Boron Neutron Capture Therapy (BNCT)

Boron Neutron Capture Therapy is an experimental radiation therapy that is being developed for the treatment of highly malignant brain tumors. BNCT requires the infusion of B-10 containing chemicals (delivery agents) to the tumors. B-10 concentrate at the cancerous tumor while they clear from the healthy tissues. Then the tumor is exposed to thermal/epithermal neutron beam. B-10 absorb the neutrons, alpha particles and gamma rays are emitted. Substantial kinetic energy is released. Currently, effective B-10 delivery agents are being sought. Research is also being done to obtain desirable epithermal neutrons by using beam filters and to find optimal beam energy for a given tumor depth in the brain.
Boron Neutron Capture Therapy

$^{10}\text{B}(n,\alpha)^7\text{Li}$

B -10 thermal neutron cross section: 3,840 barns

$\alpha$ \hspace{1cm} recoil $^7\text{Li}$

energy: \hspace{1cm} 1,472 keV \hspace{1cm} 840 keV

range in soft tissue: \hspace{1cm} 9 microns \hspace{1cm} 4.8 microns

short ranges

B-10 must be in the cell or on the cell surfaces
tumor/blood and tumor/tissue concentration
epithermal neutron needed for deep-seated tumors
localized in the cell
Boron Neutron Capture Therapy
(Locher 1936)
Beam characteristics of the existing epithermal neutron beam facilities for BNCT in published data based on measurements. The last two columns show the undesired fast neutrons and from the photons.

<table>
<thead>
<tr>
<th>Reactor / location</th>
<th>Reactor power [MW]</th>
<th>Epithermal flux $[\text{cm}^{-2} \times \text{s}^{-1}]$</th>
<th>Neutron current / flux</th>
<th>Fast Neutron Dose / Epitherm Fluence $[\text{Gy}/10^{13} \text{ cm}^{-2}]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>FiR 1 / Finland 1)</td>
<td>0.25</td>
<td>$1.1 \times 10^9$</td>
<td>0.77</td>
<td>2.4</td>
</tr>
<tr>
<td>BMRR/USA 2)</td>
<td>3</td>
<td>$0.84 \times 10^9$</td>
<td>0.80</td>
<td>4.8</td>
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<tr>
<td>MITR/USA 3)</td>
<td>5</td>
<td>$0.2 \times 10^9$</td>
<td>0.55</td>
<td>13</td>
</tr>
<tr>
<td>HFR / Netherlands 4)</td>
<td>45</td>
<td>$0.33 \times 10^9$</td>
<td>0.95</td>
<td>10</td>
</tr>
</tbody>
</table>

1) Values refer to the centre of the 14 cm diam. exit aperture plane for 63 cm thick (measured value) [September 1998]
2) Values refer to the center of the 12 cm diam. exit aperture plane. [Med. Phys. 23, 1996, 1175-1182]
4) HB11/BNCT Epithermal Neuron Beam. Parameters at 1cm from the exit of the [beam parameter, 17/3/94]
Boron Neutron Capture Therapy (BNCT)
BNCT Facilities in the World

USA
MIT
Washington State University/ INEEL
Brookhaven National Lab.
Ohio State University
Rhode Island Atomic Energy Commission
University of Tennessee/ ORNL
UC-McClellan Nuclear Radiation Center
Armed Forces Radiobiological Research Inst.

JAPAN
Musashi Institute of Technology

FINLAND
FiR1

NETHERLANDS
Petten

GERMANY
Petten

SWEDEN
Studsvik

ITALY
Tapiro

AUSTRALIA
MSTA

ARGENTINA
CNEA, RA-6