

AbstractID: 9567 Title: Comparison Studies of Thermistor-based and Ultrasonic Water Calorimeters

Purpose: High-precision ultrasonic thermometry offers a compelling technology for use in water calorimetry, since existing prototypes are able to register temperature changes corresponding to tens of mGy without the confounding difficulty of excess heat. In addition, its potential for providing three-dimensional dose distributions in real time via CT may offer attractive options for reference dosimetry of nonstandard beams. The present study compares ultrasonic thermometry to thermistor-based devices with respect to sensitivity to thermal signals, noise and susceptibility to systematic errors, with the objective of motivating further developments.

Method and Materials: Single-channel ultrasonic thermometer systems – one, a pulsed, phase-locked loop; the other, a pulsed digital phase monitor – are compared to thermistor-based water calorimeter cells monitored via a dual-phase lock-in amplifier. Radiation from incandescent sources, ^{60}Co , and a Clinac 2100C are used to evaluate performance. Estimated signal-detection limits, obtained from overall system resolution and characteristic noise, are compared with experimental output and analyzed with regard to frequency content and heat transport effects.

Results: RMS noise in the ultrasonic systems exceeded both theoretical estimates and that observed with thermistor –based systems over comparable integration times; however, thermistor-based systems are dominated by $1/f$ noise. Spatial averaging of temperature along the acoustic path reduces heat-conduction effects in ultrasonic measurements, but the latter are relatively more susceptible to convection because of the open-phantom design. At reduced exposure times, ultrasonic dose measurements are within a few percent of expected values.

Conclusion: Noise reduction for both technologies is needed for rapid quantification of heat transport effects. For ultrasonic systems, improvements to low-pass filter circuits and algorithms are recommended; for thermistor-based systems, proper phasing of the shutter with respect to the bridge-excitation signal may alleviate flicker noise.

Conflict of Interest (only if applicable):