PenRed-GUI: User Manual

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1 Introduction

The PenRed Graphic User Interface software has been developed to streamline the process of creating simulation configuration files. While it may not encompass all of the present PenRed features, these will be incorporated in future versions. Nevertheless, the configuration files generated can be edited to incorporate them.

Note that this program is not designed for constructing or providing a detailed view of the geometry. Instead, it reads wavefront objects rather than PenRed geometry files. However, you can generate the corresponding wavefront file for any PenRed-compatible geometry using the 'geo2mesh' utility.

The program is still under development; therefore, the code has not been released at this time. However, pre-release compiled versions are publicly accessible and can be downloaded from the respective GitHub[1] repository releases[2].

The following sections will explain how to utilize the program to generate configuration files for PenRed simulations.

2 Interface

The interface is divided into several windows for specifying parameters related to materials, bodies, sources, and tallies involved in the simulation. Additionally, the main window provides a 3D view of the geometry and configured elements (Figure 1). Users can navigate through the 3D space using the following controls:

- Move the camera up, left, down, and right using the 'WASD' keys or the arrow keys on the keyboard.

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[1]`https://github.com/PenRed/PenRed-GUI`
[2]`https://github.com/PenRed/PenRed-GUI/releases`

- Shift the camera on the view plane by pressing 'Shift + Center mouse button' and moving the mouse.
- Move the camera in the normal direction to the view plane using the mouse wheel.
- Rotate the camera around the pivot point by pressing the center mouse button and moving the mouse.
- Zoom in and out by pressing 'Control + Center mouse button' and moving the mouse.

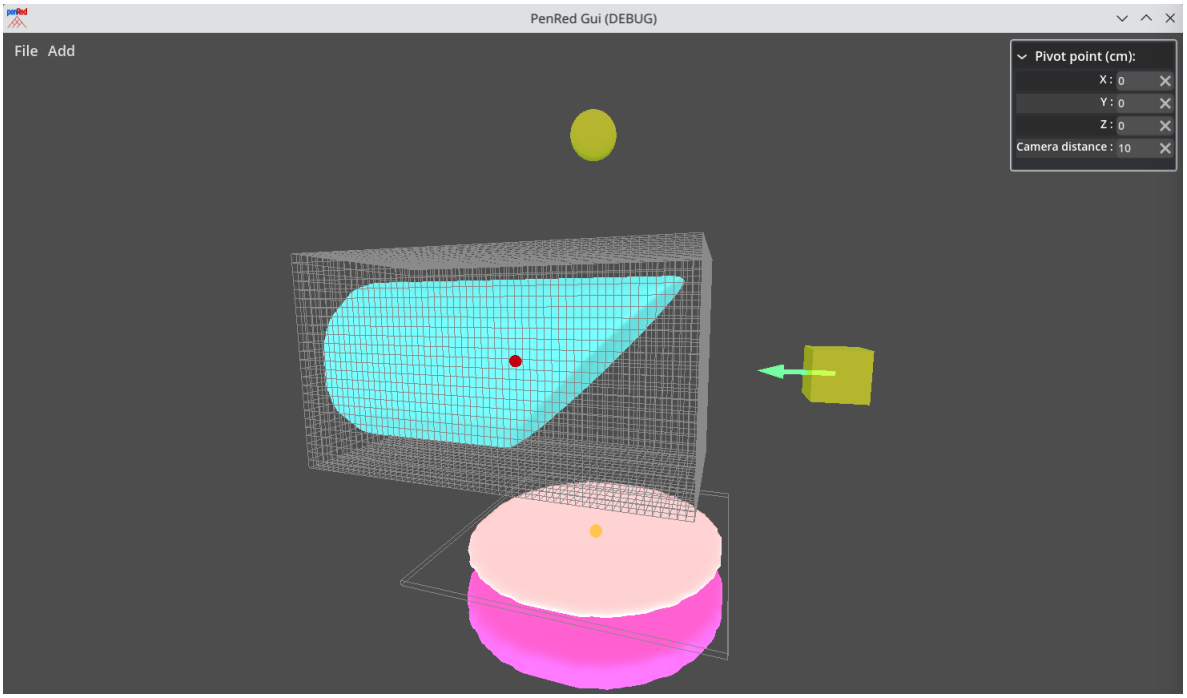

Figure 1: Configuration 3D view window.

The 3D viewer comprises two dropdown menus: 'Files' and 'Add.' The following descriptions detail their functionalities:

- **File** → **Load** → **File**: Loads a configuration file in the format of the GUI program. Notice that this is not the PenRed configuration file format.
- **File** → **Load** → **Object**: This option allows the user to load a geometry from a wavefront object file format. To create a wavefront file from a PenRed-compatible geometry file, the 'geo2mesh' utility provided within the PenRed package should be used.
- **File** → **Save** → **File**: Saves the current configuration, including the geometry, in the specified file using the GUI program format.
- **File** → **Save** → **Configuration**: Creates a simulation configuration file to be used with penRed.
- **File** → **Exit**: Close the program.
- **Add** → **Region**: This function is used to create a new region for tallies.

- **Add** → **Source**: Creates a new particle source.

All geometry bodies, materials, tally regions, and sources are listed in the 'geometry objects' window (Figure 2), with the currently selected one highlighted. For bodies, regions, and sources, users can select them by either clicking on their names in the lists or by clicking on them in the 3D viewer.

Figure 2: Geometry objects window with material list (left) and regions and source lists (right).

2.1 Material properties

Material properties can be configured in the 'Geometry Objects' window when the 'Materials' section is selected. Within this section, by selecting the material you wish to edit (by clicking on its corresponding number), you can specify the following parameters:

- **Name**: Modify the material's name. This name will be used to set the material filename in the configuration file by adding the '.mat' extension to the provided name.

- **Simulation Cutoffs**: This feature allows the user to define cutoff values for simulating each particle type. These cutoffs can be assigned either by energy, in electronvolts (eV), or by distance, in centimeters (cm).
- **Advanced Parameters**: When this menu is enabled, the user can configure advanced simulation parameters for this material. Specifically, these parameters include the 'Class II' values C1, C2, WCC, and WCR, which are described in the PenRed user manual. If this option is disabled, PenRed will automatically assign these values.

2.2 Body properties

When a body is selected, the 'body properties' window (Figure 3) pops up, allowing the user to view and edit its properties. These properties are described below:

- **Name**: The body's name, read from the loaded file. It cannot be changed.
- **Material**: The material index assigned to the body. This value cannot be changed.
- **Show bounds**: When enabled, it displays a box outlining the entire body in the 3D viewer.
- **Opacity**: Allows the user to adjust the body's opacity in the 3D viewer.
- **Position**: Indicates the position of the bounding box center in centimeters.
- **Bounding box size**: Specifies the size of the body's bounding box in centimeters. Please be aware that position and size values may differ from the actual geometry, as the program utilizes an approximation of the geometry.
- **Local absorption energies**: Permits the user to specify local absorption energies for this body. If these values are more restrictive than those specified for the body's material, the local values will be used.
- **Tallies**: Allows to set parameters for body-specific tallies. If not provided, default values will be used. These parameters include:
  - Minimum energy for tallies, in electronvolts (eV).
  - Maximum energy for tallies, in electronvolts (eV).
  - Number of energy bins.

  In addition, a list of body-specific tallies is provided to be enabled or disabled using the corresponding checkboxes.

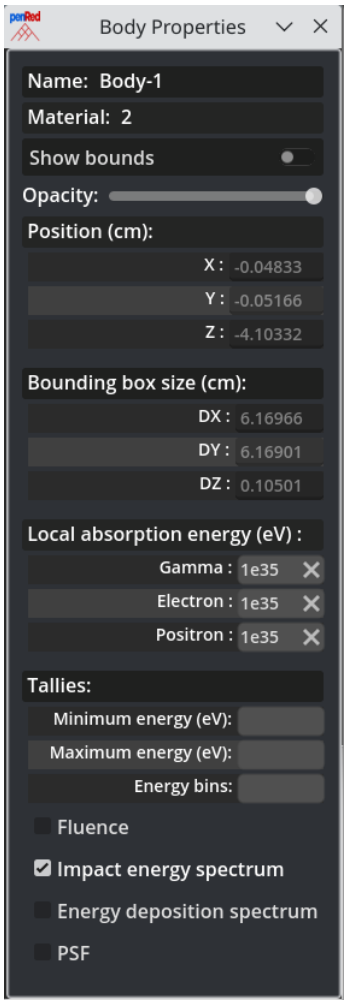

Figure 3: Body properties window.

2.3 Region properties

Similar to bodies, when a region is selected, the corresponding 'Region properties' window (Figure 4) appears, allowing the user to modify its properties. These regions are designed for use with tallies that require a spatial mesh to record information. Consequently, three types of regions can be chosen: Cartesian, cylindrical, and spherical. For each region type, users can enable two different tallies:

- **Spatial dose**: Records the energy deposited in each mesh bin.
- **Kerma**: Records the kerma in each mesh bin using the track length estimator.

Also, the user must specify the following:

- **Center position**: The center position of the region, in centimeters.
- **Bin size**: The size of the mesh bins, measured in centimeters or degrees depending on the region type.
- **Number of bins**: The number of bins in each coordinate.
- **Name**: Additionally, the name of the region can be edited.

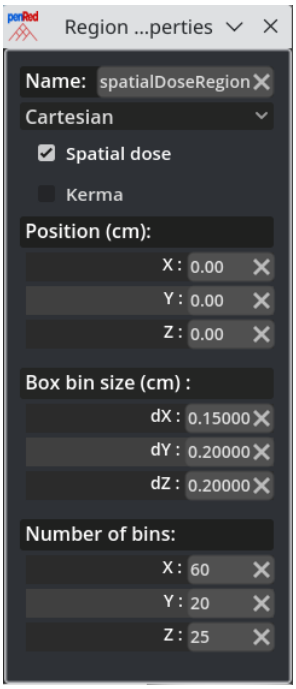

Figure 4: Region properties window.

2.4 Source properties

Sources define the generation of primary particles for the simulation and have their own dedicated configuration window (Figure 5). Currently, the following source types for the spatial distribution are available:

- **Point**: This employs a point-like source where all particles originate from a single point.
- **Box**: Particles initial positions are generated within a predefined box.
- **Cylindrical Shell**: This samples particle positions in the space between an outer and an inner cylinder.
- **Brachy**: Particles are sampled based on the seed information provided by the geometry DICOM files. Consequently, this source type is only compatible with DICOM geometries.
- **PSF (Phase Space File)**: Particles are read from a phase space file.

Depending on the selected source type, the user must specify the following parameters:

- **History Information**: This includes particle type (only for non-PSF based sources), the number of histories to be simulated, and, exclusively for PSF-based geometries, the maximum energy of the sampled particles.
- **Position**: Specifies the source center in centimeters.
- **Direction**: Specifies the source direction. If disabled, an isotropic source will be used.

- **Filter**: When enabled, allows the user to specify the material from which particles must be sampled.
- **Box Size**: Applicable only for the box source type, specifying the box size in centimeters from which particles will be sampled.
- **External Cylinder**: Exclusive to cylinder sources, this specifies the radius and height of the outer cylinder in centimeters.
- **Internal Cylinder**: Also for cylinder sources, this specifies the radius and height of the inner cylinder in centimeters. The internal cylinder must be contained within the external one.
- **Rotation ZYZ**: Reserved for PSF-based sources, this allows specifying angles for constructing a rotation around the Z, Y, and Z axes, respectively.

2.4.1 Energy spectrum

The energy spectrum is visualized in the graph, with energy on the X-axis and weight on the Y-axis. It is important to note that the weights do not need to be normalized. The spectrum is generated in accordance with the description in the penRed user manual, specifically within the section:

Framework Usage → Particle sources → Energy samplers → File spectrum

Therefore, each spectrum point requires values for energy and weight. To add points, users can input these values through the 'Add Spectrum Point' menu. Furthermore, if the 'discrete' checkbox is enabled, the point to be added will be treated as a monoenergetic spectrum line rather than a continuous interval between this point and the next one. To modify or remove an existing point, simply click on the desired point on the graph and then edit its properties in the 'Edit Spectrum Point' menu.

Please note that the spectrum is only applicable to non-PSF-based sources. Additionally, users have the option to save and load it in the format described in the PenRed user manual.

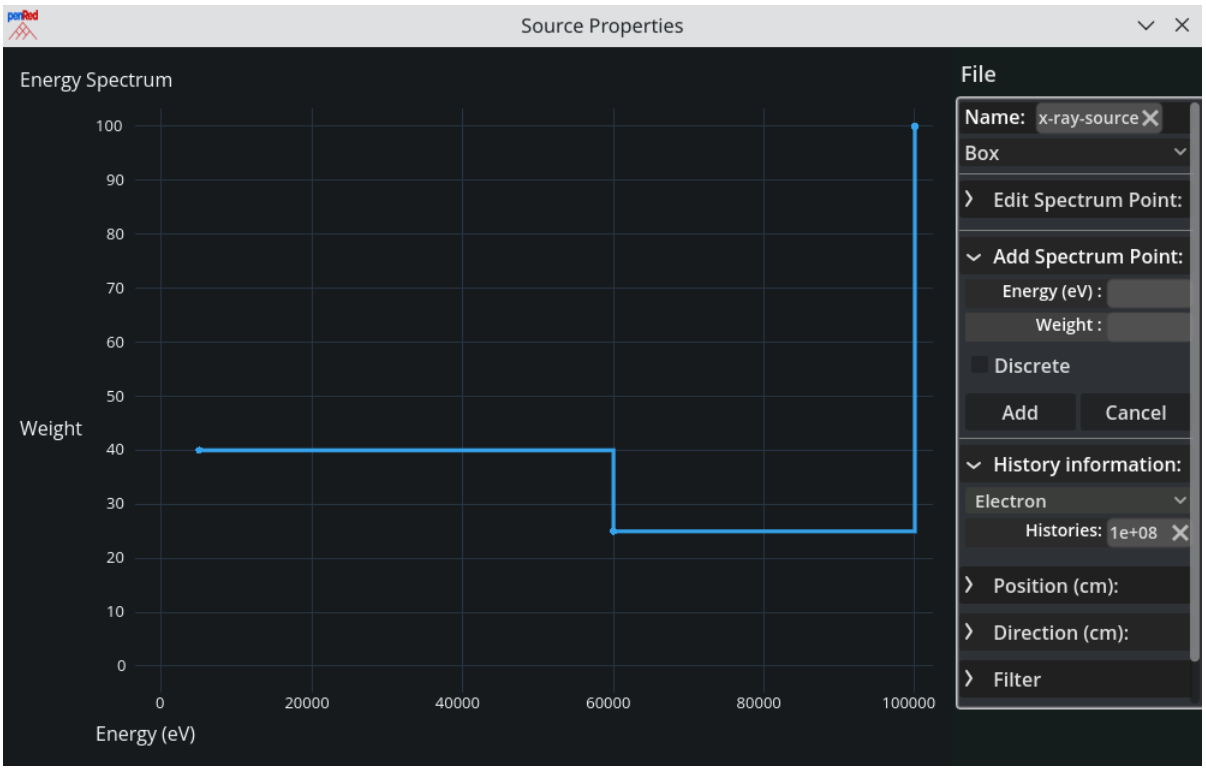

Figure 5: Source properties window.