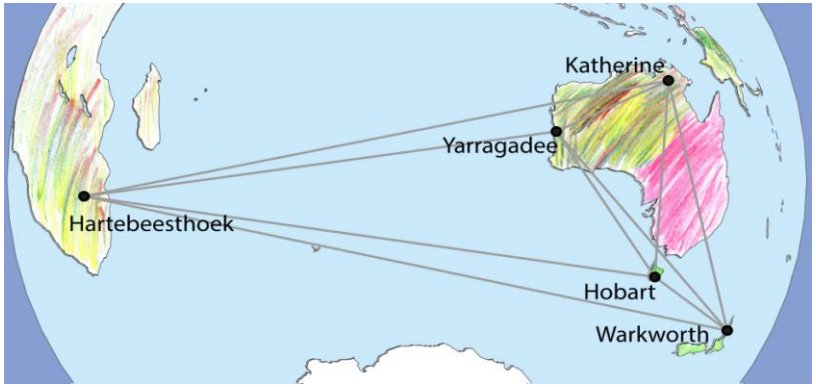
The AuScope VLBI Array



Jim Lovell, Jamie McCallum, Lucia Plank, Elizaveta Rastorgueva-Foi, Stas Shabala : *University of Tasmania*

David Mayer, Johannes Böhm : *Technical University of Vienna*

Oleg Titov : *Geoscience Australia*

Jonathan Quick : *Hartebeesthoek Radio Astronomy Observatory*

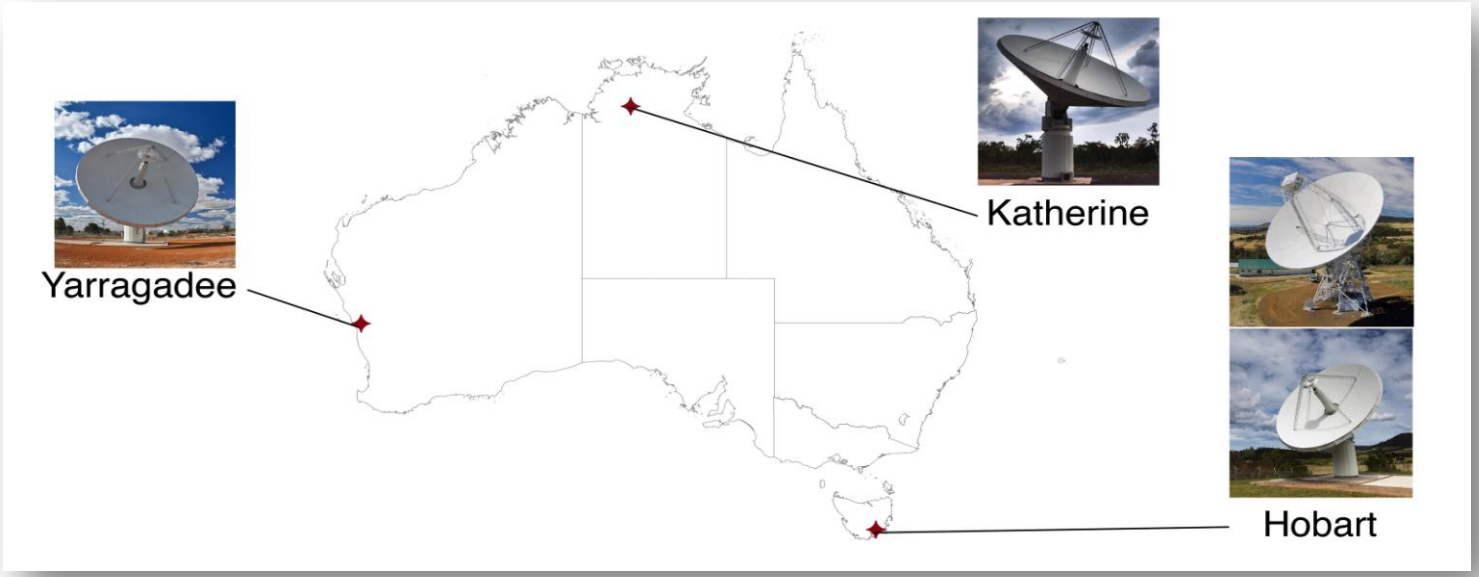
Stuart Weston, Sergei Gulyaev, Tim Natusch : *Auckland University of Technology*

Cormac Reynolds, Hayley Bignall : *Curtin University*

Jing Sun : *Shanghai Astronomical Observatory*

Alexander Neidhardt : *Technical University of Munich*

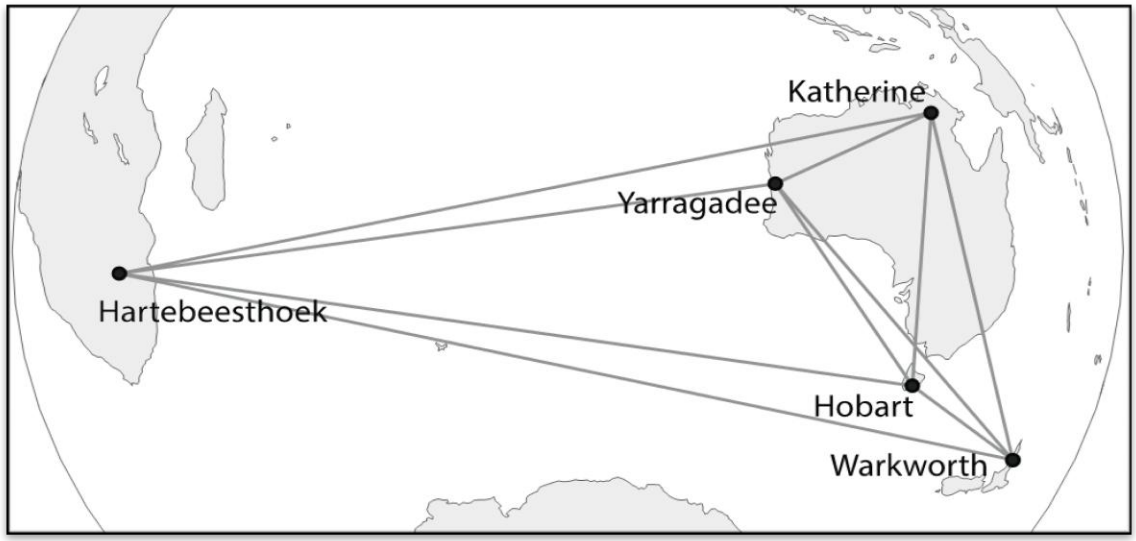
AuScope VLBI Array: 2010 - 2015



- 3 x 12m telescopes. Small, fast
- Room temperature SX, 3500 Jy
- DBBC2, Mark5B+
- Operations centre at UTAS
- Correlation at Curtin Uni (WA) until Sep 2015
- Scheduling and analysis capability in collaboration with TUW

The AUSTRAL Program 2013 - 2015

- As well as regular IVS observations (~100 days per year), 120 days per year AUSTRAL from 7/2104 to 6/2015
- AuScope (100%) + Warkworth (50%) + Hart15 (50%)
- Aims
  - 11 days of astrometry to monitor and enhance the southern hemisphere celestial reference frame (~6 sessions including Parkes 64m);
  - 184 days of geodesy to improve the southern hemisphere terrestrial reference frame and the baseline time series;
  - 2 x 15-day CONT-like sessions to densify the time series and investigate a range of observing strategies.
  - 6 sessions changed to AOV for regional geodesy and astrometry (Poster P2-02)
- Scheduling in ViEVS
- 1 Gbps data rates (4 x R1/R4 rates)
- Correlation at Curtin
- Analysis at UTAS

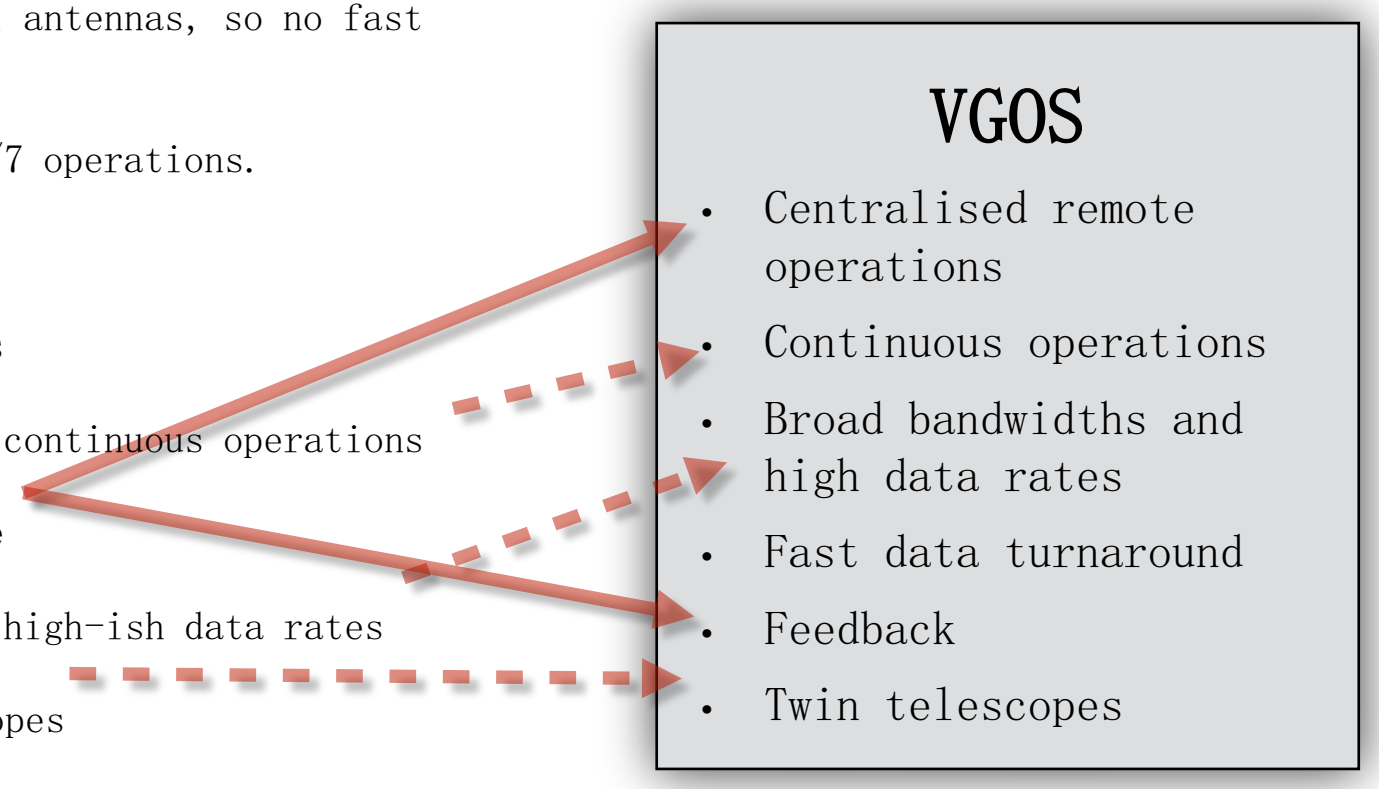


The Challenges of VGOS

- Continuous operations
- Centralised remote operations
- Broad bandwidths and high data rates
- Fast data turnaround
- Feedback:
  - Closing the loop from scheduling to analysis to scheduling
  - During observations: Dynamic observing
- How best to use twin telescopes

AuScope and the AUSTRAL program can address some of the challenges

- We don't have:
  - Broadband systems yet
  - Fast networks to all antennas, so no fast turnaround
  - Enough funds for 24/7 operations.
- But we do have:
  - Small, fast antennas
  - Funding for ~60% of continuous operations
  - An operations centre
  - DBBCs and Mark5B+ : high-ish data rates
  - ~~Twin~~ sibling telescopes



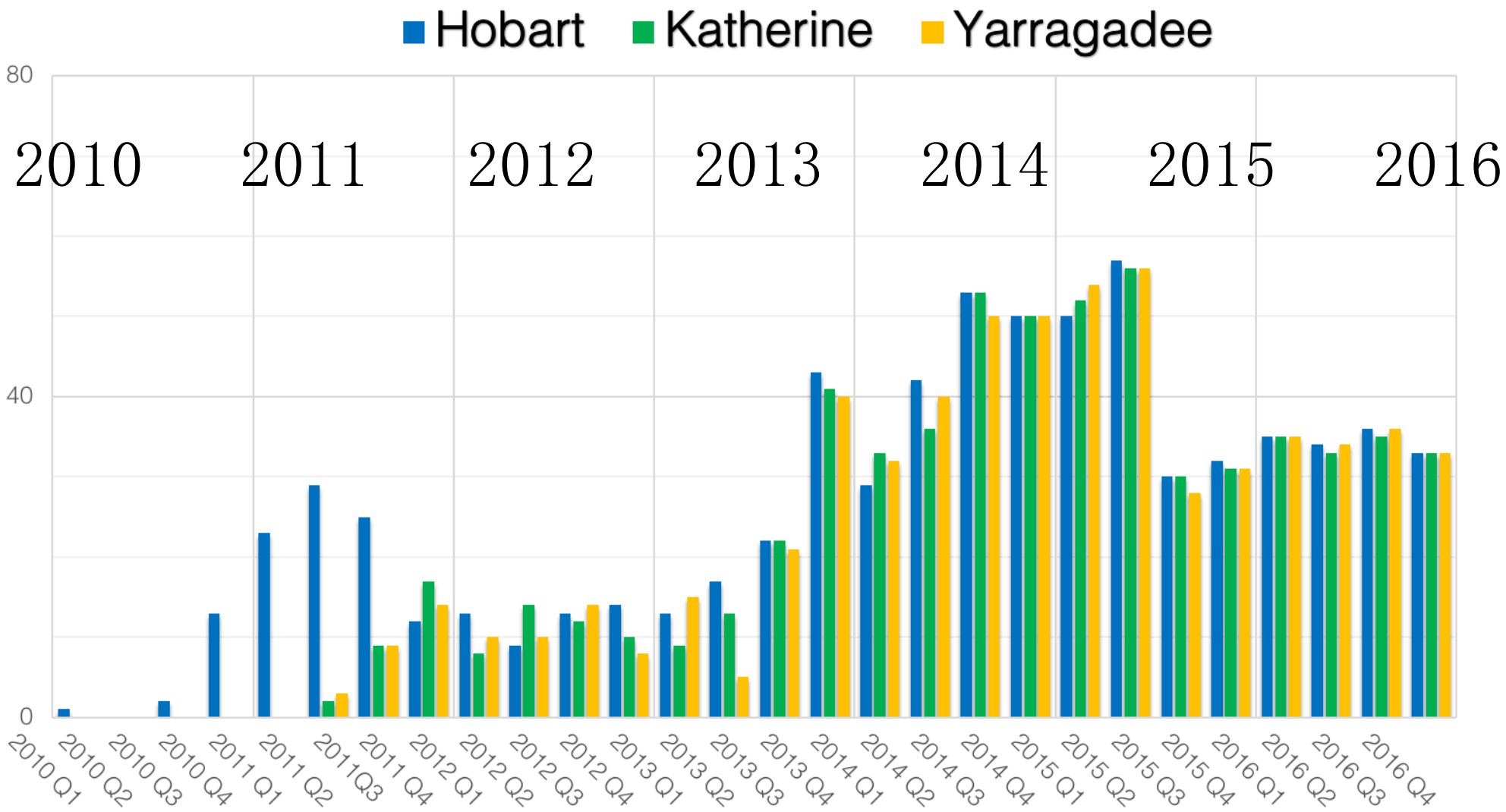
Centralised Remote Operations

Remote Operations

- All AuScope antennas and Parkes are remotely operated.
  Monitor Ht, Ww
- ERemoteCtrl (Wettzel)
- MONICA (CSIRO)
- PCFS (NASA)
- jive5ab (JIVE)

Continuous Operations

We're Busy


Hobart
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2014 Q3
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2015 Q1
2015 Q2
2015 Q3
2015 Q4
2016 Q1
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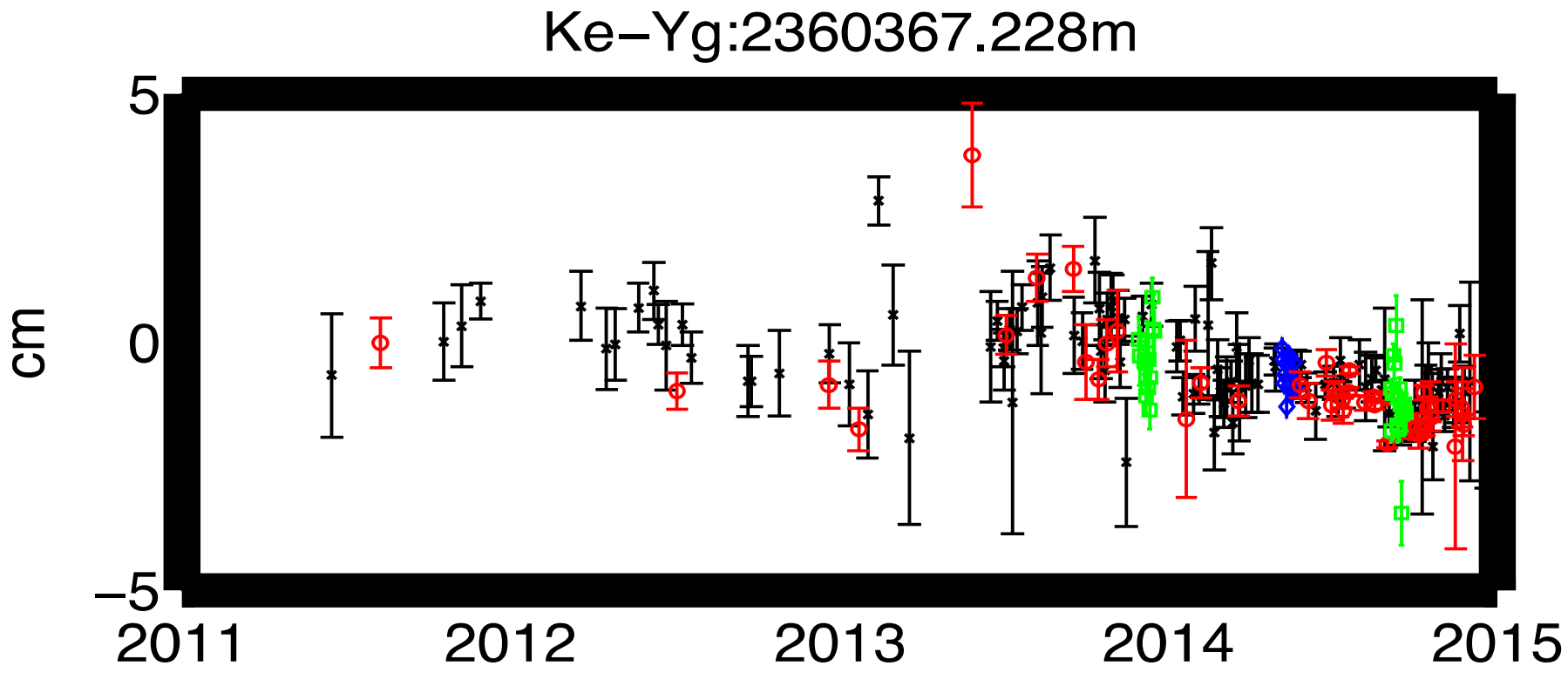
2016 Q3
2016 Q4

Dense time-series

- Identify systematics, trends on shorter timescales
- Comparison of GNSS and VLBI



From Plank et al 2015. , IAG Symposia (REFAG), accepted

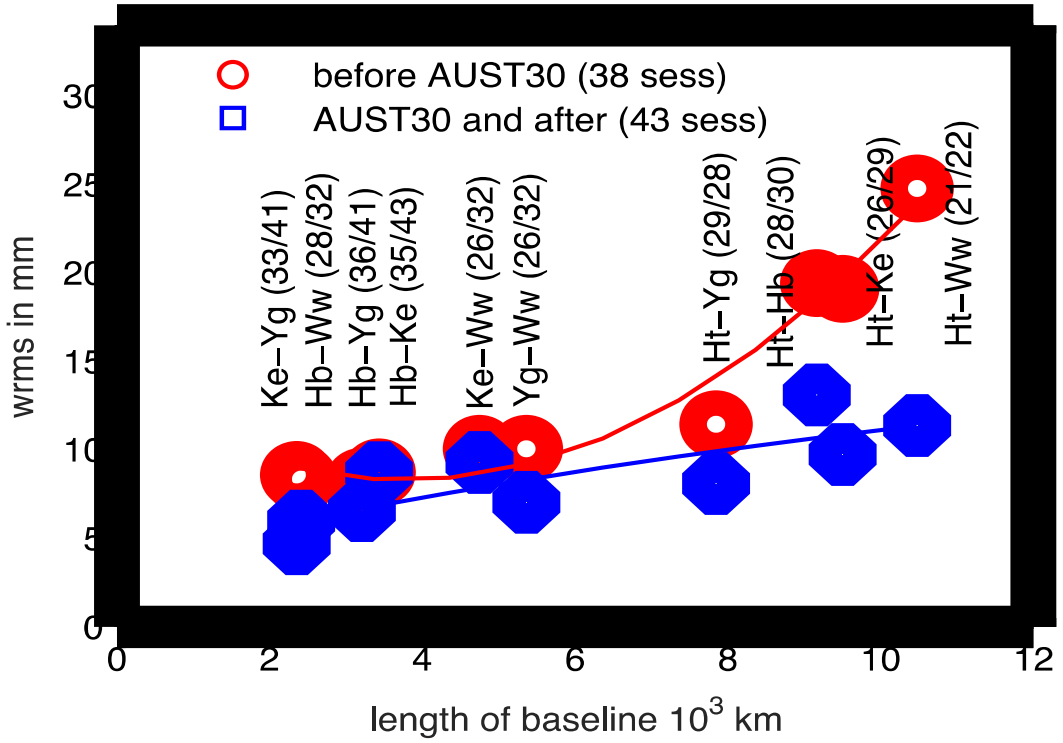
Broad bandwidths, high data rates

- AUST data rates are currently 1 Gbps (16 MHz IFs, 2 bit). compensates for higher SEFD of small antennas with room temperature SX systems.
- 2 Gbps is also possible

Feedback

Post-session feedback: Scheduling Optimisations

Scheduling strategy changed after AUST30. Stronger sources and algorithm changes gave a 2 x increase in scans per day

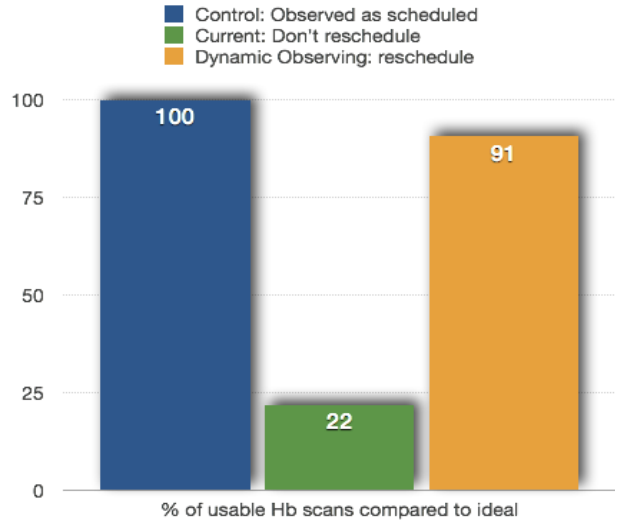


From Plank et al 2015. , IAG Symposia (REFAG), accepted

Intra-session optimisations: Dynamic Observing

- We schedule VLBI observations in the same way we did 30 years ago. Antennas, correlators are scheduled the year before, schedule files produced a week before. Inflexible!
- 80% of the data are kept for R1/R4 sessions. Losses due to station problems/failures.
- We can do better!
- Dynamic observing:
  - Feedback from telescopes and correlator in real-time to optimise schedule on-the-fly
  - Requires centralised operation of array, good networks etc.

- Advantages in re-scheduling in real time (real data):
  - Effectively a simulation of an antenna with poorer than expected sensitivity



Scenario)	Number)of)scans)	Number)of) observa1ons)	Number)of)successful) Hb)observa1ons)	%)successful)Hb) observa1ons)
Observed(as(scheduled(	804(	1498(	394(	100(
Current:(Don't(reschedule(	652(	1190(	86(	22(
Dynamic(Observing:(reschedule(	793(	1470(	357(	91(

Source structure feedback

- Source structure mitigation strategies.
  - Stas' talk tomorrow

Twins

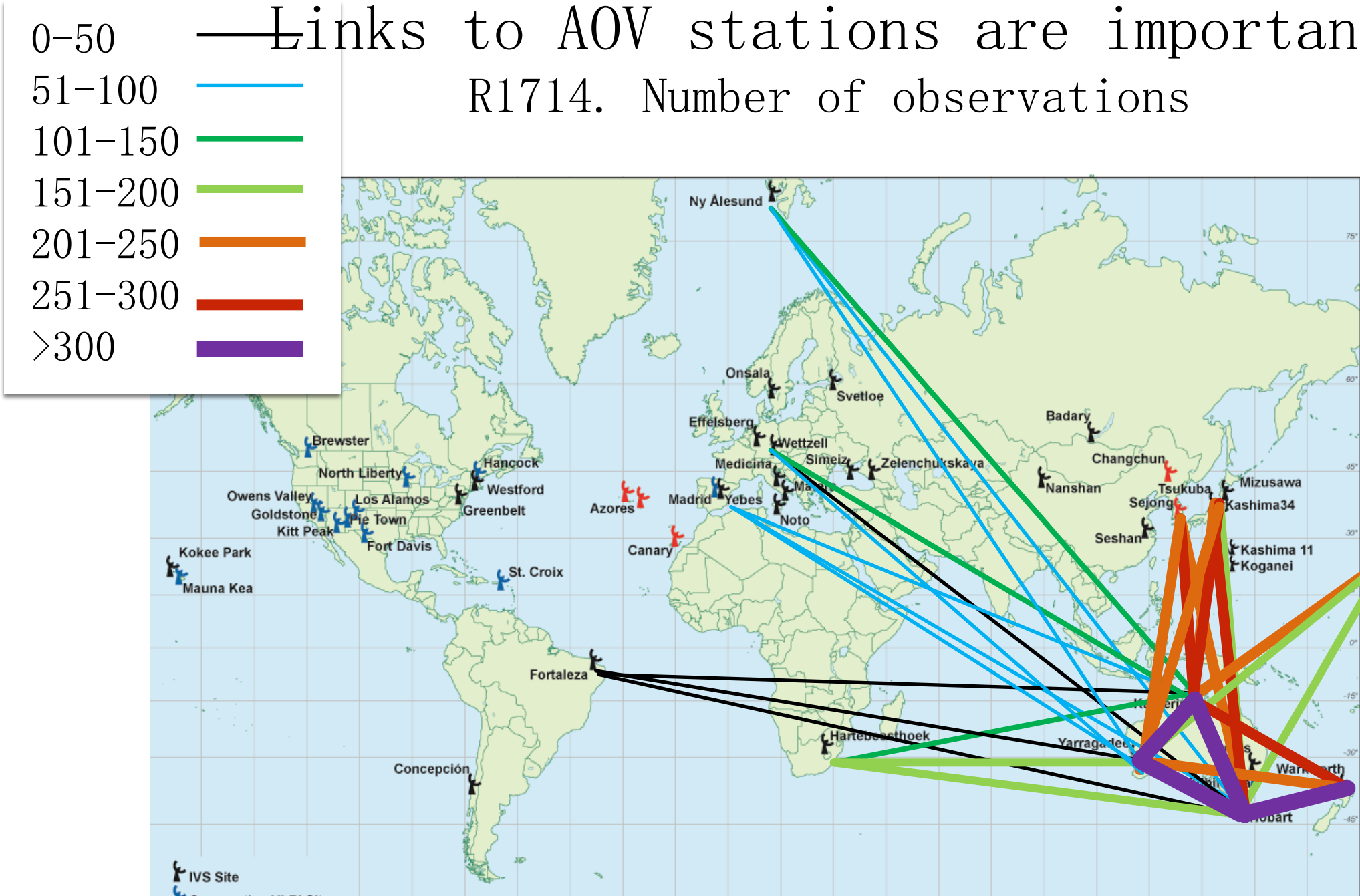
- See Lucia's talk tomorrow

We need to upgrade to VGOS

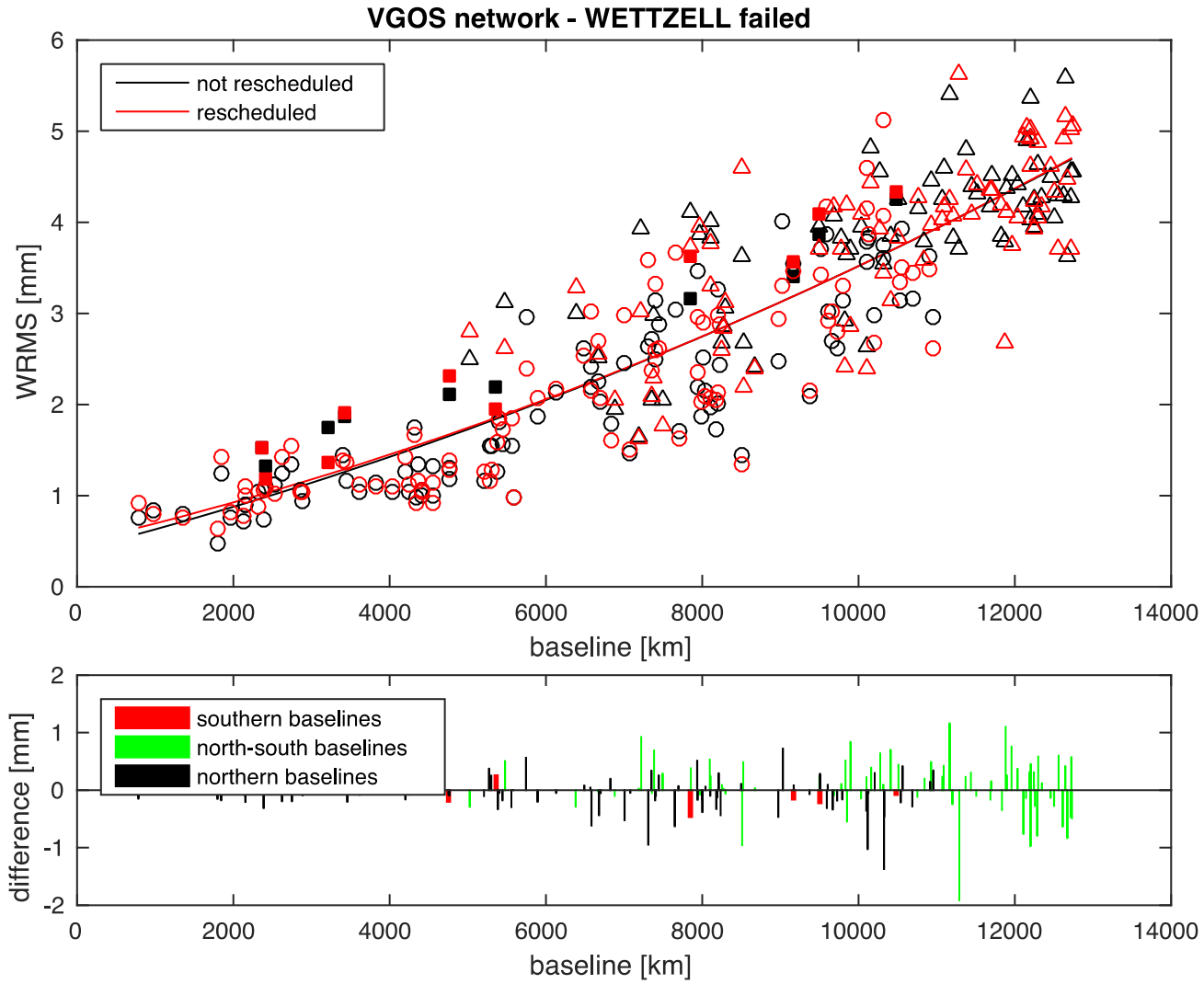
- All southern stations need to upgrade, and we need more southern stations. If not, the north-south imbalance will be back.

Links to AOV stations are importan

R1714. Number of observations



VGOS simulation (D. Mayer, L. Plank)



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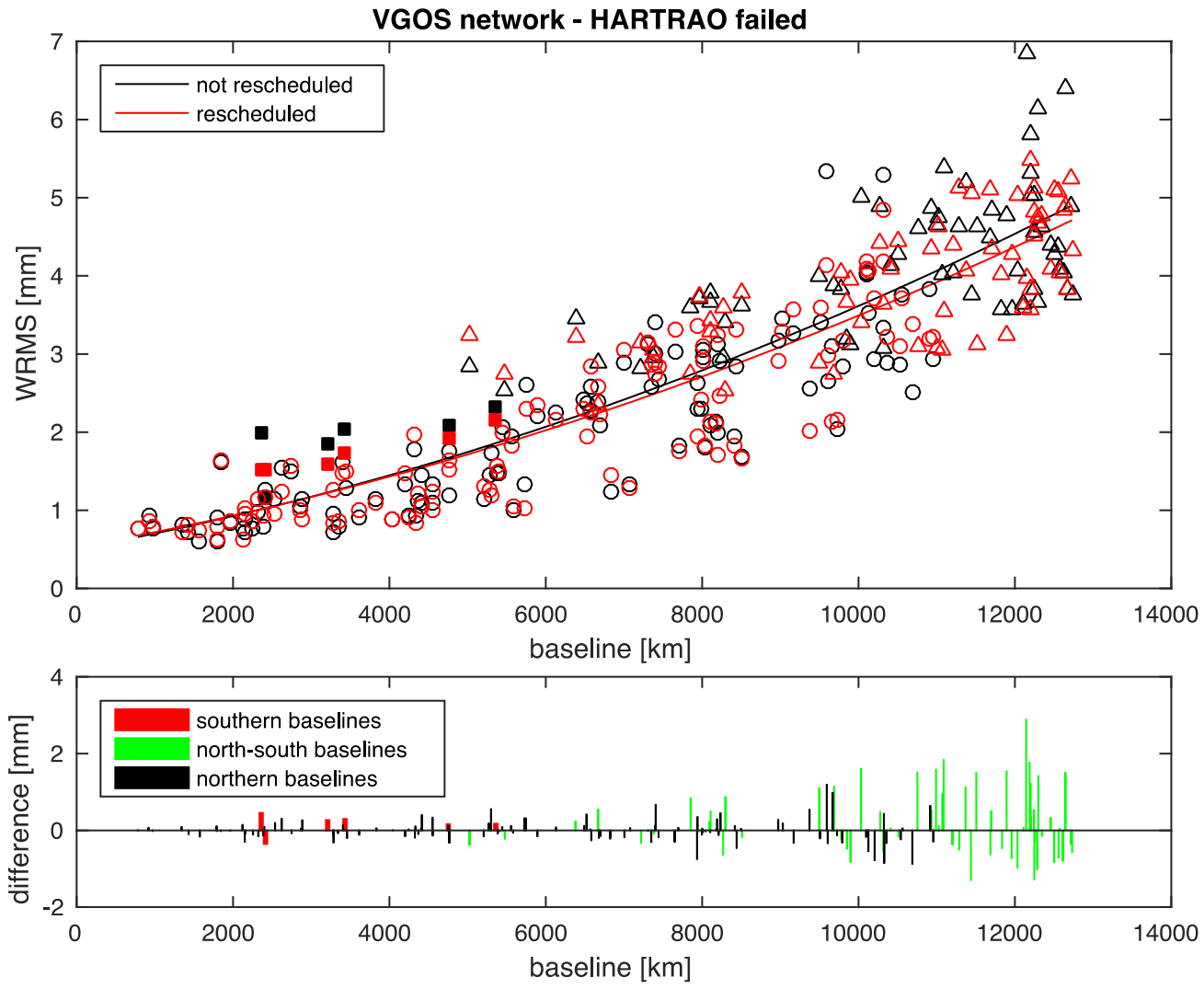
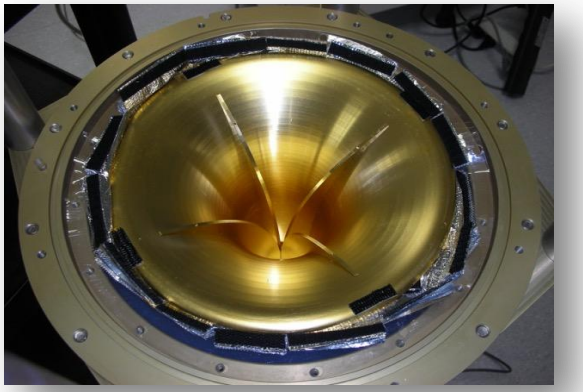


What Next for AuScope?

- Bringing AuScope closer to VGOS



- Broadband upgrade to 3 AuScope telescopes.
  Callisto feeds, new DBBC3 systems,
  Mark6 or Flexbuf

- Trial source structure mitigation strategies.
  - Avoid/flag scans when a baseline resolves the jet
  - Sidereal scheduling trials
  - Variability monitoring (feedback)

- Implement and test some DO ideas
- Further scheduling optimisation tests with ViEVS and eRemoteCtrl
- Trial shared operations
- AUSTRAL is back, 12 per year, SHAO correlation, Thanks!
- More twin (sibling) telescope trials with Hobart 12m and 26m

What the AOV can do

- Many of our sites have good network connectivity:
  - Share operations and monitoring. This could be tested using eRemoteCtrl
  - Fringe-checking prior to AOV sessions. Schedule for tests the day before
  - Fringe-checking during other IVS sessions. Need minor VEX file changes and a willing correlator
  - GSI (for example) has great experience in real-time correlation and analysis (ultra-rapid EOP). Let's make it routine!
  - AuScope array can try out dynamic scheduling strategies
  - Can we fully-automate stations using legacy systems?
    - When antennas are free, run a continuous real-time, observing program.
    - Similar to the NICT Key Stone Project (1995 - 2001, ksp.nict.go.jp) maybe, but international