NEWSLETTER

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FROM THE SKA PROGRAM DEVELOPMENT OFFICE

As many of you will have noticed, the last six months have been another action-packed session in the life of the international SKA project. We have seen the Kick-off Meeting for PrepSKA Work Package 2 on the SKA design, good progress in developing the Reference Science Mission following the recommendations of the SKA Specifications Review Committee a year ago, a significant ramp-up of activity in Work Package 3 on site characterisation, a series of meetings in Washington on SKA governance and funding, and impressive progress on SKA-related R&D around the world. All these activities are described in more detail in this newsletter.

The WP2 Kick-off was particularly important in focusing attention on the primary issue for the international project for the next 3 or 4 years – the definition and costing of the SKA design. The approach proposed by the SPDO is to establish verification programs for the major sub-systems as part of PrepSKA in order to characterise and reduce the risk associated with particular technologies. These verification programs will be followed in the post-PrepSKA era by detailed design, production engineering & tooling, and then construction. During the next few months, we will be working with our partner institutes and organisations around the world to finalise collaboration agreements on the WP2 deliverables and timescales.

The SPDO itself is getting close to full strength now that most of the senior engineering appointments have been made. It has taken a long time to achieve (!), and points out yet again that recruitment of staff is not instantaneous and is a pacing item in the early development of projects. Let me introduce the new people to you in order of their arrival in the SPDO: Roshene McCool is the Domain Specialist in Signal Transport & Networks and comes from Jodrell Bank, Rob Millenaar is Site Engineer and is based at ASTRON in the Netherlands, Kobus Cloete is the System Engineer and comes from the SKA project in South Africa, Duncan Hall is Domain Specialist for Computing & Software and comes from the software industry in New Zealand, and Billy Adams is Project Management Officer and hails from the telecoms industry in South Africa. We are about to appoint a Manager for Industry Participation Strategy, and a Domain Specialist for Signal Processing. Many of you will have already met or heard from the SPDO staff, or will soon do so, communication and coordination being the lifeblood of the international project.

Looking through this newsletter, a number of items caught my eye as being of particular note in our “united nations of radio astronomy”. These include the bursary scheme in South Africa that has stimulated 90 post-graduate students and post-doctoral fellows and 29 undergraduates to get involved in the SKA project, the letting of a contract to a Chinese company for the manufacture and delivery of the 36 antennas for the SKA precursor in Australia, the addition of Portugal to the list of countries offering significant resources to the SKA, and the 800 square degree field being monitored for transient sources by the Allen Telescope Array in the USA.

The complexities of the policy issues confronting a global project like the SKA came into sharp focus at the Washington meetings in November attended by representatives of the Funding Agencies and Governments potentially involved in the SKA, SSEC and project members, and invited experts on governance in other scientific projects. It is clear that governance, funding, procurement policy, and site selection are all related issues, and a decision-making process needs to be agreed. The latter will, no doubt, be the subject of many future discussions!

There are many substantial challenges ahead of us including solving these policy questions and carrying out the Verification Programs in Work Package 2 in the time allotted. But I’m sure that the enthusiasm, focus and dedication shown so far will carry us through.

As part of the process, I hope to see many of you at the series of SKA meetings in South Africa in February.

Richard Schilizzi, Director

NEWS FROM THE PROJECT

WORK PACKAGE 2 ACTIVITIES

PrepSKA WP2 Kick-off Meeting, Manchester University
Nov 10-14, 2008

The purpose of the meeting was to provide a forum for face-to-face discussions on WP2 between the SPDO staff and representatives of institutions who will contribute to WP2, and to review the setup of Work Package 2. Members of the Science Working Group (SWG) and the Engineering Working Group (who were not already attending as institutional representatives) were also invited. Forty-seven people attended the meeting.

A summary of presentations, discussion points, and other information:

- Present and review the Reference Science Mission and discuss its implications for informing the SKA design – see SWG report below. Developing the RSM is still an on-going activity. A solid draft is expected in March 2009.
- Present, review and discuss how the 40 tasks in WP2 description of work could be carried out to achieve the main goal of producing a "Costed System Design" for the SKA by the end of PrepSKA. The SPDO presented plans that amalgamate many of these tasks into larger "Verification Programs" that can more easily be related to an overall telescope system.
- Present and discuss a top-down timeline implied by the combination of the goals of WP2 and the time available for PrepSKA. This timeline provoked quite a lot of discussion and some concern over the speed with which decisions on technology selection must be made. This timeline must be consistent with the goal of obtaining a well defined system whose cost can be estimated.
- Present and discuss the project management setup (documentation, reviews, etc.) that are planned for WP2 and hopefully will be used later. (At the time of the meeting we had not yet filled the position of Project Management Officer. This has now been filled by Mr William (Billy) Adams.)
- Present and discuss a model for delivery of the PrepSKA program via Memoranda of Agreement (MoA) with participating institutions. The purpose of these agreements is to fix deliverables from these institutions so that the SPDO has a clear idea of what to expect from the various work packages. Since the WP2 meeting a few of these have been drafted and sent to the appropriate parties for comment. The draft MoA contain quite detailed breakdowns of work, review points, etc.
- Present and discuss concurrent work in WP3 – site issues that impact the SKA design.
- Parallel discussion sessions were held in most of the key technology areas, led by the SPDO Domain Specialists – antennas feeds and receivers; data transport; software and computing; (digital signal processing was not covered because that position has not yet been filled). Notes from these meetings can be downloaded from the web site (see below) under the agenda item "Plenary – Presentation & Discussion, Issues arising from parallel sessions".
- Representatives of the contributing institutions were asked to make brief, informal presentations on what they were planning to do as a result of the meeting, and how they were going to proceed at their home institutions. Neil Roddis compiled a short document, WP2 kick-off meeting: brief outlines from contributing institutions, containing notes on these presentations, which can be found on the SKA website. After the meeting, the notes were circulated to the original contributors for editing.
- Some important input documents, containing much of the SPDO and

other material presented at the meeting, were released in advance, and are available on the SKA website.
- The agenda, presentations, list of attendees, and the outlines from contributing institutions can be found on the SKA website at (http://www.skatelescope.org/pages/presentations_WP2-Nov2008.htm)
- The SPDO plans to hold a similar WP2 meeting, October 29-31, 2009 (Thur-Sat), in conjunction with the SSEC3 meeting. Please note these dates.

Peter Dewdney
International Project Engineer and Chair EWG

SCIENCE

PrepSKA Work Package 2 Kick-off and State-of-the-Art

This meeting was held in Manchester (November 10–14). SWG participation included the presentation of the Reference Science Mission to the engineers responsible for the SKA design activities under PrepSKA WP2. There was also discussion by SWG members present about the Reference Science Mission, their experience in bringing instruments online, and the state-of-the-art performance of current generation telescopes. One of the key recommendations arising out of this meeting was that the SWG collect and document state-of-the-art performance for a series of technical parameters (e.g., integration time, image rms noise, …) as a means for providing a benchmark for SKA performance.

Activities involving the Science Working Group have been varied and include continuing refinement and expansion of the Reference Science Mission, organising a series of workshops that focus on the multi-wavelength and multi-messenger astronomical landscape to which the SKA will contribute, and participation in the PrepSKA Work Package 2 kickoff meeting.

Reference Science Mission

Following the recommendation of the SKA Specifications Review Committee (in January), the Project Scientist and SWG began development of a Reference Science Mission. The Reference Science Mission is intended to describe clearly the science requirements, and the resulting technical requirements, on a set of observations required to execute key components of the SKA Science Case. The Reference Science Mission is also intended to illuminate the "envelope" of the technical requirements for the SKA. Ultimately the Reference Science Mission will serve as input to an SKA requirements document. The term "Reference Science Mission" was chosen to align the SKA with other major projects (PanSTARRs, LSST, JWST, etc.), which typically have "Design Reference Missions," and to have a format consistent with generic NASA traceability matrices.

Current components for the Reference Science Mission include (and are listed in alphabetical order):

- **Astrobiology:** Search for organic molecules in molecular clouds and link them to proto-planetary disks; likely to require higher frequencies.
- **Cosmic Magnetism:** Understand the origin and evolution of cosmic magnetism; likely to require high polarization purity
- **Deep Continuum Field:** Probe the first galaxies and protoclusters; likely to require high sensitivity, high imaging dynamic range, and long baselines.
- **Deep H I Field:** Track the evolution of galaxies over a significant cosmic epoch; likely to require high sensitivity and high spectral dynamic range.
- **Galactic Center survey:** Probe the spacetime environment around Sgr A*, the central supermassive black hole in the Milky Way Galaxy; likely to require higher frequencies and high time resolution.
- **Galactic Plane survey:** Test theories of gravity using ultra-relativistic binaries in the Milky Way Galaxy's spiral disk; likely to require high time resolution.

- **H I Absorption survey:** Track the evolution of gas in galaxies to the earliest epochs; likely to require lower frequencies.
- **Wide Area survey (a.k.a. "all-sky survey"):** Various tests of theories of gravity, including studying gravitational waves using an array of millisecond pulsars and using baryon acoustic oscillations in the galaxy distribution as a means of exploring dark energy; likely to require high survey speed and high time resolution.

For all components, it is anticipated that the observations would be conducted so as to explore the largely unknown dynamic radio sky, consistent with the SKA design philosophy of "Exploration of the Unknown."

International Astronomical Union General Assembly

Preparations for the IAU General Assembly to be held in August in Rio de Janeiro, Brazil, are well underway. Many SWG members are on the Scientific Organizing Committees for different symposia, and we expect that the SKA will be widely and well represented.

Science Synergies

Members of the SWG are attending and organising many conferences and workshops, with more multi-wavelength or multi-messenger emphases, and presenting the science case for the SKA as well as science synergies with facilities across the spectrum. A sample includes:

SKA Continuum Imaging Workshop

This workshop will be held in conjunction with a variety of other SKA 2009 activities in Cape Town (2009 February 18–20). As the SKA moves into a more intensive design phase, its intended scientific observations need to be specified in more detail. Key aspects for the design are the scientific drivers and the technical implications of obtaining extremely high-dynamic range images in the continuum.

Astrophysics with E-LOFAR

This workshop was held in Hamburg, Germany (September 16–19) and focused on the discussion of scientific topics covered by the six LOFAR Key Science Projects, together with the associated technical and software development and possible synergies with other future instruments.

Black Hole Astrophysics with Radio and Gravitational Wave Observations

A workshop held at NRAO (November 7–8), this workshop focused on the study of supermassive black hole binaries, their role in galaxy evolution, and the impact of radio and gravitational wave observatories. The detection of gravitational waves is part of the SKA Key Science Projects, and the SKA was presented as one of the essential future steps toward the study of supermassive black hole binaries.

Great Surveys and The First Science with LOFAR Surveys:

The first was a workshop held at Los Almos National Laboratory (November 20–22) and which looked ahead to the next decade and explored the role of multi-wavelength surveys in the landscape of astronomy. The second is a workshop to be held at the Lorentz Center in Leiden (December 10–12) and which focuses on the science output from LOFAR surveys. Surveys are a crucial aspect of the observations needed to prosecute many SKA Key Science Projects, and numerous radio surveys and radio follow-up projects either were or will be presented as part of the suite of surveys needed over the next decade.

Galaxies Through Cosmic Time

The first in a series of workshops focusing on the EVLA (December 16–18), this workshop will focus galaxy evolution through cosmic time. Galaxy evolution is one of the SKA Key Science Projects, and observations with the EVLA will be crucial to refining the SKA science case.

LOFAR and the Transient Radio Sky

This workshop will be held in Amsterdam (December 15–17) and will focus on the role of LOFAR in exploring the transient radio sky. "Exploration of the Unknown" is a goal for the SKA, and radio transients represent one of the most promising areas of exploration for SKA and future radio telescopes.

Panoramic Radio Astronomy

During the first week of 2009 June, ASTRON, co-sponsored by the ATNF and the University of Cape Town, will host a meeting in Groningen, the Netherlands. The conference is concerned with the next generation of radio telescopes in the 1–2 GHz regime, such as ASKAP, MeerKAT, and Apertif.

The Monster's Fiery Breath: Feedback in Galaxies, Groups, and Clusters

This workshop will be held in Madison, WI, USA (June 1–5). Its goal is to explore the nature, strength, and ultimate relevance of the link between black hole growth and the formation of large-scale structure with next generation of low frequency radio telescopes, *Chandra*, and *Fermi*/GLAST.

Exoplanet Forum

An international group of astronomers has prepared an extensive document (http://exep.jpl.nasa.gov/exep_exForum.cfm) describing the various techniques for detecting and characterizing extrasolar planets, motivated by the recent Exoplanet Task Force report. The SKA is mentioned in two chapters, one for detection of the magnetospheric emission of extrasolar planets and the other on astrometric studies. While neither form a key science driver for the SKA, it is important that the larger community recognise that the SKA will deliver scientific results beyond its main scientific foci.

Joseph Lazio
International Project Scientist and Chair SWG

SITE CHARACTERISATION

Site characterisation is an important aspect in preparing for the SKA, and also towards a well balanced final site selection process. Work Package 3 in PrepSKA deals with these issues, ranging from radio interference minimisation and prevention, to characterizing the ionosphere high over the site to down below the surface.

PrepSKA Work Package 3

At the SPDO the Site Engineer has been working on “Further Siting Issues”, which is the working area for WP3 of PrepSKA. Since the beginning of September many of the topics that are on the list of investigations for the work package have been started up or continued. With the help of representatives of both short listed sites, Australia and South Africa, information in the broadest sense is being gathered to characterise the sites. The activities that are currently taking place are summarised here.

First of all, a Site Characterisation Working Group (SCWG) has been put together with members from the two candidate sites as well as the ASTRON institute, the chairs of the SPDO Operations and Simulations Working Groups and other experts involved in site characterisation. It is chaired by the SPDO Site Engineer, and the SPDO Project Engineer and Director are ex-officio members. The SCWG will assist the Site Engineer in the coordination of the additional studies needed to further characterise the two sites before the final selection is made. The SCWG’s first teleconference was held recently and a meeting will be held in Cape Town in February 2009.

In 2005 and 2006 RFI monitoring campaigns were undertaken in order to investigate the Radio Frequency Interference environment at the, then, 4 candidate sites. Recognizing that the RFI environment is such an important parameter for assessing the quality of a site, it was decided that an extra survey was to be undertaken at the two remaining candidate sites, but now at much higher sensitivity. In fact, the target sensitivity that is specified is close to the golden standard against which RFI levels are judged: the ITU RA769 levels. This is not an easy task: reaching such a high sensitivity, using uncooled commercial-off-the-shelf (COTS) hardware preferably, is very difficult. In addition, traditional swept mode spectrum analyzer based methods would be far too slow to complete the survey in a reasonable amount of time. Engineers from Australia, South Africa, ASTRON and the SPDO, together forming the RFI Monitoring Task Force within the SCWG,

have come up with a design of the equipment and methods, that facilitate these requirements, maximising the sensitivity while keeping the cost down. Design and construction is going on presently, on RF electronics in South Africa and a digital spectrometer backend in Australia. Both parts will be integrated in two separate RFI monitoring trailers, which will subsequently be put to work at both sites in 2009. Watch these pages for progress reports on these activities.

Within the SCWG a group of experts on spectrum regulatory issues has been brought together in the form of the RQZ and Spectrum Management Task Force, with representatives from the SPDO, Europe, the US, South Africa and Australia. The candidate countries are currently setting up their Radio Quiet Zones (RQZ) for their SKA pathfinder instruments, but are also working with the international community on rules and guidelines for establishing RQZs. The work within ITU Working Party 7D is of importance here. The Task Force will further guide these activities. A well working RQZ, together with a long term active frequency management involvement is essential for maximising the science output of the SKA in the early stages, but certainly also to keep it that way during the entire life of the instrument.

The ionosphere above the sites is of great importance for the quality of observations that can be expected, during all solar cycle phases, especially at the lower frequencies. We are fortunate enough that it is very likely already that we are investigating the Earth's two best locations that are available on the sparingly available large landmasses at the desired Southern latitudes. A great deal of information has already been collected and reported earlier concerning the variations in Total Electron Content (TEC) measures. WP3 specifies that more information should be made available concerning the ionospheric scintillation properties and also the occurrence of Travelling Ionospheric Disturbances (TIDs) over the sites. Further studies have been initiated and reports based on model data have been prepared.

In recent months work has been done on the aspect of array configurations in cooperation with the SPDO Simulations Working Group. Case studies of the placement of antennas in an optimal configuration were already undertaken for the proposals that were submitted by the candidate sites in 2005. Now, additional studies will be built on these foundations to come up with configurations that have good properties, as based on a suite of Figures of Merit, and that can physically be placed in the field, in good RFI conditions and with good economic possibilities. Within WP3 work needs to be done on some of these aspects.

Physical and environmental characteristics are also part of the work package, and reports are being produced to inform designers about the environmental conditions, such as the climate, at which their designs will have to be deployed. The sites feature extremes in temperature, humidity and wind and dust conditions. Also soil conditions are of prime importance to the feasibility of digging trenches for power and fibre cables.

Rob Millenaar
SPDO Site Engineer, and Chair SCWG

OUTREACH

Membership

We are very pleased to welcome Mary Mulcahy, Communications and Outreach Manager of the Australian Telescope National Facility, to our committee. She has taken over from Helen Sim who has given sterling service to the committee for several years. The committee would like to express their thanks to Helen for her contribution to its work and look forward to our links with Mary.

Brochure, Poster and animations

The updated SKA Brochure was given a print run of 8000 copies in India and distributed world-wide. The SPDO holds a reserve of copies and will be happy to supply these to promote the SKA at

conferences and other events. Please contact Lisa Bell to request copies. A new print run of the A4 fold out poster has been made and, again, please contact Lisa should you wish to make use of them. It folds out to an A2 poster of the SKA central core on one side with information about the SKA across 4 A4 pages on the other.

SKA Animation

A shortened version of the SKA animation has been placed on the SKA website in a number of formats which you may find more useful than the full length version when giving presentations. It lasts 1 minute 24 seconds, about half that of the full length version. It is planned to produce a new animation which would have a different layout of the central core. In the current version, the phased array is shown at the heart of the core surrounded by a ring of dishes. It now seems likely that the phased array will be placed at some distance from what would be a fully filled circular array of dishes whose density would gradually reduce from the centre. When the central core design is sufficiently well specified we will produce a new animation to more closely represent how the SKA is likely to appear.

Posters

The Outreach Committee offers to produce posters; either the artwork for local printing or the final laminated poster, for any use to help promote the SKA. A poster template has been produced which can include appropriate material as required. Please contact the OC Chair if you require a custom SKA poster designed to support your work at meetings or conferences.

Website

We are well aware that there is plenty of scope for improving the user experience for visitors to the website and so it is intended to redesign the website in the near future. To kick off the revamp of the website, a questionnaire was circulated as part of the process to consult users about the changes needed. We intend to move to a more dynamic website that will be easier to maintain and to keep the content up-to-date. The design and functional specifications of the new website are now being established and web consultants will shortly be engaged to develop the new website.

Exhibitions and Conferences

In September, the SKA was well represented at a one day UK conference to bring large scientific projects together with representatives from industry. This was to alert possible industrial partners to the fact that major contributions will be needed by them as the SKA nears its initial construction phase.

In December, Phil Diamond, Ian Morison and Lisa Bell represented the SKA at a major European conference for scientific administrators involved in big science and were able to distribute brochures and posters and generally lift the profile of the SKA amongst many significant members of the EU funding agencies.

Figure 1. The SKA stand at the ECRI Conference in Paris, December2008

Ian Morison
Chair Outreach Committee

MEETINGS

Future Meetings

Electronics Knowledge Transfer Network, "SKA – Phased Array Antennas"
Manchester, GB (10 February 2009)

Power Investigation Task Force meeting
Cape Town, ZA (pm - 17 February 2009)

Community Workshop on High Dynamic Range Continuum Imaging with the SKA
Cape Town, ZA (18-20 February 2009)

Visit to SKA candidate site
Cape Town, ZA (20-22 February 2009)

SSEC Executive Committee (XC-SSEC) meeting
Cape Town, ZA (pm - 22 February 2009)

SKA Science and Engineering Committee meeting - SSEC 2
Cape Town, ZA (23-24 February 2009)

International SKA Forum
Cape Town, ZA (25 February 2009)

Informal Funding Agencies Group meeting
Cape Town, ZA (am - 26 February 2009)

PrepSKA WP5 (Procurement) Workshop
Cape Town, ZA (pm - 26 February 2009)

Site Characterisation Working Group meeting
Cape Town, ZA (pm - 26 February 2009)

PrepSKA Board meeting
Cape Town, ZA (am - 27 February 2009)

SKA Configuration Simulations and Optimisations
Manchester, GB (12-13 March 2009)

MCCT Workshop: Multifield and multibeam science with SKA
Oxford, GB (16-27 March 2009)

Calibration & Imaging Meeting (CALIM 2009)
Socorro, USA (30 March – 2 April 2009)

European Week of Astronomy and Space Science (JENAM 2009)
Hatfield, GB (20-23 April 2009)

International Engineering Advisory Committee (IEAC)
Manchester, GB (29-30 April 2009)

IEEE International Symposium on Antennas & Propagation
& USNC/URSI National Radio Science Meeting
Charleston, USA (1-5 June 2009)

Panoramic Radio Astronomy Wide-field 1-2 GHz research on galaxy evolution
Groningen, NL (2-5 June 2009)

International Astronomical Union (IAU)
Rio de Janeiro, BR (3-14 August 2009)

SSEC3
Manchester, GB (26-28 October 2009)

PrepSKA WP2 Meeting
Manchester, GB (29-31 October 2009)

NEWS FROM THE CONSORTIA AND INSTITUTES – SUMMARY

The reports that follow from around the world describe a large number of exciting developments that show progress towards the SKA is quickening its pace! Below is a brief summary of the various articles which I hope will wet your appetite to read the full versions.

Ian Morison

Australia

The contract for the thirty-six 12m antennas to build the ASKAP array has been given with a cost per telescope of $300,000 per antenna - meeting a key cost target.

A new International Radio Astronomy Research Centre is to be established in Perth with Prof. Peter Quinn as its first director. It will undertake pure radio astronomy research, new ICT and engineering systems.

The Murchison Widefield Array, located at the Australia SKA candidate site is making rapid progress. Currently 32 "tiles" spread over a 300m diameter area are beginning to make test observations of the Sun. It is expected that the array will be expanded to 265 tiles by the end of this year with a further 256 tiles installed by the middle of 2010.

Canada

Canadian engineers have built a second composite 10m radio telescope whose 0.5mm rms surface accuracy significantly improves on the first. In October 2008 a phased array consisting of 212 Vivaldi elements was placed at its focus and tests are being made of its performance using geostationary satellites and bright astronomical sources as targets.

China

A new simulation exercise has suggested a significant change to the design of FAST and a small scale model of the telescope is now being built to test the new ideas in practice. Reflector panels and actuators that will make up the active surface are also undergoing testing.

Europe

SKADS

Results from the SKADS project are now being published and a set of 16 tiles for the EMBRACE aperture array demonstrator is now being tested. All being well, the "green light" will be given for full EMBRACE production. The full array will consist of 144 tiles within a radome at Westerbork and be equivalent to a 15m single dish in effective aperture. A 64 tile array is also to be built at Nancay, France and both should be up and running by this summer.

LOFAR

Installation of the first full LOFAR station is now underway and by this summer the project expects to have 13 stations in the central core with a further 7 stations extending out to 30km. 3-4 European stations are ready for commissioning with work on the Garching and Tautenburg LOFAR sites well under way. In parallel, the LOFAR processing supercomputer has been upgraded and is expect to be at full capability by the time the LOFAR stations are completed.

JIVE

Work continues on the Astronomical Data Simulations project. Given actual measurements for the Vivaldi elements a model for the element beam has been determined and used to simulate the response of an EMBRACE station beam.

South Africa

The SKA project has been given very firm support from the South African Government which has so far invested more than ZAR 750 million. The South African SKA pathfinder MeerKAT "will provide a fantastic instrument and "is a done deal irrespective of whether SA wins the SKA bid or not". "With the SALT optical telescope, local astronomers will be in an extremely fortunate position". A SKA Project Bursary Conference has been judged a great success and, impressively, the South African SKA project will have funded more than 90 postgraduate students as well as 29 undergraduates.

USA

Technology Development Project

This is now in its second year and will serve as a clearing house for antenna work done around the world, establish a uniform feed testing program and investigate the optimum optics to accommodate both single pixel and phased array feeds.

Expanded Very Large Array (EVLA)

Currently on schedule, the project aims to complete the conversion of antennas to the EVLA design by the autumn of 2010 with the new EVLA WIDAR correlator completed by the spring of that year. It is expected that the final receivers will be installed in late 2012 to bring the project to

completion. In a significant milestone, first fringes from two EVLA antennas using a prototype WIDAR correlator were achieved on August 7th 2008.

Long Wavelength Array (LWA)

JPL has joined the project and is designing the beamformers and digital receivers for the LWA stations. Prototypes for most other aspects of the project have been built and tested in the field. Construction of the first LWA station is scheduled to start in the summer.

Allen Telescope Array

Over the last year, the ATA team has been busy commissioning the 42-antenna array and making a number of minor mechanical and electrical retrofits to improve the reliability of the antennas. As part of the USA SKA Technical Development Program, improvements are being made to the wide band feeds and low noise amplifiers. Significantly, test signals form the Voyager 1 spacecraft, now ~100 AU from Earth have been easily detected. Observations in the hydrogen line of some galaxy clusters and new dwarf galaxies are already demonstrating its capability.

Murchison Widefield Array (MWA)

After a period of substantial progress at the site, observations of many celestial objects were made in an observing run using 26 tiles and 4 digital receivers. The full MWA 80-300 MHz frequency range was utilised. A 32 tile system is to be tested and verified in preparation for large scale replication this year.

Precision Array to Probe the Epoch of Reionization (PAPER)

Over the past year, significant improvements have been made to the efficiency of the individual receiving elements which now have an effective collecting area of 7 square metres. Progress in signal processing is also advancing rapidly with the deployment of a new 8 antenna correlator. The project is preparing for the deployment of a 64 antenna PAPER experiment at the Murchison site in Western Australia for initial operation during the autumn of 2009.

NEWS FROM THE CONSORTIA AND INSTITUTES

AUSTRALIA

CSIRO lets major antenna contract for ASKAP

CSIRO announced on 3 November that the major contract for the antennas for ASKAP was awarded to the 54th Research Institute of China Electronics Technology Group Corporation (known as CETC54). CETC54 will supply thirty-six 12 m antennas for A$10 million, meeting a key cost target of under $300,000 per delivered antenna.

CETC54 is a state-owned institution established in 1952. It has undertaken thousands of government and commercial projects in satellite communication, tracking, telemetry and control, and has designed and built the 50-m Miyun radio telescope for receiving data from China's Chang'E1 satellite. The institute is headquartered in Shijiazhuang, in Hebei province, about 200 km south of Beijing.

Mary Mulcahy, CSIRO ATNF

Opportunities for Industry on $100M Radio Telescope

In September 2008 Senator Kim Carr, Minister for Innovation, Industry, Science and Research, launched a register of the opportunities available to industry to participate in building the Australian Square Kilometre Array Pathfinder (ASKAP) radio telescope.

The ASKAP Industry Opportunities Register outlines the technology and infrastructure requirements to 2012 in areas where industry partnerships are needed. The opportunities for industry

participation will be in the vicinity of $70 million of budgeted projects.

"The Industry Opportunities Register reflects CSIRO's commitment to working with industry to provide innovative and value-for-money solutions for ASKAP and potentially for the SKA," Professor Brian Boyle, CSIRO's Australia Telescope National Facility director, said.

Figure 2. ASKAP Theme Leader Dave DeBoer with prototype receiver for the Parkes testbed focal plane array

"The register is important to businesses with the capacity to contribute to the Pathfinder telescope and, in time, the SKA radio telescope," Professor Boyle said.

John Humphreys, Chair of the Australian SKA Industry Consortium, said that "the information in the register will be essential for planning and understanding the ASKAP technology pathway."

To access the ASKAP Industry Opportunities Register visit: (www.atnf.csiro.au/projects/askap/industry or email: ASKAP-contact@csiro.au)

Mike Bryson, SKA Taskforce, Department of Innovation, Industry, Science and Research, Commonwealth Government

Murchison Widefield Array Update

Over the last six months, the Murchison Widefield Array (MWA) project has been making rapid progress at the Murchison Radio-astronomy Observatory (MRO), Australia's candidate site for the core of the SKA located in the Mid West of Western Australia. The MWA is a low frequency (80 – 300 MHz) telescope and is funded by a consortium of Australian and US universities and national research organisations (Raman Research Institute in India and the CSIRO in Australia). Goals for the MWA include Solar, Heliospheric and Ionospheric (SHI) research, detection of the Epoch of Reionisation (EoR), Galactic and Extragalactic (GEG) science, and the search for transient radio events.

Since July, the MWA project has run monthly visits to the MRO to install antennas, receivers, data recorders and an interim software correlator. At the end of November the MWA consisted of 32 "tiles" distributed over an approximate 300 m diameter area within the Early Research Area (ERA) of the MRO. Each tile is constructed of a steel mesh ground-plane and a 4 x 4 grid of low frequency dipole antennas (Figure 3).

Figure 3. An MWA tile in the field, showing the ground-plane and the 16 dipoles. Credit: Steven Tingay

Signals from the 16 dipoles on each tile are combined to form a directional beam on a celestial target, before being distributed to a receiver (that converts the analogue radio signals into digital signals). Each receiver processes the signals from 8 tiles; therefore the 32 tile system requires 4 receivers. Currently these 4 receivers reside in a radio frequency interference (RFI) screened room, with laboratory work space provisioned in a separate building (Figure 4).

Figure 4. The MWA screened room (right) and laboratory space (left) at the MRO. Credit: Steven Tingay

A data acquisition rack is also located within the screened room with server-class PCs recording the digital signals produced by the receivers.

Following the installation of the system, test science observations were made of the Sun. At the moment the Sun is in its quietest Sun spot state in almost a century, making low frequency observations of the quiet sun very interesting (the Sun is a strong and detectable radio source, even in its quiet state).

Science and engineering test observations will be made with the current system between December and February 2009. By approximately May 2009 a full end-to-end 32 tile MWA system will be operational. The MWA project goals call for an expansion of the system to 256 tiles by the end of 2009 and up to 512 tiles by the middle of 2010.

The step from prototype to mass manufacture for the MWA is being explored in conjunction with industry partners.

Prof. Steven Tingay, MWA Project Manager, Curtin University of Technology, WA

NASA award to ASKAP Scientist

The US space agency NASA has announced that CSIRO research scientist, Dr John Bunton, is to receive a NASA Space Act Board Award for research into the development of a novel 'beamformer' capable of providing a live video link from Mars.

Dr Bunton is a senior member of the CSIRO ICT Centre Wireless Technology laboratory, and Project Engineer for ASKAP. He was originally asked to provide an assessment of the NASA-developed Deep Space Array Based Network beamformer, but decided instead to suggest a totally new design that would provide a better solution.

Dr Bunton's beamformer uses novel frequency domain architecture in which the video signal data is divided into narrow channels and transported to beamformer boards. Each board sums the narrow channel data from all 400 antennas. This data can then be reconstructed back into a broadband signal.

Dr Bunton's expertise in beamformer design is also being put to good use in his role as ASKAP project Engineer and lead Scientist for the ASKAP Digital Systems team.

Diana Londish, CSIRO ATNF

International Centre for Radio Astronomy Research

The Western Australian Science and Innovation Minister Troy Buswell announced in December 2008 the establishment of an International Centre for Radio Astronomy Research (ICRAR), a joint venture between the University of Western Australia (UWA) and Curtin University of Technology. The centre will be based in Perth with a branch at Geraldton, in the State's Mid West region.

UWA's Professor Peter Quinn, has been appointed centre director, together with deputy directors Professor Lister Staveley-Smith (UWA) and Professor Steven Tingay and Professor Peter Hall, both leading radio astronomers based at Curtin.

ICRAR aims to play a leading role in scientific and technical programs supporting the Australian SKA Pathfinder and the SKA.

The centre will add to Australia's already significant radio astronomy research capability, undertaking pure radio astronomy science and developing new ICT and engineering systems.

The $20 million State Government funding for the centre will contribute towards:

- the employment of scientists and technicians to undertake radio astronomy research and development;
- developing new software and technologies;
- developing radio astronomy-related industry capability;
- undertaking public outreach and education programs; and
- creating national and international linkages and partnerships in radio astronomy and the SKA.

Jonathon Jones, Dept of Industry and Resources, WA Government

Outreach and Education

Visit to Pia Wadjarri Remote Community School

Outreach staff from CSIRO ATNF and Curtin University visited Pia Wadjarri Remote Community School in early October. Students from Yalgoo Primary School travelled up for the day and stayed overnight. During the afternoon students participated in activities on the solar system, made balloon rockets. Unfortunately the evening turned cloudy and so the viewing night was cancelled.

Highlights included meeting a number of teachers and educators in Geraldton; and working with a fantastic group of teachers and students from Yalgoo and Pia Wadjarri remote community schools.

Mary Mulcahy, CSIRO ATNF

AstronomyWA November Tour

AstronomyWA treated students, teachers and community members in Northam, Geraldton and Kalgoorlie to an experience that was out of this world. Funded by ASISTM (Australian School Innovation in Science, Technology and Mathematics) the week-long regional tour included workshops for teachers and "Observing on the Oval" public viewing nights delivered by CSIRO Education Officer Rob Hollow and AstronomyWA coordinator Pete Wheeler.

Eminent astronomer and science communicator Professor Fred Watson explored space tourism as a reality and the recent interest in planetary investigation in a series of public lectures. He also gave audiences an insight into his award winning book, "Why is Uranus upside down?"

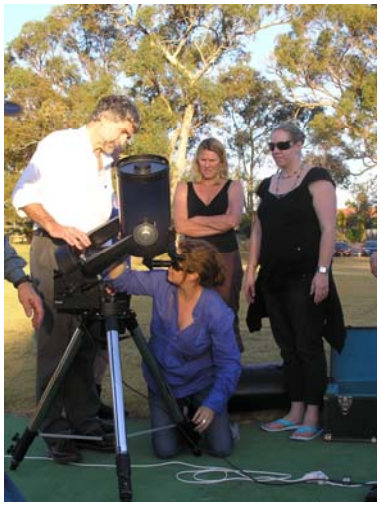

Figure 5. Regional Tour Photo - Right to left: Murray Thomas from Shenton College and Teachers from Halls Head Primary School participating in an 'Observing on the Oval' event in WA. Credit: Scitech

Jonathon Jones, Dept of Industry and Resources, WA

CANADA

First-light for the Canadian New-Technology Telescope system

Figure 6. Is this what an SKA dish will look like? The 10-m Mk2 CART reflector with the PHAD phased-array demonstrator feed at the focus that were completed by NRC-HIA DRAO in Penticton during in October 2008.

In recent months Canadian engineers at the National Research Council (NRC) Herzberg Institute have made great strides in the development of new technology for the SKA. In the summer of 2008, the CART (Composite Applications for Radio Telescopes) team at DRAO completed a second prototype composite dish, the Mk 2. The Mk2 has a 0.5 mm rms surface accuracy that improves significantly on the Mk1 produced last year. The CART team will continue analysis of the surface to fully characterise the performance of the reflector through temperatures changes through the year.

The second significant accomplishment is PHAD, the Phased-Array Feed Demonstrator that was installed on the Mk2 reflector in October. The PHAD array consists of 212 Vivaldi elements, with 180 active elements designed to operate at 1-2 GHz. The signals are fed to single-chip receivers that convert radio signals to baseband. A set of 84 outputs (42 polarisation pairs) are transmitted off the feed for digitisation and off-line processing and beamforming. The array has been subjected to a series of on-the-sky tests using geostationary satellites (Figure 8) and bright astronomical sources. These tests are to determine the system temperature of the array, system stability, and suppression of ground radiation through beamforming.

Figure 7. PHAD at the focus (radome removed)

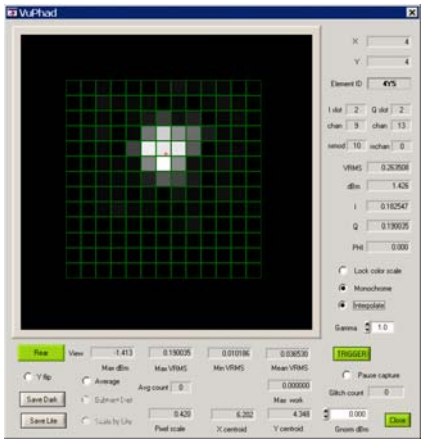

Figure 8. Raw image of a satellite detected with PHAD

What comes next? Our eyes are on the PrepSKA effort and the construction of a verification system. The CART team is working on parameter and cost studies related to novel optical layouts and integrated mounts. Manufacture of these

designs on SKA scales is being explored, with an investigation of multi-piece composite reflector options by Jan Kragt from ASTRON in the Netherlands, who has been seconded to the CART team for a year, and a detailed analysis of the complete manufacturing process required for an SKA. With many synergies in this R&D area, DRAO is starting to work in closer collaboration with the TDP to maximise development in reflector technologies.

Once the initial sky tests are completed, the PHAD system will evolve into a true low-noise receiving system with the integration of the University of Calgary room temperature CMOS low-noise amplifier chips onto the Vivaldi elements. This is a vital step in determining the sensitivity capabilities of array receiver systems.

Astronomy Technology Research Group, NRC-HIA DRAO

CHINA

Progress of the new cabin suspension FAST model

The FAST concept has been the subject of a full simulation to evaluate its performance. This has resulted in a new baseline design for the FAST cabin suspension which is significantly different from the current model. To verify its conclusion, a model of the new cabin suspension is now being developed at Miyun station: a sketch of the design shown is shown in Figure 9. The new model will test the feasibility of several important design concepts that the simulation has shown to be very promising. These include:

- Suspension of the focus cabin by six cables and towers;
- Power savings by the use of elevator-type counterweights on the six towers;
- Compensation of the difference between the natural and required tilt with a “slow” X-Y positioner;
- Compensation of the remaining wind influence via a “fast” Stewart platform.

Other key technologies will also be tested and verified via the new demonstrator as, for example, the support of power supply cables and the influence of tower compliance on the positioning accuracy of the whole system. Since the highest tower in the prototype might be more than 150 metres, the tower compliance cannot be ignored. Figure 10 shows the construction of a compliant tower on site, compared with a highly stiff tower constructed before, seen standing nearby.

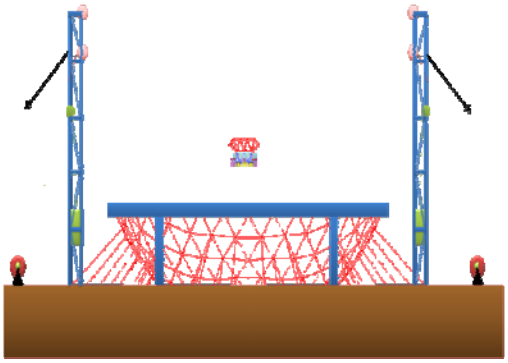

Figure 9. Design of the new suspension of FAST model

Figure 10. Construction of a new compliant tower on site

Progress of FAST reflector unit experiment

The reflector units and actuators to be used in the FAST prototype are still in development. Recently, a new reflector unit has been finished, as shown in Figure 11. Three reflector units have now been be in place at the Miyun Observatory experiment site of NAOC for some time and the tests and resultant analysis of, for

example, their rigidity and surface error, have now been completed. As a result, we found that it is possible to control the curve and deformation of the unit by introducing a modulating screw acting on the central part of the supporting shelf. Exposed in the atmosphere, the erosion proofing of the shelf and reflector surface, made of the Aluminium and steel composite metal, have been also been subject to tests.

Figure 11. The 1-1 scaled reflector unit of FAST prototype

A series of the indoor tests on the two new actuators, revealed some design bugs which are to be corrected shortly. Figure 12 shows the appearance of the revised actuator.

Figure 12. A new kind of the tested actuator

NAOC, China

EUROPE

SKADS

Results from the SKADS project are now being published, and preprints can be found on our website (http://www.skads-eu.org/p/memos.php) The science simulations have reached a significant level of maturity, as can be seen from the publication list and the simulations and tools are available to the wider SKA community through the website hosted at Oxford. The page can be found from the astronomy section on the SKADS website (http://www.skads-eu.org/p/s-cubed.php)

EMBRACE

Production is now underway of the "null" series of tiles for the EMBRACE aperture array demonstrator. This is a set of 16 tiles and the first integrated tiles are expected at ASTRON in mid January 2009. These initial tiles will undergo a week of intensive electronic check-out, and all going well, the "green light" will be given for EMBRACE production. While waiting for the full array, we will begin work on a smaller version of 3x3 tiles to be installed in the new radome at Westerbork (Figure 13 & 14). The full EMBRACE array will consist of 144 tiles in the radome at Westerbork. With each tile having a geometric area of 1.12 sq. metres, we expect EMBRACE to have an effective collecting area of over 160 sq. metres (roughly equivalent to a 15m single dish). There will also be a 64 tile array built at Nancay, France, and we expect both arrays to be up and running by the summer 2009.

Figure 13. The new radome at Westerbork is setup between antennas 4 & 5 of the WSRT. It covers an area of over 160 sq. metres. There will be a 12x12 tile aperture array setup inside, with the first tiles to be installed in January 2009

Figure 14. Inside the radome, beams of composite material are used to make the platform for the tiles European Plans after the end of SKADS

As we move into the final year of SKADS, discussions have already begun on the next step beyond SKADS, and this is the Aperture Array Verification Program (AAVP). AAVP will continue the aperture array development program of SKADS and deliver its results to PrepSKA. Before the start of the 4th SKADS Workshop, we had a visit to the Portuguese site where the world's largest Photovoltaic power station is being built (Figure 15). The group photo includes representatives from Evora University, the Institute of Science and Technology (IST) in Lisbon, the Institute of Telecommunications (IT) in Aveiro, ESKAC (the European SKA Consortium) and SKADS. They are standing in front of one of 2500 solar trackers which gives an idea of the size of the entire installation. Each one-axis solar panel is 141sqm, which is just 15% smaller than the EMBRACE test aperture array now being set up at the Westerbork site. The plant is already delivering to the power grid, on the order of 46MW this year. Its collecting area is close to 350.000 sqm. and its sheer size gives a distinct feel of how big the SKA will be! Obviously, renewable energies like this may become essential for the operation of the SKA.

Figure 15. SKADS collaborators were invited to visit the MOURA solar power generation station in Portugal on 1 October. MOURA will be one of the largest such stations in Europe, and demonstrates the possibility of using solar energy for a "Green SKA".

New Version of the SKADS Benchmark Design and Costing

In SKA Memo 93 we introduced the main concepts of the SKADS vision for the SKA. Following a specifications review by the international project, culminating in the publication of a preliminary ISPO/SPDO specification for the SKA (SKA Memo 100) we have revised the SKADS vision to keep it in line with the international expectations for the SKA. Essentially, the SKADS vision of the SKA matches the Phase 2 Aperture Array scenario (option 3c) of Memo 100. The resulting system design is described in detail in the updated version of our document and we also highlight the way in which some parameters are likely to drive the system design and costs.

This work has been conducted using information from throughout the SKADS project and using some costs from the early costing tool, SKACost. SKADS is currently working in collaboration with the SPDO to develop a more sophisticated costing tool: this has not been used to determine the costs and scaling relations in our latest document, instead we have

used an updated version of the spreadsheet approach that was used in Memo 93. In future, it is anticipated that the new costing tool will be used to determine cost and performance trade-offs with greatly improved functionality compared to a spreadsheet.

The new SKADS Design and Costing memo will be available as an International SKA Memo. Meanwhile, it is available from the SKADS website (Benchmark section) at the following link: (http://www.skads-eu.org/p/benchmark.php)

4th SKADS Workshop in Lisbon

Our newest SKADS partner, Portugal, hosted our 4th Workshop on 2-3 October, 2008. It was held in Lisbon at the Instituto Superior Tecnico, home of the Multidisciplinary Centre for Astrophysics (CENTRA). The two-day workshop was the forum for nearly fifty presentations, with an accent on the final deliverables of SKADS. The workshop marks the beginning of our final year of EC funding for SKADS, and the presentations showed that we are on-track to honour the promise of SKADS, and deliver results and hardware demonstrators which will be input to an overall, detailed design proposal for the SKA.

The conference dinner was held at the beautiful restaurant Casa do Alentejo. The restaurant is nestled in the old centre town of Lisbon amongst buildings with decorative ceramic tiles, and the streets, reserved for pedestrians, are paved with the polished white cobble stones typical of Lisbon. The restaurant itself was particularly well chosen for another reason. The Alentejo region is the site of the proposed Aperture Array Verification Program, and is home to Europe's largest solar power generation station which can demonstrate the feasibility of using green power for the Square Kilometre Array.

Presentations and pictures from the 4th SKADS Workshop are available on our website at (http://www.skads-eu.org/LisbonWorkshop/)

Figure 16. The SKADS 4th Workshop conference dinner at Casa do Alentejo

Marie-Curie Conferences and Training

The Marie-Curie Conferences and Training program is in full swing, with six events having already taken place, and several more to come before the end of the SKADS program in less than a year. Two workshops held during the summer of 2008 are described below. The next workshop, "Multifield and multibeam science with SKA" will be held at Oxford from 15-27 March 2008.

MCCT-SKADS Deep Field Imaging with SKA

The 2nd MCCT-SKADS astronomical workshop was hosted by the University of Cambridge from 25-29 August 2008. The workshop attracted 25 young researchers as well as 17 keynote speakers from EU and non EU countries. This was a valuable workshop looking at deep field imaging in the context of the SKA and other future instruments such as LOFAR and eMERLIN. As such, the talks focused on the new science that these very deep observations would make possible and the data processing challenges that would have to be met to fully exploit the instruments. The workshop gave many early researchers the opportunity to give short talks in line with the workshop theme and three panel sessions were held on the subject of “SKA for the user.” These sessions allowed a good exchange of ideas on what kind of data flow should be used for the SKA, and how flexible would the overall interface need to be, given the primary limitation of the size of the data.

An excursion to the Mullard Radio Astronomy Observatory (MRAO) at Lord’s Bridge was organised to give participants the chance to see both the very early radio

telescopes used by Nobel laureates Ryle and Hewish to do earth rotation aperture synthesis and newer instruments being used today. The response to the workshop was very positive by all those who participated. We organised many social events along with the daily lectures to produce an environment where researchers could easily exchange ideas. More information can be found at (http://www.mrao.cam.ac.uk/projects/skads/mcct/index.html)

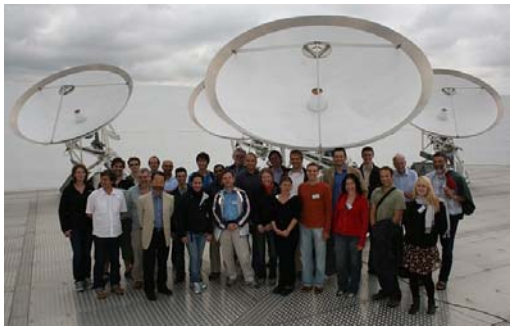

Figure 17. Participants at the Cambridge MCCT workshop.

MCCT SKADS Radio Astronomy: fundamentals and the new instruments

From August 26th to September 4th 2008, the 2nd MCCT-SKADS School on Radio Astronomy was hold in Sigüenza (Spain). This 2nd issue of the school was hosted and organized by the National Astronomical Observatory of Spain (OAN) and the University of Alcalá Foundation (FGUA). 32 young researchers from all around the world attended the lectures given by 19 radio astronomers and engineers from the OAN and other European institutes, universities and observatories. The title of the school was "Radio Astronomy: fundamentals and the new instruments", to very much reflect the topics covered in the different sessions. The first week was devoted to the fundamentals of Radio Astronomy, from the basics of the equation of transfer to the mathematical framework of aperture synthesis. On the second week, lessons focused on the new radio telescopes are will come online in the near future, paying special attention to the SKA, for which both technical requirements and characteristics, and the scientific program were outlined.

In spite of the tight program of the school, after the sessions and during the weekend, both lecturers and students could enjoy the medieval city of Sigüenza and its surroundings. The school indeed developed a very smooth and friendly atmosphere, which very much favored the exchange of ideas between both young and senior participants. I am quite sure that this school will not be easy to forget for all of us, organisers, lecturers and attendees. For further information, please visit the local web pages of the school at (http://mcct-skads.oan.es/)

Figure 18. Participants at the MCCT school in Sigüenza.

Steve Torchinsky
SKADS Project Scientist

LOFAR

Over the last couple of months, LOFAR has undergone an important transition from its design phase to the rollout of the actual station and central processing hardware. All tenders for the station hardware have been closed and orders for the various components have been placed with the selected companies. Groundwork in the LOFAR core has been underway since mid-July in preparation for the placement of the first stations. Similarly vendors for the central processing (CEP) systems including the wide-area network (WAN) equipment and post-processing cluster have been selected with hardware starting to arrive. Most dramatically, the project also completed the upgrade of the LOFAR correlator to a BG/P supercomputer over the summer.

As the final LOFAR station hardware begins to be delivered, the preparatory groundwork in the core area close to Exloo continues to progress. This central 200m core (shown in Figure 19) will be developed as part of a nature preserve

and will contain 6 individual LOFAR stations as well as functioning as a single "super-station". Work has also begun on a number of station locations outside this central area. Due to delays in the delivery of various hardware components, installation of the first full LOFAR station is expected to begin in December 2008. Installation of the subsequent stations should continue from then on. In any event, by summer of next year, the project expects to have 13 stations in the core, 7 stations outside the core up to distances of 30km, and 3-4 European stations ready for commissioning. In fact, work on the Garching and Tautenburg LOFAR sites in Germany are well underway.

Over the summer, the LOFAR project also upgraded the BG/L supercomputer to a BG/P model. This upgrade was necessary due to the discontinuation of the maintenance contract for BG/L systems. Although originally expected to take 3-4 months for the hardware replacement and software porting activities, with the help of personnel from IBM and the University of Groningen, the replacement went smoothly and was accomplished in only 2 months. First test correlations of CS1 (Core Station 1 – the current LOFAR test facility) data have shown that the correlator works as before, although currently with limited bandwidth. The performance of the correlator software will be improved over the next few months and is expected to be at full capability by the time the first new LOFAR stations are ready.

While the BG/P upgrade was underway, the LOFAR wide-area network (WAN) was also upgraded to the new 10 GbE equipment required to handle the full station data rates. New network switches were installed and a more robust network security protocol implemented.

Commissioning activities using CS1 data over the last two years have been continued. These activities have ranged widely from simple data quality inspection, system monitoring and trouble-shooting, RFI studies, beam model verification, initial map making, and of course software testing. In the past year, special focus has been placed on commissioning the final design of the HBA tiles. Several pulsar observations have been scheduled (see Figure 20) as well as regular experiments using the 96 LBA antennas distributed over CS1. Coordinated observations between LOFAR CS1 and the Nancay Decametric Array were also used to detect low frequency bursts from Jupiter.

These activities will intensify throughout the winter as the first full LOFAR stations come online. Initial commissioning activities will focus on single station verification tests including the formation of multiple station beams and ramp up to multiple station tests as the rollout proceeds. Much of the commissioning activity throughout the remainder of 2008 and into early 2009 will be to prepare for a first all-sky survey to populate the LOFAR global sky model (GSM). This survey (dubbed the MSSS – The Million Source Shallow Survey) is currently planned to begin in June 2009 and takes approximately 3 months.

The population of the GSM is a crucial milestone to achieve a good LOFAR calibration. The goal to conduct such a survey in a timely fashion is also an excellent opportunity to test the overall system software, standard imagine pipeline prototype, preliminary archiving capabilities, and the Radio Observatory operations.

Figure 19. The central mound of the LOFAR core, which will host 6 LOFAR core stations and can serve as a super-station as seen from the air**.**

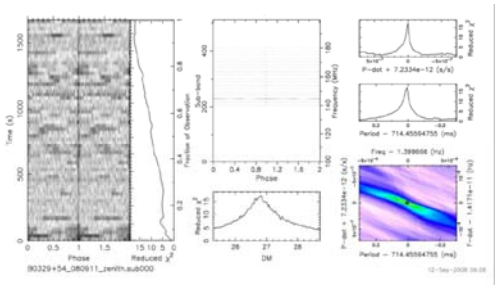

Figure 20. Recent observation of the bright pulsar B0329+54 using 4 HBA tiles in the LOFAR core. This observation was performed on Sept. 11, 2008. Raw beam-formed station data were transported to CEP, written to the standard LOFAR time series data product format, and then read into the PRESTO reduction package for subsequent offline analysis. Credit: Jason Hessels, ASTRON

The LOFAR Team

SOUTH AFRICA

The SA SKA Project Postgraduate Bursary Conference a huge success

"I firmly believe that we should provide good, inspirational teachers and lecturers, but we also need to offer opportunities to young scientists. SKA is one of these projects that offer huge possibilities where they can develop the skills that they have acquired. I have all reason to believe that the next Nobel prize winner could come from the ranks of the SA SKA team," said Minister Mosibudi Mangena, Minister of Science and Technology, at the opening ceremony of the third annual SA SKA postgraduate bursary conference held in Stellenbosch from 1 – 5 December 2008.

"Two months ago South Africa launched its first electrical car. Now we are a very strong contender to build the largest telescope in the world. Projects like these are doing our psyche good. We are beginning to believe in ourselves," he said.

Prof. Arnold van Zyl, Vice-Rector: Research at the University of Stellenbosch explained that as at January 2009, more than 90 postgraduate students and postdoctoral fellows as well as 29 undergraduates will have been funded by the South African SKA Project.

"Through this project South Africa is building a core of scientists and there is no project in South Africa that can compare to this when it comes to human capacity building and the development of post graduate skills. At the same time it is drawing top scientists of the world to South Africa," he said.

"We started in 2004 from zero and it is astonishing what good work has been done. We have young, enthusiastic engineers and scientists. We are now actually at a point where the supervisors have been saturated, but we are increasingly getting co-supervision from the international community. We believe that the input from leading international scientists are extremely important and are also thankful for the enthusiasm from the other eight African countries participating in SKA," said Dr. Bernie Fanaroff, Director SA SKA Project.

"SKA is one of the most important science projects of the 21st century; therefore it is a valuable prize. However, irrespective of whether we do win the bid or not, the big investment that was made in people and the spin-offs that South Africa will get from the project is just astounding."

When asked if government fully supports this project, Dr. Phil Mjwara, Director General of the Department of Science and Technology, said: "If government didn't believe in this project, we surely would not have invested more than three quarters of a billion Rand in it. So, yes, we are so fully behind SA SKA. By passing the South African Astronomy Geographical Advantage (AGA) Bill, we have put our money where our mouth is."

To increase the number of highly-skilled scientists and engineers able to support the SKA and MeerKAT during the design, construction and operational phases of the telescopes, the DST through the NRF and the South African SKA Project Office

initiated a human capital development program in 2004.

"The South African SKA Project's Human Capital Development Program's deliberate focus on capacity development has been recognised internationally as unique and highly successful. Heads of astronomy departments and radio astronomy engineering facilities around the world have commented on the high quality of research being done by the postgraduate students and academic staff working with the MeetKAT team. A big thank you must go to all students, postdoctoral fellows and the supervisors for boosting South Africa's reputation internationally."

"The SKA will be one of the largest facilities in the world and will consolidate Southern Africa as a major hub for astronomy in the world. It will attract the best scientists and engineers to work in Africa and will provide opportunities for scientists and engineers from African countries to work on cutting edge research and collaborate in joint projects with the best universities in the world."

"The SKA therefore represents an unrivalled opportunity for the development of very high level skills and expertise in Africa in science and technology which will be crucial in the next ten to twenty years in the global knowledge economy. These technologies include very fast grid computing, very fast data transport, data storage, wireless engineering, digital electronics, image processing and software development, among others. Hosting the SKA would make Africa a world centre of physics, astronomy and high tech engineering thus strengthening Africa's capacity to innovate."

According to Dr. Mjwara other positive spin-offs of the postgraduate program include:

- The increase in collaboration between industry and universities in South Africa and the rest of the world around the engineering challenges of the MeerKAT.
- The increase in collaboration between South African universities and the astronomy effort in South Africa.
- Collaboration between the SKA team and SA universities with the universities of Oxford, Cambridge, Manchester, Berkeley and Caltech and the National Radio Astronomy Observatories of the USA and with institutions in the Netherlands, Sweden, Germany, Italy, Canada, Australia and France.

After attending the conference, Prof. Justin Jonas, Associate Director: Science and Technology of the SA SKA Project, was extremely impressed by the amount of enthusiasm of the students, universities, supervisors and everybody involved in the project: "Enthusiasm is everything and I saw enough of it at the conference" he says.

"I have always believed in peer support and at the conference the students experienced that. The standard of the presentations were excellent, as in previous years. I believe that our students can easily match with their international peers and I give a lot of credit for that to the supervisors, both local and international.

Prof. Jonas was one of the major forces behind the project from the beginning. "When we realised that we needed to grow people in the fields of engineering and astronomy, we started out by identifying specific academics as possible supervisors. They got all enthusiastic about the project and in their turn got the right students. On looking back that was absolutely the right way to go. We have succeeded in creating centers of critical mass. The Universities of Cape Town, Western Cape and Rhodes have become very strong in Astronomy and the Universities of Stellenbosch and Cape Town excel in Engineering. Previously only one or two universities did radio astronomy research, but currently there are about ten universities working together on this project.

Commenting on the excellent financial backup that the students get, he says: "We believe in funding for success. If students are under financial stress, their academics will suffer."

"We are extremely fortunate in that this project is a government priority. Winning the SKA bid will be a major step forward for the government's Astronomy Geographical Advantage Program (AGAP). It will not only be to South

Africa's advantage, but also to the other eight African countries that will site the outstations.

What the students said about the conference

Gideon Wiid, PhD student from the Engineering Faculty at the University of Stellenbosch, who was working with Eskom for six years after finishing his Masters at Stellenbosch, was sourced to do his PhD on SKA. He is all smiles when he says: This was the best move I could ever have made. It is just so exciting doing research again, and specifically on this project." On being asked how he could afford to study full time again after being in the market for six years, he says that he did have to take a slight dip in income, but that it was thoroughly worth it and that the SKA Youth into Science and Engineering Programme is looking after its students extremely well.

One of his fellow PhD-students at the same faculty, Phillip Kibbet, is from Kenya. He is thoroughly enjoying South Africa, and more specifically Stellenbosch. On going back to Kenya he will be lecturing and doing research on their SKA project. He says that working in South Africa with fellow engineers on SKA is an excellent networking opportunity for him.

Another fellow student of theirs, who is busy with her MSc, Jacki van der Merwe, is of the opinion that the conference was very well organised and the ideal opportunity to network not only with peers but also the top specialists attending the conference. "It also gave us an excellent opportunity to gain experience with for instance presentations, as the environment was not so stressful."

Two MSc students from the University of the Western Cape were surprised to meet each other for the first time at the conference. Lwando Kondlo and Claudio Moises are both Astronomers, but with different supervisors. They see the conference as a wonderful opportunity to learn. "When you present your work to your peers, you get a feeling of the standard of your work and get some valuable advice from other supervisors and internationally recognized specialists." For this reason Lwandlo feels that it would even be good for the students and supervisors to meet twice a year.

Both are extremely enthusiastic about Astronomy as a field of study. "Astronomy opens up your mind therefore it can teach the new generation to ask questions," Claudio says. Both of them have a soft spot for the younger generation and would like to invest in the scientists of tomorrow.

Claudio comes from Mozambique and has got the vision of establishing Astronomy in their curriculum at high school level. Currently he is one of only three Astronomers in Mozambique, but he foresees the development of a strong contingent of Astronomers, especially if South Africa wins the bid and one of the outstations is build in Mozambique.

Lwandlo comes from the small Eastern Cape village of Whittlesea and he dreams of taking his laptop and a small telescope, sitting down with the children of the village, and showing them the wonders of the universe.

Both these students feel that they are extremely fortunate to be part of the SKA Youth into Science and Engineering Programme. "We as students have the best possible academic and financial back-up and opportunities to even travel abroad to meet with our international supervisors and gain international experience. It is our responsibility to grab the opportunities and learn as much as possible," they say.

What the supervisors and co-supervisors said about the conference

Prof. Athol Kemball from the Department of Astronomy and Center for Extreme-scale Computing at the University of Illinois, USA, was extremely positive about the overall standard of the conference. "The work reported by the postgraduate students at the meeting was of a very high standard and is a vital contribution to the South African SKA project, MeerKAT, as well as to the broader international SKA project."

"The human capacity project under which the students are supported by DST and NRF is outstanding and a leading-edge example of how to build a scientific and engineering community for such an advanced instrument. The research projects in which the students are engaged are also directly related to skills

in advanced technology, engineering, science, and computing needed to build the workforce of the future in South Africa. This DST programme is also broadening and diversifying the base of human capital within South Africa and the local region in this area and is succeeding in addressing inequities in opportunity in an effective manner. This conference was refreshing, exciting, and scientifically stimulating. It was a priviledge to attend," he said.

According to Dr. Riana Geschke who is lecturing at the Engineering Faculty at the University of Stellenbosch, the strongest attraction for students to work on SKA is the fact that it is a real project. "We're not only talking text book here. Students like exciting projects like this and there are so many people working on it that they don't feel isolated."

Dr. Wim van Driel, Astronomer at the Paris Observatory, has been involved with SKA for a number of years and represents France on the international SKA committee. As such he will be a member of the committee who makes the final decision on who wins the bid.

In his opinion it still is a very fair competition. "Australia does have the advantage of 50 years of radio astronomy experience, but I am amazed with the effort that the South Africans have put into this project. First of all there is the commitment from the government and then there is the investment in building human capacity. You can have all the money in the world, but if you don't have the right people to do the job, nothing will happen. I have nowhere in the world seen 90 KAT bursary holders working on one project. It is truly remarkable!"

It is clear that Dr. Van Driel is extremely excited about MeerKAT. "MeerKAT is a done deal, irrespective of whether South Africa wins the SKA bid or not. It is a fantastic instrument and a real path finder to SKA."

According to Prof. Renee Kraan-Korteweg, who heads the Astronomy Department at the University of Cape Town, there really are some top quality students working in the SKA program and she feels that the bursaries and good future prospective are two of the main reasons for the success of the program.

"MeerKAT is a fantastic instrument for a relatively small community which means that South African astronomers will have large access to observation time. Salt will be fully commissioned soon, and with Salt and MeerKAT local astronomers really are in an extremely fortunate position."

"I get the impression that this is a pride building exercise for the government. South Africa wants to show that we can be up there with the best in the world, and with MeerKAT we indeed are," she says.

Prof. Pieter Meintjes from the University of the Free State who is the supervisor for two PhD-students (one from Uganda and one from Rwanda), describes this project as a lifeline for research in Astrophysics.

"Radio astronomy was starting to die down in South Africa, but this project opened up new horizons. The Australians are strong in radio astronomy and will be difficult to beat, but even if we don't win the SKA bid, this will be a huge injection for astronomy, technology and communication in South Africa. As a spin-off to the research done on the SKA, I foresee that our internet development will take quantum leaps over the next five years in terms of data analysis, high level manpower and software development."

Figure 21. Delegates from the SKA bursars' conference held in Stellenbosch, South Africa

SKA South Africa

USA

Technology Development Project (TDP)

The TDP has just begun its second year and undergone review by both the SKA TDP Advisory Committee which reports to the TDP Director (J. Cordes) and the NSF's SKA TDP Oversight Group. Work has progressed in the two main areas (1) Antennas, Feeds and Receivers and (2) Calibration and Processing. These are organised in part through the Antennas Working Group (AWG) and the Calibration and Processing Group (CPG). Both groups have met several times in the last year, both face to face and by telecon. The TDP also funds the US contribution to the Common Fund for the SPDO and payments are up to date through the end of 2008. The TDP also funds the travel of US participants to SSEC meetings.

Recent findings and work in the Antennas area includes:

- Decision that the TDP will serve as a clearing house for antenna work done around the world, consolidating information for use by the international SKA project
- Decision to establish a uniform feed testing program either through a commercial contract or by setting up a pattern testing program at Cornell. Initially, this program is for the wideband, single-pixel feeds being developed under the TDP but it can be extended to other feeds.
- Identification of a small set of reflector types and associated optics to investigate optimized optics that will accommodate single-pixel feeds as well as phased-array feeds.
- Development of a work plan to be presented to an industry consultant/partner as part of the antenna fabrication study aspect of the TDP. A contract is likely to be let in the next month or two.

In the Calibration and Processing area, recent work includes:

- Finalising a work plan that includes deliverables for internal TDP consumption (such as specifications and criteria for antenna designs to be communicated to the AWG) and for communication to the international SKA project.
- Hiring two out of three of the postdocs at UC Berkeley, MIT/Haystack and University of Illinois who will be doing work on calibration and processing.

TDP representatives attended the PrepSKA kickoff meeting of liaison engineers in Manchester the week of 10 Nov (L. Baker, G. Cortes and A. Kemball). Much effort has been put into aligning the TDP work plan with that for PrepSKA and ensuring that goals, deliverables and timeline are agreed upon.

U.S. Demonstrator Arrays

Expanded Very Large Array (EVLA)

Overall, the EVLA project remains on schedule. The conversion of antennas to the EVLA design is scheduled to be complete in the third quarter of 2010. The installation of the WIDAR correlator, constructed by our Canadian partners at the Herzberg Institute for Astrophysics, is scheduled for completion in the first quarter of 2010. The last EVLA receiver will be installed in late 2012.

Recent EVLA highlights include the following:

- The installation of all infrastructures for the final WIDAR correlator was completed. First fringes were recorded with a prototype WIDAR correlator, using two EVLA antennas, on August 7, 2008.
- A total of 18 antennas have been retrofitted to the EVLA design and account for over 65% of all antenna hours in scientific observations.
- Production quantities of the 3-bit, 4 gigasamples per second digitisers were delivered by the vendor to the NRAO.
- Six of the new 26.5-40 GHz receivers have been installed on EVLA antennas in the array. It is expected that there will be 12 of these receivers by mid-2009, and first scientific

observations are expected in the new band.

- The first of a series of EVLA science planning meetings will be held in December 2008; the meeting topic will be "The EVLA Vision: Galaxies Through Cosmic Time."
- Final designs of the orthomode transducers at the lowest frequency bands (below 8 GHz) have been shown to meet project specifications, enabling retrofitting to move forward on the prototype systems at 1-2 and 4-8 GHz.

Long Wavelength Array (LWA)

Since the last newsletter JPL has joined the LWA project and is hard at work on designing the beamformers and digital receivers for the stations. Prototypes for most other aspects of the project have been built and tested in the field. This includes the analog receiver that was designed and built by Joe Craig at UNM. This receiver provides 70 dB of gain with 60 dB of control in 2 dB steps, and has a reconfigurable filter that can be used to adapt to changing RFI conditions. Following design reviews early next year we look forward to starting construction of the first LWA station next summer. To aid in field testing and deployment we have purchased and outfitted a mobile workstation. This will provide a workbench, a shielded rack for electronics, and some well deserved amenities (like a kitchen).

At the URSI meeting in Chicago last August, Ylva Pihlstrom organized a one-day session on Low Frequency Software. We hope that event, and other meetings to follow, will result in an increase in collaboration on software efforts between groups.

Tracy Clarke led the implementation of a weather station at the LWDA site. In addition to tracking wind and weather near the ground, this provides a visual record of the site with frames captured every minute. All information is available from the weather underground at: (http://www.wunderground.com/weatherstation/WXDailyHistory.asp?ID=KNMSOCOR9)

Allen Telescope Array (ATA)

The ATA team (Berkeley, SETI Institute (SI)) has been busy with commissioning the 42-antenna array over the past year. Two 100-MHz, 1024-channel FX correlators, which were assembled in the Radio Astronomy Laboratory (RAL), are now working and allow simultaneous synthesis imaging at two independent frequencies in the 0.5-11.0 GHz band. Two beamformers are working and connected to two other tunings in the band. A third beamformer is under construction. This digital signal processing has relied heavily on contributions from the Center for Astronomical Signal Processing and Engineering Research (CASPER) as well as a generous contribution of FPGA devices from Xilinx, Inc. A series of minor mechanical and electrical retrofits to the array antennas that provide improved stability are nearly completed. The feed/LNA units are also undergoing a series of retrofits and improvements; this work is nearing halfway point. The beamformers feed multiple backends: the SI Prelude and SonATA processors and a prototype pulsar processor. A complete description of the ATA design, current state and buildout plans are presented in Welch et al. (Proc IEEE, 2009).

A major effort during the year has gone into development of monitor, control and data acquisition software that matches the growing signal processing capabilities and requirements of early science and technical observations. Calibration of the antennas and signal paths is ongoing: pointing, beam patterns, holography, and system temperature. The focus now is on stability and reliability along with system feed/LNA improvements, which are part of the US SKA Technical Development Program.

The SI staff are exercising these beamformers that allow them to analyse signals from multiple stars at multiple frequencies. In the dual star tracking mode a null is placed on star B for the beam tracking star A, et v.v. Test signals from the Voyager 1 satellite now just beyond 100 AU from Earth are easily detected; see "waterfall" plot to right. Other satellite tracking and detection observations are being conducted in an exploratory program for the USAF.

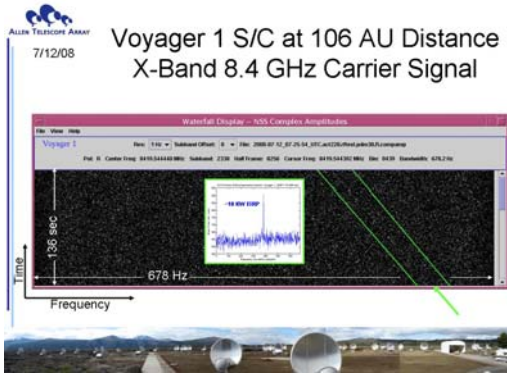

Figure 22. Voyager 1 S/C at 106 AU Distance X-Band 8.4 GHz Carrier Signal

The ATA has a nominal survey speed for detection of continuum radiation of a 1mJy source at 1.4 GHz of 2.4 square degrees per minute, which is comparable to the GBT, Arecibo (single pixel) and VLA. An 800 square degree field is being monitoring at 1.4 GHz in preparation for a 5-GHz sky survey of transient and static sky starting in 2009. A "Fly's Eye" experiment for 500 hours was conducted to look for giant dispersed pulses by pointing each 6m-diameter antenna in a different direction; no new sources have been found. Deep imaging of some galaxy clusters and new dwarf galaxies in the 21cm line is preliminary to an all sky hydrogen survey.

We are grateful to the Paul G. Allen Family Foundation for their support of both the development of the ATA as well as a grant for this past year of commissioning activities.

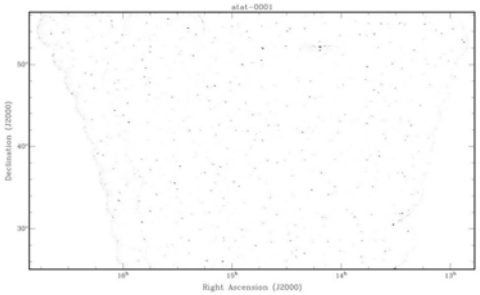

Figure 23. Top: ATA 1.4-GHz, 800 Sq. deg. field: a mosaic from 350 100-second integrations.

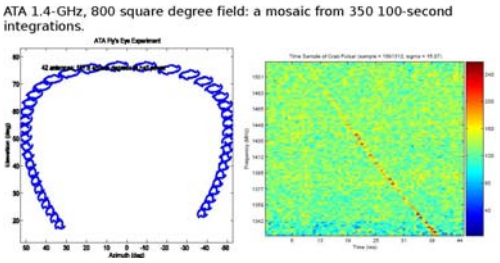

Figure 24. Bottom: Fly's Eye experiment: (left) positions of 42 antennas; (right) Crab pulse

Murchison Widefield Array (MWA)

Progress on the Murchison Widefield Array (MWA) has been substantial in recent months. Major upgrades in site infrastructure have been made, with the acquisition of a 12-metre by 3-metre portable building. A 35 kVA diesel generator provided by CSIRO has been installed, providing ample high-quality, reliable power for equipment, air conditioning, and other necessities, and the satellite internet link at the CSIRO site office has been extended to the MWA site via fiber. Initial steps have been taken toward supporting remote operations in the next few months. The environment is now comfortable and suitable for extensive on-site work regardless of season, and a schedule of one site visit per month has been established.

The most recent site visit took place in November, ending on the 19th. This trip culminated in the successful simultaneous operation of 26 tiles, utilising 4 digital receiver units, and real-time software correlation. To achieve this level of operation, several technical issues were identified and dealt with by a strong and dedicated field team. Many celestial objects were targeted with hundreds of independent imaging and non-imaging observations across the full MWA frequency range of 80-300 MHz, and data reduction is in progress at the time of writing. This highly successful trip represents a major milestone for the project, opening the path to in-depth characterisation of the performance of multiple subsystems. Over the next few months, hardware correlation capability will be deployed, and a full end-to-end 32-tile system will be tested and verified, in preparation for large-scale replication during 2009.

Precision Array to Probe the Epoch of Reionization (PAPER)

The PAPER team (Berkeley, NRAO-CV/Soc, UVA, Penn, Curtin) has made important progress in the past year in instrumentation, deployments and data analysis. The antenna design has progressed from a "sleeved-dipole" over a simple 2m-squareground plane to the same dipole over a "trough" reflector (same 2m square with "flaps" on each side). The design increases collecting area to 7 m2, while maintaining a single lobe forward beam pattern that evolves smoothly with frequency. The active balun has been redesigned to increase modularity and ease construction for minimum cost. The balun unit feeds a 75-ohm coaxial line to bring the signals to a central equipment hut for amplification and filtering in an improved receiver board. Cost of this analog system is approximately $150/m2. Digital signal processing for PAPER advanced significantly with the deployment of a "packetized" FX 8-antenna, full Stokes parameter correlator in 2008 January atour NRAO Green Bank, WV test site (2008arXiv0809.2266P). This unit digitises the full band at 8-bit resolution, splits incoming signals into 2048 channels using a polyphase filter bank algorithm, equalizes passband response, requantizes to 4-bitresolution and transmits to correlator modules over 10 GbE standard. The correlator is being expanded to 16 antenna operation to match the 16 dipole deployment at the Galford Meadow site in Green Bank. Important parallel work is continuing on characterising the temperature dependence of gain for a priori gain stabilisation at the 0.1% level. Another activity is the development of an Orbcom (137-MHz) satellite constellation measurement system for relative gain and ionospheric monitoring.

Analysis is proceeding primarily with the development of the AIPY package led by Parsons (http://pypi.python.org/pypi/aipy). Dynamic range limited full-sky maps using full-bandwidth multifrequency synthesis have achieved dynamic ranges of 10^4:1 and 15 arcmin resolution. This corresponds to noise limits around 1 Jy in "hot" parts of the sky (Galactic plane and, in particular, near Cyg A and Cas A; see Figure 25 of Cygnus region where blue is at the Jylevel while Cyg A, red spot, is 104 Jy), and 100 mJy in "cold" parts of the sky. We are starting to explore ionospheric refraction and amplitude scintillation and the full fitting of source fluxes and spectral indices with array parameters of antenna positions, beam gain and electronic gain, cross coupling and ambient temperature dependences.

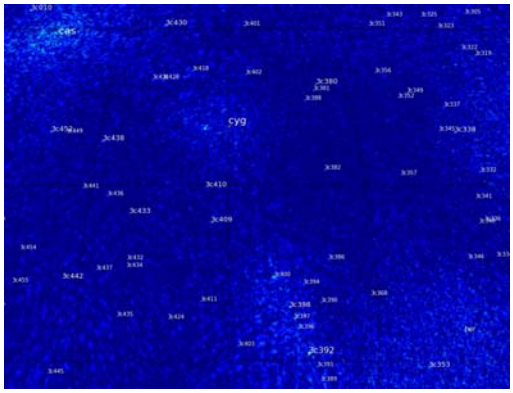

Figure 25. Cygnus region where blue is at the Jy level while Cyg A, red spot, is 104 Jy), and 100 mJy in "cold" parts of the sky.

We are preparing for deployment of a 64-antenna PAPER experiment at the Murchison Radio Observatory site in Western Australia for a multi-month integration during 2009 September-November.

Trish Henning
US SKA Consortium