BEAM COLLIMATOR SYSTEM IN THE J-PARC 3-50BT LINE

M. J. Shirakata, T. Oogoe, Y. Takeuchi and M. Yoshioka, KEK, Tsukuba, Japan
H. Oki, KDC Engineering Co., Tokyo, Japan

Abstract

For the J-PARC 50 GeV Main Ring Synchrotron (MR), the injection beam emittance is designed to be 54π mm mrad. On the other hand, the incoming beam from the 3 GeV Rapid Cycling Synchrotron (RCS) may have a large halo component upto 216π mm mrad. In order to absorb the halo component, a beam collimator system is installed in the beam transport line, which is called as the 3-50BT line because it connects the 3 GeV RCS and the 50 GeV MR. From the view of the hands-on maintenance, high endurance structure is adopted. The beam collimator design including the beam optics is reported in this paper.

INTRODUCTION

In J-PARC accelerator complex [1], a beam collimator system which is called as the '3-50BT collimator' is installed in the beam transport line which connects the Rapid Cycling Synchrotron (RCS) and the Main Ring (MR) in order to reduce the beam loss in the MR during the injection period. The beam aperture of the MR is designed to have 81π mm mrad at the maximum and the injection beam emittance is designed to be 54π mm mrad. On the other hand, the incoming beam emittance from the RCS may have a large halo component upto 216π mm mrad. The 3-50BT collimator removes the halo component around the beam core. Schematic view of the collimator section in the 3-50BT line is shown in Fig. 1.

Six drift spaces of 3.3 m long and one drift space of 1.8 m long are prepared for the collimator system among the quadrupole magnets. Six collimator sets and one absorber are installed. The absorber is just a beam pipe surrounded by the iron shields of 500 mm thich at the minimum.

OPTICS IN COLLIMATOR SECTION

Fig. 2 shows the betatron phase advances in the collimator section. The betatron phase increases $2/3\pi$ radian in every two quadrupoles in both planes, alternately. It allows to cut the beam halo off to the right hexagonal shape in horizontal phase space by putting two jaws onto the left and right sides of the beam in every $2/3\pi$ radian phase advance. The number of indispensable jaws is six for this scheme. In actual, the number of jaws is twelve because they are prepared for all drift spaces among the quadrupoles. The additional jaws modify the beam shape in phase space to the deformed dodecagon from the right hexagon. For the vertical phase space, jaws are located onto the up and down sides. The situation is quite similar to the horizontal phase space.

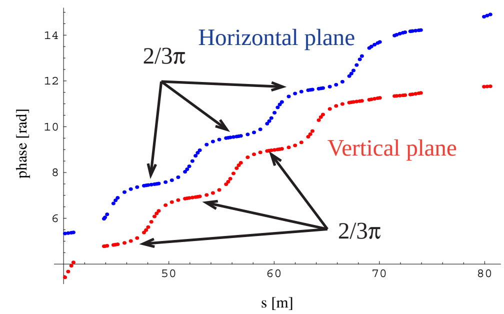

Figure 2: Betatron phase advances in the collimator section.

COLLIMATOR SET

Fig. 3 shows the schematic view of the 3-50BT collimator. A set of collimator consists of one beam duct which has two L-type jaws, and two movable shield units. It was designed to avoid any insersions into the vacuum chambers for the high reliability on the mechanical action.

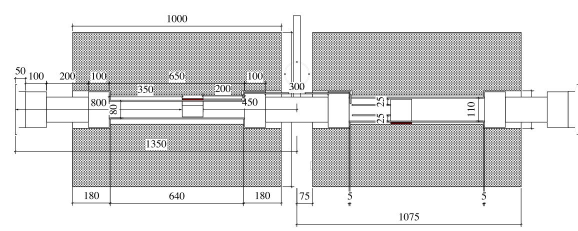

Figure 3: Schematic drawing of the 3-50BT collimator. (1 set)

Collimator Duct

The collimator duct is fabricated as an integrated functional beam pipe with two flanges, two rectangular ducts, three short pipes and six bellows pipes which are made from titanium, avoiding any junctions which require hands-on maintenance. A pair of bellows with a short pipe composes a movable joint. The collimator duct has three movable joints which permit the tranverse motion of rectangular ducts. The rectangular duct has a L-type jaw, which is made from tantalum, on inner surface of it, only left or right and top or bottom. When the upstream duct has jaws on its left and top, the downstream one has jaws on its right and bottom. Fig. 4 shows the cross section view with the beam envelopes at the jaw entrance of the upstream duct after the QFS3. The required dynamic range of the allowed beam emittance is designed to be 54 to 120π mm mrad and

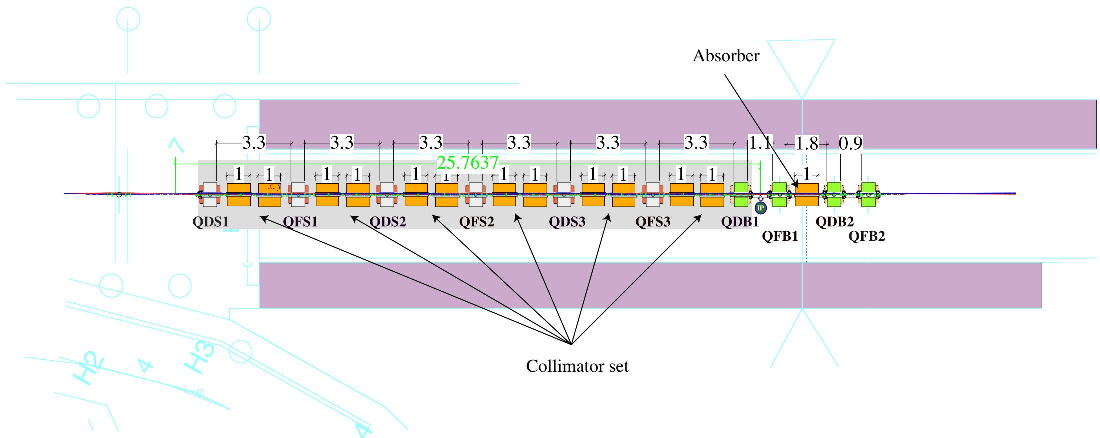

Figure 1: A schematic view of the collimator section in the 3-50BT line.

the amount of the transverse displacement of jaws is limited to ± 10 mm. The thickness of jaws is decided to 20 mm and 25 mm, respectively, in order to satisfy these conditions. The jaw is fixed by using Hot Isostatic Pressing (HIP) method as shown in Fig. 5. It was found that the tantalum is well-suited to the titanium.

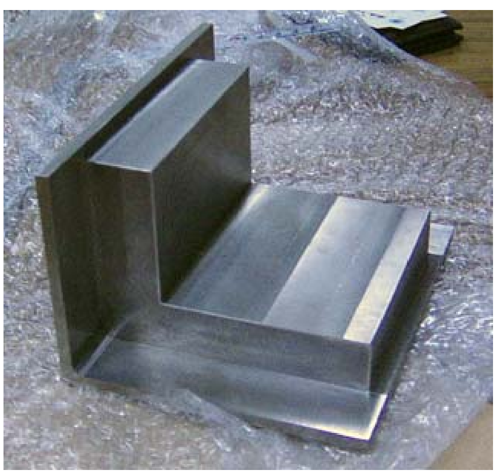

Figure 5: Tantalum blocks are fixed on the titanium plate by HIP method.

Movable Shield Unit

The radiation shield is made of iron blocks. The collimator duct is fixed on the shield block of 760 × 300 × 1000 mm as shown in Fig. 6, and surrounded by other iron blocks to have a shield thickness of 300 mm at the minimum, which are called as core shields. The core shields will never be removed from the duct in future in order to ensure the minimum radiation shield. In addition to the core shields, top, side and bottom shield panels are installed on each shield unit, resulting the weight of the shield unit of about 10 t. The shield unit can move toward both left-right and up-down directions by LM guide and gear jack system as shown in Fig. 7.

Figure 6: Collimator duct is fixed on the shield block.

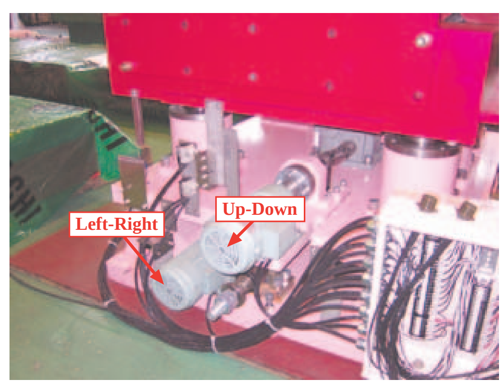

Figure 7: Shield movers for transverse displacement. Typical speed is 0.1 mm/s for each direction.

The collimator duct is installed into a pair of shield units which move independently. The rectangular ducts at the both sides of the movable joint moves toward the transverse directions each other up to the 10 mm at the maximum. The movable joint easily permits this displacement as shown in Fig. 8.

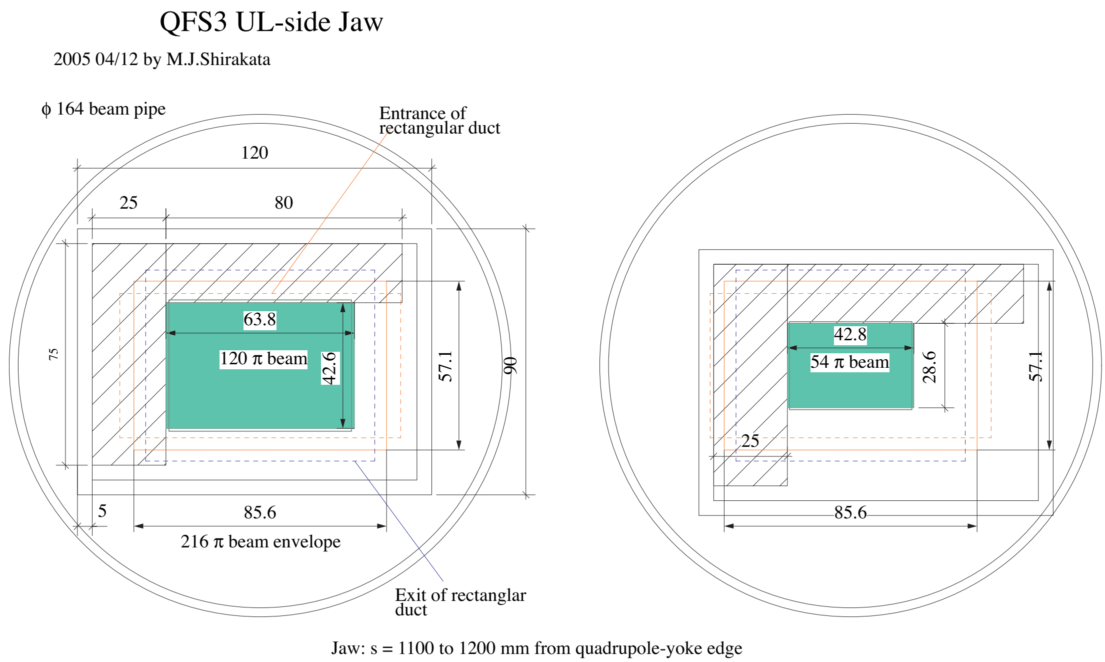

Figure 4: Beam envelope and jaw location. Jaws can be moved to up, down, left and right directions within 10 mm. Beam pipe and rectangular duct are also shown in order to figure out the required thickness of jaws.

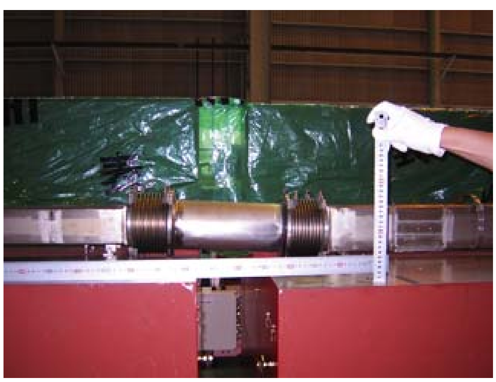

Figure 8: Movable joint transversely dispositioned of 20 mm.

Figure 9: Cooler panel is binded on the collimator duct.

Cooler Panel

The total beam power from the collimated halo component is designed to be 450W in the collimator section. In order to remove the heat deposited to the jaw by the scraped beam, a cooler panel which consists of copper plate and stainless-steel pipe is binded on the duct surface at the jaw position by a stainless-steel belt as shown in Fig. 9. The amount of flowing coolant is about 1 l/min.

SUMMARY

The beam collimator system has been developed for the J-PARC 3-50BT line. It can be summarized as follows:

- A specially integrated beam duct has been developed for high endurance.
- The shield mover works very well.
- The arm action of the collimator duct is very smooth.

The 3-50BT collimator system will be installed in July 2006 into the J-PARC tunnel.

REFERENCES

[1] Acc. Group JAERI/KEK, "ACCELERATOR TECHNICAL DESIGN REPORT FOR J-PARC", KEK Report 2002-13, JAERI-Tech 2003-044, J-PARC 03-01, March 2003