



Update from SKA-Low Science Commissioning

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On behalf of the SKA-Low Science Commissioning team

CSIRO Space and Astronomy, Co-learnium Talk Series

16th October 2025



We recognise and acknowledge the Traditional Owners of the lands on which our facilities are located, and pay our respects to their Elders past and present.

Australia's Indigenous people are the first scientists and have long standing knowledge of the Universe that we continue to build on today.

We acknowledge the Wajarri Yamaji as the Traditional Owners and native title holders of Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory, where we are building the SKA-Low telescope in Australia.

We acknowledge the Whadjuk Noongar as the traditional owners of the land where our Science Operations Centre is situated in Perth, and the Southern Yamatji as the traditional owners of the land where our Engineering Operations Centre is situated in Geraldton.

I also pay my respects to all First Nations people in attendance.

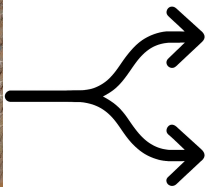
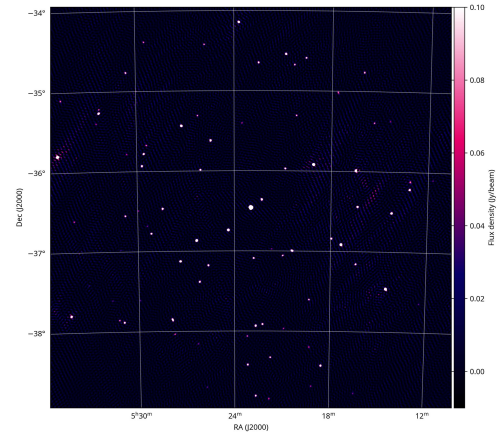


A collaborative painting from Aboriginal Yamaji artists from WA for the SKAO *Shared Sky* exhibition. Credit: Yamaji Arts Centre.



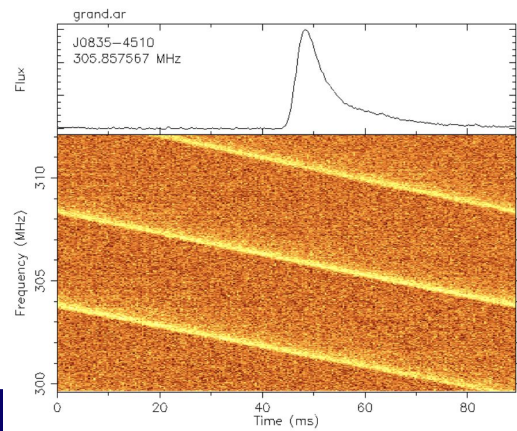


307 (512) stations
Distributed over 74 km
50-350 MHz



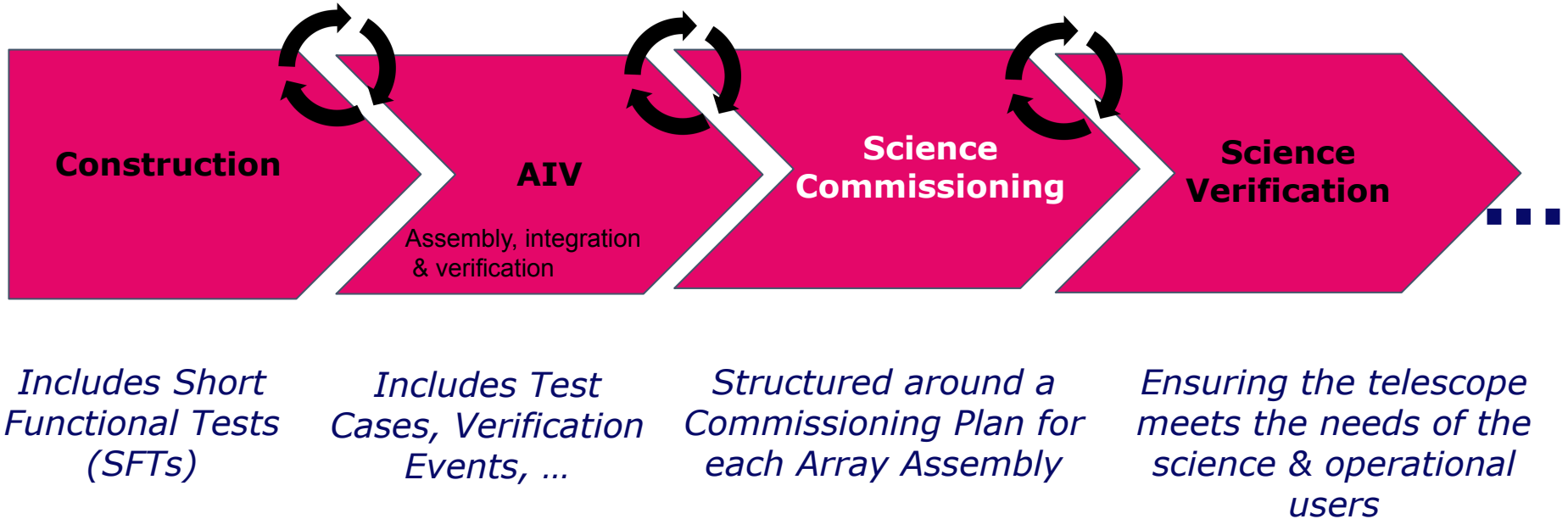
Images

Tied-array beams



How Commissioning fits in the big picture

Science Commissioning focuses on tests of science capability, using astronomical observations



SKA-Low staged delivery

Milestone Event

Low Stations

AA0.5

4



AA1

16



AA2

68



Science Verification begins 2027

AA*

307



Operations Readiness Review

End of Staged Delivery

Early Operations begin 2029 (shared risk)

AA4 (Full Design Baseline SKA1)

512



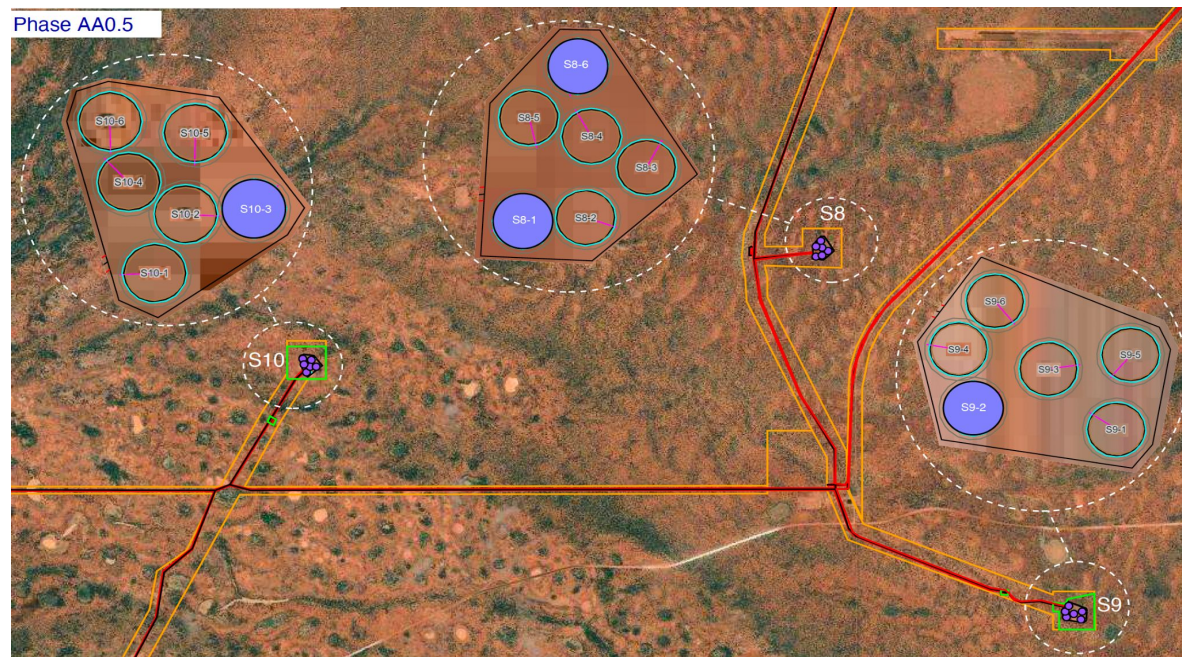
As of today 14,512
antennas had been
laid on ground
(~11% of AA4)!



SKA-Low AA0.5 - layout

AA0.5 Complete!

- Four stations: S8-1, S8-6, S9-2 and S10-3
- Shortest baseline $\sim 120\text{m}$, longest $\sim 5.5\text{km}$
- Stations are rigidly rotated relative to each other
- Next milestone: AA1 (16 stations in the same clusters)



Four operational stations spread across the Southern spiral arm



Low Science Commissioning: Plans & progress

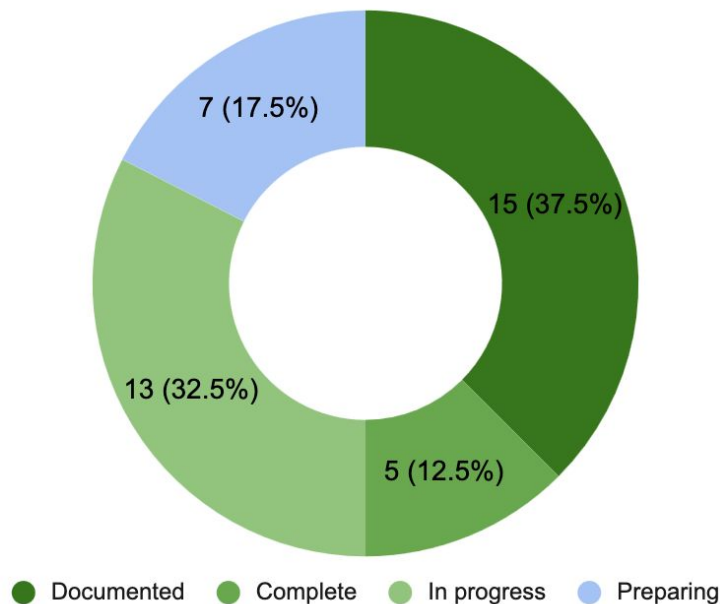
Based on set of ~40 commissioning tests for AA0.5 (defined and prioritised)

- **Fundamentals**: fringes/delays; closure; array calibration; cross calibration; quality of beams and bandpass; linearity; frequency accuracy and contiguity; RFI
- **Imaging**: full Stokes; sensitivity; stability of beams and bandpass; spectral line
- **Beamforming**: pointing; tracking; polarization alignment; sensitivity

Close collaboration with Science Operations to undertake test observations

- Joint planning/coordination meetings
- Shared documentation & logs

Low AA0.5 Science Commissioning test progress

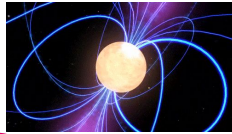


Science Commissioning focus areas

- Single station performance
- Array beamforming performance
- Array calibration and imaging performance
- Development of SKA-Low Calibrator Database
- Software algorithms and workflows

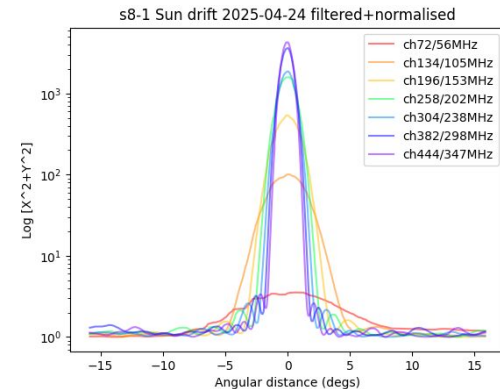
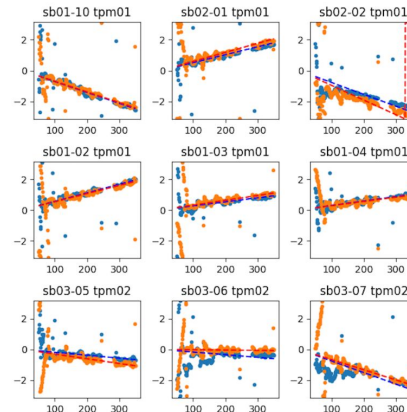


Single station behaviour



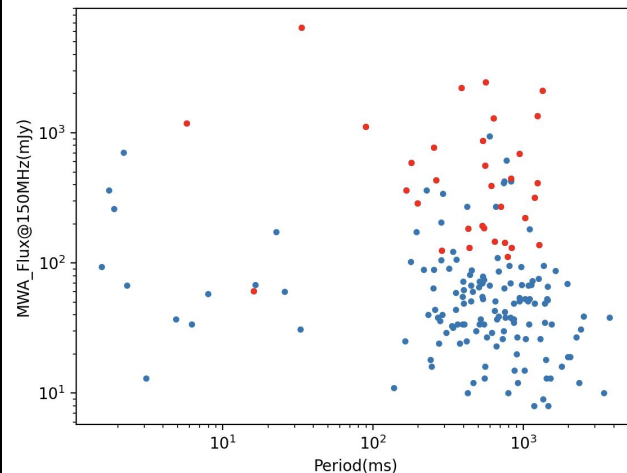
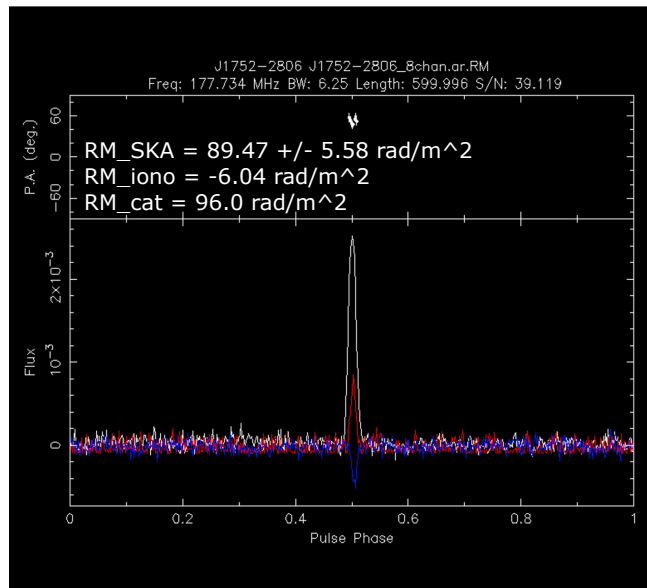
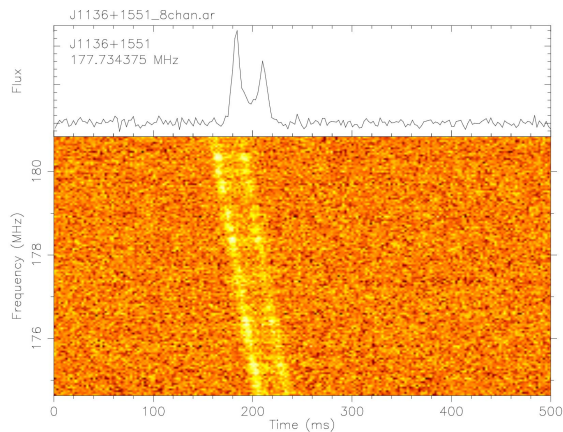
Commissioning outcomes so far:

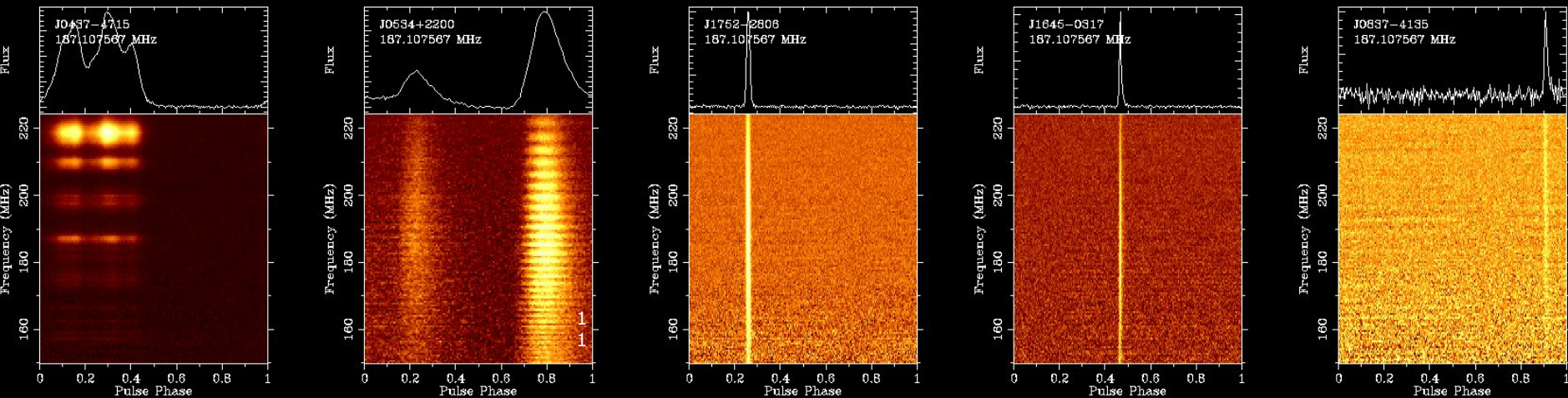
- Good calibration solutions for each antenna within a station
- Stable performance with time and varying environmental conditions
- Per-antenna delays for pointing and tracking are fit for purpose
- Beam shape and sensitivity are approximately as expected



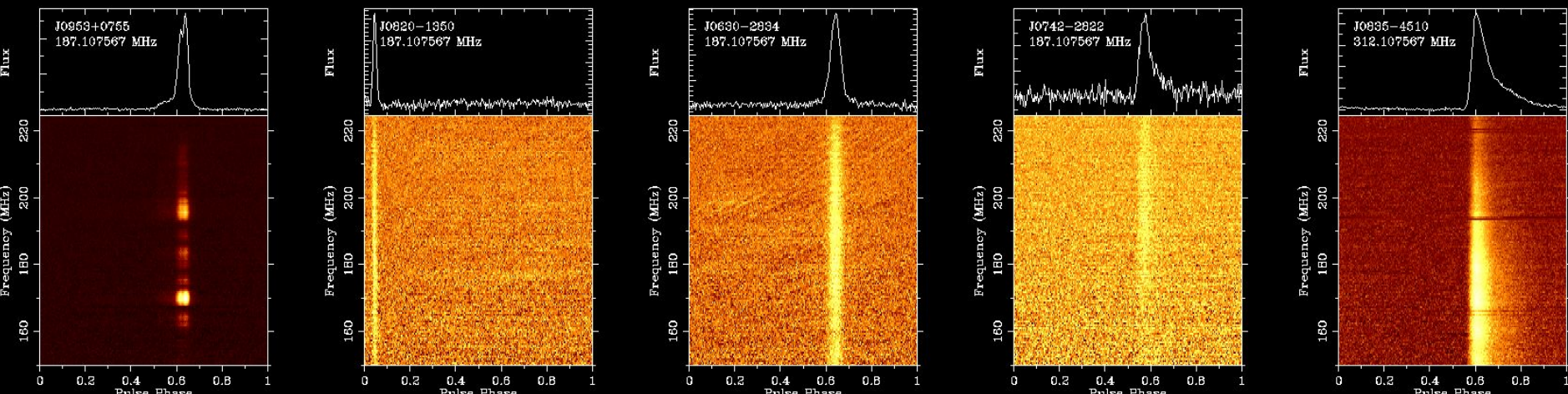
Low Science Commissioning: Pulsar detections

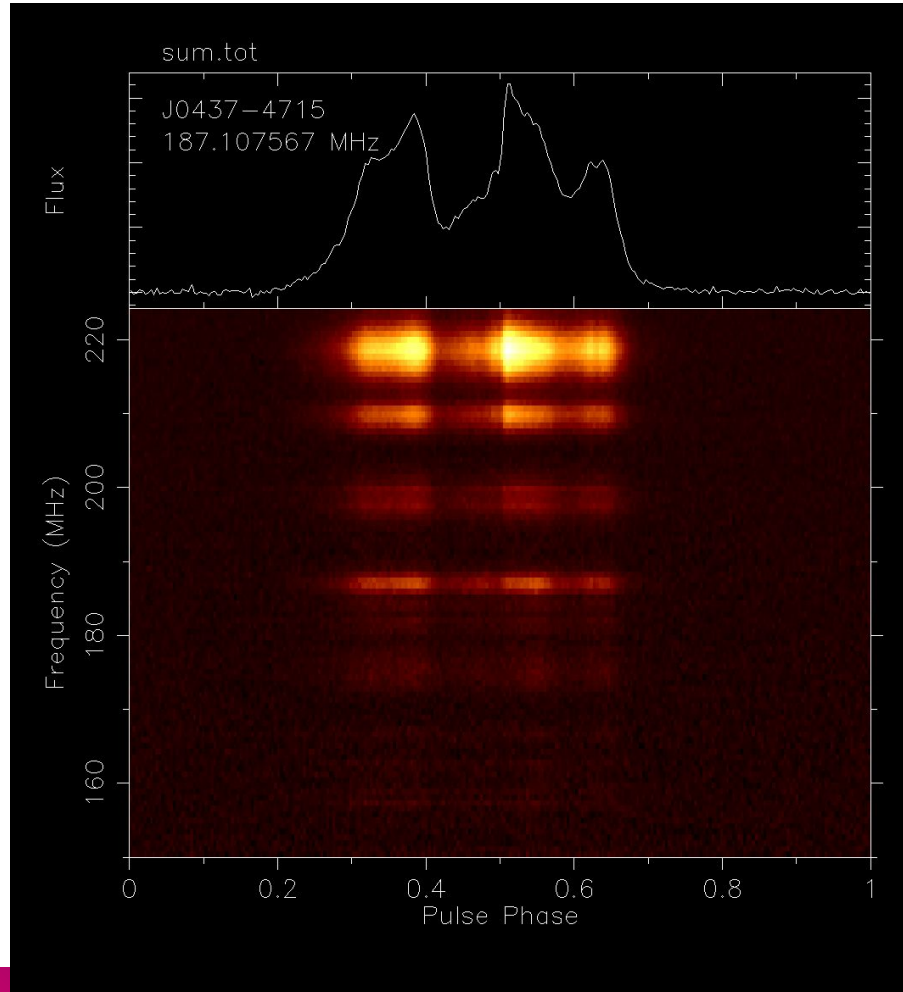
- Detected **56** known pulsars so far using raw voltages from single stations
- Sneak peek at full polarisation properties, with promising results
- Initial testing of *tied-array* performance - realtime calibration loop in development so full coherence not yet available





Excellent data quality !!





- Special version of dspsr performing Polyphase Filter Bank inversion
- Time resolution improved to $1.28 \mu\text{s}$!

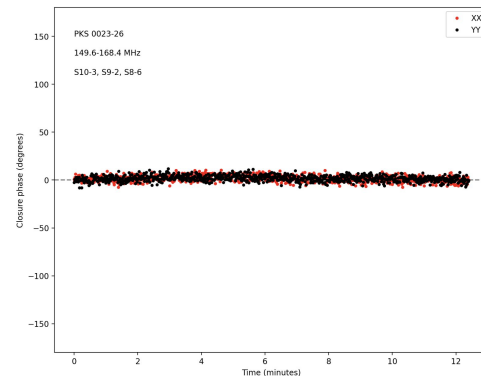
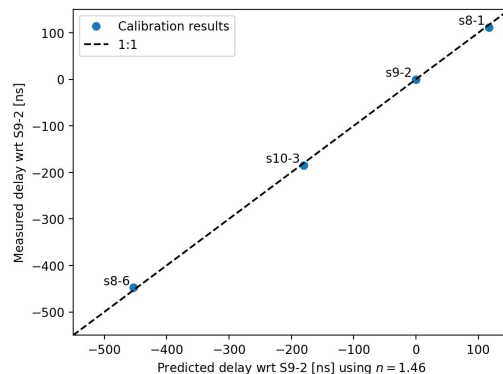
Credits: Willem van Straten, PST team



Basic array performance

Commissioning outcomes so far:

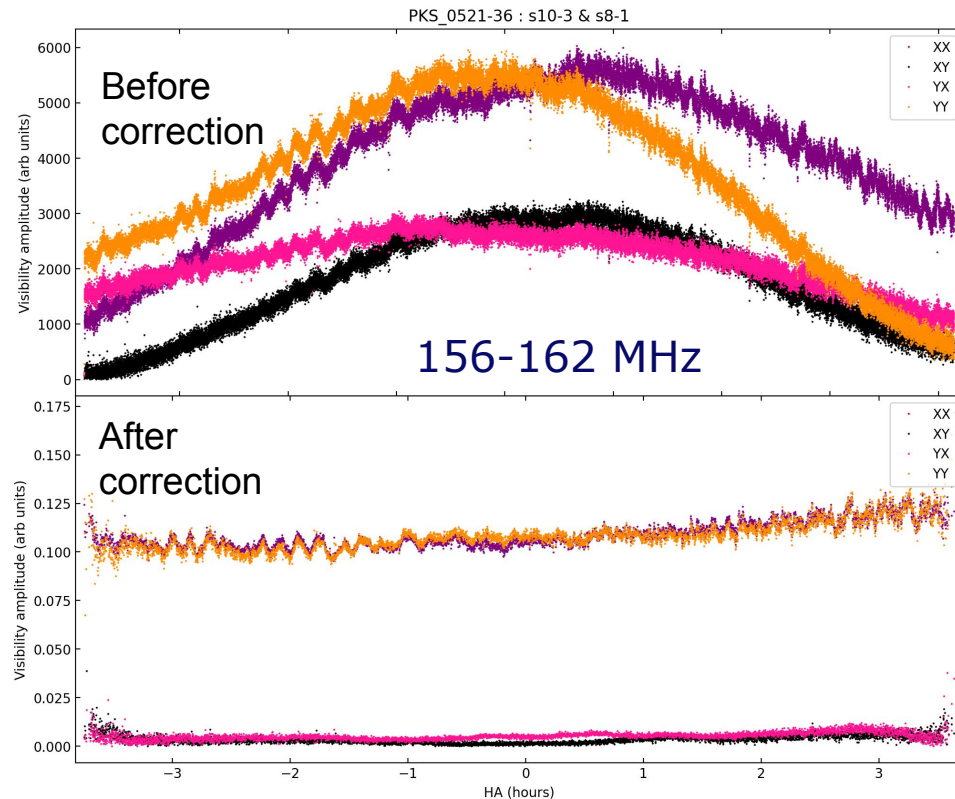
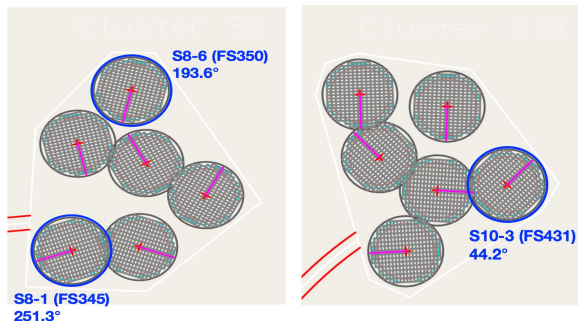
- Interferometric fringes detected
- Per-station delays determined to be stable and match fibre lengths
- Closure phase verified (indicating that visibilities can be calibrated)
- Station sensitivities measured
- First images produced
- Station bandpasses determined



Credit:
The Far Side

Low AA0.5 visibilities: path to first image

- Excellent baseline sensitivity
- Progress with compensation for station rotation effect
(Baseline between S8-1 & S10-3: relative angle 27.1° ; $B \sim 3.6$ km)

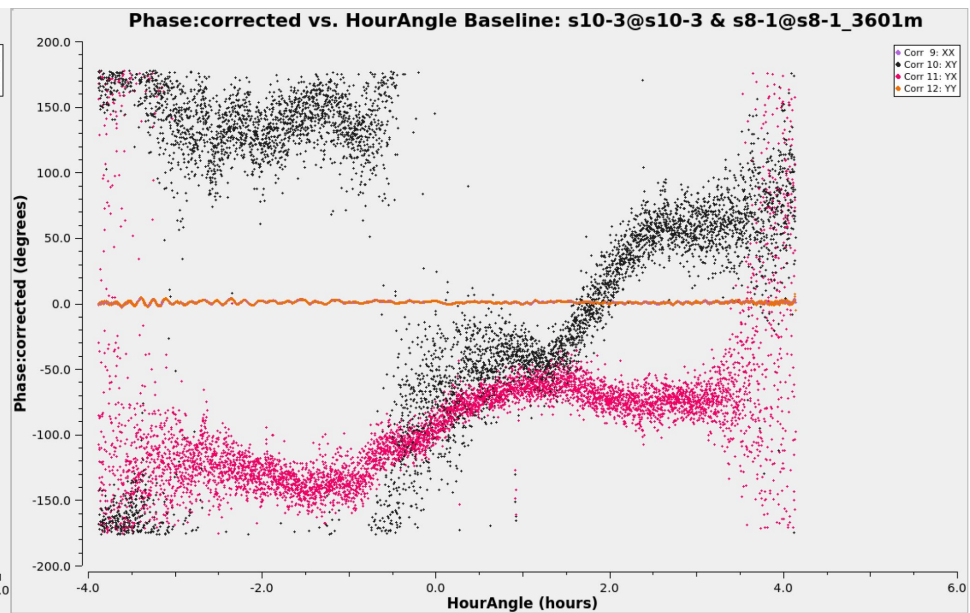
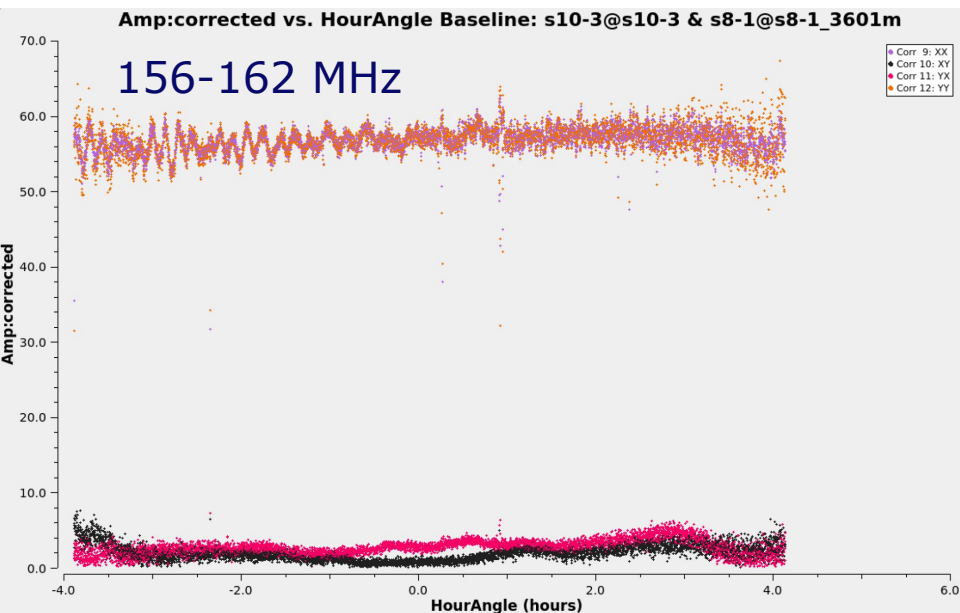


Raw (unflagged!), delay calibrated and averaged data

Low AA0.5 visibilities: path to first image

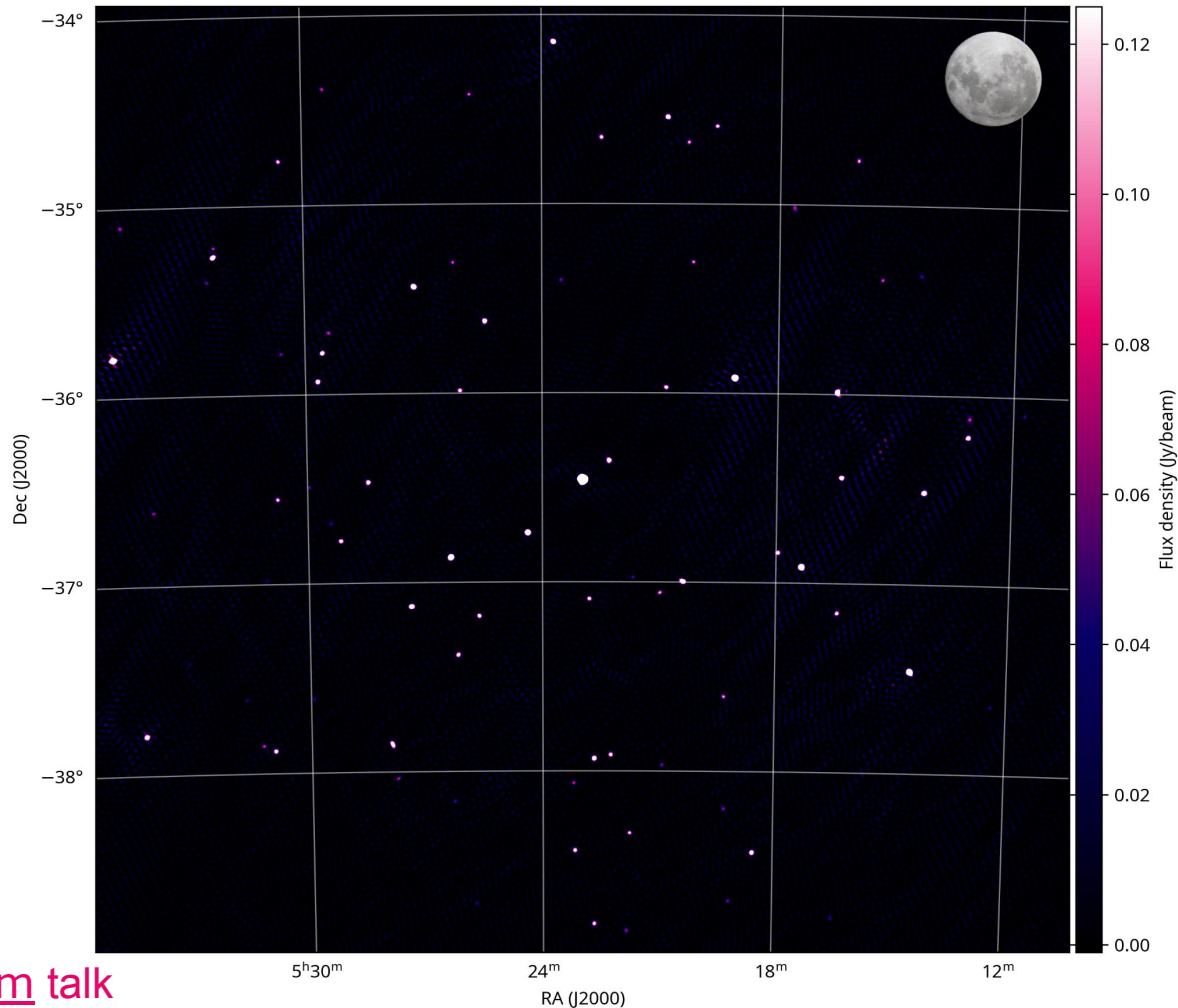
- Excellent baseline sensitivity
- Progress too with (self-)calibration ...

*Unflagged data, after bandpass and gain (**self**-)calibration*



First SKA-Low AA0.5 image!

- Field surrounding PKS 0521-36 (~ 56 Jy at 150 MHz)
- 150-175 MHz BW
- 7 hours effective integration time
- Image noise ~ 5 -6 mJy/beam at $70''$ final resolution
- 85 sources detected and matched to GLEAM-X catalog

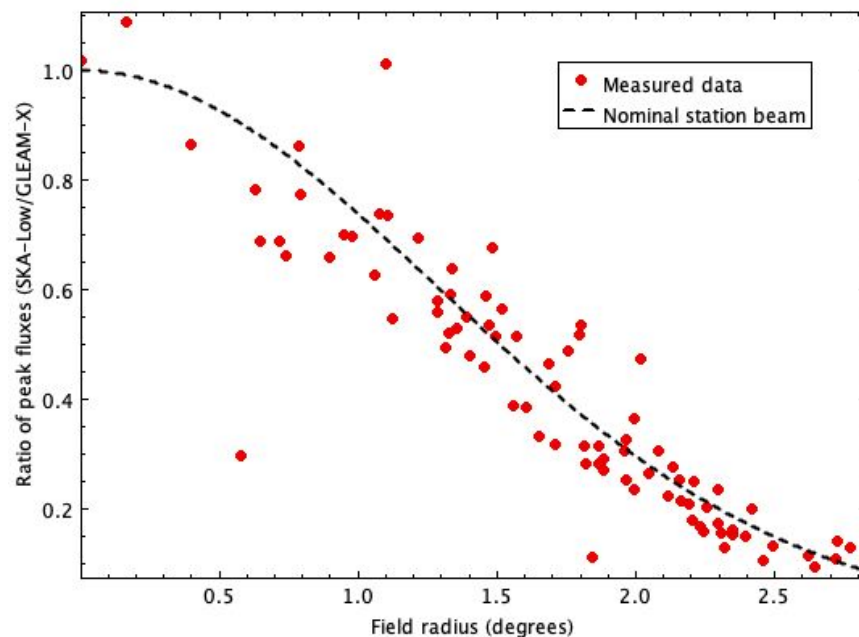
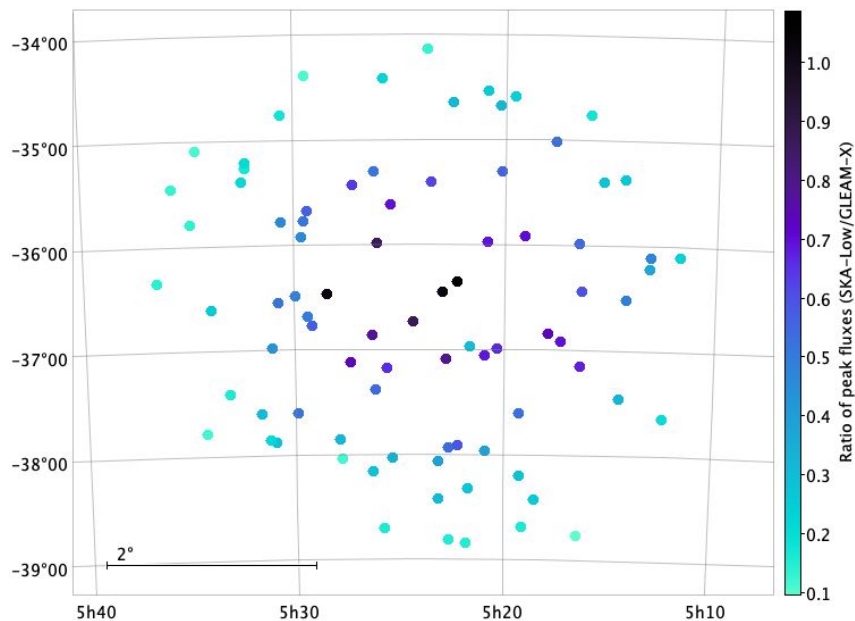


See [George's Colearnum](#) talk



First Low AA0.5 image: comparison to GLEAM-X

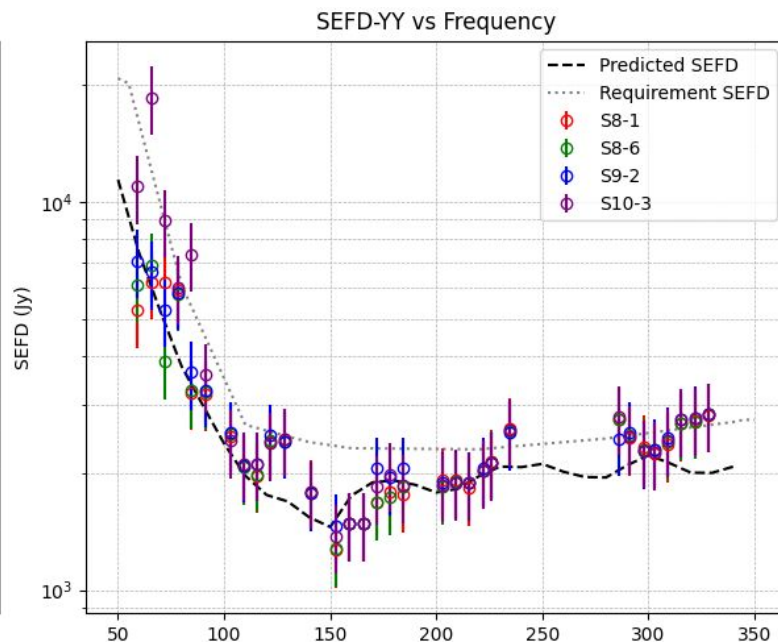
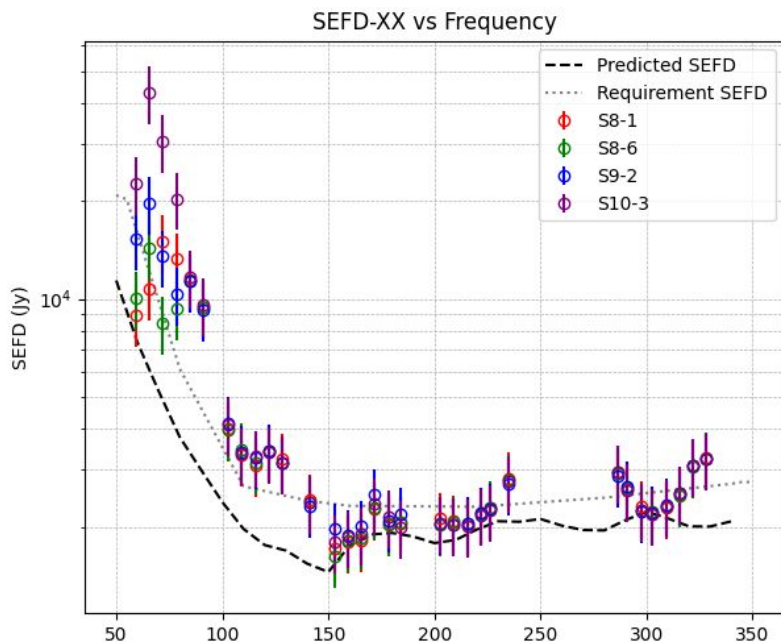
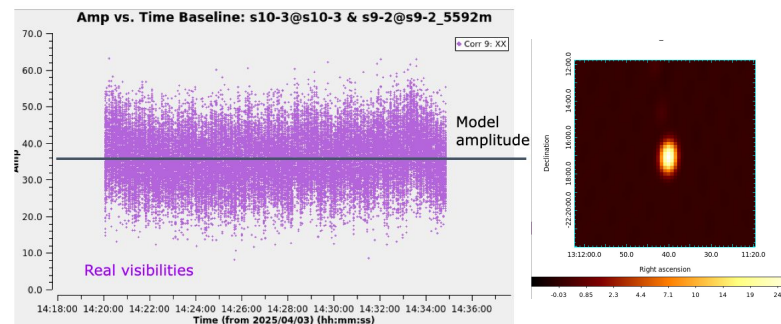
- Self-calibration process was mostly unguided but produced a field with source fluxes that mainly line up very well with expectations!



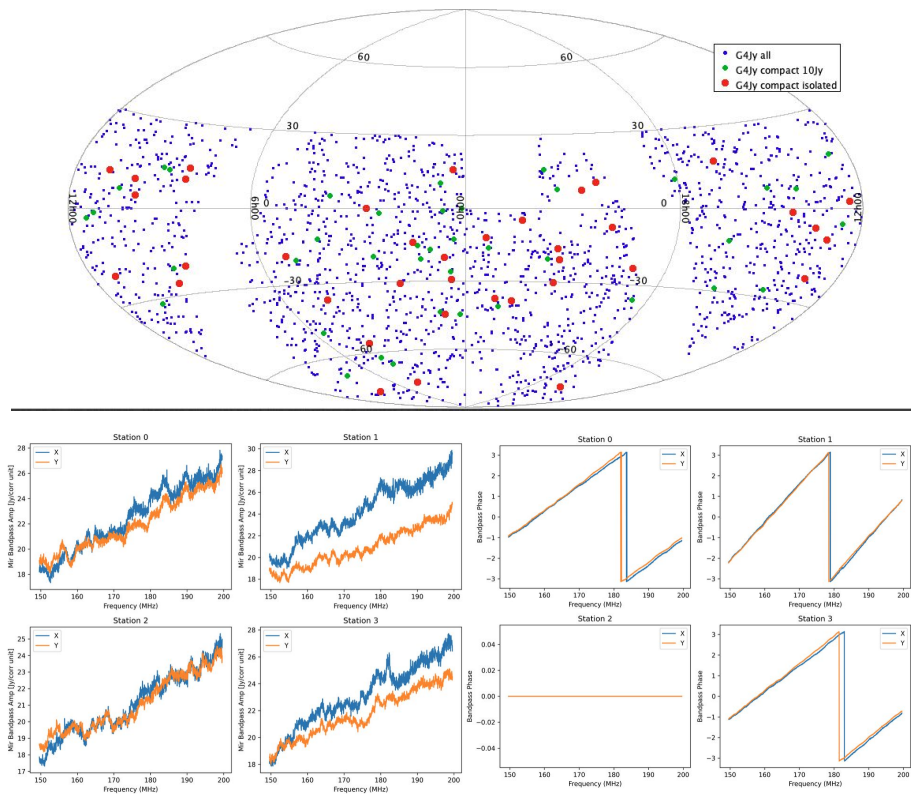
SKA-Low station SEFD

SEFD is a measure of sensitivity:
lower is better!

Estimated from S/N of pt src visibilities



SKA-Low Calibrator Database (ongoing effort)



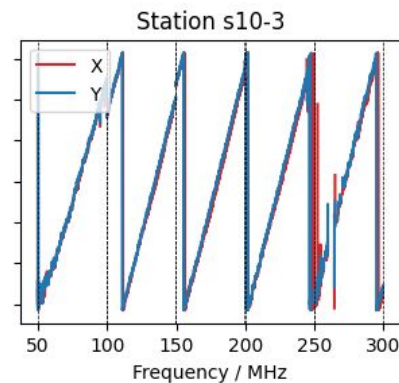
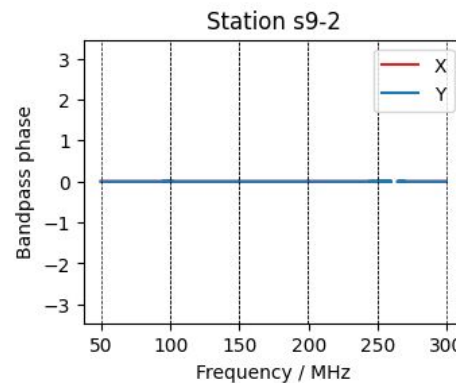
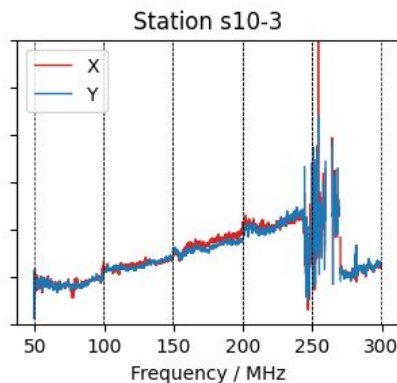
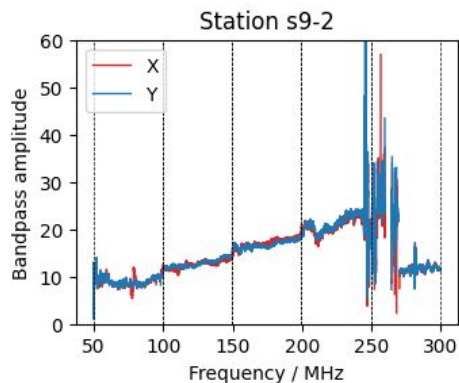
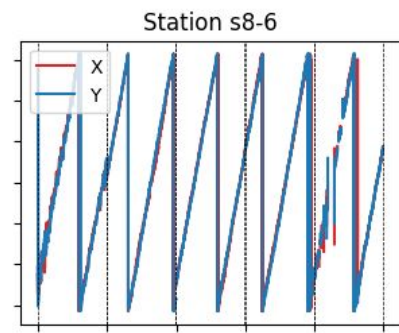
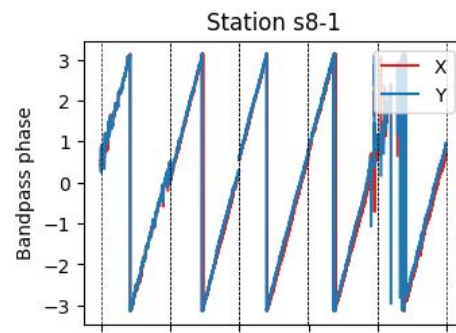
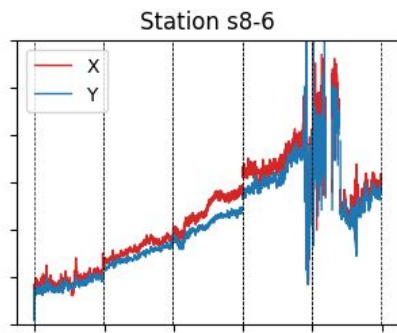
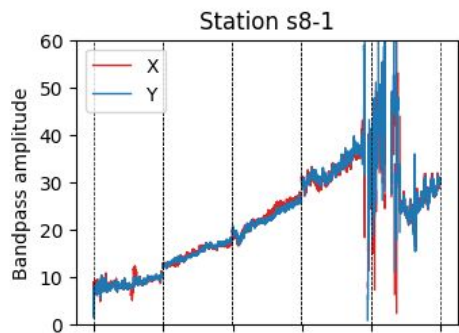
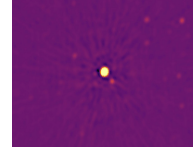
SciComm+SciOps outcomes so far:

- 23/38 compact isolated sources observed, across full 50-350 MHz
- Q&A plots of raw visibilities to support Operators
- Bandpass calibration tests for *all* sources (150-200 MHz only)
- Sky model tests with single point source, also with field sources
- Comparing legacy software (Miriad/CASA) and AO Calibrate
- Testing the developing SDP INST pipeline on real AA0.5 data
- Testing OSO tools
- Active planning is underway for Commissioning Calibrator Surveys

Goal: Build-up the SKA-Low calibrator list! - Stage 1 of SKA-Low sky model



First look at full BW calibration (3C273)

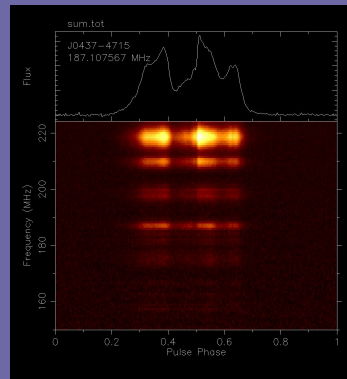
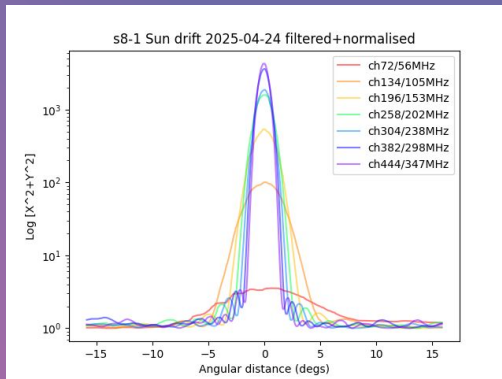


AO Calibrate



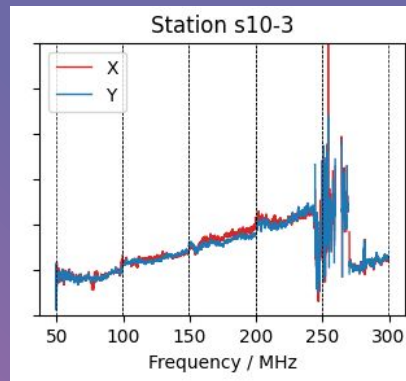
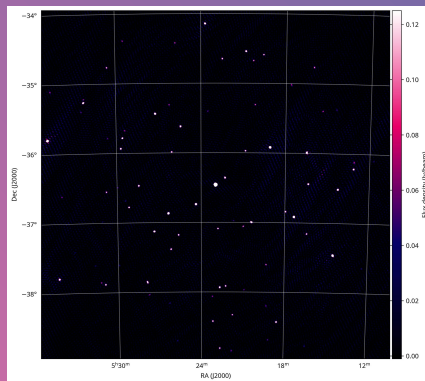
Recap: Science Commissioning outcomes

Good single station calibration, pointing, tracking



Initial tied-array beam results in pulsar timing (PST) mode, with full coherence coming soon

Good array calibration demonstrated, with first images being produced



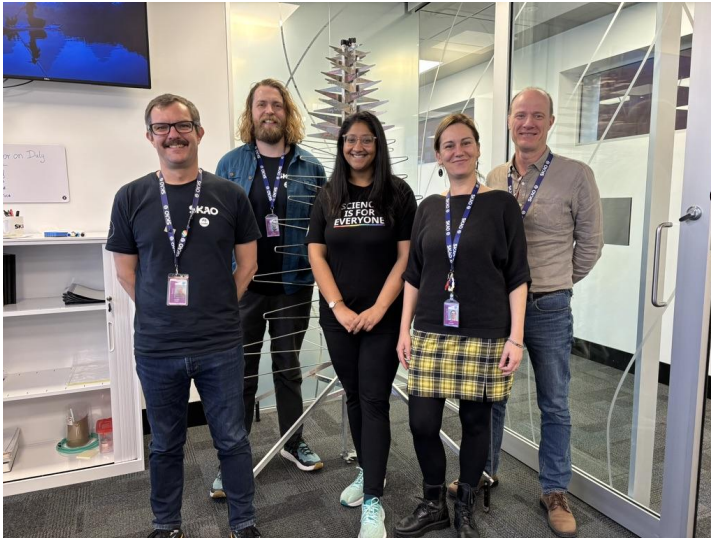
Development of calibrator database and testing the instrumental calibration pipeline

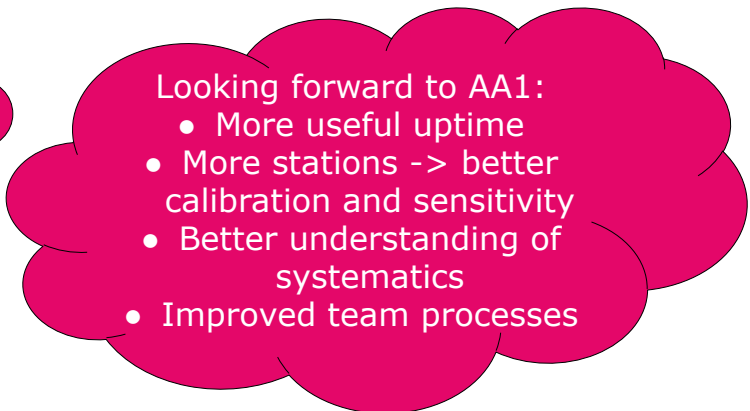


Science Commissioning status and next steps



- So far, >80% of the planned AA0.5 commissioning tests are completed or significantly advanced; remainder carry over to AA1
- Now writing AA1 plans, with AA2 plans to be developed soon as well
- Developing updated Calibration Plan, and Commissioning Survey Plan
- Collaborating closely with several adjacent teams: Science Operations, AIV/Vulcan, System Science, and others



- 
- Looking forward to AA1:
 - More useful uptime
 - More stations -> better calibration and sensitivity
 - Better understanding of systematics
 - Improved team processes



*We recognise and acknowledge the
Indigenous peoples and cultures that have
traditionally lived on the lands on which
our facilities are located.*



www.skao.int