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NuclideNavigator-Pro V5.0

Interactive Chart of the Nuclides and Reference Software



NuclideNavigator-Pro V5.0

NuclideNavigator-Pro is an invaluable resource for nuclear decay and emissions data. It is compatible with Windows 10/11 in English, French, Spanish, German, and Simplified Chinese languages with the following key features:

- Master data libraries composed of data from reputable sources.
- Chart of the Nuclides with detailed nuclide and elemental emissions data with informative layout and color-coded views, and powerful search capabilities.
- Library Manager to build gamma spectroscopy libraries for use in ORTEC's Gamma Spectroscopy applications, such as GammaVision.
- Synthetic spectra for individual nuclides (alpha, beta, and gamma) and decay chain emissions (gamma only) which can be saved to ORTEC software compatible file formats.
- Extensive Nuclide Decay Scheme documentation.
- Periodic Table of the Elements with elemental properties.

Cu 61 ^{3/2-} 3.339 h E 2.237488 60.933456	Cu 62 ¹⁺ 9.670 m E 3.968897 61.932594	Cu 63 ^{3/2-} 69.150 σ_{γ} 4.5, 5.0 62.929696	Cu 64 ¹⁺ 12.70 h σ_{γ} 8E3 E 1.574384 63.929764
Ni 60 ⁰⁺ 26.223 σ_{γ} 2.9, 1.5 58.930786	Ni 61 ^{3/2-} 1.140 σ_{γ} 2.5, 1.5 60.931057	Ni 62 ⁰⁺ 3.635 σ_{γ} 15, 6.6 61.928345	Ni 63 ^{1/2-} 101.2 a σ_{γ} 24 E .066977 62.929668
Co 59 ^{7/2-, 2+} 100.000 σ_{γ} (20+37), (39+74) 58.933193	Co 60 ⁵⁺ 10.47 m 5.271 a σ_{γ} 2.0, 4.3 59.933815	Co 61 ^{7/2-, (5)+} 98.94 m E 1.323699 60.932476	Co 62 ⁽²⁾⁺ 13.86 m 92.40 s E 5.322039 61.934059
Fe 58 ⁰⁺ 0.282 σ_{γ} 1.3, 1.7 57.933273	Fe 59 ^{3/2-} 44.50 d E 1.564955 58.934575	Fe 60 ⁰⁺ 2.62E6 a E 2.37345 59.934071	Fe 61 ^{3/2-, 5+} 5.980 m E 3.977129 60.936745

New Features in Version 5

- New!** Windows 11 Compatibility.
- New!** Multi-Language Support including French, German, Spanish, and Simplified Chinese.
- New!** Nuclear Data Libraries updated to include Nudat 3.0 from the National Nuclear Data Center at Brookhaven National Lab.
- New!** Configurable Detectors for Synthetic Spectrum Generation including Energy, Peak Shape, and Efficiency calibration data imported from GammaVision spectrum files.
- New!** Export Synthetic Spectra to standard ORTEC Spectrum File formats for evaluation in applications such as GammaVision.
- New!** Save Target Libraries to SQLite database format in addition to GammaVision Libraries and XML files.
- New!** Ingrowth calculations for Single Nuclides in addition to the standard Decay model.
- New!** Selectable Metastable Daughters are available when using the Parent-Daughter decay mode.
- New!** Metalloid color coding applied to the Periodic Table of the Elements.
- New!** Updated interface for the Units Converter with the addition of several new conversion types.

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Nuclide and Elemental Energy Emissions

Co-60 Properties:
 Half Life: 5.271 a
 Abundance: 100.0000
 Thermal Resonance: 4.3
 Radiation: Gamma

Energy	Branch (%)	BR Codes
1332.49	99.98260	A
1173.23	99.95000	A
826.10	0.00760	A
347.14	0.00760	A
7.48	0.00630	AX
7.46	0.00332	AX
2159.57	0.00120	
8.27	0.00000	
8.27	0.00000	
0.85	0.00000	
2505.69	0.00000	

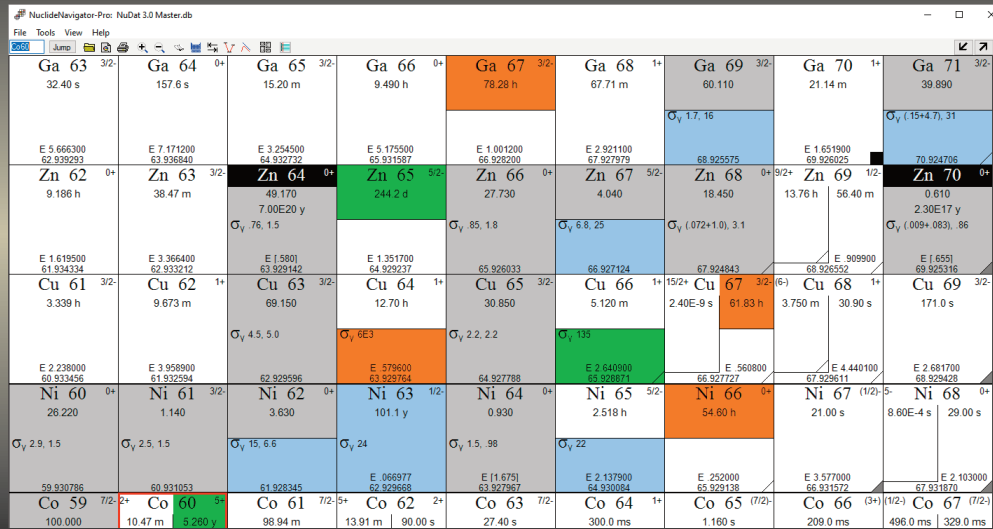
Library Manager

Source Library: NuDat 2.6 [10-21-16].db

Mn-54 Properties:
 Half-Life: 312.2 Days
 Nuclide Type: Undefined
 Uncertainty: 0.1 (%)

Energy	Branch (g/d)	Index
834.85	0.99976	1
5.41	0.14600	2
5.41	0.07400	3
5.95	0.01640	4
5.95	0.00840	5
0.57	0.00370	6

Chart of the Nuclides



Radioactivity Decay Calculator

Parent: Daughter:

Activity @ T0: Activity @ T1:

Activity @ T2: Activity @ T3:

Radioactivity Decay Calculator

Periodic Table and Unit Converter

Physical Properties for Mn:
 Density: 7.43 g/cc
 Abundance: 85.2800
 Melting point: 1542 °C
 Boiling point: 2527 °C

Units to Convert:

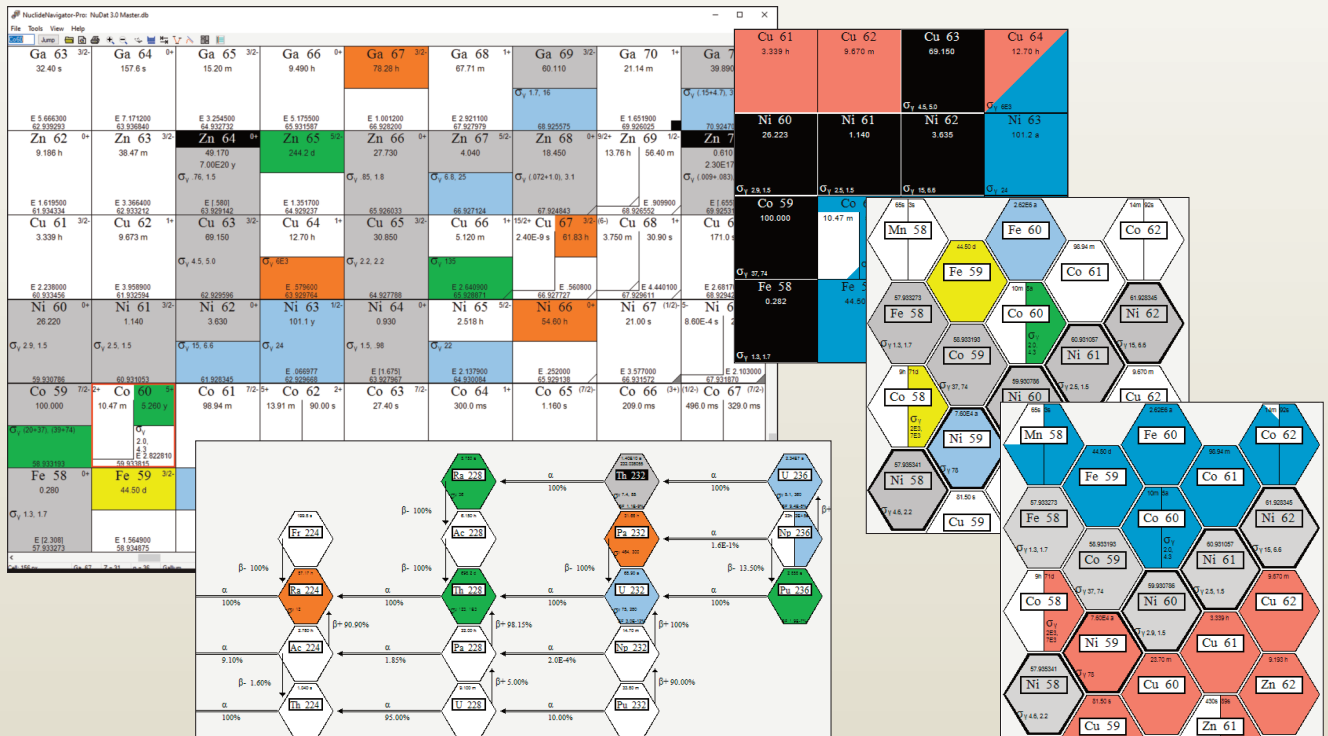
Output:

Periodic Table and Unit Converter

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Chart of the Nuclides

The main interface for NuclideNavigator-Pro is the Chart of the Nuclides which can be displayed in a variety of informative views including General Electric, Karlsruhe, and Trilinear formats. The General Electric and Karlsruhe formats use a common layout with a nuclide grid defined by the number of protons on the vertical axis and neutrons on the horizontal axis such that isotopes of a common element are displayed in rows. However, they use different color schemes with the General Electric view representing nuclide half-life and neutron cross section and the Karlsruhe representing nuclide decay modes. The Trilinear format, which is available in both color schemes, aligns isotopes on a diagonal. When "walking down" decay chains this layout uses vertical navigation for beta decay and horizontal movement for alpha decay instead of the diagonal movement associated with the traditional grid layout. The chart can also be limited to the natural series (Thorium, Neptunium, Uranium, and Actinium) to simplify evaluation of these decay chains.



Finding the source of gamma and alpha emissions is simple with the intuitive query tool. It not only allows setting an energy range for potential nuclide matches, but also allows filtering by nuclide generation mode, half-life, and secondary emissions. This additional information can greatly improve the quality of the search results and help the spectroscopist evaluate analysis results and optimize libraries.

Search for Gammas by Energy and Selected Options

File Search For

Generator Search Options

Thermal Neutron Activation (T)

Fast Neutron Activation (F)

Fission Product (I)

Naturally Occurring Isotope (N)

Photon Reaction (P)

Charged Particle Reaction (C)

Additional Search Options

Prompt Capture Gammas

Energy (keV) **Window (+/- keV)**

Match Associated Lines

First +/-

Second +/-

Half Life Search Options

Minimum

Maximum

Search Results

File Edit

Library Search

Library: C:\ProgramData\AMETEK\Data Libraries\NuDat 2.6 [10-21-16].db

SEARCH CRITERIA:

Gamma Energy = 1330.46 keV - 1334.46 keV

Associated line(s) = 1171 keV - 1175 keV

Half Lives = 1 y - 10 y

Generators = T

.... Gamma-Ray							
Energy	Br Ratio	Nuclide	Gen	Half Life	First Associated Gamma	Br Ratio	Second Associated Gamma
1332.49	1.0E+00	Co- 60	TF	5.271 a	1173.23	1.0E+00	826.10

RESULTS:

1 Line(s) Matched the Search Criteria.

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Nuclide and Element Emission Data

Nuclide Properties are accessed by double-clicking a nuclide in the Chart of the Nuclides or a peak energy in the Peak Search results. The properties page includes basic nuclide information, such as half-life, energy emissions for the ground and metastable states, parent nuclides, and daughter nuclides with their generation probabilities. Clicking on the parent and daughter nuclides will navigate up or down the decay chain as applicable.

Energy emission type can be switched between gamma, beta, and alpha emissions and sorted by energy or branching ratio. A synthetic spectrum for the associated radiation type is also available with gamma spectra configurable for specific detector characteristics including energy range, peak width, and energy dependent efficiency. These synthetic spectra give the spectroscopist a good idea of what to expect with different types of instrumentation and can be used as a teaching aid in lieu of actual measurements. They can also be saved to standard ORTEC spectrum formats for evaluation in applications such as GammaVision, and the spectrum image and supporting data may be used in other software applications including spreadsheets and presentations.

Comprehensive reports of nuclide and emissions data can be generated for a subset of nuclides from the master libraries using the Library Lister. The content of the report is controlled through selectable parameter options including the decay mode, energy range, parent/daughter nuclides, and several other useful parameters.

The image displays several screenshots of the NuclideNavigator-Pro V5.0 software interface:

- Co-60 Properties:** Shows basic information for Cobalt-60, including a half-life of 5.271 a, abundance, thermal resonance, and radiation type (Gamma, Beta, Alpha). It also lists daughter nuclides (Ni-60, Fe-60) and parent nuclides (Co-60m).
- Library Lister:** A window for selecting nuclides from a library. It shows a list of nuclides (Co-60, Cs-137) and options for decay mode (Gamma, Alpha), sort mode (Energy, Yield), and various checkboxes for data inclusion like Isotopic Mass, Spin and Parity, and Neutron Cross sections.
- Spectrum Co-60:** A plot showing a synthetic gamma-ray detector response function. The x-axis is Energy (keV) from 0 to 2500, and the y-axis is Counts on a log scale from 0.01 to 100,000. It features a prominent peak at approximately 1332 keV.
- Spectrum Co-60 (Synthetic NaI-3x3):** A plot showing a synthetic NaI-3x3 detector response function. The x-axis is Energy (keV) from 0 to 4000, and the y-axis is Counts on a log scale from 10 to 10^7. It shows a peak at approximately 1332 keV with a broader energy distribution compared to the first spectrum.
- Elemental Properties:** A window showing X-Ray Energies and Intensities for the element Cobalt (Co). It lists energy levels (K, L1, L2, L3) and their corresponding intensities. Below this, it shows Elemental Abundance for Solar System (7.30E-06 %), Crustal (25 mg/kg), and Sea Water (2.00E-05 mg/L).

Elemental Properties are accessed by double-clicking an element box in the Chart of the Nuclides. The properties page includes basic elemental abundance information and x-ray energies/intensities for the different electron shells. This information is invaluable when assessing x-ray emissions of different materials associated with detector shielding, attenuation layers, and sample matrices.

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Library Manager

The Library Manager greatly simplifies the generation of application specific libraries. Simply load a master library and drag the desired nuclides to the Target library list. Preferences can also be set to restrict which nuclides and peaks are copied to the Target, and the content can be manually adjusted as necessary for the intended library use. Target libraries can be saved in the SQLite database format, the standard ORTEC library format for use in applications such as GammaVision, an XML format that is readable in any text editor and can be processed by custom applications.

The screenshot displays the Library Manager interface. On the left, the 'Source Library: NuDat 2.6 [10-21-16]' window shows a list of nuclides from Mn-53 to Mn-69. A blue arrow points from this list to the 'Options' window in the center, which shows the 'Mn-54' nuclide selected. The 'Options' window includes fields for Half-Life (312.2 Days), Radiation (Gamma, Beta, Alpha), and a table of gamma emissions. On the right, the 'Preferences' dialog is open, showing options for 'Number' (All, Top 5, Top 10, Top 15, Top 20) and checkboxes for 'Prompt Before Copy if No Gammas', 'Prompt Before Copy if No Alphas', 'Copy if Zero Branching Ratio', and 'Copy Escape Peaks'. It also features input fields for 'Gamma Energy Threshold (keV)' (0), 'Gamma Energy Maximum (keV)' (3000), and 'Minimum Relative Yield' (1.0E-06).

Decay Calculator

NuclideNavigator-Pro's Decay Calculator makes it easy to perform and visualize complex decay calculations. It includes calculations for simple decay or ingrowth of a single nuclide, parent-daughter decay, full decay chains, user-defined nuclide groups, and Cf-252 with neutron count rate calculations. The calculation results for each nuclide and total activity are displayed graphically in addition to being available in comprehensive reports.

A synthetic spectrum of gamma emissions similar to those available for individual nuclides is also available when assessing full Decay Chains. This spectrum view can be useful for relatively simple parent-daughter relationships as well as the complex natural decay chains that include numerous nuclides.

The screenshot shows two windows from the Decay Calculator. The left window, 'Decay Calculator: NuDat 3.0 Master.db', displays a 'Decay Chain Calculation for Th-232' graph. The graph plots Activity (0 to 1) against Decay Time (Years) (0 to 30). Multiple colored lines represent different nuclides in the chain. Below the graph are controls for 'Decay Time' (Time Zero: Wednesday, June 7, 2023; Count Time: Wednesday, June 7, 2023) and 'Quantity' (Activity @ T0, Mass (g)). A 'Nuclide' list is shown with Th-232 selected. The right window, 'Spectrum: Decay Chain Calculation for Th-232', displays a 'Synthetic GEM-90 detector response function' plot. The plot shows Counts (log scale, 1 to 10000) versus Energy (keV) (0 to 8000). The plot shows a complex spectrum with many peaks. Below the plot are 'Options' for 'Statistical Noise' (checked), 'Activity (Bq)' (10000), 'Count Time (s)' (10000), and 'Detectors' (GEM-90.det).

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Periodic Chart of the Elements and Units Converter

The Periodic Chart of the Elements is a rich, interactive resource for element properties. The main interface is the classic Periodic Table with informative color coding associated with chemical groups and the physical form of the element at room temperature. Basic physical properties are displayed as the mouse is moved over the elements and more detailed chemical properties are accessed by double-clicking the element. A short history for each element is available by right-clicking the element.

The Units Converter is a useful utility program for converting common measurement units. Simply enter a value for the known units and instantly calculate the value for the desired units.

Measurement types include: Acceleration, Angle, Area, Concentration, Data Storage, Density, Energy, Flow, Force, Length, Light, Mass, Power, Pressure, Radiation – Activity, Radiation – Exposure, Radiation – Absorbed Dose, Radiation – Dose Equivalent, Temperature, Time, Torque, Velocity, and Volume. Most of the common units for each measurement are available for conversion – as well as quite a few uncommon ones!

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Ordering Information

Model	Description
C53-BW	Nuclide Navigator Pro Single Computer License
C53-UW	Nuclide Navigator Pro update from C53-B32 or C53-BW
C53-CDW	Nuclide Navigator Pro 5-User License. Requires purchase of C53-BW.

References

Master Nuclear Data Libraries

NuDat 3.0: National Nuclear Data Center, information extracted from the NuDat 3 database, <http://www.nndc.bnl.gov/>, and supplemented with Fission yields and Neutron cross sections referenced below.

NuDat 2.6 [10-21-16]: National Nuclear Data Center, information extracted from the NuDat 2 database, <http://www.nndc.bnl.gov/>, and supplemented with Fission yields and Neutron cross sections referenced below.

TORI-99c5x: Table of Radioactive Isotopes, The Isotopes Project at LBNL, <http://ie.lbl.gov/toi/> supplemented with Cascade coincidence data derived from ENSDF, Positron annihilation data from PC_NuDat-04, and Fission yields and Neutron cross sections referenced below.

PC_NuDat-04: National Nuclear Data Center, <http://www.nndc.bnl.gov/>.

Erdtmann_Soyka: The Gamma Rays of the Radionuclides, G. Erdtmann and W Soyka, Verlag Chemie, Weinheim, 1979.

NNDC-Prompt: National Nuclear Data Center, Brookhaven National Laboratory, 2004.

RSICC-Prompt: THERMGAM, DLC-140, 1981, RSICC, Oak Ridge National Laboratory, <https://rsicc.ornl.gov>.

CapGam-2013: National Nuclear Data Center, information extracted from the CapGam data, <http://www.nndc.bnl.gov/capgam>.

Decay Schemes

The Isotopes Project at LBNL, <http://ie.lbl.gov>.

Fission Yields

T. R. England and B. F. Rider, LA-UR-94-3106, ENDF-349.

Neutron Cross Section Data

S. F. Mughabghab, M. Divadeenam and N. E. Holden, Neutron Cross Sections from Neutron Resonance Parameters and Thermal Cross Sections, Academic Press (1981).

Example Spectra Methodology

Synthetic emission spectra for gamma rays and alpha particles are generated using algorithms developed by the author for typical HPGe and NaI sensors. A significant amount of credit is due to the published works of, and private communications with Ray Gunnink.

Beta particle shapes are generated using the equations associated with the standard (Fermi) theory of beta decay. Coulomb corrections for positrons are non-relativistic point-charge approximations. Corrections for electrons are calculated using the equations from G. K. Schenter and P. Vogel, Nuclear Science 1983, Volume 83, page 393-396.

Decay Calculation Methodology

H. Bateman, The solution of a system of differential equations occurring in the theory of radioactive transformations, Proc. Cambridge Phil. Soc., v.15 (1910) 423-427.

M. Amaku, P.R. Pascholati, V. R. Vanin, Decay chain differential equations: Solution through matrix algebra, Computer Physics Communications 181 (2010) 21-23.

Elemental Data

Based on the "History of the Origin of the Chemical Elements and Their Discoverers" generated by Norman E. Holden, National Nuclear Data Center, Brookhaven National Laboratory.

Specifications subject to change
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