New Features and Improved Uncertainty Analysis in the NEA Nuclear Data Sensitivity Tool (NDaST)

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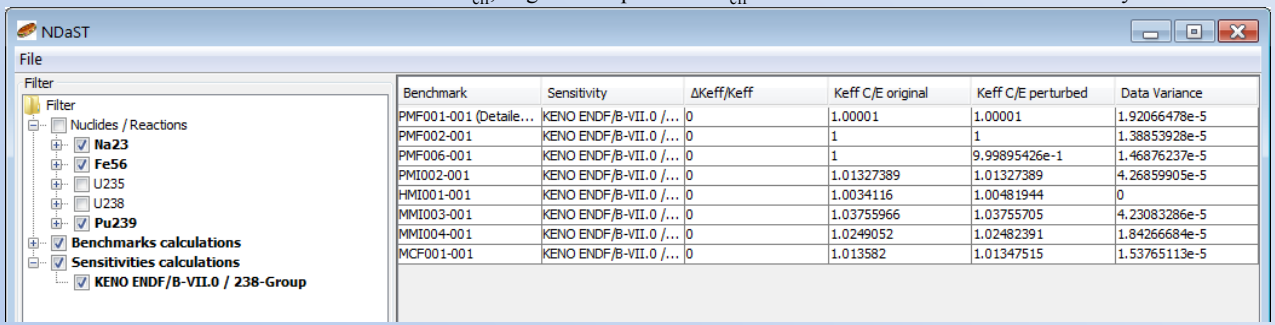
Revised Input and Output Features

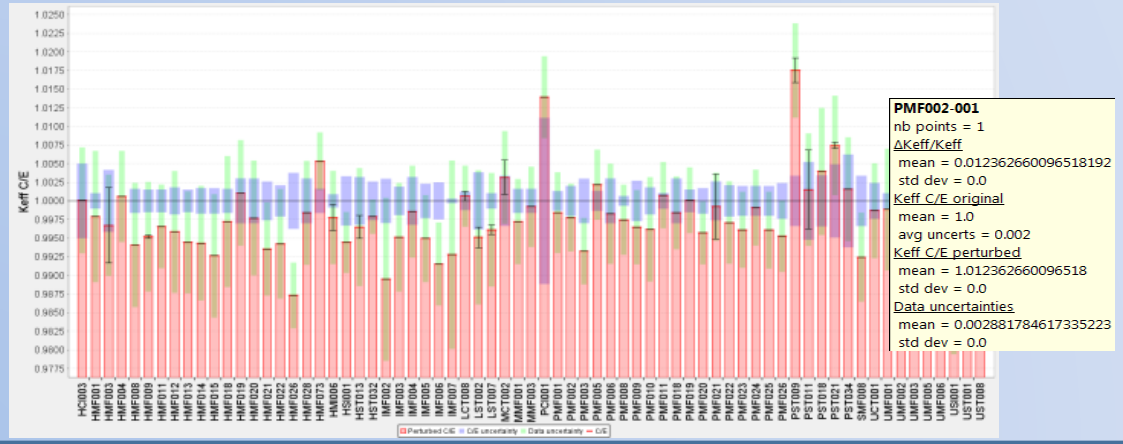
Several new features revising the overall "look" of the NDaST software have been developed for the 2016 release version.

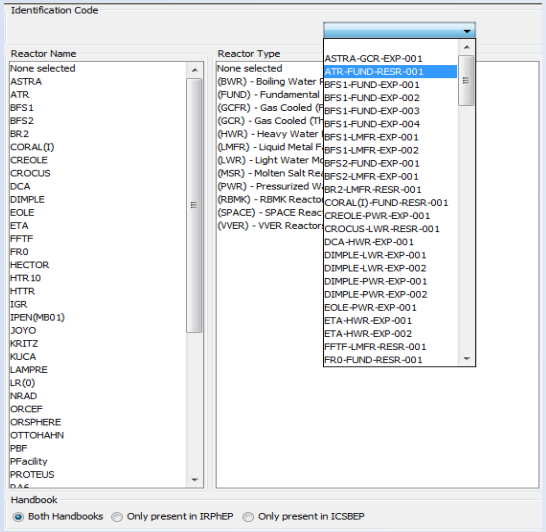
In addition to the Database for the International Handbook of Evaluated Criticality Safety Benchmark Experiments (DICE), the new version allows access to the International Reactor Physics Handbook Database and Analysis Tool (IDAT).

Sorting of output figures by DICE and IDAT criteria (for instance evaluation ID, spectrum, calculation code etc.) in single plot.

Similarly to DICE and IDAT, NDaST now features 'tool-tips'; access data on the number of points constituting each 'grouping' and mean and standard deviation values for Δk_{eff}, original and perturbed k_{eff} C/E values and nuclear data uncertainty.







In addition to the Δk_{eff} and data variance, the output table now shows columns for the (mean) original and perturbed k_{eff} C/E values of each benchmark.

The new 'detail popup' format for each benchmark shows perturbation and uncertainty breakdown for each code / library combination and nuclide-reaction pair.

Filter tree to the side of the plot allows nuclide-reaction pairs and code / library combination results to be included or excluded with live update of the resulting plot and table.

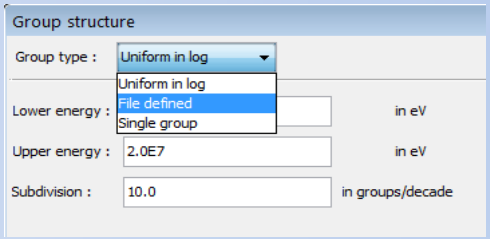
Automated JANIS Computations

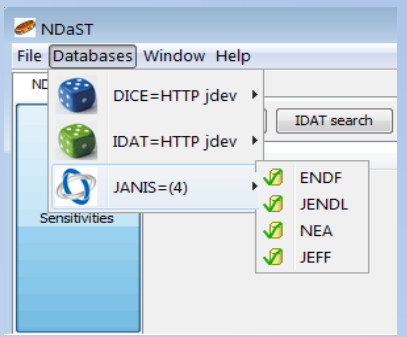
An automated link has been introduced to the JANIS nuclear data viewing software. Selection of two nuclear data evaluations as numerator and denominator, prompts the software to generate the relevant perturbation ratios.

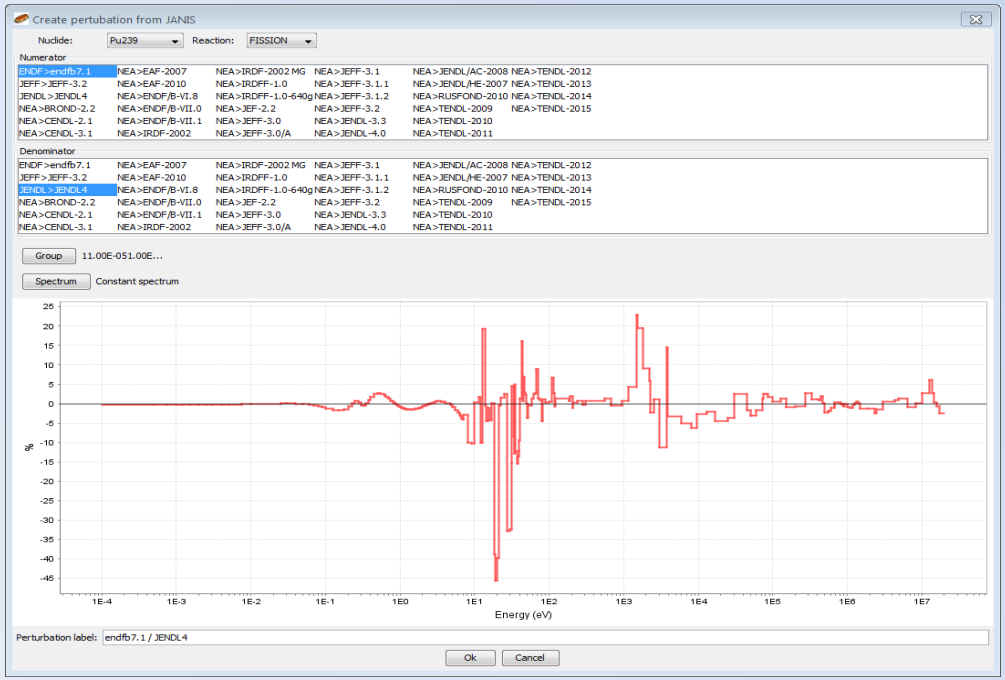
These are represented within any energy group structure required.

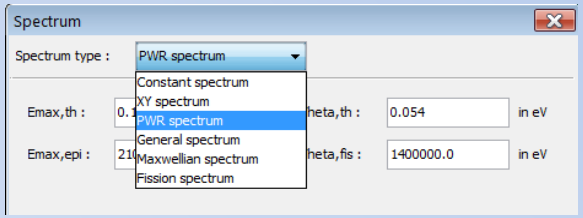
A number of common analytical spectrum weightings may also be applied from a list.

More specificity can be obtained through use of X-Y text file input spectra, where linear or logarithmic interpolation may be applied to either dimension.









NDaST is also being designed to provide a 'file upload' feature, so as to avoid the necessity to already have the desired data libraries held in a JANIS database prior to launching the software.

Another option it will present is a capability to run a 'Total Monte Carlo' (TMC)-like series of calculations; 'Total NDaST' could be used to predict the effect of many (hundreds or thousands) randomly perturbed nuclear data evaluations to specified integral parameters.

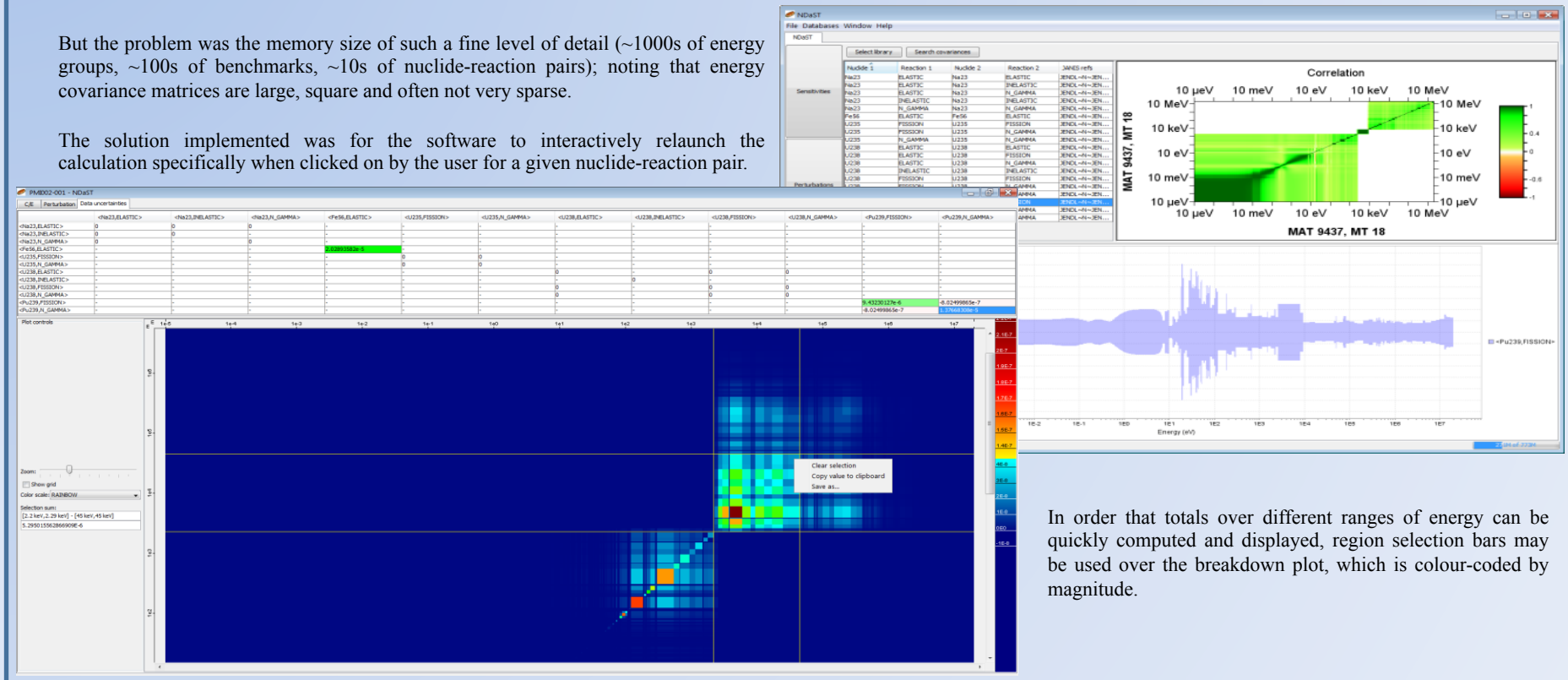
Energy Dependence Breakdown

NDaST was previously able to display in its output the breakdown of either a perturbation (i.e. Δk_{eff}) or uncertainty (covariance in k_{eff}) calculation as a function of the contributing nuclide-reaction pairings.

However, limitation to this degree of detail does not allow a deeper analysis of which energy regions constitute the greatest or smallest values within the total for that nuclide-reaction.

But the problem was the memory size of such a fine level of detail (~1000s of energy groups, ~100s of benchmarks, ~10s of nuclide-reaction pairs); noting that energy covariance matrices are large, square and often not very sparse.

The solution implemented was for the software to interactively relaunch the calculation specifically when clicked on by the user for a given nuclide-reaction pair.



In order that totals over different ranges of energy can be quickly computed and displayed, region selection bars may be used over the breakdown plot, which is colour-coded by magnitude.

Additional Uncertainty Capabilities

In order for the NDaST tool to be effective for general nuclear data testing, efforts have been made to provide sensitivity / uncertainty capabilities for nubar, Chi and angular scattering, with respect to the underlying Legendre series coefficients (tested for the P1 term only).

NDaST will also compare evaluated data with fundamental analytical expressions, such as the basic Maxwellian or Watt fission energy distributions. In order to verify perturbation techniques such as these, and to test the accuracy of sensitivity data based on a 238 multi-group energy structure, a series of simple tests were completed:

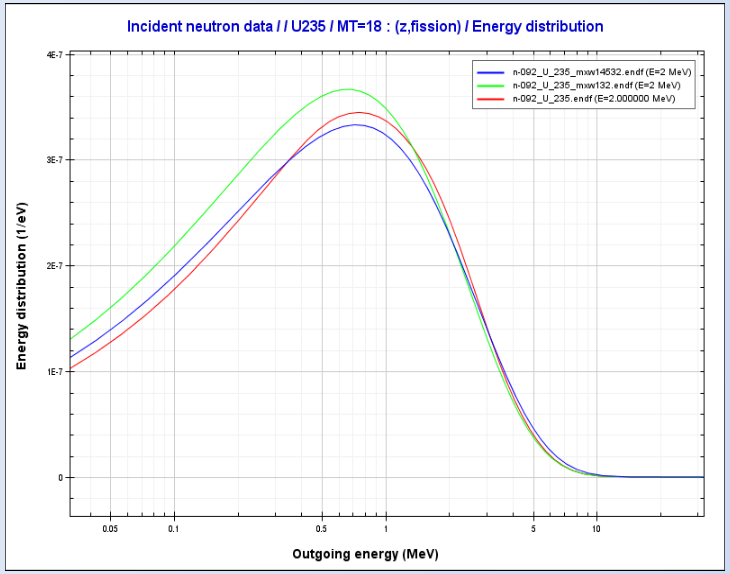
The ENDF/B-VII.1 U235 evaluation was modified in the following three ways:

- Original is an arbitrary probability representation (LF=1) at 20 incident energies
- It was changed to a Maxwellian distribution (LF=7) at neutron temperature of 1.32 MeV, independent of incident neutron energy
- Also produced was another Maxwellian at 10% greater neutron temperature of 1.452 MeV

$$\chi(E)= A\sqrt{E}\,e^{-bE} \qquad \int_0^\infty \chi(E) \qquad A=2b^{3/2}/\sqrt{\pi}$$

These were used to test the prediction of both perturbations for HEU-MET-FAST-062 made by NDaST and via direct calculation

1. Using a 1keV linear interpolation in JANIS, then averaging back to 238 group and input to NDaST
2. Processing modified ENDF files to make MCNP compatible ACE datafiles (considered as reference value)



Perturbation	Δk MCNP (reference)	Δk NDaST
ENDF/B-VII.1 evaluation → Maxwellian 1.32 MeV	-183 ± 21 pcm	-118 pcm
Maxwellian 1.32 MeV → Maxwellian 1.452 MeV	+988 ± 21 pcm	+925 pcm