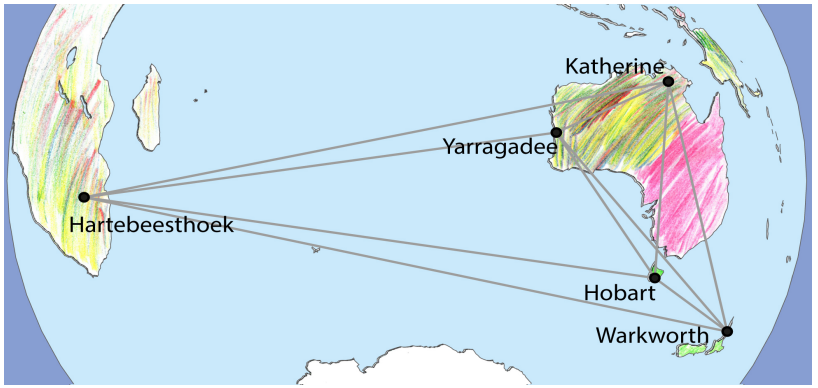
The Southern Hemisphere AUSTRAL Program: A Pathway to VGOS



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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*

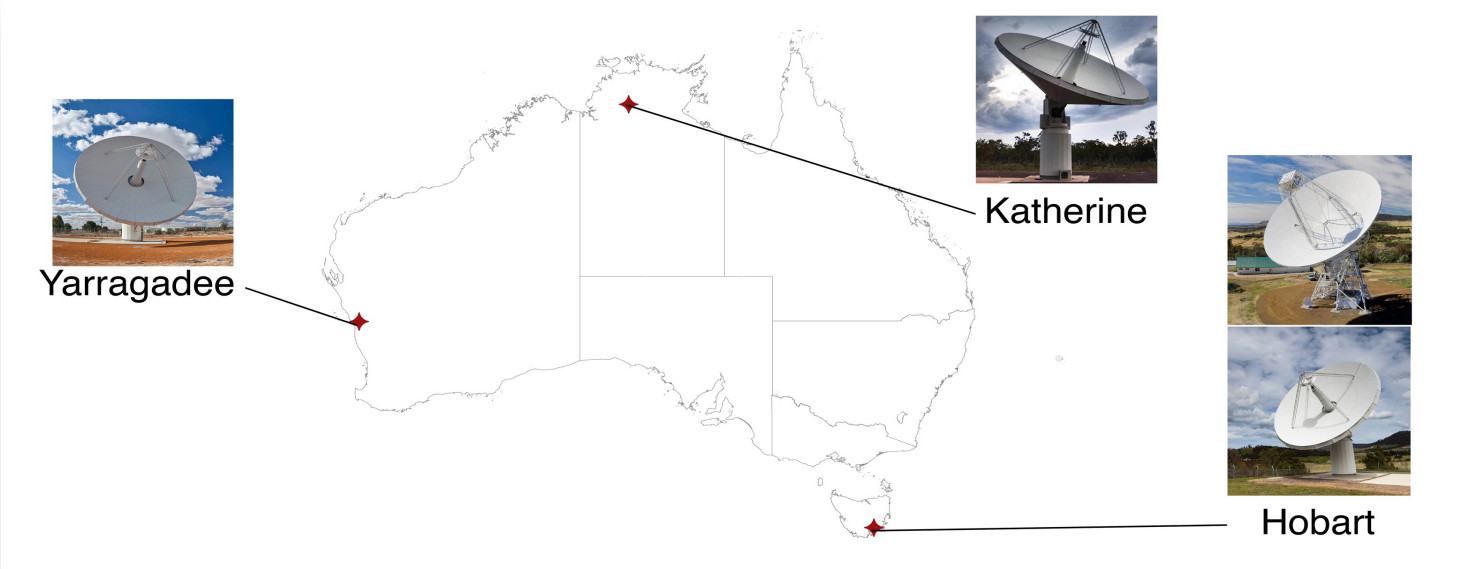
Jing Sun : *Shanghai Astronomical Observatory*

Alexander Neidhardt : *Technical University of Munich*

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 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)
- Scheduling and analysis capability in collaboration with TUW

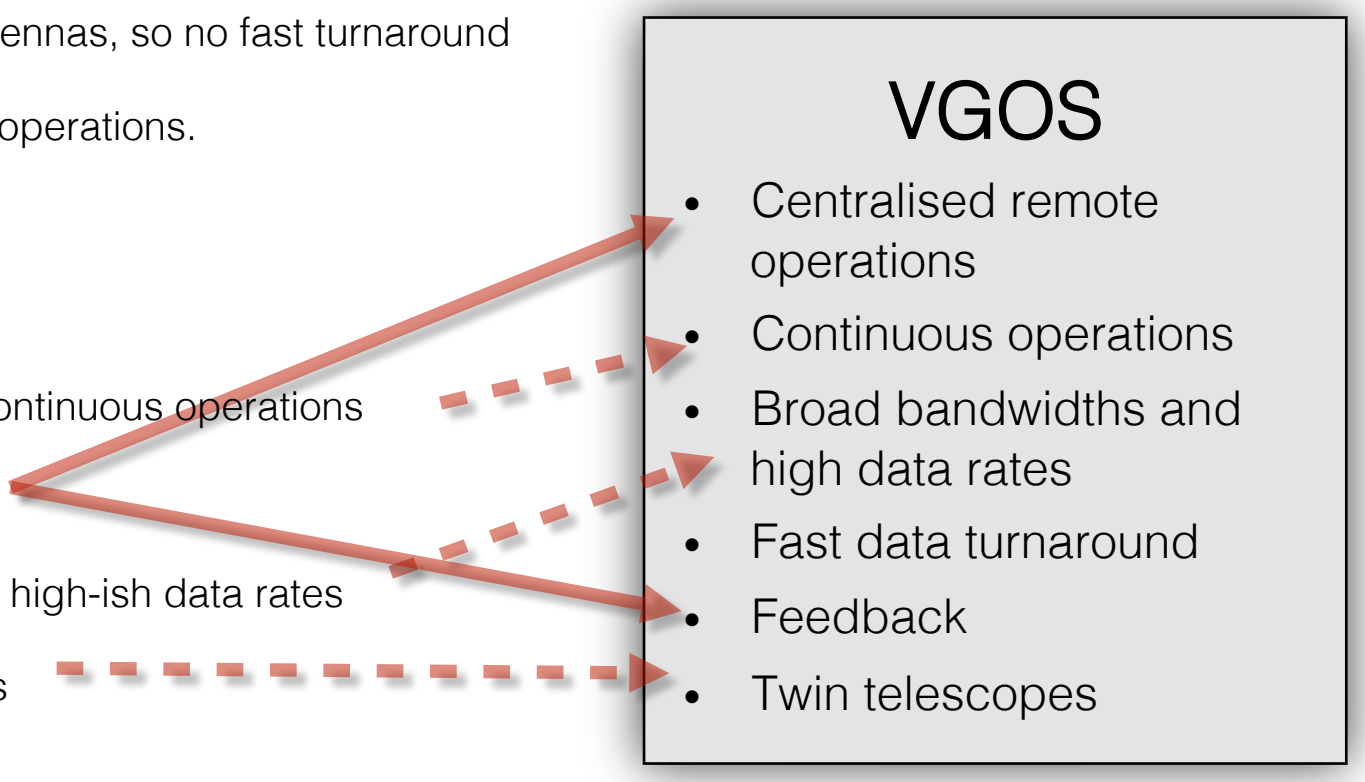
The AUSTRAL Program

- 120 days per year. AuScope (100%) + Warkworth (50%) + Hart15 (50%)
- Aims
  - 11 days of strometry 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

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

League table | Full table | All | Primeira Liga | League Cup | Champions League

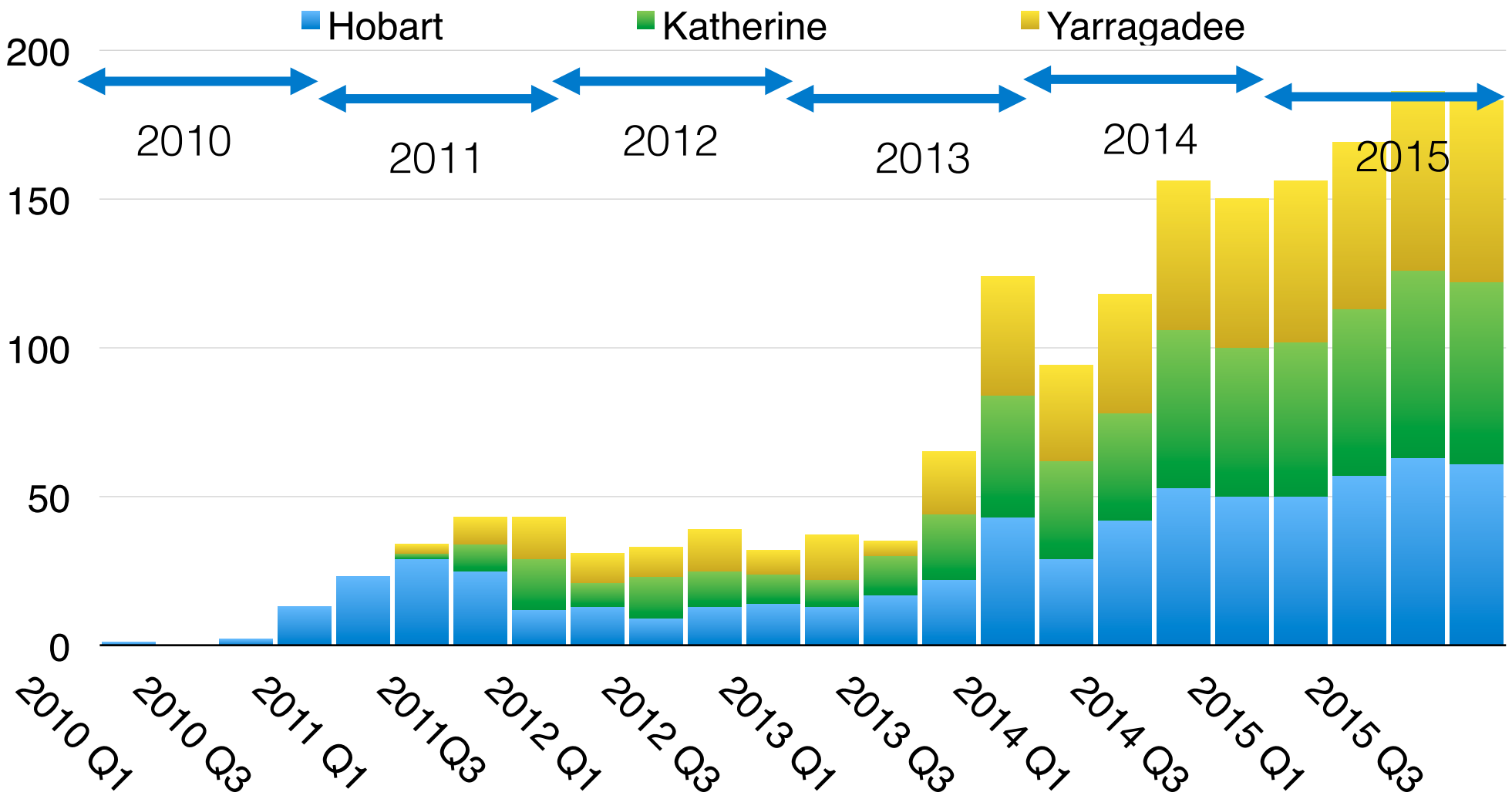
Pos.	Team	GP	Pts	W	D	L	GF	GA	+/-
1	**SL Benfica**	33	**82**	26	4	3	82	15	67
2	**FC Porto**	33	**79**	24	7	2	72	13	59
3	**Sporting Lisboa**	33	**73**	21	10	2	66	29	37
4	**Sporting Braga**	33	**55**	16	7	10	50	28	22
5	**Vitória Guimarães**	33	**52**	14	10	9	46	33	13
6	**Paços de Ferreira**	33	**47**	12	11	10	40	42	-2
7	**Belenenses**	33	**45**	11	12	10	32	35	-3
8	**Marítimo**	33	**44**	12	8	13	45	41	4
9	**Rio Ave**	33	**43**	10	13	10	38	41	-3
10	**Nacional Madeira**	32	**41**	11	8	13	41	46	-5
11	**Moreirense FC**	33	**40**	10	10	13	31	41	-10
12	**GD Estoril**	33	**37**	8	13	12	36	56	-20
13	**Boavista FC**	32	**34**	9	7	16	27	47	-20
14	**Académica Coimbra**	33	**29**	4	17	12	24	42	-18
15	**Vitória Setúbal**								
16	**FC Arouca**								
17	**Gil Vicente**								
18	**FC Penafiel**								

Champions League | Champions League 2

We're Busy: 2015 Schedule

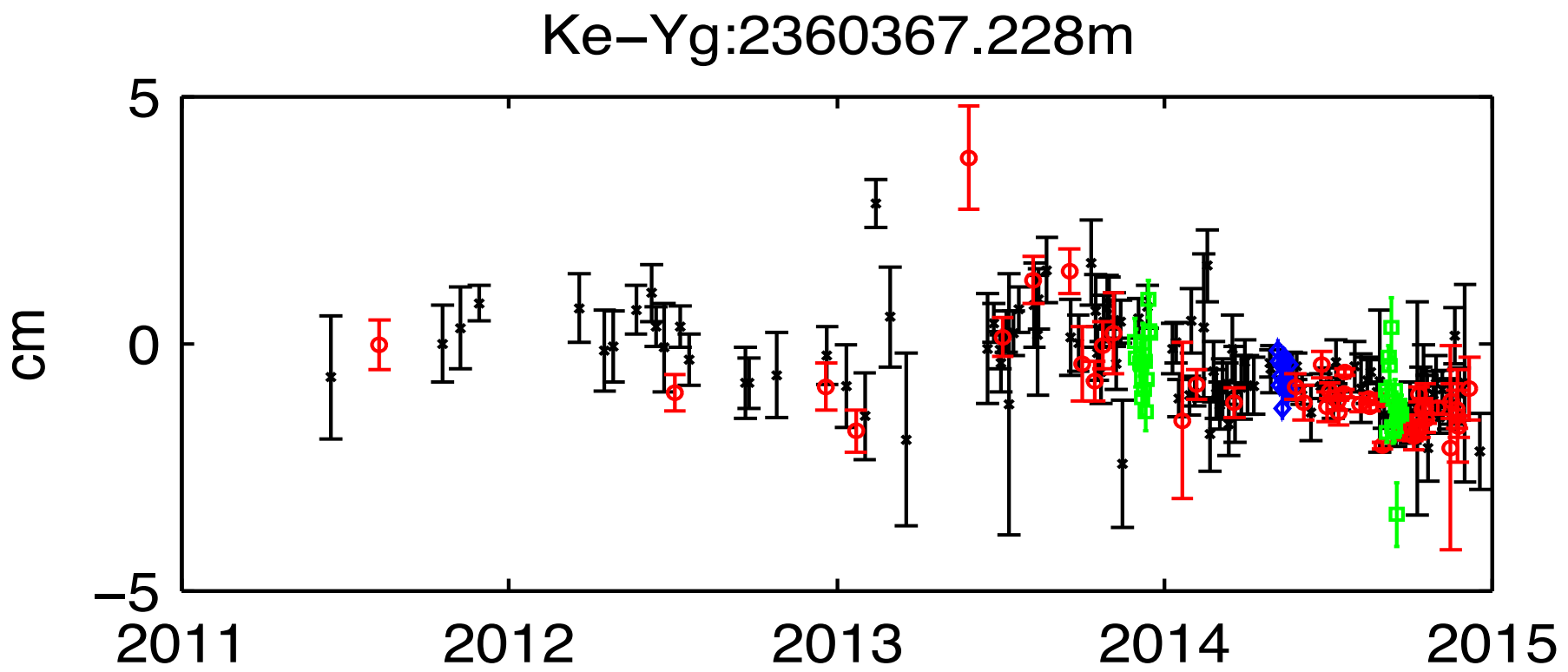
Station	Number of Sessions	AUST Cont	AUST Geo	AUST Astro	Total AUSTRAL
Ke	232	30	79	11	120
Hb	231	30	79	11	120
Yg	231	30	79	11	120
Ht	170	30	26	4	60
Wz	133				
Ny	123				
Ww	120	30	36	9	75
Kk	104				
Ft	86				
Ts	60				

We're Busy


Hobart
Katherine
Yarragadee
200
150
100
50
0
2010
2011
2012
2013
2014
2015
2010 Q1
2010 Q3
2011 Q1
2011Q3
2012 Q1
2012 Q3
2013 Q1
2013 Q3
2014 Q1
2014 Q3
2015 Q1
2015 Q3

Dense time-series

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



= R1/R4

= CONT14

= AUST

= AUST Cont

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

Broad bandwidths, high data rates

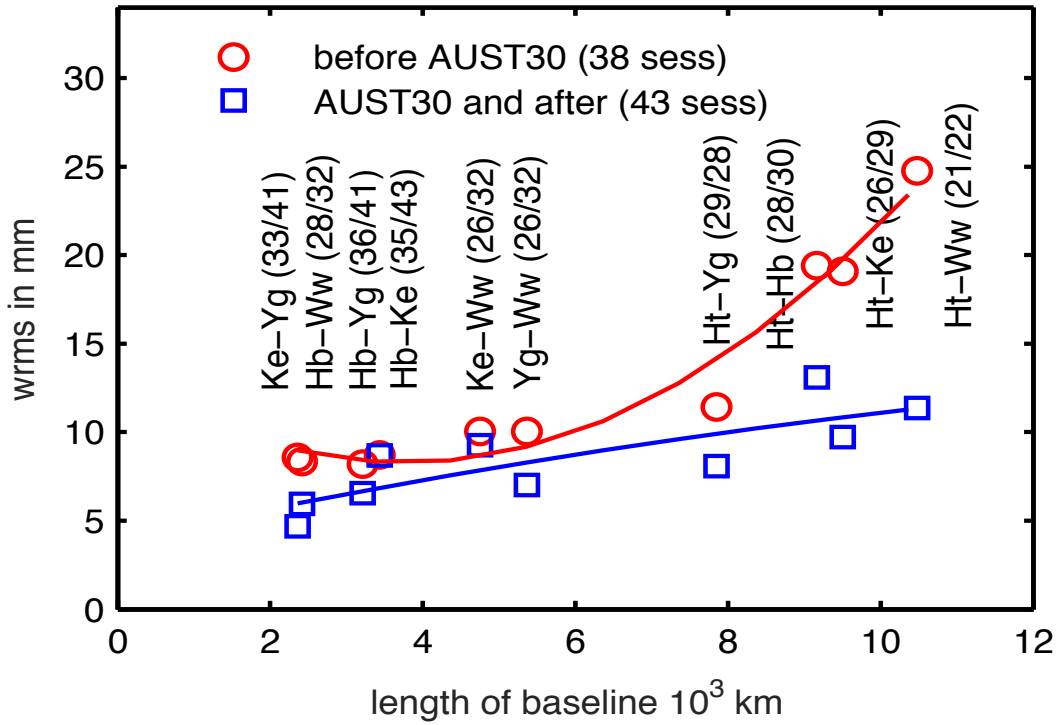
- AUST data rates are currently 1 Gbps (16 MHz IFs, 2 bit). compensates for higher SEFD of small antennas with room temperature SX systems.

- 30 ps delay residuals being achieved (CONT14 levels) but 50 ps is more typical. Cause?

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.

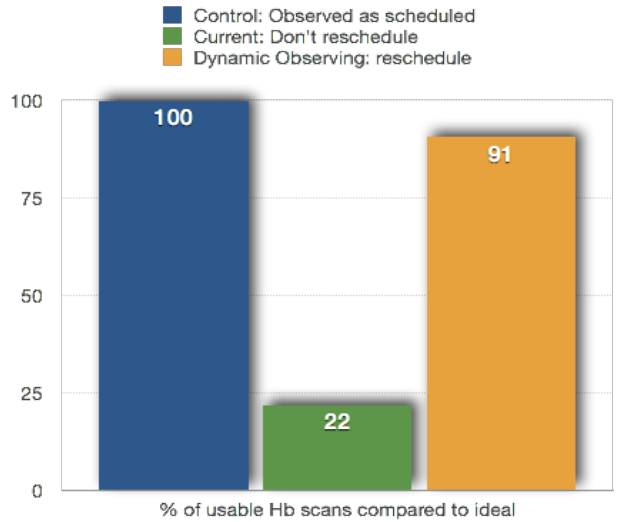


From Plank et al 2015. , IAG Symposia (REFAG), accepted

Intra-session optimisations: Dynamic Observing

- 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:
  - Simulation of antenna with poorer than expected sensitivity



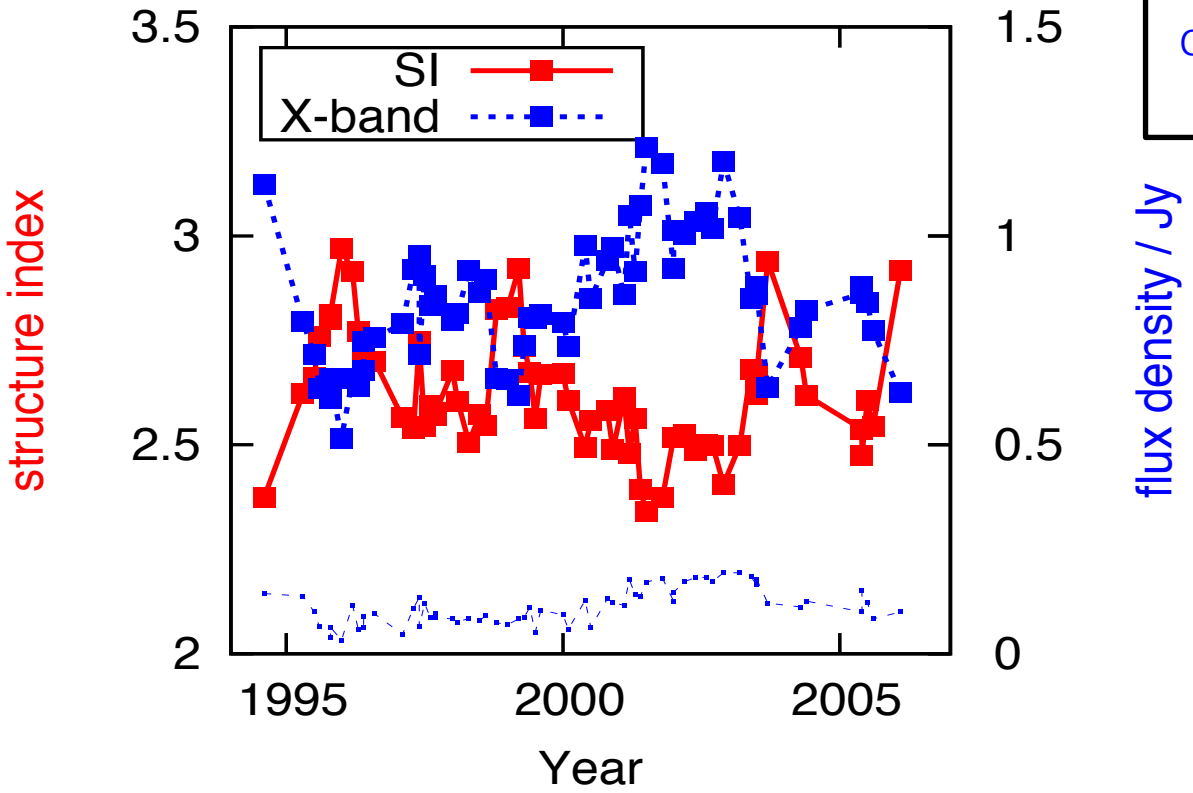
Scenario	Number of scans	Number of observations	Number of successful Hb observations	% successful Hb observations
Observed as scheduled	804	1498	394	100
Current: Don't reschedule	652	1190	86	22
Dynamic Observing: reschedule	793	1470	357	91

Source structure feedback

- Source structure mitigation strategies.
  - Position shifts when a baseline resolves the jet
  - Variability = structure
  - Scintillation = stability

Variability = structure

Source 1357+769



Structure anti-correlates with flux density

➔ Observe sources when flux density is high (and so structure is small)

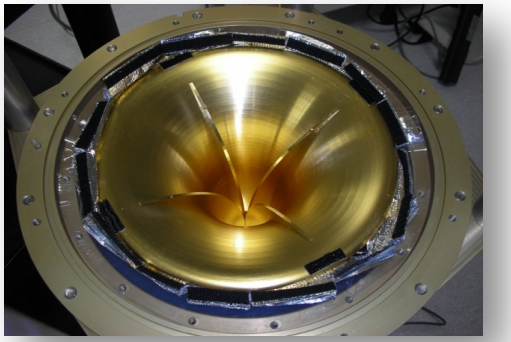
S. Shabala et al 2015.
More on this tomorrow…

Twins

- See poster P2-01

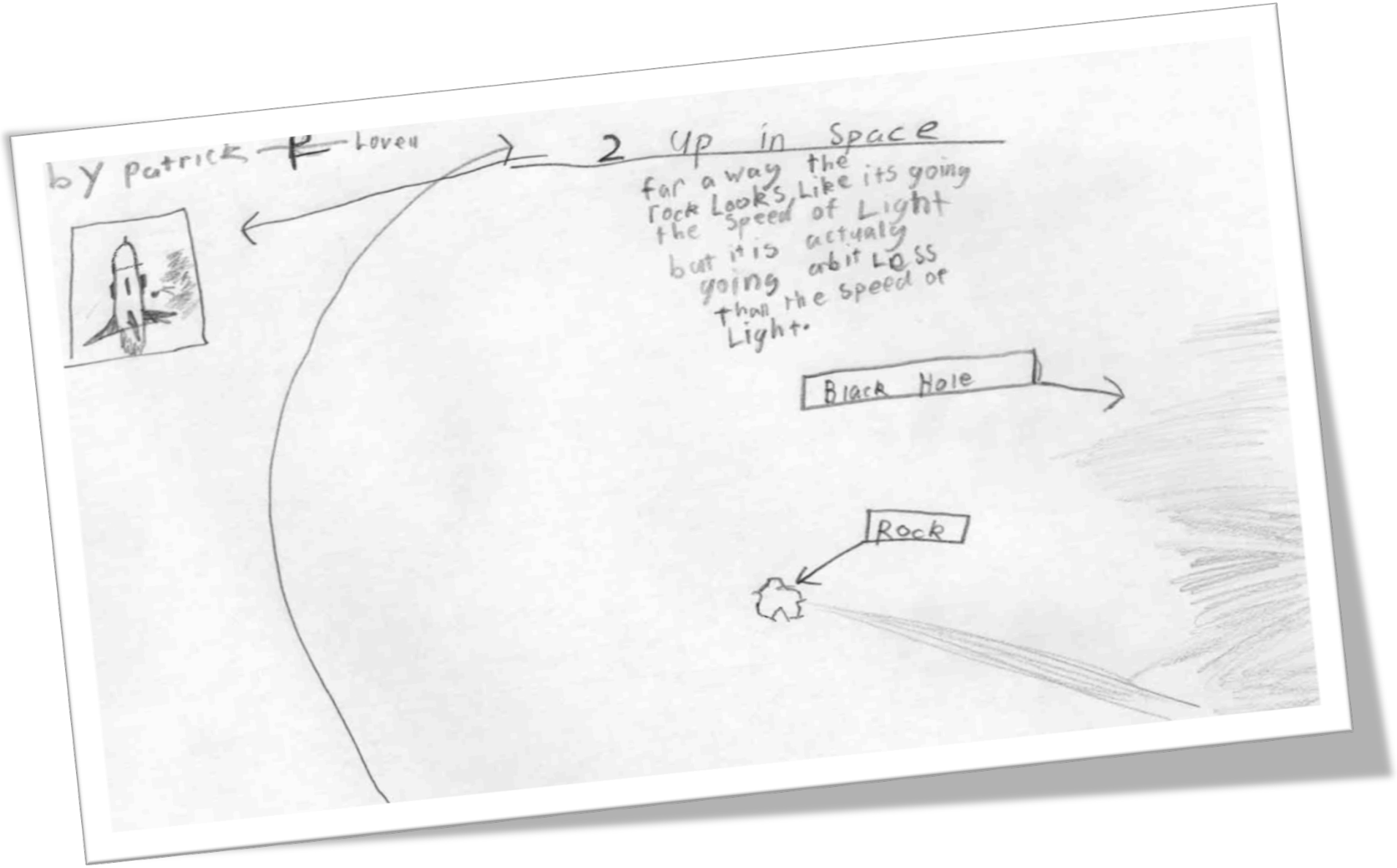
What Next

- Broadband upgrade to 3 AuScope telescopes. Callisto feeds (Poster P1-01), new DBBCs, Mark6 or Flexbuf



- 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 (antenna wind stow)
- Further scheduling optimisation tests with ViEVS and eRemoteCtrl
- Trial shared operations
- Correlation moving to UTAS in September (turn-around time should drop)
- More twin (sibling) telescope trials with Hobart 12m and 26m



Variable source structure for 9-year-olds.