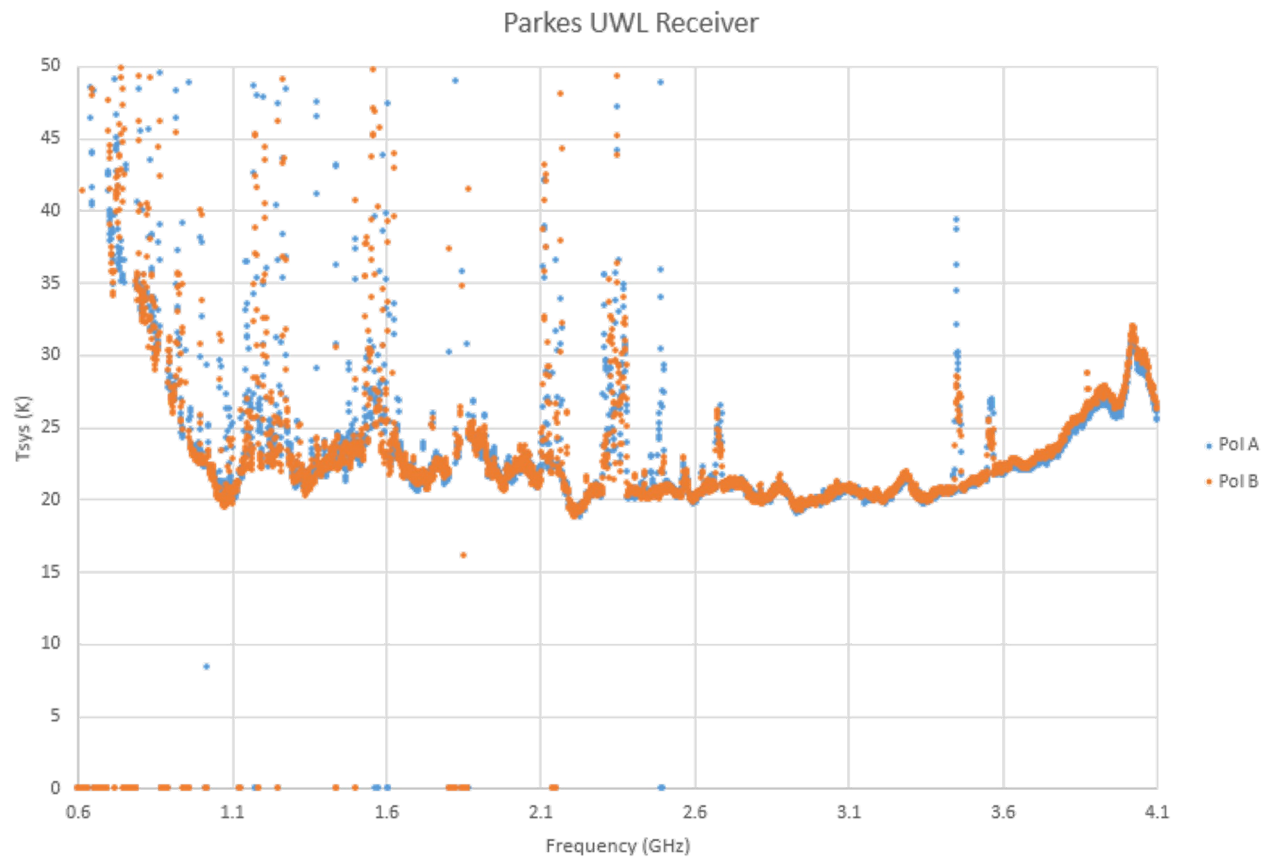


Ultra-wideband Receiver (UWL)

- Quadridge design
 - Central core of dielectric
- 700 MHz – 4.2 GHz
 - ~21K Tsys

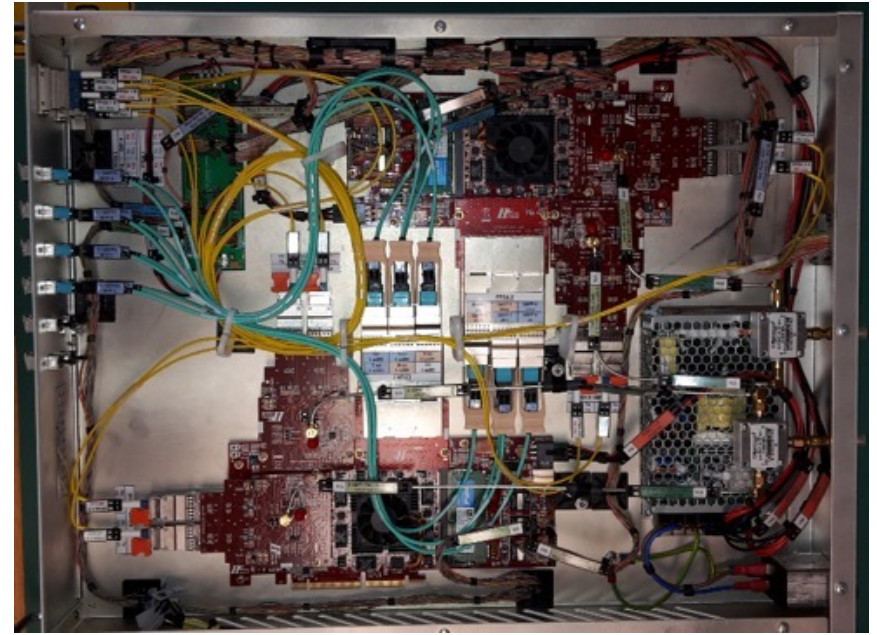


System temperature on Dish



UWL: Digitization

- Sampling at the focus
 - 12-bits (TI ADC12J4000)
 - 2 sample clocks:
 - 2560MHz and 4096MHz
 - JESD204B serial data transport over optical fibre
- FPGA-based DSP (Xilinx Kintex Ultrascale xcku115)
 - Polyphase filterbank channeliser (128 MHz sub-bands)
 - 10 Gbps Ethernet packetiser



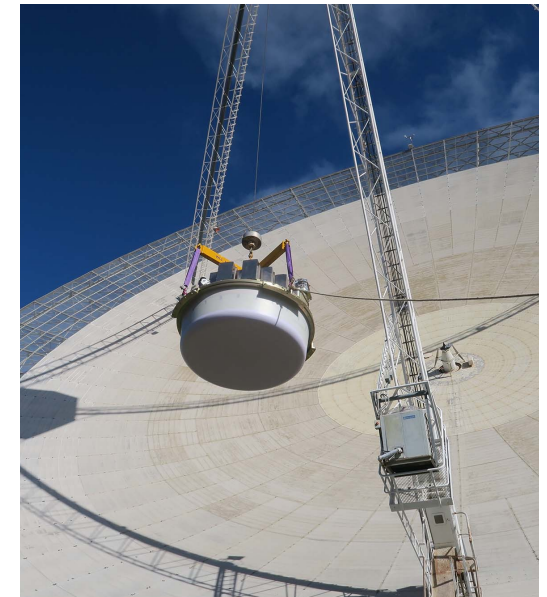
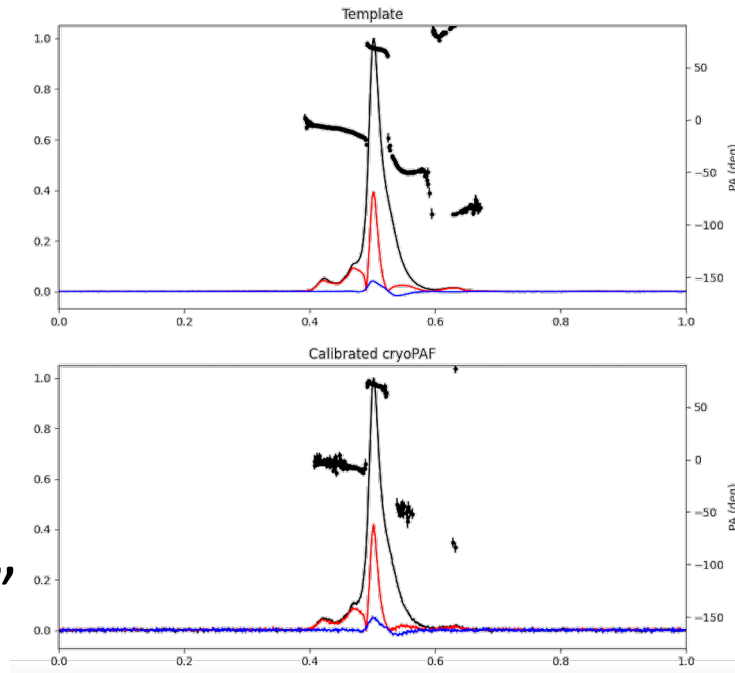
UWL: GPU Processing

- 9 GPU servers
- Four NVIDIA Titan X each
 - Currently deploying Nvidia A10
- 128 MHz dual pol sideband per GPU
 - 16-bit complex sampled VDIF
 - UDP Multicast
- Pulsar search and timing modes
- Continuum and spectrometry
- Initial VLBI demonstrated – waiting on next software release
- Plus Tsys, RFI mitigation (adaptive filtering with reference signal, clipping)
- Software developed by Fourier Space



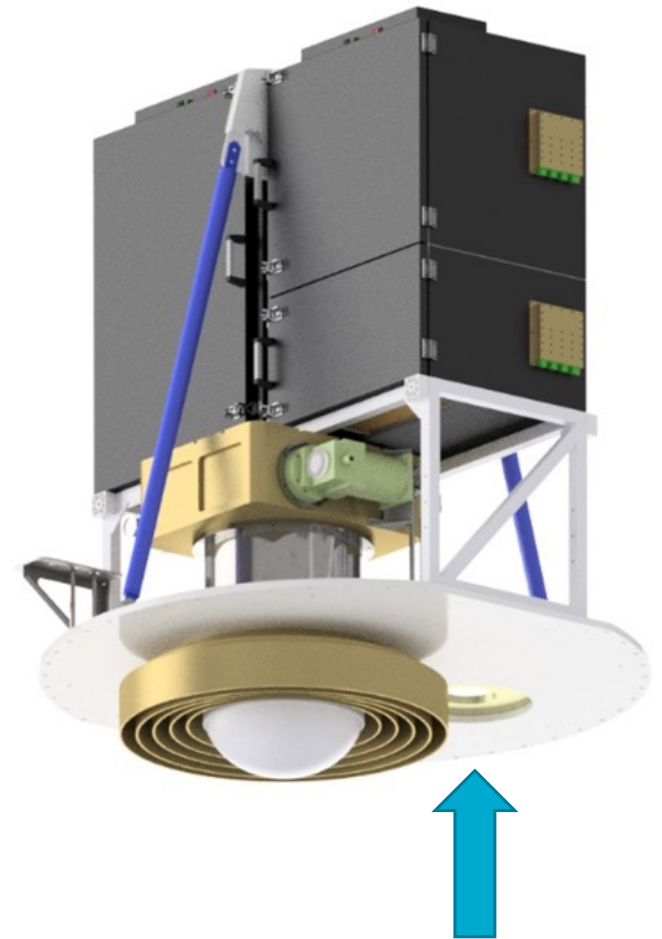
Cryogenically Cooled PAF

- Mark3 cryogenically cooled 'Rocket' PAF
- Currently under commissioning
- 700 – 2000 MHz
 - Sub 20K Rx Tsys
 - ~27K on sky
 - 72 dual pol beams
- Jimble digitizer
- Alveo Beamformer
 - PCI-E based Xilinx FPGA
- GPU “science processing”



Parkes UWB Mid/High

- Based around UWL and ATCA CX system
- Utilizing much of the UWL system
 - Samplers; Back-end; GPUs; Software
- 2 Bands: 4-15 GHz, 15-27 GHz
- Using Jimble digitizers (see following slides)
- Design started – delivery ~3 years time



ATCA



ATCA

- 6x22m interferometer
- 6km max baseline
 - Reconfigurable
- 1-105 GHz
- 2x2 GHz “CABB” correlator
 - 2x64 MHz for VLBI
- Aging electronics...



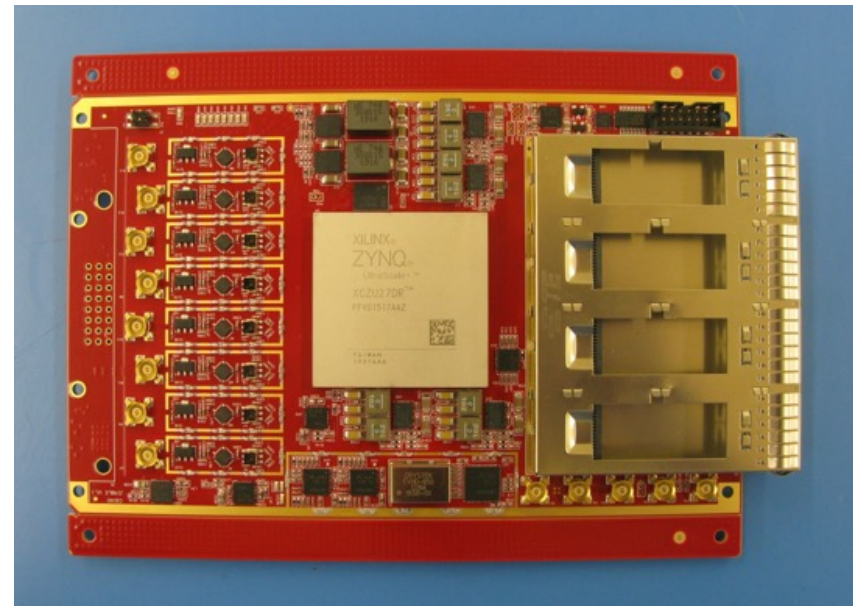
ATCA

- “BIGCAT” upgrade under development
 - Replace “CABB” 4 GHz with 8 GHz bandwidth
 - “Jimble” digitiser
 - GPU based correlator
 - Feb 2025
- Flexible VLBI backend
 - 2-16 bits
 - Up to 8 GHz bandwidth
 - Multiple tied array beams
 - VLBI subarrays (position & frequency)



Jimble

- New digitizer board based on Xilinx RFSoc
 - 8 ADC
 - 4 used for BIGCAT firmware
 - 2 GHz bandwidth
 - 12-bit quantisation
 - 2x 100 GbE in hardware
 - FPGA fabric (PFB, packetiser)
- No external memory (RFI concerns)
- 100 GbE (4x25) “soft” core
- Electrical & Optical PPS/clock
- 1/10 GbE M&C



LAMBDA



LAMBDA –

Low-frequency Australian Megametre Baseline Demonstrator Array

- Goal: Demonstrate Feasibility of Long Baseline Science with SKA-Low
- Low frequency antennas, e.g. CRAB, SKALA
 - 256 dual polarization antennas
 - VLBI target frequency – 100-350 MHz
- Locate at existing LBA observatories (or CSIRO sites)
 - Saves on site costs (power, network etc)
- Extend with new stations near existing networks and internationally

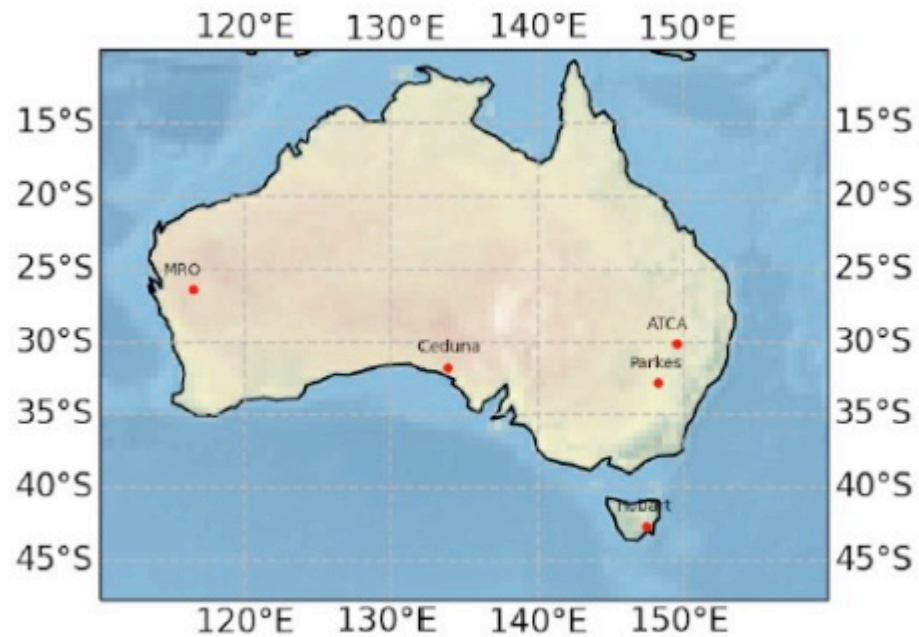


LAMBDA Project Rollout

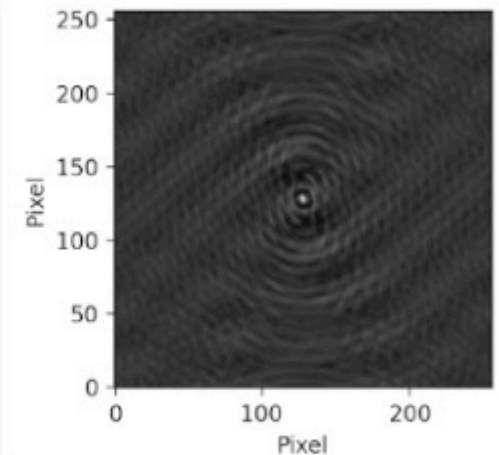
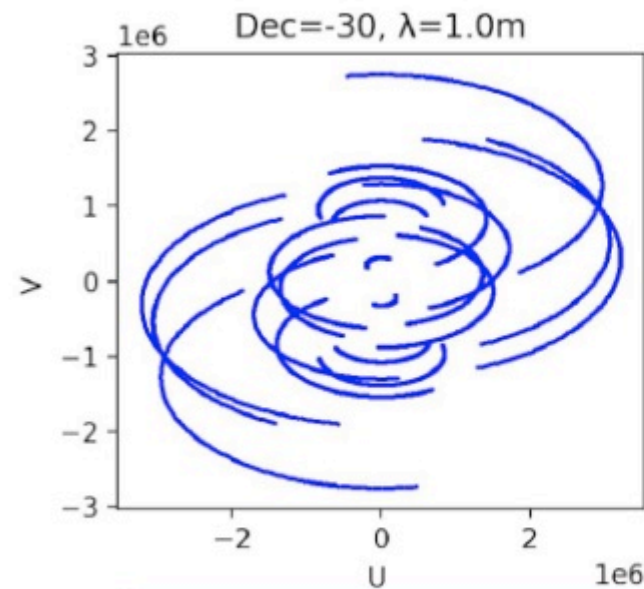
- CSIRO funding to develop LAMBDA
 - *Science & Technology* demonstrator
 - Prototype and initial cluster at Narrabri
 - Second cluster at Parkes for interferometric tests
 - Longer term, expand to other LBA site(s) or even new sites
- Exploring options with MWA to provide a phased array output



LAMBDA – Possible Demonstrator



Plots courtesy of Cormac Reynolds (CSIRO) and Yun Yu (SHAO)



Example uv coverage: 70 mas @ 300 MHz

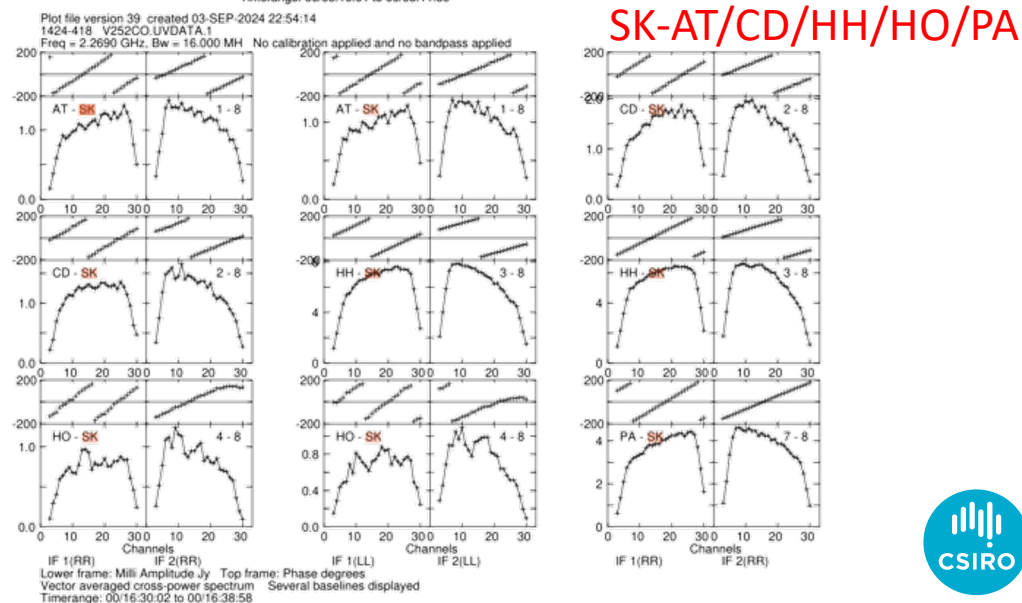
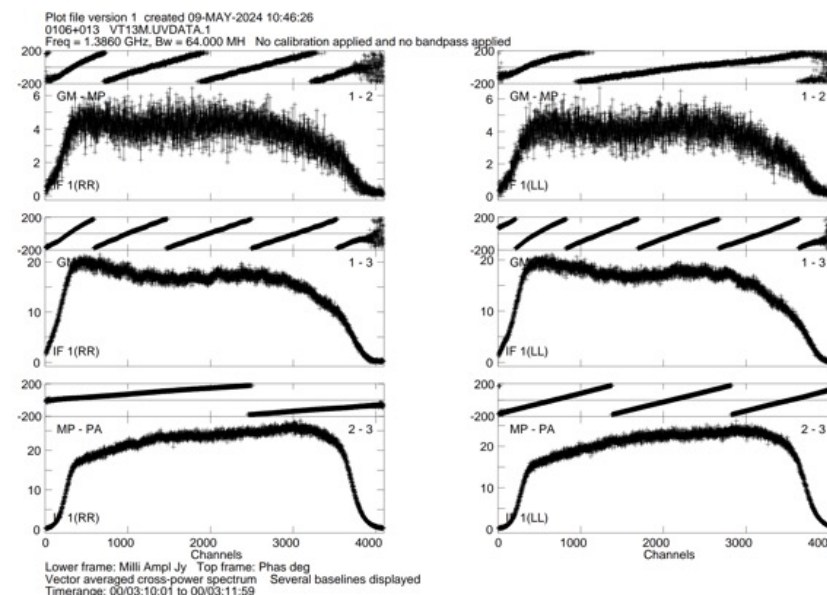
LAMBDA project - sensitivity

	Baseline rms (60s, 48 MHz)	rms (1h, 48 MHz)	rms (8h, 48 MHz)
6x 256 dipoles	26 mJy	870 μ Jy	310 μ Jy
6x 256 + MWA-III	6 mJy	460 μ Jy	160 μ Jy
16x 256 dipoles	26 mJy	310 μ Jy	110 μ Jy
16x 256 + MWA-III	6 mJy	180 μ Jy	64 μ Jy
32x 256 + SKA1 core	2 mJy	77 μ Jy	27 μ Jy

Misc Updates

- Mopra: Continued use for LBA, and contracted usage by KASI
- AuScope: Katherine and Yarragadee upgrade to 2—14 GHz
- Warkworth: Now operated by SpaceOps NZ
- Tidbinbilla: New CSIRO L-band receiver for the 70m in early 2025
- Ceduna: 4-8 GHz Rx development, fibre installed
- Continued tests with uGMRT
- Initial SKAMPI tests

Mopra-Parkes-
uGMRT



Summary

- Many ongoing upgrades for the LBA
- Developing LAMBDA array to extend SKA-low baselines to VLBI

On 30th October we will hold a one-day science workshop to discuss Australian VLBI and links to both SKA-Mid and SKA-Low. Online participation is available (Perth time)

<https://www.atnf.csiro.au/research/workshops/2024/vlbi.html>

Contact me, Cormac or George.Hobbs@csiro.au



Thank you

CSIRO Space and Astronomy

Chris Phillips

Chris.Phillips@csiro.au

www.csiro.au/atnf

Australia's National Science Agency



Problems!

- Multibit samplers all sorts of issues
 - Not particularly linear
- 10 GbE optics major issue
 - Packet loss increases with time – requires new QSFP
 - Use industrial optics
- Don't use critically sampled PFB if you will be combine bands in any way (including astronomical analysis)
- Don't use evaluation boards for production