DESIGN STUDIES WITH DEMIRCI FOR SPP RFQ

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ABSTRACT

To design a Radio Frequency Quadrupole (RFQ) is a onerous job which requires a good understanding of all the main parameters and the relevant calculations. Up to the present there are only a few software packages performing this task in a reliable way. These legacy software, though proven in time, could benefit from the modern software development tools like Object Oriented (OO) programming. In this note, a new RFQ design software, DEMIRCI is introduced. It is written entirely from scratch using C++ and based on CERN's OO ROOT library. It has a friendly graphical user interface and also a command line interface for batch calculations. It can also interact by file exchange with similar software in the field. After presenting the generic properties of DEMIRCI, its compatibility with similar software packages is discussed based on the results from the reference design parameters of SPP (SNRTC Project Prometheus), a demonstration accelerator at Ankara, Turkey.

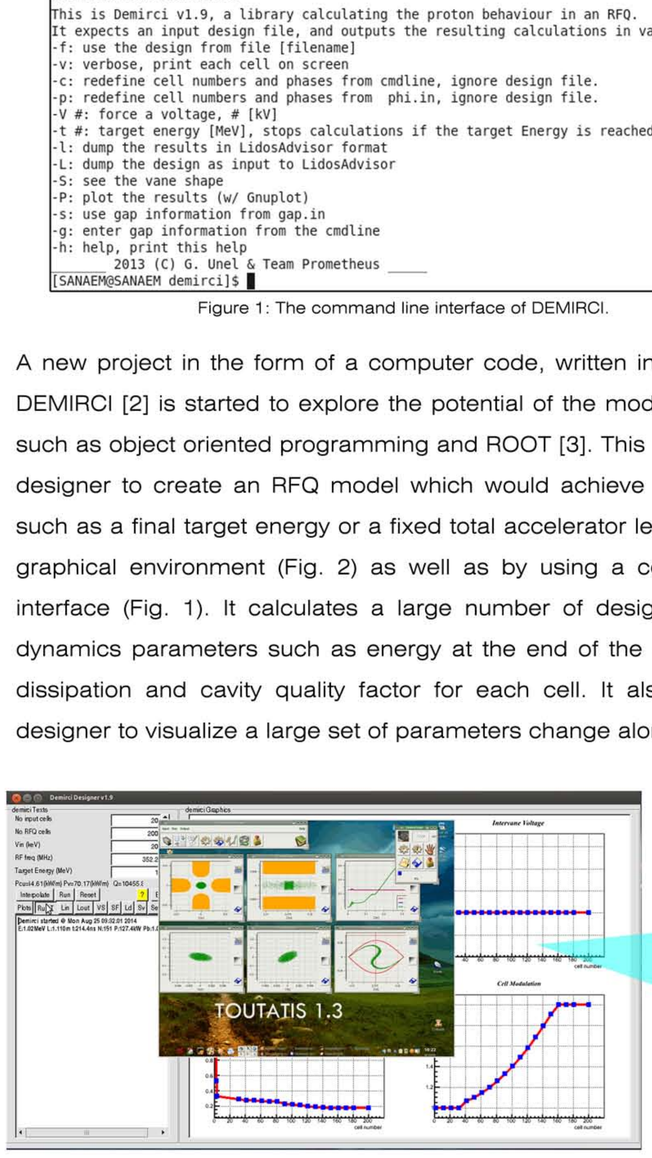
INTRODUCTION

The design of a 4-vane RFQ, which is the focus of this poster, and its manufacture require precise calculation of the relevant parameters, a good understanding of the materials and high precision machining [1]. The high precision modulation requirement on the vanes can be met by the computerized milling tools, i.e. CNC machines. However, the art of designing an efficient RFQ and the study of its beam dynamics properties necessitate repetitive lengthy calculations: an ideal task for computers. Additionally, the commonly used Unix-like environment provided by Linux and OSX workstations does not have access directly to Microsoft Windows specific software packages.

```
[SANAEM@SANAEM demirci]$ ./demirci.exe -h
~~~~~~~~~~~~~~~~~~~~~~~~
Welcome to  Demirci  v1.9
~~~~~~~~~~~~~~~~~~~~~~~~
This is Demirci v1.9, a library calculating the proton behaviour in an RFQ.
It expects an input design file, and outputs the resulting calculations in various formats.
-f: use the design from file [filename]
-v: verbose, print each cell on screen
-c: redefine cell numbers and phases from cmdline, ignore design file.
-p: redefine cell numbers and phases from  phi.in, ignore design file.
-V #: force a voltage, # [kV]
-t #: target energy [MeV], stops calculations if the target Energy is reached.
-l: dump the results in LidosAdvisor format
-L: dump the design as input to LidosAdvisor
-S: see the vane shape
-P: plot the results (w/ Gnuplot)
-s: use gap information from gap.in
-g: enter gap information from the cmdline
-h: help, print this help
_____ 2013 (C) G. Unel & Team Prometheus _____
[SANAEM@SANAEM demirci]$
```

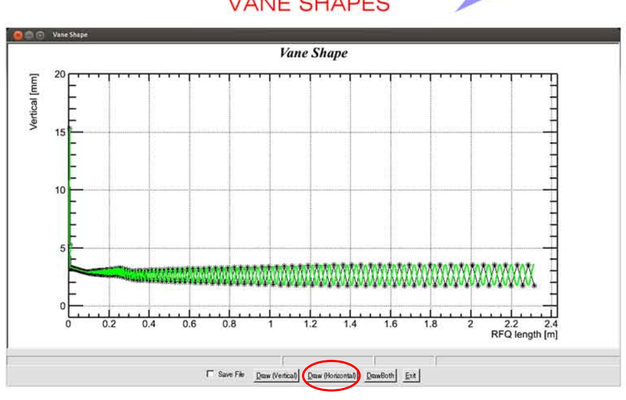
Figure 1: The command line interface of DEMIRCI.

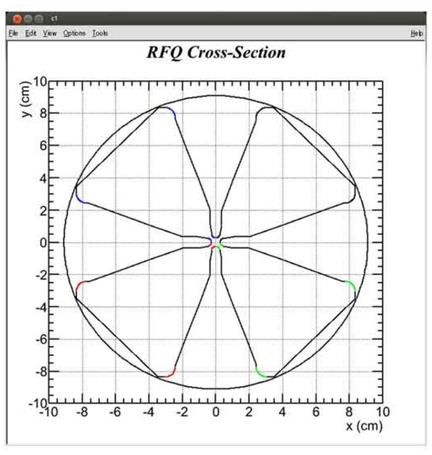
A new project in the form of a computer code, written in C++, called DEMIRCI [2] is started to explore the potential of the modern concepts such as object oriented programming and ROOT [3]. This tool helps the designer to create an RFQ model which would achieve certain goals such as a final target energy or a fixed total accelerator length in a fully graphical environment (Fig. 2) as well as by using a command line interface (Fig. 1). It calculates a large number of design and beam dynamics parameters such as energy at the end of the cavity, power dissipation and cavity quality factor for each cell. It also allows the designer to visualize a large set of parameters change along the RFQ.

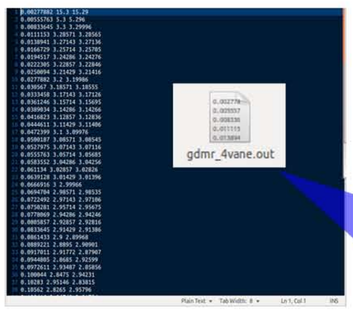


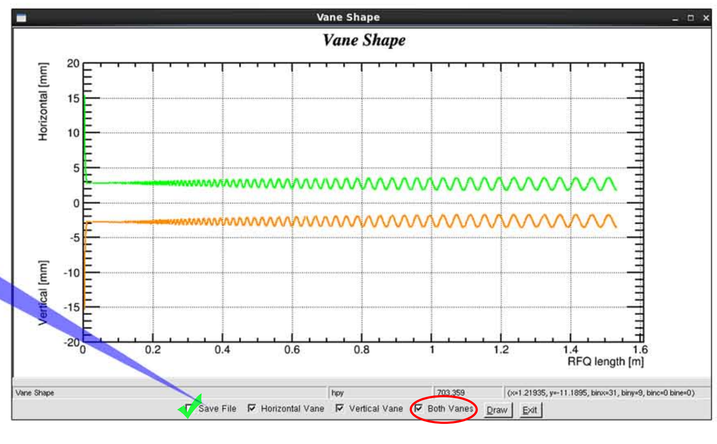
TOUTATIS [4] is a beam dynamics simulator for high intensity RFQs and makes this using Poisson solver for fields which provides to get values such as space charge effects or cavity fields between the electrodes. It interacts with DEMIRCI for RFQ beam dynamics simulation purposes. DEMIRCI's default output file is compatible with TOUTATIS's input. In fact, DEMIRCI's current version relies on TOUTATIS for all beam dynamics simulations.

VANE SHAPES







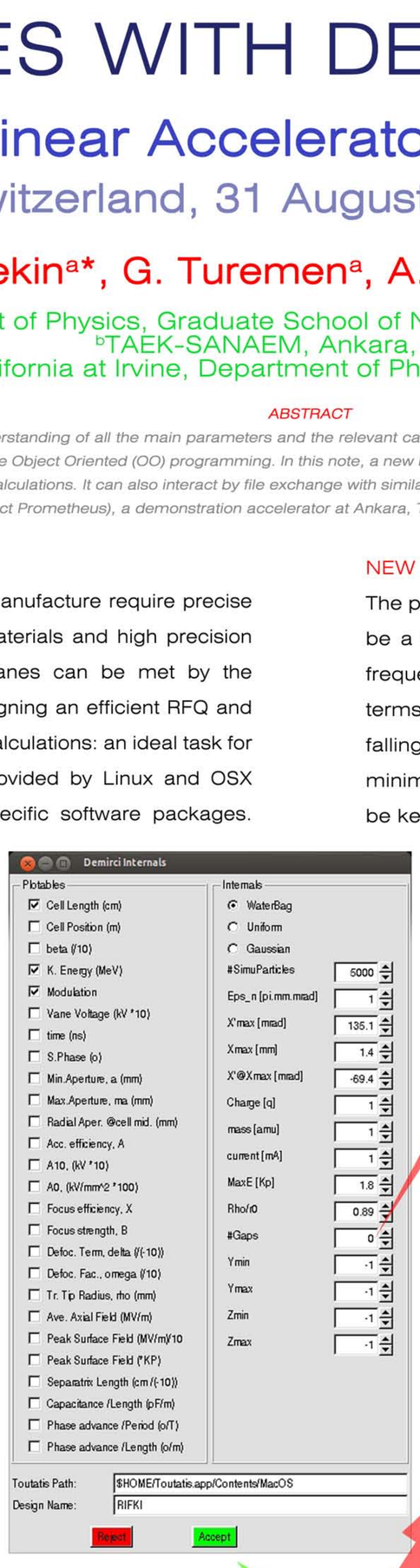


REFERENCES

[1] T. Wangler, "RF Linear Accelerators", 2nd edition, Wiley Books, 2008.
[2] G. Turemen, G. Unel, H.B. Yasatekin, DEMIRCI: An RFQ Design Code Description, In Preparation.
Demirci authors can be contacted by email at the following address: demirci.info@gmail.com
[3] R. Brun and F. Rademakers, ROOT - An Object Oriented Data Analysis Framework, Proceedings AIHENP'96 Workshop, Lausanne, Sep. 1996, Nucl. Inst. & Meth. in Phys. Res. A 389 81-86, 1997.
[4] R. Duperrier, "TOUTATIS: A Radio Frequency Quadrupole Code", Phys. Rev. Vol.3, 124201, 2000.

NEW DESIGN PROCEDURE

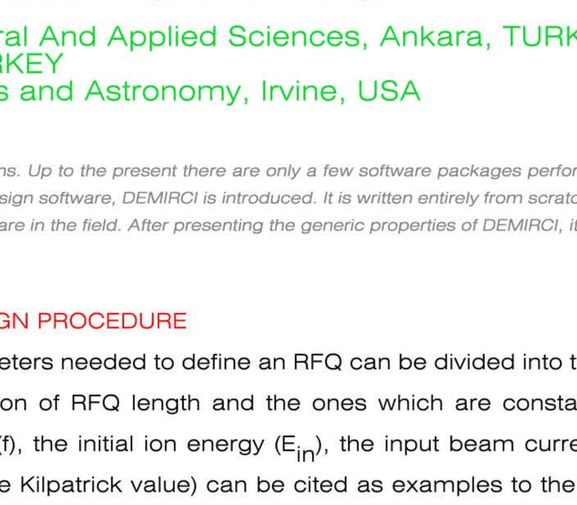
The parameters needed to define an RFQ can be divided into two categories: the ones which can be a function of RFQ length and the ones which are constant for a given RFQ. The resonant frequency (f), the initial ion energy (E_{in}), the input beam current (I) and the braveness factor (in terms of the Kilpatrick value) can be cited as examples to the latter. The four parameter vectors falling into the first category are: the synchronous phase (phi), the cell modulation (m), the minimum bore radius (a) and the inter-vane voltage (V). This last one, together with R/rho could be kept constant along the RFQ length to simplify the design and manufacture.

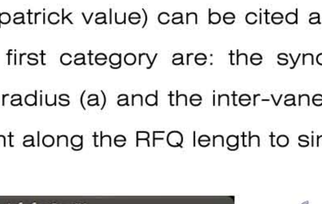


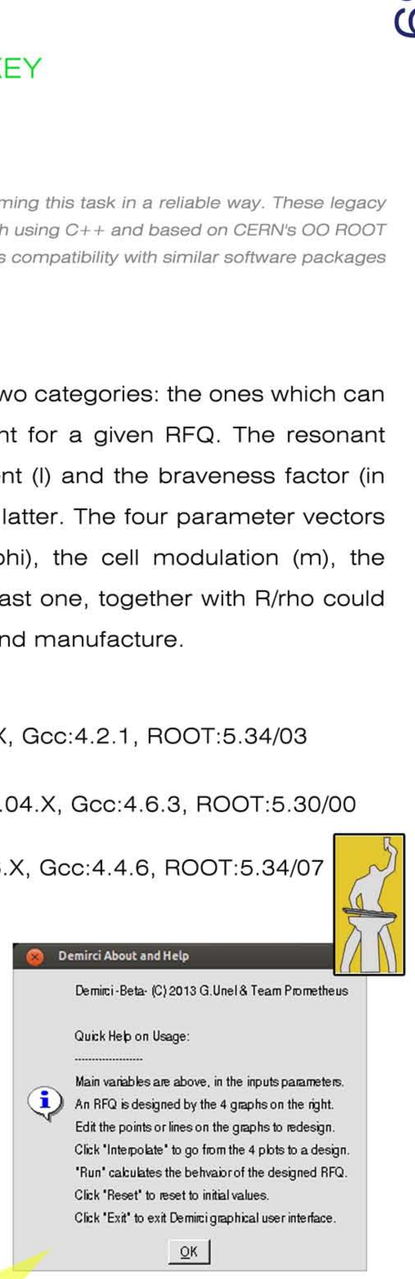
Mac OS X : 10.8.X, Gcc:4.2.1, ROOT:5.34/03

Linux Ubuntu : 12.04.X, Gcc:4.6.3, ROOT:5.30/00

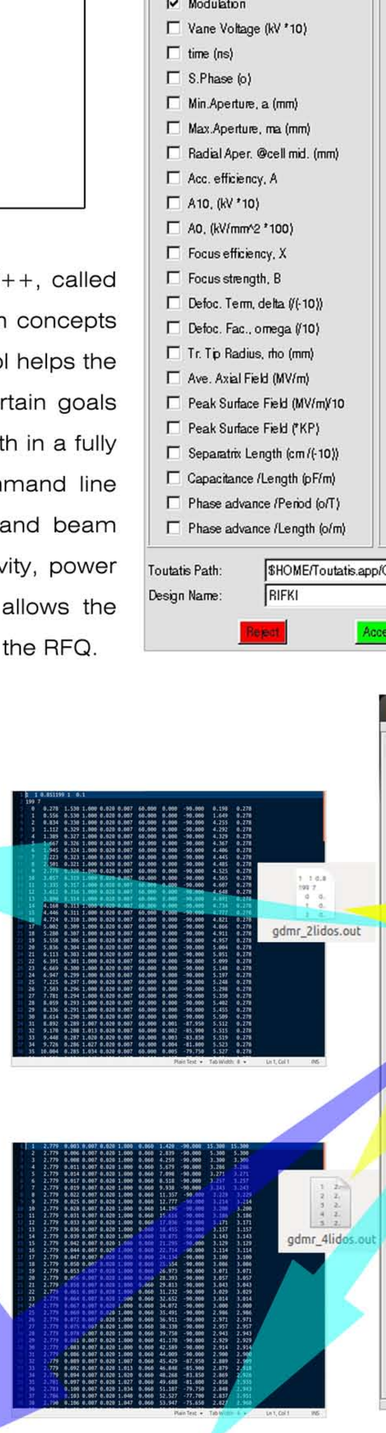
Scientific Linux : 6.X, Gcc:4.4.6, ROOT:5.34/07







The number of RFQ cells can be changed from the default value of 200 to allow the design of longer RFQ cavities.



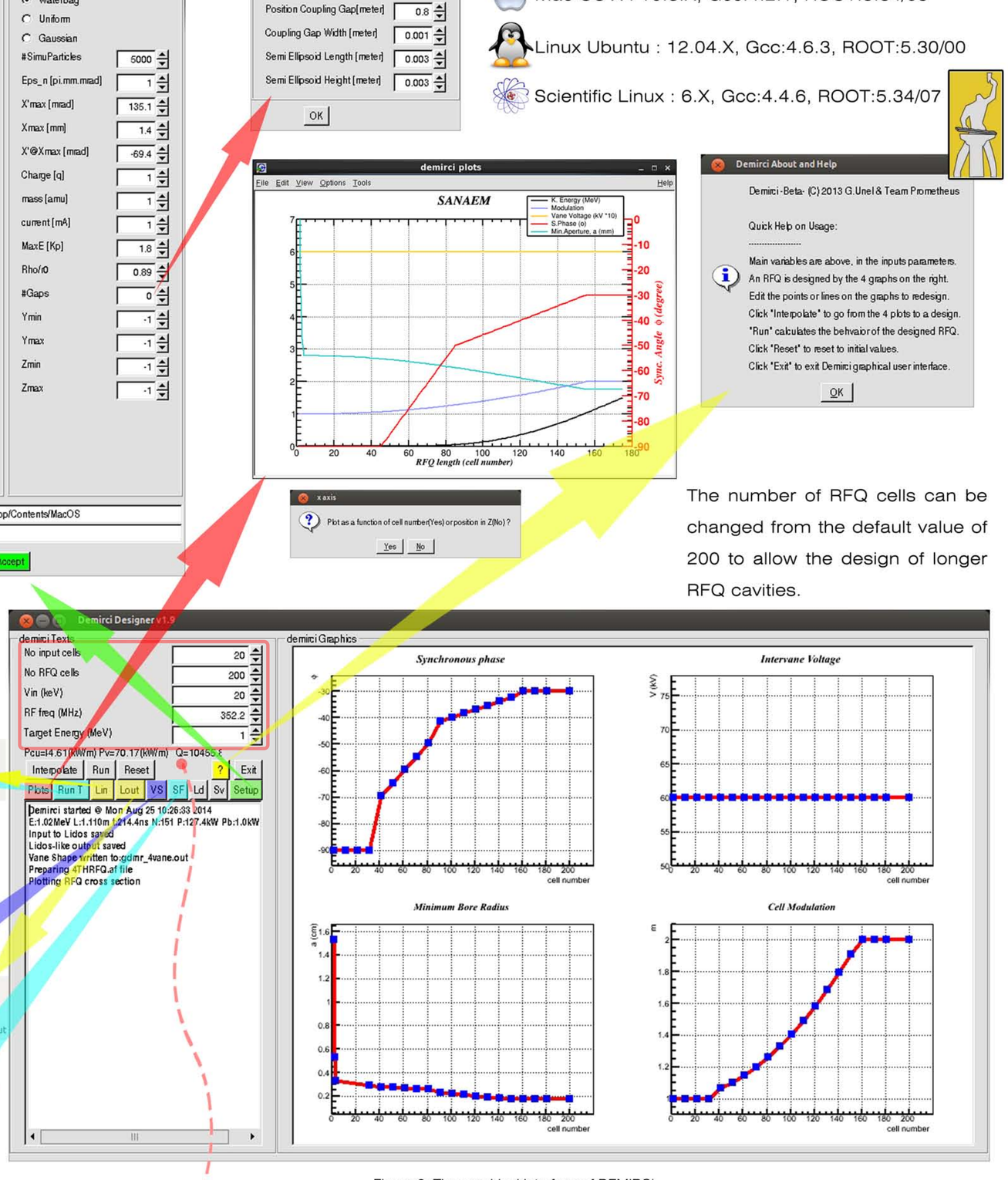
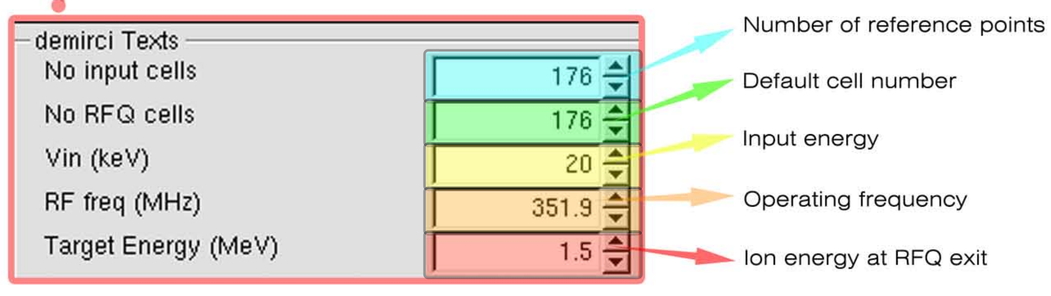


Figure 2: The graphical interface of DEMIRCI.

All the scalar RFQ parameters can be tuned using the number entry boxes at the upper left side of the designer window.



Parameter	DEMIRCI	Other	%Δ
RFQ Length (m)	1.555	1.585 |L|	1.89
		1.549 |T|	0.39
Exit Energy (MeV)	1.54	1.52 |L|	1.32
		1.49 |T|	3.36
Travel Time (ns)	249.9	265.8 |L|	5.98
		243.8 |T|	2.50
Quality Factor	10461.6	10341.6 |S|	1.17
		10216.4 |C|	2.40
RF Power (W/cm)	128.12	123.56 |S|	3.69
		125.08 |C|	0.03

Table 1: Results from DEMIRCI's calculations as compared to other programs results. Keys are T:TOUTATIS, L:LIDOS, C:CST, S:SUPERFISH

The compatibility between DEMIRCI and similar programs in the field, for basic parameters such as beam energy, RFQ length, quality factor and so on, is given in Table 1. The input parameters used by different programs are all the same, originating from the previously discussed design of the SPP RFQ.

FUTURE PROSPECTS

A number of additions and enhancements are being planned for this new tool. The first goal is to use the more complex 8 term potential to allow a more realistic calculation of the EM fields inside the RFQ. This enhancement is expected to further reduce the small deviations in the results obtained with this tool and similar ones. Furthermore, addition of beam dynamics calculations would make DEMIRCI a more complete solution for the RFQ design.

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