BETA-BEAT CORRECTION USING STRONG SEXTUPOLE BUMPS IN PEP-II*

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Abstract

A method for correcting lattice beta mismatches has been developed for the PEP-II collider using orbit offsets in strong sextupoles. The solution is first predicted in the MAD program by modelling closed orbit bumps in the plane of correction at the sextupoles strongest in that plane. The derived solution is then tested in the machine to confirm prediction, and finally dialled into the machine under high-current conditions.

INTRODUCTION

During PEP Run 5, a large horizontal beta-beat developed in the LER (Fig 1) of approximately four to one. The vertical beta-beat of about 1.4:1 (Fig 2) was less a worry. Concern for the dynamic aperture of the machine as well as the desire to have a machine that matches the design lattice for future optics work led to the search for a fix.

Several constraints limited the approach, however. The most prominent of which was delivering luminosity to BaBar. Given that any quadrupole magnet perturbed would require a full machine standardize, a process which takes 30 minutes, a beta-fix solution that includes electromagnets is less likely to find machine development time to test.

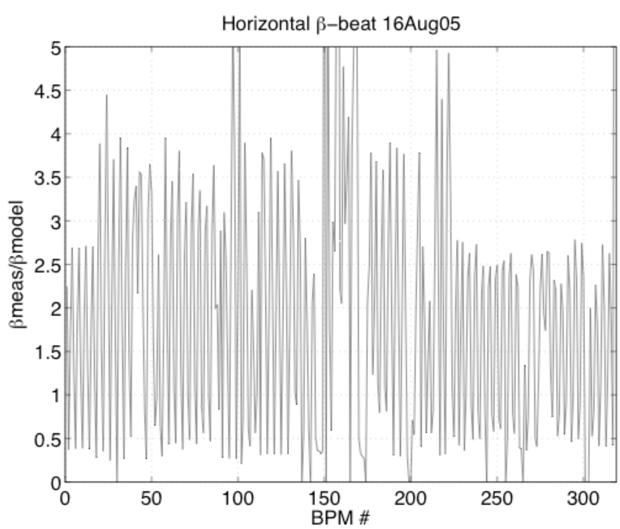

Fig. 1: LER horizontal beta-beat from 16-Aug-2005.

Since the LER lattice has relatively few, strong sextupoles segregated into focussing and defocussing arcs, a closed orbit bump in a sextupole of the proper phase can be made that creates a beta-wave that cancels the beta deviation from design.

By using the MAD program iteratively, it is possible to find a solution of closed orbit bumps in the sextupoles to find such a solution.

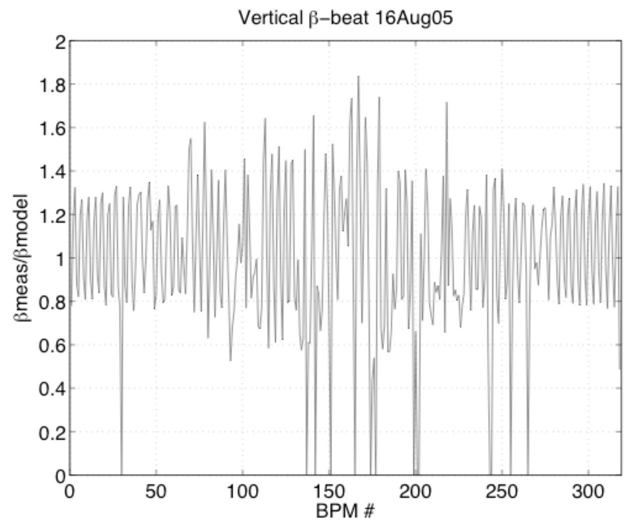

Fig. 2: LER vertical beta-beat from 16-Aug-2005.

SOFTWARE

In order to model the solution, two tools were used. Primarily, an OSX port of MAD 8.51 [1] was used iteratively with Matlab R14 to produce and analyze potential solutions. A Matlab script was created that auto-generated the MAD input files for ease of use and to allow a looping mechanism that determined whether or not a potential solution was of the desired class or not.

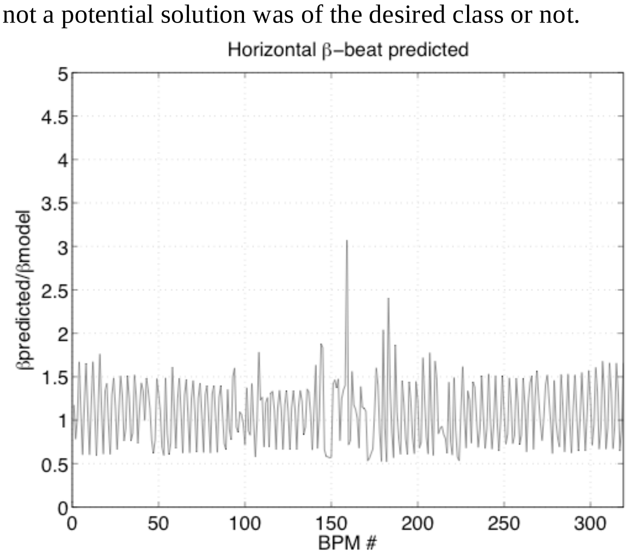

Figure 3: LER horizontal beta-beat, MAD-derived modelled solution.

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THE SOLUTION

It was found that by inserting a 1.4mm symmetric bump in the first two arc9 SF2 sextupoles, -1.4 symmetric bump in the second two arc9 SF2 sextupoles, a -1mm symmetric bump in the first two arc7 SF2 sextupoles, and a 1mm symmetric bump in the second two arc7 SF2 sextupoles (Figure 4) that the beta beat could be reduced down to about 1.5:1 whilst not compromising the dispersion nor coupling throughout the ring (Figures 3 & 5).

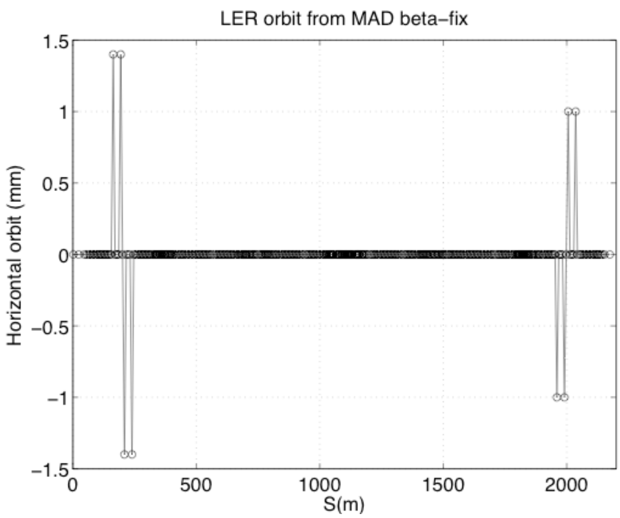

Figure 4: LER horizontal orbit, MAD-derived modelled solution.

A MAD model was created by using the machine magnet strengths, machine orbit, and ORM derived fudge factors for the magnets. This model, while not totally accurately describing the machine, was deemed adequate for the purposes of this particular endeavor.

While not completely optimized, the solution was determined to be the best possible given the limitations of accurately modelling the Low Energy Ring in MAD. The same sextupoles that allow easy beta, dispersion, and coupling correction also makes accurate modelling of the ring nigh-impossible. The LEGO modelling code may make such a task possible in the future, but for the purpose of this paper, MAD was sufficient.

Experience in the LER

A multi-knob with the closed orbit bump solution described previously was slowly dialled into the machine over the course of several shifts. It was found that a full solution could not be dialled in under high beam-beam conditions without too much disruption. A 20% implementation at a time with a few hours for operators to compensate the tunes, etc. did prove to be easy.

During the dial-in it was noted that the actual machine responded slightly differently than the modelled machine. Operators were required to make small adjustments to the coupling and dispersion knobs to maintain luminosity at a constant level. This failure of complete knob closure with respect to coupling and dispersion lay with the fact that the starting model for comparison was not entirely sufficient for the task at hand.

Measurement of Solution

The predicted solution was, however, dialled in prior to high-current, high luminosity running during an opportunistic machine characterization shift. The measured beta-functions closely matched the predicted values (Figures 6 & 7).

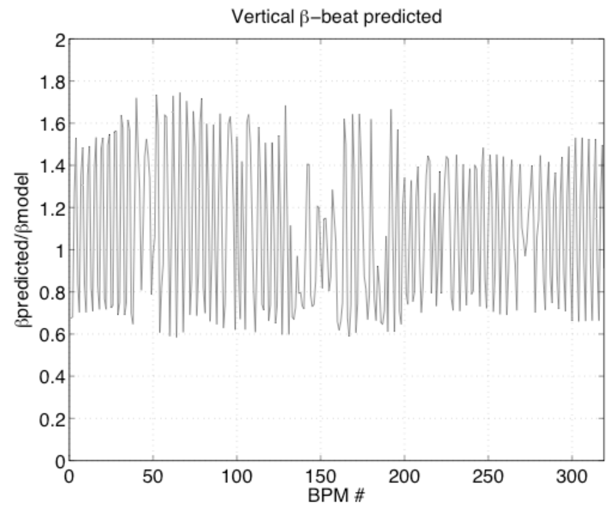

Figure 5: LER vertical beta-beat, MAD-derived modelled solution.

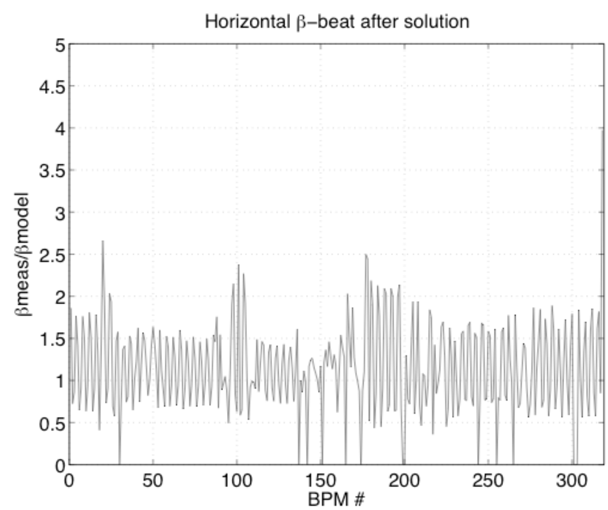

Figure 6: LER horizontal beta-beat, after dialing in closed orbit bump solution.

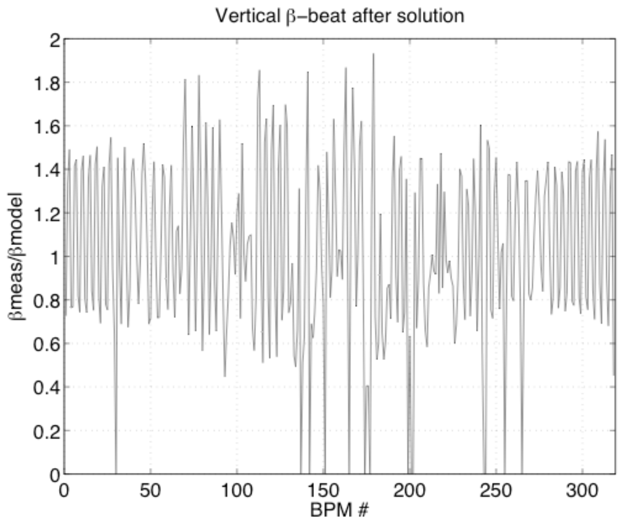

Figure 7: LER vertical beta-beat, after dialing in closed orbit bump solution.

SUMMARY

Having implemented this solution during high-current operation in the PEP-II collider, one might think that this would be a valuable resource in on-the-fly optics corrections. The experience was smooth and had little affect on the luminosity nor the backgrounds in the BaBar detector when implementing the solution in steps that allowed time to tune out the residual coupling and dispersion that arose from using a poor starting model. However, in the medium term, no real gains were seen in the machine lifetime nor luminosity. It should be noted that subsequently in Run 5, a much larger beta-beat than the one presented here has arisen (approximately 7:1) as the LER has been pushed down further to the half-integer that seems to have little affect on luminosity or machine lifetime. In fact, the PEP-II collider is performing at record levels with said beta-beat.

More study is needed to understand how the machine performs so well with such a large deviation from the design beta functions.

REFERENCES

[1] http://www.slac.stanford.edu/~yocky/osx_acc_phys