[MO-POS] COMP/OCPM — Monday *Lundi*

MO-POS-125

A Note on Interpolation and Extrapolation Methods in Brachytherapy Dose Calculations*, **Jason Sun**, *Nucletron Canada Inc.,* — In brachytherapy treatment planning, dose-rate distribution data for a given source, obtained from phantom measurements or Monte Carlo calculations, are usually reported on a polar or Cartesian grid. Interpolation and extrapolation are always required for determining the dose rate on off-grid points. Since the dose rate changes rapidly around a source, there has been a general belief that one would have more accurate results if the inverse-square factor were extracted from the dose-rate distribution before interpolation or extrapolation is performed. This is found to be true for point sources. For line sources, the AAPM TG-43 recommends that a geometric factor, which is different from the inverse-square factor, be separated from other slow-varying factors or functions, *e.g.*, radial dose function and anisotropy function. According to TG-43 and its revised protocol (drafted by the AAPM LIBD subcommittee), for each off-grid point, one should calculate the geometric factor specifically, using the well-defined equation. Interpolation or extrapolation should be made only on other factors. Recently, within the brachytherapy community, there is an open debate on the necessity of making such a separation. This paper clearly shows that, without a proper handling of the geometric factor, *i.e.*, not separating this factor from dose-rate distribution, or simply applying the inverse-square factor for a line-source, the interpolation or extrapolation may certainly result in errors well beyond the acceptable range. The published dosimetric data of Iodine-125 6711 source, commonly used for treating prostate cancer, are used in this study.

* This work is supported by Nucletron Canada Inc.

MO-POS-126

Simulation of a Radioactive Eluting Stent Using Geant4*, **Jean-Francois Carrier** [1,2], L. Beaulieu [1,2], R. Roy [2] and O. Bertrand [3], [1] *Hôtel-Dieu de Québec,* [2] *Université Laval* and [3] Hôpital Laval — Radiation therapy has been identified as a promising means of treating coronary restenosis. However, precise dosimetry simulations have to be done in order to make sure the dose deposited in the artery wall is uniformly distributed. The project currently under study is a radioactive eluting stent with a polymer coating. Following stent implantation in the vessel, radioactive 45 isotopes are delivered to the artery wall from the polymer matrix. Numerical simulations were done in order to study the diffusion of the isotopes through the wall. Afterwards, the irradiation of the target volume is studied with Monte Carlo simulations. The Monte Carlo toolkit used for the dosimetry simulations is Geant4, an object-oriented toolkit developed at CERN. Simulations were done for a 2D artery static model for specific parameter values. The parameters are inter-strut spacing, polymer coating thickness and diffusivity coefficients in wall, blood and coating. Dose deposited distributions were also calculated for a dynamic model. The total dose distribution in the artery wall after two weeks of diffusion and radiation will be presented. The dose delivery success is measured using two quantities: the dose homogeneity in the therapeutic region and the percentage of activity remaining in the therapeutic region after a defined duration. A 3D artery model has also been developed and preliminary results will also be presented.

* This work is being supported by FQRNT.

MO-POS-127

Performance Evaluation of a CT/PET Imaging System for Radiation Oncology Treatment Simulation. **P.S. Basran** [1], C. Caldwell [2] and K. Mah [1], [1] *Department of Medical Physics, Toronto-Sunnybrook Regional Cancer Centre & Department of Radiation Oncology and* [2] *Sunnybrook and Womens College Health Science Centre & Department of Medical Imaging, University of Toronto* — Acceptance testing of a new combined Positron Emission Tomography (PET) multi-slice CT scanner (Philips Gemini PET-CT System) dedicated for radiation oncology simulation was undertaken at our institute. Testing was divided into the evaluation of the i) CT-simulator and imaging system; ii) PET-imaging system; and iii) the registration of the PET and CT data. Performance of the CT-simulator system was evaluated with tests described by the American Association of Medical Physicists Task Group Reports 2 and 66, plus some additional tests that examine the multi-slice capabilities of the system. In this poster, we present details on the electromechanical and image quality characteristics of the multi-slice CT scanner. To summarize our results, the performance characteristics of the imaging systems were favourable; however, there were some mechanical challenges when using the system as a radiotherapy simulator due to greater demands in geometrical accuracy when simulating radiation therapy. Some key findings include: a systematic couch tilt with and without the flat-bed top; an (expected) increase in radiation profile thickness for the multiple CT images due to beam divergence; signature image artifacts from multi-slice helical scanning; and, a systematic in-plane rotation in reconstructed images. While many of these findings do not impact radiation therapy simulation significantly, some findings required in-house modifications or other ameliorations. Since November 2003, the CT simulator component of the imaging system has been commissioned for clinical use. In this poster, we describe the major results of these tests along with modifications to the radiation therapy CT simulator.

MO-POS-128

A Bench-top Megavoltage CT Scanner with Cadmium Tungstate-Photodiode Detectors*, **D. Tu** [1], T.T. Monajemi [1], D. Rickey [2], B.G. Fallone [1], S. Rathee [1], [1] *Medical Physics, Cross Cancer Institute, University of Alberta* and [2] Medical Physics, CancerCare Manitoba — Imaging patients in treatment position for accurate patient set up and dose delivery verification in radiotherapy is possible with megavoltage computed tomography (MVCT). However, in order to overcome the poor contrast and higher dose resulting from megavoltage photons, the MVCT detector must be designed to provide the optimal detective quantum efficiency (DQE). The aim of the present study is to fabricate a prototype (80-element, 25 cm) fan-beam CT detector using $CdWO_4$ scintillator and photodiodes. In a previous study, we determined that the zero frequency DQE of an 8-element $CdWO_4$ array was 26% and 19% in 1.25 MeV and 6 MV photons, respectively. We have designed, fabricated and tested the data acquisition timing control, precision rotary stage control and an analog data multiplexer unit for the prototype 80-element detector array. The data acquisition is synchronized with radiation producing pulses from the linear accelerator. We have tested the linearity of the prototype detector array with respect to the dose rate, and its ability to accurately measure the attenuation of 6 MV photon beam by solid water. The pre-sampled line spread function, modulation transfer function (MTF), the noise power spectrum, and the spatial frequency dependent DQE of the detector have been measured in 6 MV photon beam. In future, this detector, along with the precision rotary stage, will be used for collecting the fan beam projection data for a standard CT phantom (CATPHAN500) in order to assess the basic MVCT image quality. The system block diagram and the preliminary results will be presented.

* This work is being supported by CIHR(MOP 43254), ACB (RE-78).

MO-POS-129

Development of Megavoltage Cone-beam CT for Image-guided Radiotherapy Treatment*, **Geordi Pang**, J.A. Rowlands, P.F. O'Brien, X. Mei, C. Yeboah, M. Tambasco, *Toronto-Sunnybrook Regional Cancer Centre* — Soft tissue imaging in the treatment room is one of the main challenges faced today in radiation therapy. Our overall goal is to develop a megavoltage cone beam CT (MVCT) which can be used to image soft tissue targets, such as the prostate, with a low dose (<5% of the treatment dose) so that daily imaging would become feasible and image-guided radiotherapy using MVCT could be realised. The precise knowledge of patient anatomy at the time of treatment obtained with MVCT will permit higher radiation doses to be delivered to the target volume with potentially greater cancer control but without an increase of side effects. Compared to kVCT (*i.e.*, cone beam CT with a kilovoltage x-ray source mounted on the linear accelerator), MVCT has the advantages of simplicity and potentially higher accuracy. A MVCT system has been built which consists of a flat panel detector and a linear accelerator fitted with a low-z target and a removable flattening filter. Effects of various factors on phantom image quality such as the x-ray focal spot, x-ray spectrum, phantom scatter, imaging geometry and detector quality have been investigated. A method aimed to improve the MVCT image quality and reduce the imaging dose has been proposed. This includes the optimization of the beamline components, the reduction of x-ray scatter as well as a significant increase in the quantum efficiency of the flat panel detector for MV x-rays.

* This work was supported by Siemens Medical Solutions USA, Inc.

MO-POS-130

An Empirical Model to Estimate the Mean Square Scattering Angle of Electron Beams for Use in Treatment Planning Systems, **Deborah Hodefi**, *Hôpital Maisonneuve-Rosemont* — Electron pencil beam algorithms, such as that employed by CadPlan (Varian), generally rely on the mean square scattering angle (msa) to characterize the beam spread. Usually, one virtual machine is created per electron energy. This practice implies that one value for the msa is sufficient to model dose distributions of any field size. The field size is delimited by the jaw positions, applicator and cut-out. As electrons are easily scattered, variation of these parameters will influence the angular spread. The msa used as input for a treatment planning system may differ considerably from the msa associated with a given set of conditions. Subsequently, error may be introduced into the calculated dose distribution The objective of this work was to develop an empirical formula, suitable for use in a treatment planning system, which is capable of determining the msa particular to each case. Measurements were carried out using an Elekta SL25 accelerator. A p-type silicon diode was utilized to measure profiles at the surface of a water phantom for various combinations of energy, applicator, cut-out size and jaw position. The corresponding msa was derived from the penumbra of each profile. For a given energy, the msa has been shown to vary dramatically over the range of applicators used in the clinic. An expression was formulated which predicts the msa, accounting for applicator, cut-out size, energy and jaw effects. By providing a significantly more accurate msa for a given set of conditions, more realistic dose distributions may be generated.

MO-POS-131

Proposed Definitions for Isodose Flatness and Symmetry in Clinical Radiotherapy Beams, **Eduardo Galiano** [1], T. Joly [1] and F. Wiebe [2], [1] *Laurentian University* and [2] Universidad Nacional de Asuncion — In radiotherapy it is important that beam intensity be as homogeneous as possible to reduce the probability of treatment failure. As extensions of the concepts of beam flatness and symmetry, the concepts of isodose flatness (IF) and symmetry (IS) are introduced. An isodose curve is a planar curve across a radiation beam, such that every point on the curve receives the same dose. Using a 10 x 10 cm field, an 80 cm SSD, and a phantom measurement depth of 10 cm, we propose defining isodose flatness for an isodose curve as the maximum absolute spatial deviation from the mean expressed as a percentage of the measurement depth of 10 cm. With identical geometry we propose defining isodose symmetry (IS) as the maximum spatial deviation between any pair of symmetric points about the beam midline expressed as a percentage of the same measurement depth. Mathematically:

$$IF = (½x_i - m½_{max} \text{ x } 100\%) / 10 \text{ cm}$$

and

$$IS = (½x_i – x_i'½_{max} \text{ x } 100\%) / 10 \text{ cm}$$

where x_i is any point on the isodose curve, x_i' is its symmetric point with respect to the beam midline, and m is the mean of all x_i's. These definitions were tested with actual data obtained from a Co-60 unit and a linear accelerator, with film. The calculated IF and IS for the Co-60 unit were 3.20 ± 69 % and 3.02 ± 69 % respectively. The calculated IF and IS for the accelerator were 6.11 ± 2.19 % and 11.01 ± 2.19 % respectively.

MO-POS-132

Analytic Expressions for Depth-Dose Curve in a Homogeneous Cylindrical Phantom for Photon Beam Irradiation, **Jose M. Martinez-Ortega**, *Ottawa-Carleton Medical Physics Institute,.Carleton University* — Analytic expression for dose calculation is quite rare in radiotherapy context. The main reason of that is due to the high complexity of the catastrophic electron-transport mechanism as the electron slowing down in media. Currently condensed histories of MC algorithms have been postulated as the best candidate for dose calculation purposes. The present work is one of the first attempts toward to find analytic solutions for the depth-dose curve in a homogeneous cylindrical phantom irradiated by photon beam. In order to illustrate how this theory works the scatter fluence inside of homogeneous cylinder irradiated by monenergetic Cobalt-60 beam was determined. The beam was considered a set of parallel photons rays hitting perpendicular to the top of cylinder's surface and the probability of photon scattering was assumed via Thomson. As result a set of fast convergent analytic series were obtained allowing compute the depth-dose curve along the main axis of the cylinder. Due to the simplicity of the photon-electron transport mechanism considered here, this first model has been considered for academic purposes only. However, further development of this theory is an outgoing investigation.

MO-POS-133

Virtual Compensation Compared with Physical Compensation in Head and Neck Radiotherapy, **Darcy Mason**, C. Araujo, J. Wilson and A. Baillie, *BC Cancer Agency - Southern Interior* — A common head and neck technique uses parallel opposed lateral fields matched to a supraclavicular field. The lateral fields need tissue compensation in two dimensions; this was formerly achieved at our centre using wedges placed thick end anterior for most fractions, and thick end inferior for the last few fractions. We now use "virtual compensation" provided by beam segments shaped by multi-leaf collimators (MLC). The segments are designed by inspection of a dose distribution on a mid-sagittal slice. Uniform doses can be achieved with three segments per field, and often with only two segments by staggering the shapes from the opposing fields. We compared the virtual compensator (v-comp) technique with physical compensators (p-comps) made of brass. Dose distributions were measured for v-comps and p-comps for an anthropomorphic head phantom and a flat phantom. The two compensator types produced clinically equivalent dose distributions, and the measurements confirmed the dose predictions of the treatment planning system within a few percent. Initially the v-comp technique required a lot of planning time, but we have streamlined the process. Patient treatment times are not significantly different from the previous technique. Unlike inverse-planned intensity modulated radiation therapy (IMRT), our field sizes and shapes fall within the normal parameters of conventional treatment. The only extra work needed was to confirm our linear accelerator stability for the low monitor units used in some segments. Thus the v-comp technique provides a simple but effective IMRT without the complications of special planning software or per-patient measurements.

MO-POS-134

A Dosimetric Comparison of Four External Beam Techniques for Accelerated Partial Breast Irradiation: Set-up of Study and Preliminary Results, **Mike Oliver**, Jeff Chen, Eugene Wong, Tomas Kron, Jake Van Dyk and Francisco Perera, *Department of Medical Biophysics, University of Western Ontario and Department of Physics and Engineering, London Regional Cancer Center* — Conventional early breast cancer treatment consists of a lumpectomy followed by whole breast radiation therapy (WBRT). Accelerated partial breast irradiation (APBI) is a method to reduce the irradiation volume to the lumpectomy site only. APBI may deliver more uniform dose to the target, while sparing healthy tissues better than WBRT. In addition, APBI reduces the overall treatment time from 5-6 weeks to 1 week. A treatment planning study was undertaken to compare four external beam techniques for APBI: small-field tangents, conformal radiotherapy (2 and 4-field), intensity-modulated radiation therapy (2 and 4-field) and helical tomotherapy. Critical structures (heart, contra-lateral breast, uninvolved breast, lungs and skin) were contoured on the CT simulator. The gross tumour volume (GTV) was defined as the union of seroma volume and the volume bounding the surgical clips. Clinical target volume (CTV) was defined with a 1.5 cm margin around GTV, constrained to within 5 mm to the skin surface. A further 1 cm uniform expansion was used to create the planning target volume (PTV). Treatment plans were generated using conventional and tomotherapy planning systems with plans normalized to D_{95}=37.2 Gy to the PTV. The ratio of CTV to whole breast volume was determined for 13 cases and varied greatly from case to case with an average of 30.1 ± 13.4 % (min: 12.7%, max: 60.1%). Initial dose volume histogram analysis showed that the four APBI techniques produce superior dose distributions compared to WBRT. Results for the superior APBI technique will be presented.

MO-POS-135

Distributed Monte Carlo Calculations in a Multi-Platform Environment, **Patrice Munger**, *Hôpital Maisonneuve-Rosemont* — Clinically realistic, Monte Carlo calculations with BEAMnrc and DOSXYZnrc may require large amounts of computing power. In a typical configuration, several computers are used in parallel. In our department, only one Linux workstation is completely dedicated to Monte Carlo calculations. The majority of the other computers in the department run various flavours of Windows operating systems. We also have a few IRIX and HP-UX workstations. In an attempt to make maximum use of this heterogeneous computer park, we have created a distributed job submission system which allows any of the computers present in our department, regardless if the OS it runs, to act as a Monte Carlo computation engine. All components of our system were written in Python, a high-level, object-oriented, multi-purpose language. In addition to allowing compact programs to be written, its multi-platform character is an obvious advantage in an heterogeneous environment like ours. The system was designed to satisfy some important requirements. First, due to the low priority assigned to Monte Carlo processes running on the computation engines, these processes do not disturb users that may be using these computers locally. Also, limits on the number of Monte Carlo processes simultaneously running, and on the maximum memory that they can consume, can be adjusted for every computation engine, preventing Monte Carlo processes to use all the resources of a given computer. Our system has been proven to be efficient at employing the existing computer resources of our department that otherwise would not be fully exploited.

MO-POS-136

Web-based Electronic Physics Database in the Grand River Regional Cancer Center, **Rob B. Barnett**, James C.L. Chow, David Shenton and Steve Kennedy, *Medical Physics Department, Grand River Regional Cancer Center* — An "In-house" web-based Physics database was developed and implemented in the Medical Physics Department of the Grand River Regional Cancer Center (GRRCC). The database has a window front-end and web application domain developed by VB.NET and ASP.NET respectively. The database architecture is designed to be easily maintainable and extensible. It also provides an arbitrary file/data format, report generation and graphical analysis tools for analyzing the QA data. The database contains both "static" and "dynamic" records. The "static" records include the treatment unit commissioning data, a physics handbook, the radiation survey/protection data, physics equipment inventory, electronic instrument manuals and manufacturers' contact information. For the "dynamic" records (data varying over time) such as the linac maintenance/repair history, and routine QA test data, the user can submit the information on a computer (desktop or laptop with wireless Internet) through a web interface linked to the Cancer Center network. For example, for routine machine QA, the testing user can input measured results through the web. Physicist can access, investigate and approve the results once data has been entered electronically. Comparison can easily be made between current and previous data, which can be graphically analyzed and printed. Physicist approval is password controlled and can be assigned to specific tasks. Such a web-based database is needed for a "paperless center" which was a principal objective for GRRCC.

MO-POS-137

Characterization of the Energy Spectra of a Cobalt-60 Tomotherapy Beam, **Johnson Darko**, C.P. Joshi , L.J. Schreiner and A.T. Kerr, *Kingston Regional Cancer Centre and Queen's University* — Tomotherapy is a technique for delivering Intensity Modulated Radiation Therapy based on a rotating fan-beam geometry, analogous to a CT-like delivery. The geometry is ideally suited for CT image acquisition for patient position verification. We have been investigating the feasibility of using a Co-60 source for CT imaging (Co-60CT) in the context of tomotherapy. We have observed that Co-60CT images lack beam-hardening characteristics and thus offer a potential advantage in dose reconstruction analysis. As part of our effort to more carefully quantify this behavior, and to design an optimal detector for Co-60CT imaging, the goal of this work is to model the fluence spectra for our Co-60CT benchtop pencil-beam (1x1cm^2) and fan-beam (1x30cm^2). The BEAMnrc Monte Carlo code was used to model a realistic Co-60 source and associated collimation and patient geometries. The fluence spectra were scored at the imaging detector plane with and without a typical patient in the beam. In-air simulations (no patient in the beam) yielded spectra with fairly evenly distributed low energy components, forming 30 % of the total fluence. The pencil beam collimator had no significant effect on the in-air spectrum compared to a broad beam. When the beam passes through a typical patient the total low energy component of fluence changes, as does the relative contribution of scatter, depending on the shape and size of the beam. Details of these simulations will be presented. The results obtained from this work form a strong basis for future work designing an optimal detector for Co-60CT imaging.

MO-POS-138

Gantry Angle Optimization for Conventional Radiotherapy*, **Peter Potrebko** and B. McCurdy, *CancerCare Manitoba/The University of Manitoba* — In conventional radiotherapy, the incident beam orientations are often determined using a manual trial and error search and may not be truly optimal. A fast, 3D-geometric-based optimization algorithm for gantry angle selection is proposed. The algorithm is interfaced with the Pinnacle^3 treatment planning system to extract patient contour data. The voxels contained in a particular patient structure are uniquely identified with a tagging index allowing the determination of which structure each voxel is attributed to. The radiation portal is defined by the Beams-Eye-View perspective of the planning target volume (PTV). Each beam portal is divided into a grid of beamlets. A score function is used to measure the 'goodness' of each beamlet at a given gantry angle. The overall score of the beam angle is given by a sum of the scores of all beamlets. The score function contains geometric factors that are taken into account in radiation therapy treatment planning. Such factors include: maximizing irradiation of the PTV, minimizing irradiation of the Organs-At-Risk (OARS), the depth of the OARS with respect to the PTV (avoiding irradiation of OARS upstream of the PTV), minimizing irradiation of other normal tissue both upstream and downstream of the PTV, the incidence angle of the beam (perpendicular incidence is favourable because it creates less skin reaction), and the separation angle of the beams. Once the algorithm populates the solution space, the optimal orientations are input into the Pinnacle^3 treatment planning system. Optimal solutions are presented for phantom and patient examples.

* This work is being supported by NSERC

MO-POS-139

Measurement of Beam-Spot Size for Siemens Linear Accelerators, **Collins Yeboah**, P. O'Brien and G. Pang, *Toronto-Sunnybrook Regional Cancer Centre* — The goal of intensity-modulated radiotherapy is to minimize the volume of normal tissues irradiated to high doses so that the tumour dose may be escalated without increasing normal tissue complications. This necessitates precise localization of tumour and adjacent sensitive structures just prior to delivery of each treatment fraction. To accomplish this, megavoltage cone-beam CT (MV-CBCT) has been proposed for repeatedly imaging and guiding patient positioning throughout the entire course of treatment. For this to be clinically feasible low doses (≤5% of treatment dose) must be used for each imaging session. Consequently, stability of the beam-spot size and position during the first few seconds after beam start-up becomes crucial. Therefore, measurement of beam-spot size and motion, assessment of their effects on low-dose MV-CBCT, and methods for minimizing them are of interest. In this work, measurements of the beam-spot size in the two principal planes were performed on a number of Siemens linacs using 20-cm long laminated beam-spot camera and verification films. The measured beam-spot diameters (FWHM) range from 2.0-3.4 mm. In all cases, the in-plane spot size was equal to or larger than the corresponding cross-plane spot size. For machines of the same design, the spot sizes were, in general, not identical but differences of up to 0.7 mm were observed. Comparison of measurements on the old and newer models of the linacs showed that the spot sizes for the latter are not necessarily sharper. For a given dual-energy linac, the spot sizes for the two energies were found to be similar.

MO-POS-140

An Intuitive Algorithm for Converting Electron Beam Ionization Measurements to Absorbed Dose*, **Myron Rogers** and L.J. Schreiner, *Kingston Regional Cancer Centre* — In medical physics, electron dosimetry with ionization chambers tends to be complicated since the energy spectrum changes so rapidly as electrons travel through a medium. Of particular concern in dosimetry is the depth dependence of the mean restricted stopping power ratios (SPR) between air and water $(L/\rho)^{w}_{air}$ that results from this energy loss. Early protocols for electron dosimetry attempted to account for this by correlating the SPR with beam energy for depths in water, although the average beam energies were either crudely estimated using the Harder equation, or lost within look-up tables. Furthermore, the approximations provided by these approaches weren't sufficiently accurate, therefore, current dosimetry protocols (the AAPM TG-51 and the IAEA TRS-398) now use a universal fit to Monte Carlo data to determine the SPR. In this work, we revisit the energy dependence of an electron beam in water using historical work and current modelling within the BEAM/egsnrc Monte Carlo program. We determine the full energy spectra at depth for various monoenergetic beams from 4 MeV to 40 MeV impinging on a water phantom. We show that the complications in some of the earlier approaches arise from the differences in the spectra for beams that have similar average energies. However, with a small correction determined from the initial beam energy, one can approximate the SPR at any depth from the average electron beam energy at that depth.

* This work is being supported by ORDCF (OCITS).

MO-POS-141

Unsettling Behaviour; Pre-irradiation Effects and Long-term Stability of Ionization Chambers, **John McCaffrey** [1], M. McEwen [1], D. Niven [2], B. Downton [1] and H. Shen [1], [1] *National Research Council (NRC)* and [2] Carleton University — Dosimetry protocols recommend that ionization chambers be pre-irradiated until a stable reading is obtained. Previous studies have shown that a lack of any pre-irradiation could result in errors up to several percent. Recently, data collected for a large number of commonly used ion chambers at the Institute for National Measurement Standards, NRC, Canada and the National Physical Laboratory, UK, have been collated and analysed. With such a data set it is now possible to relate patterns of ion chamber behaviour to design parameters. While several mechanisms seem to contribute, the most obvious correlation relates the extent of collector electrode shielding to settling time. Ion chambers with guarded electrodes up to the active air volume settle quickly (~6 minutes) and the change in response is less (up to 0.2%). For ion chambers where the guard connection around the central collector electrode does not extend up to the active air volume, settling times of 20 minutes (with an associated change in response of up to 1%) are typical. This settling time is not dependent on beam quality. This settling data was combined with a study of long-term stability and it was found that there was no correlation between settling behaviour and stability of response, and a change in settling behaviour was no predictor of chamber failure. The air-kerma to absorbed dose ratio, Ck, is shown to be a very sensitive parameter for monitoring ion chamber response.

MO-POS-142

Fractal Quantification of the Architectural Complexity of Computer Simulated Vasculature, **Brian Lim** [1] and Ivan Yeung [1,2], [1] *Department of Radiation Physics, Princess Margaret Hospital* and [2] Department of Radiation Oncology, University of Toronto — It is well known that tumour vascular architecture differs greatly from that of normal tissue, tending to be quite tortuous with seemingly irregular spatial distribution. While the measurement of microvascular density (MVD) has been widely applied to many kinds of tumours, and is generally accepted as having prognostic value for long-term survival, it has been recently suggested that the fractal dimension (FD) is more useful for quantifying the complexity of tumor and normal vascular architecture. In contrast to MVD, which may only be a rough indicator of the complexity of vascular architecture in a 2D cross-sectional slice, the FD is a measure of the vascular network's topology when calculated on a 3D volume. However, the FD is usually measured on 2D sectioned slices. The correlation between the FD of 2D slices and the 3D vascular structure remains unclear, although it is hypothesized that higher 3D complexity should be reflected in the slice FD. The purpose of this computer simulation study was to investigate this hypothesis. Three-dimensional networks representing tumor and normal vasculature were simulated, and the architectural complexity of the resulting networks was then analyzed by calculating the FD. The FD was calculated for the 3D volumes and for orthogonal and oblique slices. The results showed that simulated tumour networks displayed consistently higher slice and volume FDs than for normal vasculature, demonstrating the robustness of the FD as a measure of vascular architecture complexity. The FD promises to be useful for validating functional imaging techniques being developed for vascular characterization.

MO-POS-143

Estimation of X-Ray Dual-Basis-Material Thicknesses from Multiple Energy-Bin Measurements**, Yang Cai** [1] and Paul C. Johns [1,2], [1] *Dept. of Physics, Carleton University* and [2] Dept. of Radiology, University of Ottawa — Detectors now under development, capable of counting xray photons and scoring the energy detected at clinical fluence rates, will facilitate single-exposure dual-energy radiography and CT. The natural logarithm of the patient transmission at energy E is given quite accurately by $T(E) = A_\alpha\mu_\alpha(E) + A_\beta\mu_\beta(E)$, where A_α and A_β are the thicknesses of the equivalent basis materials a , b (e.g., poly methyl methacrylate, aluminum), and μ_α , μ_β are their linear attenuation coefficients. The crux of dual-energy radiography is to determine A_α , A_β for each pixel. Classically, measurements are made with two spectra and an empirical nonlinear transformation is made from the two log transmissions T_1 , T_2 to A_α , A_b . Suppose an energy-scoring detector measures a single spectrum and bins the events into energy intervals i=1,2,...,n. $\text{Log}_2 n$ is the number of bits to which the detector must digitize the energies in real time. At the bin centres, $T_i = A_\alpha\mu_\alpha(E_i) + A_\beta\mu_\beta(E_i)$, i=1,2...,n. Algebraically, write **T=UA**, where **T** is a vector of length n, **A** is a vector of length 2 containing A_α , A_β , and **U** is an n x 2 matrix. In the limit of infinitesimal bin widths, the basis thicknesses are $\mathbf{A}=(\mathbf{U}^T\mathbf{U})^{-1}\mathbf{U}^T\mathbf{T}$. In reality the bins are of finite width and the transmission $\exp[-(A_\alpha\mu_\alpha(E)+A_\beta\mu_\beta(E))]$, weighted by the incident spectrum, must be integrated over the bin. We use Taylor expansions of the transmissions about their values at the bin centres E_i . The linear terms in the expansion are sufficient for accurate determination of the basis material thicknesses. For an imaging task in which the patient is 18 cm soft tissue plus 2 cm bone and the final image is to have bone-tissue contrast suppressed, by sorting the transmission of a 140 kV spectrum into 8 bins one can obtain accuracy of 2.3 % in the pixel value. If 16 bins are used, 0.50 % is achieved.

MO-POS-144

Projection Imaging of Plastic Materials using Coherently-Scattered X Rays, **Mohammad Nisar** [1] and Paul C. Johns [1,2], [1] *Dept. of Physics, Carleton University* and [2] Dept. of Radiology, University of Ottawa - The conventional x-ray imaging technique based on the transmission of primary photons works well to distinguish between hard and soft tissues. To distinguish between different kinds of soft tissues the scatter x-ray imaging technique can be used. Low-angle scattered photons can only be distinguished from primary on the basis of direction and consequently a well-collimated x-ray system is required. A hexagonal array of seven pinholes, each with a diameter of 1.5 mm, has been designed and tested to record the diffraction patterns of homogeneous plastic phantoms and of phantoms comprised of slabs of different plastics in a water tank. The phantom materials are amorphous solids and result in rotationally-symmetric diffraction patterns which are characteristic of the materials. The intensities of the diffraction patterns are numerically integrated over concentric rings and the scatter images are made by assigning the ring sums as the pixel values. A finite size (5 x 5 x 5 cm^3) water tank containing plastics is scanned to make the scatter images. For these measurements the tube is operated at 100 kV and 800 mAs. A storage phosphor image plate is used to record the scatter patterns. The ultimate goal is to make scatter images of different kinds of tissues for better diagnostic information.

MO-POS-145

Energy-DispersiveTechnique to Measure X-Ray Scattering Form Factors over a Wide Momentum Transfer Range, **Ziaul Hasan** [1] and Paul C. Johns [1,2], [1] *Dept. of Physics, Carleton University* and [2] Dept. of Radiology, University of Ottawa — In some particular diagnostic xray exams such as neuroradiology and breast imaging, scattered radiation can give more information than conventional transmission imaging. To optimize a scatter imaging system, it is required to know the coherent scattering form factors of biological materials. An energy-dispersive form factor measurement technique has been developed. It uses a geometry that consists of an x-ray tube, target, and high purity germanium detector. The tube and detector are kept fixed and the target is moved transversely to get the desired scatter angles. Geometry was optimized by analyzing the variation of scatter angle with the dimensions of the extended target and with other geometric parameters. To develop the technique, coherent form factors in the range 0.15 nm^{-1} to 11.87 nm^{-1} of the momentum transfer parameter $x = \lambda^{-1}\sin(\theta/2)$ were measured for lexan, poly methyl methacrylate, polystyrene, polyethylene, nylon, and water. The scatter angles as obtained by geometry optimization and the respective x-ray spectra used were 1.32°, 86 kV; 3.13°, 106 kV; and 15.41°, 121 kV. Weighted averaging was done at the two overlapping regions of the three form factor datasets to get one continuous dataset. Comparison of our data with published data obtained by the angle-dispersive technique using a powder diffractometer shows that the energy-dispersive technique can be used as a substitute for the angle-dispersive technique.

MO-POS-146

An Improved Volumetric (3d) Look-Locker Imaging Method for Longitudinal Relaxation Time (T1) Estimation, **Ken Nkongchu**, G. Santyr, *Carleton University* — A three-dimensional (3D) Look-Locker imaging pulse sequence employing a segmented acquisition of k-space with an improved accuracy in the estimation of the longitudinal relaxation time, T_1, was achieved in this study. To achieve adequate signal-to-noise ratio (SNR), the conventional 3D Look-Locker imaging sequence presented uses a large number (> 150) of small angles of only about 5° and a constant inter-pulse timing through out the image acquisition. In this study, a novel modification of the 3D Look-Locker imaging sequence is described where the inter-pulse timings are not constant. This variable inter-pulse timing allows for the inclusion of an intermediate recovery timing variable, and permits use of tip angles as large as 15° in the k-space acquisition, thereby improving the SNR. The T_1 accuracy of the method was tested for a phantom containing Gd-DTPA doped water with T_1 values varying between approximately 300 ms and 1700ms. For a 10° tip angle, T_1 accuracy was found to be within 3 % compared to conventional inversion recovery estimates. This compares favourably with an accuracy of only 11 % for the conventional 3D Look-Locker imaging sequence using an optimal 5° tip angle pulse.

MO-POS-147

Assessment of Phototimer Operation, **Harry Johnson** [1], L. Kurjewicz [1] and C. Neduzak [2], [1] *University of Winnipeg* and [2] CancerCare Manitoba — Phototimer systems provide automatic exposure control (AEC) to terminate the imaging exposure of a diagnostic x-ray beam. Proper functioning of the AEC system is essential to control x-ray image exposure, both for diagnostic image quality and patient dose. Quantitiative assessment of the calibration and operability of the photo cells is needed but is time consuming and requires repeated films. Radiation Protection Services, a department of the Medical Physics Division of CancerCare Manitoba regulates x-ray safety and compliance in Manitoba. RPS has undertaken tests of a new quantitative digital tool to measure exposure to the x-ray imaging plane. The device consists of a casette and a digital readout unit. The cassette contains the sensory components and is placed in the film plane – image plate plane, It measures the exposure (calibrated re mR) required to produce the image and hence also the imaging speed, independent of the processor (either film or computed radiographic plate). In a 400 speed system, the skin entrance dose for a chest x-ray is 0.11 mGy, effective patient dose is 0.03 mSv. This is the average for film systems in Manitoba. CR imaging is at lower speed, higher dose. Our findings indicate: (1) Calibrations of the left-centre-right photo cells vary; (2) Photo cells have been found inoperative, unknown to the technologists; (3) Speed of most film systems is at “400” plus; (4) Speed of CR systems is approximately “200”. Data will be provided of the results of surveys and the review will include service- related discussions.

MO-POS-148

Standards for Quality Control for Canadian Radiation Treatment Centres, Peter Dunscombe [1], Clément Arsenault [2], **Jean-Pierre Bissonnette** [3], Harry Johnson [4], George Mawko [5], and Jan Seuntjens [6], [1] Tom Baker Cancer Centre, [2] Hôpital Dr Georges-L Dumont, [3] *Princess Margaret Hospital*, [4] CancerCare Manitoba, [5] QEII Health Sciences Centre and [6] Montreal General Hospital — The Canadian Association of Provincial Cancer Agencies (CAPCA) has begun a standardisation process for the establishment and maintenance of quality radiation treatment across Canada. A final draft of the “Standards for Quality Assurance at Canadian Radiation Treatment Centers” has been submitted, and the Canadian Organisation of Medical Physicists has been mandated to develop a series of appendices to this final draft to document national quality control standards for the equipment used in Canadian radiation therapy clinics. All documents use a standard format, thereby providing a unique consistency across the entire proposed quality assurance standard. Each document details quality control frequencies, tolerances, and action levels for the given equipment or modality. All quality control procedures echo, where applicable, accepted international standards, such as those endorsed by the AAPM or IPEM, or with other current publications. We have submitted the content of each quality control protocol for review by a recognized Canadian expert. Documents have been drafted so far for simulators, cobalt units, linear accelerator, dosimetry instruments, orthovoltage units, multi-leaf collimators, portal imaging systems, brachytherapy, and intensity-modulated radiotherapy, and will be made available through the COMP/CCPM web site. Other standards are planned for CT simulation, record-and-verify systems, radiosurgery, and prostate implants. These documents reflect the spirit of continuous quality improvement: clinics can use them as templates and revise test frequencies and tolerances based on accumulated evidence. We expect that, upon approval from CAPCA, federal and provincial regulations and accreditations bodies shall require compliance to these quality control standard.

MO-POS-149

The BioMedical Imaging and Therapy Beamline at the Canadian Light Source Inc. **Colleen Christensen**, *Canadian Light Source Inc* — The BioMedical Imaging and Therapy (BMIT) Beamline is a multidisciplinary, multiuse facility that is being proposed for the Canadian Light Source, Canada’s National Synchrotron Facility. The BMIT Beamline will have two specific research uses, non destructive imaging of tissues and radiation therapy in living organisms. The total cost of this project will be approximately $17M. Funding for this project will be obtained from the Canadian Foundation for Innovation, the provincial governments and charitable foundations. The BMIT Beamline is projected to be ready for operations in 2006.