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**Message from the Editor**

*Steve Torchinsky*

SKADS is now well into its final phase with many of the tasks to be completed before the end of June, as originally planned more than four years ago. Some understandable delays have occurred for the hardware demonstrators, and as a result SKADS will be extended by six months through to the end of 2009. This extra time has been granted by the European Commission, though without any added funds, but by delaying the writing of the final reports, we will have more time to perform interesting measurements, and even astronomical observations with the demonstrators.

EMBRACE is well on the way to full implementation with tiles setup at Westerbork, and an initial tile already at Nançay. For more information, have a look at the article on EMBRACE in this issue of the Newsletter. The BEST demonstrator at the Northern Cross is up and running, and we’re looking forward to results of astronomical observations in the coming months which will be undertaken in collaboration with the SKADS group at Oxford. The article by Germano Bianchi et al. has more details. The article by Georgina Harris et al describes the impressive progress 2-PAD has made over the course of the SKADS project.

The SKADS Sky Simulations have been available online for nearly a year, and a number of publications have resulted from this effort. The article by Hans Rainer Klckner gives more details, and a list of SKADS related publications, including those arising from the SKADS Simulated Skies, can be found on the SKADS website. Just click documents at [www.skads-eu.org](http://www.skads-eu.org).

With the end of SKADS in sight, we will take stock of our achievements during the final SKADS Conference at which we hope to see participants from the world wide SKA community. The theme of the conference is “Wide Field Science and Technology for the SKA” and it will take place at the Château de Limelette in Belgium where SKADS was kicked-off in 2005. You can register for the conference and find logistical information on the SKADS website at [www.skads-eu.org/p/limelette2.php](http://www.skads-eu.org/p/limelette2.php).

I hope you’ll enjoy this issue of the SKADS newsletter!

**Message from the Coordinator**

*Arnold van Ardenne*

SKADS has entered its final year and everything is tuned toward achieving its goals of a simulated and costed SKA system design focusing on the use of phased aperture arrays in the SKA mid-frequency range.

Important developments in the international SKA project have taken place over the last year and it is clear that SKADS must incorporate them into our ongoing work. For example, the issue of siting is a primary activity in the International SKA Program Development Office (SPDO). On the other hand, SKADS has contributed significantly with the SKADS costing tool, SKADS simulations, and the SKADS technological and demonstrator developments emphasizing the potential of phased arrays for the SKA.

SKADS achievements were clearly described in its third Annual Report which was delivered to the EC over half a year ago. It gives an impressive overview of the work done in SKADS during its third year. The third Annual Report is in the process of awaiting formal EC-approval, but this informative piece of work is already available on the SKADS website (go to “documents” and select “annual reports” from the side menu).

Time flies however, and thanks to its thorough reporting, it also became clear that SKADS could not accomplish its ambitious goals within the nominal timeframe *i.e.* to be finished on 1 July 2009. In that case, this newsletter probably would have been the last! Considering the importance of achieving the SKADS goals, the proposal by the SKADS MT was agreed by the Board to forward a request to the EC for a no-cost extension of half a year,
giving a new end-date for SKADS of December this year.

The request for extension is now formally approved by the EC, and as a result SKADS will be able to report first test results of the completed demonstrators and achieve the required deliverables before the new due date.

The System Group was established last year for getting the system report done as the deliverable for DS8. This System Group will focus on technological readiness, and remaining key issues to address in the last year, and of course, the System Group will focus on delivering a costed SKA architecture. It met several times already and uses the SKADS costing document (SKA Memo #93) as a reference.

Wherever possible, deliverables should be finished at the original SKADS end-date which was 1 July 2009, and we should not give in to the natural tendency to finish everything at the last second. It is possible to complete a number of tasks before 1 July. For example, DS2, the science and technical simulations, is well on track. Well done DS2! It is obviously not possible for the demonstrators to complete before 1 July because, while impressive progress had been made, they are nonetheless delayed somewhat.

Many presentations were given by the SKADS family at various international events reporting on science and technology progress and making an increasingly convincing case for aperture arrays for the SKA. Please consult the SKADS website for publications and note that we are very happy to list new ones. I personally feel that a more complete list must be possible.

With support from the SKADS-Marie Curie program, we will have a final SKADS conference from 5-6 November to be held at Limelette, near Brussels (see SKADS website). It is the intention to publish the presentations, both oral and poster, as a conference book so that the final SKADS results will remain available as a reference.

This SKADS Newsletter focuses on some of the recent SKADS achievements but almost in closing, I would like to mention that AA development and verification after SKADS will be done through the Aperture Array Verification Program (AAVP) under the aegis of ESKAC. AAVP will continue the AA efforts from SKADS and deliver its results to Prep-SKA. At this point the AAVP is shaping up and funding opportunities are sought. A draft version of the Project Plan is awaiting the approval of ESKAC while we finalize the Description of Work. As a recent development, it is worth mentioning that funded participation from Australia through the newly established ICRAR has been agreed and that South Africa has become an associate partner.

Also, RFI tests were performed at several sites in Portugal near Evora. We already know that the area offers comparable solar intensity levels with the two potential SKA sites. A preferred “SKA emulation site” has been chosen and our Portuguese colleagues are planning further steps toward establishing this as the site of choice. Great!

SKADS-Marie Curie has also entered its last year. A successful workshop was organized in March by Oxford University and planning is progressing on a next workshop in University of Manchester on advanced signal processing techniques for the SKA. There will also be a school to be held in Paris organized by Paris Observatory (see the article by Wim van Driel in this newsletter).

With all this, keep an eye on the SKADS website, and for now, enjoy reading!

Message from the Chairman of the SKADS Board

Peter Wilkinson

The SKADS programme was put together as a fully integrated study combining science and technical simulations, architectural studies, technology sub-system developments, demonstrators and costings. There is little doubt, however, that the perceived success of
the programme will pivot around the success of the electronic beamforming demonstrator arrays: EMBRACE, 2PAD and BEST. In any innovative R&D-based project the completion and testing of the main hardware systems always happens very close to the final deadline. With this in mind and cognisant of the delays in the start-up phase in many institutes as new staff were recruited, our coordinator, Arnold van Ardenne and the Management Team have negotiated with the EC an additional 6 months on the end of the project - good job Arnold! We now have to make sure that the benefits of this additional time are maximised.

The individual reports show how quickly progress is being made and I need say no more. But there is additional “hidden” progress being made as the, initially separate, design teams in many institutions are coming together to share their problems and their successes. Thus different manufacturing techniques, different ways of doing digital processing, different antenna and amplifier designs are being tested against each other - but all with the common goal of moving together into the next development phase under the umbrellas of PrepSKA and the the Aperture Array Verification Programme.

The SKADS programme was ambitious but we can now see that it will be a great success in establishing, and propelling forward, the innovative European contribution to the International SKA project.

EMBRACE
Steve Torchinsky

EMBRACE has made significant progress towards the working systems at Westerbork and at Nançay. We expect a system of 144 tiles at Westerbork to be operational as a system by August. The system in Nançay will have 80 tiles, and that will be setup soon after the Westerbork system.

Each tile has a physical area of 1.12 m², so our total physical collecting area will be ∼160 m² in Westerbork. We will, of course, measure the effective collecting area, which is one of the primary goals of the EMBRACE testing. The effective area will hopefully come close to the physical area which is equivalent to a 14 m diameter dish. At Nançay, the 80 tiles represent a physical area equivalent to a 10m dish.

The null production run of tiles has been delivered and is being assembled at Dwingeloo. Some tiles are already installed in the radome at Westerbork (see picture). One tile has also been delivered to Nançay.

If you are interested to participate actively in the EMBRACE testing, you might consider spending your summer in Westerbork or Nançay!

2-PAD: The New Arrival
Georgina Harris, Chris Shenton, Tim Ikin, Kris Zarb-Adami, Andy Faulkner, Tony Brown, Peter Wilkinson, Sascha Schediwy

2-PAD has been progressing quietly since 2007 and now, to the delight of its designers, it is finally rising from the Cheshire countryside.
The first EMBRACE tile has arrived at Nançay, and is undergoing test in the lab. (photo by Jean-Michel Martin)

A great deal is expected of 2-PAD (the dual-polarisation all-digital) aperture array; especially considering its heritage and having been sited in the shadow of its older, more experienced bigger brother, the Lovell telescope, the UK’s largest radio telescope.

The short-term goal of 2-PAD is to demonstrate, by the end of the year, digital beamforming capabilities for the mid-frequency (0.3-1.0GHz) aperture array portion of the SKA. 2-PAD is designed to be a modular test-bed for evaluating a variety of new and novel technologies in every part of the system: it is small enough to upgrade individual sub-systems such as LNAs and processing systems whilst large enough to conduct meaningful experiments and explore its capabilities. The modularity of the system also means that its capabilities can be scaled up quickly and easily in the future.

The main aims of 2-PAD are summarized below:

- Formation of 1 or more beams pointing in different directions
- Process more than 100 MHz of Bandwidth instantaneously
- Demonstrate a clear understanding of Tsys in a digital array
- Demonstrate a cost-effective route to mass-manufacture on SKA timescales
- Show properly calibrated dual polarization performance for an aperture array

2-PAD is based at Jodrell Bank Observatory where the various subsystems are currently entering the commissioning and integration phase. The 2-PAD design team are based at the University of Manchester (both Jodrell Bank Centre for Astrophysics and the University of Manchester Antenna and LNA Teams), the University of Oxford and the University of Cambridge. Although 2-PAD is a UK demonstrator we have also been working in very close
collaboration with our colleagues at ASTRON on many aspects of the design. A brief description of the main blocks of 2-PAD is below:

**Antenna Arrays**

The 2-PAD antenna development based in Manchester has involved the design of two novel technologies, the BECA (Bunny Ear Combline Antenna) and the ORA (Octagon Ring Antenna) arrays. Both arrays’ electromagnetics were designed by the Communications Engineering Group at the University of Manchester and their mechanical design was by Jodrell Bank Centre for Astrophysics, the University of Manchester. 2-PAD will also include the integration and testing of a “reference” Vivaldi antenna, FLOTT (FlowPAD Towards TwoPAD), a larger implementation of ASTRON’s FlowPAD array which uses advanced, printed manufacturing technology; the aim of which is a high performance, low cost antenna.

Detailed electromagnetic simulations have been carried out for the central 8x8 array of antennae which are embedded in a 16x16 array for electromagnetic purposes. All these arrays (BECA, ORA and FlowPAD) are currently in test in the electromagnetic facilities of SELEX-
The FLOTT Antenna Array at Jodrell Bank Observatory (photo G. Harris)

GALILEO in Edinburgh, in order to compare the RF-performance of the array with the predictions made by the modelling software. This should enable us to select which array to use initially on 2-PAD.

The 2-PAD team in Manchester have taken a novel approach to LNA design, specifically in the match-criterion between the antenna and the active element. The input impedance of the transistors was matched to that of the antenna element in order to minimize the input reflection-loss. Simulations of the designs are shown below.

The innovative large periphery InP transistors have been designed and manufactured in the Microelectronics & Nanostructures (M&N) Group in the University of Manchester and will be tested during the month of May against commercially available GaAs transistors. The InP simulations look good and we eagerly await test results on the real components so that we can integrate them soon onto 2-PAD.

Analogue Signal Chain
We have designed an analogue signal chain capable of amplifying 32 RF-signal(s), with appropriate filters such that we can select a

The complex input reflection co-efficient of the ORA at broadside and the modeled polynomial fit extracted in order to design the transistor characteristics.

Simulated characteristics of the ORA-LNA. Field tests are expected to be complete by the end of May.
The RF-Analogue System of 2-PAD, with the Analogue-to-Digital conversion process taking place in the Data Acquisition Card (Diagram T. Ikin)

low-frequency channel (0-400MHz) and a high-frequency channel (500-1000MHz). The RF-output of this signal chain is designed to be directly digitized for processing. These are being built and bench evaluated at Oxford prior to integration with 2-PAD. The analogue chain is deliberately split out with substantial gain at the antenna, combining into the signal transport and equalizing the bandpass within the processing bunker. This enables alternative approaches to be tested, in particular we are using low cost commodity cable transpor (CAT-7) and working on resolving any performance issues and RFI shielding challenges. It is essential that we achieve the consistency and stability such that the digital signal processing system can be used to calibrate the system.

Digital Processing System

When the Analogue Signal arrives at the boundary of the Digital System. It must be band limited & filtered, digitised and then processed into many narrow bands (channelisation). This channelised frequency domain data is then passed to the Beamformer. A number of implementations are being pursued at Manchester and Oxford.

The Custom 2PAD Digital System consists of two major elements;

1) The Data Acquisition and Channelisation Subsystem: containing 4 main units:
   i) The Signal Conditioning Board - this board provides various configurable filtering options for band limiting and RFI rejection.
   ii) The DAQ Board - this board contains the major functionality of the DA Subsystem. It Contains a Dual Channel 1Gs/s ADC, A Large Xilinx Virtex 5 FPGA. Its job is to Digitise a pair of Analogue signals, convert the time domain samples into 1024 narrow band frequency bins. Create data frames and send via multiple 2.5Gb/s transceivers to the beamformer subsystem. The DAQ board has up to 20Gb/s of data transmission bandwidth available for the digital signal transport.
   iii) Midplane & Card Frame - The DA Subsystem is built around a standard Eurocard form factor card frame. The Cardframe houses a midplane which provides power distribution and length matched clock routing.
The midplane is a 10 slot midplane with cards mounted both front and rear. The DAQ Card is mounted in the front of the cardframe, and the signal conditioning board is mounted as a rear transition module. Both cards are single Eurocard form factor. The middle front slot houses the shelf level clock distribution card. A Spare slot is available for powering a System Clock Card.

iv) Clock Distribution - The DA Subsystem requires an accurate phase controlled clock tree to ensure that the analogue signals are sampled coherently. This is achieved using a 2 stage LVPECL clock fanout system. This consists of a system level clock synthesiser card, and a shelf level clock distribution board. This system has been characterised and provides better than 15 ps (rms) jitter at each slot in the DA Cardframe

The Beamformer Subsystem
The Manchester Team has developed an innovative software beamformer originally intended for deployment on a locally-installed compact supercomputer built from large-scale Multi Core Processors. This beamformer has been simulated and is currently being deployed onto a remotely-installed supercomputer installation.
Because of the developmental basis of the custom system in Manchester, the Oxford team has been developing an alternative system based around standard hardware & firmware building blocks available from the CASPER group at Berkeley.

This alternative system is currently based around iBOB and iADC hardware, but will soon be upgraded to use the ROACH hardware platform.

We anticipate a merging of the two systems in the near future with an Oxford beamformer implementation based on ROACH hardware providing a high performance FPGA-based beamforming subsystem. In the meantime the iBOB based system provides the proving ground for the firmware design, and provides a small scale, narrow band system suitable for use in testing a digital beamformer in an antenna test range environment.

Implementation and Testing
All the infrastructure and Bunker has been installed by the Manchester team at Jodrell Bank. The integration of the subsystems is scheduled for the end of June/beginning of July. After a period of integration testing there will be performance testing with both astronomical and artificial sources through to the end of October. This leaves time to report in detail on the results by the end of SKADS at the end of the year. Of course, 2-PAD will have valuable ongoing use in the next stages of aperture array development in the AAVP (aperture array verification programme) as part of Prep-SKA.

BEST
Germano Bianchi, Aris Karastergiou, Kris Zarb-Adami, Stelio Montebugnoli

The Best-2 SKA pathfinder is composed of 32 receivers with the front ends installed on the focal line of 8 cylinders offering a collecting area of about 1400 m². The signal is sent to the receiver room via an optical fibre. The rough schematic block diagram is shown in the figure.

A DDC (Digital Down Converter) block and a Polyphase filter bank (“FFT” block of the FX correlator) has been designed and used to configure a 32 receivers FX correlator. The back-end is composed of 8 Ibobs, 16 dual ADC boards (8 bit, 1GSPS) and a Bee2 FPGA cluster (1 Tops/sec).

Possible tests of the BEST 2 system at the Northern Cross in Bologna
Following a meeting between a team from Oxford and the BEST team in Bologna, we are currently thinking of the details of test observations that will exploit the BEST 2 upgrade of the Northern Cross telescope. The two different observing modes that we are considering are aimed at a) testing the multi-beaming capabilities of the instrument and b) testing post-processing hardware and algorithms while conducting a survey for dispersed transient signals of astrophysical origin.

The first test project would be to form two synthesized beams and observe pairs of bright northern pulsars that have an angular separation on the sky which fits within the primary beam of the BEST 2 collecting
Table 1: The main features of BEST-2

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>System temperature</td>
<td>86 K</td>
</tr>
<tr>
<td>Central frequency</td>
<td>408 MHz</td>
</tr>
<tr>
<td>Frequency BW</td>
<td>16 MHz</td>
</tr>
<tr>
<td>IF</td>
<td>30 MHz</td>
</tr>
<tr>
<td>Instantaneous BW</td>
<td>16 MHz</td>
</tr>
<tr>
<td>Instantaneous primary FOV</td>
<td>37.62 deg</td>
</tr>
<tr>
<td>declination</td>
<td>5.7 deg</td>
</tr>
<tr>
<td>right ascension</td>
<td>6.6 deg</td>
</tr>
<tr>
<td>Synthesized beam size</td>
<td>0.9 deg²</td>
</tr>
<tr>
<td>declination</td>
<td>31.1 arcmin</td>
</tr>
<tr>
<td>right ascension</td>
<td>104 arcmin</td>
</tr>
<tr>
<td>Independent beams within FOV</td>
<td>21</td>
</tr>
<tr>
<td>Continuum sensitivity</td>
<td></td>
</tr>
<tr>
<td>BW</td>
<td>16 MHz</td>
</tr>
<tr>
<td>Integration Time</td>
<td>30 sec</td>
</tr>
<tr>
<td>Total power mode (full array)</td>
<td></td>
</tr>
<tr>
<td>RMS noise / Sensitivity</td>
<td>5.4 mJy</td>
</tr>
<tr>
<td>RMS noise / Sensitivity</td>
<td>2.0 mK</td>
</tr>
<tr>
<td>Correlation (full array)</td>
<td></td>
</tr>
<tr>
<td>RMS noise / Sensitivity</td>
<td>43.3 mJy</td>
</tr>
<tr>
<td>RMS noise / Sensitivity</td>
<td>2.8 mK</td>
</tr>
</tbody>
</table>

*IF, data acquisition and processing blocks for BEST*
In doing so, we need to implement beamforming algorithms in the instrument back-end that electronically steer two independent beams to track pairs of sources as they transit through the primary beam. The data need to be recorded such that dedispersion and folding algorithms can be applied, to reveal the pulse profiles of the chosen pairs. Early calculations indicate that, with the sensitivity of BEST 2, there is a small number of pulsar pairs with the desired maximum angular separation and high enough flux density to be detected within a single transit through the primary beam.

The second possibility for testing of BEST 2 is related to post-processing using high performance computing, to search for dispersed bursts of emission of astrophysical origin. The chance of detecting a transient burst source increases with the sensitivity (collecting area) but also with the field of view. We will consider recording raw 8-bit sampled data from all 32 BEST 2 receivers over periods of time which correspond to the transit time of a source through the primary beam (roughly 7 minutes). The data, about 8.2 GB per receiving element, will be stored on disk for each 7-minute run. The total of 262.4 GB per run can then be processed using dedicated high performance hardware (such as GPU boards available to Oxford) to perform off-line beamforming and the necessary dedispersion algorithms to detect possible signals of astronomical origin. These tests will push the post-processing hardware to its limits. We will aim for quasi real-time processing of the raw data (including RFI identification), but will adjust the scope after conclusion of first tests. Events will be flagged in the data, while most raw data will be discarded after processing.

SKADS Tools for a full SKA Simulation
Hans Rainer Klöckner, François Levrer, Aris Karastergiou, Steve Rawlings

The SKADS Simulated Skies (S³) catalogue is the result of the coordinated effort of SKADS partners working on SKA sky simulations. The resulting simulated data and associated software tools are available on the S³ website hosted by the University of Oxford at s-cubed.physics.ox.ac.uk. The S³ database is available to the whole community, and number of results have already been published which make use of the S³ simulations. These include the continuum simulation description by Wilman et al. (2008 MNRAS, 388, 1335). A number of papers on H_I and H_2 line emission have been published by Obreschkow et al. (arXiv:0904.2221, arXiv:0904.0213, arXiv:0901.2526) and several more are submitted! For the pulsar simulations the publication is by Smits et al (2009 A&A, 493, 1161) and papers on the S³ simulations of the Epoch of Reionisation have been published by the Lisbon group by Santos et al. (2008 ApJ, 689, 1) and the Paris group by Baek et al. (2009 A&A, 495, 389). A recent paper has been submitted by O’Sullivan et al. from the University of Calgary (arXiv:0902.1995) making use of the S³ database to create a simulation of the polarised sky at 1.4 GHz.

The SKADS Simulated Skies are a set of simulations of the radio sky suitable for planning science with the Square Kilometre Array (SKA) radio telescope. Three simulations can be accessed:

- S³-SEX (Semi-Empirical eXtragalactic database) This simulation of the extragalactic radio continuum sky puts an emphasis on modelling the large-scale cosmological distribution of radio sources rather than the internal structure of individual galaxies. The simulation covers a sky area of 20 by 20 degrees, out to a cosmological
redshift of $z=20$, and down to flux density limits of 10 nJy at 151 MHz, 610 MHz, 1.4 GHz, 4.86 GHz and 18 GHz. Status: Total intensity simulation complete. Linear polarization information available.

- **S$^3$-SAX** (Semi-Analytical eXtragalactic database) This simulation of the extragalactic radio sky puts an emphasis on modelling the small-scale HI emission at smaller scale, and covers a sky area of 5.2 by 5.2 degrees, out to a redshift of $z=4$. Continuum emission information at 151 MHz, 610 MHz, 1.4 GHz, 4.86 GHz and 18 GHz is yet to be added. Status: Total intensity simulation complete. Database in progress.

- **S$^3$-PUL** (PULsar database) This database includes the parameters of a simulated Galactic population of pulsars, including an average pulse profile for each source. The population is derived using the PSRPOP package (http://psrpop.sourceforge.net/) in collaboration with Roy Smits (Jodrell Bank Centre for Astrophysics). The pulsar profiles are generated using a stochastic model of the pulsar beam by Karastergiou & Johnston (2007 MNRAS, 380, 1678), the viewing geometry from the population synthesis, and temporal smearing caused by interstellar scattering. Status: Simulation complete, database in progress.

Regarding the extragalactic simulations, query results may be subjected to post-processing algorithms described in the relevant sections, and used to build maps or data cubes.

A set of standalone python tools may be used to build and query local databases, apply post-processing to query results and build maps and cubes on a local system. These SKADS Simulated Skies Interactive Tools are described here and may be downloaded here. They use the same routines that are implemented on the server, so that users may for instance query the online databases, download results, and use local post-processing and map-making tools.

This project has been supported by the University of Oxford (sub-department of Astrophysics and Oxford e-Research Center) and by the European Community Framework Programme 6, Square Kilometer Array Design Study (SKADS), contract #011938.

The polarization efforts have been supported by the Cavendish Laboratory at the University of Cambridge and the Max Planck Institut fr Radioastronomie in Bonn.

The EoR simulation efforts have been supported by the Observatoire de Paris and the Instituto Superior Tecnico (Lisbon).

**Multifield and Multibeam Science with the SKA:**

**MCCT-SKADS Workshop in Oxford**

*Ian Heywood*

The latest Marie Curie Conferences and Training (MCCT) workshop for the SKADS programme took place in Oxford between the 16th and 27th of March. The motivation for these workshops is the transfer of knowledge between the current project scientists and those researchers who are new to the field. The theme for this, the 5th workshop, was multifield and multi-beam science with the Square Kilometre Array.

It is anticipated that a large fraction of the SKA collecting area will be phased aperture array receivers in which digital signal processing replaces conventional analogue electronics and mechanical hardware to create an ‘all-electronic’ radio telescope. This facilitates novel observing modes such as almost-instant repointing and multiple beams on the sky.

The Oxford MCCT workshop covered the scientific rationale for the use of such observing modes and introduced some of the new
Participants at the Oxford MCCT workshop, 16-27 March 2009

“Towards the SKA: increasing the evolution rate in radio astronomy” 3rd MCCT SKADS Training School

Wim van Driel

In this Darwinian year, the Observatoire de Paris will be organising the Third MCCT-SKADS Training School, entitled “Towards the SKA: increasing the evolution rate in radio astronomy”. The school will be held in Paris, France, from 25 to 29 August 2009. The school is fully sponsored by the Marie Curie MCCT-SKADS programme, within the Sixth Framework Programme of the European Commission.

This is the third, and final, School organised within the framework of the training activities of the Square Kilometre Array Design Studies (SKADS) initiative. The main goal of the Schools is to attract and train potential users of the new generation of radio interferometers, with special focus on the Square Kilometre Array (SKA). This school is not only aimed at radio astronomers, but also at young astronomers and engineers from all fields of astronomy.

A requirement for participation is to have

hardware and software techniques which are involved in the development and data processing of aperture arrays. The first week of lectures was followed by a week of practical courses, involving simulation and calibration with the MeqTrees software package (Oleg Smirnov), LOFAR calibration (Sarod Yatawatta), distributed computing with Nereus (Rhys Newman, Aris Karastergiou), the OSKAR station beamforming simulator (Fred Dulwich, Ben Mort) and digital signal processing with the CASPER FPGA hardware (Richard Armstrong, Kris Zarb-Adami).

The workshop attracted almost 50 participants (of which 1/5 were female!), of 17 nationalities, from every continent except Antarctica. There was also a busy social schedule, including an ‘Inspector Morse’ pub crawl and a football match which attracted a remarkable 25 participants. Furthermore information and downloadable resources can be found at the conference web page: www.physics.ox.ac.uk/MCCT-SKADS.
finished undergraduate (university) studies.

The school covers the following areas:

- science and technology highlights of the SKA
- scientific projects for the SKA Precursor instruments (ASKAP and MeerKAT)
- science with SKA pathfinder instruments, such as LOFAR
- scientific synergy with, e.g., the higher-frequency radio telescope ALMA and with future large optical telescopes like the E-ELT
- new approaches in radio astronomy imaging and calibration (like MeqTrees)

The programme will consist of a series lectures, spread over a period of 5 days, in morning and afternoon sessions. The participation will be limited to a maximum of 40 people.

**Venue, accommodation and costs**

The venue of the School will be the original site of the Observatoire de Paris, located near the centre of the City of Lights. Accommodation for participants will be provided in nearby hotels.

Participants are expected to stay for the full length of the school arriving on Sunday 24 August 2009 and departing on Saturday 30 August 2009. There is a School fee of 150€ (taxes included), and a full board lodging cost from 24 to 30 August of about 650€ (taxes included) has been arranged.

Both the participation fee and the full board lodging costs will be covered by the MCCT-SKADS programme for selected participants with less than 10 yr of experience in research. These participants will also receive a contribution in their travel expenses, which should be enough to fully cover low-cost airline tickets.

The School organization is bound by strict rules imposed by the European Commission, e.g. related to last-minute cancellations. To minimize the risks to the funding of the Training School, we therefore require that all attendees who are accepted for the Training School advance the School fee of 150€. This amount will be restituted at the beginning of the School.

More information and the registration form is available at the MCCT-SKADS website [mcct.skads-eu.org/paris/](http://mcct.skads-eu.org/paris/)