Treatment Planning System Beam Modeling Parameters Exhibit High Variation Among Radiotherapy Institutions

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2018 AAPM Annual Meeting
August 1, 2018
IROC Houston Phantom Credentialing

- IROC mission is to provide quality control programs in support of the National Cancer Institute’s National Clinical Trial Network
- Phantom credentialing is the first step to entering NCI-sponsored clinical trials using IMRT
- IROC phantom pass rate: 85-90%\(^1\)
  - Where do these errors come from?
  - How can this be improved?

Previous Work Indicates Dosimetric Issues

- ~70% of failed irradiations due to systematic errors in dose calculation\(^1\)

- 68% of failing phantom associated with considerable calculation errors in TPS\(^2\)
  - 56% overestimated dose when compared to TLD/film

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How Does the Beam Model Affect Phantom Outcomes?

• Previous work examining IROC site visit data shows that several different accelerator types exhibit comparable dosimetric characteristics (PDD, output factors, etc.)³

• If many accelerators behave the same, should they be modeled similarly?

• If not, can this be an indication of where errors arise in IMRT treatments?  
  • What are the limitations of creating a model following a different method/variables? Small field dosimetry? Etc.

Methods: Survey Creation

• Designed survey requesting beam modeling parameters for Eclipse, Pinnacle, and RayStation
  • Included detailed instructions on how to find parameters in respective TPS environment

• Implemented survey with individual phantom irradiations (August 2017) and annual online facility questionnaire (January 2018)

• Responses were broken down and analyzed separately according to:
  • Linear accelerator class
  • Beam energy
  • MLC configuration (in progress)
## Methods: TPS Beam Modeling Parameters

<table>
<thead>
<tr>
<th>Eclipse*</th>
<th>Pinnacle&lt;sup&gt;3&lt;/sup&gt;</th>
<th>RayStation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective Target Spot Size (X and Y)</td>
<td>Effective Source Size</td>
<td>Primary Source X/Y Width</td>
</tr>
<tr>
<td>MLC Transmission Factor</td>
<td>MLC Transmission</td>
<td>MLC Transmission</td>
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<tr>
<td>Dosimetric Leaf Gap</td>
<td>Tongue and Groove Width</td>
<td>Tongue and Groove</td>
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<td></td>
<td>Additional T&amp;G Transmission</td>
<td>Leaf Tip Width</td>
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<td></td>
<td>Flattening Filter Gaussian Height/Width</td>
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<td></td>
<td>Rounded Leaf Tip Radius</td>
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</tbody>
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* AAA and AcurosXB
Results

• 1,227 responses as of June 1st
• TPS versions: Eclipse (v8.6+), Pinnacle (v8.0+), RayStation (v3.1+)
• General TPS demographics:
Histograms: Varian Base 6X/Eclipse Parameters

Varian Base (6X)
Eclipse AAA: Eff. Target Spot Size X

- 166
- 1
- 10
- 1
- 2
- 1

X Dimension (mm)

Varian Base (6X)
Eclipse AcurosXB: Eff. Target Spot Size X

- 26
- 1
- 2
- 4

X Dimension (mm)

Varian Base (6X)
Eclipse AAA: Eff. Target Spot Size Y

- 165
- 1
- 1
- 4

Y Dimension (mm)

Varian Base (6X)
Eclipse AcurosXB: Eff. Target Spot Size Y

- 27
- 1
- 3
- 8

Y Dimension (mm)

AAA Algorithm

AcurosXB Algorithm
Histograms: Varian Base 6X/Eclipse Parameters

Varian Base (6X) Eclipse AAA: Dosimetric Leaf Gap

Varian Base (6X) Eclipse AcurosXB: Dosimetric Leaf Gap

Varian Base (6X) Eclipse AAA: MLC Transmission

Varian Base (6X) Eclipse AcurosXB: MLC Transmission

AAA Algorithm

AcurosXB Algorithm
Histograms: Varian Base 6X/Pinnacle Parameters

Varian Base (6X)
Pinnacle: Leaf Tip Radius

Varian Base (6X)
Pinnacle: Eff. Source Size X

Varian Base (6X)
Pinnacle: Tongue & Groove Width

Varian Base (6X)
Pinnacle: Eff. Source Size Y
Histograms: Varian Base 6X/Pinnacle Parameters

**Varian Base (6X)**

**Pinnacle: Additional T&G**

Add T&G

- Frequency
- 20
- 10
- 0

Varian Base (6X)

**Pinnacle: Gaussian Height**

Gaussian Height

- Frequency
- 10
- 5
- 0

Varian Base (6X)

**Pinnacle: MLC Transmission**

MLC Transmission Factor

- Frequency
- 10
- 5
- 0

Varian Base (6X)

**Pinnacle: Gaussian Width**

Gaussian Width

- Frequency
- 15
- 10
- 5
- 0
Implications & Future Work

• Disparate modeling may contribute to inaccuracies in IMRT dose calculation, small field calculations, etc.

• Determining reasonable ranges on modeling parameters can help institutions achieve more robust models and better accuracy

• Future work: determine expected changes in from these distributions of beam modeling parameters
Thank you for your attention!

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