Evaluation of the

Institute of Nuclear Physics

Polish Academy of Sciences

Krakow

by the International Scientific Advisory Board
February 2009

1. Introduction

On 1st September 2003 the Henryk Niewodniczanski Institute of Nuclear Physics (INP) in Krakow joined the Polish Academy of Sciences, and became its largest research institution. In November 2004, an International Scientific Advisory Board, ISAB, was constituted by Professor Legocki, then President of the Academy of Sciences.

The role of this Board is:

(i) to advise on the scientific activities of the Institute,
(ii) to review its scientific output and future plans,
(iii) to assess the state and strategy of the Institute, in particular the quality of its research, as measured on an international scale, and
(iv) to provide recommendations in order for the Institute to strengthen its position and future research goals.

In February 2005, the first Review took place, resulting in a number of observations and recommendations. In February 2007 the ISAB reviewed the Institute for a second time under the chairmanship of Professor Albrecht Wagner, Director of DESY in Hamburg, and again a number of specific comments and recommendations were given. On this occasion the progress made with the recommendations of the first review was able to be assessed. The conclusions were very positive and encouraging: "The Scientific Advisory Board came to the conclusion that the Institute … has done excellent research of high international visibility in its five main areas of research" and "The SAB is of the opinion that the structure of the Institute should continue to evolve in order to match even better the new scientific opportunities available at the European and international levels."

The current review, the third in the series, took place from February 4th to 6th 2009 in the premises of the Institute itself, on the outskirts of Krakow, with a rotated Board membership, as given in Appendix 1. The programme was very comprehensive and varied in style, ranging from formal presentations from the Director, Professor Marek Jezabek, and his Division Heads; meetings with the IFJ Directorate in closed session; plenary presentations by a large number of young researchers; visits to the various facilities of the Institute; and a well-attended meeting of the ISAB with the young doctoral and post-doctoral researchers of the Institute without the presence of the Management. Further meetings of the ISAB were conducted in closed session where the major findings and recommendations of the Board could be presented, debated and formulated. These recommendations were then presented to the IFJ Directorate prior to a concluding presentation in plenary session to all staff, feeding back the overall impressions and recommendations of the Board.

The detailed programme is shown in Appendix 2.

2. General Conclusions and Recommendations

2.1 Developments since the 2007 Review

The International Scientific Advisory Board continue to witness improvements in the reshaping of the programme of IFJ. There has been a serious effort put into outreach to the local community and an engagement to publicise science as being an essential part of society and to attract the next generation of scientists. Accredited Laboratories also feature highly in demonstrating the international quality of the Institute and this is to be applauded. The emergence of Centres of Excellence and Centres of Advanced Technology as well as the clearer definition

of Technical Sections is enabling the laboratory priorities to be more visible, both internally & externally.

Income has fallen significantly from 11.4M€ in 2007 to 9.4M€ in 2008, a 17% fall in one year, largely due to a drop from 6.3M€ to 4.8M€ in basic State R&D income. It is difficult to see how such a significant fall can be accommodated in an organic manner and the ISAB fervently hope this fall, which cannot be ascribed solely, or even majorly, to the fall in the value of the Polish currency, is reversed with immediate effect. The nanotechnology project has attracted a significant proportion of the IFJ's budget in a relatively short time, and Development and Construction as well as Outreach have expanded in financial terms. Relative funding for other areas has diminished, in particular for Condensed Matter physics. It is very necessary that investment in infrastructure should increase, as recommended by the 2007 Review, and this must be a continuous and sustained process.

2.2 General recommendations of the 2009 Review

The IFJ is performing scientific research of a high quality and gives excellent value-for-money with its broad programme. However the Institute is funded below the level at which it is sustainable and growth in such a situation is almost impossible. A sustained effort must therefore be undertaken in order to convince the various funding bodies in Poland and elsewhere that investment funds must be made available to the Laboratory with some urgency. The ISAB believes that one important way towards achieving this goal is to prepare a well-focussed strategy plan for the next 5 years with a view forward for the whole decade.

Specific recommendations are contained within the individual sections of this report.

3. Evaluation of the Material provided by the Institute

The formal presentations were, as expected, of high quality and comprehensive. In particular the short talks given by the young researchers were enthralling. The wide range of scientific subjects presented and the evident involvement of very many international laboratories is a credit to the staff and to the management's strategy of outward thinking. The tours around the laboratories allowed us to get a feel for the facilities available and to judge the morale of the staff at their workplace. We were greeted with enthusiasm as we passed through, sometimes too swiftly to do justice to the preparation made and the anticipation created by such a review. We regret if we have not been able to give each location the attention that it truly deserved. In planning the 2011 Review perhaps an extension of this aspect could be considered.

4. Research Activities

4.1 Particle Physics and Astrophysics

The Division of Particle Physics and Astrophysics carries out a diverse and strong research programme, with significant participation in major international experiments. As recommended by the ISAB, and following the review of 2005, the activity in this area has been maintained at similar levels as in the past. The comments presented here are based on the material that the ISAB had prior to the meeting, in the discussions during the review and one-to-one conversations with the laboratory management, and in the excellent presentations of specific research topics during the open session. All the projects in this area are at the forefront of scientific research worldwide, and the Krakow contributions to them are quite visible. The ISAB appreciates the evolution of the group in the direction

of joining the most interesting experiments, both at present and in the foreseeable future.

During the last two years significant results have been obtained in some experiments, such as BELLE and AUGER, and substantial progress has been achieved in others, such as those of the LHC and JPARC. These experiments will continue in the future and the groups at the Institute have clear strategies to maintain their participation in them, something that the ISAB considers very favourably. Other activities, such as the analysis of HERA data, will most likely be coming to an end in the near future and this will require that those involved in that task join other efforts, as it is already happening.

The Department of Cosmic Rays participates in the Pierre Auger experiment taking place in Argentina. This experiment aims at the study of the highest energy cosmic rays, with energies exceeding 10^{19} eV. The Southern Pierre Auger Observatory was essentially completed in 2008. The collaboration has published two very important results. One is that the distribution of the arrival direction of these highest energy cosmic rays is not isotropic, but appears to be correlated with nearby active galactic nuclei. The other, that there is a flux suppression above $4x10^{19}$ eV, thus hinting at the existence of the so-called GZK cut-off. This experiment will continue taking data for many years and there are plans for building another observatory in the Northern Hemisphere (in Colorado, USA). The Krakow group intends to continue participating in this project.

The Leptonic Interactions Department participates in the BELLE experiment at KEK, Japan. This experiment has continued to collect impressive data sets on the production and decay of particles containing beauty quarks, allowing the most precise studies ever of the violation of the CP asymmetry. Among several "first-ever" results obtained by BELLE, was the observation of the exclusive decay

channel $B^0 \rightarrow D^{*-}\tau^+\nu_t$, which was made possible by a method of reconstruction developed entirely by the Krakow group. This experiment will also continue for many years, since there are plans to upgrade the KEK B-factory accelerator to the so-called Super-KEKB. The Krakow group will contribute to the upgrade of the BELLE detector, and particularly to the electronics.

The ATLAS Department is fully involved in the experiment of the same name at the CERN Large Hadron Collider (LHC). The Krakow group has contributed substantially to the Silicon and Transition Radiation Trackers, particularly to the powering and detector control systems. The ATLAS detector was commissioned by September 2008 and collisions of the first circulating beams with the collimators were recorded and reconstructed, before the incident of the LHC. The Krakow group is also contributing to the preparation of the physics analysis, in particular to the tau-lepton reconstruction and identification in hadronic jets, which will form the basis for several physics studies.

A small group within the ATLAS Department is also involved in the PHOBOS experiment at the Relativistic Heavy Ion Collider (RHIC) at the Brookhaven National Laboratory in the USA. This experiment studies the hot and dense strongly interacting medium produced in ion-ion collisions. A natural continuation of this physics programme would be in the ALICE experiment at the LHC, in which the Department of Ultrarelativistic Nuclear Physics of the Nuclear Physics and Strong Interactions Division is also involved. Coordination between the two groups is thus encouraged by the SAB.

A group of the Leptonic Interactions Department is also involved in LHCb, a detector that was also commissioned by the foreseen start of the LHC in September of 2008. This experiment also aims at the study of CP violation in the neutral B^0 system, with unprecedented data statistics. The Krakow group

contributed to the design and construction of the Outer Tracker detector and has also developed selection algorithms for the High Level Trigger, in addition to preparing for the physics analysis.

The Linear Collider Department is involved in the development of the detector for the International Linear Collider (ILC), specifically in the preparation of the LumiCal subdetector, which will be used for the precise measurement of the luminosity. The work is being done in collaboration with other Polish and European groups in the framework of the EUDET project funded by the EU.
The departments of Leptonic Interactions and of Hadron Structure were involved in the HERA experiments H1 and Zeus respectively, which took place in DESY, Hamburg. The HERA accelerator was closed in June of 2007 after 15 years of operation. The Krakow groups had a very visible participation in these experiments, which are now in the phase of publishing their final results.

The Department of Neutrino and Dark Matter Studies has teamed up with several groups in Poland to develop a programme in neutrino physics and dark matter searches. In neutrinos the group has been participating for several years in the ICARUS detector, which aims at demonstrating the viability of the Liquid Argon Technique with a large, 600 tonne detector, which is being installed in the Gran Sasso Laboratory in Italy. Liquid Argon is also being used for direct searches of dark matter particles. A small prototype of 2.3 litres, named WARP, has already published competitive results demonstrating the technique. A 100 litres detector is now under construction. The group has also joined recently the T2K experiment in Japan, expected to start later this year. This experiment will advance the knowledge of the neutrino oscillation parameters. The results of T2K are likely to be determinant in defining the next major steps in neutrino physics based on accelerators. The Krakow group is contributing to the reconstruction software of the near detector and has provided engineering support for its

cooling and the mounting of the SMRD sub-detector. In the area of neutrinos the group also participates in the studies of the LAGUNA detector concept, which contemplates a detector of a total mass of 10^5 to 10^6 tonnes of water or liquid argon, for neutrino studies and proton decay searches. The Polish groups are studying the possibility of installing that detector in an existing mine in Poland.

The LHC groups also contribute to the development of the LHC Computing Grid. Krakow hosts almost one half of the total federated Tier-2 Polish computing cluster. The groups have participated in the data challenges carried out in preparation for the processing and analysis of actual LHC data.

The ISAB considers that the programme of the Division of Particle Physics and Astrophysics is excellent. The ISAB encourages the groups to team up among themselves and with the technical divisions of the Institute to make a major contribution to a future experiment. The partition of the groups into Divisions and Departments should occur according the activities taking place. Overall the contribution of the Krakow groups to the experiments in which they participate is of high standing and this level of participation should be maintained.

4.2 Nuclear Physics and Strong Interactions

Following the recommendations given in the previous ISAB reports, the Division of Nuclear Physics and Strong Interactions has consolidated the reorganisation of its research in three departments:

(i) Strong Interactions and Mechanism of Nuclear Reactions,

(ii) Structure of Atomic Nucleus, and

(iii) Ultrarelativistic Nuclear Physics.

Presently, there are underlying efforts to merge the two groups at IFJ that are involved in the ultra-relativistic heavy-ion research to investigate the quark-gluon plasma phase of matter at LHC/ALICE. These are the groups embedded within the Department of Ultrarelativistic Nuclear Physics and the Department of Hadron Structure of the Division of Particle Physics & Astrophysics. The ISAB applauds this step because it will give the merged group better visibility and stronger impact within the large ALICE collaboration.

The research programmes of this Division span studies of the nuclear structure of exotic nuclei in the low-energy regime, mainly at GSI and GANIL, to the structure of hadrons at intermediate energies, mainly at COSY, up to the thermodynamics of quark-gluon plasmas at the highest energies provided by LHC at CERN. In all of these fields the groups from IFJ have been very visible and their strong contributions appreciated by the collaborations pursuing research at these facilities.

The scientific programmes presented for the Division of Nuclear Physics and Strong Interactions, with strong projects at leading international facilities, are in accordance with the "NuPECC Long Range Plan 2004: Perspectives for Nuclear Physics Research in Europe in the Coming Decade and Beyond". The programmes are addressing topics of much current interest.

In the field of nuclear structure, emphasis is made by the Department of The Structure of Atomic Nucleus on the study of the structure of exotic nuclei (with N/Z values far from the island of stability), or nuclei with high spin and/or high temperature. Both stable and radioactive beams have been employed in these studies. In the written report as well as in the presentations, many highlights were presented using techniques some of which have been developed by IFJ scientists such as, for example, using deep inelastic heavy-ion reactions to access

the structure of neutron-rich nuclei. In addition, the spin alignment achieved in fragmentation of ^{238}U at relativistic energies allowed *g*-factor measurements of heavy-mass fragments, thereby opening the way for a campaign of measuring *g*-factors with the RISING detector at GSI, to which IFJ contributed significantly. The observation of the pygmy dipole resonance in ^{68}Ni by Coulomb excitation at relativistic energies is another interesting result in which information obtained on nuclear structure can lead to an understanding of astrophysical phenomena. In the future, the emphasis will be put on using radioactive beams from FAIR and SPIRAL2. For these research projects, detector development is necessary, in particular, because the reactions are mainly performed in inverse kinematics. The Department has taken the main responsibility for the PARIS detection system. This is a novel detector development and it is strongly recommended that IFJ seeks investment funds from Polish sources to finance a large part of this detection system. In such a way, IFJ can make an important claim on this movable detection system and allow its groups to pursue vibrant scientific programmes with it at various international large-scale facilities, and including possibly the future upgraded IFJ facility.

The Department of Ultrarelativistic Nuclear Physics has been involved earlier with the NA49/SPS experiment, which has now been stopped. However, it has provided a wealth of data that are still being analysed. On the other hand, this Department was involved in the preparation of the ALICE experiment contributing significantly to the building of the TPC. Data-taking was expected to start in the autumn of last year. Unfortunately, due to a mishap with the LHC magnets, a delay in the data-taking has occurred. However, it is expected that in the course of this year ALICE will start collecting data to unravel the nature of the intriguing transition from ordinary matter to quark-gluon plasma. This will put IFJ at the forefront of discoveries in this exciting field of physics.

The Department of Strong Interactions and Mechanism of Nuclear Reactions has a broad programme, including studies of time-reversal invariance in neutron decay at PSI, Villigen, reaction mechanism studies at FLNR, Dubna, and spallation-related measurements at COSY, Jülich with the PISA setup. However, the strongest part of the programme concerns studies of hadron structure and interactions at COSY, Jülich in the framework of the GEM and ANKE collaborations and more recently with the WASA collaboration. In these studies, the production of η-mesic nuclei is measured as well as the η-α and η-^{3}He scattering lengths. A highlight is the measurement of the $\eta \rightarrow 3\pi^0$ Dalitz plot, the investigation of which provides a sensitive test of the χPT.

Considering the strong participation of Poland as a member state of the FAIR collaboration and being one of the signatories of the MoU for FAIR, it is natural that IFJ participates strongly in the FAIR programme not only in NuSTAR covered by the Department of Structure of Atomic Nucleus, but also in other collaborations. Given the long-standing strong collaboration of IFJ in the hadronic physics programme of the COSY facility at Jülich, and recently in the WASA collaboration, and the full commitment of the Jülich institutes to build the High-Energy Storage Ring (HESR) at FAIR where the PANDA experiment is located, it is logical that the Department of Strong Interactions and Mechanism of Nuclear Reactions becomes involved in the PANDA collaboration. The SAB recommends that the role of this Department in the PANDA collaboration be strengthened by taking a leading role in the construction of central parts of the PANDA detector.

The *Bronowice Cyclotron Centre,* with its plan to install a 250 MeV cyclotron for research and proton radiotherapy, offers new research opportunities for physicists both from IFJ and from universities in Poland, especially the University of Krakow. This could be in nuclear structure but also in studies of

Few-body Physics, in particular if it becomes possible to accelerate polarised protons as well. Furthermore, this centre could offer excellent training programmes for students. However, these research opportunities cannot be a substitute to the research pursued by the groups from the Division of Nuclear Physics and Strong Interactions at large-scale European facilities where cutting-edge research is performed with unique instrumentation that can only be built in the framework of large collaborations.

Specific Recommendations:

PARIS is a novel detector array that is supported presently by the SPIRAL2 preparatory phase and will be one of the most important detectors at the SPIRAL2 facility. It is strongly recommended that IFJ seeks investment funds from Polish sources to finance a large part of this detection system, which could be in the framework of the COPIGAL.

SAB further recommends that the involvement in the PANDA collaboration be strengthened by taking a leading role in the construction of central parts of PANDA.

4.3 Condensed Matter Physics

The broadly-based work in Condensed Matter Physics continues to impress. CMD is however now the smallest Division at IFJ and is visibly contracting. Research programmes cover a very wide area of study from ceramic composites, organic solids and liquid crystals, to ferroelectric, auxetic and magnetic materials, to hydrides and superconductors, continuing on to surfaces and zeolites. This is a very diverse range of topics. Experimental techniques used are equally diverse - positron annihilation spectroscopy, x-ray diffraction, pulsed NMR, neutron scattering, muon spin rotation, calorimetry, magnetometry, and synchrotron radiation, supported by theoretical studies. These theoretical studies

are of high standing and visible internationally, but care must be taken to ensure that experimental and theoretical studies are coherent, with each other.

In particular we can point out the very nice work pioneering the use of polarised neutron techniques in the study of ceramic-elastometer composites, employed in the cement industry, thereby pinpointing the origin of residual stress. A collaboration with the world-renowned Research Centre for Molecular Thermodynamics in Osaka has resulted in the identification of different solid phases – orientationally disordered glass phases - in plastic crystals

Whilst much of this work is very worthy, it is difficult to discern a clear direction with such a broad diversity of both experimental techniques and scientific topics in the programme. It appears to be driven by a bottom-up approach rather than by any top-down strategy and risks to become so thinly spread as to lose impact at the international level. The ISAB would like to see a focussing of activities, the creation of a strategy and the elimination of less relevant topics. Concentrate on what you do best, rather than being totally curiosity-driven, which brings with it the risk of being too thinly spread over too many fields.

We wish to emphasise that Poland is becoming increasingly visible on the European scene and is looking to be considered as a location for one of the large-scale facilities on the expanding ESFRI Roadmap of LSFs, the second edition of which was published in October 2008 and contains 44 projects. It is clear that in a European Union of 27 countries these large-scale facilities cannot all be built in the big countries, those that wield a big influence scientifically. There are therefore opportunities to be prepared for by the Polish scientific community, and the IFJ can be part of this. Specifically the IFJ has played the leading, and determined, role in achieving, not without some difficulties, Polish membership of ILL. Equally well, the IFJ is represented in the newly formed Steering

Committee of the European Spallation Source. Poland has a strong history here with novel time-of-flight instrumentation at Swierk, and molecular science led by Professor Janik in Krakow. These international facilities are world-leaders and the Condensed Matter Division can play a leading role in supporting a much stronger role for IFJ, and also act. Such a role would undoubtedly open up funding pathways for the Institute.

Specific Recommendations:

- Critically review the programme of the Condensed Matter Division and reshape it.
- Refocus the current "blue skies" attitude towards strategic topics and selected techniques and reduce peripheral areas and strengthen those areas that are identified as priority areas.
- Develop support activities that would consolidate the IFJ's role in heading the Polish thrust towards full participation in European large-scale facilities for materials research such as ILL & ESRF in Grenoble, and future facilities like XFEL in Hamburg and ESS in Lund.

4.4 Theoretical Physics

The Theoretical Physics Division has an established tradition as one of the most important research groups at the Institute. The research in the Division is mainly devoted to particle physics, nuclear physics and also astrophysics and cosmology. In all these domains the focus is on phenomenology, in close connection with experiments, rather than on formal theory. Recently a Department on the Theory of Complex Systems was added to the Division.

In the particle physics domain, the Krakow theory group has, in the recent past, made highly visible and important contributions to the interpretation of results

at LEP, HERA and Beauty Factories. Today, the most important part of theoretical research is related to the experiments at the Large Hadron Collider (LHC) at CERN that will start data taking in late 2009. The analysis of the forthcoming experimental data needs advanced theoretical work in the form of precise analytical or numerical calculations and/or of event generators and simulation methods, both within and beyond the Standard Model. The group is particularly strong and established in the domain of event generators, where at present some innovative directions are being explored. In addition, work is being done on better modelling of the non-perturbative phenomena, mainly in the sector of strong interactions. Other areas of research are related to physics at other colliders, such as the Tevatron, ILC and *B*-factories.

Collisions of ultra-relativistic heavy ions have become one of the main research interests in the Division, in connection with the experimental activity at RHIC. The main research activity on heavy-ion collisions was focused on the problem of explaining the observed spectra, azimuthal asymmetric flow and the HBT correlations.

The group has an excellent publication record. Overall the particle and nuclear theoretical physics of the Institute has a remarkably high and established standard with great international involvement, recognition, and visibility and a close link to the most exciting areas of research in the years to come.

Specific Recommendations:

- Maintain the present profile and give a strong support to the group now that the LHC is starting and additional opportunities of relevance and visibility arise.
- Theoretical particle, nuclear and astro-particle theoretical physics should be maintained at its present level.

4.5 Applications of Physics and Interdisciplinary Research

In the report on this area we concentrate on the rather large field spanning many disciplines of the APIR that range from Physical Chemistry and Surface Engineering, Radiation and Environmental Biology to the Physico-chemistry of Ecosystems, to name but three. Also encompassed are the Laboratory of Individual and Environmental Dosimetry and the Laboratory Chromatographic Trace Analysis, amongst several others.

In addition

a) an aged cyclotron facility is now starting to be operated for eye tumour treatment by local medical specialists. This Division, thus, has the additional task of treatment planning.

b) A 2-dimensional TLD System for the Krakow Centre of Oncology has been developed with 1 mm spatial resolution, which could prove to be useful for IMRT planning and verification.

c) An artificial diamond-based clinical dosimeter has been developed and tested at various therapy facilities in Krakow.

d) An X-ray microprobe for biological irradiation has been developed,

e) A laboratory for retrospective biological dosimetry is operated, and

f) a whole body counter for in-vivo measurements has been installed.

Our evaluation is based on the written material send to us before the meeting, on the short visit to the laboratories on February 5th, and the selected oral presentations delivered on February 5th and 6th.

a. General recommendations:

The research done and the diverse services delivered in the areas of "life and health", "energy and civilisation hazard" and "material and nanostructure science" are generally of high quality where evaluated. Partly they are embedded in European Programmes. In part, however, they appear to be at the borderline of the tasks of an Institute centred on nuclear physics (for example cytogenetics, and environmental chlorocarbon gas measurements). It is important to clarify whether these unquestionably important tasks, which are somewhat beyond the scope of the IJF's mission, are tasks that were assigned to this Institute by the Polish Administration for other national reasons.

The ageing cyclotron is likely to have only a short residual life-time. For the benefit of the envisaged medical applications, for certain nuclear physics research projects, for radionuclide production and for activation analysis, as well as for higher education and training, and for Masters and Doctoral work it is highly desirable to substitute it with a new, higher energy cyclotron as soon as possible. This would give the Institute its own important instrument and increase national and international visibility. Thus, the management of IFJ is encouraged to follow up on this already submitted proposal with determination and energy.

Returning to the education of Masters and Doctoral students it would be of the greatest benefit for them to also have a series of courses in this Institute in soft skills like project management, formation of a start-up company, and the

application for third party funds, etc. To attract more foreign students, and to ease their integration, administrative and financial help in immigration procedures, etc. would be very useful. We treat this topic in more depth in Section 6 below.

In the ongoing restructuring of the Institute that is having a revitalising effect, the following general recommendation might be considered by the Institute Directorate. The individual and environmental dosimetry section and, separately, the unit providing quality control of medical X-ray equipment, could be floated as private companies. They are financially sound and could stand on their own legs, in the view of the ISAB. Such an action could represent very positive examples for the further formation of start-up companies (where separate national and European funds are available), e.g. on the nanotechnology of coated thin surfaces of commercial interest. Such changes could also provide new positions for completed PhD students and other physicists. Any such start-up companies would retain links to the parent organisation as an incubator, but successful creation of such companies can have both political, public-relational and financial benefits to the parent organisation. Importantly, addition employment opportunities can be created.

Furthermore, the Institute might also consider forming a dedicated unit for the higher education of physicists (offset by course fees) in the specialised methodology of scientific radiation protection for the purposes of medical/clinical developments, as well as assisting a Polish nuclear energy renaissance. The expertise is well available in Poland.

To summarise, the existence of this Applied Nuclear Physics Division and its fraction of about 30 % of the Institute's resources is seen as very good and must be maintained at this level if its tasks area to be fulfilled This fact could also be

used to the benefit of the Institute in several public outreach events per year and for increased numbers of invitations to media and selected members of national and European politics to ensure a positive development of future funding and to maintain a positive public perception of its activities.

b. Special recommendations

(i) The newly-developed Micro-X-ray facility is of excellent and promising use in a variety of important physical and medical applications. It might also be used for phase contrast medical imaging. This newly emerging field is very promising in the provision of excellent images with smaller X-ray doses. The hardware and software technologies needed for this new technique, pioneered for example by Franz Pfeiffer, at ILL and PSI, now at TUM, are both readily available at the INP. This opportunity promises a much greater scientific (and finally commercial) harvest than the, nevertheless worthy, planned radiation biology experiments.

(ii) The environmental radioactivity measurements done in the past should be complemented by one or two theoretical modelling scientists, so that also in this field, where expertise is necessary in Poland, good science can be produced, for example on environmental transport processes described with mathematical models, instead of simply empirical episode reporting, which often is of little scientific value other than for record-keeping purposes.

(iii) If extra fund were to become available (otherwise the small scientific impact of the results would not warrant the effort), the measurements by TLD of the radiation exposure of astronauts reported, should be complemented by radiation transport calculations for the same scenarios. The expertise is already available in the Institute. Thus the biological effectiveness of the moderated mixed radiation fields in different parts of the body could be determined and real health

risk estimates could be based on such data, which would be of value to both ESA and NASA.

(iv) Magnetic resonance imaging and spectroscopy is an important and publicly relevant application of nuclear physics in medicine and should be strengthened. The Institute has both excellent theoretical and experimental capabilities in this area and could contribute much to medical progress in this diagnostically promising interdisciplinary field.

(v) If resources do not permit the intensification of these activities without reduction of others, we would recommend reducing the AFM and DNA-related biological studies as well as breath and environmental gas analyses. Here the Institute does not have, nor is it ever likely to develop a visible "lighthouse" capability as it has done in other fields. Neither are these fields, comparatively speaking, sufficiently important for, nor close enough to the "heart" of a nuclear physics institute.

(vi) Thin layer materials physics is likely to remain important in the future. Thus one should carefully consider, in a long-term strategic plan, whether diversification into other areas of nanotechnology would be useful for this institute of currently limited resources.

(vii) Here also the possibility of further radiation detector development should be taken into account, e.g. of energy dispersive, mini-pixel X-ray detectors (such as MEDIPIX 2 of Erlangen University). We consider the diamond detector development of this Division as being very positive and useful in several medical applications.

(viii) Because of the direct intelligent employment of several experimental and theoretical nuclear physics methods, which other Institutes would not have readily available, and its the large importance for future energy research, the photosynthetic studies on bacteria and algae are considered as being very positive for this Institute and should be encouraged.

5. Interaction with Universities and Outreach

The Institute has a remarkably rich participation with programmes carried out at large-scale facilities world-wide. This results in making available to IFJ researchers facilities that are unavailable in-house and accounts for the quality of science that is achieved. Equally well this allows a parallel activity that is the contribution made to the construction activities to, for example, the LHC, W7-X and other such facilities, bringing credit to the Institute. We strongly recommend the Institute to continue and even to enhance this activity. However we see a significant mismatch between what is available to IFJ researchers abroad and what is available within the laboratory itself. This leads us, again, to emphasise the importance of inward investment. We recognise that it is difficult to assign funds from within the Institute's own limited and decreasing annual budget. We would therefore strongly recommend a special externally resourced fund with the clear goal of investment in the fabric and infrastructure of the Institute and we would welcome suggestions and initiatives as to how this might be achieved. The strategic plan, which we firmly encourage elsewhere in this document, can be a vehicle to persuade funding agencies of this urgent need.

The increased activities with respect to the world at large are to be applauded. The public is increasingly conscious of scientific activities, which are not always viewed in a positive light. They are however less aware of the benefits to everyday life which only exist because of the application of scientific research – lasers in supermarket checkouts, mobile phones, the internet and so on. We therefore strongly support and encourage the activity of the Institute in this area. Equally well, staff awareness of the importance of public outreach to the Institute should be emphasised.

6. Resources of the IFJ

It is highly regrettable that the Institutes experiences a falling budget. The ISAB is concerned that financial levels have fallen close to a level at which the Institute cannot hope to fulfil its programmatic responsibilities effectively. We therefore urge enhanced inward investment by a concerted effort of Polish funding bodies and IFJ management. It would be tragic to lose the capability of the current staff and worse still to demotivate the extremely rich reservoir of young scientists and engineers that the Institute has, by its determined initiative, attracted to the Institute.

7. Structure of the Institute

Post-doctoral researchers and doctoral students

The Institute is richly endowed with a pool of young researchers – almost eighty Ph.D. students in 2008 rising from less than sixty in 2004. This rising trend is a great credit to the Institute and demonstrates the attractiveness of science as a career in Poland and the Institute itself. The staff age distribution is double-peaked with the upper peak at ~ 58 years and the lower peak at ~ 35 years with a distinct minimum in between. Within a few years there will be a significant loss of expertise due to normal retirements. This must be anticipated, planned for, and mitigated as far as possible.

Whilst material resources at the Institute are less than ideal, the human resources in particular the young researchers are a great strength especially when compared to western European laboratories of a similar status. In the view of the

International Science Advisory Board a greater emphasis on the value of the young researchers to the future of the laboratory has to be placed.

A meeting was held with the young researchers who were encouraged to express their views. This meeting was very fruitful although there was a certain need for the ISAB to strongly activate open discussion. In that discussion the following points emerged:

(i) As an international Ph.D. programme, consideration should be given to presenting more of the course work in English. Equally well it was felt that much of the formal teaching would be better conducted in a winter or summer school environment.

(ii) On occasions it appears that the resources provided by the young professionals are not sufficient. There are concerns that the Ph.D. courses can last too long without, in some cases, clear definitions of project topics until well into the course. Desk space, computing facilities and, in particular, access to library facilities are less than ideal. Assistance for foreign students in administrative requirements would be appreciated as would accessible information on the repayment of visa fees and other items.

(iii) There is considerable disquiet about the lowering of the stipends of the doctoral students by what appears to be a significant amount. This is a delicate issue on which the ISAB does not wish to take sides. Nevertheless such issues can cause demotivation and even result in staff wastage, and two-way open communication is necessary to mitigate such effects.

(iv) A group of eighty young people, intelligent and having similar goals in life, can self-organise to become a force for good within the Institute well beyond their individual research topic. This can happen on the social level as well as on the intellectual level. For

this to occur certain facilities should be at their disposal containing a vending machine for evening snacks and coffee/soft drinks. Such a club room could be used for student seminars, social events and information exchange. Since this meeting, the students have started a webpage and there are moves to create a club/association. The ISAB strongly encourages the IFJ management to support those initiatives.

Specific Recommendations:

1. More emphasis should be devoted to the doctoral students and post-doctoral staff. We recommend they be provided with a club room so that they can begin the process of self-organisation. A staff-student liaison committee would be beneficial.
2. A critical review of formal coursework should be launched in order to ascertain whether changes are required to better serve the needs of the Institute and the students alike.

8. Long term scientific strategy

The International Scientific Advisory Board is impressed by the way in which the organisation has evolved in an organic manner. One cannot fail to be impressed by the very wide range of good quality scientific work that is being carried out, and particularly so when one considers the limited resources available. Scientific visibility is high and collaboration with IFJ teams is clearly valued by international projects and laboratories. The intellectual resources available are vast, particularly so when one considers the pool of young researcher talent. However it should be noted that the materials resources available are too low and are not properly balanced to these intellectual resources despite the best efforts of the Direction.

For this reason the ISAB considers it to be timely that the Institute should launch an internal review of the strategic directions and scientific options for the laboratory over the next decade until 2020 and produce a high-level document which will inform politicians, scientists and funding bodies both within Poland and more widely.

We appreciate that such an idea requires a lot of additional work, but we believe that the benefits will far outweigh the effort put in. Such a strategic plan will help greatly to look towards the horizon and to anticipate the growing economic power of Poland, which will inevitably occur during this coming decade, and will assist the drive to improve the materials resources at the laboratory. We would hope that such a document could be prepared for discussion at the 2011 Review.

9. Summary, Conclusions and Outlook

The ISAB spent two and a half days reviewing the activities of the IFJ in February of 2009. They were presented with a broad overview of the work of the Institute and were given all opportunities to enquire into the programme and the workings of the Institute at all levels.

The ISAB were impressed by the quality of the work being undertaken across the whole spectrum of the discipline of nuclear physics, which extends even into areas which are peripheral and supportive to the subject, some of which activities approach commercialisation. A balance between experimental and theoretical work is clearly evident. Public outreach work is also commendable.

The Institute enjoys a significant array of bright young scientists and they are the future of the Institute and even of the viability of the subject in Poland.

The resources of the Institute are however falling below the level at which its programme can be sustained. Inward investment is needed without delay.
The Institute is urged to commence a comprehensive appraisal of its current programme and to create a high quality and properly costed strategy plan for the coming 5 years with a glimpse to the end of the next decade

10. Acknowledgements

The International Scientific Advisory Board greatly appreciated the hospitality shown to them and wish to compliment those responsible for the well-organised programme. They remarked upon the openness of the review and the opportunity presented to them to meet a wide cross-section of the staff. The willingness of the Director, Professor Marek Jezabek, and his Management team

to listen to and to be receptive to our thoughts and recommendations has been an important element in enabling us to carry out our task. We wish the Institute well.

Appendix 1

Membership of the International Scientific Advisory Board (ISAB) of the IFJ Krakow 2009

1. **Guido Altarelli**
   Dipartimento di Fisica, Universita' di RomaTre
   Via della Vasca Navale 84
   00146 Rome, ITALY
   Tel. (+39) 0657337044
   and
   CERN
   CH-1211 Genève 23
   SWITZERLAND
   Tel. (+41) 22 76 74145
   email: guido.altarelli@cern.ch

2. **Colin Carlile (Chair)**
   The European Spallation Source
   Lund University
   P.O. Box 117
   SE-221 00 Lund
   SWEDEN
   Tel. (+46) 761 3333 99
   email: colin.carlile@esss.se

3. **Enrique Fernández**
   Institut de Fisica d'Altes Energies Edifici
   Cn. Facultat Ciencies UAB
   E-08193 Bellaterra (Barcelona)
   Spain
   Tel. (+34) 93 581 1984
   email: fernandez@ifae.es

4. **Muhsin N. Harakeh**
   NuPECC, and
   Rijksuniversiteit Groningen
   Kernfysisch Versneller Institut – KVI
   Zernikelaan 25
   NL 9747 AA Groningen
   The Netherlands
   Tel. (+31) 50 363 3600
   email: harakeh@kvi.nl

5. **Herwig G. Paretzke**
   Helmholtz Zentrum München Ingolstädter

Landstrasse 1
D-85764 Neuherberg
Germany
Tel. (+49) 89 3187 4006
email paretzke@helmholtz-muenchen.de

6. **Henryk Szymczak**

Instytut Fizyki PAN
Al. Lotnikov 32/46
02-668 Warszawa
Poland
Tel. (+48) 22 843 7001 & (+48) 22 843 6601 wew 3137
email: szymh@ifpan.edu.pl

Appendix 2

Review of the Research Activities of the INP - 2007 to 2008

Programme

Wednesday 4th February 2009

18.00 – 19.00 Preparatory meeting with IFJ PAN Directorate

19.00 Dinner

Thursday 5th February 2009

Open Session of the SAB:

Presentations of the Divisions (Chair Prof Marek Jezabek)

9.00 – 9.15 Report on implementation of the Scientific Advisory Board recommendations after the 2007 Review. Marek Jezabek

9.15 – 10.00 Particle Physics and Astrophysics Division. Piotr Malecki

10.00 – 10.30 Nuclear Physics and Strong Interactions Division. Jan Styczen

10.30 – 11.00 Condensed Matter Physics Division. Tadeusz Wasiutynski

11.00 – 11.30 Coffee break

11.30 – 12.00 Theoretical Physics Division. Stanislaw Jadach

12.00 – 12.35 Applications of Physics and Interdisciplinary Research. Urszula Woznicka

12.35 – 12.50 Accredited Laboratories. Pawel Olko

12.50 – 13.00 Scientific Equipment and Infrastructure construction. Marek Stodulski

13.00 – 14.00 Lunch break

14.00 – 15.30 Visits to Laboratories and Local Infrastructure

15.30 – 16.00 Meeting with doctoral and post-doctoral students

16.00 – 16.30 Coffee break

Closed Session of SAB (with IFJ PAN Directorate and Division Heads)

16.30 – 17.00 Discussion on future plans. Marek Jezabek

17.00 – 17.45 Closed session (SAB members only)

17.45 – 18.45 Closed session (SAB members + Directorate + Division Heads)

19.30 – 22.00 Dinner in Dom Polonii restaurant

Friday 6th February 2009

Open session: Presentations of the highlights by young physicists (Chair Pawel Olko)

9.00 – 10.15 5 talks of 15 minutes including discussion

- Highlights from BELLE — Jolanta Brodzicka
- Tau laptons as an exciting probe for a New Physics in ATLAS — Anna Kaczmarska
- Automatic calculation of one-loop amplitudes — Andreas van Hameren
- Wounded quarks and diquarks in hign energy collisions — Adam Bzdak
- Exclusive production of vector quarkonia in proton-proton and proton-antiproton collisions — Wolfgang Schäfer

10.15 – 10.45 Coffee break

10.45 – 12.00 5 talks of 15 minutes including discussion

- Spin alignment and g-factor measurements with RISING — Maria Kmiecik
- Phonons, electron-phonon coupling and superconductivity in Mo_3Sb_7 from *ab initio* calculations — Malgorzata Sternik
- Signature of Berezinski-Kosterlitz-Thouless transition in Cu4[W(CN)8]4 molecular magnet — Robert Pelka

- Magnetic resonance imaging of the cardiac function in small animals *in vivo* Sylwia Heinze-Paluchowska
- Radiation hazards to astronauts on low-Earth orbit
  Monika Puchalska

12.00 – 13.00 Closed session (SAB members only)

13.00 – 13.30 Close-out – Presentation to Staff of SAB preliminary conclusions