RADIATION, REACTORS, NEUTRONS AND MEDICAL APPLICATIONS IN THE 20TH CENTURY AND BEYOND

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ABSTRACT

Although the PHYSOR 2000 conference is primarily focused on computational and experimental reactor physics, it also includes some discussions of medical applications of nuclear technology. This is of particular relevance when it is noted that many of the computational and experimental methods developed by the reactor physics community have direct parallels in the medical physics arena. Furthermore, some key computational methods in reactor physics have been directly adapted for medical usage, especially during the last 10 years or so.

The applications of nuclear science to medicine began in 1895 with the discovery of x-rays by Rontgen, whose initial publications stimulated an enormous amount of work by some of the most eminent physicists of the time. These efforts were directed toward the development of methods to experimentally quantify the new phenomenon and to identify and refine the many applications that immediately suggested themselves. In particular, it was observed very early on that x-rays (as well as radiation from radionuclides) had the ability to retard the proliferation of cancer cells and could in fact sterilize malignant tumors under certain conditions. However this useful property was tempered by the fact that the new tool was a double-edged sword --- it could also cause serious damage to normal tissues. Thus was born the science of Radiation Oncology, which to this day seeks improved treatment of malignant disease while sparing healthy tissue via the selective application of radiation.

Improvements in radiation oncology over the century have come about largely through advances in the technology of producing and administering photon radiation as well as through the selective use of different types of radiation. The advent of megavoltage X-ray equipment in the 1950's produced a major advance in tumor control probabilities and cure rates as a result of improved penetration as well as significant surface tissue sparing. More recently, medical image based three-dimensional treatment planning methodologies, the most sophisticated of which depend on Monte Carlo simulation techniques originally developed for non-medical nuclear applications, have come into favor. These can be shown in many cases to improve the administration of radiotherapy by providing the physician with better information about (and thereby greater control over) the tumor and normal-tissue absorbed dose distributions for a given patient.

Another encouraging development in modern radiation oncology involves the advent of technology for reliably and economically administering other types of radiation (e.g. neutrons or protons) that feature higher LET and in some cases greater selectivity and improved radiobiological properties. The parallels between reactor physics and the physics of neutron therapy are particularly apparent, both with regard to

the development and deployment of neutron sources as well as with regard to methodologies for dosimetry and treatment planning. Neutron therapy is the modality of choice for certain types of inoperable salivary gland tumors and it also appears to be emerging, on the basis of recent research data, as a promising modality for sarcomas, locally advanced prostate cancer, and certain other malignancies as well. Neutron capture therapy, which involves the sensitization of the target tissue with a neutron capture agent prior to administration of neutron radiation at a suitable energy has also attracted a great deal of research interest over the years.

Computational advances made for traditional applications – like reactor physics – are finding niches that have life-saving impacts.