NUFRA2015, Kemer, Turkey, October 2015

The SHIELD-HIT code for hadron therapy: decomposition in LET of dose fields in tissue and BNCT option

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1. The biological effects of radiation in hadron therapy depends not only on the absorbed dose D. This impact is determined by an equivalent dose H, which essentially depends on the Linear Energy Transfer (LET).

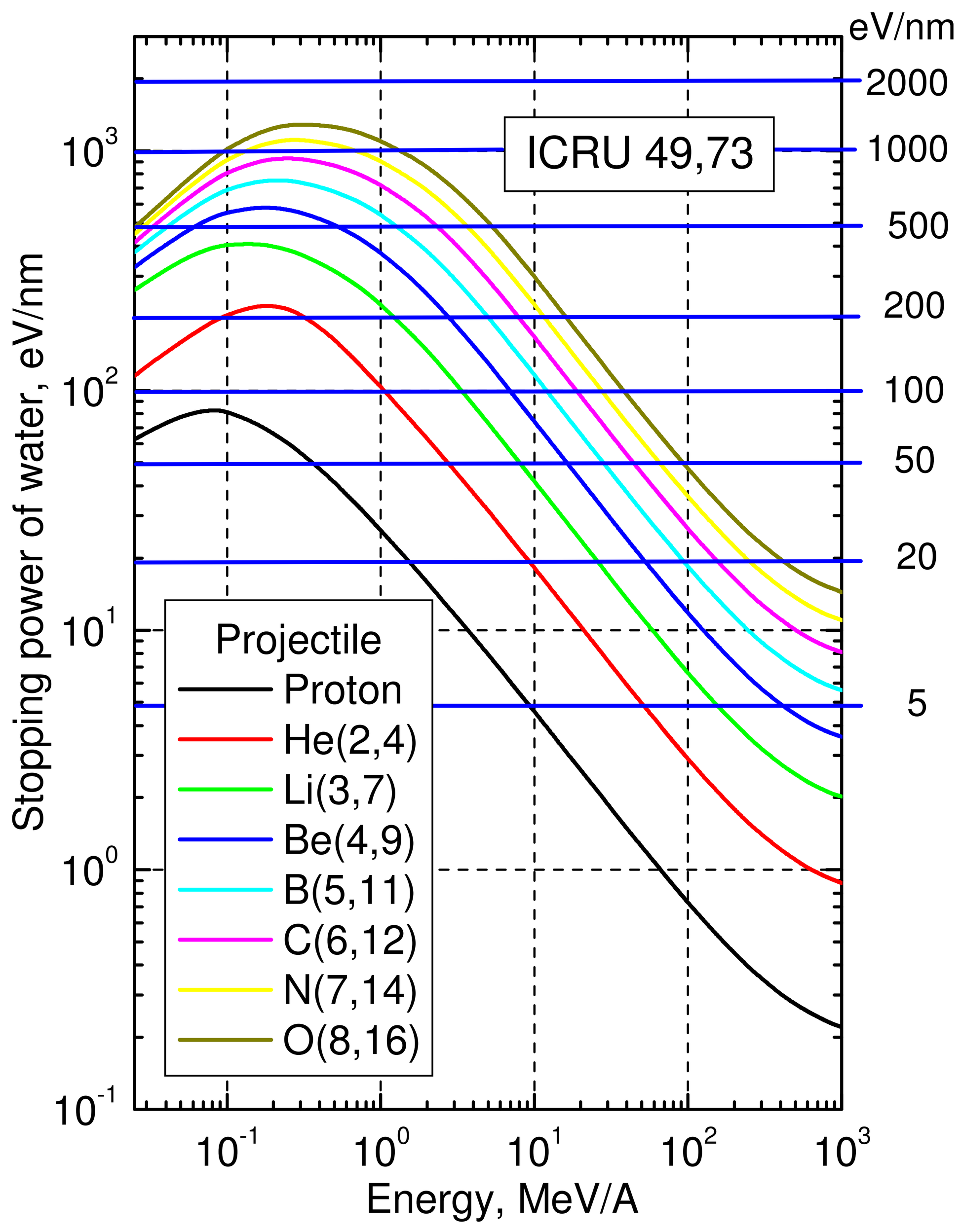
This raises the problem decomposition of the absorbed dose D in the LET, i.e. in which interval of LET the energy deposition occurs in the target.

The relation between doses D and H is:

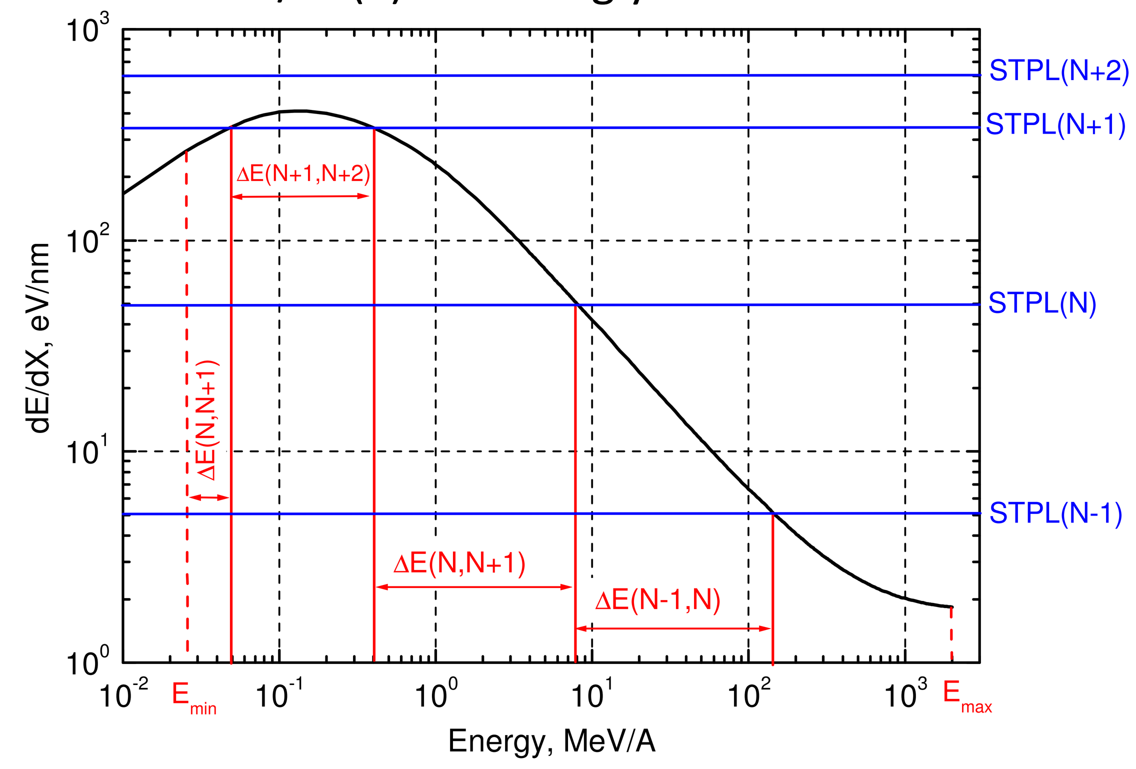
H(Sv)=D(Gy)×K,

where K is the dimensionless quality factor of the radiation (1≤K≤20).

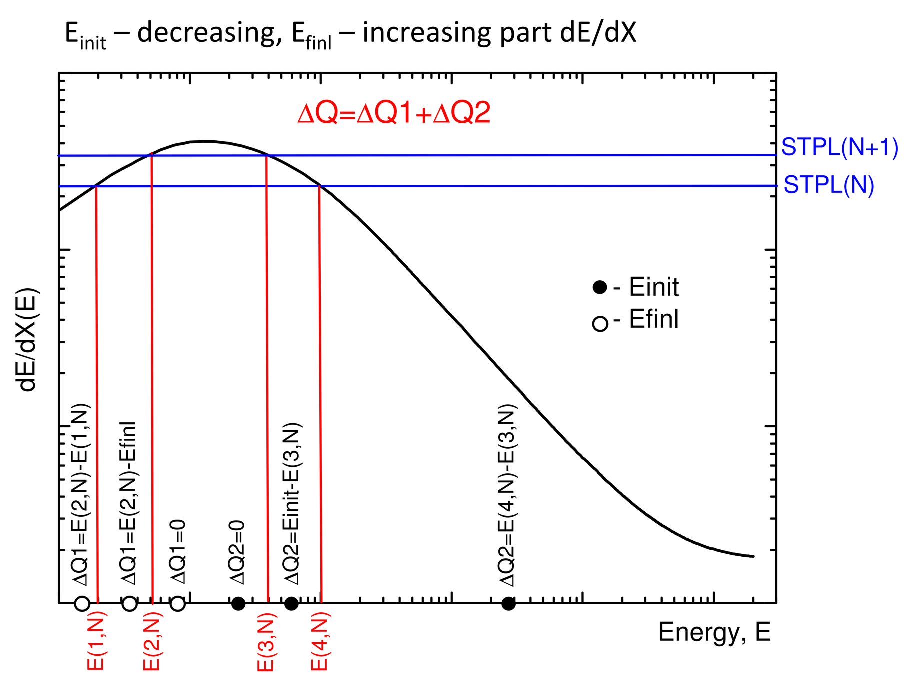
In the context of hadron therapy, the LET is equivalent to the stopping power (STP): LET≡dE/dX. The user of SHIELD–HIT can define intervals of STP on his/her discretion, see figure right for STP of water for various projectiles (1eV/nm=10 MeV/cm).

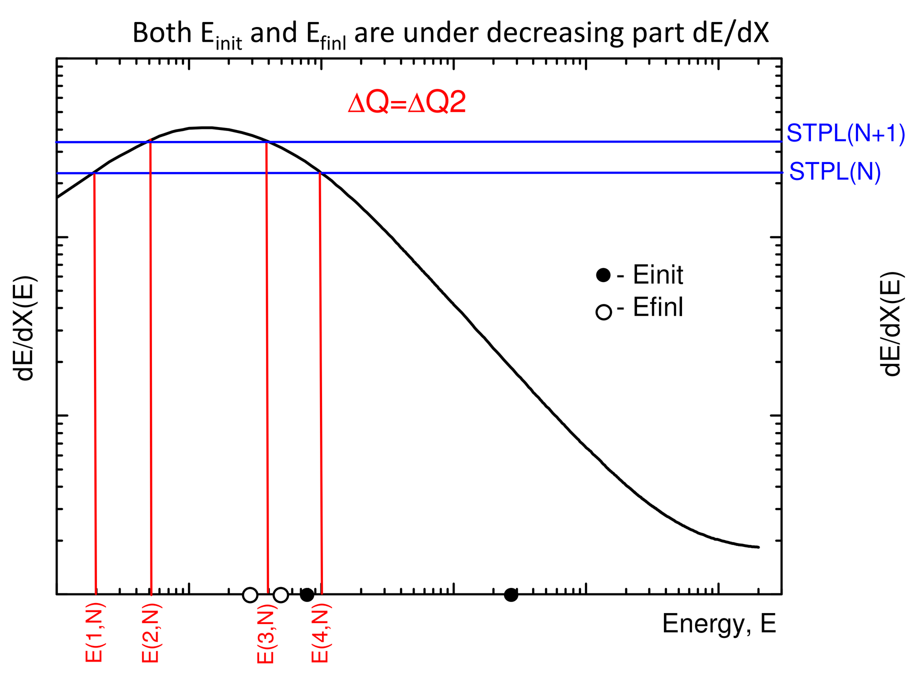


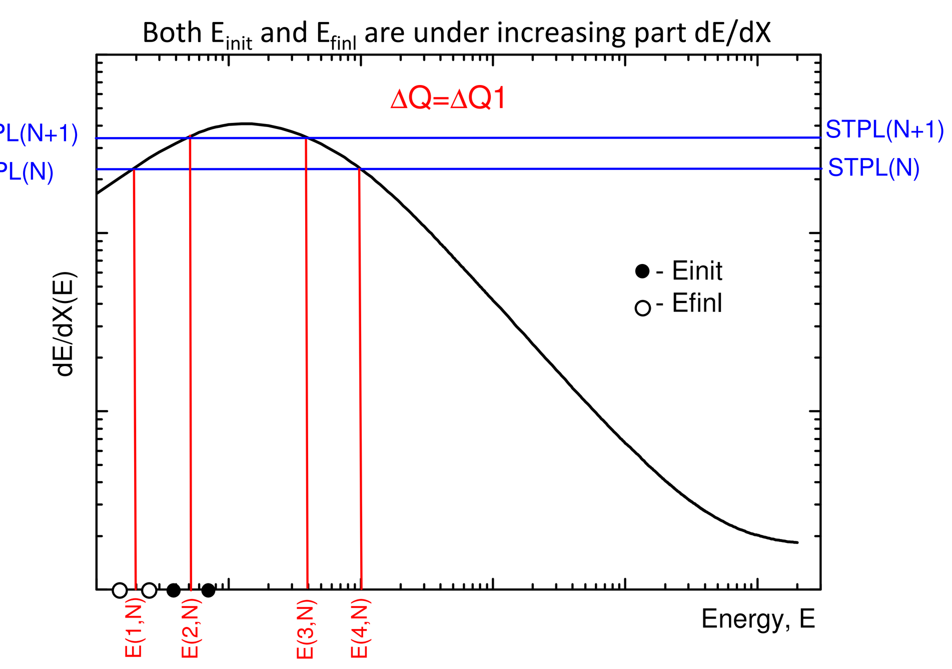
2. The algorithm of decomposition, step 1: find boundaries of the energy intervals ΔE, which correspond to the given intervals of LET, and save values of these boundaries in the array $E(4,N_{STP})$. Boundary intervals [E(1,N),E(2,N)] and [E(3,N),E(4,N)], $N=2,\dots,N_{STP}$, in the array $E(4,N_{STP})$ refers to increasing and decreasing parts of the curve dE/dX(E) accordingly.



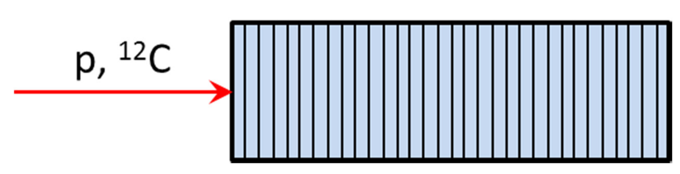
2. The algorithm of decomposition, step 2: energy deposition ΔQ within the LET interval [STPL(N),STPL(N+1)] depends on the boundary energies [E(1,N),E(2,N)], [E(3,N),E(4,N)], and depends on position of initial E_{init} (•) and final E_{finl} (o) energy of a projectile on the energy axis. Denotations of the energy deposition ΔQ1 and ΔQ2 refer to increasing and decreasing parts of the curve dE/dX(E) accordingly.

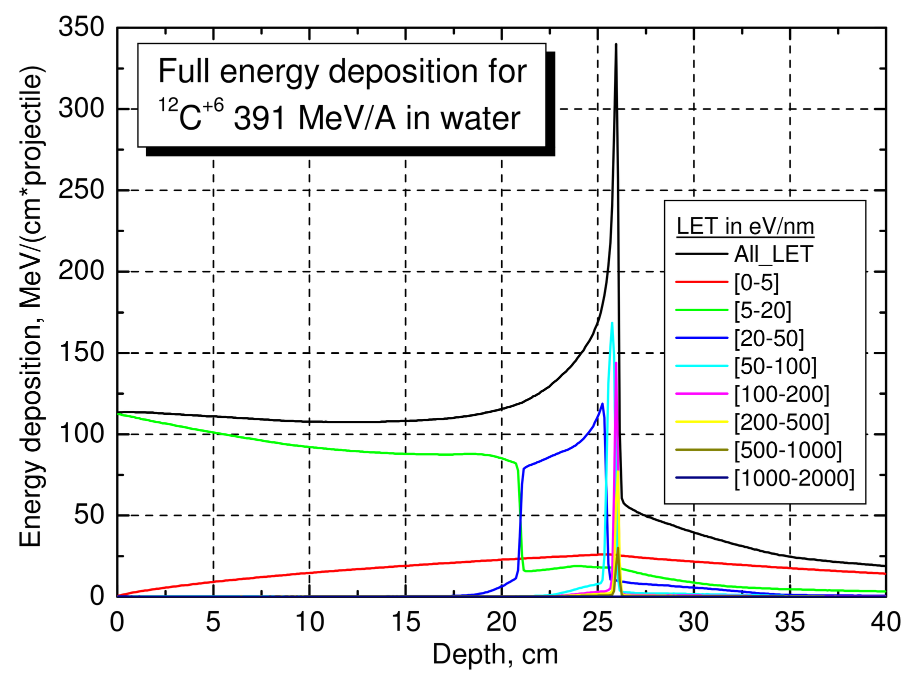


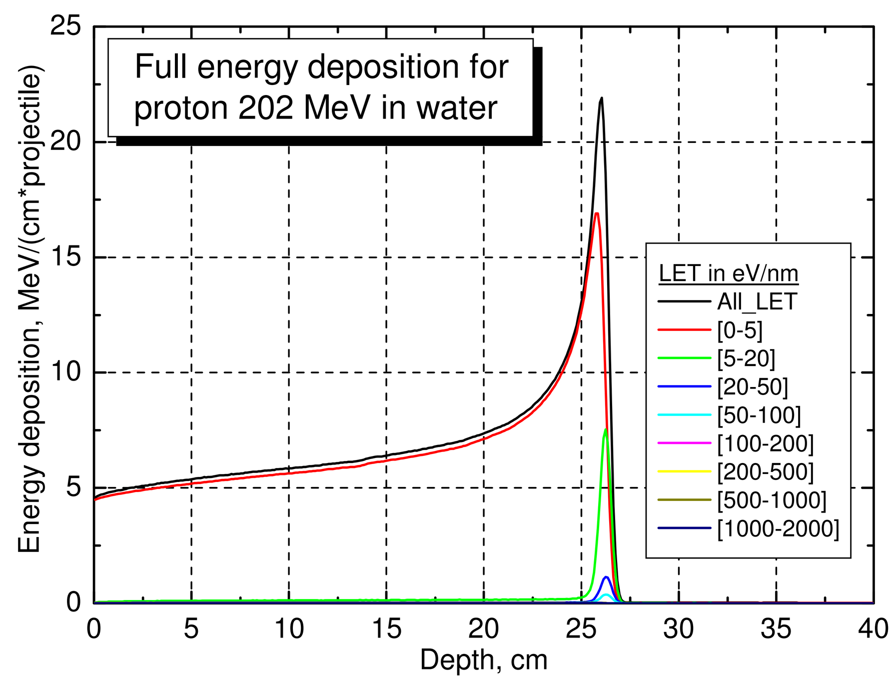


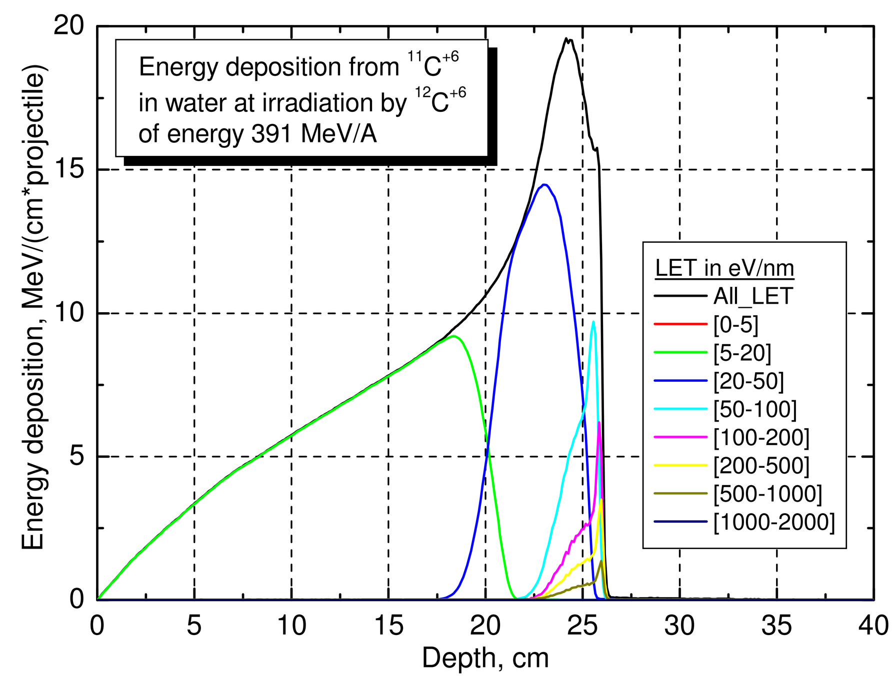


3. Some results of decomposition of the Bragg curve for the cylindrical water phantom of ∅20×40cm in size, sliced by 0.1cm along z-axis, are presented on the figures below for irradiation by protons of energy 202MeV and by $^{12}C^{6+}$-ions of energy 391MeV/A.



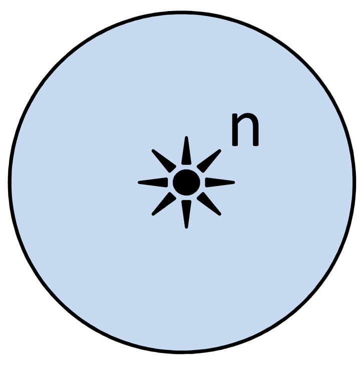


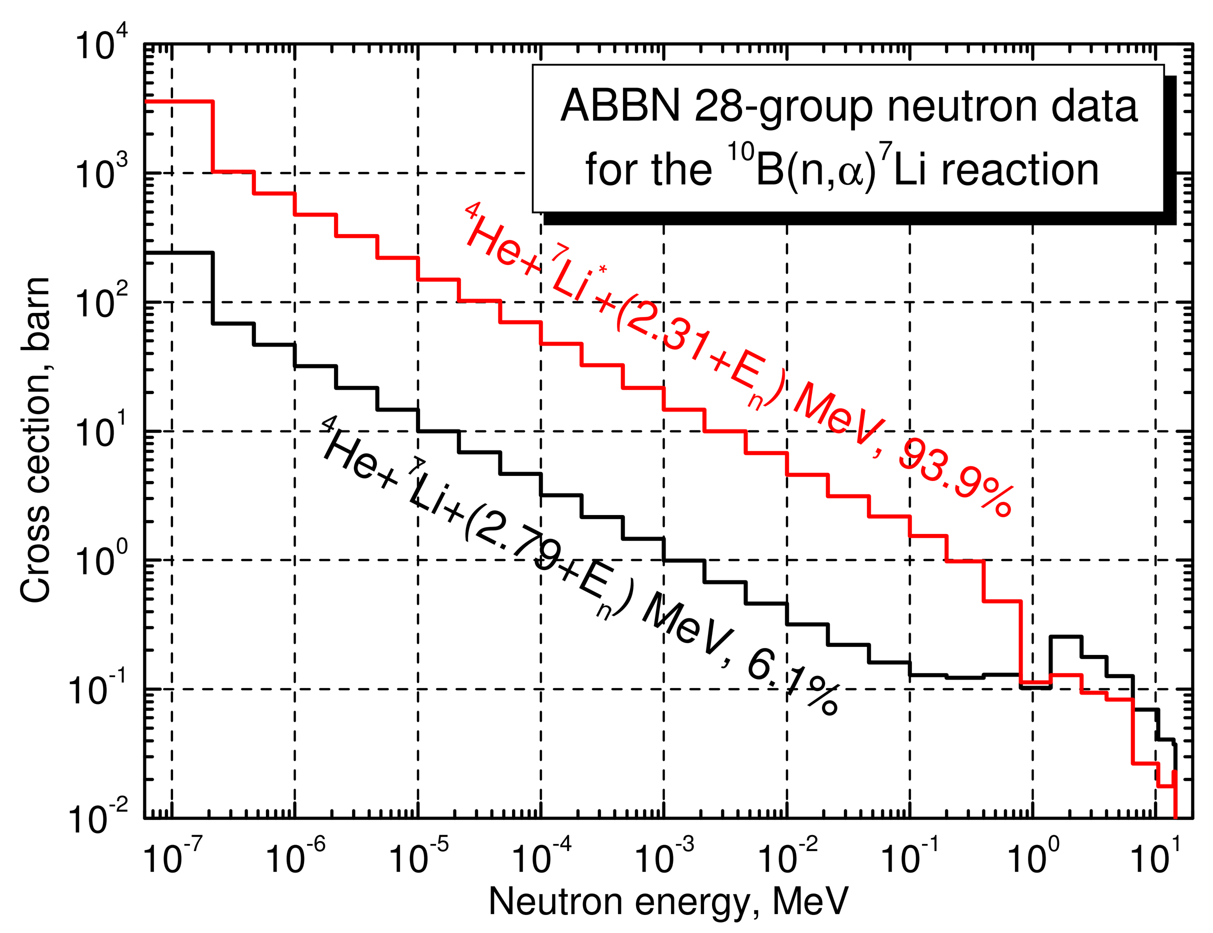




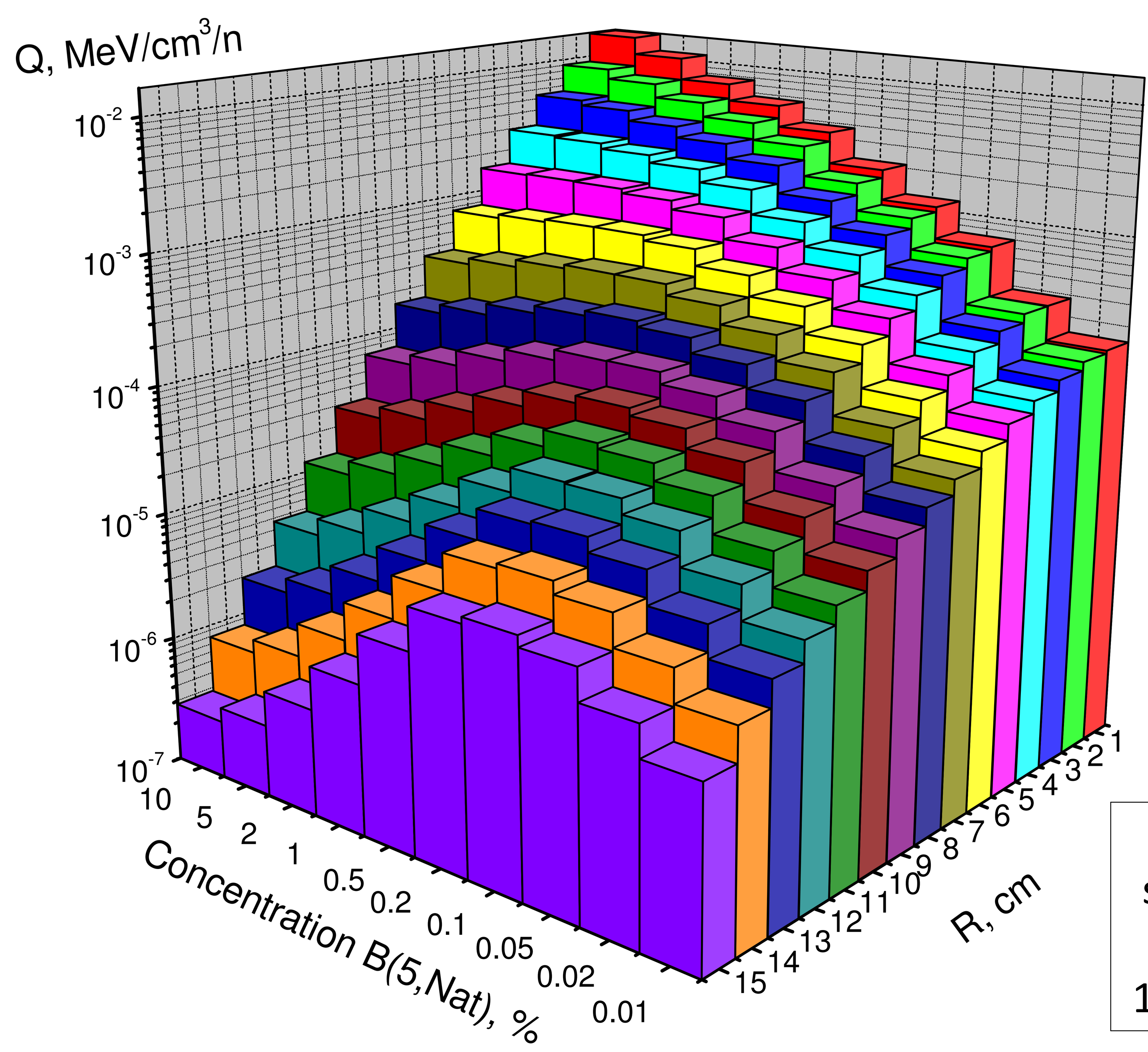
4. **Boron Neutron Capture Therapy** is based on energy release in $^{10}B(n,\alpha)^{7}Li+Q$ reaction

Spherical water phantom, R=15cm





Radial distribution of the energy deposition in spherical water phantom of R=15cm from the monoenergetic neutron source in the center, as a function of B(5,Nat) concentration in water at neutron energy E_n=10 keV



This work is supported by the grant RFBR 15-52-46004 CT_a