Use of a 2-dimensional ion chamber array to measure head leakage of a Varian Truebeam® linear accelerator

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PURPOSE / OBJECTIVE(s)

- During linear accelerator acceptance, leakage radiation is measured to evaluate the adequacy of shielding of the treatment head
- NCRP report 109 reports that leakage radiation as radiation measured outside of the maximum field size produced. The leakage radiation limit is 0.2% of the absorbed dose rate on the central axis and at the same treatment depth
- Conventional measurements involve wrapping the gantry in film to isolate the point of maximum leakage, then using an ion chamber to verify the dose at 1 meter
- This method is challenging due to film processing limitations and the accuracy of ion chamber positioning during absolute dose measurements

AIMS

- To evaluate the use of a two dimensional (2D) planar ion chamber array to characterize leakage radiation
- To compare leakage dose measurements between the ion chamber array and conventional measurement techniques

MATERIAL & METHODS

- A Varian TrueBeam® with a maximum photon energy of 15 MV was used for all measurements
- Conventional leakage measurements were performed: Portal Pack for Localization (PPL) film (Carestream Health Inc.) was used to determine the area of maximum leakage (Figure 1)
- A PPL calibration curve was generated to quantify the dose-to-film (Figure 2)
- Leakage radiation was measured using an ion chamber array, the IC Profiler™ manufactured by Sun Nuclear Corporation (Figure 3)
- Measurements with the IC Profiler were completed at three locations around the gantry head (Figure 4)
- All measurements were normalized to leakage at 100 cm from the target and relative to the central axis
- Comparison of leakage (%) measured by PPL film and the IC Profiler was performed

PPL Film Measurements

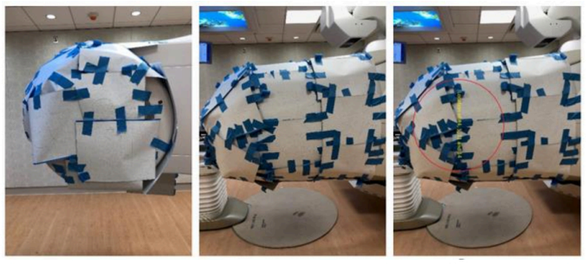

Figure 1: Photographs of the TrueBeam linear accelerator gantry head wrapped with PPL film (left: collimator side, middle: source side, right: location of maximum leakage)

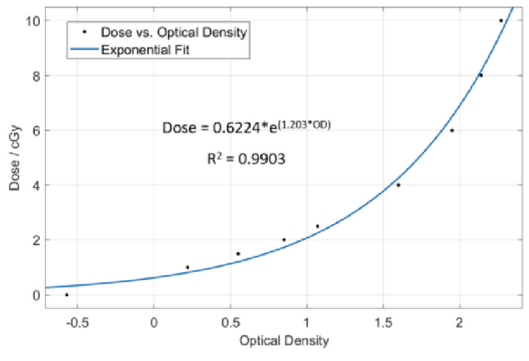

Figure 2: Calibration curve for the Carestream PPL radiographic film generated by irradiating PPL film to doses ranging from 0 to 10 Gy

IC Profiler Measurements

Figure 3: Alignment of the IC Profiler to the point of maximum leakage at 100 cm from the target

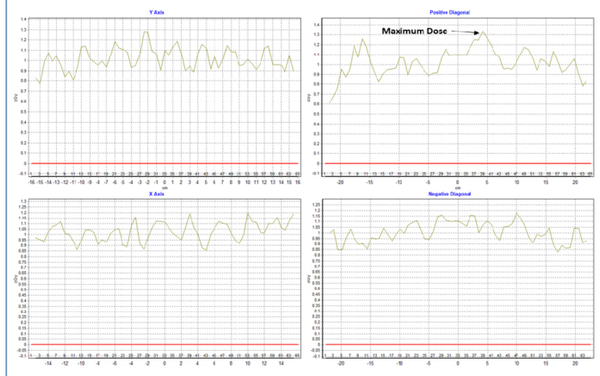

Figure 4: Results from the IC Profiler placed at 180° from the central axis. Arrays along the y-axis, x-axis, positive, and negative diagonals are presented. The maximum dose delivered to the Profiler was 1.38 cGy measured along the positive diagonal

RESULTS

Table 1: Results from the IC Profiler measurements and a comparison of measured leakage using the IC Profiler and PPL Film

Location	Angular/Azimuthal	MUs	Dose to IC Profiler (cGy)	% Leakage (IC Profiler)	Uncertainty (%)	% Leakage (PPL film)
Central axis (Open)*		100	90.8	-		-
Top of gantry	180°/0°	1000	1.29	0.142	3.75	0.1334
Varian Logo	90°/0°	1000	0.328	0.036	9.12	0.020
Side of Gantry	0°/90°	1000	0.123	0.014	2.15	0.019

RESULTS

- Three locations were investigated, including the top of the gantry, the Varian logo, and the side of the gantry
- Leakage measurement results are presented in Table 1 for the PPL film and the IC Profiler
- PPL film and the IC Profiler showed good agreement for each location, with measurements of 0.142% and 0.131%, 0.036% and 0.030%, and 0.014% and 0.019% for each of the three locations
- Maximum deviations were 0.008%, 0.006%, and -0.005%

SUMMARY / CONCLUSION

- Current methods for evaluation leakage radiation is challenging due to the cost and availability of film and film processors
- This work validated the accuracy of leakage measurements using an IC Profiler and comparing the results with conventional measurement techniques
- There are two main considerations for medical physicists when characterizing leakage radiation from the gantry head, (1) isolating the point of maximum leakage and (2) accurately measuring the leakage to determine if the accelerator meets NCRP recommendations.
- Ideally, a physicist will wrap the gantry head in film to visually determine the location of maximum leakage and confirm with ion chamber measurements
- The use of an ion chamber array presented in this work will not be able to isolate the point of maximum leakage, but will provide a more efficient method for determining the dose at 100 cm when compared with an ion chamber

REFERENCES

[1] National Council on Radiation Protection and Measurements, *NCRP Report No 49: Structural shielding design and evaluation for megavoltage x- and gamma-ray radiotherapy facilities : recommendations of the National Council on Radiation Protection and Measurements*. 1976.

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