Data Acquisition for Treatment Planning Systems

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Introduction

What data do we need to acquire for our treatment planning system?

How do we intend to use this data?
– acceptance testing (verify what you specify)
– Commissioning (acquisition of all data necessary to use the system clinically)
Introduction, cont.

• A comprehensive set of beam data must be acquired and entered into the radiotherapy treatment planning (RTP) system.

• “Commissioning” refers to the process whereby the needed machine-specific beam data are acquired and operational procedures are defined.
Outline

• Beam data requirements for treatment planning systems
  – General data requirements for commissioning (Task Group 45) and 3D Planning Systems (Task Group 53)
  – Photon beam data
  – Electron beam data

• Selection of appropriate tools for beam data acquisition

• Basic considerations when collecting TPS data
  – Dosimetric facts
  – Self-consistent dataset
  – Post collection data processing

• Test cases for TPS commissioning

• Future needs
  – MLC characterization (leakage, penumbra)
AAPM Code of Practice for Radiotherapy Accelerators

AAPM code of practice for radiotherapy accelerators: Report of AAPM Radiation Therapy Task Group No. 45

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IV COMMISSIONING

A. Overview of Commissioning a Radiotherapy Accelerator

B. Dosimetry Calibration

C. Commissioning Photon Beams
   1. Square and Rectangular Photon Beams
   2. Wedged Photon Beams
   3. Beam-Shaping Blocks for Photons

D. Commissioning Stationary Electron Beams
   1. Dosimetry Data for Electron Beams
   2. Field Shaping for Electrons
   3. Corrections for Air Gap or Extended SSD
   4. Effects of Oblique Incidence and Tissue Heterogeneities
• **Commissioning Photon Beams – cax data**
  
  (1) tables and/or graphs of percentage depth dose and/or tissue air ratios and/or tissue phantom ratios, for all square fields with suitable increments in dimensions;  
  (2) a table of “equivalent square fields:”  
  (3) a table of output factors in air and in phantom;  
  (4) correction factors for changes in PDD for nonstandard SSDs;  
  (5) peak scatter factors;  
  (6) tray and wedge correction factors.
TG-45 Report

• Commissioning Photon Beams – off axis data
  (1) isodose charts (for constant SSD) for square fields, with suitable increments in field size;
  (2) isodose charts (for constant SSD) for a selection of elongated fields, and/or suitable rules to convert charts for square fields to the desired rectangular field:
  (3) a method to correct for oblique incidence,
TG-45 Report

Commissioning Electron Beams

• calibration of beam output;
• central-axis depth dose curves in water;
• isodose charts in water;
• cross beam profiles in water;
• output factors;
• corrections for field shaping; and
• corrections for air gap.
TG-45 Report - Electrons

Additional electron beam data often needed for TPS commissioning
• oblique incidence,
• patient contour,
• tissue heterogeneities

Consult AAPM Task Group 25 for recommendations
TG-45 Report – Special Procedures

• Total and Half Body Photon Irradiation
• Total Skin Electron Irradiation
• Electron Arc Therapy
• Intraoperative Radiotherapy
• Stereotactic Radiosurgery
TG-45 Report – Instrumentation Needs

Instrumentation Needed For Acceptance Testing And Commissioning Of A Radiotherapy Accelerator

• Ionization chamber dosimetry system:
  – two ionization chambers, two electrometers, constancy checkers, cables, thermometer, barometer, and phantoms.

• Film dosimetry system:
  – densitometer and phantoms.

• TLD dosimetry system:
  – reader, ovens, jigs, phantoms.

• Dosimetry scanning system:
  – electrometers, scanning devices.

• Personal computer system:
  – computer, software for report generation, data collection and analysis, printer and plotter.
Dosimetry measurements for acquiring beam data are best performed in water using appropriate radiation detectors. The essential features required of any measuring device are:

1. sufficient sensitivity;
2. stability;
3. negligible leakage;
4. energy independence;
5. sufficient spatial resolution, and
6. linearity.
TG-53 Report

American Association of Physicists in Medicine
Radiation Therapy Committee Task Group 53:
Quality assurance for clinical radiotherapy treatment planning

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TG-53 Report – Basic Dosimetric Facts to Consider When Commissioning a TPS

• Most dose calculation verification tests traditionally involve comparison of calculated doses with measured data for a range of clinical situations. As treatment planning in the institution becomes more sophisticated, the range of dosimetric testing should expand and will eventually become quite extensive. Identifying the various effects or situations to be tested, and defining the limits over which each effect will be tested, will help the physicist organize the testing.
Calculation verification tests generally fall into two categories: 1) comparisons involving simple water phantom-type geometries, which are usually easy to interpret; and 2) comparisons involving complex geometries (often with anthropomorphic phantoms) in clinically realistic situations, which are difficult to interpret, since uncertainties in measurements, errors in input data, parameter fitting, algorithm coding and/or design, calculation grid effects, and various other uncertainties are all incorporated into the results. Although these complex tests are critical for evaluating the overall system precision for particular calculations, their usefulness in explaining discrepancies is limited.
TG-53 Report – Basic Dosimetric Facts to Consider When Commissioning a TPS

• Often, in an attempt to minimize effort, some of the tests and measured data are used repeatedly to test multiple aspects of the planning system. When this is done, the tests should be designed to be as independent as possible, so that the appropriate analysis and actions are taken when necessary.
TG-53 Report – Basic Dosimetric Facts to Consider When Commissioning a TPS

- The comparison of calculation results and measurements is not a competition. The task of performing the measurements and parameter determination and calculation verification testing should begin by assuming that there are likely to be many errors and inconsistencies uncovered, and that these will have to be resolved by the whole team in an open, cooperative fashion. are difficult or impossible to access, so these systems normally must be maintained on-site at each clinic. A QA program for the test tools must be instituted for the QA tools to be effective.
TG-53 Report – Methods for Obtaining a Self-Consistent Dataset

• Design the measurements so that the data required to tie all the various separate measurements together are obtained during the same measurement session.
TG-53 Report – Methods for Obtaining a Self-Consistent Dataset

- Make measurements over the shortest time span possible consistent with obtaining representative dose measurements.
- Use the same equipment and procedures for all similar measurements.
TG-53 Report – Methods for Obtaining a Self-Consistent Dataset

- Relate measurements made with different measurement methods to each other. Ideally, some of the measurements should be repeated with an independent, preferably different type, dosimeter.
- Use a reference chamber to account for output fluctuations when making measurements with a scanning ionization chamber.
TG-53 Report – Methods for Obtaining a Self-Consistent Dataset

• Periodically repeat base measurements, such as the dose at 10 cm depth for a 10x10 cm² field, to monitor the consistency of the machine output and the measuring system. Note that this may involve use of temperature equilibrated water and/or monitoring the barometric pressure, in certain situations.

TG-53 Report - Post-data collection processing

- **Post-processing.** All measurements must be converted to dose, either relative or absolute.
- **Smoothing.** Raw data often should be smoothed to remove artifacts of the measurement technique. Care must be taken to ensure that the smoothing is not done too aggressively, smoothing out real dose variations.
TG-53 Report - Post-data collection processing

- Renormalization. All data (depth doses, profiles, etc) should be renormalized to make the dataset self-consistent.
TG-53 Report

• Tables A3-2 through A3-9 in TG-53 specify the recommended data to be measured for adequate QA of a 3D TPS for photon beams.

• Tables A4-1 through A4-4 cover electron beams.
TG-53 Report

Appendix 3: Photon dose calculation commissioning

- depth dose, output factors, open field data, patient shape effects, wedges, blocks, multileaf collimator, asymmetric fields, density corrections, compensators, anthropomorphic phantoms
**Table A3-2. Depth Dose Data**

<table>
<thead>
<tr>
<th>FDDs at standard SSD</th>
<th>FDD curves for a number of open field sizes at a standard SSD:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• SSD: 90 cm</td>
</tr>
<tr>
<td></td>
<td>• Norm depth: 10 cm</td>
</tr>
<tr>
<td></td>
<td>• Field sizes: 3×3, 4×4, 5×5, 6×6, 7×7, 8×8, 10×10, 12×12, 14×14, 17×17, 20×20, 25×25, 30×30, 35×35, 40×40</td>
</tr>
<tr>
<td></td>
<td>• Rectangular fields for various equivalent squares</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FDDs at other SSDs</th>
<th>FDD tables at other SSDs that cover the clinical range used:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• SSDs: 80 and 110 cm</td>
</tr>
<tr>
<td></td>
<td>• Field sizes: 5×5, 10×10, 20×20, 30×30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TPR, TMR</th>
<th>TPR or TMR for a number of field sizes and depths. Since these measurements are quite time intensive, limit to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Field sizes: 5×5, 10×10, 20×20, 30×30, and 40×40</td>
</tr>
<tr>
<td></td>
<td>• Depths: nominal d(_{max}), 5, 10, and 20 cm</td>
</tr>
<tr>
<td></td>
<td>• Norm Point: 10×10, d=10 cm</td>
</tr>
<tr>
<td></td>
<td>• For all other field sizes, calculate TPR/TMR from FDD and verify calculation</td>
</tr>
</tbody>
</table>

### Table A3.3. Output Factors

<table>
<thead>
<tr>
<th>Factor Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phantom Scatter Factor ($S_p$)</td>
<td>These data are typically obtained at the same field sizes used for the standard FDD data:</td>
</tr>
<tr>
<td></td>
<td>• SSD: isocentric</td>
</tr>
<tr>
<td></td>
<td>• Norm pt: 10×10, at 10 cm depth</td>
</tr>
<tr>
<td>Collimator Scatter Factor ($S_c$)</td>
<td>These data are typically obtained at the same field sizes used for the standard FDD data:</td>
</tr>
<tr>
<td></td>
<td>• SSD: isocentric</td>
</tr>
<tr>
<td></td>
<td>• Norm pt: 10×10, at 10 cm depth</td>
</tr>
<tr>
<td>Wedge factors</td>
<td>As required and/or used by the planning system.</td>
</tr>
<tr>
<td></td>
<td>• SSD: isocentric</td>
</tr>
<tr>
<td></td>
<td>• Norm pt: 10×10, at 10 cm depth</td>
</tr>
<tr>
<td></td>
<td>• Wedge factors at various field sizes (5×5, 10×10, 20×20, max)</td>
</tr>
<tr>
<td>Tray factors</td>
<td>As required and/or used by the planning system.</td>
</tr>
<tr>
<td></td>
<td>• SSD: isocentric</td>
</tr>
<tr>
<td></td>
<td>• Norm pt: 10×10, at 10 cm depth</td>
</tr>
<tr>
<td>Other factors</td>
<td>As required and/or used by the planning system.</td>
</tr>
<tr>
<td></td>
<td>• SSD: isocentric</td>
</tr>
<tr>
<td></td>
<td>• Norm pt: 10×10, at 10 cm depth</td>
</tr>
</tbody>
</table>

### Table A3-4. Open Field Data

<table>
<thead>
<tr>
<th>Square fields, standard SSD</th>
<th>2-D dose distributions at standard SSD:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Field sizes for axial planes: $3 \times 3$, $5 \times 5$, $10 \times 10$, $20 \times 20$, $30 \times 30$, $40 \times 40$</td>
</tr>
<tr>
<td></td>
<td>- Field sizes for sagittal planes: $5 \times 5$, $20 \times 20$, $40 \times 40$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Square fields, extended SSD</th>
<th>2-D dose distributions:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- SSDs: 90 and 110 cm</td>
</tr>
<tr>
<td></td>
<td>- Field sizes: $5 \times 5$, $10 \times 10$, $20 \times 20$, $30 \times 30$</td>
</tr>
</tbody>
</table>

| Rectangular fields | The behavior of the depth dose for rectangular fields should be tested. Check at least that the equivalent square is reproduced. For example, use a series of rectangular fields with equivalent square equal to 6 and 12 cm². |

| Oblique incidence | The oblique incidence data should be obtained at the largest angle possible. A 30×30 field at 30 degree oblique incidence may be barely possible in some water tanks, and a 10×10 field at a 40 degree oblique angle may also work. |
| Surface irregularity | Use a step phantom to look at the effects of non-flat surface contours using a 30×30 field incident on a large (5 cm) step in the surface of the phantom. Repeat the calculation with the beam displaced laterally by half of the dose grid spacing to assess effect of dose grid size. |
| Tangential geometry | Measure dose delivered to axial plane for square phantom by 10×20 tangential fields. Normalize the MU so absolute dose at isocenter is known. Compare isodose lines. |
| Square phantom | 20×20 or 25×25 beam normal to a large square phantom. Compare measurements with beam centered on phantom and with beam off-center and flashing off one edge. |

**TABLE A3-6. Wedges**

<table>
<thead>
<tr>
<th>Input data</th>
<th>The minimum set of input data must include 2-D isodose distributions in the axial and sagittal planes for the largest wedged field size.</th>
</tr>
</thead>
</table>
| Depth dose | Wedged field depth dose curves must be verified as a function of field size, SSD, etc., for each wedge.  
• $5 \times 5$, $10 \times 10$, $20 \times 20$, max field size, at least. |
| Field size checks | 2-D isodose distributions:  
• Axial plane: $5 \times 5$, $10 \times 10$, $20 \times 20$, max field size  
• Sagittal plane: $10 \times 10$, max field size  
• Coronal planes at $d = d_{\text{max}}$, $d = 10$, $d = 20$ cm (or full 3-D distribution): $10 \times 10$, max field size |
| Extended SSDs | Axial 2-D isodose distributions:  
• SSDs: 80 and 110 cm  
• Field sizes: $10 \times 10$, $20 \times 20$ |
| Asymmetric and shaped fields | Wedged asymmetric and/or shaped fields also should be verified, at least at a standard SSD. |

<table>
<thead>
<tr>
<th><strong>Table A3-7. Blocks</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input data</strong></td>
</tr>
<tr>
<td>• 15×15 blocked to 4×15</td>
</tr>
<tr>
<td>• 30×30 blocked to 20×20, 10×10, 5×5</td>
</tr>
<tr>
<td>• 30×30 with island blocks of size 20×20, 10×10, 5×5</td>
</tr>
<tr>
<td><strong>SSD checks</strong></td>
</tr>
<tr>
<td>30×30 blocked to 10×10 at SSD of 80 and 110 cm</td>
</tr>
<tr>
<td><strong>Conformal blocks</strong></td>
</tr>
<tr>
<td>Oval, C and squiggle shapes (shown in Fig. A3-1).</td>
</tr>
<tr>
<td><strong>Transmission blocks</strong></td>
</tr>
<tr>
<td>10×10 island block in 30×30 field, but with calc’d primary transmission through island block of 10%, 25%, 50%. Also do 100% transmission calculation.</td>
</tr>
<tr>
<td><strong>Clinical checks</strong></td>
</tr>
<tr>
<td>• Mantle field blocks</td>
</tr>
<tr>
<td>• Spinal cord block</td>
</tr>
</tbody>
</table>

**Table A3-8. MLC**

<table>
<thead>
<tr>
<th>Input data</th>
<th>Same as that for conventional blocks.</th>
</tr>
</thead>
</table>
| Standard shapes | • Circular field \( r = 3 \) cm.  
• Diagonal Edge test: 15, 30, 45, and 60 degrees to MLC edges |
| SSD checks | Circle shape at SSD 80 cm and 110 cm. |
| Conformal shapes | Oval, C and squiggle shapes (shown in Fig. A3-1). |
| Leaf transmission | Jaws open, leaves closed to small field \(5 \times 5\). Deliver > 1000 cGy or so, so leaf transmission can be measured. |
| Clinical checks | • Mantle field block or other large commonly-treated MLC shape  
• Spinal cord block  
• Others |

### Table A3-9. Asymmetric Field Tests

<table>
<thead>
<tr>
<th>Jaw X1</th>
<th>Jaw X2</th>
<th>Jaw Y1</th>
<th>Jaw Y2</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>0</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>-5</td>
<td>15</td>
<td>5</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>-10</td>
<td>20</td>
<td>5</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>0</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>-5</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>-10</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>0</td>
<td>10</td>
<td>-10</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>-5</td>
<td>15</td>
<td>-10</td>
<td>20</td>
<td>-</td>
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<tr>
<td>-10</td>
<td>20</td>
<td>-10</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>-10</td>
<td>20</td>
<td>-10</td>
<td>20</td>
<td>W45</td>
</tr>
<tr>
<td>-10</td>
<td>20</td>
<td>-10</td>
<td>20</td>
<td>Block</td>
</tr>
<tr>
<td>-10</td>
<td>20</td>
<td>-10</td>
<td>20</td>
<td>MLC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>shape</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Algorithm verification tests</th>
<th>Square phantoms with various inhomogeneities are used. These tests are verifications that the algorithm is working correctly and have nothing to do with analysis of clinical results.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark data</td>
<td>To document the accuracy of the correction method in a number of basic but clinically relevant geometries, the dataset measured and reported by Rice's is used. Check results with all 4 geometries included in the Rice dataset, with both 4 and 15 MV. Further benchmark data, especially 2-D and 3-D data for various geometries, are needed.</td>
</tr>
<tr>
<td>2-D and 3-D inhomogeneity checks</td>
<td>Measure depth dose and profiles for layer, partial layer, complex 2-D and 3-D inhomogeneity geometries. These tests can be performed on benchmark data, if available, but the beam definition/parameterization for the beam used must be carefully completed in the same fashion that the user’s clinical beams are fit.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mantle field</th>
<th>Verify dose in coronal midline plane of phantom using TLD or film.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangential breast fields</td>
<td>Include lung. Verify dose in axial plane.</td>
</tr>
<tr>
<td>3-field non-coplanar plan</td>
<td>Verify dose in axial, sagittal, and/or coronal planes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compensators</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing tissue compensation</td>
<td>Only a few simple phantom tests are needed:</td>
</tr>
<tr>
<td></td>
<td>• Lateral Head/Neck field</td>
</tr>
<tr>
<td></td>
<td>• Anterior Mantle field with lung blocks</td>
</tr>
<tr>
<td>Dose compensation</td>
<td>Many different geometries of patient and compensator need to be</td>
</tr>
<tr>
<td></td>
<td>checked, particularly if density corrections are used. The</td>
</tr>
<tr>
<td></td>
<td>complexity of the algorithm should be the main guide in designing</td>
</tr>
<tr>
<td></td>
<td>the tests. Typical geometries include:</td>
</tr>
<tr>
<td></td>
<td>• Lateral Head/Neck field</td>
</tr>
<tr>
<td></td>
<td>• Anterior Mantle field with lung blocks</td>
</tr>
<tr>
<td></td>
<td>• Non-coplanar brain plan, 3 fields</td>
</tr>
<tr>
<td></td>
<td>• Non-axial abdomen plan, 3 fields</td>
</tr>
</tbody>
</table>

Appendix 4: Electron dose calculation commissioning

- depth dose and open fields, output factors, extended distance, shaped fields, ECWG test cases
**TABLE A4-1. Open Fields**

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDD on Cx</td>
<td>FDD curves for each energy for a number of field sizes at a standard SSD.</td>
</tr>
<tr>
<td></td>
<td>- SSD: 100 cm</td>
</tr>
<tr>
<td></td>
<td>- Norm depth: $d_{\text{max}}$</td>
</tr>
<tr>
<td></td>
<td>- Field sizes: 4×4, 6×6, 10×10, 15×15, 20×20, 25×25</td>
</tr>
<tr>
<td>Profiles/2-D dose distribution</td>
<td>2-D isodose distributions in the axial plane for each energy.</td>
</tr>
<tr>
<td></td>
<td>- SSD: 100 cm</td>
</tr>
<tr>
<td></td>
<td>- Field sizes: 4×4, 6×6, 10×10, 15×15, 20×20, 25×25</td>
</tr>
<tr>
<td>Coronal or 3-D data</td>
<td>For 3-D algorithms, 3-D verification checks should be performed. Measure</td>
</tr>
<tr>
<td></td>
<td>multiple coronal plane dose distributions or generate 3-D distributions.</td>
</tr>
</tbody>
</table>

**Table A4-2. Output Factors**

<table>
<thead>
<tr>
<th>Output factor</th>
<th>Typically obtained at same field sizes used for standard FDD data:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• SSD: 100 cm</td>
</tr>
<tr>
<td></td>
<td>• Norm pt: 15×15, at ( d_{\text{max}} ).</td>
</tr>
<tr>
<td>Effective source distance (ESD)</td>
<td>Measure output as a function of distance to determine effective source distance to use for inverse square law corrections.</td>
</tr>
<tr>
<td>Output for shaped fields</td>
<td>Many clinics determine output factors for a set of standard shaped fields.</td>
</tr>
</tbody>
</table>
### Table A4-3. Extended Distance

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDD on Cx</td>
<td>FDD curves are measured for each energy for a subset of field sizes at various SSDs.</td>
</tr>
<tr>
<td></td>
<td>- SSD: 110 cm, others used clinically</td>
</tr>
<tr>
<td></td>
<td>- Norm depth: $d_{\text{max}}$</td>
</tr>
<tr>
<td></td>
<td>- Field sizes: $6 \times 6$, $15 \times 15$, $25 \times 25$</td>
</tr>
<tr>
<td>Profiles/2-D dose distribution</td>
<td>2-D isodose distributions in axial plane for each energy.</td>
</tr>
<tr>
<td></td>
<td>- SSDs: 110 and others used clinically</td>
</tr>
<tr>
<td></td>
<td>- Field sizes: $6 \times 6$, $15 \times 15$, $25 \times 25$.</td>
</tr>
<tr>
<td>Coronal or 3-D data</td>
<td>For 3-D algorithms, 3-D verification checks should be performed.</td>
</tr>
<tr>
<td></td>
<td>Measure multiple coronal plane dose distributions or generate 3-D distributions.</td>
</tr>
</tbody>
</table>

### Table A4-4. Shaped Fields

<table>
<thead>
<tr>
<th>Expt #</th>
<th>Shape</th>
<th>Applicator</th>
<th>SSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>max circle,</td>
<td>25×25</td>
<td>stnd</td>
</tr>
<tr>
<td></td>
<td>$r = 12$ cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>circle,</td>
<td>6×6</td>
<td>stnd</td>
</tr>
<tr>
<td></td>
<td>$r = 2$ cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2_S110</td>
<td>circle,</td>
<td>6×6</td>
<td>stnd+10</td>
</tr>
<tr>
<td></td>
<td>$r = 2$ cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Oval 8×20</td>
<td>20×20</td>
<td>stnd</td>
</tr>
<tr>
<td>4</td>
<td>“C” shape</td>
<td>25×25</td>
<td>stnd</td>
</tr>
<tr>
<td>5</td>
<td>Squiggle shape</td>
<td>25×25</td>
<td>stnd</td>
</tr>
<tr>
<td>6</td>
<td>ECWG House Block</td>
<td>15×15</td>
<td>stnd</td>
</tr>
</tbody>
</table>

AAPM Radiation Therapy
Committee Task Group 67
Benchmark Datasets for Photon Beams

John Bayouth, UTMB at Galveston, co-chair
David Followill, Radiological Physics Center
Benedick Fraas, University of Michigan
Chihray Liu, University of Florida
Daniel Low, Mallinckrodt Institute of Radiology
Thomas R. Mackie, University of Wisconsin
Dan Pavord, The Western Pennsylvania Hospital, co-chair
Charge of TG-67

• Define a benchmark dataset and a set of test cases that could be used as a tool to perform algorithm verification for any TPS. Further, the accelerators and test conditions specified will cover an extensive list of clinical situations.

• The finished project will define a global dataset that could be used to complete the dose calculation checks outlined in TG-53.
Beam Data Requirements for the Planning Systems Listed Below

- ADAC Pinnacle
- CMS Focus
- Helax
- Isis
- Medicalibration
- Multidata
- DSS
- NOMOS Corvus
- Nucletron Plato
- Prowess
- Theratronics
- Theraplan
Verification of the accuracy of a photon dose-calculation algorithm

Kent A. Gifford,* David S. Fallowill,† H. Helen Liu,‡
and George Starkschall§

Department of Radiation Physics, The University of Texas M. D. Anderson Cancer Center,
1515 Holcombe Boulevard, Houston, Texas 77030

(Received 12 September 2001; accepted 16 November 2001)
Compilation of the required data for 10 TPS systems

<table>
<thead>
<tr>
<th>CAX %dd, open fields</th>
<th>Open field profiles, in air</th>
<th>Output factors (Sc,p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAX %dd, wedge fields</td>
<td>Open field profiles, 2 SSD's</td>
<td>Output factors measured at 10 cm depth</td>
</tr>
<tr>
<td>CAX %dd, 90 cm SSD, open and wedged</td>
<td>Off axis HVL</td>
<td>Collimator factors (Sc)</td>
</tr>
<tr>
<td>Diagonal profile for max collimator setting, in phantom</td>
<td>MLC penumbra profiles</td>
<td>Phantom scatter factors (Sp) (either published data or values derived from Sc,p and Sc values)</td>
</tr>
<tr>
<td>Diagonal profile for max collimator setting, in air</td>
<td>MLC/Collimator jaw transmission</td>
<td>Collimator transmission</td>
</tr>
<tr>
<td>Diagonal profile for max square field</td>
<td>MLC setting and radiation field offset</td>
<td>Wedge transmission factors</td>
</tr>
<tr>
<td>Star profiles for max square field</td>
<td>Wedge profiles, nominal SSD</td>
<td>Tray transmission factors</td>
</tr>
<tr>
<td>Open field profiles, nominal SSD</td>
<td>Physical wedge dimensions</td>
<td>Absolute dose reference condition and value</td>
</tr>
<tr>
<td>Open field profiles, 90 cm SSD</td>
<td>Block edge profiles</td>
<td>Absolute dose for 100cm SSD</td>
</tr>
<tr>
<td>Data Type</td>
<td>CMS</td>
<td>NOMOS</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>-----</td>
<td>-------</td>
</tr>
<tr>
<td>CAX (%), open fields</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>CAX (%), wedge fields</td>
<td>X</td>
<td>NA</td>
</tr>
<tr>
<td>CAX (%), 90 cm SSD, open and wedged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagonal profile for max collimator setting, in phant</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Diagonal profile for max collimator setting, in air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagonal profile for max square field</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Star profiles for max square field</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open field profiles, nominal SSD</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Open field profiles, 90 cm SSD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open field profiles, in air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open field profiles, 2 SSD's</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off axis HVL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MLC penumbra profiles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MLC/MLC/MLC, jaw transmission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MLC setting and radiation field offset</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wedge profiles, nominal SSD</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Physical wedge dimensions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block edge profiles</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Output factors (Sc,p)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Output factors measured at 10 cm depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collimator factors (Sc)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Phantom scatter factors (Sp)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Collimator transmission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wedge transmission factors</td>
<td>X</td>
<td>NA</td>
</tr>
<tr>
<td>Tray transmission factors</td>
<td>X</td>
<td>NA</td>
</tr>
<tr>
<td>Absolute dose reference condition and value</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Absolute dose for 100 cm SSD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* = either one
** = suggested, not required
Use the appropriate dosimeter…

<table>
<thead>
<tr>
<th>Type of Measurement</th>
<th>Recommended Dosimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profile</td>
<td>Small Volume Ion Chamber(&lt;0.1cc), Diode, or Diamond</td>
</tr>
<tr>
<td>Depth Dose</td>
<td>Small Volume Ion Chamber (0.125cc)</td>
</tr>
<tr>
<td>Soft Wedge Profile</td>
<td>Ion Chamber Array</td>
</tr>
</tbody>
</table>
JE Bayouth and SM Morrill, “Study Of IMRT Dose Model Inadequacies”, ESTRO 2002
### Comparison of TLD Measurements with TPS Results

*(model 1 – conventional, model 2 – adjusted for IMRT)*

<table>
<thead>
<tr>
<th>TLD Location</th>
<th>Measured Dose (Gy)</th>
<th>TPS 2 model 1 Dose (Gy)</th>
<th>TPS 2 model 2 Dose (Gy)</th>
<th>% diff TPS 2 model 1</th>
<th>% diff TPS 2 model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary PTV Superior</td>
<td>6.84</td>
<td>7.00</td>
<td>6.98</td>
<td>2.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Primary PTV Inferior</td>
<td>6.90</td>
<td>7.05</td>
<td>6.70</td>
<td>2.2</td>
<td>-2.9</td>
</tr>
<tr>
<td>Secondary PTV</td>
<td>5.51</td>
<td>5.69</td>
<td>5.42</td>
<td>3.3</td>
<td>-1.6</td>
</tr>
<tr>
<td>Critical Structure</td>
<td>2.07</td>
<td>2.35</td>
<td>2.13</td>
<td><strong>13.6</strong></td>
<td><strong>2.9</strong></td>
</tr>
</tbody>
</table>

JE Bayouth and SM Morrill, “Study Of IMRT Dose Model Inadequacies”, ESTRO 2002
Finally, How long with this process take?

An appropriate time must be scheduled for the proper commissioning

The length of time needed depends on many factors, such as availability and experience of personnel and proper instrumentation and type of accelerator.

• a single energy photon machine can be commissioned in about 2-4 weeks
• a multimodality accelerator with two photon energies and several electron energies can take about 6-8 weeks of intensive effort (requiring 16-h shifts)
Through data acquisition and TPS commissioning is laborious and necessary work. In the end, we don’t want any surprises …