AN INTERACTIVE GRAPHICAL USER INTERFACE FOR THE LINAC BEAM DYNAMICS CODE PARMILA

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Abstract

An advanced graphical user interface (GUI) has been developed for use with the PARMILA program. PARMILA (Phase and Radial Motion in Ion Linear Accelerators) is a multi-particle simulation program that provides a detailed description of the evolution of the beam in a linear accelerator. We have ported the Los Alamos Accelerator Code Group's Cray version of PARMILA to the Macintosh and integrated it with the Shell for Particle Accelerator Related Codes (SPARC) GUI environment. Using SPARC, problem set up is accomplished graphically. The configuration of a PARMILA beamline is defined by selecting icons representing transport elements from a palette and dragging them to a window. All input parameters are set using unique Data Tables built into multiple-pane windows. Rule-of-thumb upper and lower guidance limits for each parameter can be displayed to assist users in problem specification. A new interactive mode of PARMILA execution is incorporated. This interactive mode allows users to "step through" the beamline and display phase-space distributions, coordinate scatter plots and other output at specified steps. The impacts of design changes, beamline errors, different initial distributions and other problems addressed by PARMILA are easily studied. The integrated SPARC/PARMILA software is described and examples of using this new approach to running PARMILA are illustrated.

Introduction

PARMILA [1] is the standard program used to model drift tube linacs, and it is also utilized in the design of high-current beam transport lines. Despite PARMILA's widespread use the program is not easy to use, and the initial set up of a design problem is often time consuming, even for experienced users. We have developed a new approach to using PARMILA by integrating it with a GUI designed specifically to support particle beam simulation and analysis programs. Known as the Shell for Particle Accelerator Related Codes (SPARC), this GUI provides a unique software environment customized to the needs of the accelerator community [2]. The approach adopted for PARMILA is similar to that used for integrating the TRACE 3-D program into the SPARC environment [3,4]. The emphasis has been placed upon the "front end" requirements for the GUI, concentrating on the initial problem set up, while retaining the PARMILA output in essentially the same form as users are accustomed to seeing.

Overview of the GUI for PARMILA

Figure 1 shows a computer interface screen for the PARMILA GUI. Three primary elements of the interface are shown: a Menu Bar, Palette Bar, and Document Window. The Menu Bar contains standard menu items as well as specific menus used to support PARMILA.

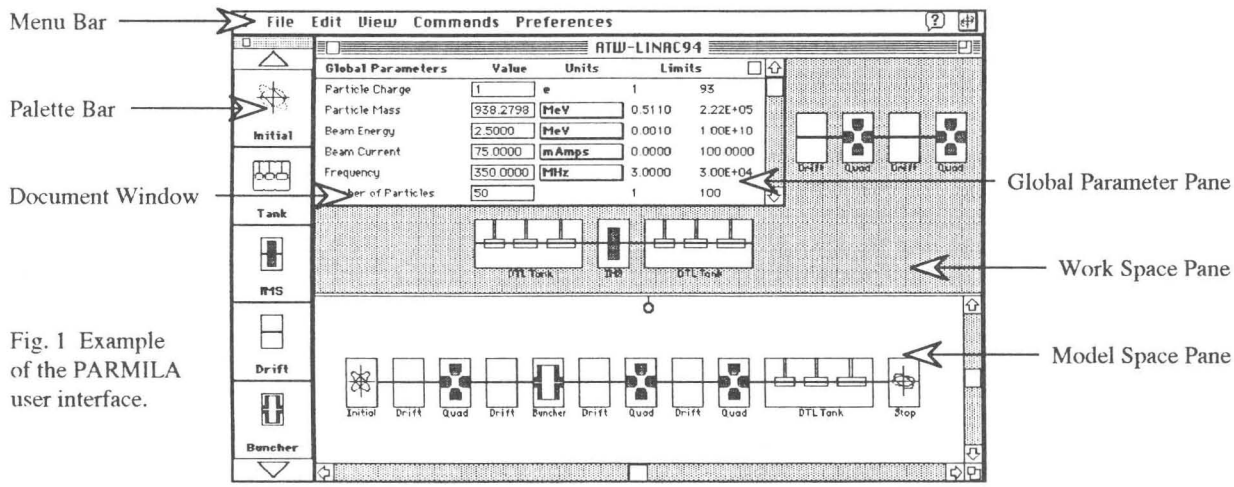

Fig. 1 Example of the PARMILA user interface.

The Document Window and Palette Bar are the primary interface components for setting up a beamline. An example of a PARMILA beamline appears on the lower part (Model Space Pane) of the Document Window in Figure 1. To build a beamline, transport elements are selected from the Palette Bar and dragged to the Model Space Pane of the Document Window. The Palette Bar contains icons representing all of the transport components, DTL tanks, and other elements available in PARMILA, as well as icons for setting up the initial beam and for identifying the stop point of a calculation. The beamline illustrated in Figure 1 contains a 350 MHz proton DTL, with an eight element input matching section, typical of designs for the first part of an accelerator for the transmutation of nuclear waste (ATW). This is one of several examples [5] being used to verify and validate our prototype PARMILA package.

As Figure 1 indicates, low- and high-energy beam transport lines utilize icons for each individual drift, quadrupole, etc., but a complete drift tube linac (DTL) tank is represented by a single icon. Figure 1 also shows beamline segments on the Work Space Pane of the Document Window. The Work Space Pane is useful for temporarily storing elements, or groups of elements, which may be moved in and out of the beamline to examine different beamline designs.

Data Input

Parameters are input using Data Tables. The Global Parameter Pane shown in Figure 1 illustrates the most common type of Data Table that contains five fields for each parameter. These fields provide the parameter name, a value input box, the units of the parameter, and two user guidance limits for the parameter value. The lower and upper guidance limits can incorporate expert system type rules-of-thumb [3,4] to assist the user in setting up problems. The user may select different options for the units of a parameter via pop-up menus in the units field. The guidance limits, as well as the current value, are immediately displayed in the selected units.

The Global Parameters include all of the top level beam parameters, the particle charge and mass, the initial beam energy and current, etc. Data Tables for inputting parameters for each of the beamline elements are accessed via Piece Windows that are displayed on the computer screen by "double clicking" the corresponding icon in the Document Window. Figure 2 illustrates a Piece Window and Data Table for a PARMILA transport element. Some parameters have only a finite number of logical options. In these cases the value input and units fields are combined into a pop-up menu providing the user options. For beamline elements requiring a large number of inputs, such as a DTL tank, multiple pane Piece Windows are utilized that allow the user to flip between different sets of logically grouped elements [6].

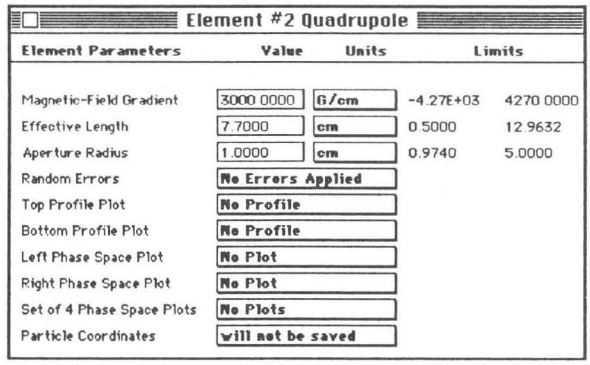

Fig. 2. Piece Window, with Data Table for parameter input, for the quadrupole transport element of PARMILA.

Output Displays

Several run-time output display options are available using the interface we have developed. Profile plots and a variety of phase space plots may be displayed on-screen as the the PARMILA beam dynamics calculations (in subroutines Pardyn and Partran) are proceeding. Figure 3 shows two profile plots, for the DTL through cell 100, for the beamline illustrated in Figure 1. These types of displays have traditionally been available, in main frame versions of PARMILA, only by using postprocessor programs with data archive files. With our interface, the displays are updated during the calculation at user specified points (e.g. after each transport element or DTL cell). An option is available to step through the calculation, from each specified point to the next, to aid in examining the evolution of the beam during the calculation.

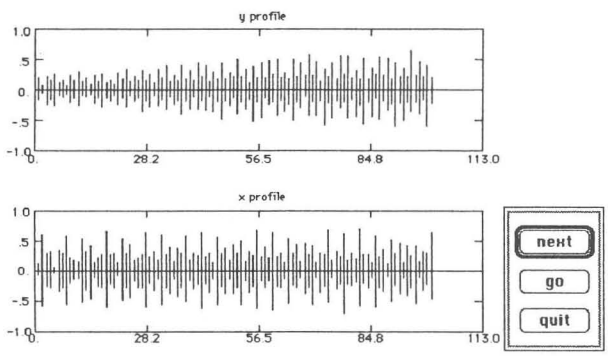

Fig. 3. Vertical and horizontal beam profile displays during the interactive running of PARMILA from the interface.

Scatter plots of the two dimensional projections of the particle distributions may also be displayed during a run. Locations in the beamline, where displays are to be shown during a run, are set using pop-up menus in the Data Tables for transport element. For example, selecting the Show Plots option in the "Set of 4 Phase Space Plots" entry in the Piece Window (see Figure 2) for the first quadrupole in the Figure 1 beamline, provides the display shown in Figure 4. The x'-x, y'-y and Δw-$\Delta\phi$ projections, together with the beam's cross sectional distribution (x-y), are displayed after the calculation has proceeded through the quadrupole. The user is offered options to proceed to the next display (next button), continue through the calculations with only a pause at each display (go button) or to return to the interface (quit button) to modify the beamline or to the change simulation or display options.

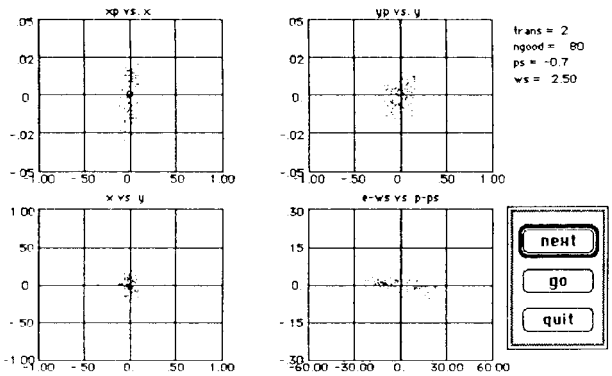

Fig. 4. Example of phase-space displays during the interactive running of PARMILA from the interface.

PARMILA generates large amounts of output data, not all of which can be accommodated simultaneously on the computer screen. Typically, selected output is written to data files for later analysis. For our PARMILA, the user has the same options available for archiving this data as is found in the main frame versions [1]. A set of analysis tools is under development to provide immediate post-processing capability, and displays of the results, from within the graphical interface environment.

Summary

A new graphical user interface has been developed for the PARMILA code. The new program provides an interactive and intuitive package for designing beamlines and greatly simplifies the use of PARMILA. Both accomplished and novice users of PARMILA should realize increased productivity. The new package compliments other codes operating in the same software environment [3,7] and provides accelerator scientists with a useful and powerful new tool.

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