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LATTICE COMMISSIONING STRATEGY FOR THE B-FACTORY *

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Abstract

To prepare for the PEP-II turn on, we have studied one commissioning strategy with simulated lattice errors. Features such as difference and absolute orbit analysis and correction are discussed

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1 INTRODUCTION

To prepare for the commissioning of the PEP-II injection line and high energy ring (HER), we have developed a system for on-line orbit analysis by merging two existing codes: LEGO [1] and RESOLVE [2]. With the LEGO-RESOLVE system, we can study the problem of finding quadrupole alignment and beam position (BPM) offset errors with simulated data. We have increased the speed and versatility of the orbit analysis process by using a command file written in a script language designed specifically for RESOLVE. In addition, we have interfaced the LEGO-RESOLVE system to the control system of the B-Factory. In this paper, we describe on-line analysis features of the LEGO-RESOLVE system and present examples of practical applications

2 THE RESOLVE PROCESS

Orbit analysis has been used for almost two decades to find errors in accelerator lattices [3,4,5]. One code that provides a interactive graphical user interface for orbit analysis is RESOLVE. RESOLVE was developed specifically to find errors in the beamline elements such as magnet strength and position. The orbit analysis procedure to find "modeling" errors is typically a two step process: The first step is to adjust the value of the modeling errors to produce a simulated orbit which matches to the measured orbit. The second step is to interpret this result. Up to now, both of these steps have been performed manually via the graphical interface provided by RESOLVE. In many cases, this manual application of RESOLVE can be a time consuming process. Our desire to speed up the error-finding procedure motivated the development of a command file language.

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3 THE LEGO-RESOLVE CONNECTION

LEGO is an object-oriented environment for integration of accelerator design, beam simulation and machine modeling codes. At present, we have connected RESOLVE with LEGO by means of a file-driven interface as shown in Fig. 1. A similar file-driven interface has also been implemented between LEGO and the B-Factory control system. With these file-driven connections, we also can use the RESOLVE Graphical User Interface for other on-line LEGO applications such as orbit correction and lattice calculation.

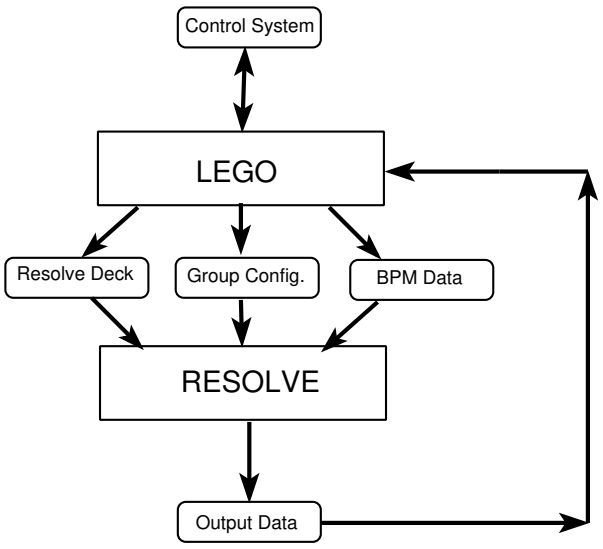

Figure 1. Schematic diagram of connections between LEGO, RESOLVE, and the Control System.

To use RESOLVE, we first create a directory for the input and output files. Then, we use LEGO to place the following input files in the RESOLVE directory: (1) a "beamline" file which describes the lattice, (2) a "groups" file which defines how the magnets are connected by common power supplies, and (3) "BPM" with the simulated or measured orbit data to be analyzed. After

loading these files into the RESOLVE directory, the measured or simulated data can be analyzed either manually or automatically. To analyze data automatically, we need to create a "cmd" or command in the RESOLVE directory. At present, the command files are created manually. Eventually, we will use LEGO to create command files automatically. Examples of input files for RESOLVE can be found at: "http://www. slac.stanford.edu /grp/ara/ ".

For a typical application, a "cmd" file contains the following commands: (1) select the region of beamline to be studied, (2) choose the elements with errors (such as quadrupole misalignments or BPM offsets), (3) delete the "bad" BPMs, (4) define the launch conditions (such as the initial beam position and angle), and (5) find the value of the errors. To find the errors, RESOLVE minimizes the sum of the squares of the discrepancy between the measured orbit and the simulated orbit at all BPMs. With these commands automatically read by RESOLVE, the error analysis process can proceed quickly. In some cases, on-line data processing of PEP-II orbit data will be possible during machine physics studies.

4 MULTI-CONFIGURATION ANALYSIS

In the past, RESOLVE was used primarily for analysis of the "difference orbit" to find optical errors [6,7,8,9]. The difference orbit is defined as the change in the orbit introduced by a kick from a dipole corrector. RESOLVE can be used to find the errors in the strength of quadrupole magnets by minimizing the sum of the least squares of the measured orbit changes and simulated orbit changes. In practice, we often measured the orbit change at all BPMs for every corrector in the beamline or ring. We also can solve for the values of BPM sensitivity errors with RESOLVE. We call this process "multi-track" analysis.

In the case of beam-based misalignment studies [9,10,11,12], we analyze orbit data taken for several configurations with different quadrupole magnet settings. There is one track for each configuration. Each track is not a "difference" orbit but an "absolute" orbit [10,11,12,13]. We call this process "multi-configuration analysis".

5 BEAM-BASED ALIGNMENT STUDY

Recently, we used the command file feature in RESOLVE to study beam-based alignment in the HER. The beam-based misalignment study in HER is the first time RESOLVE is used for multi-configuration analysis. In this study, LEGO was used to simulate the measured orbit for 10 different configurations. Each configuration is defined by a set of quadrupole strength values. A set of 10 orbits was produced by tracking with LEGO.

Each orbit or "track" was simulated for the same launch conditions (the beam is injected into HER with same position, angle, and energy), and every quadrupole magnet randomly misaligned. Two kinds of errors were introduced into the BPMs: offsets and noise. The BPM offsets were the same for all tracks, but the BPM noise was different for each track.

To simplify the analysis, we assume no quadrupole strength errors. Under this condition, we did not need a "groups" file for our analysis. Instead, we use the "set" option in each BPM file to set the strength of the quadrupoles for the corresponding track. Since the launch conditions, the quadrupole misalignment, the BPM offsets, and the beam energy are the same for all tracks, we use the "vary" option in the command file to declare them as variables. We use the interactive RESOLVE interface to read the beamline file, read the BPM files, and then to read the "cmd" file.

With these three actions, RESOLVE will solve for the misalignment and offsets automatically. The result will be displayed graphically in the output windows or written into an output file. LEGO can read this output file and can pass the information to the control system (see Fig. 1).

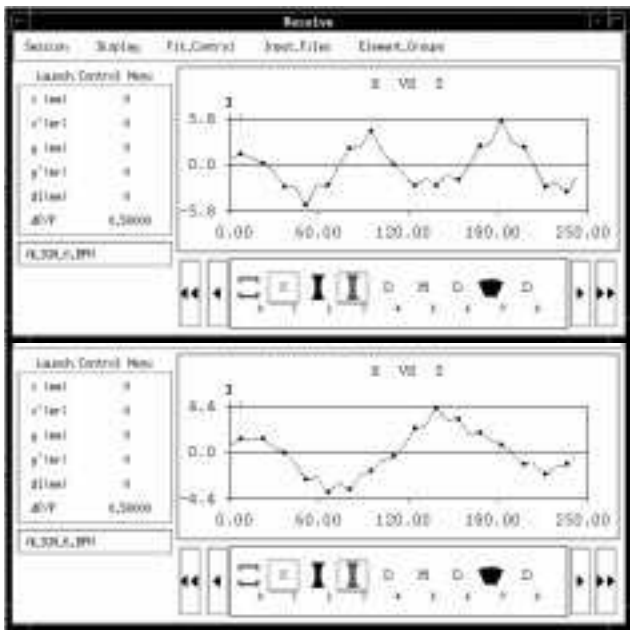

Figure 2. Typical trajectories used in our example.

An analysis of simulated data provides us an example using the LEGO-RESOLVE system for on-line beam-based alignment studies. Examples of two tracks over one arc of HER are shown in Fig. 2, where the dots represent sampled BPM data, and the solid lines are the simulated trajectories in RESOLVE. This study provided us a way to study alignment errors and to see how the command file works for on-line data analysis.

6 A NEW ERROR-FINDING ALGORITHM

We have developed a new procedure for finding magnet alignment and monitor offset errors by means of an automated procedure. This method requires searching for the solution with the least-square error values as we vary the energy of the beam. To do an energy scan, we simply set the beam energy to a given value, and use RESOLVE to find the misalignment and offset errors for this energy. By comparing the solution over a range of beam energy values, we can make a choice on the best solution. With simulated rms. BPM noise value of 0.03 mm, we have been able to determine the beam energy error within 0.002% as shown in Fig. 3

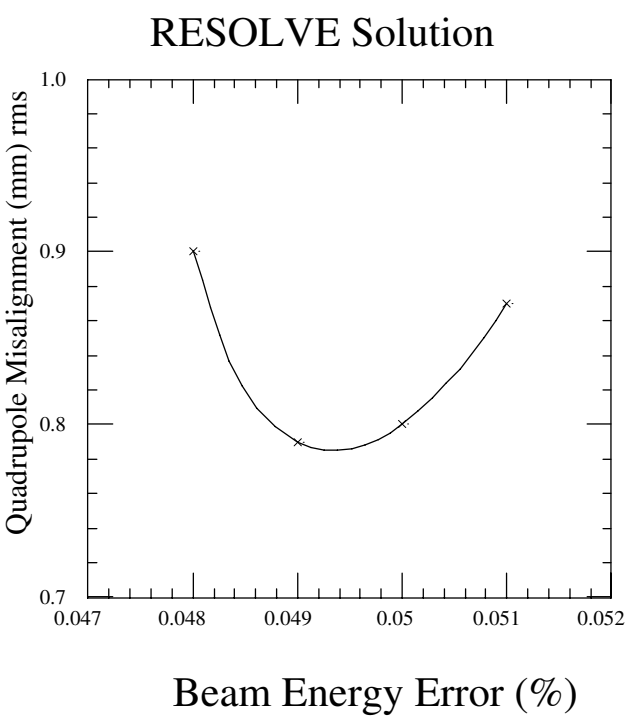

Figure 3. A plot of the solution for different beam energy error values for a case with simulated error of 0.05%.

7 SUMMARY

The combination of LEGO and RESOLVE has provided us with a state-of-the-art on-line accelerator modeling and analysis system. This system enables us to study error finding and correction strategies with simulated errors. These simulation studies give us a way to practice commissioning of the high-energy ring for PEP-II. The experience we gain from this practice increases our ability to find errors in the real machine. To find real errors in the PEP-II, we simply replace the simulated data with the measured data.

6 REFERENCES

[1]. Y. Cai, M. Donald, J. Irwin, and Y. Yan, "LEGO: A Modular Accelerator Design Code", see these proceedings.

[2]. M. Lee, Y. Zambre, and J. Corbett, "Accelerator Simulation Using Computers", International Conference on Current Trends in Data Acquisition and Control of Accelerators, Calcutta, India, 1991; SLAC-PUB-5701(A).

[3]. M. Lee, J. Sheppard, and M. Sullenberger, "Models and Simulations", Proceedings of the Europhysics Conference on Computing in Accelerator Design and Operation, Berlin, 1983; SLAC-PUB-3217(A).

[4]. M. Lee, et al., "Analysis of the Orbit Errors in the CERN Accelerators", Proceedings of the Europhysics Conference on Control Systems for Experimental Physics, Villiars, Switzerland, 1987; SLAC-PUB-4411(A).

[5]. M. Lee, "GLAD: A Generic Lattice Debugger", Proceedings of the International Conference on Accelerators and Large Experimental Physics Control Systems, Tsukuba, Japan, 1991; SLAC-PUB-5700(A).

[6]. J. Corbett, M. Lee, and Y. Zambre, "Automatic Beamline Calibration Procedures", Proceedings of the 3rd EPACS, Berlin, 1992; SLAC-PUB-5776(A).

[7]. J. Safranek and M. Lee, "Calibration of the X-ray Ring Quadrupoles, BPMs, and Orbit Correctors Using the Measured Orbit Response Matrix", AIP Conference Proceedings 315 on Orbit Corrections and Analysis in Circular Accelerators, Brookhaven, 1994.

[8]. J. Safranek, "Experimental Determination of Storage Ring Optics Using Orbit Response Measurements", NIM(A), vol. 388, no. 1 & 2, 1997.

[9]. G. LeBlac and W. J. Corbett, "Accelerator Modeling at SPEAR", see these proceedings.

[10]. C. E. Adolphsen, et al., "Beam-Based Alignment Technique for the SLC LINAC", Proceedings of the 1989 PAC, Chicago; SLAC-PUB-4902(A).

[11]. C. Adolphsen and T. Raubenheimer, "Method to Evaluate Steering and Alignment Algorithms for Controlling Emittance Growth", Proceedings of the 1993 PAC; SLAC-PUB-6233.

[12]. W. J. Corbett and V. Ziemann, "Procedure for Determining Quadrupole and BPM Offset Values in Storage Rings', Proceedings of the 1993 PAC; SLAC-PUB-6112(A).

[13]. K. Ott, "Quadrupole Misalignment Determination at BESSY", Proceedings of the 1996 EPAC, Barcelona, Spain.