Present Status of Experiments for the Medical Application of Radioactive Nuclear beams at HIMAC

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The position of a short-lived positron emitting nuclei, such as ^{10}C and ^{11}C, can be precisely detected by measuring annihilation gamma-rays. By using the radioactive nuclear beam (RNB) of such nuclei, a particle range and an irradiated area can be observed in the human body. In order to improve the heavy ion cancer therapy, the RNB verification system has been developed at National Institute of Radiological Sciences (NIRS). The RNB has been obtained by the projectile fragmentation method from the relativistic high-energy heavy ion beams from the Heavy Ion Medical Accelerator in Chiba (HIMAC). The RNB system consists of a secondary beam course, a beam irradiation system, a patient's positioning system, and annihilation gamma-rays detectors. We measured the precise range by the positron camera detector and observed 3-D irradiate areas as PET images. Details of the system have been reported[1, 2].

The instrumental accuracy obtained by experiments using the plastic phantom satisfied the requirement. However, the study of the biological and chemical process of the metabolism is important for the medical application. We determined the lifetime of the ^{10}C and ^{11}C injected into different organs of alive and dead rabbits. The lifetime in the alive rabbit has at least three components. These components are due to the very fast blood-stream in the blood vessel, the regional blood flow in the tissue, and unknown products which had the slow diffusion speed. In addition, The lifetimes for brains are faster than the muscle's ones.

The microscopic process around the cell is also interested to study the biological effectiveness. The experiment of ^{9}C and ^{8}B beam is utilized for the research of the multi-hit cell. Because of the incident ^{8}B produces ^{8}Be, and then it emits two alpha particles. The range of these alpha particles in the water is about 10μm and it is equivalent as the size of normal cell. It means the cell is hit by three charged particles at the same time. We obtained the difference between ^{9}C and ^{12}C.

[1] M. Kanazawa et al., Nucl. Phys. A 746, 393c (2004).
[2] Y. Iseki et al., Phys. Med. Biol. 49, 1 (2004).