

# SKA SWG Update

SWG Chairs Meeting – March 2024

Tyler Bourke  
SKA Project Scientist  
SKAO Senior Scientist



SKAO

# 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-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**



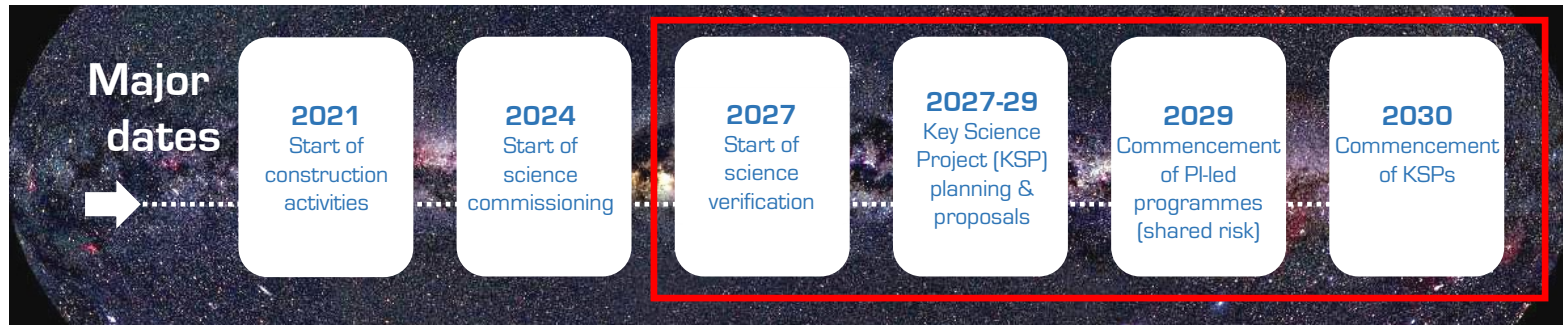
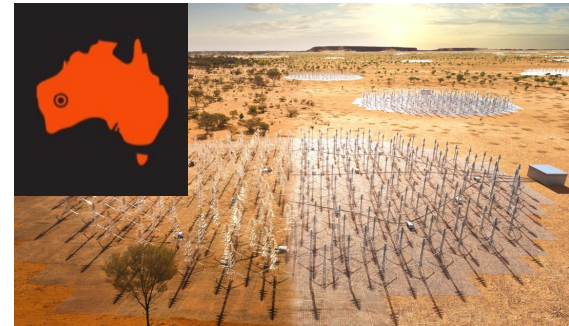
## SKA-Low

131,072 log-periodic antennas  
(512 stations each with 256 dipoles)

50 – 350 MHz

74 km baselines (9.5" @ 110 MHz)

Murchison, **Western Australia**




# 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

  
KSPs  
Calls for proposals  
Observing cycles

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
<b>Science Verification begins</b>		<b>2027+</b>	<b>2027+</b>
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
<b>Early Operations begin (shared risk)</b>		<b>2029+</b>	<b>2029+</b>
AA4 (Design Baseline)	197 dishes 512 stations	TBD	TBD

AA = Array Assembly

Updated December 2023



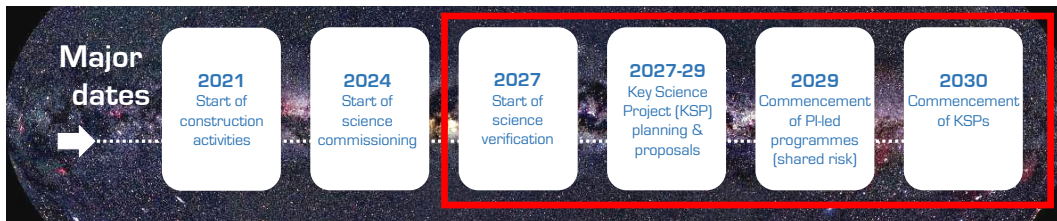
# The Road to Science

Update in progress



## 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



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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,

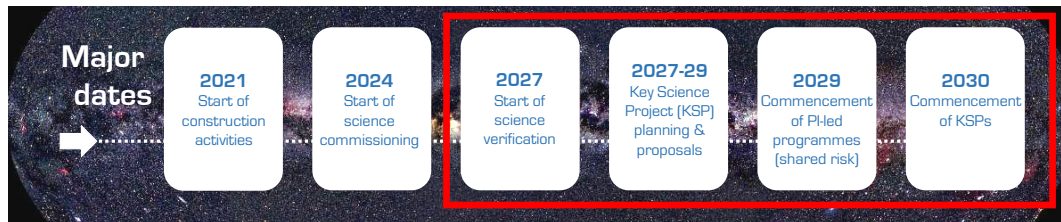
Regional Centres → “SKA Data & Archives”

New: Science meetings

To come: “Observing with the SKA”, “Simulations”

SKA Tools (incl. sensitivity calculators):

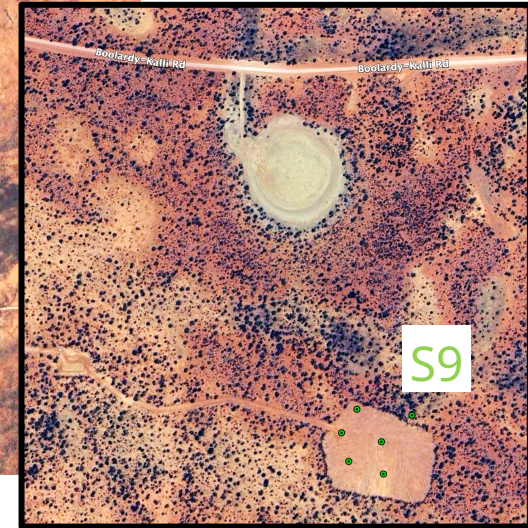
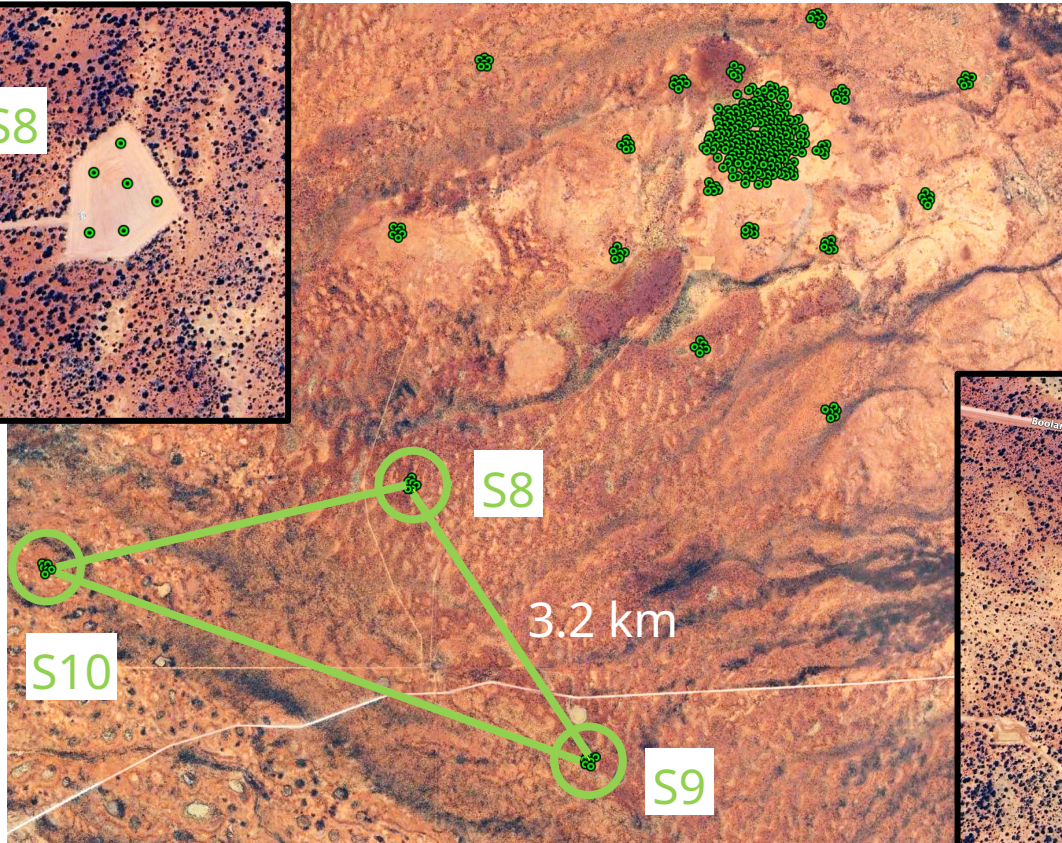
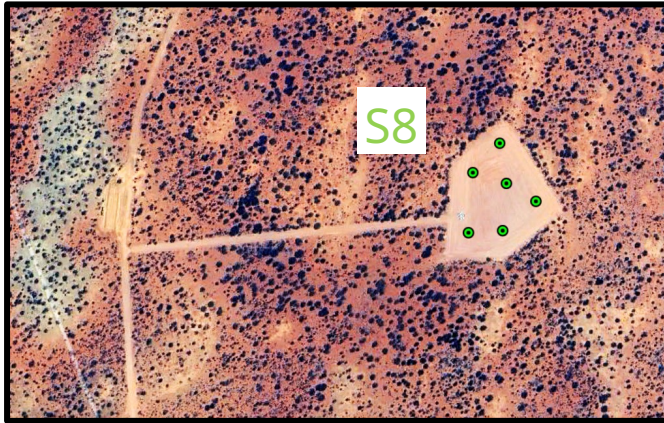
<https://www.skao.int/en/science-users/ska-tools>



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# Construction Update – AA 0.5

SKA-Low  
AA 0.5



4 Stations  
2 x S8  
1 x S9, S10





1<sup>st</sup> Low antenna deployed (S8) – 7 March 2024





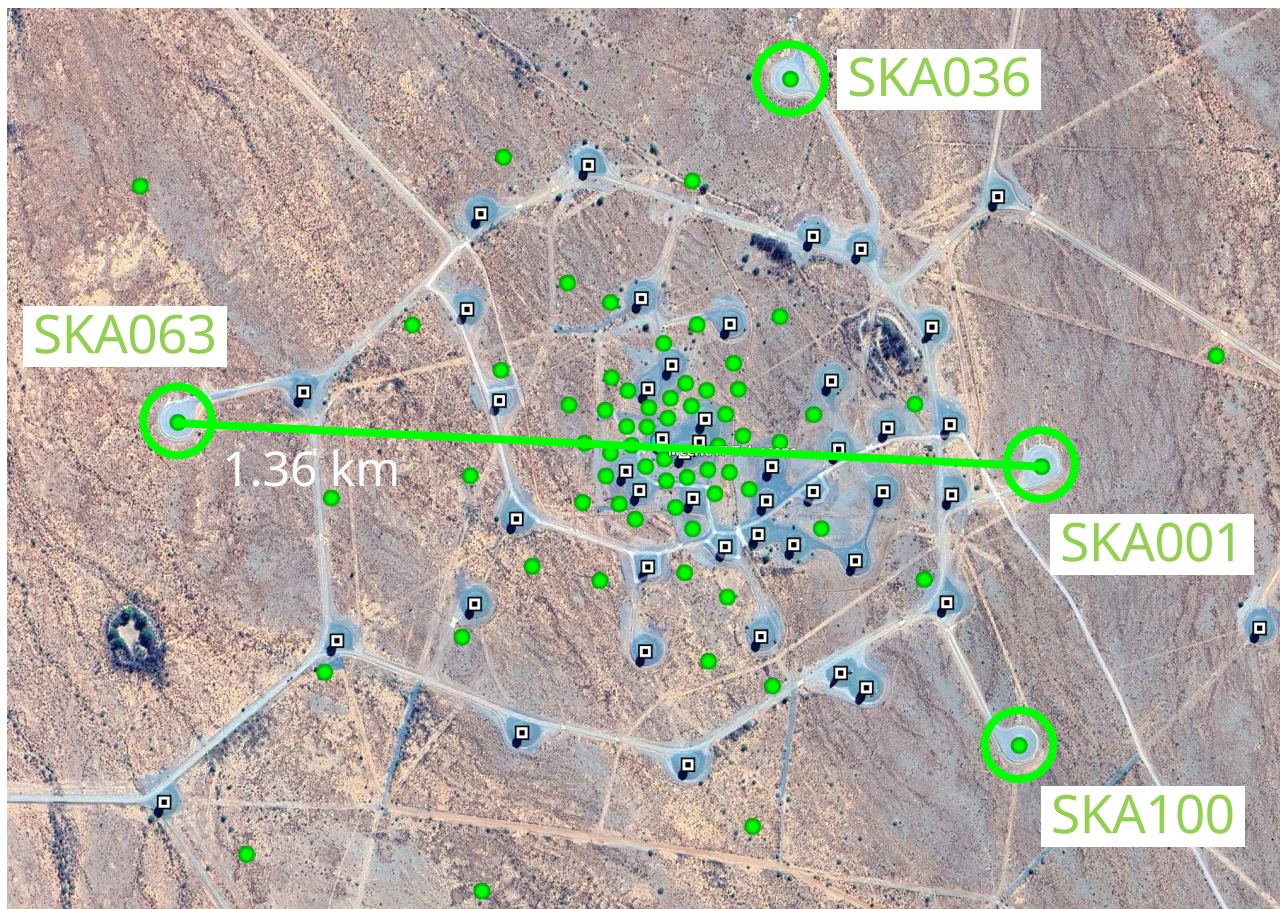


# Construction Update – AA 0.5

## SKA-Mid

▣ MeerKAT

● SKA dish locations



# Construction Update – AA 0.5

## SKA-Mid SKA063

1<sup>st</sup> pedestal lift  
(SKA063)  
7 March 2024

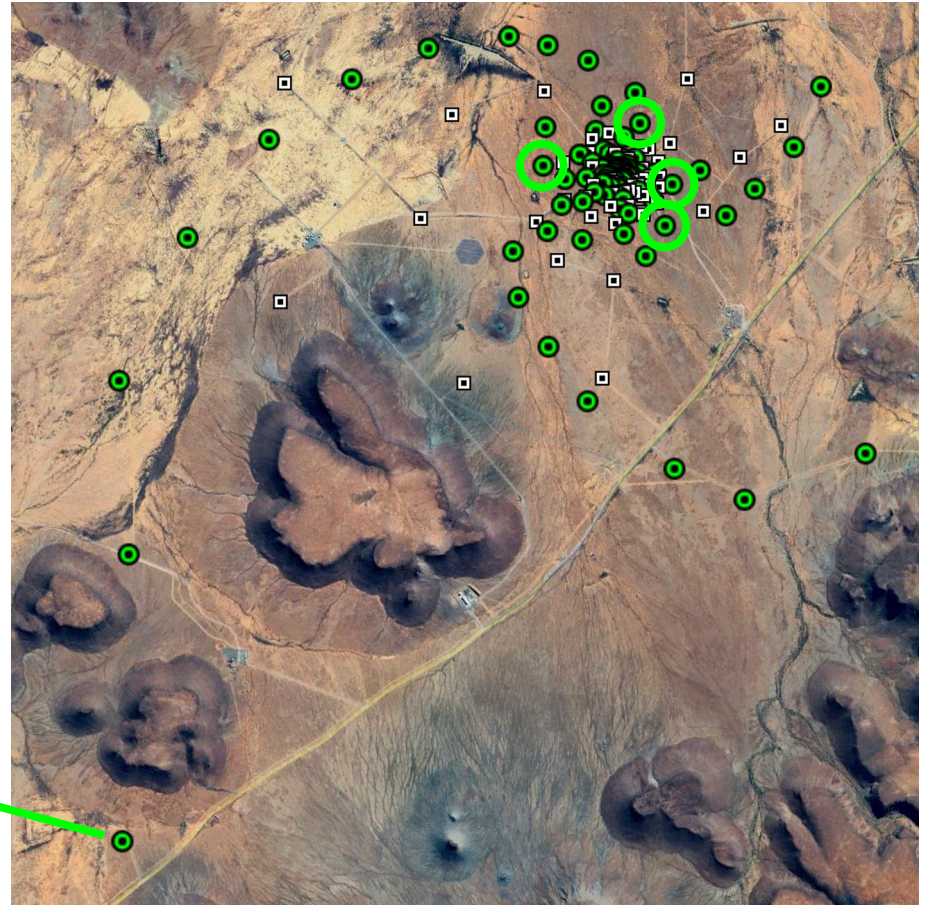


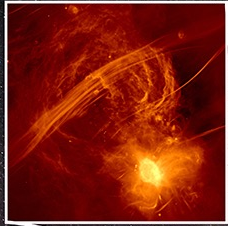
# Construction Update – MeerKAT+

MeerKAT+, adding 14-16 SKA dishes to MeerKAT on longer baselines  
Paid for by MPG, SARAO and INAF



# Construction Update – MeerKAT+





- 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



science & innovation

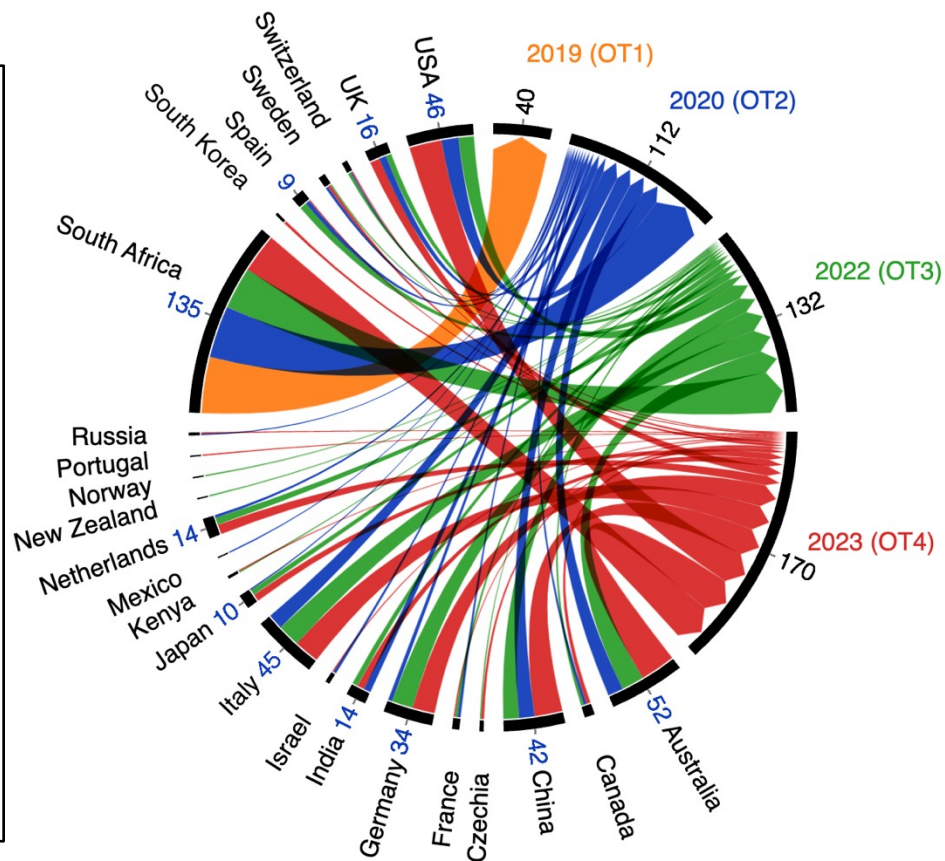
Department  
of Science and Innovation  
REPUBLIC OF SOUTH AFRICA



# MeerKAT @ 5

# MeerKAT Science After 5 Years

- **1<sup>st</sup> 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

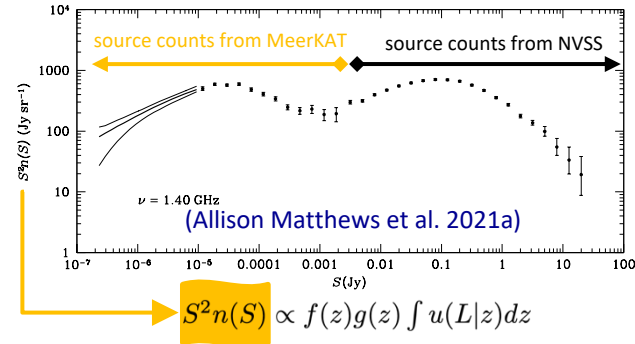
Top continuum science goal of SKA-MID: measure the Star Formation History of the Universe (SFHU) (Prandoni & Seymour 2014)



Image specs:  $\theta = 7.6''$ ,  $\sigma = 0.55 \mu\text{Jy}/\text{beam}$ ,  $\nu = 1.28 \text{ GHz}$ ,  $\Theta = 1.1 \text{ deg}^2$  (Mauch et al. 2020)

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

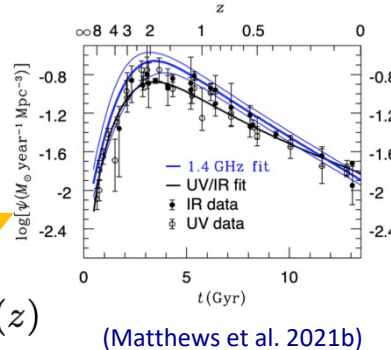
Source counts were measured down to  $0.25 \mu\text{Jy}$  with the MeerKAT DEEP2 commissioning image (using confusion statistics for  $S < 10 \mu\text{Jy}$ )



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

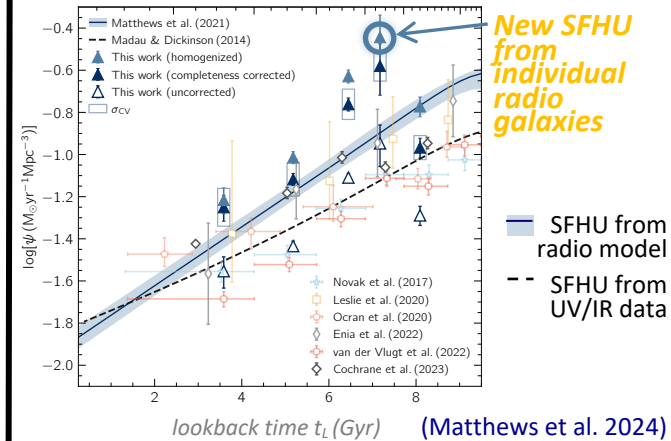
function  $u(L|z)$ .  $f(z)$  and  $g(z)$  constrain the SFHU for a global population.

$$\psi(z) \propto f(z)g(z)$$



Multiwavelength analysis of an ensemble of individual galaxies:

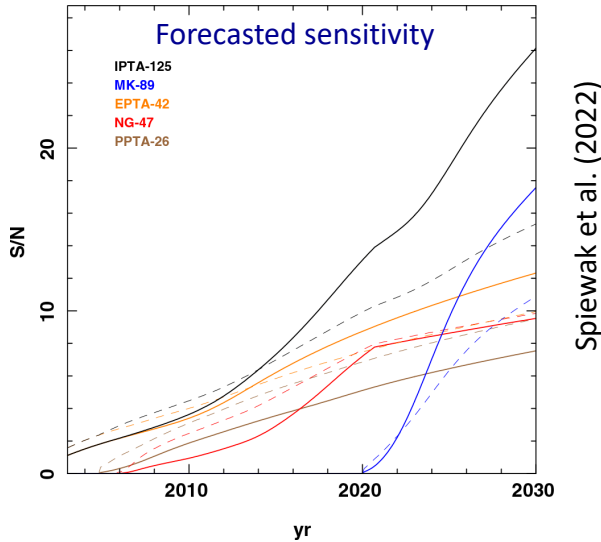
3839 galaxies with low-resolution spectra + photometry for accurate SED fitting.



Radio-based SFRD evolution confirmed, and its discrepancy with UV/IR data strengthened. Next step: But why?



# The MeerKAT Pulsar Timing Array



- 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- $\mu$ s timing residuals in any 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**

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

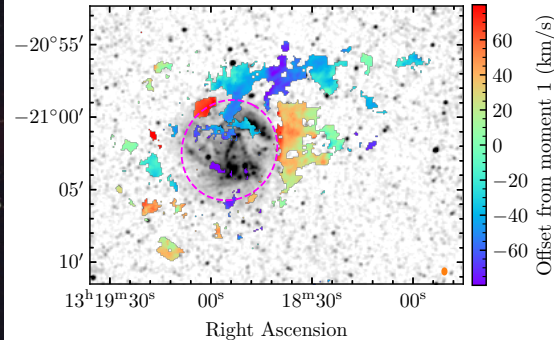


# MHONGOOSE: NGC 5068

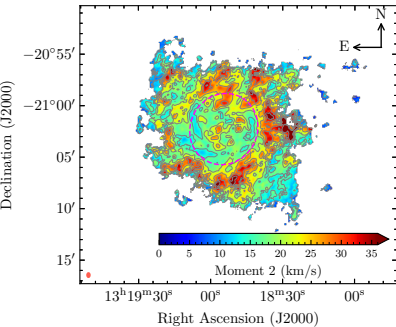


Julia Healy et al. 2024

Accreting gas and its velocity



Accreting gas increasing the velocity dispersion



- 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  $N_{\text{HI}} = 1 \times 10^{18} \text{ cm}^{-2}$  ( $3\sigma / 16 \text{ km s}^{-1}$ ) with 60'' resolution
- NGC 5068 shows strong evidence for gas accretion
- Would be first time “cold accretion” is directly detected



# SWG Chair rotation

SWG	First	Last	Country	Rotation Status
Cosmology	Stefano	Camera	Italy	under discussion
EoR	Abhirup	Datta	India	candidate identified
EoR	Andrei	Mesinger	Italy	candidate identified
Exgal Cont	Fatemeh	Tabatabaei	Iran	replaced Natasha
Exgal Cont	Mark	Sargent	Switzerland	Catherine Hale (UK) 2024/05
Exgal Line	Viviana	Casasola	Italy	replaced Francoise
Exgal Line	Jacco	van Loon	UK	replaced Sebatien
GW	Samaya	Nissanke	Netherlands	to be replaced by Nicola Bellomo
GW	Alvise	Raccanelli	Italy	candidate asked
HI Galaxy	Neeraj	Gupta	India	replaced Barbara
High Energy	Katie	Mulrey	Germany	replaced Anna
Magnetism	Jennifer	West	Canada	replaced Valentina
Our Galaxy	Ke	Wang	China	replaced Jan
Our Galaxy	Adriano	Ingallinera	Italy	Marc Audard (Switzerland) 2024/05
Pulsars	Bhal Chandra	Joshi	India	replaced Natasha
SHI	Rohit	Sharma	India	replaced Eduard
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

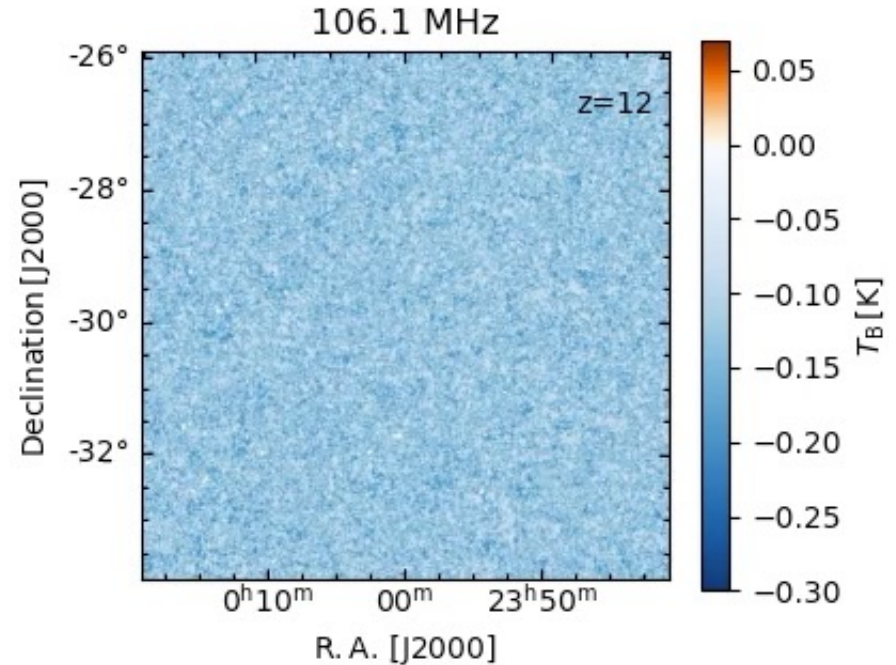
- Prepare Science Community
  - Science extraction from SKA Observatory Data Products (ODPs)
  - Stimulate advance of state-of-the-art in source finding, source characterisation and reliable inference of astrophysical parameters
  - Promote reproducibility and analysis pipeline sharing
- Develop proto-SRC 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 NOW – deadline early 2025**



[sdc3.skao.int](http://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 10<sup>th</sup> April**

[SDC3 Inference webpage](#)

- 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.



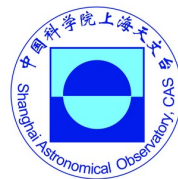
ASTRON



CSIC

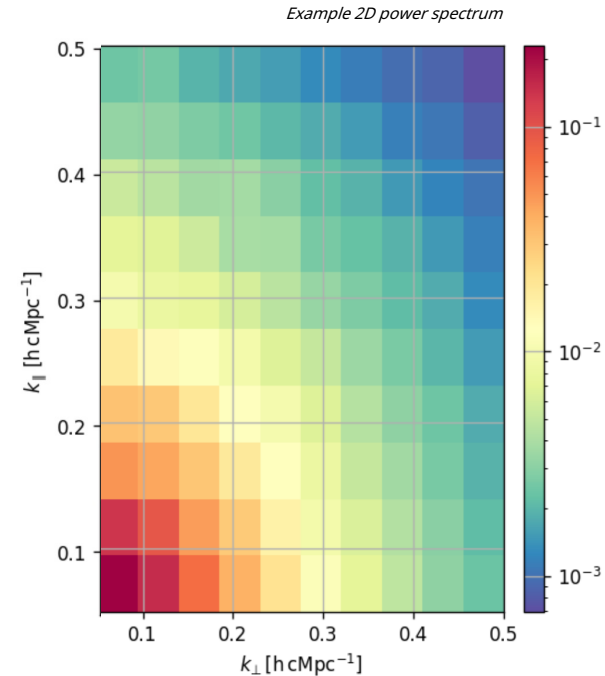


The University of Manchester



# 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



## How to make your script ready for publication

Put your code under version control

01



02

Make sure that your code is in a sharable state

Add essential documentation

03



04

Add a license

Mark the stable version of your code

05



06

Make your code citable

[www.software.ac.uk/research-software-camps](http://www.software.ac.uk/research-software-camps)



# 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)
  - 2<sup>nd</sup> 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+)



**SKAO** *SKAO Speaker Series*

My personal journey as a female astronomer of colour



**Cherry Ng**  
*Permanent Astronomer  
Centre National de la Recherche Scientifique (CNRS)  
Laboratoire de Physique et Chimie de l'Environnement et de l'Espace (LPC2E)  
Orléans, France*

This talk is a collection of reflections on my career: from X-ray binaries to exoplanets, from pulsars to Fast Radio Bursts and SETI; on the challenges of motherhood and how it shapes my personality, and on the search for my cultural identity moving through six countries.

Wednesday 13 March 2024 | 10.00am UTC | [Click to access the Speaker Series talk here](#)

Most recent talk – thanks Cherry



# SKA positions

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





# AOB

- SWG News?

## Reminder:

- SWG Chairs meetings 3<sup>rd</sup> Tuesday each month
- Alternating between 09.00 UT (March, May, ...) and 15.00 UT (Feb, Apr, ...)

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



*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](http://www.skao.int)