

Benchmark Experiments on Neutron Moderator Assembly for Cyclotron-Based Boron Neutron Capture Therapy

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IV. 2. Benchmark Experiments on Neutron Moderator Assembly for Cyclotron-Based Boron Neutron Capture Therapy

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In ref.^{1,2)}, we have proposed a neutron moderator system for a cyclotron-based Boron Neutron Capture Therapy (BNCT). Nevertheless, a cyclotron with a beam power of 50 MeV and 300 μ A is not realized yet. Therefore, to facilitate the realization of a cyclotron-based BNCT neutron field, we started the design of the BNCT assembly employing a commercially available high-intensity cyclotron with a beam power of 30 MeVx750 μ A. The design resulted in very promising feature and engineering design also indicated feasibility of the assembly. However, the validity of the design depends on the adequacy of the simulations by the MCNPX code³⁾ and LA150 data library⁴⁾ which were used in the design calculation and not validated yet.

In order to confirm the adequacy of neutron production and transport by MCNPX, we carried out two experiments; 1) measurement of neutron energy spectra from a tantalum thick target for 30 MeV protons with the TOF method, 2) measurement of the neutron energy spectrum for treatment using multi-moderator spectrometer⁵⁾ with the sand-II unfolding code⁶⁾.

The results for angle-dependent neutron energy spectra for the Ta(p,xn) reaction at 30 MeV (experiment 1) are shown in Fig.1. The present study is to evaluate the adequacy of the calculation of the neutron source. Then, Figure 2 shows the comparison between the calculation and the measurement of the Ta(p,xn) neutron spectra at 90-deg. The data for tungsten is shown for LA150 data because, in LA150 library, the neutron emission data is available only for tungsten and we confirmed the identity of tantalum data and tungsten data experimentally. The sum of the measured spectrum from 1 MeV to 5 MeV which affects directly the required beam current or therapeutic time agree with calculation within 24%.

In Fig. 3, the results of neutron energy spectra for treatment (experiment 2.) are shown in count rate. The calculation result is obtained by folding the response function of multi-moderator spectrometer with neutron energy spectrum behind the moderator calculated by MCNPX. The

result of the neutron energy spectra for treatment is shown in Fig.4. The measured data is in general agreement with the calculation except for the region above 40 keV, where the measurement is lower than the calculation. This is favorable feature because high energy neutrons cause damage to normal tissues. In conclusion, therefore, the feasibility of our proposal assembly is confirmed also from view point of neutronics.

References

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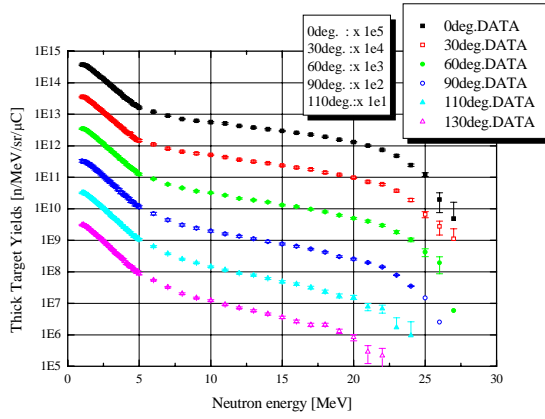


Figure 1. Neutron spectrum Ta(p,xn) [Ep=30 MeV]

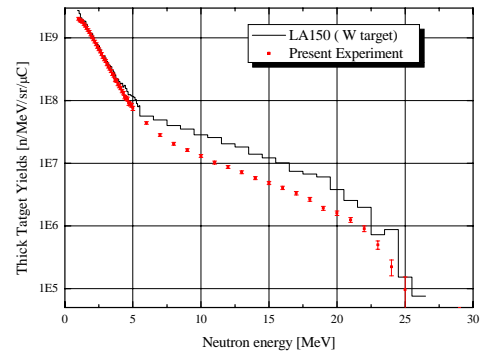


Figure 2. The measurement vs. The calculation [at 90 deg.]

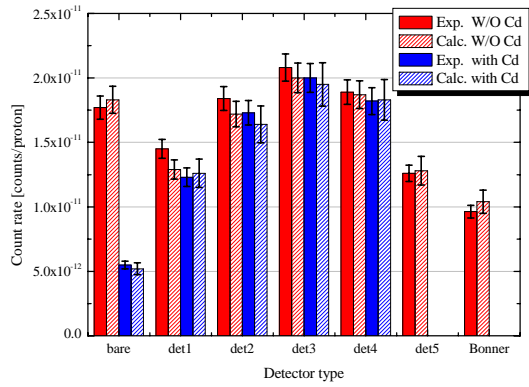


Figure 3. The count rate (The Experiment vs. The Calculation).

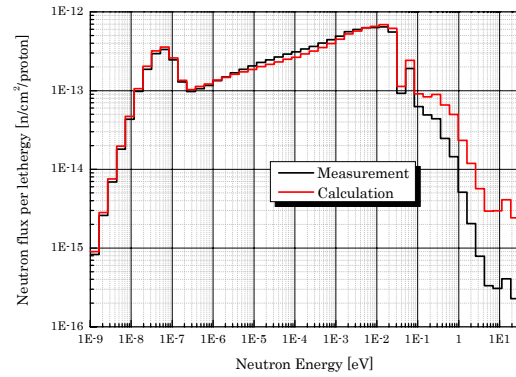


Figure 4. The neutron energy spectra for treatment.