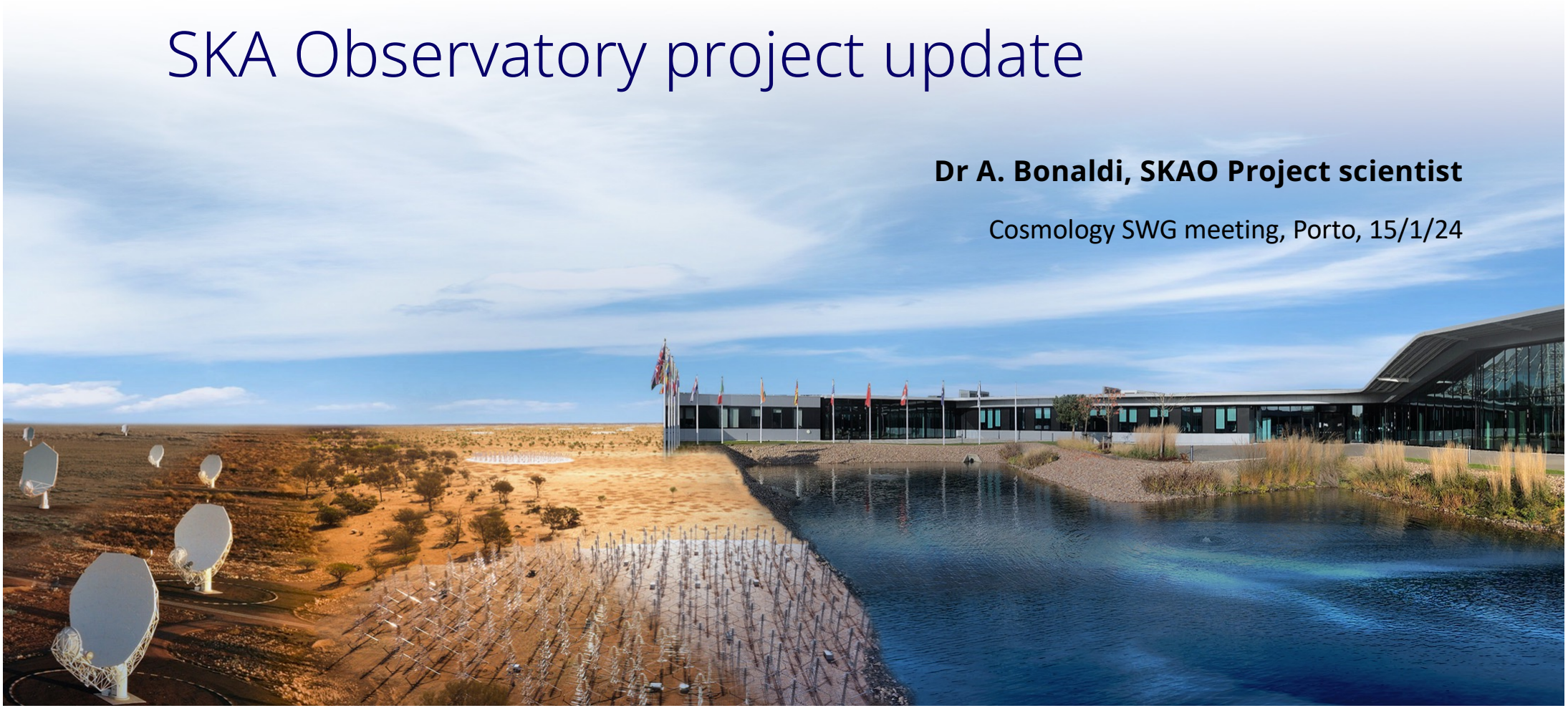
SKA Observatory project update

Dr A. Bonaldi, SKAO Project scientist

Cosmology SWG meeting, Porto, 15/1/24



SKA-LOW

THE SKAO'S LOW-FREQUENCY TELESCOPE

FREQUENCY RANGE:
50 MHz–
350 MHz

131,072
ANTENNAS
SPREAD ACROSS **512** STATIONS

MAXIMUM BASELINE:
~74km

SKA-MID

THE SKAO'S MID-FREQUENCY TELESCOPE

FREQUENCY RANGE:
350 MHz–
15.4 GHz
WITH A GOAL OF 24 GHz

197 DISHES
(INCLUDING 64 MEERKAT DISHES)

MAXIMUM BASELINE:
150km

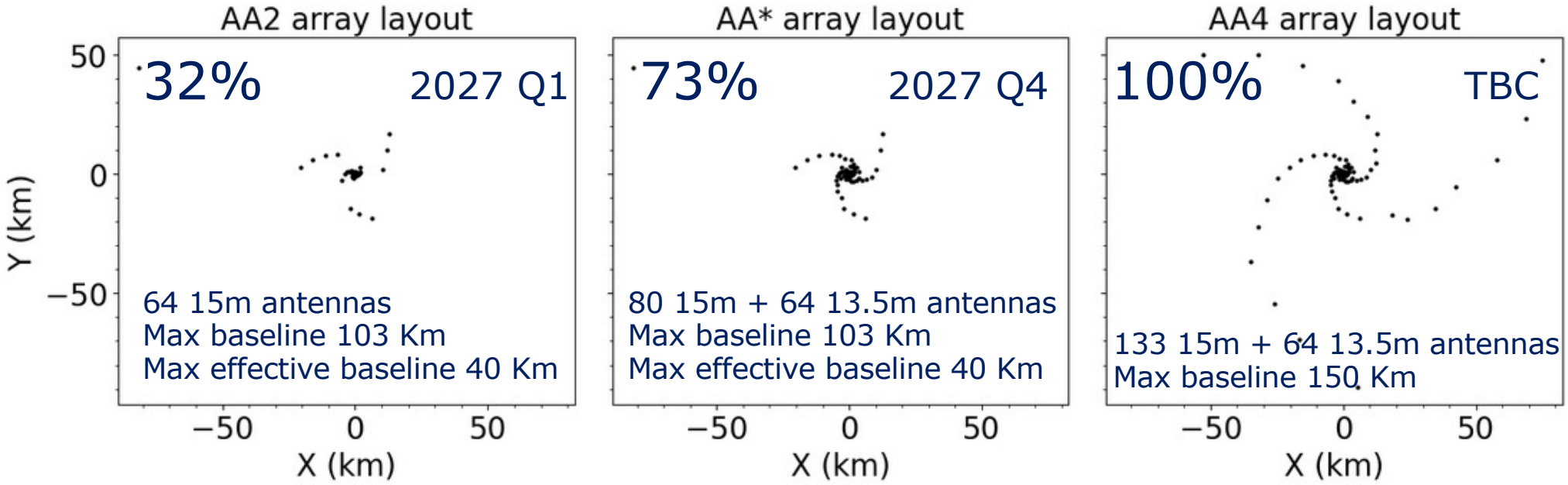
Construction Strategy

- **Target**: build the SKA Baseline Design: AA4)
- Not all funding yet secured, therefore following Staged Delivery Plan (AA*)

Milestone Event		SKA-Mid	SKA-Low
AA0.5	4 dishes 6 stations	2025 Q1	2024 Q4
AA1	8 dishes 18 stations	2026 Q1	2025 Q4
AA2	64 dishes 64 stations	2027 Q1	2026 Q4
AA*	144 dishes 307 stations	2027 Q4	2028 Q1
Operations Readiness Review		2028 Q1	2028 Q2
End of staged delivery programme		2028 Q3	2028 Q3
AA4	197 dishes 512 stations	TBD	TBD

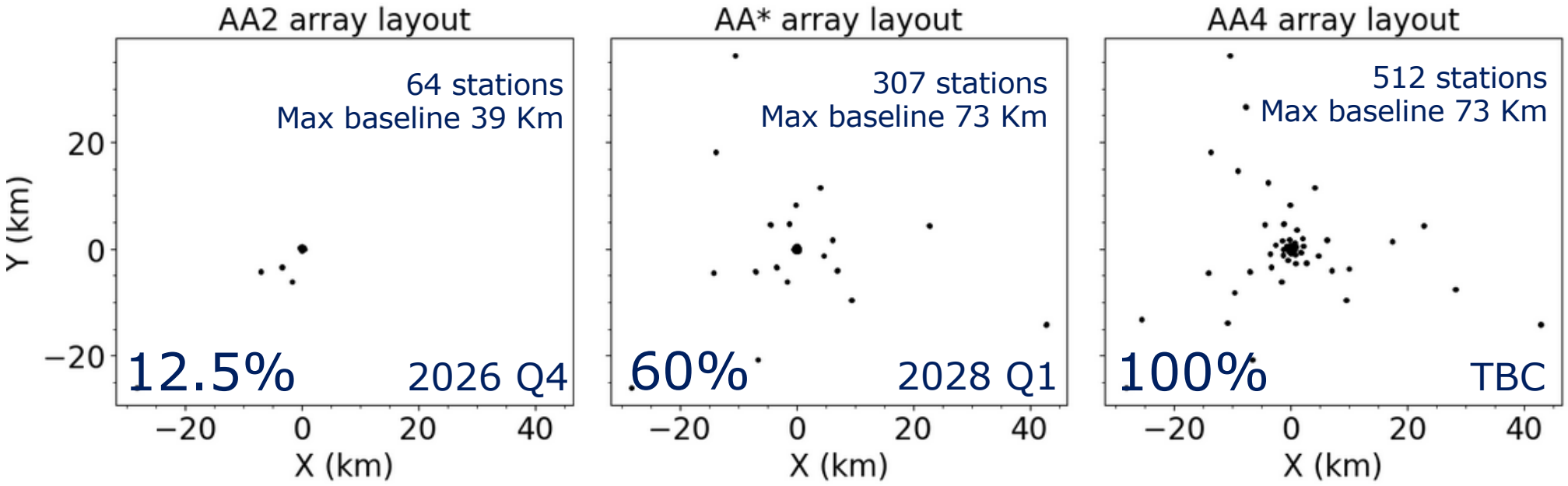
First data release to the community expected in 2026/27 (for science verification)

AA* vs AA4 – SKA Mid



Staged delivery memo, python package and Jupiter notebook at https://www.skao.int/en/ska-subarrays

AA* vs AA4 – SKA Low



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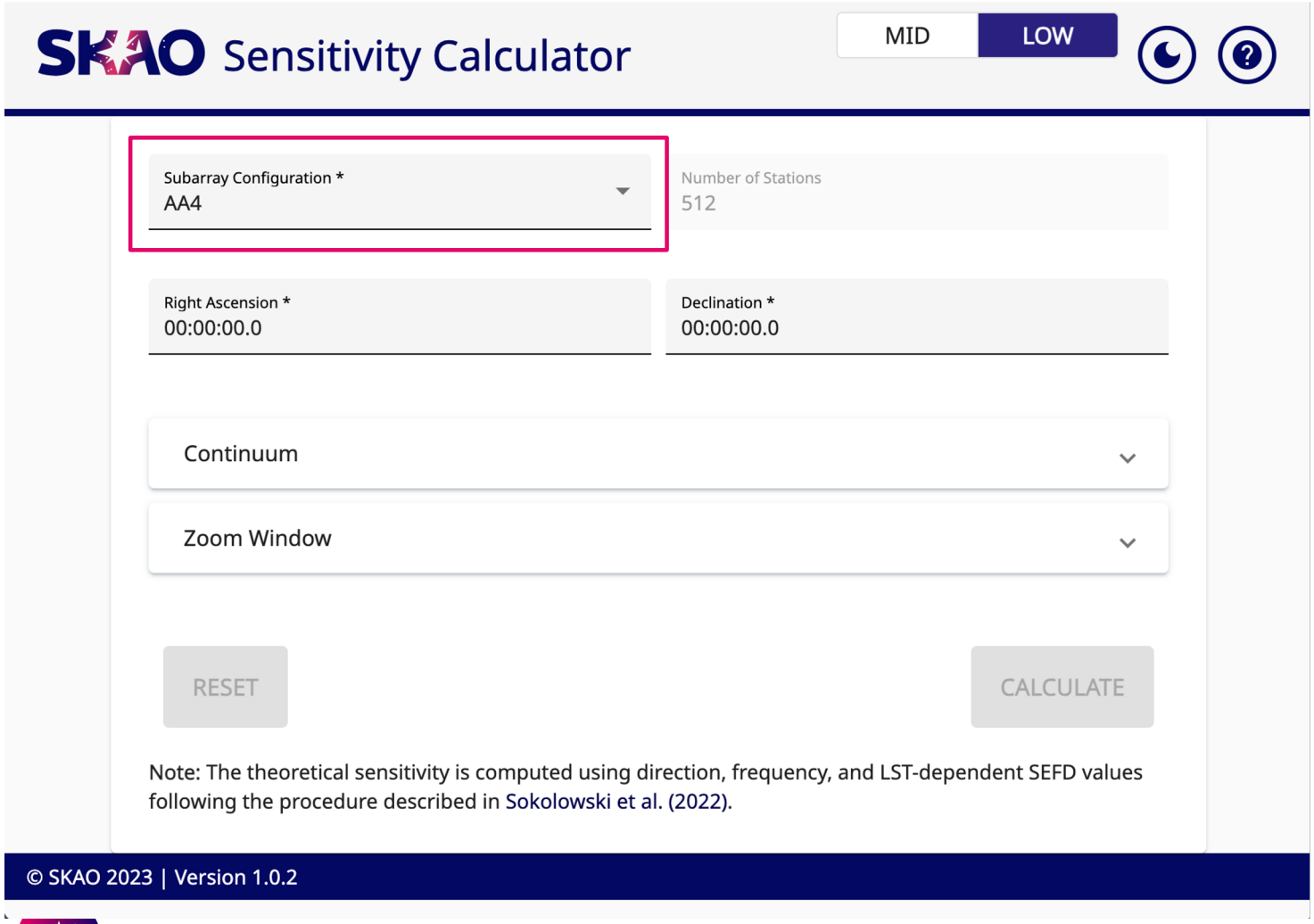
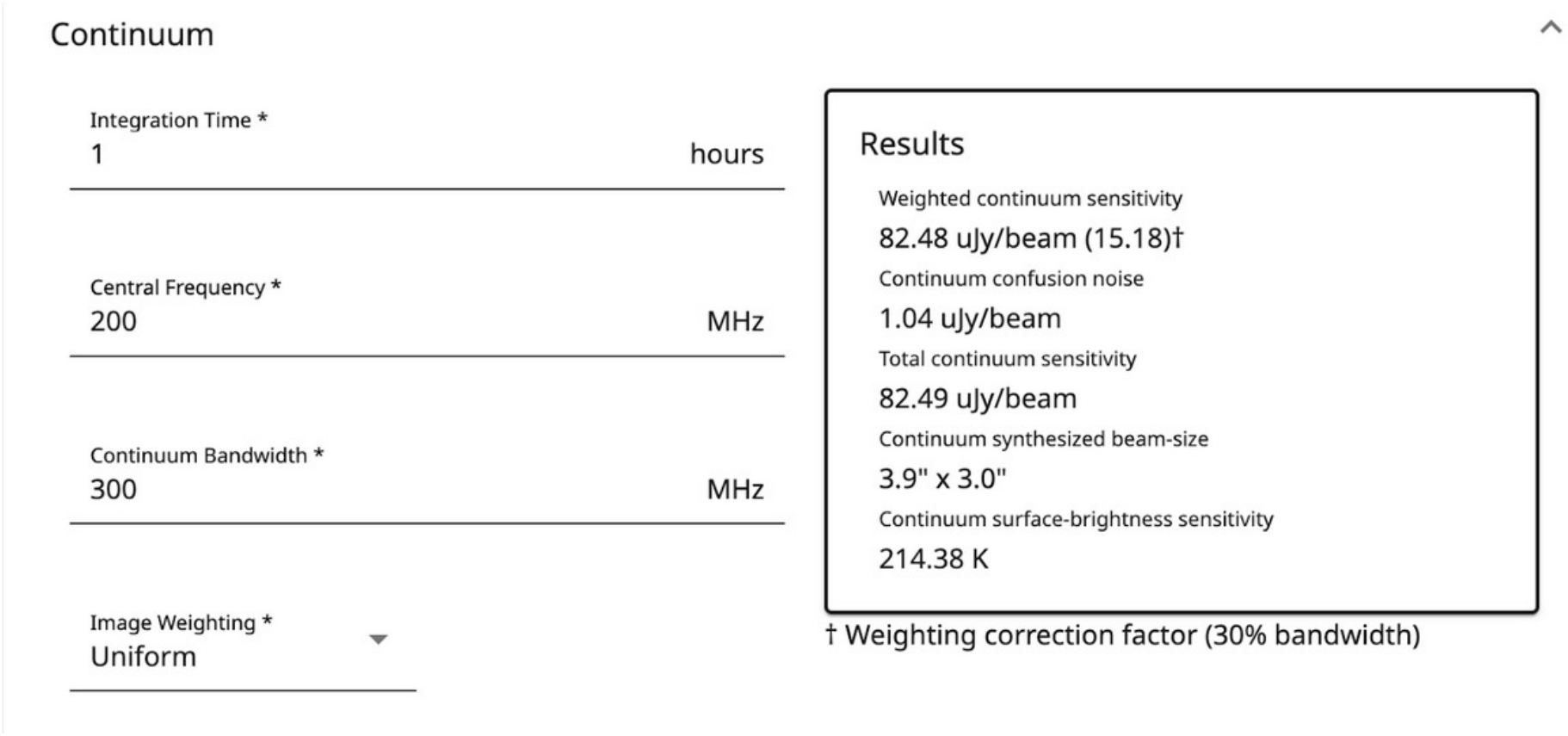
SKA-Low sensitivity calculator



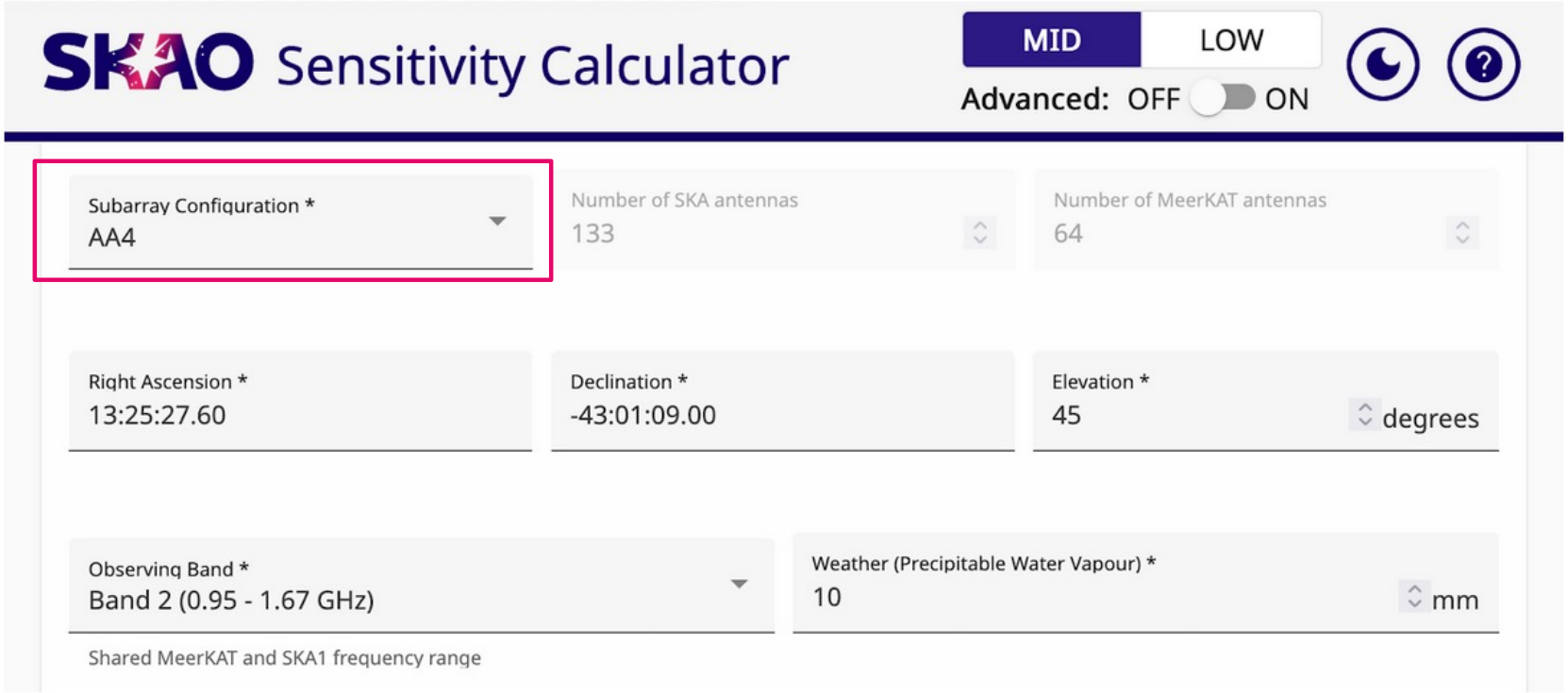
More subarrays will be added as we come up subarray templates

Web interface at https://sensitivity-calculator.skao.int/low.

SKA Low sensitivity calculator



SKA Mid sensitivity calculator

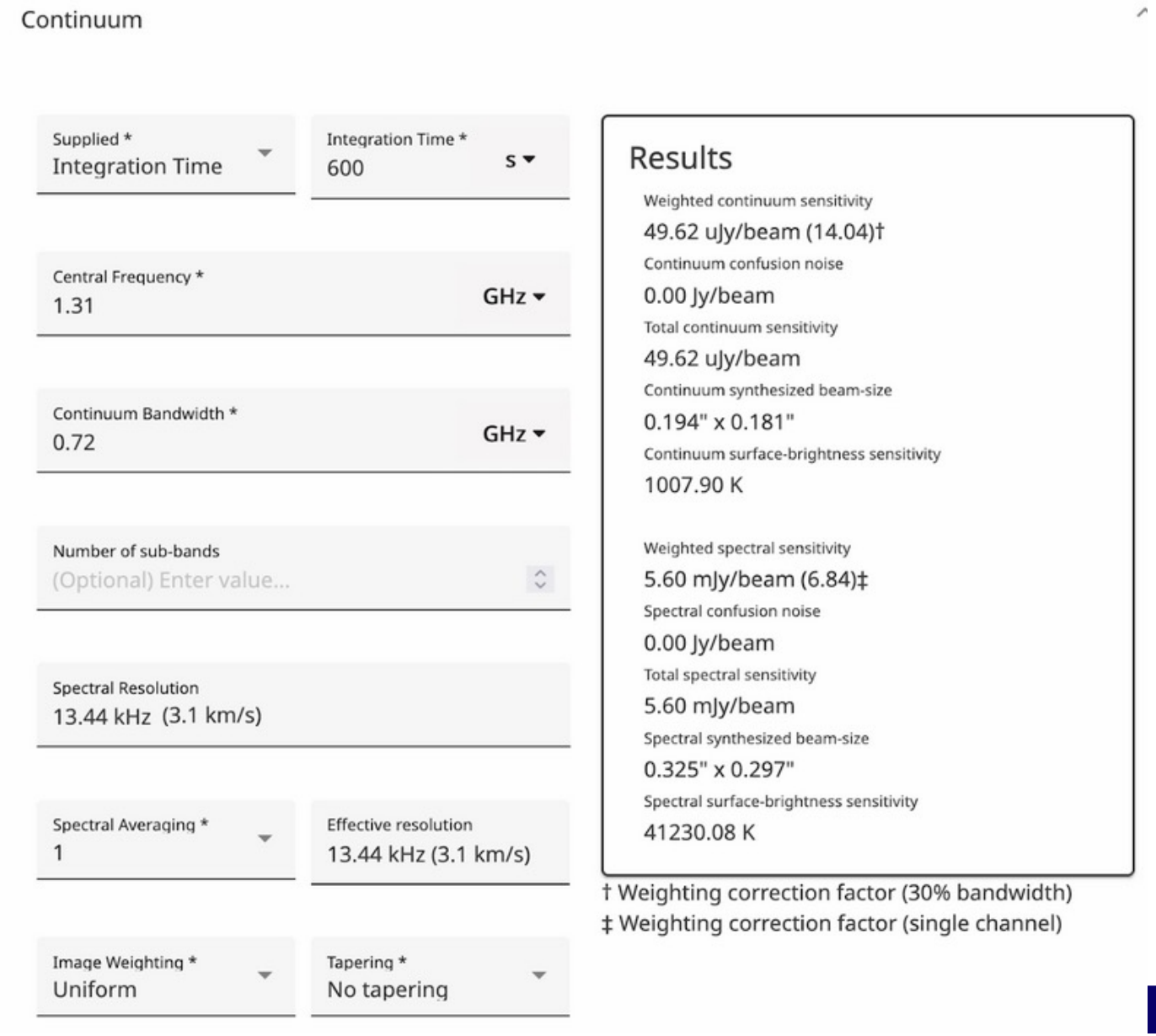


More subarrays will be added as we come up subarray templates

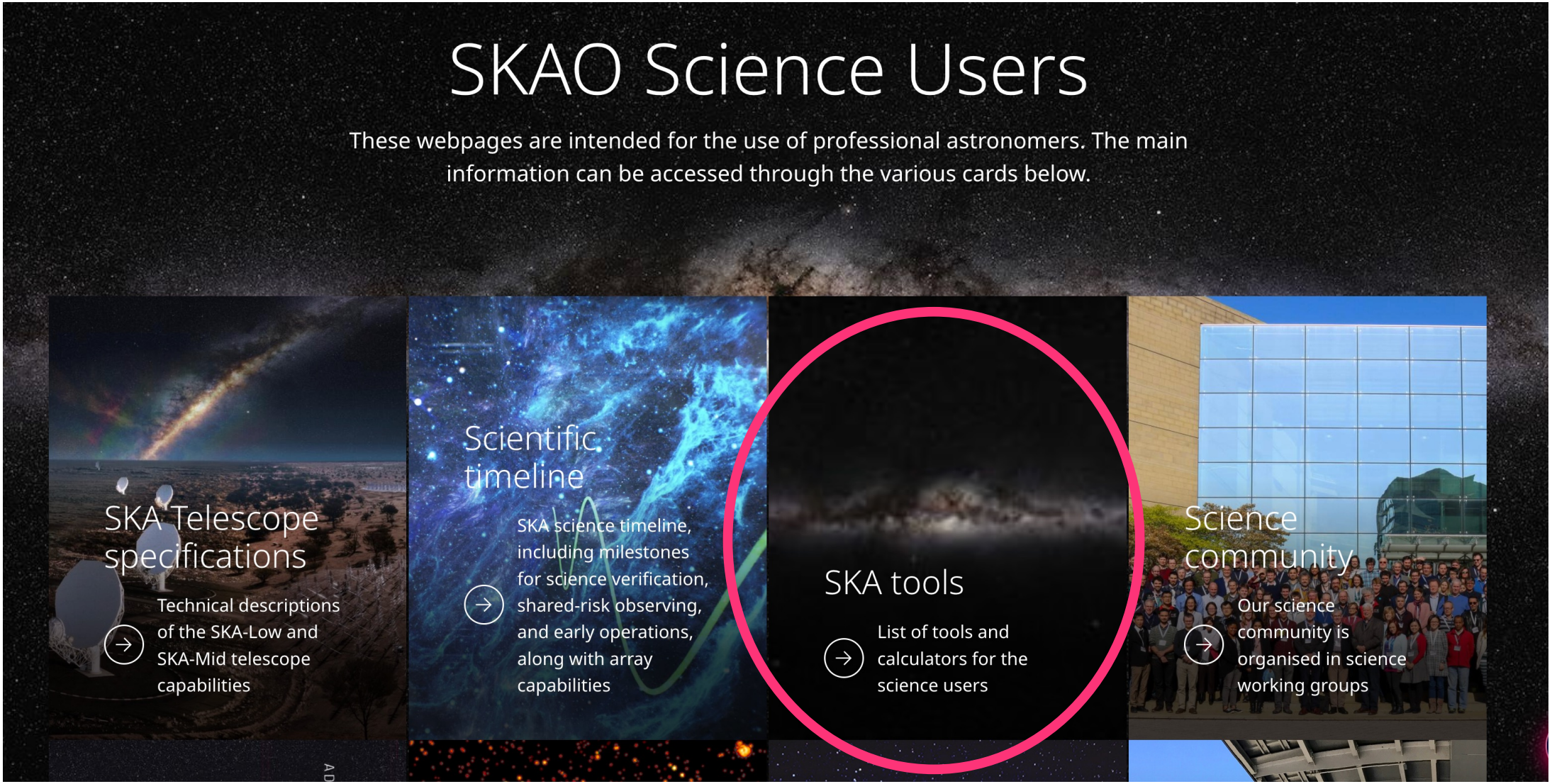
Web interface at https://sensitivity-calculator.skao.int/mid.

SKA Mid sensitivity calculator

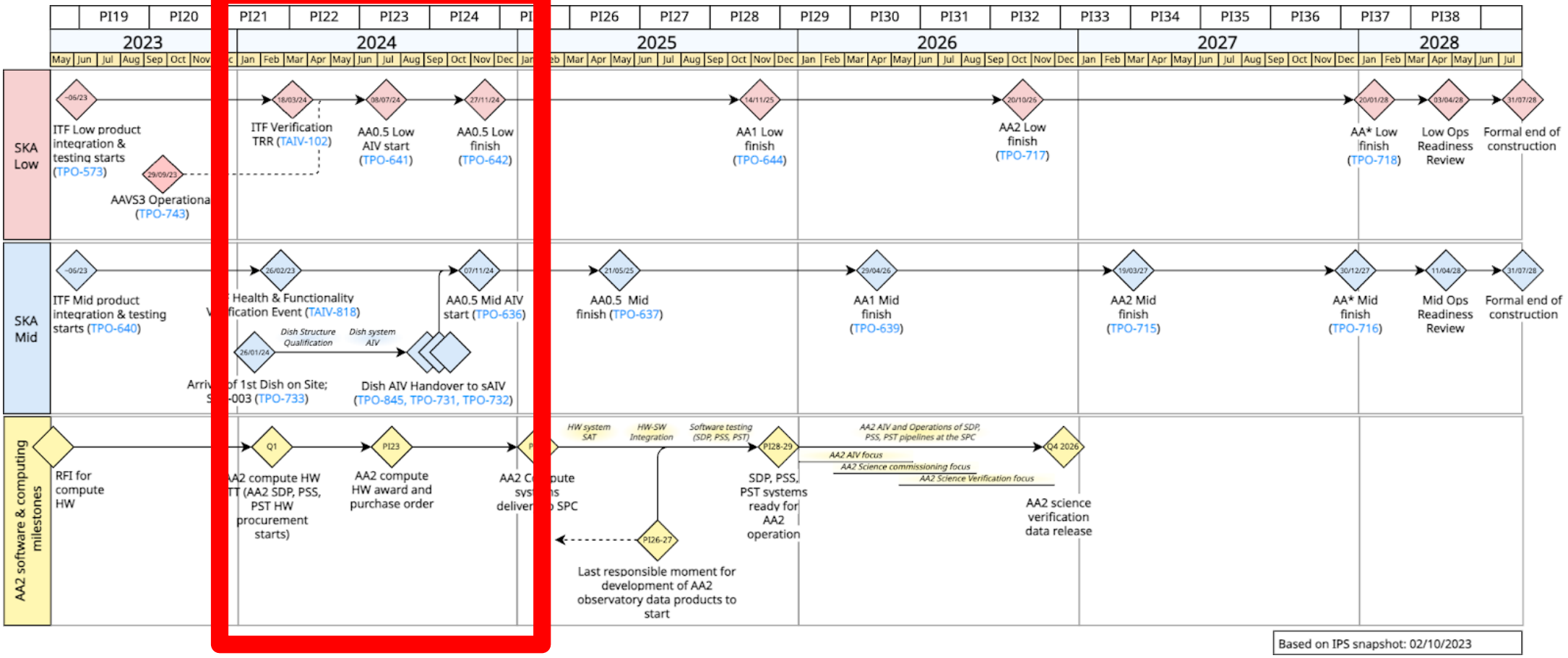
- First release, feedback welcome!
- Modes available: continuum and spectral line



Where you find these tools: on skao.int/science users



High-Level Project Milestones

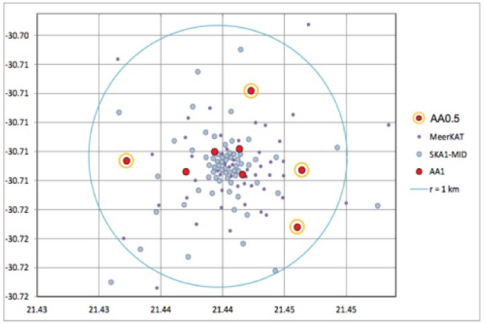


Focus on Array Assembly (AA)0.5

SKAO Construction Status (end Oct 2023)

- 28 months into ~7 year construction phase: 75 contracts awarded; €617M total value.
- Majority of remaining contracts to be placed by end 2023.
- Progress: 18.9% complete, compared with 21.4% planned and 18.8% spent (i.e. behind schedule but on budget).
- SKA-Low and Mid infrastructure works well underway
- AA0.5 components either delivered or in manufacture

Path to interferometry: What *is* Array Assembly (AA)0.5?



- Deployment of minimal (4 dish/6 station) short-baseline arrays on-site as early as possible
- Primary goal: end-to-end test of interferometry
  - Tied-array beamforming is secondary goal
- (Almost) all sub-systems (including control and data processing software)
  - Includes Dish/Station (cannot be tested in a lab environment)
- Verify fundamentals of system performance
  - in a realistic operating environment (Radio Frequency Interference, wind, temperature, ...)
- Test interfaces
- Develop AIV (Assembly, Integration and Verification), Commissioning, Operations teams and procedures
- Identify failures to meet requirements, lack of reliability
- Reduce risk by fixing problems as soon as possible, ideally before mass production
- Verify the supply chain

Data Processing Pipelines for AA2 and beyond

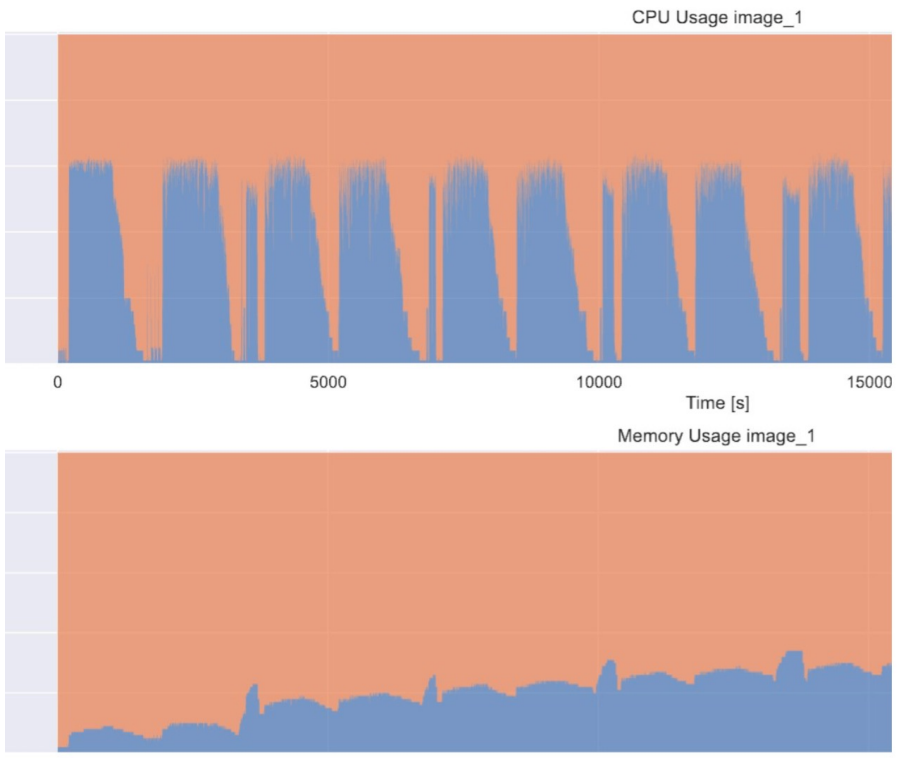
Two important goals:

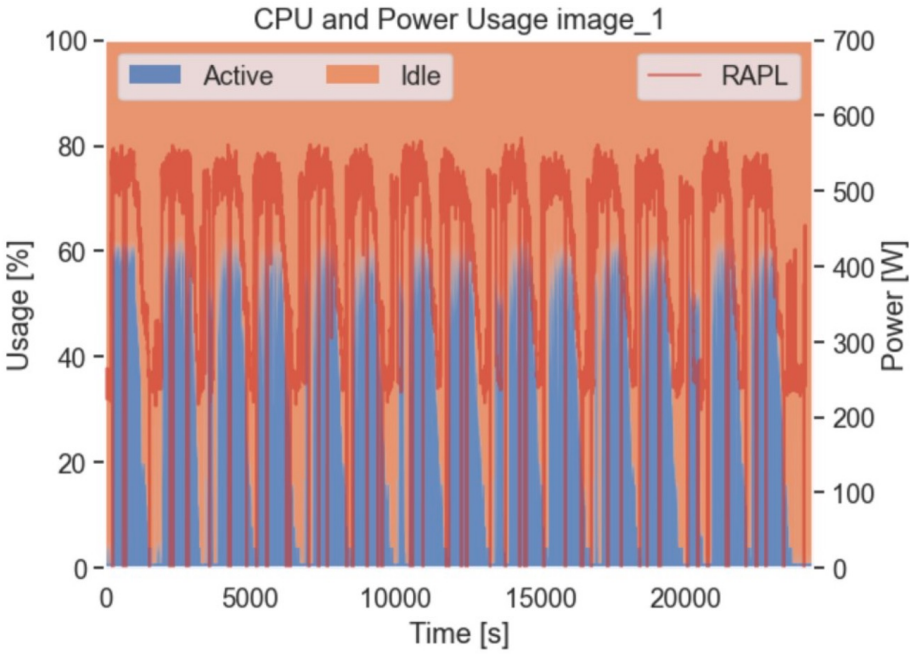
- Immediate: make the current self-calibration and imaging pipelines work at AA2 scale on the anticipated computing platforms.
- Longer-term: plot a plausible path to scale to AA* and the Design Baseline.

SDP: scalability of calibration and imaging

Slide credit: Shan Mignot

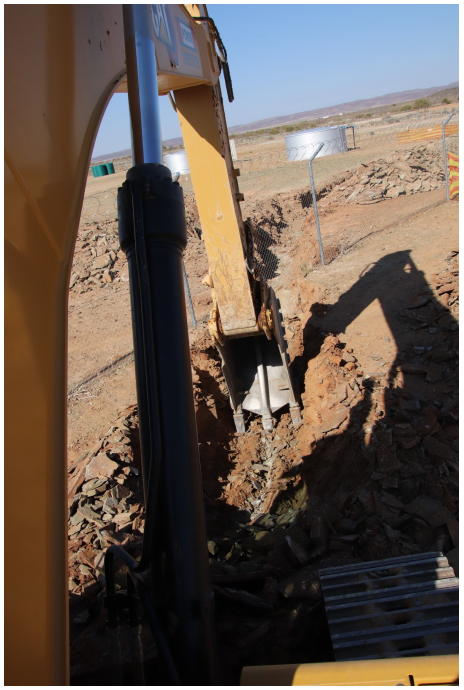
Execution metrics (II)





resource usage recordings for the image_1 step (WSClean)

SKAO Construction Status: Mid



- Contractor camp

SKAO Construction Status: Mid

- First four AA0.5 production dishes nearing completion and shipping to site

SKAO Construction Status: Low



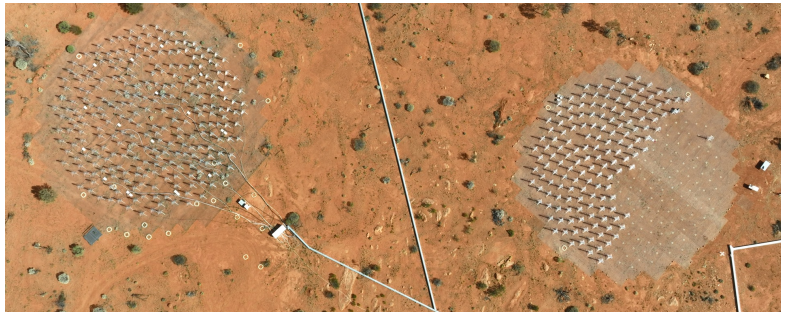



- "Fly" camp (103 beds) complete to support build of full camp (first beds by late October)

SKAO Construction Status: Low

- “Turkey’s nests” (water dams), borrow pits and tracks in progress
- Mesh, fibre and power cables delivered to on-site laydown yard

SKAO Construction Status: Low



- AAVS3 deployed using SKAO staff, in lead-up to full deployment

Science Data Challenges

"The purpose of SDCs is to prepare the astronomical community, and SKAO itself, for the novel, yet challenging, nature of SKA data"

Science Data Challenges

Primary goals:

- Familiarise the science community with **size and complexity of SKA data**
- Support the **design** of future SKA observations
- Drive the development of **data analysis techniques**

Additional benefits:

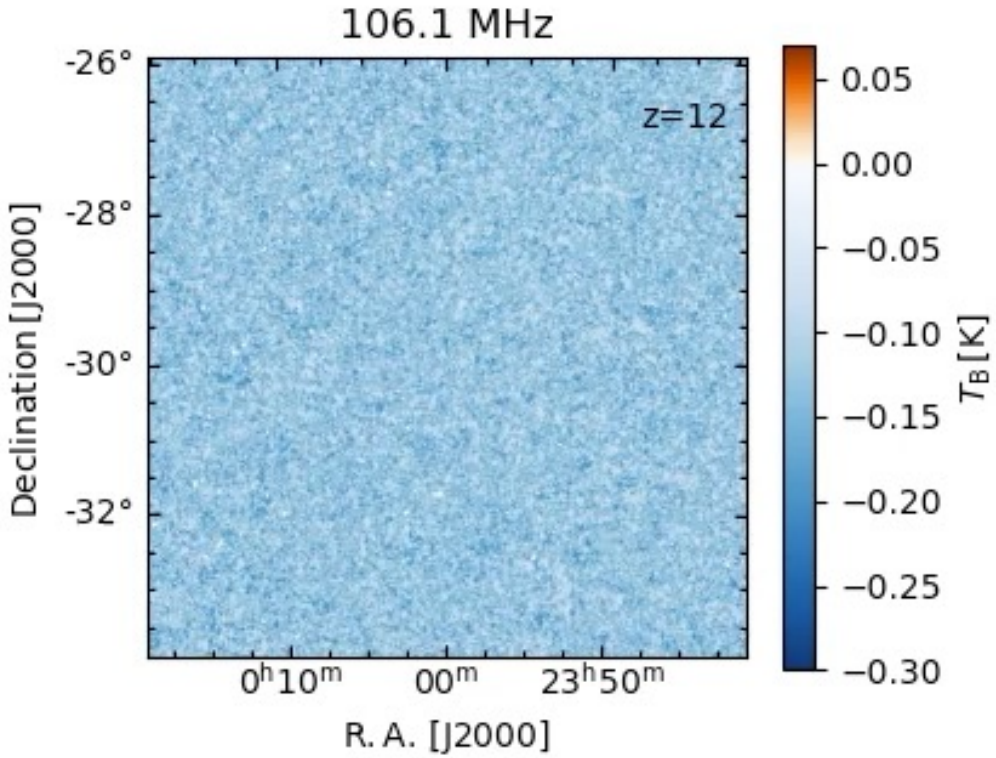
- Familiarise the science community with **data access models**
- Test SKA Regional Centre **prototyping**
- Encourage best practices for **Open Science** and **reproducibility**

SDC data products are made publicly available for the long term

Science Data Challenge 3

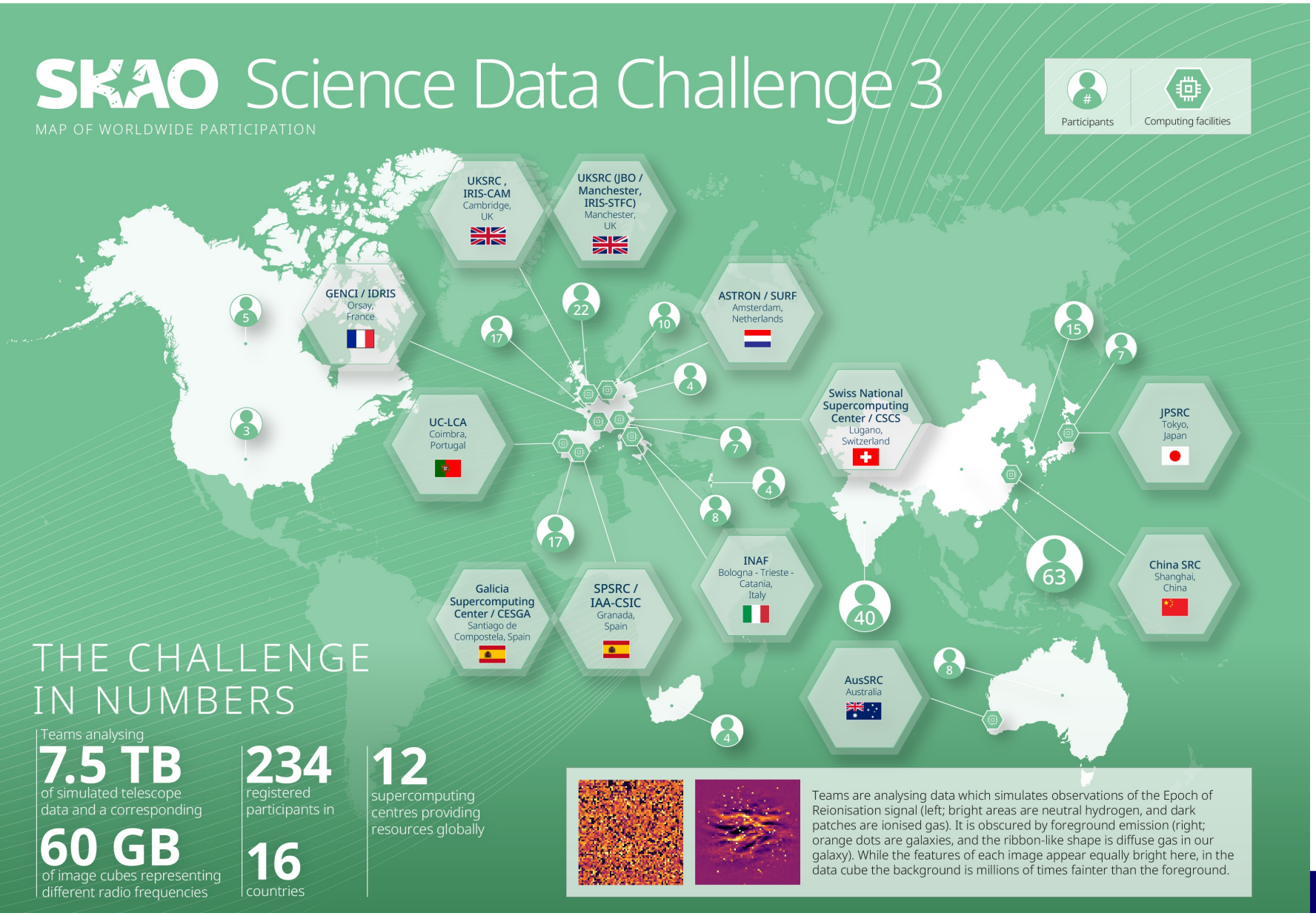
Developed in collaboration with SKA EoR SWG members

- SDC3a ”**Foregrounds**” (SDC3a; SWG Coordinators: C. Trott, V. Jelic)
  - **Foreground removal** exercise
  - SDC3a submission deadline 30th Oct 2023
- SDC3b “**Inference**” (SDC3b; SWG Coordinators: A. Mesinger, G. Melema)
  - Extraction of **cosmological parameters**
  - SDC3b launching Q1 2024



SKAO Science Data Challenge 3

MAP OF WORLDWIDE PARTICIPATION



THE CHALLENGE IN NUMBERS

Teams analysing

7.5 TB of simulated telescope data and a corresponding

60 GB of image cubes representing different radio frequencies

234 registered participants in

16 countries

12 supercomputing centres providing resources globally

Teams are analysing data which simulates observations of the Epoch of Reionisation signal (left; bright areas are neutral hydrogen, and dark patches are ionised gas). It is obscured by foreground emission (right; orange dots are galaxies, and the ribbon-like shape is diffuse gas in our galaxy). While the features of each image appear equally bright here, in the data cube the background is millions of times fainter than the foreground.

SCD3 foregrounds
And the winner is…

- 20 submissions from teams around the world
- Score computed on the accuracy of EoR power spectrum and associated error bars
- Congratulations to team HIMALAYA (China, School of Physics and Astronomy, Sun Yat-Sen University)

HIMALAYA

DOTSS-21cm_ML-GPR

DOTSS-21cm_Advanced_ML-GPR

ERWA

DOTSS-21cm_Avoidance

Shuimu-Tianlai

Wizards_of_Oz_3D

Akashganga

REACTOR

SKACH

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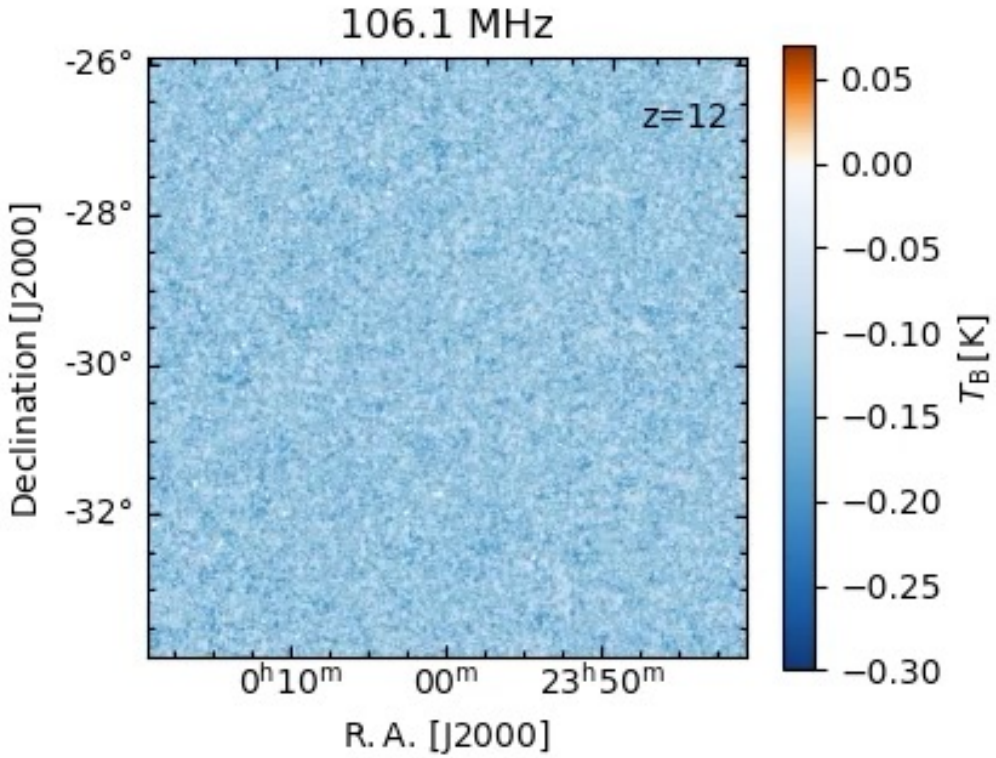
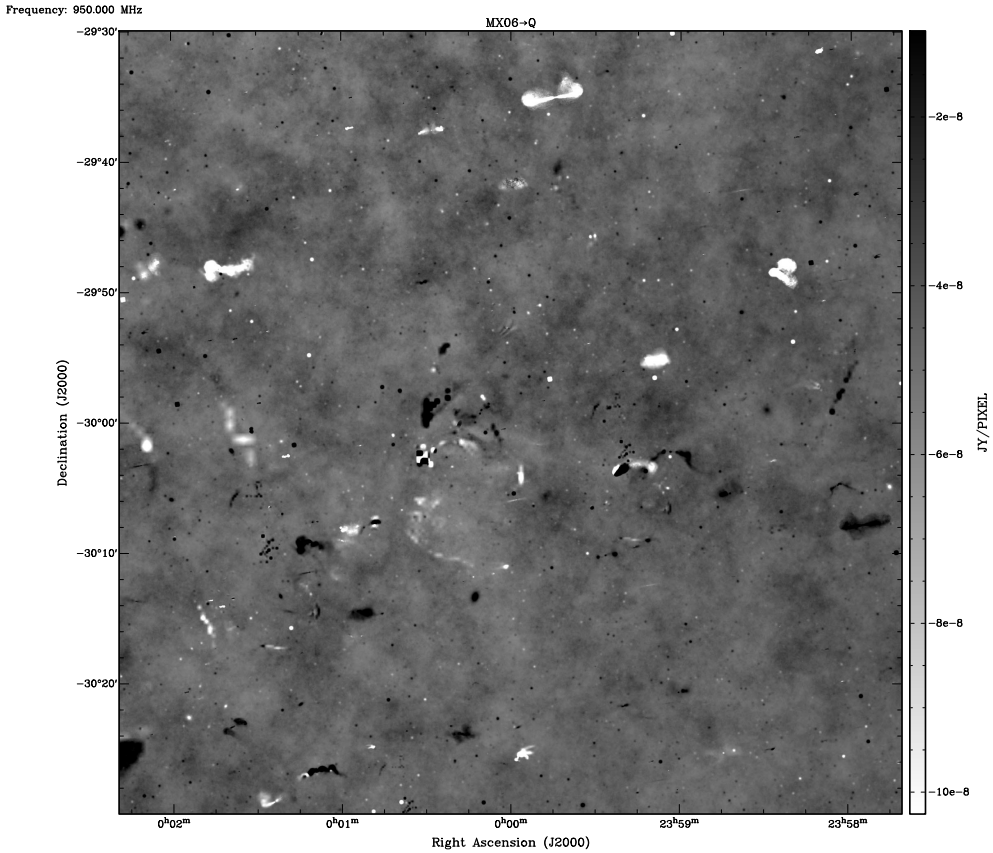


sdc3.skao.int

Science Data Challenge 4 – Magnetism

- Developed in collaboration with Magnetism SWG (Akahori, Vernstrom, Vacca, …)
  - Scope still being refined, but full Stokes compact plus diffuse sky model with IGM, ISM, and ionosphere propagation
  - 10 square deg, 950 – 1760 MHz, 3 arcsec beam, source finding and characterisation
  - 100 square deg, 100 – 350 MHz, 350 – 1760 MHz, 10 arcsec beam, source finding and characterisation
  - Thermal noise equivalent few 1000 h
- Sky and Propagation Models nearing completion and looking good
- Telescope and Error Models
  - OSKAR for LOW has clear development path (building on SDC3a)
  - RASCIL for MID will be challenging (lack of effective starting point)



Propagated Stokes Q Sky Model at 950 MHz

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