

LINAC-MULTITOOL – AN OPEN SOURCE JAVA-TOOLKIT*

M. Schwarz[†], D. Bade, J. Corbet, H. Podlech
 IAP, Goethe University, Frankfurt am Main, Germany

Abstract

Dedicating more precious time to advanced research instead of spending it towards time-consuming routine tasks is a desirable goal in particle accelerator simulation and development. Requirements engineering was started at IAP in order to identify routine processes at our institute's R&D that can be automated or simplified. Results indicated that there were several areas to consider: Bead pull measurements, data processing and visualization for the beam dynamics code LORASR, CST field map processing for the use with TraceWin, conversion between different particle distribution data formats and more. Subsequently development of the LINAC-Multitool started to rationalize these processes and replace preexisting scripts also to ensure consistency of results and increase transparency and reliability of computation. In order to guarantee maintainability, expandability and platform independence, LINAC-Multitool is programmed using Java and will be open source. This contribution presents the current state of development.

SOFTWARE ARCHITECTURE

In preparation of choosing an appropriate platform (programming language, GUI toolkit, other libraries) three key factors emerged: Ease of use, maintainability and expandability. In conclusion Java, the probably most widely used programming language for the development of desktop applications, was chosen. It offers a convenient GUI toolkit (JavaFX [1]), which is bound to be supported for a long time by Oracle but still enables us to integrate all the features one would expect from a modern UI. The same goes for Java as a programming language and has been proven in the past as code that was written years ago can still be used. Other languages which sparked our interest however have undergone design changes in their past which broke source code compatibility and therefore were not as suitable as Java. In addition, we profited from the availability of a competent plotting framework – JFreeChart [2], which allowed us to introduce advanced features like data selection into our graphs and proved to be a stable base. As a team of two students and one supervisor kicked off this project, we chose to part the program along the lines of frontend and backend. The backend part includes all the parsing of files and most of the computational aspects for bead-pull measurements while the frontend part focuses on GUI, handling 3d field maps as well as particle distributions and better visualizations for LORASR-computations [3] in order to minimize friction and overall improve efficiency of implementation. In order to maximize our throughput we chose to minimize our re-

liance on expensive computational libraries wherever we could come up with more resource-conservative ideas. Figure 1 depicts an excerpt of the program architecture whose classes and functions can be categorized on the whole as *read*, *parse*, *analyze* and *visualize*.

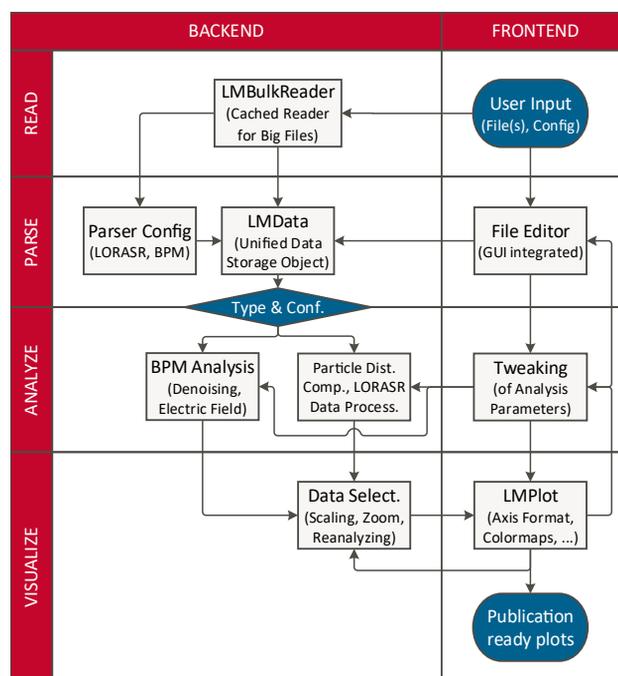


Figure 1: Schematic layout of the program architecture.

RANGE OF FUNCTIONS

An overview of the planned features for the LINAC-Multitool is given in Fig. 2. Up to now they can be divided into four parts: *LORASR*, *Bead Pull Measurement*, *Particle Distributions* and *CST Field Maps*. Finally, they will be documented in detail both in the source code and the user manual. The initial features are given in the following:

LORASR LORASR is a multi-particle tracking code for the beam dynamics design for all kind of DTLs, optimized for the "Combined Zero Degree Structure (KONUS)" lattices [4–8]. The code has been used for the beam dynamics design of many linacs in operation or under construction like GSI-HLI, -HSI and -pLINAC, CERN Linac 3, TRIUMF ISAC-I, HIT, MedAustron, HILac/NICA and MYRRHA. As its first code version was already developed in the late 80s, the possibilities for graphical user interactions were and are still not very wide-ranging. Nevertheless, the code has been significantly improved in the past decades with better gap field representation, a PIC space charge routine, error study

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[†] schwarz@iap.uni-frankfurt.de

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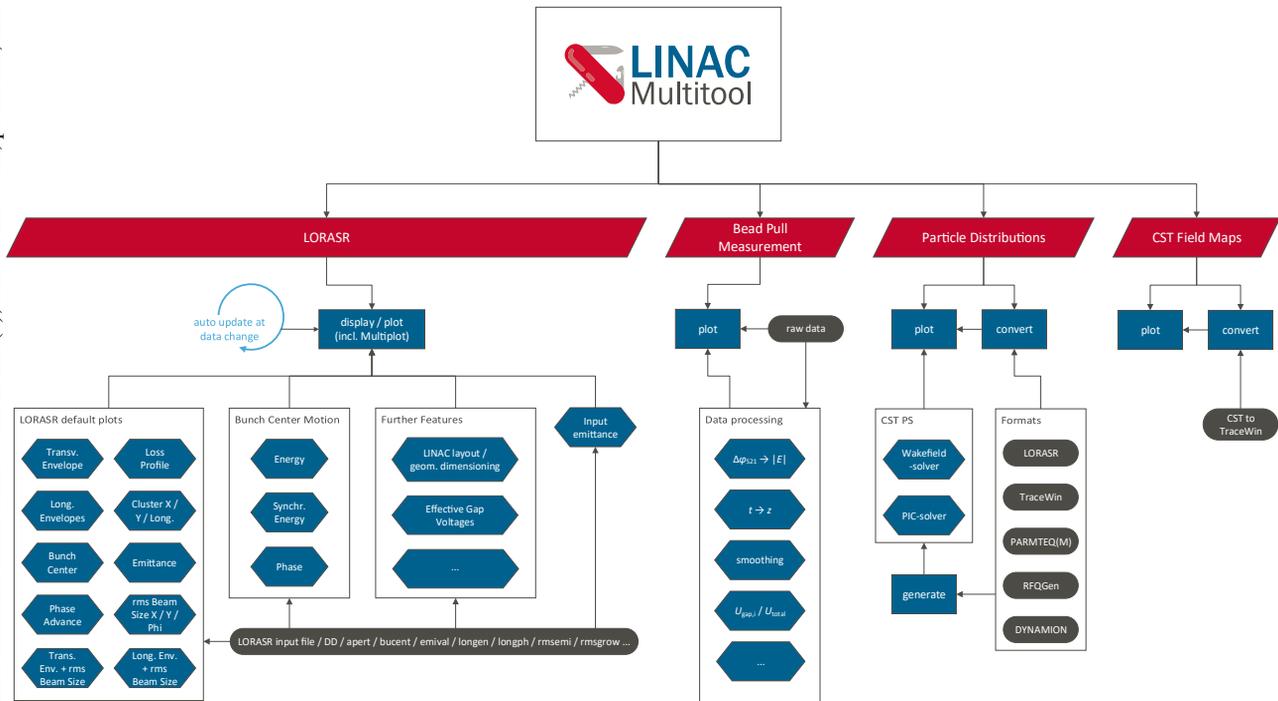


Figure 2: Feature diagram of the LINAC-Multitool giving an overview of the so far planned subprograms.

tools and more so it is still an important and powerful design tool. To optimize the workflow in daily work routines, LINAC-Multitool offers users not only the same plotting functionalities as already given by LORASR, but extends it by features like export of vector graphics, color-coded plots of phase space distributions (see Fig. 3), a schematic of the designed linac layout geometry, stacked plots and additional plots like energy and gap voltages as function of z -position.

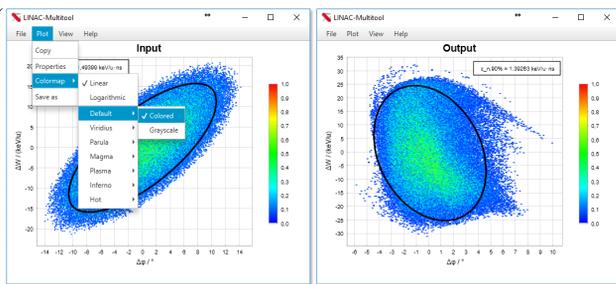


Figure 3: Longitudinal phase space input/output distribution of a LORASR-simulation, plotted with color-coded density. Beside the standard rainbow-colormap, perceptually-uniform colormaps will be implemented to ensure printability in color and grayscale as well as for being viewed by persons with a color vision deficiency, too.

Bead-pull measurement A bead-pull measurement is usually done after cavity manufacturing by placing a small dielectric or metallic bead inside the cavity. By pulling it with a non-conducting wire (e.g. made of a polyamide or rather nylon fishing line) through the cavity, one can measure the electromagnetic fields distribution on resonance inside.

To speed up the analysis of bead-pull measurements, usual data processing steps can be manually and automatically done with the LINAC-Multitool (Fig. 4). These involve:

- Plotting the absolute value of the relative E -field distribution $|E(z)|$ (obtained by calculation from the measured phase shift $\Delta\varphi_{S21}$) as function of the position on beam axis z (obtained by the acquisition time t),
- smoothing the measurement by a weighted moving average with adjustable window size,
- classification of noise at the beginning and end points,
- identification of individual gaps and calculation of the relative voltage distribution,
- comparison between multiple measurements and/or imported simulation data,
- extensive data and graphic export functionalities,
- potentially further calculations like R/Q and more.

Particle Distributions The data format of particle distributions of most beam dynamics codes like LORASR, TraceWin [9], DYNAMION [10] and PARMTEQ [11] differ from each other. While converting is basically quite simple, LINAC-Multitool makes programming of separate converting scripts redundant. However, additional data formats can be defined straightforward and saved by the user for future use.

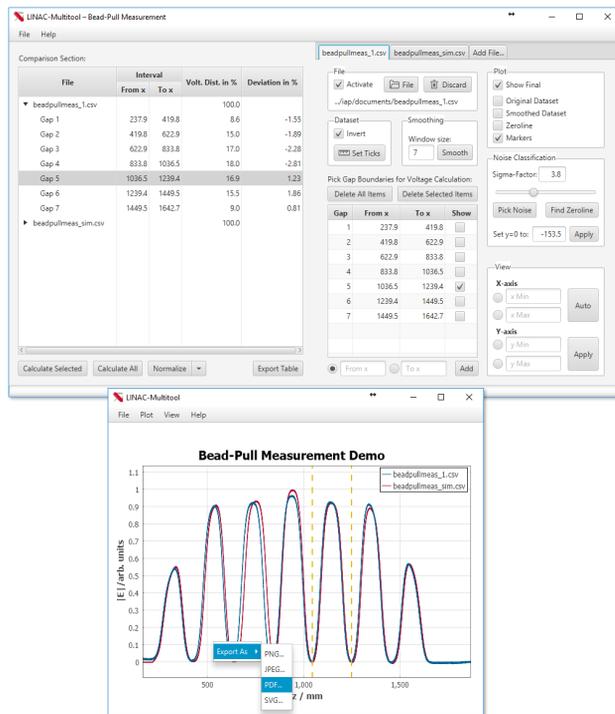


Figure 4: Screenshot of the bead-pull measurement GUI.

3D Field Maps Electric and magnetic field data gained by simulations of CST EM STUDIO and CST MICROWAVE STUDIO [12] can be used in TraceWin after data format conversion. With LINAC-Multitool this conversion can easily be done, providing 3D field maps for TraceWin as an alternative to the use of elements with "hard edge"-approximation.

Outlook

Code development for the LINAC-Multitool has started successfully and first nightly build versions will be tested in the next months. An extensive feature list will tackle several routine tasks in R&D of linear accelerators and thus simplify workflows. A first release is envisaged for the second half of 2018.

ACKNOWLEDGMENT

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