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Evaluation of the Exradin A30 Parallel Plate Ion Chamber as a Reference Dosimeter in Ultra-High Dose Rate (UHDR) Electron Beam

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Introduction and Purpose

- Ultra-high dose rate (UHDR) beams ($\geq$ 40Gy/s) compromise the accuracy of conventional reference ion chambers due to saturation effects.
- The Exradin A30 is an ultra-thin parallel-plate ion chamber featuring a 0.3mm electrode spacing to enhance the charge collection efficiency (CCE).
- This study aimed to evaluate key characteristics of the A30 IC as a reference dosimeter for UHDR pulsed electron beams.

Methods

- UHDR irradiations were performed with an UHDR capable IntraOp® Mobetron® electron accelerator, and all measurements were acquired at a gap distance of 1.5 cm from the exit window to achieve a maximum dose per pulse (DPP) of 9.6 Gy using a 9 MeV electron beam.
- The chamber was connected to a Max4000 electrometer and it was positioned at reference depth (1.5 cm).
- Various phantoms were tested, including grounded virtual water, distilled water, and saline water. To ground the virtual water, a thin slab of virtual water was positioned beneath the A30 ion chamber to support the placement of a thin aluminum foil layer beneath it, which was connected to a grounding cable.

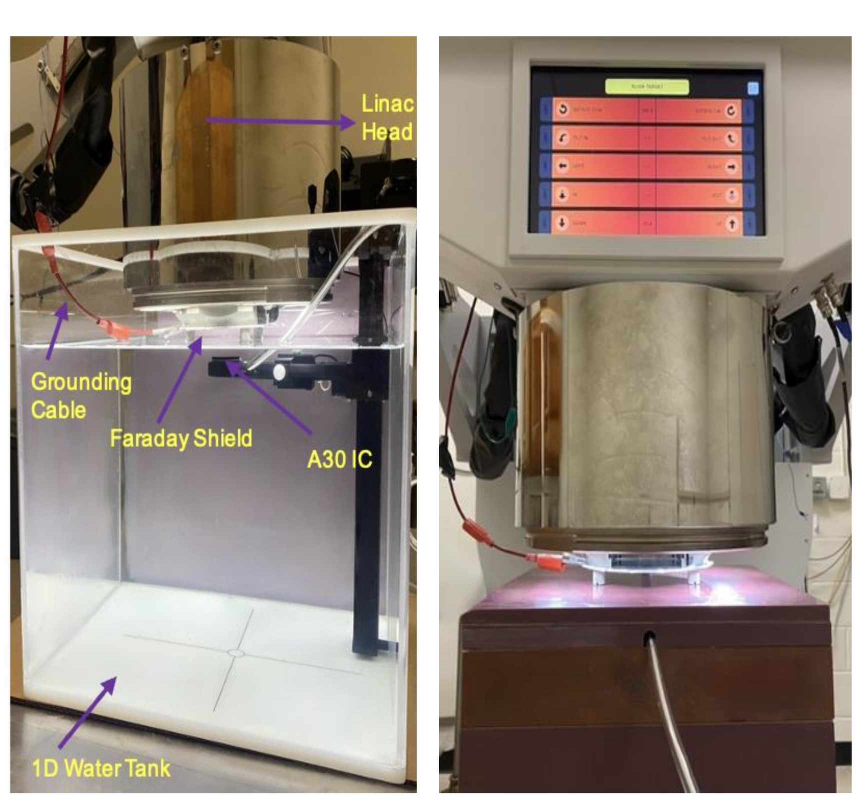

Figure 1: Measurement setup in a 1D water tank (right)), and virtual water (left).

Methods

- DPPs were modulated by varying the pulse width (PW) from 0.5 to 4 µs while pulse repetition frequency (PRF) was varied between from 5 to 90 Hz.
- The CCE was calculated using EBT-XD radiochromic films under both UHDR and conventional beam conditions at identical dose and energy settings. Both CCE and polarity effect (P_{pol}) were also measured as a function of DPP and PRF.
- Beam quality correction factors, K_Q, were measured under conventional electron-beam conditions at energies of 6-20 MeV from two linear accelerators and compared with Monte Carlo-simulated results.

Results

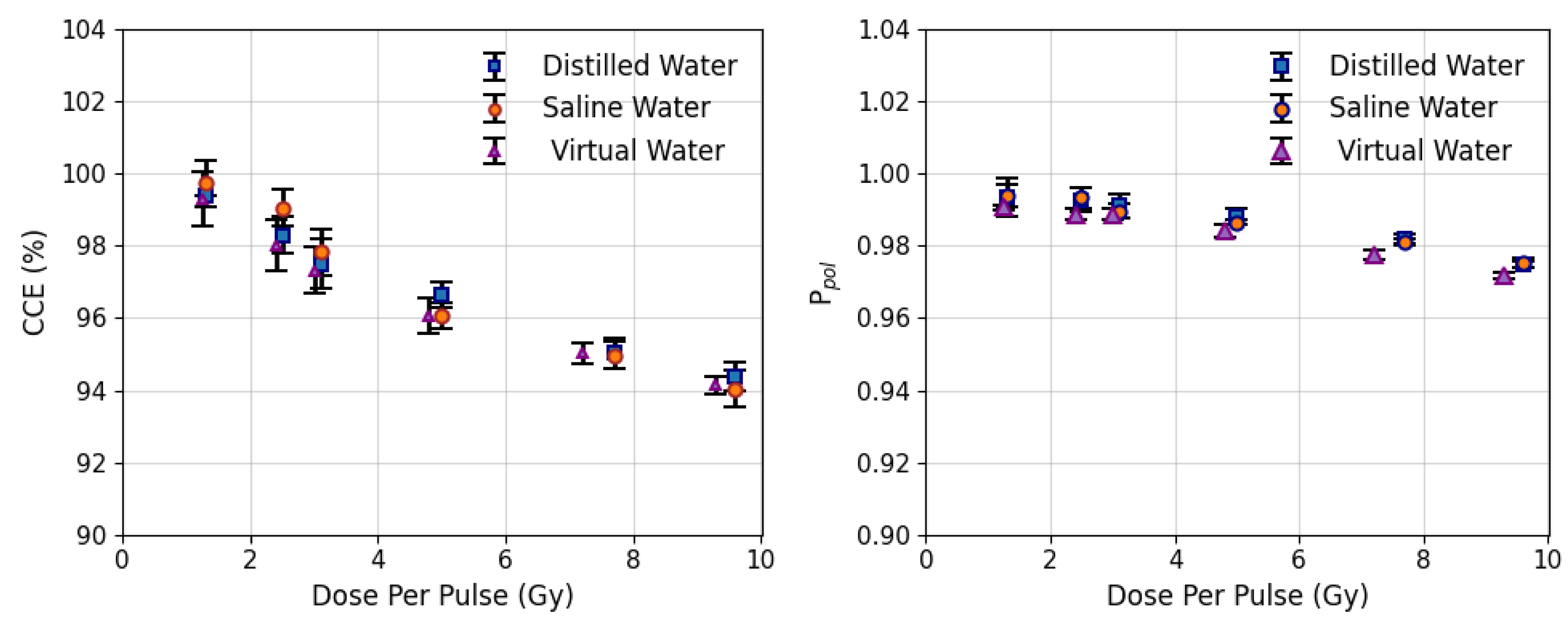

Figure 2: Charge collection efficiency (CCE) (left) and polarity correction factor (P_{pol}) (right) as a function of dose per pulse in distilled, saline, and virtual water. The error bars indicate one standard deviation of the measured values of each data point.

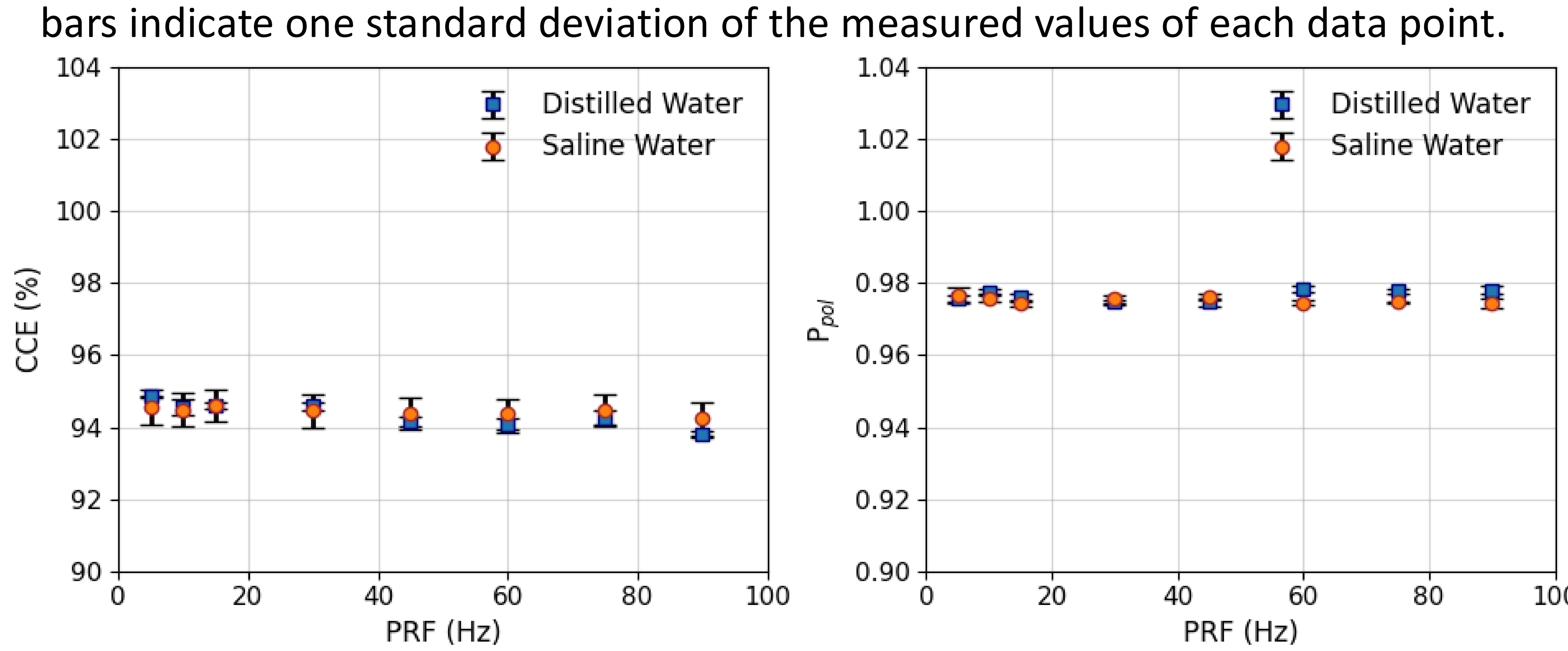

Figure 3: Charge collection efficiency (CCE) (left) and polarity correction factor (P_{pol}) (right) as a function of PRF, corresponding to mean dose rates of 69-1242 Gy/s, and at 4 µs in distilled, saline, and virtual water. The error bars indicate one standard deviation of the measured values of each data point.

Results

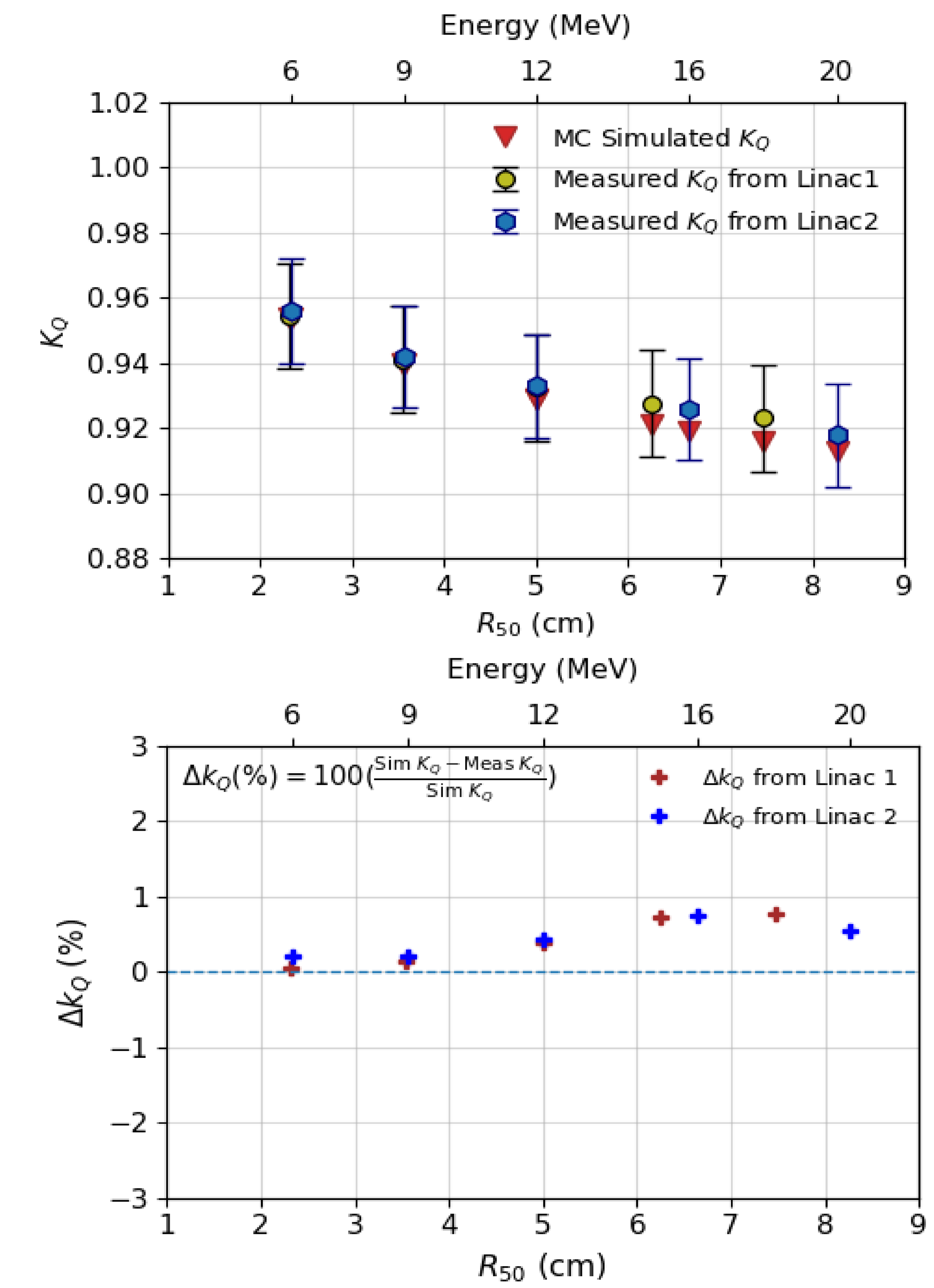

Figure 4: MC-simulated and measured beam quality correction factor (K_Q) from two linear accelerators under conventional beam conditions across different electron energies (top), and the percent difference between the simulated and calculated kQ (bottom). Error bars represent the combined standard uncertainty (k = 1).

Conclusions

- The A30 IC exhibited a leakage current < 2 fA.
- The A30 IC exhibited <5% recombination with DPP of up to 7 Gy and a polarity correction factor of 0.995 up to 5 Gy DPP in all media.
- The agreement between measured and simulated K_Q is in within 0.7%.
- The commercial A30 is well-suited for UHDR electron reference dosimetry