BEAM BASED CALIBRATION OF SLOW ORBIT BUMP IN THE NSLS BOOSTER

X. Yang#, T. Shaftan, and J. Rose
National Synchrotron Light Source, Brookhaven National Laboratory, Upton, NY 11973, U.S.A.

Abstract

The orbit bumps in NSLS booster are used to move the beam orbit within 2mm of the extraction septum aperture on a time scale of millisecond at extraction in order to reduce the requirement on the amplitude of the fast extraction kicker. This may cause charge losses since before extraction, the beam stays on the distorted orbit for thousands of revolutions. In order to find the optimal orbit bump setpoint, which brings the maximum distortion at the extraction position and minimum distortions everywhere else, we developed an extraction model and performed an experiment to validate it. Afterwards, the model was applied to optimize the extraction process.

INTRODUCTION

Development of a model for the booster extraction requires a good understanding of the extraction process. Secondary coils around the booster dipoles (backleg windings, (BLW)) are used to distort the beam orbit at extraction, moving it within 2mm to the first extraction septum aperture on a time scale of millisecond. Afterwards, a fast kicker magnet (BXEKF for extraction to X-ray ring (XMODE) and BUEKF for extraction to UV ring (UMODE)) is triggered. This magnet produces a field waveform with the rise time less than one booster revolution (~100ns). On the last revolution when the kicker has reached its operating magnetic field, it bends the bunch outward into the extraction channel, which is formed by the first extraction septum (BXESH1 in XMODE and BUESH1 in UMODE), second extraction septum (BXESH2 in XMODE and BUESH2 in UMODE), and the subsequent transport line.

Since before extraction, the beam stays on the distorted orbit thousands of revolutions, this may cause charge losses in routine operations. In order to find the optimal BLW setpoint, which brings the maximum distortion at the extraction position and minimum distortions elsewhere around the booster, we developed the extraction model and performed an experiment to validate it. Afterwards, the model was applied to optimize the extraction process.

DESCRIPTION OF MEASUREMNTS

The booster layout is shown in Figure 1.

First, the polarities of BLW were checked in both XMODE and UMODE, as shown in table 1. Positive polarity refers to the situation that the magnetic field induced by BLW is in the same direction of the booster dipole field and vice versa. Two Pick-Up Electrodes (PUEs), B1D1PUE and B3D1PUE, as shown on Figure 1, were used to measure the difference orbit induced by BLW *via* program BEAMTRACK [1,2]. The difference orbit was obtained by subtracting the PUE readout when BLW is ON from the orbit when BLW is OFF, as shown on Figure 2.

#xiyang@bnl.gov

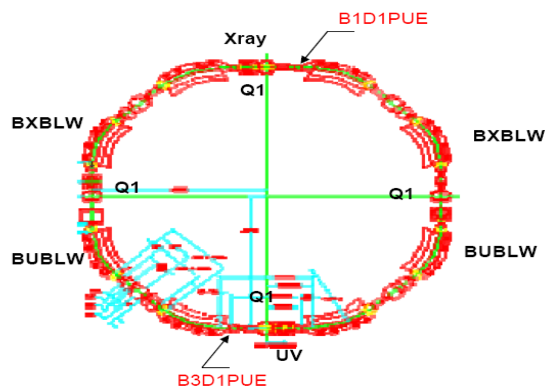

Figure 1: The booster layout.

Table 1: Setpoints of BLW (arb. units)

	XMODE setpoint	UMODE setpoint
BUBLW	+4690	-628
BXBLW	0	+4333

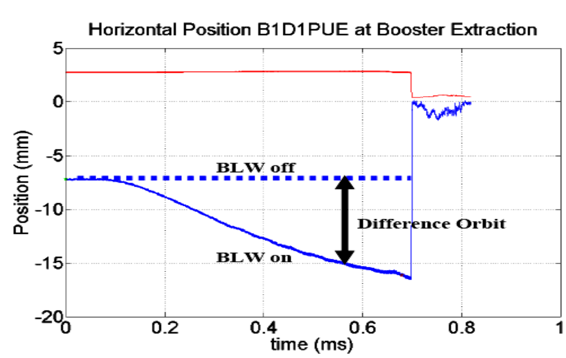

Figure 2: The sum (red) and position (blue) signals of the booster PUEs measured by BEAMTRACK.

Sum signal is un-calibrated and it is proportional to the beam intensity; position signal is normalized to the sum signal and it gives the beam position in mm. Blue solid and dash lines give beam positions when BLW is ON and OFF respectively, and their difference gives the orbit distortion induced by BLW at extraction.

DESCRIPTION OF EXTRACTION SIMULATION

Since the difference orbit depends on the phase advance between locations of BLW and the diagnostic PUE, it is important to match the tunes predicted by the model precisely with the measurement. The MAD [3] lattice functions with the tunes corresponding to those measured by Spectrum Analyzer [4] is shown on Figure 3.

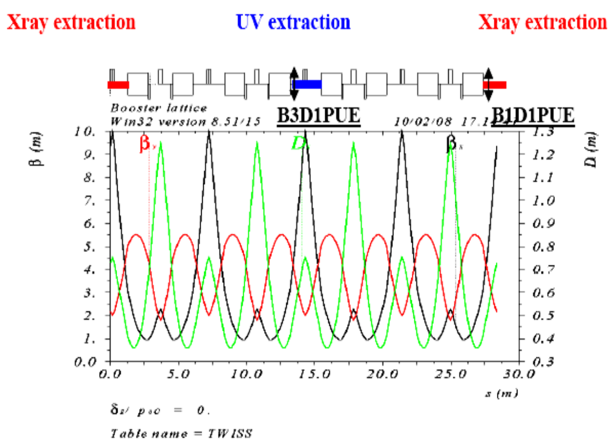

Figure 3: The horizontal (black) and vertical (red) beta functions, and dispersion function (green). Positions of B1D1PUE and B3D1PUE are indicated by vertical arrows (black).

The effect of BLW in the MAD model was considered in two ways. First, the BLW was assumed to modify only the dipole component of booster dipole magnets; second, since the booster dipoles are gradient magnets, which include dipole, quadrupole, and sextupole components, the BLW was assumed to modify all of those components proportionally. The differences between these two models are negligible, and so we choose Model #1 for simplicity.

Using the model, we were able to obtain a good agreement between the measured difference orbit and that predicted by the model at locations of both PUEs.

RESULTS

In this paper we discuss the extraction process to the X-Ray ring only, since the results apply similarly for the extraction to the VUV ring. To validate the extraction model we carried out the beam studies measuring the orbit at the PUE locations, changing the BLW settings and comparing the measured values with the model predictions. Maximum excursions of the difference orbit vs. BUBLW setpoint measured at B1D1PUE and

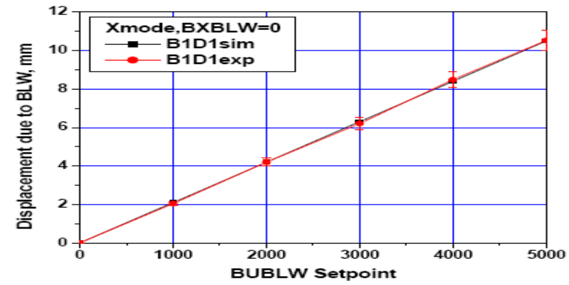

Figure 4: Maximum excursion of the difference orbit vs. BUBLW setpoint at B1D1PUE while BXBLW is OFF.

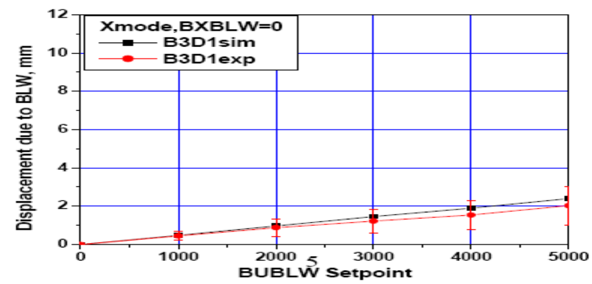

Figure 5: Maximum excursion of the difference orbit vs. BUBLW setpoint at B3D1PUE while BXBLW is OFF.

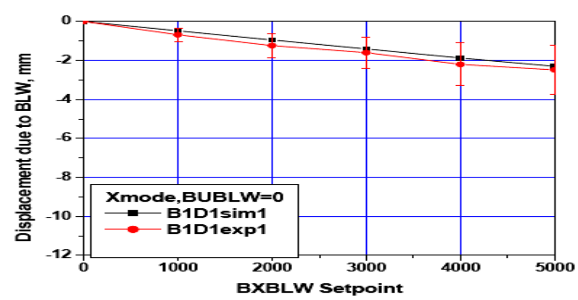

Figure 6: Maximum excursion of the difference orbit vs. BXBLW setpoint at B1D1PUE while BUBLW is OFF.

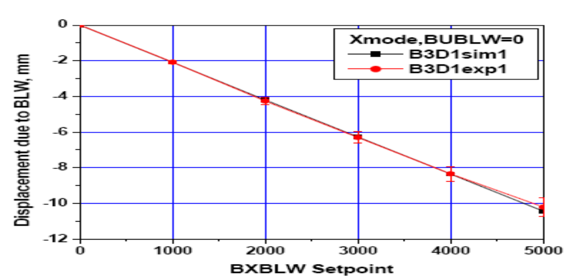

Figure 7: Maximum excursion of the difference orbit vs. BXBLW setpoint at B3D1PUE while BUBLW is OFF.

B3D1PUE are shown on Figures 4 and 5 respectively. Black and red curves represent the simulation and the measurement respectively. Similarly, the maximum excursions for the difference orbits vs. BXBLW setpoint at B1D1PUE and B3D1PUE are shown on Figures 6 and 7 respectively.

At the last turn just before the booster-to-Xray extraction, the difference orbit is plotted on Figure 8. The plot starts from Q1 quadrupole in the middle of Xray extraction straight section.

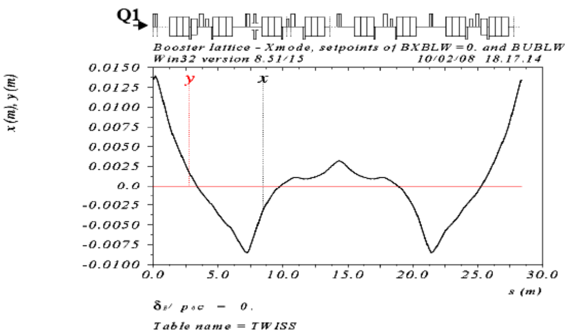

Figure 8: Difference orbit vs. longitudinal position at the operational XMODE with BUBLW=4700 and BXBLW=0.

CONCLUSION

We obtained a good agreement between the measurement and the simulation on the booster orbit distortions due to BLW at extraction. In the present configuration, BUBLW produces nearly four times more displacement as compared with BXBLW in the Xray section than that in the UV section and vice versa. This is determined by the booster optics and the extraction process since the difference orbit needs to be maximized in the extraction section and minimized in the rest of the ring to avoid beam size increase and beam losses.

Since the position of the beam extraction before the last turn is determined by the geometry of the extraction channel, and it is the sum of the initial position and the orbit distortion induced by BLW, BLW setpoint needs to be constantly monitored and adjusted whenever the orbit changes at the extraction period. Once in a while, we observed some beam losses before extraction, which were caused by the excessive orbit distortion. Part of the beam was scraped during the orbit distortion, and it can be avoided by optimizing the orbit distortion, which we described in this paper. As a result of our studies the operation setpoint of BLW were optimized at the present condition.

ACKNOWLEDGEMENTS

We are grateful for the help from Gary Weiner and Michael Santana during the studies, Peter Zuhoski and Mike Fulkerson for their help in checking the polarity of the backleg windings.

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