AuScope

AN ORGANISATION FOR A NATIONAL
EARTH SCIENCE INFRASTRUCTURE PROGRAM

UTAS

The AuScope VLBI Array

Astounding Stories of Super Science

Hobart, Tasmania
April 2012

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Outline

- AuScope project overview
- The VLBI array
- Current operations
- Future work

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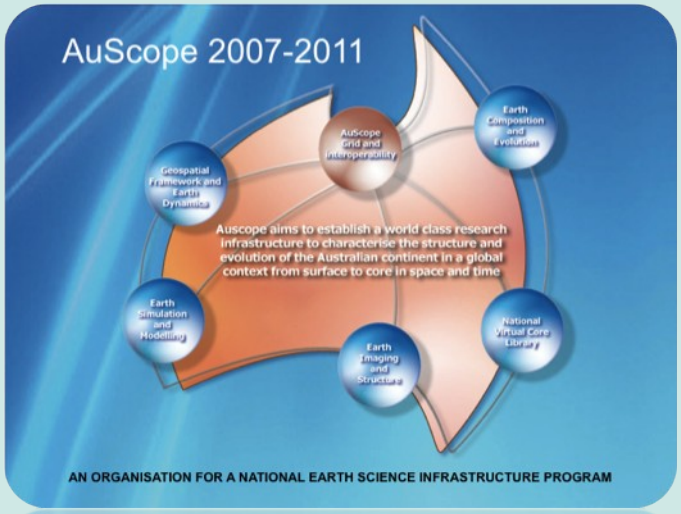
The AuScope Project



- AuScope is funded through the Federal Government's National Collaborative Research Infrastructure Strategy (NCRIS). Infrastructure to provide an integrated spatial positioning system spanning the whole continent. Divided into 5 components, including Geospatial
- The Geospatial component received $15.8M in NCRIS funding plus funds from Universities and State/Territory government. Infrastructure includes
  - 3 x 12m radio telescopes and a correlator
  - ~100 GNSS receivers spanning the continent
  - SLR upgrades
  - An absolute gravimeter and 3 tidal gravimeters
  - Improved computing facilities

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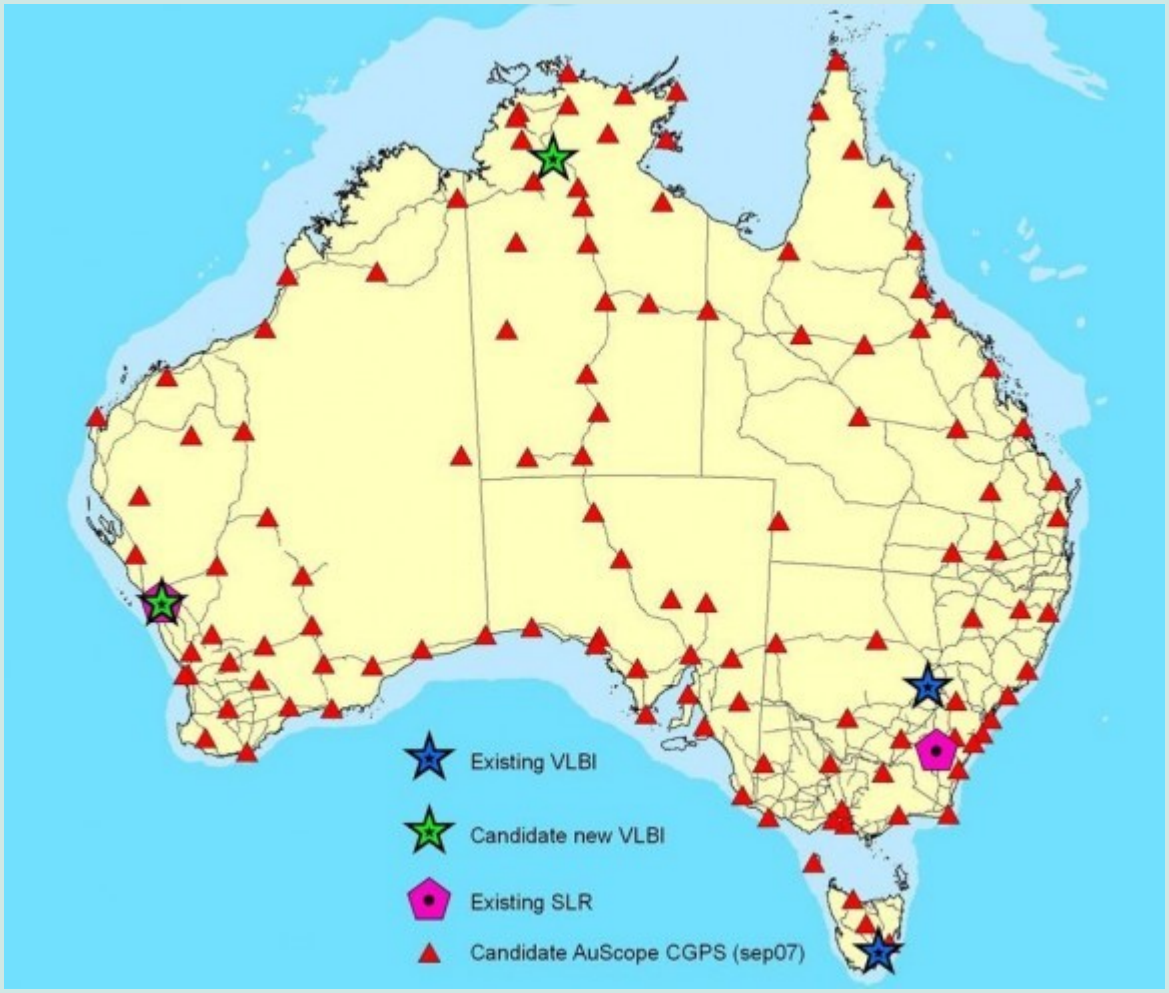
The AuScope VLBI Array

- Three new telescopes built in Hobart (Tas), Katherine (NT) and Yarragadee (WA)
- Remotely operated from University of Tasmania campus



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Timeline

- 2007-2009 – Project planning, contracts, design
- April 2010 - First fringes to Hobart 12m
- November 2010 – Katherine telescope built
- December 2010 – First fringes to Katherine
- April 2011 – Yarragadee completed & first fringes
- June 2011 – First IVS observation using entire AuScope array

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The AuScope VLBI Array

- Locations chosen for infrastructure, baselines.
- Co-located with other geodetic techniques if possible

- Hobart near to existing 26m dish, gravimeter
- Katherine is a new site
- Yarragadee has an SLR station, gravimeter, DORIS.

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Telescope Specs

- 12m diameter dishes
- Fast slewing rates (Az 5°/s, El 1.5°/s)
- S/X coaxial feeds
- Tsys ~ 80-100 K
- SEFD ~ 3200-4000 Jy
- Capable of recording up to data rates of 2 Gbps

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VLBI2010

- “VLBI2010” is a set of design principles for next-generation geodetic observatories
- Laid out in 2006/2007
- Primary aim is to have very short integration times & very fast slew rates (atmosphere)
- Accurate construction, high stability (1mm position, 0.1 mm/year over lifetime of telescope)
- Requires small(-ish) telescopes, high data rates (16-32 Gbps)
- Wideband receivers
- e-transfer / e-vlbi

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VLBI2010

- Aim is 1mm position accuracy is geodetic solutions, 0.1 mm/year in velocity on a global scale
- Continuous observations & real-time results.

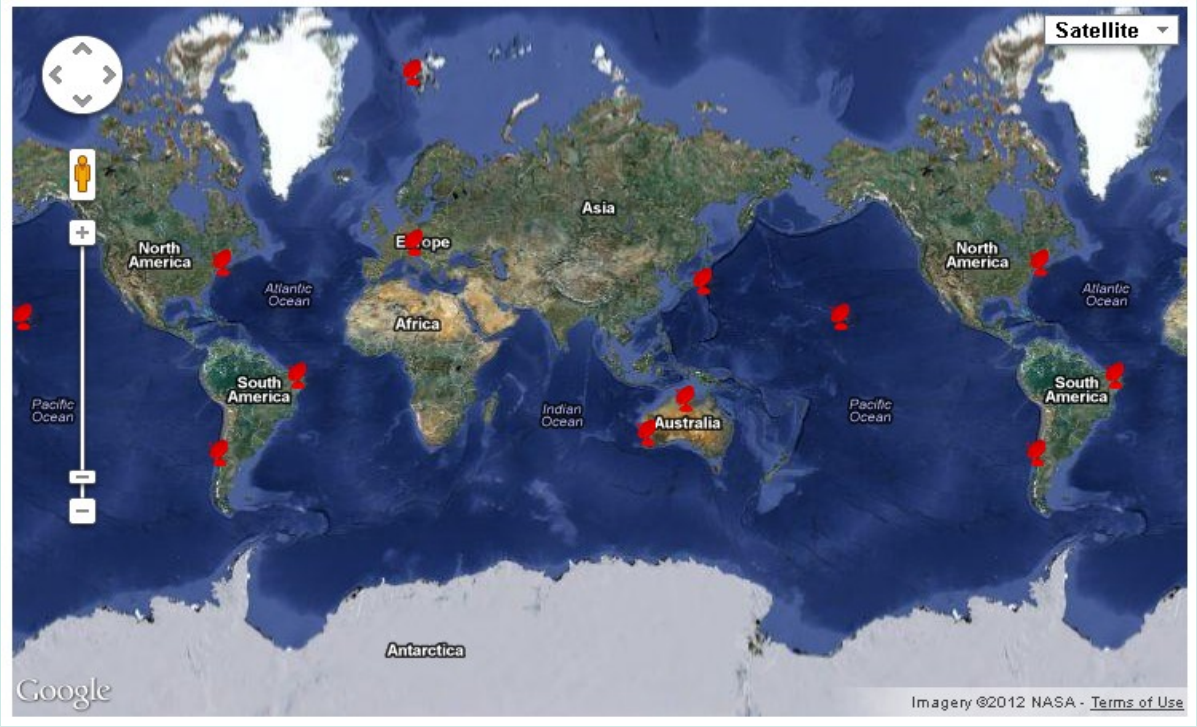
- AuScope telescopes are not full VLBI2010 systems but have upgrade paths
- Are in operation now.

Current Operations

- All 3 telescopes in regular IVS observations
- CONT11
- e-VLBI to Tsukuba
- AUSTRAL experiments
- Astronomical observations with the LBA

IVS Observations

- Scheduled for 142 observations in 2012 (53 Hb, 43 Ke, 46 Yg)
- Mostly “Rapid” experiments (2-weeks from observation to geodetic results
- Observing in legacy mode (256 Mbps) to match other telescopes in the network



Station map of last night's IVS observation using Ke & Yg

From the IVS live page at http://ivslive.obs.u-bordeaux1.fr/

IVS Observations

- Station positions at cm-level precision

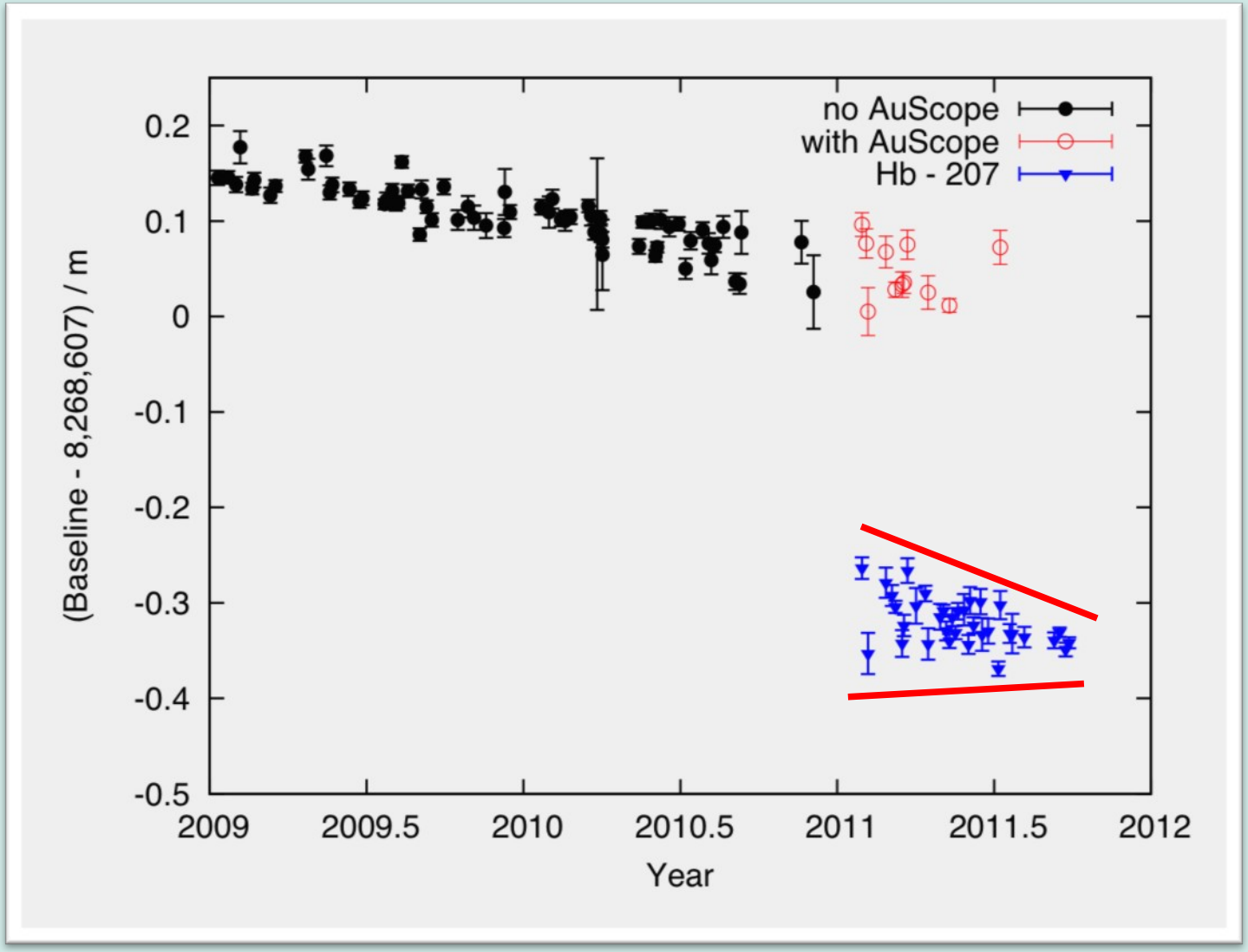
Station	Latitude	Longitude	Height (m)
Hobart	−42 48 20.06380 (±0.0004, 0.0004)	147 26 17.3055 (±0.0005, 0.0008)	40.971 (±0.011, 0.012)
Katherine	−14 22 31.66897 (±0.00024, 0.00033)	132 09 08.5430 (±0.00044, 0.0005)	189.257 (±0.013, 0.013)
Yarragadee	−29 02 49.72375 (±0.00044, 0.0004)	115 20 44.2564 (±0.0009, 0.00054	248.239 (±0.014, 0.012)

- Hb position in good agreement with local tie survey
  - Hobart 12m-26m baseline

    VLBI 295.92 ± (σ = 0.007, wrms = 0.020) m

    Local tie 295.918 ± 0.001 m (Ruddick & Woods 2009)

Hobart to Kokee



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CONT11

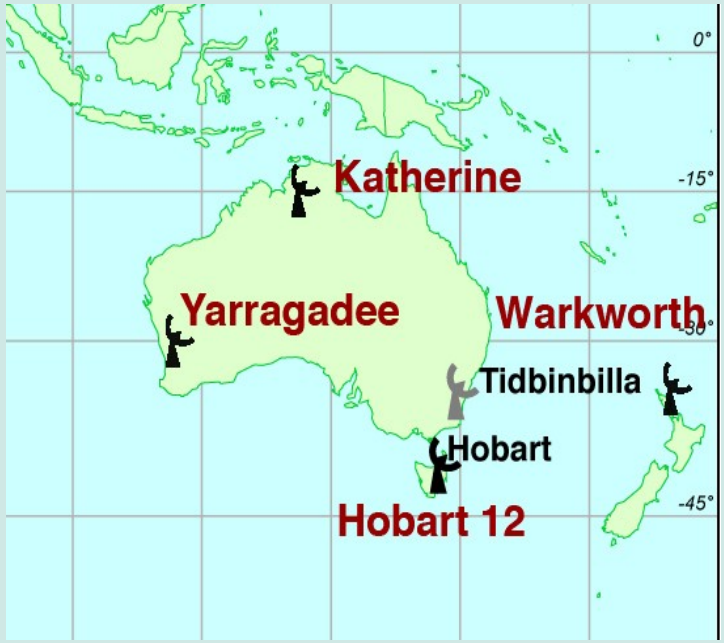
- Hb participated in CONT11
- 15 days of continuous IVS observations
- Daily EOP measurements
- Opportunity to estimate systematic errors

e-VLBI to Tsukuba

- 10 Gbps link out of Hb
- Hobart 12m has joined with the Ultra-Rapid EOP project with Tsukuba, Onsala
- Near-real-time data transfer, correlation and analysis
- On-Ts gives dUT1
- Hb-Ts baseline provides axis orientation (Xp, Yp)
- First successful observation in Nov 2011. More observations this year.

AUSTRAL experiments

- AuScope + NZ Warkworth telescope
- Scheduled to use the high slewing rates of these antennas
- Recording at 1 Gbps
- Early analysis indicates improvement in solutions (vertical component by factor of ~2), and atmosphere.
- Further experiments planned...



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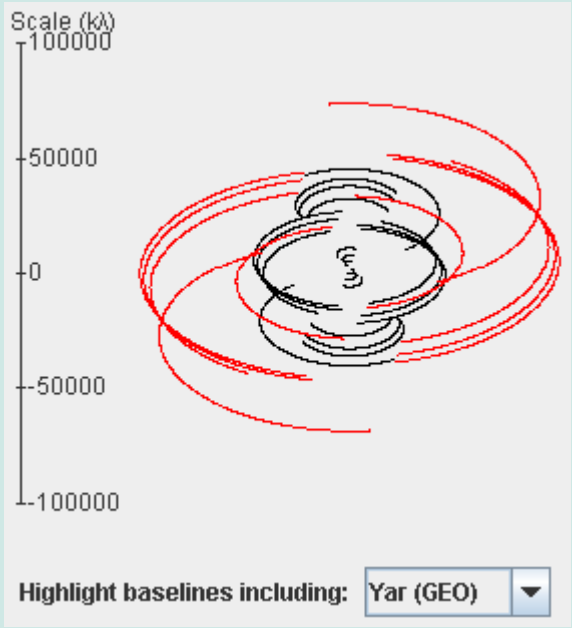
Astronomical observations

- Adding Ke & Yg to the LBA increases the number of stations and adds long baselines (2000-3500 km)
- Fills in *u,v* plane when NZ & ASKAP are included
- One trial observation successfully correlated
- Ke & Yg will participate in the next session (26th April - 3rd May)



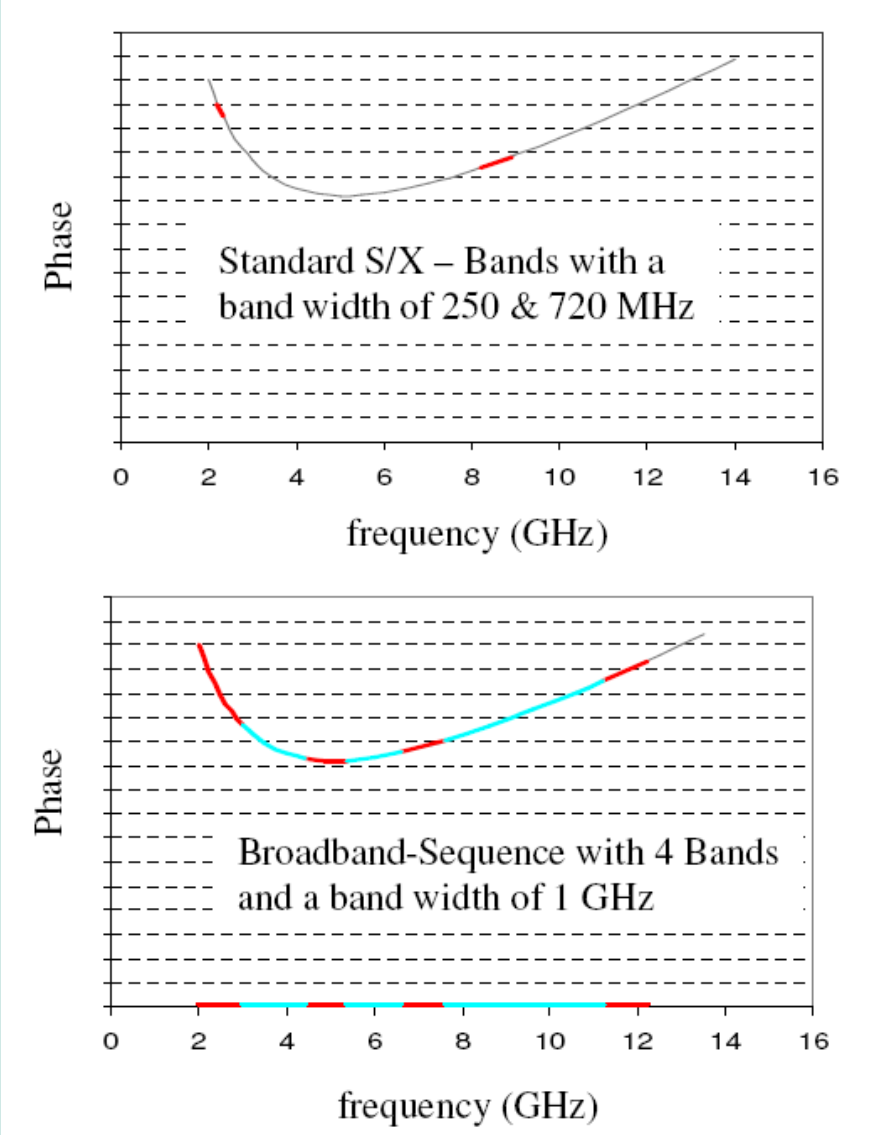
From the ATNF sensitivity calculator, showing simulated coverage of a source at declination -30, using ATCA, Mopra, Parkes, Hobart & Ceduna.

Future Work

- Broadband feed upgrade
- Deformation studies
- “Sibling” telescopes at Hobart
- NZ collaborations

Broadband Feed

- Better freq coverage means better delay resolution
- More bandwidth means greater sensitivity
- Receivers are becoming available, but require cryogenic systems...
- Also requires wideband mixers and/or samplers
- Upgrade plans under consideration but this is a priority for AuScope



From Kronschnabl et al. (2011)

Deformation Studies

- AuScope telescopes were designed to have good mechanical properties, but this is untested
- Geodetic analysis has a model of site deformation for thermal expansion
- Can independently measure these with a robotic survey instrument together with thermal sensors
- Useful in establishing & correcting systematic errors

Fig 2: Target placement on front (left) and back (right) of the Hobart 12m telescope. The red circles are targets used to determine the azimuth axis, and the blue circles are targets used to determine the elevation axis.

TDRA6000 3D Point Accuracy*:
U_{XYZ} ≤ 30 m: ± 0.5 mm
U_{XYZ} > 30 m: ± 0.3 mm + 13 µm/m
*Maximum Permissible Error (MPE) ~±3σ, Typical accuracies are ½ MPE)

0.5" TBR Targets:
Acceptance angle ± 20°
Magnetic mounts, rotating stands for each TBR (Fig 5).

Fig 4: Robotic total station (Leica TDRA6000) specifications and 0.5" TBR reflector selected for targeting over the telescope.

From Watson et al. (2012)

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“Sibling” Telescopes

- A number of geodetic sites are building “twin telescopes” for VLBI2010 observation
- Share common clocks, atmosphere during an observation
- At Hobart, have “sibling” telescopes with the new AuScope 12m & 26m

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“Sibling” telescopes

- Common clocks & atmosphere should be useful in constraining geodetic solutions*
- Several proposed observing modes
  - Both observe the same source
  - Each observes a different source (with different network of other telescopes)
  - One observes while the other slews to source
- Simulations indicate that option 2 is best for twin telescopes.
- Aim to simulate for sibling telescopes & test predictions

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NZ Collaborations

- AUT's Warkworth antenna same design as AuScope, located on Australian continental plate
- Expanded AUSTRAL experiments using high slewing & data rates.
- A dedicated CONT experiment to better characterise systematic errors.
- Regular NZ-Australia baseline measurement
- Rapid EOP estimation via e-VLBI
- Imaging of geodetic quasars

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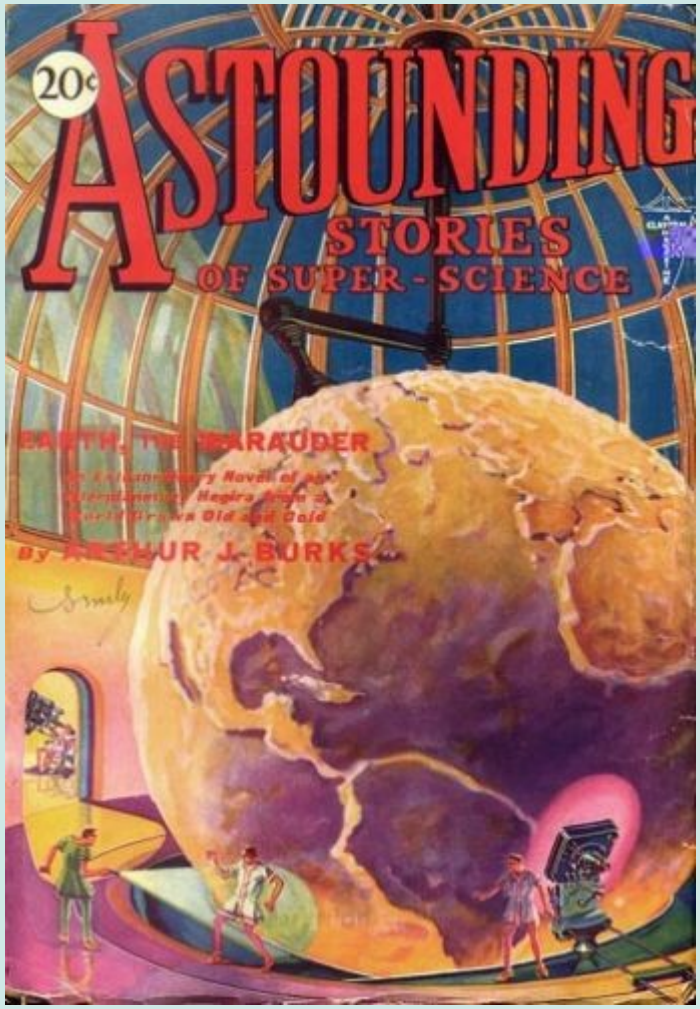
Thank you.

Any Questions?



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