AuScope VLBI Array and Hobart 26-m Antenna

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Abstract This is a report on the activities carried out at the University of Tasmania in support of the three AuScope VLBI observatories and the Hobart 26-m antenna in 2023 and 2024. Our research programs are outlined, along with our planned developments of the array.

1 General Information

The Australian AuScope VLBI array consists of 12-m VLBI telescopes located in Hobart, Tasmania (Hb), Katherine, Northern Territory (Ke), and Yarragadee, Western Australia (Yg). Those three telescopes have all been upgraded to VGOS receivers and backends. This contribution also covers the Hobart 26-m telescope (Ho). While the telescopes are owned and operated by the University of Tasmania (UTAS), the Australian IVS observations are contracted through Geoscience Australia, in the research collaboration *AuScope VLBI Project*. Support for infrastructure is also provided through AuScope, funded by the Australian Government through the National Collaborative Research Infrastructure Strategy, NCRIS. During the reporting period, a new funding agreement was signed for the period 2023 through 2028 (five years).

Since 2024, the University of Tasmania has been a recognized partner of the United Nations Global Geodetic Centre of Excellence.

University of Tasmania, Australia

UTAS, AuScope, Hb, Ho, Ke, Yg Network Stations

IVS 2023+2024 Biennial Report

Fig. 1 UNGG-CE partnership logo.

2 Component Description

The AuScope VLBI array was initially designed as three identical telescopes with the technical specifications for legacy operations detailed in [2]. Today, all three telescopes have been upgraded to VGOS sites and have joined the IVS VO sessions. Details about the system can be found in [3]. It should be noted that Yg and Ke are remote sites, more than a full day's travel away from the VLBI specialists in Hobart. While there is support at Yarragadee through the co-located SLR equipment, there is no permanent technical support in Katherine.

The AuScope array continues to contribute important southern baselines to the IVS network across both legacy and VGOS sessions. Having three stations provides redundancy, with the effects of unforeseen outages and maintenance at one site offset by the other two stations.

The Hobart26 telescope's availability has been reduced over the period due to ongoing maintenance issues. Repairs and upgrades are pending on the completion of work being carried out by other groups at the University of Tasmania.

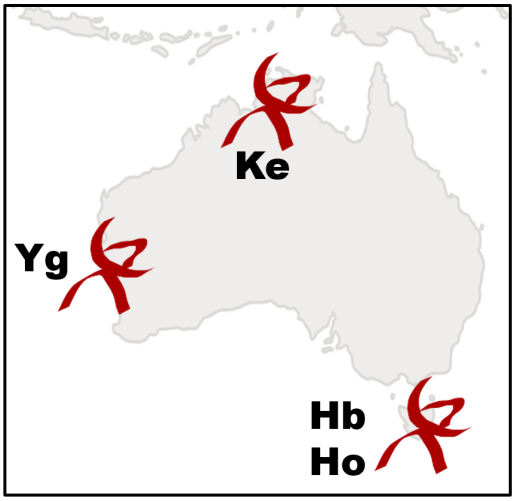

Fig. 2 Map of AuScope VLBI array.

2.1 Hobart 12-m

Hobart12 has been observing in legacy S/X and regular VGOS sessions throughout this period, although with ongoing issues with the phase calibration system. A number of tests and modifications have been made but without resolving the problem.

Hobart12 is also suffering from an increasingly hostile RFI environment with strong local transmitters pushing towards the LNA saturation point. With little remaining "headroom" we are vulnerable to desensitization of the entire receiving system when new transmitters become active or more prominent due to boresight alignment.

2.2 Yarragadee 12-m

The transition from the S/X system to the VGOS feed began mid-2023 with the installation of the receiver. Unfortunately, the RF-over-Fiber (RFoF) system was damaged during installation, and its repair caused a six month outage for the station. Yarragadee began observing with the VGOS feed at the start of 2024 in the "mixed-mode" configuration and subsequently as a tagged-along VGOS station over the course of 2024. A 10 Gbps fiber-optic connection was installed and brought into operation at the start of 2024, bringing the era of physical data transport to an end.

2.3 Katherine 12 m

Katherine has had a number of unplanned outages over the period, mostly due to issues with the power supply or cooling systems. As the previous S/X system was non-cryogenic and our receiver commissioning was undertaken in Hobart, we had not fully understood the challenges involved in operating the cryogenic VGOS receiver in tropical conditions. Upgrades to both our cooling design and monitoring systems will hopefully improve the situation.

2.4 AuScope VGOS Signal Chain

The AuScope VGOS setup emerges from a retro-fit of callisto receivers into the original telescopes and has repurposed parts of the original S/X signal chain. A splitter is in place immediately after the LNA output where one output passes through a 3-GHz High-Pass Filter. This 3–13.5 GHz bandpass is then sent via an RFoF system to the control room and then bandpass-filtered (at RF) as inputs to the DBBC3, where down-conversion to IF is performed. The other output of the splitter is sent to the original S/X downconversion system, where the S-band signal is bandpass-filtered, downconverted, and conveyed at IF to the control room over coaxial cables. A coax switch is installed with the S-band and 3–7 GHz inputs, connected to the DBBC3, which allows us to switch between a mixed-mode or VGOS configuration without requiring any recabling. A modification was made in 2024 to make an additional split of the unfiltered signal and send the L-band component over coax to the control room; this signal path is re-using the old X-band post-downconversion backend. It should be noted that L-band is well outside of the nominal operating range of the receiver, and the sensitivity is far too low for detecting astronomical sources, but it is well-suited to making observations of GNSS satellites [4].

2.5 Hobart26

The 26-m telescope is available for occasional IVS observing (primarily CRF sessions). This telescope is currently functional, although with many systems being

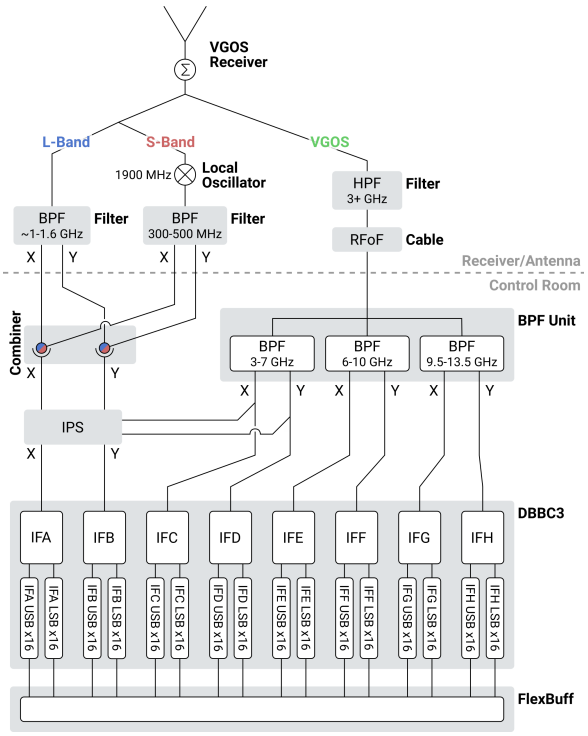

Fig. 3 Signal chain of the AuScope 12-m VGOS telescopes.

overhauled at the moment, performance is unreliable. The K-band receiver is currently inoperational.

3 Staff

Routine operations, maintenance, and development are undertaken by staff members, while experiment monitoring is usually carried out by PhD students. All staff are affiliated with the University of Tasmania in Hobart, where we have also established a small research group (see Table 1).

4 Current Status and Activities

During 2023 the AuScope array and Hobart26 participated in 189 IVS-scheduled 24-hour sessions, with the number decreasing to 168 in 2024. The difference is largely due to the completion of the AUM experiment series in 2023.

4.1 Observations

The AuScope stations have contributed to 168 days of IVS observing in 2024. Additionally, we have observed 45 Southern Intensives with Ht (Hb and Yg) over the same period. Australian VGOS sessions (VAU, one to four hours) are currently observed at a monthly cadence.

All three telescopes have joined the VO sessions (with Yg currently in commissioning period), although the performance is not satisfactory. The phase cal stability seems to be the primary issue and has been improved but is still unreliable, with odd systematics.

It should also be noted that the AuScope telescopes are of lower sensitivity than other VGOS stations ($\approx$ 4500 SEFD across the band) and that the stations are slower slewing than the VGOS specifications. New mobile phone services in Hb are causing severe issues for the wideband receiver and DBBC3, especially in VGOS bands A and B.

All three telescopes join the R1/R4 and other legacy sessions in the “Australian” mixed-mode. This means that the VGOS equipment is used to record the legacy S/X frequencies only [3].

4.1.1 AUSTRAL Sessions

AUSTRAL sessions [5] are an important part of the AuScope project, contributing observations of Southern sky sources as well as providing an opportunity for quick feedback about station performance.

4.1.2 Southern Intensives

Since 2021, the Southern Intensive sessions [1] have been operationally observed on the Hart15M-Hobart12 baseline. With Yarragadee now having access to a fast network connection, it has been added to the network. The sessions are observed on Monday evening (Australia time) and the results are made available the next day, generally in less than 24 hours.

4.1.3 Correlation

Routine UTAS correlation has now shifted almost entirely to the *Gadi* HPC located on mainland Aus-

Table 1 Staff.

Name	Role	Topics
Jamie McCallum	AuScope array manager	Operations & Development
Warren Hankey	Technical support	Technical support and data transfers
Brett Reid	Observatory manager	Maintenance, repairs, and implementation of new systems
Earl Sullivan Lester	Technical support	telescope technician
Anthony Polowy	Technical support	Electronics specialist, part-time
Lucia McCallum	AuScope scientist	Research, AOV chair, IVS network representative, part-time
Tiege McCarthy	Post-doc	Project work, correlation
Boye Zhou	Post-doc	Research, until 12/2024
Lim Chin Chuan	PhD student	Research, dynamic observing, graduated in 2023
David Schunck	PhD student	Research, satellite VLBI
AuScope observers		about 12 regular observers

tralia. This routine correlation includes the weekly Southern Intensive (IVS-INT-S) sessions, the monthly AUSTRAL 24-hour sessions, and our local Australian VGOS test sessions. The flexibility of the *Gadi* HPC allows for scaling of our correlation operations up into the future as data volumes and computational requirements increase. Moving correlation off-site, and onto mainland Australia, allows for increased data transfer throughput, with all raw data for correlated sessions e-transferred directly onto our *Gadi* storage allocation.

4.1.4 New Connections

Yarragadee has been connected with a 10 Gbps fiber optic cable since mid-2024 and has shifted entirely to e-transfer. Katherine is due to follow in mid-2025, although this is still awaiting planning approval for the new cables to be laid.

Data transport is still a major bottleneck for our observations. We currently get multi-Gbps (2 – 3) within Australia and around 1 Gbps to Bonn. Ending media shipments has removed an unavoidable latency and improved the ease and reliability of data transport.

4.2 Spectrum Protection

The AuScope VLBI project acknowledges the need for increased frequency protection for VGOS. Project staff have now liased with the Australian representatives for Radio Astronomy Service (RAS) frequencies and joined the Australian Spectrum Authority (ACMA), as well as the Radio Astronomy Frequency Committee in the Asia-Pacific region (RAFCAP).

4.3 Students and Generating a Future VLBI Workforce

In 2023, the first PhD student at UTAS with a topic in geodetic VLBI graduated [10]. This hopefully marks the beginning of a number of VLBI scientists to graduate in the future. The group also provides co-supervision to a PhD student from the Indian Institute of Technology Kanpur. In 2023, we hosted a VLBI staff member from GSI Japan for a one year research stay, greatly enhancing our long-term collaboration in the region.

4.4 Station Feedback

We are working on generating station performance reports, enabling improved feedback to stations. This is a collaboration with colleagues from Ny-Ålesund, Yebes, and Santa Maria, and it is recognized as an IVS pilot project.

4.5 Hobart 26-m Gravitational Deformation Model

In 2024, the Hobart 26-m telescope was surveyed via close-range aerial photogrammetry with the aim of de-

riving a model accounting for VLBI path length variation due to gravitational deformation. This project was done in collaboration with Cornelia Eschelbach and Michael Lösler from Frankfurt University of Applied Sciences and Ansgar Greiwe from Hochschule Bochum. The results of this survey are published in [9].

Fig. 4 Ho telescope being surveyed via aerial photogrammetry.

4.6 VLBI Satellite Tracking

Funded by the Australian Research Council (ARC), at UTAS we investigate VLBI observations to satellites, aiming for improved space ties. Current work covers the technical realization of such observations [4] as well as simulation studies [8, 7, 6]. We are also active contributors to relevant working groups, in particular by chairing IVS WG7.

5 Future Plans

The next priority for the AuScope project is reliable VGOS performance and increased feedback and performance monitoring. This goes along with more automation of our operations, in order to prepare for increased cadence. In-house VGOS sessions and close collaboration within the AOV are a priority as well. We are most excited about the fiber connection coming to Katherine, which will be a major game changer and enabler for our future observations.

Acknowledgements

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