DETROIT FAST NEUTRON THERAPY FACILITY: STATUS AND DEVELOPMENT

International Workshop on Neutron Therapy
in Essen. September 14 - 16, 2006
Overview

- Joint project between National Superconducting Cyclotron Laboratory at MSU and Harper Hospital in Detroit - 1990
- Neutron Source: Isochronous Superconducting 100K Cyclotron
  - d(48.5)+Be on internal target (maximum current: 15 μA)
  - Neutron dose yield: 3.2 cGy·min⁻¹·μA⁻¹ at d_{max} in 10 × 10 cm² field and SSD = 1829 mm
- Cyclotron mounted on ring gantry capable for full 360° rotation
- Technical support: MedCyc Corp.
- Annual cost of operation: $750K
Neutron Therapy Facility
Neutron Multi-Leaf Collimator

• Project supported by $300K grant from Williams International, Farmington Hills, MI
• Total cost ~ $500K
• R. L. Maughan, Ph.D. - University of Pennsylvania, Philadelphia, PA
• J. B. Farr, Ph.D. – MPRI, Bloomington, IN
• E. Blosser and J. Brandon – MedCyc Corp., East Lansing, MI
• T. Horst – TD Engineering, Milford, MI
• B. Ammons, Ph.D. – Ammons Engineering, Mt. Morris, MI
• Installation and commissioning: July – September 2005
• Clinical application since October 2005

- 120 semifocused leafs projecting 5.0 mm at the isocenter
- Maximum aperture: 229 × 214 mm²
- Two opposite leaf stacks constrained between Nylatron® bearings
- Each leaf is coupled with an individual stepping motor receiving drive pulses form indexers capable of decoding ASCII based test instructions
- Barcoded patterns on back of the leafs allow to recognize their position by a Vision system for verification purposes
MLC Control

- PCI Counter/Digital I/O Card
- Motor/Wedge Indexers
- Digital Camera
- LAN - TCP/IP
- MLC

BEV on TPS

Collimator

Leafs
Portal Verification

- Two x-ray tubes mounted on the gantry at ±60º from the central axis
- Film verification
  - Superposition of neutron beam imprint on X-ray image
  - Requires gantry rotation between exposures and film processing
- Electronic Portal Imaging
  - Combines image of the port by MLC Vision system and X-ray image obtained by EPID (flat panel)
- Reconstruction of fiducial or anatomical markers for image guided adoptive therapy
Image Guided Adaptive Neutron Radiotherapy

- Upgrade of patient support system
- Development of electronic portal imaging
- Increased degrees of freedom
- Fully motorized
- Computer controlled
- Non-axial beam orientation
- Set-up of the patients outside the doughnut
Neutron IMRT

• Strategy:
  – Forward-planned, SMLC delivery using chosen beam orientations, and segments

• In-house treatment planning optimization algorithm (T. He, Med. Phys., 2003):
  – DVH-based objective function and parallel platform algorithm for optimization of segment weights
Feasibility Study for Prostate IMNRT  

### Rectum cDVH

<table>
<thead>
<tr>
<th>Treatment Plan</th>
<th>Target Minimum, Maximum, and Mean</th>
<th>%Dose:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GTV\textsubscript{PROS}</td>
<td>GTV\textsubscript{SV}</td>
</tr>
<tr>
<td>Standard Plan</td>
<td>96 103 101</td>
<td>98 105 103</td>
</tr>
<tr>
<td>Optimized (11 seg)</td>
<td>90 105 103</td>
<td>91 105 102</td>
</tr>
<tr>
<td>Optimized (13 seg)</td>
<td>90 107 104</td>
<td>83 107 101</td>
</tr>
</tbody>
</table>

### Bladder cDVH

<table>
<thead>
<tr>
<th>Treatment Plan</th>
<th>Femoral Head (Min, Max, Mean)</th>
<th>Pelvic Muscle (%V → 60%D) AM IPM GM</th>
<th>MU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Plan</td>
<td>27 87 51</td>
<td>8 8 12</td>
<td>249</td>
</tr>
<tr>
<td>Optimized (11 seg)</td>
<td>23 78 48</td>
<td>0 2 8</td>
<td>258</td>
</tr>
<tr>
<td>Optimized (13 seg)</td>
<td>20 73 51</td>
<td>0 1 12</td>
<td>278</td>
</tr>
</tbody>
</table>
Patients Statistics

- Total patients treated: 2160
- Total treatment sessions: 20750
- Average Ports/Trx: 4.16
- Treatment scheme: 10 neutron fxs followed by photons

Patients Treated per Site

- Prostate
- Head & Neck
- Sarcomas
- Lung
- Other < 1% ea.
Phase I Dose Escalating Study of Neutron Radiotherapy for Lung Carcinoma

(A. Turrisi, M.D. – Principal Investigator)

- Objectives - to find maximum tolerated dose of neutron radiotherapy for treatment of lung carcinoma refractory to chemotherapy or chemoradiotherapy and define dose limiting toxicities
- Eligibility – patients with NSCLC (adenocarcinoma, squamous, large cell), SCLC, or carcinoid tumors > 1 cm who failed two chemo- or chemoradiotherapy locally and one salvage chemotherapy regimen for stage III disease
- Schema – dose escalation from 15 to 25 nGy in 10 fx by 2.5 nGy steps (6 patients)
- Acceptance criteria – minimal grade 4 or 5 toxicities (< 2 patients)
- Treatment plan – conformal 3-D or IMNRT including lung heterogeneity correction (modified Power Law method)