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EVALUATION OF THE FINNISH CERN ACTIVITIES

PANEL REPORT

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Executive Summary

The Panel summarises its findings as follows:

- The first ten years of the Finnish membership in CERN have been successful. In the future as well Finland has great opportunities and benefits deriving from the membership in CERN. The Finnish presentations at the review clearly show progress and rapid development in experimental particle physics since Finland has joined CERN. In this development the Helsinki Institute of Physics (HIP) and previously the Finnish Research Institute for High Energy Physics (SEFT) have played key roles. Finland is still a young Member State in CERN, but one of the most dynamic new partners.
- A key finding of the Panel was the unclear instructions given to HIP what concerns activities and policies involved with CERN. To maximize the benefits of CERN membership Finland needs a general Government strategy to efficiently use all opportunities offered by CERN in science and in the training of scientists and engineers in an international environment.

More detail is provided in the following statements:

1. The Finnish participation in CERN has been scientifically and, recently, technologically successful. It merits continuation at a healthy level that optimises the return on investment for Finland. The CERN program provides Finland with access to one of the most exciting, and expensive, scientific endeavours that mankind has ever undertaken. Participation in CERN also guarantees Finland a seat at the core of European research and technology developments.

2. Over the past decade the Finnish presence at CERN has been focussed and visible. The Finnish role is much appreciated by CERN management and is considered a role model for other potential Member States. In the future Finland will be involved with the major experiments at CERN and the plans are, for the most part, sound. However, there appears to be a need to state clearly to the Finnish personnel involved with CERN what Finland expects for its contribution to CERN. Beyond the manifest benefit of “sitting at the table” in Europe, is the main expectation that of excellent research or the establishment of a scientific-technical research environment, or involvement in high-tech development? Perhaps all of these.

3. The Helsinki Institute of Physics (HIP) has played an important role as co-ordinator of the Finnish effort at CERN. By comparison, such a co-ordination has lead to a significant visibility of Finnish Physics at CERN in contrast to that of other small countries such as Sweden. HIP has new and energetic leadership. A negative side effect of HIP appears to have been an uncoupling of the link between Finnish CERN activity and the Finnish universities. This needs to be reversed. HIP must play a strong role in maintaining a home base for High Energy Physics in Finland. The inclusion in HIP of additional Finnish Universities is a good development broadening the science base for the Finnish involvement at CERN and can serve to strengthen the connections between CERN base and research and education at home. HIP’s scientific advisory

board is composed of first-class European science leaders. It should also include a Finnish physicist. In view of the size of the investment in CERN activity, one should consider who is the *national forum* which advises on Finnish activities at CERN. Funding for HIP has recently been split up between direct funding from the Government and university contributions that are tied to numbers of degrees connected with the CERN research effort. This muddles the mission of HIP. The Panel recommends that the funding for HIP should come directly from the Ministry, as it has in the past. The essential institutional review for quality can include a consideration that HIP fulfils its educational mission. Exciting and high-quality projects will automatically attract students, and the present reviewers are pleased with the number of theses that have been completed in the CERN program

4. Although the mission statement of HIP defines the role as one of co-ordination and directing, this statement is ill defined. The Government should state clearly what it expects of HIP. Is it co-ordination, or the setting of scientific priorities, or indeed both? This is closely tied to the expectations that the Finnish Government has for its participation in CERN. HIP could be defining scientific priorities: then a five-year plan should be developed, with scientific, academic and technical manpower and financial needs identified. On the other hand, HIP then takes on a heavy responsibility assuring close connection between the CERN research groups and their universities.

5. Although there is Finnish personnel placed into CERN management, the Panel feels that the time has come for Finland to have one or two members on the permanent scientific staff, i.e. in a key position, of CERN. If a suitable candidate is not available now, a cadre of candidates should be carefully developed. Only in this way will Finnish scientists be able to participate in the important scientific decisions inside the Laboratory.

6. The past Finnish participation in UA1 and DELPHI has been successful and impactful. It provided the base from which Finland moved into a presence in the LHC program. The division where UA1 moved into the CMS collaboration early, while the DELPHI –HEP continued taking and analysing data, was a good decision. In this way Finnish scientists were in at the beginning of CMS construction, while the HEP provided a continuing base for thesis work. Now HEP has to decide how to fit itself into the three detector collaborations (CMS, ATLAS, ALICE). Concentration in CMS, and perhaps ALICE, would focus Finnish resources. HEP has developed very interesting plans involving small-angle physics with an innovative detector proposal that could be incorporated in either CMS or ATLAS, or perhaps ALICE. The decision where this group finds its home should be made soon.

7. Finnish participation in ISOLDE is very strong. Its scientific program is a natural complement to the activities at the Jyväskylä cyclotron. The collaboration provides technology that is directly useful to Jyväskylä. For example Finnish scientists are involved with the major upgrades of ISOLDE.

8. Finnish participation in ALICE is a natural extension of the experimental home effort in nuclear physics and follows the strong Finnish activities in relativistic

heavy ion theory. However, at present, the effort is ill defined at best, has no discernible leader and no plan what task to assume in the experiment. It is not even clear where scientific manpower would come from, unless the DELPHI HEP group decides to participate in ALICE. Critical decisions need to be made very soon in this area.

9. The Finnish software developments at CERN are of high quality. This is to be applauded because it is clearly an area where a small group can make a powerful contribution to an experimental program. The effort has also been commercially quite successful. On the other hand, the result so far has more managerial than scientific applications. The participation in the development of the DataGrid effort is a logical next step. The Panel is concerned about what appears to be divergent views between the Finnish group and the detector spokesmen, about the structure of the scientific DataGrid. Unless any disagreement is resolved early the Finnish development could fail to deliver a useful product.

10. The Finnish high-energy and nuclear theory program that is involved with CERN is relatively large and of high quality. It is respected at CERN. However, it has only loose connections to the main thrust of CERN theory and to the experimental high-energy physics program at CERN. Thus there seems to be minimal interaction between the Finnish experimental and theoretical groups. The numerical balance between experimental and theoretical high-energy physics in Finland has shifted too far toward theory. HIP should take steps to better integrate theory and experiment.

11. Good scientific return from the Finnish investment in CERN obviously requires a strong home-based particle physics education at Finnish Universities. At present there is only one professorial position in *experimental* high-energy physics. By comparison, Sweden has 12 professorships in experimental high-energy physics at Lund, Stockholm and Upsala. Steps should be taken to at least double this number. This increase would also provide a better connection to the student base at the Finnish universities that have recently connected to HIP. In addition the balance between the presence at CERN and at home universities needs to be addressed.

12. The Finnish high-energy physics program needs a technical base in Finland where students can do advanced experimental work. The Detector Laboratory can be such a base, if it shifts itself to the technology that is now at the core of the CERN detectors, or to the new small-angle detectors proposed by the HEP group. To be useful for the CERN program this laboratory needs to have a critical mass, in order to develop, test, and produce detector elements on a useful scale. Detector funds from CERN could then flow into such a laboratory.

13. The Panel interacted with a number of good young people during its visit to CERN. They were excited about the excellent working conditions at CERN and about their own research in particular. However, there was great apprehension about their futures in science and about the opportunities in Finland. Some of these concerns might be alleviated by better contacts between the home universities and the CERN groups. Another positive step would be the establishment of more postdoctoral

positions, to give young Ph.D.s time to develop their careers and for the best ones to gain profile for academic positions. HIP should play an active role to help plan the careers of the young Finnish CERN scientists; otherwise much of the educational effort may be lost.

14. The student exchange between Finnish universities and CERN is an outstanding program in terms of size. Also a good number of thesis projects (Masters and Ph.D.) have been connected to work at CERN. However, as the students come to CERN, it is equally important that the scientific staff residing at CERN come to Finland. One of the connections between CERN and Finnish universities is the web-based transmission of lectures and seminars. This is an innovative program in search of a fiscal home. HIP could provide such a home base.

15. The "return" to Finnish industry in proportion to the Finnish CERN contribution has been sub-par in the past. However, there has been great progress recently, both in term of the technological level of items ordered from Finnish firms and the size of the orders. This has been helped by the outstanding efforts of the Cerntech organisation, which is a very small but highly effective consulting effort that connects needs of CERN with the capabilities of Finnish industry. This very valuable organisation presently stands on shaky footing: it is too small (only one person at CERN) and its financial future is uncertain. It needs to be strengthened on both accounts.

Preface

In November 2000 the Board of the Academy of Finland decided that Finnish activity at the European Laboratory of Particle Physics, CERN, should be evaluated. It gave the task of organising the evaluation to the Research Council for Natural Sciences and Engineering, who invited the following panel to carry out the review:

Professor Peter Paul (chairperson), Deputy Director, Brookhaven National Laboratory, USA
Vice-President Kari-Pekka Estola, Nokia Research Centre, Nokia Oyj, Finland
President Pauli Juuti, Helsoft Ltd., Finland
Professor Sven Kullander, Inst. of High Energy Physics, University of Uppsala, Sweden

The Panel was supported by Senior Advisor Eeva Ikonen from the Academy of Finland and Professor Jukka Maalampi from University of Jyväskylä, who acted as secretaries of the Panel and co-ordinated the evaluation by collecting background information and arranging the Panel meeting at CERN.

Finnish physicists started their collaboration with CERN already 1966, and a new era in this activity began ten years ago when Finland became the fifteenth Member State of CERN. The CERN membership represents one of the largest international scientific collaborations in Finland.

The assignment of the Panel was to carry out an evaluation of the state, visibility and impacts of the Finnish membership of CERN, particularly in terms of research activities in the fields of physics and applied sciences, research training, and industrial collaboration. The Evaluation Panel was also expected to make proposals for future strategies and for possible improvements and changes in Finnish CERN activities.

The Panel met at CERN on March 25–27, 2001, for one and a half days to review the Finnish activities at CERN. Prior to this meeting the Panel had been given extensive background material about the organisation and the history of the Finnish involvement with CERN. At the site review the Panel heard presentations from all the scientific programs, met with members of the CERN Directorate and with the spokesmen of the two large LHC experiments (CMS and ATLAS) as well as with key personnel of ISOLDE. Only ALICE has not been discussed in detail. The Panel also had discussions with Finnish students, postdoctoral scientists, and managerial personnel who worked in the CERN program. We believe that this agenda provided a good overview of the achievements, problems and plans of the Finnish participation at CERN. Recommendations are differentiated from background material by bullets.

The Panel was unanimous in its deliberations and conclusions. The Panel expresses its hope that this report will be seen as a constructive basis for the future development of the Finnish membership at CERN.

The Evaluation Report is presented to the Academy of Finland on May 15, 2001, by Professor Peter Paul, chairman of the Evaluation Panel.

1 Background

Connection to CERN

The European Laboratory for Particle Physics, CERN, was one of Europe's first joint ventures, and it has become an outstanding example of international collaboration. According to CERN convention signed in 1954, the Organisation provides for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto. The dominant activity of CERN today is in high-energy particle physics. From the original 12 signatories of the convention, membership has grown to the present 20 Member States. Finland became the fifteenth Member State when it joined CERN in 1991. The number of CERN staff is (as of 1999) 2700, and some 6500 scientists use CERN's facilities.

The beginning of the collaboration between Finland and CERN

The collaboration between Finland and CERN started in 1966 with an agreement that allowed Finnish scientists to take part in research work at CERN on an "ad-hoc" basis. According to the agreement Finland was not expected to contribute to the general costs of the Laboratory, but on the other hand was supposed to take care of the funding of the Finnish physicists working at CERN.

Actually, already since September 1964 there had existed a bubble chamber research group in the Department of Physics at the University of Helsinki, which collaborated with the bubble chamber groups in Denmark, Sweden, and Norway in analysing bubble chamber films from experiments carried on at CERN. (In contrast to Finland, Denmark, Norway, and Sweden were Member States of CERN as original signatories.) The Finnish effort in experimental particle physics was centred on bubble chamber experiments for more than a decade.

Participation in the UA1 and DELPHI collaborations

In 1979 part of the former bubble chamber group joined the UA1 Collaboration, at first unofficially as a part of the CERN group, later officially as a participating institute.

The main contribution of the Finnish team in the highly successful UA1 experiment was to the data reconstruction software. In addition to this, the Department of High-Energy Physics (SEFL) at the University of Helsinki participated in designing and manufacturing the fast data acquisition system. This was the first hardware contribution of Finland to CERN accelerator experiments, and it led to the first contacts between particle physics researchers and industry in Finland.

The Finnish contribution to the UA1 experiment was well recognised, and the participation in UA1 opened doors for the Finnish experimentalists to other major experiments at CERN, such as the DELPHI experiment at LEP and more recently the CMS experiment at LHC. It also generated much publicity and made CERN known among the general audience in Finland.

SEFL joined the DELPHI Collaboration at LEP in 1983. Apart from physics simulations, the SEFL group had from the beginning a major hardware responsibility in designing and building the readout electronics for the hadron calorimeter. In the course of the construction effort it also contributed to the design and manufacture of streamer tubes and to the data acquisition system of the calorimeter. A group from SEFL and Åbo Akademi University contributed at a later stage to the electronics and support system of the Delphi microvertex detector. The DELPHI effort emphasised the technological spin-off aspects throughout and favoured active collaboration with industry. This led eventually to the foundation of Cerntech Oy, a company supporting Finnish industry in commercial and technological relations to CERN.

The hardware contribution to the DELPHI experiment brought a new kind of visibility to the Finnish presence at CERN and an essential new element – detector design and building – to the experimental particle physics activity in Finland.

During the DELPHI activity the Finnish participation in the CERN summer student program increased many-fold, spreading the recruitment of a new generation of physicists from the University of Helsinki to other Finnish universities, in particular to the Helsinki University of Technology.

The joining of Finland to CERN

In the early stages Finland benefited from the access to CERN research facilities without contributing to the general costs of the Laboratory with a membership fee. Through the participation in the UA1 and DELPHI experiments the presence of Finland at CERN became much more visible than before and increased considerably in volume. This made the possible joining of Finland to CERN a topical issue in the 1980's.

In January 1985 the Director-General of CERN and President of the Academy of Finland signed a Memorandum of Understanding, defining the common interests and aims of Finland and CERN. A working group appointed by the Finnish Ministry of Education in 1987 did not, however, find the scientific arguments strong enough for Finland to aim for membership at CERN, considering the high costs of the membership. It proposed instead that a research institute for experimental high-energy physics should be founded at the University of Helsinki for a better co-ordination of the collaboration between CERN and Finland. This led to the Helsinki Institute of Physics (HIP)

In 1988 the President of the Council and the Director-General of CERN suggested to the Finnish Minister of Education that Finland should become a Member State of CERN. Another working group was appointed by the Finnish Ministry of Education to consider the suggestion, and it gave its recommendations in the spring of 1989. On 28 August 1989 the Government of Finland made the decision to apply for CERN Membership. The decision was not based on the needs of physics research alone, but the Government placed a special emphasis on the general image and position of Finland in the European community. Thus Finland became the fifteenth Member State of CERN from the beginning of 1991. During a transition period of four years with a reduced membership fee, special efforts were made in training, technology transfer, visits and

seminars by CERN experts in Finland, as well as in visit of Finnish scientists engineers and students at CERN.

- The Panel finds that the first ten years of the CERN membership of Finland have been very successful in terms of research achievements and impact, in education and in technological spin – off. The strong concentration of the effort through one Institute (HIP) has led to an impactful and visible program. The Panel sees the great opportunities and benefits which continuing participation in CERN will offer for basic and applied research and for science education in Finland also in the future. The Panel recommends unanimously that the collaboration between Finland and CERN should continue.

2 The present Finnish research activities at CERN

The CMS Collaboration

The main Finnish research activity at CERN takes place in the CMS experiment at LHC (Large Hadron Collider). The CMS project was initiated in the beginning of the 1990's, and the Finnish team has participated in the Collaboration from the beginning. The heart of the Finnish team consists of the senior physicists that had participated in the UA1 experiment. The CMS experiment is a natural continuation of the previous activity of the group. The discovery and the study of the properties of the Higgs boson are the major goal of the CMS experiment, as well as of the LHC as a whole.

The Finnish participation in the CMS Collaboration is organised in two projects, the CMS Software and Physics Project and the CMS Tracker Project. As far as the CMS Software and Physics are concerned, contributions by the Finnish team are in the areas of detector simulation and detector design optimisation, event reconstruction and study of the discovery potential of the CMS experiment through physics simulation. The main emphasis is on the software for the CMS Tracking system. In the physics analysis the group is responsible on the simulation studies of Higgs boson production by tt and bb fusion and of the decay channels to $\tau\tau$ and WW^* or $\tau\nu$.

The Finnish CMS Software and Physics group consists of eight physicists and four graduate students. A former member of the group, Martti Pimiä, is the Manager of the Computing and Core Software Project of the CMS Collaboration, and in the hierarchy of the collaboration, he is on the level next to the spokesperson. He belongs to the permanent staff of CERN, and his position in the CERN hierarchy is the Deputy Group Leader of the CMS Computing Group in the EP-Division. His position is the highest of all the Finnish physicists at CERN.

- Although Dr. Pimiä is in an important position within CERN management, the Panel feels strongly that the size and success of the Finnish effort merits at least one physicist in a scientific key position among the about 100 permanent scientific positions at CERN. In this way Finland would have a modicum of input into the internal decisions about scientific program of CERN. If a suitable person is not available now, an eventual candidate should be "groomed" for such a position.

The Tracker project consists of three subprojects: design and construction of the mechanical support of the Tracker Outer Barrel, Tracker detector development, and Trigger and Data acquisition development. The Finnish engineering team, which originates in the Helsinki University of Technology, has participated actively in the development of the mechanical structure of the CMS central Tracker since 1992. A full-scale prototype (Big Wheel) of the mechanical structure of the Tracker Outer Barrel was completed in 1999 in collaboration with CERN and with Finnish industry. The team is now working on the detailed design of the layout of the services and on the preparation for the manufacture of the final structure. The head of the engineering team, Antti

Onnela, is the leader of Design Office Section of the Technical Assistance Group in the EP-Division.

In order to gain thorough understanding of the functioning of the Silicon Strip Tracker (SST) modules a small number of modules is planned to be manufactured in Finland. HIP, the home institute of the group, does not have the necessary infrastructure for this and the production will therefore be contracted to Finnish industry. The SST modules will be tested for system aspects in Helsinki, at the common Detector Laboratory of HIP and the Physics Department of the University of Helsinki. There is also a plan to perform irradiation tests to silicon sensors in the Accelerator Laboratory of the University of Jyväskylä. The detector team consists of three physicists and a student.

The main activity of the Finnish Trigger and data acquisition team has recently been the design of the Pattern Comparator Trigger (PACT) system for the Resistive Plate Muon chambers of CMS. The first level muon trigger is one of the most important aspects in the CMS detector design for the discovery of new physics. The Finnish team is responsible for the PACT Optical Communication System. During year 2001 the project should reach the state that pre-production prototypes of all boards needed for the system can be manufactured. The team consists of a senior scientist, a doctoral student, and three students.

- The CMS experiment is the dominant Finnish activity at CERN now and will be so in coming years. Finland should focus its efforts in experimental particle physics to this project, thereby improving its influence and visibility at CERN. The CMS group should also maintain its visibility in home institutions in order to attract young physicists and engineers to the team. At present the presence of senior members, as well as of research students, of the CMS team at their home institutions is far too small in comparison with the presence at CERN. Measures should be undertaken to change this unsatisfactory situation.

High-Energy Physics Program (HEP)

The Finnish experimental activity at CERN is at present divided into two main programs, the CMS program described above and the High-Energy Physics Program. This division of the effort of the relatively small experimental particle physics community of Finland may have diminished the influence of Finland at CERN, but it has an understandable historical reason: the CMS group stems from the previous UA1 activity, whereas the origin of the High-Energy Program is in the DELPHI experiment.
Until recently the main activity of the High-Energy Physics (HEP) Program has been the physics analysis of the LEP data within the DELPHI Collaboration. The data acquisition phase of the LEP experiments was completed in November 2000. The research activity of the HEP team now continues with physics analysis of the collected data set. This will be completed within a year. The main physics topics analysed by the Finnish group include t and *B* decays, colour coherent phenomena in QCD, and the search of charged Higgs bosons.

The main aim of the HEP Program for the future is to make a serious physics contribution to the LHC effort that combines the physics interests of the group with the

experience it gained in the DELPHI experiment. The group has defined the study of very forward physics (small-angle scattering) as its niche area. This is in fact an area where no competition exists at this time. The two large detector groups recognise event detection at small angles as an important project. The Finnish group has started to investigate options for a second-generation experiment on forward physics and luminosity studies at LHC, and has invented a novel small-angle detector system. Such a detector could in principle be integrated with any of the coming LHC experiments, but discussions have so far been mainly with the ATLAS collaboration, which has encouraged the group for a further development of the concept.

The High-Energy Program has been successful in training students: 16 Doctoral theses and some 30 Master theses have been completed in the program since 1988.

- The Panel finds the development of the small-angle physics program and the associated novel detector innovative and very interesting, especially since construction of the system might support activity at the home institution. This effort is well matched to the capability and interest of the HEP group. It is well regarded by the ATLAS management (even though a first proposal was sent back for further studies). From the point of view of a focussed Finnish effort it would be best if the HEP group would join in with either the CMS or the understaffed ALICE effort.

Detector Laboratory

The Detector Laboratory of the Helsinki Institute of Physics was founded in connection with the Finnish participation in the DELPHI experiment. The Laboratory was involved with detector design, manufacture, and development for the hadron calorimeter and silicon microvertex detector of the DELPHI, which lead to progressive accumulation of technical expertise. During the recent years the volume of the activity and the staff of the Laboratory has decreased considerably. At present the number of the personnel is five The present activity of the Laboratory consists of the study of the aging of gaseous radiation detectors and manufacturing methods of GEM foils.

- The experimental research at CERN needs a technological platform in Finland. It is therefore important that the Detector Laboratory is maintained. It may be seen as an essential part of the home base of particle experimentalists, especially now when it has moved to the same campus with the rest of the group. The activity of the Laboratory should, however, be re-directed towards silicon technology and it should be integrated with the Finnish activity in the CMS and ALICE experiments, and the forward-physics program. It is a challenge for the Laboratory to keep up with the rapid development of detector technology. It is difficult to conceive of a strong experimental HEP program without hardware involvement in experiments. The Laboratory also will provide invaluable advanced training for young researchers at home.

The Nuclear Matter Project

The University of Jyväskylä in collaboration with HIP conducts the Nuclear Matter Project. It consists of two activities, low-energy nuclear physics at the ISOLDE facility

and high-energy heavy ion physics in the ALICE Collaboration. With its very effective in-house low-energy nuclear physics activity, built around the cyclotron, Jyväskylä is the appropriate base for the nuclear matter project.

The participation of the Finnish group in ISOLDE increased steadily in the 1990's, and in 1998 Finland officially joined the ISOLDE Collaboration. The Finnish research at ISOLDE concentrates on studies of exotic beta- and multiparticle decays near the proton-drip line, studies of nuclei along the Z=N line with a special emphasis on nuclear astrophysics and weak interaction strength studies, and searches for the predicted shell structure anomalies of extremely neutron-rich nuclei in the vicinity of the 'standard' magic numbers in the valley of stability.

At present six Ph.D. students from the University of Jyväskylä participate the experimental program at ISOLDE, two PhD theses have been published and two more are expected in 2001. In the fall 1999 Professor Juha Äystö from the Department of Physics at the University of Jyväskylä was appointed as the physics group leader at ISOLDE.

- The Finnish participation in the ISOLDE Collaboration has been very successful and visible. The ISOLDE group has a strong home base and the ISOLDE activity forms a good natural complement to the activity at the Cyclotron Laboratory in the University of Jyväskylä for achieving the physics goals of the group. It is also satisfying that the group has participation in the ISOLDE upgrades that are presently being implemented.

The Finnish group at Jyväskylä joined the ALICE Collaboration nearly a decade after the start of the project. A suitable sub-project within ALICE had to be identified consistent with the requirement that it should match the available expertise among domestic high-tech enterprises. The best match was found in the development of the Inner Tracking System (ITS). The Finnish group has recently concentrated mainly on software development. Finland has in the University of Helsinki and in the University of Jyväskylä a strong activity in theoretical relativistic heavy ion physics with excellent international reputation. The initiative for joining the ALICE experiment has probably come from that side.

- The Panel finds that the experimental side of ALICE participation is still ill defined and shapeless. So far there seems to be no senior experienced experimentalist fully devoting him/herself to the project. The international collaboration of ALICE is moving forward rapidly, and if the Finnish contribution is to be effective, serious decisions have to be made soon. To be a successful project, the aims of the Finnish participation in the ALICE should be rethought. Also, the manpower resources allocated to this project should be considerably increased from their present level; for example, by recruiting people from the soon-ending DELPHI participation.

Technology Program

The Finnish Technology Program at CERN concentrated during 1995-2000 on developing software for a data management system working on the world-wide web to

communicate between the thousands of computers around the world at the institutes participating in the LHC construction. The software, called TuoviWDM, is now used by several European high-energy physics laboratories to interface and manage documents in their distributed engineering and design projects. The commercial rights, maintenance, and further development of TuoviWDM are now almost completely taken over by a commercial spin-off company.

Altogether 41 people, almost all Finns, were involved in the TuoviWDM research and development activities. The project produced 18 Master's theses and contributed to two dissertations. A significant educational contribution was also related to the 18 short-term students that were received, trained in the international environment, and employed in research and software development. Following their mission in the project, about 80% of them ended up in industry in similar software development positions.

In 2000 Technology Program shifted its activity to the DataGrid project. The global DataGrid has two long-term objectives: the delivery of an infrastructure for very widely distributed analysis of particle physics data at petabyte level and the acceleration of the development of network and middleware infrastructure aimed broadly at data-intensive collaborative science. The LHC experiment, once operational, will produce terabytes of raw data, which will be stored and analysed in a globally distributed manner via DataGrid. The efforts of the Finnish technology group have so-far concentrated on testing different development platforms and implementation languages with small-scale prototype applications.

- The Technology Program has been successful. It has a clear profile and good visibility at CERN. The DataGrid project forms a natural continuation for its previous activities. It can also nicely integrate the work of the Technology Group with the Finnish research program at LHC. However, the Panel is concerned about a possible disconnect between the Finnish group's concept and the main ideas of the CERN detector groups about the conceptual basis of the DataGrid. The software development's success so far has been in the administrative sector, not yet in the scientific data sector. The Technology Program should be careful to remain in touch with the detector collaborations who are the real "customers" of the end product. This is especially important as the main leader of the Program is now associated with a Swiss University and may follow technological interests that are different form those of the Finnish experimental groups at CERN.

Theory Program

Finland has a strong tradition in theoretical particle physics and built a relatively large program in terms of university faculty. Over the last decade or two, theoretical activity has moved from particle phenomenology towards cosmology and formal theory, which has weakened the connections to the experimental research carried out by Finnish experimentalists at CERN. Finland has placed quite consistently a Fellow, in 1995-1998 a staff member and since 1998 a junior staff member in the Theory Division of CERN. Their research interests have been in the fields of cosmology and relativistic heavy ion physics and not so much in the conventional particle phenomenology that is the main activity of the CERN Theory Division. Nevertheless, strong scientific contacts have

developed during the decades between Finnish particle theorists and the CERN theory group. However, the connections to the experimental program have been less strong. The recently started Nordic Workshop on LHC Physics is a good initiative for improving the situation.

- The Panel was impressed with the high quality of the Finnish theoretical program but saw little connection to the experimental Finnish CERN program, either topically or as collaboration. Considering the relatively large size of the theory faculty, compared to the experimental high-energy physics faculty, the lack of collaboration is regrettable. Even modest steps, like truly joint seminars, might go a long way in improving the situation.

3 Organisation of the Finnish CERN activity

The Finnish authority that takes care of the official matters concerning CERN is the Academy of Finland, to whom this duty was transferred as of the beginning of 1997 from the Ministry of Education. The Finnish Government nominates the Finnish delegate in the Council, the Committee of the Council, and the Academy of Finland Finance Committee of CERN (FC). The Finnish CERN delegation may send one observer to the CERN Science Policy Council (SPC). Operational activities, such as research collaboration, have since 1997 been co-ordinated by the Helsinki Institute of Physics (HIP) and before that by the Research Institute for High Energy Physics (SEFT).

- The Council, the Committee of the Council, and the Finance Committee make important, far-reaching decisions, which also affect the position of Finland at CERN. Finnish authorities should pay attention to appropriate expertise and familiarity of their representatives in these organs in scientific and administrative aspects, as well as to the Finnish national expectations of the CERN activity.

Research Institute for High Energy Physics (SEFT)

SEFT was founded in 1990, just before Finland became a Member State of CERN, by the University of Helsinki to strengthen research in experimental particle physics and to co-ordinate nation-wide the collaboration of CERN and Finland. SEFT was an independent unit directly under the Board of the University, and it got its operational funding from the Ministry of Education through the University.

Helsinki Institute of Physics (HIP)

As a result of administrative reorganisations in the University of Helsinki, SEFT was replaced in 1996 by the Helsinki Institute of Physics (HIP). HIP was formed as a merger of SEFT, the Research Institute for Theoretical Physics (TFT), which was another independent unit under the Board of the University of Helsinki, and the Institute of Particle Technology (HTI), which was founded 1990 in the Helsinki University of Technology. HIP had a status of an independent national institute, meaning that its funding was decided as a separate item in the annual state budget. HIP was supervised by the University of Helsinki and the Helsinki University of Technology, and the Board of the Institute was the highest decision making body.

By statute the tasks of the Helsinki Institute of Physics are (1) to conduct and facilitate research in basic and applied physics, and (2) to provide graduate training in physics. The HIP (3) is responsible for co-operation between Finland and CERN and (4) participates in other international research co-operation.

During the year 2001 the University of Jyväskylä joins the University of Helsinki and the Helsinki University of Technology in operating the Helsinki Institute of Physics. At the same time the statute of the HIP will be replaced by a mutual agreement between the three Universities. There are three representatives of the University of Helsinki, two

representatives of the Helsinki University of Technology and two representatives of the University of Jyväskylä in the Board of the Institute.

A six-member Scientific Advisory Board advises the board of HIP. For the period 2000-2002 Professor Hans Falk Hoffmann (CERN) serves as chairman of the Scientific Advisory Board. The director, the head of administration, and the head of finances form the administrative leadership of the HIP.

HIP has four research programs: the theoretical physics programme, the high-energy physics programme, the LHC programme, and the technology programme. The programs are further divided into research projects. About two thirds of the scientific activity of HIP is related to CERN. A part of the theory program works in other fields of physics.

- HIP as an institutional concept has been unquestionably successful. It has served to concentrate the Finnish activities at CERN (much more so than, e.g., in Sweden) into a very visible program. It has new and vigorous leadership. The addition of the other major Finnish Universities to HIP is a major step forward and will strengthen the role of HIP. The membership of the Board consists of science leaders of the highest quality, and will certainly provide excellent advice on the scientific program. On the other hand, the Panel perceives a lack of connection to the Finnish Government agencies. The role of HIP should be defined more clearly than is stated in the mission statement: Does it co-ordinate and direct research? Or does it facilitate research? What does the Government expect in terms of impact on education and research at Finnish universities? A strategic plan should be developed for the next five years, with consideration of the necessary manpower and funding needed to execute it. The creation of HIP has clearly weakened the connections between the CERN groups and Finnish Universities. The Panel believes that the new HIP leadership understands its obligation to strengthen these connections.

4 Funding

The main funding agencies of the Finnish CERN activity are the Ministry of Education, the Academy of Finland and National Technology Agency of Finland, Tekes.

Membership fee

Member States contribute to the funding of CERN in relation to their GNP. The membership fee of Finland is 1.35% (as of year 2000) of the total budget of CERN. During the transition period 1991-1994 the fee gradually increased from 20% in 1991 to the full fee in 1995. The fee in 2000 was 46,6 MFIM. (See Appendix, Table 1).

Research Institute for High Energy Physics

The main funding of the Finnish activities at CERN came in the period 1991-1996 through the Research Institute for High Energy Physics (SEFT). It was a goal of the Ministry of Education to increase the domestic funding of particle physics gradually from 5 MFIM in 1991 (excluding tenured salaries and rents of about 4 MFIM, which were later on included in the budget) to 15 MFIM for the year 1995. The budget funding, transferred to SEFT through the University of Helsinki, did not, however, follow this plan, but remained practically constant (Table 2). Even if one takes into account external funding, which was in general competed money achieved by research projects of the Institute, the total budget did not quite reach the level planned by the Ministry.

The Institute of Particle Technology

The basic budget of the Institute of Particle technology (HTI) at the Helsinki University of Technology was in the period 1990–1996 in the level of 2 MFIM/a. Research projects carried at HTI obtained external funding, mainly from Tekes, on the level of 1 MFIM/a.

Helsinki Institute of Physics (HIP)

Since 1997 the main funding of the Finnish CERN activities has come through HIP. Until 2000 the complete budget of HIP was obtained directly from the Ministry of Education as one *undivided* contribution of 22 MFIM/a (Table 3). As of 2001, the budget of the HIP comes from *three different* components: (1) a base budget from the Ministry of Education (15 MFIM), (2) a host university contribution from the University of Helsinki (4 MFIM), and (3) productivity-based contributions from Member Universities.

The productivity contribution from the Member Universities is based on the degrees awarded on the basis of research supported by the HIP. Although the target set by the Ministry of Education for the productivity contribution from the Member Universities for 2001 was 3 MFIM, the total productivity contribution received from the Member Universities in 2001 was only 0.8 MFIM. This has meant 10% cut in the budget funding of HIP.

- The funding of HIP should be put on a stable and predictable basis to allow for long-term planning of the activity. While the Universities justifiably look at the return on their contributions in terms of the educational productivity, it appears too narrow a point of view to see the educational impact of HIP only in terms of these delivered. The HIP program at CERN contributes to the intellectual base and the reputation of the member University overall. A prime example of the powerful effect of an internationally visible research program is the University of Jyväskylä, which is now internationally known through its program in nuclear physics. This additional benefit must be credited in financial terms as well. A first-class research program will naturally attract good students and is a "leading indicator" (whereas the number of produced theses is a "trailing indicator"). In order to avoid the danger of many conflicting interests impinging onto HIP the Panel recommends that HIP be funded fully by a lump sum from the Ministry of Education. Outside reviews can then assure that the roles in research education and technology development and transfer have been properly covered.

The Academy of Finland

The Academy of Finland is a central Government agency for research administration and science policy operating under the Ministry of Education. Its mission is to fund high-quality research and to promote international collaboration and research training.

The Academy of Finland allocates funding to basic research on a competitive basis. The main part of its support to CERN activity goes to research projects and researchers at HIP, and it forms the main part of the HIP external funding quoted in Table 3. The increase of the CERN fee during the transition period 1991-1994 was not reflected in the other funding of physics but the share of physics from the total funding of natural sciences and engineering has remained since 1991 constantly on the level of 20-25% (Table 4).

The total funding of the Finnish CERN activity in 2000, excluding the membership fee, is estimated to be 25 MFIM. This consists of the budget funding of the Helsinki Institute of Physics and universities, the support from the Academy of Finland, the LHC core contribution (the total contribution of 21 MFIM divided over 5 years), and estimated funding of 0.5 MFIM from private foundations. The membership fee for the year 2000 was 46.6 MFIM.

- The Academy of Finland plays a very important role in the funding of Ph.D. studies. Since the Finnish commitment in CERN involves very large scientific groups, an appropriate balance must be found between pre- and post-doctoral training in particle physics in order to exploit the opportunities offered by CERN.

5 Education

Teaching of particle physics in Finland

The Department of Physics at the University of Helsinki is the main teaching unit for particle physics in Finland. In a less regular basis or with a more limited curriculum, particle physics is also taught in Universities of Jyväskylä, Oulu and Turku and in Helsinki University of Technology.

The first professorship in experimental particle physics, held by Risto Orava, was established in 2000 jointly by the Department of Physics at the University of Helsinki and HIP. Particle experimentalist Heimo Saarikko was appointed to a professorship two years ago with responsibility for teachers' education. Previously teaching in experimental particle physics was taken care by three senior assistants, as well as by researchers at SEFT and at HIP. The number of lecture courses delivered by experimental particle physicists has diminished after HIP started its operation (Table 5). The main reason for this is that some physicists previously in teaching positions in the University moved to research positions at HIP. This resulted in loosening of the contacts to the university education in Finland.

Theoretical particle physics is taught in the Universities of Helsinki, Jyväskylä, Oulu, and Turku. There are altogether 9 theoretical particle physicists in professor position in Finland.

One professorship for experimental high-energy physics is manifestly not sufficient to hold a base in Finland and simultaneously run a vigorous experimental program at CERN. This has led to discussions about establishing at least one further professorship, in addition to the position of experimental particle physics in the University of Helsinki, in an area related to the research at CERN. The most natural places for such a chair (or chairs) would be the Helsinki University of Technology, the Tampere University of Technology (They are involved with the Finnish CERN activities and provide the majority of the Finnish students in the CERN Summer Student Program) and the University of Jyväskylä, which has strong scientific contacts with CERN.

- Obviously, a good scientific return on the Finnish investment in CERN depends crucially on strong home-based particle physics research and education at Finnish Universities. From this point of view the undergraduate and graduate education in particle physics in Finland is at present too much weighted toward theory, and new professorial positions should be allocated to experimental particle physics in order to create a more balanced program. Compared with Sweden, which has 12 professor in experimental particle physics at three Universities, Finland suffers from having only one professor's chair for exercising leadership at the highest academic level. In addition, the distribution between the presence in CERN and at the home universities needs to be addressed. The home universities and the group residing at CERN appear to be somewhat disconnected. Redress should include shifting more of the technological developments to the Finnish site and maintaining the Detector Laboratory.

Graduate School

The promotion of research training in Finland has been one of the main priorities of Finnish science policy. The Graduate School system was created in 1995 by the Ministry of Education to increase the effectiveness of Ph.D. training in Finland. Ph.D. training in high-energy and nuclear physics is carried out in collaboration with the Departments of Physics of the University of Helsinki, University of Jyväskylä, University of Oulu, University of Turku, Åbo Akademy University and Helsinki University of Technology through a joint *Graduate School of Particle and Nuclear Physics* (GRASPANP) supported by the Ministry of Education and the Academy of Finland. The School involves at present 54 students, out of which 21 are working for Doctoral degrees in a subject related to the activity at CERN: eight students in the University of Jyväskylä (four in particle physics, four nuclear physics), six in the Helsinki University of Technology, five in the University of Helsinki, one in the University of Oulu and one in the University of Turku.

Out of the 54 students in the School, 13 are funded by the Ministry of Education (graduate school positions), two by the Academy of Finland and the other through research projects. Since 1995 altogether 18 Doctoral degrees have been awarded in the Graduate School of Particle and Nuclear Physics based on the research carried on at CERN.

- The Panel met with the students in residence at CERN. They were enthusiastic about the working conditions at CERN, but apprehensive about their future in Finland. The first career steps after a Ph.D. in Physics today most often is a postdoctoral position. Consideration should be given to increase the number of such positions, in order to give graduates the opportunity to develop their career plans, and for the best to develop visibility in the research community.

Training at CERN

CERN provides training for students in high-tech, multicultural and multilingual environment. The Summer Student, Technical Student, and Doctoral Student Programmes offer training places for students of universities and technical schools as part of their curriculum. During the membership Finland has benefited from these possibilities.

Summer Students

During the period 1990–2000 the number of summer students has varied in the range 8-23 annually (Table 6), and the total number has been 189. A majority of the students came from the Helsinki University of Technology (48.6%), the Technical University of Tampere (13.8%) and the University of Helsinki (7.9%). Apart from universities, a number of students also came from polytechnics. A majority of the summer students has got their training in the Finnish research teams at CERN, and this has offered an effective way to recruit new people to the teams. In addition to working in the research groups, the program of summer students includes lecture courses in phenomenological and experimental particle physics. This is useful in particular to those students whose home universities or schools have a limited (or lacking) lecture program in these subjects.

The number of Finnish summer students at CERN started to grow already before the membership when Finland joined the DELPHI Collaboration at LEP in 1983, having been before that typically two to three annually.

Technical Students

Since Finland is a member of CERN Finnish polytechnics have started collaborations with CERN for the training of their students. On the most regular basis this has been with the Espoo-Vantaa and Rovaniemi Polytechnics, who each sent annually four to six students for technical training periods of six months. Funding is partly from domestic sources and partly from the research groups for whom they are working.

Doctoral Students

Practically all the Master and Doctoral degrees in experimental particle physics achieved by Finnish students are based on research made at CERN in international collaborations. The total number of Doctoral degrees in CERN-related research during the period 1989-2000 is 26 (15 in the University of Helsinki, seven in the Helsinki University of Technology, four in other universities).

In the education of Finnish particle physics theorists the role of CERN has been relatively small. This is obviously related to the fact that the topical connection to CERN is tenuous.

Apart from scientific and technical training, CERN has been used to some extent also in other fields of education. A number of students from the Helsinki Business Polytechnic has been as trainees in the SEFT/HIP "Finnish Office" at CERN as a part of their curriculum for the Multilingual Executive Assistant's degree.

High School Students

Organising of visits of Finnish high-school students at CERN has started recently. A typical size of groups is 10–20 students, and groups spend typically five to seven days at CERN with a tailored study program. Experiences have been very encouraging.

One to two Finnish high- school teachers participate annually in the CERN Summer Program for Physics High School Teachers.

Web University

Web University is a CERN European wide project where distance audiences participate real-time in CERN seminars and lectures from their personal workstations in their home countries. Teaching is interactive, and it is principally targeting researchers and post-graduate students, but some material has been also offered to undergraduates and special groups like journalists and general public. Nowadays transmissions are also recorded to a server, where they can be studied via net.

The Web University project was originally a Finnish initiative, and the pilot activity was transmitting of CERN lectures to Finnish universities via ISND. The project has been under Finnish leadership (Riitta Rinta-Filppula) and mainly Tekes and some Finnish companies have funded it. At the moment the activity is carried on within and funded partly by the Education and Technology Transfer Division of CERN.

- The Web University project is very interesting and has achieved some significant goals: interactive real-time transmission of seminars and lectures via the web. However, to be successful in the long term this effort needs a funding base. The Helsinki Institute of Physics, as the central conduit for the connection between the Universities and CERN, should serve as a catalyst for use of this new education media in Finnish universities.

6 Industrial and technological relations

CERN spends about 30% of its annual budget on purchases from industry. In 1999 supplies amounted to 250 MCHF, out of the total budget of 955 MCHF. Purchasing procedures are tightly regulated by the rules set by the Finance Committee and the CERN Council. According to these rules, invitations to tender is limited to manufacturers and contractors located within the territories of CERN Member States, and no fewer than three competitive tenders are sought for each purchase. The procedure for obtaining tenders differs depending on the contract value.

A goal of the purchasing policy is to achieve a balanced industrial return for all Member States. The balance is measured by the so-called return coefficient, which is the ratio between the percentage of expenditure in an individual Member State and that member state's percentage contribution to the budget. A member state is considered poorly balanced if its industrial return coefficient for supply contracts falls below the mean average return based on the current overall budget expenditure (0.87 for the year 2000). The reference period to calculate these ratios is the previous four calendar years. A bid from a poorly balanced country can be put before a lower bid from a well-balanced country.

The return coefficient of Finland for the years 1994-2000 is presented in Table 7. Except for the transition period of the membership, when the membership fee was reduced, Finland has belonged to poorly balanced countries. The return coefficient of Finland for the year 2000 was 0.58. It was better than return coefficients of the other Nordic countries (Denmark 0.45, Norway 0.26, and Sweden 0.44) but below the average return coefficient 0.87 of all the member states.

Recently a few large value contracts have been made between CERN and Finnish industry, which will increase the return coefficient considerably. In 2000 OUTOKUMPU obtained a contract of 83 MFIM for the supply of superconducting cable for the main quadrupole magnets of the LHC. This will evidently move Finland to the category of well-balanced countries in a few years time. (As the return coefficient is calculated according to payments, not to contracts themselves, the effect of this contract on the return coefficient is not immediate). In addition with CERN, contracts have also been made with experimental collaborations on supplies for detectors. This is not included in the return coefficient. The value of the contracts of this kind during the Finnish membership at CERN is estimated to be 35 MFIM. The total number of Finnish companies with commercial relations to CERN is about 60.

- In the past too little of the direct investment in CERN by Finland was coming back in the form of interesting high-tech orders. The Panel was assured by discussions with CERN management that CERN was aware of this history. The recent purchase orders for LHC and its detectors are already changing the character of the involvement of Finnish industry and in fact have already a very beneficial effect on some companies. However, maintaining a high-tech return beyond these recent orders for Finnish industry will require an ongoing lobbying effort both at CERN and in Finland.

Cerntech Ltd

Cerntech is an industrial co-ordination program helping Finnish companies regarding industrial and commercial relations in particular with CERN, but also with other big-science institutions like ESRF in Grenoble. Cerntech Ltd began operations in 1990, just before Finland came a member of CERN, and its shareholders include e.g. technology centres in all main university cities of Finland and the University of Helsinki. After a reorganisation in 1995, Cerntech was operated by Finntech, a publicly held company specialising in marketing, brokerage, and international transfer of technology from Finnish academic sources. From the beginning of 2001 Cerntech has operated within Licentia Ltd (the merger of Finntech Finnish Technology Ltd and Helsinki University Licensing Ltd). Cerntech employs at present two people, one at CERN and one in Finland.

The annual budget of Cerntech is (as to year 2000) 1.4 MFIM, main part of which consists of project funding from Tekes. The funding is provided on annual basis.

The role of Cerntech is, on one hand, to scan the technology needs of CERN and maintain good relations to the purchasing and engineering personnel of CERN and experimental collaborations working there, seeking potential subjects for technological and commercial collaboration. On the other hand, it has created and maintains a contact network of Finnish companies giving information of forthcoming marketing surveys and calls for tenders and offering consultancy. Due to its special nature, the trade with CERN differs from that with more conventional markets, and therefore consultant help is essential.

Cerntech has organised, in collaboration with CERN, one exhibition of Finnish industry at CERN (1992, 15 companies), as well as one collective visit of Finnish companies (1997, 19 companies). The activity has been on the level typical for comparable Member States. In addition, Cerntech organises tailored visits for companies (some 20 visits per year).

- The consultancy and lobbying effort done by Cerntech is obviously very helpful for creating and maintaining connections between Finnish industry and CERN. The successes of Cerntech in finding projects for Finnish industry that address CERN needs have in recent times been impressive. As a result of it the industrial return to Finland will remarkably improve in the near future. The activity of Cerntech should be supported in a long-term basis, and its organisation should be put on a sound framework in terms of staffing and financing. The present staffing level is too low. The activity of Cerntech should be backed up by a national strategy for the goals of the industrial collaboration and technology transfer between Finland and CERN and other big-science projects.

7 Finnish representation in CERN personnel

The number of Finnish scientists and managers on the CERN staff has constantly increased during the membership, and was in the end of 2000 27 people or 1% of the whole staff (Table 8) (Finland contributes 1.32% to the CERN budget.) The number of all CERN paid Finnish personnel, including staff, fellows and paid associates, was 33 or 1.1% of the total. The total amount of salary money paid by CERN to Finnish personnel is estimated to be 10 MFIM in 2000.

During 1992-2000 there were altogether 1769 applications from Finland to CERN staff positions, making 5.2% of all applications. The number of Finnish personnel recruited was 36 or 3.5% from the total recruitment. The number applications from Finland has dramatically decreased recently (only 34 applications in 2000), presumably because of the good employment situation in Finland, especially in IT industry.
Finland has been quite successful with fellow positions, which are scientific positions for young researchers. On the other hand, Finland has been under-represented among paid associates. The highest position in administration is held by Matti Tiirakari, who is the group leader of the Logistics Services in the Supplies, Procurement & Logistics Division and in hierarchy next to the Division Leader.

- Finland does not have at this time enough people in key scientific positions at the level where scientific or programmatic decisions are made at CERN. Steps should be taken to select or prepare at least one scientist for a permanent position, and to inform the CERN directorate of the need for such a scientific key position. For the general job level announcements of vacancies for CERN positions should be more widely disseminated in Finland. HIP could play a role in assuring that advertisements for positions of all kinds appear in a public medium.

Appendix

Statistical data on Finnish CERN activity

Table 1. The membership fee of Finland (MFIM), in percentage of the calculated full fee, and the full contribution percentage of the CERN budget calculated according to GNP

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CERN membership fee	9.8	20.3	28.8	28.1	34.9	37.4	39.4	42.5	42.1	46.6
CERN membership fee %	20 %	40 %	70 %	90 %	100 %	100 %	100 %	100 %	100 %	100 %
GNP fraction %	1.9 %	1.8 %	1.2 %	0.86 %	1.00 %	1.21 %	1.33 %	1.31 %	1.25 %	1.35 %

Table 2. Use of funding (MFIM) of the Research Institute of High-Energy Physics in 1992–1996. (The budget money includes the salaries of tenured personnel as well as rents.)

	1992	1993	1994	1995	1996
Budget money	10.0	8.9	11.1	9.7	10.0
External funding	3.6	5.5	7.0	2.5	2.5
Total funding	**13.6**	**14.4**	**17.1**	**12.2**	**12.5**

Table 3a. The use of funding (MFIM) of the Helsinki Institute of Physics in 1997–2000. The part of funding used to CERN related activity is separately shown.

	1997	1998	1999	2000
Budget money CERN activity	20.5 13.6	20.8 13.7	21.9 15.4	22.3 16.2
External funding CERN activity	3.4 1.2	4.4 2.8	5.3 4.2	4.6 2.8
Total funding **CERN activity total**	**23.9** **14.8**	**25.2** **16.5**	**27.2** **19.6**	**26.9** **19.0**

Table 3b. Division of the budget money (decisions) (MFIM) of the Helsinki Institute of Physics to the research programs and administration in 1997–2001.

	1997	1998	1999	2000	2001
Theory	3.85	4.60	4.91	5.78	4.40
High-energy phys.	5.35	3.65	2.75	3.50	2.50
LHC	3.95	4.85	5.97	5.90	6.00
Technology	3.00	3.65	3.66	3.25	2.70
Administration	3.15	3.20	2.76	2.52	2.43
General	2.70	2.05	1.95	1.05	1.78
Total	**22.0**	**22.0**	**22.0**	**22.0**	**19.81**

Table 4. The research funding (MFIM) used for physics and for natural sciences and engineering (1991–2000) by the Academy of Finland and the contribution for CERN (membership fee and the extra contribution for LEP experiment)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Physics	25. 3	25.7	17. 8	26. 8	23. 8	25. 5	28. 2	37. 0	53. 1	56. 0
Natural Sciences and Engineering	107. 7	110. 0	93. 3	122. 6	116. 6	107. 5	105	138. 5	179. 4	209.0
LEP extra contribution								0.03		
Core contribution to LHC								7		
CERN membership fee	9. 8	20. 3	28. 8	28. 1	34. 9	37. 4	39. 4	42. 5	42. 1	46. 6
CERN membership fee %	20 %	40 %	70 %	90 %	100 %	100 %	100 %	100 %	100 %	100 %

Table 5. Lecture courses related to experimental particle physics and given by particle experimentalists at the University of Helsinki in 1990–2001.

Academic year	1990–1991	1991–1992	1992–1993	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001
Lecture courses Nb.	8	6	8	6	5	9	4	5	1	1	2
Credit points	28	22	30	19	19	35	12	16	3	3	10

Table 6. Finnish summer students at CERN (1990–2000).

University/ Polytechnics	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	%
UH		1	1	1	1		1	1	5	2	2	7.9
HUT		10	12	3	3		12	13	13	14	12	48.6
UJ		1					1					1.1
UT		1					1					1.1
UO		1	1	1								1.6
TUT		3	5	6	2		2	1	1	3	3	13.8
LUT				1								0.5
Evitek				1			1					1.1
Rotol			1	2	2		2					3.7
Vto			2									1.1
Total	**23**	**17**	**22**	**15**	**8**	**14**	**20**	**15**	**19**	**19**	**17**	**189**

UH University of Helsinki
HUT Helsinki University of Technology
UJ University of Jyväskylä
UT University of Turku
UO University of Oulu
TUT Tampere University of Technology
LUT Lappeenranta University of Technology
Evitek Espoo-Vantaa Polytechnics
Rotol Rovaniemi Polytechnics
Vto Vaasa Polytechnics

Table 7. Total supplies (MSFR), membership fee (MSFR), and return index of Finland in 1992-2000. (Exchange rate in 2001 is 1 SFR=3.8 FIM.) Supplies to experimental collaborations are excluded.

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Supplies	1.46	1.46	1.74	2.70	2.55	1.44	0.84	1.67	1.72
Membership fee	6.64	7.89	7.21	9.44	11.65	11.43	11.38	11.43	12.56
Return index	–	–	0.89	1.14	0.96	0.60	0.28	0.49	0.53

Table 8. Finnish employees in the CERN personnel by status in 1991–1999. (In the second column the numbers in parenthesis give the actual percentage contribution of Finland to the CERN budget during the transition period.)

Year	GNP frac. on CERN budget %		Staff members		Fellows		Paid associates		Total		Unpaid assoc. +Users	
			Nb.	%	Nb.	%	Nb.	%	Nb.	%	Nb.	%
1991	1.9	(0.4)	6	0.19	3	1.79	3	1.12	12	0.32	56	0.89
1992	1.8	(0.7)	9	0.29	6	3.41	8	3.02	28	0.75	63	1.07
1993	1.2	(0.5)	10	0.33	8	4.10	3	1.50	24	0.67	64	1.15
1994	0.9	(0.8)	12	0.40	8	4.28	1	0.57	29	0.82	56	0.91
1995		1.0	13	0.44	5	2.87	1	0.60	23	0.65	48	0.93
1996		1.2	17	0.59	2	1.12	3	1.65	25	0.72	46	0.83
1997		1.3	17	0.60	4	2.00	2	0.98	26	0.75	57	1.07
1998		1.3	20	0.73	6	2.74	1	0.4	28	0.81	76	1.41
1999		1.3	23	0.8	8	3.7	1	0.4	33	1.0	62	1.1
2000		1.3	27	1.0	6	2.7	2	0.8	35	1.1	64	1.1