New application of a cyclotron to ^{211}At production for targeted alpha therapy

M. Fukuda and T. Yorita

A new project for realizing targeted alpha therapy using a relatively short-lived alpha emitter ^{211}At produced by the nuclear reaction ^{209}Bi(α, 2n)^{211}At was started under the framework of cooperation among RCNP, Graduate Schools of Medicine and Science in Osaka University.

Both the annual number of patients diagnosed as any kinds of cancer and the death toll due to any cancer except for stomach and lever cancer are steadily increasing in these thirty years due to increase of senior citizens. In contrast to the increase of cancer patients, a five-year relative survival rate has been gradually enhanced in these twenty years. This tendency might be supported by remarkable development in cancer therapy and diagnostic technology. For that purpose Cooperation among RCNP, Graduate Schools of Medicine and Science at Osaka University started to look for a realistic way of constructing of a particle therapy facility in Osaka and to develop RIs for nuclear medicine research. A collaboration scheme for the joint research on the targeted alpha therapy at Osaka University is shown in Fig. 1.

Beam time for production of this alpha particle emitter ^{211}At is regularly allocated every month at the RCNP cyclotron facility. At present a bismuth target is irradiated with a 1 μA ^{4}He ion beam at an energy of 29 MeV where a cross section of the ^{209}Bi(α, 2n)^{211}At reaction reaches a maximum and contamination of ^{210}At produced by ^{209}Bi(α,3n)^{210}At reaction is greatly reduced. The ^{211}At nuclei are chemically separated and extracted from the target materials, and transferred to a natural product chemistry laboratory to label a molecule transporter with ^{211}At. The labeled molecule transporter delivers ^{211}At to cancer cells. Alpha particles emitted from decayed ^{211}At at 5.9 and 7.5 MeV have an average range of 55 μm in water and deposit a large amount of energy only in cancer cells which is enough to kill the cancer cells completely. The effect of the pinpoint attack and the safety of the targeted alpha therapy treatment will be evaluated rigidly in the unique First-in-Human treatment facility. The cooperative research procedure of the ^{211}At baton pass as shown in Fig. 1 is available only at Osaka University.

In order to promote the fundamental research on the targeted alpha therapy, a new beam line F-course specialized for medical-use RI production was constructed in the M experimental room of the AVF cyclotron building in 2013. This beam line is equipped

with an irradiation chamber specially designed for RI production at the end of the beamline (Figure 2). The total beam time for RI production amounted to 360 hours in 2016, including 252 hours for ^{211}At production at F-course.

The ratio of these RI production beam time hours to the total annual beam time was around 8 %. The goal of this project is supply of 370 MBq/day ^{211}At required for daily treatment of 10 patients. Beam current and irradiation time for the ^{211}At production is estimated to be about 13 particle/μA/hours.

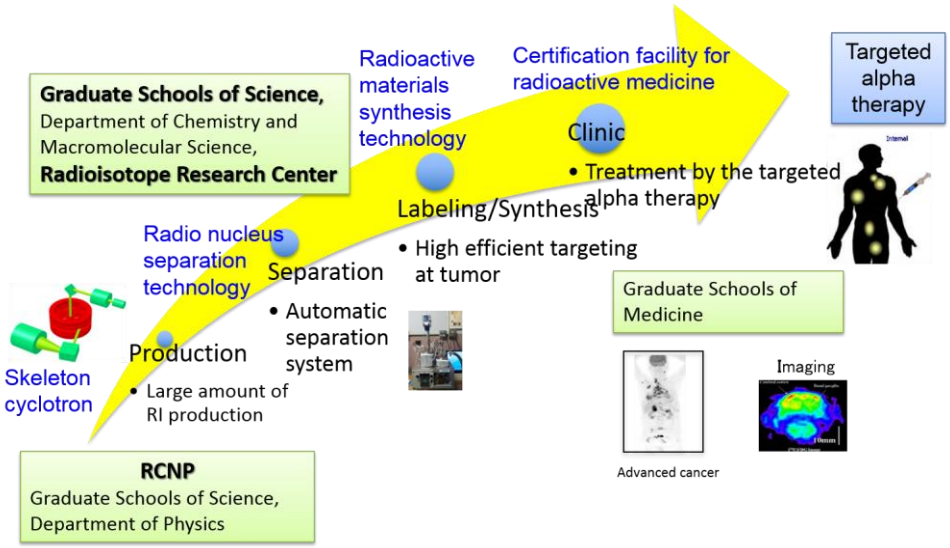

Figure 1: Collaboration scheme for the joint research on the targeted alpha therapy at Osaka University.

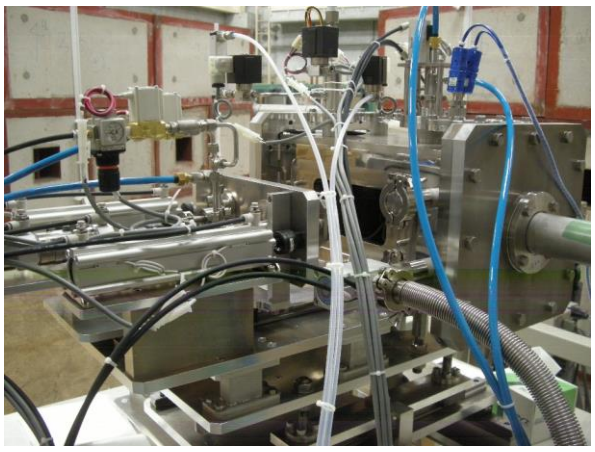

Figure 2: Irradiation chamber for RI production placed at the end of F-course in M-exp. room.