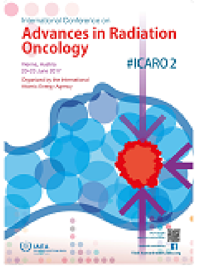


Contribution ID: **295**

Type: **Poster**

# Uncertainties in measuring absorbed dose from a low-energy miniature X-ray source

*Wednesday, 21 June 2017 15:45 (5 minutes)*

**Introduction**

In brachytherapy, miniature low-energy X-ray sources offer a number of advantages over traditional radioactive sources. These include their ease of portability, and reduced regulatory and shielding requirements. However, the dosimetry of these devices is challenging due to their steep dose gradients, soft X-ray spectra (< 100 kV) and influence of target spectral lines. Accurate and precise knowledge of the absorbed dose would allow for better confidence in target dose delivery, tracking of dose to organs at risk and optimisation of treatment plans. A greater understanding of the delivered dose is also important for combining modalities (i.e. brachytherapy with external beam radiotherapy), and for exploring treatments with these devices in other cancer sites.

In this work, we evaluate the uncertainties in the measurement of absorbed dose to water from a commercially available miniature X-ray system, the INTRABEAM System (Carl Zeiss, Germany). The dose measurement method investigated was an air-kerma calibrated ionization chamber situated in a water phantom with the INTRABEAM.

**Methodology**

Depth-dose rate measurements were performed with the INTRABEAM System X-ray source (XRS) using a dedicated water phantom offered by Zeiss. The self-shielded phantom includes a platform stage for mounting and positioning the XRS, and two waterproof holders for mounting a soft X-ray ionization chamber (PTW 34013 parallel plate chamber) connected to an electrometer. Charge measurements were performed at depths between 1.7 to 20 mm from the source tip.

The absorbed dose rate to water was calculated from the measured charge by two different methods: the absorbed dose formula recommended by Zeiss, and our own derived dose formalism for ionization chambers calibrated in terms of air-kerma. This dose formalism relies on a Monte Carlo (MC) calculated conversion factor, $C_Q$, to go from air-kerma in a reference beam to absorbed dose to water at a beam quality of interest. This conversion factor was calculated using the EGSnrc particle transport code.

The sources of uncertainty investigated in the dose measurement were:

- source positioning accuracy
- uncertainty in the geometry of the PTW 34013 ionization chamber in the calculation of $C_Q$
- MC statistical uncertainty in the calculation of $C_Q$

The dose uncertainty associated with source positioning error was determined by calculating the percent difference in dose due to a depth shift of 0.1 mm. The uncertainty due to geometry tolerance was evaluated by calculating $C_Q$ with the maximum and minimum chamber cavity dimensions as specified by the manufacturer. Assuming a rectangular distribution, an uncertainty was extracted from these extreme values. Lastly, the statistical uncertainty of $C_Q$ was estimated by the standard error in the tally statistics as reported by EGSnrc. The total combined uncertainty in measured dose was estimated by adding these effects in quadrature.

**Results**

Due to the steep dose gradients near the INTRABEAM source, the dominant source of uncertainty was determined to be in the source positioning. A positioning error of 0.1 mm led to an uncertainty of 7 % in absorbed dose at a depth of 3 mm in water. This uncertainty decreased as a function of depth to 1.4 % at 20 mm. In the calculation of $C_Q$, the dimensional tolerance of the PTW 34014 ionization chamber had a significant contribution to the uncertainty, ranging from 5.6 to 1.8 %. The MC statistical uncertainties were kept below 1.2 %, and could be further reduced by increasing the total number of particle histories in the simulations. The total uncertainty in measured dose was found to range from 8.9% at 3 mm, to 2.8 % at 15 mm depth in water. However, the absorbed dose as calculated using the recommended formula was shown to disagree with the results from our method by up to 14.8 %, going beyond the uncertainties investigated in this work.

**Conclusion**

Despite all their advantages, accurate dosimetry of miniature low-energy X-ray sources remains a challenge. Steep dose gradients lead to large dose uncertainties, both from source positioning error and ionization chamber dimension variations. The results of this work show a measurement uncertainty of up to 8.9 % at 3 mm depth, which reduces with increasing distance from the source (2.8 % at 15 mm). To reduce this uncertainty further, another ionization chamber with tighter dimension tolerances could be investigated.

## Country

Canada

## Institution

McGill University

**Primary author:** WATSON, Peter (McGill University)

**Co-authors:** SEUNTJENS, Jan (McGill University); POPOVIC, Marija (McGill University)

**Presenter:** WATSON, Peter (McGill University)

**Session Classification:** Wednesday afternoon - Poster Presentations - Screen1

**Track Classification:** New Technologies in Radiation Oncology/Radiotherapy