



The Square Kilometre Array

Lister Staveley-Smith^{1,2} (with thanks to Minh Huynh and Joe Lazio)



1. International Centre for Radio Astronomy Research (ICRAR), University of Western Australia
2. ARC Centre for All-sky Astrophysics (CAASTRO)

SKA

Kloster Seeon 2011 June 14

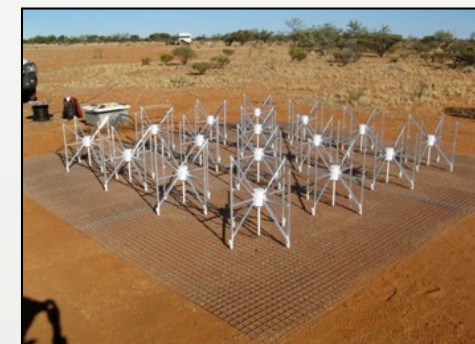
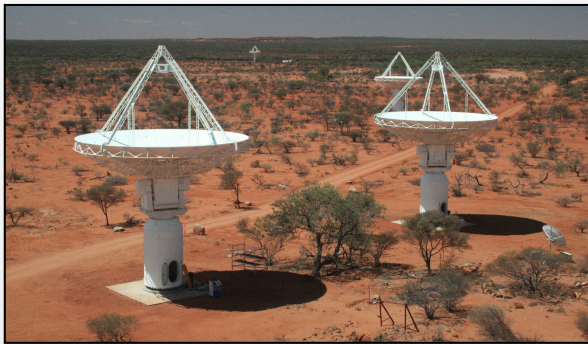


The Centre for All-sky Astrophysics



Australian Government
Australian Research Council

The CAASTRO Vision: To be the international leader in wide-field astronomy, positioning Australia to address fundamental unsolved questions about the Universe with the dramatic capabilities of next-generation telescopes and advanced instrumentation.



Six Australian Universities, two national facilities and international partners

- DISCOVER: Ground-breaking advances in understanding the Universe
- INNOVATE: New ways of processing & visualising complex data sets
- PERFORM: High-impact discoveries using SKA pathfinders
- UNITE: A new network of talented researchers
- EDUCATE: Exciting opportunities for students and young scientists

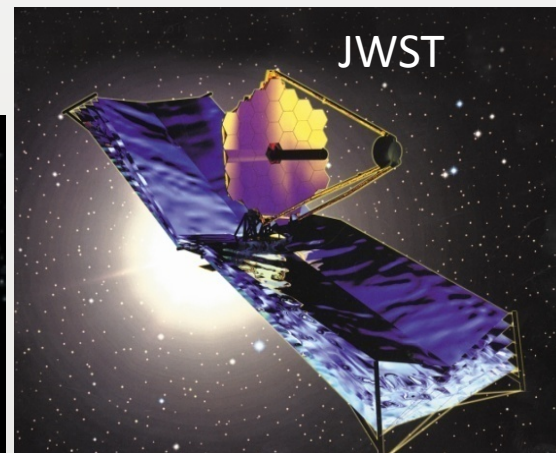
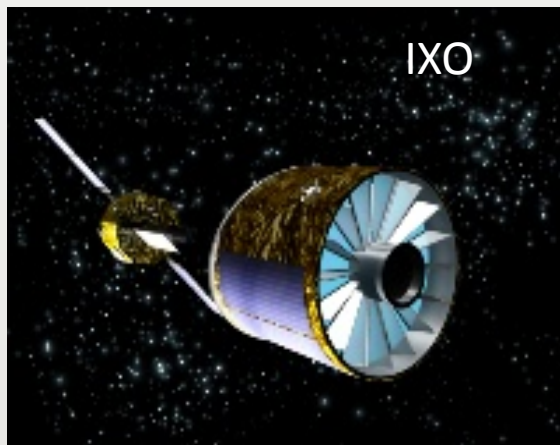
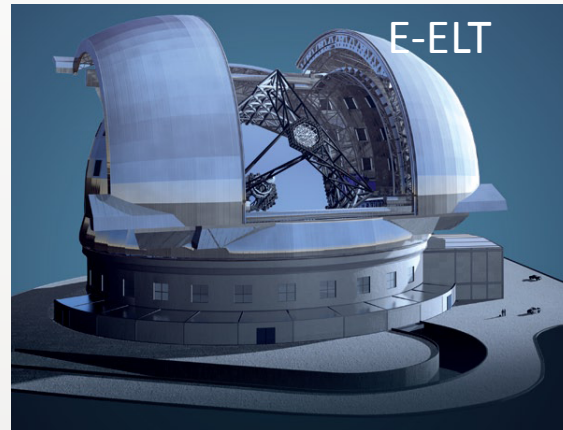
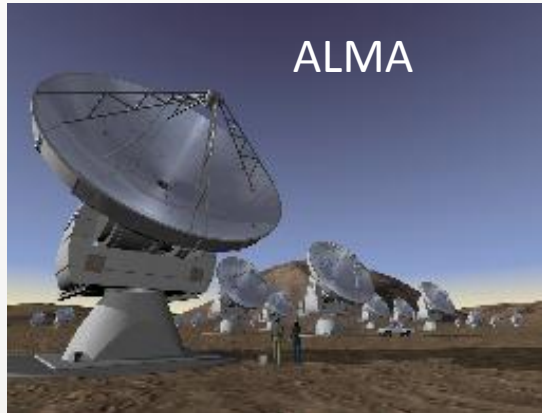


Outline

- SKA Overview
- Science drivers
- Baseline design
 - phase 1 and 2
- Status
 - schedule



Great Observatories for the coming decade



SKA Key Science Drivers

ORIGINS

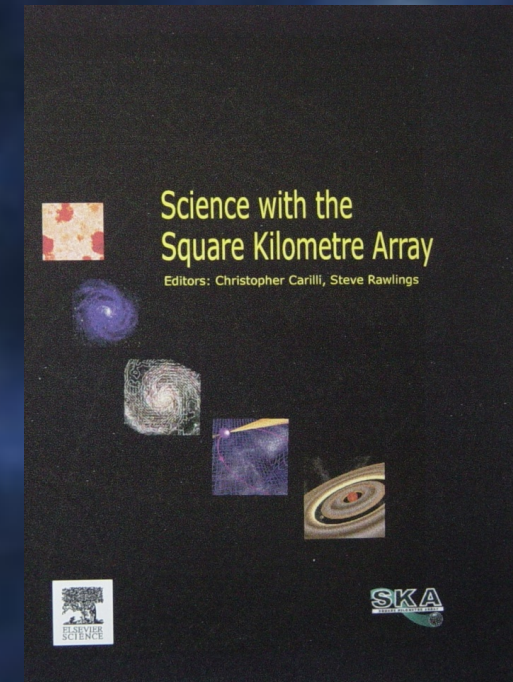
- Probing the Dark Ages and the Epoch of Reionization
 - EoR, first galaxies and active galactic nuclei
- Galaxy Evolution, Cosmology, and Dark Energy
 - When did the first stars and galaxies form?
 - How did galaxies evolve?
 - Dark Energy, Dark Matter
- Cradle of Life
 - Organic molecules in interstellar space and proto-planetary disks
 - SETI

FUNDAMENTAL FORCES

- Pulsars, General Relativity & Gravitational Waves
- Origin & evolution of cosmic magnetism

EXPLORATION OF THE UNKNOWN

- Transients and new phenomena



Science with the Square Kilometre Array
(2004, eds. C. Carilli & S. Rawlings, *New Astron. Rev.*, 48)

Galaxy Evolution, Cosmology and Dark Energy

- What is the equation of state of dark energy?
- What is the efficiency of gas accretion onto galaxies at different epochs?
- How do baryons affect the distribution of dark matter?
- How does AGN feedback affect the growth of galaxies?
- What is the relative role of thermal, magnetic and CR pressure?
- How does gas content vary with redshift and environment?

Probing the Dark Ages and the Epoch of Reionization

Imaging the transition from a neutral to an ionised IGM

- What reionizes the Universe at the end of the dark ages?
- When does reionization end and how quickly did it proceed?
- How quickly did supermassive black holes form?
- What is the topology of the ionised IGM; how sharp are the edges around QSO HII regions?
- When did the first radio sources form?

Astrobiology at Long Wavelengths

- Imaging of thermal dust emission from proto-planetary nebulae
- Astrochemistry of complex molecules
- Prebiotic molecules
- Proto-planetary chemistry

Did Einstein Have the Last Word on Gravity?

Relativistic binaries:

- Equivalence principle
- Strong-field tests of gravity
- Black hole-neutron star binaries?

Direct detection of Gravity Waves:

- Pulsar timing array
- LIGO: suspended masses
- LISA: freely falling mirrors

Cosmic Magnetism



- How are magnetic fields generated and maintained?
- How do magnetic fields evolve as galaxies evolve?
- What is the strength and structure of the magnetic field of the intergalactic medium (IGM)
- Are magnetic fields in galaxies and clusters primordial or generated at later epochs?
- What is the efficiency of cosmic ray acceleration in the warm-hot intergalactic medium?

Exploration of the Unknown

- Are there new physical phenomena?
- Gamma Ray Bursts/Hypernovae/Supernovae/Neutron stars
- What is the frequency of strong radio emission from sub-stellar objects?
- Are there other detectable civilisations?

The SKA concept

a large radio telescope for transformational science

- up to 1 million m² collecting area distributed over a distance of 3000+ km (<0.1 arcsec resolution)
- an interferometer at frequencies from 70 MHz to 10 GHz with two or more detector technologies
- wide field of view , approx:
 - 100 sq. deg (70 to 400 MHz),
 - 30 sq. deg (0.4 to 2 GHz)
 - 1 sq. deg. (2 to 10 GHz)
- connected to fast signal transport network and high performance computing system

providing

- 40x sensitivity of EVLA
- up to 10,000x survey speed of today's facilities

SKA Phase 1

- 10% of full SKA
- sparse aperture arrays operating at 70 to 450 MHz
- 250×15m dishes operating between 0.45 and 3 GHz
- Advanced instrumentation program
 - Phased Array Feeds (ASKAP/APERTIF)
 - Dense Aperture Arrays

SKA Key Science Drivers

ORIGINS

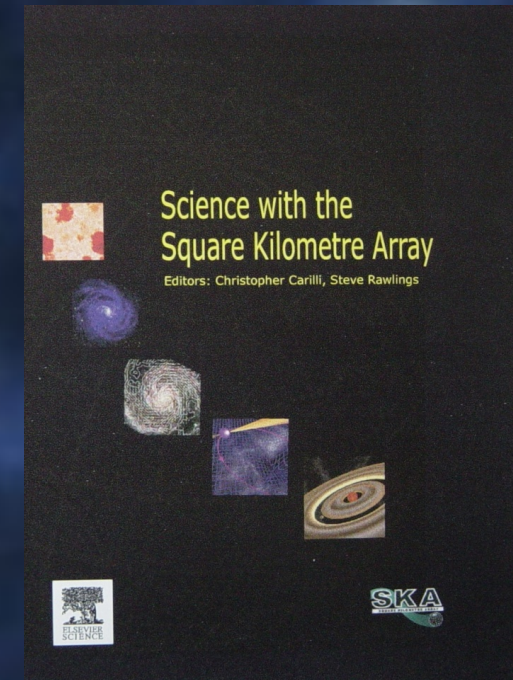
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Science with the Square Kilometre Array
(2004, eds. C. Carilli & S. Rawlings, *New Astron. Rev.*, 48)

SKA Phase 1 Key Science Drivers

ORIGINS

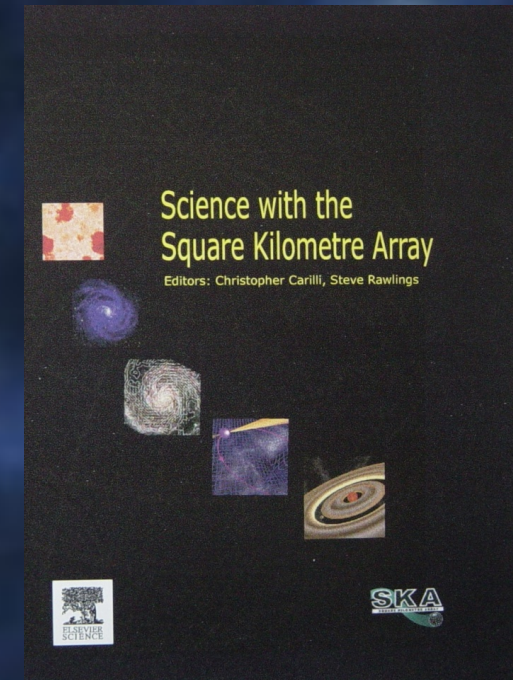
- Neutral hydrogen in the universe from the Epoch of Reionization to now
 - EoR
 - first galaxies and active galactic nuclei
 - Galaxy Evolution
 - Dark energy, Dark Matter
- Cradle of Life
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EXPLORATION OF THE UNKNOWN

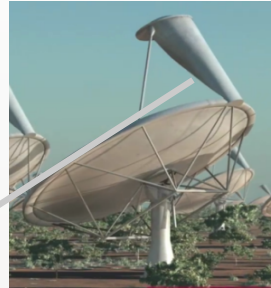
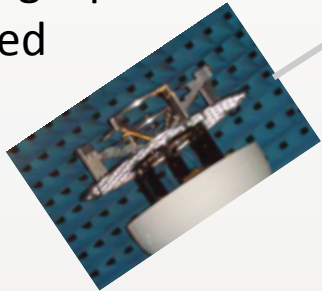
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Science with the Square Kilometre Array
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Phase 1 (SKA₁) baseline design

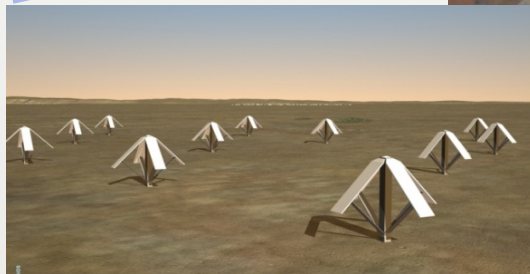
Single pixel feed



250 Dishes



Central Region



50 Sparse Aperture Array Stations

Sparse Aperture Arrays

Omnidirectional dipoles
No moving parts.
Cheap!



LOFAR

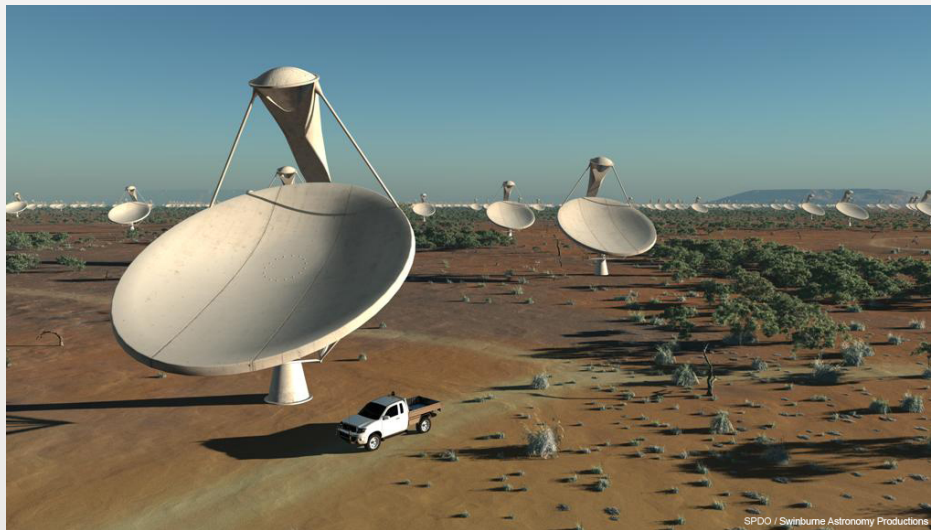
SKA

Dishes

15m offset Gregorians



Allen Telescope Array



SKA

Advanced Instrumentation Program (AIP)

Phased Array Feeds

- analogous to CCDs in optical
- e.g. ASKAP, APERTIF, Arecibo AO40 PAF



Dense Aperture Arrays

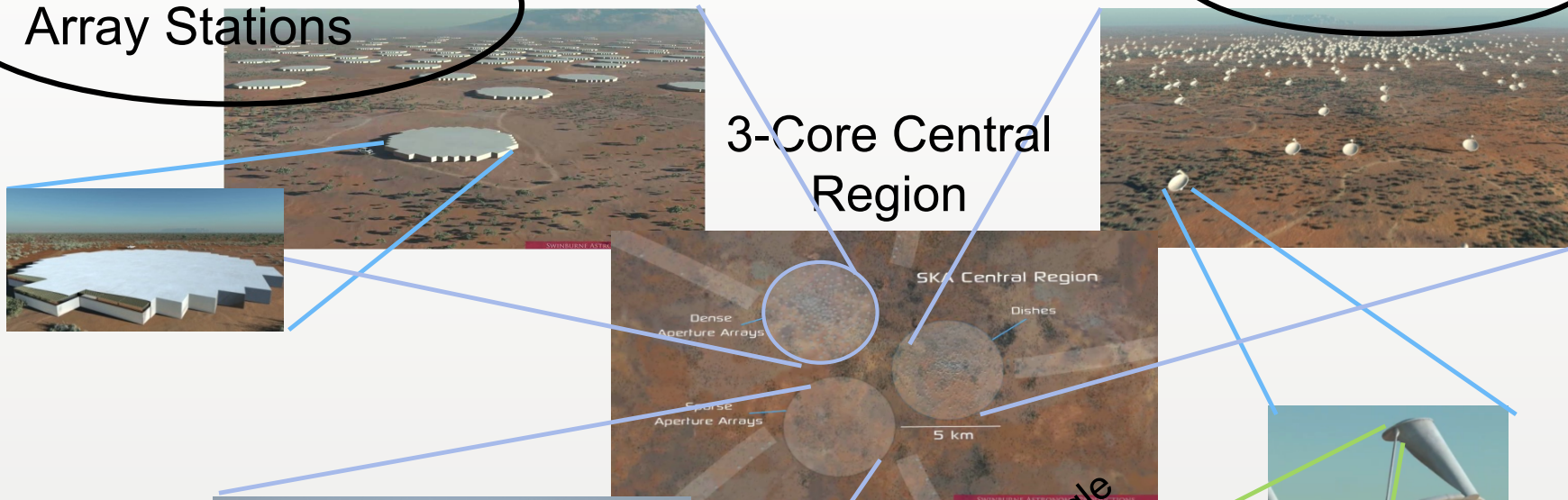
- To operate ~ 0.5 to 1.5 GHz
- e.g. EMBRACE

SKA Phase 2 including AIP technologies

250 Dense Aperture Array Stations

3000 Dishes

3-Core Central Region



250 Sparse Aperture Array Stations

Wide Band Single Pixel Feeds

Phased Array Feeds

Artist renditions from Swinburne Astronomy Productions

Australia and New Zealand



South Africa + 8 countries



0 1000 2000 3000 km



ARC
ARC CENTRE OF EXCELLENCE
ALL-SKY ASTROPHYSICS

The Path to the SKA

EVLA



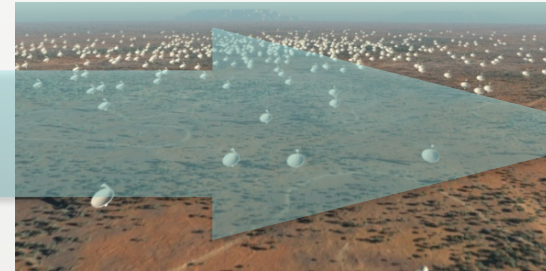
MeerKAT



FAST

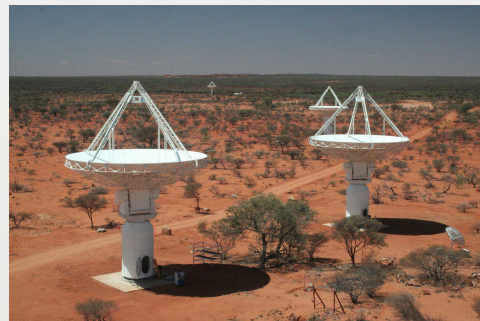


SKA phase 2



NOW

APERTIF



ASKAP



SKA phase 1

2024

Top-level schedule for the SKA

Technical

2008-12	Preparatory Phase (system design and cost)	✓
2013-15	Project Execution Phase (€90M pre-construction)	
2016-19	Phase 1 construction	
2016	Advanced Instrumentation Program (AIP) decisions	
2018-23	Phase 2 construction	
2020+	Science operations with Phase 1	
2024+	Science operations with Phase 2	

Programmatic

2011	Founding Board and SPO location announced	✓
2011	SPO director selected (Schilizzi retires)	
2012	SKA site selection	
2014	Phase 1 construction approval (350 M€, 2007)	
2017	Phase 2 construction approval (1.2 B€, 2007)	

Current Project Status

SKA Founding Board formed:

- Nine countries: Australia, China, France, Germany, Italy, Netherlands, New Zealand, South Africa, UK
- Other countries likely to join in SKA2011 (Banff)
- €90M committed to pre-construction funding

SKA Project Office location selected:

- Jodrell Bank Observatory

Siting roadmap drafted by SKA siting group:

- Siting decision in Feb 2012

Project Execution Plan developed

- Work to be done and resources needed for next phase 2012 to 2015

RFI measurements taken at both candidate sites



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Published: 04 Apr 2011

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BRITAIN is set to lead the search for alien life after being chosen as the base for the world's biggest collection of radio telescopes.

Jodrell Bank Observatory has been placed at the heart of a new £1.3billion project to investigate the mysteries of



Long wave ... Jodrell Bank
Anthony Holloway

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Some Engineering Challenges remain...

- Low cost, high performance dishes, receivers and digital
- Phased array feed technology for large field of view
- Wideband optical-fibre signal transport systems (~20 Tbps, raw data to correlator in Phase 1)
- High performance computing (exaflop imaging machines needed)
- Data storage and retrieval (1 to 10 PB/day of image data)
- Remote/renewable power generation (~100 MW needed to run full SKA)

Summary

- SKA Project Office begins operation 1 Jan 2012
- €90M committed to pre-construction
- Site decision early-2012
- Phase 1 construction 2016-19
- SKA will improve our understanding of the formation and evolution of the gaseous Universe from the EOR to the present day.



Thank you

