# YOSHIHASHI-1: Development of an Accelerator driven Neutron Source for BNCT at Nagoya University

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An accelerator-driven neutron source by combining a Li target and a DC accelerator has been constructed for developing a patient-friendly BNCT system at Nagoya University. A DC accelerator adopted is a Proton-Dynamitron (IBA). The proton energy can be selected from 1.9 to 2.8 MeV and the maximum beam current is 15 mA. It is well known Li is a suitable and efficient target material to generate low energy neutrons through the $^{7}$Li(p,n)$^{7}$Be reaction and it can reduce activation of the BNCT equipment and then radiation exposure to a patient and medical staff. However, in handling Li target, there are several difficulties due to the following properties; high chemical activities, activative $^{7}$Be production and low melting point. For resolving those issues, we have developed a sealed Li target, in which a thin Li disk on the target base is covered by a Ti foil and irradiated by proton beam through the foil. By the Ti foil, scatter of Li and $^{7}$Be due to the beam irradiation can be prevented and this will keep vacuum surface of beamline and accelerator clean. To remove the high heat flux of the proton beam from the target (>6MW/m$^2$), a highly efficient cooling technique has been developed by inducing a turbulent flow in the water channel with a rib structure [ref] and was proved to be able to remove a heat flux of more than 15MW/m$^2$. By a long time beam irradiation test of the sealed Li target (50 hours at 5.6 MW/m$^2$), we confirmed the soundness of the Ti foil and of the Li metal kept in the target.

In parallel, we developed a beam transport model so that a high current beam can be transported onto the target through the three sets of beam collimators in the beamline. Furthermore, the proton beam is scanned by a set of scanning magnets to expand the beam irradiation area (up to 80 x 80 mm$^2$) on the Li target inn order to obtain more flat beam distribution.

A beam shaping assembly (BSA) is needed to reduce the energy of fast neutrons down to the epi-thermal energy region for BNCT. We designed and manufactured a compact and unique BSA system with a nozzle from the view point of the patient-friendly treatment. Our BSA can satisfy the IAEA's recommended neutron qualities and will be able to mount on a gantry.

A neutron flux of 1 x $10^8$ n/s/cm$^2$ was achieved in a preliminary experiment performed with a proton beam of 1 mA. Now, we are increasing the proton current to start the "In vivo" test.

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