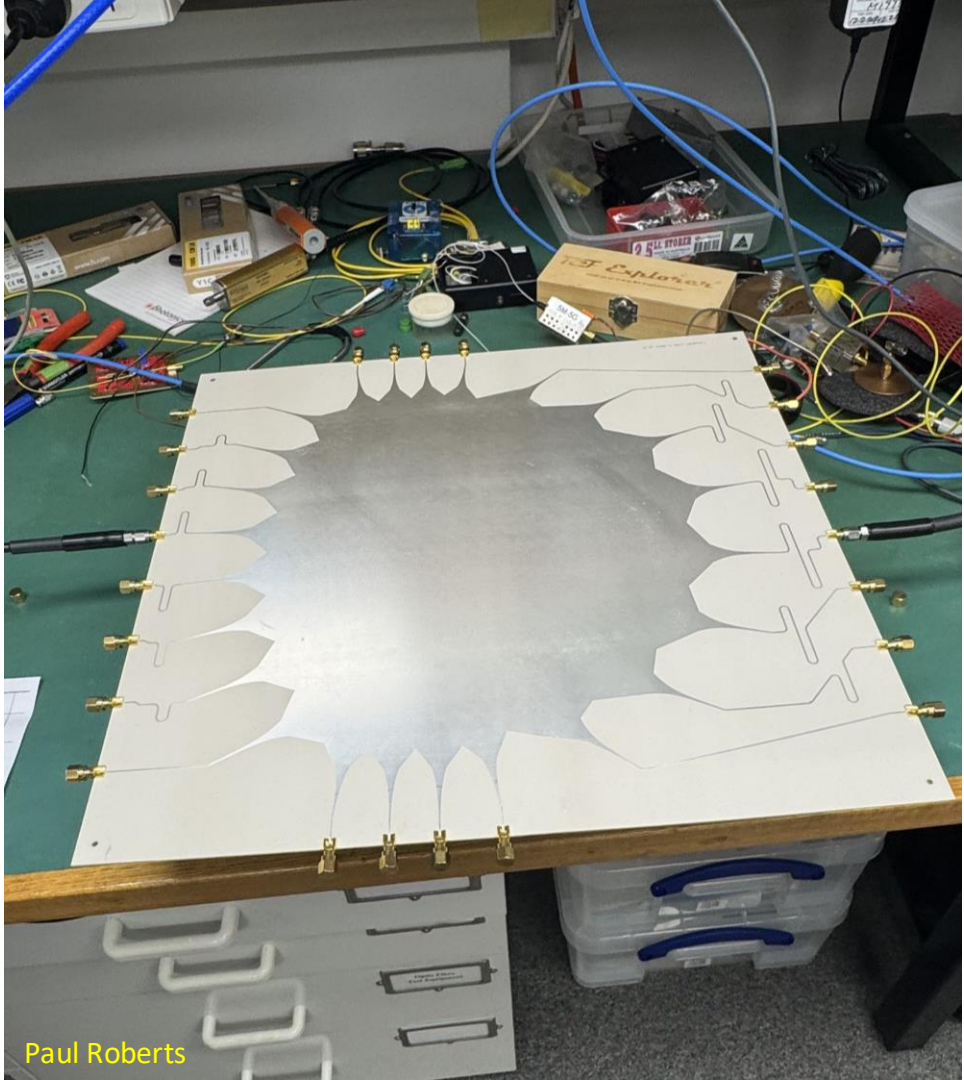
ATUC: Session 5 From now to the future

ATUC meeting
9 April 2025



ATNF Science: next 6-months for our observatories

George Hobbs

(10 minutes)

April 2025 proposal statistics

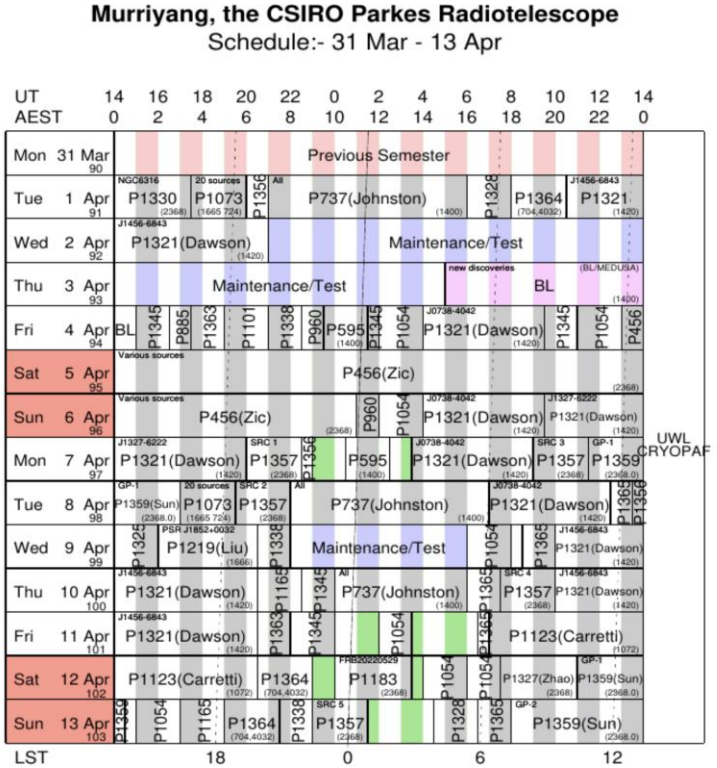
	ATCA	Murriyang	LBA	ASKAP
Number of proposals	84	56	19	11
Percentage of NAPA proposals	48%	16%	21%	18%
Over-subscription	3.1	1.7	1.9	2.9
Available schedulable time (90% efficiency)	1945 hr	2078 hr	259 hr	150 hr

Statistics from Jamie Stevens, Jane Kaczmarek, Phil Edwards, Aidan Hotan, Shinji Horiuchi

Scientific schedules for April 2025 semester

Murriyang:

- The schedule for entire semester will be released in stages because of cryoPAF commissioning and spacecraft tracking
- The schedule for April/May has already been released
- Large shutdown between 12th May to 16th June
- Schedule after that shutdown is still to be released. Complicated because of cryoPAF commissioning and the required vacuum regeneration approximately 2 days in 3 to 4 weeks



Scientific schedules for April 2025 semester

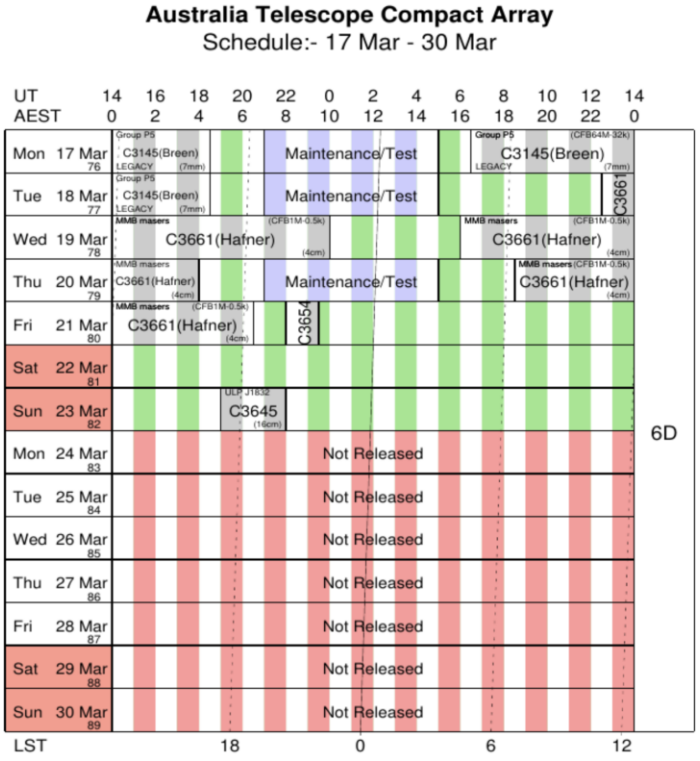
Murriyang schedule going to be very tight for the rest of the semester

- **Comment to ATUC**: later in the semester, large, long-term projects with high grades + purchased time projects get the majority of the Galactic time and hence hard for new projects (such as PAF projects) to get a look in.
  - Need some nuance in scheduling – not purely based on scientific grade. Should we do this informally, or formally (weighted metrics)?
- **Comment to ATUC**: our users keep getting shuffled because of Space craft tracking and hard to predict when and hard to provide make-up time.
- **Comment to all**: the schedule after the shut-down will be very uncertain this semester

Scientific schedules for April 2025 semester

ATCA:

- Currently no schedule for the April 2025 semester.
- Waiting for BIGCAT commissioning
- ATCA schedule will be released when science commissioning deemed complete
    - Working towards the schedule being announced by June
- Currently no tied-array LBA mode, but planned



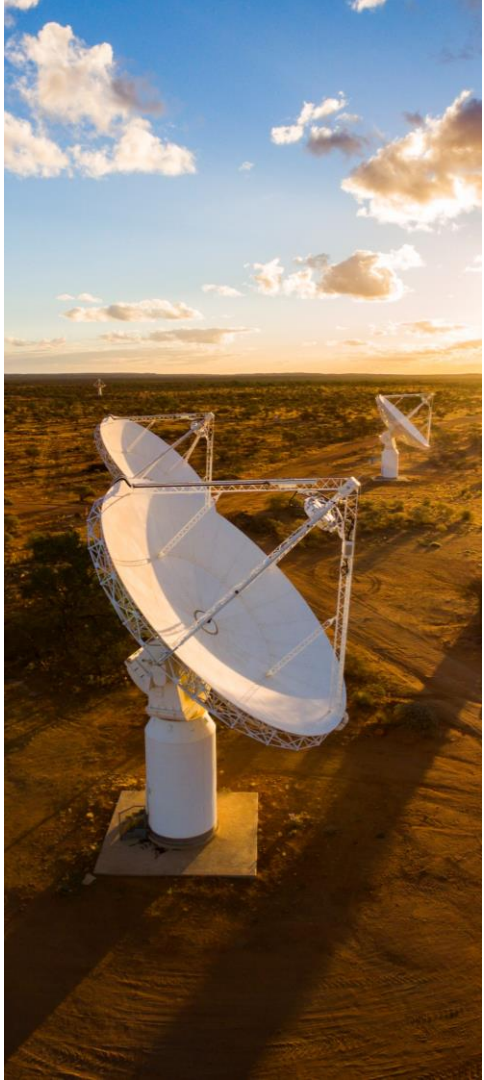
Scientific schedules for April 2025 semester

LBA:

- Two LBA sessions have been suggested in the April 2025 semester
  - One in July and one in September (roughly two weeks each)
    - Note: dates still in discussion, noting shut-downs etc.
  - For Murriyang, not clear whether both require the high-frequency receivers or not
    - If they do, then will need to schedule in a receiver change (UWL likely, but not definitely, would come out; much harder to remove the CryoPAF).

ASKAP:

- Vanessa already presented on ASKAP survey completion and forecasting
- Will seek feedback from the ATNF Steering Committee in May on this topic.



Key performance indicators

- We have KPIs for amount of time on-sky versus maintenance and downtime.
- Can we measure a statistic more directly linked to **user satisfaction**?
  - i.e., if CryoPAF (or ASKAP, or ATCA) requires a large amount of on-sky time for calibration then KPI = good and the system will work well, but user satisfaction may not be high.
  - How to measure/track this?
  - If all time calibrating/beamforming => no science. But this is necessary to get any science outputs!
  - Perhaps “fraction of available time that directly corresponds to an archived data file”?
    - Sum T_obs over files in archive / totalTime
- Would be useful to receive ATUC advice on this topic.

Operations updates for our observatories

Daleen Koch

(10 minutes)

ATCA - General

People
- New starter – Kannan Krishan as electronics tech
- Retirement due – Chris Wilson after 35 years
- Three unfilled vacancies (electrical, electronic, mechanical)

Safety
- Localised flooding w/s 31 March (credit: Christoph Brem)

Reliability
- Station power:
  - Critical transformer experienced catastrophic failure.
  - 12 of 44 stations without power, workarounds in place.
  - Long term remediation plan ongoing.
- New masers installed – 1x Mopra, 2x ATCA, ~10 years uninterrupted


ATCA – Next 6 months

Power upgrades (CBIS)

- Operations staff working to improve station availability to 39/44.
- Replacement transformers delivery Aug 2025, installation timeline uncertain.
- Seven transformer replacements completed, enabling bypass options to minimise interruption to astronomy user time. Four still to go with one high risk unit to be prioritised.

ATCA Infrastructure project

- Azimuth & elevation drives, air conditioner replacements ongoing 2025/26.
- Incremental preparation activities in predefined maintenance weeks up to Sep 2025.
- Major works shutdown 8 weeks (Sep/Oct 2025).

BIGCAT integration

- Phase 2 planning same time as ATCA Infrastructure upgrades.

Murriyang – General

People

- Critically low staffing levels – may affect responsiveness and time to repair.
- Parkes Observatory Manager vacancy in progress, two other unfilled.

Safety

- Implementation from Height Safety Audit to progress.

Reliability

- CryoPAF potentially require a vacuum regen cycle every ~4 weeks for 48 hours. Potential user impact is two day of astronomy time per month until issue is resolved.

Murriyang – Next 6 months

Activities for this semester:

- Zenith gearbox refurbishment - 12 May to 16 Jun 2025.
- Potential CryoPAF remediation works under discussion - (mid to late June)
- Maser installation - Jul 2025.

Lookahead for 2025/26:

Zenith brake upgrade

- Planning started to install a new hydraulic brake system, for controlled auto stow function in the event of a complete power loss (age & safety driven).
- Preliminary design in progress.
- Planned parallel installation with existing system as part of performance testing.

ASKAP & BAF – General

People
- BAF staff now on ongoing contracts.
- One vacancy for ASKAP electrician.

Safety
- Duress alarm installed.
- Tender for Boolardy airstrip upgrades on AusTender.
- Fire system upgrades.

Reliability
- Drive replacement ongoing ~87% completed.
- Drive cabinet rearrangement for improved cooling in progress.

ASKAP – Next 6 months

Maintenance approach for new users

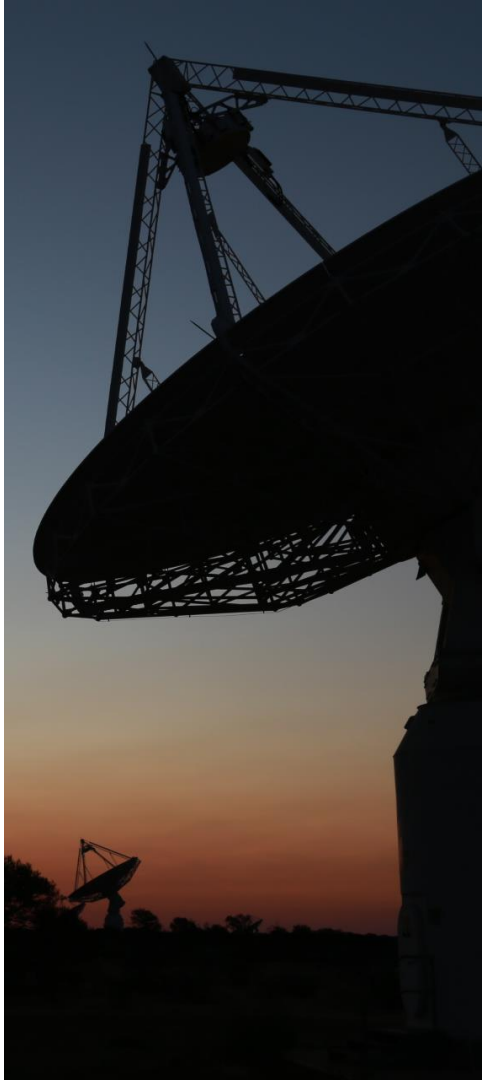
- Different approach to scheduling and performing maintenance to match automated scheduling model.
- Allocate one to three antennas at a time (n-1,-2,-3).

End May 2025:

- Five day shut for fire system upgrades.
- Shut to include opportunistic preventative maintenance, including HV and LV.

Lookahead for 2025/26, as schedule allows:

- Controlled Environment Vaults (CEVs) (telecoms repeater) installation at Boolardy expected ~June.
- Drive replacement program ongoing for remaining 13%.
- Dish panel upgrades as staffing and opportunities allow.



Space Tracking Update

Parkes Observatory

- Murriyang used for NASA missions since inception.
- Additional new segment to focus on commercial tracking, for missions that may not always carry scientific payloads.
- Supported both IM-1, IM-2, currently supporting CHIMERA GEO 1, often at short notice – thanks all for your cooperation!
- Commercial-in-confidence.

Mopra

- More schedule capacity.
- Ongoing support opportunities getting explored.

*"**Immensely grateful** to the science community and CSIRO for understanding and helping bring a spacecraft back home!"*

- EPIC Aerospace

Space tracking update

- Thanks for your patience with short notice tracking requests.
- Paid time on Murriyang and other facilities supports merit-based astronomy
- Policy development in progress to deal with tracking requests for both long and short notice.
- ATNF open for paid external science opportunities as well as opportunistic tracking support (Daleen / George)

Technologies for ATNF of the future

Keith Bannister

(5 minutes)

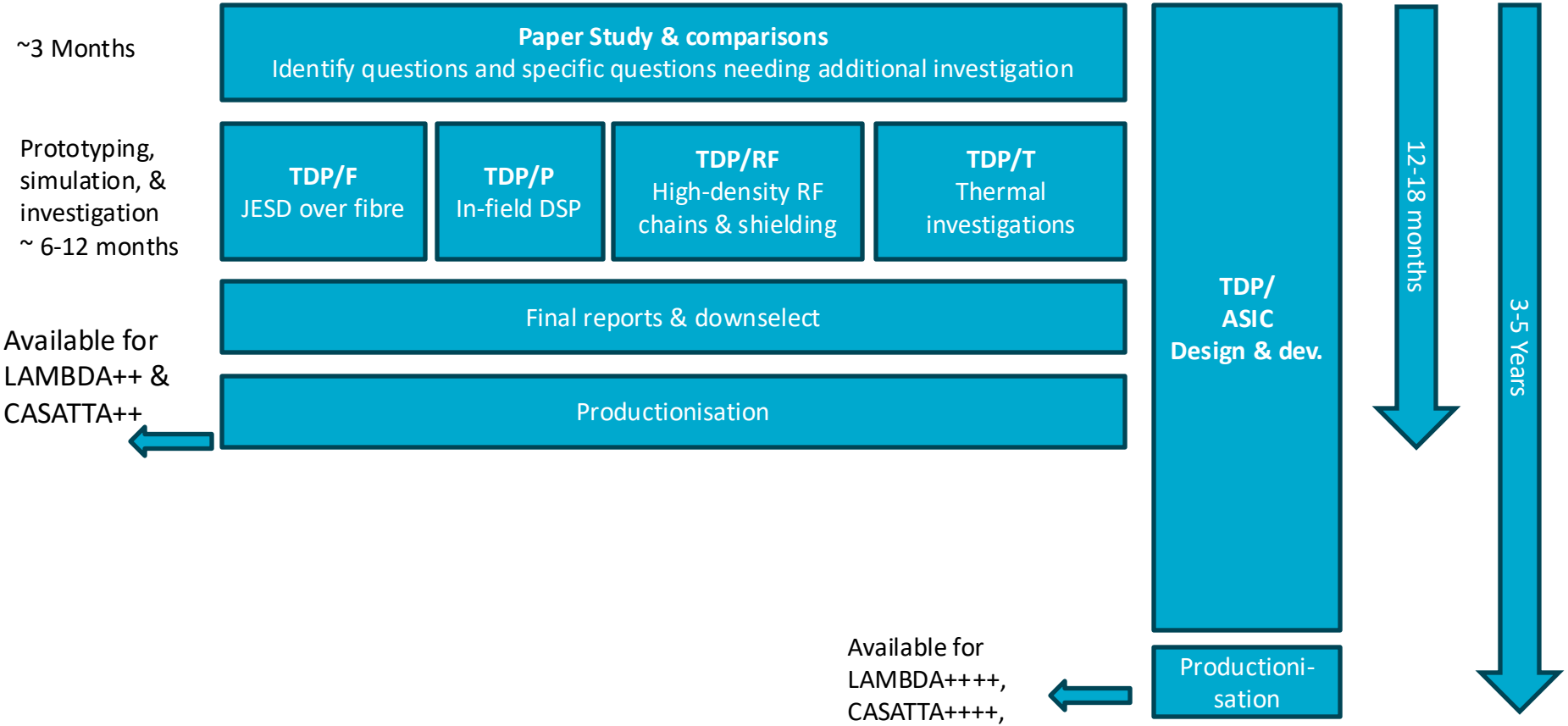
Technology development context

- ATNF receivers, e.g. Ultra wide-band and phased-array feed technologies are mature.
  - New receivers (e.g. ASKAP upgrade) address incremental changes rather than fundamental leaps in technology
- Digital signal processing will be done increasingly on commodity hardware (CPU / NVIDIA GPU / Xilinx FPGA)
- RFI will continue to worsen
- The challenge question: What technologies should we invest in *now* that will pay off in *5 years time*?
  - E.g. SKA-low/mid are operational, DSA-2000 operational, ALMA is post-mid-life, ASKAP upgraded, ngVLA under construction, SKA2 in planning / design.
- Unaddressed niche: Massive mid-frequency aperture arrays.

Technology R&D streams

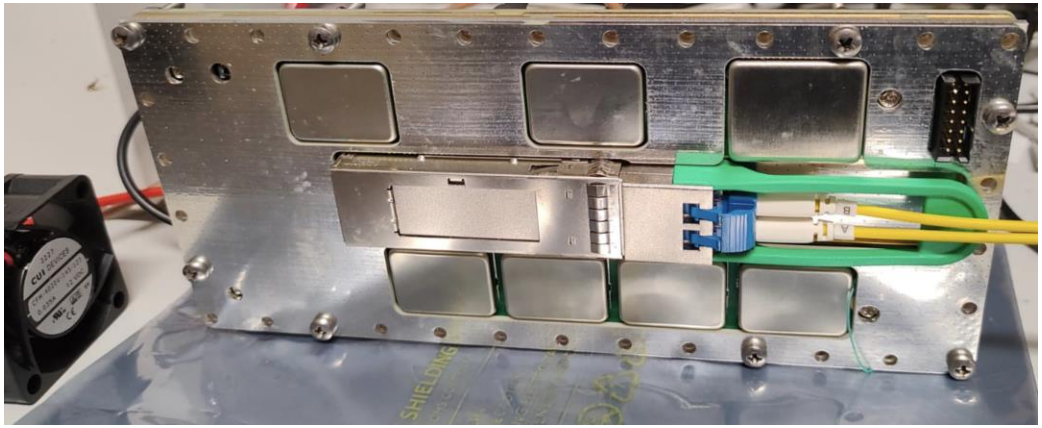
- **Short term (18-months):** Field-deployable ~gigasample digitisers & array processors for low- and mid-frequency aperture arrays. Clever packaging of off-the-shelf parts. Target: LAMBDA, SKA-Low, CASATTA, SKA2, (ASKAP).
- **Long term (3-5 years):**
  - Custom chips (ASICs) for radio astronomy.
  - Novel materials & methods for RA signal processing. E.g. analog, electro-optical, electro-acoustic … electro-X.
- **Rapid investigations**: Engineer-led, 3-month investigation projects to open new lines of inquiry. Software / firmware / hardware / algorithms. (e.g. stimulated bBruillon scattering for RFI mitigation,
- **Demonstration projects**: Small instruments deployed to test technologies or address niche science questions (e.g. GINAN or prototypes for LAMBDA / CASATTA).

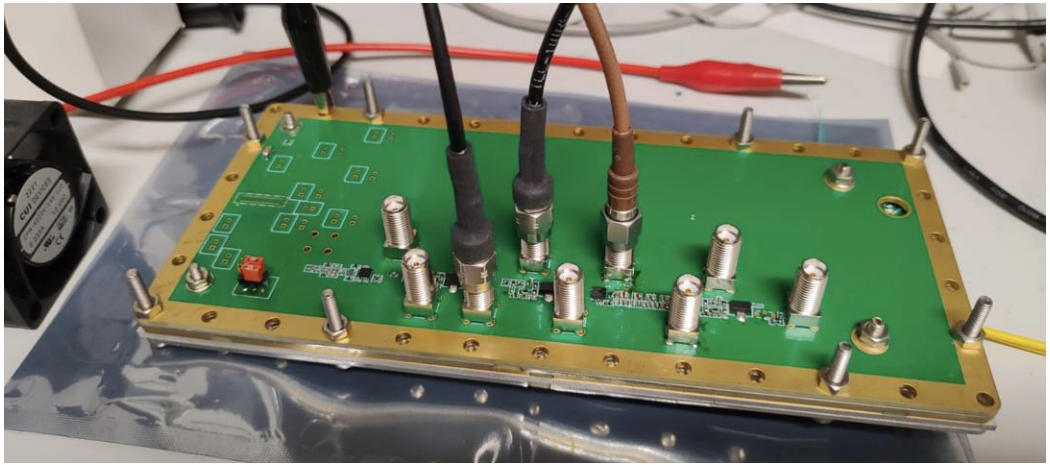
Digitizer Technology development plan



Recent progress

- Prototype: 4 channel, 14bit digitizer (LAMBDA)
- Prototype: 8 channel, 8 bit digitizer (CASATTA)
- Starting a new collaboration with ASIC designers (this morning)





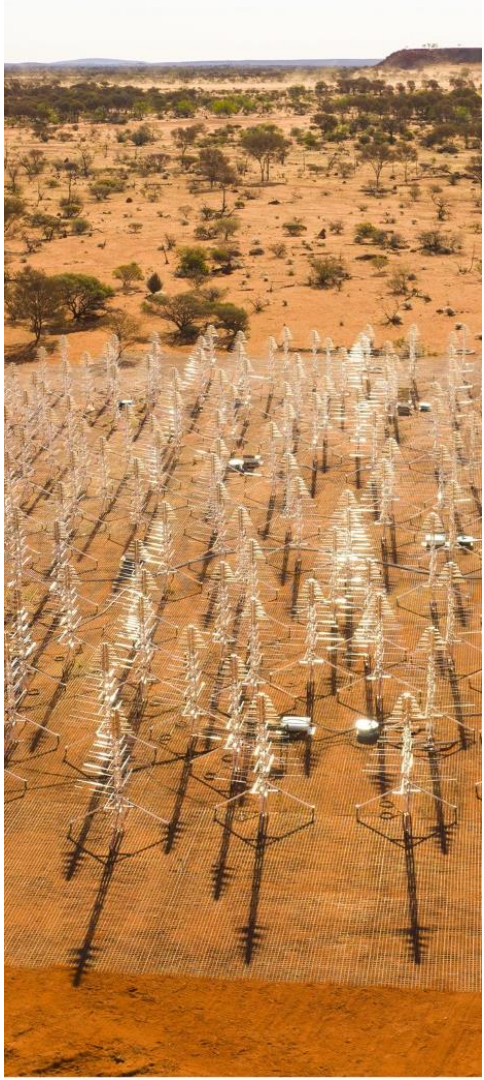
Status of the LAMBDA project

Tessa Vernstrom

(5 minutes)

LAMBDA – Low-frequency Australian Megametre Baseline Demonstrator Array

- Goal: Demonstrate Feasibility of Long Baseline Science with SKA-Low
- Provide evidence and motivation for SKAO to extend their baselines in next phase
- Low frequency antennas - SKALA
  - 256 dual polarisation antennas
  - SKA-Low frequency range 50-350MHz
  - Locate at existing LBA observatories (or CSIRO sites)
- Saves on site costs (power, network etc)
- Extend with new stations near existing networks and internationally
- Develop new backend – testbed for future SKA-Low upgrades
- Allows for commissioning of SKA-Low VLBI mode



LAMBDA – Low-frequency Australian Megametre Baseline Demonstrator Array

- 36 SKALA in Narrabri
  - Start small subset of full station to test and demonstrate the backend
- Mesh and cabling to be laid soon (weather, and snakes, permitting) -delivery Mesh April 29
- 4-6 months to get antennas on the ground with a backend
- Optimisation can proceed after
- Possible to get baseline with subset of SKA-Low
- Work towards building out from there


Narrabri LAMBDA Station
Narrabri
Legend
Clearance Cricle >=45m dia
Existing Narrabri Conduit (~450m)
Lambda Ground Plane 42m dia
New Array Conduit (power & fibre) (~12m)
New Fibre Conduit Path (~180m)
Google Earth
Image © 2025 Airbus
200 m
N

LAMBDA – Low-frequency Australian Megametre Baseline Demonstrator Array

- Receiver
  - ADC Enclosure is fully assembled with the ADC and RF boards
  - Going to run shielding tests shortly
- Filter
  - In the process of being assembled
  - Firmware written to control the Receiver functionality (gain, ADC, LNA)
  - Firmware written implement 781kHz filterbank and packetiser

ASKAP PAF

Aidan Hotan

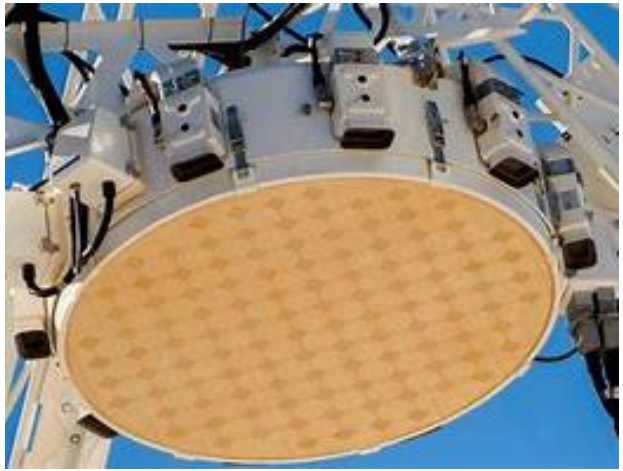
(5 minutes)

ASKAP Mk III PAF Prototype

- Primary objective: design and construct a prototype PAF to demonstrate a sensitivity improvement by a factor of 2 to 3 over the existing model
- Approved by Project Review Board in September 2024
  - $2.6M over 3 years
- Prototype should integrate into existing digital backend
  - Test in the existing array for a complete performance assessment
- Where possible, address known issues with Mk II PAF
  - Build existing operational experience into the design process

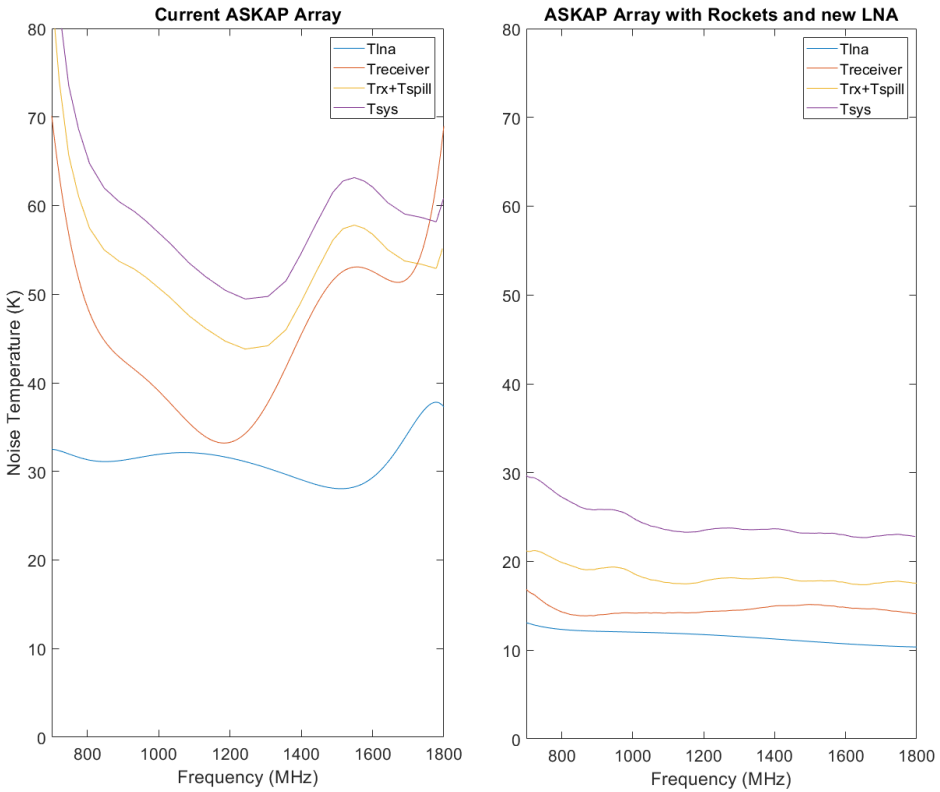
Project Roles:

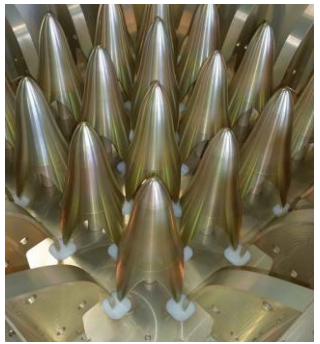
- Project Lead/Mgr: Simon Mackay
- Project Sponsor: Mark Bowen
- Project Scientist: Aidan Hotan
- Project Engineer: Alex Dunning

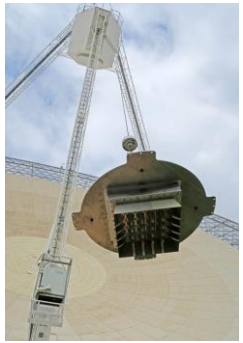


Mk II ADE PAF currently installed on ASKAP

Sensitivity Improvements: New LNA + Rocket Elements







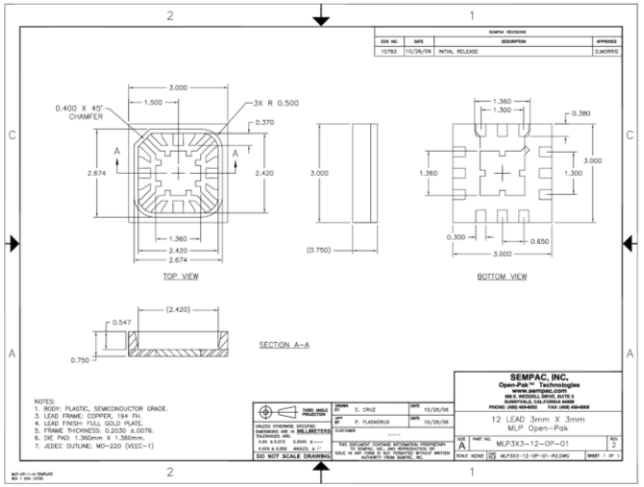
- **Rocket elements**
  - Offer more uniform frequency response over current chequerboard design
  - Reduced lightning sensitivity
  - Front of PAF more tolerant to sun damage
  - Elements are not exposed to environment

- Significant mechanical re-design of ground plane and hence PAF is required to utilise rocket elements

New LNA

- Diramics transistors (InP pHEMTs) have been evaluated and found to have lowest noise performance of commercially available devices.
  - **Pros:**
    - Highest performing transistors on the market
  - **Cons:**
    - Cost is significant (~AU$180 ea. Qty 400)
    - Devices operate at lower than usual voltages (~0.5V)
    - Devices are unpackaged
- **Packaging:**
  - Need to develop and evaluate packaged transistor performance. Bond-wire lengths will be critical
  - Sample packages have been procured for prototyping
  - CSIRO Lindfield has a Quantum Device Packaging facility - Defence Trailblazer Program
    - Two highly precise wire bonding machines
    - Use of these is encouraged to demonstrate local need

DIRAMICS



Desirable operational improvements

- New power supply for improved reliability and uptime
- New control and monitoring system to allow:
  - Continuous monitoring during astronomy observations
  - Improved reliability of startup and reconfiguration sequences
- New cooling system to increase thermal & gain stability
  - Remove one of the major sources of variability in ASKAP's flux scale

ASKAP Mk III PAF prototype status and plans

- LNA design progressing
- Mechanical study of existing structure underway (on site this week!)
- Discussions with the ASKAP Operations team around desirable improvements are ongoing

- Performance of the complete prototype will determine the benefit of a full (as yet unfunded) upgrade across the array
  - A full upgrade would most likely occur after the current surveys conclude
  - Need to consider options for a digital backend upgrade as well

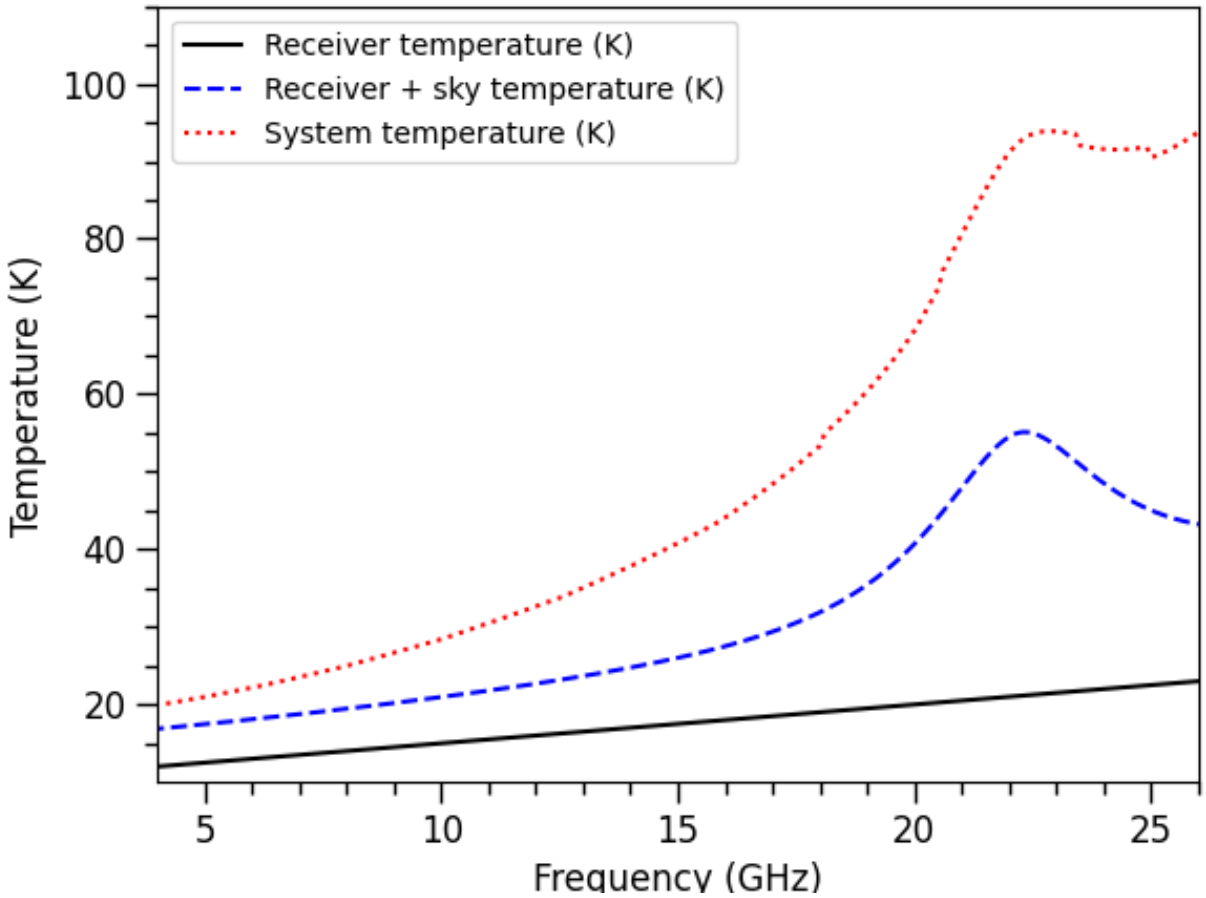
The Parkes ultra wideband mid and high receivers

Shi Dai

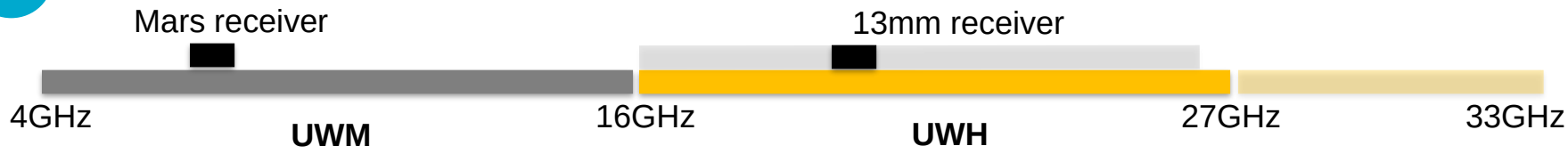
(5 minutes)

Updates on Ultra-Wideband Mid and High

- Two single pixel receivers, each providing 11.5 GHz of processed bandwidth: 4-16 GHz and 16-27 GHz (with a tuneable extension for spacecraft tracking up to about 33 GHz)
- Incorporated into the existing UWL receiver package
- Motivations
  - ✓ Improving Murriyang science capability
  - ✓ Improving operational efficiency (no need for receiver changes)
  - ✓ Technology demonstration (ultra-wideband feed, LNA, DSP…)
  - ✓ Good use of capability developed by other projects (ngVLA, BIGCAT, Jimbles…)
- The project commenced in 2025 with an expected duration of approximately two years.



Credit: Alex Dunning



- **Very Long Baseline Interferometry (VLBI):**
  - Wideband VLBI (e.g., ~8GHz bandwidth together with BIGCAT)
  - Milky Way structure and dynamics with masers
  - Binaries, compact objects, jets …
  - Geodetic VLBI
- **ISM and molecular lines:** simultaneous observation of multiple lines/transitions, Zeeman splitting
- **Stellar radio emission:** magnetic field, magnetosphere
- **Magnetars and FRBs:** radiation mechanism, polarisation and local environments
- **Searching for technosignatures:** full coverage from 0.7 to 27GHz
- **Spacecraft tracking and bi-static radar**
- **Cosmic Magnetism, space weather, dark matter …… more ideas/suggestions welcome!**

Science with all sky monitors

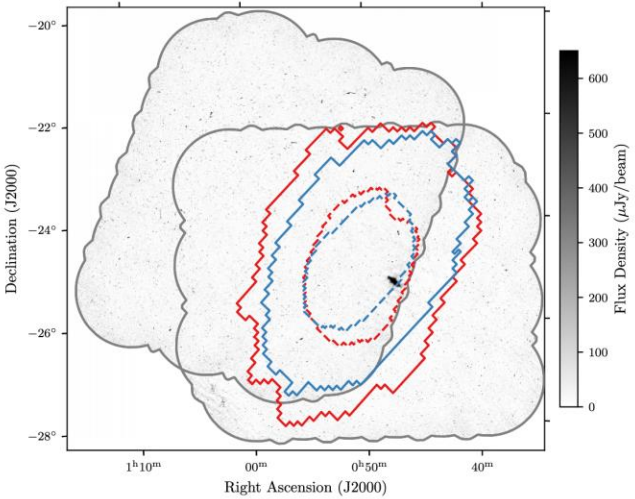
Josh Pritchard

(5 minutes)

Commensality with multi-wavelength observations

- Prompt emission from explosive transients
  - On-sky coverage of high energy triggers (e.g. supernovae / GRBs)
  - Binary merger gravitational wave events
- Localisation of GW triggers
  - Inform other facilities of candidates for early time followup
- Overlap with Rubin / LSST
  - Matching radio coverage for large volume of optical transients
  - Infeasible with targeted pointing observations

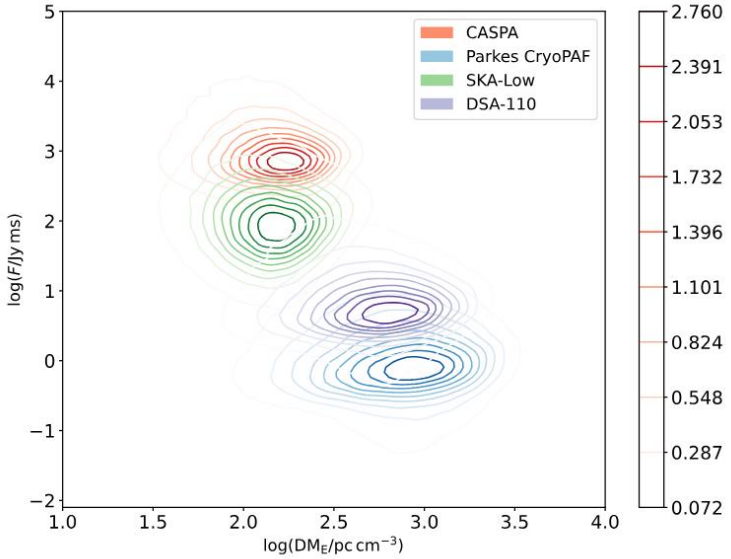
Dobie et al. 2022, MNRAS, 510, 3794



Fast Transients: FRBs, magnetar outbursts, RRATs

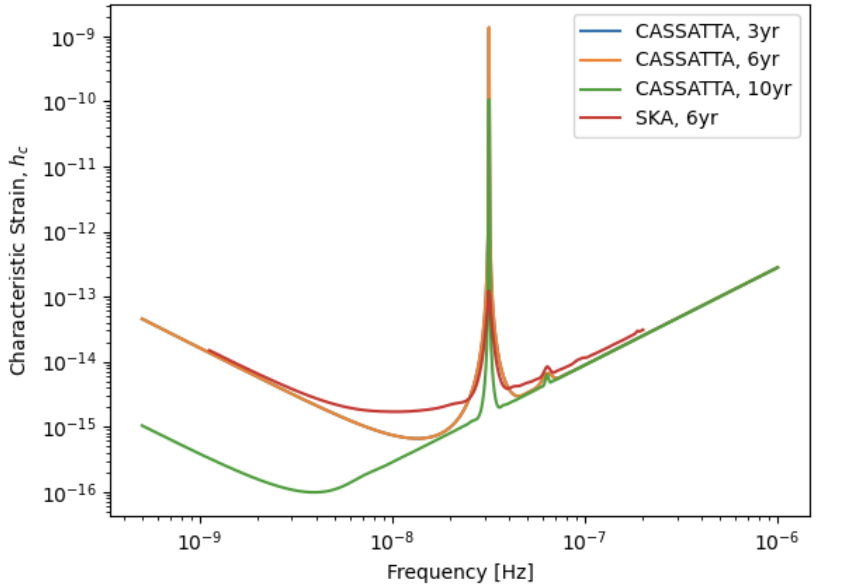
- All-sky monitors probe a completely distinct population
  - Nearby / Galactic events with potential multi-wavelength counterparts
  - Rare high-luminosity events
- Build large populations sampled over redshift
  - Cosmology over large redshift range
  - Emission physics and progenitor association

Luo et al. 2024, PASA, 41, e109



Pulsar Timing

- Collect pulse times of arrival on all pulsars in the sky every day
- Capability to detect glitches / profile changes as they occur
- Measure ToA every day for all pulsars in the sky
- Excellent sensitivity to nanohertz gravitational waves
- A survey for giant pulses



Credit: Andrew Zic

Stellar bursts / exoplanets / long period transients

- Space weather / exoplanet habitability from nearby stars
    - Statistical studies of simultaneous optical / radio behaviour
- Auroral radio emission from stars / planetary systems
    - Tracer of plasma energetics and stellar magnetism
    - Star / exoplanet / exomoon interactions
- Discovery / monitoring of long period transients
    - Short duty cycle, periodic on hours to days
    - Hard to anticipate ideal cadence for the unknown!
- Require all-sky monitoring to effectively study large populations