Uncertainty analysis for dose measurements using OSLD nanoDots

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Introduction

• NanoDots are a popular dosimeter
• IROC Houston (formerly RPC) uses OSLD to monitor beam output
  – Reference conditions

• How precise is the OSLD program?
Dose calculation

• Signal: \[ M_{cor} = \left( \sum_{n} \frac{M_{raw,n} \cdot k_{d,n}}{n} \right) \cdot k_{s,i} \]

• \[ D = M_{cor} \cdot C_D \cdot k_E \cdot k_F \cdot k_L \]

• Calibration factor \((C_D)\) is based on irradiation of standards to a known dose

• \[ C_D = \frac{D_S}{M_{cor,s} \cdot k_{F,s} \cdot k_{L,s}} \]
Methods

• Estimated Uncertainty in each parameter
• Based on commissioning data for batches of 5,000 – 20,000 dosimeters
• Fancy error propagation
  – Recursive solving of: 
    \[ \text{var}(XY) = \text{var}(X)\text{var}(Y) + \text{var}(X)E(Y)^2 + \text{var}(Y)E(X)^2 \]
  and 
    \[ \text{var}(X + Y) = \text{var}(X) + \text{var}(Y) + 2\text{Cov}(X,Y) \]
  where x is \( M_{cor} \) and Y is the product of the remaining factors used to calculate dose.
  – No assumptions about shape of distribution
  – Accounts for cross correlation
• Based on measurement with 2 detectors
Calculated Uncertainty Results

\[ D = M_{\text{cor}} \cdot C_D \cdot k_L \cdot k_E \cdot k_F \]

\[ D = D_S \cdot \frac{M_{\text{cor}}}{M_{\text{cor},S}} \cdot \frac{k_L}{k_{L,S}} \cdot \frac{k_E}{k_{E,S}} \cdot \frac{k_F}{k_{F,S}} \]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D_s</td>
<td>0.6</td>
</tr>
<tr>
<td>M_{\text{cor}}</td>
<td>0.8</td>
</tr>
<tr>
<td>k_L</td>
<td>0.3</td>
</tr>
<tr>
<td>k_E</td>
<td>0.8</td>
</tr>
<tr>
<td>k_F</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1.6%</strong></td>
</tr>
</tbody>
</table>

**Reference conditions:**
100 cGy
Read after 5 days
Irradiated with Co-60

For doses ranging between 90-110 cGy
For time ranging between 2 and 30 days
These can be expanded to 25-300 cGy and 1-120 days:
The uncertainty increases to **1.7%**
IROC Houston measured results

- **Photons:**
  - IROC-H/Inst: 0.997 +/- 1.6%

- **Electrons:**
  - IROC-H/Inst: 0.999 +/- 1.9%
Summary

- Under well controlled conditions, 2 dosimeters provide ±1.6% uncertainty. – 1 sigma level

- This is consistent with the uncertainty in TLD measurements (±1.3% for 3 detectors) Kirby et al, Med Phys 1992.

- IROC Houston’s 5% criterion is reasonable
Thank You!

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