HPS Annual Meeting Accelerator Section Special Session, Morgan Lecture

G. William Morgan Lecturer Ralph H. Thomas led off the Accelerator Section Special Session at the Health Physics Society (HPS) Annual Meeting on 23 July 2003 with his talk "Accelerator Radiological Protection—A Personal and Privileged Odyssey." Professor Thomas' presentation was one of two Morgan lectures given at the annual meeting. These lectures are supported by a fund which was bequeathed to the Society by G. William Morgan upon his death in 1984. His will requires that the fund's interest be used to have internationally known experts present papers at the Society's meetings.

Thomas' career spans seven decades, most of it spent at the University of California. Born in England, he started work at the age of 15 at the Atomic Energy Research Establishment at Harwell, United Kingdom. He studied at University College London where he graduated with honours in physics and was later awarded a PhD in nuclear physics. He also holds the degrees of DSc from the University of London and MPH from the University of California at Berkeley.

After working briefly in industry, Thomas returned to Rutherford Laboratory at Harwell in 1960 where he studied skyshine and shield design of the 50-MeV proton linear accelerator and the 7-GeV proton synchrotron. Subsequently he joined the Radiation Laboratory of the University of California to design a 200-BeV proton synchrotron. On returning to the Rutherford Laboratory from Berkeley, Thomas was appointed head of Radiation Protection. In 1970, Thomas returned to the Lawrence Berkeley National Laboratory where he rose through the ranks becoming Head of the Health Physics Department, Deputy Head for Laboratory Health and Safety in the Engineering Division, and Head of the Occupational Health Division.

Presidents Emeritus Committee Chair Richard J. Vetter (left) presents the G. William Morgan Lecture plaque to Ralph H. Thomas.

Thomas retired from the University of California in 1993. For more than 20 years he has served on International Commission on Radiological Protection, International Commission on Radiation Units and Measurements, and National Council on Radiation Protection and Measurements committees. He is a Fellow of the Health Physics Society, the Society of Radiological Protection, the Institute of Physics, and the Royal Society of Health. He continues to remain active in his field as a private consultant.

G. William Morgan Lecture Summary*

Accelerator Radiological Protection—A Personal and Privileged Odyssey

Ralph H. Thomas, DSc

Accelerators and the Birth of "Health Physics"

The dying years of the nineteenth century saw Roentgen's discovery of x rays with the aid of a primitive electron accelerator, foreshadowing the important role that particle accelerators were to play in laying the foundations of the health physics profession.

X rays immediately found application to medicine and for the next 30 years the primary concern of radiological protection was the prevention of harm that might result from overexposure to photons (low-LET radiations).

In 1932 the invention of ion accelerators at Berkeley and Cambridge led to the first concerns for protection from external exposure to neutrons (high-LET radiations). By 1934 John Lawrence suggested that the RBE for neutrons was between 5 and 10 and appropriate protection standards were set at Berkeley.

From 1932 a succession of

discoveries followed—the neutron, induced radioactivity, radioactivity of tritium (1938) and neptunium and plutonium (1940-42). These fundamental discoveries directly led to the birth of nuclear medicine (1934); studies of radionuclide metabolism, neutron radiobiology, and neutron radiotherapy (1936); and initial studies of the medical effects of transuranics (1942).

Thus by the end of 1942 the fundamental aspects of the tasks that have occupied health physics for the past 60 years were defined by the work of accelerator laboratories. On 2 December 1942 the first self-sustaining neutron chain reaction was achieved by Fermi and his colleagues at the University of Chicago.

Burton J. Moyer (1912-1973)—“The Father of Accelerator Health Physics”

In 1947 Ernest Lawrence requested that Professor Burton Moyer establish a professional health physics group at the Radlab. With his creation of an independent health physics group, with which accelerator designers could consult on matters of accelerator radiation safety, Moyer set a pattern followed by accelerator laboratories around the world.

Moyer is best remembered for the “Moyer Model,” first used to design the shielding for the Bevatron, and subsequently assisted in the design of many accelerator shields. Moyer’s publications on the philosophy of radiation dosimetry have had a lasting impact around the world. It is a philosophy that seems all the wiser with the passage of time.

Shielding

In the mid-1950s the early proton synchrotrons, the Cosmotron and the Bevatron, were at the centre of a radiation crisis that needed prompt attention. Ironically it was a crisis caused neither by failure nor by any sin of omission but rather by overperformance by the machines.

In 1962 Moyer successfully installed shielding, designed to reduce radiation intensities by a factor of 100, at the Bevatron. During the 60s studies of the hadronic cascade in matter provided data that facilitated efficient accelerator-shield design and assisted in the development of modern radiation transport codes. Laboratories cooperating in these experiments included Brookhaven National Laboratory, DESY, CERN, Lawrence Berkeley Laboratory, Oak Ridge National Laboratory, Rutherford Laboratory, and the Stanford Linear Accelerator Center.

Radiation Dosimetry at High-Energy Accelerators

Radiation fields outside the shielding of high-energy accelerators are “mixed” in character, consisting of muons, neutrons, and photons. Neutrons, with widely distributed energies, are usually the most important component. The physical parameters of the radiation field (integrated particle fluence, energy spectrum, and the angular distributions of particles in the field) are clearly defined and measurable and are the basis for dosimetry of accelerator radiation fields.

Any desired modified adsorbed dose quantity, D_m, (radiation protection quantity) may be related to the total fluence, Φ by $D_m = <g>\Phi$ where $<g>$ is the appropriate spectrum-weighted conversion coefficient. Modern transport calculational methods now make it possible to determine neutron spectra and conversion coefficients for typical irradiation geometries of anthropomorphic phantoms.

The Future

The application of accelerator technologies will lead to an increasing potential for exposure to neutrons. This trend suggests that the dosimetry and radiation protection quantities for high-LET radiations deserve prompt attention.

Over the past 30 years the International Commission on Radiological Protection (ICRP) had paid insufficient attention to these topics and the advice it has given has often been confused and ephemeral. Consequently the logical and theoretical basis for ICRP protection standards for high-LET radiations has been much criticized in the scientific literature. ICRP is aware of these difficulties and has announced that it is in the process of revising its comprehensive recommendations in 2005. It is to be hoped that this revision will adequately address these important topics.

* This summary is based on the complete text which, together with the slides used during the lecture, is available on the HPS Accelerator Section Web site (www.hps.org/accel/).