COLLIMATOR UPGRADE PLAN OF THE J-PARC MAIN RING

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Abstract

A halo collimation system is prepared in the middle of injection-straight section in order to localize the beam loss occurred in main ring. It consists of three collimator units. The first unit scatters halo components, and the other two units work as halo catchers. The permitted amount of beam losses in the collimator section is designed to be 450 W at the present. The upgrade plan of halo collimation system is running in order to achieve about ten times larger beam loss capability for high-power beam operation. The collimator upgrade is planned by installing a new collimator set and radiation shields which cover the collimator section. New collimator units are designed to be able to line-out the jaw with a part of radiation shield including the mechanical devices. The design work of collimator units and radiation shields is presented in this report.

INTRODUCTION

The J-PARC main ring has three straight sections where one is for the beam injection and two are for beam extractions. A halo collimation system is installed after the injection devices as shown in Fig. 1. The halo collimation system consists of one scatterer and two catchers. The acceptable beam power deposited into the collimator units was designed to be 450 W in total. The thickness of concrete walls of accelerator tunnel changes according to the expected radiation level. The J-PARC main ring has three power stations (D1, D2, D3) and three machine stations (M1, M2, M3). For the injection straight, the electrical power is supplied from D1 power station, and the subtunnel to the D1 is located at the end of collimator section. The cooling water is supplied from M1 machine station. As the M1 subtunnel is located at the middle of next arc section, where is 270 meters downstream from D1 subtunnel, main pipes of cooling water go across the entrance floor of D1 subtunnel.

The beam power of J-PARC main ring has achieved more than 100 kW for the neutrino experiments in early 2011, and it is expected to rise beyond 200 kW in a few years. The capacity of the halo collimation system in main ring have to be increased more than 2 kW for the high intensity operation [1].

UPGRADE PLAN

The upgrade plan consists of three components. The first is the introduction of additional radiation shields for thin concrete area. The second is remodeling of cooling water system for the maintenance in high radiation area. The last is the installation of additional collimator units. The acceptable power deposited on a local point is restricted by the radiation level toward the floor direction because the available space for the radiation shielding is limited from the floor to the beam pipe. In order to increase the capacity of halo collection, it is the effective way to multiply the beam loss point.

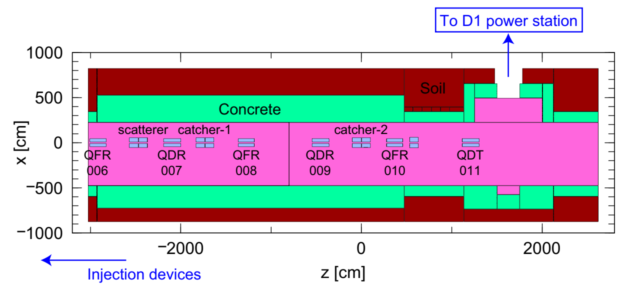

Figure 1: Layout of a part of the injection straight which includes the halo collimation system.

Wall-type Radiation Shield

The radiation level on the outer surface of accelerator tunnel is restricted to be 11 mSv/h by the tritium production rate of ground water. For the introduction of another halo collimation system, some catchers have to be installed in the thin wall area because the collimator section has to be expanded to downstream area. In order to keep the radiation limit on the outer surface of tunnel, additional radiation shields are introduced. Fig. 2 shows the schematic drawing of the wall-type radiation shield. This shield system is composed basing on the gate-type shield in 3-50BT line [2]. Two wall-type shields stand both sides of the collimator units and magnets with the same distance from the beam line. One wall-type shield consists of six pieces of panels which is 500 mm thich, 1360 mm long, and 2090 mm high. The shield panels are made of iron, but they can move smoothly by using LM guides. For the maintenance of involved devices, the shield easily opens and closes at any point. The LM guide rails and shield panels can be added according to the new layout of halo collimation system.

In addition, the absorber which prevent the activation of quadrupole magnets is also upgraded. The absorber is the iron blocks around the beam pipe. Although the present length of absorber along the beam line is one meter, that of the new aborber is set to be two meters long. Two new absorbers will be installed between QFR010 and QDT011 also as shown in Fig. 2. The existing absorber which is one

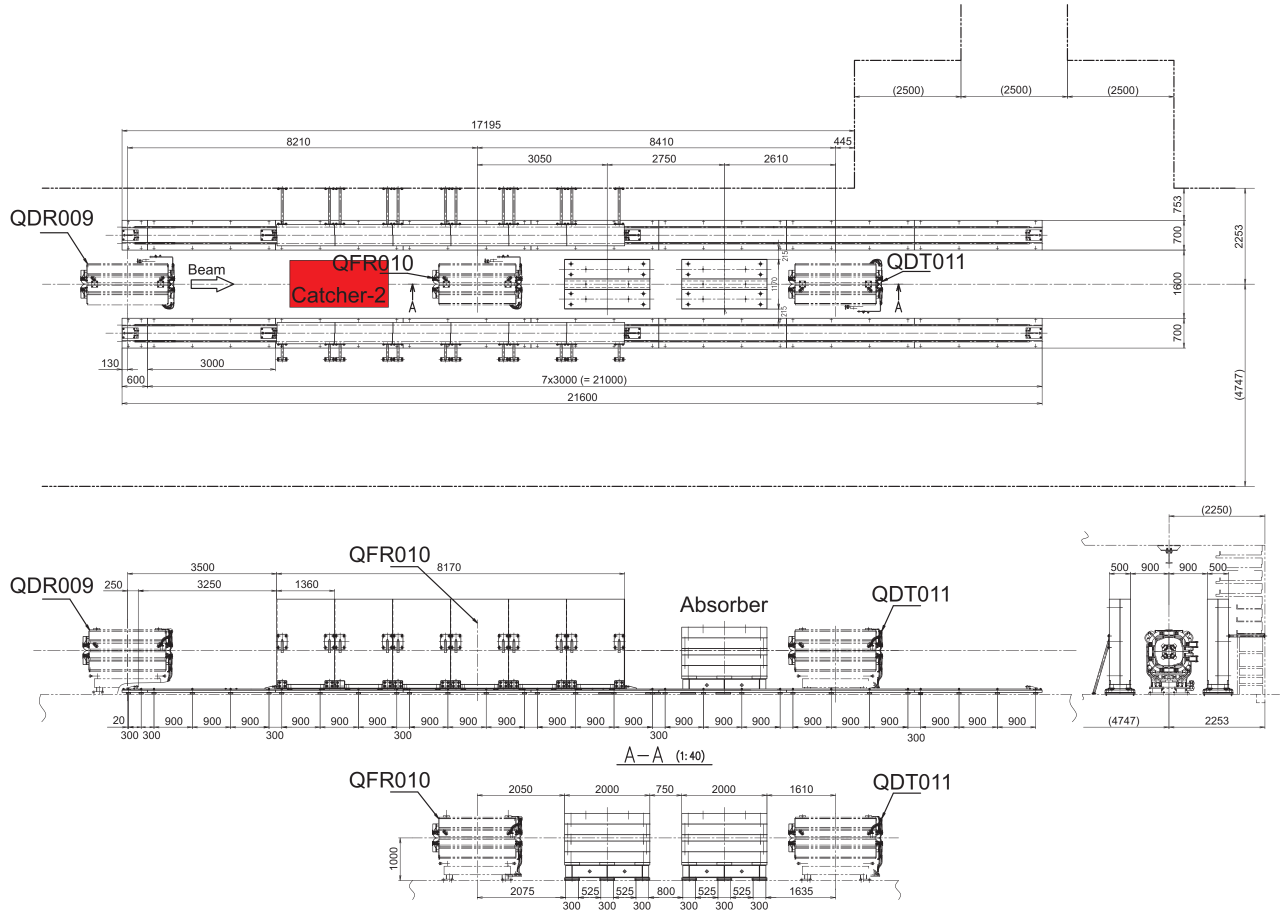

Figure 2: Wall-type radiation shield.

meter long will be recycled after the QDT011.

Remodeling of Cooling Water System

For the flow check, adjustment, and maintenance, the layout of cooling water system is remodeled. According to the increase of radioactive points, the scenario of hands-on maintenace was altered. Though the cooling water was supplied from M1 machine station to all the magnets located in the injection straight at the present, the upstream part of the subtunnel to the D1 power station is moved to the M3 supply chain. It prevents main water pipes from going through the high radioactive area. The crossing pipes were taken away in order to clear the passage of D1 subtunnel. The header tanks which put flow meters, adjustment valves, and flow switches together, are prepared at the upsream points of QFR006 and QDS015 where are the quiet places as shown in Fig. 3. The header tank 1 belongs to the M3, and header tank 2 belongs to the M1. The sizes of newly added main pipes are 100A, 125A, and 150A, and those of header tank 1 and 2 are 100A and 65A, respectively.

The classification of magnets and collimator units are listed in Table 1, where the name started with 'STR' means the steering dipoles. Magnets in the most upstream area are connected to the main pipes directly. The header tank 1 provides the water to the devices upstream part of collimator section. The header tank 2 provides to the devices downtream part of it. Both header tanks have two or three reserved lines for the future requirements.

Table 1: Classification of Cooling Water Tree

Class	Devices
Direct	STR_216, QDX216, Skew-Q1, STR_001, QFS001, STR_002, QDS002, STR_003, QFT003, Inj-bump 1, QFP004, Inj-septum I, Inj-septum II, Inj-bump 2
Header 1	QDT005, STR_005, Injection kicker STR_006, QFR006, STR_007, QDR007, STR_008, QFR008, STR_009, QDR009, STR_010, QFR010, STR_011, QDT011, Collimator unit 1 to 7
Header 2	QFP012, STR_013, QFT013, STR_014, QDS014, STR_015, QFS015, Collimator unit 8 and 9

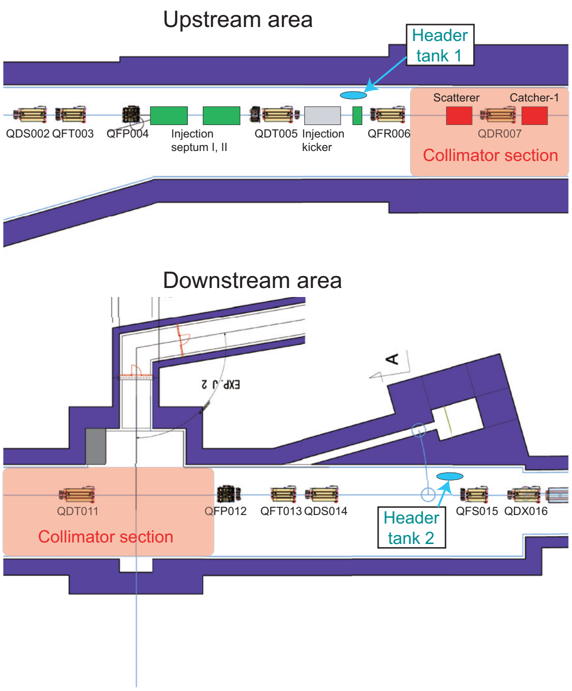

Figure 3: Header tank location.

New Halo Collimator Unit

The requirements for the additional collimator units are as follows:

- Short shapes.
- Top mount mechanism.
- Easy line in-out system.

Fig. 4 shows the schematic design of new collimator unit. In order to shorten the total length of beam pipes, both horizontal and vertical jaws are mounted on one shield unit. The shield block can move ±20 mm four directions, namely, left, right, up, and down. The LM guides on the base block are used to line out the collimator unit itself. From the point of view of the maintenance, all mechanism for the position control of collimator jaws is mounted on the top of the unit.

The additional collimator units will be installed during the long shutdown period in 2012. The layout of new halo collimation system is under consideration in order to optimize the halo collection ratio. According to the result, the absorbers described above will be relocated. Three or six at the maximum additional collimator units are planned to be installed. During long shutdown period in 2011, beam position monitors and steering dipoles before QFR008, QFR010, and QDT011 are relocated to the back of them for the preparation.

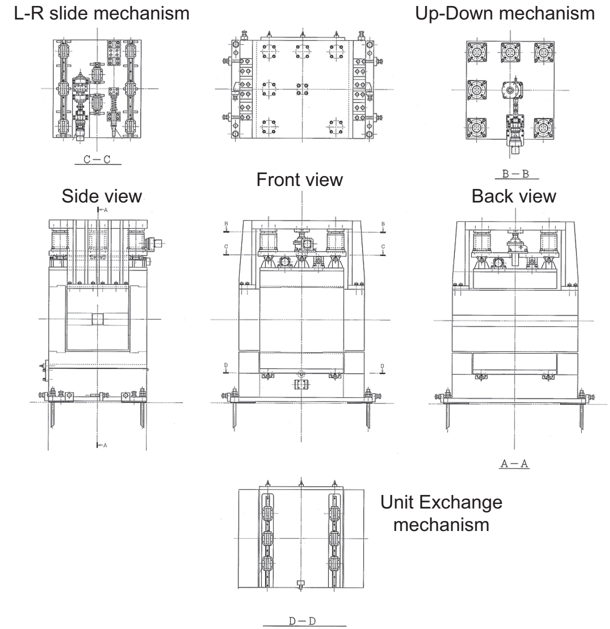

Figure 4: New collimator unit. (preliminary)

SUMMARY

Halo collimation system is planning to be upgraded in order to accept more than 2 kW of beam loss for high intensity operation of main ring. The upgrade plan consists of wall-type radiation shield system, remodeling of water cooling system, and newly designed collimator units. The wall-type radiation shield and remodeling of water cooling system are installed from August to October 2011. The new halo collimation system is going to be installed during a long shutdown period in 2012.

REFERENCES

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