COMPARISON OF THE RESIDUAL DOSES BEFORE AND AFTER RESUMPTION OF USER OPERATION IN J-PARC RCS

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Abstract

J-PARC Facilities were seriously damaged by the Great East Japan Earthquake in March 2011, but all facilities resumed a beam operation from December 2012. Beam commissioning results indicated that the beam loss and the residual dose at injection area in the RCS were reduced to less than 20% of before the earthquake. This result owed to new collimator at injection area. The losses and residual doses of other area were almost same level as before the earthquake.

INTRODUCTION

User operation of the neutron target by the Rapid Cycling Synchrotron (RCS) in Japan Proton Accelerator Research Complex (J-PARC) was started since May 2008[1][2]. First output beam power is only 4kW, but it was increased thereafter. Finally it reached more than 200kW just before the Great East Japan Earthquake in March 2011. However, the catastrophic earthquake caused many serious damages to all J-PARC facilities. After the earthquake, recovery operation was planned and carried out in a great hurry. This effort enabled a re-commission of all J-PARC facilities in only nine months. We restarted the beam commissioning on December 2011. In this paper, we compare and report the beam loss and residual dose distribution before and after the earthquake.

INFLUENCE OF THE EARTHQUAKE

When the earthquake occurred, the linac beam commissioning was carried out in the J-PARC, but the beam was immediately stopped. Although RCS was near 400m from the coast, the Tsunami of Tokai area is about 5m and the seawall protected JAEA tokai site including J-PARC facilities from the flood.

On the one hand, the RCS accelerator tunnel and the utility building have many deep piles under those floors and endured a strong vibration. Therefore, the damage of the structure itself was only small amount of water leakage from the boundary of the building and tunnel.

On the other hand, the ground around the RCS building subsided because it was newly developed and loose. The transformers for the resonant circuit system of RCS bending and quadrupole magnets, the equipment of the water cooling system and the electric power supply system were put on the subsided ground. Thus those received serious damage[3].

Regarding the accelerator components in the tunnel, there was no damage except the snapping of few cables. RCS vacuum chambers including the ceramic ducts were also no damage. When pumping started, the pressure fell to almost same as before the earthquake. All magnet positions were moved. In the maximum, the magnet horizontally moved to 10mm and longitudinally moved by 5mm[4] .

The simulation result of 300kW output power indicated that an increment of the loss was enough small to accept[5]. For that reason, we decided to give user operation the highest priority, and the re-alignment will be done after the summer of 2013.

BEAM LOSS AND RESIDUAL DOSE AFTER THE EARTHQUAKE

As mentioned above, RCS restarted the beam commissioning on December 2011. To begin with, we set all parameters to the values that were used before the earthquake and checked the distribution of the beam loss around the RCS. Figure 1 shows the integration of the beam loss monitor (BLM) signals at 300 kW output power operations before and after the earthquake.

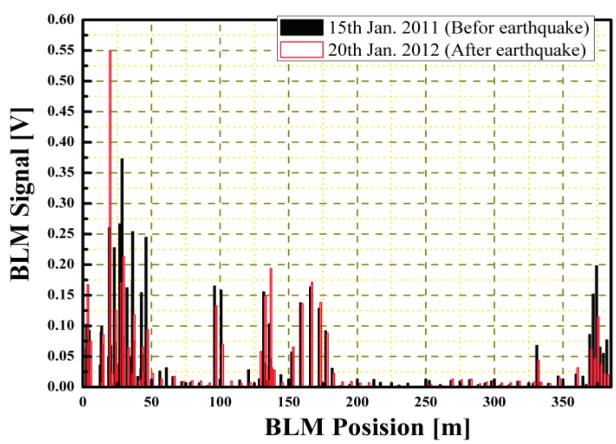

Figure 1: BLM signals at 300 kW output power operations before and after the earthquake.

Black lines show the BLM signals before the earthquake. Red lines show the BLM signals after the earthquake.

The horizontal axis is the BLM position of the longitudinal direction. The origin of this axis means the exit of the first quadrupole magnet in the injection straight section. The circumference of RCS orbit is 348.3m, and the signals more than 350m position represented the BLM signals at the branch lines such as the H0 dump line and

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the beam transport line from the 3GeV RCS to the neutron target(3NBT).

The loss can be seen to concentrate on 20-50m of the graph. These areas are devoted to the collimator. The peak of the vicinity of the dispersion maximum points(100, 330m) and the extraction septum(130-150m) are slightly large. These BLMs are more sensitive for a detailed observation. Thus, residual doses of only several μSv/hr are observed in these areas. The broad peak of about 170m position is due to the reflection of the secondary particles from the dump of the 3NBT line. The dump of 3NBT line is used for only beam commissioning, and this peak disappears when the beam direction is changed from the dump to the neutron target. The signals after 350m are also due to the reflection from the H0 dump, too.

Comparing between the BLM signals before and after the earthquake, the loss monitor signal at 20m became 2 times larger. This was owing to the loss at new collimator that installed in parallel with recovery work, and the loss by the foil scattering can be decreased less than 20% by this new collimator[6][7]. The loss of other area was almost same as before the earthquake.

HISTRY OF THE OUTPUT POWER AND RESIDUAL DOSE

It seemed that there was no loss increment in the RCS. Then the user operation was restarted in January 2012 by 120kW output. It was recovered up to 200kW afterwards. The residual dose distributions in the RCS tunnel after 200kW, 10days operation and 4hr cooling are shown in Figure 2, and the history of the residual dose of typical loss points and output power from RCS are shown in Figure 3.

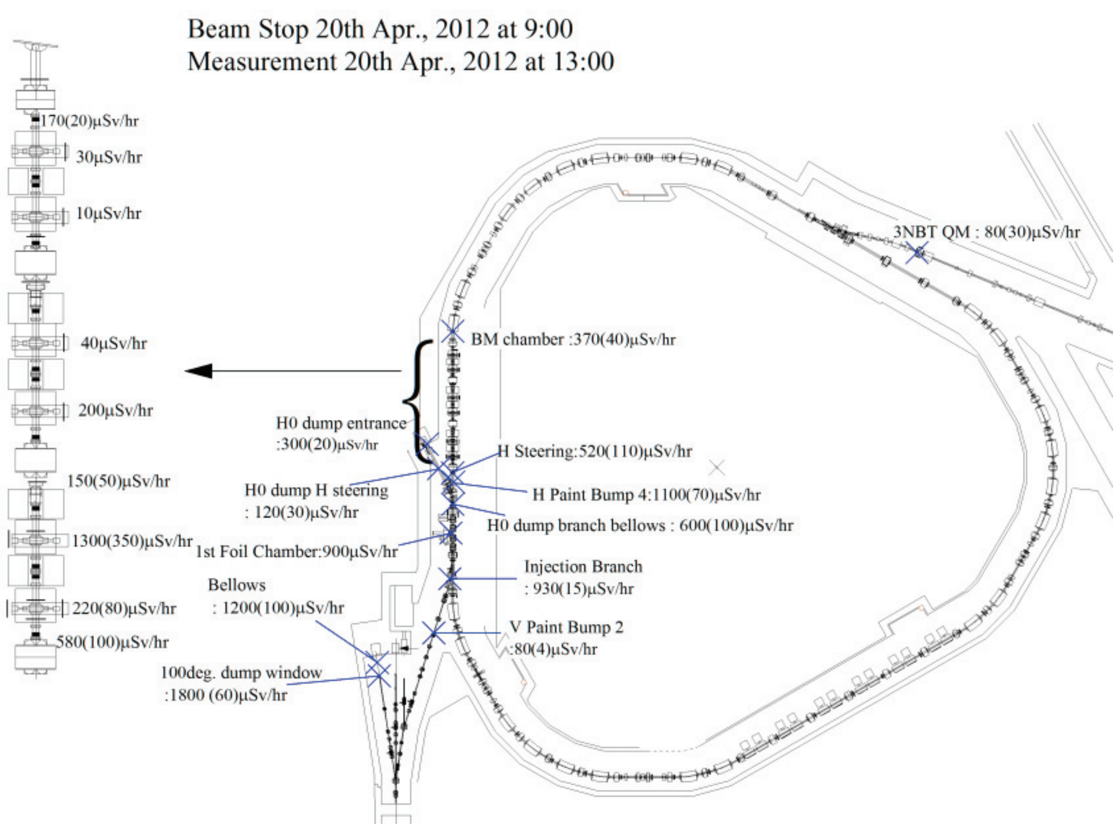

Figure 2: Residual dose distribution with 200kW operation after the earthquake.

A left value means a contact dose rate and a right(bracket) value means a dose at “one-foot”(30cm from surface) position.

In spite of the same output power, the doses of the H0 branch part and the ring collimator were rather decreased less than 20%. These were due to the new collimator and the additional shielding of the ring collimators.

We were not able to understand well the reason of the dose decrease between the injection septum 1 and 2.

CONCLUSION

The great earthquake caused the alignment errors in the RCS magnets, but we could not find a loss increment in the RCS by 200kW output.

We confirmed the performance of new collimator and the additional shielding of ring collimators. These components decreased the doses of the H0 branch part and the ring collimator to less than 20%.

We will keep the beam power more than 200kW till summer shutdown of 2013. We schedule to build up the linac energy from 181MeV to 400MeV in that period, and the re-alignment of RCS will also be executed in same time.

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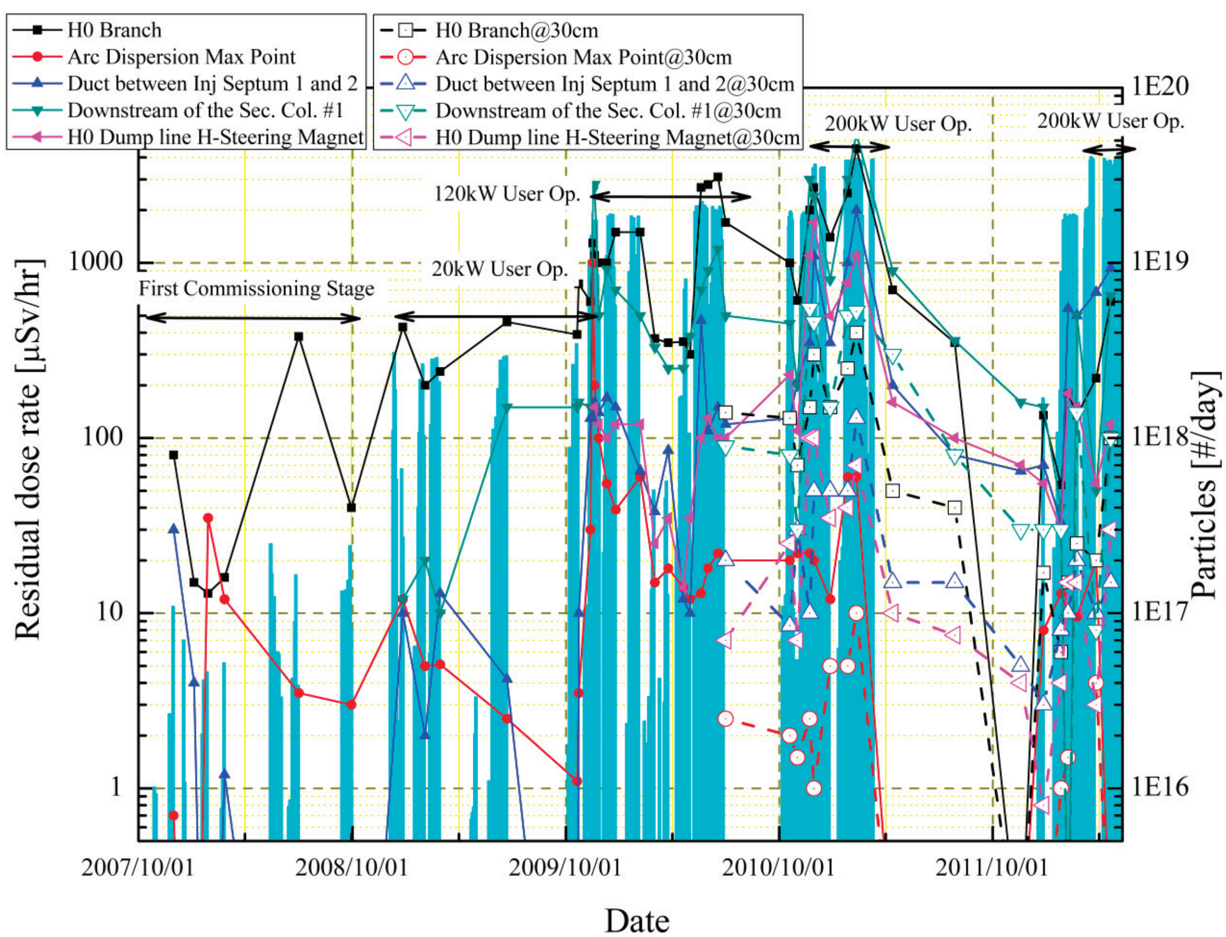

Figure 3: the history of the residual dose of typical loss point and output power of RCS.

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