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## **Integrated Interactive Visualization for KENO**

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## INTEGRATED INTERACTIVE VISUALIZATION FOR KENO

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### ABSTRACT

The KENO V.a and KENO-VI three-dimensional Monte Carlo criticality computer codes in the SCALE (Standardized Computer Analyses for Licensing Evaluation) computer software system developed at Oak Ridge National Laboratory are widely used and accepted around the world for criticality safety analyses. As part of current development efforts to improve SCALE's ease of use, the SCALE project team at ORNL has developed a new integrated graphical visualization package for KENO V.a and KENO-VI. This package uses the SCALE Graphically Enhanced Editing Wizard (GeeWiz) as the visualization control center that provides users the capability to set up, execute, plot, and view results from KENO in a friendly, colorful, and interactive computing environment without ever using a text editor or a command prompt.

*Key Words:* Visualization, KENO, graphics, plot, interface

### 1 INTRODUCTION

The KENO V.a and KENO-VI three-dimensional (3-D) Monte Carlo criticality computer codes in the SCALE (Standardized Computer Analyses for Licensing Evaluation) [1] computer software system developed at Oak Ridge National Laboratory (ORNL) are widely used and accepted around the world for criticality safety analyses. The primary objective in the initial development and ongoing enhancements to SCALE is to provide easy-to-use calculational tools for performing accurate safety analyses of nuclear facilities and packages using current computing techniques.

As part of current development efforts to improve SCALE's ease of use, the SCALE project team at ORNL has developed a new integrated graphical visualization package for KENO V.a and KENO-VI. This package uses the SCALE Graphically Enhanced Editing Wizard (GeeWiz) [2] as the visualization control center that provides users access to

- point-and-click input menus for KENO input setup,
- KENO3D [3] interactive 3-D geometry visualization tool,
- Javapeno (**J**ava **P**lots **E**specially **N**ice **O**utput) [1] interactive two-dimensional (2-D) data plotting code, and
- HTML-formatted KENO output [4].

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GeeWiz and KENO3D are compatible with KENO V.a and KENO-VI in SCALE 5 and run on Windows personal computers (PCs). Javapeno is a Java application that runs on multiple computing platforms, including Windows, Unix, Linux, and Macintosh. GeeWiz, KENO3D, and Javapeno provide pulldown menus, toolbars, and context-sensitive help to guide users. GeeWiz and KENO3D are compatible with the CSAS/KENO V.a, CSAS6/KENO-VI, and TSUNAMI-3D/KENO V.a sequences [5] in SCALE.

## 2 GeeWiz

GeeWiz serves as a control center for execution of the SCALE automated sequences that use KENO V.a or KENO-VI, including CSAS, CSAS6, and TSUNAMI-3D. GeeWiz provides input menus and context-sensitive help to guide users through the setup of their input. It includes a direct link to KENO3D to allow the user to view the components of their geometry model as it is constructed. Once the input is complete, the user can click a button to run SCALE and another button to view the output. KENO3D has also been upgraded and interfaces directly with GeeWiz.

GeeWiz provides a simple user interface with toolbar buttons to access the primary functions of the program (Fig. 1). Two toolbars are always active. The Main Toolbar at the top of the screen has buttons that invoke a variety of commands and options, including create a new problem, open an input file, save an input file, execute SCALE, view output, view 2-D color geometry model plots (if plot data are entered), access on-line help, view the model in KENO3D, and plot results in Javapeno. The Forms Toolbar is located on the left side of the main window and contains buttons that vary depending on the SCALE sequence selected by the user. In addition, many of the forms have toolbars that become visible when the associated form is activated.

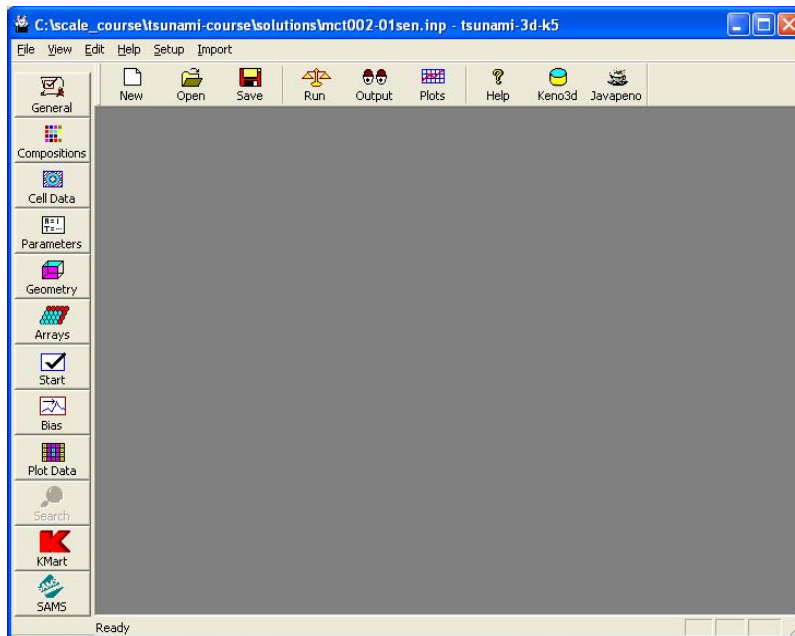


Figure 1. GeeWiz toolbars

The Geometry form in GeeWiz allows the user to easily navigate through the units that define the geometry model. This form includes all the options for specifying KENO V.a or KENO-VI geometry models. The user may view, create, and edit unit data in the geometry data block. The user may select a unit to edit by using the drop-down list displaying the unit number. Alternatively, the user may navigate through the units using the Next, Previous, First, and Last buttons. The Geometry Builder Toolbar includes buttons for creating geometric objects and defining regions within the model. The Geometry Builder includes a button for each KENO V.a or KENO-VI geometry type. Each geometry button invokes a dialog that allows the user to specify the geometric parameters and the modification data such as rotate, translate, and truncate.

The Arrays button presents a form for creating and modifying arrays to be used in the KENO geometry (Fig. 2). When an array is displayed and a “fill unit” is selected, the contents of selected cells in the array may be changed to the fill unit by using the Fill Tools Toolbar on the right side of the screen. The Hand tool enables the user to click on individual cells to fill them with the fill unit. The Line tool allows the user to drag the mouse across the cells to be filled. The Rectangle and Circle tools permit the user to drag the mouse to fill the array cells within a rectangle or circle. The Fill All button fills all cells in the displayed plane. The Move button shifts the array fill data horizontally and/or vertically. The Undo button cancels any changes made since the last fill tool was selected.

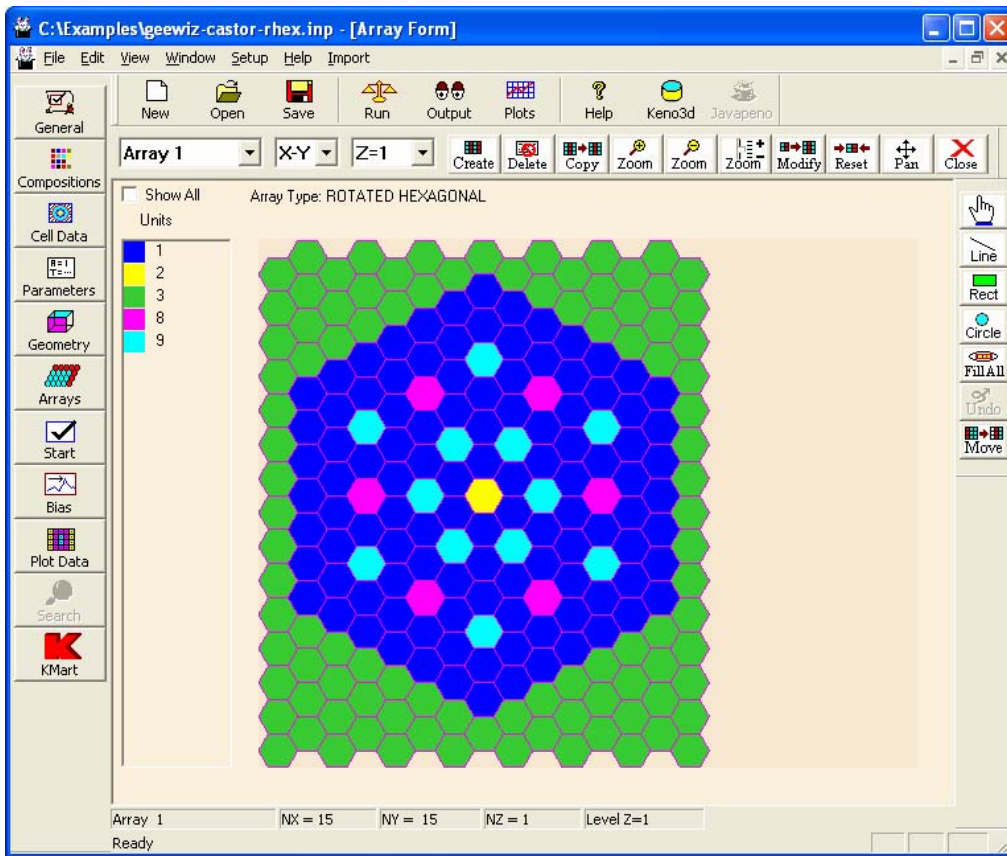
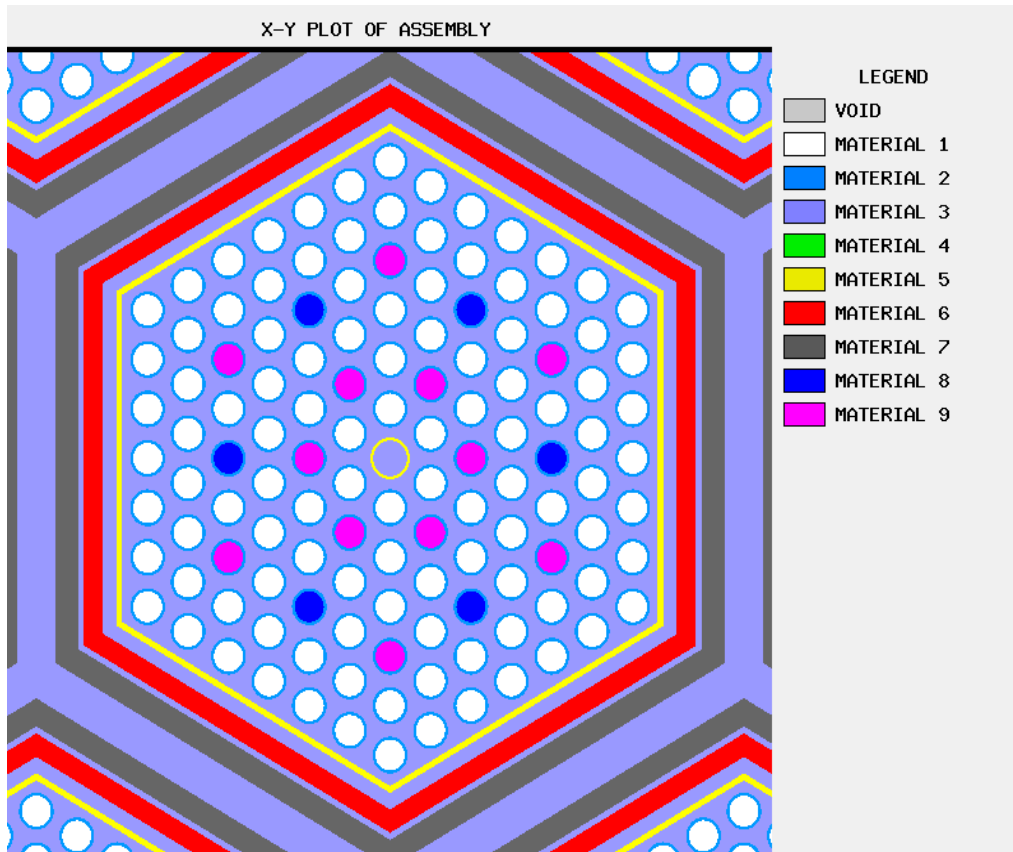


Figure 2. Array form for rotated hexagonal array in KENO-VI

The Plot Data button on the Forms Toolbar opens the Plot Data form, which assists the user in generating 2-D color plots of KENO geometry. The user can customize the plot by selecting colors for one or more of the materials plotted. A sample 2-D geometry plot generated with KENO is shown in Fig. 3. The plots are generated in the Portable Network Graphics (PNG) format and include a title and color legend. Once the plots are generated, the user can view them by clicking on the Plots button on the Main Toolbar, which opens the PNG plot files in a graphics viewer specified by the user.



**Figure 3. Sample 2-D KENO-VI geometry plot**

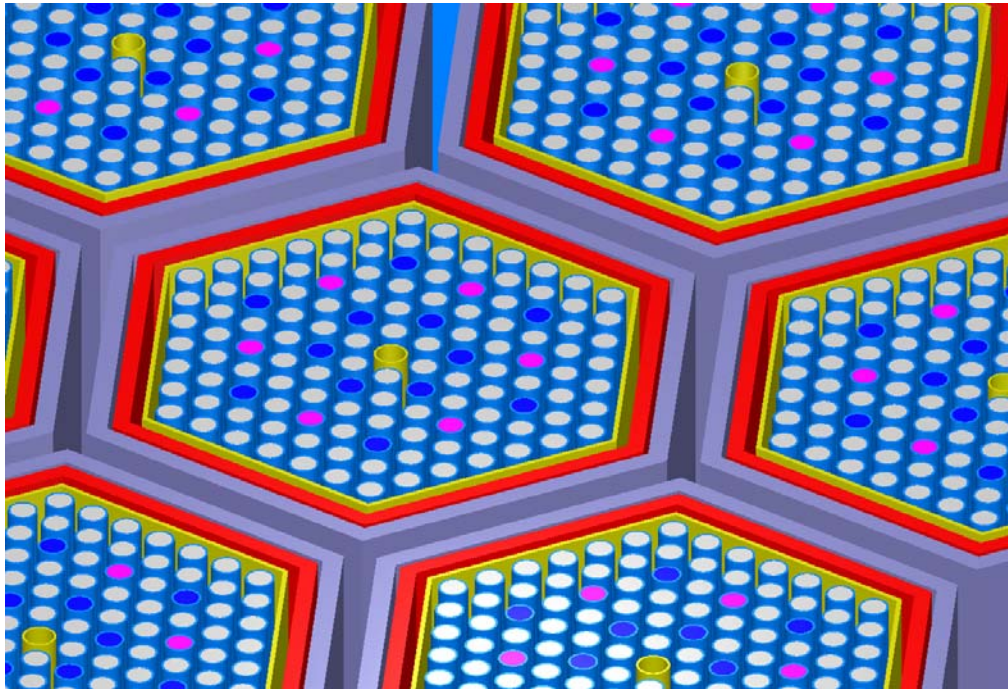
The KMART button on the Forms Toolbar opens the form to specify reaction types and nuclides for calculation of activities, fluxes, and fission production in the KMART postprocessor. KMART calculates these results globally or by group, integrated over the system volume or by unit volume. Activities for particular reaction types are requested by entering the desired nuclide identifier and the MT number corresponding to the reaction rate. KMART writes the results to an ASCII output file to allow the results to be plotted with KENO3D or Javapeno.

Once the input is complete, the user can click the Run button to execute the problem in SCALE.

### 3 KENO3D

The GeeWiz toolbar button for KENO3D allows users to interactively view the components of their geometry model as it is constructed. GeeWiz can invoke the KENO3D visualization tool to provide interactive 3-D viewing of the KENO geometry model. Figure 4 displays a KENO3D zoom view of a KENO-VI spent fuel transport cask model. KENO3D provides users with a powerful tool for checking the accuracy of their models. The interactive options include

- creating shaded or wireframe images;
- displaying standard views, such as top view, side view, front view, and isometric (3-D) view;
- rotating the model;
- zooming in on selected locations;
- selecting parts of the model to display;
- editing colors and displaying legends;
- displaying properties of any unit in the model;
- creating cutaway views;
- hiding units in the displayed model; and
- printing an image or saving an image to common graphics formats.



**Figure 4. KENO3D close-up view of assemblies in cask**

KENO3D can read the KMART output file and plot the results overlaid on the KENO geometry model. Figure 5 displays a KENO3D cutaway view of the Sheba-II critical experiment with an overlay of the KENO V.a  $^{235}\text{U}$  fission densities as calculated by KMART. Note that more than 900 regions were required in the KENO V.a geometry model to obtain the high level of resolution shown in the figure.

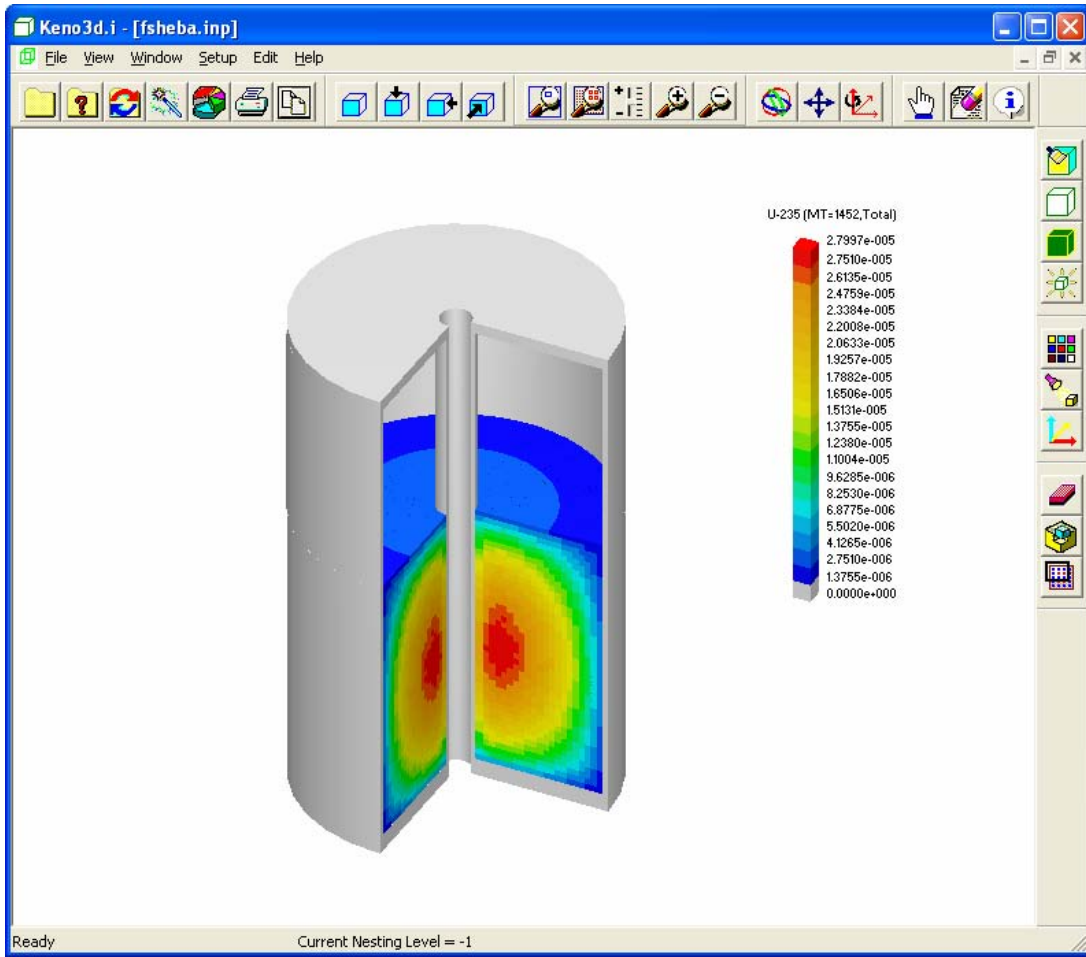


Figure 5. KENO3D plot of the  $^{235}\text{U}$  fission activity

### 4 Javapeno

The Javapeno toolbar button in GeeWiz launches the interactive 2-D data-plotting program Javapeno to plot calculated results. Javapeno plots sensitivity, reaction-rate, or flux data by geometry region as a function of energy group normalized by the unit lethargy for each group, thus eliminating the relative group width from the analysis. Figure 6 contains a Javapeno plot of  $^{235}\text{U}$  and  $^{238}\text{U}$  fission activities as a function of energy in the same region of Sheba-II. Javapeno plots can be printed directly from the software package or can be exported to a variety of graphics formats to use in reports or presentations. Because of the cross-platform capabilities of Java, Javapeno can execute on any computer for which the Java Runtime Environment is available.

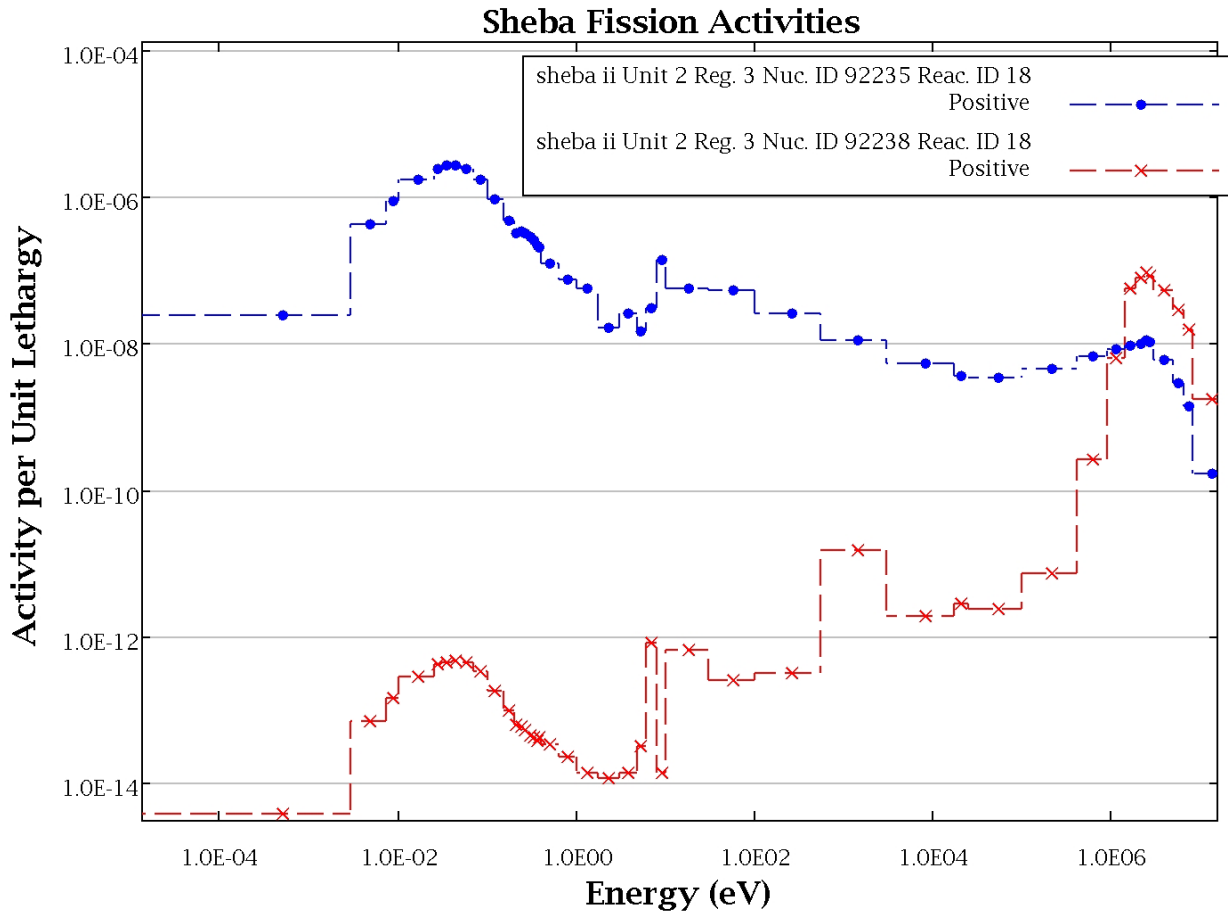


Figure 6. Javapeno plot of  $^{235}\text{U}$  and  $^{238}\text{U}$  fission activities



## 5 KENO HTML OUTPUT

An advanced HTML-formatted output interface for KENO has been developed as part of the integrated visualization package. The use of HTML as an alternative output interface for SCALE codes provides the user with a convenient and familiar means of navigating and visualizing data. HTML can be viewed in any of several modern web browsers that are freely distributed and are preinstalled on many computer systems. Most computer users are familiar with website navigation and require no special training to use the new output format. HTML presents a wide variety of formatting options for differing fonts, colors, and data tables. More advanced technologies such as Java applets and JavaScript are readily incorporated into the output for advanced navigation and data visualization. In addition to easily navigated and color-coded tables of data, interactive plotting capabilities are available. A version of Javapeno has been developed that executes within the web browser as a Java applet. Javapeno-compatible data files are created by KENO so that the user may view data in colorful, interactive, and customizable plots. Data available for plotting within the HTML interface include  $k_{\text{eff}}$  by generation (Fig. 7), the distribution of  $k_{\text{eff}}$  values (Fig. 8), flux spectra by region (Fig. 9), and fission and absorption rates by region (Fig. 10).

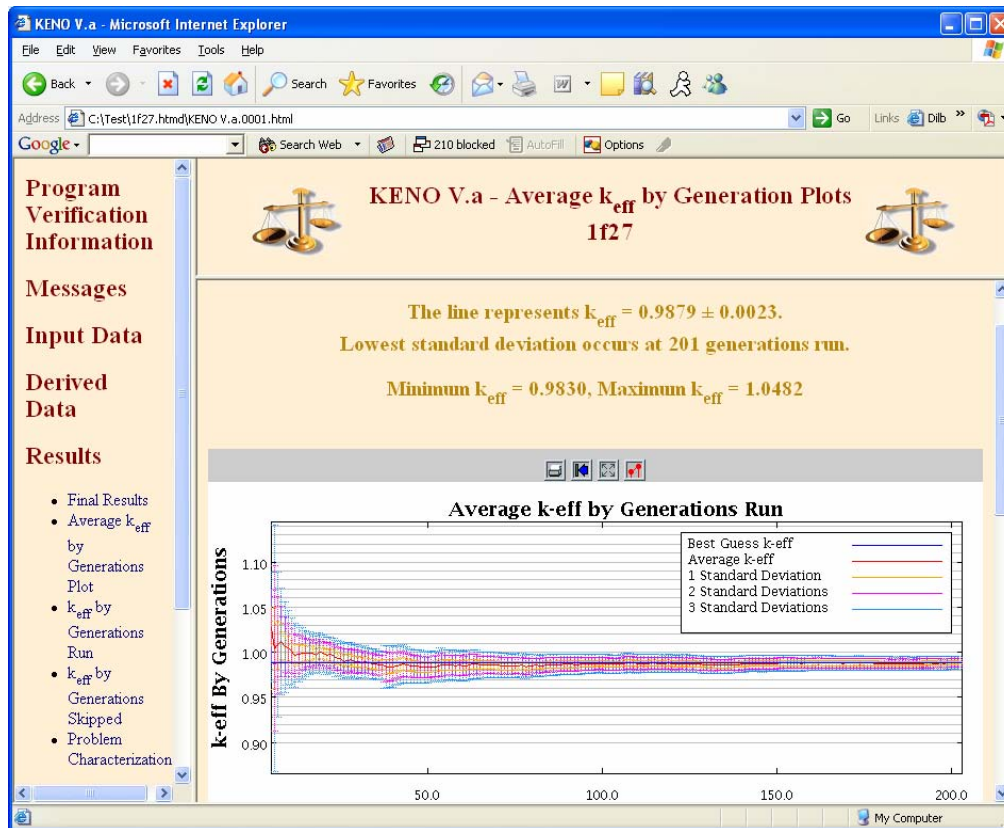


Figure 7. Plot of average  $k_{\text{eff}}$  by generations run

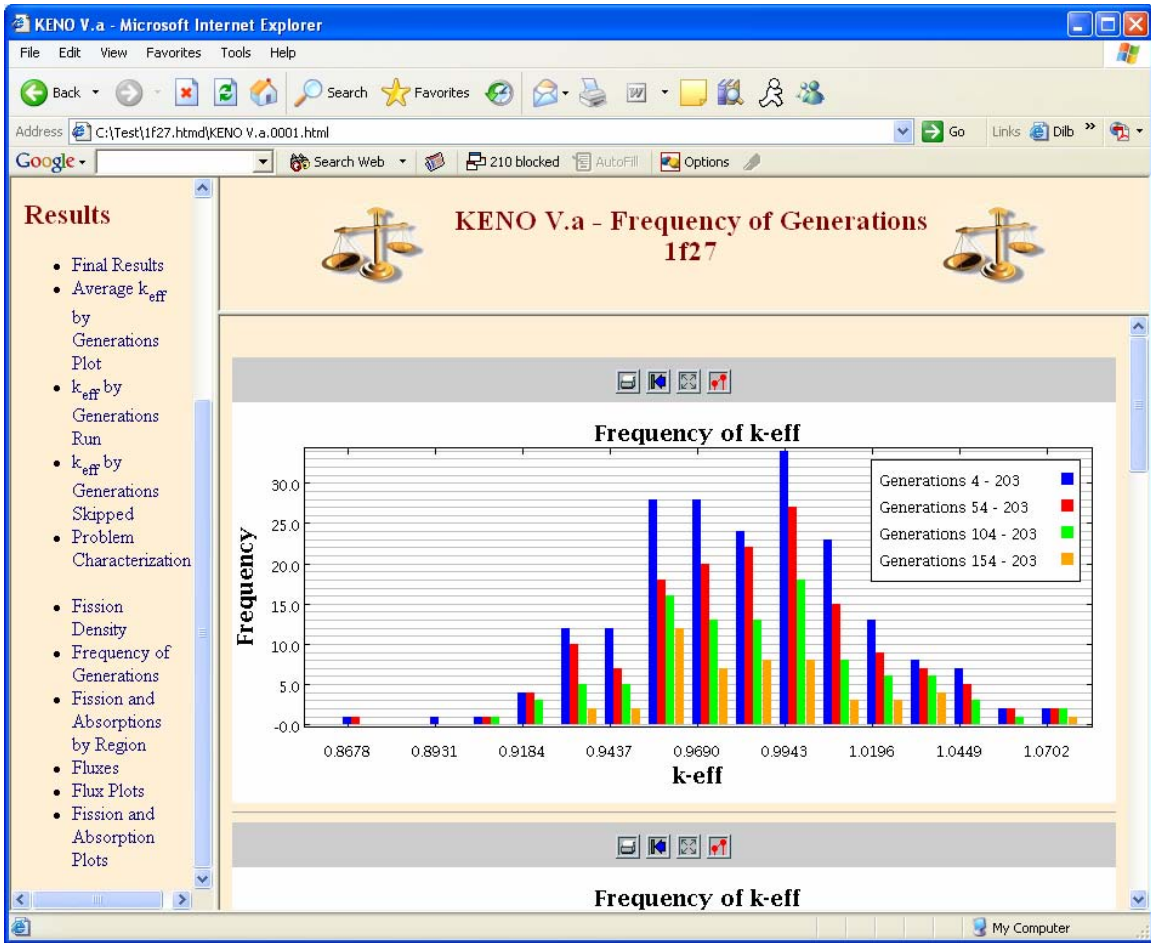


Figure 8. Frequency of  $k_{eff}$  plot

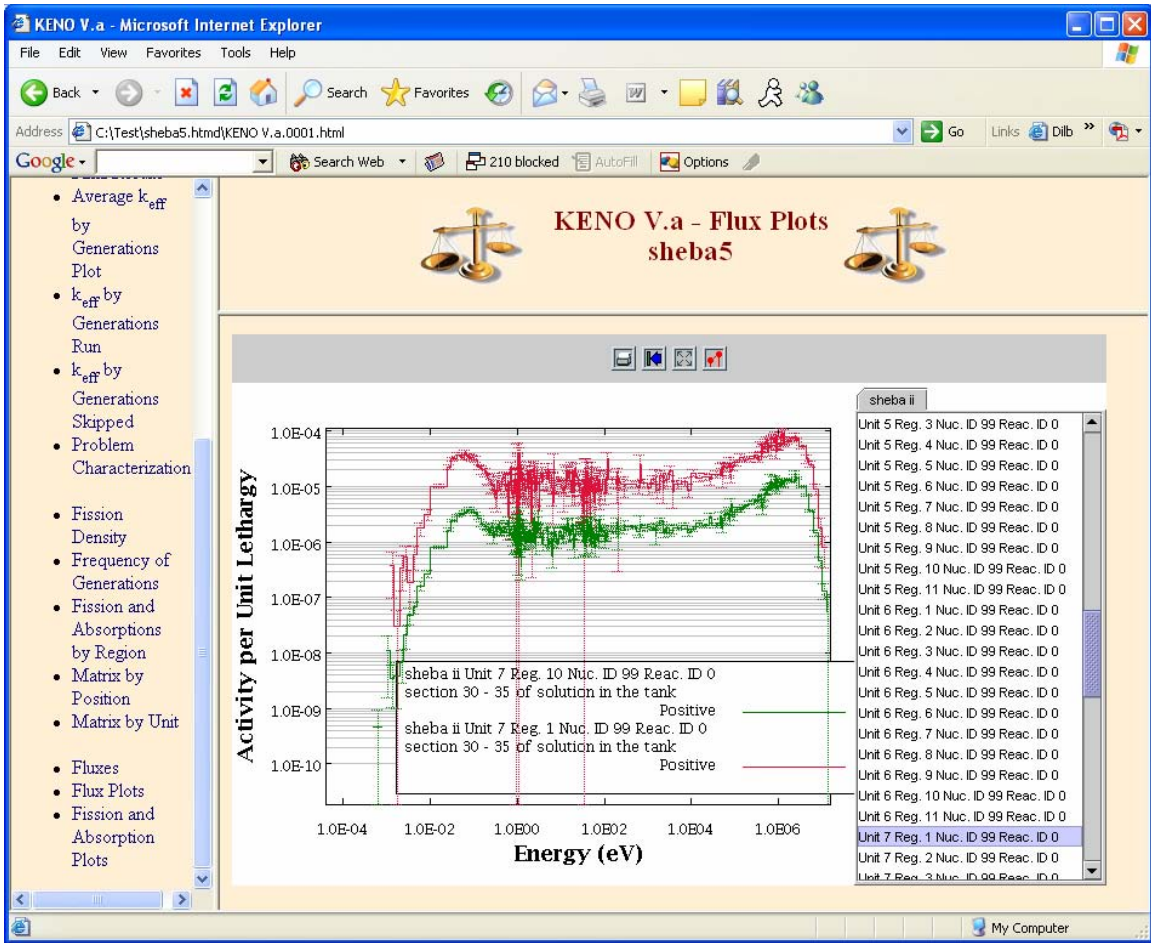


Figure 9. Plot of flux spectra by region

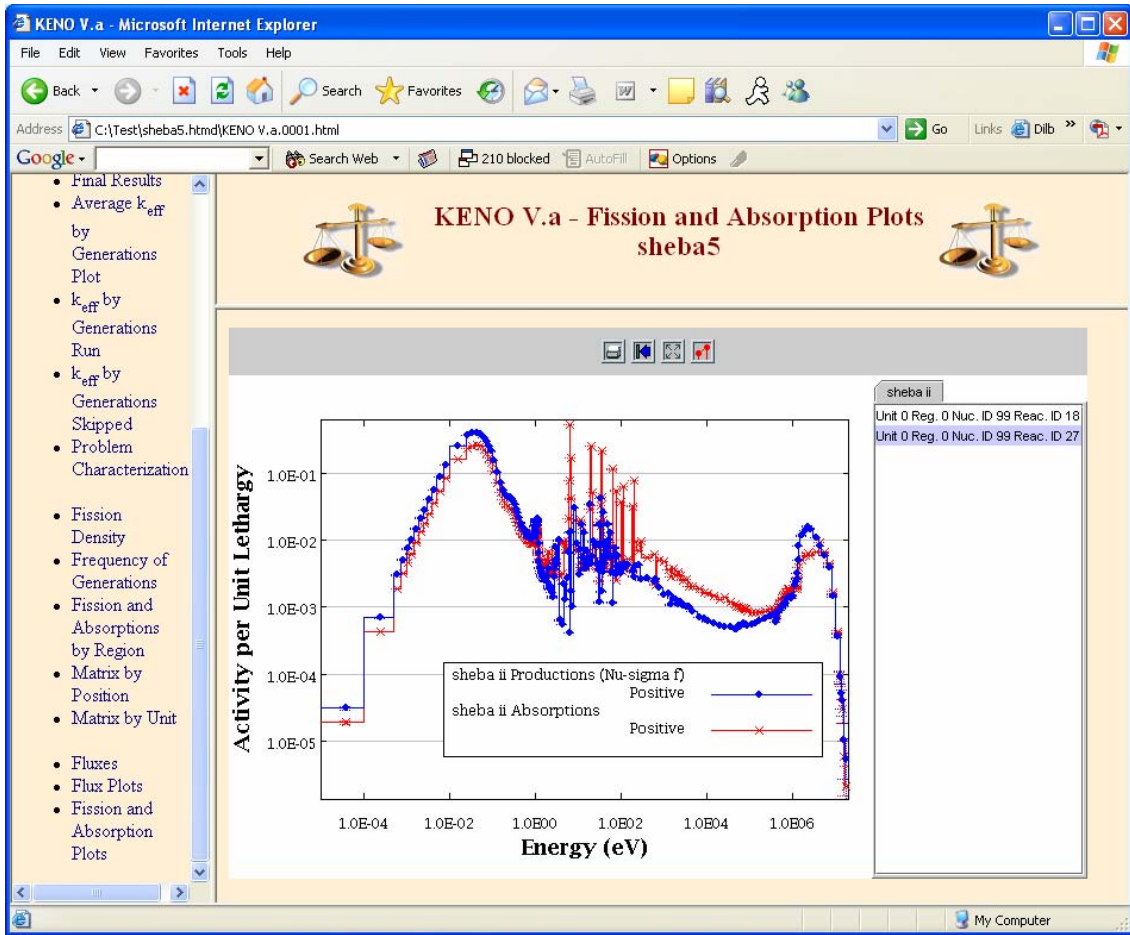


Figure 10. Plot of fission and absorption rates by region

## 6 CONCLUSIONS

The SCALE integrated visualization package for KENO marks a new step forward in using current visualization technologies for Monte Carlo analyses. With the implementation of this package, it is possible for a user to set up, execute, plot, and view results from KENO in a friendly, colorful, and interactive computing environment without ever using a text editor or a command prompt.

## 7 ACKNOWLEDGMENTS

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