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Contents

Tumor Therapy with Carbon Ion Beams

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Abstract

Beams of heavy charged particles like protons or carbon ions represent the optimum tool for the treatment of deep seated, inoperable and radioresistant tumors growing in close vicinity to organs at risk. In contrast to photon therapy, the dose deposited by heavy charged particles increases with the penetration depth, culminating in a sharp maximum at the end of the particle range – the Bragg peak. This peak can be shifted in depth by energy variation and distributed laterally through magnetic deflection of the particle beam, thus allowing a precise and conform irradiation of the selected target volume. Furthermore, carbon ions offer the most conform irradiation due to their lower lateral scattering when compared to protons. In addition to this excellent physical selectivity, the biological efficiency concerning cell killing increases towards the end of the carbon ion range. Therefore, the high dose at the Bragg peak is further enhanced by an increase in biological efficiency. Finally, by applying PET techniques, an in-situ dose localization control can be performed by tracing the small amount of β^+ emitters (^{11}C, ^{15}O, ^{10}C) which are produced in nuclear fragmentation reactions between the ^{12}C projectiles and atomic nuclei in the target volume. A pilot tumor therapy unit that fully exploits the advantages of carbon ions is under operation at GSI since December 1997 and has now treated more than 70 patients. Its mayor goal is to demonstrate the safe and routine application of charged particle beams for radiotherapy.

KEYWORDS: Radiotherapy, Heavy ions, Protons, PET.

Use of General Brachytherapy Planning System with Epiescleral Plaques

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Abstract

Choroidal melanoma and other ophthalmic tumors are treated with episcleral plaques. Planning treatment is used in order to assess doses at risk organs, fovea, optic disk and lens, and apex tumor. To compare a specific plaque planning system with an unspecific one for reconstruction and for dose calculation. To assess last one for planning or for independent calculation. Specific plaque planning, Bebig, is compared with Theraplan Plus. Ropes I-125 epiescleral plaques are used. Seeds in plaques have been considerate in three ways: as templates, as point sources and line sources. For these ones, orthogonal radiographs are made. Reconstructions are evaluated by descriptive statistics. Dose calculations are also compared both for punctual and lineal approximation. Anisotropy and other corrections are not considerate. Differences in apex dose are less than 3% for all reconstruction methods. Dose in other points could not be evaluated. Reconstruction is possible but differences in inter seeds distances is greater than 0.5 mm. For lineal approximation, length is assessed and the error is less than 0.5 mm. Template coordinates were taken from manufacturer data. Dose calculation at apex tumor is possible with general planning system, but it is more difficult at another points with greater uncertainties in position. Accuracy in reconstruction of seeds position is not good enough for epiescleral brachytherapy. Adapted brachytherapy system allows better assessment of doses at risk organs, but it is possible to use the general brachytherapy system as independent or second calculation.

KEYWORDS: Choroidal melanoma, epiescleral plaques, treatment planning system, independent calculation.

Exit dose as a method to verify external radiotherapy treatments *in vivo* by TLD's

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Abstract

A termoluminiscence dosimetry system (TLD) has been assessed as a tool to verify radiotherapy treatment dose prescription by exit dose measurements. LiF chips (TLD-100, Harsaw), irradiated with a 6 MV x-ray beam and calibrated in a monitored ionisation chamber acrylic phantom, are placed at the exit surface of a slab phantom and a set of irradiations is made for different radiation field sizes and PMMA thickness. 20 patient results are reported.

KEYWORDS: *In vivo* dosimetry, termoluminiscence, exit dose.

Assessment of Different Reconstruction Methods in a Brachytherapy Treatment Planning System

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Abstract

Reconstruction is necessary in brachytherapy planning process. Orthogonal methods are the most frequently used, however sometimes it is not possible due to patient or devices characteristics. Then, another method must be applied. To evaluate the different methods in a commercial brachytherapy treatment planning. To assess a suitable reconstruction method for our department. A phantom with line and point dummy sources was constructed. Coordinates of seeds are known. The different reconstruction methods of brachytherapy treatment planning Theraplan Plus are applied. Radiographs are made in a radiotherapy simulator. The results were analysed by descriptive statistics. Local procedures for brachytherapy treatment were used in order to experiment in real conditions. For line sources, orthogonal method: larger difference in coordinates is 0.27 cm, mean is 0.06 cm, standard deviation 0.07 cm and larger difference in length is 0.09 cm. Methods differences are insignificant. For point sources, greater differences are observed. For orthogonal reconstruction larger differences are 0.6 cm, mean 0.15 cm and standard deviation 0.18 cm. Different reconstruction methods were investigated. In our institution the orthogonal reconstruction, method can be adequate, but it is not always possible. Then, other angles could be used. For point sources, other methods, as three fields matching, are often preferred. Each institution must choose a method adapted to daily procedures.

KEYWORDS: Brachytherapy, planning system, reconstruction, assessment.

4 MV Photon Beams Dosimetry with Kodak X-Omat V Films for External Radiotherapy

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Abstract

An accurate calibration method was developed to overcome the depth, field size and film plane orientation sensitivity dependence of Kodak X-OMAT V film and to allow the measurement of dose distributions with the required accuracy in Radiotherapy. The developed method was tested with 4 MV photon beams, the lowest available linear accelerator energy where the effect of film sensitivity changes with depth and field size is most pronounced.

KEYWORDS: Film, Dosimetry, Kodak X-OMAT V, Radiotherapy.

A Biological Study on the Effects of High and Low LET Radiations Following Boron Neutron Capture Reaction at the Portuguese Research Reactor

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Abstract

The biological effect in tumour cells due to high and low LET radiation produced in the neutron capture reaction in boron was analysed. Three biological parameters were determined: mitotic index, micronucleated cells frequency and binucleate cells frequency. Female mice (Mus musculus), bearing Ehrlich ascites tumour cells, have been irradiated at the Portuguese Research Reactor (RPI). A strong mitosis synchronisation was detected after high LET irradiation, as a consequence of the mitotic overcharge. The potentialities of RPI as a neutron source, for research work in Boron Neutron Capture Therapy (BNCT), were studied.

KEYWORDS: BNCT, mouse tumours, micronuclei.

Electron Output Factors for Irregular Fields Following Commissioning Procedures in Plato RTS 2

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Abstract

Commissioning and validation of treatment planning systems are crucial in the overall radiotherapy process as the accuracy in dose delivery is deeply dependent on each of the component steps.

After having performed a quite deep inspection on the main features, possibilities, limitations and accuracy regarding photon beams including open, wedged, blocked and asymmetric fields for Plato (Nucletron) treatment planning system, we present in this work the corresponding study concerning electron beams produced by the Mevatron KD-2 (Siemens) linear accelerator existing at the Centro Regional de Oncologia de Coimbra - IPOFG.

Following the recommended procedures in the process of basic data input and having adjusted namely the $\sigma_{\theta x}$ measured parameter in order for the higher isodoses (80 and 90%) to fit the experimental data, we calculate output factors in water, for all the standard inserts (made up with 1 cm lead frames to form rectangular apertures) and also for the irregular fields specially customized with 1.5 cm cerrobend frames. We compare these point calculations with the corresponding experimental results for each energy and establish the percentage deviations, defining the security boundaries beyond which electron calculations should be confirmed by measurements- namely for small fields and low energies.

KEYWORDS: Commissioning, electron calculations, treatment planning systems, Plato.

Build-up Measurements and Calculations for Photon Beams

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Abstract

Accurate measurement of dose at the surface and in the build-up region for photon beams is a very difficult but important task due to its influence in surface dose prescriptions in some clinical situations.

The instrument of choice, as it provides the most accurate means of measuring dose in such cases, is the parallel plate extrapolation chamber but it is not a common device to perform routine measurements. The most used detectors are thimble and fixed separation parallel plate chambers, diodes and thermoluminescent (TLD) dosimeters.

After having established the effective point of measurement ($P_{eff.}$) for the detectors available at the radiotherapy department of the Oncology Center of Coimbra (Portugal) in four photon energies (^{60}Co, 4, 6 and 18 MV) and due to the different detectors characteristics, the buildup region and the dose values at the surface show discrepancies. In order to have an independent method of dose determination, Monte Carlo (MC) calculations, using the MCNP4C, GEANT4 and EGS4 codes, were performed for the 6MV photon beam. A comparison between the calculated and the published experimental surface dose values, obtained with an extrapolation chamber, was established. A close agreement was achieved enabling the estimation of the detectors surface over-responses, in the other energies.

KEYWORDS: Build-up, surface dose, dosimetry, Monte Carlo.

Influence of radiotherapy treatments in head and neck oncological patients with biomaterial prostheses

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Abstract

Biomaterials used for implants in biological tissue has suffered tremendous development in the last decade. Materials such as stainless-steel, titanium and vitalium alloys have been the used more frequently, particularly in maxillo-facial implants for head & neck oncological patients.

When radiotherapy treatments are recommended, two factors must be taken into consideration, in the treatment protocol: beam attenuation and scattering in the prosthesis material.

In most cases the target volume for irradiation is an heterogeneous medium with soft biological tissue and metallic biomaterial. Although some work has been done in this filed, the influence of the prostheses during the irradiation process is still an open question.

The main goal of this study is to develop some experimental work in order to understand, and quantify the influence of attenuation of radiation beam and scattering effects, in the dose delivered to the target volume and surrounding tissues. From the experimental data analysis, conclusions about benefits and risks that arise during radiotherapy treatments in those conditions are drawn.

The first part of this study involved the characterization of the implant composition, using nuclear techniques. Afterwards, dosimetric studies were performed in an acrylic phantom in order to evaluate the perturbation caused by the prosthesis in the dose distribution in the target tissues surrounding the implant.

KEYWORDS: Biomaterials, prosthesis, dosimetry, TLD.

Dosimetric Procedures and Problems of IMRT

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Abstract

Intensity modulated radiotherapy provides the potentially most important improvement of clinical radiation treatments in the near future. Its clinical application however, relies on a sequence of steps necessary to evaluate the implementation of this new treatment technique. Among others, like the adaption of new planning tools or more precise patient positioning techniques, the verification of IMRT delivered dose patterns is of utmost importance. The dose verification process naturally relies on the dose calculation algorithm and the experimental procedures used for verification of the calculated dose. After describing the basic components employed for clinical IMRT treatments at DKFZ we discuss in detail, the implemented dose algorithm and the dosimetric procedures currently applied for IMRT verification. The final part of the paper describes QA procedures developed for IMRT, especially methods for the evaluation of the leaf positioning accuracy of the used multi-leaf collimator.

KEYWORDS: IMRT, dose calculation, dosimetric verification, QA procedures.

A Tool for Contour Comparison in Different Image Sets

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Abstract

A tool for comparing contours in different image sets is been made to use with a Radiotherapy planning system. The aim is delineating GTV in a non-simulation image set and translating it into a simulation one where GTV cannot be easily segmented. To do so, a singular value decomposition mathematical method is used.

We have two image sets per patient digitized in our Theraplan Plus planning system. Only one of the sets is made under simulation conditions. Contours are segmented in both of them and anatomical reference points are defined. Files containing the contour coordinates are read by an in house VBA (Visual Basic Application) tool which performs rotations and translations to match reference points using a least squares method. After that, we overlap the contour sets.

The method has been applied to patients with brain tumors. Good agreement between eyes, brain and external contours has been found.

This tool is helpful to segment the volume to be irradiated in simulation CT scan image using complementary information.

KEYWORDS: Contours matching, image fusion, singular value decomposition.

Pulmonary Arterial-Venous Shunts: A Method for Detection and Quantification

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Abstract

A method for detection and quantification of arterial-venous shunts in the pulmonary circulation using first-pass fast acquisition after human albumin microspheres labelled with ^{99m}Tc (HAM-^{99m}Tc) intra-venous injection and gamma camera acquisition is described. The contribution to the lung activity/time curve of the colloid activity carried through the lung circulation that is retained in the capillaries at the first pass, is a step-like function. Any activity carried through intrapulmonary shunts contributes with a dilution curve. Thus, the activity/time curve for the lung area is the superposition of the two curves. The normalization of the output for an instantaneous input injection at the entrance in the lungs is obtained by deconvolution.

The collateral flow expressed as a fraction of the total flow is given by $D = A/(A + H \cdot \bar{t})$, where A is the area subtended by the dilution curve and the amplitude of the step function (H), and $\bar{t}$ is the mean transit time of the dilution curve.

KEYWORDS: Nuclear medicine, pulmonary arteriovenous shunts, deconvolution.

A PC Program for Building of Database for Quality Control in Diagnostic Radiology

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Abstract

Normally Quality Control (QC) in Diagnostic Radiology covers significant number of X-ray imaging equipment in one region or several hospitals. Based on several tenths of measurements, each QC survey includes calculation and analysis of at least 15 different parameters. Most often the QC protocols are made with MS Excel spreadsheets, where these parameters are calculated from the measurements. Thus after several years of QC a great number of data is accumulated. Handling of this data becomes very difficult and requires some form of organisation. The paper describes a PC based program with database, which keeps information for all surveyed equipment and measured parameters. The program has two main functions. The first function is used to extract information from old (existing) MS Excel spreadsheets with QC surveys. This function is very useful for assessing the performance of the X-ray imaging equipment during certain period of time. The second function of the program is used for input of measurements, which are automatically organised in MS Excel spreadsheets and built into the database. The MS Excel spreadsheets are based on the protocols described in the EMERALD Training Scheme. Additionally the program can make statistics of all measured parameters, both in absolute term and in the time. The PC program runs on PC Pentium 75 MHz or higher with installed MS Office.

KEYWORDS: Database, Diagnostic Radiology, PC program, Quality Control (QC).

The Effect of Quality Control on Some X-Ray Tube Output Parameters

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Abstract

Quality Control (QC) in Diagnostic Radiology includes regular (yearly) tests of various parameters of the X-ray medical imaging equipment. These include accuracy and consistency of X-ray tube output (mGy), kVp, timer, etc. One of the most important parameters, directly related to patient dose, is X-ray tube output consistency and further the dependence of the X-ray tube output from the anode current (mA). The lesser the consistency error and the variation of the output with the mA, the better the equipment performance. The statistical analysis of QC data from more than 50 different radiographic equipment show that as a result of regular QC tests these two parameters minimise and stabilise with time. The X-ray equipment has been surveyed by the Department of Medical Engineering and Physics at King's College Hospital in the period from 1992 to 1999. The data has been analysed at the Inter-University Medical Physics Centre, Plovdiv. In general the QC protocols used in the tests are these described in the EMERALD Training Scheme. The trend for improvement of the consistency error and the variation of the output with the mA is analysed on the basis of identical tests during a period of three years. The trend is further verified with tests during the 5^{th} and 7^{th} year of regular QC procedures. The results from this survey show that QC procedures have a positive effect on the performance of radiographic X-ray equipment and the production of precise and stable X-ray exposures. This minimises the possibility of repeating exposures and hence the patients dose.

KEYWORDS: Quality Control (QC), Diagnostic Radiology, statistics.

Estimation of absorbed doses to patients from PET imaging

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Abstract

Presently, positron emission tomography (PET) studies used in conjunction with [^{18}F]FDG has increased significantly in the past few years, but few experimental results on the radiation doses delivered to patients and workers are available. In the present work, surface doses to patients on selected organs undergoing PET studies after fluordeoxyglucose (^{18}F-FDG) administration were measured and related to published data on the topic.

Diagnostic studies were performed with PET tomograph ADAC C-PET model 250 from UGM Medical Systems Inc. Dose measurements were done with standard LiF:Mg:,Ti TLD-100 chips from Harshaw TLD/Bicron/NE-Technology. Chip readout was carried out with a Harshaw unit model 4400. Three TLD chips were used to monitor each patient, two of them located on breasts, at the of the middle of the mammalian fold, the third one placed near gonads. Chips were placed before the injection, remaining on the patient nearly two hours. More than 80 patients were monitored.

Measured surface doses to breasts and gonads make possible to establish surface dose values, as a way to audit the patient dose. The need for further experimental work to establish typical dose levels is stressed.

KEYWORDS: PET imaging, Patient dose, Fluorodeoxyglucose.

Assessing Response to Treatment Using Magnetic Resonance

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Abstract

Magnetic Resonance Imaging (MRI) and Spectroscopy (MRS) provide methods of measuring tumour morphology, function and metabolism. MRI often provides better soft tissue contrast than CT, and is widely used for assessing changes in tumour volume, the most widely used method for assessing response to treatment. However, a wide range of new treatments is now being developed, based on our rapidly growing knowledge of the genetic and molecular basis of cancer. These treatments are often directed at specific signalling pathways or at processes upon which tumour development depends, such as neoangiogenesis or failure to apoptose on cell damage. These treatments may be anti-proliferative but not tumouricidal, resulting in tumour stasis rather than regression, and thus requiring methods of assessing response that depend on tumour function or ideally a measure of action against a specific molecular pathway, rather than volume change.

Dynamic contrast enhanced MRI allows assessment of the vascular transport of small molecules, providing information about perfusion and vascular permeability. This is providing insight into the vascular changes that underpin tumour growth. These changes are affected by both conventional chemotherapy, hormone therapy and by new therapies targeted against vascular endothelial growth factors. Examples of the use of these methods to monitor conventional and new treatments are discussed.

Clinical localised MRS provides information on cellular lipid and energy metabolism, by measuring ^{1}H and ^{31}P metabolites. These provide information on the metabolic response to treatment, and examples of studies in breast and brain cancer, non-germ cell tumours and lymphoma illustrate the potential for assessing and predicting response. Cell studies are showing how metabolite changes can provide specific markers of cell death, oncogene upregulation and drug action against specific endpoints.

KEYWORDS: Magnetic resonance, imaging, cancer treatment, therapeutic response, spectroscopy.

Optimalisation of Radiolabelled Polymin-MP of Different Molecular Sizes as a Selective Bone Seeker for Therapy in Animal Models

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Abstract

Abnormal blood supply and lack of lymphatics of neoplastic tissue lead to enhanced permeability and retention effects which form the basis of this study using various sizes of the radiolabelled macromolecule polyethyleniminomethyl phosphonic acid (polymin-mp) to increase the selectivity of bone seeking radiopharmaceuticals. Polymin-mp was synthesised and fractionated by membrane ultrafiltration into different molecular sizes, viz. 3-10, 10-30, 30-50, 50-100 and 100-300 kDa. Labelling efficiency to ^{99m}Tc as radiotracer was 99% with complexes stable for 24 hours. The pharmacokinetics and biodistribution of all ^{99m}Tc-polymin fractions were investigated in five experimental baboons per fraction and dogs (n = 5) with naturally occuring appendicular osteosarcomas. Scintigraphy followed a bolus injection of ^{99m}Tc-polymin (185 MBq) to the baboons and data were acquired as 30 × 1 min frames dynamic, and hourly static studies for four hours. Regular blood and urine samples were taken. The dogs underwent static studies of the tumours at four hours p.i. For baboons, the macromolecular size fraction 10–30 kDa had comparatively low accumulation and short residence times in the liver and kidney (resp. 20%, $T_{1/2} = 22 \pm 4$ min; 18%, $T_{1/2} = 20 \pm 3$ min) and although the bone uptake of 18% in this case was comparatively high, it is still low for a bone seeking agent, e.g.40 % for ^{153}Sm-EDTMP. Results from the dogs showed good uptake in the tumour (e.g.1:4, 1:8 and 1:9) with 3-10 kDa but reduced uptake with the larger molecular sizes.

KEYWORDS: Radiopharmaceutical, neoplastic bone diseases, targeted therapy, polyethyleniminomethyl phosphonic acid

Critical Analyses of the Calibration of PDR/HDR Source

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Abstract

One of the most important questions related with the Quality Control in Brachytherapy, namely with the afterloading equipment like PDR and HDR, is the knowledge of the activity of the ^{192}Ir source. The manufacturer of the source indicates the value of the activity in the calibration certificate, but it is mandatory for the user to calibrate the source and compare with the manufacturer's value.

The ^{192}Ir is an isotope that has a half-life of 74,2 days. The pontual source installed in the above-mentioned afterloading equipments, have to be changed every three to six months, depending on the practical and therapeutic aspects.

This study intend to discuss two methodologies used in the calibration of the ^{192}Ir pontual source for PDR and HDR equipment's, based on more than four years of experience of the Radiotherapy Department of the Lisbon Center of Portuguese Cancer Institute (IPO).

A well type ionisation chamber connected to an electrometer has been used with two different types of electrometers in the two different approaches.

Both methodologies are discussed based on experimental results obtained in our department.

KEYWORDS: PDR, HDR, calibration, well chamber.

SafeSpecs - A Web Based Solution for x-ray Equipment Specification

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Abstract

Selection of x-ray equipment requires careful consideration of equipment specifications provided by suppliers. Software has been written to provide specification questionnaires for a number of different x-ray units. Suppliers responses to these standard questionnaires facilitate comparison between units offered by different suppliers. The software is accessed via the KCARE web site; www.kcare.co.uk

KEYWORDS: X-ray, Equipment, Specification, Internet.

Medical Physics Education at the Undergraduate Level

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Abstract

A great deal of education in Medical Physics is targeted at the graduate student. This represents a well tested, widely respected model. There are numerous stimulating and fruitful variations on the theme, but the basic model appears relatively uncontroversial. In some jurisdictions at least, an undergraduate degree in Medical Physics or similar, is viewed with caution. It is felt that such a degree necessitates an unsatisfactory compromise between foundational, core material in physical science and discipline specific 'icing on the cake' Medical Physics courses.

An analysis of the McMaster Honours Medical & Health Physics programme will be presented under the following general headings: foundation in science; core material in mathematics and physics; interdisciplinary background in life sciences; discipline specific Medical Physics courses. The impact of this model on recruitment, retention and graduate destinations will be discussed. A comparison will be made with another programme being developed in a different jurisdiction.

KEYWORDS: Education, Medical Physics, Health Physics, Undergraduate.

Introduction to Medical Physics (Radiotherapy) for Physics Sciences Students

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Abstract

Physics Sciences Students should know about the Medical Physics field due to give them information about a different professional activity that they could realise. In order to supply that information, the students are invited to attend to the following activities: Theoretical lecture "Radiation Physics in Radiotherapy", Visit to the Medical Physics Department (Radiotherapy), Practical work about the Medical Physicist tasks. Physics Sciences students are introduced to the Medical Physics applied to Radiotherapy, and after the activities the student should be able to summarise the basics of Radiation Physics applied to Radiotherapy, to describe the different units of a Medical Physics Department, and to specify the main professional tasks of a Medical Physicist.

KEYWORDS: Training, Medical Physics, Radiotherapy, Physics Sciences.

EMERALD Training in Medical Radiation Physics

C. Roberts, S. Tabakov, C. Lewis, S. Bowring, D. Smith, D. Evans, A. Litchev, B.-A. Jonsson, M. Ljungberg, S.-E. Strand, I.-L. Lamm, L. Jonsson, F. Milano, L. Riccardi, A. Benini, G. da Silva, N. Teixeira, A. Pascoal, P. Ferreira, A. Noel, P. Smith, L. Musilek, N. Sheahan, P.J. Blake, J. Young, M. Folkesson, U. Peterson

EMERALD project Consortium (http://www.emerald2.net)

Abstract

The last decade has seen great strides towards the emergence of professional training in Medical Physics and Medical Engineering throughout the world. The developments have, however, been patchy and of variable quality. In an attempt to support these initiatives more widely, the Leonardo EU project for European Medical Radiation Learning Development (EMERALD), a Consortium of Universities and Hospitals from the UK, Sweden, Italy and Portugal, has developed three training modules in medical radiation physics (Diagnostic Radiology, Nuclear Medicine, Radiotherapy). Each Training Module encompasses the physics and engineering of the topic and consists of a Workbook with tasks, leading to certain competencies (based on the IPEM Training scheme) and a CD-ROM image database (IDB).

There are various types of tasks in the Workbooks: They include observing real medical physics activities; understanding the basic characteristics and parameters of equipment; using existing regulations, protocols and software; using various types of measuring equipment; dosimetry in medical radiation physics; performing measurements, collecting results and calculating parameters; assessment (QC) of various types of equipment. The three volumes of training materials and the Course Guide, total some 700 pages. The IDB includes 1300 images of: radiological equipment and its components; block diagrams and performance parameters, graphs, waveforms; QA procedures and measuring equipment; test objects and image quality examples; as well as typical images and artefacts, etc. The EMERALD Training Scheme is aimed at young graduates entering the field and each topic is structured to cover 4 months with the expectation that this core training will be supplemented at each location in which it is used to suit local needs. It was tested and introduced into practice during 1998. The next phase of the project – EMERALD II – which will extend over the next three years, includes additional partners from France, Ireland, the Czech Republic and Bulgaria. Its objectives include the development and dissemination of multimedia training material via the Internet.

KEYWORDS: Training, Education.

The Spatial Structure of Photons Scattered in Water

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Abstract

The aim of this work is to analyse the set of energy deposition points, obtained in a Monte Carlo simulation, using a new method designated dynamic analysis. Comparing with a uniform probability distribution of points, we obtained a new insight in the structure of the scatter radiation.

KEYWORDS: Radiation physics, mathematical methods, space structure, scattered radiation.

Important Radiotherapy Quantities Using Statistical Analysis of PDD Simulation Curves

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Abstract

This work aims to contribute to the comprehension of the way the depth dose behaves when one is dealing with high energy electromagnetic radiation beams (photon beams from ^{60}Co and LINACs with 4 to 25 MV).

The experimental data were obtained mainly with ionometry (very few times thermoluminescent and photographic dosimetry were used); the choice of parallel plan ionisation chambers is due to the necessity of having a good spatial resolution.

Based on the already known characteristics of the percentage depth dose curves, one assumed the hypothesis that either photons and electrons moving in the irradiated medium are attenuated exponentially. Based on a semi-empirical model where dose is a result of photons and the electrons contributions, we simulated approximately 200 PDD experimental curves with this model, obtaining differences from measured and simulated values usually within 0.5%. Those simulations allowed us to obtain numerical values for a set of parameters which are very relevant to understand the characteristics of the depth dose curves: attenuation coefficients, build-up depth, build-up region, *quasi* electronic equilibrium region, surface dose. A statistical study of the values of those parameters was done, giving us some simple ways to obtain good results of interesting Radiotherapy Quantities.

KEYWORDS: Buildup depth, attenuation coefficients, *quasi*-electronic equilibrium region, skin dose.

Distributed processing for CPU time optimisation in Monte Carlo simulation

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Abstract

CPU time is one of the most important inconveniences in the general use of Monte Carlo calculations applied to Radiotherapy. Although some variance reduction techniques have been developed, the time lessening achieved is not enough for the practical use of Full Monte Carlo (FMC). Moreover, the expected evolution of processors is not as fast as desirable. Our choice has then been the optimisation of CPU time by means of the distributed processing technique by which, the model developed divides the simulation of the treatment in several parts, having each a given physical sense. The EGS4 code implemented under OMEGA-BEAM has been used. This code has been compiled on a HP X-Class SPP 2000 machine with 24 processors PA-RISC 8000 type. The distribution process is carried out by means of customised script which run under graphical interface. Most treatments are solved in less than one hour, while complex multi-isocentric arc treatments (10 arcs with three different isocentres on a 256x256 voxel geometry applied to 72 CT slices with 4096 density levels) are calculated between one and two hours.

KEYWORDS: Distributed processing, Monte Carlo simulation, Radiotherapy.

Monte Carlo as a tool for treatment planning verification

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Abstract

The dramatic advance in the modern linacs has led to the implementation of new treatment techniques involving very small fields and non-homogeneous fluence beams. This has revealed some deficiencies in the commercial treatment planning systems as some effects, which are negligible in standard Radiotherapy and hence not properly accounted for, become now critical. Monte Carlo is the only method that considers accurately every single boundary crossing and non-equilibrium situation. However, there is still a main drawback for the routinary use of this technique, namely, the long calculation time needed. The aim of this work is then the reduction.

KEYWORDS: Monte Carlo simulation, Radiotherapy, IMRT, Distributed processing.

The Use of Entrance Skin Exposure Nomograms for Patient Dosimetry in the Absence of a DAP Meter

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Abstract

The implementation of the Ionising Radiation (Medical Exposure) Regulations 2000, (IR(ME)R 2000) [1] in the UK requires Local Reference Doses (LRD's) to be set for radiodiagnostic examinations to ensure that patient doses are kept as low as reasonably practicable. In order to set LRD's doses from current practice must first be measured, this can be particularly difficult in mobile radiography where there is no Dose-Area Product (DAP) meter or Automatic Exposure Control (AEC) present.

A study of exposure parameters for mobile chest examinations was carried out, doses were calculated and LRD's set appropriately. Using a mathematical spreadsheet application, entrance skin exposure (ESE) nomograms were produced and tested for each mobile x-ray unit. The nomograms were used by radiographers as a guide to set appropriate exposure parameters to ensure LRD's were not exceeded unless clinically justified.

It was concluded that the nomograms compared well to corresponding DAP readings. They are a useful tool as they provide ESE for a variety of kVp and mAs values. However they were not generally liked by radiographers, therefore a second method has been proposed.

KEYWORDS: Nomogram, Dose, Mobile Radiography.

Recognition of the Qualified Expert in the United Kingdom

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Abstract

The EU Basic Safety Standards (BSS) Directive requires employers to seek the advice of a "Qualified Expert" in radiation protection. In the UK the BSS is implemented as the Ionising Radiation Regulations 1999 in which the Qualified Expert is termed the Radiation Protection Adviser (RPA). The UK Competent Authority, the Health and Safety Executive (HSE), have specified the level of knowledge, training and experience required of an RPA. This is either a National Vocational Qualification in radiation protection at level 4 or an assessment by peer review. RPA2000 is an HSE accredited assessing body which considers applications from candidates wishing to become an RPA. The candidate must provide evidence of their knowledge and ability by submitting a portfolio of examples of work from their practice. Certificates are issued to successful candidates for a 5 year period. RPA's must demonstrate that they have successfully followed a scheme for Continuous Professional Development (CPD) to renew their certificate.

KEYWORDS: Qualified Expert, United Kingdom.

Specific Radiation Protection Training for Supervisors of Medical Installations in Spain

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Abstract

The Spanish guidance on Radiation Protection (RP) training for exposed workers who need a supervisor license in radioactive installations, medical installations included, has been recently modified by the RP Regulatory Body (CSN) following the international recommendations. Taking into account the new guidance, the Instituto de Estudios de la Energía (IEE) of CIEMAT, which has regularly provided RP training since 1964, has held a pilot project of this specific course, improving and modifying the previous RP courses for medical installations. The objective of this project is to train exposed workers so they can obtain the supervisor licence to work with ionising radiation in different medical application fields (nuclear medicine, radiotherapy and non-sealed source laboratories). The project includes higher specialisation according to the interests of these specific fields and wider practical sessions. A new syllabus, objectives and evaluation have been developed. The course has been finally carried out in May and June of this year. An evaluation of the modifications and the results of this pilot project are shown.

KEYWORDS: Radiation Protection training, medical installation, supervisor.

Scientific Bases and Principles of the Radiation Protection System for Medical Applications

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Abstract

A short review is presented of the scientific bases and principles for the Radiation Protection System for Medical Applications.

KEYWORDS: Radiation Protection, ICRP, Medical Exposure.