Report to the 49th Regular Session of the IAEA General Conference from the 8th Scientific Forum

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Mr. President,

As the Chairman of the 8th Scientific Forum, it is my privilege to report to you and the Plenary the main points from the presentations and debates of the Forum. The Forum took place in an excellent and constructive spirit under the title "Nuclear Science: Physics Helping the World". The four sessions of the Forum focused on: Meeting Energy Needs; Developing Advanced Materials and Technologies; Advancing Radiation Medicine and Supporting Nuclear Safety.

This Forum took place in the U.N.'s World Year of Physics. This is the 100th anniversary of Albert Einstein's revolutionary year - perhaps the greatest single year of innovation by any one scientist. In 1905 Einstein wrote on Relativity, the Photoelectric Effect, and Brownian motion. None of these papers was as mathematically complex as were his later papers on general relativity, but all showed new ways of looking at nature. The impact of all of them has been profound.

Looking backward in time, there is no problem in demonstrating that physics not only has helped the world, but is fundamental to the world of today. It is not an exaggeration to say that the foundation of almost all of today's technology rests on the physics of the 20th century. There are new things in the laboratories of the 21st century that are not yet fully understood, ranging in scale from the cosmic to the sub-nuclear. Some are already at the threshold of application. For example, carbon nanotubes can make transistors or strengthen materials. Others are at an earlier stage. For example, quantum computing may or may not ever work, but if it does it promises speed ups of a factor of a million or more for certain classes of problems.

The physics of the 21st century will surely bring great practical benefits.

The four sessions of the Forum focused on the future in areas related to critical needs of society, and that are related to the mission of the IAEA.

Session 1 presented how nuclear science is helping meet the world's energy needs. Keynote lectures, panellists' remarks, and the panel discussion illustrated the tangible benefits of fundamental physics by drawing the big arch from Einstein's mass-energy equivalence formula to the R&D and the engineering applications in the various fields that form the basis for both fission and fusion energy.

Demographics and economic development worldwide, especially in developing countries, are projected to lead to a doubling of primary energy demand by 2050. This trend, coupled with rising concerns about global warming, has brought the nuclear option to the forefront of attention and has highlighted the importance of innovation in this area. Nuclear energy cannot solve all energy problems but it can be an important contributor.

The Session presented the status of both fission and fusion energy, addressing major issues and prospects, discussed novel approaches, and identified the way forward and the potential role that IAEA could play.

As far as fission is concerned, it was noted that a big expansion of fission energy requires closing the fuel cycle, from both a waste management and proliferation point of view. Hence, the importance of the fast reactor, which provides the flexibility to either breed or incinerate minor actinides, was highlighted. By 2010 only two high-power fast reactors will be available for R & D work. Therefore, it was suggested that coherent international programmes be set up to maximize the use of these fast reactors.

With regard to the proliferation issue, once-through fuel cycles do not seem to be that much more beneficial than recycle strategies. The importance of research and technology development to strengthen technical safeguards was stressed.

The idea of internationalising the nuclear fuel cycle was discussed. It was recognized that this option could offer substantial benefits to smaller countries. However, the realization of such an idea presupposes that solutions to many political, legal and administrative issues are found. As a possible way forward, it was suggested that IAEA start working on such strategies.

As far as fusion is concerned, the decision to build ITER at Cadarache, France is a very positive development. ITER must succeed in demonstrating a burning plasma for fusion energy to become

practical. Even if it does, the earliest commercial deployment of fusion is anticipated around 2040 to 2050, setting fusion development into the same timeframe as Generation IV Reactors.

The Session's highlights can be summarized as follows:

There is no single solution to the problem of "meeting energy needs". All options will be needed, including conservation and increased efficiency.

The energy debate has to involve all players – developed as well as developing countries. In this context, international collaboration under the aegis of organizations like the IAEA has a crucial role to play. Initiatives like the Agency's INPRO project and also Generation IV could serve as a mechanism for such collaboration. Such initiatives could also extend their scope to include new ideas that ongoing R&D will produce, and address issues such as development of infrastructure in developing countries to enhance the efficiency of energy use.

For post-Kyoto (after 2012), it will be necessary to include the nuclear option in the clean development mechanism and to bring in the developing countries as participants.

As far as proliferation resistance is concerned, science can play a role but alone cannot solve the problem. Politicians must be called upon to produce and enforce binding agreements to address this issue. IAEA's safeguards at their present size cannot cope with a considerable increase in nuclear power production worldwide.

The objective of Session 2 was to discuss how the principles of nuclear science have helped in the analysis and understanding of various materials.

Advanced materials and technologies are a direct result of basic science. The improved performance of the present generation of nuclear reactors is an outcome of advances in materials. More will have to be done since some advanced Generation IV reactors are beyond the capabilities of current materials. Higher operating temperature, higher fuel burn-up and structural integrity at higher fluence all require development of new materials in meeting the exacting requirements of nuclear systems comprising fuels, structural materials, moderators and coolants. The development of new fuels that can contain the minor actinides, which create the biggest waste disposal problems, is of the highest priority. A closed fuel cycle will enable a considerable reduction of the burden of long lived radioactive waste.

Radiation sources, including accelerators, are important in such diverse fields as industrial processes, agriculture and health care. Many technologies in these fields, such as the sterile insect technology and mutation plant breeding, are supported by the IAEA. New radiation applications are being developed based on reliable accelerators that are commercially available at reasonable prices.

Charged particle accelerators are playing an increasing role in industry and medicine. Neutrons produced with a high power proton accelerator are used for basic research and industrial radiography. They may also play a role in transmutation of highly radioactive fission products. Neutron radiography is complementary to x-ray tomography as neutrons can penetrate deeper into heavy materials.

Accelerator Mass Spectroscopy is an extremely sensitive method to detect trace materials and has applications in nuclear non-proliferation, climate research, archaeology and even in the food industry.

Nuclear measurements are essential for IAEA safeguards programme. The science and technology have made considerable progress, and this area is an attractive field for young scientists and engineers. The trend in nuclear measurements is towards higher detection efficiency and capability to measure short-lived isotopes in very low quantities. Specific methods like laser technology open new and innovative areas of fundamental science and applications within this realm.

For long-term benefits to IAEA programs, cooperation with universities and research institutes should be strengthened. Collaboration of nuclear centres with universities also increases the potential for collaboration with students from developing countries.

This session concluded with a presentation on the International Nuclear information System (INIS).

The third session on Radiation Medicine discussed the use of ionising radiation for the diagnosis and treatment of diseases such as cancer. There have been significant advances in diagnostic imaging to visualise tumours in 3-dimensions and more recently, in functional imaging to localise the disease more precisely. At the same time, there have been advances in cancer treatment

delivery that promise gains in therapeutic effectiveness as a consequence of escalating the dose to the precisely known location of the tumour. However, the lack of sufficient numbers of well-trained medical physicists in various regions of the world may prevent the transfer of high technology advances to developing countries resulting in a technology gap.

The first presentation concentrated on the impact of physics solutions to imaging for improved radiotherapy. 45% of cancer patients can be cured and of the 55%, for whom treatment fails, 18% are because of failure of local control and this could be improved. The integration of cross-sectional, anatomical and functional imaging into real-time radiotherapy was stressed. The techniques used include computed tomography, magnetic resonance imaging and positron emission tomography. Following the movement of the tumour in space and time using gated radiotherapy and other techniques such as biological profiling using MR spectroscopy within the treatment plan, can avoid irradiating healthy tissue and thus reduce complications.

The second presentation discussed better targeting of therapy and stressed that intensity modulated radiotherapy (IMRT) had enabled dose sculpting in 3D. Conformal avoidance radiotherapy avoids irradiation of normal tissue and the treatments can be more cost-effective. IMRT and tomotherapy can shorten treatment times, can be less expensive to deliver and will reduce the number of tumour recurrences.

The third presentation explained the role of medical physicists and the training they need to fulfil this role. Eight years after the setting up of the graduate programme in Mexico, 25 % of the clinically based medical physicists now have Master degrees, a qualification necessary to practice appropriately.

The fourth presentation demonstrated the effectiveness of concentrating research resources around a centre of excellence. Combining nuclear science with biotechnology has enabled Cuba to develop drugs, vaccines, therapeutics and diagnostics culminating in an FDA licence for a specific cancer vaccine. The link between isotope production and radiopharmaceuticals is clearly beneficial.

The panel discussion focused on the importance of regulatory needs for sustaining the use of radiotherapy equipment. A further point of major concern was in having access to trained staff in all the necessary disciplines. Various collaborative methods were proposed and one suggestion, to avoid brain drain, was to provide regional centres of excellence with on-site training, possibly

with an Agency Professorial Chair to support this. The lack of recognition of Medical Physics as a profession was also highlighted and the Agency is addressing this issue.

It was also pointed out that although the sophisticated new combined imaging and treatment systems could improve the treatment of about 15 % of cancers, the older, more established, less expensive techniques could be used with great effect especially in countries where 70 % of cancers are not currently treated at all. It was agreed that having sophisticated equipment in place without trained staff is futile.

This session concluded with a presentation on the Agency's Programme of Action for Cancer Therapy (PACT), which is open to all Member States.

A precondition for continuing reliance on nuclear power, is assurance of nuclear safety. The fourth session explored various dimensions of this imperative.

The global nuclear safety regime provides the framework for nuclear safety. The international component of that regime should be strengthened by establishing a more effective network for sharing operating experience, undertaking further modification of IAEA safety standards to provide more complete guidance, enhancing safety culture, strengthening practices under the Nuclear Safety Convention, and undertaking multinational design review programs for new reactors. A fully engaged and informed regulator is essential.

The public perception of the risk of nuclear power must be directly addressed. This requires efforts to reach out to the public and to address their concerns candidly and completely. Operators and regulators have the obligation to achieve transparency in order to alleviate public concerns.

The particular importance of safety culture was emphasized. It is not possible to develop a comprehensive indicator of safety culture, but its achievement is of singular importance. Chief among its characteristics is the recognition that nuclear safety is the prime responsibility of those who own and operate nuclear plants.

The achievement of safety requires focused consideration of the management of technical knowledge. This includes the encouragement of the flow of information from countries that are sophisticated on nuclear operations to those that are just developing nuclear power capabilities. In this connection there is a need for an experienced and accomplished workforce.

There also is an opportunity to learn from past accidents, including those in other industries. Critical lessons include the need for sincere and committed leadership in making safety the highest priority, in encouraging continuing communication and learning, and encouraging alertness to organizational drift.

The session emphasized the critical importance of encouraging nuclear safety in the years ahead. Even with many decades of experience, we still have much to learn.

The scientific community greatly appreciates the IAEA initiative to organize this Scientific Forum on Nuclear Science: Physics Helping the World. It allowed very fruitful discussions and provided opportunities to share new ideas, to learn from each other and to forge new collaboration. The meeting showed that large progresses have been made in advancing nuclear science, but much needs to be done. Therefore, it is important for all countries to work together to realize the potential of nuclear science in addressing human needs.