ATCA and LBA Updates

Phil Edwards,
Elizabeth Mahony,
Barnali Das

28 October 2024

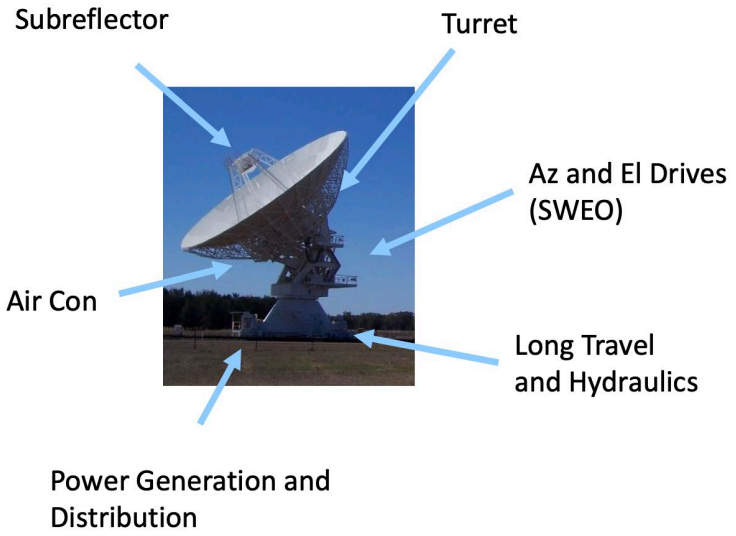
https://www.atnf.csiro.au/ATNF-DailyImage/archive/2023/19-Sep-2023.html

Outline

- ATCA
  - ATCA Upgrades and Improvements
  - Evolution of ATCA frequency, array configuration, and NAPA demand
  - Can we improve things?
- LBA
  - LBA current status
  - Recent activities
  - Recent publications

ATCA upgrades and improvements

- BIGCAT
- Turret, Translator & Subreflector Control
- Power supply and distribution
- Antenna hydraulics and long travel)
- Antenna Tracking (SWEO)
- Vertex Air Conditioning



- All this being done while keeping the array operating, and with too few staff!

ATCA infrastructure upgrade

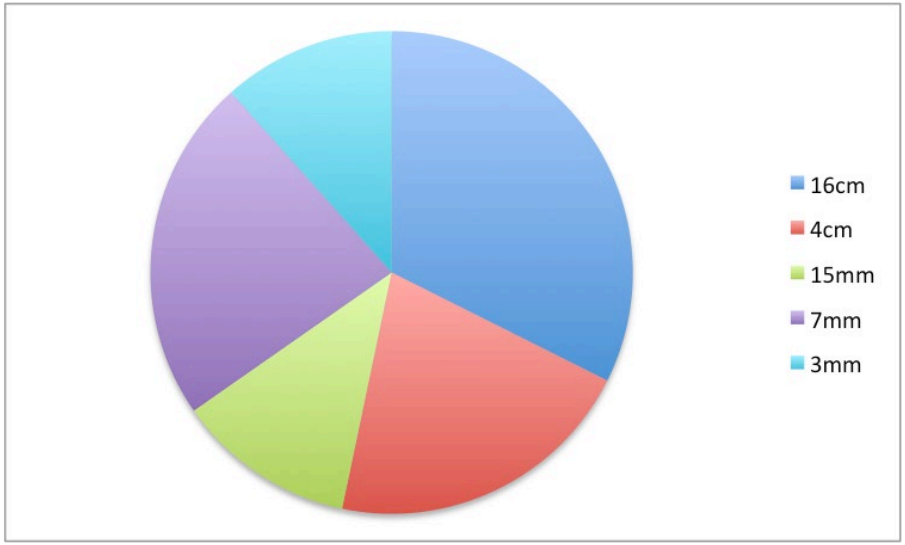
- A ~$2M upgrade of up to 35 year old equipment
- Procurement and first installations well underway
- Anticipating one 8-week shutdown in late 2025, or two 4-week shutdowns in 2025 and 2026.

ATCA usage…

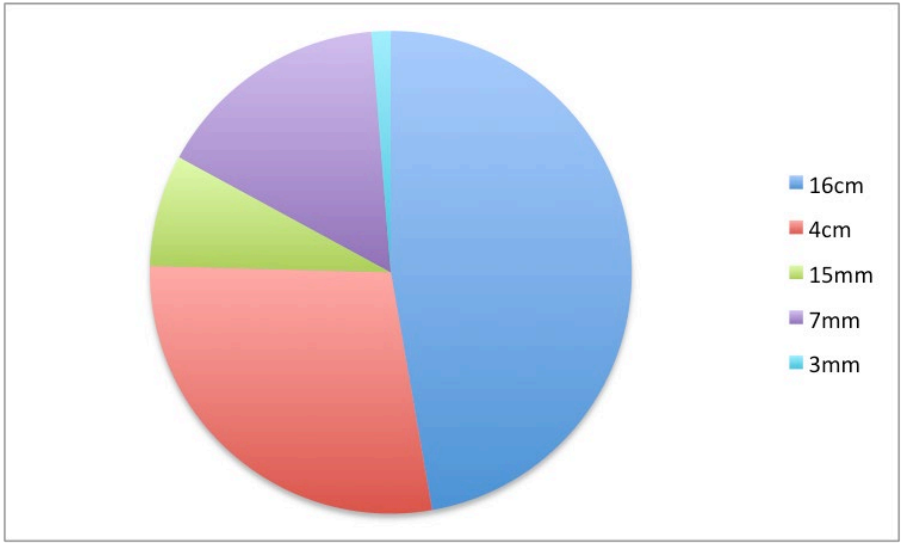
- … is changing with time
  - Proposal pressure for frequency bands
  - Proposal for array configurations
  - More time-critical observations
    - Both schedule-able in advance and NAPA/ToO

ATCA use of Observing bands (from June 2015 ATUC Sci Ops report)

2012—14 APR semesters



2012—14 OCT semesters



ATCA use of Observing bands

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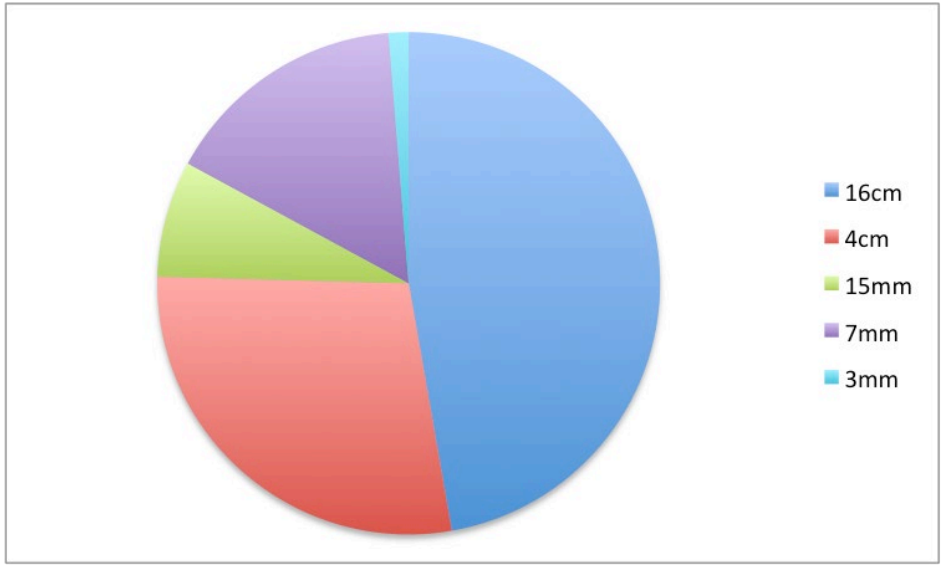
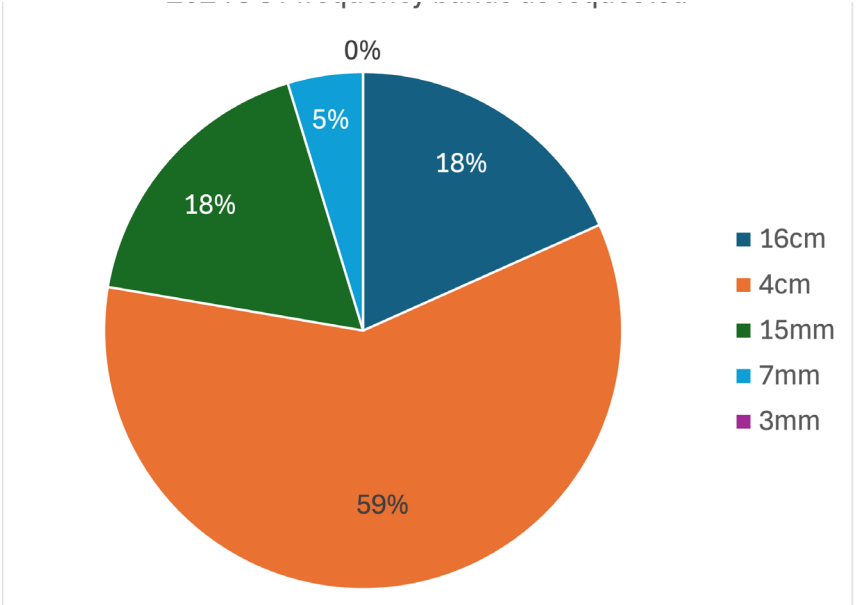
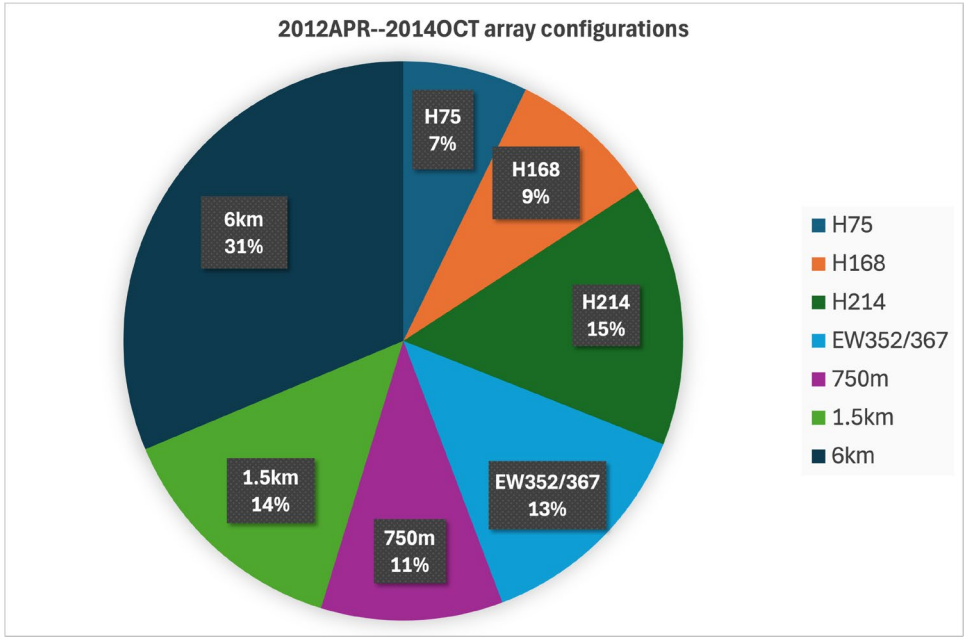
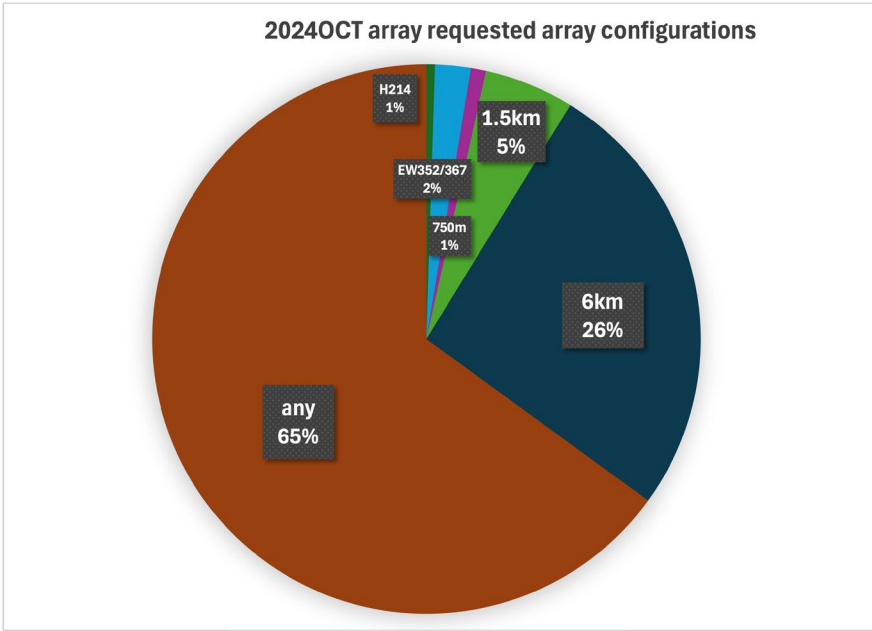


2024OCT semester proposal requests

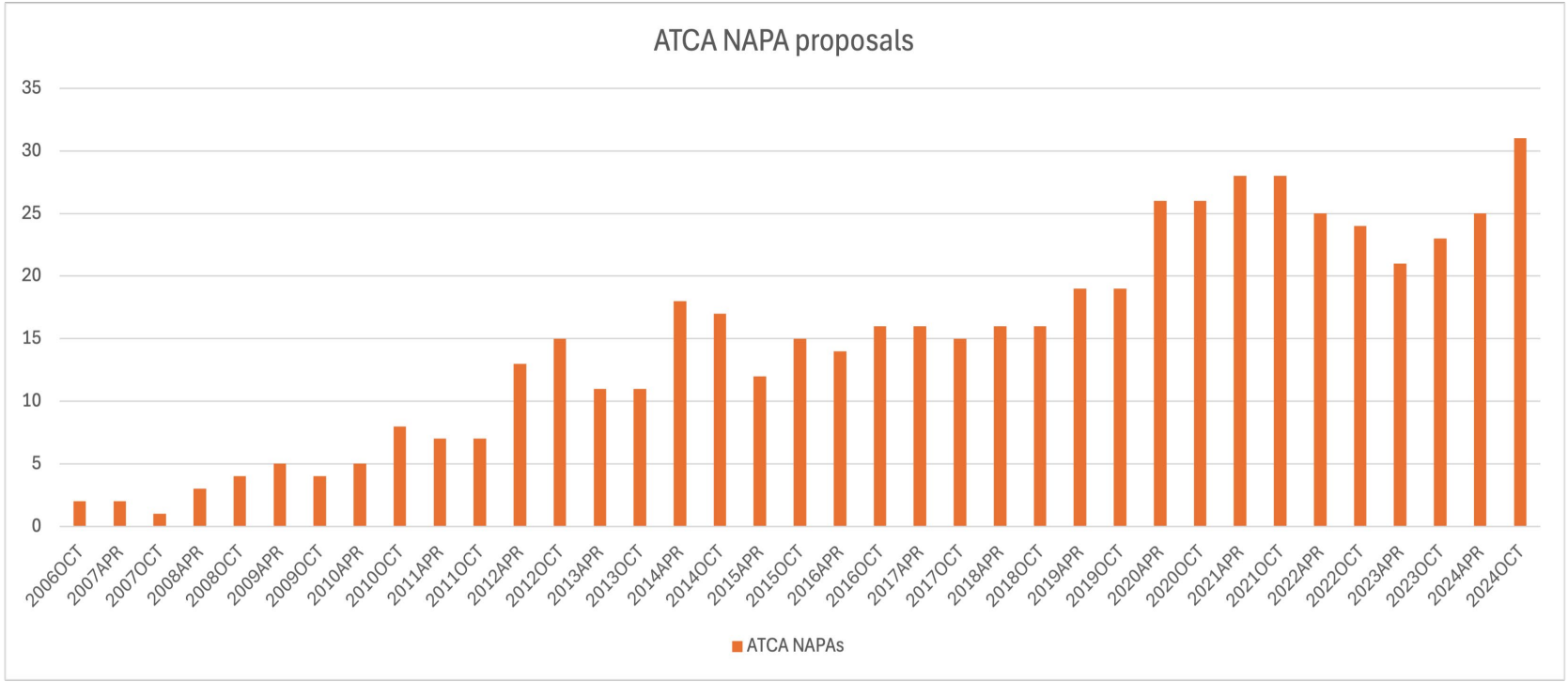


Array configurations

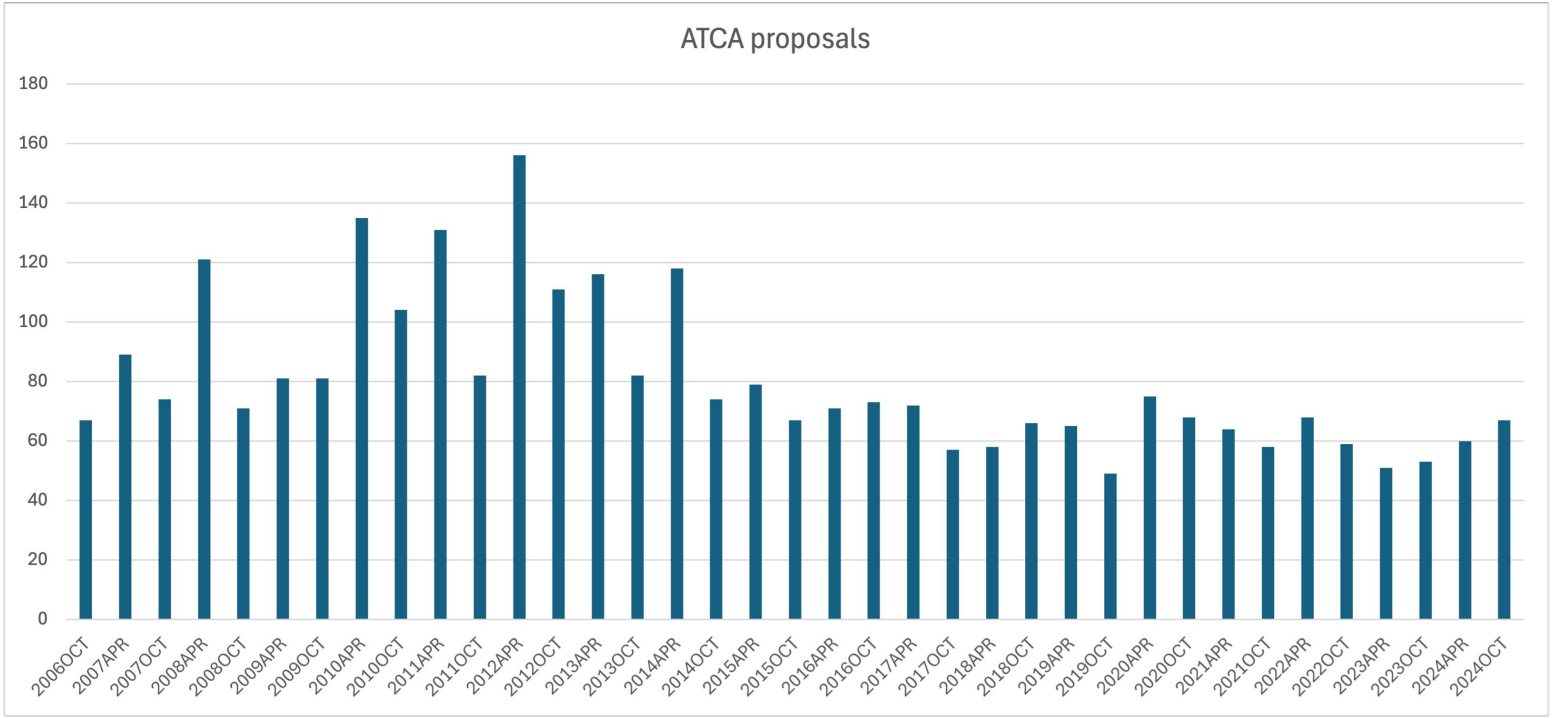




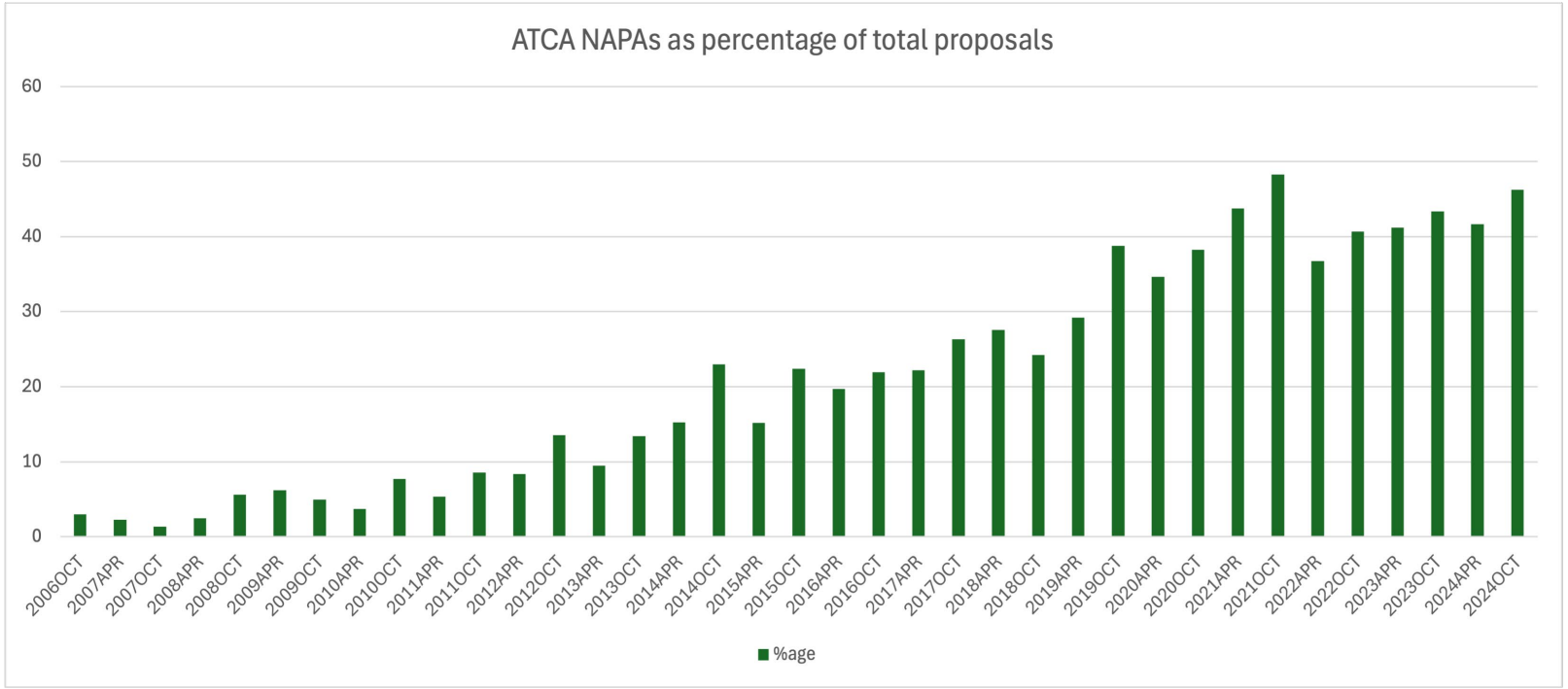
ATCA NAPA proposals



ATCA proposal numbers



ATCA NAPA proposals as percentage



NAPAs can be disruptive to scheduled observations

- With the change in NAPA policy several years ago, a NAPA* can displace any scheduled observation
  - “A reasonable attempt will be made to replace time lost due to override by a NAPA or ToO proposal, or to equipment failure...”
- Not all NAPAs are triggered in each semester
  - Ultimately, ~20% of time used for observing is NAPA/ToO
- Many NAPAs make use of blocks of unscheduled (“green”) time
- Rapid Response triggers are more disruptive
  - There were 9 Rapid Response triggers last semester

Filling the radio transients gap (or: The case for a dedicated radio transients monitoring array in the southern hemisphere)

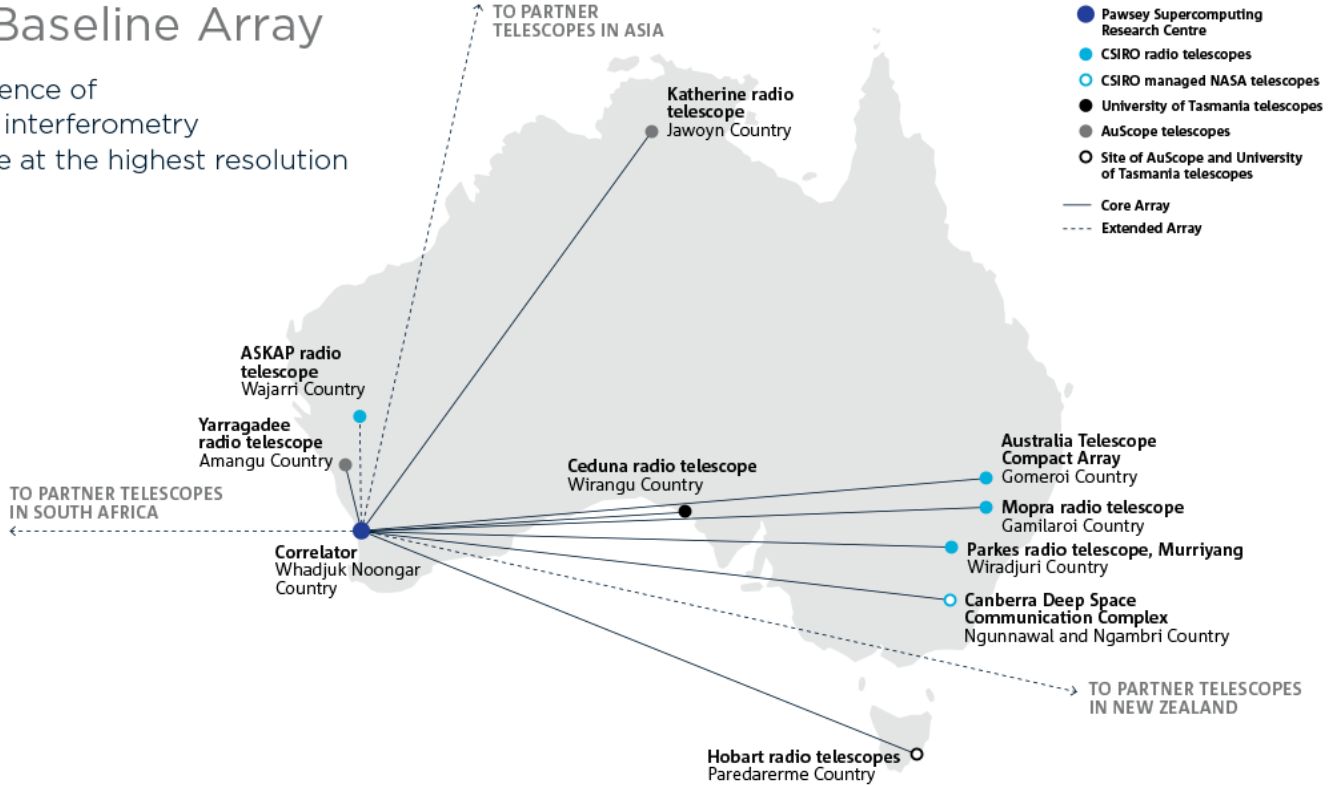
- Fender, Horesh, Charles, Woudt, Miller-Jones, and Bright (arXiv:2402.04698)
- … outline the case for a small radio telescope array in the southern hemisphere with operations dedicated to rapid follow-up and monitoring of astrophysical transients.
- They argue that the science harvest from such a facility would be very large, using AMI-LA as an outstanding example of how such a programme is already being operated in the north with an enormous track record of success.
- A southern radio transients facility would in turn take pressure off the SKA and the other world class larger arrays with 10—100 times more collecting area, which will never have the programme time available to comprehensively pursue this science.

Can we improve this?

- Do not schedule the last ~2 days in any array configuration, in order to make rescheduling displaced or disrupted observations easier?
- Reserve one day per month(?) for a 24-hour run of all current NAPA targets, providing better (u,v) coverage?
- Implement more dynamic scheduling?
- Consider new array configurations to improve (u,v) coverage for shorter observations
- *Feedback from ATUC, and the user community, welcomed!*

The Long Baseline Array

Harnessing the science of
very long baseline interferometry
to see our Universe at the highest resolution



LBA current status and recent activities

- Only one LBA block in 2024APR, and none scheduled yet for 2024OCT, due to CryoPAF and BIGCAT schedules
  - Email to PIs to be sent in November
- Some out-of-session participation in EAVN and EVN observations
- Upcoming trial of ATCA CA06 in a K-band global astrometry run
- Further tests with GMRT planned
- Fringes to a SKAMPI antenna

LBA current status and activities

- New H-masers at Mopra and ATCA
- LBA data are correlated at the Pawsey Supercomputing Research Centre. The median time from observation to data release was 70 days
- LBA data are now archived to CASDA instead of ATOA
- The LBA Science Case is nearing completion... still!
- ATUC has received a proposal for commensal LBA wide-field correlation
  - If the proposal team can contribute resources to the project, it is feasible

Observations 2022/23 vs. 2023/24

Band		Hours 22/23	%age	Hours 23/24	%age
1.5 GHz	(20cm)	93	22%	63	16%
2.3 GHz	(13cm)	58	14%	93	25%
4.8 GHz	(6cm)	19	4%	8	2%
6.7 GHz	(5cm)	8	2%		
8.4 GHz	(3cm)	190	45%	166	44%
22 GHz	(1.5cm)	12	3%	16	4%
86 GHz	(3mm)	45	10%	32	8%
Total hours		425		379	

LBA global participation

- 16th DiFX Users and Developers meeting
  - https://www.vlbi.at/2024/09/24/16th-difx-users-and-developers-meeting-2024/
- 16th European VLBI Network Symposium
  - https://events.mpifr-bonn.mpg.de/indico/event/371/
- 9th International VLBI Technology Workshop (IVTW)
  - https://www.haystack.mit.edu/ivtw2024
- (15th East Asian VLBI Workshop is on this week)
- Global VLBI Alliance
- LBA Science Day this Wednesday!

Recent LBA publications

- TANAMI: Tracking Active Galactic Nuclei with Austral Milliarcsecond Interferometry. III. First-epoch S band images

  Benke et al., 2024, A&A, 681 A69

- First Very Long Baseline Interferometry detection of Fornax A

  Paraschos et al. 2024, A&A, 687, L6

- Swift J1727.8–1613 Has the Largest Resolved Continuous Jet Ever Seen in an X-Ray Binary

  Wood et al., 2024, ApJL, 971, L9

- Discovery of Limb Brightening in the Parsec-scale Jet of NGC 315 through Global Very Long Baseline Interferometry Observations and Its Implications for Jet Models

  Park et al., 2024, ApJL, 973, L45

BIGCAT update

Elizabeth Mahony

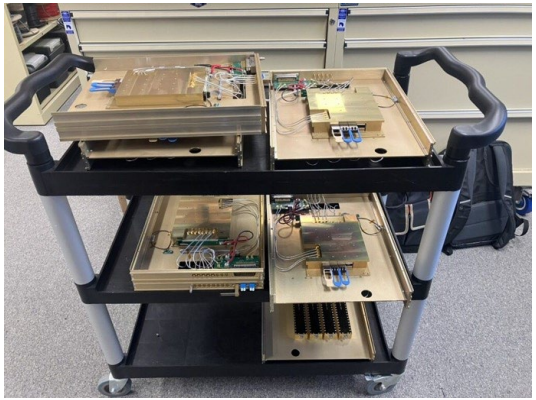
BIGCAT Technical Updates

- First 7 (out of 18) Jimble modules assembled
  - This is enough for CABB replacement (with existing RF modules)
- BIGCAT Jimble firmware testing in lab @ Marsfield
- Ran test using prototype jimbles on 2 antennas @ ATCA on Oct 18
  - Observed 0823-500 at 6 GHz over 2km baseline
- Ran GPU correlator on test data + compared with DIFX (next slide)
- Ingest pipeline + data format progressing
  - Ran into issue loading data into CASA, requiring updates to CASA
- RF upgrade progressing well, manufacturing of new RF modules starting in Jan 2025

Planning for installation + engineering commissioning: Feb – Mar 2025

Science commissioning: Mar – April 2025

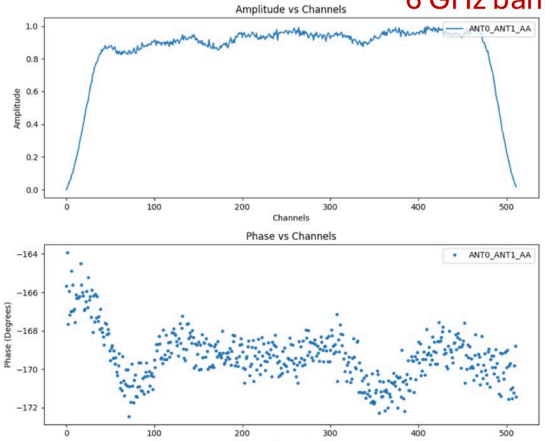
BIGCAT available from 2025APRS (standard observing modes, 2x2 GHz bandwidth)

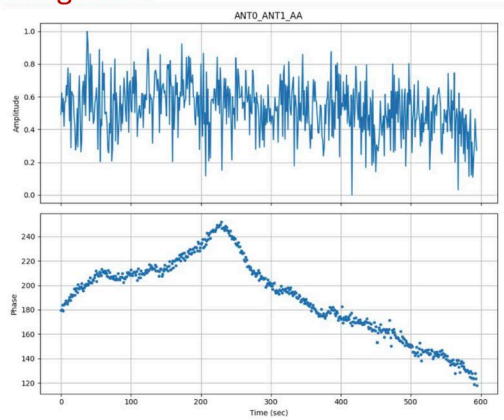


BIGCAT Technical Updates

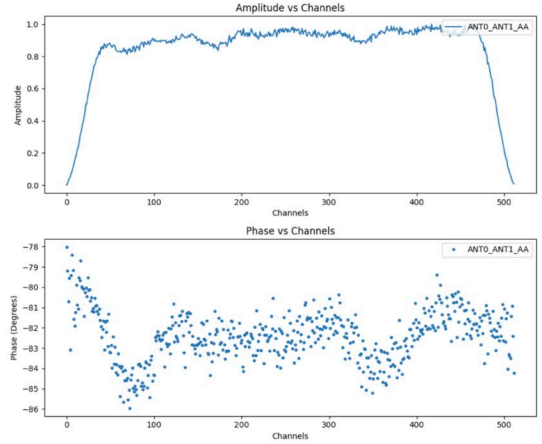
6 GHz band, ~10 min integration

DIFX





GPU



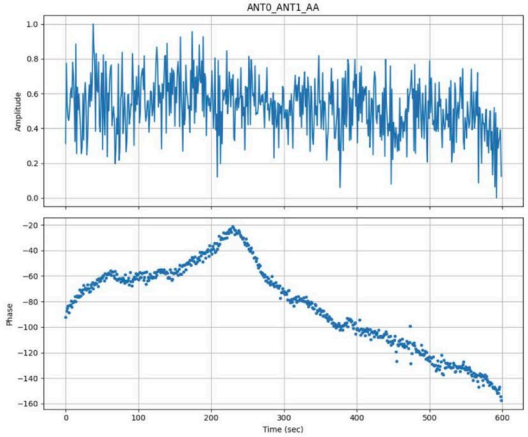
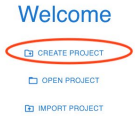
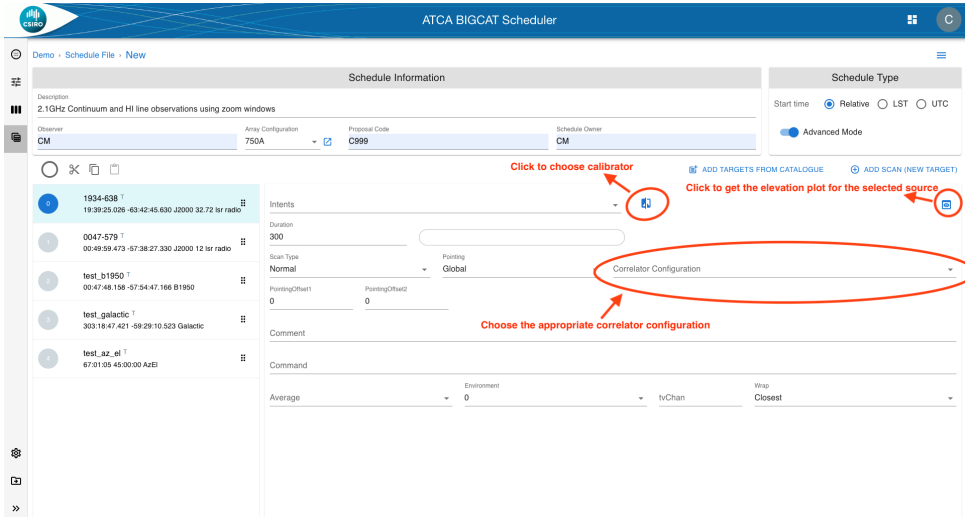


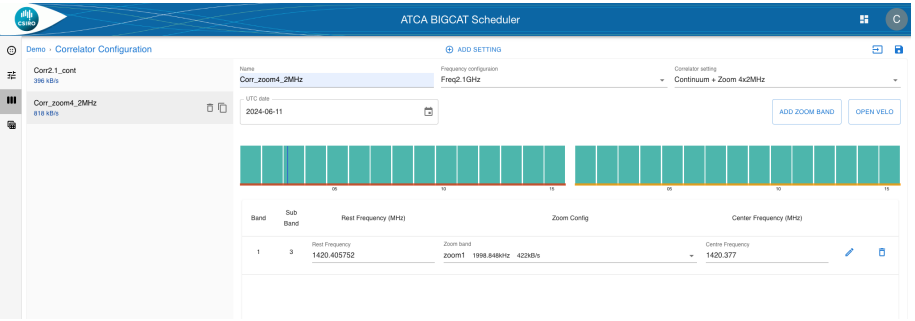
Image credit:
Chandra Murugeshan

The BIGCAT user experience - scheduler

- New BIGCAT scheduler
  - Web-based
  - linked to OPAL accounts to enable team sharing
  - Has simulator attached







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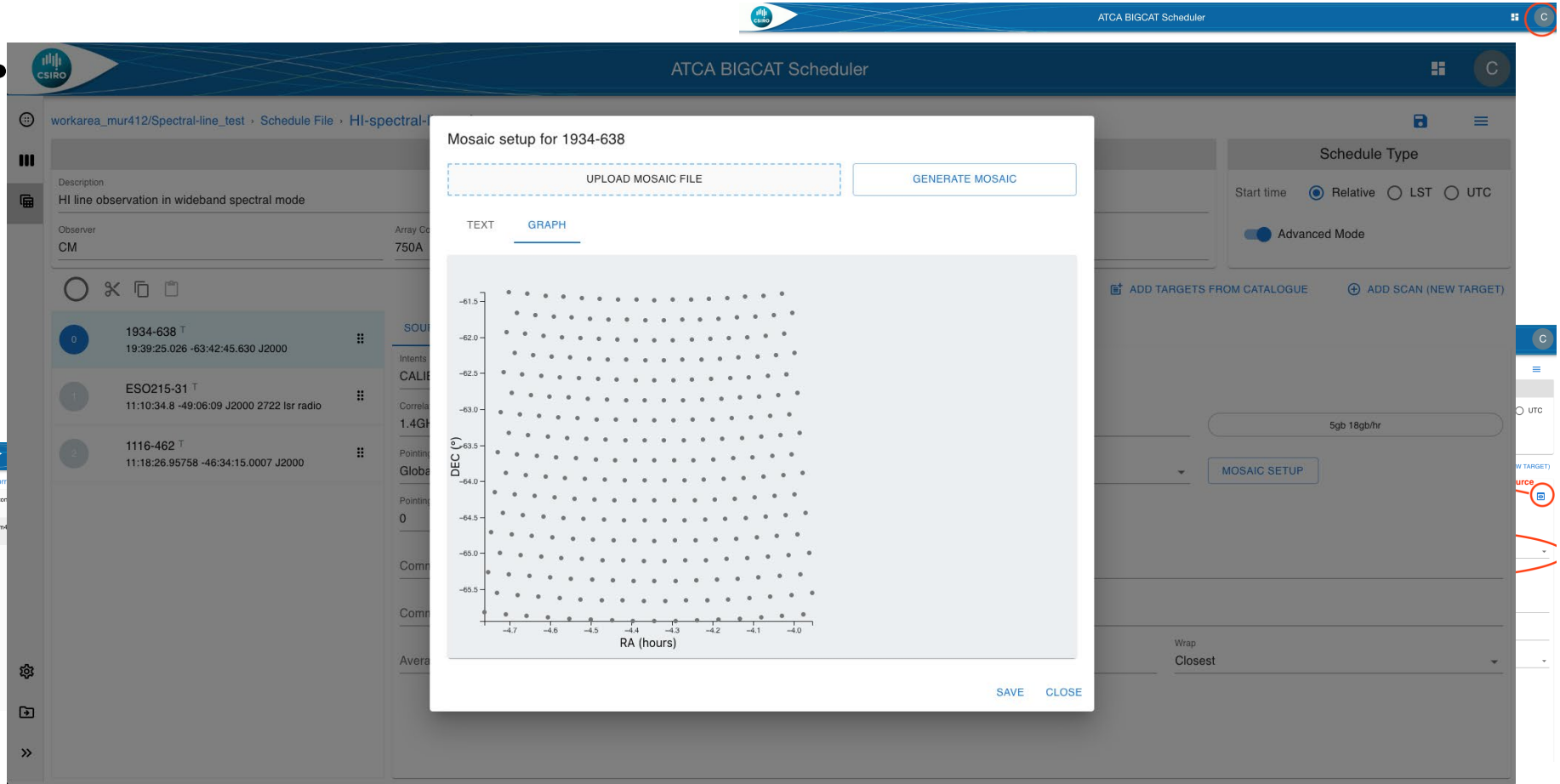

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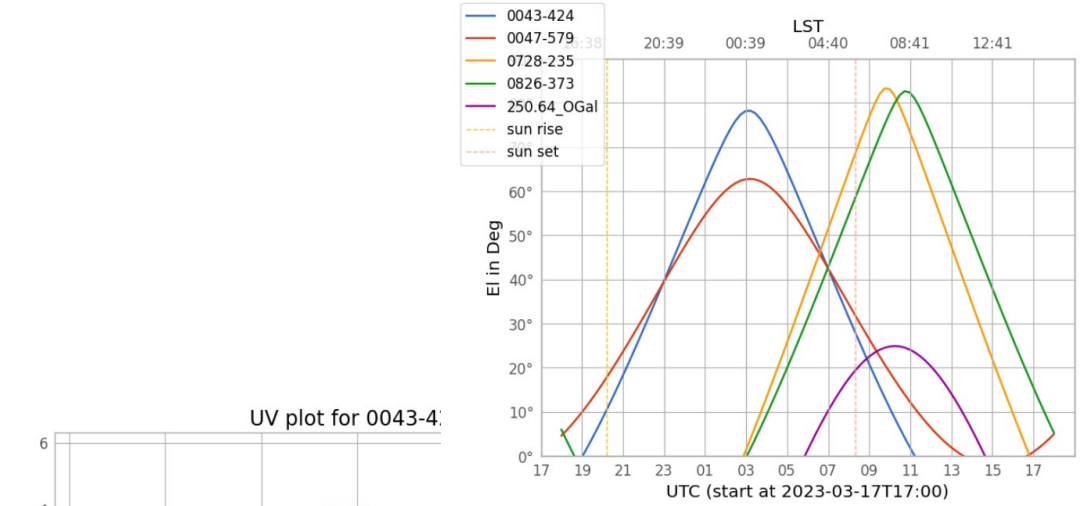
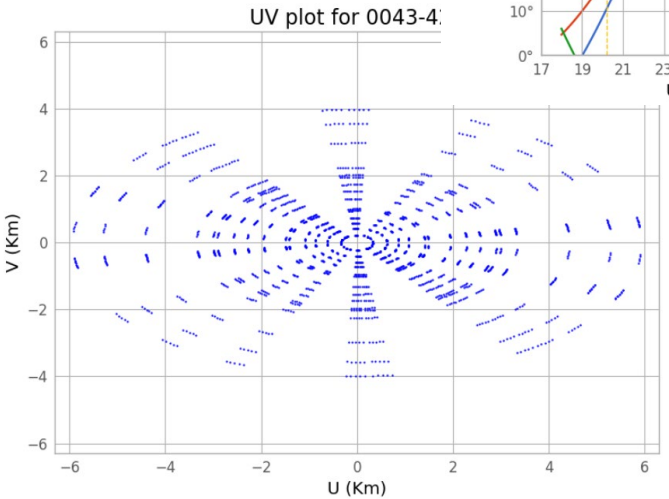
- New BIGCAT simulator
  - Linked to scheduler to allow users to model u,v coverage, observability etc.
    - Will also include ability to do model image according to array config, psf etc. (currently in development)





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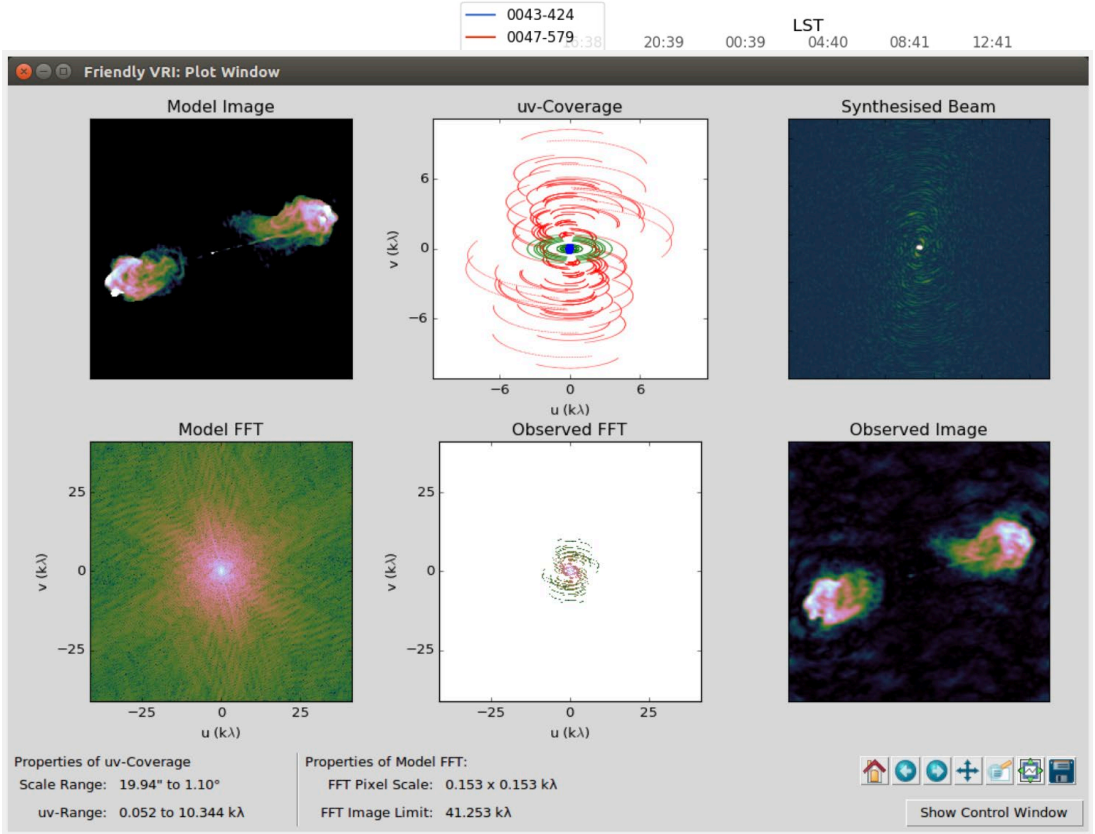

Image: friendlyVRI, https://crpurcell.github.io/friendlyVRI/

The BIGCAT user experience - caobs

- New CAOBS
  - Will look very familiar, designed to be similar to current CAOBS, but easier to update + automate
- Data + archive
  - ASDM file format
  - Will use casa task to convert to fits for miriad compatibility
  - Data archived in CASDA

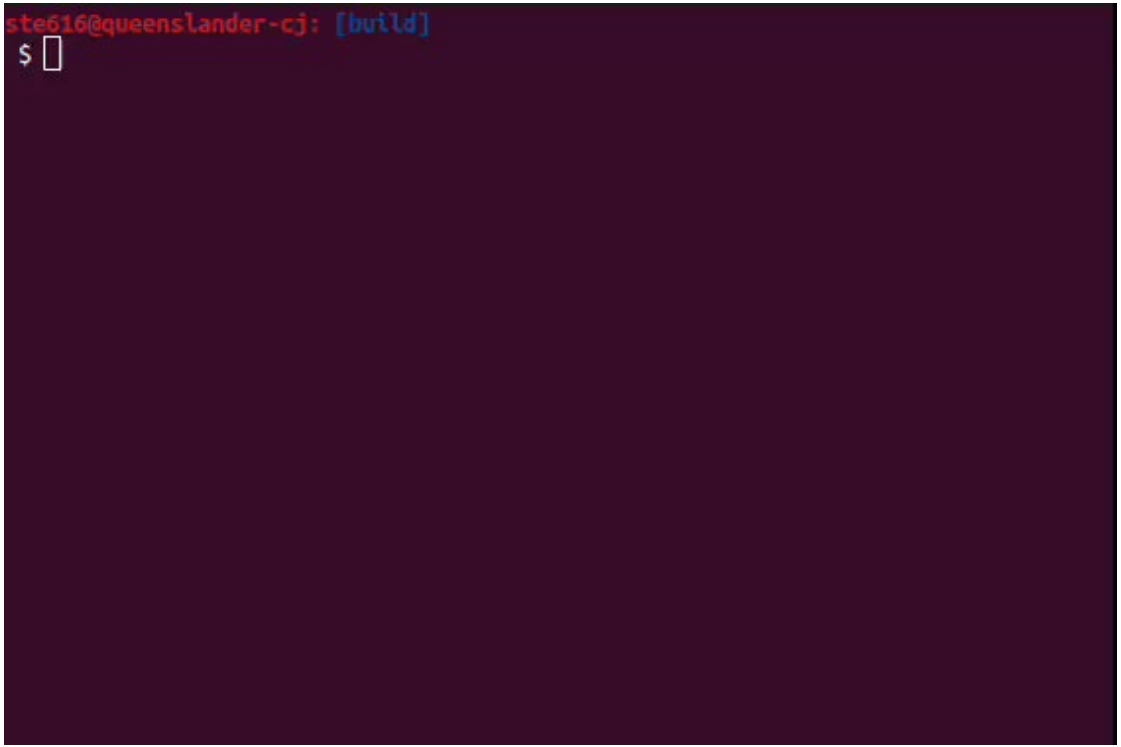

Image credit: Jamie Stevens

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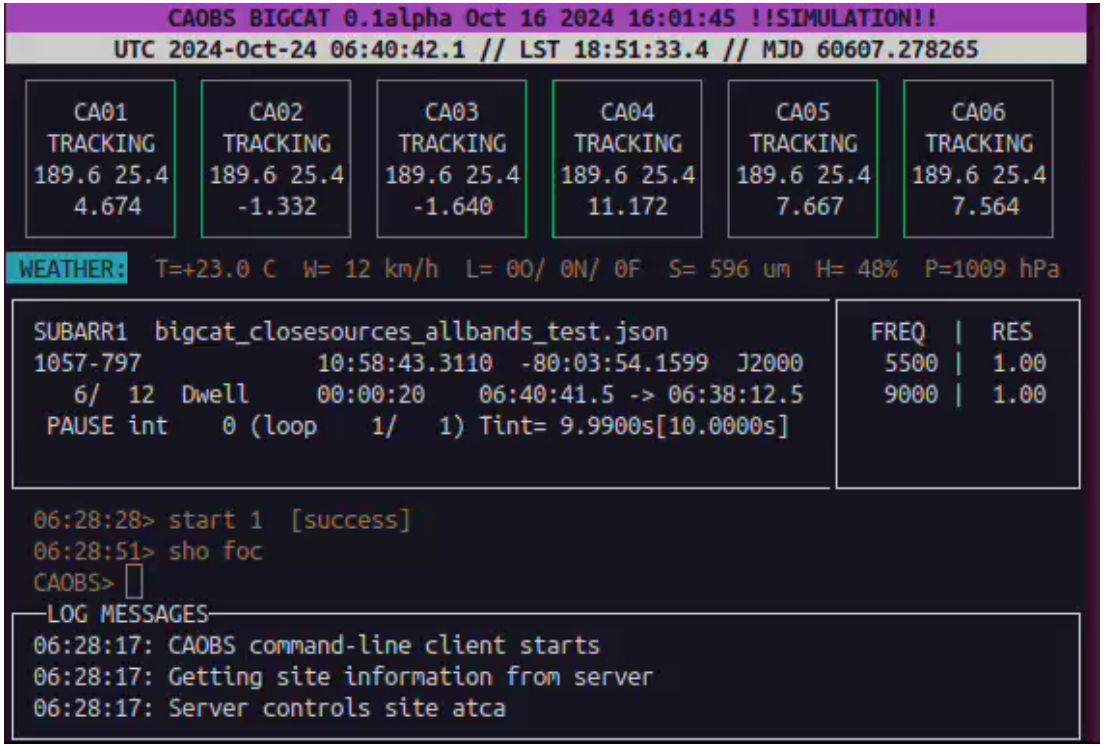


Image credit: Jamie Stevens

BIGCAT Spectral line modes

Name	Points over 152 MHz	Points over 128 MHz	Spec. Resolution (kHz)	Vel. Res at 1.4 GHz (km/s)	Vel. Res at 40 GHz (km/s)	Zoom Bands	Zoom Bands Specification
Continuum	152	128	1000	~211	~7.5	NA	NA
Spectral – 74kHz	2048	1728	74	~16	~0.6	NA	NA
Spectral – 37kHz	4096	3456	~37	~8	~0.28	NA	NA
Spectral – 18.5kHz	8192	6912	18.5	~4	~0.14	NA	NA
Spectral – 9kHz	16384	13824	~9.2	~2	~0.07	NA	NA
Continuum + Zoom 4 x 2MHz_0.5kHz		128	1000			4	Points: 4096 Spec. Res.: 0.5 kHz; Vel. Res: 0.1 km/s (at 1.4 GHz) or 0.004 km/s (at 40 GHz) Band Width: ~2 MHz per zoom
Spectral + Zoom 4 x 4MHz_0.24kHz		1728	74			4	Points: 16384 Spec. Res.: 0.24 kHz; Vel. Res: 0.05 km/s (at 1.4 GHz) or 0.0018 km/s (at 40 GHz) Band Width: 4 MHz per zoom
Continuum + Zoom 4 x 2MHz_0.06kHz		128	1000			4	Points: 32768 Spec. Res.: 0.06 kHz; Vel. Res: 0.013 km/s (at 1.4 GHz) or 0.00045 km/s (at 40 GHz) Band Width: 2 MHz (per zoom)

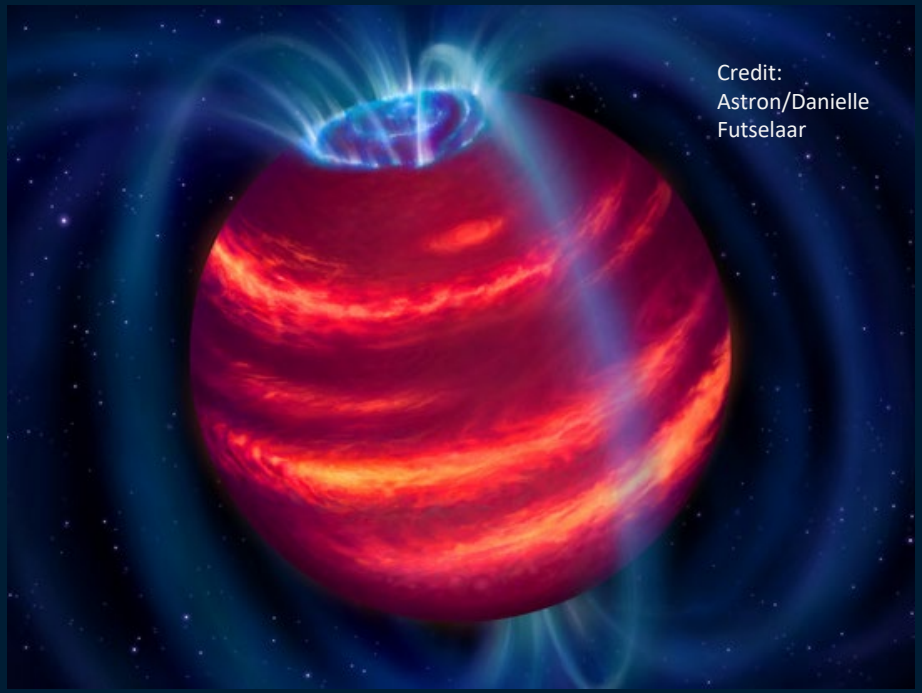
Question for users: Are there any other configurations that you would like to see as a "default/recommended" option?

Using BIGCAT to study wideband properties of radio pulses from brown dwarfs

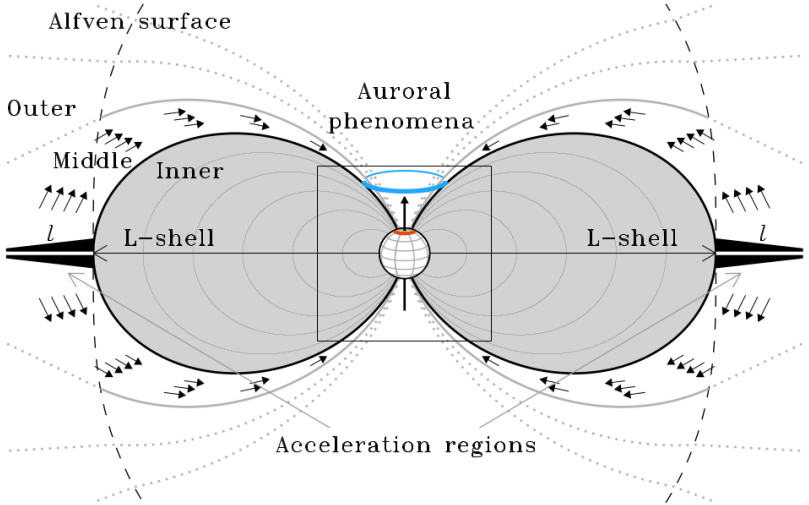
Barnali Das

Brown dwarfs are fascinating objects!!!

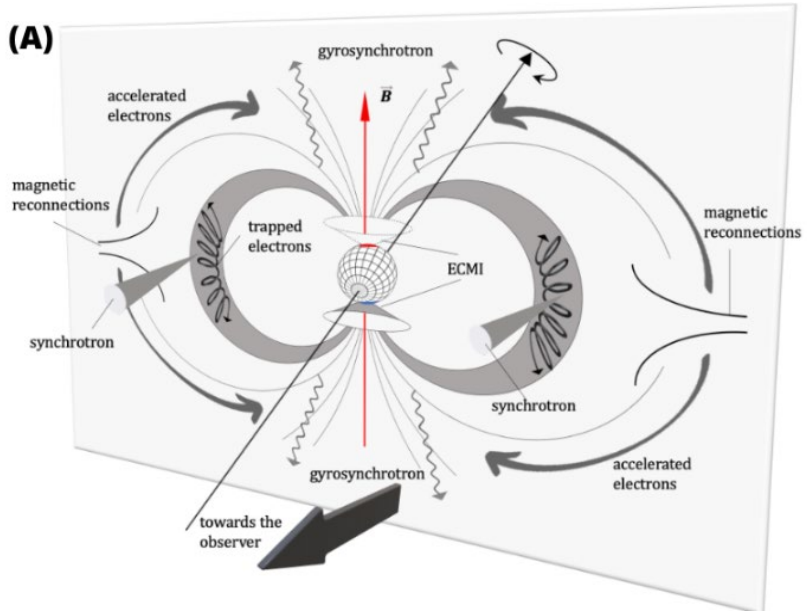
- Connect stars and planets, harbour large-scale, ~kG strength magnetic fields
- Produce periodic radio pulses, different frequencies probe different parts of the magnetosphere.



Their magnetospheres are very similar to that of magnetic hot stars, especially in radio!!!



(Leto et al. 2021)



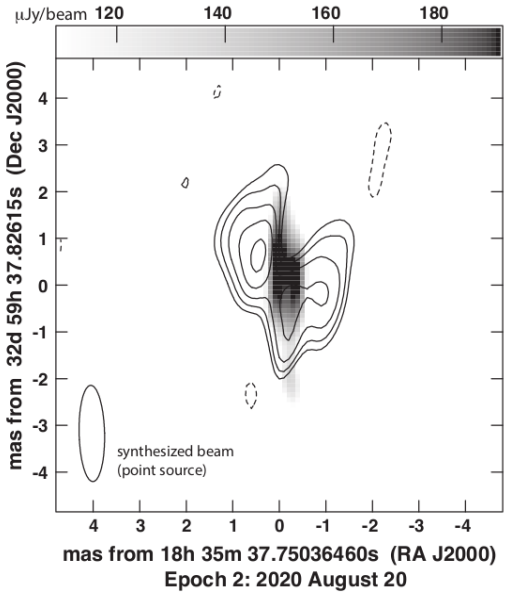
(Climent et al. 2023)

BIGCAT 4-12 GHz will be extremely suitable for that!!!

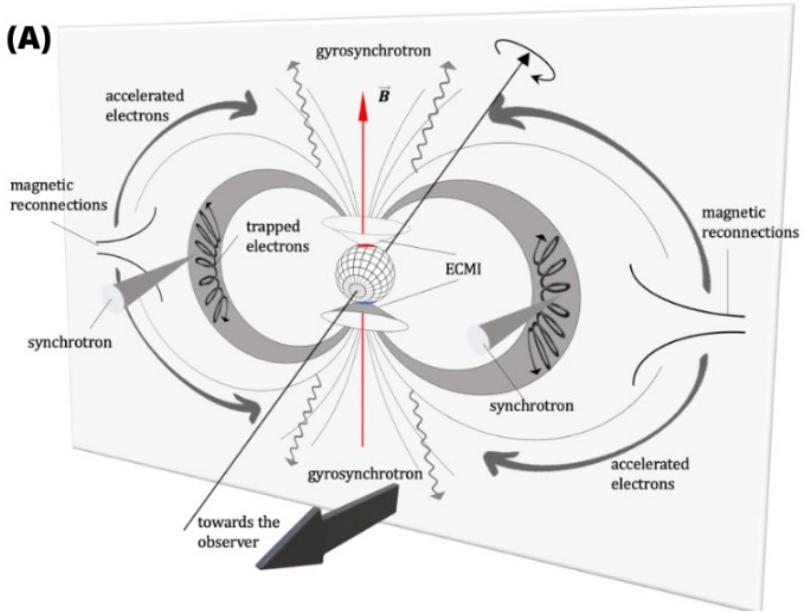
- Could provide us a way to estimate plasma density, and even plasma distribution in BD's magnetosphere
- Valuable inputs for developing theories of how magnetospheres form and operate in these objects.

EXTRA SLIDES (BD)

(BD) Radio is the best probe to study them



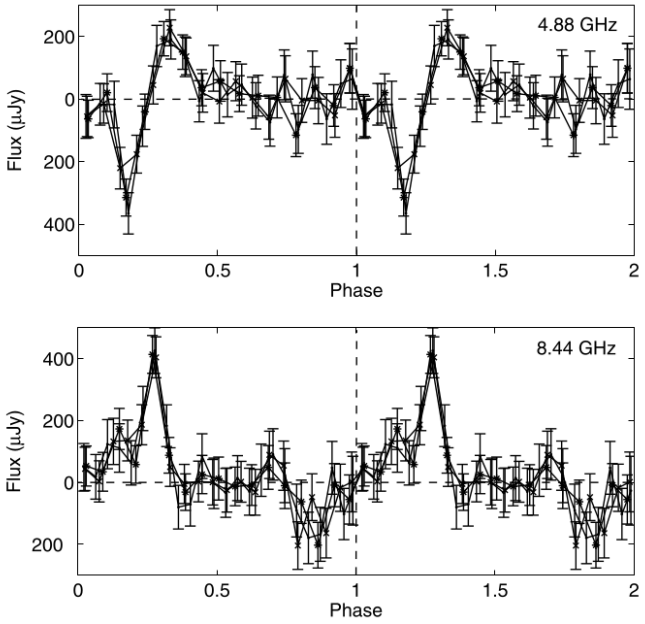
(Kao et al. 2023)



(Climent et al. 2023)

What is that strategy?

- BDs emit 'periodic' radio pulses just like the hot stars.
- We can extract information on magnetospheric plasma density by modelling the lags between the arrival times of radio pulses over a wide range of frequencies
- Requirement: Wideband, simultaneous radio data



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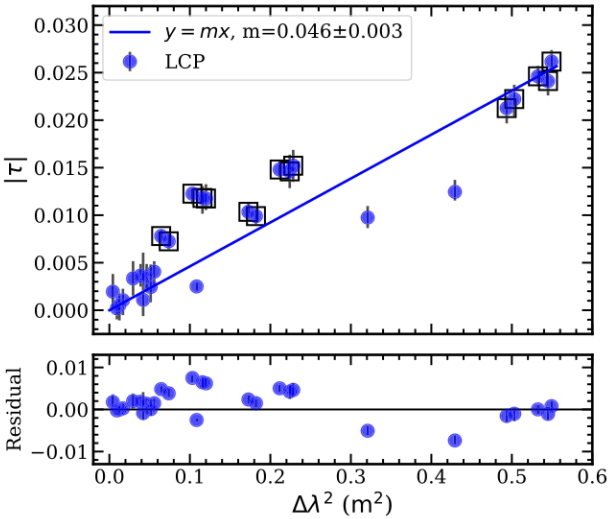

(Das et al. 2024)