

ASTRON

Annual report 2010





Image on front cover:

Her Majesty Queen Beatrix visits the LOFAR antennas after officially inaugurating the telescope near Exloo, the Netherlands.

Credits: Hans Hordijk.

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Preface

2010 was perhaps the most memorable year in ASTRON's 60 year history. The year was dominated by the formal inauguration of LOFAR by her majesty Queen Beatrix and the organisation of the International Square Kilometre Array (SKA) Forum 2010 in Assen. Both of these events were unqualified successes and drew national and international attention to both ASTRON's activities and to the SKA project. However, 2010 was also a year in which major progress was made

with many of our technical projects - in particular, LOFAR, APERTIF and EMBRACE. By the end of the year, more than 30 LOFAR stations were operational and the telescope was beginning to produce some stunning pulsar results and spectacular images of distant radio sources. Many international LOFAR stations also became operational during this period and the first long-baseline images began to appear. At the end of the year, a major step forward occurred with the establishment of the International LOFAR Telescope (ILT) foundation. The Astronomy Group within ASTRON also continued to expand and flourish, changing the balance of the institute and strengthening our end-to-end capability of designing, building, commissioning and scientifically exploiting new instruments for radio astronomy. At the end of 2010, the institute was well placed to complete the roll-out of the LOFAR telescope and begin the process of moving forward into the challenges associated with the commissioning phase. The prospect of the first scientific results appearing in 2011 is a tantalising one.



Prof. Mike Garrett
General Director



The superterp forms the heart of the LOFAR telescope, located between the villages of Exloo and Buinen in the province of Drenthe. Credits: Top-Foto, Assen.

Radio Observatory

LOFAR in 2010

World's largest eye completed

In the summer of 2010, the LOFAR core area in Exloo was completed and by the end of the year almost all remote stations were completed as well. The progress that was made in the last few years has been in the words of ASTRON's Scientific Advisory Committee "amazing" - there have been some challenges, including the weather and other delays associated with the bird breeding season but in the end it all worked out very well.

The official inauguration of LOFAR

It was a beautiful, sunny afternoon on Saturday 12 June 2010 near the village of Exloo. More than seven hundred people were invited for the first part of the ceremony in which Her Majesty Queen Beatrix would carry out the official inauguration of the International LOFAR Telescope (ILT). In his speech, managing director of the LOFAR foundation Michiel van Haarlem stated with obvious relief: "This ends the phase when LOFAR only belongs to the engineers." In an interview later on the day he added: "I expect the first science results before the end of this year."



Queen Beatrix of the Netherlands on one of the LOFAR stations near Exloo and Buinen, Drenthe. Credit: Hans Hordijk.



In March 2010 the LOFAR superterp began to emerge from the central core region.

During the ceremony, Van Haarlem briefly interviewed a number of LOFAR stakeholders on stage. For LOFAR is not just a radio telescope, it is a multi-purpose sensor network connected by glass fibres. It is already being used as a test bed for precision agriculture, for the study of infrasound in the atmosphere and for geophysical research. Also, the central part of the telescope is a protected area for wildlife.

A nostalgic note was struck when grainy black-and-white footage was shown of another inauguration, by Beatrix' mother, Juliana. In April 1956, she ceremonially pushed a button to start the 25-metre Dwingeloo single-dish radio telescope, which was the largest in the world for several months.

This time the stage was set with a dazzling, full colour display of countless LEDs and spotlights, but once again a Dutch Queen inaugurated a radio telescope that will be unique in the world for some years to come. As in sport, no scientific instrument stays at the top for very long. Michiel van Haarlem put it: "We hope to learn many valuable lessons that we can pass on to the Square Kilometre Array."

While the 700 guests reflected on the event over a drink, the Queen was invited to visit one of the antenna stations in the field. On a red carpet, Queen Beatrix ventured from her bus to one of the deceptively simple looking antennas in the clay. She was accompanied by half a dozen officials, and filmed in close-up by at least as many camera crews.



Queen Beatrix officially opened the LOFAR telescope by pushing the button, which started live observations, displayed on a full colour screen. Credit: Hans Hordijk.

With the Queen safely dispatched to her waiting helicopter, the day was concluded with a signing ceremony that brought into being the International LOFAR Telescope (ILT). With Ralph Wijers (University of

Amsterdam) wielding a large hammer, the various Dutch and European ILT representatives duly signed up for what promises to be a very long and successful collaboration.



Prof. Mike Garrett signed the agreement of the International LOFAR Telescope, just after the official inauguration. Credit: Hans Hordijk.

Operational dress rehearsals for LOFAR

With all the excitement surrounding the rollout of the LOFAR station hardware, one could have easily missed an equally important rollout that has been underway since the beginning of 2010. Starting in January 2010, staff from the Radio Observatory and ASTRON R&D division began field-testing the operational control software for LOFAR. This system allows LOFAR scientists and operators to configure, execute, and process observations from start to finish including ingest of the resulting scientific data products into the Long Term Archive (LTA). Configuration interfaces for various observing modes, creation and propagation of metadata through the system, and interfaces to actually initiate and control the science pipelines were all under active development. Borrowing a page from the scientific commissioning efforts, the Radio Observatory organized a series of focused "busy weeks" to get this new control system up and running.

The Observatory's operational busy weeks serve several functions. First they provide an opportunity to test and debug the software systems, but just as importantly they allow both operators and support scientists to gain experience actually using that system. The ultimate goal is to produce a system where the full data flow of a LOFAR observation from proposal to archived scientific data product can be supported. With this goal in mind, these busy weeks are striving to emulate the actual operational LOFAR data taking process as much as possible even

while the full system functionality was still being deployed. These “dress rehearsals” were an important part of preparing for the sustained operations required to execute the full science operations that follow.



The LOFAR busy week in full action in the control room in Dwingeloo.

The Westerbork Synthesis Radio Telescope in 2010

New technology dramatically increases field of view Westerbork telescope

The Apertif project, which aims to increase the survey speed of the Westerbork Synthesis Radio Telescope (WSRT) by a factor thirty by installing so-called Phased Array Feeds, successfully passed the Preliminary Design Review (PDR) in 2010. A panel consisting of Albert-Jan Boonstra (chair, ASTRON), Ger de Bruyn (ASTRON), Aaron Chippendale (CSIRO, Australia), Jason Hessels (ASTRON), Lister Staveley-Smith (UWA, Australia) and Bruce Veidt (NRC-DRAO, Canada) reviewed the project progress to make sure that the current baseline design optimally covers the science case and is technically feasible. The Apertif team produced an extensive set of documentation for the review that included the science requirements, the system requirements, the system architectural design and the design of the subsystems.

The panel considered Apertif a perfect science project, with a good link between astronomers and engineers, and also with links to other front-line Focal Plane Array (FPA) work in the world. Also, the good synergy between Apertif and the new LOFAR telescope was acknowledged.



Across Europe, international LOFAR stations began to appear - including Chilbolton (UK) shown here.

Various valuable suggestions were made by the panel to further improve the science case and the proposed design. The panel concluded that the Apertif science case is broad, and justifies upgrading the WSRT with focal plane arrays in L-band. To the best of their knowledge, all major risks had been identified and they concluded that, with Apertif, ASTRON is at the international forefront with respect to developing FPA technology for radio telescopes. Apertif now continues with the detailed design phase, aiming for rollout in 2012.



The Apertif Design Review in 2010



The Design Review panel took a closer look at the Apertif hardware in one of the Westerbork dishes

After the PDR, the Netherlands Organisation for Scientific Research (NWO) announced that it will fund the Apertif proposal with 2.5 million euro. This proposal was submitted to the NWO-Groot programme

in the summer of 2010 and requested funding of the correlator, calibration/reduction pipeline and the data archive of Apertif. With this success, together with several earlier successful proposals, funding is now secured for the entire Apertif upgrade of the Westerbork telescope. Due to the many upgrades over the years, the telescope has been at the forefront of radio astronomy over its entire life. Now that it is certain that Apertif will be built, the WSRT will continue to be one of the most advanced radio telescopes in the world for many years to come.

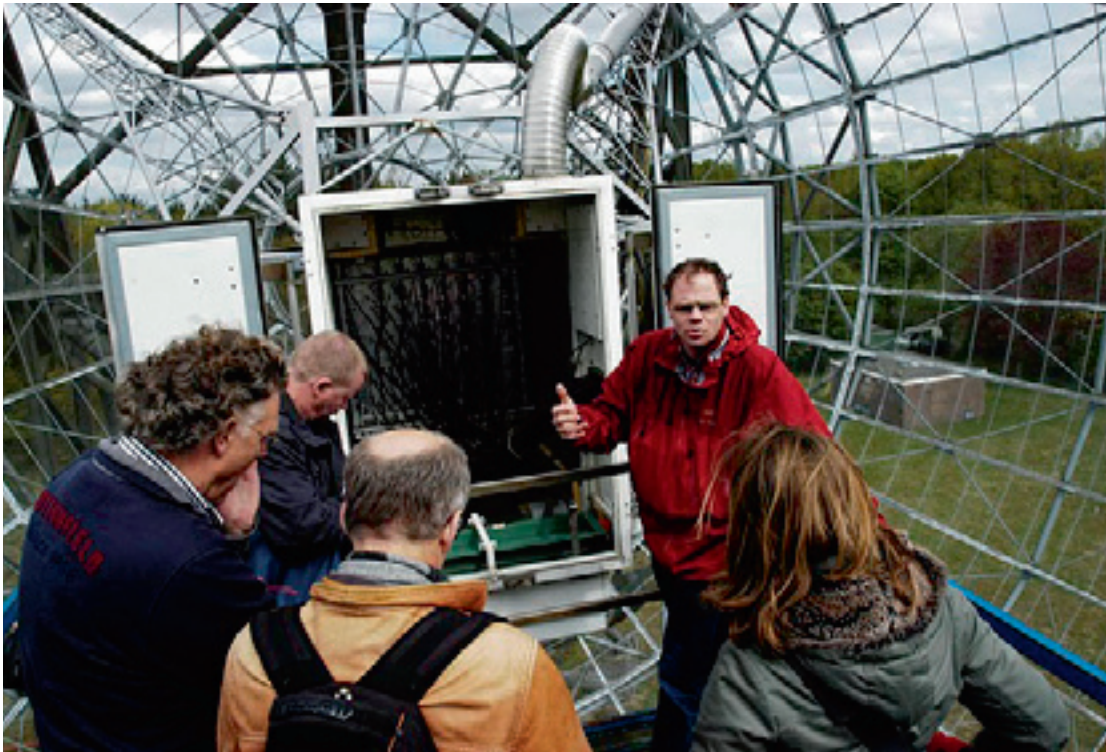
Westerbork telescope still going strong after 40 years of discoveries

On 24 June 2010, the Westerbork Synthesis Radio Telescope (WSRT) existed for exactly forty years. In 1970, the official inauguration of the Westerbork Telescope by Her Majesty Queen Juliana took place. ASTRON celebrated this 40th anniversary of the telescope in October 2010, just before the ASTRON & JIVE Open Day with a mini-symposium, near the Westerbork array.

During the symposium, the technical and scientific achievements of the last forty years were covered, and the participants looked forward to the next decade when the new Apertif technology on the WSRT will come to fruition. Many of the people that gave the WSRT such a glorious start joined the symposium, as well as the people that kept it going, and its past and current users.



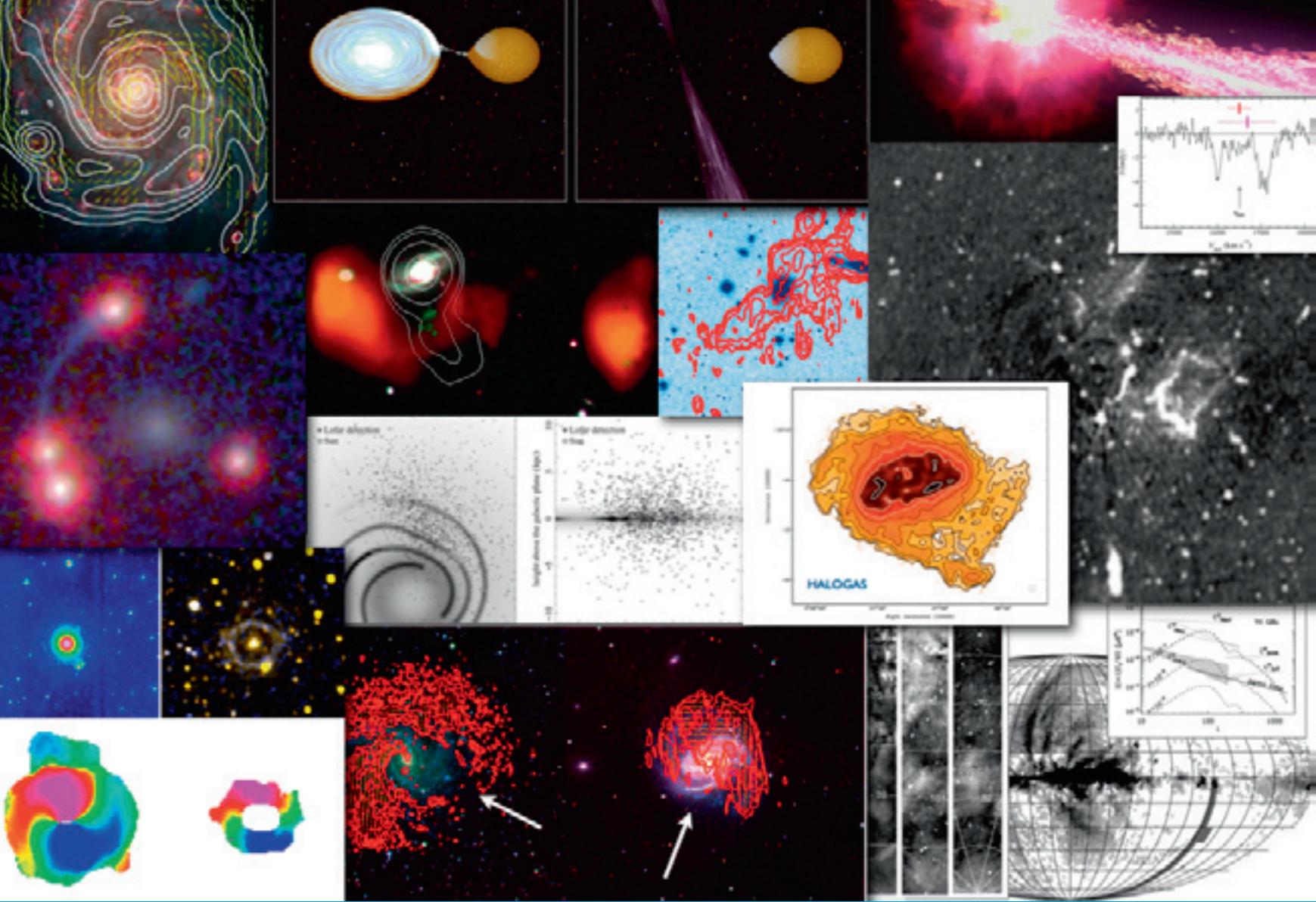
The ILT foundation was established at the end of the year. The first action of the embryo board (Falcke, Garrett & Wijers) was to appoint Rene Vermeulen as the ILT's first director.



In 2010 the APERTIF Phased Array Feed (PAF) systems being developed drew a lot of interest - from scientists and journalists alike.



At the 40th anniversary celebrations of the WSRT many of the original personnel involved in the design and scientific exploitation of the telescope returned to share their memories.



Astronomy Group

Science

In 2010, the astronomy group published 87 refereed papers, topping the previous high of 68 papers from 2009. The majority was published equally over A&A (impact factor 4.2), MNRAS (5.1) and ApJ (7.4); one appeared in Science Magazine and two in Nature. Some highlights are listed below.

Neutral hydrogen in nearby galaxies

Oosterloo, Morganti and collaborators presented an analysis of deep Westerbork Synthesis Radio Telescope observations of the neutral hydrogen in 33 nearby early-type galaxies. This is the deepest homogeneous set of HI imaging data available for this class of objects. The sample covers both field environments and the Virgo cluster. Their analysis shows that gas accretion plays a role in the evolution of field early-type galaxies, but less so for those in clusters (Oosterloo et al. 2010, MNRAS 409, 500).

Meanwhile Serra & Oosterloo (2010, MNRAS 401, L29) analysed the neutral hydrogen and stellar populations in a sample of elliptical galaxies. They found that a large fraction of ellipticals continued their assembly accompanied by significant star formation.



An international team including Morganti, Oosterloo and Serra presented a formation scenario for the Leo ring (Michel-Dansac et al. 2010, ApJ 717 L143).

A New Golden Age for Radio Astronomy
First results from the new generation of radio telescopes
10-14 June 2010, The Netherlands, <http://www.astron.nl/iskaf2010/>

International SKA Forum 2010
The Netherlands

SKA: Anantha Mangam (ASTRON, NLD), Anuran Chatterjee (NSA, IND), Logana Ferrero (OAS, USA), G. Ramani (IIT, IND), Simon Conway (University of Manchester, UK), Anton van der Kruit (Radboud University, NL), Michael Kramer (MPIFR, Bonn, Germany), David Parag (RNO, NL), Abhishek Prasad (ALMA Observatory, Chile), Bo Peng (MOC, China), Elaine Sadler (Sydney University, AUS), Steven Dierker (OAS, Carle University of Technology, NZ), Paul van der Werf (Leiden University, NL), Ralph Wijers (Amsterdam University, NL), Sabreen Zahedi (Cranfield University, UK) - LDC: Raffaella Morganti (IIT), Jozsef Galambos, Sandra Malbon, Paolo Serra, Marjetta Zlotnik

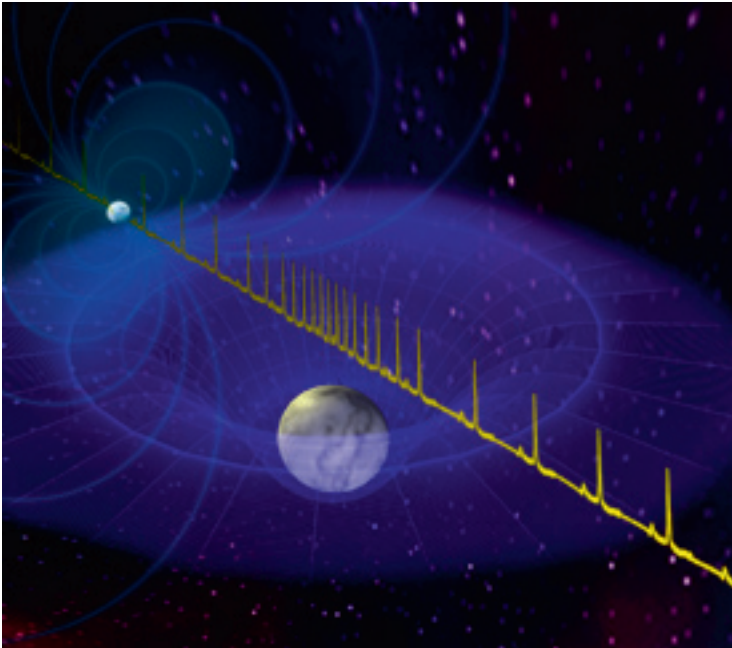
ASTRON RadioNet NWO

The Astronomy Group organised the ISKAF2010 meeting - A new golden age for radio astronomy.

Radio pulsars

Using the computer power of hundreds of thousands of home PCs, a pulsar-survey collaboration including Van Leeuwen & Hessels made the first pulsar discovery by global volunteer computing. After the detection in Arecibo data, the Westerbork telescope pinpointed this 41-Hz pulsar, most likely a disrupted recycled pulsar (Knispel et al. 2010, *Science* 329, 1305).

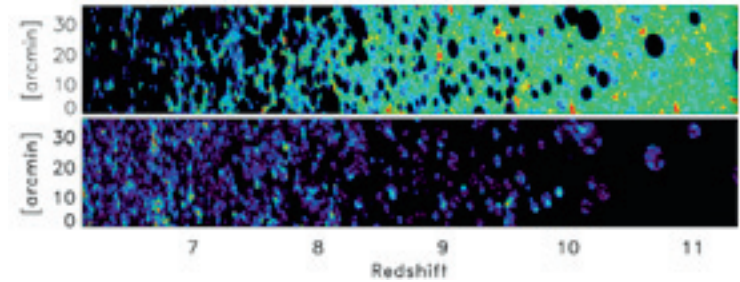
Later in the year, Hessels and colleagues announced their discovery of the most massive neutron star yet known. At a mass of 2.0 solar masses, this star strongly constrains the allowed neutron-star equation of state (Demorest et al. 2010, *Nature* 467, 1081).



Artist impression of the gravitational time delay effect used to weigh the 2.0 solar-mass neutron star (credit: Bill Saxton).

The Epoch of Reionisation and foregrounds

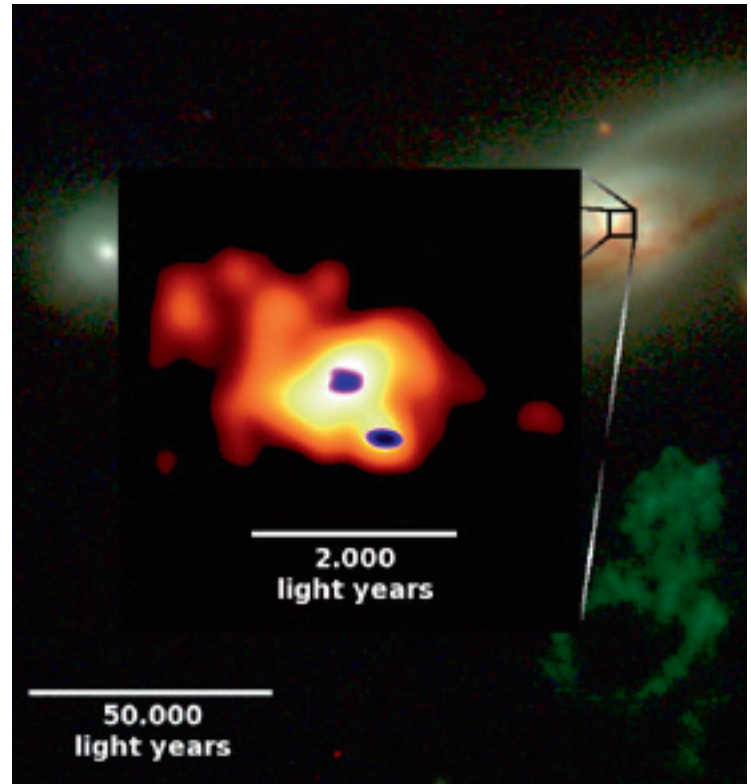
In preparation for LOFAR Epoch of Reionisation (EoR) work, de Bruyn, Brentjens, Jelic, Labropoulos and colleagues published realistic simulations of the cosmological signal, the foregrounds and noise, to estimate the sensitivity of the LOFAR EoR experiment (Harker et al. 2010, *MNRAS* 405, 2492). They also presented 140-160 MHz Westerbork observations to characterize foregrounds to the cosmological 21 cm line. The Galactic total intensity emission was found to lack small-scale power and galactic polarization is not a severe contaminant (Bernardi et al. 2010, *A&A* 522, 67).



Slices through the simulated redshift cube of the the cosmological 21 cm signal (top) and the kSZ effect (bottom) from Jelic et al. 2010, *MNRAS* 402, 2279.

Hanny's Voorwerp

High-resolution radio observations by a team including Garrett, Józsa, Oosterloo and Paragi showed that "Hanny's Voorwerp" is a nebula, ionised by the radiation from the central black-hole of nearby spiral galaxy IC 2497 (Rampadarath et al. 2010, *A&A* 517, L8). From X-ray observations of this galaxy, they measured the shutdown timescale for such a black hole for the first time (Schawinski et al. 2010 *ApJ*, 724, L30).



Radio contours of the "8 o'clock arc", overlaid on the optical emission (McKean et al. 2010, *MNRAS* 404, 749)

Gravitational lensing

McKean, Berciano Alba and Garrett, with various colleagues, investigated several lensing systems. From lensing and kinematics McKean et al. (2010, MNRAS 404, 749) determined the mass distribution of the moderate redshift galaxy group that creates lens system CLASS B2108+213. For the "8 o'clock arc lens system" a limit is placed on the star-formation rate (Volino et al. 2010, A&A 524, A79).

For the lensed sub-millimeter emission in the cluster MS0451.6-0305, a radio counterpart was detected that supports a merger scenario (Berciano Alba et al. 2010, 509, A54).



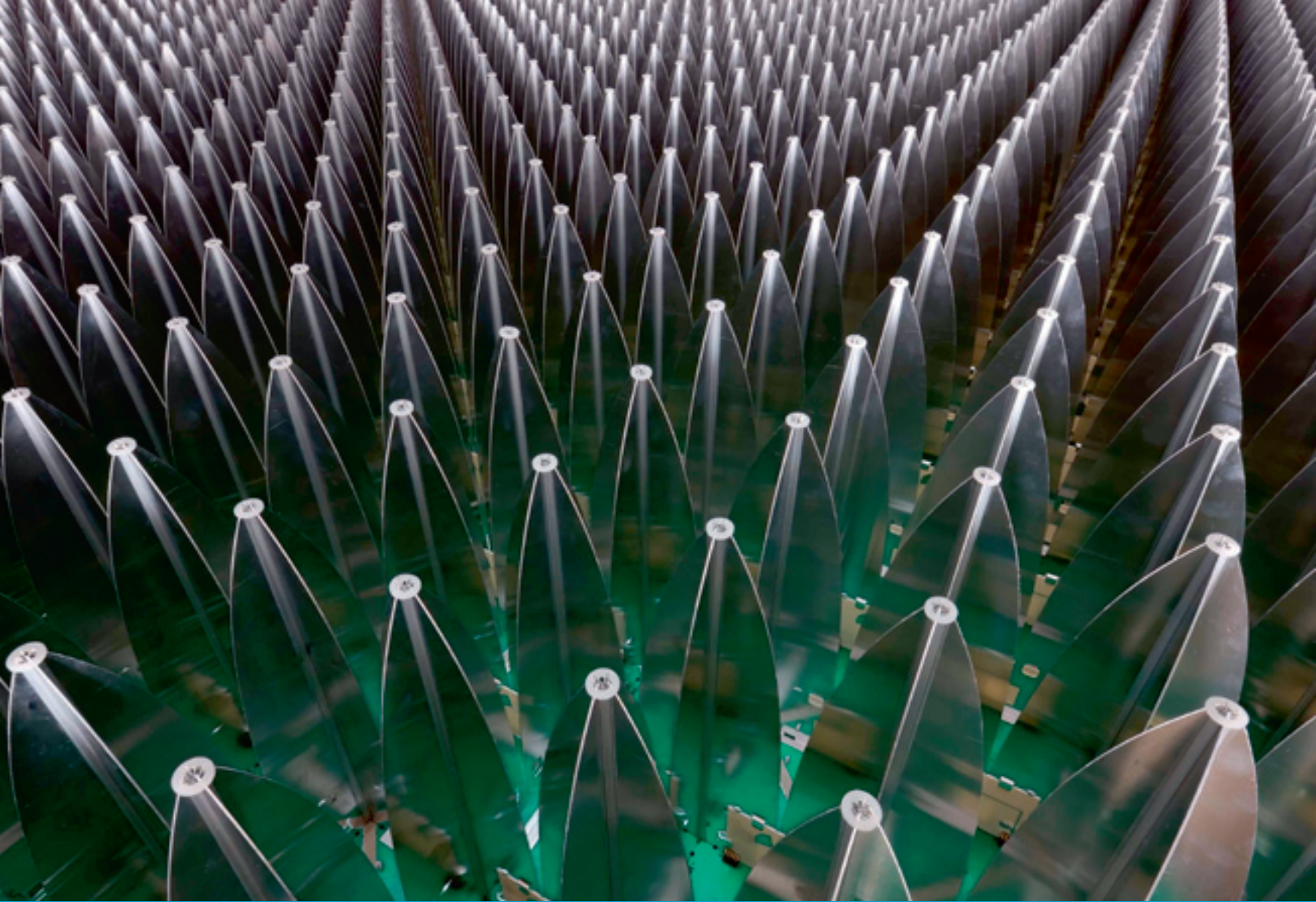
Figure: counterclockwise from top: Gajjar (India), Trasatti (Italy), Giessuebel (Germany), Chen (China), de Maio (USA), Samuel (USA), Alexandroff (USA) and Allan (USA).

Visiting astronomers and students

2010 saw many visitors: a new record of six summer students for the astronomy group, introduced below; an increasing number of bachelor and master students; and four guests through the Helena Kluver female visitor programme.



Caption: top, left to right: Lambrechts (Leiden, NL), Slougher (GER), Dagtekin (Turkey), den Heijer (Germany), Lee (USA) and Dekker (Amsterdam, NL). Middle row, from the left: Maccone (Italy), Penny (UK), Shafi (South Africa) and Kiziltan (USA). Part of our Helena Kluver female visitor programme participants are pictured at the bottom row, from left to right: Bilous (USA), Henning (USA), Stanimirovic (USA). Finally on the middle row, on the right: Ostorero (Italy).



Research & Development

International SKA Forum 2010

On 15 June 2010, ASTRON and its parent organisation the Netherlands Organisation for Scientific Research (NWO), hosted the International Square Kilometre Array (SKA) Forum 2010 or 'ISKAF2010' for short. The SKA will be the world's biggest radio telescope with a collecting area of one square kilometre. The Forum aimed to highlight the many opportunities the SKA offers to all sectors of society, and to advance the process of securing wide support and significant European/global funding for the project. It was attended by scientists, engineers, industrialists and decision makers. The latter included representation at the highest levels: government ministers from Australia (Kim Carr, Minister for Industry, Innovation, Science and Research), South Africa (Naledi Pandor, Minister of Science and Technology) and the Netherlands (Maria van der Hoeven, Minister of Economic Affairs) were all present.

Minister Van der Hoeven, together with the Queen's commissioner Jacques Tichelaar, announced a new, four million euro financial investment in ASTRON's SKA technology programme and re-stated the Dutch ambition to play a major role in establishing a European Centre for the SKA.

As well as many presentations from the broad SKA community, an exhibition was held at the Forum with around thirty companies and organisations represented.

Dutch industry interest in SKA was expressed by an SKA position paper. This successful week could not have been realised without the support of many different sponsors and partners and in particular contributions from the European Commission's FP7 programme, the Province of Drenthe, Sensor Universe and Marketing Drenthe.



NWO chairman Jos Engelen (left) and the Queen's Commissioner of Drenthe Jacques Tichelaar (right) address the participants of the ISKAF2010.

Credits: Hans Hordijk.



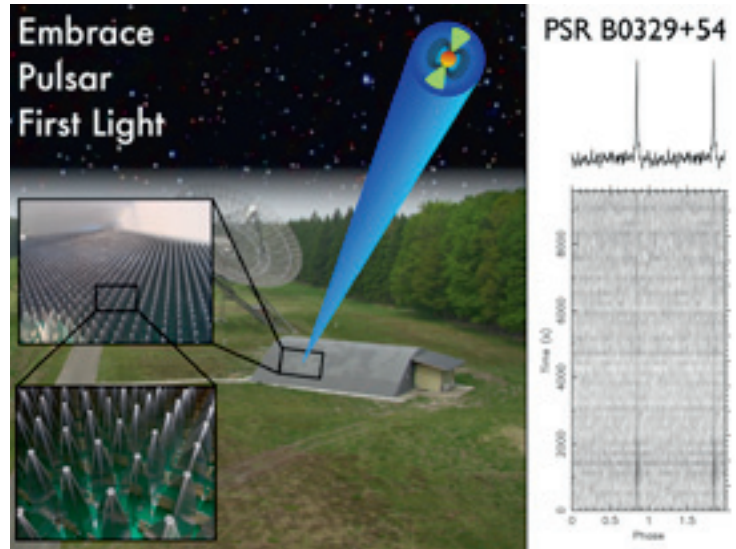
The SKA Agencies Group met in Assen with ASTRON director Michael Garrett in attendance as chair of the SKA Science & Engineering Committee

ASTRON researchers demonstrate 10 K room-temperature LNA

In 2010, technical scientists and engineers beat performance records for room temperature Low-Noise Amplifiers. The detection of weak astronomical signals requires extremely sensitive amplifiers right after the antenna. These so-called Low-Noise Amplifiers (LNA's) used to be cooled to extremely low temperatures (below $-250\text{ }^{\circ}\text{C}$) with large and expensive refrigerators to reduce the noise signals generated by the electronics themselves. For the next generation of radio telescopes like LOFAR and the SKA, this approach is no longer feasible. The Aperture Array approach, advocated by ASTRON and its European partners, uses large numbers of inexpensive antennas. These antennas cannot be cooled individually and require new approaches in un-cooled LNA designs. The technology for these devices is studied world-wide. Through innovative designs and careful measurements ASTRON demonstrated that noise signals can be brought down to 10 K in room temperature LNA's. A new approach on simultaneous power and noise matching to a (non standard) 150 Ohm antenna source impedance, in combination with a low noise 70 nm GaAs semiconductor process, paved the way for a new generation of Low Noise Amplifiers, resulting in these exciting low noise temperatures for room temperature amplifiers.

EMBRACE detects its first pulsar

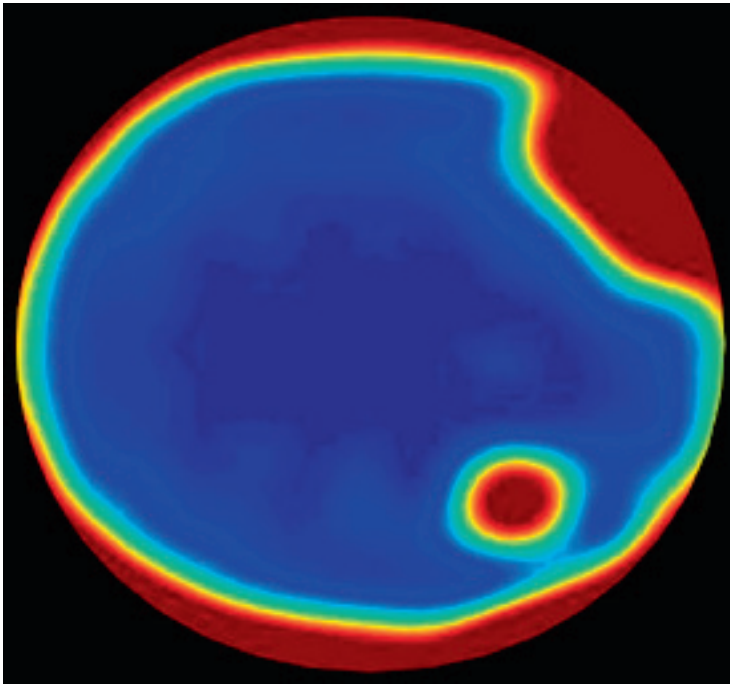
EMBRACE has achieved the first ever pulsar detection with an L-Band Aperture Array. This first light measurement was carried out in December at a central frequency of 1207 MHz, and using a total bandwidth of 12 MHz. The detected pulsar, PSR B0329+54, has a rotational period of 714 milliseconds, and a phase-averaged flux density of 203 mJy. Given the results obtained with this current limited available collecting area, we expect more exciting observations as the scale of EMBRACE grows in the course of the Aperture Array Verification Program. The picture shows the pulsar signal as a function of time and rotational phase, with the cumulative pulse profile, i.e. the sum of all pulses, shown at the top (and repeated twice for clarity).



Pulsar PSR B0329+54 detected with EMBRACE

AAVP and SKA-NN

In 2010, the international SKA project decided on a phased implementation of the SKA telescope. One of the components of the first phase, SKA1, will be a 10x LOFAR sized low-frequency aperture array. In an Advanced Instrumentation Program, mid-frequency aperture arrays will be further developed towards inclusion in SKA2. The work done in LOFAR and SKADS played an important role in this technology selection. In March 2010 the Aperture Array Verification Program (AAVP) started with a kick-off meeting in Zaandam. AAVP is the successor of SKADS in many respects; international teams will work together on the next phase in the realization of Aperture Arrays. AAVP includes a plan for the realization of a 2000m² AA Verification System: AAVS. The project "SKA Noord-Nederland", a Northern Dutch project in line with the AAVP program, was awarded in June 2010. One of the aims is to strengthen the innovation potential of Dutch companies and their position in the competition for SKA construction.



Array noise temperature when scanning the sky with APERTIF tile as aperture array

APERTIF

With DIGESTIF, a prototype system for the APERTIF Focal Plane Array project for the WSRT, it was shown that system noise temperatures below 50 K can be achieved when used in an aperture array tile configuration. The picture shows an all sky scan using DIGESTIF as an aperture array at 1.4 GHz; the colors indicate the observed system temperature: 47 K (blue) at the zenith, and 200 K (brown) at the horizon. The large red spot in the upper right corner is RT5. The large red spot in the lower right corner of the picture turned out to be the sun. As expected a strong increase in the noise temperature is visible near the horizon. In a demonstration of its revolutionary wide-field capabilities, the DIGESTIF phased array feed system (configured as a focal plane array in one of the WSRT telescopes) also simultaneously detected two pulsars (B0329+54 and B0355+54) at around 1420 MHz. These two pulsars are 3.8 degrees or seven full moons apart. Westerbork as it currently stands can only simultaneously observe sources closer to each other than one full moon. This double detection showcases one of the strengths of APERTIF: the wide field of view.

Technology Transfer

In 2010, the Dutch ministry of Economical affairs issued “innovatievouchers” to make knowledge institutes like ASTRON easier accessible for Small and Medium size Enterprises (SME). For SMEs this

reduces the cost of support and consultancy. Several SMEs contacted ASTRON’s Bureau of Technology Transfer for a request on development support on their application development. Subject of these projects are typically development support in the domains of Radio Frequency and Opto/Mechanics. Thanks to a broad range of highly skilled technical specialists in the R&D division, we support SME in solving issues about for example antenna design, antenna measurements, impedance matching, transceiver designs and/or performance evaluation, etc. For instance an SME specialized in telecommunication equipment for public services (e.g. Police and Fire departments) executed receiver measurements on their 400 MHz systems.

Special projects: Galileo Site Monitoring Facility

The GALSEE-SMF project passed the milestone of the Test Review Board / Delivery Review Board (TRB/DRB). This means that when all actions resulting from this review are finished, the facility is ready to be used for Galileo satellite signal qualification measurements.



Calibration antenna for Galileo mounted in one of the WSRT dishes

SMF stands for Signal-in-Space Monitoring Facility and will be used to perform in-depth analysis of the signals transmitted by the first 4 satellites of the Galileo constellation. The signals from the satellites are received with one of the 14 WSRT telescopes. The telescope front-end has been adapted to cope with the relatively strong (and circularly polarized) signals. A special antenna has been placed in the mirror of the telescope to perform accurate frequency dependent phase and gain calibration of the complete receiver chain that is connected to this single dish, see picture. The signals from the telescope are routed to a dedicated SMF back-end in which the full IF band can be analyzed at once using a spectrum analyzer and a fast (400 MHz) analogue-to-digital converter with a high-speed storage facility.

Education: course on Applied Radio Frequency Technology

The ASTRON RF-course had a triple run in 2010. An in-company training was organised for STE-Ericsson (Nijmegen). Hands-on training was carried out in Dwingeloo because of the amount (and weight!) of microwave equipment needed for the measurement set-ups this RF-course. The ASTRON course on Applied Radio-Frequency Technology attracted nearly 250 attendees since the start.

FEU2MP - "From the Edge of the Universe to the Market Place"

ASTRON has received a grant ("Stimuleringsbijdrage Kennisbenutting") from NWO for support on new business initiatives originated from our know-how as developed for scientific applications. ASTRON has chosen to support some leads with an intentionally viable business case as New Business Initiatives. Of course our Astrotec Holding is in place when entering the commercial phase. Valorisation of our knowledge already is the main activity of our Bureau of Technology Transfer. Technology developed for LOFAR and the SKA brings up opportunities for exploiting non-scientific applications. For example, for the SKA we are dealing with electronically steerable antennas which in principle are applicable in many other areas. The Electronic Small Aperture Terminal (ESAT) project is one of the development projects in which we, together with several industrial partners, participate. Within FE2MP also opportunities for utilizing our high-performance computing boards (e.g. UniBoard) are investigated, and support is given to the development of a technology demonstrator of an optical scanner intended for performing in-line measuring of mechanical/machined parts.

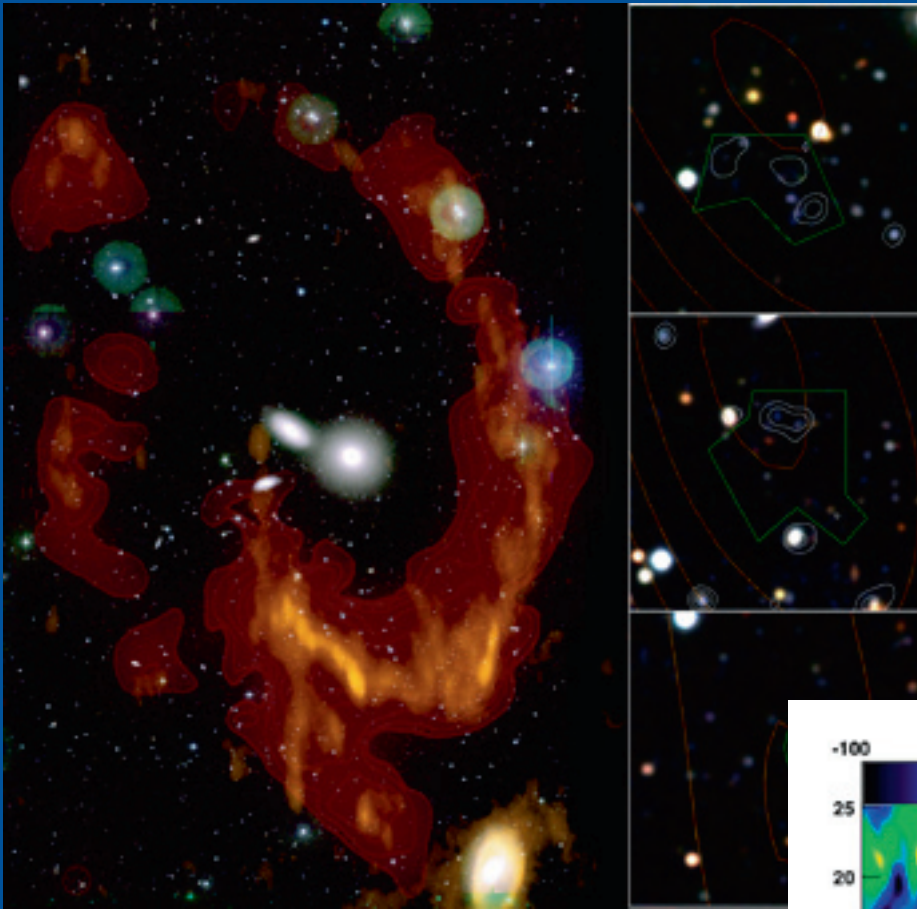
Fifth SKA calibration & imaging workshop success

In 2010, the fifth Square Kilometre Array Calibration and Imaging workshop (CALIM 2010) was hosted by ASTRON in Dwingeloo. The workshop focused on progress in algorithms, software and computing

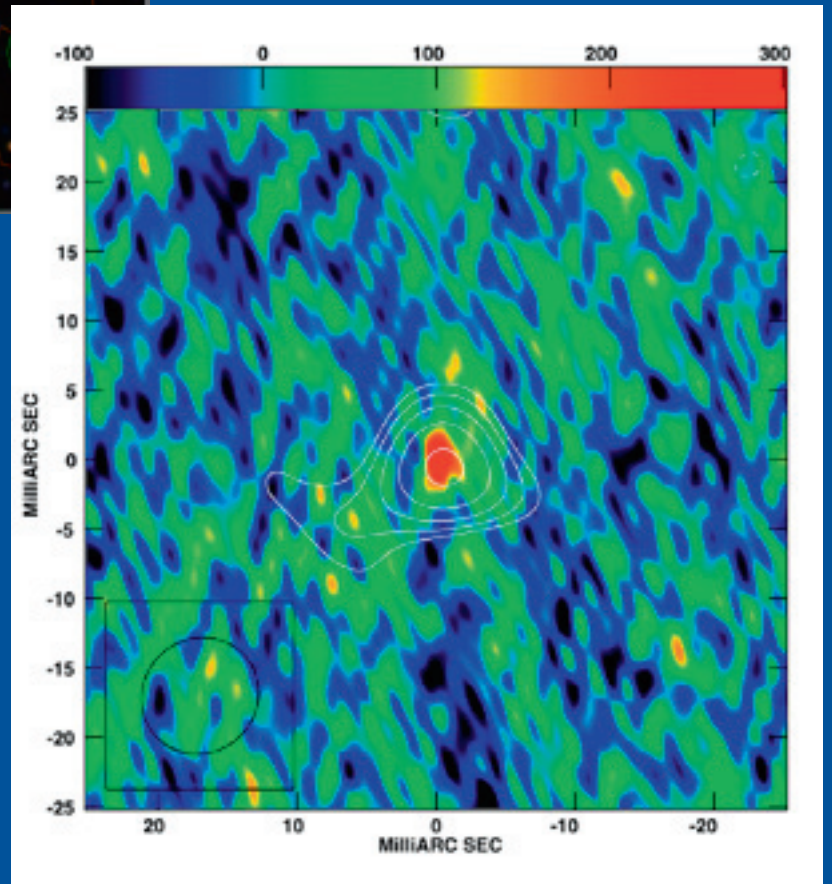
aimed at solving the challenges in calibration and imaging requirements of the Square Kilometre Array (SKA), its pathfinders and other major new radio telescopes. The workshop attracted more than sixty participants from all over the world. There was a good representation of all the major new and upgraded radio facilities (LOFAR, MeerKat, ASKAP, MWA, ATA, ALMA, EVLA, WSRT/Apertif), particularly from those that are beginning to produce data. The workshop consisted of four days of presentations, with ample time in between for discussion. A visit to the LOFAR Core and the Westerbork Synthesis Radio Telescope (WSRT) was also part of the programme. The CALIM 2010 programme very much reflected the issues of the day. The meeting started off with a discussion of a common list of practical and immediate problems by representatives of the various telescopes. In addition, there was the start of another common list with more fundamental problems. At the top of this second list was the problem associated with direction-dependent instrumental effects (DDE), like station beam shapes and the ionosphere. It has now been demonstrated that there is sufficient information available (in the form of fainter sources in the field that serve as calibration beacons) to measure DDE's. The more fundamental problem is how to apply these corrections to the data. This was the subject of various presentations. Another important subject was the handling of the huge data volumes that will be generated by the new radio telescopes. The sheer volume of data forces an agonizing trade-off between what is possible (in terms of image quality) and what is feasible (in terms of available processing power). There was an increasing realization that we should endeavour to address the problem together, for example, by adopting the same efficient data format, or by sharing tools.

Participants of the CALIM2010 workshop on the terrace of the ASTRON building in Dwingeloo. Credits: Lars Bühren, ASTRON.

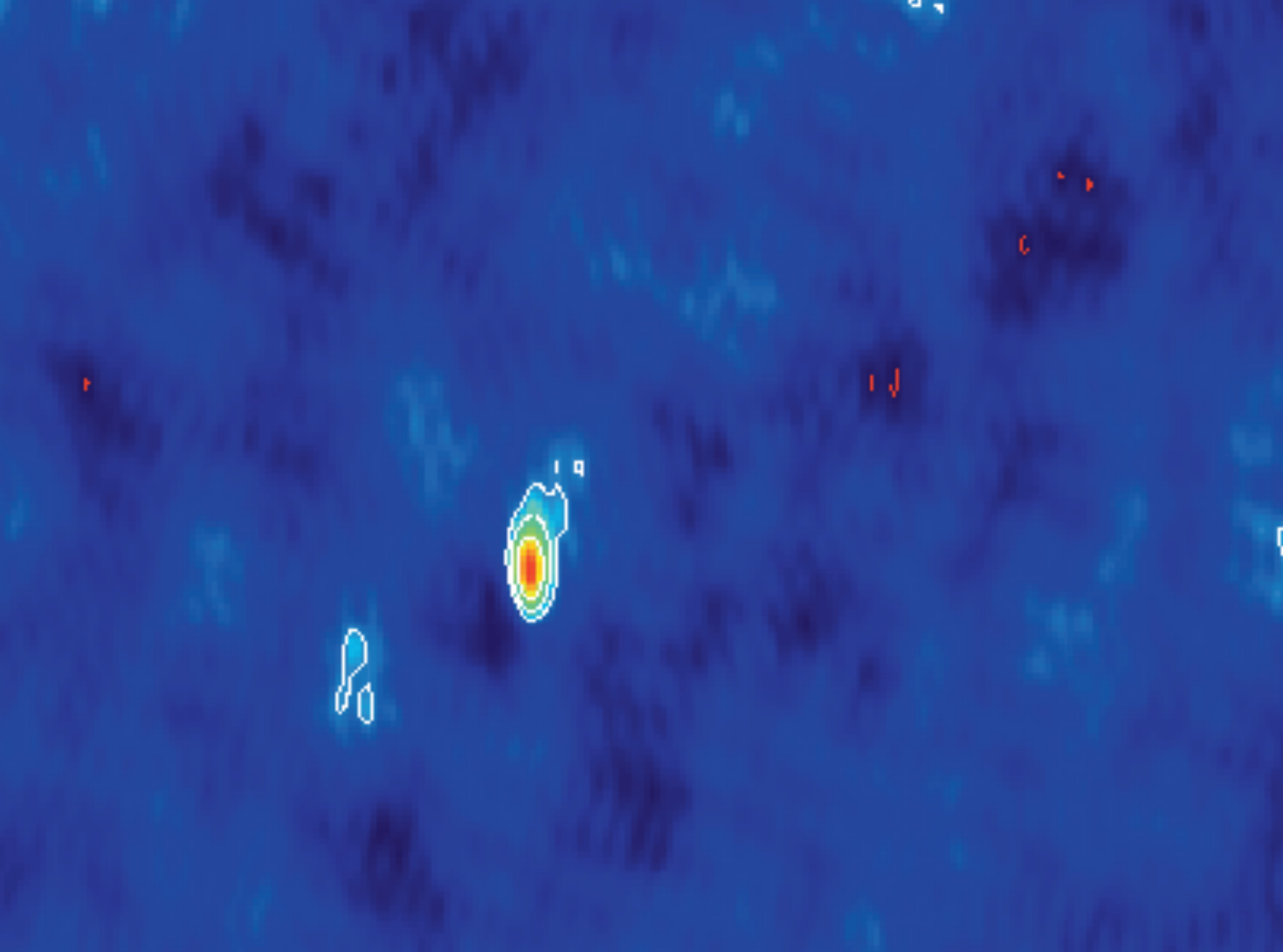




<< Polarized intensity of the Fan Region, a region of about 20 by 40 degrees in the second Galactic quadrant.



First detection of Aql X-1 with VLBI. >>



JIVE

Over the last few years the science capabilities of the European VLBI Network have been enhanced with e-VLBI for real-time observations. In 2010 this was demonstrated to be a mature scientific capability, resulting in a record number of proposals, often targeting transient phenomena. After successfully concluding the EXPRoS project, JIVE took the lead in coordinating the NEXPRoS programme, which aims to introduce e-VLBI to all EVN experiments by enabling transparent caching of the data along the entire operational chain.

Besides the obvious technical advantages through which e-VLBI is improving the reliability of connecting the international telescopes, it has also brought about a change in culture. Clearly, VLBI is more exciting when you have direct access to the data, and e-VLBI allows astronomers to show off their results within months after writing the proposal. This was noticeable at the 8th EVN symposium at Manchester, where a large number of radio astronomers shared their latest results and discussed recent developments.



Participants of the 10th European VLBI Network meeting, "VLBI and the new generation of radio arrays", in front of the Lovell telescope

Next to the e-VLBI upgrades are JIVE's efforts to establish new correlator platforms for the EVN. Already in 2010, the first EVN user experiments have been processed on the software correlator, which is available for special experiments, like pulsar gating and spectral polarimetry. For the longer term JIVE is developing a correlator platform based on FPGA components, realizing this can provide a flexible, high accuracy correlator with substantially lower power consumption. Such a platform is the combined goal of the RadioNet programme UniBoard

and the joint ASTRON/JIVE NWO project ExBoX, and now also part of an innovative collaboration with Shanghai that started in 2010.

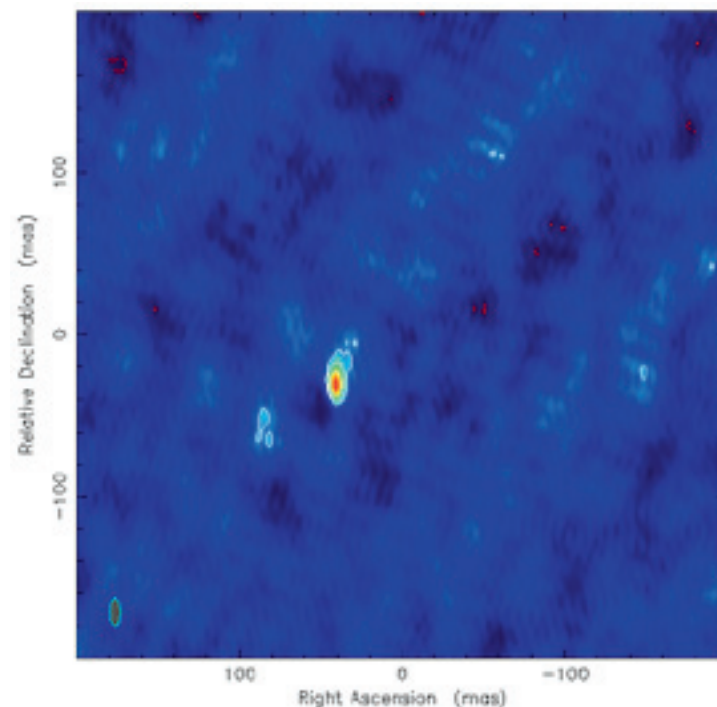


Figure 5.12: The EVN detection of the millisecond pulsar PSR J0218+4232 using the newly established SFX correlator (Yang et al. in progress).

Another aspect of the collaboration with China concerns space applications in which both JIVE and Shanghai have unique expertise. Notably, JIVE with its EVN partners is developing Planetary Radio Interferometry and Doppler Tracking Experiment (PRIDE), aiming at a number of future planetary missions. PRIDE applications range from studies of the dynamics of extraterrestrial atmospheres to gravimetric diagnostics of the planetary interiors and fundamental physics. In preparation for such campaigns several experimental observations were carried out of the Mars and Venus Express spacecrafts. This work is also feeding into the development of e-VLBI techniques and correlator techniques.

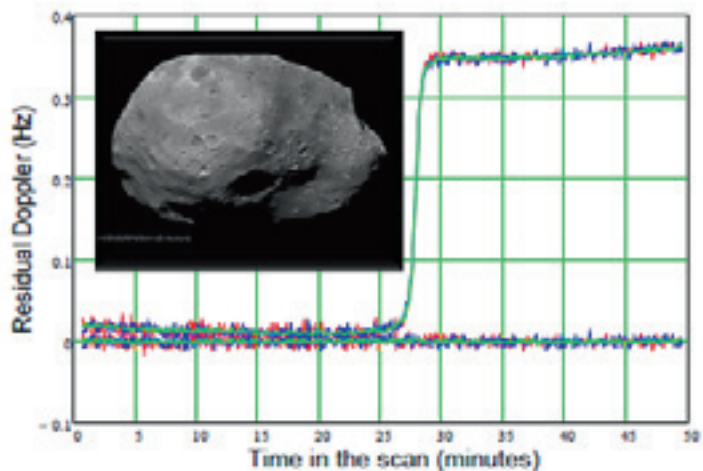


Figure 6.3: The residual Doppler shift of the MEX signal, as detected by the Yebes, Wettzell and Metsähovi stations, measuring the presence gravity of the Mars moon Phobos.

The various technical and scientific efforts at JIVE are improving the European VLBI Network capabilities in order to deliver top-class science. At the same time several components in the JIVE portfolio are of recognized importance for the definition of the SKA. JIVE staff has secured official SKA pathfinder status for the e-EVN programme. Moreover JIVE supports the European radio astronomy community in their SKA ambitions and is considering the optimal way to play a role in the European SKA participation.

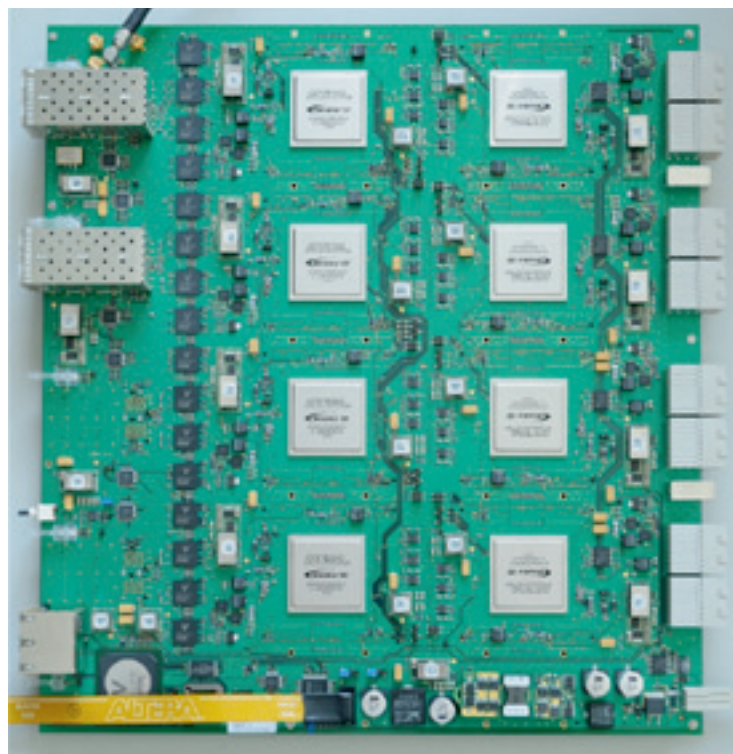
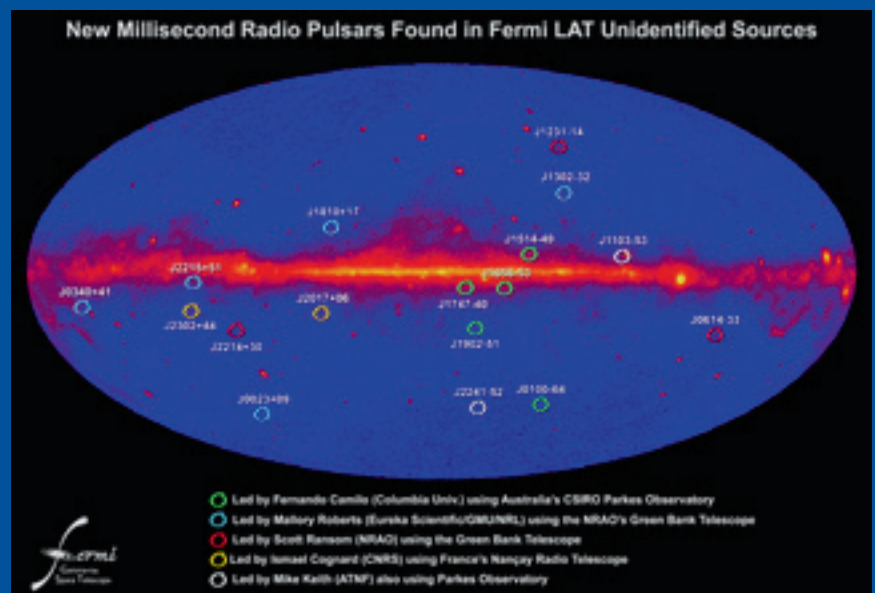


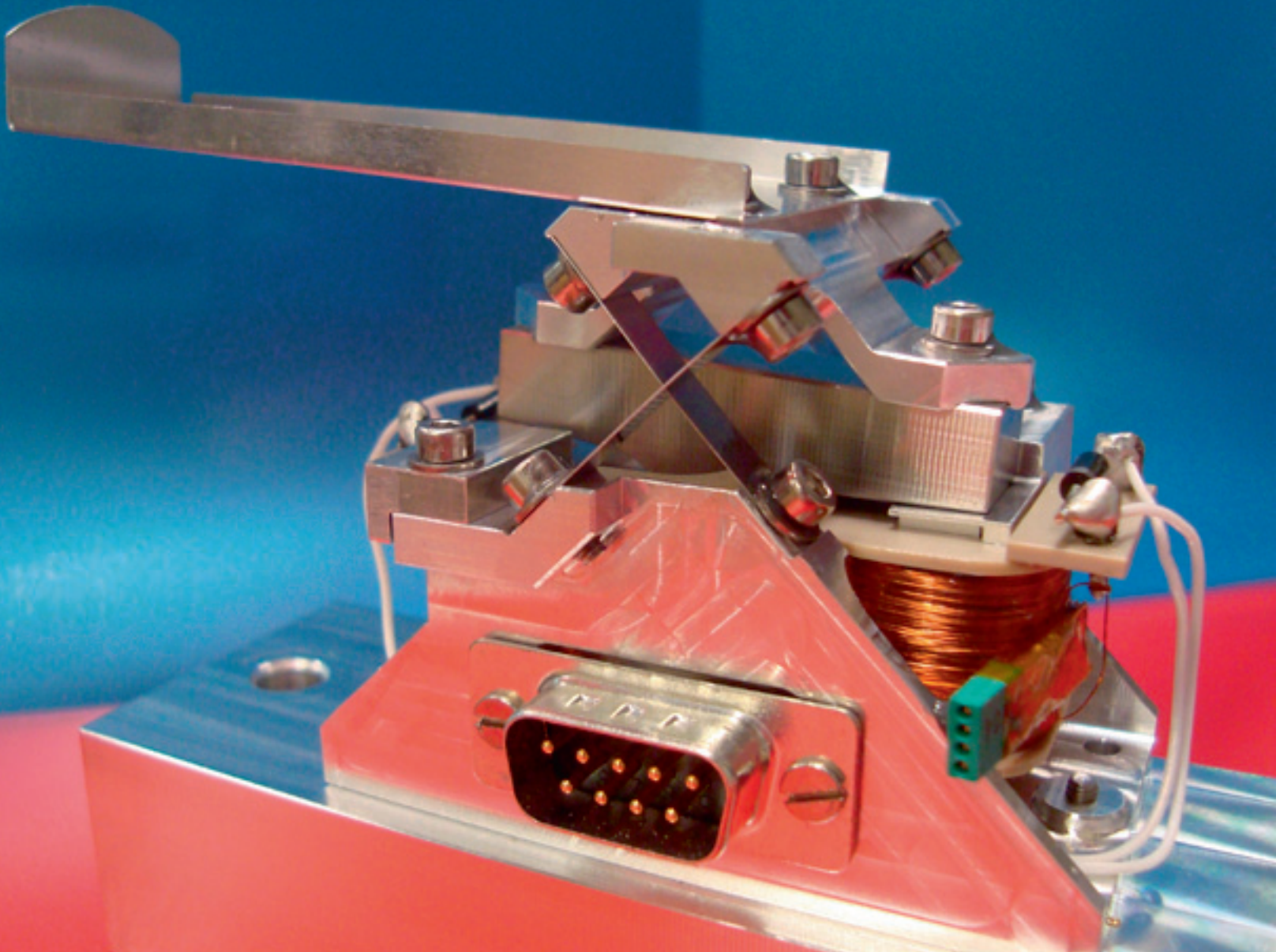
Figure 3.9: UniBoard prototype, delivered May 17, 2010



Unveiling the secrets of Centaurus A - More than sixty years ago, the largest extragalactic radio source on the sky was discovered - Centaurus A - and has received great interest ever since. The galaxy associated with Centaurus A has been called a "freak" (Walter Baade) and referred to as a "pathological specimen" (Harlow Shapley) because the nature of its peculiarity was a complete puzzle. Today we understand the origin and nature of the radio source a bit better, but astronomers still "freak out" when they perform new observations, as Centaurus A still has secrets to be shared. The figure shows the optical host (left panel; credit Robert Gendler & Stephane Guisard), called NGC 5128, with the famous dust lane, and the panel to the right overlays (in blue) the innermost radio lobes that get fueled with relativistic plasma by the active black hole in the centre. Observations of the neutral hydrogen gas (HI) with the Australian Telescope Compact Array have now allowed, for the first time, to study in detail the atomic gas in the disk of Centaurus A (middle panel shows the HI emission in orange).

The Fermi satellite has been observing the sky at gamma-ray energies (> 100 MeV) since August 2008, and its Large Area Telescope instrument has been pin-pointing faint sources of gamma-rays like never before possible. This image shows the Fermi Large Area Telescope first year map of the gamma-ray sky at energies above 100 MeV with the locations of the new millisecond pulsars. The symbols are color coded according to the discovery team. Credit: NASA/DOE/ Fermi LAT Collaboration.

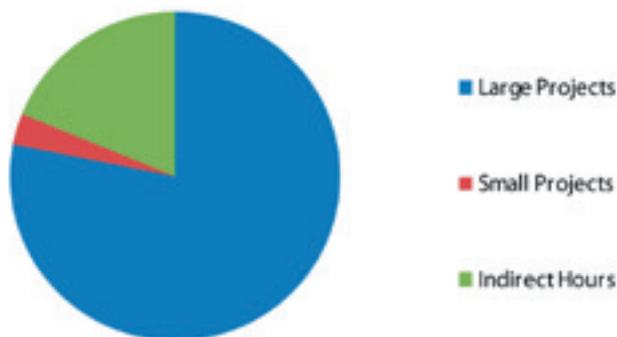




NOVA optical/infrared instrumentation group

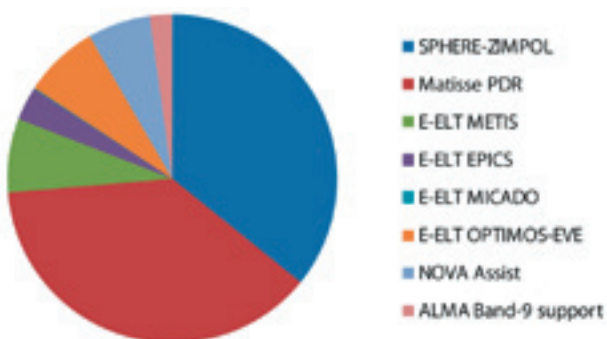
Fast Cryogenic Shutter. Due to the thermal behavior of infrared radiation a vacuum environment is required for the MATISSE cold optics. The instrument has 8 shutters operating at 40 Kelvin at a switching speed faster than 0.03 seconds. The shutter design is bi-stable and only requires active operation of solenoids to switch from one stable position to the other stable position. The shutter is held in the open and closed position by permanent magnets.

In the NOVA optical/infrared instrumentation group, 11.2 Full Time Equivalent (FTE) worked 18951 hours in total, excluding vacation and illness. In 2010, 81% of the staff hours in the NOVA optical/infrared instrumentation group are project related and 19% of the staff hours are indirect hours.



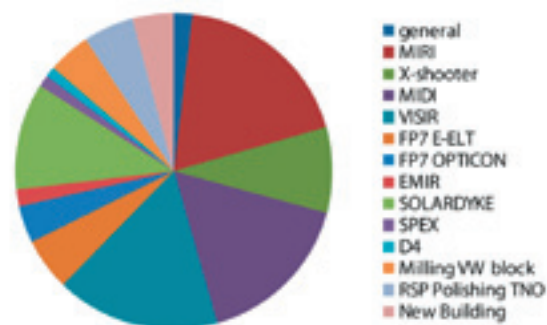
Staff hour spending in 2010

Two projects are clearly larger than other projects in 2010: Sphere-ZIMPOL and MATISSE. These projects used 4.5 staff years each. Sphere-ZIMPOL was in the Manufacturing, Assembly, Integration and Test phase, focusing on hardware and performance testing. MATISSE was in the preliminary design phase, focusing on specifications, interfaces and design aspects of various concepts. All European Extremely Large Telescope (E-ELT) instrumentation phase A studies were concluded in the first quarter of 2010. Together the E-ELT projects used over two staff years in 2010. Staff from Dwingeloo contributed to other NOVA projects such as ASSIST and ALMA band 9.



Large Projects in 2010

There are a lot of smaller projects. This includes support to previous projects e.g. in the case of an upgrade (MIRI, X-shooter, MIDI, VISIR) or support to instrument developments at other institutes (EMIR at IAC). Research and development activities for future projects (FP7, polishing) are also listed as smaller projects.



Small Projects in 2010

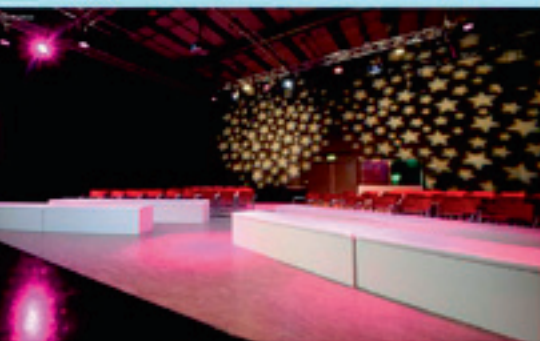
Activities like acquisition of new projects are reported in the indirect hours. In 2010 this is mostly related to the ESO call for proposals for multi object spectrographs. The NOVA group at ASTRON participates in four different proposals for MOS instruments. Other activities reported as indirect hours are study, publications, management, infrastructure and group meetings.



Indirect Hours in 2010



ASTRON



Management and communications

Public relations and outreach

After the International Year of Astronomy 2009 (IYA2009), 2010 was another exciting year for ASTRON with many outreach activities. With the International SKA Forum 2010 and the Open Day up ahead, there was no rest for ASTRON, JIVE and the NOVA Optical/ Infrared group at ASTRON!



Sunday 24 October 2010: the fun lab in action during the Open Day 2010.



April 2010: girls from different Northern Dutch high schools and ASTRON staff members during the Girlsday 2010, outside on the terrace of the ASTRON building.



Sunday 24 October 2010: live comet show by ASTRON's own nutty professor during the Open Day 2010.



June 2010: the Outreach booth at the exhibition during the SKA Forum in the TT-hall in Assen, where people could interact in different activities relating to (radio) astronomy, such as GalaxyZoo, SETI@home and the activities of Universe Awareness. The photo shows: Jo Bowler of the SKA Programme Development Office (SPDO) (left), Carolina Ödman of Universe Awareness en Gyula Józsa (ASTRON).



Sunday 24 October 2010: kids exploded chocolate foam candy during the Open Day 2010.



May 2010: Primary school kids talked live to kids from South Africa and Australia. They did this during a live internet exchange, organized by ASTRON and Universe Awareness (UNAWA) in honour of the International SKA Forum 2010. The purpose of the event was to show how kids, the scientists of the future, are also influenced by the building of a new telescope and the ideas they have about astronomy. Before the internet exchange, the kids put together small homemade radio telescopes and compared them live with the ones the kids in South Africa and Australia had made.



April 2010: during Girlsday, the girls participated in experiments in the Dwingeloo Telescope.



December 2010: One of astronomers at ASTRON held an Earthball workshop at a primary school in the North of the Netherlands and explained kids all about stars, galaxies and planets. The kids also experienced a journey through the Universe in de mobile planetarium of the University of Groningen.



May 2010: Dutch high school students visited ASTRON and observed with the Parkes radio telescope in Australia as part of the educational programma PULSE@Parkes (and in this case @Dwingeloo), set up by the CSIRO Astronomy and Space Science (CASS) institute, ASTRON's sister organisation in Australia.



Press releases

Below is an overview of the press releases ASTRON has issued in 2010. The complete press releases with accompanying high resolution images can be found on the ASTRON web pages: www.astron.nl.



27 December 2010: ASTRON astronomer Marijke Haverkorn winner of the National Science Quiz 2010



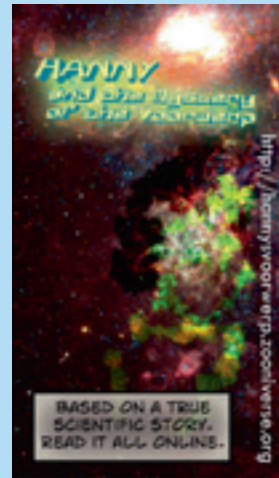
29 November 2010: An Earthball for all primary schools in Drenthe

22 November 2010: Astronomers over the moon about Apertif

28 October 2010: Astronomers discover most massive neutron star yet known

25 October 2010: The most distant galaxy ever measured

25 October 2010: Open Day 2010 big success



31 August 2010: Dutch school teacher stars in American comic

13 August 2010: Citizen scientists' discover new pulsar in Arecibo telescope data

22 July 2010: NEXPreS to further advanced computing and networking for astronomy use

8 July 2010: Two Rubicon awards for astronomy researchers

24 June 2010: Unravelling the mystery of Hanny's Voorwerp

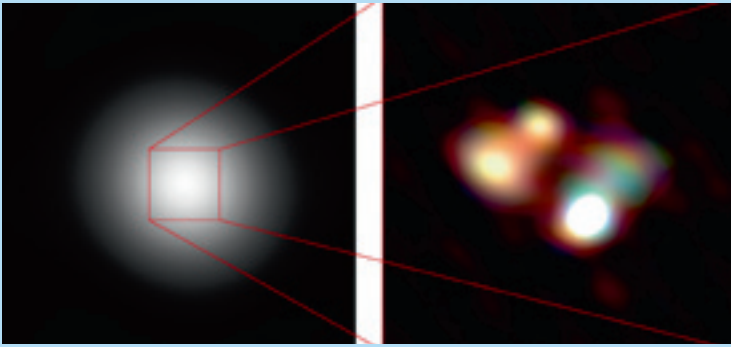
21 June 2010: ASTRON is working together with Australia and South Africa on SKA



14 June 2010: Queen opens new LOFAR telescope in Drenthe



9 June 2010: Astronomical world top meets in Drenthe, the Netherlands



2 June 2010: Details in the Structure of a distant Quasar

27 May 2010: Dutch high school students operate Australian telescope from Drenthe

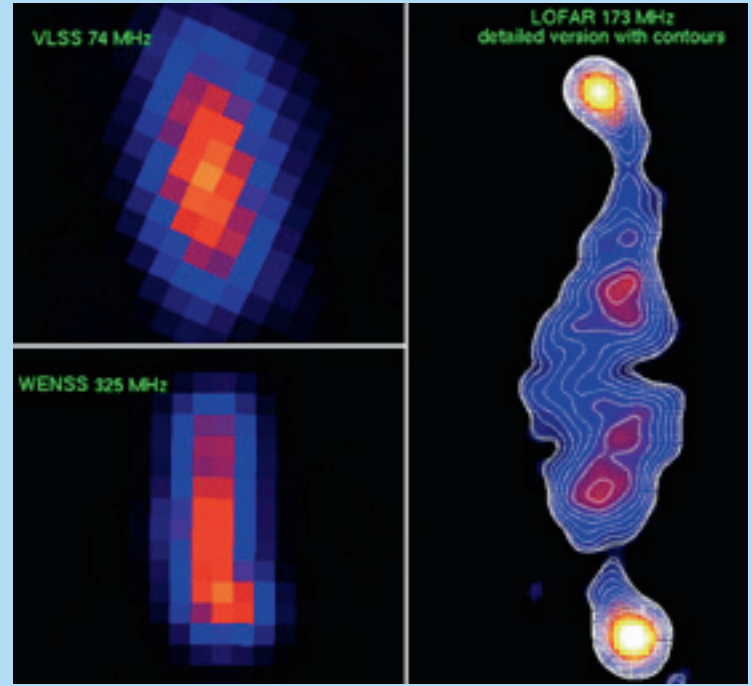
26 May 2010: New lease of life for the Westerbork telescope



12 May 2010: School kids Dwingeloo chat globally about stars

23 April 2010: Additional Eyes for Pulsar Astronomers

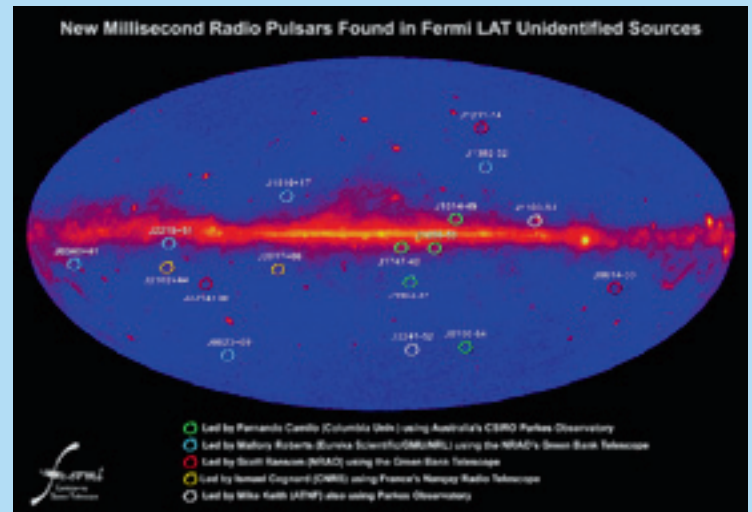
21 April 2010: Girlsday 2010: girls on board at ASTRON and JIVE



13 April 2010: LOFAR opens up low-frequency universe - and starts new SETI search

31 March 2010: ASTRON and NWO organise International SKA Forum 2010

28 January 2010: e-VLBI reveals missing link between Supernovae-Gamma Ray Burst explosions



6 January 2010: Astronomers are finding millisecond pulsars faster than ever

4 January 2010: ERC Advanced Grant for astronomer Ralph Wijers

Major group visits in 2010

Tue 09 Mar 2010

National Institute for Subatomic Physics visits CAMRAS and ASTRON

Thu 20 May 2010

Province of Drenthe and city of Assen visit the EMBRACE site near the Westerbork array

Fri 28 May 2010

High school students for Pulse@Parkes session: school kids work with Parkes telescope in Australia



Thu 25 Nov 2010

High school students visit ASTRON

Mon 04 Oct 2010 Fri 08 Oct 2010

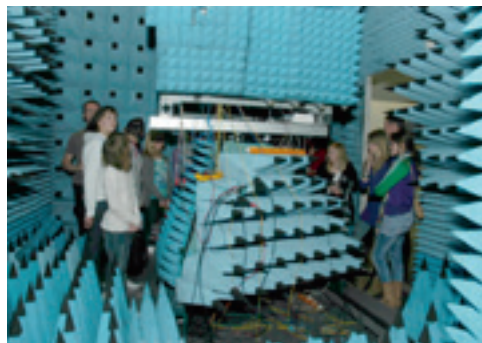
Dutch research school for astronomy of the University of Amsterdam: fall school 2010

Fri 02 Apr 2010

Northern Netherlands Provinces (SNN) visits the LOFAR field in Exloo.

Thu 22 Apr 2010

Girlsday



Mon 14 Jun 2010

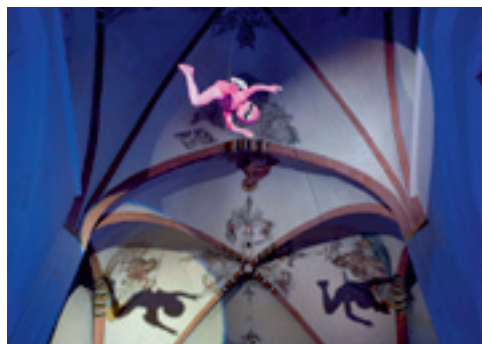
Agencies SKA Group (ASG) meeting

Mon 14 Jun 2010

Connect Industry, Science and Society workshop

Tue 15 Jun 2010

International SKA Forum 2010



An alien appeared from the roof of the Der Aa Church in Groningen during the International SKA Forum dinner. Credit: Hans Hordijk

Mon 23 Aug 2010

5th SKA workshop on Calibration and Imaging 2010 (CALIM)

Fri 22 Oct 2010

Mini-symposium for the 40th anniversary of the Westerbork telescope



Thu 04 Nov 2010

Visit of Northern college: educational council on electrical engineering

Wed 17 Nov 2010

Visit of representatives of the ministry of Education, Culture and Science (OC&W) and the Netherlands Organisation for Scientific Research (NWO)

Personnel & Organisation

2010 was amongst others the year in which NWO (and ASTRON) committed themselves to the Charter "Talent to the Top". By signing this Charter the intention to enable more women to enter employment at their organization, retain their jobs and gain promotion to top positions was publicly announced by the NWO umbrella organization. ASTRON, on a small scale, has been focusing on diversity over the last five years. The Helena Kluyver female visitors program is one of these efforts. During a short period of time, female scientists and engineers can come to our institute to collaborate with their counterparts in Dwingeloo. We also try in different ways to enthuse girls for science and engineering (Girls day and visits). As an NWO institute, we focus on increasing the male/female diversity in our organisation and try and reach the figures the taskforce has defined.

Absenteeism

In 2010, the absenteeism rate was 3.6%. This is a slight decrease compared to 2009 (3,7%). This number is mostly due to a few employees who became ill for a longer period of time.

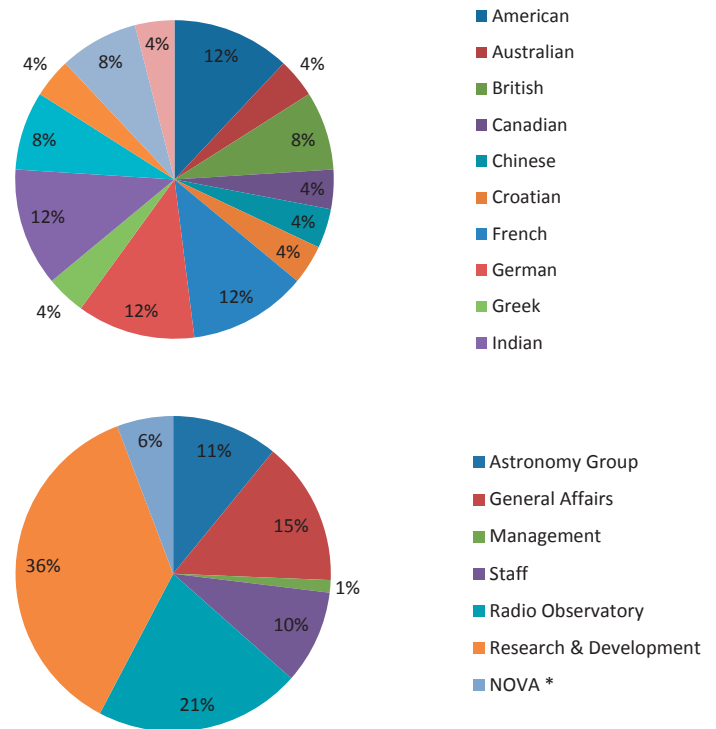
Number of employees

Division	Number of people
Management and Staff	17
Astronomy	17
Radio Observatory	33
Research & Development	57
General affairs	23
NOVA*	9
	156

* NOVA, the Dutch research school for astronomy, is a separate entity but all personnel of the NOVA/Infrared group is employed by ASTRON (NWO).

Personnel per 31-12-2010

Non Dutch nationalities 31-12-2010



Financial report 2010

Below you can find the financial report 2010, compared with 2009.

	2010 Budget	2010 Actual	2010 Difference	2009 Actual
REVENUES				
Government Grants-Ministry of Education, Culture & Science	11.155.375	10.858.446	296.929	10.746.857
Subsidies / Contributions	4.261.498	6.758.684	-2.497.186	7.390.814
Release to provision	0	591.707	-591.707	1.063.219
Other Income	320.000	447.021	-127.021	660.171
Cash management	25.000	42.824	-17.824	78.143
<i>Subtotal</i>	<u>15.761.873</u>	<u>18.698.682</u>	<u>-2.936.809</u>	<u>19.939.204</u>
Results Subsidiaries				
Subsidiary ATH	0	0	0	0
<i>Subtotal</i>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Special Income				
Special Income	0	149.304	-149.304	253.127
<i>Subtotal</i>	<u>0</u>	<u>149.304</u>	<u>-149.304</u>	<u>253.127</u>
Total Income	<u>15.761.873</u>	<u>18.847.986</u>	<u>-3.086.113</u>	<u>20.192.331</u>
EXPENDITURES				
Grants / Expenditures				
Operations	15.442.899	15.195.447	-247.452	14.136.351
Allocation to Projects	0	-7.870.304	-7.870.304	-8.059.883
Project costs	0	10.472.704	10.472.704	12.496.426
<i>Subtotal</i>	<u>15.442.899</u>	<u>17.797.847</u>	<u>2.354.948</u>	<u>18.572.894</u>
Results Subsidiaries				
Subsidiary ATH	0	7.448	7.448	114.423
<i>Subtotal</i>	<u>0</u>	<u>7.448</u>	<u>7.448</u>	<u>114.423</u>
Other Expenditures				
Other Expenditures	0	37.393	37.393	62.974
<i>Subtotal</i>	<u>0</u>	<u>37.393</u>	<u>37.393</u>	<u>62.974</u>
Total Expenditures	<u>15.442.899</u>	<u>17.842.688</u>	<u>2.399.789</u>	<u>18.750.291</u>
BALANCE	<u>318.974</u>	<u>1.005.298</u>	<u>-686.324</u>	<u>1.442.040</u>

ASTRON/ JIVE colloquia

Year: 2010		
Date	Speaker	Topic
09 Dec 2010	Marco Spaans Kapteyn Astronomical Institute	Close to a supermassive black hole: the clumpy torus and the IMF
02 Dec 2010	Sharon Meidt MPIA	Uncovering the origins of spiral structure via measurement of radial variation in pattern speeds
30 Nov 2010	Andrey Baryshev SRON	Microwave Kinetic Detector Arrays technology for ground based submm wave astronomy
25 Nov 2010	Mariano Mendez University of Groningen	Time variability and X-ray spectra: probe of the inner accretion disc in compact objects
24 Nov 2010	Ron Ekers CSIRO, Australia	The Australia Telescope 20GHz blind survey of the Southern Sky
16 Nov 2010	Katarzyna Otmianowska-Mazu Jagiellonian University, Cracow	3D numerical simulations of magnetic field evolution in barred and spiral galaxies
11 Nov 2010	Stefanie Komossa MPE	Supermassive black holes in galaxies: singles, binaries, and escapees
04 Nov 2010	Andreas Brunthaler MPIfR	Mapping the Milky Way with VLBI Astrometry
28 Oct 2010	Joris Verbiest MPIfR	Gravitational Wave Detection Through Pulsar Timing
21 Oct 2010	Alexander Lazarian University of Wisconsin	Turbulent ISM, reconnection diffusion and star formation
14 Oct 2010	Philippe Zarka Observatoire de Paris / LESIA	Planetary Science with LOFAR and more
28 Sep 2010	Jun Yang JIVE	A decelerating jet observed in the X-ray transient XTE J1752-2
23 Sep 2010	Gyula Josza ASTRON	Galactic Warps
16 Sep 2010	Vibor Jelic ASTRON	Cosmological 21cm experiments: Searching for a needle in a haystack
26 Aug 2010	Oleg Smirnov(1), Ludwig Schwordt(2), Ian Heywood(3) Astron(1), Cape Town(2), Oxford(3)	"Mob Colloquium"
08 Jul 2010	Roberto Pizzo ASTRON	Tomography of galaxy clusters through low-frequency radio polarimetry
01 Jul 2010	Trish Henning University of New Mexico	Extragalactic HI Surveys: Current Status and Future Prospects
29 Jun 2010	Sanjay Bhatnagar NRAO	Interferometric Imaging and Direction Dependent Effects
22 Jun 2010	Snezana Stanimirovic University of Wisconsin	The turbulent interstellar medium: confluence of observations and numerical simulations
17 Jun 2010	Karl Gebhardt University of Texas	Black Holes and Dark Matter in Nearby Galaxies

08 Jun 2010	Rob Beswick Jodrell Bank Centre for Astrophysics	Starburst galaxies and radio supernovae: The central kpc of M82
03 Jun 2010	Chris van Diepenbeek, Herman Teinsma, Albert Heijl	Passive Spectrum use and upcoming changes in the spectrum environment
01 Jun 2010	Emil Kraaikamp RUG	Planet imaging using Castrator and Autostakkert!
27 May 2010	Scott Tremaine Institute for Advanced Study	The centers of galaxies
18 May 2010	Paulo Freire Max-Planck-Institut fuer Radioastronomie, Bonn	Measuring the masses of millisecond pulsars: new constraints on the equation of state
11 May 2010	Marc van der Sluys University of Alberta	Population synthesis of common-envelope mergers on the giant branches
27 Apr 2010	Shinji Horiuchi NASA DSN/CSIRO	Tracking Jupiter at microwave frequencies after the 2009 impact
15 Apr 2010	Alicia Berciano Alba ASTRON	Strong gravitational lensing in the radio domain
08 Apr 2010	Carolina Ödman UNAWÉ	Universe Awareness for Young Children: A big impact on small children
01 Apr 2010	Tao An Shanghai Astronomical Observatory	VLBI observations of the CSS 3C48 and five GPS sources
23 Mar 2010	Sara Seager MIT	Exoplanet Atmospheres: from Discovery to Characterization and Beyond
18 Mar 2010	Jacco Vink Utrecht University	X-ray synchrotron and H-alpha emission from supernova remnant shock fronts
04 Mar 2010	Konrad Tristram MPIfR	Resolving the dusty cores of nearby AGN with mid-infrared interferometry
25 Feb 2010	Mallory Roberts Eureka Scientific	Pulsar Wind Nebulae Across the Electromagnetic Spectrum
18 Feb 2010	Sungsoo Kim Kyung Hee University, Korea	Star Formation in the Central Molecular Zone of the Milky Way
11 Feb 2010	Richard Plotkin Amsterdam	Mining the SDSS for BL Lac Objects
04 Feb 2010	David Smith Centre d'Études Nucleaires de Bordeaux-Gradignan	Gamma-ray pulsars and their nebulae with Fermi
28 Jan 2010	Marc Sarzi University of Hertfordshire	The Sources of Ionisation for the Gas in Early-type Galaxies
21 Jan 2010	Marina Rejkuba ESO	The stellar populations and structure of the Milky Way analogue galaxy NGC 891
14 Jan 2010	Vlad Kondratiev ASTRON	Crab giant pulses: from radio to gamma-rays



Publications 2010

Astronomy Group and Radio Observatory

Astronomical publications in refereed journals 2010

- 1 G. Bernardi, **A. G. de Bruyn**, G. Harker, **M. A. Brentjens**, B. Ciardi, **V. Jelic**, L. V. E. Koopmans, **P. Labropoulos**, A. Offringa, V. N. Pandey, J. Schaye, R. M. Thomas, S. Yatawatta, S. Zaroubi: *Foregrounds for observations of the cosmological 21 cm line. II. Westerbork observations of the fields around 3C 196 and the North Celestial Pole*, 2010, *Astronomy and Astrophysics*, 522, 67
- 2 Geraint Harker, Saleem Zaroubi, Gianni Bernardi, **Michiel A. Brentjens**, **A. G. de Bruyn**, Benedetta Ciardi, **Vibor Jelic**, Leon V. E. Koopmans, **Panagiotis Labropoulos**, Garrelt Mellema, André Offringa, V. N. Pandey, Andreas H. Pawlik, Joop Schaye, Rajat M. Thomas, Sarod Yatawatta: *Power spectrum extraction for redshifted 21-cm Epoch of Reionization experiments: the LOFAR case*, 2010, *Monthly Notices of the Royal Astronomical Society*, 405, 2492-2504
- 3 **Vibor Jelic**, Saleem Zaroubi, **Panagiotis Labropoulos**, Gianni Bernardi, **A. G. de Bruyn**, Léon V. E. Koopmans: *Realistic simulations of the Galactic polarized foreground: consequences for 21-cm reionization detection experiments*, 2010, *Monthly Notices of the Royal Astronomical Society*, 409, 1647-1659
- 4 **C. Struve**, **T. Oosterloo**, R. Sancisi, **R. Morganti**, B. H. C. Emonts: *Cold gas in massive early-type galaxies: the case of NGC 1167*, 2010, *Astronomy and Astrophysics*, 523, 75
- 5 **Christian Struve**, **Raffaella Morganti**, **Tom A. Oosterloo**, Bjorn H. C. Emonts: *Is Centaurus A Special? A Neutral-Hydrogen Perspective*, 2010, *Publications of the Astronomical Society of Australia*, 27, 390-395
- 6 S. Buitink, O. Scholten, J. Bacelar, R. Braun, **A. G. de Bruyn**, **H. Falcke**, K. Singh, B. Stappers, **R. G. Strom**, R. Al Yahyaoui: *Constraints on the flux of ultra-high energy neutrinos from Westerbork Synthesis Radio Telescope observations*, 2010, *Astronomy and Astrophysics*, 521, 47
- 7 M. Bois, F. Bournaud, E. Emsellem, K. Alatalo, L. Blitz, M. Bureau, M. Cappellari, R. L. Davies, T. A. Davis, P. T. de Zeeuw, P.-A. Duc, S. Khochfar, D. Krajnovic, H. Kuntschner, P.-Y. Lablanche, R. M. McDermid, **R. Morganti**, T. Naab, **T. Oosterloo**, M. Sarzi, N. Scott, **P. Serra**, A. Weijmans, L. M. Young: *Formation of slowly rotating early-type galaxies via major mergers: a resolution study*, 2010, *Monthly Notices of the Royal Astronomical Society*, 406, 2405-2420
- 8 B. H. C. Emonts, **R. Morganti**, **C. Struve**, **T. A. Oosterloo**, G. van Moorsel, C. N. Tadhunter, J. M. van der Hulst, E. Brogt, J. Holt, N. Mirabal: *Large-scale HI in nearby radio galaxies - II. The nature of classical low-power radio sources*, 2010, *Monthly Notices of the Royal Astronomical Society*, 406, 987-1006
- 9 Leo Michel-Dansac, Pierre-Alain Duc, Frederic Bournaud, Jean-Charles Cuillandre, Eric Emsellem, **Tom Oosterloo**, **Raffaella Morganti**, **Paolo Serra**, Rodrigo Ibatá: *A Collisional Origin for the Leo Ring*, 2010, *The Astrophysical Journal*, 717, L143-L148
- 10 H. Rampadarath, **M. A. Garrett**, **G. I. G. Józsa**, T. Muxlow, **T. A. Oosterloo**, Z. Paragi, R. Beswick, H. van Arkel, W. C. Keel, K. Schawinski: *Hanny's Voorwerp. Evidence of AGN activity and a nuclear starburst in the central regions of IC 2497*, 2010, *Astronomy and Astrophysics*, 517, L8
- 11 **C. Struve**, **T. A. Oosterloo**, **R. Morganti**, L. Saripalli: *Centaurus A: morphology and kinematics of the atomic hydrogen*, 2010, *Astronomy and Astrophysics*, 515, 67
- 12 R. D. Ferdman, R. van Haasteren, C. G. Bassa, M. Burgay, I. Cognard, A. Corongiu, N. D'Amico, G. Desvignes, **J. W. T. Hessels**, G. H. Janssen, A. Jessner, C. Jordan, **R. Karuppusamy**, E. F. Keane, M. Kramer, K. Lazaridis, Y. Levin, A. G. Lyne, M. Pilia, A. Possenti, M. Purver, B. Stappers, S. Sanidas, **R. Smits**, G. Theureau: *The European Pulsar Timing Array: current efforts and a LEAP toward the future*, 2010, *Classical and Quantum Gravity*, 27, 4014
- 13 **Tom Oosterloo**, **Raffaella Morganti**, Alison Crocker, Eva Jütte, Michele Cappellari, Tim de Zeeuw, Davor Krajnovic, Richard McDermid, Harald Kuntschner, Marc Sarzi, Anne-Marie Weijmans: *Early-type galaxies in different environments: an HI view*, 2010, *Monthly Notices of the Royal Astronomical Society*, 409, 500-514
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