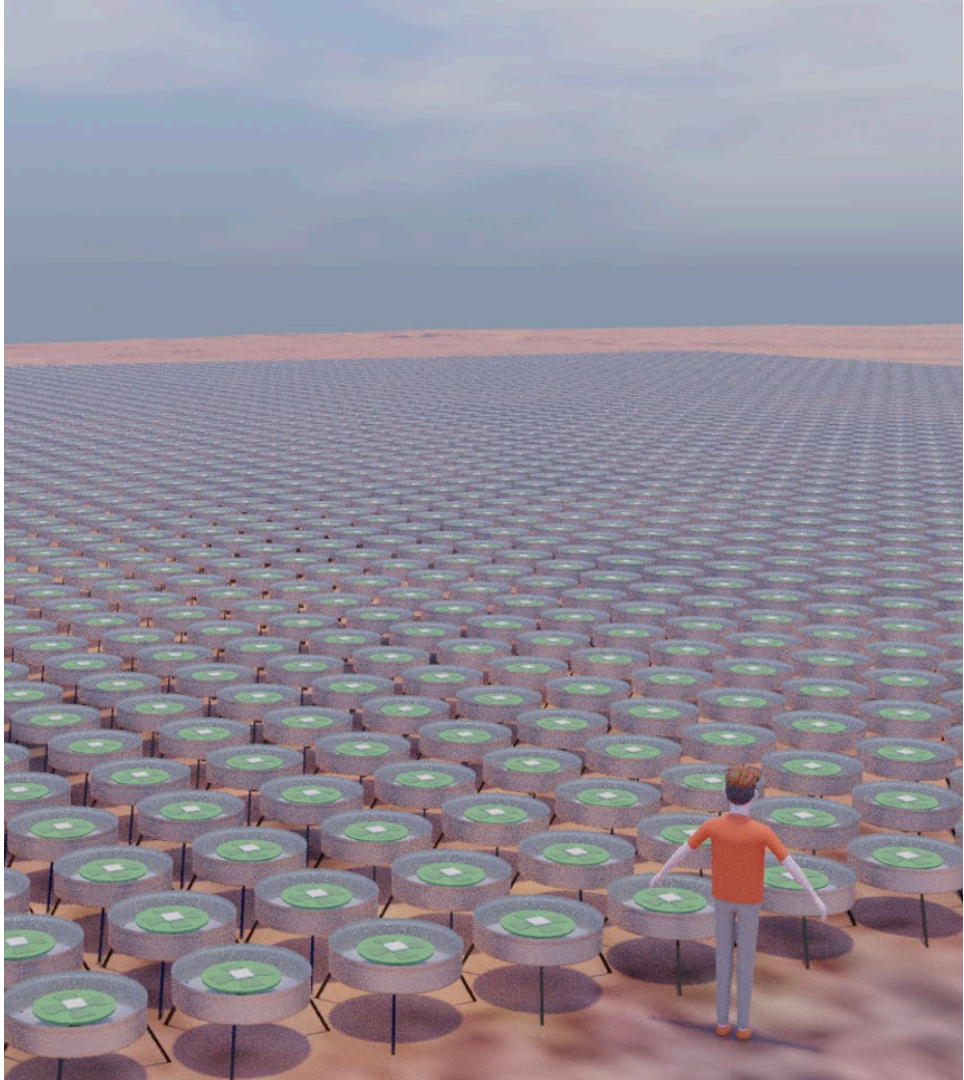
Future ATNF projects

Mark Bowen, Tessa Vernstrom,
Keith Bannister, Minh Huynh

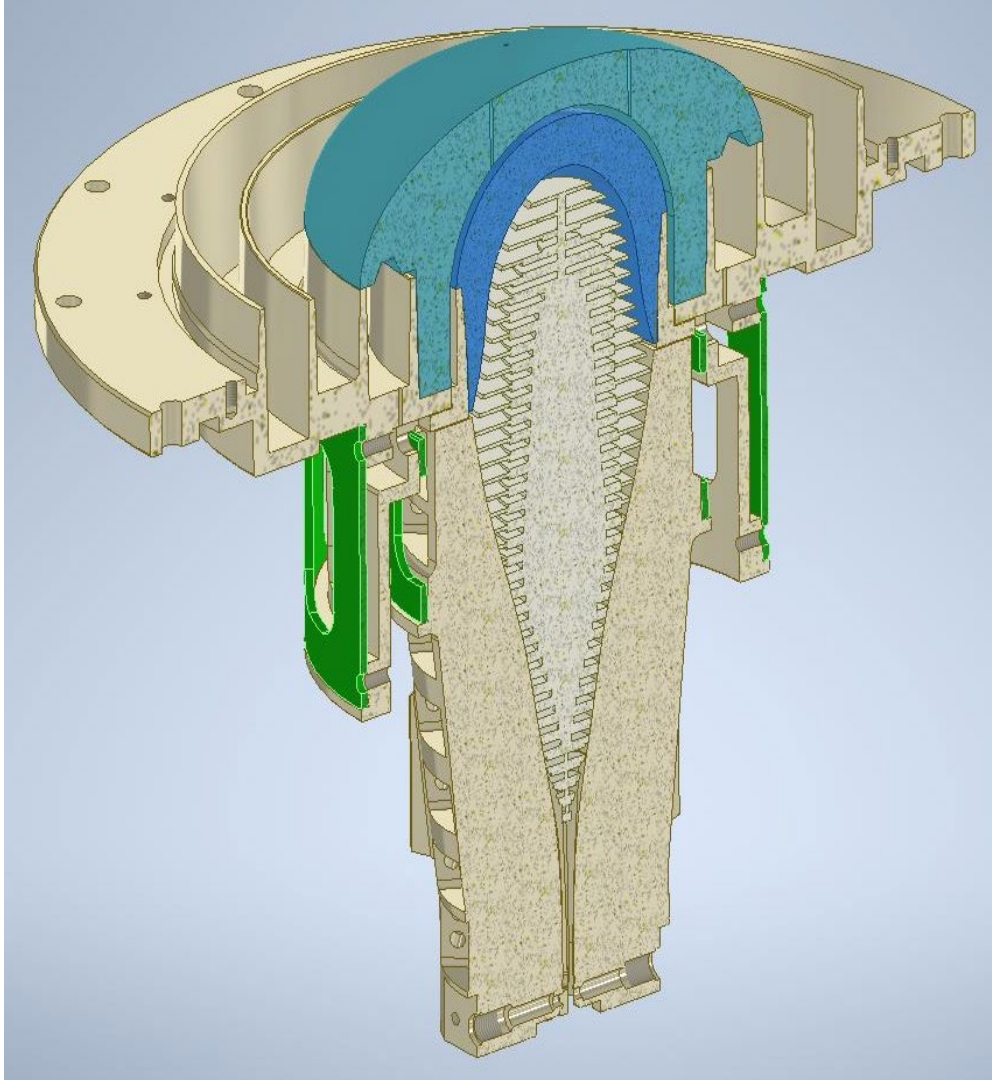


Technologies Update

Mark Bowen

Future Large Projects

1. ASKAP PAF Upgrade
2. Parkes UWM-H
3. LAMBDA
4. SKA Mid Band 5 SPF Tender



ASKAP PAF Upgrade

- Project approved to commence – budget allocated
- Work commences in early 2025 – LNA development underway

Parkes UWM-H

- Project approved to commence – budget allocated
- Work commences in early/mid 2025

LAMBDA

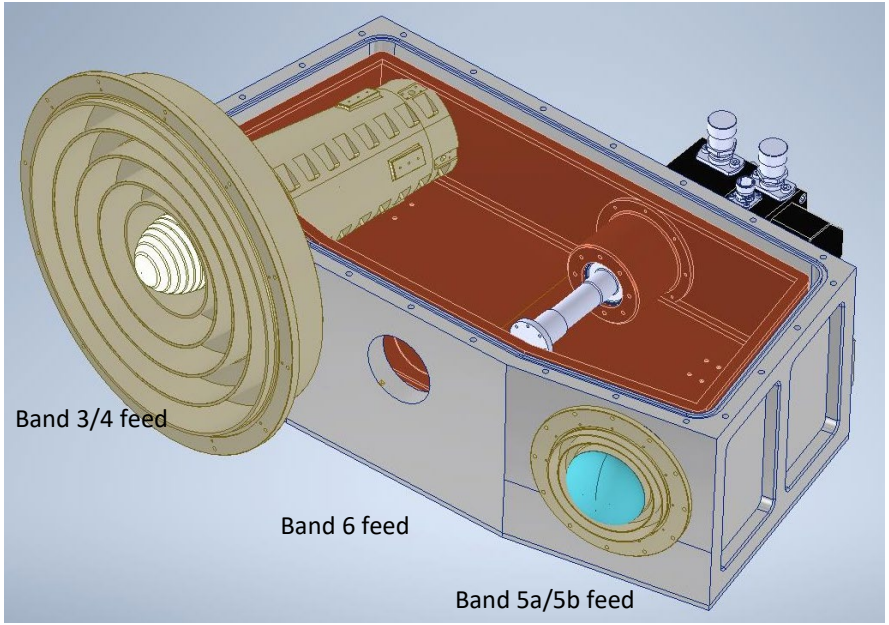
- Development of detailed science case
- Early prototyping and concept testing

SKA Mid Band 5 SPF - Tender

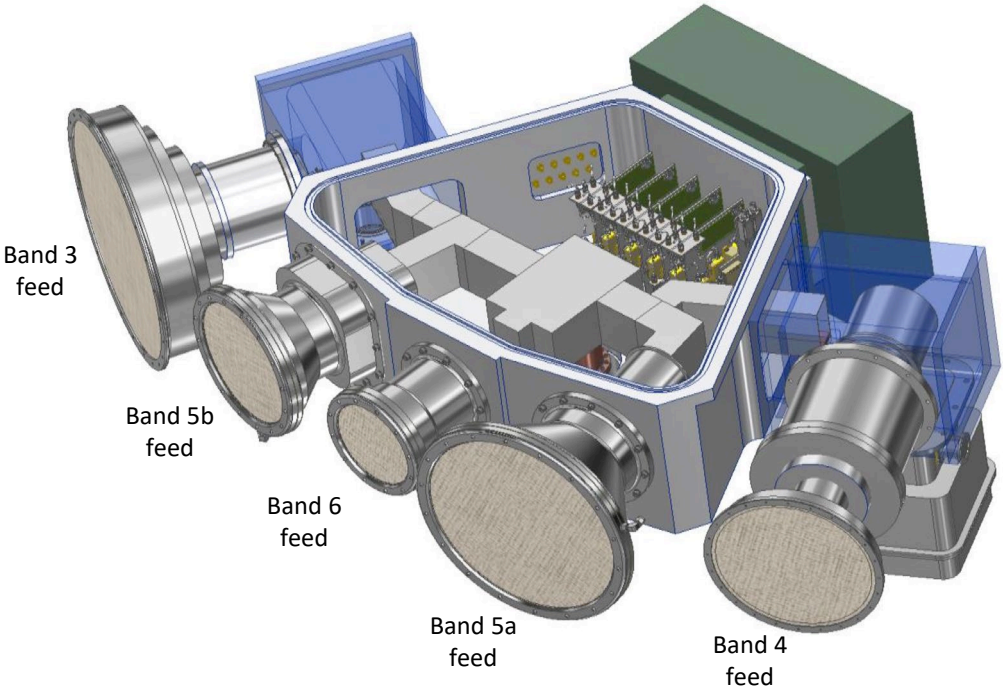
Project Scope

- **Open competitive tender** – due 14 Nov 2024 (31 Oct 2024)
- Proposed start date – 01 Jan 2025 (tender award Dec 2024)
- Duration – 3 years approx.
- Design and manufacture of 86 SKA Mid Band 5 (4.6 – 15.4 GHz) receivers (SPF). Comprised of:
  - 5 pre-production units
  - 75 production units, in batches of 4, 8 or 10
  - 6 spare units, in 2 batches of 3
- Feed design based on Parkes UWL and ngVLA (UWM-H)

ATNF Concept Design verses SKAO Reference Design



CAD Model of the SPF Band 345 feed package ‘CSIRO design’



CAD Model of the SPF Band 345 feed package ‘reference design’

Implications

Opportunity

ATNF UWB feed technology on two newest and largest telescopes in the world

SKA-Mid band 5 observing time halved for the same frequency coverage

Impact

- ASKAP PAF Upgrade

  Delay of up to 12 months in some (but not all) areas of the project

- Parkes UWM – H

  Delay of up to 18 months in some (but not all) areas of the project

- LAMBDA

  Little or no impact – overlap is minimal

LAMBDA

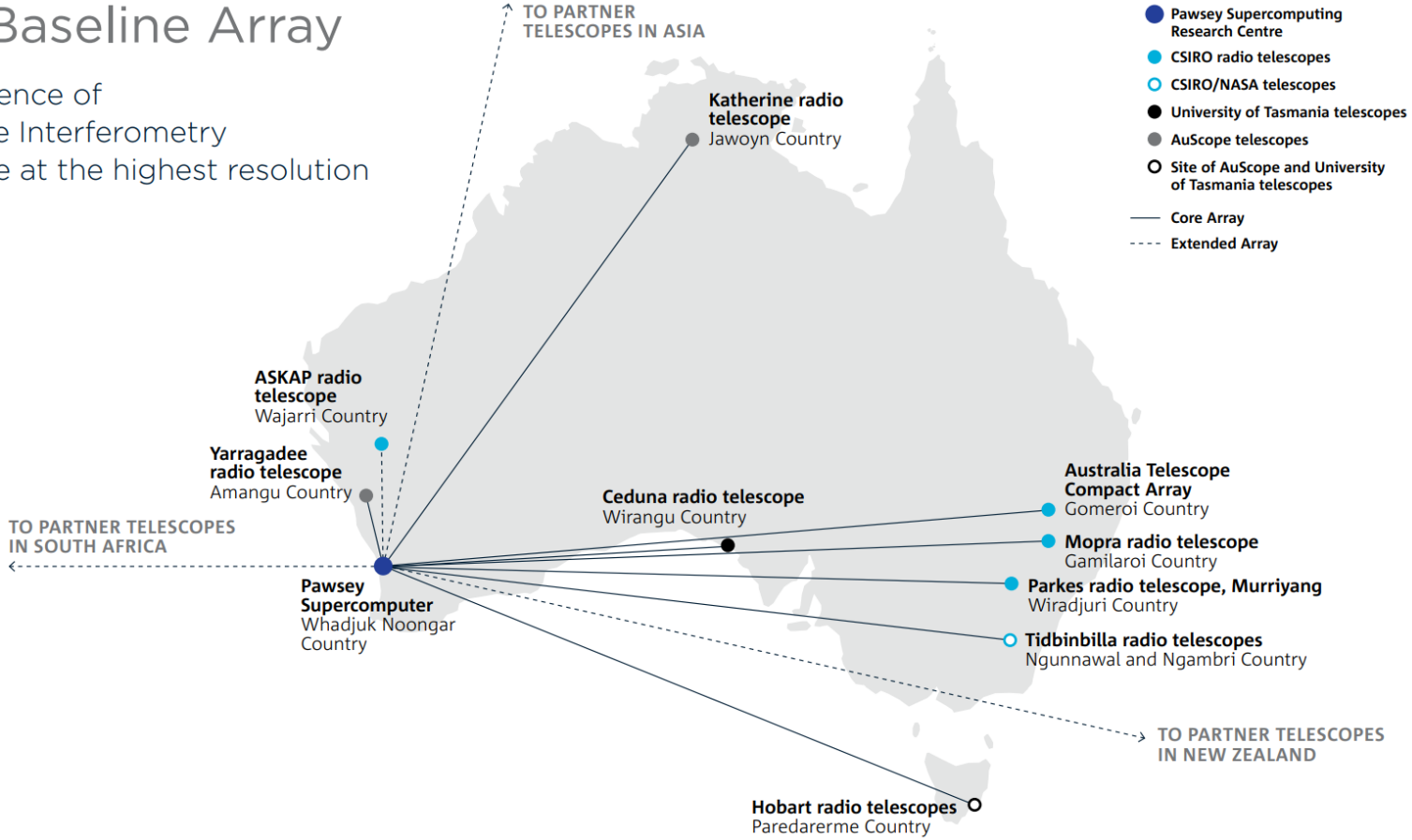
Tessa Vernstrom

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 – 150(?)-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
- Leverage CryoPAF/SKA efforts

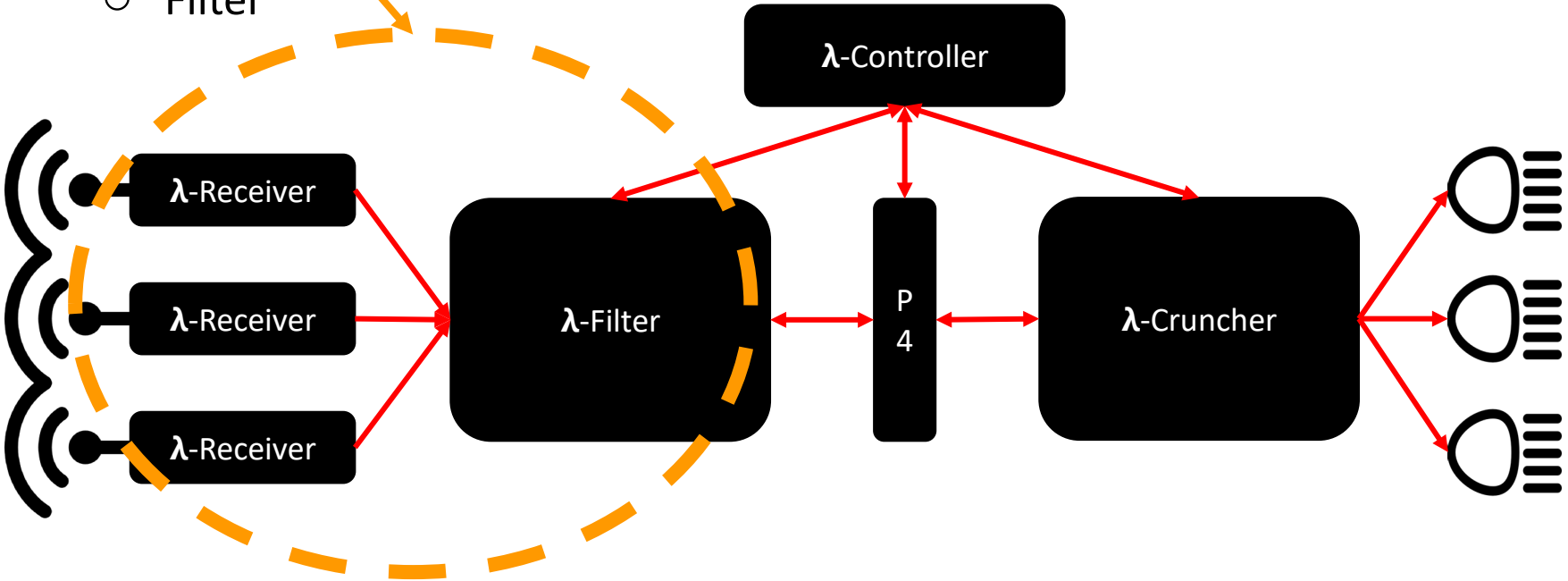
The Long Baseline Array

Harnessing the science of
Very Long Baseline Interferometry
to see our Universe at the highest resolution



λ System

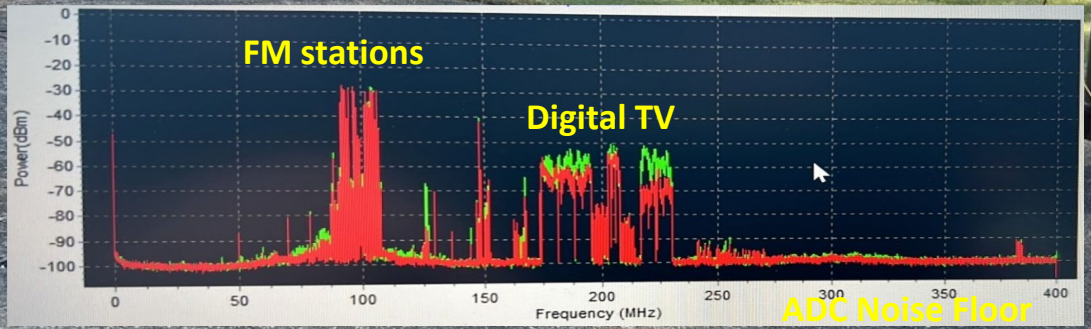
- Major λ parts we are currently prototyping
  - Receiver
  - Filter



Sydney Measurements

λ Receiver

MWA CRAB Antenna



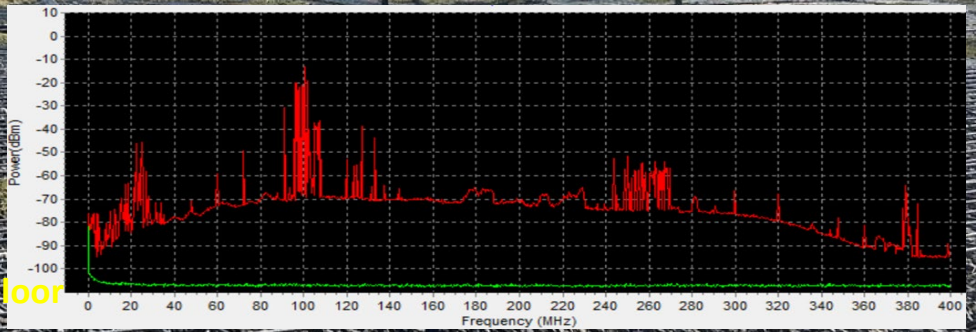
ADC Noise Floor

Fibre to λ Filter

Note: SKALA Antenna has too much gain to work in Sydney

Narrabri Measurements

- Can use SKALA antenna without saturating it with FM radio

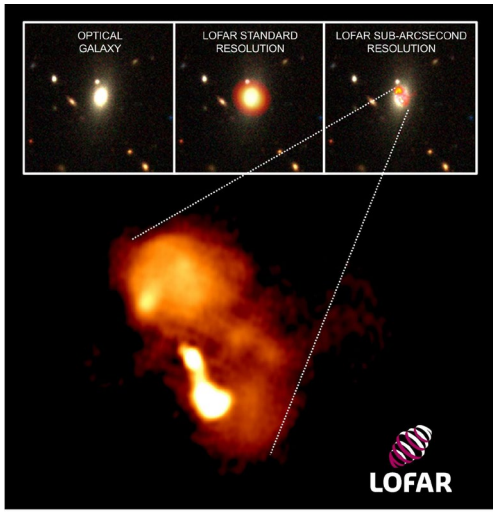


λ Timeline

- Key is an end-to-end demonstrator
  - Key parts to demonstrate are the receiver and filter - the fundamental building blocks of any system
- Minimum Viable VLBI Station
  - Hardware: 36 antennas, 18 receivers, 1 filter (4 Alveo)
  - Firmware: JESD, Filterbank, Packetiser, 100GbE, VLBI beamformer
  - Software: Receiver control, Filter control, Beamformer control
- Near term items key to making progress
  - Prototype RF board - 3 months
  - Revision of ADC board (with quantity 1) - 3 months
  - Production of ADC board (quantity 18) - 1 month
  - Receiver shielding (revision) and measurements - 3 months
  - Putting all the firmware in a continuous chain - 3 months
  - Getting the processor established with monitoring and control - 3 months
- Aim to have a prototype VLBI station at Narrabri in Easter 2025
  - Seasonal considerations - feel it's going to be a hot summer - aiming for Easter
  - Note that there is an established testbed at Narrabri with power and some fibre

Science cases and community engagement

- High resolution (sub-kiloparsec scale at all redshifts) mapping of AGN and other radio sources detected with ASKAP, MWA, MeerKAT, and SKA-Low and SKA-Mid
  - 2/3 of ASKAP sky inaccessible at low frequencies with long baselines
- Pulsar astrometry, distances, proper motions, scintillometry
- Young stellar objects and Supernova Remnants in our Galaxy
- Gravitational lens discovery / imaging
- Resolving stellar systems, distinguishing planet from host star
  - (e.g., Sun-Jupiter system to D ~ 50 parsecs)
- FRB follow-up and host imaging with optical resolution
- Determination of high-precision ISM properties,
- Technosignature Searches



Galaxy-scale jets revealed by new calibration techniques ("Sub-arcsecond imaging with the International LOFAR Telescope" Special issue, 2022, A&A, 658)

Give your input! Community survey on science technical requirements – what do you want LAMBDA to do/be?
https://forms.gle/ff2qEbrrPMgKsdoW7

Cassata and all-sky monitors

Keith Bannister

CASATTA-N – Coherent all-sky array

- **Aim:** Build a N-element all-sky array at 400-800 MHz
- **Engineering Demonstrators N**=4,16
- **Science arrays**: N=64, 256,1024,4096,16k,64k(!)
- **Science**: nearby FRBs and magnetars, pulsar timing & GW, SETI, SSA, EMGW follow-up, HI intensity, HI absorption
- **N**=256, target system hardware cost < $500k USD
- **RF/Antenna**: ATNF design
- **Digitisation & front end:** Re-use as much of LAMBA hardware / firmware / software as possible
- **GPU software:** Possible collaboration with Caltech
- **Pragmatic design**: Modest bandwidth, design re-use, minimise NRE (e.g. prefer COTS).
- **Early work**: Prototyping designs to get a better idea of costs and requirements. Deploy small array for testing the architecture.

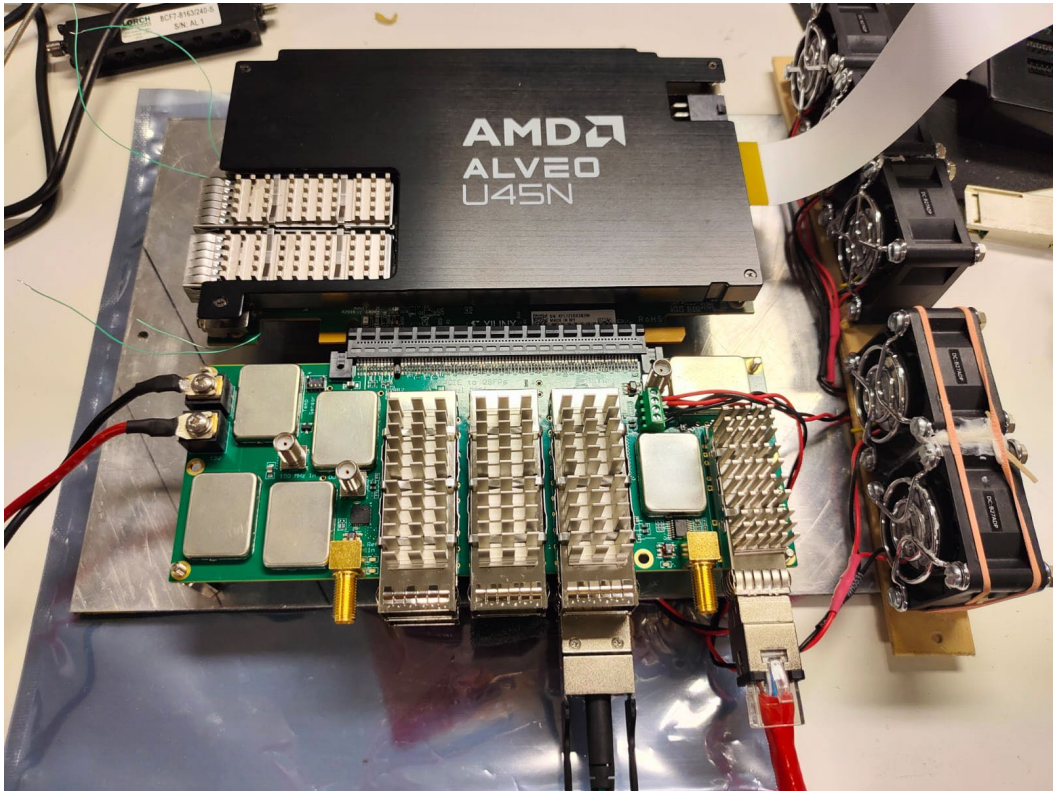
Strategic objectives of N=4-256 arrays:

- Test & improve key technologies
- Train students / postdocs
- Develop all-sky science case at 400-800 MHz
- Stepping stone to mid-scale facility – e.g. 16k elements, with outriggers. 1M FRBs in 5 years. Many other all-sky science cases.

- Develop large-N technologies for industry (e.g. space tracking, SSA)

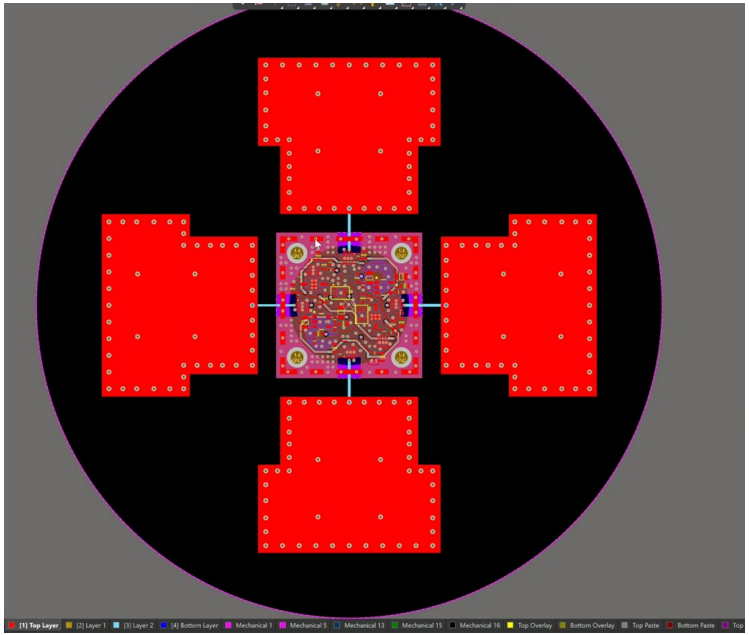
ADC interface, channelizer and packetiser

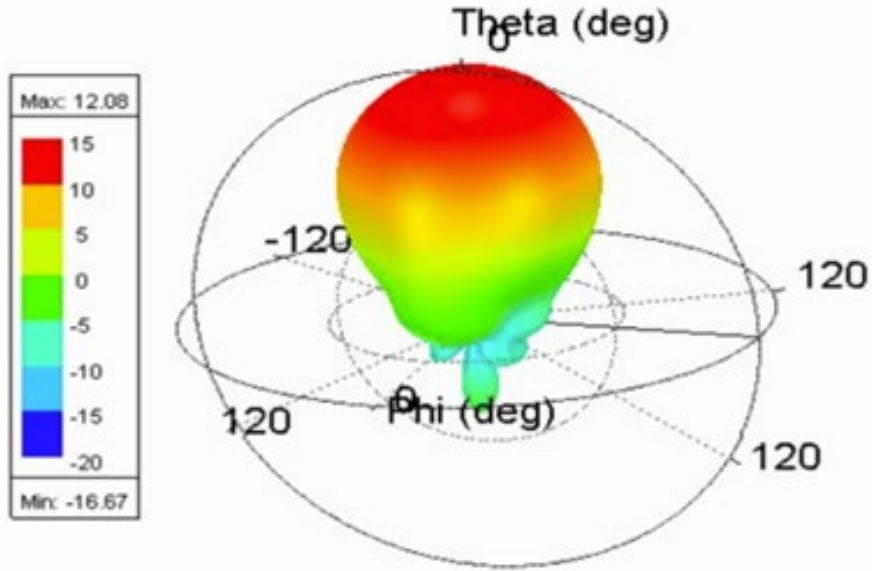
- Handles up to 20 inputs
- Being developed for LAMBDA
- Lost cost.
- Off-the-shelf FPGA board from large vendor.

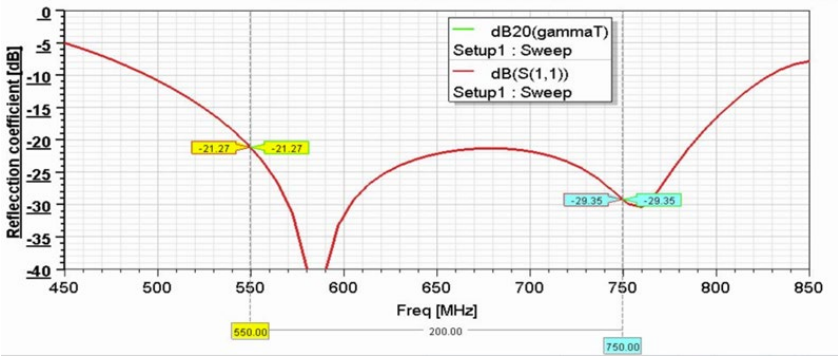


Joseph Pathikulangara

Antenna/LNA design







Maral Ansari – “Impossible Without You” Postdoc

Next steps = prototyping + science case

- ATNF postdocs continue working on various engineering tasks
- Testing small demonstrators with hardware as it becomes available
- Produce science case for CASATTA-N (N=64,256,…)
  - We need your input
  - E.g. ATUC science day workshop in 2025
  - E.g. start from SKA mid frequency aperture array science case
  - Contributions will be collated / requested by Baerbel Koribalski (project scientist)
  - If you’re interested / have opinions come along or contact Baerbel or Keith

Data!

Minh Huynh

What next with data and data access?

For ATUC Oct 2024

Minh Huynh

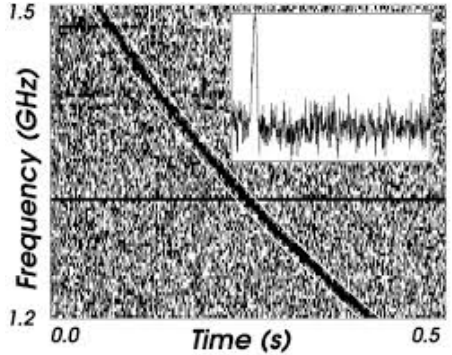
Value of Archival Data

Publications using archival can outnumber that of the original science team.

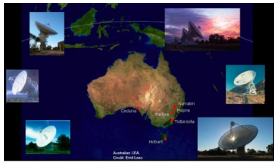
Survey science is archival science

- RACS already very widely used (McConnell and Hale papers have 100+ citations)

Fast Radio Bursts are seminal example



ATNF Archives Current Status



Continuum and Spectral Line

Pulsar

ATOA

- At Marsfield
- Volume: 0.6 PB
- Growth: 50 TB in last year

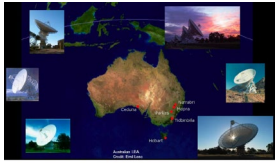
Parkes Pulsar DAP

- Part of CSIRO Data Access Portal
- Canberra, CSIRO Data centre
- Volume: 4.4 PB
- Growth: 0.5 PB in last year

CASDA

- Data and Services at Pawsey
- Uses DAP front end (Canberra CDC)
- Volume: 7.6 PB
- Growth: 3.4 PB in last year

ATNF Archives Future Status



Continuum and Spectral Line

Pulsar

CASDA - ATOA

- Data and Services at Pawsey
- Uses DAP front end (Canberra CDC)
- 5 - 6 PB/yr ASKAP surveys
- up to 0.8 PB/yr Murriyang/Parkes, ATCA, LBA
- Current ATOA data migrated by end of 2025 (expected)

Parkes Pulsar DAP

- CSIRO Data Access Portal
- Canberra, CSIRO Data Centre
- Up to 2 - 4 PB/yr with CryoPAF search mode

ATNF Archives Long Term Storage

CASDA - ATOA

Will grow to 35+ PB in 5 years

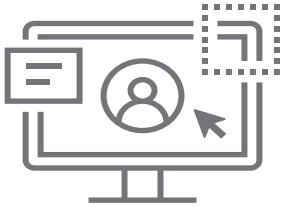
Need an off-site copy of most important data (primary images/cubes + ATOA)

Parkes Pulsar DAP

At 2 PB/yr (possible with CryoPAF) growth will run out of DAP storage in 2027 without expansion

Actively seeking solutions for long term storage, data preservation will need community support and funding

ATNF Archives/Data Access Development Priorities



CASDA - ATOA

- New cutout tools (images/cubes but also portions of visibility and single dish data)
- CARTA improvements (e.g. FITS2IDIA HDF5)
- GLOBUS integration

Parkes Pulsar DAP

- Trialling AWS for some projects
- Exploring EASI platform for data analysis
- Set of default pipelines at Parkes, pre-process/reduce data for users

Large body of work identified, but resourcing is needed

The future of ATNF Archives

- Need to think about data and data access/archiving from the start for new projects like UWMH, LAMBDA, Casatta ...

- Data volumes so large now we need to move to User to the Data model, or science platforms
  - Will need funding, but is the future of radio astronomy

Thank you

Space and Astronomy
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