SKA AFRICA
SQUARE KILOMETRE ARRAY

Newsletter

September/October 2011

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SKA South Africa shines at the SKA Forum 2011 in Banff, Canada

"It was truly a great event and, in some sense, represents the culmination of our efforts over the last seven years," Jasper Horrell from the SKA South Africa office in Cape Town summarised the team's attendance at the SKA Forum 2011 in Banff, Canada, held during the first week of July 2011. Jasper Horrell and Simon Ratcliffe were part of the SKA South Africa team, who joined representatives from the Department of Science and Technology and the Northern Cape Government.

The SKA Forum 2011 was the last major international SKA meeting before the final site decision is made in February 2012. As such, it provided the ideal platform for strategic and scientific discussion on the current state of the SKA, and the efforts of the final two competing proposals.

The South African team showed the international community that, in addition to having the ideal geographical environment and climatic conditions, the country also has the technical capacity, engineering ability and above all, the political commitment to build a world class scientific instrument. South Africa put in a strong presence, with presentations by science and technology minister Ms Naledi Pandor, and SKA SA project director Dr Bernie Fanaroff, driving home the point that South Africa is not only ready to host the bid, but that considerable advances have already been made with regard to the infrastructure (such as roads, buildings, optical fibre network and power lines).

According to Minister Pandor, the African commitment to hosting the SKA on the continent was clear from the financial, political, legal, technical and infrastructural support given by all involved parties.

As part of the overall presence in Banff, live demonstrations were conducted of the KAT-7 telescope in operation, including controlling KAT-7 remotely from Banff. The feed from the site included streaming webcam images, system health and configuration displays, as well as real-time displays of data from the telescope.

"A major highlight of the South African team's attendance at this event was that the rest of the world really sat up and took notice of our efforts," said Simon Ratcliffe, praising the team effort. His words were echoed by Jasper Horrell: "By proving the competence of the team and emphasising the strong support from government, we have shown without doubt that Africa is ready to host major scientific instruments such as the SKA."

The SKA South Africa stand at the SKA Forum 2011 in Banff

The road to the final SKA site decision

At the SKA Forum 2011 in Banff, the Founding Board of the SKA unveiled the process and timeline for selecting the site that will host the largest radio telescope array in the world.

Since March this year the two candidate sites – South Africa in conjunction with its eight African partner countries (Namibia, Botswana, Ghana, Kenya, Madagascar, Mauritius, Mozambique and Zambia), and Australia together with New Zealand – have been finalising their respective site proposals in response to a Request for Information (RfI) from the SKA Site Selection Group (SSG). Detailed documentation on all the relevant scientific and technical factors, infrastructure costs, and legal, environmental and security issues, were due on 15 September 2011. South Africa submitted its proposal, consisting of a 150 page summary report and several thousand pages of supporting documentation, before the deadline. Selection factors include levels of radio frequency interference, the long-term sustainability of a radio quiet zone, the physical characteristics of the site, data network connectivity across the vast distances covered by the telescope as well as operating and infrastructure costs.

South African Minister of Science and Technology, Naledi Pandor, addresses a press conference at the SKA Forum 2011

"I wish to emphasise the critical urgency of taking this project beyond conception to practical action," urged the South African Minister of Science and Technology, Naledi Pandor, at the SKA Forum 2011, held in Banff, Canada during July 2011. "We are keen to move into the design and implementation phase," she declared.

These submissions will be thoroughly scrutinised and evaluated by panels of experts and the independent SKA Site Advisory Committee (SSAC) until November 2011.

By the end of this year the SSAC, an external body of independent experts, will evaluate the findings and recommend a preferred site. They will present their final reports to the SKA Board of Directors, which is due to make its final site decision in February 2012.

More industry contracts for SKA South Africa

The SKA South Africa project has awarded four significant contracts for its KAT-7 and MeerKAT projects:

1. **EMSS** (Electromagnetic Software and Systems, Stellenbosch) were awarded a contract to develop, produce and qualify the L-band receivers for MeerKAT Phase 1. "These receivers are essentially small hi-fidelity antennas that operate at minus 200°C and colder, inside a vacuum vessel where the pressure goes down to 0.000 000 001 bar and lower," explains LJ du Toit of EMSS. "It is quite a challenge to get the sensitive electronics in all the antennas working together under these conditions".
2. **MMS**, a Centurion-based engineering company, has been awarded a contract to analyse the MeerKAT antennas structurally – working closely with the electromagnetic modelling experts at EMSS in order to optimise the mechanical structure and scientific performance of the antenna simultaneously. An important part of their contract is a curing distortion study to verify that the composite dishes will not distort on the mould during production. Scale model casts, 3 – 4 m in diameter, will be prepared to qualify the model. They are also assessing whether the reflectors for MeerKAT should be made of carbon fibre or fibreglass, and doing a mould design for the offset MeerKAT reflectors. Surface accuracy of both reflector elements has to conform to very tight tolerances because of the requirements of the Gregorian offset antenna.
3. The **CSIR** has been tasked with qualifying the composite materials used for reflector elements to ensure that these can withstand 30 years of service. This work package will consider structural creep, UV resistance, fungal growth, hail damage, thermal fatigue, and verifying structural properties of the material and bonding interfaces. An on-site wind study has been conducted to evaluate the predicted wind forces on the antennas, which is important for pointing stability and protecting the antennas.

4. Two contracts were awarded to **BAE Systems Dynamics (SA)**. The first of these was for the development of an elevation load measure system for KAT-7 to analyse the loading on the most critical (single point of failure) component of the antenna in order to provide design data and qualify the leadscrew design for the MeerKAT antennas. The second comprises offset antenna concept analyses to complete the preliminary work required to finalise specifications for the MeerKAT antennas.

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MeerKAT passes Preliminary Design Review with flying colours

"The panel unanimously concludes that the PDR has been successfully passed and congratulates the project teams." These were the findings of the panel of international experts who conducted the Preliminary Design Review (PDR) for the 64-dish MeerKAT array during July 2011.

The PDR is an important milestone, verifying that the system design satisfies the system requirements. It establishes the design baseline, from which the requirements of the various subsystems are derived.

To give the panel an insight into the geographic location of the telescope in the vast open spaces of the Northern Cape, and to demonstrate the progress that has been made at the site, they visited the KAT-7 site, as well as the Losberg complex and the support base at Klerefontein.

"We are extremely impressed by the quality of the project team, and the continued tremendous progress in realising KAT-7 and bringing MeerKAT to its current stage," they declared in their report.

The expert review panel was chaired by Marco de Vos (ASTRON, Netherlands), and other attending members were Rick Perley (NRAO, USA), Tim Stevenson (SPDO, UK), Peter Hall (CIRA, Australia), Paul Alexander (Cambridge, UK), and Thijs de Graauw (ALMA, Chile). The panel also included Dr Yashwant Gupta (GMRT, India) who could not take part in the visit, but contributed to the PDR via correspondence.

PAPER array extended to 64 dishes

After a very successful deployment, the Precision Array for Probing the Epoch of Reionisation or PAPER experiment is now a proud 64-antenna array. Collaborators from the US (National Radio Astronomy Observatory and Universities of Virginia, Berkeley and Pennsylvania) gathered in the Karoo to accomplish this feat within a mere three week timeframe.

The recent deployment involved the assembly and installation of an additional 26 dipole antennas constructed from parts shipped from the USA. New antenna positions were accurately marked during a previous deployment, with the array being in a minimum redundancy configuration to optimize image quality. Subsequently, 100's of metres of overground cables were carefully laid to the central computing container in such a way as to avoid cable cross-talk, and simplify the process of array reconfiguration. Furthermore, new analogue receivers were installed and the digital backend was upgraded, featuring a new 64-input ROACH-based correlator.

Concurrent with the deployment, two essential additions were made to the PAPER infrastructure. Grid electrical power, conditioned via a UPS system at the KAT-7 site, has now replaced a diesel generator. Together with this, a fibre optic data cable was installed along a 2 km trench to the nearest KAT-7 infrastructure. This data link will enable remote monitoring and power cycling of the instrument, and also allow distant scientists to download data fragments in order to evaluate the instrument's performance whilst data is recorded to a bulk storage unit within the computing container.

Intern technicians from the Hartebeesthoek Radio Astronomy Observatory helped to install the new PAPER antennas – they are (fltr) Monde Manzini, Raphael van Rensburg and Khulekhani Zulu.

"Scientists who will be using PAPER were very impressed with preliminary images from the instrument, proving that the Karoo region is ideal for this type of research," says William Walbrugh, junior project manager for PAPER based at the MeerKAT office in Cape Town. "We plan to extend PAPER to 128 antennas by 2013."

Agreements with INTEL, SEACOM and NOKIA-SIEMENS boost SA's SKA bid

On 26 July 2011 Intel Corporation signed a memorandum of understanding (MoU) with South Africa's Department of Science and Technology (DST) and the MeerKAT engineering team. Intel has undertaken to supply to SKA SA, for a joint evaluation, cutting edge, high-performance computing technologies that will be required to capture, process and analyse the vast amounts of data that will be generated by the SKA and MeerKAT telescopes.

Christian Morales, Intel Corporation Vice President and General Manager for Europe, the Middle East and Africa, explained: "Intel will be providing cutting edge hardware and software architecture and the development tools necessary to make this project succeed. We are looking at providing a flexible architecture that is capable of evolving in the future and developing a high performance computing system that is able to stream and process a huge amount of data. We will be relying on the best architecture available today with strong capacity and the most efficient energy consumption." (Source: ITNewsAfrica.com)

For instance, the radio telescopes will require the latest technology motherboards supporting massive data rates and fast solid state drives that make it possible to record the data at high throughput rates. Much of this technology is in fact still under development.

Jasper Horrell, sub-system manager of the MeerKAT Science Processing Team at the SKA South Africa office in Cape Town that has been working closely with Intel, stated: "Intel has for a long time been one of the major players in computing innovation and their next generation hardware and software continues to reflect this trend. They are an important partner for SKA precursor instruments such as MeerKAT."

The Intel technology is currently being used to develop an ability to deal with so-called "raw voltage data" on KAT-7, itself a precursor to MeerKAT. This raw voltage data is the first stage of digital data that emerges at a very high rate (currently 1.6 GBps) from each antenna. This data stream is diverted into a raw voltage processor constructed using Intel technology as an alternative to the FPGA-based KAT-7 correlator. The raw voltage processor provides a new level of flexibility to the telescope. For example, data can be converted to a very long baseline interferometry (VLBI) format or recorded to high speed disk with some pre-processing to look for radio transient signals from the universe.

Prototype lab system, incorporating Intel solid state disk technology, used for high speed data capture and stream processing.

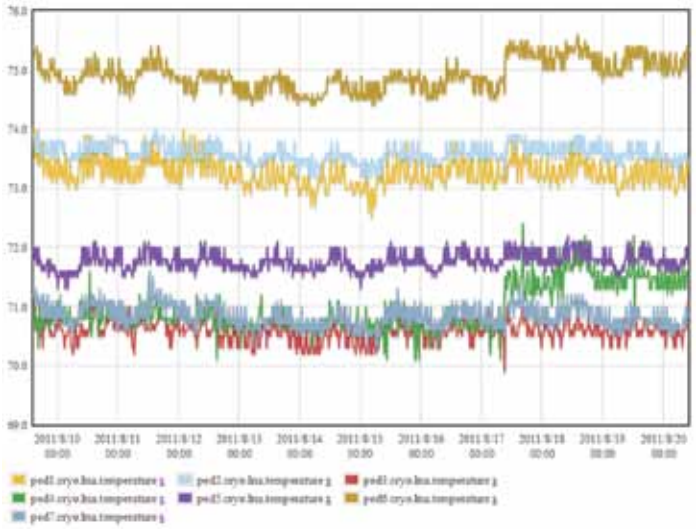
The DST and SKA South Africa also recently signed MoUs with submarine cable operator Seacom – to provide connectivity between remote SKA stations, as well as with Nokia Siemens Network (NSN) – to model the signal transport requirements of the SKA telescope. Other key partnerships in support of SKA SA include agreements with Eskom and Telkom – for provision of reliable and low-cost electrical power and data transport.

Crucial cold receivers successfully installed on KAT-7

On 8 August 2011, all seven dishes of the KAT-7 telescope had been successfully fitted with "cold" radio receivers. These receivers, designed and manufactured by EMSS in Stellenbosch, are cryogenically cooled to temperatures of about 70 Kelvin, or -203 celsius. This significantly lowers the noise floor of the telescope system, which enables scientists to make observations with significantly better sensitivity, thereby "seeing" much fainter objects than would otherwise be possible.

The successful installation of the 7th cold receiver is a significant milestone that marks the last major hardware installation effort on KAT-7 by the engineering team. It coincides with the formal acceptance of the KAT-7 correlator, which means that KAT-7 is now ready for more in-depth interferometric commissioning. The Science Processing Team wasted no time to start producing radio images with the new receivers.

Feed for cold receivers and dish with feed mounted



KAT-7 LNA (Low Noise Amplifier) temperatures(K) for the period of 9–20 August 2011

Apart from the interferometric commissioning work that lies ahead, the system engineering team is busy finalising the formal acceptance testing of phase one of KAT-7. Phase one includes the wideband correlator mode, whereas phase two includes the spectral line mode, tied-array beam-forming mode and very long baseline interferometry (VLBI). The formal acceptance testing of phase one, together with the as-built, operations, logistic support and maintenance documentation, forms the operational baseline of KAT-7, a further significant milestone.

"We are extremely proud of the KAT-7 achievements to date", remarks Richard Lord, KAT-7 system engineer. "This has been a fantastic team effort, involving the on-site technicians, the engineers and commissioners in Cape Town, and subcontracted companies like EMSS and Tellumat. We are looking forward to start using the telescope for some early science in the near future."

Progress with KAT-7 commissioning

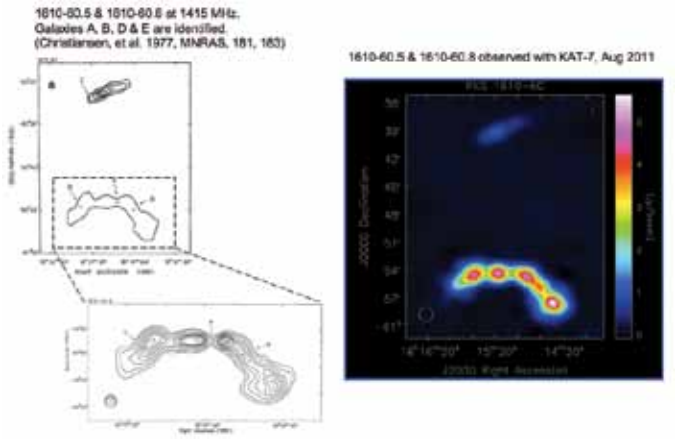
Commissioning of the KAT-7 telescope is going full steam ahead with seven cold receivers installed and working, the KAT-7 correlator operating in continuum, and dual polarization mode and fringe stopping now implemented.

Baseline solutions, pointing models and Tsys/gain performance for the new receivers are being determined and detailed beam maps are being obtained. Science-like data is now being collected in continuum mode, with the HDF5 data format used for storing visibilities and meta-data being converted into a measurement set for end-to-end CASA processing.

An exciting achievement occurred in August 2011, when a demonstration image of the galaxy cluster PKS 1610-60.5 was obtained, using the cold receivers on all seven KAT-7 dishes.

The main cluster has a combined flux density of ~40 Jy at 1415 MHz while the northern component, PKS 1610-60.8, has a flux density of ~3 Jy (Christiansen, et al. 1977 MNRAS, 181, 183). The field was observed with KAT-7 at 1822 MHz with 7 antennas, full polarization, for about 14 hours (10 hours on source).

The data, reduced and imaged in CASA by members of the Science Processing Team (Simon Ratcliffe and Ludwig Schwardt), shows the correct source structure and flux density, 39.7 Jy for the southern source and 2.6 Jy for the northern (see figure on the right, which shows a comparison between the image presented by Christiansen et al and that generated by KAT-7).



Having seven cold receivers has significantly improved the telescope's sensitivity and the quality of the processed images.

(Additional info obtained from article titled "KAT-7 scopes out Centaurus", Gadget magazine, 25 August 2011, http://ht.ly/6cwLk)

Control and monitoring upgrades for KAT-7

A new set of server computers for KAT-7 was recently installed in the computing container at Losberg, while the project engineers also finished refactoring the "fringe finder" CAM (Control & Monitoring) software to be ready for KAT-7 and to support both the FF correlator and the KAT-7 correlator.

The control room in Cape Town has also been furnished with operator stations, and is being used by telescope commissioning operators and engineers for remote control of the KAT-7 telescope in the Karoo. A live webcam stream from two webcams in the Karoo is streamed to Cape Town so that operators, commissioners and engineers can monitor the real-time antenna movements and activity on site.

With regard to the control and monitoring software, the KAT-7 CAM core software is ready and in use. This includes providing a proxy layer for hardware devices, monitoring all sensor points on all devices and storing these in a monitoring store, providing access to monitoring data for data augmentation and analysis, raising alarms and notifications when things go wrong or when maintenance is required, webcam streaming to operator stations, a portal for operator and maintainer graphical user interfaces (GUIs), system configuration and system control.

New functionality that will be developed in the next two years to accommodate MeerKAT CAM requirements include an observation framework, task executor and scheduler, sub-array management, MeerKAT GUIs, and tools for observation preparation management and observation planning.

Nadeem Oozeer (commissioning team) and Siphelele Blose (operator) in the KAT-7 remote operator room in Cape Town, looking at a live display of the KAT-7 site in the Karoo (using the webcams on site), as well as at various health and signal displays. From this control room, they can also operate the KAT-7 telescope remotely.

On-site UPS for KAT-7

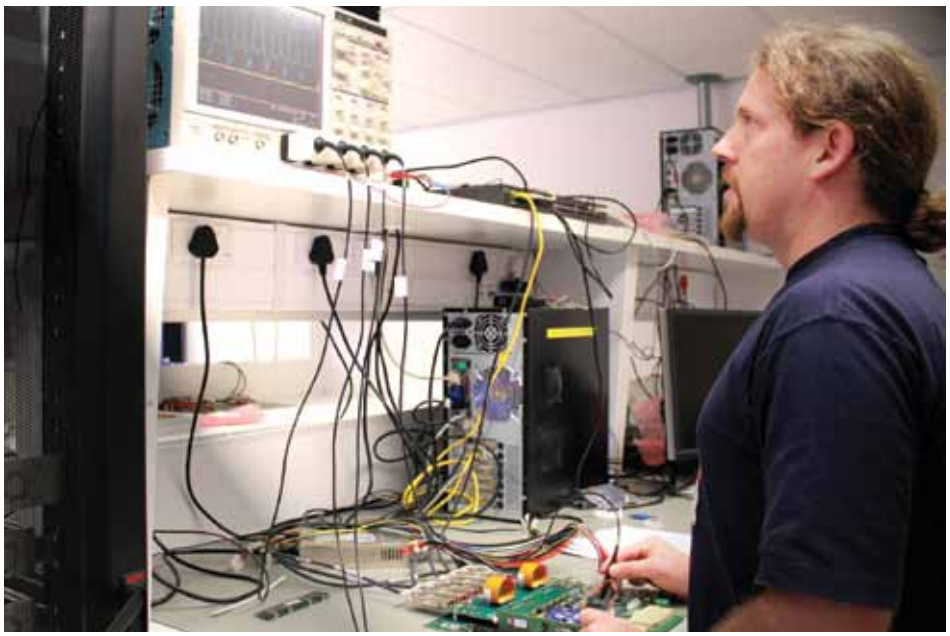
A significant operational improvement for the KAT-7 telescope has been the switch-over to grid power supplied by ESKOM, the South African electrical utility company. Back-up diesel generators are available to safeguard against any potential sustained power outages, but even a very brief power interruption can interrupt the telescope operation and possibly damage its sensitive electronics. That is why a 100kVA UPS (uninterruptable power supply), linked to all seven dishes, was recently installed on site. To avoid causing interference with the telescope itself, the UPS had to be installed in a specially shielded antenna services container.

With this UPS unit and back-up diesel generators in place, the sensitive KAT-7 receivers have a fully conditioned power supply.

KAT-7 digital back-end (DBE) acceptance test procedure (ATP)

A close-up of one of the Roach II FPGA boards that will be used in the MeerKAT commissioning correlator

The KAT-7 laboratory correlator (a copy of the actual correlator on site to allow for complete testing of the system in a controlled environment). This correlator is based on ROACH I boards.



Philip Gibbs testing one of the next generation ROACH II boards

The correlator is a fundamental element of the MeerKAT telescope: It receives the inward bound sky signals from the individual telescope dishes and converts those analogue signals into digital signals that the computer can process. It also has to combine the signals from the various dishes into a form that can be processed into radio images for scientific analysis. A key concern is that the telescope will be observing very weak signals, and it is therefore critically important not to degrade the already weak signals by adding noise. It is equally important to ensure that the correlator functionality achieves optimal signal retrieval. During a recent acceptance test procedure (ATP) process, MeerKAT engineers and scientists made sure that all specifications set for the correlator have been met to ensure high signal fidelity, before using the correlator for science observations.

Super-realistic MeerKAT movie

The SKA South Africa project office contracted Luma, a Johannesburg-based animation studio, to produce a realistic 3D animation of the MeerKAT telescope as it will appear on-site in the Karoo when it is completed in 2016. The Luma team spent two days in the Karoo to photograph sample images of the actual terrain and vegetation so that they could digitally recreate the site as realistically as possible. They used geo-survey data from the MeerKAT infrastructure team to recreate the terrain as a 3D model. "Realism was key throughout the project and we were rendering close to 160 billion polygons per frame in order to preserve the accuracy and achieve the final look," says Paul Meyer, MD for Luma.

Download the two-minute MeerKAT movie at http://www.ska.ac.za/media/animations.php

Scenes from the MeerKAT animated sequence produced by Luma.

SA promotes the African SKA bid abroad

"Africa is both the cradle of humankind and the continent of the future, and we are confident that we present an outstanding site and the best home for the SKA," stated South African Minister of Science and Technology, Naledi Pandor. She was speaking at a press conference at the World Congress of Science Journalists (WCSJ) in Doha, Qatar at the start of July 2011, giving them an insider's view of Africa's bid to host the Square Kilometre Array on the continent. SKA South Africa had a significant presence at the WCSJ, including a display stand and the very popular Mission MeerKAT comics.

SKA South Africa's information stand at the WCSJ 2011

The SKA SA project office took part in two major international scientific conferences recently to create awareness of the SKA and South Africa's participation in the international SKA project, including the proposal to host the SKA in Africa. The two conferences were the 11th Asia-Pacific Regional IAU meeting (APRIM 2011) in Thailand (photo above), and the XXXth URSI General Assembly and Scientific Symposium (URSIGASS 2011) in Turkey. At the URSI GASS meeting Justin Jonas, Associate Director for Science and Engineering in the SKA South Africa project office, took over as Chair of Commision J (Radio Astronomy) from Subramanian Ananthakrishnan of India.

SKA SA presentations in London – Youth Day 2011

"Revolutionary science on the continent of opportunity" was the title of a presentation by Dr Bernie Fanaroff at the South African High Commission in London on 16 June 2011 (as part of the celebration of Youth Day). A packed audience of scientists, journalists, policy-makers and diplomatic representatives heard about recent achievements in astronomy in South Africa. Attendees included Dr Richard Schilizzi, Director of the SKA Project Development Office (SPDO), academics from the Universities of Oxford, Cambridge, Southampton, Keele, Manchester and the Open University. Professor David Cope, Director of the Parliamentary Office for Science and Technology, Mr Colin Vincent and Mr Simon Berry from the Science and Technology Facilities Council, MP Mr Nigel Evans, Patron of the All Party Parliamentary Group on Space, MP Ms Chinyelu Onwurah, Shadow Junior Minister for Science and Technology, MP Mr Stephen Mosley, Science and Technology Select Committee and diplomatic representatives from Germany, France, China, Nigeria, Zimbabwe, Lesotho, Malawi, Zambia, Australia and New Zealand.

Dr Fanaroff showcased the KAT-7 and MeerKAT telescopes and the South African proposal to host the SKA. He set out South Africa's experience in delivering large high-tech projects and explained how iconic projects like the SKA are attracting young people into science and engineering studies. The South African government's commitment to building a knowledge economy was illustrated by the investment in bursaries for students from across Africa. In addition to working with global industrial partners, the South Africa SKA bid has also supported economic development in South Africa with emerging clusters of high tech companies. The exceptional radio quietness of the Karoo site, protected by legislation and agreements with broadcasting companies and other radio operators, is a real asset for radio astronomy. Dr Fanaroff explained that South Africa provides real value because less cash spent on infrastructure and operating costs means more telescope for the money – a real advantage in times of tight public budgets.

Dr Fanaroff in conversation with British MP Mr Stephen Mosley

Outreach programme hosted at SAAO wins prestigious international award

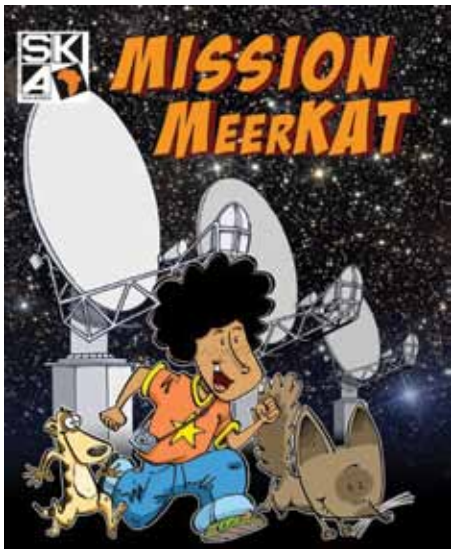
The Universe Awareness (UNAWE) programme, with which the SA Astronomical Observatory (SAAO) is intimately involved, has been honoured with the Science Prize for Online Resources in Education (SPORE) award. Science Magazine introduced the SPORE award as a means to showcase the best educational resources that are available on the Internet and to bring them to a wider audience.

The prize goes to Dr. Carolina Ödman-Govender, a core developer of the UNAWE programme. She has worked in science for development for many years in the Netherlands, before joining the SAAO and the African Institute for Mathematical Science (AIMS) in 2010. She now holds the position of director of academic development of the AIMS – Next Einstein Initiative (AIMS – NEI). "One of the key features of UNAWE is its openness; it is a form of crowd-sourced education. A vast network of educators contribute educational materials and resources, which are uploaded to the UNAWE website. They can then be distributed, adapted and translated for use in other countries", she says.

UNAWE is an international programme that uses the beauty and grandeur of the Universe to inspire children aged 4–10 years, particularly those from an underprivileged background. The programme uses astronomy to cultivate a sense of perspective, foster a global citizenship and stimulate interest in science at a crucial age in a child's development. The UNAWE website hosts a vast repository of educational materials that are produced by the programme's network of almost 500 educators and astronomers in 40 countries – one of the biggest international networks of science educators. UNAWE is a programme endorsed by the International Astronomical Union (IAU). Visit UNAWE at www.unawe.org.

"The web site is intended to give a sense of perspective to everyone who uses it," says Dr Ödman-Govender. "You can see the universe as a big place and a beautiful place in which you fit."

Mission MeerKAT – the adventure continues



In the third edition of SKA South Africa's popular comic series, Hannah, the intrepid school reporter from Carnarvon, explores the involvement of our African partners in the SKA project. Download Mission Meerkat 1, 2 and 3 at http://www.ska.ac.za/education/mkcartoon.php

SKA SA bursar wins top UCT research award

SKA South Africa MSc bursary holder James Newling has been awarded a University of Cape Town (UCT) Research Associateship for 2011 for his thesis, entitled "Novel Methods of Supernova Classification and Type Probability Estimation". His work builds on the previous research of his thesis supervisor and collaborators, towards a better understanding of dark energy through observing supernovae. There were only 5 such awards made in the whole Science Faculty, and James' is one of only two at the MSc level.

His thesis supervisor Prof Bruce Bassett said the following about his talented student: "James did fantastic work for his MSc, leading a team that came second overall in the international supernova typing challenge. His research, which produced two first author papers, would be enough for a PhD in many places. We wish him the best with his future studies and expect big things!"

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