BEAM INJECTION STUDY OF J-PARC MR

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Abstract

At the J-PARC MR(Main Ring), two septa, four kickers and three bump magnets are installed for beam injection. In the first commissioning run, however, a new injection scheme, which does not use the bump magnets, is adopted. The "without bump" scheme is simpler than the normal "with bump" scheme. Although the physical aperture in injection section of the "without bump" scheme is smaller than that of the normal scheme, it is applicable to the commissioning run because the injection beam emittance of ~15 π mm-mrad in the commissioning run is much smaller than the nominal injection beam emittance of 81 π mm-mrad for the full beam power. Compared with the normal scheme, the "without bump" scheme requires kick angle of -10% by decrease for each kickers, bending angles of +0.258% and +8.386% by increase for the first and second septum, respectively.

INTRODUCTION

For commissioning of the 1st stage in May and June 2008[1], beam size would be 1/2.3 as full emittance beam. So a new injection scheme without bumps was studied. This scheme should consider the apertures of all magnets and power limits of septa and kickers. Furthermore, beam optics matching and detailed orbit correction in 3-50 BT were studied.

LAYOUT OF INJECTION SECTION AND CORRESPONDING MAGNETS

The layout of injection section is shown in Fig 1. The length between Bump1(BP01) and Bump3(BP03) is about 22 m. These two bumps are the same type, with core length of 0.2 m, aperture of 135 mm and maximum current of 240 A. Another bump is Bump2(BP02) with core length of 0.5 m, aperture of 165 mm and the maximum Current of 255 A. All the three bumps have rise time of 0.1-0.2 s, flattop of 0.12-0.6 s and fall time of 0.1-0.2 s.

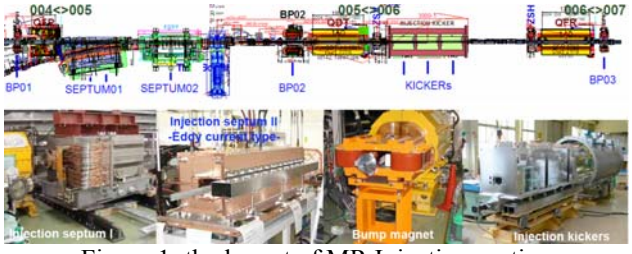

Figure 1: the layout of MR Injection section

The first septum, Septum 1, contains two identical parts, each core length of whom is 0.9 m long. The maximum current of power supply is 2900 A, and rise time of 0.25 s, flattop of 0.2 s. The second septum, Septum 2 is an eddy current type, with core length of 1.5 m long, maximum current of 11 kA.

Three kickers are used for day one operation. All the core lengths of three kickers are 0.75 m long, with the same aperture of 130 mm. And the maximum voltages are all settled at 65 kV.

And there are also three Quadrupoles and two steering magnets in the injection section. Apertures of quadrupoles are: 130 mm for QFP, 142 mm for QDT, and 130 mm for QFR.

THE OPTICS OF 3-50 BT AND MR

The lattice functions of 3-50 BT is shown in Fig 2. There are 5 sections in 3-50 BT. Scraper section, slope section, and three matching sections. And injection matching section has 11 separate quadrupoles which can be used for optics matching.

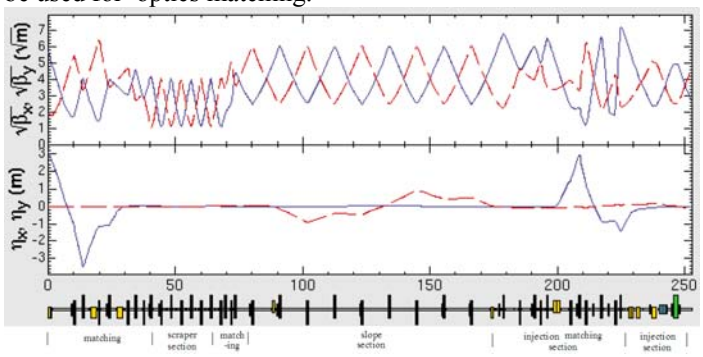

Figure 2: the lattice functions of 3-50 BT (including injection section)

For MR, three straight lines and three 120° arcs are contained. A super-period lattice of MR is shown in Fig 3. In injection straight line, beam injection, beam dump, and beam collimation are available.

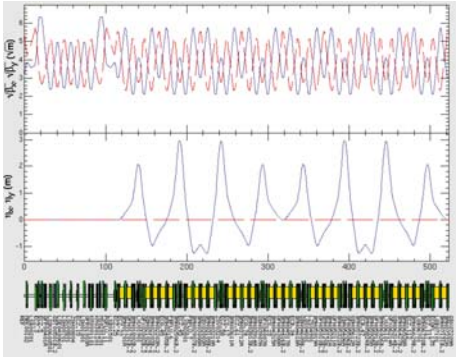

Figure 3: MR Lattice of a superperiod

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INJECTION SCHEMES WITH AND WITHOUT BUMPS

Injection orbits

The injection orbits of "with bump" scheme [2] and "without bump" scheme are shown in Fig 4. The strengths of dipole magnets are given in Table 1. Compared with "with bump" scheme, the "without bump" scheme requires kick angle of -10% by decrease for each kickers, bending angles of +0.258% and +8.386% by increase for the first and second septum, respectively.

According to MR coordinate, the injection beam at the entrance of Septum1 is 0.5115 m from the injection straight line with an angle -271.9 mrad. At BPM 5 and BPM 6 which can be seen in Fig 4, the beam X positions of "with bump" scheme are 4.3 mm and -5.0 mm in design compared with 16.5 mm and 0.0 mm of "without bump" scheme.

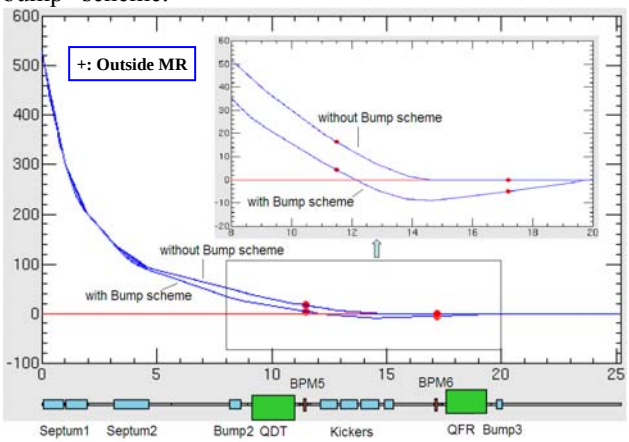

Figure 4: two orbits of "with bump" and "without bump" scheme

Table 1: Strengths of dipole magnets in two schemes

	"with bumps"		"without bump"	
	Hardware Setting	Angle (mrad)	Hardware Setting	Angle (mrad)
Septum 1	2864 A (main)	-223.5	2872 A	-224.08
	4.25 A(over-shot)		4.30 A(over-shot)	
Septum 2	9020 A	-36.04	9710 A	-39.07
Kicker 01	58.7 kV	-2.05	52.8 kV	-1.85
Kicker 02	58.7 kV	-2.05	52.8 kV	-1.85
Kicker 03	63.3 kV	-4.48	57 kV	-4.03
Bump1	101.3 A	2.48	0.0 A	0
Bump2	141.8 A	-6.39	0.0 A	0
Bump3	86.4 A	2.08	0.0 A	0

Injection optics of normal scheme

The last eight quadrupoles in injection matching section are used to do matching. The optics is shown in Fig 5. The maximum βx and βy are 52.8 m and 40.0 m with ηx of 2.9 m. Considering orbit distortions less than ±1 mm and momentum spread less than 0.63 %, the physical apertures are: 134.8 and 177.3 π mm-mrad for entrance and exit of Septum1, 317.8 and 95.5 π mm-mrad for Septum2, 325.8 and 468.0 π mm-mrad for Bump2, 355.5 and 672.0 π mm-mrad for QDT, 551.8 and 394.7 π mm-mrad for the kickers, 192.9 and 171.6 π mm-mrad for QFR, 182.6 and 188.3 π mm-mrad for Bump3.

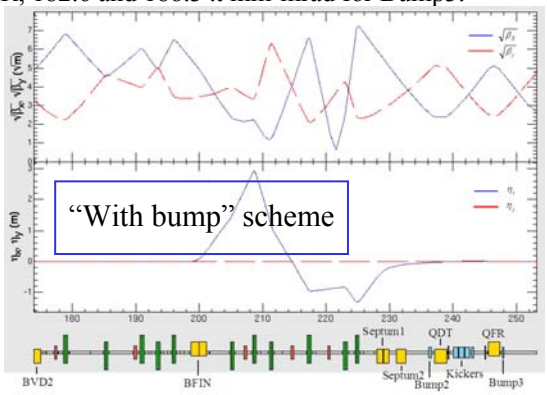

Figure 5: Optics of "with bump" scheme between BVD2 and Bump3

Injection optics of "without bumps" scheme

The optics is shown in Fig 6. The difference of β function in two schemes is less than 0.1 %. The maximum βx and βy are 52.7 m and 39.8 m with ηx of 2.9 m. Considering orbit distortions less than ±1 mm and momentum spread less than 0.63 %, the physical apertures are: 134.8 and 178.0 π mm-mrad for entrance and exit of Septum1, 328.0 and 118.5 π mm-mrad for Septum 2, 137.1 and 219.6 π mm-mrad for Bump 2, 148.5 and 435.2 π mm-mrad for QDT, 368.2 and 303.4 π mm-mrad for the kickers, 167.9 and 167.9 π mm-mrad for QFR, 182.0 and 188.8 π mm-mrad for Bump3.

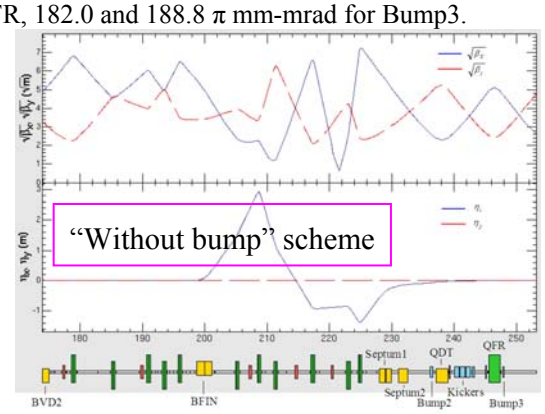

Figure 6: Optics of "without bump" scheme between BVD2 and Bump3

DETAILED ORBIT CORRECTION IN 3-50 BT BY STEERING MAGNETS

Beam orbit distortion in 3-50 BT with real misalignment is shown in Fig 7. Δx and Δy of orbit distortion are less than 0.6 mm.

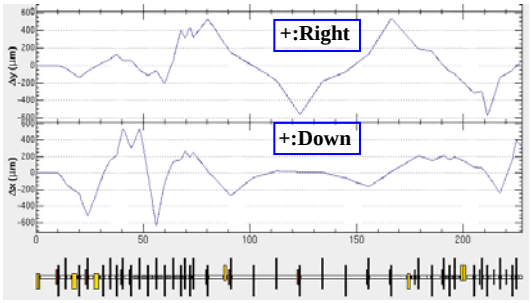

Figure 7: Beam orbit distortion in 3-50 BT according to magnets' misalignments

There are 14 BPMs in 3-50 BT, meanwhile 14 steering magnets, 7 in vertical and 7 in horizontal. Fig 8 shows a correcting result according to measured orbit distortion during commissioning by steerings using SAD.

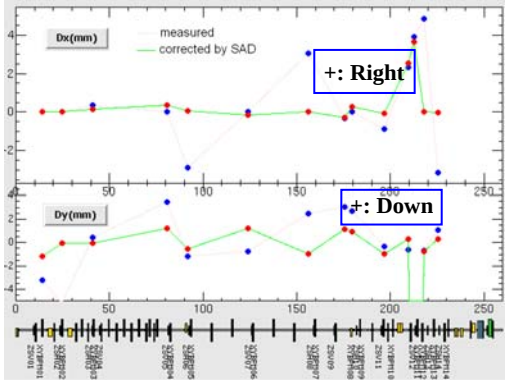

Figure 8: One correcting result during commissioning

COMMISSIONING RESULT

May 19-24 and June 14-21 2008 were the days for the commissioning day-one of MR, good achievements were attained. A measured injection orbit was shown in Fig 9. The measured values from 5th BPM and 6th BPM were 17.8 mm and 0.25 mm compared with design values 16.5 mm and 0 mm. The commissioning setting values of septum1, septum2 and kickers 1-3 were 2827 A, 9704 A, 46 kV, 46 kV, and 51 kV compared with design values 2872 A, 9710 A, 52.8 kV, 52.8 kV and 57 kV.

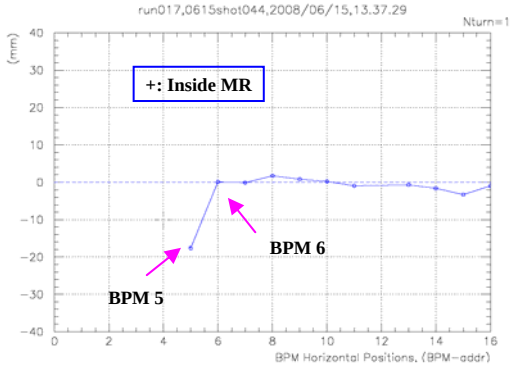

Figure 9: Injection orbit during commissioning day-one

The measured beam sizes at three MWPMs in the 3-50 BT are shown in Fig 10 [3]. Measured results were almost coincided with design values. And also 3-50 BT orbit corrections were tried to do. One result was shown in Fig 11. For each steering magnets has uniopolar power supply not bipolar and commissioning time was tight, only part of orbit was corrected.

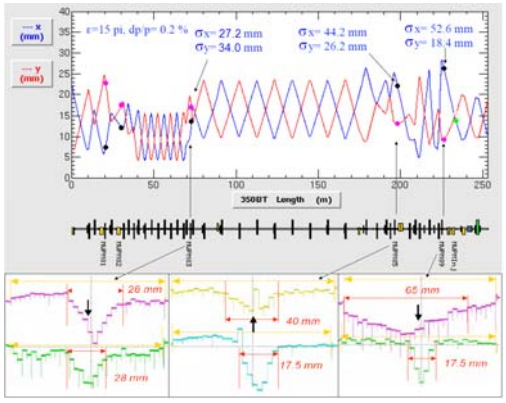

Figure 10: Measured beam sizes during commissioning day one

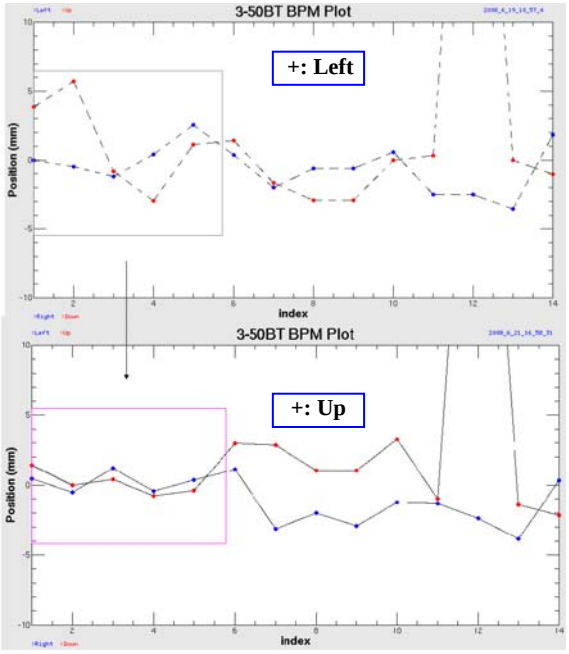

Figure 11: 3-50 BT orbit correction during commissioning day-one

CONCLUSIONS

We studied the simple injection scheme without local bump orbit for the J-PARC MR. The scheme was used successfully in the day-one beam commissioning. We will adopt the scheme in the second stage of beam commissioning which will be started in December 2008.

REFERENCES

[1] T. Koseki, Beam commissioning of J-PARC MR, in these proceedings.
[2] M. Tomizawa et al., PAC07, P.1510.
[3] Y. Hashimoto, Multi-Wire Beam Profile Monitor for J-PARC 3-50 BT and MR, in these proceedings.