Evaluation of scatter effects on in-air irradiation of TLD badge dosimeters

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Overview

• Objective
• Experiment
• Monte Carlo simulation
• Connecting experiment with simulation
Objective

- Determine scatter correction factor when irradiating TLD badges and compare with historical data
- Investigated scatter variation based on:
  1) Location on Sheet
  2) Source to Badge Distance
  3) Badge Proximity
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Experimental Setup

- 33.1 x 30.9 cm Lucite sheet with 5 placements for badges
- NE2530 35cc ion chamber is substituted as the fifth badge

Can be placed in any of the 5 positions using the independent stage system.
Experimental Setup

- 1m or 3 m source to sheet distance $d$
- Ion chamber positioned in front of sheet, centered on a substituted position of a badge
- Two $^{60}$Co irradiators:
  - Atlan-Tech (AT3)
  - Theratron Junior (JR)
History Repeats Itself!

- Using the JR source at 3m, with the Ion Chamber in the center position:

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<tbody>
<tr>
<td>Historical:</td>
<td>1.0040</td>
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<tr>
<td>Sept 2008:</td>
<td>1.0058</td>
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<tr>
<td>Feb. 2017:</td>
<td>1.0050 ± 0.0008 (k=2 Error)</td>
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Abscissa is detector signal normalized to ion chamber signal in air
**JR at 3m: Chamber in Top Right Corner**

- Ion Chamber
- Ion Chamber + frame
- Ion Chamber + frame + sheet
- Ion Chamber + frame + sheet + badges

**JR at 3m: Chamber in Bottom Right Corner**

- Ion Chamber
- Ion Chamber + frame
- Ion Chamber + frame + sheet
- Ion Chamber + frame + sheet + badges

**JR at 3m: Chamber in Center**

- Ion Chamber
- Ion Chamber + frame
- Ion Chamber + frame + sheet
- Ion Chamber + frame + sheet + badges

Abscissa is detector signal normalized to ion chamber signal in air.
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Scatter Contributions from Varying Positions of Ion Chamber: JR at 3m

Bottom Right: 1.0063
Center: 1.0050
Top Right: 1.0036
Scatter Contributions from Varying Positions of Ion Chamber: JR at 1m

Top Right: 1.0039
Center: 1.0055
Bottom Right: 1.0037
Scatter Contributions from Varying Positions of Ion Chamber: AT3 at 1m

- Top Right: 1.0030
- Center: 1.0042
- Bottom Right: 1.0044

Compared later with Monte Carlo
Note: The spaced data taken from an average of 3 measurements with the chamber in the top right corner and the clustered data is taken from one measurement with the chamber in the same position.
**Note:** The spaced data taken from an average of 3 measurements with the chamber in the **top right corner** and the clustered data is taken from one measurement with the chamber in the same position.
**Modelling the Irradiation Setup**

**EGSnrc Monte Carlo simulation system:** Shown to calculate dose to the cavity of an ionization chamber at the 0.1 % accuracy level by means of Fano test calculations.
EGSnrc Monte Carlo Simulation System

- Simulates transport of photons, electrons and positrons between 1 keV and 100 GeV
- Fast electron transport algorithm accurate at the 0.1% level for ion chamber simulation
- Distributed with tailored applications to solve a large range of problems
- Applications make extensive use of variance reduction techniques speeding up calculation times significantly
Modelling the Irradiation Setup
Adding the Ionization Chamber
Ion Chamber Results

![Graph showing ion chamber results with normalized dose to TLD (Normalized to Single Badge in Air) plotted against different configurations: Single Badge, Frame, Frame & Sheet, All Features. The graph compares Badge Sim., Experiment, and Chamber Sim. results.]
Conclusions

• Current results confirm historical value of a small scatter contribution

• Ion chamber underestimates scatter “seen” by the badges

• Excellent agreement between experiment and chamber simulation warrants the use of a MC badge scatter correction
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