Netherlands
Foundation for Research
in Astronomy

Annual Report 1994

The real Traviata
Antonia Fraser on Verdi's unhappy wife - the model for a masterpiece. **Books, p 41**

Branagh's monster
Frankenstein, ill-made and lurching. And that's just the movie, **pp 3,37**

Publish and be damned
William Rees-Mogg says that the press has put itself above the law, **p 18**

20P

THE TIMES

No. 65,102 THURSDAY NOVEMBER 3 1994 2W

Heseltine suffers stirging defeat

Rebel Tories reject PO compromise

BY NICHOLAS WOOD, CHIEF POLITICAL CORRESPONDENT

MICHAEL Heseltine's plans to privatise the Post Office were in tatters last night after a large group of backbench Tory rebels told him to abandon all ideas of selling off even part of the industry.

Amid signs that the controversy was fanning simmering ideological divisions and raising fresh doubts about John Major's leadership, the rebels dismissed a compromise formula hastily put together by the President of the Board of Trade and tabled at a critical meeting at Westminster yesterday afternoon.

They also rejected Mr Heseltine's preferred option of a sale of 51 per cent of the Royal Mail and an alternative scheme involving the sale of a minority stake while keeping the business in the public sector. All he apparently has left to offer is what he has regarded as his least favoured outcome — the creation of greater commercial freedom within the public sector — and the one repeatedly pressed on him by Labour.

The vehemence of diehard Conservative opposition to the scheme and the apparent reluctance of Mr Major and Richard Ryder, the Chief Whip, to confront as many as 20 dissidents — comfortably outweighing the Government's majority of 14 — means that today's Cabinet meeting is almost certain to drop Post Office privatisation from the Queen's Speech on November 16 announcing legislation for the new session of Parliament.

Many Tory rightwingers and personal allies of Mr Heseltine were fuming about the Government's apparent weakness in the face of the threatened revolt. But Mr Heseltine appeared ready to concede defeat and forgo his right to appeal to his Cabinet colleagues to gamble on beating off their backbench critics in the division lobbies.

Despite the reluctance of Mr Major and Mr Ryder to provoke a confrontation that could well end in a humiliating defeat for the Government, some MPs believe that a tough line from the top would force most of the rebels back into line. But last night there was little sign that the Prime Minister would want to take such a risk.

Heseltine: fought hard to save the privatisation

MPs also detected wider political implications in the affair, with angry Thatcherites claiming that the apparent climbdown was a further sign of Prime Ministerial weakness. Some leftwingers close to Mr Heseltine joined the chorus, saying that the Government was losing control of the political agenda and putting itself at the mercy of events in its quest for a quiet life.

Edward Leigh, a junior trade minister responsible for Post Office privatisation until sacked by Mr Major last year, said: "If we bottle out of this, Labour will accuse us of drift and having run out of steam. This is about the whole nature of the Government and what we are here to do. We look like having a technical Queen's Speech. Are we in the business of politics or administration?"

Mr Heseltine was widely seen as having suffered a serious personal defeat but one mitigated by the fact that he had shown backbone and reminded the restive Right of the party that he, at least, was prepared to press ahead with the radical agenda established in the 1980s.

One leading leftwinger said: "The Government seems to think that a light legislative programme is the way to avoid trouble. It is not: it is a recipe for trouble."

But senior ministers said that from the outset the privatisation proposal had looked hazardous. Mr Heseltine had been given every chance to deploy his renowned powers of persuasion on the dissidents. His failure to do so meant that the Government could not press ahead knowing it stared defeat in the face. "The majority is not there. You cannot do it. It would be

Continued on page 2, col 4

Peter Riddell, page 9
Leading article, page 19

DWINGELOO OBSCURED GALAXY SURVEY

A new spiral galaxy has been discovered behind the Milky Way. It has been named Dwingeloo 1 after the Dutch radio telescope through which it was first spotted. Page 7

MPs call for editor to face charges over fax deception

BY PHILIP WEBSTER, POLITICAL EDITOR

CONSERVATIVE MPs last night stepped up their war against *The Guardian* by calling for criminal charges to be laid against Peter Preston, its editor.

As the Commons voted to refer the newspaper's behaviour in the Jonathan Aitken affair to a Privileges Committee investigation, Mr Preston was accused of forgery, criminal conspiracy and impersonation and a senior Tory MP revealed that the matter had already been put before the police. MPs carried by 313 votes to 38 a motion calling on Parliament's most senior committee to launch an inquiry.

Earlier Betty Boothroyd, the Speaker, called on the Privileges Committee to make a report on Tony Benn's defiance of the Commons by publishing his account of a private meeting of its hearing on Tuesday.

During a debate in which Tory fury at the media's handling of recent sleaze allegations boiled over, MPs suggested that in forging a letter with a House of Commons logo to obtain details of Mr Aitken's stay at the Ritz Hotel in Paris, the newspaper might be guilty of a "criminal conspiracy".

David Wilshire, Tory MP for Spelthorne, who moved the motion proposing an investigation, said that at best *The Guardian's* methods were "ethically flawed, at worst they were downright criminal".

But Labour MPs seized on the fresh disclosure yesterday that the Government knew of *The Guardian's* use of a forged fax almost six months ago but had decided to let the matter rest.

Mohamed Al-Fayed, owner of the Ritz, produced a letter dated May 11 and signed by Mr Aitken which was sent to the hotel manager, Frank Klein, after the minister's discovery of the use of the fax, containing its forged signature of Jeremy Wright, the minister's private secretary. In it Mr Aitken reveals that both he and the Government considered legal action over the newspaper's activities.

He wrote: "*The Guardian* article has caused surprisingly little serious interest here, probably because it was one of the most boring journalistic examples of an editor's personalised obsession ever to find its way into print in a newspaper.

"Moreover there is really little or nothing for even an ill-wisher to follow up since nobody has done anything wrong, even in the light of *The Guardian's* somewhat flawed and inaccurate story. Because of the above-mentioned reaction my present plan is, as my teenage children would say, to 'stay cool'.

"However, I am taking further legal advice and so is the Government in the light of the new dimension to the story which your fax has revealed. As you suspected, the letter on House of Commons notepaper faxed to your accounts department on November 24 1993 is a complete forgery."

Government sources said the decision on whether to take any action at the time against *The Guardian* had been left to Mr Aitken.

Mr Preston had not only admitted to an abuse of Parliament but to criminal activity, Mr Wilshire said, adding: "That is why I have referred this matter to the police as well ... I would welcome the

Continued on page 2, col 3

INSIDE

Special: Recent high *z* work with WSRT

Netherlands

Foundation for Research

in Astronomy

Annual Report 1994

Radiosterrenwacht Dwingeloo
P.O. Box 2
7990 AA Dwingeloo
tel. +31 5219 7244
fax +31 5219 7332
E-mail SECRETARY@NFRA.NL

Radiosterrenwacht Westerbork
Schattenberg 1
9433 TA Zwiggelte
tel. +31 5939 2421
fax +31 5939 2486

The Netherlands Foundation for Research in Astronomy is sponsored by the Netherlands Organisation for Scientific Research (NWO)

Contents

Report from the Board

It is evident that the financial climate for higher education and scientific research is becoming far from favourable. The new government coalition in its policy intentions has announced substantial budget cuts for the universities, but what is more dangerous (because in public and political discussions it does receive much less attention than the issues of the educational programmes and the financial support of students) is the fact that scientific research is also under much pressure.

In the first place there is much attention to the budget cuts in the educational programme of universities and other institutions of higher education, while it is obvious that, when the influx of students into the universities remains more or less constant, the universities will have to channel the budget cuts into the research activities. In the report that the so-called technical committee of Minister Ritzen of Education, Culture and Science produced, civil servants felt that they have to conclude that there is *too much* research in the Netherlands. This report treats this issue using a single table with a single line, namely the total number of Netherlands scientific publications now and ten years ago, without any international comparison. Bibliometrist van Raan has pointed out in a leading national newspaper (NRC-Handelsblad) that *percentage-wise* the share of Netherlands publications in the world total has only increased from 1.7 to 2.1 % in the period considered and that the increase in the absolute number of publications can be explained to a large extent to global changes in publication habits.

All of this is of fundamental importance to a foundation like ASTRON, that would operate as a partner of the university institutes. It would be very dangerous for ASTRON if one or more of the university institutes would be closed; although it is unlikely that significantly fewer students would receive a training in astronomy, it would immediately translate into a significant decrease in the research potential in the country.

In the second place there are also significant savings on the research budgets, both those provided by the government and those by industry. The percentage that these budgets make up of the Gross Domestic Product has now decreased to only 1.8 %, of which the government provides about half. As a result the Netherlands has become a mediocre nation in this respect with a substantial backlog compared to the important industrialised countries (USA, France, Germany, Japan) and also Sweden and Switzerland. There is no indication whatsoever that politicians are sensitive to the unavoidable backlog in knowledge, talent utilisation and innovation and the consequences for economic development. Let alone the attention for fundamental research -as in astronomy- as part of our culture.

There is a growing acceptance of the idea that studies of citation scores of scientific publications can at least give an indication of the scientific quality and visibility of research, as long as it is complemented by a well-founded opinion of a visiting committee. In both of these respects there have been important activities in 1994 for NFRA/ASTRON and Netherlands astronomy, that confirm the prominent role in the international arena. It has been found that compared to the economically developed nations (members of the O.E.C.D.), the level of budgets for astronomy, if properly normalised, is clearly average (which in itself is no reason for alarm). But in measures of citations per publication, researcher or unit of expenditure the Netherlands is among the very top. In other words, astronomy in this country is excellent value for money. In another study, performed by the Centre for Science and Technology Studies of Prof. van Raan in Leiden, also the conclusion is reached that Netherlands astronomy is of high to very high quality.

The ASTRON Foreign Evaluation Committee AFEC-II that visited the Netherlands late October, early November 1994, has under the chairmanship of Prof. Jerry Ostriker of Princeton stressed in its report that Netherlands astronomy is of very high standard. They say: ''Astronomy and astrophysics in the Netherlands are of the highest calibre. In terms of quality, the overall programme is arguably the best in the world (using such figures of merit as mean number of citations per researcher per year). The size of the programme is small within the European context, comparable in budget or human input to the programme in Spain, considerably smaller than the French, German or Italian programmes, and only 1/5 the size of the U.K. programme. But, the contributions of the programme are far greater than these measures would indicate, as a consequence of the above noted, high mean quality. The situation could be noted metaphorically that, when the ministers of the world's largest economies meet at the "G7" annual events, the Netherlands is not represented. But, at the International Astronomical Union meetings (most recently held at Den Haag in 1994), the Dutch scientific contribution would rank with that of the top few nations, with an even greater contribution to the leadership of the world organisation (whose current president is L. Woltjer).''

In spite of the dark clouds that pack in financial and political respect over NFRA/ASTRON and Netherlands astronomy, there is hope that these favourable results and judgements can help us strengthen and consolidate our position.

The following important milestones have been achieved in 1994:

1. In a letter of May 17, NWO has approved our plans for an almost complete rebuilding of our headquarters in Dwingeloo and made available the sum of 13.8 Mfl. to this end. The preparations are now well underway and the actual building can start soon. We are very pleased that this important matter has come now to a satisfactory solution.

2. The milestone that we all have looked forward to for many years is the completion of the prototype of the Multi Frequency Front-Ends, the tests on the Westerbork telescope and the detailed project review on September 15. The production can now start. We expect that with the final completion early in 1998, the Westerbork Radiotelescope will be once more of world class.

Unfortunately the production of the back-end, the DZB correlator, is still hampered by a shortfall of about 1.5 Mfl. (out of the total of 6.5 Mfl. required) in allocations from NWO.

3. In 1994 also a start has been made with a major maintenance programme on the telescope structures of the WSRT. Also for this programme the finances have not been fully identified. As far as the WSRT is concerned it is also of importance to note that the Caltech/ASTRON pulsar filter back-end will be operational early in 1995 on the telescope. This will make an entirely new use of the WSRT possible. This is further of importance, because astronomers at the universities of Amsterdam and Utrecht will become as a result a more integrated part of the user community in radioastronomy.

4. The year 1994 was the first full year of JIVE. The funding on a longer timescale remains an area of concern, but at least a good start has been made. In the area of VLBI mention should be made also of the fact that in 1994 the flight model of the RadioAstron receiver has been delivered in Russia and has been accepted.

5. Various activities took place in the preparation of a large new project, mainly in the establishment of international contacts and an inventory of plans elsewhere. AFEC also confirmed the choice of the two projects selected (a millimeter array and a large collecting area cm/dm radiotelescope) and stressed the fact that these two do not interfere in time and cost. In the case of a mm-array the joining of an existing consortium is a realistic option.

There are two matters for which we had expected that they would come to a clear resolution in 1994. The first is the integration of the Dwingeloo laboratory and the Kapteyn Observatory Working Group for optical instrumentation at Roden. Although eventually an agreement of the financial aspects and the redistribution of some tasks between ASTRON and the university institutes had been reached, the governing body of Groningen university remained opposed. Early 1995, however, it appeared that agreement between all concerned would be (and was eventually) reached.

The second issue, that did not yet come to a satisfactory solution was the matter of our need for structural savings on the UK/NL collaboration. Partly this was due to the ongoing long-term planning reviews that were ongoing in both countries. It now seems that the partners will choose to keep the budget of the JCMT at the current level and that we will have to relinquish part of our telescope time. For La Palma our UK partners and we appear to have a more comparable attitude.

Finally, a few words on the composition of the Board. Ir. Cees Kramer had indicated that at the end of his term on December 31, 1994, he did not wish to renew his membership. Cees has been a member of the Board of the old Netherlands Foundation for Radio Astronomy since January 1, 1975 and later of that of the current Foundation ASTRON. His accomplishments are numerous, in particular in the area of personel as well as management aspects of the Board's work. We will miss him.

The Board has proposed to the Royal Academy of Arts and Sciences that Prof. Ed van den Heuvel be appointed member and the Board has further resolved that it will choose him chairman per January 1, 1996. At the same time is was proposed that Prof. Piet van der Kruit would remain for a final year member (and chairman) of the Board, until van den Heuvel is available to take this upon him. We are very pleased that he has indicated his willingness to take up this task.

The Board held its 31st to 35th meetings in 1994 on the dates February 18, April 15, June 28, September 28 and December 15.

Piet van der Kruit

Chairman of the Board

Report of the ASTRON Foreign Evaluation Committee

A. Background for AFEC-II

The ASTRON Foreign Evaluation Committee II was convened by the Board of ASTRON/NFRA (Netherlands Foundation for Research in Astronomy) in consultation with the advisory group NCA (Netherlands Committee on Astronomy) and the ultimately responsible funding agency NWO (Netherlands Organisation for Scientific Research). Its assigned tasks were to review the current state of ground-based astronomy in the Netherlands, to comment on current plans for future steps and to assess progress since the completion of the AFEC-I report in 1985.

The Committee consisted of Professors R. Blandford (Executive Officer for Astronomy, Caltech, USA), R. Ekers (Director, Australia Telescope National Facility, Australia), R. Ellis(Director, Institute of Astronomy, Cambridge, U.K.), J. P. Ostriker, Chair (Director, Princeton University Observatory, USA), and V. Radhakrishnan (Director-Emeritus, Raman Research Institute, Bangalore, India). The review was based on visits to the four primary University institutions specialising in astronomy at Amsterdam, Leiden, Utrecht and Groningen, as well as the ASTRON headquarters at Dwingeloo during the period October 30 - November 3, 1994.

In addition, we had available, as written input provided to AFEC-II, an excellent survey, Astronomy in the Netherlands (9/28/94) prepared by Prof. P. C. van der Kruit, and the Strategic Plan for Astronomy in the Netherlands (10/17/94) prepared by the NCA (chairman, Professor E.P.J. van den Heuvel), as well as the annual reports of the institutions surveyed and some special documentation prepared at the explicit request of AFEC-II. Despite the shortness of the time available, we benefited from the good preparation of the host institutions, the intensive schedule and the previous familiarity of several of the Committee members with astronomy in the Netherlands, leading to confidence in the adequacy of the information available to the Committee.

In the next section of this report, we will respond to the specific queries put to us in the Terms of Reference (items [1] - [9]), as well as to other questions which we added to our charge as a result of our readings and discussions (items [10] - [15]), and, in a third and final section, we summarise certain recommendations. But first, it is vital to make absolutely clear one central point that might otherwise be lost in the detail of the following sections.

Astronomy and astrophysics in the Netherlands are of the highest calibre. In terms of quality, the overall program is arguably the best in the world (using such figures of merit as mean number of citations per researcher per year). The size of the program is small within the European context, comparable in budget or human input to the program in Spain, considerably smaller than the French, German or Italian programs, and only 1/5 the size of the U.K. program. But, the contributions of the program are far greater than these measures would indicate, as a consequence of the above noted, high mean quality. The situation could be noted metaphorically that, when the ministers of the world's largest economies meet at the "G7" annual events, the Netherlands is not represented. But, at the International Astronomical Union meetings (most recently held at the Hague in 1994), the NL scientific contribution would rank with that of the top few nations, with an even greater contribution to the leadership of the world organisation (whose current president is L. Woltjer).

B. Response to Terms of Reference

1) Advise on the quality and quantity of astronomical research in the Netherlands in comparison with other nations.

This issue, addressed above, has been treated in considerable statistical detail in three documents examined by the AFEC: "A Comparison of Astronomy in Fifteen Member Countries of the Organisation for Economic Co-operation and Development," by P.C. van der Kruit, Scientometrics, 31, No. 2 (1994); "Bibliometric Research Performance Analysis of Astronomy in the Netherlands," draft report by A.F.J. van Raan, A.M.P.H. Ramaekers, and Th. N. van Leeuwen to the NFRA (ASTRON), and to the NWO (October 1994), and "Astronomy in the Netherlands" (9/28/94) prepared by Prof. P. C. van der Kruit. A uniform picture emerges that, whether measured by citations per paper (properly normalised) or papers produced per unit expenditure, astronomy in the Netherlands is typically more efficient by a factor of order 1.5 than its astronomical competitors in other nations or its competitors in other fields within the Netherlands. In the higher profile, international, cooperative ventures in which they have taken part, the efficiency is still larger. The variations amongst the major NL institutions or the variations as a function of time (in the period 1980-1990) are relatively small. This quantitative but perhaps spuriously precise information, derived from statistical analyses, is confirmed by our own impressions. The average quality is quite high, in large part due to the relative absence of cadres of unmotivated and scientifically weak workers found in greater numbers in other nations.

The size of the NL astronomical institutions is roughly comparable to that of the stronger institutions in other nations. The Committee noted that beyond a certain size there are dis-economies of scale. Quality tends to be lower than average in some of the world's largest astronomical institutions, so far more would likely be lost than gained by reducing/combining the number of institutions in the Netherlands. There would be a further loss in that physics students at the universities from which astronomy programs were removed would no longer have the opportunity to study or do research in one of the forefront fields of modern physics: astrophysics.

An important corollary of this overall strength is a spillover from education into research. We had the impression that educational activities, both academic and popular, are taken quite seriously. It is not within our charge to address the effectiveness of these educational programmes, but we can say that the high quality of human skills demonstrated in research, particularly the scientists' dedication to and knowledge of their scientific fields, must enhance the value of the astronomical education received by the public.

2) Advise on whether the selection of the areas for financial support through temporary appointments, as made in recent years, deserves important revision.

All of the recent appointments are strong, most are at the highest international level and, contextual, they are in appropriate scientific areas. There was a feeling among some of the AFEC II Committee that astronomy in the Netherlands had not extended its horizons outwards towards cosmological issues as rapidly as they might profitably have done and certainly less so than has the equivalent community in the U.S. and the U.K.

3) Express views on the choice of activities in astronomical research and provision of observing facilities by the institute of ASTRON Dwingeloo.

The per capita access to first-rate instrumentation for the Netherlands astronomers must surely be close to the best in the world. They also have a very powerful and competent organisation to facilitate their access to instrumentation and to operate their own instrument, the WSRT. The upgrade of the WSRT has been in progress for a number of years and will still take 2 to 3 years to complete. When completed, it will again be one of the most powerful facilities in the world. Their assessment of the competitive performance of the WSRT compared with the VLA is realistic, but it does depend on the completion of the WSRT upgrade and assumes that the proposed upgrades to the VLA will not be funded. If the WSRT upgrade is not completed rapidly, they will again risk being out-performed by the VLA.

Most of the Dutch astronomical community is making effective use of both the southern and northern hemisphere optical telescopes through ESO and the UK/NL collaboration. The situation with the UK/NL James Clerk Maxwell Telescope was less satisfactory with relatively little scientific outcome, little technical involvement of the NFRA and a very expensive operation. This telescope is operating at the forefront of technology and at the highest radio frequencies for which observations are possible from the surface of the earth. As such, it is a far more experimental facility and perhaps less suited for the more operationally oriented style of use which is customary in the Netherlands. It is hoped that access to an MM array could be provided to the community in association with other facilities being planned or built.

4) Express views on the choice of priorities of research fields made by the University institutes, as apparent from the description of their research programs and the current and recently completed thesis projects.

The Committee found an admirable range of research covered in the Netherlands astronomical institutes, representing well the most exciting areas of current interest. It is no longer practical to cover all active areas even with as large a research effort as is found in Dutch astronomy, and so there are important areas which are lightly covered (e.g., cosmology/ large-scale structure) that are directly related to current and planned instrumentation. However, the areas that have been emphasised lie at the core of the subject and continue to provide considerable challenges to our understanding. The Committee saw several examples of new and timely research initiatives (e.g., millimetre astronomy and pulsar timing). The Committee endorses the principle of developing complementary research efforts within the different institutes as being cost-effective, provided that inter-departmental communication is maintained. The quality of Dutch theses has been maintained at its traditional high level.

5) Advise on whether, given the available funds and manpower, astronomical research in the Netherlands should restrict itself to a narrower choice of themes to be pursued in more depth.

This question can be asked with regard to scientific topics/sub-fields or with regard to facilities/instrumentation. On the first of these, the Committee was satisfied with the present distribution and even felt that some expansion of scientific areas of investigation might be useful. But, with regard to the latter, we did find ourselves asking the question: "Is the plate too full?" Are there too many activities being undertaken or being initiated - more than the instrumental resource level can accommodate or staff can handle in terms of oversight, data reduction and interpretation? Fragmentation of effort may be a danger given the size of the community.

7) Advise on the appropriate proportion of thesis projects as compared to postdocs, given the available funds.

We were happy to note that the postdoctoral program, which was almost absent at the time of AFEC-1, is now flourishing and makes a great contribution to the overall scientific community in terms of both output and ambiance. The exact mix of postdocs (PD) to graduate students (GS) varies greatly from institution to institution, and, in some cases, is not optimal. But,community-wide, this balance seemed good to the AFEC-II committee. The ratio of scientific staff to (PD+GS) also was observed to vary greatly from institution to institution with the staff apparently overloaded in some institutions and underutilised in others. ASTRON/NFRA should be in a position to address the disparities in the PD/GS ratios.

6 & 8) Advise on the possible improvement of the balance between observational work, instrumental development and theoretical work. Remark on the developments since AFEC-I on the basis of the report of that committee.

AFEC-I was unanimous, loud and clear in stating the excellence of Dutch astronomy in both the quality and quantity of its research output, and in recognising the continuing success of a long-standing tradition of creating a new generation of outstanding young astronomers. The fact that AFEC-II feels the same on these two matters shows that there has been no diminution in the vigour with which the country has pursued research in astronomy

Together with the foregoing assessment of excellence, AFEC-I placed equal emphasis on its serious concern about the ability of Dutch astronomy to achieve, within its financial and manpower constraints, both the breadth that it had undertaken and the depth to which it must continue to aspire. In particular, there was a danger of falling behind in the interpretation of observations, for which the country had been famous for so many decades.

The recommendations of AFEC-I for increasing interpretative efforts were (a) more postdocs and junior faculty in the institutes, (b) increased emphasis on interpretation through more or less theoretical approaches, and (c) the selection of (a), Huygens Fellows and foreign visitors based on their ability to strengthen the end-product, i.e., the drawing of conclusions about the nature of the universe. AFEC-II notes that there has been significant progress in the above recommended directions in the intervening decade or so. Another recommendation of AFEC-I was that there could be more interactive use of computers. In this direction also, there has been some progress, but more could be achieved.

We were gratified to note that new appointments have led to much greater strength in interpretive work as compared to the situation at the time of AFEC-1. There may still be some weakness in the area of fundamental theory (directly related to observations) which is evident in some scientific areas. However, there are strong variations in the ratios of instrumentation:observation:interpretation:theory at the different institutions, which may be healthy, and the overall balance now seems to be good.

An important recommendation of AFEC-I was the need for a close rapport between the astronomical institutes and both the space groups and the physics departments at their universities. The response to this recommendation has been very different at the different places visited by AFEC-II. Generally speaking, there was more interaction with the space groups than with the physicists. But the variation at different centres went from good interactions with both physicists and space scientists to no more connection of the astronomy institute with either of these than with biologists or civil engineers. The poor relations between different groups who could collaborate to great mutual benefit was one of the very few things that distressed AFEC-II. But these are matters that can be discussed further only in the separate letters to the individual institutes visited.

A last observation and recommendation of AFEC-I concerned the lack of involvement of Dutch students in the development of, and "hands-on" experience with, astronomical instrumentation. AFEC-II regrets to note no improvement whatsoever in this regard.

9) Remark on the current and future planned range of observing facilities at various wavelength regions open to Netherlands' astronomers and future plans in view of financial constraints.

a) The strategic planning by the Netherlands Committee for Astronomy ("NCA" chaired by E.P.J. van den Heuvel) was applauded by AFEC-II as an excellent means for assuring community participation and for approaching a consensus regarding priorities. Also, the two proposals that have risen to the top of the list - the millimetre array and the square kilometre radio telescope - were both considered by AFEC-II to be excellent choices. These are both areas where investment of resources may be expected to lead to great technological and scientific advances.

b) But, the treatment by NCA of these two projects as competitive with each other seemed to us to be flawed. Each should be examined carefully on its own merits. Our reasons for believing that the two choices should not be seen to be in competition with one another can be summarised schematically as follows:

i)Time: The MMA can be initiated only if the start is made very promptly. Other groups are well into the design phase of similar projects and, if the NL community does not join one such group, the opportunity will be foreclosed. A later start (in say five years) would make little sense given the likely progress by other groups in the interim. But, the 1 km^2 radio telescope cannot be started promptly. The technology and design issues to be faced are manifold, as well as the complicated questions of site, cost and partnerships. It is very difficult to imagine any significant level of funding for this latter project to occur before the end of the century.

ii)Leadership: As noted above, NL astronomers would likely participate in any ongoing project (U.S., Japanese or European) should an investment be made in an mm array, but the 1 km^2 radio telescope would probably occur, if at all, only under the aegis of NL technological leadership, even if the NL contributed a minority of the funding.
iii)Cost: Meaningful amounts of observing time on an mm array could be arranged for at modest to moderate cost, but the 1 km2 telescope would be a major item which should not be undertaken unless it is on a scale significantly greater than the GMRT now being built in Pune, India.

c)The scientific cases for the two facilities should be carefully evaluated before further decisions are made. Good presentations were made to the Committee on both projects. Here, more thought seems to have been given to the uses of the MMA than to the 1 km^2 telescope (judged by the presentations to AFEC-II), where some exciting possibilities exist which have not been studied (such as measurements of large-scale cosmic structure).

d) Since both options being considered will require partnership with scientists and administrators in other nations, it would make sense to explore these options first. The decision of which, if either, large project to pursue (and it may be possible to do both) can only be made rationally in the context of what it is possible to do with the other likely actors.

e) We expect that an incremental increase in the investment subsidy for research support would be less likely to occur than would be a significant award for funding a major, scientifically compelling project, supported by the community and presented with flair. Item (10) in the Terms of Reference asked AFEC-II to address other issues which seemed of significance to the Committee. This we do with items (10 - 15) below.

10) Is there an appropriate balance between national, partnership and international ventures? Are NL astronomers obtaining maximum, feasible use of the international facilities?

The NL astronomical community makes excellent use of both national and international facilities. However, the relatively small community is taxed heavily by the need to service international committees.

Concerning the community's regard for the international facilities, enthusiasm was high for both the ESO and La Palma telescopes. Strong advocates of both facilities exist across the land. Great hopes are evident for the ESO VLT despite the relatively low level of NL participation in its instrumentation program. There is some concern about the complex management structure and overall cost of the La Palma facilities, whose operation could be streamlined. The scientific productivity of the JCMT is also currently low, but the facility remains at an early stage of development with only a small group of users. Participation in the UK/NL facilities should be monitored closely and consideration given to reapportionment across Hawaii and La Palma depending on scientific value.

Within the NL, the Westerbork and Dwingeloo telescopes remain productive, particularly in survey work. The NL participation in JIVE is progressing well, but the long-term financing of this project and its support is an issue that must be faced.

On other world-ranked facilities where there is no explicit NL participation, e.g., VLA/AT, NL astronomers are very successful in gaining access which reflects very positively on their scientific proposals in the international arena.

11) Review mechanisms by which new instrumentation is conceived, produced and commissioned.

The Committee is concerned that inadequate thought has been given to the provision of the next generation of instrument builders. Logically these should arise from within the University groups. In recent years, however, there has been a steady transfer of the instrument building activity from the Universities to ASTRON, the primary argument being the need to consolidate these activities for economic reasons.

We are concerned that this process may have gone too far for the long-term health of the community and suggest that ASTRON should foster genuine technical partnerships with University groups. ASTRON's role should be to invite new collaborations rather than be the sole provider of instruments.

12) Is support for infrastructure appropriately managed in terms of sources and distribution of funds?

Large resources have been made available to the NL astronomical community, as, for example, with access to ESA provided space facilities or postdoctoral fellows supported by the European Economic Community ("Brussels Fellows"). These gifts are accompanied by an obligation on the part of the institutions that accept them to provide office space, secretarial support and, most importantly, computer system support. Some appropriate mechanism for providing these necessary and proper costs of performing research should be established within the NL administrative system. The working but imperfect U.S. model of "overhead" support might be considered. On a related matter, the actual costs of computer systems paid by NL institutions seemed excessive by U.S. experience (this is of course due in part to import duties), and efforts to find more economical solutions (i.e. bargaining with vendors) could be made.

13) Will access to space facilities through ESA itself be sufficient to satisfy all the needs for observations of the NL astronomical community in the future?

This is a question that was asked of AFEC-II by a senior group of administrators from GB-E. The answer is very straightforward: "No!" There are two reasons for this.

a) Space observations are only made in areas where ground-based observations cannot be made (e.g., in the gamma-ray domain). They are too expensive to be made in areas where one can work from the ground, e.g. radio. Thus, they are complementary and not substitutive to ground-based observations.

b) Priorities for space research are set elsewhere. Not only does the NL scientific community have a small role in the scientific direction of ESA programmes, but the rationale for space observations often has limited scientific component, being based on perceived social utility, opportunities for technological advance, or financial return to the countries providing the major funding input.

14) Is there a rational policy in place for adjusting to the expected demographic changes in scientific manpower - specifically to anticipated vacancies in the epoch 2005-2010?

As compared with the condition observed by AFEC-I, the situation is much improved through a combination of five-year Royal Academy (KNAW) fellowships and new senior appointments. Thus, the age distribution is now more favourable than it was previously. We would advise the institutions involved to make other, additional adjustments to level the rate of hiring. One mechanism might be to "borrow" vacancies that will become open at a somewhat later time so that positions of senior researchers can be filled slightly in advance of their actual retirement.

15) Are the structural arrangements between ASTRON and the university groups working well?

The current structure is relatively new and it may take some time for all the participants to accommodate to it. There are two major changes that have occurred. First, the effective number of players has increased. It is no longer possible for a very small number of individuals to chart the course of NL astronomy by mutual and informal agreement, and the recent emphasis on a less hierarchical ordering of the players makes the situation still more complex. Second, ASTRON has two very distinct roles: one as a provider of grants to others and one as an operating agency. This is unusual; it can cause conflict of interest situations to arise, and it is bound to produce tensions. We heard and saw no evidence for any inappropriate actions on the part of ASTRON, but it is clear that the current structure puts a burden on the participants. Our summary thoughts are as follows.

With regard to functionality, there is little to criticise. On the contrary, the system is working very well. There are excellent, well maintained and instrumented observing facilities, which are fairly provided to a diverse user community. And, the grants programme appears to be administered with a carefully maintained balance between the criteria of "excellence" and "fairness." Finally, the financial efficiency of the overall system is good, with little worry evident over bureaucratic inflexibility or delay.

But, it is also evident that there is a moderately high level of tension among participants in the system, among the different university groups and between these groups and ASTRON. Some level of competitiveness and mutual criticism is clearly healthy in any system, but we had the impression that the current level was above the optimum. In fact, day-to-day cooperation seems to be functioning well amongst the groups, but it was noticeable that a fair amount of waste motion was being generated. Part of the problem is that ASTRON as an operating agency must pursue a reasonably steady course based on a long-range plan, but community views in a democratic system may fluctuate rapidly in time and space, so ASTRON cannot be in very perfect consonance with the instantaneous sentiments of any given generation of university leaders. With regard to remedy, we can only recommend the time honoured maxim of more attention to channels of communication, especially on the part of ASTRON, and, for the community, greater exercise of leadership amongst participants, submerging local for national goals and present for long-term advantage. A stronger participation of University group leadership by full professors on the ASTRON board might be helpful, and a cleaner division within ASTRON of its two roles might also be useful.

Publications and Citations

There is currently much interest in the study of publication and citation scores as indicators used for science policy. With a grant from NWO, the Centre for Science and Technology Studies (CWTS) at Leiden University has performed a bibliometric study of Netherlands astronomy. The main results are collected in Tables 1 and 2.

It concerns papers published in the period 1980 to (and including) 1991. It uses fractional counts (correcting for co-authors from other countries) and collects the total number of citations in the same period. All papers have been assigned, mostly by their own authors, to various categories such as institute, area of research and instrumentation used. Publications and citations are all per year. Only papers in refereed journals are included and there is no correction for self-citation.

The columns for the two periods are the following. The first is the mean number of publications per year and the second the number of citations per publication over the same period. The first period of 12 years therefore contains a mix of long- and short-term citation histories, while the second period has only short-term histories. The next column lists the same citation rate for all papers in the field, that is a normalisation to the citation histories of papers in the same scientific area (and the same mix of time scales). The final column, the so-called 'impact ratio', is the ratio of the previous two. This is generally rounded off to one decimal.

It is important to stress that the normalisation is done by the average citation rates of the relevant journals. Astronomy papers are usually published in general astronomy journals and the citation rate of the journal is then often not representative for a particular subfield. In particular this is probably an important consideration to take along in the numbers for the VU; the field of scattering in planetary atmospheres is likely to produce inherently fewer citations per paper, but the group publishes often in Astronomy & Astrophysics. For this reason, but also because of the very small numbers involved for this group there is no statistics provided in the report for the VU.

For all Netherlands astronomy the impact ratio in the eighties is 1.41 (we will see below that on an international level this corresponds to the top world-wide), while in the more recent period it dropped to 1.31, but is still well above the criterion used (the impact ratio must exceed about 1.08 for above average). Detailed inspection of the data in the report shows that there is a clear effect of a new facility becoming available, but with a time-lag of two years or so for the first sizeable number of papers to appear in the literature and a few more years for the number of citations to build up. We see that Netherlands astronomy over a wide range of fields and wavelength regions is statistically well above average. Also, for most lines in the Table we see that the second 5-year period is often too short for reliable results; it often occurs that the impact ratio over the whole period indicates above average, but the shorter period not always. We will leave the data in Table 1 mostly undiscussed and turn to Table 2 for an evaluation of the comparison of facilities.

	1980-1991				1987-1991			
	publ./year	cits/publ	field mean	ratio	publ./year	cits/publ	field mean	ratio
All	174	13.1	9.3	1.41	189	5.3	4.0	1.31
Sun & stars	79	11.4	9.4	1.2	92	5.3	4.4	1.3
ISM	32	13.6	9.4	1.4	32	4.9	3.7	1.3
Galaxies	49	16.4	9.5	1.7	55	6.0	3.8	1.6
Techn./instr.	7	11.4	6.3	1.8	6	0.9	3.3	0.3
Rest	7	9.4	9.0	1.1	7	1.6	3.5	0.5
Comp. bin.	32	10.7	8.9	1.2	41	5.4	4.5	1.2
Stars/winds	9	9.5	9.7	1.0	10	5.5	4.5	1.2
Late stars	18	12.5	8.2	1.5	24	6.5	4.1	1.6
Sun/MHD	18	13.7	11.5	1.2	14	5.5	4.5	1.2
Photom.	4	4.7	10.5	0.5	3	2.9	4.3	0.7
ISM	32	13.6	9.4	1.4	32	4.9	3.7	1.3
Nearby gal.	26	17.3	9.0	1.9	30	6.1	4.1	1.5
AGN	16	17.7	9.8	1.8	17	5.9	3.2	1.9
Cosmology	7	10.4	10.3	1.0	8	5.7	4.2	1.4
Techn./inst.	7	11.4	6.3	1.8	6	0.9	3.3	0.3
UvA	34	11.4	8.1	1.3	45	5.0	4.2	1.2
RUG	40	15.2	9.4	1.6	44	4.9	4.2	1.2
RUL	43	14.7	9.6	1.5	43	6.2	3.9	1.6
UU	20	11.3	9.6	1.2	21	5.5	4.1	1.3
ASTRON	21	14.7	9.4	1.6	22	6.1	3.7	1.7
SRON	38	14.8	9.2	1.6	40	5.6	4.2	1.4

Table 1. Publication and citation data 1980-1991.

Especially for the space facilities there is an understandable relation to the time of launch of a satellite and an increase in the number of papers a few years later. This is most evident for the IRAS numbers, which had a very definite peak in the number of citations in the middle eighties, but is still enjoying a long tail of papers (and Ph.D. theses) on the basis of the archive.

	1980-1991				1987-1991			
	publ./year	cits/publ.	field mean	ratio	publ./year	cits/publ.	field mean	ratio
γ, X, UV	28	14.0	9.6	1.5	21	5.9	4.2	1.4
Optical	40	12.3	8.3	1.5	35	4.0	3.6	1.1
IR-sats	15	19.3	7.7	2.5	11	10.1	4.8	2.1
(Sub-)mm	5	12.4	6.0	2.1	4	6.5	2.8	2.3
Radio	45	13.4	9.9	1.3	28	4.8	4.2	1.1
Theory/interp.	62	12.9	9.8	1.3	58	5.1	4.4	1.2
Technical	9	8.5	7.1	1.2	5	1.0	2.9	0.3
γ-ray	4	30.8	14.1	2.2	1	5.2	3.4	1.5
X-ray	15	11.5	7.9	1.5	15	5.9	4.3	1.5
UV	9	11.5	10.6	1.1	5	4.7	4.1	1.2
ESO	15	6.9	7.5	0.9	17	2.8	3.4	0.8
ING	4	4.7	3.3	1.4	8	3.7	3.4	1.1
UKIRT	4	12.8	8.3	1.5	3	6.1	4.6	1.3
HST	< 1	0.5	0.5	1.0	1	0.5	0.4	1.1
Other opt.	17	19.2	10.7	1.8	6	7.2	4.4	1.6
Far-IR sats	1	13.3	15.2	0.9	0			
IRAS	14	19.8	7.7	2.5	11	10.1	4.8	2.1
Hawaii submm	1	3.1	5.6	0.8	1	2.0	2.6	0.8
SEST	1	1.2	1.0	1.2	1	0.8	1.2	0.7
Other submm	3	18.3	7.5	2.4	2	11.1	3.6	3.0
Dwingeloo	2	9.1	9.6	0.9	2	3.1	2.3	1.4
WSRT	22	13.3	10.7	1.3	16	3.8	4.5	0.8
VLA	12	14.0	7.9	1.8	10	6.6	4.2	1.6
Other radio	6	15.5	10.4	1.5	2	1.9	3.0	0.6
VLBI	4	9.6	10.9	0.9	2	5.9	5.7	1.0
Theory	46	12.8	9.9	1.3	45	4.5	4.4	1.0
Interpret.	16	13.2	9.7	1.4	13	7.3	4.6	1.6
Technical	9	8.5	7.1	1.2	5	1.0	2.9	0.3

Table2. Publication and citation data (cont.).

For the WSRT there has been a slow decline in the number of papers published annually, compensated by an increase for the VLA, which is used extensively by Netherlands astronomers in collaborations often with American astronomers. Facilities that became available during the latter part of the eighties have as yet little impact on the citation numbers. The JCMT only became operational in 1987 (the line with Hawaii sub-mm refers mostly to such observing using UKIRT) and SEST also about that time. Judging from the current preprints the number of publications from these facilities (in particular for the JCMT) will be rising sharply only around the present time and in the next few years. It should be noted that the JCMT will receive its first unique instrumentation (in particular the bolometer-array SCUBA) only next year. The high impact ratio for ‘other mm’ is likely to transfer to JCMT and SEST in the nineties.

A similar situation occurs for the optical. At the La Palma observatory, the WHT has been operational since 1987, but the major spectrograph ISIS is only available since 1991 and the full instrumentation (prime focus camera, fiber optics spectrograph WYFFOS with Autofib-2) is only reached by the end of 1995. The number of papers from the ING is only increasing now (to about 20 in 1990 and 1991). For the ESO, instrumentation for extragalactic observers (CCD’s, the spectrograph EFOSC, etc.) came to the telescopes later in the eighties and here we only see a recent rise in the number of papers (the earlier ones were usually based on smaller telescopes for stellar photometry and/or spectroscopy). The line ‘other optical’ indicates that extragalactic researchers have obtained their optical data mostly elsewhere (and to some extent still do). The high impact ratio here is likely to transfer to ESO and ING in the nineties.

A very important effect is obvious from Table 2, namely that for ground-based facilities those above average are often those not directly owned by the Netherlands and that facilities that were not yet or no longer state-of-the-art (WSRT, ESO) in the eighties or were still being built (INT, JCMT) indicated impact ratios that were not statistically above average. Most impact was apparently made by using alternative facilities than our own. As discussed, this is likely to be changing rapidly. This shows that it is of major importance to have a continuous program of upgrades and new facilities to remain at the front of research in a global context.

It is also important to point out the high impact ratio for ‘‘interpretation’’, which concerns papers with analysis of observational data that are presented elsewhere or taken from the literature.

Conclusions are that Netherlands astronomy is generally strong. There is a decline in the impact ratio in the second half of the eighties, but this refers to a period just before an impact of the new instruments (JCMT, La Palma, ESO-extragalactic) can be felt. In this period the IRAS peak had passed and the WSRT was in a period where its instrumentation had been at a relatively constant level, falling behind developments elsewhere. This will only be remedied during the nineties. There are furthermore no very obvious weak areas, wavelength regions or institutes identifiable from the tables. The major impact of new developments on the ground (ESO major large telescopes, La Palma, JCMT) is not adequately addressed by this study, as papers from these will only start to have an impact in the early and middle nineties.

Publications and Citations on International Scale

It is of interest to calibrate the publication and citation data on an international scale. For this purpose a recent publication of prof. P.C. van der Kruit is used (Scientometrics, 31, no.2, 1994), in which he made comparisons for publication, citation, funding and community size data pertaining to 15 OECD countries. The input data were:

From an OECD listing and supplemented with data from other sources the annual astronomy budget, Gross National Product, number of astronomical researchers, science researchers in general and size of the population.

From the literature numbers of papers published in 1981-1985 and the citations to these papers in the same period (so on average a citation window of 2.5 years) for both astronomy and all sciences. It is therefore comparable to the CWTS study for the early eighties. Attribution to countries is done solely by first author, however.

From these numbers ranks for the countries were calculated using the following criteria:

For a ranking of astronomy funding: number of researchers per head of population, budget per head of population, budget per researcher, budget as fraction of the GNP. These are recent figures, but should not be wildly different from the situation in the first half of the eighties. Note that variations in the balance between space and ground-based facilities can in extreme cases distort this ranking.

For a ranking of astronomy output: citations per paper, publications and citations per researcher, corrected (for journal averages) citations per paper, worldshare of publications and of citations in astronomy versus all sciences.

For a ranking of output versus funding in astronomy: budget per publication and per citation, difference in the above two rankings.

For a ranking of output in all sciences: citations per paper, publications and citations per researcher, corrected (for journal averages) citations per paper, publications and citations per head of population.

For a ranking of astronomy versus all sciences output: ratio of citation rates and world percentages of citations between astronomy and all sciences, difference in the ranks for output in astronomy and all sciences.

	Astronomy Funding	Astronomy Output	Astronomy Budget-Output	All Science Output	Astronomy-All Science
1	Finland	**Netherlands**	Canada	Switzerland	**Netherlands**
2	France	USA	**Netherlands**	Sweden	Australia
3	Switzerland	Germany	Australia	USA	Italy
4	Germany	Australia	USA	Denmark	Germany
5	UK	Switzerland	UK	UK	USA
6	Italy	UK	Denmark	**Netherlands**	France
7	USA	Canada	Sweden	Canada	UK
8	**Netherlands**	Italy	Belgium	Belgium	Switzerland
9	Australia	France	Germany	Germany	Canada
10	Belgium	Belgium	Switzerland	Finland	Belgium
11	Spain	Denmark	Japan	Australia	Spain
12	Denmark	Sweden	Italy	France	Japan
13	Japan	Japan	France	Japan	Finland
14	Sweden	Finland	Spain	Italy	Denmark
15	Canada	Spain	Finland	Spain	Sweden

Table 3. Summary of various rankings of OECD countries.

The results of this excercise are in summarised in Table 3. Conclusions from this are:

1. Astronomy funding in the Netherlands on a relative basis is very average.

2. In astronomy output the Netherlands ranks first. This calibrates the CWTS impact ratio of 1.41 for the eighties for the Netherlands (see Table 10) to mean top class.

3. Astronomy, judged from the comparison of budgets and output, is in the Netherlands good value for money.

4. Although the Netherlands does very well internationally in performance of scientific research in general, this particularly holds for astronomy.

Recent High z work with the WSRT

Jayaram N. Chengalur, Ger de Bruyn, Chris Carilli

Introduction

At centimetre wavelengths, the HI 21cm line which is both ubiquitous and also the brightest non maser amplified line is observable in emission only in the very local universe using existing telescopes. To detect HI emission from galaxy sized objects at cosmological redshifts will require a telescope with effective aperture more than an order of magnitude larger than the 300m Arecibo telescope. HI at column densities and spin temperatures corresponding to that observed in local disk galaxies is however easily detectable in *absorption* at high redshift, and the neutral hydrogen associated with the precursor of a galaxy cluster (as opposed to a single galaxy) could also be detectable in emission (provided of course that such objects exist and have substantial quantities of neutral gas). A major impetus to the study of gas at high z came from the recent observations of CO in emission at cosmological redshifts (e.g.. Brown & Vanden Bout, 1992). The observations are very challenging however and the objects detected in emission in CO are extremely singular. Of course CO emission even from high z objects is at frequencies much higher than the maximum operational frequency of the WSRT. This article summarises high redshift work that has been (or is being) done at the WSRT. The emphasis is on recent work, including 'progress reports' for projects that are still on going.

The lowest frequency system available at the WSRT (until the installation of the MFFE's) is at 92cm, corresponding to a redshift of ~ 3.4 for the HI 21cm line. Until recently, the bandwidth of the 92cm system at the WSRT was determined solely by the width of the RF filters in the front end, both the feed itself and the RF amplifier have intrinsically large bandwidth. Frequency monitoring at the WSRT site showed that interference capable of saturating the system is surprisingly infrequent, meaning that the filters could be removed without adverse effect, opening up a considerably larger bandwidth for astronomical use. The current sensitivity of the 92cm system at WSRT (i.e. after removal of the filters) is shown in figure 1, (see also Carilli, de Bruyn & Boonstra, 1994) showing that about 80 MHz (or about a unit redshift) is available for use at high sensitivity. This large bandwidth and high sensitivity (including the interference suppression in an interferometer because of the fact that terrestrial interference picked up by different telescopes does not correlate) makes the WSRT a leading facility for high redshift radio observations. For comparison while the VLA 92cm band sensitivity (at the band centre) is comparable to the WSRT, the VLA 92cm system extends from 300 MHz to 340 MHz (figure 1). A large variety of observing programmes have been initiated over the last year to take advantage of this new capability of the WSRT.

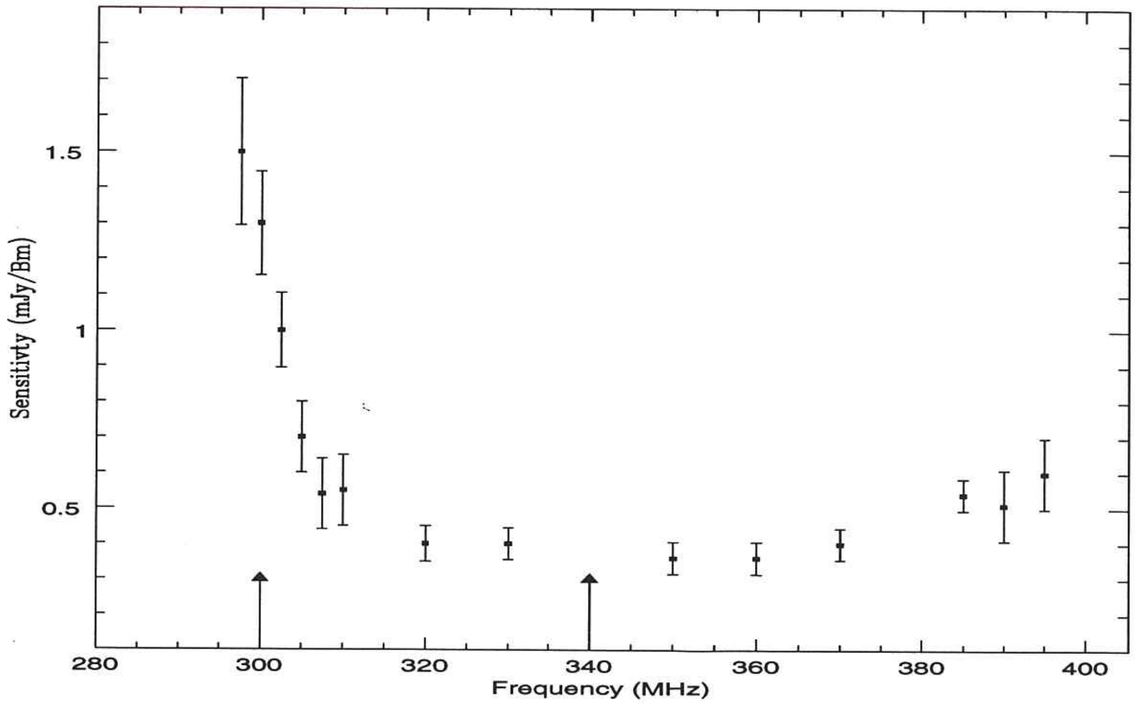


Figure 1. Sensitivity of the new broad band WSRT 92 cm system for an integration time of 12 hr, bandwidth of 5 MHz, 40 baselines and two polarisations. The arrows mark the range of the VLA 92cm system. At the band centre the VLA has comparable sensitivity to the WSRT.

Emission from high redshift objects

As mentioned in the introduction the smallest high redshift objects from which it might be possible to detect HI in emission are the precursors of the current galaxy clusters. These could be either a large single unit (i.e. 'pancakes' in the HDM scenario) or a collection of small cool subsystems in hierarchical models of structure formation, e.g. the CDM scenario. Uncertainties in calculations of the expected 21cm emission from protoclusters under different models of structure formation has been reduced considerably because the amplitude of the power spectrum is now known from COBE measurements. The principal remaining uncertainties are (i) the fractional neutral hydrogen content of the object, and (ii) the profile of the emission line, in particular its width. Numerous past searches for emission from protoclusters have yielded primarily upper limits (Subrahmanyan & Swarup, 1990, Uson, Bagri & Cornwell, 1991a, Wieringa, de Bruyn & Katgert 1992), although there has been one claimed detection (Uson, Bagri & Cornwell, 1991b) which has however not been confirmed by subsequent observations at different telescopes (Briggs, Sorar & Taramopoulos 1993, de Bruyn & Katgert 1995). These studies all used relatively narrow line widths, in part because typically, the 92cm systems of most radio telescopes have relatively small bandwidth. However, the virialised velocity dispersion of a protocluster corresponding to current cluster of richness class $R \geq 1$ translates to a velocity profile with a FWHM $\Delta\upsilon \geq 3$ MHz. Although it is controversial as to whether the virialized gas will still have a significant neutral component, large width emission lines are more likely than not.

Braun, de Bruyn, Chengalur & Katgert have recently used the WSRT broadband 92cm system in combination with the continuum correlator (DCB) to search for large velocity width redshifted 21cm HI emission. The DCB gives 8 spectral points each with a width of 5 MHz. A total of 3 fields were observed, with an integration time of 4 ×12 hr each, corresponding to a sensitivity (1 σ) of $10^{12.8}h^{-2}$ $M_\odot$ and a total volume of ~ $10^7 h^{-3}$ Mpc^3 ($\Omega_0 = 1$). Observations for this project were taken mostly at night and in the weekends to limit RF interference. Initial reduction of part of the data has shown that the external interference was generally low and the goals of the experiments may well be within reach. However, this requires further software developments within NEWSTAR, the WSRT data reduction package. The software will have to take care of frequency dependent beams and source spectral index effects (for which software is now available), interferometer based amplitude and phase closure errors (not yet available) and be able to undo total power corrections for system gain (available since February 1995). These software tools will make the broadband 92cm system useful for many other applications.

Other attempts at the WSRT to detect emission from high z objects include observations by Braun, Carilli & Chengalur to look for OH maser emission from ultraluminous IRAS sources and high redshift radio galaxies.

Absorption Studies

Absorption studies at high redshift fall into two categories, absorption from HI associated with the high redshift object itself, and absorption arising from objects along the line of sight to the high redshift object.

Absorption from line of sight objects at high redshift arise from the so called damped Ly-α systems. These are the rarest highest column density objects seen in UV absorption towards the line of sight towards high redshift quasars and are believed to be the precursors of the local disk galaxies. Evidence for this includes the fact that they have low velocity dispersion and that the total neutral hydrogen contained in high redshift damped Ly-α systems corresponds approximately to the total luminous mass seen locally. Radio detections require both that the background quasar be radio loud and also typically require long integration times, but are nonetheless extremely useful because, unlike the Ly-α profile, the HI 21cm profile is determined by doppler broadening. Consequently radio observations yield the velocity dispersion of the system. In addition the spin temperature can be determined since the column density is already known from the optical profile, and if the background continuum source is extended the transverse dimension of the object measured by spectral line VLBI.

The new broad band 92cm receivers at the WSRT has been used by Carilli & de Bruyn to search for redshifted HI 21cm absorption associated with damped Ly-α absorption systems at high redshift (redshifts between 2.6 and 3.6, a much larger range in redshift than was previously available with radio interferometers). Moreover the sensitivity of the array is such that even in the case of a non detection the resulting limits to the spin temperature of the gas are physically interesting. A preliminary analysis of the new data reveals an interesting trend: the high redshift HI gas appears to be much warmer than typical HI absorbing gas in nearby disk galaxies (1000 K vs. 100 K respectively). This trend of high spin temperatures at high redshifts is also remarked on by de Bruyn, O' Dea and Baum (1995) who have detected a faint narrow HI absorption line at a redshift of 3.38 against the GPS quasar PKS 0201+113 which itself has an emission redshift of 3.61 (figure 2). The absorption line redshift agrees, to within the errors, with that of a damped Ly-α line. The line has a halfwidth of about 9 km s^{-1}. Comparing the line equivalent width with the HI column density of the neutral gas they deduced a spin temperature for the gas of about

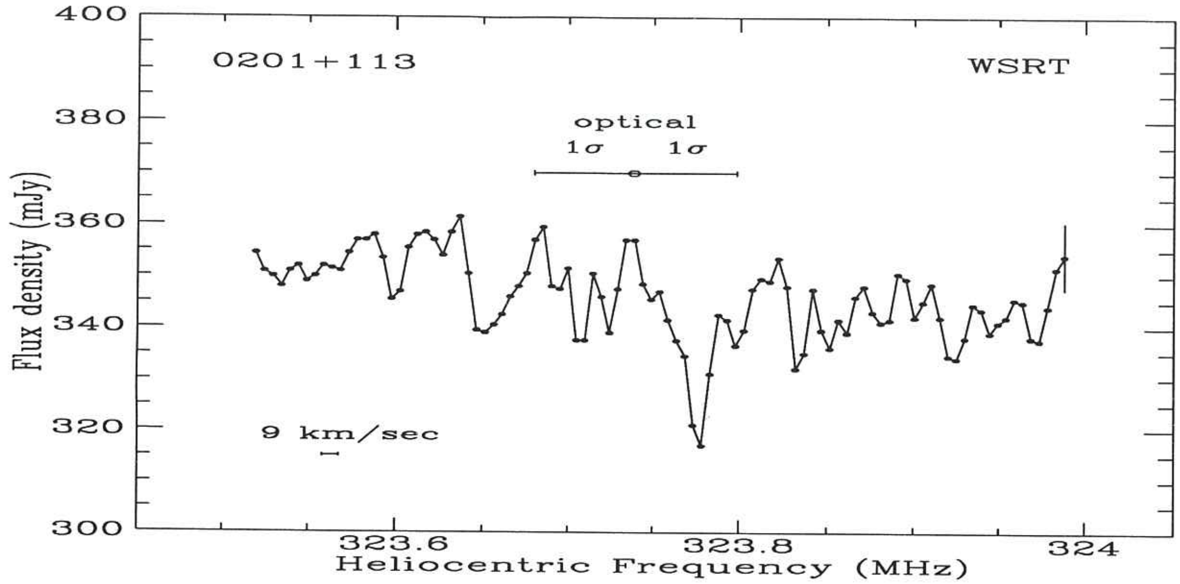


Figure 2. WSRT spectrum of PKS 0201+113. The spectral resolution, (two channels wide), is indicated by the horizontal bar. The line frequency corresponding to the optically determined redshift is shown above the spectrum. A typical 1σ error is shown on the last data point. This is the most distant system detected in the HI 21cm line to date. (From de Bruyn, O'Dea and Baum, 1995).

Ly-α line. The line has a halfwidth of about 9 km s^{-1}. Comparing the line equivalent width with the HI column density of the neutral gas they deduced a spin temperature for the gas of about 1100 K. In view of the fact that the spin temperature is remarkably similar to that derived for other high redshift absorption systems they consider it unlikely that it is due to different lines-of-sight for the ultraviolet continuum and the compact radio source. The high spin temperature may reflect a high kinetic temperature in most of the intervening HI. The HI in high redshift damped Ly-α absorbers may therefore contain relatively more warm gas than our own and nearby galaxies. The damped Ly-α system in PKS 0201+113 is currently the most distant system detected through the 21 cm line of atomic hydrogen, nonetheless, its properties appear to be remarkably similar to those of systems at redshifts around 1. If damped Ly-α systems are due to protodisks and/or disks of spiral galaxies, then galaxies similar to those of present day spiral galaxies were already forming at a redshift of 3.4.

Since UV searches for damped Ly-α systems are much more time efficient than radio searches, most radio observations of damped Ly-α systems are the consequence of directed observation of previously known damped Ly-α systems along the line of sight to radio loud quasars. However searches for Ly-α absorption cannot be done against radio galaxies which do not have bright UV continuum emission. A search for damped Ly-α systems along such lines of sight are however interesting because they are less affected by the presence of dust in the absorbing system and should hence produce a fair sample of high redshift hight column density systems. High column density systems detected in absorption towards bright quasars typically have low dust content. The existence of dust in damped Ly-α systems is however not merely a theoretical conjecture, firm detections of dust in high redshift damped Ly-α systems have been presented by Pei *et al.* 1991. However, the number density of dusty systems is hard to estimate because of the extreme bias against including them in samples of quasars chosen for bright UV continuum. (For example, for systems as dusty as the Galaxy, a column density of 2×10^{21} cm^{-2} corresponds to over 5 magnitudes of extinction at a wavelength of 1200 Å). The broadbandwith WSRT 92cm system along with a new correlator configuration (which divides the WSRT into two phased arrays and trades of baselines for extremely high spectral resolution) is being used by Chengalur, de Bruyn, Carilli & Braun to make a blind search for damped Ly-α systems along the line of sight to high redshift radio galaxies. The results of a test observation with the new correlator configuration is shown in figure 3, which is a spectrum of the Galactic absorption towards 3C409 (a 12 minute integration using a total of 4 telescopes). The velocity resolution after smoothing is 0.8 km s^{-1}.

The interaction between the radio source and the surrounding medium in high z radio galaxies has been of considerable interest since the discovery that radio galaxies have extended optical continua that are aligned with the radio axes (e.g.. Chambers *et al.* 1987). While the there is no wide consensus on the mechanism for producing this alignment effect, models include those in

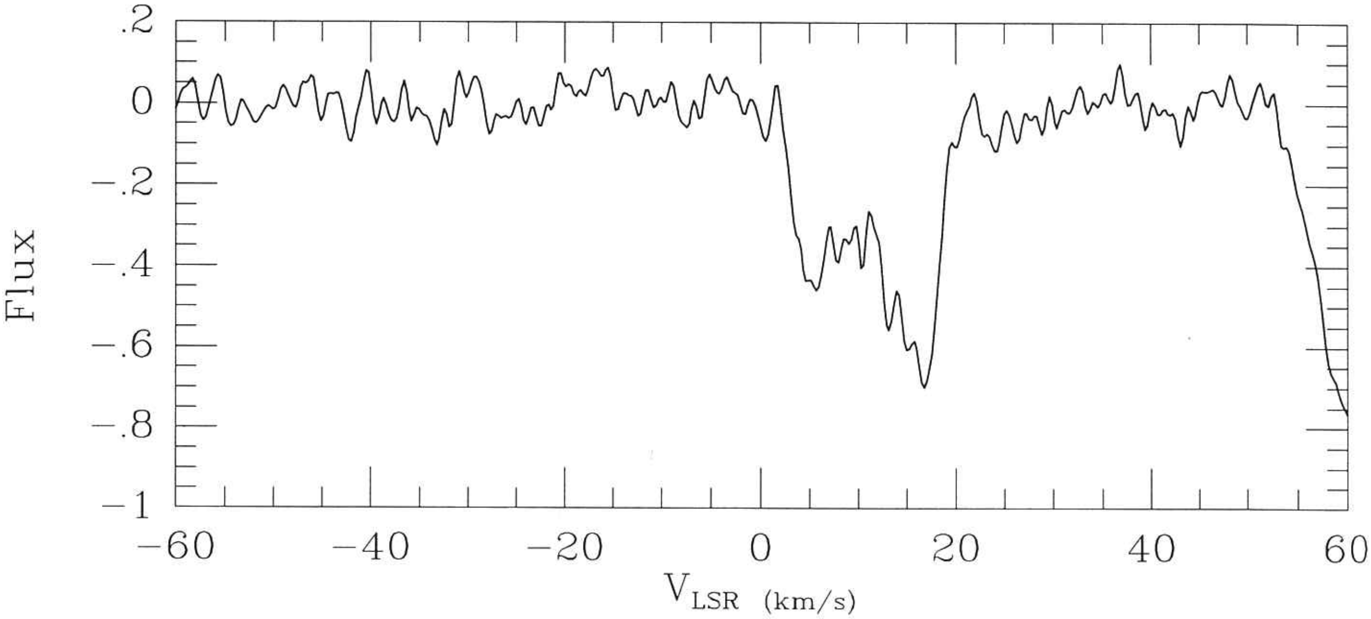


Figure 3. 'First light' for the new WSRT Compound Interferometer mode. The absorption spectrum from Galactic HI towards 3C409 after a 12 minute integration using a total of 4 telescopes. There are 512 spectral channels, corresponding to a spectral resolution of 0.8 km s^{-1} after smoothing. This newly available mode (configured to 2048 spectral channels across a 40 MHz bandwidth), will be used to make a blind search for damped Ly-α systems along the line of sight to high redshift radio galaxies.

which an expanding radio source triggers collapse to dense clouds and subsequent star formation in a surrounding clumpy two phase medium (e.g.. De Young 1989, Rees 1989). Again, while there is not much observational data on the state of the medium in high redshift radio galaxies, substantial amounts of neutral hydrogen have been observed in at least one case (0902+34, where ~ 10^9 M⊙ (assuming T_S ~ 10^3 K) was detected, Uson, Bagri & Cornwell, 1991b). Determination of spatial distribution and kinematics of the neutral hydrogen in galaxies at these early epochs via radio absorption studies are particularly useful inputs to theories of galaxy formation.

Using the new broad band WSRT 92cm system de Bruyn, Miley, van Ojik and Röttgering embarked on a project to search for {\it associated} HI in a sample of high redshift radio galaxies and quasars. Although none of the quasars revealed damped Ly-α lines in their optical spectrum a radio search still seemed useful in view of the fact that the radio sources are often extended on scales of kpc or tens of kpc, much larger than the cross section subtended by the optical continuum. A weak detection in the z=3.58 radio galaxy TX1243+036 was not confirmed when more data were obtained in 1994. Typical limits in the sources for which the reduction has been completed are at the 1 % level (3σ) when smoothed to a few 100 km s^{-1}.

The Future

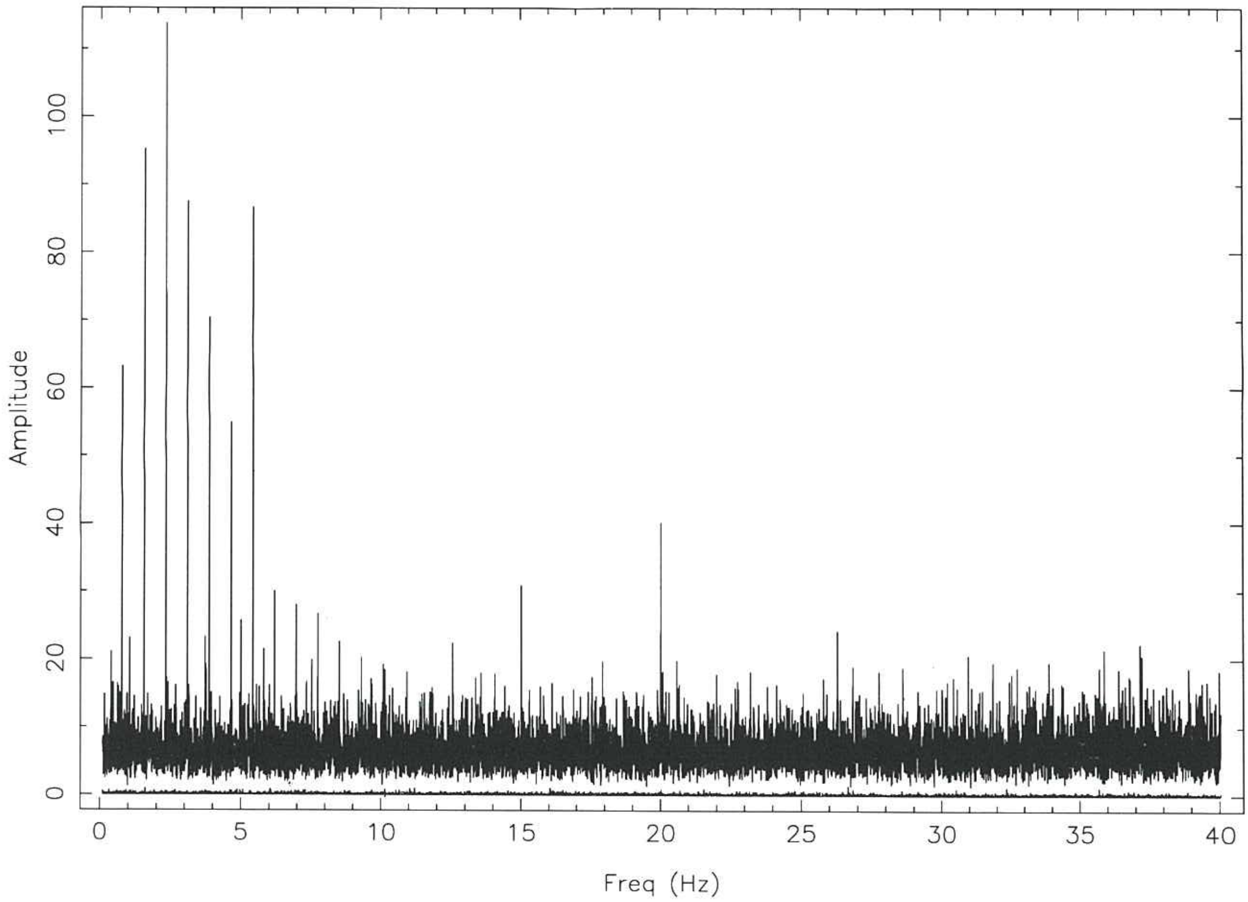
Both the operational frequencies and the frequency flexibility of the WSRT will change dramatically after the installation of the new frontends (the MFFEs, Tan 1990). At low frequencies in addition to the 92cm (for which the MFFE will have similar bandwidth as the current frontend, but with a system temperature that could be lower by as much as a factor of two) there will be two other broadband systems, UHF_{low}, and UHF_{high}. The UHF_{low} system will have a frequency range from 250-460 MHz (and T_{sys} ~ 175 - 75 K) corresponding to redshifts between ~ 2.1 - 4.7 for neutral hydrogen. The UHF_{high} will have a frequency range from 700-1200 MHz (and T_{sys} ~ 98 - 76 K) corresponding to redshifts between ~ 0.2 - 1.0 for redshifted neutral hydrogen. No other existing or planned aperture synthesis instrument will provide comparable coverage (in particular the GMRT will provide coverage in only a relatively small part of these two bands). The two UHF bands will hence be a unique facility at the WSRT and will be extremely useful in extending the range of both the emission and absorption studies of the type that are already underway at the WSRT. For emission studies it is extremely important to search for protoclusters at higher redshifts than the accessible currently, since galaxy formation has clearly started before z ~ 3.3. For absorption studies the greater path length that is available will increase the number of accessible objects. A modest but extremely important increase in the accessible redshift range will also occur in the 21cm band, for which the MFFE will provide coverage from 1200-1450 MHz with (T_{sys} ~ 27 K, or with some additional shielding against ground pickup as low as 18 K, Braun 1993). A dramatic increase in the obtainable spectral resolution (and also a non trivial sensitivity increase because of increase in the sampling from 1 bit to multibit) will be available once the new correlator (the DZB, Bos 1993) is available.

References

Bos A. 1993, Design Considerations for the DZB: A New Backend for the WSRT, NFRA ITR 200
Brown, R. L. & Vanden Bout, P. A. 1992 Ap. J. 397 L19.
Braun, R., System Temperature Contribution for the WSRT, 1993 NFRA note 614.
Briggs F., H., Sorar, E., Taramopoulos A., 1993Ap. J., 415, L19
Carilli, C. L., de Bruyn, A. G. & Boonstra, A. J. 1994, Astron Newsletter, Issue No. 6
Chambers, K. C. Miley G. K., van Breugel W. J. M. 1987, Nature 329, 604
de Bruyn, A. G., O'Dea, C. P. & Baum, S. A.1995, A&A, in press
de Bruyn, A. G. & Katgert, P.1995, in preparation
Pei, Y. C., Fall, M. S. & Bechtold, J.1991, Ap.J., 378, 6
Subrahmanyan R. & Swarup G.1990, JA&A, 11, 237
Tan, G. H.1990, Report Feasibility Study Multi Frequency Front End, NFRA note 555
Uson, J. M., Bagri D. S. & Cornwell, T. J.1991a, Ap. J., 377, L85
Uson, J. M., Bagri D. S. & Cornwell, T. J.1991b, PRL, 67, 3228
Wieringa M. H., de Bruyn A. G., Katgert, P.1992, A. & A, 256, 331

First light in the flexible filterbank backend

As a powerful hailstorm crashed down on the roof of the WSRT control room on October 4th, 1994, the first pulsar was detected with the new 'Flexible Filterbank' pulsar backend. After a day and a half without success (due to such trivial things as pointing errors, wrong electronics settings and digital addressing errors), the telescope was pointed to the 1.29 second pulsar PSR 0809+74. The new backend successfully recorded 900 s of timing data, and transferred it to the off-line computer for analysis. The initial display of the fluctuation power spectrum (that is, the power spectrum of the time series, rather than the power spectrum of the bandpass) was disappointing: it showed the usual large DC spike, and the rest of the spectrum was empty. By this time we were used to disappointment and were not surprised to see nothing, but we dutifully pressed the button to zoom in on the low-frequency end of the display; and there it was, the 0.77 Hz pulsar spike plus its harmonics (see figure 1).



Radio pulsars

Radio pulsars are spinning, strongly magnetised neutron stars, that emit beams of radio waves that sweep the universe much in the way of a lighthouse beam. Pulsar periods vary from 1.5 milliseconds to several seconds. More that 600 pulsars are known; the total number in the galaxy may be several 10^5. Several dozen pulsars are known to have periods in the millisecond range; many of these are in orbit around another star, in some cases another *neutron* star. These pulsars have acquired their rapid rotation in a process of transfer of matter (and angular momentum) to them by a companion star; they are sometimes called 'recycled' pulsars as, because of this mass transfer process, they are living a second life, after their life as an ordinary, slow radio pulsar.

There is a large interest in searches for recycled pulsars and in detailed timing studies of these objects. They are commonly thought to be the evolutionary products of accretion-driven binary X-ray sources and as such provide crucial information on the evolution of these progenitor systems, and on the long-term evolution of neutron stars and their magnetic fields. A considerable number of them have been found in globular clusters; this extends the time intervals accessible to evolutionary studies to 10^{10} years, as compared to the 10^7 years lifespan of standard single radio pulsars.

Precise timing studies of binary and millisecond pulsars provide, in addition, unique tests of a variety of general relativistic effects in the systems themselves, as well as in the solar system. Primordial gravitational waves, if they exist, could be detected using millisecond pulsars, and there is at least one case of a millisecond pulsar that, also by precise timing, has been demonstrated to have planet-mass objects orbiting it. Furthermore, tracking of millisecond pulsars in globular clusters and the galactic bulge will provide important information on the dynamical properties of these stellar systems.

WSRT as a radio pulsar observatory

The WSRT has a large collecting area and unique polarisation capabilities. During the six-month workshop on neutron stars in binary systems in Santa Barbara in 1991, the idea arose that equipping the observatory with pulsar detection hardware would transform it into a powerful instrument for the discovery and subsequent study of radio pulsars. Ed van den Heuvel and Shri Kulkarni came up with the idea to provide WSRT with a copy of pulsar hardware that was already under development in Kulkarni's group in Caltech. With ASTRON, the plan was developed to begin with hardware most suited to the *detection* of pulsations, and to move on to an instrument optimised for high-accuracy *timing* in the second stage of the project. An IAS proposal was submitted by ASTRON to NWO in July 1992. The proposal was approved; as described in the first paragraph, the first pulsar was detected with the instrument at WSRT in October 1994.

Pulsar observations are distinguished from most other radio observations by a number of requirements which can be quite challenging to all meet at the same time. First, one needs a wide bandwidth to obtain a good signal-to-noise ratio from these typically faint sources (the median flux density at 400 MHz is 15 mJy). This is especially important for millisecond pulsars in tight binary systems, where the pulse frequency is Doppler-shifted during the course of an observation, so that minimising the integration time is important for pulse detection. Second, the instrument should have good spectral resolution to deal with the dispersion of the pulses in the ISM. Due to dispersion, pulses arrive at slightly different times in different radio frequencies, and if the radio bandwidth is too large this leads to smearing of the pulses. This is remedied by using many narrow radio frequency channels and shifting the pulses detected in each channel in such a way that they all coincide. Then the signals in all channels can be added together without smearing the pulse profile. Obviously, the need for good spectral resolution *and* large total bandwidth leads to the requirement of a large number of (effective) spectral channels. Finally, high time resolution is required to detect pulses from millisecond pulsars.

The two main instruments used for pulsar observations are autocorrelators and filterbanks. Autocorrelators sample the full bandpass at the Nyquist rate or higher, and synthesise (the Fourier transform of) an n-channel spectrum by generating the n-sample autocorrelation of the sampled bandpass. Filterbanks directly form an n-channel spectrum by providing n RF filters. Historically, analog filterbanks have been cheaper to construct (at least when $n \leq 100$), but do not offer the bandpass stability of a digital system such as an autocorrelator. The tradeoff between spectral resolution and bandwidth has typically been provided for by having several filterbanks of varying spectral resolution.

It was decided to begin the pulsar era in Westerbork with a filterbank suited for the detection of pulsars, and to move on to the more sophisticated timing hardware in the second stage of the pulsar project.

The flexible filterbank backend

The new pulsar backend at WSRT, constructed by S.R. Kulkarni's group at Caltech, is a filterbank with 64 channels, 32 for each linear polarisation. The machine has the novel feature that the usual arrangement of several sets of fixed channel bandwidths has been replaced by a single set of digitally-tunable bandwidths in either of two ranges (0--320 kHz and 0.4--2.8 MHz per channel). The 32 radio channels can be positioned across the 8 sky frequency bands of 5 or 10 MHz bandwidth each received and amplified by the existing WSRT hardware. This flexibility in channel width and the additional freedom in choosing the 8 radio bands makes it possible to fine tune the instrument to the dispersion of the pulsar being observed and to the radio interference environment.

Analog filterbanks usually have limited timing performance because of their long-term bandpass variations, which in turn affect the measured time-of-arrival of pulses. However, because the pulsar backend filters are digitally synthesised, they will probably offer much better long-term stability than analog filters.

The operation of the pulsar backend is controlled by an on-board computer. The software allows for dynamic optimisation of the gain and digitiser settings of all channels. The 64 outputs of the filterbank's channels are sampled and the information is stored on tape or disk for subsequent analysis. The sampling rate is programmable, with an upper limit of 10--20 kHz. The inaccuracy in the time at which the signals are sampled is less than a micro-second over the duration of the whole pulsar measurement. This will be further improved when a GPS receiver is linked to the present maser timing system at WSRT.

Tests and teething troubles

The second set of observations was carried out on November 8th. The pulsar that was observed was PSR 2016+28. We observed at 92 cm, using 320 kHz bandwidth per channel. The outputs from ten antennas were combined in the tied-array mode and fed to the pulsar backend. The filtered signal was smoothed with a 320 μs time constant, followed by sampling and digitization every 320 μs. The data were written to disk for off-line analysis. Figure 2 shows the pulse profile in each channel. Note the offsets of the pulses with respect to each other due to the ISM dispersion delays.

After correcting for the ISM delays, it is possible to construct an overall average pulse profile. This average pulse is shown in figure 3. It shows an overshoot-like figure which is due to the presence in the circuit of RC filters with a time constant around 0.1 s. This feature will be removed at some stage in data acquisition or analysis in future.

The testing of the pulsar backend is in full progress now. A number of technical problems has been identified and solved, and the understanding of how the instrument works in detail has increased enormously in the last few weeks. Of a list of 24 problems drafted a few weeks ago, only one or two presently remain, and their solution seems at hand. This work has led to an improvement in both the instrument's stability and its signal-to-noise. This (mostly off-line) testing will be followed with a series of test observations of various pulsars, designed to verify the capabilities of the instrument and the associated software in real-life circumstances.

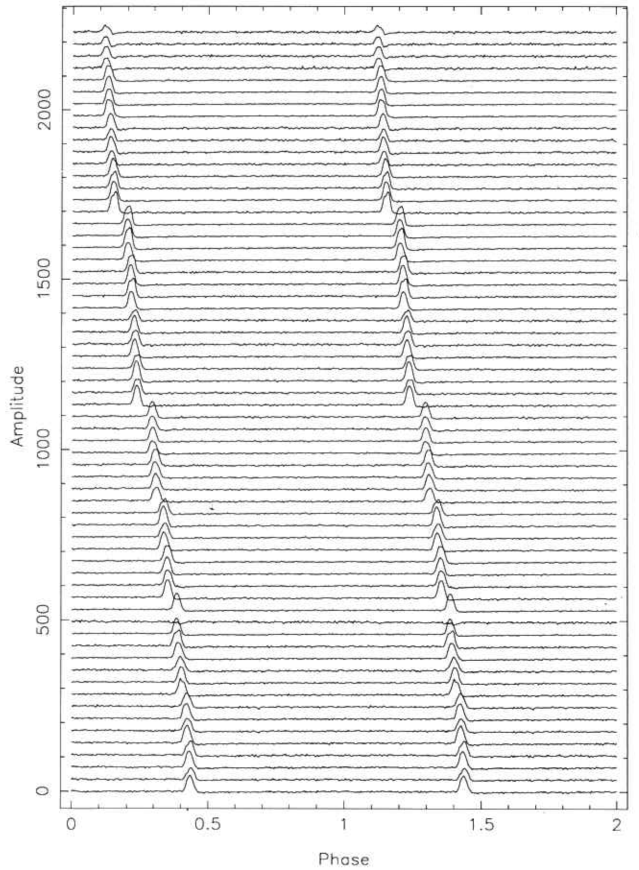


Figure 2. Time-averaged pulse profiles for all channels, PSR 2016+28. The abscissa shows two pulse cycles, with a resolution of 256 phase bins per cycle. The ordinate shows the 32 × 2 channels in increasing frequency order, with an arbitrary offset between succesive channels for clarity. The progressive shift towards earlier phase with increasing frequency is due to the dispersion delay of the pulse signal passing through the ISM. The dispersion delay from one channel to the next is irregular because the channels are not regularly spaced in frequency. The fifteenth channel up from the bottom shows no pulse profile because it contains some 'dead' chips.

Thinking has started on longer term improvements, such as higher sampling rates and the possibility to recover all 4 Stokes parameters; with the present set-up only the signal powers in the X and Y polarisation are known.

Near future and beyond

The design of the pulsar backend is well-suited to searching for pulsars in candidate point sources. A project has already been approved to search for pulsations in millisecond pulsar candidates turned up by WENSS, and analyses of WENSS data with exactly that purpose are in progress. Additional surveys aimed at using the imaging capabilities of WSRT to find more pulsar candidates are already being executed.

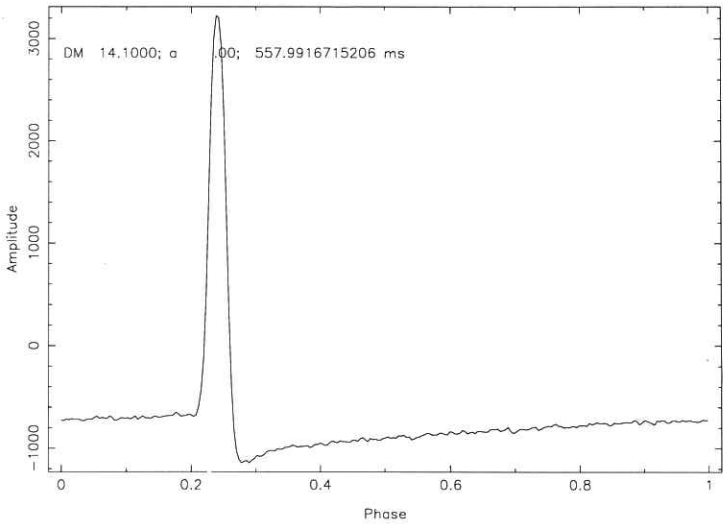


Figure 3.Time-averaged pulse profile of PSR 2016+28 obtained by adding the signal in all channels after correcting for the interstellar dispersion time shifts.

As it looks now, the flexible filterbank backend will probably prove to be effective for timing all but the fastest pulsars. There are two main limitations for pulsar observing at WSRT: the small field of view of a tied-array interferometer prevents the WSRT from being an efficient system for blind (as opposed to targeted) pulsed-emission searches; and high-precision timing of very fast millisecond pulsars is difficult to do without full polarisation information.

Two further pulsar hardware projects are presently being considered. One project, which was planned as the second stage of the pulsar project right from the beginning, is the development of a true timing instrument to make it possible to carry out sub-microsecond timing of millisecond pulsars. A new idea is a time resolved imaging scheme which would enable the WSRT to record data cubes in which each two-dimensional slice is an image, and the third axis is time, sampled as quickly as one slice every 10 ms. Such a system would make the WSRT a more efficient pulsar search machine (for non-millisecond pulsars), than even the Arecibo Observatory. However, it requires a massive computing ability. A project to explore the possibilities of massively parallel computers for this purpose has been initiated in collaboration with the University of Amsterdam Computer Science department.

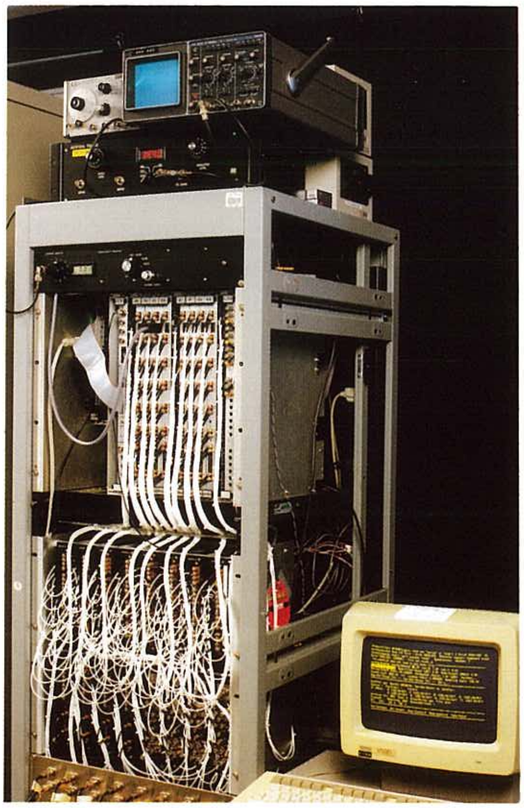


Figure 4. The flexible filterbank backend (photo HJ Stiepel).

The Westerbork Northern Sky Survey

Short description of the project

The WEsterbork Northern Sky Survey (WENSS) is a large-sky survey being carried out at 92 and 49 cm with the Westerbork Synthesis Radio Telescope (WSRT). Some general parameters of the survey are listed in table 1. At 92 cm WENSS should cover the sky north of declination +30° (an area of 10,000 square degrees) to a limiting (5σ) flux density of 15 mJy. At 49 cm about a third of this area will be covered to approximately the same limiting flux density. The resulting catalogue will contain about 300,000 sources at 92 cm and 60,000 sources at 49 cm. In the spring of 1995 we will have completed the observations for about 80% of the survey area at 92 cm (see fig.1). The coverage of the 49 cm survey will depend on available observing time (the current coverage is shown in fig. 2)

	92cm	49cm
Region	$\delta > 30°$	d > 30°, b > 30°
Limiting flux density (5σ)	15-20 mJy	15 mJy
No. of sources expected	300,000	60,000
Polarisations	I, Q, U, V	I, Q, U, V
Nominal resolution	55" × 55" cosec(d)	30" × 30" cosec(d)
Expected positional accuracy (Strong sources)	2" × 2" cosec(d)	1" × 1" cosec(d)

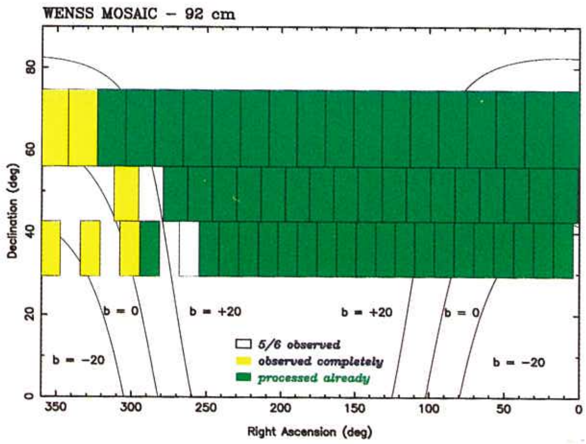
Table 1. Characteristics of the survey. The region indicated for 49 cm is our goal which we may not succeed in completing. There will, however, be many fields observed outside this area.

The most important additional information that WENSS will provide compared to previous radio surveys are:

- radio spectral information on an unprecedented number of sources over a substantial fraction of the sky
- positional accuracy sufficient for optical identification purposes for a large percentage of the catalogued sources
- information on the polarisation of a huge sample of discrete radio sources
- data on faint extended structure over a large region of the sky (SNR, HII regions and diffuse galactic polarised emission)

- morphological information at 30"-60" resolution
- limited data on the low-frequency variability of a large number of sources over time-scales from hours to years.

We expect to finish the observations for the WENSS project in early 1996. The final reductions should be finished by the end of 1996. We expect that the first results of the survey will become available to the astronomical community in late 1995. The WENSS product will consist of a catalogue of radio sources extracted from the survey and a set of FITS images (each 1024x1024 pixels covering 6° × 6° at 92cm). They will become available in both digital (DAT/CD-ROM) as well as graphical form (atlas). Images will be centered at the locations for the new Palomar Observatory Sky Survey plates. A variety of low resolution images will be made as well to facilitate comparison with other radio surveys.



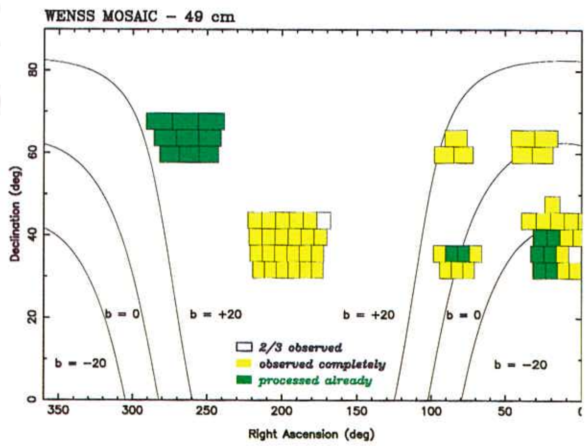


Figure 1. Status of the 92cm observations and reductions of WENSS. Lines of constant galactic latitude of -20°, 0° and +20° are indicated.

Figure 2. Status of the WENSS 49cm coverage.

The mosaicing concept: observations and reductions

To image large areas of the sky with the WSRT within a reasonable amount of time we have to make use of the mosaicing technique whereby the array is repeatedly stepping through a fixed pattern (a mosaic) on the sky in a relatively short time. At the long wavelength of 92 cm the individual pointing centres are separated by about 1.3 degrees, which is about half the primary beam width of the individual dishes. In a time span of 40 minutes we steer the 14-element array through a mosaic with 80 fields covering a region of about 10° × 10° in size. At each field we integrate for 20 seconds followed by 10 seconds to move the array to the next field. The net observing efficiency is therefore 67%. In 12 hours we thus accumulate 18 observations for each field. In order to bring down the sidelobe confusion to acceptable levels each mosaic is observed for 6 x 12 hours, with different array configurations. This typically takes six weeks. The starting field during each 12 hour observation is chosen such that we get uniform coverage of the UV-plane leading to very low (1%) sidelobe levels in the raw images. The net observing time spent on each field is only 36 minutes.

The sky has been divided in four declination zones (cf. fig. 1). The lower two zones each have mosaics containing 8 × 10 fields. The high declination zones will have more complicated pointing patterns resulting in a slight non-uniformity in the sensitivity across the mosaics.

The reduction of the data is done in Dwingeloo on a dedicated HP730 workstation with about 3 Gbyte of disk space. Early 1995 a second HP715 workstation with 6 Gbytes of disk space was added to speed up processing. All data are selfcalibrated to remove ionospheric and instrumental phase errors which dominate the raw images at low frequencies. The positions are calibrated using point sources from the Jodrell-VLA-Astrometric Survey (JVAS) as much as possible. However, in several areas of the sky the density of suitable calibrators was too low, resulting in systematic position errors of up to 5". In these areas WSRT 21cm snapshots of bright unresolved WENSS sources were used to determine absolute positions. This has enabled us to reduce the systematic position errors to about 1" across the sky. Subsequent analysis is done at Leiden Observatory. In addition to the large mosaic images we also construct 'frames' of 1024x1024 pixels, measuring 6° × 6°. After converting to FITS format they are sent to Leiden where they are searched for discrete sources. Both the peak flux and integrated flux densities are determined. The catalogued sources are cross-correlated with other catalogues to define spectral indices.

Scientific drivers and first results

The unique aspects described above make WENSS an important and fundamental database for tackling a wide range of astronomical problems. It is expected that this will lead to exciting new science in a number of areas. Below we will describe the science drivers and the projects that we have already started. For several of them first results are becoming available and have led to publications now in press. Although the dataprocessing for the project is still in full swing, and will remain so for another one and a half years, the scientific exploitation has clearly taken off in a very significant way. Several Ph.D. projects have started making use of the mosaiced images produced in Dwingeloo.

As was to be expected many projects require optical follow-up and higher resolution radio data (VLA, MERLIN or VLBI). The optical follow-up was given a significant boost when the CCI selected this project as the 1995 International Time Project at the Canarian Islands telescopes.

Radio spectra

WENSS will provide spectral information both internally (325/610 MHz) and by comparison with radio surveys at other frequencies. In combination with available (6C/7C at 151 MHz, 87GB at 5 GHz) and planned (VLA-B/D at 1.4 GHz) higher frequency surveys this will permit the study of very large numbers of the following types of radio sources:

- Ultra-steep spectra sources with indices between -1.3 and -3. Such spectra are often seen in the most distant radio galaxies, in radio sources which populate rich clusters and in pulsars. The oldest extragalactic radio sources are also believed to have ultra-steep spectra. From a small area near the North Ecliptic Pole (500 square degrees at 92 cm, part of this at 49 cm) we have extracted about 10,000 radio sources which are been studied for clustering and spectral index.
- Flat spectrum sources at low flux levels (25-100 mJy). Most flat spectrum sources are identified with quasars and BL Lac-type objects. One of the many uses of such a sample is the search for radio-loud gravitational lensed objects. The selection of flat spectrum sources increases the chance of finding lenses suitable for detailed mass-modelling and determination of the Hubble constant. In collaboration with teams from Jodrell Bank and Caltech the WENSS database is compared with the Condon and Gregory 1987GB 6cm catalogue to identify about 5000 flat spectrum radio sources. VLA A-configuration 3.6cm observations (which yield a resolution of about 0.25") are then used to select sources showing evidence for lensing. In the first phase of CLASS more than 3000 radio sources were observed (about 750 of which selected through WENSS). This year we will observe a further 5000 sources, most of which will come through the WENSS filter. In the first CLASS sample we have already detected two certain and two very probable lenses. Fig. 3 shows the VLA CLASS image of B1600+434 which was found to be a double with two variable components (Jackson et al, MNRAS, 274, L25, 1995). It is identified with a quasar at redshift 1.6. The lens redshift is still unknown. HST imaging observations are scheduled for later this year. A second confirmed CLASS lens is B1608+656 consisting of 4 compact components (Myers et al., Ap.J. Letters, in press). This object turned out to be the core of a high

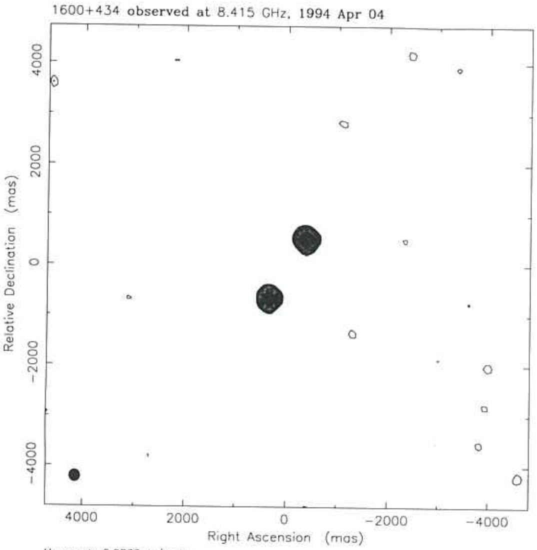


Figure 3. VLA 3.6cm image of one of the WENSS selected flat spectrum radio sources (B1600+434) that turned out to be gravitational lensed. (see Jackson et al., MNRAS, 274, L25, 1995).

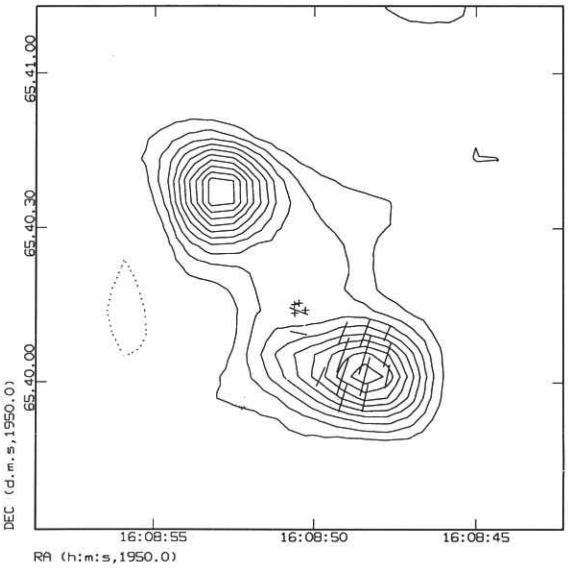


Figure 4. WSRT 21cm image of another gravitational lensed radio source discovered through WENSS (see Snellen et al., Ap.J. Letters s, in press). The four crosses indicate the positions of the four components of the core of the radio galaxy that were lensed by a massive galaxy at a redshift of 0.68 (cf. Myers et al., Ap.J. Letters, in press).

redshift radio galaxy (cf. fig. 4 taken from Snellen et al., ApJ. Letters, in press). A second application of the large number of flat spectrum radio sources is the study of large samples of high-redshift quasars selected in an obscuration free manner.

- Peaked-spectrum sources with maxima in their spectra at a few 100 MHz (CSS peaker) and a few GHz (GPS peaker). This is a little-studied but important class of extragalactic radio source which have typical sizes of ten to a few hundred parsecs and are probably undergoing vigorous interaction with the media of their parent galaxies. There is good evidence that, just as in the case of the ultra-steep spectra, peaked radio spectra may be a pointer to high-redshift objects.

Positional accuracy

Apart from reaching fainter sources the WENSS will also yield excellent positional information (from 5-10" for the faintest sources to better than 2" for the brighter ones). In a large fraction of the sources this will be sufficient for obtaining optical identifications. Comparison of the positions of such a large number of radio sources with digital versions of the deep optical sky survey now being produced and with large-sky catalogues in the X-ray (ROSAT) and infrared (IRAS) regions will be important for many classes of extragalactic and galactic studies. In addition, for many years to come, WENSS will be a database for searching for radio emission from objects discovered in non-radio regions of the electromagnetic spectrum.

Polarisation

The sensitive polarisation information coupled with the large number of sources give WENSS unique capabilities in searching for radio sources having (anomalously) high linear polarisations at low frequencies. These include pulsars as well as interesting variable extragalactic radio sources. The noise level achieved in linear polarisation is about 2 mJy which will permit the detection of many hundreds of polarised sources. We have also re-discovered, through its high linear polarisation (40%), the milli-second pulsar J0218+4232.

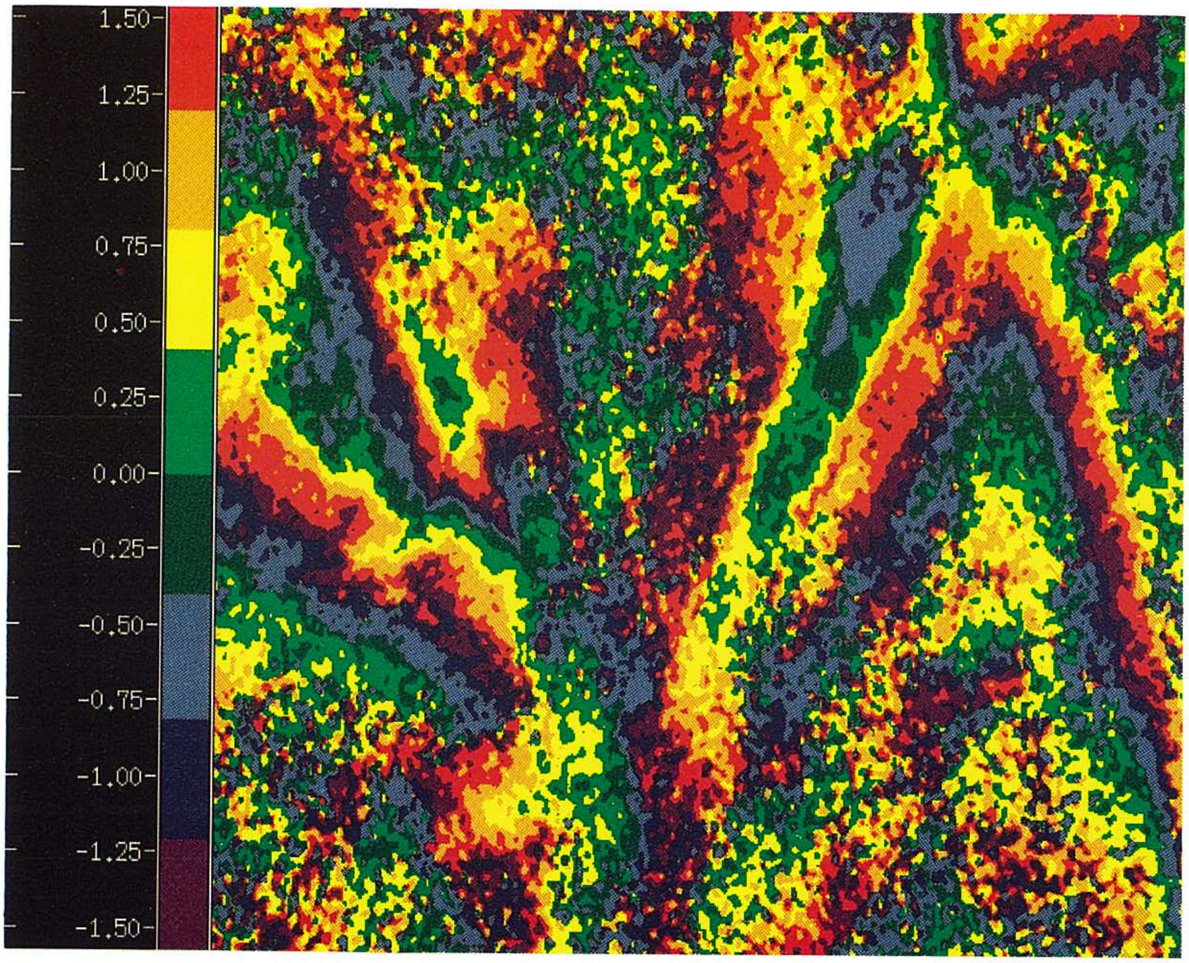


Figure 5. Colour radiograph of the polarisation angle (values between -1.57 and 1.57 radians) of a region of about 6° × 6° in the galactic anticentre with very spectacular polarised emission.

In addition, the sensitivity to extended structure (up to one degree) will make it possible to study the large scale distribution of diffuse polarised galactic foreground emission. The sensitivity of WENSS and its wide field coverage turned out to be sufficient to image the fine-structure in the galactic foreground polarisation discovered by Wieringa et al. (A&A 268, 215, 1993). Fig.5 shows a picture of the polarisation angle (at 4' resolution) of the polarised emission in part of a mosaic in the galactic anti-centre. The combination of many mosaics will lead to a panoramic view of the Faraday rotation in the magneto-ionic medium within about 1-2 kpc from the sun.

Variability

Although not primarily intended to search for variability, the mosaicing technique on which WENSS is based means that information on source variability is available on a variety of timescales ranging from hours, weeks to months The edges of adjacent mosaics, observed in different years of the survey, will also contain information about long term source variability. The survey is thus expected to yield new information about low frequency variability of both galactic and extragalactic sources (pulsars, flare stars, SS433-alikes, low-frequency variable AGN etc). The famous low-frequency variable 4C38.41, recently discovered to be a GRO γ-ray source, increased its flux density by 20% in just 6 weeks (fig. 6; Peng Bo and de Bruyn, A&A, in press). In addition, WENSS could detect new classes of variable radio sources.

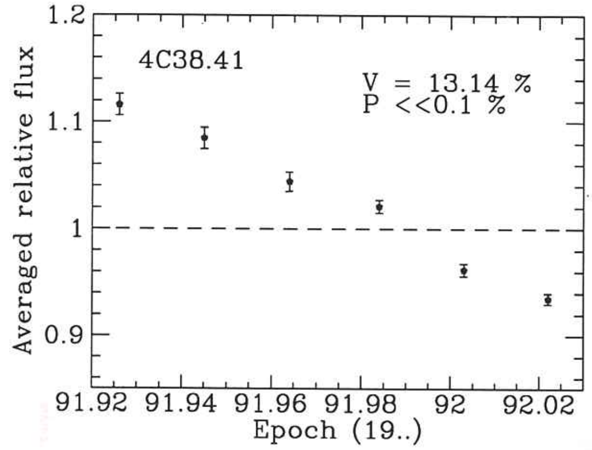
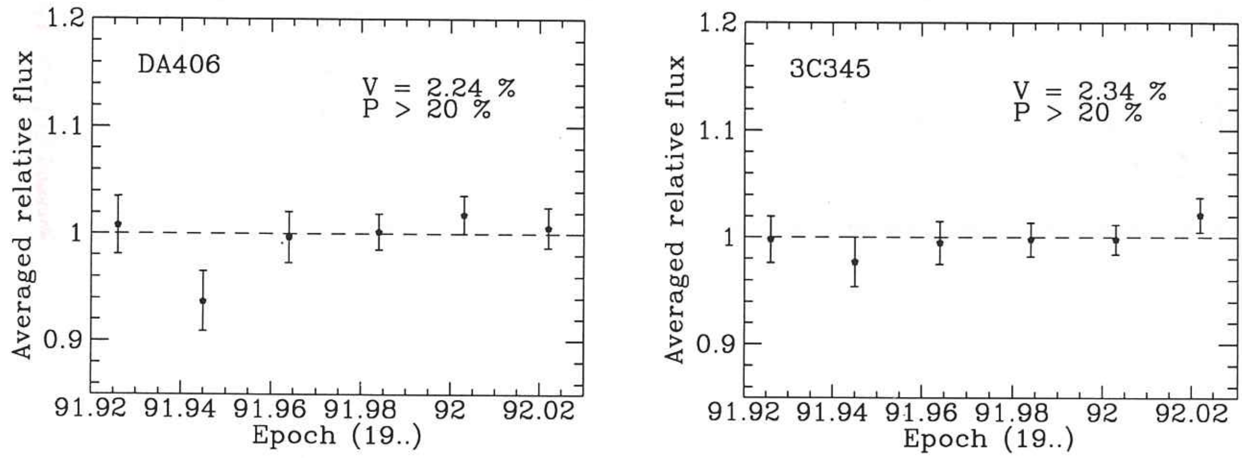


Figure 6. Radio light curves of the sources 4C38.41, DA406 and 3C345, three well known radio sources observed within the same mosaic. The object 4C38.41 declined by 20% in just 6 weeks (cf. Peng Bo and de Bruyn, 1995, A&A, in press)



Pulsars are also known to exhibit variations on timescales from hours to years. The bright pulsar B0329+54 revealed itself in the WENSS data through non-cancelling grating rings (fig. 7). Another well-known pulsar (B0809+74) was found to exhibit dramatic variations on timescales of hours.

General statistical studies

A combination of WENSS with existing large-sky radio catalogues will produce radio colour-colour diagrams which will enable large numbers of all these sources to be selected to flux-levels fainter by at least an order of magnitude than was previously possible. Using the radio spectral

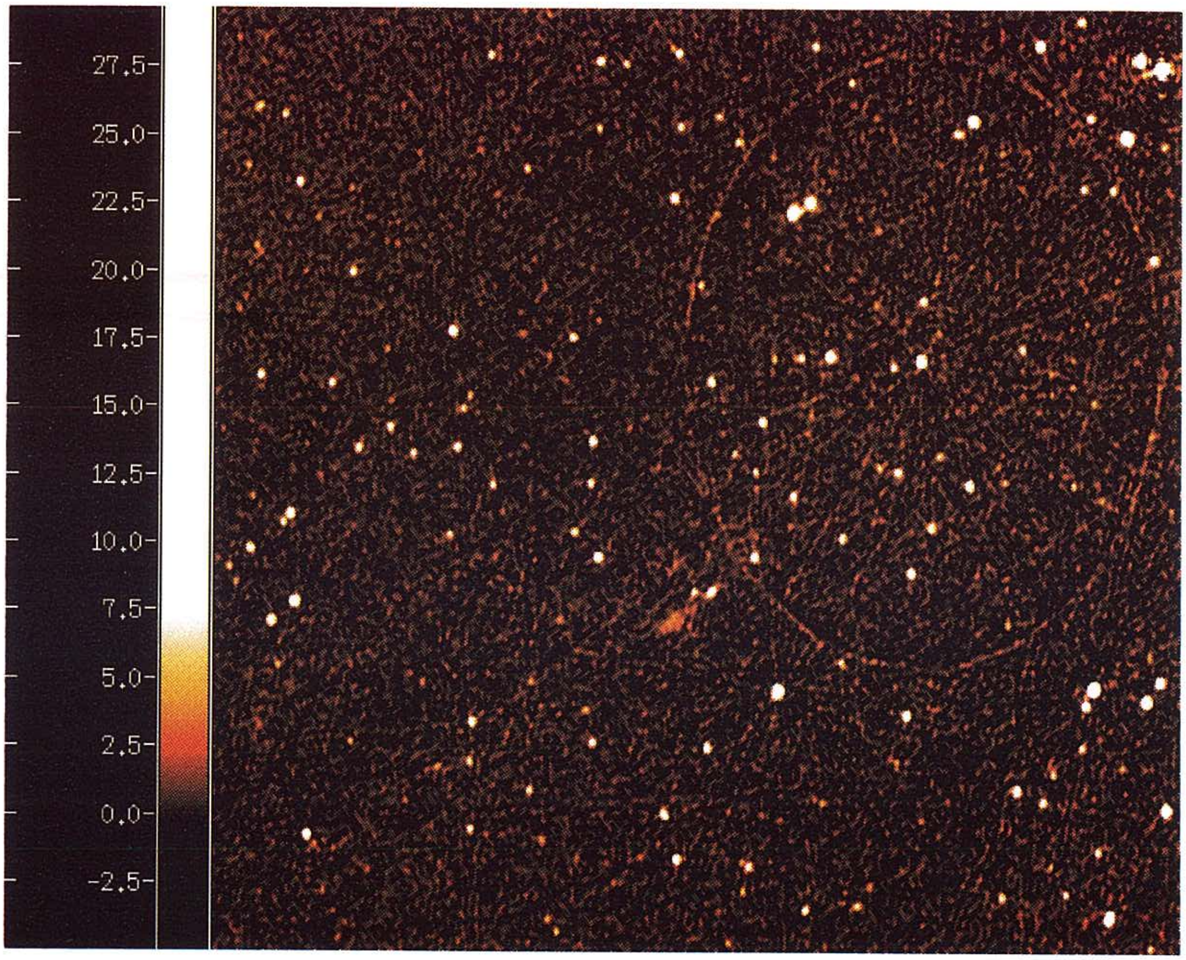


Figure 7. Colour radiograph of the field near the bright pulsar B0329+54. The variations of the pulsar intensity during the 6 weeks taken to complete the mosaic lead no non-cancelling first grating ring (radius 44' in Right Ascension). The spikes emanating from the source show that in addition to weekly variations the pulsar also exhibited rapid hourly variations.

information these various types of sources can be separated. This should provide valuable new data about the evolution of the space density of distant galaxies. In addition, WENSS will allow for the first time studies of large-scale clustering of radio sources to be made which take into account the radio colour discriminant and optical identification information.

Giant radio galaxies

The WENSS survey has already detected many tens of radio sources with angular sizes of order 10' or more. Most of these will probably turn out to be giant radio galaxies with linear size of 1 Mpc or more. Fig. 8 shows a contour image of the largest new radio source discovered thus far. It has been identified with a broad-lined Markarian galaxy whose redshift indicates that the radio source is about 2 Mpc in diameter (Röttgering et al, A&A, submitted)

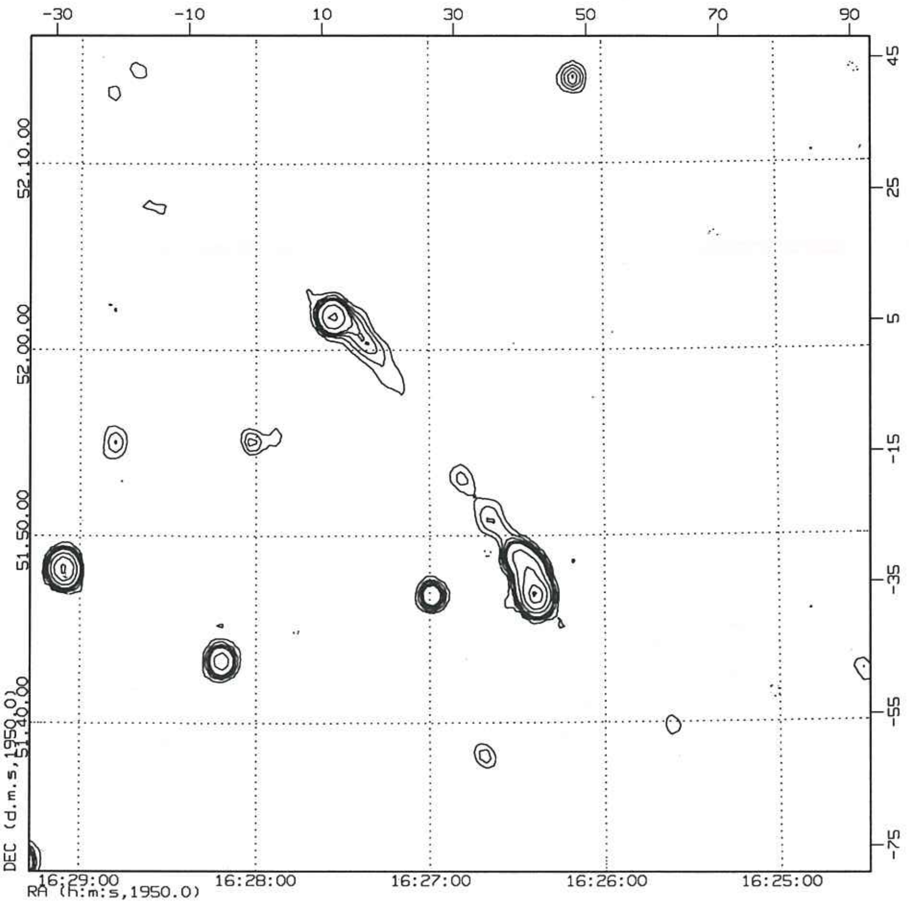


Figure 8. Radio contour image of the giant radio source (20') identified with the broad lines Seyfert galaxy Mkn1498. The source measures 1.9 Mpc in diameter.

Large scale emission from the galaxy

The shortest spacings measured in WENSS are 36 meters (or about 40 wavelengths). This gives the survey excellent sensitivity to large scale emission from our galaxy. The polarisation results from the galactic foreground were already mentioned above. However, many HII regions and SNR's as well as filamentary thermal structures show up in those mosaics where WENSS cuts through the galactic plane. The bright SNR Auriga A is shown in fig. 9.

Radio bright spiral galaxies

Cross correlation of the WENSS survey with e.g. the Nilsson catalogue of bright galaxies will produce many hundreds of objects with information about spiral galaxy disks and halos. The study of the non thermal disk-halo connection can then be undertaken on large samples of edge-on objects. In addition, the selection of samples of nearby galaxies via an obscuration-free emission component will be useful in studies where extinction is a complicating factor.

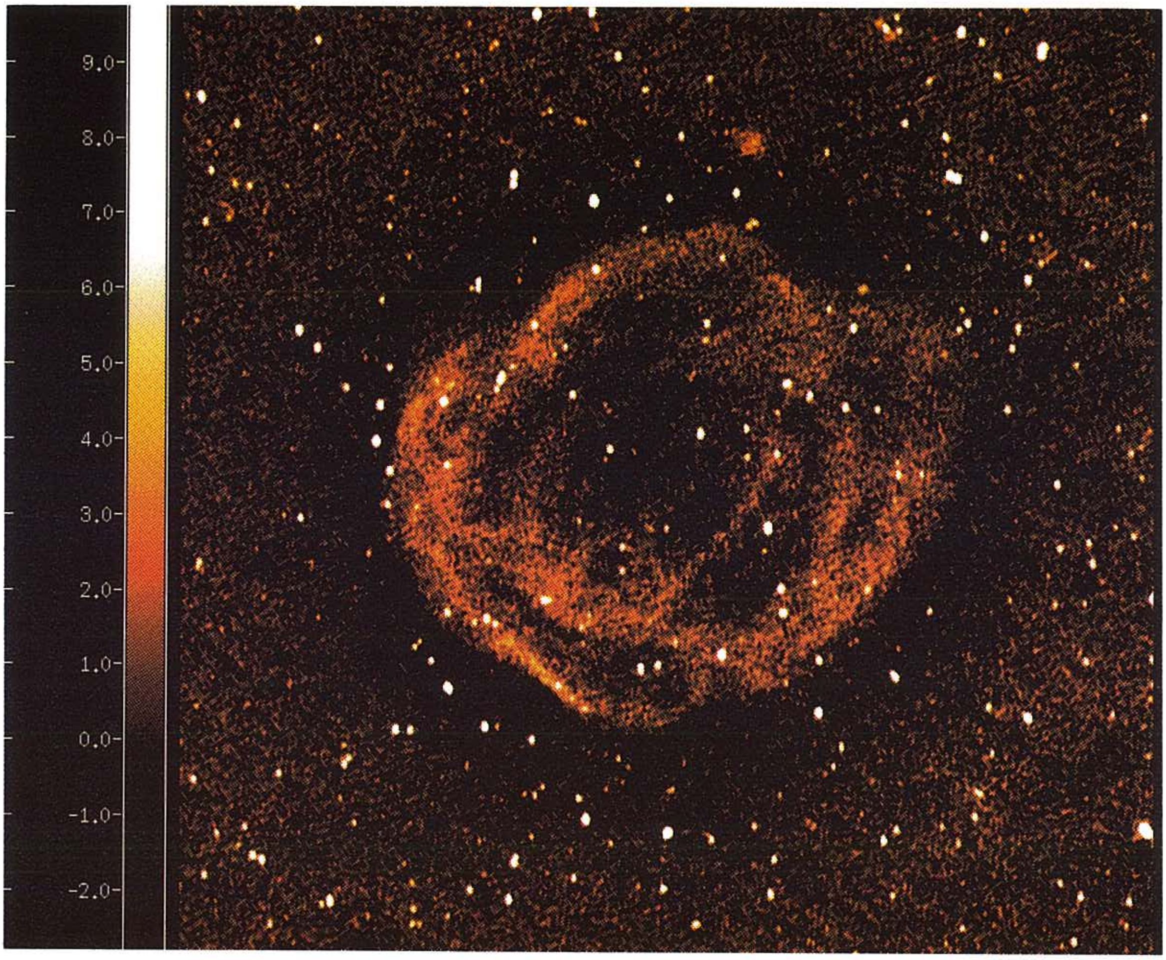


Figure 9. Colour radiograph of the SNR Auriga A which has a diameter of 2.4°. The lack of short spacings (12 and 24 meters) is responsible for the shallow negative 'bowl' around the supernova shell.

Prototype Multi Frequency Front End

A major milestone has been reached in May 1994; the delivery of a fully operational prototype Multi Frequency Front End which was going to be used in one of the WSRT antenna's for astronomical testing. To come to this milestone we first had to test all the (sub)systems and modules intensively. Furthermore the integration of these components into a complete front end was of critical importance. Due to the modular approach of the MFFE project it was possible to work on these tests in parallel. This also gave us the advantage of not suffering major delays in the overall project because of problems in the separate working fields. The integration phase was very successful thanks to the clear and functional distinction between the different components and interfaces. This all led to the delivery of the prototype within the stipulated time on May 18, 1994.

In the week prior to this, the prototype was put on display in a fully functional state at the Netherlands Astronomers Conference in Boekelo. The presentation of the front end and the adjacent information exhibit was very well received by the participants of this conference. It was the first time R&D work of the NFRA was displayed at one of these annual conferences. In view of the positive reactions it was certainly worth the effort.

After one week of further integration of the front end in the WSRT system, the official inauguration of the prototype MFFE took place at Westerbork on May 26. In the presence of NFRA employees and guests from the various Dutch universities, Prof. dr. R. Sancisi revealed a model of the new front end at the foot of Radio Telescope 2 in which the prototype was already mounted. Following these festivities an extensive testing programme was started to determine the characteristics of the front end and validate the design. System temperatures, stability (phase and gain) and operational reliability were given special attendance.

MFFE design review

On Thursday, September 15 1994, the MFFE design review was held at the Dwingeloo observatory. The primary goal of this meeting was to inform the Dutch astronomical society about the prototype MFFE test results, the MFFE series schedule and to freeze the MFFE specifications. Next to that we wanted to inform others interested in the MFFE design. The meeting itself was well attended by staff from the astronomy departments of all Dutch universities and NFRA staff, as well as representatives from several foreign radio observatories.

The morning session addressed the results that were obtained from the prototype MFFE tests and the MFFE series project. The results showed that an operational front end design had been

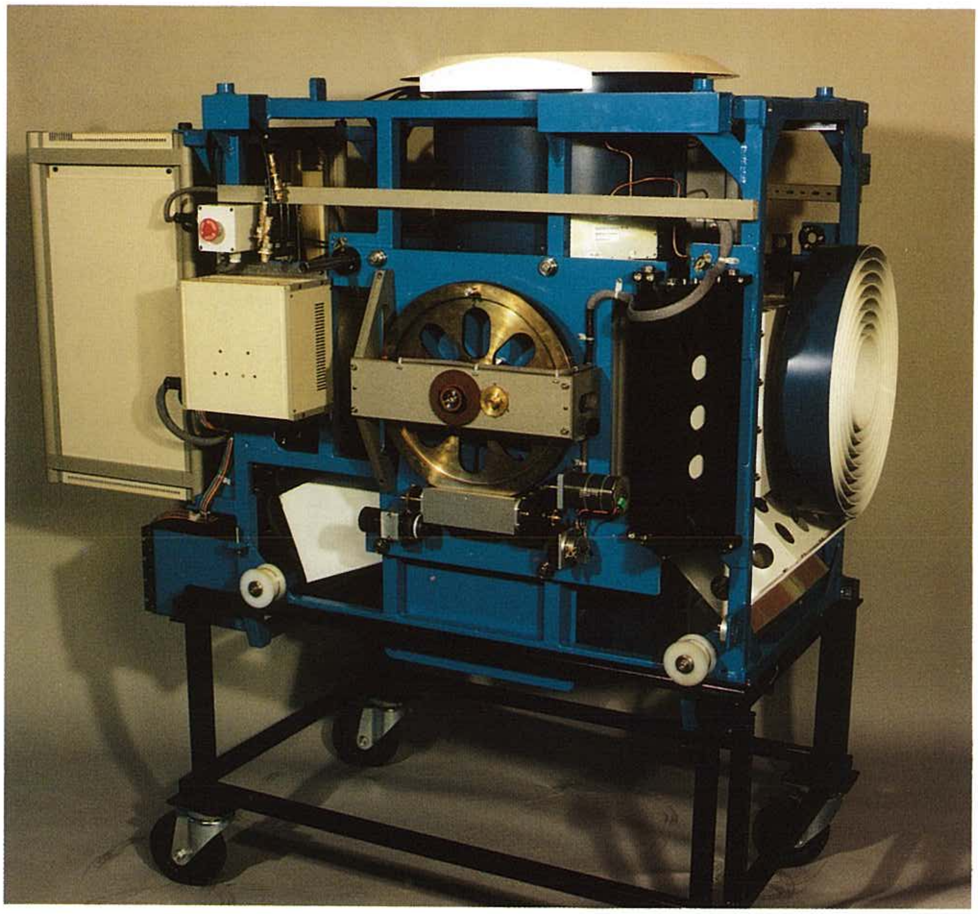


Photo: H.J. Stiepel

created. The technologically novel design of the MFFE performed satisfactory during the several months of testing. The reliability of the design was even such that the WSRT observing group had decided to use this front end for the unique Jupiter collision observations. However it became also apparent that not all specifications are at a satisfactory level yet. Especially the receiver temperatures need more attention to reach the projected, state of the art values.

On the MFFE series project more information was given on the time schedule and the two phases in which the project is divided. The first phase will produce a series of MFFE's equipped with the UHF_{low} and UHF_{high} receivers while in the second phase the other receivers will be installed. To meet the wishes of the important 21 cm WSRT users group, at least 6 months before the completion of the second project phase a fully cooled WSRT system will be available. This interim configuration will be made up of the five existing cooled 21 cm front ends and the MFFE's.

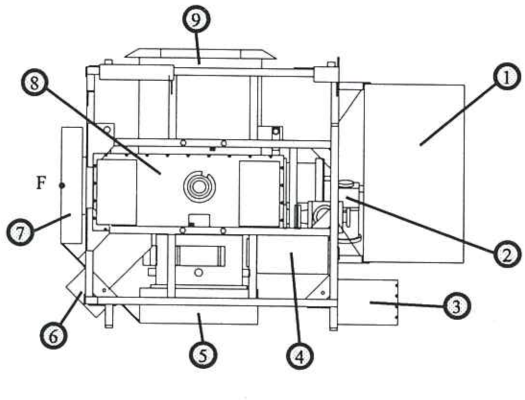
The afternoon session started with a demonstration of the unique observing capabilities of the MFFE concept. The frequency agility of the MFFE gives the possibility to observe the various frequency bands almost instantaneously. A feature that opens an area to observational capabilities that were not present in the past.

The rest of the afternoon was spend on discussion on the presented information. General opinion was that the proposed technical specifications of the MFFE are acceptable for the future but the time schedule of the project should not be delayed and if possible even be shortened. Some ideas were put forward to make improvements to the proposed specs. In particular a broader frequency coverage for the 49 cm receiver was discussed.

The meeting as a whole was evaluated by an advisory committee. Members of this committee were Chris Carilli (R.U. Leiden), Neil Roddis (NRAL Jodrell Bank), Renzo Sancisi (R.U. Groningen) and Richard Strom (NFRA). Summarising their report it can be said that highest priority is to be given to completion of the project as soon as possible and changes which have a risk of delaying the project, should not be made to the design because of the risk of timedelay in the project. The presented MFFE design is satisfactory and should be frozen. The only exception that can be made concerns the possibility of broadbanding the 49 cm receiver. For this, the technical feasibility and the accompanying effort should be investigated in more detail. However if this requires a major time effort, it should be dropped.

Based on the recommendations from the advisory committee and the comments made by the participants of the design review, a project document was made which gives an overview of action items together with their priorities. This document is a guide line for the tasks that have to be done within the MFFE project.

1. 19" cabinet, IF-LO-/ control systems
2. cryogenic cooler
3. power supply
4. RF-unit
5. 6cm / 49cm feed
6. UHF_{high} feed
7. 21cm / 18cm feed
8. cryostat
9. triple feed (92cm / 13cm / 3.6cm)



MFFE cross section

MFFE Series project

Next to the work on the prototype preparations were made for the MFFE series phase. In the course of doing this it was crucial to come to a detailed and reliable planning. With the delivery of the prototype we gained insight in the activities that had to be dealt with in the series phase of the MFFE project. For each of these activities we needed to establish the exact manpower needed as well as the possibilities of contracting out some of the work and of course the costs of the latter.

After the delivery of the prototype we started the actual production of parts for the series. This was done both inside and outside the NFRA. By contracting some of the work we learned that this could very well contribute to the timely delivery of the series phase, but also that it is important to gear all activities of the contractors and the NFRA to one another. This also meant a more formal and structured approach within the NFRA than usual.

By the end of the year this new approach of contracting part of the work proved to be a major factor in our goal to come about a timely delivery of the series MFFE's.

WSRT Maintenance; reflector telescope 5

For the Westerbork Synthesis Radio Telescope, the first 12 telescopes, 25 meter diameter each, were built in 1969. In 1974 two telescopes were added. The reflecting surface on the telescope is wire mesh. This mesh is fixed on a lightsteel frame. Mesh and frame together are called a 'facet'. Each reflector consists of 98 facets. The material on the wire mesh is stainless steel. All other parts of the telescope are made of common type carbon steel. The steel parts were protected against corrosion by a three-layer painting system. In 1975 it appeared that the mesh separated from the panel, and thus did not form the original parabolic shape anymore. With assistance of astronomers from our several universities, about two hundred thousand little screws were installed to tight the mesh back onto the frame. In 1981 all telescopes received additional corrosion protection.

Telescope condition

With the planning of both new design front-ends and backend it is expected to operate the WSRT for an additional 15 to 20 years. In this respect it is important to keep the telescope in an excellent condition. The telescope has been inspected by several companies and technical advisors. The overall impression was that attention to weather protection cannot be postponed much longer. The old brittle paint has no bonding with the steel structure. On several places the rust-process has started. The telescope under-structure (static part) is made of steel profiles with high wall thickness. The rust process on this part of the construction will continue, but the wall-thickness will not reduce by an alarming percentage. The telescope upper structure is 'under-designed', so there is no corrosion allowed. Conservation can be done without disassembling the telescope. The most critical part of the telescope is the reflector. The facet frames are only 2 mm wall-thickness and, under the old glue, severely rusted. To treat this part the mesh has to be removed from the facets. Due to the limited budget it is decided to focus conservation on the critical parts, only for the required period of the WSRT operation. Therefore, cosmetics are not allowed (heavy rusted over designed parts have to be accepted).

The operation

In order to gain experience in way of working, schedule and costs, we started the operation on telescope number 5 under own supervision. With help of four additional staff members we made a platform to reach the bolts of the reflector. On 1 August 1994, two 120 tons cranes lifted the 20 ton reflector from the telescope on a 64 wheel flatbed truck, and transported it to the old

The reflector is re-assembled. The flat-bed truck is being positioned under the temporary spreader beams of the reflector

assembly hall. The panels, as well as the attached mesh, were tagged with number plates for later correct repositioning.

The odd-numbered facets were taken first from the reflector. Numeral little screws were removed from the mesh. The mesh was taken carefully from the panel and laid aside for storage. The frames were put into special transport crates. The crates were transported to a company for professional conservation treatment (sand lasting, chemical removal of old zinc, hot dip galvanising, powder painting). After 5 weeks the 48 frames were returned in shining condition. The mesh was put back again on the corresponding numbered frame, now connected with 4 mm aluminium blind rivets (24,000) per reflector). During this period the ring-girder (reflector supporting frame on which the facets are attached) was sand-blasted and protected by a coating system (zinc-phosphate-epoxy, epoxy, poly-urethane). The new-looking facets were reinstalled and fixed with new high tension bolts. After tightening of the bolts the even numbered facets were removed and treated likewise the odd numbered series. This process again took 5 weeks.

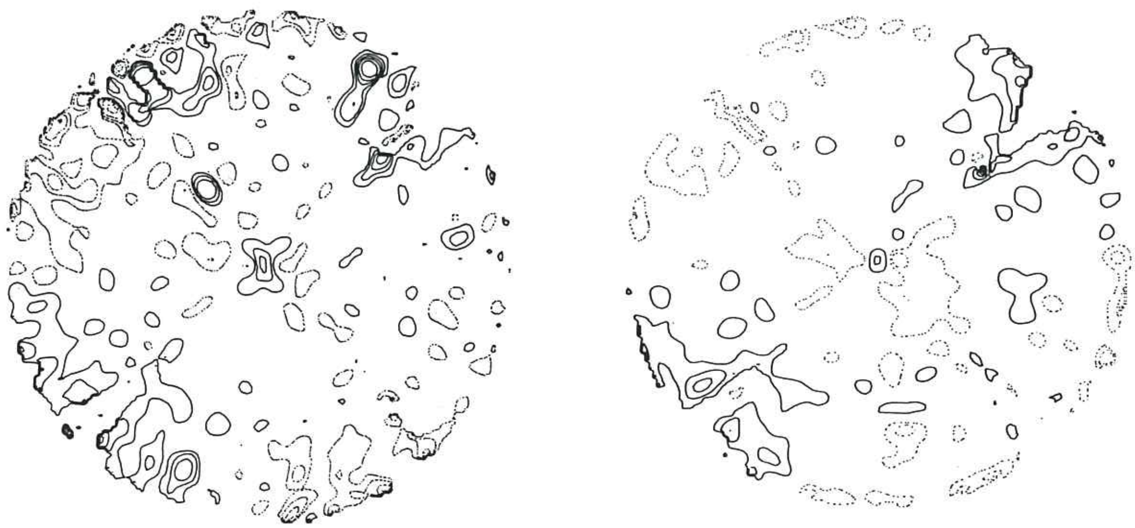
During the four month operation on the reflector the focus box and the four legs were stored outside the hall on the old template. On 6 December the reflector was completed and driven outside the assembly hall. The focus box was lifted back on the reflector. The combination was returned on top of the telescope by a single 200 tons crane. The platform was removed and the coax- and electrical cables were put back again on the leg to the focus box. On 13 December we

The reflector is lifted on top of the telescope. In spite of the three ropes, and five men on the platform, the reflector swinged about 60 cm in the strong wind (force 4).

were able to perform a so-called 'holog-observation' on 6 cm wavelength, on 3C84. With this observation we can retrieve, on a 70 cm grid, the position of the reflecting surface (+/- 1 mm).

Conclusion

The resulting 'holog' surface plot was compared to a surface plot made previously. The actual reflecting shape is improved and therefore acceptable. It has now been proved that the reflector can be disassembled and re-assembled without using the reflector template. The steel under the old glue of the facet-mesh is reduced in wall-thickness by heavy rust. In order to keep the mesh in the required parabolic shape, until about 2015, conservation is essential.



Surface plots of WSRT-reflector number 5, before (left) and after maintenance. Each contour line symbolises a 2 mm deviation from the parabolic shape (full contour: positive, dotted contour: negative deviation).

WSRT Projects

In 1994 38 projects for WSRT observations were allocated by the Programme Committe. These project were given 62.1% of the telescope time. An additional 3.9% was allocated to VLBI projects. For testing and calibration 34.0% of the telescope time was used.

The 92cm and 21cm bands still are the most popular with a share of 43.6% and 40.6% respectively. In the dual mode 92/21cm another 5.3% was allocated. The other three bands, 50 cm, 18 cm and 6 cm had shares of 8.3%, 1.3% and 0.9% respectively.

Project	Subject	
888	Dwingeloo 1 galaxy	B. Burton
947	HI in cooling flows	W. Jaffe
1019	HVC distances	U.J. Schwartz
1027	Cygnus X-1	R. Strom
1030	HVC distances	U.J. Schwartz
1043	Variable non-thermal WR binaries	K.A. van de Hucht
1046	Dark matter in UMa cluster	M.A.W. Verheijen
1103	WHISP	T.S. van Albade
1109	NovaGyg 1992	T.A.T. Spoelstra
1111	GROJ0422+32	C. Hanlon
1120	Emission high redshift HI	R. Braun
1121	Nearby starburst systems	R. Braun
1123	Unusual pulsar	G. de Bruyn, S. Kulkarni
1127	Dark matter in UMa cluster	M.A.W. Verheijen
1135	Comet-Jupiter crash	I. de Pater
1136	Polarised halo in Perseus	G. de Bruyn
1138	HI in galaxy pairs	J. Chengalur
1140	Gamma-ray bursters	J. van Paradijs
1141	HI absorption damped Ly-α system	C. Carilli
1143	HI in low-z Ly-α forest	C. Carilli
1145	Intergalactic HI	R. Giovanelli
1146	BL Lac objects	J. McBreen
1147	Intermediate lat. pulsar search	M. van der Klis
1148	Pulsars OB associations	V. Vashisht
1150	WENSS peaked spectrum sources	R. Schilizzi
1151	SS433 stellar wind	R. Schilizzi
1152	Spectral line P-band	C. Carilli
1153	Molecular gas in early universe	R. Braun
1154	Opacity HI-gas in the galaxy	B. Burton
1159	HI in high-z radio galaxies	J. Chengalur
1160	Scattering halo's Cyg. A,3C295	M. Bremer
1162	Soft gamma ray in SGR1900+14	R. Strom
1164	Polarisation in M51 and N6946	E. Hummel
1166	Low frequency turnover high-z quasar	F. Briggs
1167	BL Lac objects	M. Hanlon

1175	Lobes around soft X-ray transc.	J. van Paradijs
1183	Gravitational lens	I. Snellen
2000	WENSS	G. de Bruyn

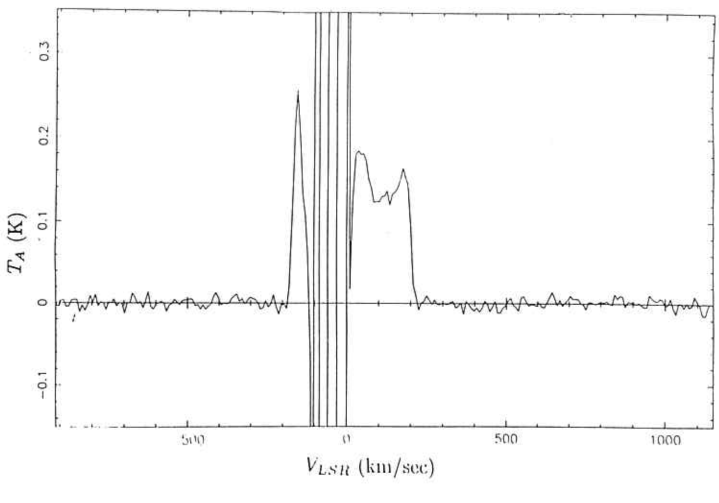
Project	**92 cm**	**92/21**	**50 cm**	**21 cm**	**18 cm**	**6 cm**	**total**
888				53.2			53.2
947				12.0			12.0
1019	21.3						21.3
1027					27.4		27.4
1030				12.0			12.0
1043	83.3	27.0		75.6		18.4	204.3
1046				48.0			48.0
1103				867.4			867.4
1109				71.1		8.1	79.2
1111	39.9	16.7		131.7			188.3
1120	143.9						143.9
1121				12.0			12.0
1123		9.8					9.8
1127				74.5			74.5
1135	85.4	164.4		125	27.4	4.9	407.1
1136				24.0			24.0
1138				12.0			12.0
1140	34.7	12.0					46.7
1141	50.5						50.5
1143				24.0			24.0
1145				24.0			24.0
1146	25.0						25.0
1147	60.0						60.0
1148	72.0						72.0
1150				10.2		7.1	17.3
1151	13.9						13.9
1152	9.3						9.3
1153	20.9						20.9
1154				12.0			12.0
1159	32.9						32.9
1160				51.5			51.5
1162	12.0						12.0
1164	12.0						12.0
1166	6.0						6.0
1167				112.1			112.1
1175				10.4			10.4
1183				12.0			12.0
2000	1184.3		365.4				1549.7
Tot.	**1907.3**	**229.9**	**365.4**	**1774.7**	**54.8**	**38.5**	**4370.6**
VLBI	9.9				122.3	140.6	272.8
Cal.	615.9	125.8	42.0	529.6	59.8	48.7	1421.8
Test	333.9	24.1	59.8	174.0	149.5	226.9	968.2
Tot.	**2867.0**	**379.8**	**467.2**	**2478.3**	**386.4**	**416.2**	**7033.4**

Dwingeloo 1: A New Nearby Spiral Galaxy

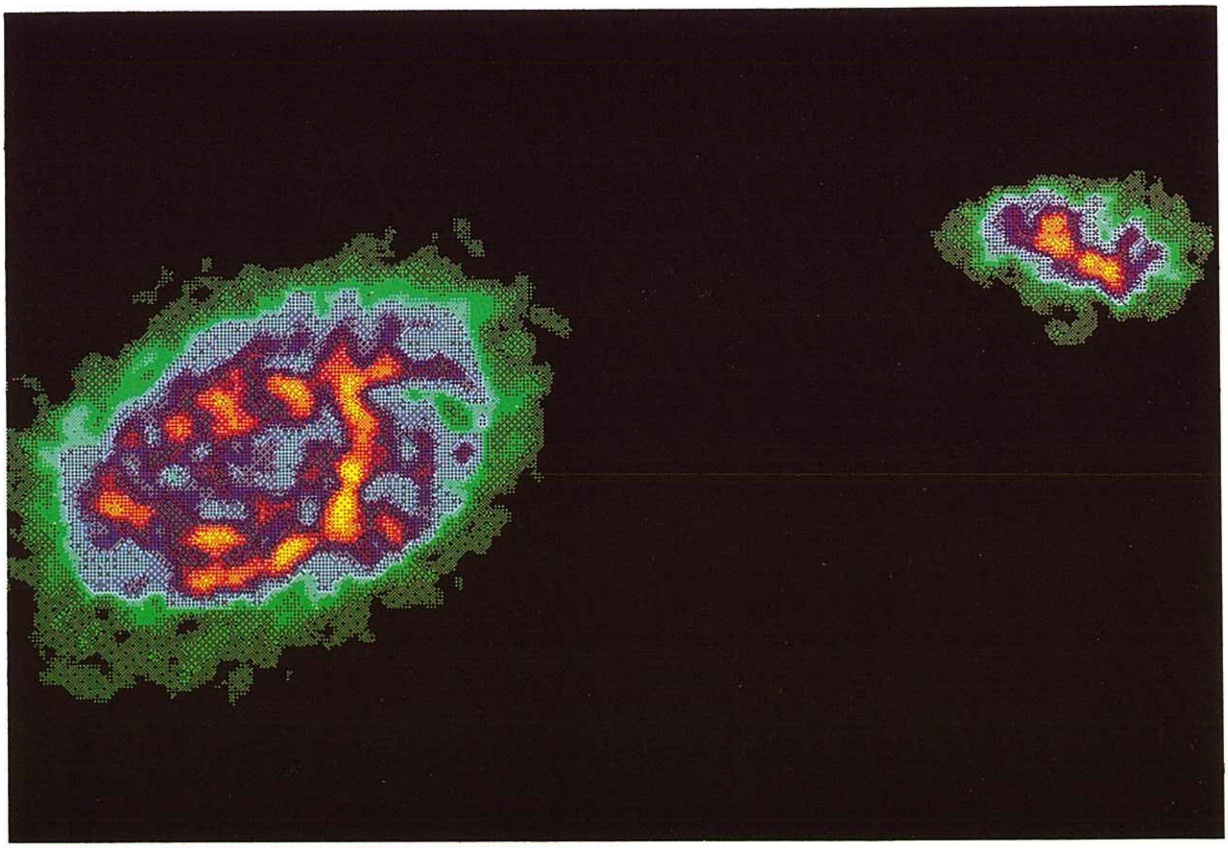
The disc of the Milky Way contains gas and dust which obscures about 20% of the extragalactic sky, the so called 'Zone of Avoidance' (ZOA). Nearby galaxies hidden behind the ZOA may have an important influence on the dynamics of the Local Group and its peculiar motion relative to the cosmic microwave 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. Thus, it is possible to detect in HI galaxies behind the ZOA which are very difficult to detect at other wavelenghts.

The Dwingeloo Obscured Galaxy Survey (DOGS) is a long-term collaboration of Dutch, British and American astronomers to search about 2000 square degrees of the northern Galactic Plane at 21 cm for new galaxies, using the 25 m radiotelescope (built in 1956, and probably the world's oldest operational radio-telescope). The first stage of this project was a 'fast' 5 minute-per-point search of the whole survey area. The first result of this search, in August 1994, was the detection of the radio emission from a new galaxy, Dwingeloo 1 (galactic coordinates l = 138.5 degrees; b = -0.1 degrees) coincided with a feature 2 arcminute in diameter previously noted by George Hau (IoA) on a red Palomar Sky Survey plate.

Follow-up service observations of the new galaxy by the UK Infrared Telescope in Hawaii revealed that Dwingeloo 1 has a bar and possibly spiral arms. Further service observations with the Isaac Newton Telescope on La Palma at optical wavelengths revealed Dwingeloo 1 in full glory, despite the fact that less than 1% of the light emitted in the blue-band from Dwingeloo 1 reaches the earth due to absorption in the Milky Way. Similar observations by the Wise Observatory in Israel, and the William Herschel Telescope on La Palma confirmed our detection.



First observation of Dwingeloo 1, taken with the Dwingeloo 25 meter radio telescope.



This image shows the HI column density of Dwingeloo 1 and its companion galaxy Dwingeloo 2, as observed with the Westerbork Synthesis Radio Telescope (courtesy Marc Verheyen).

The observations suggest that Dwingeloo 1 is a barred spiral galaxy (type Sbb), rotating at about 130 km/s, hence with a mass approximately one third that of the Milky Way. Using the Tully-Fisher relation, it lies at a distance of approximately 3 Mpc from our Galaxy. Its angular and radial proximity to three other well known galaxies, Maffei 1 & 2 and IC342, suggest that it is a prominent member of this group of galaxies, one of the neighbouring groups to the Local Group. Dwingeloo 1 is probably one of the most massive galaxies within 4 Mpc.

The discovery of such a large galaxy close to the Local Group so soon after the start of our survey bodes well for future observations. It is probable that there are many galaxies behind the galactic plane, waiting for us to find them. We are currently combining Palomar plate measurements (utilising the PDS at RGO, with the help of John Pilkington) with optical imaging and spectroscopy at the Wise Observatory and the Isaac Newton Telescope, and with Dwingeloo at 21 cm.

This article by A.J. Loan, O. Lahav and R.C. Kraan-Korteweg was previously published in Spectrum, Newsletter of the Royal Observatories, Issue no. 5

Observing facilities

The Netherlands Foundation for Research in Astronomy operates two radio telescopes the (Westerbork Synthesis Radio Telescope and the Dwingeloo 25 m single dish radio telescope) and is, in collaboration with sister organisations in the United Kingdom and Canada, involved in the operation of three optical telescopes of the Observatorio del Roque de los Muchachos on La Palma, Canary Islands, and a sub-millimetre telescope on Mauna Kea, Hawaii. The coordinating institutes for the La Palma and Hawaii observatories are the Royal Greenwich Observatory, Cambridge and the Royal Observatory Edinburgh, respectively.

Below, the relevant parameters of the WSRT and Dwingeloo telescope are summarised, facilities for which the NFRA is fully responsible. This responsibility includes the operation, the maintenance, the instrumentation and the data processing of these telescopes.

The Westerbork Synthesis Radio Telescope

The Array

The WSRT consists of an East-West array of fourteen equatorial mounted 25-m dishes. Ten of them are on fixed mountings, 144 metres apart; the four (2 x 2) remaining dishes are movable along two railtracks, one, 300 m long, adjacent to the fixed array and another, 180 m long, 9 x 144 m more towards the East. The movable dishes can be used at any position of the rail tracks. The pointing accuracy of the dishes is 15 to 20 arcseconds, the surface accuracy is of the order of 2 mm.

Observing modes

In its 'normal', local mode of operation the WSRT is used as an aperture synthesis array with a total length of 2.8 km. It then consists of a basic set of 40 interferometers, each interferometer comprising one fixed and one movable dish, and a variable number of 'redundant' interferometers (fixed-fixed and/or movable-movable). The redundant interferometers are generally used to calibrate the short term phase and amplitude variations caused by instabilities in the atmosphere. This method, in combination with self calibration techniques, allows very high dynamic ranges to be obtained in continuum observations in particular. The redundant interferometers can, of course, also be used to contribute to aperture-synthesis maps.

A new method of using the WSRT in local mode was developed in 1990. This mosaic method allows mapping of large areas of the sky in a relatively short time. During one 12-hour period the telescopes along with the fringe-stopping and delay centres cycle through a grid of positions a number of times. The grid may contain as many as 120 positions; it can be arranged in a flexible way. If done sensibly no more than 10 seconds are required to change positions within the grid. This allows large surveys of continuum or line radiation which are not limited by the ultimate sensitivity of a full 12-hour observation per position.

Part of the time the WSRT is used for Very Long Baseline Interferometry (VLBI) along with other radiotelescopes in Europe and elsewhere (mainly the USA). The fourteen WSRT dishes are then used as a 'tied array', together yielding the equivalent of one 93-metre single dish in the VLBI network.

wavelength (cm)	6	18	21	49	92
frequency rang (MHz)	4770-5020	1590-1730	1365-1425	607-610	300-380
field size HPBW (degr)	0.17	0.5	0.6	1.4	2.6
max. bandwidth (MHz)	80	40	40	2.5	80
synth. beam in RA (arcsec)	3.7	11	13	30	55
cont. sensitivity (r.m.s. in 12-hour obs. mJy/beam)	0.07	-	0.06	0.6	0.5

Table 1 Characteristics of the WSRT and its receivers

Receivers and backends

Table 1 summarises the characteristics of the WSRT at each of the five wavelengths for which receivers are available. At 18 cm there are only five (cryogenically cooled) receivers. At this wavelength the WSRT is generally used in the VLBI tied-array mode. For the other four wavelengths a complete set of 14 receivers can be used. All receivers have two polarisation channels.

Two digital correlators and two VLBI recording systems can be used to combine the signals from the array for different types of observations. A summary of their characteristics is given in table 2. Note that the Mk2 VLBI mode is from 1994 no longer a standard mode supported by the European VLBI Network. Below we give some additional information.

DXB spectral line backend								
bandwidth options (MHz):	10	5	2.5	1.25	.625	.313	.156	.078
# complex channels (2bit)	1280	2560	5120	10240	20480	40960	40960	40960
(3 bit)	2560	5120	10240	20480	40960	40960	40960	40960
spectral resolution (kHz):								
40 interf. 2 polaris. 2 bit	625	156.3	39.1	9.8	2.4	0.6	0.3	0.15
10 interf. 1 polaris. 1 bit	39.06	9.77	2.44	0.61	0.31	0.15	0.08	0.04
DCB continuum backend								
total bandwidth (MHz):	8×10	40						
bandwidth options (MHz)	10	5						
# complex channels:	2048							
Mk2 VLBI backend								
max. total bandwidth (MHz):	2							
bandwidth options (MHz):	2	1	.5	.25	.125	.0625		
Mk3 VLBI backend								
max. total bandw. (MHz):	14×4							
bandwidth options (MHz):	4	2	1	.5	.25	.125		

Table 2 Characteristics of the WSRT backends

The spectral line backend (DXB)

The basic number of independent 1-bit correlation products the DXB can produce simultaneously is 2560. In 2 bit mode the correlator produces half the number of products (1280) with a sensitivity improved by approximately 1.2. When the observed spectrum can be covered adequately with an overall bandwidth (B) narrower than its maximum value (10 MHz), the clockrate of the correlator (20 MHz) allows the number of correlation products obtained in one integration time to be increased by a factor 10/B to a maximum of 40960 (10/B is a power of 2). The number of complex channels, obtained after Fourier transform of the correlation functions, may be distributed over interferometers and polarisation channels of the array. How one chooses to do this depends not only on the spectral resolution required, but also on the sensitivity needed per frequency point (=complex channel) on each interferometer.

Sensitivity may be increased by changing the correlator's bit-mode, but also by observing the same spectrum simultaneously in two independent polarisation channels. The number of independent frequency channels F in each observed spectrum depends on the overall bandwidth B (MHz), the correlator bit-mode M (1 or 2), the number of interferometers I, and the number of polarisation channels P by the relation:

F x M x I x P = 2560 x 10/B

As an example the spectral resolution is given for each of the eight possible overall bandwidths available and for two rather extreme choices: (i) use of 40 interferometers in two polarisation channels and 2-bit correlation mode for maximum sensitivity, and (ii) use of all possible correlation products on, for instance, 10 interferometers in one polarisation channel and in 1-bit correlation mode for high spectral resolution.

The Continuum Backend (DCB)

The DCB has eight independent bands, each with a width of either 10 MHz or 5 MHz. The central frequencies of the eight bands may be chosen independently within an overall range of about 90 MHz. This choice can be useful to avoid interference at a particular frequency.

Very Long Baseline Interferometry (VLBI)

Any combination of the WSRT dishes can be used as a 'tied array' to serve as one station in a VLBI network. Two types of VLBI backends are available: the narrow-band Mark2C system and the wide-band Mark3A system. In front of the recording terminals one of the normal WSRT backends is used: the DXB in combination with Mk2 and the DCB in combination with Mk3. It is possible to observe two polarisation channels simultaneously with the Mk3 system. With the Mk2 system one can switch between polarisation but one cannot observe them simultaneously. Again, from 1994 Mk2 observations will only be supported on an ad hoc basis.

Archiving and Data processing

The NFRA Reduction Group in Dwingeloo archives all data obtained with the WSRT on optical disks. In addition, it determines and stores standard calibration parameters. The observations catalogue of the WSRT archive can be queried by anybody at any time by running the program ARCQUERY on a captive account with userid : ARCQUERY (no password necessary) on the NFRA microVAX cluster. During the proprietary period (2 years) requests for the actual data (on regular or DAT tape) will only be granted to the original proposers. The requester of data may stipulate whether he or she wants the data with or without the standard calibrations applied. When the data will be processed the redundancy/selfcalibration programmes, it is often unnecessary or even undesirable to apply the standard corrections first.

The 25-metre Dwingeloo telescope

Unlike the WSRT the Dwingeloo telescope is available for use by astronomers who are able to schedule and to carry out their observations themselves. Although a schedule can be prepared for periods of the order of a week, the astronomer's monitoring of the progress will generally require some regular physical presence in Dwingeloo.

The characteristic parameters of the telescope are given below:

Diameter:	25 m
Mount:	alt-azimuth
Pointing accuracy:	approximately 1 arcminute
Surface accuracy:	2 - 2.5 mm
Aperture efficiency:	0.64 (λ = 18 or 21 cm)
	0.40 (λ = 6 cm)

Frontend receivers are available for 21 cm and for 18 cm wavelengths (and, upon request for 6 cm). Their parameters are:

System temperature:	36 K
Frequency range:	1375-1425 MHz (λ = 21 cm)
	1580-1725 MHz (λ = 18 cm)

Sensitivities (5 x rms noise) in 60 min integration time:

cont., bandwidth 10 MHz	20 mJy (2 mK)
line channel, 78 kHz wide	150 mJy (17 mK)

As a backend a prototype of the Dwingeloo Autocorrelation Spectrometer (DAS), developed for the JCMT, is used. It has 1024 channels (if desired to be used with two IFs as 2*512 channels). It operates at overall bandwidths of 10, 5, 2.5 .... 0.067 MHz. If desired observations with a time resolution of 0.1 sec can be done.

The RadioAstron Project

In the middle of May 1994 the two Flight Models of the 6 cm RadioAstron receiver were delivered to the Astro Space Centre (ASC) of the Lebedev Physical Institute of the Academy of Science in Moscow. On June 4, after extensive acceptance tests, the receivers have been formally accepted. This event concludes the construction phase for this receiver. In the coming period, between now and the launch which is planned for 1997, the various receivers will be integrated in the spacecraft and as a whole thoroughly tested. Extensive tests on the complete system will be conducted in the course of next year at the ASC Radio Astronomy Station in Pushchino, some 100 km south of Moscow. Our involvement in the RadioAstron project dates officially from April 1987 when Prof. G. Setti, at the time Chairman of the EVN directorate, signed with Prof. N. Kardashev from IKI (Institute of Space Science of the USSR, now of Russia) and presently at the ASC the Memorandum of Understanding. This action had been triggered by ESA who had received a request for cooperation from IKI and had notified the EVN community.

The RadioAstron Project involves a spacecraft with a deployable parabolic radio reflector of 10 meters diameter for VLBI purposes. The one day orbit of the spacecraft is highly elliptical with an apogee height of 80,000 km and a perigee height of 2500 km. The orbit inclination is 51.6 degrees. The satellite is built for reception of radiowaves in 4 different bands: 92 cm, 18 cm, 6 cm and 1.35 cm. Except for the low frequency option, all receivers are meant to be cooled to about 80 K by combined passive and active cooling. All receivers have dual channel capability. The receiver channels are connected to circularly polarised antenna probes. This novel feed, developed at the St. Petersburg Polytechnical University consists of concentric rings and allows simultaneous reception in the planned radio bands. For the shortest wavelength the feed consists of a waveguide mounted at the centre of the multiband feed.

While the construction of the satellite, including support and communication hardware, remained a Russian responsibility, the design and construction of the receivers became a task for the international community: the 18 cm receiver was allocated to the CSIRO Division of Radiophysics, Sydney, Australia, the 1.35 cm option went to the University of Technology, Helsinki, Finland and the 92 cm receiver became a joint effort between Russia (KB Gorizont in Nizhnii Novgorod) and India (Tata Institute). EVN accepted the task of building the 6 cm receiver. In practice the task went to NFRA in Dwingeloo and MPIfR in Bonn. The receiver is built up by two main items: a Low Noise Amplifier (LNA) and an IF module. In total EVN delivered three 6 cm receivers: an engineering model and two flight models. Next to that, for testing purposes in the Netherlands and in Russia, two Test Sets have been designed, constructed and delivered to the ASC. The engineering model and the first Test Set were delivered in 1990.

Considering the limited funds available for the project and after consultation with experts, it was decided to build the 6 cm receiver out of conventional components instead of space qualified components. In order to meet the reliability requirements set in the contract, special care needed to be taken in the design and the selection of the components. The theoretical relialibility of the receiver system needed to be demonstrated. Based on theoretical grounds one could show that the receiver with its relialibility factor of .987 does meet the specification of .95 as set in the IKI specification document for a mission planned for 3 years and a 60 % active time.

Furthermore, an extensive test program which lasted nearly one year was undertaken. Some of these tests have been carried out cost free at ESTEC in Noordwijk, the Netherlands. They concerned mainly the vibrational and electomagnetic compatibility (EMC) tests. The receivers had to pass both tests which meant for instance that no change in behaviour should be detected after dynamic loading up to 40 G and 2 KHz. The EMC tests concerned the measurement of the emission level from the receivers up to 300 MHz and the susceptibility of the receivers for outside radio radiation. The complete receiver is shown in the figure mounted on the vibration jig at ESTEC. The receiver lifetests consisted of a specified series of varying surrounding conditions during which the receiver functions needed to be accurately measured. These tests were specified to last more than 6 months and were carried out using the specially made computer controlled Test Set . The Test Sets have the possibility to measure and control all functions of the receivers; they in fact simulate the satellite Service Module. They are meant to accompany the receivers up to the launch in Baikonur.

Measurement of the noise temperatures of the 6 cm LNA's yielded 17/25 K and 22/22 K, for the X and the Y channels of model one and two respectively. Taking into account the antenna and cable losses, this leads to a system temperature for the two channels of about 40 K. The output level of both channels is remote controllable from the earth. The receiver system can be calibrated using the stable noise source in the IF module. The LNA's are to be mounted on the coolable radiation plate at the prime focus of the antenna. They are connected to the IF unit in the Focal Container installed on top. The temperature of the gas filled container is expected to vary between 0 and 40 degrees centigrade. Under these severe circumstances good amplitude and phase stability had to be secured. This was taken care of by mounting the critical units on miniature thermostats. The project has been conducted under the leadership of L. H. Sondaar. For his contribution to the project Sondaar was awarded in 1992 the Gagarin medal of the Russian Cosmonaut Federation. In Bonn at MPIfR, A.Schmidt organised the design, construction and testing of the LNA's. The project has been made difficult as a result of language problems and poor communications. The project nevertheless took place in great spirits thanks to the enthusiasm of the construction team.

The total project has costed EVN 330 Kfl; this includes all the receivers (thus also the prototypes), the tests sets and the travel costs. The project has been financed from the contributions of the EVN member Institutes. It has been made possible thanks the support of ESTEC in Noordwijk and the advises from SRON in Utrecht.

EVN-MarkIV correlator

The EVN-MarkIV correlator is being designed and built at different locations and by different institutes: the Correlator hardware is primarily a task for the Haystack Observatory with a contribution from NFRA (system design and input board), the Playback units and the Station units have been contracted to Penny & Giles (P&G) in the UK. The realisation of a custom correlator chip has been contracted out to the NASA Space Engineering Research Center (SERC) for VLSI System Design at the University of New Mexico. The high level line software has been granted to the Nuffield Radio Astronomy Laboratories (NRAL) at Jodrell Bank. The Station Unit Interface Module (SUIM) linking the correlator and the clock, test and gating modules is the responsibility of JIVE in Dwingeloo with part of the work subcontracted to the Institute of Radio Astronomy at Bologna. The Data Distributor which links the Station Units to the Correlator module is the responsibility of NFRA . The cooperation between JIVE, NFRA and NASA (representing itself, the Haystack Observatory, the Smithsonian Center for Astrophysics (CfA) and UNM) has been formalised with the creation of the International Advanced Correlator Consortium (IACC).

The large scale monitoring of the Station Unit project takes place through the so-called Critical Design Reviews (CDR) which were attended by representatives from the EVN, P&G, Haystack and NASA. Next to these meetings the complete IACC team has also met twice in 1994.

Correlator

The key building block of the correlator subsystem is the *Haystack correlator chip*. The logical design has been carried out at Haystack. The physical design, production and testing of prototypes has been contracted to SERC. A condition for letting the contract was the demonstration of a working correlator chip initially designed for the Arecibo telescope. After a second iteration this chip was demonstrated to work at a clock rate of 130 Mhz, well above the specification. The design problems with the Arecibo Chip has caused the Haystack chip to be delayed.

The first 12 wafers yielding over 1300 Haystack chips have been delivered from the Hewlett Packard (HP) foundry to the University of New Mexico (UNM) in December 1994. A number of correlator chips were still being packaged at the end of the year when the chip designer from UNM started the testing procedures. In parallel to these developments, the correlator chip has undergone extensive simulation testing at both Haystack and UNM. A limited amount of VLBI data has been fed to the virtual correlator chip and "first IACC correlator fringes", in good agreement with the expectations, have been obtained.

At a IACC meeting in July at Haystack a prototype *correlator board* and a *correlator crate* were displayed. The design of the *input boards* at Haystack was completed at the beginning of December. Haystack is also responsible for the *serial link boards* which are in use throughout the whole correlator for fast data transmission; their design is complete. In Dwingeloo the prototype *control board* was received back from the manufacturer and testing started. NFRA is also in charge of the correlator and Data Distributor sections of the EVN-MarkIV correlator.

Station units

The contract with P&G concerning the Station Units (SU) involves the design of four prototype units, including full documentation and full rights for reproduction outside P&G. At the Critical Design Review meeting in November the detailed implementation for the Station Units was extensively discussed and a number of unclear items like the treatment of SYNC errors for example has been cleared. P&G brought a number of exhibits to the meeting: a crate with backplane and power supply, a track recovery module and a data input module.

Playback units

A contract was let in 1994 to Penny and Giles Data Systems Ltd for 16 Playback units. These units have been specified to operate at the standard MarkIIIA, MarkIV and VLBA speeds with thin and thick tapes. P&G demonstrated for JIVE and MPIfR visitors on a prototype recorder that it could read the tracks written by a Metrum data Acquisition System and hence meet the specification.

SUIM/TSPU

The SUIM is the interface module between the Station unit and the Data Distributor. It plugs into one of the slots of the Station units backplane. It has many other functions like the gating of the signals (for instance for pulsar work), the injection of test signals, etc. The Test-Synchronisation-Pulsar gate-Unit (TSPU) feeds the whole correlator with the appropriate clock and gating waveforms. At the end of the year the XILINX-implemented modules and the software for the SUIM have been tested. The XILINX firmware for the SUIM proved to be complete while the TSPU board design was 50 % complete. The software for the SUIM is still under design at JIVE. The first iteration of the SUIM board layout has now been completed in Medicina and prototype manufacturing is contracted to industry.

High level control software

The final quarter of 1994 was the first with the Control Software team up to its final strength of four. Progress on what is best described as the "infrastructure" has been steady. The basic design has had some detailed changes as the requirements become clearer, but it remains basically unchanged.

The *Message System* is the glue that holds the different modules of the control software together. The code underlying this is now essentially complete, although objects for individual message types have to be written as they are needed. The Message System interacts with the Process Model at the level of signal and message delivery, and some details of this still have to be worked out. Parts of the Message System have been passed to Penny & Giles for potential use in the Station Unit code.

The coding of the *Job Descriptor* object is now practically complete. This is a "container" class capable of holding whatever information is needed by other parts of the software. In particular it contains the parameters needed to process an experiment on the Correlator. The construction of this class has resulted in some useful spin-off classes that are used elsewhere. Much of what is stored in a Job Descriptor still has to be decided.

Messages Display and Editing contain methods that enable themselves to be displayed and edited. These will enable messages to be constructed and examined both at the testing stage and when required during Correlator operation, and provides a low-level control of Correlator software and hardware available to the operators. A design of the editing/display system is ready.

Command Queues: some parts of the control system require the ability to queue command messages for execution at a later time, together with the option of repeating certain commands at regular intervals. This is made more complicated by the fact that the time scale is likely to change discontinuously (including jumping backwards). The Command Queue system provides an object that handles these requirements, and has had the useful side-effect of providing a general queue object that will be used in the Process Model. The Command Queue objects will be shipped to Penny & Giles for use in the Station Unit code.

Process Model : a general design for the way that a process (a separate part of the control software) will run has been completed. This includes the movement of control within the process as different events are delivered, and a means of queuing the received events. Events here include the arrival of messages and the raising of signals.

Much progress has been in the specification of the contents of *Command Messages* to and responses from, the Station Unit. Some areas still need to be decided, but these mainly depend on details of the Station Unit hardware and software which are waited for from Penny & Giles.

Test strategy

In preparation for the testing and integration phase a correlator testing area with the necessary infrastructure is being prepared at the Dwingeloo Observatory. A complete integration and test plan for the prototype correlator (one of the 4 crates) has been made which shows the critical paths and the milestones. It is clear that there is little difference in criticallity between the planning of the various subsystems.

Timeline

The planning of the prototype still indicates that "first fringes" could be observed before the end of 1995. As a result of delays with the delivery of a number of items, the slack in the planning has vanished. It can be concluded from the planning that the Station Units, the SUIM/TSPU modules, the correlator hardware and software are all on the critical path. The plans for the building extension in Dwingeloo will be integrated to the overall planning as soon as they have been finalised.

The Isaac Newton Group, La Palma

1994 was a particularly successful year for the Isaac Newton Group of Telescopes (ING) on La Palma, which is part of the UK/NL collaboration. The success in operating the telescopes may be measured, for instance by the scientific output, or by the down-time due to technical failure. The number of papers published in refereed journals which are based on data obtained at the ING still shows a rising trend. The publication rate reflects, however, a substantial time delay but the down-time statistics, on the other hand provide a more direct indicator for how successful the telescopes are operating. The technical down-time over 1994 has been remarkably low at approximately 4 percent, which has been the result of a coordinated program of quality control, strict procedures for testing new equipment, and improved coordination between different members of on-island staff in maintaining the telescopes and their instrumentation in optimal working condition. The next step in this program to improve the success of the observatory will concentrate on improving the efficiency of operation and maintenance of the telescopes.

Telescopes and instruments

The prime focus of the 4.2 meter William Herschel Telescope (WHT) has now been established as a focal station. The prime focus platform with its CCD autoguider, field corrector optics and automatic atmospheric dispersion corrector optics has been used for imaging projects by visiting astronomers to great satisfaction. With our current CCD detectors the field of view is typically 7.2 x 7.2 arcminutes with a resolution of 0.4 arcseconds per pixel.

The prime focus platform of the WHT will in the future also feed other instruments through optical fibres. Towards the end of the year the first stage of commissioning of the robotic fibre positioning system, AUTOFIB, was completed successfully. This unit can position 160 optical fibres with great accuracy over a field spanning one degree on the sky. The first set of fibres have a diameter of 2.7 arcseconds projected on the sky. A second set with 1.3 arcsecond fibres will become available later on. AUTOFIB will feed light into a new intermediate dispersion spectrograph (WYFFOS) which will be delivered in 1995. The combination of AUTOFIB and WYFFOS will make the WHT into a powerful and highly efficient tool for multi-object wide-field spectroscopy.

The CCD detectors available to observers have seen a steady development. Most noteworthy in this respect is the advent of three new thinned 1024 x 1024 TEK CCDs of excellent performance. Maintenance of the TEK CCDs has to be done with much greater care than experienced with other CCDs. Working practices have been implemented to keep these CCDs performing to the highest possible standard.

The high resolution Utrecht Echelle Spectrograph (UES) in one of the Nasmyth foci of the WHT has undergone a small but important improvement. Two new, larger coherent fibre bundles have been installed in the UES autoguider for on-slit autoguiding as well as off-axis autoguiding. This has greatly improved the autoguiding performance and has made operation easier. Work is now concentrating on optimising the autoguider software to allow best guiding performance under widely varying atmospheric conditions.

Infrastructure

The control room of the WHT has undergone substantial changes in order to improve it as a working environment both for night-time observing and for maintenance and development work during the day. The single, large area has been partitioned into a control room, a terminal room and a computer room. This work involved substantial recabling effort and was carried out with a minimum disruption to observing.

On the ground floor of the WHT building a test focal station came into use. Here instruments and detectors can be tested as if they were mounted on the telescope. This test facility has proven to be invaluable for most of the servicing and development work which is carried out.

On the computer side a number of enhancements have been implemented. The VAX system driving the instruments on the WHT now consists of two CPUs, one of which is used as a backup system. Also there is a volume shadowing system active which allows a quick recovery even after a major hardware crash.

The Unix cluster is gradually maturing. Now, with Sparc stations, hard disk and tape drives available in each control room the cluster can be accessed easily by observer. The software organisation and availability of different packages for data reduction has been substantially improved. The disks on the VAX and Unix clusters have been cross-mounted, allowing files on the VAX disks to be accessed from the Unix cluster.

The Half-Arcsecond Program

The program to improve the image quality on the telescopes, the so-called Half-Arcsecond Program, is well under way. This program comprises a large number of projects. As a diagnostic tool for weather conditions a professional meteorology station has been erected close to the building of the 1 meter Jacobus Kapteyn Telescope, which transmits the data continually to all telescopes and is available for interrogation in each control room. Also each telescope has a small meteo station to monitor the most important atmospheric variables locally. Furthermore, the dome and telescope structure of the WHT has been equipped with nearly 100 temperature sensors to investigate the thermal behaviour of the dome. Finally, in order to measure the seeing of the free atmosphere a seeing monitor (Differential Image Motion Monitor, DIMM) has been purchased. It will be installed on a small tower which has already been erected not far from the dome of the WHT.

Some of the most important sources of heat in the WHT dome area have already been tackled by improving the thermal insulation in various places. The Half-Arcsecond Program will help our telescopes to take full advantage of the generally good seeing conditions on La Palma.

Financial Report 1994

Received funds	*(kf)*	*total*
Operations		12,910
NWO	12,249	
NWO beleidsruimte GB-E	284	
Expertise Centrum	225	
Restant GS budget/saldo 1993	152	
Capital outlay subsidies		7,708
NWO middelgroot	4,000	
NWO groot	2,200	
Reservering herbesteding	1,508	
Total		**20,618**

Expenditures	*(kf)*	*total*
Operations institute + WSRT		11,339
Staff	8,249	
Exploitation	1,654	
Computers & instrumentation	1,436	
Grants programme		2,021
Projects	1,521	
Programme's	500	
WSRT construction maintenance		584
WSRT development projects		2,325
Multi Frequency Front Ends	965	
New digital backend	800	
Software: AIPS++ project	40	
WENSS	20	
VLBI support	500	
Expertise Centrum ECAB		225
UK/NL Cooperation		2,866
Staff and overhead	766	
Contribution and overhead	2,100	
Credit balance 1994		1,258
Total		**20,618**

NFRA Organisation

Board

	end of term
Dr. R. Hoekstra	dec 1995
Dr. F.P. Israel	dec 1997
Ir. C. Kramer	dec 1994
Prof. dr. P.C. van der Kruit, chair	dec 1995
Prof. dr. J.M.E. Kuijpers	dec 1994
Prof. dr. J.A. van Paradijs	dec 1996
Prof. dr. R. Sancisi	dec 1995

Executive secretary
Prof. dr. H.R. Butcher

Advisory council

Prof. dr. T.S. van Albada
Prof. dr. H.J. Habing
Prof. dr. J.W. Hovenier
Prof. dr. T. de Jong
Prof. dr. H.J.G.L.M. Lamers
Prof. dr. G.K. Miley
Prof. dr. J.A. van Paradijs, chair
Dr. J.W. Pel
Dr. R.G. Strom
Prof. dr. C. Zwaan

Management Team

Dr. W.H.W.M. Boland (secr.),	Hoofd Beheer, Organisatie en Astronomie
Prof. dr. H.R. Butcher (voorz.)	Algemeen Directeur
Ir. A. van Ardenne	Hoofd Onderzoek en Ontwikkeling
Ir. H.C. Kahlmann	Hoofd Waarneembedrijf
B.A.P. Schipper	Hoofd Instrumentatie en Constructie

Dienst Commissie

J. Buiter, chair
A. Doorduin
J. Hofman
J.P. de Reijer
J. Slagter
R.H. Stevens-Kremers
J. Tenkink

Programme Committee

Prof. dr. A.G. de Bruyn
Dr. E.F. van Dishoeck
Dr. S.F. Gilmore
Dr. H. Henrichs
Dr. F.P. Israel, chair
Dr. P. Katgert
Prof. dr. P.C. van der Kruit
Prof. dr. R.H. Sanders
Dr. T.A.Th. Spoelstra, secretary

UNCoc (UK/NL/Can committee)

Dr. W.H.W.M. Boland
Prof. dr. W.B. Burton
Prof. dr. H.R. Butcher
Prof. dr. P.C. van der Kruit
Prof. dr. J.A. van Paradijs
Dr. H. Weijma (NWO)

Landelijke Werkgemeenschappen

LWG Zon en Sterren

UvA	Prof. dr. E.P.J. van den Heuvel	Prof. dr. J.A. van Paradijs
	Dr. G.J. Savonije, secretary	Dr. M. van der Klis
VU	Prof. dr. J.W. Hovenier	
RUL	Dr. J. Lub	
RUG	Dr. J.W. Pel	
UU	Dr. A. Achterberg	Prof. dr. A.G. Hearn
	Dr. J. Kuijpers	Prof. dr. M. Kuperus
	Prof. dr. F. Verbunt	Prof. dr. C. Zwaan
ROU	Prof.dr. H.J.G.L.M. Lamers, chair	Dr. P. Hoyng

LWG Interstellaire Materie

Uva	Prof. dr. T. de Jong, chair	
ASTRON	Dr. R.G. Strom	
RUG	Prof. dr. S.R. Pottasch	Dr. U.J. Schwarz
ROG	Dr. P.R. Wesselius	
RUL	Prof. dr. W.B. Burton	Prof. dr. H.J. Habing
	Dr. E.F. van Dishoeck, secretary	
ROU	Dr. K.A. van der Hucht	

LWG Sterrenstelsels

UvA	Prof. dr. T. de Jong	
ASTRON	Prof. dr. H.R. Butcher	Prof. dr. A.G. de Bruyn
	Dr. E. Raimond	Prof.dr. R.T. Schilizzi
RUG	Prof. dr. T.S. van Albada	Prof. dr. R. Sancisi
	Dr. J.M. van der Hulst, secretary	Prof. dr. H. van Woerden
	Prof. dr. P.C. van der Kruit	
RUL	Prof. dr. W.B. Burton	Drs. R.S. le Poole
	Dr. P. Katgert	Dr. V. Icke
	Prof. dr. G.K. Miley, chair	
RUU	Dr. A. Achterberg	

Personnel

			E-mail: <user>@nfra.nl
Algemeen Directeur		Prof. dr. H.R. Butcher	hbutcher
Beheer, Organisatie en Astronomie			
Adjunct Directeur		Dr. W.H.W.M. Boland	boland
Algemene Dienst			
	Hoofd Algemene Dienst	N.B.B. de Vries	
	Conciërge	R. Wagner	
	Medewerker Onderhoudsdienst	D.P. Kuipers	
	Medewerkster Kantine- en Huishoudelijke Dienst	Mw. G. Sterk	
		Mw. I. Lenten	
Medewerkster Huishoudelijke Dienst		Mw. H. Eising	
		Mw. I. Hoek	
		Mw. I. Lefferts	
		Mw. E. Oosterloo	
Secretariaat			
	Hoofd Secretariaat	Mw. K.A.A. Oving	ninie
	Secretaresse/Adm. Medewerkster	Mw. S. Mellema	sandra
	Administratief Medewerkster	Mw. M.W.M. Vos	mvos
	Telefoniste/Receptioniste	Mw. R.H. Stevens	roelie
	Secretariaatsmedewerker PC	Mw. H.A. Versteege	
Personeelszaken			
	Personeelsfunctionaris	Mw. K.C.M. Mast	
	Medewerkster Personeelszaken	Mw. A. Bennen	abennen
Financiële Zaken/Inkoop Administratie			
	Medewerker Financiële Zaken	P. Hellinga	hellinga
	Adm. Medewerker FZ/Inkoop Adm.	A. Koster	koster
		Mw. J.B. Mulder	jmulder
Voorlichting & Communicatie		Drs. R.O. Genee	genee
Astronomie			
	Astronoom	Dr. R. Braun	braun
		Prof. dr. A.G. de Bruyn	ger
		Dr. E. Raimond	exr
		Dr. R.G. Strom	strom
	Postdoctoral Medewerker	Dr. J. Chengalur	chengalur
		Dr. W. Deich (from 1/7)	wdeich
		Dr. A.K. Singal	asingal
	Research Assistent	Dr. Y. Tang	tang
UK/NL samenwerking			
Hawaii			
	Support-astronoom	Dr. R. Tilanus	rpt@jach.hawaii.edu
	Support-fysicus	Dr. F. Baas	baas@jach.hawaii.edu
	Microgolf ingenieur	D. Urbain	

La Palma			
	Support-astronoom	Dr. R.G.M. Rutten	rgmr@ing.iac.es
	Mechanisch ontwikkelingstechn.	J.H. Haan	jh@ing.iac.es
	Ontwikkelings electronicus	R.J. Pit	rjp@ing.iac.es
	Programmeur	P. van der Velde	pvdp@ing.iac.es
	Computertechnicus	G.P.J. Benneker	benneker@ing.iac.es
Onderzoek en Ontwikkeling			
Hoofd Onderzoek en Ontwikkeling		Ir. A. van Ardenne (from 1/9)	ardenne
Software			
	Wetenschappelijk projectleider	Drs. J.P. Hamaker	hamaker
		Ir. J.E. Noordam	jnoordam
		Dr. F.M. Olnon	folnon
		Drs. H.W. van Someren-Gréve	greve
	Onderzoeksmedewerker	Dr. C.M. de Vos	devoscm
		H.J. van Amerongen	
	Systeemontwerper	G.N.J. van Diepen	gvandiep
	Senior Programmeur	H.J. Vosmeijer	hjvosmeijer
Hardware			
	Wetenschappelijk projectleider	Dr.ir. A. Bos	bos
		Ir. J.D. Bregman	jbregman
		Ir. A.B.J. Kokkeler	akokkeler
		Ir. G.H. Tan	tan
		Ir. E.E.M. Woestenburg	woestenburg
	Electronisch Projectontwerper	A. Doorduin	doorduin
		Ing. A. Henzen	henzen
		Ing. H. Heutink	heutink
		Ing. J. Hofman	hofman
		Ing. P. de Jong	dejong
		Ing. R.P. Millenaar	millenaar
		L.J. van der Ree	vdree
	Project Electronicus	K. Brouwer	kbrouwer
		J. Buiter	buiter
		Y.J. Koopman	koopman
		M. Leeuwinga (from 1/9)	leeuwinga
		L. Nieuwenhuis	nieuwenhuis
		P.H. Riemers	riemers
		N. Schonewille	swille
	Ontwikkelings Electronicus	R. Kiers	kiers
		S.Th. Zwier	zwier
Waarneembedrijf			
Hoofd Waarneembedrijf		Ir. H.C. Kahlmann	hakah
Waarneemgroep			
	Hoofd Waarneemgroep	Dr. T.A.Th. Spoelstra	spoelstra
	Radioastronomisch Waarnemer	P. van der Akker	
		L.H.R de Haan	dhaan
		G. Kuper	kuper
		J.J. Sluman	jsluman
		J. Tenkink	tenkink

	Reductieleider/VLBI Coördinator	Dr. A.R. Foley	tony.foley
	Astr. Gegevensverwerker	A.H.W.M. Coolen	coolen
		D.J.J. Moorrees	daniel
		K. Weerstra (te Leiden)	
Systeemgroep			
	Hoofd Systeemgroep	Ir. A.J. Boonstra	boonstra
	Werktuigkundig ingenieur	Ing. J.P.R. de Reijer	
	Systeemtechn. digitale technieken	J. Weggemans	
	Systeemtechn analoge technieken	H.J. Stiepel	
	Mechanisch technicus	J. Stolt	
		P.G.J. Gruppen	
	Electro-mechanisch technicus	P. Donker	
	Senior Programmeur	T. Grit	grit
		B. Kramer	kramer
Terrein en Gebouwen			
	Bewakings- en Onderhoudsdienst	H. Bokhorst	
		D.J. Haanstra	
		A. Wieringh	
	Adm. Medewerkster/Telefoniste	Mw. A.C.H. Heijne	heyne
	Medew. Huishoudelijke Dienst	Mw. H. Braam	
Instrumentatie en Constructie			
Hoofd Instrumentatie en Constructie		B.A.P. Schipper	schipper
Technisch Ondersteunende Dienst			
	Techn. Ondersteunende Dienst	H. Snijder	snijder
	Inkoop Documentalist	S. Sijtsma	sijtsma
	Technisch Magazijnmeester	P.C. Jager	jager
	Instrumentatie Technicus	H.J. Borkhuis	borkhuis
	Electronisch Monteur	A.M. Koster	
Technische Documentatie			
	Technisch Documentalist	R. van Dalen	vandalen
		J. Slagter	slagter
Computer Systeem Beheer			
	PC-systemen en Netwerken	R. Boesenkool	boesenkool
	Minisystemen en Netwerken	Mw. H.H.J. Lem	hlem
	UNIX-werkstations en Hardware	K.J.C. Stuurwold	stuurwold
	Software programmeur	A. van Schie (from 7/4)	avanschie
Instrument Makerij			
	Hoofd Instrumentmakerij	W. van Emden	emden
	Werkcoörd. Instrumentmakerij	J. Idserda	idserda
	Mech. Ontwikkelings Technicus	J. Bakker	jbakker
		M. Bakker	mbakker
		J.S. Dekker	dekker
		T.J. de Jong	tdejong
		G.J.M. Koenderink	
		M. Schuil	schuil
JIVE			
	Directeur	Prof. dr. R.T. Schilizzi	rts
	Coördinator	Dr. C. Slottje	slottje

Senior-scientist	Dr. S.V. Pogrebenko	svp
Support-scientist	Dr. D. Dallacasa	daniele
	Dr. H.J. van Langevelde	huib
	Dr. M.J. Rioja	rioja
	Dr. H.S. Sanghera	hss

Summerstudents

		supervisor
Mark Robison	University of Minnesota	Richard Strom
Patrizia Romano	University of Padua	Ashok Singal
Alison Peck	University of Nebraska	Leonid Gurvits
Arno Schoenmakers	Rijks Universiteit Leiden	Robert Braun

Stagiaires

		supervisor
Marga Haveman	Opleidingsinstituut DAC	Peter Hellinga
André Hulshof	Hogeschool Enschede	Hans Kahlmann
Gerard de Jager	Morgenland College	Arie Doorduin
Frank Jonker	HTO Windesheim	Wim van Emden
Lennart Kalk	MBO College Oost-Groningen	Jan Idserda
Hilleen Kok	Morgenland College	Peter Hellinga
Gerjo Lambers	Hogeschool Drenthe	Albert Bos
Erik Moddejonge	Hogeschool Enschede	Bert Woestenburg
Michel Rieff	HTO Windesheim	Bert Woestenburg
Jan-Willem Smits	HTO Windesheim	Wim van Emden

Visitors

Marco Bondi (Jodrell Bank)
Wim Brouw (ATNF)
Salvatore Buttaccio (NOTO)
Imke de Pater (UC Berkely)
Peter Dewdney (HIA, Penticton)
Jiang Dong-Rong (Shanghai Observatory)
Victor Dubrovich (ASC)
Irma Eggenkamp (Leiden)
Istvan Fejes (Budapest)
Stephan Frey (Penc Hongary)
Titus Galama (Amsterdam)
Brian Glendenning (NRAO)
Richard Gooch (ATNF)
Diah Setya Gunawan Utrecht
Karel Hol (Nijmegen)
Marco Kouwenhoven (Utrecht)
Andrew Lobanov (NRAO/ASC)
Sangeeta Malhotra (Princeton)
Rakesh Malik (Pune)
Ari Mujunen (Metsahovi)
Andrew Readhead (Caltech)
Xu Ren (Shanghai Observatory)
David Roberts (Brandeis University)
Neil Roddis (Jodrell Bank)
Jacques Roland (Leiden/Paris)
Bob Sault (ATNF)
Gert-Jan Schurer (Utrecht)
Seth Shostak (SETI Institute)
Dave Shone (Jodrell Bank)
Richard Simon (NRAO)
Peter Swaanenvelt (SRON)
T. Venturi (Bologna)
Anne Wehrle (SPAC, Caltech)
Wen Wu Tian (Beijing)
Rudy Wijmands (Leiden)
Gino Tuccari (Noto)
Jos van Riswick (Nijmegen)
Anton Zensus (NRAO/MPIfR)

Projectsubsidies

These projects are being supported by NFRA.

LWG Zon en sterren

Code 782-371	Aanvrager(s)	Titel onderzoek	Onderzoeker
038	Prof.dr. J. van Paradijs	Een optische studie van röntgen bronnen in M31	Drs. T. Augusteijn UvA (tot 15/1)
040	Prof.dr. H. Lamers Prof.dr. E. v.d. Heuvel Dr. L.B.F.M. Waters	De evolutie van lage-massa dubbel sterren van de AGB via post-AGB tot planetaire nevels	Drs. E.J. Bakker UU
041	Dr. P. Hoyng Prof.dr. M. Kuperus Prof.dr. H. v. Beijeren	Stochastische aanslag van grootschalige magneetvelden	Drs. A.J.H. Ossendrijver UU
042	Prof.dr. J.van Paradijs Dr. W. Hermsen	Produktie van gammastraling in compacte objekten in het melkwegstelsel	Drs. R.C.A. van Dijk, UvA 50% ASTRON/50% SRON
043	Dr. H.F. Henrichs	Seismologie van O sterren	Drs. J.H. Telting UvA
044	Prof.dr. J. Kuijpers	Radiopulsars en lineaire versnellingsstraling	Dr. E.T. Rowe UU
045	Dr. R.J. Rutten	Stralingshydrodynamica van de rustige chromosfeer	Drs. N.M. Hoekzema UU
046	Dr. G.J. Savonije	Niet-lineaire getijden interactie in zware dubbelsterren	Drs. F. Alberts UvA
047	Dr. G.H.J. v d Oord Prof.dr. M. Kuperus	Het effect van retardatie op MHD-configuraties	Drs. N.A.J. Schutgens UU
048	Prof.dr. H. Lamers	Een studie van de variabiliteit van luminous blue variables	Drs. R. Noordhoek UU
76-014/ MPR	Prof.dr. A.G. Hearn	MHD: parallel rekenen aan de dynamica van astrofysische plasma's	Dr. G. Töth UU (vanaf 1/9)

LWG Interstellaire Materie

Code 782-372	Aanvrager(s)	Titel onderzoek	Onderzoeker
031	Prof.dr. S.R. Pottasch	Vroege evolutiestadia van planetaire nevels	Drs. R.D. Oudmaijer RUG
032	Dr. J.M. van der Hulst Dr. R. Braun	Interactie tussen stervorming en het interstellaire medium in M33 en M31	Drs. O.M. Kolkman RUG
033	Dr. J.M. van der Hulst	Een theoretische studie van de spectra van planetaire nevels melkwegkernen en HII gebieden in het Infrarood	Drs. P.A.M. van Hoof RUG
034	Dr. E.F. van Dishoeck Prof.dr. H.J. Habing Dr. Th. de Graauw	Aard en evolutie van interstellair stof bestudeerd met laboratorium infra-rode spectroscopie	Dr. W. Schutte, RUL 50% ASTRON 50% SRON

035	Prof.dr. S.R. Pottasch	Early evolution of planetary nebulae	Drs. G.C.M. v.d. Steene RUG (tot 1/8)
036	Prof.dr. H.J. Habing	De keuze van een dynamisch model voor de binnenschijf en de bult van ons melkwegstelsel	Drs. M. Sevenster RUL
037	Prof.dr. W.B. Burton	Scientitic exploitation of the Leiden Dwingeloo Hl survey; physical characteristics of galactic HI	Drs. S.R.D. West RUL

LWG Sterrenstelsels

Code 782-373	Aanvrager(s)	Titel onderzoek	Onderzoeker
039	Prof.dr. R. Sancisi Prof.dr. T. van Albada	De vorm van donkere halo's	Drs. F.J. Sicking RUG (tot 1/11)
048	Prof.dr. T. de Zeeuw	Structuur en dynamica van elliptische sterrenstelsels	Drs. F. Robijn RUL (tot 1/5)
049	Prof.dr. V. Icke	Oorsprong en eigenschappen van emissielijngas in aktieve sterrenstelsels	Dr. N. Roos, RUL (50%) (tot 1/9)
050	Prof.dr. G.K. Miley	Studies van extragalactische jets met de Hubble Space Telescope	Dr. N.F. Jackson, RUL (50%) (tot 1/8)
051	Prof.dr. G.K. Miley Prof.dr. P.T. de Zeeuw	Formatie van melkwegstelsels	Dr. M.J. West RUL (tot 29/9)
052	Prof.dr. P.T. de Zeeuw Dr. L. Braes Dr. J. Lub Drs. R. le Poole	Structuur en evolutie van OB associaties	Drs. A. Brown RUL
053	Prof.dr. T. van Albada	Standaard calibratie en fysische principes van de Tully-Fischer relatie	Drs. M.H. Rhee RUG
055	Dr. W. Jaffe	Dynamica van de kernen van elliptische stelsels	Drs. F.C. van den Bosch RUL
056	Prof.dr. G.K. Miley Prof.dr. A.G. de Bruyn	Superclustering in het vroege heelal	Drs. R.B. Rengelink RUL
057	Dr. P.D. Barthel	Elfs versus QSOs: leidt extreme stervorming tot QSO aktiviteit	Drs. J.P.E. Gerritsen RUG
058	Dr. P.D. Barthel	Structuur en samenstelling van gaswolken en sterrenstelsels in het vroege heelal	Dr. A.J. Smette RUG (vanaf 1/7)

Programmesubsidies

No.	Titel	Onderzoekers
010	Jonge heelal	Dr. M. Bremer (RUL) Dr. L. Gurvits (JIVE) Dr. H. Röttgering (RUL)
011	Nauwe dubbelsterren	Dr. E.A. Magnier (UvA) Drs. F. van der Hooft (UvA, oio)
012	WENSS	Drs. M.A.R. Bremer (research assistant tot 16/10)

Publications

Publications by NFRA staff

Braun R., Walterbos R.A.M., Kennicutt, R.C. Tacconi, L.J. Counterrotating gaseous disks in NGC 4826, Astrophys. J. 420, 558.

Walterbos, R.A.M., **Braun, R.** Diffuse ionized gas in the spiral galaxy M31 1994, Astrophys.J. 431, 156-171

"Dynamics of Binary Galaxies II: Close Pairs", **Jayaram N. Chengalur**, E. E. Salpeter & Yervant Terzian, A. J. vol. 107 pp. 1984.

Dietrich M. et al (incl. **de Bruyn A.G.**): Spectroscopic monitoring of active galactic nuclei: IV The Seyfert 1 galaxy NGC4593. Astron. & Astrophys. 284, 33-43.

Salamanca I. et al (incl **de Bruyn A.G.**) Spectroscopic monitoring of active galactic nuclei III. Size of the broad line region in NGC 3227. Astron. & Astrophys. 282, 742

Stirpe G.S. et al. (incl. **de Bruyn A.G.**): Spectroscopic monitoring of active galactic nuclei: V The Seyfert 1 galaxy Markarian 279. Astron. & Astrophys. 285, 857-867.

van den Oord B. and **de Bruyn A.G.**: Unusual flares at 360 and 609 MHz in the RS CVn-system II Peg observed with the WSRT: coherent emisssion from II Pegasi, Astron. & Astrophys. 286, 181-193

Muxlow T.W.B et al (incl. **de Bruyn A.G.**) The structure of young supernova remnants in M82 MNRAS 266, 455-467.

Dressler A. Oemler A. Butcher H.R., Gunn J.E. The morphology of distant cluster galaxies I. HST observations of CL 0939+4713 Astrophys. J. 430,107, 160-D3.

Raimond E. Two observatories and their archives: the Isaac Newton Group of Telescopes, La Palma and the Westerbork Synthesis Radio Telescope In: Databases and On-Line date in astronomy ESO conference & workshop proceedings no.50, pp. 115-124, eds M.A. Albrecht and F. Pasian.

Spoelstra T.A.Th., Reduction of interference in radio astronomy In: Electromagnetic compatibility 1994, proceedings 520-524, eds: Janiszewski, Moron & Sega

Schaefer et al. (incl. **Spoelstra T.A.Th.**) Rapid searches for counterparts of GRB 930131 Astrophys. J. 422, L71, 45-A11.

R.G. Strom, SN 185, its associated remnant and PSR 1509-58 MNRAS, 268, L5 (1994).

R.G. Strom, Guest stars, sample completeness and the local supernova rate, Astron. & Astrophys. 288, L1.

Klein U., Mack K.-H., **Strom R.G.**, Wielebinski R., Aschatz U. A high frequency radio continuum investigation of giant radio galaxies. I. Observations of six objects at 2.8 cm wavelength Astron. & Astrophys. 283, 729.

Ashok K. Singal, Further evidence against the orientation based unified scheme for quasars and FR II radio galaxies In the First Stromlo Symposium : The Physics of Active Galaxies, VOl. 54, 269 (1994).

Woestenburg E.E.M. and **Nieuwenhuis L.**, Cryogenic noise performance of HEMTs and MESFETs between 300 and 700 Mhz Electronics Letter vol. 30, no. 6.

NFRA notes & ITR's

Note 618	*A. Doorduin* Het controle syteem voor het MFFE
Note 619	*A. Bos, P. de Jong* The EVNFRA correlator; the controlboard functional description
Note 620	*A. Bos* Correlator frame header treatment in the EVN and DZB correlators
Note 621	*G.H. Tan* Reliability aspects of a 1 km2 array
Note 622	*A. Doorduin* Een discussiestuk voor het functionele ontwerp van de ADC module voor het DZB
Note 623	*A. Doorduin* Enkele mogelijkheden voor de uitvoering van het bulkdelay
Note 624	*A. Kokkeler* Level regulation in the DZB A/D convertors
Note 625	*C. Slottje* Optimal ambient temperature and humidity conditions to avoid excessive head wear for VLBI recording at Westerbork
Note 626	*M. de Vos* Towards a TMS for the WSRT
ITR 204	*T.A.Th. Spoelstra, H.A.C. Kahlmann* Interference problems in radio-astronomy. Report of a meeting in Brussels.
ITR 206	*E.E.M. Woestenburg, L. Nieuwenhuis* Cryogenic noise performance of HEMTs and MESFETs between 300 and 700 MHz
ITR 207	*A. Bos* The Haystack correlator chip; a functional description
ITR 208	*Ren Xu* A two stage cryogenically coolable S-band amplifier

Publications of NFRA supported research project

Augusteijn T. Time resolved spectroscopy of the dwarf nova VY Aquarii in superoutburst and quiescence Astron. & Astrophys. 292, 481

Augusteijn T. et al Periodicities in the optical brightness variations of the intermediate polar TV Columbae Astron. & Astrophys. 291, 990

Bakker E.J. Spectral line identification of the ultraviolet spectrum of the peculiar post-AGB star HD 101584 Astron. & Astrophys. 281, 640.

Brown A.G.A. et al The Orion OB 1 association. I. Stellar content. Astron. & Astrophys. 289, 101.

Oudmaijer R.D. et al Discovery of near-infrared hydrogen line emission in the peculiar F8 hypergiant IRC+10420 Astron. & Astrophys. 281, L33.

Roland J., Teyssier R. **Roos N.** On the origin of the variability of superluminal radio sources similar to 3C 273 Astron. & Astrophys. 290, 357.

Ryan J. et al (incl. van Dijk R.) Measurements of the gamma-ray burst GRB 930131. Astrophys. J. 422, L67, 45-A6.

Schaefer et al. (incl. **Smette A.**) Rapid searches for counterparts of GRB 930131 Astrophys. J. 422, L71, 45-A11.

Telting J.H. et al Observational evidenc for a prograde one-armed density structure in the equatorial disc of a Be star Astron. & Astrophys. 288, 515.

Telting J.H. and Kaper L. Long term periodic variability in UV absorption lines of the Be star γ Cassiopeiae: on the relation with V/R variations in the Hβ line Astron. & Astrophys. 284, 515.

Van de Steene G.C. and Zijlstra A.A. On an alternative statistical distance scale for planetary nebulae. Catalog with statistical distances to planetary nebulae Astron. & Astrophys. 292, 365.

van Dijk R., Bloemen H., Hermsen W. Comptel detection of the variable radio source GT 0236+610 AIP Conerence Proceedings 304, p. 324.

van Dijk R., Bloemen H., Hermsen W. MeV emission from the black-hole candidate GRO J0422+32 measured with Comptel AIP Conerence Proceedings 304, p. 197.

Rank G. et al (incl. **van Dijk R.**) Observations of the 1991 June 11 solar flare with Comptel AIP Conerence Proceedings 294, p. 100.

McConnell M. et al (incl. **van Dijk R.**) Observations of Cygnus X-1 by Comptel during 1991 Astrophys. J. 424, 933.

Ryan J. et al (incl. **van Dijk R.**) Comptel measurements of the gamma-ray burst GRB 930131 Astrophys. J. 422, L67.

Hanlon L. et al (incl. **van Dijk R.**) Observations of gamma-ray bursts by Comptel Astron. & Astrophys. 285, 161

Zijlstra A.A., **van Hoof P.A.M.** et al. Radio and infrared emission from a [WC]-type planetary nebula in the LMC Astron. & Astrophys. 290, 601.

Dwingeloo colloquia 1994

Lammert Beukema (Hogeschool Drenthe)
"Schuim-lenzen voor de WSRT telescopen"

Dr Huib-Jan van Langevelde (JIVE, Dwingeloo)
"The exciting molecules around T Tauri"

Dr Ir Hans van der Marel (TU Delft, Geodesy)
"Determination of the Vertical Total Electron Content of the ionosphere with 2-frequency GPS"

Prof Frank Briggs (Univ of Pittsburgh, USA)
"Scouring the Skies for Intergalactic Hydrogen"

Dr Jan Koornneef (SRON, Groningen)
"Molecular hydrogen in galactic nuclei"

Dr Ir Harm Tolner (Philips Components BV)
"Management of innovative projects"

Prof Tjeerd van Albada (Kapteyn Lab, Groningen)
"The WHISP Project"

Dr Richard Strom (NFRA Dwingeloo)
"Een schoenlapper in spijkerbroek botst met de Oppergod"

Prof Joe Taylor (Princeton Univ, USA)
"Future Pulsar Research"

J. Taurits, M.Sc (TU Delft)
"Research Program of the Microwave Component Group at the faculty of Electrical Engineering"

Ir S. Wallage (TU Delft)
"Toepassing van hoge-temperatuur super-geleiders in microgolf schakelingen"

Prof Harm Habing (Sterrewacht Leiden)
"OH/IR stars as tracers of Galactic Structure"

Prof Bob Sanders (Kapteyn Lab, Groningen)
"The observational status of Modified Dynamics"

Dr Victor Dubrovich (Special Astrophysical Obs, Russia)
"Spectroscopy of the Universe as a Whole"

Prof George Miley (Sterrewacht Leiden)
"Distant Radio Galaxies"

Dr Murray Lewis (NAIC, Arecibo Observatory)
"The composition of color selected IRAS samples"

Ir Hans Kahlmann (NFRA Westerbork)
"A radiation-free oasis for radio astronomy"

Prof L.O.Hertzberger (Univ van Amsterdam)
"New developments in Computational Science"

Prof Michiel van de Klis (UVA Amsterdam)
"Rapid fluctuations in accreting black holes and neutron stars"

Dr Craig Walker (NRAO, Socorro)
"The 3c84 counter-jet and the VLBA status"

Dr Joan Wrobel (NRAO, Socorro)
"Relativistic jets in UGC galaxy nuclei"

Dr Sebastian von Hoerner (Esslingen, Germany)
"Chaos and Fractals"

Dr Peng Bo (NFRA/Beijing Astronomy Observatory)
"A survey for low-frequency (weeks) variability with the WSRT at 92 cm wavelength"

Dr Lakshmi Saripalli (MPIfR, Bonn)
"Characteristics of Mpc-size radio galaxies"

Prof Tony Readhead (Caltech, USA)
"Compact Symmetric Objects - A population of short-lived radio sources or starburst galaxies"

Dr Michael Rupen (NRAO Socorro)
"Tales of Two Supernovae: Radio emission from supernovae 1993J in M81, and 1994I in M51"

Dr Liese van der Zee (Cornell University)
"HI envelopes around low luminosity galaxies"

Dr Lodewijk Bergmans (TU Twente, Enschede)
"Obstacles in Object-Oriented software development"

Dr Erik Deul (Sterrewacht Leiden)
"Image Data Language (IDL)"

Dr Willem Baan (Arecibo Observatory /NAIC)
"Looking into Active Nuclei"

Dr A. Zensus (NRAO/MPIfR)
"Monitoring of milliarcsec radio structures of Active Galactic Nuclei"

Dr Titus Spoelstra (NFRA Dwingeloo)
"Ionospheric weather: A reconsideration of the role of the Sun"

Dr Jacques Roland (Institut d'Astrophysique, Paris)
"On the Nature of the Plasma ejected by AGN"

Andrei Lobanov (NRAO Socorro / ASC Moscow)
"Long-Term Evolution of the Parsec-Scale Jet in 3C345"

Dr Dap Hartmann (Leiden)
"De Leiden/Dwingeloo Survey"

Prof Butler Burton (Sterrewacht Leiden)
"De ontdekking van Dwingeloo-1"

Dr Fred Lo (Univ. of Illinois)
"Dwarf galaxies: evolution and dark matter"

Dr Peter Dewdney (DRAO Penticton, Canada)
"Stellar Photo-dissociation zones and other recent results from the DRAO"

Dr Giorgio Frossati (Kamerlingh Onnes Lab, Leiden)
"GRAIL: A 100 ton 10 mK spherical gravitional wave antenna"

Jan Willem Smits, Frank Jonkers (HTS Zwolle)
"Sterkte analyse van de WSRT telescopen"

Research & development projects

Project	Project Leader	Project Scientist	<user>@nfra.nl
Multifrequency frontend	Ir. G.H. Tan	Dr. R.G. Strom	tan, strom
LNA	Ir. B. Woestenburg	Dr. R.G. Strom	woestenburg
RadioAstron	Ir. L. Sondaar	Prof.dr. R.T. Schilizzi	rts
EVNFRA correlator	Dr. ir. A. Bos	Prof.dr. R.T. Schilizzi	bos
DZB project	Dr. ir. A. Bos/	open	
	Ir. A. Kokkeler		kokkeler
Pulsar backend	Ir. J. Bregman	Prof.dr. M. vd Klis	jbregman
Newstar	Ir. J.E. Noordam	Prof.dr. A. de Bruyn	jnoordam, ger
AIPS++	Ir. J.E. Noordam		

Secondments

La Palma, operations Isaac Newton Group

1.	G.P.J. Benneker	ASTRON	computer technician	1 dec 91	1 dec. 95
2.	J. Haan	ASTRON	mechanic technician	1 aug 87	1 aug. 95
3.	R. Peletier	RUG	support astronomer	1 juni 93	1 juni 95
4.	R.J. Pit	ASTRON/RUL	electronics engineer	1 aug 86	-
5.	R.G.M. Rutten	ASTRON-subsidy	support astronomer	1 mei 93	1 mei 98
6.	P.H. v.d. Velde	ASTRON	programmer	1 okt. 84	-

Royal Greenwich Observatory

1.	E.J. Zuiderwijk	RUG	liaison astronomer	permanent	

Hawaï, operations James Clerk Maxwell Telescope

1.	F. Baas	RUL/ASTRON	support fysisist	1 aug. 89	1 aug. 95
2.	R.P. Millenaar	ASTRON	elektronics engineer	1 aug. 93	1 aug. 94
3.	R. Tilanus	ASTRON-subsidy	support astronomer	1 april 93	-
4.	D. Urbain	ASTRON	mm wave engineer	1 nov. 93	-

Adresses

NFRA Board

Prof.dr. E.P.J. van den Heuvel	Sterrekundig Instituut, "Anton Pannekoek" Kruislaan 403, 1098 SJ AMSTERDAM 020-5257494, EDVDH@ASTRO.UVA.NL
Dr. R. Hoekstra	TNO/TPD, Postbus 155, 2600 AD DELFT, 015-692161
Dr. F.P. Israel	Sterrewacht Leiden, Postbus 9513, 2300 RA LEIDEN 071-275819, ISRAEL@RULHL1.LEIDENUNIV.NL
Prof.dr. P.C. van der Kruit	Kapteyn Laboratorium, Postbus 800, 9700 AV GRONINGEN 050-634053, VDKRUIT@ASTRO.RUG.NL
Prof.dr. J.M.E Kuijpers	Sterrekundig Instituut, Postbus 80 000, 3508 TA UTRECHT 030-535209, KUIJPERS@FYS.RUU.NL
Prof.dr. J.A. van Paradijs	Sterrekundig Instituut, "Anton Pannekoek" Kruislaan 403, 1098 SJ AMSTERDAM 020-5257494, JVP@ASTRO.UVA.NL
Prof.dr. R. Sancisi	Kapteyn Laboratorium, Postbus 800, 9700 AV GRONINGEN 050-634057, SANCISI@ASTRO.RUG.NL

National Institutes

Amsterdam	Sterrenkundig Instituut "Anton Pannekoek", Universiteit van Amsterdam Kruislaan 403, 1098 SJ Amsterdam, tel. 020-5257491/7492, fax 020-5257484
	Vakgroep Sterrenkunde en Atoomfysica, Vrije Universiteit Amsterdam De Boelelaan 1081, 1081 HV Amsterdam, tel. 020-4447777, fax 020-6461459
	Centrum Hoge-Energie Astrofysica (CHEAF) Kruislaan 403, 1098 SJ Amsterdam, tel. 020-5257491, fax 020-5257484
Den Haag	Nederlandse organisatie voor wetenschappelijk onderzoek (NWO) Laan van Nieuw Oost Indië 131, Postbus 93138, 2509 AC Den Haag tel. 070-3440640, fax 070-3850971
Dwingeloo	Stichting ASTRON Oude Hoogeveensedijk 4, Postbus 2, 7990 AA Dwingeloo tel. 05219-7244, fax 05219-7332

	Joint Institute for VLBI in Europe (JIVE) Oude Hoogeveensedijk 4, Postbus 2, 7990 AA Dwingeloo tel. 05219-7244, fax 05219-7332
Groningen	Kapteyn Laboratorium Zernike Gebouw Postbus 800, 9700 AV Groningen tel. 050-634073, fax 050-636100
	Ruimteonderzoek Groningen, Zernike Gebouw Postbus 800, 9700 AV Groningen tel. 050-634073, fax 050-634033
Roden	Kapteyn Sterrewacht Werkgroep Mensingheweg 20, 9301 KA Roden, tel. 05908-28888, fax 05908-28800
Leiden	Sterrewacht Leiden Huygens Laboratorium, Niels Bohrweg 2, Postbus 9513, 2300 RA Leiden tel. 071-275835, fax 071-275819
Nijmegen	Sterrekundig Instituut Katholieke Universiteit Nijmegen, Toernooiveld, 6525 ED Nijmegen tel. 080-611111, fax 080-515938
Noordwijk	Estec Keplerweg 1, Postbus 299, 2200 AG Noordwijk tel. 01719-86555, fax 01719-17400
Utrecht	Sterrenkundig Instituut Princetonplein 5, Postbus 80000, 3508 TA Utrecht, tel. 030-535200, fax 030-535201
	Ruimteonderzoek Utrecht Sorbonnelaan 2, 3584 CA Utrecht, tel. 030-535600, fax 030-540860
Westerbork	Radiosterrenwacht Westerbork Schattenberg 1, 9433 TA Zwiggelte, tel. 05939-2421, fax 05939-2486

International Institutes

Beijing	Beijing Astronomical Observatory, Chinese Academy of Sciences, Zhongguancun Beijing 100080, China tel. +86 12551968/12551261, fax +86 12561085
Bologna	Istituto di Radioastronomia, CNR, Via P. Gobetti 101, I-40129 Bologna, Italy tel. +39 51 6399385, fax +39 51 6399431
Bonn	Max Planck Institut für Radioastronomie, Auf dem Hügel 69, D 53121 Bonn, Germany tel. +49 228 525251, fax +49 228 525229
Bordeaux	Observatoire de l'Université de Bordeaux, Ave. Pierre Sémirot, BP 89, 33270 Floirac, France tel. +33 56 864330, fax +33 56 404251

Cambridge	Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, Engeland, tel. +44 223 337548, fax +44 223 337523
	Mullard Radio Astronomy Observatory (MRAO), University of Cambridge Department of Physics, Cavendish Laboratory, Madingley Road, Cambridge CB3 0HA, Engeland tel. +44 223 337200, fax 09-44-223-63263.
	Royal Greenwich Observatory (RGO), Madingley Road, Cambridge CB3 0EZ England tel. +44 223 374000, fax +44 223 374700
Charlottesville	NRAO, Edgemont Road, Charlottesville, VA 22903, USA tel. +1 804 2960211, fax +1 804 2960278
Edinburgh	Royal Observatory Edinburgh (ROE), Blackford Hill, Edinburgh EH9 3HJ Scotland tel. +44 31 6688100, fax +44 31 6688264
Effelsberg	Radio Observatorium Effelsberg, D 53902 Bad Munstereifel, Effelsberg, Germany tel.+49 2257 3010, fax +49 228525229
Epping	Australia Telescope National Facility (ATNF), P.O. Box 76, Epping NSW 2121, Australia tel. +61 23724100, fax +61 23724310
	CSIRO, Division of Radiophysics, P.O. Box 76, Epping NSW 2121, Australia tel. +61 23724222, fax +61 23724400
Granada	IRAM, c/o Nucleo Central, Bloque 6/2B, Av. Divina Pastora 7, 18012 Granada, Spain tel. +34 58 279508, fax +34 58 207662
Green Bank	NRAO, P.O. Box 2, Green Bank, WV 24944, USA tel. +1 304 4562011, fax +1 304 4562271
Grenoble	IRAM, Voie 10 - Domaine Universitaire de Grenoble, 38406 St. Martin d'Heres Cedex, France tel. +33 76 824900, fax +33 76 515938
Guadalajara	Centro Astronomico de Yebes, Apartado 148, 19080 Guadalajara, Spain tel. +34 11 290311, fax +34 44290063
Hawaii	Joint Astronomy Centre (JAC), 660 N. A'ohoku Place, University Park, Hilo Hawaii 96720, USA, office: tel. +1 808 9613756, fax +1 808 9616516
	JCMT, (See Joint Astronomy Centre) Telescope: tel. +1 808 9350852, fax +1 808 9355493
	UKIRT, (See Joint Astromomy Centre) Telescope: tel. +1 808 9616091/9354690
Haystack	Haystack Observatory, NEROC, Route 40, Westford, MA 01886, USA tel. +1 617 692 4765, fax: +1 617 981 0590

Helsinki	Helsinki University of Technology, Metsahovi Radio Research Station, Metsahovintie 114 SF-02540 Kylmala, Finland, tel. +358 0 264831, fax +358 0 264531
Jodrell Bank	University of Manchester, Nuffield Radio Astronomy Laboratories, Jodrell Bank Macclesfield, Cheshire SK11 9DL, England, tel +44 477 571321, fax +44 477 571618
Kashima	Kashima Space Research Center, 893-1, Hirai, Kashima-machi, Ibaraki 314, Japan tel. +81 299 821211, fax +81 299 844128
La Laguna	Instituto de Astrofysica de Canarias (IAC), Camino de la Hornera s/n, E-38071 La Laguna Tenerife, Canarias, Spain, tel. +34 22 262211, fax +34 22 605210
La Palma	Observatorio del Roque de los Muchachos, Isaac Newton Group of Telescopes office: RGO, Apartado de Correos 321, 38780 Santa Cruz de La Palma, Prov. de Tenerife Canarias, Spain, tel. +34 22 411005/411048/411049, fax +34 22 414203 INT tel. +34 22 405655, fax: +34 22 405646 WHT tel. +34 22 405560, fax +34 22 405566 Residencia tel. +34 22 405500, fax +34 22 4055501
Meudon	Observatoire de Paris, Section de Meudon, Place Jules Janssen, 92195 Meudon Cedex, France tel. +33 1 45077934, fax +33 1 45077469
Moscow	Astro Space Center (ASC), Profsojuznaja 84/32, Moscow 117810, Russia tel. +7 095 333 2189, fax +7 095 333 2378
München	ESO, Karl Schwarzschildstrasse 2, 85748 Garching (bei München), Germany, tel. +49 89 320060, fax: +49 89 3202362
Nançay	Station de Radioastronomie de Nançay, 18330 Neuvy sur Barangeon, France tel. +33 48 518241, fax +33 48 518318
Onsala	Onsala Space Observatory, S-43992 Onsala, Sweden tel. +46 317 725500, fax +46 317725590
Ottawa	Herzberg Institute of Astrophysics (HIA), National Research Council of Canada, Ottawa Ontario K1A 0R6, Canada, tel. +1 613 9900910, fax +1 613 9526602
Paris	European Space Agency, 8-10 rue Mario-Nikis 75738 Paris Cedex 15, France tel. +33 1 5369 7654, fax +33 1 5369 7560
Pasadena	California Institute of Technology (Caltech), Astronomy Dept. 105-24, 1201 E. Calif. Blvd. Pasadena, CA 91125, USA, tel. +1 818 356 4009, fax +1 818 795 1547
Shanghai	Shanghai Observatory, Chinese Academy of Science, 80 Nandan Road, Shanghai, China tel. +86 21 4386191, fax +86 21 4384618
Socorro	Array Operations Center, P.O. Box 0, Socorro, NM 87801, USA tel. +1 505 835 7000, fax +1 505 835 7027

	VLA-Site, P.O. Box 0, Socorro, NM 87801, USA tel. +1 505 772 4011, fax +1 505 772 4243
Swindon	Particle Physics and Astronomy Research Council (PPARC), Polaris House North Star Avenue, Swindon Wiltshire SN2 IET, United Kingdom tel. +44 793 442089, fax +44 793 442106
Torun	Torun Radio Astronomy Observatory, Uniwersytet Mikolaja Kopernika, ul. Chopina 12/18 PL 87-100 Torun, tel. Inst. +48 5626018/10, Obs. +48 5611655, fax +48 56 11651
Wettzell	Satellitenbeobachtenstation Wettzel, D 93444 Koetzting, Germany tel. +49 9941 6031, fax +49 9941 603222

Abbreviations

AAT	Anglo Australian Telescope
ADAM	Astronomical Data Analysis & Management system
AGB	Asymptotic Giant Branch
AGN	Active Galactic Nuclei
AIPS	Astronomical Image Processing System
AOS	Acousto Optical Spectrograph
ASTRON	Stichting Astronomisch Onderzoek in Nederland
ATNF	Australia Telescope National Facility
AU	Astronomical Unit
BHB	Blue Horizontal Branch
BLR	Broad Line Region
Caltech	California Institute of Technology
CAT	Coudé Auxiliary Telescope
CCD	Charge Coupled Device
CCI	Comité Cientifíco Internacional (La Palma/Tenerife)
CCIR	Comité Consultatif International Radio Communication
CESRA	Committee of European Solar Radio Astronomers
CIT	California Institute of Technology
CLRO	Clark Lake Radio Observatory
CRAF	Commission on Radio Astronomical Frequencies
CSIRO	Commonwealth Scientific & Industrial Research Organization
CSS	Compact Steep Spectrum source
DAS	Dwingeloo Autocorrelation Spectrometer
DCB	Digital Continuum Backend
DLB	Digital Line Backend
DMA	Direct Memory Acces
DRAO	Dominion Radio Astronomy Observatory
DWARF	Dwingeloo/Westerbork Astronomical Reduction Facility
DWOFS	Dwingeloo/Westerbork OFfline System
DXB	Extended Digital Line Backend
EFOSC	ESO Faint Object Spectrograph and Camera
ESA	European Space Agency
ESF	European Science Foundation
ESO	European Southern Observatory
EVN	European VLBI Network
FAST	Fundamental Astronomy by Space Techniques consortium
FET	Field Effect Transistor
FFT	Fast Fourier Transform
FITS	Flexible Image Transport System
FK4	Vierde Fundamentele Katalogus van sterposities
FWHM	Full Width Half Maximum
GB-E	Gebiedsbestuur Exacte wetenschappen NWO
GHRILL	Ground based High Resolution Imaging Laboratory
GIPSY	Groningen Image Processing System
GPS	Gigahertz Peaked Spectrum
HPBW	Half Power Beam Width

HVC	High Velocity Cloud
IAC	Instituto de Astrofysica de Canarias
IACG	Inter Agency Consultative Group
IAU	International Astronomical Union
IC	Integrated Circuit
IFA	Institute For Astronomy, Hawaii
IKI	Space Research Institute, Moskou
ING	Isaac Newton Group of telescopes
INT	Isaac Newton Telescope
IPCS	Image Photon Counting System
IRAF	Image Reduction and Analysis Facility
IRAS	Infra Red Astronomical Satallite
IRS	Intermediate Resolution Spectrograph
ISM	Inter Stellar Matter
ITR	Internal Technical Report
IUCAF	Inter Union Commission for the Allocation of Frequencies
IUE	International Ultraviolet Explorer
IVS	International VLBI Satellite
JCMT	James Clerk Maxwell Telescope
JIVE	Joint Institute for VLBI in Europe
JKT	Jacobus Kapteyn Telescope
JPL	Jet Propulsion Laboratory
Jy	Jansky
KPNO	Kitt Peak National Observatory
LAG	Lovers of Active Galaxies
LBDS	Leiden Berkeley Deep Survey
LINER	Low Ionazation Nuclear Emission Regions
LMC	Large Magellanic Cloud
LO	Locale Oscillator
LST	Local Sidereal Time
LWG	Landelijke WerkGemeenschap
MIDAS	Munich Image Data Analysis System
MIT	Massachusetts Institute of Technology
MOST	Molonglo Synthesis Telescope
MPIfR	Max Planck Institut für Radioastronomie
MWLCO	Mount Wilson & Las Campanas Observatories
NAC	Nederlandse Astronomen Club
NASA	National Aeronautics and Space Administration
NCA	Nederlands Comité Astronomie
NFRA	Netherlands Foundation for Research in Astronomy
NGC	New General Catalog
NLR	Narrow Line Region
NOAO	National Optical Astronomy Observatories (USA)
NRAO	National Radio Astronomy Observatory (USA)
NRC	National Research Council (Canada)
NSF	National Science Foundation (USA)
NWO	Nederlandse organisatie voor Wetenschappelijk Onderzoek
OVRO	Owens Valley Radio Observatory
PATT	Panell for Allocation of Telescope Time (UK/NL)
PC	Programma Commissie

pc	parsec
PSS	Palomar Observatory Sky Survey
QSO	Quasi Stellar Object
Quasar	Quasi Stellar Radio source
RAL	Rutherford Appleton Laboratories
RAS	Royal Astronomical Society (UK)
RF	Radio Frequency
RGO	Royal Greenwich Observatory (UK)
ROG	Ruimte Onderzoek Groningen (SRON)
ROL	Ruimte Onderzoek Leiden (SRON)
ROU	Ruimte Onderzoek Utrecht (SRON)
RSN	Radio Super Nova
RUG	Rijks Universiteit Groningen
RUL	Rijks Universiteit Leiden
SATSI	Segmented Aperture Tilted Shearing Interferometer
SCASIS	Seeing Cell Aperture Synthesis Imaging Spectrometer
SERS	Science and Engineering Research Council (UK)
SEST	Swedish ESO Submillimetre Telescope
SMC	Small Magellanic Cloud
SNR	Super Nova Remnant
SRON	Stichting Ruimte Onderzoek Nederland
SRT	Synthese Radio Telescoop
ST-ECF	Space Telescope European Coordinating Facility
STScI	Space Telescope Science Institute
TAP	Technical Advisory Panel (JCMT)
TNO	Toegepast Natuurwetenschappelijk Onderzoek
TWG	Technical Working Group (VLBI)
UCB	University of California at Berkeley
UGC	Uppsala General Catalog
UKIRT	United Kingdom Infrared Telescope
URSI	Union Radio Scientifique International
UU	Universiteit Utrecht
UV	Ultra Violet
UvA	Universiteit van Amsterdam
VLBI	Very Long Baseline Interferometry
VUA	Vrije Universiteit Amsterdam
WARC	World Administrative Radio Conference
WENSS	WEsterbork Northern Sky Survey
WGAR	Working Group on Astronomical Refraction
WHT	William Herschell Telescope
WSRT	Westerbork Synthesis Radio Telescope
YERAC	Young European Radio Astronomers Conference