Model S544
NuChart Nuclide Table Software

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User's Manual

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Preface

NuChart for Windows95/NT is a visual Nuclear Data Library. It can be used as a stand-alone information system or combined with nuclear spectrum analysis programs, such as Canberra's Genie-2000.

This program will provide you with visual information and reliable data on elements and their isotopes. The "Chart of the Nuclides" (the Segre chart) includes details on each nuclide and its metastable states. NuChart uses the well-known NuDat nuclear data files as its source database file.

The available data for each isotope are:

- Basic nuclide properties
- Decay radiation
- Internal structure
- Neutron thermal cross sections

You can create your own data libraries for later use with Genie-2000. Make reports in either ASCII or Rich Text Format (RTF) file format on nuclide data, or just "surf" over the whole chart. A powerful search engine is built into the software for fast and specific access to data. Data can be cut-and-pasted to any Windows application.

Many menu commands, toolbar icons and keystrokes enhance the operation of the software.

With NuChart you can:

- Visualize the whole Chart of the Nuclides, with details on ground and isomeric states, decay modes and half-lives for each nuclide and its states.
- Search for specific decay energy line, internal gamma-ray transition, or thermal neutron cross section. The search can be implemented with multiple constraints.
- Follow a radioactive decay or a nuclear reaction chain.
- Create library files for later inclusion into Canberra CAM files and use in the Genie-2000 environment.
- Export a nuclide's data in either ASCII or RTF file format.
- Copy all or part of a nuclide's data into Notepad or any other Windows 95/NT application.

Modes of Operation

NuChart data can be retrieved using an interactive-visual mode or by means of a multi-constraint search.

In the interactive-visual mode, you can retrieve data using the mouse, keyboard shortcuts, menu commands or toolbar icons. You can retrieve data by seeing and clicking on the specific nuclide you want.

In the search mode, a request for data can be made for specific nuclides, energy entries for decay or internal gammas, and for thermal neutron cross sections. The search can be bounded using several parameters.

The Chart of the Nuclides in NuChart is shown in colors. There are two types of color conventions for viewing the Chart: by the decay modes or by the nuclide's half-life.

The main source database file provides access to two types of data: Decay Data or Internal Structure Data.

The source of nuclear data can be restricted to your choice of nuclides. So you can choose to operate with data from the complete NuChart database or you can create/load your own sub-group of data.

Retrieved data can be exported in ASCII or Rich Text Format (RTF) file formats, or can be saved as a Canberra CAM file.

The Chart of the Nuclides is a plot of all known nuclides as a function of Z (number of protons, or Atomic number) on the y-axis and N (number of neutrons) on the x-axis.

Best Performance

This program is a visual Nuclear Database, where nuclear properties of the nuclides are shown (e.g., colors carry certain physical information). Therefore it is very important how you chose to view the data.

Reasonable performance of this program can be achieved by using personal computers with a 486 66 MHz or better CPU, a fast hard drive (better than 12 ms average access time) and color-SVGA monitor. A mouse is required, although many of the commands can be executed from the keyboard. Video resolution should be at least 800x600 pixels and 256 colors.

1. Introduction

NuChart shows each isotope in the program's source database as a colored cell, with the location of the isotope in the chart corresponding to its atomic number and number of neutrons (Figure 1). The way the cell is displayed carries information about nuclide's states and the way it is colored gives information about the nuclide's radioactive decay or its half-life, depending on the chosen color scheme.

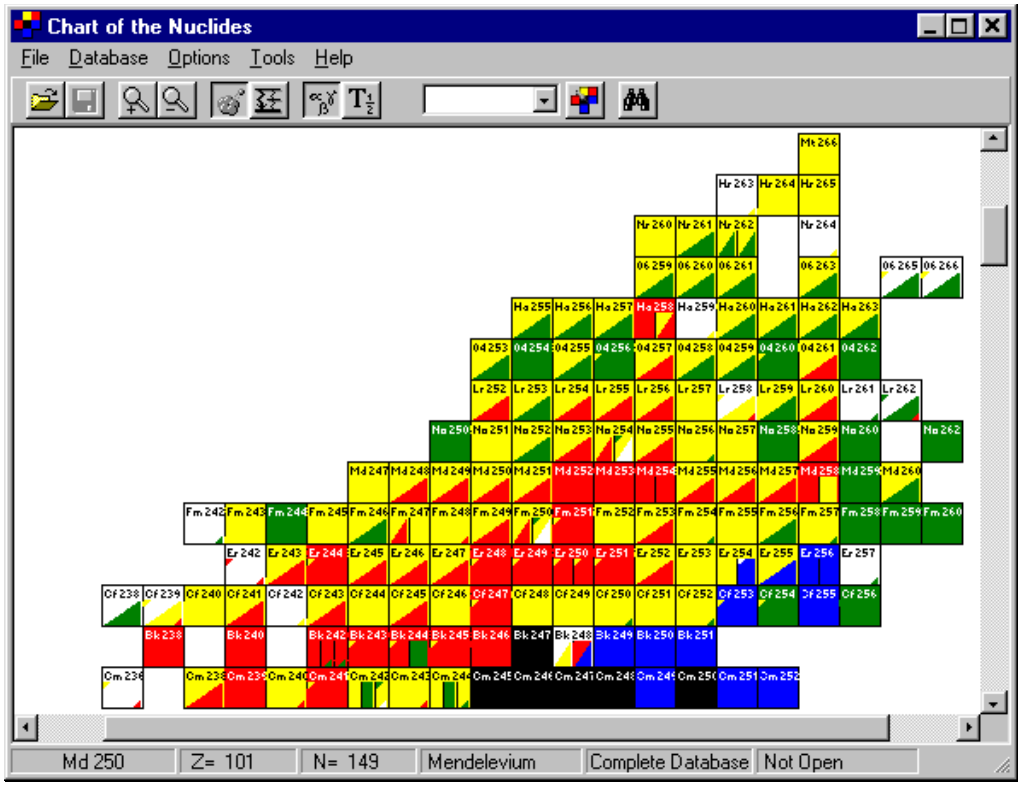

Figure 1 NuChart Nuclide Display

While moving the mouse cursor over the chart, the corresponding isotope, if any, its symbol, name, Z- and N-numbers will be displayed in the Status Bar, described in the next section.

Clicking on the isotope's cell will show you the isotope's nuclear data, with the type of data depending on the type of database chosen. See "Data Output" on page 10 for complete information on the contents and use of the Data Output window.

1.1 Status Bar

The status bar, the horizontal area at the bottom in program's main window, provides information about the current state of what you are viewing in the window and any other contextual information. The Status Bar is divided into six information boxes.

The first four boxes provide information about the isotope under the mouse cursor. The contents of these four boxes changes continuously while you move the mouse cursor over the chart and act as a nuclide locator. The first box displays the isotope's symbol and mass number, the second box its atomic number, the third its N-number and the fourth box, the isotope's (element) name.

The fifth box displays the current settings for the source database. If you are using the full NuChart database, "Complete Database" will be shown in this box. If you are using a sub-database, the file name and location of the sub-database file will be shown.

The last status box shows if a CAM nuclide library file has been created/opened. In the case of a currently open CAM library file, this box will display its file name and location. Otherwise a "Not open" message will be displayed.

1.2 Data Organization

Since NuChart is a visual Nuclear Data system, you should understand how the data is organized, stored and visualized. First of all, the data that you get is stored in the source database file. This source database file can be operated at full capacity (full source database mode of operation) or by using a database containing information only on a set of nuclides defined by the user, this is called the sub-database mode of operation.

The data in this source database is organized in sections called data types. Some sections are accessed freely, but the two main sections, Decay Radiation and Internal Structure types of data, are accessible only by selecting the data type mode of operation. In other words the data type of operation selects the type of data between Decay Data or Internal Structure Data.

A nuclide's data can be retrieved by searching for it or by using the interactive mode, where the whole Chart of the Nuclides is shown and data is retrieved by pointing and clicking.

Finally, data retrievals can be reported. There are several types of reports built into the software. Reports can be printed or saved as ASCII or Rich Text Format (RTF) files (see "Reports" on page 13.

2. The Main Menu

The commands in the Main Menu for the Chart of the Nuclides are described in this section.

2.1 File

The File menu is primarily used to work with new or existing CAM Libraries, which is a binary CAM-formatted file compatible with the Genie-2000 Nuclides Library. It can be opened, edited, and its information extracted using the Nuclide Library Editor provided with the Genie-2000 software. This file will have the .NLB file extension. The name of the opened/created CAM Library file will be displayed at the NuChart status bar.

Open CAM Library

This command is used to open an existing CAM Library file or create a new library file. If you create a new one, be aware that although NuChart will let you save a file with a long file name, Genie-2000 will see only files with an eight character file name.

Close CAM Library

This will close the current CAM Library file. Closing the file will automatically save any changes to the file.

Save CAM Library

This will save the current CAM Library file.

2.2 Database

The Database commands deal with the settings and operation of the NuChart source database files.

- The first two items refer to the NuChart data source files.
- The second item selects the database type of data.
- The last item reports on the currently selected source data file.

2.2.1 Full

In the Full database mode, the software will base all database operations on the complete NuChart database set of files. Alternatively, you can create a new, or use an existing, sub-database file.

2.2.1.1 Create New

The **Database** | **Specialized** | **Create New** command lets you creat a new sub-database group. You might want to create sub-database files for various reasons, such as:

- You don’t want to work with the full database, just a sub-database containing a subset of useful nuclides.

- You want to organize the full NuChart database by set(s) of nuclides related to specific applications, such as environmental measurements, detector calibration, nuclear power plant measurements, or nuclear medicine.

A sample sub-database file, CALIB.SDF, for detector calibration purposes is provided with the NuChart installation package.

Sub-Database Editor

When you select Create New, you'll be able to create a user-defined sub-database in the Sub-Database Editor window. The list box on its left will display all NuChart available elements. When selecting an element, the next list box will show all of the isotopes for that element in the NuChart database.

You can populate the sub-database list box (on the right side) by pressing the "Add" command button.

You can edit (delete) the list of isotopes in the sub-database, by using the command button "Remove".

The list of sub-databases is saved by pressing "Save" command button. This action will call out a standard Windows file dialog box for entering the sub-database file's name and location. The default extension .SDF is used for NuChart sub-database file types.

By double clicking on an element symbol, the whole range of existing isotopes will be automatically added to your list for the sub-database. Also, by SHIFT-click or CTRL-Click, you can select consecutive or non-consecutive group of isotopes of that element.

There is not much difference in performance from working with the NuChart full source database or with sub-database files.

2.2.1.2 Open Existing

The **Database | Specialized | Open Existing** command will invoke the standard Windows file dialog box for selecting/entering the name and location (path) for the NuChart sub-database file to be used as source database. The default extension is .SDF the adopted one for NuChart sub-database type of files. In order to successfully execute this action the file must exist and contain a valid .SDF format.

2.2.2 Types

There are two types of data for operation and retrievals in NuChart: **Decay Radiations** or **Internal Structure** data. A check mark in front of the corresponding database type menu item will denote the currently selected data type.

The type of database chosen determines the type of data you will see (retrieve) in the data output window and the data reports.

2.3 Options

All of the Option commands can be also executed from the popup menu or the main icon toolbar.

2.3.1 Decay

The **Options** | **View** | **Decay** command will sort the Chart of the Nuclides by the nuclides' decay modes using the corresponding Decay Color Scheme. More help on the type of representations NuChart uses is in "Color Toolbox Window" on page 9.

2.3.2 Half Life

The **Options** | **View** | **Half life** command will set the representation of the Chart of the Nuclides to be according to the nuclides' half-life value using the Half-Life Color Scheme. More help on the type of representations NuChart uses is in "Color Toolbox Window" on page 9.

2.3.3 Zoom In

This command will expand the graphical representation of Nuclide's Chart into more details.

2.3.4 Zoom Out

This command will give fewer details in the graphical representation of Nuclide's Chart.

2.4 Tools

The Tools menu item comprises the commands for calling out NuChart's tools.

2.4.1 Search

NuChart's "Search for" window serves as a common place for entering data parameters for searching the NuChart database. The search can be done by: Decay Radiation, Internal structure data or Neutron thermal data. The search can be done in the complete database or the current sub-database. Choose the source database for searching by clicking the corresponding checkbox on the right side of the window. Note that the "current sub-database" option for search only becomes available if you are working with a defined sub-database.

Output Data Window from Search

The window in Figure 2 will display the search results. They will be displayed in a data table in the center of the window. The contents of the data table depends on the type of data you were searching for. Click on the column header to sort the data table for that field.

On the bottom-right side of the window, a table shows the search results statistics as total of lines found, then total of lines in each category according to the type of decay radiation. By double clicking on a data row or by using "Look at" command button while a data search result row is highlighted, you can retrieve full information on that nuclide, calling out the nuclide's data output window.

Note that the data window will show nuclide's data depending on the search type. That is, if you were searching the Internal Structure data, the "show it" action would call out the

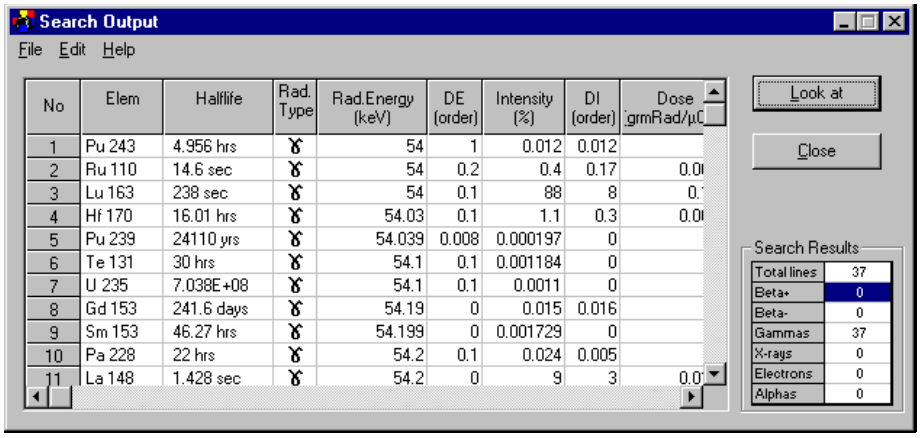

Figure 2 The Search Output Window

nuclide's output window for internal structure data. In the case of searching thermal neutron data, the nuclide's output window will correspond to the current database type.

- The **File** | **Report** command lets you create a report of search results.
- The **Edit** | **Copy** command lets you copy part of the data table, individual rows or group of rows to the clipboard, allowing you to paste the data into another Windows application.
- The **Edit** | **Look at** command calls up the nuclide's data output window for displaying the entire data records available on that specific nuclide. In case of multiple selection, the last nuclide line will be taken.

2.4.1.1 Search for Decay Radiation

The Search for Decay Radiation window (Figure 3) displays the nuclide's data in the interactive mode of operation.

Enter the value of the energy decay you are looking for, followed by a value for a tolerance to be used in searching the energy values. All entry values should be in keV.

Using the check boxes in "Radiation type", you can limit your energy search to a specific type of radiation.

In the "Search Parameters" frame, several data entry boxes for minimum and maximum values are available, for constraining your search. You can enter minimum and maximum values in radiation intensities (%), half-life values (including units). When appropriate, the default value is shown in the data entry box.

Checking the "Resulting from Decay Modes" check box will activate a more advanced search constraint. The "Decay Modes" frame will be enabled, allowing you to search for energy lines emitted from nuclides under specific type of radioactive decays only. By default, the search includes all decay modes.

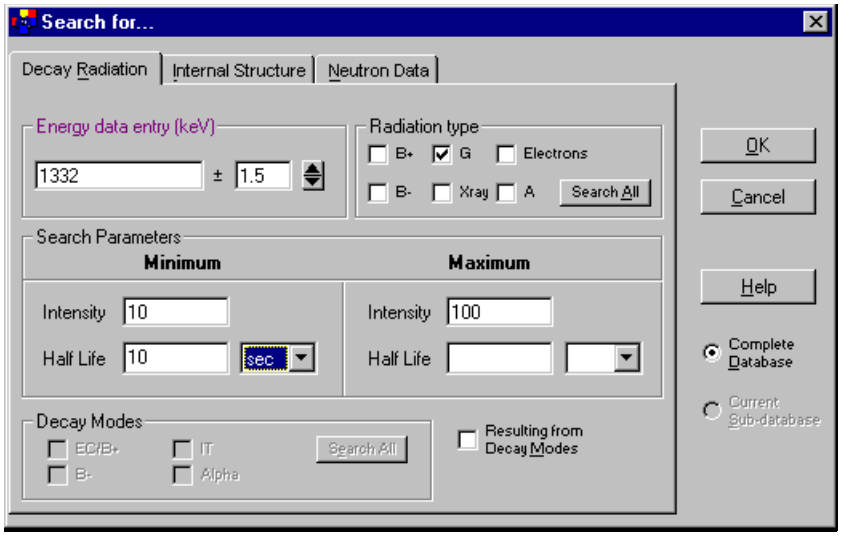

Figure 3 The Decay Radiation Search Window

You can search the full source database or an active sub-database by clicking either the "Complete Database" button or the "Current Sub-database" button. You can search the full source database or an active sub-database by clicking at the options buttons Complete Database or Current Sub-Database.

2.4.1.2 Search for Internal Structure

The Search for Internal Structure window (Figure 4) displays the nuclide's data in the interactive mode of operation. Retrievals will be shown corresponding to the current database type: Internal Structure Data.

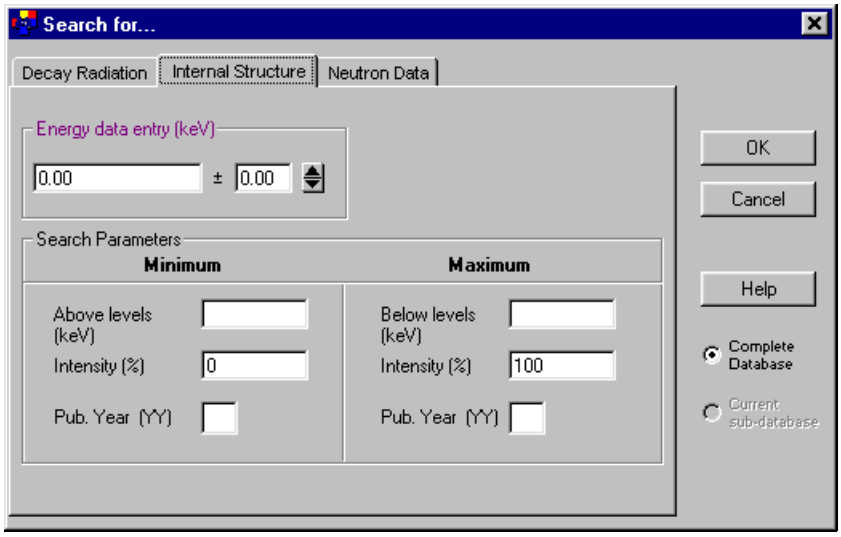

Figure 4 The Internal Structure Search Window

Enter the energy value of the nuclide's internal gamma-ray transition you are looking for, followed by a value for a tolerance to be used in searching the energy values. All energy values should be in keV.

In the "Search Parameters" frame, several data entry boxes for minimum and maximum values are available for constraining your search. You could narrow your search for isomeric transitions from above a specific energy level (Above or Minimum Energy Level) or below a specific energy level (Below or Maximum Energy Level). You could also specify the Minimum and Maximum values for the Intensity (in %) of those internal nuclear gamma transitions and in the year of their publication.

2.4.1.3 Search for Neutron Data

The Search for Neutron Data window (Figure 5) lets you enter the neutron cross section value (in barns) you are looking for. Use the tolerance to tune your search for possible multiple entries.

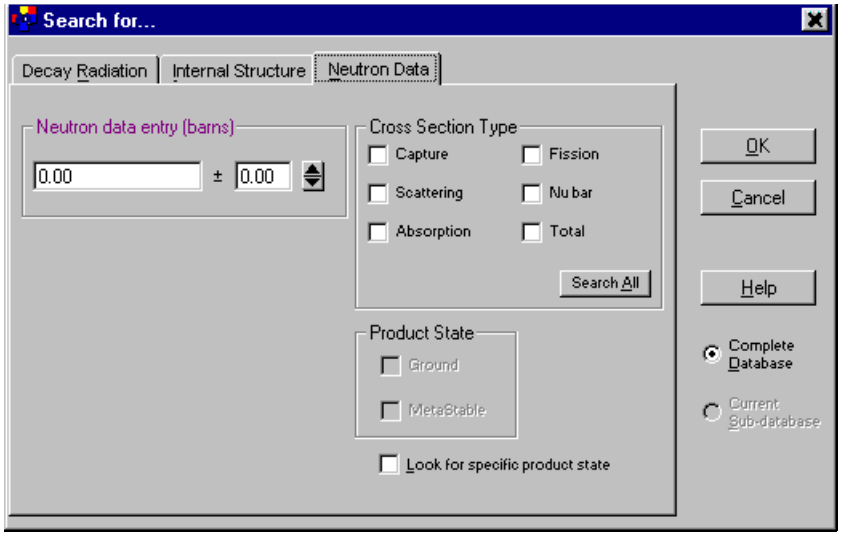

Figure 5 The Neutron Data Search Window

You can specify which type of neutron cross sections you would like to search for by checking the options in the "Cross Section Type" frame.

To search for reactions in a specific state, first click on "Look For Specific Product State", then select either Ground or Metastable (isomeric state) in the Product State frame.

You can search either the Complete Database or the Current Sub-Database.

2.4.2 Color Toolbox

The Color Toolbox window (Figure 6) can be minimized and put in the Windows task bar for later recall while you continue operating the NuChart. The Toolbox can be set to "stay on top" of any window for permanent reference. This action is enabled/disabled by a check box labeled "Stay on top" at the bottom of the window.

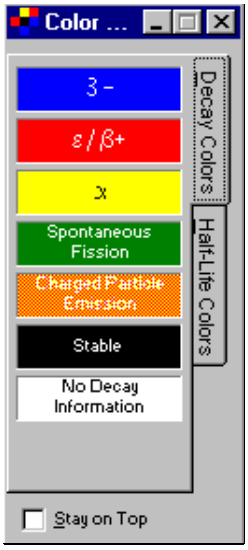

Figure 6 The Color Toolbox

There are two color schemes built into NuChart software: one for representing the decay mode of the nuclides, the Decay Mode Color Scheme, the other for representing the type of nuclide according to its half-life: Half-Life Color Scheme.

You can chose your color schemes for the chart of the nuclides from the main menu's commands, main toolbar icons or the popup menu options.

2.4.3 Decay and Nuclear Reaction Toolbox

The Decay and Nuclear Reaction Toolbox window (Figure 7) can be minimized and put in the Windows task bar for later recall while you continue operating the NuChart. The Toolbox can be set to "stay on top" of any window for permanent reference. This action is enabled or disabled by a check box labeled "Stay on top" at the bottom of the window.

The diagram of the decay is depicting a nuclide in the center and its decay products (by means of beta and alpha decay). For obvious reasons spontaneous fission is not included. Decay products are also shown in the corresponding adopted color scheme.

The diagram for nuclear reaction products is represented in a group of cells (as in the chart of the nuclides) with the supposed target nuclide in the center. Products resulting from nuclear reactions are shown in a cell labeled with the nuclear reaction that produces it.

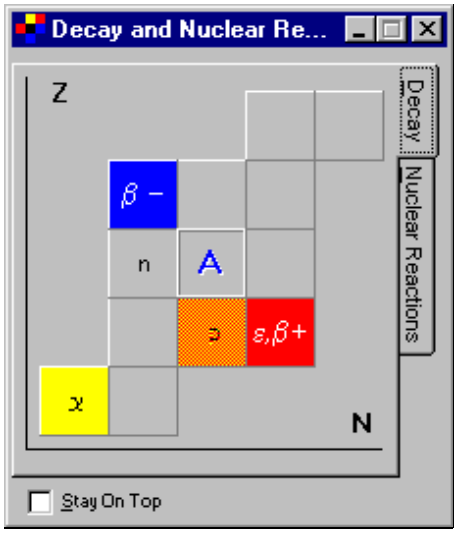

Figure 7 The Decay and Nuclear Reaction Toolbox

2.5 Help

In addition to a complete list of help contents and indexes, NuChart's help includes tables of elements and constants and a "tip of the day" feature. You can also invoke context sensitive help at any time by pressing the F1 key.

Contents and Index

This will show the contents and indexes for NuChart's help text.

Elements

This will open a window displaying a table of all the elements, their symbols, names and atomic weights.

Constants

This will open a window displaying a table of the major physical constants, their symbols and values.

Tip of the Day

Select this to see a window at startup showing some tips on the effective operation of NuChart.

2.6 Data Output

Clicking on the isotope's cell in the Chart of the Nuclides will show you the isotope's nuclear data, as shown in Figure 8.

Common information will always be displayed for both modes. The "Nuclide" frame contains nuclide's symbol and its mass number (A=Z+N), element name, nuclide's abundance (in %) for naturally occurring nuclides, and mass excess in MeV for ground states.

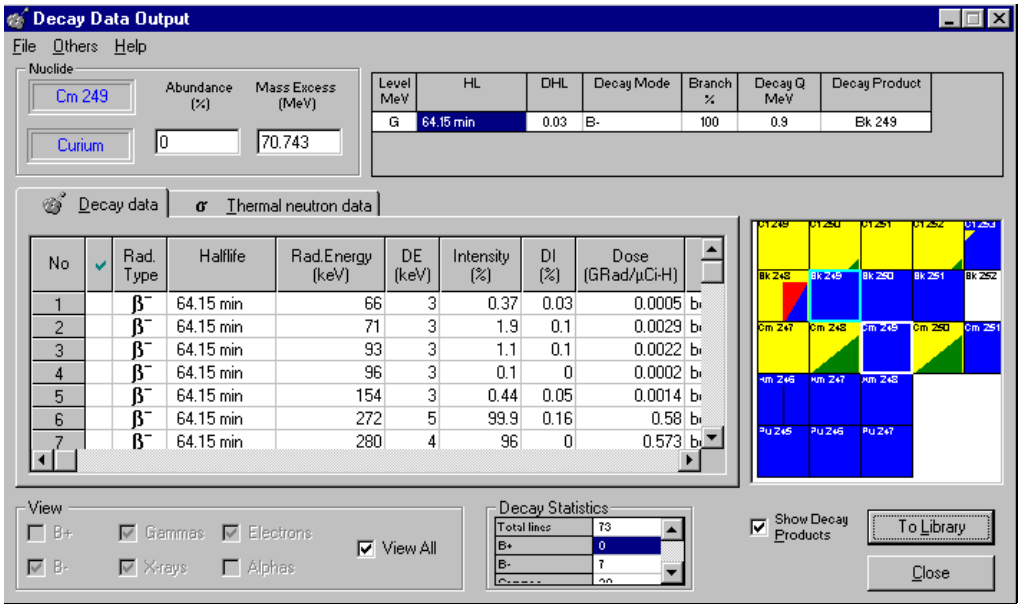

Figure 8 The Data Output Window

A table at the top-right side of the window shows basic nuclide decay properties. In the center of the window a main Tab-control shows the retrieved information according to the current database type and nuclide's neutron thermal data, if any. The former is also commonly displayed for any database type setting.

To view the data, just click on the corresponding Tab. Data inside the Tab form is displayed in an ordered table. Click on the top of the column to sort the table by that column field. The width of the columns can be adjusted by dragging its edges with the mouse while pressing the mouse's left button.

At the bottom of the form, a "View" frame allows you to chose for "viewing" all the retrieved data or selecting them by the type of decay radiation. The default mode of view is "View All" decay radiation. Click on the "View All" check box to disable it, then select only the particular types of radiation you want to display.

A little table shows the statistics of the retrieved data as total of nuclide's decay lines found and then their distribution according to type of decay radiation.

At the right-center of the window, a graphical box shows an expanded region of the selected nuclide. The initially selected nuclide is highlighted in a white fame. Its decay products (if any) are shown also highlighted using the same color scheme for decay. By leaving the mouse pointer over the highlighted zone, a floating toolbar help will appear showing the corresponding decay chain. You can still "browse" the nuclide's neighborhood or follow its decay chain by still clicking into nuclides of the zoomed area. Note that this is limited to the shown area and the highlighted nuclide will be the initially selected one.

The presentation of the decay products can be enabled/disabled by clicking on the "Show Decay Products" checkbox.

Retrieved data can also be viewed or operated on by the menu commands of this window.

2.6.1 Report

The **File** | **Report** command lets you prepare a report on the results of your nuclide search.

2.6.2 Others

View: Enables/disables the view of retrieved decay data lines by their type.

Copy: Copy the selected contents of the active data table into the clipboard.

To Library: Copy selected nuclide's data into the CAM format nuclide library, described under "File" on page 3. Only those data lines selected – marked with a checkmark in the second column – would be copied into the CAM library. You can do this also by using the window command button "To Library".

Active data table: the data table where the cursor is actually located.

3. Reports

The Report window is actually a rich text format (RTF) editor which lets you view, edit or highlight your data reports. NuChart data reports can be of two types: a report on the search results or a report on a specific nuclide.

File

The items under File have to do with the report operations as a file.

Save as: will call out a standard Windows file dialog box for entering the file name, directory and type of the file under which the report will be saved.

Print: Will also call out a Windows file dialog box for printing the report.

Close: Will close the Report Window

Edit

The items under Edit have to do with editing the report.

Copy: will copy the selected part of the report into the clipboard.

Paste: will copy the contents of the clipboard into the report, at the location of the cursor.

Cut: will delete the selected part of the report and store it into the clipboard.

Bullets: will set the selected text into a bullet style of text. If the text is already in bullets, it will turn it off.

Colors: will call out a Windows standard dialog box for defining the text and background colors for the selected text of the report.

3.1 The Search Results Report

After a search of the NuChart source database, you can generate a report on the search results. The Search Report, shown in Figure 9, is divided into three major sections: general, statistics and results. You can use the menu options and the toolbar of this window to print and edit the report and can save it as a plain ASCII or a rich text format (RTF) file.

General

A general section, recording all the input search parameters, used in the search, including the source and the type of database searched.

Statistics

The statistics section presents the total of data records found during data retrieval.

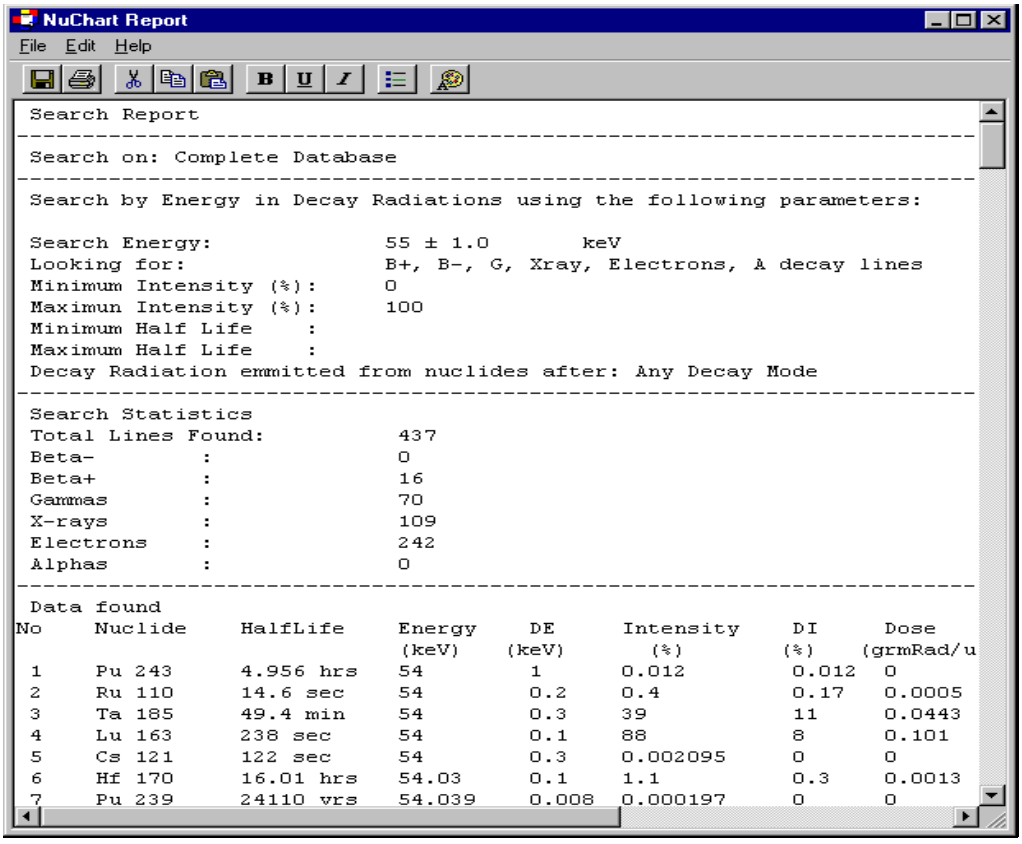

Figure 9 A Typical Search Report

Results

A section for the search results. Here the data records found are presented. As in other parts of the program the data records will be according to the type of data you were looking for. For example, if you performed a search for Internal Structure data, that would be the data contained in the search results lines.

3.2 The Nuclide Report

The Nuclide Report, shown in Figure 10, contains all the available nuclear data on a specific nuclide. It is divided into three or four major sections: general, statistics, nuclide specific data and, possibly, neutron data. The first three sections will be part of any nuclide's report independent of the type of database that is currently active. You can use the menu options and the toolbar of this window to print and edit the report and can save it as a plain ASCII or a rich text format (RTF) file.

The contents of nuclide's report will be displayed in the Report Window. Using the menu options and the toolbar of this window you can print, edit, and save the contents of the report.

General

In the general section, the nuclide's name, symbol, atomic number, z and n numbers, and basic properties will be reported.

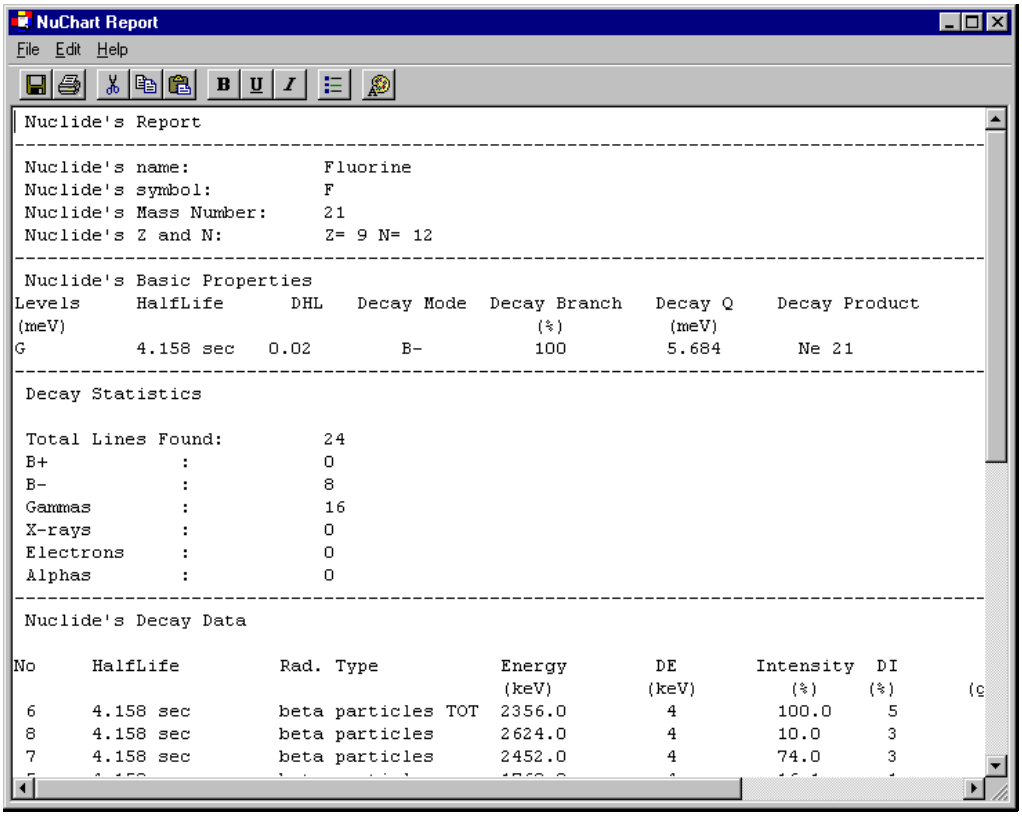

Figure 10 A Typical Nuclide Report

Statistics

In the statistics section the total number of lines and their distribution by types will be reported.

Nuclide Specific Data

The nuclide's specific nuclear data is generated corresponding to the type of active database. That is, for the type of Decay Radiation data, the nuclide's specific data part of the report would contain all nuclide's decay radiation information.

Neutron Data

A neutron data section (if available).

4. Database Types

NuChart's data is presented with four major sections of information on each nuclide: the nuclide's Basic Properties, Decay Information, Internal Structure and Thermal Neutron Data.

The first and the last database sections (or types) are always accessible and shown for any nuclide, while the other two are selectable. Thus, leaving the term of type of database to the selection between data on decay or data on nuclide's internal structure.

During the data retrieval operations, all data records retrieved will show the nuclide's Basic Properties, its Neutron Data (if any) and the rest of information would be according to the selected type of database, that is Decay or Internal Structure data.

4.1 Nuclide's Basic Properties

Under Nuclide's Basic Properties the following data records are stored:

Nuclide's Name

The nuclides' names and symbols are consistent with those adopted by NuDat. For elements from Z=104-109, names that are not yet accepted internationally due to conflicting claims about their discovery, have been named with their symbols.

Symbol

Internationally adopted elements' symbols have been used here.

Mass Number

Mass Number, (At) as the sum of number of protons (Z) and number of neutrons (N).

Atomic and N Numbers

Atomic or Z-Number: The number of protons in the nuclide, which is also referred to as the Atomic Number. The N-number is the number of neutrons.

Abundance (in case of stable isotope)

Natural isotopic abundance given in percent. Abundance is only given for naturally occurring isotopes.

Mass Excess

Calculated as M – A and expressed in MeV on the unified mass scale (Mass Excess of C12=0)

Levels

Refers to the levels for which decay and basic properties are given. Can be G for ground or a value for the energy level width (in MeV) of the isomeric state.

Half-life value and units (HL)

Time units on which the half-life is expressed. psec for picoseconds, nsec for nanoseconds, usec for microseconds, sec for seconds, min for minutes, hrs for hours, days and yrs for years.

Stable nuclides are marked as STABLE here. Uncertainty of the half-life value (DHL) is expressed in the same units as HL.

Decay Mode

The type of nuclide's radioactive decay. B– for Beta– decay or negatron emission, B+ for Beta+ decay or positron emission, EC for electron capture, IT for Isomeric transition, A for alpha decay or alpha particle emission, SF for Spontaneous fission, n or p for neutron or proton emission. In addition to that there might be rare cases of decays emitting nuclides, they are denoted by the symbol of the nuclide emitted. E.g. C14 would be a decay mode of C14 emission. Multiparticle decays are expressed as a combination of these. E.g. AP– for alpha nd proton simultaneous decay or 2B+ for double Beta– decay.

Decay Branch

Relative emission probability of that type of decay from a level populating a specific product (daughter) nuclide's level. Given in %. When there are no competing decays, 100% is assigned to the primary decay mode. In the case of delayed emission particles (ECP, ECA, B-N, B-P, etc.) 100% is assigned to the main decay (that is to EC), while the second value represents the probability of emission of a delayed particle after a 100% occurrence of that main decay. A zero value in this field means there are no measurements or reporting values.

Decay QBP

Decay energy for the corresponding decay mode, or particle separation energy in the case of particle emissions. Given in MeV.

Decay Product

The resulting nuclide after a certain decay scheme or mode. Also referred to as the Daughter nuclide.

4.2 Decay Radiations Data Type

Under this part of the database, nuclide's data related to its decay (including ground and metastable states) are stored using the following records:

Type of Radiation

Half-life value and units for identifying the level for which the decay records are given.

Radiation Energy

Energy in keV that characterizes that radioactive emission. In the case of beta radiation the median energy of the spectrum is given. Radiation energies are in the Laboratory System.

Radioactive decays have a specific signature on the type of particles or energy emission that results. In NuChart we have divided the radiation types into positron emission, negatron emission, gamma-ray emission, orbital electron emission, X-ray emission and alpha particle emission.

Although several of them are of the same nature, we decided to differentiate for a more clear representation.

Example: Gamma and X rays are photons, so in principle they can be symbolized as a photon-emission, but the clear differentiation between them emphasizes the different nature of their emission process: nuclear and usually as a result of an Isomeric Transition for gammas and atomic emission and as a result of beta/EC decay for X rays.

Same applies for electrons and negatrons (B–) particles. The first as a result of atomic interactions and reorganization and the later pure nuclear

Also this type of distribution is internationally accepted and used.

Often more information on the specific type of radiation is also given under the Comments field.

Uncertainty

Uncertainty for Decay Radiation Energy: Uncertainty of the radioactive emission energy. Expressed in keV.

Intensity

Frequency of occurrence of this radiation energy per 100 decays. Expressed in %.

Intensity's Uncertainty

Uncertainty of the Radiation Intensity. Expressed in %.

Dose

Absolute.

Comments

More specific information about the nature and the type of radiation coded into 12-character fields, which are self-explanatory. Some examples and their meanings are:

gamma AN: annihilation gamma ray.

X K: X rays from the K-shell.

X KA2: K-alpha2 X rays.

E AU K: Auger electron from the K-shell.

E CE L: Conversion electron from the L-shell.

End-point Energy

Since the beta emission energy spectrum is a continuous one, the end-point energy value is given (in keV) for this type radiation.

LSD Uncertainty: Uncertainties expressed in the Least Significant Digit(s) of the value. Example: 37.2 ± 22 represents 32.2 ± 2.2 or 2000.0 ± 0.25% becomes 2000 ± 5 in LSD representation.

4.3 Internal Structure Data Type

Under this part of the database, nuclide's data concerning internal nuclear transitions (also internationally known as Adopted Gammas) are stored using the following records:

Energy of the internal gamma transition (a gamma-ray emitted from an excited nuclear level), expressed in keV and for the center of mass system.

Intensity: Branching ratio for all gamma transitions depopulating at a specific level, with 100 for the strongest gamma transition from that particular level.

Nuclide's energy level, from where the internal transition is emitted. Since an energy level of a nucleus is determined by its excitation energy, this field can be also interpreted as such. Expressed in keV and in the center of mass system.

Publication Year: The publication of that record in the Nuclear Data Sheets in YY format.

4.4 Thermal Neutron Data

Under this part of the database, nuclide's data concerning thermal neutron cross sections and resonance integrals are stored, in the following records:

Level

G (ground) or M (metastable or isomeric) for identifying the Level to which this neutron data record is linked.

Reaction

The type of thermal neutron reaction for which the cross-section is given.

Product State

The resulting product-state or level for which this cross section or resonance integral data is given

Thermal Cross Section or Sigma

The value for the thermal neutron cross section for the specific reaction from Level and forming the Product State. Given in barns.

Uncertainty of the Thermal Cross Section

Uncertainty for the cross section, in absolute values and expressed in barns.

Resonance Integral

Expressed in barns

Uncertainty of the Resonance Integral

Uncertainty of the RI, in absolute values and in barns.

5. Displaying the Chart of the Nuclides

NuChart shows the Chart of the Nuclides as an interactive data retrieval system. The way the Chart of Nuclides is represented carries specific information on each nuclide.

In NuChart, each nuclide is visually represented as a cell plotted in a graph with nuclide's Z- as the Y-axis and the N-number as the X-axis. Each cell is colored if the nuclide "experimentally has been observed" and it has internal divisions if the nuclide has isomeric or metastable states.

The chart in the main window shows a nuclide's positions, its colors and its internal division.

From the nuclide's positions you can tell whether the nuclide exists (observed), its atomic number and its number of neutrons (N-number). This positional information is given to you for the nuclide under the mouse cursor. The mouse coordinates are related to Z-number and N-numbers in the Chart. Thus the program will show you the actual nuclide's atomic number and n-number, its symbol and its name corresponding to the current location of your mouse pointer.

NuChart displays the entire Chart of the Nuclides in color-coded view modes: the decay mode and the half-life mode.

In both modes, color color-coding represents three major levels of the nuclide: The ground state and the two most prominent metastable (isomeric) states.

5.1 Decay Color Scheme

NuChart in its Decay Mode of View displays the entire Chart of the Nuclides in colors corresponding to the nuclide's radioactive decay. In this view, the color convention NuChart uses is:

- Red for positron decay (Beta+)/Electron capture.
- Blue for negatron decay (Beta–).
- Yellow for alpha decay.
- Green for spontaneous fission decay.
- White for no decay information.
- Dark orange for proton or charged particle emission decay.
- Black is reserved for stable nuclides and long-lived or terrestrial formed radionuclides.

Color representation is given up to the nuclide's level detail. The three major nuclide's nuclear levels (ground state and the two most prominent metastable states) are displayed with their corresponding decay color representation.

In addition, colors in this scheme also denote their strengths in relation to the competing decays for the same nucleus or level.

Internal Divisions

The internal divisions shown in Figure 11 will give you the information about the metastable states that the nuclide might have. Only three major nuclide's states are represented: the ground and two others. When there are divisions, the ground level is shown first (from the left).

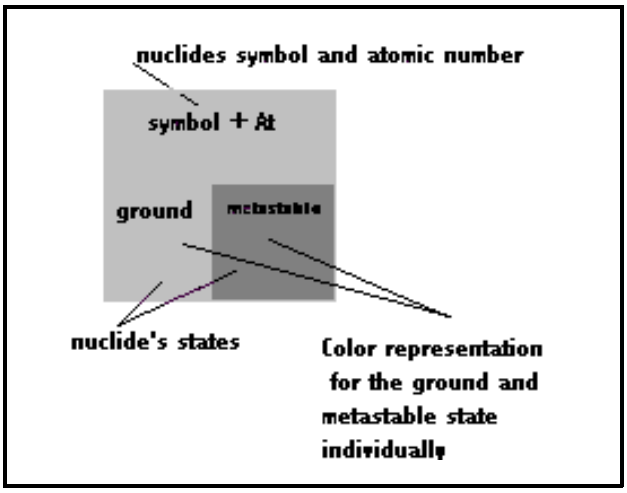

Figure 11 Internal Divisions

Colors carry information about nuclide's type of radioactive disintegration or its half-life, depending on the color scheme that you have selected. The color representation is applied to the nuclides and to its metastable states individually.

Fill Patterns

The colored fill patterns for each state, shown in Figure 12, are related to the value of the Decay Branch for that particular decay mode, thus telling you how strong that decay mode might be.

Fill patterns are interpreted as a separate percentage of the Decay Branch or as the sum of the parts to give the total for that Decay Branch. For example, 95% of Decay Branch for a decay mode will result in a 3/4 parts of filled colored pattern for that level or nuclide.

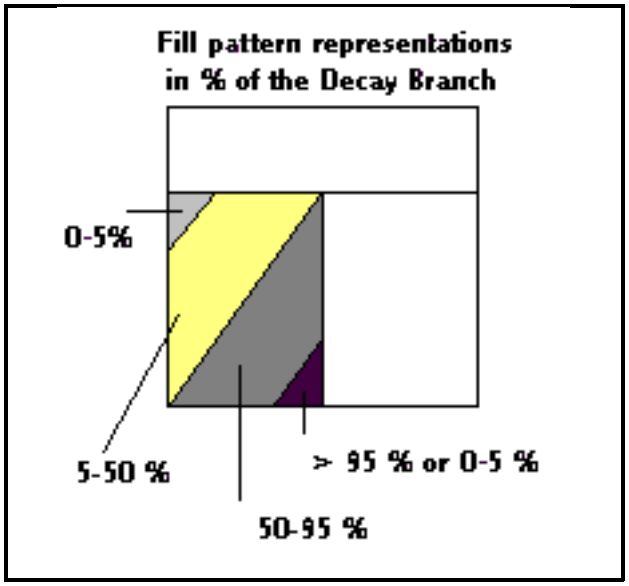

Figure 12 Fill Pattern Representations

5.1.1 Examples of the Decay Color Coding

Here are color representations of some nuclides (using the decay color scheme) and their interpretation.

Nuclide Cl-34 with two states: ground (HL=1.5264 sec) decaying 100% Electron Capture and a metastable state (HL=32 mins) and 55% decaying as Electron Capture and 44.6% Isomeric Transitions.

Nuclide Cl-38 with two states: ground state (HL=37.24 min) 100% B– decaying and a metastable state decaying 100% Isomeric Transitions (IT).

Nuclide Co-60 with two states: Ground (5.2714 years) decaying 100% B–, and an metastable state (HL=10.467 min) with two decay modes; IT 99.7% and 0.24% as B– decay.

Nuclide As-74 with no isomeric states: decays 66% Electron Capture decay and 34% B– decay.

Nuclide Sb-122 with three states: The ground (HL=2.7209 days) decays 97.6% B– and 2.4% EC. The metastable state (HL=0.53 msec) decays 100% IT and the other metastable state (HL=4.191 min) also decaying 100% IT.

Nuclide W-183, a long life nuclide with two states: The ground (HL=1.1E+17 years), considered as STABLE and therefore no color decay assigned (colored black) and an metastable state (HL=5.2 secs) decaying 100% by Isomeric Transitions.

5.2 Half-life Color Scheme

NuChart in its Half-life Mode of View displays the entire Chart of the Nuclides in colors corresponding to the nuclide's (or nuclide's levels) half-life value. In this view the color convention NuChart uses is:

- Yellow for nuclides with half-life < 10 minutes.
- Dark orange for nuclides with half-life between 10 minutes (inclusively) and one day.
- Red for nuclides with half-life between 1 day (inclusively) and 10 days.
- Green for nuclides with half-life between 10 days (inclusively) and 100 days.
- Blue for nuclides with half-life between 100 days (inclusively) and 5E+08 years.
- Grey for nuclides with half-life longer than 5E+08 years (inclusively).
- White for no HL reported.
- Black for stable nuclides.

Notice that in contrast to the Decay view mode, distinction is made between Stable and Long-lived nuclides.

Color representation is given up to nuclide's level detail. The three major nuclide's nuclear levels (ground state and the two most prominent metastable states) are displayed in color according to their half-life values.

Contrary to the decay color scheme, this color scheme does not have more meaning than the unique half-life value for the nuclides or nuclide's states.

5.3 Examples of Half-Life Color Coding

Here are some of the nuclide's color representations, using Half-life View Mode, and their interpretation.

Stable nuclide: black on the left; with an isomeric state of 5.47 msec of half-life: yellow on the right.

Long-life or Earth forming nuclide: gray color representation.

Indium 114 has three states, the ground with HL=71.9 sec: yellow at the left. Isomeric state HL=49.5 days: green middle. Isomeric state HL=43.1 msec: yellow on the right.

Antimony has three states: ground (12.46 days); isomeric state with 19.15 mins and another isomeric state with HL=11 sec. Producing the green-orange-yellow color representation.

A. Installing NuChart

If you are installing this software as an upgrade from a previous version, make sure that NuChart is not running on your system. If you are installing an upgrade over an existing version, it is recommended that you first uninstall the previous version (using the Add/Remove Program item in the Windows Control Panel).

Follow these steps to install the software:

1. Put the disk labelled "NuChart Software - Disk 1 of n" into your floppy drive.
2. Open an MS-DOS prompt window and at the command line prompt, type:

   ```
   a:\setup
   ```

   If you are installing from drive B:, type `b:\setup`.
3. You will see an introductory screen describing the installation of the NuChart software. Press Ok to continue.
4. Next, you'll see the screen shown in Figure A.1, which shows the default drive and directory that the NuChart software will be installed in. If you want to install the software in another directory, use the Change Directory button to select it, then press the large icon button in the upper left corner of the screen to continue the installation.

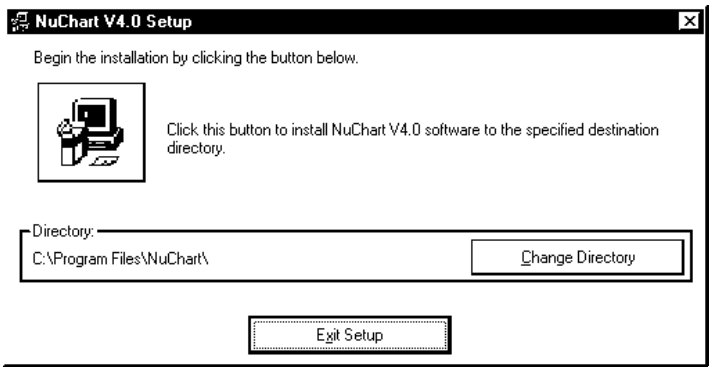

Figure 13 Selecting the Drive and Directory

5. Now you'll see the screen in Figure A.2, which shows the default program group to which the NuChart program shortcut will be added. If you want to add the shortcut to a different program group, either select it from the list box or type in the name of a new program group to be created. Press the Continue button to proceed.

6. Follow the on-screen instructions to install the NuChart software.

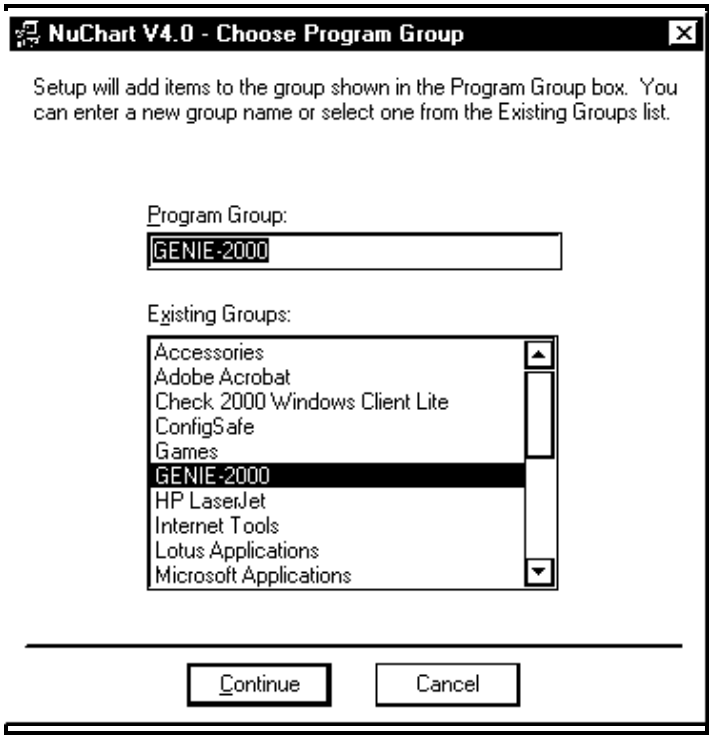

Figure 14 Selecting the Program Group

B. Nuclear Data Files

NuChart software bases its operation on a set of source database files containing nuclear data information, stored in a binary format, for all nuclides represented in this software. The contents of NuChart nuclear data files were extracted from the well-known and internationally available NuDat data files as of October, 1997. Not all data fields contained in NuDat were extracted.

The NuChart full data source contains the following information:

- 4750 records on Nuclide's Basic Properties
- 145 888 records on Decay Radiation
- 172 205 records on Internal Structure data
- 1448 records on Thermal Neutron data.
- Elements with Atomic Number 1-109 and isotopes 1-266.

B.1 NuDat Files

Nuclear Data (NuDat) files were first created, and are maintained, by Brookhaven National Laboratory (BNL) - National Nuclear Data Center, USA.

NuDat[1] contains information on:

- Level and Adopted gamma rays, derived from ENSDF[1].
- Nuclear and metastable state properties extracted from "Nuclear Wallet Cards and its updates".
- Decay data extracted from ENSDF. Additional calculations performed by the program RADLST, T.W. Burrows ["The Program RADLST", Report BNL-NCS-52142 (1988), National Nuclear Data Center, BNL, USA]
- Thermal neutron cross sections and resonance integrals as per those contained in the Neutron Cross Sections publications, Vol 1.

B.2 Creating a CAM Library File

With NuChart software you can create your own nuclear data file in CAM format for use with Genie-2000 software. To do this, follow these steps:

1. Use main menu's "File | Open CAM Library" for creating a new CAM NLB file.

1 NuDat and ENSDF are available from and are maintained by major Nuclear Data Centers. For further inquires on NUDAT, contact BNL at http://www.nndc.bnl.gov.

2. A Windows file dialog box will appear. Enter the CAM file name (*.NLB) and location (drive and sub-directory).

3. Populate the CAM NLB file by adding the isotopes' information you are interested in (see "Populating a CAM File" in Section B.2.1).

4. Save the CAM file with "File | Save CAM Library".

5. Close the CAM file with "File | Close CAM Library".

Note Before you can use a CAM nuclide library created in NuChart, it must be opened and saved in Genie-2000's Nuclide Library Editor to be sure that it is properly sorted for use by the Genie-2000 software.

B.2.1 Populating a CAM Library File

You can populate a CAM Library file from the Data Output window or from the Search Output window.

Data Output

To add nuclide data to a CAM NLB file from the Data Output window, open the file, then select the nuclide's records (lines). You can select the records by either double clicking on the corresponding line or by pressing ENTER key. The nuclide records you have selected will be marked with a check (√).

Search Output

To populate a nuclide's data after finding it through a search, go to the found nuclide's data in the Search Output window by selecting it and pressing the "Look At" button. Then follow the above steps.

B.3 Using Sub-Database Files

In NuChart you can define your source database to contain only a certain set of isotopes.

B.3.1 Creating a New Sub-Database File

To create a new Sub-database file, use "Database/Specialized/Create New...", then select the Sub-database's isotopes in the sub-database editor window.

B.3.2 Opening an Existing Sub-Database File

Use "Database/Specialized/Open Existing..." to select the file from the standard Windows file dialog box. The default file extension is *.SDF.

Notice that after opening a sub-database file, NuChart's database mode will change from FULL to SUB-DATABASE, displayed in the program's status bar (bottom of the main window).

B.3.3 Populating a Sub-database

To populate a sub-database click on the element symbols you are interest in, listed on the left side of the sub-database editor's window.

When the element has been selected, the existing isotopes in the NuChart will be shown in the Isotopes list box.

- Add the isotopes by pressing the Add button in the center of the window. The selected isotopes will appear in the "Sub-database list" list box.
- You can remove isotope(s) from the sub-database list by using "Remove" button.
- You can add an identification text to the Sub-database by pressing "Id" button.
- Use the "Save" button to save the set of isotopes of your sub-database.

Tip: Double click on the element's symbol for adding all its isotopes.

Tip: Use mouse shortcuts for adding consecutive (SHIFT+Click) or nonconsecutive (CTRL+Click) element's isotopes.

Searching For an Energy Line.

You can search for energy lines (Decay energies or Internal Gamma energies) in the NuChart database. Start the search, then select the appropriate Tab to enter the input search parameters.

In the case for energy lines search, enter the energy value and a tolerance (in keV), in the data enter boxes listed under the frame "data entry values". You can search the active sub-database by clicking at the corresponding option button on the right of the window. You can restrict your search by entering other parameters.

B.4 Sorting Data Tables

Most of data tables can be sorted by clicking at the title column. The data table will be sorted by the column's field. Numerical sorts are descending. Columns containing text are sorted in ascending alphabetical order.

B.5 Locating a Nuclide

Use the entry list box at the main icon toolbar for entering the symbol and mass number of the nuclide you are interested on.

Use ENTER key or the nearby icon button for starting the locating action.

A list of entered isotopes is stored and can be called back by clicking at the arrow sign in the nuclide's list box.

B.6 File Extensions Conventions

The following file extensions have been adopted for NuChart.

- .SDF for sub-database files. ASCII formatted files.
- ".NLB" for CAM Library files. In Canberra's CAM format.

- ”.DAT” for NuChart’s data source files. In NuChart binary format.
- ”.IDX” for NuChart’s index files. In NuChart binary format.
- ”.TXT” for ASCII report files, e.g. reports file.
- ”.RTF” for rich text format (RTF) reports file.

C. Troubleshooting

The following errors can occur during the operation of the NuChart

Opening/Saving/Closing NLB Files

If you opened an existing CAM NLB file, make sure that it has the right format and it is not corrupted.

For other errors, look for the specific error code in Appendix C "Error Messages" in the *Genie-2000 Optimization Tools Manual*.

Opening/Saving Sub-database Files

Make sure that the file is in ASCII format. Visually inspect it. It should have one isotope per line.

Poor graphical performance Poor graphical representation has been found when using S3-processor based video cards.

Nuclides are painted inside the cells or parts of the cells (when metastable states) except for one-pixel line at the border of the cell.

Error Opening DLL Files

Be sure that the NuChart Dynamic Link Library (DLL) files are in the program's location and that they are not corrupted. If this problem persists, reinstall the software.

Who to Contact

For other problems or questions, contact your Canberra dealer or technical support office.

D. Uninstalling NuChart

For uninstalling NuChart software package use the Windows uninstallation feature.

1. From the Windows Task Bar button START select "Settings/Control Panel"
2. From the Control Panel chose Add/Remove Programs module.
3. Click to the Tab labelled "Install/Uninstall". Then the NuChart should appear as one of the items for uninstallation (if it was properly installed).
4, Select it and press Add/Remove button.

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DOMESTIC WARRANTY

Canberra (we, us, our) warrants to the customer (you, your) that equipment manufactured by us shall be free from defects in materials and workmanship under normal use for a period of one (1) year from the date of shipment.

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