PhD Thesis Title: Determination of W_{air} value in high energy electron beams

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ABSTRACT:

Purpose: The mean energy expended by a charged particle slowing to a stop in air to create an ion pair, W_{air}, is a key value in radiation dosimetry standards. It is used to convert the charge created into the energy deposited. The ICRU Report 90 has reaffirmed the accepted value to be 33.97(12)~eV and to be energetically independent above 10~keV. However, a recent publication by Tessier *et al.* (DOI: 10.1002/mp.12660) has shown a possible energy dependence. The present work aims to determine the value of W_{air} in high-energy electron beams and to investigate the assumption that W_{air} is energy independent.

Methods: W_{air} can be evaluated by combining ionometric and calorimetric measurements with a calculated ratio of the absorbed dose in the detectors. Graphite and aluminum detectors were used and the dose ratio was calculated using the EGSnrc Monte Carlo code. A range of average energies at the measurement point were obtained by inserting absorber plates in the primary beam.

Results: The overall standard uncertainty in the determination of W_{air} was approximately 0.5 %, and similar for both sets of detectors. Good agreement was obtained between the two separate experiments, but the data appear to separate into two sets. The smaller (9 points) yielding a value for W_{air} of 33.76(16) eV, consistent with the current consensus value of 33.97(12) eV; the larger (31 points) reproducing the energy dependency observed by Tessier *et al.*

Conclusion: This investigation cannot rule out a possible energy dependence of W_{air} in high-energy electron beams of -0.18(3) % per MeV. Although not supported by theory, a systematic review of the methods used and the parameters influencing the overall result did not identify any experimental error that could explain the unexpected energy dependence.

References to author publications that relate specifically to the dissertation:

1. Domen S and Lamperti P, "Comparisons of calorimetric and ionometric measurements in graphite irradiated with electrons from 15 to 50 MeV." *Med Phys*.,1976;3(5):294-301. https://doi.org/10.1118/1.594290

2. Tessier F, Cojocaru CD, and Ross CK, "Extracting Wair from the electron beam measurements of Domen and Lamperti." *Med Phys*., 2018;45(1):370-381. https://doi.org/10.1002/mp.12660

3. Burns DT, Picard S, Kessler C, and Roger P, "Use of the BIPM calorimetric and ionometric standards in megavoltage photon beams to determine Wair and Ic." *Phys Med Biol*. 2014;59(6):1353-1365. DOI: 10.1088/0031-9155/59/6/1353

4. **Bourgouin A**, Cojocaru C, Ross C, and McEwen M, "Determination of Wair in high-energy electron beams using graphite detectors." *Med Phys*. 2019;46(11):5195-5208. https://doi.org/10.1002/mp.13772