# BEAMnrc, DOSXYZnrc and BEAMDP GUI User's Manual

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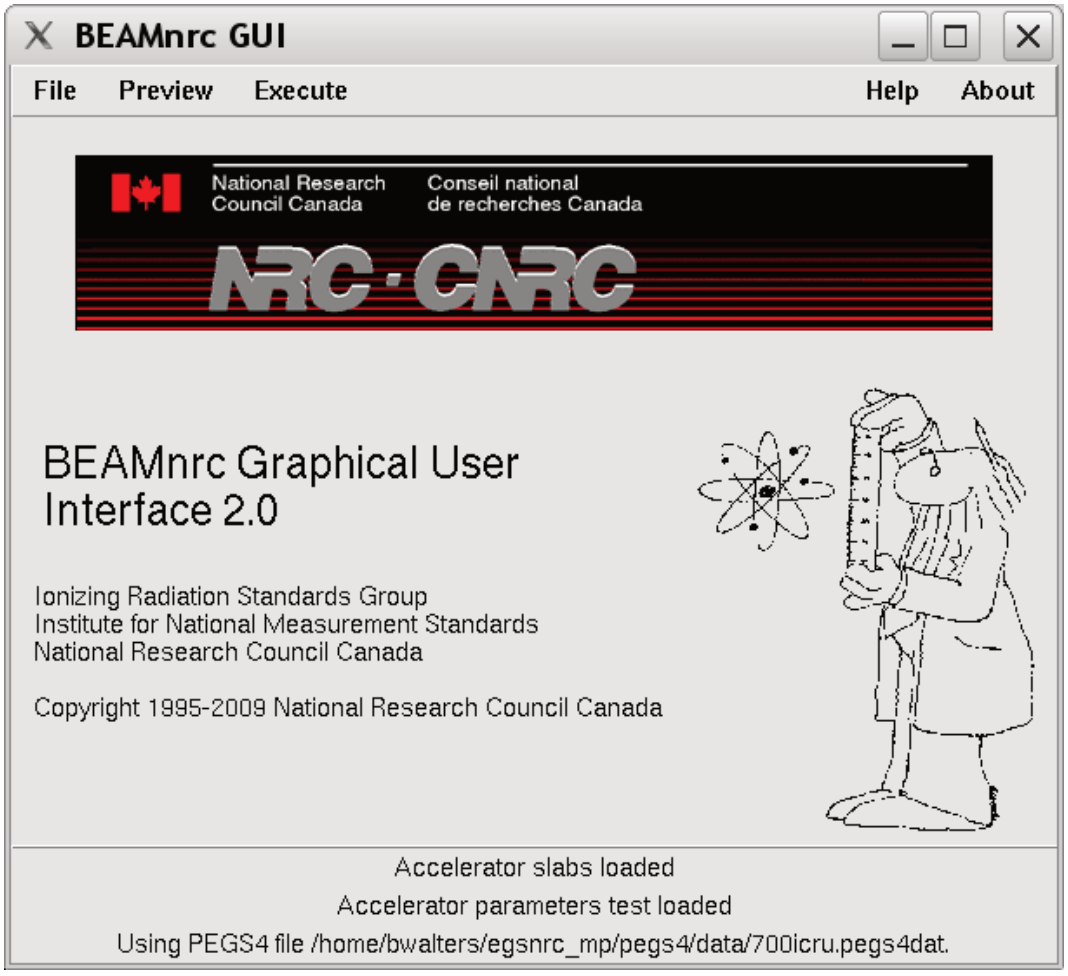

The main window of the BEAMnrc GUI.

# Abstract

The BEAMnrc GUI and the DOSXYZnrc GUI were created for the generation of input files for the BEAMnrc and DOSXYZnrc codes. They are equipped to compile and run BEAMnrc and DOSXYZnrc through the interface. The BEAMDP GUI is a graphical front-end for the BEAMDP code.

This document reports how to get hold of and install the GUIs, and briefly describes their capabilities.


# Contents

# 1 Why YOU Need These GUIs!

The BEAMnrc and DOSXYZnrc codes are large EGSnrc user-codes for simulating radiotherapy units and doing CT based dose calculations, respectively [1, 2, 3]. BEAMDP is a data processing tool for use after BEAMnrc has been run[4, 5].

For large and/or complicated accelerators, the input required for BEAMnrc can lead to files which are large and confusing to the user. Similarly the inputs for DOSXYZnrc can be complex, especially for beams coming from arbitrary directions. The BEAMnrc and DOSXYZnrc GUIs were created to aid the user in both creating and editing these files by providing a label and a text box or option menu for each parameter, with a detailed explanation available in a help window. Much of the content of the User's manuals [2, 3] is actually available within the GUIs, although the User's manuals represent the final authority. An added benefit in the BEAMnrc GUI is the preview option for each CM, wherein you may look at a graphical representation of the CM that you have defined, a preview of the entire accelerator, so that you may see the relative positioning of the CMs, and a print/export option.

When the accelerator components and input parameters have been defined, the GUIs write the files required to run the BEAMnrc or DOSXYZnrc code.

The interface to BEAMDP writes an input file based on the selections made and runs BEAMDP with it.

# 2 Getting and Installing the GUIs

## 2.1 Tcl/Tk

All of the GUIs use `Tcl/Tk` and `wish`, a freeware package. The GUIs were developed using `Tcl` version 7.5, `Tk` version 4.1 and `wish` 4.1 or `wishx`. You can obtain version 8.4 of `Tcl/Tk` at `http://www.activestate.com/Products/ActiveTcl`. Once you have installed `Tcl/Tk` you must ensure that the directory `/(directory where Tcl/Tk was installed)/bin` is included in your `PATH` environment variable.

Note that most Linux distributions already include `Tcl/Tk`, so there is no need to download it (unless it's a version of `Tcl/Tk` that does not work with the GUIs).

Note that the makers of `Tcl/Tk` have made no promises of backwards compatibility. We therefore cannot yet guarantee that these GUIs will work for all versions of `Tcl/Tk`, although we strive to do so in the near future. Version 8.4 appears to work satisfactorily with the current versions of the GUIs.

## 2.2 Installing the GUIs

The GUIs are installed as part of the standard OMEGA/BEAM installation. See the BEAMnrc Manual[3] for complete instructions on how to install the OMEGA/BEAM codes.

# 3 The BEAMnrc GUI

To run the BEAMnrc GUI from a Linux/Unix window, type `beamnrc_gui` at the prompt. Note that you must have sourced the Unix script `beamnrc_cshrc_additions` (or `beamnrc_bashrc_additions`) in your `.cshrc` (or `.bashrc`) file. See the BEAMnrc Manual[3] for more information about these scripts.

To run the GUI in a Windows environment, either double click on the GUI icon or use Windows Explorer to go into directory `$OMEGA_HOME/progs/gui/beamnrc` and double click on `beamnrc_gui`.

The GUI generates two input files which are required by BEAMnrc. The first is a file with extension `.module`, which contains the component modules included in the accelerator and their identifying names. These are stored in the `$EGS_HOME/beamnrc/spec_modules` directory. The second file created has an extension `.egsinp` and contains all of the simulation parameters, and is usually stored in a directory corresponding to its module filename, *i.e.* `$EGS_HOME/BEAM_`<*modulename*>.

## 3.1 Setting the GUI defaults

The BEAMnrc GUI loads a resource file when it starts, defining colours and fonts for the application. This file is called `.gui_defaults` and is first searched for in your home directory, then in the directory where the GUI code is stored if not found. To change the settings, copy the file from `$OMEGA_HOME/progs/gui/beamnrc` to `$HOME` and edit it to reflect your preferences.

## 3.2 Specifying an accelerator

The first step in using the GUI is to load an accelerator. If you wish to load a previously defined accelerator, select the Load a previous accelerator option from the main window File menu (shown on the front of this manual). A browser will allow you to select the file you wish to load from the `$EGS_HOME/beamnrc/spec_modules` directory closest to the directory in which the GUI was started. Otherwise, select the Specify a new accelerator option. A window will appear which allows you to select the CMs you would like to add to the accelerator, shown on the left of figure 1. Double-clicking a CM name on the list, or clicking once to select then clicking the ">>" button, will insert the CM name into the text box. Enter an identifier name (maximum of 8 characters) then click Add to add the CM to the accelerator. The window on the right of figure 1 shows the window which holds the selected CMs.

When the accelerator has been completely specified, it must be saved before continuing. You don't have to enter the extension of the filename; the GUI will do that for you.

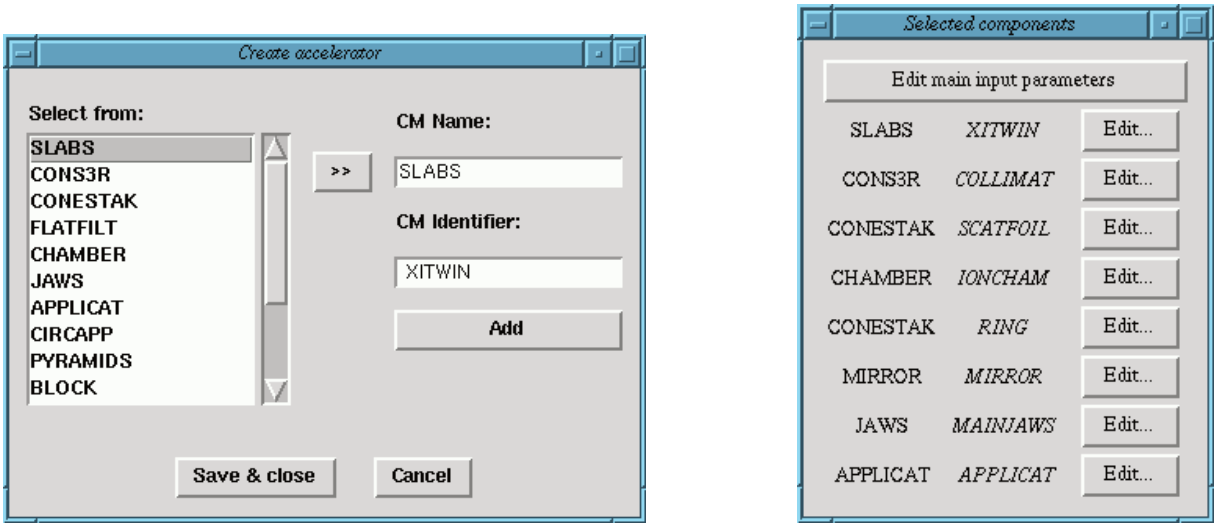


Figure 1: The windows for specifying a new accelerator (left) and for displaying the selected CMs in the accelerator (right).

## 3.3 Loading PEGS4 cross-sectional data

After the accelerator has been loaded or defined, you will be asked to enter the name of the PEGS4 cross-sectional data file that you wish to use. This is so that the GUI can properly assign your options for materials. The full pathname of the file must be entered in the space provided, so it is more efficient to simply browse directories.

If you have a PEGS4 file in both your user's `$EGS_HOME/pegs4/data` directory and in the `$HEN_HOUSE/pegs4/data` area, you must select the one in your user's area. This is enforced because BEAMnrc first searches your user's `$EGS_HOME/pegs4/data` directory for the cross-sectional data file.

If at any time you wish to change the PEGS4 data file, you can select the Change PEGS4 file option on the main File menu. Note that you will have to change the materials you have selected to correspond to the new names.

## 3.4 Defining simulation parameters

After loading or specifying an accelerator, you are ready to define the simulation parameters. If you have an input file already made, select Load a previous input file on the main window File menu. A browser will allow you to select the file; it will search your directory tree for the directory corresponding to the module loaded, *i.e.* `BEAM_`<*modulename*>, and if found, the browser will start there. Otherwise it will start in the directory in which the GUI was started. To change directories, double-click on the directory name. To select a file, single-click on the filename.

To edit the main simulation parameters, select the Edit main parameters button on the selected CMs window. Each parameter on this window should be filled in. You will be prompted for additional related parameters.

The file `$OMEGA_HOME/beamnrc/beamnrc_user_macros.mortran` contains macros which define the default maximum and minimum values for some of the main simulation parameters, as well as the default maximum number of CMs allowed. You will have to edit this file (and recompile BEAMnrc) to change the values of these parameters.

### 3.4.1 EGSnrc input parameters

Within the "Main Inputs" window, there is a Edit EGSnrc Parameters button. If you click on this, then a window opens which allows you to adjust the EGSnrc input parameters (see Figure 2). If you are working from an EGS4/BEAM input file or if you are starting from scratch, then you will find that these EGSnrc inputs are set to their default values (as they are in Figure 2). The defaults are adequate for most accelerator simulations, however, you may want to change parameters to take better advantage of EGSnrc's improved physics, especially in low-energy applications. When you save the input file from the GUI, the EGSnrc input parameters are automatically appended to the end of the `.egsinp` file in a specific, text-based format. See the BEAMnrc manual for a more detailed description of the EGSnrc inputs, their default values, and the input format.

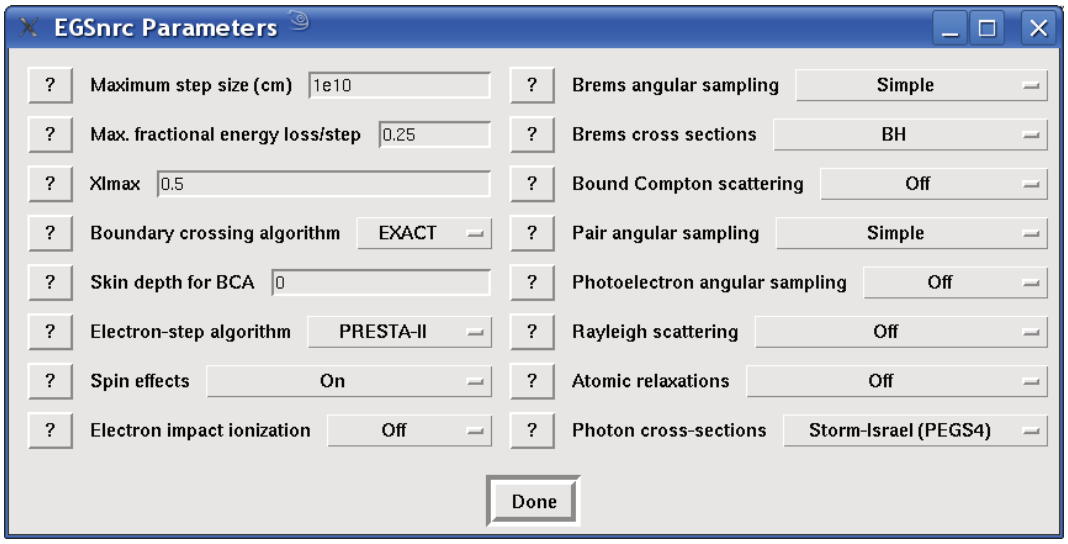


Figure 2: The EGSnrc input window with showing default values.

## 3.5 The fast track

In the case where you have already made the module and input files you can start with the Load a previous input file option on the main window File menu. The browser will start in the directory in which the GUI was started. When you select an input file, the GUI will search for the module filename which corresponds to the input file selected and load it first, *i.e.* `BEAM_`<*modulename*>/<*inputfile*> should have it's accelerator defined in *modulename*`.module`.

Alternatively, if the accelerator has already been compiled and the input file exists in the

the `$EGS_HOME/BEAM_accelname` directory, you can specify the input file (and accompanying PEGS4 data) as command line arguments. Within the `$EGS_HOME/BEAM_accelname` directory type:

```
beam_gui inputfilename [pegsfilename]
```

The `.egsinp` and `.pegs4dat` extensions on the input file and PEGS4 data file are optional. If you do not supply the PEGS4 data file name, the GUI will immediately open a window requesting that you do so.

## 3.6 Defining component modules

To edit the parameters for a component module (CM), click on the Edit... button associated with it (see the window on the right of figure 1). A window will appear with the necessary parameter entry boxes for the CM. A typical CONESTAK CM parameter window is shown in figure 3. The default values associated with that type of CM are displayed at the top of the window. If they are not appropriate for what you need, they may be edited in the file `$OMEGA_HOME/beamnrc/CMs/`<*CMname*>`_macros.mortran`. Note that if these files are changed, the changes will apply to all users. Also shown is the current Z-position on the accelerator of the front of that CM, based on the geometry defined for the previous CM at the time the window was opened (reopen the window to get an update of this value).

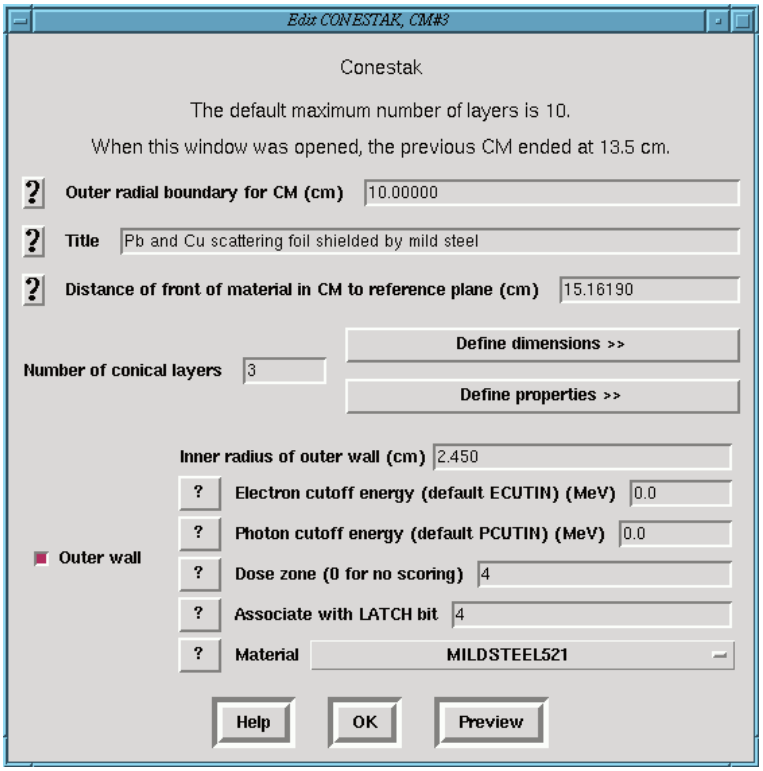


Figure 3: A typical CONESTAK CM parameter input window.

### 3.6.1 Option to define JAW settings automatically

The GUI for the JAWS component module allows you to specify the x/y coordinates of jaw openings in two ways. You can either input the coordinates directly, or you can define the coordinates using field size and SSD. If you choose the latter option, then a window will open asking you to specify the half-width, SSD and the value of Z at the beam focus (usually the front of the photon target and the point from which the SSD is measured) and the pairs of jaws that you wish to apply this field to. The Z positions of the jaws must also be defined. Once you have specified these parameters, click on Update x/y coords. and the GUI will calculate the opening coordinates for the selected jaws and update them in the "Define jaws" window. You can then go on to define different fields for different pairs of jaws within the same CM. The algorithm is based on a simple straight line beam edge and it is only useful for the settings of the photon beams. For example, in a 10 cm x10 cm electron beam, the photon jaws might be set for a 15 x 15 field since the scrapers define the field size.

## 3.7 Previewing components

The Preview button at the bottom of each CM generates a diagram of the CM based on the parameters you have entered. (Should an error occur on previewing a CM, close any new windows and check that you have entered all parameters.) Note that you may need to rescale the axes to show it realistically; this is achieved by selecting Change plot properties on the preview window. The default scale maximises the space available in any direction.

One or more canvases may appear, depending on the number of perspectives required to display the CM geometry. The mouse cursor position is shown in the bottom right corner of each canvas.

A separate print button is used for each canvas so that each perspective may be printed or exported individually. On selecting Print, you will be prompted to select colour or black and white, portrait or landscape, and printing to a file or to a printer.

Note that the materials corresponding to the colours used in these previews can be seen by selecting Change colour scheme in the Preview menu bar. If a material has not been specified or does not exist in the PEGS4 file selected, it will be shown as black on the preview.

## 3.8 Previewing the accelerator

The Preview menu button on the BEAMnrc GUI main window has a selection Preview accelerator, which leads to a 2-dimensional preview of the entire accelerator. An option menu located in the lower left corner of the accelerator preview window allows you to choose either the x-z cross-section (through y=0) or the y-z cross-section (through x=0) of the accelerator.

The canvas on which the accelerator is drawn is contained within scrollbars. The default scale of the canvas is 20 pixels per centimetre in the z dimension, and the scale of the x or y dimension is chosen based on the width of the canvas so that at least the width of the accelerator is shown without the need for scrolling. To change the scale, the axis ranges and the number of ticks, select the Plot Properties button.

To print the canvas on which the accelerator is drawn, select the Print button. Be aware that the diagram will be scaled automatically to fit on a page; if you want the fonts to be legible it is recommended that you adjust the zoom factors to scale it properly before printing.

To the left of the canvas is a legend which shows all of the materials used in your accelerator and the colours which are used to display them. To change any of these colours, click on the colour swatch and change the RGB values on the sliding scales. The canvas will be redrawn using the new colour set. As with the individual CM previews, if a material selected is not in the PEGS4 file specified, that material will appear as black in the preview.

Figure 4 shows an example of the output of such a preview.

## 3.9 Selecting a colour scheme

Under the Preview menu button on the main BEAMnrc GUI window is the selection Change colour scheme. Selecting this will show a legend of all the materials available in the PEGS4 cross-sectional data file and the colours each has been assigned. To change a colour, click on the colour swatch and select the new RGB colour to be associated with that material.

If you prefer to use grey-scale (likely for printing), you can change the colour scheme to grey-scale by selecting the Grey-scale radio-button. Then when editing a colour a single scale widget of intensity is used.

## 3.10 Compiling and Running BEAMnrc

When all of the parameters have been set, select the Save input file as... option from the main window File menu. If the directory corresponding to the module filename does not exist, *i.e.* `BEAM_`<*modulename*>, you will be asked if you want to create it before continuing. If you don't, the browser will start in your `$EGS_HOME` directory. Change to the directory that you wish to save the file in, enter the desired filename and click "OK" to write the file.

At this point you may exit the GUI and run the BEAMnrc code from the command line. For details on this, see the BEAMnrc User's Manual[3]. You can also run BEAMnrc though the GUI. Note that for either method **you** *must* **save your input file before starting**.

First you will need to compile the accelerator code. From the Execute menu, choose Compile. A window with the different compiler options will appear. The default options are already set. If you would like more information on these options, please see the BEAMnrc Manual. Select COMPILE to compile the code. It can take some time to compile, depending on the speed of your machine and on the size of your accelerator. You will be notified when compilation is complete.

Finally, select Run from the Execute menu. A window with the run options appears, defaulting to interactive mode. If you wish to submit jobs to a queue, select batch. long is the default run time option. For parallel jobs, select Run in parallel and enter the number of jobs into which to split the run in the text box. Click EXECUTE to execute the code. You will be notified when the job is finished.

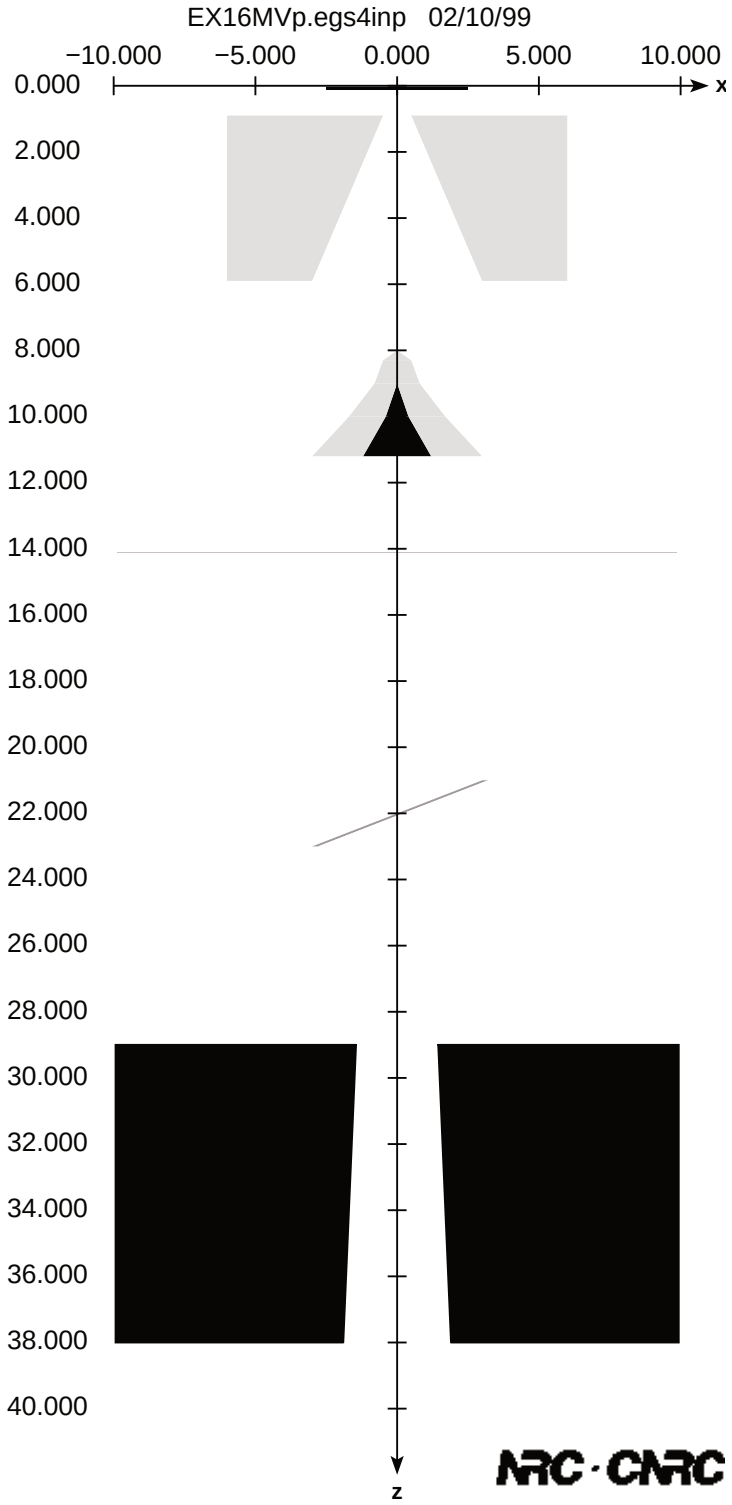


Figure 4: Preview of the EX16MVp accelerator example using the "Preview accelerator" option.

## 3.11 Known bugs and further changes

There is, unfortunately, no method to make changes to the structure of an accelerator after it has been made, *i.e.* removing a CM, adding a CM, without rebuilding it entirely. If you find that you need to do this, you may have to resort to editing the file manually, or you can build a new accelerator with the components you want and read in the old file. The GUI will encounter an error, but read the parameters it found before that point.

# 4 The DOSXYZnrc GUI

To run the DOSXYZnrc GUI from a Linux/Unix window, type `dosxyznrc_gui` at the prompt. Note that you must have sourced the Unix script `beamnrc_cshrc_additions` (or `beamnrc_bashrc_additions`) in your `.cshrc` (or `.bashrc`) file. See the BEAMnrc Manual[3] for more information about these scripts.

To run the GUI in a Windows environment, either double click on the GUI icon or use Windows Explorer to go into directory `$OMEGA_HOME/progs/gui/dosxyznrc` and double click on `dosxyznrc_gui`.

DOSXYZnrc requires one input file to be generated by the user, giving a complete description of the phantom and the source. At the top level of the GUI, you are presented with four options:

1. Start a new input file. This option allows you to start creating a new set of inputs. If you select this after having loaded an input file, those parameters will be discarded.

2. Load a previous input file. This allows you to select an input file that you have already made.

3. Edit parameters. This takes you to the main editing screen, whether you have loaded an input file or not. On start-up, this option has the same effect as Start a new input file.

4. Save input parameters as... allows you to save the input parameters to a file in your `$EGS_HOME/dosxyznrc` directory.

## 4.1 Editing DOSXYZnrc parameters

The Edit parameters option takes you to a main window with four sections. The first is the title. It is recommended that you include the name of the input file in the title as an identifier. In the second section, you are asked to define the phantom for the simulation. To do this, you can use a phantom created from CT data, or you can define a phantom voxel-by-voxel. Select the radio-button corresponding to the method of your choice, then click the Define phantom using... button. A new window will pop up in which you can define the phantom. The third section of the Edit parameters window requires that you enter general simulation parameters.

## 4.2 Loading a previous input file

The Load a previous input file option takes you to a directory browser from which you can select the input file to load. The default filter for the browser is for files with the extension `.egsinp`. After selecting a file, you will be asked for the name of a PEGS4 data file. Note that unlike the BEAMnrc GUI, the DOSXYZnrc GUI does not have the error-checking routine of testing that the materials listed in the PEGS4 file match those used in the input file. After selecting the PEGS4 file, the parameter editing window appears.

Similar to the BEAMnrc GUI, the DOSXYZnrc GUI also gives you the option to specify an existing input file (with accompanying PEGS4 data) as command line arguments. From within the `$EGS_HOME/dosxyznrc` directory, type:

```
dosxyz_gui inputfilename [pegsfilename]
```

The `.egsinp` and `.pegs4dat` extensions are optional. If you do not supply a PEGS4 data file, then a window will immediately open requesting that you do so. Note that `inputfilename` must be in the `$EGS_HOME/dosxyznrc` directory.

## 4.3 Defining the phantom using CT data

If you selected phantom definition using CT data, you will be asked to choose a `.egsphant` file by browsing starting in the current directory. These files can be created using ctcreate. For more information, please see section 15 of the 2004 DOSXYZnrc User's manual[2].

## 4.4 Defining the phantom voxel-by-voxel

With voxel-by-voxel phantom definition, you will be prompted to choose a `PEGS4` cross-sectional data file (if not already defined). This is essential for defining the materials used in the phantom. Select the file by browsing either your `$EGS_HOME/pegs4/data` directory or the `$HEN_HOUSE/pegs4/data` area. If you select a file from the `$HEN_HOUSE/pegs4/data` area which also exists in your `$EGS_HOME/pegs4/data` directory, you will be asked to select the latter instead. This is enforced because DOSXYZnrc, like BEAMnrc, looks first in your `$EGS_HOME/pegs4/data` directory for these files.

Once the `PEGS4` file has been selected, the phantom definition window will appear, containing 3 sections. The first step is to define the voxel dimensions in the x, y and z directions. To accomplish this, you have a choice of 2 methods. You may define the voxels individually by entering the position of the beginning of each voxel and the end of each voxel, *eg.* for voxel $i$, $x_{i-1}$ and $x_i$ form the x-boundaries. You may also define the dimensions in groups by specifying the number of voxels in the group and the width of each voxel in the group, for as many groups as is required.

The second step is to define the media used in the phantom. The number of media that you intend to use must be entered first, the the Define media button selected. On this new window, an option menu is used to select each medium. The first entry, medium 1, is the default medium. Once these have been specified, click on Define voxel media to set the

medium of individual voxels. You only need to explicitly specify the medium of those voxels NOT comprised of medium 1, the first entry on the previous window.

Finally, set the output option, formerly known as IZSCAN. Here you may specify a region for which dose is output. An x-scan per page means that each page of output will contain data along the x-axis for one value of z. A z-scan per page means that each page of output will contain data from the z-direction for one value of y, *eg.*, if you wanted to see the dose along the central-axis region.

Four other parameters are required in this phantom definition section, the global electron and photon cutoff energies, the maximum step size and an option which allows you to print a summary of the 20 highest doses.

## 4.5 Defining the source

The next section asks for a definition of the source. The first option menu allows you to choose the incident particle type. Note that "all" can only be used when a phase-space source is selected. The source available include standard source types and phase space sources which may be obtained from the output of BEAMnrc. Figure 5 shows the window for defining source options for a parallel beam from the front. Radio-buttons allow the user to choose between a monoenergetic beam or spectrum. The Help button generates a window with a complete description of the parameters required for each source.

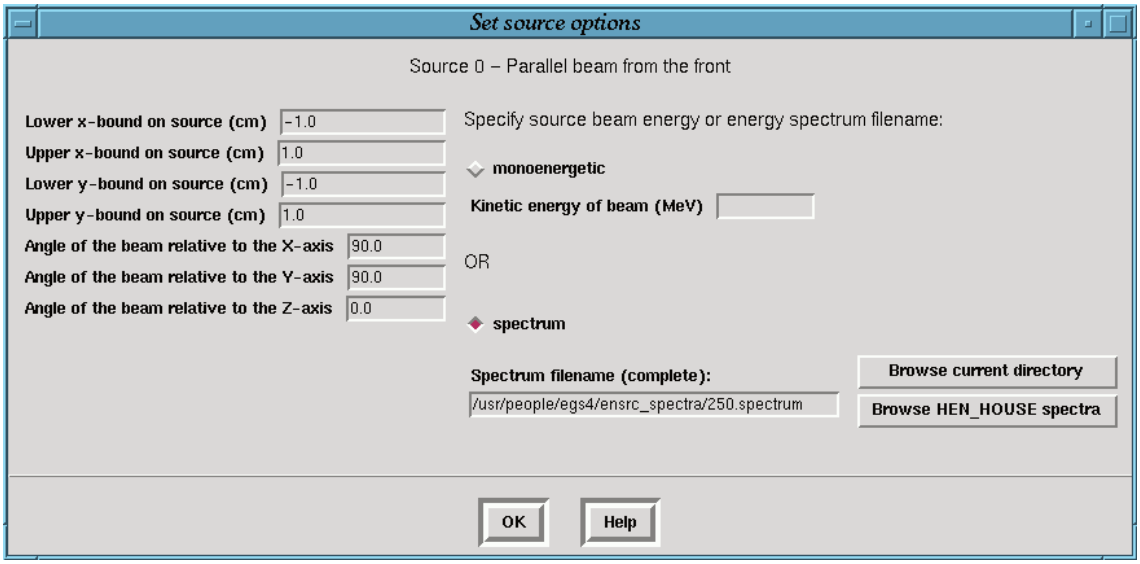


Figure 5: The source option window for a parallel beam from the front.

For phase space sources, in addition to the parameters required for the source, the thickness and medium of the region surrounding the phantom should be input. The default medium is VACUUM and the default thickness is 50cm. The phase space beam input file should be selected by browsing your home directory or `$OMEGA_HOME`. The format of this file must also be specified. You may also choose to use inclusive and/or exclusive bit filters to calculate the dose. To do so, select the Phase space input + dose components radio-button.

The option menu for bit filters will then become active and you may set the type of filter and the bits to include/exclude.

## 4.6 Simulation parameters

The third section of the Edit parameters window requires that you enter general simulation parameters, such as the number of histories, IWATCH output, maximum CPU time, random number generator seeds, incident beam size, phase space redistribution, run option, output restart data, range rejection and ESAVE inputs. The help buttons to the left of each parameter will provide you with the information necessary to properly specify these values.

## 4.7 EGSnrc parameters

Similar to the BEAMnrc GUI, the DOSXYZnrc GUI allows you to edit the EGSnrc input parameters. This is done by clicking on the Edit EGSnrc Parameters button at the bottom of the Edit parameters window. This will open up a window identical to that used to set EGSnrc parameters in the BEAMnrc GUI. If you are working from an EGS4/DOSXYZ file or starting from scratch, the EGSnrc parameters will be set to their defaults. When you save the file, these parameters will be appended to the end of the `.egsinp` file in a specific text-based format. See the DOSXYZnrc manual for a more detailed description of the EGSnrc input parameters.

## 4.8 Compiling and running DOSXYZnrc

Once the parameters have been completely defined, select Save and close on the `Edit parameters` window or Save input parameters as... on the main File menu. The browser will start in the directory that you are running the GUI from. Enter a filename and click "OK" to save the file.

At this point you may exit the GUI and run DOSXYZnrc from the command line, or use the GUI as a front end by selecting Compile the Run from the Run menu. Please refer to the DOSXYZnrc User's Manual[2] for more details on how to run dosxyznrc from the command line, and for details on the various compiling and execution options.

# 5 The BEAMDP GUI

The BEAMDP GUI greatly facilitates running BEAMDP by not requiring the user to re-enter parameters from scratch every time phase space data is analyzed.

In a Linux/Unix window, the GUI is invoked by typing `beamdp_gui`. Note that you must have sourced the Unix script `beamnrc_cshrc_additions` (or `beamnrc_bashrc_additions`) in your `.cshrc` (or `.bashrc`) file. See the BEAMnrc Manual[3] for more information about these scripts.

To run the GUI in a Windows environment, either double click on the GUI icon or use Windows Explorer to go into directory `$OMEGA_HOME/progs/gui/beamdp` and double click on `beamdp_gui`.

The Help menu option will show you a list of the available options on the main menu and their meanings. There is on-line help for any option which is not self-explanatory; simply press the "?" to the left of the option. Please refer to the BEAMDP User's Manuals[4, 5] for further information.

To get multiple graphs on the same plot, simply make any changes to the data and execute again. If the file exists, the GUI will prompt you for whether you want to add this graph or overwrite the file with it. If you want multiple plots, select Add.

# 6 References


[1] D. W. O. Rogers, B. A. Faddegon, G. X. Ding, C.-M. Ma, J. Wei, and T. R. Mackie. BEAM: A Monte Carlo code to simulate radiotherapy treatment units. *Med. Phys.*, 22:503 – 524, 1995.

[2] B. R. B. Walters and D. W. O. Rogers. DOSXYZnrc Users Manual. *NRC Report PIRS 794 (rev B)*, 2004.

[3] D. W. O. Rogers. Accuracy of the Burns equation for stopping-power ratio as a function of depth and $R_{50}$. *Med. Phys.*, 31:2961 – 2963, 2004.

[4] C.-M. Ma and D. W. O. Rogers. BEAMDP Users Manual. *NRC Report PIRS 509c(rev A)*, 2004.

[5] C.-M. Ma and D. W. O. Rogers. BEAMDP as a General-Purpose Utility. *NRC Report PIRS 509e(rev A)*, 2004.