HIGH DOSE RATE SOURCES AND DELIVERY SYSTEMS

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Dose Rate

- Low: Continuous, 2 Gy/h at 1 cm.
- Medium: Continuous, 2Gy - 12Gy/h at 1 cm.
- High: Discrete (weekly), 12Gy - 42Gy/h at 1 cm.
- Pulsed: Discrete (hourly), simulates LDR.
Single Stepping Source

1, 2, 3 - Dwell positions
T1, T2, T3 - Dwell times
HDR RALs
### Specific features of 3 HDR RALs.

<table>
<thead>
<tr>
<th></th>
<th>MicroSelectron V₂</th>
<th>GammaMed+</th>
<th>VariSource 200/200t</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vendor</strong></td>
<td>Nucletron</td>
<td>Varian</td>
<td>Varian</td>
</tr>
<tr>
<td><strong>Sources</strong></td>
<td>10Ci of $^{192}$Ir</td>
<td>10Ci of $^{192}$Ir</td>
<td>10Ci of $^{192}$Ir</td>
</tr>
<tr>
<td><strong>Source Dimension</strong></td>
<td>3.5mm L, 1.1mm OD</td>
<td>4.52mm L, 0.9mm OD</td>
<td>5mm L, 0.59mm OD</td>
</tr>
<tr>
<td><strong>Source Cycle</strong></td>
<td>25,000 transfer</td>
<td>5,000 transfer</td>
<td>5,000 transfer</td>
</tr>
<tr>
<td><strong>Channels</strong></td>
<td>18</td>
<td>2, 3 or 24</td>
<td>20</td>
</tr>
<tr>
<td><strong>Source Extension</strong></td>
<td>1500mm</td>
<td>1300mm</td>
<td>1500mm</td>
</tr>
<tr>
<td><strong>Channel Length</strong></td>
<td>Variable</td>
<td>Fixed</td>
<td>Variable</td>
</tr>
<tr>
<td><strong>Source Movement</strong></td>
<td>Stepping forward</td>
<td>Stepping backward</td>
<td>Stepping backward</td>
</tr>
<tr>
<td><strong>Step sizes</strong></td>
<td>2.5, 5 or 10mm</td>
<td>1-10mm, 1mm steps</td>
<td>2-99mm, 1mm steps</td>
</tr>
<tr>
<td><strong>Dwells/channel</strong></td>
<td>48</td>
<td>60</td>
<td>20</td>
</tr>
</tbody>
</table>
Components of HDR RALs

- Shielded Safe
- Radioactive Source
- Source Drive Mechanism
- Indexer
- Transfer Tubes
- Treatment Control Station
- Treatment Control Panel
- Source cable drive, consisting of:
  1. Source stepper motor
  2. Shaft encoder
  3. Wire-in switch
  4. Emergency stop motor
  5. Cable guide tube

- Check cable drive, consisting of:
  6. Check cable stepper motor
  7. Shaft encoder
  8. Cable guide tube

- Indexer, consisting of:
  9. Indexer stepper motor
  10. Indexer disc
  11. Indexer channel encoder
  12. Treatment tube / adaptor optopair
  13. Locking ring optopair
  14. Channel selection tube
A $^{192}$Ir source of 5 - 10 Ci provides a dose rate of 7Gy/min at 1cm from the source.

- Shielding needed to reduce the air kerma rate to 1-4μGy/h.
- Tungsten or depleted uranium provides the shielding.
HDR source

MicroSelectron High Dose-rate Source
- Source diameter: 0.6 mm
- Iridium Source
- Cable diameter: 1.1 mm

VariSource High Dose-rate Source
- Source diameter: 0.34 mm
- Iridium Source
- Cable diameter: 0.59 mm
Indexer
Treatment Control Station
Treatment Control Panel
Safety Features

- Emergency Switches
- Emergency Crank
- Door Interlock
- Audio/Visual System
- Radiation Monitor/Treatment On Indicator
- Emergency Service Instruments
- Back-up Battery
Emergency Crank
<table>
<thead>
<tr>
<th>Typical situation</th>
<th>Distance [m]</th>
<th>Dose equivalent rates [Sv/h]</th>
<th>Time to receive 10 Sv (Likely injury)</th>
<th>Time to receive 0.05 Sv (Annual body limit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Patient</td>
<td>0.01</td>
<td></td>
<td>1.35 min</td>
<td>0.007 minutes 0.4 seconds</td>
</tr>
<tr>
<td>Handling with Kelly Clamps, to hands</td>
<td>0.1</td>
<td>4.44</td>
<td>2.3 hours</td>
<td>0.67 minutes for hand limit</td>
</tr>
<tr>
<td>Handling with Kelly Clamps, to body</td>
<td>0.3</td>
<td>0.5</td>
<td>20 hours</td>
<td>0.10 hour</td>
</tr>
<tr>
<td>Standing near</td>
<td>1</td>
<td>0.044</td>
<td>9.5 days</td>
<td>1.1 hours</td>
</tr>
<tr>
<td>Standing far</td>
<td>2</td>
<td>0.012</td>
<td>34.7 days</td>
<td>4.5 hours</td>
</tr>
</tbody>
</table>
Shielding

- For a 10Ci source exposure rate is 45mSv/h at 1 meter.

- Limits
  - Public (annual): 1mSv
  - Occupational (annual): 50mSv
  - Dose rate (unrestricted): 0.02mSv/h

- ALARA - 10% of Limits

- Shielding
  - 40 to 50cm concrete (5' from the source)
Quality Assurance

- Verification of Dose Variables
  - Source Strength, Time.
- Verification of Position Control
  - Location, Coincidence, Consistence
- Verification of Proper Operation of Safety Features
  - Interlocks, Detectors, Emergency, Interrupt.
Costs

- Remote Afterloader + Treatment Plan
  + some applicator with transfer tubes
    - $0.5 - 1.0M

- Shielding + Emergency Systems
  - $0.5 - 0.75M
Advantages

- Safety
- Optimization
- Stability
- Dose reduction to normal tissue
- Applicator size
- Out-Patient Treatment
Disadvantages

- Investment ($1M - $2M)
- Complexity
- Compressed Time Frame
- Radiobiology