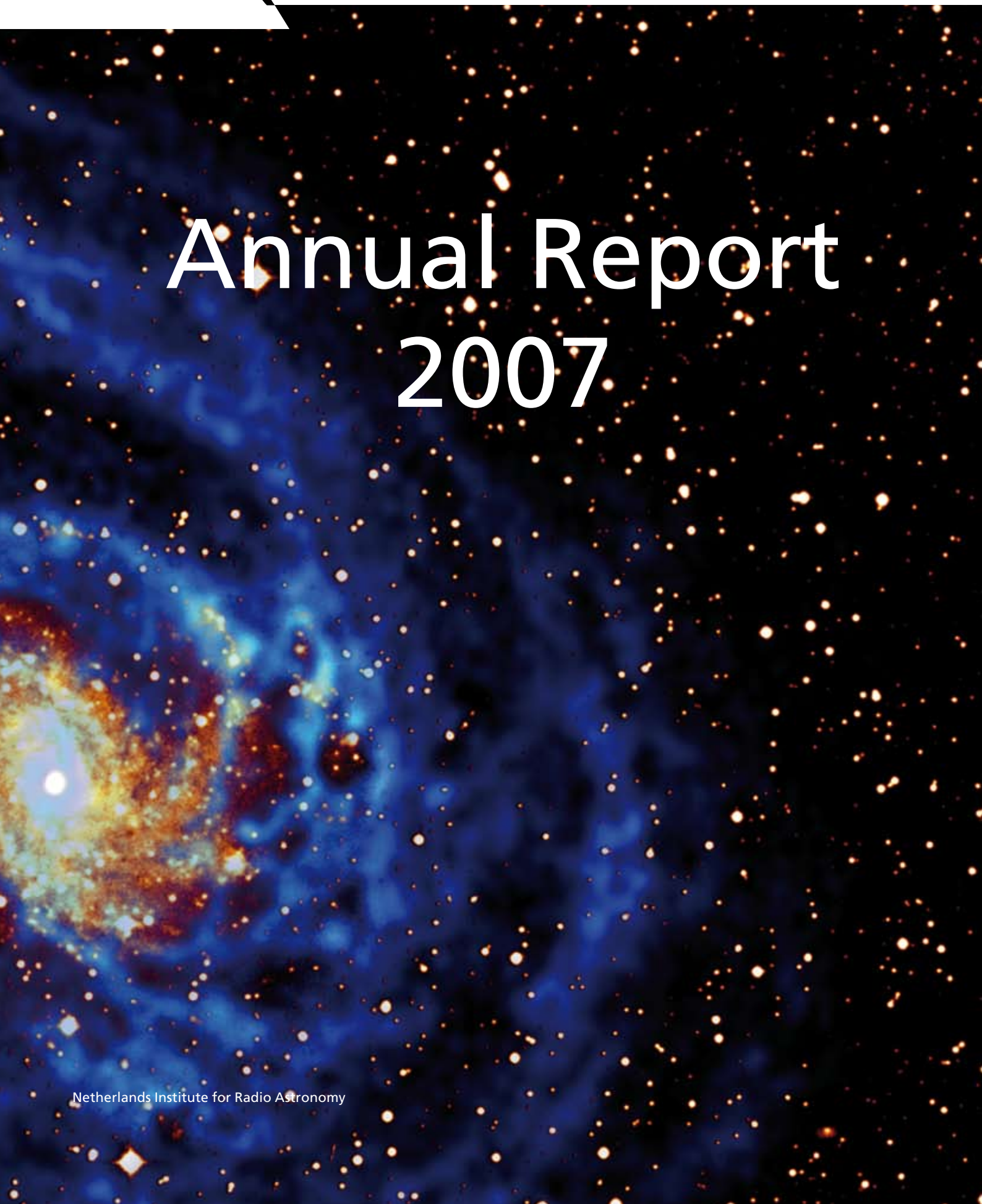
ASTRON

Annual Report 2007



Netherlands Institute for Radio Astronomy

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Preface

This year has seen many changes introduced to the ASTRON organisation. After the completion of an international search process, Prof. Michael A. Garrett succeeded Prof. Harvey R. Butcher as General Director of ASTRON. In his fifteen years at ASTRON, Harvey steered the institute through two reorganisations, and saw the institute grow from around 100 FTEs in the 1990's to well over 200 FTE in the current configuration. Other changes to the ASTRON top management structure in 2007, included the appointment of Dr. Rene Vermeulen (Director of the Radio Observatory), Dr. IR. Bert Geerken (Head of Administration, ad interim), Dr. Marco de Vos (Director of the R&D laboratories and Adjunct Director, ad interim) and Dr. Raffaella Morganti (Head of the Astronomy Group). Dr. Morganti's appointment underlines the importance that the new management attaches to the role of fundamental astronomical research in the institute's mission. In 2007, these senior staff members formed the new ASTRON Management Team.

In September, we received the very welcome news that we should prepare for an increase in our annual budget of 2 Million Euro per year over the next 10 years! This is the first significant increase in ASTRON's annual budget for many decades, and is provided by the Dutch ministry of Education, Culture and Science, after successful negotiations conducted via ASTRON's parent organisation, NWO. These additional resources help to ensure that ASTRON can fully exploit operations of the LOFAR radio telescope, and continue to play a major role in the development and design of innovative instruments and technologies for the Square Kilometre Array (SKA) project.

LOFAR continued to make astounding progress. The first deep, all-sky images using the low-band antennas sited at the test station in Exloo were generated, providing a glimpse of the potential of this fantastic new instrument. By the end of the year, tests of the high-band antennas were nearing completion, the several external reviews were satisfactorily completed, and preparations for the process of tendering and hardware procurement were well underway. The expectation is that the first production LOFAR stations should begin to be deployed in the autumn of 2008. The planning calls for the first 20 stations to be complete and fully deployed before the end of 2009. In addition, international interest in the LOFAR project continued to grow. The first international LOFAR station was completed at Effelsberg, Germany, and additional orders for stations in Germany (Garching, Tautenburg and Potsdam), Sweden (Onsala), France (Nancay) and the UK were received. The expectation is that Italy, Poland and Austria/Ukraine will soon follow suit.

In this year, the mission of the institute also sharpened its focus towards radio astronomy, and negotiations began with NOVA (The Netherlands Research School for Astronomy) on the future funding of the Optical/IR laboratory at ASTRON. All stakeholders agree on the need to maintain and indeed strengthen a well-founded laboratory for Optical/IR instrumentation in the Netherlands. There are likely to be many opportunities in this area over the next decade, especially in the area of instrumentation for the European Extremely Large Telescope (E-ELT). By the end of the year, a draft MoU securing the long-term future of the Optical/IR laboratory was agreed (in principle) by all relevant parties. Despite the initial uncertainties surrounding these developments, the Optical/IR group continued to play a key role in the construction of various astronomical instruments, including MIRI (the infrared camera and spectrometer for the James Webb Space Telescope) and X-shooter (a high-efficiency echelle spectrograph for ESO's VLT). The group was also involved in several E-ELT pre-studies.

One of the key ambitions of the new management team is to expand the size of the Astronomy Group. A good deal of energy was invested in recruiting new staff members and post-doctoral research positions. Further growth is expected in 2009/2010, doubling the size of the group to around 20 people. The group's research programme continues to make use of the Westerbork Synthesis Radio Telescope (WSRT) but covers a very broad range of topics. ASTRON's participation in the Auger NL collaboration bore fruit with the publication in the journal Science, of a measured correlation between the source of high-energy cosmic rays and Active Galactic Nuclei (AGN). Various members of the Astronomy Group made key contributions to LOFAR commissioning and several R&D projects e.g. WSRT-APERTIF, and EMBRACE projects. The group generated 55 refereed publications, and 32 papers in conference proceedings.

The Radio Observatory continued to prepare for the deployment of LOFAR and initial telescope operations. Observatory staff became involved in an increa-

sing number of LOFAR tasks and the process of re-locating Westerbork staff to Dwingeloo continued. In particular, the new Radio Observatory Control room in Dwingeloo became operational. Despite the new responsibilities associated with LOFAR commissioning, the WSRT continued to operate reliably and efficiently. The development of electronic VLBI (e-VLBI) featured prominently in the WSRT's VLBI activities. The Joint Institute for VLBI in Europe (JIVE, hosted by ASTRON) has been at the forefront of this new technique, and in 2007 demonstrated the feasibility of global e-VLBI by connecting together telescopes in Europe, China and Australia. The first e-VLBI publications also appeared this year, involving several ASTRON and JIVE staff members.

The SKA project moved into a new phase in 2007 with the submission of the EC FP7 Preparation study – 'PrepSKA'. The proposal was highly rated and will be funded to the tune of ~ 5.5 Million Euro. The study included several policy work packages (e.g. procurement, funding models) as well as the technical development of a telescope Verification System. NWO leads the 'SKA Governance' policy work package and other international funding agencies are involved in the full programme; the PrepSKA project is expected to start in 2008. The International SKA Project Office (ISPO) relocated from Dwingeloo to Manchester at the end of the year.

The R&D laboratories at ASTRON continued to enhance its reputation as a leading player in the development of new and innovative technology for radio astronomy. Highlights through the year included the successful mid-term review of the FP6 SKA Design Study, the first successful tests of the APERTIF focal-plane array system, and the uptake by the community of the MeqTrees calibration and simulation software. The Bureau of Technology Transfer continued to facilitate the important process of ensuring that state-of-the-art technology developed for radio astronomy within ASTRON can also find application in the commercial sector via various industrial partners. ASTRON's own holding company, AstroTec Holding, looks forward to a future in which the scope of its activities will be regulated towards relevant developments in (for example) sensor technologies.

The annual report before you tries to provide a comprehensive overview of the year's activities and discoveries, that have also been shared in the media with scientists worldwide and the public at large. The world of radio astronomy finds itself undergoing rapid alteration and adjustment as the era of the SKA approaches. No institute can afford to stand still, least of all one that prides itself in being at the forefront of novel and innovative developments. Change is always difficult, but I believe the new course we have laid out is right for ASTRON and right for the broader community here in the Netherlands. Embracing change means that we will successfully meet the demands and challenge of LOFAR – an instrument of unbounded potential. Embracing change also means preparing ourselves for active participation in a future world in which the SKA looms large.

Prof. Mike Garrett
General Director

1. Radio Observatory

The Radio Observatory in change

One of the highlights of the year 2007 was the official opening of the new integrated Control Room in Dwingeloo for LOFAR (the Low Frequency Array) and the WSRT (Westerbork Synthesis Radio Telescope). It marked a very positive turning point during a year in which the Radio Observatory staff members were faced with the difficult situation of having to pick up an increasing number of LOFAR tasks. At the same time a change of organisation was imminent, that, for a variety of reasons, took quite some time to get carried through to formal completion at year's end. The urgency of the new tasks, related to LOFAR development, and the existence of numerous vacancies within the Radio Observatory's new staffing plan, led to significant dynamics in task assignments. Nevertheless, actions were taken on, with, on the whole, an excellent spirit of dedication and collectively making things happen, in the style already familiar to the Radio Observatory staff with regard to the WSRT.

From the moment it was occupied, the Radio Observatory Control Room became a central point from which the LOFAR commissioning activities are planned, coordinated, and in some cases carried out. The informal and open character of the room invites engineers, operators, and anybody with an interest in the ASTRON operational facilities, to drop in and inform themselves about the latest status and developments. The control room has ample computer monitor surface area (approximately fifteen square feet) and excellent connectivity (10 Gbit/s network) to both the LOFAR and the WSRT systems. Working space is available in the control room for engineers to join in and perform inspection and small programming tasks in support of commissioning and operational activities. The back room provides a calmer environment, for example for the operators to carry out data inspection activities.

The new Radio Observatory Control Room in Dwingeloo

Normal observing runs on the WSRT were already conducted from the new Dwingeloo Control Room immediately after its opening, and at the end of the year, only VLBI (Very Long baseline Interferometry) observing and certain types of system maintenance still required on-site attendance at the WSRT.

Westerbork operations

Observing programme

The WSRT collected science data for 5414 hours, of which 4617 hours were associated with stand-alone WSRT projects, 619 hours for participation in disk-based VLBI (including 218 hours with a single dish), and 178 hours for participation in electronic VLBI (eVLBI) (including 40 hours with a single dish).

These usage statistics exclude the gaps between successive synthesis observations, which are typical for the WSRT as an East-West interferometer; they also exclude all overheads in setup, slewing, and the time spent on system maintenance and improvements. The numbers reflect the high reliability and good efficiency achieved on the WSRT in 2007, despite the increasing attention that the staff needed to pay to initiating LOFAR activities.


The Westerbork Synthesis Radio Telescope

Maintenance and improvements

Telescopes and infrastructure

Maintenance was focused on prevention of excessive wear and avoidance of attendant problems before they could affect the reliability and accuracy of the telescopes. The hour angle gear box weighs over two tons and travels twelve meters in every twelve-hour synthesis (see picture). The diameter of the top wheels decreases due to wear of both wheel and running rim. To circumvent this problem, oversized top wheels were installed on the gearbox of RTC. This will also be done for other telescopes, scheduled for 2008. At the same time, telescopes will be inspected for other possible mechanical problems.

Receivers

Mechanical, electronic, and cryogenic maintenance and repairs of the Multi Frequency Front Ends (MFFEs) occurred at routine levels comparable to previous years. There were no malfunctions of individual units that led to major disruption of observations. A few of the MFFEs (frequency range 250 MHz to 8.6 GHz) have shown subtle total power instabilities, related to temperature variations inside the cryostat, which seem to be caused by attitude-dependent heat leakage to the cold stations. This will be investigated in more detail in 2008 as it may be an indication for possibly similar future effects in other front ends.

Multi Frequency Front Ends (MFFEs)

The Low Frequency Front End (LFFE, frequency range 115 to175 MHz) systems required particular attention. The LFFE antennas are moved to and from their observing location by pneumatic power. It was found that this movement rotates the coax cable, thus damaging the connector internals. On all fourteen telescopes, a more flexible coax cable has been installed. The picture shows a side view of the focus box with the LFFE antennas, after installation of the new cables.

Low Frequency Front Ends (LFFEs)

One of the MFFEs was modified for participation in the GALILEO project (described below), to enable switching between linear and circular polarisation capabilities in the front end at L-band.

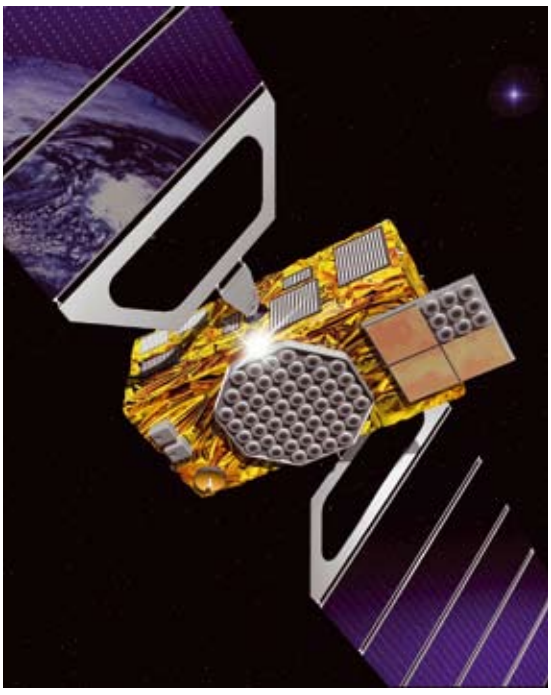
Software and systems

Important steps were taken to improve robustness and maintainability of the software and systems specific to the WSRT, in preparation for curtailed development and limited operational attention during the LOFAR commissioning period. The WSRT HP-UX systems have been phased out, except where required for real-time control with HP-RT systems as an integral part of the DZB backend. The Telescope Management System (TMS) now runs fully on Linux systems. This means fewer dependencies on different platforms and thus easier maintenance and development of the software.

Upgrades and special projects

Telescope Management System, real-time, online and offline software

The focus of WSRT software development was on finishing upgrade projects, supporting two new applications (the experimental Digestive focal-plane, and tracking satellites for the Galileo Signal Monitoring Facility project), and on supporting more direct interaction of WSRT users with the observatory systems and procedures.



Galileo Satellite System, ©ESA-J.Huart

Work on the Telescope Management System (TMS) control of the DZB-MAX system was completed. TMS now supports all observing modes available in DZB-MAX, including multiple simultaneous sub arrays and recirculation factors of 2 and 4. Work on TMS control of TADU-MAX proceeded well, with completion scheduled for 2008, thereby finishing the last part of the WSRT upgrade project. TMS now also allows specification and control of observations done with the PuMaII pulsar back end.

Support has been added for the DIGESTIF prototype focal-plane array mounted in Telescope 5. This permits Digestif project engineers full control over Telescope 5 without impeding observations done with the remaining telescopes in any way.

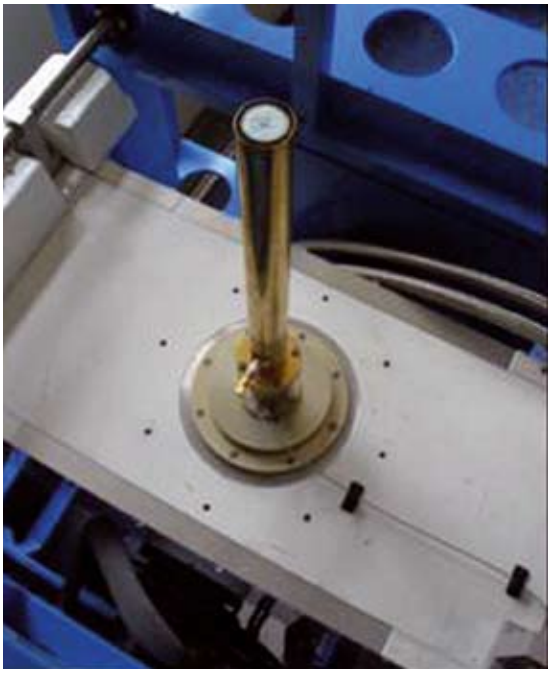
Digestif focal-plane array on one of the dishes of the Westerbork telescope

Support for the Galileo satellite test project has been added as well. The WSRT can now track any satellite, provided its fly-over velocity is within the tracking speed range of the telescope.

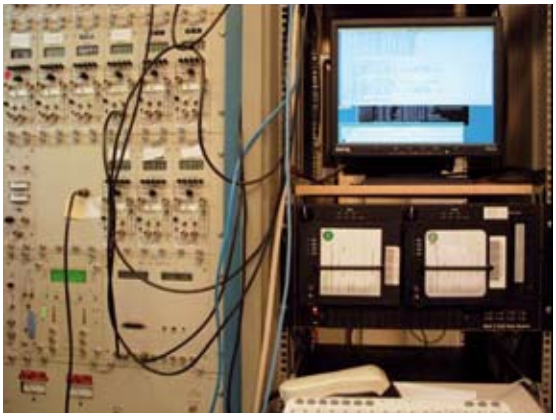
The web based WSRT Management of Measurements (MoM) application, previously used only within ASTRON, has been made available for use by all astronomers associated with a WSRT observing project. In this way, astronomers all over the world have immediate access to information about (the progress of) their observing projects. They are now engaged more directly in the setup and scheduling of their projects, rather than being required to act through ASTRON support staff. MoM has also been extended with facilities for users to define requests for data taken for their project, which they can now retrieve over the internet at their own convenience, or request on DVD.

VLBI equipment

The dedicated 5 cm VLBI MFFE was modified to include a 3.6 cm circular polarisation antenna for single dish measurements. A modification to the mixing scheme and filtering in the receiver was made, to allow a full 160 MHz bandwidth per IF cable. The result is a more simple and flexible system, with better compatibility with geodesy receiver systems. The picture shows the 3.6 cm feed mounted in the 5 cm MFFE frame.



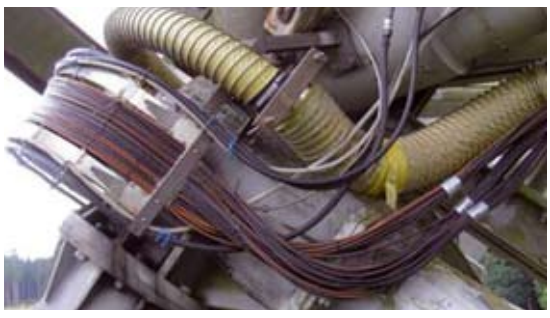
The VLBI - Mk 4 recorder in the Faraday cage was dismantled and completely replaced by the Mark 5-A system, with the hard disk units now being used during VLBI observations. The next step is to replace the field system by TADUmax. Commissioning of TADUmax, in combination with Mark 5-B, was in full progress at the end of the year.



Digestif and Apertif

As of spring 2007, Telescope 5 has been temporarily taken out of the array to facilitate the Digestif focal-plane array pilot technology research project. An important motivation is to investigate prospects for equipping the WSRT with a focal-plane array system, to enable extensive wide-area surveys in the 1—1.7 GHz band. An extensive programme of tests is being carried out to characterise the antenna elements, their interaction, the LNAs, and the beam forming properties of the array in dishes of this F/D ratio. The Observatory was responsible for providing the infrastructure for this project, adapting the systems, making the connections to the mains power and the network, and allowing the experimenters to autonomously control the antennas and the telescope. Initial, promising results were obtained by year's end; they are further described in chapter 3.

The focus box of Telescope 5 was adapted to hold the Digestif phased array feed system: 8x7 crossed polarisation Vivaldi elements in an 80x80cm aperture. A total of 60 receiver chains are available. Coaxial cables were installed to feed the signals from the low-noise amplifiers to frequency convertors and the central processing system, which consists of a prototype LOFAR digital back end. The two telescope jumpers required special attention, to assure that the coax cable bundle would not bend below its specified minimum radius. The back end electronics were installed in an RFI-tight shelter and placed near Telescope 5.



Galileo Signal Monitoring Facility (SMF)

The observing capabilities of the WSRT have possible applications outside of radio astronomy. The European Space Agency (ESA) is interested in using the WSRT for the in-orbit validation of the first satellites of the Galileo constellation (the European global navigation satellite system). In 2007, ASTRON

signed a contract with Thales Alenia Space Italy (TAS-I), contractor of ESA, for the set-up of a Signal-in-Space Monitoring Facility (SMF). ASTRON is carrying out this work together with Science & Technology B.V., Delft University of Technology and TNO, all situated in Delft. As part of the contract ASTRON receives payment for the use of a specific number of WSRT observing hours, mostly with a single dish; the impact of the contracted programme on the overall availability of the WSRT for radio astronomy is modest.

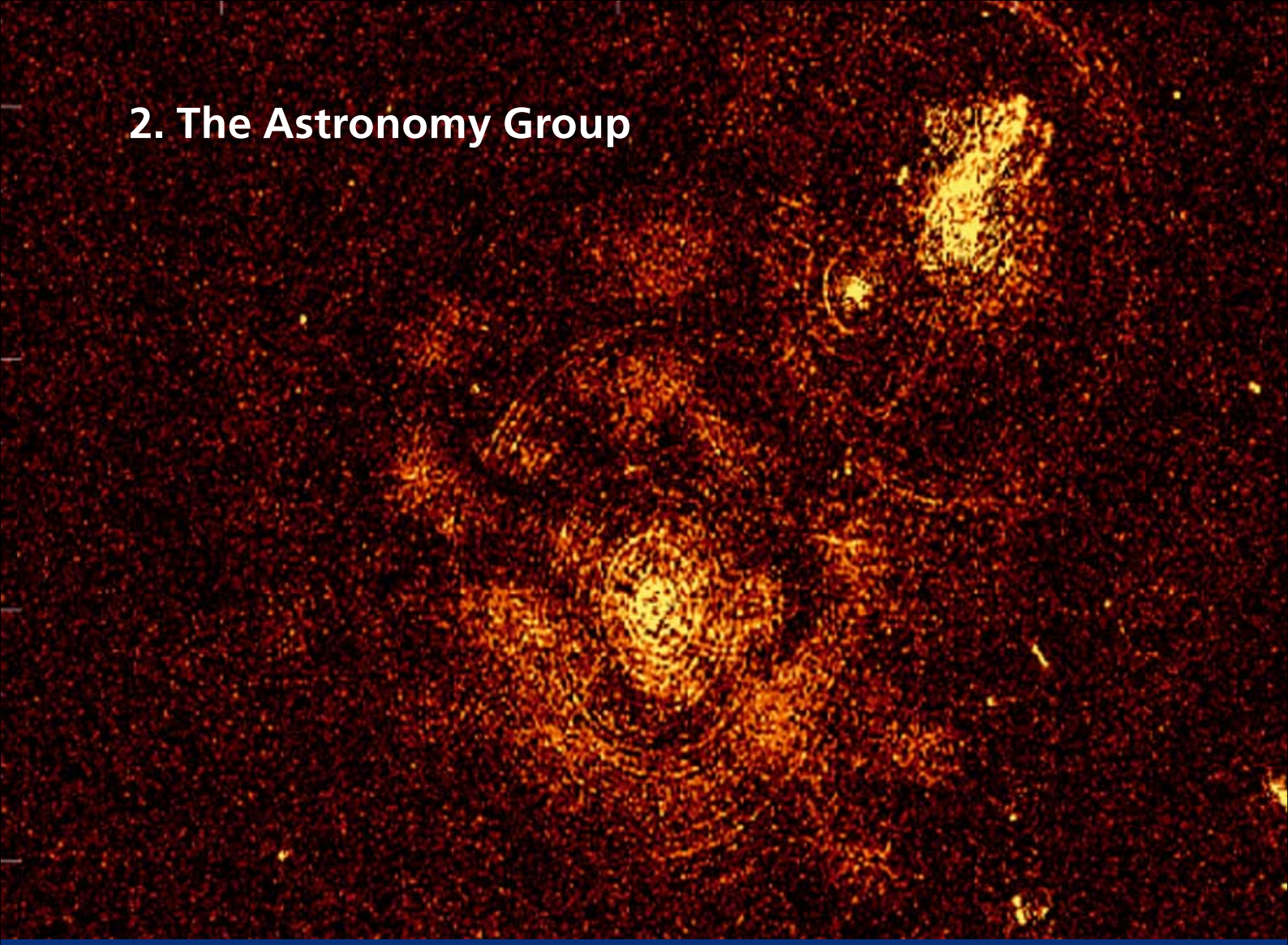
The purpose of SMF is to measure the signals of the individual Galileo satellites with a high signal-to-noise ratio and to analyse the signal properties in great detail to verify whether they comply with the specifications. The infrastructure of the WSRT with its 25-meter dishes, its sensitive receivers, and extremely accurate atomic clock, is quite well suited for this type of measurement. However, some enhancements were needed to the telescope control system to allow calculation and tracking of satellites with specified orbital parameters. Since Galileo signals are broad (up to 92 MHz bandwidth), a dedicated ADC was installed to digitise the entire 20-180 MHz band at once, as it comes into the control building from a single dish. Since the circularly polarised signals from the Galileo satellites are some orders of magnitude stronger than from astronomical sources, a switchable attenuator, including a hybrid for linear-to-circular polarisation conversion, was developed and installed in one of the MFFEs. Work on a dedicated calibration procedure, especially with respect to group delay effects, was proceeding at the end of the year.

First LOFAR test station in Exloo

LOFAR operations and associated activities

Most of the Observatory staff members were involved in LOFAR activities in one form or another in 2007. Some Observatory engineers carried out measurements and repairs of LOFAR electronics, mainly to acquaint them with new systems that will eventually need to be maintained. Other Observatory staff members spent almost all of their time on a wide range of LOFAR development and rollout activities, including the assembly of hardware, installation of computer systems and equipment for the wide area network, and the development of firmware and online and offline software. The operators took up residence in their new integrated LOFAR and WSRT Control Room in the fall; the support scientists were there as well a significant fraction of the time.

2. The Astronomy Group

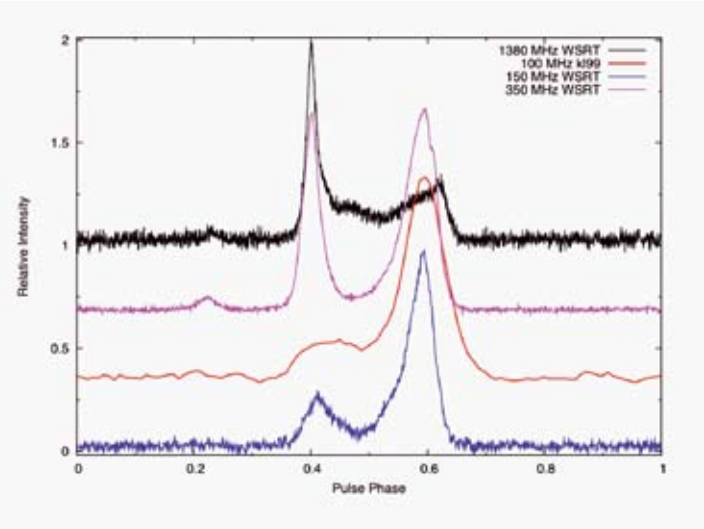


The Astronomy Group is now a separate entity within ASTRON, and represents one of the three pillars of the organisation. The group is engaged in many frontline research areas: galaxy structure and evolution, pulsars and compact objects, Active Galactic Nuclei (AGN) evolution and studies of the magnetic universe, large radio continuum and HI surveys, and gravitational lensing.
In addition to this, the experienced scientists of the astronomy group interact with Research & Development and the Radio Observatory and they are involved in the commissioning of LOFAR, as well as in other new instruments, for example the pulsar machine PuMaII, the WSRT Focal-Plane Array system (APERTIF) and the Aperture Array (EMBRACE).

The Astronomy Group has liaisons with the Dutch universities and takes on the supervision of PhD students and summer students. ASTRON is one the nodes of the EU Marie Curie programme ESTRELA, Early-stage Training Site for European Long-wavelength Astronomy. Two students are supported by this programme and supervised by members of the group. Last, but not least, the Astronomy Group plays an important role in the international scene by being involved in the planning of other major radio facilities (e.g. SKA) and related initiatives (e.g. RadioNet).

The following pages describe these and a few of the other research projects and activities carried out by the Astronomy Group in 2007.

Pulsars and compact objects

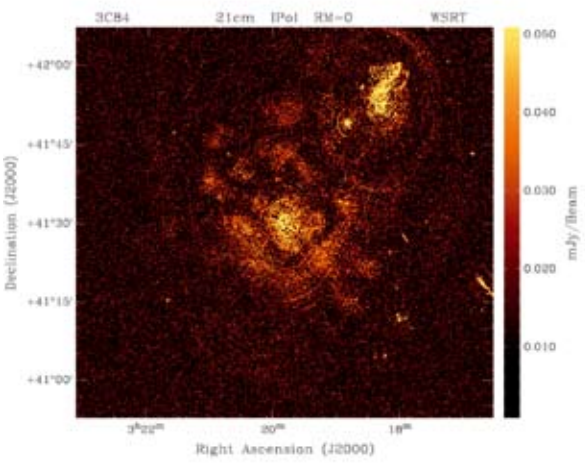


With its extremely good sensitivity, LOFAR can detect many new 'normal' radio pulsars in the proposed pulsar surveys. However, it is less well known how many millisecond pulsars (MSPs) it will find. This is because the low frequency properties of these pulsars are much less well studied. MSPs are particularly interesting to find, because they are the most clock-like of all radio pulsars and therefore ideal for testing theories of gravity and directly detecting gravitational waves. To gain a better understanding of their properties in the LOFAR frequency range, Ben Stappers made observations using the LFFEs (Low Frequency Front Ends) on the WSRT. Combining the sensitivity of this system with the coherent dedispersion capabilities of the pulsar backend PuMa II he was able to present much sharper pulse profiles than previously possible. The combination of the rapid periods of these objects and the deleterious effects of the interstellar medium causing dispersion and scattering of their signal, may make them difficult to detect with LOFAR, despite its extremely good sensitivity. However, with the successful observations made with the LFFEs, 8 of the 14 MSPs studied, were detected. This bodes very well for the much more sensitive LOFAR surveys.

Ben Stappers and PhD student Gemma Janssen have worked on measuring and modelling the times of arrival of pulses of the double neutron star binary PSR J1518+4904. The results, presented in a series of papers, include data for high precision pulsar timing from the EPTA telescopes (European Pulsar Timing Array), the WSRT, Effelsberg, Lovell, and, for the first time, data from Nançay. The proper motion of the pulsar was determined with higher accuracy than before, which shows quite clearly that it did not get a large kick when it formed, and thus confirms the binary evolutionary models that suggest it formed via a different channel than the other double neutron star systems. By measuring the apparent change in the inclination of the binary system due to the proper motion, an upper limit could be placed on the inclination of the system to better constrain the masses of the constituent neutron stars.

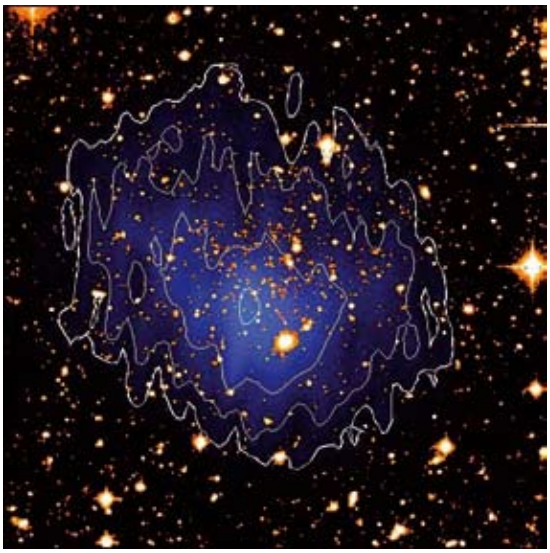
Galactic foreground polarisation and the (local) interstellar medium

Ger de Bruyn has continued his long-term observational and theoretical analysis of the polarised Galactic foreground emission. This work has been carried out in cooperation with Dominic Schnitzeler (PhD student) and Peter Katgert in Leiden, Michiel Brentjens (thesis defense in June 2007 at the Kapteyn Institute, now ASTRON), Roberto Pizzo (PhD student) and Gianni Bernardi in Groningen and the Italian colleagues Luigina Feretti and Federica Govoni. The study of the polarised emission is interesting in its own right but also because the Galactic synchrotron emission is the most important foreground contaminant for LOFAR observations in search for redshifted 21cm signals from the 'Epoch of Reionization' (EoR).
Observations with the WSRT in the 20 cm (1150-1800 MHz), 1-meter (315-380 MHz) and 2-meter (115-175 MHz) bands have been obtained in several projects. Together with Michiel Brentjens observations of the Perseus cluster were reduced. Michiel Brentjes argued strongly in his thesis that the 85cm polarised emission observed towards the Perseus cluster may in fact be largely due to our Galaxy, rather than associated with the Perseus cluster itself. However,

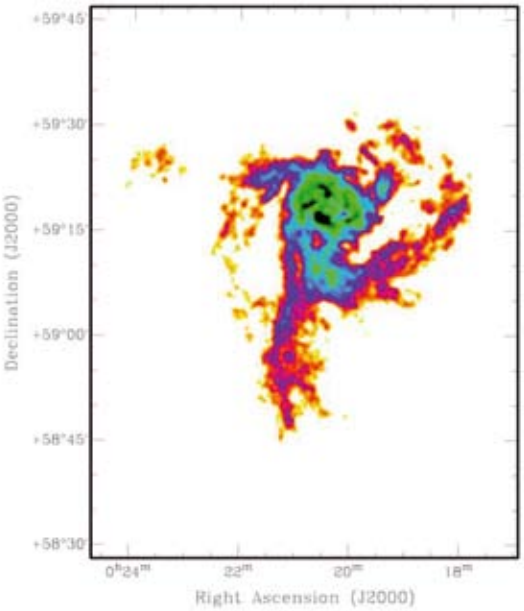


the bi-polar pattern previously observed at 21cm, and now imaged with a dynamic range of more than a million to one, appears to be centred at 3C84 arguing for a relation with (the central source in) the cluster (see figure). The group also detected several sources towards the central part of the cluster that have rather large rotation measure (RM) values.

Neutral hydrogen in the Local Group



WSRT observations of the recently discovered Local Group dwarf galaxy Leo T were performed by Tom Oosterloo and colleagues from Cambridge University. Leo T is a particularly interesting galaxy because it is the smallest galaxy known (absolute magnitude in *V* is -7) where continuous star formation has taken place, at a small rate, over the Hubble time. Star formation in such small systems is a difficult problem. In such small galaxies there are many processes that slow down star formation. In some models, such small galaxies should hardly have stars because as soon as a few stars form, supernovae and stellar winds will expel the gas. The WSRT observations gave the very interesting result that Leo T is very gas rich (M_{HI}/L = 5) and the HI distribution is very regular. No signs of any gas outflows are observed, despite the recent star formation. Leo T appears to have a normal interstellar medium (ISM): it has both cold (<500 K) and warm (≈6000 K) HI, very similar to larger galaxies. One scenario is that the ISM in Leo T cools the same way as in larger galaxies, but as soon as a few stars form, their radiation prevents further cooling and star formation halts temporarily, leading to a small trickle of periodic star formation. Leo T is not only the lowest luminosity galaxy with on-going star formation discovered to date, it is also the most dark matter dominated, gas-rich dwarf in the Local Group.

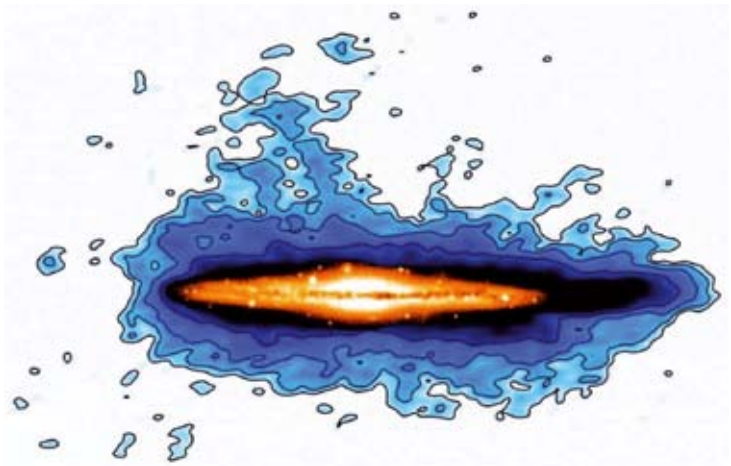


An HI mosaic - from WSRT observations - of the dwarf galaxy, IC 10 has been completed by Eva Manthey (see figure). IC 10 is a nearby irregular dwarf galaxy (*D*=820 kpc) undergoing a phase of enhanced star formation. Based on the large number of Wolf-Rayet stars and a deficiency of red supergiants, the starburst must have occurred a few million years ago. The mosaic shows the very complex distribution of the gas with a variety of extended features. Since the extended HI filaments do not have any optical counterpart, it is likely that IC 10 might be interacting with an intergalactic (primordial) gas cloud, fuelling the starburst. The figure shows the HI distribution. A complex kinematics structure in the outer regions is observed, with at least four large filaments. If the chaotic structure is due to interaction/merging with a companion galaxy, a more regular velocity would be expected in the outer parts. Therefore, the observations seem to favour the scenario of cold accretion of HI.

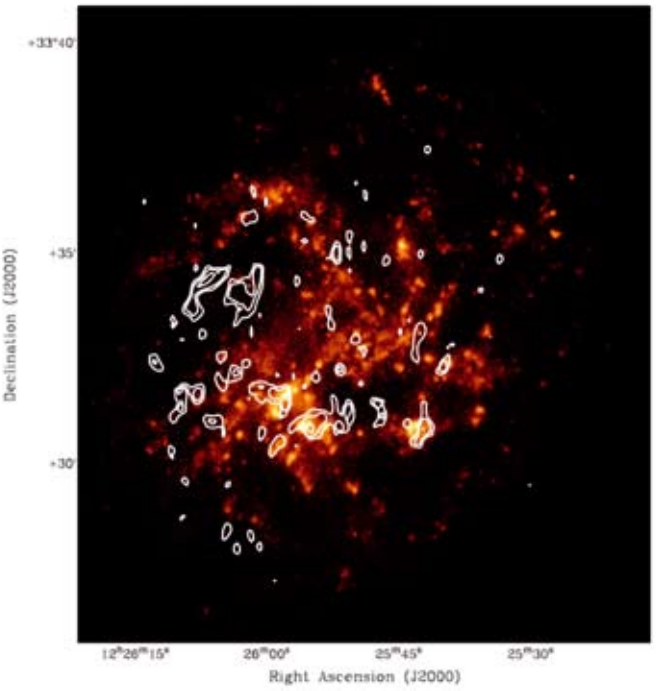
Neutral hydrogen tracing accretion and dark matter in nearby galaxies

Spiral galaxies contain large amounts of gas in their extra-planar regions (i.e. outside the star-forming disk). Oosterloo, in collaboration with Renzo Sancisi (University of Bologna, Kapteyn Institute) and Filippo Fraternali (University of Bologna), published

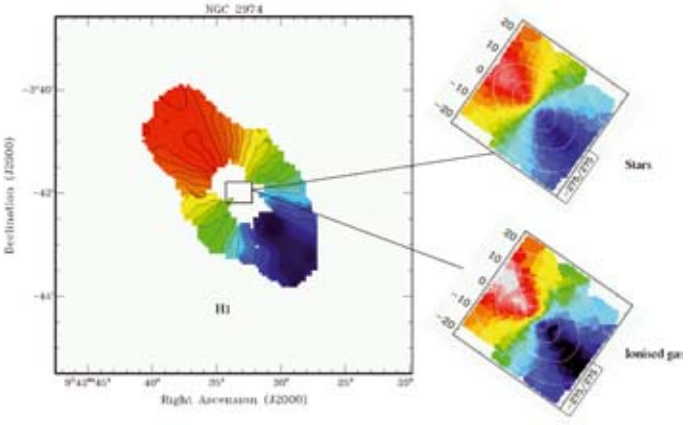
very deep WSRT HI observations of the edge-on galaxy NGC 891. These are among the deepest ever performed on an external galaxy. They reveal a huge gaseous halo that is much more extended than seen previously, and that contains almost 30% of the HI of this galaxy. This HI halo shows structures on various scales. On one side, there is a filament extending (in projection) up to 22 kpc vertically from the disk. Moreover, small halo clouds (with a gas mass of about 10^6 solar masses), some with forbidden (i.e. apparently counter-rotating) velocities, are also detected. The overall kinematics of the halo gas is characterised by differential rotation lagging with respect to that of the disk. The lag, more pronounced at small radii, increases with height from the plane. There is evidence that a significant fraction of the halo is due to a galactic fountain. However, accretion from intergalactic space must also play a role in building up the halo and providing the low angular momentum material needed to account for the observed rotation lag. The long HI filament, and the counter rotating clouds, may be direct evidence of such accretion.



The study of the extended extra-planar gas in spiral galaxies has been performed also using optical spectroscopy. George Heald has derived rotation curves of the ionised component of this gas in three edge-on spiral galaxies: NGC 5775, NGC 891 and NGC 4302. In all three cases, the rotation speed of the ionised gas declines with increasing vertical distance from the disk. The magnitude of this decline is different in each galaxy, and may be related to the star-forming properties of the individual galaxies. The observed trend is in the opposite direction from what would be expected if the extra-planar gas originates solely from star formation, and follows simple ballistic orbits in the halo. Instead, additional effects (possibly including the effects of gas accretion) are needed to understand the observed kinematics.

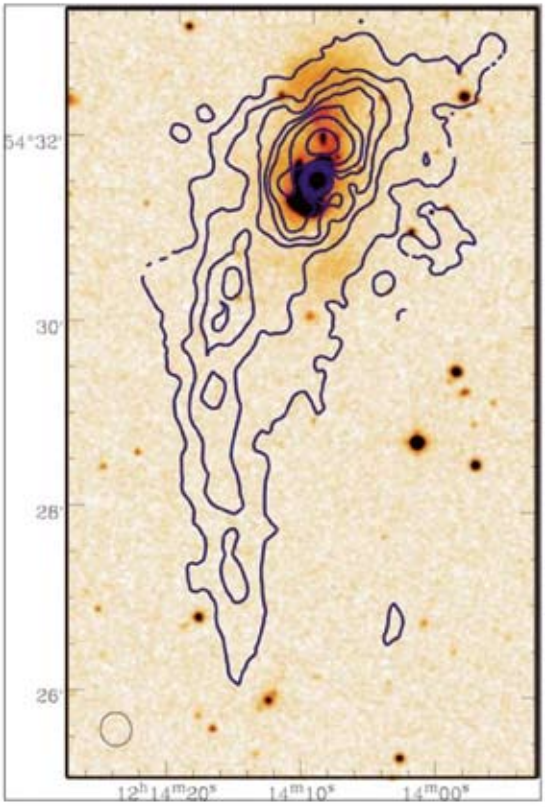


Claims have been made in the literature that some elliptical galaxies, contrary to spiral galaxies, do not contain much dark matter. To investigate this, HI observations of the elliptical galaxy NGC 2974, obtained with the Very Large Array, were used by Anne-Marie Weijmans (Leiden), in cooperation with Raffaella Morganti and Oosterloo, to derive the mass distribution in this galaxy. Mass models were constructed by combining the HI rotation curve with the kinematics of the central regions by using measurements, obtained with the optical integral-field spectrograph SAURON, of the ionised gas. To reproduce the observed flat rotation curve of the HI gas, a dark halo has to be included in the mass models. The result is that the dark matter properties of this elliptical galaxy are very similar to those observed in large spiral galaxies: within five effective radii at least 60 % of the total mass is dark. The figure shows the velocity field derived for the HI as well as those found for the stars and the ionised gas.

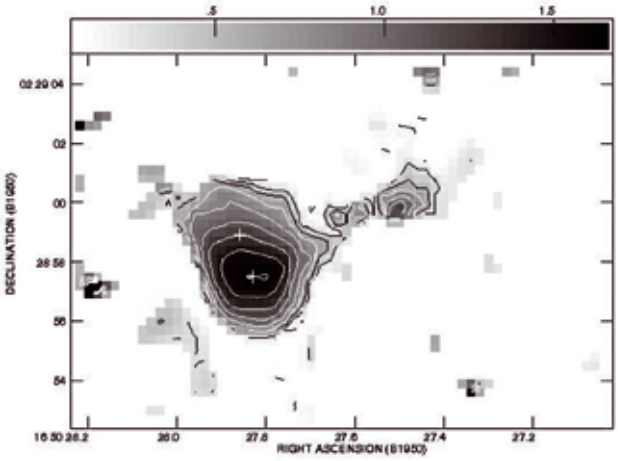


Gas tracing interacting galaxies

Galaxy interactions and mergers are important drivers for galaxy evolution. It is widely accepted that every large galaxy has undergone at least one and probably several merger events in its lifetime. Besides the growth of mass, interaction processes can influence the properties of the remnant, e.g. the structure, the morphology, the stellar populations, and the gas content.
Manthey worked (with Aalto and Horellou, both OSO, Sweden) on a multi-wavelength investigation of a sample of spiral/elliptical (S+E) mergers. These objects are in advanced merger stage each showing one tidal tail and several shells in the optical. In addition to previous observations of the molecular (CO) and atomic (HI) gas, dense molecular gas tracers were observed with the Onsala Space Observatory and the James Clerk Maxwell Telescope (JCMT) to investigate the properties and chemistry of the interstellar medium in more detail. Most of the sample galaxies were not detectable in HCN and HCO+, although they host a large amount of molecular gas based on the CO emission. The absence of dense cores agrees with the moderate ongoing star formation rate of the galaxies. The molecular gas occurs mainly in a diffuse phase and is often spread over several kiloparsecs. Therefore, gas condensations leading to the formation of new stars is suppressed.



Absorption against the radio continuum of a galaxy can be a valuable tool to study the velocity field of the gas. The absorption of neutral hydrogen (HI) and the molecule hydroxyl (OH) against the extended continuum emission of the well-known merging system NGC 6240 has been used by Willem Baan, Yoshiaki Hagiwara (National Astronomical Observatory Japan) and Peter Hofner (New Mexico Tech) to study the dynamics of the nuclear region and the extended debris structure of the interaction. NGC 6240 is well-known for its intense nuclear starburst, large scale nuclear outflows, and prominent FIR and X-ray emission structures.
The spatial structure of the velocity field of the HI and OH absorption provides a consistent picture of two merging/orbiting nuclei and all the debris surrounding them. It visualises the presence of a dust lane located in front of the galaxy and the powerful outflows resulting from the starburst-related nuclear blow-out. The accurate velocity data allows for the construction of a dynamical model for the interacting nuclei with the northern nucleus being far behind the southern nucleus. This also reveals the nature of the strong OH and HI absorption in between the two nuclei (also seen in the Carbon Monoxide emission) as being due to a superposition of the disks of the two galaxies.

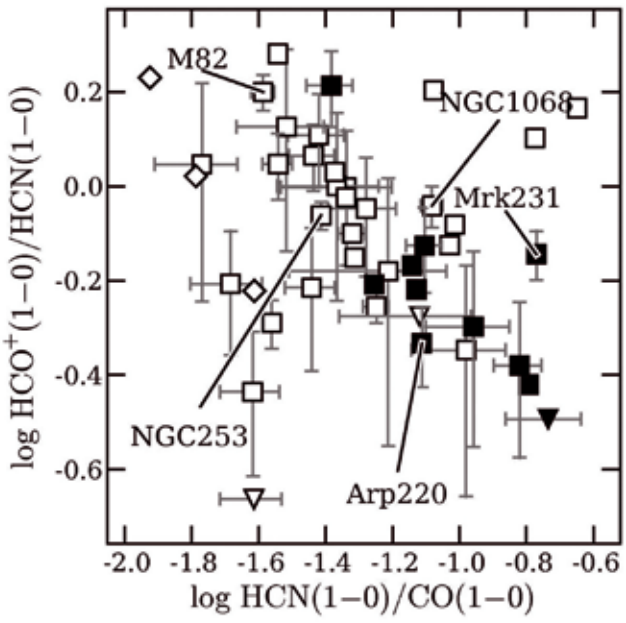


Dense molecular gas in galaxies

Molecular line emissions provide a powerful diagnostic of the properties of the prominent emission regions in the ISM. The power sources for such regions are the radiation from newly formed stars or from embedded X-ray sources. Together these molecular emissions provide insights into the physical properties of the medium such as the temperature and density, and its chemical evolution, which is different for different environments. A large compi-

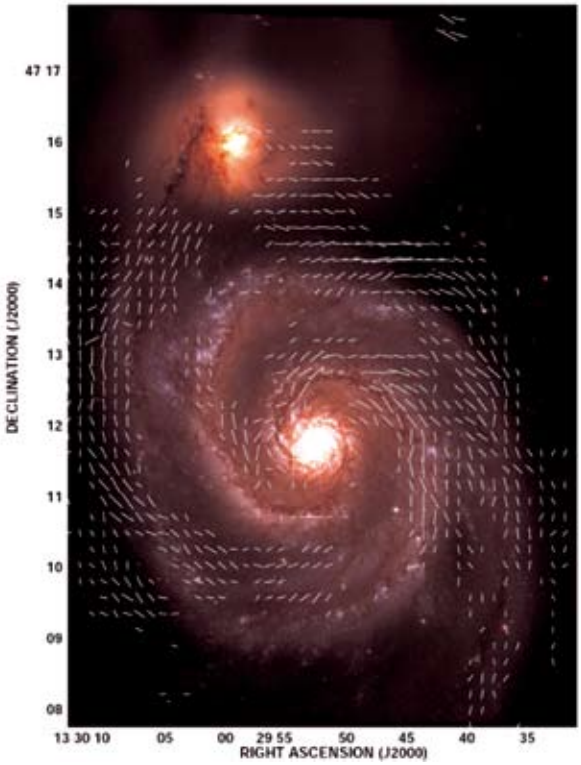
lation of molecular line data of galaxies across a range of far-infrared (FIR) luminosities, which is a measure of activity in the nucleus of the galaxy, was used by Baan, C. Henkel (MPIfR Bonn), A.F. Loenen (University of Groningen, and ASTRON), A. Baudry (University of Bordeaux) and T. Wiklind (Onsala) to do first-order diagnostics of the nuclear emissions. New data from the Sweden-ESO SEST and the IRAM 30m Pico Veleta telescopes was complemented by data from the literature to reveal properties of the ensemble of high- and low-density molecular tracers in the nuclei of the galaxies.

Results of theoretical modelling of the molecular environment under a variety of circumstances were used for a first analysis of the data by Marco Spaans (University of Groningen) and Rowan Meijerink (University of Berkeley). The data show that conditions change significantly in the nuclear ISM and the line ratios vary during the course of the starburst. Starburst-related shocks and cosmic rays provide feedback into the ISM and affect the properties of these molecules. Luminous FIR galaxies, including OH Megamasers, have an environment that is dominated by radiation from the starburst; only more evolved FIR galaxies will experience the influence of X-ray heating. The first results strongly support the idea that multi-molecule multi-transition studies need to be used together with detailed physical and chemical modelling to determine the excitation and status of the ISM in these galaxies.

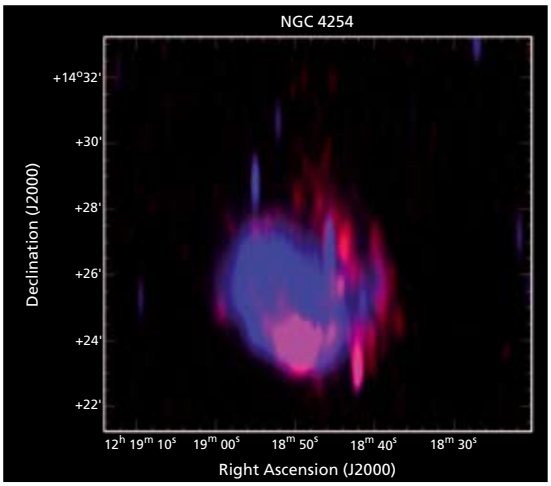


Nearby galaxies and clusters - polarisation

In spiral galaxies, magnetic fields are an extremely important component of the interstellar medium. However, their exact role in galactic evolution is very unclear, because observational studies are difficult and relatively little data is available. Heald investigated the 18- and 22-cm polarised continuum emission in the WSRT-SINGS galaxies (Westerbork observations of galaxies in the Spitzer Infrared Nearby Galaxies Survey). Fully 2/3 of the 34 galaxies in the sample show some level of polarised emission. An interesting example of the galaxies with detected polarised emission is NGC 4254.



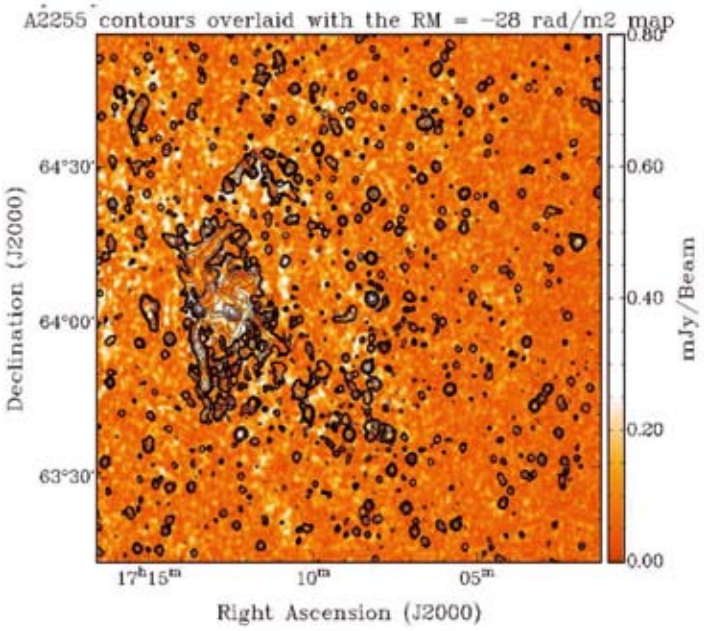
This galaxy is plunging into the Virgo cluster, and the tail of polarised continuum points in the direction opposite the cluster centre. Accurate determination of the Faraday rotation measure (RM) in all of the polarised sample galaxies was achieved using the 'RM Synthesis' technique that was developed by Brentjens and de Bruyn. The use of this technique allowed a determination of the intrinsic orientations of the magnetic field lines in the plane of the sky. A nice example of this is NGC 5194 (M51, the Whirlpool Galaxy), shown in the figure (background image: Hubble Heritage). This 'grand-design' spiral galaxy has beautiful arm structure in the optical,

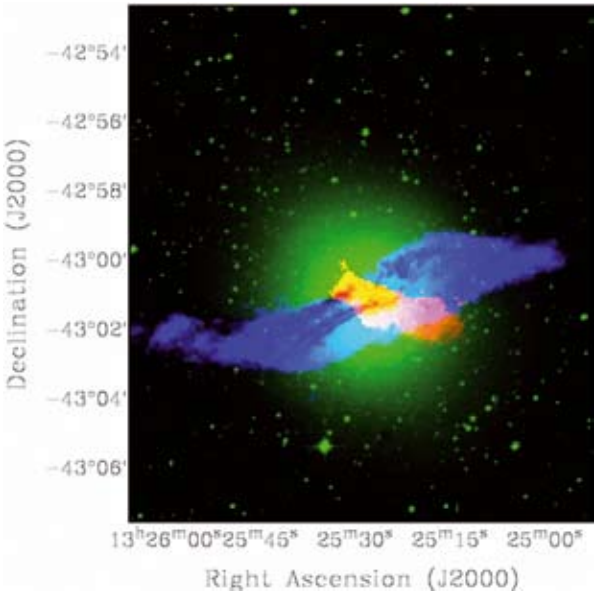


and that arm structure is very well traced out by the magnetic fields. In some regions, the magnetic fields appear to move from the inside edge of an arm to the outside edge of the arm – this may be indicative of shock compression of the magnetic fields.
De Bruyn and Brentjens worked on various WSRT projects related to the polarised radio emission observed from the direction of the Perseus cluster of galaxies as described above (ISM). Together with Roberto Pizzo (PhD student), WSRT observations were done at 21-cm and 92-cm of the cluster Abell2255. They revealed several new diffuse radio sources at projected distances of 2 Mpc from the centre of the cluster. The radio emission from these features is most likely connected with large scale structure accretion shocks.

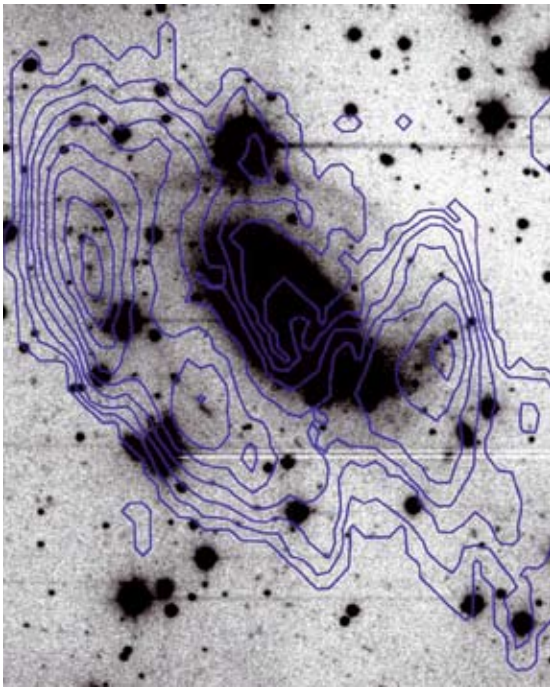
Radio-loud Active Galactic Nuclei

Huge amounts of energy are produced through the accretion of material onto the super-massive black hole situated in the centre of an Active Galactic Nucleus (AGN). The regions around an AGN are therefore highly complex and host a wealth of physical processes. Gas in different phases (atomic, molecular and ionised) is observed in this very hostile environment. This gas, in particular through its kinematics and ionisation, can carry the signatures of the effect of the AGN on its surrounding medium. Nearby radio galaxy Centaurus A has been the object of study of Christian Struve (PhD student) supervised by R. Morganti and T. Oosterloo. His reduction of the ATCA HI data resulted in observations with higher resolution and better sensitivity than previous HI studies. They detect red- and blueshifted HI in absorption against the nucleus covering a velocity width of 400 km/s, which is much broader than previously observed. Not only a broader (~200 km/s) redshifted component is present, but for the first time a *blueshifted* component was detected. The width of the nuclear absorption is in agreement with the velocities found for the circumnuclear molecular disk detected in CO and H_2. Therefore, the conclusion is that the atomic counterpart of this disk produces the HI in the central region. This means that the gas producing the absorption is not, as was previously assumed, associated with infalling gas feeding the



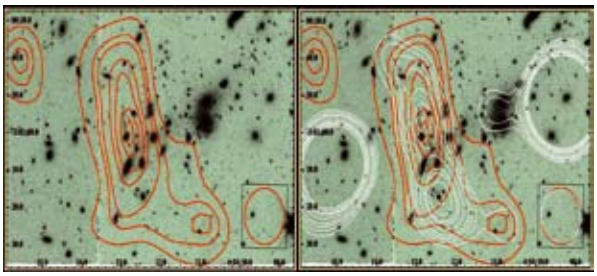


AGN. A tilted-ring analysis of the heavily warped large-scale disk has also been performed.
Merger events are often invoked as trigger of the activity in galaxies. The presence of large amounts of neutral hydrogen distributed over large radii can be used to reconstruct the formation and history of galaxies and to trace whether mergers have occurred. A number of projects, involving Morganti, B. Emonts (Columbia University), Oosterloo and C. Tadhunter (Sheffield University), have studied the distribution and kinematics of large-scale neutral hydrogen (HI) gas in and around nearby radio galaxies. The main goal was to search for evidence of gas-rich galaxy mergers or interactions (tails, bridges, disks, etc.) that could be related to the triggering of the radio source in these systems. A remarkable discovery was made by the detection of enormous disks and rings of neutral hydrogen (HI) gas around several nearby radio galaxies. These HI disks/rings appear to be in regular rotation and reach diameters up to 190 kpc and masses up to 4x the HI mass of the Milky Way. One case, B2 0648+27, has been studied in great detail and was found to be a product of a major merger. The HI ring formed from tidally expelled debris that fell back and settled around the host galaxy. A multi-wavelength analysis was performed, including synthesis modelling of the stellar population throughout the galaxy, and deep optical imaging of the stellar counterpart to the HI ring. Evidence was found for a young stellar population of 0.3 Gyr. All the observations suggest that B2 0648+27 is a direct link between (Ultra-) Luminous Infra-Red Galaxies and Radio Galaxies.



Gravitational lenses and deep fields

Mike Garrett and Alicia Alba Berciano (PhD student, Kapteyn Institute Groningen) have continued to pursue the use of massive cluster lensing as cosmic magnifying glasses – enabling the detection of very faint background radio sources, that would otherwise be undetectable. Two examples of multiply imaged radio sources in clusters are now known in Abell 2218 and MS0451.6-0305. Both systems have been found by searching for radio counterparts of multiply imaged submillimetre galaxies (SMGs). Alicia has analysed higher resolution VLA observations of this system, resolving the radio emission into various distince components. Both the radio and sub-mm emission probably arises from multiple imaging of a merging system, located at z ~ 2.9.

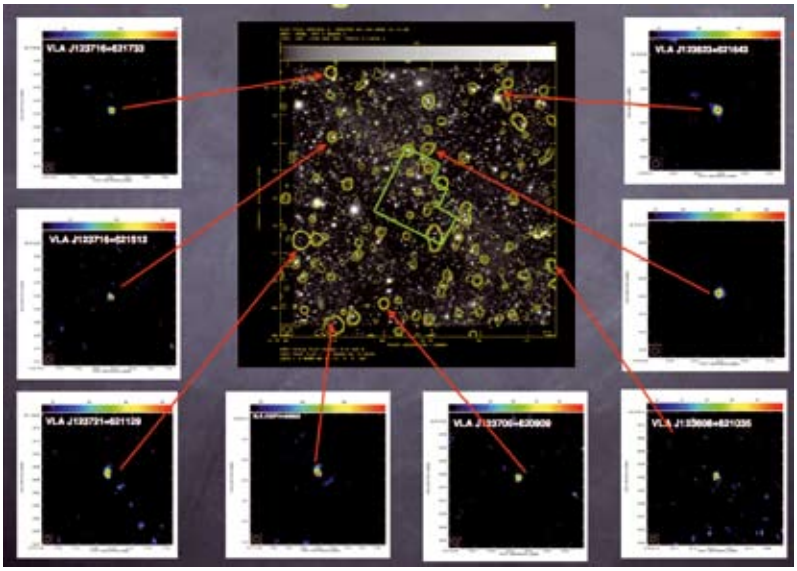


Highly magnified sub-mm emission (red contours) as detected by SCUBA, superimposed on an HST image of the massive cluster MS0451. Right: the radio counterpart (white contours) superimposed on the sub-mm emission and HST image.

Seungyoup Chi (PhD student Kapteyn Institute/ ASTRON) supervised by Mike Garrett, continued his work on Global VLBI observations of the HDF-N. About eight new sources were detected in the HDF and flanking fields, and work began on a paper presenting the initial results. Images of radio sources reach a noise level of 7 μJy per beam. VLBI permits the detection of AGN systems that would otherwise be obscured at other wavelengths (including the x-ray domain). Some of the sources show evidence for significant obscuration at other wavelengths and are likely to be hybrid systems in which both AGN and star formation are present.

Garrett obtained WSRT observations of the *8 o'clock arc* gravitational lens system. In this system, a Bright Red Galaxy (BRG) magnifies and multiplies images of a distant (z=2.7) Lyman Break Galaxy (LBG). The magnification is ~ 10, making it possible to study the LBG in great detail. The data were analysed by Ivan Marti-Vidal (University of Valencia), images of the system were made from both the 6 and 18 cm data.

The source is weak and extended but clearly detected. Accurate astrometric measurements of the centroid of the radio emission show it to be centred several arcseconds to the north of the BRG. A VLA (Very Large Array) proposal was submitted to make higher resolution follow-up observations at 1.4 GHz. Preliminary images suggest that the BRG is a radio galaxy with a strong jet pointing to the north. The new VLA observations suggest that this jet is the source of the extended emission, rather than the extended arc.
During his visit, Marti-Vidal wrote a python program that uses both the VLA NVSS and SDSS databases to conduct a stacking analysis of various types of cosmic objects, including G-type stars. In the latter case, a stacking analysis should provide some limits on the level of natural radio emission that might be detected from such objects and place interesting constraints on attempts to detect artificial signals from extra-terrestrial civilisations (ETCs). Garrett modified the script and created new SDSS catalogues of objects that can be used to test the program and methods further. A regular arithmetic and median average was implemented in the stacking analysis.

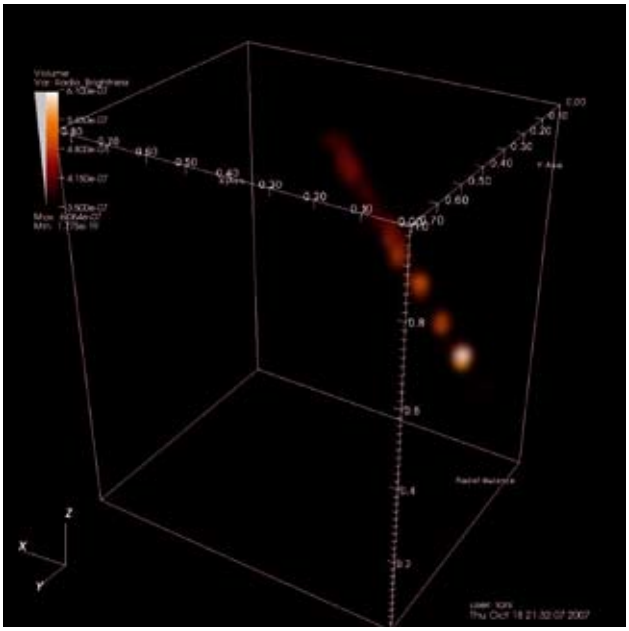


Some of the compact radio sources detected in the Hubble flanking fields.

Ultra-High energy cosmic rays

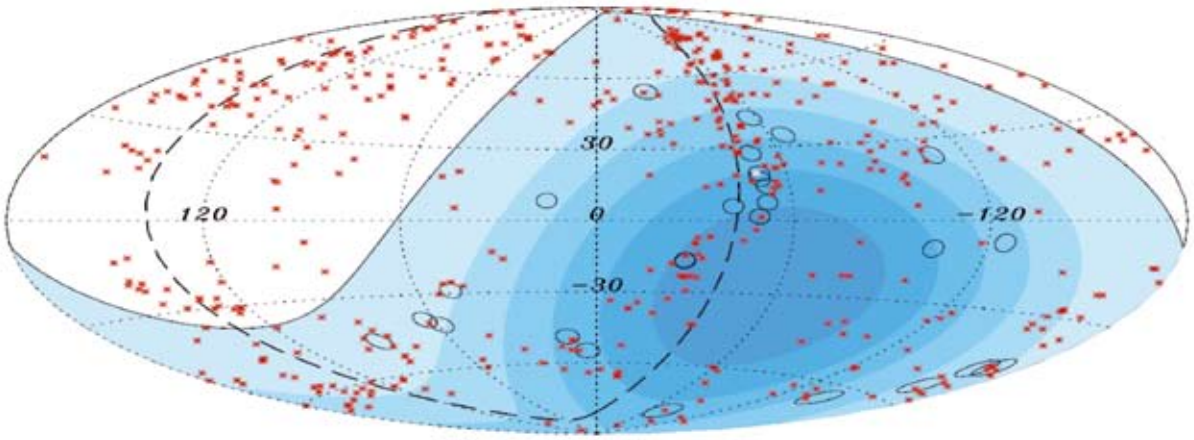
For a long time the link between cosmic ray acceleration and radio astronomy was merely indirect, through the observation of synchrotron radiation of high-energy electrons produced in cosmic sources (e.g. supernova remnants and plasma jets from black holes). However, the direct detection of cosmic ray particles using low-frequency radio antennas has seen a major revival in recent years. Radio emission of air showers from ultra-high energy cosmic particles offers a number of interesting advantages. Since radio waves suffer no attenuation, radio measurements allow the detection of very distant or highly inclined showers, can be used day and night, and provide a bolometric measure of the leptonic shower component. The LOPES experiment has detected the radio emission from cosmic rays, confirmed the geosynchrotron effect for extensive air showers, and in 2007 finally provided a good calibration formula to convert the radio signal into primary particle energy. The radio signal seems to have much lower statistical fluctuations in the energy determination than any other technique, thus allowing a major improvement in the energy measurement of cosmic rays in the future.

Also, the radio imaging technique of cosmic rays has been further developed allowing one to obtain (uncleaned) three dimensional images of nanosecond radio flashes produced by cosmic rays hitting the Earth atmosphere (see figure). The technique is currently being further developed to be introduced in LOFAR. This will allow one to also search for short-



time astrophysical transients, such as the millisecond radio sparkers recently detected by Lorimer et al., and clearly distinguish them from terrestrial signals.

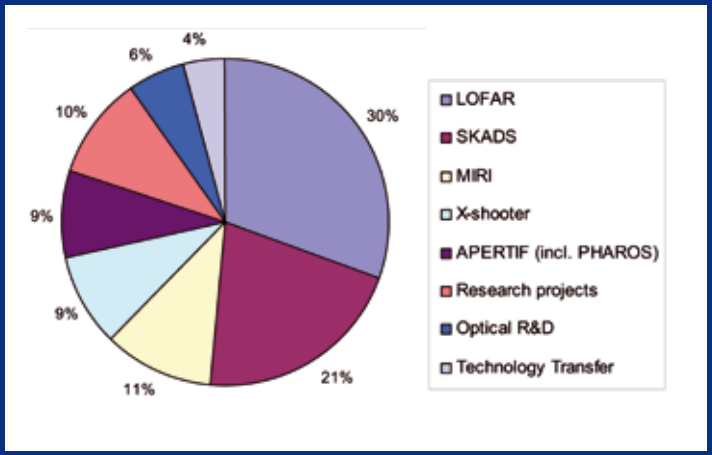
In this respect efforts have been continued to find radio flashes from cosmic rays hitting the lunar surface using the WSRT. Future steps will be the installation of radio antennas at the Auger experiment to measure the composition of ultra-high energy cosmic rays. Here a first test-setup has already detected the first radio events at Auger. Moreover, ASTRON's contribution to the Auger collaboration has borne fruits this year, with the first major breakthrough result of the observatory. Using data collected at the Pierre Auger Observatory during the past 3.7 years, we demonstrated a correlation between the arrival directions of cosmic rays with energy above 6×10^{19} electron volts and the positions of active galactic nuclei (AGN) lying within ~75 megaparsecs. One of the most intriguing candidates for the origin of some of the excess is the nearby radio galaxy Centaurus A.



Auger collaboration 2007, Science, Nov. 9 issue

3. Research & Development

Research & Development activities in 2007 were dominated by five major projects: LOFAR, SKADS and APERTIF in the radio-domain, X-shooter and MIRI for the Optical/IR. R&D staff were further involved in sixteen smaller research projects, leading to a steady stream of publications in (mainly IEEE) journals and conference proceedings. Some ten technology transfer projects were carried out in 2007. The chart shows the fraction of R&D capacity dedicated to each of these categories.



LOFAR R&D

Technical R&D activities for the LOFAR project were driven largely by the commissioning of Core Station 1 (CS-1), a number of important reviews and the process of adjusting the LOFAR system and configuration to the available roll-out funding.
System engineering manager André Gunst and his team supported the commissioning of the 96

Single element LOFAR High Band Antennas

antenna system that has been deployed in the core of LOFAR, near Exloo in the north-east of the Netherlands, since December 2006. The 96 Low Band Antennas (LBA) are optimised for operation in the 30-80 MHz frequency range, and are distributed over four fields, which are up to 400 metres apart providing good UV-coverage for excellent calibration and imaging capability. In March, 32 individual High Band Antennas (HBA, looking like 'spiders'), optimised for operation in the 110-240 MHz frequency window, were made operational and six prototype tiles (each 4x4 antennas, combined with a beam-former) were delivered in late May. Initial processing of the signals takes place on location

Stella, the IBM BlueGene/L supercomputer at the RUG

with dedicated digital hardware. Afterwards, the signals are transported to the central processing facility at the University of Groningen, some 60 km away, where they are correlated on the IBM BlueGene/L supercomputer and stored as AIPS++ Measurement Sets. Currently up to sixteen microstations can be formed from the 96 LBA antennas.

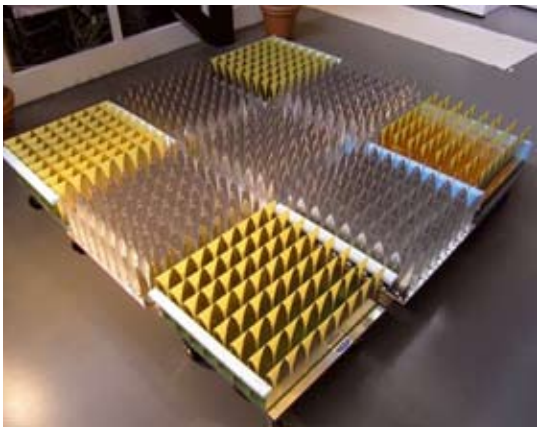
Astronomers and (software) engineers teamed up to test the full signal chain, leading to a steady stream of images with increasing quality and dynamic ranges, as our understanding of the system and the radio sky at these frequencies increases.

In a careful process involving scientists from the Key Science Programs and engineering experts, the configuration of LOFAR stations and the array were redefined to obtain maximal performance within the given funding constraints. After successfully passing the system-level Critical Design Review and the BSIK Mid-Term review, the project was ready to embark on the major procurements for the full roll-out. Requests for quotation were issued by the end of the year. Assuming contracts can be signed in early 2008, components and subsystems are expected to start arriving shortly after the summer.

Although the hardware systems for LOFAR are essentially completed, major developments in the software, both on-line and for calibration and astronomical processing will be going on in the coming years. This will increasingly be a joint effort between software engineers at R&D and the Radio Observatory, support scientists and university-based researchers.

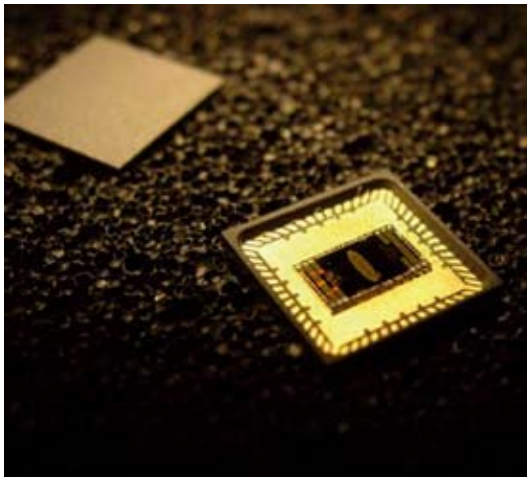
SKA Design Study (SKADS)

The European SKA Design Study is a program of research activities that will lead to a preliminary design for the SKA, using Aperture Array technology for the Mid SKA array. Work packages cover science and system simulations, research on innovative technologies (including an innovation of the Italian BEST telescope) and the construction of two aperture array demonstrators: EMBRACE (led by ASTRON) and 2-PAD (led by University of Manchester). EMBRACE will demonstrate a high-volume, low-cost tile using both analogue and digital beam forming. The 2-PAD system will evaluate an all-digital beam forming approach. Together these demonstrators will provide the necessary input on performance and costing.



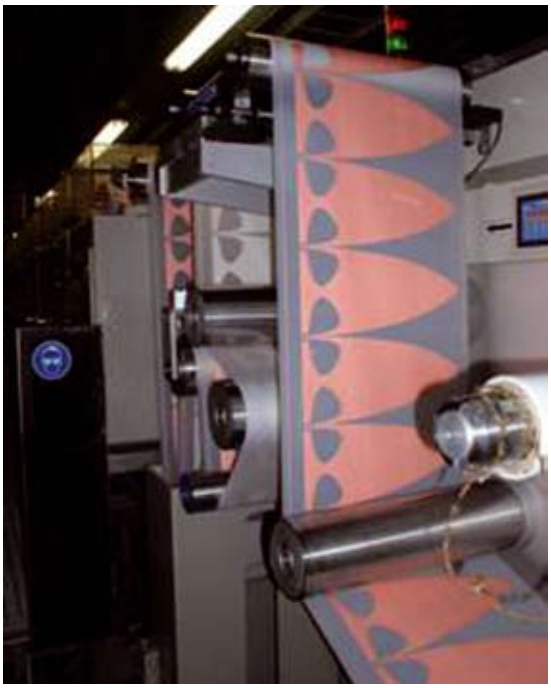
Embrace Ten-Tile Prototype

EMBRACE, (also known as SKADS/DS5, the fifth design study in SKADS), is concerned with the design and development of a large scale European SKA demonstrator based on the aperture array concept. Project managers at ASTRON are Parbhu Patel and Dion Kant. The acronym literally means 'Electronic Multi-Beam Radio Astronomy ConcEpt.' More important though is the message it tries to convey that AA technology will be brought to a sufficient level of maturity that the worldwide SKA community can safely embrace it. The physical scale of EMBRACE is such that cost-figures can be established with sufficient confidence, and performance can be demonstrated with sufficient accuracy. EMBRACE progressed well in the course of 2007. The Ten-Tile prototype was delivered (just) in time for the SKADS mid-term review. A complex analogue beam former chip was designed and manufactured using 0.25 µm SiGe:C BiCMOS technology. The signal chain of this chip includes a low-noise dual feedback amplifier, poly-phase networks, switching networks, amplitude correction facility as well as output drivers. All settings of the chip are under full digital control, through an SPI interface.



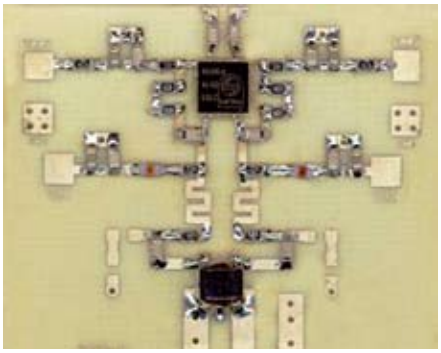
Analogue Beam former Chip

The whole system-on-chip design is based on a differential paradigm. Based on the experiences with the Ten-Tile Prototype, the final boards and mechanical systems for EMBRACE are now being developed. Production of the full EMBRACE system will start in mid-2008.



Plating of the antenna foil

In SKADS DS4, ASTRON investigates innovative antenna production technologies and differential Low Noise Amplifiers (LNAs). Project managers are Jan Gerald bij de Vaate and Johan Pragt. Developments come together in the Foilbased LOW cost PAcman Differential Dualpolarised Demonstrator (FLOWPAD^3). The basic design consists of a foil based single layer antenna array which will be supported with foam and Low Noise Amplifiers. The array will be dual polarised and will have a total of 64 antenna elements. The LNA chip package is mounted on a small separate PCB that in turn is mounted on the antenna foil. Analysis of LNA dissipation and the required cooling shows no active cooling is needed.



Test board for the differential LNA

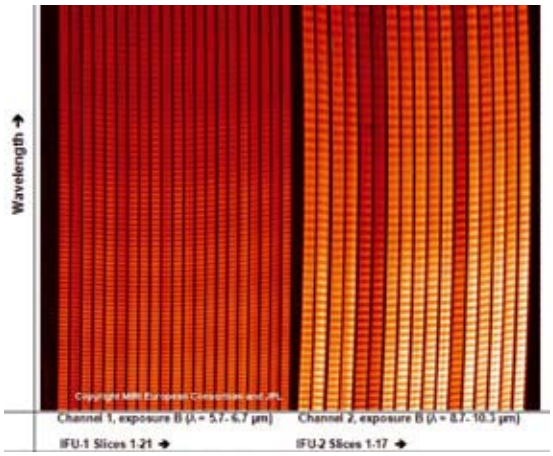
MIRI

MIRI is the infrared camera and spectrometer for the James Webb Space Telescope (JWST). It will operate between wavelengths of 5 to 28,7 microns including the H2 - line, a region of the electro-magnetic spectrum that is hardly accessible by ground-based telescopes. Primary investigator for the Dutch MIRI project is van Dishoeck, programme manager at ASTRON is Rieks Jager (SRON).

James Webb Space Telescope: full-scale model at Goddard Space Flight Centre

First cryogenic images were obtained from the fully integrated JWST-MIRI Verification Model in the test facility at Rutherford Appleton Laboratories with a system temperature of ~43 Kelvin and detectors at 6.7 Kelvin. Both the imager and spectrometer perform very well optically. The spectrometer slices are as expected from modelling. The fringes are due to the detector substrate behaving like an etalon which is also predicted from modelling. The wavelength range is confirmed to be 5.7 to 6.7 micron in channel 1B (in the image on the left) and 8.7 to 10.3 micron in channel 2B. The imager PSF at 11.3 micron is also as expected from modelling.

Construction and integration of the Flight Model (FM) has been completed; testing will start early 2008, with delivery to RAL expected this summer.



First VM test results obtained in the cryo-vacuum chamber at RAL on December 19, 2007. The individual image slices are seen clearly

X-shooter

X-shooter will be the ultimate machine for high-quality spectroscopy of the faintest single objects reachable with 8m-class telescopes over the spectral range 300-2500 nm (from the UV to the K band), the most sensitive medium-resolution wide-band spectrograph in the world. The X-shooter consortium members are from Denmark, France, Italy, The Netherlands and ESO. X-shooter will be the first second-generation instrument to be installed on the Very Large Telescope and commissioned in 2008. The Dutch contribution to X-shooter is one of the three spectrographs: the near-infrared arm (1000-2500 nm). Primary investigator is Lex Kaper (University of Amsterdam), co-PI is Paul Groot (Radboud University Nijmegen) and project manager is Ramon Navarro. ASTRON is responsible for the design, construction and testing of the near-infrared arm.

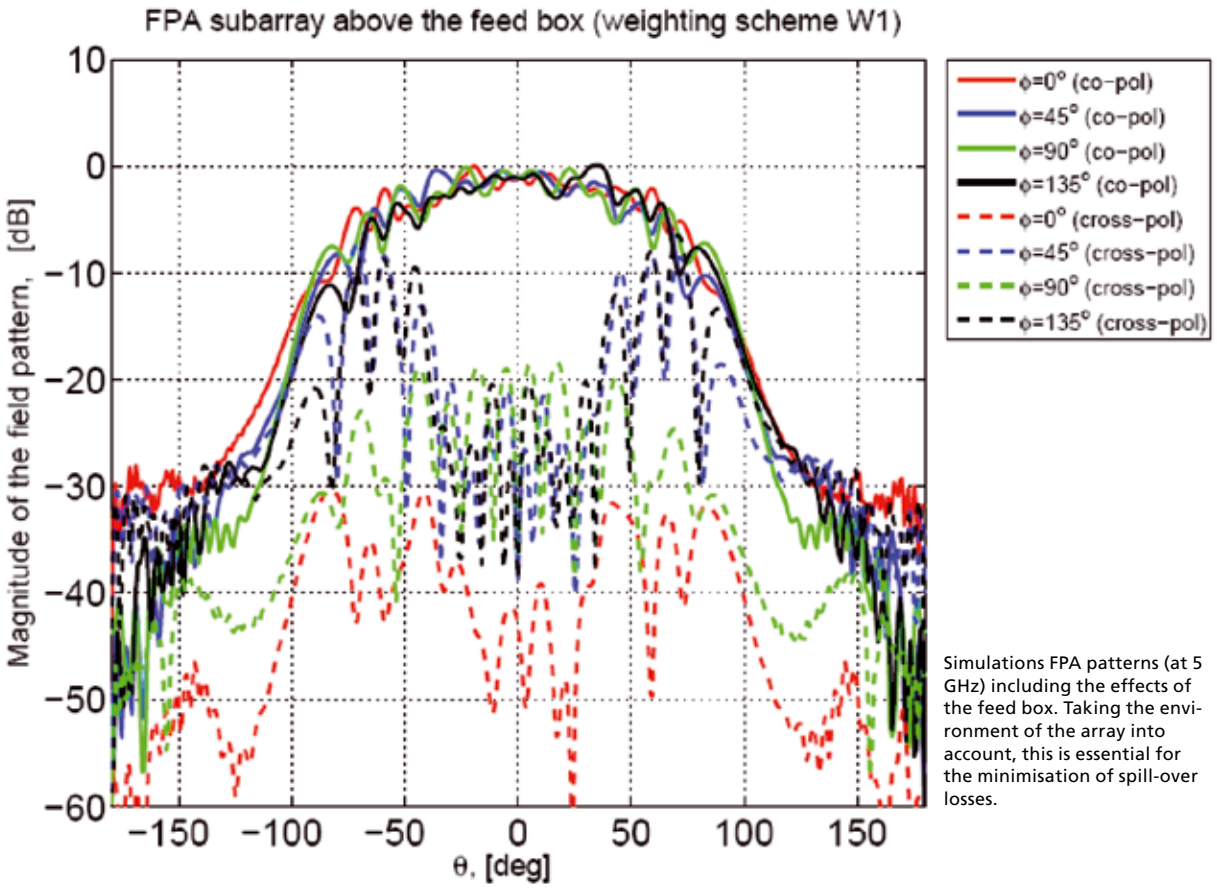
After a successful Final Design Review in 2006, the construction of the optical and mechanical subsystems was completed this year. The X-shooter boxes were integrated with the cryostat built at the Radboud University. First light in the near-infrared arm was achieved on December 17, 2007. Subsequent cool-down runs have been used, e.g. to establish the spectrograph focus, to test the cryogenic system, to investigate the presence and impact of instrument flexure, to measure the efficiency and spectral format, and to obtain data to test the data reduction pipeline. The preliminary acceptance review is scheduled on March 13, 2008. After a successful review, the system will be shipped to ESO headquarters in Garching for integration with the other arms.

The integrated cold optical box mounted on the VLT simulator at ASTRON

APERTIF

The NWO-G funded APERTIF project ('APERture Tile In Focus') aims to substantially increase the field of view of the Westerbork Synthesis Radio Telescope (WSRT) using Focal-Plane Array (FPA) technology. The traditional horn antenna located in the focus of each Westerbork dish will be replaced by a cluster of antennas, the Focal Plane Arrays, thus creating a radio 'camera' in every dish. The FPA system permits for a single telescope to observe in multiple directions at the same time, forming a continuous extended field of view which has not been possible before. Astronomers can now collect much more information in a shorter period of time and from a larger area of the sky. This transformational FPA technology has been pioneered and brought to maturity by ASTRON and international partners in the FARADAY and PHAROS projects. With the enlarged field of view it becomes feasible to survey the entire sky on short timescales with high sensitivity and at high spatial resolution.

The Digestif system in the focus one of the WSRT dishes.



Simulations FPA patterns (at 5 GHz) including the effects of the feed box. Taking the environment of the array into account, this is essential for the minimisation of spill-over losses.

This will enable entirely new types of astronomical research. Primary investigators for APERTIF are Marc Verheijen (University of Groningen) and Tom Oosterloo (ASTRON), project manager is Wim van Cappellen (ASTRON).

The R&D for APERTIF was gradually built up in the course of 2007, culminating in the development of a digital focal-plane array demonstrator (conveniently called Digestif) placed in telescope RT5 of the WSRT. A 112 element Vivaldi array, initial LNAs and down conversion units have been manufactured, tested and installed in the telescope, which has been equipped with 62 coaxial cables from the focus box to transport the analogue signal to the backend in an EMC-cabin.

Extensive modelling and simulations have been carried out by Marianna Ivashina and Rob Maaskant to get a better understanding of critical design parameters and to get better estimates of the maximum attainable performance. Studying the effects of the mutual interaction between the FPA and its nearby environment at the telescope, permitted the determination of the optimal FPA position at the telescope and an optimal cancellation of the spillover loss.

In early 2008, the Digestif system is expected to produce the first astronomical images with a focal-plane array receiver in the L-band.

While the primary goal of APERTIF is to enhance the scientific productivity of the WSRT, the APERTIF system forms an important step towards a broad application of this innovative and promising FPA technology. The development of such a receiver system will play an important role in the international Square Kilometre Array (SKA) project and complements ASTRON's R&D program in Aperture Array systems.

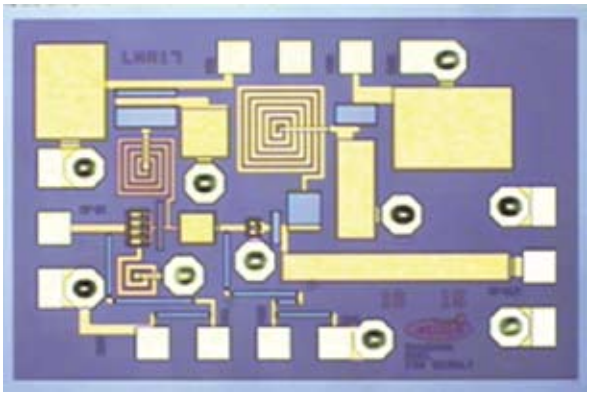
Technical research projects

Each of the seven competence groups in the R&D division carries out a technical research programme to ensure that emerging technologies can be applied to future astronomical instruments in an adequate and timely fashion. Most of this research is conducted through partnerships with research groups, both industrial and at universities. Some highlights of the research activities over 2007 are given below.

In the System Design and Integration group (group leader Dion Kant), a programme on photonic processing is conducted with Technical Univesity Twente and high-tech SME Lionix. ASTRON participates in the SmartMix program MEMPHIS, where Peter Maat is leading a work package developing a photonic beam former for a high-frequency focal-plane array tile. In another research line in the group, Stephan Wijnholds studies the mathematical foundations of LOFAR station and array calibration with the Circuits and Systems Group of Delft Technical University.

In the Antenna group (group leader Wim van Cappellen), Rob Maaskant works on a PhD with Eindhoven Technical University on the modelling of Large Finite Array Antennas for the SKA using the Characteristic Basis Function Method (CBFM). He further developed his CAESAR simulation package, which is now also being used by researchers in the UK. The group hosted several foreign students, in particular through collaborations with Sevastopol National Technical University, Ukraine.

The RF and Low Noise Systems group (group leader Bert Woestenburg) was formed in 2007 as a merger of the Microwave/IF and MMIC groups. Considerable effort was dedicated to the sensitivity analysis and improvement of (focal-plane) array systems. Contributions providing a theoretical basis for these subjects, in particular the calculation of the array receiver noise, have been presented at the FPA-workshop in Sydney in March. The effects of noise coupling have been published in two papers (APS, ICATT). Low Noise Amplifier (LNA) research continued with two LNAs designed in 70 nm mHEMT technology.



A 70nm mHEMT GaAs chip

The Digital & Embedded Signal Processing group (group leader Albert-Jan Boonstra) formally completed it's involvement on the MASSIVE project on large scalable systems with the third and final PhD thesis within this project (by Jerome Lemaitre) being completed. RFI studies continued on LOFAR test data, analysing the spectral-temporal-spatial distribution of interference. A movie of the occurrence of long-distance timing signal transmitters was made, which triggered a study with the Dutch Telecom Agency (Agentschap Telecom) and the University of Groningen on improving existing propagation models. For the successful PhD thesis defence of Martijn van Veelen, the group co-organised a workshop in Groningen on dependable distributed sensing.

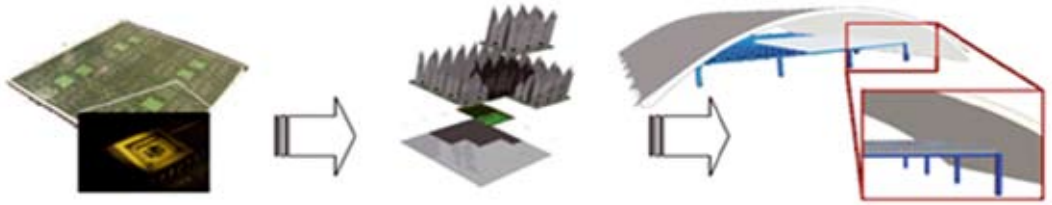
Within the scientific computing and software engineering group (group leader Ronald Nijboer), Jan Noordam and Oleg Smirnov further developed the MeqTree simulation package. The system is now actively being used within SKADS, and has had some limited application in the modelling of flexible optical systems. The software was made available to the outside world through SourceForge. John Romein started up activities in the ASTROStream project (NWO-STARE) together with Delft Technical University, looking into various architectures for high-throughput streaming processing. With postdoc Rob van Nieuwpoort, he successfully implemented a correlator function on a PlayStation3 cell processor chip. The group participates in the Australian MIRANdA-project through the work on the imager software by Ger van Diepen.

The Mechanics group (group leader Johan Pragt) continued the collaboration with Technical University Twente on cryogenic materials, even though an STW proposal on this subject was not successful. A collaboration with the Dominion Radio Astrophysical Observatory (DRAO) has been set up that will lead to the exchange of a mechanical engineer with the Calgary group, to work on composite antennas. The group fully mastered the new Hermle 5-axis milling machine. After a short period of parallel production on two machines for MIRI and X-shooter, the old 5-axis Deckle machine was sold. The size of the new machine is sufficient to accommodate the large sizes required by most present day astronomical instruments. The extreme light-weighting procedures developed in the group have been successfully applied in X-shooter and will continue to be developed for scientific and industrial applications.

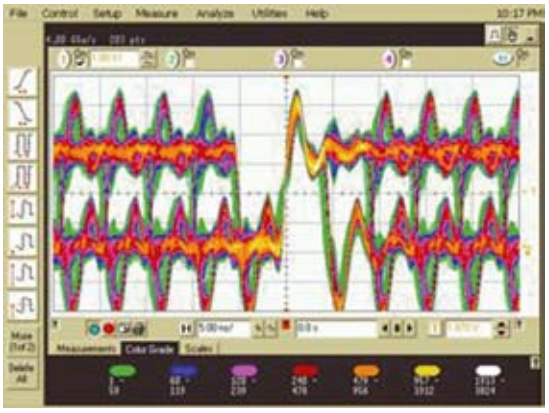
The Optics group (group leader Ramon Navarro) was involved in several ELT pre-studies, most notably in the point-design study for MIDIR. Primary investigator is Bernard Brändl (Leiden University), the system engineer is Lars Venema. The preliminary design of SPHERE-ZIMPOL was completed, leading to a successful Optical PDR. The group is in a major transition as NOVA will assume responsibility for the Optical/IR instrumentation programme in 2008. This should lead to an increased collaboration with the astronomy groups at Dutch universities. The R&D program of the group will further focus on ELT instrumentation.

Technology Transfer

Within ASTRON, the Bureau of Technology Transfer (BTT, Ronald Halfwerk, Koos Kegel) is responsible for valorisation. Industrial collaboration on ASTRON's large R&D projects forms an excellent way to make technology transfer between ASTRON and industrial partners happen. In 2007, the Innovative Actions Program Drenthe allowed us to involve a number of Small and Medium sized Enterprises (SMEs) in the EMBRACE projects. ASTRON transferred knowledge about (automated) testing of the complex Hex-board PCBs and got feedback about optimisation of PCB designs to achieve higher yields from future production runs. For the radome/housing, a pilot on applying a polyurethane coating on expanded polystyrene led to promising results on obtaining low (rf) loss radomes for EMBRACE. Another thread was a pilot on getting a low-cost feed board for the Vivaldi-type antennas. The companies have used the possibilities of the IAP programme to work on the preparation of the EMBRACE activities within R&D and to work on the exploration of new business on the basis of technology and knowledge gained through their involvement within this project.



Technology transfer on EMBRACE in the IAP



Measurement results of signal acquisition systems showing the over and undershoot of one acquisition channel probably caused by Simultaneous Switching Noise (SSN), also known as ground bounce.

The number of shorter term consultancy trajectories is steadily increasing. Various knowledge transfer projects were carried out for industries under the so called 'Innovation voucher' initiative. These projects are ranging from *consultancy about reflection measurement on gold coatings on several substrates* to *Finite Element Analysis (FEA) on lifting tools* to *numerical analysis on an alternative detection method for Touch-screen applications.* The knowledge built up in R&D on high-speed data-acquisition boards for LOFAR, could be applied through contract research. For a commercial supplier of high-grade signal acquisition systems, Gijs Schoonderbeek carried out an extensive characterisation of three of their boards. The data acquisition boards were tested against a broad range of performance indicators. ASTRON could suggest several design changes to significantly reduce the over and undershoot.

This year we were able to run our course on Applied RF Technology three times, including an on-site training for RF-engineers from our Royal Air force. This three day course attracts various professionals from Dutch (RF) industries, telecom operators and governmental organisations.

Industrial trainees developing hands-on RF experience at one of the 2007 courses.

4. LOFAR

This year, the LOFAR project took a number of major steps forward, demonstrating end-to-end functionality (including the first interferometric results), passing its critical design review and starting the procurement process that will result in the roll-out of 36 stations, due to be built in the Netherlands before the end of 2009.

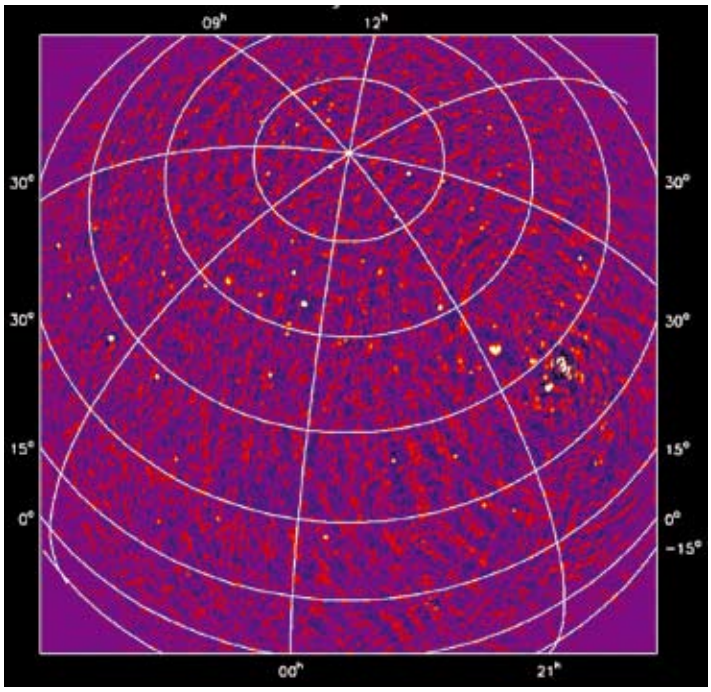


Figure 1: The first deep, wide-field image made with the first LOFAR station (CS-1) at a frequency of about 50 MHz. The angular resolution of the image is about 0.5 degrees. The image is centred on Cas-A, the brightest radio source in the sky, which was itself subtracted. The image was made by Ger de Bruyn (ASTRON & Kapteyn Institute Groningen) and Sarod Yatawatta (Kapteyn Institute Groningen).

In late 2006, a total of 96 antennas, the equivalent of a full LOFAR station, were deployed in the core of LOFAR, near Exloo in the province of Drenthe in the north-east of the Netherlands. The 96 low-band antennas (LBA) are optimised for operation in the 30-80 MHz frequency range, and were distributed over four fields which are up to 400 metres apart, providing good UV-coverage for calibration and imaging. In March 2007, 32 individual High-band Antennas, optimised for operation in the 110-240 MHz frequency window, became operational and six prototype tiles (each consisting of 4x4 antennas, combined with an analogue beam former) were delivered in late May. Initial processing of the signals takes place on location at the stations with dedicated digital hardware. Afterwards, the signals are transported to the central processing facility at the University of Groningen, some 60 km away, where they are correlated on ASTRON's IBM BlueGene/L supercomputer and stored as Measurement Sets.

On 23/24 February, 2007, 29 hours of data were acquired using 16 micro-stations at frequencies ranging from 44 – 60 MHz. The total effective bandwidth was about 0.5 MHz. The data were calibrated using the MeqTrees package developed at ASTRON, and imaging was done using AIPS++ software. The result is shown in Figure 1. What makes this image impressive is the formidable dynamic range of about 4000:1 that it already shows. At least fourty other sources, all much fainter than Cas-A, can be seen. This image clearly demonstrated the end-to-end capability of the system.

The quality of these results from CS-1 confirmed LOFAR's scientific potential and was an important demonstration of the design that was presented at the system critical design review (CDR) held in Assen on 17 and 18 April 2007. A panel of experts reviewed the status of the project and gave the green light for the construction phase, which started towards the end of the year.

A scientific workshop to discuss the potential science which can be done with LOFAR was held from April 23-27, 2007 in Emmen (NL). With 120 participants from fifteen countries in attendance, the science to be done with LOFAR was discussed by an enthusiastic community, all of whom are eager to see LOFAR coming 'on-line'. One of the conclusions of the workshop was that this science spans almost the whole age of the universe, from the Epoch of Reionisation to lightning occurring in real time right over the antenna fields and astronomer's heads!

Figure 2: Participants of the LOFAR Science Workshop held in Emmen from 23-27 April 2007.

In preparation for the roll-out phase – which involves major financial commitments with suppliers – the project held a review of its funding in the light of cost estimates of the final system as reviewed during the CDR. It became clear that the co-financing that had been secured or was previously foreseen, was largely in the form of 'in-kind' contributions, rather than as cash that could be used directly for the procurement of hardware. Although plans to realise the

full (ultimately 77) station layout remain, they depend on extra funding for a second phase after 2009. A re-scope of phase 1 of the project was deemed necessary and conducted in the summer of 2007 through a series of workshops in which the community was widely consulted. Their recommendation to the project was to keep the number of stations as high as possible and try to retain the ~100 km maximum baseline within the Netherlands. In the end, it was decided that a minimum of 36 stations could be built with the funds available for phase 1: half within the core, the other half on distances of up to 50 km from the core, yielding station-station baselines as close as possible to 100 km. The first batch of eighteen stations will be deployed in 2008, the second in 2009. Each station in the Netherlands will have 96 Low Band Antenna's that are connected to 48 receivers in two configurations: a compact layout that is optimised for the high frequency end of the band and a more extended configuration optimised for the low frequency range. Each station will have 48 High Band Antenna tiles (4x4).

Figure 3: LOFAR HBA test field

Another important milestone for LOFAR was the successful BSIK mid-term review which took place in September 2007. LOFAR is one of 37 projects funded from the ICES/KIS-3 (also known as BSIK) subsidy programme. In order to monitor these projects, regular progress reports are sent to a monitoring committee. A milestone in this regard was the mid-term review which was held half-way through the period of the BSIK projects and is intended to give the government insight into their progress and quality. An independent panel led by Prof. Ed van den Heuvel (University of Amsterdam) was asked to conduct a review of the project's progress, with emphasis on its scientific quality, substantive coherence, management of progress and milestones, as well as its vision and strategy for the future of the project after the end of the grant period (in the LOFAR case of 2010).

The Review Panel met in Dwingeloo on 21 September and in Groningen on 25 September 2007. The project received a favourable report from the committee, which rated the (scientific) quality in all four target areas (astronomy, geophysics, precision agriculture and ICT) to be very high. The panel was impressed with the results achieved with CS-1 and the way the BlueGene/L based central processor was being used – including work on improved I/O protocols that makes new use of BlueGene's fast internal network. Although the recent descope of the project had led to reductions in speed/sensitivity for the main astronomical applications of LOFAR, the panel commented that Phase 1 of LOFAR (the central Netherlands part) remains a unique instrument in the world, both in sensitivity and angular resolution. The committee also strongly supported the efforts for further extension with LOFAR stations in the Netherlands and in other European countries (E-LOFAR).

In addition to the extensive astronomy plans, the mid-term review panel was also presented results from the other LOFAR applications. The geophysical application successfully passed its own critical design review in July 2007. A two-dimensional array of geophones is to be completed in 2008 over the Annerveen gas field – some 20 km North of the astronomy core. At the same time a more distributed array of geophones is to be rolled out. Two infra-sound arrays are also planned. The agriculture project has achieved good progress in its micro-climate modelling of potato crops, dynamic real time decision support models for precise soil and water monitoring and solving the last-mile problem of connecting its (often wireless) sensors to fixed infrastructure (last-mile problem). Both communities have also started to investigate follow-up opportunities for the period after the current subsidies end.

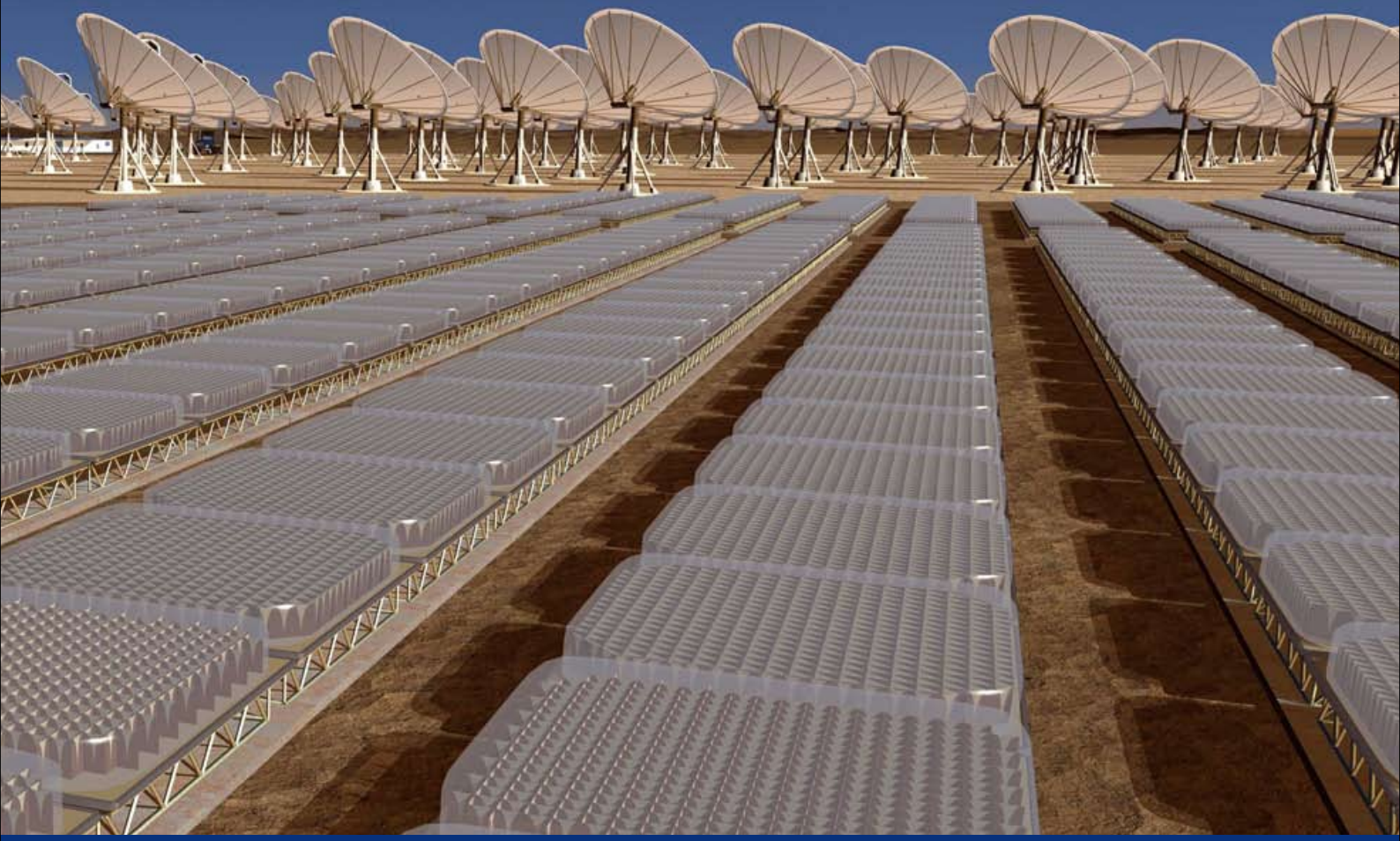
At the end of October 2007, the official handover of the operation of CS-1 from the Research & Development department to ASTRON's newly established LOFAR/WSRT Radio Observatory took place. With this step a new era for initial LOFAR operations began. The software infrastructure is now in place to enable operators at ASTRON in Dwingeloo to run observations and monitor the LOFAR antennas.

The year also showed a further increase of interest in LOFAR from the radio astronomy community across Europe. Contracts for the delivery of stations in Effelsberg and near Munich (both Germany) had already been signed in 2006. This year, a station near Tautenburg (Germany) was confirmed, with contracts likely to be signed in 2008 for stations near Onsala (Sweden), Nançay (France), Potsdam (Germany) as well as at least one in the UK. Further stations in Germany, the UK, Poland, Italy and the Ukraine (in collaboration with Austria) appear possible. These will greatly extend the LOFAR baselines and allow much higher resolutions to be achieved. However, these developments also increase the strength of the European radio astronomy community as it is preparing for the Square Kilometre Array. Many of the technologies that have been developed for LOFAR (phased arrays, station level processing, multiple beam operation, software tools) will be of direct use in the SKA.

The first international LOFAR station was built in the direct neighbourhood of the 100-meter Effelsberg radio telescope in a collaboration between ASTRON and the Max Planck Institut für Radio Astronomie (MPIfR). The costs of the station were borne by the Max Planck Society. The first successful tests of the Effelsberg LOFAR station were performed on March 21, 2007 during a meeting of GLOW, the German Long Wavelength Consortium. Eight of the 96 LBA antennas were connected in a live demonstration. Snapshot images made at a frequency of 25 MHz were generated. With the first low-band station now complete in Effelsberg, LOFARs roll-out team is preparing for the delivery of more stations to Germany (i.e. Garching, Tautenburg and Potsdam), Sweden, the UK and France.

Figure 4: The first international LOFAR Station in the direct vicinity of the 100-meter Radio Telescope in Effelsberg

5. Partners



JIVE

For the Joint Institute for VLBI in Europe (JIVE), 2007 was very much a transitional year, starting with the departure of Mike Garrett as director of JIVE in order to become general director of ASTRON in February. After serving as interim director for several months, Huib Jan van Langevelde was appointed as the new JIVE director. A new MoU amongst the JIVE partners had to be negotiated, as the previous five-year MoU ran out during this year. Good progress was made; the new arrangement was ready for signing by the end of the year. For the new period France re-joined JIVE as a contributing partner.

During this year, JIVE continued to focus on its core responsibility, which is to deliver high quality data to the users of the European VLBI Network (EVN). In 2007, the efficiency statistics broke several records. Besides the obvious advantages which the now mature disk-recording system brings, much progress was made towards increasing the robustness of the overall correlator system, often as a result of the requirements of operational e-VLBI (see below). For example, it became possible to run unattended ten hour correlator jobs, allowing overnight correlation without the presence of operators. In 2007, the largest correlator experiment to date produced one TeraByte of data.

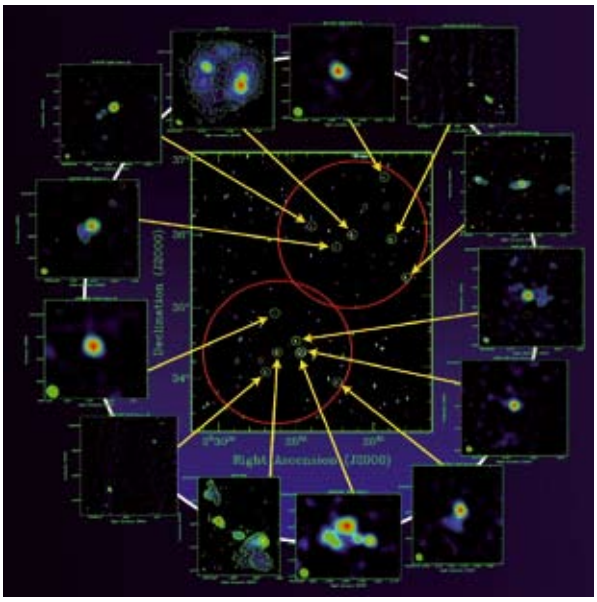


Figure 1.The first wide-field VLBI survey at 90 cm, in which 27 out of 270 potentially detectable WENSS sources were detected in two partially overlapping 28 square degree fields (Lenc et al., 2008, ApJ 673, 78)

An important improvement to the data quality was the fractional bit-shift correction. In the area of user support, the major improvement was the introduction of the Northstar proposal tool, developed at ASTRON within the context of the RadioNet programme; JIVE took responsibility for the definition and maintenance of the EVN implementation. All the EVN proposals are now handled by this system and it is very much appreciated by the user community.

In the RadioNet programme JIVE manages the ALBUS project, in which new tools for radio astronomical data processing are developed. The focus in 2007 was on wide field imaging and ionospheric calibration (Fig 1). But generally the success of ALBUS is associated with the ParselTongue package that provides a Python interface to classic AIPS.

This software was developed at and distributed from JIVE, and has a steadily growing user base in Europe.

However, most of the R&D effort at JIVE focused on the advancement of e-VLBI. In order to improve the robustness and throughput of the e-VLBI network, an entire new network configuration was established around the correlator at JIVE. These improvements were accompanied by an upgrade of the Mark5 hardware, both locally and at the stations. On the correlator side software upgrades were introduced that allow much faster start-up and on-the-fly modifications to ongoing (e-VLBI) jobs.

An important step forward was made with a local re-write of the Mark 5 control software, which allows the units at the remote telescopes to make use of the UDP protocol instead of TCP. TCP/IP is widely used in Internet communications, but is designed to be very sensitive to congestion; particularly on long-haul networks this protocol is completely unsuited to the demands of e-VLBI. Together with the dedicated light-paths that were established for most European antennas, this has enabled a robust VLBI network, capable of reaching speeds close to 1 Gbps.

These technological advances made several real-time intercontinental tests with the EVN correlator at JIVE possible. During a demonstration at a conference in Xi'An, China, telescopes from China, Australia and Europe were connected together, producing fringes between all three continents on 28 August 2007. This was followed by a science run during which three telescopes in Australia were connected in order to observe supernova SN1987A, using the correlator in Dwingeloo. These demonstrations, which were all part of the JIVE-led FP6 EC-funded project EXPReS, received a large amount of attention in the scientific press.

After intense discussions throughout 2007, policy changes in the allocation of EVN time for e-VLBI and so-called 'Target of Opportunity' (ToO) observations were established. This, in principle, makes the e-VLBI system much more readily deployable for observations of transient phenomena. A perfect example of this was the observation of the supernova SN2007gr, which was observed shortly after the initial report of its detection. With e-VLBI a very accurate position of the source was determined and subsequently reported in an Astronomers' Telegram (Fig 3).

Figure 2. VLBI network spanning three continents during one of the e-VLBI demos.

JIVE continued to be very active in the area of astronomical research. By the end of 2007 it had a record of three PhD students employed, and JIVE staff were involved in the supervision of many students in the Netherlands and beyond. The very successful summer student programme continued and JIVE staff participated in various training programs and schools. It is clear that JIVE will need to develop a next generation correlator in order to be able to continue its role at the heart of the EVN in the next decade. In 2007, new concepts were developed for studies of a new FPGA-based correlator. These featured in funding proposals, amongst others in RadioNet FP7. Besides correlator oriented R&D, JIVE is also in charge of the software development project and the EVN visitors programme in this proposal.

In 2007, JIVE made substantial progress with its distributed correlator project, which is part of EXPReS. The core of this software correlator was deployed for the so-called ftp-tests, which serve to check telescope performance before each EVN observing session.

It is obvious that the long-term future of radio astronomy, and thus VLBI, is intimately related to the development of the SKA. JIVE is looking for a possible role in the European operational science support for the SKA. On a shorter timescale JIVE follows the development of processing techniques related to the SKA and is involved in technology evaluations, especially when related to correlator development. For these reasons JIVE decided to become involved in the FP7 PrepSKA programme and has accepted the role of secretary of the European SKA Consortium (ESKAC).

Another long-term strategic strength of JIVE has been its involvement in planetary space missions and the development of spacecraft tracking techniques. With this expertise JIVE has become involved in plans for future space missions to both the Jovian and Saturnian systems. In 2007, these programmes were selected for further study by ESA.

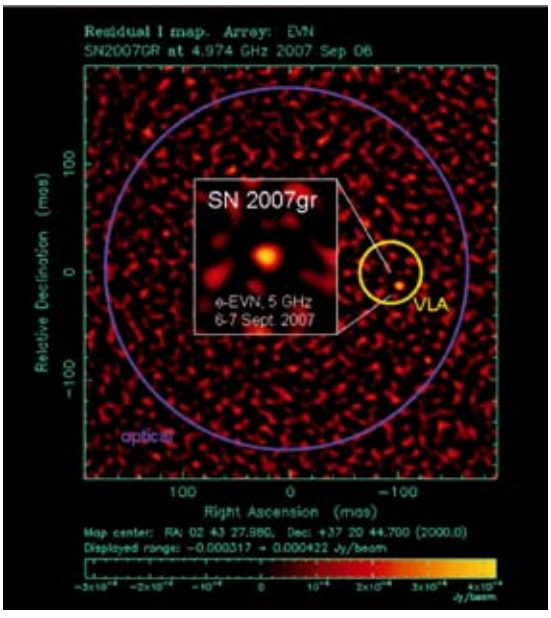


Figure 3. e-VLBI image of the supernova SN2007gr (Paragi et al., 2007, ATel #1215)

SKA

The Square Kilometre Array (SKA) is a next-generation radio astronomy facility for the global astronomy community. It will cover the frequency range from 70 MHz to >25 GHz and will play a major role in answering key questions in modern astrophysics and cosmology. More than fifty institutes in nineteen countries are partners in a collaborative research and development programme toward construction of the SKA. The first observations from the SKA telescope are scheduled for 2015.

Artist impression of focal-plane arrays and small dishes of SKA

The International SKA project office

The International SKA Project Office (ISPO) was established under the provisions of a 'Memorandum of Agreement to collaborate in the development of the SKA', which came into force on 1 January 2005 and which was extended until 31 December 2007. In 2007, ISPO was hosted by ASTRON in Dwingeloo. The ISPO coordinates international SKA activities, which include development of the science case, engineering system design, operational plan, telescope performance simulation, site evaluation, and scientific and public outreach.

In 2007, the key achievements of the ISPO included:

- Support for the successful submission of a preparatory phase proposal for the Square Kilometre Array to the EC FP7 programme (PrepSKA)
- Establishment of a governance structure for the international collaboration for 2008 and beyond
- Development of a performance-cost evaluation tool in collaboration with the Australia Telescope National Facility and SKADS project
- Drafting of preliminary specifications for the SKA
- Outreach – meetings, publications and resources

FP7: PrepSKA

The PrepSKA proposal was prepared by a global team of writers and was submitted by the UK Science and Technology Facilities Council for funding under the European Commission (EC) 7th Framework Program. The proposal was successful and received full funding of € 5.5 million to run from 2008-2011. Funding of € 2 million for a further year, foreseen in the PrepSKA proposal for the system design work, will be sought at a later date. Twelve institutes around the world signed up to PrepSKA and to provide matching funds, as did eight funding agencies and government departments (including NWO).

PrepSKA will provide an ideal opportunity to integrate the SKA engineering and site characterisation activity around the world into a coherent design for the telescope, while at the same time providing sup-

port for the investigation of funding and governance issues that are crucial to approval for construction. Thus, the project will address issues of fundamental importance to the SKA project, such as:

- What is the design and cost for the SKA? Where will the SKA be located?
- What is the legal framework and governance structure under which the SKA will operate?
- What is the most cost-effective mechanism for the procurement of the various components of the SKA?
- How will the SKA be funded?

Governance

Three agreements were signed during the year to secure the future of the international collaboration:

(a) International Collaboration Agreement for the SKA
(b) Memorandum of Agreement to Establish the SKA Program Development Office (SPDO)
(c) Memorandum of Understanding between the University of Manchester and the ISSC (International SKA Steering Committee)

Performance-cost evaluation tool

In late 2006, the ISPO sponsored an effort to develop a SKA cost modelling tool. This contract was placed with the ATNF (the Australia Telescope National Facility) and in June 2007, ISPO and the SKA Design Studies started working together, under the direction of the ISPO, to develop a new cost modelling tool capable of handling all SKA Reference Design technologies and accessible to those working in the SKA specification area. The new tool was based on the existing 'ISPO' cost modelling engine.

The new system supports many realisations of the system design and was used in practice for the first time by the SKA Specifications Tiger Team to better understand how costs scale with design considerations. Both the engine and its interface are under continuing development.

Preliminary specifications for the SKA

A SKA Specifications Tiger Team was established under the direction of the ISPO in the second quarter of 2007. The remit of this Tiger Team was to generate a set of preliminary specifications for the SKA to guide the work done by the CDIT in its first year. A draft of the preliminary specifications and representative implementations for the SKA was debated by the 120+ astronomers and engineers at SKA2007 in September 2007 and further discussed by the ISSC and the SKA Forum at their subsequent meetings. The SKA Specifications Review Committee, chaired by Roy Booth, reviewed the specifications at its meeting in January 2008. Final approval of the preliminary specifications by the SSEC Executive Committee, with the concurrence of the SSEC itself, is expected in April 2008.

The ISPO has been hosted at ASTRON since its inception and, during this time, great steps forward have been made to make the SKA telescope a reality. The achievements of the ISPO reflect the support and resources contributed by ASTRON over the years and the assistance provided was greatly appreciated.

SKADS

Within SKA, ASTRON coordinates the FP6 SKA Design Study (SKADS). SKADS entails a detailed investigation of the scientific and cost-effectiveness of the new SKA concept, and is developing the necessary breakthrough technologies which will enable the radio telescope to be built at an affordable cost.

SKADS aims to arrive at a costed SKA design, optimally serving the SKA science goals. The structure of SKADS ensures maximum interaction between engineering and scientific activities and combines studies with technological and demonstration work at universities, institutes and companies all over Europe and elsewhere (see also www.skads-eu.org).

SKADS passed its Mid-Term Review successfully in October at the premises of the Observatoire de Paris with a small review team led by the European Commission and Professor John Seiradakis of the University of Thessaloniki (external reviewer).

SKADS results in 2007 include the first detailed sky simulations. A telescope simulation data pipeline was developed to produce a realistic simulated sky. Through these studies, together with the study on the data network, an impressive level of involvement of (also younger) astronomers was generated, closely collaborating for the purpose of developing the SKA. As a system level study, this activity took the SKADS costing activity onboard, resulting in a

solid framework for the overall costing of the SKA. The framework is capable of incorporating costing at component up to subsystem level. The tool by design remains flexible with respect to design changes. Experience with initial costing exercises clearly showed that this flexibility is quite essential. Costing trade-offs compare for example the all-digital approach followed in 2-PAD with the analogue beam formers as used in EMBRACE (see Figure 4). The first prototype was mainly built to verify the design tools, design strategies and the understanding of lowering cost of phased array systems.

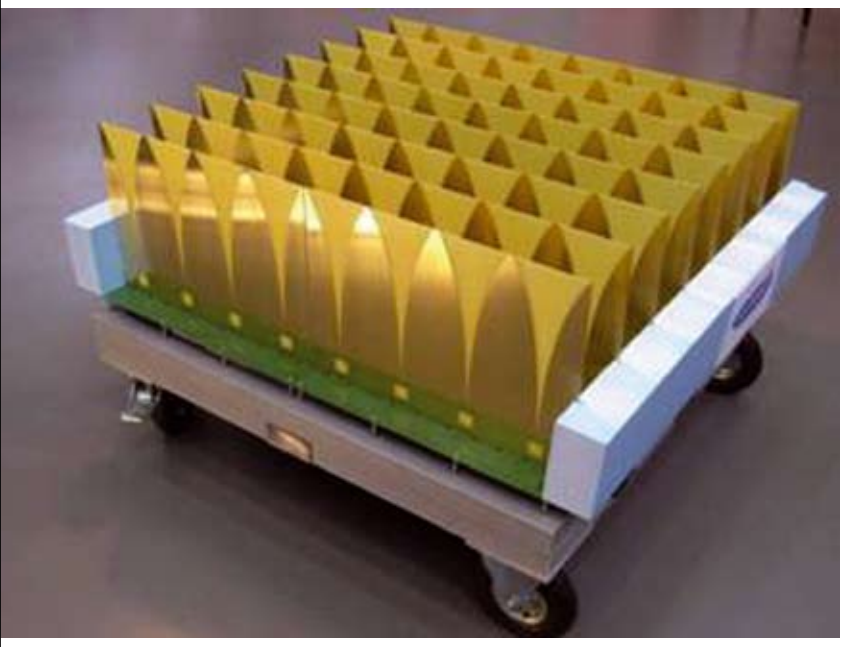


Figure 4: The first version of the EMBRACE tile proving the antenna design and tile approach. Subsequently, two newer versions were made, lowering the cost e.g. using metal sheet antennas, which in addition allowed to construct a dual polarisation tile.

Network topologies, technologies and signal processing architectures were also investigated in detail, and includes a clock and phase distribution architecture mostly as a result of excellent activities of Jodrell Bank/University of Manchester. Costed results were input to the Design and Costing report indicating the relative high cost for longer (few hundred km) baselines infrastructure. Details of all these efforts can be found in the SKADS Annual Report. As a result of the international SKA siting activities, the relevant SKADS activities were fully coordinated with the global effort. In particular, SKADS efforts on RFI mitigation were closely connected to international activities. A May Workshop on EMC zone thresholds was organised by CSIRO, ATNF, on RFI issues, and work continued on Regulatory issues concerning the requirements of a Radio Quiet Zone for the SKA. This has led to a global Recommendation by the International Telecommunication Union (ITU) on the requirements for a SKA Radio Quiet Zone. This has also led to input of papers to the ITU Working Party on radio astronomy.

International collaboration

Members of the SKADS MT paid visits to participants, the US, South-Africa, Canada, Australia and elsewhere, to coordinate and communicate the general state of affairs. At the US-SKA Consortium meetings, a representative of the SKADS MT was presented and the coordinator attended two international SKA working group meetings in Argentina and the UK.

SKADS Marie Curie programme

On January 1st 2007, the SKADS MCCT project started another project parallel to SKADS, that will allow young engineers and scientists to learn from the developments in the Design Study. This program is run trough the SKADS office and ten out of the 26 SKADS participants are also participating in the MCCT program (see the Marie Curie website http//:mcct.skads-eu.org). Knowledge about the technologies developed in and used by the engineers in SKADS, will be transferred to young engineers in workshops and schools. Similarly, young astronomers will learn about the possibilities of future telescopes and will be trained in the use of these instruments. In 2007, the first Astronomical School was organised in Bologna and like the first workshop held at ASTRON (focusing on phased array antenna systems and design), proved highly successful. Other planned workshops were delayed and planned for 2008.

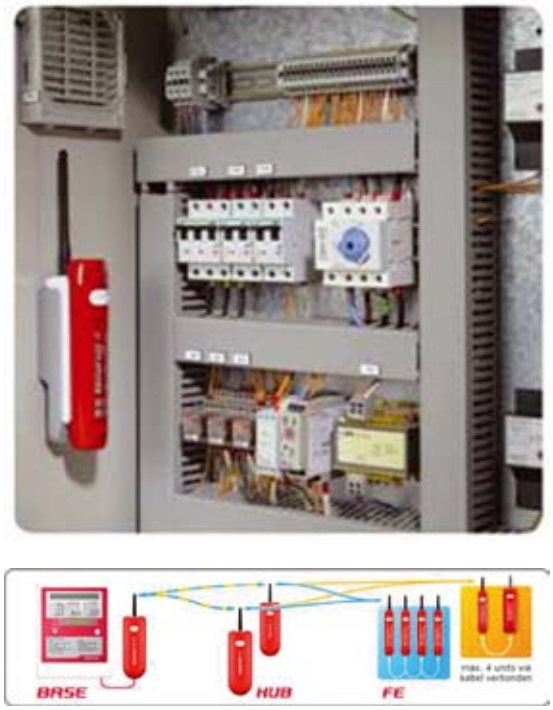
Participants of the first Marie Curie School held in September 2007 in Bologna, Italy

AstroTec Holding

The focus of AstroTec Holding B.V. (ATH) is exploiting ASTRON's knowledge and skills commercially, for companies, governments and social organisations. ATH is the commercial branch of ASTRON's technology transfer organisation and develops activities that make the knowledge and skills accessible to the commercial market.

ATH has contributed to many product improvements of small and medium sized enterprises through advisory relations and other actions. For example, a complicated instrument for the health care sector, for which higher operating speeds were required, was considerably improved due to the advice of ATH personnel. Also a wireless LAN antenna was designed and produced, subsequently improved and marketed elsewhere with ATH receiving a license fee.

ATH's work force concentrates on business and product development, with a clear view on marketable opportunities. ATH also acts as the management organisation of a large (4 million) regional project (Innovatieve Acties Programma) which has reached its peak activity in 2007. Half of the funds came from the European Commission, the rest came from regional funds and commercial contributions. So far, the program is being led from another ATH location in Assen. It involves innovation projects of twelve companies including production aspects of ASTRON's EMBRACE project. Based on an increase of 50% of companies involved in ATH (twelve instead of the eight projected initially), ATH is considered very successful.



An overview of the NOFIQ fire prevention system. Together with others, it is connected to a central alarm system through a low-power radio link. The tube called 'Firepro' contains the active fire extinguisher (based on an aerosol) to become active in the case of fire. In the mean time, sensors will have already indicated an early-alarm condition through the robust radio-link. The picture on the top shows the front-end in its 'natural' environment.

The main thrust of ATH, however, is on projects involving (wireless) sensor technologies. In this area some wide ranging activities were deployed. In 2007, a niche approach in the area of Radio Frequency Identification resulted in a novel access product.

The continuing pursuit of technical developments of flat antenna arrays for commercial applications resulted in the identification of a first market application now being worked out in further detail together with IDL Sensor Solutions and interested commercial partners. The system design of practical every-day domestic and industrial applications resulted in finalising the development of a unique fire protection system. This system is marketed by NOFIQ Systems and after a slow start, sales look promising.

6. Management & communications

2007 was marked by many different events that concerned management and communications of ASTRON. There were changes in the Board and the Management Team. ASTRON was also clearly visible in the media on a number of occasions, with a variety of events aimed at a broad audience.

Public relations and outreach

Visitors of ASTRON are primarily professional astronomers and engineers. In its search for new talent, ASTRON also welcomes students from universities as well as high schools. Other guests are associated with leading industrial companies, science journalists, politicians and the general public. 2007 was a year full of different activities, such as the Open Day, the re-opening of the Dwingeloo telescope, Girls Day and visits from politicians.

Minister van den Hoeven (on the left) officially opened the Dwingeloo telescope during Girls Day

One of the activities during Girls Day.

The Dwingeloo telescope and Girls Day

On 29 January 2007, ASTRON officially started the project that will make the Dwingeloo telescope operational again. The project is led by the CAMRAS-foundation (C.A. Muller Radio Astronomie Station). During this day, several activities were organised to mark the start of the project: a mini-symposium took place, forty girls from the Stad en Esch school from Diever attended a Girls Day at ASTRON and JIVE, and former minister for OC&W, mrs. M.J.A. van der Hoeven, officially opened the project. During the Mini-symposium, the chairman of the Society for Experimental Radio Research in the Netherlands (VERON), the Koninklijke Nederlandse Vereniging voor Weer en Sterrenkunde (KNVWS) and people from CAMRAS explained why using the Dwingeloo telescope is the best guarantee for preserving it. The telescope is nominated by Monumentenzorg to be subsidised as a scientific industrial monument. Besides the symposium, forty girls from HAVO/ VWO class 1 and 2 of the school Stad en Esch (Diever) visited ASTRON and JIVE during Girls Day. The female scientific engineering staff of ASTRON and JIVE introduced the girls to science and technology by organising several activities. One of the activities included a fox hunt. The girls were set out to search for a key, which was handed to the former minister for OC&W. With this key, the minister officially opened the project for the rejuvenation of the Dwingeloo telescope.

The Dwingeloo telescope

A compilation of photos, taken during the Open Day 2007 at Westerbork

Open Day 2007

On 21 October, ASTRON and JIVE opened the institute for visitors during the Open Day. Approximately 1500 people visited Westerbork to enjoy an afternoon of insight into ASTRON and JIVE's astronomical results and technical achievements. One large tent provided exposition space for many ASTRON and JIVE exhibits as well as for CAMRAS and amateur astronomer participants; as usual, a prototypical mad professor could be spotted making comets! Smaller tents were used for a children's play lab, and for popular lectures. A viewing tour through the WSRT control building and labs was set up, the Digestif cabin was also open for visitors, and the opportunity to steer a 25 meter dish with a joystick again proved irresistible to many. Public attendance was well in excess of 1500, more than satisfactory given that the day started off quite rainy.

Opening of the new Radio Observatory Control Room

On 6 December 2007, ASTRON opened the new Radio Observatory Control Room in Dwingeloo during a short ceremony (see also chapter 1). The astronomical observations made by LOFAR and the Westerbork Synthesis Radio Telescope are being coordinated from this Control Room. The operational activities for both radio telescopes are integrated in the Radio Observatory of ASTRON.

Grote Reber ashes ceremony

On 26 July 2007, a small ceremony took place at the Dwingeloo telescope to distribute part of the ashes of Grote Reber (1911-2002), one of the pioneers of radio astronomy. The ashes of Grote Reber have been distributed to the main radio observatories around the world. ASTRON organised an informal ceremony. About 45 people attended this ceremony.

Grote Reber ashes ceremony

Press releases 2007

ASTRON has been in the press on a number of occasions in 2007. Below an overview of the press releases that were issued during this year. They can also be found on the website: www.astron.nl.

19 January 2007

Dwingeloo telescope becomes available for amateurs and educational purposes

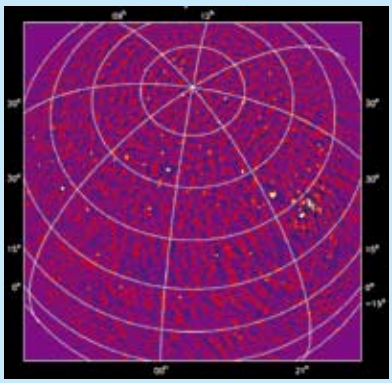
29 January 2007

New Executive Director ASTRON as per 1 February 2007

27 March 2007

LOFAR is going international

The LOFAR station next to the Effelsberg 100 meter radio telescope



First deep wide field image made with the first LOFAR stations at a frequency of about 50 MHz.

25 April 2007

First high quality wide field LOFAR image

18 June 2007

Agreement James Webb Space Telescope signed; The Netherlands helps build one of the instruments for follow-up of Hubble-telescoop

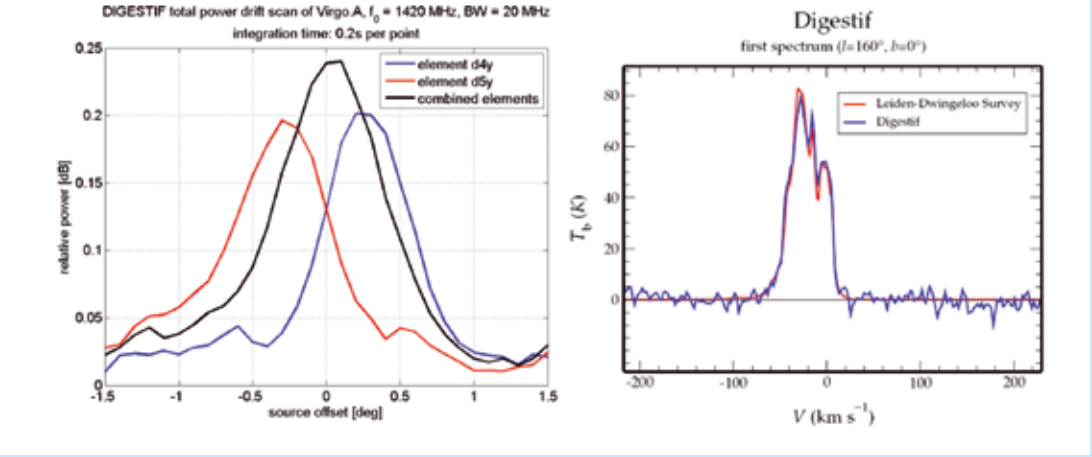
17 July 2007

First pulsar detection with LOFAR station

28 August 2007

Westerbork telescope participates in first e-VLBI data from China-Australia, China-Europe and Australia-Europe baselines

10 September 2007 First light of Digestif digital focal-plane array



27 September 2007

New director for ASTRON Radio Observatory

18 October 2007

Open Day at ASTRON's Radio Observatory in Westerbork

19 October 2007

SKADS successfully passed its Mid Term Review at the Paris Observatory

13 November 2007

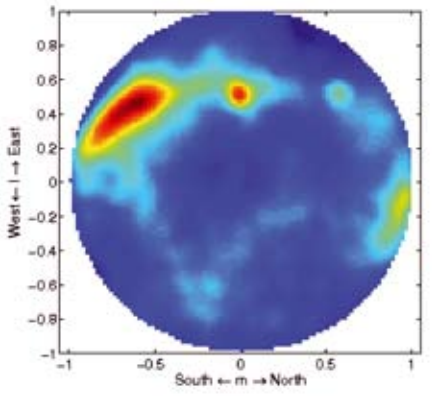
Auger Observatory connects cosmic rays to violent black holes

29 November 2007

European call for tenders of LOFAR components

29 November 2007

ASTRON opens Radio Observatory Control Room



11 December 2007

LOFAR picks up speed

The radio sky above Effelsberg on 29 October 2007, as observed in only one second. First image with all 96 LOFAR antennas in Effelsberg at 42 MHz.
Image: Stephan Wijnholds, Astron; Peter Müller, MPIfR

Major visits 2007

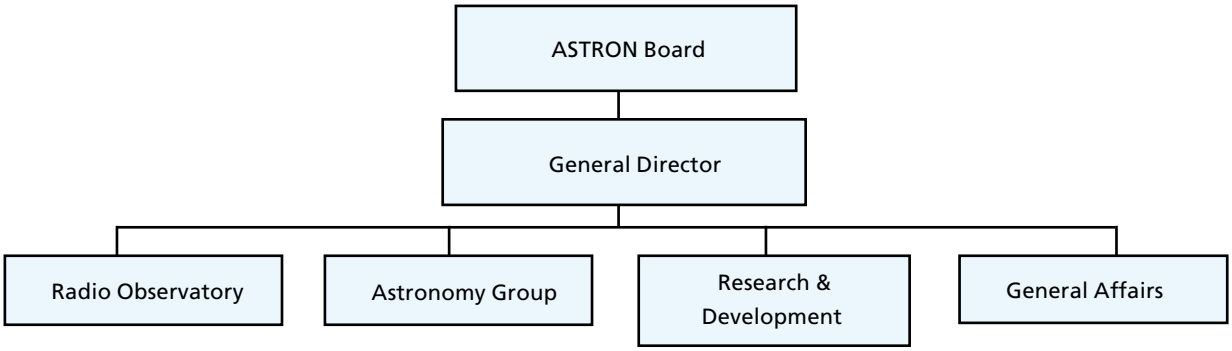
29/1	Opening Dwingeloo Telescope by minister M.J.A. van der Hoeven of OC&W (Education, Culture and Science) during mini-symposium of CAMRAS and Girls Day.
10/1	Wubbo Ockels (Delft University of Technology)
15/1-18/1	ESTRELA workshop
22/2	SRON
26/2	VVD campaign visit
27/2	Students Masterclass Astronomy (Kapteyn Institute)
1/3	EVN2015 Vision Brainstorm
16/3	Provincie Drenthe (Productgroep Miliebeheer (+ conference visitors))
20/3	Coaches technology primary education North-East of the Netherlands
30/3	Young OC&W
4/4	"LAPP-Top" Pre-University college students (University of Leiden)
18/4	Europe Direct Network Holland
12/5	VERON meeting
8/6	Physics 'Olympiade' (High school students VWO, Un iversity of Groningen)
11/6	SP Statenfractie three northern provinces
12/6	Donald Smits Centre for IT (University of Groningen)
12/6	Science journalists Holland
15/6	NOM (investment and development agency for the northern Netherlands)
10/7	OC&W, Senter Novem
10/7	Work visit Tweede Kamer: mrs. Besselink and mrs. Wolbert
16/7	West Australian Government Delegation
15/9	Gedeputeerden Provincie Drenthe
1/10	Chairman CDA and CDA Westerveld
8/10	NOVA (Netherlands research school for astronomy)
23/10	TNO-Space
29/10	Beta-Gamma students (University of Amsterdam)
3/12	Information meeting Lhee
17/12	Borger-Odoorn Horeca Nederland

Personnel and Organisation

In 2007, there have been changes in the top management structure. Harvey Butcher, having led ASTRON for fifteen years, has been succeeded by Prof. Mike Garrett, former director of JIVE. The Radio Observatory has also had organisational changes to prepare for the integration of the Westerbork Telescope with the new LOFAR telescope. The balance within the institute is evolving, in particular with an expected expansion in the astronomy group.

ASTRON Board and Management Team

In 2007, ASTRON was defined by the following hierarchy:



Below an overview of the Board members and the Management Team in 2007.

ASTRON Board members:

• Prof. Dr. J.M. van der Hulst (Chairman)	Kapteyn Astronomical Institute
• Prof. Dr. Ir. J.H. Blom	Technical University of Eindhoven
• Prof. Dr. J.H. van Gorkom	Columbia University, New York
• Prof. Ir. P. Hoogeboom	TNO Defense and Security
• Prof. Dr. C.U. Keller	Utrecht University (from May 2006)
• Prof. Dr. K.H. Kuijken	Leiden University (from October 2005)
• Prof. Dr. J.M.E. Kuijpers	Radboud University
• Prof. Dr. L.B.F.M. Waters	University of Amsterdam

ASTRON Management Team:

• Prof. Dr. H.R. Butcher	Executive Director, Chair (until 01-02-2007)
• Prof. Dr. M.A. Garrett	Executive Director, Chair (from 01-02-2007)
• Dr. C.M. de Vos	Director R & D and acting adjunct Director
• Dr. R.C. Vermeulen	Director Radio Observatory
• Dr. R. Morganti	Head of the Astronomy Group (from 01-02-2007)
• Mr. K. Determan	Head General Affairs (until 30-04-2007)
• Dr. Ir. B.M. Geerken	Head General Affairs (from 01-05-2007)

•

Invited to MT meetings:

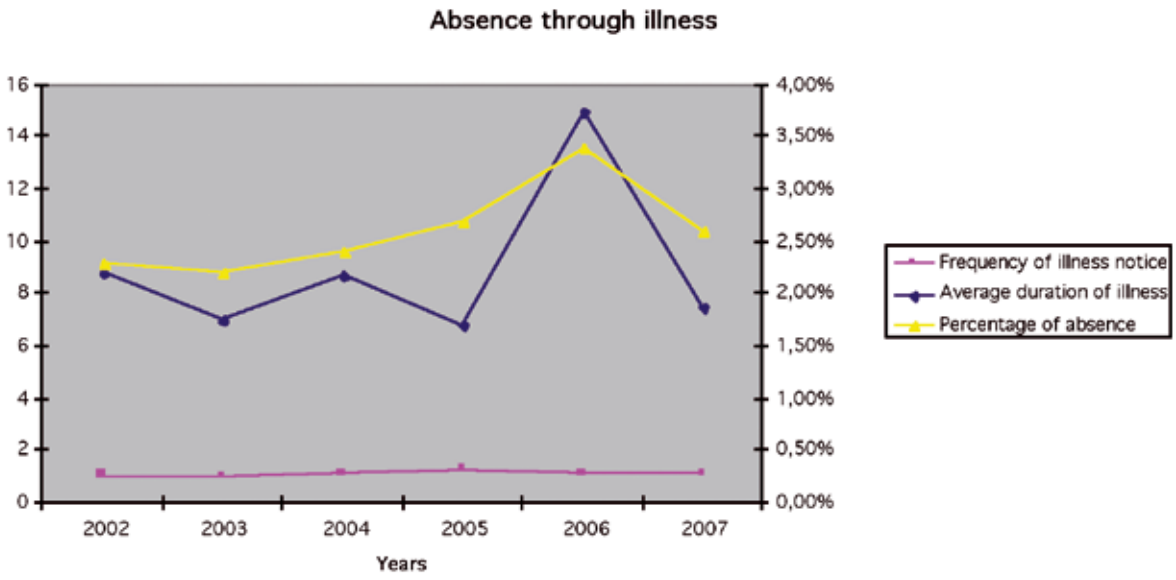
• Mrs. J.W. Roorda	Head of the Human Resource department
• Mrs. J.H. Wubs	Head of the Finance, Planning and Control department
• Dr. H.J. van Langevelde	Director JIVE

Absenteeism

Year	Absence percentage	Absence report rate*	Mean period	
2002	2,30%	1	8.8	days
2003	2,20%	0.95	7	days
2004	2,40%	1.06	8.7	days
2005	2,70%	1.23	6.8	days
2006	3,40%	1.1	15	days
2007	2,60%	1.1	7.5	days

* The absence report rate is the number of times on average an employee calls in sick, over 2007.

In 2007, the numbers of absenteeism were stable on all criteria. The outlier in 2006 was caused by some long term cases of (non work related) sickness. In 2007, there were two minor industrial accidents.



This figure shows a steady image of the absence by illness over six years. An exception is 2006. This high percentage was due to a few cases of serious illnesses, not work related.

At the end of 2007, a risk inventory and evaluation was executed. The most important aspects concern policy, documentation and information. In 2008, a Periodical Industrial Medicinal Research will be conducted.

Composition of personnel

The average age of employees at ASTRON is 45. The total number of ASTRON staff was 165 on 31 December 2007. The number of men is considerably higher than the number of women. Of all the women, only 25% (8 people) work in science or technology.

Diversity Committee

As can be seen in figure 1, the number of women in science and technology is very low. In general, there are not many women working in this field, and in Dutch schools the number of female students that choose for the profile nature and technology is not very high. ASTRON has therefore started the Helena Kluyver visitors program, to attract more women in this field and create a more balanced men/women ratio. Within this program, funds are available for women working in astronomy and technical R&D and who aspire to work at ASTRON or JIVE on their own research projects or wish to contribute to existing projects. The name of the program, Helena Kluyver, refers to one of the first female Dutch astronomers. With this program, miss Elena Redkina visited ASTRON for a period of three weeks during the summer of 2007. She performed the assembling and measurements of the 16 Vivaldi element array, which was initially designed by her in collaboration with antenna designers of ASTRON. This array was used for verification of the combined EM-MW model of the connected Vivaldi elements with microstrip feed excitations. The positive measurement results of this array complement the initial modelling study and are currently being prepared for submission to AP Trans. journal. Elena is currently lecturer at the Sevastopol National Technical University, Crimia, Ukraine.

Figure. 1 Women ratio in 2007 within ASTRON

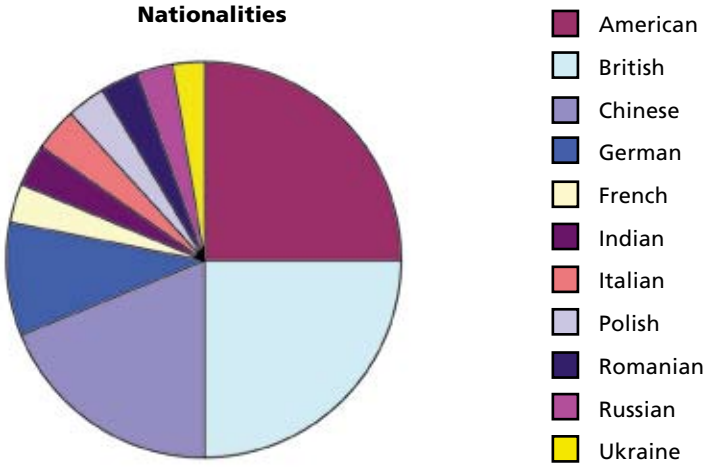


Figure. 2 There are eleven different nationalities at ASTRON

Ms. Redkina performing the measurements of the scattering parameters of the 16-Vivaldi element array

More information about the Helena Kluyver program can be found at www.astron.nl/p/HK/index.html. The gender policy at ASTRON/JIVE will be developed further in the next few years.

ASTRON also aspires to have more women in higher positions. In 2007, an important step has been taken with the appointment of Raffaella Morganti as head of the Astronomy Group. With this, the first female member of the ASTRON management team was now appointed.

Helena Kluyver, one of the first female Dutch astronomers

Workers council

The ten meetings between the directorate and the Works council had one central topic: the organisational changes. For the processes in the Radio Observatory, the R&D division and for the change in the top structure, the Worksers council has been asked for advice. Other important items concerned the organisation about labour conditions and solutions for the reservoir of leave hours within the organisation.

Finance and control

In 2007, ASTRON, in cooperation with NWO and OCW, restructured its financial and operational situation. At the end of the year negotiations were completed. They will be formalised in 2008. Together with NWO, ASTRON will sign a covenant, based on a multi-annual budget plan. An important aspect of this plan is the additional support of 2 million per year during a ten year period (2008-2017). This also results in a modified mission for ASTRON with the focus falling on radio astronomy, in particular on LOFAR and SKA.

In 2007, ASTRON continued with an existing plan to restructure the premises. The original building should only accommodate 144 people. By adding two temporary pavilions and reducing the library, more people could be accommodated. In the next few years, the pavilions will be removed and staff working in Westerbork will move to the building in Dwingeloo, into a new wing. Construction of this new wing is expected to begin in 2009. Two hundred people can then be accommodated in Dwingeloo. On 3 December, during an information meeting organised by ASTRON, the province of Drenthe and the local population agreed with these plans. As agreed with NWO, ASTRON will complete a detailed plan about the restructuring in spring 2008.
In 2007, the ASTRON buildings were cleaned. Subsequently the catering has been outsourced. This trajectory was closed at the end of 2007.

Financial report 2007

Compared with 2006	2007 Budget	2007 Actual	2007 Difference	2006 Actual
REVENUES				
Government Grants- Ministry of Education, Culture & Science	9.622.240	6.492.888	3.129.352	7.458.002
Subsidies / Contributions	5.545.399	8.698.787	-3.153.388	4.187.110
Release to provision	0	1.964.090	-1.964.090	
Other Income	217.764	1.424.599	-1.206.835	1.922.456
Cash management	0	197.046	-197.046	86.432
Subtotal	15.385.403	18.777.410	-3.392.007	13.654.000
Results Subsidiaries				
Subsidiaries ATH	0	0	0	79.716
Subtotal	0	0	0	79.716
Special Income				
Special Income	0	70.081	-70.081	9.473
Subtotal		70.081	-70.081	9.473
Total revenues	**15.385.403**	**18.847.492**	**-3.462.089**	**13.743.189**
	========	========	=======	========

EXPENDITURES				
Grants / Expenditures				
Projects	9.744.588	15.125.043	5.380.455	9.928.654
Radio Observatory	2.323.931	2.523.688	199.757	2.736.787
Operations	13.061.472	12.475.702	-585.770	25.628.184
Allocation to Projects	-9.744.588	-10.610.577	-865.989	-11.358.992
	15.385.403	19.513.856	4.128.453	14.269.192
Results Subsidiaries				
Subsidiaries ATH	0	289.428	289.428	0
Subtotal	0	289.428	289.428	0
Other Expenditures				
Other Expenditures	0	225.998	225.998	19.550
Subtotal	0	225.998	225.998	19.550
Total Expenditures	**15.385.403**	**20.029.282**	**4.643.879**	**14.288.742**
	========	========	========	========
BALANCE	**0**	**-1.181.790**	**1.181.790**	**-545.553**
	========	========	========	========

Cooperation with other universities

Some of the staff within ASTRON and JIVE also have an appointment at universities, such as the University of Groningen and the University of Leiden. In the table below the different positions of some of the ASTRON/JIVE staff are pointed out.

Connections with universities ASTRON / JIVE staff

ASTRON (zero-)appointment, professor, the Netherlands:
- Ger de Bruyn (University of Groningen, appointment for 30%, 70% appointment at ASTRON)
- Heino Falcke (University of Utrecht, appointment with financial contribution of ASTRON)
- Mike Garrett (University of Leiden, zero-appointment, professor)
- Richard Schilizzi (University of Leiden, zero-appointment, professor)
- Richard Strom (University of Amsterdam, zero-appointment, professor)

ASTRON zero-appointment, senior lecturer, the Netherlands:
- Raffaella Morganti (University of Groningen, zero-appointment, associate professor)
- Tom Oosterloo (University of Groningen, zero-appointment, associate professor)

ASTRON zero-appointment, other countries:
- Arnold van Ardenne (zero-appointment, professor, Chalmers, Sweden)
- Willem Baan (Sweden)
- Mike Garrett (zero-appointment, professor, Swinburne, Australia)

Guidance and housing of PhD students of Dutch universities:
- Alicia Berciano (University of Groningen)
- Seungyoup Chi (University of Groningen)
- Ramesh Karuppusami (University of Amsterdam)
- Rob Maaskant (University of Technology, Eindhoven)
- Maciek Serylak (University of Amsterdam)
- Christian Struve (University of Groningen)
- Valeriu Tuclose (University of Amsterdam)
- Stefan Wijnholds (Delft University of Technology)

Guidance and housing of PhD students of universities outside the Netherlands
- Erik Zeitler (Uppsala)

JIVE zero-appointment, the Netherlands:
- Huib-Jan van Langevelde (University of Leiden, zero-appointment, associate professor)

JIVE zero-appointment, other countries:
- Leonid Gurvits (Ventspils University College, Latvia, adjunct professor)

JIVE PhD students of Dutch universities:
- Nikta Amiri (University of Leiden)
- Hayden Ramparadath (University of Leiden)
- Karl Tortensson (University of Leiden)

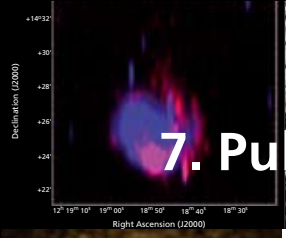
JIVE PhD students of foreign universities:
- Jun Yang (China)

ASTRON/ JIVE colloquia 2007

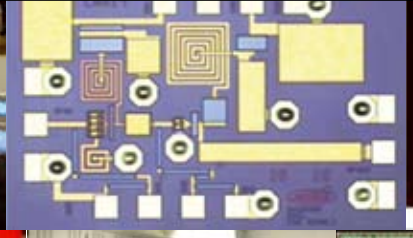
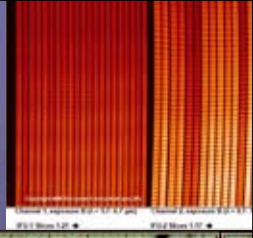
Wed 10 Jan 2007	Speaker: Wubbo Ockels (Delft University of Technology) Title: Is Life Earth-like?
Thu 25 Jan 2007	Speaker: Giuseppe Cimo (JIVE) Title: Intraday Variability of AGN in the Southern Hemisphere
Thu 15 Feb 2007	Speaker: Yurii Pidopryhora (JIVE) Title: Extra-Planar HI in the Inner Milky Way
Thu 22 Feb 2007	Speaker: Nanda Rea (SRON Utrecht) Title: Neutron stars: an overview and new results
Wed 28 Feb 2007	Speaker: Shanmugha Sundaram (JIVE) Title: Long-wave Observations of Solar Noise Storms Sub-title: Associated Coronal Plasma Parameters from Supplementary Multi-wavelength Spacecraft Data
Thu 08 Mar 2007	Speaker: Rense Boomsma (Kapteyn Astronomical Institute) Title: The Disk-Halo connection in NGC 6946 & NGC 253
Thu 22 Mar 2007	Speaker: Leon Koopmans (Kapteyn Astronomical Institute) Title: The structure, formation and evolution of early-type galaxies
Tue 27 Mar 2007	Speaker: Bruno Letarte (Kapteyn Astronomical Institute & Caltech) Title: Chemical Analysis of the Fornax Dwarf Galaxy
Thu 05 Apr 2007	Speaker: Bob Sanders (Kapteyn Astronomical Institute) Title: Neutrinos as Cluster Dark Matter
Thu 12 Apr 2007	Speaker: Lisa Young (New Mexico Tech) Title: Cold Gas in Hot Galaxies
Thu 19 Apr 2007	Speaker: Isabella Prandoni (INAF) Title: A view of the sub-mJy radio population: radio/optical properties, modeling
Thu 03 May 2007	Speaker: Lawrence Rudnick (University of Minnesota) Title: Illuminating Shocks from pc to Mpc scales
Thu 10 May 2007	Speaker: Amina Helmi (Kapteyn Astronomical Institute) Title: Cosmology with the Galaxy
Thu 24 May 2007	Speaker: Sergei Fabrika (SAO, Russia) Title: SS433 as an ultraluminous X-ray source in the Milky Way
Thu 31 May 2007	Speaker: Roald Schnerr (University of Amsterdam/SRON) Title: The radio emission of magnetic massive stars
Mon 04 Jun 2007	Speaker: Mona Moren (Chalmers University of Technology) Sub-title: RFI Environment Characterization and Receiver Front-End Design for Radio Astronomical Observations below 30MHz
Thu 07 Jun 2007	Speaker: Leonie Snijders (Leiden Observatory) Title: Young star clusters in starburst galaxies

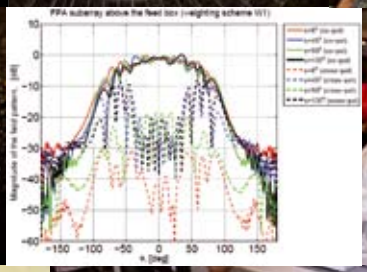
Thu 21 Jun 2007	Speaker: Patrick Weltevrede (Astronomical Institute) Title: The modulation and propagation of the radio emission of pulsars
Thu 28 Jun 2007	Speaker: Olaf Wucknitz (JIVE) Title: Do gravitational lenses always magnify?
Mon 02 Jul 2007	Speaker: Donald Fraser (UNSW, ADFA) Title: Image Restoration at UNSW@ADFA
Thu 09 Aug 2007	Speaker: Steven Tingay (Curtin University of Technology) Title: An illustrated update on the Australian VLBI/e-VLBI project
Thu 06 Sep 2007	Speaker: Donald Lynden-Bell (University of Cambridge) Title: Magnetic Jets from Swirling Disks
Thu 20 Sep 2007	Speaker: Andrei Lobanov (MPIfR Bonn) Title: Extragalactic outflows and supermassive black holes in a broader context.
Thu 20 Sep 2007	Speaker: Tracey Hill (Sterrewacht Leiden) Title: Profiling Young Massive Stars
Mon 24 Sep 2007	Speaker: Ylva Pihlstroem (University of New Mexico) Title: Stirring the Embers: High Resolution Observations of Gamma-ray Burst Afterglows
Thu 04 Oct 2007	Speaker: Michiel Brentjens (ASTRON) Title: Radio Polarimetry in 2.5D
Thu 11 Oct 2007	Speaker: Bärbel Koribalski (ATNF) Title: The Local Volume HI Survey (LVHIS)
Thu 18 Oct 2007	Speaker: Eline Tolstoy (Kapteyn Astronomical Institute) Title: Galactic Archaeology
Thu 25 Oct 2007	Speaker: Stefanie Muehle (JIVE) Title: Starbursts: The Heat is On? Sub-title: Formaldehyde as a Tracer of the Molecular Gas in External Galaxies
Mon 05 Nov 2007	Speaker: Aris Karastergiou (University of Oxford) Title: Refining the lighthouse model: The complex radio beams of pulsars
Thu 08 Nov 2007	Speaker: Claudio Maccone (International Academy of Astronautics) Title: SETI by LOFAR: Searching for ETs by a supercomputer, the KLT and LOFAR
Thu 15 Nov 2007	Speaker: Piet de Korte (SRON) Title: Development of Cryogenic Sensor arrays for X-ray imaging spectroscopy & sensitive IR/ sub-mm imaging
Thu 22 Nov 2007	Speaker: Soeren Larsen (Utrecht) Title: Star Clusters: Their demographics and some applications
Tue 04 Dec 2007	Speaker: Elena Gallo (UC Santa Barbara) Title: AMUSE-Virgo: on the survival of super-massive black holes in faint spheroids

7. Publications 2007

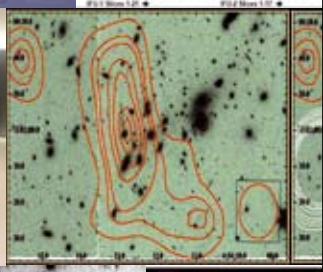


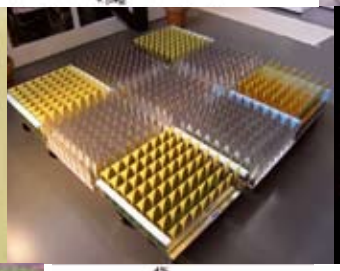
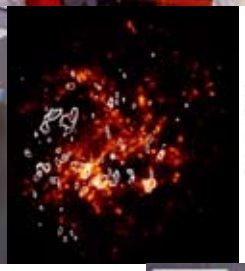
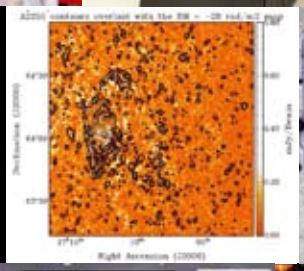
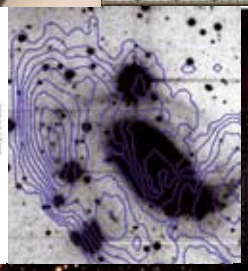


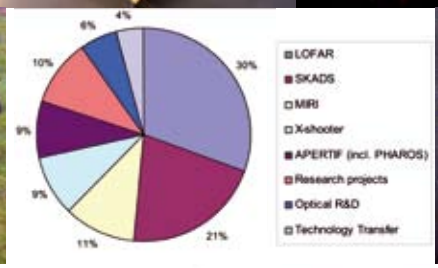



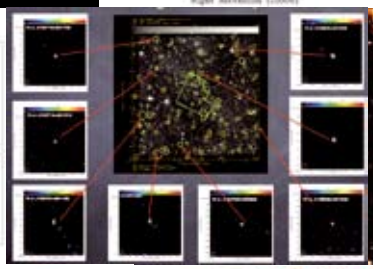
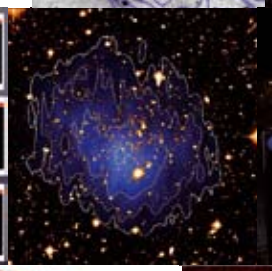


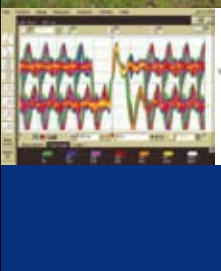
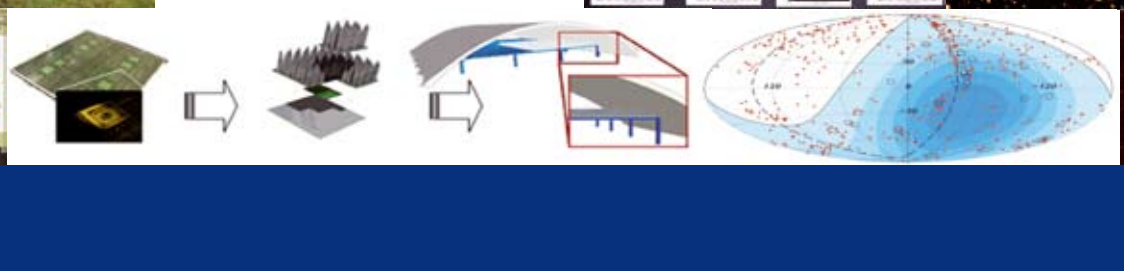
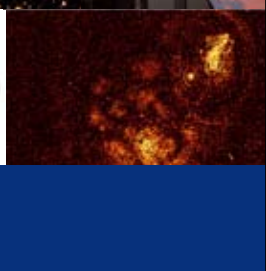




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4. Yusef-Zadeh, F., Wardle, M., Roy, S.,: *Cosmic-ray heating of molecular gas in the nuclear disk: low star formation efficiency, 2007,* ApJ 665, L123
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7. Emonts, B. H. C., Morganti, R., Oosterloo, T. A., van der Hulst, J. M., van Moorsel, G., Tadhunter, C. N.; *Large-scale HI in nearby radio galaxies: segregation in neutral gas content with radio source size*, 2007, A&A, 464, L1
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10. Schnitzeler, D.H.F.M., Katgert, P., Haverkorn, M., de Bruyn, A.G.; *The WENSS & Dwingeloo surveys and the Galactic magnetic field*, 2007, Astronomy & Astrophysics, 461, 963
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1. Hüttemeister, S., Manthey, E.; *The Structure and Interaction History of Moderate Luminosity Mergers*, 2007, Galaxy Evolution Across the Hubble Time, Edited by F. Combes and J. Palous, Proceedings of the International Astronomical Union 2, IAU Symposium #235, held 14-17 August, 2006 in Prague, Czech Republic. Cambridge: Cambridge University Press, 2007, 206
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