reflective tape provided an adequate correction, but additional study is required to identify the limits of the utility of this approach.

## Scientific Session 4A: Radiation Dosimetry – 10

**An investigation of neutron weighting factors using a Geant4-based microdosimetry pipeline**

Christopher Lund, Gabriel Famulari, Logan Montgomery, John Kildea, McGill University, McGill University Health Centre

**Purpose:** Nuclear reactions induced during high-energy radiotherapy produce secondary neutrons that, due to their carcinogenic potential, constitute an important risk for the development of iatrogenic cancer. To quantify this risk, the ICRP neutron weighting factors may be applied; however, these factors are based on a pooling of experimental RBE data and are thus not representative of any given situation. We aim to build on previously-reported neutron microdosimetry studies by applying a weighted track-sampling approach for the determination of dose-mean lineal energy (yD) in order to help improve a bottom-up model of neutron RBE. **Methods:** We have constructed a pipeline to explicitly calculate yD that consists of (a) the open source Monte Carlo (MC) toolkit Geant4, (b) its radiobiological extension Geant4-DNA, and (c) a weighted track-sampling algorithm. This approach was used to evaluate the yD of monoenergetic neutrons between 1 eV and 10 MeV at multiple depths in the ICRU sphere. A variety of scoring volumes representative of different biological targets were considered. To obtain a measure of RBE, the neutron yDs will be compared to those calculated for 250 kV x-rays. **Results and Conclusions:** Graphs of neutron RBE as a function of neutron energy, based on yD ratios, will be shown for each situation using the combined contributions of secondary electrons, protons, and alphas. The shape of the yD graphs closely follows that of the ICRP weighting factors. Extension to nanometre-scale volumes had little effect on the shape of the graphs but altered the magnitude of the most prominent peak.

## Scientific Session 4A: Radiation Dosimetry – 11

**Europium-doped optical fibre scintillator detectors for proton dosimetry**

Crystal Penner, Peter Woulfe, Sinead O'Keeffe, Cheryl Duzenli, Cornelia Hoehr, University of British Columbia, Galway Medical Clinic, University of Limerick, BC Cancer Agency-Vancouver, TRIUMF

**Purpose:** Studies were carried out on the 74 MeV proton beam at TRIUMF to determine if three Europium-doped scintillator powders are suitable for use in proton therapy dosimetry and beam characterization applications. **Methods:** Phosphors tested were Y2O2S:Eu, YVO4:Eu, and Gd2O2S:Eu. Each sensor was comprised of a length (0.3–0.5 m) of 1 mm diameter plastic optical fibre with a 0.7 mm diameter by 7 mm deep cavity drilled in the end. The cavity was filled with one of the scintillator powders and sealed with epoxy. Europium-doped sensors were compared to a Gd2O2S:Tb sensor fabricated in the same way. Tests were carried out to determine dose response, lateral beam profiles and axial beam profiles. **Results:** Gd2O2S:Eu yielded the highest light yield but also the highest error (11%) as well as long-lasting after glow; YVO4:Eu had the lowest light yield as well as the lowest error (4.5%). Dose response for all four detectors was linear. Lateral beam profiles of all four sensors are mostly in agreement with YVO4:Eu and Gd2O2S:Tb having the most regular profiles. Measuring the axial profiles, or the Bragg peak, all sensors experienced quenching with a peak-to-entrance ratios as follows for the four sensors: Y2O2S:Eu- 2.97; YVO4:Eu-2.88; Gd2O2S:Eu-2.66 and Gd2O2S:Tb 2.99. **Conclusion:** In conclusion, all three tested Eu-doped sensors are suitable for beam characterization and small-field proton-therapy dosimetry. But for measuring the axial profile, corrections for quenching need to be applied.

## Scientific Session 4A: Radiation Dosimetry – 12

**A real-time deformable scintillation dosimeter that simultaneously measures dose and deformation vector fields**

Émily Cloutier, Louis Archambault, Luc Beaulieu, CHU de Quebec - Université Laval

**Purpose:** Deformable image registration (DIR) algorithms are increasingly used in the clinics to either map organ contours or dose distribution from one image set to another using the computed deformation vector field (DVF). In this work, we present a novel 3D deformable water-equivalent scintillation dosimeter that provides real-time measurements of both the dose and DVF. **Methods:** A deformable dosimeter was developed consisting of a clear, flexible cylinder in which an array of 19 scintillating fibers was embedded. The linearity, SNR and SBR of the dosimeter were characterized while varying the camera's integration time, the dose deposited or the dose rate. DVF and dose variations resulting from a 1 cm compression were measured and respectively compared to the one computed by the Plastimatch DIR algorithm and the treatment planning system (TPS). **Results:** Signal characterization of the detector exhibited a linear dose-light relationship ($r^2 > 0.99$) for all of the 19 scintillation fibers that remained valid while varying the dose rate or the camera's integration time. For the SNR and SBR analysis, the signal stayed over the detectability (SNR > 5) and sensitivity (SBR > 2) thresholds for all the explored doses and dose rates. The applied deformation resulted in a measured maximal displacement of $0.80 \pm 0.02$ cm that compares with the DIR prediction of $0.78 \pm 0.02$ cm. The resulting dose variations present deviations of $0.8 \pm 0.7\%$ from the expected variations calculated on the TPS. **Conclusion:** We developed and characterized a novel real-time 3D deformable dosimeter that can simultaneously measure dose and deformation vector fields, while being deformed.

# Scientific Session 4B – Imaging
# Thursday, September 26, 2019 11:00-13:00

## Scientific Session 4B: Imaging – 01

**Feasibility of iterative cone-beam CT reconstruction for adaptive radiotherapy: a preliminary study**

Peter Martin, Kundan Thind, Tom Baker Cancer Centre, Department of Oncology, University of Calgary, Calgary, AB

**Purpose:** Iterative reconstruction methods for x-ray computed tomography (CT) and cone-beam CT (CBCT) have demonstrated improved image quality when compared to conventional analytic methods for CT reconstruction. While there is evidence that iterative CBCT (iCBCT) reconstruction leads to an improvement in image quality, it was the purpose of this work to determine if any improvements in HU accuracy and uniformity were obtained through the use of iCBCT reconstruction over the default analytical reconstruction method provided with Varian TrueBeam systems (Varian Medical Systems, Palo Alto, CA), as part of an ongoing study to investigate the efficacy of iCBCT in adaptive patient replanning. **Methods:** The CIRS electron density phantom (CIRS Inc., Norfolk, VA) was used to investigate the HU accuracy and uniformity of the TrueBeam 2.7 Pelvis protocol for CBCT, using both default and iCBCT reconstruction methods. This phantom includes materials with equivalent electron densities to anatomical structures, with identical materials arranged in both the outer and inner rings of the phantom. The difference in measured HU values between identical materials in the outer and inner ring of the phantom were determined for the CBCT images using both standard and iCBCT reconstruction. **Results and Conclusions:** We observed that the image produced using iCBCT reconstruction shows improved HU accuracy and uniformity when compared with standard reconstruction. These results indicate that methods for iterative reconstruction of CBCT images may be better suited to recalculate patient dose when compared with images produced using conventional analytic CBCT reconstruction methods, and therefore may be more effective for use in adaptive patient replanning in radiotherapy.

## Scientific Session 4B: Imaging – 02

**3D/2D Image Registration for Microsphere Tracking in Radioembolization**

E. Courtney Henry, Dr. Alasdair Syme, Dr. George Mawko, Department of Physics & Atmospheric Science, Dalhousie University, Halifax, NS, Canada, Department of Medical Physics, Nova Scotia Health Authority, Halifax, NS, Canada

**Purpose:** Radioembolization (RE) is a treatment for unresectable liver cancer where yttrium-90 (90Y)-infused microspheres (MS) are administered through the arterial vasculature of the liver to selectively target liver tumours