
LIDOS

Linac Ion Dynamic Optimization & Simulation

LIDOS.RFQ.DesignerTM

Version 1.0

User's Guide

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1. Introduction

The computer codes **LIDOS.RFQ.Designer™** is intended for RFQ designing and analysis. It contains three items:

"Adviser"	or RFQ Designer Level 1 Advisor
"Vane Real Shape"	or RFQ Designer Level 2 Modeler
"Beam Simulation"	or RFQ Designer Level 3 Simulator.

The item "Adviser" gives a possibility to make preliminary data analysis and to calculate the main parameters. It can to

- set linac parameters;
- plot variations of intervane voltage, synchronous phase, bore radius and modulation factor;
- calculate cell lengths;
- simulate beam motion in the frame of ideal RF field approximation;
- estimate RF losses in cooper and RF supply parameters.

This item gives also a possibility to simulate beam motion in the frame of ideal RF field approximation using data obtained by PARMTEQ.

The item "Vane Real Shape" gets parameters for vane shape description and allows finding input beam optimal size and convergence.

The item "Beam Simulation" allows to simulate beam motion taking into account vane real shape, gaps between cavity sections, fringe fields, Crandall cell, etc.

2. Code Package

The complete code package includes the following directories:

LIDOS.RFQ	contains main executive codes, library of image-based subroutines and help files.
\RFQ	directory contains executive files for linac designing and file for intermediate result keeping.
\DAT	directory contains used constants.
\DAT1	directory contains data for different calculated linacs and cavity parameter for additional ones proposed by user.
\MANUAL	directory contains user guide, description of mathematical models as well as subdirectory SOURCE with source files for linac calculation codes.

NOTE: The contents of the directories included on your depending upon the LIDOS RFQ Designer modules (Levels 1, 2, 3, Standard or Professional) for which you have purchased licenses.

3. Code Run

To run program

Run START.BAT file.

4. Main Menu

4.1. Main Window

4.1.1. Main Window Description

The main Windows form was opened after RFQ.EXE running (see Fig.1). Windows form contains:

- Menu (1)
- Three buttons for new accelerator parameter definition or previously calculated linac (2-4).
- Five buttons for corresponding code running (5):
 - Adviser
 - Vane Real Shape
 - Beam Simulation
 - About
 - Exit
- Marker with linac name (6).

The following procedures can be made in this window:

- parameter record for new linac,
- parameter record for new linac on the base of PARMTEQ input data,
- using previously calculated linac parameters,
- linac directory cancellation,
- user cavity directory cancellation,
- exit.

The running of “Adviser”, “Vane Real Shape” and “Beam Simulation” is made by corresponding button click.

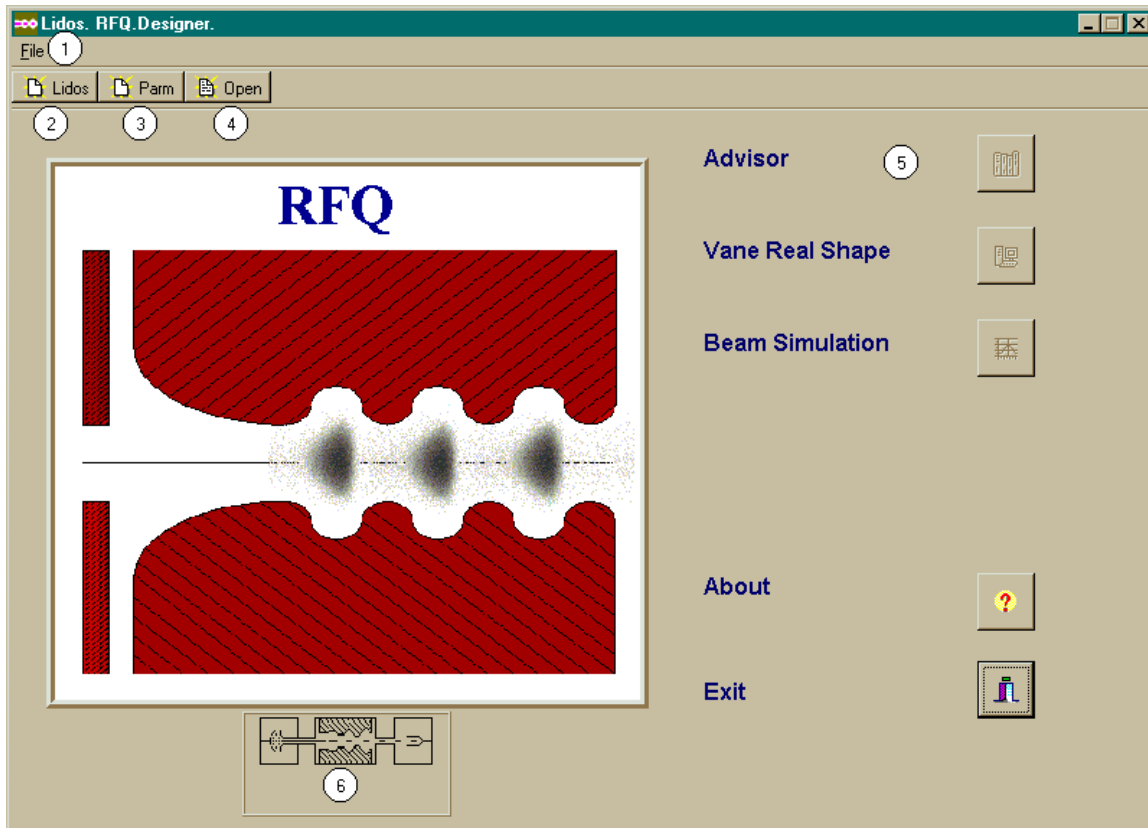


Fig.1. Main Window.

4.1.2. New Linac Parameter Record

To record new linac parameter

Press quick button Lidos (2) to open new file (see Fig.1 - Main Window).

or

Choose menu commands File, New, Lidos to open Create New Linac window (see Fig.2). Insert file filename and click Ok button (2). Insert file short description and click Ok button (4).

Note

File name must not coincide with names of pre-calculated linacs listed in (5)

New Linac window appears (see Fig 3).

Fulfill tables Linac Parameters, Beam Parameters (2)

Press Ok button (3).

Find needed cavity type on Cavity Parameters panel with help of switch (5).

Press Ok button (8).

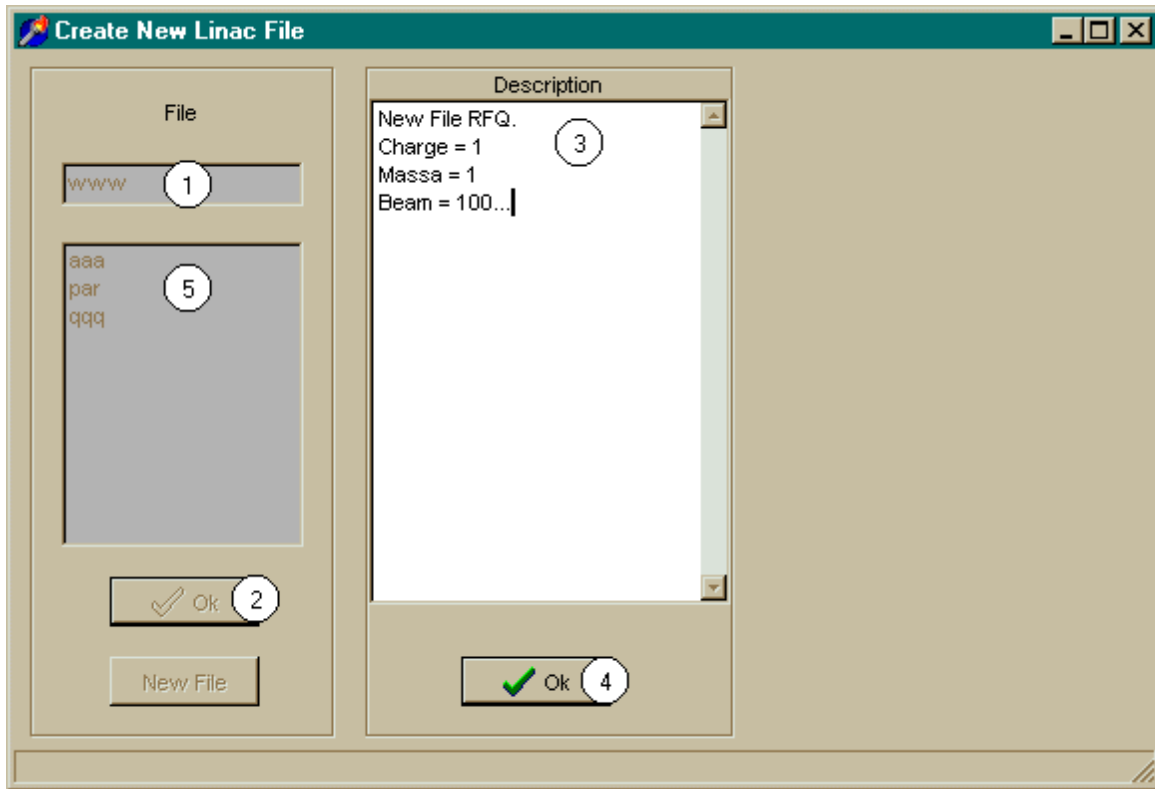


Fig.2. Create New Linac Window.

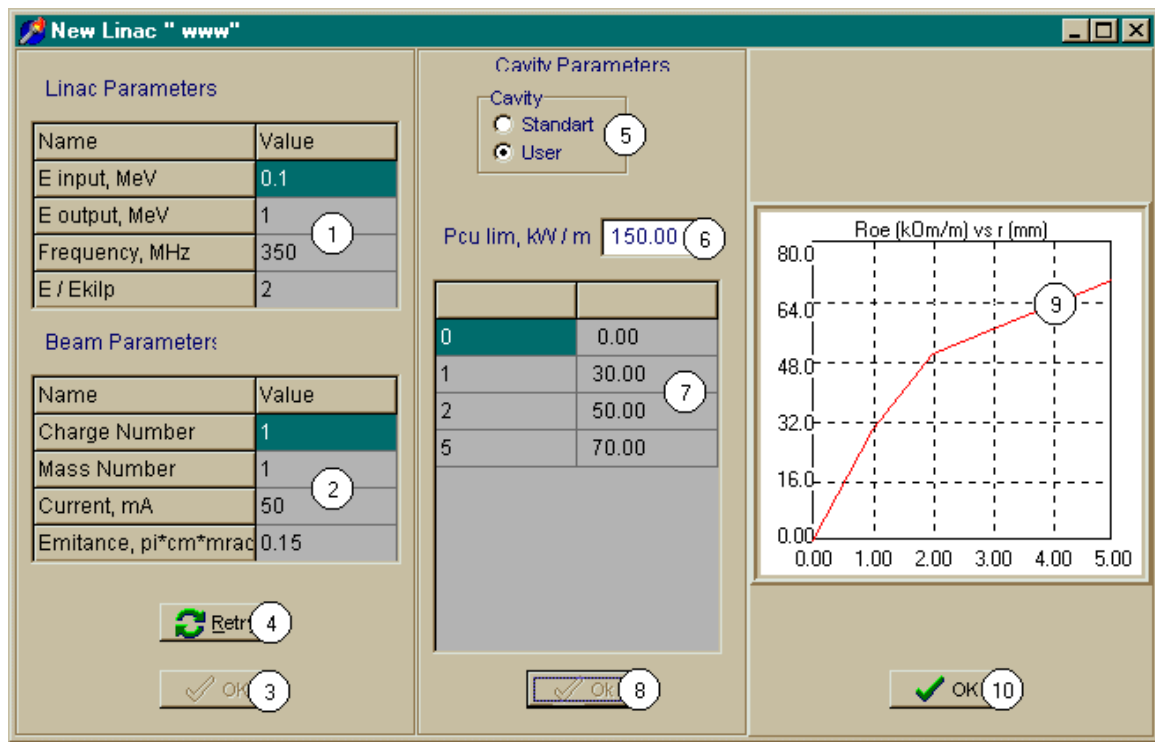


Fig.3. New Linac Window.

If **Standard** set was used for **Cavity Parameters** choice, then cavity parameters are brought out into edition row (6) and into table (7). Cavity parameters were re-calculated taking into account linac operating frequency. Among cavity parameters are: power limit per meter (Pcu lim, kW/m) and shunt impedance as function of bore radius (Roe [kOm/m]). The last one is plotted at right side of the window (9). Power limit value can be edited.

If **User** options is used for **Cavity Parameters** choice, than **Open Cavity File** window appears (see Fig 4).

If needed cavity can be found in file list (1) that it can be marked by mouse.

Press **Ok** button (2).

Open Cavity File window had closed.

Cavity parameters were brought out into **New Linac**.

Press **New File** button (3) if needed cavity is absent in file list.

Type new file name and press **Ok** button (2).

Type file short description and press **Ok** button (6).

For additional cavity insert base frequency (7), limit of power dissipated in cavity walls per unit length (8) and shunt impedance as function of bore radius (9).

Press **Ok** button (10).

Open Cavity File window closed and cavity parameters at operating frequency appear in **New Linac** window (Fig.3)

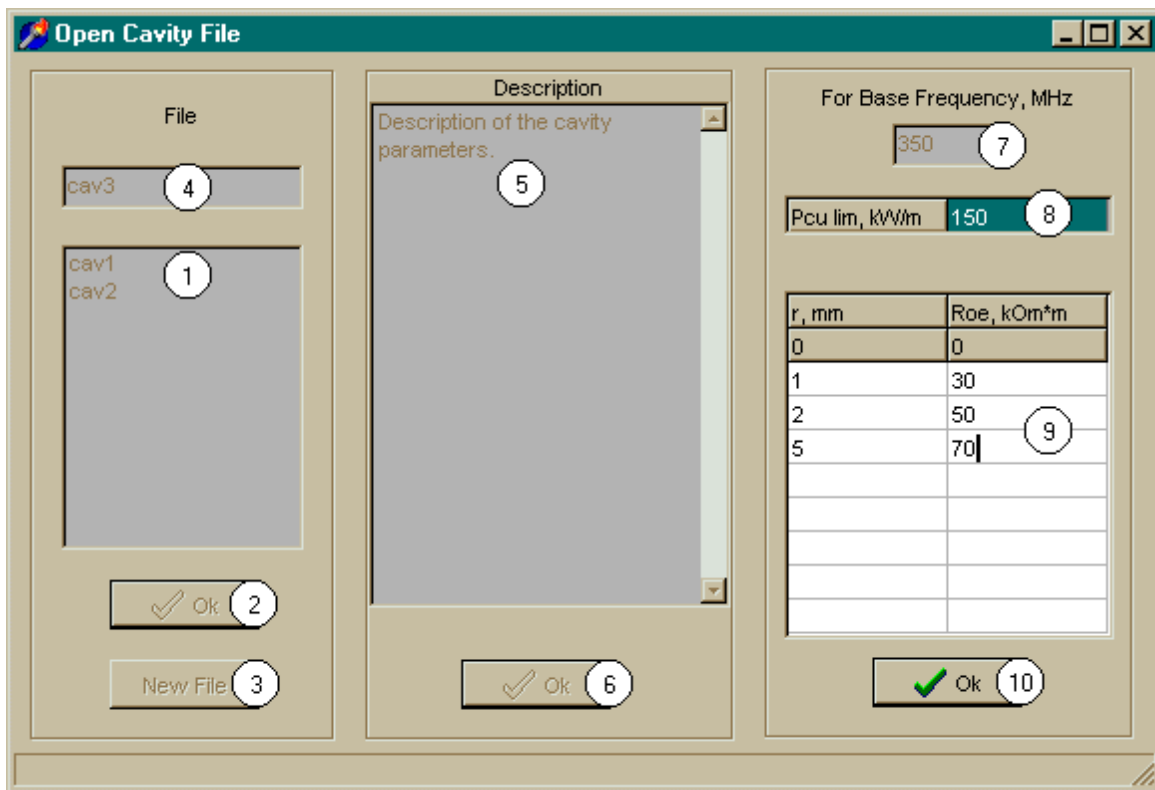


Fig.4. Open Cavity File window.

Press **Retry** button (4) in **New Linac** window (fig.3)
It makes it possible to retune to accelerator parameter edit.
Press **Ok** (10) button to close window.
Adviser button of main form becomes active.

Note

1. In the table use **ENTER** key or mouse to transfer from one edit field to another one.
2. White background of edited strings, fields and tables identifies editing values. Silver color identifies non-editing values. Blue color is used for values entered into the program by user, but permitted editing for concrete calculation. Yellow color indicates values don't taken into account in calculation.

4.1.3. Open PARMTEQ file.

PARMTEQ file means file for new accelerator parameters record. Accelerator parameters are defined by the table calculated by PARMTEQ code.

To open PARMTEQ file

Press quick button **Parm** (3)

or

Chose menu commands **File, New, Parmteq**.

Standard window for file chose appears.

Select needed file and press **Ok** button.

Dialog window **Create New Linac File** appears (fig.2).

Type filename in editing string (1) and press **Ok** button (2).

Then in editing field (3) type brief file description and press **Ok** button (4).

Adviser button of main form becomes active. (fig.1)

Note

File used by program has to be specially prepared (see Appendix).

4.1.4. Open file with previously saved accelerator parameters.

To open file with previously saved accelerator parameters

Press quick button **Open**

or

Chose menu commands **File, Open**.

Dialog window **Open Linac File** appears (analog to window in fig.2).

Select needed file (5) from the list.

As this take place name of selected file appears in editing string (1) and its description appears in editing field (3).

Press Ok button (4).
Adviser button of main form becomes active.

Vane Real Shape and Beam Simulation button become active if appropriate calculations have been made previously.

4.1.5. Delete accelerator description file.

To delete accelerator description file

Chose menu commands File, Delete, Linac

Dialog window Delete Linac File appears (analog window in fig.2).

Select needed file in the list (5).

As this take place name of selected file appears in editing string (1) and its description appears in editing field (3).

Press Ok button (2).

Selected file will be deleted.

To delete several files

To delete several files select next file to be deleted and press Ok button (2).

Press Close button (6) to quit window.

4.1.6. Delete cavity description file.

To delete cavity description file

Chose menu commands File, Delete, Linac.

Dialog window Delete Linac File appears (analog window in fig.2).

Select demanded file in the list (5). As this take place name of chosen file appears in editing string (1) and its description appears in editing field (3).

Press Ok button (2).

Selected file will be deleted.

To delete several files

To delete several files select next file to be deleted and press Ok button (2).

Press Close button (6) to quit window.

4.1.7. Run Program items.

To run Program items.

To run different program items press one of the buttons **Adviser**, **Vane Real Shape** or **Beam Simulation**. Appropriate window **Adviser** (see Part 5) or **Vane Real Shape** (see Part 6) or **Beam Simulation** (see Part 7) appears.

4.1.8. Quit Program.

To quit Program

To quit Program chose menu commands **File, Exit**
or
Press **Exit** button.

5. Adviser

5.1. Adviser Window

5.1.1. Adviser Window Description

Adviser window (fig.5) contains:

- Instrument panel switch (1) containing
 - Preliminary
 - Calculation
 - Simulation
- Linac Parameters (2) and Beam Parameters (3) tables

Note

1. In this and next windows parameters value in the table are set equals preset values (for-early calculated accelerators) or default values (in some cases fields can be free).
 2. With first **Adviser** window activation accelerating voltage between electrodes **Intervane Voltage** is set automatically.
 3. E/E_k parameter means limit value of the ratio of voltage between electrodes to mean aperture radius (E) in terms of Kilpatrick voltage (E_k).
- Ok button (5).
 - Edit field (6) for limit power per unit length dissipated in the structure, table for shunt impedance dependence from aperture radius (7) and graph (8) presented this dependence.

- Ok (9), Run (10), Close (11) button.

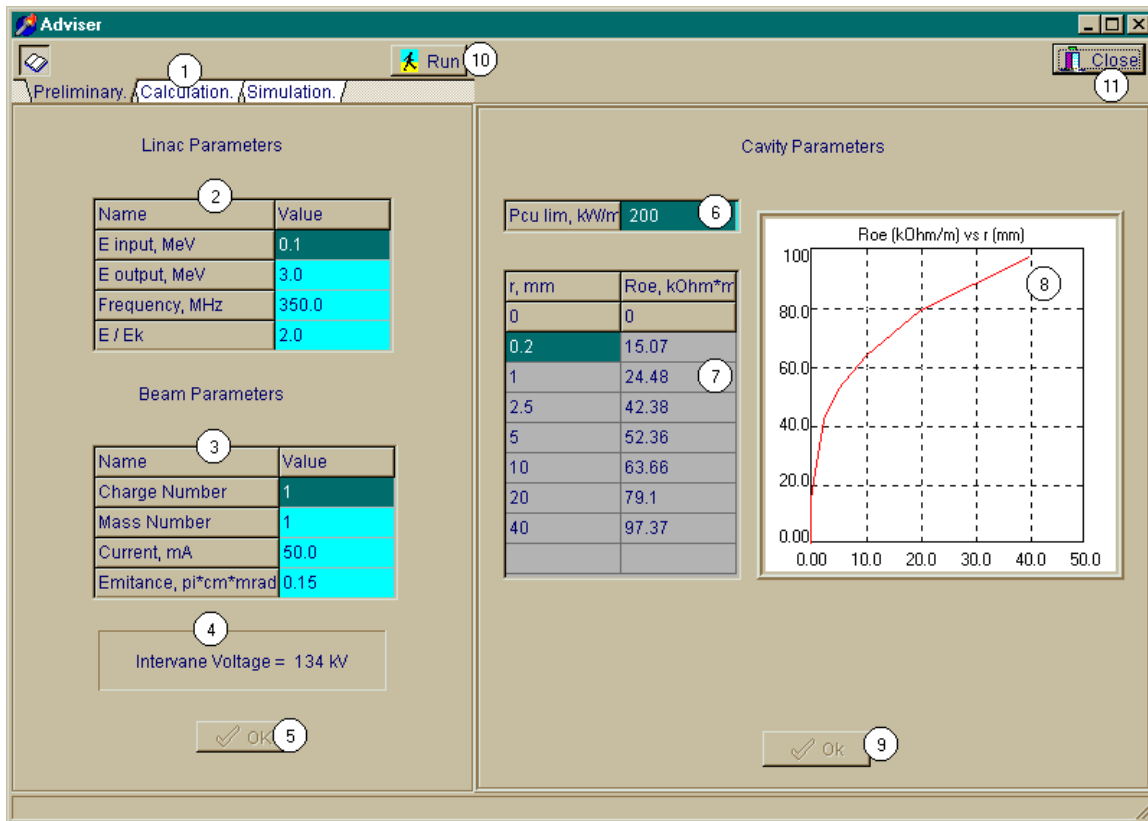


Fig.5. Adviser window. Preliminary page.

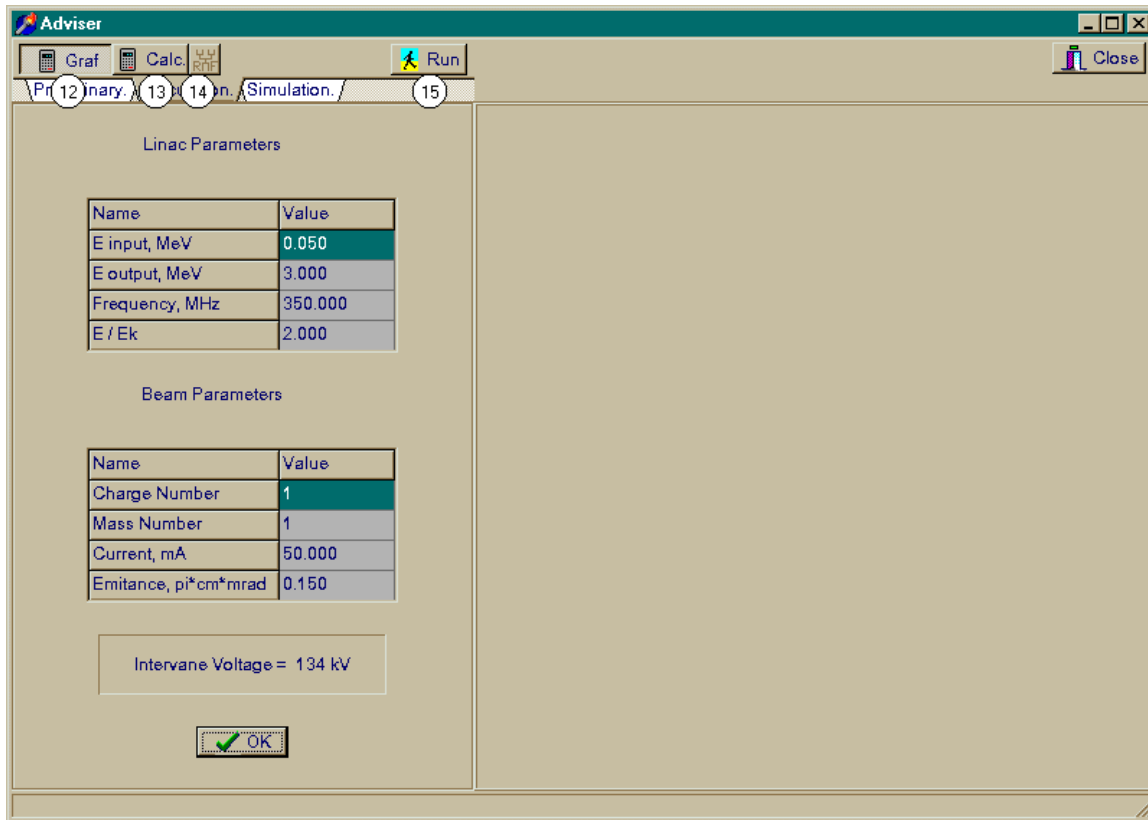


Fig.6. Adviser window. Calculation page.

Instrument panel includes different buttons number depending on chosen page.

Adviser Window with Preliminary page is presented at fig.5. There is just Run button (10) on the panel.

Adviser Window with Calculation page is presented in fig.6. In this case there are Graf (12), Calc (13), RF (14) and Run (15) buttons on the panel.

Adviser Window with Simulation page is presented in fig.7. In this case there are View (27) and Run (25) buttons on the panel.

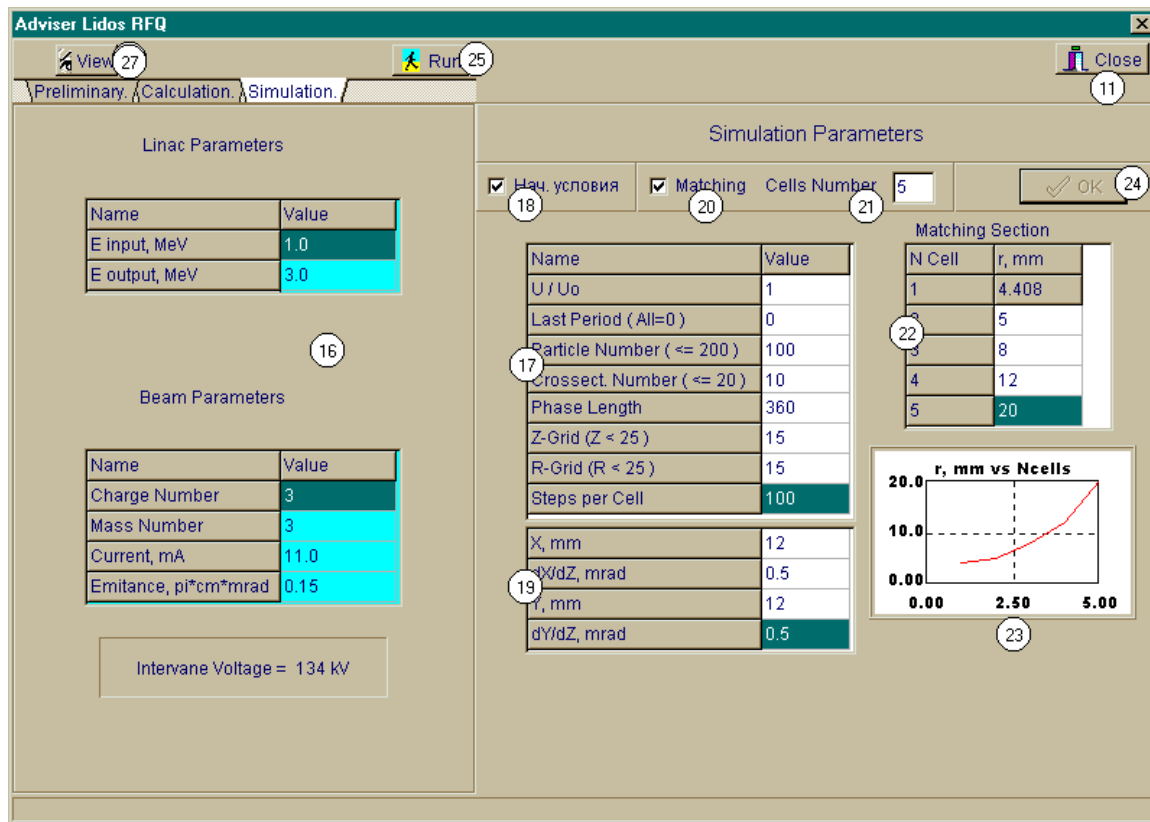


Fig.7. Adviser window. Simulation page.

The following procedures can be made in this window:

- Run programs
- Calculation of voltage, mean aperture radius permissible area, structure heat dissipation per unit length as well (page Preliminary)
- Determination of voltage, mean aperture radius, modulation and equilibrium phase dependence along the structure (Graf button on Calculation page)
- Cells length calculation in ideal field approximation (Calc button on Calculation page)
- RF system parameter calculation (RF button on Calculation page)
- Beam dynamics simulation in ideal field approximation (Simulation page)
- View of simulation results (View button on Simulation page)
- Close window

Note

With new accelerator calculation operations have to be execute in the listed order.

5.1.2. Calculation of voltage, mean aperture radius and structure heat dissipation per unit length permissible area

Press Preliminary on instrument panel (1) (fig.5).

Edit data (if necessary) listed in table (2), (3).

To save new data press Ok button (5).

Edit (if necessary) the limit value of permissible structure dissipated power per unit length (6).
To save new value press Ok button (9).

Press Run button (10).

Preliminary window appears (see part 5.2).

Note

Data edit options is disable for accelerator with the parameters defined by PARMTEQ calculated table.

5.1.3. Determination of voltage, mean aperture radius, modulation and equilibrium phase dependence along the structure

Press Calculation on instrument panel (1) (fig.5).

Press Graf button.

Press Run button (see fig.6).

Graphics window appears (see part 5.3).

Note

Run Graf is disable for accelerator with the parameters defined by PARMTEQ calculated table.

5.1.4. Cells length calculation in ideal field approximation

Press Calculation on instrument panel (1) (fig.5).

Press Calc button.

Press Run button (see fig.6).

Program for cells length calculation runs (see part 5.4).

5.1.5. RF system parameters calculation.

Press Calculation on instrument panel (1) (fig.5).

Press RF button.

Press Run button (see fig.6).

RF System.RFQ windows appears (see part 5.5).

5.1.6. Beam dynamics simulation in ideal field approximation.

Press Simulation on instrument panel (1) (fig.5).

Edit (if necessary) data listed in Linac Parameters and Beam Parameters table (17) (see fig.7). Edit data in Simulation parameter table (17):

U/U ₀	- ratio of accelerating voltage to its nominal value
Last Period	- simulation period number - (for simulation up to the end of accelerator input Value equals 0)

Particle Number	- particle number (not higher than 200)
Crossect.Number	- crossection number (not higher than 20)
Phase Length	- phase length
Z-Grid	- z-grid step for Coulomb field calculation
R-Grid	- r-grid step for Coulomb field calculation
Step per Period	- time step per cell length for particle motion calculation

For initial data of injected beam input mark **Input Data** checkbox (18) and input beam dimensions at accelerator input in the table (19): X, Y and dX/dZ, dY/dZ.

For matching section consideration mark **Matching** checkbox (20). In the field **Cells Number** input matching section length in cells number and fill **Matching Section** table (22) for aperture radius dependence on period number.

Press **Ok** button (24) for input data saving. Graph (23) presents aperture radius dependence on cell number.

Press **Run** button (25).

Beam simulation starts (see part 5.6)

Note

Matching section option is disable for accelerator with the parameters defined by PARMTEQ calculated table.

5.1.7. Run View program

To run View program

Press **Simulation** on instrument panel (1) (fig.7).
Press **View** button.

Simulation Results View window appears (see part 5.7).

5.1.8. Close Window

To close window

Press **Close** button.

Program returns to main window.

5.2. RFQ.Preliminary Window

5.2.1. RFQ.Preliminary window description

RFQ.Preliminary window (see fig.8) contains:

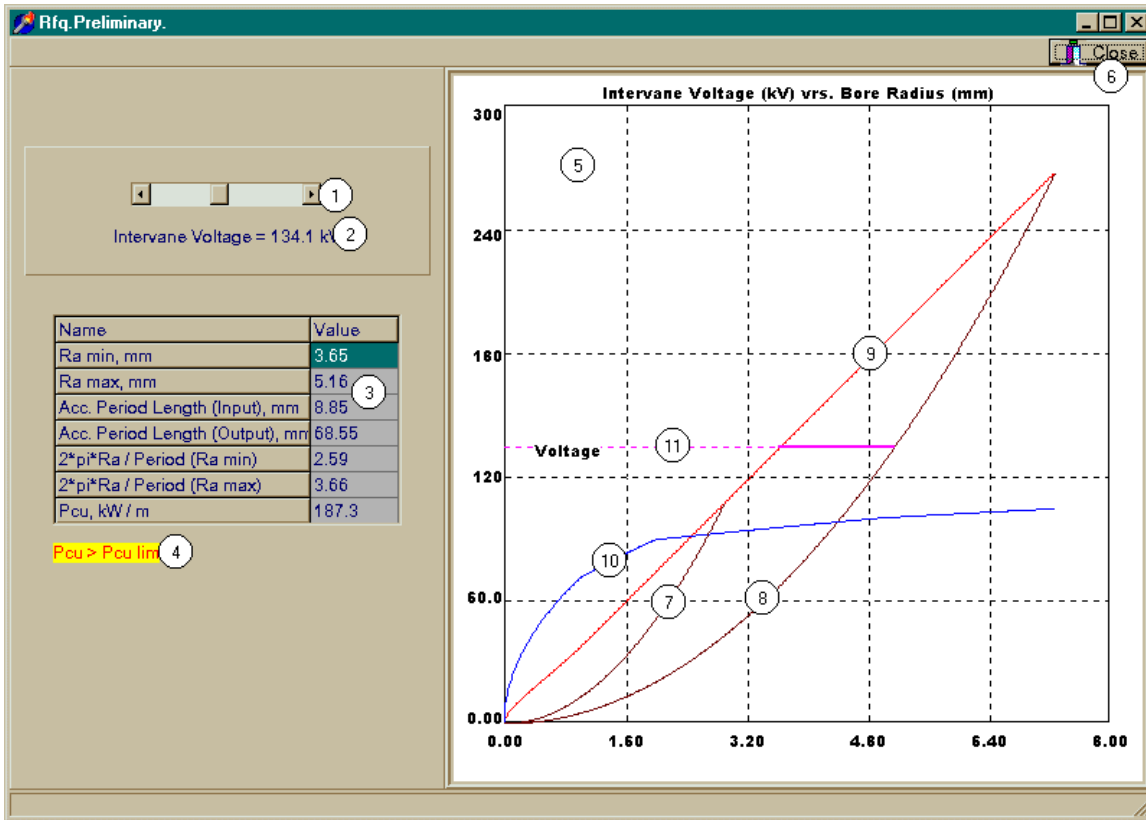


Fig.8. RFQ.Preliminary window.

- Horizontal scroll bar for accelerating voltage variation (1).
- Accelerating voltage value (for further accelerating voltage normalization) (2)
- Calculation result table (3) containing
 - Ra min and Ra max - minimum and maximum permissible accelerator aperture radius for chosen accelerating voltage
 - Acc. Period Length (input) and Acc. Period Length (output) - accelerating period length at accelerator input and output
 - $2\pi Ra / \text{Period (Ra min)}$ and $2\pi Ra / \text{Period (Ra max)}$
 - Pcu - power dissipating in accelerating structure per unit length with chosen accelerating voltage
- Field (4). If Pcu is higher than maximum permissible value defined with cavity parameter input, than Pcu > Pcu lim warning appears
- Field (5). Curves (7) and (8) limit area with permissible focusing parameter value (from 0.2 to 0.5). Ratio of voltage between electrodes to mean aperture radius is equals to maximum permissible value along the line (9), that is permissible voltage and mean aperture radius value lies in the area limited by these lines. Power dissipating in the

structure per unit length is equals to maximum permissible value along the curve (10). Straight line (11) corresponds to chosen accelerating voltage value.

The following procedures can be made in the window:

- Accelerating voltage variation
- Close window

5.2.2. Accelerating voltage variation

To vary accelerating voltage

Use scroll bar (1) to vary accelerating voltage.

With accelerating voltage change data listed in table (3) are automatically changed and figure (5) is automatically redraw.

5.2.3. Close window.

To close window

Press Close button (6) to close window.

Program returns to Adviser window.

5.3. Graphics Window

5.3.1. Graphics window description

Graphics window (see fig.9) contains:

- Instrument panel (1), containing U-m, E-q and Ω buttons
- Panel (2) with number of accelerator cells and arrows for it variation
- Panel (3) with notations. If mouse pointer is somewhere in the graph, than first notation presents cell number Cell, second one presents title and parameter value in indicated point.
- Panel (4) with notation appearing with pressed E-q button. If mouse pointer is in the area of E and q graphs, than first notation presents voltage value U/Unom and second one presents radius value R/Rnom whereby chosen value of parameter E (q) is effected. (E is ratio of voltage to mean aperture radius and q is focusing parameter.)
- Close button (5).

- Figure (6) presenting cell number dependence of normalized voltage U/U_{nom} .
- Figure (7) presenting cell number dependence of radius R/R_{nom} with pressed U-m or E-q buttons and cell number dependence of defocusing factor Ω with pressed Ω button.
- Figure (8) presenting cell number dependence of synchronous phase $-Fi$ with pressed U-m or Ω button and cell number dependence of voltage E with pressed E-q button.
- Figure (9) presenting cell number dependence of modulation coefficient M with pressed U-m or Ω button and cell number dependence of focusing parameter q with pressed E-q button.
- Panel with parameters table (10) and Ok button (11) (see fig.10)

Note

1. U/U_{nom} , R/R_{nom} , $-Fi$ and M graphs are plotted on the base of data from the table (10).
2. With first window opening graphs are plotted on the base of default data (in the case of new accelerator) or on the base of previously saved data.
3. Table (10) can be invisible.

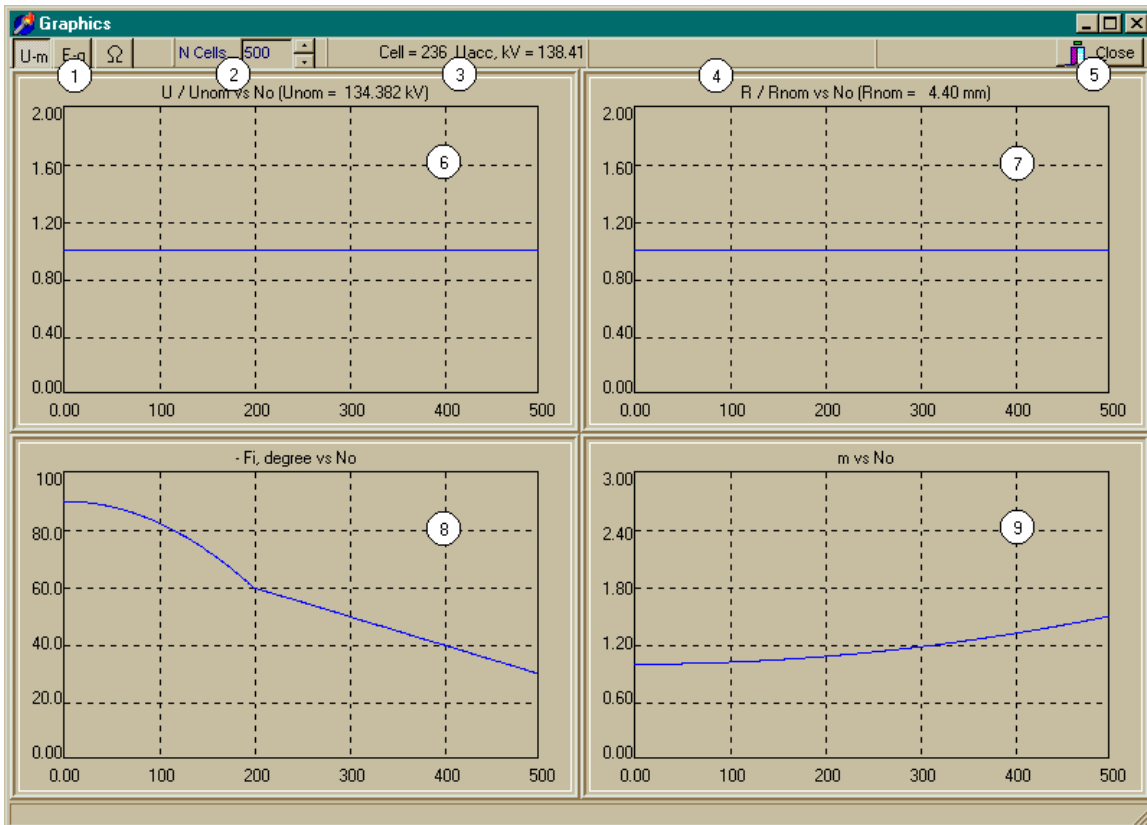


Fig.9. Graphics window with pressed U-m button.

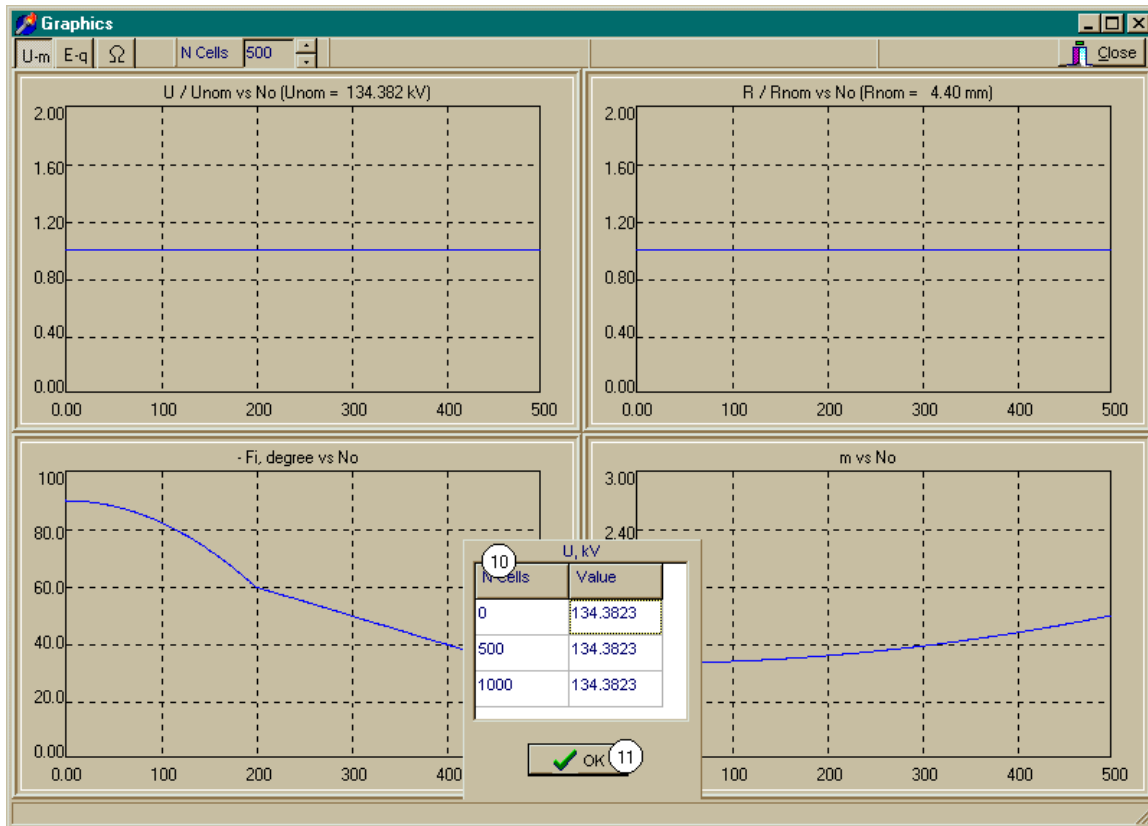


Fig.10. Graphics window during graphs edit.

The following procedures can be made in the window:

- Cell number variation
- U/Unom, R/Rnom, -Fi and M value edit
- View E, q, Omega (see fig.11, 12) dependence
- Calculation of U/Unom, R/Rnom values for chosen voltage E and/or focusing parameter q.
- Close window

5.3.2. Cell number variation

📄 To vary cell number

To vary cell number on the panel (2) (see fig.9) press Up or Down arrows.

Changing step is equal to 100. Maximal cell number is 1000.

Note

Change in cell number leads to change in curve scale at the graph. In all instance curves are determined in the range from 0 to 1000. If N cells are presented at the screen, than parameters of the cells with number $n > N$ are rely equal to parameters of cell number N.

5.3.3. U/Unom, R/Rnom, -Fi and M value edit.

To edit U/Uo, R/Rnom, -Fi and M value

Place mouse pointer in the field of editing graph and right click.

Table (10) becomes visible (see fig.10).
Edit parameters and press Ok button.

When the occasion requires rows can be added or deleted.

To add or delete row

Left click to chose line in the table.
Right click.

Popup menu with Insert Row and Delete Row operations appears.
Chose demanded operation.

With Insert Row chosen, new blank row for data input appears, previously input data move down on one string.

With Delete Row chosen row will be deleted.

Note

- 1) It is not possible to remove first and last row.
- 2) It is not possible to insert new row in the first row.

5.3.4. View dependence of E, q, Omega.

To view dependence of E, q, Omega

Press E-q button (see fig.11).

Limit field intensity corresponding to chosen E/Ekilp criteria is presented on the same graph as field intensity (12).

Press Ω button to view Omega dependence (see fig.12).

5.3.5. Close window

To close window

Press Close button.

Program returns to Adviser window.

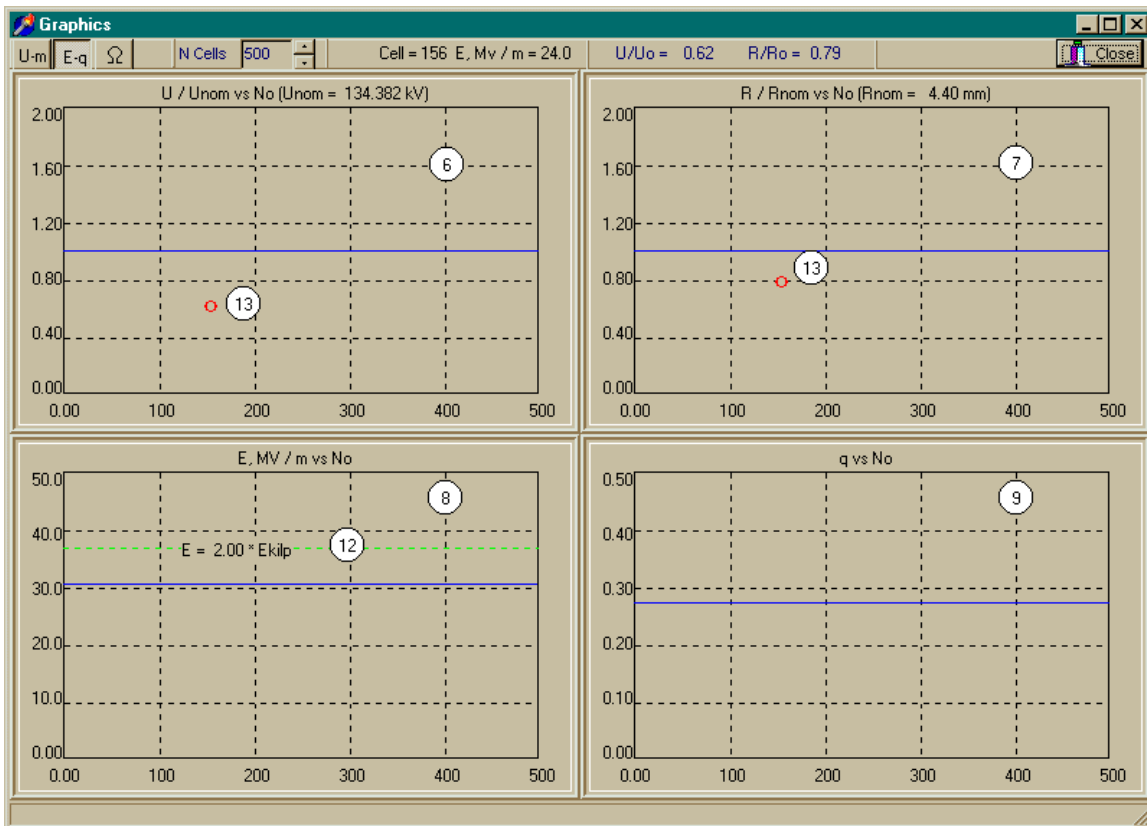


Fig.11. Graphics window with pressed E-q button.

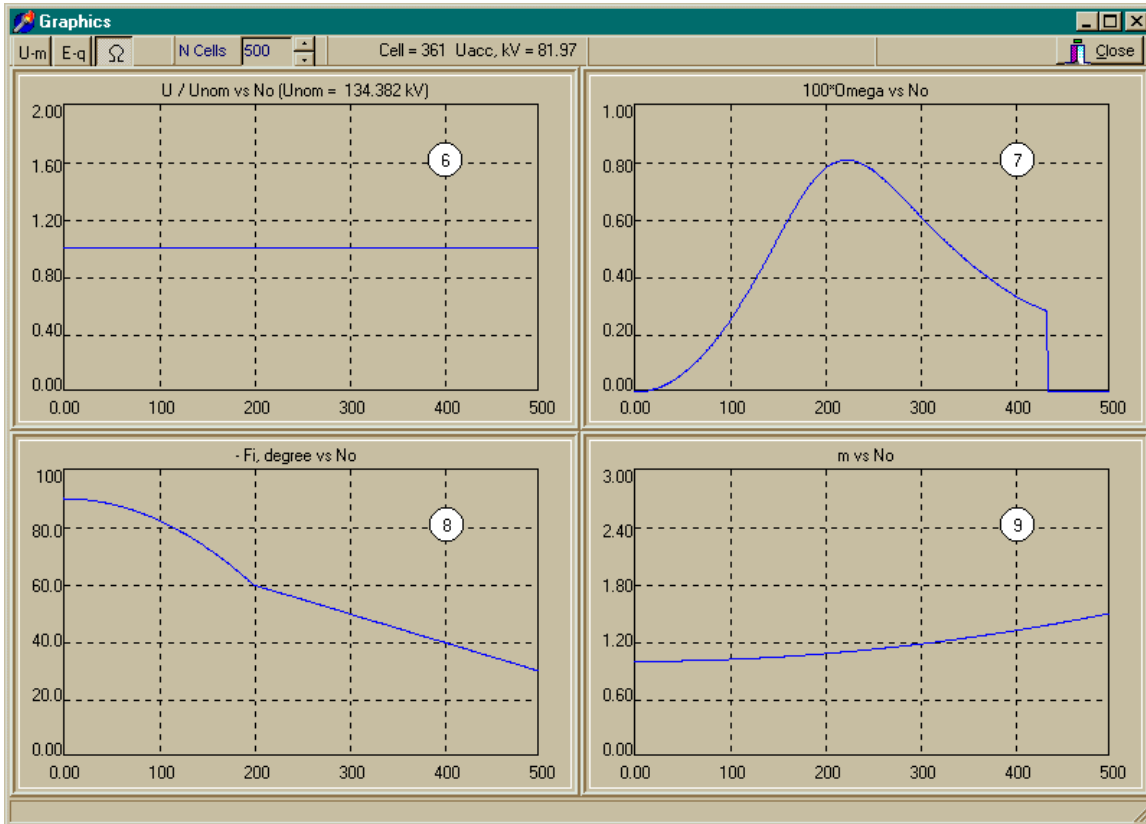


Fig.12. Graphics window with pressed Ω button.

5.4. Cell Length Calculations

RFQ cell calculations are based on user data (operating frequency, ion charge and mass, input and output energies) as well as on intervane voltage and vane modulation plots, bore radius and synchronous phase plots.

Iteration procedure is used for RFQ cell calculations. RF phasing is used as criteria for cell length. Calculation is accompanied by synchronous energy plotting as function of cell number. When calculations are finished generalized characteristics of RFQ channel are displayed as color plots inside three windows. Plot notations as well as parameter minimal and maximal values are displayed by the same colors. In the first two columns minimal and maximal values of vertical scale are listed, in the next columns minimal and maximal values of the parameter are listed.

For RFQ linac described by PARMTEQ files cell calculation procedure is omitted. Data from PARMTEQ table is used for RFQ characteristic creation.

There are displayed in windows
 accelerating channel characteristics

- synchronous phase,
- amplitude of RF field accelerating harmonics,
- intervane voltage,
- vane modulation,

- efficiency of acceleration,
- focusing channel characteristics
- focusing parameter,
 - defocusing parameter,
 - bore aperture,
 - matching beam transverse size (on the base of given beam current and emittance)
- oscillation frequency
- transverse oscillation frequency based on beam zero current,
 - transverse oscillation frequency based on given beam current,
 - longitudinal oscillation frequency based on beam zero current,
 - ratio of longitudinal oscillation frequency to transverse one based on beam zero current

5.5. RF Devices

5.5.1. RF System.RFQ Window

RF System.RFQ window (see Fig.13) contains:

- Edit Button (1);
- Run Button (2);
- Close Button (3);
- Panel (4) with:
 - Radio button switch Transmission Line
 - Radio button switch Circulator
 - Table RF Amplifier
 - Table Transmission Line
 - Table Circulator
- Panel (5), (see fig.14) with:
 - Table RF Channel
 - Table Cavity
- RF device functional scheme (6).

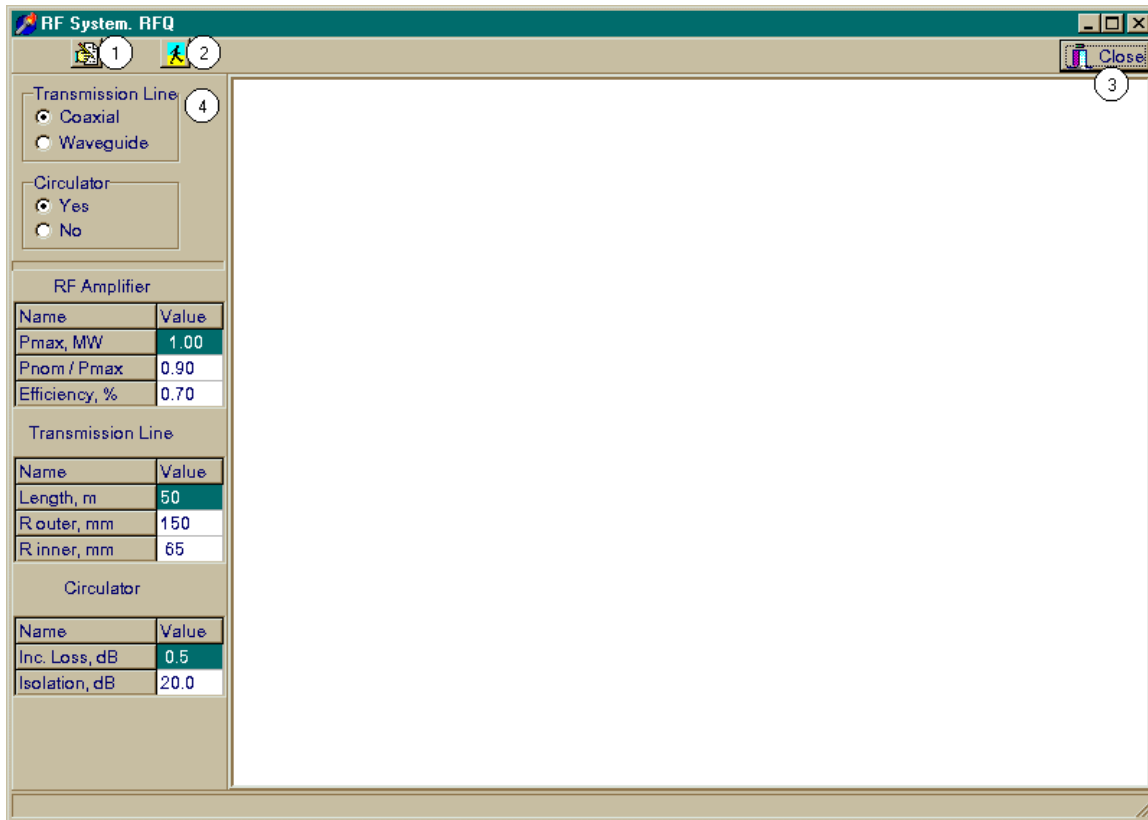


Fig.13. RF System.RFQ window. Parameter Input.

Note

When above form is opened panel (5) and figure (6) are viewless.

The following operations are permissible in RF Devices for RFQ window:

- RF device parameter definition
- Run of RF device functional scheme calculations
- RF device parameter edition
- Closing window

5.5.2. RF device parameter definition

Choose transmission line type using Transmission Line switch.

Mark Circulator switch if circulator will be used in RF scheme.

Fulfill tables RF Amplifier, Transmission Line and Circulator.

The following notations are used in the table:

- Pmax - RF generator maximal power (power in saturation mode).
- Pnom/Pmax - ratio of RF generator maximal power in automatic control mode Pnom to maximal power in saturation mode.

Efficiency	- RF generator efficiency.
Length	- length of transmission line.
R outer and R inner	- outer and inner radii of transmission line (when coaxial line is used).
Width and Height	- waveguide width and height (if waveguide is used)
Inc.Loss and Isolation	- circulator attenuation and isolation.

5.5.3. Run RF functional scheme calculations

Run RF functional scheme calculations.

Click Run button (2).

Panel 5 with tables RF Channel and Cavity appears (if linac contains more than one cavity), as well as fig. 6.

In tables and on figure the following notations are used:

N cav	- cavity number.
Pmax cav	- maximal power could be transferred into cavity with
Pnom	- output generator power (taking into account power losses in transmission line and circulator)
Pnom cav	- RF power entered to cavity
Length	- cavity length
Pcu	- RF power expended for accelerating field creation
Pbeam	- RF power expended for beam acceleration
Poutput	- RF generator output power.

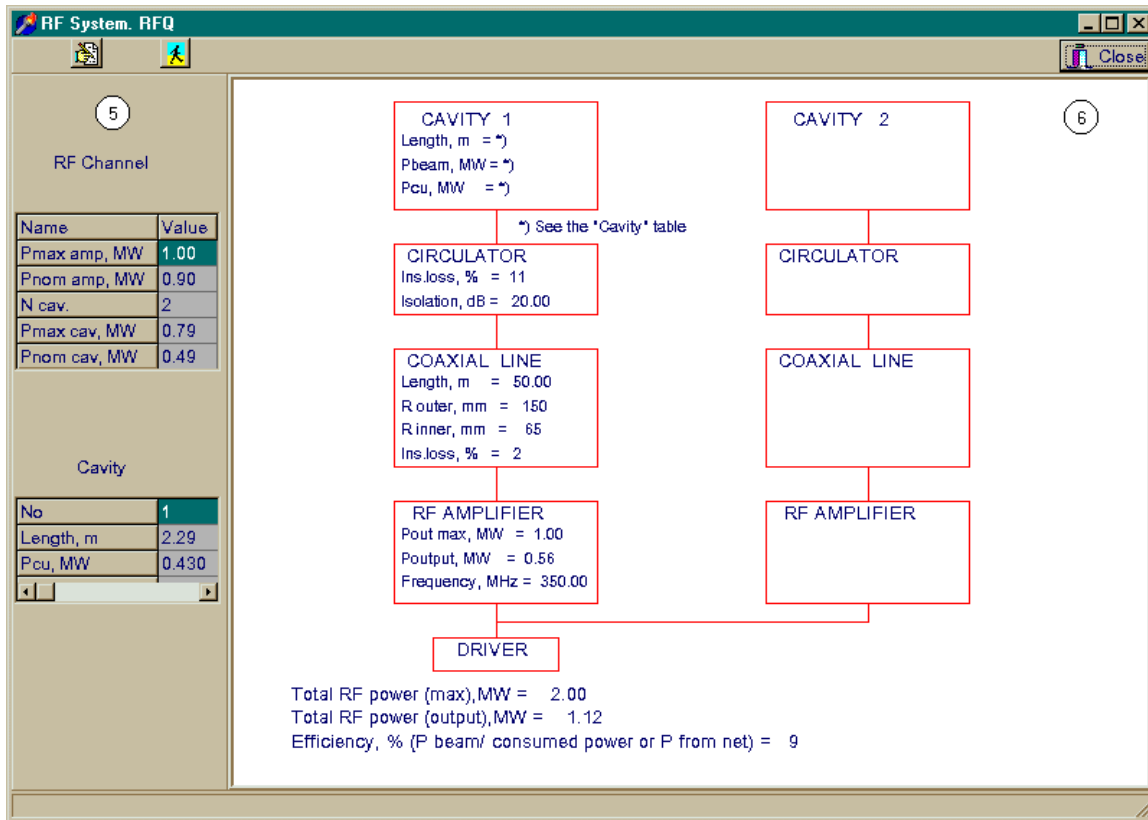


Fig.14. RF System.RFQ Window. Calculation results.

5.5.4. RF Device Parameter Edit

After RF scheme calculations it is possible to change RF device parameters by recalculations.

📄 To edit RF device parameters

Press Edit button (1).

5.5.5. Close Window

📄 To close window

Press Close button (3).

Program returns into Adviser window.

5.6. Beam Simulation.

5.6.1. Calculation Methods

The main goal of beam dynamics calculations on this stage is beam quality fast estimations in deduced accelerating/focusing channel. Simplified model is used for fast calculations. The model gives Coulomb field reliability estimations even for small macroparticle number.

The main model features are as follows.

1. Different macroparticle presentations are used for longitudinal and transverse Coulomb field components. First type macroparticle is used for longitudinal Coulomb field component. Each macroparticle are presented as circular uniform charged disc with mesh step as disc thickness. All discs have the same transverse size. This size definition will be given at item 2. Disposition of discs gives beam charge distribution. That is to say that for longitudinal component calculation beam is presented as circular tall hat with uniform charge distribution in each transverse crosssection and periodical charge density distribution along longitudinal axis Z. Mesh task solution by Furrier method is used for Coulomb field calculations. The method is simplified due to uniform charge distribution and neediness in field potential only on channel axis. In the frame of used model one hundred macroparticles are enough.
2. Beam is "divided" on several crosssections with uniform charge density distribution along transverse direction. Beam envelope equations are solved together with longitudinal motion equation for crosssection centre. The second type macroparticles are moved in Coulomb field created by the first type macroparticles. Tall hat radius (defined in item 1) is equal to rms transverse size of crosssections. In the frame of this model from 10 to 20 crosssections are needed for reliability estimates.
3. The third type macroparticles are used for possible resonant effect emergence. For these particle motion equations are solved in full volume. They did not take part in Coulomb field creation but they felt Coulomb field created by macroparticles of the first and the second types.

5.6.2. Input Data

Input data table is described in item 5.1.6. The following notations are used:

U/U ₀	- voltage factor
Particle Number	- the first type particle number
Crossect. Number	- the second type particle number
Z-Grid, R-Grid	- mesh node number for Coulomb field component calculations.

5.6.3. Visual Information

The window #1 appears after code running. Input beam optimal parameters are displayed in this window. Matching ellipses for all crosssections are appeared in upper right corner. If initial values of X , Y , dX/dZ , dY/dZ were given then green ellipse corresponds to input beam given by user. Diagram in lower right corner shows mismatching factors for each crosssections regarding synchronous one (0 means that the beam contains only synchronous crosssection. Information about optimal input parameters can be found in lower left corner. User is suggested to chose optimal input parameters. If user clicks "YES" then the figure is represented. Beam dynamics calculations are started if "OK" button is used.

Current information about beam simulation is displayed in the window #2. Proportion of the first type particle left in separatrix is displayed in the left upper corner on the background of plots of vane modulation and synchronous phase as function of cell number. On the same window there are displayed (from left to right) phase portrait for the first type particles (synchronous one is red) on the separatrix background. The middle figure contains phase trajectories of the second type (white) and the third type ones (red). On the lower figure envelope trajectories are displayed (synchronous one is yellow) on the background of minimal and maximal bore aperture (cyanic) and mean bore aperture (white).

Output beam information is displayed in windows #3 and #4 after calculations are finished. In the window #3 phase/energy characteristics of output beam are displayed. There are phase portrait as well as phase and pulse distributions. In the window #4 output beam transverse characteristics are displayed: phase portraits for each crosssections both for $X, dX/dZ$ and $Y, dY/dZ$ planes, transverse sizes and divergences as well as Twiss matrix elements and current diagram for each output crosssections.

5.7. View Window.

5.7.1. View window description.

View window contains (see fig.15):

- Menu (1)
- Print button (2)
- Calculation results area (3)
- Close button (4)

The following procedures can be made in the window

- Print calculation results
- Save calculation results in user directory
- Close window

5.7.2. Print calculation results.

To print calculation results

Press Print button (2)

or

Chose File, Print menu command.

RFQ Accelerator											
Frequency 349.8 MGz											
N	LT mm	L0 m	BS	W MeV	M	U HU	T	FS	rmi mm	rma mm	
1	19.77	.0198	.0461	.9984	1.000	.134	.000	-90.00	26.26	26.26	
2	19.77	.0395	.0461	.9984	1.000	.134	.000	-90.00	21.13	21.13	
3	19.77	.0593	.0461	.9984	1.000	.134	.000	-90.00	16.68	16.68	
4	19.77	.0791	.0461	.9984	1.000	.134	.000	-90.00	12.92	12.92	
5	19.77	.0989	.0461	.9984	1.000	.134	.000	-90.00	9.85	9.85	
6	19.77	.1186	.0461	.9984	1.000	.134	.000	-90.00	7.45	7.45	
7	19.77	.1384	.0461	.9984	1.000	.134	.000	-90.00	5.74	5.74	
8	19.77	.1582	.0461	.9984	1.000	.134	.000	-90.00	4.72	4.72	
9	19.79	.1780	.0461	.9984	1.000	.134	.002	-90.00	4.38	4.38	
10	19.79	.1978	.0461	.9984	1.003	.134	.003	-89.85	4.37	4.38	
11	19.79	.2176	.0461	.9983	1.005	.134	.006	-89.70	4.37	4.39	
12	19.79	.2373	.0461	.9983	1.008	.134	.007	-89.55	4.36	4.39	
13	19.79	.2571	.0461	.9983	1.010	.134	.009	-89.40	4.35	4.40	
14	19.79	.2769	.0461	.9983	1.013	.134	.010	-89.25	4.35	4.40	
15	19.79	.2967	.0461	.9982	1.015	.134	.012	-89.10	4.34	4.41	
16	19.79	.3165	.0461	.9982	1.018	.134	.014	-88.95	4.34	4.41	
17	19.79	.3363	.0461	.9983	1.020	.134	.016	-88.80	4.33	4.42	
18	19.79	.3561	.0461	.9983	1.023	.134	.017	-88.65	4.33	4.43	
19	19.79	.3759	.0461	.9983	1.025	.134	.019	-88.50	4.32	4.43	
20	19.79	.3957	.0461	.9983	1.028	.134	.021	-88.35	4.32	4.44	
21	19.79	.4155	.0461	.9984	1.030	.134	.023	-88.20	4.31	4.44	
22	19.79	.4353	.0461	.9985	1.033	.134	.024	-88.05	4.30	4.45	
23	19.80	.4551	.0461	.9985	1.035	.134	.026	-87.90	4.30	4.45	
24	19.80	.4749	.0461	.9987	1.038	.134	.027	-87.75	4.29	4.46	
25	19.80	.4946	.0461	.9988	1.040	.134	.029	-87.60	4.29	4.46	

Fig.15. View window.

5.7.3. Save calculation results in user directory

 To save calculation results in user directory

Chose File, Save As menu command.

Standard dialog window appears.

Type filename.

Chose directory.

Press Ok button.

Note

Do not save calculation results in program directories.

5.7.4. Close Window.

 To close window

Press Close button (3).

Program returns into Adviser window.

6. Vane Real Shape

6.1. Vane Real Shape Window

6.1.1. Vane Real Shape Window Description

Vane Real Shape Window contains (see fig.16)

- Instrument panel with
 - Input Part (1) and Output Part (3) checkboxes
 - "Open Book" button (2)
 - Edit field Number of Gaps (4)
 - Show (5), Run (6), Notation (7) and Close (8) button
- Crandall Cell checkbox
- Five tables (9-12)
- Ok button
- Three graphs (16-18)

The following procedures can be made in this window:

- Input of parameters describing vane shape
- Input of parameters describing input and output parts
- Calculate optimal input beam transverse size and convergence
- Help
- Close window

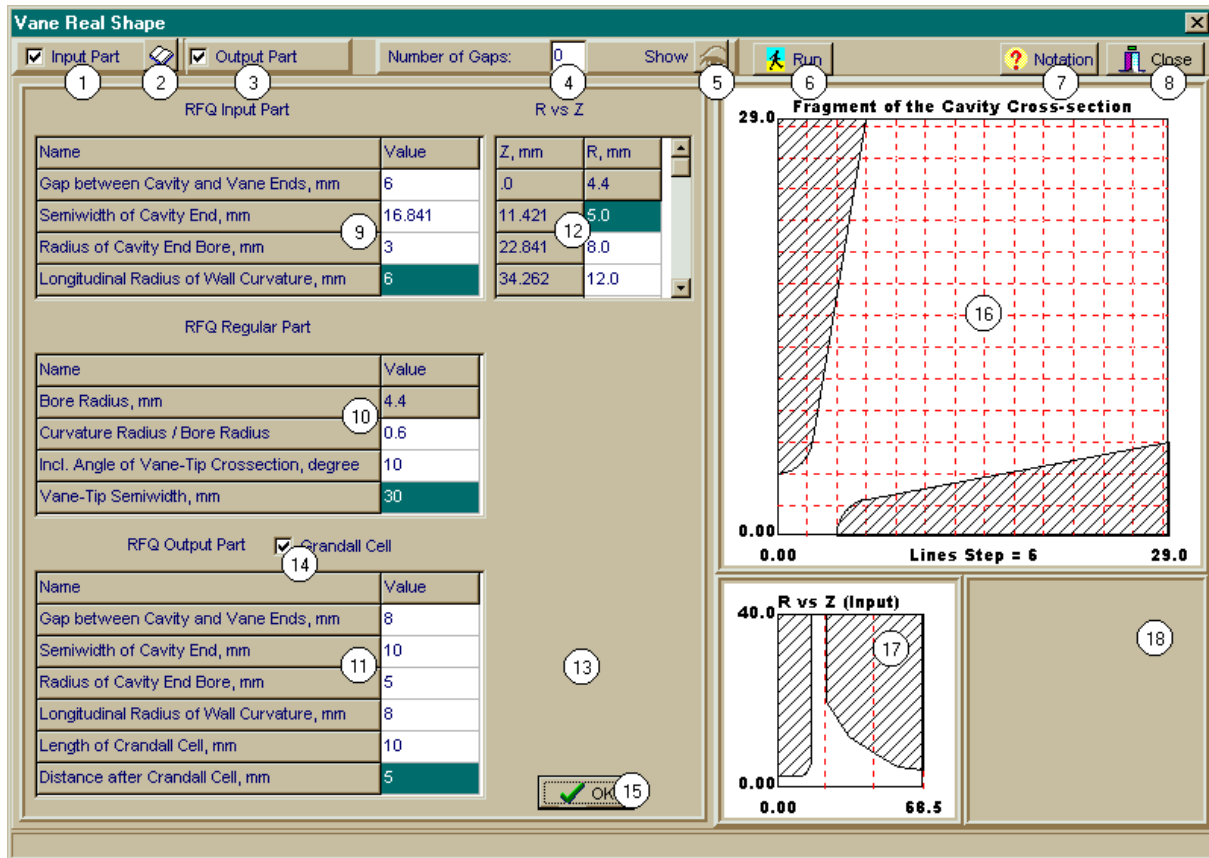


Fig.16. Calculation window.

6.1.2. Input of parameters describing vane shape. Input of parameters describing input and output parts. Calculate optimal input beam transverse size and convergence.

It is conventionally supposed that channel is subdivided into three parts: input consisting of special-form matching section and flange divided by the gap, regular part and output part consisting of special-form output section and flange divided by the gap. Input and output parts can be absent. RFQ.Regular Part table (10) is active and available for edition (edit field color is white). Other tables (RFQ.Input Part (9), RFQ.Output Part (14)) and two tables R vs Z (12, 13) are disable (edit field color is yellow). During repeated calculation of accelerator (with parameters loaded by the Open button of the main menu) the possibility of edition for tables (9-13) depends on previous calculation results.

To edit parameters

Edit parameters in RFQ.Regular Part table.

To include/exclude input and/or output parts use Input Part (1) and Output Part (3) checkboxes. Field color of according tables change to white.

Note

Transfer from one table to another one is possible just after filling of previous tables.

If the occasion requires, rows can be insert /delete into the R vs Z table.

To insert /delete row

- Pass mouse in table area
- Left click.
- Right click.

Popup menu with operations Insert Row and Delete Row appears.

Popup menu with Insert Row and Delete Row operations appears.

Chose demanded operation.

With Insert Row chosen, new blank row for data input appears, previously input data move down on one string.

With Delete Row chosen row will be deleted.

Note

Click (2) button to restore R(z) table used in Adviser part.

Click checkbox (14) and fill additional rows in the table (11) to use non-standard output cell (Crandall cell).

Accelerating structure can be divided by gaps into separate parts. In this case input gap number in edit field (4) and press Show button (5). Additional panel appears. Fill in table and press Ok button in this table.

It is supposed that gaps are cut in accelerating channel and its presence does not increase accelerator length.

The following parameters are specified in the table:

- gap number
- its center position
- gap width
- semi-axis of ellipse describing round of the section edge
- c, f, e, n codes describing desirable displacement of gap center
 - c - gap center is automatically moved to the center of the nearest cell
 - f - gap center is automatically moved to the place with zero field acting on equilibrium particle
 - e - gap center is automatically moved to the end of the nearest cell
 - n - gap center stays at the position indicated in the table

Press Ok button (15).

Transverse crossection of electrode (16) and longitudinal crossections of input and/or output part (see (17) and (18) in fig.16) appears on the graph.

Press Run button (6).

Program for input beam optimal parameters calculation runs (see part 6.3).

6.1.3. Help

To obtain Help

Press Notation button (7) to obtain Help.

Tables with parameter notations and figures appear.

6.1.4. Close window

Press Close button (8) to close window.

Program returns to main window.

7. Beam Simulation

7.1. Simulation window

7.1.1. Simulation window description

Simulation window (see fig.17) contains:

- Simulation (1), Cartoon (2) and Result (3) buttons for operation mode switch
- Load (4), Run (3) and Close (8) button
- Number of Ion Types edit field (5) with Show button (6)
- Input Data table (9)
- Distribution (10) and Field (11) switches
- Graph Parameters (12) panel with three edit fields
- Calculated Parameters (13) panel with calculated parameters switches and edit fields for input of its maximum values
- Ok button (14)

The following procedures can be made in this window:

- Input data edition
- Beam simulation program run
- Data saving for further view of cartoon and calculation results
- Simulation cartoon view
- Simulation results view with previously specified parameters and its scale. Output beam parameters, particle and power loss distribution along the accelerator are simulation results.
- Close window

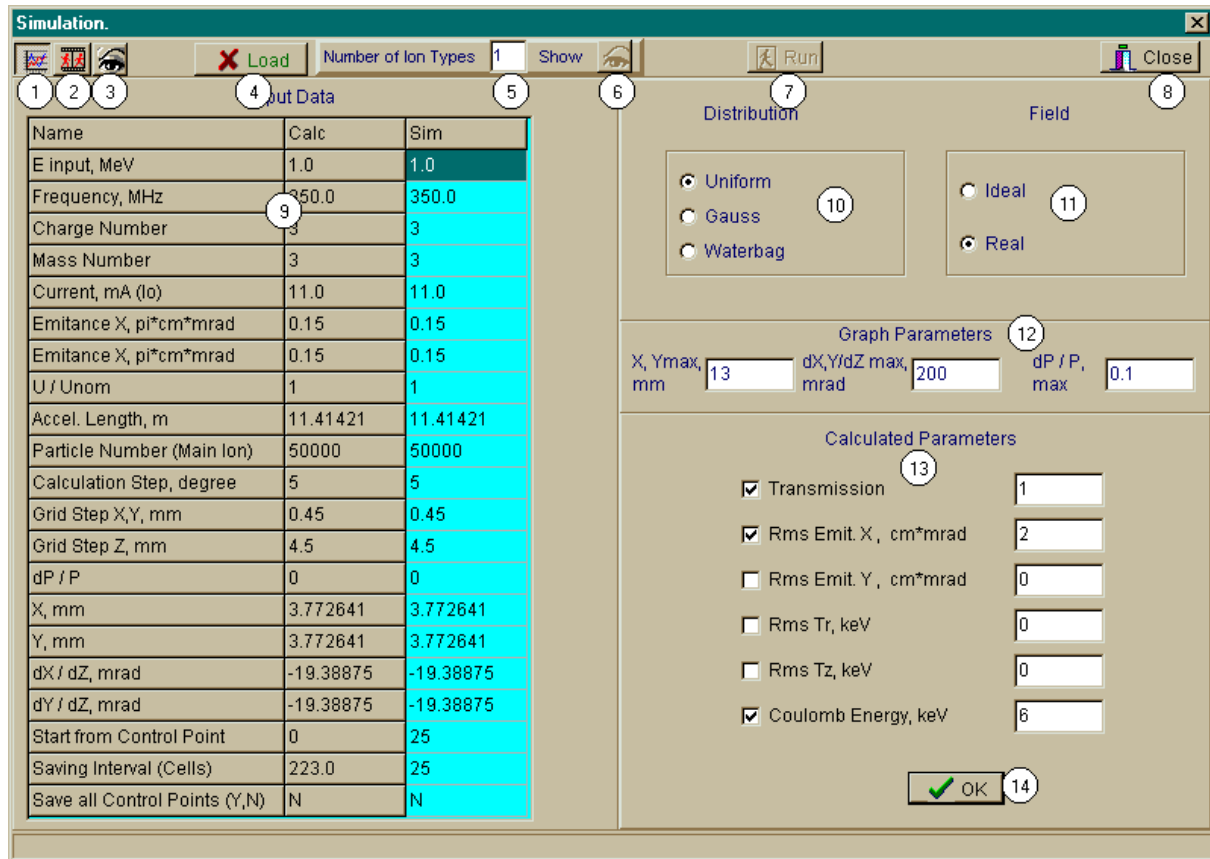


Fig.17. Simulation window.

7.1.2. Input data edition and beam simulation program run

Simulation button (1) has to be pressed for beam simulation.

To input data for simulation

Second column of Input Data table (9) presents default parameter set. Third column presents parameter set for beam simulation. Default parameter set is channel characteristics and calculation results of Adviser and Vane Real Shape.

For the first simulation default parameter set is used. With the next simulations dialog window with file list appears. These files contain parameter sets used and saved (see part 7.1.3) in previous simulations.

To make simulation with needed parameter set select appropriate file from the list (2). User can edit parameters in third column and make simulation with new parameter set.

To simulate with several ion types

Input number of ion types in **Number of Ion Types** edit field (5) to simulate motion of beam with several ion types.

Press **Show** button (6).

Additional panel appears.

Fill in **Types of Ion** table.

Press **Ok** button on this panel.

Ordinal number of ion, its charge and mass in proton values, current for specified ion as a part of total current, particle number for specified ion type are filled in the table. Table begins from ion number 2. Charge, mass and particle number for modeling base ion beam are defined in the table (9).

Table (9) notations are as follows:

Current (I ₀)	- total beam current including all ions
Emittance	- beam normalized emittance
U/U _{norm}	- voltage ratio to nominal one (nominal voltage has been used for cell lengths calculation); nominal voltage will be multiply to this ration in each cell
Accel.Length	- length of calculated area (may be less than accelerator length)
Calculation Step (degree)	- time step of motion equation calculation (if step is $\Delta\varphi$ than number of time step is $360/\Delta\varphi$)
Grid Step	- grid step for calculation of external and Coulomb fields
dP/P	- momentum spread in initial beam
X, Y, dX/dZ, dY/dZ	- envelope parameters of input beam
Saving Interval	- cell number between control point saving (it is supposed that calculation results can be saved for the following continuation of simulation)
(X,Y,dX/dZ,dY/dZ,dP/P)max	- scales for phase portrait displaying

Use **Distribution** (10) and **Field** (11) switches to choose beam distribution and field types.

Use **Calculated Parameters** (13) to choose parameters with its maximum values to be displayed.

Press **Ok** button (14).

Dialog window (see 7.1.3) for data file saving appears.

Press Ok button in dialog window.

Press Run button (3).

7.1.3. Initial data file saving for further simulation or results view

Dialog window for existing data files view and chose of file for new initial data saving is presented at the fig.18.

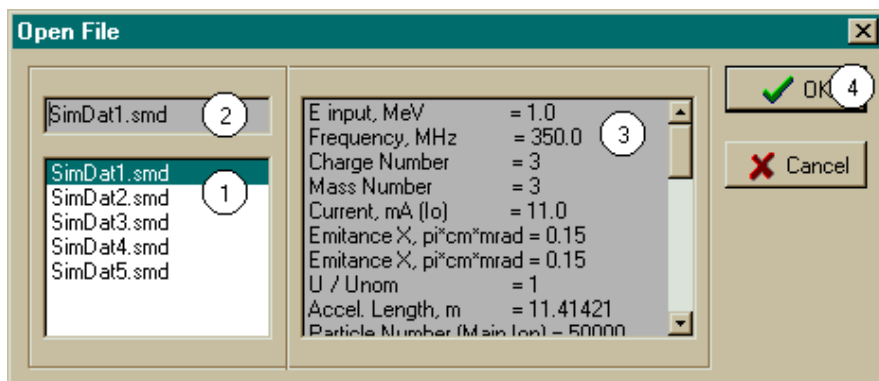


Fig.18. Open/Save File window.

Window contains:

- field (1) with five accessible files (that is possible to save five versions of initial data for each accelerator)
- string (2) with chosen file name
- field (3) with chosen file contents
- Ok button (4)

During simulation dialog window opens two times:

- before edition for viewing of file with calculation results
- after edition to chose file for data saving

During cartoon and calculation results view dialog window opens one time

- for choosing file for view.

Use Load button (item (4) in fig.17) for repeated call of dialog window (for example to load other data file).

7.1.4. View Cartoon with Beam Simulation Results

To view cartoon

Press Cartoon button (2).
Select file in Open File window.
Press Ok (14) button.
Press Run button (7).

7.1.5. Results Displaying with Needed Parameters and Scales

To display results

Press button (3).
Select needed file.
Edit data in Graph Parameters (12) and Calculated Parameters (13) panel.
Press Ok button (14).
Save data for calculation.
Press Run button (7)

Notations

Vmin/Vs - velocity selection level (non-accelerating particles with less velocity do not displayed at the output phase portrait)
Nle/Ntot - particle portion in ellipses describing output beam
Nmax - number of used particles (for calculation acceleration this number may be less than total one)

7.1.6. Close Window

To close window

Press Close button (8).

Program return to main window.

8. Appendix

Results of PARMTEQ code operation is the file with data of accelerating channel geometry and results of beam calculation. To use PARMTEQ file by LIDOS.RFQ.Designer input file has to be specially prepared. Prepared file has to contain the following information:

First string:

particle charge, particle mass, wavelength (m), beam current (mA), emittance ($\pi \cdot \text{cm} \cdot \text{mrad}$)

Second string

Number of cell in accelerating structure ($n \leq 1000$), number of cell in input matching section (integer number)

Massive including n string.

Each string includes: n, sl, sa, sq, sw, sv, st, sf, fl, scl

n	- cell number (integer),
sl	- accumulated length (cm)
sa	- minimum aperture of cell (cm)
sq	- electrode modulation
sw	- energy of equilibrium particle (MeV)
sv	- β of equilibrium particle
su	- inter-vane voltage (kV)
st	- acceleration efficiency
sf	- equilibrium phase (degree)
fl	- focusing parameter B
scl	- cell length (cm)

It is desirable to write this file in Parmteq directory of this program.

Use standard Window and DOS tools to copy and delete files in this directory.