

BNL-105084-2014-TECH

Booster Technical Note No. 37;BNL-105084-2014-IR

Tracking results from a hybrid booster lattice at working points (?x ?y) = (4.83, 4.82) and (3.83, 3.82)

G. F. Dell

May 1986

Collider Accelerator Department Brookhaven National Laboratory

## **U.S. Department of Energy**

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No.DE-AC02-76CH00016 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

## DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

TRACKING RESULTS FROM A HYBRID BOOSTER LATTICE AT WORKING POINTS  $(\mathcal{D}_x, \mathcal{D}_y) = (4.83, 4.82)$  AND (3.83, 3.82)

# Booster Technical Note No. 37

G.F. Dell MAY 30, 1986

ACCELERATOR DEVELOPMENT DEPARTMENT Brookhaven National Laboratory Upton, N.Y. 11973 TRACKING RESULTS FROM A HYBRID BOOSTER LATTICE AT WORKING POINTS

$$(\mathcal{U}_{x}, \mathcal{T}_{y}) = (4.83, 4.82) \text{ AND } (3.83, 3.82)$$

G.F. Dell

#### Abstract

Tracking at  $\Delta P/P = 0.0\%$  of particles having emittances of  $\mathcal{E}_x = \mathcal{E}_y = 50\pi$  mm mrad suggests that the operating point (3.83,3.82) is too close to the 3rd order structure resonance  $3\mathcal{U} = 12$ . Even without chromaticity correcting sextupoles, the eddy current sextupoles are sufficient to drive this resonance.

## Introduction

Tracking of particles with emittances of  $\mathcal{E}_x = \mathcal{E}_y = 50\pi$  mm mrad through a hybrid lattice<sup>1</sup> has been performed with PATRICIA. The lattice contains combined function dipoles as well as one focusing and one defocusing quadrupole per superperiod. Sextupoles near these discrete quadrupoles are used to correct the chromaticity.

Three cases have been studied with and without the presence of eddy current multipoles<sup>2</sup>:

1).  $\mathcal{U}_{x} = 4.83$ ,  $\mathcal{U}_{y} = 4.82$  with the chromaticity corrected to zero, 2).  $\mathcal{U}_{x} = 3.83$ ,  $\mathcal{U}_{y} = 3.82$  with the chromaticity corrected to zero, 3).  $\mathcal{U}_{x} = 3.83$ ,  $\mathcal{U}_{y} = 3.82$  with no chromaticity correction.

The results for these three cases are discussed below.

#### Results

I.  $\mathcal{U}_{\dot{x}}$  = 4.83,  $\mathcal{U}_{y}$  = 4.82 with chromaticity corrected to zero.

The phase plots are shown in Fig. 1(a) for tracking without eddy current multipoles and in Fig. 1(b) with eddy current multipoles. In both cases the phase plots have a finite radial width that is attributed to coupling. The width increases when eddy current multipoles are present and indicates increased coupling. Although the radial width increases, the basic shape of the phase plots is not changed when eddy current multipoles are present.

II.  $\mathcal{V}_x$  = 3.83,  $\mathcal{V}_y$  = 3.82 with chromaticity corrected to zero.

Results without eddy current multipoles are shown in Fig. 2(a). The phase plot for the x motion shows six islands indicating the proximity to the resonance  $\mathcal{V}_x = 3.833$ . Both x and y plots have radial widths that are essentially unchanged from case-I above. Inclusion of the eddy current multipoles produces phase plots that are triangular in shape, Fig. 2(b). The radial width has increased significantly and indicates coupling of nearly 100%. The shape has become triangular and is consistent with driving the 3 $\mathcal{V}=12$ structure resonance at  $\mathcal{V}=4$ .

III.  $\mathcal{V}_{x}$  = 3.83,  $\mathcal{V}_{y}$  = 3.82 with no chromaticity correction.

It was suggested that the sextupoles required to correct chromaticity might be driving the 3rd order structure resonance<sup>3</sup>. Consequently a run was made for which there was no chromaticity correction. The results in Fig. 3(a) show phase plots having essentially zero radial width and are consistent with zero coupling. Inclusion of the eddy current multipoles Fig. 3(b) again produces triangular shaped phase plots with large coupling. One concludes that the eddy current multipoles by themselves are capable of driving the 3rd order structure resonance.

## Conclusions

These preliminary tracking studies at  $\Delta P/P = 0.0\%$  indicate that the operating point ( $\mathcal{V}_x, \mathcal{V}_y$ ) = (4.83,4.82) is preferable to operation at (3.83,3.82).

## References

- 1. J. Claus and S.Y. Lee, private communication.
- 2. G. Morgan and S. Kahn, Booster Tech Note #4.
- 3. S.Y. Lee, private communication.



Fig. 1(a) Hybrid lattice,  $\mathcal{V}_x = 4.830$ ,  $\mathcal{V}_y = 4.820$ , No eddy current multipoles.  $\Delta P/P = 0.0$ %, Chromaticity = 0 in both planes,  $\mathcal{E}_x = \mathcal{E}_y = 50 \pi$  mm mrad, 600 Turns.



Fig. 1(b) Hybrid lattice,  $\mathcal{V}_x = 4.830$ ,  $\mathcal{V}_y = 4.820$ , With eddy current multipoles.  $\Delta_{P/P} = 0.0$ %, Chromaticity = 0 in both planes,  $\mathcal{E}_x = \mathcal{E}_y = 50$  mm mrad, 600 Turns.



Fig. 2(a) Hybrid lattice,  $\mathcal{V}_x = 3.830$ ,  $\mathcal{V}_y = 3.820$ , No eddy current multipoles.  $\Delta P/P = 0.0$ %, Chromaticity = 0 in both planes,  $\mathcal{E}_x = \mathcal{E}_y = 50\pi$  mm mrad, 600 Turns.



Fig. 2(b) Hybrid lattice,  $\mathcal{V}_x = 3.830$ ,  $\mathcal{V}_y = 3.820$ , With eddy current multipoles.  $\Delta P/P = 0.0$ %, Chromaticity = 0 in both planes,  $\mathcal{E}_x = \mathcal{E}_y = 50 \pi$  mm mrad, 600 Turns.



Fig. 3(a) Hybrid lattice,  $\mathcal{V}_x = 3.830$ ,  $\mathcal{V}_y = 3.820$ , No eddy current multipoles.  $\Delta P/P = 0.0$ %, No chromaticity correction,  $\mathcal{E}_x = \mathcal{E}_y = 50$  mm mrad, 600 Turns.



Fig. 3(b) Hybrid lattice,  $\mathcal{U}_x = 3.83$ ,  $\mathcal{U}_y = 3.82$ , With eddy current multipoles.  $\Delta P/P = 0.0$ %, No chromaticity correction,  $\mathcal{E}_x = \mathcal{E}_y = 50 \, \pi$  mm mrad, 600 Turns.