Directional pulsed neutron flux generation for BNCT based on laser ion source technology

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Boron Neutron Capture Therapy (BNCT) using an accelerator-driven neutron source is becoming more practical. BNCT is a cancer treatment method that takes advantage of the fact that thermal neutrons have a very high cross section for boron. A boron-containing pharmaceutical is injected into the patient and the active ingredient is focused on the site of the cancer. There, irradiation with neutron beams of appropriate energy causes alpha and lithium rays to be emitted inside the cancer cells. In fact, basic research on BNCT using reactors had been conducted actively at Brookhaven National Laboratory (BNL). However, after our activities ended more than twenty years ago, excellent drugs were developed and the focus of activities has now shifted to Asian countries. Clinical trials have already been initiated at several hospitals there (but not in the U.S.).

Recently, we are proposing a new system that uses a small accelerator to supply neutrons without generating unwanted radiation. In this system, fully stripped lithium ions are extracted from a high-density lithium plasma generated by laser ablation, accelerated by a small accelerator, and irradiating a hydrogen target to generate neutrons. All other accelerator-driven devices currently in operation or under consideration accelerate proton beams, and require massive shielding, because unwanted neutron radiation is emitted in all directions. However, if lithium is accelerated (instead of used as a target) and intersects with a hydrogen target (instead of used as a proton beam), the generated neutrons will be directed only in the forward direction due to momentum conservation, realizing a clean accelerator-driven neutron source [1]. Though, it has been difficult to supply high-intensity lithium ion beams, and their practical application of BNCT has been considered impossible. The newly proposed technique is achieved by injecting lithium ions contained by a laser ablation plasma into the linear accelerator in a very efficient manner. We have already demonstrated high peak current lithium beam acceleration [2]. The peak beam current of $^{7}Li^{3+}$ reached more than 35 mA, which has never been achieved before.

Since induced neutron beam has good directivity, we can fabricate a neutron converter, beam dump for the primary beam and moderator separately those are usually assembled in one package structure. This feature enables us to suppress unwanted radiation to patients further. A schematic view of the proposed converter is shown at Fig. 1.

We also plan to measure neutron flux using a low current test beam provided by the BNL Tandem Van de Graaff accelerator. Some preliminary results may be reported and discussed.

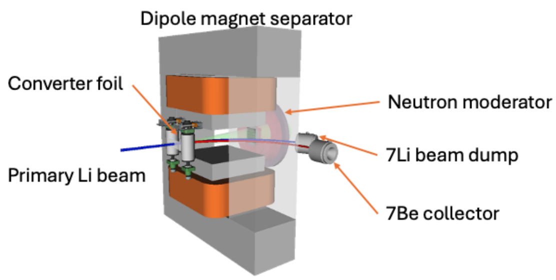

Figure xx

References:
[1] Lebois, M. et al. Development of a kinematically focused neutron source with the p(7Li, n)7Be inverse reaction. Nucl. Instrum. Methods A 735, 145–151.
[2] Okamura, M., Ikeda, S., Kanesue, T. et al. Demonstration of an intense lithium beam for forward-directed pulsed neutron generation. Sci Rep 12, 14016 (2022).