ICNC Workshop: DICE and NDaST Hands on Demonstration

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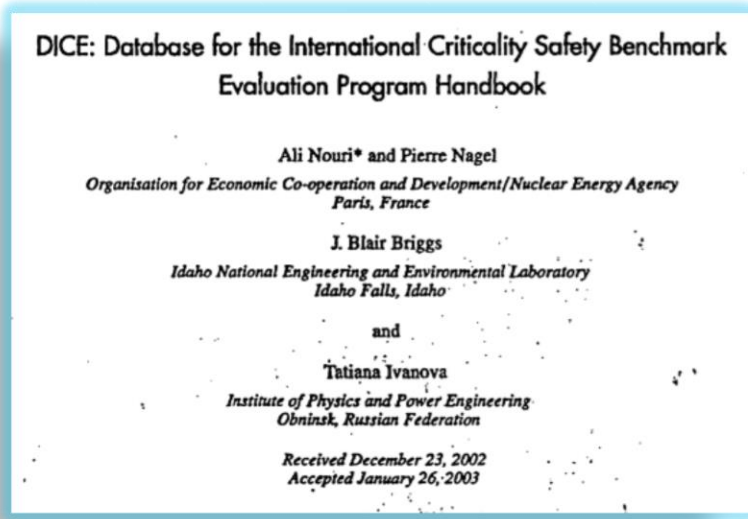
Database for ICSBEP

Answers How Efficiently Search the Handbook

- Distributed with the Handbook since 2001
- Released and improved annually
- Available on the DVD or as a web start java application
  https://www.oecd-nea.org/science/wpncs/icsbep/dice.html
- User Manual/Video Examples
- Data extracted from the evaluation, supplemented with calculation data
- Nearly 5000 cases in ICSBEP, many questions about Handbook content are difficult to answer without help!


DICE: Database for the International Criticality Safety Benchmark Evaluation Program Handbook

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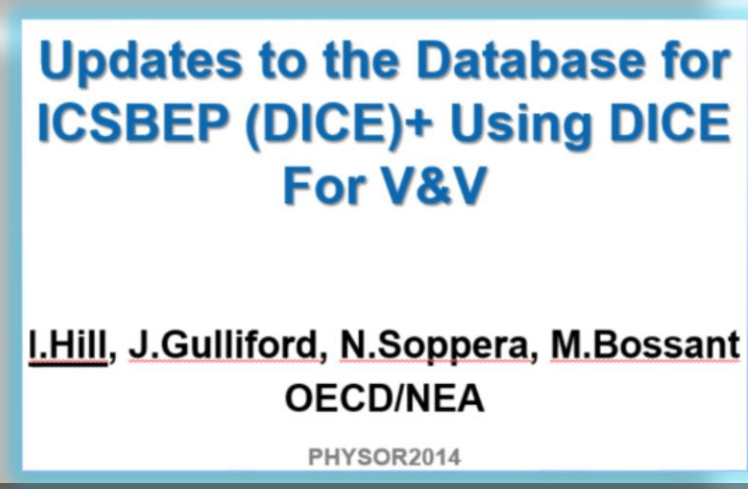
Updates to the Database for ICSBEP (DICE)+ Using DICE For V&V

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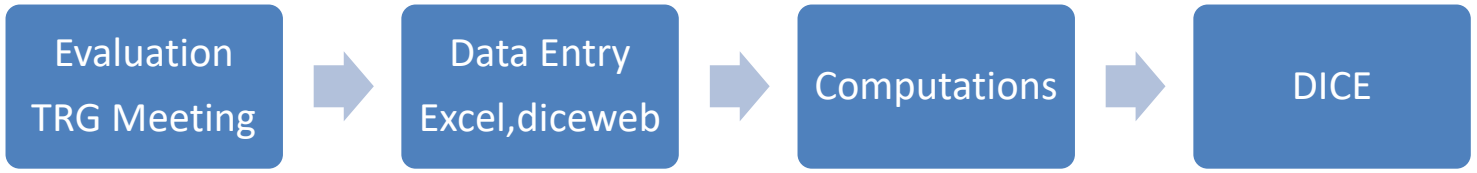
OECD/NEA

PHYSOR2014

Under the hood



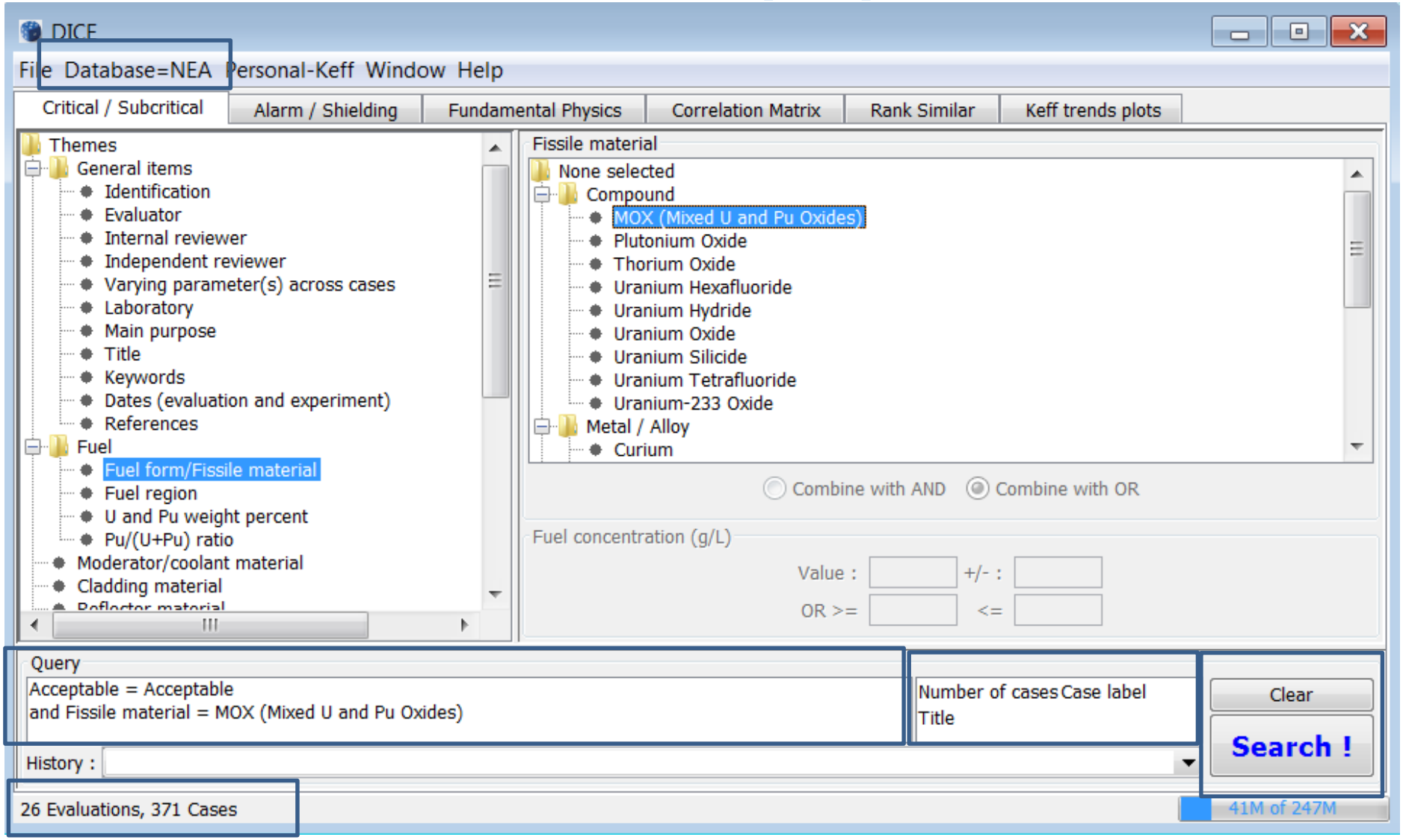
Programming language: JAVA, SQL and XML

~Several modules

- Web entry application (diceweb)
- GUI
- Data access layer
- Remote database connection (local or NEA)
- Webversion
- Live Update
- Bug report (sent to JIRA)

Introduction to Basic DICE Searches

Search (1/2)



Search (2/2)

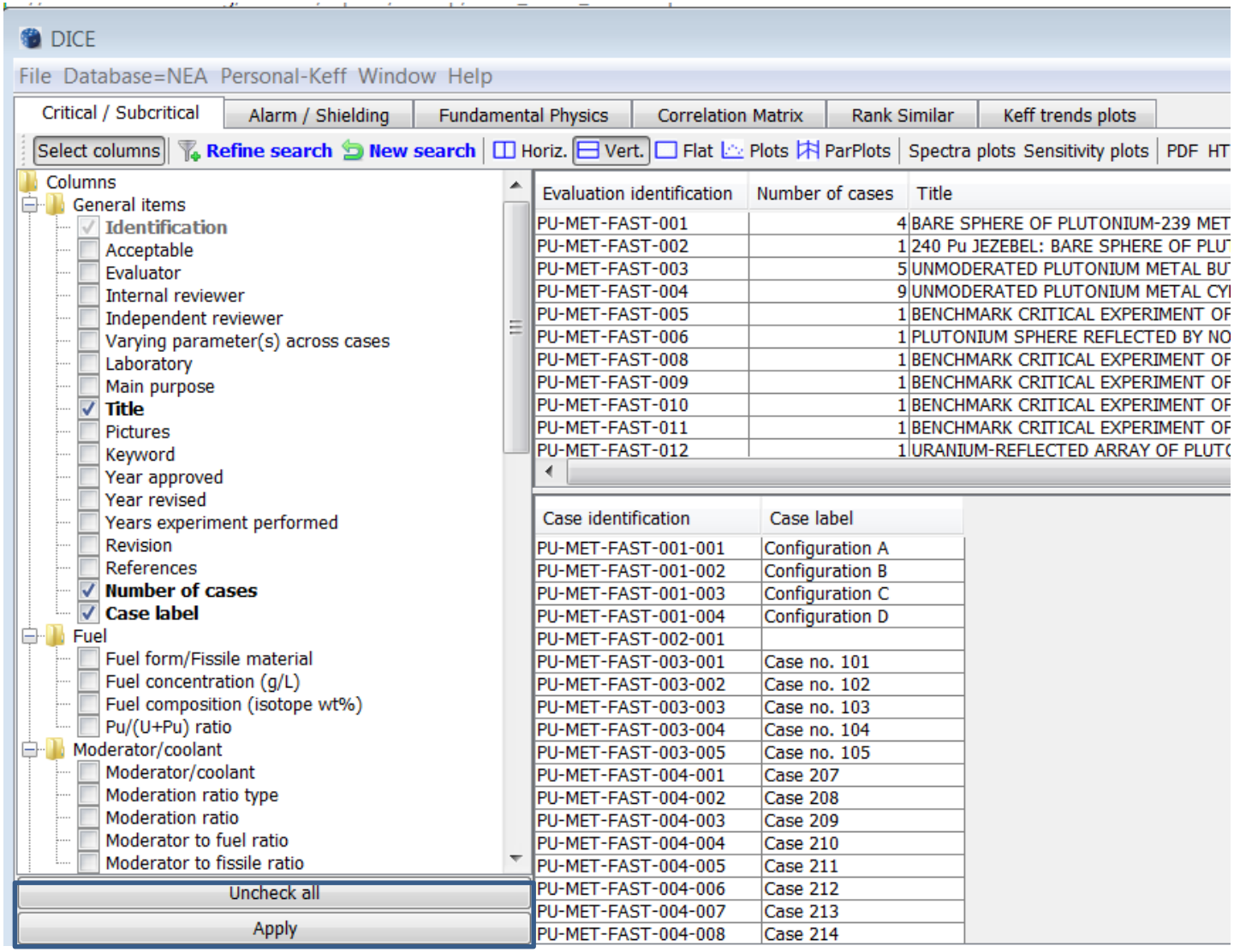
- General items
  - Identification
  - Evaluator
  - Internal reviewer
  - Independent reviewer
  - Varying parameter(s) across cases
  - Laboratory
  - Main purpose
  - Title
  - Keywords
  - Dates (evaluation and experiment)
  - References
- Fuel
  - Fuel form/Fissile material
  - Fuel region
  - U and Pu weight percent
  - Pu/(U+Pu) ratio
  - Moderator/coolant material
  - Cladding material
  - Reflector material
  - Neutron absorbing material
  - Separation material
  - Geometry
  - Temperature
  - Benchmark Keff and Calculations

Filled by Evaluators + Extracted from Handbook

- Energy, spectra, sensitivities
  - Energy of Average Neutron Lethargy causing Fission
  - Average Fission Group Energy
  - Flux distribution (3-g)
  - Fission distribution (3-g)
  - Capture distribution (3-g)
  - Neutron balance
  - Neutron gas temperature
  - Average fission neutrons per neutron absorbed in the core
  - Keff Sensitivities
  - Keff Sensitivities (additional criterion)

Computed data

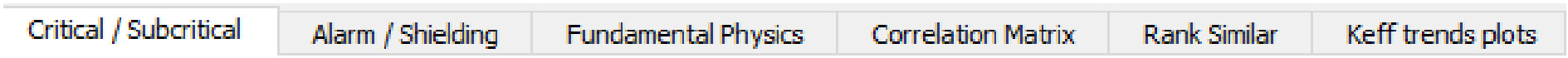
Results



Evaluations

Cases

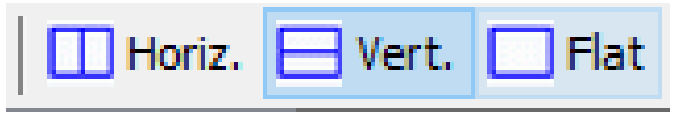
Results: What are the Buttons/Tabs?



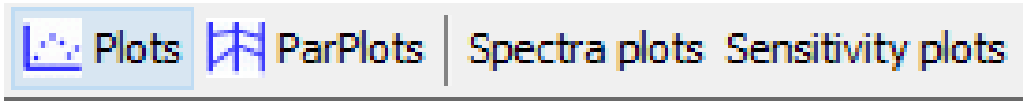
Handbook Volumes

Specialised Information

Keep or Clear previous filters when returning to search page



Separate Evaluations/Cases by horizontal or vertical divider, or display together.



Plot DICE data, or computed data retrieved from search

View either the evaluation PDF, or an HTML summary of the information

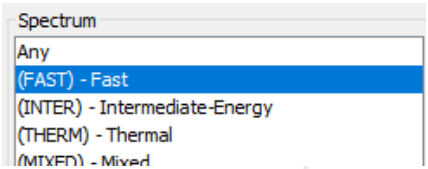
DICE is Strongly Linked to Handbook Structure and Classifications

Evaluation ID: HEU-MET-FAST

Case ID: HEU-MET-FAST-001, HEU-MET-FAST-002

Consider: An evaluation was performed for an HEU-MET system, but some of the cases are mixed spectrum.

If I search for 'FAST', do I return these cases?



Evaluation identification	Number of cases	Title
HEU-MET-FAST-044	5	HEU CYLINDERS AXIALLY REFLECTED BY ALUMINUM
HEU-MET-FAST-047	1	NIOBIUM - 1wt.% ZIRCONIUM MODERATED BY POLYETHYLENE AND FUELED
HEU-MET-FAST-048	17	OIL-REFLECTED SPHERES AND HEMISPHERES OF HIGHLY ENRICHED URANI

Evaluation identification	Number of cases	Title
HEU-MET-MIXED-009	43	URANIUM METAL SLABS MODERATED WITH POLYETHYLENE, PLEXIGLAS,
HEU-MET-MIXED-010	7	LATTICES OF ORALLOY CUBES IN WATER
HEU-MET-MIXED-011	17	OIL-REFLECTED SPHERES AND HEMISPHERES OF HIGHLY ENRICHED URA

Case identification	Case label
HEU-MET-FAST-048-001	
HEU-MET-FAST-048-002	
HEU-MET-FAST-048-006	

cases

Case	Year(s) experiments performed
HMF048-001	1965 - 1967
HMF048-002	1965 - 1967
HMM011-003	1965 - 1967
HMM011-004	1965 - 1967
HMM011-005	1965 - 1967
HMF048-006	1965 - 1967

Exercises (1)
What information can we see?

Let's Try Some Example Searches

1. PU-MET-FAST experiments
2. Experiments done at ORNL
3. Evaluations published in 2015
4. LEU-SOL-THERM experiments
5. Iron reflected experiments
6. Unreflected spheres

- **Access to representative picture**
- **Fuel composition (multiple fuel comps=subcases)**
- **HTML summary**
- **Calculated quantities (after evaluation)**
- **Plots**
- **Input files**
- **(DVD version access PDFs)**

Calculated DICE Data

Calculated Data

Initial Calculated Data (Began in 1999)

Y. Rozhikhin, A.Tsiboulia, T.Ivanova, J.Briggs, V. Dean, **"DETAILED SPECTRA DATA FOR THE INTERNATIONAL HANDBOOK OF EVALUATED CRITICALITY SAFETY BENCHMARK EXPERIMENTS" ICNC1999**

Computed with KENO+MMK+ABBN

Quantities:

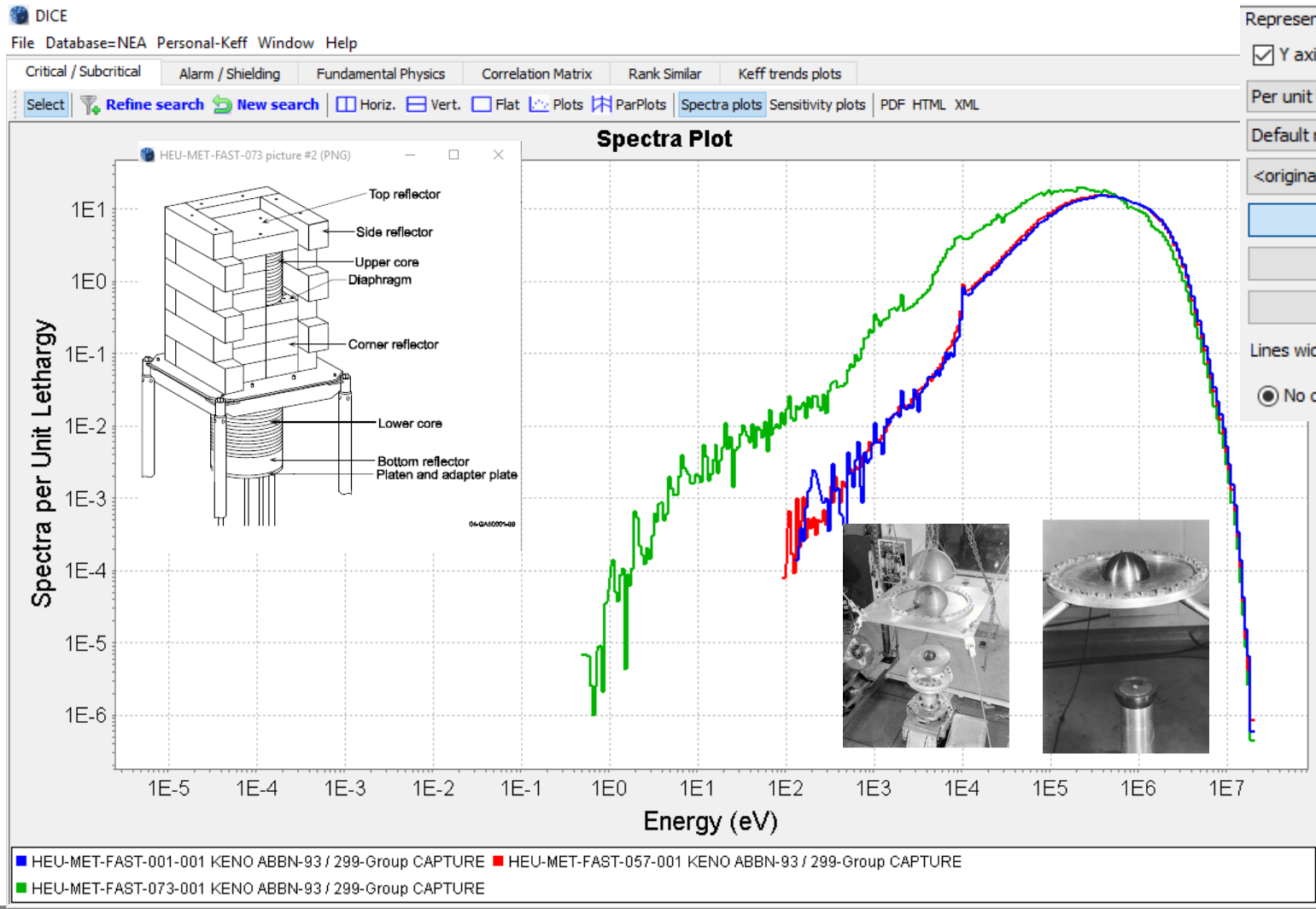
- 3 Group Flux, Fission, Capture
- EALF, AFGE
- Neutron gas temperature
- Neutron Balance
- Inputs

Example Calculated Data: Unreflected HMF Fission Energy

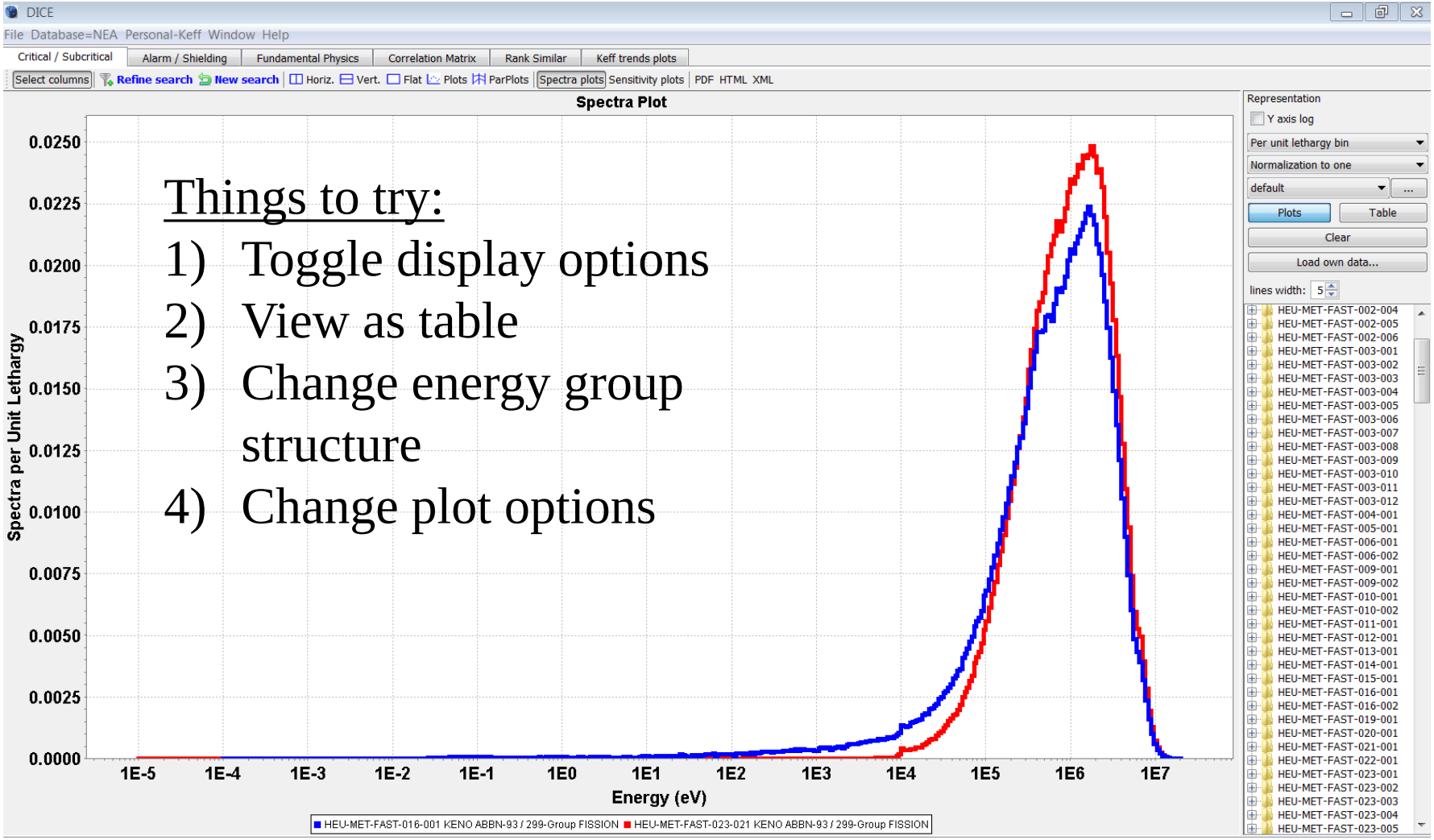
Case identification	Case label	EALF (eV)	AFGE (eV)	Fission < 0.625 eV	Fission 0.625 eV - 100 keV	Fission > 100 keV
HEU-MET-FAST-001-001		881000	866000	0.0%	5.6%	94.4%
HEU-MET-FAST-002-001	Sphere	834000	822000	0.0%	9.6%	90.4%
HEU-MET-FAST-002-002	Cylinder	823000	811000	0.0%	9.9%	90.1%
HEU-MET-FAST-002-003	Box 4x4x3.66	819000	808000	0.0%	9.9%	90.1%
HEU-MET-FAST-002-004	Box 5x5x2.53	810000	799000	0.0%	10.3%	89.7%
HEU-MET-FAST-002-005	Box 3x3x7.56	806000	795000	0.0%	10.4%	89.6%
HEU-MET-FAST-002-006	Box 3x3.5x6	812000	801000	0.0%	10.2%	89.8%
HEU-MET-FAST-003-001	24.5/2.0	867000	853000	0.0%	7.2%	92.8%
HEU-MET-FAST-003-002	21.0/3.0	864000	851000	0.0%	7.9%	92.1%
HEU-MET-FAST-003-003	19.5/4.0	859000	845000	0.0%	8.5%	91.5%
HEU-MET-FAST-003-004	18.3/5.0	854000	841000	0.0%	8.9%	91.1%
HEU-MET-FAST-003-005	17.6/7.0	841000	828000	0.0%	9.5%	90.5%
HEU-MET-FAST-003-006	17.4/8.0	834000	822000	0.0%	9.6%	90.4%
HEU-MET-FAST-003-007	17.2/11.0	817000	805000	0.0%	9.8%	90.2%
HEU-MET-FAST-003-008	22.6/1.9	695000	681000	0.0%	9.3%	90.7%
HEU-MET-FAST-003-009	19.2/2.9	634000	617000	0.0%	11.4%	88.6%
HEU-MET-FAST-003-010	17.4/4.5	577000	556000	0.0%	13.6%	86.4%
HEU-MET-FAST-003-011	17.1/6.5	551000	529000	0.0%	14.5%	85.5%
HEU-MET-FAST-003-012	21.2/8.0	697000	679000	0.0%	8.5%	91.5%
HEU-MET-FAST-004-001	1-D Idealization	33800	28200	15.0%	16.1%	68.9%
HEU-MET-FAST-005-001		640000	626000	0.0%	9.2%	90.8%
HEU-MET-FAST-006-001		20700	17900	17.1%	17.8%	65.1%
HEU-MET-FAST-006-002		19500	16900	17.4%	17.9%	64.7%
HEU-MET-FAST-008-001		870000	855000	0.0%	5.7%	94.3%
HEU-MET-FAST-009-001	Be-Reflected	713000	696000	0.0%	9.5%	90.5%

Can result in ‘cross-reference’, where one evaluation does not fit into the DICE spectrum classification system

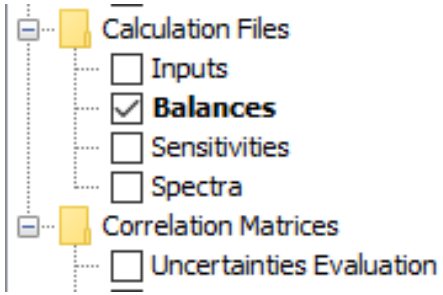
Spectra Plots



Fission Spectrum Plot Example



Balance Data + Calculation Files



HEU-MET-FAST-005-003	KENO	ABBN-93 / 299-Group	Balance
HEU-MET-FAST-005-004	KENO	ABBN-93 / 299-Group	Balance
HEU-MET-FAST-005-005	KENO	ABBN-93 / 299-Group	Balance
HEU-MET-FAST-005-006	KENO	ABBN-93 / 299-Group	Balance
HEU-MET-FAST-006-001	KENO	ABBN-93 / 299-Group	Balance
HEU-MET-FAST-006-002	KENO	ABBN-93 / 299-Group	Balance
HEU-MET-FAST-007-001	KENO	ABBN-93 / 299-Group	Balance

All reactions rates are normalised to 1000 neutrons emitted in the system. Furthermore, the following relation holds:

(PRODUCT + (n,2n))/(CAPTURE + FISSION + LEAKAGE))=KEFF

BALANCE TABLE

NUMBER OF ZONES IN THE CORE: 1
THE CORE CONSISTS OF ZONES: 1

ZONE 1 VOLUME=1.1791E+03

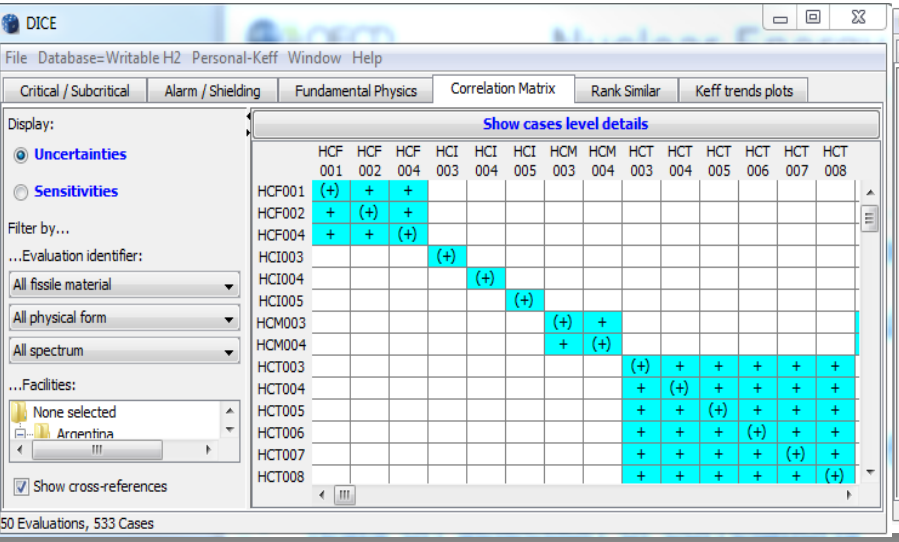
ISOTOP	CONC	MASS	CAPTURE	FISSION	(n,2n)	PRODUCT	Sig-C	Sig-F	Sig-2N	NU
U234	5.3678E-04	0.246	1.39	2.58	0.00	6.82	0.513	0.955	0.001	2.639
U235	4.7033E-02	21.645	59.62	388.66	1.91	992.78	0.252	1.640	0.008	2.554
U236	9.5896E-05	0.044	0.18	0.20	0.00	0.53	0.364	0.408	0.004	2.683
U238	4.7782E-04	0.223	0.55	0.49	0.03	1.39	0.229	0.204	0.010	2.833
O	0.0000E+00	0.000	0.00	0.00	0.00	0.00	0.008	0.000	0.000	0.000
H	0.0000E+00	0.000	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000
TOTAL:			61.73	391.93	1.94	1001.52				

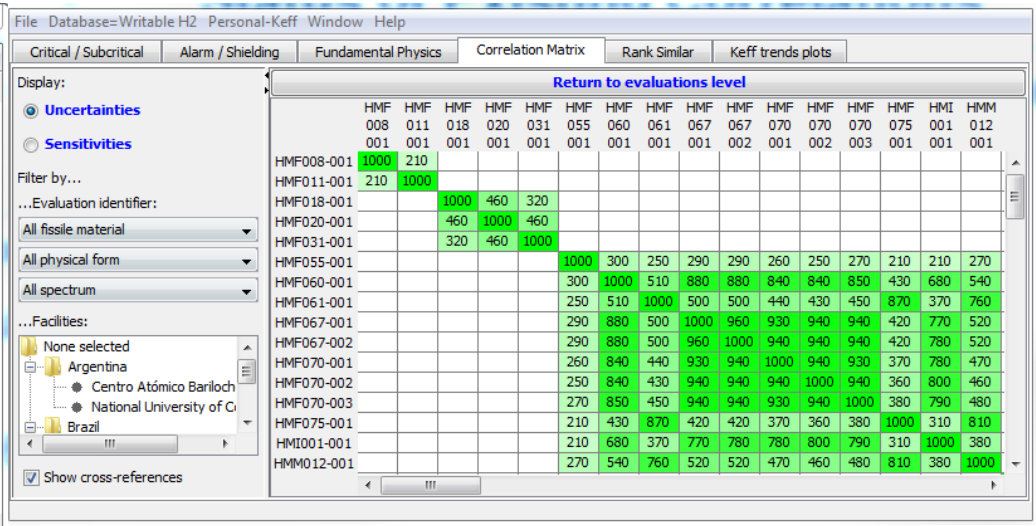
Experimental Correlation Data

Correspond to the correlations of benchmark model uncertainties

- **Level 1 correlations show that evaluations are correlated**
- **Level 2 correlations give the quantitative information about the correlations between cases**
- **Currently 94 cases have correlation data [level2] in DICE**

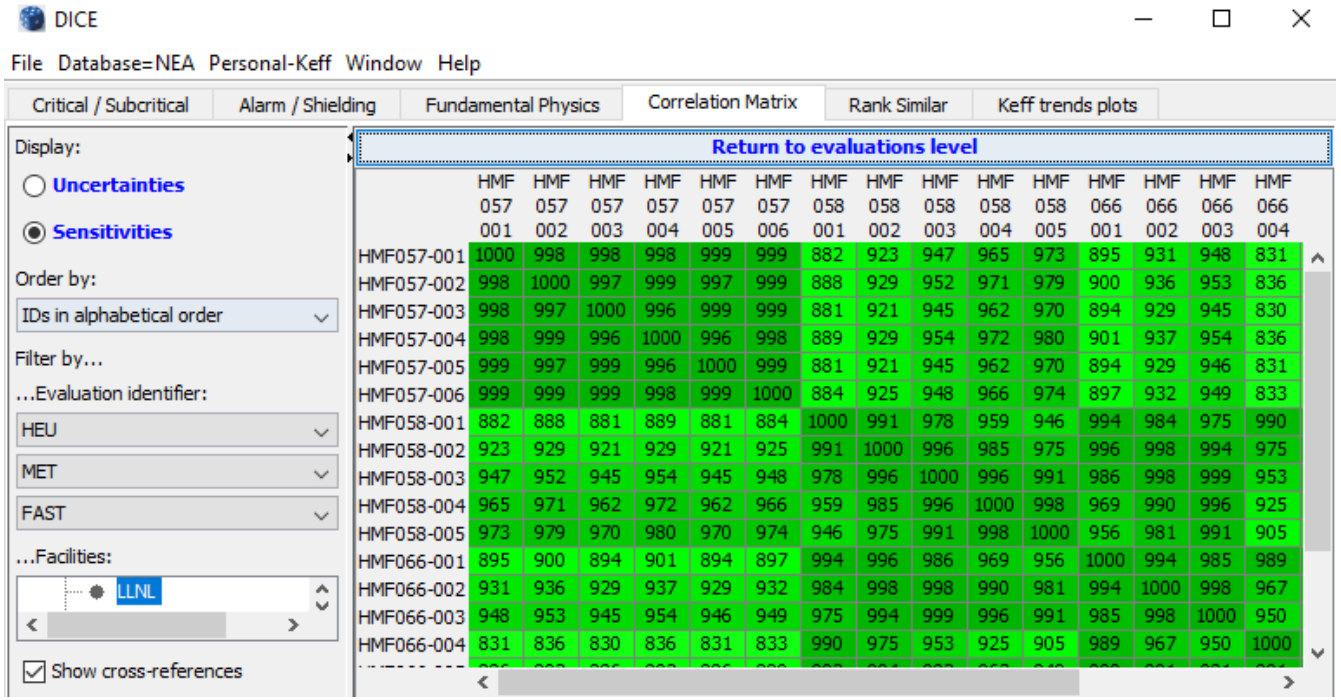
(or ~2%). Level 2 required for analysis.





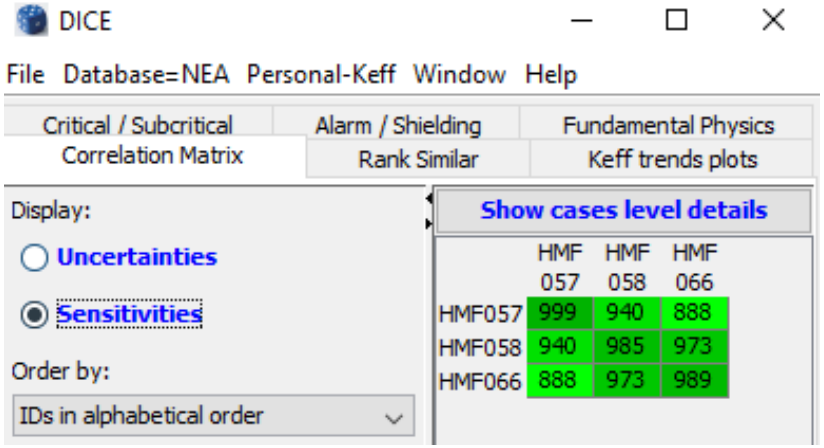
Different Case Response to Nuclear Data

Case Level



	HMF057-001	HMF057-002	HMF057-003	HMF057-004	HMF057-005	HMF057-006	HMF058-001	HMF058-002	HMF058-003	HMF058-004	HMF058-005	HMF066-001	HMF066-002	HMF066-003	HMF066-004
HMF057-001	1000	998	998	998	999	999	882	923	947	965	973	895	931	948	831
HMF057-002	998	1000	997	999	997	999	888	929	952	971	979	900	936	953	836
HMF057-003	998	997	1000	996	999	999	881	921	945	962	970	894	929	945	830
HMF057-004	998	999	996	1000	996	998	889	929	954	972	980	901	937	954	836
HMF057-005	999	997	999	996	1000	999	881	921	945	962	970	894	929	946	831
HMF057-006	999	999	999	998	999	1000	884	925	948	966	974	897	932	949	833
HMF058-001	882	888	881	889	881	884	1000	991	978	959	946	994	984	975	990
HMF058-002	923	929	921	929	921	925	991	1000	996	985	975	996	998	994	975
HMF058-003	947	952	945	954	945	948	978	996	1000	996	991	986	998	999	953
HMF058-004	965	971	962	972	962	966	959	985	996	1000	998	969	990	996	925
HMF058-005	973	979	970	980	970	974	946	975	991	998	1000	956	981	991	905
HMF066-001	895	900	894	901	894	897	994	996	986	969	956	1000	994	985	989
HMF066-002	931	936	929	937	929	932	984	998	998	990	981	994	1000	998	967
HMF066-003	948	953	945	954	946	949	975	994	999	996	991	985	998	1000	950
HMF066-004	831	836	830	836	831	833	990	975	953	925	905	989	967	950	1000

Evaluation Level



	HMF057	HMF058	HMF066
HMF057	999	940	888
HMF058	940	985	973
HMF066	888	973	989

$$E \equiv \frac{\mathbf{S}_a^T \mathbf{S}_e}{\|\mathbf{S}_a\| \|\mathbf{S}_e\|}$$

New: Order by Similarity Clusters

DICE

File Database=NEA Personal-Keff Window Help

Critical / Subcritical | Alarm / Shielding | Fundamental Physics | Correlation Matrix | Rank Similar | Keff trends plots

Display:

- ○ Uncertainties
- ◉ Sensitivities

Order by:

Similarity clusters

Filter by...

...Evaluation identifier:

All fissile material

All physical form

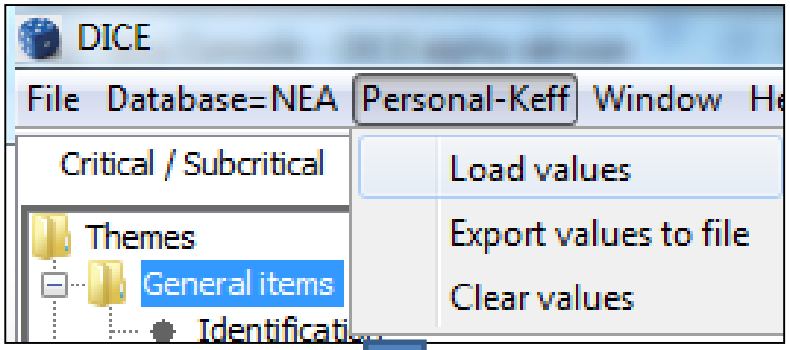
All spectrum

Show c

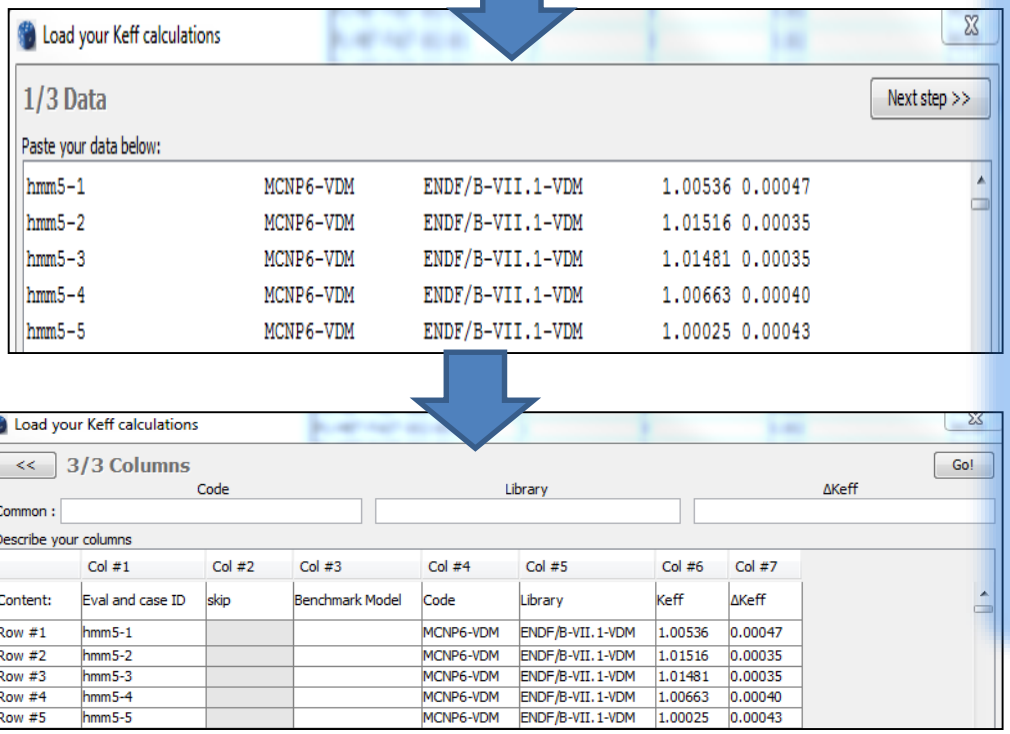
	UMF 003	UMF 006	UMF 002	UMF 001	UMF 005	PCI 001	PMF 033	PMF 016	PMF 013	MMF 005	MMF 001	MMF 003	PMF 046	PMF 010
UMF003	998	986	967	982	973	0	6	0	0	2	2	2	8	20
UMF006	986	1000	938	946	949	0	11	0	0	4	4	5	14	32
UMF002	967	938	996	977	961	0	1	0	0	43	46	52	1	2
UMF001	982	946	977	1000	978	0	0	0	0	0	0	0	0	0
UMF005	973	949	961	978	998	0	0	0	0	0	0	0	0	0
PCI001	0	0	0	0	0	1000	163	195	124	107	104	104	124	112
PMF033	6	11	1	0	0	163	1000	817	925	869	853	852	950	907
PMF016	0	0	0	0	0	195	817	992	890	906	907	898	897	914
PMF013	0	0	0	0	0	124	925	890	1000	937	930	925	984	962
MMF005	2	4	43	0	0	107	869	906	937	1000	994	994	947	959
MMF001	2	4	46	0	0	104	853	907	930	994	1000	998	939	956
MMF003	2	5	52	0	0	104	852	898	925	994	998	1000	934	950

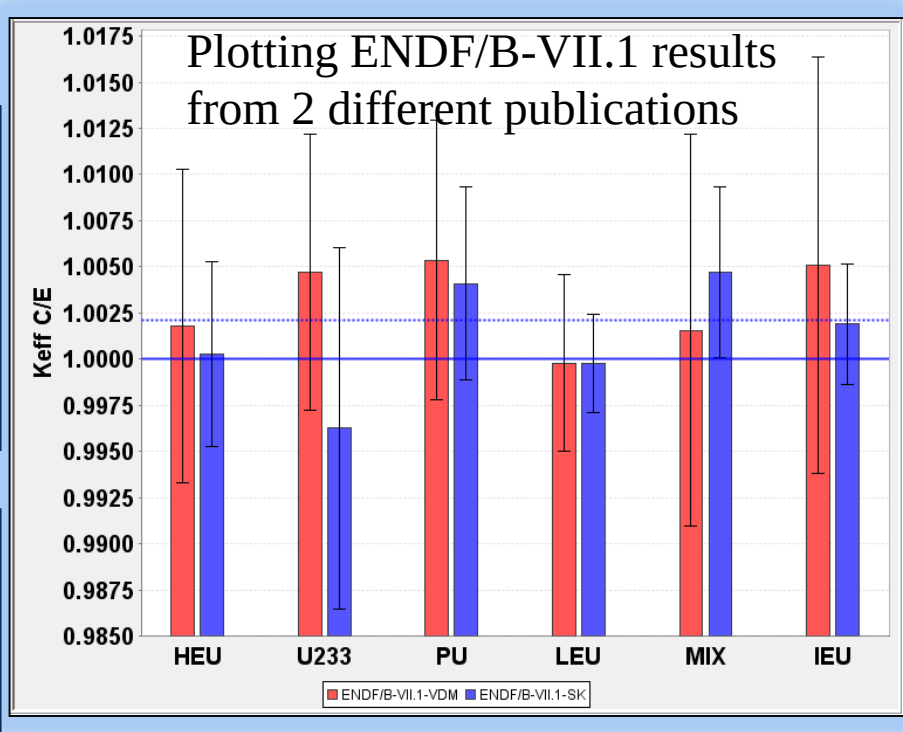
Personal Keff in Local Database
+
Trend Plots

Storing K_{eff} from external calculations

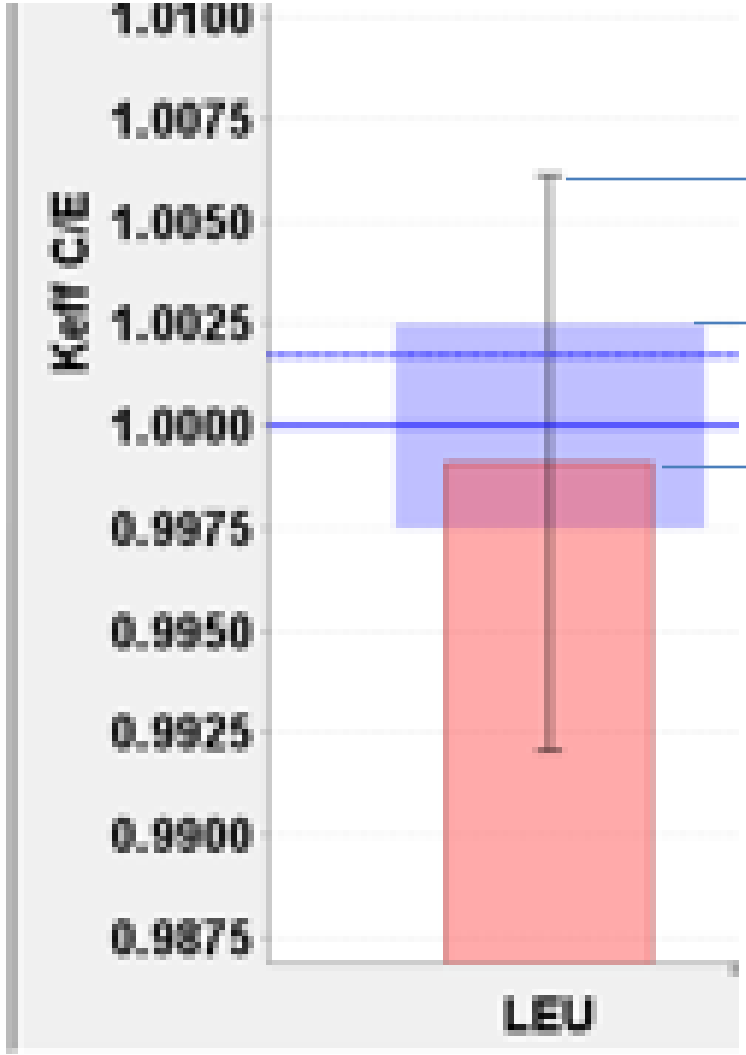


Available only with local database (need to copy DICE to a writeable area)





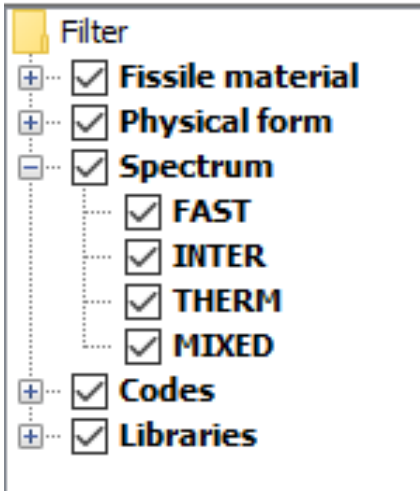
How to Interpret Trend Plots



Spread of all C/E's

RMS Uncertainty
(Experimental and Calculated)

Averaged (mean) C/E's



Trend Plots

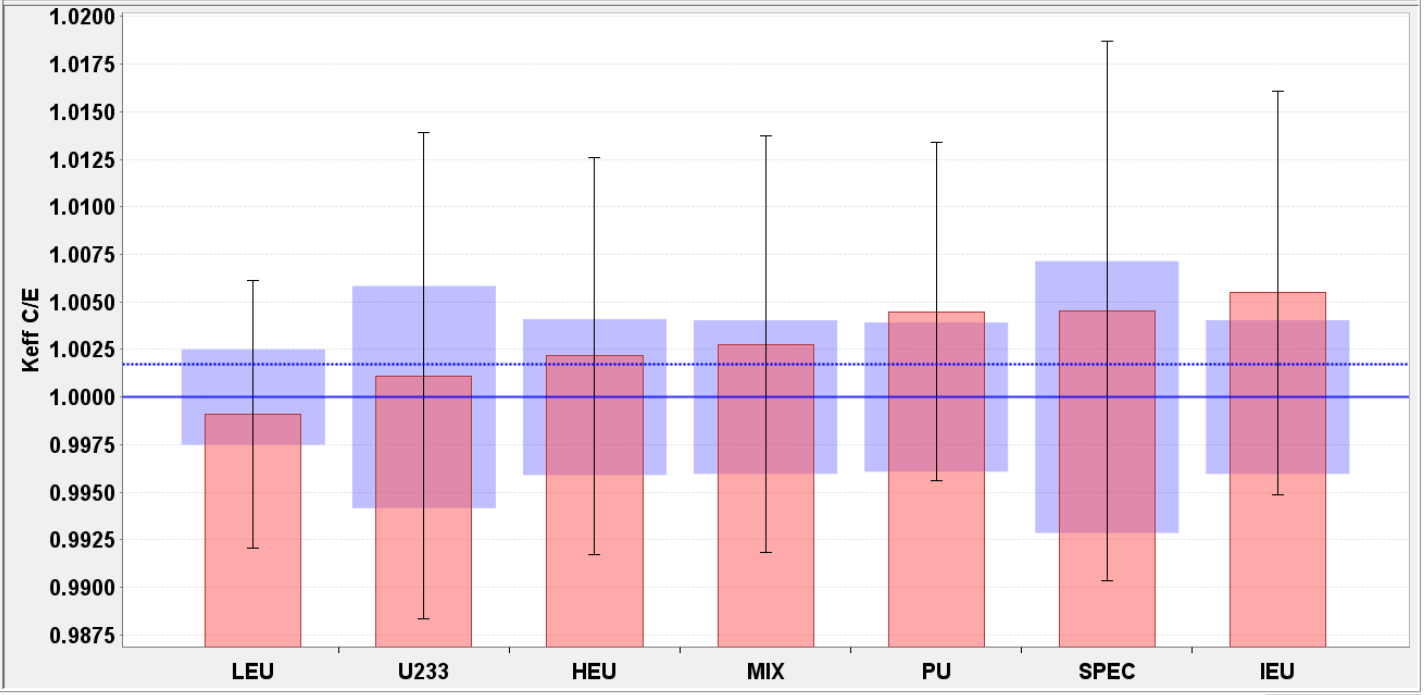
DICE

File Database=HTTP jdev Personal-Keff Window Help

Critical / Subcritical | Alarm / Shielding | Fundamental Physics | Correlation Matrix | Rank Similar | Keff trends plots

Filter
- Fissile material
- Physical form
- Spectrum
- Codes
- Libraries

Case ID	E. Mean	E. Std dev	E. Uncertainty RMS	Code	Library	C. Mean	C. Std dev	C. Uncertainty RMS	C/E
PU-MET-FAST-001-001	0.999995	5e-6	0.00129	MCNP	ENDF/B-VII.1 Continuous	1.000745	2.5e-5	1.581139e-5	1.00075
PU-MET-FAST-001-002	1.00008	8e-5	0.00129	MCNP	ENDF/B-VII.1 Continuous	1.00096	1.9e-4	1.581139e-5	1.00088
PU-MET-FAST-001-003	1.0001	1e-4	0.00129	MCNP	ENDF/B-VII.1 Continuous	1.000855	8.5e-5	1.581139e-5	1.000755
PU-MET-FAST-001-004	1.00064	6.4e-4	0.00129	MCNP	ENDF/B-VII.1 Continuous	1.001335	5.65e-4	1.581139e-5	1.000695
PU-MET-FAST-002-001	1	0	0.002	APOLLO-MORET	JEF-2.2 / 172-Group	0.9945	0	3e-4	0.9945
PU-MET-FAST-002-001	1	0	0.002	KENO	ABBN-93 / 299-Group	1	0	6e-4	1
PU-MET-FAST-002-001	1	0	0.002	KENO	ENDF/B-IV / 27-Group	0.9995	0	0.0012	0.9995
PU-MET-FAST-002-001	1	0	0.002	KENO	Hansen-Roach / 16-Group	1.0045	0	0.0017	1.0045
PU-MET-FAST-002-001	1	0	0.002	MCNP	ENDF/B-V Continuous	0.9985	0	0.0014	0.9985
PU-MET-FAST-002-001	1	0	0.002	MCNP	ENDF/B-VI.8 Continuous	0.998	0	1e-4	0.998
PU-MET-FAST-002-001	1	0	0.002	MCNP	ENDF/B-VII.0 Continuous	1.0001	0	1e-4	1.0001
PU-MET-FAST-002-001	1	0	0.002	MCNP	JEFF-3.1.2 Continuous	1.00413	0	2.6e-4	1.00413
PU-MET-FAST-002-001	1	0	0.002	MONK	UKNDL	1.0119	0	0.0011	1.0119
PU-MET-FAST-002-001	1	0	0.002	ONEDANT	ENDF/B-IV / 27-Group	0.9999	0	0	0.9999
PU-MET-FAST-003-001	1	0	0.003	KENO	ABBN-93 / 299-Group	1.0006	0	9e-4	1.0006
PU-MET-FAST-003-001	1	0	0.003	KENO	ENDF/B-IV / 27-Group	0.9947	0	0.0011	0.9947
PU-MET-FAST-003-001	1	0	0.003	KENO	Hansen-Roach / 16-Group	1.0027	0	0.0011	1.0027



Filter with 'Rank Similar' criteria

Plot options

Averaging: Arithmetic

reduced chi-squared | bars | points

Group by: Fissile Material

...and: -

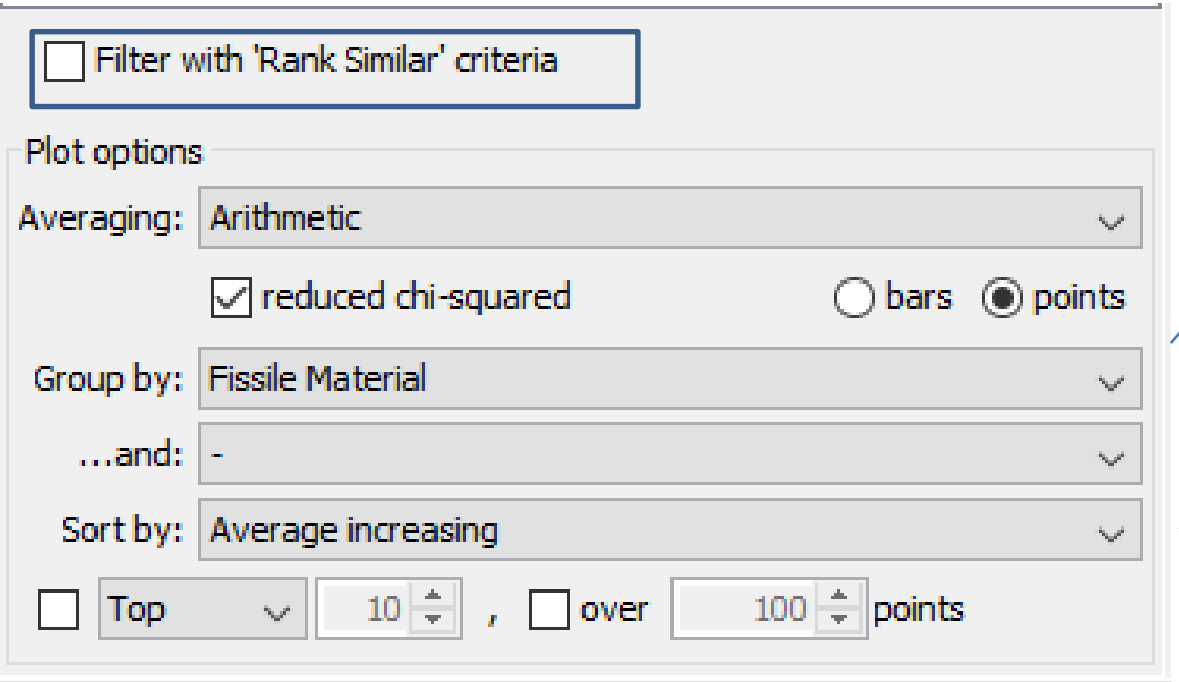
Sort by: Average increasing

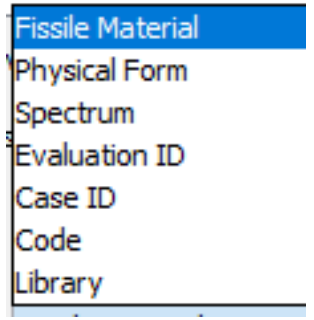
Top 10 , over 100 points

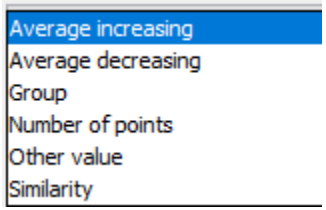
44 Evaluations, 114 Cases

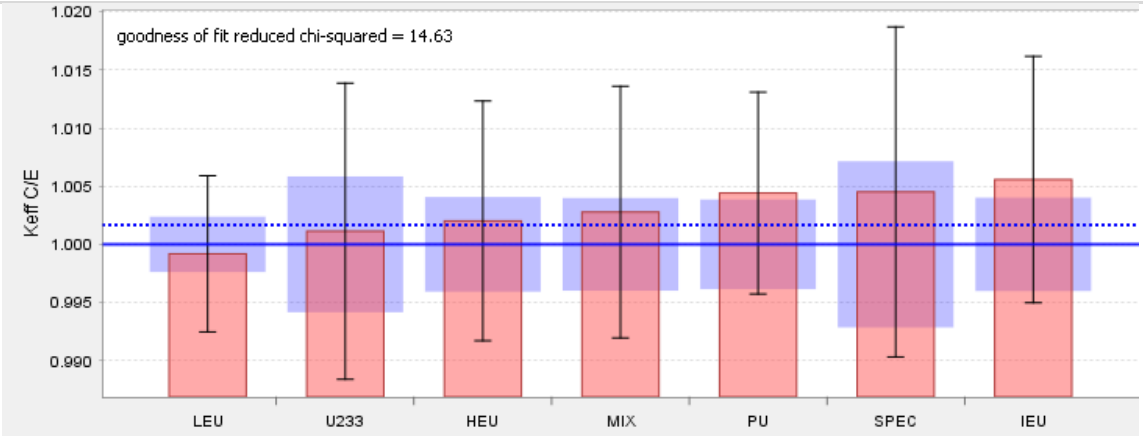
70M of 247M

Trend Plots Options

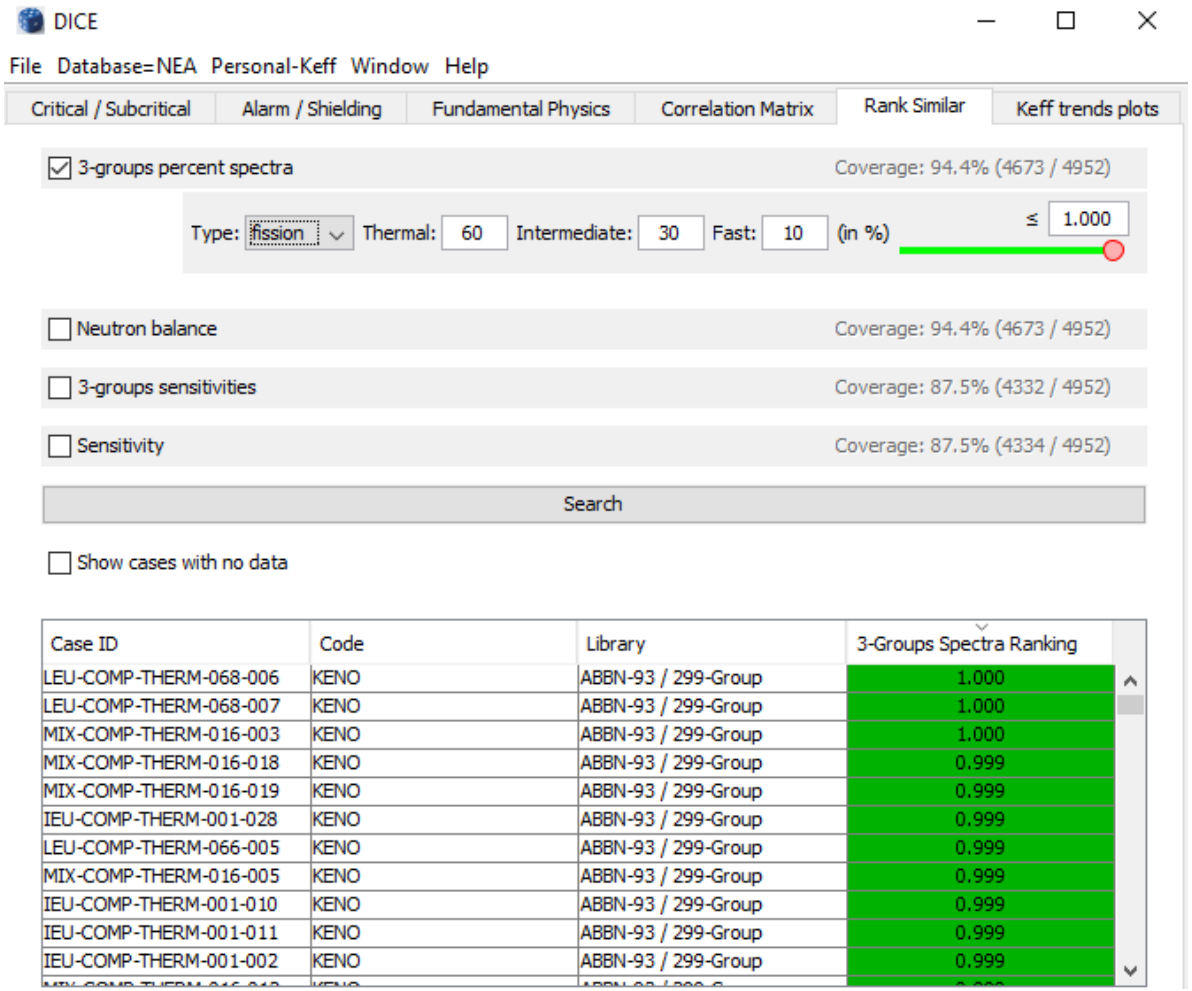








Find Cases With Similar Spectrum/Balance/Sensitivity Data



Enter Different Fission Spectra Here

Normalized Euclidean Distance Metric

Sensitivity Data

Sensitivity Data

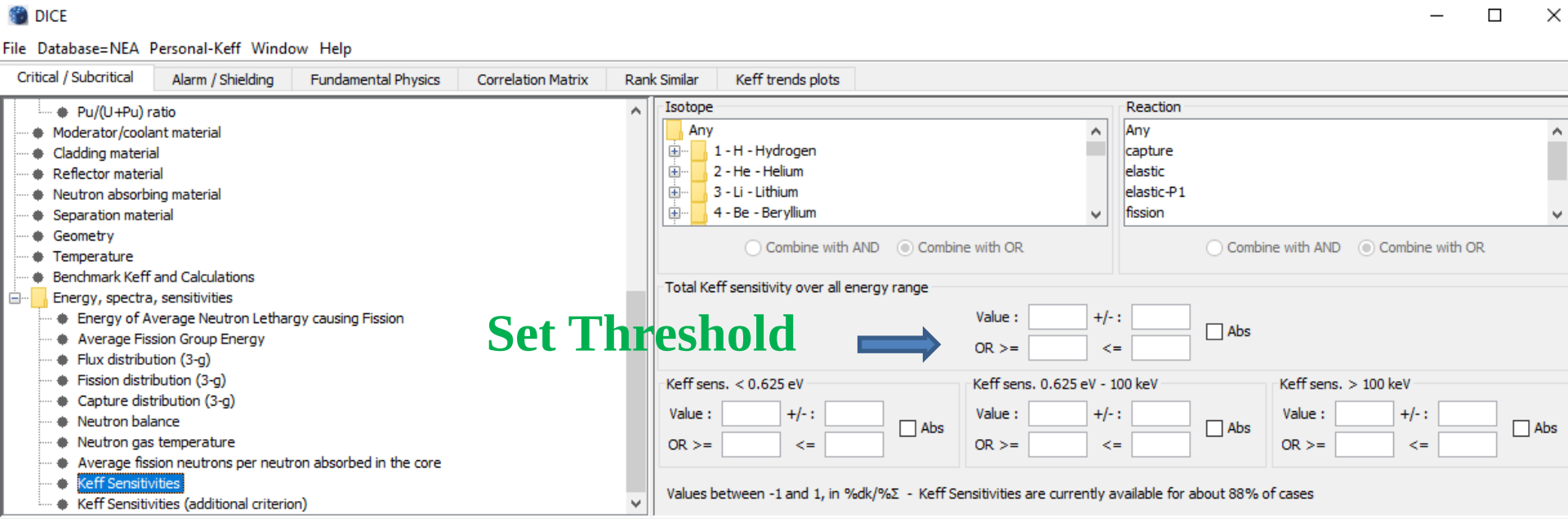
Sensitivity Profiles Available [DICE + IDAT]

Handbook Edition	Number of Unique Cases	Sources
2012	727	TSUNAMI1D+TSUNAMI3D [VALID]+MMK-KENO
2013	3575	Previous +Non VALID cases SCALE6.0 from Balance Inputs
2014	4011	Previous + MCNP6 + SCALE6.2BClutch
2015	4065	Previous + New Cases
2016	~4200	Previous + New Cases + P1 Sensitivities [~400 cases]
2017	~4200	Previous+P1 Sensitivities [~700 cases]
2017	~600	IDAT Sensitivities [Waiting input +Code GPT]

- Inputs derived from balance/spectra files
- Usually computed in 238 Groups
- Relational Database contains 3 Group data and subset of reaction data (capture, elastic, elastic P1, fission, inelastic, nubar, total), plot/tables of original group structure and reactions
- ASCII versions of inputs(2014) /SDFs available on previous DVD

Example: Searching by Sensitivity in DICE

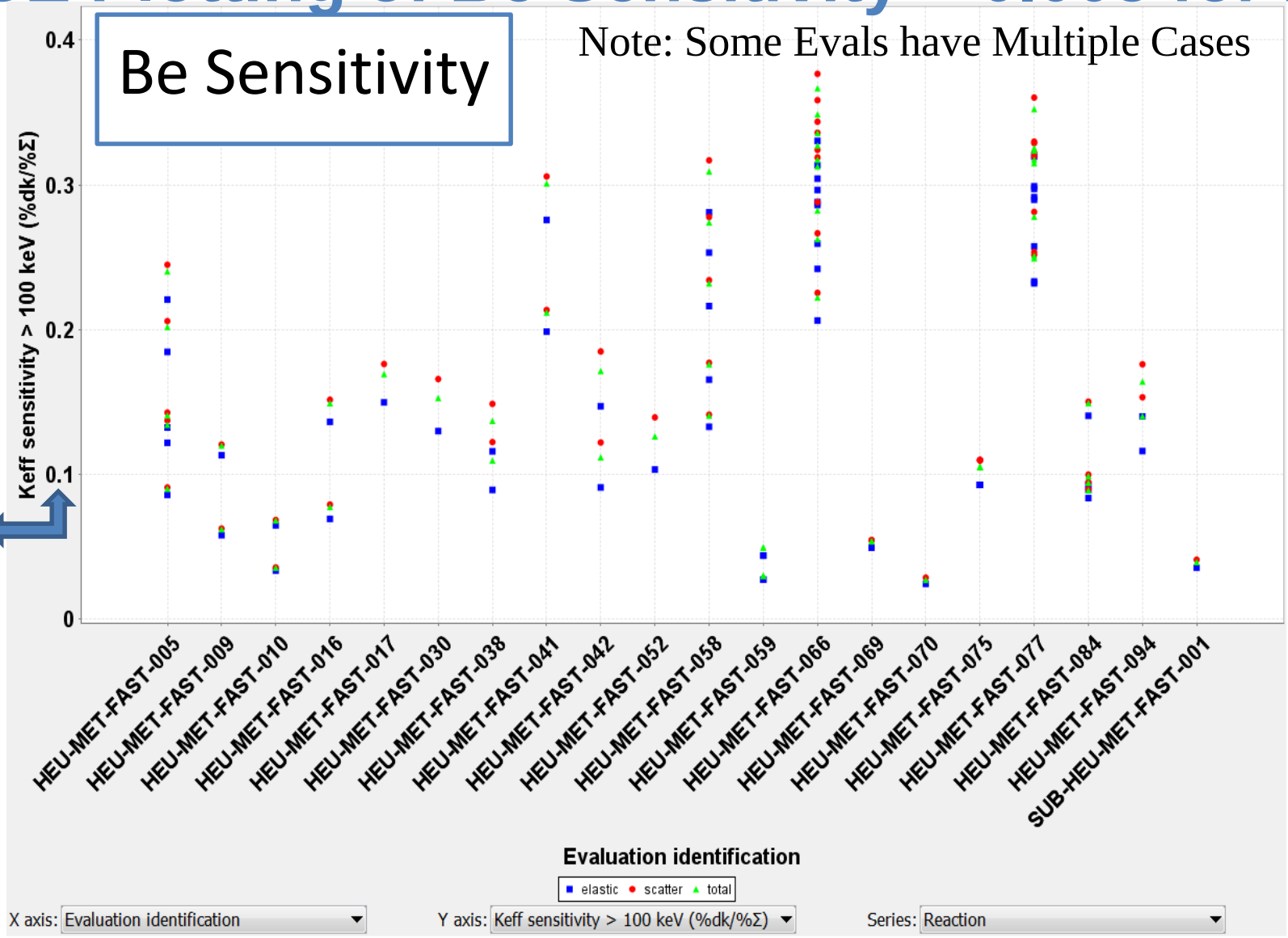
3 GROUP SEARCH, FULL GROUP STRUCTURE SDF'S ARE STORED



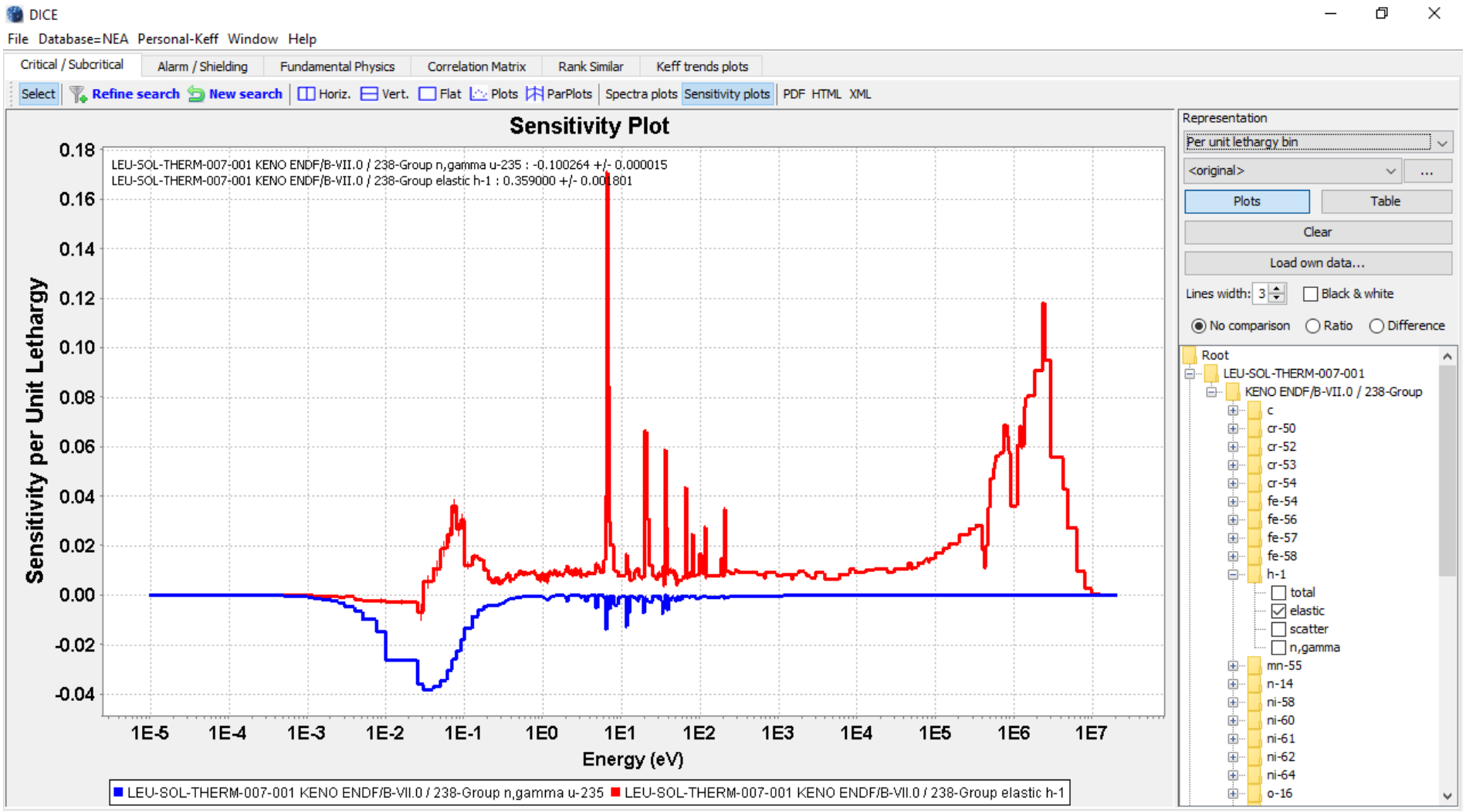
Set Threshold

DICE Plotting of Be Sensitivity > 0.005 for HMF

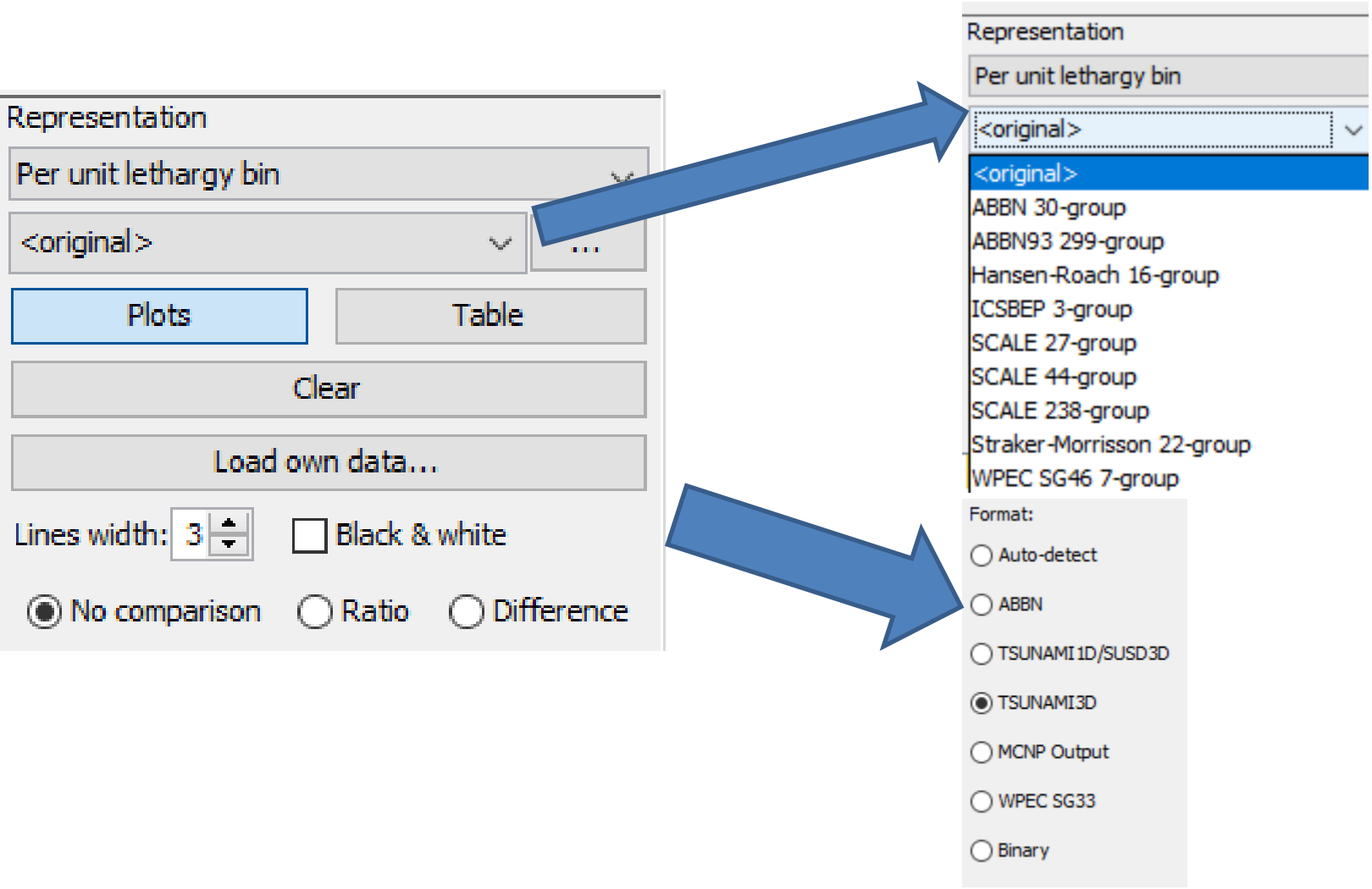
Can also read as 100 pcm/1% change in Σ



Sensitivity Viewer

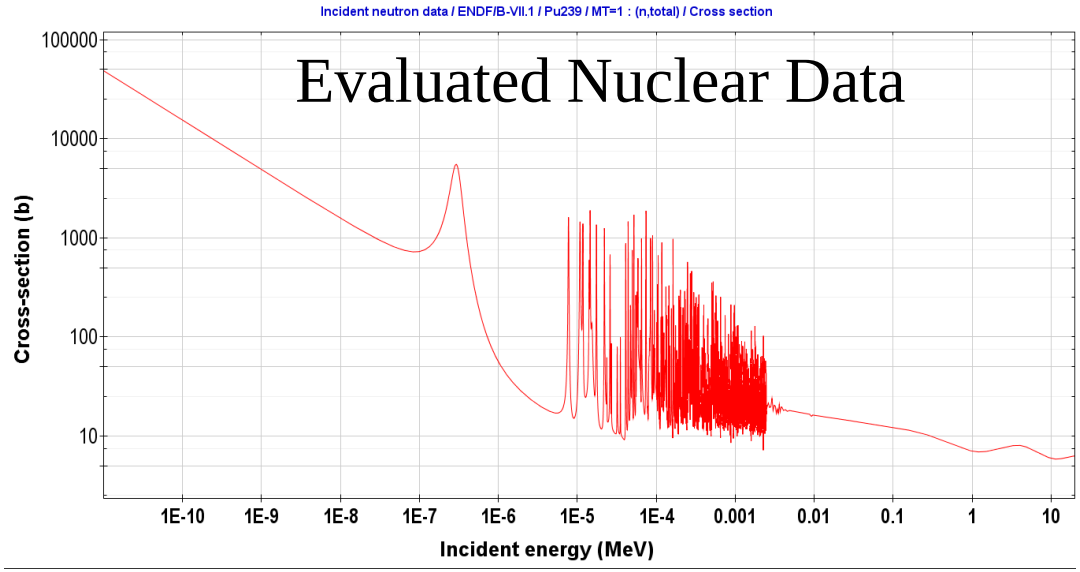


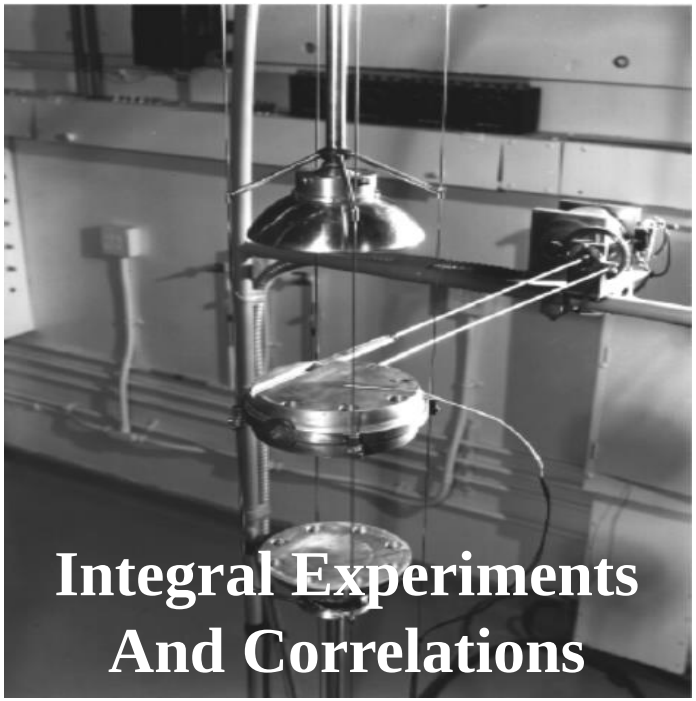
Sensitivity Viewer

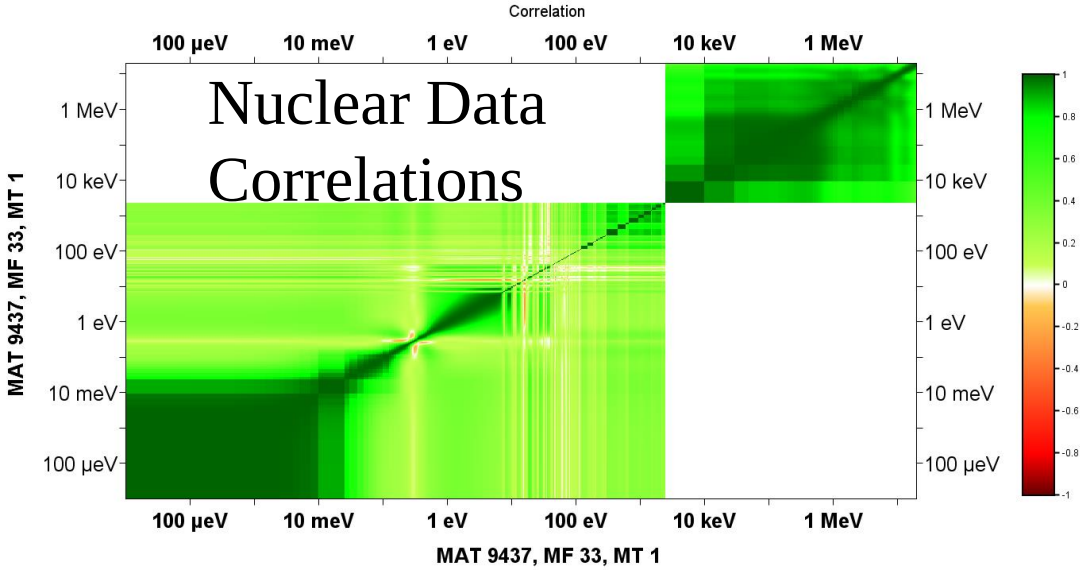


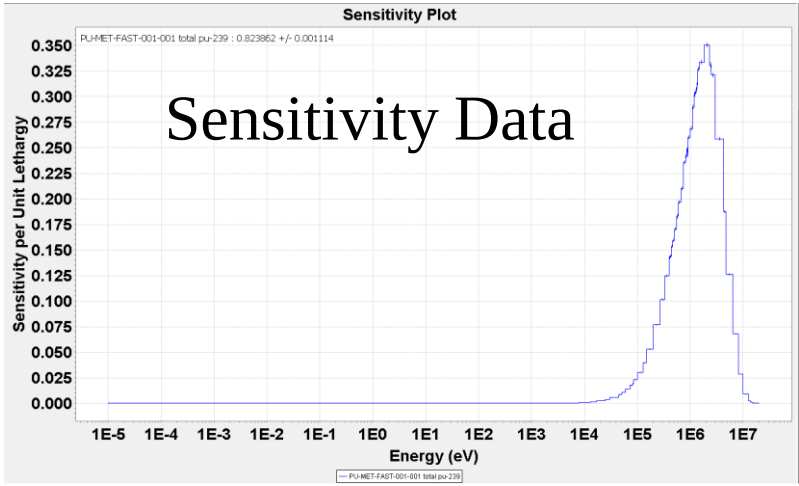
The **NEA**
Nuclear **Da**ta **S**ensitivity **T**ool
NDaST

Content adapted/updated from: **J.Dyrda et al. 'GENTLE intersemester course' – EC-JRC Geel, Belgium**
14 - 18 November 2016









Overview

This is a presentation designed to give a starter's introduction to the main features of NDaST and basic instructions for its use

What is it exactly?!

NDaST is an analysis tool to propagate the impact of changes in nuclear data cross sections and of nuclear data covariance to benchmark uncertainties.

Integrating Sensitivity Data With Nuclear Data

Idea: Potential scoping tool that leverages sensitivity data to make rapid predictions of the integral responses to changes in nuclear data.

- Changes and trends in Δk_{eff} for broad nuclear data perturbations
- Propagation of nuclear covariance data to benchmark C/E results

Integral Data Sources: Criticality (DICE), Reactor Physics (IDAT), Spent fuel (SFCOMPO), Numerical / computational benchmarks, Shielding (SINBAD).

Nuclear Data: Evaluated nuclear covariance data files are accessible via the NEA JANIS application

A revival?

- Sensitivity analyses are successfully performed for decades
- NRG proposal: "3D uncertainty calculations with MCNP"
  A. Hogenbirk,
  S. van der Marck,
  JEF/DOC-1286,
  June 2009.

Conclusions NRG

- Automated 3D uncertainty calculations can easily be performed for all (benchmark) problems for which MCNP inputs exist
- Method works well for both shielding and k_{eff} benchmarks
- Method could be applied to exploit the large source of experimental benchmark data available
- Result: automated feedback to evaluator possible and hence reduced time for updated evaluation

JEFF Meeting, December 2010 OECD NEA – E. Dupont 3

Sensitivity/Uncertainty tools NRG

Status:

* Sensitivity/uncertainty tools were developed in the '70s and '80s
* No substantial recent developments
* Almost all tools based on deterministic methodology

5 years later, NDaST went into development.
James Dyrda
Nicolas Soppera
Ian Hill

Nuclear Data Sensitivity Tool (NDaST) Flowchart

Benchmarks (Sensitivities) → Nuclear Data (% Change or Covariance) → Integral Results

Select / load benchmarks

Sensitivities (S) & C/E data

DICE

IDAT

Personal

Numerical Benchmarks

User Input Perturbation (P)

isotope/reaction/energy cross section

AND /OR

JANIS 4

Covariance data via JANIS (C)

Built in processed data for major libraries

Load personal (coverx)

M energy groups (fixed)

S*P

Δk_{eff} for selected cases

C/E output plot grouped by criteria

S*C*S^T

$U_{C(XS)}$ for selected cases

Additional uncertainty on output plot grouped by criteria

Matrix plot showing individual contribution to $U_{C(XS)}$ by isotope-reaction

JANIS MF33: ENDF/B-VII.1 = 2138 files, JEFF-3.2 = 5688 files JENDL-4.0 = 2155 files TENDL-2013 = 77811 files

Depending on What You Want Benchmarking Can Be Computer Intensive

To assess the impact on all PU-SOL-THERM

→ Run 600 Benchmarks, k_{eff} 5 pcm

To assess the impact of each reaction on the benchmarks

→ 600 X #Reactions [Look what is driving the k_{eff} change]

To assess the impact of each reaction and each energy range on the benchmarks

→ 600 X #Reactions X #Energies [Look at energy region driving the change]

To decide between different options in each reaction and energy

→ 600 X #Reactions X #Energies X #Options

Example: 10 h per run, 5 reactions, 10 energy groups, 5 options
= 600 X 10 h X 5 X 10 X 5 = **1.5 Million Computer Hours** or **171 Computer Years! (per isotope ☺)**

Attempt to reduce this to minutes!

Benefits

Goal: Given a new nuclear data evaluation, provide evaluators and other users a tool to see how the changes they've made will impact integral benchmarks…**in minutes**.

- See individual reaction effects, not just final totals
- Analyse how these 'compete' if they are correlated
- Understand specifically which energy regions matter
- How do perturbations compare with given uncertainties
- Propagate uncertainties and judge their reasonability
- Do this time and time again as small iterations take place
- Allow internationally co-operating projects to manage these processes more easily

Limitations

- All based on simple, first order approximations
  - These might not hold beyond certain limits, depending on strength of secondary effects
- Not all cases (around 85% of the total database)
- Sensitivities mostly the SCALE 238 group energy structure
  - Bad choice for certain types of systems & perturbations e.g. movement of large resonances across group boundaries
- Reactions (not all are loaded into database)
  - Difficult to properly handle the energy-dependent PFNS
- Angular sensitivity (being addressed – 600 P1 sensitivities)
- Experimental correlations are not considered
  - This is not (yet) an adjustment tool

Intended Scientific Value

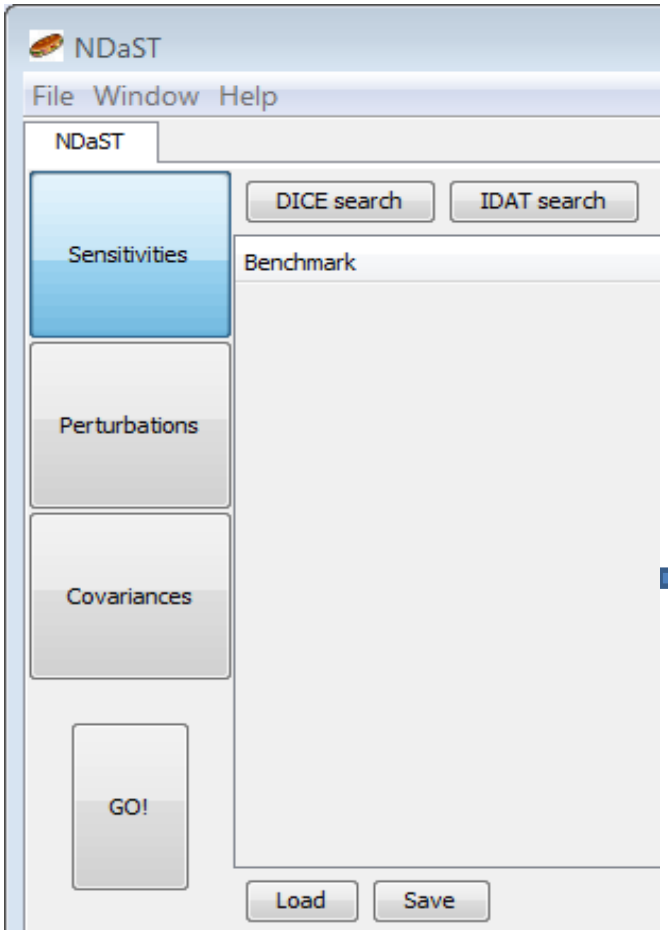
NDaST is a complement to, not a replacement for integral benchmark testing, by actually making code runs – it is invaluable to do this, but on a less frequent basis

You will see approximated results, suitable for general trending and broad conclusions – more data, of lower accuracy can help to focus more precise efforts

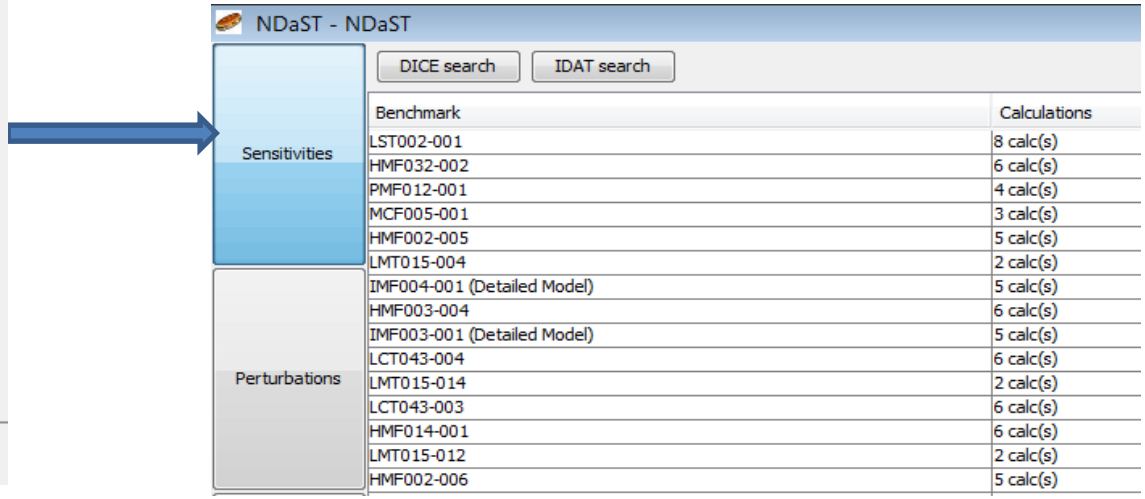
However, it should offer a practical alternative means to more quickly optimise new libraries and allow evaluators to make better informed decisions

Panel 1: Select Benchmark Sensitivity Data

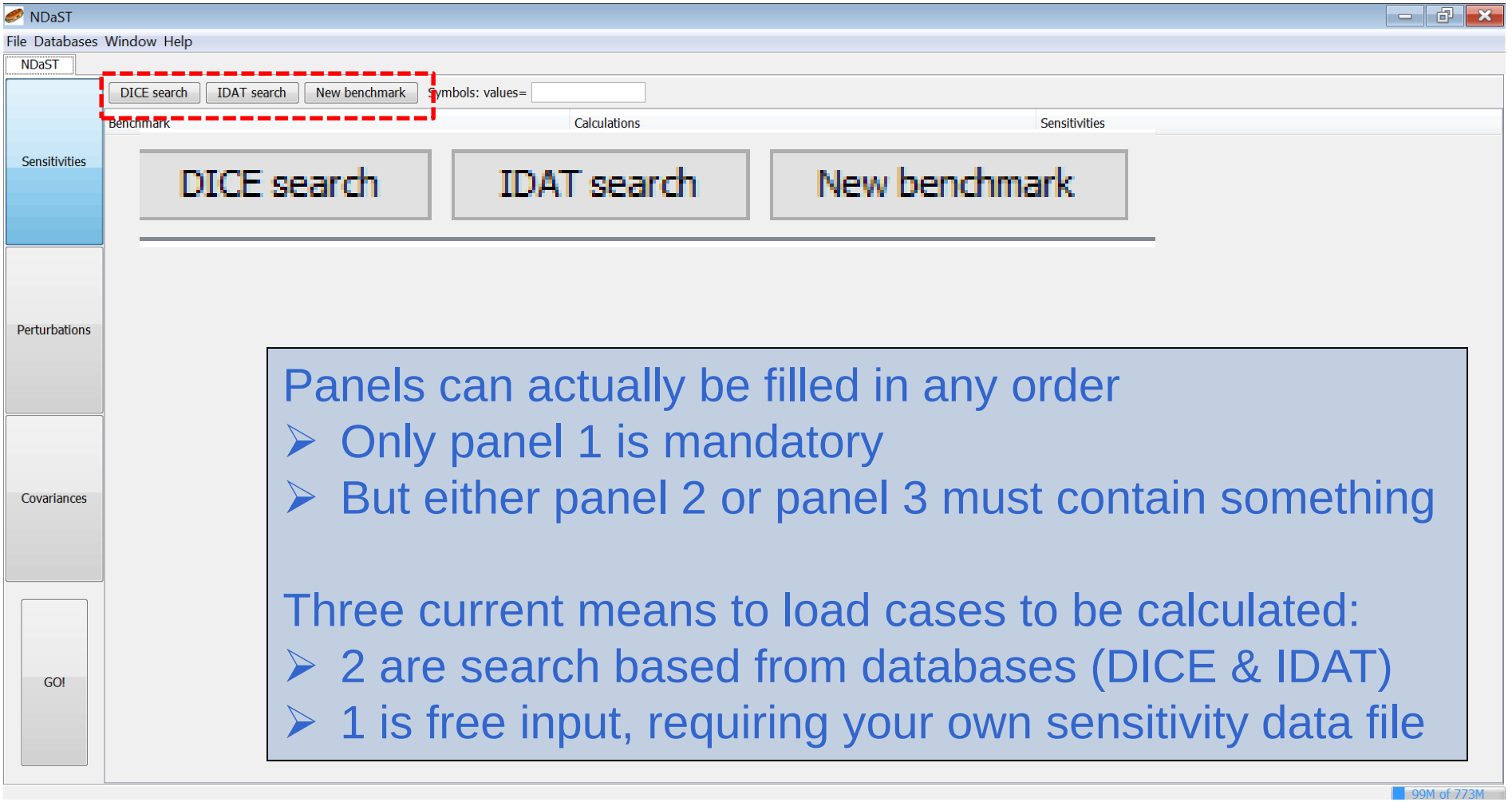
Currently can select benchmarks via DICE and IDAT plug-ins.



- Search using all the usual DB attributes
- Modify the results or add personal case results & sensitivity data
- 'Create' your own personal benchmark
- Save/load custom benchmark suite e.g. CSEWG
- Enable sharing of editable xml file datasets for collaborators / inter-comparisons



Panel 1: Select Benchmark Sensitivity Data



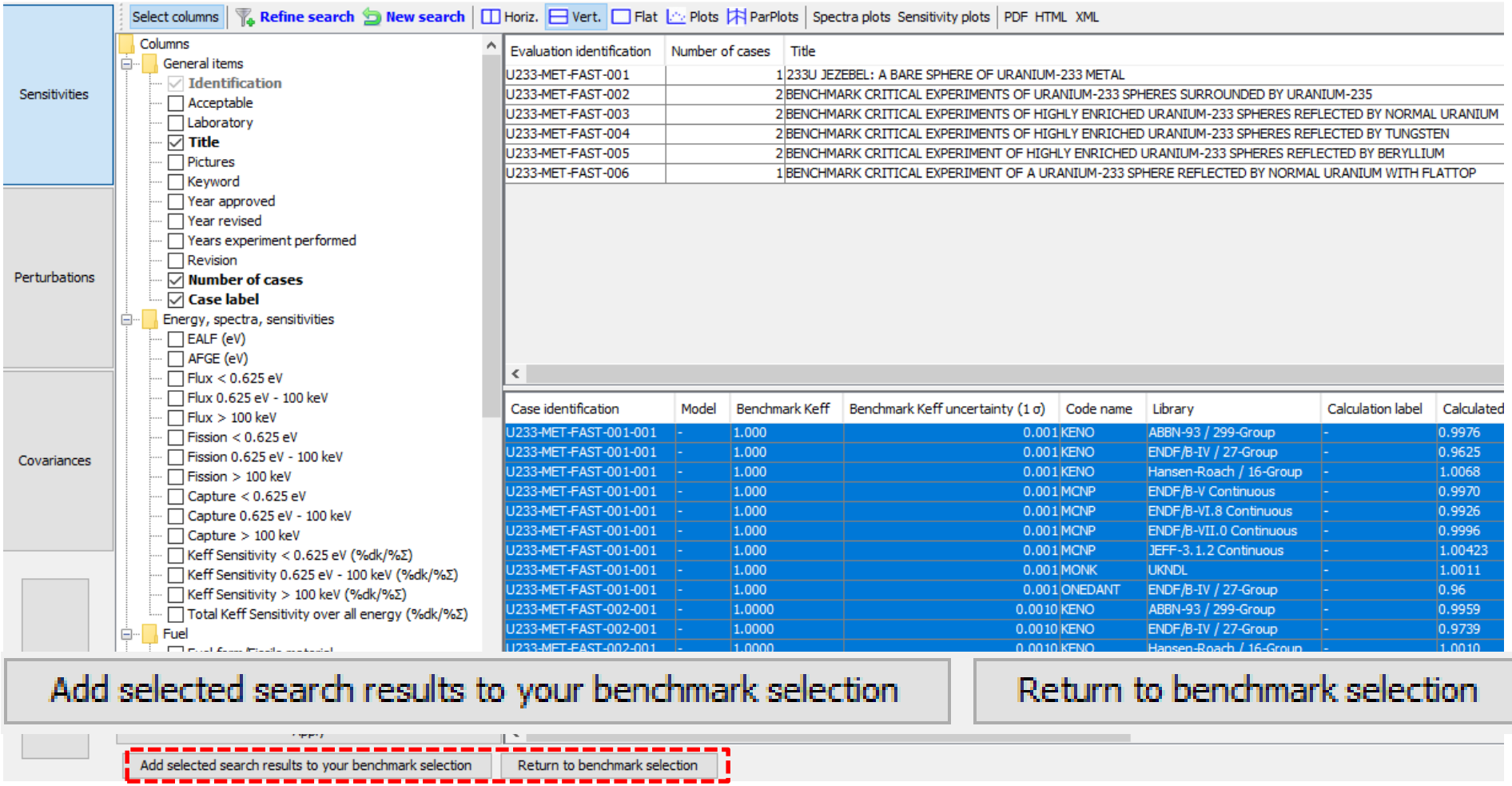
Panels can actually be filled in any order

- Only panel 1 is mandatory
- But either panel 2 or panel 3 must contain something

Three current means to load cases to be calculated:

- 2 are search based from databases (DICE & IDAT)
- 1 is free input, requiring your own sensitivity data file

Addition of Benchmarks to Set



Add selected search results to your benchmark selection

Return to benchmark selection

Tip: Order your table and use Ctrl+click or Ctrl+a

NDaST

File Databases Window Help

NDaST

Sensitivities
8 benchmarks
8 profiles

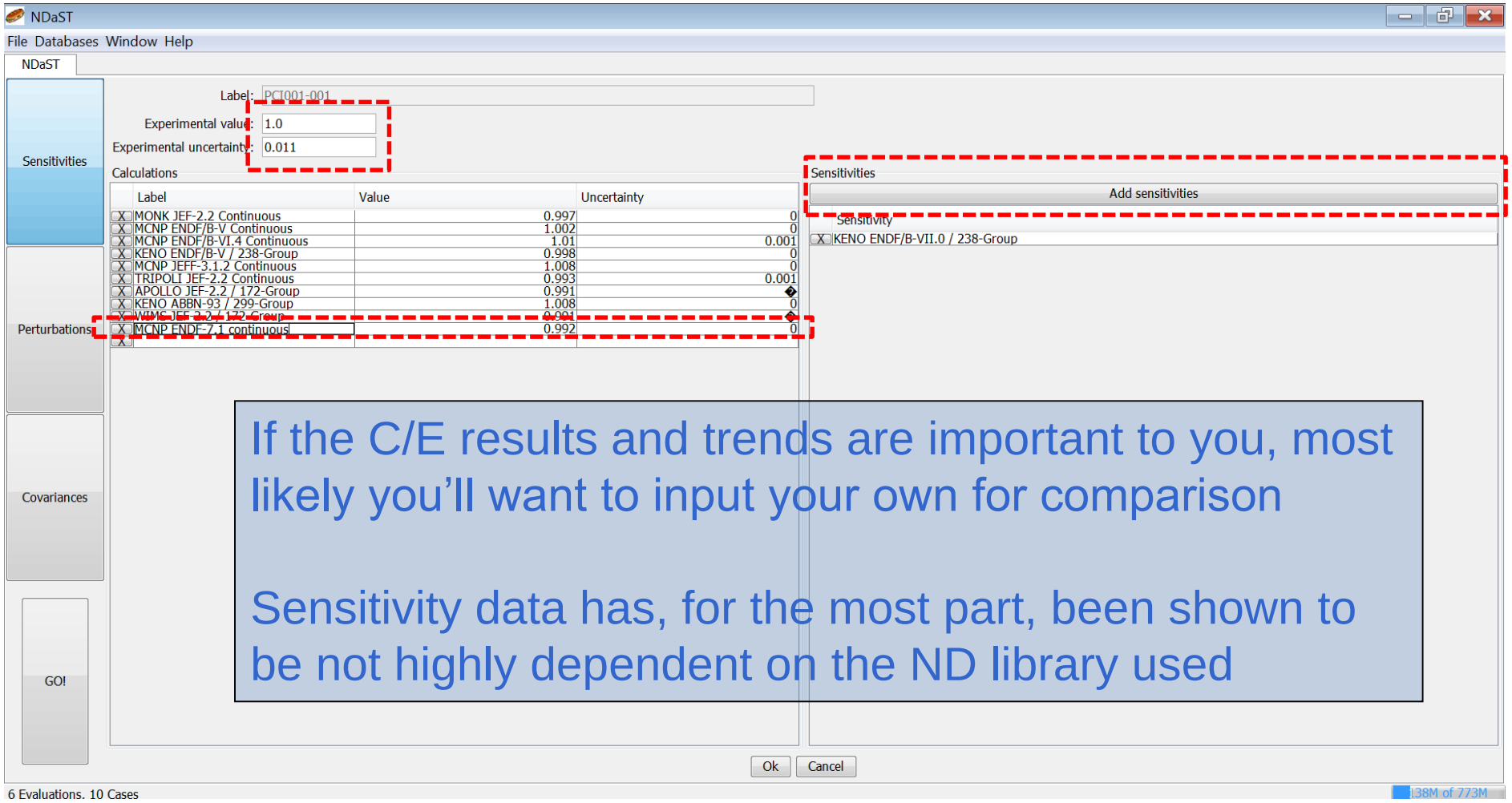
DICE search | IDAT search | New benchmark | Symbols: values= Keff

Benchmark	Calculati...	Sensitivities	ICBEVALS.NUMBER_CASES	ICBCALCS.C_OVER_E
UMF001-001	8 calc(s)	1 sensitivity(ies)	1	1.00423
UMF002-001	7 calc(s)	1 sensitivity(ies)	2	0.9739
UMF002-002	7 calc(s)	1 sensitivity(ies)	2	1.0007
UMF003-001	7 calc(s)	1 sensitivity(ies)	2	1.00485
UMF003-002	7 calc(s)	1 sensitivity(ies)	2	1.00481
UMF005-001	7 calc(s)	1 sensitivity(ies)	2	1.0147
UMF005-002	6 calc(s)	1 sensitivity(ies)	2	1.0187
UMF006-001	8 calc(s)	1 sensitivity(ies)	1	0.9931

This is just a summary table of everything retrieved from the search

The actual data can be viewed and modified by double-clicking on an entry

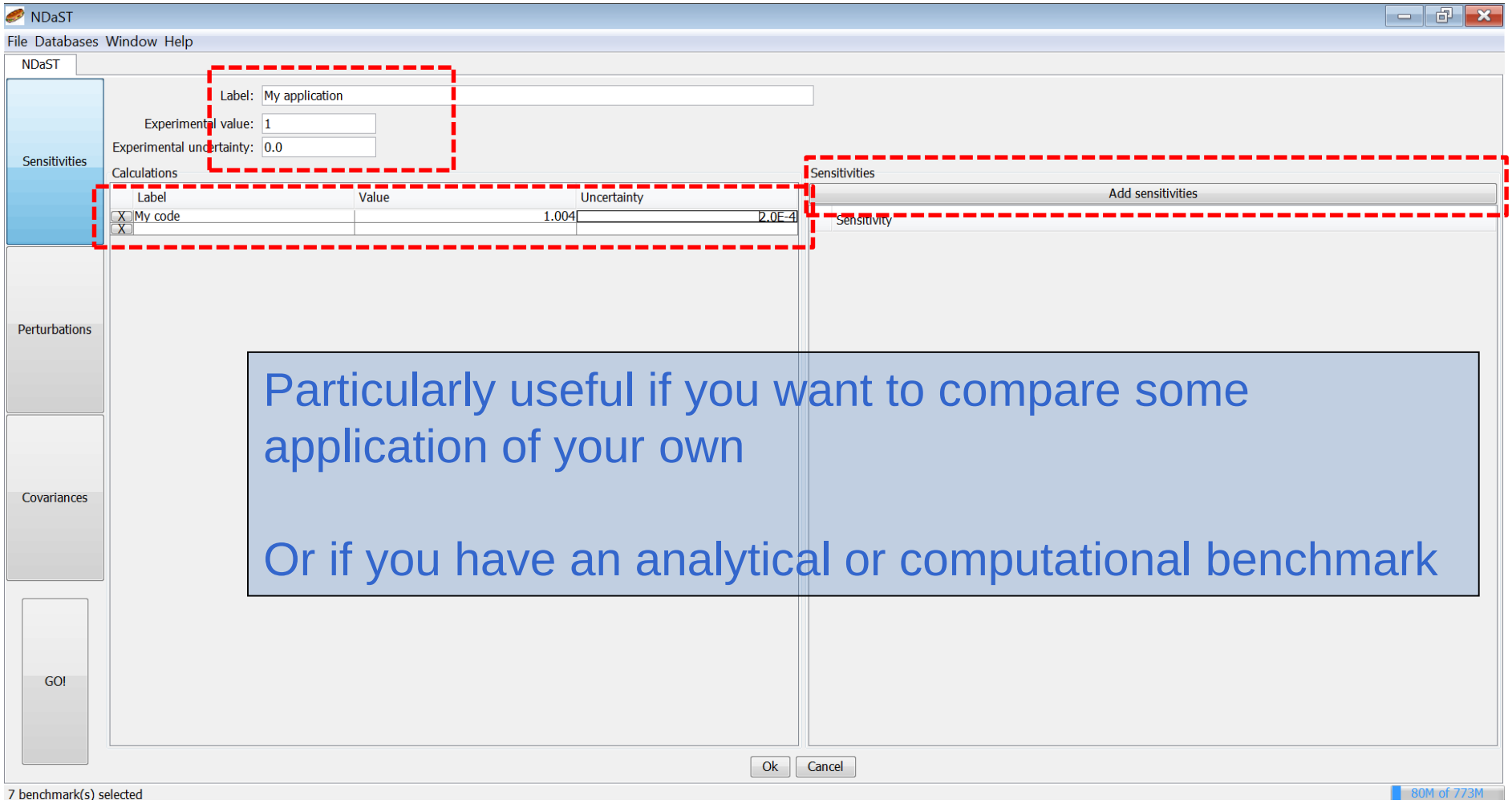
Edit Benchmark Data



If the C/E results and trends are important to you, most likely you'll want to input your own for comparison

Sensitivity data has, for the most part, been shown to be not highly dependent on the ND library used

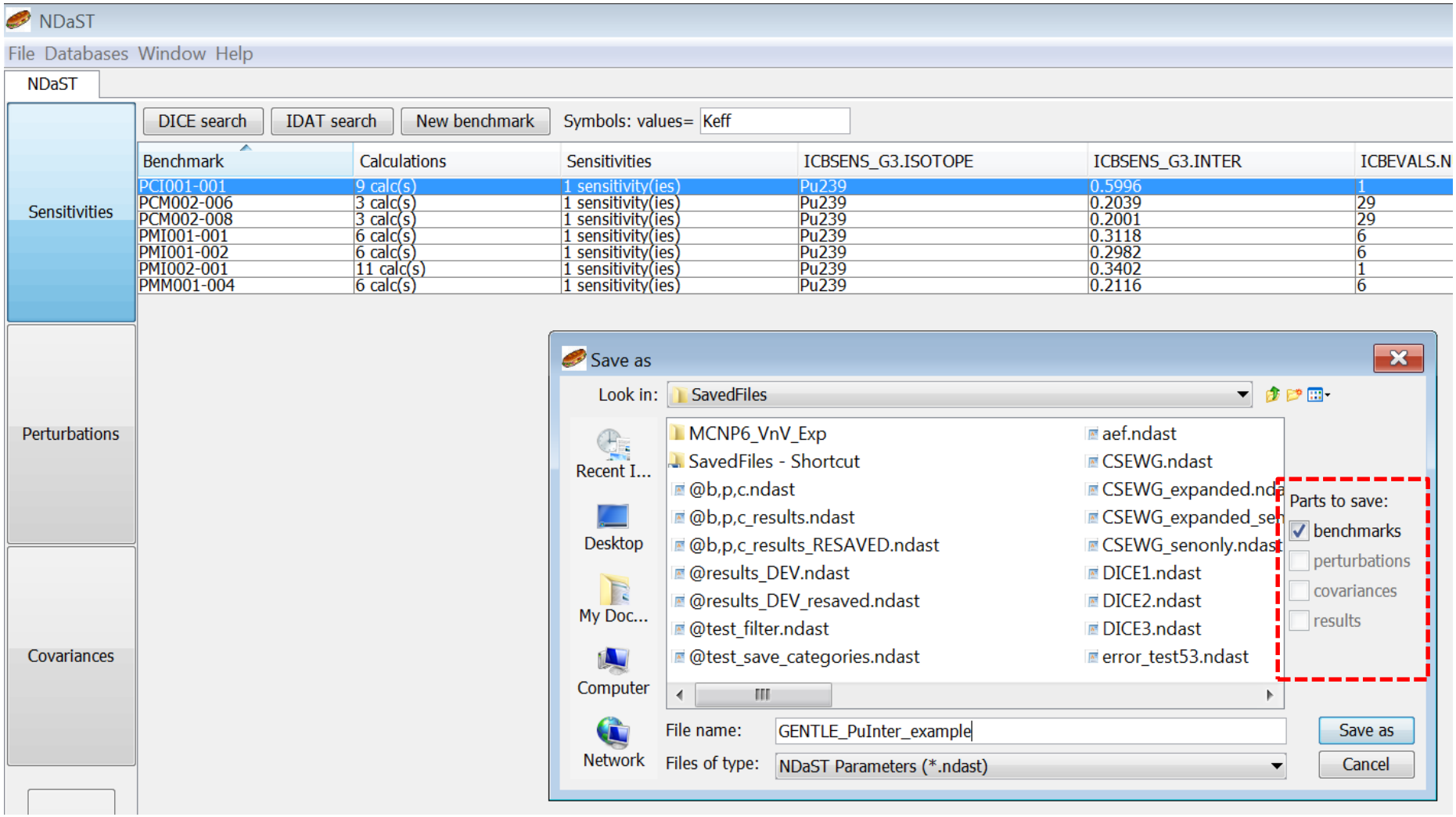
Add ‘New Benchmark’



Particularly useful if you want to compare some application of your own

Or if you have an analytical or computational benchmark

Save and Load Options



Editable xml File

```
<?xml version="1.0" encoding="UTF-8" ?>
<ndast>
  <params>
    <benchmarks symbolValue="Keff" symbolDelta="Î”Keff">
      <benchmark>
        <id type="DICE" case="PU-MET-INTER-001-001" model=""/>
        <exp val="1.0002" unc="0.0037"/>
        <calc type="DICE" code="MCNP" lib="ENDF/B-VI.4
Continuous" freetext="" val="1.012" unc="5.0E-4"/>
        <calc type="DICE" code="MMK-KENO" lib="ABBN-93 / 299-
Group" freetext="" val="1.0107" unc="6.0E-4"/>
        <calc type="DICE" code="MCNP" lib="ENDF/B-V
Continuous" freetext="" val="0.9996" unc="5.0E-4"/>
        <calc type="DICE" code="MONK" lib="JEF-2.2 Continuous"
freetext="" val="1.0124" unc="0.001"/>
        <calc type="DICE" code="MCNP" lib="ENDF/B-VI
Continuous" freetext="" val="1.0148" unc="6.0E-4"/>
        <calc type="DICE" code="MONK" lib="ENDF/B-VI.3
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        <sens type="DICE" case="PU-MET-INTER-001-001"
code="MCNP" lib="ENDF/B-VI Continuous"/>
        <category key="ICBSENS_G3.ISOTOPE">Pu239</category>
        <category key="ICBSENS_G3.INTER">0.3118</category>
        <category key="ICBEVALS.NUMBER_CASES">6</category>
        <category key="ICBSENS_G3.REACTION">fission</category>
      </benchmark>
```
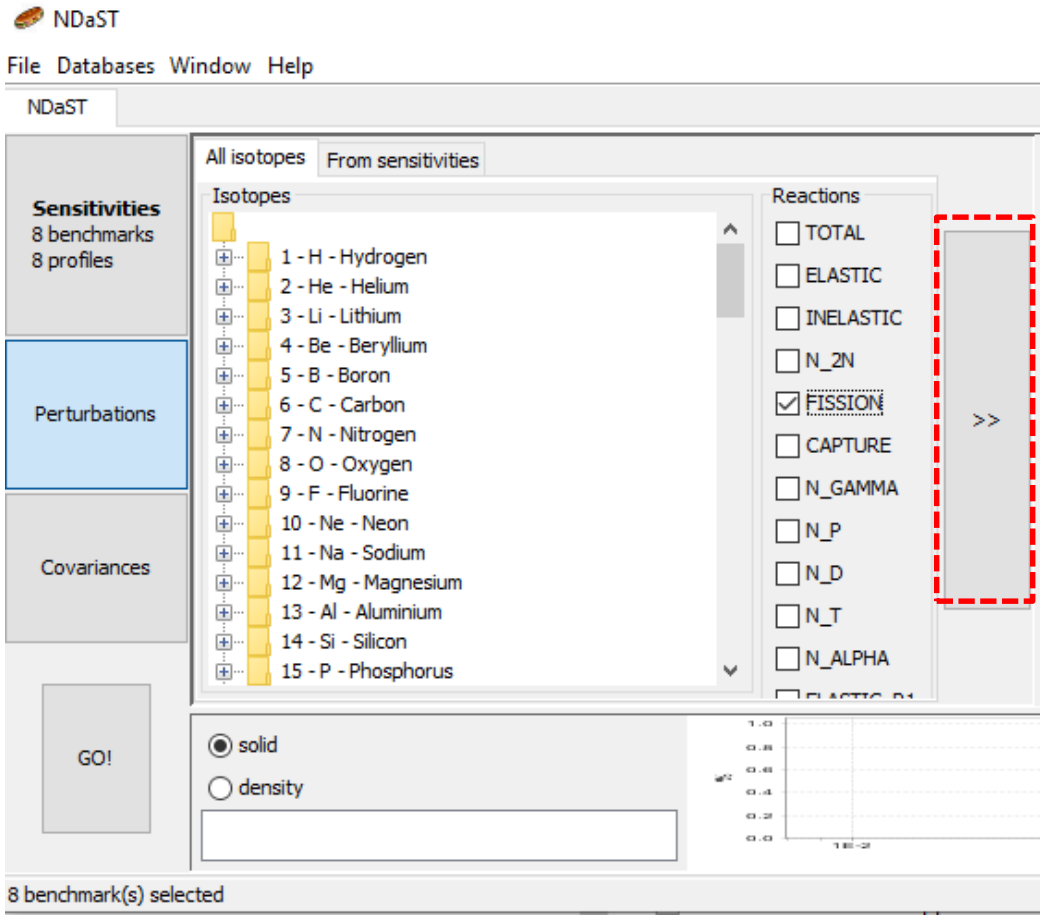

Consult your ‘How To NDaST’ guide for format

Panel 2: Isotope-Reaction-Energy Perturbations

Each isotope-reaction represented by a column with N energy group rows



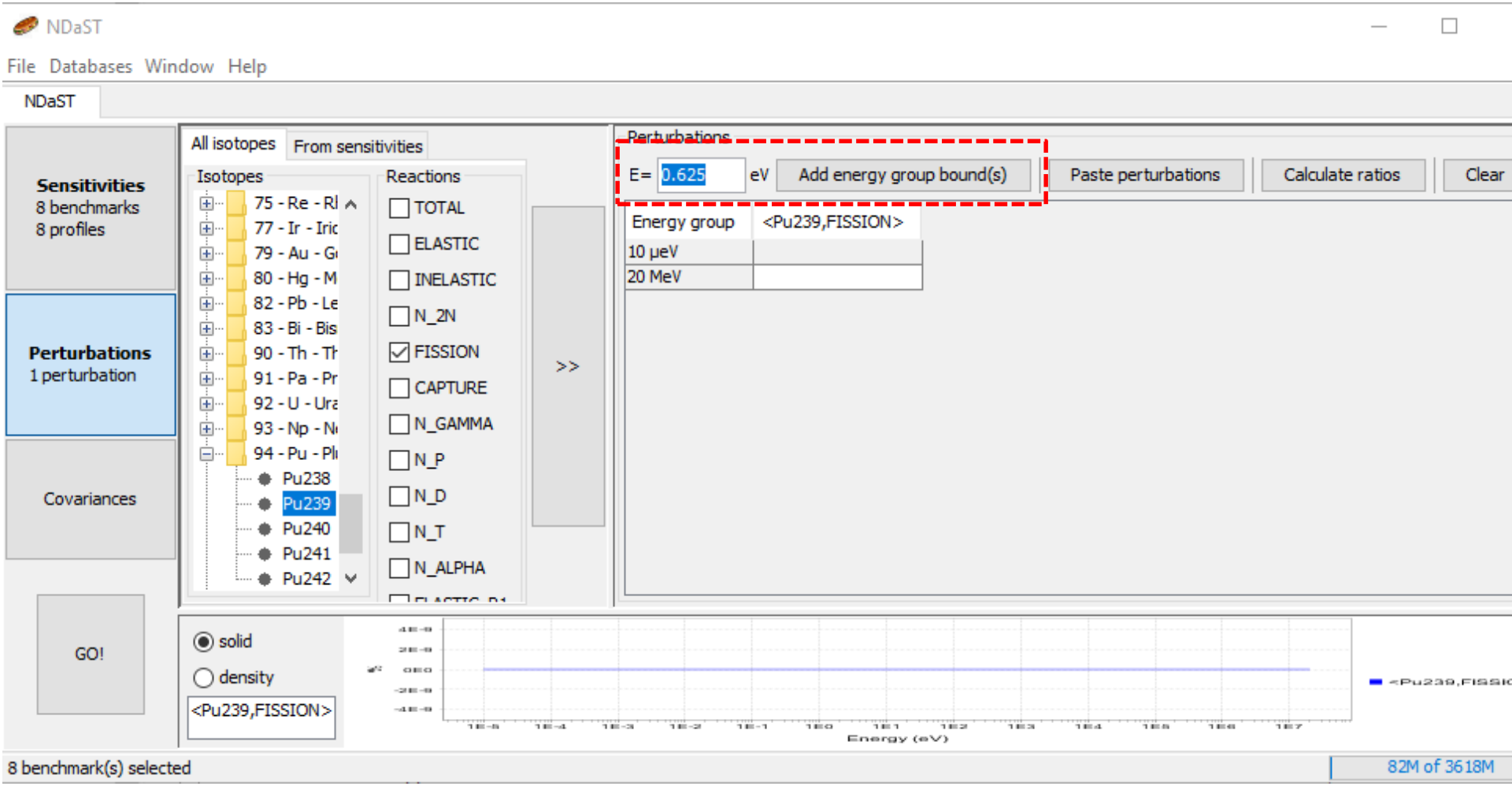
Loading Options:

- Manually
- Copy/paste e.g. from file
- Auto-computed by dividing 2 evaluated files (via JANIS) Example:

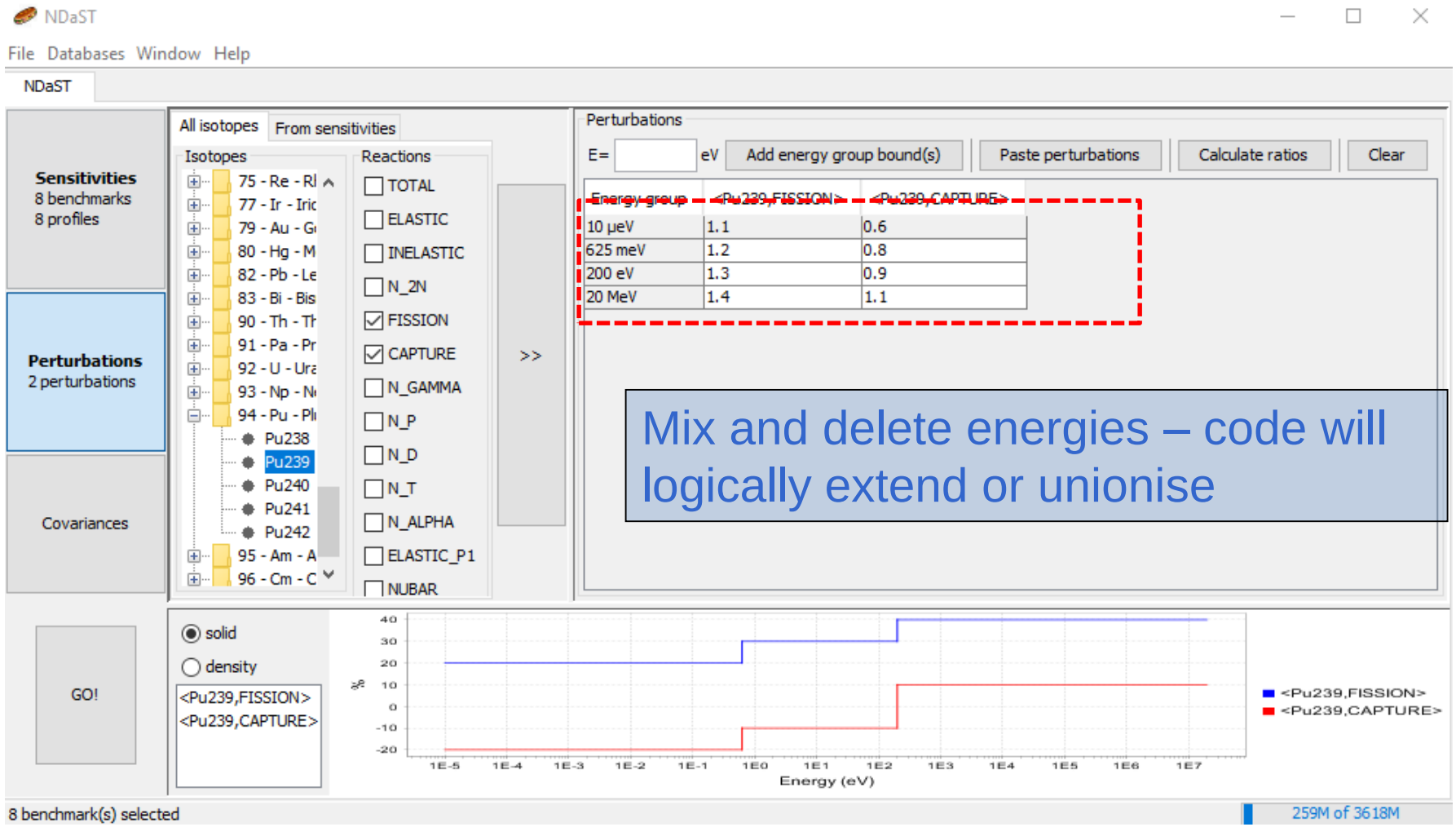
CIELO ÷ ENDF/B-VII.1

- Save in isolation or with panel 1 benchmarks

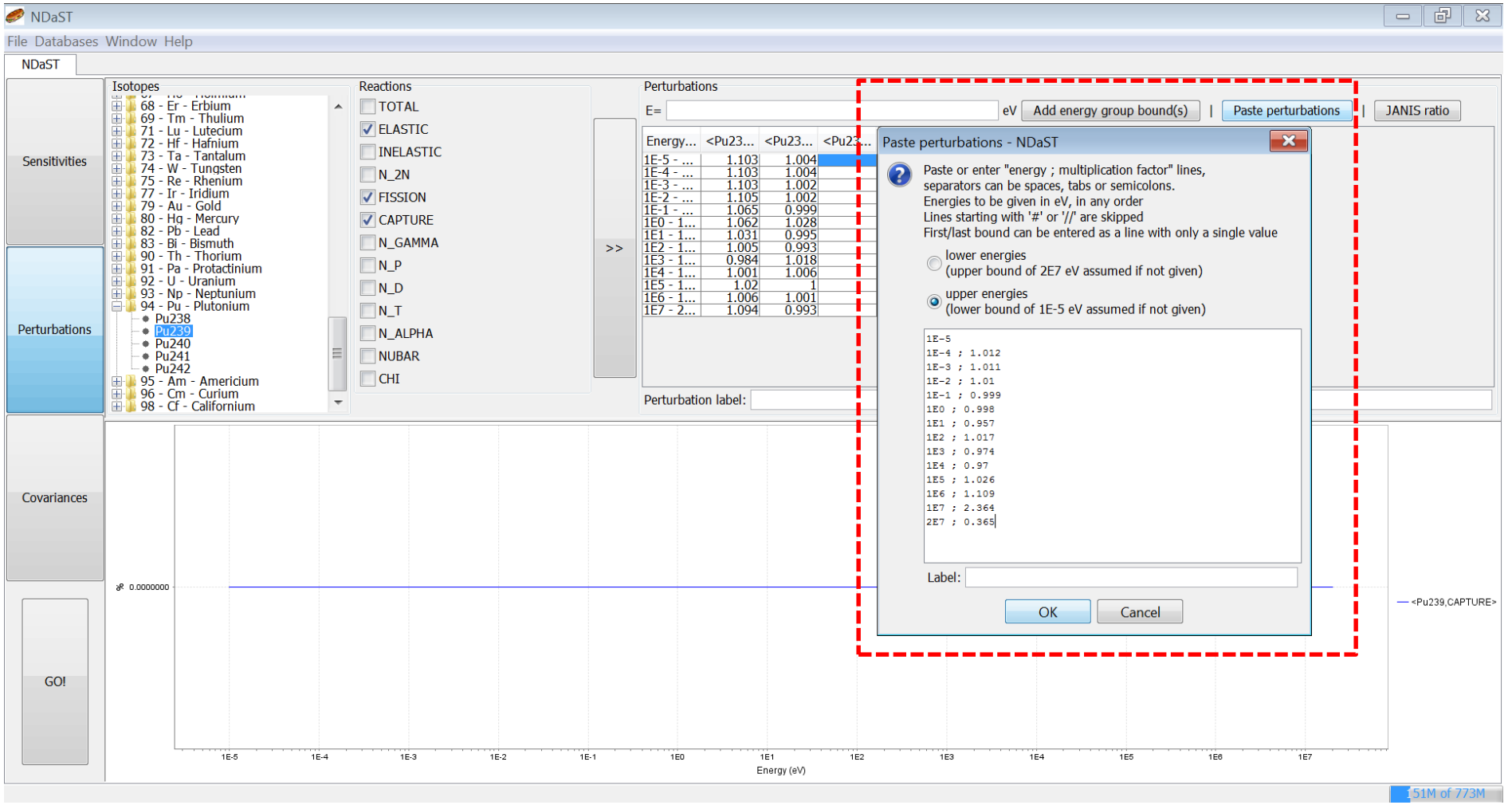
Add Energy & Perturbation Manually



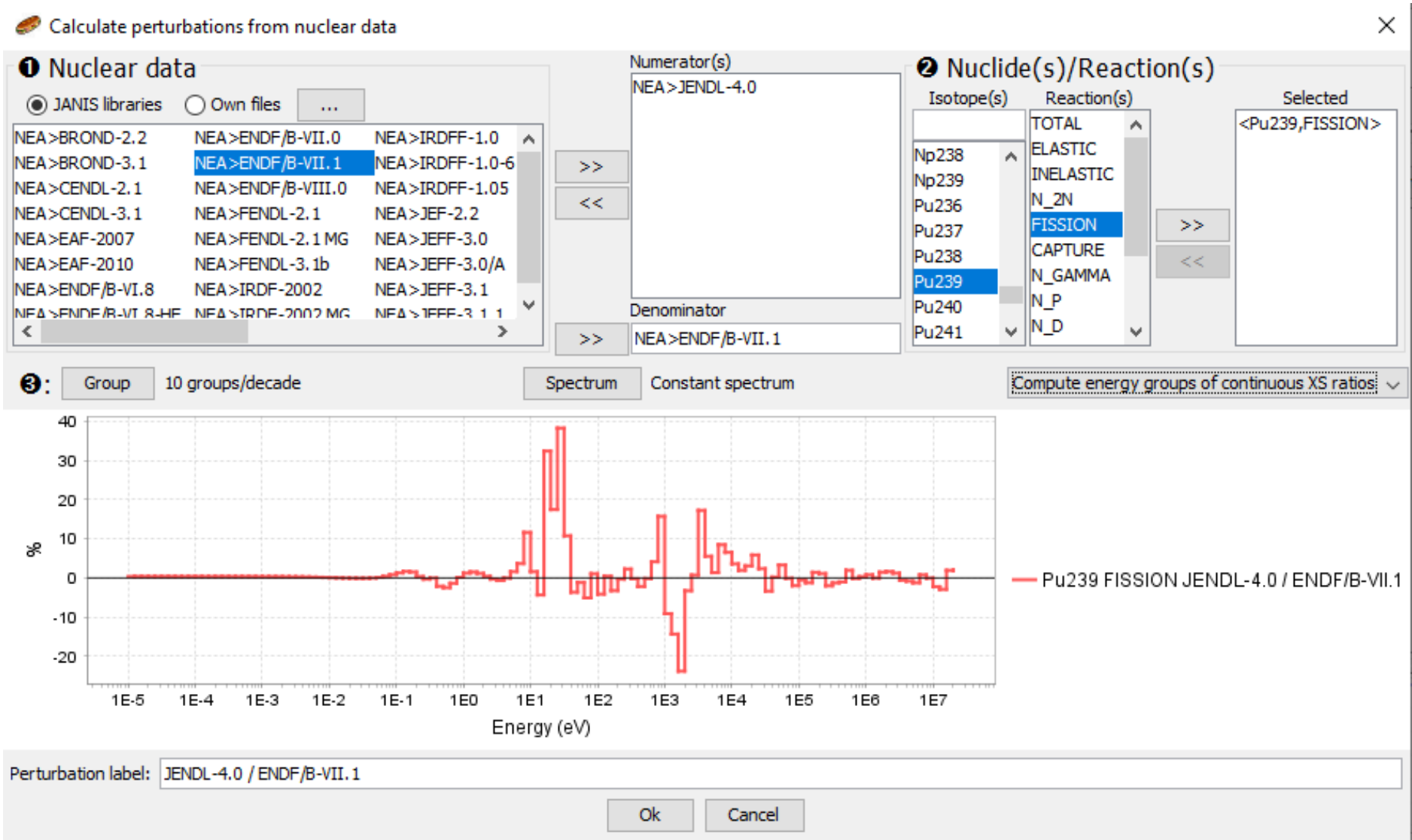
Add Energy & Perturbation Manually



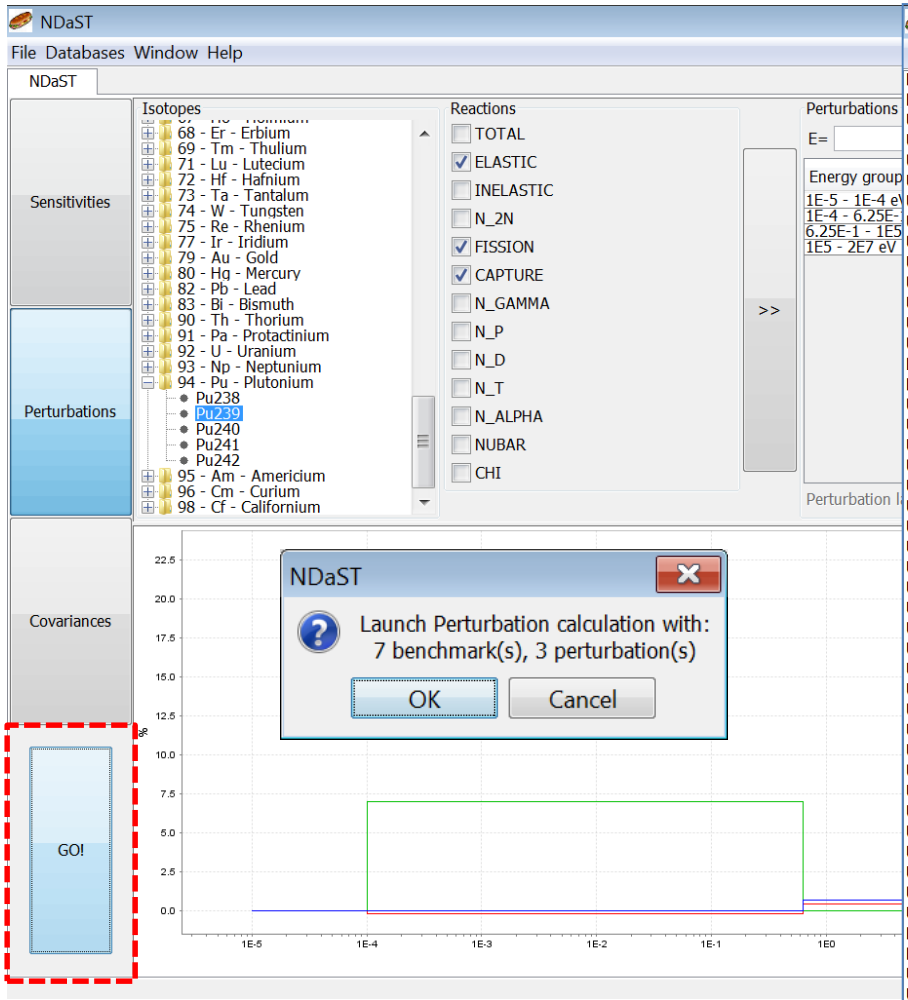
Paste Energies & Perturbations



Computation of Ratios in JANIS



Launch Perturbation Calculation



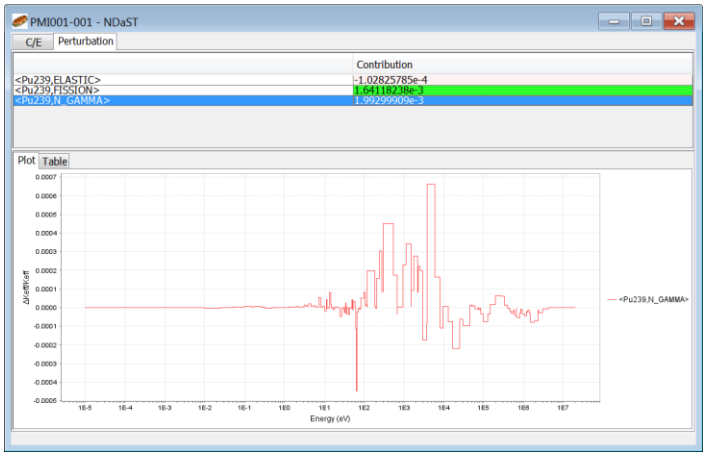
Results - NDaST

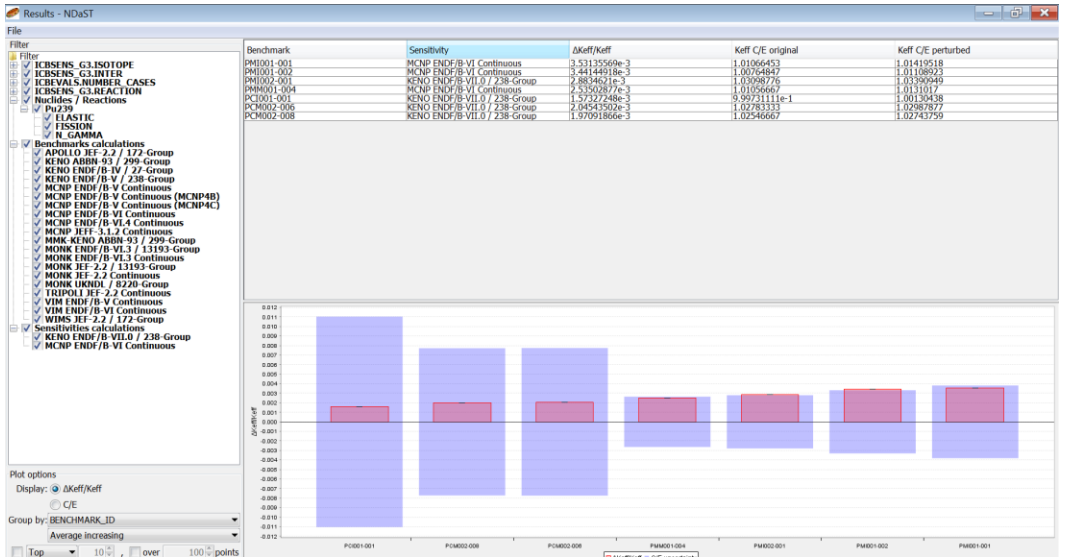
File

```
PERT>   DICE[PCI001-001;]
PERT>    DICE[case=PU-COMP-INTER-001-001 type=SENSITIVITY code=KENO library=ENDF/B-VII.0 / 238-Group]
UNCER>    -> 6.08441252864059E-6
UNCER>     {<Pu239,FISSION>,<Pu239,N_GAMMA>}
UNCER>    -> 1.687825268113648E-7
UNCER>     {<Pu239,ELASTIC>,<Pu239,N_GAMMA>}
UNCER>    -> -1.1965019794201889E-8
UNCER>     {<Pu239,ELASTIC>,<Pu239,FISSION>}
UNCER>    -> 1.5416086410375235E-8
UNCER>   DICE[PCM002-008;]
UNCER>    DICE[case=PU-COMP-MIXED-002-008 type=SENSITIVITY code=KENO library=ENDF/B-VII.0 / 238-Group]
UNCER>     {<Pu239,ELASTIC>,<Pu239,ELASTIC>}
UNCER>    -> 5.242279257862125E-8
UNCER>     {<Pu239,FISSION>,<Pu239,FISSION>}
PERT>   DICE[PMI001-002;]
PERT>    DICE[case=PU-MET-INTER-001-002 type=SENSITIVITY code=MCNP library=ENDF/B-VI Continuous]
UNCER>    -> 5.0727034537967136E-6
UNCER>     {<Pu239,N_GAMMA>,<Pu239,N_GAMMA>}
UNCER>    -> 4.7570066074159375E-6
UNCER>     {<Pu239,FISSION>,<Pu239,N_GAMMA>}
UNCER>    -> 3.1421634518774925E-9
UNCER>     {<Pu239,ELASTIC>,<Pu239,N_GAMMA>}
UNCER>    -> 1.986559163054255E-8
UNCER>     {<Pu239,ELASTIC>,<Pu239,FISSION>}
UNCER>    -> 4.0788668839728676E-10
UNCER>   DICE[PCI001-001;]
UNCER>    DICE[case=PU-COMP-INTER-001-001 type=SENSITIVITY code=KENO library=ENDF/B-VII.0 / 238-Group]
UNCER>     {<Pu239,ELASTIC>,<Pu239,ELASTIC>}
UNCER>    -> 1.2538544368114808E-7
UNCER>     {<Pu239,FISSION>,<Pu239,FISSION>}
UNCER>    -> 2.489041557364693E-5
UNCER>     {<Pu239,N_GAMMA>,<Pu239,N_GAMMA>}
UNCER>    -> 7.035549444764207E-6
UNCER>     {<Pu239,FISSION>,<Pu239,N_GAMMA>}
UNCER>    -> -2.0381817191270436E-6
UNCER>     {<Pu239,ELASTIC>,<Pu239,N_GAMMA>}
UNCER>    -> -1.5883094343585428E-7
UNCER>     {<Pu239,ELASTIC>,<Pu239,FISSION>}
UNCER>    -> -8.747587206254423E-8
UNCER>   DICE[PMI001-002;]
UNCER>    DICE[case=PU-MET-INTER-001-002 type=SENSITIVITY code=MCNP library=ENDF/B-VI Continuous]
UNCER>     {<Pu239,ELASTIC>,<Pu239,ELASTIC>}
PERT>   DICE[PMI002-001;]
PERT>    DICE[case=PU-MET-INTER-002-001 type=SENSITIVITY code=KENO library=ENDF/B-VII.0 / 238-Group]
UNCER>    -> 2.7880762358182364E-8
UNCER>     {<Pu239,FISSION>,<Pu239,FISSION>}
UNCER>    -> 5.484742575128667E-6
UNCER>     {<Pu239,N_GAMMA>,<Pu239,N_GAMMA>}
```

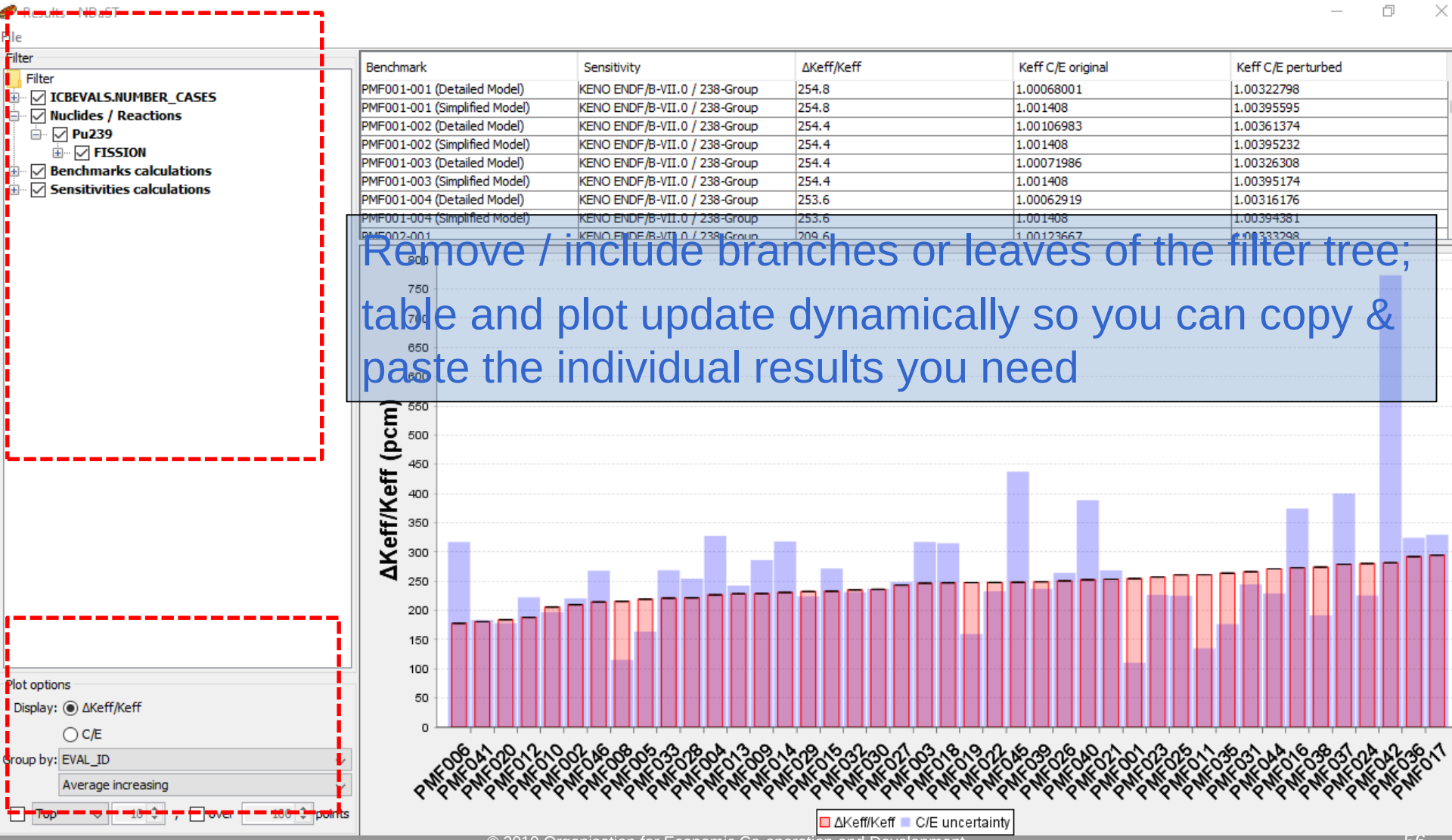
Output Window and Plots (1)

- Window with results table of $\Delta k_{eff}/k_{eff}$, original & perturbed mean C/E
- Filter tree to the side – dynamic inclusion by nuclide, reaction, fuel, code…
- Grouped plot below – toggle either Δk_{eff} or C/E
- Grouping and sorting options, plus tool-tip data for the plot
- Detail pop-up to see complete data behind each benchmark in the table
  - Nuclide-reaction breakdown of total Δk_{eff}
  - Individual C/E for all results loaded to that case
  - Energy breakdown of Δk_{eff}





Delta k_{eff} Output and Plot



C/E Output Plot: Calculation Library + Tooltips

Results - NDaST

File

Filter

- Filter
  - Nuclides / Reactions
    - Pu239
      - ELASTIC
      - FISSION
      - N_GAMMA
  - Benchmarks calculations
    - APOLLO JEF-2.2 / 172-Group
    - KENO ABBN-93 / 299-Group
    - KENO ENDF/B-IV / 27-Group
    - KENO ENDF/B-V / 238-Group
    - MCNP ENDF-7.1 continuous
    - MCNP ENDF/B-V Continuous
    - MCNP ENDF/B-V Continuous (MCNP4B)
    - MCNP ENDF/B-V Continuous (MCNP4C)
    - MCNP ENDF/B-VI Continuous
    - MCNP ENDF/B-VI.4 Continuous
    - MCNP JEFF-3.1.2 Continuous
    - MMK-KENO ABBN-93 / 299-Group
    - MONK ENDF/B-VI.3 / 13193-Group
    - MONK ENDF/B-VI.3 Continuous
    - MONK JEF-2.2 / 13193-Group
    - MONK JEF-2.2 Continuous
    - MONK UKNDL / 8220-Group
    - TRIPOLI JEF-2.2 Continuous
    - VIM ENDF/B-V Continuous
    - VIM ENDF/B-VI Continuous
    - WIMS JEF-2.2 / 172-Group
  - Sensitivities calculations
    - KENO ENDF/B-VII.0 / 238-Group
    - MCNP ENDF/B-VI Continuous

Plot options

Display: ΔKeff/Keff / C/E

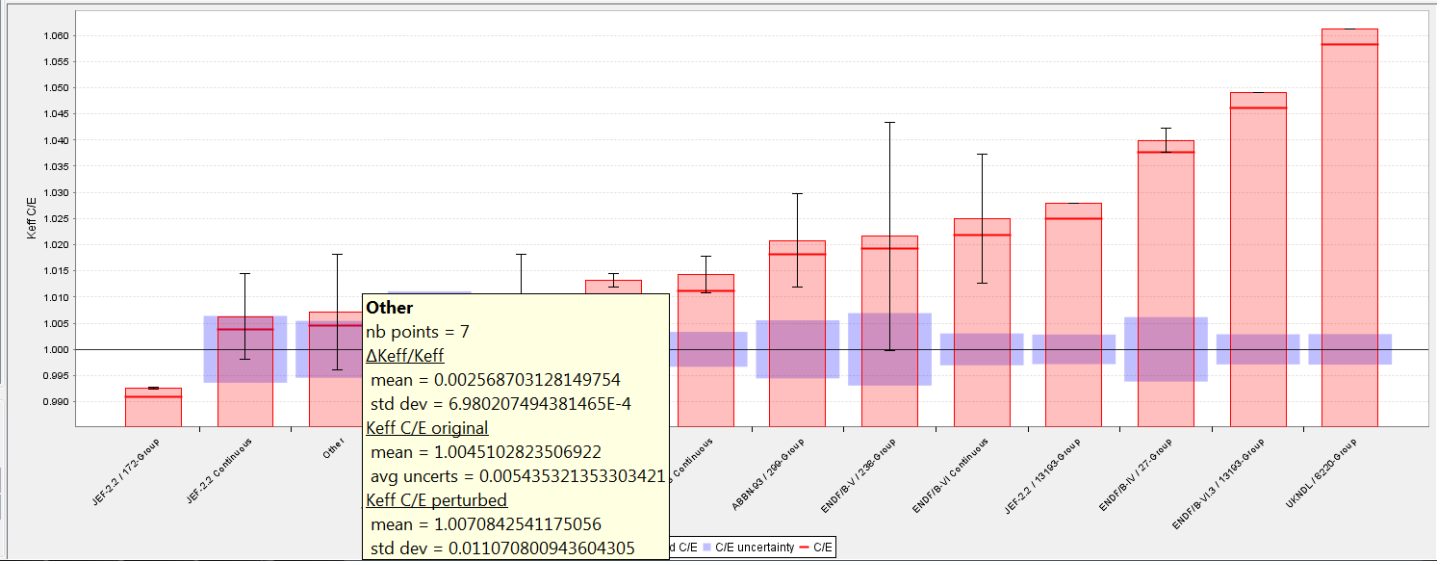
Group by: CALC_LIB

Average increasing

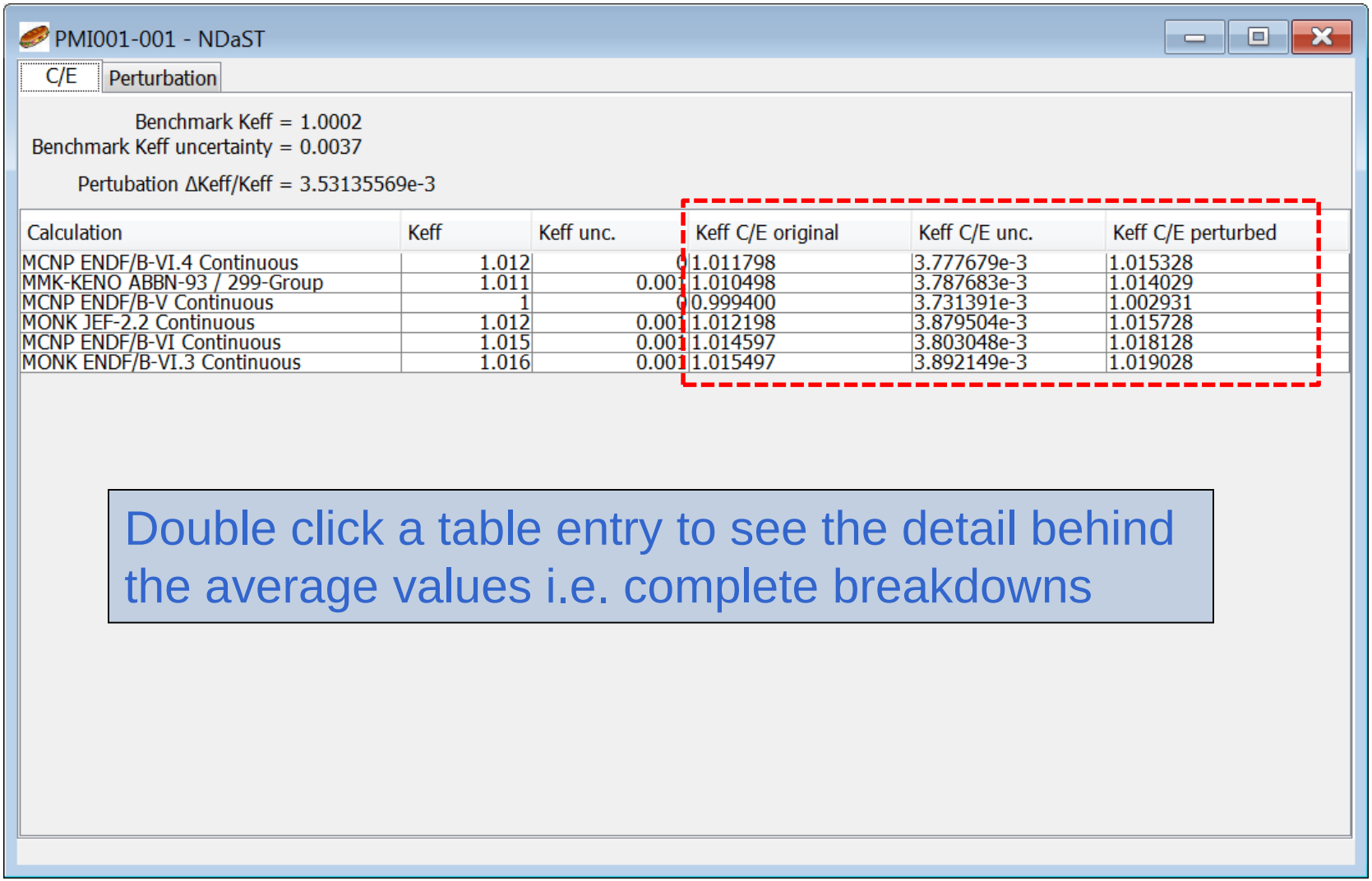
Top 10 , over 100 points

Benchmark	Sensitivity	ΔKeff/Keff	Keff C/E original	Keff C/E perturbed
PMI001-001	MCNP ENDF/B-VI Continuous	3.53135569e-3	1.00918388	1.01271453
PMI001-002	MCNP ENDF/B-VI Continuous	3.44144918e-3	1.00724141	1.01068217
PMI002-001	KENO ENDF/B-VII.0 / 238-Group	2.8834621e-3	1.03077819	1.03369993
PMM001-004	MCNP ENDF/B-VI Continuous	2.5350287 7e-3	1.01005714	1.01259217
PCI001-001	KENO ENDF/B-VII.0 / 238-Group	1.57327248e-3	9.98958e-1	1.00053127
PCM002-006	KENO ENDF/B-VII.0 / 238-Group	2.04543502e-3	1.020375	1.02242044
PCM002-008	KENO ENDF/B-VII.0 / 238-Group	1.97091866e-3	1.01935	1.02132092

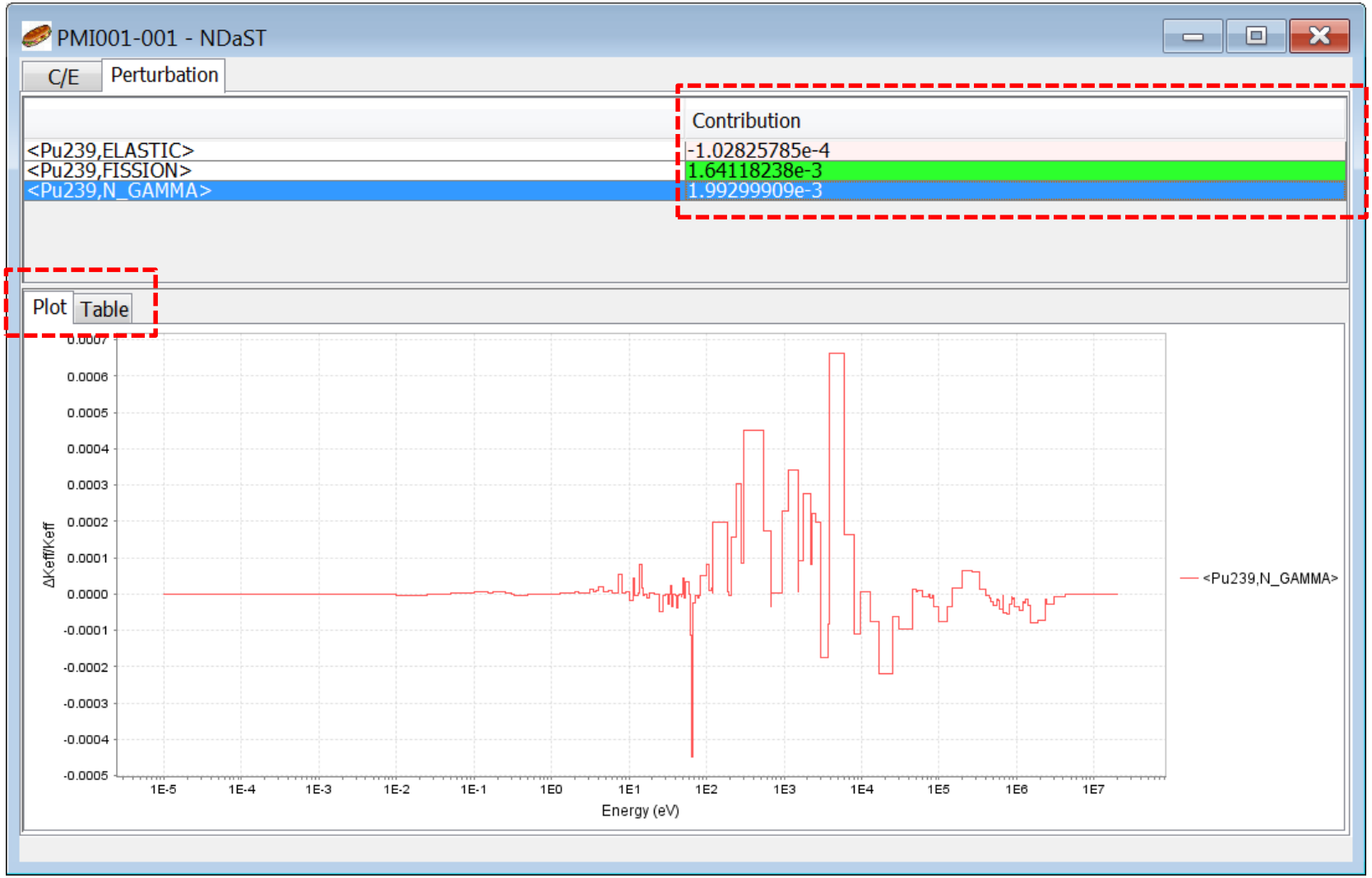
Use tool-tips for a quick reference quantification of each bar



Output Table: Detail Popup (C/E)



Output Table: Detail Popup (Perturbation)



Exercise 1 - Perturbations

I. Choose BMs based on some sensitivity criteria to Pu239
   - Select top cases (max ~10)

II. Edit the cases with 'personal' k_{eff} calculations

III. Input a simple 3 group perturbation for 3 main reactions
   - Elastic, capture, fission

IV. Run the tool and get an output sorted by spectrum
   - Try excluding all non 'personal' results

V. Decide if this improves each of the results

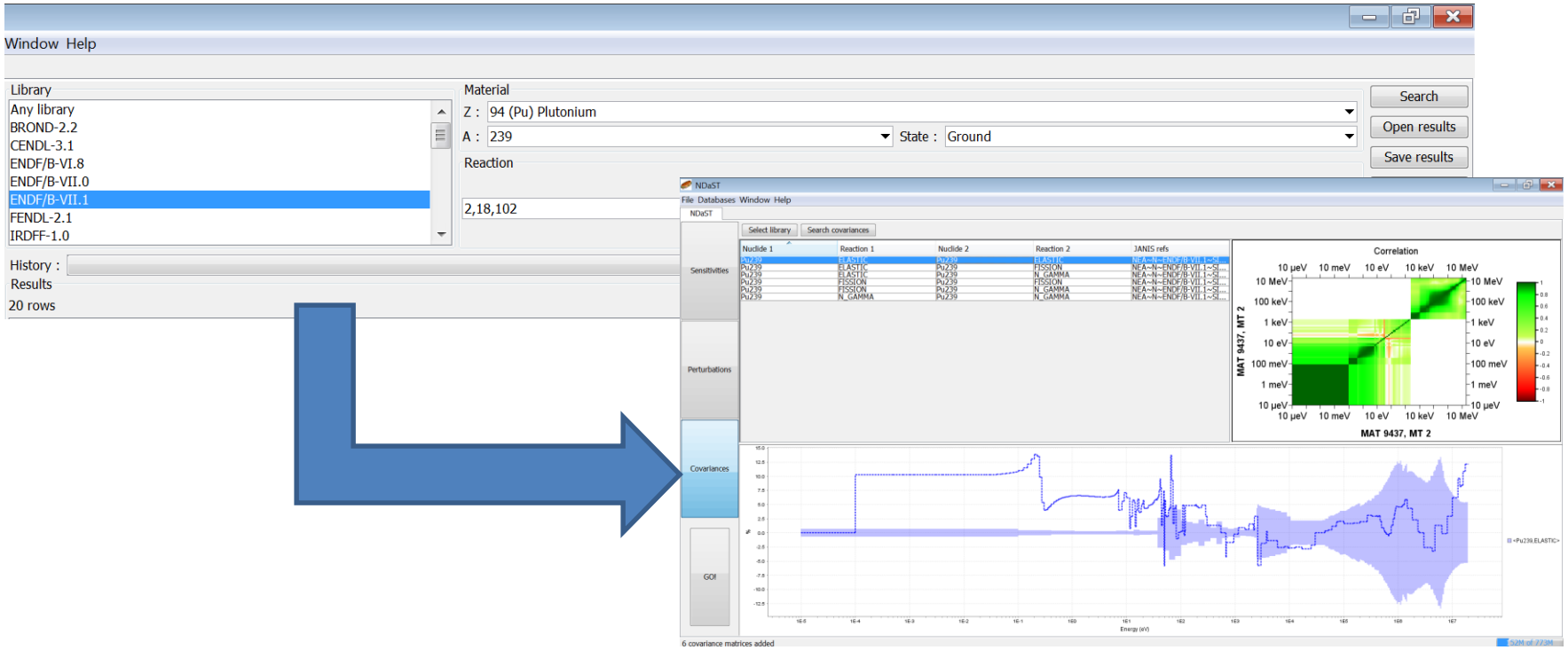
VI. Do this again, but with a full 'JANIS ratio' computation

VII. Analyse which energy region has the biggest impact

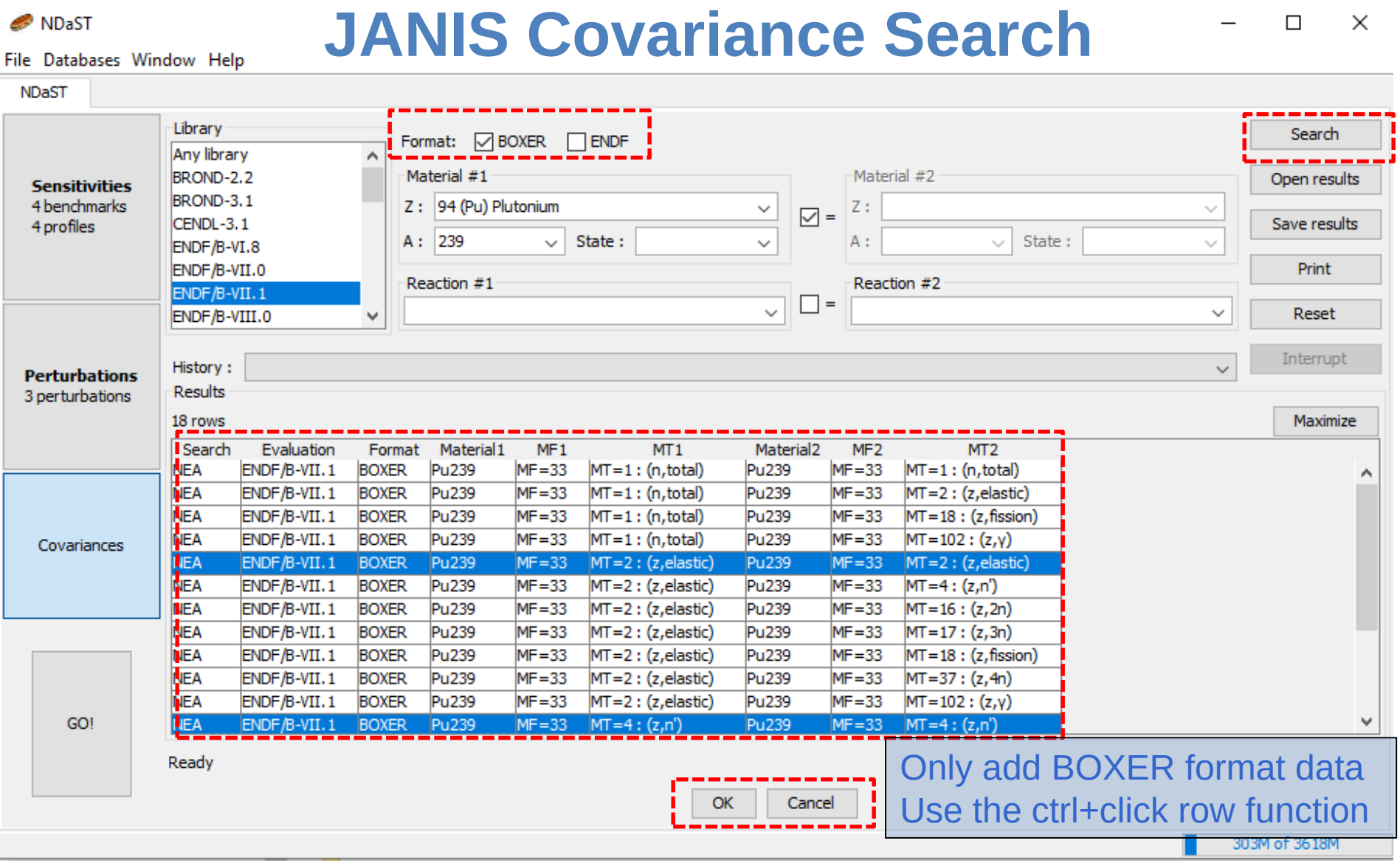
Panel 3: Select XS Covariance Data

Covariance data selected from JANIS for uncertainty propagation calculation

- Many different sources of covariance in NEA base
- You can also add your own to JANIS and use within NDaST (slightly advanced)
- Correlation and standard deviation plots from JANIS are shown
- Relative standard deviations plotted against perturbations if they exist

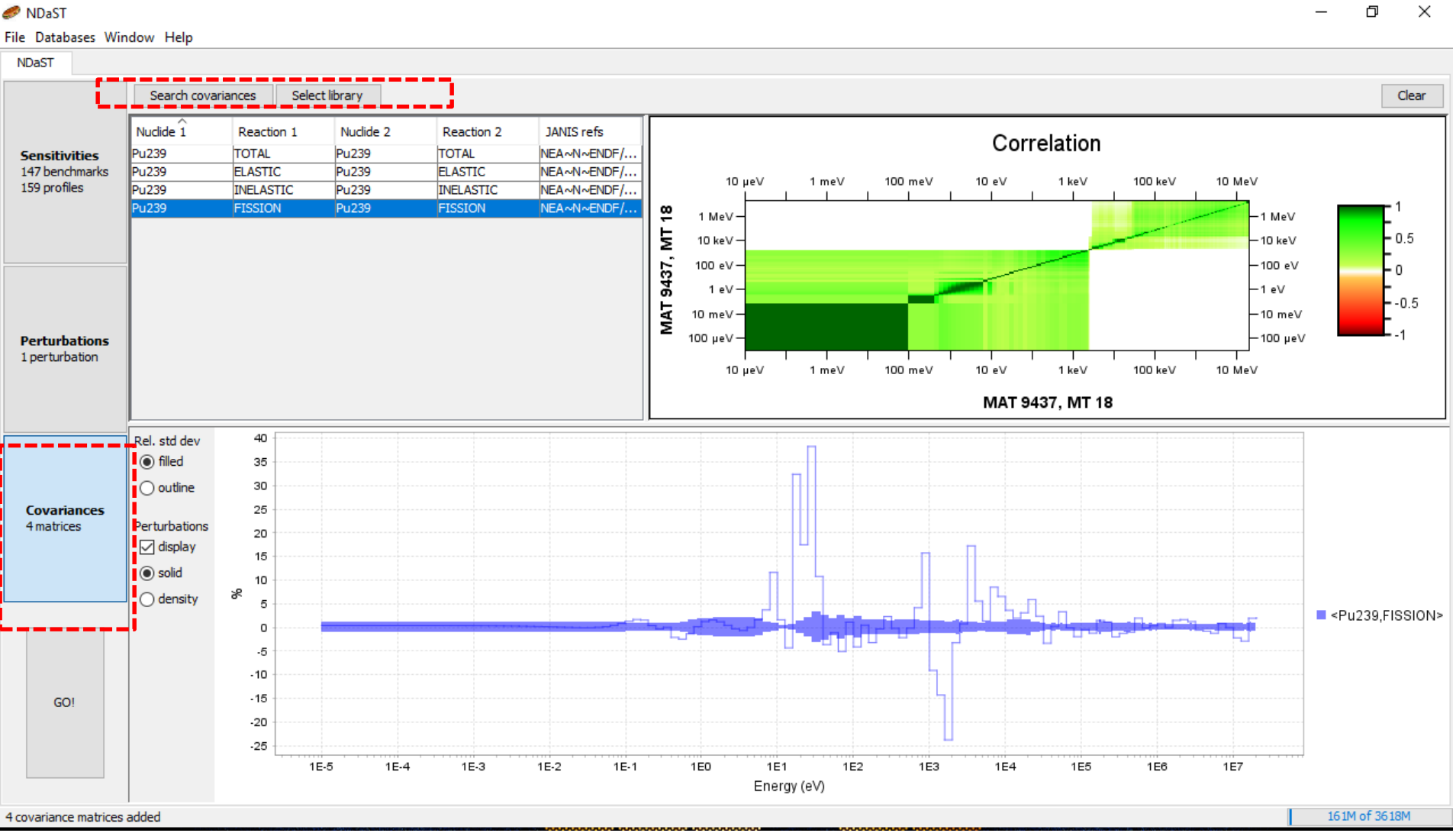


JANIS Covariance Search

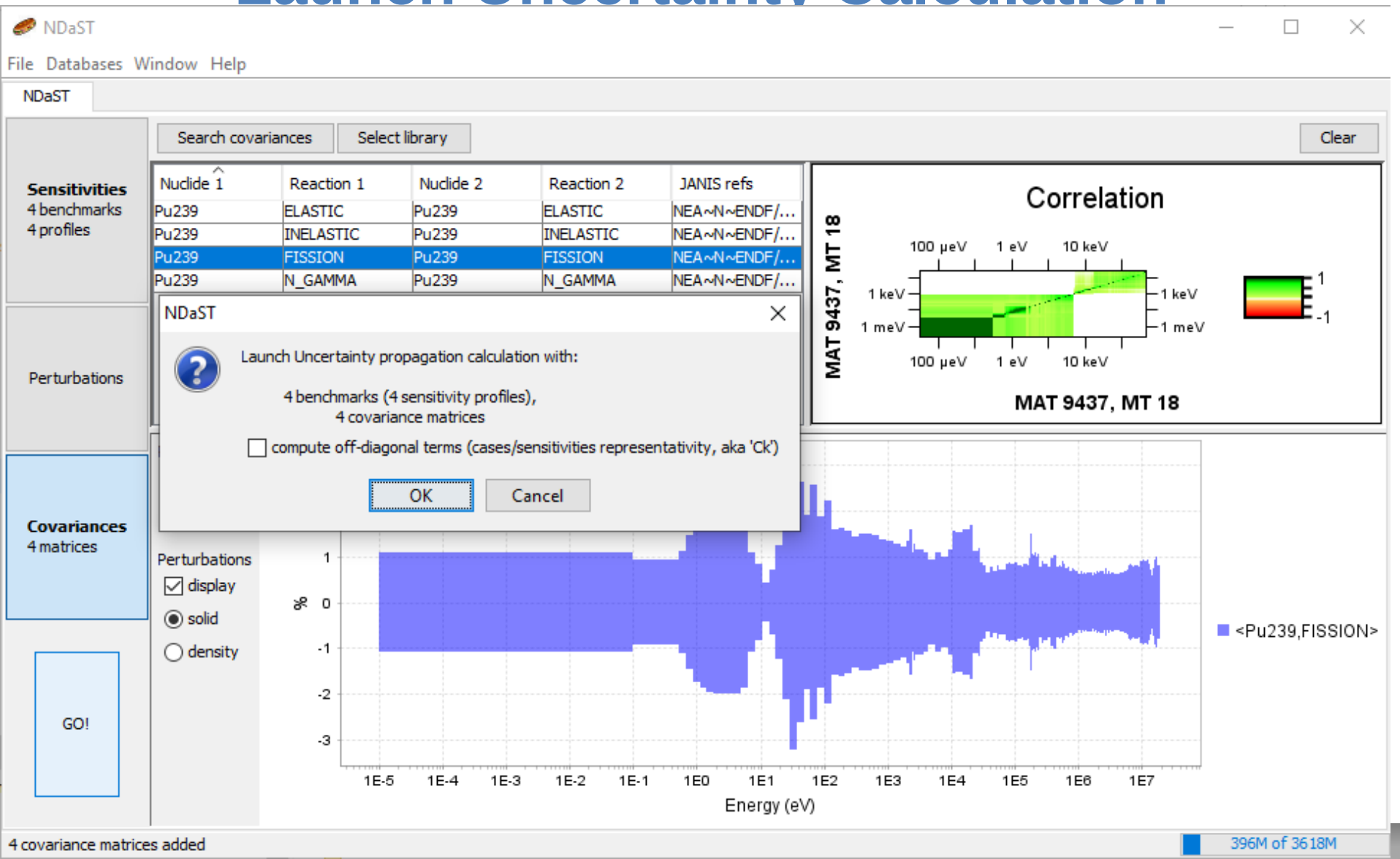


Only add BOXER format data
Use the ctrl+click row function

View Selected Covariance Files

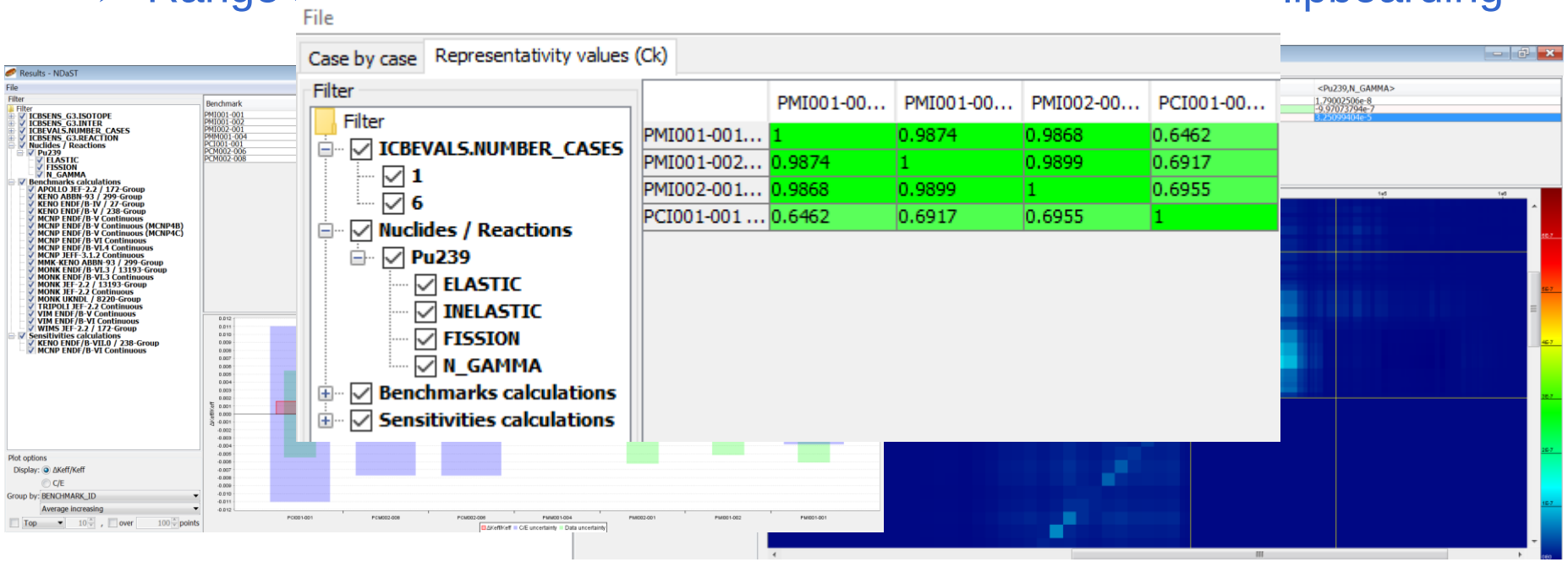


Launch Uncertainty Calculation



Output Window and Plots (2)

- Results table of $\Delta k_{eff}/k_{eff}$, original & perturbed C/E **+ XS uncertainty**
- Grouped plot below – toggle either Δk_{eff} or C/E **+ XS uncertainty bar**
- Detail pop-up to see complete data behind each benchmark in the table
  - Nuclide-reaction breakdown of total Δk_{eff} **+ XS uncertainty (new tab)**
  - Energy breakdown of **XS uncertainty as colour / heat map**
  - Range … lipboarding



Delta k_{eff} Output and Plot

Results - NDaST

File

Filter

- Filter
- ICBSENS_G3.ISOTOPE
- ICBSENS_G3.INTER
- ICBEVALS.NUMBER_CASES
- ICBSENS_G3.REACTION
- Nuclides / Reactions
  - Pu239
    - ELASTIC
    - FISSION
    - N_GAMMA
- Benchmarks calculations
  - APOLLO JEF-2.2 / 172-Group
  - KENO ABBN-93 / 299-Group
  - KENO ENDF/B-IV / 27-Group
  - KENO ENDF/B-V / 238-Group
  - MCNP ENDF/B-V Continuous
  - MCNP ENDF/B-V Continuous (MCNP4B)
  - MCNP ENDF/B-V Continuous (MCNP4C)
  - MCNP ENDF/B-VI Continuous
  - MCNP ENDF/B-VI.4 Continuous
  - MCNP JEFF-3.1.2 Continuous
  - MMK-KENO ABBN-93 / 299-Group
  - MONK ENDF/B-VI.3 / 13193-Group
  - MONK ENDF/B-VI.3 Continuous
  - MONK JEF-2.2 / 13193-Group
  - MONK JEF-2.2 Continuous
  - MONK UKNDL / 8220-Group
  - TRIPOLI JEF-2.2 Continuous
  - VIM ENDF/B-V Continuous
  - VIM ENDF/B-VI Continuous
  - WIMS JEF-2.2 / 172-Group
- Sensitivities calculations
  - KENO ENDF/B-VII.0 / 238-Group
  - MCNP ENDF/B-VI Continuous

Plot options

Display: ΔKeff/Keff

C/E

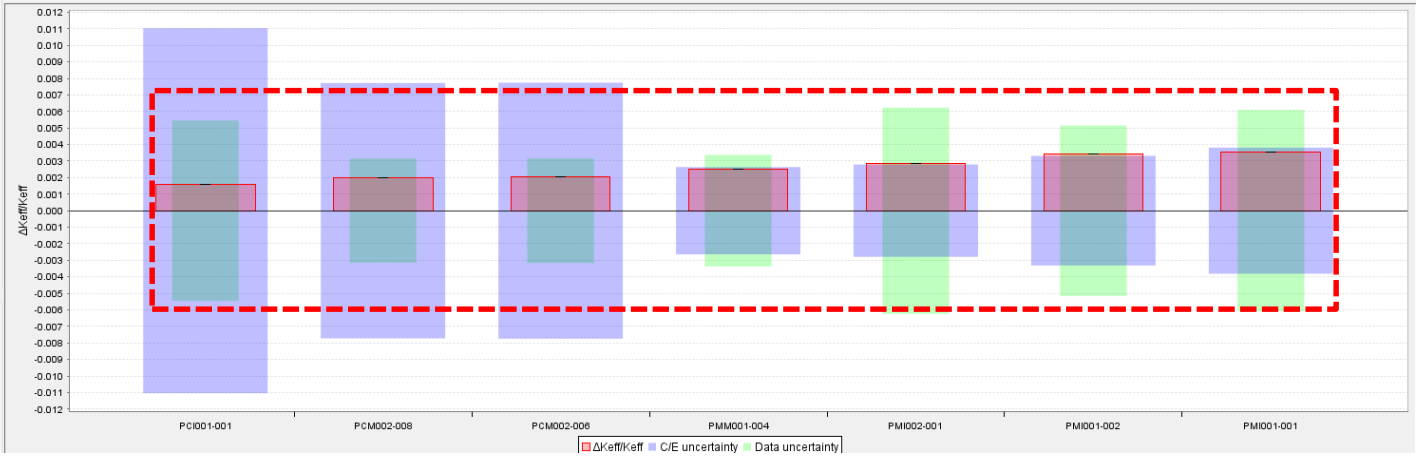
Group by: BENCHMARK_ID

Average increasing

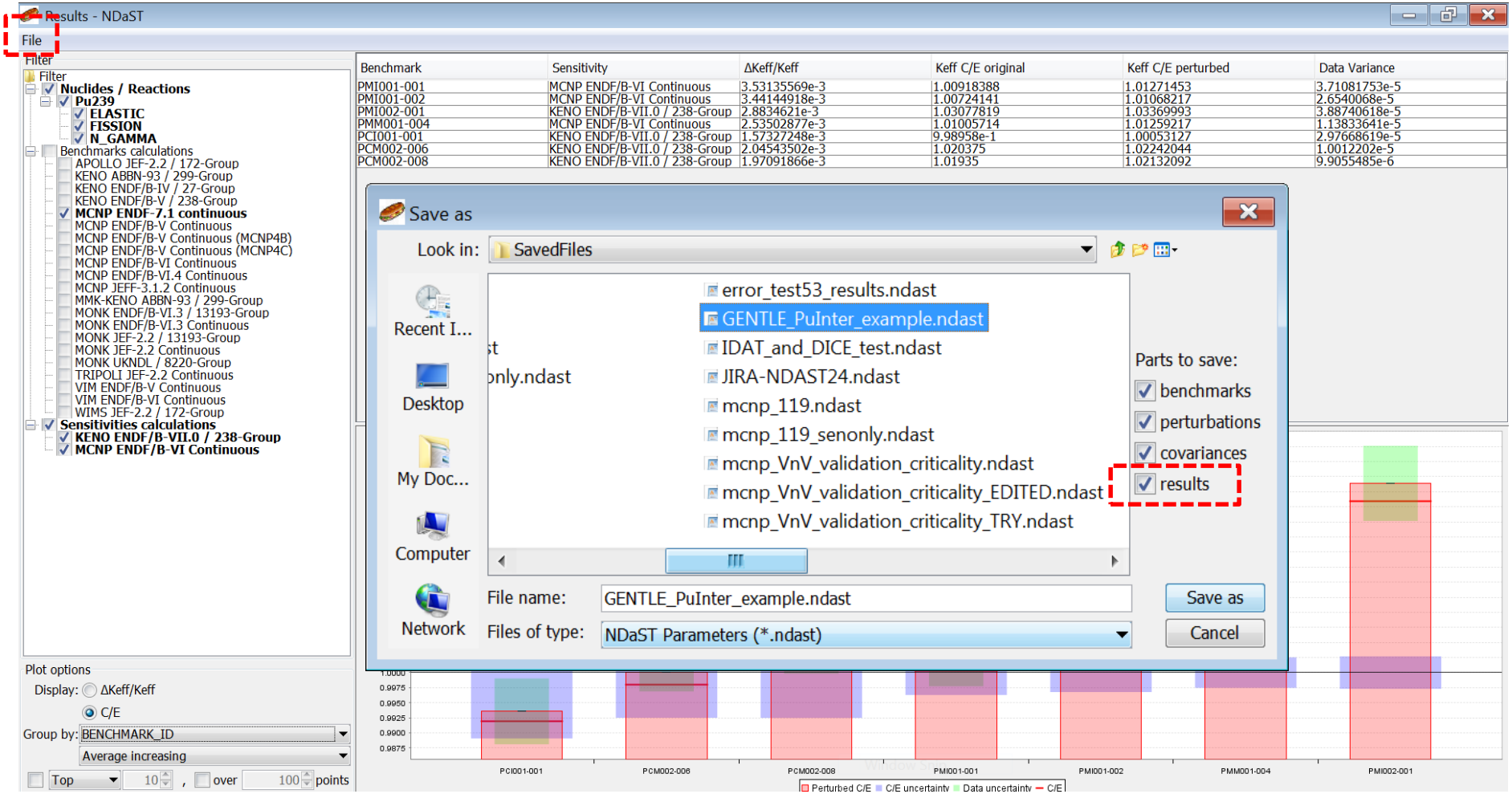
Top 10 , over 100 points

Benchmark	Sensitivity	ΔKeff/Keff	Keff C/E original	Keff C/E perturbed	Data Variance
PMI001-001	MCNP ENDF/B-VI Continuous	3.53135569e-3	1.01066453	1.01419518	3.71081753e-5
PMI001-002	MCNP ENDF/B-VI Continuous	3.44144918e-3	1.00764847	1.01108923	2.6540068e-5
PMI002-001	KENO ENDF/B-VII.0 / 238-Group	2.8834621e-3	1.03098776	1.03390949	3.88740618e-5
PMM001-004	MCNP ENDF/B-VI Continuous	2.53502877e-3	1.01056667	1.0131017	1.13833641e-5
PCI001-001	KENO ENDF/B-VII.0 / 238-Group	1.57327248e-3	9.99731111e-1	1.00130438	2.97668619e-5
PCM002-006	KENO ENDF/B-VII.0 / 238-Group	2.04543502e-3	1.02783333	1.02987877	1.0012202e-5
PCM002-008	KENO ENDF/B-VII.0 / 238-Group	1.97091866e-3	1.02546667	1.02743759	9.9055485e-6

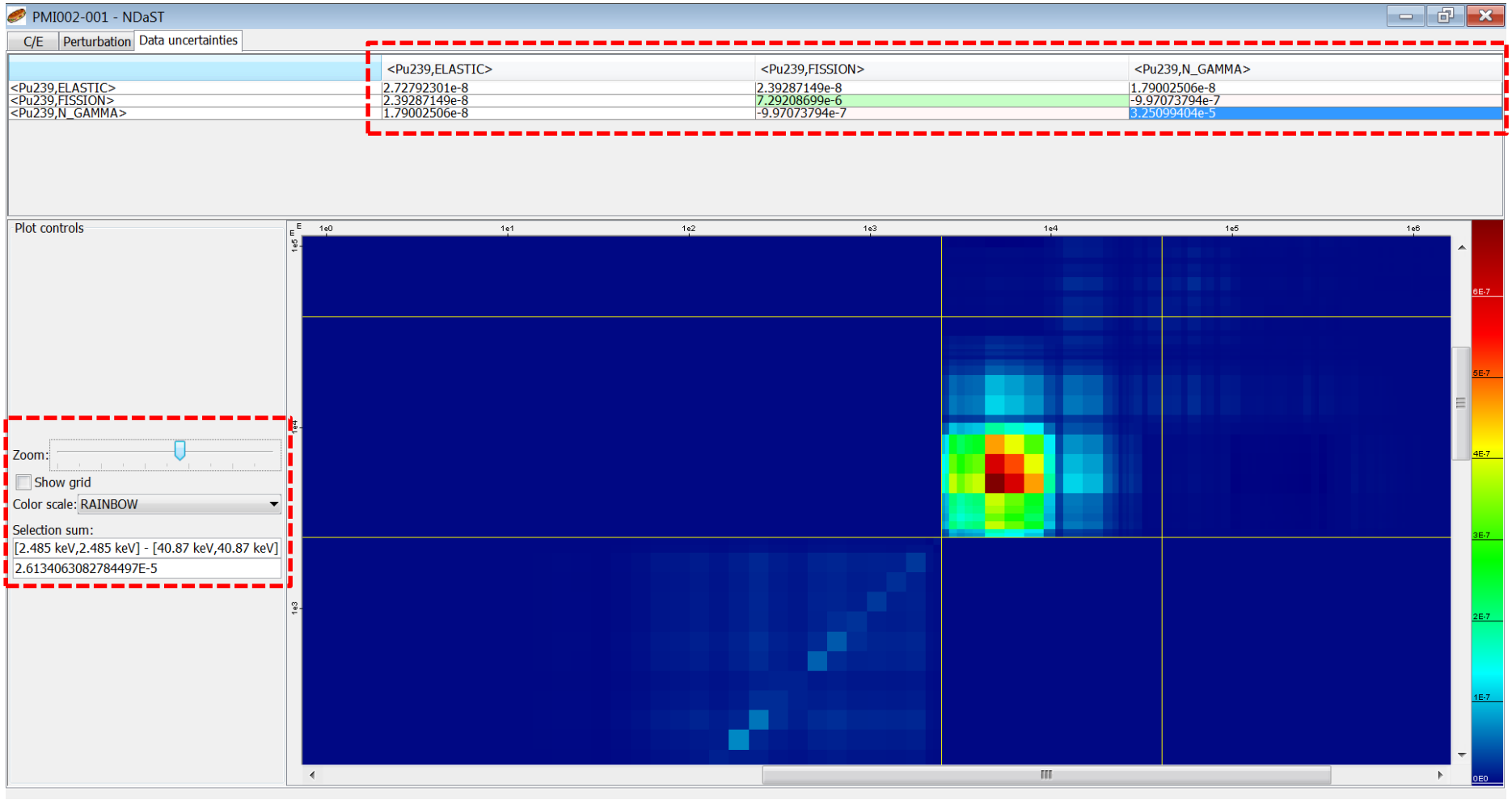
The added green bars show the grouped nuclear data uncertainty (1σ)



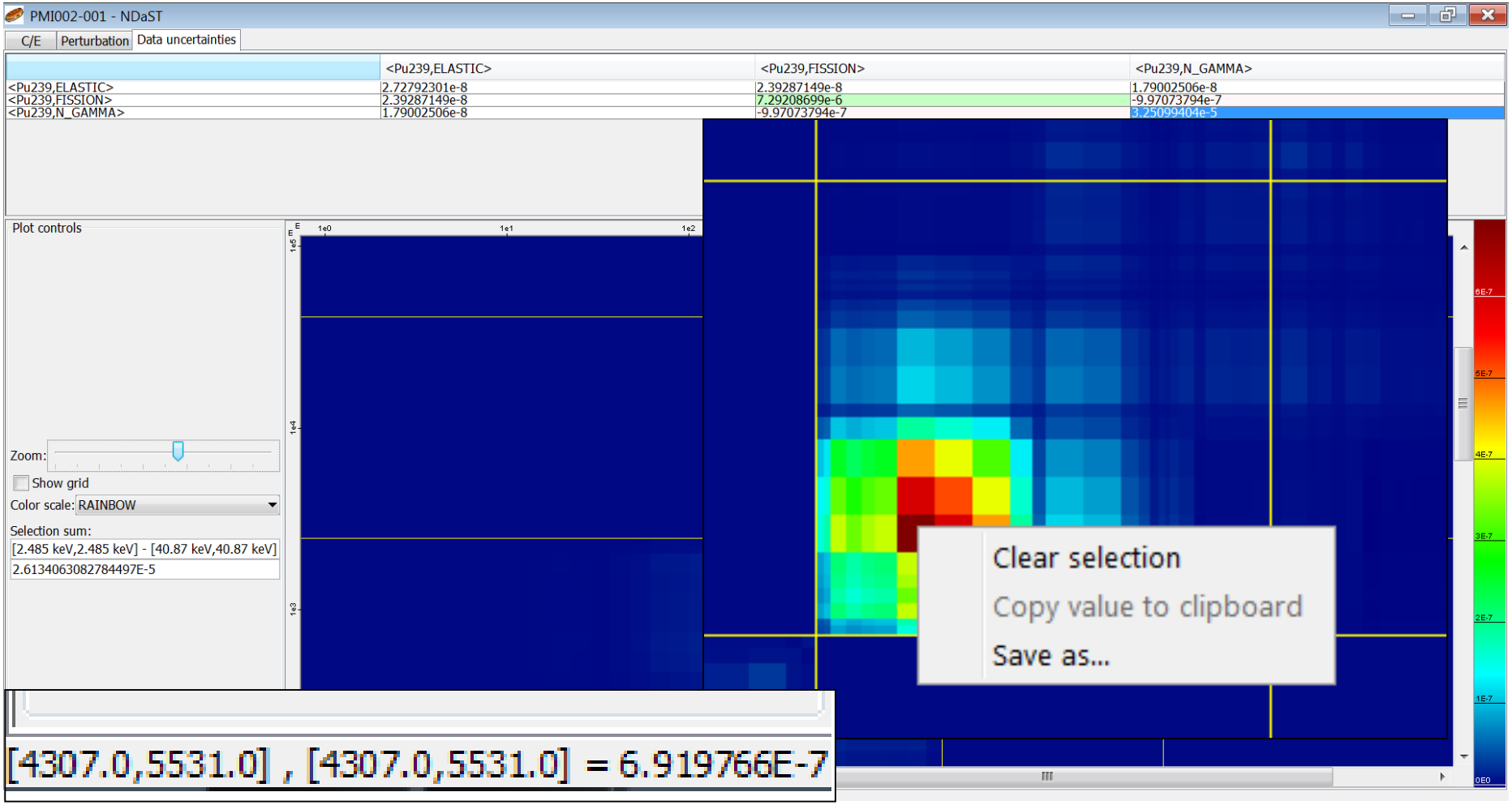
Save Output Data



Output Table: Detail Popup (Uncertainty)



Output Table: Detail Popup (Uncertainty)



Thank you for your attention

Now you're trained, please try out NDaST in your own time, for your own applications

- We are interested in all feedback (good and bad) as we build and understand the user base
- New features will be prioritised according to our estimation of user interest

Website: www.oecd-nea.org/ndast/

Email: ndast@oecd-nea.org

Thank you for your attention

All NEA publications and institutional documentation available at
www.oecd-nea.org