Institute for Hadron Therapy
A Multidisciplinary Program

- Physicians treat up to 1500 patients per year
- Specialists work to make hadron therapy more cost effective and accessible
  - Accelerator, mechanical, electrical engineers
  - Accelerator and medical physicists
  - Software and controls specialists
- Radiobiologists study biological effectiveness
- Pharmaceutical specialists develop radiosensitizers
- Isotope specialists track changes in tumors
- Basic scientists have access to research isotopes

A Lennox 11/6/03
Institute for Hadron Therapy
Pre-construction R & D

• **Physics/Engineering**
  – Accelerator Design -
    • 70 MeV, 200µA linac for neutron therapy/isotopes
    • 70 - 300 MeV 10 nA synchrotron for proton therapy
  – Beamline and Transfer Design
  – Remote Collimator Handling
  – Patient Manipulation
  – Shielding for neutron and proton rooms

• **Chemistry/Biology/Physics**
  – Choice of isotopes
    • Basic Research
    • Clinical research and/or sales
  – Production rooms design and shielding
Engineering Challenges

**Protons**
Beam Scanning

**Neutrons**
Remote handling of collimators

**Neutrons and Protons**
Patient Immobilization
Upright Imaging
INSTITUTE FOR HADRON THERAPY

7 MeV Injector from AccSys Technology/Hitachi
# Isotopes Produced by 70 MeV Protons

*Mausner et al - Brookhaven*

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Half-life</th>
<th>Nuclide</th>
<th>Half-life</th>
<th>Nuclide</th>
<th>Half-life</th>
</tr>
</thead>
<tbody>
<tr>
<td>7Be</td>
<td>53.3 d</td>
<td>7Be</td>
<td>53.3 d</td>
<td>7Be</td>
<td>53.3 d</td>
</tr>
<tr>
<td>22Na</td>
<td>2.6 y</td>
<td>22Na</td>
<td>2.6 y</td>
<td>22Na</td>
<td>2.6 y</td>
</tr>
<tr>
<td>28Mg</td>
<td>21 h</td>
<td>28Mg</td>
<td>21 h</td>
<td>28Mg</td>
<td>21 h</td>
</tr>
<tr>
<td>48V</td>
<td>16 d</td>
<td>48V</td>
<td>16 d</td>
<td>48V</td>
<td>16 d</td>
</tr>
<tr>
<td>52Fe</td>
<td>8.3 h</td>
<td>52Fe</td>
<td>8.3 h</td>
<td>52Fe</td>
<td>8.3 h</td>
</tr>
<tr>
<td>55Fe</td>
<td>2.73 y</td>
<td>55Fe</td>
<td>2.73 y</td>
<td>55Fe</td>
<td>2.73 y</td>
</tr>
<tr>
<td>55Co</td>
<td>17.5 h</td>
<td>55Co</td>
<td>17.5 h</td>
<td>55Co</td>
<td>17.5 h</td>
</tr>
<tr>
<td>57Co</td>
<td>271 d</td>
<td>57Co</td>
<td>271 d</td>
<td>57Co</td>
<td>271 d</td>
</tr>
<tr>
<td>61Cu</td>
<td>3.35 h</td>
<td>61Cu</td>
<td>3.35 h</td>
<td>61Cu</td>
<td>3.35 h</td>
</tr>
<tr>
<td>64Cu</td>
<td>12.7 h</td>
<td>64Cu</td>
<td>12.7 h</td>
<td>64Cu</td>
<td>12.7 h</td>
</tr>
<tr>
<td>67Cu</td>
<td>2.58 d</td>
<td>67Cu</td>
<td>2.58 d</td>
<td>67Cu</td>
<td>2.58 d</td>
</tr>
<tr>
<td>68Ge</td>
<td>272 d</td>
<td>68Ge</td>
<td>272 d</td>
<td>68Ge</td>
<td>272 d</td>
</tr>
<tr>
<td>73As</td>
<td>80.3 d</td>
<td>73As</td>
<td>80.3 d</td>
<td>73As</td>
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<td>74As</td>
<td>17.8 d</td>
<td>74As</td>
<td>17.8 d</td>
<td>74As</td>
<td>17.8 d</td>
</tr>
</tbody>
</table>

- **7Be**
  - Half-life: 53.3 days
- **22Na**
  - Half-life: 2.6 years
- **28Mg**
  - Half-life: 21 hours
- **48V**
  - Half-life: 16 days
- **52Fe**
  - Half-life: 8.3 hours
- **55Fe**
  - Half-life: 2.73 years
- **55Co**
  - Half-life: 17.5 hours
- **57Co**
  - Half-life: 271 days
- **61Cu**
  - Half-life: 3.35 hours
- **64Cu**
  - Half-life: 12.7 hours
- **67Cu**
  - Half-life: 2.58 days
- **68Ge**
  - Half-life: 272 days
- **73As**
  - Half-life: 80.3 days
- **74As**
  - Half-life: 17.8 days
## Short-lived Isotopes with Medical Applications

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Application</th>
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</thead>
<tbody>
<tr>
<td>52Fe(8.2hr)</td>
<td>Bone Marrow Scanning</td>
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<tr>
<td>62Zn(9.1hr)</td>
<td>Heart/brain Imaging</td>
</tr>
<tr>
<td>67Ga(78hr)</td>
<td>Tumor Localization</td>
</tr>
<tr>
<td>111In(67.2hr)</td>
<td>Label Leucocytes</td>
</tr>
<tr>
<td>123I(13.3hr)</td>
<td>Thyroid Scan</td>
</tr>
<tr>
<td>201Tl(74hr) Elute from 201Pb</td>
<td>Heart Imaging</td>
</tr>
<tr>
<td>11C(20.5min)</td>
<td>Metabolic Tracer</td>
</tr>
</tbody>
</table>
## Long-lived Isotopes with Medical Applications

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>68Ge(280d) ⊆ 68Ga(68min)</td>
<td>Calibrate PET imagers</td>
</tr>
<tr>
<td>82Sr(25d) ⊆ 82Rb(1.5min)</td>
<td>Heart Imaging</td>
</tr>
<tr>
<td>103Pd(17d)</td>
<td>Prostate Seed Implants</td>
</tr>
<tr>
<td>127Xe(36.4d)</td>
<td>Lung Ventilation</td>
</tr>
</tbody>
</table>
Streaming video:
vmsstreamer1.fnal.gov/VMS_Site_02/Lectures/Colloquium/Lennox/index.htm


Coutrakon, “Proton Synchrotrons for Cancer Therapy,” pp 36 - 42.
