Evaluation 2005 – 2010

FOM-Institute for subatomic physics Nikhef

The Hague, 2011

Netherlands Organisation for Scientific Research

Contents

1 Introduction

1.1 Scope and context of this evaluation

The Netherlands Organisation for Scientific Research (NWO) and the Foundation for Fundamental Research on Matter regularly evaluate the scientific performance of its research institutes. As part of this evaluation scheme, the FOM-institute for Subatomic Physics Nikhef[1] has been evaluated by an international committee. The aims of the assessment system are:

- Improvement of research quality based on an external peer review, including scientific and societal relevance of research, research policy and research management;
- Accountability to the board of the research organisation, and towards funding agencies, government and society at large.

The committee is asked to produce a reasoned judgement on the mission, strategy and performance of the institute. The evaluation contains retrospective and prospective elements. The assessment is based on the Standard Evaluation Protocol 2009-2015 (SEP) (FOM-11.0317), which calls for an evaluation both of the research institute itself and of the research programmes it conducts. FOM-Nikhef submits details of the results that have been achieved in each research programme over the previous six years (including quantitative data about staff input, key publications and a list of publications), a short outline of the mission statement of each programme, and details of developments anticipated in the context of the research profile of the institute. Important elements of each review are a site visit, which includes interviews with the management and the programme leaders, and a tour of the facilities.

1.2 The evaluation committee

The evaluation committee was appointed by the Governing Board of NWO following consultation with FOM. Its members are:

- Professor Torsten Åkesson (chair), Lund, Sweden;
- Dr. Theun Baller, Philips, Eindhoven, The Netherlands;
- Professor Nigel Glover, Durham, UK;
- Professor Thomas Hebbeker, RWTH Aachen, Germany;
- Dr. Patricia McBride, Fermilab, Batavia, USA;
- Professor Ken Peach, Oxford, UK;
- Dr. Francesco Ronga, INFN, Frascati, Italy.

A short curriculum vitae of each of the members is included in Appendix 7.1. The committee was supported by FOM programme officers Drs. Job de Kleuver and Dr.ir. Christa Hooijer.

All members of the committee declared that their assessment had been free of bias, personal preference or personal interest, and that it had been reached without undue influence from the institute, the programme directors or other stakeholders. Any existing professional relationships between committee members and programmes under review were brought to the attention of the committee. The committee concluded that there were no conflicts of interest.

[1] In this report, Nikhef will refer to the collaboration of the laboratory FOM-Nikhef and the four University groups. FOM-Nikhef will refer specifically to the FOM laboratory located in the Science Park in Amsterdam.

1.3 Data supplied to the committee

The documentation included all the information required by the SEP, as well as answers to the additional questions addressed to FOM-Nikhef by NWO and FOM. It included:

- The self-evaluation report 2005-2010 by FOM-Nikhef;
- The strategic plan FOM-Nikhef 2011-2016.

During the site visit, handouts of all the presentations were made available.

1.4 Procedures followed by the committee

The committee proceeded in accordance with the Standard Evaluation Protocol 2009-2015. The assessment was based on the documentation provided by the institute and the interviews conducted during the site visit on 19-21 September 2011. The programme of the site visit is included in Appendices 7.2 and 7.3.

The documentation was sent to the committee one month before the site visit. The chair and the secretary of the committee established a timetable for the site visit (see Appendix 7.2).

The committee was installed on the first day (Monday 19 September 2011) by Prof. Ben de Kruijff, member of the General Board of NWO in the presence of the director of FOM, Dr. Wim van Saarloos. Prof. Frank Linde, director of FOM-Nikhef, gave a short introduction to his institute. Afterwards the committee met in closed session and discussed the agenda and the activities for the following days, and for a first exchange of views.

On day 2 (Tuesday 20 September 2011), the committee discussed progress with all programme leaders and members of the research teams. The committee had the opportunity to visit some of the technical facilities in Nikhef, and also to talk to about 35 of the PhD students and two master students about their experiences and to the chairman of the external Scientific Advisory Committee.

On day 3 (Wednesday 21 September 2011) the committee met the director and discussed the long term future plans, the lab infrastructure and technical skills, knowledge transfer, education, outreach and finances, including the request for an increased mission budget. After that day 3 was spent discussing and writing a preliminary draft of the evaluation report and formulating the conclusions of the committee together. The conclusions of the committee were presented to the director of FOM and several members of the staff of Nikhef by Prof. Torsten Åkesson over dinner. After the visit, the chairman together with the secretary prepared a proposal for the final version of the evaluation report. This report was approved by the committee members and sent to the director of FOM-Nikhef to be checked for factual errors. The report was completed on 19 October 2011.

1.5 Assessment scale

The committee used the scale provided in the Standard Evaluation Protocol (see Appendix 7.4).

2 Introduction to particle & astroparticle physics, experiments & collaborations

Particle Physics is concerned with identifying the most basic constituents of the universe around us, and describing how they interact. Towards the end of the nineteenth century, it was realised that atoms, then still not universally accepted as physical entities, were probably not fundamental but had internal structure. Much of the twentieth century was devoted to exploring the consequences. The twin pillars of quantum mechanics and relativity led eventually to the development of the Standard Model of Particles and their Interaction, or simply the Standard Model. This describes the sub-atomic (actually, sub-nuclear) domain in terms of twelve constituent particles (six quarks and six leptons, arranged in three families) and their anti-particles, together with five force-carrying particles (the gluon, the photon and W^+, W^- and Z bosons). Over the past thirty years, the Standard Model has been subjected to increasingly stringent tests, and has been found to describe a large range of phenomena with an impressive precision. Despite this success, the Standard Model is known to be incomplete, and must itself be derived from an even more fundamental theory.

Some of the motivation for physics "beyond the Standard Model" comes from the model itself – while it is successful in describing the physics universe, its basic structure is unexplained. Further clues that there is a more fundamental theory come from astronomy and cosmology – it seems that the Standard Model accounts for only about 5% of the energy content of the universe, and that other forms of matter ("Dark Matter") and energy ("Dark Energy") are all pervasive. There is thus an increasing interest in astroparticle physics, which uses particle physics techniques and e.g. high-energy cosmic rays to study astrophysical phenomena, providing valuable insights to both particle physicists and astronomers.

Experiments in both particle and astroparticle physics use advanced technologies on a large scale, often operating close to the limit. For example, the detectors at the Large Hadron Collider (LHC) at CERN weigh thousands of tonnes and have millions of electronics channels distributed over detectors tens of metres in length, and yet can measure the position of individual particles to a precision of a few microns. Both the wide range of technical skills needed and the scale of the construction require that the experiments are organised as large collaborations, involving hundreds of institutes (universities and laboratories) and thousands of physicists, engineers, PhD students and technicians.

Alongside the experimental work, there is a need for theoretical studies, which range from the development of tools (e.g. Monte Carlo algorithms, parton distributions functions) essential to the analysis of the data from experiments to the exploration of the consequences of extensions to the Standard Model and to the creation of new theoretical ideas to explain new phenomena or address perceived defects in existing theories.

The Netherlands have a long tradition of experimental and theoretical research in particle physics. S. van der Meer shared the 1984 Nobel Prize for his work on stochastic cooling, an essential technological breakthrough key to the discovery of the W and Z bosons at CERN. The award of Nobel Prize to G. 't Hooft and M. Veltman in 1999 for their role in establishing the basis of the Standard Model, which predicted the existence and masses of the W and Z bosons. C.J. Bakker was the Director-General of CERN from September 1955 to April 1960, and L. van Hove (born in Belgium) was Director of the Theoretical Physics Institute at the University of Utrecht from 1954 to 1961, when he left to become leader of the Theory Division at CERN and later (1976-1980) was Research Director General of CERN. W. Hoogland was Research Director at CERN from 1989 to 1992. This tradition of excellence continued, with the appointment of J. Engelen, the director of FOM-Nikhef from 2001-2003, and in 2004-2008 as Chief Scientific Officer and deputy Director General of CERN.

Nikhef researchers are also taking key positions of responsibilities in the different collaborations they participate in, and we should have in mind that these collaborations are by themselves of magnitudes like large laboratories. Please consult the corresponding sections for this information.

3 FOM-Nikhef

The scale of particle- and astroparticle physics experiments, and the range of technical skills required to design, build and operate them, make it difficult for all but the largest institutes to take full responsibility for a major contribution of the detector. As a response to this, many countries have developed a consortium approach, with universities and national laboratories working together on a coordinated programme. Such networks exist in Belgium, Italy and the UK, for example, and the US has organised its contribution to the ATLAS and CMS detectors at the LHC on similar lines. Germany has created an alliance of 17 universities and two HGF laboratories (DESY and FzK) to pursue physics at the high-energy frontier. The Nikhef collaboration implements this model in an exemplary way as a tightly-coupled collaboration of four university groups and a national FOM laboratory, with one common scientific programme and many of the senior scientific staff having joint appointments between one of the universities and the laboratory. While there is some administrative overhead involved in managing the network, this is more than compensated through the reduction in the duplication of administrative effort that would be required in each of the institutes were they to participate individually in the research programmes. In terms of organisational structure it can be noted that Finland was inspired by Nikhef when it organised its research in this field around the Helsinki Institute of Physics.

The Nikhef collaboration consists of the FOM-Nikhef laboratory at the Science Park Amsterdam, and four universities, the Universiteit van Amsterdam (UvA), the Vrije Universiteit Amsterdam (VU), the Radboud Universiteit Nijmegen (RU) and the Utrecht Universiteit (UU). Nikhef coordinates and supports all activities in experimental subatomic physics in the Netherlands. FOM-Nikhef is an integral part of the FOM organization, the Foundation for Fundamental Research on Matter. Through the Nikhef collaboration, which builds upon the international reputation of the FOM-Nikhef laboratory over many years, the Dutch universities are highly visible in particle and astroparticle physics world-wide.

3.1 Mission

The mission of Nikhef is to study the interactions and structure of all elementary particles and fields at the smallest distance scale and the highest attainable energy.

Two complementary approaches are followed:

- **Accelerator-based particle physics**
  Experiments studying interactions in particle collision processes at particle accelerators, in particular at CERN;
- **Astroparticle physics**
  Experiments studying interactions of particles and radiation emanating from the Universe.

Nikhef coordinates and leads the Dutch experimental activities in these fields.

3.2 Research

Information about the achieved and expected research of the programmes, in general and with Nikhef personnel as key players, are reported in the corresponding chapters of this report.

3.2.1 Accelerator-based particle physics

For the **Accelerator-based particle physics**, the period of the review (2005-2010) was marked by the completion and commissioning of the experiments at the LHC, followed by their first data taking period in 2010. The three groups running the LHC programmes participated in the preceding experiments D0, BaBar and STAR with some overlap in time.

For the *physics at the TeV-scale* ATLAS became an active experiment in the period of this review, and the D0 participation was ramped down. The start of ATLAS is reflected in the decrease of the technical staff and the corresponding increase of PhD students. The Nikhef combined ATLAS and D0 activity corresponds to an annual budget of 4,237 k€ including 56.5 FTEs (15.7 scientific staff) in 2010.

For the *physics with b-quarks* LHCb became an active experiment with the start of the LHC while the involvement in BaBar at SLAC was stopped earlier following the DoE decision to close the accelerator in 2008. The LHCb Nikhef activity corresponds to 2,675 k€ including 30.4 FTEs (10.0 scientific staff) in 2010.

For the programme of *relativistic heavy-ion physics*, ALICE, got its first heavy ion data under this period, and of course also pp comparison data. The start of ALICE is reflected in the decrease of the technical staff and the corresponding increase of PhD students. Nikhef has concluded its activities in STAR. The Nikhef activities in heavy ion physics correspond to 1,811 k€ including 24.8 FTEs (6.7 scientific staff) in 2010.

Future on Accelerator-based particle physics: Nikhef is preparing for upgrades for each of its LHC experiments. These upgrades are well defined for LHCb and for ALICE, while they are more conceptual for ATLAS. Upgrades are also foreseen for the Tier-1 grid computing facilities. These would be natural components of the Dutch Research Infrastructure Roadmap and part of the corresponding funding strategy. To prepare for the longer time scale, Nikhef participates in studies for a linear collider experiment, and contributes to the alignment in CLIC.

3.2.2 Astroparticle physics

For the **Astroparticle physics**, FOM-Nikhef followed up to 2010 three programmes of neutrino telescopes, gravitational waves and cosmic rays, and a fourth programme started 2010 on dark matter.

For observations with *neutrino telescopes*, ANTARES started operation with searches for point-like sources well underway and preparations started for the larger KM3NeT. There is a challenge for the latter since the preparedness of Nikhef to launch its construction is more advanced than its international partners, and point-like sources have not yet been observed. The Nikhef activities in neutrino telescopes correspond to 2,236 k€ including 27.6 FTEs (5.7 scientific staff) in 2010.

For the *gravitational physics*, Virgo, the 3 km laser interferometer is operational and has provided its first limits. It has a major upgrade in the pipeline: Advanced Virgo. On the longer term the group is looking at the space-based LISA and the ground-based Einstein Telescope (ET). The Nikhef activities in gravitational waves correspond to 1,034 k€ including 13.0 FTEs (3.0 scientific staff) in 2010.

For *cosmic rays*, the Pierre Auger Observatory in Argentina is active since early 2004 and with Nikhef participation since 2006, being complemented by a radio detection technique proposed by Nikhef. The Nikhef activities in cosmic rays correspond to 537 k€ including 8.8 FTEs (1.8 scientific staff) in 2010.

The XENON *direct dark matter search* experiment at Grand Sasso was joined by Nikhef in 2010. The Nikhef activities involve 4-5 FTEs (2-3 scientific staff).

Future of Astroparticle physics: Nikhef is working on four programmes with upgrades and next generation installations. It is positioning itself to be part of discoveries on neutrino point sources, gravitational waves, dark matter and the origin of cosmic rays.

3.2.3 Cross cutting the Mission

Cross cutting the Mission is the programme in research in *Theoretical Physics* with research lines in many areas including ones directly linked to the experimental/observational programmes. The Nikhef activities in theoretical physics correspond to 1,862 k€ including 27.9 FTEs (7.6 scientific staff) in 2010.

Another cross cutting programme is *detector R&D*, opening new experimental possibilities and transferring the knowhow to the outside world, e.g. medical applications. The Nikhef activities in detector R&D correspond to 1,897 k€ including 17.3 FTEs (4.1 scientific staff) in 2010.

Finally, there is the enabling programme of *physics data processing, grid computing*. This activity includes providing the Dutch LHC Tier-1. The strength of the Nikhef activities in computing also led to that the EGI (European Grid Initiative) head quarters were placed in the Science Park Amsterdam. The Nikhef activities in computing correspond to 954 k€ including 13.2 FTEs (3.0 scientific staff) in 2010.

3.3 Organisational structure

The organisational structure is compact (see Figure 1), with a small senior management team led by the director and consisting of the institute manager and the head of personnel, supported by the head of the secretariat. Each of the projects and technical departments has a project or technical group leader, reporting to the director. In addition, technical support in the university groups is embedded locally. Each project or programme has its own internal structure and project plan, agreed with the director. The projects are structured across the collaborating institutes of Nikhef in an integrated way.

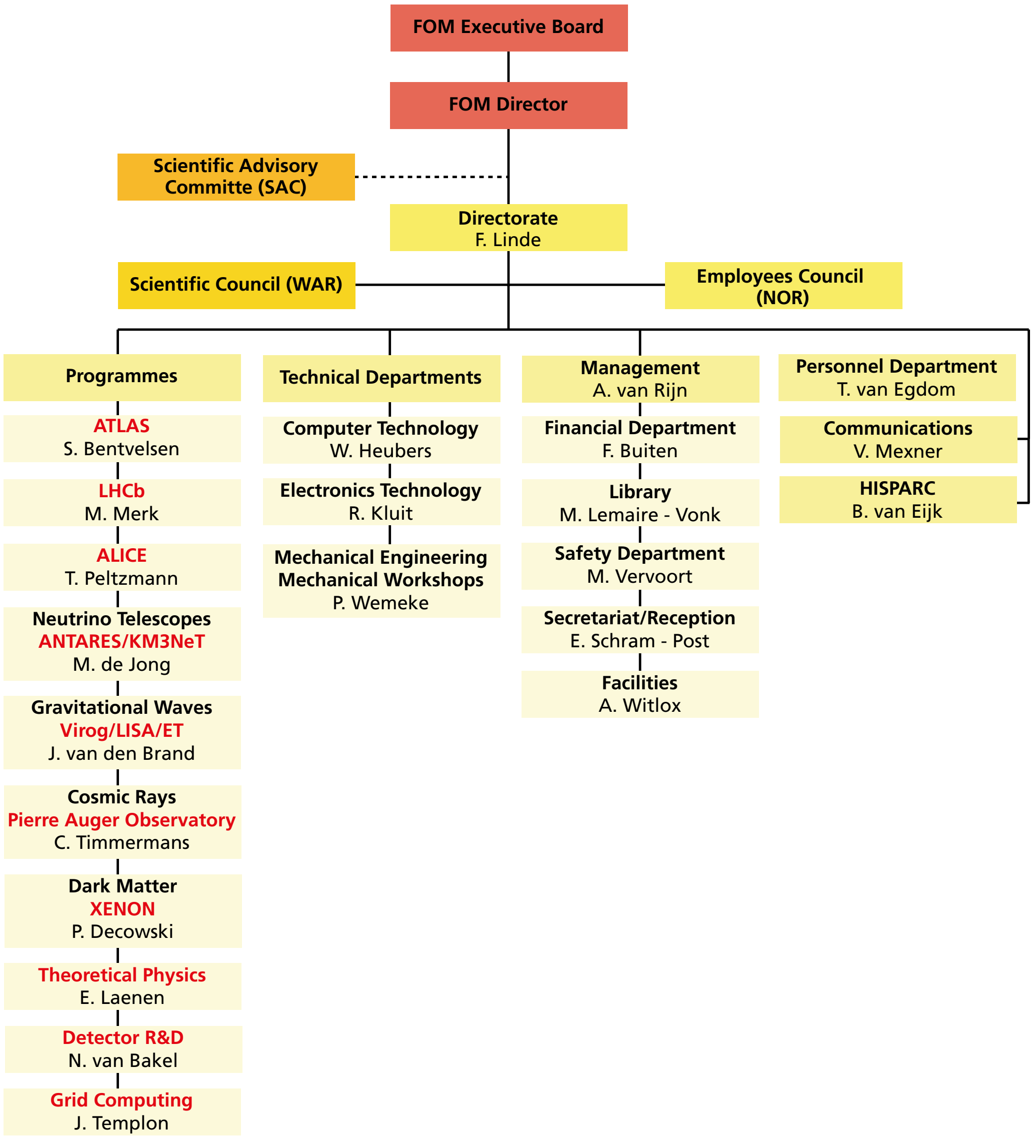


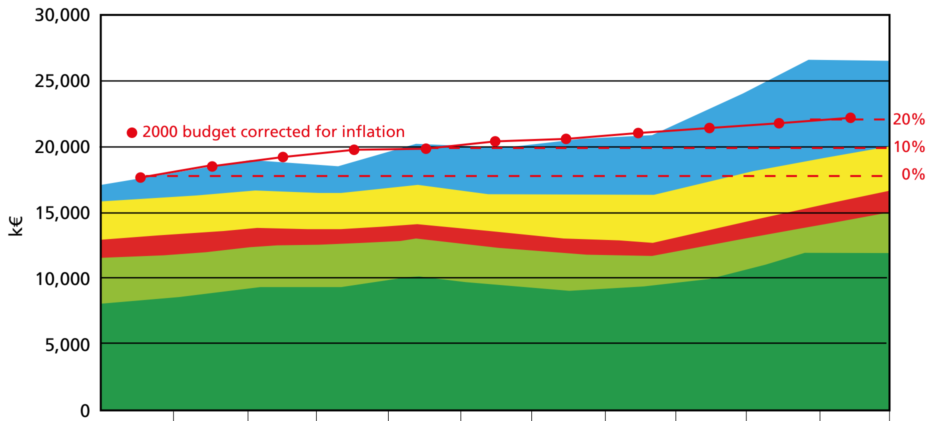
Figure 1 | Organisational structure.

3.3.1 Location

The FOM-Nikhef laboratory is located in the Science Park Amsterdam, and the collaboration also has a presence in the four collaborating universities, Universiteit van Amsterdam, the Vrije Universiteit Amsterdam, the Radboud Universiteit Nijmegen and the Utrecht Universiteit.

3.3.2 Financial matters

The research programme of the Nikhef collaboration is funded by four separate sources (see Figure 2) – (1) FOM funding of the base budget of the institute and for its programmes, (2) FOM funding for the university groups, (3) university funding for personnel and materials in the universities, and (4) additional project funding acquired competitively by the institute from FOM, the EU, NWO, the Ministry of Economic Affairs etc, as well as income from the lease of the former accelerator buildings and from hosting a large part of the Amsterdam Internet Exchange (AMS–IX). In 2010, the total funding of Nikhef was about 26.6 M€, 63% from FOM, 12% from the universities and 25% from third-party funding. Over the six years under review, the nominal budget of Nikhef has increased by about 34%, through the increase in the FOM Mission Budget and from the additional funding acquired competitively and also due to inflation.

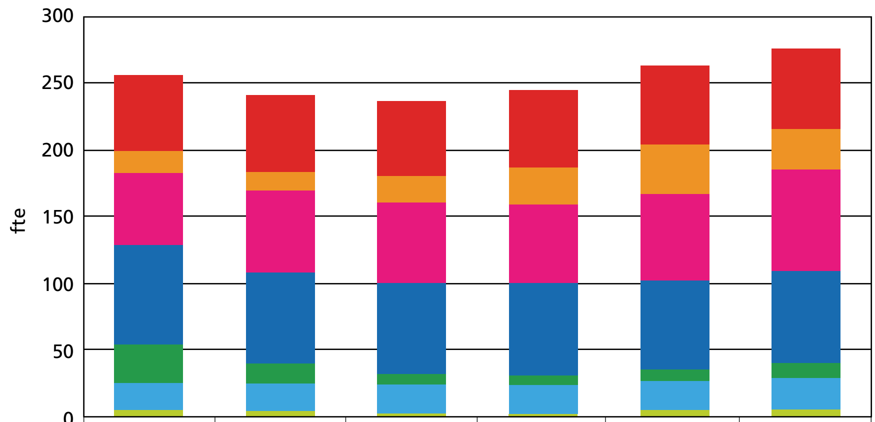


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Additional funding	1,350	2,041	2,342	2,014	2,991	3,575	4,166	4,588	5,816	7,732	6,565
Universities	2,815	2,877	2,813	2,788	2,987	2,838	3,388	3,486	3,527	3,523	3,318
FOM univ. groups	1,415	1,463	1,342	1,220	1,203	1,230	1,166	1,186	1,303	1,522	1,679
FOM-NIKHEF programme	3,353	3,253	3,109	3,119	2,807	2,667	2,018	2,032	2,255	1,391	2,806
FOM-NIKHEF mission	8,209	8,579	9,327	9,376	10,143	9,600	9,780	9,616	10,577	12,451	12,243

Figure 2 | Sources of funding for Nikhef.

3.3.3 Current staff

The number of personnel, expressed in full–time equivalents (FTE) has significantly increased in the period 2005–2010 from about 256 to about 277, i.e. by 8% (see Figure 3). The number of permanent scientific staff has increased from about 57 to 61 FTE. The strongest increase is in the category of postdocs (79%) followed by PhD students (41%). There are about 31 post–docs and 75 PhD students in 2010. Staff reductions are primarily in the area of technical staff, and in particular the temporary positions. This development, i.e. reduction of technical staff and increase of postdocs and PhD students is fully consistent with the transitioning from construction to exploitation. About 35% of the permanent scientific staff of Nikhef, including all full professors, is employed by the university partners. In addition, there are about 29 FTE in managerial, secretarial, safety, library and technical services. The number of female scientific permanent staff has increased from 2 to 5 and is now 6% of the total scientific permanent staff.



	2005	2006	2007	2008	2009	2010
Scientific permanent	56.6	56.9	56	57.8	58.5	61.1
Postdocs	17.1	14.6	19.2	27.9	36.7	30.6
PhD students	53.4	60.6	60.8	59.4	66.1	75.2
Non-scientific permanent	75.3	68.9	67.8	69.6	66.2	69.1
Non-scientific temporary	28.4	15.4	8.1	6.6	9.4	11.5
Support permanent	21.1	19.7	22	22	21.5	23.9
Support temporary	4.2	5.2	2.4	2.5	4.4	5.4

Figure 3 | Evolution of the staff profile.

4 Assessment of the Institute

4.1 Answers to the Standard Evaluation Protocol

The committee grades the institute as indicated in the table below (scale 5 – 1; see also appendix 7.4). The section numbers refer to the sections where these grades are argued.

Assesment on	Grade	Section
A. Quality		
Quality and scientific relevance of the research	5	4.1.A1
Leadership	5	4.1.A2
Academic reputation	5	4.1.A3
Organisation	5	4.1.A4
Resources	4	4.1.A5
PhD training	4.5	4.1.A6
B. Productivity		
Productivity strategy	5	4.1.B1
Productivity	5	4.1.B2
C. Relevance		
Societal relevance	5	4.1.C1
D. Vitality and feasibility		
Strategy	5	4.1.D1
SWOT-analysis	not graded	4.1.D2
Robustness and stability	4	4.1.D3

Overall assessment of the institute – 5

FOM-Nikhef is one of the leading laboratories in experimental particle physics in the world, with an outstanding record of achievement in detector and electronics design, construction and commissioning, physics analysis and advanced computing techniques, supported by a strong theory group. In addition, through the Nikhef organization, it is more than a laboratory; it is bringing a number of University groups to work together in an integrated way since the faculty members are taking larger responsibilities than would have happened if the same resources were spread to a number of independent University groups. Nikhef with FOM-Nikhef in the centre, is a model of efficiency giving the Dutch research a much larger international impact than if the corresponding resources were distributed among a set of independent university groups, and has a strong focussing effect.

The period under review has seen the LHC programmes entering into exploitation with a strategically increased participation by PhD students and postdocs with results being produced with an astonishing speed, ANTARES demonstrating its excellent precision and looking into our galaxy, Virgo starting to set limits on gravitational waves and AUGER confirming the GZK cut-off.

The accelerator-based particle physics programme is composed of the three LHC experiments – ATLAS, LHCb and ALICE – all in operation with an excellent performance.

Nikhef has delivered on all of its commitments, and taken the lead in many areas, including the development of Grid technology. The participation in the preceding experiments at the energy frontier/b-physics/heavy ion physics, are completed or close to it.

Nikhef's four programmes in astroparticle physics are all ongoing and producing important scientific results, with promising outlooks for upgrades or next generation experiments.

The Nikhef programmes have all together produced 77 new PhDs during the review period. The success rate is high, but the time to a PhD somewhat too long. The revitalisation of the graduate school will improve the PhD training even further and may result in reducing the time to a PhD. The PhD students are proud of being at Nikhef, and very satisfied with their training.

Nikhef also has a strong and innovative outreach and educational programme which is internationally recognised, and is developing a strong knowledge transfer portfolio. Its interaction with the rest of the society is in many ways pioneering and increasing, and may well become an international model.

Overall, the FOM-Nikhef institute has an outstanding reputation in the field.

4.1 A1 Quality and scientific relevance of the research – 5

The research is at the absolute frontier of the field. All experiments are the best, or share top positions, in their domains: Energy frontier – ATLAS, b-physics – LHCb, heavy ion physics – ALICE, gravitational physics – Virgo, cosmic rays – AUGER, neutrino telescopes – ANTARES, and dark matter search – XENON, and the underpinning theoretical effort; the committee cannot see any domain where a stronger approach could have been taken. In each programme the committee sees clear, efficient, leading and original Nikhef contributions, thanks to the technical strength of the institute.

There are also fields where Nikhef is not active, such as gamma ray astroparticle physics, studies of the cosmic microwave radiation and accelerator/reactor-based neutrino physics.

The committee understands that a selection must be made and strongly supports the choices that Nikhef has made, and agrees that more consolidations are needed in AUGER and XENON before other programmes are considered.

4.1 A2 Leadership – 5

The mission, please see 3.1, is fully supported by the committee. Indeed, it is short and clear, and captures the main issues in today's particle- and astroparticle physics. However, it is clear that what is produced by Nikhef makes its way outside the research sector amounting to a continuously increasing valorisation activity. The committee is of the view that this should be made explicit in the Mission Statement.

Under the energetic and direct leadership of Prof. dr. F. Linde, supported by the institute manager Drs. A. Van Rijn and his staff, the institute is developing in an excellent manner with a broadening of its research in astroparticle physics while fully exploiting the experiments in accelerator-based particle physics. The staff is engaged and proud of being part of Nikhef. This engagement and enthusiasm are also demonstrated by the substantial additional funding that the institute attracts from the NWO excellence programmes and from the ERC.

4.1 A3 Academic reputation – 5

FOM-Nikhef is one of the leading laboratories in experimental particle physics in the world. It has a remarkable scientific reputation. It rests on its excellent work in experiments and in theory. The self-evaluations show the leadership roles that Nikhef staff takes in the collaborations where it participates. Nikhef members are also visible in the different international committees and boards of the field, and appointed to scientific advisory boards at other national laboratories outside the Netherlands.

All the Nikhef programmes are producing, or are expected to produce, the key information needed for the further development of particle- and astroparticle physics. Nikhef is engaged in the best possible experiments to address its mission.

4.1 A4 Organisation – 5

The description of the organisation can be captured with the words clear and direct. It is led by the director appointed by FOM who has a Directors team meeting weekly. Above the Director is the Executive Board of FOM. Programme Leaders responsible for the programmes are appointed by the Director. FOM-Nikhef has two councils, one more for workplace related matters (mandatory by law) and one for scientific affairs. FOM-Nikhef is advised by an external Scientific Advisory Committee, SAC. SAC considers that its interaction with Nikhef and FOM works very well.

Matrix structures are, as usual, required for construction. These have always some intrinsic tensions, but that is unavoidable and sometimes even healthy.

In general, the committee cannot see any need to change this organisation, and the performance of the institute is a witness to its efficiency.

4.1 A5 Resources – 4

A change has taken place in reducing resources from non-scientific staff, in particular temporary, and increasing postdocs and PhD students. This shift is fully in line with entering the exploitation of the many facilities that Nikhef has contributed to during their construction. In overall numbers, the staff has also increased by 8% during the period of review. The overall gender balance is still unfavourable with only 12.5% women, and only 6% among the scientific staff. However, the balance has favourably increased for PhD students to 19.5%.

During the same period, also the financial resources have increased from FOM, and also from additional sources, in competition where the main criteria are scientific excellence of the individual staff members, i.e. there is an increased activity from the staff to actively seek such support. A concern is the end of the *temporary increase of the mission budget by NWO* and the *dynamiseringsimpuls* resulting in a 1.1 M€/year reduction in the mission budget as of 2012. This reduction of the stable institutional funding could hurt the activities preparing for the future and supporting the programmes, i.e. the detector R&D, theoretical physics and the grid computing. The increasing activity of knowledge and technology transfer (from an already excellent level) should be made more visible and is a strong argument for not reducing the base funding for the institute. There are therefore strong arguments for maintaining the mission budget at around 11.5 M€.

FOM-Nikhef's facilities include electronic capability, mechanical shops, and assembly facilities. These are complemented by networking and computing installation. All are of the highest quality and have completed major construction projects for the different programmes. Through its clean rooms and contacts with specialized institutions there is an excellent environment for development work. The strength of the facilities is also demonstrated by the impressive way in which Nikhef is expanding its activities in astroparticle physics.

The committee sees the very positive effect from the increased resources during the period of the review, and the lower grade of this section is due to concerns over the 1.1 M€/year potential reduction.

4.1 A6 PhD training – 4.5

The universities in Nikhef and FOM-Nikhef started in 2010, with new resources from NWO, a revitalisation of the graduate school OSAF (Research School Subatomic Physics), for the training of PhD students, and with a secretariat at Nijmegen. This organisation will ensure a consistent supervision, learning and training environment. It will still take a few years before the fruits from this revitalisation approach will be seen in the statistics. The success rate of the PhD studies is already high while the median time for the studies is nearly 5 years, although this is not taking into account unproductive periods like sick leave. It is likely that OSAF is the best way to address the issue of the length of the PhD studies, while it will increase its quality even further. Nikhef produced on the average about 14 PhDs per year. The slightly lower grade of 4.5 in this area is due to the length of the PhD training, and that it is too early to see the effects of the revitalised OSAF.

4.1 B1 Productivity strategy – 5

The institute produces knowledge published in high impact peer reviewed journals, presented in international conferences, and communicated to the public through its outreach activities.

Spin-offs from its research are actively transferred to the rest of the society in an increasing and more systematic way than most, if not all, other institutes whose main mission is fundamental research.

Nikhef's staff is encouraged to seek support from programmes rewarding excellence, and are successful in doing so.

Another output of the institute is trained researchers, and it produces on the average 14 PhDs per year. This activity is strengthened further by the graduate school OSAF.

4.1 B2 Productivity – 5

The Nikhef publication rate has increased by 40% during the period of the review. Its staff presents results at major conferences with a rate significantly above the size of the Nikhef participation in the respective collaboration. The knowledge transfer to the society at large has increased even further by the turn-on of the LHC.

The output of trained researchers is constant, but with normal fluctuations year-by-year. An exception is the drop related to the delay of the LHC, however, this is compensated by an increase in 2011.

Nikhef has organized and hosted 42 international meetings during the period of the review.

As a consequence of Nikhef's growing awareness of the importance of patents one patent was granted in the review period, one is submitted for review and one is in preparation.

4.1 C1 Societal relevance – 5

The mission of Nikhef is to increase our knowledge of the basic laws of nature, the building blocks, forces that act on them, and how that determined the development of the early universe. Nikhef is making an ever increasing effort in communicating this knowledge increase to the public at large. The start of the LHC, and the media attention around it, became naturally an additional boost for this communication. This broad societal impact is made through education actions for primary and secondary school pupils, and training of secondary school teachers. The programme of HiSPARC, i.e. cosmic ray detectors to be placed at high schools and connected to a global network, is inspiring pupils around the Netherlands and several other countries. Efforts are also made through open days and outreach talks, website, guided tours of Nikhef and CERN, and media events. All aim to bring the main product of Nikhef, knowledge, to the society at large.

The experimental program requires a lot of technology developments as well. For Nikhef that includes the RASNIK alignment system, pixel devices, CO_2 cooling, and computing and networking. In all these areas there are strong transfers and effects for the society in general. The RASNIK is commercialised and applied to e.g. monitor buildings (the Weena tunnel in Rotterdam), the pixel devices through PANalytical, a company for material diagnostics, the CO_2 cooling for e.g. space applications, and the computing and networking of Nikhef has positioned Amsterdam, and the Nikhef site, as a centre for internet and grid computing.

Nikhef's interaction with the rest of the society is in many ways pioneering and increasing, and may well become an international model.

4.1 D1 Strategy – 5

There is a consistent strategic plan 2011-2016 on how the institute should fulfil its mission. The two branches particle- and astroparticle physics are engaged with a 2:1 ratio according to the original ambition. It includes upgrades of the LHC experiments, increased installation for radio detection of cosmic rays, upgrade of the gravitational wave interferometer, deployment of the next generation neutrino telescope and a new detector for dark matter detection. These detectors, Auger, Antares, Virgo and Xenon, are all prepared and deployed consistently while exploiting the running LHC experiments.

Nikhef is in the unique situation that major discoveries are expected; Nikhef is therefore entering an extraordinary period of exciting scientific results.

The dominant uncertainty is therefore what nature will reveal. The broad but focussed programmes of Nikhef, could not be better optimized.

4.1 D2 SWOT-analysis – **Not graded**

The committee agrees with the SWOT analysis performed by the institute.

4.1 D3 Robustness and stability – 4

Nikhef is currently well equipped for exploiting its experiments, taking major responsibilities in new experiments and upgrades, and for detector R&D.

Its staff is very competitive and is regularly awarded grants based on personal excellence. Nikhef is an attractive employer and with few exceptions there are no difficulties in recruitment.

The FOM programme funds are crucial for the LHC-exploitation since postdocs and PhD students are essentially covered from this source. These funds end in 2013-2015. The committee supports that proposals are submitted to safeguard the excellence of the programmes until at least 2020.

Investment funds for the upgrades for each of its LHC experiments and for the Tier-1 grid computing facilities are also crucial within the next years. These would be natural components of the Dutch Research Infrastructure Roadmap and part of the corresponding funding strategy.

The lower grade of this section is due to the fact that both programme funds and investment funds are not yet secured.

4.2 Answers to the questions addressed to the committee by NWO

Six questions were put by NWO in addition to the Standard Evaluation Protocol.

4.2.1 Is the mission still correct and fitting? Considering the mission of the institute, is there a proper balance between the research, R&D and research facilities (their development and use)?

The mission, please see 3.1, is fully supported by the committee. Indeed, it is short and clear, and captures the main issues in today's particle- and astroparticle physics. However, it is clear that what is produced by Nikhef makes its way outside the research sector amounting to a continuously increasing valorisation activity. The committee is of the view that this should be made explicit in the Mission Statement.

4.2.2 What is the national and international importance of the institute, now and in the near future? Is the institute's policy ready for new challenges?

FOM-Nikhef is one of the leading laboratories in experimental particle physics in the world, with an outstanding record of achievement in detector and electronics design, construction and commissioning, physics analysis and advanced computing techniques, supported by a strong theory group. In addition, through the Nikhef organization, it is more than a laboratory; it is bringing a number of University groups to work together in an integrated way for with faculty members taking larger responsibilities than would have happened if the same resources were spread to a number of independent University groups. Nikhef has a strong focussing effect.

The choice of Nikhef to join the Virgo and Xenon experiments in recent years proves that Nikhef is very capable to handle new challenges.

4.2.3 Should NWO continue to support the institute, if so, for what reasons? Are there more effective alternatives for NWO for supporting the same type of research and/or facility?

As written in 4.2.2, the Nikhef organization, it is more than a laboratory; it is bringing a number of University groups to work together in an integrated way for with faculty members taking larger responsibilities than would have happened if the same resources were spread to a number of independent University groups. Nikhef has a strong focussing effect. The committee cannot see any organisational model that more efficiently gives value for money in this research field.

4.2.4 Does the institute use sufficiently any opportunities for co-operation with organisations outside the academic world?

The institute cooperates successfully with high schools, and is indeed a model for such co-operations, see e.g. HiSPARC.

The institute also cooperates successfully with industry for the construction of the research infrastructure.

Finally, the institutes work with several companies bringing its knowhow and product to use outside the research sector.

Nikhef's interaction with the rest of the society is in many ways pioneering and increasing, and may well become an international model.

4.2.5 What is FOM-Nikhef's strategy for the next six years with regard to its own research and its support role (development and exploitation of in-house research facilities and access to international facilities), especially in the light of national and international developments?

Nikhef is ensuring a consistent Dutch strategy for this research. It has established an optimal Dutch strategy for 2011-2016, guarantees a national consistency and will through its unique organisation ensure a large international impact of FOM-Nikhef and its university partners. In fact its organisation and state-of-the-art facilities enable excellent Dutch participation and contributions on the international scene.

See also paragraph 4.1.D1.

4.2.6 What choices does FOM-Nikhef face as regards participation in new, large-scale (research infrastructure and other) projects in the long term (after LHC)? And what are the implications of these choices for the institute's national support and research roles and for its national and international position within the field?

As stated in 4.1.A1 the research is at the absolute frontier of the field, and some hard choices have been made. All experiments are the best, or share top position, in their domains and the committee cannot see any domain where a stronger approach could have been taken. In each programme the committee sees clear, efficient, leading and original Nikhef contributions, thanks to the technical strength of the institute. In this field programmes are rather long. E.g., the LHC experiments will go on beyond 2020. Continued support (as stated above) is necessary to continue the visible position in these experiments.

During this period Nikhef will have to position itself with respect to what will follow, basing their considerations on the results from the LHC after the runs ending in 2012. This decision is connected to the strategy of Europe in this field. This strategy is agreed between the European governments in the context of the updating of the European Strategy for Particle Physics. Nikhef is an active partner when this strategy is drafted.

The committee has confidence that Nikhef, like in the past, will make the right choices considering a visible and essential Dutch participation in new collaborations. New research infrastructures will of course require investment funds for their construction.

During the review period 2005-2010, Nikhef has identified and engaged in two new astroparticle physics projects. Like all vital research organisations, Nikhef is moving with the scientific development, and it is therefore likely that more new programmes will follow in the future.

5 Programme assessments

5.1 Research programme ATLAS

Current research programme leader:	Stan Bentvelsen
Tenured staff:	16
Other personnel (end 2010):	8 Postdocs, 24 PhD-students, 8 Technical Staff
Publications (2005-2010):	296 (including ATLAS and D0)

Quality	5
Productivity	5
Relevance	5
Vitality	4.5
Overall	**5**

Overall assessment

ATLAS is the flagship experiment for Nikhef. Inside the international ATLAS collaboration Nikhef is very visible and has an excellent reputation. Dutch physicists have been entrusted with positions of high responsibility (analysis group convenors, computing or trigger coordinators). The Nikhef share of the ATLAS authors is around 2.7%.

All ATLAS detector components designed, built, commissioned and calibrated by Nikhef groups are working at or beyond design specifications, with a very low number of dead channels. The excellent start of the ATLAS physics programme with many seminal publications heavily relied on these detectors, in particular the muon drift tube chambers and the corresponding read out electronics and the RASNIK-alignment system, which were (partially) provided by Nikhef. In addition one complete Semiconductor Tracker endcap had been assembled at Nikhef. Also the magnet system, to which the Netherlands made substantial in kind contributions in form of vacuum vessels and cold mass components, is operating flawlessly.

In the past years the Nikhef ATLAS group successfully moved the focus from detector construction and commissioning to operation, event reconstruction and data analysis. They initiated a big (Tier-1) Grid computing site in Amsterdam, from which ATLAS and several Nikhef groups are profiting a lot. The Nikhef ATLAS group has maintained and extended its very strong position inside the ATLAS collaboration, and Dutch physicists made significant contributions to the reconstruction software and the first ATLAS publications on LHC collision data. On national level Nikhef's ATLAS group was rewarded with several grants (FOM, NWO: 1xVeni 3xVidi 2xVici, EU), allowing the group to employ several PhD students and postdocs.

The ATLAS collaboration made early measurements with cosmic muons and proton proton collision data at center of mass energies up to 2.3 TeV. The most important physics results were obtained on the 7 TeV pp data. In 2010 nearly 40/pb of data were collected. Major contributions of the Nikhef team are: i) Reconstruction of known resonances with tracker und muon system (J/Psi, K, ϕ etc) and search for new states; study of the detector resolution from the invariant mass distributions. ii) Measurement of the top-antitop production cross section. iii) Setting limits on SUSY parameters.

Parallel to the ATLAS detector construction and analysis preparations a small team of Dutch physicists participated in the analysis of the D0 proton-antiproton data at Fermilab, resulting in key publications of top and bottom physics and Higgs search limits. Nikhef profited from the D0 involvement by gaining important knowledge on how to improve hadron collider data reconstruction, Monte Carlo simulation and (grid) computing, at the Tevatron and at the LHC!

With the fast increasing LHC luminosity in the years 2011 and 2012 the data analysis will be intensified, the Nikhef main interests and strengths are top physics and searches for Higgs and supersymmetric particles. These are fundamental topics which have a high chance to lead to major discoveries. The team is not only tackling the standard channels but explores also special signatures and model variants, and is ready to adapt the analysis to new theoretical developments. In some areas like single top production the experimentalists and Nikhef theorists collaborate closely. The widespread statistical analysis package RooFit developed at Nikhef will be developed further.

While LHC data analysis is the main effort in the forthcoming years, Nikhef is also preparing for the different ATLAS upgrade steps, which will be necessary, due to the increasing (S)LHC rates and/or the ageing of detector components. The principal Dutch contribution for phase 0 is the cooling system and new readout electronics for the new insertable B layer silicon detector, with a possible extension to all silicon-based trackers at a later stage.

The longer term (5-10 years) ATLAS and Nikhef upgrade plans are less clear at this moment. Nikhef intends to participate to both phase 1 and phase 2 upgrades, and wants to profit from its expertise on how to build particle detectors, and in particular from the recent developments at Nikhef (Gossip gas-silicon detector).

Recommendations

- Nikhef-ATLAS is a very successful project. It should continue on this remarkable high level of scientific quality and visibility for at least one more decade. This requires the funding of scientists, in particular PhD students and postdocs, at least at the current level.
- The phase 0 upgrade projects and also future upgrade plans will allow Nikhef to bring in again its unique detector R&D expertise and to strengthen the scientific reach of ATLAS further. Nikhef-ATLAS should receive the corresponding investment and manpower support. For the medium and long term upgrade projects Nikhef should develop timely a concrete roadmap matching the capabilities of the institute and the needs and schedule of the ATLAS experiment.

5.2 Research programme LHCb

Current research programme leader:	Marcel Merk
Tenured staff:	10
Other personnel (end 2010):	2.4 Postdocs, 9 PhD-students, 9 Technical Staff
Publications (2005-2010):	363 (including LHCb, BaBar, Hera-B)

Quality	5
Productivity	5
Relevance	4.5
Vitality	5
Overall	**5**

Overall assessment

The LHCb scientific program aims to make precision measurements of the B-meson sector to search for new phenomena that could help to explain the matter-antimatter asymmetry in nature. The Nikhef-LHCb group has experience in this area through participation in Hera-B (DESY) and from analysis of data from the BaBar (SLAC, US) experiment.

Nikhef is one of the founding members of the LHCb collaboration, with funding starting in 1999. The LHCb collaboration consists of 731 physicists from 15 countries. The Nikhef investment represents a fraction of 9% of the LHCb collaboration and Nikhef is the second largest group in the collaboration. On the national level, the group has attracted two NWO Vidi grants and two FOM Projectruimte grants.

The Nikhef group played a leading role in the construction of the LHCb Outer Tracker (OT) and the Vertex Locator (VELO). These detectors are critical to measuring charged tracks and vertices of particles from B-meson decays. In addition to the construction of the VELO and OT detectors, the group has led some of the software development for precision measurement of charged tracks and decay vertices. Nikhef staff also played a leading role in the design and implementation of the high-level trigger (HLT), a critical component for LHCb physics. The delivered LHC luminosity for LHCb was higher than anticipated and the Nikhef group was instrumental in adapting the HLT to handle the unanticipated complexity from pileup.

The LHC completed a successful year of operations in 2010 and the collaboration has begun to produce many excellent physics publication and conference results. The group had a strategy to select four key topics: the measurement of the time-dependent CP-asymmetry of the decay $B_s \rightarrow J/\psi\ \phi$ which is a sensitive probe for new physics, the measurement of the CP-phase parameter Υ using Bs-meson decays to $D_s^{\pm}K^{\pm}$, and the rare decays $B_s \rightarrow \mu^+\mu^-$ and $B \rightarrow K^*\mu^+\mu^-$. The Nikhef group physics focus has paid off and has led to several important results presented at the recent summer conferences. The strong connection between the LHCb scientists at Nikhef and the Nikhef theory group has resulted in new strategies for analysis and several joint physics publications.

The LHCb Collaboration has produced a Letter of Intent outlining an upgrade to the LHCb trigger for higher luminosity operations. (For LHCb, this luminosity is 10^{33} $cm^{-2}s^{-1}$.) The readout for all LHCb sub-detectors will need to be upgraded to operate at 40 MHz and there is a plan to replace the Vertex Locator (VELO) during the planned 2017-2018 LHC shutdown. The Nikhef group is well positioned to contribute to these upgrade projects that will open up new physics possibilities for the collaboration. Together with the Nikhef R&D group, they are studying possible electronics upgrades for the Outer Tracker and investigating a read-out chip design for the proposed pixel vertex detector system.

Nikhef LHCb group has demonstrated its excellent skills in management and contributes to LHCb through a variety of coordination functions including project leader of the Outer Tracker(OT), deputy-project leader of the VELO, deputy coordinator for the trigger project, LHCb operations coordinator and coordinator of the LHCb physics working group focusing on fs/Time dependent CP Violation.

Recommendations

- Nikhef has a leadership role in many aspects of LHCb. We recommend continued funding of LHCb to continue their excellent record of scientific achievement. The funding of scientists, in particular PhD students and postdocs, at the current level, at least, is needed to maintain the strong physics record. Strong involvement in the upgrades projects may require additional staff.
- The proposed upgrade projects for LHCb are a good match for Nikhef's technical and R&D expertise. The committee recommends Nikhef continue the upgrade R&D and work together LHCb to develop plans for Nikhef involvement in the proposed LHCb upgrades.

5.3 Research programme ALICE

Current research programme leader:	Thomas Peitzmann
Tenured staff:	8
Other personnel (end 2010):	5 Postdocs, 10 PhD-students, 4 Technical Staff
Publications (2005-2010):	174 (including ALICE and STAR)

Quality	5
Productivity	5
Relevance	4.5
Vitality	5
Overall	**5**

Overall assessment

Physicists from the Nikhef-ALICE team have filled or fill several important management and coordinator positions. In relation to the 1.9% share of Dutch physicists in the ALICE collaboration this is quite remarkable, demonstrating the high visibility and quality of the Dutch contributions. Also on national level the Nikhef-ALICE group was very successful, it was awarded several NWO (3xVidi), FOM and ERC grants.

ALICE is concentrating on heavy ion physics. Nikhef has a long tradition in this field, the previous main project was the STAR experiment at the RHIC collider at Brookhaven.

The main Nikhef hardware contribution to ALICE was the Silicon Strip Detector (SSD), a thin and lightweight tracking detector. Nikhef played leading roles in the design, construction, commissioning and operation. This detector component, along with the other parts of ALICE, is working very well. The SSD played a crucial role in the data analyses, for example in the very first LHC publication on p p physics (charged hadron production), submitted by ALICE in the year 2009.

The analysis of lead-lead collisions at the end of 2010 brought exciting insights in the formation of a quark gluon plasma. A seminal ALICE publication on the elliptic flow was based on a Dutch analysis.

The physics analyses at Nikhef are concentrating on three topics, which are all aimed at measuring the properties of the quark gluon plasma: i) elliptical flow, ii) jet quenching and iii) charm production. While Nikhef-ALICE is already playing a leading role in the elliptic flow analysis, it is strengthening its contributions to the two other analysis topics by involving more young scientists.

In the future a new interesting physics topic, the study of gluon saturation at small Bjorken-x, could be addressed. This is only possible with a new forward electromagnetic calorimeter. Nikhef is already designing a high granularity silicon-tungsten detector for this purpose and wants to participate in the construction of this calorimeter, which could start in the year 2014.

Recommendations

- Nikhef-ALICE is performing very well, it is extremely visible in the ALICE collaboration. The physics potential can only be exploited if the experiment runs till 2020 and possibly beyond. In order to reach the ambitious analysis goals the strength of the Nikhef-ALICE group must be kept at the current level, at least.
- The envisaged ALICE upgrade with a forward calorimeter should not compromise the analysis efforts with regard to the quark gluon plasma.

5.4 Research programme ANTARES/KM3NeT

Current research programme leader:	Maarten de Jong
Tenured staff:	5 staff scientists
Other personnel (end 2010):	6 Postdocs, 6 PhD-students, 10 Technical Staff
Publications (2005-2010):	28

Quality	5
Productivity	5
Relevance	5
Vitality	4.5
Overall	**5**

Overall assessment

Neutrino astronomy (accessible through the conversion of astrophysically generated high-energy neutrinos into high energy muons and detected through their interaction with a large-scale detector) is a relatively new field, which offers the prospect of studying astrophysical objects in a new way. ANTARES is an experiment which uses a series of photodetectors in long “strings”, located some 40 km off Toulon at a depth of about 2500 m, where the sea water provides both the target for the neutrino interactions and the detection medium for the muons through their Cerenkov radiation. The first of 12 detector strings was deployed in 2006, and the detector was completed in 2010. The Nikhef group has been highly visible in ANTARES (for example, Maarten de Jong was Deputy Spokesperson), and has significant responsibilities for the track reconstruction, which gives them a strong position to drive the subsequent analyses. Through their technical expertise in developing the track reconstruction algorithms, they have achieved an angular resolution of 0.4°, significantly better than ICECUBE. This is crucial for the identification, for example, of events associated with Gamma Ray Bursts. The performance of the track reconstruction is very impressive, more than doubling the sensitivity of the detector compared with expectations. There is now a substantial dataset available for analysis but so far no point sources or correlations with known astrophysical objects have been established, consistent with the finding of the ICECUBE experiment at the South Pole. This research has attracted 3 NWO-Veni & Vidi grants. There is an excellent programme of research that will be pursued over the next five years or so.

The next stage is to instrument a much larger volume, and a new project KM3NET aims for a volume of several km^3 (about 100 times the current fiducial volume), to be deployed at several deep water sites in the Mediterranean. The Nikhef group has been instrumental in driving KM3NeT, and has designed a new optical module which is both more effective and cheaper by using several small photomultipliers rather than a small number of very large photomultipliers. The inclusion in the collaboration of the Royal Netherlands Institute for Sea Research (NIOZ) is an important development, bringing in marine expertise. This is already producing new ideas for the efficient deployment of the detector strings; it is also possible that interesting information about the marine environment could come from the instrumentation needed to calibrate and monitor the KM3NeT detector. The experience in the track reconstruction from ANTARES is being utilised to develop the KM3NET reconstruction procedures. KM3NeT was selected as one of five research facilities for central financing from the ministry, and is a recognised as a European Infrastructure project by ESFRI.

The KM3NeT Conceptual Design Report (largely driven by Nikhef) was submitted in 2008, and a Technical Design Report has been produced this year. The Netherlands is bidding to host the KM3NeT headquarters. New scientific goals have been identified, for example the observation of high energy neutrinos from supernova remnants. If the ultra high energy cosmic rays are protons, then the mechanism behind the GZK cut-off will result in very high energy neutrinos. The committee recommends that if possible KM3NeT is designed such that a measurement of these neutrinos, with a future extension, could be considered.

There is no doubt that the quality and productivity of the work for both ANTARES and KM3NET is in the highest category, and the team is both excellent and enthusiastic. Equally, there is no doubt about the large impact that the Nikhef group has on both of these projects. ANTARES is now producing promising data which, when combined with the observations from ICECUBE, could significantly enhance the strong case for KM3NeT.

Recommendations

- There is a strong case for continuing the present commitments to ANTARES for the next five years.
- The technical development of the KM3NeT proposal should be continued.
- Nikhef should continue with the ambition to host the KM3NeT headquarters in the Netherlands.
- Nikhef should consider organising a workshop within the next 2 years or so to assess the implications and prospects for astrophysics and cosmology in the light of the ANTARES, ICECUBE and Auger data.

5.5 Research programme Virgo

Current research programme leader:	Jo van den Brand
Tenured staff:	3
Other personnel (end 2010):	0.5 Postdocs, 3 PhD-students, 6 Technical Staff
Publications (2005-2010):	43

Quality	5
Productivity	5
Relevance	5
Vitality	5
Overall	**5**

Overall assessment

The objective of this program is the first direct detection of the gravitational waves predicted by Einstein’s general relativity and the beginning of a new astronomy using the Virgo 3 km 2 arms laser interferometer located near Pisa (Italy). On 2 July 2009 Nikhef become an associate member of the EGO France-Italy council operating the VIRGO laboratory.

The Dutch group joined the Virgo collaboration at the beginning of an improvement of Virgo called Virgo+. This improvement took place at the same time of a similar improvement in the US Ligo interferometer called eLigo. There is a strong agreement between LIGO and VIRGO for data taking and analysis.

Virgo has reached excellent record sensitivity, with world record values, in the low frequency region. However this sensitivity is not yet enough to detect Gravitational Waves (GW) and new upper limits have been published. Some of these limits like the one on the stochastic cosmic background of GW, published on Nature, or the one on the spin-down of the Crab Nebula, already restrict theoretical models and are of great astrophysical relevance.

The upgrade to a next generation “Advanced” Virgo and Ligo will allow to scan a 1000 times larger volume of the Universe. The improvements in sensitivity should guarantee the detection of gravitational waves by 2015-2016: lack of detection would then imply some deep problem in our understanding of how gravitational waves are generated according to general relativity.

The Dutch group has recently started this activity, and has achieved excellent results in a short time. Nikhef is fully involved in the Advanced Virgo construction and has important responsibilities in the electronics, suspended benches and mirrors, optical systems. All those items have very important technological aspects of industrial interest.

Concerning longer term prospects, the Nikhef group is involved in the design study of a future third generation underground interferometer called Einstein Telescope (ET). ET received the maximum scientific score in the EU-FP7 call. The Dutch group has also interest in the future space interferometer LISA.

Recommendations

- The committee endorses the participation in Advanced VIRGO (and the investment proposal to get the corresponding funding) and in a latter stage the design of ET, a third generation interferometer.
- The committee recommends that Nikhef should consider to become a full member of the EGO council.
- The technical support to Virgo is excellent, the committee recommends that there should be a proportionally sufficient number of research staff physicists involved in VIRGO.

5.6 Research programme Pierre Auger Observatory

Current research programme leader:	A.M. van der Berg (KVI), C.W.J.P Timmermans (Nikhef)
Tenured staff:	1.8
Other personnel (end 2010):	1 Postdocs, 3.5 PhD-students, 2.5 Technical Staff
Publications (2006-2010):	38 (including astrophysics)

Quality	5
Productivity	5
Relevance	5
Vitality	4
Overall	**5**

Overall assessment

After more than 100 years the origin of the very high energy cosmic rays is still a mystery.

The Auger South detector, covering an area of 3000 km^2 in the Mendoza region in Argentina, is by far the largest detector in the world dedicated to the study of the cosmic rays of energies up to 10^{20} eV. The main results of this experiment up to now are: the evidence of the cut-off at energies around 10^{20} eV and the evidence for anisotropy in the arrival direction correlated probably with the origin of cosmic rays.

The AUGER excellent results are confirmed by the publications in very large impact factor journals.

The Dutch effort concentrates on the radio detection of atmospheric showers, a promising method to measure the energy and direction of cosmic particles with 100% duty cycle. The Nikhef group has pioneered this method in the context of the LOFAR observatory.

There is a plan to continue to install in Auger South an array of such antennas of increasing surfaces, to study the performances compared to the standard detectors. Since the planned Auger North detector was not approved, new cheaper techniques are important to cover very large area and increase the sensitivity.

Nikhef is leader in different hardware components of the radio array, including all the digital electronics.

Excellent outreach by-products of this kind of searches are the project HiSPARC and the project Cosmic Sensation. The first has received an European Physical Society prize and the second the Dutch annual academic prize.

Recommendations

- The committee endorses the plan to further develop radio detectors inside AUGER. The committee recommends to continue the full integration of the radio array in the standard Auger analysis stream.
- The committee recommends that there should be a sufficient number of research staff physicists to exploit fully the investment made in Auger, to maintain the leadership in the promising radio detection and to continue the composition analysis.

5.7 Research programme XENON

Current research programme leader:	Patrick Decowski
Tenured staff:	1.5 FTE
Other personnel (end 2010):	1 Postdocs, 1 PhD-students, 1.5 Technical Staff
Publications (2006-2010):	This is a new activity; there are no publications so far

Quality	5
Productivity	Not rated (this is a new programme)
Relevance	Not rated (this is a new programme)
Vitality	4
Overall	**5** (rated on potential)

Overall assessment

This is a new activity for Nikhef. The question of the existence and nature (if it exists) of galactic Dark Matter is currently one of the major questions, both in contemporary particle physics and astronomy. Failure to detect it would require a major revision of our understanding of the dynamics of the galactic motion, and could have implications for the standard model of particle physics. The Xenon dual-phase technique is one of the most promising methods searching for galactic dark matter, essentially because it has a good discrimination of the signal from the background, and the scaling of the sensitivity is proportional to the volume of the detector, so that extrapolation from the current target volume (a few tens of kg) to the tonne scale is relatively straightforward. This proposed programme therefore addresses an important issue of contemporary science, and is a good fit to the technical competences of Nikhef, building upon existing strengths, in particular the excellent engineering for the design of the cryostat, which needs the resources of a large laboratory. In due course, there will be results from the analysis of the data from the currently running XENON100 detector, while the design for the next 1 tonne scale detector is developed. The group, while small, is enthusiastic. Nikhef is also involved in the advanced planning for a much larger noble-liquid multi-phase Dark Matter detector (DARWIN). There is a strong connection with the R&D group on the development work (the physical properties of liquid Xenon and the use of the GridPix detectors in Dark Matter experiments) for both projects.

The group leader is young and enthusiastic, and leads a small but well-motivated team. His recent joint appointment with the University of Amsterdam as part of their Centre of Excellence (GRAPPA) is welcomed. There is a well thought through plan to build a small Xenon test facility to gain experience with the properties of Xenon. This is an exciting project that ought to be attractive to post-doctoral researchers and Ph.D. students, and to be in a good position to bid for external funding. It is of course not guaranteed that Dark Matter does exist in a form that is amenable to detection in this way, and technical risks with the cryostat, which requires engineering of the highest quality – xenon purification, material properties, welding etc – but the scientific questions addressed by XENON are very important.

Recommendations

- The current work on XENON100 and XENON1T should continue and the group should be expanded, e.g. by a new FOM-programme, so that Nikhef can fully exploit its investment in this important research area.

5.8 Research programme Theory

Current research programme leader:	Eric Laenen
Tenured staff:	7.6
Other personnel (end 2010):	8 Postdocs, 10 PhD-students, 2 Technical Staff
Publications (2006-2010):	205

Quality	5
Productivity	5
Relevance	4.5
Vitality	5
Overall	**5**

Overall assessment

Theoretical physics has been pivotal in shaping and consolidating the Standard Model and is now crucial for formulating possible scenarios for future discoveries. It directly addresses the key scientific questions in this area and provides many of the scientific justifications for designing and constructing new experimental facilities.

The FOM-Nikhef theory group has a high international standing. The group sets its own research agenda covering a wide range of topics, from astroparticle physics, cosmology and string theory to analytical calculations in perturbative QCD, Monte Carlo CP-violation and B-physics, event generators and the phenomenology of the Standard Model and beyond. In addition, it plays a vital enabling role in supporting the experimental groups in the interpretation of data, giving coherence to the wider theoretical effort in the Netherlands and providing a valuable resource for the training and education of students. There is significantly increased collaboration with experimentalists, particularly in the areas of flavour physics and gravitational waves, and increased interaction with theorists elsewhere in the Netherlands, particularly at the Radboud University Nijmegen.

The theory group has improved its productivity substantially and increased its fraction of Nikhef's published research output from 9% (2005), 11% (2006), 11% (2007), 12% (2008), 17% (2009) to 23% (2010), while still maintaining the high quality and high impact of its research. This increase is partly attributable to increased interactions with other theory groups in the Netherlands but also to the support from the FOM programme "Theoretical Particle Physics in the Era of the LHC" which started in 2007. The programme has provided additional postdoc and PhD student positions and has cemented Nikhef's role in developing and coordinating theoretical research in the Netherlands.

Over the past twenty years, Vermaseren's FORM computer algebra program has become indispensable for the most technically challenging calculations in quantum field theory, such as the landmark calculation of the third-order splitting functions by Vermaseren and his colleagues. FORM has now been released as open source, thereby increasing the number of people who can directly contribute to the code. Nevertheless, it will be important to find a suitable leader for the FORM project when Vermaseren retires.

During this period, it has, to some extent, rejuvenated the permanent staff and increased the numbers of postdocs and students leading to a more vibrant research activity. The addition of new staff at the senior level has given fresh impetus in the sectors of CP-violation and B-physics and astroparticle physics. A continuous stream of fresh talent in the form of postdocs and students are key to the vitality of the group. With the support of the FOM programme "Theoretical Particle Physics in the Era of the LHC", together with funding from other NWO (Vidi) programmes, EU Initial Training Networks (HEPTOOLS, LHCPhenonet) and EU Marie Curie Fellowships, the group is approaching the "ideal" balance of staff:postdoc:Phd student ratio of 1:1:2. Nikhef has an excellent track record of recruiting outstanding young postdocs who go on to have permanent positions in academia. All members of the group are involved in the general outreach programme of Nikhef and one of the staff is responsible for the coordination and operations of the HiSPARC cosmic ray stations in and around Leiden.

Recommendations

- The committee endorses the proposed focus on theoretical work that is directly linked to the Nikhef experimental effort, particularly for the LHC experiments, and on the actual confrontations of precise calculations with data in collaboration with experimental colleagues.
- The committee endorses the suggestion by the Nikhef Scientific Advisory Committee that the funding of postdocs and students should become part of the increased Nikhef mission funding.
- The committee encourages the theory group to continue its efforts to obtain external funding to enlarge their overall research output.
- The FORM project is uniquely associated with Nikhef and its long term support is vital.

5.9 Research programme Detector R&D

Current research programme leader:	Niels van Bakel
Tenured staff:	4
Other personnel (end 2010):	2 Postdocs, 3 PhD-students, 8.5 Technical Staff
Publications (2006-2010):	36

Quality	5
Productivity	5
Impact	5
Vitality	5
Overall	**5**

Overall assessment

In the last evaluation in 2007 two recommendations were made: 1) finding the right people; target to grow to a staff of 10-15 people and 2) establish strong link to CMOS and MEMS competence centers. Since then Nikhef was successful on both: the staff has grown to 16 staff members and in the last period they have a strong cooperation with MESA+ and prof. J. Schmitz, University of Twente.

The detector R&D at Nikhef results in a large impact in its experiments, and makes the Netherlands a very attractive collaborator in all international collaborations.

The detector R&D programme has a well recognized position in the detector design and prototyping with a very strong contribution to the mission via development of GridPix detectors, RASNIK, novel electronics and read out for Medipix and Timepix ASICs and CO_2 detector cooling.

This great expertise base enables Nikhef to be impactful in a unique position to contribute to the scientific programs.

The collaboration with competence centers increased, especially in the MEMS and CMOS area with MESA+. Continuation asks for a facility working with larger wafer sizes which will increase the cost involved. This hampers an easy start of new collaborations.

With industry the number of partnerships increased both for attracting expertise as well as for transferring knowledge in joint programs (Hidralon, Medipix). Transfer of technology to industry increased leading to new products for other markets. Several spin-off initiatives have been started and supported, contributing to new business activities in the Netherlands.

The patented RASNIK alignments system is being used in large quantities for the mission projects and is being applied for commercial applications as well (the Weena tunnel in Rotterdam).

The newly developed CO_2 cooling equipment is not only used in the Alpha Magnetic Spectrometer and part of the LHC-upgrade plans but also finds its way to non mission applications.

Recommendations

- The ambitious plans of all programs for the coming years regarding detector upgrades are well motivated. In most cases contributions from the Detector R&D group are expected. Collaborations with industry will be in competition for these valuable resources. Given the limited size of the group it is recommended to look carefully at the available resources in the group and with the collaboration partners. Some expansion of the group should be considered; please see 4.1.A5.
- Given the increased demand for valorization it is suggested to define a strategic plan dealing with balancing of the activities for core business and valorization activities including IP and spin-off generation.

5.10 Research programme Grid

Current research programme leader:	Jeff Templon
Tenured staff:	3.0
Other personnel (end 2010):	0 Postdocs, 0.2 PhD-students, 10 Technical Staff
Publications (2006-2010):	17

Quality	5
Productivity	5
Relevance	5
Vitality	4.5
Overall	**5**

Overall assessment

Over the review period the Grid has transitioned from test platforms into a large scale global computing system. The Nikhef Grid program focuses on operations, applications, engineering research and a small component of fundamental research in computer science. They have been instrumental in developing a national strategy for Grid computing that has achieved a sustainable operations model for distributed computing in support of science research. The group has a world class team in grid security which has made important contributions on the international level. Nikhef has provided cpu cycles and data access to the scientific research groups and have made cpu cycles available to the broader scientific community through the national BiG Grid project.

The BiG Grid project, started in 2007, provides grid infrastructure for the Dutch scientific community. The Nikhef LHC Tier-1 is in transition to become a service operated by BiG Grid. The Nikhef group has been a leader in the BiG Grid project from the beginning and is part of the leadership of the project. About 10% of the Big Grid cpu resources are used by other sciences. The Nikhef group provides consulting and grid expertise to the broader scientific community.

Nikhef has a long history in charting a strategy for distributed computing infrastructure. Nikhef was a core member of the European Datagrid (EDG) project, a major player in the successor, EGEE project to develop grid infrastructure. The strength of the Nikhef program in grid computing is reflected by the location of the EGI.eu headquarters in the Science Park Amsterdam. A major achievement for grid computing has been the development of a coherent security architecture for the European grid infrastructures and Nikhef was a part of the team to define the fundamental security strategy.

The Grid computing team has a demanding support load in support of the scientific program. They also develop applications for the particular scientific programs and members of the group provide user support for scientists to utilize the grid. They have been reactive to user needs and responsive to unanticipated technical challenges of operations. Several research initiatives have been started to improve data access for large scale distributed systems and the group was recently augmented by a PhD student in computer science working on the application of formal methods to distributed systems. The publications in this area consist primarily of conference reports.

The Nikhef staff continue to play leadership roles in computing, both nationally and internationally. They were recently asked to host the 20th International Computing in High Energy Physics Conference (CHEP) in 2013. K. Bos has served as the Chair of the WLCG Grid Deployment Board and ATLAS computing coordinator. D. Groep is the director of the European Policy Management Authority for Grid Authentication (EUGridPMA) and was the first chair of the International Grid Trust Federation (IGTF). A. van Rijn is a member of the EGI.eu Executive Board. F. Linde is one of the directors of the national grid project BiG Grid.

Recommendations

- The computing infrastructure at Nikhef enables the science from the LHC and from the other areas of the Nikhef scientific program. The committee endorses continued support for the computing operations teams and for the associated computing R&D.
- Nikhef has been playing a leadership role in HEP computing. We recommend that Nikhef pursue a senior scientist with expertise in scientific computing to succeed Kors Bos.
- The group has a successful history in strategic planning for distributed computing both on the national and international level. Now that the stabilization of grid operations is on track and operations responsibilities have transitioned over to other organizations, we recommend Nikhef update its long-term strategic plan for research and development in the area of scientific computing.
- The computing infrastructure (Tier-1, Stoomboot) must be upgraded following the increasing amount of data produced by the LHC.

5.11 Education and outreach

In keeping with its mission statement, Nikhef supports a strong programme of educational and outreach activities to many audiences ranging from science and technology decision makers to primary school children to industrial partners. Indeed, some form of outreach activity takes place every working day. Nikhef actively encourages extensive involvement of the Nikhef community, recognizing that every member of Nikhef is a potential ambassador for the institute and particle physics.

Nikhef successfully employs a variety of approaches, starting with the ubiquitous and nowadays compulsory attractive (public) website, open days and guided tours at the laboratory as well as scientific talks for general audiences. Particularly effective are dedicated exhibits, such as the larger spark chambers installed in the main hall, and at the NEMO science museum in Amsterdam and innovative events such as the "Cosmic Sensation". The interaction with schools is also excellent. The "Techniek Toernooi" is an effective way of introducing primary school children to experiments. Secondary school students are well supported through the IPPOG masterclasses, "profielwerkstuk" projects, the award winning HiSPARC cosmic ray project and visits to CERN. Equally important is the support for secondary school teachers, such as the FOM teacher-in-research programme, and the participation of Nikhef staff in the development of the new physics curriculum for secondary schools.

Nikhef has made the most of the massive public interest in the LHC with an LHC startup event in September 2008, featuring mock-ups of the ATLAS and LHCb experiments as well as the LHC tunnel, as well as displaying collisions on the ceiling of the main hall. Media coverage was excellent, and the LHC startup event made it to the main evening news. The "First Physics" event in March 2010 was equally successful, featuring on the national news and 15 different radio programmes. Two Nikhef PhD students were able to explain the significance of the first proton collisions on the popular prime-time TV talk show "De Wereld Draait Door". One of the major physics goals of the LHC is encapsulated through the movie "Higgs into the heart of imagination". In the coming years, it will be important to tap into the enormous public interest by providing continuous updates on results (and discoveries) from the LHC and astroparticle experiments of the Nikhef programme. Nikhef is well placed to maximize their penetration into the public consciousness through the media contacts they have established, as well as through the personalities of their staff.

Nikhef is able to recruit a strong cohort of PhD students, both nationally through the very successful (average of 14 students per year) Master's programme in Particle and Astroparticle Physics and internationally. Although there is significant monitoring, and a high success rate, the average time taken for a PhD is rather long, currently around 60 months. The Research School for Subatomic Physics (OSAF), funded by a NWO Graduate Programme, has been set up to train PhD students to the highest international standards. OSAF therefore matches the Nikhef mission extremely well. It is a strong point that the FOM-Nikhef staff are directly involved in the training with the Universities. The programme maximises the possibilities for training "at home" and "away" via national and international schools, periods at CERN or other laboratories. It is very likely that OSAF will lead to shorter PhD times, however it is still too soon to see the effects.

The committee rates the educational and outreach activities of Nikhef as excellent and appreciates it as an important tool to raise the public awareness of and support for science in general and high energy physics in particular. The committee has talked to a representative number of graduate students, which were very enthusiastic about the way in which they participate in exciting research and about the way they are supervised.

6 Conclusions and recommendations

The committee was very impressed by FOM-Nikhef and assess it as an outstanding centre of excellence. It is one of the leading laboratories in particle physics in the world, with outstanding achievements in detector and electronics design, construction and commissioning, physics analysis and advanced computing techniques, supported by a strong theory group.

It is remarkable how the Netherlands, thanks to this unique organization, play a central role in particle- and astroparticle physics while the level of Dutch investments are just at the European average. Nikhef, with FOM-Nikhef in the centre, is a unique and very efficient model, giving the Dutch research a much larger international impact than if the corresponding resources were distributed among a set of independent university groups and institutes, as is the case in most other countries in the world.

The success of Nikhef is also due to the strong leadership and active management within FOM-Nikhef. It has resulted in a restrictive set of programmes covering the mission of the institute with experiments at the most competitive level. For each programme, there are no experiments with a higher potential, than the ones in which Nikhef is engaged. There are also several programmes in which Nikhef is not active, like observations on the cosmic microwave background, astroparticle physics with gamma rays, and accelerator and reactor based neutrino physics; choices had to be made on what to do and what not to do. The committee supports the choices made by Nikhef.

Nikhef has also a strong and innovative outreach and educational programme which is internationally recognised. Nikhef is developing a strong knowledge transfer portfolio. Its interaction with the rest of the society is in many ways pioneering and increasing, and may well become an international model.

Nikhef has a clear strategic plan for 2011-2016; the committee fully supports this plan.

Overall, the FOM-Nikhef institute has an outstanding reputation in the field.

General recommendations for the Institute

- The *temporary increase of the mission budget by NWO* and the *dynamiseringsimpuls* is coming to an end. The committee ***recommends*** that this is compensated by an increase in the mission budget of 1.1 M€/year to enable Nikhef to maintain its vitality and to achieve its goals. The increasing activity of knowledge and technology transfer (from an already excellent level) is a strong argument for not reducing the base funding for the institute.

- The current mission is fully supported by the committee. What is produced by Nikhef makes its way outside the research sector amounting to a continuously increasing valorisation activity. The committee ***recommends*** that this should be included in the Mission Statement.

- The committee ***encourages*** a continuation, and if possible strengthening, of the effort to improve the gender balance of the personnel.

- The median for the PhD training is five years, not corrected for sick leaves etc; the committee considers this somewhat long, and ***recommends*** that Nikhef continues to work towards making it somewhat shorter.

The broader recommendations for the different programmes

(more detailed recommendations can be found in chapter 5)

- The committee ***recommends*** that funding of scientists for the Large Hadron Collider experiments, in particular PhD students and postdocs, is maintained at least at the current level until at least 2020.

- The committee ***endorses*** that investment funds for the upgrades for each of its LHC experiments and for the Tier-1 grid computing facilities are also crucial within the next years. These would be natural components of the Dutch Research Infrastructure Roadmap and part of the corresponding funding strategy.

- The committee ***recommends*** that Nikhef should continue with the ambition to host the headquarters of the next generation Mediterranean neutrino telescope, in the Netherlands.

- On gravitational waves, the committee ***recommends*** that Nikhef gets support to contribute to the construction of the observatory Advanced VIRGO, and if that is the case, explores a full membership in the European Gravitational Observatory Council.

- On direct detection of dark matter, the committee ***recommends*** that the research with its existing detector and preparations for the next generation detector should continue and that the group should be expanded to fully exploit its investment in this important research area, e.g. by a new FOM-programme.

- On theoretical physics, the committee ***endorses*** the suggestion by the Nikhef Scientific Advisory Council that the funding of postdocs and students should become part of the Nikhef mission funding, if increased.

- On detector R&D: Given the increased demand for valorization, the committee ***suggests*** Nikhef to define a strategic plan dealing with balancing of the activities for core business and valorization activities including IP and spin-off generation.

- Now that the operations responsibilities of distributed grid computing operations are being transitioned to other organizations, the committee ***recommends*** Nikhef to update its long-term strategic plan in the area of scientific computing.

7 Appendices

7.1 Curricula vitae of the committee members

Curriculum Vitae: Prof. Torsten Åkesson (chair)

Personal information

Paul, Åke, Torsten ÅKESSON, born November 7th 1954
Married with two children
Home page: http://hep.lu.se/staff/akesson

Education

PhD, Lund University 1986
Engineer in engineering physics, LTH 1979

Employment

Professor, Lund University 2000 –

Activities

International coordination

- President of the CERN Council 2007 – 2009
- Co-chairman of the CERN Council Strategy Group 2005 – 2006
- Chairman European Committee for Future Accelerators 2005 – 2006
- ATLAS deputy spokesperson 1996 – 2004

Responsibilities at Lund University

- Principal investigator for research at LHC 1990 –
- Coordinator of a graduate school 2006 –
- Principal Investigator for collaboration with China 2006 – 2008

Research

- Research at the Large Hadron Collider 1987 –
- R&D for a new detector and its construction 1987 –
- Studies of e+e- annihilation at LEP 1990 – 1991
- Studies of p-pbar interactions at high energies 1989 – 1990
- Studies of heavy ion collisions and lepton production 1986 – 1989
- Jet-studies at the ISR 1983 – 1987
- Thesis work; jet-studies 1979 – 1983

Scientific committees

- DESY Extended Scientific Committee, 2005 – 2006
- LNF's Scientific Committee 2006 –
- European Commission Expert Group 2008
- European Physical Society Particle Physics Board 2005 – 2006
- International Committee for Future Accelerators, ICFA 2005 – 2006

Miscellaneous

- Editor: Journal of Instrumentation, JINST 2006 –

Curriculum Vitae: Dr. T.S. Baller

Work e-mail: theun.baller@philips.com

Positions

Jan 2011- now	Senior Vice President Philips Research, Manager Open Innovation Accelerator, spinning-in and spinning-out technology and start-up ventures
2010	Senior Vice President Philips Research, Program Manager Open Innovation Program Establish research programs with other parties, Managing internal venture portfolio
2001 - 2010	Senior Vice President Philips Research Chief Operations Officer Philips Research (1,600 people, budget 200 M€)
1996 – 2001	Department Head Philips Research Support group DTS (Devices, Technology and Services) 250 people, total budget of 40 M€ Transformation of internal service group to externally operating service business
1992 – 1996	Research Sub-project leader Thin-Electron Based Displays project (ZEUS) 70 people, budget of 10 M€ Responsible for mechanical design and prototyping, pilot production
1990 – 1992	Research Scientist Philips Research Technology development for touch and pen input devices for LCD screens
1986 – 1990	Research Scientist Philips Research Laser assisted chemical etching of metals and semiconductors Laser ablation deposition of high temp. super conductor thin films
1978 - 1986	Institute for Atomic and Molecular Physics (AMOLF) as technical assistant
1977 – 1978	Nederland-Haarlem Company for traffic light installations

Board memberships

- Advisory Board TNO Industrie en Techniek till end 2010
- Board Stichting Incubator3+ (financial support and coaching of technical and design start-up companies)
- Board Stichting Twice (office buildings for starters)
- Board Brainport Industries (organization for first and second tier suppliers)
- Advisory Board High Med Campus Eindhoven

Publications & Patents

More than 65 scientific papers in international journals in the areas of:

- Atomic and molecular physics
- High Tc superconducting materials
- Laser assisted chemical etching of metals and semiconductors
- Thin Electron Based Displays

34 patents in several countries (11 US patents)

Education

1990	PhD Physics, University of Twente, thesis: Laser Assisted Chemical Etching
1978 – 1986	University of Amsterdam Chemistry and Physics (Part-time)
1976 – 1978	HAVO (evening education)
1973 - 1977	MTS electronics

Curriculum Vitae: Prof. Nigel Glover

Personal Details

Name: Edward William Nigel GLOVER
Date of Birth: 20 June 1961
Nationality: British
Family Status: Married (Prof. Anne Taormina) with two children

Contact Details

Work Address: Physics Department, Durham University, South Road, Durham, DH1 3LE
E-Mail: E.W.N.Glover@durham.ac.uk
Tel. number: +44 191 334 36 02
Fax number: +44 191 334 36 58

Education, Professional Academic History

Academic Record and Qualifications

1979 – 1982	B.A. Hons 1st class, Natural Sciences (Physics and Theoretical Physics) Downing College, Cambridge University. Whitby Scholarship 1980-82
1982 – 1985	Ph.D. Studies in high energy $\bar{p}p$ collisions, (1985) Hatfield College, Durham University.

Professional Associations

2001	Fellow of the Institute of Physics.
2007	Fellow of the Higher Education Academy.

Appointments

1985 – 1987	Research Assistant, Cavendish Laboratory, Cambridge University.
1987 – 1989	CERN Fellow, TH Division, CERN, Geneva, Switzerland.
1989 – 1991	Research Associate, TH Division, Fermilab, Batavia, U.S.A.
1990 – 1991	SSC Fellow, Fermilab, Batavia, U.S.A.
1991 – 1996	Lecturer in Physics, University of Durham
1996 – 2002	Reader in Physics, University of Durham.
2001 – 2005	Deputy Director, Institute for Particle Physics Phenomenology, University of Durham.
2003 – 2006	PPARC Senior Fellow.
2004 – 2007	External Examiner of Undergraduate Programme in Physics, University of Lancaster
2004 – 2009	External Examiner of Undergraduate Programme in Mathematical Physics, University of Edinburgh
2005 – 2007	Editorial Board, Physics Letters B
2005 – 2010	Director, Institute for Particle Physics Phenomenology, University of Durham.
2005 – 2010	Director, Centre for Particle Theory, University of Durham.

Current Appointments

2002 –	Professor of Physics, University of Durham.
2005 –	Governor, Newcastle Royal Grammar School.
2008 –	Royal Society Wolfson Research Merit Award.

External committees

1993 – 1997	Institute of Physics High Energy Particle Physics Committee
1993 – 1996	PPARC Particle Physics Experiments Selection Panel
2000 – 2001	PPARC Particle Physics Theory Sub Committee
2001 – 2003	PPARC Particle Physics Grants Committee
2002 – 2003	PPARC High Performance Computing Review Panel
2004 – 2007	PPARC Particle Physics Advisory Panel
2005	PPARC Dark Matter Panel
2006	PPARC Scientific Computing Strategy Panel
2007	STFC Project Peer Review Panel - Visiting Panel for High Performance Computing
2008	STFC Particle Physics Consultation Panel
2008	External expert for the visiting committee of the Laboratoire de Physique Theorique et Hautes Energies (LPTHE in Paris)
2009 –	STFC Particle Physics Advisory Panel
2010	External expert for the visiting committee of the Laboratoire de Physique Theorique d'Annecy le Vieux (LAPTH in Annecy)
2010	External expert for the visiting committee of the Transregional Collaborative Research Centre (Sonderforschungsbereich/Transregio) 9 - Computational Particle Physics (Universities of Aachen, Berlin and the Karlsruhe Institute of Technology (KIT))
2011	UK representative on the Plenary European Committee for Future Accelerators (Plenary ECFA)

Curriculum Vitae: Prof. Thomas Hebbeker

Date of Birth:	18th November 1958
Institute Address:	Phys. Inst. III A
	RWTH Aachen
Homepage:	web.physik.rwth-aachen.de/~hebbeker

Education

1977 – 1983	Study of Physics, Aachen University
1983	Diploma degree (Springorum medal award)
1983 – 1986	PhD Graduate Student, Hamburg University
1986	PhD in Physics
1993	Habilitation, Aachen University

Previous Scientific Projects

1981 – 1983	MARK-J experiment at PETRA, DESY: semileptonic charm and bottom decays
1983 – 1986	CHARM neutrino experiment at CERN: scintillation counters and electronics, elastic scattering of muon (anti)neutrinos
1986 – 2001	L3 experiment at LEP: first level trigger, QCD analyses (QCD analysis group leader), searches, L3-cosmics

Current Research Areas

- experimental particle physics (experiments at Hadron-Colliders: D0 at Tevatron/Fermilab, USA and CMS at LHC/CERN, Switzerland). In particular: data analysis (new phenomena), muon detectors.
- astroparticle physics (cosmic shower observatory Auger in Argentina).

Publications

about 500

Employment

1986 – 1989	Fellow, CERN, Geneva
1989 – 1993	Scientific Associate, Aachen University
1993 – 1994	Staff Scientist, CERN, Geneva
1994 – 2001	Professor (C3) Humboldt University, Berlin
since 2001	Full professor (C4) Aachen University

Functions

2003 – 2007	chair/deputy of CMS muon institution board
2004 – 2006	spokesperson of physics department Aachen
2008 – 2010	chair of Scientific Advisory Committee Nikhef
2006 – 2009	spokesperson of German CMS groups
2009 –	member BMBF Advisory Committee particle physics
2010 –	member management board HGF Alliance Terascale

Curriculum Vitae: Dr. Patricia L. McBride

E-mail: mcbride@fnal.gov

Education

1984	Ph.D. in Physics , Yale University
1977	B.S. in Physics with Honors, Carnegie-Mellon University

Research experience

1998 – present	***Scientist, Computing Division, Fermilab***
2007 – 2011	Deputy Division Head/Associate Head for Scientific Programs
2005 –	Member of the CMS Collaboration
2007 – 2011	Deputy Computing Coordinator for CMS Experiment at CERN
2005 – 2006	Associate Division Head and “ILC and Accelerator R&D” Department Head
2002 – 2005	Computing and Engineering for Physics Applications Department Head
2001 – 2002	Computational Physics Department Head
1998 – 2001	Physics Analysis Tools Department Head
	Member of the KTeV and BTeV Collaborations
1994 – 1998	Computing Division Simulation Group Leader
	Head of BTeV Physics and Simulation Group
1995 – 1996	***Visiting Professor, Department of Physics, Princeton University***
1992 – 1993	***Staff Scientist II, Physics Research, SSC Laboratory***
	Deputy Head of SDC Muon Detector Group
1984 – 1992	***Research Associate, High Energy Physics, Harvard University***
	Member of the L3 Collaboration (CERN), Member of the Crystal Ball Collaboration (DESY)
1979 – 1984	***Research Assistant, High Energy Physics, Yale University***
	Fermilab Fixed Target Experiment (E630) with a High Resolution Streamer Chamber
1976	***Research Assistant, Semiconductor Research, Bell Laboratories***

Awards

2010	APS Fellow
2010	AAAS Fellow
1995 – 1996	NSF Visiting Professorships for Women Award

Committees, reviews and other service

2011 –	European Particle Physics Strategy Update Preparatory Group
2011	High Energy Physics Advisory Panel (HEPAP)
2011 –	American Physical Society Physics Policy Committee, American Physical Society
	Division of Particles and Fields (DPF) Executive Committee 2009 –; Chair 2011
2008 – 2011	International Committee on Future Accelerators (ICFA)
2008 – 2011	International Union of Pure and Applied Physics (IUPAP), Executive Council Vice President
2008 – 2011	International Union of Pure and Applied Physics (IUPAP) C11 Commission 2005-2011; Chair
2006 –	US Liaison Committee for the International Union of Pure and Applied Physics (USLC/IUPAP)
2002 – 2005	CERN LHC Committee (LHCC)
2000 – 2007	CERN School of Computing Advisory Board
1997 – 2001	Cornell CESR/CLEO Program Advisory Council

Curriculum Vitae: Professor K.J. Peach

Biographical Details, Qualifications, Prizes and Membership of Learned Societies

- Kenneth Joseph Peach, born 5th November 1945 in Derby, UK.
- B.Sc. (Hons) Physics (1967) University of Edinburgh
- Ph.D. (1972) University of Edinburgh; Thesis *A Study of the charged decays of the* K_L
- EPS-HEPP Prize 2005 as a member of the NA31 Collaboration "*which showed for the first time direct CP violation in the decays of neutral K mesons*".
- Institute of Physics 2006 Rutherford Medal and Prize "*For his contributions to high energy physics as a leader of key experiments at CERN investigating CP violation, and as Director of Particle Physics at CCLRC's Rutherford Appleton Laboratory where he has played a key role in reviving accelerator science for particle physics applications in the UK.*"
- F.Inst.P, C.Phys (1989) (associate member since 1967)
- FRSE (1999)

Current Position

Professor of Accelerator Physics and
co-Director, Particle Therapy Cancer Research Institute, University of Oxford

Address for correspondence

Denys Wilkinson Building,
Keble Road,Oxford OX1 3RH.
Tel: +44 (0) 7770 65 25 48
e-mail: Ken.Peach@adams-institute.ac.uk

Previous employment and awards

October 1967 to September 1970	SERC Studentship
October 1970 to September 1975	Demonstrator, Department of Physics, University of Edinburgh
October 1975 to September 1981	Research Assistant, Department of Physics, University of Edinburgh.
October 1981 to September 1986	Advanced Fellow, Department of Physics, University of Edinburgh
October 1986 to September 1992	Research Officer, Department of Physics, University of Edinburgh
October 1992 to September 1996	Reader, Dept. of Physics & Astronomy, University of Edinburgh
September 1996 to April 1998	Deputy Leader of the Particle Physics Experiments Division, CERN
October 1996 to March 2002	Personal Chair in Particle Physics Experiments, University of Edinburgh
January 1998 t0 July 2005	Director, Particle Physics, CCLRC Rutherford Appleton Laboratory
January 2004 to October 2005	Director, CCLRC e-Science Centre, CCLRC
May 2005 to July 2010	Director, John Adams Institute for Accelerator Science (University of Oxford and Royal Holloway University of London)

Leader and principal investigator of the Edinburgh Particle Physics experimental group from October 1990 – September 1996. Visiting chair Edinburgh (2003-2007).

Research Interests

1. K_L decays using a heavy liquid bubble chamber (1967 – 1973)
2. K_L decays, and on $K_L p$ scattering in a hydrogen bubble chamber (1970 – 1978)
3. Intermediate energy $\pi^+ p$ scattering (1975 – 1983)
4. CP-violation in K_L decays – NA31 (1981 – 1993) and NA48 (1990 – 1996)
5. B-physics decays at BaBar at SLAC (1993 – 1996)
6. Neutrino Factories and Muon Ionisation Cooling Experiment (1998 – 2005)
7. Accelerator R&D (2005 –)
8. Non-Scaling Fixed-Field Alternating Gradient Accelerators for research (EMMA) and medicine (PAMELA) (2006 –)
9. Various aspects of Charged Particle Therapy (2009 –)

Academic and Research Responsibilities since 2000

1. Member, SNO Advisory Research Committee and Scientific Sub-Committee (1999 – 2005)
2. Member, ANTARES External Review Committee (1999 – 2003)
3. Member, Frascati Scientific Advisory Committee, (1999 – 2005)
4. Director, SUSSP, St. Andrews, (2001).
5. Chair, Scientific Review Committee of the Department of Astrophysics, Nuclear Physics, Particle Physics and Associated Instruments (DAPNIA), CEA, Saclay (2000 and 2003), Member (2007)
6. Member, Steering Committee for the Institute for Particle Physics Phenomenology (2001 – 2005)
7. Member, CERN Scientific Policy Committee (2002-2007), Chair (2005 – 2007). As Chair, I was also member of several CERN Council Working Groups.
8. Member, Search Committee for CERN Director General for CERN, (April – May 2002)
9. Lecturer, BUSSTEPP-Glasgow (2002).
10. Member, Scientific Advisory Committee, FZK, Karlsruhe (2003 –)
11. Member of the e-Science Steering Committee (2004 – 2005)
12. Member, Scientific Advisory Committee, ICE, Denmark (2004 –)
13. Review of the Birmingham School of Physics Strategy (2005)
14. Member, Evaluation Committee of the Belgian Particle Physics Integrated project (December 2005 –)
15. Co-chair, Strategy Group for European Particle Physics (September 2005 – July 2006)
16. Member, Particle Physics Advisory Panel (2005 – 2006)
17. Secretary and Member of the Board of the British Accelerator Science and radiation Oncology Consortium (BASROC) (2006 –)
18. co-Director, SUSSP, St. Andrews (2006)
19. Member of the Review of the Helmholtz Society Call for Alliances (2006-2007)
20. Member, CERN Council Working Group on the implementation of the European Strategy for Particle Physics (2006 – 2007)
21. Member, Local Organising Committee, ERL07
22. Chair of the Review Panel, Osaka Centre of Scientific Excellence (2007)
23. Chair, Search Committee for CERN Director General for CERN (2007)
24. Member, Organising Committee, KEK-Fermilab Neutrino Summer School (2007)
25. Editor-in-Chief, PhysMathCentral (PMC) Physics A (April 2007 – December 2010)
26. Chair, LNGS Scientific Advisory Committee (2010 –)
27. Member of the SNOLAB Institute Management Board (2010 –)

Curriculum Vitae: Dr. Francesco Ronga

Personal data

Born Nola (Naples) Italy 14/4/1945
Married with three sons.
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Education

1963	secondary school diploma
1968	Laurea in Physics 110/110 lode University of Naples ITALY with the thesis "Barion anti Barion production in e+ e- storage rings (Adone)"

Professional Development and Experience

1967 – 1968	Student fellowship at CNEN Frascati (National Committee for Nuclear Energy)
1969	Fellowship position at CNEN Frascati
1970 – 1975	Staff Physicist at CNEN Frascati
1972	Lecturer Naples University "Electromagnetic Waves"
1975 – 2010	Staff Physicist at INFN (National Institute for Nuclear Physics) Laboratori Nazionali di Frascati
1989 – 1996	member of the INFN national scientific committee for neutrino and astroparticle physics first and second mandate
1990 – 2010	INFN Research Director (senior scientist)
1990 – 1992	Lecturer Astroparticle Physics -Perugia University
1994	member of the organizing committee and of the editorial board of the first Amaldi conference on Gravitational Waves
1997 – 1999	Member of the INFN national committee for computers and network
2003 – 2006	Elected chairman of the INFN national scientific committee for neutrino and astroparticle physics
2006 – 2009	Elected again chairman of the INFN national scientific committee for neutrino and astroparticle physics
2003 – 2009	Member of the INFN internal evaluation committee
2005 – 2009	Member of the ApPEC Program Review Committee
2007-2009	Member of the EGO – VIRGO scientific and technical advisory committee
2008	Chair of the selection committee of the Rossi prize for the best Ph. D. thesis in astroparticle physics
2009	chair of the selection committee of the Rossi prize for the best Ph.D. thesis in astroparticle physics
2009	Aspera program committee
2011	INFN senior research associate

Chair and member of many committees for selection and promotion of INFN researches and fellows.

Short Scientific Curriculum

I am expert in the areas of high energy experimental physics (in particular in the field of neutrino physics) cosmic ray physics and gravitational waves.

1970 – 1984

Initially my field of interest was connected with experiments performed at the electron positron storage rings ADONE and PEP, located in Frascati (Italy) and Stanford (USA). I was in one of the teams that discovered the J/PSI particle in Frascati, in November 1974, a few days after Stanford and Brookhaven.

The main results obtained in Adone with the MEA experiment, were connected to tests of quantum electrodynamics, measurement of multi-hadron production and searches for other narrow resonances like the J/PSI. In Stanford I have worked to the PEP14 experiment dedicated to the free quark searches and to the MAC general purpose detector. Analyzing the MAC data I have seen, for the first time in the world, the asymmetry in the jet production due to the Z particle.

1984 – 2004

After 1984 my field of interest has switched to cosmic ray physics and particle physics without the use of accelerators in underground experiments.

I was one of the proponents of the MACRO Italian-US experiment at the Gran Sasso laboratory Italy for the search of monopoles, the study of cosmic rays, the study of neutrino oscillations and of neutrino and cosmic ray astronomy. Within the MACRO collaboration, I was the coordinator of the data acquisition working group and the coordinator of the neutrino physics working group.

I have presented the neutrino data of the MACRO collaboration at the historical Neutrino 98 conference in Takayama (Japan). This conference is considered now the conference in which it was established that the neutrino mass is different from zero. The MACRO data, together with data from SOUDAN2 and SuperKamiokande, were crucial to reach this conclusion.

1992 – now.

Since 1992 I have started to work on the search for gravitational waves using aluminium resonant cylinders at very low temperature, joining to the ROG gravitational wave group. I had the responsibility to study the noise due to cosmic rays. I had also a collaboration with a Nikhef group to study the cosmic rays noise on a spherical detector.

In 1999 we have detected, for the first time in the world, cosmic rays using the NAUTILUS gravitational bar detector, located in Frascati. We have found some unexpected very large signal. To study this problem we have proposed in 2002 an experiment using a particle beam to study the acoustic excitation on an aluminium bar cooled at 0.1 Kelvin. This experiment has done measurements with aluminium and niobium in normal and superconductive state, showing that in aluminium in superconductive state larger signals are produced confirming the observation of cosmic rays with the gravitational wave antennas.

2011

I have joined the JEM_EUSO collaboration for a space experiment dedicated to the study of the very high energy cosmic rays.

Publications

I am the author of about 280 publications (SPIRES data base). One paper is with more than 500 citations (the J/PSI paper) and two papers are with more than 250 citations (the paper on the atmospheric neutrino oscillations and the paper on the B lifetimes).

7.2 Programme of the site visit 19-21 September 2011

Monday, 19 September 2011

Location: **NH Barbizon Palace Hotel, Henry Hudson Room I**

All day	Arrival of committee members
17:00 – 18:00	Installation of the committee by Ben de Kruijff, member NWO Board and Wim van Saarloos, director FOM General introduction to Nikhef by Frank Linde, director of the FOM-institute Nikhef
18:00 – 19:00	Internal discussion
19:30	Dinner with Ben de Kruijff and Wim van Saarloos at Restaurant 'de Vijff Vlieghen'

Tuesday, 20 September 2011

Location: **Nikhef-institute**

08:30 – 09:00	Taxi from NH Barbizon Palace to Nikhef
09:00 – 09:10	Reception with coffee, checking internet connections
	PIERRE AUGER OBSERVATORY
09:10 – 09:15	Introduction by panel discussion leader
09:15 – 09.25	Presentation by Sijbrand de Jong
09:25 – 09:45	Discussion with several staff members
09:45 – 09:50	Internal committee discussion
	VIRGO
09:50 – 09:55	Introduction by panel discussion leader
09:55 – 10:05	Presentation by Jo van den Brand
10:05 – 10:25	Discussion with several staff members
10:25 – 10:30	Internal committee discussion
10:30 – 10:40	Coffee break
	XENON
10:40 – 10:45	Introduction by panel discussion leader
10:45 – 10:55	Presentation by Patrick Decowski
10:55 – 11:15	Discussion with several staff members
11:15 – 11:20	Internal committee discussion
	ANTARES/KM3NeT
11:20 – 11:25	Introduction by panel discussion leader
11:25 – 11:35	Presentation by Maarten de Jong
11:35 – 11:55	Discussion with several staff members
11:55 – 12:00	Internal committee discussion
	SCIENTIFIC ADVISORY COMMITTEE
12:00 – 12:30	Meeting with chairman of the SAC prof. Yannis Karyotakis
12:30 – 13:30	Lunch with programme leaders in Spectrum
	THEORY
13:30 – 13:35	Introduction by panel discussion leader
13:35 – 13:45	Presentation by Eric Laenen
13:45 – 14:05	Discussion with several staff members
14:05 – 14:10	Internal committee discussion

	DETECTOR R&D
14:10 – 14:15	Introduction by panel discussion leader
14:15 – 14:25	Presentation by Niels van Bakel
14:25 – 14:45	Discussion with several staff members
14:45 – 14:50	Internal committee discussion
14:50 – 15:40	Lab tour
15:40 – 16:10	Tea break with PhD students in Spectrum
	ATLAS
16:15 – 16:20	Introduction by panel discussion leader
16:20 – 16:30	Presentation by Stan Bentvelsen
16:30 – 16:50	Discussion with several staff members
16:50 – 16:55	Internal committee discussion
	LHCb
16:55 – 17:00	Introduction by panel discussion leader
17:00 – 17:10	Presentation by Marcel Merk
17:10 – 17:30	Discussion with several staff members
17:30 – 17:35	Internal committee discussion
	ALICE
17:35 – 17:40	Introduction by panel discussion leader
17:40 – 17:50	Presentation by Thomas Peitzmann
17:50 – 18:10	Discussion with several staff members
18:10 – 18:15	Internal committee discussion
	GRID COMPUTING
18:15 – 18:20	Introduction by panel discussion leader Patricia McBride
18:20 – 18:30	Presentation by Jeff Templon
18:30 – 18:50	Discussion with several staff members
18:50 – 18:55	Internal committee discussion
19:00 – 19:15	Taxi from Nikhef to hotel
20:00 – 22:00	Dinner at Restaurant Vermeer in NH Barbizon Palace

Wednesday, 21 September 2011

Location: **Nikhef-institute**

08:30 – 09:00	Taxi from NH Barbizon Palace to Nikhef
	Meeting with the directorate (Frank Linde & Arjen van Rijn)
09:00 – 09:20	Introduction Frank Linde about – Long term future plans (ILC, etc.) – Technical skills, infrastructure – Knowledge transfer – Education, outreach – Finances
09:20 – 10:00	Discussion
10:00 – 10:15	Coffee break
10.15 – 12:30	Internal committee discussion and report writing
12:30	Lunch in Spectrum (committee)
13:30 – 16:00	Report writing
16:00 – 18:45	Report consolidation
18:45 – 19:15	Meeting with Nikhef director Frank Linde
19:30 – 19:50	Taxi from Nikhef to restaurant 'Rosarium'
20:00	Dinner at restaurant 'Rosarium' with presentation of main conclusions to FOM and to Nikhef staff members

7.3 List of programme leaders, staff members and PhD students interviewed

Program presentations

On Tuesday, the committee heard presentations and discussed with following staff members:

Auger:	Sijbrand de Jong, Ad van den Berg, Charles Timmermans, John Kelley, Harm Schoorlemmer.
Virgo:	Jo van den Brand, Chris van den Broeck, David Rabeling, Tjonnie Li
Xenon:	Patrick Decowski, Matteo Alfonsi, Gijs Hemmink (Master)
Antares/KM3Net:	Maarten de Jong, Els de Wolf, Aart Heijboer
Theory:	Eric Laenen, Rober Fleischer, Mert Aybat, Reinier de Adelhart Toorop
Detector R&D:	Niels van Bakel, Harry van der Graaf, Martin van Beuzekom, Marten Bosma, Martin Fransen
ATLAS:	Stan Bentvelsen, Paul de Jong, Olya Igonkina, Nicolo de Groot, Egge van der Poel
LHCb:	Marcel Merk, Antonio Pellegrino, Niels Tuning, Gerhard Raven, Daan van Eijk
ALICE:	Thomas Peitzmann, Paul Kuijer, Marco van Leeuwen, Marta Verweij
Grid computing:	Jeff Templon, Wim Heubers, Arjen van Rijn, Daniela Remenska

Lunch with programme leaders

On Tuesday, the committee had an informal lunch with the following programme leaders (in the absence of the Nikhef management):
Niels van Bakel, Stan Bentvelsen, Chris van den Broeck, Patrick Decowski, Harry van der Graaf, Aart Heijboer, Wim Heubers, Maarten de Jong, Paul de Jong, Sijbrand de Jong, Paul Kuijer, Eric Laenen, Marcel Merk, Thomas Peitzmann, Antonio Pellegrino, Jeff Templon, Leo Wiggers and Els de Wolf

Tea break with PhD-students

On Friday, the committee had an informal tea break with the following PhD-students and master students (in the absence of their advisors and Nikhef management):
Tjonnie Li, Mark Beker, Mathieu Blom, Gideon Koekoek, Sipho van der Putten, Michail Agathos, Gijs Hemmink (master), Erwin Visser, Bardo Bakker (master), Reinier de Adelhart Toorop, Sander Mooij, Michele Maio, Marten Bosma, Martin Fransen, Wilco Koppert, Joris van Heijningen, Egge van der Poel, Magda Chelstowska, Rogier van der Geer, Rosemarie Aben, Hurng Chung Lee, Lucie de Nooij, Nicole Ruckstuhl, Daan van Eijk, Serena Oggero, Rose Koopman, Veerle Heijne, Jeroen van Leerdam, Chiara Farinelli, Ivan Mous, Fabian Jansen, Marta Verweij, Marek Chojnacki, Ante Bilandzic, Raoul de Rooij, Daniela Remenska and Cristian Cirstea

Figure 4 | Tea break with Nikhef PhD-students and the committee

7.4 Extended description of the five point scale

(source: Standard Evaluation Protocol, Appendix 2)

5: Excellent

Research is world leading. Researchers are working at the forefront of their field internationally and their research has an important and substantial impact in the field.

4: Very good

Research is internationally competitive and makes a significant contribution to the field. Research is considered nationally leading.

3: Good

Work is competitive at the national level and makes a valuable contribution in the international field. Research is considered internationally visible.

2: Satisfactory

Work adds to our understanding and is solid, but not exciting. Research is nationally visible.

1: Unsatisfactory

Work is neither solid nor exciting, flawed in the scientific and or technical approach, repetitions of other work, etc.