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Main

FROM THE EDITOR

Dudley Creagh

When I look back at the developments in science and technology in the time since I graduated from Queensland University forty years ago, I am, to put it mildly…flabbergasted.

My first task as a graduate student engaged in ionospheric physics was the construction of a prototype computer for the correlation of signals from three orthogonally sited antennae. This was made with thermionic valves and other components liberated from surplus WW2 LORAN receivers. Then came transistors, integrated circuits, nano-technology…and now my wristwatch has more memory and functions than that early attempt at computer construction

X-ray diffraction, electron microscopy, particle induced x-ray emission, x-ray fluorescence spectroscopy…all essential techniques for the study of the physics of materials, for quality control in the mining and manufacturing industries, for use in biology and pharmacology…were in their infancy, and the province of dedicated physicists. The techniques were not user-friendly for non-physicists.

Gradually all of these techniques have become capable of being operated by relatively unskilled people. The focus is now more on the science, and less on developing techniques for the study of science: which is perhaps a good thing.

Students, however, learn a minimal amount about the techniques of analysis they use and less about the limitations of those techniques.

This is of concern because, as I am finding in the development of new techniques for the science of the future using synchrotron radiation, very few students are willing to undertake the demanding task of instrument design and development. It seems that all society freely accepts the benefits of the new technology, but is unwilling to devote time, effort and money to become anything but unsophisticated users of technology.

Somehow, we must try to reverse this trend.

I hope 1999 brings joy, happiness and success to you all.

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PRESIDENT'S COLUMN

Bikash Sinha

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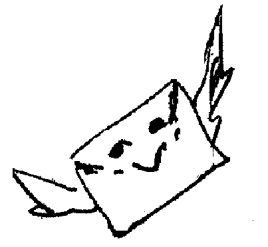
LETTERS TO THE EDITOR



No letters this issue. But we look forward to receiving them for the next issue!

Ed.

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! ! ! ! !
IDEAS ! ! ! ! !

Give us a job!!!

Do you need a Ph.D. student? Do you need a research assistant? Are you looking for a Postdoc position?

We are considering having a slot in the Bulletin for vacancies and posts wanted. It would be a way to advertise these positions, wanted or vacant, within the IRPS membership with no cost. If this idea interests you, contact the editorial members of the Bulletin and we can place your 'advertisement' in the next issue and put it on the web page.

E-mail Addresses

We are organising a register of the e-mail addresses of members (thanks to those who have already contacted us).
This will facilitate our ability to communicate rapidly with you.

If you are interested, please send your e-mail address (by e-mail!) to :

s-mckeown@adfa.edu.au

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INFORMATION PAGE

CITY UNIVERSITY

Department of Radiography

The Department of Radiography at City University has a vacancy for a research assistant to work on the detection of Fe levels in the skin of beta thalassaemia sufferers.

The successful candidate will be required to continue with pilot work carried out at City University in collaboration with Dr. David Bradley, University of Malaya.

Candidates should have a minimum BSc Physics at 2.1 or above with general knowledge of radiation physics.

The post is for a fixed term of one year in the first instance and will be on the scale of £15735 - £18275 plus London allowance, depending on qualification and experience.

For details of the post and application procedure contact

m.j.farquharson@city.ac.uk
or phone 0171 505 5681

The Swedish Radiation Protection Institute

announces its home page:

www.ssi.se

To subscribe to SSI-News

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We are always very interested in receiving from members such things as:

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ISRP-8
CONFERENCE
INFORMATION

ISRP-8

8th International Symposium on Radiation Physics

Prague (Czech Republic)

June 5-9, 2000

1st Announcement

SCOPE

The *International Symposium on Radiation Physics (ISRP)* is a triennial event organised by the *International Radiation Physics Society (IRPS)*. The meeting is devoted both to current trends in radiation physics research and potential future issues. The scientific sessions will include invited lectures by leading experts in the field and poster presentations of contributed papers. The symposium in Prague forms one of a series of symposia which began in Calcutta in 1974 and continued in Penang (1982), Ferrara (1985), Sao Paulo (1988), Dubrovnik (1991), Rabat (1994) and Jaipur (1997).

SCIENTIFIC SESSIONS

A. Fundamental processes in radiation physics

B. Radiation sources and detectors

C. Radiation in physical and material sciences

D. Radiation in medicine and biology

E. Radiation in space, earth and environmental sciences

F. Radiation in archaeometry and the history of art

G. Radiation technologies and industrial applications

CONFERENCE SITE

The symposium will be held at the *Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University in Prague.* Situated on the bank of the river Vltava, in the centre of this ancient national capital, the Faculty enjoys unique views of the surrounding hilly landscape, looking towards Prague Castle. Prague, home to more than 1.2 million inhabitants, is an important industrial and business centre, but it is undoubtedly as a centre of history and of long cultural, social and political traditions that it is most famed. Many interesting museums, galleries, theatres and other cultural venues are located within a short walking distance of the Symposium site.

Attending the symposium will offer not only an opportunity to enjoy a full scientific programme, including discussions of state of the art developments by leading figures, but will also allow a chance to discover the beauties of the city, its valuable historical monuments and rich cultural and social life.

SOCIAL PROGRAMME

A rich opportunity of social events will be offered to the participants and accompanying persons. These will include not only the welcome party and conference dinner, but also excursions to many of the most interesting places and sights of Prague and its environs. A schedule of concert and theatre performances will be included; details of these will be available once the performance programmes are known.

ATTENDANCE AND PAPERS

Papers are solicited in the areas listed under the heading "Scientific Sessions". If you are interested in attending the symposium, please return the enclosed Registration Form to the Chairman of the Organising Committee (see the address below) by March 31, 1999.

Details regarding abstract submissions will be given in the 2nd announcement. The full text of invited lectures and refereed extended abstracts of contributed papers (maximum of 2 pages) will be included in a Special Issue of the Elsevier journal *Radiation Physics and Chemistry*.

LANGUAGE

The language of the Symposium will be English. No simultaneous translation will be available.

EXHIBITION

Some space adjacent to the lecture and poster rooms will be available for the exhibition of small instruments, books and leaflets related to the topics of the symposium. Companies interested to exhibit their products should contact the Chairman of the Organising Committee as soon as possible, but not later than 31 March 2000.

ACCOMMODATION

Accommodation will be offered in hotels of various categories located in the centre of Prague and near to the symposium site. Limited number of cheaper rooms will be available in the university facilities, however these will be far from the city centre (about 30 minutes by public transport).

WEB PAGE OF THE SYMPOSIUM

Updated information on the symposium is available at the following Internet address:

http://www.fjfi.cvut.cz/isrp-8.htm

ENQUIRIES

Please, address all general enquiries relating to the symposium
to the Chairman of the Organising Committee:

Professor Ladislav Musílek
Czech Technical University in Prague
Faculty of Nuclear Sciences and Physical Engineering
Behová 7, 115 19 Praha 1,
Czech Republic

Fax: +4202 2320861

e-mail: musilek@br.fjfi.cvut.cz

Enquiries related to the symposium scientific programme should be addressed to the Chairman of the Scientific Programme Committee:

Assoc. Professor David A. Bradley
Department of Physics, Faculty of Science
University of Malaya, Pantai Valley
56100 Kuala Lumpur,
Malaysia

Fax: +603 759 4146,

e-mail: bradley@pc.jaring.my

IMPORTANT DEADLINES

Preliminary registration:	31 March 1999
Second announcement and call for abstracts:	30 June 1999
Abstract submission:	31 October 1999
Information about acceptance:	31 December 1999
Third announcement and preliminary programme:	31 January 2000
Registration and final hotel reservation:	15 March 2000

REGISTRATION FEES

(preliminary information)

	Before dead-line	Post dead-line
IRPS Members	350$	390$
Non-members	390$	430$
Accompanying persons	100$	140$

The fee includes: symposium programme and book of abstracts (participants only), proceedings (participants only), coffee breaks, welcome reception, symposium dinner, symposium excursion.

PRELIMINARY APPLICATION FORM

Download application form here.

REPORTS FROM MEMBERS

The Role of Amorphous Silicon Large Area Flat-Panel Detector Technology in Future Digital Mammography

Dimitra G. Darambara

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Breast cancer is a significant problem in the western world, leading to 60,000 deaths in Europe each year. It is the most frequent cancer in women with 1 in 12 women developing the disease. In the UK, approximately 16,000 women die each year of breast cancer. The fundamental goal of mammography is to identify structures which happen to have very low inherent contrast to their surroundings. Consequently considerable attention is currently focused on improving the technology for diagnosis. Within this scope the various developments in breast imaging play an important role for the detection and diagnosis of breast cancer. The gold standard of breast imaging methods should have high specificity and sensitivity and should be non-invasive and harmless.

X-ray mammography is currently the only diagnostic procedure with proven efficacy for early detection of breast cancer. In fact, it is the only non-invasive imaging method that can detect clinically occult non-palpable breast nodules and depict malignant calcifications within the breast. For over 60 years, x-ray film in combination with intensifying screens has been the standard for medical imaging because of its functional utility and perceived high image quality. Indeed, the x-ray screen-film mammography produces consistently high contrast, high resolution images at the lowest radiation dose possible. Although mammography is the single most successful method of detection of breast cancer because of its high spatial resolution, its specificity is low. For example, one third of patients undergoing mammography present "abnormal" mammograms that require further investigation often involving biopsies. A large percentage of these are found to be benign. The trauma and anxiety for such patients is significant and there is need for improvements in x-ray screening techniques. Moreover, it is well known that the x-ray mammographic technique suffers from limitations: inefficient scatter rejection, insufficient latitude of film/screen imaging system and film granularity. X-ray films also perform the multi-fold functions of capture, display, storage and communication of the image data leading obviously to organisational problems. Such limitations of the standard film/ screen imaging systems can be reduced with the use of digital detectors. A digital mammographic imaging system could effectively overcome these limitations and improve the performance of mammography. The advent of digital mammography could also lead to the application of contrast enhancement techniques which are desirable in order to increase tumour detectability. It is believed that digital mammography offers a wide range of functional advantages over conventional imaging techniques, most notably: low-noise imaging, wider dynamic range, improved contrast resolution, minimised need for retakes, the potential for lowering patient dose and for faster imaging for future clinical applications without delays due to heat loading, and independent optimisation of acquisition, display and storage parameters. The challenges in creating a digital mammographic system with improved performance are mainly related to the choice and design of the digital detector technology. A digital detector to be acceptable for digital mammography should possess an appropriate combination of spatial resolution, field coverage and signal-to-noise ratio performance. Recent technological inventions and developments in the area of digital detectors have created new possibilities and breakthroughs in medical diagnostics.

In diagnostic imaging applications, currently available instrumentation imposes significant constraints and limitations. However, recent advances in the fabrication and development of hydrogenated amorphous silicon (a-Si:H) sensors and transistors offer the prospect of *large-area, flat-panel, real-time imaging arrays* which would eliminate many of these restrictions. Such devices will offer efficient, compact and flexible x-ray image detection using integral self-scanned readout of the image. The active-matrix flat-panel imagers exhibit high x-ray sensitivity combined with low-noise, and hence offer high image quality over a wide range of radiation exposure and anatomical thickness, meaning faster imaging and reduced radiation exposure to the patient. Moreover, amorphous silicon is ideal for x-ray detectors because it is nearly immune to radiation damage. A flat-panel digital detector, in principle, could perform all current radiological modalities. Most developments so far have been aimed at general radiography. Flat-panel sensor imaging promises to eliminate film in radiography by supplanting it with an area detector of a-Si that has a comparable field-of-view. It also permits significant improvement of present day digital fluoroscopy by replacing the bulky image-intensifier/video camera fluoroscopy combination with smaller, lighter, more portable imagers. Nevertheless, progress in this field may lead to systems appropriate to *direct digital mammography*. Amorphous silicon detectors may also benefit other x-ray imaging applications, such as bone mineral densitometry, x-ray crystallography and diffraction analysis. An additional application is the detection of explosive devices.

Certain non-crystalline forms of silicon can be used to construct thin-film transistor (TFT) micro-circuit arrays of large area. Unlike the more well-known form of silicon, which is carefully grown and refined in the laboratory as a crystal, amorphous silicon begins life as a vapor and eventually is deposited in a whisper-thin layer on a surface, usually glass. This means that the a-Si devices can be much larger than the crystalline variety because no single crystal is needed. The form which has received the greatest attention in imaging devices is the *hydrogenated amorphous silicon* (a-Si:H), i.e. amorphous silicon is permeated with hydrogen and diffused with p and n dopants to provide device junctions. The a-Si:H is very sensitive to visible light, with an efficiency close to 1 and has low pixel noise. Arrays of discrete circuit elements are manufactured using high definition photo-lithographic and etching techniques.

These panels comprise a regular two-dimensional array of photo-sensing elements combined with the relevant micro-electronic circuitry. Each TFT element comprises a photodiode with its associate field effect transistor (FET). Superimposed upon the matrix array is a layer of material, --*scintillator screen*--, which provides x-ray photon detection and energy conversion. The sensors are sufficiently thin, thus the signal generated in them through direct interaction of the incident radiation is negligible. The absorption coefficient of a-Si:H is such that the sensor responds to light in the wavelength range from 400 to about 650nm, with its peak response at 550-600nm, where it has a quantum efficiency of 80-90%. For diagnostic x-ray imaging, several x-ray sensitive materials can be used with TFT flat panels, such as $Gd_2O_2S_2$:Tb phosphor screen or thallium-doped caesium iodide (CsI:Tl) scintillating material. It has been found that the measured relative light response of an a-Si:H photodiode sensor is very well matched to the spectral output of these phosphor materials. The choice of the scintillator depends on specific requirements for each detector application, namely, the type and source of radiation, speed requirement and spatial resolution. At the present, *thallium-doped caesium iodide* (CsI:Tl) is the favoured x-ray detection material for use with TFT readout, because it produces the largest amount of light of any other high Z scintillator. This channeled-scintillator has good light emission and spectral match to a-Si: H photodiodes and offers high detective quantum efficiency combined with good spatial resolution. These properties, which are essential for good image quality, arise from the columnar structure of CsI:Tl layers (act as fibre optics), when grown by evaporated deposition at high temperature.

This technology is already used in a variety of commercial products such as solar cells and flat-panel displays. More recently, prominent groups in the field of x-ray imaging including the Lawrence Berkeley Laboratory, the University of Michigan and Xerox RAPC Research Center have been developing large area a-Si:H TFT-based digital x-ray image acquisition panels. Both radiographic and fluoroscopic systems have been described using indirect-detection active-matrix arrays. In the Radiation Physics Group, Department of Medical Physics & Bioengineering, UCL, we have been working on the design and development of an advanced 3D digital x-ray imaging system for breast screening under a MedLINK programme. Our consortium partners are: Image Scan Holdings Ltd, The Nottingham Trend University, St. Bartholomew's Hospital, London, Breast Screening Directorate, City Hospital, Nottingham and Feinfocus Medizintechnik GmbH, Germany. The detector that we currently evaluate with a view to using it in this application is the FlashScan-30 amorphous silicon imaging system supplied by the dpiX, inc, a Xerox New Enterprise Company, USA combined with the direct magnification method adapted by the Feinfocus mammographic unit to provide high resolution images. To enhance even further the information embodied into the digital image produced by the a-Si array, it has been proposed to use stereoscopic images created by viewing the object from two points and recombining the images. This method developed by the Nottingham Trend University will provide a full 3D x-ray image of an object as well as left and right perspective 2D images all at the same time. Stereoscopic visualisation of the breast will allow overlying structures to be separated.

The application of a-Si large area flat-panel imaging arrays in mammography has advantages but also drawbacks in the practical realisation of mammographic systems. Due to their compact dimensions and overall superior performance, the large area flat panel detectors will soon be used for various clinical x-rays tasks allowing geometrically more attractive system designs. Further advances are expected in the next few years which should improve digital mammography in the next century, and therefore, further research in system development and optimization is needed including further improvements to the overall performance of these new digital imaging systems. It is expected that a careful scientific approach to the design, fabrication, testing and evaluation of the imagers will be necessary for the full potential of this technology to be realised. Customer evaluation arrays available by the manufacturers are the ideal platform for investigating, differentiating and addressing the unique needs of its specific amorphous silicon based imaging application.

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Possible Health Effects of Low Level Exposures to Ionising Radiation

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1. Introduction

The United Nations Scientific Committee on the Effects of Ionising Radiations (UNSCEAR), in its 1993 report to the General Assembly states that ' The Committee's interest in the biological effects of radiation is mainly concentrated on the effects of low doses'(1). This highlights the fact that today probably no other topic in radiation sciences has been drawing so much attention as the likely health effects of exposure to ionising radiation at low levels. This is so for several valid reasons. In occupations dealing with radioactivity and ionising radiations, while one can bring down the radiation fields and exposures to very low levels by proper practices and control, they can not be totally eliminated. This will be over and above the background radiation which is ubiquitous with wide spatial variation depending on the geochemical and other features of the area. Further, the health effects associated with these low level exposures are, if at all, likely to be a small fraction of natural incidence of such maladies. An obvious question would be, why not extrapolate backwards from the high exposure risk data which is more or less well established. This is not always possible since such extrapolations are wrought with severe uncertainties due to dose-rate effect, repair mechanism, adaptive response etc. Thus the exact determination of the health risk at low exposures continues to be a challenging task. Various aspects of this problem are presented in the paper.

2. Low Level Exposures

The global average dose due to natural background radiation is about 2 mSv/yr. This corresponds to an average life-time dose of 140 mSv. However the natural background radiation and consequent life-time dose vary from place to place ranging up to two orders of magnitude. The internationally accepted limit for occupational exposure is 20 mSv per year averaged over 5 years. But the globally averaged exposures for radiation workers in different fields are in the range of 2 to 8 mSv/yr (2) . Further, there is a declining trend in this due to improved technology and practices.

When we say low level exposure, it generally refers to dose rates of fraction of a mSv per minute and/or integrated dose in the range of 200 to 400 mSv.

3. Biological Effects

It is well established that biological effects are of two types; deterministic and probabilistic. The deterministic effects, such as depression of red blood cells, skin reddening and blistering, induction of sterility etc., arise out of massive cell damage or cell-killing due to the exposure of the biological system to ionising radiation. These effects are characterised by their appearance within a few hours to a few weeks after the exposure. A very important feature of the deterministic effects is that they occur only above a particular level of exposure called 'Threshold Dose'. The threshold doses are different for high dose rate (acute) and low dose rate exposures. For human species, about 200 mSv of acute exposure is needed for any discernible deterministic effect. Such exposures can occur only in serious radiation accidents or from unwanted but inevitable exposure of healthy tissues in radiation therapy. For more commonly encountered low dose rate exposures the threshold is significantly higher, of the order of a few Sieverts.

Probabilistic effects, also known as 'Stochastic Effects' result from the 'Mutagenic' action of ionising radiation, a simplified picture of which is as follows:

In a living cell the Deoxyribonucleic acid (DNA), present in the chromosomes residing inside the nucleus, is the repository of all the information required for governing the cell-functioning and its replication. The DNA is a double-stranded helical macro molecule. The backbone of each strand is a string of sugar and phosphate residues and the two strands are linked by a pair of 'Nucleotide' bases. Four different types of nucleotide bases namely Adenine, Guanine, Cytosine and Thymine occur in the DNA molecule. The cardinal feature of the DNA is that while the occurrence of a particular nucleotide base along the strand of the molecule is not influenced by the neighboring ones, the base pairing is highly specific. That is, Adenine on one strand can pair only with Thymine on the other strand with a similar matching between Cytosine and Guanine. Thus, the sequence of nucleotide bases on one of the strands of DNA completely determines the sequence on the other. (This plays a paramount role in cell replication but we need not go into its details here.) The sequence of such base pairs in the DNA molecule is the 'Text' of information required for all cell activities. If the DNA molecule is affected either by affecting the individual base pair or its sequence, the information content gets altered and such a change is called Mutation. If the cell happens to be a somatic (non-germinal) cell in the body, the mutagenic disturbance can lead to loss of control over the cell division which may eventually result in cancer induction. Or if it happens to be a germ cell, the mutated information can get passed on to the progeny leading to genetic effects. Ionising radiations are known to bring about such mutations either by directly affecting the DNA or by producing active chemical species in its vicinity which can affect the DNA. Both direct and indirect modes of damage are probabilistic in nature and the probability increases with radiation dose. Some common types of damage to DNA are; (i) base damage, (ii) single strand break, (iii) double strand break and (iv) cross linkage of the molecule. The damage to DNA is subject to very efficient repair mechanisms mediated by enzyme actions. If the damage is confined to a single strand, the repair mechanism uses the information provided by the other strand. The repair is then highly efficient and error free. Misrepairs are frequent in the case of double strand breaks. Such instances result in the loss of biological information which may lead to carcinogenic or genetic effects. It must be mentioned here that the mutations are nothing new nor specific to ionising radiations; they are also introduced by other agents such as excessive heat, certain type of chemicals and viruses etc. The mutagenic phenomenon has always existed in nature and it is part of our evolutionary system. The frequency of natural mutations is about a million times more compared to the number introduced by the radiation at the levels we are interested in, as can be seen from Table 1.

Table 1. DNA damage in Mammalian cells(3)

Type of Event	Spontaneous events/yr	Events/10 mSv
Single strand breaks	~4.4 x 107	10.0
Double strand break		0.4
Depurination and/or base legions	~1.4 x 107	
	~1.1 x 107	9.5
Total	~7 x 107	20.0

4. Risk Evaluation

It is the mutagenic effect of radiation which has given rise to maximum concern amongst the public. Unlike the deterministic effects, these effects are supposed to have no threshold levels of exposure. Though there are arguments against this no-threshold model, it is generally accepted as a safe hypothesis in the absence of firm data to disprove it. According to this, however small the radiation dose is and whether it incurred in one shot or over an extended period, the effect, or more appropriately the probability of its occurrence, is proportional to the integrated dose. Furthermore, irrespective of the number of persons exposed in the population and the levels of their exposure, the probability of the manifestation of these effects in the population is proportional to the sum total of all the individual exposures called cumulative dose expressed in Person-Sieverts (PY).

The biological information system has been built with a large redundancy which provides a degree of resilience to the system. Besides, cancer is a multifactorial disease which needs more than just an initiator. It is in this context that these effects are called stochastic and dealt with in terms of probabilities. For quantitative assessment, the biological detriment of these effects are expressed in terms of Risk coefficients. Simply put, the risk coefficient is the frequency of undesirable events introduced in the population due to unit collective dose (there are several variants of this definition, each one having its own advantages).

Understandably, there has been an enormous scientific effort in terms of laboratory studies on animals, in-vitro experiments on mammalian cells and epidemiological studies towards determining the risk coefficients. While the laboratory experiments have significantly contributed to our understanding of radiobiological basis for risk determination, the risk coefficients themselves have been obtained basically from epidemiological studies. The data base currently available from such studies fall under two categories; High Dose Rate Exposures (HDR) and the Low dose or Low Dose Rate Exposures (LD/LDR). The HDR data base consists of more than $3x10^5$ Person-Years (PY) of Life Span Studies (LSS) of the Atomic bomb survivors in Hiroshima and Nagasaki and more than 10^6 PY each from radiation treatment and diagnostic cases. Of them, the LSS is the most thoroughly planned one and it is essentially based on this study that the risk coefficient for cancer is estimated to be about 5×10^{-2} per Sievert.

For the genetic effects, the UNSCEAR specifies a risk factor of 1×10^{-2} per Sievert. This figure has been derived essentially from animal studies involving higher levels of exposure. None of the epidemiological studies conducted so far, including the LSS, have shown any evidence of genetic effects.

5. Low Level Exposures

It is well established that for gamma-rays, which is of primary concern in the population exposure, the biological risk has a strong dose and dose rate dependence. Firstly, the dose response curve is observed to be non-linear and the effects at low doses estimated by the backward interpolation of high exposure data tend to be over estimates. Second and more important observation is that for the same total dose, the lower dose rate exposure results in a significantly lower detriment. Based on extensive experimental and epidemiological studies the Dose and Dose-Rate Effective Factor (DDREF) has been observed to be in the range of 2-13. It may be mentioned here that the basis for presently used risk coefficients is the LSS of Atomic Bomb Survivors which is essentially a high dose rate category. Of course, to extend its application to low level exposures, a DDREF of 2 has been used. However the actual DDREF applicable could be significantly lower resulting in much lower risk coefficients as observed in the low dose low dose-rate (LDR) epidemiological studies discussed below.

The presently available LDR data consists of about 2×10^6 PY of occupational workers and more than 10^6 PY of environmental exposure in High Background Radiation Areas (HBRA). This data does not provide a clear support to the presently adopted risk coefficients. It is even consistent with a 'No-Risk' model. Amongst the LDR, the epidemiological investigations in China happen to be the largest. It has about 10^6 PY of observation for people living in HBRA with a mean radiation dose of 5.4 mSv/yr and a similar number in control areas with a mean dose of 2 mSv/yr. The study shows no increase in the cancer mortality for the HBRA population (4) . As a matter of fact, the frequency of observed cancers in the HBRA population is marginally less compared to that of control population (but not significant enough to firmly support any negative correlation of cancer with radiation exposure). Large scale LDR epidemiological studies have also been conducted amongst the radiation workers in USA, Japan, France, Canada and Sweden. None of them show any significant association of cancer with low level exposure. Recently, the International Agency for Research on Cancer conducted a study on the data pooled for radiation workers from three countries (5) . The combined data clearly indicate that the presently used risk factors for cancer are significant over estimates at least up to 300 mSv.

There have also been other reports of occurrence of health effects due to low level exposure. In general, they have not been able to stand the rigorous scientific analysis and have been discredited by subsequent large scale studies. Some time back Kochu Pillai et al (6) reported higher prevalence of mentally retarded children (12 in the surveyed population of 12918) in the monazite belt of Kerala as compared to zero prevalence (none in 6000) in the control population. The difference was attributed to the higher background radiation, 15-30 mGy/yr, in the monazite belt as compared to 1 mGy/yr in the control area. However, later analyses faulted this report on several counts including the anomalous observation of zero incidence in the control population (7). Similarly in UK, Knox et al, reported correlation of cancer (leukemia) with high background radiation (8) . But a subsequent large scale study on the same did not provide any confirmation for the conclusions of Knox (9) . It was noted that the statistical methods employed by Knox were obscure and the results were difficult to interpret.

Gardner et al (10) reported clusters of childhood leukemia amongst the population living in the vicinity of UK Sellafield Nuclear facilities. A possible linkage of these clusters to the radiation exposure of the fathers was suggested. This was in total contradiction of the LSS data; no excess cancer has been observed amongst the children of atomic bomb survivors who had significantly higher exposure. Still, the report created quite a sensation and prompted several large scale and systematic surveys. These studies did not provide any support to the suggestion that fathers' radiation exposure increases the cancer risk for the children11. Studies have also been conducted amongst the children in the vicinity of nuclear facilities in France, USA, Germany and Canada. None of them gave any evidence for the excess cancer as reported by Gardner.

6. Adaptive Response

Over the years, there has been a large number of studies which provide support for the hypothesis that an initial low level exposure to ionising radiation can mitigate the severity of deleterious effects of subsequent high exposures. There have also been reports that such low exposures can even be beneficial by preparing the cell to face the deleterious agents other than ionising radiation. However the evidences for such effects are still not unequivocal. If firmly established, they can lead to substantial reduction of risk coefficients at low level exposures.

7. Conclusion

Detrimental effects of exposure to the ionising radiations is one of the most widely studied subjects. Based on extensive laboratory studies and epidemiological surveys, the risk coefficients have been arrived at on a conservative basis. They have been derived from high exposure data. Quite small as they are, there are strong reasons to believe that they are over estimates for low level exposures and can be considered only as upper limits. How small they are or whether they exist at all at low exposures are the issues of interest at present.

References

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WORLD NEWS

Report makes a case for more neutrons

Judy Redfearn

(From *"News", Physics World*, Vol. 11, No. 12, December, 1998, p.9)

The worldwide "scientific impact" of neutrons should more than double by 2012 if spallation sources that are currently being planned get the go-ahead within the next ,even years. So says a report published last month by the OECD Megascience Forum, which looked at the supply and demand for neutrons over the next 20 years in Europe, North America and the Pacific.

The report was written by Dieter Richter and Tasso Springer from the Institute for solid-state physics in Julich, Germany. They quantified "scientific impact" by recording the flux of neutrons and the number of instruments at each source. They found that if all of the world's planned spallation sources are actually built, the scientific impact of the Pacific would catch up with - or even overtake - North America and Europe, by virtue of a neutron source being planned for Japan. They also say that North America will "significantly strengthen" its capacity if it builds the Spallation Neutron Source (SNS) at Oak Ridge in Tennessee.

Front runner - the ISIS spallation source in the UK

The two most advanced high-flux neutron sources in the world are currently in Europe, namely the high-flux reactor at the Institut Laue Langevin in France and the ISIS spallation source at the Rutherford Appleton Laboratory in the UK. However, if Europe does not build the planned European Spallation Source (ESS), it will start to lose ground over its competitors, according to the report. Andrew Taylor, director of ISIS, says time must not be lost. "In order to get the ESS up and running for 2010-2015 we have already started on its R&D programme," he says. Twelve European countries are involved in this programme, which will run until 2003 (*Physics World* , May 1997 p5; December 1997 pp27-32). Funding for the ESS therefore needs to be in place by 2005. But Taylor admits the Europeans have a "comfort zone" - the Americans do not anticipate that SNS will have "ISIS-like" capability before 2005.

As well as advocating the need for new neutron sources, the report recommends that existing sources could be better exploited by increasing the number of beamlines and instruments. This finding supports plans at ISIS to add a second target station for soft-condensed-matter research, which Taylor thinks would be "highly cost effective". The new target station would cost around £50m, a snip compared with the
£1 - 1.3 billion needed for a next-generation spallation neutron source.

The report also complains that not enough attention has been paid to instrument development in the past, and recommends that a "substantial fraction" of the investment for new sources be set aside specifically for instrumcnts.

The problem for the neutron-scattering community is that it is not as cohesive as other communities that use large-scale facilities, such as CERN, and is therefore poor at lobbying for new spallation sources. "The users I serve are worried about quantum magnetism or growing crystals or polymers," says Taylor. "They're not too concerned about the source, or organized about thinking about its future." The OECD report will provide scientists who rely on neutron scattering with the facts and figures they need to get organized.

Cash cuts for Brazilian science

(From *"News in Brief", Physics World*
Vol. 11, No. 12, December, 1998, p.13)

The impact of the global recession in Brazil has caused the country to implement a 18.7% budget cut to its $747m (about £451m) science budget. Many of its scientific institutions, such as the National Observatory, now face insolvency. Research is particularly hard hit with the budget of the science research council being trimmed by 25% to $361m. The cuts have been demanded by the International Monetary Fund in order that Brazil can qualify for a $41.5bn loan.

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Full contact details for the following Members are listed in the Members' Contact Details, accessible from the home page. The Contact Details list is updated regularly between issues

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