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New SCALE Graphical Interface for Criticality Safety

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New SCALE Graphical Interface for Criticality Safety

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The SCALE (**S**tandardized **C**omputer **A**nalyses for **L**icensing **E**valuation) computer software system developed at Oak Ridge National Laboratory is widely used and accepted around the world for criticality safety analyses. SCALE includes the well-known KENO V.a and KENO-VI three-dimensional (3-D) Monte Carlo criticality computer codes.

One of the current development efforts aimed at making SCALE easier to use is the SCALE Graphically Enhanced Editing Wizard (GeeWiz). GeeWiz is compatible with SCALE 5 and runs on Windows personal computers. 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 for compatibility with SCALE 5 and interfaces directly with GeeWiz. GeeWiz and KENO3D for SCALE 5 are planned for release in late 2003. The presentation of this paper is designed as a live demonstration of GeeWiz and KENO3D for SCALE 5.

KEYWORDS: SCALE, KENO, GUI, visualization, GeeWiz

1. Introduction

The SCALE (**S**tandardized **C**omputer **A**nalyses for **L**icensing **E**valuation)[1] computer software system developed at Oak Ridge National Laboratory (ORNL) is widely used and accepted around the world for criticality safety analyses. SCALE includes the well-known KENO V.a and KENO-VI three-dimensional (3-D) Monte Carlo criticality computer codes.

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. One of the current development efforts aimed at making SCALE easier to use is the SCALE Graphically Enhanced Editing Wizard (GeeWiz).

Criticality safety analyses often require detailed modeling of complex geometries. To improve the ease of use, especially for new and occasional users, the CSPAN[2] (**C**riticality **S**afety Input **P**rocessor for **An**alyses) and CSPAN-VI graphical user interfaces (GUIs) were previously developed to assist users in the input setup and execution of KENO V.a and KENO-VI, respectively. The CSPAN GUI for CSAS/KENO V.a, written in Visual Basic, did not have the usability features or the robustness of the newer CSPAN-VI for CSAS6/KENO-VI, written in Visual C++. In particular, CSPAN did not have the CSAS search capability for criticality searches and could not interface with the KENO3D 3-D visualization tool.[2] In addition, SCALE 5 has several important new features that are not available in these GUIs:

- multiple unit cells for cross-section processing,
- new criticality sequences using the CENTRM continuous-energy module, and
- new geometry and array options in KENO-VI.

To address these needs, ORNL has developed a new integrated GUI called GeeWiz. The GeeWiz GUI is compatible with KENO V.a and KENO-VI in SCALE 5 and runs on Windows personal computers (PCs). 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 for compatibility with SCALE 5 and interfaces directly with GeeWiz. GeeWiz and KENO3D for SCALE 5 are planned for release in late 2003.

2. Description

GeeWiz provides a simple user interface with toolbar buttons to access the primary functions of the program (Figure 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 creating a new problem, opening a file,

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saving the problem, executing SCALE, viewing output, viewing plots, accessing on-line help, and activating KENO3D. In addition, many of the forms have toolbars that become visible when the associated form is activated.

The Forms Toolbar has buttons that may be used to view or create the CSAS/KENO V.a or CSAS6/KENO-VI data blocks. This toolbar, which is permanently "docked" on the left side of the main window, contains the following buttons:

- General
- Compositions
- Unit Cell
- More Data
- Parameters
- Geometry
- Arrays
- Start
- Bias
- Plot
- Search

The forms activated by these buttons are discussed in detail in the following sections.

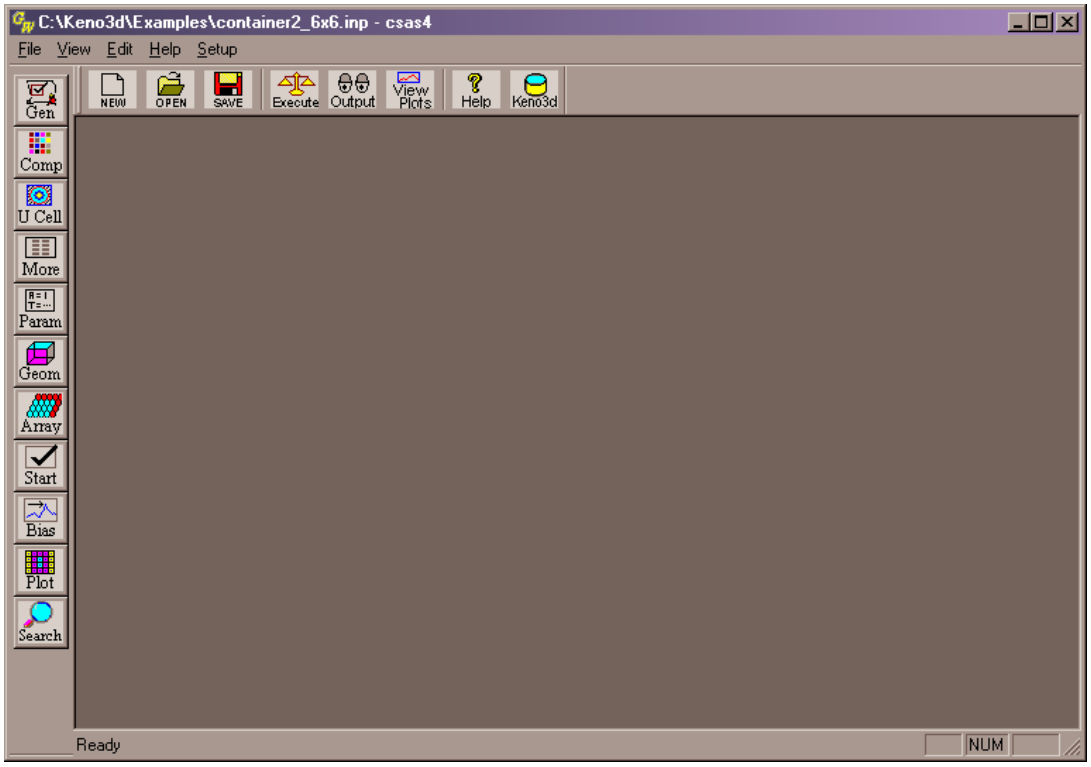

Fig. 1 GeeWiz toolbars.

2.1 General

The General button starts a dialog for general problem information such as title, calculational sequence, execution options, and cross-section library.

2.2 Compositions

The Compositions button opens the Standard Compositions window, which contains the input menus for the three types of composition data that are common to the SCALE control sequences: basic standard compositions, arbitrary materials, and fissile solutions. The SCALE Standard Composition Library contains over 600 basic standard compositions with alphanumeric names (e.g., "UO2" or "H2O"). Default densities and isotopic compositions are provided but may be overridden by the user. The user may use arbitrary materials to construct other compositions by specifying the content in weight percent (wt %) or as a chemical formula of elements and/or isotopes. SCALE automatically calculates the number densities for each isotope and provides problem-dependent resonance self-shielded cross sections.

The Standard Compositions window (Figure 2) displays a list (in spreadsheet format) of the compositions and their properties created by the user. Pressing the Create button and selecting "Basic Compositions" allows the user to define mixtures by selecting valid basic standard compositions from a multiple-choice menu. If the composition contains a multiple-isotope nuclide, GeeWiz displays the isotopic distribution and allows the user to modify it (Figure 3).

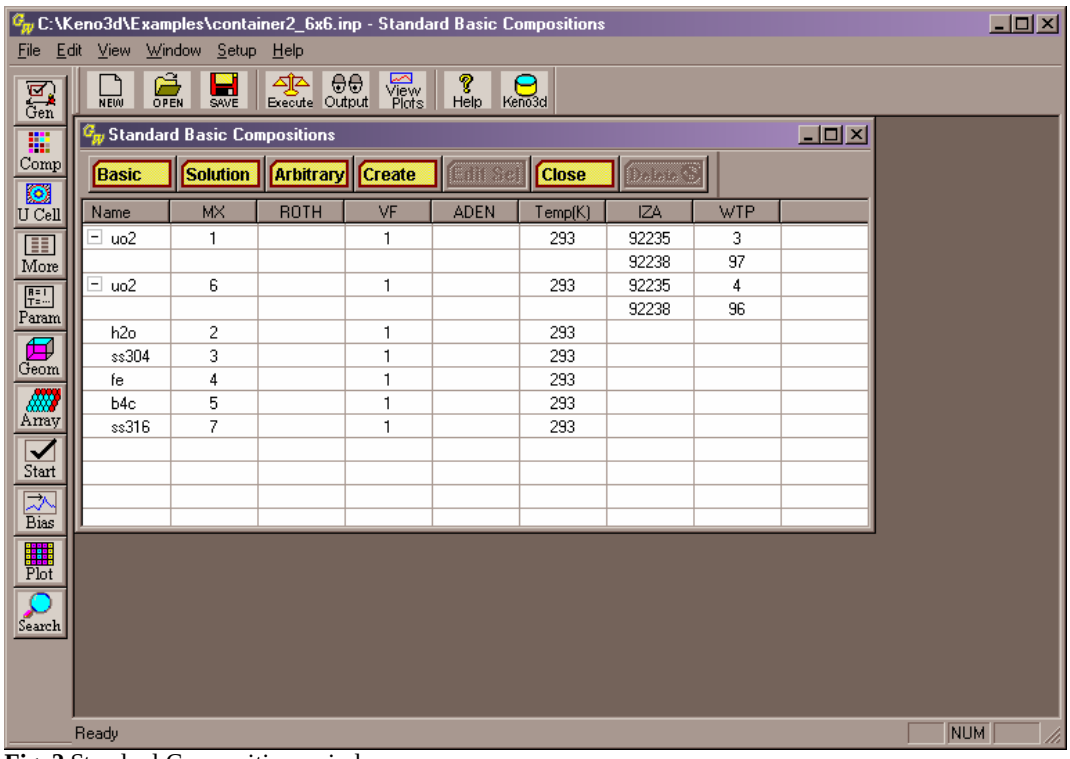

Fig. 2 Standard Compositions window.

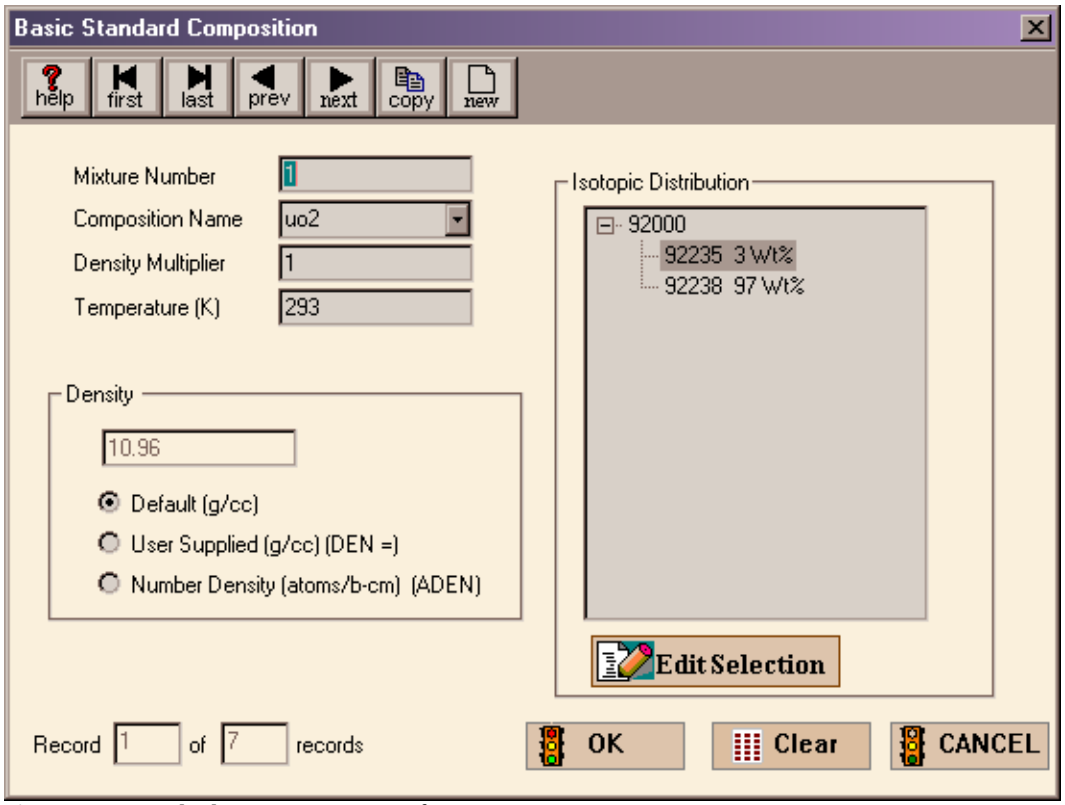

Fig. 3 Basic Standard Composition input form.

The Arbitrary Materials form allows the user to define arbitrary material mixtures by selecting valid nuclides from a multiple-choice menu. The nuclide distribution can be specified by atoms per molecule or by weight percent (wt %).

The Solutions form contains three fissile solutions available in SCALE. The window is very similar to the Standard Compositions window.

2.3 Unit Cell

The Unit Cell forms are available for infinite homogeneous medium, lattice cell, and multiregion unit cell types. The data are used for resonance processing of the problem-dependent multigroup cross sections.

The data on the lattice cell form define the dimensions and compositions of the fuel, clad, and moderator in the fuel assembly lattice. The data on the multiregion form describe a one-dimensional (1-D) model for resonance processing of cross sections for geometries other than lattice cell.

2.4 More Data

The More Data button activates a tabbed dialog form that includes optional input for NITAWL and XSDRNPM, primarily related to cross-section processing.

2.5 Parameters

The Parameters form is a tabbed input screen for the KENO parameter data. The parameters are divided into four groups: (1) Key Parameters that users most often specify, (2) Numeric Parameters, (3) Logical Parameters that have “Yes” or “No” values, and (4) I/O Unit Numbers.

2.6 Geometry

The Geometry form (Figure 4) 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 portion 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 (Figure 5).

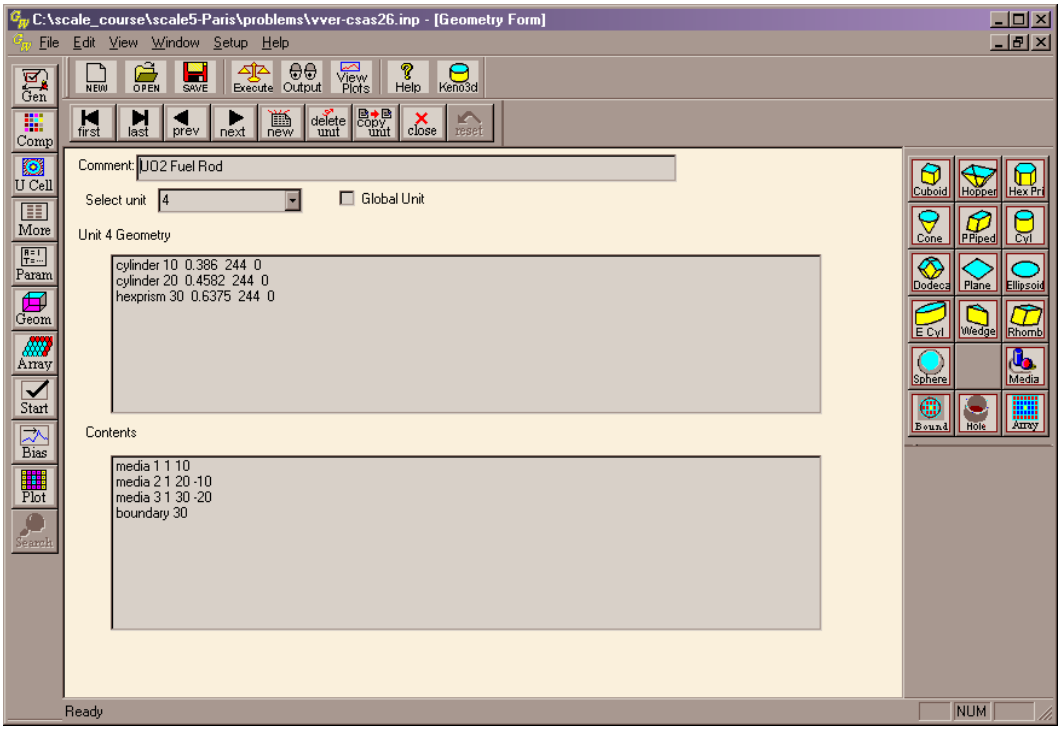

Fig. 4 Geometry form.

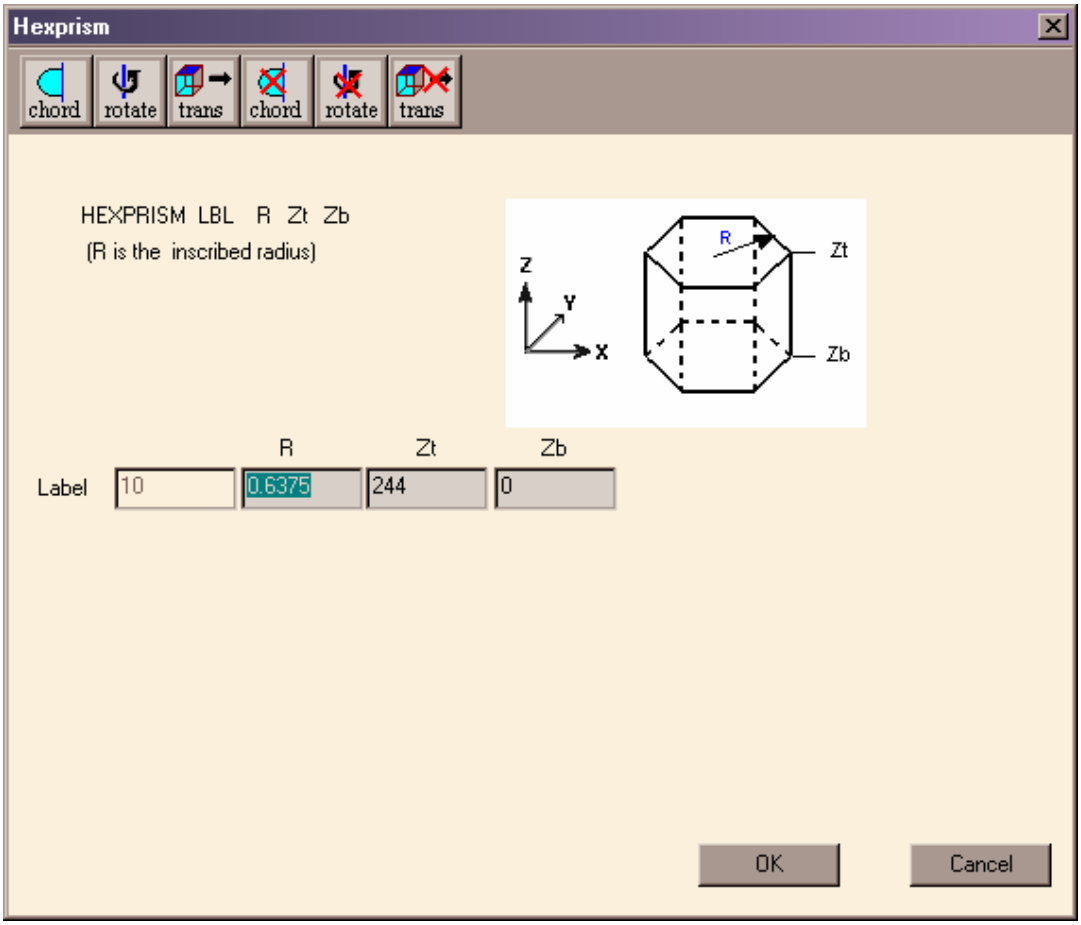

Fig. 5 Geometry dialog for KENO-VI hexprism.

2.7 Arrays

The Array button presents a form for creating and modifying arrays to be used in the KENO geometry (Figure 6).

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.

2.8 Start

The Start Data button allows input and display of the optional data block for specifying the starting neutron distribution.

2.9 Bias

The Bias Data button is used for entering optional data that relate bias identifiers to built-in weighting functions in KENO for automated reflector biasing.

2.10 Plot

The Plot button assists the user in generating 2-D color plots in KENO. The user can customize the plot by selecting colors for one or more of the materials plotted. A sample plot generated with KENO is shown in Figure 7.

2.11 Search

The Search form is available only for KENO V.a cases in which the CSAS4 or CSAS4X search sequence is selected. It is a tabbed dialog form that allows the user to select from optimum, critical, or minimum k_{eff} searches by varying either nuclide concentrations or geometry dimensions.

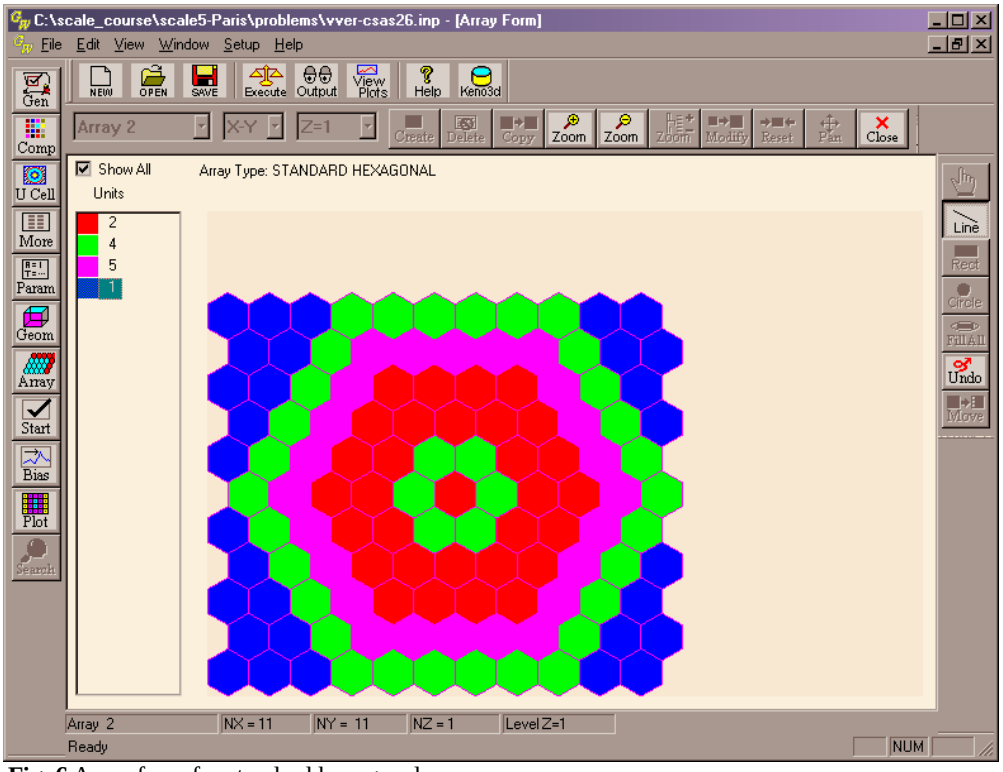

Fig. 6 Array form for standard hexagonal array.

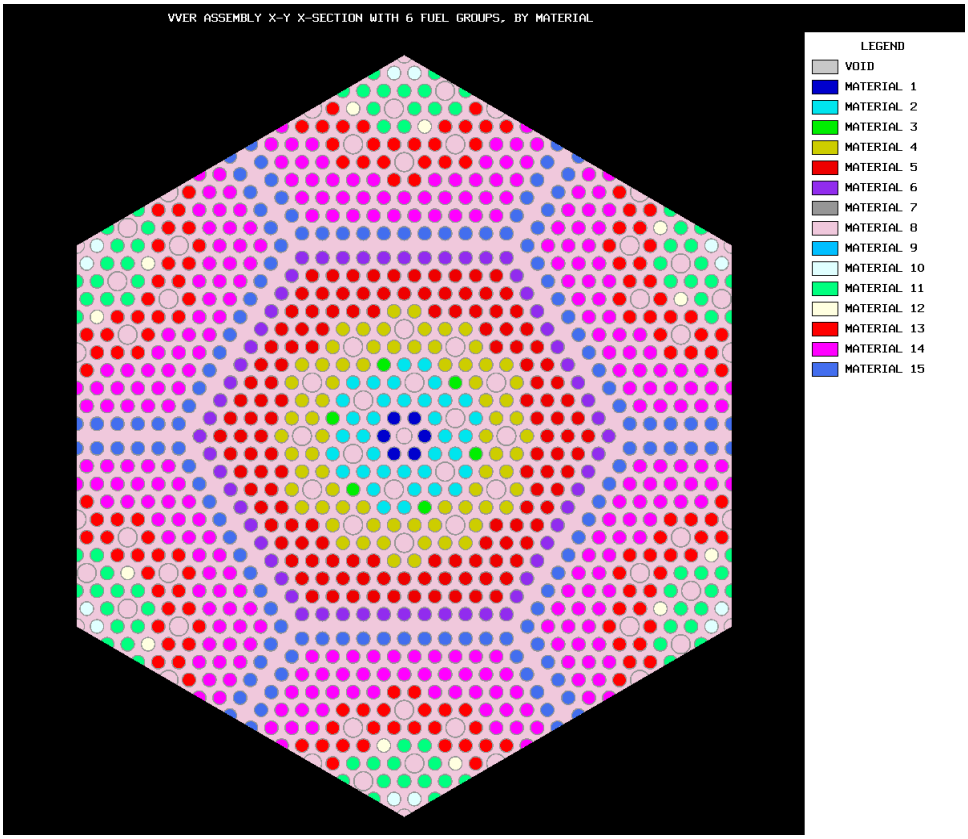

Fig. 7 Sample KENO-VI 2-D plot.

2.12 KENO3D

GeeWiz can invoke the KENO3D visualization tool to provide interactive 3-D viewing of the KENO geometry model. Figure 8 displays a KENO3D cutaway view that has been invoked via GeeWiz.

3. Conclusion

GeeWiz provides a complete and robust interactive user interface to enable new and experienced KENO V.a and KENO-VI users to perform model setup, execute SCALE, and view output and plots.

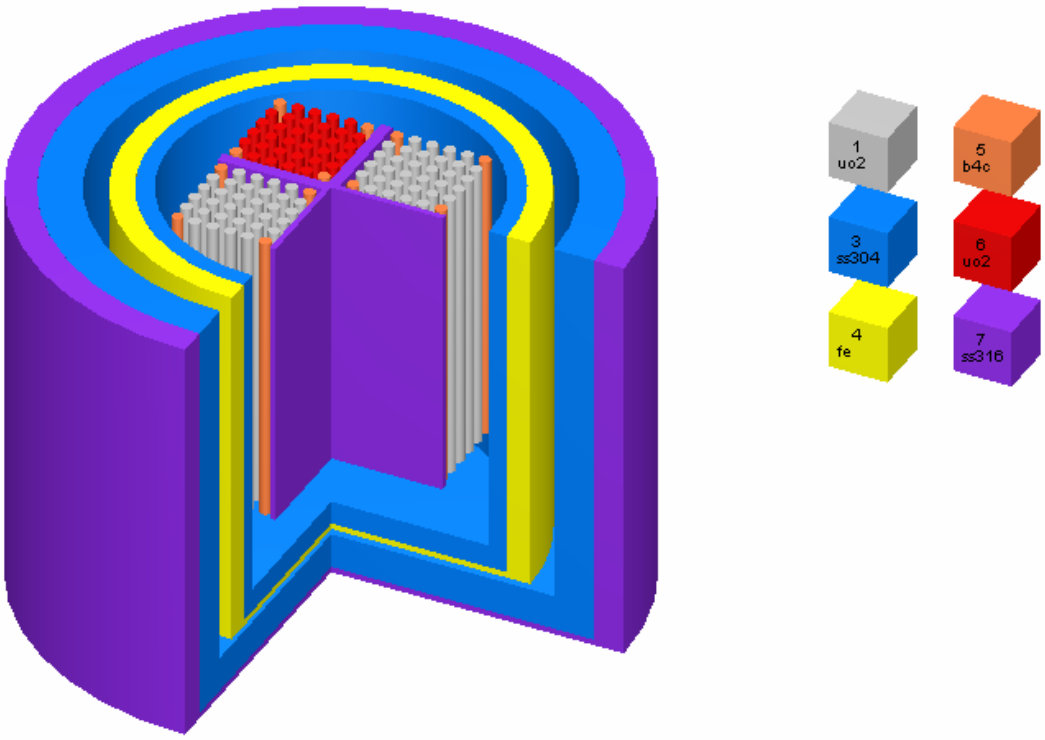

Fig. 8 KENO3D cutaway view.

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1) "SCALE: A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation," NUREG/CR-0200, Rev. 6, ORNL/NUREG/CSD-2/R6, Vols. I, II, and III (2000).
2) S. M. Bowman, J. E. Horwedel, D. L. Barnett and L. M. Petrie, "SCALE Graphical Developments for Improved Criticality Safety Analyses," Proc. Int. Conf. on Nuclear Criticality Safety, ICNC'99, Versailles, France, Sept. 20–24, 1999, **I,** 278–287 (1999).