# OptiChamber Software (version 1.3) for Modeling Laser-Pumping Trains

© Centre "TOM"

## *1. Overview*

OptiChamber v.1.3. is intended for computational modeling of optical trains containing

- lamp or diode pumping unit,
- laser rod being pumped,
- and surrounding reflector.

Present software implies 2D geometry, i.e., all the above elements are assumed to have infinite length along the laser beam direction. This enables to omit consideration of the fringe effects and describe radiation transfer within the cross-section plane only. Version 1.3 of the software provides modeling of continuous (stationary) pumping for seven different configurations, indicated by the type number, *iCfg*=1…7, five of which containing cylindric lamps and rods. For these configurations the modeling software package yields:

- two-dimensional distribution of the power density absorbed in the area of active medium [W/cm$^3$];
- histogram of area distribution for different levels of the absorbed power density [percents of the total area];
- maximum value of the absorbed power density [W/cm$^3$];
- total lineal (per unit length) power absorbed in the active medium [W/cm];
- efficiency, that is, the ratio of total power absorbed in the active medium to total power emitted by the lamp or diode [percents].

## *2. First-Step Installation*

Full-operation version of the OptiChamber software is installed in two steps. First you install the Pre-Registration Copy, whose setup does not require any serial number. It allows changing only few parameters of the optical train and can serve as a demo version. The second-step installation, which requires entering a serial number (to be discussed in the next section), upgrades the demo copy to the full-operation version.

### 2.1. System requirements

- Computer: IBM PC Compatible.
- CPU type: 80486 or higher.
- RAM: 16Mb or more.
- Video Card: providing at least SVGA 640x480, 256 colors (16-bit Hi Color mode is recommended for adequate reproduction of two-dimensional plots).
- Available disk space: about 10 MB
- Operation system: Windows 95/98.

### 2.2. Setup procedure

- Insert the Setup Disk in 3" drive (usually drive A).
- Run file **SETUP.EXE** on this drive.
- Follow the instructions on your screen.
  *During the installation you will be prompted to enter your and your company's name and to select the destination folder in which the program files are stored* (*by default*, **C:\Program Files\OptiChamber**). When the setup procedure finishes, the following files appear in the selected folder:
  Main files
  - **OptiChamber.exe (shell file)**- main program file providing end-user interface,
  - **OptiChamberCalcDemo.exe (kernel file)**- program providing calculations.

  Supplementary files
  - **OptiChamber.rtf** - User's Guide,
  - **Readme.txt** - list of last-minute changes,
  - **pump.dan -** input data file for OptiChamberCalc,
  - **pump1.dat -** output data file of OptiChamberCalc, which is used for representation of final results,
  - **pump2.dat -** auxiliary file containing additional information output of OptiChamberCalc,
  - files representing sample lamp (***.ls**) and laser rod (***.rs**) emission and absorption spectra,
  - ***.shp** files representing sample reflector's shapes.

  File **pump.ini -** default OptiChamber configuration - appear in the OptiChamber folder after the first run and saving configuration.

The following extensions are used to by default to identify additional files that can be read or written by the software from/to the OptiChamber home or another directory indicated by user:

- ***.dan** - OptiChamber configuration file (parameters to be inserted into user interface fields of OptiChamber),
- ***.dat** - calculation results in OptiChamber native or Surfer format,
- ***.prn** - two-dimensional distribution of the absorbed power density in MathCad format,
- ***.ls** - lamp or diode emission spectra,
- ***.rs** - laser rod absorption spectrum,
- ***.shp** - file describing custom-shape reflector.

### 2.3. Uninstall procedure

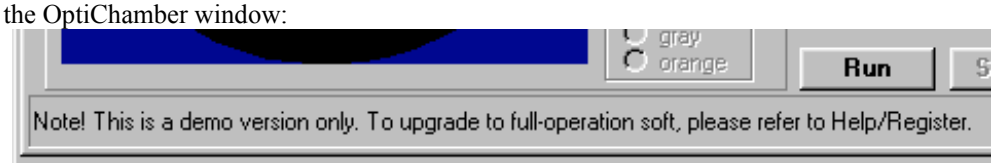
You can readily remove the OptiChamber software after any stage of installation:

- Press the button **Start** at the Windows Taskbar, then choose **Settings | Control Panel** from the pop-up menu.
- In the **Control Panel** window open the item **Add/Remove Programs**.
- Click **OptiChamber** in the program list of the panel **Install/Uninstall** and press the button **Add/Remove**.

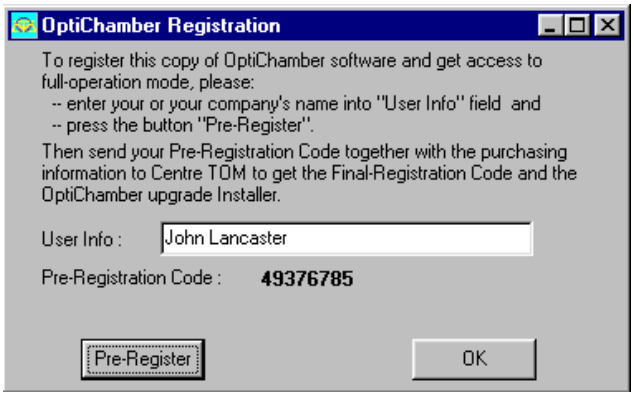
## *3. Registration and Installation of the Full-Operation Copy*

### 3.1. Registration

After the first-step installation the user gets a demonstration copy only. This is indicated on the status line at the bottom of the OptiChamber window:

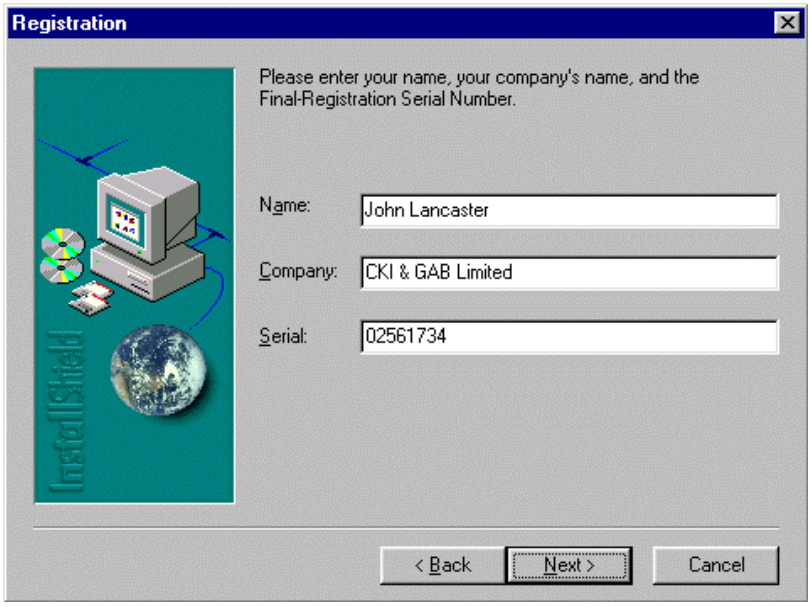



At this stage you are unable to work with real optical chamber parameters that you enter into the data fields except for the number of rays being traced, and the laser rod parameters. All other data have some preset values that remain unchanged regardless of your input.




To turn this demo version into a full-operation package, you first should obtain your personal Pre-Registration Code. Open the item Help/Register of the main menu. This brings about the OptiChamber Registration form. Follow the instructions and enter your personal information into the User Info form (for example, **John Lancaster**). Then click the Pre-Registration button and read the numerical code that appears in the field Pre-Registration Code (e.g., **49376785**). ). Send this Pre-Registration Code along with your Purchase Order to DDC Technologies, Inc.

***DDC Technologies, Inc.***
***311 Woods Ave.,***
***Oceanside, NY 11572***
***Phone:*** ***(516) 770-0441***
***E-mail:*** ***sales@ddctech.com***




### 3.2. Final Registration

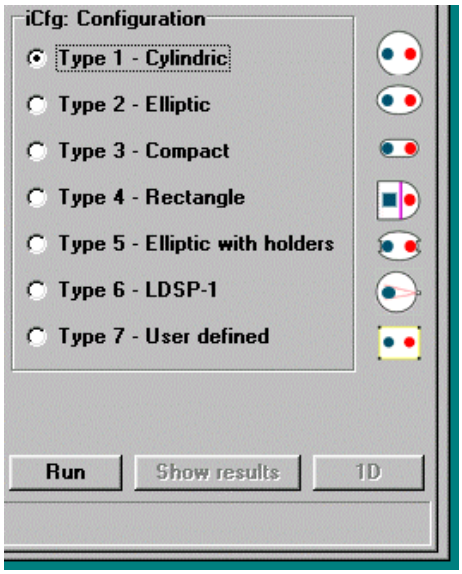
In response the Developer will email you the payment requisites. After the payment you will receive by email the Final (Second-Step) Installer and your personal Final-Registration Serial Number (for example, **02561734**), which is needed to launch the setup program. Follow once more the procedure of item 2.2 and run the second-step installation. This time you must enter

the Final-Registration Serial Number. On completing the installation you get a full-operation copy of the OptiChamber 1.3 software.

## *4. Getting started*

### 4.1. Setting desired configuration of the pumping system

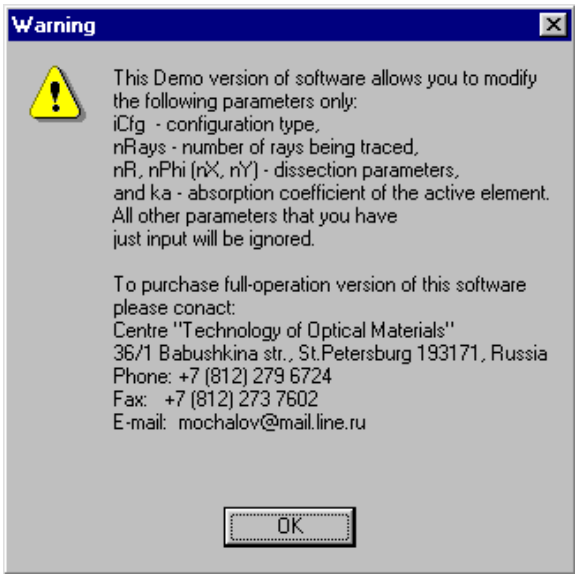
Run **OptiChamber.exe** from the corresponding program group of the **Start/Programs** menu or from the directory to which it was installed. Being properly installed, the program starts with the message "**OptiChamber license status is OK**" on the status bar at the bottom of the panel **General**. Choose the desired configuration type from the panel **General**, group **iCfg: Configuration**. After that all the panels which are necessary for definition of the modeling parameters, - **General**, **Lamp** (or **Diode**), **Laser Rod**, and **Config_n** - becomes accessible.




### 4.2. Starting calculations

To look how the software works, you can start calculation of the pumping system characteristics immediately with predefined parameters by clicking the button **Run** on the panel **General**. This starts the console application, or kernel, **OptiChamberCalc.exe** performing all necessary calculations, the status bar being set to "**Starting…**", then to "**Calculations in progress, please wait…**". To save the screen space, the program runs in minimized-window mode and appears at the Windows taskbar only.

If you are running the Pre-Registration copy instead of the full-operation software, the Demo-version kernel, **OptiChamberCalcDemo.exe**, starts after the warning message.




### 4.3. Calculation progress

At present, only the number of traced rays that is output in the kernel (**OptiChamberCalc.exe**) window is indication of the kernel progress. OptiChamberCalc.exe window is DOS-styled, with black background. It first appears as an icon (a rectangular with the title **OptiChamberCalc**) at the Windows95/98 taskbar when the Run button is pressed. It may be opened with the mouse by a double-click. The window shows the progress of the *Monte-Carlo* procedure in the form

**N = <number of rays being already traced>.**

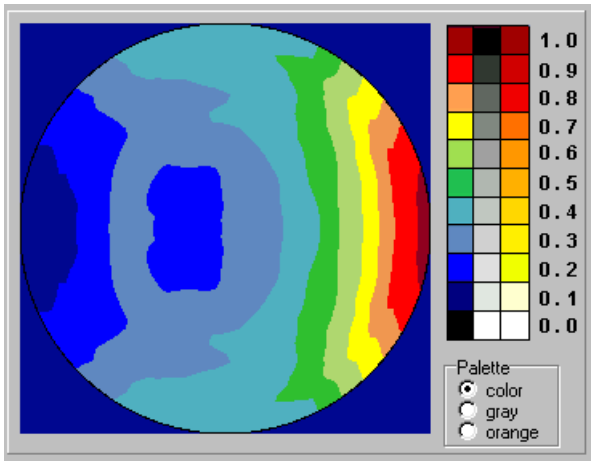
Having total number of the traced rays shown on OptiChamber panel **General**, the user can easily define how much work is done.

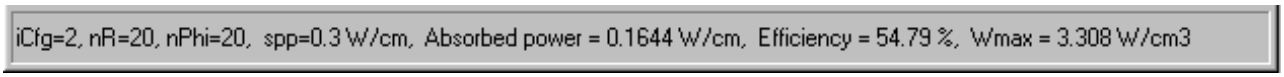
You can **abort calculations** by double-clicking the **OptiChamberCalc** icon at the Windows95/98 taskbar and closing the OptiChamberCalc's window with the help of the X button at the right top of this window.

When the calculations finish, **OptiChamberCalc** quits, the status bar is "**Calculations are finished. Press [Show results] to visualize**", and two buttons, **Show results** and **1D**, become active.

### 4.4. Visualizing results

Click on Show results button to build two-dimensional plot of the absorbed power density distribution over area of active medium (the lamp is located at the right side of the rod). Status bar changes to "Drawing…", then, after the plot is created, to the results set containing:





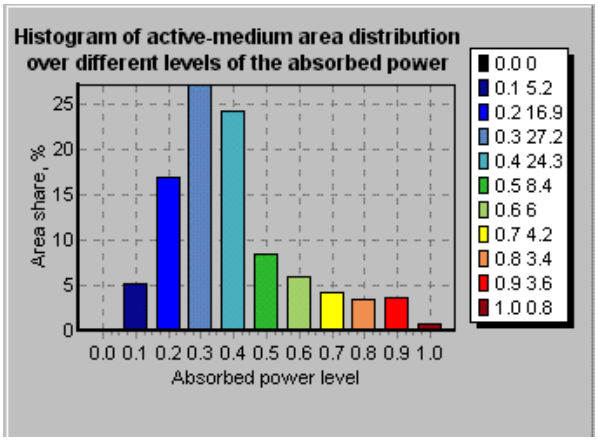

- current configuration type *iCfg*,
- number of radial layers *nR* and angular slices *nPhi* (or numbers of X and Y layers, *nX* and *nY*, for configuration 4) of the active element dissection,
- total lineal power of the pumping pulse emitted by the lamp or diode *Plp* [W/cm],
- total lineal power absorbed in the active medium [W/cm],
- efficiency, that is, the ratio of total power absorbed in the active medium to total power emitted by the lamp or diode [percents].
- maximum value of the absorbed power density *Wmax* [W/cm$^3$].

When the mouse pointer enters the plot area, it changes to a cross. Simultaneously, the status bar content changes to show parameters of the point under the mouse pointer:

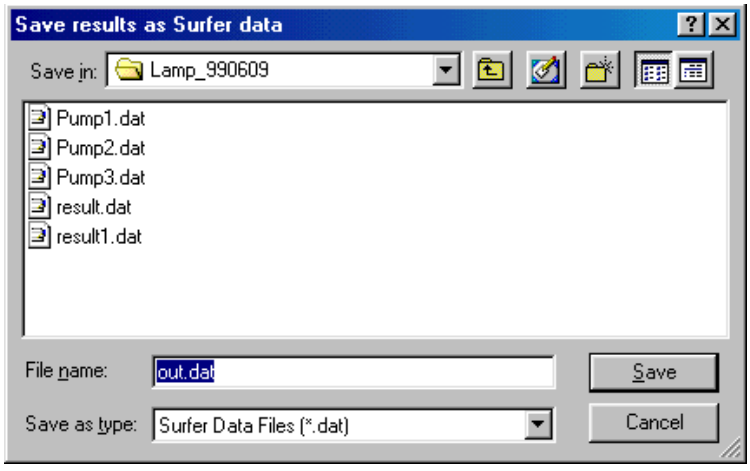
- physical coordinates of the point with respect to the rod center (bottom left corner in case of rectangular rod) *X* and *Y* [cm],
- radial coordinate of the point *R* [cm], $R^2 = X^2 + Y^2$,
- azimuth angle of the point, degrees,
- ratio of the local specific absorbed power density to its maximum value over the rod cross section $Wrel \in [0,1]$,
- absolute value of the local absorbed power density *Wabs* [W/cm$^3$].

Radio group **Palette** provides switching between **Color**, **Gray**, and **Orange** palettes which are used for marking areas with the same range of the absorbed power. There are eleven ranges whose colors are indicated in the scale on the right of the plot, representing the following grades of the relative absorbed power density *Wrel*:

| range label | range definition |
|---|---|
| 0.0 | $0.00 \le Wrel \le 0.05$ |
| 0.1 | $0.05 < Wrel \le 0.15$ |
| 0.2 | $0.15 < Wrel \le 0.25$ |
| 0.3 | $0.25 < Wrel \le 0.35$ |
| 0.4 | $0.35 < Wrel \le 0.45$ |
| 0.5 | $0.45 < Wrel \le 0.55$ |
| 0.6 | $0.55 < Wrel \le 0.65$ |
| 0.7 | $0.65 < Wrel \le 0.75$ |
| 0.8 | $0.75 < Wrel \le 0.85$ |
| 0.9 | $0.85 < Wrel \le 0.95$ |
| 1.0 | $0.95 < Wrel \le 1.00$ |




The button **1D** allows passing to another representation of the data obtained: a histogram. Being pressed, this button replaces the 2D plot by its one-dimensional counterpart in which the area share of each absorbed power level is plotted versus the value of the relative absorbed power density *Wrel*. Next click on the same button (now its caption is **2D**) brings us back to two-dimensional picture.



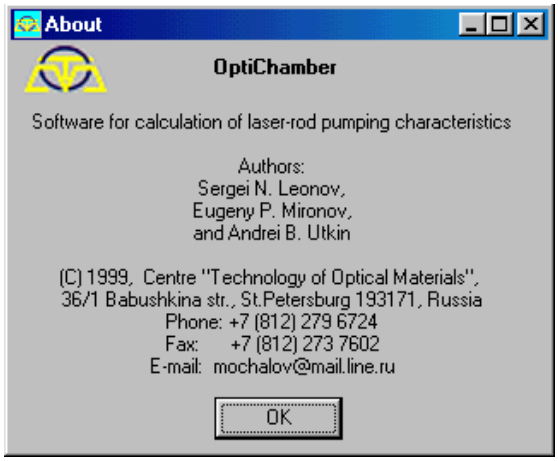

### 4.5. Saving results

You can save the obtained results on disk with **Results / Save As** item of the main menu. Three submenus - **OptiChamber, MathCAD, and Surfer data** - offer to save resulting figures and plots in OptiChamber native (***.dat** file), MathCAD (***.prn** file) and Surfer (***.dat** file) scientific-graphics package formats respectively. The last menu **Bitmap** enables to save 2D plot in bitmap format (***.bmp** file). *Warning: bitmap format of the saved pictures has extended features that sometimes cannot be properly recognized by popular graphic editors and viewers (for example, Adobe PhotoShop). If the picture looks distorted in your graphics package, please open the bitmap file with the help of Windows Paint (that is a part of Windows 95/98 package that can be launched from the Start/Programs menu, program group Accessories) and, then, save it back to*

*the disk. After that the bitmap is decoded properly by all packages*. In all cases the standard Windows 95 Save File dialog will guide you through the save procedure, including choice of drive, folder, and file name.

### 4.6. Loading previously saved results

Results that were previously saved with **Results / Save As / OptiChamber data** option may be read and re-converted into plots with the help of **Results / Load From File** item of the main menu. Corresponding graphics is created just after you close standard Windows 95 Open File dialog window (that enables to choose desired file), so there is no need to click on **Show results** button.

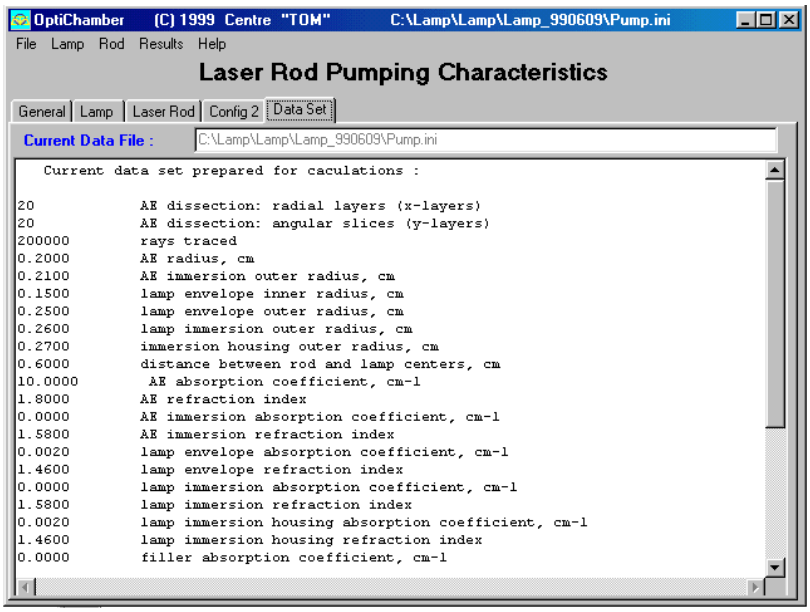


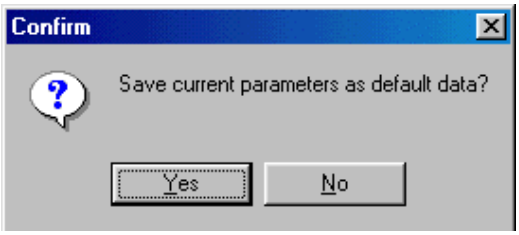

### 4.7. Getting help

Current version of the software package does not support on-line help. Instead, some comments to the particular program units are added as hints that appear as the mouse pointer enters the unit's area. In addition, this User's Guide can be read directly from the program shell with **Help / OptiChamber Info** item of the main menu (however, illustrations cannot be shown, so you are strongly encouraged to use Microsoft Word instead). Use **Help / Spectral Data Summary** and **Help / About** item to display information about the reference spectra files and the authors.

### 4.8. Getting auxiliary information

To get information about the parameters that are currently set as the initial data for the *kernel* program **OptiChamberCalc.exe**, bring to front the **Data Set** worksheet clicking on corresponding bookmark at the top bookmark row. The upper field **Current Data File** contains the name of resent file (**pump.ini** by default) from which the initial data were loaded (see section 4.5). Below one can read full list of currently active parameters prepared for the next-in-turn calculation run. In the next sections we explain how to change each of these parameters with the help of interface fields on other worksheets.



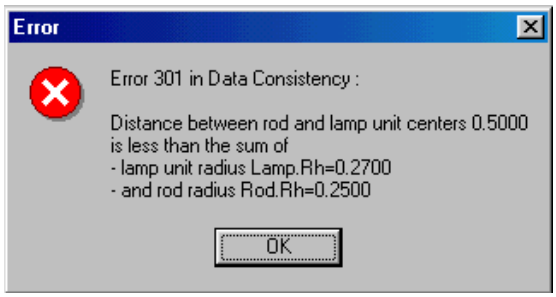

### 4.9. Exiting program

To exit to the program, use the standard **File / Exit** item of the main menu. Before quitting, the program prompts you to save data that you entered into the interface fields during current session. If you click on **Yes**, the parameters you defined will be written into the file **pump.ini** and retrieved during the next start-up, otherwise the startup data file remains unchanged.

## *5. Worksheet General: Changing General Parameters*

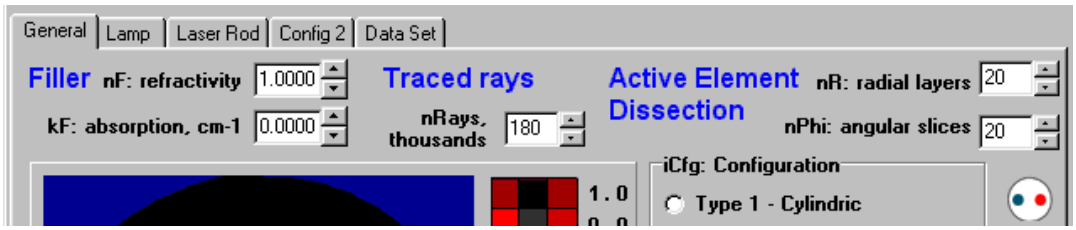
### 5.1. Input fields

Now, when you have learned how to start calculations and exit the program, let us explain how to change parameters of the optical system under modeling. This should be done by changing values in corresponding *input fields*. Each input field is supplied by *up-down control* consisting of a pair of arrow buttons, allowing users to change the size of a numerical value by clicking on them. The step of increase and decrease is predefined for each field and the excursion length is confined in accordance with the physical meaning of the parameter in question and current values of other parameters. For example, it is possible to decrease the refraction indices down to the



value 1 only and it is impossible to make, say, the rod radius greater then the current radius of surrounding reflector. If you prefer to be free of finite-step and data-consistency restrictions, you can enter in the input field any desired value using a keyboard. However, when you start calculations (see section 4.2) the program shell first performs the data-consistency check and in case of any data mismatch opens pop-up window with error diagnostics rather then starts the kernel file **OptiChamberCalc.exe**. All input fields are subdivided into groups representing closely related parameters: General, Lamp/Diode, Laser Rod, and Configuration. Groups are placed in separate worksheets, each of which can be brought to front by clicking on **General**, **Lamp**/**Diode**, **Laser Rod**, or **Config n** bookmark at the top row.

On the worksheet **General**, apart from the **Configuration** radio group allowing to choose desired pumping system configuration type *iCfg*, there are five input fields in three local subgroups. The subgroup **Filler** provides opportunity to insert two optical characteristics of the medium in which the entire pumping system is embedded: the **absorption coefficient** *kF* [cm$^{-1}$] and the **refraction index** *nF*. As in most cases this medium is air, the default values of these parameters are zero and unity respectively. The subgroup **Traced rays** consists of a single field in which one can

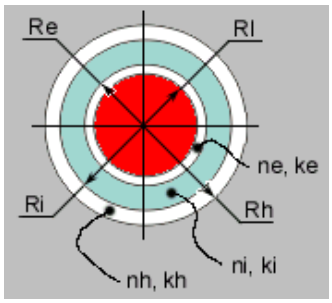



change number of rays *nRays* being generated by the kernel in the course of the *Monte-Carlo* procedure. The subgroup **Active Element Dissection** includes two input fields for the number of radial layers *nR* and number angular slices *nPhi* to subdivision of the active-medium area into finite sample elements by the polar-coordinate dissection. For configuration 4 rectangular, or Cartesian-coordinate, dissection of the rectangular rod is preformed, so here corresponding parameters are the numbers of X and Y layers, *nX* and *nY*.

### *6. Worksheet Lamp / Diode*

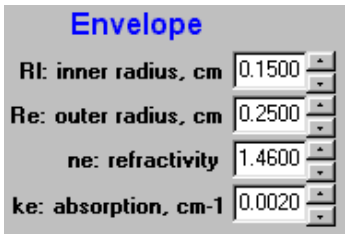
Use this worksheet to modify parameters of the pumping source. The worksheet **Diode** is involved for configuration 6 while **Lamp** is used for other configurations.

#### 6.1. Worksheet Lamp subgroups




The cylindric lamp embodies the plasma core with up to three outer layers, - the envelope, immersion, and housing, - whose radii and optical properties are defined by user. The plasma core is supposed to be a non-transparent light source whose surface radiates uniformly within the solid angle $2\pi$. There are five subgroups in this worksheet: **Envelope**, **Immersion**, **Housing**, **Lineal Pumping Power**, and **Spectral Properties**. The first three correspond to surrounding layers. The immersion and/or housing layers can be eliminated from the model by setting correspondent outer layer radius equal to the radius of the previous layer (assigning zero thickness). **Lineal Pumping Power** let you enter the power of the pumping pulse that is emitted by unit-length segment of the lamp. The table **Spectral Properties** allows user to enter spectral characteristics of the lamp.

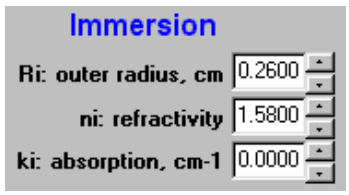
#### 6.2. Worksheet Lamp, subgroup Envelope




Here the user can change parameters of the primary lamp shell - the envelope, which is represented by four parameters:

- inner radius *Rl* [cm],
- outer radius *Re* [cm],
- refraction index *ne*,
- absorption coefficient *ke* [cm$^{-1}$].

#### 6.3. Worksheet Lamp, subgroup Immersion

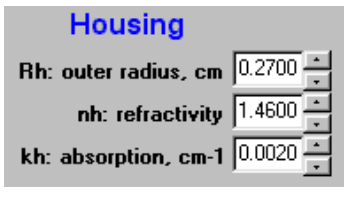



The immersion layer may be used for improvement of the lamp radiation as well as for modeling of liquid cooling. As the inner radius of the immersion is defined by the outer radius of the envelope, there are only three parameters in this group:

- outer radius *Ri* [cm],
- refraction index *ni*,
- absorption coefficient *ki* [cm$^{-1}$].

If *Ri*=*Re*, the immersion layer is omitted.

#### 6.4. Worksheet Lamp, subgroup Housing



The housing layer may be introduced into the lamp for formation of the immersion cavity in the case of liquid filler as well as for additional mechanical strength and protection. Its parameters are akin to those of the immersion layer:

- outer radius *Rh* [cm],
- refraction index *nh*,
- absorption coefficient *kh* [$cm^{-1}$].

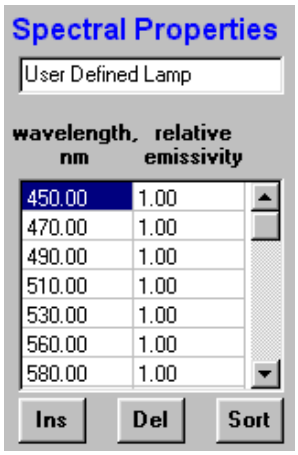
Housing layer can be excluded by setting zero thickness (*Rh* = *Ri*).

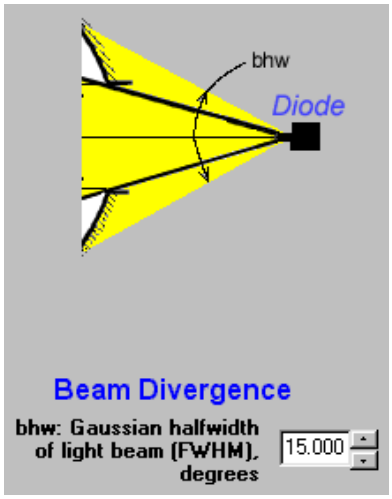
### 6.5. Worksheet Lamp, subgroup Lineal Pumping Power

Here you can enter the power *Plp* of the pumping source. As far as the two-dimensional approximation is used that implies the infinitely long lamp, the power is measured in Watts per unit (1 cm) of the lamp length (so-called lineal power). Since all energy relations are linear, you can threat *Plp* as the total lamp power (implying uniform distribution of radiation along the lamp length) or, furthermore, as the total lamp energy (implying constant value of the lamp power for all duration of the pumping pulse).

### 6.6. Worksheet Lamp, subgroup Spectral Properties

The software in its present form uses the one-spectral-band approximation that actually means that all rays are generated in the *Monte-Carlo* procedure at the same wavelength. Thus, the model fails to reproduce spectral variations of the pumping system parameters. The only thing that can be done in the framework of the one-band approximation is to calculate a rough estimation for the effective absorption coefficient of the laser rod *ka* for given combination of the lamp emission and rod absorption spectra. Initial data for this procedure (to be discussed in section 7.2) concerning the lamp spectral properties should be entered into the *Spectral Properties* table. The table consists of the editable title field (containing user-defined reference information) and two columns: wavelength [nm] and lamp emissivity. The final absorption coefficient is normalized on the integral lamp emissivity, so you can enter the lamp emissivity in any desired units. You can insert and delete single lines of the table using the **Ins** and **Del** buttons beneath. To sort the table in the ascending-wavelength order, use the **Sort** button. Input data (together with the reference information in the title field) can be loaded from or saved to a file with **Load Lamp Spectrum** and **Save Lamp Spectrum** items of the section **Lamp** of main menu. Default extension for the lamp-spectrum data file is ***.ls**. Several files containing standard lamp spectra are included with corresponding comments in the present package as a reference information. Use **Help / Spectral Data Summary** item of the main menu to see the list of all lamp-spectrum files and their brief descriptions.




### 6.7. Worksheet Diode

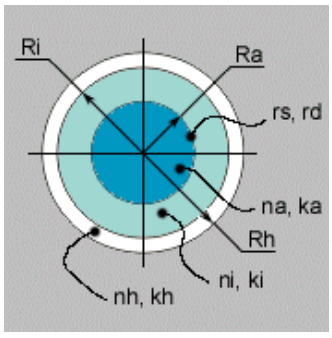
In case of configuration 6 that is called LDSP-1 (Laser-Diode Set Pumping), a diode with the Gaussian beam distribution is used as a pumping source. Full width of this distribution at half maximum, *bhw* [degrees], is defined by user in **Beam Divergence** subgroup. There are two other subgroups on this sheet, **Lineal Pumping Power** and **Spectral Properties** that are akin to those described in sections 6.5 and 6.6.

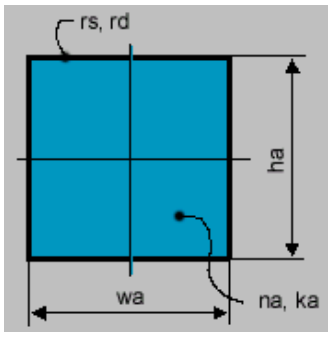
## *7. Worksheet Laser Rod*

This worksheet allows to modify parameters of the laser rod to be pumped.

### 7.1. Worksheet Laser Rod subgroups

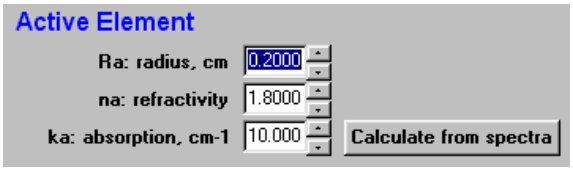
All configurations except 4 include cylindric laser rods whose solid core (active element) does not need forming envelope layer as in case of lamp while optional immersion and housing (outer protection) layers are included as in the case of lamp. Worksheet subgroups are: **Active Element**, **Active Element Surface**, **Immersion**, **Housing**, and **Spectral Properties**. Configuration 4 stands out because of rectangular rod shape. Here other parameters appear is the **Active Element** subgroup while



**Immersion** and **Housing** subgroups do not present.

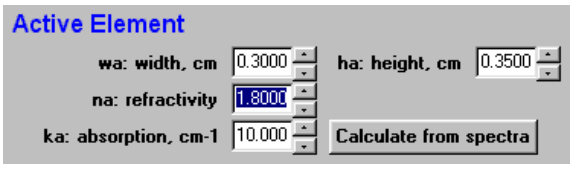
### 7.2. Worksheet Laser Rod, subgroup Active Element




The subgroup contains parameters of the active-medium area:

- radius *Ra* [cm],
- refraction index *na*,
- absorption coefficient *ka* [$cm^{-1}$].

In the case of configuration 4 the first parameter is replaced by two - *wa* [cm] and *ha* [cm] - characterizing size of the rectangular rod.




The button **Calculate from spectra** allows calculating effective absorption coefficient *ka* on the basis of lamp (diode) and rod spectra that is input in the **Spectral Properties** tables of the **Lamp** (**Diode**) and **Laser Rod** worksheets. First the program defines the spectral area Λ which is the intersection lamp and rod spectra. Then the effective absorption coefficient *ka* is calculated according to the expression

$$ka = ddf \int_{\Lambda} \sigma(\lambda)\, k(\lambda)\, d\lambda \,/\, \int_{\Lambda} \sigma(\lambda)\, d\lambda$$

where *ddf* is a dopant density factor that you can enter into the field below *ka* input field, $\sigma(\lambda)$ is the lamp emissivity measured in some conventional units and $k(\lambda)$ is the absorption coefficient for the wavelength $\lambda$. The default value of the dopant density factor *ddf* is unity, so it does not affect the resulting value of *ka*. However, if you have to calculate the absorption coefficient for the dopant density that differ from that of the spectral table, you should calculate *ddf* as a ratio of the actual dopant density to that for which the spectrum table is calculated. In this case the correct value of the absorption coefficient is calculated without need of re-insertion of the scaled absorption coefficients throughout the entire spectrum.

Finally, the obtained value is inserted into the absorption coefficient field. In integrating, linear data interpolation is used, so in case of linear spectrum one should use zero limiting values to mark separate spectral lines. That is, the set

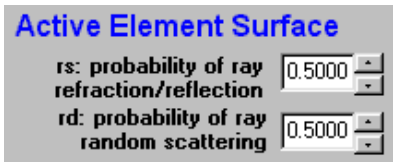
450 200
670 200

represents uniform emission or absorption within the broad spectral area 450-670 nm while the set

449 0
450 200
451 0
669 0
670 200
671 0

corresponds to two narrow spectral lines.

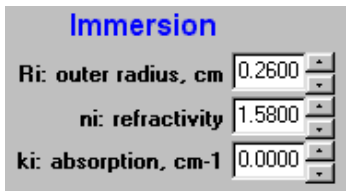
### 7.3. Worksheet Laser Rod, subgroup Active Element Surface




Optical properties of the active element surface, which can be coarse due to special treatment, are characterized by two parameters:

- probability of ray refraction/reflection *rs* and
- probability of ray isotropic random scattering *rd*.

### 7.4. Worksheet Laser Rod, subgroup Immersion

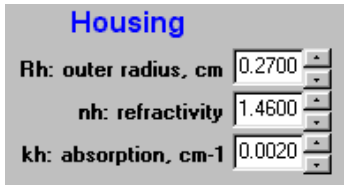



This subgroup is the same as that of worksheet Lamp (see section 6.3) and contains the following parameters:

- outer radius *Ri* [cm],
- refraction index *ni*,
- absorption coefficient *ki* [$cm^{-1}$].

Immersion layer can be excluded by setting zero thickness (*Ri* = *Ra*).

### 7.5. Worksheet Laser Rod, subgroup Housing

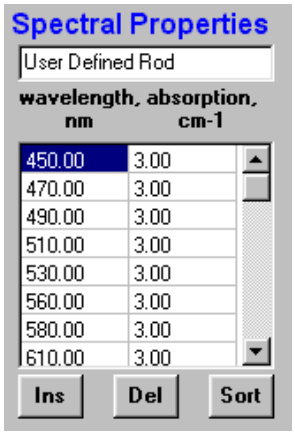



The housing parameters are:

- outer radius *Rh* [cm],
- refraction index *nh*,
- absorption coefficient *kh* [$cm^{-1}$].

Housing layer can be excluded by setting zero thickness (*Rh* = *Ri*).

### 7.6. Worksheet Laser Rod, subgroup Spectral Properties




The table **Spectral Properties** enables the user to enter dependence of the absorption coefficient of the active medium on the wavelength, which is used by **Calculate from spectra** procedure (see sections 6.6 and 7.2). It consists of the editable title field (containing user-defined reference information) and two columns: wavelength [nm] and absorption [$cm^{-1}$]. You can insert and delete single lines of the table using the **Ins** and **Del** buttons. To sort the table in the ascending-wavelength order, use the **Sort** button. Input data (together with user-defined reference information of the title field) can be loaded from or saved to a file with **Load Rod Spectrum** and **Save Rod Spectrum** items of the section **Rod** of main menu. Default extension for the rod-spectrum data file is ***.rs**. Several files containing standard rod absorption spectra are included with corresponding comments in the present package as a reference information. Use **Help / Spectral Data Summary** item of the main menu to see the list of all rod-spectrum files and their brief descriptions.

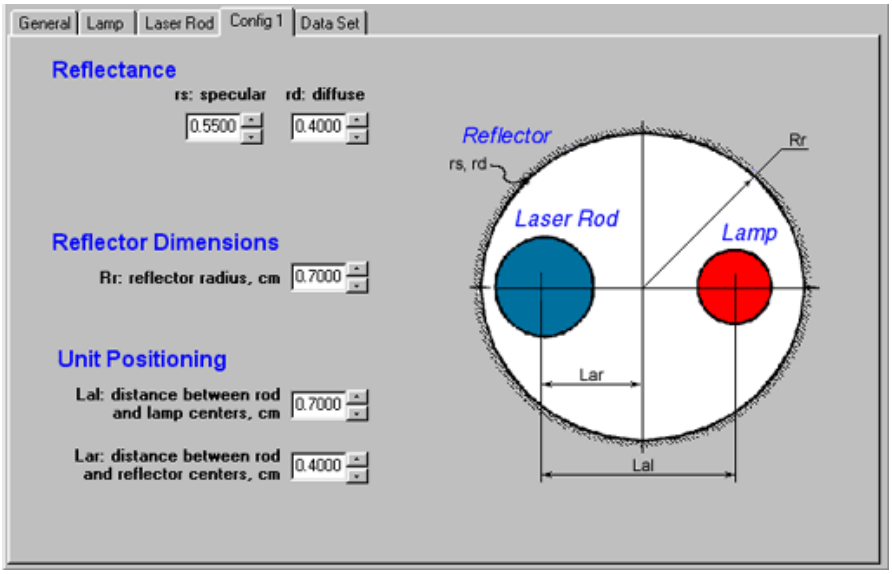
## *8. Configuration Worksheets*

Parameters that are related to lamp and rod position and the reflector dimensions are placed on seven worksheets from **Config 1** to **Config 7**, one worksheet per each pumping-system configuration type. Only one worksheet is active at a time - one that is chosen in *iCfg* radio group on the worksheet **General**.

The **reflective surfaces** are characterized by two coefficients *rs* and *rd*. Sample rays hitting the surface are subjected to: specular reflection with probability *rs* (**specular reflectance**), uniform back scattering within the solid angle $2\pi$ with probability *rd* (**diffuse reflectance**), and absorption with probability *1-rs-rd*.

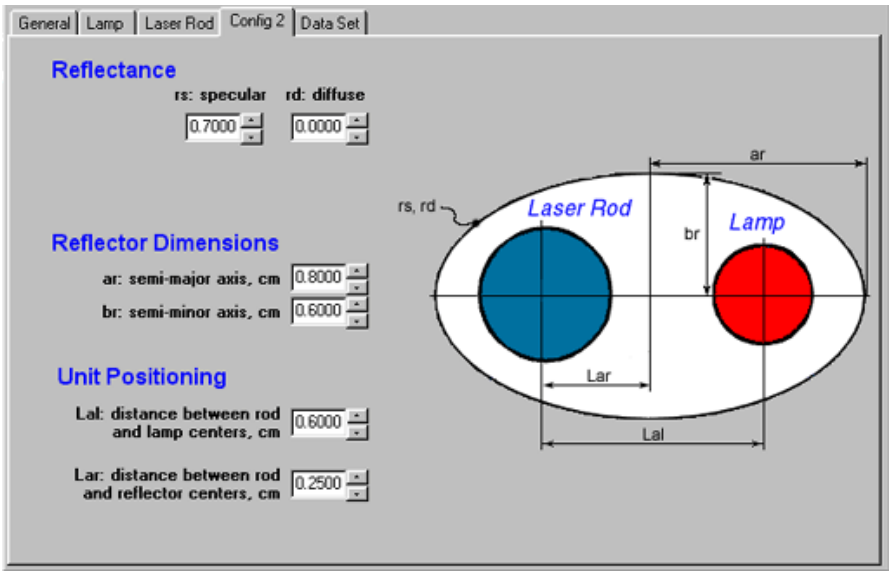
System composition and subgroups for each configuration are listed below. Configuration parameters are listed in Appendix A.

### 8.1. Config 1



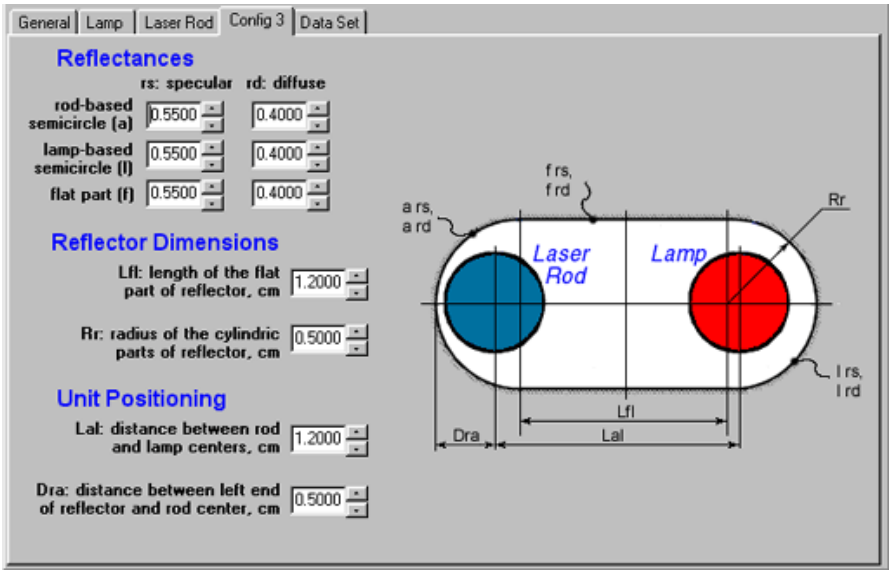

**Composition:** laser rod, lamp, and cylindric reflector.
**Subgroups:** Reflectance, Reflector Dimensions, and Unit Positioning.

### 8.2. Config 2



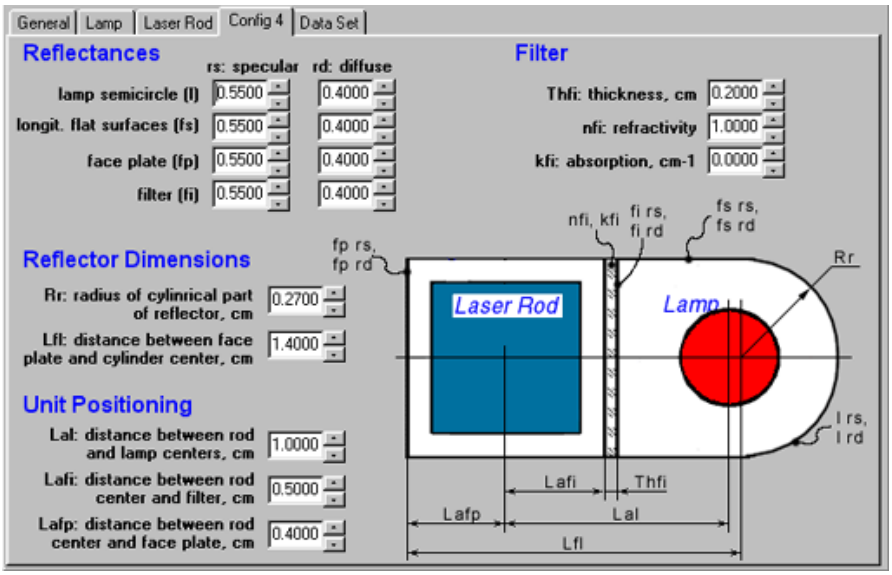

**Composition:** laser rod, lamp, and elliptic reflector.
**Subgroups:** Reflectance, Reflector Dimensions, and Unit Positioning.

### 8.3. Config 3



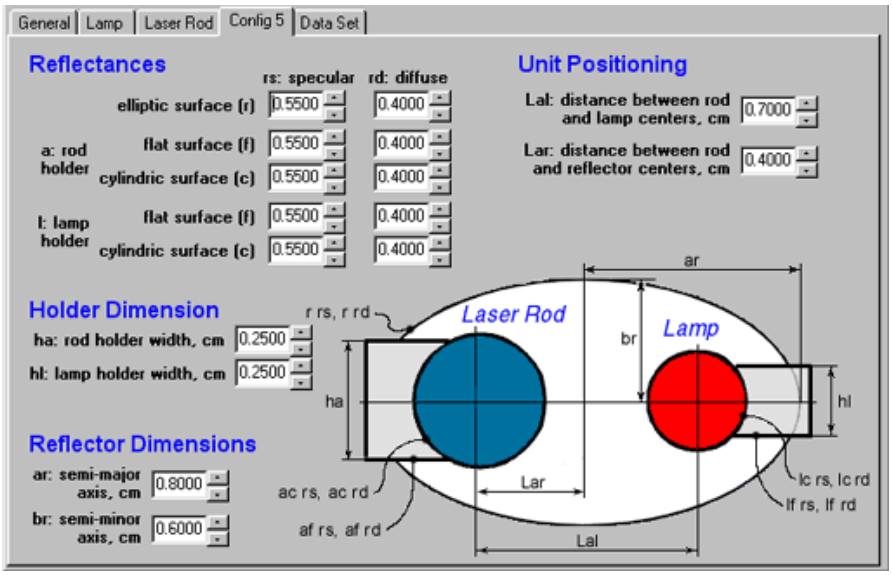

**Composition:** laser rod, lamp, and so-called compact reflector consisting of two flat surfaces confined at the ends by adjoined semi-cylinders.
**Subgroups:** Reflectances, Reflector Dimensions, and Unit Positioning.

### 8.4. Config 4




**Composition:** laser rod, lamp, quasi-parallelepiped reflector confined at the lamp side by adjoined semi-cylinder, and filter plate.
**Subgroups:** Reflectance, Reflector Dimensions, Unit Positioning, and Filter.
Config 4 differs from other configurations in laser rod construction. It has parallelepiped shape and does not contain immersion and housing layers. These peculiarities influence the Laser Rod worksheet and representation of calculation results.

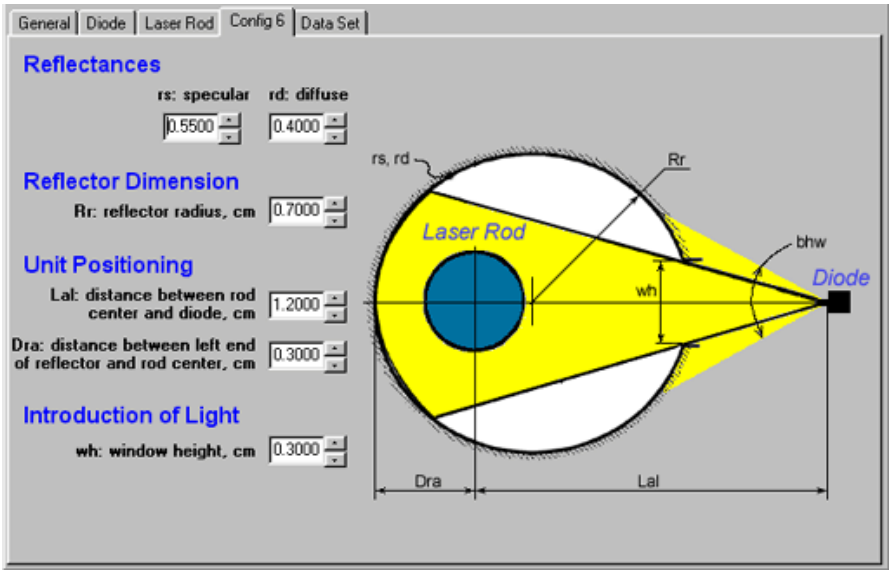
### 8.5. Config 5




**Composition:** laser rod, lamp, elliptic reflector, and rod and lamp holders.
**Subgroups:** Reflectance, Holder Dimension, Reflector Dimensions, and Unit Positioning.

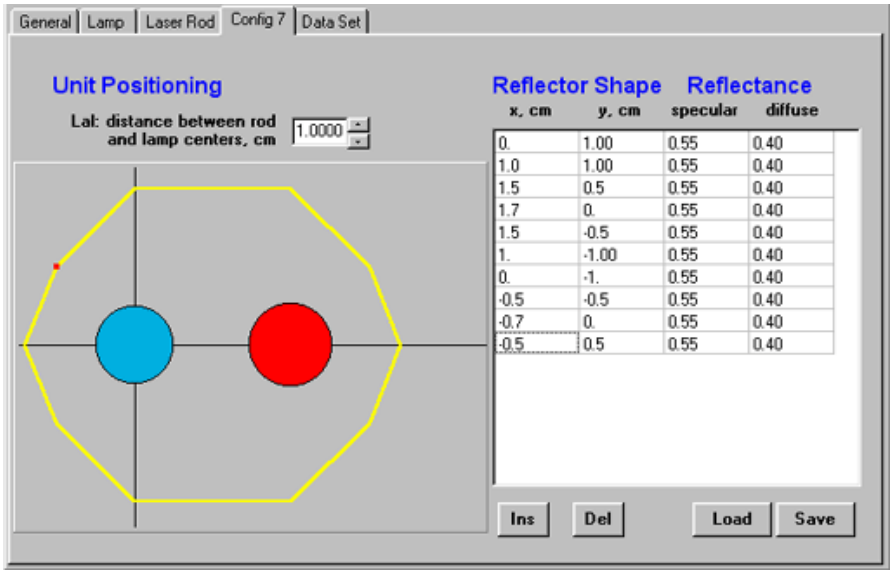
### 8.6. Config 6

**Composition:** laser rod, diode, and cylindric reflector with the input window.

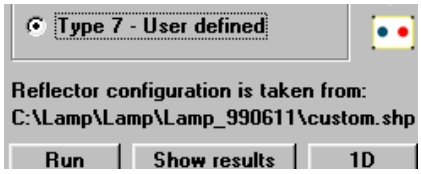



**Subgroups:** Reflectance, Reflector Dimensions, Unit Positioning, and Introduction of Light.
Config 6 differs from other configurations in pumping source: here it is diode rather than lamp. This peculiarity influences the active pumping source worksheet, which for this particular case is **Diode** rather than **Lamp** worksheet (see section 5.7).

### 8.7. Config 7




**Composition:** laser rod, lamp, and reflector described by a polygon.
**Subgroups:** Unit Positioning, Reflector Shape, and Reflectance.
Coordinates of the reflector polygon vertexes and reflectances of corresponding segments are defined by user in the table at the right side of panel. When you are editing the table, the changes are reflected in the sketch at the left, current point or segment being marked by color. The origin of coordinates coincides with the laser rod center. You can insert and delete single lines of the table using the **Ins** and **Del** buttons beneath. Input data can be loaded from or saved to a file with **Load** (in this case the filename appears below the **Configuration** radio group on the worksheet **General**) and **Save** buttons. Default extension for the lamp-spectrum data file is ***.shp**.

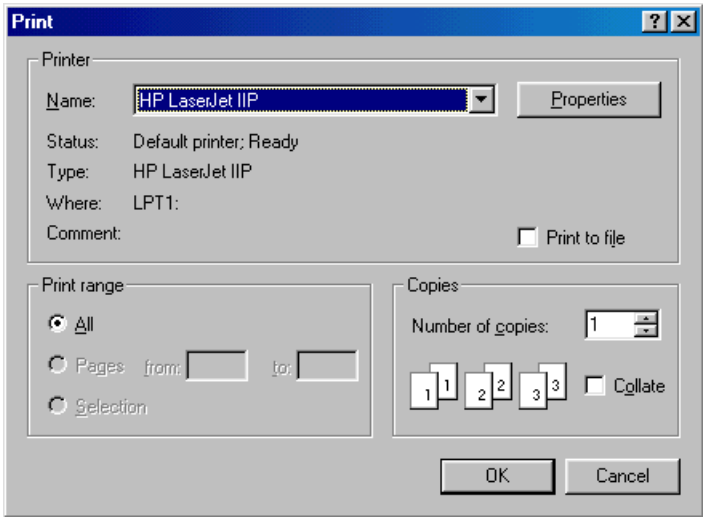



## *9. Main Menu*

Pull-down main menu is located at the top of the OptiChamber window. It consists of five top-level items: **File**, **Lamp**, **Rod**, **Results**, and **Help**. The last four are already described above: **Lamp** in section 6.6, **Rod** in 7.6, **Results** in 4.4 and 4.5, and **Help** in 4.6. The item **File** consists of five sub-items:

- **Open Chamber** allows you to open previously saved data that were input in **OptiChamber** interface shell. In this case corresponding file name will appear on the right in the window title.

- **Save Chamber** lets you to save the input data on file (default file extension is ***.dan**). It differs from **Save As** item of the **Results** menu in that the latter saves *results* of work of the kernel program **OptiChamberCals** while here the *initial parameters* are saved.
- **Save Chamber as Default** enables to write the input data into **pump.ini** file. The parameters you entered will be retrieved at the next start-up.
- **Printer setup** opens standard Windows Print Setup Dialog in which the user can setup desired printer and its parameters.
- **Print results** allows to print the plot of two-dimensional absorbed power density distribution (see section 3.3) together with the list of initial parameters. It brings about standard Windows Print Dialog in which you can setup desired printer and its options.




- **Exit** closes the program OptiChamber. Before quitting, the program prompts you to save data that you entered into the interface fields during current session (see section 3.8). If you click on **Yes**, the parameters you defined will be written into the file **pump.ini** and retrieved during the next start-up, otherwise the startup data file remains unchanged.

### *Appendix A. List of Parameters*

```
G. General

G.1. Filler
G.1.1. Filler absorption coefficient (kF), [cm-1]
G.1.2. Filler refractivity           (nF)

G.2. Traced rays
G.2.1. Number of rays being traced (nRays)

G.3. Active Element Dissection
G.3.1.1. Radial layers  (nR)   (all configurations except 4)
G.3.1.2. X layers       (nX)   (configuration 4)
G.3.2.1. Angular slices (nPhi) (all configurations except 4)
G.3.2.2. Y layers       (nY)   (configuration 4)

G.4. Configuration type
G.4.1. Number indicating configuration type (iCfg) [1..7]

L. Lamp (all configurations except 6)

L.1. Envelope
L.1.1. Inner radius (Rl), [cm]
L.1.2. Outer radius (Re), [cm]
L.1.3. Refractivity (ne)
L.1.4. Absorption   (ke), [cm-1]

L.2. Immersion
L.2.1. Outer radius (Ri), [cm]
L.2.2. Refractivity (ni)
L.2.3. Absorption   (ki), [cm-1]
```

L.3. Housing
L.3.1. Outer radius (Rh), [cm-1]
L.3.2. Refractivity (nh)
L.3.3. Absorption (kh), [cm-1]

L.4. Spectral properties
L.4.1. Wavelength [nm]
L.4.2. Relative emissivity

D. Diode (Lamp panel replacement for configuration 6)

D.1. Beam divergence
D.1.1. Gaussian halfwidth of light beam, FWHM, (bhw), [degrees]

R. Laser Rod

R.1. Active Element
R.1.1.1. Radius (Ra), [cm] (all confirurations except 4)
R.1.1.2. Width (wa), [cm] (configuration 4)
R.1.1.3. Height (ha), [cm] (configuration 4)
R.1.2. Refractivity (na)
R.1.3. Absorption (ka), [cm-1]
R.1.4. Dopant density factor (ddf)

R.2. Ray Interaction with Active Element Surface
R.2.1. Probability of ray refraction/reflection (rs)
R.2.2. Probability of ray random scattering (rd)

R.3. Immersion
R.3.1. Outer radius (Ri), [cm]
R.3.2. Refractivity (ni)
R.3.3. Absorption (ki), [cm-1]

R.4. Housing
R.4.1. Outer radius (Rh), [cm]
R.4.2. Refractivity (nh)
R.4.3. Absorption (kh), [cm-1]

R.5. Spectral Properties
R.5.1. Wavelength [nm]
R.5.2. Absorption [cm-1]

1. Configuration 1.

1.1. Reflectance
1.1.1. Specular (rs)
1.1.2. Diffuse (rd)

1.2. Reflector Dimensions
1.2.1. Reflector radius (Rr), [cm]

1.3. Unit Positioning
1.3.1. Distance between rod and lamp centers (Lal), [cm]
1.3.2. Distance between rod and reflector centers (Lar), [cm]

2. Configuration 2.

2.1. Reflectance
2.1.1. Specular (rs)
2.1.2. Diffuse (rd)

2.2. Reflector Dimensions
2.2.1. Semi-major axis (ar), [cm]
2.2.2. Semi-minor axis (br), [cm]

2.3. Unit Positioning
2.3.1. Distance between rod and lamp centers (Lal), [cm]
2.3.2. Distance between rod and reflector centers (Lar), [cm]

3. Configuration 3.

3.1. Reflectances
3.1.1.1. Specular reflectance of the rod-based semicircle (a rs)
3.1.1.2. Diffuse reflectance of the rod-based semicircle (a rd)
3.1.2.1. Specular reflectance of the lamp-based semicircle (l rs)
3.1.2.2. Diffuse reflectance of the lamp-based semicircle (l rd)
3.1.3.1. Specular reflectance of the flat part (f rs)
3.1.3.2. Diffuse reflectance of the flat part (f rd)

3.2. Reflector Dimensions
3.2.1. Length of the flat part of reflector (Lfl), [cm]
3.2.2. Radius of the cylindric part of reflector (Rr), [cm]

3.3. Unit Positioning
3.3.1. Distance between rod and lamp centers (Lal), [cm]
3.3.2. Distance between left end of reflector and rod center (Dra), [cm]

4. Configuration 4.

4.1. Reflectances
4.1.1.1. Specular reflectance of the lamp-based semicycle (l rs)
4.1.1.2. Diffuse reflectance of the lamp-based semicycle (l rd)
4.1.2.1. Specular reflectance of the longitudinal flat surfaces (fs rs)
4.1.2.2. Diffuse reflectance of the longitudinal flat surfaces (fs rd)
4.1.3.1. Specular reflectance of the face plate (fp rs)
4.1.3.2. Diffuse reflectance of the face plate (fp rd)
4.1.3.1. Specular reflectance of the filter (fi rs)
4.1.3.2. Diffuse reflectance of the filter (fi rd)

4.2. Reflector Dimensions
4.2.1. Radius of the cylindric part of reflector (Rr), [cm]
4.2.2. Distance between face plate and cylinder center (Lfl), [cm]

4.3. Unit Positioning
4.3.1. Distance between rod and lamp centers (Lal), [cm]
4.3.2. Distance between rod center and filter (Lafi), [cm]
4.3.3. Distance between rod center and face plate (Lafp), [cm]

4.4. Filter
4.4.1. Thickness (Thfi), [cm]
4.4.2. Refractivity (nfi)
4.4.3. Absorption (kfi), [cm-1]

5. Configuration 5.

5.1. Reflectances
5.1.1.1. Specular reflectance of the elliptic surface (r rs)
5.1.1.2. Diffuse reflectance of the elliptic surface (r rd)
5.1.2.1. Specular reflectance of the rod holder flat surface (af rs)
5.1.2.2. Diffuse reflectance of the rod holder flat surface (af rd)
5.1.3.1. Specular reflectance of the rod holder cylindric surface (ac rs)
5.1.3.2. Diffuse reflectance of the rod holder cylindric surface (ac rd)
5.1.4.1. Specular reflectance of the lamp holder flat surface (lf rs)
5.1.4.2. Diffuse reflectance of the lamp holder flat surface (lf rd)
5.1.5.1. Specular reflectance of the lamp holder cylindric surface (lc rs)
5.1.5.2. Diffuse reflectance of the lamp holder cylindric surface (lc rd)

5.2. Holder Dimension

5.2.1. Rod  holder width (ha), [cm]
5.2.2. Lamp holder width (hl), [cm]

5.3. Reflector Dimensions
5.3.1. Semi-major axis (ar), [cm]
5.3.2. Semi-minor axis (br), [cm]

5.4. Unit Positioning
5.4.1. Distance between rod and lamp centers (Lal), [cm]
5.4.2. Distance between rod and reflector centers (Lar), [cm]

6. Configuration 6.

6.1. Reflectances
6.1.1. Specular (rs)
6.1.2. Diffuse  (rd)

6.2. Reflector Dimension
6.2.1. reflector radius (Rr), [cm]

6.3. Unit Positioning
6.3.1. Distance between rod center and diode (Lal), [cm]
6.3.2. Distance between left end of reflector and rod center (Dra), [cm]

6.4. Introduction of Light
6.4.1. Window height (wh), [cm]

7. Configuration 7.

7.1. Unit Positioning
7.1.1. Distance between rod and lamp centers (Lal), [cm]

7.2. Reflector shape and reflectances
7.2.1. X coordinate of the segment origin (X), [cm]
7.2.2. Y coordinate of the segment origin (X), [cm]
7.2.3. Specular reflectance of the segment (rs)
7.2.4. Diffuse  reflectance of the segment (rd)