TRANSPORT LINE ORBIT CORRECTION FOR CSNS/RTBT

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Abstract

China Spallation Neutron Sources (CSNS) accelerator consists of an 80MeV linac, the linac to RCS transport beam line (LEBT), 1.6GeV Rapid Cycling Synchrotron (RCS) and the RCS to target beam transfer line (RTBT) Dipole filed kickers arisen from the construction and alignment of the magnets may cause the particle travels away from the ideal orbit in the transport line. In this paper, orbit distortion correction of the RTBT lattice was successfully done by the general XAL Orbit Correction application with modification on orbit display. Two orbit correction programs of XAL and AT (matlab) toolbox are compared and there results are according with each other. The orbit correction during extraction and striking the target was special considered due to the angle problem. Besides, the first version of beam-based alignment (BBA) application program can work for measuring the offset of Beam Position Monitor (BPM) with the application of virtual accelerator.

INTRODUCTION

The RTBT line of CSNS [1] transports extracted high power protons from RCS to the target station, matches and tailors the beam to get the required profile and beam density on the target. Table 1 list some main design parameters of the RTBT line.

Table 1: RTBT parameters

Parameters	Value
Beam energy (GeV)	1.6
Total length of the line (m)	144.2
Magnetic rigidity (T.m)	7.86707
Repetition rate(Hz)	25
Number of dipoles	2
Number of quadrupoles	37
Number of octupoles	2
Number of BPMs	30
Number of Correctors	19

The errors brought by construction and alignment of the magnets may cause the particle deviate the ideal orbit. The orbit distortion in transport line can reduce the efficiency of injection, extraction and striking the target even impact on the normal work.

In this paper, the orbit display for RTBT and two programs compassion was first introduced. The special consideration of the orbit correction for commissioning was proposed latter. Another application program about beam-based alignment will introduce at last.

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ORBIT CORRECTION

Orbit correction contains the measurement of the orbit distortion and correction. BPM is usually used to measure the orbit distortion, while the singular value decomposition (SVD) or least square algorithm is always adopted to correct the distortion [2-3]. By several times correction, the satisfying results of beam orbit can be obtained.

Orbit display for one directional bpm

The part of the orbit display in XAL gave simultaneously two directions with their channels correlated to one BPM. However, some of the BPMs on RTBT line only offer one direction in our design. There are 12 horizontal and 12 vertical BPMs and others are temporally called normal BPMs. CSNS plan to transplant the XAL software to our machine, so the part of orbit display must be rewritten and the part of orbit correction can use directly. Now the modified program about orbit display is suitable for both single direction BPM and normal BPM. Fig1 shows the result of beam displacement in RTBT by giving a little offset of correctors.

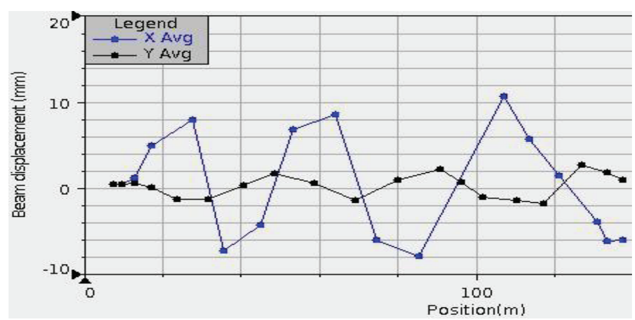

Figure1: Beam displacement in RTBT line . The frontal four and the last two BPMs are normal BPMs and the middle 24 BPMs are either horizontal or vertical BPMs.

Comparison of different programs

AT program is extensively used in accelerator field which can achieve orbit correction with the response matrix and SVD algorithm. While the XAL Orbit Correction application [4] in Java is now gradually used in modern accelerator like SNS, JPARC and so on. The program of latter has a solver that adapts its algorithms as solutions are scored and provide hints to the solver to improve performance. When correcting an orbit, the user can choose whether to correct the orbit based on the online model or through empirical measurement.

We just give the first horizontal corrector in RTBT line with the value of 0.05T to kick up the beam orbit in two programs. The orbits before and after correction are compared with the results shown in fig2. Two programs are according with each other, so we can transplant XAL

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Orbit Correction application to our machine with algorithm unchanged.

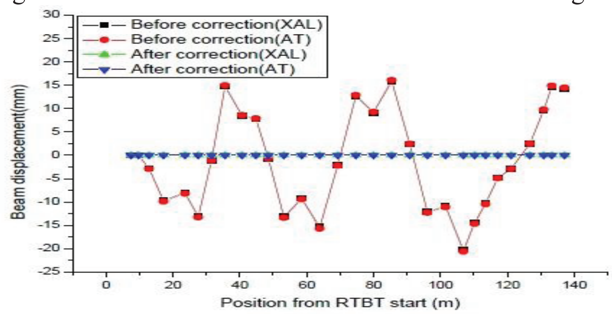

Figure 2: Orbit correction comparison

Special consideration for commissioning

Although the orbit correction can work well, some places must be specially considered during commissioning in the future. You can see the sketch map of fig3 that shows the beam cannot strike target vertically due to a corrector laid between the last two BPMs. If proton beam cannot strike the target vertically, the outputs of the neutrons are decreased sharply. There are three ways to improve this matter. First, the last corrector will not used in operation. Secondly, adjusting the last corrector based on the beam profile of the multi-wirescanner before the target. The last is the angle from the last BPM was restricted near zero by adding some angle restriction in the application. We are preparing to do the last to make the application perfect.

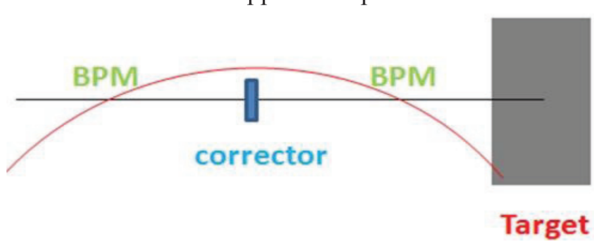

Figure 3: Schematic of orbit correction before the target.

The part of extraction with layout shown in fig4 also needs attention before normal operation. The two correctors of BV1 and BV2 after Lambertson in RTBT are designed for eliminating the orbit and the 20mrad in vertical direction brought by eight kickers. The orbit and the angle of the BV2 exit should firstly correct to zero with two or three near downstream BPMs. The specific number of the BPMs attending the correction can finally obtain based on the correction effect. After getting good result at the start part of RTBT, the orbit distortion correction continues with the latter correctors and BPMs.

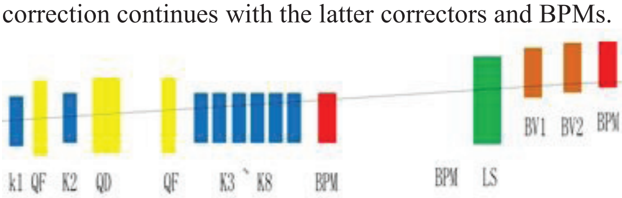

Figure 4: Layout of the extraction elements.

BEAM BASED ALIGNMENT

We have mentioned that orbit correction contains the measurement of the orbit distortion which is measured by BPM. The BPM is always installed close to the quadrupole, so the position of BPM is considered same as the quadtupole. However, the BPM's alignment center always cannot coincide with the electrical center due to sorts of errors. The offset of BPMs with respect to the magnetic center of the quadrupole can be determined by the method of the beam-based alignment [5-7] which varies individual quadrupole magnet strength and observes its effects on the orbit.

Our BBA application program, based on the XAL frame, has two steps as follows: firstly, changing the orbit of the nearest quadrupole by changing the upperstream corrector, then measuring downstream accessorial BPM readings for five times by increasing quadrupole field strength from zero to the maximal value (considering the magnetic hysteresis loop effect) and fitting BPM readings with quadrupole values. After the steps repeating several times, the BPM offset can be obtained from the linear fitting.

A screen snapshot of the first version BBA application is shown in fig5. Linear fitting is used in the application and the parabolic curve fitting with all the BPMs which may bring little error is planned to apply in second version in the future.

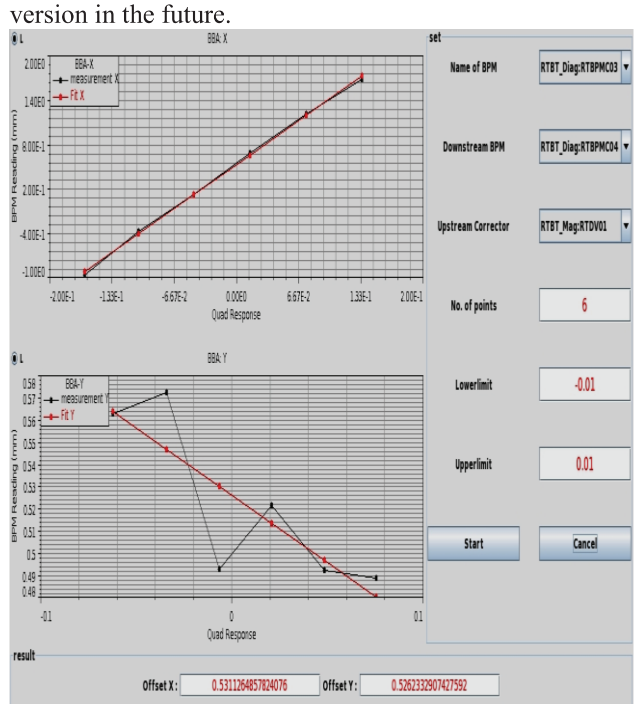

Figure 5: Screen snapshot of the BBA application applied to the CSNS /RTBT. The right part of the screen contains the setting of the needed measurement and accessorial BPMs, the measurement number, the upperstream corrector and its low limit and up limit. The two graphs of the screen show the horizontal and vertical BBA measurement and fitted result, respectively.

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Before the measurement, we must pay attention to some settings. For example, the number of points should greater than 5 to get better fitting effect; we should firstly choose the adjacent BPM and corrector except they cannot work or lay in improper phase; the low limit and up limit of the corrector mustn't exceed the range of the design value.

CONCLUSION

In this paper, orbit display program with singular directional BPM was done successfully applied in RTBT line. The part of orbit correction based on the general XAL application have transplanted to our machine with little modification. Two orbit correction programs based on XAL and AT are compared with the orbit before and after correction and there results are according with each other. The beginning and end of the RTBT was specially considered during the orbit correction for commissioning. The first version of BBA application program can work for measuring the offset of BPM and the second version will consider of improving the interface and the fitting method in the future.

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