Cover photo: a small window onto the 150 MHz sky, as viewed by the LOFAR Multifrequency Snapshot Sky Survey (MSSS). This image shows the central 150 square degrees of a 32-field mosaic produced using MSSS data, at 2 arcminute resolution and with an image noise of 10 mJy/beam. The full MSSS survey covers an area over 100 times larger, and the survey observations at these frequencies are projected to be completed by mid-2013. Credits: George Heald (ASTRON) and the MSSS Team.

Photo on this page: Low Band Antennas of the LOFAR telescope with deerm grazing in between them.

Facts and figures of 2012

- 2 Awards or grants
- 158 employees
- 168 refereed articles
- 19 press releases

Funding: € 18.816.174
Expenditure: € 19.630.066
Balance: € -813.892
2012 has seen a strong focus within ASTRON on getting the LOFAR telescope ready for the winter observing campaign. A priority has been to ensure that we are ready to take science quality data over a broad range of different Key Science Projects, with a particular emphasis on the EoR (Epoch of Reionisation) experiment. Over the summer and autumn period, various aspects of the LOFAR hardware were upgraded; in particular a problem distributing time coherently across the antennas has been solved by the addition of new hardware at all of the stations. This fix has improved the performance of individual stations by a substantial factor in some cases. In addition, a new 8-bit observing mode was tested and successfully introduced to the system - the advantage here is that we can trade bits for instantaneous bandwidth, the latter being important for many science applications and crucial for the EoR. In a single observing run, it is now possible to observe across almost the full HBA observing band, bringing the early HI Universe into view, from redshift 6 to 12. The first deep images coming from early observations of the North Celestial Pole (NCP) suggest that all these upgrades are paying dividends with noise levels continuing to scale with observing time in the expected way.

This year has also seen a huge amount of progress being made by the Square Kilometre Array (SKA) project. The SKA will be the next big radio astronomy project involving partners from all over the world. The Dutch community is keen to play a major role in the project, especially in the area of Low and Mid‑frequency Aperture Arrays, not to mention the expertise we have in handling Big Data and calibration issues. In 2012, several major decisions were made in the SKA project. A dual site decision was adopted with the main dish and Mid ‑Frequency Aperture Arrays located in South Africa and a Low Frequency Array in Western Australia. ASTRON hopes to bring the expertise we have built up in LOFAR to the SKA table – especially in the area of Aperture Arrays, including systems that can work at GHz frequencies. Other major SKA milestones were the appointment of a new Director General (Philip Diamond) and the establishment of a new SKA Office at Jodrell Bank. For most of 2012, Michiel van Haarlem served as interim DG.

While LOFAR was surely ASTRON’s main priority in 2012, the Focal Plane Array (FPA) upgrade of the Westerbork Synthesis Radio Telescope (APERTIF) also made good progress. One disappointment was the need to insert an uncooled filter in the APERTIF front-end, this has reduced the overall performance of the system by 20% and also limited the full observing band. This was necessary due to the need to suppress very strong radio frequency interference induced by nearby radio and TV transmitters. Nevertheless, the aim is to achieve a system temperature of ~75K on the new FPAs, and this, coupled with the greater field of view (and indeed dish efficiency), makes APERTIF a very competitive survey instrument.
Another high point this year was the continued collaboration between ASTRON and IBM. This has now developed into the establishment of a Center for Exascale Technology in Dwingeloo, otherwise known as DOME. Via DOME, ASTRON and IBM jointly carry out fundamental research into the technologies needed to develop the next generation radio telescopes, such as the SKA. The research addresses three main areas: green computing, Nano-photonics and Data & Streaming. Towards the end of the year, the South African SKA team also joined the project. DOME is supported by grants from the Dutch EL&I Ministry and the Province of Drenthe, and is part of ASTRON’s contribution to the ‘top-sectoren’.

Finally, I want to end on another high note – we were delighted to hear in 2012 that Prof. Raffaella Morganti (Head of the Astronomy Group) was awarded an ERC Advanced Grant worth 2.5 MEuro. This is yet another individual award secured by our staff over the last few years and with more ERC applications already in the pipeline, our policy of growing the Astronomy Group via external funding is beginning to really bear fruit. In 2012, I was extremely proud to note that the institute published almost 200 refereed papers – that’s about five times more than in 2007 and makes us one of the largest and most successful astronomy and technical research centres in the Netherlands. We’ve come a long way but perhaps the best is yet to come!

Prof. Mike Garrett
General Director, ASTRON
ASTRON is the Netherlands Institute for Radio Astronomy. Its main mission is to make discoveries in radio astronomy happen, via the development of new and innovative technologies, the operation of world-class radio astronomy facilities (the Westerbork Synthesis Radio Telescope and the International LOFAR Telescope), and the pursuit of fundamental astronomical research. Engineers and astronomers at ASTRON have an outstanding international reputation for novel technology development and fundamental research in galactic and extra-galactic astronomy. ASTRON hosts the Joint Institute for VLBI in Europe (JIVE) and the Optical/Infrared instrumentation group of NOVA (the Netherlands Research School for Astronomy).

ASTRON is an institute of the Netherlands Organisation for Scientific Research (NWO).

Organisation & Governance
ASTRON is a foundation under Dutch law with an oversight Board. Executive authority is vested in the directorate consisting of Prof.dr. Michael Garrett, Scientific Director and Director General, and Dr. Marco de Vos, Managing Director and Deputy Director General. They report to both the ASTRON Board and the Director of NWO. NWO is also the formal employer of ASTRON staff.

The ASTRON Director General is advised by an International Science Advisory Committee (SAC) on all aspects of the institute’s programme. A telescope Programme Committee sets priorities for allocating observing time on ASTRON’s telescopes.

The ASTRON Management Team consists of the directorate and department heads.

The Westerbork Synthesis Radio Telescope
ASTRON operates the Westerbork Synthesis Radio Telescope (WSRT). The WSRT has been built in 1969-1970. The WSRT is one of the most sensitive radio telescopes in the world and offers astronomers the chance to study a wide variety of astrophysics problems. The telescope consists of fourteen parabolic (dish) antennas of 25-meter in diameter.

In the APERTIF project, advanced receiver technology is developed for the WSRT, creating a two-dimensional radio ‘camera’ in the focal point of twelve of the dishes. This will increase the field of view of all the antennas by a factor of almost forty. Astronomers can thus quickly survey large parts of the sky, leading to a dramatic increase of the discovery space. With APERTIF, the WSRT will be once more brought to the forefront of radio astronomical facilities.

The International LOFAR Telescope
ASTRON designed and built the International LOFAR Telescope (ILT). LOFAR, the Low Frequency Array, operates at the lowest frequencies that can be observed from Earth. With LOFAR astronomers can look back billions of years to a time before the first stars and galaxies were formed, the so-called ‘Dark Ages’. Much of the infrastructure that was needed to build this new radio telescope can also be used by other applications. The common theme throughout is the collection, transport and real-time processing of enormous quantities of data from sensors distributed over a large area.

LOFAR will address some of the most important questions in modern astronomy and astrophysics. The key science projects are:

- The Epoch of Reionization
- Deep extragalactic surveys
- Transient sources and pulsars
- Ultra high energy cosmic rays
- Solar science and space weather
- Cosmic magnetism

Making Discoveries in Radio Astronomy Happen!
Astronomy Group

The Astronomy Group is engaged in many frontline research areas. Hydrogen is studied in both nearby and the most distant parts of the Universe. The Transient Universe is characterized at the shortest possible time-scales. The magnetic Universe is studied, from galaxies to clusters. The group is involved in the commissioning of LOFAR and in all LOFAR key science projects, as well as in the development of other new instruments like the pulsar machine PuMa-II and the APERTIF system mentioned above.

Research & Development laboratories

The ASTRON Research & Development (R&D) laboratories focus on innovative instruments for existing telescopes, such as the Westerbork telescope and LOFAR, as well as on developing technologies for future observing facilities, such as the Square Kilometre Array. The technical laboratory has several unique facilities at its disposal, such as an anechoic chamber, a clean room facility and an instrument test location. These serve both research and development of astronomical instruments and other product development.

Target areas in R&D for the Square Kilometre Array are Smart Antennas (Aperture arrays and Phased Array Feeds) and Science Data Processing (Calibration and Data Intensive Computing).

The R&D department is organized along the main disciplines: antennas, low noise systems, digital and embedded signal processing, computing, mechanics and system design and integration.

Technology Transfer

ASTRON implements its mission in such a way that the benefit for industry and society is maximised. Partnerships in large development projects are a key aspect of ASTRON’s Technology Transfer strategy. ASTRON is a top international research institute and as such offers its partners access to knowledge, expertise and networks. From the perspective of the Top sectors in the Netherlands

The Dutch cabinet invests in research and innovation within a number of top sectors. NWO links the ambitions of the top sectors to the financing of scientific research within the top sectors. In 2012-2013, NWO invests 225 million euro from its own funds in fundamental research within the top sectors. A large part of this contribution concerns theme programmes, focused on the top sectors. Many of these programmes are aimed at public-private partnerships and demand a financial contribution of the participating private parties.

Besides this, the NWO institutes contribute considerably with their research lines and national research facilities, and the associated first-rate technology development. They actively cooperate with different companies in and outside their region. ASTRON contributes primarily to the top sector High Tech Systems and Materials (HTSM).
ASTRON has three connected legal entities: AstroTec Holding B.V. (ATH), the LOFAR Foundation/Limited Partnership and the International LOFAR Telescope Foundation (ILT).

**AstroTec Holding B.V.**
ATH is a wholly owned subsidiary of ASTRON to facilitate commercial activities that require a joint venture or private partner. ATH is governed by a small Board of Commissioners who report to the shareholder, ASTRON. In 2012, ATH participated in three companies, all start-ups that originated from ASTRON or LOFAR developments. Filtron, developing RF-ID technology, continued to be dormant in 2012. Two of the shareholders (ATH and S&T) are considering a restart focusing on embedded processing applications, rather than on the radio component. DySI, developing software for dynamic system intelligence, continued its steady growth, broadening the technical basis to data analysis in the health care sector and introducing new hardware/service combinations. Dutch Sigma is working towards market introduction of the optical precision scanner in 2013.

In 2012, two RF Courses were offered by ATH, which were again evaluated very positively by the participants. ATH is now also responsible for the handling of export and installation of international LOFAR stations. Especially as new manufacturing tenders are needed for additional stations, this is better handled through a private company than through ASTRON. The Hamburg station was the first LOFAR station handled in this way.

ATH was further involved in several technology transfer initiatives that are likely to result in new business initiatives and gave support to an ASTRON startup (MCC), as yet without taking a share in the company.

**LOFAR Foundation/Limited Partnership**
To develop, operate and exploit the LOFAR sensor network, a Limited Partnership (Dutch: Commanditaire Vennootschap) was established by the partners. The LOFAR Foundation is the sole general partner (‘beherend vennoot’). With LOFAR being an operational entity, the role of the LOFAR Foundation is primarily to handle contracts. The LOFAR infrastructure is rented out commercially to various users, including the ILT. In 2012, the contract with the ILT was completed. Contracts with TU/Delft (Geophysics) and KNMI (Infrasound) were negotiated. The contract with TU/Delft is expected to be processed early 2013. The LOFAR Foundation will search for new potential users of the infrastructure, in particular to help continue that Infrasound application. Limited capacity is available however, and new applications will have to be developed through the technology transfer offices of the partners.

**International LOFAR Telescope Foundation**
The ILT has been established for the operation of LOFAR as a radio telescope. The ILT was founded in November 2010 as a Foundation under Dutch law. International partners joined in June 2011: the German GLOW consortium, the French FLOW consortium, LOFAR Sweden and LOFAR-UK. All these consortia own one or more LOFAR stations, which are used in connection with the forty LOFAR stations in the Netherlands and the central computing facilities. The partners share the cost of the central functions in an agreed ratio and support their national stations. ASTRON provides the staff for the central support. The General Director of ASTRON is member of the ILT Board. The ILT Director is seconded from ASTRON, the current director is dr. René Vermeulen.
Performance indicators

Observing time on the Westerbork telescope

The Westerbork Synthesis Radio Telescope (WSRT) again achieved a very satisfactory 70% yield net ‘science time’: 6114 hours (69.6% of the year) were observed, excluding all overheads. Only 51 hours needed to be repeated because of failures. An additional 1134 telescope hours were spent on general calibration, tuning, regular maintenance, and limited software development work; the remaining 1560 hours were unallocated due to inevitable gaps related to scheduling mostly 12-hour full synthesis observations on this east-west array. Of the science time, 890 hours were for participation in (e)EVN and Global VLBI projects (648 disk-recorded, 242 e-VLBI).

The International LOFAR Telescope

Operations with the International LOFAR Telescope (ILT) in 2012 were mostly devoted to supporting coordinated system development and integration tests. Still, 1786 hours were spent in production mode on Beam Formed, TBB, and interferometric observing runs. The latter were divided among commissioning projects (376 hours) and the ongoing Multifrequency Snapshot Sky Survey (MSSS, 566 hours). Cycle 0 production observing, which started on 1 December 2012, took up 205 hours.

Time allocation on the telescopes

Publications

The pie chart below shows the number of publications, such as refereed articles and conference proceedings, published in 2012 by the astronomers and engineers of ASTRON.

- Referred articles: 168; 37%
- Other research output: 137; 30%
- Conference proceedings: 109; 24%
- Non-refereed articles: 17; 4%
- Professional publications: 11; 3%
- Chapters in books: 4; 1%
- Publications for a wide audience: 2; 0.5%
- Theses: 2; 0.5%

The different research output of ASTRON in 2012. Behind each category, the number of publications in that category is listed as well as the percentage. Legend:

- Referred articles: articles published in scientific journals that use an anonymous peer review system, which is separate from the editors.
- Non-refereed articles: publications in journals that are not refereed, but considered important by the field.
- Conference proceedings: publications in which the doctoral dissertation was obtained.
- Professional publications: publications intended for professionals in the public and private sectors including annotations.
- Chapters in books: chapters in textbooks aimed at an audience of scientists and researchers.
- Publications for a wide audience: popular publications on results of scientific research.
- Theses: full papers of a doctorate.
This recovered to the more typical number of 30 proposals in semester 12B. Correspondingly, the oversubscription rate, which in 2011 had been sharply above the long-term average factor of 2, fell below average for semester 12A, but then recovered in Semester 12B. The temporary dip in demand for Semester 12A can be interpreted as an after-effect of the surge in 2011 of large legacy projects that were kicked off before the planned replacement of the current generation of multi-frequency frontend receivers by AperTif. Many groups were apparently so heavily engaged in processing and interpreting their legacy datasets, that they postponed the submission of new proposals. As shown by the oversubscription and allocation statistics diagrams, however, the demand still outstripped the available time throughout the year, and several proposals had to be rejected or trimmed down. The receiver usage statistics (see figure bottom right) show the classical preponderance of 21+18 cm observing, playing to the dominant strength of the WSRT for line and continuum imaging in this band, plus a somewhat higher than usual fraction of 6 cm observing, mostly related to transient source follow-up, which is increasingly occurring on the WSRT.

Time allocation on the LOFAR telescope LOFAR early access proposals, submitted in 2010, continued to serve as the basis for the early-science observing programme in 2012. The Technical Advisory Group (TAG) and the LOFAR Commissioning Coordination Group (LCCG), which also met regularly with the PIs of the LOFAR Key Science Projects, carefully monitored the commissioning needs. A total of 33 commissioning projects, which combine commissioning goals with early science potential, were submitted for approval to the Technical Advisory Group (TAG) in 2012. Of these, 30 were observed and by the end of the year, 21 commissioning reports had been delivered by the teams either in written form to the TAG or presented at LOFAR Status Meetings.

The first operational cycle of LOFAR, Cycle 0, was started on 1 December 2012, after thorough characterization of the functional modes and system performance. To kick-start the operational period of the International LOFAR Telescope (ILT), the ILT Board mandated an iterated cycle of proposal calls to the worldwide astronomical community. For Cycle 0, 10% of the time was distributed purely on scientific merit, with the remaining allocations in part reflecting national interests in each of the LOFAR national consortia that participate in the ILT.

First, Reserved Access Proposals were solicited for a deadline of 5 March, to describe long-term, large-scale, astrophysically and observationally cohesive programmes. Seven proposals were received; all were from groups within the LOFAR Key Science Project teams. Review involved the observatory-led Technical Review Panel, that met face-to-face, and the independent ILT Program Committee, that met via telecon. The National LOFAR Consortia (GLOW, FLOW, NLLAC, LOFAR-Sweden, and LOFAR-UK) then decided on ‘umbrella’ observing and processing time reservation for these projects, using part of their reserved access quota for Cycle 0. Regular Proposals for specific focused observing projects to be carried out in Cycle 0 were then solicited in a follow-up proposal call, with deadline 17 September. In total, 43 proposals were received. The Technical Review Panel produced reports on each Regular proposal. The 229 individual authors (some participating in more than one proposal) had affiliations in 16 countries. In the figures above we show the country of affiliation of the first authors of each proposal and of all individual authors.

Between them, the seven individual Reserved Access project leaders found a total of 33 of the 43 Regular Proposals to be eligible to receive a part of an ‘umbrella’ allocation for Cycle 0 (some were found eligible by more than one Reserved Access PI). The ‘umbrella’ shares were then distributed in detail by the national LOFAR consortia. With so-called ‘may-sponsor’ flags, each national consortium also decided which of the full set of 43 Regular Proposals were eligible for further detailed allocations from the remainder of its national quota for Cycle 0, made by the ILT PC in its face-to-face meeting on 28-29 November. Taking into account scientific merit and overall schedule productivity, the LOFAR PC also distributed the 10% Open Skies time available for Cycle 0. In view of the predicted ramp-up in observing efficiency, and also to accommodate night-time observing for a larger fraction of the proposed targets, the ILT Director decided during the PC meeting that Cycle 0 would run for nine months (1 December 2012 through 31 August 2013), whereas a half-yearly cycle had originally been anticipated. Even using this extended period, the total oversubscription in observing and CEP2 processing time still came to 133% and 169%, respectively. Of the 43 proposals, 38 were awarded some fraction of their requested time.

Public Relations activities The year 2012 was, among other things, dominated by the launch of the ASTRON & IBM Center for Exascale Technology.
ASTRON issued nineteen press releases in 2012 and appeared roughly 110 times in print (newspapers and magazines) and online articles, and thirteen times on TV and radio. In the charts, we made a comparison with the number of press releases and media appearances of 2012 with the years 2008-2011.

ASTRON/ JIVE Daily Image
In 2012, the ASTRON/JIVE Daily Image counted 37,397 visits of which 7,957 are unique. The total number of page views is 265,221. The visitors came from 87 countries. Most visits are from the Netherlands, the UK, France, Germany, and the US.

The map shows the division of people all over the world visiting the daily image in 2012. Compared to 2011, overall visits have decreased by about 20%, unique visits by 30%. The reason for this decline is not clear.

In the plot you can see a comparison between the weekly visits of 2011 and those of 2012. 2011 showed two weeks with very high 'scores' (around week 20 and week 40, after the outcome of the institute evaluation was made public), but they do not explain the difference. Somewhere halfway 2011, the number of visits to the daily image decreased and stayed more or less constant since then.

Comparison of the weekly visits to the ASTRON/ JIVE daily image in 2011 and 2012.
Science

The highlights:

Epoch of Reionization and LOFAR
The LOFAR EoR key science project will use the LOFAR telescope to detect the redshifted 21 cm line of neutral hydrogen coming from the Epoch of Reionization (EoR). The EoR is a pivotal period in the history of the Universe during which all-pervasive hydrogen gas was transformed from a neutral to an ionized state. It holds the key to structure formation and evolution, and also represents a missing piece of the puzzle in our current knowledge of the Universe. One of the major astrophysical challenges of the EoR experiments is the extraction of the EoR signal from the prominent Galactic and extragalactic foregrounds. Currently, there is no prevailing consensus on the most effective foreground removal method. In 2012 however, the LOFAR EoR team (including ASTRON scientists Jelic, Labropoulos, Brentjens & de Bruyn) showed that the independent component analysis algorithm successfully removes the most important foregrounds (paper: Chapman et al. 2012, MNRAS 423, 2518).

LOFAR observations illuminate pulsar profile variations
The second LOFAR pulsar paper, ‘Wide-band simultaneous observations of pulsars: disentangling dispersion measure and profile variations’ appeared in A&A in 2012. A team including astronomers Hessels, Kondratiev and van Leeuwen reported the results of simultaneous observations of four pulsars using LOFAR, the Lovell and the Effelsberg telescopes at observing frequencies between 48 MHz and 8 GHz. In general, pulse profiles from radio pulsars are seen to get broader at lower observing frequencies. This can be explained by low frequency radio emission coming from higher up in the pulsar magnetosphere. In the standard model, radio emission is produced along dipolar magnetic field lines emanating from the magnetic poles, leading to a broadening of the average pulse profile as the field lines move further apart higher in the magnetosphere. This model also predicts that pulses from lower in the magnetosphere (at high frequencies) should take a longer time to reach us than the pulses from higher in the magnetosphere (at low frequencies), as they have further to travel. By carefully timing when the pulses at different frequencies arrived at Earth it was possible to show that, for all four of the pulsars we observed, their radio emission is confined to a remarkably narrow range of heights above the neutron star surface. In the case of PSR B1133+16 (pulse profiles shown in the image below), this range is less than 110 km.

Neutral hydrogen and Early-type galaxies
The Atlas3D project consists of a multi-wavelength study of a volume-limited sample of 260 nearby early-type galaxies, supported by semi-analytic models and N-body simulations. The team included Serra, Oosterloo and Morganti from ASTRON. In 2012, this team produced four new papers. The ASTRON researchers published the WSRT HI survey of galaxies in the sample. The main results of this paper are the high HI detection rate of early-type galaxies outside clusters (~40 percent); the high fraction of galaxies with very large HI discs and rings (half of the HI detections) and the correlation between a central HI detection and signatures of ongoing star formation. These results highlight that the family of early-type galaxies, often thought of as very regular (to the point of having sometimes been called boring) and homogeneous, is in fact composed of very diverse and heterogeneous systems which are still evolving under the major influence of the environment around them (paper: Serra et al. 2012, MNRAS 422, 1835).

Evidence for a clumpy, rotating gas disk in a submillimeter galaxy at z=4
As part of an international team, ASTRON scientist de Blok investigated the dynamics of the CO(2-1) emission in the z=4.05 submillimeter galaxy GN20. These high resolution data allow us to image the molecular gas at 1.3 kpc resolution just 1.6 Gyr after the Big Bang. The data reveal a clumpy, extended gas reservoir 14 ± 4 kpc in diameter, unprecedented detail. A dynamical analysis shows that the data are consistent with a rotating disk of total dynamical mass 5.4 ± 2.4 1011 solar masses.

The pulse broadening which we observe cannot be explained by the curvature of a dipolar field in this narrow range of emission heights, suggesting that something may be wrong with our current model of pulsars. Further work needs to be done to reconcile these observations with theory. LOFAR will be vital for such studies since it probes the highest altitudes of the radio emission region (paper: Hassall et al., 2012, A&A 543, 66).

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Another highlight of 2012 is the publication of a Nature paper demonstrating that galaxies stellar initial mass function (IMF) is not universal but depends strongly on their star formation history. This work employs a unique combination of dynamical modelling based on optical integral-field spectroscopy and stellar populations analysis. It demonstrates that the IMF depends on the way galaxies formed their stars (e.g. in an intense and short burst as opposed to an extended period of moderate star formation). Different star-formation histories correspond to different physical conditions in which stars form and our results clearly states that these conditions affect the relative number of stars of different mass (paper: Cappellari et al. 2012, Nature 484, 485).

Gravitational lensing: testing galaxy formation models on the smallest scales
The SHARP collaboration, which includes ASTRON astronomer McKean, studies the mass properties of gravitational lens galaxies. The main aim is to test galaxy formation models by measuring the mass function of low mass substructure in dark matter halos. The first target of the survey is B1938+666, which shows an almost complete infrared Einstein ring of a radio-loud AGN at redshift 2.059 that is gravitationally lensed by a massive elliptical galaxy at redshift 0.881. Through Keck, a small perturbation in the surface brightness distribution of the ring emission was found. This perturbation can be explained by the presence of a 1.9 x 108 Møl substucture in the lensing halo. Note that the mass of the substructure is similar to that of the Sagittarius dwarf companion of our own Milky Way. Combining this result with the detection of a distant dwarf galaxy in another lens galaxy, the SHARP team were able to place the first constraints on the slope of the substructure mass function beyond our Local Group, finding a slope of ~1.1 +/- 0.6. This is just consistent with the expectations from galaxy formation models with cold dark matter (paper: Veggetti et al. 2012, Nature 481, 341).

The pulse broadening which we observe cannot be explained by the curvature of a dipolar field in this narrow range of emission heights, suggesting that something may be wrong with our current model of pulsars. Further work needs to be done to reconcile these observations with theory. LOFAR will be vital for such studies since it probes the highest altitudes of the radio emission region (paper: Hassall et al., 2012, A&A 543, 66).
We identify five distinct kpc–sized gas clumps in the disk of GN20 with masses a few percent of the total gas mass. Their volume densities are in the order of local giant molecular clouds (\sim 100 cm\(^{-3}\)), consistent with expectations for kpc–sized clumps in a high–pressure environment.


**Search for cold gas; the nature and evolution of 21-cm absorbers**

While it is well established that absorbing gas is seen in the spectra of distant quasars, the exact nature and the underlying physical processes driving this gas is still a matter of debate. A systematic survey of 21-cm absorption in a sample of absorbers towards radio loud quasars allows us to measure the fraction of cold gas associated with these absorbers and investigate the physical conditions in the interstellar medium of distant galaxies. A paper led by Gupta (ASTRON) reported four new detections of 21‑cm absorption from a systematic search of 21‑cm absorption in a sample of MgII absorbers at 0.5 < z < 1.5. The observed detections can be understood if the absorbing gas is ‘patchy’ with a typical correlation length of ~30‑100 pc.

**Exploring the radio bimodality of QSOs**

Quasi–Stellar Objects (QSOs) are often classified into two broad categories; radio‑loud and radio‑quiet, but the underlying distribution of radio luminosities has long been debated in the literature. There are two opposing views; the first is that the distribution is bimodal with approximately 5‑10% of QSOs being radio‑loud, and the second is that there is a broad, continuous distribution with no clear dividing line between radio‑loud and radio‑quiet QSOs.

Resolving this issue can provide insight into the physics associated with forming radio jets. A bimodal distribution suggests that there are two intrinsically different classes of QSOs, only one of which is able to become a strong radio source, while a continuous distribution suggests that all QSOs have low-luminosity radio sources which become stronger during episodes of unusually high activity.

ASTRON astronomer Elizabeth Mahony and collaborators have obtained 20 GHz observations using the Australia Telescope Compact Array (ATCA) for a large sample of QSOs to investigate whether the luminosity distribution is bimodal. High frequency observations ensure that we pick up the central core component of the QSO and hence see the most recent activity. At lower frequencies the observed emission is often dominated by large-scale radio lobes, which could be relics of past activity integrated over large timescales, thereby confusing our results. The resulting distributions shown here confirm that neither the radio luminosity distribution nor the distribution in radio-loudness (the ratio of the radio to optical luminosities termed the ‘R’ parameter) are bimodal (paper: Mahony et al., 2012, ApJ 754, 12).
Operations with the Westerbork Synthesis Radio Telescope

With an operations model aimed at the minimal staff effort compatible with reasonable output, the Westerbork Synthesis Radio Telescope (WSRT) nevertheless kept its net science efficiency at nearly 70%. Maintenance over the year took about four FTE, divided over about a dozen Radio Observatory staff (mechanical, electronics, cryogenic, software, and network engineers, with specialist support from one of the systems engineers). Sadly, our cryogenics engineer, Jan Stolt, passed away in October; his tasks were divided amongst two experienced engineers of the ASTRON R&D department. The three operators continued their regular weekly duty roster, rotating primary WSRT, primary LOFAR, and backup responsibilities. One support scientist was in charge of WSRT scheduling, assistance to the PC, and data inspection.

Planned maintenance on the WSRT took one day a week, with repairs in the lab continuing on other days. Corrective maintenance was needed for only four mechanical problems in the year. However, the incidence of electronic and related problems is slowly rising. Especially the analogue part of the backend is showing its age with nearly 45 units requiring repairs last year. Four ADC units had to be replaced, and five DZB units required repairs. There were 16 MFFE receiver exchanges due to failed cryogenic parts; five MFFE feed revolvers developed problems. The MFFE communications and control system had six problems. There were three ICT related problems (failing hardware, one software problem).

On four occasions lightning strikes caused damage to the WSRT, twice in the position tracking system. On one occasion the weather monitoring station was damaged. In early September, a 70 minutes power outage at the WSRT caused significant damage and disruption to the system. Although the cryogenic system in only one MFFE failed, several subsystems in the backend failed when powered up. All in all, it took roughly one week to bring the whole WSRT back on line.

Preparations continued for the installation of Apertif. Ducts were placed to carry the fibers from radio telescopes 0 to 8 to the service building. Concrete pads to carry the containers housing the beamformers were placed in late 2012. Plans were developed for required extensive maintenance on the telescope’s mechanical structure, the drive mechanics, and the drive electronics, in conjunction with the installation of Apertif.

Science Highlights with the Westerbork telescope

The WSRT Bluedisk HI project

The Bluedisk project (Kauffmann et al.) is a large WSRT HI survey of 50 galaxies, selected on their optical and ultraviolet properties. Half of the sample galaxies, with unusually blue outer disks have an excess HI component, while the other half form a control sample. A typical image is shown in the figure on the top right. The Bluedisk team has concluded that their results do not conform to a scenario in which new gas has been brought in by mergers, but are possibly more with cooling from a surrounding quasi-static halo of warm/hot gas.

PSR J0337+1715: A Pulsar in a Compact, Hierarchical Triple System

In early 2012, the WSRT rapidly provided a precise localization of the newly discovered pulsar PSR J0337+1715, which was critical for phase-connecting the timing data of this unique system in a compact, hierarchical triple system (see figure below).
LOFAR Hardware Improvements

After the major HBA repair effort in 2011, the number of defective HBAs at any given time remained fairly constant at the 1-2% level, thanks to the use of new parts with improved shielding against high moisture levels and measures to obtain dryer conditions in and around the HBA tiles.

All eight international stations were visited by Radio Observatory engineers for annual maintenance. Repair work was done in cooperation with local personnel.

In the autumn of 2012, the so-called SyncOptic boards, that distribute a common clock signal to the receivers in a station in a phase-locked loop, were installed on all Dutch stations; the international stations will follow next year. This has significantly improved the forward gain and stability of the station beams. Furthermore, within the LOFAR core, all of the stations were connected through these boards to one single clock, which has resulted in the ability to form coherent Core Tied Array beams, with a dramatic improvement in sensitivity for pulsar and other point-source observations.

Testing was conducted on a LOFAR core station with upgraded Transient Buffer Board memory to hold 5.2 seconds of data (up from 1.3 seconds) at full bandwidth. Memory boards for these upgrades were then ordered for all Dutch stations and five of the international stations.

LOFAR software development and commissioning

LOFAR software development and commissioning continued as a joint effort of Radio Observatory and R&D staff, under the supervision of the LCCG, with significant contributions from others in the wider LOFAR community.

During so-called ‘Busy Thursdays’, bi-weekly one day commissioning workshops, an average of 20 commissioners, participating in person or remotely from all over Europe, discuss calibration issues, present recent results and plan tests on new features of the software; activities are illustrated in the figure. Commissioners are asked to work on specific issues, write missing parts of code when needed, test and certify newly implemented features in the software, experiment with new calibration algorithms, document with written reports all the tests (available in the wiki) and contribute to write and update the LOFAR imaging cookbook.

In addition, the Technical Advisory Group (TAG) continued bi-weekly meetings. The TAG maintained the overall set of top commissioning priorities, reviewed and approved commissioning proposals in pursuit of those priorities, discussed LOFAR calibration issues in detail, and coordinated the activities of KSP commissioners through the bi-weekly LOFAR Status Meeting (LSM). Members of the TAG also served in 2012 as a technical review panel to evaluate the feasibility of all submitted Cycle 0 observing proposals.

A number of significant development goals were reached in 2012. By far the most important was the rollout of the first version of the full operational observing system to support the start of regular Cycle 0 science operations. It constitutes a minimal base functionality including a core set of observing modes, initial versions of both the imaging and pulsar processing pipelines, and preliminary archiving capabilities.

In addition to the core functionality of the Version 1.0 system, a number of enhancements were deployed during the second half of 2012. The most important enhancement was the 8-bit observing mode; the default LOFAR data sampling rate is 16 bits. The 8-bit mode, doubling the usable LOFAR bandwidth from 48 MHz to 96 MHz, was designated a crucial capability for the EoR KSP programme and given the highest development priority. It has come into wide use for Cycle 0 observing programmes.

The figure on page 28 shows an early, deep image of the NCP field taken in 8-bit mode late in 2012.

Furthermore, an ‘HBA inner’ observing mode was developed, to allow selection of only the innermost 24 HBA tiles in a LOFAR remote station, which reduces calibrations issues due to inhomogeneous HBA station beams. Updates to the beam model in the standard imaging pipeline were rolled out, and initial work on integrating the GSM database and source finding into the pipeline began. Performance improvements to the gridding and w-projection components of the AWimager codebase were achieved, yielding better image quality and an order of magnitude increase in execution speed (see figure on top). Finally, enhancements to the NDPPP pre-processing code to support post-correlation baseline addition were implemented as a first component of a tailored processing pipeline to support long-baseline imaging.

The MSSS project

Multi-frequency Snapshot Sky Survey (MSSS) observations began in the LBA band late in 2011 and have been the focus of a concerted development and analysis campaign for 2012, as illustrated in the status diagram below.

The on-going MSSS effort has involved significant manpower contributions from both the Astronomy Group and Radio Observatory at ASTRON, as well as a steady stream of KSP-contributed commissioners. Over the course of 2012, between 4-8 members of the various KSP teams travelled to ASTRON on a weekly basis to take part in the MSSS commissioning effort. MSSS is a crucial driver and testing ground for the imaging pipeline development, as well as delivering one of LOFAR’s most important initial science products: a shallow all-sky survey.
Early image of the NCP field using the 96 MHz, 8-bit observing mode taken late in 2012. The image covers a field-of-view of 30 deg x 30 deg and achieved a noise level of 0.1 mJy. Subsequent deep images of this field have yielded even higher dynamic range. Image credits: S. Yatawatta (ASTRON).

Photo: In September 2012, a group of people from the Radboud University Nijmegen, Aachen and ASTRON performed a three-day measurement campaign with LOFAR core-stations using a highly advanced toy, an octocopter (see images), to study effects of timing and element pattern in more detail. Read more about this measurement on the ASTRON/JIVE Daily Image http://www.astron.nl/dailyimage/main.php?date=20121009 and check out http://www.youtube.com/watch?v=9zqu_RQ12NOQ&feature=youtu.be.

R&D Laboratory
The DOME project, as a public-private R&D partnership between IBM and ASTRON officially started on February 1st 2012. The project, focusing on signal processing challenges for the Square Kilometre Array (SKA), is realized with financial support from the Dutch Ministry of Economics, Agriculture and Innovation (EL&I) and the province of Drenthe. The partners, ASTRON and the IBM Zurich Research Laboratories (ZRL), started the project with a kick-off workshop in Dwingeloo, Drenthe.

The DOME researchers are working at the newly established ASTRON & IBM Center for Exascale Technology in Dwingeloo. At the centre, the researchers are investigating enabling technologies for the SKA in the context of the following research themes:

- Green Computing: addressing technologies to radically reduce the power needed to do computationally intensive work on extremely large amounts of data,
- Nano-photonics: addressing technologies that are necessary to drastically reduce the power necessary for data transport over longer distances and inside computing machines,
- Data & Streaming: addressing technologies to process data on-the-fly and store data at a high efficiency for later use.

To make sure investments also find their way into society, ASTRON and IBM have set up a DOME Users Platform for industry, small and medium sized businesses, universities, and knowledge institutes. In this way partners can work together with IBM and ASTRON scientists, participate in the project, and contribute to the project goals. In June, the kick off of the Users Platform took place at a networking meeting of Sensor Universe in Assen.

A new clock system for the LOFAR core

In order to improve the LOFAR clock stability (jitter on the 1 PPS signal), R&D have developed a new clock board: the SynOptics board. In the original configuration, a rubidium clock and GPS-based synchronization were employed. The improved system makes use of a central clock at the network Concentrator Node in Buinen (near Exloo), in combination with an optical distribution of the signal along the LOFAR fibre optic cable infrastructure. By using optical transmitters (lasers) at unoccupied wavelengths, in combination with wavelength multiplexing, it was not necessary to lay new fibres for this upgrade. Experiments in October 2012 confirmed that the board indeed solves the stability problems.

UniBoard Liquid Cooling

ASTRON and JIVE have taken first steps towards applying liquid cooling to UniBoards. The image shows the set-up of an experiment in which heat sinks of two FPGA chips are replaced by liquid cooling blocks. A special liquid is pumped through the blocks to remove heat from the FPGAs. The heated liquid is then cooled down in the air-vented radiator (bottom left in the image).

Even when the system is running at half speed (fans in the radiator at half speed and water flow at half speed) the selected FPGAs are cooler than the other ones: 41°C instead of 57°C. The goal of liquid cooling is to increase power efficiency. Normally, forced-air cooling is used: an air-flow passes the FPGAs, thus transporting heat from the FPGAs in a subrack to the cabinet. With liquid cooling, the heat exchange can be done from the FPGA to the outside of the cabinet directly, thus reducing the number of fans. Above all, we expect higher cooling capacity will be needed for future FPGA boards. With liquid cooling the aim is to both increase cooling capacity as well as power efficiency. This technology will be further developed for use in the UniBoard2, a new-generation UniBoard.

AARTFAAC Correlation Record

The AARTFAAC project, which stands for Amsterdam-ASTRON Radio Transients Facility and Analysis Centre, is a collaboration between ASTRON and the University of Amsterdam (UvA) that aims to continuously image the entire northern sky at 1-sec time resolution, and thus find the brightest and rarest types of transients and figure out what they might be.

The project uses 288 individual LOFAR LBA dipoles on the superterp, to detect transients in the radio sky. With 288 dipoles, no less than 41,328 baselines can be formed, yielding an incredible instantaneous (u, v) coverage as shown in the left part of the top figure on page 32, made at the end of January 2012. The right part of this figure shows the corresponding array beam pattern with a color scale in dB. In this example, over three hours of data from 288 antennas (576 dipoles) was captured. Even though only five 195-kHz subbands (59.7 - 60.6 MHz) were observed, this already resulted in 27 TB of data. As the LOFAR correlator could not handle more than 64 station inputs, the data was moved to the Das-4 computer cluster in Dwingeloo, using a 10 Gb/s Ethernet connection. With a number of quick ‘hacks’ the researchers were able to run the LOFAR correlator on the system. Using 21 machines, correlating the data took less than 9 hours. At 64 channels per subband, this resulted in 619 billion correlations. We think that correlating 288 dual-polarized antennas broke the world record. By chance, the LOFAR all-sky transient detection facility detected its first transient in this first observation: a solar burst!

APERTIF Polarization Calibration

Magnetic fields are present in all different types of astronomic objects; studying these requires polarimetric observations. The Westerbork Synthesis Radio Telescope (WSRT) has proven to be an excellent instrument for this type of observations. In the coming years, the WSRT will be upgraded with APERTIF Phased Array Feeds (PAFs). Due to the very different nature of the APERTIF feed system, its polarimetric calibration required a novel approach. To verify the new approach, the Rotation Measure (RM) of BL Lac was measured in March. Due to its large RM, the observed polarization angle varies strongly over frequency.
Such measurement is very challenging since it requires a polarimetrically calibrated and stable interferometer system. Five measurements were combined to span the frequency range from 1150 to 1390 MHz. The observations were performed twice: on March 14, BL Lac was observed through an on-axis PAF beam. On March 22, BL Lac was observed through a 1 degree scanned beam.

The image displays the observed Stokes parameters. The flux scale was not calibrated accurately, resulting in variations of Stokes I. The observed polarization angle has been derived from Stokes Q and U and plotted as a function of lambda squared. Using a linear least-squares fit, an RM of -204.9 rad/m² was found for the on-axis measurement and -204.1 rad/m² for the 1 degree scanned beam. These results agree very well with a measurement by Ger de Bruyn using the entire Westerbork telescope. He measured an RM of -205.1 rad/m² on April 1, 2012. The slight differences can be explained by variations of the source and ionospheric conditions.

This convincingly demonstrated that the APERTIF prototype can be polarimetrically calibrated and, most importantly, that there are no major issues to perform polarimetric measurements with APERTIF phased array feeds.

EMBRACE tracking and stability tests

Being a ‘new kid on the block’, aperture array systems still have to demonstrate their technological merit when it comes to astronomical observations. Even something seemingly simple like pointing/tracking requires proper verification when the beam is synthesized from many stationary elements.

To demonstrate EMBRACE’s multi-hour stability and tracking capabilities, in April 2012, ASTRON researchers observed the pulsar B0329+54 for nine hours (from an elevation of 50 degrees, through transit, and then back down to 50 degrees elevation). The array was calibrated only once before the start of the observation, using GPS satellites to determine the phase calibration coefficients necessary to phase the array into a single beam on the sky.

As can be seen in the image, the pulsar was visible throughout the 9-hour observation, though the signal strength varied on an time scales of typically 15-30 minutes. It is quite possible that this variation is simply due to scintillation of the source in the small 12-MHz band we recorded. In any case, this 9-hour observation is a major step forward compared with previous attempts to track a source continuously over multiple hours.

The successful tracking of such a weak astronomical signal places high demands on the re-pointing precision of the beam and the dynamical behavior of the EMBRACE array at the WSRT. Such observations demonstrate the usefulness of aperture array technologies for radio astronomy, which will be important for the Square Kilometre Array (SKA).

Conferences and exhibitions in 2012

Besides conducting busy projects such as the ones listed above, staff of the R&D department were also involved in showing ASTRON technologies to the astronomical and engineering community, and of course to the general public. The R&D department participated in a number of workshops, conferences, and open days, some of which are depicted here.

OLFar at the IAC

From 1 to 5 October 2012, ASTRON and partners had a booth at the International Astronautical Congress (IAC) to promote various research projects, including Orbiting Low Frequency Antennas for Radio Astronomy (OLFAR). The OLFAR project is a feasibility study for a low-frequency radio telescope in space, consisting of a swarm of scalable and autonomous ‘nano’ satellites. These will be spread over a virtual sphere with a diameter of 100 km, emulating a large all-sky radio telescope. As the Earth’s ionosphere is opaque at low radio frequencies (f<10 MHz), OLFAR needs to be space based.

The figure below on the left shows an artist impression of one of the OLFAR satellites in orbit around the Moon.

Astronomy (OLFAR). The OLFAR project

In April 2012, the top sector High Tech Systems and Materials (HTSM) presented itself with the Holland high Tech House at the Hannover Messe, the largest industrial trade fair in the world, in Hannover, Germany. ASTRON participated in the Holland House showing amongst others LOFAR telescope technology, water-cooled Uniboards, and a photonic smart-antenna demonstrator. The picture to the left shows the VIP-meeting at the Holland High Tech House.

The VIP-meeting at the Holland High Tech House in 2012

The VIP-meeting at the Holland High Tech House in 2012
He is outlining the open communication in Dutch industries. Director General General Hans de Groene of NWO, the Netherlands Organisation for Scientific Research, emphasized with his presence (left of the far table) that the Advanced Instrumentation Programmes of the NWO institutes firmly contribute to the Dutch High Tech Systems and Materials programme.

**DOME at CeBIT**
The ASTRON-IBM DOME project was presented at CeBIT 2013 in Hannover, Germany, as part of the Big-Data focus area of the IBM booth; the DOME theme was ‘Big Bang Meets Big Data’. The CeBIT was opened by Dr. Angela Merkel, Chancellor of the Federal Republic of Germany. The picture at the top of the page shows the Chancellor at the IBM Booth talking to the IBM Germany General Manager Martina Koederitz. The inset lower-left shows some of the goodies presented at the DOME booth: a dense aperture array antenna, a 3-D stacked chip, a phase-change memory chip, a low power ADC chip so small a magnifier is needed to see it, a very thin photonic link replacing a wire stack the size of a small tree trunk. Also a printed circuit board for a micro-server was on display, produced by a manufacturer in Drenthe. The SKA signal processing challenges are impressive; the items on display showed we are on a route towards affordable low-power computing and signal processing as is required for the SKA.

**IEEE European Microwave Week**
The annual IEEE European Microwave Week made Amsterdam RAI its home location for the 2012 edition. The microwave week combines three European conferences of importance for ASTRON: the Microwave Integrated Circuits conference, the Microwave conference, and the RADAR conference. On various levels, ASTRON contributed to the success of the week: as a secretary of the organization committee, with contributions to workshops, publications, and with an ASTRON presence at the exhibition. At a good spot in the Space & Defense Pavilion, achievements such as LOFAR, the EMBRACE antennas and Uniboard were presented. The booth was shared with ESA, TNO, and Dutch technical universities.
These are exciting times at the NOVA optical infrared instrumentation group. A lot of progress has been made on a suite of interesting projects. These projects can be in an entirely different phase from a first idea, the development of the concept, design, hardware realization, all the way up to commissioning at the telescope. Below you can find a short summary of the projects and activities in 2012.

Funding for the European Extremely Large Telescope is not complete yet. We have to wait for the Brazilian parliament to approve ESO membership. This allows us to develop prototypes for some essential components in collaboration with several Dutch high tech companies: an immersed grating for the METIS high resolution spectrograph, a cryogenic chopper that allows accurate observation of objects that are fainter than the sky background and vibration free cooling techniques. Also the possibilities and implications for micro-arcsecond astrometry using MIRACO have been investigated. EAGLE and OPTIMOS-EVE have merged into a new multi object instrument called MOSAIC. Extremely fast converging adaptive optics algorithms are developed for EPICS and tested on a GPU based cluster.

NOVA is working on several Multi Object Spectrographs projects: WEAVE, 4MOST and MOONS. In all these projects NOVA is responsible for the design of the spectrograph.

WEAVE is an optical multi object spectrograph for the Ing William Herschel Telescope on La Palma. Its location on the Northern hemisphere is ideal for LOFAR and APERTF follow up. 4MOST is an optical all sky survey instrument for the VISTA telescope on Paranal. The spectrograph is very similar to WEAVE. The combination of WEAVE and 4MOST allow for GAIA follow up on both hemispheres. MOONS is a near infrared expansion or replacement of the VLT Flames-Giraffe multi object spectrograph. In 2012, documents were prepared for review early in 2013: the concept review for 4MOST and MOONS and the preliminary design review for WEAVE.

MATISSE is the mid infrared interferometer for the ESO VLT, combining the light of all four Very Large Telescopes at the same time, creating six baselines and micro-arcsecond angular accuracy. NOVA is responsible for the MATISSE Cryogenic Optics, MPIA (Heidelberg) for the Cryostats, MPIF (Bonn) for the detectors and data reduction and OCA (Nice) for the warm optics, integration and overall management. The MATISSE Cold Optics is a challenging design with many optical components and mechanisms for observation modes and alignment, all with extreme stability and accuracy requirements situated in a vacuum cryogenic environment. The final design review is successfully passed in 2012. A lot of hardware is being manufactured and procured. In September 2012, a dummy cold optics box has been delivered to MPIA for cryogenic tests. This dummy cold optics box contains the thermal mass and external interfaces of the cold optics box, however without optics or mechanisms.

Just as last year, MATISSE is the most important project in 2012 in terms of staff effort.

ZIMPOL is a high contrast imaging polarimeter for the SPHERE instrument on the ESO VLT, being developed by ETH (Zürich) and NOVA. ZIMPOL operates in the visual range and is based on a differential comparison of the two polarization images at 1kHz using a Ferro-electric Liquid Crystal. Both polarization directions are measured on the same pixel, allowing to reach a star to planet contrast ratio of 10⁻⁷. In ZIMPOL, planets are revealed, because their reflected light is polarized, while starlight is not polarized. In 2012, Sphere-ZIMPOL has been tested thoroughly at the Grenoble test facility. The late delivery of the deformable mirror caused some delay, but this time is used to increase reliability of the instrument. Some final test campaigns are planned for 2013 and first light on the VLT in Chile is expected before the end of 2013.

On May 9th 2012, the European MIRI consortium and ESA officially delivered the Mid InfraRed Instrument (MIRI) to NASA in a special gathering in London. NASA will integrate MIRI in the James Webb Space Telescope (JWST). Progress on the telescope is as planned and the project is on schedule for launch in 2018. Other highlights in 2012 were the SPIE Astronomical Telescopes and Instrumentation Conference in the RAI Amsterdam, drawing over 2300 participants for a long week of presentations, posters, meetings and excursions to e.g. the LOFAR telescope, ASTRON and ESTEC. Dutch knowledge institutes and several companies presented themselves in a highly visible Holland pavilion at the exhibition.

Furthermore we should not forget to mention the iSpex team winning the 100,000 Euro Academic Year Prize for the best translation of scientific research to a broad audience. The team created a simple but clever extension piece for the (camera of the) iPhone, which allows people to measure the concentration of particles in the atmosphere.

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JIVE, the Joint Institute for VLBI in Europe, faced an international review in March 2012 in preparation for a new funding agreement between its partners. In parallel, discussions concerning whether JIVE should transform into an ERIC (European Research Infrastructure Consortium, a legal entity with an EC basis) continued. A panel of recognized international experts visited JIVE and evaluated the operations, research and development programme (Figure 1), as well as the scientific potential of the European VLBI Network (EVN) and JIVE. In its report the panel expressed great confidence in JIVE and its plans for the future. This result was followed up by a decision of the international partners to sign a two-year extension of the JIVE contributions agreement, recognising this period as a transition to the ERIC establishment.

Very relevant in this process was the positive decision by the South African NRF to become a member of JIVE in May 2012. The Hartebeesthoek telescope has been a long-standing member of the EVN. However, with the construction of the MeerKAT and the ambition to start an African VLBI Network, this formal partnership could be the starting point for building up important new VLBI capabilities during the years that the SKA is being constructed, and even during its operation.

The review was held after serious construction work had started in Dwingeloo. Several JIVE staff members moved to temporary offices in the spring, and during the summer there were considerable further disturbances as the old building was prepared for integration with the new wing. JIVE offices were ready just before Christmas, and the last days of 2012 were used for moving staff into the new wing.

In 2012, the EVN users continued to enjoy an increasing number of VLBI capabilities offered by the EVN infrastructure and the JIVE correlators. Notably the EVN software correlator at JIVE (SFXC) matured significantly to the point that it was doing almost all correlation at the end of the year, in addition to the special wide field, pulsar gating and spectral line modes. A notable event showcasing the effort of the JIVE and EVN teams was the 11th EVN symposium. In a great setting the EVN users demonstrated the breadth of modern VLBI science, particularly showing the latest scientific progress with e-VLBI and software correlation.

The R&D programme at JIVE depends largely on external funding. Efforts on the UniBoard were extended in 2012 within the new RadioNet3 project. JIVE’s user software efforts, as well as the vital Trans National Access funds used to implement user support for VLBI in Europe, are also supported by RadioNet3.

The e-VLBI development effort, sponsored by the EC through the NEXPReS project, has been focusing on methods to implement the best of both worlds: e-VLBI data streaming in real-time, as well as transparent caching if the data is needed (again) in a later stage. In this project the consortium members are also pioneering methods to allocate connectivity bandwidth on demand. The progress of the project was rated excellent by the EC’s review panel in September 2012.

In pushing the scientific application of VLBI, again significant progress was made in facilitating VLBI observations of spacecraft. Among the experiments carried out were the successful measurements of the drag forces on the Venus Express when skimming the...
Venus upper atmosphere. Major efforts also went into preparing the science case for various future missions, such as the Marco-Polo-R and JUICE. Actual measurements were made of the RadioAstron orbiting radio telescope, eventually attempting to refine its state vector and getting fringes on space baselines with these results.

From all the science results that JIVE staff obtained, in collaboration with other EVN users, we highlight the measurement of methanol maser magnetic fields (Fig. 3). Probing the close environment of high-mass proto-stars the team is researching the relation between magnetic fields and outflows, attempting to decide on the scenario for high-mass star formation.

This programme too benefits from the new capabilities that the SFXC correlator offers, as it provides very accurate polarization products at very high spectral resolution and it was a result obtained by one of the summer students (Luis Henry Quiroga-Nunez).

**Figure 3.** EVN observations of maser polarization in the massive star-forming region IRAS22272+6358A. Left: CO blue-shifted and red-shifted CO emission overlaid on the 2.7 mm continuum emission (from Beltrán et al., 2006, A&A, 457, 865). Right: Distribution of 6.7 GHz methanol masers detected around IRAS22272+6358A. The linear polarization vectors are over-plotted. The thick line is the projection on the plane of the sky of the magnetic field. Surcis et al., submitted.
to understand the multi-frequency survey with the LOFAR telescope (USA) working at the project MSSS young scientists: Patricia Carroll from the University of Ljubljana, looking for Ammonia in Galaxy Cluster Cores and Vibor Jelic; Janez Kos, from the Institute of Technology) working on the Strong Lensing at High Angular Resolution Program (SHARP) with the goal of searching for low mass substructure in cosmological distant galaxies.

Outreach activities

Renovation of the old Dwingeloo Telescope
On Tuesday 5 June 2012, the skyline of the National Park Dwingelerveld changed drastically. On that day at 14.00 hrs, the 25-meter dish of the Dwingeloo Radio Telescope was lifted off its tower and placed on a special construction next to it, so that it could be restored. The dish, which weighs over 30,000 kilo’s, has not been out of place since its construction in 1956. Without restoration, the risk of the structure collapsing was too big and it would have to be taken down. After the dish of the telescope was removed, all steel parts were sandblasted and repainted. On Monday 19 November, the dish was placed back on its tower.

The restoration of the Dwingeloo Radio Telescope is made possible by grants from the National Heritage Board of the Ministry of Education, Culture and Science, the province of Drenthe, the municipality of Westerveld and contributions of the VSB, SNS REALF FUND, Rabobank Southwest Drenthe, ASTRON and the Netherlands Organization for Scientific Research (NWO). The restoration is expected to be completed by mid-2013. More information about the telescope can be found on http://www.astron.nl/node/516 and on www.camras.nl.

Re-opening of the Milky Way path
On Sunday 7 October 2012, over four hundred people visited the Milky Way path near ASTRON’s Westerbork telescope. In the months before, the path, which houses a scale model of our solar system, was renewed. During the Dutch Weekend of Science (6 and 7 October), ASTRON, Universe Awareness, the remembrance centre for Camp Westerbork (which lies next to the telescope)
One of the ASTRON astronomers helped kids (and adults!) make their own pulsar during the LOFAR open day in May 2012.

Kids and adults can experience gravity on the weights activity on the Milky Way path.

and the State forest organisation re-opened the path and organised a number of activities on and around the Milky Way path and the Westerbork telescope. The activities were mainly aimed at kids, as October is also kids’ month in the Netherlands.

A couple hundred kids showed up with their parents and looked at the stars and planets in the mobile planetarium, blew up chocolate marshmallows (and ate them), looked at the sun through the solar telescope and moved one of the Westerbork dishes by themselves.

On the Milky Way path they also made their own star, painted the Earth as they thought it would look like from the sky and juggled with planets to put them in the right order.

Open day at the LOFAR telescope

In May 2012, over 800 people visited the LOFAR telescope during ASTRON’s open day. The day was organized in the context of the so-called EU ‘Kijkdagen’ (EU Open days), an initiative of the Northern Netherlands Provinces (SNN). On these open days, organizations in the Netherlands that received funding from the European Union (EU) can open their doors to the public.

ASTRON invited visitors to come and see LOFAR, the largest radio telescope in the world. Here they could perform an observation with the telescope, get a tour at the telescope in the field, travel through the universe in the mobile planetarium and learn about an even larger telescope than LOFAR, the Square Kilometre Array. The Square Kilometre Array (SKA) will be the world’s largest and most sensitive radio telescope with a total collecting area of approximately one square kilometre. The SKA will be built in Southern Africa and in Australia. It is a global enterprise bringing together eleven countries from the five continents. ASTRON is one of the major players in this project. In the Netherlands, ASTRON has set up the SKA Northern Netherlands (SKA-NN) project to, in cooperation with industry, strengthen its position in the race to build the SKA. During the LOFAR open day, visitors could learn everything about the SKA-NN project. You can find more information about the EU open days on http://www.europaomdehoek.nl/.

Press releases

10 January 2012
A Boost for European Radio Astronomy

26 January 2012
Dwingeloo telescope live monument

16 January 2012
International LOFAR radio telescope kicks off all-sky survey

19 January 2012
Astronomers find dark matter galaxy far, far away

7 April 2012
ASTRON & IBM collaborate to explore origins of Universe
Major group visits 2012
As every year, many people visited ASTRON in 2012. Below you can find an overview of some of these groups.

January
12 January 2012
Students from the Edsalcollege, Borger (near the LOFAR telescope).

18 January 2012
Students from the Kandinsky school, Nijmegen.

February
3 February 2012
Anniversary symposium of CAMRAS (the foundation that manages the Dwingeloo telescope).

21 February 2012
VNO-NCW Noord (entrepreneur organization in the northern Netherlands, interest group for 12,000 companies).

March
March 2012
Students electrical engineering and mechanical engineering from Windesheim, Zwolle.

21 March 2012
High school students from Leiden and university astronomy students from the university of Leiden.

21 March 2012
Students post-college education for heritage and space, college from Utrecht, visited the Dwingeloo telescope.

22 June 2012
Member of European parliament Thijs Berman.

April
19 April 2012
Physics students from the University of Hasselt, Belgium.

26 April 2012
Girlsday at ASTRON, JIVE and the NOVA Optical/ Infrared group.

27 April 2012
Students from the Hanze Institute of Technology, Assen.

May
31 May 2012
High school students from the Celaenium, Zwolle.

June
22 June 2012
Member of European parliament Thijs Berman (3rd person from the left) visited ASTRON.

25 June 2012
Students from the Leiden instrument making school (LIS).

July
3 July 2012
Participants of the SPI Astronomy conference in Amsterdam.

4 July 2012
SKA NL Industry meeting.

October
5 Oct 2012
Students for the NOVA Fall school.

31 Oct 2012
Students from the college in Utrecht.

November
19 Nov 2012
Trade organisation from Dwingeloo.

22 Nov 2012
High school students from the Technasium of the Roelof van Echten school, Hoogeveen.

23 Nov 2012
City council of Westerveld/ Project IJsseldelta.

December
19 Dec 2012
High school students Kandinsky school, Nijmegen.
Appendix 1: financial summary

Financial report 2012
The financial report of 2012 compared with 2011

<table>
<thead>
<tr>
<th>Year</th>
<th>Budget</th>
<th>Actual</th>
<th>Difference</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Government Grants-Ministry of Education, Culture &amp; Science</td>
<td>12,474,800</td>
<td>11,849,877</td>
<td>624,923</td>
<td>11,190,309</td>
</tr>
<tr>
<td>Subsidies / Contributions</td>
<td>5,887,265</td>
<td>5,988,853</td>
<td>-101,588</td>
<td>18,013,218</td>
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<tr>
<td>Release to provision</td>
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<td>10,348</td>
<td>-10,348</td>
<td>412,370</td>
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<tr>
<td>Other Income</td>
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<td>440,044</td>
<td>-28,044</td>
<td>487,381</td>
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<tr>
<td>Cash management</td>
<td>50,000</td>
<td>32,675</td>
<td>17,325</td>
<td>114,992</td>
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<td>Subtotal</td>
<td>18,824,065</td>
<td>18,321,797</td>
<td>502,268</td>
<td>30,218,270</td>
</tr>
<tr>
<td>Results Subsidiaries</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Subsidiary ATH</td>
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<td>14,045</td>
<td>-14,045</td>
<td>10,954</td>
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<tr>
<td>Subtotal</td>
<td>0</td>
<td>14,045</td>
<td>-14,045</td>
<td>10,954</td>
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<tr>
<td>Special Income</td>
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<td></td>
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<tr>
<td>Special Income</td>
<td>0</td>
<td>480,332</td>
<td>-480,332</td>
<td>217,006</td>
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<tr>
<td>Subtotal</td>
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<td>480,332</td>
<td>-480,332</td>
<td>217,006</td>
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<tr>
<td>Total Income</td>
<td>18,824,065</td>
<td>18,816,174</td>
<td>7,891</td>
<td>30,446,230</td>
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</table>

Expenses

<table>
<thead>
<tr>
<th>Year</th>
<th>Budget</th>
<th>Actual</th>
<th>Difference</th>
<th>Actual</th>
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</thead>
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<tr>
<td>Expenditure</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grants / Expenditures</td>
<td>16,397,606</td>
<td>15,161,801</td>
<td>-1,235,805</td>
<td>14,826,316</td>
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<td>Operations</td>
<td>1,400,000</td>
<td>1,213,396</td>
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<td>2,021,282</td>
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<td>Allocation to Projects</td>
<td>17,797,606</td>
<td>19,395,669</td>
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<td>30,441,143</td>
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<tr>
<td>Subtotal</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Results Subsidiaries</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Subsidiary ATH</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Subtotal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other Expenditures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Expenditures</td>
<td>17,797,606</td>
<td>19,630,066</td>
<td>1,832,460</td>
<td>30,482,073</td>
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<tr>
<td>Total Expenditures</td>
<td>1,026,459</td>
<td>-813,892</td>
<td>1,840,351</td>
<td>-35,843</td>
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</tbody>
</table>

Appendix 2: personnel highlights

The year 2012 was very busy for the Human Resources department at ASTRON. The Netherlands Organisation for Scientific Research (NWO) started two projects to renew, improve and refocus on several HR instruments such as competences and performance & development. ASTRON participated in both projects. The execution of these new instruments will follow in 2013 and we hope to reap the benefits from this in 2013 and onwards. Recruiting new personnel for several positions (both new and replacement positions) covered the better part of 2012.

As part of the project ‘Talent to the top’ within NWO, NWO has provided ASTRON with funds to offer two talented female scientists positions at ASTRON to develop themselves. ASTRON has started the recruitment and we hope to fill both positions in 2013.

Absenteeism
In 2012, the absenteeism percentage was 2.9%. This is slightly higher compared to 2011 (2.8%), but still lower compared to 2010 (3.6%) and 2009 (3.7%).

Building project
One of the big projects with a major impact on ASTRON staff in 2012, was the start of the building process. The building project entails the building of a new wing, renovations of wing ‘1980’ and upgrading several aspects of wing ‘1996’. We kicked off the project with building a new wing (called building ‘2012’).

At the end of 2012, the new wing was ready to be used. The remaining parts of the project will most likely be finished by the end of 2013.

The building process had a lot of impact since many people needed to move to temporary offices to create enough room to build. ASTRON stayed fully operational while the building project was in progress so it was important to collaborate with the builders and keep each other informed about any nuisances (noise and so on) that occurred throughout the process.

Number of employees at ASTRON in 2012

<table>
<thead>
<tr>
<th>Department</th>
<th>Number of people</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management and Staff</td>
<td>9</td>
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<tr>
<td>Astronomy Group</td>
<td>22</td>
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<tr>
<td>Radio Observatory</td>
<td>32</td>
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<tr>
<td>Research &amp; Development</td>
<td>55</td>
</tr>
<tr>
<td>General affairs</td>
<td>31</td>
</tr>
<tr>
<td>NOVA*</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>158</td>
</tr>
</tbody>
</table>

*NOVA, the Dutch research school for astronomy, is a separate entity but all personnel of the NOVA Infrared group is employed by ASTRON (NWO).
Appendix 3: WSRT and LOFAR proposals in 2012

Table of proposals submitted to the WSRT in 2012 and accepted by the WSRT Programme Committee; rejected proposals are not shown.

<table>
<thead>
<tr>
<th>Project-ID</th>
<th>Name of Project</th>
<th>Name of PI</th>
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<tbody>
<tr>
<td><strong>Semester 12A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R12A/001</td>
<td>Cyg X-3 in outburst: from gamma-ray to radio wavelengths</td>
<td>Tudose</td>
</tr>
<tr>
<td>R12A/002</td>
<td>The large-scale diffuse radio emission in A781</td>
<td>Pizzo</td>
</tr>
<tr>
<td>R12A/004</td>
<td>The Nature of Hoag's Object</td>
<td>Finkelman</td>
</tr>
<tr>
<td>R12A/005</td>
<td>The Large European Array for Pulsars</td>
<td>Janssen</td>
</tr>
<tr>
<td>R12A/006</td>
<td>Cold accretion in massive elliptical galaxies</td>
<td>Bemmel</td>
</tr>
<tr>
<td>R12A/007</td>
<td>High-magnetic field neutron star X-ray binaries during outburst</td>
<td>Migliari</td>
</tr>
<tr>
<td>R12A/008</td>
<td>Mapping the HI in galaxies with actively star-forming outer disks</td>
<td>Kauffmann</td>
</tr>
<tr>
<td>R12A/009</td>
<td>Characterisation of a sample of &quot;Voorwerpjes&quot; with the WSRT</td>
<td>Argo</td>
</tr>
<tr>
<td>R12A/010</td>
<td>Studying the profile variation of PSR J1022+1001</td>
<td>Liu</td>
</tr>
<tr>
<td>R12A/011</td>
<td>Studying the HI content of two subregions in the Ursa Major cluster</td>
<td>Wolfinger</td>
</tr>
<tr>
<td>R12A/012</td>
<td>WSRT High-Resolution Observations of Newly Detected, Nearby Spiral Galaxy</td>
<td>McIntyre</td>
</tr>
<tr>
<td>S12A/003</td>
<td>PSR J2129+04: studying the eclipse properties of a rare type of millisecond pulsar binary system</td>
<td>Helsels</td>
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<tr>
<td>S12A/004</td>
<td>PSR J0337+17: Characterization of a Possible Pulsar Triple Star System</td>
<td>Helsels</td>
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<tr>
<td>S12A/005</td>
<td>Revisiting the Intra-Hour-Variable Quasar J1819+3845</td>
<td>Bruyn</td>
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<tr>
<td>S12A/006</td>
<td>The variable Faraday structure of Billac</td>
<td>Bruyn</td>
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<tr>
<td><strong>Semester 12B</strong></td>
<td></td>
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<tr>
<td>R12B/005</td>
<td>Following up study of the profile variation of PSR J1022+1001</td>
<td>Liu</td>
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<tr>
<td>R12B/008</td>
<td>Magnetization of the Universe with starbursting dwarf galaxies</td>
<td>Chyzy</td>
</tr>
<tr>
<td>R12B/009</td>
<td>Multi-frequency simultaneous observations of nulling phenomena in PSR B2111+46</td>
<td>Gajjar</td>
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<tr>
<td>R12B/010</td>
<td>Unraveling the Physics of Gamma-Ray Burst Blast Waves</td>
<td>Horst</td>
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<tr>
<td>R12B/011</td>
<td>A HI SKA Pathfinder pilot survey in the ZOA: A previously unexplored rich cluster and its immediate surroundings in the Perseus-Pices Chain</td>
<td>Kraan-Korteweg</td>
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<tr>
<td>R12B/012</td>
<td>The last throes of star formation in blue early-type galaxies</td>
<td>Wong</td>
</tr>
<tr>
<td>R12B/013</td>
<td>A Daily WSRT Timing Campaign of a Pulsar in a Triple Star System</td>
<td>Helsels</td>
</tr>
<tr>
<td>R12B/014</td>
<td>Cyg X-3 in outburst: from gamma-ray to radio wavelengths</td>
<td>Tudose</td>
</tr>
<tr>
<td>R12B/015</td>
<td>RadioAstron Space VLBI survey of AGN at the highest angular resolutions</td>
<td>Kowalev</td>
</tr>
<tr>
<td>R12B/016</td>
<td>High-magnetic field neutron star X-ray binaries during outburst</td>
<td>Migliari</td>
</tr>
<tr>
<td>R12B/017</td>
<td>The European Pulsar Timing Array</td>
<td>Janssen</td>
</tr>
<tr>
<td>R12B/018</td>
<td>Shock and Awe: Do cluster collisions change the history of cluster galaxies?</td>
<td>Rottgering</td>
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<tr>
<td>R12B/019</td>
<td>The WSRT Coma Survey</td>
<td>Serra</td>
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<tr>
<td>R12B/020</td>
<td>The Large European Array for Pulsars</td>
<td>Janssen</td>
</tr>
<tr>
<td>R12B/021</td>
<td>Revisiting the Intra-Hour-Variable Quasar J1819+3845</td>
<td>Bruyn</td>
</tr>
<tr>
<td>R12B/022</td>
<td>A WSRT continuum legacy survey: Galactic foregrounds towards LOFAR EoR windows</td>
<td>Jelic</td>
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<tr>
<td>S12B/001</td>
<td>A search for radio relics in the Musket Ball Cluster</td>
<td>Van Weeren</td>
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<tr>
<td>S12B/002</td>
<td>Space-ground maser observations of hydroxyl masers in W75N</td>
<td>Alakoz</td>
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<tr>
<td>S12B/003</td>
<td>Is TYC 4051-1277-1 a new gamma-ray binary?</td>
<td>Marcote</td>
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<tr>
<td>S12B/004</td>
<td>PSR J2339+8772/0533: Characterizing the eclipses of a new pulsar &quot;redback&quot; system</td>
<td>Helsels</td>
</tr>
<tr>
<td>S12B/005</td>
<td>Timing the Crab pulsar during a large scattering event</td>
<td>Janssen</td>
</tr>
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### Tables of LOFAR Proposals in 2012

<table>
<thead>
<tr>
<th>Proposal code</th>
<th>PI</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>LRA12A002</td>
<td>G. Mann</td>
<td>Solar Observations with LOFAR</td>
</tr>
<tr>
<td>LRA12A003</td>
<td>H. Rottgering</td>
<td>LOFAR Survey: Opening up a New Window on the Universe</td>
</tr>
<tr>
<td>LRA12A004</td>
<td>R. Fender</td>
<td>The LOFAR Transients Key Science Project</td>
</tr>
<tr>
<td>LRA12A005</td>
<td>J. Hoerandel</td>
<td>Cosmic Ray KSP Reserved Access Proposal</td>
</tr>
<tr>
<td>LRA12A006</td>
<td>G. de Bruyn</td>
<td>Studying the Epoch of Reionization and Cosmic Dawn on the Universe</td>
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<td>LRA12A007</td>
<td>M. Bisi</td>
<td>Observations of Interstellar Scintillation (IPS) with LOFAR</td>
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<tr>
<td>LRA12A008</td>
<td>R. Beck</td>
<td>The LOFAR Magnetism Key Science Project (MKSP)</td>
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<table>
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<tr>
<td>LC0_002</td>
<td>Olaf Wucknitz</td>
<td>Location and motion of sources of Jupiter’s magnetospheric/auroral decameter emissions</td>
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<tr>
<td>LC0_003</td>
<td>Rob Fender</td>
<td>Wide field searches for image-plane radio transients</td>
</tr>
<tr>
<td>LC0_004</td>
<td>Neal Jackson</td>
<td>Gravitational lenses at low frequencies</td>
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<tr>
<td>LC0_005</td>
<td>Regis Courtin</td>
<td>A determination of the abundance of water in Saturn’s deep atmosphere with LOFAR</td>
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<tr>
<td>LC0_006</td>
<td>Imke de Pater</td>
<td>LOFAR Observations of Jupiter’s Synchrotron Radiation</td>
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<tr>
<td>LC0_007</td>
<td>Philippa Zarka</td>
<td>Exoplanet radio search and characterization</td>
</tr>
<tr>
<td>LC0_008</td>
<td>Ben Stappers</td>
<td>LOFAR studies of pulsars, fast transients and the interstellar medium</td>
</tr>
<tr>
<td>LC0_009</td>
<td>George Miley</td>
<td>Particle acceleration and cold gas in high-redshift radio sources - long baseline and recombination line studies</td>
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<td>LC0_010**</td>
<td>Aris Karastergiou</td>
<td>ARTEMIS on LOFAR: real-time searches for fast transients with international LOFAR stations</td>
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<td>LC0_011</td>
<td>Joris Verbiest</td>
<td>Pulsar timing with LOFAR</td>
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<tr>
<td>LC0_012</td>
<td>Rafalla Mangianti</td>
<td>Using LOFAR for detailed studies of AGN, and AGN physics</td>
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<td>LC0_013</td>
<td>Rachel Osten</td>
<td>Stellar Radio Astronomy with LOFAR</td>
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<td>Maciej Serylak</td>
<td>Studying pulsars and the interstellar medium using International LOFAR stations</td>
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<tr>
<td>LC0_015</td>
<td>Philip Best</td>
<td>A deep and wide extragalactic survey at low frequencies: AGN evolution, star formation, and cosmology</td>
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<tr>
<td>LC0_016</td>
<td>Ewan O’Sullivan</td>
<td>Stephan’s Quintet: the role of shocks in the formation of the hot intracluster medium</td>
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<tr>
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<td>Ewan O’Sullivan</td>
<td>Stephan’s Quintet: the role of shocks in the formation of the hot intracluster medium</td>
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<td>LC0_019</td>
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<td>LC0_020</td>
<td>David Jones</td>
<td>Determining the origin and (magnetic) substructure of the Fermi bubbles</td>
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<tr>
<td>LC0_022</td>
<td>Scott Ransom</td>
<td>LOFAR timing of pulsars and rotating radio transients discovered in 3B 350-695 MHz surveys</td>
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<tr>
<td>LC0_024</td>
<td>Leonid Gurvits</td>
<td>Atomic hydrogen at z=5</td>
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<td>LC0_025</td>
<td>Anna Scaife</td>
<td>Low Frequency Investigation of the Super-CLAS Super-cluster</td>
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<tr>
<td>LC0_026</td>
<td>John Conway</td>
<td>Imaging compact SNR, Supernova and AGN emission in M82 and M81</td>
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<tr>
<td>LC0_027</td>
<td>Gottfried Mann</td>
<td>Solar activity studies with LOFAR</td>
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<tr>
<td>LC0_028</td>
<td>Raymond Oonk</td>
<td>LOFAR Galactic Radio Reconnection Line Survey (LG-RRLS)</td>
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<tr>
<td>LC0_029</td>
<td>Jean-Pierre Macquart</td>
<td>The polarization footprint of a nearby anomalously turbulent scattering screen</td>
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<tr>
<td>LC0_030</td>
<td>Gottfried Mann</td>
<td>LOFAR studies of the evolution of coronal mass ejections in the heliosphere</td>
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<tr>
<td>LC0_031</td>
<td>Brian McNamara</td>
<td>AGN outburst in MS0735.6+7421</td>
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<tr>
<td>LC0_032</td>
<td>Glenn White</td>
<td>LOFAR Survey of High Mass star forming regions in Galactic plane</td>
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<td>LC0_034</td>
<td>Jason Hessels</td>
<td>LOTAAS: The LOFAR Tied-Array All-Sky Survey for Pulsars and Fast Transients</td>
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<tr>
<td>LC0_035</td>
<td>Joeri van Leeuwen</td>
<td>Targeted searches for pulsars and fast transients</td>
</tr>
<tr>
<td>LC0_037</td>
<td>Marcus Brueggen</td>
<td>Exploitation of LOFAR surveys to study galaxy clusters</td>
</tr>
<tr>
<td>LC0_038*</td>
<td>Stijn Buitink</td>
<td>Cosmic ray detection using LORA triggers</td>
</tr>
<tr>
<td>LC0_039</td>
<td>James Miller-Jones</td>
<td>Variable jet sources in the LOFAR band</td>
</tr>
<tr>
<td>LC0_040</td>
<td>James Cordes</td>
<td>Using Diffraction Interstellar Scintillations (DISS) to Resolve Pulsar magnetospheres and the issue of potential DC emission</td>
</tr>
<tr>
<td>LC0_041</td>
<td>Stijn Buitink</td>
<td>Imaging of the Moon</td>
</tr>
<tr>
<td>LC0_042</td>
<td>Natalia Lewandowska</td>
<td>Multi-frequency observations of giant radio pulse emission from pulsars</td>
</tr>
<tr>
<td>LC0_043</td>
<td>Rainer Beck</td>
<td>LOFAR Survey of nearby galaxies</td>
</tr>
<tr>
<td>LC0_044**</td>
<td>Jana Koehler</td>
<td>Studying large-scale polarization properties of the Milky Way ISM at low frequencies</td>
</tr>
</tbody>
</table>

### Tables of Reserved Access Proposals leading up to LOFAR Cycle 0

<table>
<thead>
<tr>
<th>Proposal code</th>
<th>PI</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRA12A002</td>
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<td>LRA12A006</td>
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</tr>
<tr>
<td>LRA12A008</td>
<td>R. Beck</td>
<td>The LOFAR Magnetism Key Science Project (MKSP)</td>
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<th>Proposal code</th>
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<tr>
<td>LC0_002</td>
<td>Olaf Wucknitz</td>
<td>Location and motion of sources of Jupiter’s magnetospheric/auroral decameter emissions</td>
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<tr>
<td>LC0_003</td>
<td>Rob Fender</td>
<td>Wide field searches for image-plane radio transients</td>
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<tr>
<td>LC0_004</td>
<td>Neal Jackson</td>
<td>Gravitational lenses at low frequencies</td>
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<td>LC0_005</td>
<td>Regis Courtin</td>
<td>A determination of the abundance of water in Saturn’s deep atmosphere with LOFAR</td>
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<td>LC0_006</td>
<td>Imke de Pater</td>
<td>LOFAR Observations of Jupiter’s Synchrotron Radiation</td>
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<td>LC0_007</td>
<td>Philippa Zarka</td>
<td>Exoplanet radio search and characterization</td>
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<td>LC0_008</td>
<td>Ben Stappers</td>
<td>LOFAR studies of pulsars, fast transients and the interstellar medium</td>
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<td>LC0_009</td>
<td>George Miley</td>
<td>Particle acceleration and cold gas in high-redshift radio sources - long baseline and recombination line studies</td>
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<td>LC0_010**</td>
<td>Aris Karastergiou</td>
<td>ARTEMIS on LOFAR: real-time searches for fast transients with international LOFAR stations</td>
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<tr>
<td>LC0_011</td>
<td>Joris Verbiest</td>
<td>Pulsar timing with LOFAR</td>
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<tr>
<td>LC0_012</td>
<td>Rafalla Mangianti</td>
<td>Using LOFAR for detailed studies of AGN, and AGN physics</td>
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<td>LC0_013</td>
<td>Rachel Osten</td>
<td>Stellar Radio Astronomy with LOFAR</td>
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<tr>
<td>LC0_014**</td>
<td>Maciej Serylak</td>
<td>Studying pulsars and the interstellar medium using International LOFAR stations</td>
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<td>LC0_015</td>
<td>Philip Best</td>
<td>A deep and wide extragalactic survey at low frequencies: AGN evolution, star formation, and cosmology</td>
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<td>LC0_016</td>
<td>Ewan O’Sullivan</td>
<td>Stephan’s Quintet: the role of shocks in the formation of the hot intracluster medium</td>
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<td>Ewan O’Sullivan</td>
<td>Stephan’s Quintet: the role of shocks in the formation of the hot intracluster medium</td>
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<td>LC0_017</td>
<td>Joseph Lazio</td>
<td>A Search for radio emissions from HD 80606b near planetary periastron</td>
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<td>A G de Bruyn</td>
<td>Studying the Epoch of Reionization and cosmic dawn of the Universe</td>
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<td>LC0_020</td>
<td>David Jones</td>
<td>Determining the origin and (magnetic) substructure of the Fermi bubbles</td>
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<td>LC0_022</td>
<td>Scott Ransom</td>
<td>LOFAR timing of pulsars and rotating radio transients discovered in 3B 350-695 MHz surveys</td>
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<tr>
<td>LC0_024</td>
<td>Leonid Gurvits</td>
<td>Atomic hydrogen at z=5</td>
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<td>LC0_025</td>
<td>Anna Scaife</td>
<td>Low Frequency Investigation of the Super-CLAS Super-cluster</td>
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<td>LC0_026</td>
<td>John Conway</td>
<td>Imaging compact SNR, Supernova and AGN emission in M82 and M81</td>
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<td>LC0_027</td>
<td>Gottfried Mann</td>
<td>Solar activity studies with LOFAR</td>
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<td>LC0_028</td>
<td>Raymond Oonk</td>
<td>LOFAR Galactic Radio Reconnection Line Survey (LG-RRLS)</td>
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<td>LC0_029</td>
<td>Jean-Pierre Macquart</td>
<td>The polarization footprint of a nearby anomalously turbulent scattering screen</td>
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<td>LC0_030</td>
<td>Gottfried Mann</td>
<td>LOFAR studies of the evolution of coronal mass ejections in the heliosphere</td>
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<td>LC0_031</td>
<td>Brian McNamara</td>
<td>AGN outburst in MS0735.6+7421</td>
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<td>LC0_032</td>
<td>Glenn White</td>
<td>LOFAR Survey of High Mass star forming regions in Galactic plane</td>
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<td>LC0_034</td>
<td>Jason Hessels</td>
<td>LOTAAS: The LOFAR Tied-Array All-Sky Survey for Pulsars and Fast Transients</td>
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<td>LC0_035</td>
<td>Joeri van Leeuwen</td>
<td>Targeted searches for pulsars and fast transients</td>
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<td>LC0_037</td>
<td>Marcus Brueggen</td>
<td>Exploitation of LOFAR surveys to study galaxy clusters</td>
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<td>LC0_038*</td>
<td>Stijn Buitink</td>
<td>Cosmic ray detection using LORA triggers</td>
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<td>LC0_039</td>
<td>James Miller-Jones</td>
<td>Variable jet sources in the LOFAR band</td>
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<td>LC0_040</td>
<td>James Cordes</td>
<td>Using Diffraction Interstellar Scintillations (DISS) to Resolve Pulsar magnetospheres and the issue of potential DC emission</td>
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<tr>
<td>LC0_041</td>
<td>Stijn Buitink</td>
<td>Imaging of the Moon</td>
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<tr>
<td>LC0_042</td>
<td>Natalia Lewandowska</td>
<td>Multi-frequency observations of giant radio pulse emission from pulsars</td>
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<tr>
<td>LC0_043</td>
<td>Rainer Beck</td>
<td>LOFAR Survey of nearby galaxies</td>
</tr>
<tr>
<td>LC0_044**</td>
<td>Jana Koehler</td>
<td>Studying large-scale polarization properties of the Milky Way ISM at low frequencies</td>
</tr>
</tbody>
</table>
Appendix 4: board, committees and staff in 2012

Board members
Prof. K. Gaemers (Chair of the Board)
Prof. dr. J.T.M. de Hosson
Prof. dr. J.C.M. van Eijndhoven
Prof. dr. ir. J.A.M. Bleeker
Drs. S.B. Seviestra
Drs. J.P. Rijdijk

Members of the Science Advisory Committee
Prof. dr. J.H. van Gorkom, Columbia University
Dr. D.R. DelBoer, CSIRO-ATNF
Dr. L.E. Koopmans, Kapteyn Institute
Dr. J. Uijtdehaag, NRAO
Prof. dr. J.H. Jonas, Rhodes University
Prof. dr. H.J.A. Röttgering, Radio Observatory Leiden
Dr. J. Vink, University Utrecht
Prof. dr. R.A.M. Wiljes, University of Amsterdam

Members of the WSRT Program Committee
Prof. P. Biermann
Dr. D. Gabuzda
Dr. J. Kraanta
Dr. U. Klein
Prof. dr. M. Kramer
Dr. T. Oosterloo
Dr. I. Pandoni
Prof. dr. T. van der Hulst
Prof. dr. G. Woan

Directorate
Michael Garrett, Scientific director
Director General
Marco de Vos, Managing director/Deputy Director General

Staff functions
Diana van Dijk, Management assistant
Truus van den Brink-Having, Office manager
Michiel van Haarlem, Interim Director General
SKA Organisation
Arnold van Ardenne, Coordinator
ASTRON SKA Program Office
Femke Boekhorst, PR & Communications office
Ina Lenten-Streutker, Secretary
Marja Carnal – v.d. Spek, Secretary
André van Es, Project manager European projects
Anno Gregoor, Employee general affairs

Human Resources and Internal Communications
Diana Venjeij, Head HR & AC
Carin Lubbers, HR assistant
Erika Timmerman, HR officer
Marianne Wielink-Strating, HR assistant
Finance, Planning & Control
Jannike Wubs-Komdeur, Head FP & C
Ingrid Arling, Assistant FP & C
Emmy Boerma, Project controller
Anne Doek, Assistant FP & C
Bertine Koek-Winters, Financial administrative assistant
Anno Koster, Purchasing administrative assistant
Karin Spijkerman-Hogenkamp, Project controller

ICT support
Rooif Nieuwenhoud, Head of ICT
Marc Luchsies, System and network support
Merijn Martens, ICT assistant
Jan Slagter, System and network support
Klaas Stuurwold, Senior officer ICT
Henk Voosmeijer, Application and system administrator

Facilities
Anne Veendijk, Head of Facilities
Alex Benjamins, Technical support engineer
Henk Bakhorst, Security
Roelie Kremers, Telephone operator
Derk Kuipers, Building and terrain
Arjen Meijer, Technical support
Frits Möller, Facilities coordinator
Miranda Vos, Telephone operator
Albert Wieringh, Security

Astronomy Group
Raffaella Morganti, Head of Astronomy
Monique Ankoné, Coordinator education and diversity*
Megan Argo, Research assistant
Ike van Bennemel, PostDoc
Alicia Berisano Alba, PostDoc
Erwin de Blok, Senior staff astronomer*
Ger de Bruyn, Senior astronomer
Adam Deller, Junior scientist
Liesbet Elpenhof, Secretary
Neeraj Gupta, Senior staff astronomer*
Marco Drost, Instrument engineer mechanics
Albert van Dun, Support engineer
Nicolas Ebbendörfer, Head of Technical support
Benedetta Fiorelli, Antenna Design Engineer
Marchel Gerbers, Reliability engineer
André Gunst, System engineer
Ronald Halfwerk, Technology Transfer Officer
Hiddo Hanenburg, Instrument mechanics
Jan Iserda, Head of Mechanics Workshop
Dion Kant, Head System design & Integration
Kees Kegel, Senior RF engineer
Eric Kooistra, System engineer
Anne Koster, Project support scientist
Sjoeko Kuipers, Support engineer
Rolf Liddle, Head of Mechanics
Peter Maat, System researcher Photons
Maike Mevius, Researcher*
Jürgen Morawietz, RF Instrument engineer
Eim Mulder, Support engineer
Jan Nijboer, Project support engineer
Ronald Nijboer, Head of Computing
Jan Nordeam, Senior software engineer
Ruud Oostrum, Instrument engineer software
Arash Ovarog, PHD researcher
Vishalbath Nand Pansey, Researcher

Research and Development
Albert-Jan Boonstra, Head of R&D & a.i.
Alexander van Amstelmoor, HPC software engineer
Michel Arts, Antenna Researcher
Laurens Bakker, RF System engineer
Pieter Benthem, Instrument engineer
Mark Bentum, Senior scientist DESP
Sasovata Bhaumik, RFI Microwave instrument engineer*
Jan Geralt Bij de Baate, Senior Project Manager
Patricia Breman, Office manager
Raymond van den Brink, Instrument engineer
Christian Broeckh, HPC Researcher
Wim van Cappellen, Head Antenna Group
Arthur Coolen, Software Design engineer
Renate van Dalen-Bremer, Secretary
Sietse Damsma, Design engineer
Ger van Diepen, Software System engineer
Marco Drost, Instrument engineer mechanics
Albert van Duin, Support engineer
Nicolas Ebbendörfer, Head of Technical support
Benedetta Fiorelli, Antenna Design Engineer
Marchel Gerbers, Reliability engineer
André Gunst, System engineer
Ronald Halfwerk, Technology Transfer Officer
Hiddo Hanenburg, Instrument mechanics
Jan Iserda, Head of Mechanics Workshop
Dion Kant, Head System design & Integration
Kees Kegel, Senior RF engineer
Eric Kooistra, System engineer
Anne Koster, Project support scientist
Sjoeko Kuipers, Support engineer
Rolf Liddle, Head of Mechanics
Peter Maat, System researcher Photons
Maike Mevius, Researcher*
Jürgen Morawietz, RF Instrument engineer
Eim Mulder, Support engineer
Jan Nijboer, Project support engineer
Ronald Nijboer, Head of Computing
Jan Nordeam, Senior software engineer
Ruud Oostrum, Instrument engineer software
Arash Ovarog, PHD researcher
Vishalbath Nand Pansey, Researcher
Harm-Jan Pepping, Design engineer DESP
Johan Pragt, Head of Mechanics
RajThilak Rajan, Digital signal processing engineer
John Romaine, System researcher Software
Mark Ruiter, RF Instrument engineer
Gjis Schoonderbeek, Instrument engineer DESP
David Smith, PostDoc OLFAR*
Niel Tromp, Instrument engineer
Mechanics
Lars Venema, Senior researcher
Klaus Visser, RF Instrument engineer
Erik van der Wal, RF Instrument engineer
Stefan Wijnholds, Researcher
Ronald de Wild, Head of Instrument engineer DESP
Roel Witvers, RF Instrument engineer
Bert Woostenberg, Head of RF & low noise systems
Sarav Yatavwatta, Researcher Software
Sjoeko Zwier, Design engineer DESP

Radio Observatory
René Vermeulen, Director Radio Observatory
Michiel Brentjens, Researcher science support
Pieter Donker, ICT/Software engineer
Liesbet Elpenhof, Secretary
Richard Failows, Support scientist*
Wilfred Friesevijk, Support scientist
Van Grange, Scientific Programmer*
Teun Git, ICT/Software engineer
Peter Groupen, Support engineer electronics
Hanno Holties, System engineer
Alvin de Jong, ICT/Software engineer
Guyla Józsa, Support scientist
Wouter Klijn, Software engineer
Geert Kuper, Operator
Hans van der Marel, System engineer
Henri Meulman, Head of Science Support
Niels Tromp, Instrument engineer
Sasowata Bhaumik, Support scientist
Mark Bentum, Senior scientist
Sjoeko Kuipers, Support engineer
Rolf Liddle, Head of Mechanics
Peter Maat, System researcher Photons
Maike Mevius, Researcher*
Jürgen Morawietz, RF Instrument engineer
Eim Mulder, Support engineer
Jan Nijboer, Project support engineer
Ronald Nijboer, Head of Computing
Jan Nordeam, Senior software engineer
Ruud Oostrum, Instrument engineer software
Arash Ovarog, PHD researcher
Vishalbath Nand Pansey, Researcher

*New employee in 2012
Appendix 5: publications

Astronomy Group and Observatory publications in refereed journals

1. Xu Han, Tao An, Jun-Yang Wang, Jing-Min Lin, Ming-Xie Xie, Hai-Guang Xu, Xiao-Yu Hong, Sandor Frey: Confirming the 115.5-day periodicity in the X-ray light curve of ULX NGC 5408 X-1, 2012, Research in Astronomy and Astrophysics, 12, 1597-1602

2. Marc Klein Wott, Amin Aminei, Philippe Zarka, Jan-André Schneider, Albert-Jan Boonstra, Heino Falcke: Radio astronomy with the European Lunar Lander: Opening up the last unexplored frequency regime, 2012, planetary and space science, 74, 167-178


112. P. Abreu, [32 authors collapsed]: H. Falcke and [367 authors collapsed]: A search for anisotropy in the arrival directions of ultra high energy cosmic rays recorded at the Pierre Auger Observatory, 2012, Journal of Cosmology and Astro-Particle Physics, 04, 040.


Research & Development

Referred journal publications


Non-refereed publications (papers)

1. Bultink, S., Falcke, H., James, C., Mevis, M., Scholten, O., Singh, K., Stappers, B. & ter Veen, S.
   Constraints on ultra-high-energy neutrino flux from radio observations of the Moon
   Astrophysics and Space Sciences Transactions, 2012, Vol. 8, pp. 29-33

Non-refereed publications (papers)

   Preliminary optical design for the WEAVE two-degree prime focus corrector

1. Agós, T., Navarro, R., Venema, L., Kroes, G.
   Optimizing an active extreme asphere based optical system

1. Agós, T., Venema, L., Korkiakoski, V. & Kroes, G.
   Optimizing optical systems with active components

1. Amerongen, A.H. van, Agós, T., Brug, H. van, Nieuwland, G., Venema, L. & Hoogeveen, R.W.M.
   Development of silicon immersed gratings for METIS on E-ELT

1. Ardenne, A. van, Faulkner, A., Vaate, J.G. bij de
   Optimization of radio interferometer beam shapes using Riemannian optimization
   Experimental Astronomy, 2012, pp. 29-33

1. Ardenne, A. van, Bentum, M. & Boonstra, A.J.
   METIS: the thermal infrared instrument for the E-ELT
   Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series 2012, Vol. 8446

1. Bemmel, I.M. van, Ardenne, A. van, Vaate, J.G. bij de, Faulkner, A.J., Morganti, R.
   High-frequency Aperture Arrays, the future of Radio Astronomy

1. Bonn, P. & Kant, G.
   EMBRACE: Results from an aperture array for radio astronomy
   6th European Conference on Antennas and Propagation (EUCAP)
   Prague (Czech Republic), March 26-30, 2012, pp. 629-633

   METIS: the thermal infrared instrument for the E-ELT
   Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series 2012, Vol. 8446

   Non-refereed publications (papers)

1. Bregman, J.D.
   System Design and Wide-field Imaging Aspects of Synthesis Arrays with Phased Array Stations

1. Cappellen, W.A. van, Wijnholds, S.J.
   EKSA: high performance computing in the square kilometer array
   Delft ACM (NL), June 2012, pp. 9-16

1. Cappellen, W.A. van, & Wijnholds, S.J.
   Communication schemes for LOFAR's inter-satellite links
   63rd International Astronautical Congress (IAC2012), Naples (Italy), October 1-5, 2012

   Experimental evaluation of polarimetric beamformers for an L-band phased array feed
   6th European Conference on Antennas and Propagation (EUCAP)
   Prague (Czech Republic), March 26-30, 2012, pp. 634-637

   METIS: the thermal infrared instrument for the E-ELT
   Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series 2012, Vol. 8446

   MOONS: a multi-object optical and near-infrared spectrograph for the VLT
   Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series 2012, Vol. 8446

   MOONS: a multi-object optical and near-infrared spectrograph for the VLT
   Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series 2012, Vol. 8446

1. Dohlen, K., Mouillet, D. & Wildi, F.
   SPHERE / ZIMPOL: characterization of the FLC polarization modulator
   Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series 2012, Vol. 8446
WEAVE: the next generation wide-field spectroscopy facility for the William Herschel Telescope
School of Photo-Optical Instrumentation Engineers (SPIE) Conference Series 2012, Vol. 8446

MUltI INPUT lNB – DEMONSTRATOR OF A REFLECTOR FEED ARRAY RECEIVER FOR SATELLITE BROADCAST RECEPTION
94th ESA Antenna Workshop, Noordwijk, NL, October 3-5, 2012

System design for SKA capable aperture arrays
International Conference on Electromagnetics in Advanced Applications (ICEAA)
Cape Town, South Africa, Sept. 2-8, 2012, pp. 752 - 755

The LOFAR Multifrequency Snapshot Sky Survey (MSSS): Description and First Results
American Astronomical Society Meeting Abstracts 219,

Oblique projection beamforming for RFI mitigation in radio astronomy
IEEE Statistical Signal Processing Workshop (SSP), Ann Arbor, MI, USA, August 5-8, 2012, pp. 93-96

24. Heilburg, G., Trainini, T., Weber, R., Moreau, E., Capdessus, C., Boonstra, A.J.,
RFI subspace estimation techniques for new generation radio telescopes

Oblique projection beamforming for RFI mitigation in radio astronomy
IEEE Statistical Signal Processing Workshop (SSP), Ann Arbor, MI, USA, August 5-8, 2012, pp. 93-96

American Astronomical Society Meeting Abstracts 219,

A new generation active array for optical flexibility in astronomical instrumentation
American Astronomical Society Meeting Abstracts 219,

Modeling the instrumental polarization of the VLT and E-ELT telescopes

Modeling the instrumental polarization of the VLT and E-ELT telescopes

Performance analysis of clustered radio interferometric calibration
International Conference on Acoustics, Speech and Signal Processing (ICASSP), IEEE, Kyoto (Japan), March 25-30, 2012, pp. 2533 -2536

VISIR upgrade overview and status

Potential of phase-diversity for metrology of active instruments

33. Kragt, J., Elshwi, E. & Duin, A.
Cyrogenic fast shutter design and test results for the MATISSE instrument

MATISSE selection mechanism development

35. Kroes, G., Navarro, R., Venema, L.
A new generation active array for optical flexibility in astronomical instrumentation
American Astronomical Society Meeting Abstracts 219,

36. Kroes, G., Navarro, R., Venema, L.
Matroso-optical design for transmission optics in cryogenic space instrumentation
International Conference on Electromagnetics in Advanced Applications (ICEAA)
Cape Town, South Africa, Sept. 2-8, 2012

MATISSE selection mechanism development

38. Kroes, G., Navarro, R., Venema, L.
Matroso-optical design for transmission optics in cryogenic space instrumentation
International Conference on Electromagnetics in Advanced Applications (ICEAA)
Cape Town, South Africa, Sept. 2-8, 2012

39. Kroes, G., Navarro, R., Venema, L.
A new generation active array for optical flexibility in astronomical instrumentation
American Astronomical Society Meeting Abstracts 219,
41. Noordam, J.E.
The Start of SKA: What Really Happened?

The design of the MMONS VST spectrometer

Development of a 2D precision cryogenic chopper for METIS

Alignment of the SPHERE-ZIMPOL imaging polarimeter

45. Roy, M., Bhaumik, S. and George, D.
Efficient Work-Distribution Strategy for Gridding Radio-Telescope Data on GPUs
International Conference on Acoustics, Speech and Signal Processing (ICASSP), IEEE, Hoboken, NJ (USA), June 17-20, 2012, pp. 525-528

46. Ramein, J.W.
An Efficient Wind-Distribution Strategy for Gridding Radio-Telescope Data on GPUs

47. Roy, M., Bhaumik, S. and George, D.
Cost-effective aperture arrays for SKA Phase 1: single or dual-band?
SKA memo series, memo 140, 2012

Tests of the demodulating CCDs for the SPHERE / ZIMPOL imaging polarimeter

Improve axial ratio quality for radio telescope applications with a phased array feed
6th European Conference on Antennas and Propagation (EUCAP), pp. 1077 -1080, Praque (Czech Republic), March 26-30, 2012

50. Wijnholds, S.J., Noorishad, P.
Statistically Optimal Self-Calibration of Regular Imaging Arrays
20th European Signal Processing Conference (EUSIPCO), Bucharest (Romania), August 27-31, 2012 (refereed conference, co-sponsored by IEEE and Eusipco), pp. 1304-1308

51. Wijnholds, S.J.
A planned Green Powered high-frequency array demonstrator
Workshop The Power Challenges of Mega-Science Infrastructures: the example of SKA
Moura (Portugal) and Sevilla (Spain), June 20-21, 2012

52. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

53. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

54. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

55. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

56. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

57. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

58. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

59. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

60. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

61. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

62. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

63. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

64. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

65. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

66. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

67. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

68. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
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69. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

70. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

71. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

72. Wijnholds, S.J.
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SKA Memo Series, no. 140, July 2012

73. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

74. Wijnholds, S.J.
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77. Wijnholds, S.J.
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SKA Memo Series, no. 140, July 2012

78. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

79. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

80. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

81. Wijnholds, S.J.
LOFAR Configuration Considerations as a Design Exercise for SKA
SKA Memo Series, no. 140, July 2012

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IBM Inspire Beyond Today’s Technology Event, Amsterdam (NL), Sept. 14, 2012

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8. Cappellen, W.A. van
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URSI Benelux Forum 2012, Brussels (Belgium), Sept. 14, 2012

9. Diepen, G. van,
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11. Maat, P.
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13. Nijboer, R.
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Presentation on CALIM (CALibration and IMaging for the SKA) 2012 workshop, Cape Town (South Africa), Dec. 2-7, 2012

15. Romein, J.W. and Nieuwpoort, R.V. van,
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17. Schuur, D. van der
Integrating Uniboards: high performance processing systems for radio astronomy (presentation)
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19. Vaate, J.G. bij de
Aperture Arrays for the SKA in South Africa (presentation)
South African SKA Office, Sept. 6th, 2012

20. Vaate, J.G. bij de
Radio Astronomy R&D (presentation)
Cape Town University (South Africa), Oct. 18, 2012
### Appendix 6: abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A&amp;A</td>
<td>Astronomy &amp; Astrophysics</td>
</tr>
<tr>
<td>AA</td>
<td>Aperture Array</td>
</tr>
<tr>
<td>AAS</td>
<td>American Astronomical Society</td>
</tr>
<tr>
<td>AAVP</td>
<td>Aperture Array Verification Programme</td>
</tr>
<tr>
<td>AG</td>
<td>Astronomy Group</td>
</tr>
<tr>
<td>AGN</td>
<td>Active Galactic Nuclei</td>
</tr>
<tr>
<td>APERTIF</td>
<td>APERture Tiles In Focus, a focal plane array upgrade project for the WSRT</td>
</tr>
<tr>
<td>ASTRON</td>
<td>Netherlands Institute for Radio Astronomy</td>
</tr>
<tr>
<td>ATH</td>
<td>ASTROTEC Holding Company</td>
</tr>
<tr>
<td>DAS-4</td>
<td>The Distributed ASCI Supercomputer 4</td>
</tr>
<tr>
<td>EC</td>
<td>European Commission</td>
</tr>
<tr>
<td>E-ELT</td>
<td>European Extremely Large Telescope</td>
</tr>
<tr>
<td>EMBRACE</td>
<td>European Multi-Beam Radio Astronomy Concept - a dense aperture array demonstrator</td>
</tr>
<tr>
<td>EoR</td>
<td>Epoch of Reionisation</td>
</tr>
<tr>
<td>ESA</td>
<td>European Space Agency</td>
</tr>
<tr>
<td>ESTEC</td>
<td>European Space Research and Technology Centre</td>
</tr>
<tr>
<td>EVN</td>
<td>European VLBI Network</td>
</tr>
<tr>
<td>FPGA</td>
<td>Field Programmable Gate Array</td>
</tr>
<tr>
<td>FTE</td>
<td>Full Time Equivalent; the effort expended by one full-time employee</td>
</tr>
<tr>
<td>GPU</td>
<td>Graphical Processing Unit</td>
</tr>
<tr>
<td>GRB</td>
<td>Gamma-ray bursts</td>
</tr>
<tr>
<td>HI</td>
<td>Neutral Hydrogen</td>
</tr>
<tr>
<td>IAC</td>
<td>International Astronautical Congress</td>
</tr>
<tr>
<td>IAU</td>
<td>International Astronomical Union</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
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<tr>
<td>ILT</td>
<td>International LOFAR Telescope</td>
</tr>
<tr>
<td>IR</td>
<td>InfraRed</td>
</tr>
<tr>
<td>ISM</td>
<td>Interstellar Matter</td>
</tr>
<tr>
<td>JIVE</td>
<td>Joint Institute for VLBI in Europe</td>
</tr>
<tr>
<td>LNA</td>
<td>Low-noise amplifier</td>
</tr>
<tr>
<td>LOFAR</td>
<td>Low Frequency Array</td>
</tr>
<tr>
<td>METIS</td>
<td>Multi-Frequency Front-End</td>
</tr>
<tr>
<td>MHz</td>
<td>Megahertz</td>
</tr>
<tr>
<td>MIRI</td>
<td>Infrared camera and spectrometer for the James Webb Space Telescope</td>
</tr>
<tr>
<td>MNRAS</td>
<td>Monthly Notices of the Royal Astronomical Society</td>
</tr>
<tr>
<td>NEXPRES</td>
<td>Novel Explorations Pushing Robust e-VLBI Services</td>
</tr>
<tr>
<td>NL</td>
<td>The Netherlands</td>
</tr>
<tr>
<td>NOVA</td>
<td>Netherlands Research School for Astronomy (collaboration of five Dutch universities)</td>
</tr>
<tr>
<td>NWO</td>
<td>Netherlands Organisation for Scientific Research</td>
</tr>
<tr>
<td>PAF</td>
<td>Phased Array Feed</td>
</tr>
<tr>
<td>PhD</td>
<td>Doctor of Philosophy</td>
</tr>
<tr>
<td>PSR</td>
<td>Pulsar</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>RF</td>
<td>Radio Frequency</td>
</tr>
<tr>
<td>RFI</td>
<td>Radio Frequency Interference</td>
</tr>
<tr>
<td>SAC</td>
<td>Science Advisory Committee</td>
</tr>
<tr>
<td>SKA</td>
<td>Square Kilometre Array</td>
</tr>
<tr>
<td>SNN</td>
<td>Joint Collaboration Northern Netherlands</td>
</tr>
<tr>
<td>SPHERE</td>
<td>Spectro-Polarimetric High-contrast Exoplanet Research</td>
</tr>
<tr>
<td>SPIE</td>
<td>International society for optics and photonics</td>
</tr>
<tr>
<td>URSI</td>
<td>International Union of Radio Science</td>
</tr>
<tr>
<td>VLBA</td>
<td>Very Long Baseline Array</td>
</tr>
<tr>
<td>VLB</td>
<td>Very Long Baseline Interferometry</td>
</tr>
<tr>
<td>VLT</td>
<td>Very Large Telescope</td>
</tr>
<tr>
<td>VLTI</td>
<td>VLTI Interferometer</td>
</tr>
<tr>
<td>WHT</td>
<td>William Herschel Telescope</td>
</tr>
<tr>
<td>WSRT</td>
<td>Westerbork Synthesis Radio Telescope</td>
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</table>
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ASTRON is the Netherlands Institute for Radio Astronomy. Its mission is to make discoveries in radio astronomy happen, via the development of novel and innovative technologies, the operation of world-class radio astronomy facilities, and the pursuit of fundamental astronomical research.

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