

# RECENT UPGRADES TO THE NUCLEAR DATA TOOL JANIS

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JANIS (JAVA-based Nuclear Information Software) is a display program designed to facilitate the visualisation of nuclear data, such as decay data, fission yields, cross sections, energy and angular distributions etc. Its objective is to allow the user of nuclear data to access numerical and publication-ready graphical representations without prior knowledge of the storage format. The most common nuclear data formats are supported, and data originating from the major evaluated libraries, such as JEFF, JENDL, ENDF/B, CENDL etc., can be displayed, computed, and compared together and with experimental reaction data from the EXFOR database. In addition, various navigation and search tools are available to explore the nuclear databases. The JANIS software can be used either as a standalone application or directly from the web at [www.nea.fr/janis](http://www.nea.fr/janis). This software has developed into a popular tool among students and researchers working with nuclear data. Features included in the latest release are described, including plots of covariance matrices and photon-production data. Some examples on the use of JANIS will be given and foreseen development discussed.

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KEYWORDS : JANIS, Nuclear data, EXFOR, Experimental data, ENDF, Evaluated data, Display software

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## 1. INTRODUCTION

Nuclear data are fundamental to all nuclear applications. These data should cover both the properties of single nuclei and the elementary laws of nuclear interactions. Data libraries are quite large and the diversity of applications and end-users result in a need for convenient storage in standardised formats, such as ENDF for evaluated data and EXFOR for experimental.

As part of the nuclear data services it provides, the NEA Data Bank [1] has accumulated experience in the development of user-friendly tools for accessing and manipulating these data. JEF-PC is an example of such software developed in the early nineties [2].

Its successor, the Java-based Nuclear Information Software (JANIS) [3] is a modern display program designed to facilitate the visualisation and manipulation of nuclear data. Its objective is to allow the user to access numerical and graphical representations of the data without prior knowledge of the storage format. In addition, it offers maximum flexibility for the computation and comparison of different nuclear data sets.

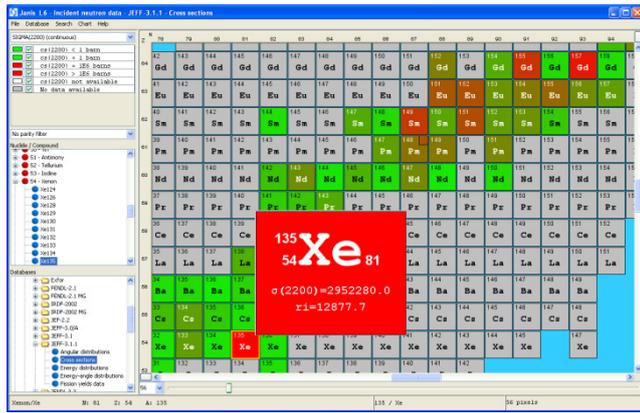
This paper describes the main characteristics of JANIS and introduces recent upgrades to the code. In particular users can now display evaluated photon-production data as well as covariance information.

## 2. GENERAL FEATURES OF JANIS

JANIS is designed to be user-friendly and straight forward to use from the beginning. The program is a standalone application with direct access to remote and local databases, as well as user's data. The remote database is available on the NEA server thanks to the Java Servlet technology. JANIS provides a direct access to evaluated, experimental, and bibliographical data. The main formats supported are: ENDF-6 [4] (and NJOY [5] derived files in ENDF-like format, such as PENDF, GENDF...), EXFOR [6], and CINDA [7]. Various navigation tools are available to help the user identify the nuclei and data of interest. The main window of JANIS is a nuclide explorer, which gives access to the data through a chart of nuclides. Another way to access and compare data is to use the powerful search tools that query the databases.

### 2.1 Nuclide Explorer

The nuclide explorer displays a chart of all nuclides available in the selected database. This chart is also used to display a number of information, such as spin-parity, half-lives, decay modes, 2200 m/s cross sections (see Fig. 1). Additional data are available by double-clicking on the chosen isotope.



**Fig. 1.** Chart of nuclides for the JEFF-3.1.1 General Purpose library. The colour scheme indicates the magnitude of the 2200 m/s cross-section values.

## 2.2 Search Tools

Various search tools allow exploring the content of the three main databases. The results of the query can be refined and selected data displayed.

- ENDF Search: access to evaluated data by library, incident particle, target, reaction (MF/MT). More specific search tools are available to retrieve evaluated resonance parameters and radioactive decay lines.
- EXFOR Search: access to experimental data by incident particle, energy, target, reaction, product, facility, bibliographic reference, etc.
- CINDA Search: access to bibliographic data by incident particle, energy, target, reaction, publication, work type (e.g. experimental, theoretical, evaluated...).

## 2.3 Data Display

JANIS gives access to various evaluated and experimental quantities:

- Decay data and basic nuclear structure information: important properties of nuclei (mass, spin-parity, half-life, decay modes, etc.), as well as discrete and continuous spectra of emitted particles.
- Fission yields: independent and cumulative yields for spontaneous and neutron-induced fission.
- Cross-sections: integral or differential (with respect to energy) and double-differential (with respect to energy and angle) cross sections, along with resonance parameters.
- Multiplicities of neutron and other emitted particles: average fission neutron multiplicities (prompt, delayed), as well as average gamma multiplicity with respect to the incident energy, e.g. in radiative capture.
- Angular, energy, energy-angle distributions: normalized distributions of emitted particles with respect to its energy or angle.

- Photon-production data: specific production cross sections of a given gamma-radiation in one or several reaction processes.
- Covariance matrices: nuclear data uncertainties and associated correlations.

These data are displayed in a separate window on different tabs depending on the quantity and the display mode chosen: information, tabular, plot, and matrix.

These data can be saved in various output formats. In particular, tabulated data can be saved in ASCII format for further use at the user's convenience. In addition, various setting options allow preparing publication-ready plots in picture graphics format (PNG) or vector graphics formats (PostScript and Windows Metafile).

## 2.4 Data Manipulation

Advanced functionalities are available to compute and compare different kinds of data:

- Group-averaging of cross-sections with different weighting flux (constant, Maxwell, reactor spectra, and user's defined).
- Basic arithmetic operations (+, −, ×, /) on most evaluated data, e.g. cross sections, yields, and secondary distributions.
- Comparison of evaluated and experimental data, automatically taking into account different units.

The results of these operations can be displayed, computed, compared, and saved in various formats as easily as original data sets.

## 3. NEW FEATURES OF JANIS 3.2

Recent developments have been implemented in JANIS 3.1 (2009) and JANIS 3.2 (2010). Compared with JANIS 3.0 [8], the following improvements are noteworthy:

- Extension of the ENDF format coverage to photon production data and covariance data. Moreover, additional NJOY formats (COVFILS, BOXER) are supported to display processed covariance data.
- New tool to automate the comparison of experimental data with evaluated data, and inter-comparison of evaluated libraries. This tool replaces the legacy “Compare Explorer” and automatically retrieves from all evaluated libraries the data that match a selected EXFOR reaction.
- Implementation of the BTSPEC code [9] to calculate continuous beta spectra.
- Display of isotopic and isobaric fission yields, i.e. distribution with respect to the nucleus charge.
- New highly compressed format to store data files on the DVD version.

### 3.1 Photon-production Data

Photon production data can be stored in the ENDF Files MF12 to MF15. JANIS now allows the user to display and manipulate the following data:

- Multiplicities and transition probabilities arrays;
- Photon-production cross sections;
- Photon angular distributions;
- Continuous photon energy spectra.

The example given in Fig. 2 shows photon-production cross sections stored in the MF13 ENDF file.

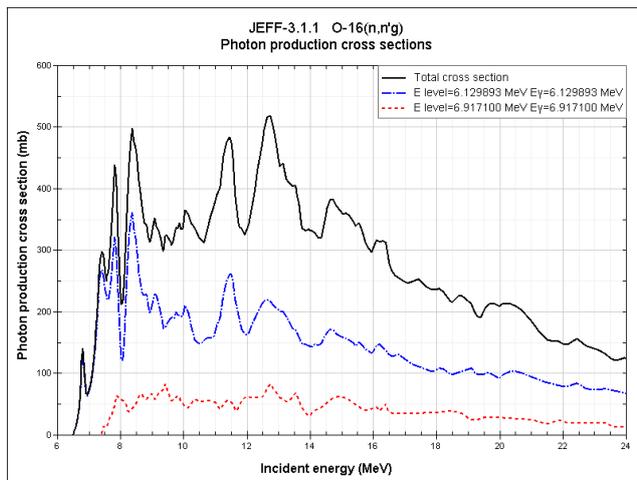


Fig. 2. Plot of total and partial photon-production cross sections from inelastic neutron scattering on  $^{16}\text{O}$ .

### 3.2 Covariance Data

The display of the ENDF MF33 file has been implemented giving access to unprocessed correlation matrices as stored in the evaluations, along with details on format options and energy grids which have been used.

Two NJOY formats are also supported: COVFILS (ERRORR) and BOXER (COVR). This gives access to processed correlation matrices, which include the contribution of MF32 in the resonance region (cf. Fig. 3). BOXER matrices have been computed in LANL-187 energy-group structure for all covariance data available in the NEA remote database and are also provided on the DVD. As for others formats supported by JANIS, the user can display any COVFILS and BOXER files using the “File/Open...” functionality. To display larger sets of processed covariance matrices, the user can also create a local database using the “Import” functionality.

The matrices displayed benefit of all features offered for plots and can be saved as pictures (PNG) or vectorial formats (WMF, PS). Matrices can also be displayed as numerical tables, which can be saved as text files (CSV) or XML spreadsheets.

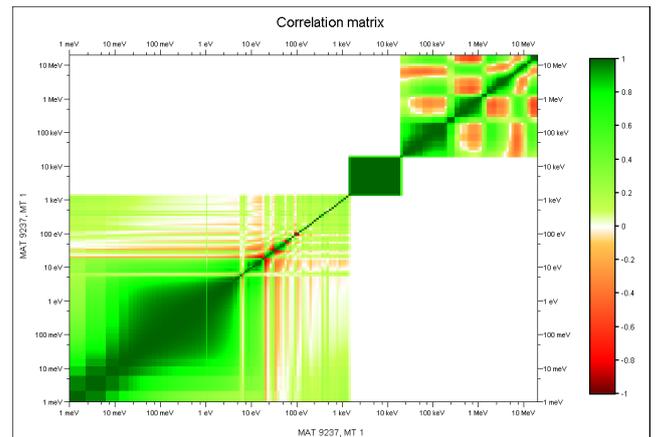


Fig. 3. Self-correlation matrix of  $^{238}\text{U}$  total cross section (JENDL-4.0), including the processed resolved resonance region.

### 3.3 Automated Comparison Tool

A new automated comparison function has been developed to replace the previous “Compare Explorer”, which was becoming less practical with larger databases. This tool can be launched to compare any kind of data with the corresponding one in all available evaluated data libraries. This allows comprehensive inter-comparison of evaluated data libraries for a given reaction quantity, as well as automated comparison of experimental and evaluated data. In the latter case, the tool makes use of built-in computing capabilities to perform all necessary operations to adapt the evaluated data to the experimental quantity to be compared with (e.g. Maxwell average, ratio).

### 3.4 New Evaluated Data

All evaluated data libraries in the NEA remote database have been processed in a consistent way using NJOY [10]. In addition, the following derived data are now available:

- Thermal neutron scattering cross sections on bound nuclei ( $\text{H}_2\text{O}$ ,  $\text{D}_2\text{O}$  ...).
- Gas-production cross sections, e.g.  $(n, x+p)$ ,  $(n, x+t)$ , and  $(n, x+\alpha)$ .
- Kinetic Energy Release in Material (KERMA) cross sections.
- Damage (dpa) cross sections.

Moreover, recent libraries have been added in the remote database and on the new DVD version:

- JENDL-4.0 (2010),
- RUSFOND-2010,
- CENDL-3.1 (2009),
- TENDL-2009, TALYS-based evaluated nuclear data library,
- EAF-2007.

### 3.5 Data Storage on the DVD

Since the first release, several ways of storing data on the CD-ROM (for versions 1.0 and 2.0) or DVD (since version 2.1) have been used. Initially, data files were binary files storing Java objects of pre-interpreted ENDF files. Hence, the data were strongly coupled to the JANIS software. However, improvement in Java Virtual Machine implementations and increase in computer power have allowed direct access to the original nuclear data files, thus decoupling the JANIS version and databases.

Nevertheless, the size of the processed ENDF libraries tends to increase over the years, especially with the generalisation of covariance data. The previous solution used for 3.0 release was to compress (ZIP) these files, but in order to put on a single DVD all major recent libraries this compression scheme was not enough for the 3.2 release.

A new solution was developed to take advantage of the specific ENDF file structure. All redundant information were removed (e.g. MAT/MF/MT/line numbers at the end of each line) and large parts of the file were packed from 8 bits ASCII characters into 4 bits before using ZIP compression algorithm. In the specific case of ENDF files, this solution has produced significantly smaller zipped files, allowing us to fit much more data on a given medium. Indeed, 18.5 GB of data have been compressed into 4 GB only. Finally, the new DVD version of JANIS 3.2 contains about ten times more data compare to the previous DVD. It also contains much less files (125 vs. 3655) for quicker copy to hard drive. Moreover, using the internal index of a ZIP file to index ENDF structures, this new storage also helps in reducing access time to the data.

### 4. FUTURE DEVELOPMENTS

JANIS has been developed to provide a user-friendly access to ENDF libraries and CINDA/EXFOR databases while keeping the original structure of these files and databases visible. The navigation and display functionalities target both experienced users in nuclear data formats as well as inexperienced ones. However, the more the coverage of ENDF and EXFOR formats is extended, the more the complexity of these formats is apparent and can represent a steep learning curve to inexperienced users. For the next releases we will consider providing the choice of the type of display which best fits the user needs: either close to the original formats or organised in a more intuitive way.

Foreseen developments will focus on two long standing requests: the possibility to display user's data in simple tabular formats and the possibility to save and restore the current state of JANIS. The first improvement should allow the user to add his data on a JANIS plot or table, and to use standard computation and comparison tools. The possibility to save the current selections and

plotting options for later use is also a functionality which would be useful.

Finally, integration of JANIS code in the NEA web data retrieval system is still an ongoing task. This would be a Web only solution and would not require Java on the client side; nevertheless this should be done in parallel with the distribution of the standalone application as many users still need an application which can be used without an Internet connection.

The JANIS version which can be launched from the NEA website through Java Web Start technology is now used by half of the users of the NEA remote database. We will continue to promote this way of distribution combined with the NEA remote database as this is the most efficient way for users to quickly benefit from latest developments and newest data libraries.

### 5. CONCLUSION

JANIS is meant to provide an easy and efficient access to nuclear data. The software is free of charge and can be downloaded from the NEA website at [www.nea.fr/janis](http://www.nea.fr/janis).

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