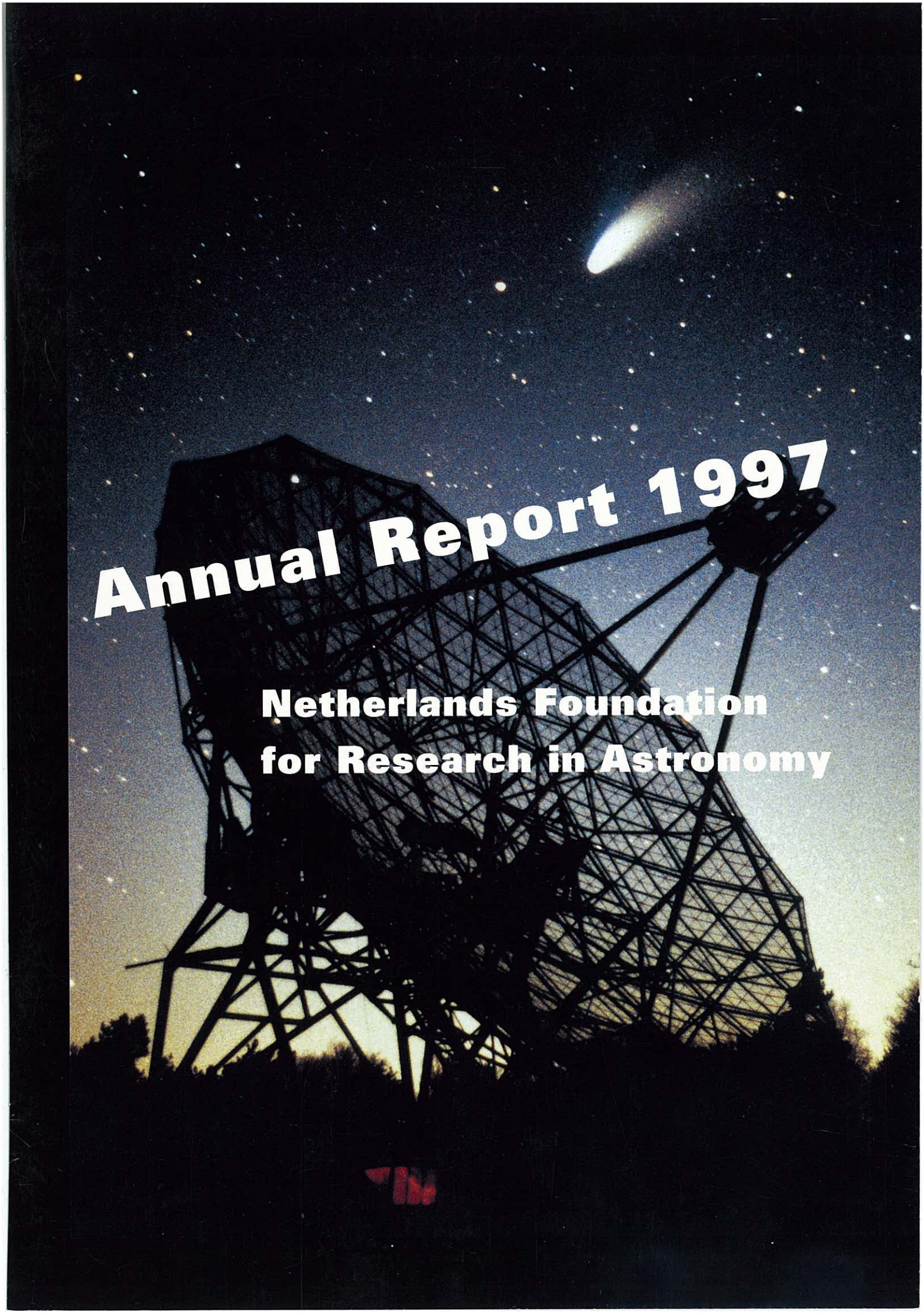
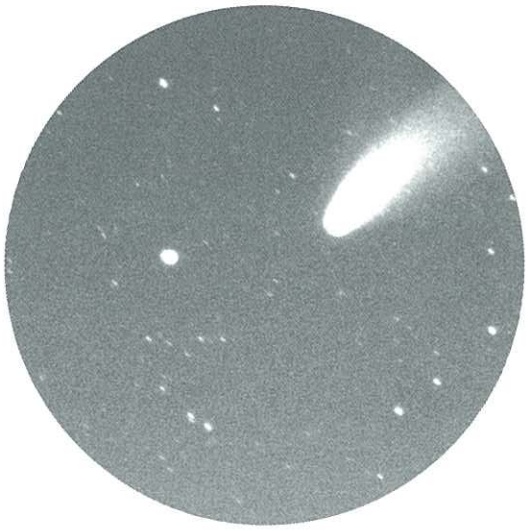

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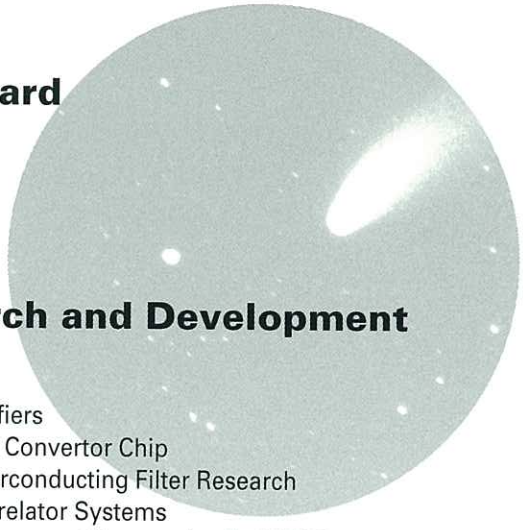
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Cover:
Comet Hale Bopp over the Dwingeloo Radio Telescope. Taken on April 1st 1997 by Albert Schuitema, Dwingeloo.

Photographs:
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Guesthouse: Rick Wagner
All others: Harm Jan Stiepel

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Report of

6

the Board 1

Highlights of 1997

High point of the year was the formal opening of NFRA's new headquarters building by Her Majesty, Queen Beatrix. Once all personnel had moved into their new offices, serious preparations for the future could begin. These included recruiting a new Director of the radio observatory, dr. Willem Baan, to spearhead expansion of the scientific programme of our radio facilities. New observing capabilities were brought into operation in Westerbork, that provide unique possibilities for studying the far reaches of the Universe. Our plans to extend the technologies of adaptive phased array antennas, and thereby set the stage for the next generation of radio telescopes, gathered full steam. New policies were put in place to enable development of innovative instrumentation to meet the research needs of our university astronomers. In order to optimize these developments, as well as to prepare for exploiting new funding channels in the future, a major reorganization of personnel and of our management structure was initiated.



Figure 1.1
Her Majesty Queen Beatrix arriving at NFRA's new headquarters, accompanied by Prof. Harvey Butcher, Director of NFRA (right) and The Queen's Commissioner for Drenthe Mr. A.L. ter Beek.

We were extraordinarily honoured to have the headquarters opening ceremony on May 6th performed by Her Majesty. Of course, the building overflowed with invited guests, including representatives from Dutch industry, from the national science community and from local and national politics. Other guests dropped by from near and far to witness the arrival and departure of the royal helicopter. Also present at the festivities was our Minister for Education, Culture and Science, His Excellency dr. Jo Ritzen, who was particularly interested to note the excellent progress being made in establishing the European centre for VLBI data processing in Dwingeloo. We were also pleased to welcome Harry Mulisch, author of "De Ontdekking van de Hemel (Discovery of the Heavens)", a best selling novel featuring the Dwingeloo and Westerbork radio observatories. The occasion provided a good opportunity to publicize our plans for the future of radio astronomy and for developing the technology necessary for the Square Kilometre Array Interferometer (SKAI). Prof. Ron Ekers from CSIRO, Australia, told the assembled guests how SKAI would revolutionize cosmology and the study of evolution in the Universe. Prof. Frank Drake of the University of California emphasized the importance of such a facility if we are ever to detect other civilizations in the Galaxy. And Dr. Reinder van Duinen, chairman of our research council, NWO, underlined NWO's support for our R&D initiatives relating to the SKAI project. The formal part of the ceremonies were concluded with Her Majesty's unveiling of a large photograph of the Netherlands, taken from earth orbit but with a possible concept for SKAI superimposed.

The new, wide band, tunable UHF receiver systems for the Westerbork Synthesis Radio Telescope (WSRT) went into regular operation early in the year. The first three months of observing yielded exciting results on several fronts, as well as valuable experience with the problems of observing in the presence of interference from other users of the radio spectrum. The science that is being carried out with these new receivers ranges from studies of pulsars and gamma-ray bursts to neutral hydrogen and OH in galaxies and quasars, both near and far. The capability of observing spectral lines at arbitrary redshifts offers exciting new perspectives, and each observing session during the year resulted in the discovery of new high redshift absorption line systems. The initial successes in tied array mode encouraged an international team to begin a VLBI campaign in the UHF-high band, to image absorbing gas clouds against their background continuum radio sources.

The telescope's new back-end correlator and spectrograph (the DZB) is being developed in collaboration with the international VLBI community under an agreement between NFRA and NASA. "First fringes" were detected on 21st July using the prototype MkIV data processor at the Joint Institute for VLBI in Europe (JIVE) in Dwingeloo. During the autumn, a copy of this prototype was installed and commissioned in Westerbork, and by the end of the year the hardware and first release of the new Telescope Management System software were being used regularly for observing.

Preparations were also completed for another kind of "observing" system. In future the Westerbork facility will assume a new function as the fundamental reference point for geodetic measurements in the Netherlands. The geodetic community will carry out research and provide practical data (water level measurements across the country and position determinations for commercial transport) based on highly accurate gravimetric, satellite laser ranging and Global Positioning System (GPS) measurements. VLBI observations with the WSRT are expected to help tie local positional measurements to the intercontinental geodetic reference frame. During the year, regular GPS data collection started, with the results being transferred automatically for analysis to the Geodesy group at the Technical University in Delft.

NFRA's phased array technology effort received major funding in the spring and reached its first milestone early in the summer, when AAD (the Adaptive Antenna Demonstrator) formed its first digital beams using a 2x4 phased array of patch antennas. Adaptive algorithms for suppressing interference were implemented, and an adaptive nulling capability of 35 dB was demonstrated. Research in key areas of technology was also begun, starting with a SKAI system feasibility analysis. Technical development began for a series of increasingly functional and increasingly integrated array antennas, to

demonstrate the feasibility of the technology for application in the next generation very large radio telescopes.

Internationally, the year saw good progress being made in working out the scientific case for SKAI. Radio astronomers from ten countries participated in three workshops, in Leiden in June, San Jose in August and Sydney in December. Discussions of future large scale facilities in astronomy generally were held during the General Assembly of the IAU in August in Kyoto, Japan. Also, the decision was made to formalize the organization of the international consortium set up at the end of 1996 to study the feasibility of the telescope.

NFRA's enabling role in Dutch astronomy could also be celebrated during the year with two notable successes. Prof.dr. Jan van Paradijs (University of Amsterdam) led an international team in demonstrating the cosmological nature of gamma-ray bursters, a discovery heralded by Science magazine as among the ten most significant in all of science in 1997. The team made excellent use of the WSRT, our telescopes on La Palma and of a multi-year research grant from NFRA. A second success was the formal "First Light Ceremony" of the Dutch Open Telescope (DOT), an innovative solar telescope designed by a team at Utrecht University led by Dr. Rob Hammerschlag. The ceremony took place on the 31st of October in the presence of Crown-Prince Willem Alexander, Minister Ritzen and an array of international dignitaries. This facility, located on La Palma under a Memorandum of Understanding between the Canarian Observatories and NFRA, has already demonstrated that open air solar telescopes, when properly designed and sited, can indeed regularly achieve diffraction limited spatial resolution at optical wavelengths.

Reorganization

To meet the needs of our future programme in a climate of constant or (in real terms) gradually declining annual funding, the Board decided on 24th September to optimize the Institute's staffing mix and streamline its management structure. On 29th September the new organizational structure took effect, creating four management divisions - the Radio Observatory, Technical Laboratory, Facilities Management, and Administrative Affairs. The first two divisions will carry out the main tasks of the organization in the coming years: the scientific and operational programme of the WSRT, and technical R&D and instrument development. The latter divisions will provide support for the primary programme and for cooperative activities with external groups. Hiring new personnel with the required new skills unavoidably means that a significant number of our current employees must retire early or find employment outside NFRA. A period of five years is planned to complete the transition, with NFRA supplementing retirement benefits for those retiring early, or helping to identify appropriate work opportunities elsewhere for employees made redundant.

Policy Development

Policy discussions during the year focussed on how to maintain an innovative and dynamic programme in the face of a heavily constrained budget. At its June meeting the Board decided not to take on any new commitments that might extend beyond the currently projected period of funding - that is beyond about 2000. A scenario was adopted whereby operation of the radio and island observatories and of JIVE, and support for the university grants programme, will be continued with available structural financing, but new technical projects will increasingly have to be financed by non-structural funding from a diversity of sources.

For almost fifteen years NFRA's technical activities have centred on developing large infrastructural instrumentation, first to build up our island observatories and more recently to upgrade the radio telescope at Westerbork. It has been evident for some time that our university-based research programmes would benefit considerably from specific new back-end instruments, either for attacking particular observational problems or for achieving early access to particular international observational facilities. During the year, the Board decided that available resources in NFRA's technical laboratory should be re-apportioned to make this possible. As a guideline, up to 30% of laboratory resources will, in future, be planned for ad hoc instrumentation in support of university programmes. Much of this work will concern optical and infrared instruments, destined for use on La Palma or at the European Southern Observatory in Chile, although specific back-ends for radio telescopes also fall within the scope of the programme. A call for proposals went out in March and five proposals were sufficiently well-defined and suitably limited in scope to be able to be developed into full proposals for submission to various subsidy programmes for funding. The remaining 70% of laboratory resources will remain dedicated to activities of a more infrastructural nature. In the short term these will entail completing the upgrade of the WSRT; in the longer term the focus will shift to sustained development of phased array antenna technologies.

Forward Look

Nineteen ninety - eight is scheduled to see the installation and commissioning at the WSRT of fourteen fully outfitted Multi-Frequency Front End receiver systems. The basic hardware of the new back-end correlator, DZB, will be installed but full functionality will only be achieved the following year. Assuming additional funding can be

acquired, full bandwidth operation (160 MHz) and improved tied-array performance will also become available in 1999. The programme of major maintenance on the telescope and strengthening of its counterweight supports will be completed at the end of 1998 or early in 1999, depending on the weather during the year.

As the WSRT upgrade winds down, increasing levels of manpower will be dedicated to R&D on phased array antenna systems and SKAI. In 1998, the 8x8 active element "One Square Metre Array (OSMA)" will be completed and will demonstrate greater than an octave bandwidth, true time delay and RF - beamforming, and adaptive digital beamforming in a hierarchical signal processing architecture. The array will permit real-time (10 msec) suppression of moving interfering signals and will provide for dual, shared aperture measurement beams.

At the same time that the WSRT upgrade nears completion so does production of the DZB's sister correlator for JIVE. Early in 1998, delivery of the MkIV play-back tape drives is expected, and full operation of the entire correlator system is scheduled for early autumn. A formal, international opening ceremony for the facility is planned for late October.

Dutch participation in the instrumentation programme of ESO's Very Large Telescope involves collaboration with colleagues at CEA/ Saclay near Paris to produce the mid-infrared imager and spectrometer, VISIR. The final design review is due to take place at the end of 1998, after which full production will begin.

NFRA's parent organization, NWO, will carry out a major reorganization during 1998, that will bring with it a new relationship between institutes such as NFRA and the structures for financing science in the Netherlands. In particular, it is expected that a basic minimal level of support for the fixed costs of operations will be guaranteed for periods of six years, while essentially all programmatic activities will be financed either competitively with proposals from other scientific disciplines and from university groups, or from external sources. A major evaluation of NFRA's institute in Dwingeloo is foreseen for early in 1999, to help determine the basic budget for the following years. Similarly, international panels will evaluate the Isaac Newton Group of optical telescopes on La Palma and the JCMT on Hawaii in 1998 and 1999, respectively. Evaluation specifically of the R&D programme on phased array antennas and SKAI is currently foreseen for late in 2000.

2

Research and Development

NFRA's technical laboratory is responsible for carrying out research and development for the instrumental projects that the Foundation is involved in. In 1997, work focussed on three main topics. First of these was the continuing upgrade of the Westerbork Radio Telescope (WSRT) - a project that involves development and installation of new receivers (the Multi-Frequency Front Ends or MFFE's), a powerful new correlator/spectrometer (the DZB) and an integrated telescope management and data reduction software system. The second pillar of the laboratory's work are the studies aimed at developing broad band adaptive phased array antennas for the Square Kilometre Array Interferometer (SKAI) project. Finally, after the integration in 1996 of the Kapteyn Observatory, formerly at Roden, NFRA is now also heavily involved in building instrumentation for optical telescopes. This year saw the successful completion of the preliminary design review of the VISIR instrument for ESO's Very Large Telescope. The developments on each of these fronts are summarized in this section.

WSRT Upgrade Projects

The WSRT upgrade can be broken down into a collection of individual projects that each focus on a specfic part of the telescope or its infrastructure. Many of the projects are closely linked to others, or indeed form part of another major strand. Together they make up the WSRT Upgrade, but for the sake of clarity they are presented separately below.

Mixer Chip

The development and application of RF Integrated Circuits (RFICs) is a necessity for SKAI.
To gain experience with these technologies in a broader context it was decided to develop a mixer chip with two types of mixer function for application in the IF-to-Video Converter (IVC-) system of the DZB. The functionality and specifications of the design were defined at NFRA, the actual design, simulation and lay-out for both functionalities on a single chip area were done at Catena Microelectronics in Delft. The figure shows a photograph of the result of this work, the ASTRON01 mixer chip. One wafer, which holds a sufficient number of individual chips for the IVC-project, was delivered by Maxim Integrated Products (California, USA) in August. Testing of a few packaged samples at Catena and NFRA revealed some problems with the Up Converter function, but showed that the quadrature mixers performed according to the specifications. A prototype for the Image Rejection Mixers (IRM) using the chip is now under development. This development process has provided us with useful experience in all aspects of this type of custom designed RFICs, as well as with a component for the IRM with inherently better properties than readily available commercial components.

MFFE Low Noise Amplifiers

The Low Noise Amplifier project was started at the end of 1992 and consists of the development and construction of low noise amplifiers for the MFFEs that operate at frequencies between 250 MHz and 8.7 GHz. Its purpose was to design and build a total of 420 state-of-the-art LNAs. Some of the highlights of the design phase of the project were presented in the 1995 annual report. In October 1997 the production phase was successfully completed with the delivery of the 3.6/6 cm amplifiers. The chips were bonded in the circuit with 25 micron gold wires at NFRA's in-house bonding facility. Over 10,000 bond wires have been used to connect these chips and other chip components in the amplifier circuit during the construction of the 70 amplifiers for these frequency bands. The LNA project has produced low noise amplifiers with noise properties that suit the needs of radio astronomy at a lower price than commercially available amplifiers. The design process, together with the need to make adaptations due to the worsening RFI environment, has given us experience in a field that will be essential for the SKAI project.

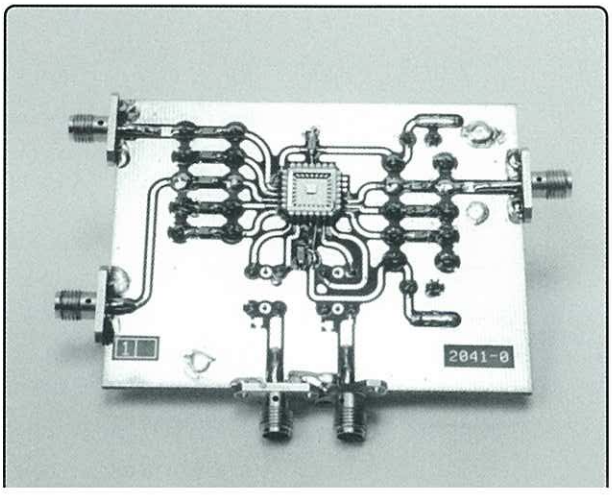


Figure 2.1
Photograph of the ASTRON01 mixer chip.

The Analogue to Digital Converter Chip

The electronics of the WSRT can be divided into two parts: the receivers (MFFEs) and the back-end (DZB). The back-end consists of three parts: an analogue part (the IF-to-Video Convertor or IVC subsystem), an analogue to digital conversion part (the Analogue-to-Digital or ADC subsystem) and a digital part (the Correlator). The IVC subsystem converts the analogue signals from the telescopes into analogue signals that can be handled by the ADC subsystem, which in turn converts the analogue signal into 2-bit digital signals and compensates for the delay differences. The correlator subsequently performs the cross- and auto-correlations of the telescope signals. In 1997 the first parts of the new ADC subsystem and the Correlator were installed and tested in Westerbork.

The use of standard Analogue-to-Digital (A/D) integrated circuits within the ADC Subsystem was not possible. The most important reason for this is that standard converters all have fixed reference levels which the analogue input signal is compared with. For application at the WSRT it was essential that the reference levels can be adapted according to the power of the analogue input signal. For this reason a converter was constructed out of discrete components. The disadvantages of this approach are obvious: the converters are relatively large (about 2 dm^2), expensive (Dfl. 1500) and their power consumption is considerable (9.2 Watts). The next generation of analogue to digital conversion systems is expected to require an increase by at least an order of magnitude in the number of A/D converters from the current 256 within the DZB. For that reason it is absolutely necessary for future systems to use integrated A/D converters in order to reduce the board space, power consumption and costs of the converter.

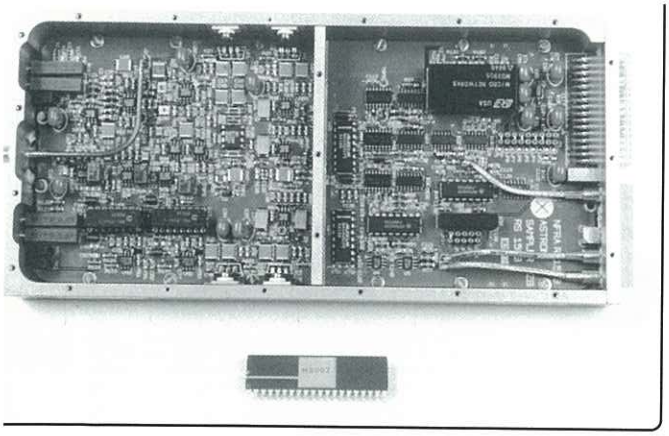


Figure 2.2
Photograph of a DZB A/D unit and the integrated single chip solution.

In 1996 a collaboration with the IC-Technology & Electronics Group of the Faculty of Electrical Engineering of the University of Twente was started in order to investigate the integration aspects of A/D converters. The first step in this process was to realize an integrated converter with the same specifications as the converters used in the DZB. It was soon realized that this would not be possible using silicon, because of the required chip area and overall complexity. Therefore, a completely new architecture was developed and a special chip designed. Manufacture of the chip was possible using a test-run of the BICMOS2 process of Philips Semiconductors. At the end of the year these chips were waiting to be tested using (a part of) the DZB Correlator giving us the opportunity to compare one-to-one the results of the integrated A/D converter with the discrete DZB A/D converter.

High Temperature Superconducting Filter Research

Strong interfering signals from man-made sources (such as TV broadcasting stations) can mix with each other in the signal chain and produce large numbers of unwanted product signals that prevent observation in parts of the spectrum opened up by the new MFFE receivers. In some cases a filter can be inserted at the start of the signal chain to reduce the strength of the product signals to a harmless level. To avoid an unacceptable increase in system noise, these filters should be made from superconducting material, and high-temperature superconducting filters promise to be an elegant solution to this problem. NFRA has been involved in a study to this end with scientists from the faculties of Electrical Engineering and Applied Physics at the Technical University in Delft for the past 5 years.

In March 1997 a major milestone was reached when a prototype filter was mounted and tested in one of the MFFEs. Tests with this front end at the WSRT clearly showed the benefit of such a filter to radio astronomy: a substantial suppression of interference is achieved without a notable decrease in sensitivity. Following the conclusion of this project, discussions have started with the newly formed Microwave Components group at the Delft Institute of Microelectronics and Submicron technology (DIMES) to build on the results of the first study. Work will focus on using novel topologies to realize physically compact filters for use at low frequencies.

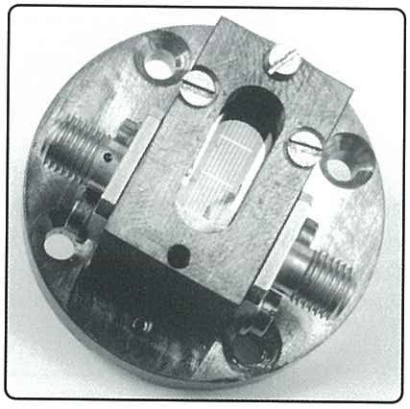


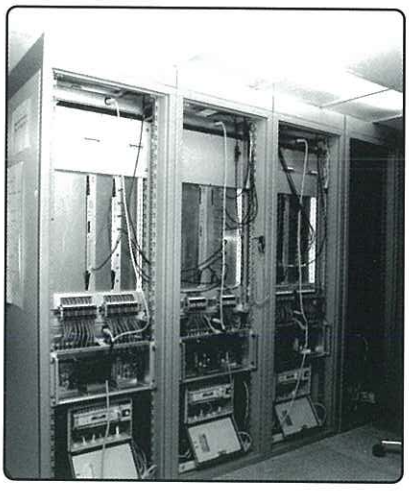
Figure 2.3
A prototype high temperature superconducting band-stop filter designed to suppress external interference at 1.52 GHz.

The NFRA and EVN Correlator Systems

Hardware for the correlator systems for the WSRT and the European VLBI Network (EVN) went into production in 1997, after an extensive and thorough test phase. So far it has led to a minimum DZB system, that replaces two of the correlators currently in use at the WSRT. A first synthesis map was produced with this system in September. The new hardware accepts output signals from the current IF-to-Video converters. These analogue signals are converted into two bit digital signals and passed on to the correlator after path length compensation in a delay module. The correlator has (in its current minimum form) 65536 lags that can be used in different configurations. A typical configuration for line observations consists of two polarizations with all redundant baselines and 256 lags (128 complex spectral points) correlated in two bit mode. Compared with the current line back-end (the DXB) this already gives a factor of eight improvement in spectral resolution and a factor $\sqrt{2}$ improvement in sensitivity.

The maximum bandwidth is currently limited to 10 MHz, but will be extended to 20 MHz in the course of 1998 using the existing IF system of the continuum back-end (the DCB). The full correlator system with 8 times the correlation capacity of the minimum system will become available in the second half of next year, but can only be used to its full capacity when the new IF-to-Video convertor system becomes available in 1999.

Figure 2.4
One of the DZB Units (after arriving in Westerbork).



TMS - a Telescope Management System for the WSRT

To make use of the larger data streams produced by the upgraded WSRT hardware and by the increasing demands on operational flexibility, a new system for instrument control, system configuration and data collection is being developed. The TMS project makes use of object-oriented design and programming techniques; existing components are retained where feasible.

In 1997 a start was made with the integration of TMS applications and databases within the WSRT operational environment. In particular the DZB correlator is fully controlled by TMS. The data stream of 160 kByte per 10 sec basic integration (for a single correlator segment) is read out by a controller application, preprocessed and written directly in an AIPS++ Measurement Set. AIPS++ is being used for on-site inspection and system calibration. Outlets were developed to Classic AIPS (via UVFITS) and Newstar SCN files, for backward compatibility with existing datareduction tools.

During 1998 the control of the DZB will be completed and extended as more hardware is delivered. Also the control of other parts of the system (IF devices, front-ends and telescopes) will be taken over by TMS applications. The new telescope management system will become the driver of the schedule, allowing the use of dynamic scheduling tools that were developed in 1997. This optimization phase will bring TMS in a position to be taken over for maintenance by the Radio Observatory.

AIPS++

The AIPS++ project aims to produce an internationally supported data reduction and analysis environment for radio astronomy. It involves programmers and scientists at seven institutes in six countries. NFRA has been heavily and centrally involved since its inception, with a view to making the WSRT more accessible to astronomers from other countries, and to making other radio telescopes more accessible to the Dutch community. AIPS++ can be used for the reduction and combination of data from all radio telescopes because of the consistent use of the Measurement Equation for a Generic Radio Telescope (formulated by scientists from NFRA and ATNF). The project engineering is based on object-oriented software technology and includes distributed objects and parallel processing. Distribution of code and documentation is Internet-based.

During 1997, a large number of powerful software components were implemented, tested and documented. In the next phase these will be integrated and equipped with a modern graphical user interface. In the meantime, some components of AIPS++ are already being used in isolation by other software projects, like the new WSRT on-line system (described above), the Green Bank Telescope reduction system, and the recent Parkes Multibeam surveys. Examples of such components are the Table system (data storage), the Measures system (coordinates and their conversions) and the Glish command language and control hub.

In the course of the year, the foundations were also laid for the use of AIPS++ in the development of SKAI. A system was designed for an alternative implementation of the Measurement Equation that allows a more flexible parameterization, and the simultaneous solution for arbitrary subsets of these parameters. This is necessary for dealing with image-plane effects that limit the very high dynamic range that will be needed for SKAI.

Self-calibration of an Inhomogeneous Synthesis Array

Interferometer arrays currently in use are of a simple type: they are homogeneous, i.e. all antennas have focal feeds that are identical in the way they receive polarized radiation. Even when independently built antennas are combined into ad-hoc VLBI arrays, their existing feeds are replaced by others that are

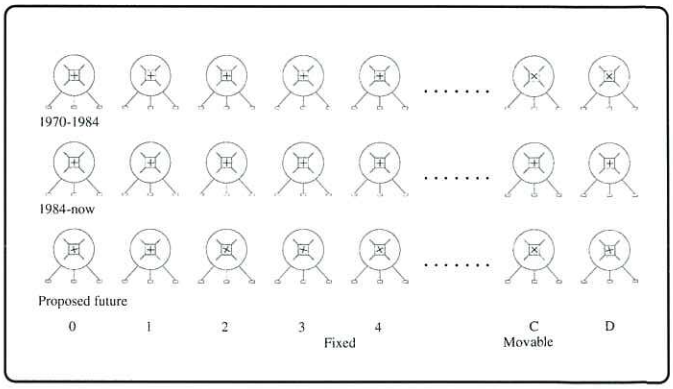


Figure 2.5
Feed configurations for the WSRT. The feed consists of two linear dipoles at right angles to one another.

Upper row:
The "crossed-dipole" configuration. The feeds in the fixed antennas are aligned vertically, those in the moving antennas in a diagonal position. That this configuration can be calibrated using only an unpolarized calibrator source had been known since 1973.

Middle row:
In the early 1980s self-calibration revolutionized synthesis imaging. The theory available at the time could only cope with sets of interferometers that have identical feeds and therefore the WSRT was forced to trade in its capability of simple calibration for the ability to exploit self-calibration.

Bottom row:
Our new theory asserts that the Measurement Equation enables the full polarization response of an inhomogeneous array to be self-calibrated by observing only one unpolarized calibrator. This technique combines the best of the two previous observing configurations.

identical for all antennas. In the mid-eighties even the mildly inhomogeneous "crossed-dipole" configuration that had been used successfully at the WSRT for many years was eventually abandoned, simply because the then novel technique of self-calibration could not be supported.

NFRA's Measurement Equation (described in the 1995 Annual Report) provided the fundamental theoretical breakthrough required for the analysis of inhomogeneous arrays in a general way. During 1997, the problem of calibrating such an array for measurements of polarization was taken up. This question is also vitally important for future telescopes because by its very nature SKAI is likely to be an inhomogeneous array, and we must learn to understand how to operate such an array.

In addition to providing a deeper understanding of the general theory of how to measure polarization, the study has produced an important new result. Under normal conditions an inhomogeneous array can be completely calibrated from a single unpolarized reference source. Unlike all homogeneous arrays, it does not need a second, polarized source to measure the so-called phase-zero difference.

This result shows that the most important asset of the WSRT's abandoned crossed-dipole mode is not a fortuitous coincidence, but rather the manifestation of a fundamental property of inhomogeneous arrays that may make them generally superior to homogeneous arrays. Indeed, for the former we can accurately predict the complete response to any polarized source by only measuring the response for one that is unpolarized. This is of practical importance because there are plenty of sources that may, for astrophysical reasons, be assumed to be unpolarized, but very few whose polarization is well enough known for them to serve as references in calibration.
Just before the old 21 cm WSRT front-ends were decommissioned, an observation was made that took advantage of the unique capability to rotate their feeds to arbitrary position angles and thereby form an inhomogeneous array. This data will be analysed with the AIPS++ software that is the first to be developed on the basis of the Measurement Equation.

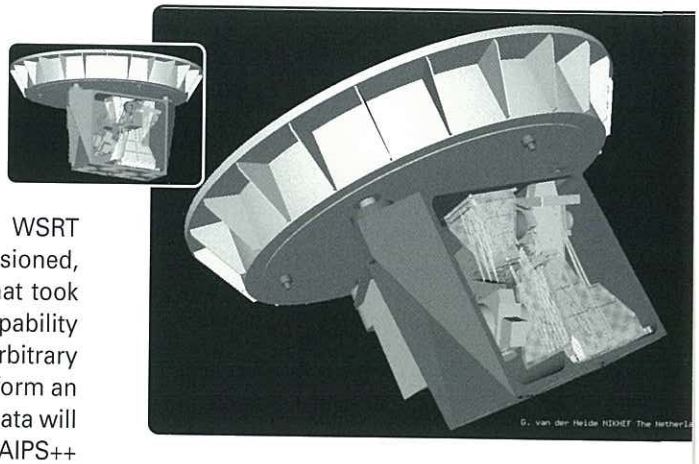


Figure 2.6
3D view of the VISIR mechanical layout.

Optical Research and Development

VISIR ESO-VLT Project

VISIR, an acronym for VLT Imaging and Spectroscopy in the InfraRed, is an instrument that will now be installed at the Cassegrain focus of VLT Unit Telescope 3 in 2001. The Service d'Astrophysique of CEA/DAPNIA at Saclay near Paris is responsible for the imager part and the instrument infrastructure while NFRA will develop and build the spectrometer. Parts of the NFRA-side of the work have been contracted out to NIKHEF (Amsterdam) and SRON (Groningen) for the design and production of specific modules. The formal kick-off was in December 1996 and the first phase ended with a successful Preliminary Design Review at ESO's headquarters in Garching (Germany) at the end of 1997. Approval was given to go ahead with the final design that is to be concluded with a review at the end of 1998.

The main task this year was to prove that a good mechanical design could be made to support the existing optical design. Because the instrument is to move with the telescope, special attention needs to be paid to the mechanical stability of the instrument while at the same time keeping its weight as low as possible. Observations in the thermal infrared require the camera to be cooled to about 30 K. The low weight is therefore also necessary to fulfil the strict requirements imposed by ESO on operational aspects like maximum cool-down time.

While NFRA acted as leader of the Dutch part of the collaboration, the expertise available at different institutes in the Netherlands were used to the full. SRON had already designed and built grating scanners for the Infrared Space Observatory (ISO) satellite. These scanners formed the basis for the low and medium resolution mode in VISIR. SRON also designed the high-resolution scanner, which contains the largest optical element in the instrument, an echelle with different gratings on both sides. A blank was produced and tested to make sure that light-weight construction would meet the strict optical requirements. NIKHEF participated in the design and especially the Finite Element Analysis and model testing. NFRA and NIKHEF together developed a method to use the results of the mechanical design to determine its effects on the stability and quality of the image on the detector (see next section below).

Integrated Opto-Mechanical Tolerance Analysis

The high requirements set on the optical quality of VISIR during astronomical observations have made an integrated approach to both optical and mechanical modelling necessary. A procedure

has therefore been developed to carry out an integrated analysis and this procedure has been applied to the VISIR spectrometer currently under development at NFRA.

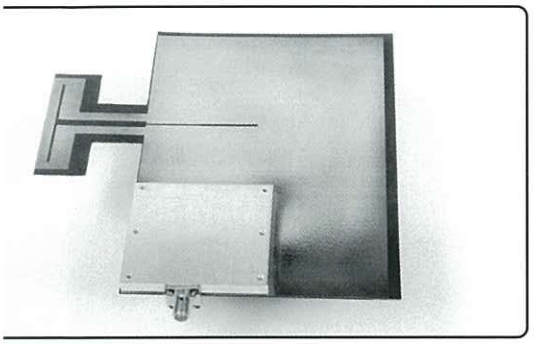
The VISIR spectrometer optics consist of a number of (mostly) non-spherical surfaces. These could easily move or tilt with respect to the telescope due to the effect of gravity during observations. In order to reach the required image stability of < 0.1" per hour, the optics need to be very stable regardless of the orientation of the telescope.

The optical design package ZEMAX was used repeatedly to guide the mechanical design process and to check the results: starting with individual optical elements, the sub-systems and finally the complete instrument. Although the intrinsic sensitivities of the system can be taken into account in the design process, this alone is never a guarantee for the accuracy of the final design. Combinations of movements or rotations might still cause changes in the optics that fall outside the specifications. Therefore ZEMAX was coupled to the mechanical design package IDEAS used at NIKHEF. The results of Finite Element calculations performed with IDEAS were written in a table of movements and rotations of elements with respect to the instrument at rest. The table was subsequently read by ZEMAX and included in the optical model. In this way the effect of gravity on the optics can be modelled, which has resulted in a mechanical design that ensures that the optics stay within specifications. This unique procedure enormously enhances the confidence in the correctness of the final design.

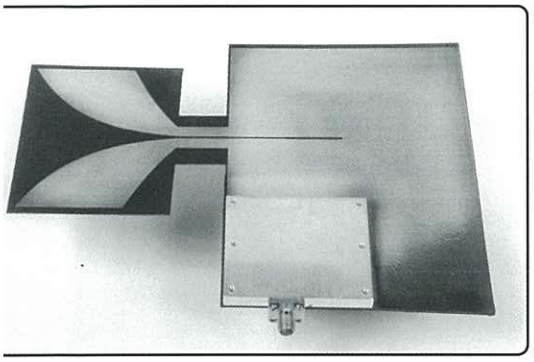
Development for SKAI

3

Momentum is gathering in the international (radio-) astronomical community for a logical next step in the field of centimetre to metre wavelength radio astronomy. The generation of radio telescopes constructed between the early seventies and mid-eighties (such as the WSRT and NRAO's VLA in New Mexico) is witnessing its last set of performance upgrades. In order to make a major advance in sensitivity it is clear that a collecting area of the order of a million square metres (one square kilometre) is needed. SKAI, which stands for Square Kilometre Array Interferometer, is the term used by astronomers in the Netherlands to describe this next generation radio telescope.



(a) Folded dipole element



(b) Bunny-ear element

Figure 3.1
Two examples of in-house developed printed antenna elements with an integrated balun.

Discussions regarding the scientific drivers for SKAI have been taking place at an international level since 1993, in the case of astronomical discussions under the stewardship of the URSI Large Telescope Working Group (LTWG). Technical workshops have also been held at regular intervals. In June of 1997, a two-day workshop was held in Leiden, to discuss scientific drivers for SKAI, and in December a combined LTWG and Technical Workshop was held at the Radiophysics Laboratories of CSIRO in Sydney, Australia.

While groups in Canada, India, China and the USA are pursuing other technologies, both NFRA and the Australian radio astronomy community are focussing on the innovative observing possibilities offered by the adaptive phased array concept. Such a telescope would consist of a large number of small receiving antenna elements placed on a grid. By combining the amplitudes and phases of each telescope in different ways, electronic steering of the measurement beam, as well as simultaneous and independent multiple beams on the sky would become a possibility. Other benefits of this design are the adaptive suppression of interfering signals, and the flat and therefore unobtrusive profile even for very large antennas.

It was decided in 1996 that a large portion of NFRA's R&D effort in the following years should be dedicated to developing the technology required to apply the adaptive phased array concept in a future radio telescope. To achieve this goal, a series of increasingly complex demonstrator systems are to be designed and built. This year saw the completion of the first system: AAD, the AdaptiveAntenna Demonstrator. Following on from this, the next stage - the One Square Metre Array (OSMA) - was designed, and a preliminary design for the third stage - the THousand Element Array (THEA) - was completed. These projects, together with several SKAI research studies are summarized below.

Phased Array Antenna Research

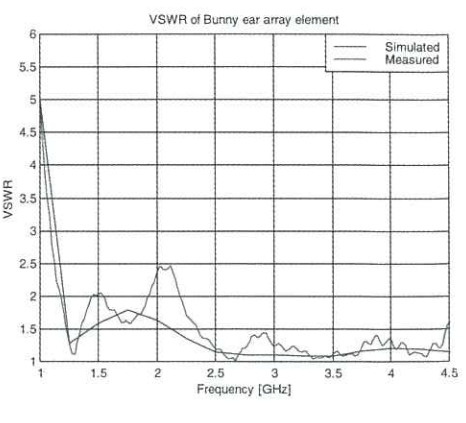
Electromagnetic Simulation of Array Antenna Structures

A phased array is an antenna that consists of a large number of small receiving elements, for example dipoles, which are placed on a regular grid. By changing the amplitude and phase of the received signals from each array element, the main beam of the array can be steered electronically to any position on the sky. So with a phased array the complete sky can be monitored without the need of any mechanical moving parts. In addition, several independent beams can be placed on the sky simultaneously without loss of sensitivity.

When an antenna element is placed in an array environment, its electromagnetic properties will change significantly due to mutual coupling between the array elements. This coupling degrades the (active) input impedance of each element and affects the radiation /receive pattern and corresponding polarization characteristics of the total array. Therefore, the electromagnetic behaviour of the complete array structure needs to be optimized rather than the performance of an isolated antenna element. The most important parameters that will be optimized for the SKAI antennas are the frequency bandwidth and the aperture efficiency. At NFRA, two approaches have been developed to analyse and optimize the electromagnetic behaviour of phased array antennas: 1) the finite-array approach and, 2) the infinite-array approach. In the case of a very large array (like SKAI), the infinite-array approach will be a very efficient and accurate way to analyse the array performance. Small arrays (like AAD and OSMA) and elements near the edge of a large array can only be analysed properly with the finite-array approach. Both approaches use a numerical procedure to solve Maxwell's equations for the array structure.

For the design of the OSMA array use was made of this electromagnetic simulation software in order to optimize the performance of the array in the frequency band from 2 to 4 GHz. Several wide-band printed antenna elements with an integrated transition (balun) from co-planar strip-line to micro-strip were designed and tested experimentally. Two examples of antenna elements that were built are shown (Figure 3.1). A second figure

Figure 3.2
Measured and calculated performance of an antenna element in an array environment.



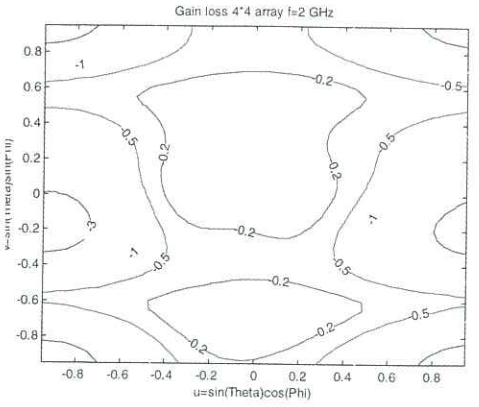


Figure 3.3
Contour plot of the computed gain loss of a 4x4 array with the bunny ear elements shown above.

(Figure 3.2) shows the predicted and measured performance of the bunny-ear element in an array environment. The diagram shows the Voltage Standing Wave Ratio (VSWR), which is related to the amount of energy that is received by the antenna. A VSWR < 2.5 is considered to be acceptable.

In general, the performance of a phased-array antenna depends on the frequency and on the scan angle of the main beam. This is illustrated in the Figure 3.3, where a contour plot of the gain (in dB) is shown as a function of the position of the main beam in antenna coordinates, here denoted (u,v), for an array of bunny-ear elements. The dependence on scan angle is caused by mutual coupling between the array elements. At larger scan angles a loss of more than 3 dB (=50% power loss) is found. Design strategies aimed at optimizing this behaviour for different array configurations have started and will be further developed in the coming years.

Dense Array Configuration Studies

Configuration studies were performed during the year to generate solutions to the simultaneous requirements of very wide bandwidth and constant effective area. Three main array concepts were studied: a fractal array, a switched array and a dense grid array.

The fractal array consists of a hierarchy of antenna elements, that each cover one octave of the desired decade bandwidth. The elements are positioned in a self-similar fractal structure to ensure complete filling of the aperture at all frequencies. Using dipole elements, good reception in three narrow bands has been achieved, but the full frequency coverage has not yet been reached, and will remain under investigation.
The switched array was made up of a set of dipoles in which the electrical lengths of the components are determined by diode switches. This concept proved unsuccessful due to the system noise contribution from the switches.

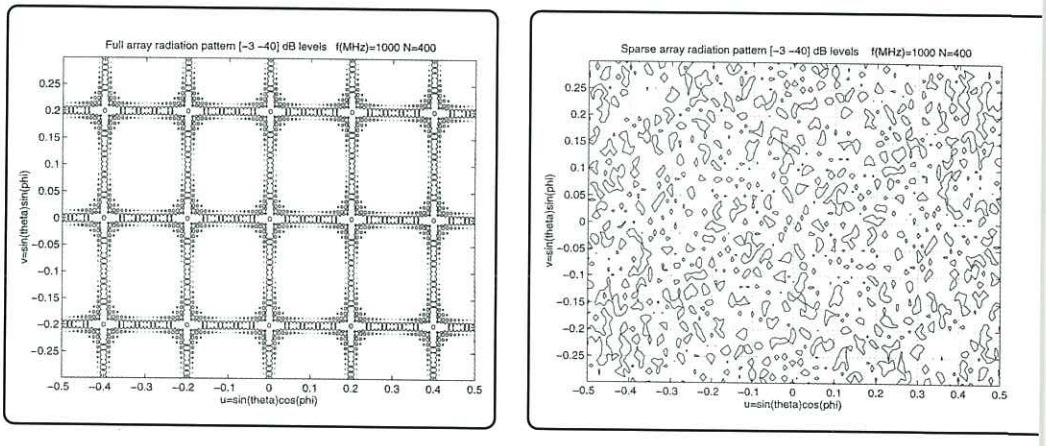
The dense grid array is constructed using individual antenna elements in a closely packed configuration. This concept uses the strong coupling between elements to achieve the decade bandwidth, while simultaneously keeping the effective area constant. Results of theoretical calculations in the literature are promising and indicate that a 1:7 bandwidth is achievable. A first design using Bunny Ear antennas will be used in OSMA.

Sparse Array Configurations

As discussed above, the desired ultra wide frequency bandwidth is one of the major challenges in the designs for SKAI. The decade of bandwidth could be split up into several frequency regions, that each use a separate antenna with an element separation less than half a wavelength in order to avoid grating lobes. The main disadvantages of this concept are the complexity (costs) and mutual coupling between the various radiating elements. An interesting alternative option for SKAI (from a cost and complexity point of view) is the use of ultra wide-band elements that cover a decade of bandwidth. These elements could be placed at half a wavelength distance at the lowest frequency. However, this would amount to an element spacing equal to ten or more wavelengths at the highest frequency. The disadvantage of this so-called sparse-array concept is the appearance of grating lobes at the higher frequencies and the fact that the effective area decreases with increasing frequency.

However, it is possible to eliminate the appearance of grating lobes in a sparse array by using a (quasi-) random distribution of the array elements. In addition, blind scan regions caused by mutual coupling in a periodic array can also be eliminated. The features of random sparse arrays can best be summarized as follows:

- Ultra wide-band grating lobe suppression over the complete scan range without a loss in efficiency.
- No blind scan regions due to mutual coupling.
- Narrow beamwidth (high resolution) compared with a dense array with the same number of elements.



a) b)

Figure 3.4
Receive patterns of a) an equi-distance sparse array and b) a random sparse array at f=1000MHz.

As an example, the figure shows the antenna pattern in the sky-plane of a sparse array with a regular spacing between the array elements and the antenna pattern of a random sparse array, both operating at a frequency of 1000 MHz. The main lobe is at (u,v) = (0,0). It is clear from these figures that the grating lobes have disappeared in the case of a random sparse array at the expense of an (almost) constant sidelobe level. The advantages and disadvantages of random sparse arrays for radio astronomy (SKAI) will be investigated in more detail at NFRA in the coming years.

Materials Research

During the year, a study was carried out to assess the support material and technologies suitable for use in flat array antennas. Various foams have been characterized for their dielectric constants and loss tangent properties, as well as for water absorption. Several promising materials have been identified, of which poly-ethene can also be used in mass production techniques such as high vapour injection moulding. Future studies will focus on Moulded Interconnect Devices that can be given a metallic coating and used in antennas, but also in housing electronic components (RF beamformer, frequency conversion, digitization) .

Photonics for SKAI

Since the advent of the semiconductor laser, the coherent light source has left the physics laboratory. Now, together with modulators, fibres, light detectors, optical splitters, amplifiers and filters, they have formed the class of photonic components that are being used by the electronic engineer to replace the coaxial cable and the microwave link as a way of transporting wide band signals.

On a SKAI antenna site we expect the need to transport signals typically with a 2 GHz bandwidth from the tiles to the beamformer over an average distance of about 200 m. In such cases, optical fibre cable is not only much cheaper than a coaxial cable, but also avoids the chain of equalizing amplifiers. In turn one needs electro-optical converters. Fortunately SKAI prototype antennas are already of a scale that make it attractive to develop the appropriate photonic converter devices at a price comparable to that of the electronic Integrated Circuits used for the WSRT upgrade.

A technology assessment study has identified a particularly interesting photonics processor. A photorefractive crystal combines all the coherent optical signals from up to many thousands of fibres onto a single linear Charge Coupled Device detector which provides all necessary delay for true time delay beam forming. The required hologram in the crystal is generated by optical interference between electro-optically modulated fibre signals with an acousto-optically modulated reference signal. In a radar application the received signals are delayed versions of a transmitted one. For an astronomical receive-only application one needs to generate at each receiver an appropriate signal that will be given the proper delay relative to the centrally generated one to make the beamformer only sensitive for received signals from a particular direction. Key to the actual implementation of this technique for SKAI and its prototypes, is the availability of appropriate optical modulators. In collaboration with a group at the Department of Electrical Engineering at the University of Colorado, an investigation has started aimed at finding a resonant low power driver that can be integrated with a conventional lithium niobate modulator.

Although these agreements have brought NFRA right at the forefront of photonic beam forming with coherent optics, there are many different ways of implementing beam forming for a phased array antenna. Most of the approaches found in the literature try to satisfy overall system requirements that stemfrom radar applications. To address the issue of photonic architectures for receiver arrays and their required key components, the scope for a joint feasibility study has been defined by the Applied Physics Laboratory (TNO-FEL) and NFRA that will receive support from the Dutch Navy.

Impedance Matching Issues

During 1997 research was started to develop techniques for optimally integrating antenna elements into the pre-amplifier circuit. Of particular interest are the possibilities afforded by matching voltages instead of the traditional power matching. This shift from the 50 Ohm paradigm is not revolutionary but offers to simplify functional integration and minimize power consumption. Research at NFRA focusses on applications in which sub-resonant elements are operated in an array environment. Our ultimate goal is to investigate this approach for minimizing cost while also producing an array antenna whose effective area increases as the square of the wavelength.

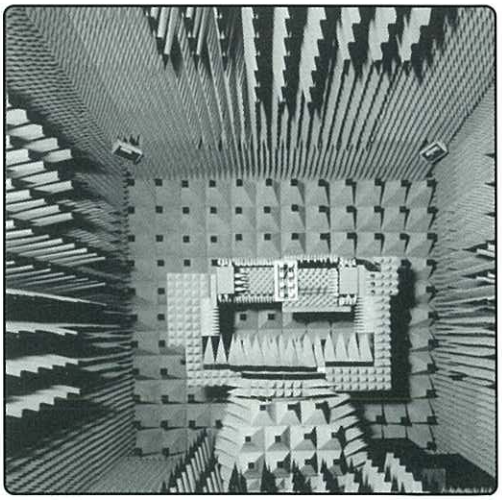


Figure 3.5
The Adaptive Antenna Demonstrator on the positioner inside the anechoic room.

Phased Array Antenna Demonstrators

The Adaptive Antenna Demonstrator

The Adaptive Antenna Demonstrator (AAD) was the first antenna array to be constructed in the SKAI feasibility study. AAD was built to demonstrate the principle of adaptive beamforming and to provide a platform on which adaptive beamforming algorithms could be tested in practice. Other features were an ability to track sources electronically and to adaptively null a Radio Frequency Interference (RFI) transmitter. The system already provides information on the achievable level of adaptive RFI suppression and on the relation between suppression level and system parameters. AAD has also given insight into the characteristics of the adaptively formed beam as a function of angles of incidence and power levels of source and RFI signals.

The AAD system consists of eight patch antennas arranged in a 2 x 4 array, eight receivers, and an adaptive digital beamformer. The array was installed in the Antenna Measurement Setup (AMS) in NFRA's anechoic room together with two far-field transmitters to simulate an astronomical and an RFI source. The antenna was mounted on an alt-azimuth positioner to simulate the movement of the earth. An adaptive beamformer spatially filters unwanted signals so that they do not interfere with the resulting image. An important feature of such beamformers is that no knowledge of the unwanted signals (such as their direction of arrival) is required. The adaptive beamformer chooses the spatial filter that is optimal regardless of the distribution of interfering signals. By contrast, the Fourier (non-adaptive) beamformer, which is the basis of astronomical imaging, is optimal only in the special case where there are no interfering signals.

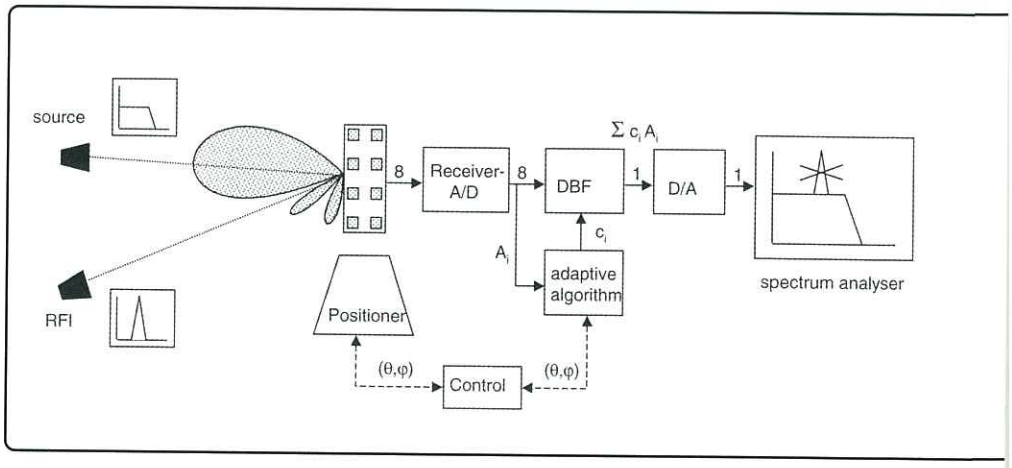
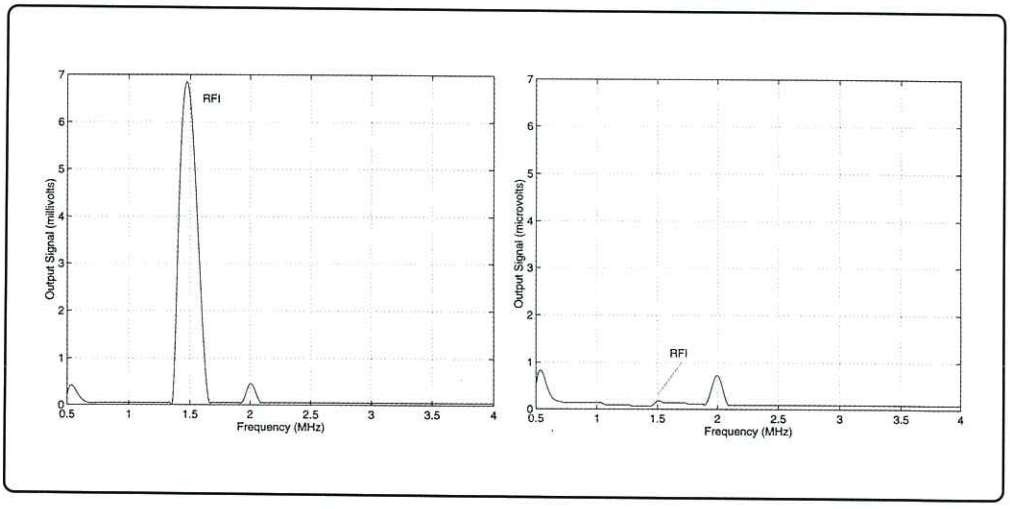


Figure 3.6
Setup of the Adaptive Antenna Demonstrator. A noise source and a single tone source simulate an astronomical signal and an RFI transmitter. Both signals are received by eight antenna elements. They are combined and steered in the direction (θ,ω) of the source by the adaptive digital beamformer (ADBF). The output of a simple Fourier beamformer would contain both signals. The Minimum Variance adaptive beamforming algorithm minimizes the ratio of signal to interference plus noise, thus reducing the RFI signal in the output.

The spectra in the figure show the output signal with standard Fourier beamforming and with adaptive beamforming. The large peak in the left graph is due to RFI. This signal has been suppressed by 33 dB (with respect to the source signal) when adaptive beamforming is applied. Up to 38 dB of suppression has been achieved.

In one of the AAD experiments two signal sources were used to make two different radio images of the room (see figure). The first image used the Fourier beamformer and the second image used an adaptive beamformer called the Minimum Variance beamformer. Ideally, both should show delta functions at the locations of the two signal sources. The Fourier beamformer image is a convolution of the source delta functions and the array's point spread function, which is very broad because the array is small. In addition, the image is also aliased because the array elements have > $\lambda/2$ spacing. The result is that the two signal sources can barely be identified in the Fourier beamformer image. On the other hand, the adaptive beamformer produces an image with two clearly identifiable point sources. The adaptive beamformer gives a superior image because it treats the signal sources as interference in all directions other than their directions of arrival.



a) b)

Figure 3.7
Spectra of RFI and noise sources with a) standard Fourier beamforming and b) with adaptive beamforming.

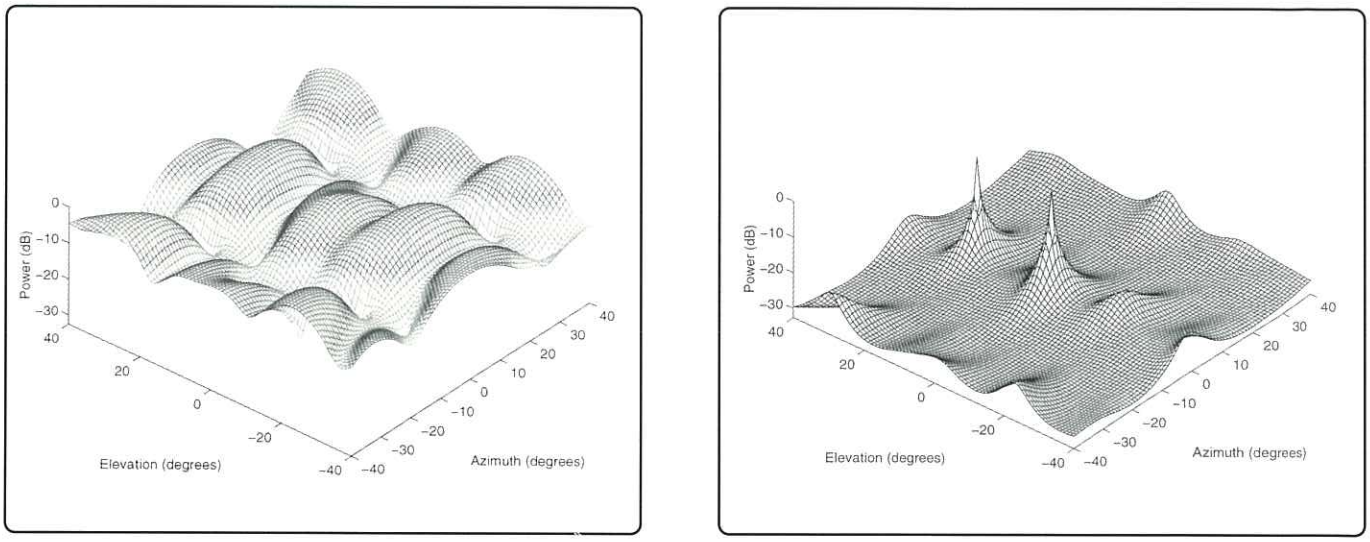


Figure 3.8
Radio images of the anechoic chamber using
(a) the Fourier beamformer and
(b) the Minimum Variance beamformer.
The images show received power versus direction of arrival (azimuth and elevation).

The One Square Metre Array

In the course of the year development of the One Square Metre Array (OSMA) started. OSMA is to be built to demonstrate the principle of multibeaming with the full collecting area being used by each beam and also to test the concept of hierarchical adaptive beamforming with both RF and digital beamforming. With a minimum bandwidth of one octave (2-4 GHz), OSMA will cover the transition zone between sparse and dense arrays. Furthermore, system noise behaviour of the array can be studied as a function of mutual coupling and electronic steering. The design of OSMA has been optimized to allow a wide variety of configurations to be studied. The basic functionality is due to be implemented in the Summer of 1998, while OSMA should be fully operational by the end of the year.

OSMA consists of a 64 element single polarisation array, a dual beam RF beamformer, a 16 channel receiver and two adaptive digital beamformers. The array is removable to allow different array types to be investigated. At present, one bunny-ear array and one bowtie array are being developed. The elements are to be positioned on a rectangular grid with a separation of 7.5 cm.

Development of new adaptive digital beamforming boards was started towards the end of 1997. An ASIC, the "OSMA chip", is being developed by DIMES with a CORDIC implementation of the Minimum Variance algorithm for application in the OSMA set-up. This chip will calculate new beamformer weights every 10 ms, which corresponds to an increase in computing power by a factor ten compared with the AAD system.

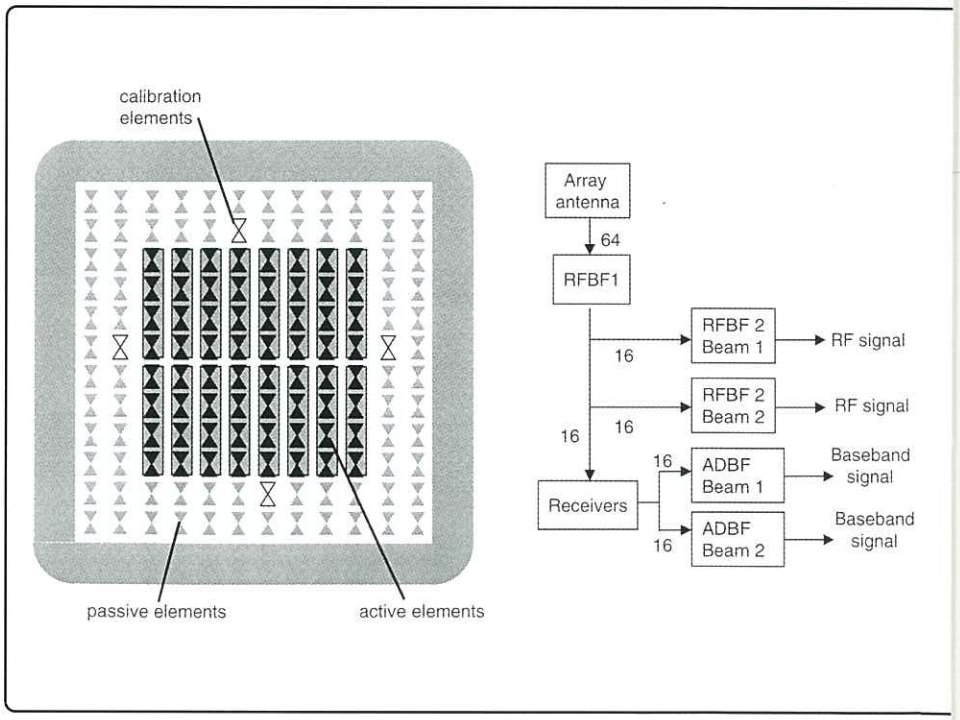
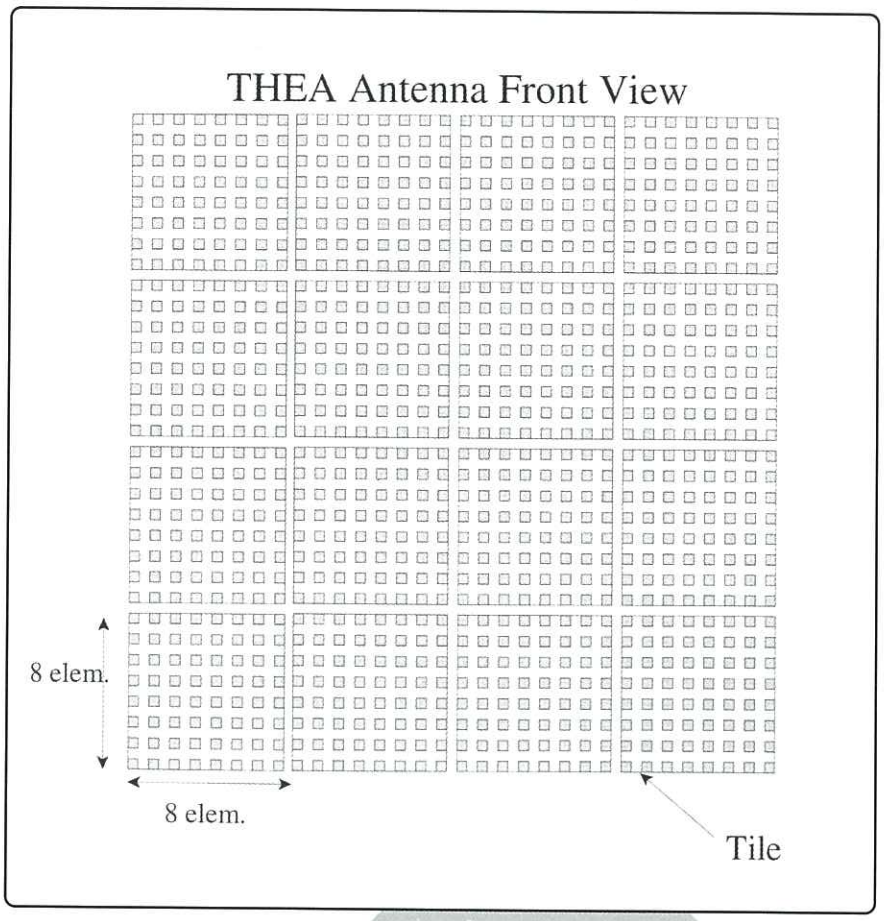


Figure 3.9
Array configuration left and functional design right of the One Square Metre Array. The 64 element central array outputs are combined to 16 RF signals by RF beamformer one (RFBF1) in vertical linear sub-arrays of four elements (grey shaded areas). The 16 outputs of these sub-array beamformers are transmitted to the second stage beamformers (RFBF2 beam 1 and 2) and to the receivers. The 16 receiver outputs are connected to both adaptive digital beamformer subsystems (ADBF beam 1 and 2).

THEA - Thousand Element Array

The THousand Element Array (THEA) is the third demonstrator phased-array system that is being developed during the initial phase of the SKAI development programme. Development will start in the second half of 1998 and is to be finished by the first half of 2000. THEA is an out-door phased-array system. The aim of THEA is to detect astronomical signals from strong sources (using simultaneous multibeaming) in an environment with a number of RFI sources. The unwanted RFI sources will be suppressed with the adaptive nulling capability of THEA. The system will consist of 1024 receiving antenna elements distributed on a regular grid over a surface of 16 m2. The performance is to be optimized in the frequency band from 750 MHz to 1500 MHz. Electronic beam-steering will be done with a mixed RF/digital beamforming architecture. In this way, multiple beams over the entire sky can be made simultaneously without the loss of sensitivity. The figure shows a front view of the proposed system. Each of the 16 tiles holds 8x8=64 receiving elements. The tiles form the building blocks of the THEA system. The signals from each of the 64 elements in a tile will be coherently combined by an RF beamforming unit and converted to a digital signal. The 16 digital output signals of the tiles are distributed to a central digital adaptive beam forming unit. Each tile will have two separate RF beamforming units. In this way, two independent RF-beams can be made simultaneously with each tile. Within each individual RF-beam multiple beams can be made simultaneously with the digital beamforming unit. An on-line calibration facility will be available to monitor and correct the performance of each receiving element.



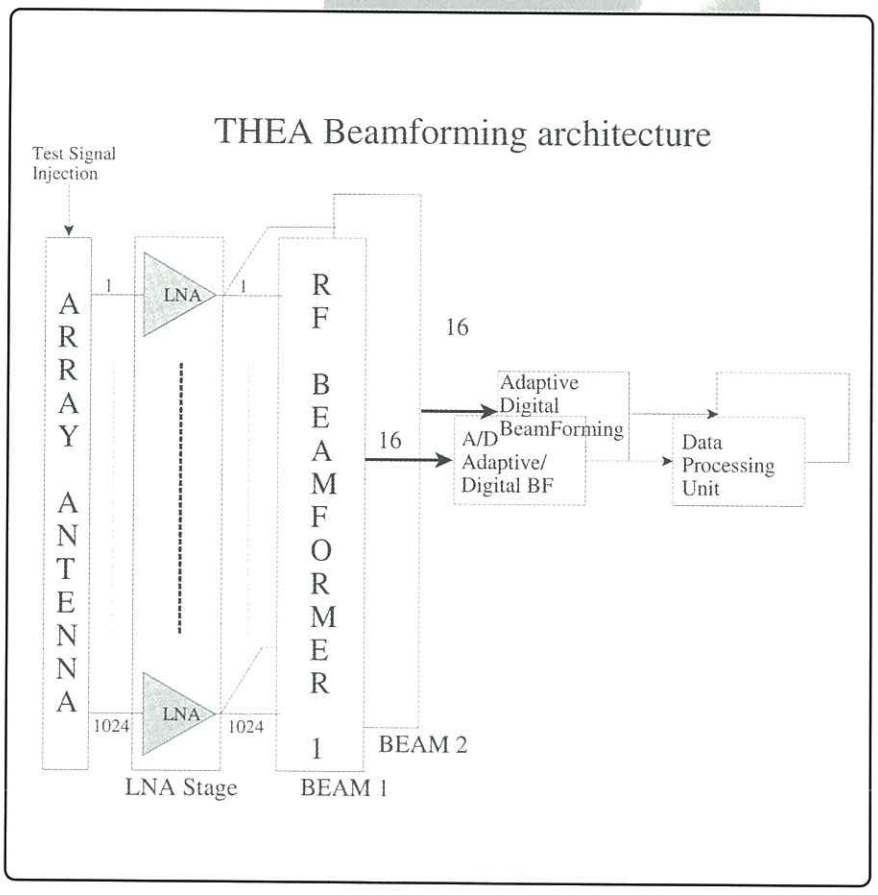


Figure 3.10
(a) THEA front view and
(b) THEA RF/digital beamforming architecture

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Institute

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Science

NFRA's institute in Dwingeloo and Westerbork is dedicated to providing world-class observing facilities and to carrying out innovative technical R&D in support of astronomical research. Essential to the success of this programme is a small research staff to provide liaison with the wider community. These staff carry out active research programmes with NFRA's facilities, wherever possible in collaboration with external users. This section reports a selection of interesting results obtained by NFRA staff astronomers, post-docs and their colleagues during 1997.

Unravelling the Mystery of Gamma Ray Bursts

Of all astronomical phenomena, gamma-ray bursts (GRBs) are probably the most energetic, bizarre, and, even now, mysterious events known. Although they have been observed for a quarter of a century, only the past year has seen a significant improvement in our knowledge beyond their pure gamma-ray properties. Discovered (accidentally) by military satellites looking for high-energy emission from nuclear tests (and, like radio emission from the sun thirty years before, first declared top secret), GRBs are (for the few seconds they shine) the brightest objects in the sky outside of the solar system. With a peak magnitude equivalent

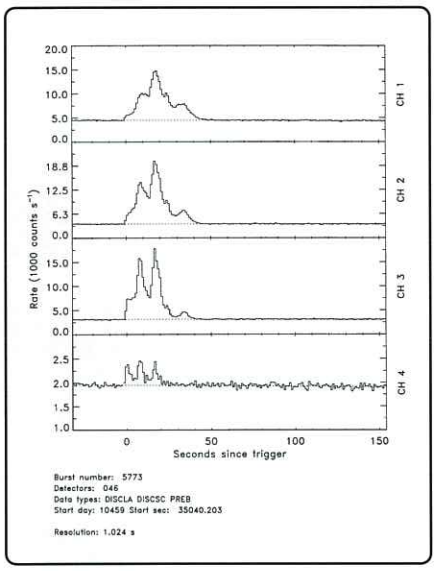


Figure 4.1
The BATSE gamma-ray light curve of GRB 970111, observed in the four energy bands of 25-50, 50-100, 100-300 and >300 keV. The time resolution is 1.024 s.

at MeV to GeV energies brighter than m_V = -6, they would outshine the brightest stars if we could "see" at such high energies. The "trouble" with GRBs is that they are so bright that if placed at extragalactic distances, the energy requirements become rather extreme, with no known class of nearby objects that could act as a plausible source. The short timescales of their gamma-ray emission (with some features lasting less than a millisecond) betray an origin in a tiny region of space, and most of the models proposed involve neutron stars, in particular the merger of a neutron star pair. The satellite-borne BATSE (Burst And Transient Source Experiment) detectors have provided a wealth of new material on GRB gamma-ray properties: light curves with good sensitivity and high time resolution, improved spectral information, many more detections for statistical studies, and much better positions. From the locations and strengths of hundreds of bursts, it is known that their distribution is uniform, while the statistics of peak burst intensity (log N/log S) reveal a population which is isotropic but not homogeneous in its spatial distribution: the data are consistent with a cosmologically evolving class of objects at Gpc distances.

Nineteen ninety seven was certainly a memorable year for GRB research, and Dutch astronomers and instruments were involved in many of the key discoveries. The first bright source of the year, GRB 970111, was monitored with the WSRT from one day to over three months after the outburst. Although no counterpart was detected, the upper limits do stretch the predictions of several models for GRB radio emission, and the observations have demonstrated the ability of the WSRT to react quickly to a transient event. A month later, GRB 970228 was the first outburst to be observed in another waveband. The gamma-ray emission was detected by a monitor aboard the Italian-Dutch BeppoSAX satellite (BATSE's view of the outburst was blocked by the earth), and by chance the SRON-built Wide Field Camera (WFC) on BeppoSAX also had the object in its 40 degree field of view. With a good position from the WFC, it was possible to direct the BeppoSAX high-resolution imaging instruments at the GRB location where a bright X-ray source was detected where none had been known before. An international team that included

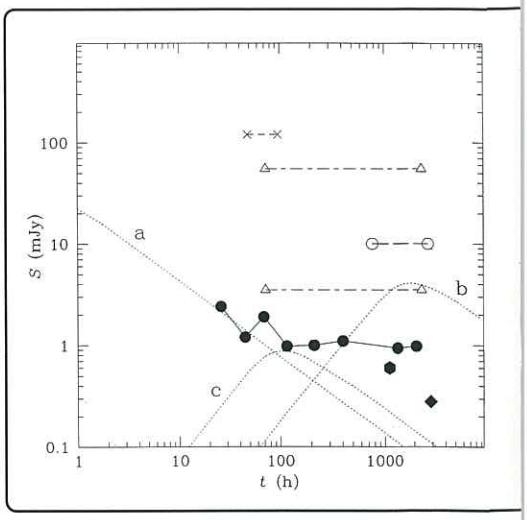


Figure 4.2
The BATSE gamma-ray light curve of GRB 970111, observed in Upper limits to the radio emission from GRB 970111 as observed by the WSRT UHF system at 840 MHz (filled circles), as well as WSRT 1.4 GHz (filled diamond) and 5 GHz (filled hexagon) limits, plotted against the time delay after the gamma-ray burst. By way of comparison, other symbols show upper limits from earlier observations of GRB 940301 with various telescopes, at 151 (crosses), 327 (open circles), 408 (upper triangles) and 1400 (lower triangles) MHz. Note in particular the improvement in sensitivity and reaction time for the 1997 data points. The dashed lines labelled a, b and c are theoretical light curves calculated for a range of model parameters. Curves a and b are for nominal burst parameters in a nearby (100 kpc) and cosmological (500 Mpc) object, respectively, while c is the behaviour expected from a gamma-ray burst with an anomalously high photon production efficiency in an extremely low ambient density.

astronomers from Amsterdam and NFRA observed the region with both the Isaac Newton and William Herschell Telescopes on La Palma, and discovered a fading, star-like object on the edge of a faint, fuzzy object, apparently a distant galaxy. GRB 970228 was also monitored for radio emission with the WSRT, but again nothing was found.

Just over two months later, GRB 970508 was also observed as an optical transient, and a spectrum obtained with the Keck Telescope revealed absorption lines that indicate a redshift of z=0.835, or more if this is an intervening system. This lower limit to its distance clearly favours an extragalactic origin for GRBs, and suggests that many are at cosmological distances, in accord with the log N/log S statistics of BATSE detections. Radio monitoring of GRB 970508 soon resulted in detections: within the first few days by the VLA at 8 GHz, and shortly thereafter by the Ryle

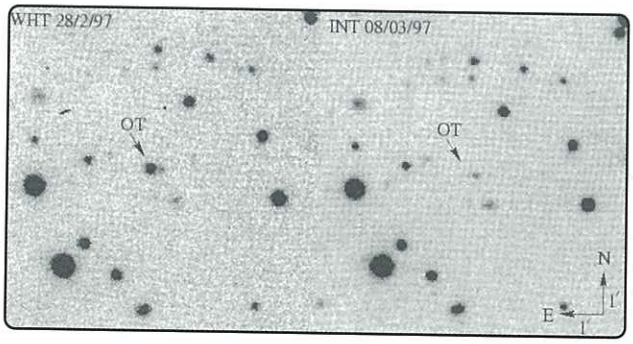


Figure 4.4
Optical images of the transient associated with GRB 970228, showing the clear decline in intensity in observations made with the William Herschel Telescope (left) some 20 hours after the burst, and the Isaac Newton Telescope (right) 8 days later (images made with Anglo-Dutch telescopes on La Palma).

Telescope at 15 GHz and by the IRAMPlateau de Bure Interferometer at 86 GHz. Emission at 21 cm was observed by the WSRT after some 50 days (with the new MFFE receivers which come into operation in 1998, it will be possible to observe and detect objects like GRB 970508 at short wavelengths within days of the outburst). The non detection at 21 cm in the early weeks sets interesting limits on the low-frequency spectral turnover, which compare well with the expected behaviour from model calculations.

In all, some 7 GRBs in the first 8 months of 1997 were the subject of intensive investigation. At least four of these were detected as X-ray sources, but just two were caught as optical transients and in only one case was radio to millimetre emission seen. For the objects detected, like GRB 970508, the behaviour appears to conform with that expected from a relativistically expanding fireball. This does not, as yet, significantly constrain the nature of the explosive event itself. So far, emission has been detected from GRBs of both average (GRB 970228) and weak (GRB 970508) gamma-ray fluence, but none was found in several intense GRB events. This makes it clear that there is no simple scaling of the energy released in different bands. The mystery of the gamma-ray bursts is beginning to unravel, but much work remains to be done in the coming years.

Neutral Hydrogen in High Redshift Galaxies.

The study of the evolution of gas content of the Universe, either in galactic disks or in the intergalactic medium, is of considerable cosmological importance and is currently one of the main foci of astronomical research. Most of the neutral gas in the local Universe is tied up in the form of spiral galaxies, and it is generally expected to be even more so at higher redshifts. Understanding how the gas content of galaxies changes with time is an essential ingredient for a proper appreciation of galaxy formation and evolution. The easiest way would be to directly measure the amount of gas present in galaxies at different epochs, but this requires the detection of emission from the neutral gas. Current radio telescopes are still not sufficiently sensitive to detect the very abundant neutral hydrogen in emission at redshifts greater than 0.2, so at present one is forced to use a bright background continuum radio source as a means of probing the gas in absorption. The new tunable UHF receivers installed at the WSRT were designed with this sort of observation in mind. An example of one of the first systems studied with the new receivers is the absorber towards the 3C196.

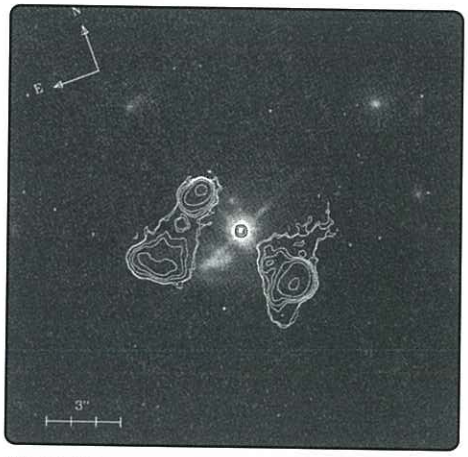
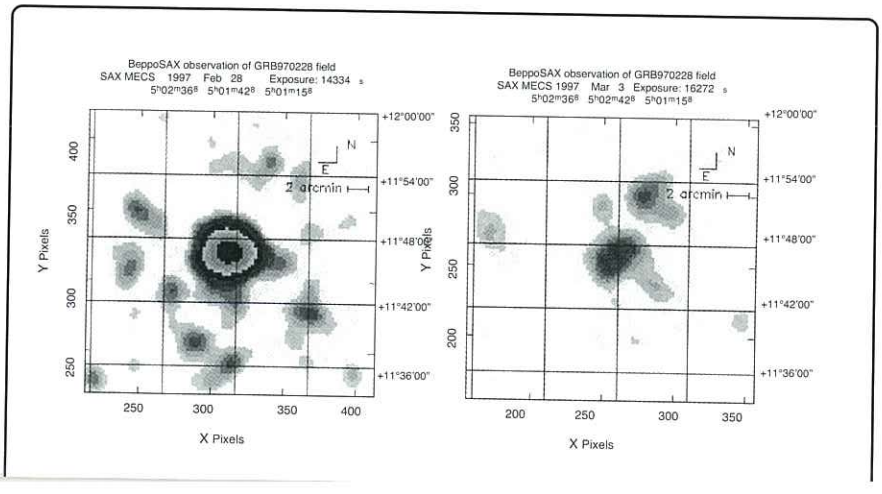


Figure 4.5
An HST image centred on 3C196. Also shown are the 6 cm flux contours. The QSO image is saturated, which causes the spikes, but a barred spiral galaxy is clearly visible to the south-east of the QSO. (Image courtesy of R. D. Cohen)

The intervening absorption system (at a redshift of 0.473) towards the quasar 3C196 (itself at z=0.871) had already been detected in the early eighties, but a recent HST image, reproduced above reveals the intervening object to be a large barred spiral galaxy located about 1.5" southeast of the optical quasar. One of the curious features about the HI absorption was its narrow velocity width: despite an extent of the continuum source of more than 8" (50 kpc at the absorber's redshift) the absorption line was only 50 km/s wide. New WSRT observations now show that not one but two systems were responsible for the absorption. The WSRT spectrum, shown below, is evidence of this fact.

The high dynamic range of the WSRT data, allows the centroid of the source to be determined with an accuracy better than 1 part in 8000 of the synthesized beam. Figure 4.7 shows how in three groups of continuum channels, away from the absorption lines, the centroid position is found to be independent of frequency to within a few milli-arcseconds. This centroid lies about

Figure 4.3
The BeppoSAX image of soft X-ray emission from GRB 970228, showing the declining X-ray emission from the transient. The first image (left) was taken just a few hours after the gamma-ray burst, while three days later the source (right) was twenty times weaker. (Image courtesy of the BeppoSAX Team and available on the BeppoSAX homepage at the ASI Science Data Centre http://www.sdc.asi.it.)



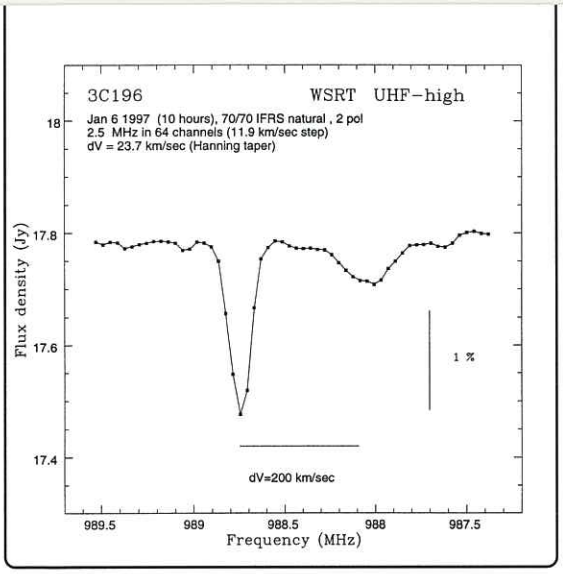


Figure 4.6
A regular synthesis mode spectrum of 3C196. The spectral resolution is about 24 km/s.

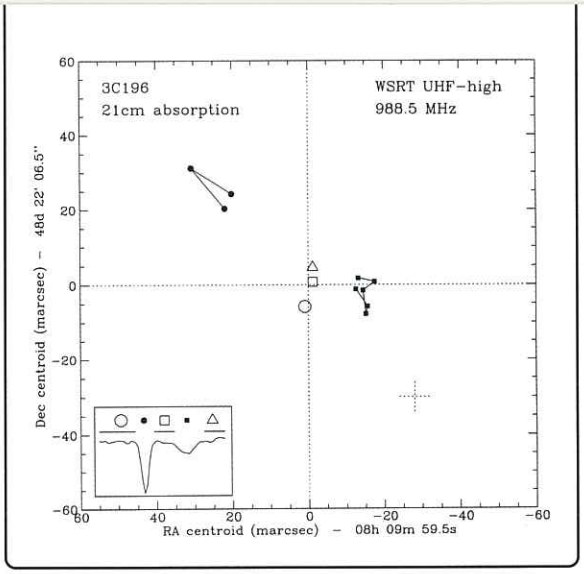


Figure 4.7
Centroid position of 3C196 as a function of frequency. Note that the scale is in milli-arcseconds. Six channels of the shallow absorption and three channels of the deep absorption feature are shown. Other symbols are explained in the box in the lower left. The 1-sigma error bar per channel (4 mas) is shown by the dotted cross. The continuum symbols represent averages over many channels, and therefore have a much smaller error.

halfway between the two radio lobes. In the absorption channels we see a systematic shift of the centroid. By taking the depth of the absorption into account we can deduce the true location of both features. The deepest absorption comes from a position 2.4" southwest of the centroid, and coincides with the brightest hotspot in the continuum radio image. The shallow absorption feature lies about 4" east-northeast of the continuum centroid. This corresponds to the much diffuser eastern lobe of 3C196.

The location of the absorbing gas leaves no doubt that the barred spiral seen in the HST image is responsible for the 21 cm absorption. The absorption found previously was caused by a single narrow beam towards a bright hotspot, which explains the small velocity spread. The velocity difference found between the two features in the new data is entirely consistent with a spiral galaxy with a rotation velocity of about 250 km/s. The total extent of the absorption indicates that we are dealing with a very gas rich spiral with projected dimensions of at least 6" (at z=0.473) or 40 kpc and a total amount of some $10^{10} M_{\odot}$ of HI.

This project has shown that HI absorption studies of extended and distant radio sources are an excellent way of probing the spatial distribution and kinematics of disks of HI at high redshift. Extensive studies of many more systems will be undertaken in future.

Jupiter's Radiation Belts and the Encounter with Shoemaker-Levy 9

The collision of the comet Shoemaker-Levy 9 (SL-9) with Jupiter in July of 1994 provided a unique opportunity to study the interaction of impacts on the atmosphere of the planet. In particular, radio observations were thought to be useful in detecting changes in the radiation belts. After it had become clear that the comet would collide with Jupiter, there was international coordination of efforts to observe the impacts with a variety of telescopes. Although it was uncertain what the effects on the Jovian radiation belts might be, a number of radio telescopes took part in an intensive campaign to monitor the planet from metre to cm wavelengths. Since the expectation had been that the effects were likely to be subtle at best, and the only printed prediction was that dust might cause a decrease in the radio emission, it was surprising to find that there was a very marked increase in radio intensity during the week of impacts. This increase was more pronounced at shorter wavelengths (the spectrum "hardened"), and the return to normality was more rapid at the long wavelengths.

At radio wavelengths, measurements of the variation in total flux density were based upon observations made with both single dishes and interferometers like the WSRT. In addition, the imaging capabilities of both the WSRT and the VLA were combined in an attempt to see whether the increase and subsequent decrease in intensity produced other changes in the brightness distribution of the radiation belts. To first order, the radiation belts can be thought of as a torus tied to the Jovian magnetic field, that produces a brightness distribution rather like a double radio source straddling the planet (see figure). The magnetic axis is tilted with respect to the rotation axis, and slightly off-centre, so the torus is not uniformly bright, and wobbles as the planet turns. Maps of the radio emission show changes in brightness and morphology linked to the rotation phase. These changes had been observed to be

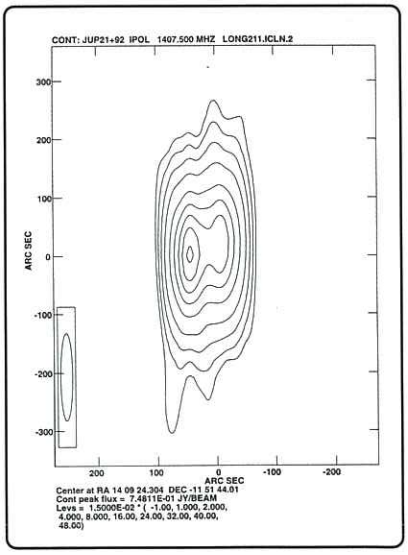


Figure 4.8
WSRT 20 cm map of Jupiter based upon pre-impact data for a Jovian central meridian longitude (CML) of about 210 deg. The contour interval is logarithmic; note the intensity difference between the peaks, which changes systematically with CML.

stable on a timescale of years before the encounter with SL-9.

The combined WSRT and VLA 20 cm observations were used by astronomers from Berkeley, Leiden and NFRA to characterize the intensity variations, by comparing quantities such as the intensity ratio of the two main peaks as a function of Jovian longitude. Normalising the ratio by the "undisturbed" behaviour (determined from observations made before the first impact), it was apparent that this simple quantity showed very substantial deviations in the week of impacts, and took over a month to return to normality. Other quantities, as well as details in high resolution VLA maps, were also abnormal, and the relaxation time was longer than the normal electron drift time. It is clear that the impacts induced major changes in the radiation belts, possibly by the excitation of long-lived plasma waves, which continued to "ring" throughout the magnetosphere for weeks after the last event.

The radio data taken during the SL-9 impacts contain crucial information on the physical processes and overall dynamics of the Jovian magnetosphere. During and immediately following the week of impacts the system could not be considered a steady-state system, where the particle motions are controlled by "known" electromagnetic forces. The experiment conducted for us by Shoemaker-Levy 9 has already triggered a flurry of activity in magnetospheric research, which may continue for several years to come.

Neutral Hydrogen in Compact Symmetric Objects

Compact Symmetric Objects (CSOs) are Active Galactic Nuclei with a radio structure that extends over less than 1 kpc. In rival hypotheses, these sources are either small because they are young, or because they remain

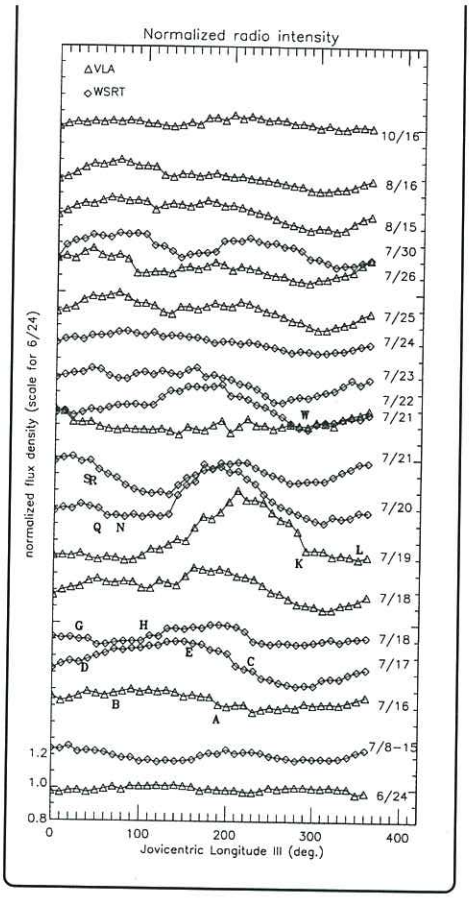


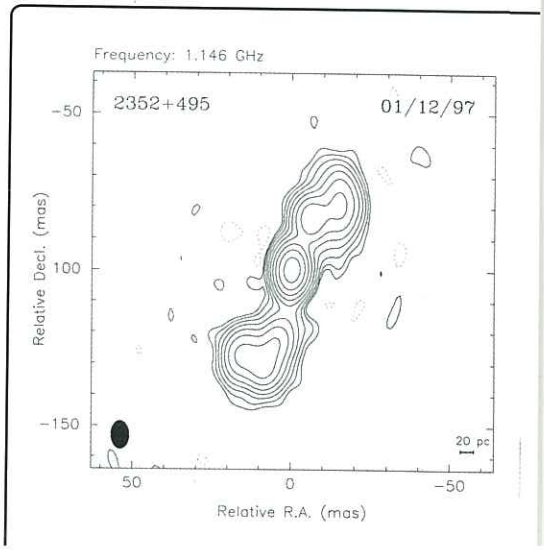
Figure 4.9
The radio brightness as a function of Jovian CML, normalized to normal behaviour. (This is in effect one-dimensional tomography of the peak brightness changes.) Because of the normalization, the pre-impact (bottom) curve is essentially straight. The intensity scale, shown at the bottom left, is the same for all curves, which have been displaced upwards for clarity. (Dates for each curve are indicated at the right.) Letters indicate the approximate longitudes of each of the recorded impacts (A-W). (Note that the sequence of observations for each curve begins somewhere near the middle, increases with longitude to the right and then "wraps around" to the left.) The largest deviations occur after the first few days of impacts, and then slowly relax to normality in October (top curve).

confined ("frustrated") by their environment. In either case the radio sources are evidently located in a dense (sub)galactic medium; a configuration which is favourable for the occurrence of significant 21 cm HI line absorption. In the first observing season with the UHF receivers at the WSRT, three such absorption line systems in objects with redshifts out to z=0.6 were discovered by a team of scientists from NFRA, JIVE, NRAO and Leiden. The integrated optical depths are a few percent, and the velocity widths a couple of hundred km/s. Since all CSOs have sub-arcsecond sizes, the WSRT detections must be followed up with VLBI before the true disposition and depth of the absorbing region can be imaged.

The success of the WSRT UHF receivers, provided enough momentum for a consortium of investigators to conduct a 4-day campaign of VLBI spectral imaging in the UHF-high band. In order to test both the technical and scientific potential of UHF VLBI, a total of ten known HI absorption lines were observed, including both intervening (e.g. gravitational lenses), and associated systems (as in the CSOs mentioned above).

The frequencies ranged from 750 MHz to 1150 MHz (z=0.25-0.9). Both the 100m Effelsberg telescope (Germany) and the 70m Lovell Telescope (Jodrell Bank, UK) participated with receivers purpose-built only weeks before the VLBI session. The NRAO Green Bank 140ft telescope also joined in. The WSRT was successfully used in Tied Array mode, which yields an effective collecting area close to that of a 100m single dish. Subsequently, the WSRT also participated in observations with the VLBA operating at the extreme low end of their L-band receivers, at 1147 MHz. All data were recorded on Mark IV terminals, and correlated at the NRAO correlator in Socorro (New Mexico). Analysis of the data has started, and initial results are encouraging, so it is hoped that the technique will lead to a decision on whether a CSO is "young" or "frustrated". In future UHF VLBI observations are likely to become routine, and it is expected that they can then be adopted by the European VLBI Network as part of standard Network sessions.

Figure 4.10
UHF-high VLBI image of the compact symmetric object 2352+495, made using the WSRT and seven VLBA antennas.



Supershell Recognition in Spiral Galaxies

Expanding supershells are perhaps the most prominent manifestation of the violent impact that massive stars have on the gaseous interstellar medium (ISM). They are commonly thought to have formed as a result of the dumping of mechanical energy into the ISM by groups of young stars. Supershells can be seen as critical gauge of the energy source that ultimately supports interstellar turbulence. As such, they are vital in our understanding of the interstellar medium in galaxies.

The past few years have seen the development of sophisticated hydrodynamic simulations that describe the evolution of expanding superbubbles in the interstellar medium of galaxies. These simulations are powerful because they can predict the kinematic signature and projected appearance of a shell evolving within a complex, specified environment. From an observational perspective, these numerical models can be used to constrain the properties of the ISM when a bubble is seen but little else is known. However, it does demand that a comparison is made between a complicated 3D theoretical model and observational data. The difficulty in assessing detailed similarity between numerical models and a spectral-line data cube have meant that the impressive potential of superbubble simulations has so far been largely overlooked.

Recent work, carried out in collaboration with astronomers from New Mexico (USA) has led to the development of the first repeatable and statistically robust method of directly comparing supershell models with observational data. A three-dimensional data cube cross correlation algorithm was developed to locate and characterize superbubble structures. Application to the spiral galaxy NGC 2403 suggests that its current supershell population is consistent with the rate of mechanical energy deposition expected from massive stars. Stalled shells appear to have a median in-plane size about 2 times larger than shells which still expand. Evidence has also been found for "HI Froth" that is composed of incomplete shell filaments.

A subsequent refinement of the technique involving colleagues from Quebec (Canada) has led to a significant improvement in the following areas:

- Incorporation of realistic numerical simulations for supershell evolution.
- Extension of the data cube cross-correlation to a fully three-dimensional technique.
- Explicitly accounting for the projected overlap of multiple structures when assessing the "goodness of fit".

The modified procedure has been reapplied to the nearby spiral galaxy NGC 2403, and a total of 601 expanding supershells have now been detected. Each of these shells is thought to be more than 50% complete. The decomposition is an excellent match to the observational data cube, reproducing a significant fraction of the fine-structure in individual channel maps.

The parameterized decomposition represents $1 \times 10^9 M_\odot$ of HI, almost 1/3 of the total amount in NGC 2403. In addition, more than 8×10^{53} ergs of kinetic energy is associated with the supershell expansion. The earlier analysis had identified only 50 high-quality shells containing $2.1 \times 10^8 M_\odot$ of HI. In total, the high-quality and fragmentary shells of the previous decomposition accounted for $6.7 \times 10^8 M_\odot$ of HI and more than 2.2×10^{54} ergs of kinetic energy. Despite the detection of many more HI shells than previously, the refined estimate of total kinetic energy is substantially smaller, almost certainly a direct result of more realistic shell modelling.

The required number of progenitor stars with mass greater than $7\ M_\odot$, responsible for each of the bubbles, was typically found to lie between 40 and 200 OB stars. Compared with previous determinations, which typically needed more than 10^3 OB-stars this illustrates the importance of fitting the observational data with realistic projected supershell simulations.

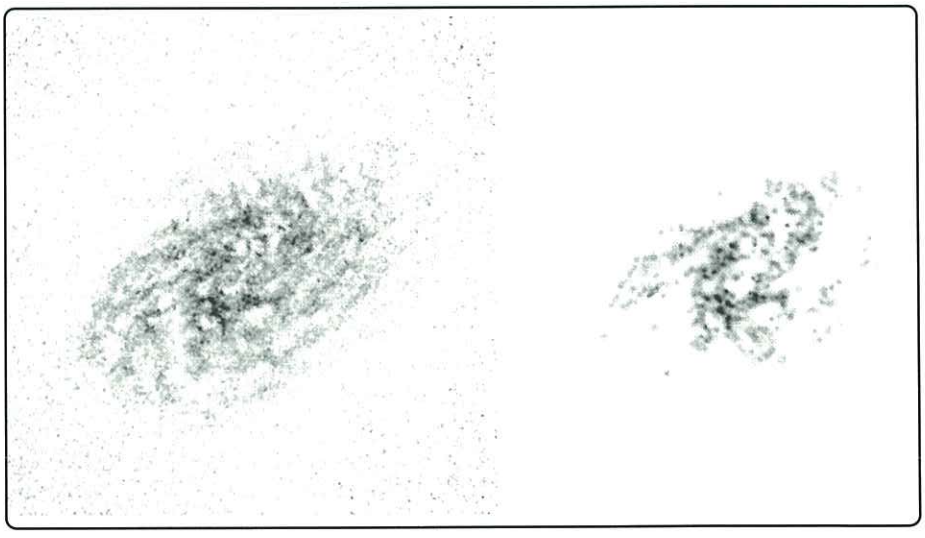


Figure 4.11
Panel (a) shows an integrated HI image of NGC 2403. The plot is linearly scaled, with black representing a column density of $4 \times 10^{21} cm^{-2}$. Panel (b) presents a velocity-integrated version of the parameterized decomposition (composite model for the entire galaxy). Note how the supershells tend to trace spiral structure, suggesting a close link to sites of massive star formation.

High Redshift Neutral Hydrogen with SKAI

A major cosmological driver for SKAI is its ability to detect individual galaxies using 21 cm emission from neutral hydrogen. The sen-sitivity that can be reached with a total collecting area of the order of a square kilometre is sufficient to detect normal galaxies back to the epoch of galaxy formation. Observations of the gas can be used to study not only the distribution of galaxies on very large scales but also their properties. Especially useful will be a systematic comparison of the gas reservoir (i.e. the amount of neutral hydrogen) and the stars that form from this gas (using optical / infra-red observations).

It is a great benefit of a synthesis radio telescope that it is possible to carry out detection, imaging and spectroscopy at the same time. Furthermore, the direct link between total instantaneous bandwidth and the volume of the Universe that is observed in a single integration, makes SKAI a very powerful redshift machine. With a bandwidth of 1 GHz, a volume of over 10 million Mpc^3 is accessible for each square degree of each primary beam. The number of galaxies in the volume covered by a single observation is therefore of the order of 10^5-10^6. How many galaxies will actually be detected, depends on the amount of HI in each galaxy, as well as on telescope sensitivity and integration time.

In order to predict the number of detections, one therefore needs information on the evolution of the HI content of galaxies. Current radio telescopes are not sufficiently sensitive to detect HI in emission much beyond a redshift of 0.3, therefore predictions must be based largely on theoretical models. By building in a large number of observational constraints taken from other sources, one can develop sophisticated models that can be used to predict the amount of HI gas in galaxies as a function of time. Two of these techniques are being employed to come up with realistic determinations of the number of galaxies that SKAI will be likely to detect. It turns out that the numbers depend sensitively on a number of parameters that go into the models, and it is through a direct comparison of models and observations that we are likely, in future, to be able to constrain theories of galaxy evolution and cosmology.

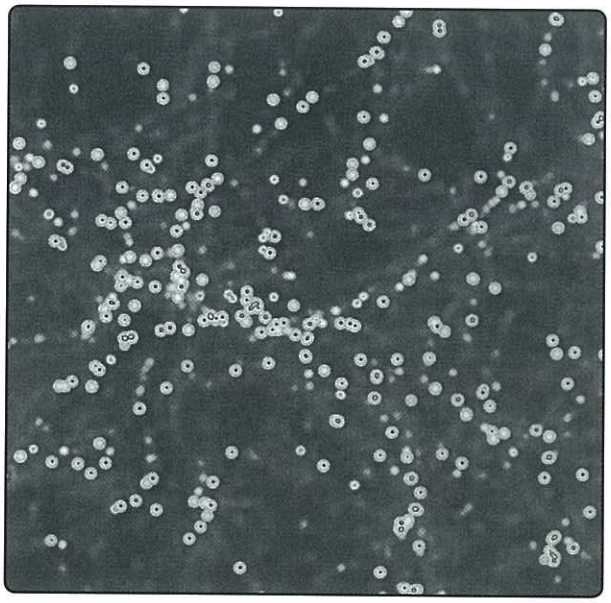


Figure 4.12
A map of a region 7.5 Mpc on a side and 7.5 Mpc deep at a redshift of 2.The 5σ contours of a 400 hour integration using 200 km/s bins and a telescope with an effective collecting area that measures 1.63 km^2 are also shown. The apparent size on the sky of this region is 10 by 10 arcminutes.

In close collaboration with colleagues from the University of Durham (UK), semi-analytical models of the evolution of galaxies are being used to predict the cold gas mass-function for a large number of different cosmological scenarios. In addition, much more detailed numerical hydrodynamic simulations of the gas and dark matter are being used to explore how the number of galaxies detected using SKAI varies with details of the telescope (i.e. collecting area, system temperature, integration time etc.). This latter work is a collaboration between NFRA and astronomers from the Universities of Massachusetts, Ohio State and Santa Cruz (USA). An example from one of these simulations is shown in the figure. It is becoming clear that SKAI is likely to detect thousands of galaxies out to z=2 quite independent of cosmology, and that beyond that redshift it becomes especially sensitive to important parameters such as baryon density, cosmological constant and dark matter density.

Superluminal Jets

Some distant galaxies show features in their radio jets that appear to be moving at velocities in excess of the speed light. Of course, this is impossible, if one believes the general theory of relativity to hold. The widely accepted explanation for this phenomenon is that it is due to projection effects in relativistic jets pointed close to the line-of-sight.

In order to understand why superluminal motion is observed in some sources but not in others, but also to understand how superluminal motion affects the apparent flux of the source, a group led by NFRA astronomers, is studying the properties of moving features in the jets of the statistically complete sample of 293 extra-galactic radio sources (galaxies and quasars) that form the CJF (Caltech-Jodrell-Bank Flat-spectrum) survey. The last phase of the third epoch of observations is to be completed early in 1998, and motions will then be available for the majority of the objects. With the unprecedented size and homogeneity of the CJF database, the distribution of both jet orientations and Lorentz factors can be studied statistically in a population with well understood selection criteria. The project is therefore important both for jet astrophysics and for studies of the relationship between various types of active galactic nuclei. Furthermore, the CJF sample allows direct access to objects ranging all the way to the highest redshifts (z=4), and it is expected that a constraint can

eventually be placed on q_0, i.e. on the geometry of the Universe. First results from the survey indicate that the observed velocities in typical jets are perhaps as much as a factor of 2 slower than those in many of the classical sources studied extensively in the past.

Short-timescale Structural Variations in AGN

VLBI monitoring of a sample of over 500 bright, compact extragalactic radio sources has now been taking place for about twenty years by the geodetic VLBI community. For some sources up to 10 observations per year have been carried out. For the study of short-time structural variations in galactic nuclei on timescales of months, such a database is a real goldmine. Structural variations seen in the radio jets from the inner regions of AGN can often be combined with optical and/or gamma ray observations and used to increase our understanding of what goes on in the engine room of these very luminous galaxies. A study has been carried out in collaboration with radio astronomers in Germany, China and France, on a group of three AGN for which such long term observations are available.

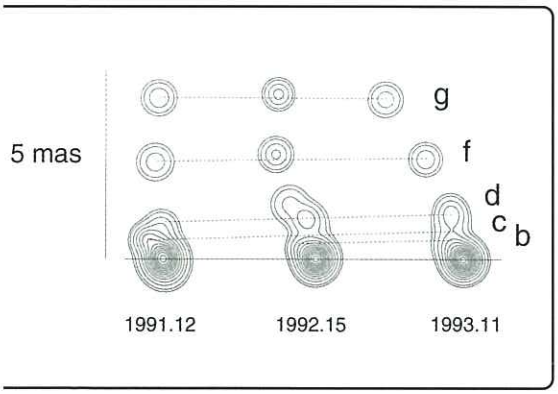


Figure 4.13
A sketch presenting maps of the model fits for PKS 0528+134 at three epochs. The lines indicate component identifications based on the component motions the solid line represents the core position.

NFRA Funded

PKS 0528+134 at z=2.06 is one of the brightest AGN and the second most distant quasar detected with the gamma-ray satellite EGRET. This source is known for its huge high-energy output and extreme flux and spectral variability. Correlated flux density variability across the wavelength spectrum had been reported previously, and a series of twenty VLBI observations performed at 8.4GHz has now revealed that increased activity in the radio and gamma-ray bands can be linked to morphological changes in the source structure. There also appears to be evidence that supports a link between jet curvature and bending with the brightness of the source at gamma ray energies.

Another of the sources PKS 0420-014 at z=0.915 was the first to exhibit simultaneous gamma-ray and optical flaring. Furthermore, the optical light-curve showed a quasi-periodic behaviour, variability was also observed in the radio bands. These observations together with the VLBI results can be explained within a precessing jet model with a binary system in the centre of the source.

The third source 1803+784 at z=0.68 is a BL Lac object that remains largely unexplained. Athough over 40 VLBI observations at 8.4 GHz are available and seem to reveal the coexistence of moving and oscillating features, a satisfactory model has so far proved elusive.

University Research

5

The foundation not only provides observing facilities and other infrastructure in support of astronomical research at universities in the Netherlands, but it also finances specific research projects and makes available administrative and technical support for instrumental research. This section gives brief summaries of these activities in 1997.

Instrumental and Observing Projects

The Dutch Open Telescope

This year saw the culmination of many years of hard work by astronomers and engineers responsible for the construction of the Dutch Open Telescope (DOT). The telescope and its support tower are both open and there is no dome, only a foldaway canopy. This highly innovative design makes the telescope well suited to perform its main function: high-resolution mapping of solar magnetic fields.

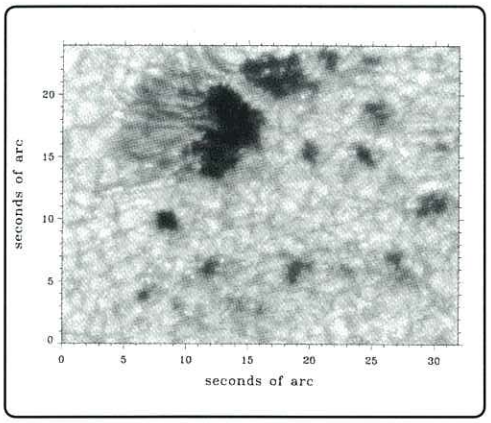


Figure 5.1
A granulation image showing small sun spots, pores and faculae in an active region that measures 23000x17000 km on the Sun's surface.

On La Palma the best daytime seeing tends to occur when strong winds blow upslope from a northerly direction. This wind confines the convective plumes that arise from local ground heating to a zone lower than the 15m height of the tower. The open structure of the telescope minimizes obstruction of air-flow which provides a source of air that performs continuous flushing and inhibits telescope and mirror seeing. The design of the DOT is a radical departure from traditional solar telescopes that rely on internal evacuation to avoid turbulence within the telescope itself. The DOT represents an important test for large solar telescope concepts. Its success implies that the open design is to be preferred, and indeed the US National Solar Observatory intends to adopt the Open design for its planned 4 m CLEAR telescope project. The current DOT aperture is 45 cm, but a 100 cm mirror can be placed without any changes, and an even larger one with only minor modifications. The open principle of the DOT was defined by C. Zwaan and R.H. Hammerschlag (both of Utrecht University) in the seventies, but its construction has been due to the persistence of Rob Hammerschlag. Along the way Hammerschlag was assisted by the workshops at Utrecht University and at the Technical University in Delft. A grant from the Dutch Technology Foundation (STW), prompted by the need for the development of extreme pointing stability, allowed completion of the project at the Central Workshop of the Technical University in Delft before construction and installation at the Roque de los Muchachos Observatory on the island of La Palma. The official opening ceremony took place on October 31st of 1997 and was performed by Dutch Crown-Prince Willem Alexander and Mr. Rojas, President of the Canary Islands. Also present were the Dutch Minister for Science, Dr. J. Ritzen, the Chairman of NWO, Dr. R.van Duinen and a large number of other international dignitaries.

The DOT is located on La Palma under a Memorandum of Understanding between NFRA and the Canarian Observatories. A proposal for the development of additional instrumentation and funding for the scientific exploitation of the instrument was selected by NFRA. A final decision will be made by NWO in the first half of 1998.

PuMa - The Pulsar Machine

Pulsars are neutron stars that rotate rapidly and emit a beam of broadband electro-magnetic radiation. The neutron star is a remnant of a fairly massive star, and can be formed through a supernova explosion that blasts away the outer layers of the star. The exact origin of the pulsed radiation that we observe is not understood, but it is generally accepted that the radiation is emitted in a fairly narrow beam that rotates rapidly. This rotation is linked to the spin period of the neutron star.

The predicted number of pulsars is more than an order of magnitude greater than the number of detections made to date. Many have probably been missed because of poor signal-to-noise ratios. Once detected, precise determination of the arrival times of the pulses is an important field of study. Because of the extreme regularity of the pulsar's (spin) period, tiny changes in arrival time can be tracked. These measurements, when performed over long periods of time reveal a slowing down of the pulse frequency. The accuracy required for such measurements is typically better than 10 ns compared with UTC. In turn, a more detailed study of the pulse profile can reveal vital information about the origin of and physical conditions under which the radiation is emitted.

The two main stumbling blocks encountered when observing pulsars are poor signal-to-noise ratio and the effects of dispersion. The signal-to-noise ratio can generally be improved either by increasing the integration time, or by using a larger bandwidth. The main drawback of the latter solution is that the dispersion, caused by interstellar matter between observer and source, leads to a smearing out of the pulse that is due to arrival of a lower frequency pulse at the same time as subsequent higher frequency pulses. The presence of such overlapping pulses make it

impossible to detect the pulsed emission. A solution to this problem is to split the incoming antenna signal in multiple narrow bands and process these in parallel.

Traditional pulsar machines, implemented using analogue electronics, are limited to a small number of bands. The Flexible Filter Bank (FFB) currently in use in Westerbork contains only 32 independent channels with programmable bandwidth. In cases of high dispersion, this can mean that less than a percent of the total 80 MHz bandwidth is used.

Construction of the new PUlsar MAchine, which is to replace the FFB, was started in 1996, with the following goals:

- to develop a machine that takes full advantage of the 80 MHz signal band even in cases of severe dispersion.
- to optimize the machine for pulsar searching and timing, and also for the study of the pulse profile.
- to allow for a great amount of experimental freedom (reconfigurability)
- to realize this within tight budgetary and time constraints.

The approach that was chosen was to apply Fast Fourier Transforms on short, successive time series of the sampled antenna signal. The eight incoming dual polarization 10 MHz signals are discretized immediately using ADCs and are fed directly into a cluster of Digital Signal Processing units (DSPs). Each DSP receives a time series and starts executing FFT and data reduction software. After processing, the output is sent to a mass storage system. The number of DSPs available is sufficient to allow seamless processing of all incoming data.
PuMa's A/D conversion is done using industry standard video ADCs that deliver 12 bit accuracy at 20 MHz sampling rate. The digital signal processing is done using 192 SHARC processors (ADSP2106X) that each take 2048 samples and are filled successively. Two identical mass storage systems are used to archive the data, each consisting of an HP743 VME workstation running HP-RT and four hard disks. Data is transferred from the DSPs by writing in shared memory on the VMEbus. Subsequently, the HP workstation moves the data to disk, without further processing. By using the four disks in parallel, archiving speeds in excess of 15 MB/s can be reached.

During 1997, development and testing of all components was completed. What remained was the integration of the system. This final phase before PUMA is brought to the telescope is expected to be completed in the first quarter of 1998. First data is expected towards the end of May 1998.

DREAM - Dutch Real-time Acquisistion Mode for SCUBA

The 15m James Clerk Maxwell telescope on the island of Hawaii is the largest facility in the world designed specifically to operate in the sub-millimetre region of the spectrum. A new instrument, the Submillimeter Common User Bolometer Array (SCUBA) allows simultaneous continuum observations using two bolometer arrays that operate in bands around 450 and 850 microns. SCUBA has been in regular use since May 1997.

The long wavelength array consists of 37 bolometers, the short wavelength array has 91 elements. The size of the horns causes the elementary pixel separation to be 4 times greater than required for Nyquist sampling. This means that 16 different observations are involved in getting a fully sampled image. The scheme chosen for performing a full sampling can either be a single integration at each of the 16 positions or repeated scans through all 16 positions. Traditional observing strategies have included sky suppression by chopping of the primary beam to an empty sky region. The standard observing mode implemented first has been the long integration combined with these offset sky measurements. An alternative is the DREAM concept that is being implemented by staff from Leiden and NFRA.
The DREAM concept allows the data gathering technique to function as a simultaneous sky suppression modulator, by ordering the way in which the 16 sub-pixel positions are visited.

For typical observations, this means that the amount of time spent off-source (measuring at the offset sky position) is eliminated, thereby effectively increasing the efficiency of the observing procedure by 100%. Success of this technique depends on the assumption that the telluric sky does not vary greatly during a modulation cycle. Whether this is the case at the JCMT remains to be investigated.

Good progress was made in 1997. A basic data reduction programme was developed at NFRA to process data taken in this mode. Extensive testing at the telescope and integration at real-time level will take place in the first half of 1998. In the first instance full operation of the long-wavelength array takes precedence. However, the output capacity of the transputer system that performs the data acquisition limits the continuous flow of data. The current system is capable of handling either 30 second "bursts" of data from the full long wave array, or continuous operation of only the inner 19 bolometers. Further extension of the mode requires at least an increase of the output capacity, although a fundamental limitation is the synchronisation between the Secondary Mirror Unit (SMU) and the sampling clock. The ultimate implementation of DREAM will require a single master clock to drive both the sampling of the bolometers and the SMU.

WHISP - Westerbork Survey of HI in Spiral Galaxies

The Westerbork Survey of HI in Spiral Galaxies (WHISP) is a survey of the neutral hydrogen content and velocity fields of a large sample of nearby galaxies. The scientific goals of the project include studies of the systematics of dark matter halos, the effects of environment on the structure and growth of galactic disks and the determination of galaxy distances. A sample of 500-1000 galaxies from the Uppsala General Catalogue of Galaxies is being observed.

In 1997, 22x12 hours of WSRT time were spent on WHISP, bringing the total to 298x12 hours. Data reduction, performed in Groningen, is progressing well, about 150 cleaned HI data cubes have been produced so far. The WHISP database site provides easy access to the content of the database. The web page (http://www.astro.rug.nl/~whisp/) contains an atlas of all the reduced galaxies. At present, three Groningen PhD students are working with WHISP data. Topics that are being studied are:

- Dark matter in dwarf galaxies.
- Velocity patterns in spiral galaxies
- Warped edge-on galaxies

WENSS - Westerbork Northern Sky Survey

Throughout the history of astronomy, surveys have been the foundation from which our knowledge of the Universe has been derived. Large sky surveys such as the Palomar Observatory Sky Survey, 3C and Parkes catalogues, IRAS and the ROSAT All Sky Survey (RASS) have (indirectly) produced countless astronomical discoveries and led to much of modern astrophysics. The Westerbork Northern Sky Survey (WENSS) is the first of a new generation of large-sky radio surveys designed to probe the radio Universe considerably deeper than was previously possible. At 92 cm WENSS covers the sky north of $\delta = +30°$, representing one-quarter of the sky. The observations for WENSS were completed in 1996. A total of almost 1 year of WSRT observing time, spread over a 6 year period, was spent on WENSS. Data reduction and catalogue production were finished in the Summer of 1997. In the autumn work began to make the survey available to the astronomical community. The first of these products is a database, electronically accessible through the world wide web at http://www.strw.leidenUniv.nl/wenss.

A detailed description of the calibration, reduction and products of the survey was published in Astronomy & Astrophysics. WENSS will distribute its images in a standard 6°x6° format, called frames. These frames are centred on the locations of the new Palomar Observatory Sky Survey (POSS-II) plates. The figure shows the layout of the 471 frames in the survey. FITS-images, 1024x1024 pixels each, accompanied by a lower resolution version and an ASCII catalogue with source parameters will be placed on a CD-ROM. Contour plots of the full-resolution images and a greyscale version of the lower resolution images will appear in a bound volume. Both the CD-ROM and atlas should be ready for shipment to customers and libraries in early June 1998.

WENSS has had, and continues to have, a considerable impact on Dutch astronomy. It has been an important starting point for 7 PhD thesis projects at various universities (see table) covering a wide variety of astrophysical themes. In addition to the PhD work, several other projects have been started that are based on WENSS, both inside the Netherlands and abroad. For example a group at Bologna are leading a definitive investigation of the radio luminosity function of bright galaxies, using a WENSS-defined bright-galaxy sample.

R. Rengelink (Leiden)	Large scale structure and radio source Surveys
I. Snellen (Leiden)	The nature of GPS sources
A. Schoenmakers (Utrecht)	Giant radio galaxies
M. Kouwenhoven (Utrecht)	Pulsars
L. Koopmans (Groningen)	Gravitational lenses
C. de Breuck (Leiden/LLNL)	High z radio galaxies
TBD, but funded (Leiden)	Galactic foreground polarization

Table: PhD projects that are (partly) based on WENSS

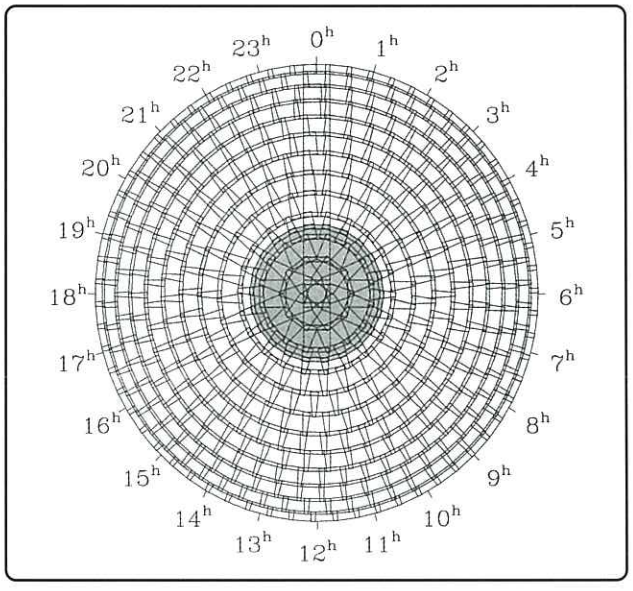


Figure 5.2
Frame layout of WENSS

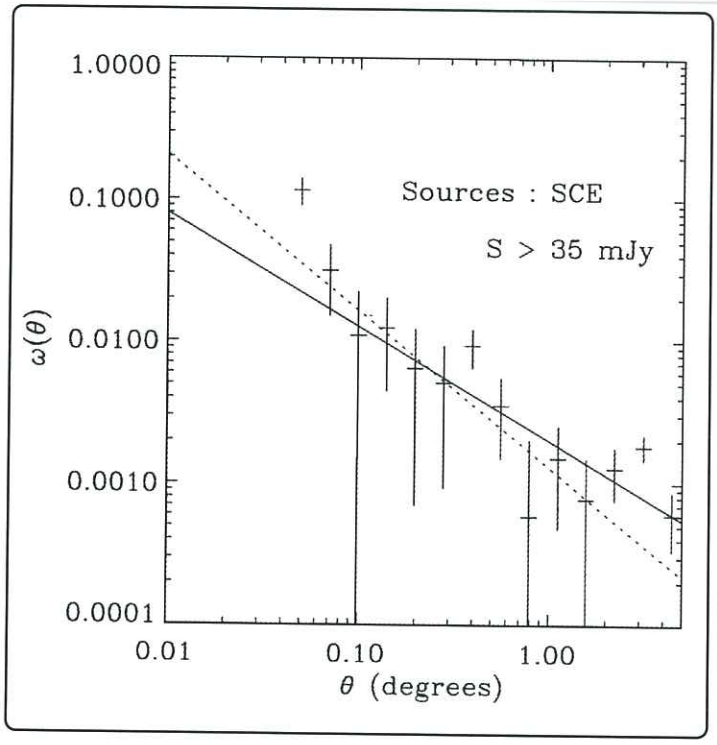


Figure 5.3
The angular correlation function $\omega(\theta)$ for the Westerbork Northern Sky Survey. The straight lines are a fit with slope -0.8 (solid line) and -1.1 (dashed line). The corresponding spatial correlation function has a scale of $5h^{-1}$Mpc and a slope of -1.8, which agrees well with the low redshift correlation function for optically selected galaxies.

WENSS exploits the capabilities of the WSRT at a frequency at which it is considered to be the best in the world. Because of its uniqueness for studying the (radio) Universe, WENSS has also been instrumental in establishing international collaborations and winning funding. In the context of the training and mobility of researchers (TMR) programme, the EU recently funded two programmes in which the WENSS team is involved. The first "The Formation and Evolution of Galaxies" aims at extending collaborations in this field between institutes in Cambridge, Durham, Paris, Leiden, Padova, Munich. The second is in connection with the CLASS-survey for gravitational lenses using the WENSS, NVSS and GB6 radio source catalogues. The huge CLASS database was instrumental in winning this contract between institutes in Bologna, Cambridge, Dwingeloo, Groningen, Jodrell Bank and Lisbon.

Since the start of WENSS, two complementary large-sky surveys have been initiated with the VLA. Both surveys (FIRST and NVSS) are being carried out at a wavelength of 20 cm, i.e. more than four times shorter than WENSS. Data from overlapping regions of WENSS and the VLA are already giving information about the radio spectra of large numbers of radio sources, allowing important new statistical studies to be carried out. Like optical colours, radio spectra provide a fundamental diagnostic for a wide range of astrophysical phenomena. In previous NFRA Annual Reports (1994, 1995 and 1996) some of the science that has come out of WENSS has already been presented. Below a brief description of a few of the results from two other projects are given.

Large Scale Structure

One of the prime scientific motivations for large scale radio surveys is to investigate the large scale distribution of radio sources. Radio sources sample the Universe out to great distances (z>1) and therefore a detection of large scale structure within radio samples constrains the evolution of the large scale distribution of galaxies out to those redshifts. Furthermore, the large scale distribution of radio sources gives an indication of the environment of individual sources. This will give further insights into the relation of the radio sources and their environment. A study of the angular two-point correlation function for WENSS, as well as for the new version of the Green Bank 6 cm survey has started. For both surveys a clear signal is detected (see Figure). The amplitude of the angular two-point correlation function for the Green Bank survey is about a factor 3 higher than it is for WENSS. This result has been modelled and it was found that the difference in amplitude between the two surveys indicates that the evolution of the spatial distribution of radio sources is a function of the characteristics of the radio sources. Extension of this work using the combined WENSS/VLA surveys promises to provide new information about dependence of large-scale structure on spectral index.

Giant Radio Galaxies

Radio galaxies with linear sizes exceeding about 1 Mpc are an interesting class. The aims of studying these objects are twofold. First, because their radio sizes are so extreme, they are important laboratories for studying the physics of radio sources. Are they so extreme in size because the ratio of their jet power to the density of their environment is so high, or because they are relatively old radio sources in comparison with the bulk of the FRII population? Secondly, these are the only radio sources that probe the intergalactic medium (IGM) over such a large scale. Studying these sources will therefore constrain the structure of the IGM. Studies of giants have been significantly hampered by poor sample definition and small numbers of objects. Because of its good sensitivity to low surface brightness features at a low frequency on scales of a few arcminutes, the WENSS survey has provided a well defined and a relatively large sample of giant radio galaxies. The source WNB2147+817 is one of the largest sources to be discovered in WENSS. At a redshift of 0.145 its 19' angular size translates to an enormous 3.7 Mpc (assuming H_0=50 km/s/Mpc) which makes it the second largest radio source known (after 3C236).

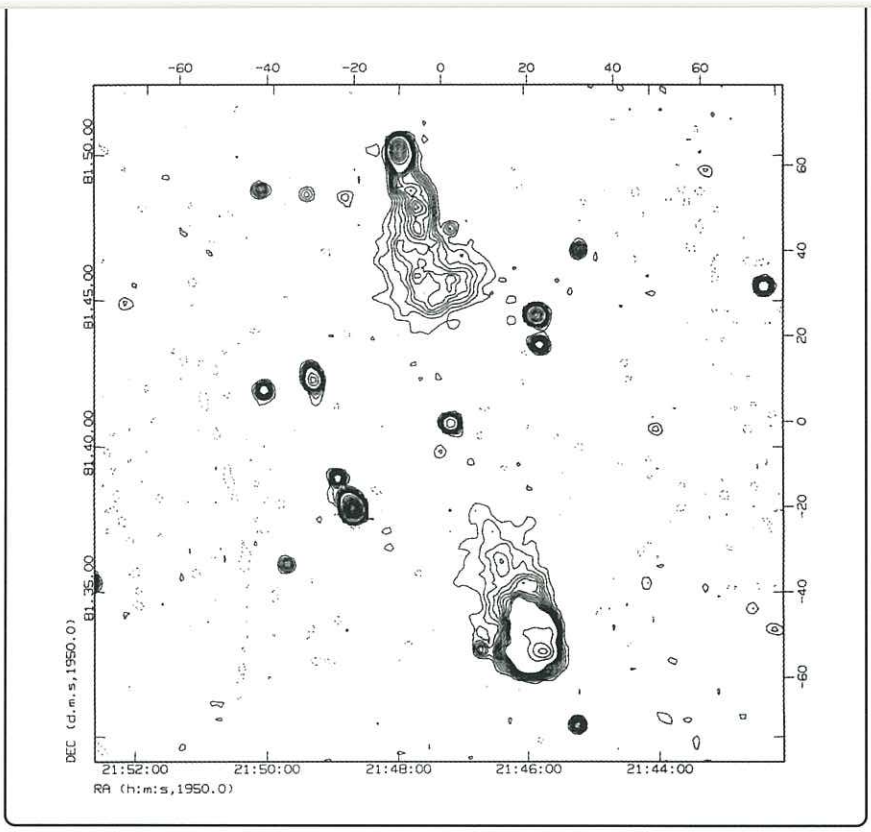


Figure 5.4
A continuum image at 840 MHz taken with the new WSRT UHF receivers. The lowest contour is at three times the level of the noise in the map.

A Westerbork Survey In the Southern Hemisphere (WISH)

Much of the most fundamental work on radio-selected objects needs studies of optically-faint targets, and the new 8 m-class of telescopes are needed to study them properly. Although WENSS is an important database for such studies, objects from the WENSS database will be almost inaccessible from the only large optical telescope available to the Dutch community: the VLT.

A sample comparable to WENSS in the southern hemisphere is therefore essential in order to remain competitive in these fields. To obtain such a sample a new survey was started: the "'Westerbork Survey in the Southern Hemisphere (WISH)". This survey will cover the declination range from $-10^0<\delta<-30^0$, but avoids the galactic plane. Observations started in October 1997 and should be finished in May 1998. The reduction will lag behind by about 6 months.

DOGS - Dwingeloo Obscured Galaxy Survey

The disk of the Milky Way contains gas and dust that obscures about 20% of the extragalactic sky: the so called "Zone of Avoidance" (ZOA). Nearby galaxies hidden behind the ZOA may have an important influence on the dynamics of the Local Group of galaxies and hence on its peculiar motion relative to the cosmic microwave background radiation. However, such galaxies suffer extinction by dust and gas at optical wavelengths, and confusion by stars in the infrared. Emission at 21 cm by neutral atomic hydrogen (HI) associated with late-type galaxies may be observed if the velocity of the emission differs from that of the local gas. Under these conditions it is possible to detect galaxies behind the ZOA in HI that are very difficult to detect at other wavelengths.

The Dwingeloo Obscured Galaxy Survey (DOGS) is a long-term collaboration of astronomers in the Netherlands, United Kingdom, USA, France and Mexico to search about 2000 square degrees of the northern Galactic Plane at 21 cm for new galaxies, using the Dwingeloo 25 m radio telescope.

The first stage of this project was a "fast" 5 minute-per-point search of the whole survey area. A second, "deeper" survey with a total integration of one hour per pointing was subsequently started. For a galaxy with a 100 km/s line width, this means the survey is sensitive to all galaxies with $5x10^8h^{-2}M_\odot$ of HI out to $10h^{-1}$Mpc and $5x10^9h^{-2}M_\odot$ out to the edge of the survey at $40h^{-1}$Mpc. This second phase of the survey is still continuing. In 1997, a total of 90 days' telescope time was devoted to the DOGS survey.

The first major result of the survey was the detection of the radio emission from a new galaxy, Dwingeloo 1 in August 1994. The Deep search has so far yielded 40 detections over the 790 deg^2 surveyed and analysed to date.

Grants Programme

NFRA's grants programme provides financing for graduate students and postdoctoral fellows to work in the university research groups. Applications can be made, either for specific projects involving a single graduate student or postdoc, or for larger scale programmes of research that include several temporary research positions and can include non-salary funding as well. These longer programmes of research can be funded for a maximum period of five years.

Thirteen applications were received and sent for external peer review to three referees. A committee, composed of van Dishoeck (chair, RUL), Briggs (RUG), Butcher (RUG), Katgert (RUL) and Lamers (RUU) awarded funding to two projects.

Katgert (RUL) & De Bruyn (RUG) received funding for a four year PhD position to study the structure and strength of the magnetic field in the Galactic interstellar medium. Radio polarimetry obtained with the WSRT has revealed large coherent structures that are thought to be caused by Faraday Rotation Modulation of a very smooth linearly polarized galactic radio background.

Van de Weygaert (RUG) was awarded funding for a four year PhD position to study the role that tidal fields play in the shaping of large scale structure in the Universe. Galaxy redshift surveys have revealed an intriguing foamlike pattern in the galaxy distribution on large scales. The study will focus on a detailed investigation of the role of tidal forces in the formation and shaping of these anisotropic structures.

A summary of all projects and programmes that were financed by NFRA during (part of) the year is given in the table below.

Programme Subsidies

Project ID	Supervisor(s)	Project Title	Institute	Name
781-76-010	Miley de Bruyn Katgert Schilizzi	Studies of the early Universe using radio sources	RUL RUG	Röttgering Koopmans
781-76-011	van Paradijs van den Heuvel van der Klis	Structure and evolution of close binary systems with a compact companion	UvA	van der Hooft Galama Ford
781-76-014 MPR	Goedbloed Hearn van der Vorst	Magnetohydrodynamics: parallel computation of the dynamics of thermonuclear and astrophysical plasmas	RUU	G. Toth T.P. Downes
781-76-015	Habing van Dishoeck Waters Wesselius	Physical and chemical evolution of young stellar objects	RUL	C. Dominik F. van der Tak C.M. Wright
781-76-016	de Zeeuw	Formation, Structure and Evolution of Elliptical Galaxies	RUL	W. Miller
781-76-017	van der Klis Verbunt	Fundamental properties of neutron stars and black holes	UU UvA	M.C. van den Berg R.P. Fender
781-76-018	Sackett Pel	Studying Galactic Microlensing through High Temporal Resolution, Multi Band Monitoring	RUG	J.P.L. Beaulieu R.M. Naber
781-76-019	Strom	Massive Parallel Computing: Scalable I/O for the data analysis in pulsar research	UvA NFRA	R. Ramachandran

Stellar Systems

Project ID	Supervisors	Project Title	Institute	Name
781-71-047	van den Oord Kuperus	The effect of retardation on MHD configurations	UU	N.A.J. Schutgens
781-71-048	Lamers	A study of the variability of Luminous Blue Variables	UU	J.S. Vink
781-71-050	Achterberg	The Highest-Energy Cosmic Rays	UU	Y.A. Gallant
781-71-051	Lamers	The winds of B[e]-supergiants and B-supergiants	UU	T.M. Lanz
781-71-052	Waters de Jong Waelkens	The evolution of Post-AGB stars	UvA	F.J. Molster
781-71-053	Henrichs	Origin of wind variability in massive stars	UvA	J.A. de Jong
781-71-054	de Bruyn Schilizzi Verbunt	Motion and birthplaces of pulsars through VLBI astrometry	NFRA	R.M. Campbell

Interstellar Medium

Project ID	Supervisor(s)	Project Title	Institute	Name
781-72-034	van Dishoeck Habing de Graauw	Nature and Evolution of interstellar dust studied by laboratory infrared spectroscopy	RUL	W. Schutte
781-72-036	Habing	The selection of a dynamical model for the inner disk and the bulge of our galaxy based on an upgraded sample of OH/IR stars	RUL	M. Sevenster
781-72-038	Bloemen Habing	Gamma-ray spectroscopy of the interstellar medium using COMPTEL	ROU	R.D. van der Meulen
781-72-039	Katgert de Bruyn	Structure and strength of the Magnetic Field in the Galactic ISM	RUL	

Galaxies

Project ID	Supervisor(s)	Project Title	Institute	Name
781-73-056	Miley de Bruyn	Search for superclustering in the early universe	RUL	R.B. Rengelink
781-73-057	Barthel	The ELF-QSO connection: starbursts as origin of QSO activity	RUG	J.P.E. Gerritsen
781-73-058	Barthel Shaver Surdej	Structure and composition of early epoch gas clouds and galaxies	RUG	A.J. Smette
781-73-059	de Zeeuw Perryman	HIPPARCOS study of the structure of OB Associations	RUL	R. Hoogerwerf
781-73-061	Kuijken	Warps in disk galaxies	RUG	I. Garcia
781-73-063	van de Weygaert	Tidal Fields as shaping force of the Large Scale Structure in the Universe: the formation of the cosmic foam	RUG	W. Schaap

PhDs awarded in 1997 to recipients of NFRA Grants

Name	Promotor	Project Title	Date	University
L.B. van den Hoek	de Jong	On the chemical and spectro-photometric of nearby galaxies	10-04	UvA
F.C. van den Bosch	de Zeeuw, Jaffe	The central regions of early-type galaxies	25-06	RUL
F.J. Sicking	van Albada	The thickness of the HI gas Sancisi layer in spiral galaxies	12-09	RUG
P.A.M. van Hoof	Pottasch co: van der Hulst	Photo-ionization studies of Nebulae	19-09	RUG
J.P.E. Gerritsen	de Jong, Icke Briggs, co: Barthel	Star formation and the interstellar medium in galaxy simulations	14-11	RUG
N.M. Hoekzema	Zwaan co: Rutten	Statistical studies of dynamical structures in the quiet solar atmosphere	01-12	RUU
M.N. Sevenster	Habing	Stellar structure and dynamics of the Galaxy	04-12	RUL

NFRA

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Facilities



The Foundation has a number of infrastructural facilities at its disposal, of which a brief overview is given in this section.

Anechoic Antenna Measurement Chamber

A 4x6.4 metre shielded chamber has been installed to allow rapid, automated measurement of the performance of test antennas. This facility is equipped with microwave absorbers to provide a measurement volume of one metre in diameter. The reflected power in this region (due to unwanted reflections from walls, floor and ceiling) is suppressed by 45 dB at 5 GHz. Standard gain horn radiators are available, and the antennas to be measured can be mounted on a fully automated 2-axis positioner. Antenna design software packages include MAFIA (CST, Darmstadt) and WireZeus (Univ. of Belgrade), and antenna measurements use an HP 8720D model network analyzer.

Optical Laboratory

A temperature stabilized, optical fabrication and test facility that includes a mechanically isolated floor is present. All fabrication and measurement equipment previously at the Kapteyn Observatory in Roden is now installed. This includes the WYKO model 6000 test interferometer, which can be used to perform rapid automated surface shape measurements of optical components up to 152 mm in diameter. Surface accuracies of λ /100 at 632.8nm can be achieved. Other equipment includes collimators with 0.2 and 1.0 arcsec accuracies, a rotating table with 1.0 arcsec accuracy, a spherometer, 0.1 micrometer feelers and various alignment lasers.

Facilities are available for the manufacture of small prisms, lenses, beam splitters, micro-lenses, cylindrical and other off-axis optical components, in addition to optical fibre preparation. A small optics coating bell permits gold, aluminium and chrome coatings to be made on-site.

CAD/CAM Capabilities

Special attention has been paid in recent years to developing the capability to rapidly design and manufacture complex mechanical structures. NFRA's engineers use Pro-Engineer (version 18) for computer aided design, and Pro-Engineer Manufacture plus Rand Generic Post Generator for the subsequent computer aided manufacture. The latter CAM capability allows transfer from drawing file to machine programme in less than an hour for most designs, and permits doubly curved surfaces to be fabricated with full machine accuracy. A Deckel model FP4 CNC milling machine with a dialog 11 control system and 520x750 mm stage is available, as is a Schaublin model 125 CCN D lathe with a Fanuc 20-T control system and 270mm turning diameter.

Also available in the mechanical workshop are various conventional machines, measuring instruments, welding, anodizing and painting facilities. Cryogenic development and maintenance tools include closed cycle coolers, vacuum pumps and a Leybold Ultratest UL100 leak detector.

Clean Room

A class 10,000 clean room is available, containing a class 100 laminar flow cabinet with a 120x60x60 cm working volume. Temperature and humidity in the room may be regulated as required.

EMC Measurement Chamber

A 5x3.4x3 metre Euroshield Faraday cage has been installed, and allows radiated signal levels (usually qualifying as interference) to be quantified for electronic systems produced by or purchased for use at NFRA. The shielding effectiveness follows MIL-STD-285.

Environmental Chambers

To qualify systems for outdoor use, two temperature controlled chambers are available. The first is a Frigotronic ZA type CL-EU-20 unit, with internal dimensions of 2.9x5.1x2.4 m and programmable temperature control between -20°C and +60°C. Also present is an Heraeus HT4020 unit, with internal dimensions of 0.65x0.55x0.55 m and programmable between -40°C and +180°C. This unit also has an external RS232 interface for connection to external computers.

Computer Facilities

During the construction of the new NFRA building, a complete revision of the entire computer network was carried out. Both buildings are now equipped with a so-called "structured" network, which means that the wiring itself can be used for many different purposes. In our case, telephone and computer connections both use the same infrastructure. The network has been designed for a maximum bit rate of 155 Mbs (ATM-1) and is divided into four branches that are connected to the central switch by means of optical fibres. The backbone of the structure is therefore fibre-optic, working at 100 Mbs and the "leaf"-connections are shielded copper, class 5 working at 10 Mbs for each station. A sufficient amount of extra capacity has been built into the network for future upgrades.

This year saw a steady increase in the number of computers in use by NFRA staff and visitors. At the end of 1997, computing hardware totalled 41 Unix and 120 Windows workstations plus 31 X-terminals and 5 real-time computers. In order to aid in the management of these facilities, a helpdesk system was brought in place, which has proved useful in tracking errors and resolving weaknesses in the system.

In the summer, the central Novell-server has was replaced by a more powerful machine equipped with a



Figure 6.1
The NFRA Guesthouse.

RAID controller and a built-in backup system. Work also started on the installation of "Groupwise", which is an integrated set of programmes for E-mail-, diary- and document-management that will enable users to share diaries and documents and work together in a more structured way. An important upgrade was the replacement of the "Netblazer" by a new dial-in server. A Shiva system has been chosen that has worked flawlessly from day one. NFRA now has a mix of analogue and digital (ISDN) lines configured as a dial-back system. Talks with providers have continued, aimed at realizing a faster connection of the institute to the Internet. It is hoped that an upgrade can be realized in the course of 1998.

Guesthouse

The new guesthouse, was used for a total of 1180 booked nights and has therefore been used for more than 35% of its full capacity during the first year. This is in line with expectations, and is likely to increase over the years to come, mostly because of increased international involvement of both NFRA and JIVE.

16 Radio

Observatory

7

The Foundation operates two radio telescopes: the Westerbork Synthesis Radio Telescope (WSRT) and the Dwingeloo radio telescope. The WSRT consists of an East-West array of fourteen 25m dishes which has a maximum baseline of 2.8 km and a total collecting area equivalent to that of a single 93m dish.

The telescope is currently going through a complete upgrade, to strengthen its position at the forefront of radio astronomy for the foreseeable future. In the course of the year there was good progress made on all fronts of the upgrade. Major milestones reached in 1997 were the completion of the commissioning of Phase 1 of the MFFE receivers, the start of the installation of the DZB correlator system and its integration with the new Telescope Management control system (TMS) and AIPS++ inspection functionality. The parallel programme of mechanical maintenance of the telescopes also continued. Two additional smaller upgrade projects started during the year were the replacement of the old microprocessor telescope control system and the upgrade of the time and frequency reference system.

The 25m Dwingeloo radio telescope dates from 1955, and although still operational, is no longer available for new long-term projects. A final decision on its fate is to be taken in 1998, after a thorough analysis has been performed of the cost of keeping the facility open.

Further information, including the latest news on the state of the upgrade, can be obtained directly from the WSRT Web pages at http://www.nfra.nl/wsrt

Evaluation of the UHF Receivers

The UHF receiver systems (forming Phase 1 of the MFFE project) underwent extensive commissioning tests, and a period of initial use, from October 1996 to April 1997. During this test period, many problems were uncovered and solved, or at least understood; the results were summarized in a report (NFRA - Note 654). The UHF systems were built to provide access to redshifted HI (and OH), which falls outside the frequency bands allocated to radio astronomy. This means that the UHF observing bands are shared with other services, most of which are not passive like radio astronomy is. Hence the possibility of external interference (RFI) by these legitimate spectrum users is a much greater threat than is usually the case in other WSRT bands. Two important aspects that remain largely unchanged compared to the old receivers are the good dynamic range of the system (at least 50000:1 in continuum mode and better than 2000:1 in line mode), and the general method of calibration.

The spectrum environment with respect to RFI was largely as expected: large fractions of both the UHF-low and high bands are usable for a considerable fraction of the time, and it is possible to perform 80 MHz bandwidth (DCB, 8 x10 MHz) observations if the frequency range is carefully chosen. During the commissioning period, the fraction of time lost to extremely strong interference was about 10-15%. This is an acceptable figure for the future, especially considering that Phase 2 will see increased frequency agility allowing easy switching to observations at other frequencies. It has been shown that it is possible to carry out a relatively narrow-band line observation between the two strong carrier signals of a TV transmitter.

The astronomical value of these new receivers has been demonstrated by the detection of a dozen new redshifted HI absorption lines in the spectra of distant radio galaxies and quasars. Examples of such lines are presented elsewhere in this report. A workshop "Astronomy with the Westerbork UHF system", attended by twenty university astronomers (including two from abroad) and 35 NFRA staff was held in Dwingeloo on November 12. Twelve speakers presented results obtained with the WSRT in the year since the delivery of the Phase 1 MFFEs. Topics ranged from pulsars and gamma-ray bursts to neutral hydrogen and OH in galaxies and quasars. The workshop concluded with a discussion which also looked to the future, including SKAI, UHF VLBI and the establishment of a discussion group of WSRT users.

At the end of 1997 a local television station, TV Drenthe, started broadcasting from the nearby Smilde TV tower. This caused new intermodulation products in the UHF receiver systems. By designing and implementing new filters, the interfering signals were reduced by a factor 100, so most of the observational programme could be carried out. In 1998 new filters will be designed and implemented that will reduce the interfering signals even more.

DZB and TMS Integration

In September 1997, the first DZB correlator segment was sent to the WSRT. Together with two A/D convertor units and a timing unit these form the "Minimum DZB System". The first map was produced later that same month. In the subsequent months, integration of the DZB into the new Telescope Management System took place. By the end of the year the DZB was controlled by TMS, and data could be written directly to an AIPS++ Measurement Set.

The minimum system, although it has only an eighth of the full DZB capacity, already produces an order of magnitude more data than the previous correlators, which makes quality control, data reduction and interpretation a challenge. The system, as installed, allows a number of different configurations using up to 256 spectral channels with all interferometer pairs (including autocorrelations) and with a number of polarization combinations. The most common configuration is one with 256 channels, 2 polarizations and 64 baselines between 12 telescopes (the missing telescopes are not available because of reflector maintenance; see below).

Another configuration, to be completed early in 1998, is the compound interferometer mode, with 8000 spectral channels in 4 effective interferometers.

Output from the correlator is read out through a cascade of Digital Signal Processors (DSPs) using a VME based Real-Time Unix system and an HP 730 workstation. Archiving is still being done on DAT-tapes. As more correlator boards are completed in 1998, Real-Time operations will increase in number forcing replacement of the HP 730 by a C200 and a C100 work station. Archiving in the future will be done on CD-ROMS.

WSRT Reflector Maintenance.

After the pilot exercise on the reflector of telescope 5 (Annual Report 1994) the decision was taken to continue this type of treatment on all dishes of the WSRT. These dish maintenance activities are carried out in parallel with the reinforcement of the support construction of the counter weights, necessitated by the increase in weight of the MFFEs compared with the previous series of prime focus receivers.

The maintenance procedure is to take a dish off its substructure (a huge crane has to be mobilized), and transport it to the assembly hall. Here half of the 98 reflector facets are taken out, the wire mesh carefully removed and the steel frames brought to an outside company to be sand blasted and painted. In this period the supporting frame is treated likewise in the assembly hall. After treatment of the frames the wire mesh is replaced with aluminium blind rivets and the facets put back in the reflector. The second half of the facets gets similar treatment.

The maintenance of a reflector takes eleven weeks in all. To reduce the time for mounting scaffolding, and for the expensive crane, while at the same time avoiding having to take observationally important telescopes out of the array, reflectors are exchanged in such a way that the substructure of telescope 0 is without a reflector for a longer period of time, whereas the other telescopes are out of operation for two weeks only.

In 1997 telescopes 4, 6 and 7 were treated in this way. For the outstation telescope C this was not possible, so this reflector was treated in the open air. Reinforcement of the support structure of the counter weights was done on telescopes 2, 3, 4, 6, 7, 8 and C. After treatment, the maximum deviations from the desired parabolic shape are of the order of 2mm, which means a considerable improvement over the pre-treatment shape (which showed departures of more than 10mm in places).

WSRT VLBI Report

The main improvement for VLBI at Westerbork in 1997 was the acquisition of the MkIV VLBI recording system. The hardware was installed late in 1996 and extensive testing took place in 1997. The following acquisition rack and recorder systems were upgraded:

- Field system software
- Video Converters (also known as Base Band Converters)
- Formatter
- Read/Write electronics
- Tape path

The MkIV system allows for higher data rates using 32 tape tracks at 8 Mbit/sec data rate. A future upgrade (doubling the number of head stacks) will enable a data rate of 1 Gbit/sec to be achieved. Larger baseband bandwidths have also become possible (8 and 16 MHz in addition to the previous standards of 0.5, 2 and 4 MHz). The 16 MHz bandwidths are compatible with those used in the VLBA and for the VSOP mission. The MkIV system also allows sampling in 2-bit mode, giving increased sensitivity which is of particular interest for spectral line experiments, where bandwidth cannot be increased. Automatic switching between different tensions used for thin and thick tape was also implemented.

As the direct upgrade of the MkIII system, the new MkIV system has optimum backward compatibility. In particular, VLBI scheduling software such as PC-SCHED can be used to schedule MkIV observations. There is now also strong compatibility with VLBA observations, and most standard and many non-standard VLBA modes are now supported.

WSRT Time Awards 1997

Project	UHFLow	UHFHigh	21 cm	92 cm	6 cm	Total(hours)
1222			46.2			46.2
1235	33.7					33.7
1236	24.0					24.0
1238		35.2				35.2
1240		97.8				97.8
1242		8.8				8.8
1244		11.2				11.2
R/97A/01	23.4	133.3	50.9		63.2	270.8
R/97A/02	.	12.0				12.0
R/97A/03	31.4	5.9				37.3
R/97A/04		12.0			29.0	41.0
R/97A/05					32.4	32.4
R/97A/06			69.9			69.9
R/97A/07	1.1	18.5	149.7		17.5	186.8
R/97A/08			48.0			48.0
R/97A/09			62.4			62.4
R/97A/10			49.6			49.6
R/97A/11	9.8	42.4				52.2
R/97A/12			22.8			22.8
R/97A/13	19.8					19.8
R/97A/14			24.0			24.0
R/97A/17	12.0	15.2	180.8			208.0
R/97A/18		33.5				33.5
R/97A/19	37.9	10.4				48.3
R/97A/21	211.7	14.0				225.7
R/97A/22			380.1			380.1
R/97A/23			71.1			71.1
R/97A/24	12.0					12.0
R/97A/26	4.3		3.5			7.8
R/97B/01		69.6				69.6
R/97B/03	0.5	0.5				1.0
R/97B/06			76.2			76.2
R/97B/11		32.4				32.4
R/97B/12			52.2			52.2
R/97B/13		48.0				48.0
R/97B/14		124.6				124.6
R/97B/16		47.8				47.8
R/97B/17	12.0		246.1			258.1
R/97B/18			30.5	4.5		35.0
R/97B/19				656.7		656.7
R/97B/22			15.0			15.0
R/97B/23		.14.9				14.9
R/97B/25		12.0				12.0
R/97B/26		12.0				12.0
R/98A/02		121.9				121.9
R/98A/03		16.0				16.0
R/98A/15		16.6				16.6
Total	433.6	918.7	1626.8	661.2	142.1	3782.4
VLBI tied array	95.0				189.7	284.7
Total	433.6	1013.7	1626.8	661.2	331.8	4067.1

VLBI single dish simultaneous with other WSRT observations: 694.0

Projects 1997

Number	Name	Subject
1222	Carilli, C.	HI 21cm absorption of the WNM
1235	Röttgering, H.	A search for neutral gas in the most distant galaxies
1236	Vermeulen, R.C.	HI in damped Lyx systems
1238	Briggs, F.H.	Redshift 21 cm absorption in 3C286/PKS1229-021
1240	Vermeulen, R.C.	The environment of powerful young radio sources
1242	Chengalur, J.	HI & OH towards 1830-211
1244	Briggs, F.H.	Var 21cm absorption lines
R/97A/01	Galama, T.	Gamma Ray Burst error box observations
R/97A/02	Galama, T.	Gamma Ray Burst error box observations
R/97A/03	Vermeulen, R.C.	A search for OH Gigamaser Emission from BR1202
R/97A/04	Vermeulen, R.C.	Probing the config of the optically variable PKS 0116
R/97A/05	Szomoru, A.	HI observations of a cluster
R/97A/06	Rottman, H.	The nature of X-shaped radio galaxies
R/97A/07	Hucht, K.A. v/d	Radio emission from the Wolf-Rayet binaries
R/97A/08	Hucht, K.A. v/d	Wolf -Rayet stars before Cyg OB2
R/97A/09	Setia Gunawan, D.	Hi absorbsion towards WR146 & WR147
R/97A/10	Bottema, R.	Whence Barred Galaxies
R/97A/11	Snellen, I.A.G.	Role of dense interst. environment of GPS rad. Galax.
R/97A/12	Galama, T.	Variations of GRS 1915+105
R/97A/13	Bruyn, A.G. de	Structure & kinematics of HI absorber in front of 3C196
R/97A/14	Rengelink, R.B.	WNB1754+6236, a cluster halo in galaxy group
R/97A/17	Schoenmakers, A.P.	Mapping large scale structure of nearby radio galaxies
R/97A/18	Moore, C.B.	Gravitational lens redshifts by HI absorption
R/97A/19	Briggs, F.H.	Var 21 cm absorption lines against AO 0235
R/97A/21	Lane, W.M.	Low redshift HI absorption in MgII selected systems
R/97A/22	Albada, T.S. van	WHISP
R/97A/23	Woerden, H. van	Metallicity, dust content and dist. of HVC complex C
R/97A/24	Carilli, C.L.	Redshifted HI 21 cm line observations of red quasars
R/97A/26	Kouwenhoven, M.L.A.	Simultaneous single pulse observations of pulsars
R/97B/01	O'Dea, C.P.	Testing models for evolution of powerful extr. R. sources
R/97B/03	Koopmans, L.V.E.	Multi-frequency variability observ. of gravitational lens B16
R/97B/06	Galama, T.	Follow up of GRB 970111 and GRB 970228
R/97B/11	Jones, M.E.	Are cluster radio halo sources caused by merges?
R/97B/12	Henning, PA	Follow-up observations of Dwing. Obscured Galaxy Survey det.
R/97B/13	Pentericci, L.	A search for neutral gas in the most distant CSS radio galaxies
R/97B/14	Vermeulen, R.C.	Neutral gas in luminous compact radio galaxies
R/97B/16	Koopmans, L.V.E.	A variability study of three CLASS gravitational lenses
R/97B/17	Galama, T.	Follow up of arcminute sized GRB error boxes
R/97B/18	Kouwenhoven, M.L.A.	Simultaneous Single pulse observ. of pulsars
R/97B/19	Bruyn, A.G. de	WISH
R/97B/22	Strom, R.G.	Structure of giant radio galaxy 4C73.08
R/97B/23	Vermeulen, R.C.	Detectability of OH absorption towards compact AGN
R/97B/25	Bruyn, A.G. de	Properties of an unidentified very-steep-spectrum radio source
R/97B/26	Schoenmakers, A.P.	A restarting Giant Radio Galaxy?
R/98A/02	Lane, W.M.	Low redshift HI 21 cm absorption in MGII selected systems
R/98A/03	Lane, W.M.	Followup observations of 2 new HI 21 cm absorbers at low redshift
R/98A/15	Hagiwara, Y.H.	The HI gas distribution in radio-loud QSO 3C48

Allocations by Programme

the NFRA Committee in 1997

8

Telescope Time at the major observatories to which astronomers in the Netherlands have access (excluding ESO). This section gives a summary of those proposals that were awarded time by the Committee for the two semesters in 1997. Semester 1997A ran from February to July 1997 and Semester 97B from August 1997 to January 1998.

Allocations WHT Semester 97A

Proposal	PI	Subject	Allocation (nights)
W.97A.N01	Best	Nature and evolution of radio galaxies at z = 1	2D
W.97A.N02	Bremer	The Cluster environment of Distant 3C Quasars	4B
W.97A.N03	Koopmans	The shapes of spiral galaxy halos and the H_0	2B backup for N11
W.97A.N05	Schoenmakers	Spectroscopy of a sample of high z Giant Radio Galaxies	2D
W.97A.N06	Peletier	Test The formation of galactic bulges	2G
W.97A.N07	Kuijken	Weak lensing from poor clusters	1G-2D
W.97A.N08	Snellen	Near IR properties of giant ellipticals	1B backup
W.97A.N10	Snellen	GPS galaxies as cosmological probes	1D-1G
W.97A.N11	Barthel	Evolution of X-ray selected BL Lac objects	2B
W.97A.N13	Miley	Deep imaging of 1243+036	2D
W.97A.N15	van Woerden	Distance and metallicity of HVC Complex C	2B + 1B backup
Total			9D 4G 8B

Allocations WHT Semester 97B

Proposal	P.I.	Subject	Allocation (nights)
W.97B.N03	Jaffe	H-alpha emission from cooling flows	1D
W.97B.N04	v.d.Hulst	Ionisation structure of HII regions	3B
W.97B.N05	Garcia-Lario	Li abundance in massive O-rich AGB stars	2B
W.97B.N07	Galama	Imaging and spectroscopy of GRB candidates	override
W.97B.N08	Lehnert	Clusters around z=1 AGN	2G
W.97B.N09	Lehnert	Clustering around the most distant quasars	3D
W.97B.N11	Kuijken	Weak lensing from poor clusters	4D
W.97B.N14	Prins	Spectroscopy of SNR candidates in M31	3G
W.97B.N15	van Woerden	Distance and Metallicity of HVC Complexes	2B backup
W.97B.N16	Koopmans	The shapes of spiral galaxy halos and H_0	1B+1B
Total			8D+6G+7B + 2B backup

Allocations INT Semester 97A

Proposal	PI	Subject	Time (nights)
I.97A.N01	Ehrenfreund	Diffuse Interstellar Band correlations and families	2B + 4B backup
I.97A.N02	Sprayberry	Stellar Population in very low surface brightness galaxies	3D
I.97A.N03	Miley	An adaptive optics sample of quasers	3G
I.97A.N04	Briggs	CERES spectroscopy of CLASS high redshift radio quasers	3G-5D
I.97A.N06	Schrijvers	Nonradial pulsations in early-type stars	6B
I.97A.N07	Zwaan	Optical imaging of an HI selected galaxy sample	1D
Total			9D 6G 8B

Allocations INT Semester 97B

Proposal	P.I.	Subject	Allocation (nights)
I.97B.N01	Katgert	The fundamental plane in nearby, rich clusters	4D
I.97B.N02	Ehrenfreund	Environmental dependence of DIBs	3B+1B backup
I.97B.N03	Beintema	Abundance of CNO in PNe	2G
I.97B.N04	Waters	YSOs in transition	2D
I.97B.N05	Schrijvers	Nonradial pulsations in early-type stars	2G+4B+1B backup
I.97B.N06	Sackett	Microlensing in M31s halo and bulge	2D
Total			8D+4G+7B + 2B backup

Allocations JKT Semester 97A

Proposal	PI	Subject	Allocation (nights)
J.97A.N01	van Paradijs	Study of disk and halo cataclysmic variables	2D-4G
J.97A.N02	Schoenmakers	R imaging of high z Giant Radio Galaxy candidates	3D
J.97A.N04	de Jong	The rotation periods of O stars	10B + 3B backup
J.97A.N06	Zwaan	Colors if HI Selected galaxies	2D-3G
Total			7D 7G 10B

Allocations JKT Semester 97B

Proposal	PI	Subject	Allocation (nights)
J.97B.N01	Zwaan	Colors of HI selected galaxies	7D
J.97B.N02	Telting	Bow shocks around high-mass X-ray binaries	2D + 2G
J.97B.N03	de Jong	The rotation periods of O stars	4G + 9B
Total			9D+6G+9B

Allocations JCMT Semester 97A (Heterodyne only)

Proposal	P.I.	Subject	Time and Band
M.97A.N01	Wesselius	Dense cores in L183	27 A backup
M.97A.N03	van der Werf	CII emission from BR1202-0725 at z=4.7	16 B
M.97A.N04	Israel	Radial distribution of molecular gas in M33	30 A backup
M.97A.N05	Israel	CI and CO in galaxy centers	30 C
M.97A.N06	van der Werf	Measuring the microwave background temperature at z=0.886	8 A and 24 B
M.97A.N07	Röttgering	CII in the most distant radio galaxies	24 B
M.97A.N09	Boogert	Physical conditions and C budget around YSOs with ice bands	18 A + 16A backup
M.97A.N10	van Dishoeck	Physical and chemical evolution of star forming regions	40 A + 16 B + 8 C
Total			184 + 73 backup

Allocations JCMT Semester 97B

Proposal	P.I.	Subject	Receiver Time (hr)
M.97B.N01	Wesselius	Evolution of dense cores	RxA 30 low priority backup
M.97B.N03	Stark	Protoplanetary discs	RxC 16
M.97B.N04	Israel	CO in M33	RxA 28 + 12 backup
M.97B.N06	v. Dishoeck	Star Formation Regions	RxA 24 RxB 32 RxC 8
M.97B.N08	Tilanus	Molecular gas temp. in M31	RxA 12
M.97B.N09	Waters	YSOs in transition	RxA 8
M.97B.N12	van der Werf	Dust in the most distant galaxy	SCUBA 16
M.97B.N13	van der Werf	Dust in high-z star forming galaxies	SCUBA 32 for A2218 + 32 in 98A if noise integrates down
M.97B.N14	Israel	FIR Continuum of Dwarf Galaxies	SCUBA 13
M.97B.N15	Molster	Dust around post-AGB stars	SCUBA 14
M.97B.N16	Israel	Dust lane of Cen A	SCUBA 8
M.97B.N19	Smith	Gamma-Ray Burster Counterparts	SCUBA 16 override
M.97B.N21	v. d. Ancker	Environment of YSOs	SCUBA 13
M.97B.N23	Snellen	Faint radio sources	SCUBA 24
M.97B.N27	Lehnert	Cold dust in starburst galaxies	SCUBA 16
M.97B.N28	van Breugel	High-z ultraluminous IRAS galaxies	SCUBA 4
M.97B.N29	Röttgering	Dust in candidate proto-galaxies	SCUBA 8 for first 2 objects only
M.97B.N30	Voors	Dust around blue supergiants	SCUBA 8 for P Cygni
Total			300 + 42 backup

Allocations WSRT Semester 97A

Proposal	PI	Subject	time	priority	
R.97A.01	Galama	Continuation of project 1111/1140	8 x 12	1	UHF
R.97A.02	Galama	Observations of GRB 960720	1 x 12	1	UHF
R.97A.03	Vermeulen	OH Gigamaser Emission at z=4.7 from BR1202-0725	2 x 12	1	UHF
R.97A.04	Vermeulen	The optically variable CSS PKS 0116+082	1 x 12	1	UHF
R.97A.06	Rottmann	The nature of X-shaped radio galaxies	7 x 12	filler	21 cm
R.97A.07	van der Hucht	Variable non-thermal emission from WR binaries	n hours	filler	any
R.97A.08	van der Hucht	Wolf-Rayet stars in Cyg OB2	4 x 12	1	21 cm
R.97A.09	Setia Gunawan	HI absorption towards 2 radio bright WR stars	2 x 12	2	21 cm
R.97A.10	Bottema	Whence Barred galaxies	2 x 12	1	21 cm
			2 x 12	2	21 cm
R.97A.11	Snellen	The dense interstellar environment of GPS radio galaxies	5 x 12	1	UHF
R.97A.12	Galama	Continuation of project 1215, variations of GRS1915+105	3 x 12	1	21 cm
R.97A.13	Bruyn	Structure & kinematics of the HI absorber toward 3C196	3 x 12	1	UHF
R.97A.14	Rengelink	WNB1754+6236, a cluster halo in a galaxy group	2 x 12	2	UHF
R.97A.15	Strom	Probing the effects of nebular changes in the Crab pulsar	2 x 12	1	UHF
R.97A.16	Voute	Giant Pulses of radio pulsars	4.5 x 12	1	UHF
R.97A.17	Schoenmakers	Large scale structure of nearby giant radio galaxies	9 x 12	1	21 cm
			9 x 12	2	21 cm
R.97A.18	Moore	Gravitational lens redshifts by HI absorption	5 x 12	filler	UHF
R.97A.19	Briggs	Variable HI absorption at z = 0.524 toward AO 0235+164	3 x 12	1	UHF
			3 x 12	2	UHF
R.97A.20	Briggs	VLBI of HI absorbers at z = 0.7 and 0.25	4 x 12	1	UHF
R.97A.21	Lane	Low z HI absorption in MgII selected systems	12 x 12	1	UHF
			12 x 12	2	UHF
R.97A.22	Albada	WHISP	25 x 12	1	21 cm
			25 x 12	2	21 cm
R.97A.23	van Woerden	Metallicity, dust content and distance of HVC Complex C	4 x 12	1	21 cm
R.97A.24	Carilli	Redshifted HI 21 cm line observations of red quasars	5 x 12	1	UHF



Allocations WSRT Semester 97B

Proposal	P.I.	Subject	Time	priority	Band
R.97B.01	O'Dea	Evolution of powerful radio sources	6x12	1	UHF
			6x12	2	UHF
R.97B.02	Schoenmakers	0750+433: A 3 Mpc radio galaxy?	1x12	interim	UHF
R.97B.03	Koopmans	Variability of the lens B1600+434	1x12	interim	UHF
R.97B.04	McBreen	Simultaneous observations with ASCA	1x12	interim	6 cm
R.97B.05	Strom	Filler obs. of radio sources	1x12	interim	6 cm
R.97B.06	Galama	monitoring GRB970111 and GRB970228	10x12	interim	UHF/21 cm
R.97B.07	van der Hucht	Monitoring Wolf-Rayet binaries	filler	any	
R.97B.09	Deshpande	Multi-freq. obs. of pulsar B0943+10	3x12	1	UHF
R.97B.11	Jones	Are cluster halo sources caused by mergers?	2x19	1	UHF
R.97B.12	Henning	Follow-up obs. of detections in DOGS	48h block	1	21 cm
R.97B.13	Pentericci	HI in the most distant CSS radio galaxies	12x12	1	UHF
R.97B.14	Vermeulen	HI in luminous compact radio galaxies	8x12	1	UHF
			8x12	2	UHF
R.97B.15	Vermeulen	HI in 3C/4C MSOs	4x12	2	UHF
R.97B.16	Koopmans	Variability of gravitational lenses	3x12	1	21 cm
R.97B.17	Galama	Rapid follow-up of GRB candidates	12x12	1	any
R.97B.18	Kouwenhoven	Simultaneous single-pulse obs. of pulsars	4x16	1	any
R.97B.19	Miley	WISH: Westerbork survey in the Southern Hemisphere	4 weeks		92 cm
R.97B.20	Vermeulen	HI towards/at 3C336	4x12	2	UHF
R.97B.21	Voute	PuMa testing	8x12	1	any
R.97B.22	Strom	Structure of the giant radio galaxy 4C73.08	2x12	2	21 cm

NFRA

INSTITUTE

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Financial Report 1997

Received funds

Operations		**18594**
NWO	12485	
NWO beleidsruimte GB-E	1400	
NWO maintenance WSRT	2000	
NWO dynamiseringsimpuls	800	
Credit balance 1996	322	
Business activities	314	
Contributions from others	1273	
Investment Capital		**10040**
NWO middelgroot	2516	
NWO groot	1500	
Reservations project funds	6024	
Total NFRA Institute		**28634**

Expenditure

Operations Institute + WSRT		**12951**
Staff	8797	
Exploitation	3848	
Credit balance 1997	306	
WSRT development and science projects		**2574**
Multi Frequency Front Ends	691	
New digital back-end	1671	
Telescope Management System	22	
AIPS++, Newstar	48	
WENSS	52	
Enhancements	4	
VLBI projects	86	
WSRT maintenance		**1058**
R&D projects		**1312**
Phased array study	1255	
Others	57	
International Cooperation		**5783**
UK/NL	4528	
JIVE	650	
ESO-VISIR	605	
Special project funds		**4956**
Total NFRA institute		**28634**

Grants programme

Received funds		**2727**
NWO grant	1582	
Contributions from others	183	
Credit balance 1996	210	
Reservations approved programmes	752	

Expenditures		**2727**
Projects	790	
Programmes	919	
Credit balance 1997	65	
Reservations approved programmes	953	

NFRA Organization

Board

Prof. dr. T. van Albada	University of Groningen	
Prof. dr. E.P.J. van den Heuvel	University of Amsterdam	chair
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Prof. dr. G.K. Miley	Leiden University	
Prof. dr. J.A. van Paradijs	University of Amsterdam	
Prof dr. H. R. Butcher	NFRA	Executive Secretary

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R. Boesenkool	
D.P. Kuipers	
J.H. Nijboer	
J. Weggemans	



Personnel (31 December 1997)

Department /Job Title	Name	
Administrative Affairs		
Directors Office		
General Director	Butcher H.R.	
Deputy Director/Head of Secretariat	Boland W.H.W.M.	
Secretary	Oving K.A.A.	
Personnel		
Personnel Officer	Wekking F.H.	
Personnel Assistant	Bennen A.	
Finance Department		
Assistant Treasurer	Hellinga P.	
Assistant Purchasing	Koster A.	
Facilities & Management		
Head of Facilities & Management	Schipper B.A.P.	
Mechanical Workshop		
Head of Instrument Laboratory	Idserda J.	
CAM engineer	Nijboer J.H.	
Electronics Mechanic	Koster A.M.	
Instrument Engineer	Borkhuis H.J.	
Instrument Engineer	Dekker J.S.	
Instrument Engineer	Dijken van E.R.	From 10 Februari 1997
Instrument Maker	Bakker J.	
Instrument Maker	Jong de T.J.	
Instrument Maker	Koenderink G.J.M.	
Instrument Maker	Hagenauw G.	
Instrument Maker	Bakker M.	
Instrument Maker	Schuil M.R.	
Stock Manager	Jager P.C.	
Computer Systems		
Senior System Manager	Stuurwold K.J.C.	
System Manager	Boesenkool R.	
Software Administration (Novell/Windows)	Slagter J.	
Software Administration (UNIX)	Vosmeyer H.J.	
Canteen		
Assistant Canteen	Hofman-Sterk G.	
Assistant Canteen	Lenten-Streutker L.J.	
Reception		
Receptionist/telephonist	Stevens-Kremers R.H.	
Receptionist/telephonist	Vos M.W.	
Cleaning Service		
Cleaner	Braam-Piel H.	
Cleaner	Eising-Zoer H.	
Cleaner	Grit I.	

Department /Job Title	Name	
Cleaner	Hoek-Weerd de I.	
Cleaner	Oosterloo-Scheffer E.	
Buildings & Grounds		
Assistant Technical Services, Logistics & Visitor Support	Wagner R.J.	
Assistant Maintenance	Kuipers D.P.	
Assistant Maintenance & Surveillance	Bokhorst H.	
Assistant Maintenance & Surveillance	Haanstra D.J.	
Assistant Maintenance & Surveillance	Wieringh A.	
Library		
Purchasing Documentalist	Sijtsma S.	

Technical Laboratory

Head of Technical Laboratory	Ardenne van A.	
Secretary	Bartelds-Jager C.B.M.B.	
Designer/Draughtsman	Drost M.	From 9 June 1997
Electronic Design Engineer	Heutink H.	system design & engineering
Electronic Design Engineer	Jong de P.A.	
Electronic Engineer	Zwier S.T.	digital signal processing
Electronic Engineer	Riemers P.H.	antennas
Electronic Design Engineer	Ree van der L.J.	RF/IF technology
Electronic Engineer	Nieuwenhuis L.	RF/IF technology
Electronic Design Engineer	Morawietz J.	From 1 November 1997
Electronic Design Engineer	Formanoy I.J.H.	From 1 March 1997
Electronic Design Engineer	Millenaar R.P.	
Electronic Design Engineer	Doorduin A.	digital signal processing
Electronic Engineer	Koopman Y.J.	system design & engineering
Electronic Design Engineer	Joseph A.	
Mechanical Designer	Emden van W.	
Electronic Development	Kiers R.	
Electronic Development	Damstra S.	system design & engineering
Optical Designer	Jong de A.P.M.	
Optical System Designer	Schoenmaker A.A.	
PCB engineer	Snijder H.	support/development
Planner	Beuving J.W.	project management
Post doc (SKAI-project)	Hampson G.A.	From 1 September 1997
Post doc (SKAI-project)	Goris M.J.	
Engineer	Amerongen van H.J.	
Electronic Engineer	Brouwer K.	system design & engineering
Electronic Engineer	Schonewille N.	
Senior programmer	Coolen A.H.W.M.	software/image processing
Senior System Designer	Diepen van G.N.J.	software/image processing
Technical documentalist	Dalen van R.	
Senior Research Scientist	Bos A.	digital signal processing
Research Scientist	Rosenberg J.A.E.	From 1 September 1997
Research Scientist	Arts M.J.	
Research Scientist	Smits F.M.A.	
Scientific Programmer	Haller M.	From 1 July 1997
Scientific Project Leader	Smolders A.B.	From 1 September 1997
Scientific Project Leader	Bregman J.D.	system design & engineering
Scientific Project Leader	Haas de J.C.M	From 1 September 1997
Scientific Project Leader	Hamaker J.P.	

Department /Job Title	Name	
Scientific Project Leader	Kokkeler A.B.J.	digital signal processing
Scientific Project Leader	Noordam J.E.	software/image processing
Scientific Project Leader	Olnon F.M.	
Scientific Project Leader	Someren Greve van H.W.	
Scientific Project Leader	Tan G.H.	system design & engineering
Scientific Project Leader	Vos de C.M.	
Scientific Project Leader	Woestenburg E.E.M.	RF/IF technology

Radio Observatory

Head of Observatory	Kahlmann H.C.	
Head of System Group	Boonstra A.J.	

Operations Group

Astronomer	Braun R.	
Liaison astronomer	Bruyn de A.G.	
Liaison astronomer	Strom R.G.	
Postdoc astronomer	Haarlem van M.P.	
Postdoc astronomer	Vermeulen R.C.	
Postdoc astronomer	Britzen S.H.	From 19 May 1997
Postdoc astronomer	Campbell R.M.	From 1 June 1997
Postdoc astronomer	Ramachandran R.	From 16 May 1997
Telescope Operator	Akker van den P.	
Telescope Operator	Haan de L.H.R.	
Telescope Operator	Kuper G.	science support
Telescope Operator	Sluman J.J.	science support
Telescope Operator	Tenkink J.	
Data Reduction Leader /VLBI-coordinator	Foley A.R.	
Data assistant	Lem H.H.J.	
Data assistant/telescope operator	Moorrees D.J.J.	
Software/Data-assistant	Grit T.	system support

System Support Group

Telescope Physicist	Bentum M.J.	
Allround Telescope Engineer	Donker P.	system support
Analogue Electronic Engineer	Stiepel H.J.	system support
Digital Electronic Engineer	Weggemans J.	system support
Mechanical Technician	Stolt J.	system support
Mechanical Technician	Gruppen P.G.	system support
Mechanical Engineer	Reijer de J.P.R.	system support

UK/NL Personnel

Electronic Development Engineer	Pit R.J.
Head of Astronomy Group/ Deputy Director at ING	Rutten R.G.M.
Support astronomer/ Telescope Manager at ING	Telting J.H.
Senior programmer	Velde van der P.H.
Head of Mechanical Operation at ING	Venrooy van B.W.H.
Support astronomer	Tilanus R.P.J.

Miscellaneous

Secretarial Assistant Programme Committee	Versteege-Hensel H.A.
Data Assistant	Weerstra K.
Data Assistant	Tang Y.
Operations Assistant	Vries de N.B.B.

Publications in 1997

10

Papers Published by NFRA Staff in Journals and Proceedings

Braun, R., "The Temperature and Opacity of Atomic Hydrogen in Spiral Galaxies", Astrophys. J. 484, 637.

Chengalur, J.N., **Braun, R.**, Burton, W.B., "DI in the outer Galaxy", Astron.Astrophys. 318, L35.

Cohen, M.H., **Vermeulen, R.C.**, Ogle, P.M., Tran, H.D., Miller, J.S., Goodrich, R.W., "PKS 0116+082: An Optically Variable CSS Source in a NLRG", ApJ, 484, 193-201.

Cui, W., Feldkun. D., **Braun R.**, "Detection of Compact Nuclear X-ray Emission in NGC 4736", Astrophys.J. 477, 693.

de Pater, I., van der Tak, F., **Strom R.G.** and Brecht S.H., "The evolution of Jupiters radiation belts after the impact of comet Shoemaker/Levy 9", Icarus 129, 21-47.

Galama, T.J., **de Bruyn,** A.G., Paradijs, J.A. van, Hanlon, L. and Bennett, K., "Unusual increase in the 325 MHz flux density of PSR B0655+64", Astronomy & Astrophysics 325, 631.

Galama, T.J., Paradijs, J.A. van, **Strom, R.G.**, Hurley, K.C., Kouveliotou, C., Fishman, G.J., Meegan, C.A., Heise, **J., Bruyn, A.G. de**, Hanlon, L., Bennett, **K., Telting, J. Rutten, R.G.M.**, Groot, P.J., "Radio and optical follow-up observations and improved IPN position of GRB 970111", Astrophys. J. 486, L5.

Galama,T., **Strom, R.G.**, van Paradijs, J.A., Hanlon, L., Bennett, K., Kouveliotou, C., Fishman, G.J., Meegan, C.A., Heise,J., in 't Zand, J., Costa, E., Feroci, M., Piro, L., Frontera, F., Zavattini, G., Nicastro, L., Palazzi, E., Hurley, K.C., "GRB 970111", IAU Circular 6574.

Galama,T., **Strom, R.G.,** van Paradijs, J.A., Hanlon, L., Bennett, K., Kouveliotou, C., Fishman, G.J., Meegan, C.A., Heise, J., Hurley, K.C., "GRB 970111", IAU Circular 6561.

Galama, T., Groot, P.J., van Paradijs, J.A., Kouveliotou, C., Robinson, C.R., Fishman, G.J., Meegan, C.A., Sahu, K.C., Livio, M., Petro, L., Macchetto, F.D., Heise, J., In 't Zand, J., **Strom, R.G., Telting, J., Rutten, R.G.M.**, Pettini, M., Tanvir, N., Bloom, J., "The decay of optical emission from the gamma-ray burst GRB 970228", Nature 387, 479.

Galama, **T., de Bruyn, A.G.**, van Paradijs, J.A., Hanlon, L., Groot, P.J., van der Klis, M., **Strom, R.G.,** Spoelstra, T.A.Th., Bennett, K., Fishman, G.J., Hurley, K.C., "Two variable radio sources near the position of GRB 940301", Astronomy & Astrophysics 321, 229.

Greenawalt, B., Walterbos, R.A.M., **Braun, R.,** "Optical Spectroscopy of Diffuse Ionized Gas in M31", Astrophys. J. 483, 666.

Groot, P.J., Galama, T., van Paradijs, J.A., Melnick, J., van der Steene, G., Bremer, M., Tanvir, N., Bloom, J., **Strom, R.G.**, **Telting, J., Rutten, R.G.M.**, Kouveliotou, C., In 't Zand, J., Heise, J., Costa, E., Feroci, M., Piro, L., Frontera, F., Zavattini, G. Nicastro, L., Palazzi, E., "GRB 970228", IAU Circular 6588.

Groot, P.J., Galama, T., van Paradijs, J.A., **Strom, R.G., Telting, J., Rutten, R.G.M.**, Pettini, M., Tanvir, N., Naber, R., Kouveliotou, C., In 't Zand, J., Heise, J., Costa, E., Feroci, M., Piro, L., Frontera, F., Zavattini, G., Nicastro, L., Palazzi, E., "GRB 970228", IAU Circular 6584.

Groot, P.J., Galama, T., van Paradijs, J.A., Kouveliotou,C., **Strom, R.G.**, Brown, M., Webster, K., Van Zyl, L., Warner, B., Menzies, J., in 't Zand, J., Heise, J., Costa, E., Feroci, M., Piro, L, Frontera, F., Zavattini, G., Nicastro, L., Palazzi, E., "GRB 970402", IAU Circular 6616.

Haarlem, M.P. van, Frenk C.S. and White S.D.M., "Projection Effects in Cluster Catalogues", MNRAS 287, 817.

Paradijs, J.A. van., Groot, P.J., Galama, T., Kouveliotou, C., **Strom, R.G., Telting, J., Rutten, R.G.M.**, Fishman, G.J., Meegan, C.A., Pettini, M., Tanvir, N., Bloom, J., Pedersen, H., Nordgaard-Nielsen, H.U., Linden-Vornle, M., Melnick, J., Van Der Steene, G., Bremer, M., Naber, R., Heise, J., In't Zand, J., Costa, E., Feroci, M., Piro, L., Frontera, F., Zavattini, G., Nicastro, L., Palazzi, E., Bennet, K., Hanlon, L., Parmar, A., "Transient Optical Emission from the Error Box of the Gamma-Ray Burst of 28 February 1997", Nature, 386, 686.

Rengelink, R.B., **Tang, Y., de Bruyn, A.G.**, Miley, G.K., Rottgering, H.J.A., Bremer, M.A.R., "The Westerbork Northern Sky Survey (WENSS) I. A 570 square degree mini survey around the North Celestial Pole". Astron.Astrophys. Suppl. 124, 259-280.

Röttgering, H.J.A., Hunstead, R., Bremer, M.N., Edge, A.C., Ekers, R.D., **van Haarlem, M.P.**, Rengelink, R., and Wieringa, M.H.: 1997, "The connection between radio halos and rich clusters: the case of A3667 and a search for distant radio halos", in M. Bremer et al. (eds.), Observational Cosmology with the New Radio Surveys, p. 119.

Strom, R.G., "Supernovae: kosmisch vuurwerk", Zenit, nr. 1, 8.

Strom, R.G., de Pater, I., van der Tak, F., "Longitudinal asymmetry of Jupiter's radiation belts after the encounter with comet D/Shoemaker-Levy 9", in "High-sensitivity radio astronomy", (N. Jackson, R. Davis, eds.), 2, Cambridge University Press.

Taylor, G.B., **Vermeulen, R.C.**, "Bi-Directional Relativistic Jets of the Radio Galaxy 1946+708: Constraints on the Hubble Constant", ApJ, 485, L9-L12.

Thilker, D.A., **Braun, R.**, Walterbos, R.A.M., "Expanding HI shells in NGC 2403: First results from an automated object recognition package", Astronomy & Astrophysics.

Publications Funded by Grants Programme

Refereed Journals

Aitken, D.K., Smith, C.H., Moore, T.J.T., Roche, P.F., Fujiyoshi, T., Wright, C.M., "Mid- and far-infrared polarimetric studies of the core of OMC-1: the inner field configuration", MNRAS, 286, 85.

Barstow M.A., Dobbie P.D., Holberg J.B., Hubeny I., Lanz T., "Interstellar and photospheric opacity from EUV spectroscopy of DA white dwarfs", MNRAS, 286, p. 58.

Barziv, O., Kuulkers, E., Mendez, M., van der Hooft, F., Groot, P.J., van der Klis, M., Kemper, C. and van Paradijs, J.A., "Optical Photometry of Sco X-2", A&A, 325, 1035.

Beaulieu, J.P, Krokenberger, M., Sasselov, D., Ferlet, R., Vidal-Madjar, A., Guibert, J., Moreau, O., Tajahmady, F., Maurice, E., Prevot, L., Gry, C., Aubourg, E., Bareyre, P., Brehin, S., Gros, M., Lachieze-Rey, M., Laurent, B., Lesquoy, E., Magneville, C., Milsztajn, A., Moscoso, L., Queinnec, F., Rich, J., Spiro, M., Vigroux, L., Zylberajch, S., Ansari, R., Cavalier, F., Moniez, M., "EROS variable stars: Discovery of beat Cepheids in the Small Magellanic Cloud, and the effect of metallicity on the stellar pulsation", A&A, 321, L5.

Beaulieu, J.P, Sasselov, D., Renault, C., Ferlet, R., Grison, P., Vidal-Madjar, A., Guibert, J., Moreau, O., Tajahmady, F., Maurice, E., Prevot, L., Gry, C., Aubourg, E., Bareyre, P., Brehin, S., Gros, M., Lachieze-Rey, M., Laurent, B., Lesquoy, E., Magneville, C., Milsztajn, A., Moscoso, L., Queinnec, F., Rich, J., Spiro, M., Vigroux, L., Zylberajch, S., Ansari, R., Cavalier, F., Moniez, M., "The effect of metallicity on the Cepheid distance scale and its implications for the Hubble constant H_0 determination", A&A, 318, L47.

Best, P., Longair, M.S., and Röttgering, H.J.A., "A jet-cloud interaction in 3C34 at redshift z=0.69", MNRAS, 286, 785.

Best, P.N., Longair, M.S., and Röttgering, H.J.A., "HST, radio and infrared observations of 28 3CR radio galaxies at redshift z~ 1. The observations", MNRAS 292, 758

Blaes, O., Hurt, T., Antonucci, R., Hurley, K. and Smette, A, "Infrared observations of the possible X-ray counterpart to the May 1, 1992 Gamma-ray burst", ApJ 479, 868.

Bloemen, H., Bykov, A.M., Bozhokin, S.V., Diehl, R., Hermsen, W., Van der Meulen, R.D., Oberlack, U., Ryan, J., Schönfelder, V., Strong, A.W., Winkler, C., "New COMPTEL Results on MeV Gamma Rays from the Orion/Monoceros Region", ApJ 475, L25.

Boogert, A.C.A., Schutte, W.A., Helmich, F.P., Tielens, A.G.G.M., and Wooden, D.H., "Infrared observations and laboratory simulations of interstellar CH_4 and SO_2", A&A, 317, 929.

Bottema R., Gerritsen J.P.E., "An investigation of the structure and kinematics of the spiral galaxy NGC 6503", MNRAS, 290, 585

Carilli, C.L., Röttgering, H., van Ojik, R., Miley, G.K., and van Breugel, W., "Radio Continuum Imaging of High Redshift Radio Galaxies", ApJS 109, 1.

de Pater, I., van der Tak, F., Strom R.G. and Brecht S.H., "The evolution of Jupiters radiation belts after the impact of comet Shoemaker/Levy 9" Icarus 129, 21-47.

Dominik, C., Tielens, A.G.G.M. "Coagulation of dust grains and the structure of dust aggregates in space", ApJ 480, 647.

Dominik, C., Laureijs, R.L., Jourdain de Muizon, M. and Habing, H.J., "A Vega—like disk associated with the planetary system of rho1 Cnc.", A&A , 329, L53..

Galama, T.J., De Bruyn, A.G., Van Paradijs, J.A., Hanlon, L., and Bennett, K., "Two variable sources near the position of GRB 940301" ,A&A, 321, 229.

Galama, T.J., de Bruyn, A.G., Paradijs, J.A. van, Hanlon, L. and Bennett, K., "Unusual increase in the 325 MHz flux density of PSR B0655+64", A&A, 325, 631.

Galama, T.J., Paradijs, J.A. van, Strom, R.G., Hurley, Kouveliotou, Fishman, Meegan, Heise, Bruyn, A.G. de, Hanlon, L., Bennett, K., Telting, J. Rutten, Groot, "Radio and optical follow-up observations and improved IPN position of GRB 970111", ApJ, 486, L5.

Galama, Groot, Van Paradijs, Kouveliotou, Robinson, Fishman, Meegan, Sahu, Livio, Petro, Macchetto, Heise, In 't Zand, Strom, Telting, Rutten, Pettini, Tanvir, Bloom, "The decay of optical emission from the gamma-ray burst GRB 970228", Nature 387, 479.

Gerritsen J.P.E., Icke V., RMxAC 6, 261, in "Starburst Activity in Galaxies", Puebla, Mexico

Gerritsen J.P.E., Icke V., "Star Formation in N-body simulations. I. The impact of the stellar ultra violet radiation on star formation", A&A, 325, 972.

Gurbatov, S.N, Simdyankin, S.I., Aurell, E., Frisch, U. and Toth, G., "On the decay of Burgers turbulence", Journal of Fluid Mechanics, 344, pp.339.

Gurvits, L.I., Schilizzi, R.T., Miley, G.K., Peck, A., Bremer, M.N., Röttgering, H., Chambers, K.C., and van Breugel, W., " A compact radio component in 4C41.17 at z=3.8: a massive clump in a forming galaxy", A&A, 318, 11.

Holberg J.B., Barstow M.A., Lanz T., Hubeny I., "Hubble Space Telescope Ultraviolet Spectroscopy of two Hot White Dwarfs", ApJ, 484, p. 871.

Jones, M., Saunders, R., Baker, J., Cotter, G., Edge, A., Grainge, K., Lasenby, A., Pooley, G., and R^ttgering, H., "Detection of a CMB decrement towards the z = 3.8 quasar pair PC1643+463", ApJ. 479, L1.

Kirk, J.G., Duffy, P., and Gallant, Y.A., "Particle acceleration at shocks in the presence of a braided magnetic field", Advances in Space Research 19, 707.
Lamers, H.J.G.L.M., Harzevoort, J.M.A.G., Schrijver, H., Hoogerwerf, R., Kudritzki, R.P., "The effect of rotation on the absolute visual magnitudes of OB stars measured with Hipparcos", A&A, 325, L25.
Lanz T., Hubeny I., Heap S.R., "NLTE line blanketed model atmospheres of hot stars. III. Hot Subdwarfs: The sdO Star, BD +75 325", ApJ, 485, p. 843.
Mathys G., Lanz T., "The variations of the Bp star HD 137509", A&A, 323, p.881.
Mathys G., Hubrig S., Landstreet J.D., Lanz T., Manfroid J., "The mean magnetic field modulus of Ap stars", A&A Suppl. Series 123, p. 353.
Miller, B.W., Whitmore, B., Schweizer, F. and Fall, S.M., "The Star Cluster System of the Merger Remnant NGC 7252", ApJ, 114, 2381.
Paradijs, J.A. van., Groot, P.J., Galama, T., Kouveliotou, C., Strom, R.G., Telting, J., Rutten, R.G.M., Fishman, G.J., Meegan, C.A., Pettini, M., Tanvir, N., Bloom, J., Pedersen, H., Nordgaard-Nielsen, H.U., Linden-Vornle, M., Melnick, J., Van Der Steene, G., Bremer, M., Naber, R., Heise, J., In't Zand, J., Costa, E., Feroci, M., Piro, L., Frontera, F., Zavattini, G., Nicastro, L., Palazzi, E., Bennet, K., Hanlon, L., Parmar, A., "Transient Optical Emission from the Error Box of the Gamma-Ray Burst of 28 February 1997", Nature, 386, 686.
Pentericci, L., Röttgering, H., Miley, G.K., Carilli, C.L., and McCarthy, P., "The radio galaxy 1138-262 at z=2.2: a giant elliptical at the center of a proto-cluster?",A&A, 326, 580.
Renault, C., Afonso, C., Aubourg, E., Bareyre, P., Brehin, S., Gros, M., Lachieze-Rey, M., Laurent, B., Lesquoy, E., Magneville, C., Milsztajn, A., Moscoso, L., Queinnec, F., Rich, J., Spiro, M., Vigroux, L., Zylberajch, S., Ansari, R., Cavalier, F., Moniez, M., Beaulieu, J.P., Ferlet, R., Grison, Ph., Vidal-Madjar, A., Guibert, J., Moreau, O., Tajahmady, F., Maurice, E., Prevot, L., Gry, C., "Observational Limits on Machos in the Galactic Halo", A&A, 324, L69.
Rengelink, R. B., Tang, Y., de Bruyn , A.G., Miley, G.K., Bremer, M. N., R^tgering, H.J.A., and Bremer, M.A.R., "The Westerbork Northern Sky Survey (WENSS) I. A 570 square degree Mini-Survey round the North Ecliptic Pole", A&A, 124, 259.
Röttgering, H., van Ojik, R., Miley, G., Chambers, K., van Breugel, W., and de Koff, S., "Spectroscopy of Ultra-Steep Spectrum Radio Sources: A sample of z>2 Radio Galaxies, A&A, 326, 505.
Röttgering, H., Wieringa, M.H., Hunstead, R., and Ekers, R.D., "The extended radio emission in the luminous X-ray cluster A3667", Monthly Notices of the Royal Astronomical Society, 290, 577.
Sasselov, D., Beaulieu, J.P, Renault, C., Ferlet, R., Grison, P., Vidal-Madjar A., Guibert, J., Moreau, O., Tajahmady, F., Maurice, E., Prevot, L., Gry, C., Aubourg, E., Bareyre, P., Brehin, S., Gros, M., Lachieze-Rey, M., Laurent, B., Lesquoy, E., Magneville, C., Milsztajn, A., Moscoso, L., Queinnec, F., Rich, J., Spiro, M., Vigroux, L., Zylberajch, S., Ansari, R., Cavalier, F., Moniez M., "Metallicity Effects on the Cepheid Extragalactic Distance Scale from EROS photometry in LMC and SMC", A&A, 324, 471.
Schutgens,N.A.J.,"Prominence Oscillations and Stability;Communicating the distant photospheric boundary", A&A, 323, 969.
Schutgens, N.A.J., "Vertical Prominence Oscillations and Stability; A comparison of the influence of the distant photosphere in inverse polarity and normal polarity prominence models",A&A, 325, 352.
Schutte, W.A., "Thermal chemistry of ice mixtures of astrophysical relevance", Advances in Space Research, 20, 1629.
Schutte, W.A., Greenberg, J.M., "Further evidence for the OCN- assignment to the XCN band in astrophysical analogues", A&A, 317, L43.
Sevenster, M.N., Chapman, J.M., Habing, H.J., Killeen, N.E.B., Linqvist, M., "The ATCA/VLA OH 1612 MHz survey. I. Observations of the galactic bulge regio", A&A, 122, 79.
Sevenster, M.N., Chapman, J.M., Habing, H.J., Killeen, N.E.B., Linqvist, M., "The ATCA/VLA OH 1612 MHz survey. II. Observations of the galactic disk region", A&A, 124, 509.
Smette, A., Claeskens, J.-F. and Surdej, J., "Gravitational lensing by damped Ly-α absorbers", New Astronomy, 2, 53.
van der Hooft, F., Groot, P.J., Shahbaz, T., Augusteijn, T., Casares, J., Dieters, S., Greenhill, J., Hill, K., Scheers, L.H.A., Naber, R. M., de Jong, J.A., Charles, P.A., van Paradijs, "The black hole transient Nova Scorpii 1994 (=GRO J1655-40): orbital ephemeris and optical light curve", MNRAS, 286, L43.
van der Veen, P.M., van Genderen, A.M., van der Hucht, K.A., Li, A., Sterken, C., Dominik, C., "WR121 obscured by a dust cloud: the key to understanding occasional eclipses of dusty Wolf-Rayet WC stars?", A&A, 329, 199.
van Ojik, R., Röttgering, H., van der Werf, P., Miley, G.K., Carilli, C.L., Isaak, K., Lacy, M., Jenness, T.,Sleath, J., Visser, A., and Wink, J., "A search for molecular gas in high redshift radio galaxies",A&A,321, 389.
van Ojik, R., Röttgering, H.J.A., Miley, G.K., and Hunstead, R., "The Gaseous Environment of Radio Galaxies in the Early Universe: Kinematics of the Lyman α Emission and Spatially Resolved HI Absorption", A&A, 317, 358.
Whitmore, B., Miller, B.W., Schweizer, F. and Fall, S. M., "HST Observations of Two Dynamically Young Ellipticals", ApJl, 114, 1797.
Whittet, D.C.B., Boogert, A.C.A., Gerakines, P.A., Schutte, W., Tielens, A.G.G.M., de Graauw, Th., Prusti, T., van Dishoeck, E.F, Wesselius, P.R., Wright C.M. , "ISO SWS spectroscopy of dust in the diffuse interstellar medium toward Cygnus OB2 no. 12", ApJ, 490, 729.

Proceedings

Albrow, M., Beaulieu, J.P., Birch, P., Caldwell, J.A.R., Greenhill, J., Hill, K., Kane, S., Martin, S., Menzies, J., Naber, R., Pel, J.W., Pollard, K., Sackett, P., Sahu, K., Vreeswijk, P., Watson, P., Williams A., Zwaan, M., "Results from the PLANET Collaboration" (invited contribution) 6 March 1997, "The Third International Workshop on Gravitational Microlensing Surveys South Bend", Indiana, USA (6-8 March 1997).

Albrow, M., Beaulieu, J.P., Birch, P., Caldwell, J.A.R., Greenhill, J., Hill, K., Kane, S., Martin, S., Menzies, J., Naber, R., Pel, J.W., Pollard, K., Sackett, P., Sahu, K., Vreeswijk, P., Watson, P., Williams A., Zwaan, M., oral contribution, "The Planet Collaboration: Probing Lensing Anomalies NETwork", dans "Variable stars and the astrophysical return of microlensing surveys", 12th IAP Colloquium, "Variable Stars and Astrophysical Returns of Microlensing Surveys", Eds. R. Ferlet, J.P. Maillaird and B. Raban, 135.

Barstow M.A., Holberg J.B., Hubeny I., Lanz T., "Heavy Elements in White Dwarf Envelopes", in White Dwarfs, Proc. 10th European Workshop on White Dwarfs, Eds. Isern J. et al., Kluwer, p. 237-243.

Beaulieu, J.P., "Recherche de planetes par effet de microlentille gravitationnelle", dans Compte-rendus de l'ecole de Goutelas 1997.

Beaulieu, J.P. and Lamers, H., review, "EROS : serendipitous discovery of Herbig AeBe stars in the Large Magellanic Cloud", in "Variable stars and the astrophysical return of microlensing surveys", IAP Colloquium, Eds. R. Ferlet, J.P. Maillard.

Beaulieu, J.P., H_0 : Effet de métallicité et relation période-luminosité des Céphéides", JAF 53, 31.

Beaulieu, J.P., Buchler, J.R., Kollàth Z., Goupil, M.J., "A 14 days star with two phase-locked modes of pulsation in the EROS database", poster, dans "Variable stars and the astrophysical return of microlensing surveys", IAP Colloquium, Eds. R. Ferlet, J.P. Maillard.

Beaulieu,J.P. and Sasselov,D., review, "EROS : Differential studies of Cepheids in the Magellanic Clouds : stellar pulsation, stellar evolution and distance scale ", dans "Variable stars and the astrophysical return of microlensing surveys", IAP Colloquium, Eds. R. Ferlet, J.P. Maillard.

Best, P., Longair, M.S., and Röttgering, H.J.A., "The high-redshift 3CR radio galaxies: cD galaxies in high redshift clusters", in M. Bremer et al. (eds.), "Observational Cosmology with the NewRadio Surveys", p. 11.

Best, P., Longair, M.S., and R^ttgering, H.J.A., "The 3CR Radio Galaxies at z~1: Old Stellar Populations in Central Cluster Galaxies" in L.N. da Costa and A. Renzini (eds.), "Galaxy Scaling Relations: Origins, Evolution and Applications", p. 232, Springer-Verlag.

Bloemen, H., Bykov, A.M., Diehl, R., Hermsen, W., Van der Meulen, R., Schönfelder, V., Strong, A.W., "COMPTEL Spectral Study of the Inner Galaxy", in: "Proceedings of the Fourth Compton Symposium", eds. C.D. Dermer, M.S. Strickman, J.D. Kurfess, pp. 1074.

De Zeeuw, P.T., Brown, A.G.A., de Bruijne, J.H.J., Hoogerwerf, R., Lub, J., Le Poole R.S., Blaauw, A., "Structure and Evolution of Nearby OB Associations", in: "Hipparcos Venice '97", ESA-SP 402, ed. B. Battrick, pp. 495.

De Breuck, C., van Breugel, W., Röttgering, H.J.A., and Miley, G.K., "Searches for High Redshift Radio Galaxies", in M. Bremer et al. (eds.), "Observational Cosmology with the New Radio Surveys", p. 185.

De Bruijne, J.H.J., Hoogerwerf, R., Brown, A.G.A., Aguilar, L.A., de Zeeuw, P.T., "Improved Methods for Identifying Moving Groups", in: "Hipparcos Venice '97", ESA-SP 402, ed. B. Battrick, pp. 575.

Dominik, C., et al., "Observing Faint IR Excesses of Main Sequence Stars", in "Taking ISO to the Limits: Exploring the Faintest Sources in the Infrared", R. J. Laureijs and D. Levine, editors.

Dominik, C., Tielens, A.G.G.M., "Adhesion, rolling friction and the structure of dust aggregates in space", in "Proceedings of the 20th annual meeting of the Adhesion Society", eds. L. T. Drzal and H. P. Schreiber, pp. 227.

Gallant, Y.A., Tagger, M., Kuijpers, J., Fletcher, L. and Raadu, M., "Transit Time Pumping in AE Aquarii", in Proceedings of the Eight Network Workshop on "Energetic Particles in Astrophysical and Space Plasmas", held in Palmela, Portugal, March 5-7, 1997.

Gallant, Y.A., "Radio wave propagation in pulsar magnetospeheres", in Proceedings of the Symposium on "Neutron Stars and Pulsars: Thirty years after the discovery", held in Tokyo, Japan, November 17-20, 1997.

Gerritsen, Jeroen, "Star Formation and the Interstellar Medium in Galaxy Simulations", Proefschrift Faculteit Wiskunde en Natuurwetenschappen, Rijksuniversiteit Groningen (14-11-97), 95 pgs.

Gieseler, U.D.J., Duffy, P., Kirk, J.G. and Gallant, Y.A., "Monte Carlo simulation of particle transport in braided magnetic fields", in Proc. of the 25th International Cosmic Ray Conference, Durban, South Africa, vol. 4, p. 437.

Hill, V., Beaulieu, J.P., invited contribution, "RRLyrae stars in the EROS database", dans "Variable stars and the astrophysi cal return of microlensing surveys", IAP Colloquium, Eds. R. Ferlet, J.P. Maillard.

Hoogerwerf, R., De Bruijne, J.H.J., Brown, A.G.A., Lub, J., Blaauw, A., de Zeeuw, P.T., "New Results for Three Nearby OB Associations", in: "Hipparcos Venice '97", ESA-SP 402, ed. B. Battrick,pp. 571.

Hurley, K., Murakami, T., Li, O., Smette, A., Kouveliotou, C., Fishman, G., Laros, J., Cline, T., Shibata, R., Ogasaka, Y., Pedersen, H., Vrba, F., Luginbuhl, C., Palmer, D., Ricker, G., Boer, M., Kawai, N., Matsuoaka, M., Yoshida, A., Yamauchi, M., Nishimura, J., Yoshida, K., "Two Possible Soft X-Ray Counterparts to Gamma-Ray Burst Sources",

in "All-Sky X-Ray Observations in the Next Decade", RIKEN, Japan, eds. M. Matsuoka and N. Kawai, p. 173.
Koopmans, L.V.E., de Bruyn, A.G., Nair, S., "Spiral galaxy lensing, Golden Lenses", Proceeding of a workshop held at Jodrell Bank, University of Manchester, UK, June 23-25 1997.
Kollàth, Z., Buchler, J.R., Beaulieu J.P., Goupil, M.J., "Modelling the phase-locked of the 14 days EROS star", poster, dans "Variable stars and the astrophysical return of microlensing surveys", IAP Colloquium, Eds. R. Ferlet, J.P. Maillard.
Much, R., Bennett, K., Winkler, C., Diehl, R., Lichti, G., Schˆnfelder, V., Steinle, H., Strong, A., Varendorff, M., Hermsen, W., Kuiper, L., Van der Meulen, R., Connors, A., McConnell, M., Ryan, J., Buccheri, R., "5 years of Crab Pulsar observa tions with COMPTEL", in: "Proceedings of the Fourth Compton Symposium", eds. C.D. Dermer, M.S. Strickman, J.D. Kurfess, pp. 542.
Pentericci, L., Röttgering, H., and Miley, G.K.., "The radio galaxy 1138-262 at z=2.2: a starburst galaxy at the center of a cluster?", Memorie Societa Astronomica Italiana 68, 247.
Pentericci, L. and Röttgering, H., "The radio galaxy 1138-262 at z=2.2: a forming cD galaxy at the center of a cluster?", in M. Bremer et al. (eds.), "Observational Cosmology with the New Radio Surveys", p. 123
Rengelink, R.B., Miley, G.K., Bremer, M.N., Röttgering, H.J.A., de Bruyn, A.G., and Tang, Y., "The Westerbork Northern Sky Survey: Current status of the survey and the study of Large Scale Structure", in M. Bremer et al. (eds.), Observational Cosmology with the New Radio Surveys, p. 143
Röttgering, H.J.A., Hunstead, R., Bremer, M.N., Edge, A.C., Ekers, R.D., van Haarlem, M., Rengelink, R., and Wieringa, M.H.: 1997, "The connection between radio halos and rich clusters: the case of A3667 and a search for distant radio halos", in M. Bremer et al. (eds.), Observational Cosmology with the New Radio Surveys, p. 119.
Schoenmakers, A.P., Rˆttgering, H.J.A., van der Laan, H., and de Bruyn, A.G., "A new sample of z > 0.3 Giant radio Galaxies from the WENSS and the FIRST surveys", in M. Bremer et al. (eds.), Observational Cosmology with the New Radio Surveys, p. 239.
Schutte, W.A., "Laboratory simulation of physical and chemical processes in interstellar ices", IAU Symp. 178: "Molecules in Astrophysics: Probes & Processes", ed. E.F. van Dishoeck (Dordrecht: Kluwer), 331.
Toth, G., "Versatile Advection Code", Lecture Notes in Computer Science, 1225, pp.253, proceedings of the High-Performance Computing and Networking '97 conference, Vienna, Austria.
Van der Meulen, R.D., Bloemen, H., Bennett, K., Hermsen, W., Kuiper, L., Much, R.P., Ryan, J., Schönfelder, V., Strong, A., "COMPTEL gamma-ray study of the Crab nebula", in: "Proceedings of the Fourth Compton Symposium", eds. C.D. Dermer, M.S. Strickman, J.D. Kurfess, pp. 537.

Van der Hooft, F., Kouveliotou, C., van Paradijs, J.A., Crary, D.J., Rubin, B.C., Finger, M.H., Harmon, B.A., van der Klis, M., Lewin, W.H.G and Fishman, G.J., "Rapid X-ray variability in GRO J0422+32 (Nova Per 1992)", in: AIP Conf. Proc. 410, "Proceedings of the Fourth Compton Symposium", eds. C.D. Dermer, M.S. Strickman, and J.D. Kurfess, (New York: AIP), 947.
Van der Ploeg, A., Keppens, R. and Toth, G., "Block Incomplete LU-preconditioners for Implicit Solution of Advection Dominated Problems", Lecture Notes in Computer Science, 1225, pp.421, proceedings of the High-Performance Computing and Networking '97 conference, Vienna, Austria.
Veen, P.M., van Genderen, A.M., de Jong, J., "Two new variable stars near the variable WR7 (= HD56925) and the constant WR18 (= HD89358), Information Bulletin on Variable Stars, 4490, 1.
Wright, C.M., Smith, C.H., Krabbe, A., Lehmann, T., Boeker, T., "Comet C/1995 O1 (Hale-Bopp)", IAU Circular no. 6590, March 17, 1997.

Reports/Publications by Technical Laboratory Staff

Amerongen, H.J. van, "Test Report: Scanner controls (LVDT)", October 97, VLT-MAN-VIS-14300-5002
Amerongen, H.J. van, en Donker, P., "Telescoop besturingshardware en microprocessor software in de komende 20 jaar", March 97, Note 653
Amerongen, H.J. van, "Preliminary Design Report for the VISIR Spectrometer mechanisms controls and LCU, October 97, VLT-MAN-VIS-14300-5003
Arts, M.J., "Reflectivity levels of the AMS", 16 September 97, SKAI/Development/45
Arts, M.J., "Reflectivity levels of the AMS at 1.8 GHz, Oktober 97, SKAI/Development/46
Arts, M.J., "Overview of antenna element types", 8 August 97, SKAI/Research/22
Arts, M.J., "Overview of illumination horns in the 2-4 GHz range, November 97, SKAI/Product/7
Arts, M.J., "Experiments with a bowtie antenna", 13 August 97, SKAI/Development/35
Bats, W., "Dielectric properties of Air", 25 September 97, SKAI/Research/28
Bats, W., "Absorbtion of water by foam materials", November 97, SKAI/Research/43
Bats, W., "Excel file dielectric properties of air and foam", November 97, SKAI/Research/42
Braun, R., Bregman, J.D., "Interferometry with Adaptive Arrays", SKAI note.
Bregman, J.D., "Identification of common problem fields and critical study items", January 97, SS#003
Bregman, J.D., "Growth path design for a SKAI Phase One Target Telescope", March 97, SS#016
Bregman, J.D., "Study Specification groupw as link between Design cycle and study program or Research cycle, February 97, SS#008
Bregman, J.D., "Innovative Antenna Technology Assessment report", March 97, SS#005
Bruyn, A.G. de, "RM-synthesis via Wide-band low frequency polarimetry", Maart 97, Note 655
Coolen, A.H.W.M., "CtrlTCS modifications", 24/02/97, NFRA/TMS/Memo 231
Coolen, A.H.W.M., "How to setup Linux for NIS (Yellow pages)", 27 Augustus 97, TMS/Memo/267
Doorduin, A., "Manpower estimating for the OSMA DBF board", October 97, SKAI/Project/110
Drost, M., "Thermal Analysis of VISIR", October 97, VLT-MAN-VIS-14300-5006
Drost, M., "Verification of Finite Element Tools", October 97, VLT-MAN-VIS-14300-5001
Formanoy, I.J.H., "Mechanical tests on the dipole test model", October 97, SKAI/Research/33
Formanoy, I.J.H., "Planning voor de bouw (dipool) antenne model", 15 July 97, SKAI/Project/101
Formanoy, I.J.H., "Mechanical design of the fractal dipole array", 26 September 97, SKAI/Research/29
Formanoy, I.J.H., "Specificatie antenne model", 19 September 97, SKAI/Research/26
Formanoy, I.J.H., "Visit from and to PARABEAM", October 97, SKAI/Research/31
Formanoy, I.J.H., "Construction of the support structure", 19 September 97, SKAI/Research/27
Formanoy, I.J.H., "Time schedule for SKAI/VISIR", October 97, SKAI/Project/107
Formanoy, I.J.H., "Technical feasibility study of the OSMA antenna array subsystem", 22 August 97, SKAI/Development/39
Formanoy, I.J.H., "Time planning of the mechanical tests on the (dipole) test model", 16 September 97, SKAI/Project/104
Formanoy I.J.H., "Possibilities of connections between the Bowtie and the electronics", 18 September 97, SKAI/Research/25
Formanoy, I.J.H., "Visit to exhibition of LPKF", November 97, SKAI/Research/38
Formanoy, I.J.H., "Effects of molding techniques on the fractal array", October 97, SKAI/Research/32
Formanoy, I.J.H., "Visit to the exhibition in Munich", November 97, SKAI/Project/117
Formanoy, I.J.H., "Some pictures of things that happened during testing", November 97, SKAI/Research/37
Goris, M.J., "Categories of Radio Frequence Interference", 3 September 97, SKAI/Research/24
Goris, M.J., "Reducing the computational load of a Kalman Filter", October 97, SKAI/Other/12
Goris, M.J., "Technical Research Objective Document", 27 August 97, SKAI/Research/TROD 1
Goris, M.J., "Using Matlab to debug software", October 97, SKAI/Development/47
Goris, M.J., "Reducing the computational load of a Kalman Filter", 27 August 97, in Electronics Letters, eds Sir Eric Ash, Prof. Peter Clarricoats, vol. 33, p 1539 - 1541
Goris, M.J., "Report on RFI Research", December 97, SKAI/Other/13
Goris, M.J., "The adaptive beamformer of the SKAI Adaptive Antenna Demonstrator", 21 August 97, SKAI/Development/37
Grit, T., "Ethernet - HPIB deamon for SUN system", 14 February 97, NFRA/TMS/Memo 225
Grit, T., "Problemen bij overgang HPUX 9 naar HPUX 10", 14 February 97, NFRA/TMS/Memo/224
Grit, T., "Dynamic Scheduling: Stage Analysis Report", 5 September 97, TMS/SAR/51 (v.01)
Hampson, G.A., Paplinski, A., "Hardware implementation of an Ultrasonic Beamformer", August 97, submitted in Tencon '97, Brisbane, Australia, December 97
Hampson, G.A., "OSMA software outline/timeline", November 97, SKAI/Project/114
Hampson, G.A., "The Adaptive Antenna Demonstrator", December 97, SKAI/Other/14
Hampson, G.A., "Control of the OSMA system", December 97, SKAI/Development/49
Hampson, G.A., "Stagiair for OSMA Data Acquisition", December 97, SKAI/Project/118
Hampson, G.A., "Adaptive Testing Time Line", October 97, SKAI/Project/109

Hampson, G.A., Goris, M.J., Joseph, A., Smits, F.M.A., "The Adaptive Antenna Demonstrator", September 97,
Hampson, G.A., "Defining OSMA positioning system accuracy", October 97, SKAI/Development/48
Hanekamp, M.J., "Het ontwerpen van een interface voor de aansturing van het IVC-systeem", June 97, stageverslag
Hanekamp, M.J., "De besturing van het IVC-systeem", April 97
Jong, A.P.M. de, "Test Report: Single-Point-Mounted-Mirror and GHUR blank", October 97, VLT-MAN-VIS-14300-5007
Jong, A.P.M. de, "TS and SOW for the Spectrometer Mirrors", October 97, VLT-MAN-VIS-14300-5008
Joseph, A., "Digital Beamforming system - upgrade options", December 97, SKAI/Development/42
Joseph, A., "SKAI hardware description - AAD Frontend Unit", 10 July 97, SKAI/Development/33
Joseph, A., "A New Digital Beamforming System", 27 August 97, SKAI/Development/43
Joseph, A., "Receiver system upgrade for OSMA", 26 August 97, SKAI/Development/41
Joseph, A., "Digital Beamforming system - Upgrade Options", 26 August 97, SKAI/Development/42
Joseph, A., "RF Beamforming feasibility study for OSMA", 13 August 97, SKAI/Development/36
Joseph, A., "Adaptive Antenna Demonstrator documentation structure", 12 August 97, SKAI/Project/18
Kan, R., "Analysis Report for the VISIR Single Point Mounted Mirror", October 97, VLT-MAN-VIS-14300-5004
Koopman, Y.J., "Design Report: Wiring, Connectors, Sensors and Heaters of VISIR, October 97, VLT-MAN-VIS-14300-5005
Kroes, G., "Mechanical Design Report for the VISIR Spectrometer", October 97, VLT-MAN-VIS-14300-5008
Millenaar, R.P., "The EVNFRA Data Distributor Unit: Hardware Description", December 97, Note 659
Noordam, J.E., "On synthesis reduction in AIPS++", June 97,
Noordam, J.E., "Mns Parm: Interaction between Mns Trees and persistently stored values", June 97
Noordam, J.E., "A generic Solver for AIPS++", June 97
Noordam, J.E., "Description of Mns classes", June 97
Pel, J.W., "Spectrometer System Specifications", October 97, VLT-MAN-VIS-14300-5004
Schoenmaker, A.A., "TS and SOW for het Gratings", October 97, VLT-MAN-VIS-14300-5006
Schoenmaker, A.A., "TS and SOW for the etalons", October 97, VLT-MAN-VIS-14300-5005
Schoenmaker, A.A., "Analysis Report for the VISIR Spectrometer opto-mechanical tolerances, October 97, VLT-MAN-VIS-14300-5001
Schoenmaker, A.A., "TS and SOW for the filters", October 97, VLT-MAN-VIS-14300-5005
Smits, F.M.A., "The Use of the AMW documentation control for SKAI", 12 August 97, SKAI/Project/102
Smits, F.M.A., "OSMA development project specification", 22 August 97, SKAI Development/40
Smits, F.M.A., "SKAI hierarchical level overview", October 97, SKAI/Project/106
Smits, F.M.A., "SKAI R&D budget numbering structure 1997", October 97, SKAI/Project/105
Smits, F.M.A., "OSMA technical feasibility study", 5 September 97, SKAI/Development/44
Smits, F.M.A., "OSMA system specification", 21 August 97, SKAI/Development/38
Smits, F.M.A., "Definition of SKAI budget number items", November 97, SKAI/Project/113
Smits, F.M.A., "Definition of SKAI budget items '98", October 97, SKAI/Project/112
Smolders, A.B., Arts, M.J., "Wide-band antenna element with integrated Balun", September 97, submitted to IEEE APS symposium Atlanta, June 98
Smolders, A.B., "Random sparse arrays", November 97, SKAI/Research/34
Someren Gréve, H.W. van, "HP1000 systeem tijdens DZB metingen", 19 March 97, NFRA/TMS/Memo 236
Someren Gréve, H.W. van, Le Poole, R., "The SCUBA fast data mode", Oktober 97, ITR 220
Someren Gréve, H.W. van, "Computer Plan WSRT", April 97, TMS/DOC/50 (v.2)
Strom, R.G., "Report of the UHF Test Period", March 97, Note 654
Swindlehurst, A.J., Goris, M.J., Ottersten, B., "Some Experiments with Array Data Collected in Actual Urban and Suburban Environments", April 97, "Proceedings of IEEE workshop on Signal Processing Advances in Wireless Communications"
Tinbergen, J., "Analysis Report: Polarization-induced photometric errors; system requirements for (spectro) polarimetry", October 97, VLT-MAN-VIS-14300-5009
Tolsma, H.P.T., "Spectrometer Development Plan", October 97, VLT-MAN-VIS-14300-5001
Tolsma, H.P.T., "Procedures and User Manual for the VISIR NFRA documentation system", October 97, VLT-MAN-VIS-14300-5001
Vos, C.M. de, "Graphical User Interfaces: Stage Definition", 20 January 97, TMS42 (v.1)
Vos, C.M. de, "AIPS++ installation at WSRT", 22 August 97, TMS/Memo/265
Vos, C.M. de, "Phase-out of existing software: Stage Definition", 20/01/97, TMS40 (v.1)
Vos, C.M. de, "Archiving of DZB data", 23 September 97, TMS/Memo/269
Vos, C.M. de, "Quality improvement: Stage Analysis Report", April 97, TMS/SAR/49 (v.1)
Vos, C.M. de, "Automatic Schedule: Stage Definition" , 20 January 97, TMS44 (v.1)
Vos, C.M. de, Grit T., "Project Specification: Stage Analysis Report" , 20 March 97 TMS46 (v.3)
Vos, C.M. de, "DZB Control: Stage Definition", 20 January 97,TMS41 (v.1)
Vos, C.M. de, "TMS/Rtap demonstration", 18 February 97, NFRA/TMS/Memo/226

Vos, C.M. de, van Someren Gréve H.W., "Computerplan WSRT", March 97, TMS50 (v.1)
Vos, C.M. de, "Quality Improvement Release 1 code: Stage Definition" 20 January 97, TMS45 (v.1)
Vos, C.M. de, "A strategy for handling TMS Calibration parameters", May 97, TMS/Memo/251
Vos, C.M. de,, "Baseline for TMS Release 2", 30 January 97, TMS47 (v.1)
Vos, C.M. de, "Presentation HP/Rtap for Logica and HP", 24 February 97, NFRA/TMS/Memo/230
Vos, C.M. de, "Some thoughts on DZB archiving", 17 March 97, NFRA/TMS/Memo 235
Vos, C.M. de, "Project Specification: Stage Definition", 20 January 97, TMS43 (v.1)
Vos, C.M. de, "Newsletter article TMS Release 1", 10 February 97, NFRA/TMS/Memo/223
Witvers, R.H., "Results of a survey of Radio-ICs for possible use", October 97, SKAI/Research/30
Witvers, R.H., "Resultaten van een onderzoek naar de mogelijke toepassing van radio ICs voor SKAI", August 97, Note 656
Woestenburg, E.E.M., "The LNAs for the Multi Frequency Front Ends", August 97, ITR 219
Woestenburg, E.E.M., "Interference suppression in the LNAs", November 97, Note 658
Woestenburg, E.E.M., "The LNAs for the Multi Frequency Front Ends", August 97, IRT 219
Woestenburg, E.E.M., "Modelling of LNA-sensitivity for input impedance variations", October 97, Note 657

Publications Based on WSRT Observations

Briggs F.H., Brinks E., Wolfe A.M., "Warm Neutral Gas at Redshift 3.4" AJ 113, 467
Broeils, A. H.,Rhee, M. -H. "Short 21 cm WSRT observations of spiral and irregular galaxies. HI properties" A&A, 324, 877 (1997)
Bravo-Alfaro H., Szomoru A., Cayatte V., Balkowski C., Sancisi R., "The HI distribution of spiral galaxies in the cluster A262" A&AS, 126, 537
Chengalur J.N., Braun R., Burton, B., "DI in the outer Galaxy", A&A 318, L35.
De Blok W.J.G., McGaugh S.S.," The dark and visible matter content of low surface brightness disc galaxies" MNRAS 290, 33
De Pater, I., van der Tak F., Strom R.G., Brecht S.H., "The Evolution of Jupiter's Radiation Belts after the Impact of Comet Shoemaker-Levy 9" Icarus, 129, 21
Feretti L., Boehringer H., Giovannini G., Neumann D., "The radio and X-ray properties of Abell 2255", A&A 317, 432.
Galama T.J., Groot P.J., Strom R.G., van Paradijs J., et al., "Radio and Optical Follow-up Observations and Improved Interplanetary Network Position of GRB 970111", ApJ 486, L5
Galama, T.J., de Bruyn A.G., van Paradijs J., Hanlon L., et al. " Two variable radio sources near the position of GRB 940301" A&A 321, 229
Galama T.J., Groot P.J., van Paradijs J., Kouveliotou, C., "Optical and radio observations of GRB 970228." Fourth Huntsville Gamma-Ray Burst Symposium, p. 3.
Galama T.J., de Bruyn A.G., van Paradijs J., Hanlon L., Bennett K., "Unusual increase in the 325 MHz flux density of PSR B0655+64" A&A 325, 631.
Groot, P.J., Galama, T.J., van Paradijs J., Strom R.G., et al. "GRB 970228", IAU Circular 6584.
Groot P., Galama T., van Paradijs, J., Kouveliotou C. "Optical and radio follow-up of GRB970508" Fourth Huntsville Gamma-Ray Burst Symposium, p. 8.
Hurley, K., Kouveliotou, C., Fishman, G., Meegan, C., et al., "GRB 970111", IAU Circular 6571.
Knapen, J.H., "Atomic Hydrogen in the spiral galaxy NGC 3631", MNRAS, 286, 403
Mack K.-H., Klein U., O'Dea C.P., Willis A.G. "Multi-frequency radio continuum mapping of giant radio galaxies" A&A Suppl., 123, 423
Rengelink R.B., Tang Y., De Bruyn A.G., Miley G.K., Bremer M.N., Rottgering H.J.A., The Westerbork Northern Sky Survey (WENSS), I. A 570 square degree Mini-Survey around the North Ecliptic Pole", A&A Suppl. 124, 259
Schwarz U.J., Goss, W.M., Kalberla P.M.W., "WSRT HI synthesis absorption study towards Cassiopeia A" A&A Suppl. 123, 43
Strom, R.G., Hanlon, L., Bennett K., Kouveliotou C. et al., "GRB 970228", IAU Circular 6574.
Swaters R.A., Sancisi R., van der Hulst J.M., "The HI halo of NGC 891" ApJ 491, 140
Tully R.B., Verheijen M.A.W., "The Ursa Major Cluster of Galaxies. II. Bimodality of the Distribution of Central Surface Brightnesses" ApJ 484, 145
Verdes-Montenegro L., Bosma A., Athanassoula E., "The ringed, warped and isolated galaxy NGC 6015" A&A 321, 754
Wakker B.P., Murphy E.M., van Woerden H., Dame T.M., "A Sensitive Search for Molecular Gas in High-Velocity Clouds", ApJ 488, 216.
Wakker B.P., van Woerden H., "High-Velocity Clouds" ARA&A 35, 217.

Publications Based on Observations with the Dwingeloo telescope

Phillipps S., Davies J. I., "The surface brightness and distance of Dwingeloo 1" A&A 327, 963.

Tilanus R.P.J., Burton W.B., "CO J=2->1 observations of the nearby galaxies Dwingeloo 1 and Dwingeloo 2", A&A 324, 899

Henning P.A., "HI searches in the Zone of Avoidance: Past and present (and future)" PASA 14, 21.

Reynolds C.S., Loan A.J., Fabian A.C., Makishima K., et al. "ASCA observations of the nearby galaxies Dwingeloo 1 and Maffei 1" MNRAS, 286, 349.

Blades, J.C., Sahu M.S., He, L., Crawford I.A., et al. "Ultra—High-Resolution Observations of Interstellar Na i and Ca ii K toward the High Galactic Latitude Star HD 28497", ApJ 478, 648.

McCall, M.L., Buta R.J., "Discovery of a Second Companion of Dwingeloo 1", AJ, 113, 981.

Westphalen G., Kalberla P.M.W., Mebold U., Hartmann D., Burton W.B., "The Leiden/Dwingeloo Survey at its Limits: σ ~ 70 km.s HI emission at high lattitudes" in "The Physics of Galactic Halos", Proceedings of the 156th WE-Heraeus Seminar, Bad Honnef, Germany p.27.

Kalberla P.M.W., Westphalen G., Pietz J., Mebold U., Hartmann D., Burton W.B. "HI Gas in the Galactic Halo" in "The Physics of Galactic Halos", Proceedings of the 156th WE-Heraeus Seminar, Bad Honnef, Germany p.3.

Abbreviations

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AAD	Adaptive Antenna Demonstrator
ADBF	Adaptive Digital Beam Former
AIPS	Astronomical Image Processing System
AMS	Antenna Measurement Setup
ASIC	Application Specific Integrated Circuit
ATNF	Australia Telescope National Facility
BATSE	Balloon And Transient Source Experiment
CERES	Consortium for European Research on Extragalactic Surveys
CJF	Caltech-Jodrell Bank Flat spectrum survey
CLASS	Cosmic Lens All-Sky Survey
CLEAR	Coronagraphic & Low Emissivity Astronomical Reflector
CML	Central Meridian Longitude
COBRA	Communication Technology Basic Research and Applications
CORDIC	Coordinate Rotation Digital Computer
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSO	Compact Symmetric Object
DCB	Digital Continuum Back End
DIMES	Delft Institute for MicroElectronics and Submicron technology
DOGS	Dwingeloo Obscured Galaxy Survey
DOT	Dutch Open Telescope
DREAM	Dutch REal Time Acquisition Mode
DSP	Digital Signal Processor
DXB	Extended Digital Line Back-end
DZB	New WSRT Correlator (latest back-end)
EGRET	Energetic Gamma Ray Experiment Telescope
ESO	European Southern Observatory
EVN	European VLBI Network
FFB	Flexible Filter Bank
GPS	Global Positioning Satellite
GRB	Gamma Ray Burst
HST	Hubble Space Telescope
IAU	International Astronomical Union
IRAM	Institut de Radio Astronomie MillimÈtrique
IRM	Image Rejection Mixer
ISM	Interstellar Medium
ISO	Infrared Space Observatory
IVC	IF-to-Video Convertor system
JCMT	James Clerk Maxwell Telescope
JIVE	Joint Institute for VLBI in Europe
LNA	Low Noise Amplifier
LTWG	Large Telescope Working Group
MFFE	Multi Frequency Front End
MPIfR	Max Planck Institut für Radioastronomie
NASA	National Aeronautics and Space Administration
NFRA	Netherlands Foundation for Research in Astronomy
NIKHEF	Nationaal Instituut voor Kern- en Hoge Energie Fysica
NRAO	National Radio Astronomy Observatory (USA)
NWO	Nederlandse organisatie voor Wetenschappelijk Onderzoek
OSMA	One Square Metre Array
PUMA	Pulsar Machine
RF	Radio Frequency
RFI	Radio Frequency Interference
SCUBA	Submillimeter Common User Bolometer Array
SKAI	Square Kilometre Array Interferometer
SRON	Space Research Organisation of the Netherlands
STW	Stichting voor de Technische Wetenschappen
THEA	THousand Element Array
TMS	Telescope Management System
TNO-FEL	Toegepast Natuurwetenschappelijk Onderzoek - Fysisch Electronisch Laboratorium
UHF	Ultra High Frequency
UTC	Coordinated Universal Time
VISIR	VLT Imaging and Spectroscopy in the InfraRed
VLBA	Very Long Baseline Array
VLBI	Very Long Baseline Interferometry
VSOP	VLBI Space Observatory Program
VSWR	Voltage Standing Wave Ratio
WENSS	Westerbork Northern Sky Survey
WFC	Wide Field Camera
WHISP	Westerbork Survey of HI in Spiral Galaxies
WISH	Westerbork Survey in the Southern Hemisphere
WSRT	Westerbork Synthesis Radio Telescope



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