PAFAR2022

Workshop Summary

17 November 2022

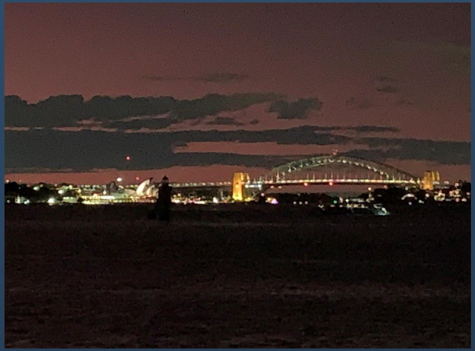
Wim van Cappellen

15 – 17 November 2022

Sydney, Australia



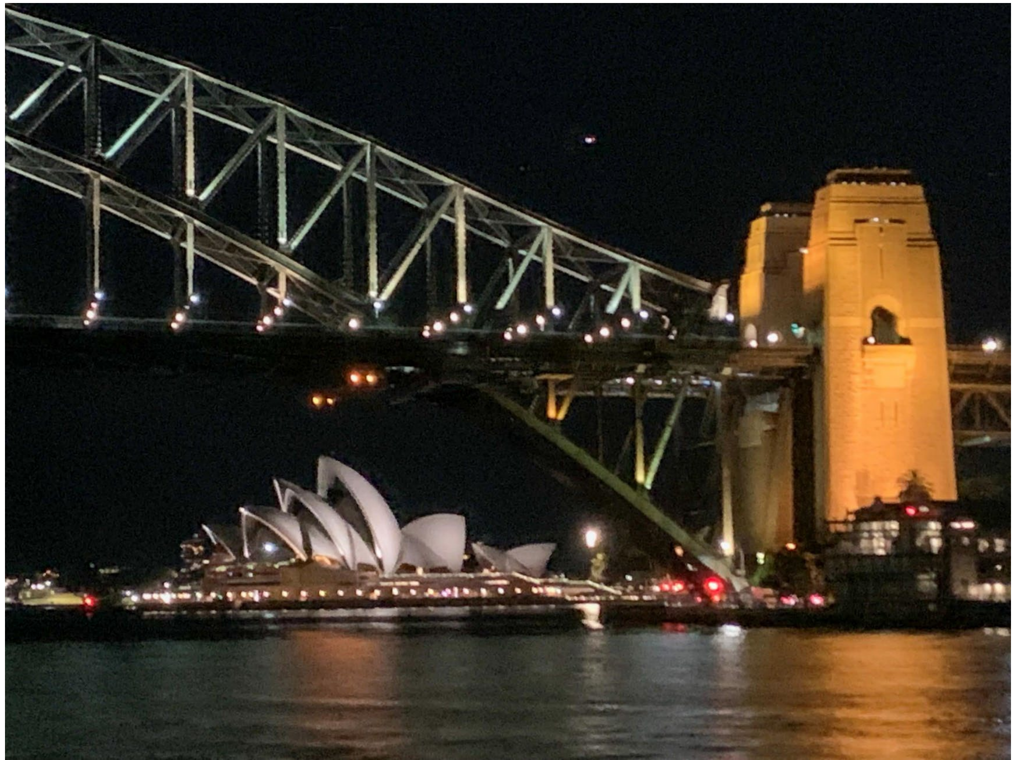


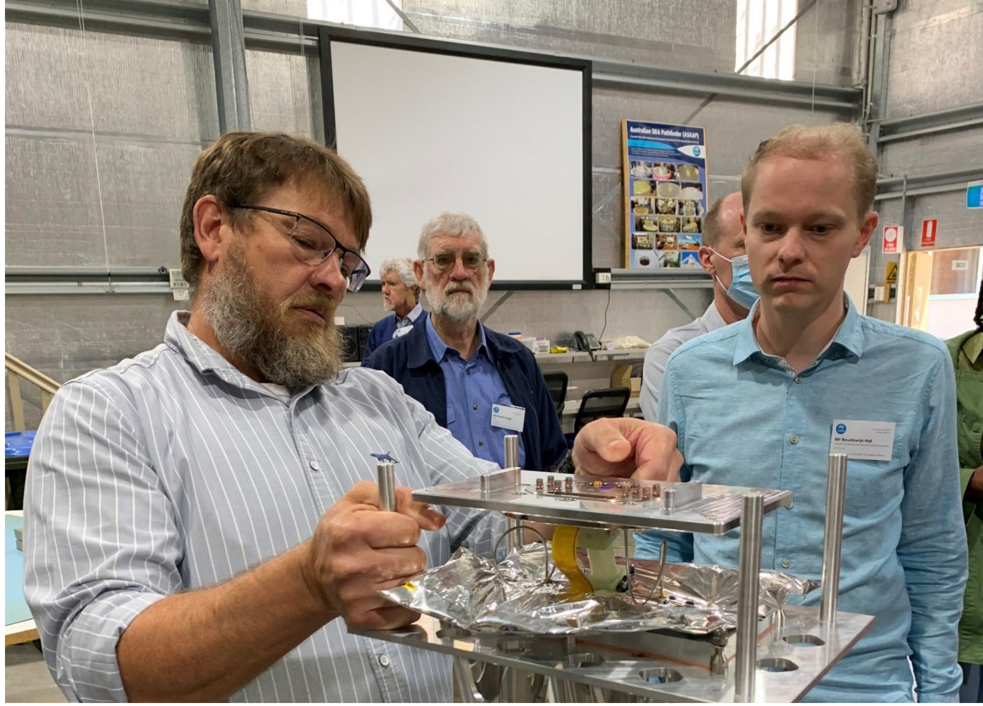


Long Jiang (Guest)
EXIT


RECEPTION
ALL DELIVERIES TO STORE
DELIVERIES NOT ACCEPTED AT RECEPTION
CSIRO

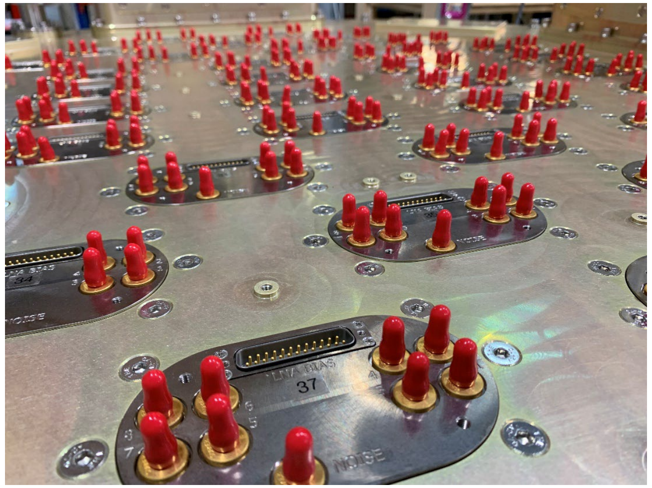


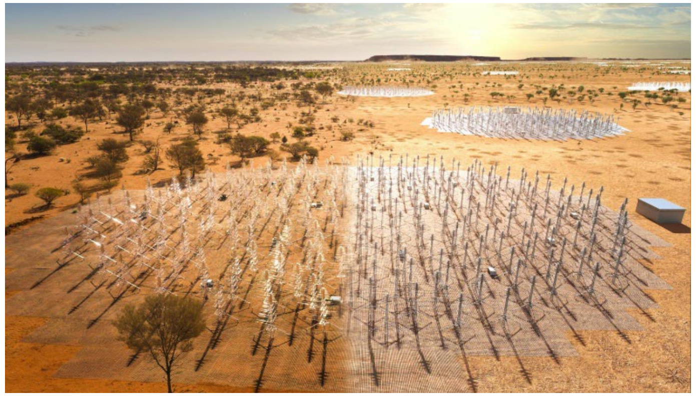

Mr Sias Malan
Grant Hampson



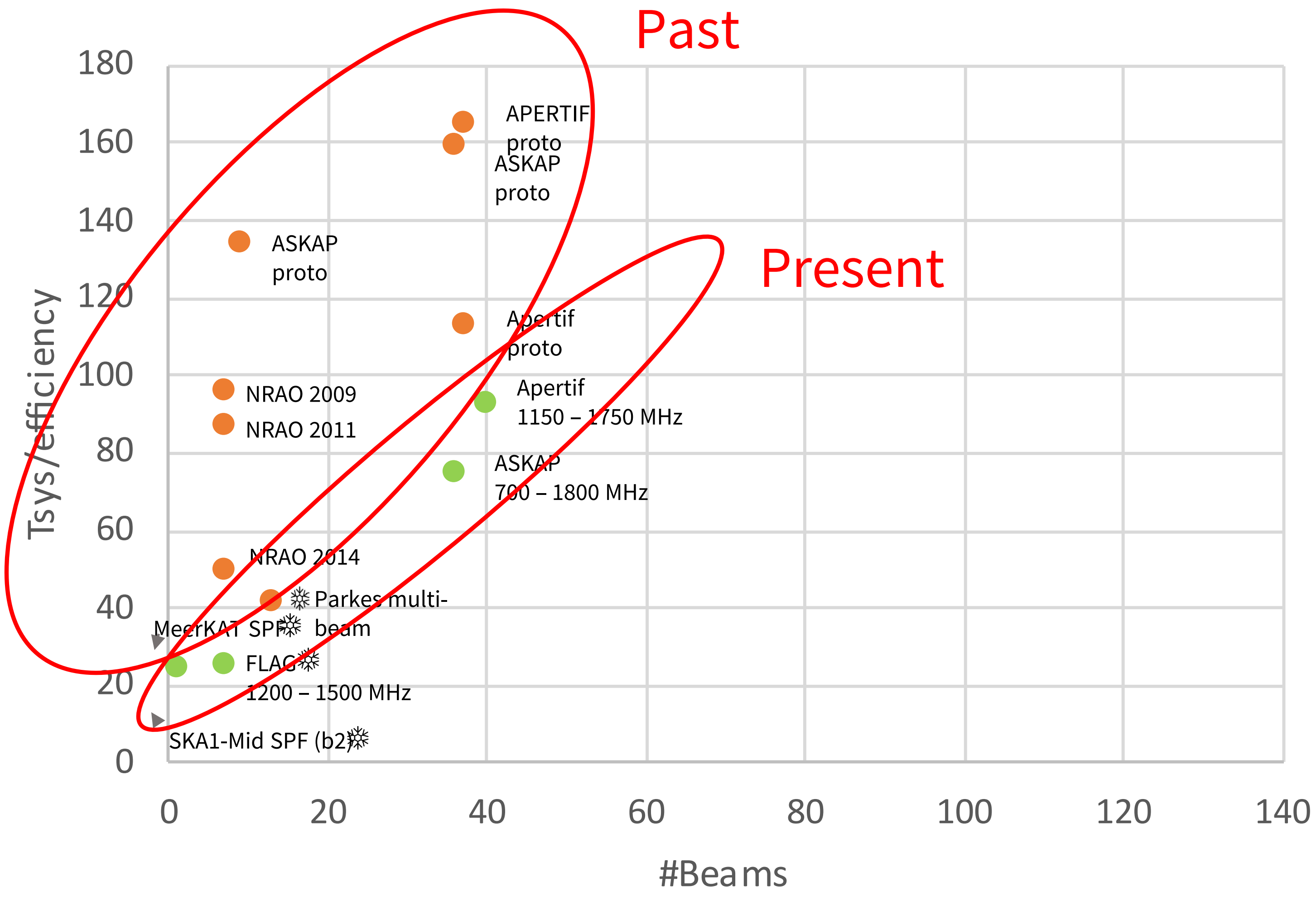
Workshop contributions

- Historical perspectives on PAF
- System updates/overviews
  - LOFAR2.0, ALPACA, Parkes CryoPAF, Space debris radar, Effelsberg CryoPAF, C-Band PAF, SKA1-Low, FAST, CryoPAF for commercial applications, TNRT PAF
- Frontend design and modeling
  - Effelsberg CryoPAF, ALPACA, GMRT PAF
  - RF and LNA design and characterization, highly integrated RF electronics
  - PAF noise and sensitivity modeling
- Receivers, beamformers, data processing
  - EDD, MeerKAT next generation receiver, Parkes CryoPAF (Jimble, CNIC)
  - High-level synthesis using Alveo
  - EMI shielding
  - Realtime imaging correlator
- Calibration, characterization and beam forming algorithms
  - SKA1-Low Embedded element patterns, AAVS and EDA2 calibration,
  - Adaptive beaforming using deep learning
  - RFI mitigation studies





Overview of PAF systems



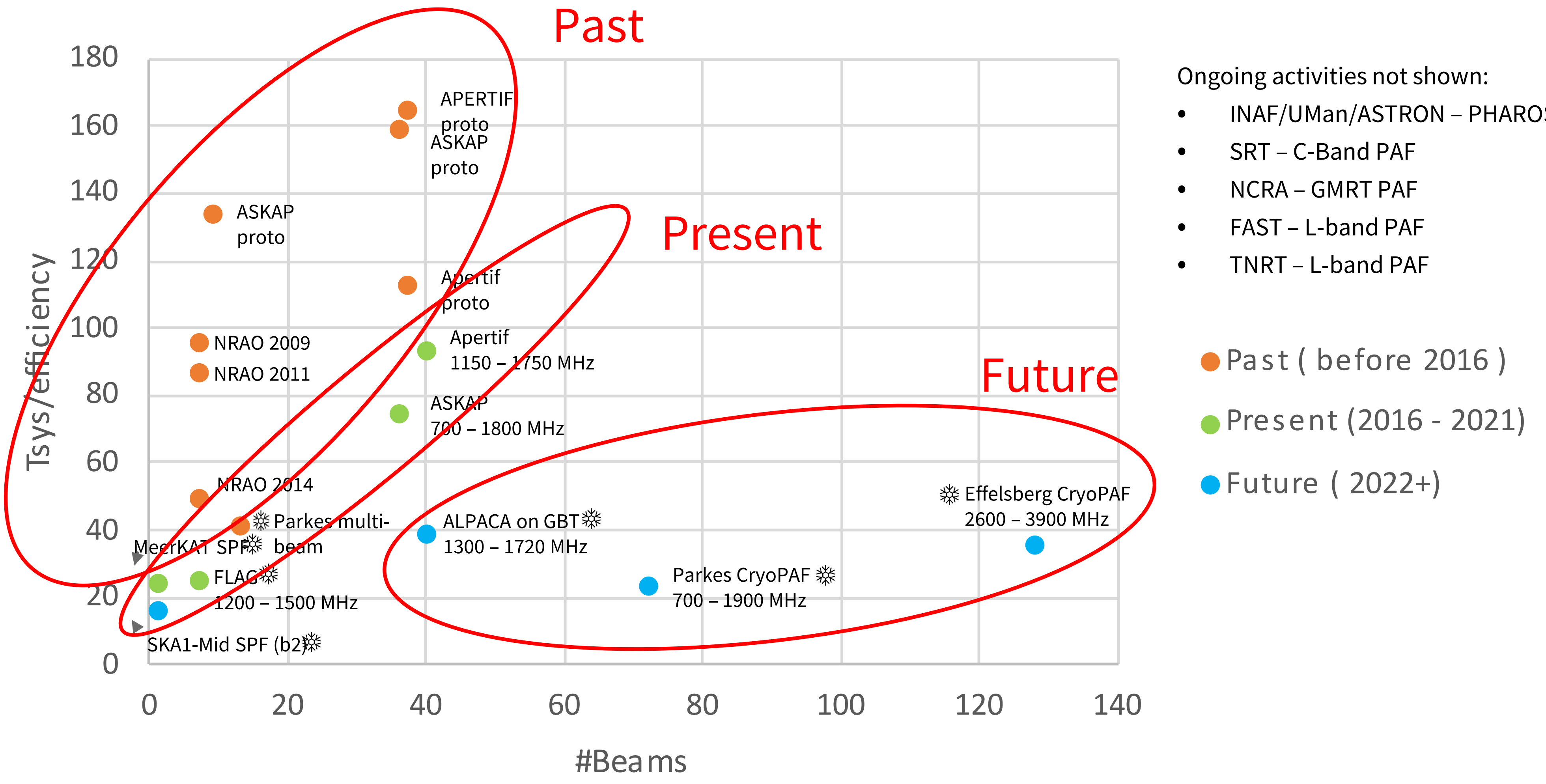
Ongoing activities not shown:

- INAF/UMan/ASTRON – PHAROS2
- SRT – C-Band PAF
- NCRA – GMRT PAF
- FAST – L-band PAF
- TNRT – L-band PAF

Past (before 2016)

Present (2016 - 2021)

Past, present and future PAF’s



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Progress – Systems

- The second generation of PAF systems for science operations is coming
  - Improved sensitivity, stability, calibration and beamforming
- SKA1-Low construction is started, rollout will be staged
- LOFAR2.0 is upgrading station electronics and its clock distribution system enabling a 10 – 80 MHz survey
- Several PAF systems are being developed roughly between 550 MHz and 8 GHz

Progress – Antennas/EM

- New antenna designs are enabling wideband, dense packing and cryogenic cooled PAF's: rocket array, dielectric resonator antenna, Vivaldi's, dipoles with pie shaped outer arms
- Accuracy of radiation pattern modeling and verification of SKA1-Low stations is improving
- *Robust* methods have been developed in ASKAP to holographically measure the primary beams of PAF's
- The performance of a PAF on a shaped (non-parabolic) reflector is being evaluated (SRT)
- Progress in EM modelling tools enable to do a full-EM simulation and optimisation of aperture arrays and PAF
- ASKAP and Apertif are using the equatorial mount (or equivalent). No work is being done on electronic derotation

Progress – LNA’s and Receivers

- Miniaturisation of LNA’s is essential for building high-frequency array antennas (e.g. 70 – 116 GHz).
- Measuring large numbers of cryo-cooled LNA’s is challenging but achievable. Automated setups have been demonstrated
- Costs of COTS cooled LNA’s in the 4-8 GHz band are high (~€5000) and prohibit large arrays
- RFSoC-based receivers offer high integration, optimization of power consumption and cost-effective solutions for SPF’s and PAF’s
- Room temperature LNA’s < 2GHz continue to go down in noise temperature. It is however all about optimization: For small-N large-D systems the most efficient design will likely use a cryo cooled LNA. Large-N small-D systems are probably better off using room temperature LNA’s
- Cryo-cooling the receivers of commercial applications (GESTRA, Quasar) is explored to improve sensitivity

Progress – Calibration

- The models of PAF systems are becoming more accurate as we are running into smaller and smaller artifacts. Discrepancies of a few percent are investigated in ASKAP beams.
- Temperature stabilization of RFSoC needed? Alternative: Noise injection
- The sensitivity of EDA2 and AAVS2 are measured accurately by observing differences between 2 all-sky images
- Holographic calibration of gain and phase errors of AAVS2 has been demonstrated
- The on-dish calibration source is used for synchronization the ADC's of a PAF and is a powerful debugging tool
- Substantial effort has gone into understanding and quantifying the calibration accuracy and calibration stability of the AAVS SKA1-Low verification systems

Progress – RFI

- RFI forced the Parkes CryoPAF to split the RF band to avoid 2nd order intermodulation products
- Systems (LOFAR2.0, EDD) are increasing dynamic range to deal with the increased RFI
- “Static” RFI mitigation during beam-weight determination works reliably for Effelsberg
- To adopt RFI mitigation techniques, astronomers need to understand the effects of the algorithms on astronomical figures of merit
- Arrays are more susceptible to RFI (no notch filters), and have more options to mitigate
- Critically sampled filter banks complicate RFI mitigation

Progress – Realtime processing and testing

- RFSoC: facilitates digitization at the receiver, high density, and integrated processing. Careful shielding is needed
- Real-time processing backends based on FPGA's, GPU's and Alveo cards are being used
- Alveo enables moving avoid from custom FPGA board designs. Key advantages are cost savings in hardware and development, less risk, and easier upgrade paths
- Alveo enables flexible full datarate testing (CNIC) of digital backends

Prospects / open issues

- Handling RFI
  - Improved linearity
  - Online RFI mitigation
- Power consumption
- Phased Array Feeds:
  - Reduction of weight
  - Hardware and labor costs
  - Very high system complexity, steep learning curve

PAFAR 2023?

✓Sure!

Thanks to all attendees for your contributions!

Thanks CSIRO and the LOC!