ARCHIVE EDITION OF

IRPS BULLETIN

Volume 18 No 1 August, 2004

Office Bearers : 2003 - 2006

Editorial	President's Report
Reports from Regional Vice Presidents	Reports from Members

Obituaries

New Members and Address Changes

Return to Archive Home Page

OFFICE BEARERS : 2003 - 2006

President:

R.H. Pratt
Dept. of Physics
Univ Pittsburgh, PA
15260 USA

Secretariat:

D.A. Bradley
School of Physics,
University of Exeter
Stocker Road
Exeter EX4 4QL UK

Treasurer:

A. Ljubicic
Rudjer Boskovic Institute
Bijenicka 54
Zagreb 41000 Croatia

Chair, Advisory Board

M.J. Cooper
Department of Physics
University of Warwick
Coventry CV4 7AL U.K.

Regional Vice Presidents:

North America:
J. Hubbell (USA)

South and Central America:

A. Paschoa (Brazil)

Africa and Middle East:

D.T.L. Jones (South Africa)

East Europe
L. Musilek (Czech Republic)

F.S.U
A.V. Korol (Russia)

Western Europe:

M.J. Farquharson (U. K.)

S.E. Asia :

S.C. Roy (India)

Australasia :
D.C. Creagh (Australia)

North East Asia:

Luo Zhengming (PR China)

Executive Councillors:

P. Bergstrom (U.S.A.)

L. Gerward (Denmark)

J.E. Fernandez (Italy)

R.T. Mainardi (Argentina)

J. O'Meara (Canada)

K. Singh Thind (India)

D. McLean (Australia)

T. Nakamura (Japan)

EDITORIAL BOARD

Editor : P.M. Bergstrom (U.S.A.)
Editorial Committee : D.C. Creagh (Australia) S.A. McKeown (Australia)

Home Page

EDITORIAL **Paul Bergstrom**

This issue begins our new volume and is blessed with a wealth of contributions. I highly encourage the members of the Society to write and contribute such pieces. It is through these articles that the rest of the society can become familiar with how Radiation Physics is practiced in your neighborhood.

Professor Richard Pratt contributes his first column as President of the Society to us. Additionally, two of our regional Vice Presidents, Dr Suprakash Roy and Professor Anselmo Paschoa have written and forwarded a number of contributions that reflect the intellectual richness of our field in India and in South America.

Regrettably, two influential figures of the IRPS have recently passed away. Professor Ananda Ghose, one of our two Lifetime Honorary Members, and Dr. Dan Beninson, IRPS President from 1991-1994. Their obituaries are given in this issue

Home Page | Next

PRESIDENT'S COLUMN

As the new President of IRPS, let me summarize in this first column my remarks at the General Membership Meeting of the Society held as part of ISRP-9 in Cape Town last November.

As is stated in its Constitution, the primary purpose of the IRPS is "to promote the global exchange and integration of scientific information regarding the interdisciplinary subject of radiation physics". I will hope to work with you toward those ends in my three years as President.

Let me begin by thanking Dan Jones, the organizer of ISRP-9 in Cape Town, as well as all his colleagues and associates, for their efforts and hard work in making ISRP-9 such a success, both professionally and in the introduction it gave us to South Africa. We should also thank Malcolm Cooper and Dudley Creagh, the Program Chairs, for their work and success in achieving a very fine program. And I want to also thank all the participants, for their contributions and their enthusiasm, making the Symposium a very fine experience for everyone.

We will now be looking forward to ISRP-10, to be held in Coimbra, Portugal September 18-22, 2006. The organizers will be Margerida Costa and Isabel Lopes, who are already beginning planning for the meeting. We will be hearing more from them in the coming months. (For your information, it has just been decided that ISRP-11 will be in Melbourne, Australia in 2009, organized by Chris Chantler.)

The Society has a proud tradition in its sequence of Symposia, and we should recognize the outstanding efforts of the organizers, from the beginning in Calcutta in 1974 organized by Ananda Ghose, ISRP-2 (Penang, 1982, Ananda Ghose), ISRP-3 (Ferrara, 1985, Ernesto Casnati), ISRP-4 (Sao Paulo, 1988, Ivan Nascimento), ISRP-5 (Dubrovnik, 1991, Ante Ljubicic), ISRP-6 (Rabat, 1994, Mohamed Berrada), ISRP-7 (Jaipur, 1997, Bikash Sinha), ISRP-8 (Prague, 2000, Ladislav Musilek).

Let me next thank Malcolm Cooper, who has just finished his three year term as President of the IRPS, for his strong and continuing efforts on behalf of the Society. We will look forward to further working with him as he now becomes Chair of the Advisory Board of the Society. We should also recognize his illustrious predecessors as President, for all their work on behalf of the Society, beginning with our Founding President, P. K. Iyengar of India (who served two terms 1985-1991), the late Dan Beninson of Argentina (1991-1994), John Hubbell of the USA (1994-1997), and Bikash Sinha of India (1997-2000).

Finally, let me acknowledge and thank John Hubbell and the late Ananda Ghose, widely recognized as responsible for the conception and creation of the IRPS. As stated in the minutes of the June 14, 2002 IRPS Council meeting in Bologna: "The Council approved the award of honorary life memberships in IRPS to Ananda Mohan Ghose and John Hubbell, recognizing their pivotal role in developments and progress in radiation physics over many decades, and their role in the foundation of the IRPS." Ghose and Hubbell are the only individuals who have been so designated.

But now we should turn to the future. We welcome our new members, and we hope you will find your membership helping to open opportunities. We encourage our existing members both to be active in the affairs of the Society, and to recruit more members. Our purpose is to promote the global exchange and integration of information regarding radiation physics. How can a member do that? A more senior member may already have the international contacts and interests and be ready to proceed. If so, keep us informed as to what you are trying to do, try to come to some Council meetings, and allow the Society to try to suggest further contacts and approaches. A new member may start with interests and activities in his/her own country, and from them begin to make international contacts. Again, keep the Society informed (contact any of the officers or Council), and we can try to provide suggestions and other assistance.

Please also contact me if you have other ideas as to how to make the Society more useful, in fulfilling its objectives and in helping its members. I can be reached at rpratt@pitt.edu . I'll look forward to hearing from you. Best wishes for the year ahead!

Richard Pratt

Previous | Home Page | Next

REPORTS FROM REGIONAL VICE PRESIDENTS

Report by Suprakash Roy, Regional Vice President, South East Asia

Report by Anselmo Paschoa, Regional Vice President, South and Central America

Previous | Home Page | Next

REPORTS FROM MEMBERS

Kulwant Singh Thind : Research Activities in Radiation Physics,
Department of Physics,
Guru Nanak Dev University, Amritsar, India

Anselmo S Paschoa : Radiological Impact Due to Oil and Gas Extraction

Previous | Home Page | Next

OBITUARIES

Professor Dr Ananda Mohan "Anu" Ghose

Dr Dan J Beninson

Previous | Home Page | Next

NEW MEMBERS and ADDRESS CHANGES

Welcome to New Members :

Prof David D. Cohen, Australia

Dr R Figueroa, Chile

Mr Kresimir Jakovcic, Croatia

Prof Syed M. Qaim, Germany

Ms Rupa Sarkar, India

Mr Michael Josiah Mangala, Kenya

Mr Nagi A. Hussein, Malaysia

Prof. Hassane Erramli, Morocco

Dr Christopher Mayaki, Nigeria

Dr Folorundso O. Ogundare, Nigeria

Dr Olusola I. Okunade, Nigeria

Mr Joao S. Barata, Portugal

Prof A.N. Conde, Portugal

Mr Benjamin Nyarko, Ghana

Dr Dmitry A. Kovalev, Russia

Dr Eugene A. Shikanov, Russia

Ms Mary Assiamah, South Africa

Mr Andy Buffler, South Africa

Dr Given G. K. Mabala, South Africa

Mr Risimati D. Mavunda, South Africa

Mr Tshepp Ntsoane, South Africa

Mr Dawid De Villiers, South Africa

Prof Klas Malmqvist, Sweden

Prof Jason Lee, Taiwan

Dr Orhan Gurler, Turkey

Dr Sezai Yalcin, Turkey

Ms Layla Mohammed Ali, U.K.

Mr Michael P Shannon, U.S.A.

Prof Herman Winick, U.S.A.

New Members' addresses are listed in the Contact Members' Details (click on country next to name)

Previous	Home Page

Report from Regional Vice President South East Asia

SUPRAKASH ROY

Dear Readers,

As was decided in the last Council meeting, all regional Vice-Presidents of the IRPS are responsible for reporting on the Radiation Physics activities of his/her region periodically in the IRPS Newsletter.

I welcomed the decision because this will help our members learn about what is being done and what will be done in future on radiation physics globally, without realizing how hard this task is going to be. Presumably noting my enthusiasm the Council decided to start this section with me.

I have been told to submit a report for this issue of the newsletter. While I was preparing the report on my own, following the preachings of the great Indian poet Rabindranath Tagore,

> ***"If no one answers your call walk alone.***
> ***Walk alone, walk alone, and walk alone.***
> ***If none talk to you, O you luckless,***
> ***If all are fearful and turn their faces,***
> ***Be outspoken and speak your mind***
> ***All by yourself to all mankind."***

I received some materials from Dr. Kulwant Singh Thind, which are included in the Reports from Members.

(For those uninitiated, Rabindranath Tagore was the first Indian and first non-European to receive the Nobel Prize in literature in 1913).

I am sure readers of the Newsletter will get a glimpse of what has been happening in this part of the world on radiation physics and also the activities at one of the youngest universities of India.

Enjoy!

Suprakash Roy

* * * * *

Indo-US Workshop in Radiation Physics: New Directions in the Study of Interaction of Energetic Photons with Matter

The above workshop was held at North Bengal University and a part in Darjeeling during March 22-27, 2004, under the auspices of the Department of Science and Technology (DST), Govt. of India from the Indian side and National Science Foundation (NSF) from the US side. Prof. Swapan K. Sengupta, presently at Jalpaiguri Engineering College, is the Principal Investigator from the Indian side and Prof. Richard H. Pratt of the University of Pittsburgh is the Principal Investigator from the US side. After its inauguration at North Bengal University with some pedagogical lectures on some important topics of Radiation Physics (primarily for the benefits of graduate and post graduate students of that region), the workshop shifted to a more serene atmosphere at the foothills of the Himalayas, a place known as Darjeeling, for more rigorous and vigorous discussions. It is to be noted in this connection that a similar workshop was organised by the duo in 1996.

The primary objective of the present Workshop was to identify and initiate joint activities within this research community, responding to the opportunities of the new synchrotron facilities and other technologies, which are of fundamental interest and importance. The Workshop sought to achieve consensus on what has been accomplished, what needs to be accomplished, and what opportunities are provided by the new technologies, in this very modern field of the interaction of energetic photons with matter. All fundamental interaction mechanisms of photons with matter were considered both from an experimental and from a theoretical perspective, and in each case asking what new and fundamental insights can be anticipated. An important outcome of the Workshop will be a report summarizing these directions and opportunities, which hopefully will provide guidance to the research community in the years ahead. We hope that Indian and US scientists who interacted freely will be able to identify problems of mutual interest, and submit joint proposals in this area of Atomic Physics.

Indo-US Collaborative Programme.

This is not outsourcing. An Indo-US collaborative programme on "Investigations on theoretical aspects of Compton scattering" is under active consideration for support by the DST, Govt. of India on the Indian side and NSF on the US side. This programme has been proposed jointly by Bose Institute, India and University of Pittsburgh, USA. The idea was concieved during the Indo-US Workshop on Radiation Physics held at Argonne National Laboratory last May (organised by Prof. S.C. Roy of Bose Institute, India and Dr. Linda Young of Argonne National Laboratory, USA). If approved, this will be the second such programme between Bose Institute and University of Pittsburgh.

Proceedings of the Indo-US Workshop on Radiation Physics using Synchrotrons and other New Sources.

Proceedings of the above workshop were published in the July/August, 2004 issue of Radiation Physics and Chemistry (Volume 70, Issues 4-5). Those who missed attending the workshop and those who are interested to learn all about the workshop may look at the special issue of the Radiation Physics and Chemistry (Guest Editors: Suprakash Roy and Linda Young).

National Workshop on Radiochemistry and Applications of Radioisotopes

The 51st National Workshop on Radiochemistry and Applications of Radioisotopes was organized from November 10-17, 2003 in the Department of Physics, Guru Nanak Dev University, Amritsar from November 10-17, 2003. About 40 students from various colleges of Punjab State and universities participated in the workshop. The workshop was grouped into theory and practical sessions. In theory sessions, lectures on :

(i) introduction to radioactivity

(ii) nuclear structure and stability

(iii) interaction of radiation with matter

(iv) radiation detection

(v) nuclear reactors

(vi) introduction to radiation chemistry

(vii) application of radioisotopes in medicine, and

(viii) health and safety

were delivered by eminent scientists from different parts of India. In practical sessions, stress was given to the detection of beta particles and gamma radiations with G.M. counter and Scintillation counter, radio immuno-assay, Isotope dilution analysis and separation of Thorium -234 from Uranium. In order to familiarize the M.Sc students with the radiation detection and applications of radioisotopes, a one day lecture and practical session was also arranged in D.A.V College Jalandhar and D.A.V. College Amritsar.

Radiation Physics Research in Guru Nanak Dev University, Amritsar, India

Guru Nanak Dev University was founded in 1969 to commemorate the quincentenary of Guru Nanak Dev (1469- 1539), the founder of the Sikh religion. The university is located in Amritsar, the city famous for its golden temple. The university is one of the youngest universities of the nation, but it has already shown promise. The university is known for its teaching and research activities on radiation physics leading to Ph.D. degrees. It is to be noted that one of the newly elected Council members of the IRPS, Prof. Kulwant Singh Thind belongs to this university.

Research activities covered both theoretical and practical aspects of the subject, which include research on the following specific areas:

- Radiation Damage Studies in Solids using solid state nuclear track detectors (SSNTD);
- Environmental Studies involving uranium exploration and environmental radon pollution in Himachal and Uttar Pradesh Himalayas;
- Nuclear Spectroscopy;
- Basic Interactions of Photons with composite materials, glasses, liquids and ionic solutions;
- Nuclear Chemistry primarily to investigate the interplay between the oxidation states of Ag and Cd and its coordination geometry in proteins using perturbed angular correlation technique.

Return to Regional Vice President Reports

Previous | Home Page | Next

Report from Regional Vice President South and Central Americas

Anselmo Paschoa

- The largest scientific meeting in South America this year was the 56th Annual Meeting of the SBPC (the Brazilian Society for Advancement of Science) held in the University of Mato Grosso, Brazil, 18 - 23 July, 2004. The central topic of this year's meeting was Frontiers in Science: Ethics and development.

  Further information on the SBPC Annual Meeting can be found, in Portuguese, in the site

  http://www.sbpcnet.org.br/eventos/56ra

- The 7th Latin-American Conference on Space Geophysics (VII COLAGE): Space Sciences for the XXI Century was held in Atibaia, Sao Paulo, Brazil, 29 March - 2 April, 2004.

  The Latin America Conference on Space Geophysics aims to promote scientific interactions between scientists and students in Latin America interested in the study of Space Geophysics. The site to obtain further information on the VII COLAGE is

  http://www.cea.inpe.br/colage

Return to Regional Vice President Reports

Previous | Home Page | Next

Research Activities in Radiation Physics, Department of Physics, Guru Nanak Dev University, Amritsar, India

Kulwant SinghThind

Professor, Department of Physics,
Guru Nanak Dev University, Amritsar, India

This Physics Department is one of the youngest departments in the region. However, it has created a niche for itself by virtue of diversification and of innovative programmes in both teaching as well as research.

The Radiation Physics Group in the Physics Department has acquired sophisticated instruments such as Multi-Channel Analyzers, HPGe and Si (Li) Detectors, Angular Correlation setup etc. The research activities leading to the Ph.D. are carried out in the major thrust areas such as Radiation Physics, Nuclear Spectroscopy, Nuclear Structure, Solid and State Nuclear Track Detectors.

Despite limited financial and other resources available, the department has made commendable progress in both teaching and research. Teaching and research activities in Radiation Physics is carried out in the following sub-areas.

A. Radiation Damage Studies in Solids and Applications

Radiation damage studies in Solid State Nuclear Track Detectors (SSNTDs) have been one of the major thrust areas of research in the department. Extensive work has been done on the application of SSNTDs in nuclear physics and earth sciences. Etching and annealing studies using high energy fission fragments and heavy ions have been completed on different crystallographic directions of natural minerals. Some corrections of anisotropic fission track ages in crystalline minerals are suggested. The relationship between the reduction in fission track diameter and the reduction in aerial track density in hydrated glass have been investigated under varying annealing and etching conditions. A near one-to-one relationship is observed for adequately etched tracks. The group is also engaged in a new field with potential applications in material science viz.; ion track filters and heavy ion radiation effect in insulators.

A significant contribution in the field of geochronology, geochemical exploration of uranium, radiation dosimetry, radiation damage in solids, earthquake prediction studies, ion beam modification of materials and ion track filters has been made. Inter-laboratory calibration of glass dosimeters has been achieved. The single activation energy model proposed by the group is a unique contribution with universal application and acceptance for the study of radiation damage in dielectrics / insulators.

B. Environmental Studies

The group is also engaged in uranium exploration and environmental radon pollution studies in Himachal and Uttar Pradesh Himalayas using nuclear geophysical techniques. The aim of the work is to locate uranium prospects in Himalayas and to measure the level of radon from the health hazard point of view. The efforts are also being made to measure the level of radium in soil, water and rocks in addition to uranium and radon. The laboratory studies regarding radon diffusion in soil are also being carried out. Concentrations of radon and thoron daughter products have been determined by the use of direct beta counting of filtered air samples. An air- sucking head was designed for use in sampling of air on a glass microfiber filter. Defined Solid Angle Absolute Beta Counting (DSAABC) method was employed to determine the absolute air concentration of radon daughter products and a computer programme was developed to suit the particulars of our set up. The investigations are also in progress to study mitigation materials which may be used to attenuate radon emanating from soil and building materials in dwellings. The work is also being carried out for correlating radon anomalies with the seismic events at Amritsar. Ongoing projects involve geothermobarometry and geochemical investigations of granitoids of Himalayas to evolve a model for their origin. The department is in a position to carry out various geophysical exploration work in gravity, magnetic and groundwater related research.

C. Nuclear Spectroscopy

Some aspects of the nucleus such as energies and intensities of gamma ray transitions, conversion coefficients, level schemes, level characteristics such as electric and magnetic moments and transition multipolarities are studied by applying nuclear techniques e.g. directional correlation and sum peak methods. Intensity ratios of photons emitted from some of radioactive nuclides which are known to vary with environmental conditions under which the sources are placed, are observed by applying Sum Peak method. This method is also used to study K-capture probabilities to various levels and atomic fluorescence yield of elements with single detector. This technique has also been applied to measure Nuclear Quadrupole Interaction (NQI) parameters in different inorganic compounds of ^{111}Ag, ^{160}Tb, and ^{133}Ba biological complexes and its detection between the nucleus and its local surroundings. The results obtained are checked with theoretical results predicted by Angular Overlap Model (AOM).

D. Basic Interactions

The group is working extensively on interaction of photons with composite materials like soils, cements, biological samples etc. The parameters like absorption coefficients, mass energy absorption coefficients, effective atomic numbers, atomic cross sections of shielding materials and of biologically important substances in aqueous solutions are determined by the application of transmission method. The sphere transmission method for the direct measurement of mass energy absorption coefficients is used in the Department of Physics. In case of interaction of photons with dilute solutions of salts in water, some new aspects on sample characteristics has been introduced. The results provide a base to study the interactions of photons with the solvated (hydrated ions) rather than bare ions in the solid form. Multiple scattering of gamma rays in composite materials such as water, concrete and sand is also studied for better understanding of the process of transport and energy degradation of a primary photon. From the comparison of shielding properties of materials it has been proven that glasses have a potential applications as transparent radiation shielding.

E. Nuclear Chemistry

The small electron transporting copper protein, Azurin has been studied in order to investigate the interplay between the oxidation states of the metal and its co-ordination geometry. The results show that the metal co-ordination geometry for Ag (I) in Ag (I) substituted wild type azurin is only slightly different from the geometry for Cd (I) in cadmium substituted azurin both being similar to the geometry for copper in native azurin. These results were obtained by perturbed angular correlation of gamma ray spectroscopy using two radioactive isotopes ^{111}Ag and ^{111m}Cd (II) as probes of a monovalent and a divalent ion respectively. It is suggested that the role of Met 121 is to maintain the rigid tri co-ordinated metal co-ordination geometry independent of the oxidation state of the metal. The structural details of the metal site in the [His 121} azurin mutant from Alcaligenes denitrification where the axial methionine has been replaced by a histidine has also been studied after substitution with the divalent cadmium ion and the monovalent silver ion by the application of perturbed angular correlation technique.

F. Study of Glass Materials

The study of absorption of gamma radiations in shielding materials has been an important subject in the field of radiation physics and is potentially useful in the development of semi-empirical formulations. In view of the significant importance of the study of effective atomic numbers of materials and various applications in science, technology and human health, the attenuation coefficients, cross sections and effective atomic numbers of a variety of glasses with varying elemental composition are determined by applying gamma transmission and Compton scattering technique in which Compton scattered photons will be detected only at 90 . In order to determine the mass attenuation coefficients, effective atomic numbers (Z_{eff}), interaction cross sections and effective electron densities of various glasses of the type[x M - (1-x) B_2O_3 where M = Bi_2O_3, PbO, CdO, BaO, CaO and x is the mole fraction and x ZnO - 2x PbO - (1-3x) B_2O_3] at different photon energies gamma ray transmission method is being investigated.

G. Glasses Containing Fly ash

Fly ash has emerged from the realms of a waste to that of a resource and is being utilized to an ever-increasing extent in applications as diverse as building and construction, environment rehabilitation, waste management and polymers. Despite this, the value of fly ash as a resource is still underestimated as its large quantity is being dumped in slurry form in large areas close to power plants without being put to gainful use. Knowledge of the needs in the market-place and the symbiotic relation between research and product development is paramount in creating the new opportunities for fly ash and is a challenge to the research community. The main component in the chemical composition of fly ash is SiO_2 with Al_2O_3 and Fe_2O_3 being the second major components. The other components of fly ash are CaO, MgO, K_2O, $Na_2O$and unburnt carbon particles. Samples of bismuth borate glasses (Bi_2O_3 + B_2O_3) containing different amounts of fly ash are prepared by melt-quenching technique. In addition to this, bricks of fly ash have also been prepared in the laboratory which are found to have large mechanical strength.

Return to Reports from Members

Radiological Impact Due to Oil and Gas Extraction *

Anselmo S Paschoa

Professor of Radiation Physics,
Pontifical Catholic University of Rio de Janeiro (PUC-Rio)

* This article was originally published in ***Business Briefing : Exploration and Production : Oil and Gas Review 2003***
by Business Briefings Ltd., London

Introduction

The occupational exposures to technologically enhanced natural occurring radionuclides (TENORM) in the oil and gas industries have been well documented for over two decades.[1-3] In 1996, the International Atomic Energy Agency (IAEA) adopted the International Commission on Radiological Protection (ICRP) recommendations, which were based on the principles of justification, dose limitation, and optimization.[4,5] These recommendations should be applied to workers of any industry, including oil and gas extraction and processing, if the exposure scenarios to TENORM are likely to exceed 1 $mSv.y^{-1}$.

Today, there is a great deal of knowledge on the problems involving TENORM in the oil and gas industries. However, exceptions made to the European Union (EU) legislation, and the National Academy of Sciences - National Research Council (NAS-NRC) guidelines, norms and rules dealing specifically with TENORM, are still limited.[6 - 8]

In some countries with small but well-organized oil and gas-extracting procedures, for example Australia, complex assessments were performed in oil-producing and processing installations. In countries with large oil and gas industries, and a complex legal infrastructure, for example the US, self-regulation was needed to face systematic unfavorable judicial decisions in the last decade. In Europe, the EURATOM Radiation Basic Safety Standards (EURATOM BSS) make the following recommendations.[6]

- It is the responsibility of the Member State to identify all those workplaces where handling of material with increased TENORM could occur.
- In such cases, appropriate measures should be taken in terms of monitoring and/or reduction of the TENORM-induced radiation exposure.
- The threshold for mandatory action is set at 1 $mSv.y^{-1}$.
- The activity concentration of naturally occurring radioactive material in non-nuclear industry waste should not exceed 500 $Bq.g^{-1}$.
- If the limit of 500 $Bq.g^{-1}$ is exceeded, a Member State can exempt this type of activity only if the individual annual dose of 10 μSv, irrespective of the collective dose of 1 man-Sv is not exceeded. An alternative approach can be the demonstration that the exemption is indeed the optimum solution in terms of radiation protection, for example by applying an optimization process.

The oil and gas extraction industry in Europe is subject to Radiation Protection 95 because it processes materials with enhanced levels of naturally occurring radionuclides in workplaces.[7] A group of experts, established under the EUROATOM Treaty, proposed a four band-system with marker points between each two of them for regulatory control above the limit of 1 $mSv.y^{-1}$. As far as regulatory control is concerned, the band structure is as follows:

- band 1 - no need for regulatory control (below an exemption level);
- band 2 - lower level of regulation;
- band 3 - higher level of regulation; and
- band 4 - not to be permitted without full individual assessment.

Taking into account the identified pathways for each case, screening and reference levels were derived to indicate the likely level of regulation for the radionuclides of concern to the relevant industries. Thus, for example, if the derived screening and reference level put the industrial process in band 1, there would be no need for regulatory control. However, if the derived level placed the industrial process above band 1, control measures would be applied, or the process should receive individual assessment prior to deciding which control measures to adopt.[7]

Public awareness of environmental issues is increasing worldwide. At the same time, the recycling industry is supplied more and more with metal originating from the dismantling of installations in the oil and gas industry. Such material is frequently contaminated by natural radioactive nuclides from the uranium (U) and thorium (Th) decay series, including ^{238}U, ^{235}U, ^{232}Th, ^{236}Ra, ^{228}Ra and ^{210}Pb. The contamination of the equipment results mainly from:[9]

- solid radium (^{226}Ra) contained in scales deposited on the inner surface of pipes, vessels and tanks;
- gaseous radon (^{222}Rn) concentrated in ethane and propane fractions due to the fact that the boiling point of radon lies in-between those of propane and ethane. Elevated Rn activity concentration values have been measured at several processing plant sites; and
- short-lived Rn decay products deposited on the internal surfaces of various equipment components. This radioactive decay results in radioactive contamination by the long-lived radioactive lead isotope ^{210}Pb ($T_{½}$ = 22.3 y) and the growth of the alpha-emitting polonium isotope ^{210}Po ($T_{½}$ = 138 d).

The ultimate origin of the radionuclides which contaminate pipes, pumps, and other equipment components used in the oil and gas industry is still a matter of debate. However, it has been suggested that there may be a correlation between the age of oil and the concentration of ^{238}U and ^{232}Th found in the organic materials from which the petroleum originated.[10] Experimental work to confirm such association is still to be done.

Only a crude estimate can be made of the annual total ^{226}Ra activity transferred from oil reservoirs to the surface. A United States Environmental Protection Agency (US EPA) study of 10 oil production wells analysed scale and sludge production rates.[11] The amount estimated was about 250 m^3 for a period of 20 years. The resulting amount of waste generated by one oil-producing well per year is about 2.25 tons, using a waste density of 1.8 $tonnes.m^{-3}$. In order to derive an average ^{226}Ra activity concentration, the same study used results of a large number of external gamma readings (6,274) taken in several oil production facilities and converted these to the activity concentration. There is a significant uncertainty attached to such a procedure because of the effects of equipment wall thickness, self-absorption of the radiation in the scale, thickness of the scale, and distribution of radium within the scale. The published average radium concentration was 4.6Bq g^{-1}. Hence, the resulting estimate of total ^{226}Ra activity brought to the surface is 918GBq per year. Similar studies are due to be undertaken in oil and gas-extracting facilities in other parts of the world, so an average ^{226}Ra activity brought to the surface per year can be derived with a degree of certainty.

Radiological Impact

A comprehensive international database on exposure scenarios in the oil and gas industry is still lacking. However, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has published a great deal of data on TENORM from several industries. Data on typical ^{222}Rn and ^{238}U series concentrations (or range) in the oil and gas extration are summarized in ***Table 1***.

It can be seen that the ^{222}Rn concentrations listed in ***Table 1*** though high, are not as high as the maximum values reported in the UNSCEAR report, which reach values of the order of 10kBq $^{222}Rn.m^{-3}$. However, at some processing plants, the ^{222}Rn flow rate (in GBq per day) ranges from 0.82 ± 0.01 to 6.2 ± 0.5 at the inlet, and 0.76 ± 0.01 to 6.0 ± 0.6 at the outlet.

Large amounts of brines (estimated to be around 10^8 to 10^9 tons per year) are raised to the surface as an unwanted by-product of oil and gas extraction procedures. As a consequence, increased exposure to external gamma radiation can occur in the vicinity of vessels and tanks filled with such brines. In addition, maintenance operations on scale-contaminated process equipment can generate undesirably high dust levels in the breathing area of workers.[13]

Table 1 : Typical ^{222}Rn and ^{238}U Series Concentrations (or Range) in Oil and Gas Extraction

Type of Material	Typical Concentration or Range	Reference
Gas samples near well-heads	*0.5kBq $^{222}Rn.m^{-3}$*	*12*
Ore/raw material	*0.34kBq $^{222}Rn.m^{-3}$*	*13 (UNSCEAR)*
Scales	*1 - 1000kBq ^{238}U series.kg^{-3}*	*13 (UNSCEAR)*
Production water	*8 - 43kBq ^{238}U series.m^{-3}*	*13 (UNSCEAR)*

Table 2 : Range of Typical Activity Concentration Values for ^{226}Ra in Brines and Scale from the Gas and Oil Industry

By-Product	Range of ^{226}Ra Concentration
Brines	*7.6 - 286kBq.m^{-3}*
Scale on equipment	*0.2 - 1.0kBq.kg^{-1}*

Data taken from Reference 13

Such operations occur during sand-blasting of the inside of tanks, opening of valves for repair purposes and the brushing of surfaces for grinding metal. Scales contain the following radionuclides (maximum values in $Bq.g^{-1}$ are within parenthesis): ^{226}Ra (1,000), ^{210}Pb (72), ^{228}Ra (360), ^{228}Th (360).[17] The range of typical values in brines and scale is shown in ***Table 2***.

The long half-life of ^{226}Ra (i.e., $T_{½}$ ^{226}Ra = 1,600 years) in association of the disposal of large amounts of contaminated brine and scale wastes resulting from oil and gas extraction and processing can pose an environmental problem for current and future generations if environmental regulatory controls are not be enforced.

The main TENORM exposure pathways to humans may be either by inhalation of ^{222}Rn, or by ingestion of food contaminated by ^{226}Ra. The studies of the areas with elevated natural radioactivity may provide a link between the environmental behaviour of the natural radionuclides in the biosphere and TENORM, as far as exposure to humans is concerned.[15]

Occupational doses

In many oil and gas extraction and processing plants, radiation exposure during maintenance and operations is not yet recorded routinely. Therefore, there is a scarcity of statistically significant process-related data characterising the radiological impact on humans and the environment from the TENORM in these industries. However, taking into account only the exposure due to external gamma radiation from the radon flow itself at the processing plant assuming a radon flow rate of 6GBq per day (near the maximum value reported here), and an exposure time of 20 hours per week this will result in an annual dose of $0.5mSv.y^{-1}$. Workers exposed to scale-contaminated processes may receive an additional dose due to the inhalation of various long-lived radionuclides.

In order to assess the significance of the TENORM-induced doses, it is useful to compare those with the doses reported in studies of the high-level background areas. On a global scale, the absorbed dose rate in air, including cosmic and terrestrial radiation, ranges from 0.02 to 30 $μGy.h^{-1}$ in the areas of high natural radiation background.[16,17] In the thorium rich areas of Brazil, external exposure radiation levels were reported to range from 0.3 to 13 $μGy.h^{-1}$, consistent with the exposure obtained from worldwide UNSCEAR data on this kind of area.[16,17] Moreover, the age-weighted annual intake effective dose from ingestion of uranium and thorium series radionuclides was estimated to be 160 $μGy.h^{-1}$.

Dose constraints

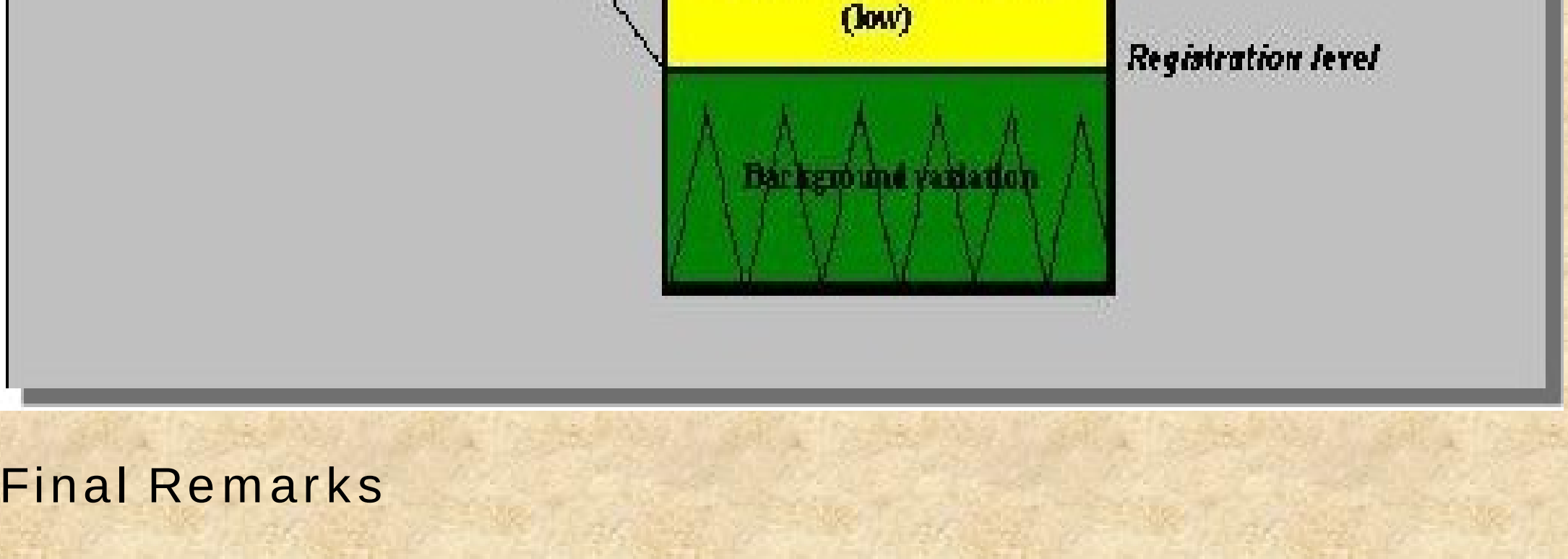
Taking into account appropriate exposure pathways in conjunction with the EURATOM bands system, the screening concentration levels can be established for ^{226}Ra plus progeny for oil and gas removal, scales in pipes, and sludge ranging from 30 to 300$Bq.g^{-1}$. Thus, for concentrations below 30$Bq.g^{-1}$, there would be no need to consider regulatory control, and, above 300$Bq.g^{-1}$, individual assessment would be necessary prior to deciding which control measures to take.

Those screening concentration levels are also in accordance also with the concept favoured by the US National Academy of Sciences National Research Council on Naturally Occurring Radioactive Material, which suggests a relationship between the concentration of radionuclides in the environment, exposure, dose, and resulting risk.[8] The underlying concept assumes cancer mortality, or in some cases cancer incidence (morbidity) as a potential measure of risk due to exposure to radiation. However, in many environmental radiation assessments the endpoint of the assessment is dose rather than cancer risk. In such a case, an assessment of the risk corresponding to a given concentration of various environmental radionuclides can be used instead, or vice versa.

In a further development, secondary levels of dose and derived limits could be adopted, for example for Ra-226 releases, as proposed in ***Figure 1***.

The sequence of dose-related levels and calculated derived limits shown in ***Figure 1*** can be used in decision-making processes involving TENORM. To do so, once a primary dose limit is established, a fraction of this primary dose unit can be chosen after taking into account societal and economical considerations. Thus, if a registration level is established near the highest value of the variation of the natural radioactive background, investigational, intervention, and remedial action levels can be defined above such level. The levels shown in ***Figure 1*** are defined in terms of fractions of a primary dose, but can be implemented practically in terms of units, for example $Bq.m^{-3}$ for water, air, and other gases; $Bq.kg^{-1}$ for pasture, soil, or scrap metals; and $Bq.y^{-1}$ for rates of discharge. Derived limits can be calculated by using environmental models, thereby allowing for a sensitive analysis for ranking the importance of individual model parameters.

Figure 1 : Schematic representation of calculated derived limits (low, nominal and high).
In accordance with parameters used in an environmental model calculation plus
registration, investigation, intervention and remedial action levels in comparison
with the natural radiation background variation.



Final Remarks

There are economically important oil and gas-extracting and processing industries all over the world. Oil is extracted in the Americas, Asia, Europe, including in the republics of the former Soviet Union, and in the Arab countries. The legal regulatory framework concerning oil and gas extraction varies from region to region, and from country to country. However, in most cases, the radiological impact of TENORM in the oil and gas-extracting and processing industry is largely ignored, either because of a too lenient legislation, or due to a lack of specificity in the relevant regulatory framework. It is well known today that the radiological impact of the oil and gas-extracting and processing industry is non-negligible. Two steps should be taken to improve the current situation in most oil-producing countries:

- establish a common basis for the international regulation of TENORM in the oil and gas industry, taking into proper account the natural radioactive background with its spatial and temporal variations, for example, the EURATOM BSS; and
- improve the international database on extraction and production processes in the oil and gas industries, for example in the framework of a co-ordinated research project under the auspices of an well-recognized international organization.

Once such steps are taken, it will be up to the authorities to insert into the national legislations the mechanisms to enforce the regulatory system adopted.

References

1. T F Gesell, ***"Occupational radiation exposure due to ^{222}Rn in natural gas and natural gas products",*** Health Physics, 29, 1975, p. 681.

2. F Steinhäusler, ***"Assessment of the radiation burden to man from the technologically enhanced natural radioactive environment",*** Turkish Atomic Energy Commission, Technical Journal, Vol. 7, No. 2, 1980, pp. 55 - 66.

3. W A Kolb and M Wojcik, ***"Enhanced radioactivity due to natural oil and gas production",*** Proc. 6th Int. IRPA-Congress , 1984, p. 93.

4. International Commission On Radiological Protection (ICRP), ***Recommendations,*** Publication No. 60, Pergamon Press, Oxford 1991.

5. International Atomic Energy Agency (IAEA), ***International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources.*** IAEA Safety Series No. 115 1996.

6. European Commission (EC), Radiation Protection 88: ***Industrial processes concerning with Title VII of the European Union Basic Safety Standards Directive.*** 96/29/Euratom of 13 May 1996, EC Luxemburg 1997.

7. European Commission (EC), ***Radiation Protection 95: Reference levels for workplaces processing materials with enhanced levels of naturally occurring radionuclides.*** EC Luxemburg 1999.

8. B D Goldstein, M Eisenbud, T F Gesell, S A Ibrahim, D C Kocher, E R Landa, and A S Paschoa, ***Evaluation of guidelines for exposures to technologically enhanced naturally occurring radioactive materials,*** National Academy of Sciences - National Research Council (NAS-NRC), National Academy Press, Washington, D.C. 1999, p. 281.

9. F Steinhäusler, A S Paschoa, W Zahorowski, ***"Radiological impact due to oil- and gas extraction processing: A comparative assessment between Asia-Pacific, Europe, and South America"***, In Proceedings of the 10th International Radiation Protection Association Congress, IRPA10, Hiroshima, 1999.

10. A S Paschoa, ***"Naturally occurring radioactive materials (NORM) and petroleum origin"***, Applied Radiation and Isotopes, 48, 1997, pp. 1,391-1,396.

11. Diffuse NORM, ***Waste Characterization and preliminary risk assessment***,. US EPA, Air and Radiation (ANR-460), 1991.

12. W A.Kolb and M Wojcik, ***"Enhanced radioactivity due to natural oil and gas production and related radiological problems"***, Science of the Total Environment, 45, 1985, pp. 77- 84.

13. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), ***"Source and Effects of Ionizing Radiation"***, Report to the General Assembly, Volume I: Sources, United Nations, New York 2000.

14. F Steinhäusler, Proc. 4th European IRPA-Congress, 1988, pp. 130 - 142 .

15. F Steinhäusler, ***"Technologically enhanced natural radiation and the significance to related risks"***, Proc. Int. Conf. "High Levels of Natural Radiation", Ramsar (Iran), 3 - 7 Nov. 1990, pp. 163 - 175.

16. A S Paschoa, ***"More than forty years of studies of natural radioactivity in Brazil"***, Technology, 7, 2000, pp. 193-212.

17. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), ***Report to the General Assembly (with Annexes)***, United Nations, New York 1988.

Return to Reports from Members

ITUARY

Professor Dr Ananda Mohan "Anu" Ghose

December 26, 1926 to May 23, 2004

Professor Dr Ananda Mohan Ghose, or "Anu" as he was affectionately known to many of us, departed this planet May 23, 2004, local India time, 1:45 am (May 22 in Europe and the Americas), from a heart attack in his sleep in his Gariahat Road residence in Calcutta, thus bringing to a close his long battle with Parkinson's disease in his last years. He was a brilliant and world-class researcher and teacher in his own right, but we know him best as the "Father of the International Radiation Physics Society."

According to available records, Prof. Ghose was born in Kishengaunge, Bihar, India December 26, 1926, to Prafulla Kumar Ghose (a graduate in Mathematics) and Surama Ghose. When Ananda was about three years old, the family moved to Calcutta where Prafulla accepted a position as head clerk at Tata's Calcutta Office. Ananda's elementary education was mostly at the Jagadbandhu Institution, following which he enrolled in St. Xavier's College for his I.Sc. and B.Sc. (1945), with honors in Physics. From Calcutta University he received his M.Sc. (1947), graduating first in his class, with high honors including the Jubilee Postgraduate Award and the University Gold Medal. Later, also from Calcutta University, he received his D.Sc. (Physics) in 1965. Among his other academic recognitions, he was named the Lafont Gold Medalist and the M.M. Roy Medalist. In 1970, he was made a Fellow in the Indian Physical Society, and was subsequently elected Vice-President of that Society 1976-1977.

As a sportsman, he excelled in badminton under the tutelage of his uncle, Sunil, and won several local tournaments. While at Brookhaven National Laboratory in 1957 under a Fulbright fellowship and a Ford Foundation fellowship, he won the badminton championship in the men's single category.

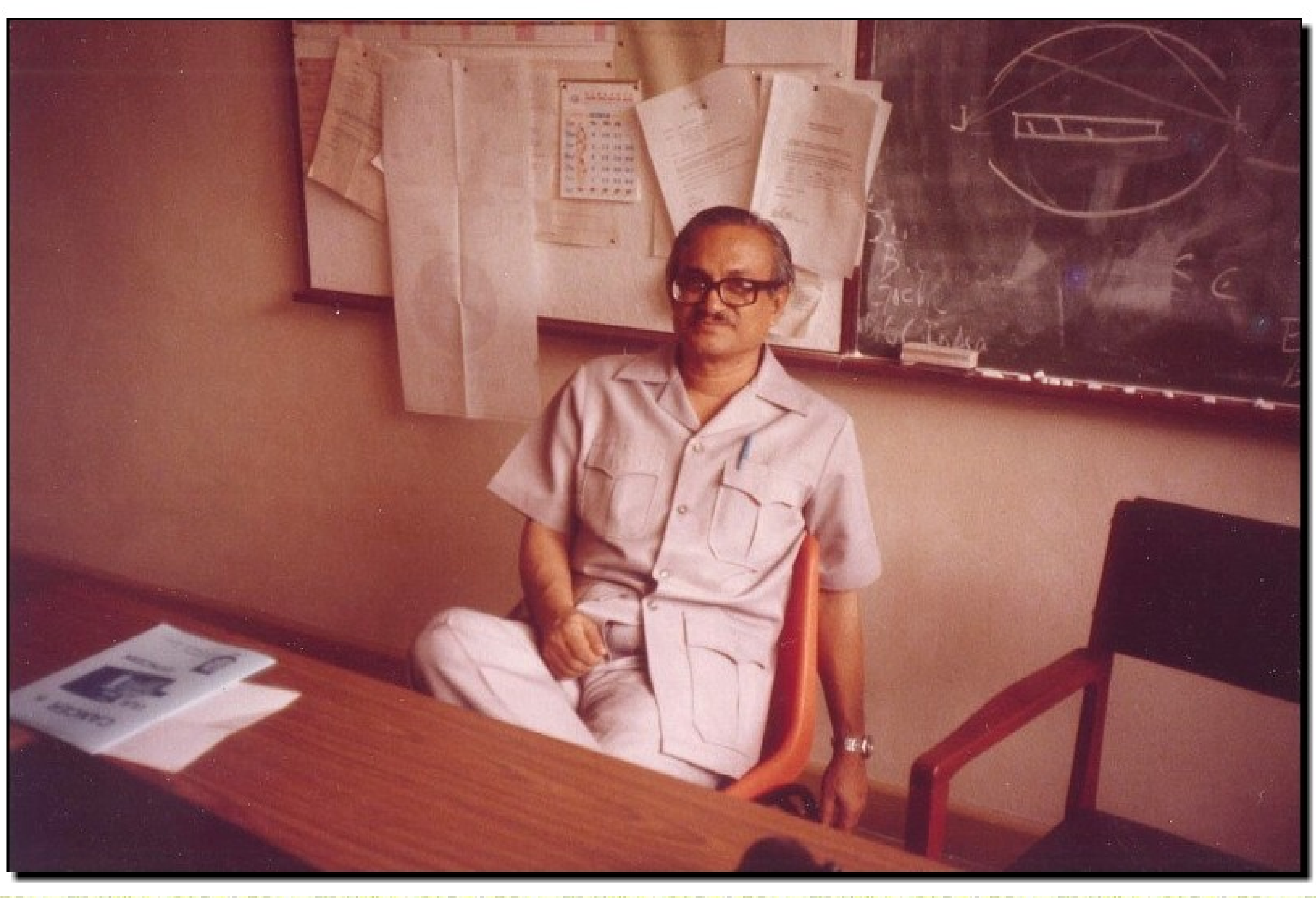
He is most closely associated with the Bose Institute in Calcutta where he was Head of the Physics Department 1970 to 1978. Among his doctoral students at the Bose Institute was Suprakash Chandra Roy who eventually rose to Head of the Physics Department himself and has held numerous offices in the IRPS including currently Vice President for Southeast Asia. Prof. Ghose then took a year's assignment in 1979 in Bangkok as a consultant to the UNESCO Regional Office for Asia and Oceania.

Through 1980 to 1988 Prof. Ghose served as Professor of Biophysics at the University of Science of Malaysia in Penang. After 1988, Prof. Ghose was associated with the group at the Variable Energy Cyclotron Centre, Calcutta. He held guest researcher and visiting professor appointments at the Brookhaven National Laboratory, at North Bengal University, at the University of Rangoon, Burma, the Joint Research Centre of the European Communities in Ispra, Italy, and elsewhere including serving as an IAEA Technical Cooperation Expert to the State University of Mongolia in Ulaan Bator.

Prof. Ghose's research areas focused on radiation physics of gamma rays, and also neutron physics, with more than 125 publications including a monograph published by EURATOM. He was active in the (Indian) National Council of Educational Research and Training (NCERT) and served on the NCERT Science Advisory Committee, also was Editor for a physics textbook for schools, published by NCERT.

Prof. Ghose's radiation physics extensive researches first came to this reporter's attention in the mid-1960's, examples of which were his original and useful works ***"Measurement of absolute differential collision cross sections of Co^{60},*** Nucl. Phys. 65, 145-155 (1965) and ***"Sphere transmission method for the measurement of atomic photoeffect cross-sections,"*** Nucl. Instr. Meth. 35, 45-54 (1965). Our mutual radiation physics interests resulted in a number of reciprocal visits, first mine in Calcutta in 1972 as the U.S.-side collaborator in a joint Indo-U.S. (PL-480/NBS) project "The Interaction of Gamma Rays with Matter." The next year, in 1973, he visited me at NIST (then NBS) in Gaithersburg where he mentioned to me his idea of an International Symposium on Radiation Physics, in Calcutta. This idea came to fruition in 1974 as ISRP-1 at the Bose Institute in which my wife Jean and I participated, and the proceedings were published by NBS as NBS Special Publication 461 (1977), edited by A.M Ghose, D.V. Gopinath, J.H. Hubbell and S. C. Roy.

Eight years after the 1974 Calcutta symposium and during his stint at the University of Science of Malaysia, in Penang, Prof. Ghose was the guiding spirit in organizing a second International Symposium on Radiation Physics, ISRP-2 in 1982, in Penang. Among his major assistants was another of his graduate students (at Penang) David Bradley, a future stalwart of the IRPS including currently Secretariat. ISRP-2 attendee Richard Pratt (Pittsburgh) would become the IRPS Secretariat for all terms up until the present one, for which he was elected to the IRPS Presidency (2004-2006). At ISRP-2, under Prof. Ghose's chairmanship, and with some input from attendee Joseph Rotblat (later, 1995 Nobel Peace Laureate for his Pugwash work), a pro tem committee was formed with the aim of establishing an International Radiation Physics Society (IRPS).



Professor Ghose at ISRP-2 in Penang

The Society came into existence at ISRP-3 in 1985 in Ferrara, Italy, Prof. Ernesto Casnati, organizer, and a triennial frequency of subsequent Symposia was established.

Prof. Ghose continued as a central figure in the organization of ISRP-4 (São Paulo 1988), ISRP-5 (Dubrovnik 1991) and ISRP-6 Rabat, Morocco 1994). ISRP-6 (Rabat 1994) was the last Symposium to benefit from Prof. Ghose's physical presence. Some surgery prevented his attendance at ISRP-7 in 1997 in Jaipur, India, and general ill health caused him to miss also the subsequent ISRP-8 (2000, Prague) and ISRP-9 (2003, Cape Town). However, Prof. Ghose's spirit and influence were very much present in these later meetings, as they will be in all future ISRP's, and at ISRP-9 in Cape Town in 2003 he was honored in absentia, being named as a Lifetime Honorary Member of the International Radiation Physics Society. Also, in preparation is an all-invited special issue of Radiation Physics and Chemistry, dedicated to Prof. Ghose and reflecting his varied radiation physics interests, now unfortunately to appear as a posthumous testimonial to his creative, productive and inspiring lifetime of radiation physics and related scientific contributions.

Prof. Ghose's quiet and charming help-mate wife Lalita predeceased him in 2001, after 49 years of marriage. He is survived by his son Kanad (and grandson Saugata and granddaughter Ipsita) and by his daughter Sudeshna (and granddaughter Sukanya). We join his family in mourning the passing of this great man of science and of scientists, and this reporter thanks son Kanad for providing some details of his father's early life. We are indebted, individually and as a Society, to Prof. Ghose and his critical role in drawing together our "global radiation physics family" from researchers throughout the developing and developed countries of the world, unusually free of the political, cultural and economic barriers, as well as by scientific discipline, normally separating and compartmentalizing the global human enterprise.

For his scientific and educational contributions as well as for his visions of our International Symposia on Radiation Physics and our International Radiation Physics Society, this small planet is thankful for the life, now complete, of Prof. Ananda Mohan "Anu" Ghose.

* * * * * *

John Hubbell

Return to Obituaries

ARY

Dr Dan J. Beninson

1931 - 2003

IRPS President 1991 - 1994

* * * * * * *

Dr. Dan J Beninson is dead. He was a great man and an exceptional radiation protection professional. During the more than half a century of his professional life he achieved such prestigious standing as to influence the international development of radiation protection and the views about radiation risks within the International Commission on Radiological Protection (ICRP) and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Dan never strove for such a position; he reached it purely on the strength of his many positive qualities. The announcement of his death, which occurred on 21 August 2003, brought deep sadness to the scientific community as he had excelled so brilliantly in the field of the sciences related to nuclear activities, primarily but not solely, to radiological protection and nuclear safety. His achievements transcended national boundaries and merited him much deserved international recognition.

Dr. Beninson was born in Buenos Aires on 19 February 1931. In 1954, he graduated from the School of Medical Sciences at Buenos Aires University, where he taught Biological Physics. Between 1955 and 1956, he was a researcher at the Donner Laboratory of the Lawrence Radiation Laboratory in the USA. After obtaining a Ph.D. degree in Applied Physics in the USA, he joined the Atomic Energy Commission of Argentina, where he conducted research in the Radioisotopes Department and co-ordinated the activities of the Radiophysics Department.

Dan's professional career in Argentina was outstanding. Over nearly half a century, he headed all Argentine activities in radiation protection. From 1994 to 1998, he was Chairman of the Nuclear Regulatory Authority of Argentina. Between 1998 and 1999 he was President of the Atomic Energy Commission of Argentina.

As early as 1956, Dan began his unique relationship with UNSCEAR. Up to 1958, he was engaged in the UNSCEAR Secretariat and from then on until his death he was the delegate for Argentina. From 1962 to 1964 he served as Chairman of UNSCEAR and from 1974 to 1979, he was Director of the Committee's Scientific Secretariat.

Another unusual relationship he established was with ICRP, of which he became a member in 1963. He acted as Vice-President of ICRP between 1977 and 1985, and as President from 1985 to 1993, when he became an Emeritus Member. He chaired ICRP Committee 1 on effects of radiations and subsequently ICRP Committee 4 on applications of the Commission's recommendations.

In 1959, he launched an extremely fruitful co-operation with the International Atomic Energy Agency (IAEA) as a member of the Panel of Experts for the determination of radioactive materials in the biosphere. His long-term association with the IAEA in a plethora of activities made him almost symbiotic with the IAEA Secretariat. It should be noted that as early as 1960 and 1961, he contributed to the establishment of the first international Basic Safety Standards by the IAEA. Between 1987 and 1994, he took part in the IAEA's International Nuclear Safety Advisory Group (INSAG).

He was founder of the International Radiation Protection Association and a charter member and President of the Sociedad Argentina de Radioprotección (SAR) (Argentine Society on Radiological Protection). He was also a member of the Swedish Royal Academy of Engineering Sciences and advisor to the Holy See's Pontifical Academy of Science.

For his studies on Nuclear and Technological Physics, he was honoured with the Konex Award. In 1991, the Health Physics Society of USA awarded him as the '1991 G William Morgan Lecturer' for his outstanding contributions to knowledge and skills in Radiological Protection. In 1991, he was selected 'Personality of the Year' by the American Nuclear Society for his scientific studies in the discipline of nuclear energy. In 1991, he was elected President of the International Radiation Physics Society (IRPS). In 1996, the International Radiological Protection Association presented him with the Rolf Sievert award, which is one of the most prestigious international awards in the field of radiation protection, and he delivered the Sievert Lecture. In 1998, in recognition of his personal career, he was honoured with the 'Premio República de Oro' (Golden Republic Award) by the Argentina 'Centro de Estudios Empresariales'.

Part of Dan Beninson's legacy are the priceless papers, many highly innovative, in the nuclear and radiological protection disciplines.

Without question, Dan Beninson exemplified a life entirely devoted to the pursuit of knowledge. He was a most impressive person; the true polyhistor, equally prominent in mathematics and physics as in biology but with far wider interests than natural sciences. He had a deep interest in history and in languages. Of course his Spanish, French and English were fluent, but in addition he spoke quite a number of other languages. He learned Japanese and took pleasure in surprising Japanese children by being able to chat with them. During his last years he studied Chinese seriously. He was a master at chess and once beat Bobby Fisher, albeit at the beginning of the latter's career.

Sometimes people thought that they had caught him saying something for which there was no real basis. He could explain so clearly that the audience was often mistaken to believe he was dealing with something self-evident. However, they always discovered that, on such occasions, they had underestimated him. He had dug deeper than they had imagined.

Dan was a courteous man but had no patience for conceit and stupidity. His anger about an injustice was formidable; the awe-inspiring thunder of his powerful voice was backed by his forceful stature. However, he was in fact an intensely kind man. He had a fondness of practical jokes and mischief that might have seemed childlike, but when it really mattered he showed deep understanding and empathy. And much was forgiven because of his wonderful sense of humour. Wherever he travelled he showed a genuine interest in the activities of the people he met, and his knowledge of names and local traditions made people feel that a true friend had visited them. Which they were, Dan liked to build up friendships.

His wife, Ambretta, a scientist in her own right, was very dear to him. Ambretta's untimely death in 1983 was a hard blow to him, after which he took less care of himself, something that greatly worried his many friends.

Dan was not a religious man - his sharp intellect made him inevitably agnostic - however he had a remarkable knowledge of, and interest in, biblical and theological issues and a surprising affection for churches which he always visited with fervour, just as he liked to visit museums, both historical and technical. As a true scientist, he made a clear distinction between facts and wishful thinking.

Many radioprotectionists who have been privileged to know and work with most of the great protagonists in radiation protection feel that Dan Beninson ranks supreme.

* * * * * *

Anselmo Paschoa

Return to Obituaries

Australia

Dr. Christopher T. Chantler	School of Physics University of Melbourne Parkville Victoria 3010 AUSTRALIA *email:* chantler@ph.unimelb.edu.au
Prof. David D Cohen	Senior Principal Research Scientist Physics Division ANSTO PMB1, Menai NSW 2234 AUSTRALIA *email :* dcz@ansto.gov.au
Prof. D.C. Creagh	Division of Health Design and Science Room 3C40 University of Canberra Canberra ACT 2601 AUSTRALIA *email :* dudley.creagh@canberra.edu.au
Dr. Ross L. Dawe	Maritime Operations Division Defence Science and Technology Organisation P.O. Box 1500 Edinburgh S.A. 5111 AUSTRALIA *email :* ross.dawe@dsto.defence.gov.au
Dr. Peter N Johnston	Department of Applied Physics RMIT University G.P.O. Box 247bv Melbourne Victoria 3001 AUSTRALIA
Ms. Shirley McKeown	Division of Health Design and Science Room 3C40 University of Canberra Canberra ACT 2601 AUSTRALIA *email:* shirley.mckeown@canberra.edu.au
Dr. D. McLean	Medical Physics Department Westmead Hospital P.O. Box 533 Wentworthville NSW 2145 AUSTRALIA *email:* rdmc@imag.wsahs.new.gov.au

Japan

Dr. Mala Das	Department of Quantum Energy Engineering Graduate School of Engineering Hokkaido University Kita-Ku, Kita-13, Nishi -8 Sapporo Hokkaido - 060 8626 JAPAN *email :* mala_das@yahoo.com
Prof. Akira Iwasaki	School of Health Sciences Hirosaki University 66-1 Hon-cho Hirosaki Aomori 036-8564 JAPAN *email:* akira@cc.hirosaki-u.ac
Dr. Ikuo Kanno	Department. of Nuclear Engineering Kyoto University Sakyo-ku Kyoto 606-01 JAPAN *email:* kanno@qsec.kyoto-u.ac.jp
Dr. Takashi Nakamura	Cyclotron and Radioisotope Center Tohoku Univeresity Aoba, Aramak Sendai JAPAN *email:* nakamura@cyric.tohoku.ac.jp
Dr. Takata Nobuhisa	Ionising Radiation Section National Institute of Advanced Industrial and Science and Technology Central 2, 1-1-1 Umezono Tsukaba 305 8568 JAPAN *email:* n.takata@aist.go.jp
Dr. Yoshitomo Uwamino	Safety Center/RIKEN 12-1 Hirosawa Wako Saitama 351-0198 JAPAN *email:* uwamino@postman.riken.go.jp

Korea

Dr. Jae-Shik Jun	G&G Radcon Co., Ltd 301 Jangyoungsil-gwan, Venture Town Shinil-dong, Daeduk-gu Daejon 306-230 KOREA (South) *email:* junjss@hanmail.net
Dr. J. K. Kim	Department of Nuclear Engineering Hanyang University 17 Haengdang Sungdong Seoul 133-791 KOREA *email:* jkkim@nural.hanyang.ac.kr

Malaysia

Mr. Nagi A. Hussein	School of Physics U.S.M. 11800 Penang MALAYSIA *email :* nagihuss@hotmail.com

New Zealand

Dr. C. M. Bartle	National Isotope Centre Institute of Geological and Nuclear Sciences P.O. Box 31312 Lower Hutt NEW ZEALAND *email:* m.bartle@gns.cri.nz

People's Republic of China

Mr. Guo Chengjun	Institute of Nuclear Science and Technology Sichuan University Chengdu 610 064 P.R. CHINA
Dr. Tao Jin	Department of Radiation Physics Xinjiang Institute of Physics Chinese Academy of Science P.O.Box. 139, Urumqi Xingiang 830011 P.R. CHINA
Dr. Zheng-ming Luo	Centre for Radiation Physics Institute of Nuclear Science and Technology Sichuan University Chengdu 610 064 P.R. CHINA
Prof. Jun Quan Xu	Sanghai Institute of Nuclear Research Academia Sinica, P.O. Box. 800-204 Shanghai 201800 P.R. CHINA
Dr. Mian Xu	National Institute of Metrology No. 18 Bei San Huan Dong Lu Beijing 100 013 P. R. CHINA
Dr. Peter K.N. Yu	Department of Physics and Material Science City University of Hong Kong 83 Tat Chee Avenue Kowloon Tong HONG KONG *email:* peter.yu@cityu.edu.hk
Mr. Wu Zhangwen	Institute of Nuclear Science and Technology Sichuan University Chengdu 610 064 P.R. CHINA
Dr. Zheng Zheng	Department of Environmental Science and Engineering Nanjing University Nanjing Jiangsu 210014 P.R. CHINA *email :* zzheng@nju.edu.cn

Taiwan

Professor Jason Lee	Institute of Radiological Sciences National Yang-Ming University 155 Li-Nong St., Sec. 2 Taipei, TAIWAN 112

Thailand

Dr. Thiraphat Vilaithong	Director Fast Neutron Research Facility Department of Physics Faculty of Science Chiang Mai University Chiang Mai 50002 THAILAND

Argentina

Dr. Raul T. Mainardi	Faculty of Physics-FaMAF University of Cordoba Ciudad Universitaria 51010 Cordoba ARGENTINA
Professor Marcelo Rubio	CEPROCOR Agencia Córdoba Ciencia Alvarez de Arenales 230 Barrio Juniors X5004 AAP Córdoba ARGENTINA *email :* mrubio@ceprocor.uncor.edu
Mr. Walter A. Salgueiro	IFIMAT-Facultad de Ciencias Exactas UNCPBA Pinto 399- 7000 Tandil ARGENTINA *email:* wsalgue@exa.unicen.edu.ar
Dr. Alberto H. Somoza	IFIMAT- UNCentro Pinto Tandil 399 - 7000 ARGENTINA *e-mail:* asomoza@exa.unicen.edu.ar

Brazil

Prof. Carlos R. Appoloni	Head Applied Nuclear Physics Laboratory Department of Physics - CCE State University of Londrina PO Box 6001 86051-900 Londrina PR BRAZIL *email:* appoloni@uel.br
Mrs. Regina Cely Barroso	UERJ - Physics Institute Rua Sao Francisco Xavier 524 Sala 3001A - Maracana, Instituto De Fisica 20550-900 Rio de Janiero RJ BRAZIL *email:* cely@uerj.br
Prof. Antonio Jose Pio Ghilardi	Centro de Instrumentacao Dosimetria e Radioprotecao Departamento ded Fisica University of Sao Paulo Av. dos Bandeirantes, 3900 14040-901 Ribeirao Preto Sao Paulo BRAZIL
Prof. Odair Dias Goncalves	Comissão Nacional de Energia Nuclear (CNEN). R. General Severiano, 90 CEP 21541 22290-901 Rio de Janeiro, RJ BRAZIL *Email :* odairdg@cnen.gov.br
Prof. Ricardo Tadeu Lopes	Federal University of Rio de Janeiro PO Box 68.509 219945.970 Rio de Janeiro BRAZIL *email:* ricardo@smb.lin.ufrj.br
Prof. Anselmo S. Paschoa	Pontificia Universidade Catolica do Rio de Janeiro Depto. de Fisica C.P. 38071 Rio de Janeiro RJ 22453-900 BRAZIL *email:* aspas@vdg.fis.puc-rio.br
Mr. Sergio A. Pereira	Rua Almirante de Inhauma, 590 City Lapa cep: 05084-030 Sao Paulo / SP BRAZIL
Ms. Maria Esmeralda R. Poli	Rua Almirante de Inhauma, 590 cep:05084-030 City Lapa Sao Paulo BRAZIL *email:* esmeraldapoli@hotmail.com

Chile

Dr R Figueroa	Ave. Francisco Salazar 01145 Temuco 54-D CHILE

Ecuador

Mr. Vasquez Pazmino Nicolas	Escuela Politecnica Nacional A.O. 17-17-28 Quito ECUADOR *email:* egocelula@yahoo.com

Mexico

Dr. Fernando Mireles-Garcia	Lago Catemaco 126 Frac. Lomas Del Lago Zacatecas ZAC 98085 MEXICO *email:* fmireles@cantera.reduaz.mx
Dr. Luis C. Longoria	Direccion de Investigacion Cientifica Instituto Nacional de Investigaciones Nucleares Carretera Mexico-Toluca Km. 36.5 Salazar, Edo. Mex. 52045 MEXICO *email:* longoria@nuclear.inin.mx
Dr. Leopoldo L. Quirino-Torres	Apartado Postal 495 Zacatecas ZAC 98000 MEXICO *email:* lquirino@cantera.reduaz.mx

Austria

Dr. Mohammed Berrada	Senior Training Officer Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) International Monitoring System Division (IMS) Vienna International Centre (VIC) PO Box 1200 A 1400 Vienna AUSTRIA

Croatia

Dr. Ines Krajcar Bronic	Radiocarbon and Tritium Laboratory Department of Physics Rudjer Boskovic Institute P.O. Box 1016, Bijenicka 54 10001 Zagreb CROATIA *email:* krajcar@rudjer.irb.hr
Mr. Kresimir Jakovcic	Rudjer Boskovic Institute Bijenicka 54 10000 Zagreb CROATIA
Dr. Ivana Jelovica	Faculty of Philosophy Omladinska 14 51000 Rijeka CROATIA
Dr. Zoran Kaliman	Faculty of Philosophy Omladinska 14 51000 Rijeka CROATIA *email:* kaliman@mapef.pefri.hr
Dr. Milica Krcmar	Rudjer Boskovic Institute Bijenicka 54 Zagreb 41001 CROATIA *email :* mkrcmar@rudjer.irb.hr
Mr. Zvonko Krecak	Rudjer Boskovic Institute P.O. Box 1016 Zagreb 41001 CROATIA *email :* krecak@rudjer.irb.hr
Dr. Ante Ljubicic	Rudjer Boskovic Institute Bijenicka 54 Zagreb 41000 CROATIA
Dr. Vladimir Lokner	Hazardous Waste Management Agency 10000 Zagreb Savska 41 IV CROATIA *email:* vladimir.lokner@apo.tel.hr
Dr. (Mrs) Saveta Milajanic	Rudjer Boskovic Institute Bijenicka c. 54 10000 Zagreb CROATIA *email:* saveta@rudjer.irb.hr
Dr. Bogomil Obelic	Rudjer Boskovic Institute P.O. Box 1016 Zagreb 41001 CROATIA *email :* obelic@rudjer.irb.hr
Dr. Nada Orlic	Faculty of Philosophy University of Rijeka Omladinska 14 Rijeka 51000 CROATIA

Czech Republic

Dr. Tomas Cechak	Czech Technical University in Prague Faculty of Nuclear Sciences and Physical Engineering Brehova 7 Prague 1 11519 CZECH REPUBLIC *email* cechak@br.fjfi.cvut.cz
Prof. Jaroslar Kluson	Czech Technical University in Prague Faculty of Nuclear Sciences and Physical Engineering Brehova 7 Prague 1 11519 CZECH REPUBLIC *email* kluson@br.fjfi.cvut.cz
Dr. Ladislav Musilek	Czech Technical University in Prague Faculty of Nuclear Sciences and Physical Engineering Brehova 7, Praha 1 115 19 CZECHOSLOVAKIA *email:* musilek@br.fjfi.cvut.cz
Dr. Miroslav Pardy	Department of Theoretical Physics and Astrophysics Masaryk University Kotlarska 2 BRNO 61137 CZECH REPUBLIC *email:* pamir@physics.muni.cz

Denmark

Prof. Leif I. Gerward	Physics Department Bldg. 307, Technical University of Denmark Kgs. Lyngby DK- 2800 DENMARK *email:* gerward@fysik.dtu.dk
Dr. Per Hedemann Jensen	Head of Section Applied Health Physics Danish Decommissioning Building 214 Riso National Laboratory Roskilde DK- 4000 DENMARK *email:* p.hedemann@dekom.dk
Dr. Bente Lauridsen	AHF-214 Riso National Laboratory Roskilde DK- 4000 DENMARK *email:* bente.lauridsen@dekom.dk

Finland

Dr. Servo Kasi	Kajavankatu 6 B 45 FIN-04230 Kerava FINLAND *email:* servo.kasi@helsinki.fi
Dr. Jouni Uusi-Simola	HUSLAB Department of Nuclear Medicine P.O. Box 340 FIN-00029 HUS FINLAND *email:* jouni.uusi-simola@helsinki.fi

France

Dr. Monique Jung	Laboratoire PHASE 23, rue du Loess B.P. 20 67037 Strasbourg-Cedex 2 FRANCE *email:* Monique.jung@phase.c-strasbourg.fr
Prof. L. Makovicka	CREST Universite de Franche-Comte (UFC) 4, Place L. Tharradibn, BP 71427 25211 Montbelliard FRANCE *email:* Libor.Makovicka@pu-pm.univ-fcomte.fr
Dr. Cecile Malgrange	Lab de Mineralogie-Cristallographie Universite Paris 6 4 place Jussieu F-75252 Paris Cedex 5 FRANCE *email :* cecile.malgrange@lmcp.jussieu.fr
Dr. Jean Paul Patau	LP2R2, Faculte de Pharmacie Universite Paul Sabatier 35 chemin des Maraichers 31062 Toulouse Cedex 4 FRANCE *email :* patau@cict.fr

Germany

Mr Nadir O. Hashim	FB-7 Physik University Siegen Emy-noether-Campus Walter Flex Str. 3 D-57068 GERMANY *email:* hashim@hep.physik.uni-siegen.de
Professor Syed M. Qaim	Research Centre Institute of Nuclear Chemistry D-52425 Juelich GERMANY
Dr. Maria S.A. Zankl	GSF-Forschugszentrum fur Umwelt und Gesundhelt Institut fur Strahlenschutz Ingolstadter Landstr 1 85764 Neuherberg GERMANY *email:* zankl@gsf.de

Gibraltar

Dr. John Pardo	32 Ross House Red Sands Road GIBRALTAR *email :* tribunal@gibnet.gi

Greece

Prof. Ioannis Kandarakis	Technological Educational Institute Department of Medical Instruments Technology Ionising Radiation Laboratory Agiou Spyridonos 12210-Aigaleo Athens GREECE *email:* kandarakis@teiath.gr

Hungary

Prof. Guyla J. Csikai	4010 Debrecen-10 Pf. 1105 HUNGARY *email :* csikai@delfin.klte.hu

Italy

Dr. Jorge E. Fernandez	Laboratorio di Ingegneria Nucleare di Montecuccolino Universita di Bologna via dei Colli 16 I-40136 ITALY *email :* jorge.fernandez@mail.ing.unibo.it
Dr. Claudio Manfredotti	Istituto di Fisica Superiore Decl' Universita di Torino Corso M. D'Azeglio N.46 Torino 10100 ITALY *email:* manfredotti@to.infn.it

Portugal

Mr Joao A.S. Barata	Universidade da Beira Interior Department of Fisica Rua marues 2 Avilae Bolama P-60201-001 Covilha PORTUGAL
Professor Carlos A.N. Conde	Department of Physics Universidade de Coimbra Coimbra P- 3004-156 PORTUGAL
Professor Margarida Costa	Departmento de Fisica Universidade de Coimbra Coimbra 3004-156 PORTUGAL *email:* guida@pollux.fis.uc.pt
Professor Isabel Lopes	Departmento de Fisica Universidade de Coimbra Coimbra 3004-156 PORTUGAL *email:* isabel@lipc.fis.uc.pt
Prof. A.P. de Leao Policarpo	Departmento de Fisica Universidade de Coimbra 3004-156 Coimbra PORTUGAL *email:* policarpo@lipc.fis.uc.pt
Dr. L. M. Tavora	ESTG, Inst. Politécnico de Leiria, Morro do Lena - Alto do Vieiro 2411-901 Leiria PORTUGAL *email:* lmtavora@estg.ipleiria.pt

Romania

Dr. Tatiana A. Angelescu	Physics Faculty University of Bucharest PO Box MG11 R 76900 Bucharest ROMANIA *email:* angt@scut.fizica.unibuc.ro
Dr. Dan M. Timus	National Institute for Laser, Plasma and Radiation Physics Electron Accelerators Department PO Box MG-36 Bucharest R-76900 ROMANIA *email :* dante@alpha2.infim.ro timusmdan@yahoo.co.uk timusdan@netscape.net

Russia

Dr. Andrei V Korol	Department of Physics St Petersburg State Maritime Technical University 101 Leninski Prospect 198262 St Petersburg RUSSIA
Dr. Dmitry A. Kovalev	Usacheve Str., 35, b/1 Moscow 119048 RUSSIA
Dr. Konstantin Kozlovskii	Moscow State Engineering Physics Institute 31 Kashimskoe Sh. Moscow 115409 RUSSIA
Dr. Vladimir A. Maisheev	Institute for High Energy Physics Protvino Moscow Region 142284 RUSSIA *email:* maisheev@mx.ihep.su
Dr. Alexander Shikanov	Federal Nuclear Geophysics and Geochemist Center (FNGGC) 140 100 Ramenskoe Neftegazosjimka RUSSIA
Dr. Eugene A. Shikanov	Usacheve Str., 35, b/1 Moscow 119048 RUSSIA
Prof. Victor L. Sukhorukov	Rostov State University of Transport Communication N. Opolcheniya Square 2 Rostov-na-Donu 344038 RUSSIA *email:* vls@AAAnet.ru
Dr. Alexander S. Tsybin	Department of Solid State Physics Moscow Engineering Physics Institute (State University) Kashirskoe Shosse 31 Moscow 115405 RUSSIA *email:* tsybin@tpark.ru

Slovenia

Dr. Matjaz Korun	Jozef Stefan Institute Jamova 39 Ljubljana 1000 SLOVENIA *email:* matjaz.korun@ijs.si

Spain

Mr. Juan Pedro Bolivar-Raya	Dep. Fisica Aplicada Universidad de Huelva Canpus de la Rabida 21819 La Rabida Huelva SPAIN *email:* bolivar@uhu.es
Prof. Pedro Coll Buti	Universidao Politecnica de Catalunya Department de Fisica i Enginyeria Nuclear C/Avenida Diagonal 647 Barcelona 08028 SPAIN
Dr. Fernando Legarda	Universidad del Pais Vasco Departamento de Ingenieria Nuclear Mecanica de Fluidos E.T.S. Ingenieros Industriales Alameda de Urquijo s/n 48013 Bilbao SPAIN *email:* inpleibf@bi.ehu.es

Sweden

Professor Klas Malmqvist	Department of Nuclear Physics University of Stockholm-Karolinsk Inst Lund Institute of Technology Lund University PO Box 128 Lund 22100 SWEDEN

Switzerland

Professor Georges Charpak	Emerging Energy Technology Group CERN Ch 1211 Geneva 23 SWITZERLAND *email:* anne.dirat@eet.cern.ch
Professor Carlo Rubbia	Emerging Energy Technology Group CERN Ch 1211 Geneva 23 SWITZERLAND *email:* Carlo.rubbia@eet.cern.ch

U.K.

Ms Layla Mohammed Ali	School of Physics University of Exeter Stocker Road EX4 4QL U.K.
Mr. A. W. Allday	Department of Radiography City University Rutland Place, Charterhouse Square London EL 1M 6PA U.K. *email:* a.w.allday@city.ac.u
Dr. Colin R. Baker	Radiotherapy Division Department of Allied Health Professions University of Liverpool Liverpool U.K. *email :* colin.baker@liverpool.ac.uk colin.baker@physics.org
Dr. David A. Bradley	School of Physics University of Exeter Stocker Road Exeter EX4 4QL U.K. *email:* d.a.bradley@exeter.ac.uk
Professor Malcolm J. Cooper	Department of Physics University of Warwick Coventry CV4 7AL U.K. *email:* m.j.cooper@warwick.ac.uk
Dr. M. J. Farquharson	Department of Radiography City University Rutland Place Charterhouse Square London EC1 M6PA U.K. *email:* M.J.Farquharson@city.ac.uk
Ms. Kalotina Geraki	Department of Radiography City University Rutland Place Charterhouse Square London EC1M 6PA U.K. *email:* k.geraki@city.ac.uk
Dr. Walter B. Gilboy	Physics Department University of Surrey Guildford Surrey GU2 5XH U.K. *email:* w.gilboy@surrey.ac.uk
Dr. Christopher C. Goddard	BNFL Environmental Services Berkeley Centre Berkeley Gloucestershire GL13 9PB U.K. *email:* goddard@myrealbox.com
Dr. Stuart Green	Department of Medical Physics and Bioengineering Queen Elizabeth Medical Centre Birmingham B15 2TH U.K. *email:* Stuart.Green@uhb.nhs.uk
Dr. Richard Hugtenburg	School of Physics and Astronomy University of Birmingham Birmingham B15 2TT U.K. *email:* r.p.hugtenburg@bham.ac.uk
Dr. Russell D. Luggar	Department of Physics University of Surrey Guildford Surrey GU2 5XH U.K. *email:* r.luggar@surrey.ac.uk
Dr. H. M. Mahesh	ETL, EERC, School of Civil Engineering David Keir Building, Stranmillis Road Queen's University of Belfast Belfast - BT9 5AG Northern Ireland U.K. *email* : hm.mahesh@rediffmail.com
Dr. Pirunthavany Muthuvelu	Biomedical Physics Group School of Physics University of Exeter Exeter Surrey EX4 4QL U.K. *email:* P.Muthuvelu@exeter.ac.uk
Dr. Hooshang Nikjoo	Medical Research Council Radiation and Genome Stability Unit Harwell Oxfordshire OX11 ORD U.K. *email:* H.Nikjoo@har.mrc.ac.uk

Ms. Elaine Ryan	Department of Radiography School of Allied Health Sciences City University Northampton Square London EC1V OHB U.K. *email:* e.ryan@city.ac.uk
Dr. D. N. Timms	School of Environmental and Earth Sciences Burnaby Building Portsmouth University Portsmouth PO1 3QL U.K. *email:* david.timms@port.ac.uk

Uzbekistan

Dr. Alexander Rakov	Phonon Scientific Indudstrial Association S.Yusupov. St. 50 Tashkent 700054 UZBEKISTAN

Yugoslavia

Professor Dragana Popovici	Department of Physics and Biophysics Faculty of Veterinary Medicine University of Belgrade, Bul. JA 18 Belgrade 11000 YUGOSLAVIA *email:* stankopo@eunet.yu

India

Mr. D.N. Avadhani	Department of Physics R.V. College of Engineering R.V. Vidyaniketan Post Mysore Road Bangalore 560 059 Karnataka INDIA *email:* d_avadhani@yahoo.com
Dr Nagappa M. Badiger	Reader, Department of Physics Karnataka University Dharwad 58003 INDIA *email:* nagappa123@yahoo.com
Dr. Barun Kumar Chatterjee	Reader, Department of Physics Bose Institute 93/1 Acharya Prafulla Chandra Road Calcutta 700 009 INDIA
Dr. Ramesh Desai	B/6 Deval Apartment (near Anjali Cinema) Chhaganlal Jadhav Marg Bhattha, Paldi Ahmedabad 380007 INDIA *email:* desairamesh99@yahoo.com
Dr. S.K. Ghosh	Saha Institute of Nuclear Physics Calcutta 700 064 INDIA
Prof. P.P. Kane	Dept. of Physics Indian Institute of Techonology Powaii Bombay 400 076 INDIA *email:* ppkane@vsnl.com
Dr. B. R. Kerur	Department of Physics Gulbarga University Gulbarga 585 106 Karnatka INDIA *email:* kerurbrk@hotmail.com
Mr Harvinder Singh Klare	Sr. Research Fellow Physics Department Guru Nanak Dev University Amritsar 143005 INDIA *email:* klarehs@yahoo.co.in
Dr. Ajay Kumar	Department of Nuclear and Atomic Physics Pelletron Division Tata Institute of Fundamental Research (TIFR) Homi Bhabha Road Colaba Mumbai - 400 005 INDIA
Mr. Rohit Mehra	Lecturer in Physics M.I.M.I.T. Malout dist. Muktsar Punjab 152 107 INDIA *email :* rohit_mimit@rediffmail.com
Dr. Govind N. Nayak	Department of Physics Mangalore University Mangalagangotri 574 199 INDIA *email :* nerolunayak@yahoo.com
Professor Biva Roy	Department of Physics Bose Institute Calcutta 700 009 INDIA *email:* biva@bosemain.boseinst.ac.in biva @indiatimes.com
Prof. Suprakash C. Roy	Dept. of Physics Bose Institute Calcutta 700 009 INDIA *email:* sup_roy@yahoo.com
Miss Gurpreet Kaur Sandhu	Sr. Resarch Fellow Physics Department Guru Nanak Dev University Amritsar 143005 INDIA *email:* sandhu_75@yahoo.com
Ms Rupa Sarkar	Department of Physics Bose Institute 93/1 Acharya P.C. Road Kolkata 700 009 INDIA
Dr. Ramkumar Saptharishi	2126 6th Cross 15th Main HAL III Stage Bangalore 560 008 INDIA *email :* mp96sr@yahoo.com Ramkumr.Saptharishi@geind.ge.com
Mrs Gopi Sharma	Research Fellow Physics Department Guru Nanak Dev University Amritsar 143005 INDIA *email :* sharmagopi28@yahoo.com
Dr. Bhajan Singh	Department of Physics Punjabi University Patiala 147 002 INDIA
Dr Gurmel Singh	Department of Physics Punjabi University Patiala 147002 INDIA
Dr Parjit Shamsher Singh	Department of Physics Punjabi University Patiala 147002 INDIA
Dr Raj Mittal Singla	Department of Physics Punjabi University Patiala 147002 INDIA *email:* rmsingla@yahoo.com
Dr Srikanta S. Sinha	Space Astronomy and Instrumentation Division ISRO Satellite Center Airport Road Bangalore 560017 INDIA *email:* sinha@isac.ernet.in
Dr. Kulwant Singh Thind	Department of Physics Guru Nanak Dev University Amritsar 143 005 INDIA *email:* kulwantsthind@yahoo.com
Dr. T.K. Umesh	Department of Studies in Physics University of Mysore Manasagangotri Mysore 570 006 INDIA *email:* tku@vsnl.net tku@uomphysics.net
Dr. Thomas Varghese	Department of Physics Nirmala College Muvattupuzha Keral 686 661 INDIA *email:* surajthomas@sancharnet.in

Nepal

Mr Krishna Prasad Aryal	Nepal Institute of Health Science Boudha Kathmandu P.O.B. 5889 NEPAL *email:* kpa2034@hotmail.com

Pakistan

Dr. Rizwan Hussain	23A Street 3, Valley Road Westriddge 1 Rawalpindi PAKISTAN

Botswana

Professor Israel Ayo Babalola	Department of Physics University of Botswana Post Bag 0022 Gaborone BOTSWANA
Dr. V.R.K. Murty	Department of Physics University of Botswana Post Bag 0022 Gaborone BOTSWANA *e-mail :* murtyvrk@mopipi.ub.b

Egypt

Prof. Ahmed Abu El-Ela Ahmed	Physics Department Mansousa University Mansousa EGYPT
Professor Nassef Comsan	Nuclear Research Centre Atomic Energy Authority Cairo EGYPT *email:* rucycle@rusys.eg.net
Prof. Abdul-Hamid Hussein El-Kateb	Faculty of Science Helwan University Post Nr. 11795 Helwan Cairo EGYPT *email:* ahelkateb@frcu.eun.eg
Dr. Wael Mohyeldin Elshemey	Biophysics Department Faculty of Science Cairo University Giza EGYPT *email:* mellshimy@internetegypt.com
Prof. Mohamed Ahmed Gomaa	17 Mohamed Mahmoud Qasem St. Heliopolis, Cairo EGYPT *email:* mohgomaa2000@yahoo.com
Dr. Abdel Megid Mamoon	C/- Egyptian Atomic Energy Authority Ahmed al Zmer St Nasr City Cairo EGYPT

Ghana

Mr. Benjamin Nyarko	Ghana Atomic Energy Commission P.O. Box LG 80 Legon-Accra REPUBLIC OF GHANA *email:* bjbnyarko@yahoo.co.uk

Jordan

Mr. B. Z. O. Shakhreet	P.O. Box 11386 Amman 11123 JORDAN *email:* bshakhreet@hotmail.co

Kenya

Mr Michael J Mangala	University of Nairobi Institute of Nuclear Science G.P.O. Box 30197 Nairobi KENYA
Dr. Amidu Mustapha	Department of Physics University of Nairobi PO Box 30197 Nairobi KENYA *e-mail :* amustapha@uonbi.ac.ke
Dr Indra V S Rathore	Physics Department Kenyata University P.O. Box 43844 Nairobi KENYA

Libya

Dr. Amina Shakir Mahmood	PO Box 40036 Al-Khoms LIBYA *Email :* aminamahmood2002@yahoo.com
Dr. Ayad Miftah Shahout	AL-KHOMS P.O. Box 40099 LIBYA *Email :* shahout@hotmail.com

Morocco

Professor L Erradi	Faculty of Sciences Department of Physics B.P. 1014 Rabat MOROCCO *Email :* erradi@hotmail.com
Professor Hassane Erramli	Faculty of Sciences Department of Physics B.P. 2390 - 4000 Marrakech MOROCCO
Professor Jillali Ghassoun	University of Cadi Ayyad Faculty of Science Semlalia Department of Physics BP 2390 Marrakech 40000 MOROCCO
Professor Fouad Lahlou	Faculte des Sciences Dhar Mehraz BP 1796 (Atlas) Fes MOROCCO *email:* flahlou@yahoo.com

Namibia

Professor J. A. Oyedele	Department of Physics University of Namibia Private Bag 13301 Windhoek NAMIBIA *email:* oyedelej@unam.na

Nigeria

Dr. Emmanuel H. Agba	Department of Physics Faculty of Science Benue State University PMB 102 119 Makurdi NIGERIA *email :* hemenagba@yahoo.com
Dr. Nneoyi Egbe	Radiography Department College of Medical Science University of Calabar PMB 1115 Calabar 540001 NIGERIA *email :* nneoyiegbe@yahoo.com
Dr. Taofeeq Ige	National Hospital (Medical Physics) PMB 425 Garki Ablja NIGERIA *email:* taofeeqige@yahoo.com
Dr. Samuel O Inyang	Department of Physics University of Calabar Calabar 540001 Cross River State NIGERIA *email :* inyangso@yahoo.com
Dr. Sunday A. Jonah	Centre for Energy Research and Training Ahmadu Bello University PMB 1014 Zaria NIGERIA *email:* jonahsa2001@yahoo.com
Dr. Christopher Mayaki	Centre for Energy Research and Training Ahmadu Bello University PMB 1014 Zaria NIGERIA
Dr. Folorunso O. Ogundare	Department of Physics University of Ibadan Ibadan NIGERIA
Dr. Olusola I. Okunade	Centre for Energy Research and Training Ahmadu Bello University PMB 1014 Zaria NIGERIA

Saudi Arabia

Dr. Osama Fageeha	Environmental Protection Department Aramaco PO Box 12526 31311 SAUDI ARABIA

South Africa

Ms Mary Assiamah	Schonland Research Institute University of the Witwatersrand Private Bag 3 Wits 2050 SOUTH AFRICA *email:* assiamah@src.wits.ac.
Mr. Samuel S. S. Bakhane	iThemba Labs P.O. Box 722 Somerset West 7129 SOUTH AFRICA
Dr Dobroslana Budka	iThemba Labs P.O. Box 722 Somerset West 7129 SOUTH AFRICA *email:* dobrusiabudka@tlabs.ac.za
Professor Andy Buffler	Department of Physics University of Cape Town Rondebusch 7701 SOUTH AFRICA *email:* abuffler@science.uct.ac.za
Dr Mohamed E.M. Eisa	iThemba Labs P.O. Box 722 Somerset West 7129 SOUTH AFRICA *email:* memeisa@yahoo.com
Dr. Egbert E. R. Hering	Department of Medical Physics Groote Schuur Hospital Observatory 7925 SOUTH AFRICA
Dr. Dan T. Jones	iThemba LABS (Laboratory for Accelerator Based Sciences) P O Box 722 Somerset West 7129 SOUTH AFRICA *email:* jones@tlabs.ac.za
Prof. Rex J. Keddy	Dept. of Medical Physics University of the Witwatersrand Private Bag 3 Powits Johannesburg 2050 SOUTH AFRICA *email:* mwrexilm@mweb.co.za keddy@sic.wits.ac.za
Dr. Steven S. Maage	iThemba Labs P.O. Box 722 Somerset West 7129 SOUTH AFRICA *email:* maagest@nac.ac.za
Dr. Given G.K. Mabala	827 Khatello Street Molapo P.O. Moroka 1860 SOUTH AFRICA
Mr Johan A. Mars	iThemba Labs P.O. Box 722 Somerset West 7129 SOUTH AFRICA
Mr R. D. Mavunda	Health Physics Service Schonland Research Institute for Nuclear Sciences University of the Witwatersrand Private Bag 3, Wits 2050 Johannesburg SOUTH AFRICA
Mr Mandlenkosi Msimange	iThemba Labs P.O. Box 722 Somerset West 7129 SOUTH AFRICA *email:* m_msimanga@hotmail.com
Mr Tshepp Ntsoane	iThemba Labs Materials Research Group P.O. Box 722 Somerset West 7129 SOUTH AFRICA
Dr Carlos A. Pineda-Vargas	iThemba Labs P.O. Box 722 Somerset West 7129 SOUTH AFRICA
Dr Gabriel G. Pitsoane	iThemba Labs P.O. Box 722 Somerset West 7129 SOUTH AFRICA
Dr Wojciech J. Przybylowicz	iThemba Labs P.O. Box 722 Somerset West 7129 SOUTH AFRICA
Dr Jolanta M. Mesjasz-Przybylowicz	iThemba Labs P.O. Box 722 Somerset West 7129 SOUTH AFRICA
Mr. Johann van Rooyen	iThemba LABS (Laboratory for Accelerator Based Sciences) P O Box 722 Somerset West 7129 SOUTH AFRICA *email:* johanvr@nac.ac.za
Dr Thulaganyo P. Sechogela	iThemba LABS (Laboratory for Accelerator Based Sciences) P O Box 722 Somerset West 7129 SOUTH AFRICA
Ms Patience P. Segonyane	IBA and SEM Radiation Utilization Group Necsa Pretoria SOUTH AFRICA *email:* sps@necsa.co.za
Professor John F. Sharpey-Schafer	iThemba LABS (Laboratory for Accelerator Based Sciences) P O Box 722 Somerset West 7129 SOUTH AFRICA
Dr. Julyan J.E. Symons	iThemba Labs P.O. Box 722 Somerset West 7129 SOUTH AFRICA *email:* symons@tlabs.ac.za
Dr. Chris Theron	iThemba Labs P.O. Box 722 Somerset West 7129 SOUTH AFRICA *email:* ctheron@tlabs.ac.za
Dr. Grzegorz J. Tylko	iThemba Labs P.O. Box 722 Somerset West 7129 SOUTH AFRICA
Mr. Dawid de Villiers	Department of Physics Stellenbosch University Stellenbosch SOUTH AFRICA *email:* dawid@sun.ac.za

Syria

Dr. Ibrahim Othman	Atomic Energy Commission P.O. Box 6091 Damascus SYRIA *email:* aecs@mail.sy

Togo

Prof. E.B.A.K. Edee	Department of Physics and Biophysics University of Lome PO Box 1515 or 2036 Lome TOGO *email:* eedee@ub.tg

Tunisia

Dr. Hedi Kharrati	Ecole Supérieure de la Santé 5000 Monastir TUNISIA *email:* hedi_kharrati@yahoo.fr

Turkey

Dr. Ahmet Cengiz	Uludag University Faculty of Science and Literature Department of Physics Gorukle Bursa 16059 TURKEY
Dr. Orhan Gurler	Uludag University Fen Edebiyat Foikultesi Fizik Bolumu Forukle Kampusu 16059 Bursa TURKEY
Dr. Arzu Kurtoglu	Istanbul Technical University Institute for Nuclear Energy Ayazaga Campus 80626 Maslak Istanbul TURKEY
Dr. Sezai Yalcin	Gaza University Kastamona Egitim Fakultesi Kastamona 37200 TURKEY

Canada

Prof. Paul C. Johns	Department of Physics Carleton University 314 Herzberg Building 1125 Colonel By Drive Ottawa ON K1S 5B6 CANADA *email:* johns@physics.carleton.ca
Mr. Ernesto Mainegra-Hing	211 7th Street New Westminster Vancouver BC V3M 3K2 CANADA *email:* mainegra@irs.phy.nrc.ca
Dr. Joanne M. O'Meara	Medical Physics, GS 105/B McMaster University 1280 Main St W Hamilton ON L8S 4K1 CANADA *email:* omearaj@mcmaster.ca

U.S.A.

Dr. Samuel T. Baker	EQD-201, Argonne National Laboratory 9700 S Cass Avenue Argonne IL 60439 U.S.A. *email:* sambaker@anl.gov
Dr. Adel M Baryoun	21 Wilson Drive MSC 6780 Bethesda Maryland 20855 U.S.A. *email:* abaryoun@nih.gov
Mr. Roland R. Benke	Center for Nuclear Waste Regulatory Analysis South West Research Institute 6220 Culebra Road San Antonio TX 78238-5166 U.S.A. *email:* rbenke@swri.edu
Dr. Paul M. Bergstrom	U.S. Department of Commerce National Institute for Standards and Technology 100 Bureau Drive Stop 8460 Gaithersburg MD 20899-8460 U.S.A. *email:* palko@nist.gov
Dr. Alex F. Bielajew	Nuclear Engineering and Radiological Sciences College of Engineering Cooley Building 2355 Bonisteel Road Ann Arbor MI 48109-2104 U.S.A. *email:* bielajew@engin.umich.edu
Mr. Steve Boddeker	Physics Department California State Polytechnic University 3801 W Temple Ave Pomona CA 91768 U.S.A. *email:* skboddeker@csupomona.edu
Dr. Patrick J. Byrne	5138 Robinsrock Way Indianapolis IN 46268 U.S.A. *email:* byrne@mpcphysics.com
Dr. Jonathan Carney	University of Tennessee Medical Centre 1924 Alcua Highway Box 93 Knoxville TN 37920 U.S.A.
Dr. Neal Carron	Mission Research Corporation PO Drawer 719 Santa Barbara CA 93102-0719 U.S.A. *email:* ncarron@alum.mit.edu
Prof. Sam J. Cipolla	Physics Department Creighton University Omaha NE 68178-0001 U.S.A.
Prof. Bernd Crasemann	Physics Department University of Oregon Eugene OR 97403-1274 U.S.A *email:* berndc@uoregon.edu
Dr. Paul L. Csonka	Institute of Theoretical Science and Department of Physics University of Oregon Eugene OR 97403-5203 U.S.A *email:* psonka@oregon.uoregon.edu
Mr. Leonard A. Dietz	135 Glen Eddy Drive Niskayuna NY 12309 U.S.A. *email:* ldietz1124@aol.com
Dr. William L. Dunn	Mechanical and Nuclear Engineering Dept. Kansas State University 346 Rathbone Hall Manhattan, KS 66506-5205 U.S.A. *email:* dunn@mne.ksu.edu
Dr. Scott M. Epstein	c/o Medical Device Labs Inc. P.O. Box 793 Natick MA 01760 U.S.A.
Ms. Jessica A. Gaskin	NSSTC 320 Sparkman Drive Huntsville AL 35805 U.S.A. *email:* jessica.gaskin@nsstc.nasa.gov
Dr. Albert L. Hanson	Department of Advanced Technology Building 475A Brookhaven National Laboratory P.O. Box 5000 Upton NY 11973-5000 U.S.A. *email:* alh@bnl.gov
Dr. John H. Hubbell	Ionizing Radiation Division National Institute for Standards and Technology C-314 Radiation Physics Building 100 Bureau Drive, Stop 8463 Gaithersburg MD 20899-8463 U.S.A. *email:* john.hubbell@nist.gov
Dr. Mitio Inokuti	Biological, Environment and Medical Research Argonne National Laboratory 9700 S. Cass Avenue Argonne IL 60439 U.S.A. *email:* inokuti@anl.gov
Dr. David Jette	The Lawrence H. Lanzl Institute of Medical Physics P.O Box 30726 Seattle WA 98113-0726 U.S.A. *email :* dave@lanzl.com
Dr. P. Andrew Karam	Rochester Institute of Technology 54 Lomb Memorial Drive Rochester, NY 14623 U.S.A. *email :* karam@mail.rit.edu
Prof. K.J. Kearfott	Department of Nuclear Engineering University of Michigan 2355 Bonisteel Blvd Ann Arbor MI 48109-2104 U.S.A. *email :* kearfott@umich.edu
Dr. Sameen Ahmed Khan	C/- Bushra Khan Apartment 12 1-G 7900 Cambridge Houston Texas 77054 U.S.A. *email :* rohelakhan@yahoo.com
Asst. Prof. Chan-Hyeong Kim	Department of Aerospace, Mechanical and Nuclear Engineering NES Bldg 1-19 Tibbit Ave Rensselaer Polytechnic Institute Troy NY 12180-3590 U.S.A. *email :* kimc@rpi.edu
Ms. Gladys A. Klemic	Environmental Measurement Laboratory U.S. Department of Energy C/- Chicago OPS Office 9800 S.Cass Ave Argonne Ill 60439-4899 U.S.A.
Dr. Glenn F. Knoll	Department of Nuclear Engineering and Radiological Sciences University of Michigan 2355 Bonisteel Blvd Ann Arbor MI 48109-2104 U.S.A. *email:* gknoll@umich.edu
Dr. Steven T. Manson	Department of Physics and Astronomy Georgia State University Atlanta GA 30303 U.S.A. *email:* smanson@gsu.edu
Dr. Veerendra K. Mathur	Carderock Division Naval Surface Warfare Center 9500 MacArthur Boulevard West Bethesda MD 20817-5700 U.S.A. *email:* mathurvk@nswccd.navy.mil
Mr. Robert Mayer, Jr.	P.O. Box 916 Addison Texas 75001 U.S.A. *email:* rmayer@aip.org
Mr. Kevin M. Miller	Environmental Science Division U.S. Department of Energy Environmental Measurements Laboratory 201 Varick Street, 5th Floor New York NY 10014-44811 U.S.A. *email:* kevin.miller@eml.doe.gov
Prof. Fearghus O'Foghludha	1513 Pinecrest Road Durham NC 27705-5816 U.S.A.
Dr. R.T. Perry	Contact details unavailable
Dr. Richard H. Pratt	Department of Physics and Astronomy University of Pittsburgh Pittsburgh PA 15260 U.S.A. *email:* rpratt@pitt.edu
Prof. George A. Sandison	School of Health Sciences Room 1263 1338 Civil Engineering Building Purdue University West Lafayette Indiana 47907 - 1338 U.S.A. *email:* sandison@purdue.edu
Mr Michael P Shannon	Department of Physics United States Military Academy West Point NY 10996 U.S.A.
Dr. Polad M. Shikhaliev	Department of Radiological Sciences University of California, Irvine Medical Science I, B-140 Irvine CA 92697 U.S.A. *email:* pshikhal@saturn.radsci.uci.edu
Dr. James E. Turner	127 Windham Road Oak Ridge TN 37830 U.S.A. *email:* jamesturner17@comcast.net
Dr. Kenneth J. Weeks	Chief of Physics Department of Radiation Oncology 4420 Lake Boone Trail Raleigh U.S.A. *email:* ken.weeks@rexhealth.com
Professor Herman Winick	SSRL / SLAC MS 69 Building 137 2575 Sand Hill Road Menlo Park California 94025-7015 U.S.A. *email:* winick@slac.stanford.edu
Dr Sung-Joon Ye	WTI~09 Radiation Oncology University of Alabama, Birmingham 1824 6th Avenue S Alabama 35294 U.S.A. *email :* sye@uab.edu