A particle-counting method to determine electron stopping powers

Innovation/Impact
This method offers the potential to accurately determine electron stopping powers experimentally to verify theoretical calculations and reduce uncertainties in electron beam reference dosimetry.

Background
Currently there is limited experimental data for electron stopping powers in the MeV energy range\textsuperscript{1,2}. Stopping power values, and particularly stopping power ratios, are determined from theoretical calculations\textsuperscript{3}. The uncertainties in these values are not easy to quantify but are estimated to be at the 1\% level – significant when compared with other uncertainty components in reference dosimetry.

Proposed method
A HPGe (hyper-pure Germanium) detector was used to directly measure the electron spectrum emerging from the exit window of a linear accelerator. The linac was modified to operate in single electron-per-pulse mode to allow particle counting. Calibration of the HPGe is by way of photon sources and detector drift is corrected by acquiring the calibration and output spectra simultaneously (Figure 1).

Results and Discussion
Measurements were made with two electron energies – 4 MeV and 6 MeV (nominal) – and with two absorbing materials – graphite and aluminum. The maximum energy loss was 0.5 MeV, representing ~ 10\% of the incident energy, and repeatability in the measurement of electron energy was typically 5 keV. The standard uncertainty in the gradient dE/dt was in the range 1.0\% to 1.7\%, which is very encouraging for a reduced set of measurements.

Two limitations of the method were identified. Firstly, the resolution of the MCA was not enough for energies above 4 MeV and secondly, the count rate was too low. Although the count rate is ultimately limited by the pulse-repetition-frequency of the linac (typically 200-400 cps) the detector geometry has an impact. A new system is therefore being commissioned with a larger HPGe crystal and 8000-channel MCA. This new system, combined with an improved energy calibration using a higher-energy photon source (Co-57) should achieve the required level of uncertainty in dE/dt of < 0.5\%.

2 M MacPherson, PhD thesis, Carleton University, Canada (1998)
3 ICRU Report 37, ICRU, Bethesda, MD (1985)