Welcome to the second volume of SURJ: The annual SEPS Undergraduate Research Journal, showcasing highlights of research-level work performed by undergraduate students in the School of Electronics and Physical Sciences (SEPS) at the University of Surrey. After a successful start last year, in which the journal was trialled in the Physics Department, this year has seen an increase in the number of articles, and the inclusion of the Department of Electronic Engineering – welcome!

As well as showcasing student excellence, SURJ provides undergraduate students with the opportunity to be involved in the scientific publishing process. This valuable skill is one which the authors of last year's articles are putting to good use. Some of them have gone on to higher study. One of them – Emma Sucking – is now studying for a PhD in nuclear physics, and her SURJ article was judged by a panel of physics staff to deserve the prize for best article of the first volume – well done Emma!

The articles this year cover again a broad range of topics, ranging from a theoretical study of quantum dots and the simulation of neutron detectors to the design and characterisation of equipment for medical diagnosis, representing a range of the research and teaching interests of the School. The Institute of Physics South Central Branch has kindly offered a prize of £250 for the best article submitted by a physics student for this year, and the winner will be announced at one of the talks arranged by the Institute which take place at Guildford throughout the academic year – entertaining and informative talks to which all are welcome. For details, please look under "Branches" on the Institute of Physics website www.iop.org.

Current undergraduates are encouraged to write articles for next year's Journal. Submission guidelines are given below. The topic can be any kind of research level project undertaken – from a piece of project or experimental work, from a research placement or professional training year. If in any doubt, please contact the editor, then get writing to experience the satisfaction of seeing your work in print!

One last word – now that the University has moved from Schools to Faculties, the acronym SURJ can no longer stand for SEPS Undergraduate Research Journal. I think I'd prefer to keep the name SURJ, so any suggestions of what it might now stand for are most welcome.

Submission Instructions

Those wishing to write an article for the next volume should discuss the suitability of the material with either the editor, and their project supervisor. Articles must be prepared using Microsoft Word, and separate copies of any figures provided. Articles, and any correspondence, should be sent to surj@surrey.ac.uk. The formatting of the articles should be kept as plain as possible as the layout will be arranged at the production stage by the designer. The deadline for submission of articles for the 2008 volume is Fri 14th Mar 2008. Following the deadline, all authors will be asked to act as referees for other articles, with publication to follow shortly after the end of the academic year.

Dr. Paul Stevenson
Editor

Monte Carlo Simulations of the Effective Neutron Dose Received by a Male Anthropomorphic Voxel Phantom outside a Medical Linac Treatment Room

M. Hussien, A. K. Ma and N. M. Spyrou
Department of Physics, University of Surrey, Guildford, Surrey, GU2 7XH

Abstract

The effective dose received by an anthropomorphic male phantom outside a medical linear accelerator (Linac) treatment room has been simulated using MCNPX [1]. In high energy Linacs used for electron and photon therapy, unwanted neutrons are produced in the accelerator head which need to be taken into account with regards to inadequate shielding and additional effective dose to staff, primarily. Calculations were made at various positions and orientations outside the room. The highest effective dose due to neutrons was found to be at the maze entrance and the effective dose due to neutron-induced photons was found to contribute an extra 15 % for a person standing facing the maze entrance.

The treatment room was specified so that it could easily be modified; a hospital could provide the dimensions of their Linac treatment room along with specifications such as concrete composition, neutron shielding etc, and simulations could be run to calculate the effective dose in the anthropomorphic phantom to determine whether their shielding is adequate.

Radiotherapy

Radiotherapy is the use of ionising radiations to treat malignant (cancerous) tumours deep within the human body. More than 200 different types of cancer have been identified to date, all cancers however are basically similar; they all result from uncontrolled cell growth causing tumours [2]. External beam therapy is the most common form of radiotherapy and is normally performed with photon beams. These photon beams are generally high energy x-rays produced by a Linac. Modern medical Linacs can produce energies from 8 MeV upto 25 MeV.

Photoneutron production

For descriptive purposes, the energy of neutrons is divided into three energy-ranges [3]:

1.1 Thermal (slow) neutrons: < 0.5 eV
Intermediate neutrons: 0.5 eV – 100 keV
Fast neutrons: >100 keV

The electrons and photons produced in high energy Linacs may undergo electroneutron (e,e′n) interactions and photoneutron (γ,n) interactions respectively. Both types of interactions produce neutrons as by-products [4]. Electroneutron production is 100 times less probable and therefore neglected in simulations. Photoneutron production is governed by the neutron separation energy and by photoneutron cross-sections.

Photoneutron sources include the treatment head, the patient, the air and the walls of the Linac treatment room. So the isotopes of interest include ^{16}O, ^{12}C, ^{14}N, ^{39}K, ^{40}Ca in the patient's body; ^{16}O and ^{14}N in the air; ^{184}W, ^{208}Pb and ^{27}Al in the treatment head and treatment accessories; ^{16}O, ^{28}Si, ^{40}Ca, ^{54}Fe and ^{12}C in the concrete walls. ^{10}B and ^{11}B are sometimes used for maze lining to shield against neutrons.

Linac bunkers are designed to attenuate photons and at the same time moderate the fast photoneutrons produced. The fast neutrons can become thermalized and subsequently captured which results in unwanted radiation.
The photoneutrons produced can result in unwanted dose to not only the patient inside the Linac treatment room but also to oncology staff and the general public outside the treatment room.