International Square Kilometre Array Newsletter

Volume 4
2002

Founding Director of the International SKA Project

The International SKA Steering Committee has appointed the first Director of the International SKA project. Professor Richard Schilizzi, currently Director of the Joint Institute for VLBI in Europe, will take up the position of SKA Director on January 1, 2003.

Richard Schilizzi was educated in Australia, obtaining his Ph.D. in Radio Astronomy from The University of Sydney in 1973. After a post-doctoral fellowship at the California Institute of Technology working with Marshall Cohen on Very Long Baseline Interferometry (VLBI), he joined the Netherlands Foundation for Research in Astronomy (now called ASTRON) in 1976 with responsibility for developing VLBI in the Netherlands.
He brings to the SKA a wealth of experience in developing collaborative international projects. During the past 25 years he has played a leading role in building up the European VLBI Network and, more recently, in establishing the Joint Institute for VLBI in Europe (JIVE) as the central data processing and support institute for the EVN. In 1993 he was appointed foundation Director of JIVE.

From 1991 to 2001, he was J. H. Oort Foundation Adjunct Professor at Leiden University; in 2002 he was appointed Professor in Radio Astronomy at Leiden.

His interests include working at the interface between science and technology as well as astronomical research on compact radio sources. As the SKA Founding Director he will quide the SKA project through the next phases toward an international concensus on the final facility design.

Meetings

Our annual international SKA meeting this year, "SKA 2002", was hosted by ASTRON in Groningen, The Netherlands. The meeting highlighted the interaction between engineering and science, centered on the white paper reports from the technical concept development projects. The program and presentations can be found at http://www.lofar.org/ska2002/.

The twice-yearly ISSC meetingsoccured in Europe this year, one in January at the Instituto di Radioastronomia in Bologna and the other in August at ASTRON in Dwingeloo. The minutes of the Bologna meeting are posted on the SKA secretariat web site. The Bologna meeting was proceeded by a science workshop "New Frontiers in Astrophysics: Square Kilometre Array" and a one-day Italian community SKA Science meeting. We are joined at both ISSC meetings by observers from Japan, Russia and South Africa. The next meeting of the ISSC will occur at Arecibo Observatory from 16 to 18 of January.

UK Workshop: The Scientific Promise of the SKA

On 7 November 2002, around 100 participants attended a one-day workshop in Oxford organized by the two UK ISAC members, Michael Kramer (JBO) and Steve Rawlings (Oxford, Vice-chair of ISAC). Attendees were from 30 different institutes, mostly from the UK, although about 10 people came from abroad.

The workshop aimed to raise the profile of the SKA project among the UK astronomy community, and was designed to encourage astronomers working outside the radio band to participate in the planning and discussion of the SKA. The active participation of a wide variety of non-radio observational astronomers, as well as theorists, meant that these aims were realised. The workshop was a great success and a wide cross-section of the UK astronomical community participated.

After introductory reviews by Peter Wilkinson for the ISSC and Chris Carilli for the ISAC, the contributions covered a large fraction of the core SKA science case: Extra-solar planets and SETI (Alan Penny, RAL); star formation (Melvin Hoare, Leeds); late stages of stellar evolution (Albert Zijlstra, UMIST); pulsars (Michael Kramer, JBO); transient phenomena (Graham Woan, Glasgow); galactic and nearby galaxies (Robert Minchin for Steve Eales, Cardiff); large-scale structure (Peter Coles, Nottingham); galaxy evolution (Carlton Baugh, Durham); gravitational lensing (Neal Jackson, JBO); starbursts and AGNs in deep fields (Simon Garrington, JBO); neutral hydrogen & early universe (Avery Meiksin, ROE); and SZ/CMB (Mike Jones, Cambridge).

The workshop (also attended by Richard Schilizzi the Director-elect of the SKA) concluded with an open discussion, including topics such as frequency coverage and multi-beaming. All participants were encouraged to contribute to conference proceedings which will be edited by Michael Kramer and Steven Rawlings, before they are published as White Papers and sent to the Science Working Group Chairs.

Michael Kramer (Jodrell Bank Observatory, Univ. Manchester)
Steve Rawlings (Univ. Oxford)
SKA 2003 Geraldton, Western Australia

The 2003 SKA International Workshop will be held in the city of Geraldton in the Mid West coastal region of Western Australia from July 29 - August 1 2003. This follows the XXVth General Assembly of the IAU in Sydney, which will be held from July 13-26, 2003

The workshop will be held in the Ocean Centre Hotel on the waterfront at Geraldton.

Geraldton has a population of 30,000 and is 400 km north of Perth on the Indian Ocean. Access is by a 1-hour plane journey from Perth, or 4.5 hours by car. Plane travel between Sydney and Perth takes about five hours.

The SKA Workshop will be followed by a two-day meeting of the International SKA Steering Committee on August 2 and 3 (also in Geraldton).

It is envisaged that many of the key scientific, technological and costing issues will need to be discussed in considerable depth at the 2003 SKA Workshop, and that the workshop will focus on discussion meetings of the various Working Groups. More details of the focus of the workshop will be available in the next few months, but we anticipate that the SKA 2003 Workshop will be roughly the same size as previous SKA Workshops.

There are locations of spectacular natural beauty and fascinating cultural and historical significance in and around Geraldton and the Local Organizers hope that many conference participants will take advantage of this opportunity to visit the region to stay a little longer and see some of the sights, and perhaps bring partners/family as well.

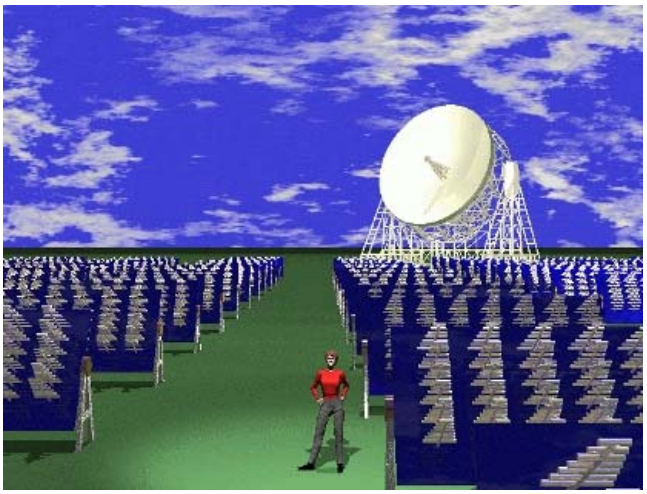
An accompanying persons program will be a feature of the Workshop, and we will arrange some group tours after the Meeting if there is sufficient interest. A website for the SKA 2003 Workshop will be created soon with further details and travel options.

Felicity Mitchell and Michelle Storey on behalf of the SKA 2003 Workshop Local Organising Committee

---

An SKA Prototype Array Proposal from Jodrell Bank

A group of University of Manchester (JBO) astronomers including Michael Kramer, Duncan Lorimer, Andrew Lyne and Peter Wilkinson, in collaboration with Graham Woan from the University of Glasgow, have submitted a Statement-of-Interest to the UK Particle Physics and Astronomy Research Council (PPARC) to prepare the ground for a future proposal for the development, installation and operation of a ~5000 square meters phased array capable of multi-beam operation with a 1-2% bandwidth at 610 MHz. The array is intended to be a 1:200-scale SKA test-bed to demonstrate multi-beam-forming technology appropriate to a mid-frequency (e.g. 150-1500 MHz) concept.
An illustration of the array is shown at right. Note that the prototype is designed as a transit instrument but one whose primary beam is quite large. Within this primary beam, covering about 30 square degrees, up to a 1000 beams (5-10 arcmin in diameter) will be synthesised simultaneously.



Our basic approach is to exploit currently available technology and simple, low-cost rf front-ends based on cheap consumer electronics in order to concentrate on the beam-forming technology which we want to implement completely in software. The computing power for the back-end will also apply largely consumer electronics in a PC-cluster. As a result, the proposed telescope will be a low-cost, low-maintenance instrument that, for about GBP 1.0M, is effectively equivalent to about a thousand (depending on the number of independent beams created) Lovell telescopes operating simultaneously. As such, it will deliver unique science ranging from pulsar astrophysics, cosmological studies of highly redshifted hydrogen, interplanetary scintillation, to searches of the transient sky.

As front-ends the phased array will make use of cost-effective commercial twin-polarized TV (yagi) antennae, which will be combined to form individual (about 30 square metres) arrays (patches) by adding the received signals in phase using r.f. cables. This is merely for practical reasons to reduce the computing requirements. The patch size sets the size of the primary beam. The patches will be mechanically pointed towards the Southern meridian to maximise the effective collective area for a particular declination range. The declination will be manually adjustable.

The back-end will require hardware for sampling and digitization of the rf signals which will then be fed into the large-scale Beowulf-cluster where all the beam-forming and data processing will be carried out. A 91 dual-processor-node Beowulf cluster is already in successful operation at JBO as the heart of the innovative pulsar back-end COBRA. The cluster envisaged for the prototype array will be several times more powerful than this.

The emerging philosophy is that of a "software" telescope array which rides on the back of consumer electronics and Moore's Law, for continuously enhancing the commercially-available computing power and hence the beam-forming and data processing capability. By restricting the array to transit operation, costs may be further held down but the concept is still well-suited to first-ranked surveying and monitoring/timing programmes as mentioned above.

Andrew Lyne, Jodrell Bank Observatory

News from Australia

Like most other SKA research groups, the Australian community gained enormous insight from the White paper process and the ensuing discussions at Groningen. The White paper authors are currently preparing short responses to the EMT commentary with a view to submitting their material before the May 2003 deadline. There have been considerable efforts to brief the wider Australian astronomy and radio science communities about the outcomes of the Groningen meeting and, in particular, to explore further the scientific merits of SKA concepts which link the high-frequency and multi-beam domains.

A significant milestone has recently been achieved with the formal signing of the Major National Research Facility (MNRF) agreement between the Commonwealth, CSIRO, the University of Sydney, Swinburne University of Technology, and a number of other collaborators. This agreement ensures a flow of about $A20M into SKA research over the next five years. In related achievements the University of Sydney has been successful in attracting a $300k grant as seed funds for its wideband line-feed project (to be conducted in conjunction with CSIRO and Argus Technologies), while CSIRO has been offered a $500k SKA engineering consultancy contribution from Connell Wagner, one of Australia's largest engineering and project management companies. This contribution, to be provided over the next 12 months, will be largely used to fund further SKA and LOFAR siting studies.

In a recent LOFAR proposal, CSIRO and the Government of Western Australia have submitted a joint submission for siting LOFAR near Mileura, a candidate Australian SKA site well-characterized by initial RF environment measurements. Members of the LOFAR executive are expected to visit Australia in February and the current schedule lists a siting decision by mid-2003.

SKA technical projects have been producing interesting results, with the artificial dielectrics work recently yielding some material samples with loss tangents < 1 x 10-4 , auguring well for the possibility of Luneburg lenses operating above 10 GHz. In a demonstration of the possibility of a "hybrid" SKA antenna element, CSIRO and ASTRON have been collaborating to demonstrate the possibilities of focal-surface arrays used with first-stage lens beam-formers; the picture shows a THEA-style 8x8 Vivaldi array and a 0.9 m lens being tested in Sydney. Good beamforming has been demonstrated and a detailed report on the experiment will be produced by the end of 2002.

8 x 8 THEA-style Vivaldi phased array (provided by ASTRON and MIT) being used as a focal surface array for a 0.9 m Luneburg lens. The array and lens combination were recently tested by CSIRO in its near-field test facility in Sydney; results will be available shortly.

In RF systems work, our 1 7 GHz uncooled GaAs LNA has been tested on-wafer and, while there are known stability issues to be resolved after packaging, the chip will be useful in initial phased array test projects. At the University of Sydney, design of the Molonglo correlator - a demonstrator for scaleable SKA technology - is well underway. Swinburne University have recently demonstrated the scientific usefulness of their baseband recording and super-computer system in the timing analysis of pulsar data, with intrinsic pulse widths of 30 s being easily visible.

In collaborative projects with international SKA groups, CSIRO will begin work shortly on both phased array prototyping and a study of the practicality of small paraboloids in the DSN application. The array work, to be conducted with ASTRON and CEA - one of our MNRF industry partners - will focus particularly on the application of time-delay beam-forming to wideband arrays.

Finally, a few personnel notes. Ron Ekers will vacate his position of ATNF Director in March 2003 after being awarded a Federation Fellowship, Australia's most prestigious scientific grant. Ron will use his Fellowship to direct and fund new initiatives in the quest for a radio-quiet reserve, to further advance SKA site work, to explore new interference mitigation techniques, and to conduct a program of Early Universe science. He will continue to based at the ATNF and will maintain close links with the CSIRO SKA program. Ron will also, of course, assume the position of IAU President in mid-2003. Recognizing the importance of SKA configuration and calibration studies, CSIRO has recently advertised and filled a post-doctoral Fellowship in this field; Maxim Voronkov from ASC (Moscow) will begin work with Mark Wieringa in early 2003. Both Maxim and Mark will be working closely with the growing Swinburne University group - to be led by Steve Tingay - to advance the general area of SKA system simulation.

Peter Hall, CSIRO

Canadian LAR Update

Much progress has been made on testing of the 1/3 scale LAR prototype balloon-tether system at HIA. Many challenges have been overcome ranging from teething problems with the data acquisition systems to data cables and tethers being chewed (!) by animals (most likely coyote's) in the field at night. The LAR flight crew has become very proficient at launching and retrieving the aerostat, Figure 1, allowing efforts to concentrate on acquiring and analyzing data.

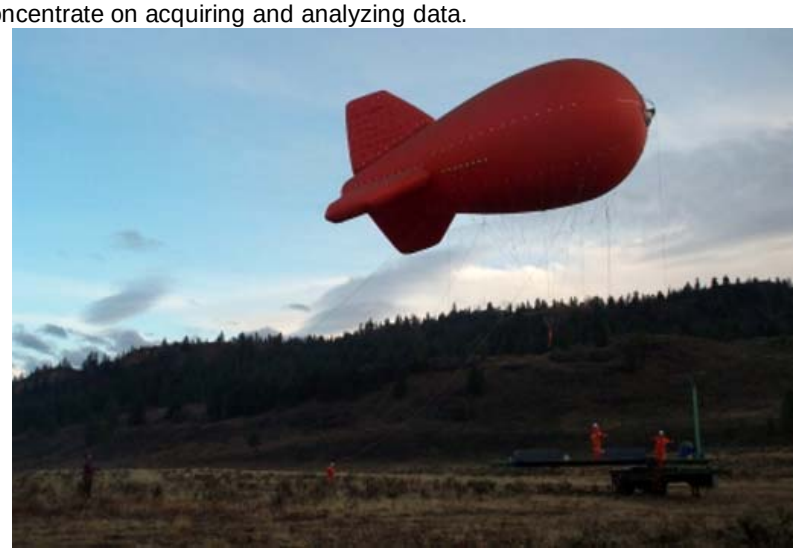


Figure 1. Retreiving the aerostat.

Good quality data for verifying theoretical models of the system performance have been obtained. These models, developed by Prof. Meyer Nahon at McGill University, are being tested with the flight data at McGill and at HIA. To date, tests have used three fixed-length tethers attached to concrete anchors, with the length of each tether preset to achieve the azimuth and zenith angle being tested. Initial results of this "open-loop" system look promising, with motion of the platform dominated by slow, large-scale motions. Based on the analysis to date, further changes to the data acquisition system are underway to capture system parameters that will enable the development of a control system for the up coming "closed-loop" tests where the tethers lengths will be varied using winches to provide dynamic control of the instrument platform's position. Winches and mounting frames have been delivered and are being readied for use, Figure 2.

Figure 2. Winch Preparation

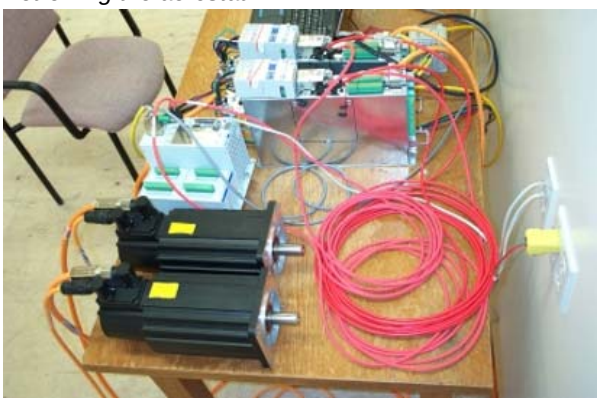


Figure 3. Testing part of the winch control system

The winches are bespoke items built by AGO Environmental Electronics of Victoria, BC. The control system is based on Bosch-Rexroth Digital AC Synchronous motors and PPC based controller connected on a SERCOS ring. Three winches are being prepared for our initial tests. Three more will be added at a later date to provide a six-tether system. Design of the control system has begun and will involve using GPS positional data as well as tether tension data as feedback to the winch control software provided by Bosch-Rexroth. Figure 3 shows the test-bed set-up for the winch control system.

Reflector

A preliminary design of the reflector panels and support structure has been completed in collaboration with AMEC Dynamic Structures of Vancouver BC. Lightweight structural steel trusses, similar to those used in steel building construction (see your local Safeway store for an example!) will be used to support the reflector panels. The panels will also be constructed of steel building materials, with a precision calibrated steel reflector surface. A contract with AMEC has been let, and construction of prototype components is planned for 2003.

Focal Plane Array Feed

Work is progressing on the densely-packed focal-plane arrays required for the LAR. This work is being led by Bruce Veidt, with the assistance of two University of Alberta electrical engineering graduate students.

Ed Reid is developing Vivaldi antenna arrays from both the electromagnetic point-of-view, and with an eye to how to actually fabricate something with thousands of elements in a way that is robust, very lightweight, and practical to implement. Ed has built and tested a small (42-element) array made with conventional printed circuit board techniques and is currently planning even larger arrays.

Angel Garcia is working on low-noise amplifiers that are mounted very close to the feed-point of an antenna. The hope is that this will reduce losses in two ways: by minimizing the length of transmission line from the feed-point to the LNA; and by reducing the number of impedance transformations that take place by matching the amplifier directly to the feed-point impedance. This second effect should also have the benefit of retaining the wide bandwidth.

Bruce Veidt is looking at several system-level questions involving wide-band focal plane arrays. He has been looking at

beamformer bandwidth and the effect of errors (amplitude, phase, and dead elements) on system performance. This work has been entirely numerical through the development of a specialized software package for analyzing focal-plane arrays.

The LAR Group

News from China: Approaching a Better Model for FAST

The feasibility study on FAST has been succeeded around earlier 2002, focusing on two key technical issues: active main reflector and light feed support system. We then have been approaching an improved FAST model, some new progress are summarized as below.

New type of elementary reflector

A tensegrity (pre-stressed) back structure (1:3 model, see Fig.1) has been designed and manufactured by the FAST group in Tongji University, Shanghai. The weight of such a structure is about 1/3 of the previous design, consequently the cost of the reflector will be reduced

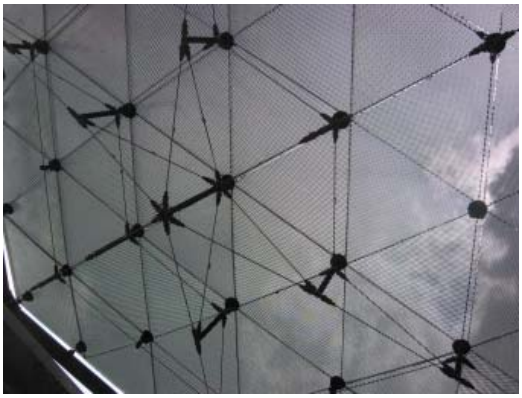


Figure 1. Segment of pre-stressed, reflector back-up structure.

Combined model of the feed support system

The experiment (1:10) of combining the cable-car driven system and a Stewart stabilizer is going smoothly in the FAST group in Tsinghua University, Beijing. The main difficulties in this experiment arose at how to get the high accurate position information at high sampling rate, and how to find the optimal control algorithm, some solutions are looking into, and the whole model is to be completed around the next Spring.

The 4th FAST annual meeting

The 4th annual FAST meeting was held at the headquarters of the National Astronomical Observatories of China in Beijing, on 13-14 October 2002. More than 50 participants from Universities and research institutes attended. The main topics were reporting up-to-date progress on the pre-research of the FAST project, and discussing the further work to be undertaken - including the proposed adaptive cable-mesh reflector and the promising application of the Dutch AAT phase array to the FAST feed system, further site surveys etc..

We are continually receiving financial support from the Chinese Academy of Sciences for the coming two years's research on the FAST project.

FAST Group in China

News from the European Consortium

In preparation for the upcoming Sixth EC Framework Programme (FP6), a group of European radio astronomers representing most of the continent's professional radio astronomy groups held a coordination meeting at the Jodrell Bank Observatory (United Kingdom) 14-15 September 2002. The main goal of the meeting was to plan radio astronomy proposals for FP6. In formation on the meeting can be found at www.jive.nl/jive/european/fp6-preparation.htm. A follow up meetings has been held at ASTRON on December 17th .

Technical R&D

Phased-Array progress: The Thousand Element Array

The Thousand Element Array (THEA) is delivering its first data, not only in terms of system evaluation but also (known) astronomical data. THEA is a phased array demonstrator system, which has been build in order to evaluate this technology for SKA. Important evaluation criteria and advanced features of THEA are

1. Multi-beam operation, THEA has two fully independent beams.
2. Adaptive nulling: interference suppression is possible on RF and on digital beamforming level.
3. Re-configurability by using sub-array units: digitized signals of small sub arrays can be used to re-configure the antenna configuration.

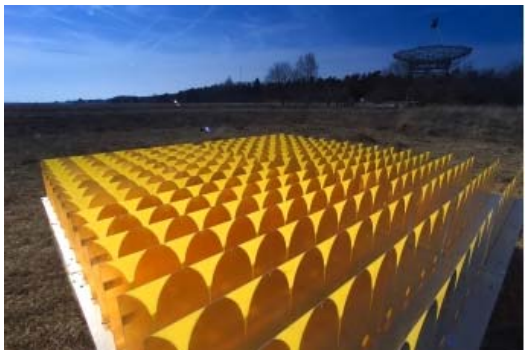


Figure 1. Four THEA tiles, a total of four square meters.

The first 256 elements of the THEA system have been build, a total of 4 tiles. Figure 1 gives a picture of the 4 tiles with the radome removed, in front of the Dwingeloo 25 meter telescope. Recent publications can be found at www.astron.nl/projects/thea.

The first results of the THEA system have been presented at the SKA workshop in Groningen: detection of celestial sources as well as Galactic Hydrogen Spectral line brightness temperatures.

Due to the electronic scanning capabilities of the phased array antenna, all sky measurement maps can be made fast. A picture of an observation of the Global Positioning Satellites (GPS) can be seen in figure 2. This is actually a snapshot of a longer observation where scans have been completed every 9 minutes. Figure 3 presents an image at 1420MHz, where the

strong hydrogen spectral line (HI) of our Galaxy can be observed. By scanning the hemisphere for 24 hours the Galactic plane moves through the image. In particular these HI observations made a strong impression in Groningen and where seen as a great achievement for the SKA phased array approach. The SKA science committee stated that this is "the worlds first full sky dynamic 24 hour HI survey".

Figure 2. GPS Satellite detection plotted in a full sky plot.

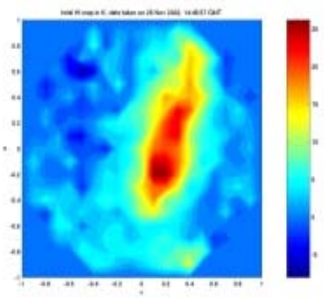


Figure 3. HI Observation

In order to get experience with lower cost production methods 12 dummy tiles where build.
These tiles will be filled with passive antenna elements. The passive elements will significantly reduce the truncation effects of the active tiles. The truncation effect causes an efficiency degradation since edge antenna elements suffer from lower gain

Figure 4. The 16 THEA tiles, 4 active tiles surrounded by 12 passive tiles.

FARADAY: Focal Plane Array Developments

ASTRON, JBO, IRA and TcfA started November the first 2001 the FARADAY EU program. In this program ASTRON is taking the lead in the development of phased-arrays to be used in the focal plane of large reflector telescopes, in particular for Westerbork Array (WSRT). The prime objective of this sub-project is the design of a focal plane array with efficient multi-beam performance.

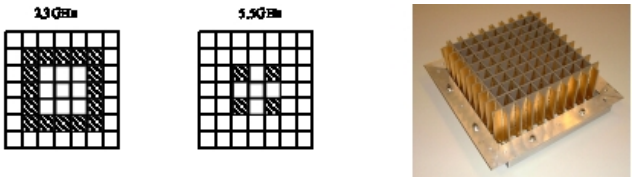


Figure 5. Sketch of the combined rings and a picture of the vivaldi array.

First analyses and measurements showed already that a significant improvement, over a coaxial horn feed, could be realized with the use of a dense array and combining rings where the optimal illumination of the reflector has been synthesized. Proceeding with this approach will lead to the design of a multi-beam system. Even with systems with a small F/D, as the WSRT, a large number beams are possible. The technology is of interest for Australian Luneburg SKA approach as well. The array pictured in figure 5 has therefore been tested at CSIRO, illuminating a 0.9-m Luneburg lens. More information of the ASTRON focal plane array activities can be found at www.astron.nl/tl/faraday.htm. And for the EU program www.jb.man.ac.uk/research/faraday/.

Jan Geralt bij de Vaate, ASTRON

News from the US SKA Consortium

The US SKA Consortium now comprises 11 members, including JPL, NAIC and Haystack that are co members respectively with Caltech, Cornell and MIT. On October 14 we had an intense meeting at Cornell University and among other issues we discussed in detail the updating of our Strawman Design Whitepaper, and organized a US Site and Hosting Committee to prepare the 'Initial Site Analysis Document' that is required by the ISSC, and is due by the end of May 2003. The US Consortium will be proposing to host the SKA in the SW of the US including parts of northern Mexico. Our next US SKA Consortium meeting will take place in Washington D.C. on April 25, 2003. On September 27, 2002, Jim Cordes (the PI on our SKA NSF Development grant), and Yervant Terzian (the current Chair of the US SKA Consortium), visited the US National Science Foundation and updated them on the results of the Groningen SKA meetings. We found the NSF officials very supportive of our efforts and we were encouraged to continue our development research.

The US SKA Consortium Technology Development was funded by the National Science Foundation on 26 November 2002. Technology development for the US Large N - Small D concept that is funded by the NSF is from the Advanced Technology and Instrumentation program. The proposal for this grant was submitted in 2001 by the US SKA Consortium that then included Caltech/JPL, Cornell and the National Astronomy and Ionosphere Center, MIT/Haystack Observatory, Naval Research Laboratory, National Radio Astronomy Observatory, Ohio State University, SAO/Harvard, SETI Institute, University of California, Berkeley, and University of Minnesota. A second proposal, submitted in September 2002, includes participation by a new member of the Consortium, the University of New Mexico.

The work plan under the received three-year grant is intended to complement ongoing efforts by the SETI Institute and UC Berkeley to build the Allen Telescope Array, development work in the US on LOFAR by NRL and MIT/Haystack, implementation of NRAO's EVLA, and work at JPL on large-array designs for the next generation Deep Space Network. Specific work areas include cost-efficient manufacturing of hydroformed antennas, electromagnetic designs for on-and-off axis reflector/feed combinations, RFI-mitigation algorithm development and demonstrator observations, feasibility studies of Epoch of Reionization observations, optimization studies of SKA configurations, correlator concept studies, and investigation of packet switching approaches to long-distance data transport. The NSF-funded work is being used to refine the US concept described in the Whitepaper submitted to the ISSC in June 2002 and which will be updated in May 2003 for evaluation at the International SKA Meeting in Geraldton in August 2003.

The second proposal, still pending, will cover work areas not fundedunder the original proposal. These include

1. Site surveys with emphasis on RFI characterization.
2. A demonstrator project for the Epoch of Reionization, recombination lines and RFI mitigation: installation of a 4+1 beam (catwalk + carriage house) system at Arecibo for detecting the EoR signal at 100 to 250 MHz.
3. Installation of prototype SKA feed antennas at Arecibo fo evaluation in an RFI-rich environment and for broadband study of giant pulses from the Crab pulsar.
4. Investigation of fiber optic networks
5. Investigation of polarization capabilities in the US SKA design.

Progress is reported at biyearly meetings of the US SKA consortium.

With the location advantage of our most recent SKA member, the University of New Mexico, we have planned to prepare detailed information on the possible SKA site in the US South West region including parts of Mexico. Extended maps denoting roads, population density, air traffic, transmitters etc will be documented. An analysis of radio quietness will be made, and the possibility of land acquisition will be explored.

In general we are hard at work in updating the US SKA design and in preparing our hosting and siting document.

Jim Cordes and Yervant Terzian, Cornell University