FOM in 2013

Foundation for Fundamental Research on Matter

FOM NWO

Cover: AMOLF researchers peek into light's forgotten component

The electrical and magnetic field of light were measured simultaneously for the first time in 2013 at the FOM Institute AMOLF. The measurements offer a new way to study the interaction between light and matter at the nanoscale. The researchers therefore expect that their discovery will give a major boost to the development of new metamaterials, for example materials for invisibility cloaks.

The illustration on the cover of the 2013 yearbook is an artistic interpretation of this unique experiment. The aluminium needle with the glass core can be seen to the right. To the left, the middle portion shows a series of scans above the structure, made at varying heights from left (380 nanometres above the crystal) to right (20 nanometres above the crystal). The researchers unravelled the electrical (upper mountain landscape) and magnetic fields (lower mountain landscape) from these measurements.

>>> The article by B. le Feber, N. Rotenberg, D.M. Beggs and L. Kuipers, Simultaneous measurement of nanoscale electric and magnetic optical fields, Nature Photonics, 15 December 2013, DOI: 10.1038/nphoton.2013.323, requests via library@amolf.nl.

FOM IN 2013

English summary of the annual report

Scientific research highlights from 2013 are available in English via www.fom.nl/highlights2013

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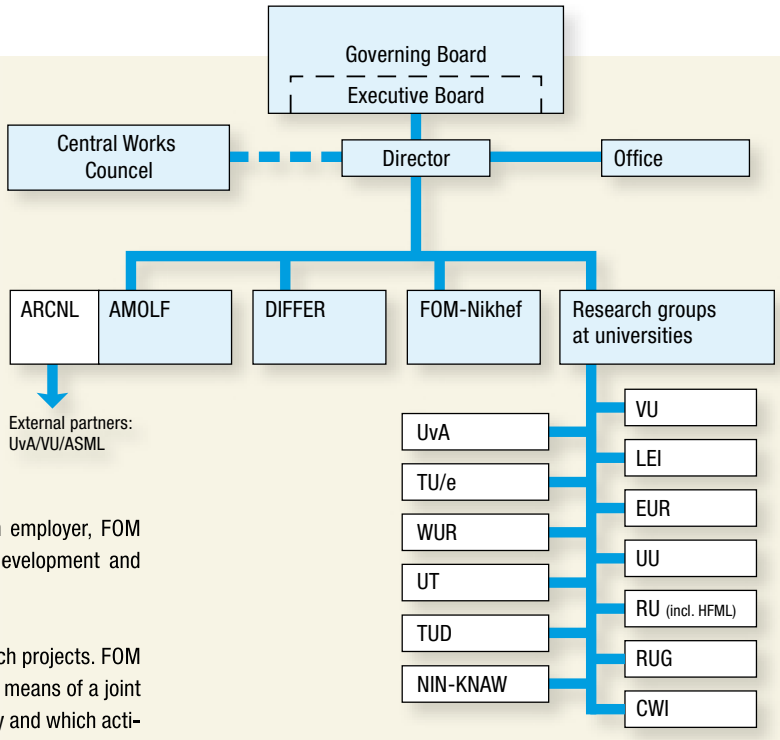
About FOM

The Foundation for Fundamental Research on Matter (FOM) is part of the Netherlands Organisation for Scientific Research (NWO). Since 1946 it has funded and performed physics research of international repute in the Netherlands. As a research employer and research-funding body, FOM has a facilitating and coordinating role within Dutch physics research.

FOM currently has more than 1100 employees. They work at one of the three FOM institutes, a Dutch university or a foreign research institute. As an employer, FOM does everything it can to facilitate the professional development and career opportunities of its talented employees.

On top of this, FOM selects and funds top quality research projects. FOM tries to embed research in universities and institutes by means of a joint agenda. FOM's Governing Board determines the strategy and which activities take place. This includes ensuring that industry and society benefit from its results and informing the public about the importance of the excellent research funded.

For the purpose of programme management, FOM distinguishes the research fields in physics it is active in. It also pays particular attention to focal points such as the theme of energy and collaboration with industry.



The public-private funded Advanced Research Centre for NanoLithography (ARCNL) is a new type of collaboration, in this case between ASML, FOM, NWO, University of Amsterdam and VU University Amsterdam. ARCNL will fall under AMOLF for the time being and will eventually become an independent centre executed by FOM.

FOM invests in:

Top quality physics research
- effective funding instruments, solid infrastructure & competitive climate;
- ample opportunities for new developments;
- multidisciplinary collaboration;

Physics for society
- valorisation of knowledge from current research;
- collaboration with industry and technology institutions;
- research subjects relevant to society;

Sustainable energy
- national institute for fundamental energy research;
- focus groups at universities;
- specific instrument: Fellowships for Young Energy Scientists (YES!);

The science system
- Sector Plan Physics and Chemistry;
- women in physics;

Research facilities
- large research infrastructures;
- positioning HFML as an international facility;
- focus groups at universities.

>>> www.fom.nl

Chapter 1. Top quality

In 2013, FOM gave physics research in the Netherlands a boost by awarding five new 'Vrij FOM-programmas', six Industrial Partnership Programmes and two mission-strengthening programmes at its institutes. A total of 64 research programmes are currently underway in which a large number of physicists from various universities and institutes in the Netherlands are working together. A new form of collaboration between a company and two universities also started this year: the Advanced Research Centre for NanoLithography (ARCNL). In addition, twenty new FOM Projectruimte projects commenced. In the context of the top sectors, the TKI allowance (a form of subsidy) generated by research within the Top Sector HTSM has been distributed among five projects. Furthermore, in 2013, FOM issued two calls in this area, resulting in five projects in the HTM call (along with Technology Foundation STW and M2i) and four projects in the HTSM call (with Technology Foundation STW). FOM also awarded seven projects in the area of CO_2-neutral fuels with Shell and NWO Chemical Sciences and 22 for the CSER PhD programme. Both of these initiatives fall within the Top Sector Energy.

A complete summary of all programmes running in 2013 can be found at www.fom.nl/highlights2013.

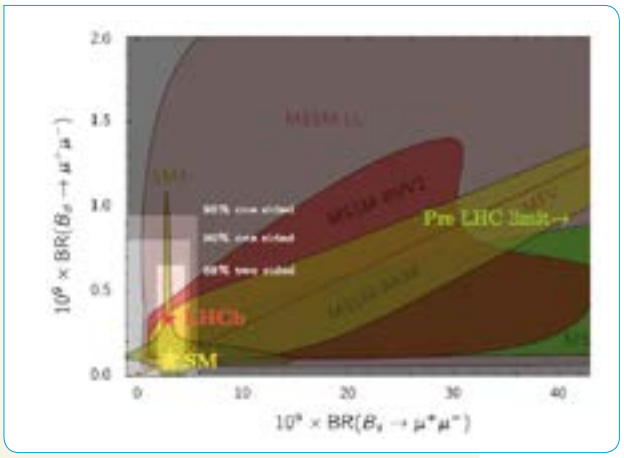
Researchers can submit proposals to FOM for various **funding instruments:**

- FOM-Projectruimte: for small projects up to k€ 400;
- Vrije FOM-programma's: for research proposals ≥ M€ 1;
- Industrial Partnership Programmes: for collaboration with companies;
- YES! Fellowships Programme: postdoc programme for young energy researchers;
- FOm/f Programme: postdoc programme for talented female researchers in physics;
- scientific conferences and workshops in the Netherlands.

A focus group is a special type of FOM programme. Under the leadership of a top researcher, a FOM focus group makes a substantial contribution to challenging scientific research. FOM can appoint a focus group top down but also bottom up, in competition based on an approved proposal from a researcher.

>>> www.fom.nl/focusgroups

2013 Nobel Prize for the Higgs mechanism theory

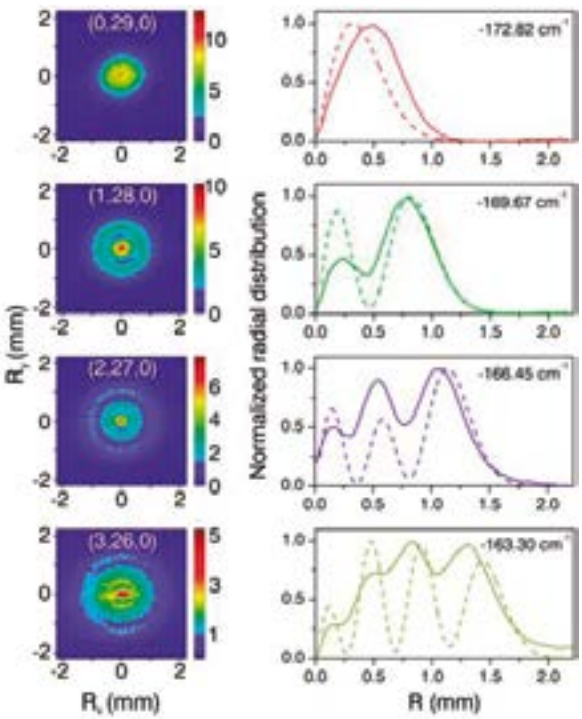


The 2013 Nobel Prize in Physics went to the Belgian **François Englert** and Englishman **Peter Higgs** for the theory they formulated (together with Robert Brout) for the so-called Higgs mechanism. The mechanism explains why elementary particles have mass, and requires the existence of a particle that had not been observed until recently. In July 2012, CERN scientists discovered a new particle during the ATLAS and CMS experiments; this actually turned out to be a Higgs particle. This result confirmed the theory from the 1960s. A significant number of Nikhef scientists were involved in the Higgs study. For the ATLAS experiment, they made important contributions in all areas: hardware (the design and construction of important components of the ATLAS detector, among other things), computing (Tier-1 LHC computing centre), software (improvement of the identification of muons, among other things), analysis of the measurement results (also decay channels) and the statistical combination of the various data sets. Researchers from the University of Twente contributed to the accelerator, the Large Hadron Collider at CERN (magnets). Various Dutch researchers are (or were) also active at CERN.

Breakthrough of 2013: image of the inside of an atom

The research of **Dr Aneta Stodolna**, who gained her doctorate at FOM Institute AMOLF, ranks among the top ten breakthroughs in physics in 2013 according to a list compiled by Physics World in December. Stodolna and former AMOLF group leader professor Marc Vrakking were able to make a direct image of the inside of an atom for the first time. This photo of electron orbits in a hydrogen atom made news around the world. Professor Florian Schreck (University of Amsterdam) is also among the top ten with his research into laser-cooled Bose-Einstein condensates. His more efficient technique, using only lasers in the cooling process, opens the door to additional applications.

The orbitals of an atom visualised for the first time by AMOLF scientists Stodolna and Vrakking.



EPS awards Emmy Noether Distinction to Nynke Dekker

The European Physical Society awarded the EPS Emmy Noether Distinction for women in physics to **professor Nynke Dekker** (Delft University of Technology), member of the FOM Executive Board. The award is described in the December 2013 issue of Europhysics News. The EPS Emmy Noether Distinction, now awarded for the second time, was established to improve the recognition of female physicists who have a strong link to Europe either by nationality or through their work. The European Physical Society hopes that the winners will also be role models so that more women will ultimately choose a career in physics. The criteria for the prize are personal achievements in the areas of research, education, outreach and industry.

#FOMonline

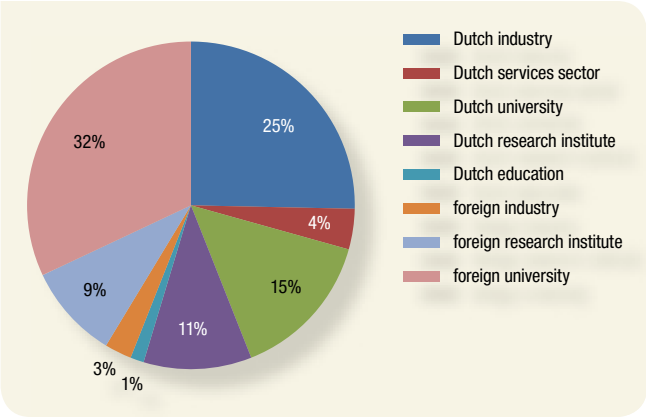
Nobelprize_org, *@Nobelprize_org, 8 oktober 2013*
In 2012, the Higgs particle is discovered at CERN - the missing piece of the Standard Model puzzle. #NobelPrize #Physics

jan van den berg, *@janyama, 8 oktober 2013*
#Higgs personally assured me that he will be unfindable today. So if it's him that they're waiting for ... let's start!

Output

PhDs provide an important contribution to the knowledge economy. FOM PhDs leave the organisation and take the knowledge and skills that they gained at FOM with them. This also applies to foreign FOM PhDs who often settle down in the Netherlands after graduation. In this way, science makes its most effective contribution to society, both inside and outside industry.

The most recent figures for the career choices of the FOM PhDs can be seen below. In Chapter 7 you can read more about the FOM personnel policy and find an analysis of the influx and outflow of FOM PhDs.



Career choices made by those FOM PhDs who graduated in 2013 and whose choice is known. Since FOM is not always able to reach its former employees, it is not always aware of everyone's current situation in the employment market. Some PhDs are also still looking for work.

In 2013, FOM research resulted in 1,192 publications that were reviewed by external referees. 91 PhD students from FOM graduated in 2013. Since 2012, FOM's policy has been to encourage publishing results in open access publications, either in open access journals or indirectly by making content accessible - by posting it on another website, for example.

Table 1. FOM output 2013.

	AMOLF	DIFFER	Nikhef	university workgroups	total
theses	10	8	12*	61	91
scientific publications (peer-reviewed)	110	129	437	516	1,192
other publications	2	60	346	1,429	1,837
patents	7	0	1	5	13

** At Nikhef in 2013, other persons gained their PhDs in addition to the 12 graduates mentioned here. However, they were not employed at FOM but by one of the other partners in the Nikhef collaborative partnership. They have not been included in the summary.*

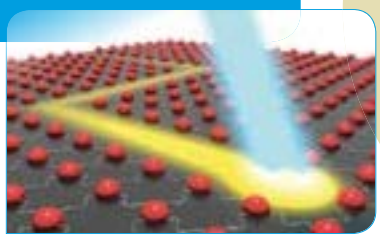
FOM research results regularly in patent applications. In 2013, ten applications were submitted. FOM's commercial knowledge policy is aimed primarily at making the results of FOM research available to third parties. Whenever potential patents are involved, FOM looks for a user as quickly as possible. Usually, a patent is applied for only after an interested party is found who wishes to buy the new knowledge. FOM encourages its employees to apply for patents by contributing financially to certain patenting costs and by offering inventors (employed by FOM) an incentive that increases along with profits generated by the invention.

>>> www.fom.nl/patents

FOM institutes

The FOM institutes are the driving force behind, or coordinator of, specific research areas and realise these responsibilities in close collaboration with the universities. They have a research budget as part of their strategic plan.

AMOLF (Amsterdam) is the driving force behind new developments within nanophotonics and biophysics.



Nanolithography with new supramolecular structures, as inspiration for the new Advanced Research Centre for NanoLithography (ARCNL). This public-private funded ARCNL is a new type of collaboration, in this case between ASML, FOM, NWO, University of Amsterdam and VU University of Amsterdam. ARCNL will fall under AMOLF for the time being and will eventually become an independent centre executed by FOM.

FOM Institute AMOLF

www.amolf.nl

AMOLF in 2013

People (in fte) 31-12-2013	
permanent scientific staff	12.23
PhDs	62.92
postdocs	35.28
permanent support staff	55.26
temporary support staff	11.75
Finances (in million Euros)	
total activity level	17.3
Output	
PhD theses	10
refereed articles	110
other articles	2
patents	7

DIFFER, the new FOM Institute for Fundamental Energy Research (Nieuwegein), carries out fundamental energy research in the area of fusion energy and solar fuels. DIFFER will move to the campus of Eindhoven University of Technology.

Kick-off of new construction at DIFFER - Festive start to the construction of the energy institute DIFFER at Eindhoven Technical University Construction can be followed live via webcam: ››› http://nieuwbouw-cam.differ.nl.

DIFFER
Dutch Institute for Fundamental Energy Research

www.differ.nl

DIFFER in 2013

People (in fte) 31-12-2013	
permanent scientific staff	17.97
PhDs	28.23
postdocs	12.71
permanent support staff	59.98
temporary support staff	5.95
Finances (in million Euros)	
total activity level	20.8
Output	
PhD theses	8
refereed articles	129
other articles	60
patents	0

Nikhef (Amsterdam) focuses on particle physics and astroparticle physics, investigating the smallest building blocks of matter and has a national coordinating role.

More than hundred physicists followed the announcement of the Nobel Prize for Physics 2013 live via a large screen at Nikhef.

NIKHEF

www.nikhef.nl

Nikhef in 2013

People (in fte) 31-12-2013	
permanent scientific staff	36.48
PhDs	54.3
postdocs	31.88
permanent support staff	88.79
temporary support staff	7.82
Finances (in million Euros)	
total activity level	25.4
Output	
PhD theses *	12
refereed articles	437
other articles	346
patents	1

** At Nikhef in 2013, other persons gained their PhDs in addition to the 12 graduates mentioned here. However, they were not employed at FOM but by one of the other partners in the Nikhef collaborative partnership.*

Grants awarded

Research of particular strategic importance that does not fit within the framework of any of FOM's funding instruments can be awarded funding as a strategy programme by FOM's Executive Board. In 2013, FOM started two mission-strengthening programmes. In September, the Executive Board decided to award Nikhef's request for a new programme in the area of LHC physics for the amount of 16.9 million euros. The programme runs from 2014 to 2021. The programme involves the utilisation (also by PhDs and postdocs) of the Dutch contribution to the LHC experiments ATLAS, LHCb and ALICE. DIFFER's request for a mission-strengthening programme with the title of 'Magnum PSI: a world-class user facility to tame the plasma-wall interface' was also awarded. This mission-strengthening strategy programme will run from 2014 to 2018.

In a 'Vrij FOM-programma', specialists from the various Dutch knowledge institutions join forces in specific domains. The research groups work in areas in which Dutch physicists excel internationally and in which a clear scientific and societal interest is present. With its Vrije programma's, FOM pursues two objectives: as high a quality of physics research in the Netherlands as possible plus a focus on scientific topics with the bundling of research activities (mass). In 2013, 12 pre-proposals were submitted for new programmes. Of these, FOM ultimately awarded five for a total amount of 10.2 million euros. At the end of 2013, there were 64 approved research programmes. FOM spends 63 percent of its total operating budget on these.

‹‹‹ The new research programmes of 2013.

The FOM Projectruimte is intended for risky, ground-breaking research and is therefore often a breeding ground for new ideas. At the end of 2013, a total of 186 Projectruimte projects were underway. Of the 58 applications submitted to FOM in the spring round of 2012, 14 requests were awarded in April for a total amount of 5.7 million euros. In December 2012, the Executive Board had already decided to award one application from the spring round so that a total of 15 projects were awarded for an amount of 6.2 million euros. Ultimately 26 percent of the proposals were funded.

As of 1 May 2013, the FOM Projectruimte started to use a system of continuous submission instead of two fixed deadlines per year, as was customary in the past. In early September, a first batch of assessments started with 17 proposals. In December, the Executive Board decided to award five projects from among these (29 percent) for an amount of 2 million euros.

››› www.fom.nl/grants

FOM prizes

The FOM Foundation has four scientific prizes available. With these prizes, FOM wishes to support physics research and the application of knowledge at various scientific levels. The FOM prizes are awarded each year during the Physics@ FOM Veldhoven conference.

>>> www.fom.nl/prizes

The FOM Physics Thesis Prize is awarded each year to the best dissertation on physics.

FOM has awarded the FOM Physics Thesis Prize 2013 to Dr. Martin Frimmer. He has won the prize with his thesis entitled 'Spontaneous emission near resonant optical antennas'. Frimmer carried out his research at FOM Institute AMOLF, under the supervision of professor Femius Koenderink. On 14 November 2012 he defended his thesis at the University of Amsterdam. The FOM Physics Thesis Prize jury is particularly impressed by the superb readability of Frimmer's thesis as well as the depth of his scientific analysis.

FOM awards the Minerva Prize once every two years to the best publication by a female researcher about a topic in physics.

FOM has awarded the Minerva Prize 2013 to Dr Katerina Dohnalová assistant professor at the University of Amsterdam. She receives the prize for research into silicon quantum dots. The committee was highly impressed by the article that she published in Light Science and Applications: 'Surface brightens up Si quantum dots: direct bandgap-like size-tunable emission'. At the end of 2013, Dohnalová received a tenured position from the MacGillavry Fellowship at the University of Amsterdam as well.

<< The article that won Dr Katerina Dohnalová (University of Amsterdam) the 2013 Minerva Prize.

The annual FOM Valorisation Chapter Prize encourages FOM PhDs to dedicate a chapter in their theses to the valorisation aspects of their doctoral research. This prize emphasises the importance that FOM places on valorisation and aims to encourage the alertness of PhDs to possibilities for using knowledge.

Dr. Adam Lassise receives the FOM Valorisation Chapter Prize 2013 for a chapter in his thesis in which he clearly describes how optical cavities can be used to improve the resolution of electron spectroscopy.

The aim of the FOM Valorisation Prize is to encourage the use of knowledge from physics research. The prize is awarded annually to a Dutch researcher (or group of researchers) in physics who has successfully made the results from his/her own research useful to society.

The FOM Valorisation Prize 2013 has been awarded to professor Freek Beekman, researcher at Delft University of Technology. "He provides direction and momentum to technical and economic improvements in medical scanning equipment", says the jury.

Josephine Scholten, Director of the Association of Universities in the Netherlands, awarded the FOM prizes on Tuesday evening at the 2014 Physics@FOM Veldhoven.

Chapter 2. Collaboration

Collaboration with adjacent areas of research is one of the focal points of FOM. This collaboration is implicit in nearly all FOM activities. FOM plays an active role in other current and new multidisciplinary developments such as in the area of fundamental energy research. FOM also works closely with a number of large international research facilities and with industry. As an organisation partner or as a participant, FOM is involved in numerous activities at an international level.

>>> www.fom.nl/collaborations

NWO

NWO realises its strategic policy through a number of research themes. FOM is active in some of these themes. In the NWO strategy for the period 2011-2014, under the title Growing through Knowledge, nine themes have been selected, two of which were inspired by top sectors designated by the Dutch Cabinet. The NWO themes most relevant to the FOM are Sustainable Energy and High-tech Systems and Materials (HTSM); the previous Nano theme is now part of HTSM.

The poster prize went on the first NWO Nano day to Marieke Snelder, MSc, FOM PhD student at the University of Twente for her research into quantum mechanics. The prize for the best presentation went to scientist Bas Cloin, MSc.

Universities

Platform University Physics
In 2012, with the approval of the science faculty deans, the Platform University Physics (PUN) was created. This informal platform consists of two representatives from each university who are strongly rooted in physics. FOM is represented as a guest by its chair and director and also acts as secretary. PUN's first ambition is to develop a broadly shared vision of the future of university physics for the coming 5-10 years. The focus is primarily on research. Furthermore, the purpose of the platform is the exchange of best practices and providing solicited and unsolicited recommendations.

In 2013, the PUN met three times and focused on vision development on the one hand and on the exchange of experiences on the other hand. The PUN was involved in the formation of a committee led by professor Robbert Dijkgraaf that was delegated the task of writing a vision document (see later in this report). In the last few meetings, the PUN has also discussed the support and evaluation of tenure-track professors, the development of research schools, the status of women in physics, limiting the length of a PhD study, and initiatives for achieving the goals agreed to earlier in the context of the sector plan (see below). On 1 September 2013, professor Eric Eliel (Leiden University) became chair of the PUN, succeeding professor Vinod Subramaniam (University of Twente).

Sector Plan for Physics and Chemistry
The Sector Plan for Physics and Chemistry, a unique collective effort in the direct and indirect government research funding, defines the pathway for the future development and positioning of physics and chemistry. At the end of 2008, a committee was formed, led by professor Douwe Breimer, to implement the plans. In this year's Strategic Agenda for Higher Education, Research and Science, the State Secretary for Education, Culture and Science explicitly reiterated that the resources in the sector plan are structural and will therefore also remain available after 2016 (for physics and chemistry, each receiving 10 million euros annually). For FOM, this represents the approval of a financial injection of 3 million euros per year.

The sector plan has contributed visibly to the positioning and focussing of university-level research. Of the 42 new positions filled that can lead to a tenured appointment for physicists, 36 percent (15 jobs) went to women.

At the end of 2013, the Breimer Committee – in close consultation with science faculty deans – completed

preparations for the second progress assessment of the sector plan that will take place in 2014. With a deadline of 1 March 2014, the faculties will report to NWO Chemical Sciences and FOM about the progress of the implementation. The science faculty deans will also submit a number of joint reports, including topics such as the linking of masters studies to research focal points and the issues of *brain gain* and *brain drain*. Then, based partly on discussions with stakeholders, the Breimer Committee will provide its second interim report to the Minister for and the State Secretary of Education, Culture and Science at the end of June 2014.

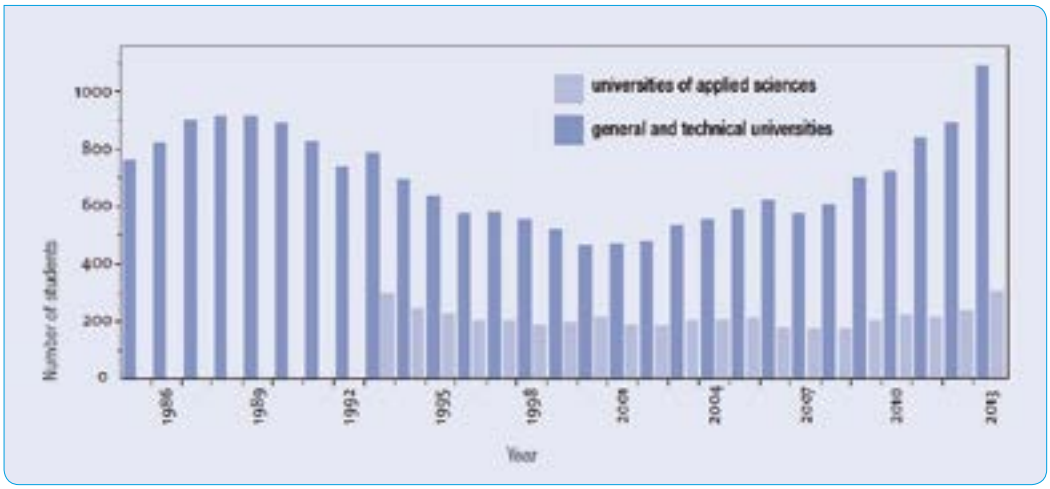
An inventory of first-year physics and applied physics students at universities and universities of applied sciences was held in October 2013. In comparison with 2012, the numbers of first-year physics and astronomy students at universities increased sharply - from 886 in 2012 to 1,083 in 2013. For the sector plan, this is an encouraging development. The increase is especially marked at the technical universities. Unfortunately, the number of female students remained consistently low - some 14 percent.

Vision document for physics and chemistry in 2025

On Monday, 2 December 2013, the Dijkgraaf Committee presented the vision document 'Chemistry & Physics, Fundamental For Our Future' to the representatives of the commissioning body professor Ben Feringa, chair of the NWO Chemical Sciences Board and member of the Regiegroep Chemie, and professor Eric Eliel, chair of the Platform University Physics. The vision document describes the ambitions for physics and chemistry for the coming ten years and is illustrated with the dreams of several young researchers.

A writers' group described the ambitions for 2025 in a single joint document on behalf of the Dutch chemistry and physics communities. This writers' group started at the end of June 2013 under the chairmanship of professor Robbert Dijkgraaf. Based on discussions with stakeholders and followers, seven areas of research were defined that align with the focal points in the Sector Plan for Physics and Chemistry. That plan arose in 2008 under the Breimer Committee's leadership and was rolled out successfully.

Professor Ben Feringa (left), chair of the NWO Chemical Sciences board and member of the 'Regiegroep Chemie', and professor Eric Eliel, chairman of the Platform University Physics in conversation with professor Robbert Dijkgraaf.



Number of first-year physics, astronomy and technical physics students at the general and technical universities from 1985 through to 2013. The number of first-year students studying applied physics courses at universities of applied sciences was added starting in 1993. Source: Nederlands Tijdschrift voor de Natuurkunde, December 2013.

EU

The European Union is becoming increasingly important as a funder of scientific research. FOM keeps an eye on what is happening in Europe and on how FOM can take part in this. FOM will further explore the opportunities next year. Collaborative partnerships with large European research facilities are mentioned in chapter 5.

Horizon 2020, the successor to the Seventh Framework Programme (FP7), started at the end of 2013. The first work programmes and calls were published in December. In broad overview, the new programme focuses on making the European funding of research and innovation projects simpler. This simplification should be expressed in both the programme structure and in the rules for participation. Further, Horizon 2020 should be an instrument that encourages innovation, supports research collaboration with third countries, and strengthens the European Research Area (ERA). Finally, with this new programme, the European Commission wants to provide promising scientists with adequate funding. Ultimately, the aim of Horizon 2020 is to better integrate the funding of research and innovation in a single coherent scheme. To achieve all this, Horizon 2020 focuses on three priorities: 1. Excellent Science, in which ERC, FET and Marie Skłodowska-Curie are the most important instruments; 2. Industrial Leadership, aimed primarily at technology development; and 3. Societal Challenges, thematic programmes aimed at major societal challenges such as energy and health.

>>> http://ec.europa.eu/programmes/horizon2020/en/h2020-sections

In January 2013, the European Union selected 'Graphene' as one of the EU Future Emerging Technology (FET) Flagships. Flagships are a new form of large-scale research in Europe with a duration of ten years and a budget of nearly one billion euros, half of which the EU provides, the Member States providing the other half. Flagships bring academic and industrial research together in a consortium whose objective is to realise breakthroughs in technological innovation. In addition to graphene, the 'Human Brain Project' was also selected as an FET Flagship.

Specific to the Graphene Flagship, is the objective to take graphene and related layered materials out of the laboratory and to make these suitable for society. On 1 October 2013, the Graphene Flagship began its start-up phase in which 75 partners from 17 countries are participating. During this first period, the flagship has a budget of 54 million euros. Several academic teams and an industrial group from the Netherlands are involved. FOM workgroup leaders professor Herre van der Zant (Delft University of Technology) and professor Bart van Wees (University of Groningen) will each coordinate one of the 15 work programmes within the Graphene Flagship: the programmes sensors and spintronics, respectively. Professor Lieven Vandersypen, FOM researcher and professor at Delft University of Technology, is the flagship leader within the Netherlands.

On 19 February 2013, the Dutch TV programme EenVandaag featured graphene.

In addition to the two Flagships Graphene and the Human Brain project, an ERA-Net has been set up in which FOM and NWO participate on behalf of the Netherlands. This ERA-Net 'FLAG-ERA' also officially started on 1 October 2013. The goal of the network is to support the Flagships, which national programmes are running within the flagships' domains at this moment, which transnational programmes could be set up, which knowledge gaps exist, and to exchange information among the national financing organisations and the flagship consortia.

In the context of the FLAG-ERA a joint call will be organised by the consortium, probably in the autumn of 2014. For the graphene-related portion of this call, FOM has received an allocation of 750.000 euros from NWO's co-funding resources for EU projects.

>>> http://www.graphene-flagship.eu

>>> Short film in English featuring the Graphene Flagship.

Chapter 3. Top sectors and collaboration with industry

In FOM/N's 2010-2015 Strategic Plan, FOM states that it will partly focus on fundamental research in areas where the possibility of economic innovations is large. FOM also focuses on topics that can contribute to solutions to major societal issues. One important aspect of science for society is knowledge utilisation (valorisation). FOM aims to support the valorisation of its scientific research along five lines of action:
1. programming a socially relevant research agenda;
2. collaborating with the business community;
3. encouraging entrepreneurship;
4. building on cultural change;
5. protecting and capitalising on knowledge.

In 2013, FOM made collaboration with industry tangible by means of the top sectors and its Industrial Partnership Programmes (IPPs). FOM IPPs are viewed as a powerful way for physics to contribute to the top sectors. In addition, this year saw a new method of institutional collaboration with universities and industry: an Advanced Research Centre. FOM is also involved in the QuTech Institute that focuses on the development of a quantum computer, and with the NIAF, a fund being set up that will allow companies to finance scientific research. You can read more about these initiatives in this chapter.

Top sectors

FOM is involved in a number of top sectors. These are areas that are particularly important for the Dutch economy and for which the government wants to develop a cohesive agenda with industry and knowledge institutions; the key words here are innovation, creativity and entrepreneurship. A total of 19 top consortia for knowledge and innovation (TKIs) have been set up in the nine top sectors. In a TKI, the government, industry, and research institutions join forces with the aim of encouraging public-private collaboration. FOM is involved most closely with the top sectors HTSM and Energy. The principle of the top sectors policy ties in well with how FOM collaborates with industry. So FOM is committed to realising the top sectors policy by means of existing instruments in combination with a number of new initiatives; in addition to the missions for the institutions, the Industrial Partnership Programmes are particularly suitable for this. You can read more about the HTSM in this section and more about FOM and the Top Sector Energy in chapter 5.

After previous cutbacks to scientific research under the first Cabinet of Dutch Prime Minister Mark Rutte, the Minister for Economic Affairs (EZ), Henk Kamp, and the State Secretary for Education, Culture and Science (OCW), Sander Dekker, announced extra investments in fundamental research on 11 February 2013 within the context of implementing the new coalition agreement. The extra resources from the government are intended to encourage fundamental research and to provide an impulse to public-private partnerships (PPP) between knowledge institutions and industry in the context of the top sector policy. Following on the 11 February 2013 letter from Kamp and Dekker, three workgroups, under the auspices of OCW and EZ, started setting up the 'rules of play' for PPP in March. These expert groups were comprised of a broad representation from industry, government, NWO, universities and universities of applied sciences. The IPPs at FOM have been a source of inspiration for these rules of play. In summary, NWO's contribution to the top sectors consists of three pillars:

1 Public-Private Partnership (PPP). Three variants, with as variable the contribution from the business community. Activities arise from joint programming. A private contribution is required;
2 Public-Private Programming: activities arise from joint programming of research. No private contribution is required;
3 Curiosity-driven research focused on the top sectors in which various NWO instruments such as the open competition and the talent programmes can be used.

NWO will develop scientific programmes (PPP) together with the top consortia for knowledge and innovation (TKIs) according to a number of substantive clusters. NWO also encourages scientific efforts in the context of the public-private programming. This includes primarily (a portion of) the basic funding of several scientific institutions (DIFFER, AMOLF, CWI) that are involved (partly) with energy research relevant to the top sector. Examples of this include substantial activities in the area of advanced instrumentation at AMOLF, DIFFER, Nikhef, ASTRON and SRON in the context of the Top Sector HTSM. NWO will establish a single point of contact for the researchers, universities and companies for each of the top sectors.

On 2 October, the 2013 Innovation Conference was held in The Hague. Prior to this, representatives of Dutch companies, public knowledge institutions and governments signed the 2014-2015 Knowledge and Innovation Contract for the Netherlands. This is an agreement about investments

in knowledge innovation in the nine top sectors for the period 2014-2015. A total of twenty parties were signatories to the agreement. Based on the new innovation contracts, researchers, entrepreneurs and government bodies will elaborate concrete research projects in the top sectors. In addition to FOM's use of its own resources, additional funds will come from NWO and a substantial contribution is expected from industry. The contribution from the indirect government research funding for the Advanced Research Centre for NanoLithography - a collaborative partnership between FOM/NWO, the University of Amsterdam, the VU University Amsterdam and ASML - is part of this innovation contract. FOM also receives extra resources from NWO for other activities, primarily for the top sectors HTSM and Energy. This involves research into materials, flow phenomena and nanophotonics. FOM plays an important role in the top sectors HTSM and Energy, and also contributes to the top sectors Chemistry, AgriFood and Life Sciences & Health.

<< FOM & Dutch top sectors
>> http://topsectorenergie.nl/english/

HTSM

The TKI HTSM is the innovation motor for the Top Sector High Tech Systems and Materials (HTSM). The TKI consolidates the strengths of all the players in the sector (via the roadmaps), coordinates the sector's alignment with EU initiatives, tries to get SMEs involved as early as possible in the roadmap networks and PPP initiatives (via the SME portal), and makes new research possible by having the TKI allowance flow back to research institutes. The Holland High Tech foundation was set up to increase the sector's visibility at home and abroad. The TKI HTSM is associated with this. The 16 roadmaps are paramount; these focus on 16 substantive themes, describe the ecosystem for R&D and innovation and indicate opportunities for public-private partnerships. They arose from close collaboration between research organisations and companies and contain the longer term plans with the research themes for research and innovation. The public-private research programmes are realised in close collaboration with the companies by means of the knowledge institutions involved (NLR, TNO, Holst Centre, M2i and NWO, via STW, FOM and EW).

Dr Marco Beijersbergen (right), chairman of the roadmap team, hands the Roadmap for Advanced Instrumentation to HTSM figurehead Amandus Lundqvist (left).

At the start of 2013, the HTSM roadmap teams took a critical look at the roadmaps and reviewed them. Advanced Instrumentation is a new inclusion in the official roadmap. On 3 June 2013, this new roadmap was formally submitted to Amandus Lundqvist, the Top Sector HTSM's figurehead, with representatives of companies and knowledge institutions attending. Advanced Instrumentation is an important area in which dozens of larger and smaller companies are active, in collaboration with knowledge institutions. This area comprises the development of integrated measurement instruments and the associated infrastructure for large scientific projects in national and international context such as CERN, ESA, ESO, ITER, SKA, and includes the development of high-end instruments for scientific, analytical and medical applications or high-tech production equipment. This development is important to FOM because the larger research facilities can also better align with the top sector policy in this manner.

TKI allowance

At the end of February 2013, it was announced that TKI HTSM had awarded a 750,000 euros TKI allowance to the FOM Foundation. At the end of November 2012, various knowledge organisations such as FOM, STW, universities and TNO submitted a request to receive a TKI allowance, along with a proposal for its expenditure. This allowance amounts to 25 percent over and above the cash contributions from companies to partnerships with organisations such as universities, NWO, FOM, STW, TNO and ECN. The Ministry of Economic Affairs encourages these partnerships by awarding the so-called TKI allowance.

At the end of December, FOM awarded five proposals that will receive funding from this TKI allowance. FOM uses the TKI allowance awarded for new research within the collaboration where the basis has been generated – as much as possible into either PhD or postdoc positions or

into valorisation projects. FOM invests in making the link between the programmes (e.g. the Industrial Partnership Programmes) and the expenditure of the allowance as strong as possible so as to maximise the incentive for companies to invest in these programmes.

High Tech Materials calls

At the initiative of the Top Team High Tech Systems and Materials (HTSM), FOM and Technology Foundation STW organise the so-called High Tech Materials calls, together with the Materials Innovation Institute (M2i). The aim of these HTM calls is to provide a boost to scientific materials research in the Netherlands. Research proposals focus on the development of new scientific insights and/or technologies and must fit within the very broad Roadmap for High Tech Materials. Each proposal must include fifty percent in-cash co-funding from industry. Companies may make their contribution to FOM available via M2i. In the call managed by STW in the spring of 2013, ten proposals were submitted. Five of these were awarded. FOM organised the 2013 autumn round. Again ten proposals were submitted for this; the decision will take place in the spring of 2014.

High tech systems and materials call

In 2012, Technology Foundation STW organised a call encompassing the entire breadth of HTSM for which a total of 72 project proposals were submitted. From the physics project proposals submitted, FOM selected four projects at the start of 2013. These have been placed under the FOM programme 'High tech systems and materials' as FOM projects. Any possible projects from future HTSM calls can be added to this.

The total FOM contribution to the four projects amounts to more than 1 million euros. The Governing Board of NWO made more than 700,000 euros available for these projects and the participating companies jointly contributed nearly that same amount in cash. The programme therefore has a total budget of 2.4 million euros. Furthermore, the companies are contributing approximately another 300,000 as in-kind contributions.

The four projects described HTSM-wide physics themes, include thin piezo layers for future inkjet printers, instabilities that entrap air in the meniscus of ink droplets, smart multilayer optics for EUV lithography and custom-made nanoparticles for cheaper solar panels.

Industrial Partnership Programmes

The primary objective of FOM's Industrial Partnership Programmes (IPPs) is to do fundamental research on physics topics of interest to companies. FOM makes an annual budget of three to four million euros available for this instrument. In these research programmes with a duration of several years, companies pay for at least half of the research costs. Just as for any other FOM programme, the scientific quality of the research is also paramount for the IPPs.

2013 marked the official start of the large-scale public-private partnership 'Computational sciences for energy research' funded in 2012 by Shell, NWO and FOM.

>>> www.fom.nl/cser

In 2013, six proposals for a new IPP were submitted that, after extensive assessment, proved to be of excellent quality and could be awarded. With the addition of these programmes, at the end of 2013 FOM was realising a total of 19 IPPs. For a number of these new IPPs, partners will finalise the partnership agreement at the start of 2014. Then these IPPs can actually start and be announced on the website.

One IPP was completed in 2013: 'Fundamentals of heterogeneous bubbly flow'. The partners involved are enthusiastic about the scientific collaboration and the interaction between the academic and the industrial partners. One concrete example of the knowledge transfer arising from this collaboration is the software implementation of a new coefficient of friction for bubbles, which was used immediately and successfully in commercial simulation software. In addition, Tata Steel is using the experimental results from the programme to test the numeric models that they develop themselves. However, the best indicator for the appreciation by the industrial partners is the fact that all of the companies involved are now participating in a new IPP in this area.

A complete overview of all the current Industrial Partnership Programmes, including additional details about the content, budget, duration and partners can be found on FOM's website.

>>> IPP information at the FOM website.

IPP partners as of 31 December 2013.

In the spring of 2013, a new IPP started with Fujifilm: 'The science of atmospheric plasma processing of functional thin films' (i31). In this IPP, a FOM group associated with the FOM Institute DIFFER will be set up at the Fujifilm laboratories in Tilburg. The research will focus on the physics of plasmas at atmospheric pressure, plasma-surface interactions and the control of properties of deposited films. «

« The IPP 'Nanophotonics for solid-state lighting' (i33) with Philips succeeds the programme 'Improved solid-state light sources' that ends in 2014. This follow-up will focus on obtaining the fundamental knowledge required for the development of efficient solid-state sources. This collaboration will acquire a more structural character by means of a so-called 'rolling grant'.

ARCNL

ASML, FOM Institute AMOLF, FOM, the University of Amsterdam, the VU University Amsterdam and NWO announced on 27 May 2013 that they plan to establish an Advanced Research Centre for NanoLithography (ARCNL). The 'bid book', which came about at AMOLF's initiative, turned out to fit best with what ASML intended with this new initiative and for which it had invited partners to submit a proposal. In 2013, under AMOLF's leadership, all the partners worked diligently together to give substance to this new research centre financed as a public-private initiative. This remarkable and substantial collaboration was given the green light by the Board of Directors in June. On 7 November, the partners signed a memorandum of understanding to the agreed principles and in February 2014 the official collaboration agreement was concluded. In close collaboration with AMOLF, ARCNL will conduct fundamental research that is essential for unlocking innovation in the global semiconductor industry. The expectation is that the centre will make an important contribution to semiconductor lithography, the most important technology for making memory chips and processors in PCs, smartphones and tablets, for example. At first, the centre will focus particularly on the physical and

Third tranche for IPP 'Topological quantum computation'

The IPP 'Topological quantum computation' (i26) entered its third phase this year. This research started in 2011, and is headed up by FOM focus group leader professor Leo Kouwenhoven. FOM and Microsoft are jointly funding the research. The IPP focuses on Majorana particles and contributes to the future development of a quantum computer. The IPP has several phases. The second phase is currently underway, but because of the promising results, FOM and Microsoft have recently decided to start up the third phase already.

Artist's impression of the new lab for ARCNL at the Science Park Amsterdam.

chemical processes that are crucial for Extreme Ultraviolet (EUV) lithography. Professor Joost Frenken has been appointed as the first director of ARCNL.

Starting from 1 January 2014, Frenken will chart the scientific course, the first priority being to recruit top scientists. He is a professor at Leiden University and leads a research group there in the area of the physics of surfaces and boundary layers. Frenken is a member of the Royal Netherlands Academy of Arts and Sciences and recently won the prestigious ERC Advanced Grant. In 2012, he received the FOM Valorisation Prize for the way in which he manages to combine fundamental research, technology development and setting up new companies.

The ARCNL will start under the aegis of FOM Institute AMOLF, and in two years it will develop into an independent research centre, located at Science Park Amsterdam. The ARCNL partners jointly guarantee an investment of around 95 million euros in the coming ten years. The Municipality of Amsterdam will supplement this to the level of 100 million euros. Private and public parties will each contribute fifty percent to the basic financing of the ARCNL. ARCNL is part of FOM. An Advanced Research Centre is a new type of collaborative partnership in which NWO provides a boost to collaboration with universities and private parties. This initiative fits very well within the government's Top Sector policy sector in the top sector High Tech Systems and Materials (HTSM).

>>> www.arcnl.nl

Other initiatives

The top sector policy results in many new initiatives and contacts with companies. Current initiatives that will crystallise in 2014 are illustrated briefly below.

NIAF

In 2012, the idea arose, against the backdrop of the top sectors policy, of giving other partners in our science system the same combination of scientific excellence and innovative dynamics as are commonly found in the environments at institutions such as MIT and Stanford. A discussion took place in the May 2013 meeting of the Board of Directors about a proposal to create a Netherlands Innovation Acceleration Fund (NIAF).

Dr Dirk Smit, Vice President of Exploration Technology at Shell and Chief Geophysics Scientist at Shell, and FOM Director Dr Wim van Saarloos are the initiators behind this fund in which companies deposit money to finance scientific research that they themselves choose. This should lead to demand-driven research and a better 'ecosystem for innovation'. If a sufficient number of companies support the initiative, a pilot can start in 2014. The Ministry of Economic Affairs has agreed in principle that the TKI allowance will become available for NIAF projects as long as these projects meet the official requirements.

NIAF follows the structure of the MIT Energy Initiative: if companies contribute to the fund, they then garner certain rights in line with the NWO rules for public-private partnership. They can indicate which scientific challenges they see in the long term. Scientists from all disciplines then respond to this by submitting research proposals. The companies then choose the desired projects from among these proposals. Two thirds of the money in the fund is intended for research directed by the participating companies and one third for research with an 'open end'.

QuTech

On 2 October 2013, the Minister for Economic Affairs, Henk Kamp, announced that the Delft University of Technology would start working on the construction of a next-generation computer: the quantum computer. The Institute QuTech would be jointly set up by science, industry and government together to achieve this. Under the leadership of FOM focus group leader professor Leo Kouwenhoven from the Delft University of Technology, QuTech will form

the bridge between scientific research into the development of the quantum computer and the Dutch high-tech industry. The Netherlands is one of the first countries worldwide to set up such a large-scale initiative.

The next-generation computer should become a reality within 15 years. This new computer uses the special quantum-mechanical properties of tiny particles, so-called quantum bits. These can generate enormous calculation capacities, making new applications possible. For example, a quantum computer is able to calculate the effects of medicines on individuals. It will also be easier to calculate and to predict the properties of specific materials and soil layers.

Kouwenhoven's research group at the Delft University of Technology is among the world's leading groups in the area of nanophysics. In the spring of 2012, he attracted major scientific and public attention due to the discovery of the Majorana fermions. This group has enjoyed strong support from the Delft University of Technology, NWO and FOM since the 1980s. FOM has made huge investments, for example, in tenured and temporary scientific and technical personnel, equipment and infrastructure and through central NWO funding substantial contributions have been made. One important example is the establishment of the FOM focus group 'Solid state quantum information processing' in 2004 under the leadership of Kouwenhoven. This FOM focus group has the objective of designing an extensive quantum system in order to study the behaviour of interlaced multi-particle states.

With the formation of QuTech, the Delft University of Technology will contribute 5 million euros per annum, and the Dutch government and TNO will jointly contribute about 4 million euros per annum. NWO, including FOM, and industry (e.g. Microsoft) will also contribute. QuTech will be shaped further in 2014.

<< YouTube film about 'Quantum computing physics at FOM'.

Valorisation projects

Through valorisation projects, FOM makes resources available to encourage the use of knowledge generated by FOM-funded scientific research within the university work groups. With these, FOM boosts the ambition to contribute more to the Dutch knowledge economy through fundamental research of high scientific quality. This underlines FOM's commitment to the utilisation of results from scientific research.

Valorisation projects are projects of short duration in which the commercial feasibility of an invention can be studied, for example, a proof-of-principle experiment can be conducted, or a recently graduated scientist can continue his research for up to one year with an industrial partner. The opportunities for valorisation are paramount in the assessment: it is about having FOM knowledge gain access to the market. In 2013, three proposals were submitted. One proposal was rejected and two proposals that were submitted at the end of the year are still in the evaluation phase.

In 2013, Nikhef nearly completed the (engineering) assignment for ASML that was awarded in 2012. The intensive discussions with Shell about the development of equipment for seismic campaigns (arising from gravitation wave research by Nikhef) resulted in a collaboration agreement for a feasibility study entitled TremorNet, with a value of 750.000 euros. InnoSeis, a new Nikhef spin-off, will conduct part of the work. In addition, Nikhef is continuing its long-term, successful collaboration with PANalytical. Also the data centre activities (in particular for clients of the Amsterdam Internet Exchange) grew further in 2013. Furthermore, Nikhef consolidated its position, gained by means of the BiG Grid project, as a SURFsara partner in the national e-Infrastructure coordinated by SURF.

AMOLF started two projects in 2013 with Shell, in which mass spectrometry is used to look at oil-water interactions and a project within the FOM programme 'Computational sciences for energy research'. A pilot study was set up with Unilever in preparation for a joint proposal for a FOM Industrial Partnership Programme. With Philips, the successor to the current IPP 'Nanophotonics for solid-state lighting' was designed, with the special features of being twice as large as the current programme and being more structurally embedded. The new IPP contract was signed by both parties in January 2014. Furthermore, AMOLF entered

The Alpha Magnetic Spectrometer looks for antimatter in cosmic radiation. Eleven years ago, scientists from the FOM Institute Nikhef designed a new cooling concept for the detector: CO_2-cooling. This cooling method allows for considerably less material in the detector in comparison with other coolants. The National Air and Space Travel laboratory further developed the AMS-02 cooling concept developed by Nikhef and ultimately built it, too. Nikhef scientist Bart Verlaat is still involved with the project. In 2010, he helped to test the system in the Space Simulator at the European Space Agency and in 2011 with tests in space of the cooling system from NASA's Mission Control Center in Houston.

into an intensive collaboration with ASML. In May, ASML decided to set up a new research centre together with FOM, NWO, University of Amsterdam and VU University Amsterdam that conducts fundamental research in the area of nanolithography (see earlier in this chapter). In addition to the collaborations with large industries in 2013, AMOLF also invested in the 'Store for Science', a web store that provides research institutions with the opportunity to make their knowledge and facilities accessible to small and medium enterprises. The first institution to join the Store for Science is NWO Institute CWI. The upgrade that includes CWI will start in the first quarter of 2014.

Start-ups

The transfer of knowledge gained from FOM research to society is one of FOM's primary objectives. For this, FOM can avail itself of all sorts of instruments. Since the changes to the articles of incorporation in December of last year, it is now possible for FOM to attain this knowledge transfer by means of participation (acting as a shareholder) in a company. Any such participation requires permission from NWO.

The first company in which FOM is participating as a shareholder is Particle Physics Inside Products (P2IP). P2IP is the holding under which recent start-ups from AMOLF and Nikhef, Amsterdam Scientific Instruments, Omics2Image and Sensiflex are incorporated. With participation, FOM intends to play an important role in guiding these companies' valorisation plans and in guiding further developments from AMOLF and Nikhef. This participation is viewed as an experiment with which FOM can gain experience for future participations. At the end of July, NWO's Governing Board gave FOM permission to participate in P2IP. The fifty percent participation will - in the future - run via a FOM business holding that FOM controls completely.

For the Nikhef start-up ASI, 2013 was an exciting year due to increasing international competition in the area of photon detection equipment based on Medipix technology. To increase the attractiveness for investors, the decision was made to incorporate ASI and Omics2Image (a spin-off arising from AMOLF) as a joint holding (ASIH). At the end of 2013, one member of the management team stepped down.

In 2013, two new start-ups were set up in which Nikhef employees were involved: NoZAP, a company that focuses on personalised live television using technology derived from distributed computing (grid), and InnoSeis, which focuses on marketing technology from Nikhef's gravitational waves programme, in particular wireless seismic sensor equipment.

AMOLF group leader professor Ron Heeren received a Netherlands Proteomics Centre Valorisation Voucher in February for his research proposal 'MobilityPix: A fast and sensitive detection device for nanoparticles utilising ambient desorption and ionisation techniques'. Heeren wants to use this voucher to bring a technology from his group to market in collaboration with his recently established start-up Omics2Image, which is incorporated in the FOM holding P2IP.

This start-up also won the 10th Venture Challenge from the Dutch Genomics Initiative. The company now has its own imaging laboratory and is looking for investment capital for the next phase.

The start-up Delmic, that sells a cathode luminescence-device developed at AMOLF, has sold its first unit by now.

SolMateS, a company in Twente, has received its first two orders for the PiezoFlare 1200, a machine based on Pulsed Laser Deposition. SolMateS arose in 2006 out of FOM research and was supported by FOM with a starters' loan.

The three FOM institutes AMOLF, DIFFER and Nikhef, together with SRON and ASTRON, comprised the NWO delegation at the 2013 Hannover Messe, in the context of Advanced Instrumentation.

The last repayment for this loan was made at the end of 2013. The patented production machine can produce computer chips with movable layers, giving the chips more functionality: a revolution in the chip industry. The system was first delivered to SINTEF in Norway in January of this year. A second order was delivered in February to the Bosch Group, the global market leader in this area. The PiezoFlare 1200 is based on deposition technology developed at the MESA+ Institute for Nanotechnology at the University of Twente in Enschede. The research groups under the leadership of professor Dave Blank and professor Guus Rijnders work with the same technology at laboratory scale on thin layers for future generations of solar cells, batteries, transparent electronics and X-ray mirrors.

Meetings

Networking during Physics@FOM Veldhoven

FOM organises a networking lunch each year during the Physics@FOM Veldhoven conference to bring researchers from industry, universities and institutes into contact with each other. This year, there were approximately one hundred participants from industry, the universities and FOM institutes. Company posters were also well attended, both by researchers and by PhDs with hard copies of their CVs in hand. Another success was the special focus session entitled 'Fundamental physics in close collaboration with companies', in which speakers talked about their research and their experiences with public-private partnership projects.

Physics with Industry

In November 2013, FOM organised the fourth edition of the Physics with Industry workshop, together with Technology Foundation STW and the Lorentz Center. The aim of this workshop is to give young physicists the opportunity to help solve industrial problems, to introduce them to the world of industry and to introduce young talent to companies. On Monday 18 November 2013, fifty physicists and scientists from universities and five companies gathered at the Lorentz Center in Leiden. On that day, the companies Tata Steel, Oranjewoud, Océ, RGS Development and Pamgene each presented a problem that they faced. A group of enthusiastic physicists then spent a week diving into the problems faced by each of the companies. The workshop turned out to be so successful that some of the results achieved were immediately useful to the companies. Several companies are interested in requesting patents on the basis of the results.

Business visit - ASML

The purpose of the visits FOM organised twice this year to ASML was twofold: experiencing the interesting research that takes place at ASML and getting a better view of career opportunities. In total, sixty FOM PhDs and postdocs, all of them in the last phase of their contracts, went to Veldhoven on 7 June and 9 October. Because of the enormous interest, another company visit was agreed to with ASML, which will take place on 18 June 2014. For more activities in the area of career support, see chapter 7.

Valorisation workshop

The valorisation workshop was held twice this year. This training is part of the curriculum for FOM PhDs (see chapter 7), and is also open to postdocs. Under the supervision of a patents expert and an entrepreneur with a background in science, the participants learned about the process of requesting patents and about skills that are important to successful entrepreneurship. During the course, they also got a good view of the opportunities for substantiating the valorisation of their research at FOM. Working on one's own ideas and appealing examples of FOM research were the focus during the course. Based partly on the experiences to date, the content will be adjusted in 2014 and the workshop will be extended to cover two days.

Chapter 4. Energy research

FOM strives to give new impulses to fundamental energy research working from the perspective of physics. This is one of the focal points of the current strategy. Fundamental energy research covers nearly the entire spectrum of scientific disciplines. For this reason, many topics require a thematic approach - based on balanced involvement of all relevant scientific disciplines. FOM therefore collaborates with various partners in this area.

>>> www.fom.nl/energy

DIFFER & FOM focus groups for fundamental energy research

FOM has two focus groups involved with research themes relevant to energy. These focus groups in the area of energy, at the University of Groningen and at the FOM Institute AMOLF, are closely allied with the FOM Institute DIFFER. They provide a substantial innovative and enriching impulse to energy research in the Netherlands.

In 2013, the FOM Institute for Fundamental Energy Research DIFFER was further defined. The first scientific publication in the area of solar fuels appeared from DIFFER in 2013 in the new line of research. You can read more about the developments at DIFFER in 2013 in chapter 1.

>>> www.differ.nl

NWO theme and the Top Sector Energy

FOM/N is the motor behind the NWO theme Sustainable Energy and works on this together with various NWO divisions (Earth and Life Sciences, Chemical and Physical Sciences, Social Sciences, Humanities and Technology Foundation STW). Via this theme, energy research at NWO is consolidated and multidisciplinary initiatives are developed. NWO wants to use the theme and expand it in order to provide a sensible, permanent and balanced contribution from fundamental science to the Top Sector Energy's innovation agendas. The management team is the point of contact at NWO (both internally and externally for the energy research and it coordinates NWO's collaboration with the seven TKIs in the Top Sector Energy (two of which also fall under the Top Sector Chemistry). Within NWO, FOM is the driving force for the Top Sector Energy as well.

The NWO theme Sustainable Energy focuses on the promotion of fundamental scientific research that contributes to (the transition to) a society based on the sustainable generation of energy. The objective is to support a thematic approach to the ecosystem of researchers, companies, government, NGOs and TKIs in the area of energy research and to develop relevant fundamental science research programmes for the top sector. The management theme for Sustainable Energy has the ambition and the task of maintaining the fundamental basis of knowledge for this energy transition and the development of energy technology within the Top Sector Energy by means of:

- Setting up and developing scientific research programmes aimed at the innovation agendas in the Top Sector Energy and encouraging public-private partnerships (PPP);
- Financing multidisciplinary scientific research programmes in the area of (sustainable) energy that are relevant to the top sector's long-term goal of achieving a CO_2-neutral society. This involves both PPP programmes with considerable co-funding from industry and research programmes that are funded largely with public monies and that have the potential to open up or encourage areas of research that are important for the future and whose development is supported by the top sector.

FOM Institute DIFFER supports the alignment with the Top Sector Energy by fulfilling a valuable task from the position of its national role in the scientific field in the substantive joint programming process.

The 2014-2015 NWO proposition for the Top Sector Energy came about via the NWO theme Sustainable Energy in 2013 (as part of the 2014-2015 Innovation Contracts). FOM played an important role as the driving force in its creation, which resulted in a strong multidisciplinary package of fundamental energy research with a budget of 34 million euros for 2014 and 2015. The contract was drawn up and contains concrete research programmes in consultation with the seven TKIs in the Top Sector Energy. In addition to FOM, several other NWO divisions participate along with DIFFER, AMOLF and the CWI. The programming follows a number of substantive clusters that are aligned with the

needs of the Top Sector Energy. FOM's contribution will lie primarily in the themes Materials and concepts for new energy technology, Foundations for energy-efficient industry, Bio-inspired energy storage in chemical bonds, and Geoscience.

<< More information about NWO's ambitions in the area of sustainable energy.

In addition, in 2013, under the auspices of NWO Chemical Sciences and in collaboration with FOM, work was done on a follow-up programme with the working title 'Bio-inspired energy storage in chemical bonds'. This programme is included in the 2014-2015 Innovation Contracts for the top sectors Chemistry and Energy.

Computational sciences for energy research

The year 2013 marked the official start of the large-scale public-private partnership 'Computational sciences for energy research' funded in 2012 by Shell, NWO and FOM. This initiative is vitally important to the Dutch energy sector and fits well within the Top Sector Energy. This makes financing available for sixty PhD positions (the PhD programme). In addition, Shell is making two grants of 2 million euros each available to two research programmes in the context of the NWO theme Sustainable Energy (CO_2-neutral fuels, see further on in this document, and Uncertainty Reduction in Smart Energy Systems, URSES). Under the CSER programme, large-scale investments in the Dutch knowledge infrastructure will be made - in new personnel, e.g., such as tenure-track appointments. As a training programme for highly qualified researchers, the programme also builds on the relationship between Indian and Dutch scientists. Shell finances the researchers' training courses; after the completion of their PhD research, they then go work at Shell's Technology Center in Bangalore. The NWO contribution is intended to strengthen computational sciences in the Netherlands. The CSER programme committee drew up a plan for this at the end of 2013. One component of this is a call in 2014 for tenure-track positions in the area of energy research.

>> www.fom.nl/cser

Shell, NWO and FOM work together in the IPP 'Computational sciences for energy research'.

CO_2-neutral fuels

Within the NWO theme Sustainable Energy, a national, multidisciplinary scientific programme - 'CO_2-neutral fuels' - was initiated in the area of the clean production of fuels from water and carbon dioxide. This programme is embedded in the NWO proposition for the Top Sector Energy. FOM, NWO and Shell have made a total of 9 million euros available to the entire research programme. The programme consists of three parts. First, the 'CO_2-neutral fuels' call, which awarded 5 million euros to 7 projects in 2013 (Shell's contribution - 2 million euros; FOM - 1 million euros, NWO Chemical Sciences - 1 million euros and NWO's Governing Board - 1 million euros). The combination of this research call and the prior research programme 'Towards BioSolar Cells' in 2010 leads to a strong positioning from an international standpoint within the field of research on solar fuels. NWO will follow up on this programme that, with 32 applications, attracted so much interest from the field in this first round. The second part of the programme is the 'Plasma Conversion of CO_2' call that focuses more on applied research and that will be completed in 2014. This call fits within the guidelines of the thematic programme

>> More information about the research programme CO_2-neutral fuels.

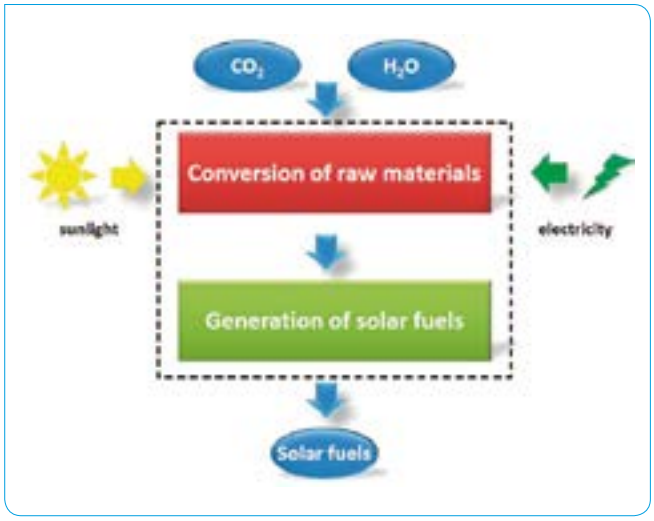


Diagram of the production of CO_2-neutral fuels from water and carbon dioxide under the influence of sunlight.

Gerald Schotman, Dr Bertholt Leeftink, professor Jos Engelen and Dr Wim van Saarloos give the symbolic starting shot for the programme 'Computational sciences for energy research'.

but has a more specific research framework. For this call, the Technology Foundation STW and Alliander have made a total of 2 million euros available. Finally, the third part consists of a programme in which tenure trackers will be appointed within the new line of research on solar fuels. This programme runs at DIFFER, the Institute For Fundamental Energy Research, and will be supported by NWO Chemical Sciences.

TKI allowance

FOM received a 190,000 euros TKI allowance from the Top Sector Energy for Shell's corporate contribution to the joint research programme with NWO and FOM entitled 'Computational sciences for energy research' (CSER). The available TKI allowance will be used for expanding the scale of the CSER programme. FOM expects to receive around another 75,000 euros from the TKI Saving Energy in the Built Environment (EnerGO).

YES! Fellowships

The YES! Fellowships programme focuses on young, promising PhD scientists who have innovative ideas for the generation, storage and transport of energy and who are pursuing a scientific career in fundamental energy research. FOM has launched this form of grant with the purpose of creating a new generation of young, excellent and original energy scientists. With this approach FOM is making a contribution to the strengthening and continued innovation in the position of the Netherlands in international energy research.

The last YES! Fellow was appointed at the start of 2013: former FOM PhD student Dr Jonathan Citrin (FOM Institute DIFFER). With this fellowship, he will study the effects of tungsten on the plasma in fusion reactors over the next four years. For his research, Citrin will go to the CEA Research Institute on Magnetic Fusion in France, near the international nuclear fusion project ITER. Citrin is the fifth YES! Fellow and, with this, is the last person in FOM's current YES! programme to receive a fellowship.

>>> View the film about the FOM Institute DIFFER with YES! Fellow Dr Jonathan Citrin.

Chapter 5. Large-scale research facilities

Large-scale research facilities are becoming increasingly vital for the realisation of top research. This requires the national consideration of a proper financing instrument with a permanent, substantial budget. In the Netherlands, FOM wishes to help large facilities with international status get established and become operational and to help Dutch scientists obtain access to large facilities abroad. From the perspective of its directive role in physics, these FOM ambitions cover both the FOM institutes and the universities.

›› www.fom.nl/collaborations

FOM is closely involved with some of the large research facilities established in the Netherlands, such as FELIX and HFML. A number of FOM's efforts in 2013 and other developments are highlighted in this chapter. FOM's structured European collaborative partnerships concern the Dutch contribution to the research in high-energy physics with the Large Hadron Collider at CERN, projects in astroparticle physics such as ANTARES, KM3NeT, Pierre Auger, Virgo and XENON, and the European fusion programme focused on ITER. The FOM institutes Nikhef and DIFFER respectively function as the home base for the Dutch contribution. Furthermore, FOM/N is involved in consultations about an integrated European magnetic field laboratory (EMFL) in the European synchrotron facilities (ESRF, Grenoble) in which NWO participates and – at a certain distance – a new European laser (XFEL, Hamburg). The institutional collaboration with the University of Groningen in the KVI - a collaboration of fourty years' duration - ended this year. Some of the FOM activities in the former KVI moved to the faculty, the rest were included in the new Centre for Advanced Radiation Technology (CART).

The purpose of the **NWO Investment Grant Large programme** is the promotion of investments in scientifically innovative equipment or in data collections of national or international importance. The size of the NWO contribution is it least 1.5 million euros. The deadline for the next round was supposed to be October 2014, but NWO's Governing Board decided for financial reasons to delay this round for a year.

1 October 2013 was the closing date for the submission of proposals for the **National Roadmap for Large Research Facilities**. This round gave the facilities that are on the current National Roadmap the opportunity to request funding for the realisation of their plans. Three of the 16 proposals submitted are at least partly in the domain of physics. The proposals are currently being reviewed by international referees, the NWO divisions are being consulted for policy and strategic recommendations and the proposals will be assessed at the beginning of 2014. In the summer of 2014, the Minister of Education, Culture and Science will make the awarding decision. Facilities that are not yet on the National Roadmap may not participate until 2015.

Table 2. External use of facilities in 2013.

facility	*external use* (as a % of total use)*	*foreign use (as a % of external use)*
AGOR (KVI)	77	80
FELIX (RU)***	61	71
FELICE (RU)**	-	-
HFML (RU)	67	81
Mass spectrometers (AMOLF)	25	75
Amsterdam nanoCenter	4	0
Magnum PSI (DIFFER)	63	100

** This concerns users from outside the knowledge institution where the facility is located. External use varies considerably from year to year.*
*** Due to the move to Radboud University in Nijmegen in 2013, this facility was not used.*
**** Due to the move to Radboud University in Nijmegen in 2013, this facility was only in limited use; the numbers are therefore not representative.*

FELIX

In 2013, the free-electron laser facilities FELIX and FELICE moved from the FOM Institute DIFFER to Nijmegen and,

On 14 July 2013, the free-electron laser FELIX produced its first light since the move from DIFFER to Radboud University in Nijmegen. As of October 2013, the new FELIX facility was once again open to users. FELIX is now a FOM focus group.

together with the top facilities HFML and FLARE already present there, form a special research site. The combination of infrared and terahertz (THz) radiation with the strong magnetic fields is unique in the world. Together, they form a new infrared and THz user facility – also called FELIX. This provides not only radiation but also advanced experimental setups. Both the lasers and the pool of employees have been merged in the joint facility. Due in part to the link with the High Field Magnet Laboratory in Nijmegen, new opportunities have arisen for physicists, chemists, materials scientists, astrophysics and bio-molecular scientists who can perform structural determinations, transport measurements and dynamic measurements there.

HFML

The High Field Magnet Laboratory (HFML) in Nijmegen – a collaboration between Radboud University in Nijmegen and the FOM Foundation – is a leading research facility to which dozens of scientists from many countries come each year to conduct experiments in strong magnetic fields. The FOM activities at HFML have the status and form of a FOM focus group. In September 2013, professor Nigel Hussey was appointed director. Furthermore, the lab now has two extra professors: HFML researcher professor Peter Christianen was awarded a professorship in September and Nobel Prize winner professor Konstantin Novoselov was appointed to the HFML as a professor by special appointment. The operation of the HFML also grew considerably in the reporting year, with a large number of foreign guest researchers and a record number of 1,837 magnet hours. Together with equivalent labs in Dresden, Grenoble and Toulouse, the HFML forms the European Magnet Field Laboratory (EMFL). The bond between the labs was strengthened last year with a meeting of all the employees in Egmond aan Zee. The EMFL also recently presented promotional films on the research with strong magnetic fields in order to provide an overview of the facilities at each location in Europe.

>>> www.ru.nl/hfml
>>> www.emfl.eu

<<< Scan to see the new EMFL-film.

ITER

Construction of the international fusion reactor ITER in Cadarache in the south of France is in full swing. ITER will be operational and will generate the first plasma at the end of 2020. The EU pays for nearly half of this global project. FOM takes care of programme management for the collaborative partnership ITER-NL2. In this, TNO, the FOM Foundation (via the FOM Institute DIFFER), the Nuclear Research and Consultancy Group and the Eindhoven University of Technology are working together. The goal is to enable high-quality participation of Dutch scientists in the scientific ITER programme and to conclude ITER contracts with Dutch industry that will result in new spin-offs.

In 2013, plasma physicist professor Marco de Baar (DIFFER and Eindhoven University of Technology) was commissioned by ITER to elaborate the details of an important and advanced control system that is crucial for the controlled start-up of the hot fusion plasma, ensuring it achieves the proper state, and keeping it under control during unplanned events.

With a unique extension, the plasma experiment Magnum-PSI at FOM Institute DIFFER has also qualified for conducting materials tests for ITER. DIFFER will test the reactor wall with a unique setup using artificial solar flares. In addition to a continuous bombardment of charged particles, the reactor wall at ITER also will be exposed to short, repeated, miniature solar flares at its exhaust. Magnum-PSI is the first laboratory setup in the world to able to simulate these conditions by producing both constant plasma streams and short-duration energy explosions that are 10 to 100 times more intense. Together with two German institutes, DIFFER is now studying whether ITER's planned wall material of tungsten will become brittle from recrystallisation due to the two types of load.

Chapter 6. Outreach and education

FOM's communication policy focuses on profiling FOM as an (inter) nationally successful research organisation and on activities that promote physics for future researchers and interested parties. For this, the external communication focuses on advocates and media, but also on high school and higher education students and potential FOM researchers. FOM also pays attention to internal communication and to relations that are closely linked to the FOM organisation.

The FOM website serves a broad public with research news. It also provides a constant stream of news and background stories via (social) media, sometimes based on the press releases issued. Below is a selection of the activities from 2013.

>>> www.fom.nl/agenda

December saw a fine climax to the year with a high auction value for a visit to CERN, auctioned off in the annual **Serious Request** initiative to help malnourished children in Africa. Nikhef scientist Dr Ivo van Vulpen offered a tour of the LHC and the ATLAS detector at CERN. This item attracted considerable interest and was finally sold as one of the auction's top items for nearly 8,000 euros - far above the auction value of a helicopter flight and lunch with the Minister of Defence or a gold record from celebrated Dutch singer Jan Smit.

The popular science **Fusion Road Show**, about the development of nuclear fusion, continues to be a success. In 2013, the show appeared at the new event KIJK Live! and for 400 participating teachers at the Woudschoten Chemistry Conference. It resulted in many invitations for 2014. Next in line, at the end of November 2013, were 3,600 students and teachers in pre-university education from Flanders and the south of the Netherlands at a visit to the University of Antwerp. The Fusion Road Show could also be seen at the Robeco Energy Investors Day.

AMOLF's Living Mirror at Naturalis Biodiversity Center.

A fluid mirror image of magnetic bacteria. That is the **Living Mirror**: an interactive bio-installation that combines electronics, cells and image manipulation. The viewer is recorded in the mirror and translated into a live 3D portrait. In this manner, the Living Mirror brings back the 'physical presence' that is currently missing in digital media. The Living Mirror was developed at AMOLF by bio-artists Howard Boland and Laura Cinti from the C-LAB in collaboration with group leaders Dr Tom Shimizu and professor Bela Mulder and could be realised thanks to the Designers & Artists for Genomics Award in December 2012. The Living Mirror was exhibited at Naturalis Biodiversity Center in Leiden from 14 September to 15 December 2013.

Both FOM Institute AMOLF and Nikhef hold an annual **open day** together with other institutes at the Science Park in Amsterdam. This is an initial low-threshold opportunity for the general public to become familiar with the research. In 2013, the Open Day was held on Saturday 5 October during the national Weekend of Science. Its main theme was the Treasury of Science. Approximately 900 visitors attended. This is roughly the same turnout as at the FOM Institute DIFFER's open day in Nieuwegein.

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Impression of Physics@FOM Veldhoven 2013.

Physics@FOM Veldhoven

On 22 and 23 January 2013, the annual Physics@FOM conference was held in Veldhoven. More than 1,900 physicists braved the snow and gathered at the NH hotel De Koningshof. Once again, the number of participants exceeded the previous years'.

Leading international professors Sibylle Günter, Anette (Peko) Hosoi, Leo Kouwenhoven and Stan Bentvelsen gave the plenary presentations this year. In addition, there were 14 focus sessions and 18 parallel sessions, with a total of 210 presentations in which participants could hear about the latest and greatest in physics. There was plenty of time between sessions to network and to discuss possible collaborations.

For 100 PhDs, Physics@FOM Veldhoven had already started on Monday evening. They could participate in a master class from professor Sibylle Günter, professor Anette (Peko) Hosoi, professor Anne Green or professor Costas Soukoulis. In this masterclass, each of these prominent physicists offered the 25 PhDs attending the opportunity to discuss their research areas in depth.

FOM's colours – blue and white – were supplemented this year with red to give the convention a Dutch touch. Traditional Dutch hotchpotch dishes graced the menu for the big Tuesday night dinner; this was followed appropriately by presentations by two top Dutch scientists, to show that the Netherlands plays an important role in physics.

Dutch meeting on Molecular and Cellular Biophysics

'Dutch Biophysics 2013', the annual Dutch meeting on Molecular and Cellular Biophysics, was held on Monday 30 September and Tuesday 1 October. Around 470 interested parties from throughout the Netherlands travelled to the convention at the NH hotel De Koningshof in Veldhoven. The group of participants consisted of researchers in molecular and cellular biophysics as well as microscopy experts.

In addition to eight plenary presentations by (inter)national speakers, the participants could choose from among 16 parallel sessions in which no less than 48 presentations were given. There were also nearly 200 poster presentations to visit. The conference also provided extensive opportunities to catch up with colleagues, of course, and to network. Participants could put together their own programme using the programme book and a handy conference app. The new corporate identity gave the conference a fresh look this year.

Impression of the Dutch meeting on Molecular and Cellular Biophysics 2013.

The honorary speaker for the conference was professor Alexey Khodjakov from the Wadsworth Center in New York. On Monday evening, Khodjakov gave a fascinating presentation about the complex mechanics of mitotic spindle assembly, an important part of the mechanism of cell division.

FOM and NWO Earth and Life Sciences organised the conference in collaboration with the Dutch Association for Microscopy and the Association for Biophysics & Biomedical Technology. This latter association sponsored the poster prize that was awarded for the first time this year. Manuel Melo from the University of Groningen won this poster prize for his poster 'Understanding how short-chain lipids help doxorubicin cross membranes'.

In 2013, at Nikhef's and CERN's invitation, a number of Dutch journalists visited the Large Hadron Collider particle accelerator along with the experiments ATLAS, LHCb and ALICE at CERN in Geneva.

AMOLF group leader professor Marileen Dogterom appeared in Dutch television programme De Wereld Leert Door on 7 March 2013 to discuss cell division. Her answer to the million dollar question: 'Without strings and motors, progress is impossible - both in cells and in real life'.

High school and higher education students

The FOM institutes have direct contact with schools and teachers, who then visit the institutes with groups of students or who do an assignment about FOM research. FOM also contributes to the Eureka Cup (an annual nationwide competition for high school students), the Technical Tournament (for primary schools) and the National Physics Olympiad, and is the partner of the Stichting Natuurkunde.nl that manages the natuurkunde.nl and sciencespace.nl website, for teachers and students in high schools. Further, on a limited scale, FOM sponsors school trips to European physics labs and trips and symposia for physics study groups in which potential new FOM researchers participate.

In March, more than sixty students in pre-university education took part in the **International Master Class on Particle Physics** at Nikhef in Amsterdam and Nijmegen. After a few introductory courses, the participants had the opportunity to study collisions between elementary particles themselves using actual data from the LHC. This annual event takes place simultaneously at other research institutions throughout the world, including a live video connection with CERN in order to discuss the results.

HiSPARC is a project in which high schools form a network together with scientific institutions in order to measure extremely high-energy cosmic radiation. HiSPARC gives students the opportunity to participate in real research, the results of which are actually used to learn more about these mysterious and rare cosmic particles. In 2013, the Dutch network consisted of one hundred measurement stations. On the international front, HiSPARC also grew steadily. In the UK, for example, the network expanded considerably.

On Wednesday 13 March, the students presented the **profile projects** that they made in the context of HiSPARC at Nikhef in Amsterdam. The winners were Elian König, Lina Mooren, Dave van der Vuurst and Kees Koomen. They won a trip to CERN on Monday 24 June.

>>> http://www.hisparc.nl/en/

Teachers

FOM has a small budget for providing a number of teachers in pre-university education a part-time research position (with a one-year contract) at three FOM institutes. The purpose of this initiative is to provide a boost for teachers in their own professional practice, an encouragement that will then reflect toward their students. With this, FOM wishes to strengthen the connection with schools and hopes to strengthen the interest for a study in physics.

Due to cutbacks, the teachers' project has been downsized and FOM has made five positions of 0.2 fte each available for the school year 2013/2014. Three positions were assigned to Nikhef, two to DIFFER. For the coming two school years, FOM will receive funding for eight one-year positions from the Ministry of Education, Culture and Science's teacher internships and guest-teaching programme.

In collaboration with the University of Amsterdam and the Bèta support centre Amsterdam (Its Academy), Nikhef organised a workshop in particle physics for teachers. Twenty teachers seized the opportunity and met for six evenings to brush up their knowledge.

In 2013, Nikhef and CERN organised the annual teachers' programme. Twelve teachers made a four-day visit to CERN and visited the underground experiments this time as well.
In April, the University of Amsterdam and VU University of Amsterdam's Support centre for Physics Teachers organised their network meeting around the topic 'nanoscience' at AMOLF.

Chapter 7. Personnel

With its personnel policy, FOM hopes to attract and retain top talent or to equip these professionals to continue their careers in another place. This chapter highlights developments concerning PhDs and postdocs. FOM's focal point of encouraging more women to enter careers in physics is discussed here as well. More information can be found in FOM's 2013 Social Annual Report.

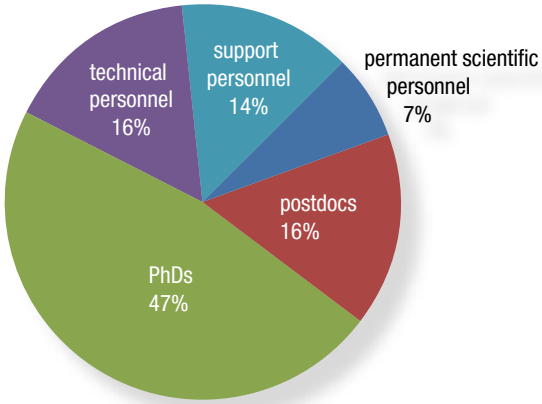
>>> www.fom.nl/annualreport

The total number of personnel decreased by 3 percent in 2013. At the end of 2013, FOM employed 1,093 people (see table 3). More than two thirds (68 percent) of these people were employed temporarily, primarily as PhD students (47 percent) or postdocs (16 percent). FOM employs these young scientists for the duration of their research projects; they continue their careers outside FOM after this. Two thirds (66 percent) of the PhD students and postdocs has a foreign nationality.

Table 3. Number of FOM employees by the end of 2013.

location	WP/V	WP/T	PhD student	TP/V	TP/T	OP/V	OP/T	total
AMOLF	13	33	64	35	10	29	7	191
DIFFER	17	16	26	38	2	23	8	130
Nikhef	37	32	55	66	7	24	3	224
FOM office					1	53	9	63
university workgroups	10	94	367	7	7			485
total	77	175	512	146	27	129	27	1,093

WP/V permanent scientific personnel
WP/T temporary scientific personnel (primarily postdocs)
TP/V permanent technical personnel
TP/T temporary technical personnel
OP/V permanent support personnel
OP/T temporary support personnel



At the end of 2013, FOM employed a total of 1,093 people: the percentage distribution across the various types of positions is illustrated here.

FOM director Dr Wim van Saarloos opened the fourth edition of the **Young Scientists' Day** on 12 December in CASA400, Amsterdam. He advised 120 FOM PhDs and postdocs to develop various skills during their research period at FOM and to keep as many career options open as possible. The Young Scientists' Day corresponds with that idea. FOM organises this day once every two years.

The FOM personnel magazine is published four times each year.

PhDs

FOM wants to actively guide and support its PhDs so that they are attractive to the labour market due to their special qualities and skills. FOM has the following objective for its PhD students:

- **graduation in four years;**
- **a job elsewhere (immediately) after FOM employment;**
- **consideration of valorisation possibilities for their own research.**

FOM supports the achievement of the goals for PhDs by means of: selection, planning and monitoring of the research, training and activities focused on alignment with the labour market.

Selection

Across all of FOM, 109 PhDs started in 2013, 63 percent of whom were foreign (see table 4). Many of the FOM PhDs and postdocs are selected by FOM workgroup leaders employed by the universities. FOM gives the workgroup leaders two guidelines for the selection: 1) the candidate's CV and personality show promise that the research project can be completed successfully and within the available time; 2) there must be the expectation that the candidate has good prospects on the labour market after the FOM appointment.

Table 4. Influx of PhDs according to gender and nationality – those entering service in 2013.

	number	percentage
influx	109	
of which women	*24*	*22*
nationality		
the Netherlands	40	37
EER+	18	16
other	51	47

Planning and monitoring of research

Good embedding in the work environment and clear work assignments are important for every PhD. A training and support plan is agreed to with FOM PhDs before they enter service. During the PhD programme, there are formal annual interviews in the form of planning and evaluation discussions intended to monitor the progress of the research. FOM's personnel department sees to it that these interviews are held and they take action if the report warrants this.

Training

FOM wants to actively guide and support its PhDs so that they are attractive to the labour market due to their special qualities and skills. To achieve this, FOM organises training courses in planning and organisation, presenting, writing scientific articles, valorisation and career planning. Individual coaching is also included in the possibilities. For all the foreign employees (and their partners, if they wish), FOM has an introductory course to the Dutch language and culture to support their integration. The figures for training participation in 2013 are given in table 5. More detailed information about the training courses can be found on the FOM website.

Table 5. Participation in the FOM training courses for PhDs in 2013.

training	number of training courses	number of participants
Dutch welcome course	6	73 (including partners and postdocs)
Taking charge of your PhD project	7	80
Managing your own PhD programme	4	40
The art of presenting science	4	45
The art of scientific writing	4	60
How to get funded	1	13 (including 7 postdocs)
Valorisation workshop	2	26 (including 4 postdocs)
Career planning	4	24
Nijenrode business orientation week	2	48

›› Summary of FOM training courses.

Connection with the labour market

In the second part of the PhD study, FOM provides various activities that promote connection to the Dutch labour market, in addition to career-focused training courses. For example, PhD students who have not yet found a job towards the end of their study are offered **individual career support**.

As an extension to the Career Planning training and individual career support, FOM also offers **START employment meetings**. These meetings are intended to accelerate the job application processes for FOM PhDs. The primary focus of this is exchanging practical tips about job application procedures and current opportunities in the labour market (networking). At the START employment meetings, recently graduated FOM PhD students are also invited to share their experiences in this area. In 2013, two such START employment meetings were held.

In 2013, FOM and ASML organised two **company visits** (on 7 June and on 9 October) - see chapter 3.

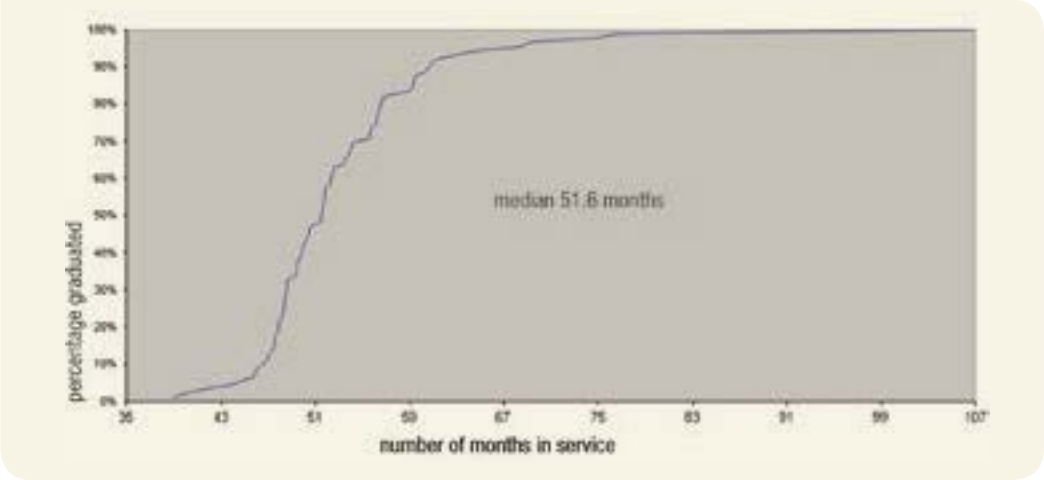
Outflow of PhDs in 2013: study duration and choices in the labour market

In 2013, 91 FOM employees graduated (76 men and 15 women) - 90 PhD students and one technician. This technician is permanently employed at FOM and has not been included in the analyses about the duration of employment and subsequent careers.

On average, the group of PhDs completing their studies in 2013 were employed at FOM for a period of just over four years and two months. The time between the moment of their entering service at FOM and the graduation ceremony averaged just over four years and five months. The cause of this difference is that the writing of the dissertations was generally completed a few months before the formal date of graduation. A committee must then evaluate the dissertation prior to graduation. At the time of graduation, PhDs are often no longer employed by FOM.

The graph shows the duration of the study for those PhDs finishing in 2013 plotted against the percentage of PhDs. The median is 51.6 months. FOM's aim is to reduce the median length of the study.

One of FOM's goals is to contribute to the availability of highly educated employees for the Dutch labour market. For 75 of the 90 PhD students who graduated in 2013, FOM knows that they have accepted a new job (see table 6). Of those 75 PhD students with a new job, 41 of them (55 percent) opted for a job in the Netherlands - 19 in industry, 18 in science (including postdoc positions at hospitals), three in the services sector and one in education. In total, 50 of the 75 chose to continue their careers in science. These people have found postdoc positions, often at prestigious research institutes and universities. For the majority of them (32 people), this was abroad. Experience shows that a significant portion of the group now choosing to continue their careers in the sciences still end up in the market sector with their next career moves.



Duration of study for PhDs in 2013. The short duration of one of the PhDs (left side of the graph) was caused by this person transferring from a university to FOM as an employer during the PhD study. The tail on the right-hand side of the graph is the result of a PhD who finally graduated several years after leaving service.

Table 6. Employers of FOM PhDs in 2013 as of 31 December 2013.

sector choice	number of PhDs	(selection of) employers
industry - Netherlands	19	8 at ASML (of whom 1 via TMC Physics), 3 at Shell, InnoSeis, Sievecorp, Invensys, Alten
services sector - Netherlands	3	KPMG, Optiver, Significance
universities - Netherlands	11	Radboud University Nijmegen, Erasmus University Rotterdam, Delft University of Technology, University of Twente, Maastricht University, Wageningen University & Research Centre
research institutions - Netherlands	7	NRG, TNO, AMC, VUmc, FOM
education - Netherlands	1	Zernike College Haren
industry - abroad	2	Endless Mobile, Cooledge Lighting
research institutions - abroad	8	Hemholtz (2), ICFO, Institut NÉEL, Research Center Pharmaceutical Engineering, SISSA, IST Austria, RCPE Research Center Pharmaceutical Engineering
universities - abroad	24	Heidelberg University (2x), University of Oxford, University of Edinburgh, École Normale Supérieure de Lyon, Gebze Institut of Technology, Princeton University, Yale University, MIT, University of Melbourne, Universidad de Chile, BITS Pilani, Inner Mongolia University
seeking work	13	
unknown	2	
total	90	

Sixty percent of the FOM PhDs who graduated in 2013 are foreign (see table 7). By choosing a PhD study outside their home country, they demonstrated their entrepreneurial spirit and ambition. These people are also exceptionally valuable to Dutch society. Of the foreign PhDs 37 percent chose to work in the Netherlands after graduation.

Table 7. Top ten nationalities of the FOM researchers graduating in 2013.

nationality	number of PhDs
Dutch	36
German	10
Italian	6
Polish	5
Russian	5
Iranian	4
Indian	3
Turkish	3
Romanian	2
Serbian	2

Postdocs

For researchers who have just gained their PhDs, experience in a well-known foreign institute is an important condition for a successful subsequent career in science. FOM therefore considers it undesirable on the one hand to employ researchers who have recently gained their PhDs in the Netherlands, and yet on the other hand it wants to provide those having obtained their PhDs abroad the opportunity to gain foreign country experience in the Netherlands.

In some disciplines, it is not unusual to have postdocs who have held three or more postdoc positions at various employers. FOM considers such long-term stacking up of postdoc contracts socially unacceptable and, for this reason, will not cooperate with this. A postdoc's opportunities for a scientific career decrease if he or she fails to fashion his/her own 'scientific signature' because of a patchwork of temporary jobs.

FOM has translated the aforementioned principles of postdoc policy into employment guidelines that allow for exceptions only in (extremely) special situations, and in consultation with the FOM personnel officer:

- **FOM provides PhDs with postdoc employment only if they have relevant work experience (for example as a PhD or as a postdoc) in a scientific institution outside the Netherlands;**
- **Generally, FOM does not employ researchers who are starting on their third postdoc contract. The director of the Central Personnel Service may deviate from this as long as the total duration of the prior postdoc contracts did not exceed four years or if there are special circumstances that would hinder strict application of the aforementioned term.**

Table 8. Influx of postdocs in 2013.

year of influx	2013
number of people flowing in	73
% women	*30*
average age upon employment	31.1 years
Nationality	
% Dutch	11
% EER+	41
% other foreign	48

Of those postdocs employed by FOM on 31 December 2013, 92 percent were foreign. Eighty postdocs left service in 2012 (there is still insufficient outflow data known about postdocs in 2013: FOM follows them less intensively than it does PhDs). The majority of the postdocs continue their career abroad (see table 9). This fits with the 'itinerant character' of postdoc positions. In 2012, among those postdocs leaving service and about whom FOM knew that they had accepted a new job, 30 percent (11 people) chose a job in the Netherlands.

Table 9. Labour market situation of FOM postdocs who left service in 2012.

paid job	45%		
in the Netherlands		30%	
at a company			45%
at a university or research institution			55%
other			
in EER+		53%	
elsewhere		17%	
unemployment benefit > 3 months	1%		
unknown	54%		

Women in physics

In the spring of 2010, FOM signed the women's charter Talent to the Top, along with many other Dutch employers. By doing so, FOM agreed to take concrete measures to attract and retain more female talent in the organisation. FOM has set itself the goal of having at least twenty percent, or 24 senior staff positions (scale 12 and higher) be occupied by women in 2020, with the intermediate objective of at least 16 women in 2015. This is an ambitious goal because the influx of women in scientific domains is traditionally limited.

Since the formulation of the FOM goals in 2010, the percentage of women scaled into scale 12 or higher (among scientific and non-scientific personnel) has increased from 7 percent to 9 percent. Unfortunately, there has also been a decrease from the 11 percent peak in 2011. This can be blamed partially on the fact that FOM is a flow-through organisation for many employees: people are employed temporarily and so flow out again as well. A number of top women have left the FOM organisation in recent years and have obtained good jobs outside FOM. So the percentage decrease is also due to the success of FOM women. FOM's task is now to take care of the next generation.

Table 10. Goal and the development of a number of women in top positions at FOM.

	baseline measurement 1-1-2010	situation as of 31-12-2011	situation as of 31-12-2012	situation as of 31-12-2013	goal for 2015	goal for 2020
number of female members of the Governing Board (total: 29 members)	2	4	4	6	4	6
number of female members of the Executive Board (total: 5 members)	0	0	1	1	1	1
percentage (and number) of women in scale 12 and higher	7% (8)	11% (13)	9% (11)	9% (10)	14% (16)	20% (24)

In 2012, by means of group meetings, FOM mapped out why female scientists who left employment did not return to the sciences. In 2013, five women who were not present at the group meeting were interviewed individually. These women were also specifically asked the question of what FOM as an employer can do to increase the number of women in the sciences. The findings from these interviews and from the previous group meetings were collected and included in FOM's plans for 2014.

During the annual **Physics@FOM Veldhoven** conference in 2013, FOM workgroup leaders were asked to pay attention to the topic of 'women in physics'. During a dinner, the workgroup leaders were challenged to think about how the percentage of women in Dutch physics, in particular those in higher positions, can be increased. Led by the Room to Grow consultancy, actors from the company 'Het Consulaat' showed pointedly how communication and interpretation on the work floor can result in unintended side effects. The lively discussion also brought attention to the fact that men can just as easily get into these situations as well.

FOm/f Programme

Since 1998, FOM has had the FOm/f Programme, under which FOM awards personal appointments to postdocs, for example. The FOm/f grant is for women who want to fashion a career in physics in the Netherlands in the long term. With this, FOM supports women in a crucial and vulnerable phase of their careers and provides them the opportunity to acquire a good starting position for the continuation of their careers. FOM funds a postdoc position of maximum three years' duration, spread over no more than five years. A condition is that the woman herself organises a stay at a foreign institution of 1-2 years that is not funded by FOM. In addition, bridging grants can be awarded to faculties and research institutions willing to employ women permanently. FOM contributes to this for a maximum of five years. Other activities within the FOm/f Programme are the biannual FOm/f Symposium, the opportunity to coach female PhD students and the biannual Minerva prize.

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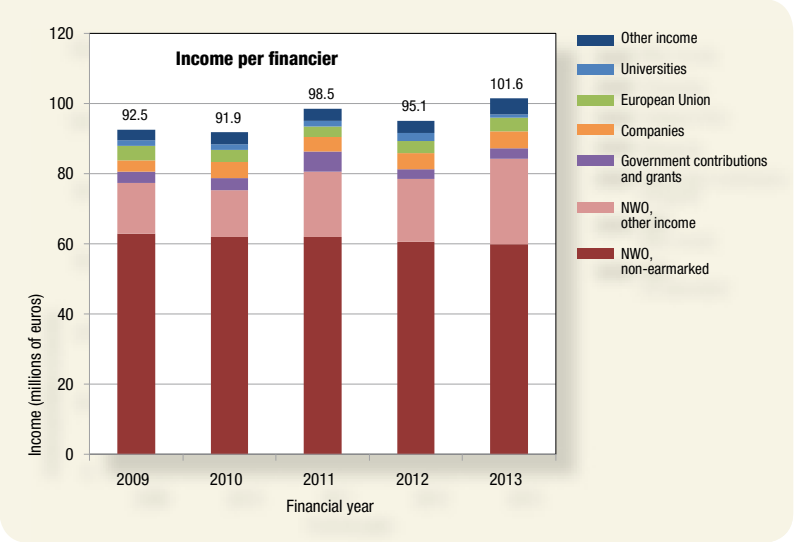
In the 2013 FOm/f Programme, three new personal appointments were awarded with a duration of three years. In 2013, FOM awarded one new bridging grant. Two previously awarded bridging grants also ran throughout the entire reporting year.

#FOMonline

***Renee-A. Koornstra**, @RAKstra, 18 September 2013*
Meeting of the FOm/f committee #fomphysics Chairman is #vrouw. But also men in the committee. #zohoorthetuiteindelijkoveral

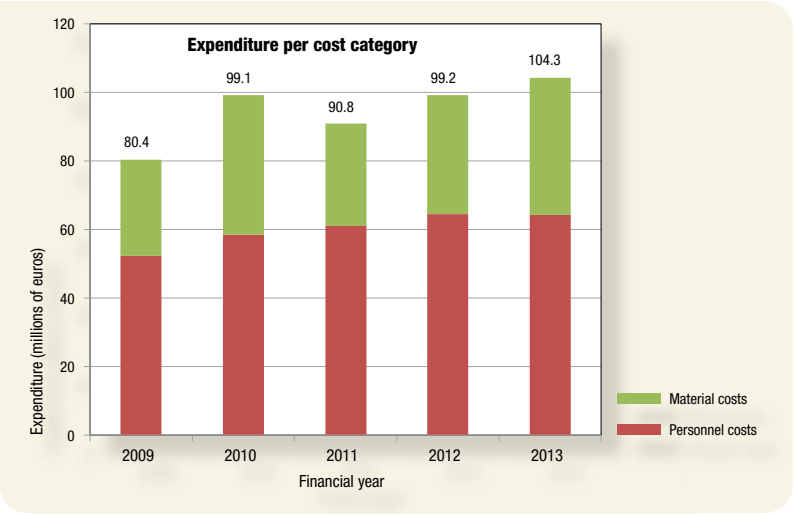
Chapter 8. Finances

FOM's most important financial management instrument is the budget that is established in a multiple-year perspective. FOM only awards programmes, projects and other activities if there is sufficient financial latitude in the budget. With each new strategic plan, the Board of Directors re-establishes the main distribution lines of FOM resources across the research activities. The budget that FOM spends annually on the operation of and investment in FOM activities comes primarily from NWO Physics and from the NWO Governing Board. Furthermore, FOM also receives resources from the European Union, from the Dutch government and from collaboration with universities and the industry.



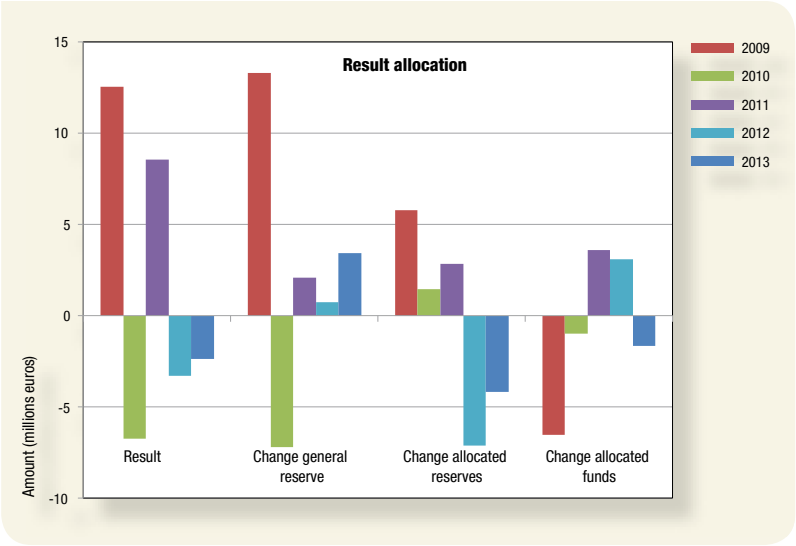
2013 in summary

With assets of 102 million euros in 2013, FOM's budget has never been so large. At the same time, FOM's freedom to disburse has shrunk because NWO's non-earmarked funds are decreasing (from 62.8 million euros in 2009 to 59.9 million euros in 2013). Due to this trend, now underway for a number of years, the share of the non-earmarked funds decreased from 68 percent in 2009 to 59 percent in 2013. Because of further cost-saving measures by NWO impacting non-earmarked FOM funds, this percentage is expected to decrease even more in the coming years (see future expectations further on in this chapter). In addition, since 2009, FOM has received no wage or price compensation from NWO. Consequently the spending power has decreased by approximately nine percent.



The total share of NWO in FOM's assets remained the same - approximately 83 percent - throughout the period from 2009 through 2013. An increase in NWO's so-called objective grants and project grants compensates the decrease in non-earmarked funds. These are earmarked grants for the new DIFFER construction, for example, initiatives within the top sectors framework, large-scale facilities and projects at the FOM institutes (NWO Investment Grant Large and the Innovational Research Incentives Scheme). Due to the increase in the number of Industrial Partnership Programmes in this period, funds from the companies grew considerably - from 3.2 million euros in 2009 to 4.7 million euros in 2013.

FOM's expenses increased from 80 million euros in 2009 to 104 million euros in 2013. This increase was caused by an increase in personnel costs resulting from an increase in the workforce (from an average of 848 fte in 2009 to an average of 1,055 fte in 2013) and by an increase in material costs. The workforce stabilised in 2013 after a number of years of increase due to the opening in 2007 of the 'programmaloket' (for applications for 'Vrije FOM-programma's') and due to extra resources for FOM from the Physics and Chemistry Sector Plan. Material costs increased more quickly than personnel costs. New construction at AMOLF has been depreciated since 2010.



The costs of large investments (KM3NeT, Advanced Virgo and HFML) have also increased beyond the average level. The peak in material costs in 2010 comes from provisions for the relocation of DIFFER and additional depreciation from the commissioning of the new construction at AMOLF.

Profit is negative in 2012 and 2013 due to the decrease in designated reserves, i.e. by catching up on the 'disbursements lag' (the difference between the moment of awarding and the moment of spending budgeted monies). This disbursement lag had accumulated in previous years. In the time period between 2009 in 2013, the disbursement lag shrank (the total of line items for designated reserves is negative). Since FOM has used the average pattern of expenditures from currently running projects as the basis for assigning its budgets for new projects for some years now, this desirable development is expected to continue.

In the period 2009 through 2013, the entry for general reserves is positive due to an increase in the value of the buildings (for new construction at AMOLF in 2009 and for new construction at DIFFER starting in 2011) and due to the addition of interest income and extraordinary income to the general reserve. Extra depreciation due to the occupation of the new construction at AMOLF and the costs of the new provision for DIFFER's relocation caused the negative entry in 2010.

The designated funds entry is the total of the annual NWO/Ministry of Education, Culture and Science grant for the new construction at AMOLF, the new construction at DIFFER and the Physics and Chemistry Sector Plans, minus the costs in that fiscal year.

Future expectations

The FOM budget is under pressure. In the budget for 2014 and beyond established in 2013 by the Executive Board, there is still a shortfall of more than 3 million euros starting in 2016. At the start of 2014, FOM was informed of new decreases in the basic NWO grant, decreases that approach approximately 1 million euros starting in 2017. New rounds of cutbacks within FOM will have to accommodate these shortfalls. Decisions about this will be made in 2014 in the context of the discussions about the new FOM/N strategic plan.

The Knowledge and Innovation Contract for the years 2014-2015 was signed on 2 October 2013 by public and private knowledge institutions and the government. A total amount of 4 billion euros will be invested in the top sectors designated by the government. In 2014 and 2015, NWO will contribute a total of 485 million euros. FOM's share in the NWO proposition amounts to 53 million euros. In 2014 and in 2015, FOM will receive an extra 13 million euros from NWO for initiatives in the top sectors, and 23 million euros from companies.

The top sectors policy implies a shift in funding from curiosity-driven scientific research toward research into topics that are important to industry. FOM is committed to executing the top sector policy by means of the existing instruments; in addition to the mission budgets from the institutes, the strategy programmes and the IPPs are the most suitable instruments for this.

In 2013, FOM received a first ANBI (Institution for Public Advancement) gift. This involves the first tranche of 50,000 euros in a periodic gift totalling 250,000 euros. The giver of this donation has the intention of allowing a young Dutch scientist to do fundamental research at the top level in the Netherlands in a curiosity-driven area in order to encourage top-level fundamental research. The conditions of the donation have been recorded in a legal writ. The research project and the researcher have now been chosen in consultation with the donor. It involves research in the area of fundamental cosmology. The selection of the research projects and the researcher took place in consultation with Margriet van der Heijden, the science editor at NRC Handelsblad newspaper. Because of FOM's ANBI status, the donor can deduct the entire gift from his income tax. The ANBI gift is included under other assets.

About FOM

31-12-2013

People at FOM

number of personnel

77	permanent scientific staff
175	postdocs
512	PhDs
329	support staff
1,093	FOM total

Organisation of the research

3	FOM institutes: AMOLF, DIFFER & Nikhef
1	Advanced Research Centre: ARCNL
205	working groups at universities
64	research programmes, of which 6 in the form of a FOM focus group
19	Industrial Partnership Programmes
186	*FOM-Projectruimte* projects

FOM's finances

annual turnover

104.3 million Euros

Annual output FOM

91	PhD theses
1,192	scientific papers (refereed)
1,837	other publications
13	patents

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FOM NWO