

Energy and geometry-dependent corrections to dose variability across cell culture irradiations

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Radiobiological studies of novel radiation and drug therapies are often performed in-vitro using cell culture irradiations. However, culture preparation variability and vessel-dependent scattering conditions have generally not been characterized, which may result in poor inter-laboratory replicability due to variation in the delivered radiation dose. The purpose of this work is to advance cell culture irradiation dosimetry practices by assessing the impact of cell culture geometries on dose delivery accuracy for three kV x-ray beam qualities commonly used in radiobiology research.

Each kV x-ray energy and filter combination on our X-RAD 320 irradiator (Precision X-Ray Inc., Madison, CT) underwent dosimetric calibration using a NIST-traceable ionization chamber following the AAPM's TG-61 protocol. This was followed by Gafchromic™ EBT3 film calibration for each beam quality, using a custom, 3D-printed in-air film calibration paddle to closely mimic the TG-61 geometry. A 100 W CO₂ laser (Boss Laser, LLC, Sanford, FL) was used to cut film to fit three common cell culture vessel types: Petri dish, multi-well plate, and T-flask. Notches in the film circumferences track the film orientation for scanning. Films were placed in the vessels and covered with two different volumes of water to represent preparation variability.

Preliminary calculations suggest that culture medium volume height variations of ± 0.3 mm correspond to 0.5% and 1% errors of delivered dose with the 320 kVp and 160 kVp beams, respectively. Relative to the Petri dish, the multi-well plate increases dose to cells due to scattering by $>0.5\%$ in the 320 kVp beam.

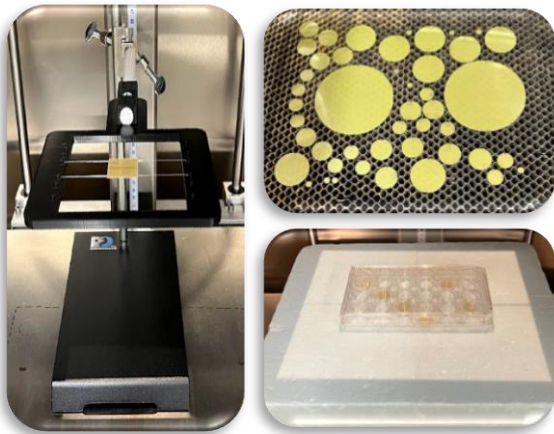


Figure 1. Left: Gafchromic™ EBT3 film segment suspended "in-air" using 3D printed paddle. Top right: Discs of laser-cut film for cell plate dosimetry. Bottom right: Cell culture irradiation geometry (films embedded).

Table 1. Beam quality combinations

Energy (kVp)	Filtration	HVL (mm Cu)	Related Equipment
320	2 mm Al	1.0	X-RAD 320
225	2 mm Al + 0.5 mm Cu	1.3	Phillips RT250, Faxitron MultiRad350
160	0.3 mm Cu	0.77	Rad Source RS2000