



# Southern Hemisphere Long Baseline Array

Chris Phillips | 3 Feb 2021

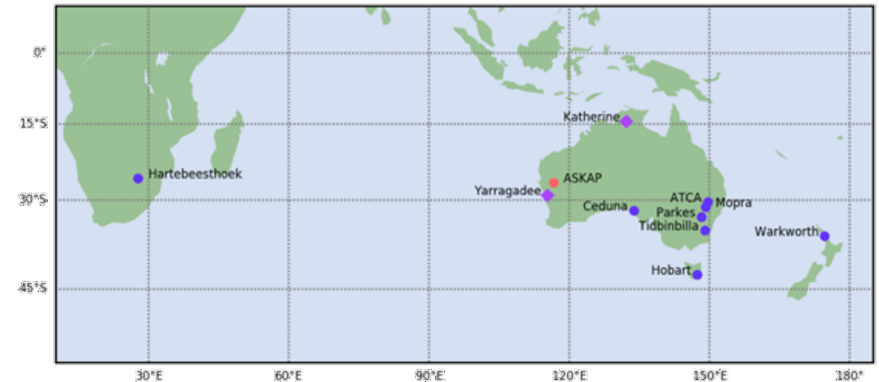
Australia's National Science Agency





# Long Baseline Array

- Partnership CSIRO, UTas, AUT, SARA0
  - Some collaboration with EVN and telescopes in Asia
- Maximum bit rate 1 Gbps (64MHz x 2IFs x 2bits x 2pols x 2Nyquist)
- Traditionally operated in 4–5 blocks of 5–6 days per year
  - Need to install receivers in Parkes focus cabin
  - Use more compact ATCA configurations
- Data correlated using DiFX software correlator at Pawsey Supercomputing Centre



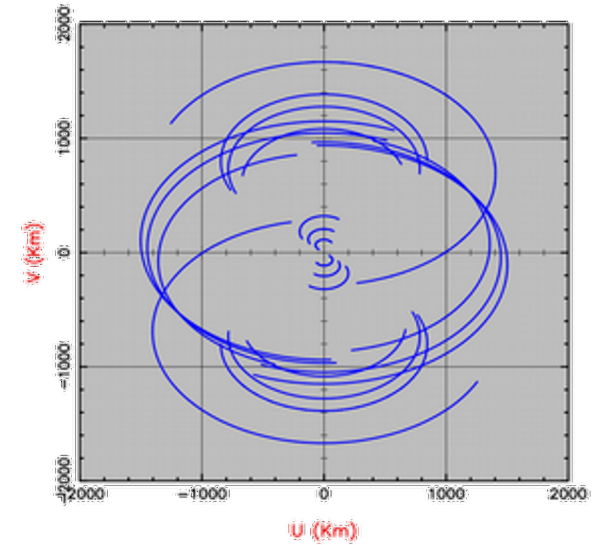


Telescope	Institution	1 GHz	2.3	4.8	6.7	8.4	22	32	86 GHz	S/X
Parkes 64m	ATNF	y	y	y	y	y	y			y
ATCA 5 x 22m	ATNF	y	y	y	y	y	y	y	y	
Mopra 22m	ATNF	y	y	y	y	y	y	y	y	
Tidbinbilla 70m	CDSCC	y	y			y	y			y
Tidbinbilla 34m	CDSCC		y			y		y		
Hobart 26m	UTas	y	y	y	y	y	y			y
Ceduna 30m	UTas	y	y	y	y	y	y			
AuScope 3 x 12m	UTas		y	y	y	y				y
Hartebeesthoek 26m	SARAO	y	y	y	y	y	y			y
Warkworth 12/30m	AUT		y		y	y				y

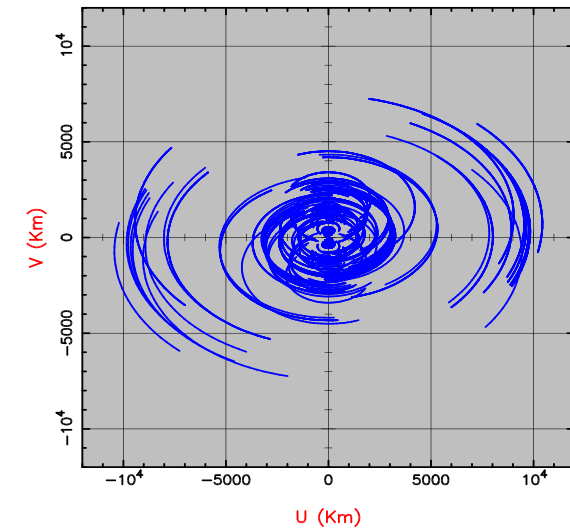


# LBA Imaging Performance

Frequency/MHz	Sensitivity/(microJy/beam) 1hr [+ Tid]
1400	45 [25]
2300	40 [20]
4800	65
8400	50 [25]
22000	230 [90]
32000	[220]



AtCdHoMpPk



+HhKeYgTiWw



# The LBA Correlator @ Pawsey

- **Magnus Specs**
  - 1488 x 24 core nodes
    - 1097 Teraflops
  - Cray Aries interconnect
    - 72 Gbps per node
  - #41 on Global Top500 list of supercomputers (2014/11)
- 200,000 CPU hours secured through merit allocation in 2020
- \$70 million upgrade of full supercomputing suite in 2021





# Access to the LBA

- An open call for proposals is made in mid-June and mid-November
- Telescope time can also be purchased (Breakthrough Listen, CAS, NASA)



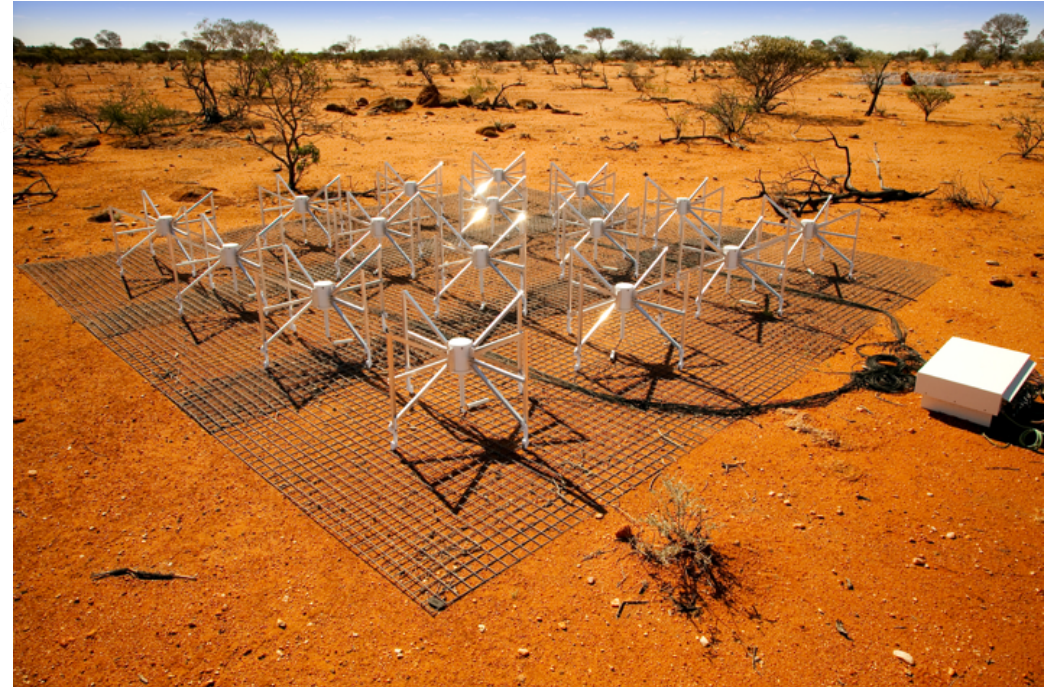
# Enhancing LBA capabilities

- Ultra-Wide-band Low (0.7—4.0 GHz) receiver installed at Parkes
- CryoPAF (0.7—2.0 GHz) being built for Parkes
  - Allows simultaneous observations of target and nearby phase calibrators
- Ultra-Wide-band High (4—15 and 15—27 GHz) under consideration for Parkes
- Replacement of ATCA correlator with GPU backend started (BIGCAT)
  - Enable much wider bandwidths for VLBI
- Tied array mode for ASKAP planned



# LAMBDA

- MWA Style dipole
  - Bluering digital processing
    - RFSoc Sampler/FPGA
    - Channelisation+BeamForming
    - \$US190/K 256 dipoles
- Locate at existing LBA observatories?
  - Saves on site costs (power, network etc)
- Possibly near existing networks
- **Unfunded**





# Thank you

**Astronomy and Space Science**

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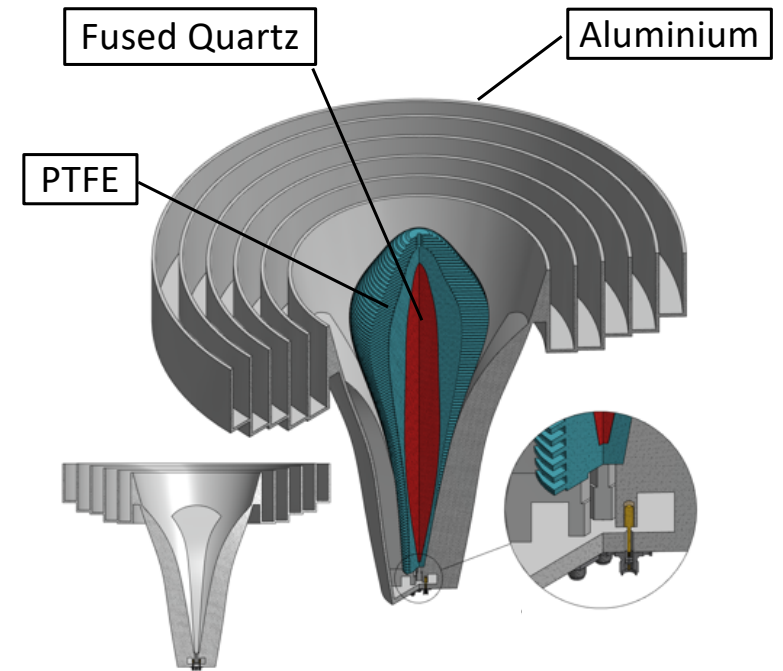
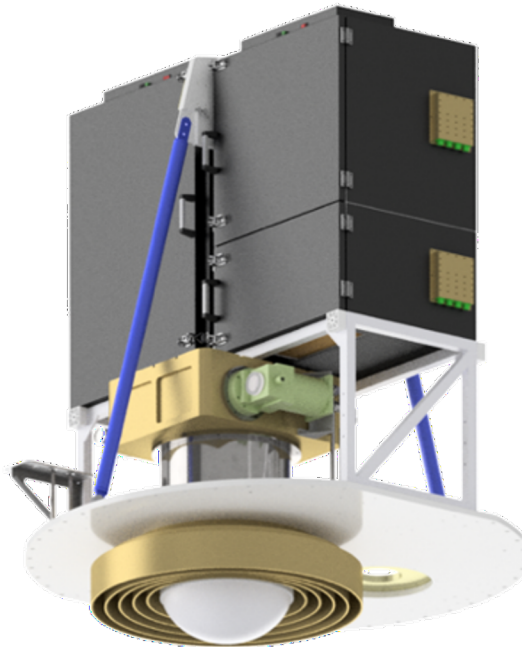
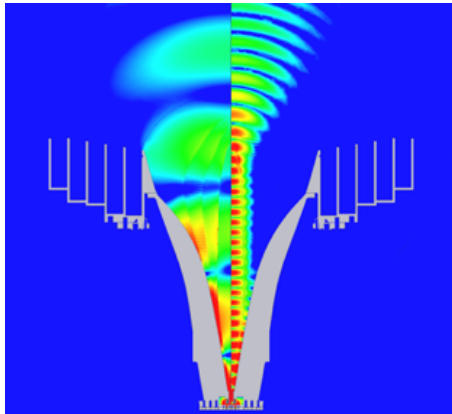
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# Ultra-wideband Receiver (UWL)

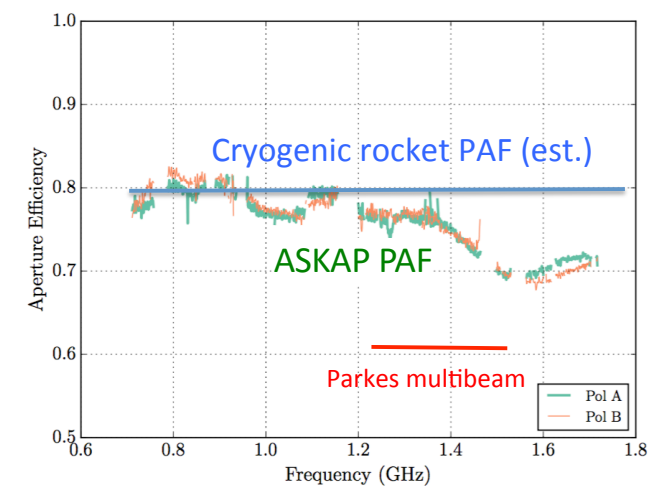
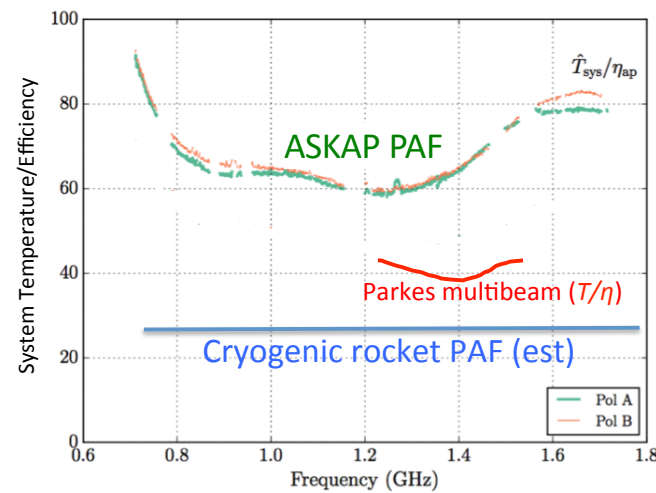
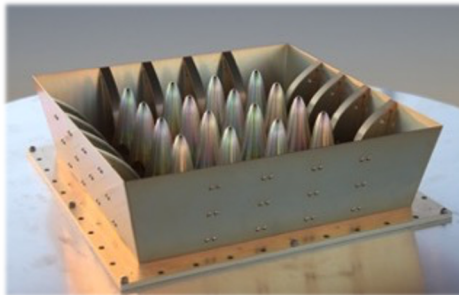
- Quadridge design
  - Central core of dielectric
- 700 MHz – 4.2 GHz
  - ~21K Tsys





# Cryogenically Cooled PAF

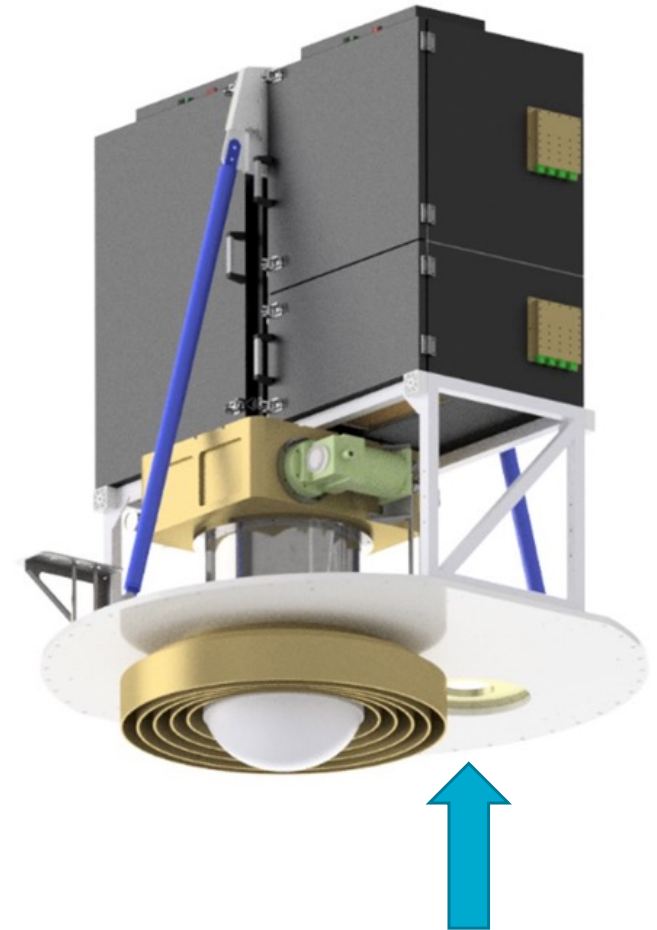
- Mark III cryogenically cooled "Rocket" PAF
- Prototype on dish 2016
- 700 – 2000 MHz
  - Sub 20K  $T_{\text{sys}}$
- Design well underway





# Parkes UWB Mid/High

- Based on UWL and ATCA 4–12 GHz system
- Utilizing much of the UWL system
  - Samplers, Back-end, GPUs, Software
- 2 Bands: 4.0–15.4 GHz, 15.4–26.9 GHz
- Using 12 UWB digitizers (6 per polarisation)
- 4–24 GHz system may be possible but does not work well with dish surface

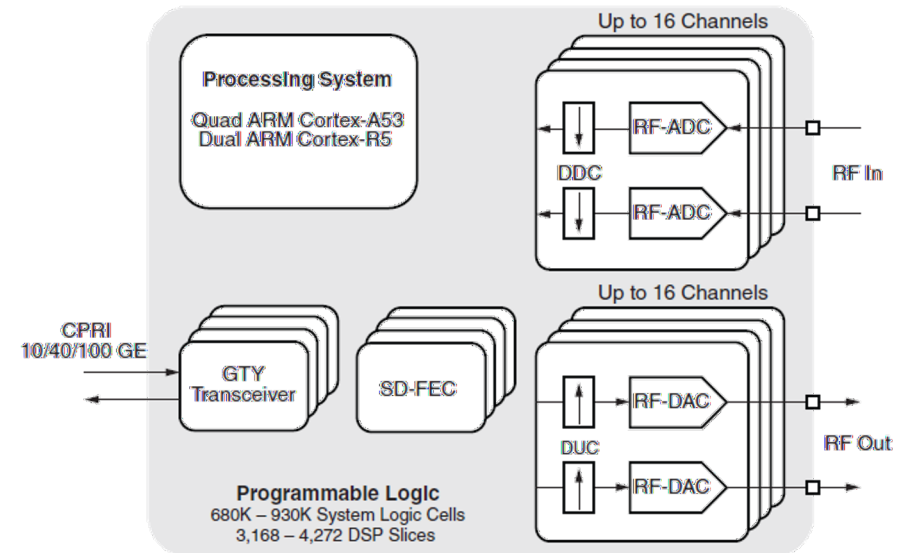


***Not currently funded***



# BIGCAT

- ATCA Digital backend upgrade
  - 8 GHz bandwidth, GPU based processing
- Xilinx RFSoc FPGA/digitizer
  - 8x 4 GSps with FPGA fabric
  - Coarse (128 MHz) filterbank
  - 100 Gbps Ethernet packetizer
- 16 dual GPU servers (32 GPU)
  - GPU fine channelizer, cross correlation
  - gCorr GPU correlator demonstrated





# Australia Telescope Compact Array (ATCA)

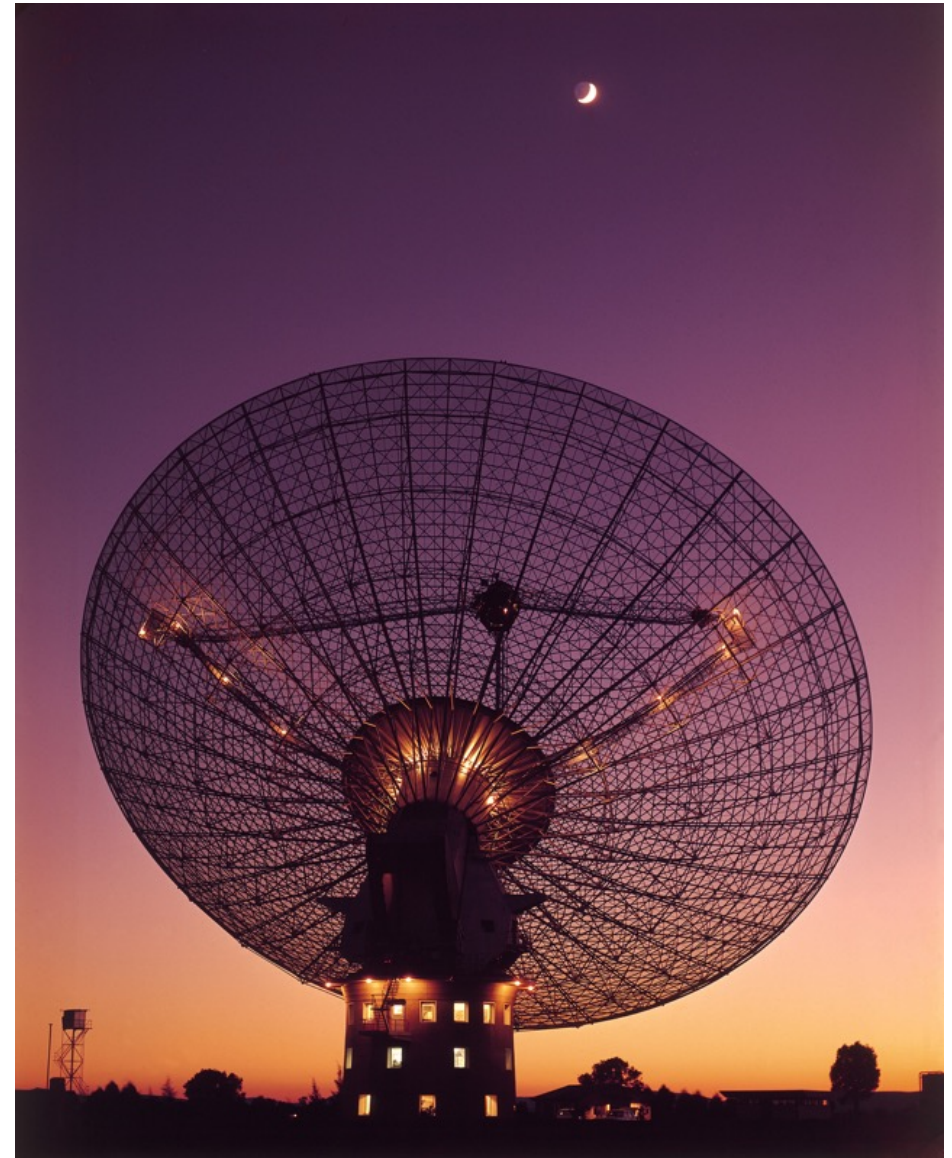
- Array of six 22m antenna
  - 6 km maximum baseline
  - 3 km east-west track with 214 m northern spur
- 1.1 – 105 GHz frequency coverage
- 4 GHz bandwidth backend
  - Only 128 MHz for VLBI
- 8 GHz “BIGCAT” backend coming





# Parkes

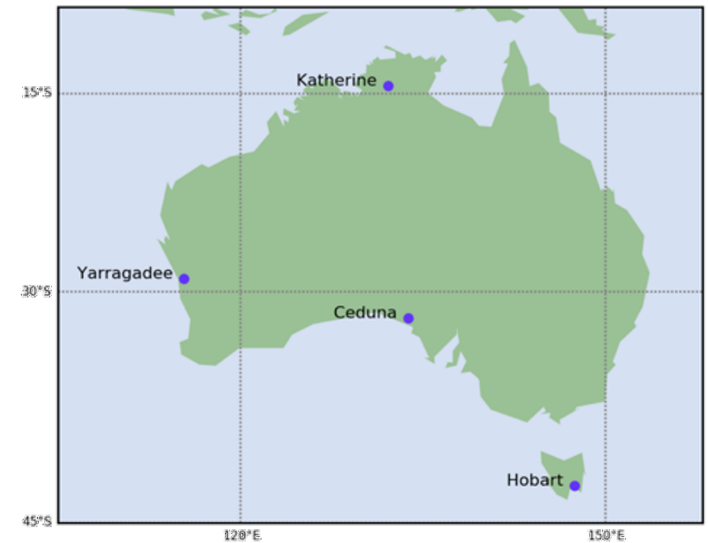
- 64m prime focus
- 700 MHz – 26 GHz
- Opened 1961, continual upgrades and evolution
- Ultra-Wideband Low (UWL)
  - 700 MHz – 4 GHz contiguous
- Cryogenically cooled PAF
  - 700 – 1900 MHz





# AuScope

- 3x 12m Cassegrain antenna
  - Katherine (NT), Yarragadee (WA) and Hobart (Tas)
  - Katherine and Yarragadee 2—14 GHz Rx
    - First VGOS fringes earlier this year
- Work with Warkworth 12m
  - Part of IVS and separate Southern Hemisphere geodesy
- Independent UTas VLBI array with Ceduna and Hobart 26m

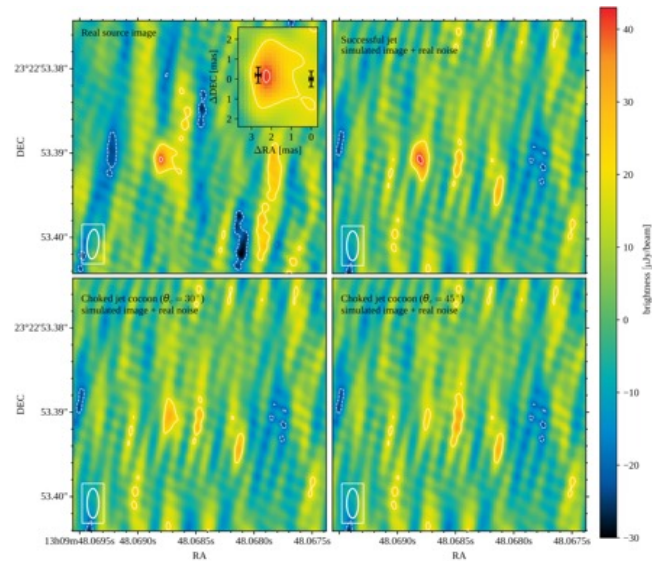




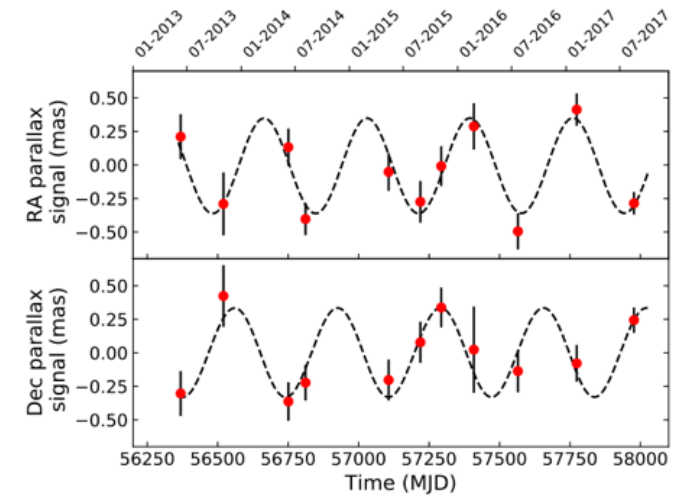


# Science

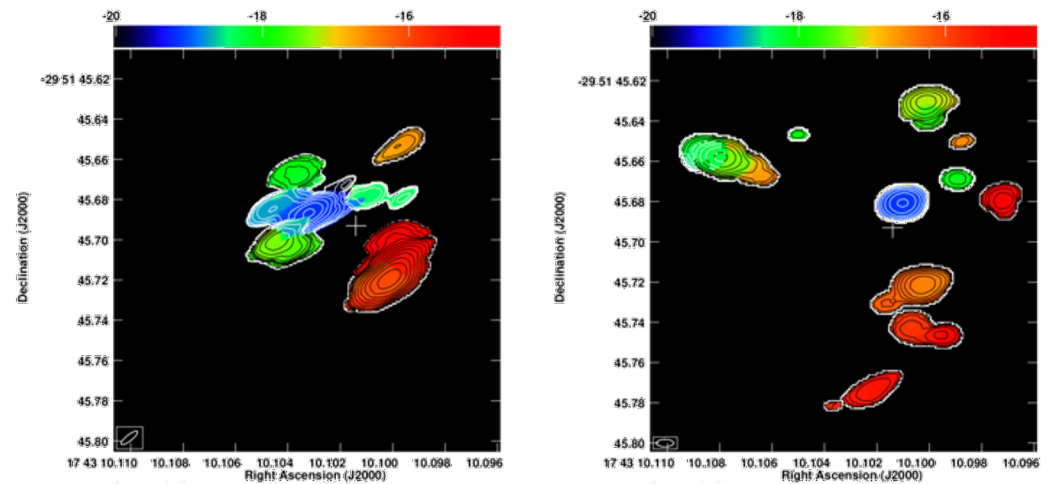
- Gravitational Wave GW170817 Counterpart
- Astrometry of pulsars, masers
- PM of black hole binaries
- ToO maser flare
- Monitoring jets in AGN



Ghirlanda et al. 2018



Miller-Jones et al. 2018



Burns et al. 2019