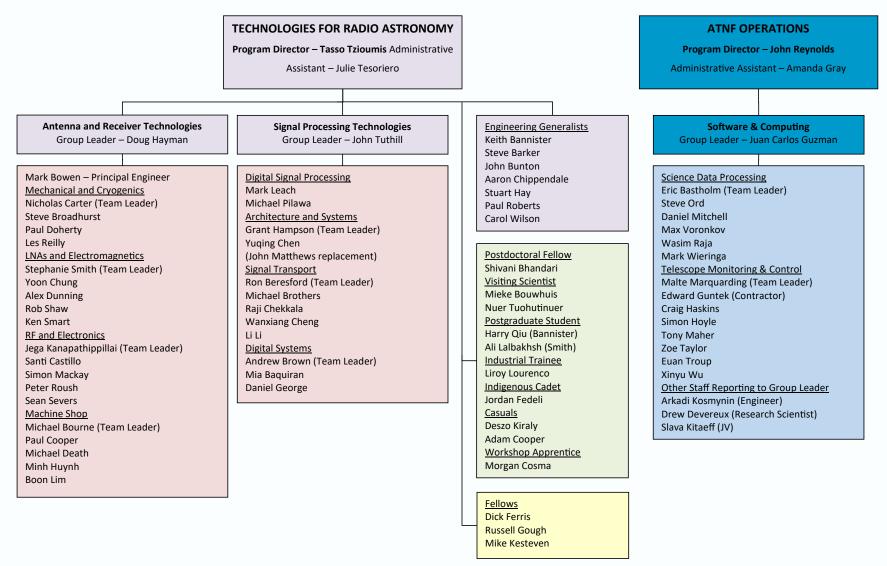
Technologies for Radio Astronomy



CSIRO Astronomy and Space Science

Tasso Tzioumis
Facilities Program Director – Technologies
May 2018





NB1: Small groups \rightarrow Single subject experts \rightarrow (Risk: Single-point failures?)

NB2: <u>Critical mass</u> issues → Could not lose ≥ 1-2 people/group



Directions for ATNF Engineering

** Broad directions largely unchanged

- ASKAP & SKA: Core business of the Engineering Program.
 - Most of the program's people and effort at present.
- Development projects for all ATNF facilities.
 - Budgetary constraints → Priorities
- Strategic developments develop capabilities.
- External contracts maintain capabilities.



Current Technologies Projects (FY 2017-18)

- **1. ASKAP:** Highest Priority; ~10-12 FTE (Engineering)
 - PAF systems technologies
 - ADE PAFs for <u>Effelsberg</u> & <u>Jodrell Bank</u> (External contracts)
 - Showcasing PAFs on single dishes; Collaborative effort in Commissioning
 - Efflesberg in Commissioning; Jodrell Bank delivered; to be installed
- 2. SKA: International commitment. ~11 FTE (Engineering)
 - Pre-construction consortia (CSP; AIV; SDP; SaDT...)
 - PAF technology development (AIP/ODP) + some internal resources
 - Strategic to maintain PAF technology lead
 - CASS leads PAF ODP Consortium (Chair: Jodrell Bank)
- 3. FAST 19-beam receiver external contract → Completed!
 - Installed and in Commissioning!! (May 2018)
- **4. UWB:** System for Parkes 700-4200 MHz; novel technology
 - Commissioning at Parkes.
- 5. Rocket PAF → CryoPAF LIEF proposal result in Nov 2018!!



FAST 19-beam Receiver (May 2018)

- Receiver system for FAST 500m telescope
 - 1050-1450 MHz
 - 19 dual-pol beams
- Contract with NAOC
 - Acceptance May 2017!!
 - Shipped Nov 2017
 - Install & Commission May 2018
- Largest Rx system made in CSIRO
 - Diameter 2m & weight > 1ton
 - Special lab for construction
- State of the art performance
 - Treceiver 7K (spec 10K)
 - Expected Tsys ~15K (cf Parkes >25K)
- CSIRO sole-supplier
 - Unique capability

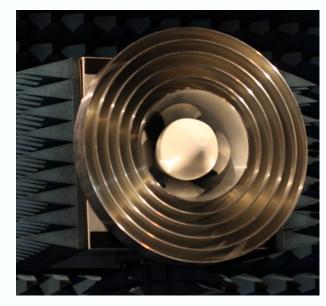


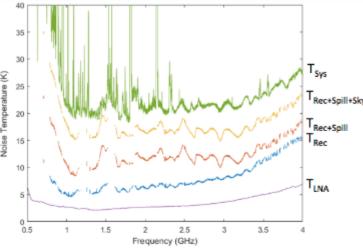




Parkes UltaWideBand system (UWB)

- Band 700 4000 MHz; Tsys <20K
- Consortium funding + ARC + CASS (labour: 6.5 FTE)
- Novel feed: ridged-horn+rings+dielectric
 - Cooled Rx version Tested on Parkes Aug'17
- LNAs designed & chips fabricated in foundry
 - Issues with cooling → 2nd run Testing
 - Interim L/S LNAs (limited at band edges)
- Sampler/digitiser and timing (Back-end)
 - Full system constructed and installed.
 - Debug issues & further developments
- Ethernet switch and GPU cluster (2016)
 - Software led by Swinbourne → Installed
- RFI mitigation built-in reference antenna
 - Chinese (XAO) secondment for 1-year
- Installation May 2018 → In Commissioning
- First results. Still in debug mode.
- Shared-risk observing APR2018 semester



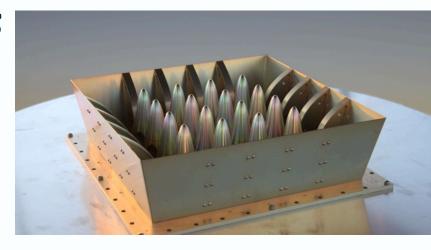


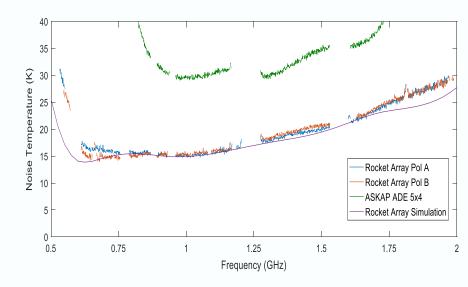
• \rightarrow New LNAs; New ADCs; Oversample \rightarrow In 2018



"Rocket" PAF → CryoPAF

- Next generation PAF
 - "rocket" elements; "edge" elements
- Superb matching with LNA
 - Key to improved performance
 - Noise Temp due to uncooled LNAs
- 4x5 prototype constructed
 - tested as aperture array
 - ~15K better than equivalent ADE tests
 - Tested on Parkes
- Design better suited to cooling
 - CryoPAF proposal Tsys <20K!?
 - Cost: ~\$3M (incl >5 FTE from CASS)
 - LIEF led by UWA Result in Nov 2018
- Thermal study underway → Prototyping.
- Strategic priority







Future Projects



ASKAP RF-transparent feed-legs

- **Proof-of-concept system:** (1FTE + \$250k)
 - Improve ASKAP Tsys by 10-20K
 - (→ achieve original ASKAP spec)
 - Survey speed x2
 - Test feasibility on 1 antenna
 - 1st system built and shipped to MRO (May 2018)
 - Testing on Antenna starts July 2018
 - Aim to complete testing within 6 months
 - Report back to ATUC and ATSC at end of 2018
 - Option 1: Fit outer 6 antennas (benefits long baselines)
 - ~\$1.3M for +5 antennas & install. ~8 months. Funding??
 - Power-supply rework??
 - Option 2: Full ASKAP conversion >\$3M in parts + >\$1M in labour effort.
 Funding?
 - Maximum benefit if done within ~2 years.
 - → Priority?? Funding proposals??



GPU upgrade of ATCA

- Update CABB and double BW (sensitivity increase) (ATUC Jun 2017)
 - Versatile; flexible; fast transients; maintainability; unattended observing; support
 - SIEF proposal for ~\$3M; ~\$2M external & ~\$1M from CASS (not funded)
 - CABB Update: ~\$1M. Possible within ~6 month period
 - Fallback if major CABB failure
 - CASS continues R&D;
 - ADC design from UWL system; Possible RFSoC design
 - 4 GPU test system now
 - Software Correlator design (GPU "hackathon" @ Pawsey) April 2018
 - → Full system needs external funds! LIEF proposal?? University to lead?
 - Priority??



Parkes UWB Mid/High

Based around UWBL and compact array CX system

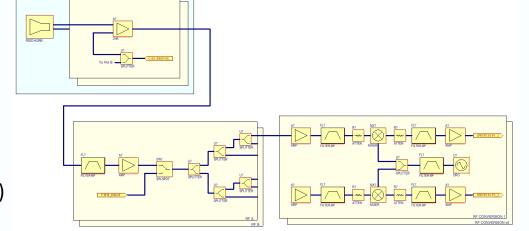
Utilising much of the UWBL system; i.e. Samplers; Back-end; GPUs; Software

Current Bands are

- 4.0-15.4GHz
- 15.4-26.9GHz

Using 12 UWBL digitizers (6 per polarisation)

- 4-15 GHz band is sampled using 6 digitizers at 4096MSPS
- 15-27 GHz band is converted down to 4-15 GHz band
- 4-24 GHz system may be possible but is problematic, would be very attractive for other telescopes



UWB Mid preliminary circuit diagram

- Discussed at ATUC 2014; Chose UWL first
- Cost: ~\$0.5M h/w; + 5 FTE Labour.
- Needs funding. LIEF??
- Priority?



Digital systems

- ADC: Faster designs
 - Current: 4 Gsps; New: 6 Gsps avail; Future: 8 Gsps & 16 Gsps!
- Xilinx RFSOC: Integrated ADC + FPGA
 - 8 x 4 Gsps ADCs or 16 x 2 Gsps ADCs
 - Chips now available
 - R&D project.
- CryoPAF back-end:
 - Now using ASKAP ADE
 - MUST develop new system
 - Also for SKA?







Priorities and Funding proposals

- Any future project requires large CASS contributions
 - e.g LIEF proposals >50% from CASS (mainly labour)
 - Limited CASS annual budgets Labour + CAPEX
- Need to prioritise what proposals go forward each year
 - Implications for future years; Strategic considerations.
- ATUC link to community input in prioritisation.
 - LIEF are university led.
 - Strong science case and support from community essential.
- Proposal: CASS to bring funding proposal suggestions to Nov ATUC
 - Help to decide support, feasibility and priorities.
- Need mechanism to develop drafts & gauge community desires
 - Have call of Expressions of Interest / Propsals ÷?? Timelines?
- Nov 2018: CABB GPU; ASKAP transparent legs; UWH@Parkes; (ASKAP tied array)
 - Others??





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