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April/May 2007

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SQUARE KILOMETRE ARRAY (SKA) SOUTH AFRICA

Update SKA SA & KAT

SKA SOUTH AFRICA

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Join SKAnet

SKAnet is an email list which keeps subscribers updated on news and latest developments about the Square Kilometre Array South Africa project. Join the list at www.ska.ac.za.

Join the KAT Science and Engineering wiki

Participate in discussions and collaboration with the KAT team and other developers and end users of the KAT by joining the "KAT Science and Engineering wiki" at www.kat.ac.za.

MeerKAT prototype antenna installed at HartRAO

From just a concept a year ago, to the complete Karoo Array Telescope prototype antenna installed in April 2007: That is what the South African meerKAT team has achieved. This achievement is not only significant because it is the first time ever (in the world) that an antenna of this size has been manufactured on site from composite materials for radio astronomy applications, but it has also enabled South African industry to build competence in manufacturing antennas of this size for radio astronomy, strengthening our participation in the global SKA community.

"We have a 15 m diameter antenna that shows great potential and promises to be significantly better than originally specified," says Willem Esterhuyse, the subsystem manager of antenna structures on the project. "We look forward to having a fully functional antenna structure installed by August 2007."

Over the next three months, the team will install the remaining sub-system components and will commission and test the antenna. "We will only know whether the antenna has fulfilled its current promise once all this is done," Esterhuyse adds.

The story of how the antenna took shape, can best be told by a series of photos taken during its construction.

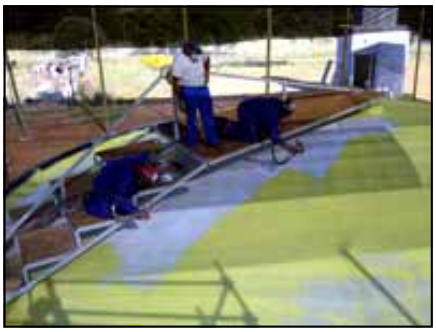
The completed pedestal

Assembly of the backing structure

Manufacturing of the yoke

Manufacturing of the feed support legs

The completed dish mould



Flame-spraying the mould

Installing the yoke

Lifting the dish onto the pedestal; followed by installation of the feed support legs

The meerKAT prototype with all major mechanical components installed. The prototype is at the Hartebeesthoek Radio Astronomy Observatory in South Africa.

Progress with KAT - XDM

View daily progress online of the eXperimental Development Model (XDM). The XDM is a 15-m diameter radio telescope antenna of novel design intended to reduce antenna construction cost per square metre and bring it close to that needed to make Square Kilometre Array (SKA) affordable. View the daily progress at www.hartrao.ac.za/xdm

Feeding the meerKAT prototype

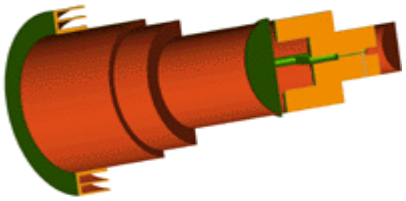
By Robert Lehmensiek and Isak Theron, EMSS Antennas

The design of the meerKAT prototype feed horns was described in the January/ February SKA/KAT Update. Each stepped circular horn will create an axis-symmetric antenna pattern with linear polarisation when excited by a TE11 mode propagating in a circular waveguide.

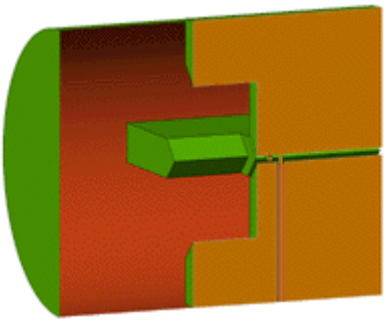
On receive, the signal in the TE11 mode must be converted to a coaxial cable mode before it can propagate to the low noise amplifiers and all the signal processing. This transition occurs in a component called an ortho-mode transducer (OMT) which conveys the two orthogonal polarisations to separate coaxial connectors. Although it may be possible - for the prototype frequency band of 1 400 to 1 670 MHz - to feed the waveguide using four pin probes (requiring double the number of low noise amplifiers), we decided to use a quad-ridged OMT to not only create a high fidelity transition, but also to gain experience with this type of structure which will be needed for future (wider) meerKAT bandwidths. Since the prototype bandwidth is moderate, we used a stepped transition instead of the normal taper between the ridged section and the input to the horns. This makes the complete horn somewhat shorter.

Calibration requires the ability to inject known noise signals into the system. Thus each feed horn has a third connector with very low coupling to the two signal ports. This is usually done with a short pin near the mouth of the horn where the fields are quite small. In our design we've placed the pin between the ridges at the back (where the fields are also quite small). This places the three connectors much closer together.

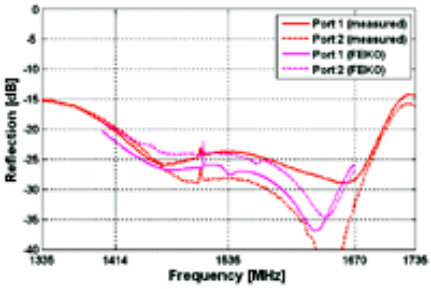
To protect the OMT against the environment, a radome is added just in front of the OMT. Instead of using the usual quarter wave transitions required for radomes supporting a vacuum, the prototype radome is anchored into a small slot cut into the inside of the waveguide wall - the reflection from the slot is less than that from the radome sheet.



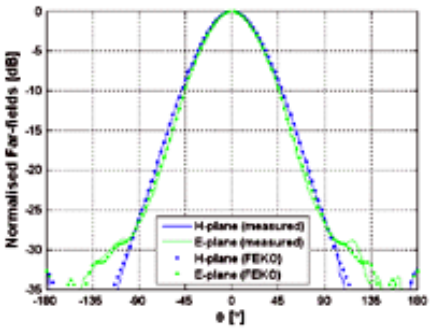
A cut through the full assembly, showing the horn, radome and quad-ridged OMT. While the model looks quite simple, it is electromagnetically quite complex. It required numerous runs of our in-house CEM software package FEKO on a SGI Altix 450 to develop the required insight intotoethe physics of the structure.



A cut through the back section of the OMT. The ridges are excited by passing a coaxial cable through the ridge and connecting the centre conductor to the opposite ridge. This high-precision pin was made by Thys Willemse, a watchmaker from On Time Watch Services in Cape Town.



The predicted reflection coefficients agree quite well with the measured values - including the frequency of the trapped TE21L mode resonance. This resonance is caused by the asymmetry of the feed pin and was not apparent in initial coarser frequency sweeps. With the insight derived from this prototype and the agreement with numerical analyses, the next step is to remove the resonance.



The measured far field pattern (shown here at 1 542 MHz) agrees very well with the values predicted using FEKO. These patterns will result in about a -13 dB edge taper on the 15 m prototype meerKAT dish.

Major European award for Southern African astronomy project

The High-Energy Stereoscopic System (HESS) research group received the European Union's prestigious Descartes Prize for Science in Brussels on 7 March 2007. They share the prize money of one million Euros with two other groups. The European Union established the Descartes Prize in 2000 to highlight and recognise scientific and technological achievements based on collaboration between many countries.

The four gamma-ray telescopes of the High Energy Stereoscopic System (HESS) in Namibia.

HESS consists of four gamma ray-telescopes in Namibia. The HESS researchers - about 100 in total - come from Germany, France, the Czech Republic, the United Kingdom, Poland, Ireland and Armenia, as well as South Africa and Namibia. Their project "A new glimpse at the highest-energy Universe" was one of 65 submissions and eventually 13 nominations.

"This award proves that we can compete at the top with the rest of the world," says project leader of the South African HESS group, Professor Okkie de Jager of the North-West University (NWU) in South Africa. "It is a great honour, but it has been incredibly hard work!" Three of the four patents resulting from the HESS research belong to the NWU.

MeerKAT meeting in Amsterdam

More than 40 South African and European scientists gathered in Amsterdam, The Netherlands, on 20 and 21 April 2007 for a meerKAT workshop hosted by the South African SKA Project Office with the cooperation of ASTRON. The South African SKA prototype is now called "meerKAT", since the country is planning to build a much larger Karoo Array Telescope than the 20-dish array originally planned.

"The meeting was a great success and we took the first steps towards a convergent specification process," said Dr Adrian Tiplady of the South African SKA project office. "We hope to arrive at a final meerKAT specification through follow-up meetings on other continents soon."

In addition to updating international partners on meerKAT, including its reference specifications and project timescales, the South Africans were keen to discuss key science themes and explore opportunities for collaboration and partnerships, as well as to explore linkages between meerKAT and other projects such as the SKA, SKADS, LOFAR, etc. Workshop delegates also discussed the evolution process for the meerKAT specification to ensure that the instrument is optimised for science delivery.

The 'meerKAT reference specification' was used as a starting point from which presenters could deviate in order to optimise performance in different science areas. The specification calls for the construction of a few percent SKA, operating in a low frequency (0.6 GHz - 3 GHz) and high frequency (somewhere between 10 GHz and 22 GHz) band.

Day one of the workshop was dedicated to key science areas for meerKAT. These include galactic and extragalactic studies in continuum and HI, pulsars and transients, gravitational lensing and cosmic magnetism. Download the presentations from the meeting at www.ska.ac.za/events/presentations.shtml

The second day was dedicated to ensuring that meerKAT was an instrument with international input and participation, and that it would complement other astronomy projects across multiple wavelengths.

CONRAD reaches second milestone

By Jasper Horrell

The CONRAD (CONvergent Radio Astronomy Demonstrator) software collaboration between the Australian MIRANdA team and the South African meerKAT team has entered a new phase. The teams completed CONRAD Milestone 2, involving a range of deliverables from each team, by the end of February 2007.

As planned, the MIRANdA computing team has scaled up substantially, particularly in the back-end processing areas of the central processor, archive, and calibration and now matches the meerKAT computing effort.

CONRAD focuses on a wide range of tasks jointly relevant to the computing systems of the future radio telescope arrays. Milestone 2 included work on subtle aspects of calibration and imaging, certain high performance computing activities related to the development of the central processor, the development of array configuration tools, RFI mitigation simulation, the refinement of the CONRAD software engineering processes and systems to support code development, wrapping of certain astronomical code libraries, and a substantial monitor and control prototype.

This collaboration demonstrates the viability of geographically separated teams working together. The day-to-day operation relies on internet-based technology such as weekly skype meetings, the use of a wiki, an issue tracking system, source code- and document revision control using subversion, as well as email and mailing lists.

To strengthen the virtual contact, the teams will also meet "for real" for two weeks during May 2007, building on previous visits by computing team members in both directions. The meeting in Sydney, Australia, will focus on technical computing architecture issues and the management of the collaboration.

SKA champions in South Africa

Two of the drivers behind the international Square Kilometre Array project visited South Africa for 18 days during May 2007 to interact with South African scientists, the local SKA and meerKAT teams and present a series of public lectures. They were hosted by Prof Roy Booth, Director of the Hartebeeshoek Radio Astronomy Observatory, as part of his international visitors programme. Professor Richard Schilizzi is the international SKA project director, while Dr Peter Hall is the SKA international project engineer, both employed by the International SKA Project Office (ISPO).

They inspected the close-to-completion meerKAT prototype dish at HartRAO, and met with several scientists, presented general public talks, met with the the SKA project staff in Johannesburg and the meerKAT engineers in Cape Town.

Professor Richard Schilizzi and Dr Peter Hall inspecting the meerKAT prototype dish.

"The President of South Africa has adopted the SKA as a project, and that is hugely exciting," said Prof Schilizzi after a public talk he delivered at the Johannesburg Planetarium on 9 May 2007. "We are very encouraged by the preparations for building meerKAT and level of commitment towards the SKA that we've seen here in South Africa". More than 200 astronomy enthusiasts turned up for Dr Schillizzi's talk on "The SKA - eavesdropping on cosmic whispers".

Exciting C-BASS science now at HartRAO

By Justin Jonas

Radio astronomy dishes are mushrooming all over the Hartebeesthoek Radio Astronomy Observatory (HartRAO) facility. Not long ago, the only radio telescope on the site was the 47-year old 26-metre dish that has been making first-rate science observations since NASA left it in the 1970s. HartRAO is now also the site for the KAT prototype, constructed there with new-generation composite fabrication techniques.

Another recent arrival is a new 7.2-metre dish, delivered at the site with the help of a massive flatbed truck and telescopic crane. This dish will be used to develop the South African component of the C-BASS project, an international collaboration that will map the polarization of the radio emission from our own galaxy, the Milky Way, with exquisite accuracy.

This dish is one of two identical units purchased by the National Research Foundation from Telkom SA Ltd. The dishes were part of a 5-dish facility at the Telkom Hartebeesthoek ground station. Dr Khotso Mokhele, then President of the NRF, negotiated with Telkom senior management for two of the dishes for scientific use. The C-BASS partners and the South African radio astronomy community are extremely grateful to Telkom for their generosity in providing the dishes at a nominal cost, which has allowed South African participation in this important experiment, and has improved the scientific prospects of the experiment by providing a southern hemisphere component.

The acronym C-BASS stands for "C-Band All Sky Survey", which in turn means that the radio frequency to be used is 5 GHz (C-band) and that the entire sky will be mapped.

The international partners in this global project are Caltech in the USA, the Universities of Oxford and Manchester in the UK, and Rhodes University and HartRAO in South Africa. Although the polarization of the Galactic radio emission is interesting in its own right (because it traces the Galactic magnetic field), the primary goal of the C-BASS project is to apply corrections to current and planned measurements of the polarization of the Cosmic Microwave Background Radiation (CMBR).

The CMBR is the relic emission from the early universe that was generated some 300 000 years after the Big Bang. The universe is now some 13 billion years old, and the CMBR gives us the earliest "picture" of the state of the universe, at an epoch some billion years before the first stars and galaxies were formed. The first detection of the CMBR in the 1960s earned Penzias and Wilkinson a Nobel Prize, and more recently George Smoot and John Mather were also awarded a Nobel prize for detecting "ripples" in the CMBR and measuring its temperature using the COBE satellite. The ripples are caused by very small density fluctuations in the primordial gas which were the seeds for later galaxy formation.

Although the CMBR gives us our earliest picture of the universe, scientists wish to determine what happened in the universe in the period from the Big Bang till the CMBR epoch. In other words, they want to understand how the primordial density ripples formed, and in doing so get a better understanding of the structure of time and space. Einstein's Theory of Relativity and competing theories provide a number of different interpretations of how the universe expanded in its infancy. The popular "inflation" theory predicts that the universe experienced a short period of explosive expansion shortly after the Big Bang. This expansion would have left a distinctive imprint in the polarization of the CMBR, and hence the measurement of the CMBR polarization has become an important scientific pursuit.

These measurements are extremely difficult to do and require very stable high-frequency receivers. The measurements are affected by many interfering effects, such as the earth's atmosphere and the radio emission from the Milky Way. The effects of the atmosphere are reduced by placing the CMBR telescopes on high mountains, high-altitude balloons and satellites. The Planck Surveyor satellite, due for launch next year, has as its primary goal the measurement of the CMBR polarization, and there are a number of terrestrial and balloon-borne experiments currently underway.

Delivery of the 7.2 m C-BASS dish at HartRAO on 14 February 2007. The C-Band All Sky Survey (C-BASS), will map the whole sky in temperature and polarization at 5GHz.

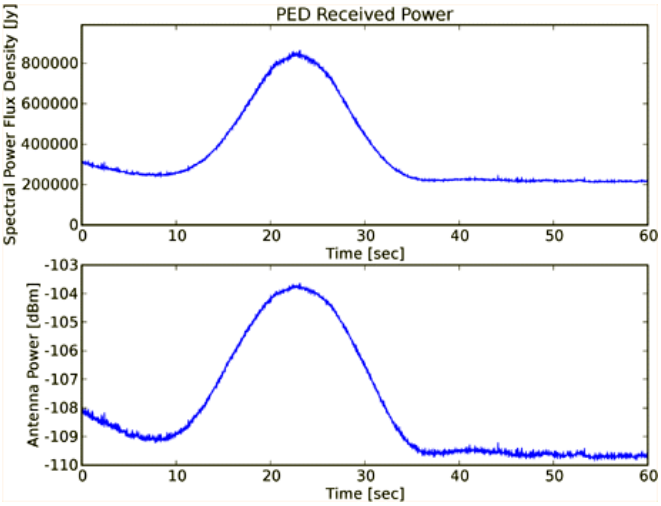
One can escape the effects of the atmosphere, but we cannot escape the radio emission from our own galaxy, so CMBR scientists need to have extremely accurate models of the Galactic emission so that they can remove its effect from the measured CMBR images. This is where C-BASS comes in: to provide the CMBR scientists with the required model of the "Galactic foreground" polarization.

The need to map the entire sky implies that two telescopes are required, one in each hemisphere. The northern hemisphere telescope will be located at the Owens Valley Radio Observatory in the USA. Ultimately the southern hemisphere telescope will be located in the Radio Quiet Reserve in the Karoo, close to the meerKAT and proposed SKA sites. The dish at HartRAO will be used to develop and test the receiver and other telescope systems. A second dish will be transported to the Karoo site for the actual measurements. The radio frequency interference (RFI) environment is far better at the Karoo site, and the atmosphere is much more stable and dry. The HartRAO dish will be used for education and public outreach programmes once C-BASS operations move to the Karoo.

PED dish first light

By Jasper Horrell

The PED, a small test radio telescope array built by the KAT team, produced its first results on 26 March 2007. Enthusiastic KAT team members connected up the receiver chain and dish drive electronics on the first dish for the first time and performed a scan across the sun. This was later followed by a longer spectral integration on- and off the galactic plane in order to detect the neutral hydrogen radio signal.



Calibrated drift scan results through the sun. Top: Measured spectral flux density versus time. Bottom: Measured power in dBm at antenna terminal. The data was calibrated by relating the received power to the LNA gain, the receiver gain, the signal bandwidth and the effective antenna area.

The Phased Experimental Demonstrator (PED) will be used primarily as a risk reduction facility for the bigger KAT project. It will be a testbed for KAT software for monitor and control, remote operations, basic scheduling, basic tied array and interferometric imaging processing, and RFI mitigation.

The PED will consist of an array of six steerable dishes and one fixed dish. The full array should be installed on the grounds of the South African Astronomical Observatory (SAAO) by July 2007. PED has a narrow instantaneous bandwidth of 4 MHz, with the centre frequency software adjustable within a 40 MHz bandwidth range (determined by the bandwidth of the low noise amplifier) and centred around the HI radio astronomy spectral line at 1420 MHz.

Since "first light", the team has focused on development of the site infrastructure and work towards more automated end-to-end single dish experiments, to be followed by interferometric experiments with the 6-dish array later in the year.

For updates, visit www.kat.ac.za/public/wiki/PED.

Sharing science with South Africans

The South African SKA and meerKAT team is using the excitement of designing and building a new telescope to generate interest and inspire a new generation of scientists in the country. They collaborate with outreach staff at the Hartebeesthoek Radio Astronomy Observatory to participate in public science events across the country. The joint stand between SKA, meerKAT and HartRAO features several information banners, scale models of the KAT prototype, a KAT terrain model and a DVD of a virtual visit to the KAT. Cartoon-style astronomy posters and a do-it-yourself planisphere kit are distributed for free at events.

So far this year, the outreach team have exhibited and presented public talks at two week-long science festivals, SciFest 2007 in Grahamstown and Science Unlimited in Pretoria. They also participated in ScopeX, an annual event for amateur astronomers and the general public, held every year at the Military History Museum in Johannesburg.

SKA and meerKAT will also feature at these events in the coming months:

- National Science Week in Kimberley, Northern Cape Province, from 14 - 19 May 2007
- A fly-inn community event in Carnavon, 15 - 17 June 2007
- An exhibition at the 52nd Annual Conference of the South African Institute of Physics in Johannesburg, 2 – 6 July 2007
- SABC Careers Expo in Kimberley, 2 - 3 August 2007
- SASOL TechnoX science week in Sasolburg, 23 - 28 August 2007

The three educational posters are especially popular with learners, educators and parents. The posters focus on:

- Our "new" solar system
- The electromagnetic spectrum
- Your place in our amazing universe

Download these posters, as well as a planisphere kit on www.ska.ac.za/education/resources.shtml

The SKA/KAT stand at SciFest 2007 was very popular and the outreach team worked long hours to answer visitors' questions about the universe, our solar system and the future of radio astronomy in South Africa.