KTH International RAE 2008

REPORT PANEL 4: APPLIED PHYSICS and MEDICAL TECHNOLOGY

GENERAL ASSESSMENT OF THE RESEARCH FIELD

The panel was very impressed by the excellent quality of both the basic and applied research. The leadership of the coordinators of the UoAs is outstanding. They have a clear vision of their units and they can convey their excitement to the various research groups and their members.

Furthermore these Units, across the board, show a very impressive entrepreneurial spirit with a good track record in commercializing their ideas and innovations. This is clearly an important part of the mission of a technical university and it is well executed in these UoAs. Moreover, the education and training of the students in these groups foster this spirit. A large number of graduates have established enterprises of their own, or are working in direct spin-off companies.

We suggest that the KTH management should consider establishing an 'industrial affiliates club' for external companies. Programmes of this kind are running with excellent success at major research universities in the US, for example MIT and Stanford. The members of this club pay a (small) annual fee and for this they are invited once or twice a year to special events arranged specifically for members of this club. At these events they are introduced to new research results ready for industrial development. Additionally, the industry representatives have the chance to meet young researchers, which they can consider as possible recruits for their own research staff.

The spokespersons for the three sub-units expressed concerns about the charges for rent of space and how it affects planning and budgeting of research projects in a negative way. The Panel is not in a position, and does not have the charge, to judge the cause of these concerns but listened to complaints about "the monopoly of the *Akademiska Hus*" as the government agency in charge of buildings for Swedish Universities. As far as the KTH administration is concerned, it is important that clear policies and processes are in place for determining and covering the rental costs. It was clear to the Panel that the present pricing structure is a serious hurdle in developing laboratory infrastructure, especially clean room facilities that are central for many of the activities. For the operation of these facilities also, a long-term professional technical staff is needed to stabilize and conserve the knowledge base. The involvement of graduate students in the operation of nanostructure/clean room facilities is an important part of the education but is not sufficient for successful operation in the long term in an environment of growth.

In a few cases, the Panel had the clear impression that a stronger coordination and a development of a common strategy between the UoAs could create synergies and help to alleviate problems due to the low staff levels.

As indicated by the name of the research area evaluated by our Panel, much of the research presented was directed towards medical technology. Also outside the area of Panel 4, KTH has research groups of high relevance for medical technology (e.g. biotechnology, biomechanics). It is our opinion that all these research efforts could be still better coordinated, and if presented as a whole, could be used to demonstrate the important role of KTH/KI in developing medical technology for the benefit of society and serve as a positive element in student recruitment. This activity is in line with the strong tradition of Swedish research for development of instruments and devices for medical diagnostics, therapy and monitoring. The unique position, that a substantial number of the faculty has a joint appointment at both KTH and KI, could be further exploited to realize positive synergies between many of the research projects in medical technology and healthcare. In network collaboration with other universities that have a strong and coordinated effort in medical technology, KTH/KI could undoubtedly position itself as a strong candidate to introduce medical technology as an upcoming research area within the European Institute of Innovation and Technology (EIT).

The hospitality and perfect planning of the logistics during the visit was highly appreciated. A large 'thank you' from the panel members to the unit coordinators, student ambassadors, and everyone involved in organising this event.

UoA: Materials Physics

General Assessment

This UoA in materials physics is a merger of three research groups: F*unctional Materials*, *Materials Physics*, and *Semiconductor Materials*. Such a coalition covers a large area of materials science from fundamental research to applied research and to device development.

Materials Physics

The Materials Physics group, the largest one, covers research in silicon nanostructures, spintronics, strongly correlated systems, and surface science. The group of Ulf Karlsson presents a good mix of physics and surface science at an internationally high standard. The younger group members are internationally well known young scientists. They all pursue, partially in collaborations, very competitive programmes. The Si nano-ribbon based sensor project is certainly worth pursuing further. It is already quite generously funded by VINNOVA.

Semiconductor Materials

Closely related to the Materials Physics group is the Semiconductor Materials group. It concentrates on materials and device processing for optoelectronics of InP, GaAs, and GaN compound semiconductors. The deposition of InP on Si is a "killer application" with large commercial potential if they succeed in growing device quality InP films. This programme led by Prof. Lourdudoss is very ambitious, but the known hurdles to be overcome should not be underestimated. S. Anand has addressed interesting aspects of photonic crystals as evidenced by a large number of publications. The work of M. Hammar on the broadband communication technology based on GaAs, rather than conventional InP, is potentially of interest for Swedish industry.

Functional Materials

The Functional Materials group designs, synthesizes, and characterizes nanomaterials. The research is focused on the development of novel nanomaterials suitable for energy savings

(incl. catalysis), biomedicine, and environment. They have an impressive research and publication record. The move of this group to Kista enhances significantly the research capabilities, not only by providing access to first rate characterization techniques but also by offering new materials preparation techniques with a large potential for collaborations. The young scientist in this group, Muhammet S. Toprak is very productive. He received a KAW post-doc fellowship for two years at Santa Barbara and has continuous support for three years after his return to Kista in 2007. Nevertheless, it will be important to find a successor for Prof. Muhammed to stabilize the research on functional nanomaterials in this Unit.

The UoA has access to Electrum Laboratory which is important for Sweden, providing excellent facilities for experimental semiconductor research and device processing (e.g., receipt of 20 MSEK award from Wallenberg foundation for the purchase of large scientific equipment). This laboratory also provides the base as a pilot plant for start-up companies. Recently, a nano-characterization laboratory was added by integrating the Functional Materials group at Kista. This action has brought in three state-of-the-art electron microscopes. Two additional grants support the spintronics development and the high resolution photoelectron spectroscopy facility.

This UoA is working in very competitive fields internationally and the younger group members show a great deal of excitement and enthusiasm about their own work. However, because of the large breadth of the various scientific fields, there is a danger that some of these projects become sub-critical.

Performance Against Evaluation Criteria

Scientific Quality (basic research)

The number of journal articles is between 27 and 48 each year; the number of conference papers varies between 26 and 44. Essentially, the rate of publications has been about the same over the past five years, roughly 75 papers per annum (journal and conference articles together). The high publication rate provides evidence for good productivity beyond any doubt and means that the majority of the UoA currently performs at a world-leading standard. Many of the journals used as publication forums, like Phys. Rev. Lett, Science, and Appl. Phys. Lett., exhibit high citation indices, which guarantee a high quality of the papers published in those journals.

The Materials Physics and Semiconductor Material groups have been very successful in obtaining research grants. Via the eight professors in these groups, a total of more than 120 MSEK has been obtained from external sources during the assessment period. Altogether, 32 PhD students have graduated from these groups in the years 2003-2007. Many of them have found employment outside of the academic sector. Additionally, there have been 57 keynote speeches at major conferences. Members of the faculty have been active in organising international conferences and workshops.

Applied Research Quality

Parts of the UoA currently performs at a world-leading standard as evidenced by the notable achievements of the UoA in applications of the scientific results, which include the recent establishment of two spin-off companies (Scint-X AB, 2007 and NanOsc AB, 2006). These companies were established to market the new X-ray pixel detector and GHz electronics based upon spintronics devices. The access to the Electrum laboratory, and the support and continuing growth of this laboratory enabled by some of the grants obtained by these groups, is an important indicator for the quality of the applied research. Successful research in

materials physics and functional materials would not be possible without the interdisciplinary approaches characteristic of this UoA.

A spintronics programme has received a large grant (10 MSEK). Recently also a VINNOVA grant has been awarded for the development of a detector system based upon nanosilicon and a collaboration was started with the ESRF to develop an x-ray pixel detector. Three patents have been filed/granted by the Functional Materials group and another three concerning spintronics applications.

Scholarship

Scholarship was considered to be excellent in some parts/individuals of the UoA. For instance, Ulf Karlsson has over many years made key contributions to MAXLAB and his continuous involvement not only at MAXLAB, but also at the ESRF and at X-FEL in the framework of NORDSYC, provides a great service to the community. If ESS is built in Sweden, this group is also ready to be the key nucleus for materials science at this new facility.

The Unit foresees that its expertise particularly in interface physics and x-ray scattering will contribute to industrial growth both in construction materials and fibre materials. The Unit also anticipates the use of the proposed MAX-IV synchrotron facility extensively, and has already taken the initiative to disseminate its expertise and build up a Materials Forum as a KTH platform to further strengthen materials physics and related technologies. The UoA has organized several large international conferences (> 1000 participants) in Sweden.

The younger group members have won prestigious young investigator awards in Sweden. The Unit has been able to attract and educate a substantial number of PhD students. Many students have taken jobs in industry, which has to be counted as very positive. This fact evidences that the UoA has given training and education in the fields of importance to the Swedish industry and society.

Vitality and Potential

The total funding has been 191 MSEK (KTH's support being 78 MSEK) for the Materials Physics group. This group has an excellent record in obtaining research grants demonstrating clearly that the vitality and potential is excellent in some parts of the UoA, and good in the remainder. This also includes two large grants for the spintronics development and the advanced photoemission system for studies of superconducting oxides. Support from EU framework programmes has been only 15 MSEK, a low figure for a grouping of nine full professors.

The figures given for the Functional Materials group (22 MSEK, KTH support 11 MSEK, during 2003-2007, Table B1.2.2) seem inconsistent with the research output of this unit. The Table on page 17 reveals that the Functional Materials group has received no money whatsoever in 2007 from any organization. This is attributed to the above mentioned incorrect recording of the central administration.

The total number of PhD degrees is 32 (only two female PhDs) over the past five years. About half of the PhD students are employed in non-academic research in companies. In the Functional Materials group, three out of the eight graduates for the years 2003-2008 are now employed by this group as researchers. For the long-term development of the research profile of the group it would be advisable if a larger fraction of the recruitment occurred from outside candidates. As mentioned above, the Panel noted that M. S. Toprak received a KAW

postdoctoral fellowship to spend two years at the University of California in Santa Barbara, UCSB, and now has continuous support for another three years after his return to Kista in 2007. The experience he gained at UCSB will certainly have a positive impact on the research in the group. The lack of women in sub-groups of the Unit is conspicuous, but the reason for this is not discussed by the UoA.

The UoA reports 41 collaborating institutes. According to the criteria presented in the evaluation package, this corresponds to concrete joint project grants or joint publications. Given these numbers, it is surprising that only one visit abroad longer than two months has been realized. The total number of visiting researchers (seven persons) is quite low, too. On the positive side, two young scientists were attracted to join this group.

Strategy

This Unit is of clear interdisciplinary character and possesses good industrial and entrepreneurial potential. The strategy for the Unit was considered outstanding with a real, if challenging, potential to achieve. The research of the Unit has resulted in two recent spin-off companies, and it is in close cooperation with the research company ACREO AB. These activities will be developed further in the future. The Unit is well positioned in Sweden in sensor and detector development and it has a promising spintronics development under way. The Unit strives to strengthen international contacts. It expects that its new laser-based photoemission equipment will give the UoA a world-leading position in high-resolution electron spectroscopy. The Unit hopes that the Swedish Research Council will support MAX-IV in Lund, and it has positioned itself to take full advantage of these new possibilities not only for researchers of the KTH Unit but also to serve other domestic and foreign groups.

In its self-assessment, the Unit regards a strong focus on telecom applications as a weakness of research. Other weaknesses include the following: The material and nanoscience work is spread out over a large number of research units. The Functional Materials group has only one senior scientist and a successor has to be found soon, otherwise this effort will be sub-critical. Recruitment of PhD students is a problem, and it is felt that acquiring EU FP funding must be improved from its present low level. There is low faculty budgetary funding, and the Unit does not have an in-house theory and modelling group. The limited faculty funding makes it difficult to establish long-term projects.

As to the most promising future trends of science, the Unit regards the following areas as extremely important: (i) energy and climate, (ii) health, (iii) information and communications, and (iv) growth of industry; all these areas being agreed to be central issues world wide. The Unit's contributions to these targets are: (i) the Unit is working on efficient LEDs (based on GaN) and solar cells; and concerning (ii), the Unit works together with Karolinska Institute on a nanoparticle-derived drug delivery project and the x-ray detector which has the potential to reduce x-ray dosage. The Unit hopes that KTH, Karolinska Institute and Stockholm University will set up a "Life Science Centre" in the future. Since area (iii) is exceptionally strong at KTH (and ACREO AB in Kista), the Unit expects that several companies will emerge as spin-offs from its related research, especially on semiconductor heterostructures and devices. As to direct applications of the Unit's outputs, spin torque oscillators in wireless telecommunications is foreseen as promising. The UoA also expects that silicon nanostructures (e.g., silicon quantum-dots) become important in fabrication of new functional structures useful in biotechnology, chemical synthesis, and optical chips. Overall, the panel agrees that not only these challenges and risks, but also the potential, for this group have been assessed correctly by the leaders.

Actions for Development

This Unit has a strong component of basic research, which is quite successful in attracting funding. This is a self regulating process which should be supported and encouraged.

For the more applied projects in materials physics, it is important that the whole line of development up to a transfer into industry or commercialization is taken into consideration. A more aggressive approach to market these results should be encouraged. The group would benefit from a closer interaction with theory and atomistic scale modelling of the materials and devices.

UoA: Medical Technology

General Assessment

This UoA is made up of three research groups.

Medical Engineering

The Medical Engineering group was started in 2004 and is located near Karolinska University Hospital at the Flemingsberg campus to assist cooperation between this group and the hospital. This close cooperation, enabled and intensified by joint appointments, is a truly unique asset for this work. Major objectives are to validate and develop non-invasive imaging techniques, mainly by ultrasound, as well as automatic analysis of human motion. The group has several interrelated activity areas: The most important is ultrasound Doppler imaging of tissue and the cardiac system. Their unique advantage is based upon an in-depth understanding of the ultrasound imaging technique. Advanced signal processing leads to a new quality in medical diagnostics. The inventions of this group are proliferated by a close cooperation with GE, a major developer of ultrasound commercial units in hospitals. The transportable 3-D mobile gamma camera shows promise for emergency room applications. Additionally, the long-term implantable pO_2 sensor enables optimal cardiac pacing. Finally, the development of a multi-functional catheter enables minimally invasive monitoring of cardiac work.

Neuronic Engineering

The Neuronic Engineering group began its work in 1997 (not then at STH KTH). Neuronics is an interdisciplinary area, combining neurotrauma and mechanics. Work by this group, based on FEM analysis and modelling, has proven to have a large potential for early diagnosis enabling the prevention of (secondary) injury to the central and peripheral nervous tissue after an accident. These computer models have also led to an improvement in the design and marketing of a safety helmet. Additionally, there is a substantial effort in the development of medical implants, which has also resulted in spin-off companies.

The research of the Medical Engineering and the Neuronic Engineering groups contributes to the proud medical research history of Sweden, combining its high-technology developments with applications in medical diagnostics. This is a truly interdisciplinary approach, where the outstanding results are derived from an application of state-of-the-art imaging methods or FEM models to the solution of important diagnostic problems in medicine and health care.

Structural Biotechnology

The Structural Biotechnology group utilizes electron microscopy to visualize biological objects at the cellular and molecular levels. The group leader is an internationally renowned

expert in cryoelectron microscopy. He came to KTH in 2005 from Lund University. The objectives of the research programme of this group are to improve the understanding of biological processes at the nanoscale, in particular relationships between molecular or cellular structures and their functions, and apply this knowledge to the development of new drugs, etc. This group concentrates its research on the structure elucidation of membrane proteins. Taking into consideration that 30% of the human proteome are membrane proteins which perform central cellular processes, and only a very few of them have been characterized structurally until now, the recent success the group has been (i) to solve two important membrane proteins at high resolution, and (ii) his contribution to analyze protein structures by a novel approach of single particle imaging analysis, which can be counted as a major contribution to the field. The group has established a very methodologically orientated basic research programme, and plays a leading role internationally. In these respects the group differs totally from the other two groups in the Unit.

Concerning networking in Stockholm, the group could certainly gain a lot from improved interactions with the x-ray microscopy efforts of the group of Hans Hertz as well as from interactions with the x-ray structure groups at the Karolinska Institute.

Performance Against Evaluation Criteria

Scientific Quality

The number of scientific articles, published in journals with high or moderate citation indices, has grown from a low figure of 12 in 2003 to a more reasonable 26 articles in 2007. The total number of publications (journal papers and conference papers) has increased from 39 (‘03) to 47 papers (‘07). This is evidence that part of the UoA currently performs at a world-leading standard with the main part performing at an internationally high standard

The total number of PhD degrees awarded in 2003-2007 is relatively low (15), while the present level of about 30 PhD students in the three groups indicates a healthy relationship. The career development of PhD students in 2003-2007 shows that the students primarily continue their work in research institutes, except for two students who have taken non-research jobs in industry.

The Unit belongs to two National Centres of Excellence and it has international collaborations in the medical sector more than in basic research. According to the Evaluation package, the overall funding has developed exceptionally fast. The external funding in 2007 is doubled and internal funding (from KTH) is quadrupled when compared to the year 2003, totalling 25 MSEK in 2007. However, according to the information given, the external funding is still relatively small (7 MSEK) compared to internal funding of 18 MSEK of 2007. Such a funding scheme, KTH / External >> 1, is in sharp contrast to what many other research groups encounter at KTH and in Sweden. According to the tables, the Unit has not received support from EU programmes.

Applied Research Quality

Part of the UoA currently performs at a world-leading standard with the main part performing at an internationally high standard. This Unit has committed itself to carrying out “useful science”, quickly applicable to the healthcare sector. In view of the growing costs of healthcare, special attention is very successfully given to affordable and readily usable (bedside) technology. Altogether, eight companies have been set up under the leadership of Profs Brodin and Holst. From all the information given by the Coordinator, it is clear that the Unit’s achievements are appreciated by the Swedish society and beyond, and that there exists

an optimistic entrepreneurial spirit within the research groups. The majority of the UoA currently performs at a world-leading standard. Major engagement with industry and government is excellent if the establishment of start-up companies is included in this assessment. The Unit has filed or obtained seven patents.

Scholarship

Obviously the impact on society to provide better, more precise and reliable medical diagnostics, which is affordable, even in times of exploding healthcare costs, cannot be overvalued. Both the Medical Engineering group as well as the Neuronic Engineering group have achieved this with their research results and thus scholarship was deemed excellent in some parts/individuals of the UoA.

Several of the senior members of these groups have held important posts and appointments of relevance to society. Hans van Holst has held several important posts with the WHO and other public organizations. Håkan Elmqvist has been a high level manager of Siemens Medical before joining Karolinska and KTH, and he is a member of the Royal Swedish Academy of Engineering Sciences.

The number of plenary or keynote speakers is two per year on average. There are five journal editorial board memberships and eight memberships of international scientific councils and academic and learned societies. These figures can be deemed excellent, indeed, when the overall size of the Unit is borne in mind. No major awards or prizes are listed.

Vitality and Potential

Vitality and potential was considered good across the majority of the UoA. The total funding of the research groups is quite low, even though it has been improving. This concerns especially too small external funding (and no support from EU framework programmes). The UoA has hired a professional project proposal writer to improve the situation.

International collaboration is quite satisfactory (14 collaborating institutes during 2003-2007), and so is the number of research visits abroad and the number of visiting researchers (six persons).

The total number of PhD degrees, four PhDs/year on average, is obtained when combining the results of KTH and KI, which is a reasonable figure but not outstanding. The number of PhD students working presently in the groups shows that this will improve in the future. The fraction of female PhD students is actually quite large (40%). This is in contrast and quite positive with respect to the other groups this panel has visited at KTH. Probably this is a consequence of the fact that this Unit is quite close to medicine.

The UoA has set up The Centre for Technology in Medicine and Health (CTMH), which has played a seminal role in establishing start-up companies, partly based on the achievements of the UoA.

The major problem of this UoA is the age distribution of the senior researchers. Five of the six full professors in these three groups have reached the age of 60 or are even considerably older. There are some younger scientists in the groups, but in order to continue with such a vigorous programme it is urgently required to hire some well established, experienced professors who can lead these groups for the next 10 to 15 years.

Strategy

The strategy for this UoA was considered excellent but challenging to achieve. The groups of Medical Engineering and Neuronic Engineering are working in a strategically very important area of research and development, which also has an excellent tradition and base in Sweden. The rising age of the population, compounded by increasing healthcare costs, provides a tremendous opportunity for developing reliable and more accurate, yet affordable, (bedside) diagnostic systems. The UoA has engaged in activities of this kind with great success and plans to continue that. Affordable improved imaging based technologies, with better spatial and temporal resolution, expand on the capability for early diagnostics. In combination with minimally invasive techniques, and novel individual monitoring of the treatment and procedures, we see great potential. Furthermore, the modelling efforts have already resulted in better quantitative results concerning treatment of head, brain, and neck injuries and the predictive power of these models can easily be expanded to other injuries or even therapies.

The strategic goal of the Structural Biotechnology group is to use the facilities of the electron microscopy (EM) laboratory for solving structural problems in biology through improved collaboration with outside users. There is, however, stiff competition from synchrotron-based protein crystallography, which limits the use of the (lower resolution) EM technology to non-crystallizable specimens. Here electron tomography of cells, cellular fragments and single molecules will play an important role in the future. In general, the feeling exists that this group could benefit from further strengthening the interactions with the applied physics groups.

Concerning the overall strategy of the Medical Technology Unit, for instance the proposed new faculty hiring, we support their plans, especially as far as the correction of the age distribution and stabilization of the current efforts are concerned. However, we are in no position to comment on this as far as new fields such as ‘hospital logistics’ are concerned, since we have only seen a part of these efforts.

Actions for Development

New hiring of established senior scientists is urgently needed to correct the age distribution of the senior research staff and to provide for a proper continuation in scientific leadership in the Medical Engineering and Neuronic Engineering groups. The panel strongly proposes enhanced interactions between the Structural Biotechnology group and the X-ray Microscopy group in Applied Physics which would foster their mutual interests.

UoA: Applied Physics and Medical Imaging

General Assessment

This UoA of Applied Physics and Medical Technology comprises six groups, including nine professors, 20 senior researchers and approximately 40 PhD students altogether. The research groups are: *Biomedical and X-ray Physics*, *Biomolecular Physics*, *Cell Physics*, *Chemical Physics*, *Laser Physics*, *Nanostructure Physics*, and *Medical Imaging*. This UoA was formed about three years ago and it has a strong base in the development of instrumentation and experimental methods for interdisciplinary applications, especially in the life sciences. In detail, these interdisciplinary activities are in cell-confocal microscopy, single molecule fluorescence spectroscopy, x-ray sources and optics, x-ray microscopy and x-ray imaging, non-linear optical materials, lasers and optical fibres, nanoscale physics and applied quantum

physics. The Unit also has significant cross-disciplinary collaborations with Karolinska Institute and Stockholm University.

The scientific quality of this UoA is internationally competitive and in many cases world leading. The outstanding achievements to be mentioned here concern especially the x-ray microscopy and the x-ray source and detector development, the pioneering work in single molecule spectroscopy, as well as the development of confocal life-time microscopy of biological specimens. Altogether, this demonstrates an impressive combination of the development of novel instrumentation and experimental methods especially for biomedical applications.

The Unit has an exceptional track record in setting up spin-off companies, providing clear-cut evidence that it is outstandingly successful in its applied research (underpinned with relevant fundamental research), in commercial exploitation of scientific results, and in social impact through companies and the careers of PhD students.

The Unit is further building up laboratories jointly with other KTH units. It has been successful in national (and international) networking. The synergies between the Applied Physics group and the Biotech group, as well as SU physics, are clearly evident both in terms of infrastructure and projects.

Comments on the Individual Groups

Biomedical and X-ray Physics
The Biomedical and X-ray Physics group is world leading in the development of innovative (soft) x-ray sources. Combined with a strong optics development, this has led to the development of a compact, laboratory based soft x-ray microscope. This instrument has unique potential for applications in the life and materials sciences.

Biomolecular Physics
The Biomolecular Physics group is developing ultra-sensitive fluorescence-based imaging methods for fundamental dynamic studies of molecules and medical diagnostics. This ‘single molecule spectroscopy’ was pioneered and continuously developed by the group leader.

Cell Physics
The Cell Physics group works on extremely challenging fields at a very high scientific level. The joint appointment of the group leader with Karolinska is very effective and unique. This cooperation model could be expanded in the future to other professorships. Cooperation with the theoretical biophysics groups at KTH and Karolinska could further strengthen the cellular and molecular biophysics activities.

Chemical Physics
This group has maintained some research activities at CERN despite the heavy academic involvement of the group leader as director of academic studies since 2001. The evaluation Panel supports the effort to restructure the laser development field of the UoA by joining the Chemical Physics group with the Laser Physics group. Accordingly, the performance of Chemical Physics group has not been included in the numerical evaluation given below.

Laser Physics
The Laser Physics group carries out laser development at a high international level in an extremely competitive field. The Linné Centre in Photonics, established jointly with the

groups at Kista, will over a long term enhance the international standing of these groups at KTH.

Nanostructure Physics
This group is of a very high standing at the European level. Concerning the spintronics devices, joining efforts with J. Åkermans group at Kista might create substantial synergies. The Nanofabrication facility lab and cleanroom operated by this group is a very important asset for many groups in applied physics.

Medical Imaging
The imaging efforts of this group are world leading, especially concerning the clinical installation of photon counting detectors for mammography. The spin-off company, founded on this development has so far installed mammography units in 15 countries.

Performance Against Evaluation Criteria

Scientific Quality (basic research)

The excellent publication record of this UoA demonstrates that the majority of the UoA currently performs at a world-leading standard. The research groups of this UoA list their present impacts in science and technology as being about 50 peer reviewed scientific papers published annually (76 in 2007), a substantial number of them in high-impact-factor journals, like Nature, PNAS, Phys. Rev. Lett., and Appl. Phys. Lett. All the groups have been active in presenting conference papers. According to the evaluation package, concerning the careers of PhD students, many graduates are currently working in companies – a desired career development from the viewpoint of the Swedish society. The Unit has produced 35 PhD doctors (in 2003-2007) of whom 75 % work in industry. This figure is certainly appreciated by the Swedish society.

The Unit has been a member of four centres of excellence. The most recent ones are the ACREO fibre optics centre, the Life Science Imaging centre, which builds an important bridge between this UoA and Karolinska, and the AlbaNova Spintronics Alliance.

The total number of co-operating institutes reported is over 85. The Unit coordinates two EU projects and is a member in three others. External funding has been roughly the same as internal funding (totaling 37-50 MSEK/year) in 2003-2004 but, for 2005-2007, the external funding has been somewhat higher than the internal one. We can see that the KTH (internal) funding has remained essentially constant, around 22 MSEK on average over the past five years.

Applied Research Quality

The majority of the UoA currently performs at a world-leading standard in applied research also. This UoA is, in the first place, characterized by world leading development of instrumentation and diagnostic methods. The research groups have been active in developing (medical) instrumentation, about which they have published many research articles. In this UoA, applied science is paired with an extraordinary ability to foster entrepreneurship. This really stands out compared to many other universities world wide.

The spin-off companies number seven since 2003, and several were founded earlier. The largest one, Sectra-Mamea, has mammography units in 15 countries; an outstanding achievement through academia-industry collaboration. This strong track record in entrepreneurship, and a concomitant development of careers of PhD students in the same

direction, indicates the strong entrepreneurial spirit of the groups which also have successfully filed an extraordinarily large number of patent applications (about 30) during the assessment period.

The research funding has developed positively when comparing the year 2003 with 2007, but the last three years have remained roughly unchanged money-wise. A comparison of the total research funding, as given by the UoA and the KTH RAE office, do not match each other. In the discussions with the group leaders it became evident that the numbers given by the central administration were incorrect.

Scholarship

Scholarship was outstanding across the majority of the UoA. The group showed an impressive combination of high quality innovative research combined with exceptional entrepreneurial activities. Such a successful demonstration has a noticeable impact on society, far beyond the creation of a few new jobs or wealth for some individuals.

The introduction of photon-counting mammography into clinical diagnostic cancer screening results in (statistically proven) saving of lives through more sensitive detection and a substantial reduction of the x-ray dose in these diagnostics. This has a large beneficial impact worldwide (or at least in the 15 countries already using these x-ray units).

Hans Hertz is a member of the Royal Swedish Academy of Sciences and four of the junior professors and scientists have received awards as outstanding young scientists (SSF Ingvar or G. Gustafsson prizes).

Altogether, 30 students have received a PhD in the years 2003 to 2007 with a peak of 10 PhD graduations in 2006. Presently there are 37 PhD students working in this UoA. With six active groups, this is a good number of students and PhD projects. Altogether about 75% of the graduates actually have positions in industry and a large fraction of these in the startup companies founded by this UoA.

Vitality and Potential

Vitality and potential were seen as or excellent in some parts of the UoA, good in the remainder. The total research funding is between 50 and 60 MSEK annually. This is at least the number given in the tables by the central administration. Additionally substantial synergies are realized by collaborating closely with SU-Physics, for example in operating the nano-fabrication laboratory at AlbaNova.

The groups are very attractive for external researchers to spend some time as guests. Presently there are two professors visiting with groups of this UoA, one from Harvard and one from Berkeley. There have been 34 visits abroad (min. 2 months duration), made by 21 researchers; both figures are very satisfactory.

The career perspectives for graduate students and the track record are excellent, allowing this UoA to actively recruit the top students for work in these groups. The number of females is still low (15%) and active measures should be taken to improve the situation.

Today this is an extremely vital group and they have attracted a substantial number of young and very talented researchers over the past years. Several of these have won well recognised young investigator awards. A careful hiring strategy with a long term perspective has to be put in place in order to keep a reasonable age distribution of the UoA. Furthermore there is a

substantial need to hire permanent technical support staff for the advanced laboratories, for example the *Nanofabrication facility* at AlbaNova. These laboratories cannot be operated by graduate students alone.

Strategy

The leadership shown by Hans Hertz in shaping the department is very impressive. The plan to consolidate the established strengths of the groups and then to venture to new, more complex endeavours, such as bio-imaging, is fully supported by the Panel which considered the strategy of this Uoa as outstanding with real potential to achieve. The Panel congratulates the UoA for receiving a Linnaeus grant for Imaging Technologies for the Life Sciences jointly with KI. This certainly will build an important bridge to direct medical applications.

The UoA finds it an opportunity (and strength) that its photonics activities are not directed towards telecommunications, but rather towards photonics of bio- and medical technologies. This is much desired strategy; the world market of bio- and medical photonics is growing faster than the telecom market. Another strong point is the plan to develop interdisciplinary bio-imaging. The groups' seminal role in entrepreneurship of mammography has been outstanding, and it is believed this success will go on.

The strategy for the 10 years ahead is clear; viz., the Unit will stay in the present fields of bio-opto-nano areas of science and technology. It feels that "more of the same" is more useful than including entirely new fields. Beyond this, the ultimate goal is to exploit effectively the resources of the UoA's multidisciplinary competencies. To achieve this, the UoA plans to build a larger interdisciplinary platform, particularly in bio-imaging, which has the highest application priority of the groups. The ultimate technological goal is to improve the spatial resolution limits of optical and x-ray microscopes and the performance characteristics of other instruments in collaboration with Karolinska Institute.

A hurdle in developing the infrastructure is the expense of operations, including rent of laboratory space, which are poorly funded by KTH. For the general support of the infrastructure, additional long term technical staff is needed to stabilize the knowledge base. A successful nanostructure facility cannot be run by graduate students alone.

Another problem is that the Unit feels small. The Unit deserves an opportunity to hire more laboratory staff and associate professors.

The future impact looks impressive. While lengthening the lists of "firsts" on a 10-year scale, the UoA plans to improve resolutions of life science imaging technologies. It predicts the present tendency of PhD students to move to Swedish industry to continue, and further commercialization of academic results via start-up firms to take place. According to the suggested strategy, the research of the UoA will have the desired impact on public health. All the above strategic predictions may be deemed realistic, judging from the Unit's achievements until now.

Actions for Development

The strategy to stay within the chosen field and to expand to new science questions from the basis of strength in instrumentation seems to be a very good choice. In general, the critical mass of some of these projects needs to be increased. The planned consolidation of the chemical physics efforts into the main field of research of the group is fully supported by the Panel.

More long-term technical infrastructure support is needed especially for the nanostructure/cleanroom efforts. To ensure the necessary stability, these infrastructure needs should be provided by intrinsic university funds.

Furthermore, the department has been growing quite extensively and one should pay attention to achieve a more even age distribution and gender balance.

There is some overlap between the activities in this UoA and the materials physics unit, for example in spintronics, and a common strategy would certainly result in synergies.

The push for a tighter connection to KI is strongly supported by the Panel. This will presumably also include collaboration with the medical physics groups at KI that are formally affiliated with SU (responsible for training candidates as Hospital Physicists, “Sjukhusfysikerprogrammet”, SU). Such a collaboration would seem particularly valuable for the x-ray source and medical imaging research efforts.