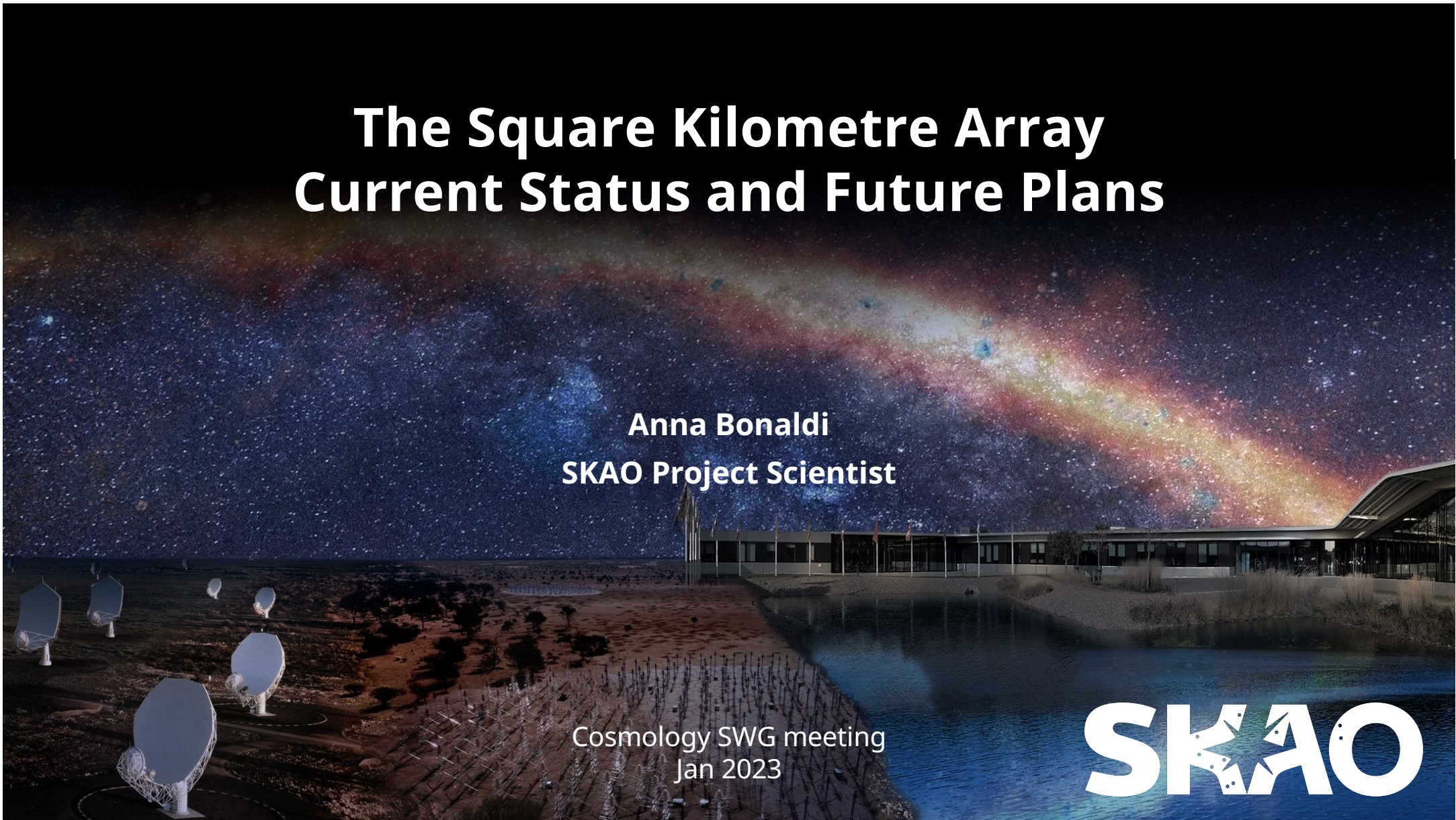


The Square Kilometre Array Current Status and Future Plans

Anna Bonaldi
SKAO Project Scientist

Cosmology SWG meeting
Jan 2023

SKAO



The SKA: a global collaboration to build and operate the next-generation radio astronomy observatory

Prime Motivation: Study the history of the Universe in Hydrogen
Will enable transformational science in many other areas



South Africa – Karoo region

Western Australian Outback



SKAO – global partnership (IGO in 2021)



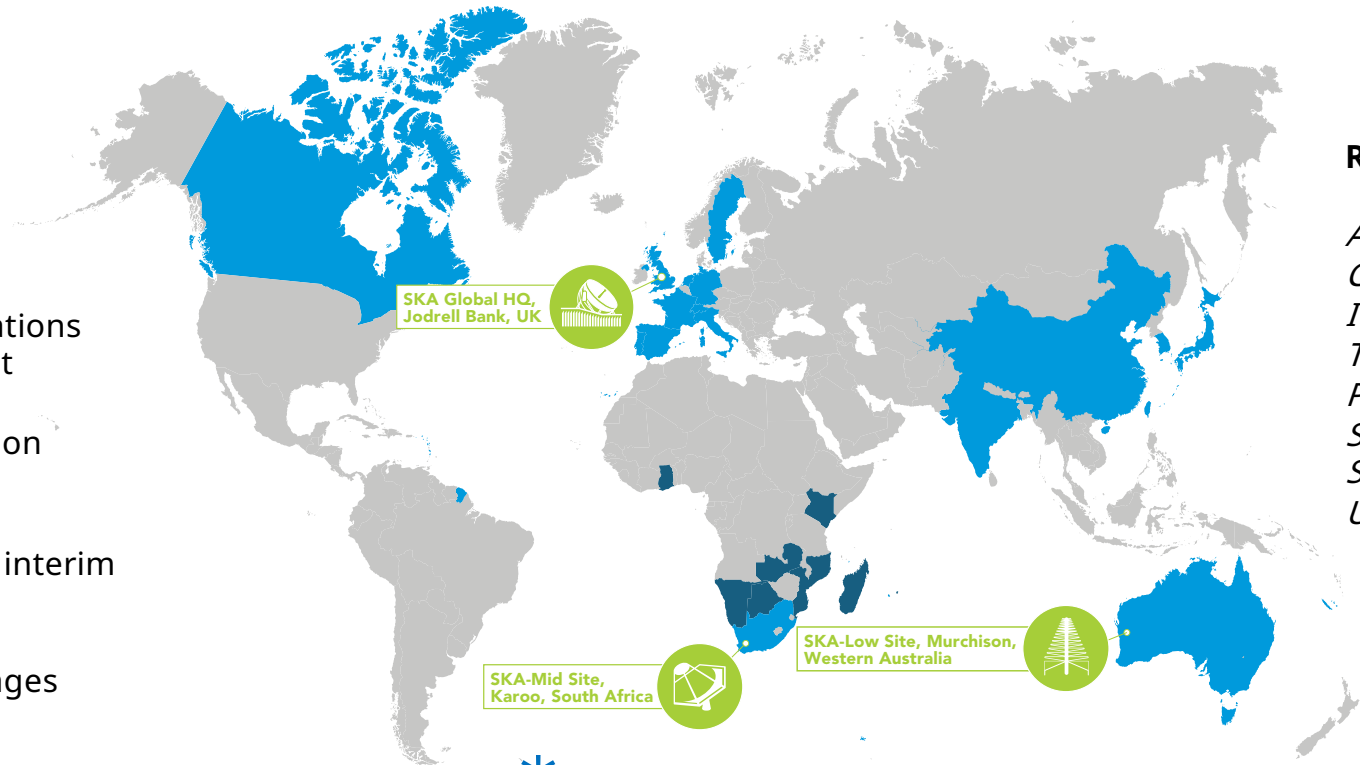
One Observatory
Two Telescopes
Three Continents

France & Spain: in negotiations on accession agreement

Germany: in negotiations on membership

Sweden, Canada & India: interim arrangements

Japan & S.Korea: early stages



Ratified Members:

- Australia*
- China*
- Italy*
- The Netherlands*
- Portugal*
- South Africa*
- Switzerland*
- United Kingdom*



The Telescopes – Phase 1

SKA1-Low: 131,072 low-freq antennas
(512 stations each with 256 log-periodic)
50 – 350 MHz

65 km baselines (11" @ 110 MHz)

Western Australia



Inyarrimanha Ilgari Bundara,
CSIRO's Murchison Radio-astronomy
Observatory.



SKA1-Mid: 197 dishes
(133 x 15m + **64 x 13.5m** dishes)

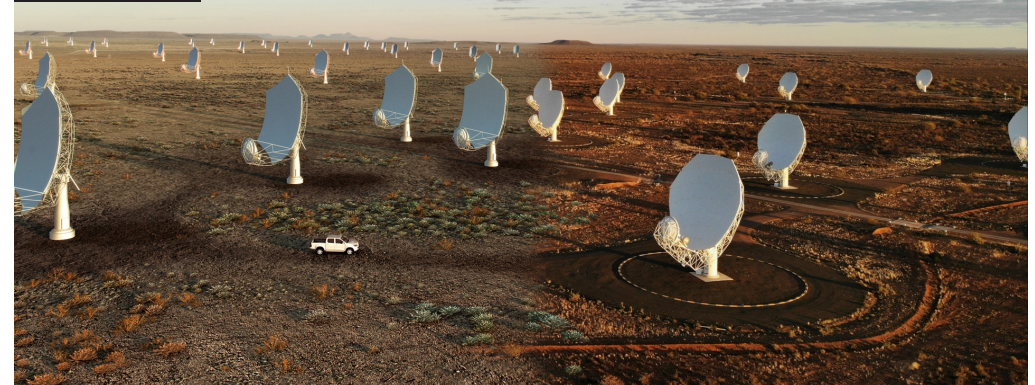
0.35 – 15 GHz

150 km baselines

(0.22" @ 1.7 GHz; 34 mas @ 15 GHz)

Karoo, **South Africa**

MeerKAT



Phase 2 (aspiration): > 2000 dishes across Africa; > 500,000 dipoles across Australia



SKA Regional Centres: SKAO data ingest

Scientists obtain their data products from the regional centres (SRCs) (SRCs funded by members, not by SKAO)

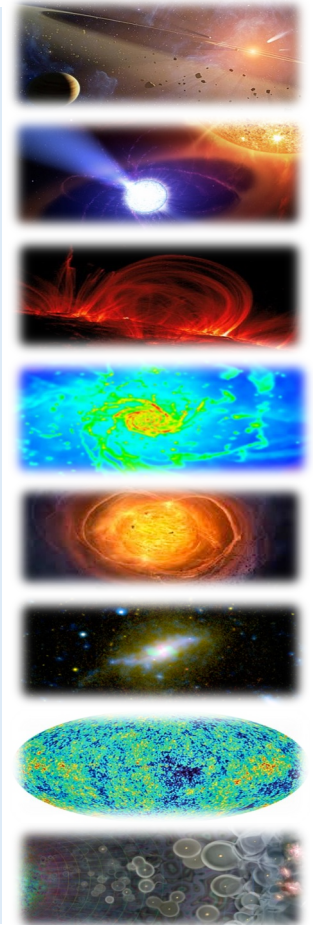


Data Archive ~600 PB/yr



SKA Big Questions

- **The Cradle of Life & Astrobiology**
How do planets form? Are we alone?
- **Strong-field Tests of Gravity with Pulsars and Black Holes**
Was Einstein right with General Relativity?
- **Our Galaxy, The Milky Way**
How does matter cycle between stars and the Interstellar Medium?
- **The Origin and Evolution of Cosmic Magnetism**
What is the role of magnetism in galaxy evolution and the structure of the cosmic web?
- **Galaxy Evolution probed by Neutral Hydrogen and Radio Continuum**
How do normal galaxies form and grow? What is their star-formation history?
- **The Transient Radio Sky**
What are Fast Radio Bursts and how can we utilise them? What haven't we discovered?
- **Cosmology & Dark Energy**
What is dark matter? What is the large-scale structure of the Universe?
- **Cosmic Dawn and the Epoch of Reionization**
How and when did the first stars and galaxies form?

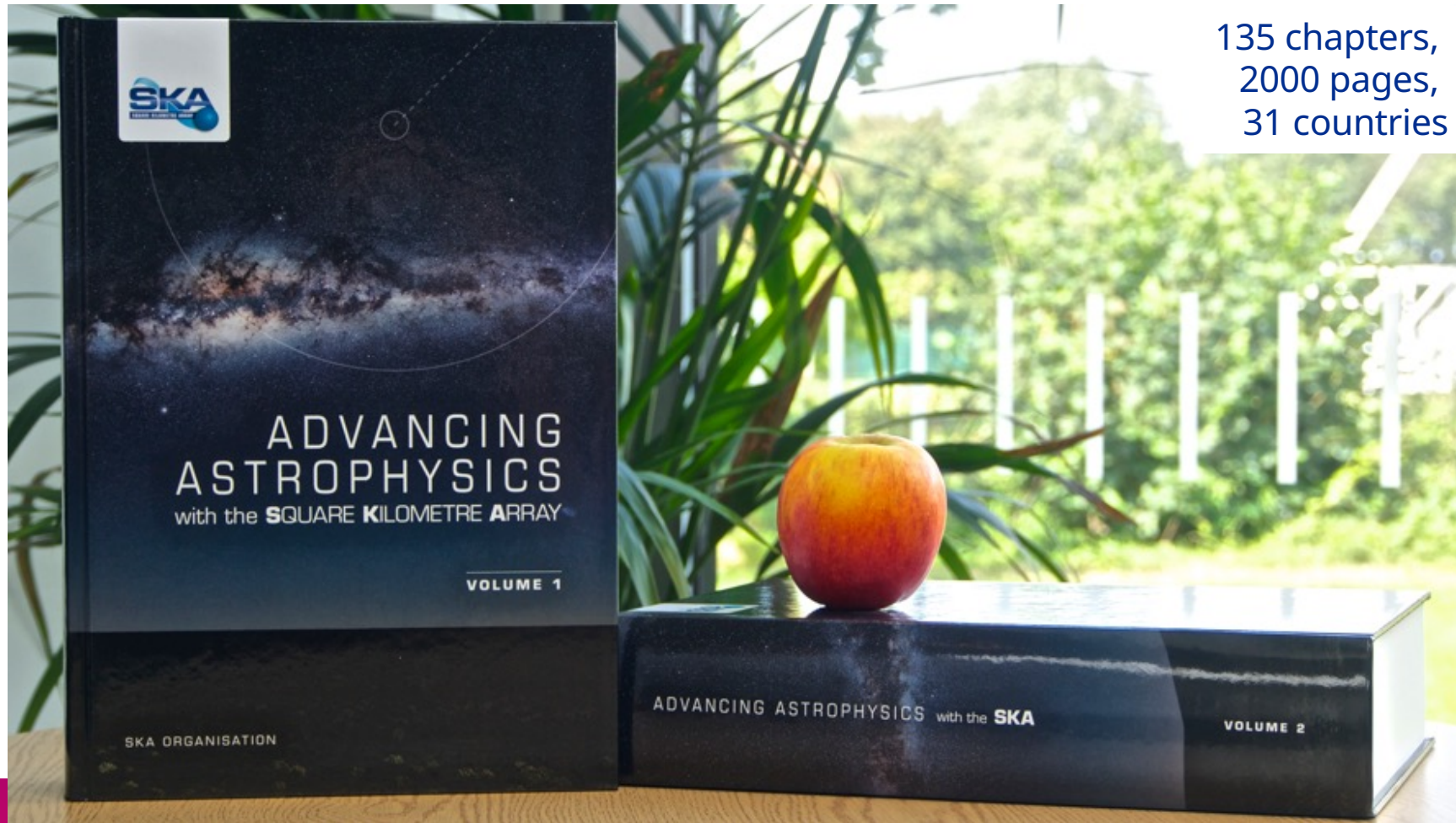


SKA Science Case

(2015 snapshot ; continuous evolution)

<http://astronomers.skatelescope.org/meetings-2/aaska14/>

www.skatelescope.org/books/



135 chapters,
2000 pages,
31 countries

SKA Precursors and Pathfinders



Precursors

Located at future SKA sites
(South Africa and Australia)



Pathfinders

Engaged in SKA related
technology and science
studies



Status Update

Construction approved, 2021

Procurement underway

Software contracts proceeding

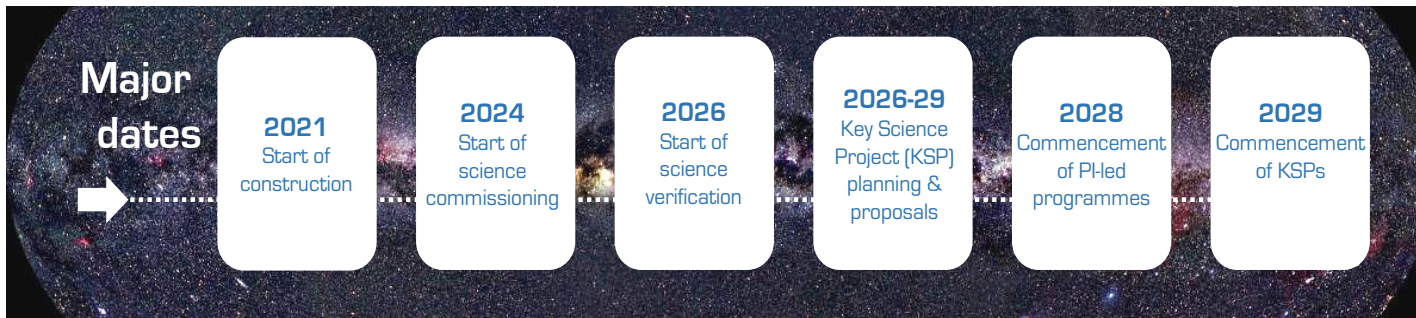
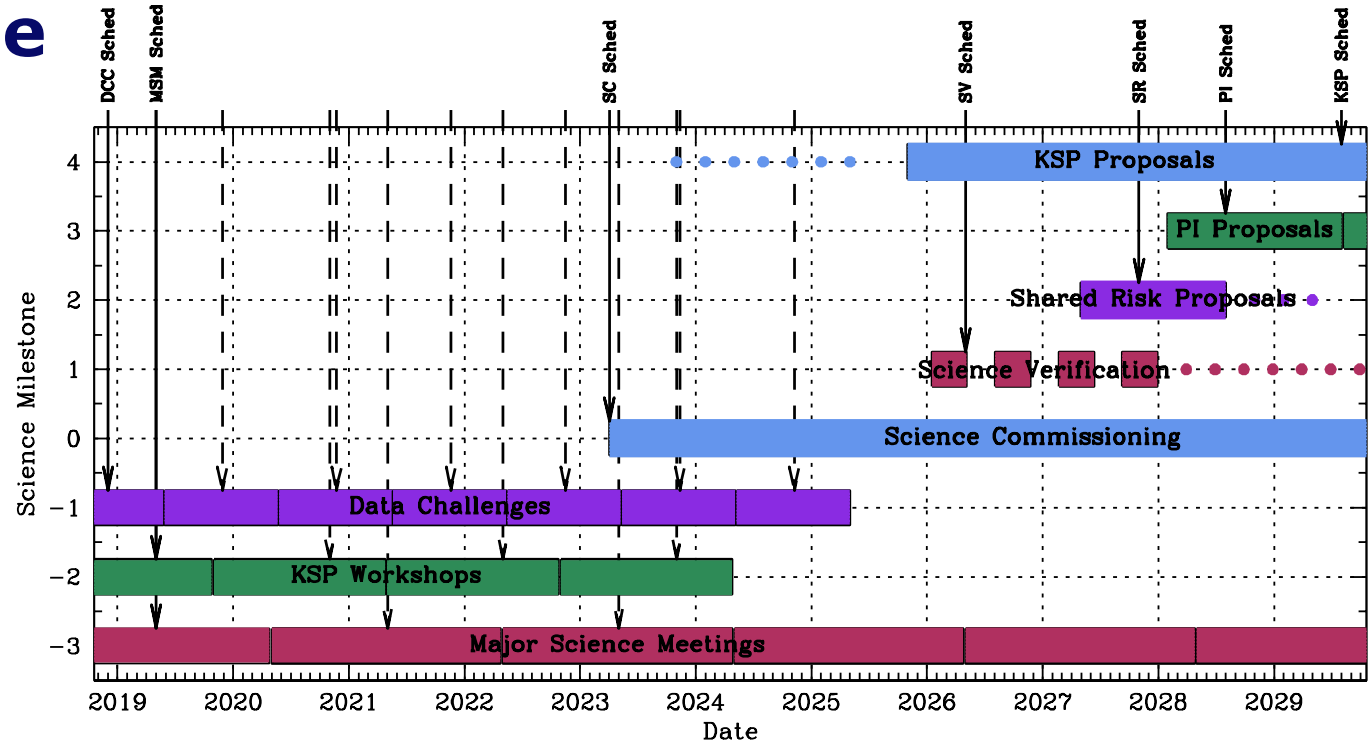
Some Hardware contract signed

Contracts awarded so far > 35

Event	SKA-Low	SKA-Mid
Start of construction (T0)	1ST JULY 2021	1ST JULY 2021
Earliest start of major contracts (C0)	AUGUST 2021	AUGUST 2021
Array Assembly 0.5 finish (AA0.5) SKA-Low = 6-station array SKA-Mid = 4-dish array	FEBRUARY 2024	MARCH 2024
Array Assembly 1 finish (AA1) SKA-Low = 18-station array SKA-Mid = 8-dish array	FEBRUARY 2025	FEBRUARY 2025
Array Assembly 2 finish (AA2) SKA-Low = 64-station array SKA-Mid = 64-dish array, baselines mostly <20km	FEBRUARY 2026	DECEMBER 2025
Array Assembly 3 finish (AA3) SKA-Low = 256-station array, including long baselines SKA-Mid = 133-dish array, including long baselines	JANUARY 2027	SEPTEMBER 2026
Array Assembly 4 finish (AA4) SKA-Low = full Low array SKA-Mid = full Mid array, including MeerKAT dishes	NOVEMBER 2027	JUNE 2027
Operations Readiness Review (ORR)	JANUARY 2028	DECEMBER 2027
End of construction	JULY 2029	JULY 2029

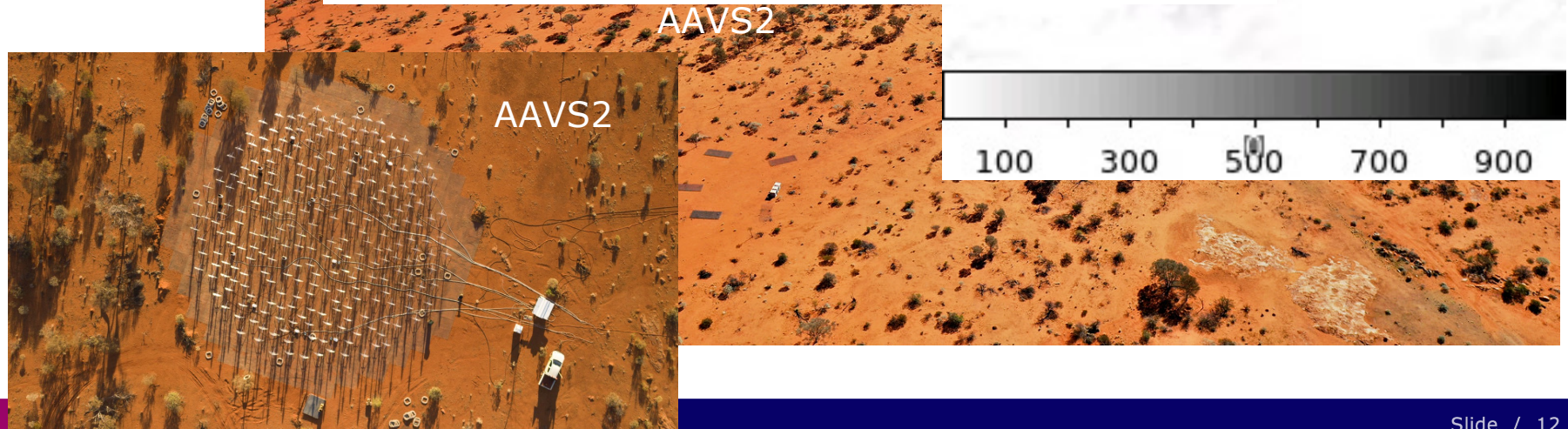
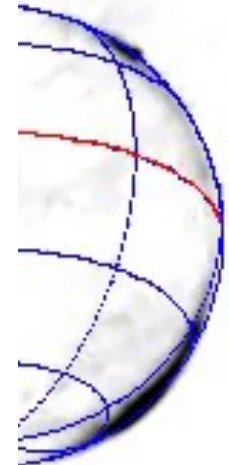
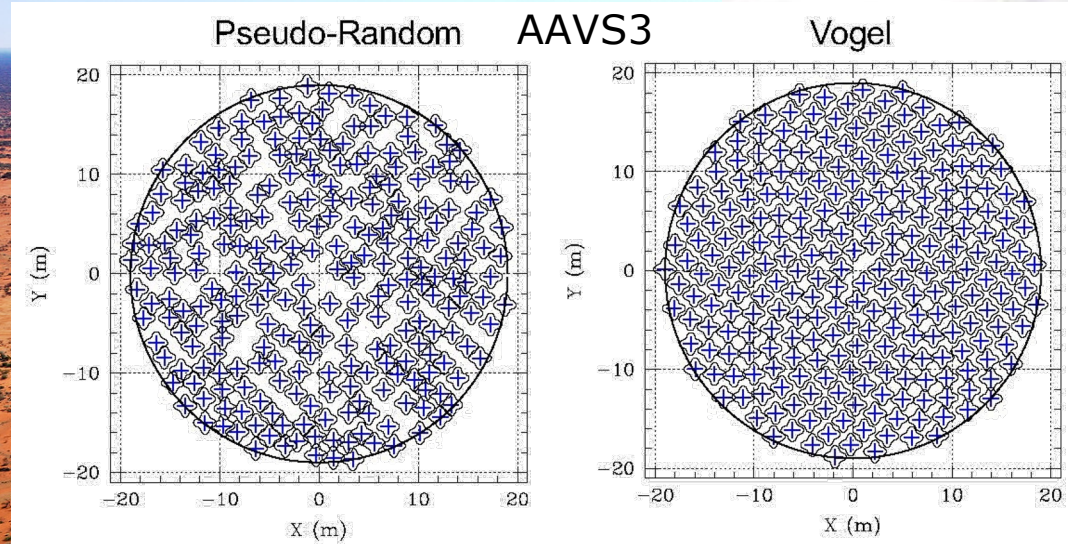


Science timeline

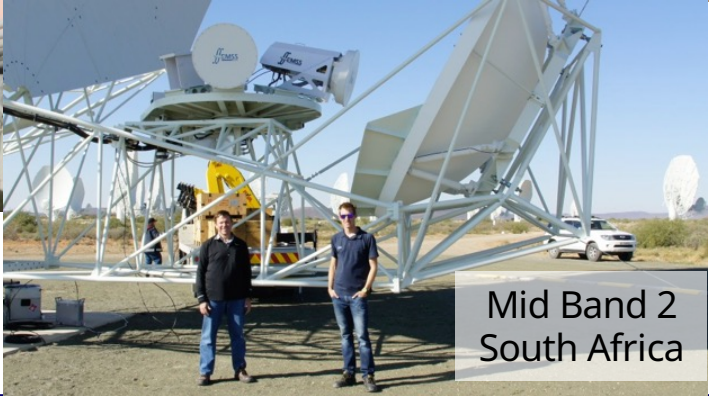


SKA-Low prototyping

- Performance of a full station
- includes prototype of the signal processing system
- Next phase: AAVS3



SKA-Mid Prototypes












Software prototyping

Agile is the norm for software development. At SKAO it is extending beyond just software.





25 teams currently working in 3 Agile Release Trains

- 15 do Software development only
- 1 is a mix of FW/SW development
- 2 develop the Correlator HW/FW
- 3 deal with sub-system and system integration
- 3 working at network and computing systems
- 1 working at the HPC co-design


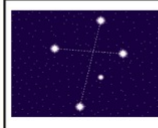
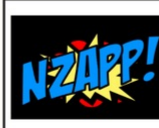





Observation Management & Control (+ Signal Chain!) Agile Release Train (ART)

TMC			TMC + Dish LMC
 Team HIMALAYA	 Team NAKSHATRA	 Team SAHYADRI	 Team Karoo
MID CBF	CSP LMC & UIs	OSO	
Team CIPA	 Team CREAM	 Team Buttons	
LOW CBF	LOW MCCS	LOW CSP integration	
 Team Perentie	 Team MCCS	 Team Topic	

Services Agile Release Train (ART)

Platform and system infrastructure	MID Assembly, Integration, Verification	LOW Assembly, Integration, Verification	IT infrastructure
 Team System	 Team ATLAS	Team VIOLA	Team IT
Networks	Compute hardware co-design & optimisation	Platform Services	
 Team SKANET	Team SCOOP	 Team BANG	

Data Processing Agile Release Train (ART)

SDP			
 Team HIPPO	 Team NALEDI	 Team NZAPP	 Team ORCA
SDP		PSS	PST
 Team SCHAAP	 Team YANDA	 Team PSS	 Team PST



Foundational Documents

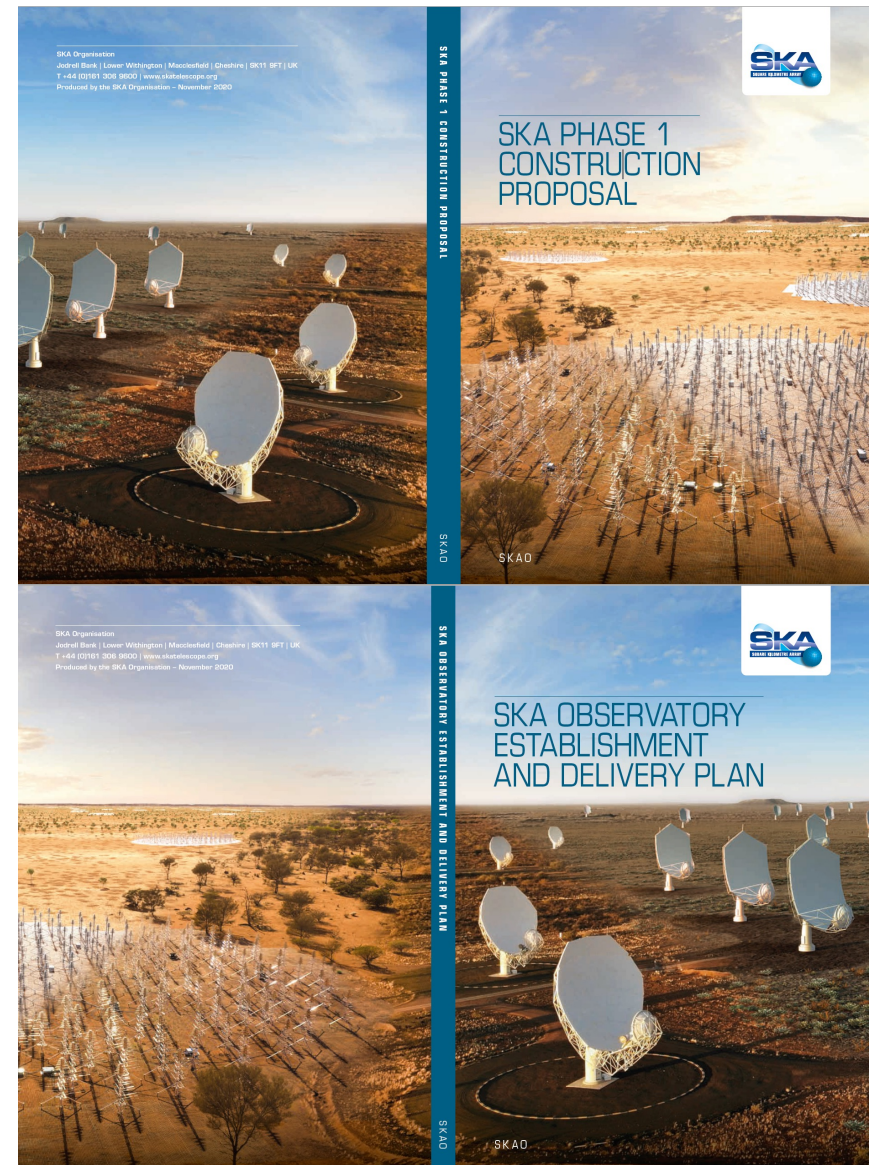
Convention (treaty)

- Commitment to diversity & equality
- ... global effort with long-term investment
- ... contribute to advances in technology and innovation and to deliver a broader benefit for industry and society

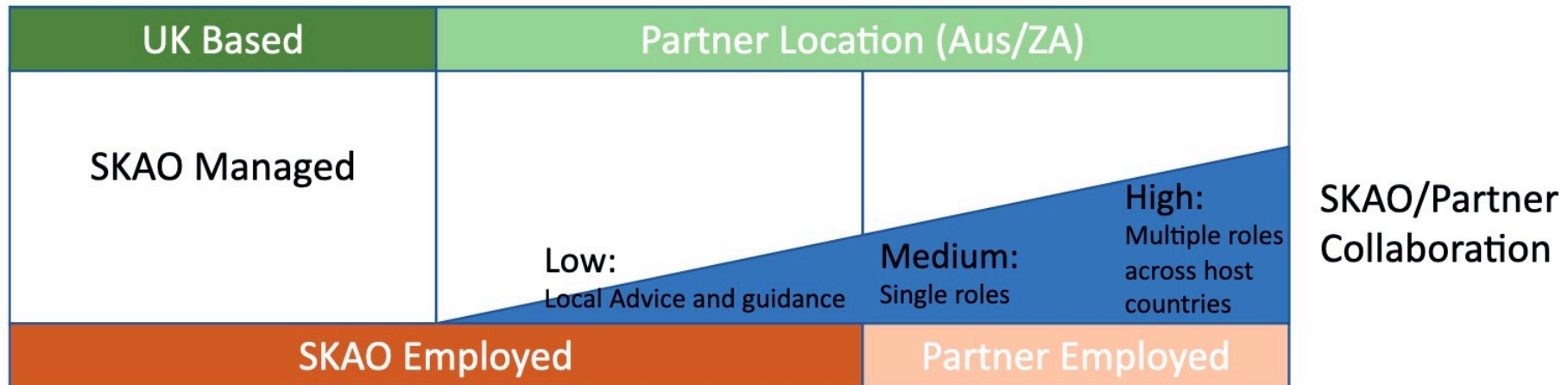
Construction Proposal Observatory Establishment & Delivery Plan Prospectus

- Open science & open source
- Reproducibility

<https://www.skao.int/en/resources/402/key-documents>



SKAO established in SA and AU



- Increasing staff presence at the SKA Low and Mid Sites. Bilateral Collaboration Agreements, Land access agreements almost complete
- Planning underway in South Africa for: Science Operations Centre (Cape Town) & Engineering Operations Center (Karoo)



Host country agreements

SKA Observatory Responsibility

- Execution of construction, operation, and maintenance of SKA1
- Be responsible for all aspects of the SKA1 Project that are not the responsibility of the host country
- Operate and maintain all equipment required for the implementation of the SKA1 project.
- Comply with relevant state and federal laws and regulations.
- Compliance with the terms for access to the sites
- Provision of adequate insurance cover for the telescopes, works, staff, contractors, assets, and infrastructure.
- Support host country stakeholder relationships.

Host Country Responsibility

- Provision of access to the telescope sites, assets and infrastructure
- Secure necessary rights to enable a grant of licenses or leases.
- Provide required registers of environment and heritage.
- Provide radiofrequency protection with respect to the telescope sites.
- Coordinate interaction with all concurrent users of the site, including indigenous land users.
- Coordinate construction and operation of other radio facilities on-site to ensure construction and operations
- Maintain stakeholder relationships with national and local governments



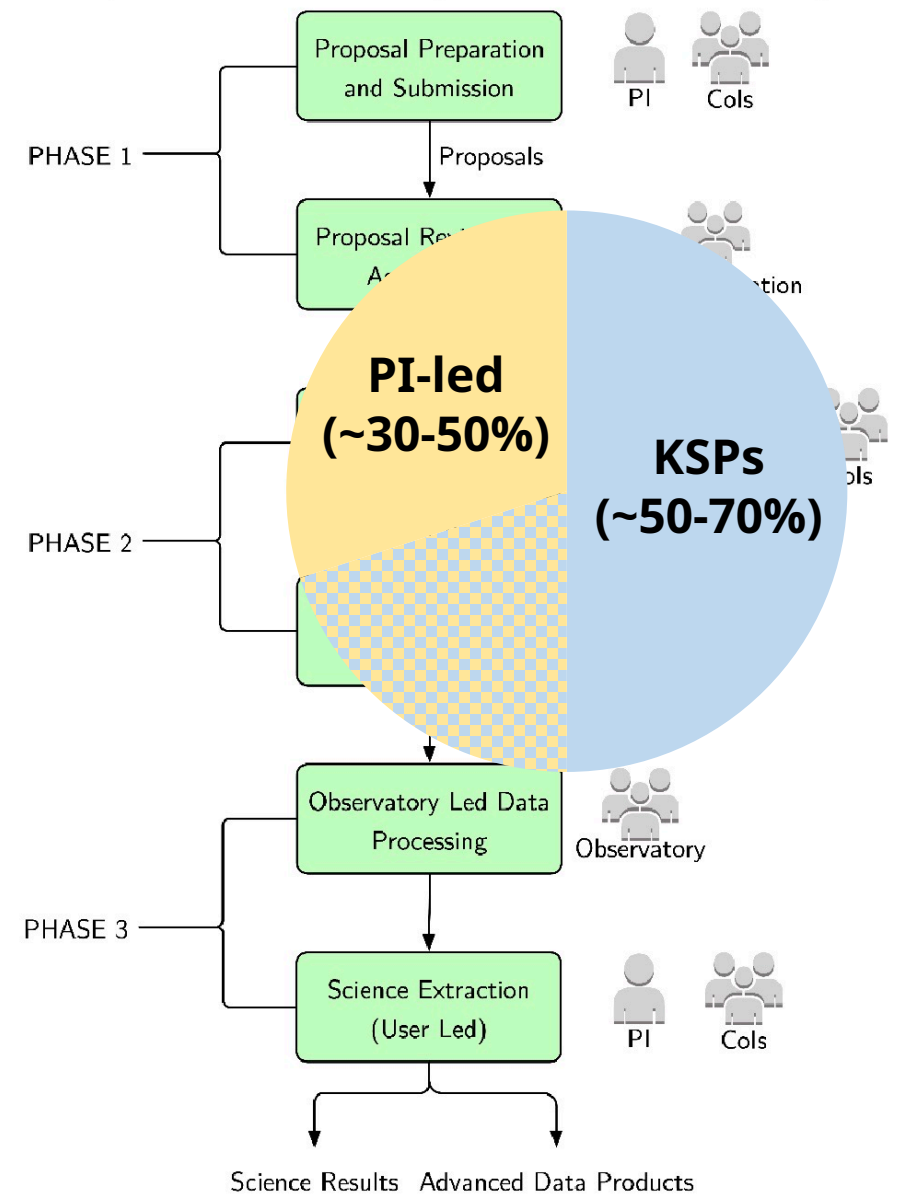
Observation Proposals

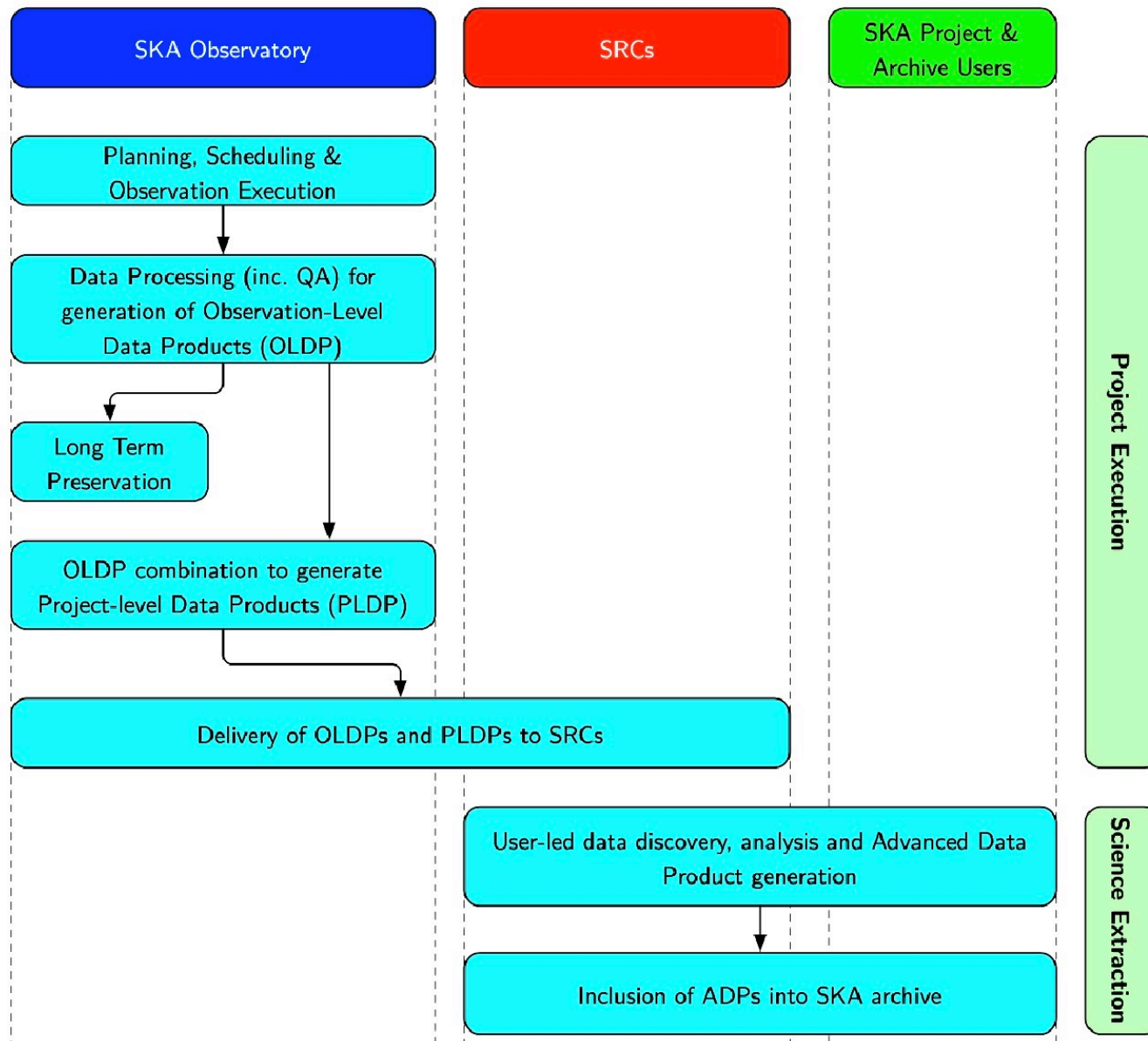
Categories:

- Standard Principal Investigator Proposal (PI): typically completed within a single time allocation cycle
- Key Science Project (KSP) : cannot be completed within a single time
- Open Time (OT) fraction of time available to PIs from member and non-member countries.
- Director-General Discretionary Time (DDT): can be submitted at any time needing only the approval of the DG.

Sub-categories:

- Target of Opportunity (ToO): triggered by events, need rapid response
- Long-term proposal (LTP): over 1 observing cycle but smaller than a KSP (e.g. monitoring campaigns)
- Joint SKA Proposal (JSP): requires both Low and Mid
- Coordinated Proposal (CP): requires SKA and another facility





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**



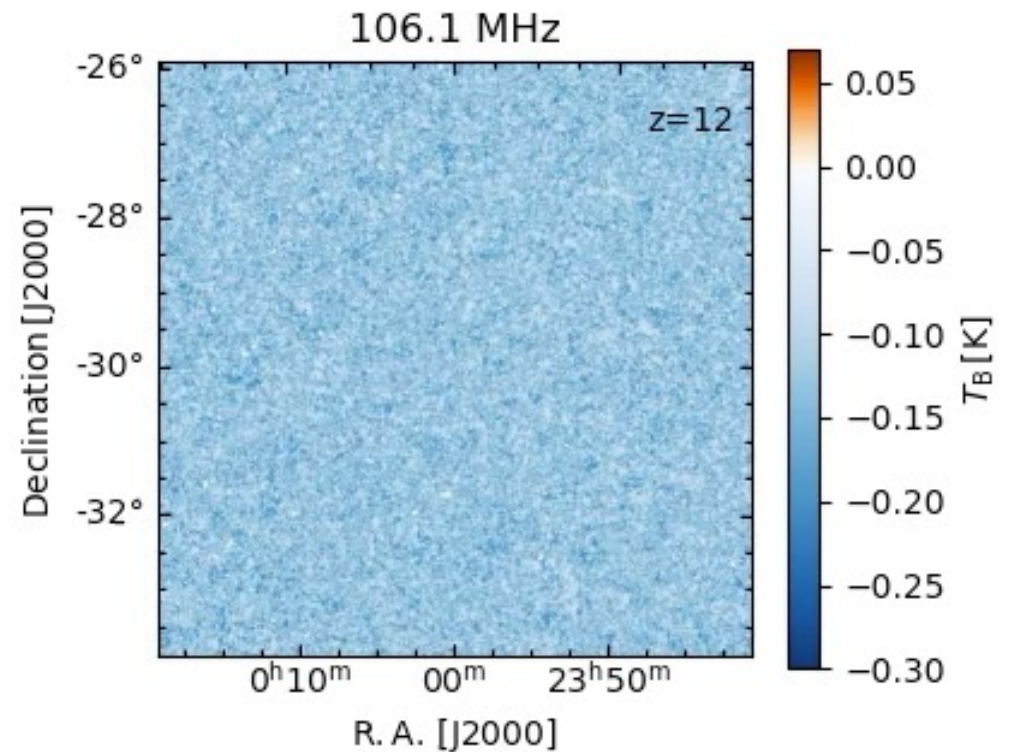
SDC data products are made publicly available for the long term



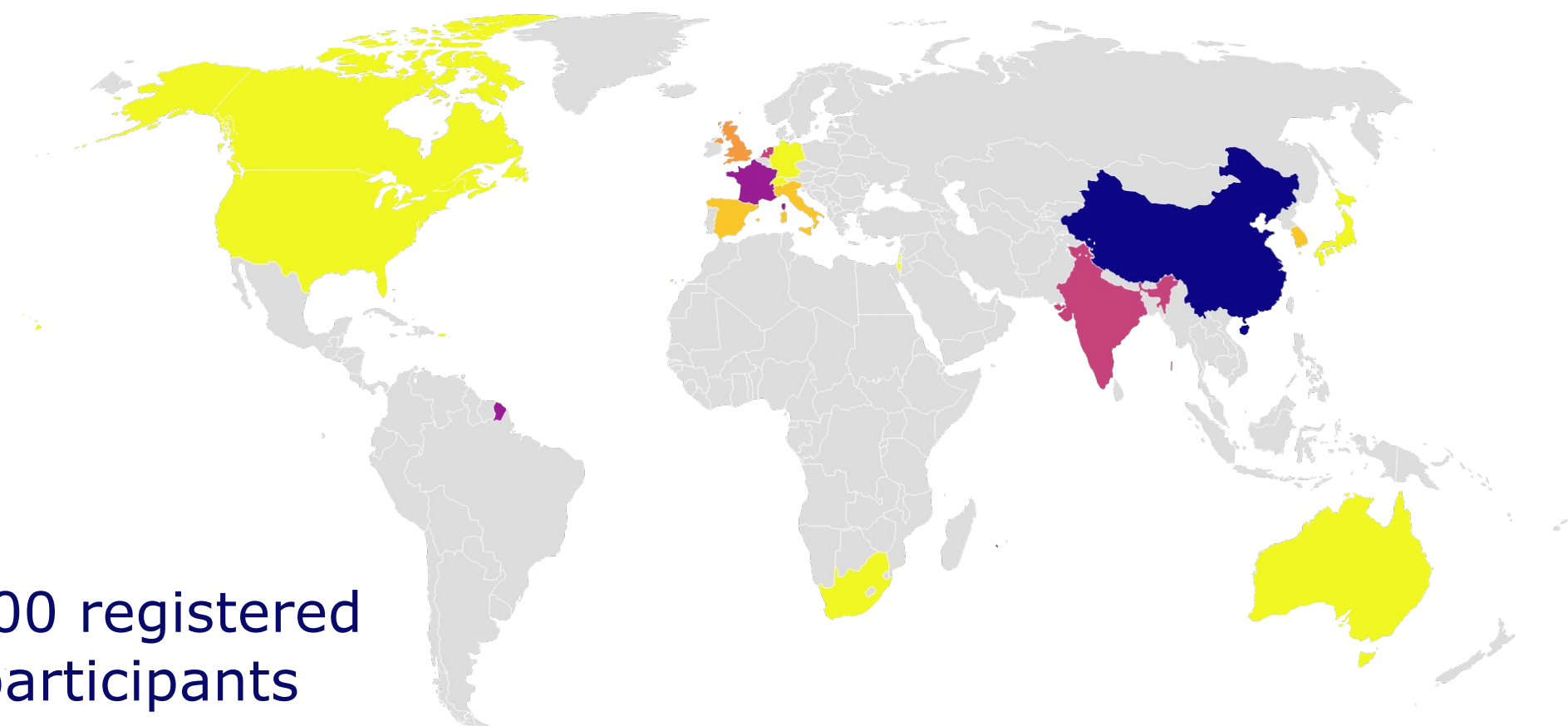
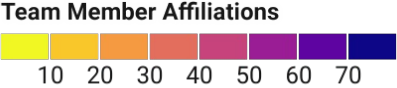
Science Data Challenge 3

Developed in collaboration with SKA EoR SWG members

- SDC3a “**Foregrounds**” (SDC3a; SWG Coordinators: C. Trott, V. Jelic)
 - **Foreground removal** exercise
 - SDC3a registration ran from 10th October 2022 – 15th November 2022
- SDC3b “**Inference**” (SDC3b; SWG Coordinators: A. Mesinger, G. Melema)
 - Extraction of **cosmological parameters**
 - SDC3b launching Q3 2023



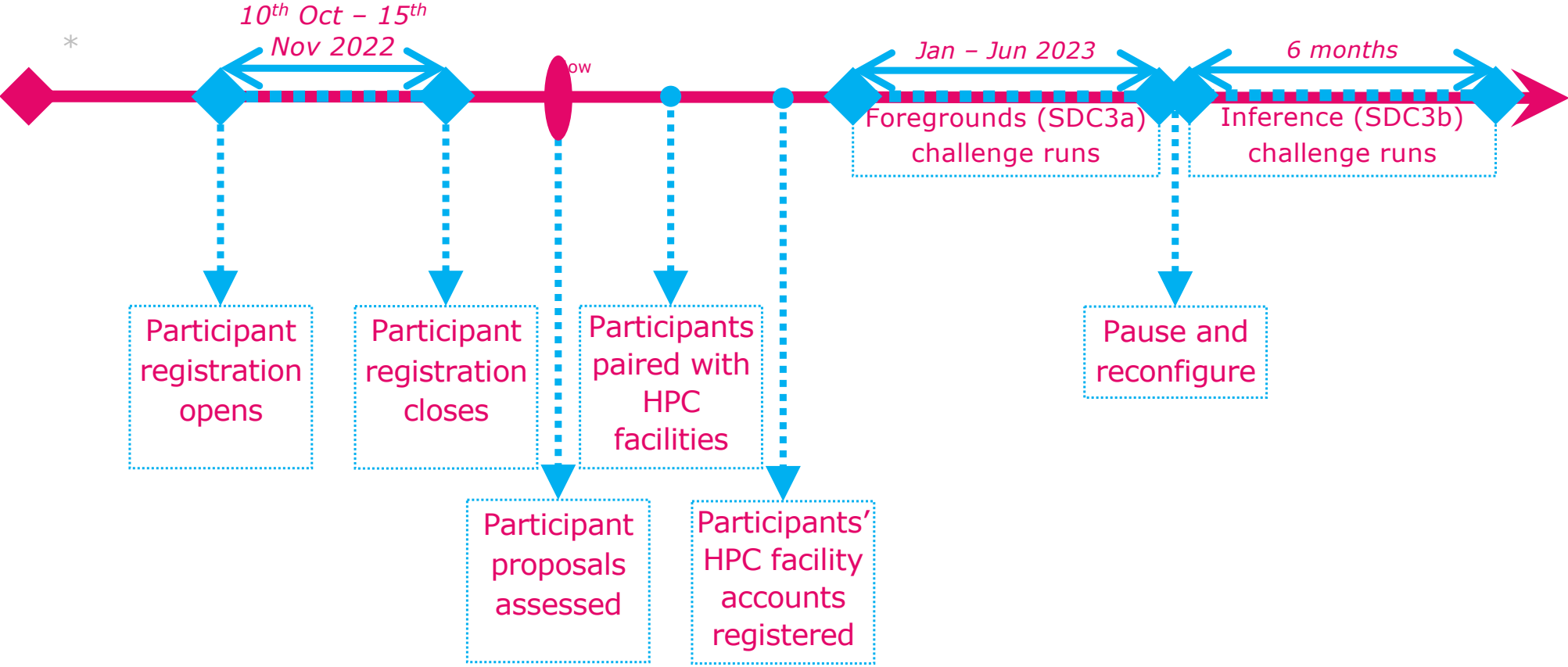
SDC3a Registrations



~300 registered participants



SDC3 Timeline – Important Events



**Not to scale*



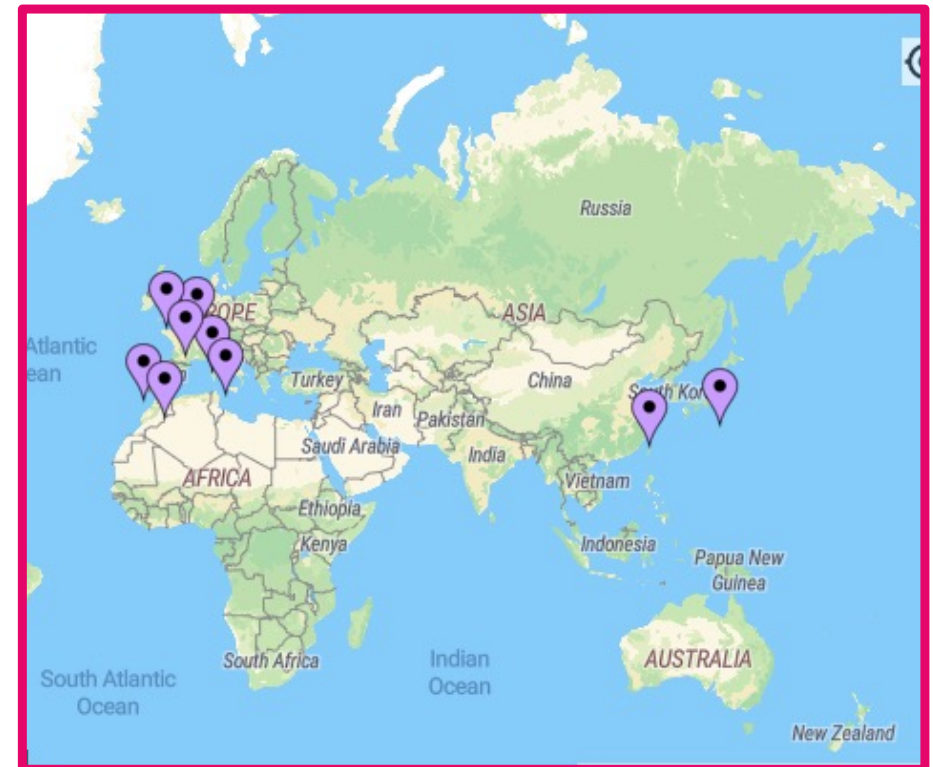
Computational facility partners

- Why computational facility partners?
 - Store the dataset in multiple locations, where teams will be able to access it;
 - Provide computational resources to inspect and analyse the dataset without transferring it to another facility;
- How will it work?
 - Teams stated their computational needs as part of the SDC3 registration;
 - The SDC team is collaborating with the facility partners to identify the facility that best matches their needs;
 - Teams will access the data through the chosen facility;
 - The data will be made available at multiple facilities at the same time to ensure a fair challenge;
 - Teams will be able to process the data there;
- Which facilities for SDC3?
 - IRIS
 - INAF ICT facility
 - SPSRC
 - GENCI-IDRIS
 - EngageSKA - UCLCA
 - Swiss SRC
 - ChinaSRC
 - ASTRON/SURF



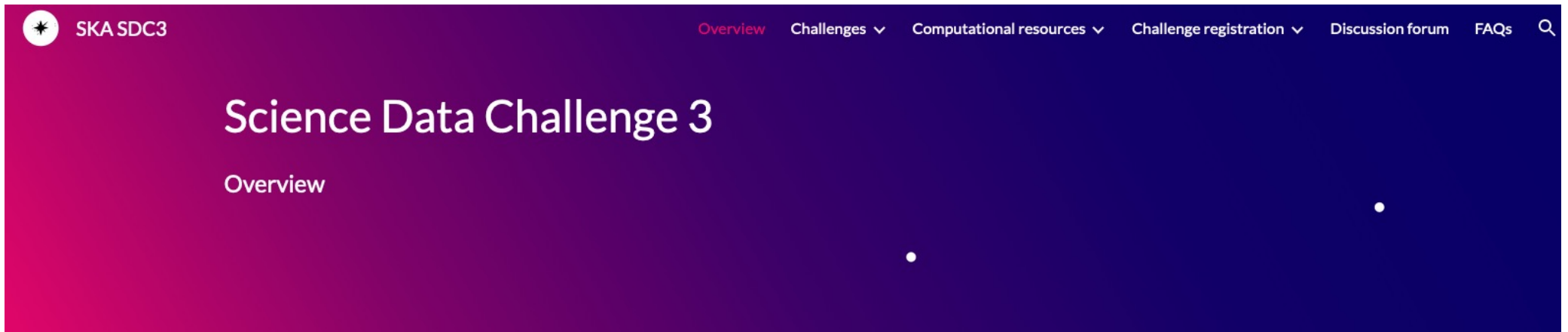
HPC Facility Partners

- IRIS
Cambridge
- IRIS
Manchester
- INAF
- SPSRC
- GENCI-
IDRIS
- UCLCA
- Swiss SRC
- ChinaSRC
- ASTRON
- AUS SRC
- EngageSKA
- JPSRC



website

sdc3.skao.int



Purpose

As with our previous two data challenges ([SDC1](#) and [SDC2](#)), our goal is to prepare the radio-astronomical community for the novel nature of the data expected from the Square Kilometre Array. Given the order-of-magnitude improvement in sensitivity, new analysis methods are required for both the challenging nature of resulting data, but also for the previously untouched science. Thus, realistic, synthetic datasets emulating the telescope's capabilities will be disseminated to the community to test the suitability of existing methods and foster the development of new ones on these next-generation, scientific datasets. Ultimately, results of each of the competing teams' approaches will be compared via a standard figure-of-merit, instigating a competitive nature to our challenges.



Summary

SKAO's mission is to build and operate the two largest and most sensitive radio telescopes in the World

SKAO is an intergovernmental organization (IGO), the 2nd in astronomy after ESO

SKAO is a global partnership, with 15 countries committed to building SKA (incl. 9 from Europe), and a number of African partner countries as part of the AVN

Construction has been approved, contracts are being signed, local use agreements are almost finalized

Staff are being recruited in the host telescope countries

Planning is underway for operations centres in the host countries

SKA construction is no longer on the horizon, it is happening



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