Measurements in a Conformal Biological Irradiator

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Preclinical Studies

- Goal: correlate delivered dose to biological endpoint
Conformal Irradiators: SARRP

- 225 kVp x-ray tube
  - Rotating gantry
- On-board CBCT
- Attached collimator assembly
  - ~5 cm from isocenter

Muriplan TPS for SARRP

AAPM TG-61 in-air method: reference dose rate

- Open field
- 30 cm SSD

From this reference dose rate:

- Film calibration curve-self or 6 MV linac

- Used in film stack
  - Profiles compared with 5%/1mm 2D $\gamma$
  - Compare dose measured with film at 5 depths to TPS
    - SmART Plan discrepancy 3-17.3%

Measure OF with film

- Scales beam-on time in TPS

3) P. Lindsay et al, Med. Phys, 38, 2011
4) S. Van Hoof, SmART Plan, Pxi, 2016
Small Field Detectors

- Limited detector choice with small fields
  - TLDs
  - Microchambers
  - Film

- Spectrum change with collimation
  - Affects detector response
  - $\frac{\mu}{\rho}$, $B_w$ related to field size\(^1\)

Goal: Validate current measurement techniques in SARRP

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1) B Grosswendt, Phys Med Biol, 38, 1993
Relative Measurements-Film stack

- EBT3 film – point of comparison to Muriplan and Monte Carlo model

- 1 mm spacers

- Compare Muriplan to measurements
  - 10 mm field size
Agrees with Muriplan within uncertainty
- Overestimation at greater depths
Relative Measurements - OF

- Nominal 1 Gy at 2 cm depth – large VW phantom
- Normalized to 10 mm field size
- Muriplan predicting change in output with field size

![Graph showing output factor vs. field size](image-url)
Dose discrepancy

- Relative measurements with Muriplan
  - Nominal Dw given was 18 ±2% higher than expected for all field sizes

- Film energy response
  - Comparing Dw from reference M-series beam
  - Discrepancy between M250 and SARRP?
  - Film change between open and 10 mm cone?

- Dose rate in Muriplan
  - Measure with microchamber in smaller fields to compare
Energy response: Film Cal Curve

- Comparison to UWMRRC M250 x-ray beam
  - 10x10 cm² vs “open field” SARRP

- Dose to water using TG-61 in air vs reference beams (MC)

- Film Details:
  - EBT3 film
  - Epson Expression 10000XL flatbed scanner
  - 300 dpi
Energy response: Film Cal Curve-Comparison
Energy response: PDDs
Energy response: PDDs

- Indicates that collimating from “open” to 10 mm cone changes the spectrum
- May impact solid state detector measurements
- Not explicitly modeled in Muriplan
Film Energy Response

- Total energy response of EBT3 film <7%
- Want to measure output with a chamber to compare

Figure courtesy of C. Hammer - Hammer et al 2018, Med Phys
Dose rate comparison

- Use water tank and A26 to perform TG-61 in-phantom method
- Determine dose rate with chamber for 10 and 5 mm cones
  - Compare Muriplan expected dose rate
  - Reference conditions at 2 cm
Water Tank vs Muriplan

- $D_w$ at 2 cm determined using TG-61 in-phantom method
  
  - Estimated using nominal HVL
    
    $$ D_{w,z=2\text{cm}} = MN_K \cdot P_{Q,\text{cham}} \cdot P_{\text{sheath}} \left[ \left( \frac{\mu_{\text{en}}}{\rho_{\text{air}}} \right)^w_{\text{water}} \right] $$

  - Comparison to Muriplan dose rate:

<table>
<thead>
<tr>
<th>Field Size</th>
<th>Chamber</th>
<th>Film</th>
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<tbody>
<tr>
<td>10 mm</td>
<td>-7.75%</td>
<td>-16.49%</td>
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Conclusions

- TG-61 compared to Muriplan
  - Overestimated delivered dose when compared to chamber
  - Future work: simulating 10- and 5 mm-specific factors

- Demonstrates the need for external comparison
  - Film in phantom disagreed with planned dose
  - Change in full scatter conditions between reference and realistic irradiations

- Future work: simulate detector response changes in SARRP
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Thank you for your attention