BTF SIMULATIONS FOR TEVATRON AND RHIC WITH RESISTIVE WALL WAKE FIELD *

V. H. Ranjbar, A. Sobol Tech-X Corp, Boulder, IL 80303 USA
T. Sen, C.Y.Tan and H.J. Kim, FNAL, Batavia, IL 60510, USA

Abstract

Recent improvements to BBSIM[1] permit detailed simulations of collective effects due to resistive wall wake fields. We compare results of beam transfer measurements (BTF) in the Tevatron and RHIC with and without the effects of resistive wall wake fields. These are then compared to actual BTF measurements made in both machines and the impact of intensity on our measurements.

INTRODUCTION

Beam Transfer function (BTF) measurements are a useful tool to help characterize state of a given accelerator. In the past it has been used to extract impedance information. measurements of this type since they are relatively non-destructive can drive a phase locked loop (PLL) tune tracking system. Such PLL systems are currently used in a number of accelerators such as the Tevatron, RHIC and the LHC. More recently BTF measurements have been used to ascertain the impact of beam-beam and wire kicks. In recent BTF measurements at both RHIC and the Tevatron have shown some deviation from current theoretical understanding and simulations. In an attempt to address these discrepancies we have added the ability to treat resistive wall wake field effects to BBSIM. To date the results of including wake fields have been mixed. In RHIC their impact appear minimal and we probably need to appeal to other physical effects to explain the observations. In the Tevatron the wake field effects do appear to significantly alter the phase and amplitude responses that there inclusion is warranted. However more simulation work is still needed to deliver a more satisfying agreement between simulation and experiment.

RHIC BTF MEASUREMENTS

Two current carrying wires, one for each beam, have been installed in the RHIC tunnel. Their impact on a beam was measured during the 2008 physics run with deuteron and gold beams. These wire were designed to compensate long-range beam-beam interactions which are known to cause beam loss in the Tevatron and are expected to deteriorate beam quality in the LHC.

During the 2008 physics run BTF measurements were made at varying wire current strengths and positions. There were previous attempts benchmark this data with the BBSIM which were reasonably successful [2]. however we decided to revisit this data to see if a better agreement could be obtained with inclusion of resistive wall wake field effects. In Fig. 1 you can see that for the baseline case (no wire current) there is only a slight impact on the structure of the beam response with the inclusion of various Wakefield strengths. With the wire turned on the impact of resistive wall wake fields was still only in the overall amplitude of the signal with no change to its structure. We believe that a more important factor would be the consideration of the higher order coupling with δ in the sextupoles and IR multipoles.

* Work supported by DOE/NP SBIR BeamBeam Phase I grant DE-FG02-08ER85183 and used NERSC resources under grant DE-AC02-05CH11231

TEVATRON BTF MEASUREMENTS

In the Tevatron much work has been done modeling Wakefields and beam response at injection energy (150 GeV) [3]. However the results of various chromaticity measurement schemes have shown that chromaticity measured appears to respond to either the beam emittance or intensity suggesting that impedance or emittance effects may play a role in altering the chromaticity measured by as much as a unit in the vertical plane. Recent simulation work has indicated that emittance size may play a role [4] this current work attempts to understand in what manner resistive wall wake fields may impact phase and amplitude measurements during a BTF measurement. In Fig. 2 we see the horizontal phase response. The slope is generally reproducible in simulations, both with and without Wakefields, however since simulations were done only over 1024 turns per frequency point not enough data to generate the same synchrotron phase oscillation observed in the data.

In Fig. 3 the impact of wake field effects are more prominent. This is due to the fact that the impedance is known to be larger in the vertical plane in the Tevatron. While the slope is generally reproduced overall the data appears too noisy to in the phase to draw any firm conclusions. Generally there is much noise in the phase plots, this is in part due to the fact that to save computational time BBSIM currently calculates both the real and imaginary components without direct frequency filter but by averaging. We anticipate cleaner results for the phase information if either a FFT low pass filter is applied or more turns are analyzed.

In Fig. 4 the amplitude response appears a bit cleaner than the phase and the inclusion of Wakefield in the vertical plane appear to yield amplitude responses more consistent with the experimental data.

CONCLUSION

We have recently developed a short range resistive wall transverse and longitudinal wake field treatment for BB-

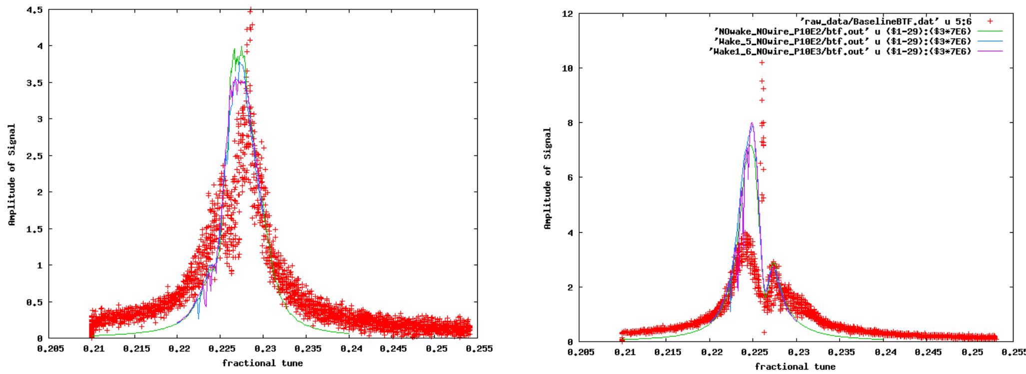

Figure 1: Impact of various Wakefield strengths on the vertical amplitude response of a BTF simulated measurements compared with actual.

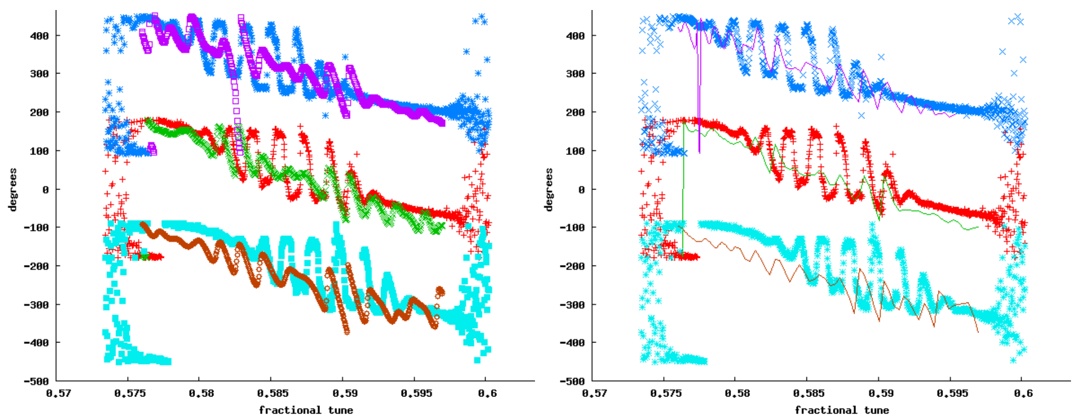

Figure 2: Horizontal phase BTF response of a chromaticity measurement +40Hz (top), -40Hz (bottom) and zero Hz middle. Simulation overlaid on actual data. Horizontal Chromaticity is set to 8.5 units. Left plot with wake fields, right plot without.

SIM. We have begun considering its impact on BTF simulations and how they compare with BTF measurements made in RHIC and the Tevatron. In RHIC it would appear that short-range resistive wall wake fields have little impact at collision energy on the overall BTF measurements. However in the Tevatron at injection energies, preliminary results indicate that such effects should not be neglected in the vertical plane. The impact on chromaticity measurements is still an open question and we hope further simulations with BBSIM will help settle the issue.

REFERENCES

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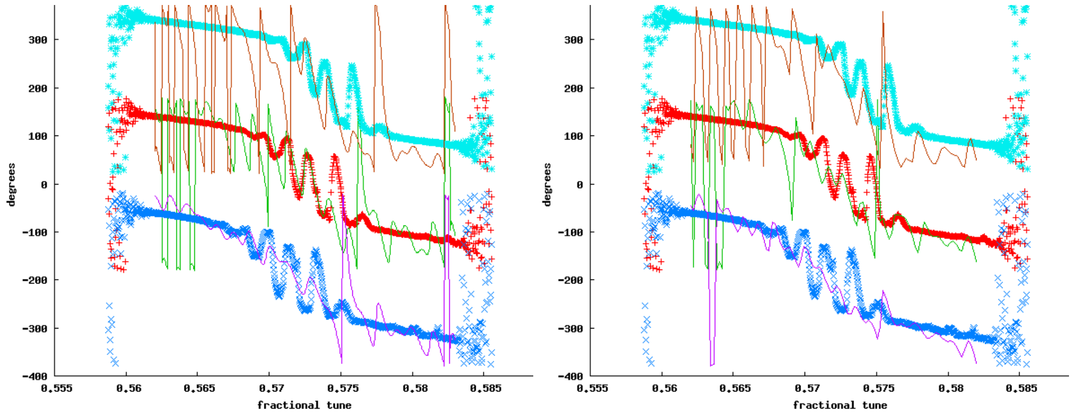

Figure 3: Vertical phase BTF response of a chromaticity measurement +40Hz (top), -40Hz (bottom) and zero Hz middle. Simulation overlaid on actual data. Vertical Chromaticity is set to 4 units. Left plot with Wakefield, right plot without.

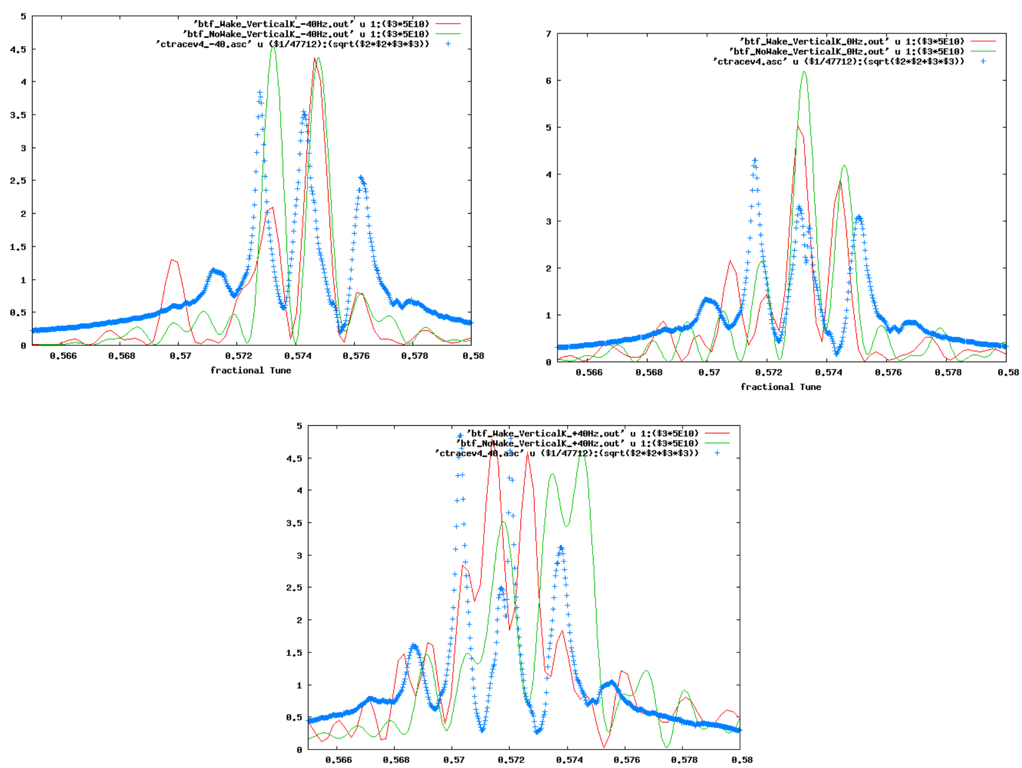

Figure 4: Vertical amplitude BTF response for a chromaticity measurement. Simulation overlaid on actual data. Vertical Chromaticity is set to 4 units. Blue trace is actual, green simulation without wake and red simulation with wake fields. Plots left to right (-40Hz,0, +40Hz)