NEUTRON THERAPY FACILITY BASED ON HIGH CURRENT PROTON ACCELERATOR KG-2,5

V.N. Kononov, M.V. Bohovko, O.E. Kononov, B.I. Fursov, IPPE, Obninsk, Russia

High current cascade generator KG-2.5 was designed and manufactured by Efremov Institute [1]. It start operation in 1970 and more ten 30 years was used as neutron source for nuclear physics investigations. This accelerator parameters were used less then 10%. In terms of activity directed to create neutronic therapeutic facility based on KG-2.5 were performed accelerator facility upgrade and neutronic-physics simulations of a dose fields for various types of neutron therapy and set of neutron sources. Pictures of KG-2,5 are presented at figure 1.

Figure 1: KG-2.5 accelerator facility.

Nowadays accelerator has ion current 3 mA at a target surface with energy 2.3 MeV. In this operation mode measured neutron yield form reaction ^{7}Li(p,n)^{7}Be is $6.3 \cdot 10^{11}$ neutrons per second. Started work on creation injector with mass-separation which make possible to increase neutron yield by 2.5 times.

To make possible neutron capture therapy beam shaping assembly (BSA) was designed and manufactured. BSA transform neutron spectra from ^{7}Li(p,n)^{7}Be reaction in to epithermal energy neutrons with energy 1-10^4 eV. Mostly appropriate BSA materials and optimal BSA configuration was found as result of simulations [2]. BSA structure are presented at the figure 2. Calculation results were verified by direct neutrons spectra measurements by time-of-flight method. On a figure 3 are presented measurements and calculation results of epithermal neutron spectra created by BSA.

For fast neutron therapy proposed to use neutron source based on ^{7}Li(d,n)2^4He reaction [3]. In this reaction neutrons with energy 1-17 MeV are generated. Neutron spectra measurements for this reaction were performed, results are presented at a figure 4.

Special assembly for shielding and beam shaping was designed. It make possible to form neutron beams with various geometry, including narrow neutron beam, which looks as analog of gamma-knife (figure 5).

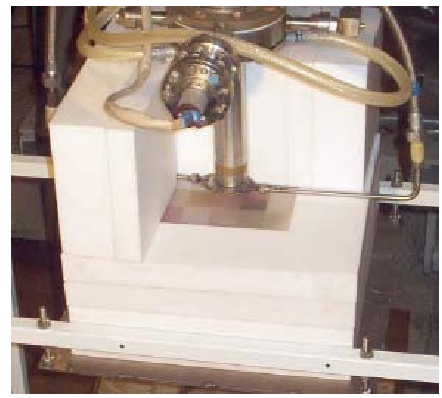

Figure 2: Epithermal neutron beam shaping assembly (disassembled in part).

In lithium target along with caused by deuteron bombarding nuclear reaction results in neutron production with high probability also goes ^{7}Li(d,p)^{8}Li reaction. Produced in this reaction nuclide ^{8}Li has half life-time period 0.84 s and then perform β decay with decay energy ~16 MeV. As a result lithium target irradiated by deuteron beam with current 1 mA became a source of fast electrons with mid-energy ~7 MeV and activity $4.5 \cdot 10^{11}$ Bk.

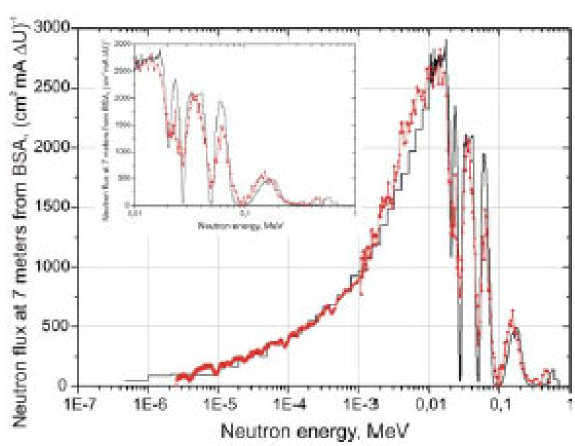

Figure 3: Measurements (dots) and calculation (line) epithermal neutron spectra from BSA

With neutron forming channel 40 cm length and deuteron beam current 1 mA absorbed dose in tissue form reactions with fast neutron will be ~0.5 Gy/min and at the same time ~1 Gy/min from fast electron. So nuclear reaction in lithium target bombarding by deuterons with energy ~2 MeV make possible to perform neutron and electron tissue irradiation at the same time.

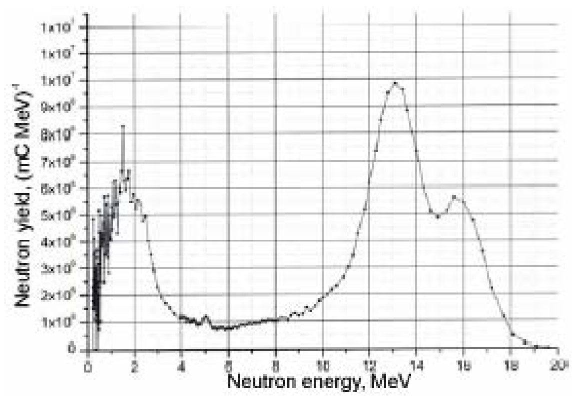

Figure 4: Neutron spectra from $^{7}Li(d,n)2^{4}He$ reaction measured by time of flight method.

Prospective type of fast neutron therapy is a boost method. This method assumed to amplify radiation effect on tissue from a neutron beam by injection in cancer tissue some substances with high neutron capture cross section like ^{10}B and ^{157}Gd. For boost therapy mostly appropriate looks neutron beams with energy 0.1-1 MeV and for such beam producing reaction $^{7}Li(p,n)^{7}Be$ with initial proton energy 2.3-2.5 MeV. A calculation investigation shows that dose in tumor is increased in about 3 times and half dose decrease depth is 4 cm. Created assembly for shielding and beam forming make possible boost method in clinical practice.

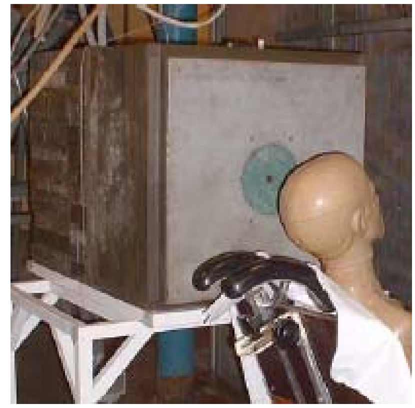

Figure 5: BSA for fast neutron therapy.

Performed investigations shows that created at accelerator KG-2.5 neutron therapeutic facility could be used as prototype of facility to be installed and operated in oncology clinics. Manufacturing set of such facilities will open new possibilities of neutrons usage in clinical practice.

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