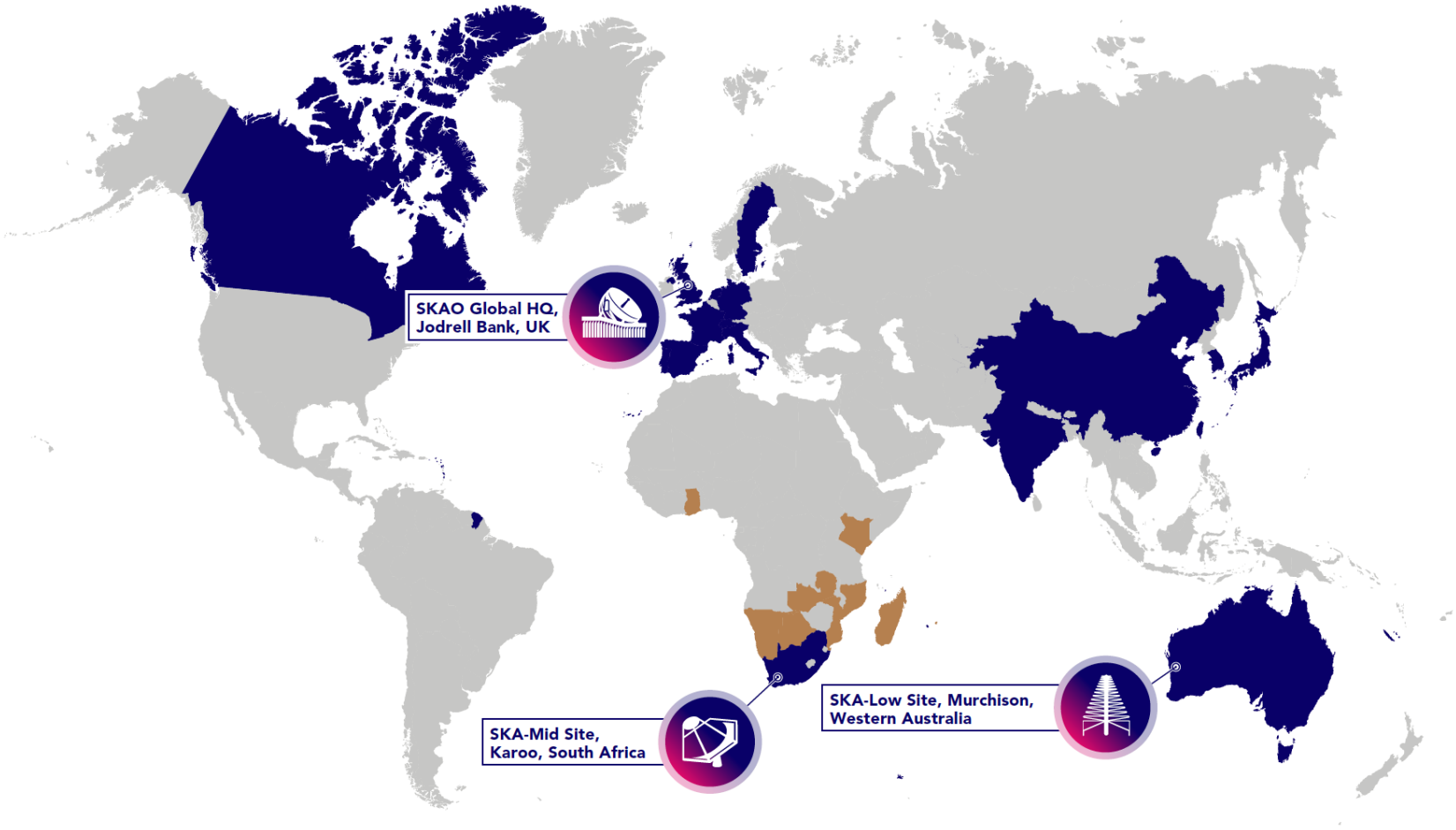
The SKA Observatory: scientific perspectives and timeline

Anna Bonaldi– Head of Scientific Services

The Fifth National workshop on the SKA project
Monday 24 November 2025


SKAO Global HQ,
Jodrell Bank, UK
SKA-Mid Site,
Karoo, South Africa
SKA-Low Site, Murchison,
Western Australia
SKAO Partnership - includes SKAO Member States* and SKAO Observers (as of June 2022)
African Partner Countries

Italy as a valued Member of SKAO

- Italian scientists participated in early definition of the SKA in 1990s
- Italian engineers participated in all SKA design activities in 2000s and 2010s
- Italy participated in all governance activities from 1999 onwards
- Italy bid to host the SKAO HQ in 2015
- Italy convened and chaired the SKAO Convention negotiations; Convention signed at Italian Ministry of Foreign Affairs in March 2019.
- Italy contributing €120M to SKAO construction and first 10-years of operations.
- Italian industry and INAF contributions
  - Feed indexers for SKA-Mid dishes; antennas for SKA-Low; SKA-Low Signal Processing System; local monitor and control software for SKA-Mid dishes; subsystems for SKAO Time scale (critical for an interferometer); software for pulsar search and timing; support from Italian National Metrology institute
- Italian scientists prominent in all SKAO Science Working Groups; major SKA Science meeting held in Catania in 2014

Key Science Projects (KSPs)

- Truly transformational & exciting science
- Significant resources and observing time (>1 observing cycle)
- Leadership team restricted to people from member countries
- Co-Is from non-member countries are possible

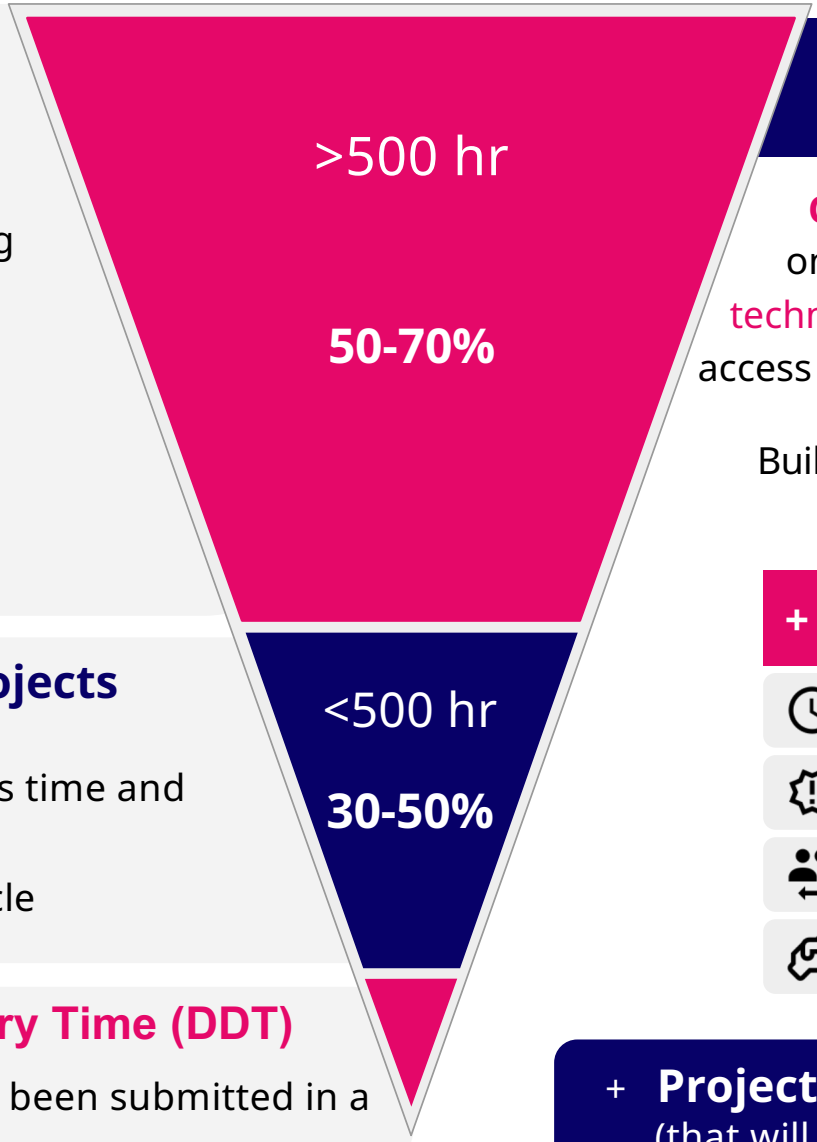
Reminder: SWGs are NOT KSPs

Principal Investigator (PI) Projects

- Observing projects that require less time and resources than a KSP
- Typically allocated over a single cycle

Director-General's Discretionary Time (DDT)

- Timely projects that could not have been submitted in a standard cycle



Access to SKA

Observing time will be allocated on the basis of scientific merit and technical feasibility while maintaining access in proportion to member shares

Building to **a small amount of Open Time**

+ Proposal attributes

- Long Term Projects
- Target of Opportunity
- Joint SKA projects
- Coordinated Projects

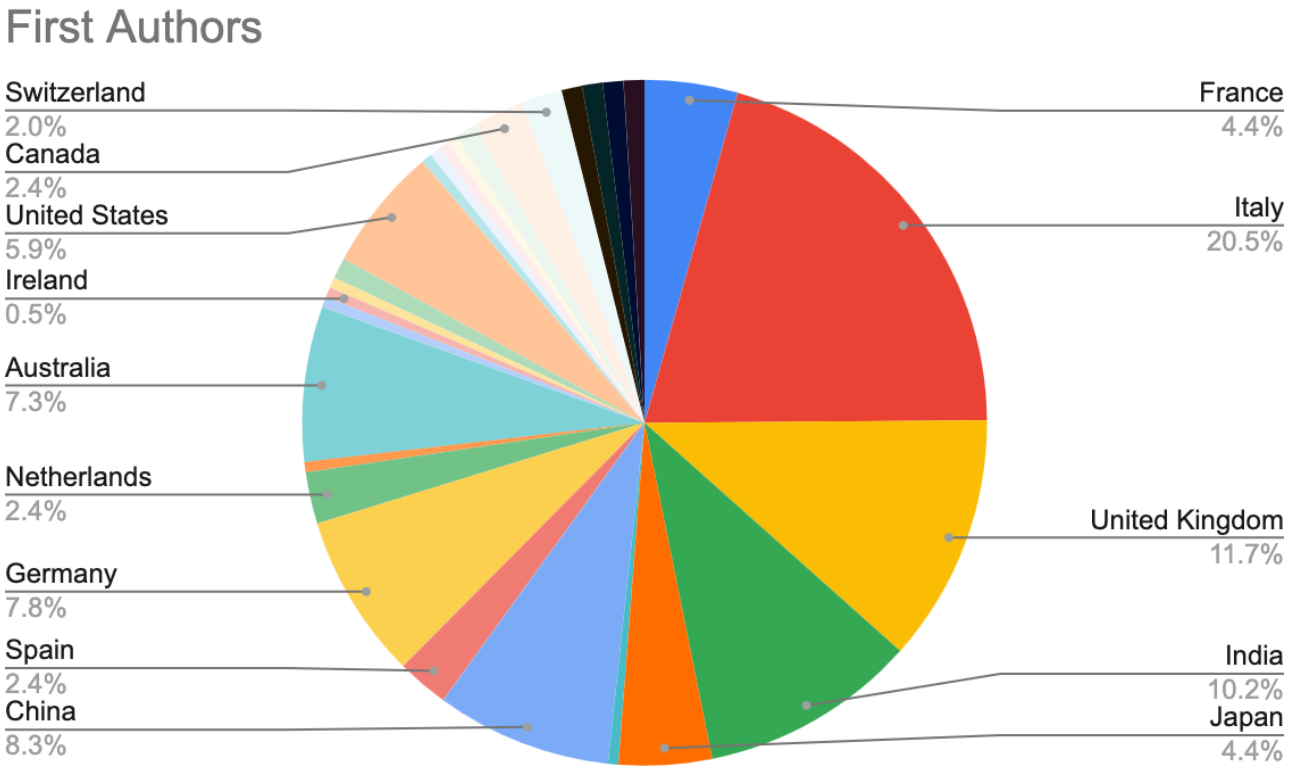
+ Projects based on archival data
(that will still require compute resources)

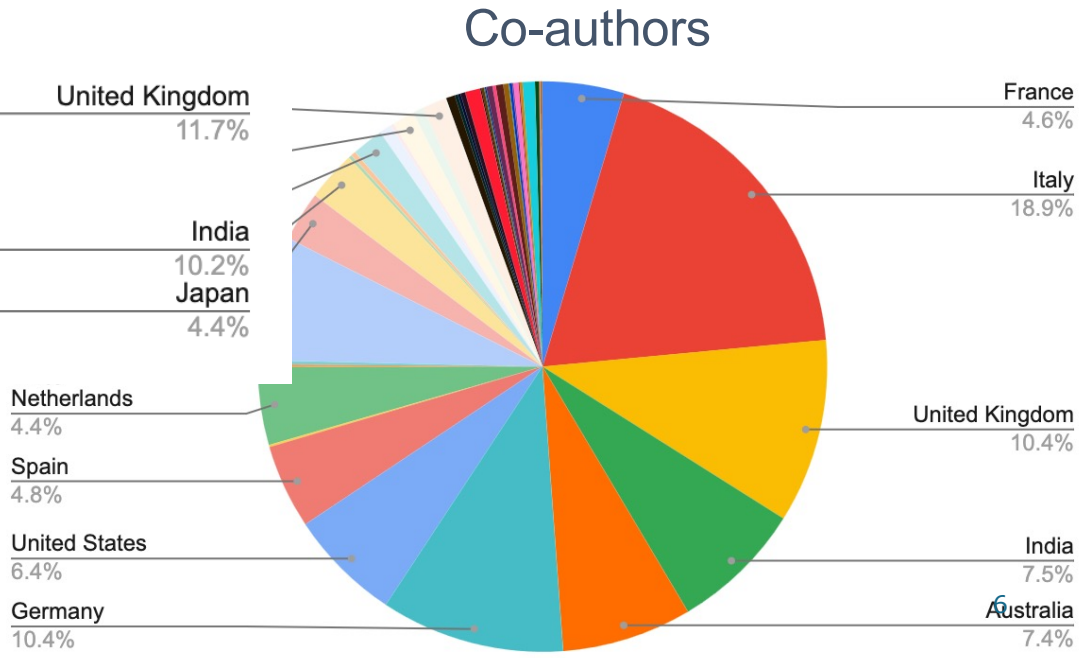
Updated SKAO Science Book

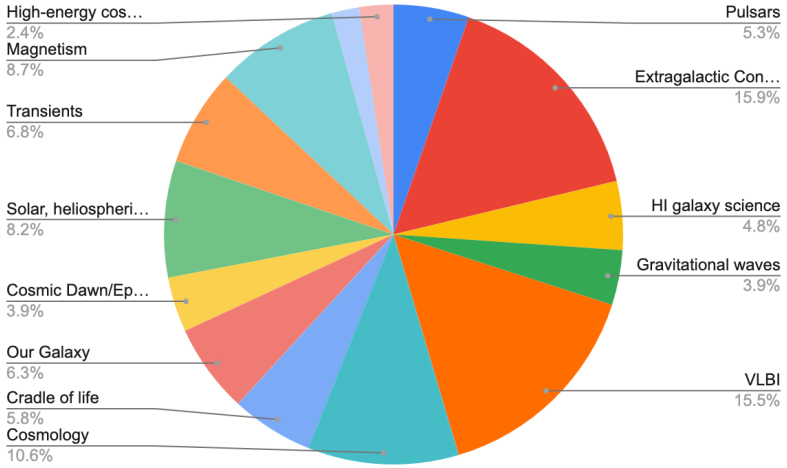
"Advancing Astrophysics II"

- 10 years from the publication of *Advancing astrophysics with the SKA*
- Up-to-date coverage of the science enabled by the SKA *Baseline Design* (AA4)
  - To what extent can the science be achieved with AA*?
  - What enhancements beyond AA4 can further support it?
- Community-driven
  - Science cases from members of our scientific community
  - Coordination and consolidation of cases from the Science Working Group chairs
  - Good representation of all our science areas
- Up-to-date
  - Changes in the scientific landscape
  - Mature set of telescope specifications and expected performance
- Support strategic direction of the Observatory, by providing detailed science requirements for
  - The path from AA* to AA4
  - The Observatory Development Plan

Italian participation to AASKAII book

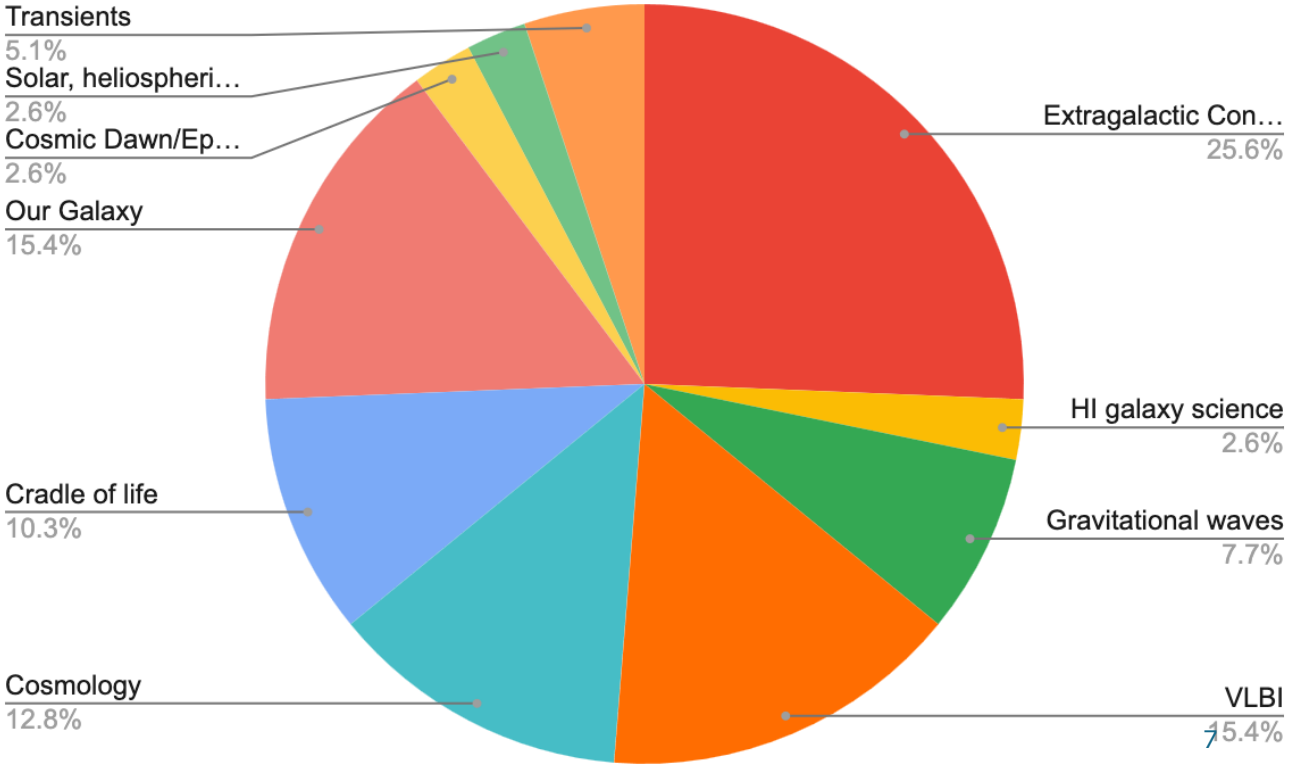






Submitted papers by SWG category - all

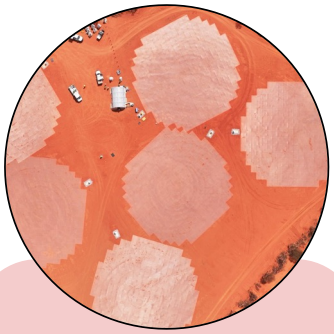
Submitted papers by SWG category - Italy



Enhanced participation to:
Extragalactic Continuum
Our Galaxy
Cradle of Life
Gravitational waves
Cosmology

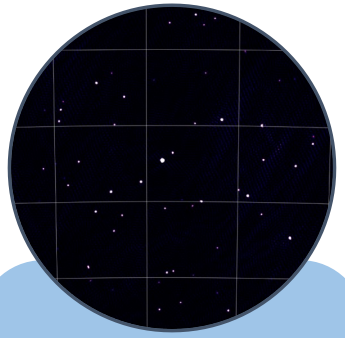
SKAO milestones

Community involvement starts



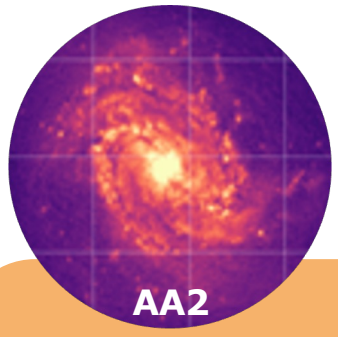
Construction

- Building antennas, dishes, roads etc!
- Followed by Assembly, Integration and Verification



Commissioning

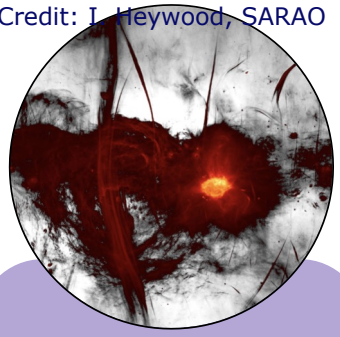
- SKAO activity
- Includes system verification and science commissioning



Science Verification

- A full dress rehearsal of the end-to-end system for every mode of operation
- Once modes and pipelines are working, the community can submit target ideas
- Data will be publicly available for scrutiny
- Build trust and fostering an early science return

Credit: I. Heywood, SARAO



Cycle 0

- Shared-risk PI projects
- SRCNet resources ready for user
- Proprietary periods

Now **Now** **First half 2027** **First half 2029** **2030**

Now **Soon** **First half 2029** **First half 2031** **2032**

SKA-Low Construction Progress

- AA0.5 (4 stations) achieved
- ~15,000 antennas assembled = 62 stations
  - 45,312 more antennas on site awaiting assembly
- Tracks, power & fibre: South, East, North arms 100% complete (excluding Kalli Station)
- Mesh: 100% complete south arm, 90% north, 100 (60) % east, core 71 (54) %

SKA-Mid Dish Structure Progress

SKA001

SKA100

SKA036

AA0.5 Fringes

SKA034

AA0.5

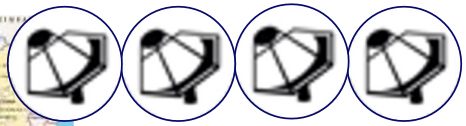
SKA063

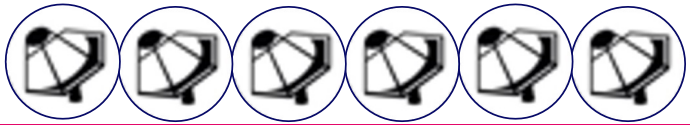
SKA031

SKA077

AA1

SKA046

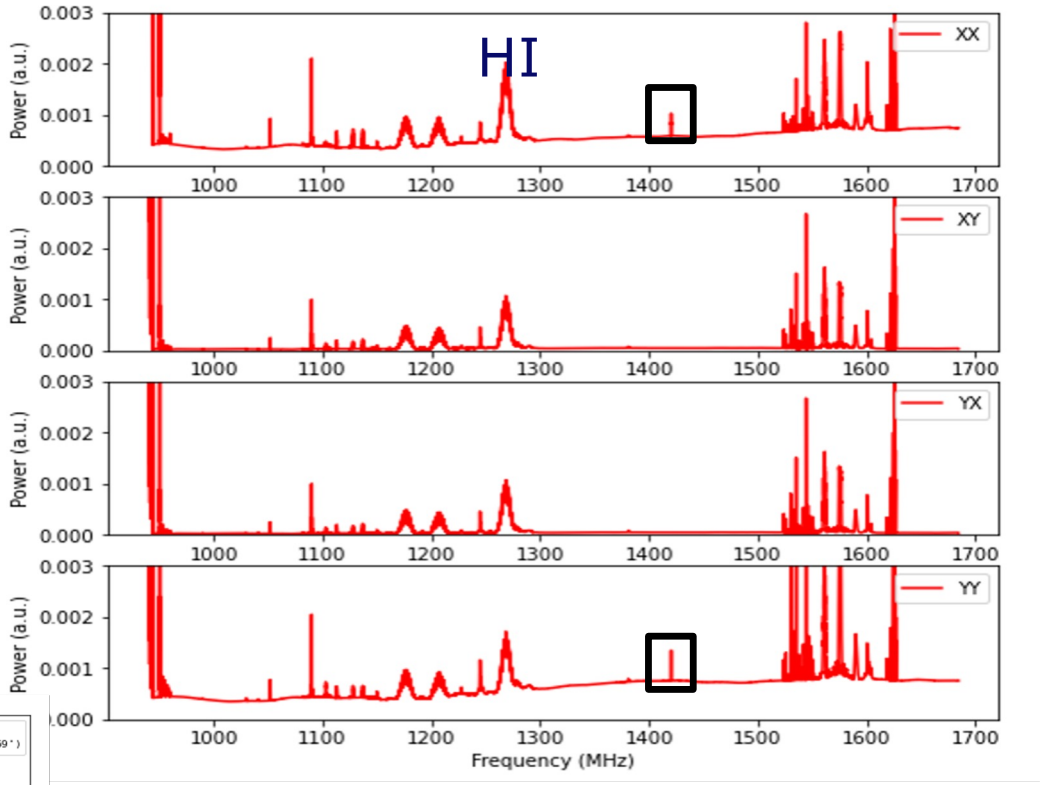


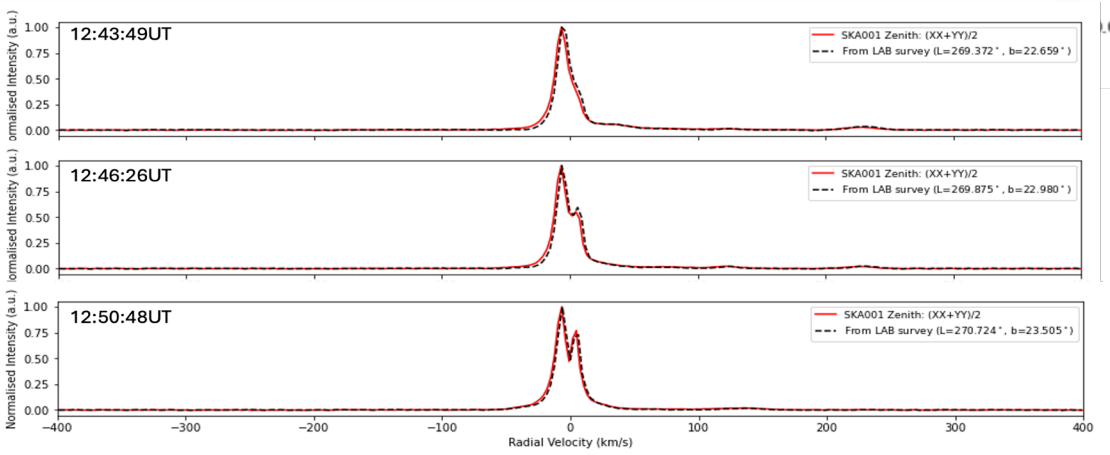


AA2 (Factory Acceptance Testing) - China

SKA-Mid Full Signal Chain Tests

- Galactic HI seen in autocorrelations (XX, YY)
- Line profiles match LAB survey
- Band 2 SPF, digitiser, Talon correlator, software all work as a system



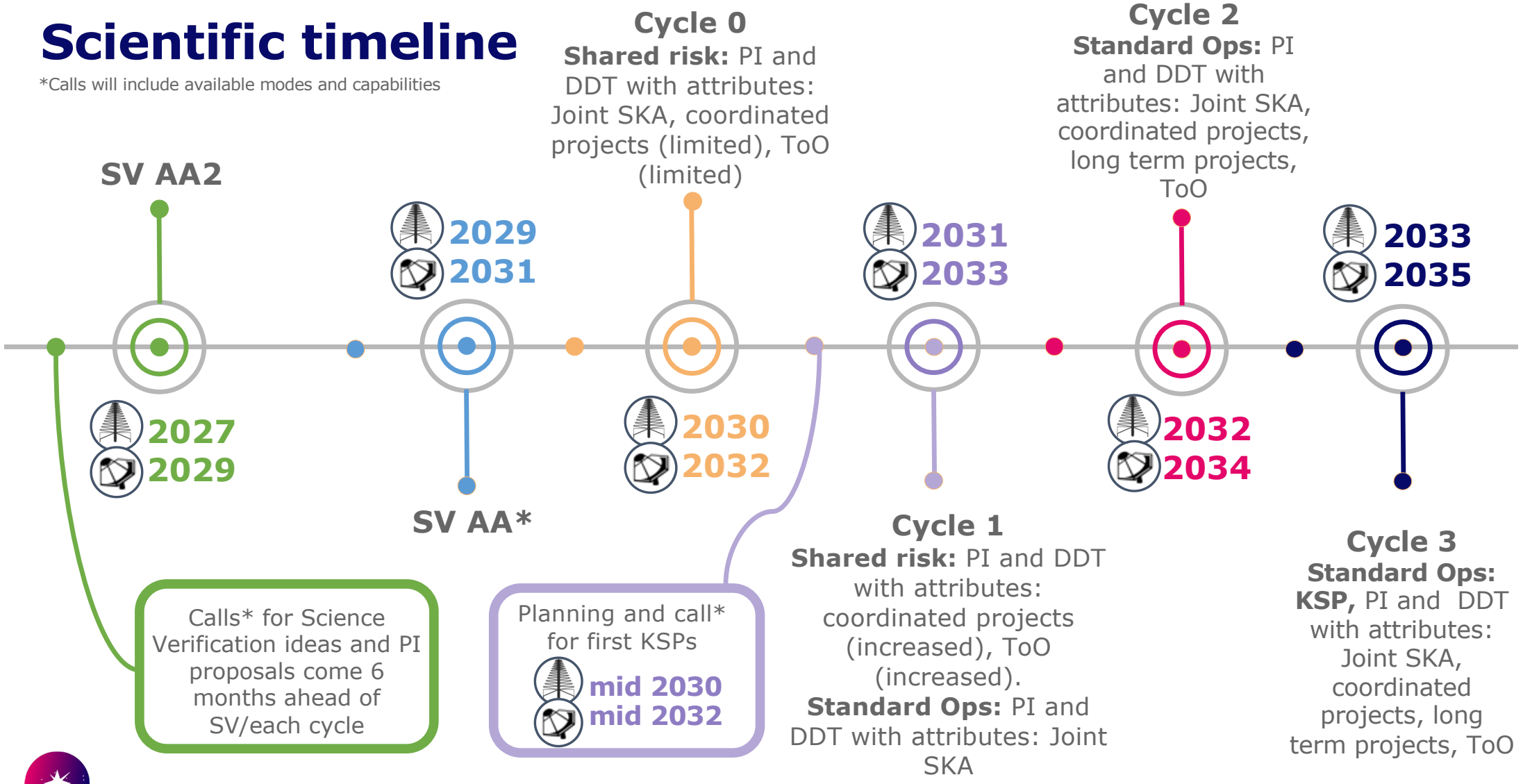


- Single-dish spectra
- Pointing at zenith
- Full signal chain

LAB = Leiden/Argentine/Bonn Galactic HI survey SPF = Single Pixel Feed

Scientific timeline

*Calls will include available modes and capabilities



Delivery of modes and ODP capabilities

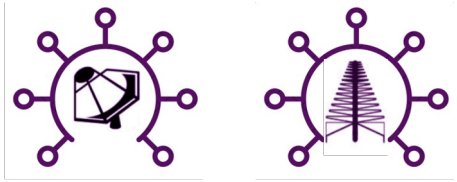
Community availability of capabilities

Capabilities will be available to the community once:

The end-to-end system is in place

They pass science commissioning

Roll through Science verification, shared risk and into standard operations



Delivery of modes & ODPs

Timeline that we are **confident is achievable** and allows the telescope to be commissioned in a sensible order

- Focused development adds confidence in our delivery
- **empowers the community** to build realistic and successful scientific plans.

! This is our best understanding today, any evolution of the plan will be communicated as we progress

Rollout of modes and ODPs

community engagement and feedback

- Presented in Gorlitz
  - Talk
  - Printed posters in SWG parallel sessions
  - Bespoke discussions between SciOps and SWGs
- Follow up email to ALL SWG members and ALL participants of the meeting asking for feedback
- Available on our website
- Further asked SWG chairs if they had coordinated feedback

AA2: Science verification

Low: 2027 68 stations

Mid: 2029 66 dishes

Calibrated, averaged and gridded visibilities, image cubes

Early implementation of continuum subtraction

Single beam, single pointing

Max 4k channels
Max 4h observations

Calibrated, averaged and gridded visibilities, image cubes

Full BW (150 MHz/800 MHz)

Single beam, single pointing

Max 40 channels
Max 4h observations

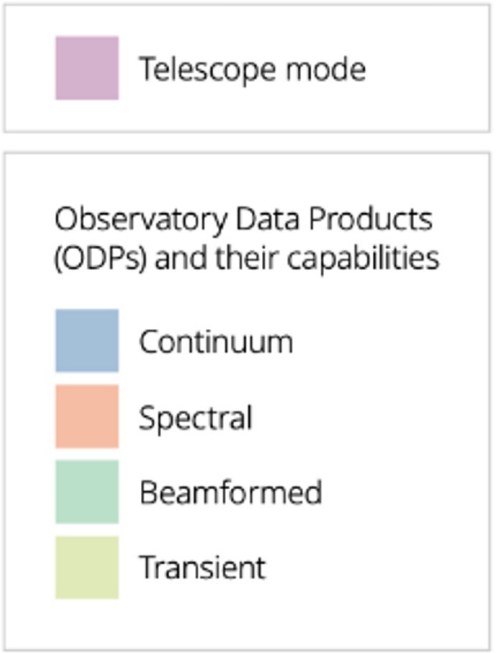
Single subarray

Sidereal and non-sidereal tracking

PST at least 1 beam, full processing

8 PSS beams

1 VLBI beam



AA*: Science verification

Low: 2029 257* (307) stations

Mid: 2031 144 dishes

Continuum subtraction

Up to 8 station beams
At least 1 substation arrangement

Max 4h observations, up to 8 images

Zoom resolution (up to 0.21 kHz)

Calibrated, averaged and gridded visibilities, image cubes

Up to 16 station beams
At least 1 substation arrangement

Full BW (300 MHz/5 GHz)

Max 8h observations, up to 16 images

Single subarray

Sidereal and non-sidereal tracking

2 / 8 PST beams

8 / 200 PSS beams

1 / 4 VLBI beams

Telescope mode

Observatory Data Products (ODPs) and their capabilities

- Continuum
- Spectral
- Beamformed
- Transient

* Restored subject to availability of funds in 2031 funding cycle

AA*: Cycle 0

Low: 2030 257* (307) stations

Mid: 2032 144 dishes

Multiple pointings (no joint deconvolution)

Basic image-based mosaicing

Up to 24 station beams
2 substation arrangement

Max 12h observations

Zoom resolution (up to 0.21 kHz)

Multiple pointings (no joint deconvolution)

Up to 24 station beams
2 substation arrangements

Max 50h observations

Transient buffer triggered by PSS observations (in SV)

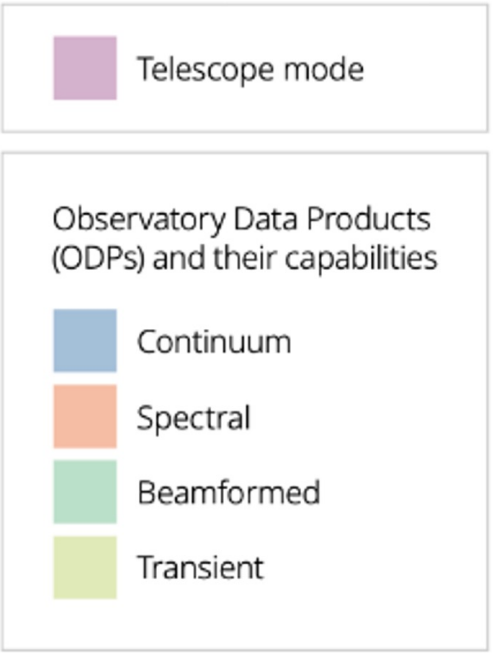
4 subarrays

Drift scanning (few mins)

8 / 16 PST beams

50 / 200 PSS beams

2 / 4 VLBI beams

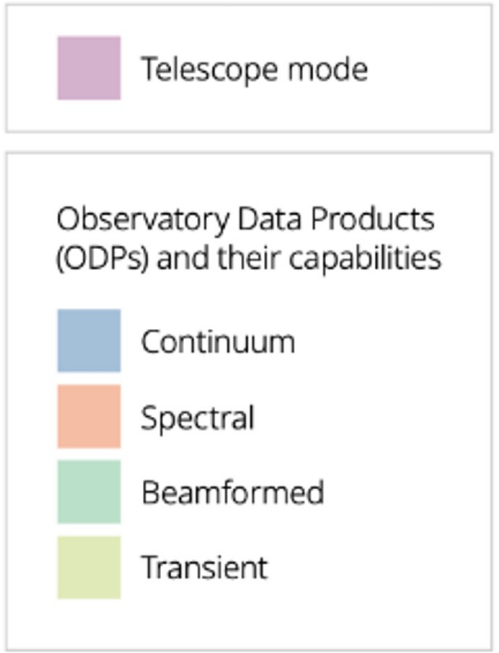


* Restored subject to availability of funds in 2031 funding cycle

AA*: Cycle 1

Low: 2031 257* (307) stations

Mid: 2033 144 dishes



Multiple pointings

Joint deconvolution (in SV)

Multiple pointings

Limited joint deconvolution (in SV)

Transient buffer triggered by PSS observations (in SV)

Fast imaging/Transient buffer triggered by fast imaging (in SV)

16 subarrays

Drift scanning (few mins)

8 / 16 PST beams

50* (250)/ 200* (1125) PSS beams

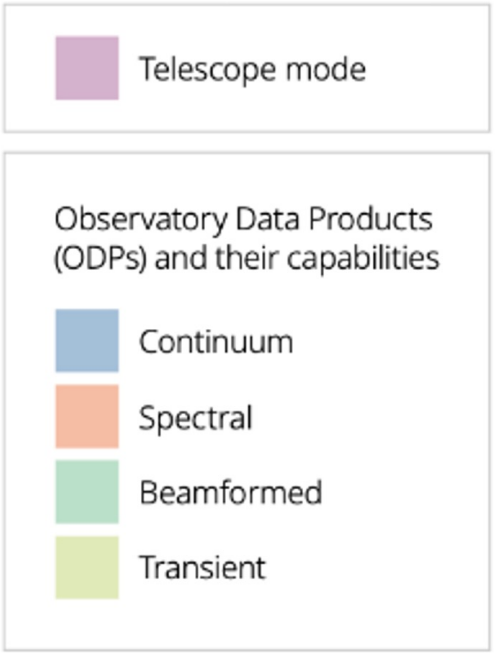
4 / 4 VLBI beams

* Restored subject to availability of funds in 2031 funding cycle

AA*: Cycle 2

Low: 2032 257* (307) stations

Mid: 2034 144 dishes



Multiple pointings
Joint deconvolution
Limited / Full PLDP generation

Multiple pointings
Joint deconvolution
Limited / Full PLDP generation

Transient buffer triggered by PSS observations

Fast imaging/Transient buffer triggered by fast imaging (in shared risk/ SV)

Full drift scan (in SV)
Wide-area scanning (in SV)

8 / 16 PST beams

50* (250)/ 200* (1125) PSS beams

4 / 4 VLBI beams

* Restored subject to availability of funds in 2031 funding cycle

AA*: Cycle 3

Low: 2033 257* (307) stations

Mid: 2035 144 dishes

Multiple pointings
Joint deconvolution
Full PLDP generation
Autocorrelaton data (shared risk)

Multiple pointings
Full Joint deconvolution
Full PLDP generation

Transient buffer triggered by PSS observations

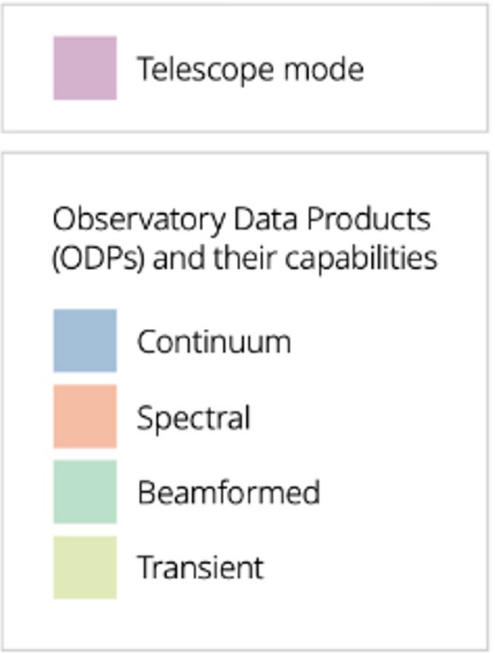
Fast imaging/Transient buffer triggered by fast imaging

Full drift scan (in SV)
Wide-area scanning

8 / 16 PST beams

50* (250)/ 200* (1125) PSS beams

4 / 4 VLBI beams



* Restored subject to availability of funds in 2031 funding cycle

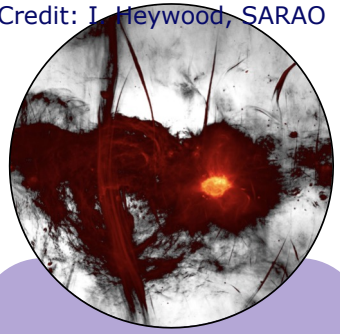
Updates to the rollout?

- Rollout based on what we think we can deliver when, but:
- Continuing to investigate:
  - Concerns from the Cosmology SWG over the current timing of Wide Area Scanning (SV with this mode starting in 2034)
    - What pipelines are available within the community and;
    - Do we think current pipelines would significantly accelerate the delivery of SKAO pipelines
  - Concerns from the Transient SWG over the current timing of fast imaging (SV with this mode starting in 2032 for Low and 2033 for Mid)

SKAO milestones

Community involvement starts

Credit: I. Heywood, SARAO



Call for SV ideas ~ 6 months before

Science Verification

- A full dress rehearsal of the end-to-end system for every mode of operation
- Once modes and pipelines are working, the community can submit target ideas
- Data will be publicly available for scrutiny
- Build trust and fostering an early science return

Cycle 0

- Shared-risk PI projects
- SRCNet resources ready for user
- proprietary periods

Middle 2026 | **First half 2027** | **First half 2029** | **2030**

Middle 2028 | **First half 2029** | **First half 2031** | **2032**

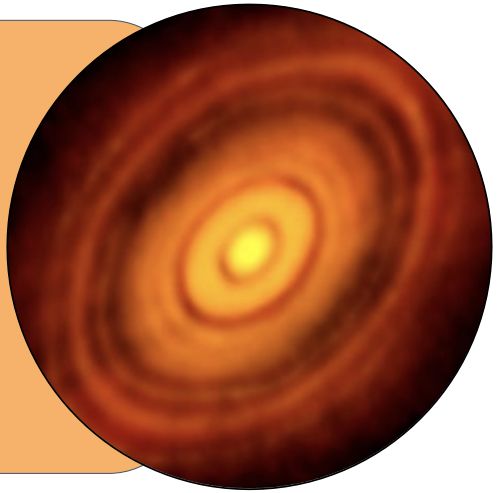
Thank you for your time…

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

SKAO

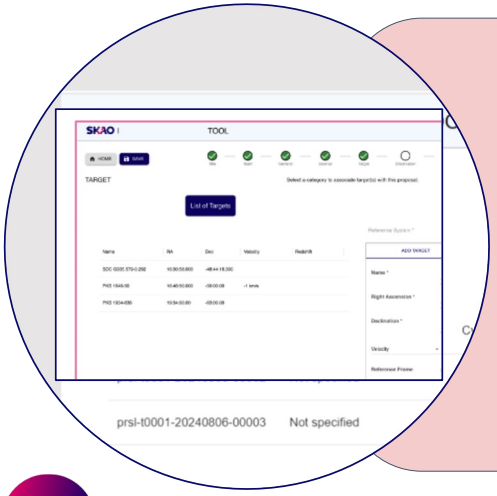
www.skao.int

Science verification



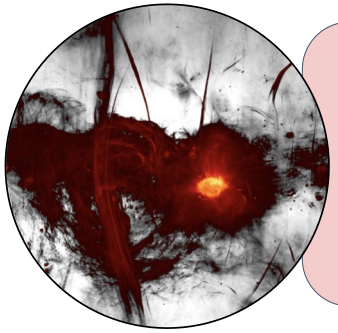
HL Tau Science Verification image from ALMA! Credit: ALMA (NRAO/ESO/NAOJ); C. Brogan, B. Saxton (NRAO/AUI/NSF)

- First chance the community will have to access SKA data - you will be closely involved!
  - Provide the ideas and targets
  - Public data releases for scientific exploitation and fostering an early science return!
  - Validating data reduction workflows (allowing the SKAO to begin to build trust in our generated data products) and the user experience
  - Begin to understand the potential of an observing mode



- End-to-end test of the system
- Important milestone before we put out the first call for proposals
  - Do all our systems work? submission, telescopes, Correlator Beam Formers, observing mode, tools, data processing, data delivery, SRCNet analysis
  - Are the Observatory staff prepared?
- Allows us to build trust in our systems and pipelines, build momentum, demonstrate potential, science!

What we will provide and support in Science Verification

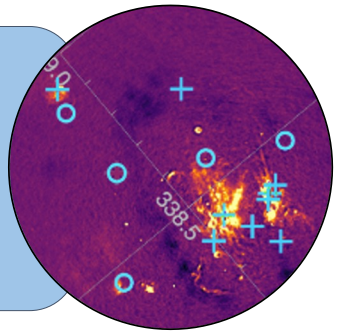


Data products

- Fully processed Observatory Data Products (ODPs)
- Calibrated constituent data products. Calibrated, averaged visibilities (including calibration solutions), time domain products.
  - **Verification of pipelines** is an important step in SV
  - **Important for building trust**
- Verification periodically as modes/array mature/grow (even into Cycle 0)

Ancillary Products

- A description of the processing that has been done to arrive at the fully processed data product (e.g., workflow scripts).
- Quality assessment report.
- Versioning information for the software, relevant copies of telescope model data etc
- Local sky model




SKAO

Memo

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Status:	Released

	Name	Designation	Affiliation	Signature	Date
Author	Astronomer	Policy & P&I Coordinator	SKAO		

Support

- **A memo series** so that early career researchers, e.g., could receive technical credit, especially if a dataset doesn't result in publication
- **A helpdesk, community training and workshops**. Including documentation, videos, online drop in sessions, podcasts, community days.
- Limited SRCNet resources for analysis, visualisation, and Advanced Data Product creation.

Programme Schedule & Risk Review (PSRR)

Covered in SKAO's webinar by Naomi McClure-Griffiths on 18/11

- Started in early 2025 to fully review the schedule (phase 1) and risk/cost (phase 2) of the Construction programme
- Phase 1 completed before Görlitz SKA Science Meeting
  - Outcome was the ~2 yr schedule slip of SKA-Mid
- Phase 2 has been underway between July - November 2025
  - Resulted in the identification of extra cost risk means the project cannot deliver AA* on budget
    - Risk identified from lessons from our delivery experience to date, cost escalation, scope gap, contractor failure, schedule delay
- Implemented extensive Observatory-wide cost-savings

To ensure costs do not exceed the budget up to 2031, we have had to make the difficult decision to defer some scientific capability

Deferred capabilities

Covered in SKAO's webinar by Naomi McClure-Griffiths on 18/11

To help resolve the budget we will defer until post-2030 the delivery of 4 capabilities:

1) 50 stations in the core of SKA-Low. The initial delivery will be 257 stations, of which 149 are in the core.
2) PSS on SKA-Mid will be limited to 200 beams until *at least* Cycle 0 as advertised
3) PSS on SKA-Low will be limited to 50 beams in the early observing cycles
4) The SKA-Low CBF will match AA* (it was previously over-scoped to match AA4)

It is our clear intent to reinstate the capabilities as soon as financially viable starting from 2031, or sooner, to minimise the impact on science.

Planned Array Assemblies

SKA Low

4 stations

SKA Low

16 stations

SKA Low

68 stations

65 km max baseline

SKA Low

257 stations

74 km max baseline

307 stations

74 km max baseline

SKA Low

512 stations

74 km max baseline

AA0.5 — AA1 — AA2 — AA* — AA4

No Change

SKA Mid

4 Mid dishes

SKA Mid

8 Mid dishes

SKA Mid

66 Mid dishes

36 km max baseline (108 km including dish SKA008)

Bands 1 & 2 on all Band 5 on 32 dishes

SKA Mid

144 dishes

36 km max baseline (108 km including dish SKA008)

Bands 1 & 2 on all Band 5 on 80 dishes

SKA Mid

197 dishes

160 km max baseline