RADIO ASTRONOMY ON THE LAND AND IN THE COMMUNITY

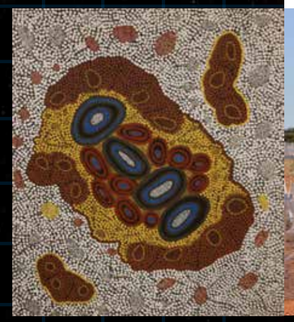
The development of radio astronomy facilities at the MRO is based upon collaboration and agreement between researchers and Aboriginal communities. The MWA is on Wajarri Yamatji land, and the traditional owners are pleased that these new-generation radio telescopes are such low-impact installations. The MWA sits lightly upon the Earth.

Collaborations between MWA researchers and the Aboriginal community have given rise to a cross-cultural sharing of knowledge about scientific views of the Universe and Aboriginal perspectives of the night sky. One outcome was the highly successful exhibition *Ilgarijiri – things belonging to the sky,* launched in June 2009, which explored different perspectives of the night sky and celebrated the connection between astronomy and Indigenous culture through the creation of original artworks.

Public outreach is difficult when the hub of activity is 300 km away from the closest regional centre (Geraldton), or buried in the basement of a computer facility in Perth. However, with Geraldton the closest gateway to the MRO, an MWA tile has been donated to the Western Australian Museum in Geraldton, and will become the heart of an exhibition about the MWA.

Information on the MWA is also available through the official website: **mwatelescope.org**, with regular progress updates and photos on Facebook: **facebook.com/Murchison.Widefield.Array**.

Outreach and education activities for teachers, high school students and the general public are ongoing through the Curtin Institute of Radio Astronomy (CIRA), ICRAR and the Australian Research Council Centre of Excellence for All-sky Astrophysics (CAASTRO).



Artist: Charmaine Green
Photo: Yamaji Art/Allison Yearwood

Photo: Dr Megan Argo, CIRA

PARTNER INSTITUTIONS

International Centre for Radio Astronomy Research

Curtin University

The University of Western Australia
Achieve International Excellence

Australian National University

CfA

CSIRO

MIT Haystack Observatory

MIT Kavli Institute

RRI

Swinburne University of Technology

The University of Melbourne

The University of Sydney

UTAS

Te Whare Wānanga o te Ūpoko o te Ika a Māui Victoria University of Wellington

CONTACT

Professor Steven Tingay
Director, MWA
Building 610, Brodie Hall
1 Turner Avenue, Technology Park
Bentley WA 6102

Curtin University
Kent Street Bentley WA 6102
GPO Box U1987 Perth WA 6845

Tel: +61 8 9266 3516
Email: s.tingay@curtin.edu.au

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mwatelescope.org

MWA
MURCHISON WIDEFIELD ARRAY

Low-frequency precursor to the Square Kilometre Array

THE MURCHISON WIDEFIELD ARRAY

The Murchison Widefield Array (MWA) is an international project to create a groundbreaking low-frequency radio telescope.

Curtin University leads the MWA consortium, made up of 13 institutions across Australia, India, New Zealand and the United States:

- Australian National University
- Commonwealth Scientific Industrial Research Organisation (CSIRO)
- Curtin University
- Harvard-Smithsonian Center for Astrophysics
- Massachusetts Institute of Technology/Haystack Observatory
- Massachusetts Institute of Technology/ Kavli Institute for Astrophysics and Space Research
- Raman Research Institute, Bangalore
- Swinburne University of Technology
- The University of Melbourne
- The University of Sydney
- The University of Western Australia
- University of Tasmania
- Victoria University of Wellington.

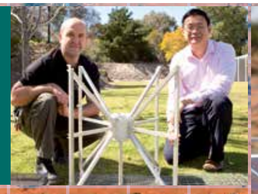
An interferometric telescope, the MWA consists of 128 aperture array 'tiles' made up of 2,048 fixed dual-polarisation dipole antennas. The majority of the tiles are placed in a core region 1.5 km across, with the remainder distributed more widely, yielding a maximum baseline of 3 km. The 128 tiles transmit signals to 16 receiver packages for initial processing in the field, and then to a high-performance computing cluster for correlation and real-time imaging and calibration. The resulting data and images are transmitted on a dedicated optical fibre data link to Perth, where they are stored at the Pawsey High-Performance Computing Centre for SKA Science. Data collected over five years of observations are expected to require 15 petabytes of storage and archive space.

The MWA has attributes including:

- a very wide field of view
- high angular resolution (several arcminutes)
- wide frequency range (80–300 MHz) with full and flexible tuning
- digital design, allowing for extreme frequency and pointing agility, wide fractional bandwidths and considerable signal processing capabilities.

The MWA is located at CSIRO's Murchison Radio-astronomy Observatory (MRO), 300 km from Geraldton.

Curtin acknowledges the financial support of the MWA project by the Australian Government through the Education Investment Fund as part of the Super Science Initiative, administered by Astronomy Australia Ltd.



Courtesy of ICRAR

EXTENDING SCIENTIFIC FRONTIERS

Research using the MWA will investigate the Universe in more detail than previously possible at low frequencies, and encompasses four broad areas of investigation:

- Early Universe cosmology – searching for and studying the Epoch of Reionisation, when the first stars, galaxies and quasars began forming, approximately 13 billion years ago.
- The dynamic Universe – high-sensitivity surveys of the dynamic radio sky, searching for short-timescale and highly variable phenomena.
- Galactic and extragalactic research – studies of phenomena in our galaxy and galaxies at great distances from us.
- Solar, heliospheric and ionospheric studies – investigating our Sun and its effect on near-Earth space weather, including applications such as improving early warnings of solar storms to protect infrastructure like satellites, power grids and communications networks.

ON THE PATH TO THE SKA

In May 2012 it was announced that Australia-New Zealand and South Africa would share hosting of the SKA project, a global megascience project to develop the world's largest and most sensitive radio telescope. The entire low-frequency SKA (SKA-low) will be built at the MRO, beginning in 2016.

The MWA is a technology and science precursor for the SKA. One of only three precursors developing the cutting-edge science and technology needed for the SKA at the two SKA sites, it is the only low-frequency precursor and is on the same site now approved for SKA-low. Through developing, constructing and operating the MWA at the MRO, the knowledge and expertise obtained will be directly applicable to the many science, engineering and computing challenges on the path to SKA-low.

The MWA has already explored engineering solutions for low-cost, high-performance antennas, and addressed some of the computing challenges produced by very high data rates and volumes, and large-scale archives. Our understanding of interferometric calibration and imaging is being pushed in highly innovative directions. Ongoing algorithm development and refinement from interpreting MWA data will also be directly relevant to the eventual processing of data from SKA-low. Finally, the science programs planned for the MWA will inform the design of science experiments for SKA-low.

The Curtin University node of the International Centre for Radio Astronomy Research (ICRAR) and the MWA consortium are collaborating nationally and internationally with prominent researchers in Europe and elsewhere around the world as SKA-low moves towards its pre-construction phase.

INDUSTRY ENGAGEMENT AND COLLABORATION

Development of the MWA and activities to develop SKA-low have impacts far beyond the field of radio astronomy, our understanding of the Universe, and fundamental physics.

These projects provide an excellent training ground for physicists, engineers, mathematicians, statisticians and computer scientists, with enormous scope for cross-disciplinary exposure and learning. The novel and cutting-edge technologies developed for these new radio telescopes also have applications in communications, wireless technologies, super-computing, data management and countless other areas. The size and scope of these activities have very real implications for fostering innovation, creating employment and stimulating the economy.

Industry involvement has been critical to the construction of the MWA. In Western Australia, Fremantle firm Poseidon Scientific Instruments was deeply involved in the early development process, helping to develop, test and then build the very complex receiver packages required. This equipment needs to operate without significant maintenance at a remote field site, and be stringently radio frequency-interference shielded. Receiver performance is critical to the successful operation of the MWA, and the expertise developed within Poseidon Scientific Instruments leaves them well placed to contribute to broader future opportunities in the SKA project, as well as many other high-technology, tight-specification projects.

On a multinational level, global companies like IBM and Cisco have been heavily engaged with the data handling and processing challenges created by the MWA through the supply of specialised hardware. The potential impact of these 'next generation' systems and products in other ICT applications is significant.

Why build in the Murchison?

CSIRO's MRO, 200 km inland from the Western Australian coast and 300 km from Geraldton, is the perfect site for world-leading radio astronomy because it is extraordinarily radio-quiet. Modern electronics generate a vast amount of radio noise, which can drown out signals coming from the sky.

The MRO is in an area with extremely low levels of radio frequency interference, and this will be maintained in the long term through the establishment of a radio-quiet zone, protected by a combination of Western Australian state and federal actions. All equipment brought to the MRO for the MWA is stringently radio-frequency shielded and tested to comply with these requirements.

Another advantage of the MRO site is that it provides excellent sky access, with flat, sparsely vegetated terrain and the Galactic Centre (the rotational centre of the Milky Way galaxy, located at a distance of approximately 27 light years from the Earth) and Magellanic Clouds (small galaxies orbiting the Milky Way) reaching high elevations. The lack of physical impediments also means there is flexibility with tile location, offering good prospects for configuration optimisation.