SKA SWG Update

SWG Chairs Meeting – 20 February 2024

Tyler Bourke
SKA Project Scientist
SKAO Senior Scientist

START RECORDING

Agenda

- Progress toward science
- SWG Chair rotation
- SKAO Membership Status
- Science Data Challenges
- Meetings
- AOB (chairs roundtable etc)

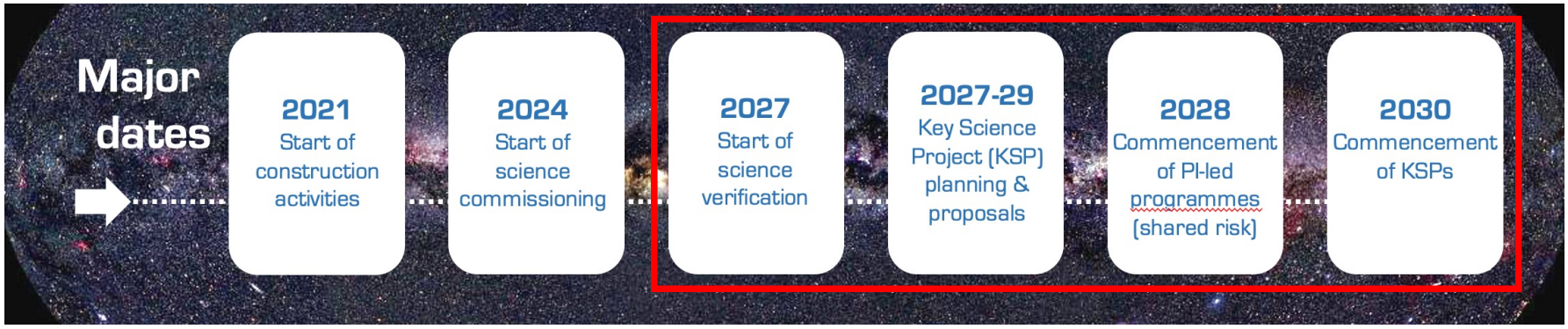
SKA Design Baseline

SKA-Low

131,072 log-periodic antennas
(512 stations each with 256 dipoles)
50 – 350 MHz
74 km baselines (9.5” @ 110 MHz)
Murchison, **Western Australia**

SKA-Mid

197 steerable dishes
(133 x SKA + 64 x MeerKAT dishes)
0.35 – 15.4 GHz
150 km baselines (0.22” @1.7 GHz; 0.034” @15 GHz)
Karoo, **South Africa**



Construction Strategy

(Staged Delivery - **Target: Design Baseline**)

- **Goal – SKA-Mid with 197 dishes & SKA-Low with 512 stations**
- Roll out the array in stages (Array Assemblies – AAs)
- Not all funding yet secured, therefore following Staged Delivery Plan (AA*)
- Maintain a continuously working and expanding facility that demonstrates the full performance capabilities of the SKA Design.
- **AA 0.5** – test array for interferometry, using prototypes; discover system level issues and develop procedures (e.g., pointing, tracking, holography)

First data release to community during SV in 2027 time-frame
(similar to ALMA SV model)
Some test data released during Commissioning

Milestone Event (earliest)		SKA-Mid (date)	SKA-Low (date)
AA0.5 (test array)	4 dishes 4 stations	2025 Q2	2024 Q4
AA1	8 dishes 18 stations	2026 Q2	2025 Q4
AA2	64 dishes 64 stations	2027 Q2	2026 Q4
Science Verification begins		**2027+**	**2027+**
AA*	144 dishes (80+64 MK) 307 stations	2028 Q1	2028 Q1
Operations Readiness Review		2028 Q2	2028 Q2
End of Staged Delivery Programme		2028 Q3	2028 Q3
Early Operations begin (shared risk)		**2029+**	**2029+**
AA4	197 dishes 512 stations	TBD	TBD

Updated December 2023

Construction Strategy

(Staged Delivery - **Target: Design Baseline**)

Array Assemblies (AA)

- Capable as acting as an end-to-end telescope system with pre-defined functionality
- Used to commission and verify the telescopes
- Different objectives for different assemblies
- **Science commissioning**: on-sky observations for testing and debugging the system (some data may be released to community)
- **Science verification**: observations to ensure the system meets the needs of the science users (e.g., test observing modes, verify science requirements)
- **AA2 – Start science verification (SV)**: Community suggests targets & observations, data made publicly available

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Updated December 2023

The Road to Science

Expectant Astronomers

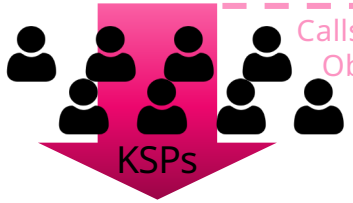
Science Commissioning

Some test data may be available

Science Verification

Suggests targets and observations
Calibrated data publicly available

Shared Risk PI



Calls for proposals
Observing cycles

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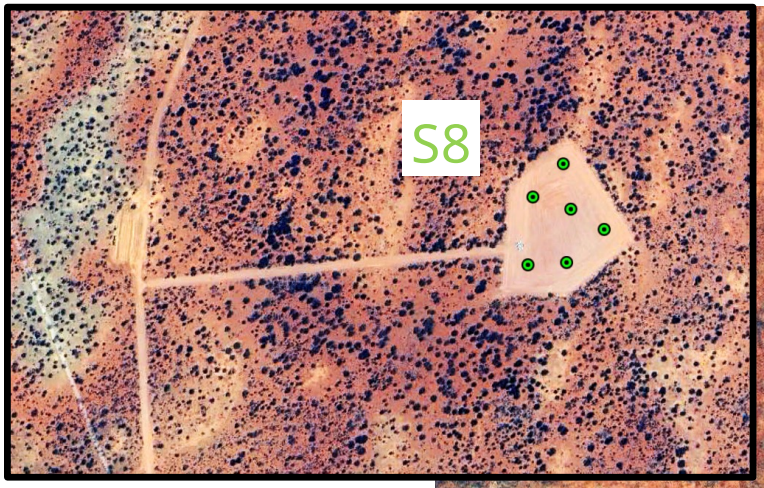
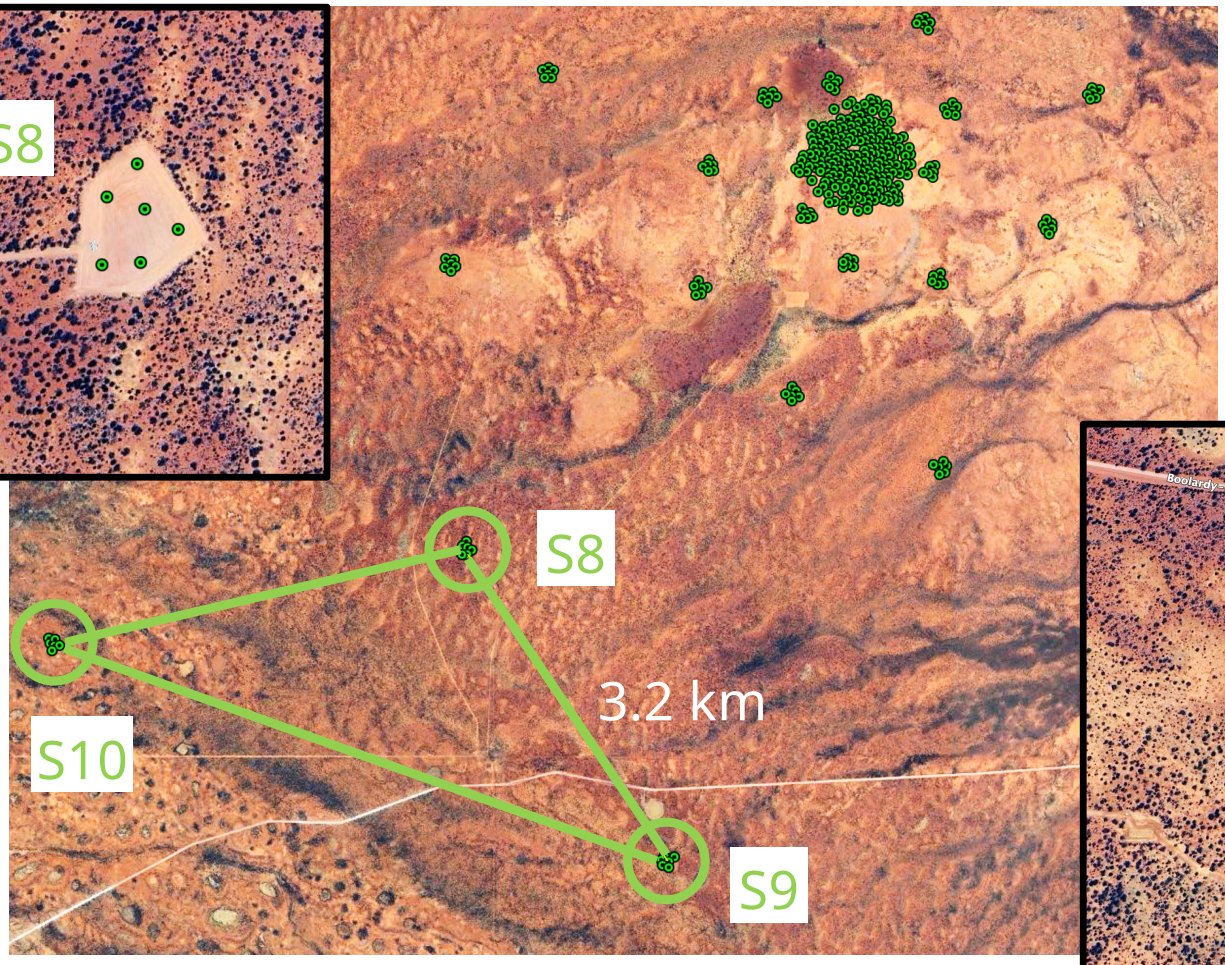
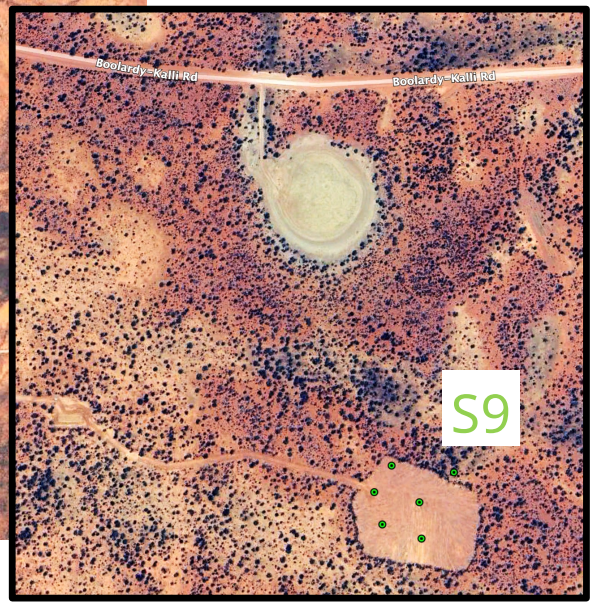
Updated December 2023

Construction Update – AA 0.5





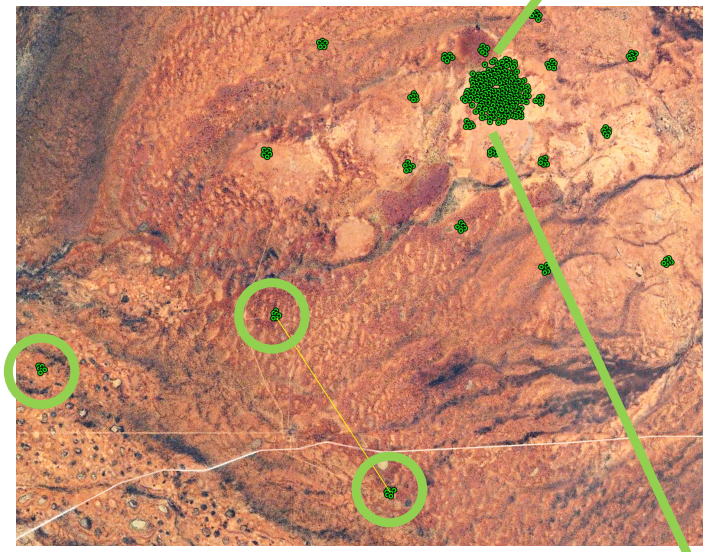


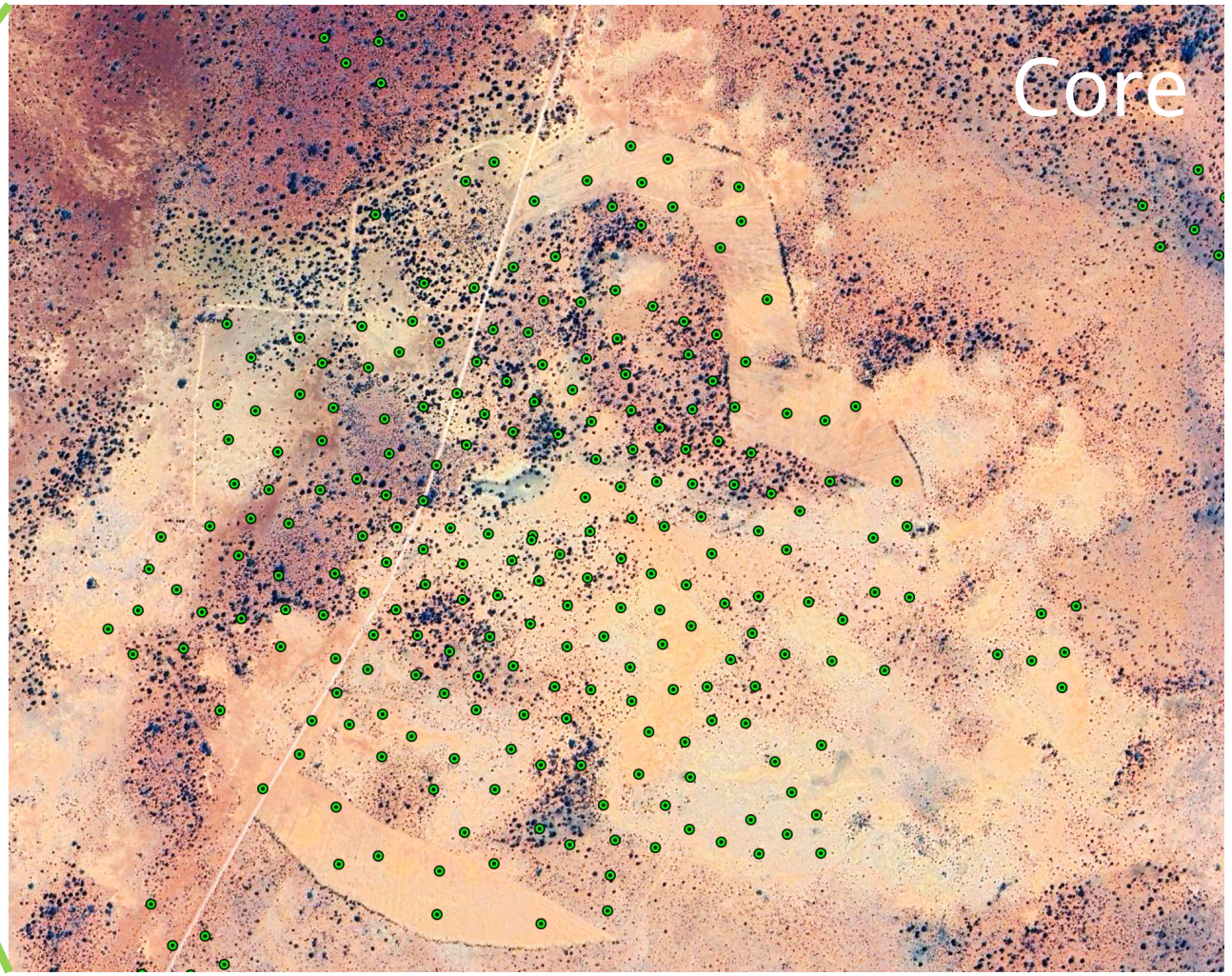
SKA-Low
AA 0.5

4 Stations
2 x S8
1 x S9, S10

Construction Update

SKA-Low





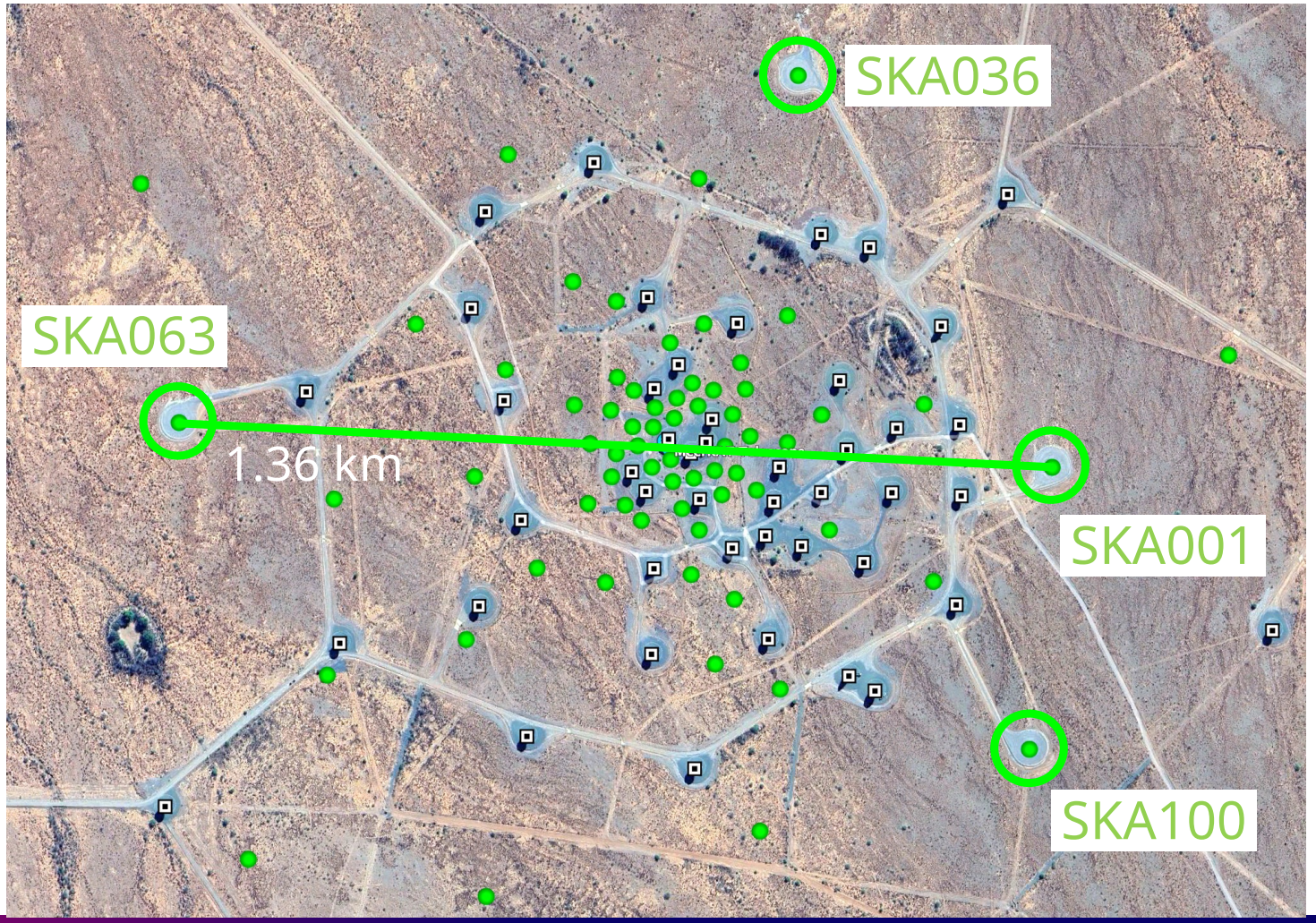
Construction Update

SKA-Low

Construction Update – AA 0.5

SKA-Mid

- MeerKAT
- SKA dish locations



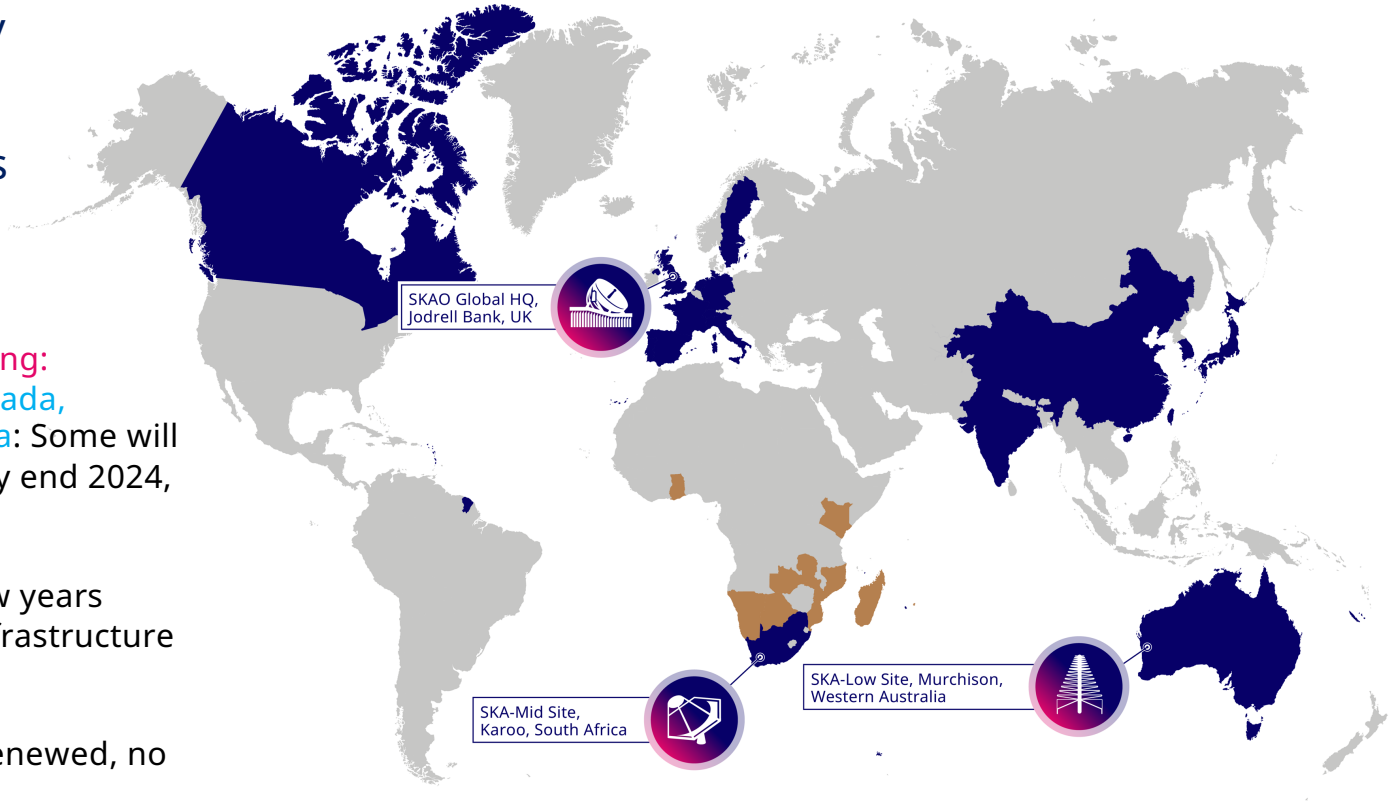
Construction Update – AA 0.5

SKAO – global partnership (IGO since 2021)

One Observatory

Two Telescopes

Three Continents



Ratified Members:

Australia
China
Italy
The Netherlands
Portugal
South Africa
Spain
Switzerland
United Kingdom

Various stages of joining:
France, Germany, Canada, Sweden, India, S.Korea: Some will be almost complete by end 2024, others in 2025

Japan: uncertain, a few years away now (internal infrastructure roadmap)

Ireland: discussions renewed, no timeline just yet

SKAO Partnership - includes SKAO Member States* and SKAO Observers (as of April 2023)

African Partner Countries

Membership Update

- Germany
  - December cabinet approval
  - Discussions on further commitment (beyond MeerKAT+ contribution)
- India
  - December cabinet approval
  - Contribution of €110M, including additional ~€25M to expected Staged Delivery budget
- *Japan*
  - *Low priority on national roadmap (TMT, CTA, Icecube*
  - *formal talks on hold until 2027/8?*
- Canada
  - Parliamentary approval being completed
- France
  - Parliamentary process in preparation
  - SKAO-CNRS agreements continue
- Sweden
  - Govt. process toward membership
  - SKAO-Chalmers agreement continues. Contribution of €26M secured.
- South Korea
  - SKAO included in national space agenda
  - discussions on agreement with KASI underway, then membership

SWG Chair rotation

SWG	First	Last	Country	Rotation Status
Cosmology	Stefano	Camera	Italy	under discussion
EoR	Abhirup	Datta	India	under discussion
EoR	Andrei	Mesinger	Italy	under discussion
Exgal Cont	Fatemeh	Tabatabaei	Iran	replaced Natasha
Exgal Cont	Mark	Sargent	Switzerland	Catherine Hale (UK) 2024/05
Exgal Line	Viviana	Casasola	Italy	replaced Fraincoise
Exgal Line	Sebastien	Muller	Sweden	Jacco van Loon (UK) 2024/03
GW	Samaya	Nissanke	Netherlands	under discussion
GW	Alvise	Raccanelli	Italy	under discussion
HI Galaxy	Neeraj	Gupta	India	replaced Barbara
High Energy	Katie	Mulrey	Germany	replaced Anna
Magnetism	Jennifer	West	Canada	replaced Valentina
Our Galaxy	Jan	Forbrich	UK	Ke Wang (China) 2024/03
Our Galaxy	Adriano	Ingallinera	Italy	Marc Audard (Switzerland) 2024
Pulsars	Bhal Chandra	Joshi	India	replaced Natasha
SHI	Eduard	Kontar	UK	Rohit Sharma (India) 2024/03
SHI	Pietro	Zucca	Netherlands	replaced Divya
Transients	Jason	Hessels	Netherlands	Due
VLBI	Jack	Radcliffe	South Africa	replaced Cormac
VLBI	Tao	An	China	Jun Yang (Sweden) 2024/06

SWG (incl. Chair) Terms of Reference (Link)

Science Data Challenges

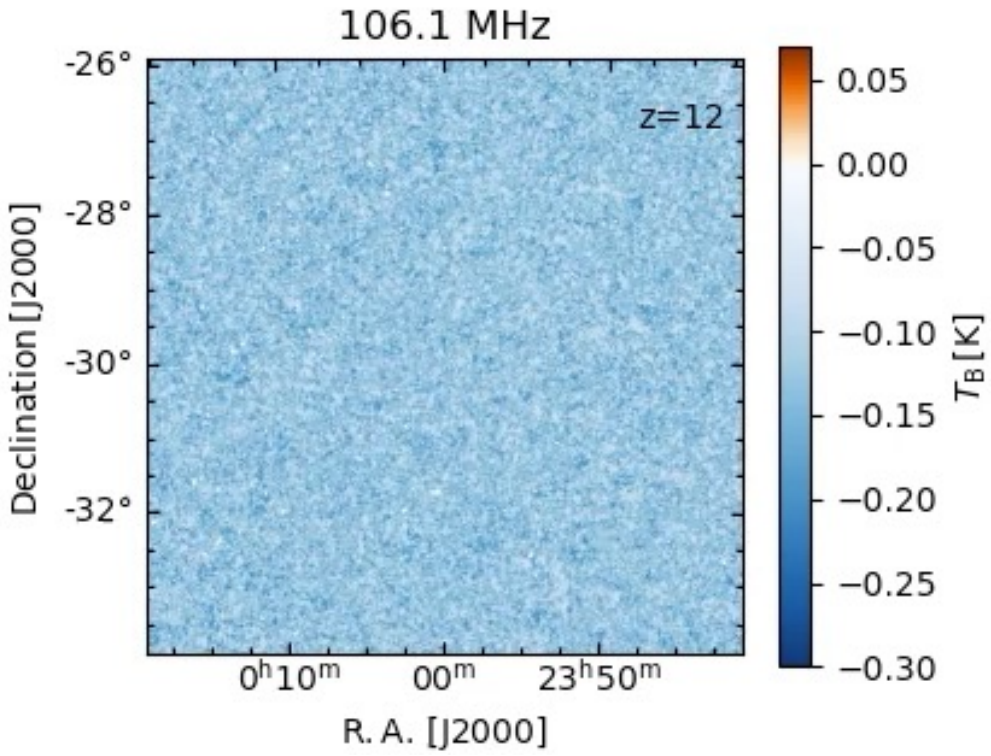
- Prepare Science Community
  - Science extraction from SKA Observatory Data Products (ODPs)
  - Stimulate advance of state-of-the-art in source finding, source characterisation and reliable inference of astrophysical parameters
  - Promote reproducibility and analysis pipeline sharing
- Develop proto-SRC Network
  - Test increasingly realistic data transfer, user access and customised user processing in proto-SRC environment
- Constrain SDP Pipeline development
  - Identify gaps in sky, telescope and error models
  - Determine necessary calibration quality and identify any other factors that might inhibit science extraction from ODPs

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 started 1 March 2023, closed 30 September 2023
  - 20 team submissions
  - Winner – team HIMALAYA (China)
  - Journal paper in preparation

- SDC3b "**Inference**" (SDC3b; SWG Coordinators: A. Mesinger, G. Melema)
  - Extraction of **cosmological parameters**
  - **SDC3b launching Q2 2024**



sdc3.skao.int

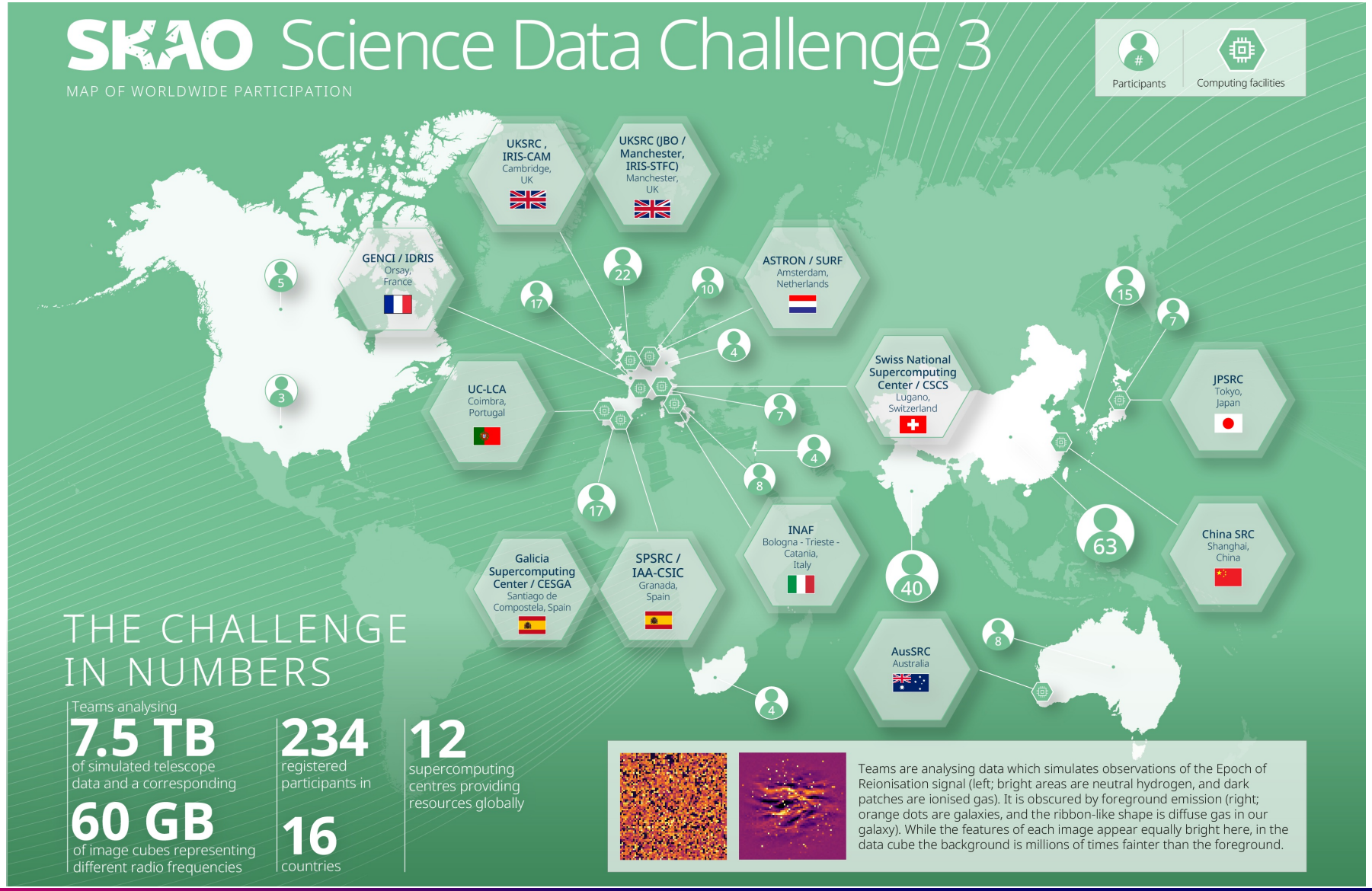
Science Data Challenge 3a – Dataset

- General
  - Observation track length HA = -2 to +2 hours
  - Thermal noise equivalent 1000 h
  - Field of View: one SKA1-Low pointing at RA, Dec = 0h, -30deg
- Visibilities
  - Size 7.5 TB
  - Integration time 10 s
  - Channel width 100 kHz
  - Frequency coverage 106 - 196 MHz
- Image cube → 2048 x 2048, 16 arcsec pixels, natural weighting

- **The Challenge:**
  - Determine intrinsic power spectrum of EoR fluctuations as function of scale and frequency despite foregrounds that are 10^5 times brighter and presence of various residual calibration errors (DI, DD, bandpass) of specific magnitude

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

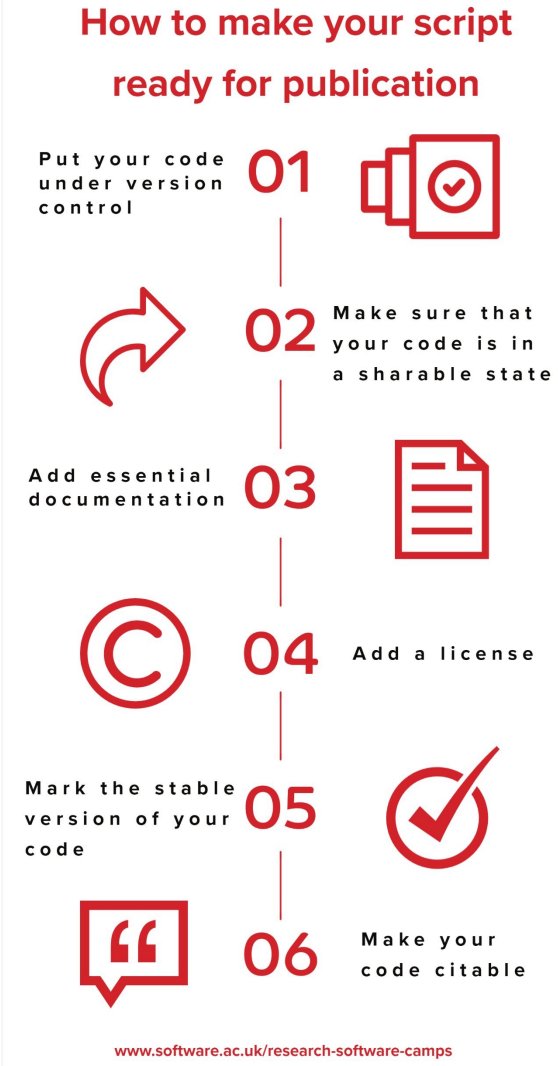
16 countries

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.

Reproducibility awards – SDC3

- Awarded to all teams who prepare software pipelines that can be reproduced and reused by others.
- Based on Software Sustainability Institute's six steps to reproducibility
- Award system revised since SDC2
- Simpler for teams to follow and achieve
- SKAO reproducibility 'badges' can be added to team's code repository



Reproducibility awards – SDC3

- Motivation:
  - Recognise that it can take extra time and effort to prepare codes into a shareable state
  - Align with FAIR principles for scientific data management and software
- Benefits
  - Easier for teams to share and learn analysis techniques → potential boost from combination of techniques
  - Pipelines (with SDC datasets) can be used as test cases for SRCNet development

Reproducibility awards – SDC3a Winners

Team	Published codes
Cantabrigians	https://github.com/ycliu23/Cambridge-SKA-SDC3-Foregrounds
DOTSS	https://gitlab.com/flomertens/dotss21_sdc3_pipeline
ERWA	https://github.com/zzh0616/SKA-DECONV
FOREGROUNDS-FRIENDS	https://github.com/espsrc/FOREGROUNDS-FRIENDS
Hausos	https://github.com/CEA-jiangming/Hausos-sdc3a/tree/v1.0
HIMALAYA	https://github.com/553445316/HIMALAYA.git
KORSDC	https://github.com/KJ-Ahn/KORSDC_FGremove
SROT	https://github.com/AkashRadio/SKA_SDC3
Wizards of Oz	https://github.com/d3v-null/sdc3-pipeline

We warmly congratulate all teams who took part in this part of the Challenge!

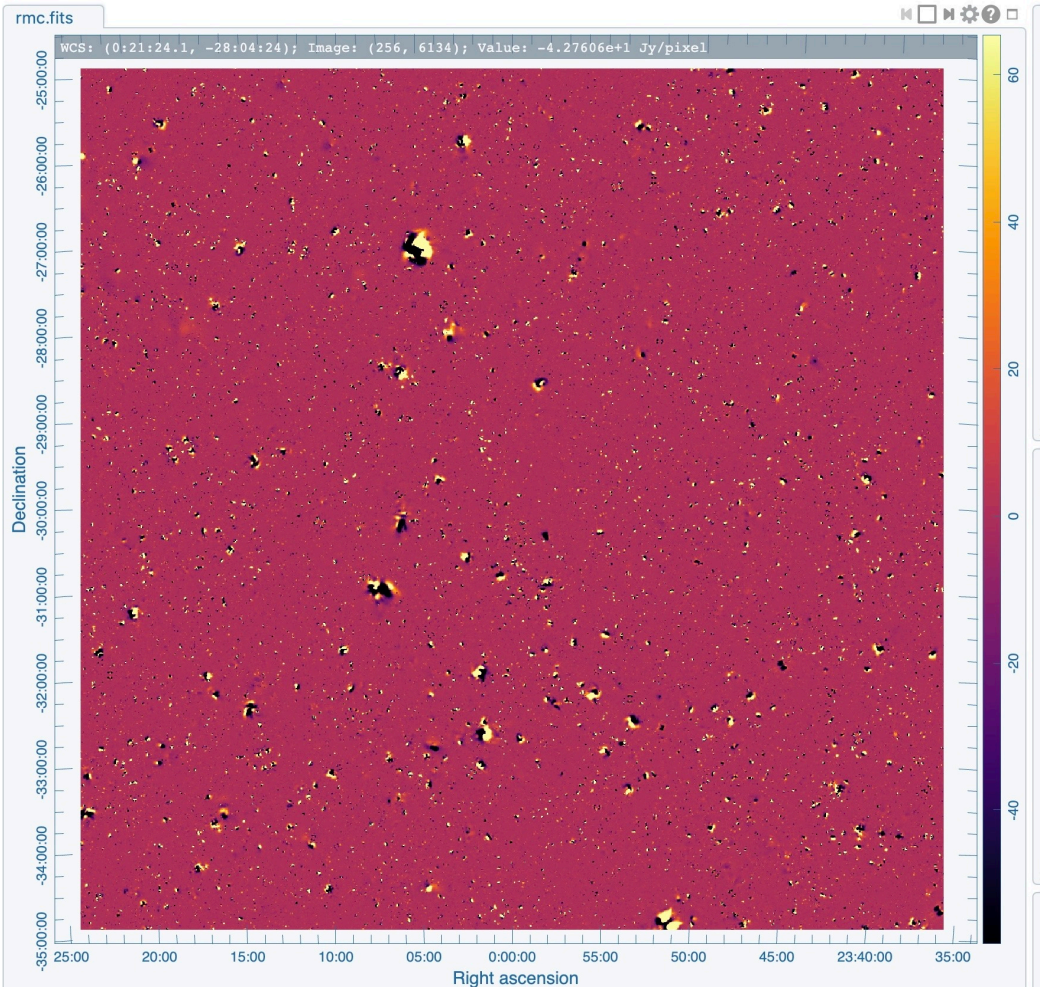
Science Data Challenge 4 – Magnetism

- Developed in collaboration with Magnetism SWG (Akahori, Vernstrom, Vazza, …)
  - 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, RM_{Max} ~ 5000 rad m^{-2}, N_{chan} ~ 650
  - 100 square deg, 100 – 350 MHz, 350 – 1760 MHz, 10 arcsec beam, source finding and characterisation, RM_{Max} ~ 500 rad m^{-2}, N_{chan} ~ (9350 + 650)
  - Thermal noise equivalent few 1000 h, AA* telescope model
- Sky and Propagation Models nearing completion and looking good
  - Fully propagated models will require several months of local server time to run
- Telescope and Error Models
  - Under development, but already clear these will be image-based rather than visibility-based due to prohibitive computing cost

Science Data Challenge 4 – Magnetism

- IGM RM Sky Model of 100 deg^2 extending from z = 0.01 to 3.2 using Vazza et al simulations
- Red-shift space built up of 70 slices of 100 Mpc depth
- Each slice is the simulation at that red-shift tiled as needed to fill 10x10 deg, with an offset and rotation to randomize projected distribution

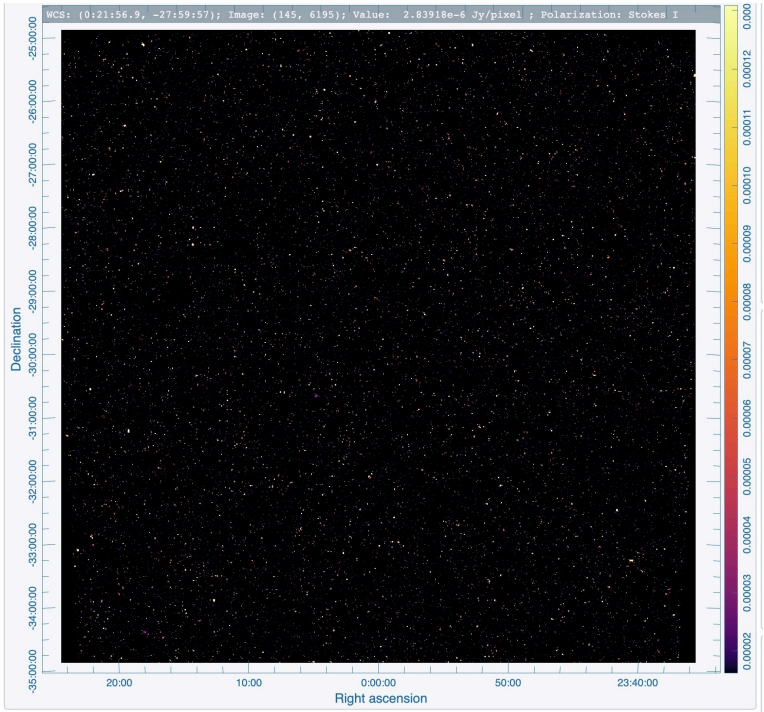
Projected RM(z) Sky Model (z = 0.01 – 3.2)



Science Data Challenge 4 – Magnetism

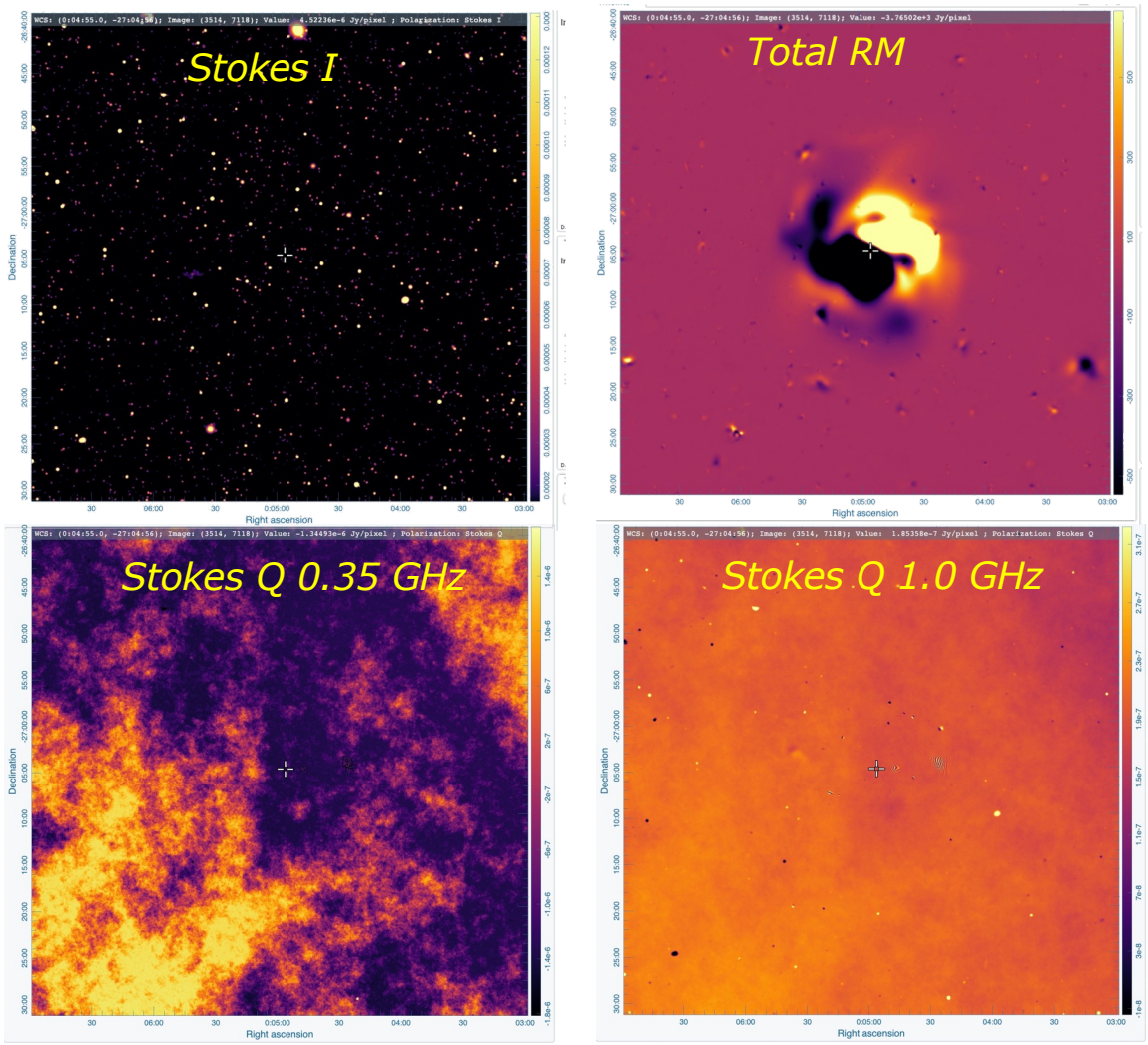
- Galaxy clusters at z = 0.1 – 0.3 in the simulation to have RM up to +/- 8000 rad m^{-2}
- Polarised IGM emission also included in sky model out to z = 0.3
- ISM and Ionosphere RM Sky Model of 100 deg^2 from Akahori et al simulations
- Also include ISM polarised emission from Akahori et al model
- Sky Emission Model consists of:
  - T-RECS (all z)
  - IGM emission (z < 0.3)
  - ISM emission
- Propagation Model consists of:
  - IGM RM (z < 3.15)
  - ISM RM
  - Ionosphere RM

Stokes I Sky Model



Science Data Challenge 4 Magnetism

- Close-up view of Galaxy cluster at z = 0.1 with RM up to +/- 8000 rad m^{-2}
- Good prospects for rich polarimetric phenomena in SDC4 data products



Science Meetings (2024 unless indicated)

- THIS WEEK: MeerKAT @ 5, 20-23 February, Stellenbosch, SA
- Interstellar Frontiers: Bridging SETI, Astrobiology, and SKA, 11-14 March, Perth AU
- Cosmology in the Alps: 18-22 March, Les Diablerets, CH
- African Astronomical Society (AfAS) Conference, 15-20 April, Marrakech, Morocco
- Raising the veil on star formation: conference in honour of Richard Hills, 22-28 April, Cambridge UK
- SPARCS XII: Pushing toward the final frontier, 6-10 May, Bologna, IT
- New Telescopes and major upgrades to existing telescopes: URSI AT-RASC, 19-24 May, Gran Canaria, ES
- Cosmic Magnetism in the pre-SKA Era: 27-31 May, Kagoshima JP
- EAS SS31: **The SKAO: pathway to science operations**, 1-5 July, Padova, IT
- IAU GA: 6-15 August, Cape Town. **SKAO Day 9 August**, and various SKA-related Symposia
- SKA Science Conference, June 2025, Gorlitz, Germany, planning underway

Outreach & Engagement

- **CONTACT** is the SKAO magazine aimed at the entire SKA community
- Ideas for articles for CONTACT are always welcome (email Tyler). These include:
  - Let's Talk About (Feature length … science focussed)
  - Pathfinders (& precursors. Short pieces on recent results)
  - SKA-related events (e.g. SPARCS, etc)
  - any other news of SKA relevance (award/honours, jobs, …)
- Encourage your SWG members to sign up

AOB

- SWG News?

Reminder:

- SWG Chairs meetings 3rd Tuesday each month
- Alternating between 09.00 UT (March, May, …) and 15.00 UT (Feb, Apr, …)

https://www.skao.int/en/science-users

SKAO

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