Planning for the Installation of a Compact Superconducting Proton Therapy Unit in a Busy Medical Center Environment

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Adapted from a presentation given by David B. Mansur, M.D.
At PTCOG 53 (June 2013)
Disclosures

• Collaboration Contract with Philips Medical Systems for Proton RTP (No cost)
Cleveland, Ohio, USA
Existing Proton Centers NE USA
Existing + Planned Proton Centers
Protons in Cleveland: Our Mission

- Build the first proton therapy facility in the region
- Establish a center of excellence for pediatric radiation oncology
- Supplement existing advanced technologies (Cyberknife, Perfexion Gamma Knife, VMAT, Tomotherapy, IORT) at Seidman CC for select patients.
- Participate in national and institutional clinical trials
Proton Clinical Benefit - Avoid collateral dose

Pediatric Medulloblastoma
Protons in Cleveland: Our plan

• A 6,000 square foot all inclusive facility in the heart of our existing NCI designated comprehensive cancer center
• Down one corridor, 30 meters from Rainbow Babies and Children’s Hospital
• 2 phase project, one vault for each phase
• Orthogonal KV, and diagnostic CT image guidance initially for IGRT.
Protons in Cleveland: Our Campus

• Case Western Reserve University and School of Medicine
• > 1000 Beds:
• University Hospitals
  – Lerner Tower
  – Mather Pavilion
  – Lakeside Hospital
  – MacDonald Women’s Hospital
  – University Psychiatric Center
  – Hanna Pavilion
• Seidman Cancer Center
  – Dedicated Cancer hospital and outpatient treatment facility
• Rainbow Babies and Children’s Hospital
  – 240 bed tertiary care children’s hospital
Size Does Matter

• Limited space precludes large, multi-gantry proton therapy systems with fixed external cyclotron

• Smaller facility using a compact superconducting Cyclotron needed to meet the mission of the UH Case Medical Center – Full Energy (250 MeV) proton beam and dose on target (2 – 4 Gy/min)

• Single room system would be ideal in this location
A 10 Tesla Superconducting Magnet enables a smaller, lower cost gantry mounted Cyclotron.
Vive la difference

• Cyclotron
  – Single large magnet
  – Constant (in time) magnetic field
  – Orbits increase in size as energy increases

• Synchrotron
  – Many small magnets
  – Orbit is constant in size (ring)
  – Magnetic field increases (ramping) as energy increases
Mevion S250
Beam Shaping

Passive Scattering and Active Scanning Beams
Patient Specific Apertures and Energy Range Shifters
Pencil Beam Scanning
Mevion Proton Therapy

Beam Delivery: Uniform Field and Dedicated IMPT

• **Uniform Field**: modern 4th generation with *exclusive direct beam modulation* – passive scattering
  – Safe, automated, and precise
  – Standard with 2012 deliveries
  – Retrofittable and upgradable

• **IMPT**: fast spot scanning supported by *exclusive direct beam modulation*
  – Under development: working prototype end 2012 with release in 2014
  – High speed with up to 10 target painting per minute
  – Retrofittable and upgradable
IMPT – Spot Scanning - Mevion

Spot Size exit accelerator: 1.3 x 1.3 mm

2 Gy/min to 1 liter with 10 repainting

<table>
<thead>
<tr>
<th>Modality/Property</th>
<th>Passive Scattering</th>
<th>Active Scattering</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 D field shaping</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3 D field shaping</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Sensitive to organ motion</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Field Adapter</td>
<td>Yes</td>
<td>Superior field definition if used</td>
</tr>
<tr>
<td>Range Compensator</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Neutron activation</td>
<td>Moderate - safe</td>
<td>Low - safe</td>
</tr>
<tr>
<td>System Maturity</td>
<td>Standard – 80,000 patient worldwide experience</td>
<td>Emerging technology &lt; 1,000 patient worldwide</td>
</tr>
<tr>
<td>System maintenance and required QA</td>
<td>Standard, patient specific compensator fabrication required</td>
<td>High, Patient specific QA required, no compensator</td>
</tr>
<tr>
<td>Patient through-put per room/day</td>
<td>10 -15 – 10 hr day</td>
<td>Low - &lt; 6 pts/day (March 2012)</td>
</tr>
</tbody>
</table>
Unique Shielding Considerations

- Primary Proton beam and neutron production
  - Occupancy Factors
- Neutrons
  - CT scanner
- Magnetic Field and Radio waves
  - Proximity of MRI
Scattered Beam
Primary and Scattered Beam

Analytical Calculations
Courtesy Jim Brindle, Ph.D and Barry Wessels, Ph.D

Monte Carlo Calculations
Courtesy Jeff Siebers, Ph.D
Elevation Section Through Maze

1’ thick maze ceiling to match tx room roof

Note: Wall is angled here, so attenuation does correspond with wall

Towards MR
Neutron Damage to CT?
RF and Magnetic Fields
RF Grounded Shield
Magnetic Field

Magnetic Active Compensation System (MACS) for MRI

ETS-Lindgren’s Magnetic Active Compensation System (MACS®) offers a maintenance-free, dynamic method for shielding MRI systems from low frequency environmental AC/DC magnetic interferences.

**Key Features**
- Can reduce fluctuations in excess of 1.20 mG to less than 1 mG.
- Uniform protection from environmental AC/DC magnetic interference over a wide frequency range.
- Offers protection against fluctuations in magnetic fields caused by Subways, Transformers, Elevators and Moving Vehicles.
- Compatible with all magnets, from 0.2T to 3T and higher.
- NACE negative feedback technology corrects itself even as the environment changes.
- A high performance, reliable concept in environmental shielding for MRI systems.

*Figure 24. Illustration of Five and Ten Gauss Magnetic Field Swept in Room*
Setting up a commissioning plan

We just bought a proton-therapy system!

A cyclotron based system with not one, not two, but three gantries!

We are going to treat 1200 patients a year, 14 hours a day, and for six days a week.

There will be pediatric cases, prostates, head&neck, lung, radio-surgery.....

We will be starting on September 1.

Can you commission the system for us?
Business plan

• Patient mix
  – Pediatric Anesthesia 35%
  – Lung 15 %
  – Brain/spine 15%
  – Targeted Reirradiation or boost 15%
  – Head and Neck 10%
  – GU/Prostate 10%

• Operation – after year 2
  – 14-16 hours scheduled – with Physics QA
  – 15-25 patients per day
Definitions of acceptance and commissioning

- **Acceptance Testing** → Vendor and customer

  ‘.. to determine that all applicable radiation safety standards are met or exceeded and that the machine meets or exceeds the contractual specifications.’

  ‘A satisfactorily completed acceptance test simply assures that the accelerator and its associated systems satisfy all performance specifications and pertinent safety requirements.’

- **Commissioning** → Customer

  ‘…refers to the process whereby the needed machine-specific beam data are acquired and operational procedures are defined.’

AAPM code of practice for radiotherapy accelerators: Report of AAPM Radiation Therapy Task Group No. 45
Determine the parameters to verify

For what subset of prescribed parameters do these need to be verified?

- range
- modulation width
- dose variation uniform region
- distal fall-off
- skin dose / proximal region
- dose rate
- dose per MU
- field size
- field size vs. depth
- lateral penumbra vs. depth
- dose rate
- depth dose
- uniformity profile (tilt/flatness)
- maximum field size
- SSD (air gap)
- snout size

Prescription → Equipment settings → Delivery
### Does the pdd uniformity depend on…….

<table>
<thead>
<tr>
<th>Option</th>
<th>Yes</th>
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</thead>
<tbody>
<tr>
<td>Suboption</td>
<td>Yes</td>
</tr>
<tr>
<td>Modulation</td>
<td>No</td>
</tr>
<tr>
<td>Field size</td>
<td>Yes</td>
</tr>
<tr>
<td>Snout size</td>
<td>Maybe</td>
</tr>
<tr>
<td>Gantry angle</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Dose rate</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Dose</td>
<td>No</td>
</tr>
<tr>
<td>SSD</td>
<td>Yes</td>
</tr>
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</table>

**Measure…**
- 1 full-mod SOBP per suboption
- 2 sobp for all snouts
- 1 sobp for 2 gantry angles
- 1 sobp for 3 dose rates
- 2 sobp for varying SSD
- sobp’s for small aperture size
Clinical Integration
Oncology Information System and TPS

Treatment Planning: Eclipse, CMS, Pinnacle
Oncology Information System: IMPAC or ARIA

- Workflow anticipated to be similar to conventional linear accelerator
- Schedule, treat, verify and record
University Hospitals Team

• **Physics and Dosimetry**
  • Director of UH Proton Medical Physics (1 FTE) - TBA
  • Staff Proton physicist and Physicist Assistant (2 FTE) - TBA
  • Proton Dosimetrist (1 FTE) - TBA
  • Barry Wessels, PhD -- Director of Medical Physics
  • Jeff Siebers, PhD and Charles Bloch, PhD. – Technical and Shielding Consultants

• **Therapist – TBA - 4 FTE**

• **Physicians**
  • David Mansur, MD – Director UH Proton Center
  • Mitch Machtay, MD – Chairman of Radiation Oncology

• **Administration**
  • Nathan Levitan, MD, MBA – President Seidman Cancer Center
  • Linda Mangosh, RTT, MBA – VP Operations Seidman Cancer Center
  • Brenda Myers, RTT – Clinical Manager Radiation Oncology

• **Construction**
  • Crandall Miller
  • Linda Hulsman

• **Administrative Assistance**
  • Edie Cawley
Shovel in the Ground – 10/11/13
<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete architectural &amp; construction design</td>
<td>Sept 2013</td>
</tr>
<tr>
<td>Ground breaking</td>
<td>Sept 2013</td>
</tr>
<tr>
<td>Gantry embeds</td>
<td>Jan 2013</td>
</tr>
<tr>
<td>Receive Accelerator</td>
<td>Sept 2014</td>
</tr>
<tr>
<td>Complete installation</td>
<td>Jan 2015</td>
</tr>
<tr>
<td>Acceptance</td>
<td>Mar 2015</td>
</tr>
<tr>
<td>Commissioning</td>
<td>August 2015</td>
</tr>
<tr>
<td>Clinical operation</td>
<td>September 2015</td>
</tr>
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</table>