

How ATCA+BIGCAT can enhance SKA's science impact ATCA Science Day

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Overview

- SKA overview
- Recap of SKA science drivers
- ATCA in the 2015 and 2025 science cases
- Notes on specific science topics
- What's next

The SKA telescopes

SKA-Low

131,072 low-freq antennas (512 stations each with 256 dipoles) 50-350 MHz 74 km baselines (9.5" @ 110 MHz) Murchison, **Western Australia**

SKA-Mid

197 dishes (133x 15m SKA + 64x 13.5m MeerKAT) 0.35-15 GHz 150 km baselines (0.22" @1.7 GHz, 34 mas @15 GHz) Karoo, **South Africa**



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

We recognise and acknowledge the Traditional Owners of the lands on which our facilities are located, and pay our respects to their Elders past and present.

Australia's Indigenous people are the first scientists and have long standing knowledge of the Universe that we continue to build on today.

We acknowledge the Wajarri Yamaji as the Traditional Owners and native title holders of Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory, where we are building the SKA-Low telescope in Australia.

We acknowledge the Whadjuk Noongar as the traditional owners of the land where our Science Operations Centre is situated in Perth, and the Southern Yamatji as the traditional owners of the land where our Engineering Operations Centre is situated in Geraldton.

I also pay my respects to all First Nations people in attendance.



A collaborative painting from Aboriginal Yamaji artists from WA for the SKAO *Shared Sky* exhibition. Credit: Yamaji Arts Centre.



SKA frequency coverage (AA*) + ATCA + ALMA



Frequency (NOT TO SCALE)

	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?	
Su	Our Galaxy, The Milky Way	Augo
.0	How does matter cycle between stars and the Interstellar Medium?	and the second of the second o
st	The Origin and Evolution of Cosmic Magnetism	
h	What is the role of magnetism in galaxy evolution and the structure of the cosmic web?	
Ō,	Galaxy Evolution probed by Neutral Hydrogen and Radio Continuum	
D	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?	
X	Cosmology & Dark Energy	A State State
	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?	
	Multi-fac	ility, multi-frequency is key

ATCA context for enhancing SKAO science impact

- Emphasis on dimensions not related to uv coverage and raw sensitivity
- Supplementing incomplete frequency coverage
 1.76-4.6 GHz, 15.4-35 GHz
- Simultaneous broadband observations (*mitigate* variability)
- Flexibility and agility
- Followup capability
- Polarimetry (widefield and broadband)

ATCA <u>highlights</u> from 2015 science book

- Book contains 136 chapters covering a very broad range of the science case (as it was at the time...)
- ATCA is mentioned in ~10% (12) of these:
 - Stacking / sub-noise image analysis
 - Nearby galaxies
 - UHECRs, neutrinos
 - VLBI
 - OH masers
 - Magnetic fields
 - Molecular clouds
 - Dark matter
 - Transients, GRBs



Opportunities from 2015 SKA science use cases

- Deep broadband polarimetry / magnetism (Mid Band 3)
- Transient searches (broadband)
- Monitoring (broadband)
- Technosignatures (broadband)
- CH lines (3.3 GHz) for cold gas in debris disks
- Hydrogen recombination lines in high-z QSOs (Mid Band 4)
- Pulsar search in highly scattered regions (expected to be rare; includes young SNRs, GCs near bulge, v. low Gal lat, GalCent)
- Pulsar timing
- Single-pulse analysis: pulsar magnetospheres

Insights from ngVLA science case

- Intermediate/high redshift low-order CO lines (1-0, 2-1)
- Key science cases:
 - KSG1 "Young Planetary Systems" Focuses on 30-116 GHz (dust emission)
 - KSG2 "Cosmic Origins of Life" Focuses on 20-50 GHz (molecules)
 - KSG3 "Galactic Evolution"
 Focuses on ~few-116 GHz
 - KSG4 "Understanding Gravity" Focuses on 1-20 GHz
 - KSG5 "Black Holes & Neutron Stars" Focuses on >30 GHz, astrometry





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ATCA highlights from 2025 science case

- (Magnetic hot) stars and star/planet interactions ECME:
 <400 MHz to ~5 GHz
- High-z radio galaxies broad frequency coverage, detailed followup
- Decoupling SF/AGN across cosmic time with SED analysis
- Rapid response followups (e.g. GRBs)
- Small-scale magnetic fields and turbulence via broadband polarimetry / Faraday complexity: λ^2 coverage
- Magnetic reconnection in galaxy clusters: SEDs and polarimetry
- Broadband monitoring of unusual transients/variables

Specific science topics



Accretion bursts in massive protostars



Courtesy Olga Bayandina

Murphy (2022)



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SKA Project phases through construction



Commissioning

All activities necessary to arrive at a working end-to-end system that can be used to perform system verification. Preceded by Assembly, Integration and Verification ('AIV')



Science Commissioning

Subset of commissioning which requires specification, execution and analysis of astronomical observations.

~2025-2028



Science Verification

All activities needed to ensure the Telescope system meets the needs of the science & operational users (from proposal submission to data delivery)

Call(s) for projects from astronomical community will be made

Data will be made available to the community (via SRCs)

~2026-2028



Cycle 0 Shared Risk

>2029

~2025-2028

SKA Science Meeting 2025

https://www.skao.int/en/science-users/skao-science-meeting-2025

- EoI form available for in-person attendance
- Early-bird virtual registration closes May 31
- In addition to Science Programme:
 - Meeting will have a dedicated plenary session from Science Operations outlining the process of Science Verification, capabilities of array assemblies, tools, etc
 - Meeting will also feature dedicated representation in parallel sessions (questionnaire for which was sent to SWG chairs) for more tailored Q/A
- Also: Join SKAO Science Working Groups! https://www.skao.int/en/science-users/science-working-groups



Questions?

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• • <u>www.skao.int</u>

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