SKA-Low Science Commissioning

Approach, plans, progress

George Heald for the SKA-Low Science Commissioning team

18 March 2025

Outline

- Context & timelines
- Current commissioning approach
- Plans and progress
- Commissioning challenges
- Next steps and priorities
- Suggested discussion topics

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.

Low Science Commissioning: Plans

Established 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

Working together closely with Science Ops to undertake test observations

- Joint planning/coordination meetings
- Shared documentation & logs

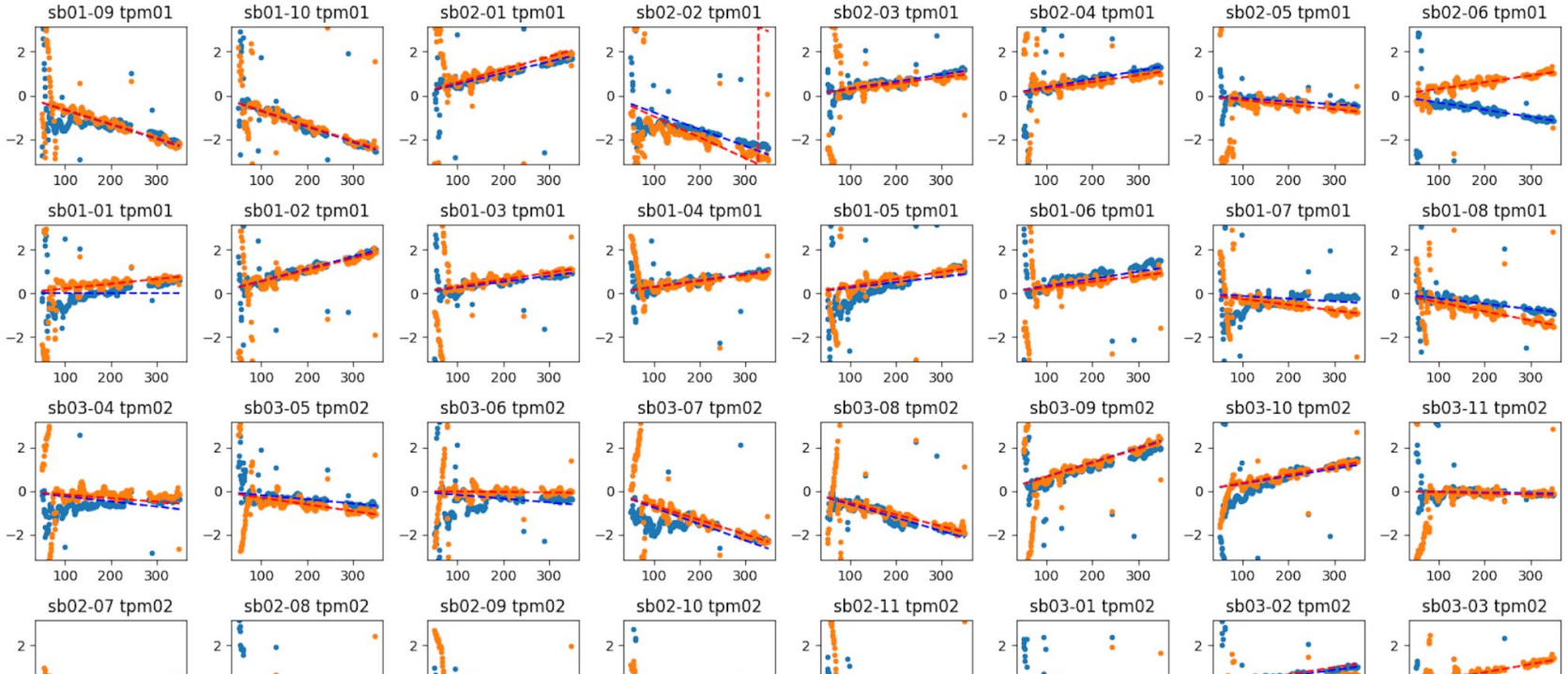
06 - First Images

Created by Wayth, Randall, last modified on Nov 08, 2024, viewed 32 times
Scroll page details

Test title	First Images	
Summary	• Generate instrumental polarisation and Stokes I images of a field • The primary goal of the test is to confirm core functionality of the array. (Lots of things have to be working correctly for sources to be in the right place in the sky) • Optionally for publicity, but it is not expected that any kind of detailed image will be made given the limited u,v coverage of AA0.5	
Linked AIV Test Case(s)?	SKAO-TC-4037	
Associated L0,L1 requirements?	Indirectly linked to SKAO-SYS_REQ-2135 (sensitivity). L1-2140	
Observing parameters	Mode (IM, BF)	IM
	Number of stations	4+
	Time resolution	~1s (default)
	Duration	2-4 hours
	Bandwidth (freq range)	75 MHz (150-225 MHz - primary range) Full SKA frequency range if possible, in chunks limited by the reasonable fractional bandwidth.
	Pointing direction (object name or coordinates)	Targets TBD. Required: field contains a source at phase centre sufficiently bright for selfcal.

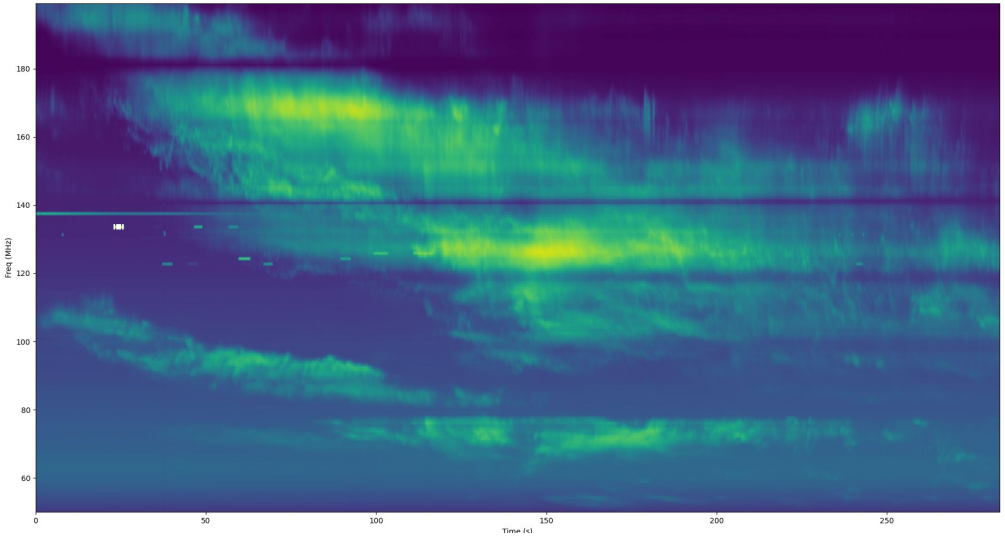
Single station behaviour

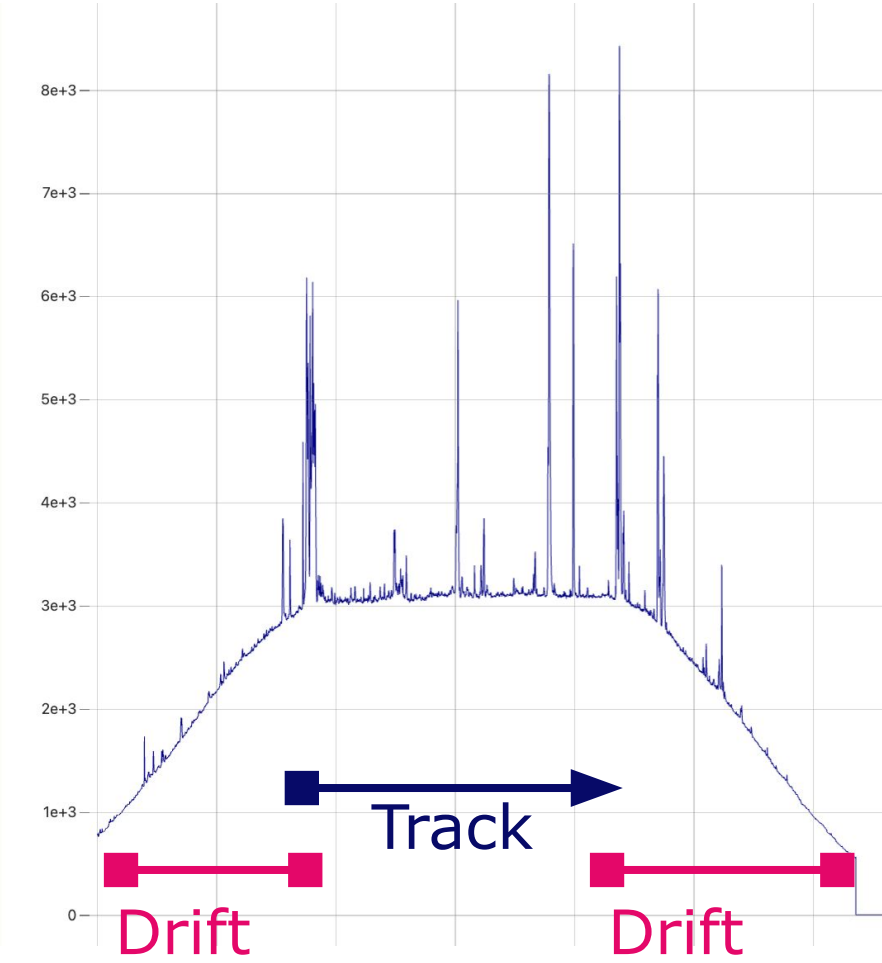
- Station calibration is well in hand and is being monitored daily for AA0.5 stations - main focus on antenna delays



Single station behaviour

- Station pointing and tracking is under control
- The Sun is very active!



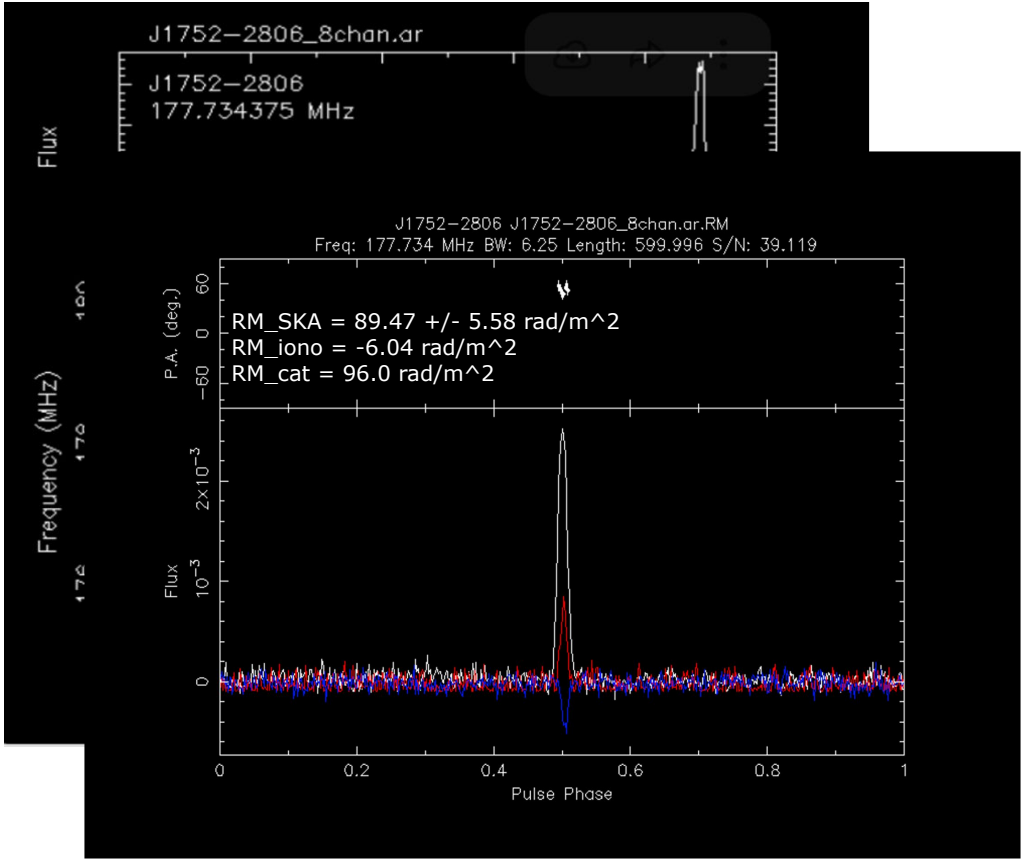


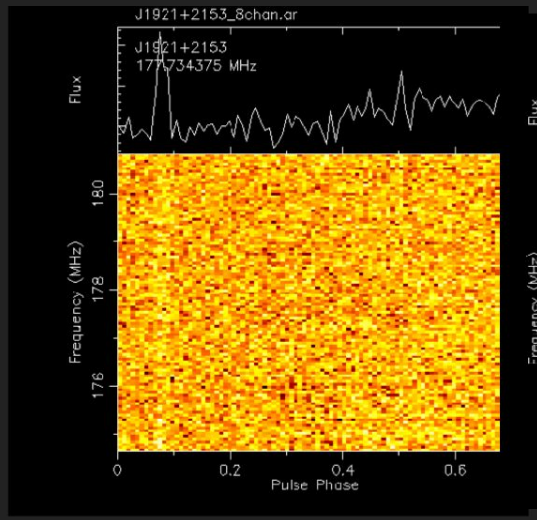
Low Science Commissioning: Outcomes & status I

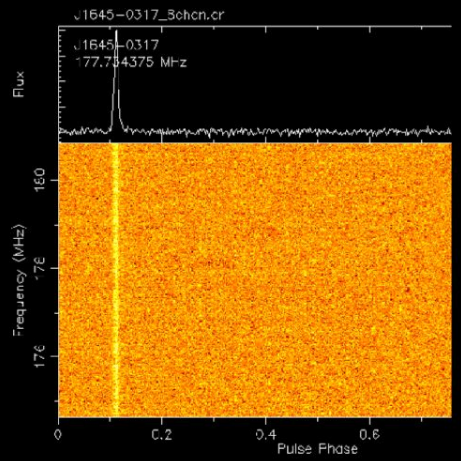
Single station progress:

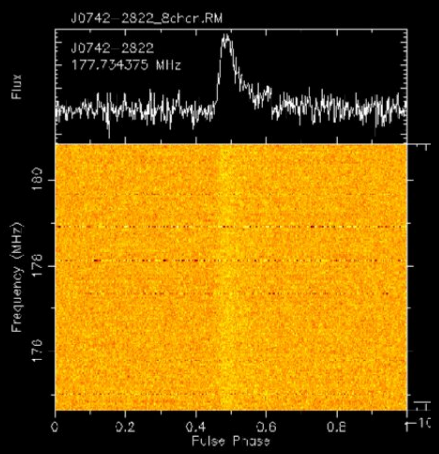
- Improving station calibration
- Station calibration efficiency
- Understanding pointing/tracking
- Improving bit statistics

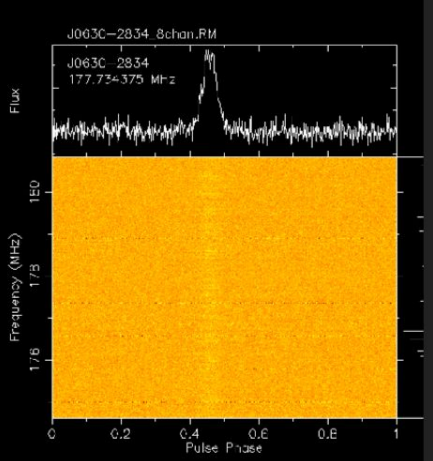
- Pulsar observations
  - Detected 12 known pulsars so far!
  - Testing methods and precision of ionospheric Faraday rotation
  - Data used for PSS/PST testing
    - We are aligned with AIV/Vulcan in prep to test this capability
- Same approach: RFI testing

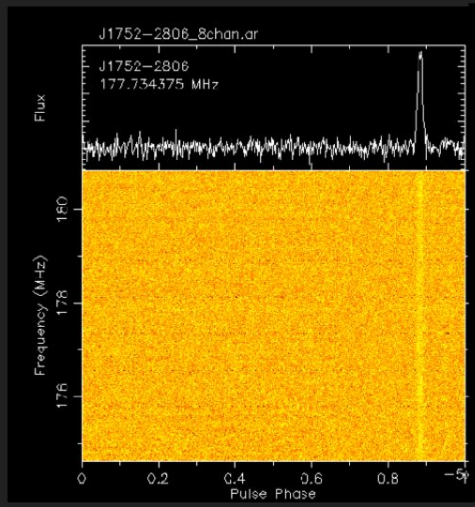


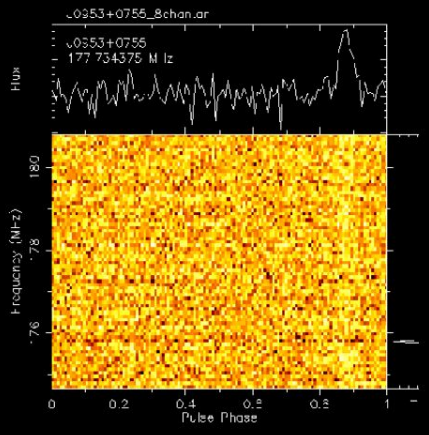

J1921+2153_8chan.ar
J1921+2153
177.734375 MHz
Flux
Frequency (MHz)
Pulse Phase

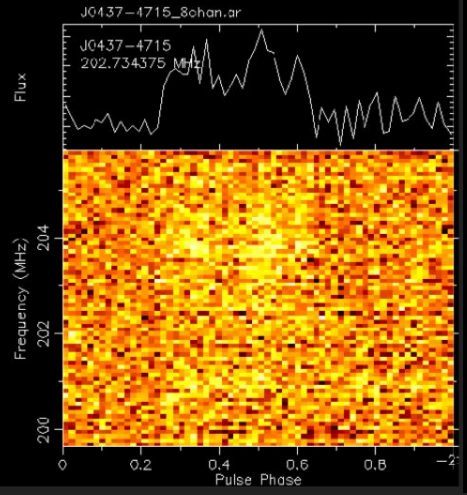

J1645-0317_8chan.ar
J1645-0317
177.734375 MHz
Flux
Frequency (MHz)
Pulse Phase

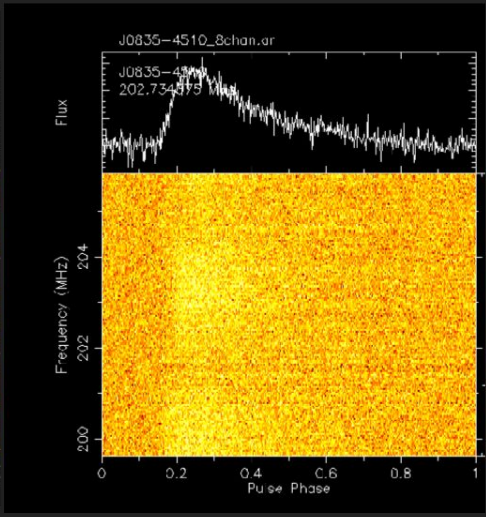

J0742-2822_8chan.RM
J0742-2822
177.734375 MHz
Flux
Frequency (MHz)
Pulse Phase


J0630-2834_8chan.RM
J0630-2834
177.734375 MHz
Flux
Frequency (MHz)
Pulse Phase


J1752-2806_8chan.ar
J1752-2806
177.734375 MHz
Flux
Frequency (MHz)
Pulse Phase

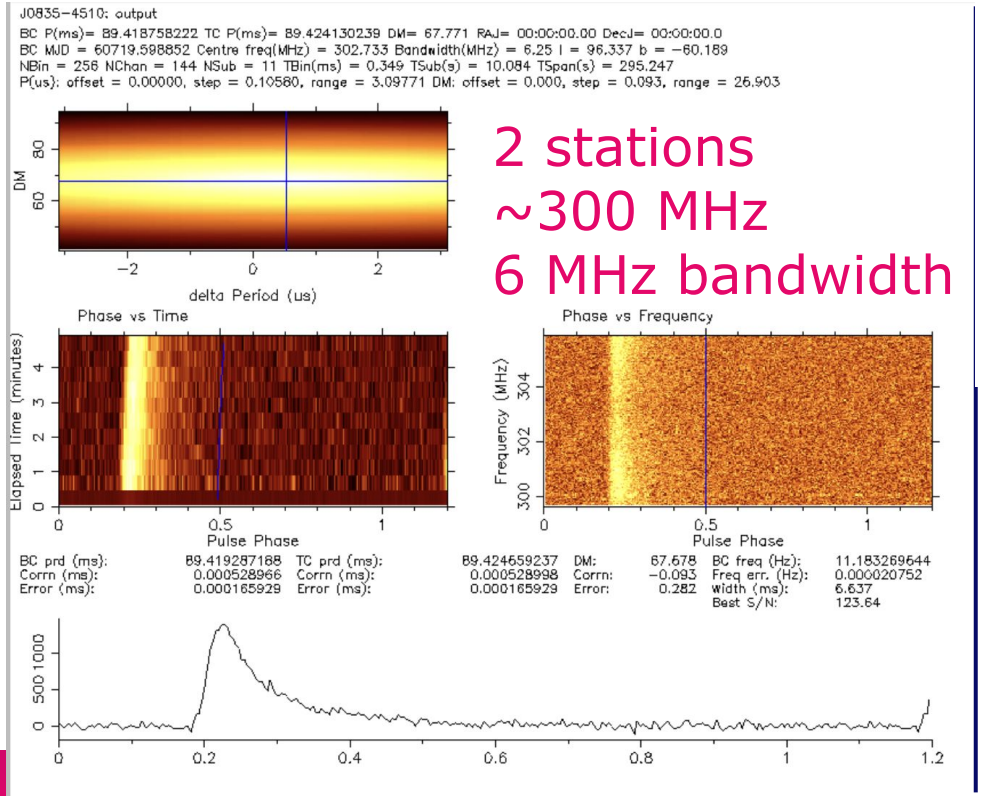

J0953+0755_8chan.ar
J0953+0755
177.734375 MHz
Flux
Frequency (MHz)
Pulse Phase


J0437-4715_8chan.ar
J0437-4715
202.734375 MHz
Flux
Frequency (MHz)
Pulse Phase

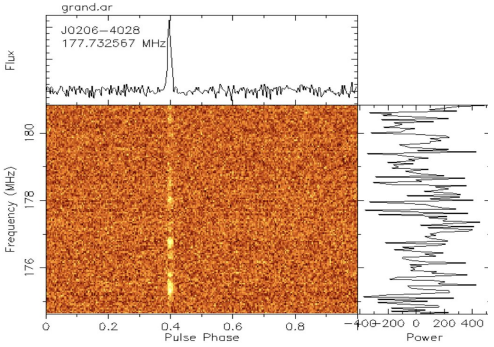

J0835-4510_8chan.ar
Flux
Frequency (MHz)
Pulse Phase

Array-level performance

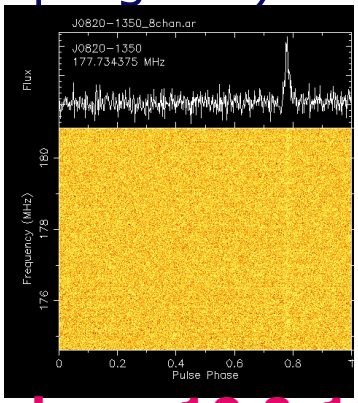
- … now PST coming along! (but TAB coherence work in progress)



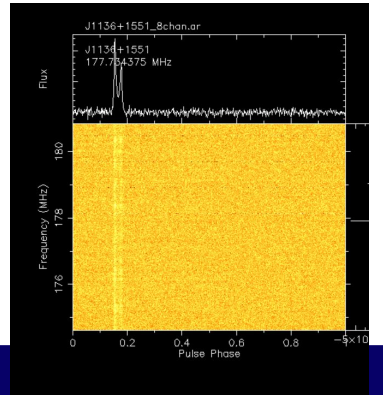
2 stations
~300 MHz
6 MHz bandwidth



Pulsar #9 (detected via PST!)



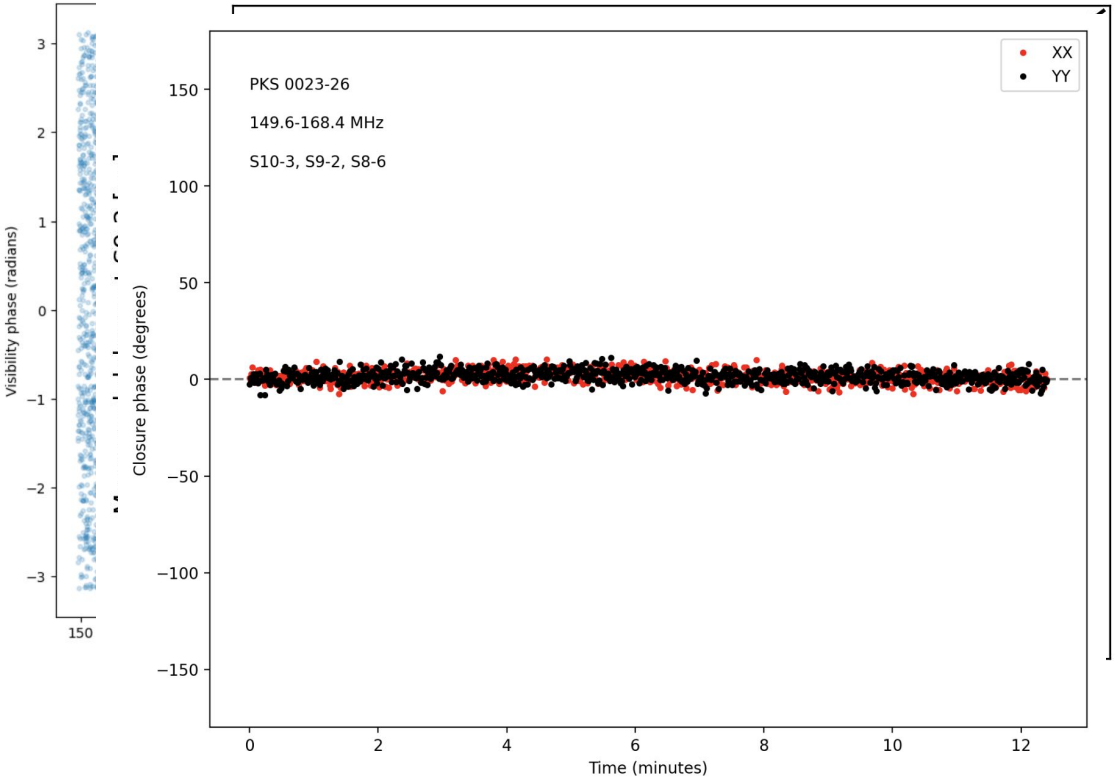
Pulsars 10 & 11



Low Science Commissioning: Outcomes & status II

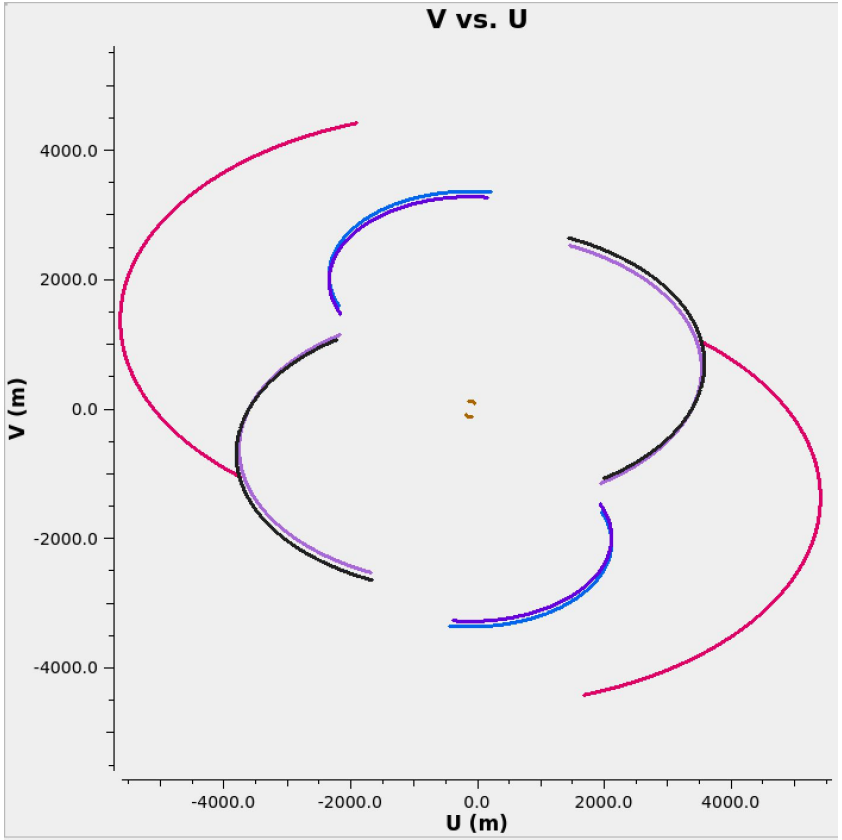
Interferometric testing:

- Fringe detections
- Validating geometric delay model as applied in CBF
- Validating/correcting residual delays arising from fibres to RPFs
- Phase closure
- Calibration heading toward the 1st image …



Array-level performance

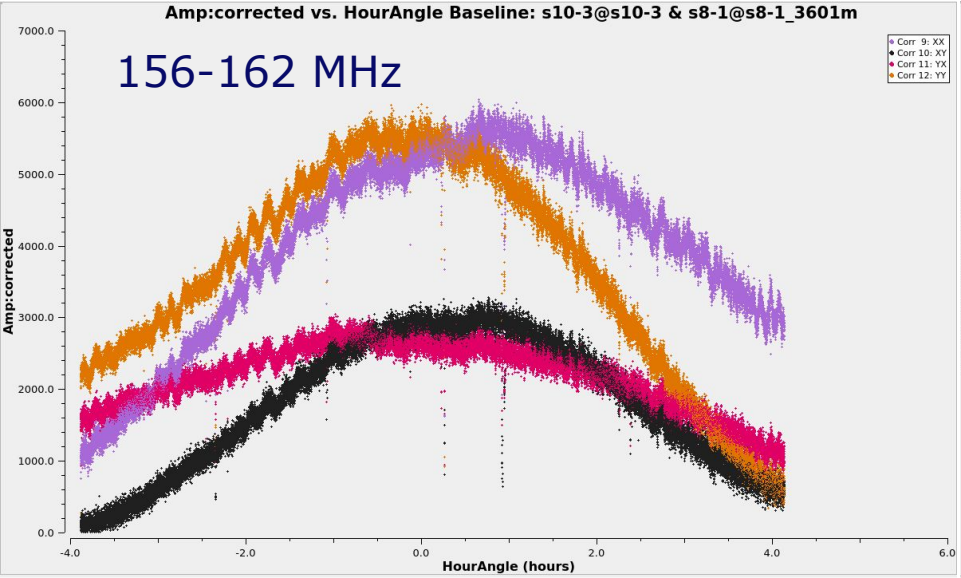
- Limited imaging capability due to sparse uv coverage
- But this isn’t stopping us :)
- Bandwidth helps quite a bit, so progress during PI26 toward use of the full 75MHz will make a big difference
- We are working toward a “first image” from Low AA0.5 that has progressed well, and you will see soon

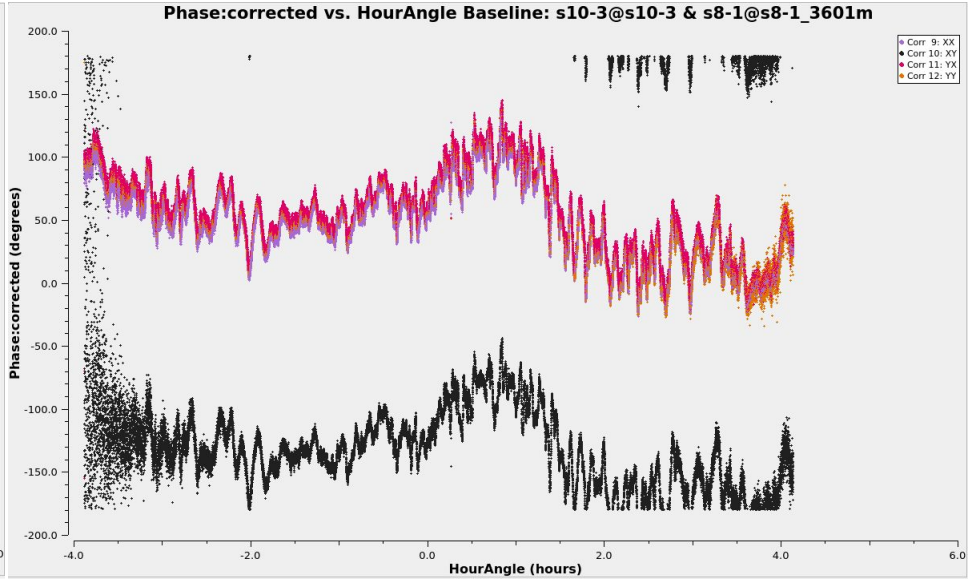


Array-level performance

- Excellent baseline sensitivity
- Progress with correction of station rotation effect

Raw (unflagged!) data, delay calibrated and averaged

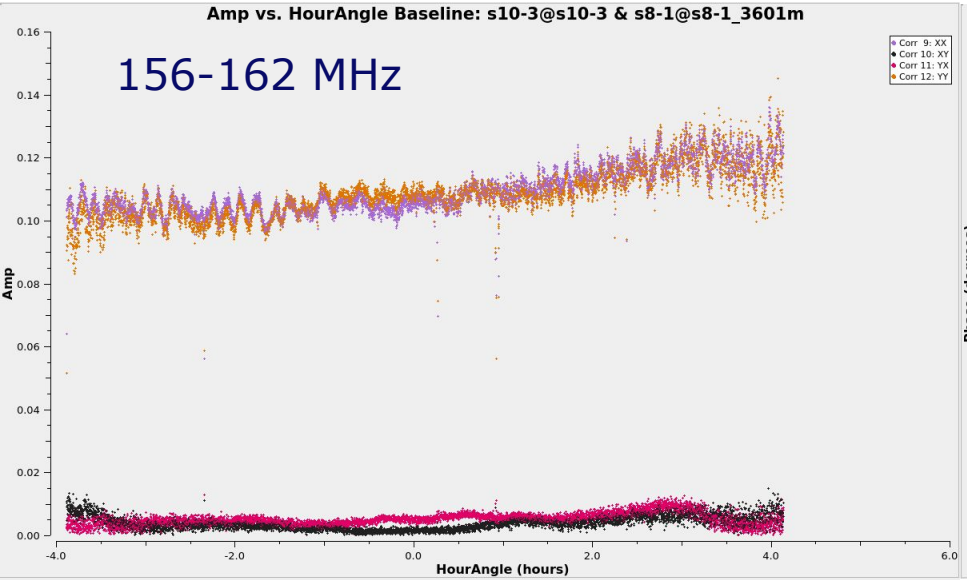


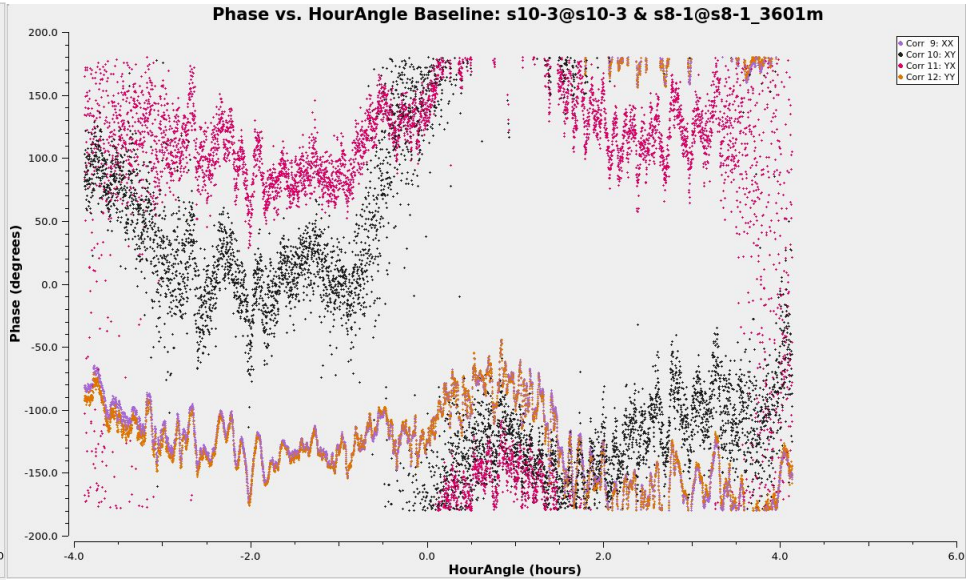


Array-level performance

- Excellent baseline sensitivity
- Progress with correction of station rotation effect

Same unflagged data, corrected for station rotation with EEPs

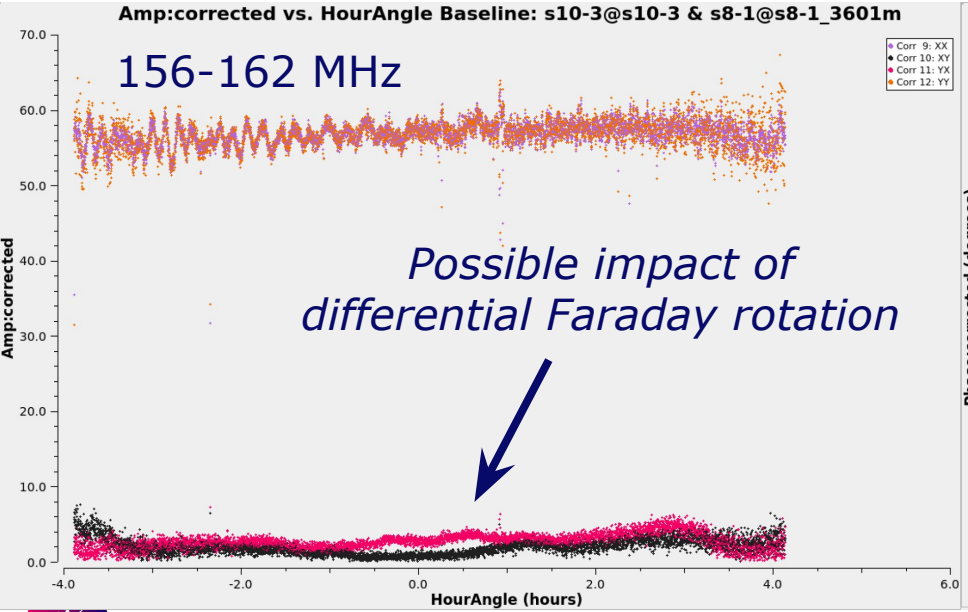


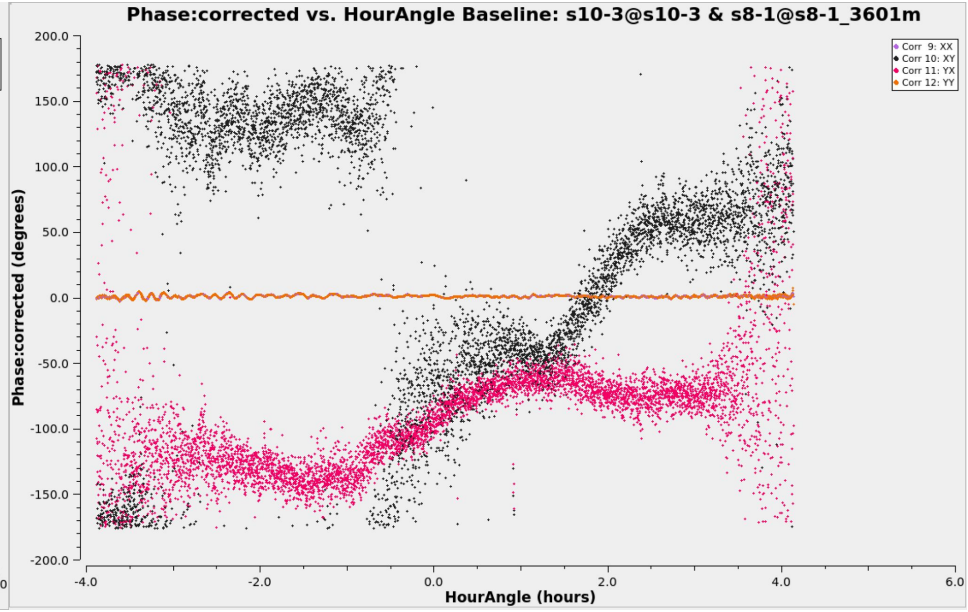


Array-level performance

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

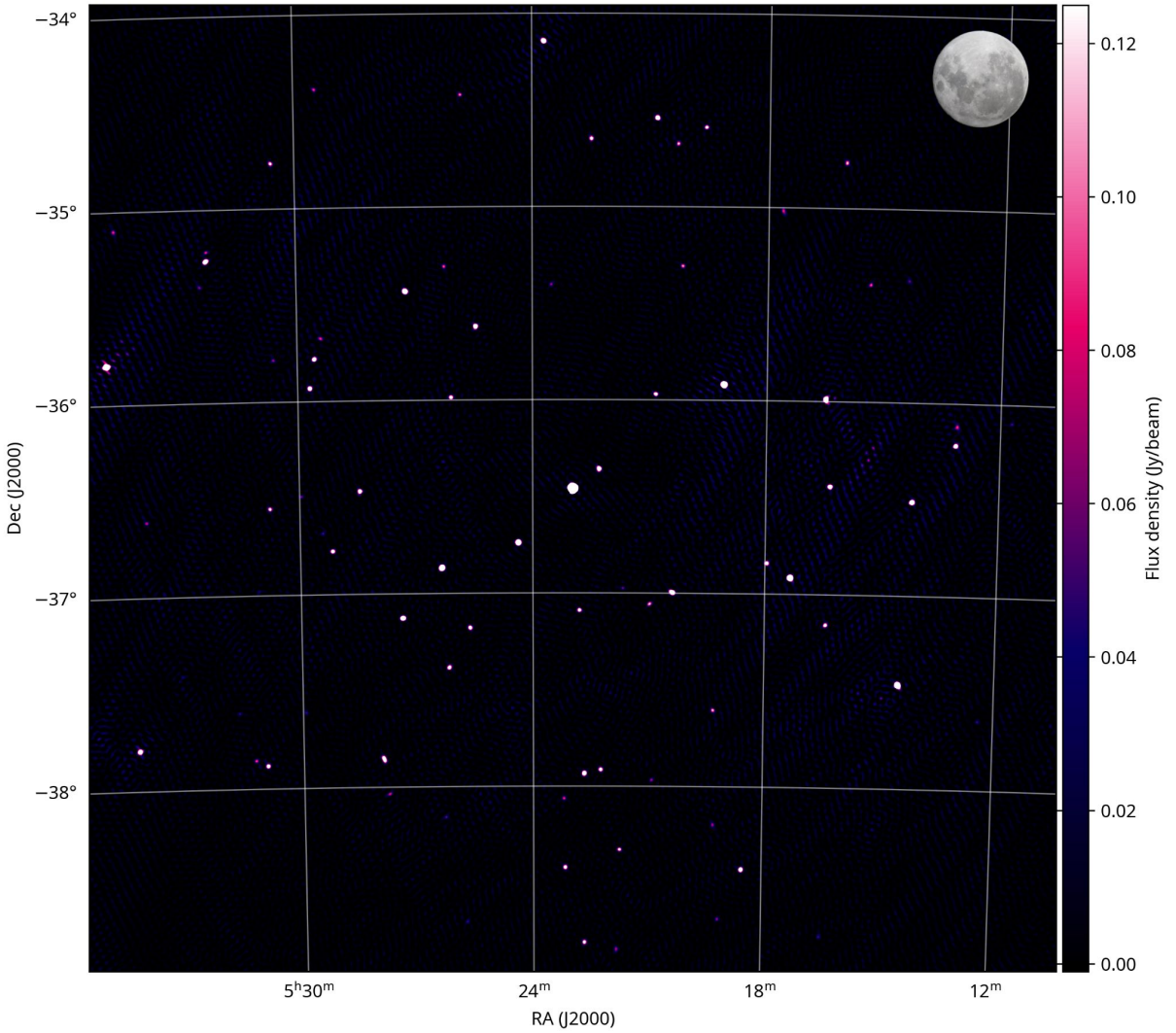
*Unflagged data, after bandpass and gain (**self**-)calibration*





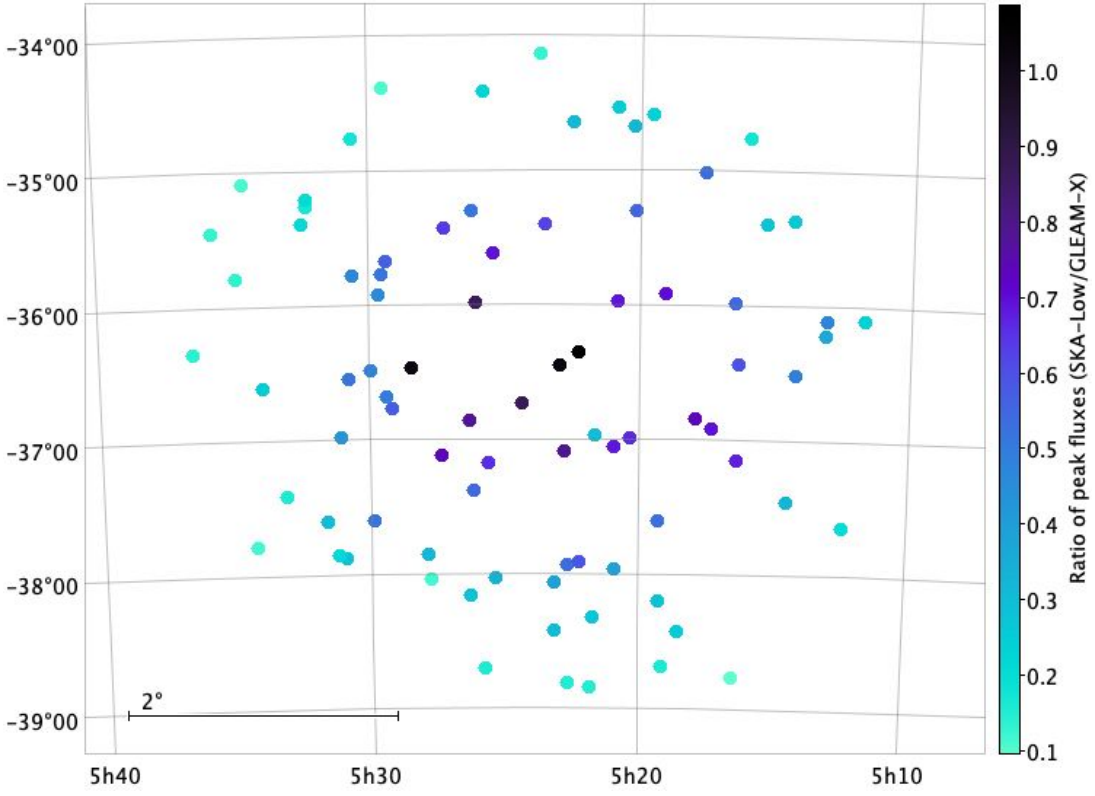
First SKA-Low AA0.5 image!

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



Comparison to GLEAM-X

- Calibration included bandpass and gains
- No source info included other than flux density of central calibrator source
- Deconvolution step did include exclusion of mask regions with no GLEAM-X counterpart
- Self-calibration process led to source fluxes that mainly line up very well with expectations!
- Cal process to be refined…



Status

- Stations are typically well calibrated. Pointing and tracking is working. Several known pulsars are detected with correct properties.
- Fibre delays within the array are taken care of
  - Recent progress on PST coherent beam - almost there!
  - Array calibration is progressing well and we will soon be at the point of pinning down a practical calibration strategy, and measuring a range of system parameters (sensitivity, stability, and station beam parameters among other things)
- Quality outcomes from design, construction, verification, and stability are enabling progression in Science Commissioning

- So far, about 25% of the planned AA0.5 commissioning tests are either complete or significantly advanced - documentation in progress

Low Science Commissioning: Next steps

AA0.5 tests
- Fundamentals: Calibration approach, data quality, stability
- Imaging: further tests and improvements
- Beamforming: deeper understanding of station beams, prep for tied array

Planning activities
- Workshop toward commissioning CoP
- Developing AA1/2 commissioning plans
- Work on updated calibration plan
- Input to revised AA2 planning

Team aspects
- Hiring 3x commissioning scientists
- Close coordination / meetings with AIV/Vulcan, System Science, Science Operations, …

Questions?

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

SKAO

www.skao.int