The Graphic Environment for Transport Line - Control and Beam Diagnostics

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Abstract

This paper describes a computer program that is used in control of beam transport line from preinjector to booster ring of dedicated synchrotron radiation source "Siberia-2" (Kurchatov Institute, Moscow). The program combines the control of magnet structure, beam simulation and on-line beam monitoring. A graphical interface and mouse input provide an easy select and control of magnet elements. The program computes the beam transport using a first-order matrix formalism. The instantaneous display of the computed beam trajectories provides the necessary feedback to the user. The program displays information from beam position monitors in specific graphical window. The dialog windows contain list of elements, control buttons and list box with the real currents of power supplies. The operator interface and beam simulation are written in C++ language under MS-Windows.

I. Introduction

The dedicated synchrotron radiation source "Siberia" includes linac injector, small storage ring booster (450 MeV), main storage ring (2.5 GeV) and two transport lines. It is comfortable, when operator has interactive access to magnet elements control, beam diagnostic and simulation of electron-optical beam lines. Also, at the beginning stage of beam alignment procedure, the magnet structure of storage ring can be presented as transport line. The presented program allows to calculate particle motion trajectories and beam envelope. The program applies at commissioning stage and makes simple beam modeling "help", but difficult to use for development and optimization magnet system.

II. Beam simulation and graphical interface

The beam transport line structure consists of element's sequence. For each element user can to define name, type, drift, magnet structure parameters and graphical image properties. The following element types are taken: bending magnets (in X and Z planes), drift spaces, quadrupoles (no skew), orbit correctors, beam position monitors. The special element type is a functional group of elements. The functional group allows to change some values of structure elements simultaneously. For example, independent control of displacement and slope of beam center at the end of transport line requires two correctors[1]. At that, kick of each corrector can be calculated:

A1 = K11*Y+K12*Y'
A2 = K21*Y+K22*Y'

where Y, Y' displacement and slope at X or Z planes.

The data base files (***.dbf) describe the beam transport line structure and functional group's spreadsheet. The program menu item "File" defines standard file exchange procedures. Beam transport line structure displays in graphical window after reading data base files. At any time user can be select structure part from list of elements. The beam position and envelope are calculated for three hundred points in selected part of magnet structure. This allows to increase accuracy for short part of structure (one or two elements) and to plot graphics in detail.

User sets initial conditions X, X', Z, Z', dp/P for computing the particle motion trajectories. To compute beam envelope Twiss parameter's phase plane ellipse α, β and emittance ϵ are defined. The program menu item "Options" contains edit control window and "listbox" with initial condition parameters. The first-order matrix method applies for computation[2]. Figure 1 shows modeling results for electron beam trajectories in the transport line from linac to booster storage ring "Siberia-1".

The trajectories are displayed in red and blue colors for X and Z planes. The "begin" and "end" values of displacement and slope present in digital form. The "Control" dialog box window may be used for new setting of elements (Fig. 2). Window contains special control buttons and listbox with the beam transport line elements. The mouse input is used for element and value of increase selection. User can to change element setting by "+", "-", "Return" buttons and defines new values of increase. When the optical structure is changed, program computes new trajectories. In the graphical window new

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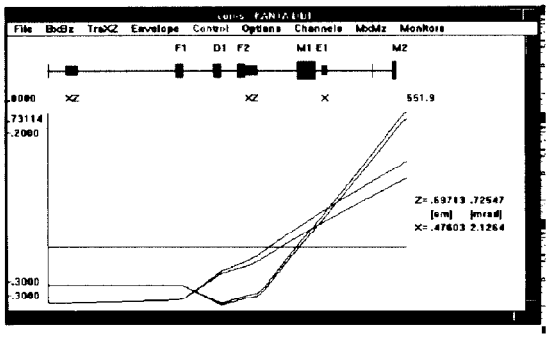

Figure 1: The beam trajectories in the transport line from linac to booster ring "Siberia-1".

trajectories display in dark color, previous in light. If user edits the initial conditions X, X', Z, Z' or dp/P in trajectory's simulation mode the new calculations are performed. The beam trajectories are presented in Fig. 1 after user changes the strength qudrupole F1 and initial displacement in X and Z planes non zero. User can to edit element, which is not presented in the graphical window, and the new computed results can also be displayed. Similarly, the beam envelope mode allows to control and display transport line optical structure.

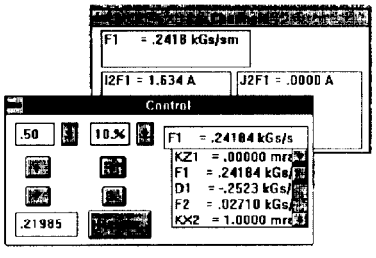

Figure 2: The console windows.

III. On-line control and diagnostic

The special data base describes control and monitoring channels. File defines names, coefficients, service information for power supplies system for each magnet element . In the case of menu item "Channels" is selected, the program performs operative control of power supplies as well as the beam simulation. The window "Channels" shows list of control and measurement parameters for element or functional group. Program is realized data exchange with the control computer, sends steering currents of power supplies and reads actual values of current. At background of Fig.2 on-line control window is presented.
The additional graphical window displays beam position monitors information. Position monitors can be selected from transport line structure using "Monitors" menu. The color marker plots beam position in X, Z plane. The program presents calculated X, Z values for each monitor, and the real beam displacement values can be read from diagnostic control computer. These values are displayed in different colors. If the profile grid monitors are used in transport line, the control computer sends center of gravity and measured profile width of beam. In this case, real beam position may be display in ellipse form at X, Z plane. Figure 3 shows program results for two selected beam position monitors.

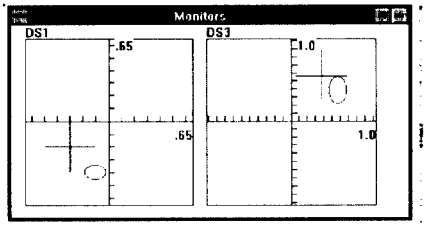

Figure 3: Calculated and measured beam position monitors information.

IV. Application

The program has been used to operate with transport line from 65 MeV linac to the storage ring "Siberia-1". Interactive graphic provides effective operator environment for commissioning. It is planned also to control transport line from booster ring to the 2.5 GeV main storage ring "Siberia-2". MS-Windows and C++ development environment allows to create "window-oriented" user interface.

References

[1] E.Levichev , The Beam Transport Lines for "Siberia" Complex. *BINP Internal Report, 1991* Novosibirsk.

[2] K.L. Brown, R.V. Servranckx, Optical modules for circular accelerator design. *NIM A258 (1987)*,pp.480-502.