SKA SWG Update

SWG Chairs Meeting – March 2024

Tyler Bourke
SKA Project Scientist
SKAO Senior Scientist
START RECORDING

Agenda

• Planning for SKA science & Construction Update
• MeerKAT Update
• SWG Chair rotation
• Science Data Challenges
• Meetings
• SKAO News
• Engagement
• Jobs
• 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**

**Major dates**
- **2021**: Start of construction activities
- **2024**: Start of science commissioning
- **2027**: Start of science verification
- **2027-29**: Key Science Project (KSP) planning & proposals
- **2029**: Commencement of PI-led programmes (shared risk)
- **2030**: Commencement of KSPs
The Road to Science

科学委员会

科学委托

科学验证

共享风险PI

一些测试数据可能可用

根据目标和观测

校准数据公开可用

期望天文学家

实验室数据

建议目标和观测

KSPs

召集提案

观察周期

共享风险

AA = 阵列组装

### 科学验证开始

- **AA0.5** (测试阵列)
  - 4个天线
  - 4个站点
  - 2025 Q2
  - 2024 Q4

- **AA1**
  - 8个天线
  - 18个站点
  - 2026 Q2
  - 2025 Q4

- **AA2**
  - 64个天线
  - 64个站点
  - 2027 Q2
  - 2026 Q4

- **科学验证开始**
  - 2027+
  - 2027+

- **AA***
  - 144个天线 (80+64 MK)
  - 307个站点
  - 2028 Q1
  - 2028 Q1

- **运行准备审查**
  - 2028 Q2
  - 2028 Q2

- **阶段交付结束**
  - 2028 Q3
  - 2028 Q3

- **早期运营开始 (共享风险)**
  - 2029+
  - 2029+

- **AA4 (设计基线)**
  - 197个天线
  - 512个站点
  - TBD
  - TBD

### 里程碑事件 (最早)

<table>
<thead>
<tr>
<th>里程碑事件</th>
<th>SKA-Mid (日期)</th>
<th>SKA-Low (日期)</th>
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<tr>
<td>AA0.5 (测试阵列)</td>
<td>2025 Q2</td>
<td>2024 Q4</td>
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<tr>
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<td>2026 Q2</td>
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<tr>
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<td>AA4 (设计基线)</td>
<td>TBD</td>
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</table>

**注释**

- 预期天文学家
- 呼吁提案
- 观测周期
- KSPs
- 共享风险

**AA = 阵列组装**

**更新日期：2023年12月**
The Road to Science

**Update in progress**

### Major dates

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
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### SCIENCE AND OPERATIONS PLANNING

Document number: SKA-TEL-SKO-00000822
Document Type: PLN
Revision: 02
Author: SKAO Science and Ops Teams
Date: 2017-11-14
Document Classification: UNRESTRICTED
Status: Released

### Progress Table

<table>
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<th>SKA-Mid (date)</th>
<th>SKA-Low (date)</th>
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<tr>
<td>AA0.5 (test array)</td>
<td>4 dishes</td>
<td>2025 Q2</td>
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<tr>
<td></td>
<td>4 stations</td>
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<tr>
<td>AA2</td>
<td>64 dishes</td>
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<td>2028 Q2</td>
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<td>AA4 (Design Baseline)</td>
<td>197 dishes</td>
<td>TBD</td>
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<tr>
<td></td>
<td>512 stations</td>
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**Updated December 2023**
The Road to Science

Science Users Webpages:
https://www.skao.int/en/science-users

Updates in progress:
Timeline, Specifications, FAQs,
Regional Centres → “SKA Data & Archives”

New: Science meetings
To come: “Observing with the SKA”, “Simulations”

SKA Tools (incl. sensitivity calculators):
https://www.skao.int/en/science-users/ska-tools

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</table>
Construction Update – AA 0.5

4 Stations
2 x S8
1 x S9, S10

SKA-Low
AA 0.5

3.2 km
Construction Update

SKA-Low

1st Low antenna deployed (S8) – 7 March 2024
Construction Update

SKA-Low

1\textsuperscript{st} Low antenna deployed (S8)
7 March 2024
Construction Update – AA 0.5

SKA-Mid

- MeerKAT
- SKA dish locations

SKA001, SKA036, SKA063, SKA100

1.36 km
Construction Update – AA 0.5

SKA-Mid
SKA063

1st pedestal lift (SKA063)
7 March 2024
Construction Update – MeerKAT+

MeerKAT+, adding 14-16 SKA dishes to MeerKAT on longer baselines
Paid for by MPG, SARAO and INAF
Feb 20–23, 2024, in Stellenbosch, South Africa

Keynote address by DHET Minister; 2 panels (*How it all began; The genesis of MeerKAT*)

- 77 science talks; 5 engineering talks (how does MeerKAT actually work?)
- ~50 posters
- 4 exhibits (*EMSS* receivers; *SARAO* digitizers; *Peralex* correlator; *Tsolo* data storage)
- ~250 participants

**MeerKAT @ 5**
MeerKAT Science After 5 Years

• **1st** MeerKAT-64 paper: “Inflation of 430-parsec bipolar radio bubbles in the Galactic Centre by an energetic event” (*Nature*, Sep 2019)

• 270 articles published since then

• **4.3x** oversubscription in latest *Open Time* Call for Proposals

• >450 proposals received since telescope inauguration with PIs from 24 countries (including all SKA nations)
First Detailed SFHU Using MeerKAT

**Top continuum science goal of SKA-MID: measure the Star Formation History of the Universe (SFHU)** (Prandoni & Seymour 2014)

At $\nu < 30$ GHz, radio synchrotron emission is a dust-unbiased probe of star formation in galaxies.

Source counts were measured down to $0.25 \, \mu$Jy with the MeerKAT DEEP2 commissioning image (Mauch et al. 2020)

Luminosity $f(z)$ and density $g(z)$ evolution can be determined when you know the source counts and local energy density function $u(L|z)$.

$f(z)$ and $g(z)$ constrain the SFHU for a global population.

Radio-based SFRD evolution confirmed, and its discrepancy with UV/IR data strengthened.

Next step: But why?

Multiwavelength analysis of an ensemble of individual galaxies:

**3839 galaxies** with low-resolution **spectra** + photometry for accurate SED fitting.

Image specs: $\theta = 7.6''$, $\sigma = 0.55 \, \mu$Jy/beam, $\nu = 1.28$ GHz, $\Theta = 1.1$ deg$^2$ (Mauch et al. 2020)
The MeerKAT Pulsar Timing Array

MPTA 4.5-year data set
(work in progress)

- Timing residuals display evidence for expected Hellings-Downs (quadrupolar) angular correlations from GWB
- Level of correlation depends on assumptions about pulsar noise: careful check underway

- Predicted to be highly sensitive to a gravitational wave background (GWB) – after only 5 years, becoming the most important contributor to worldwide effort to study GWB
- Enabled by MeerKAT’s superb sensitivity and efficiency (fast slewing) – the greatest number of millisecond pulsars with sub-μs timing residuals in any Pulsar Timing Array

MeerKAT PTA will be continued into SKA-MID to play a key role in era of GWB studies
MHONGOOSE: NGC 5068

- Galaxies need to accrete diffuse cold gas (neutral hydrogen) to sustain star formation
- Only the MHONGOOSE survey using MeerKAT’s high sensitivity can currently detect this
- 55 hr gives \( n_{\text{HI}} = 1 \times 10^{18} \text{ cm}^{-2} \) (3\( \sigma \) / 16 km s\(^{-1} \)) with 60” resolution
- NGC 5068 shows strong evidence for gas accretion
- Would be first time “cold accretion” is directly detected
## SWG Chair rotation

<table>
<thead>
<tr>
<th>SWG</th>
<th>First</th>
<th>Last</th>
<th>Country</th>
<th>Rotation Status</th>
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<td>Cosmology</td>
<td>Stefano</td>
<td>Camera</td>
<td>Italy</td>
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<tr>
<td>EoR</td>
<td>Abhirup</td>
<td>Datta</td>
<td>India</td>
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<tr>
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<td>Mesinger</td>
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<td>Fatemeh</td>
<td>Tabatabaei</td>
<td>Iran</td>
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<tr>
<td>Exgal Cont</td>
<td>Mark</td>
<td>Sargent</td>
<td>Switzerland</td>
<td>Catherine Hale (UK) 2024/05</td>
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<td>Viviana</td>
<td>Casasola</td>
<td>Italy</td>
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<tr>
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<td>van Loon</td>
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<td>Samaya</td>
<td>Nissanke</td>
<td>Netherlands</td>
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<td>GW</td>
<td>Alvise</td>
<td>Raccanelli</td>
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<td>Neeraj</td>
<td>Gupta</td>
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<td>Mulrey</td>
<td>Germany</td>
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<td>West</td>
<td>Canada</td>
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<tr>
<td>Our Galaxy</td>
<td>Ke</td>
<td>Wang</td>
<td>China</td>
<td>replaced Jan</td>
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<tr>
<td>Our Galaxy</td>
<td>Adriano</td>
<td>Ingallinera</td>
<td>Italy</td>
<td>Marc Audard (Switzerland) 2024/05</td>
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<td>Joshi</td>
<td>India</td>
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<td>Radcliffe</td>
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<td>Jun Yang (Sweden) 2024/06</td>
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**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 NOW – deadline early 2025

sdc3.skao.int
Science Data Challenge 3a – Feedback

• Questionnaire shared with all 20 SDC3a teams

• Responses received from 10 teams – thank you very much for taking the time to share your feedback

• Teams found the challenge helpful for understanding the data and testing pipelines and computational approach

• Strong interest in Open Science indicated, with teams finding the resource guides for preparing reproducible pipelines helpful

• Very useful feedback on what would be helpful next time:
  • More standardized datasets (only a single polarization used in SDC3a, chosen to reduce simulation time and complexity)
  • More details in the descriptions of the data and the simulations
  • Check for discrepancies between versions of the data descriptions

• All the feedback received will be used to improve the future data challenges
Science Data Challenge 3b – EoR Inference

Registration now open until Friday 10th April

• The challenge:
  • Infer the reionization properties of the Universe from power spectra of the hydrogen-21cm signal from the Epoch of Reionisation corresponding to different redshift ranges.
  • Submission will consist of inferred reionization fraction of the Universe for all the redshifts for which power spectra have been provided, and the associated uncertainty.

• Computation support
  • SDC3 receives generous support from our international HPC partner facilities, who will provide computational resources to teams for processing the challenge data.
  • Teams wishing to access computational resources are requested to submit a short proposal summarising their requirements with a technical justification.

SDC3 Inference webpage
Science Data Challenge 3b – EoR Inference

• The datasets:

• The data for the SDC3 Inference challenge will consist of two datasets, for two different EoR reionization models EoR1 and EoR2:
  • Power spectra of EoR1 + noise + SKA-Low telescope simulation for 3 (TBC) frequencies ranges, each corresponding to a redshift interval within the possible reionization history.
  • Power spectra of EoR2 + noise + foreground residuals + SKA-Low telescope simulation for 3 (TBC) frequencies, each corresponding to a redshift interval within the possible reionization history.
• All power spectra will be cylindrical (2D) power spectra. Dataset 1 will allow testing of the intrinsic performance of the EoR inference codes in the absence of any bias in the data. Dataset 2 will investigate the robustness of the approaches against foreground residuals.
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
Science Meetings (2024 unless indicated)

- **Cosmology in the Alps**: 18-22 March, Les Diablerets, CH - **NOW**
- **African Astronomical Society (AfAS) Conference**, 15-20 April, Marrakech, Morocco
- **Discovery of Life Beyond Earth – IAUS 387**, 15-19 April, Durham, UK
- **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 Session 9 August, and various SKA-related Symposia
- **SKA Science Conference, June 2025**, Gorlitz, Germany, planning underway
**EAS SS31: The SKAO: pathway to science operations**

- Friday 5 July, Padova, IT, 3 x1.5 hr sessions
- 50% by SKAO staff, aiming to start preparing the astronomy community for the operational phase of the SKA
- ~50% contributed talks (abstract deadline closed: ~30 received for 6-10 slots!)
  - SKA science and data challenges
  - Analysis and results from SKA precursors and pathfinder instruments
  - SKA forecasts and science case optimization
  - Data analysis pipeline development
- Programme to be finalised by SOC
Observatory News

• SKAO Council is meeting this week in China
  • Main agenda items: SRC Governance; Construction Funding

• SKA Annual Programme Review (March 25-28)
  • 2nd annual review @ SKAO HQ by external expert panel
    • Overall performance (costs, schedule, risks, compliance, delivery)
    • Project Management processes/controls (cost estimations, tracking)
    • Contracting and Procurement

• Satellite Constellation Impact item added to UN agenda
  • “Dark and Quiet Skies, astronomy and large constellations: addressing emerging issues and challenges” added to Scientific and Technical Subcommittee of the UN Committee on the Peaceful Uses of Outer Space (UN COPUOS) for next 5 years
  • IAU Centre for Protection of Dark and Quiet Skies (CPS) LINK
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, job openings, ...)

- Encourage your SWG members to [sign up](#)
Outreach & Engagement

- **SKA Speaker Series**
  - series of interesting talks, accessible to all within the broader SKA community, covering a wide range of topics, from astronomy to physics, engineering, big data and computing, EDI, and more.
  - Encourage your SWG members to sign up to give a talk (and consider giving a talk yourself).
  - Talks recorded – all available for reviewing via the [Speaker Series](#) page (2020+)

Most recent talk – thanks Cherry
SKA positions

- SKAO positions (HQ Manchester UK, Australia-Low, South Africa-Mid) [LINK]
- SARAO employee SKA positions (Cape Town, Canarvon) [LINK]
- CSIRO employee SKA positions (Perth, Geraldton) [LINK]
AOB

- SWG News?

Reminder:

- SWG Chairs meetings 3\textsuperscript{rd} Tuesday each month
- Alternating between 09.00 UT (March, May, ...) and 15.00 UT (Feb, Apr, ...)

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