# NEW GRAPHIC USER INTERFACE FOR THE CHARGED PARTICLE BEAM PROGRAM PARMILA

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## ABSTRACT

An advanced graphic user interface (GUI) has been developed for use with the PARMILA program. PARMILA (Phase and Radial Motion in Ion Linear Accelerators) is a multiparticle 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 (S.P.A.R.C.) GUI environment. 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 are displayed to assist users in problem specification. The graphic interface is described and examples using this new approach to running PARMILA are illustrated.

## I. INTRODUCTION

PARMILA [1] has been the standard program used to model drift tube linacs since the program was originally developed by Swenson and coworkers in the mid 1960's at the Midwestern Universities Research Association [2]. It is also now utilized in the design of a variety of high-current beam transport lines and several related programs have been developed from the original code for application to other accelerator structures. While the program has been in widespread use for many years, the user interface has remained largely unchanged. Setting up problems is still time consuming and, with the increased complexity created by the incorporation of many advancements and improvements over the years, is often confusing as well. We have developed a new approach to using PARMILA by integrating it with a GUI, called the Shell for Particle Accelerator Related Codes (S.P.A.R.C.), designed specifically to support particle beam simulation and analysis programs. The S.P.A.R.C. GUI provides a unique software environment customized to the needs of the accelerator community [3]. The Los Alamos Accelerator Code Group's Cray version of PARMILA [4] has been integrated into this new software environment using an approach similar to that adopted for the integration of the TRACE 3-D program into S.P.A.R.C. [5]. The emphasis is placed upon the "front end" requirements for the GUI, concentrating on the initial problem set up, while retaining the PARMILA output in a form similar to that which users are accustomed to seeing.

## II. DEFINING A BEAMLINE

Accelerator beamlines are defined graphically through a mouse-driven "drag and drop" user interface. Figure 1 illustrates the interface screen developed for PARMILA. Three primary elements of the interface are shown: a Menu Bar, Palette Bar, and two Document Windows. The Menu Bar contains standard items, associated with the operating system, as well as specific menu items used to support PARMILA. Examples of these menu items are discussed below. The Document Window and Palette Bar are the primary interface components for setting up a beamline. A Document Window contains all the information associated with a particular beamline problem. Up to six Document Windows may be open simultaneously; Figure 1 illustrates two. 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 configuration of a PARMILA beamline is defined by selecting icons from the Palette Bar and dragging them to the Model Space Pane of a Document Window. When dropped onto the Model Space Pane, each icon "snaps" into place at the end of the beamline. Elements may also be inserted into the middle of a beamline by dragging the appropriate icon to the connection line between any two adjacent icons on the Model Space Pane. The front Document Window in Figure 1 (Document Window 1) shows a beamline consisting of a low energy beam transport (LEBT) matching section, followed by one 350 MHz DTL tank. The Document Window 1 beamline is one of several [6] being used to test and evaluate the integrated PARMILA-GUI package. Document Window 2 shows a 425 MHz DTL matching section. The (Document Window 2) beamline is from the PARMILA documentation [4] and is also being used for testing.

The components of a beamline on the Model Space Pane may be rearranged using the Work Space Pane of the Document Window. Any icon representing a transport element, or any group of icons representing a segment of the beamline, may be selected and moved to the Work Space for temporary storage. Icons or groups of icons on the Work Space may then be inserted into, or placed on either end of, the beamline on the Model Space. The Work Space Pane may also be used for other purposes, such as temporarily storing alternate designs for a given beamline segment. Figure 1 shows a FODO cell on the Work Space Pane of Document Window 1.

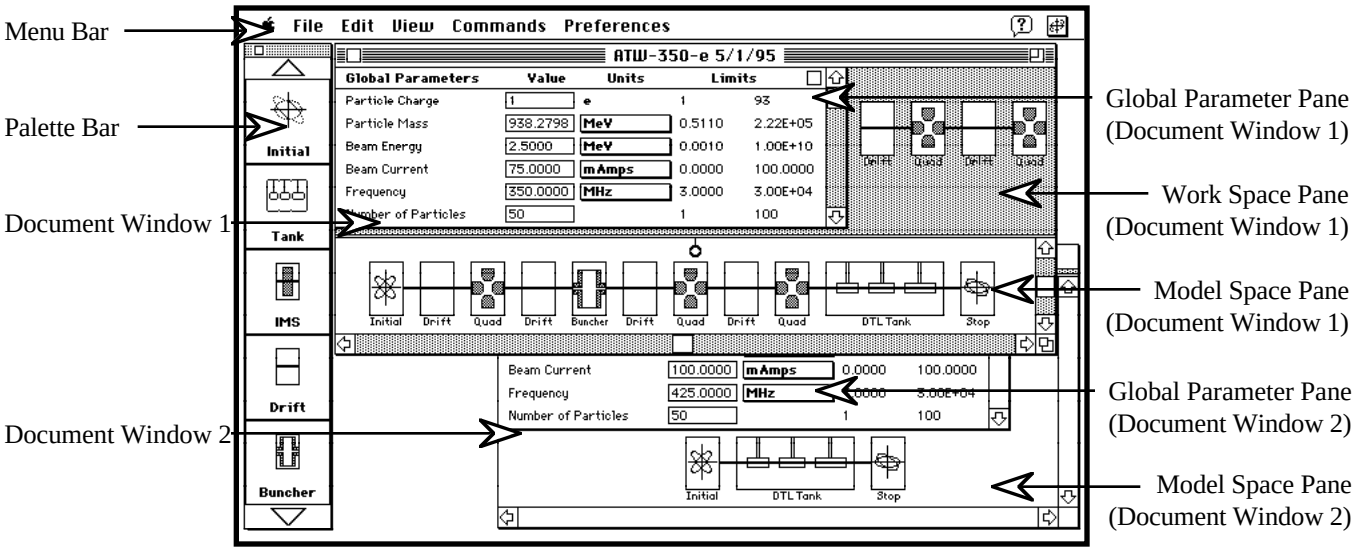


Figure 1. The PARMILA graphic user interface showing two Document Windows open, each with a different beamline.

## III. EDITING INPUT PARAMETERS

Parameters are input using Data Tables. The Global Parameter Pane shown in Figure 1 illustrates the most common type of Data Table, which 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 [5,7] to assist the user in setting up problems. The user may select different options for the units of a parameter, including unique "smart units" [3,5], 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, such as 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. The Piece Window for any beamline component is 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. Certain parameters, such as those used to specify output for the element, have a finite number of options. In these cases, the value input and units fields are combined into a pop-up menu, and no user guidance limits are needed. 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 parameters [8].

The S.P.A.R.C. GUI also provides other powerful beamline editing features. For example, beamline segments, such as the FODO lattice shown in Figure 1, may be copied from one Document Window and pasted into another. This is especially useful when examining similar beamline designs.

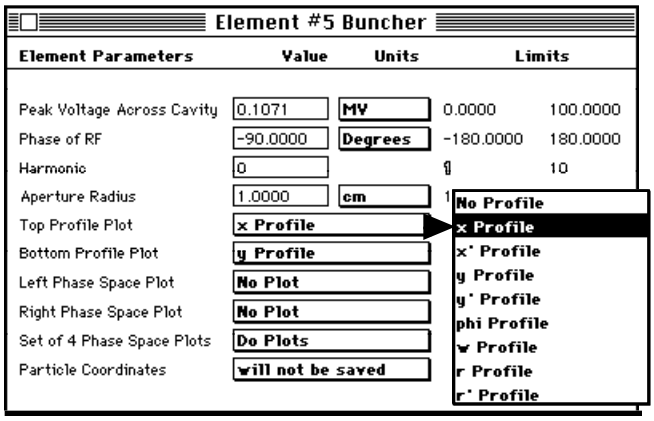


Figure 2. Piece Window, with parameter input Data Table, for the radiofrequency buncher element of PARMILA. Use of a pop-up menu for selection of a profile plot is illustrated.

## IV. SELECTING 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. These plots are the same as those normally generated from PARMILA data output files using a graphics post-processor. In a standard PARMILA input file, the user specifies the output to be generated for each transport element individually by setting a series of six two-digit codes on the data line for every element. The same specification of output options for each individual transport element may be also done using our interface, by selecting from among the options provided by the pop-up menus illustrated in Figure 2. The interface keeps track of the selections and generates the necessary series of two-digit codes for PARMILA. It is frequently desirable to use the same options for all transport elements,

which can be tedious to set up for a long transport line. Our interface provides an automated procedure for doing this.

Figure 3 illustrates a special window (accessed from the Preferences menu item shown in Figure 1) used to specify that the same Profile Plot options be applied to all elements in a section of the beamline. The window shown in Figure 3 is one of several unique input windows that can be used to specify the output displays to be created during a run.

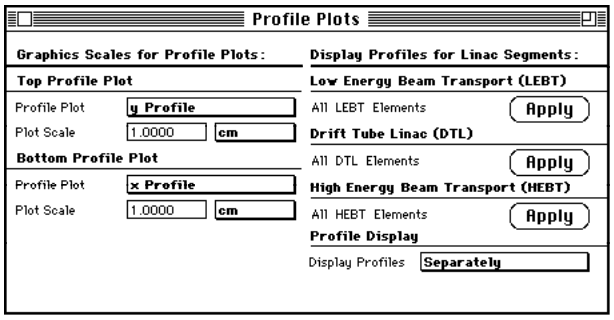


Figure 3. Selecting beam profile display options.

Figure 4 shows two profile plots, for the DTL through cell 100 of the (Document Window 1) beamline illustrated in Figure 1. The plot parameters were specified using the window shown in Figure 3. Results may be viewed, as the PARMILA beam dynamics calculation proceeds, using a new interactive mode that allows users to "step through" the beamline and display profile plots, coordinate scatter plots and other output at specified locations.

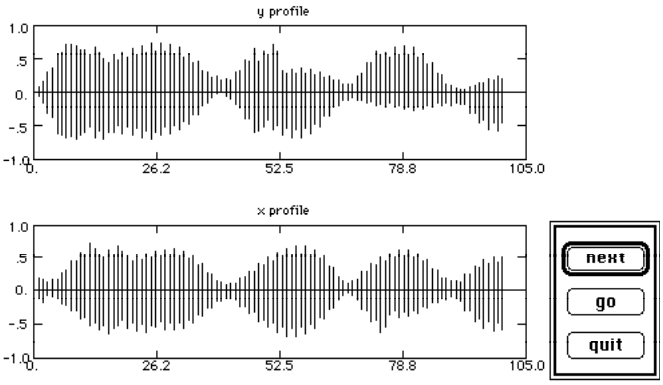


Figure 4. Vertical and horizontal beam profile displays for the interactive running of PARMILA from the interface. The profiles shown are for a severely mismatched beam being injected into the "ATW-350-e" DTL of Figure 1.

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, may be set using pop-up menus in the Data Tables for each transport element (Figure 2) or using other special phase space output selection windows (similar to Figure 3) available from the Preferences menu (Figure 1).

## V. SUMMARY

The integrated PARMILA-GUI package is a useful new tool for accelerator design and analysis. The program provides an interactive and intuitive package for designing transport lines and drift tube linacs. Both experienced and new users of PARMILA should realize increased productivity.

## VI. ACKNOWLEDGEMENTS

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## VII. REFERENCES

[1] G. P. Boicourt "PARMILA - An Overview," AIP Conf. Proc. 177, 1-21 (1988).

[2] B. Austin, T. W. Edwards, J. D. O'Meara, M. L. Palmer, D. A. Swenson and D. E. Young, "The Design of Proton Linear Accelerators of Energies up to 200 MeV," MURA-713, Appendix B "Computer Program for Linac Particle Dynamics," 115-129 (1965).

[3] G. H. Gillespie, "The Shell for Particle Accelerated Related Codes (SPARC) - A Unique Graphical User Interface," AIP Conf. Proc. 297, 576-583 (1993).

[4] G. Boicourt and J. Merson, "PARMILA Users and Reference Manual," Los Alamos National Laboratory Report No. LA-UR-90-127, Revised, 141 pages (1992).

[5] G. H. Gillespie and B. W. Hill, "A Graphical User Interface for TRACE 3-D Incorporating Some Expert System Type Features," 1992 Linear Accelerator Conference Proceedings, AECL-10728, 787-789 (1992).

[6] R. A. Jameson, private communications (1994).

[7] G. H. Gillespie, P. K. Van Staagen and B. W. Hill "Knowledge Rule Base for the Beam Optics Program TRACE 3-D," Proceedings of the 1993 Particle Accelerator Conference, Vol. 1, 86-88 (1993).

[8] G. H. Gillespie, B. W. Hill and J. S. Gillespie, "Making PARMILA Easy to Use - *Really Easy to Use!*" Proceedings of the 10th International Conference on High Power Particle Beams, NTIS Report No. PB95-144317, Vol. 2, 626-633 (1994).