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Evaluation of Subatomic Physics
within the Faculty of Science at Lund University

In January 2001 the Faculty of Science, Lund University, asked the Swedish Research Council (Vetenskapsrådet) for support in evaluating the research in subatomic physics carried out at the Department of Physics in the Science Faculty. The Swedish Research Council accepted this request and appointed two external experts, Prof Dan-Olof Riska, Helsinki University and Prof Jean-Jacque Aubert, CNRS, Paris, and, as chairman for the evaluation committee, a member of its Expert Council for Natural and Engineering Sciences (Ämnesrådet för naturvetenskap och teknikvetenskap), Prof Petter Minnhagen, Umeå University. The research groups to be evaluated submitted reports which included lists of presented results, achievements the last 5 years and plans for the years to come, impact of research, personnel structure and granting situation. This material was sent to the evaluators in June and during 28-31 August the evaluation committee visited Lund and met all senior researchers including the head of department and the director of study as well as other persons in the department and the faculty leadership. The instructions to the evaluators included a demand to consider reductions in the volume of the subatomic physics research in the department, this being necessary due to a considerable departmental budget deficit. We note that the evaluation committee in general found the quality of the research very high and trust that the conclusions will be useful in strategic decisions for successful future research in subatomic physics at Lund University.

Stockholm and Lund 2001-09-06

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Evaluation of Subatomic Physics
within the Faculty of Science at Lund University.

In accordance with the assignment we have evaluated the subatomic physics within the Faculty of Science. Our views and recommendations are given in this review report.

September 2001

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Evaluation of the Subatomic Physics within the Faculty of Science

at Lund University

J. J. Aubert, P. Minnhagen and D.-O. Riska

1. General Overview

The research activity in subatomic physics at Lund University builds on a more than 50 year long tradition and presently represents one of the largest and internationally most visible efforts in this field within the Nordic countries. This research effort comprises several research groups that cover a wide spectrum of modern nuclear and elementary particle physics, and which includes both theory and experiment. These research groups belong, with two exceptions, to the Faculty of Science. One exception is the mathematical physics group, which belongs to the Faculty of Technical Science and which mainly focuses on nuclear structure theory and the other is the applied nuclear physics group, which mostly belongs to the Faculty of Technical Science.

All the research groups that work in different aspects of subatomic physics have been continuously successful in raising external grant support, mainly from the national Swedish research council (VR/NFR). They are all led by between 1 and 3 professors at Lund University, and all of them have actively pursued graduate research training, and have generated several PhD degrees during the past decade.

2. Subatomic physics as a part of modern physics

Subatomic physics, as generally understood at the present time, comprises elementary particle (or high-energy) and nuclear physics. Elementary particle physics grew out of and separated from nuclear physics during the 1960:s, so that a fairly clear, if readily transcended demarcation line between the two fields has developed: elementary particle physics deals with the structure and dynamics of subnucleon matter, whereas nuclear physics is the physics of nuclei and systems of nucleons. Both fields are still evolving. The field of elementary particle physics is inexorably driven towards astroparticle physics and the unexplored domain of "new physics" beyond that of the hitherto discovered particles and the phenomena that can be described by the "standard model" (quantum chromodynamics + the electroweak field theory). The field of nuclear physics is driven both by the continuously expanding field of nuclear technology and medicine and by fundamental problems in astrophysics, as nucleogenesis in the universe and the dynamics of neutron stars and supernovae.

Experimental work in subatomic physics inherently requires large scale facilities: the main reason being the continuous need for higher energy and higher precision, and thus eventually for accelerator facilities of supranational dimension. By its nature the field always operates at the technology frontier, which implies that the field is and has been a driver of technology development. This latter aspect has in many cases represented the "payback" to society of the investments made, a popular example of which is the development of the "world-wide-web" at CERN.

Given the expense of experimental subatomic physics research, it is natural that the relative position of this field, and the amount of resources that it draws, has formed a focus for both debate and review in all industrialized countries. To put this into a context, an example of what might be referred to as the present "accepted" view of the most promising directions for modern physics

research in the near and intermediate future is represented by the very recent study by the (US) National Research Council ("Physics in a New Era" (www.nas.edu/bpa/projects/physicssurvey/))). This lists priority research areas in the following subfields of physics research:

1. Atomic, molecular and optical science: "An investment in the future",
2. Plasma science: "From fundamental research to technological applications",
3. Elementary particle physics: "Revealing the secrets of energy and matter",
4. Nuclear physics: "The core of matter, the fuel of the stars",
5. Condensed matter and materials physics: "Basic research for tomorrows technology",
6. Gravitational physics: "Exploring the structure of space and time".

While this list may not be universally applicable, nor comprehensive, it indicates that modern subatomic physics - both nuclear and particle physics - is likely to remain a major field in university physics research and curricula in the foreseeable future. As will emerge below, the research activity in subatomic physics at Lund University largely matches the lines of inquiry listed in the report by the US National Research Council.

3. Theoretical Physics

3.1 Particle Theory

The research group in (elementary) particle theory at Lund university comprises three professors: B. Andersson, G. Gustafsson, T. Sjöstrand, two "shared" lecturers (H.-U.Bengtsson, L. Lönnblad, short term position) and two researchers (J. Bijnens, M. Maul). It should be noted that Professor C. Jarlskog, who is in the Faculty of Technical Sciences, and who is at present responsible for member country relations full time at CERN, also works in elementary particle theory.

The research effort in theoretical particle physics in the group has focussed on QCD phenomenology and the effective hadronic field theory approach to non-perturbative phenomenology in the low-energy region. The Lund string fragmentation model has become a standard tool worldwide for modeling the hadronization processes, that appear in all fundamental collision reactions. B. Andersson, G. Gustafson and T. Sjöstrand are widely recognized for the development of this model, which is described in a monograph by B. Andersson.
J. Bijnens, who joined the group in 1995 as a special researcher, is a leading authority on meson decays and dynamics as described by chiral perturbation theory (an effective representation of QCD) up to two loop level.

The research active senior members of the group have continuously obtained external grants for their research during the last 6 year period.

The group has an excellent record in graduate education (13 PhD degrees since 1991). At present 5 graduate students do their thesis work within the group.

Members of the research group have actively engaged in educational outreach, with popular lectures in schools and other fora.

3.2 Nuclear theory

The nuclear theory effort at Lund takes place within the mathematical physics research group at the Technical faculty, is not subject for the present review. As its effort is mainly in nuclear structure theory, which is the field of one experimental group within the MNS faculty (discussed below), it has also been asked to supply information to the evaluation group. The group has since 1982 been led by Ikuko Hamamoto, who is retiring this year. The other senior members of the group are professors Ragnar Bengtsson, Ingemar Ragnarsson and Sven Åberg, who were all promoted professors during the current year.

4. Experimental Particle Physics

4.1The Lund ATLAS group

The largest effort in experimental high energy physics at the Department of Elementary Particle Physics in the Faculty of Science is that of the Lund ATLAS group. This group is formed by three professors (P. Eerola, G. Jarlskog, T. Åkesson), one lecturer (V. Hedberg) and four research/electronics engineers (partly shared with the HERA group) and research assistants. The group has taken major responsibility within the collaboration, which is building the ATLAS detector at the LHC at CERN, which should be ready for physics research in 2006. T.Åkesson serves as deputy spokesperson for the ATLAS collaboration.

The group has previously been heavily engaged in the DELPHI detector collaboration at LEP, an activity that at the present time only continues with data analysis and publication of results. During the construction phase the group is also engaged in the Swedish contribution to the D0 detector collaboration at FNAL, which already has begun datataking.

The ATLAS detector is one of the three major detectors being built for the LHC. It is one of the largest and most complex detectors ever planned, with a projected total cost of about 500 MCHF. At the design luminosity it will produce 1 petabyte of raw data per second, out of which only about 1 part in ten million will be retained. The data handling will require a new technology for distributed high throughput supercomputing. The selected technology is based on the European Datagrid, the development of which is centered at CERN. The Lund ATLAS group has made a strong contribution to the establishment of datagrid computing capacity within the Nordic countries. As the goal of grid computing is to make supercomputing into a platform independent utility a large number of technology spin-offs are foreseen to follow upon the establishment of the datagrid.

The Lund ATLAS group has the following main responsibilities in the ATLAS collaboration: T. Åkeson is deputy spokesperson. Before becoming deputy spokesperson he was project leader for developing the barrel TRT part of the detector. V.Hedberg is project leader for ATLAS radiation shielding. P. Eerola coordinator for b-flavor physics studies in the collaboration.

The senior members of the Lund ATLAS group have excellent research records, with a large number of high impact publications. P.Eerola is recognized for her contribution to the DELPHI detector and heavy flavor decay channels of the Z^0 boson. G. Jarlskog is also known for his contribution to the study of the decays of the Z^0 boson, as well as for earlier work on pp collisions at the ISR. T. Åkesson is recognized for his work on the decays of the Z^0 boson and jet production in proton-proton collisions at high energy.

The ATLAS group has continuously received external research grants. The main grant to the group for the construction of the ATLAS detector is SEK 18.5 MSEK.

The ATLAS group at Lund appears to have the necessary critical size. T. Åkesson, who is deputy spokesperson of the ATLAS collaboration is presently based at CERN. Professor G. Jarlskog reaches the present mandatory retirement age in 2001.

During the period 1990-2001 9 graduate students have completed their PhD theses in the group. Presently 1 graduate student does PhD thesis work in the group.

4.2 The DELPHI experiment

The present ATLAS group is largely formed of the Lund group that participated in the DELPHI detector collaboration at the LEP collider at CERN. DELPHI was one of 4 large detectors at LEP, the main goal of which was study of the properties and decay products of the Z^0 boson. These studies contributed to the establishment of the standard model for the electroweak interactions, and also generated significant new information on heavy flavor particles. After the decommissioning of LEP and the DELPHI detector the present DELPHI activities concern data analysis, and search for exotic particle signatures in the DELPHI data.

The Lund group carried major responsibility in the DELPHI collaboration, and contributed to three main components: the very small angle tagger, the electromagnetic calorimeter and the time projection chamber.

The DELPHI collaboration has led to and continues to generate a substantial number of publications (the present number exceeds 430 and is still growing).

A total of 9 PhD degrees were awarded at Lund between 1990 and 2001 for research done in the Lund DELPHI collaboration.

4.3 The Lund HERA group

The experimental particle physics research by the Lund group at DESY laboratory in Hamburg began in 1968, and presently is focussed on participation in upgrade of the H1 proton spectrometer at the HERA ep collider. The Lund DESY group is formed by one professor(L. Jönsson) and three researchers and research engineers (partly shared with the ATLAS group). The aim of the research by the group is to study quark (parton) and gluon distributions in the proton through precision measurements of the structure functions. The conceptual goal is to achieve a better understanding of how to apply QCD in the non-perturbative long range region. Along with the experimental work the Lund group has participated in the development of phenomenological models for the quark (parton) dynamics.

The planned work by the Lund group at DESY deals with (a) measurement of the forward jet production cross section, (b) study of diffractive scattering with the upgraded H1 spectrometer, (c) study of jet asymmetry in order to determine the gluon distribution in the proton, (d) further study of the hard pomeron contribution in diffractive scattering and (d) improve on the present phenomenological models by means of Monte Carlo simulations, especially with the goal of understanding the quark (parton) distribution at small values of the kinematical variable x.

The leader of the Lund DESY group, L. Jönsson has an outstanding publication record. This includes collaboration publications on the proton structure functions, ep scattering at HERA, charm meson production, total photoproduction cross section measurements and B-meson decays. He has also been actively engaged in educational outreach in southern Sweden.

The group has been successful in raising external grant support of moderate size since 1994 and has approved grant support until 2003.

During the time period 1990-2001 6 PhD students have completed their PhD degrees within the Lund DESY group. At the present time 2 graduate students are doing their thesis work in the group.

4.4 The NA44/Brahms Experiment Group

A small, by now dissolved group led by Professor B. Lörstad at Lund participated in the NA44 experiment at CERN/SPS and to a lesser extent in the DELPHI collaboration. The group also intially participated in the Brahms experiment at RHiC/BNL and pursued theoretical research in heavy ion physics. Besides professor Lörstad, the group involved 4 other researchers. Professor Lörstad has since taken up an administrative position at another institution (Kristianstads högskola).

The group published or contributed to 27 research papers during the period 1995-2001.

5. Experimental Nuclear Physics

5.1 High Energy Heavy Ion Physics

The Lund effort in high energy heavy ion physics has a long tradition. At the present time the group is formed by two professors (H.-Å.Gustafsson, E. Stenlund), two associate professors (S. Garpman and A. Oskarsson) and one research assistant and one research engineer.

The high energy heavy ion group is presently actively engaged in the PHENIX detector collaboration at RHiC/BNL and in the ALICE detector collaboration at the LHC. Simultaneously the group is engaged in the phase out stage of the previous WA80 experiment at CERN. The general goal of the research in the group is to produce and study the properties of deconfined quark matter, for which some experimental signatures have already been found. The quark-gluon plasma will be created in central heavy ion collisions at high energy. The senior members of the group have a well recognized research record. To these belong emeritus professor I.Otterlund. H.-Å. Gustafsson is known for his contribution to the first discovery of collective flow in relativistic heavy ion collisions.

The high energy heavy ion group is responsible for major components of the PHENIX and ALICE detectors. The design of the pad chambers at PHENIX is based on an innovation by the group. The ALICE detector is one of the three large detectors at the LHC, and the only one that is dedicated to nuclear collisions. In the ALICE detector collaboration the group has contributed to the design of the time projection chamber, and the group is responsible for the mounting and testing of the TPC.

The group has been able to raise the required external research grants for its work at CERN and RHiC/BNL.

During the period 1990-2001 6 graduate students obtained their PhD degrees based on research within the group. At the present time 4 graduate students are completing their PhD degrees within the group.

5.2 The Intermediate Energy Group

The Intermediate energy nuclear physics group at Lund is formed by one professor (B. Jakobsson) and four researchers and research engineers. The present main effort of the group is within the CHIC collaboration, which is completing the CHICSi detector, which is being installed this year at the CELSIUS storage ring at the The Svedberg Laboratory at Uppsala. The Lund group carries the main responsibility within this collaboration, which is formed by 40 members that represent 5 different countries. The CHICSi detector is a large angle detector system for studying subthreshold and near threshold meson production in proton-nucleus collisions. The commissioning of the detector is now foreseen to begin in 2001-2002. The detector is one of the main medium size detectors at the CELSIUS facility, and thus one of the main Swedish

instruments for nuclear research. The leader of the group is recognized for his research on nuclear collisions and multifragmentation.

The general programme of the intermediate energy group has been to study nuclear collisions.

During the period 1990-2001 6 graduate students obtained their PhD degrees on the basis of work within the group. At the present time 2 graduate students are completing their PhD degrees within the group.

5.3 Photonuclear Research Group

The photonuclear research group at Lund studies nuclear properties by means of electromagnetically induced interactions. The group is formed by two professors (J.-O. Adler and B. Schröder), one lecturer (B. Lindner), two research engineers and one researcher. The work of the group builds on a very long tradition in electronuclear research at Lund. The group at present works at three different Laboratories: (1) MAX-lab at Lund, (2) MAMI at Mainz and (3) the TJNAF at Newport News.

The present work at the MAX-lab involves measurement of total photon cross section measurements on very light nuclei and gamma-n reactions on the oxygen isotopes. This work is in a completion phase before the coming energy upgrade of the MAX-lab. After the energy upgrade the group will extend these measurements to higher energies, and intends to concentrate on photopion production on nuclear targets. The tagged photon facility the MAX-lab has provided exceptional energy resolution. The upgraded MAX-lab facility will be complementary to the LEGS facility at BNL and the new HIGS facility at Duke university. At MAMI the group has been part of the collaboration to measure the polarized photon cross sections on polarized nucleons to determine the integrand in the Drell-Hearn-Gerasimov sum rule. At the TJNAF the group participates in the Hall A collaboration for measuring nuclear e,e'p reactions and has contributed to the measurement of the deuteron A form factor at very high momentum transfer. The group has contributed significantly to the instrumentation at Hall A, specifically to the wire chambers in the spectrometer. The leader of the group is recognized for his work on photon induced nuclear reactions.

The group has continuously been able to raise the external grant support required for its activity.

During the period 1990-2001 7 graduate students have completed their PhD degrees on the basis of research within the photonuclear group. At the present time 5 graduate students are working members of the group.

5.4 Nuclear Structure Physics

The experimental nuclear structure group was formally reconstituted in 1997, when the present professor and group leader (C. Fahlander) took up his position. The work of the group does however build on a long local tradition in this field. Beside the one professor the group consists of two research fellows one of whom is presently based at GSI. Because of the fairly recent reactivation of the group, it only lists research and educational achievements since 1998. The mode of operation of the nuclear structure group is entirely an external user mode at internationally accessible nuclear structure facilities outside of Lund. The prime instruments used by the group are the Euroball, presently at Strasbourg and Gammasphere at LBL/Berkeley.

The main research topic are nuclear shapes and shape deformation in proton rich nuclei and exotic nuclear decay modes. The Lund group has contributed to the development of the detector systems both at Legnaro and Berkeley. The field is at present driven by several forthcoming radioactive beam facilities in different countries, and the goal is to study nuclei out to the proton and neutron driplines.

At the present time 3 graduate students work on PhD theses within the nuclear structure group.

6. Conclusions

The evaluation group is impressed by the overall high quality of the subatomic research at Lund university, both at the Faculty of Science and the Faculty of Technical Science. The present evaluation, in accordance with the instructions, concerns the subatomic physics research within the Faculty of Science, with a particular focus on the on the part of the Department of Physics which belongs to the Faculty of Science.

The evaluation group finds that the Faculty of Science has excellent research groups both at the Department of Theoretical Physics and the Department of Physics. Focusing on the Physics Department, the evaluation group is of the opinion that the Faculty of Science may be proud of the present subatomic research within the physics department. Thus, if scientific excellency was the only criterion for funding research, then the present subatomic research within the physics department definitely deserves continued adequate funding.

The evaluation group has been explicitly asked to advice on possible options for a reduction of the subatomic research within the physics department corresponding to approximately 25%, in view of the assessment by the faculty leadership that a reduction is necessary due to present economic situation.

It is most unfortunate to loose high quality research in a reduction, both because of the potential loss of intellectual power and the loss of external resources. Thus it should be considered as a last resort. If a reduction of research in physics is deemed necessary for economic reasons, then the evaluation group advises the Faculty in Science to also consider if there are other research groups within other areas of physics where the reduction could be made with less damage on the high quality physics research. Moreover the implementation of any reduction should be over a time scale which allows graduate students to complete their thesis work. Other possibilities of slimming in the faculty budget, which would damage the high quality physics research less, as e.g. reduction of office space, should also be considered. (A practical way of implementing this would be to introduce an economical incentive for such a squeezing.)

If one looks for a long term strategic future for physics at Lund University, then it may be necessary to consider an evaluation of all physics areas within both the Faculty of Science and the Faculty of Technical Science. For finding an optimal strategy such a total evaluation may be a prerequisite.

However, if the perspective is limited to the subatomic physics within the physics department (in accordance with the assignment), then it is clear that a strategic option for the future should , in addition to scientific excellence of a research group also consider the future prospects and discovery potential of the research field, the critical size needed for the group and the expected future funding situation.

We have tried to evaluate the situation by weighting in aspects as quality, international importance, national importance, local importance, future of the research area, future availability of experimental resources, critical size of a research group, external funding aspects and timing aspects. These considerations lead to following recommendations and priority settings. The evaluation group notes that most reductions of departmental expenditure based on these recommendations do not lead to immediate savings. Given the level of the present departmental deficit, a short time layoff of the departmental personnel may have to be considered. The latter, rather drastic means of action, has been resorted to in several major universities both in Europe and North America during the past decade.

7. Recommendations

The LUND ATLAS group:

Given the large responsibility of the Lund ATLAS group in the construction of the ATLAS detector at CERN, the complexity of this task and the exceptional discovery potential of the ATLAS detector, the evaluation group recommends that the group continue to be supported at a constant effort level by the Department of Physics.

The DELPHI experiment:

The evaluation group recognizes the outstanding contribution made by the Lund group to the DELPHI collaboration, and recommends that the remaining data analysis work be supported. It is expected that the DELPHI activity eventually will join with the ATLAS effort.

The Lund HERA group:

The evaluation group notes that the Lund group at DESY is rather small, and possibly undercritical, in view of its ambitious research plan. That the personnel issue is acute is emphasized by the fact that DESY has had to take over responsibility for salary (until 2002) for Docent H. Jung, who is the only research assistant in the group. In spite of this the research is of very high quality. Weighting all aspects of the research effort of the group in relation to that of the ATLAS group, the evaluation committee gives higher priority for research support to the ATLAS group than to the HERA group.

High Energy Heavy Ion Physics:

The evaluation group recognizes the value of the systematic long term research plan of the high energy heavy ion group, with present data taking in the PHENIX collaboration at RHiC/BNL and its long term focus on the ALICE collaboration at CERN. The discovery potential of this research is substantial. The group should be supported by the Department of Physics at a level, which ensures continued constant effort.

The Intermediate Energy Group:

The intermediate energy group is small and possibly undercritical. The evaluation group notes that the completion of the CHICSi detector has significantly exceeded the originally foreseen time and budget. Given the central role of that detector at the TSL the evaluation group recommends that the CHIC group be supported at a level sufficient to complete the CHICSi detector at the TSL this year, and the consequent commissioning of the detector. Continuation of this effort is contingent on obtaining adequate external research grants. Weighting all aspects of the intermediate energy nuclear effort and that in high energy heavy ion physics, the evaluation panel gives higher priority for departmental research support to the effort in high energy heavy ion physics.

Photonuclear research group:

The evaluation group notes that the photonuclear research group has, despite its small size, been able to build and maintain a unique photonuclear facility at the MAX-lab, which has drawn a substantial number of outside users. The evaluation group recommends that an effort be made to ensure effective exploitation of the photonuclear user facility after the energy upgrade at the MAX-lab. Weighting all aspects of the photonuclear research effort in relation to the effort in high energy heavy ion physics the evaluation group gives higher priority for departmental support to the latter.

Nuclear Structure Physics:

The evaluation group recommends that the recently restarted group be supported at level, which at least ensures constant research effort. The best research prospects for the effort are expected to lie in the exploration of nuclear structure near the driplines, because of the astrophysical significance.

Elementary Particle Theory in the Theoretical Physics Department:

Given the outstanding research record of the particle theory group, and its ability to obtain external research support, along with its good educational record the evaluation group recommends that the group and its research continue to be supported by the Department of Theoretical Physics at the present level. An effort should be made by the Department of Theoretical Physics to secure continuing employment for J. Bijnens after the expiration of his VR supported research position expires.

Applied Nuclear Physics:

The main facility for applied nuclear physics research within the Faculty of Science is Pelletron accelerator. This should be used as a service facility. The full cost of maintenance and operations of the Pelletron should be borne by the users of the facility. There should be no cost to the Department of Physics.

Indirect Costs:

The evaluation panel proposes that savings may be achieved by physically regrouping the divisions into more compact quarters. Additional savings may possibly be achieved by outsourcing of the physical department work at the in house workshops. Such outsourcing should be taken into account in the calculation of departmental overhead. Maintenance and operation costs for these workshops should be borne by those research groups that use them.

8a. Restructuring opportunities.

The evaluation group believes that the physics at the Faculty of Science would gain from a restructuring. The present activities are spread over two departments *i.e.* the Department of Physics and the Department of Theoretical Physics. The Department of Physics is divided into many divisions. Such a division belongs either to the Faculty of Science or the Faculty of Technical Science, with the exception of the Nuclear Physics division, which is spread between the two faculties. The undergraduate education in physics within the Faculty of Science is a separate division belonging to the Faculty of Science part of the Department of Physics.

The evaluation group suggests that the Theoretical Physics Department and the Physics Department be combined into one department. This would bring all the physics and theoretical physics activities, which already are cross linked in many ways between the Faculty of Science and the Faculty of Technical Science, into to the same department. It would eliminate the present artificial separation of the theoretical and experimental efforts in nuclear structure research into separate faculties (the former is at present part of the mathematical physics group in the Faculty of Technical Science). It would also bring all efforts in theoretical elementary particle physics into the same department.

The evaluation group also suggests exploration of a regrouping of the research activities into functional divisions. One possibility would be to regroup all theoretical activities into one division which implies a fusing of the present Department of Theoretical physics, the Solid State Theory division and the Mathematical Physics division into to a new division within the physics department. However, the evaluation group believes that joining experimental and theoretical research together would be even more advantageous allowing more flexibility for the future. Thus consideration of the following alternatives is suggested:

1) Formation of a division which contains the elementary particle theory research from the Department of Theoretical Physics, the present Elementary Particle division and the high energy heavy ion research part from the present division of Cosmic and Subatomic division.

2) Formation of a division containing the present Nuclear Physics division, the part of the present Cosmic and Subatomic division which contains the nuclear structure research part, the intermediate energy nuclear physics research part, and the part of the Mathematical Physics division which contains the nuclear theory research.

3) Formation of a division which contains the part of the Solid State Theory, which does nanophysics research and the present Solid State Physics division.

4) Formation of a division, which contains the part of the Department of Theoretical Physics which does research on complex systems and bioinformatics, and the remaining part of the Mathematical Physics division.

5) As an alternative to 4), formation of a division containing the part of the Department of Theoretical Physics concerned with complex systems and bioinformatics, the remaining part Mathematical Physics division, and the Solid State Theory division.

8b. Operational Structure.

The evaluation group got the impression that the part of physics department which belongs to the Faculty of Science seemed to lack an operational leadership structure capable of making strategic decisions for allocating the resources between the various research groups and the undergraduate education. This is an unfortunate tradition and the evaluation board strongly recommends that such a leadership structure is created in order to make optimal use of the money allocated by the Faculty of Science to its part of the Department of Physics. This leadership should be capable make long term strategic commitments.

The evaluation group recognizes that the physics department within itself has the best expertise for this task. As a consequence the evaluation group recommends that automatic formulas for distributing resources between the divisions should be abandoned as far as possible and that active strategic decisions should be given strong preference.

The evaluation panel also recognizes the importance of the undergraduate education and that the balance between the undergraduate education and the research within the Faculty of Science of the physics department would be improved if it was possible to expand the undergraduate education. It is important that the director of studies has an adequate influence on the decisions made on the department level, in order that the interests of teaching and research be well balanced.

The evaluation group was impressed by the quality and motivation of the undergraduate teaching division, especially as concerns the outreach activities towards schools and society in general. The successful activity on student recruitment should be encouraged. The synergy between the physics teaching and the research groups with expertise on computational science (simulation, distributed grid computing, data acquisition) may allow creation of new courses and opportunity for additional student interest. This type of knowledge may also be used in external physics teaching.

9. Outlook for Subatomic Physics

Reduction and restructuring of the physics education and research program should not be implemented without consideration of the intermediate and long term perspective on physics research. Thus some flexibility for making appointments in new and rapidly developing areas of physics research should to be maintained.

In elementary particle physics the LHC at CERN will be the forefront accelerator at least for the next decade. During this time new experiments in neutrino physics will give the first look into physics beyond the standard model. A decision on constructing an international electron-positron collider to follow the LHC is expected to be taken during this decade.

The important emerging field of astroparticle physics is expected to lead to rapid and dramatic scientific developments. This field is strongly linked to experimental and theoretical progress in subatomic physics. Both the ATLAS and ALICE groups have long term commitments, at least for the coming decade. These efforts should be pursued at level and long enough to exploit all the investment made during the period of construction of the LHC and the detectors. It may be natural that Lund university try to engage in astroparticle physics, when the opportunity arises, and perhaps optimally as a joint physics and astronomy effort. In medium and low energy nuclear physics new facilities are expected to be constructed at GSI/Darmstadt, GANIL/Caen, Riken as well as radioactive beam facilities both in Europe and North America. These facilities will define the next generation of nuclear physics research and will open many new physics opportunities, which the nuclear structure groups at Lund university should be well placed to exploit.