

Nuclides.net: A Web-Based Environment for Nuclear Data and Applications

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Abstract. An interactive multimedia tool, Nuclides.net, has been developed at the Institute for Transuranium Elements. The Nuclides.net "integrated environment" is a suite of computer programs ranging from a powerful user-friendly interface, which allows the user to navigate the nuclides chart and explore the properties of nuclides, to various computational modules. Through this powerful interface the user can access a wide variety of nuclear data including e.g. radioactive decay data, cross-section, fission yields and etc. from international recognized sources.

INTRODUCTION

Radionuclides have many applications in agriculture, industry, medicine and research. For basic information on such radioactive materials, the *Chart of the Nuclides* has proved to be an indispensable tool for obtaining data on radionuclides and working out qualitatively decay schemes and reaction paths. These charts are, however, of limited use when one requires quantitative information on the decaying nuclide and its daughter. This was the first motivation [1] of the Nuclides.net package [2], developed at the Institute for Transuranium Elements. This interactive multimedia tool based on the latest internet technology comes as an integrated environment for computations on radionuclides and their radiations. It has been developed by scientists working on a daily basis with radionuclides and is aimed at both students and professionals for reference data on radionuclides and calculations based on this data.

Likewise, nuclear data are fundamental in applications involving radioactive material and nuclear fuel. Specialized databases have been developed by the worldwide nuclear community. A standardized format defined: the Evaluated Nuclear Data Format (ENDF). Nevertheless retrieving data from this complex format and getting them in a user friendly readable format can be challenging for the non-specialized user. Nuclides.net offers a variety of nuclear data including

cross-sections, radioactive decay data, and fission yields from international recognized sources with the ease of a modern visual and graphical computer interface. In this way, both experienced and non-specialist users can thus benefit from an easy and efficient access to data without complex data format manipulation.

NUCLIDES.NET FEATURES THROUGH EXAMPLES

Nuclides.net offers a large variety of data, as described in the following sections, contained in a main database located in the internet server. The user can identify and access a nucleus of interest through a powerful and user friendly electronic chart interface. The Nuclides Explorer main interface is shown in Fig 1. It shows the "Chart of Nuclides" from which the user can zoom in and out and navigate before accessing the data of interest. Five standard color schemes used in paper-based nuclide chart (Karlsruhe, Strasbourg, General Electric, and JAERI) can be selected. In addition, there are nuclides chart based on spin, parity and binding energy.

Once the nuclide of interest is selected data can be retrieved via the internet to be displayed as html pages in a browser window.

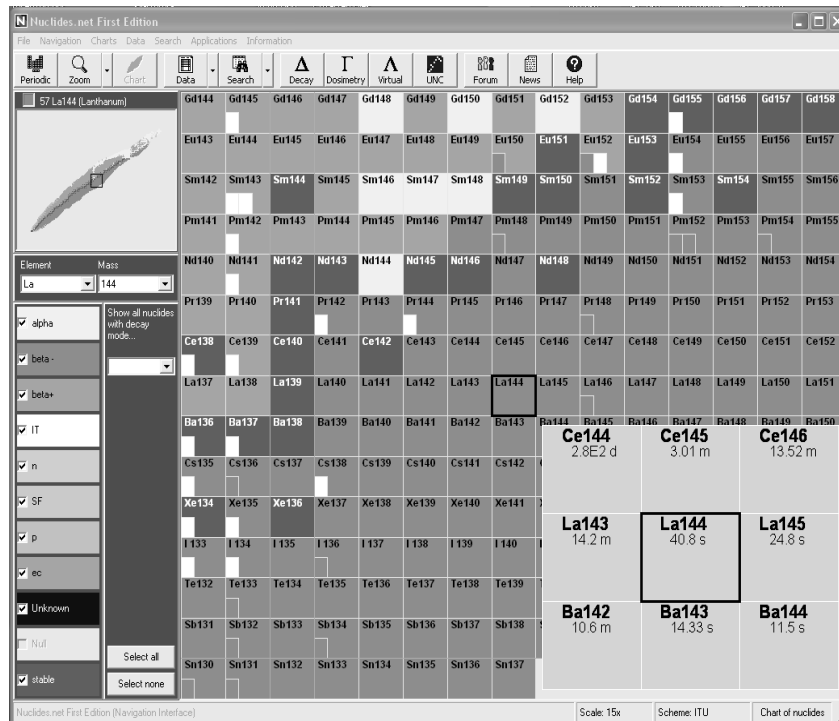


FIGURE 1. Nuclides Explorer and navigation tools through the Nuclide Chart

Radioactive decay data

The main decay data can be obtained through the Datasheets. Mass information and derived data are taken from the Nubase [3] database. It includes mass excess, mass in atomic unit, half life, spin, parity, binding energy, abundance, type of decay, branching

ratio and mean energy for each type of decay. Decay path of a specific nuclide can be displayed in using the “Decay Chain Simulator” of the “Universal Nuclide Chart”, a java applet integrated in the client. The simulated decay chain can be produced from the data in the library for over 3000 nuclides in two different arrangements (normal and compact plots) and

nuclides.net		⁶⁰ Co		DataSheet	
Print	FactSheets	Notes	Averaged Cross sections		
Mass Excess	Mass	Half-life	Abundance		
-61644.2 (± 14) keV	59.933822160 (± 1503) u	5.2714 (± 5) y	-		
Spin	Parity	Binding Energy			
5	+	8.747 MeV			
Type of decay	Branching ratio	Decay Energy, Q(MeV)	Daughters		
β-	1.00E+00	2.82	28 Ni 60		
Mean Decay Energies	Alpha(MeV)	Electron(keV)	Photon(keV)		
	0	96.6	2504		
Effective Dose Coefficient Ingestion (Sv/Bq)	Effective Dose Coefficient Inhalation (Sv/Bq)	Reference Annual Dose Workers	Reference Annual Dose Public		
3.4000E-09	2.900E-08	20 mSv	1 mSv		
Gamma		Beta -			

FIGURE 2. Datasheet with basic nuclear data . Spectral data can be accessed from the bottom buttons.

with all color schemes available.

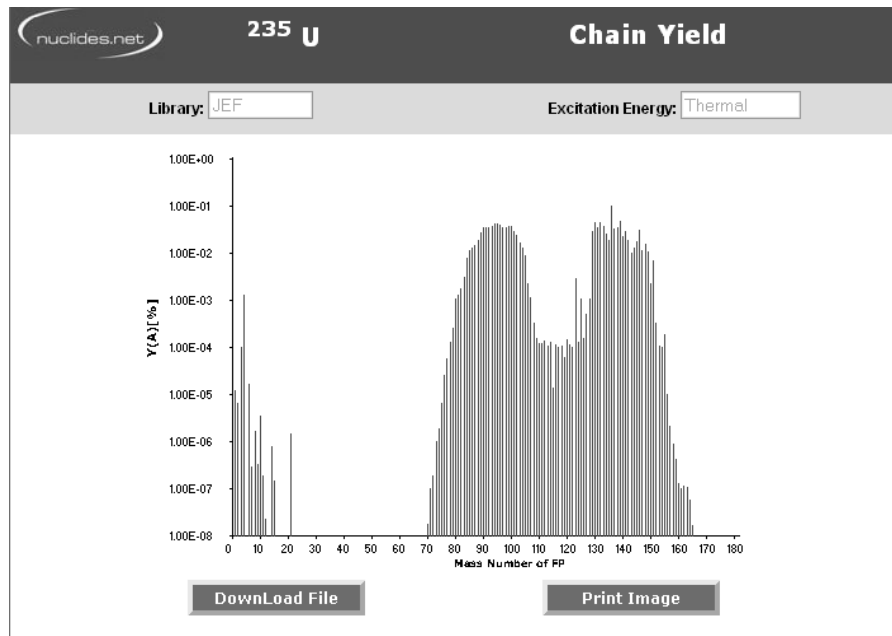
Radiation data of emitted particles (gamma, alpha, beta) can be displayed, plotted and downloaded as excel spreadsheet. The information displayed contains energy of the particles and corresponding emission probability. Currently, the radiation data have been compiled from the JEF2.2 data file [4]. Fig. 2. shows an example of the “datasheet” and of the gamma ray list associated with the selected nuclide.

A “factsheet” can be accessed displaying additional derived data for applications. This includes average half-life, specific activity, isotopic power, spontaneous fission rate when applicable, specific gamma dose rate, radiotoxicity data, and packaging activity limits.

Fission yield data

Fission yield distributions are interesting from two standpoints. The cumulative fission product distribution (yield which is produced directly and after decay of precursors) is of strong interest for practical purposes such as waste storage, control of nuclear reactors, etc. Independent yields (yield produced directly after fission, after emission of prompt neutrons but excluding radioactive decay of precursors and delayed neutrons) are of importance for the fundamental understanding of the corresponding nuclear reactions, but also for short term practical purposes in reactor operation.

The yields are dependent on the neutron energy inducing the fission. Independent and cumulative yields are then provided in database for specific neutron energy (thermal, fast and high energy). Spontaneous fission is usually provided as well. Nuclides.net fission yield module displays these yields in tabular and graphical format. The user has the choice of several international databases, namely JEF2.2/UKFY2 [5], JENDL3.2 [6] and ENDF/BVI [7]. The flexibility of the Nuclides.net module offers the possibility of comparing the different available data sets for a selected fission product. In addition the user can make inter-comparison with isobar or isotope



of a selected nucleus. Mass yield data can be plotted

FIGURE 3. Mass yield distribution obtained from the fission yield module. Tabulated data can be downloaded in excel format.

and downloaded.

Cross section data

Data displayed in this module are average cross-section which have been evaluated from the JEF2.2, BROND-2, ENDF/B-VI, JENDL-3.2 and CENDL-2 datafiles. The average cross-sections in barns are given for 2200 m/s, Maxwell averaged, resonance integral, 14 MeV, and fission spectrum averaged neutrons. Additional graph of point-wise cross-sections based on JENDL-3.2 have been recently added.

Material attenuation data

Nuclides.net offers two powerful calculation modules: a decay calculations and dosimetry and shielding calculation. This latest module allows the user to calculate gamma dose rates from point sources of single nuclide and nuclides mixtures through a choice of 10 different shield media. All known gamma lines and emission probabilities for the nuclide(s) are accounted in the calculation. Over 3000 nuclides with more than 70000 gamma lines from the JEF2.2 datafile are available in the database.

Calculations in this module require the use of different set of data which are available in an option window showing the details of the calculation gamma line by line. Attenuations in shield material (mass attenuation for the shield material and the mass absorption in tissue) are interpolated from the NIST database [8]. The build up factor value (modeling the scattering effect in the shield material) are taken from ref. [9]. Due to the complexity of the data and their double dependence on energy and mean free path lengths, tabulated values (bins) are used.

CURRENT AND FUTURE DEVELOPMENTS

The structure client/server allows changes and updates in the main database. The client is used to retrieve and manipulate the data without having to check if his local database is up to date.

Several major updates in the main database are underway. The spectral datafile JEF-2.2 has been found to have several known inaccuracies in its data (in particular several emission probability values have been re-evaluated since its release). The 8th Tables of Isotopes (ToI) [10] presents the latest evaluation of radiation data. Efforts have been made to integrate those data to the Nuclides.net and are presently under testing. The user will then have the choice of both JEF2.2 and the ToI to display and manipulate spectral data. When JEFF3.1 will be released, we will update the JEF2.2 data with the newest evaluated values.

The fission yield distribution of the latest JENDL-3.3 are planned to be implemented, likewise the UKFY3.5 and 3.6 when released in the public domain.

We have focused this paper on accessing and manipulating the nuclear data, however Nuclides.net presents powerful modules for decay and dosimetry calculations. Further modules such as a particle range calculator or a gamma spectroscopy simulator including the ability to create databases for gamma spectroscopy analysis programs are underway.

Efforts are underway to develop a fully platform independent client for the whole Nuclides.net package

CONCLUSION

Nuclides.net is designed to provide both specialized and non-specialized users with an easy and efficient access to nuclear data. From a powerful, user-friendly interface, the Nuclide Explorer, the user can

navigate through the nuclide chart. Among the multiple features, such as dosimetry and shielding calculations, a large amount of data is available to the user. This data comes from internationally recognized datafiles and provides nuclear information on 3650 ground states and isomers, including fact-sheets, cross-sections, fission products and yields. Practical examples of applications are given in ref. [11-12].

Nuclides.net has been "online" since January 2003 and has already hundreds of users over 27 countries worldwide. It is used for both professional and educational purposes in the nuclear industry, health physics and radiation protection, nuclear and radiochemistry, nuclear physics, astrophysics, etc.

More information can be found in the Nuclides.net website: www.nuclides.net

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