Commissioning a Proton Therapy Machine and TPS

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McLaren Proton Therapy Center

McLaren Cancer Institute

McLaren - Flint

2012 GLC Fall Meeting, 2012.11.09
Contents

- Overview of Proton Beam Therapy
- Commissioning
- McLaren Proton Therapy Project
- Summary
Overview of Proton Beam Therapy
Accelerated proton beams are used for the treatment of cancer.
Dose beyond the Bragg peak:

\[ p \sim 1-2\% \]
\[ C \sim 15\% \]
\[ Ne \sim 30\% \]
Rationale of Bragg Peak Therapy

- Localization is superior
- Lower entrance dose
- No exit dose

W Chu
Energy Loss of Proton

Distal Distribution

Mass electronic stopping power is the energy lost by protons in electronic collision in traversing the distance $dx$ in a material of density $\rho$.

$$\frac{S}{\rho} = \frac{1}{\rho}[\frac{dE}{dx}] \propto \frac{1}{V^2}$$
Energy Loss of Protons

Electromagnetic Interaction with Nuclear

Multiple Coloumb Scattering

- Protons are deflected frequently in the electric field of nuclei.
- Beam broadening can be approximated by a Gaussian distribution.
- Lateral distribution
Energy Loss of Protons

Lateral dose fall-off: Protons vs. Photons

80/20 Penumbra Comparison

Protons

15 MV Photons

≈ 17 cm
Energy Loss of Protons

Nuclear Interaction

- Hardronic interaction with nuclear
- Bigger transverse momentum transfer than EM interaction
- High LET process – nuclear recoil, fragmentation
- Induced radioactivities – long-lived isotopes
Depth-Dose Curves for Proton and Photon Beams

- Photon beam
- Range-modulated proton beam
- Bragg peak of a pristine proton beam
- Treatment Volume

W Chu
Goals of Radiation Therapy

- Target Dose Conformity
- Dose to Critical Normal Tissues
- Target Dose Homogeneity
- Irradiated Normal tissue Volume

Protons
Dose Sparing: Protons vs. Photons

W Chu
Protons vs. Photons
Proton Therapy is highly conformal
CSI using 3D CRT, Tomotherapy, and Proton Therapy

Protons vs. Photons
History of Proton Therapy

- 1919 Rutherford proposed existence of protons
- 1930 E. O. Lawrence built first cyclotron
- 1946 Robert Wilson proposed proton therapy
- 1955 Tobias et al treated patients at LBL
- 1961 Kjellberg et al treated patients at HCL
- 1972 MGH received first NCI grant for proton studies at HCL
- 1983 Tsukuba Univ. in Japan treated patients
- 1985 PTCOG
- 1991 First hospital-based proton facility at LLUMC
- 2009 27 facilities worldwide treating patients; over 67,000 patients treated with protons.
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83667 protons
38647 Grand Total
Worldwide Particle Therapy Facilities

31 PROTON AND 5 CARBON ION THERAPY FACILITIES IN 2011

North America = 11
Europe = 10 + 2 carbon
Russia = 3
China = 1
Korea = 1
Japan = 4 + 3 carbon
Southern Hemisphere = 1

25 additional institutions are planning to have a charged particle therapy.
## Cyclotron vs. Synchrotron

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<td><strong>Beam extract efficacy</strong></td>
<td>Low (high radiation activity)</td>
<td>High</td>
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<td><strong>Temperature stability</strong></td>
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<td><strong>Beam current</strong></td>
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<td>Low</td>
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<tr>
<td><strong>Beam quality</strong> (momentum spread)</td>
<td>Low (large)</td>
<td>High (small)</td>
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Beam Transport System
Positioning System

- Rotation: ±190°
- Isocenter within a sphere of confusion of 1 mm radius
- Angular precision: ±0.25°
- Speed: 0.2 to 1 rpm
- Achromat
Energy Selection System:

- Transform fixed energy beam extracted into a beam having a variable energy [230 MeV - 70 MeV]

Control Interface: Energy & Beam Transport Control Unit (ECUBTCU)
Beam Shaping Components

Nozzle:
- To spread the proton beam to obtain a uniform dose distribution in a large volume
- To measure accurately the dose delivered to the patient
- To help the alignment of the patient with the proton field

Control Interface: Treatment Control Unit (TCU)
Nozzle Beam Delivery Modes

- **Double Scattering**
  - Field diameter $< 25$ cm
  - "Large" Penumbra

- **Single Scattering**
  - Field diameter $< 8$ cm
  - "Sharp" Penumbra

- **Wobbling**
  - Field $30 \times 40$

- **Pencil-Beam Scanning**
  - IMPT
Double scattering principle
Range Modulator System
Second Scatterer System
Snout

- Camera
- Led
- Rotation of +/-5°
Aperture and Range Compensator
Uniform scanning principle

- High Z
- Low Z

- Fixed Scatterer
- Scanning Magnet
- Range Modulator

Proton Beam

- Graphs showing intensity profiles and waveforms.
Painting a Layer

Courtesy by H. Benteffour, IBA Physics Dept.
Comparison between scattering and scanning
Pencil Beam Scanning principle

- Tumor divided in iso-energy slices
- Scanning magnets in x and y
- Proton beam
- Slices already treated
- 2-D dose distribution on the actual scanned slice
- Bragg-peak

C. Brusasco, XXXVI PTCOG, Catania 29-31 May 2002
• Deliver many small beams to a tumor using magnetic beam deflection.

• Energy is changed in accelerator to scan each successive layer.

A full set, with a homogenous dose conformed distally and proximally

Pedroni, PSI
Advantages of PBS

Scattering

Aperture

Bolus

Dose deposition in Tumor

Scanning
Pure PBS nozzle status

Courtesy of H. Bentefour, PBS physicist in MGH
Scanning a Non-Uniform Dose Distribution

- # of passes: 1
- # lines: 50
- irr. time: 4.5 sec
- 23 x 30 cm
- $\nu = 250$ cm/sec

Spot size: $\sigma = 10$ mm

IBA
Improved Dose Distribution with IMPT

Proton vs. IMPT

Lomax, PSI
Commissioning
Commissioning?

- Refers to the process whereby the needed machine-specific beam data are acquired, and operational procedures are defined: beam data acquisition, entry of beam data into an RTP system and testing of its accuracy, development of operational procedures, and training of all concerned with the operation of the new machine. (AAPM Report No. 47)

  => has strong dependency on beam delivery system and treatment planning system.
Proton Commissioning

- Safety Interlocks
- Dosimetric Calibration
- Mechanical
- CT HU to Stopping Power Calibration
- TPS Commissioning
- Imaging System Commissioning
- R&V System
- Beam Modifying Accessories
- Integration Testing
- Clinical Procedures
NCC Proton Therapy Center (IBA, Belgium)

Proteus 235 Specification

Weight : 220 ton   Height : 210 cm   Diameter : 434 cm

Energy : 230MeV

Max. extracted beam current : 300nA

RF frequency : 106 MHz
Treatment Beam Modes

Universal nozzle

- Passive mode
  Double Scattering
  Single Scattering

-Dynamic mode
  Uniform Scanning
  Pencil Beam Scanning
# Clinical Specifications of Proton Beam

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<th>Single Scattering</th>
<th>Double Scattering</th>
<th>Uniform Scanning</th>
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<td>Range in Patient (g/cm²)</td>
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<td>4.51-28.42</td>
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<td>Range modulation (g/cm²) adjustment &amp; Size</td>
<td>0.4(R&gt;6), 0.17 9.2</td>
<td>0.2 20.75</td>
<td>0.5 Full</td>
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<td>Range adjustment (g/cm²)</td>
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<td>Average dose rate (Gy/min)</td>
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<td>Max. Field Size (cm)</td>
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H&N, RS | Conventional | Large Size

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McLaren
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Treatment Planning System Issue

- Limited vendors and just enough support for a proton treatment planning

- Proton Therapy system has a complicated beam nozzle configuration and delivery option (Too many machine dedicated parameters on TPS).

- Compatibility issues among TPS, OIS and TCS. (Treatment beam parameters, Patient setup images, Aperture & Compensator data).
1. Varian, Eclipse (version 10.x, OIS - ARIA) : Scattering mode / Scanning mode

2. Elekta, XIO (v4.64, OIS-MOSAIQ) : Scattering mode/ Scanning mode

3. Ray Search Laboratories, RayStation : Scattering mode/ Scanning mode (under development)

4. Home made TPS for eye treatment

5. Etc..
Prerequisites and Necessary tools for Beam Commissioning

Prerequisites
- The beam calibration is done by the machine vendor.
- The treatment control system is configured with the accurate beam parameters.
- The dose monitoring system is calibrated to deliver one cGy per Monitor Unit (MU) in the reference field conditions. This task is the responsibility of a medical physicist.
- The treatment Room acceptance tests are passed by a medical physicist.

Necessary Tools
- Dosimetry tools
  - The 3D Water phantom and its associated software.
  - Ion chambers (parallel plate IC & Cylindrical IC) or diode detector
  - Multi-layer Ionization chamber
  - Electrometer.
  - Film
- Treatment beam parameter converting sheet for the treatment room (ex. ConValgo/WobAlgo for IBA PT system)
- Apertures with various sizes
- Spirit level, Ruler, Barometer & Thermometer.
Beam modeling on Eclipse TPS

- **Beam data required**
  1. Depth dose curve → Depth dose
  2. Half beam block profile → Lateral penumbra
  3. Beam fluence along Z axis → Effective SAD
  4. Open field cross profiles → Virtual SAD
  5. Depth dose and Z fluence → MU calculation
  6. Cross profiles of spot fluence → Phase space

- **Nozzle Stucture (Water Equivalent Thickness)**
  1. Scatterers
  2. Range modulators
  3. Other parts on the beam path way

- **Field size, Range option, Aperture & Comensator, etc.**
# Example of Range Option

## Double Scattering

<table>
<thead>
<tr>
<th>Option</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>B5</th>
<th>B6</th>
<th>B7</th>
<th>B8</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOBP (cm)</td>
<td>5.87</td>
<td>7.49</td>
<td>9.55</td>
<td>11.65</td>
<td>15.54</td>
<td>15.6</td>
<td>18</td>
<td>20.7–25</td>
</tr>
<tr>
<td>Field size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>

## Uniform Scanning

<table>
<thead>
<tr>
<th>Option</th>
<th>Option1</th>
<th>Option2</th>
<th>Option3</th>
<th>Option4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range (cm)</td>
<td>3.5–12</td>
<td>12–18</td>
<td>18–26</td>
<td>26–32.5</td>
</tr>
<tr>
<td>SOBP (cm)</td>
<td>0.35–12</td>
<td>0.45–18</td>
<td>0.55–26</td>
<td>0.6–32.5</td>
</tr>
<tr>
<td>Field size</td>
<td>30X40</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Example of Beam Data Measurement

<table>
<thead>
<tr>
<th>Type</th>
<th># Energies</th>
<th># Position</th>
<th># NET</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth dose curves (in water)</td>
<td>5</td>
<td>1 (Central axis)</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Z Fluences (in air)</td>
<td>5</td>
<td>1 (Central axis)</td>
<td>3-5</td>
<td>15-25</td>
</tr>
<tr>
<td>X Profiles (in air)</td>
<td>5</td>
<td>4 (Z=+150mm,0mm,-150mm and 300mm)</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Half blocked profile (in air)</td>
<td>5</td>
<td>4 (Z=+150mm,0mm,-150mm and 300mm)</td>
<td>3-5</td>
<td>60-100</td>
</tr>
</tbody>
</table>

150 measurement/option * (DS:8+SS:6+US:4) options = 2,700 measurements
Proton Beam Measurements

- Output measurement (TRS 398)
  - Reference chamber: Farmer type
  - Small Field size: Pinpoint chamber

- Profile measurement
  - PDD, Distal Penumbra: Markus Chamber, MLIC
  - Lateral Penumbra: Pinpoint Chamber, Diode detector, Film (X-Omat, EDR2, and EBT)
Dosimetry Devices I
Dosimetry Devices II

There are several tools, useful for scanning beam.

Some of them are essential and others can save your beam data measurement time.

Ex.) MLIC, Scintillation Plate type detector, 2D Array type Ionization Chamber, Large size PP type chamber, etc.
Snout Position and Tray Distances
TPS Validation Test: PDD Comparison (DS)

- Planning vs Measurement
  - Range diff. < ~1mm
  - Dose diff. @ Proximal < ~3%
  - ~5% dose difference at the Beam entrance
TPS Validation Test: PDD Comparison (US)
TPS Validation Test: Lateral Penumbra

![Graph showing lateral penumbra for different air gaps.](image)

- **Eclipse: 5cm AirGap**
- **Measure.: 5cm AirGap**
- **Eclipse: 20cm AirGap**
- **Measure.: 20cm AirGap**
Dose Uncertainties in Proton Therapy

- Conversion from Hounsfield numbers to electron density does not exactly match with proton stopping power.
- Materials with different relative stopping power can have the same CT numbers.

<table>
<thead>
<tr>
<th>Phantom</th>
<th>Density</th>
<th>Electron Density</th>
<th>Proton SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB2–50</td>
<td>1.560</td>
<td>1.470</td>
<td>1.431</td>
</tr>
<tr>
<td>LN–300</td>
<td>0.280</td>
<td>0.273</td>
<td>0.273</td>
</tr>
<tr>
<td>Adipose</td>
<td>0.941</td>
<td>0.924</td>
<td>0.949</td>
</tr>
<tr>
<td>LN–450</td>
<td>0.450</td>
<td>0.437</td>
<td>0.445</td>
</tr>
<tr>
<td>B–200</td>
<td>1.153</td>
<td>1.105</td>
<td>1.110</td>
</tr>
<tr>
<td>CB2–30</td>
<td>1.334</td>
<td>1.279</td>
<td>1.267</td>
</tr>
<tr>
<td>water</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Brain</td>
<td>1.053</td>
<td>1.049</td>
<td>1.061</td>
</tr>
<tr>
<td>Breast</td>
<td>0.979</td>
<td>0.956</td>
<td>0.963</td>
</tr>
<tr>
<td>Solid water</td>
<td>1.017</td>
<td>0.988</td>
<td>1.004</td>
</tr>
<tr>
<td>Liver</td>
<td>1.094</td>
<td>1.082</td>
<td>1.070</td>
</tr>
<tr>
<td>Inner Bone</td>
<td>1.144</td>
<td>1.097</td>
<td>1.084</td>
</tr>
<tr>
<td>Cortical Bone</td>
<td>1.824</td>
<td>1.696</td>
<td>1.610</td>
</tr>
</tbody>
</table>

Ex.) CT number vs. Proton (SP)
Daily Morning QA with PMMA Phantom

Snout 100, Snout 180

PTW30013 type ion chamber
- Located at 10cm depth

Relative SP 1.158

Optimize Beam condition
Range : 14.07 cm
SOBP : 5 cm
Calibration Results

- Results from PMH.
- We need to calibrate the detector with 0.25 rotation yaw (around beam direction)

**Monthly QA Compensator Accuracy**

<table>
<thead>
<tr>
<th></th>
<th>Plan</th>
<th>Machine data</th>
<th>Compensator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>@220.5 (cm)</td>
<td>@230.0 (cm)</td>
<td>Norm. Diverg.</td>
</tr>
<tr>
<td>W1</td>
<td>24.2</td>
<td>25.3</td>
<td>1.0022727</td>
</tr>
<tr>
<td>W2</td>
<td>33.7</td>
<td>35.1</td>
<td>0.9985228</td>
</tr>
<tr>
<td>W3</td>
<td>43.2</td>
<td>45.2</td>
<td>1.0030797</td>
</tr>
<tr>
<td>H1</td>
<td>24.3</td>
<td>25.3</td>
<td>0.9981481</td>
</tr>
<tr>
<td>H2</td>
<td>33.5</td>
<td>35.0</td>
<td>1.0016223</td>
</tr>
<tr>
<td>H3</td>
<td>43.3</td>
<td>45.1</td>
<td>0.9985491</td>
</tr>
</tbody>
</table>

*드라임: 경사각 3.00*
### Monthly QA: X-ray alignment GTR1

<table>
<thead>
<tr>
<th>Gantry angle</th>
<th>Coord.</th>
<th>DIPS (Rad A)</th>
<th>Isodose = 30%</th>
<th>Isodose = 50%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Field</td>
<td>Metal Ball</td>
<td>Diff.(mm)</td>
</tr>
<tr>
<td>0</td>
<td>Xo</td>
<td>-0.046</td>
<td>31.35</td>
<td>31.35</td>
</tr>
<tr>
<td></td>
<td>Yo</td>
<td>0</td>
<td>0.15</td>
<td>0.35</td>
</tr>
<tr>
<td>90</td>
<td>Xo</td>
<td>0.046</td>
<td>34.15</td>
<td>33.55</td>
</tr>
<tr>
<td></td>
<td>Yo</td>
<td>0</td>
<td>0.9</td>
<td>1.4</td>
</tr>
<tr>
<td>180</td>
<td>Xo</td>
<td>-0.046</td>
<td>33.05</td>
<td>32.2</td>
</tr>
<tr>
<td></td>
<td>Yo</td>
<td>-0.046</td>
<td>0.5</td>
<td>0.25</td>
</tr>
<tr>
<td>270</td>
<td>Xo</td>
<td>0</td>
<td>34.9</td>
<td>34.45</td>
</tr>
<tr>
<td></td>
<td>Yo</td>
<td>0.046</td>
<td>-0.1</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Test Pattern

Initiated by Jay Flanz. Developed originally as an acceptance test pattern via a collaboration between IBA, MGH, ProCure, Florida, Orsay, Essen, and Penn.

J. McDonough, 2012
Patient Treatment QA

- Field Calibration
  - Range & SOBP: Water Phantom, MLIC
  - Output: TRS398, Farmer Chamber

- 2D dose distribution comparison:
  - Measurement in 3D water phantom & TPS Dose calculation
IBA provides the converting Algorithm for a beam delivery conditions

However, it is not enough for our clinical beam delivery tolerance!
Example of Patient QA Plan

Special case, with compensator
1. RTP parameter

**Plan**
- Prescription Dose: 235 Gy/ cm²
- Range in patient: 25.05 cm
- SOBP width: 10.39 cm
- Snout position: 27.9 cm
- Air Gap: 2.0 cm
- Gantry Angle: 270°
- Couch Angle: 0°
- Setup SSD: 223.4 cm
- Snout Size: 180 cm

**Verification**
- Dose dist.: 25.07 g/cm²
- Range: 12 cm

**Dose dist.**
- Option: B8.2
- Reference depth: 20.4 cm
- Range Modulator: RM.8

2. Range/SOBP calibration

<table>
<thead>
<tr>
<th>Convalgo</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>SOBP</td>
</tr>
<tr>
<td>1</td>
<td>25.05</td>
</tr>
<tr>
<td>2</td>
<td>24.96</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Final</td>
<td>24.96</td>
</tr>
</tbody>
</table>

3. Output Calibration

**PTW30006-04073 Ks = 1.002, Kpol = 1.000, Ndw = 0.05424**
- Range in patient: 25.07 g/cm²
- SOBP width: 10.3 g/cm²
- Reference depth: 20.4 g/cm²
- Practical Range: 25.88 g/cm²
- Dosimeter output: 50.8, 50.7, 50.7
- Average: 50.73 mC/200MU
- Beam quality factor: 1.030
- Output Factor: 1.416 cGy/MU
- Expected: 1.387 cGy/MU
- Temperature: 22.64 °C
- Pressure: 1019.2 hPa
- Dose at V.P.: 209.8 Gy
- RBE Correction: 1.1 CcGy/CcGy
- Calibration MU: 200 MU
- PT factor: 0.997
- Physical Dose: 190.73 cGy

**Difference:** 2.08%

**Treatment MU:** 134.69 MU

<table>
<thead>
<tr>
<th>Item</th>
<th>CRange</th>
<th>CSOBP</th>
<th>MRRange</th>
<th>MSOBP</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB</td>
<td>24.96</td>
<td>10.39</td>
<td>25.07</td>
<td>10.30</td>
<td>1.4164</td>
</tr>
<tr>
<td>Meas. - DB</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>-0.0003</td>
</tr>
</tbody>
</table>
Patient QA Procedure

TPS

Conv. Algorithm

Beam Measurement

Treatment Planning
- Range, SOBP, Dose calculation
- MU calculation accuracy (??)

Beam Parameter Generation

Fine-tuning the beam parameters to give the planned beam conditions

Time consuming job: ~ 2hrs/patient

Tolerances for Tx.
- Range: 1~2 mm
- Output: 3%

Range, SOBP, Dose calculation
- MU calculation accuracy (??)

Fine-tuning the beam parameters to give the planned beam conditions

Time consuming job: ~ 2hrs/patient
DB based Prediction for Output Factor, Range, and SOBP

\[ \Psi : \text{Output factor} \]
\[ \Psi_c : \text{Output factor (calib)} \]
\[ CF : \text{Constant related RM opt.} \]
\[ D_{0,c} : \text{Entrance Dose (calib)} \]
\[ r : \frac{r}{r} = \frac{(R - \text{SOBP})}{\text{SOBP}} \]
\[ a_0, a_1 : \text{theoretical values} \]

\[ y = 1.0249x - 0.5685 \]

ConvAlgo vs. Measurement data
Linear Func. Fitting Method
\[ Y = P1*X + P2 \]

ConvAlgo vs. Measurement data
4 degree Func. Fitting Method
\[ Y = P1*X^4 + P2*X^3 + P3*X^2 + P4*X + P5 \]

* Hanne Kooy’s paper(MGH)

→ PMB, 50 (2005), p5847–5856

→ Patient QA can be covered by the DB based prediction methods.
→ used for the independent check of QA.
McLaren Proton Therapy Project
Architectural rendering for MPTC and MCI

Total Construction = 52,434 SF
MPTC new construction = 42,093SF
MCI renovations = 10,341 SF
Space Layout for the MPTC

- Compact synchrotron and three 180° isocentric gantries
- IGRT using CBCT, CT-Sim and PET-CT imaging modalities
- Treatment set-up room external to the treatment rooms
McLaren Project schedule

• Contract signing with Equipment Vendor: 3/12/10
• Contract signing with Design-Build Team: 7/6/10
• Building ready for Equipment Installation: 7/1/11
• Major equipment Installation Complete: 7/20/12
• Technical Commissioning Completed: 11/30/12
• Acceptance Tests Complete: 12/16/12
• Clinical Commissioning Completed and First Treatment Begins: 3/12/2013

~ 3 yrs
Selected McLaren Specifications

- Pencil beam scanning for IMPT and SFUD
- \( \Delta E/E \) of beam at extraction: \( \leq 0.2\% \)
- Maximum treatment field size: 40 cm x 30 cm
- Beam penetration: 4 – 37 g/cm\(^2\)
- Spot sizes in air at isocenter (1 \( \sigma \)): 3 mm to 7 mm
- Beam spill length (flat top): 0.1 to 5 s
- Time between beam spills: \( \sim 1 \) s
- Beam intensity: variable within spill. DR \( \sim 10:1 \)
- Time to treat 0.5 liter volume to 2 Gy: \( \leq 1.5 \) m
- CBCT for image-guided setup and verification
- Proton Tomography to be developed
Total weight = 15 tons
4.9 m diameter

70 – 250 MeV for treatments
330 MeV for Proton tomography
Variable extraction sequence
Variable intensity
ProTom International Isocentric Gantry

180 degree rotation coupled with robotic patient positioner provides complete 360 degree treatment beam entry angles for patient treatments.

45 tons
3.5 m turning radius
McLaren Proton Therapy Center Flint, MI
Hospitality House

- Designed for Patients and Caregivers
- Most patients will travel an hour or more to Flint for Proton Therapy
- Long-term stays, typically 6 – 8 weeks
- The Hospitality House will be a non-profit
  - Room fees would be in the form of suggested donation ($35 per night)
- 20 – 30 guest rooms
- About 38,000 square feet
Summary
Summary

• The commissioning of a Proton therapy system is very time consuming work and requires good understanding of the system.

• It is a big issue to deal with the limited beam time and man-power (other room beam calibration, maintenance, patient treatment and machine/patient QA, etc.).

• There is a need to develop the standard QA program for proton therapy. => AAPM TG 224
So much work, So much fun, so little time.

thank you!