

## II. 2. Recovering Cyclotrons from the Great East Japan Earthquake

*Wakui T.<sup>1</sup>, Shinozuka T.<sup>1</sup>, Shimada K.<sup>1</sup>, Shimbara Y.<sup>1</sup>, Sakemi Y.<sup>1</sup>, Itoh M.<sup>1</sup>,  
Kawamura H.<sup>1</sup>, Inoue T.<sup>1</sup>, Ohmiya Y.<sup>2</sup>, Takahashi N.<sup>2</sup>,  
Takahashi K.<sup>2</sup>, Suzuki J.<sup>2</sup>, and Homma T.<sup>2</sup>*

<sup>1</sup>*Cyclotron and Radioisotope Center, Tohoku University*

<sup>2</sup>*SHI Accelerator Service*

On March 11, 2011, the Great East Japan Earthquake struck the CYRIC<sup>1)</sup>. The accelerator facilities of CYRIC got serious damage. Afterwards, we put all of our effort into recovering the accelerator facilities. After the restoration activity was completed, the joint use of the accelerator facilities was re-started at October 2012. In this report, we describe briefly the damage and restoration activity of two cyclotrons and related equipment.

The shake, which continued for a long time, damaged the 930 cyclotron, the HM12 cyclotron and related equipment. Damage of the 930 cyclotron appeared in the two columns on which the 930 cyclotron is placed, the main coil, the mounting base of the acceleration chamber, the puller electrodes, the dee electrode tip, and the drive component of the deflector. Furthermore, the alignment and horizontal level of all the beam lines was changed; it was necessary to adjust the alignment and level of the beam lines. Fortunately, however, the dee electrodes and earth plates were not damaged. The most serious damage in the above mentioned was the columns. Damage was found not only in the mortar of the column surface but also the internal concrete. This caused a serious tilt of the horizontal plane of the 930 cyclotron.

Damage to the HM12 cyclotron occurred in the lock pins that fix the HM12 cyclotron on the rail, the cooling water pipes, the waveguide of the RF system, the cable bearer, the water supply device for <sup>18</sup>F, and the compensator drive system. In addition, shielding door of the target room in which the HM12 cyclotron is placed was severely damaged. The shielding door blocked the entrance to the target room and made it impossible to bring in machinery and materials required for the repair work.

Before the repair work, we have discussed the master plan for recovery. Figure 1

shows the outline process flow of the repair work. We planned to start by removing the beam lines from the cyclotron room to repair the columns of the 930 cyclotron. In parallel, our priority was to repair the shielding doors, because it was difficult to bring machinery in and out for the repair work. The restoration was started at June 2011, after the implementation of the first supplemental budget was enabled.

The repair work on the 930 cyclotron started after the removal of the beam lines from the cyclotron room. We placed four 200-t jacks and lifted the 930 cyclotron without applying weight to the columns. Then the columns were repaired with grout and fixed to the base plate of the 930 cyclotron with epoxy resin. After that, all the equipment including the acceleration chamber was removed, and the position and horizontal level of the 930 cyclotron were adjusted with the accuracy of 0.2 mm. Then we sequentially conducted the vacuum test, current test of coils, and operation test of the drive component. During the tests, we found some new problems such as water leaks, a malfunction of the cryopump, and so on. After dealing with the problems, we completed the repair work of the 930 cyclotron. On July 3, we succeeded in beam acceleration and extraction for the first time after the earthquake.

Before the repair work on the HM12 cyclotron, the shielding door, which blocked the entrance to the target room, was repaired. The shielding door of 15 t fell onto the floor and its drive component was completely destroyed. Since the load capacity of the crane in the target room is only 2.8 t and there was no way to bring in large machinery through the narrow stairway, it seemed impossible to lift the shielding door. Instead the use of crane, we made full use of chain blocks, jacks, and the beam of the crane in order to lift the shielding door. Then, we exchanged the destroyed drive component and adjusted the position precisely by millimeter increments. During the repair of the shielding door, we conducted the earlier repair work on some damaged parts and the fabrication of replacement parts for the HM12 cyclotron. After the shielding door was repaired, we started the repair work on the HM12 cyclotron. Although some problems were newly found while the repair work, the repair of them was easy, fortunately. On May 2012, the repair work on the HM12 cyclotron was completed, and the beam was supplied for production tests of radiopharmaceuticals for PET.

After the repair work was finished, we finally restarted the joint use of the HM12 cyclotron on October 16, 2012, and of the 930 cyclotron on October 25, 2012. The beam parameters such as the beam current and the beam spot size were almost the same as before the earthquake for both cyclotrons. The reliability which is defined as the ratio of scheduled

beam time divided by number of faults was almost returned for both cyclotrons, though there were some minor troubles for a month after restarting the joint use.

**Reference**

- 1) Wakui T., Itoh M., Shimada K., Yoshida P. H., Shinozuka T., and Sakemi Y., *Tohoku J. Exp. Med.* **233** (2014) 221.

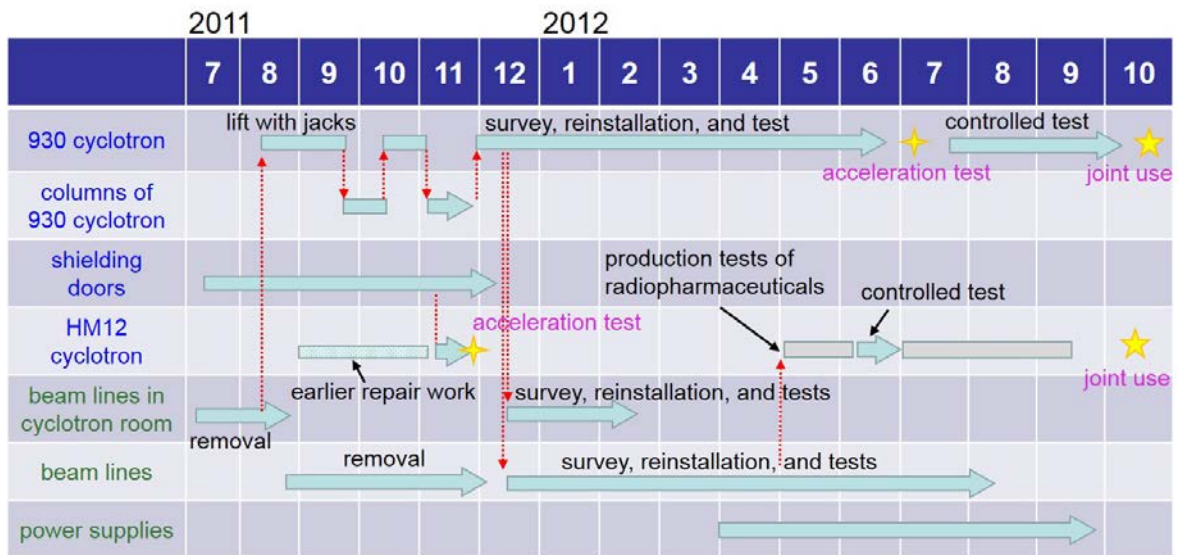


Figure 1. Outline process flow of the repair work.