

# USING PARMILA 2 WITH THE PARTICLE BEAM OPTICS LABORATORY

G. H. Gillespie and B. W. Hill

G. H. Gillespie Associates, Inc., P. O. Box 2961, Del Mar, CA 92014, USA

## Abstract

A PARMILA 2 module has been developed for the Particle Beam Optics Laboratory (PBO Lab™). PARMILA 2 is a FORTRAN program used to both design and simulate radiofrequency ion linear accelerators. The program can be used to design radiofrequency accelerators that include drift tube linac (DTL) structures, coupled cavity linac (CCL) structures, coupled-cavity drift tube linac (CCDTL) structures, and superconducting accelerator structures. PARMILA 2 can also be used to simulate beams in these structures, and in transport lines with magnetic, radiofrequency and electrostatic beam optics elements. PBO Lab provides a sophisticated graphic user interface (GUI) for multiple optics codes. From the same familiar interface users can run TRANSPORT, TURTLE, MARYLIE, TRACE 3-D and DECAY-TURTLE. PARMILA 2 now joins this suite of optics codes available as PBO Lab modules. New PBO Lab tools have also been developed to assist users in utilizing different optics codes to simulate and validate the performance of an accelerator designed with PARMILA 2. An overview of the new PARMILA 2 module and associated tools is presented and some of the GUI features are illustrated.

## INTRODUCTION

PARMILA (Phase and Radial Motion in Ion Linear Accelerators) is a computer code used for the design and simulation of proton and heavy ion linear accelerators. The program has a long history and "version 1" has been utilized extensively as a DTL design tool for many years [1, 2]. "Version 2" was developed at the Los Alamos National Laboratory [3,4] to significantly extend the program's capabilities, which now include support for the design of DTLs, CCLs, CCDTLs and two types of superconducting linac structures (SC1 and SC2). Traditional users of PARMILA have needed a detailed knowledge of the input and output file formats and syntax in order to utilize the program efficiently. The development of the PBO Lab module for PARMILA 2 provides an intuitive easy-to-use graphic interface that now simplifies the use of PARMILA and can significantly improve the scientific productivity of researchers using the program.

PBO Lab is a modular suite of software applications that support a variety of accelerator-related programs [5]. Each program is integrated into PBO Lab as an "application module". Most application modules are for specific particle beam optics modeling or simulation programs such as TRANSPORT [6], TURTLE [7], MARYLIE [8], TRACE 3-D [9] and DECAY-TURTLE [7]. Other specialized application modules are also

available [5]. All PBO Lab modules utilize a common graphic user interface (GUI) for constructing and editing iconic object-based computer models of accelerators and beamlines. The use of a standard GUI simplifies the task of setting up a beamline and then carrying out calculations for that beamline with any given optics program. PBO Lab creates input files for each optics program from the same beamline object model representation that underlies the PBO Lab GUI. In addition, PBO Lab modules can automatically display graphical results that might otherwise require post-processors. When a user selects a command from a module menu, PBO Lab generates the input files, executes computations with that optics program, and automatically opens requested text and graphics displays. The new module described here extends that capability to the PARMILA 2 program.

## PBO LAB PARMILA 2 MODULE

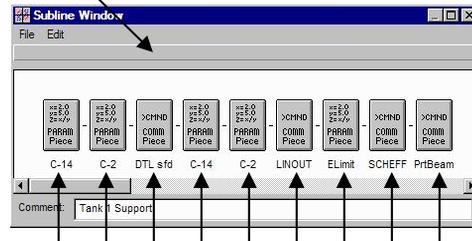
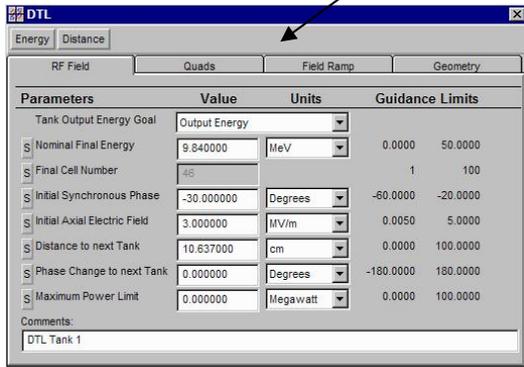
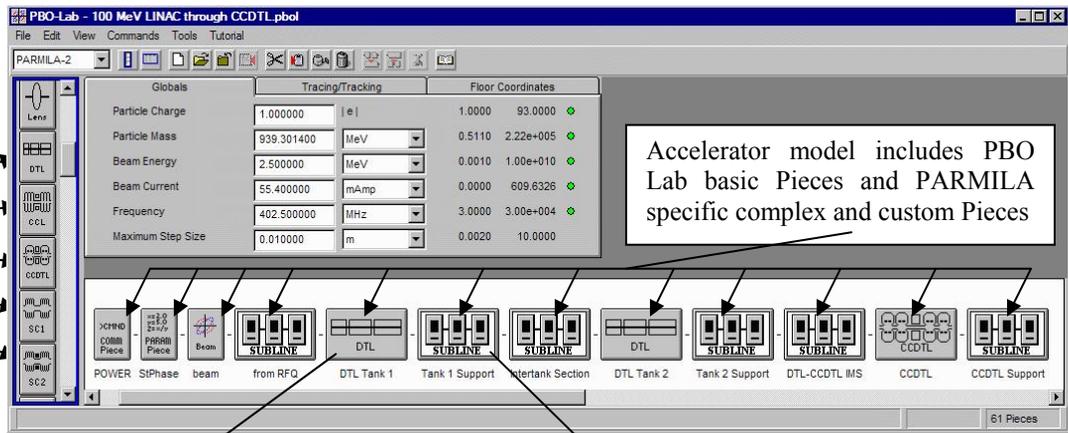
A prototype GUI for PARMILA "version 1" was developed some years ago [10] but was not widely available. To develop the PARMILA 2 module we utilized a new framework available for creating PBO Lab modules. Called OASIS (for Open Architecture Software Integration System) the framework can be used to easily create PBO Lab application modules without the need to write new source code for either the GUI (PBO Lab) or the associated optics program (PARMILA 2). OASIS [11] is a specialized PBO Lab module that is used to create additional PBO Lab modules, where the GUI and related object model provides the framework. Developers use OASIS to define new, custom, instances of objects that are specialized to the needs of their optics program.

The document (or start up) window is the same for all PBO Lab modules including PARMILA 2. Figure 1 illustrates an example document window with an iconic description of a linear accelerator displayed. Each icon represents a basic PBO Lab building block called a "Piece." The accelerator, a nominal 100 MeV proton machine, consists of a DTL, a CCDTL, and some transport sections. The accelerator model was constructed using the "drag and drop" construction kit of the PBO Lab software. The DTL and CCDTL are supported with the use of new PBO Lab "complex" Pieces.

The DTL is comprised of 2 tanks, which are represented by the icons with "DTL Tank 1" and "DTL Tank 2" user-defined labels. Double clicking on the DTL Tank 1 icon opens the data input window ("Piece window") for that DTL. The DTL Piece window is illustrated in the lower left part of Figure 1.

Specialized Pieces for complex RF LINAC structures:

- DTL
- CCL
- CCDTL
- SC1
- SC2



Subline with custom Parameter (PARAM) & Command (COMM) Pieces used to specify design goal changes, design constraints, SuperFish data, outputs, space charge mesh, & other parameters.

Figure 1: PBO Lab document window for use with PARMILA 2. This example shows a model for a proton accelerator with 2 drift tube linac (DTL) tanks and a coupled cavity drift tube linac (CCDTL).

The DTL Piece window features follow the general pattern of other PBO Lab Pieces. All parameters have short plain-language descriptions, choices for units where appropriate, and guidance limits. The guidance limits are intended to help new or infrequent users, and are just for guidance: no numerical input is constrained by the limits.

Parameters for each of the PARMILA 2 complex Pieces are grouped according to their logical relationship. Each group appears on a different tab panel in the Piece window. For example, the DTL Piece window has four such parameter groups and corresponding tab panels: RF Field, Quads, Field Ramp and Geometry. Figure 1 shows the RF Field parameter group as the front tab panel.

The PBO Lab object model hierarchy has been used in Figure 1 to group various sets of elements into Sublines. The Subline with user-specified label "Tank 1 Support" includes a number of custom PARAM and COMM Pieces, used for specialized PARMILA 2 parameters and commands. The Subline detail is displayed in the lower right of Figure 1. The default labels for each of these Pieces are shown and researchers familiar with PARMILA will likely recognize them. For example, C-14 and C-2 refer to PARMILA quadrupole "change types" 14 and 2, while LINOUT, SCHEFF and PrtBeam are PARMILA 2 command keywords. Any label may be modified by a user, for example to add information on specific parameter values set for the Piece.

The use of Sublines is not required but can be very helpful in organizing and describing beamline models. In Figure 1, PBO Lab Sublines have also been used to group the Pieces associated with the transfer lines, which have user-assigned labels "from RFQ," "Intertank Section" and "DTL-CCDTL IMS." Those Sublines include Pieces from the standard PBO Lab transport element set (e.g. drift, quadrupole) as well as specialized PARMILA 2 Pieces. The Sublines with labels "Tank 2 Support" and "CCDTL Support" include elements similar to those illustrated for the "Tank 1 Support" Subline in Figure 1.

Output data from PARMILA 2 can be displayed as text or graphics. PBO Lab custom graphics display capabilities have been adapted to the PARMILA 2 module. In addition, the "native" graphics displays associated with PARMILA 2 are fully supported. The native graphics are traditionally displayed via a post-processor application called LinGraf. The new module directly supports the LinGraf displays through easy-to-use GUI features. Figure 2 illustrates a PBO Lab produced LinGraf display.

### SUMMARY

A new PBO Lab module has been developed for the PARMILA 2 accelerator design program. The new module should benefit both new and experienced researchers involved in linac simulation and/or design.

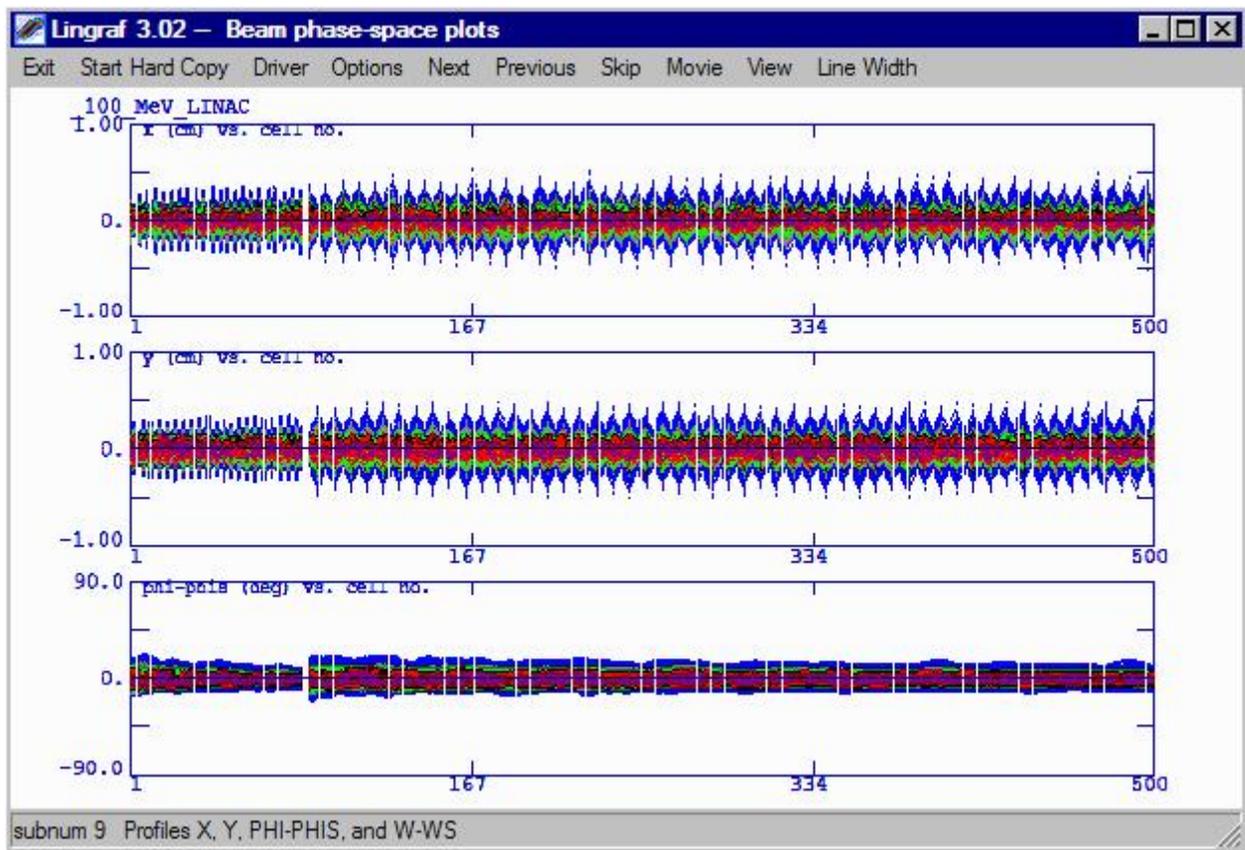


Figure 2. Transverse (upper 2 graphs) and longitudinal (lower graph) beam envelope (profile) plots for the accelerator model illustrated in Figure 1. A thousand macroparticles were used for the simulation through the complete linac. For this example, the beam transmission was 100%, i.e. no macroparticles were lost in the PARMILA 2 simulation.

## ACKNOWLEDGEMENT

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