

Control System User Interface for Accelerator Commissioning and Operation

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Abstract—An Interactive Accelerator Interface Module (AIM) has been developed in a workstation environment for the purposes of assisting in the commissioning and operation of any storage ring/collider system. The function of AIM is to integrate modeling and simulation codes into accelerator and beamline control systems for the purpose of rapid on-line data analysis and error-correction, resulting in significant time-saving. A system dependent module provides for the translation of specific control system data files to appropriate input format for application programs within AIM. Interactive screen graphics, including system function diagrams, menus, beamline element status and update information are standard in AIM. AIM is currently connected to the Stanford Linear Collider (SLC) control system, but is easily transportable to other facilities. This paper describes the development of AIM and its applications on SLC.*

I. INTRODUCTION

There have been rapid advances in the analysis and the reduction of data from accelerators and beam storage systems in recent years. Analysis tools include model reference systems in a workstation environment. The Accelerator Interface Module (AIM) is an interactive graphics interface that functions in such an environment. The goal of AIM is rapid on-line data analysis and error correction for accelerators and storage rings. AIM follows many years of similar effort at the Stanford Linear Accelerator (SLAC) [1].

II. HISTORICAL BACKGROUND

Over the past few years, as the modeling codes for data analysis improved, the time it takes to find and correct errors in beam lines decreases from months to hours. For example, in 1983, a 3% power supply error prevented the SLC damping ring from storing the beam. This problem was resolved after approximately six man-months of effort using the code COMFORT [2]. In 1989, a similar problem which had caused a beam mismatch in a Storage Ring to LINAC subsection was resolved using COMFORT and a single-track analysis in ten man-days. As a result of the October 1989 Loma Prieta

earthquake, SLAC Positron Electron Project (PEP) suffered misalignments. This problem was analyzed in two man-days using the beam trajectory simulation code RESOLVE [3].

In all cases, the man-time effort also included the time it took to develop error finding methods. Now with these analysis methods known, the time it takes to analyze similar problems is greatly reduced. AIM is a further development along this line but with automated control system data file translation to the format for the analysis codes. The resulting turn-around time from data recording, through analysis, to machine update may be reduced to as little as an hour. AIM currently is being used on the Stanford Linear Collider (SLC) to upgrade luminosity.

III. AIM STRUCTURE

In its operation mode, AIM performs some analysis functions on the measured BPM and screen/wire data, and prepares input for the spawned codes such as RESOLVE and COMFORT as needed. AIM may also be used in a design mode. Beamline and beam requirements developed by AIM may be used to suggest placement of various types of diagnostics and to study their sensitivity to errors. Additionally, AIM may be used as a simulator for the purpose of training operators off-line and for developing beam tuning procedures.

The current version of AIM functions with Digital's VMS system. The code has been developed by SAIC on a VAX-Workstation 3100 running VMS version 5.2 and VWS version 4.1 (UIS) eight plane color graphics. A four plane version is working at SLAC. There is also an earlier demo developed for Boeing that runs on a Micro VAX II GPX with VMS version 4.6 with eight plane graphics.

The interactive graphics code is mouse-and-menu driven. The menu system guides the user through different levels of the code in sequence. The user is automatically prevented from making selections out of sequence as required by a given beam tuning procedure. The user is also assisted by means of HELP menus.

AIM displays a beamline layout display of the accelerator/storage-ring/collider, Figure 1. After a subsection is selected, a beamline data file prepared by the translator from a database derived from the SLC control system is used to display graphically the components of the entire subsection in terms of mouse-active icons. The icons are set in a convenient

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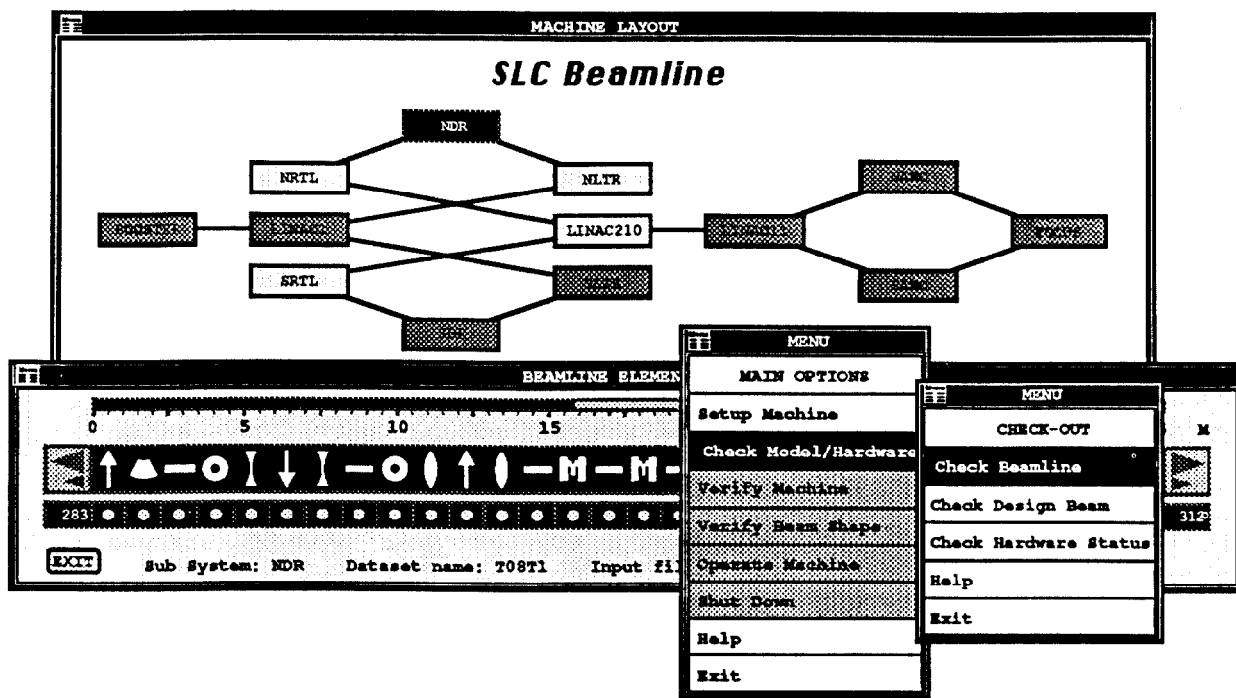


Figure 1. AIM Screen Layout

horizontal display that may be rapidly scrolled. Upon selection of a particular icon, technical data describing the element is displayed in a menu. In addition to the extensive analysis tools - all standard first order elements are available - within AIM, AIM can spawn codes such as COMFORT and RESOLVE and their associated graphics.

IV. APPLICATIONS

A. Analysis Functions in AIM

Beam launch errors, such as off-sets in position, pitch or energy may cause large trajectory deviations from the design orbit. An 'unknown' deviation in displacement and/or pitch is determined by sampling beam displacement at several BPMs interactively selected from the input data file. The values of x , x' , y , y' estimated from the selected subset of the data are displayed in a window and then used to predict beam position downstream. This kind of analysis is used in the model-reference launch feedback system.

Additionally, the beam ellipse may be determined from using beam-intrusive screens/wires and by varying upstream quadrupoles. The illustration in Figure 2 shows the simulated result of recording the beam size at a downstream fluorescent screen while varying a single upstream quadrupole over a range of values. The beam size shows a minimum over variation in upstream quad strength. Size data are inverted to determine beam Twiss parameters [4]. The difference between the design and the experimentally determined phase ellipse are shown (along with the experimentally determined Twiss parameters).

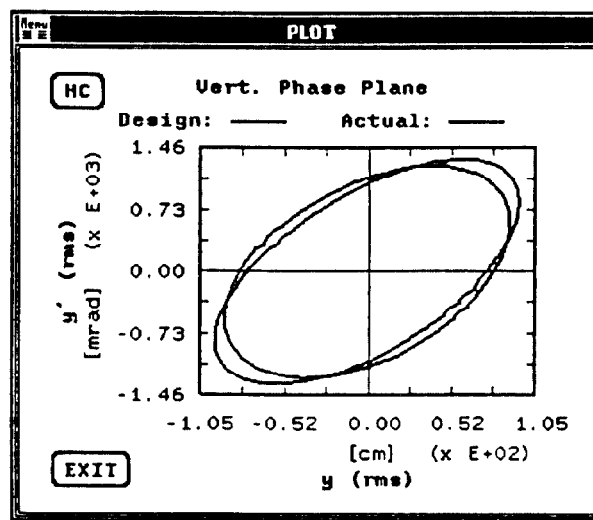


Figure 2. Shape Analysis Display.

B. Spawned Codes

Beam rematching is performed using the spawned code COMFORT. In this application, a comparison of the design beam with the unmatched simulated beam, and the design beam with the rematched beam may be displayed. Quadrupole changes required for the rematching can be determined by COMFORT.

RESOLVE is used primarily to identify errors and to recommend remedies. AIM (using RESOLVE) has been used to determine first order optical errors. The illustration in Figure 3 shows x and y displacements before and after the

location of a magnet field error and its adjustment. The fault analysis and recovery was performed using the spawned code RESOLVE. The beam was initially analyzed by finding the subsections of the beamline that agreed with design predictions, thus localizing the errors to segments between the "good" sections [5]. Then beamline model parameters - magnet field strength, BPM calibrations, and their alignments - in the "bad" sections are varied and the mean square error minimized to predict new parameter values which give the best fit to the measured orbit data. The analysis is then repeated with the new values. The effect of the located field error on the orbit is shown.

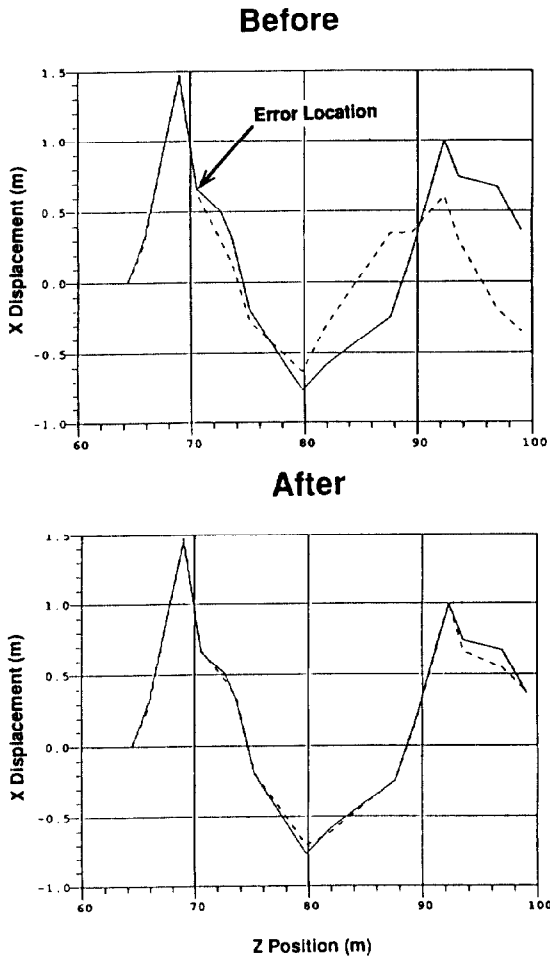


Figure 3. Field Error Analysis Displays.

RESOLVE may also be used to analyze higher order optical errors. The character of an error in the field of a septum magnet in the SLC electron damping ring is determined by using RESOLVE. The septum magnet was modified after design to add cooling channels. An electromagnetic kicker coil upstream of the septum magnet is varied and the centroid tracks downstream of the septum are studied. An 'equivalent' kicker at the septum location is deduced from the data. If the septum magnet were a pure dipole, there would

be no inferred differential 'equivalent' kick. A linear differential kick would correspond to a quadrupole. The results illustrated in Figure 4 suggest higher-order, viz. more complicated field effects. This problem is still being investigated.

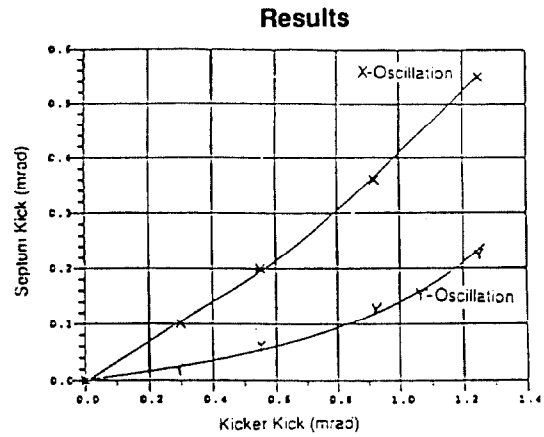


Figure 4. Field Analysis Result

V. FUTURE DEVELOPMENT

Long term objective of AIM is its software implementation in a complete on-line, model reference control system. The core of this control system software would be a real-time database RTDB, such as that developed for the PEP. Future AIM would provide the analysis, the graphics, displays, and the software interfaces for the RTDB, the system software between local nodes and the RTDB. "Look and adjust" analysis functions of AIM would be automated [6]. Other modeling and analysis capabilities will also be added. Future development is being extended to a UNIX-based Workstation and with X-WINDOWS graphics interface. For example, RESOLVE has already been extended to UNIX (with X-WINDOWS).

VII. REFERENCES

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