

TANANKA-2: Present status of cyclotron-based epithermal neutron source at Kyoto University

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Institute for Integrated Radiation and Nuclear Science, Kyoto University (KURNS) has conducted joint research and development of a cyclotron-based epithermal neutron source (C-BENS) with Sumitomo Heavy Industries, Ltd. since 2007. After designing C-BENS, at the end of 2008, C-BENS was installed in Innovation Research Laboratory of KURNS. C-BENS consists of a cyclotron that can extract a 30 MeV, 1 mA proton beam, a beam transport system, a moderator that generates an epithermal neutron beam, and an irradiation bed.

We focused on the high neutron generation efficiency obtained by injecting a 30 MeV, 1 mA proton beam into beryllium. In addition, the proton energy is as high as 30 MeV and the range in beryllium target is long, so that the protons penetrating the target are incident on the cooling water. It is possible to overcome blistering due to proton stopping in the target.

When 30 MeV, 1 mA protons are incident on the beryllium target, fast neutrons with several tens MeV are generated. In the C-BENS, the moderator materials such as lead, iron, aluminum, and calcium fluoride were used in order to produce epithermal neutron beam. Lead and iron can slow down fast neutrons. In addition, aluminum and calcium fluoride can moderate neutrons to near 10 keV. A collimator was installed at the exit of the moderator to match the size of the affected area.

It is necessary to conduct clinical trials on patients to obtain approval for manufacturing and sales of BNCT system as medical device. Before conducting clinical trials, the engineering stability of the system and the biological safety and efficacy of the treatment beam are required as non-clinical tests. In order to confirm the above, a test for evaluating the characteristics of the device and a non-clinical test using mice and cells were performed. We investigated what kind of neutrons are extracted from the collimator exit and the dose distribution when the treatment beam was incident on the water phantom assuming a human body.

After characterizing the device, a joint non-clinical trial of a boron drug with STELLA PHARMA CORPORATION was performed. As a clinical trial of Sumitomo Heavy Industries, Ltd. and STELLA PHARMA CORPORATION, the world's first accelerator-based BNCT phase I clinical trial for recurrent malignant glioma was started in 2012. Phase I clinical trial for head and neck cancer was started in 2014. Phase I and II clinical trials for recurrent malignant glioma were conducted in collaboration with Osaka Medical College, and phase I clinical trials for head and neck cancer were conducted in collaboration with Kawasaki Medical School. In 2016, we started a phase II clinical trial for recurrent malignant glioma jointly with the Southern Tohoku BNCT Research Center and the National Cancer Center Japan. From the same year, a phase II clinical trial for head and neck cancer was started at the Southern Tohoku BNCT Research Center. Based on this result, Sumitomo Heavy Industries, Ltd. obtained medical device approval for manufacturing and sales of accelerator based BNCT system on March 11, 2020 for the treatment of locally unresectable recurrent or unresectable advanced head and neck cancer. STELLA PHARMA CORPORATION received approval on March 25, 2020, to manufacture and sell Steboronin®.

In the future, KURNS is planning to develop a cell / small animal irradiation port using C-BENS for the purpose of basic research.