Status of NEA Nuclear Data Tools

DICE & NDaST

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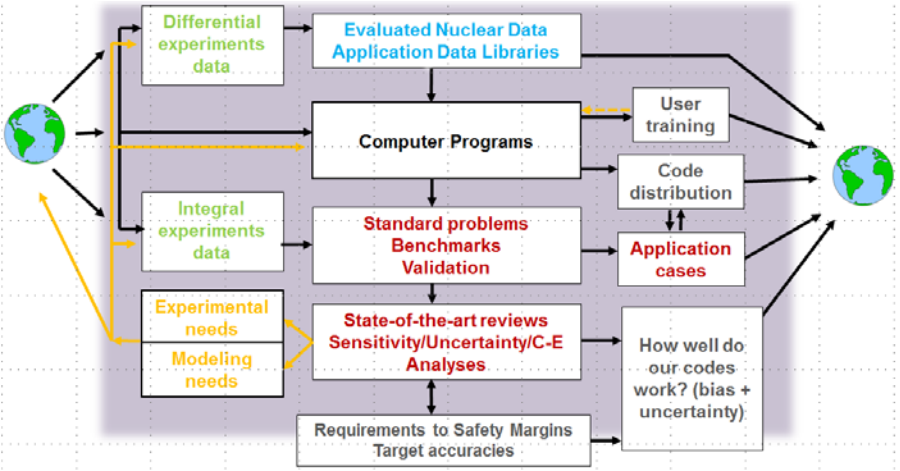
Working Party on Evaluation Co-Operation (WPEC)
SG-39 Meeting
May 16-17, 2017
OECD Conference Centre, Paris

Science and the 'Knowledge Machine'



DICE

- Find Criticality Benchmarks
- Store Experimental Correlations
- Trending Tool
- Sensitivity Coefficients

UACSA

- Uncertainty Analysis in Criticality Safety
- Tools for uncertainty analysis+Covariance

NDaST

- Link DICE+JANIS
- Leverage Sensitivities
- Perform Uncertainty Propagation

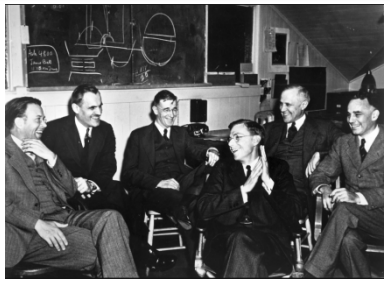
VANDAL

- Agree on Validation inputs
- Tests for Inputs
- Store Inputs

NDEC

- Nuclear data evaluation cycle
- Similar to ADVANCE

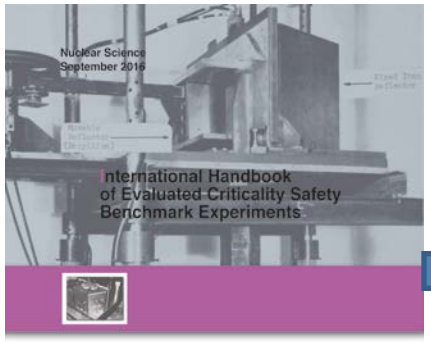
CIELO

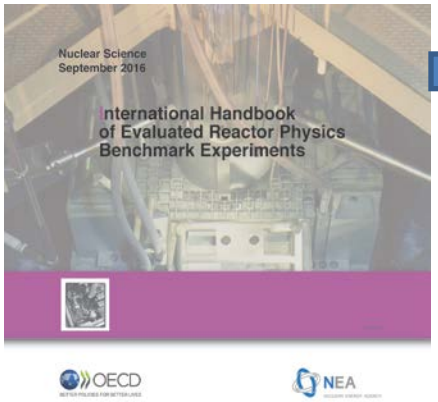


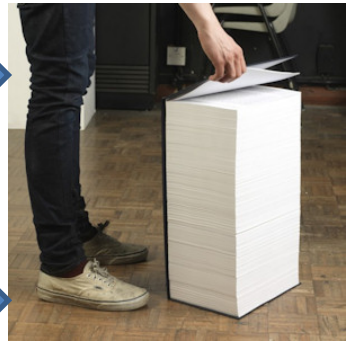
- Collaboration between libraries
- Important XS's being revised

Nuclear Science – Data Bank 'Knowledge Machine'

Accessing Benchmarks





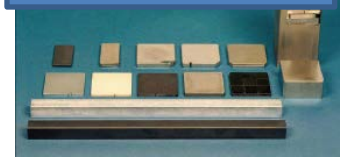


ICSBEP Handbook: 4913 Benchmarks
IRPhE Handbook: 898 Benchmarks
CSNI Documents: ~250 Benchmarks

UK: ZEBRA

USA:ZPPR

GER: SNEAK



Standard problems
Benchmarks
Validation

NEA Databases
And Tools
Examples: DICE, IDAT

How well do our codes work? (bias + uncertainty)

Integral Experiments for Criticality Safety

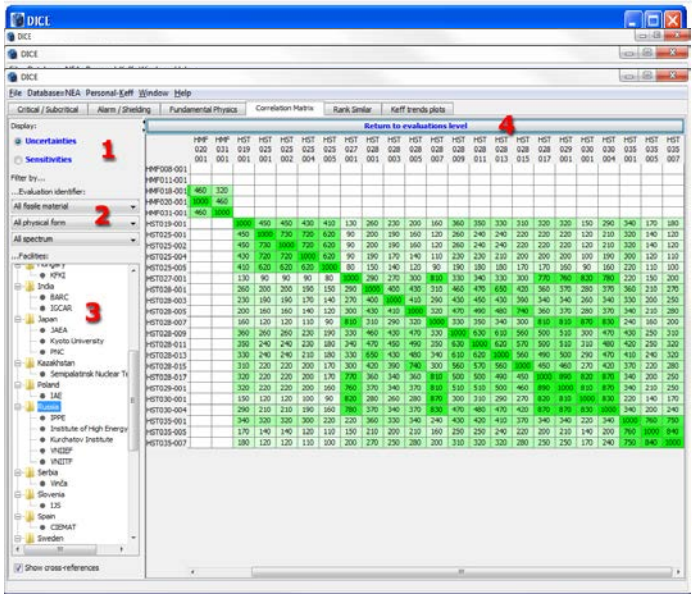
International Criticality Safety Benchmark Evaluation Project (ICSBEP)

- Est 1992/1995. Handbook Released Yearly
- ICSBEP Handbook contains criticality benchmark data

The latest edition of the Handbook contains

- 4913 critical, near-critical and sub-critical configurations
- 231 alarm/shielding and fundamental physics experiments
- Distributed on DVD, available on-line

Database for the International Criticality Safety Benchmark Evaluation Project (DICE)

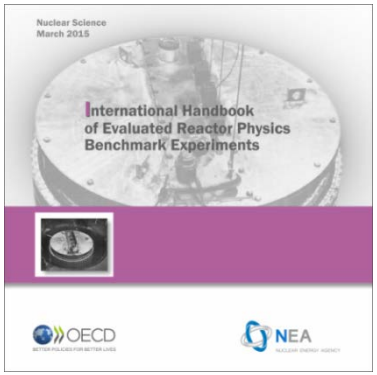


- Allows easy access to benchmark data and supplemented calculated data (neutron balance, flux, reaction rate, k_{eff} sensitivity to neutron cross sections, C/E from several codes/cross-section sets etc.)
- Trend and identify suitable benchmark experiments
- Included on the ICSBEP Handbook DVD, available on-line
- On-going work on experimental correlations

https://www.oecd-nea.org/science/wpncs/icsbep/

Integral Experiments for Reactor Physics

International Reactor Physics Experiment Evaluation (IRPhE) Project



- Initiated by NEA/NSC in 1999
- IRPhE Handbook contains benchmark data for reactor-type experiments:

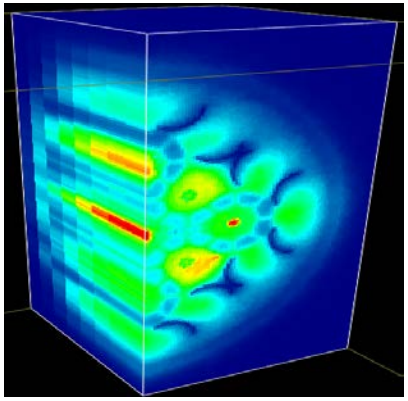
  reactivity effects/coefficients, spectral indices, reaction rates, kinetic parameters, and others

The 2015 edition of the Handbook contains

- 898 experiments performed at 50 nuclear facilities

  47 series performed at Research Reactors including TRIGA Mark II (Slovenia, USA), ATR (USA), HTTR and JOYO(Japan), HTR-1 (China) and others
- Distributed on DVD, available on-line

International Reactor Physics Handbook Database and Analysis Tool (IDAT)



- Released in 2013
- Allows easy access to benchmark data and supplemented calculated data
- Trend and identify suitable benchmark experiments
- Included on the IRPhE Handbook DVD, available on-line

https://www.oecd-nea.org/science/wprs/irphe/

Increasing the Speed of Validation! NDaST tool

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

Evaluated Nuclear Data Application Data Libraries

NEA Databases And Tools
Example: JANIS

- ✓ An open web-based JAVA tool to take advantage ICSBEP and IRPhE benchmark case nuclear data sensitivities
- ✓ Enables rapid scoping of changes to nuclear data and to propagate nuclear covariance data uncertainties
- ✓ It also gives access to JANIS for automation of computations and use of processed nuclear covariance data
- ✓ 2016 marks the full release, new features to be added on an annual basis as needed by users

NDaST

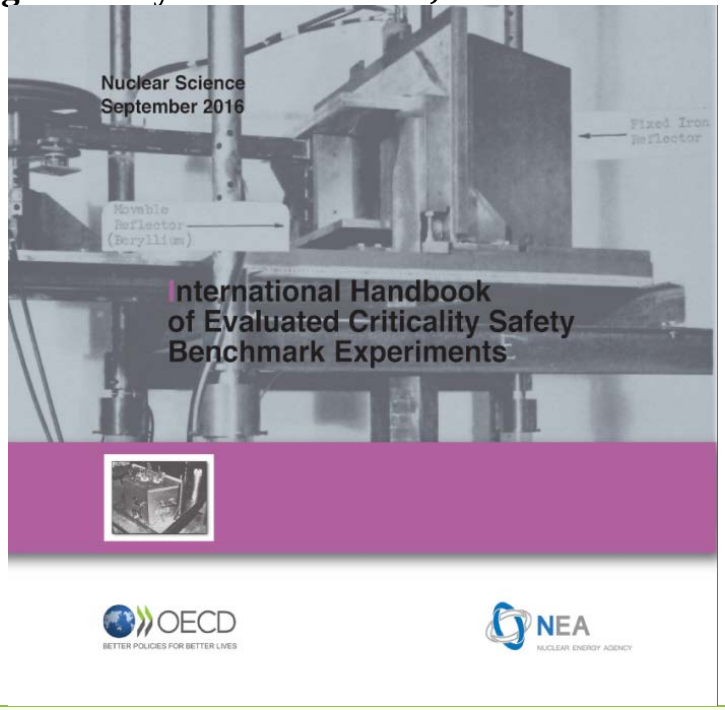
Code bias and uncertainty for nuclear applications

NEA Databases And Tools
Examples: DICE, IDAT

Database for ICSBEP (DICE)

Handbook (est 1992/1995)

4913 Critical and Subcritical Benchmarks, Organized by Fissile Material, Form and Fission



Technical review group met Apr 18th-19th 2016 @NEA
6 New evaluations reviewed
7 Revisions discussed

DICE

Answers How to Efficiently Search the Handbook

- Distributed with Handbook since 2001
- Relational database
- User Friendly Way to Search

1) New Sensitivity Data Angular Scattering
2) Read Local keffs [Links to other tools]
3) Input files retrievable from DICE [VANDAL]
4) Ability to generate XML files of returned benchmark cases
5) Stores Correlation Data

https://www.oecd-nea.org/science/wpncs/icsbep/dice.html

Status: DICE Sensitivity Coefficients

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]

Sensitivity Coefficients are guides to which benchmarks may be good for testing nuclear data changes!

Original cost estimate for sensitivity data **$100,000** per **100 cases**

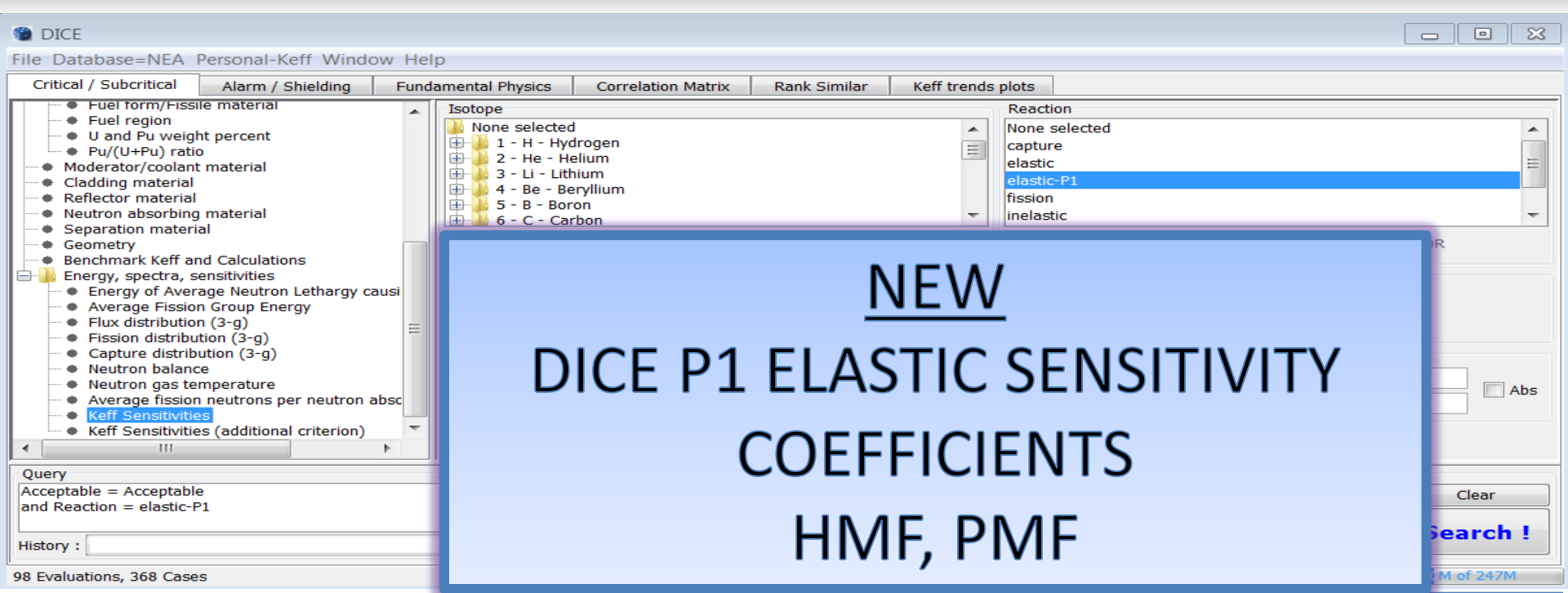
In all TSUNAMI studies, most significant effort is generation of sensitivity data for experiments from ICSBEP handbook.

#1 request from TSUNAMI users is to have TSUNAMI data distributed with ICSBEP Handbook for use in scoping calculations.

Standard problems
Benchmarks
Validation

Code bias and uncertainty for nuclear applications

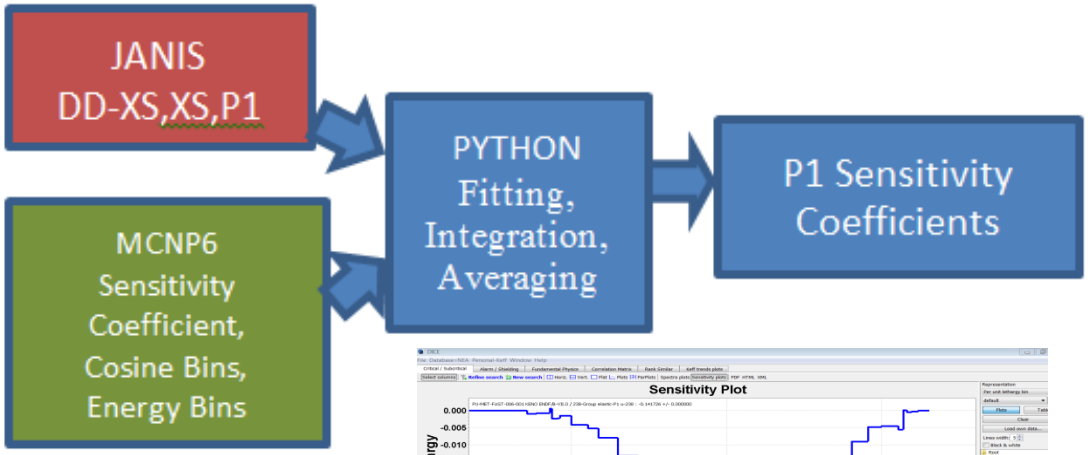
NEA Databases And Tools
Examples: DICE, IDAT

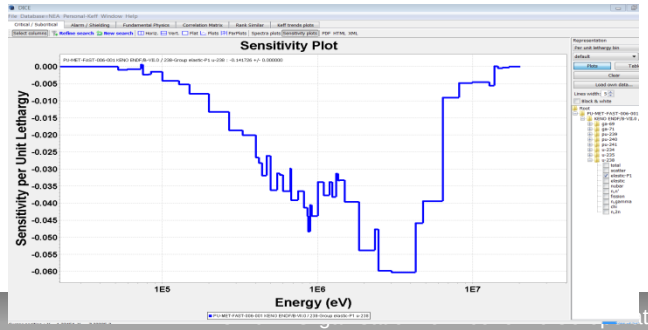


NEW

DICE P1 ELASTIC SENSITIVITY COEFFICIENTS

HMF, PMF





Benchmark	Isotope	Uncertainty (pcm)
PMF026-001	Fe^{56}	326
PMF015-001	Fe^{56}	326
PMF032-001	Fe^{56}	255
HMF001-001	U^{235}	463
HMF007-019	U^{235}	434
HMF043-001	U^{235}	406
PMF006-001	U^{238}	322
PMF041-001	U^{238}	296
HMF003-003	U^{238}	305
PMF001-001	Pu^{239}	161
PMF022-001	Pu^{239}	156
PMF025-001	Pu^{239}	134

Database for ICSBEP [DICE] Sensitivity Data Status

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
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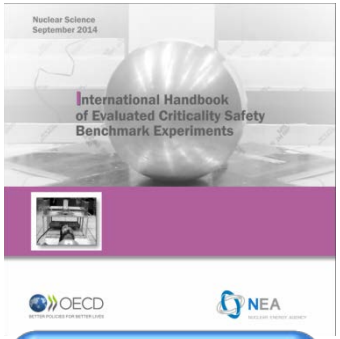


DATABASES WITH SENSITIVITY PROFILES

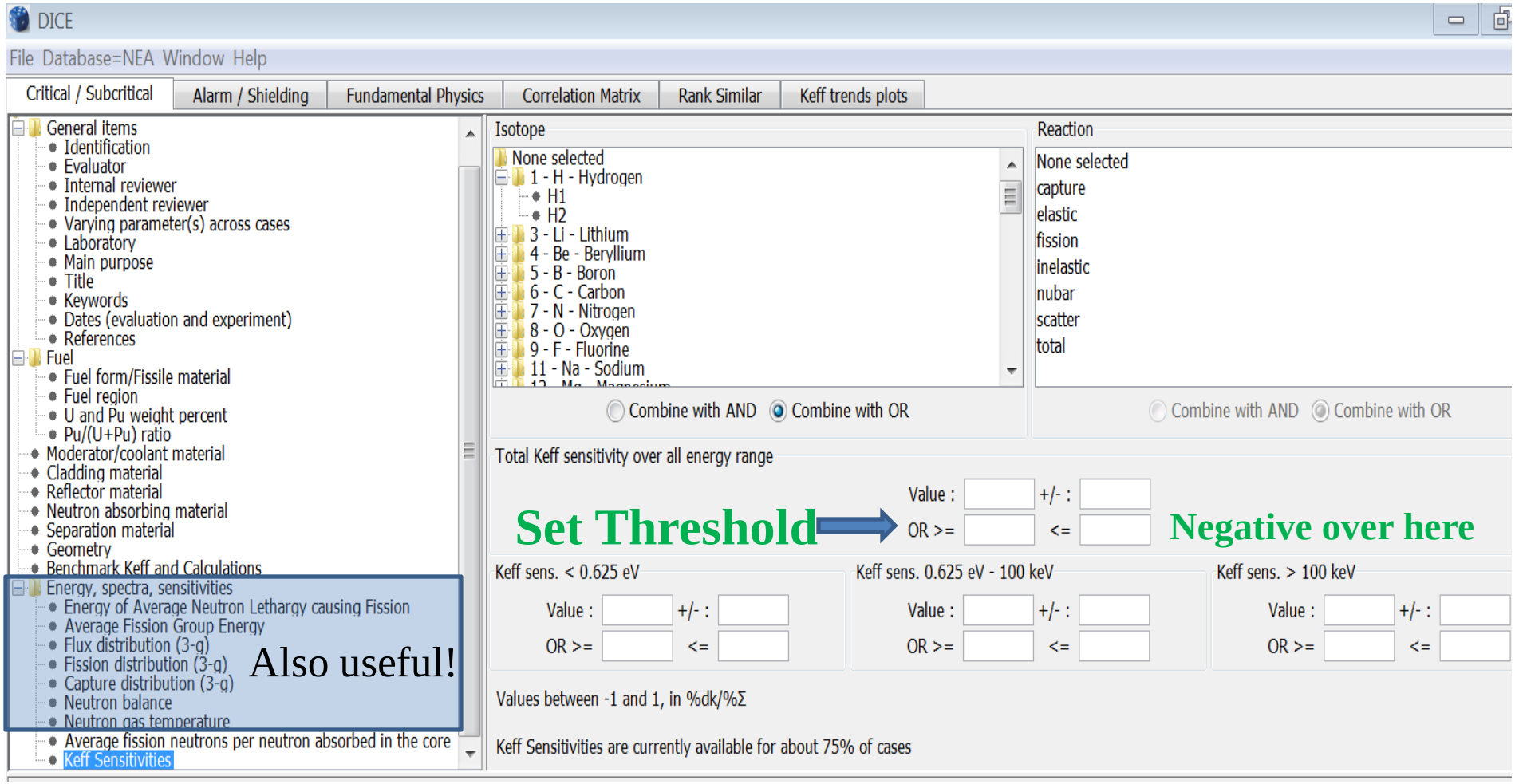
Sensitivities (S) & C/E data

DICE

2015	THERM	INTER	FAST	MIXED
PU	525/608	4/10	114/121	9/9
HEU	664/895	21/32	383/403	75/84
IEU	142/180	5/21	31/43	7/23
LEU	1424/1612	0/0	1/1	5/5
U233	186/197	29/29	8/10	8/8
MIX	323/436	2/7	40/67	1/26
SPEC	0/0	0/0	4/20	0/0

DICE k_{eff} Sensitivities Search

3 Group search, full 238 Group SDF's are stored and freely accessible. NB. Access to evaluations and input decks **are restricted to NEA member countries and participating organisations**.



Integrating Sensitivity Data With Nuclear Data via NDaST

- There was existing Sensitivity Data in DICE (Database for ICSBEP) and IDAT (Database for IRPhEP)
- This could be ‘viewed’ or used to select or order benchmarks, but little further application
- No means to link DICE and integral benchmarks to nuclear data or JANIS – expand or build specific tool?
- The Nuclear Data Sensitivity Tool (NDaST) was developed in 2015 to accomplish this
- It has already seen application use in the CIELO and JEFF nuclear data projects and SFR benchmark

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 – 400 P1 sensitivities)
- Experimental correlations are not considered
  - This is not (yet) an adjustment tool

Launching the Software

- NDaST is another JAVA based tool and feels very similar to DICE and IDAT
- It's free, there's no password and is run by launching from the NEA website
  - www.oecd-nea.org/ndast/
- Your DICE and IDAT settings will be reused
- Any personal 'bases' you have loaded into JANIS can be connected for use
- Computational load on your computer is minimal – designed to let NEA servers bear the brunt, while you reap the benefits!

Some Results of Swapping Files, vs Summing the Separate Effect and NDaST

Eval-Case	MT18		MT102		MT452		PNFS		Total		
	Direct	NDaST	Direct	NDaST	Direct	NDaST	Direct	NDaST	Direct	Sep	NDaST[a]
PST001-004	-52	-10	-1	32	-231	-212	-143	N/A	-394	-427	-333
PST004-001	-150	-119	-8	0	-199	-200	-117	N/A	-466	-474	-436
PST012-010	-156	-116	-21	-2	-197	-182	-67	N/A	-415	-441	-367
PST018-006	-116	-79	-1	-8	-183	-155	-36	N/A	-311	-342	-278
PST034-004	-73	-8	-7	-7	-215	-221	-63	N/A	-384	-372	-299
PST034-015	234	398	-32	26	-220	-209	-53	N/A	-75	-71	162

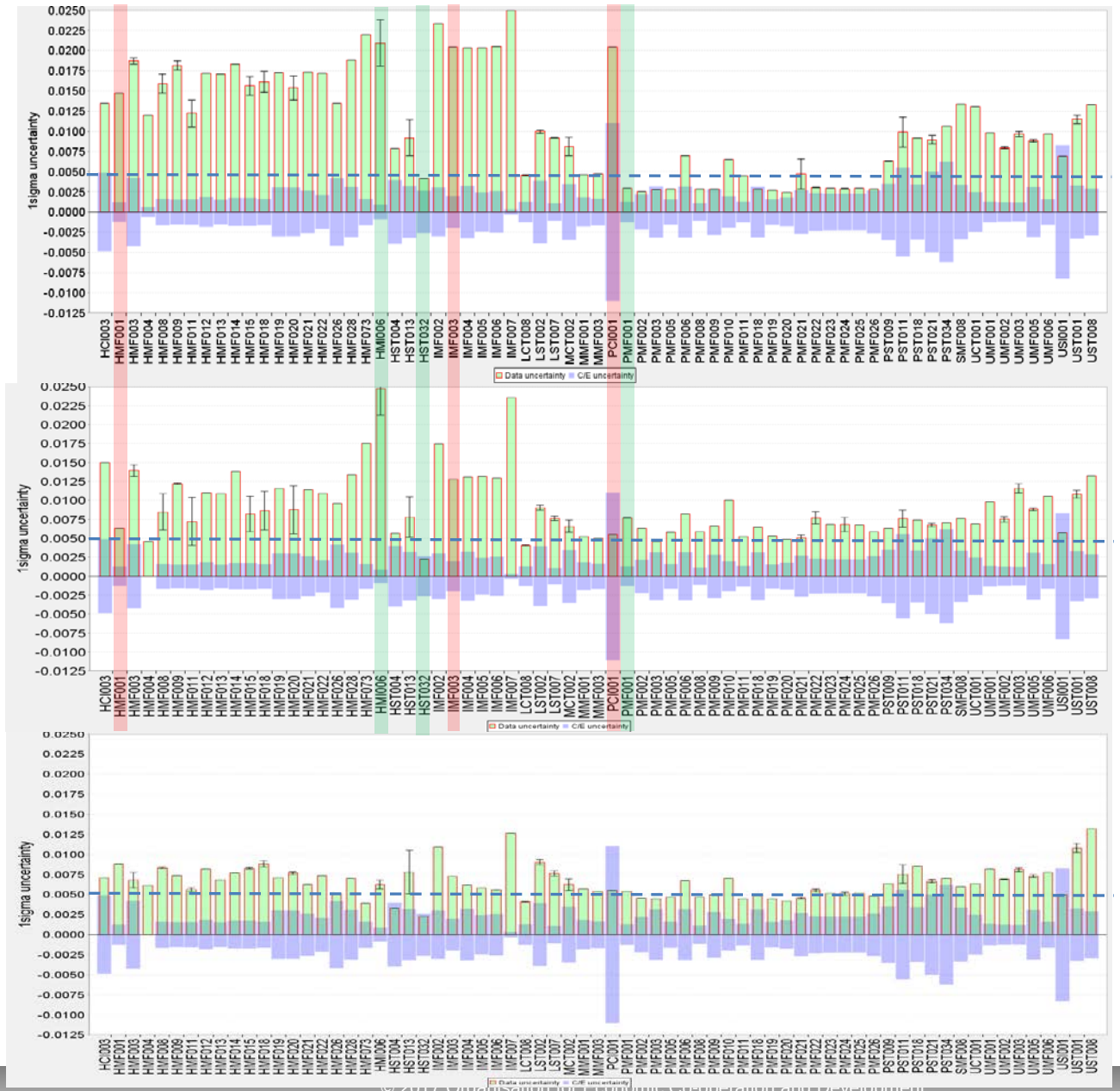
a) NDaST Total is the sum of (MT18+MT102+MT452) from NDaST + PNFS from Direct

- Limitation; CIELO files contain an energy dependent PFNS
- Existing NDaST and underlying sensitivity data currently use an energy independent PFNS
- PST034-015 is complicated by its intermediate sensitivity, plus coincident shifts in resonances. Also high Gd poison content.

See latest ANS proceedings for Ian Hill's full paper

Testing JEFF-3.3 Covariances

All Results by Evaluation ID



JEFF-3.3T3
Mean = 1100 pcm

JEFF-3.3T1
Mean = 1043 pcm

ENDF/B-VII.1
Mean = 922 pcm

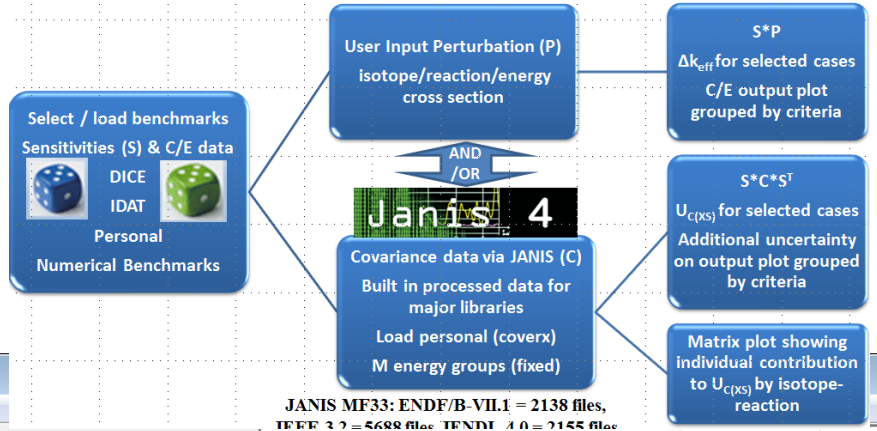
JENDL-4.0
Mean = 668 pcm

Testing JEFF-3.3 Covariances
Selected Example Benchmark Uncertainties

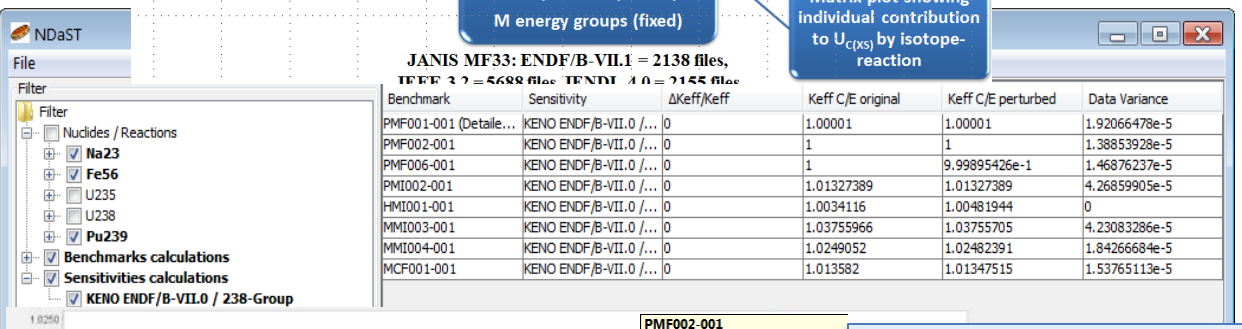
Case label	Sensitivity Code	1σ JEFF-3.3 T3	1σ JEFF-3.3 T1	Diff J33T3 – J33T1 (pcm)	1σ ENDF/B-VII.1	1σ JENDL-4.0	Ratio J33T1 / E7.1
PCI001-001	KENO ENDF/B-VII.0 / 238-Group	0.020410	0.020364	+5	0.005471	0.006559	3.72
HMF001-001 (Godiva)	KENO ABBN-93 / 299-Group	0.014788	0.014788	0	0.006302	0.008816	2.34
IMF003-001 (Detailed Model)	KENO ENDF/B-VII.0 / 238-Group	0.020409	0.020409	0	0.012785	0.007286	1.59
PST011-006	KENO ENDF/B-VII.0 / 238-Group	0.011741	0.009639	**+481**	0.009423	0.009537	1.02
UMF001-001	KENO ENDF/B-VII.0 / 238-Group	0.009813	0.009813	0	0.009813	0.008172	1.00
LCT008-001	KENO ENDF/B-VII.0 / 238-Group	0.004455	0.002937	**+151**	0.003879	0.004038	0.76
HST032-001	KENO ABBN-93 / 299-Group	0.004103	0.001186	**+292**	0.002306	0.002300	0.51
HMI006-001	KENO ENDF/B-VII.0 Continuous	0.017284	0.015995	**+129**	0.019962	0.006437	0.80
PMF001-001 (Detailed Model)	KENO ENDF/B-VII.0 / 238-Group	0.002943	0.003036	-9	0.007796	0.005421	0.38

STATUS

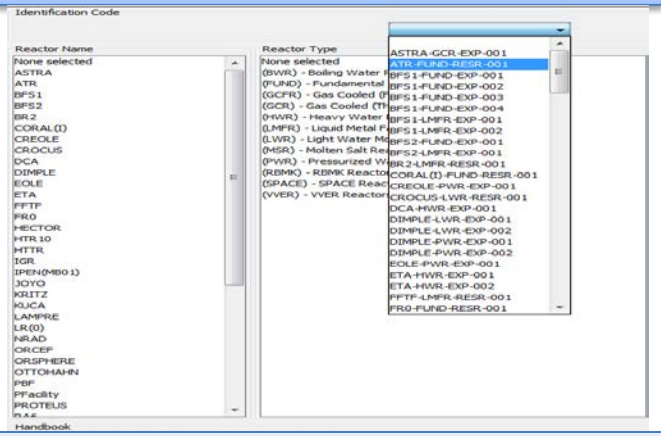
Several new features for NDaST have been developed for the December 2016 release version.

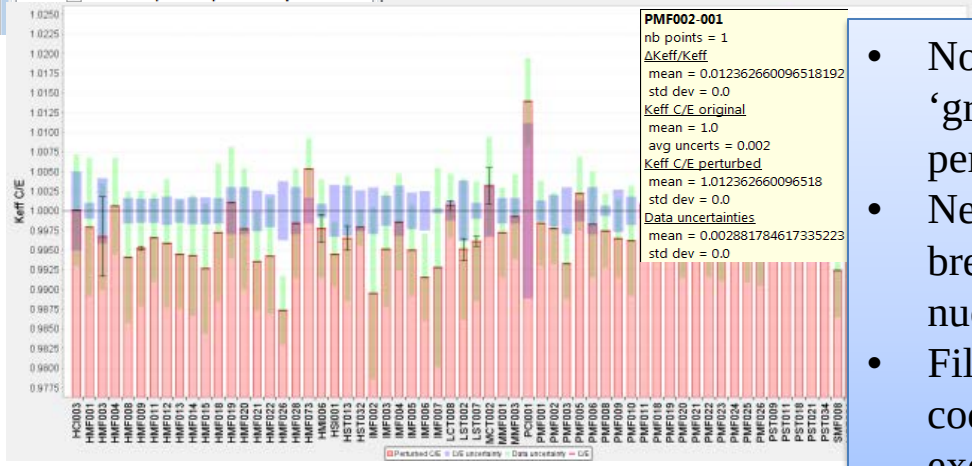


- In addition to DICE, the release version allows access to the International Reactor Physics Handbook Database and Analysis Tool (IDAT).



Benchmark	Sensitivity	ΔKeff/Keff	Keff C/E original	Keff C/E perturbed	Data Variance
PMF001-001 (Detaile…	KENO ENDF/B-VII.0 /…	0	1.00001	1.00001	1.92066478e-5
PMF002-001	KENO ENDF/B-VII.0 /…	0	1	1	1.38853928e-5
PMF006-001	KENO ENDF/B-VII.0 /…	0	1	9.99895426e-1	1.46876237e-5
PMI002-001	KENO ENDF/B-VII.0 /…	0	1.01327389	1.01327389	4.26859905e-5
HMI001-001	KENO ENDF/B-VII.0 /…	0	1.0034116	1.00481944	0
MMI003-001	KENO ENDF/B-VII.0 /…	0	1.03755966	1.03755705	4.23083286e-5
MMI004-001	KENO ENDF/B-VII.0 /…	0	1.0249052	1.02482391	1.84266684e-5
MCF001-001	KENO ENDF/B-VII.0 /…	0	1.013582	1.01347515	1.53765113e-5



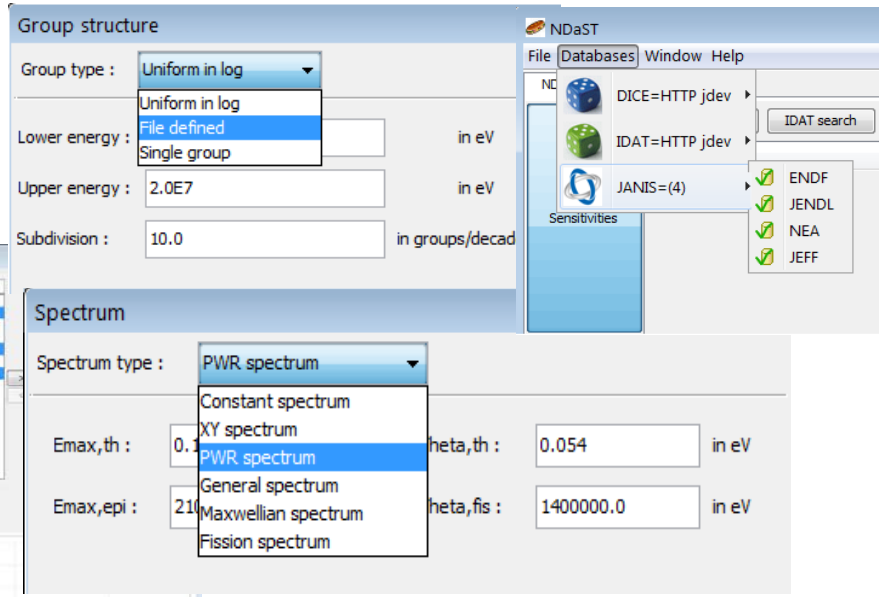


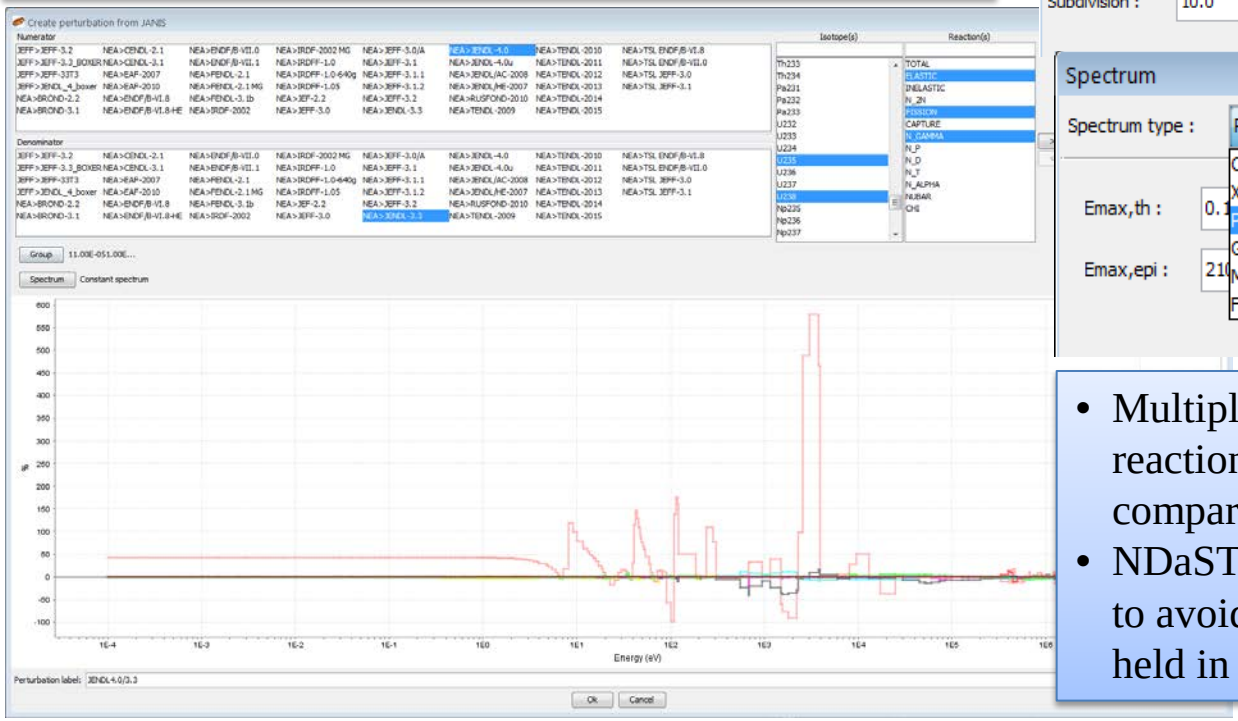
- Now features ‘tool-tips’; access data behind each plot ‘grouping’ i.e mean and s.d. values for Δk_{eff}, original and perturbed k_{eff} C/E values and nuclear data uncertainty.
- New ‘detail popup’ for each benchmark shows breakdowns for each code-library combination and nuclide-reaction pair.
- Filter tree on plot allows nuclide-reaction pairs and code-library combination results to be included or excluded

NDaST: Automated JANIS Computations

- An automated link has been introduced to the JANIS nuclear data software to generate the perturbation ratios between two evaluations.

- Represented within any energy group structure required.
- Analytical or personal spectrum weightings may also be applied

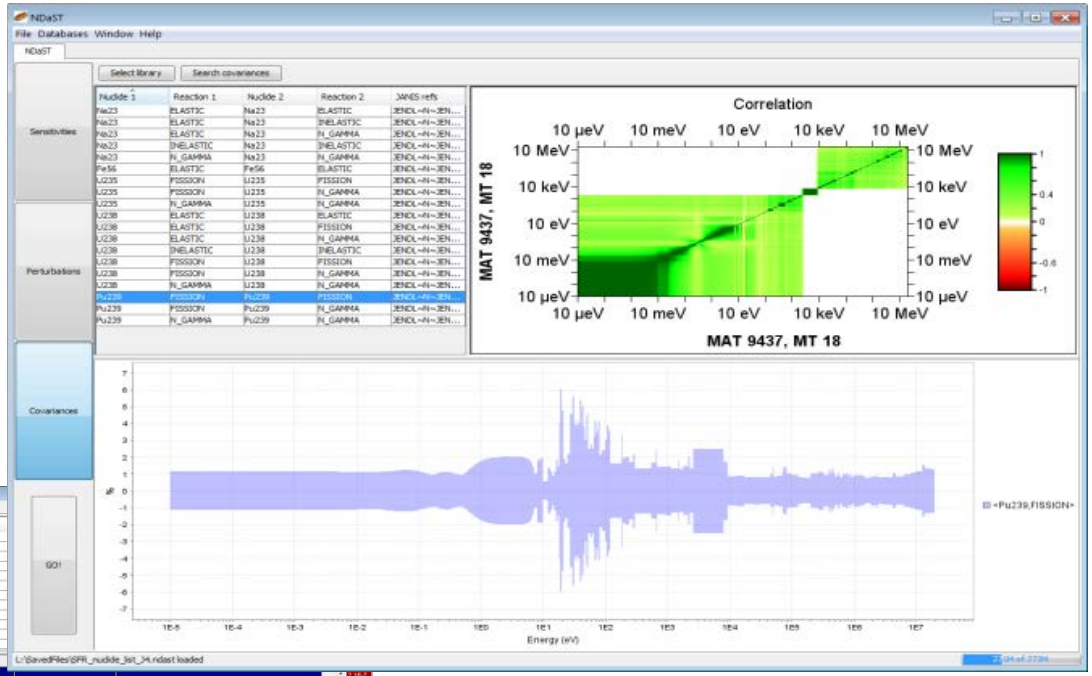


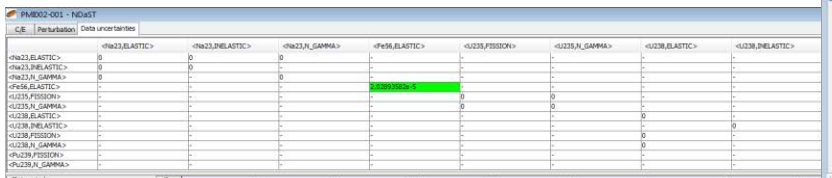


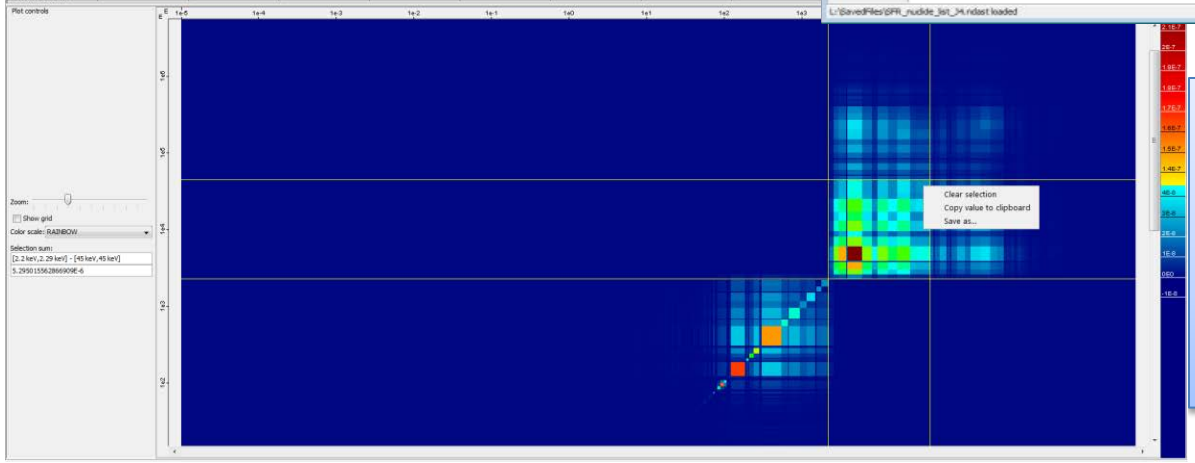
- Multiple perturbations of the same nuclide-reaction can now be input for faster comparison with one single run
- NDaST will also have a ‘file upload’ feature, to avoid needing to already have libraries held in a JANIS base.

NDaST: Energy Dependence Breakdown

- Breakdown of either a perturbation (Δk_{eff}) or uncertainty (covariance in k_{eff}) calculation as a function of the contributing nuclide-reaction pairings did not allow a deeper analysis of which energy regions constitute the greatest or smallest contribution to the total.







- 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.

NDaST: Future Outlook and Collaboration

Some planned new features (development begins April 2017):

- Complete covariance library selection option
- **Allow JANIS ENDF file import through NDaST – TMC / Half Monte Carlo**
- Compensating effects dialogue (e.g. perturbations to preserve totals)
- Pre-loadable benchmark set selections (e.g. JEFF, CSEWG, MCNP testing suites)
- **Represenativity values (i.e. calculation of Ck correlations)**
- **Spectrum weighted Chi perturbations more compatible with Chi sensitivities**
- Automatic selection of nuclides/reaction covariances from sensitivity sdf file

Collaboration areas of interest:

- Additional sensitivity files and C/E results to populate the databases
- Supported sensitivity and covariance formats (e.g. COVERX libraries)
- Compatibility with the NDEC system – propagation of test file perturbations
- Xml format to contain input / output; benchmark data, perturbations, covariances etc.

Described in the 'How-to' guide at the website
http://www.oecd-nea.org/ndast/

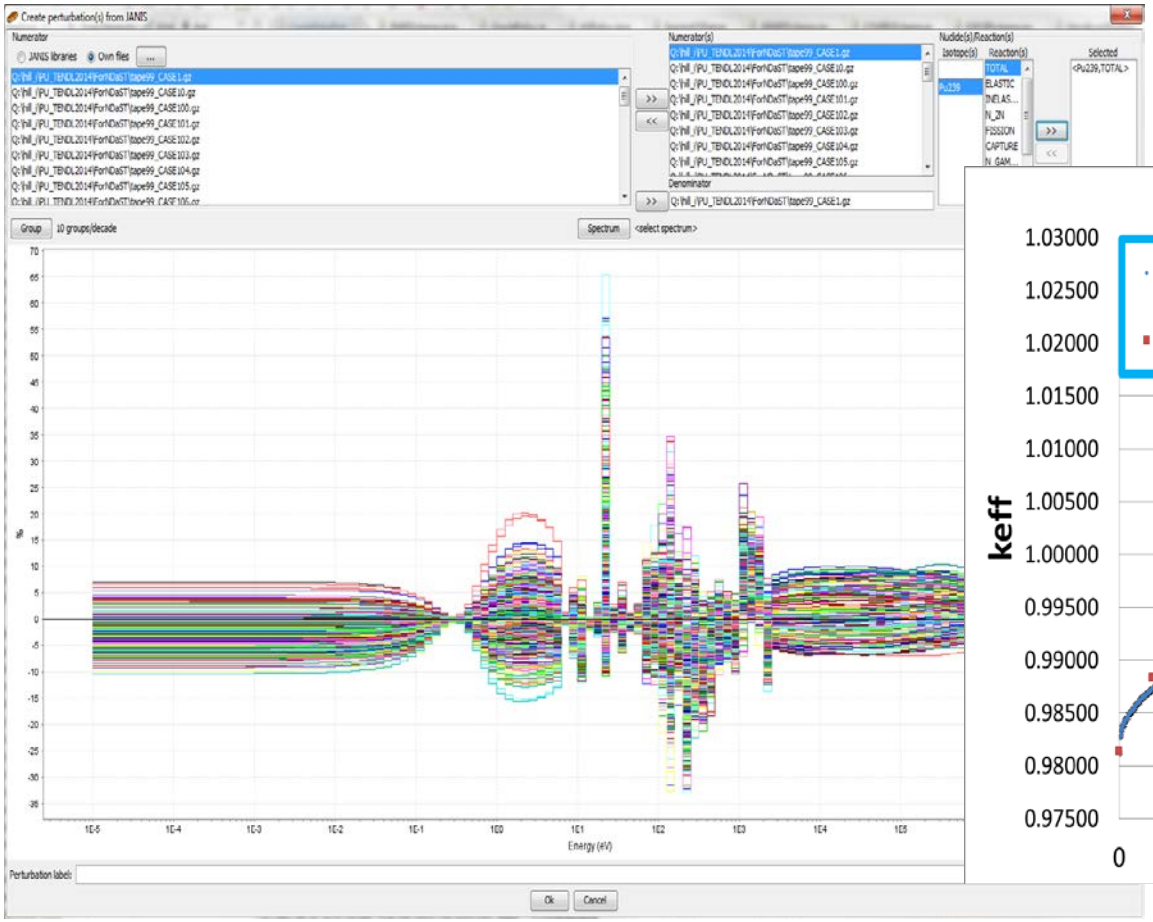
Half Monte Carlo Method

- How can we solve the uncertainty propagation problem of non-linear dependencies? Currently with TMC.
- K_{eff} sensitivities in general are not the problem, they remain linear over a large range, the same cannot always be said for nuclear data parameters and cross-sections.
- Instead of running hundreds or thousands of neutronics calculations, can we just take 1000 sampled cross section files and perform cheap perturbations with NDaST?
- Hopefully the answer is yes – we can have the normal NDaST benefits (a deeper analysis of the effects) without the normal computational burden.

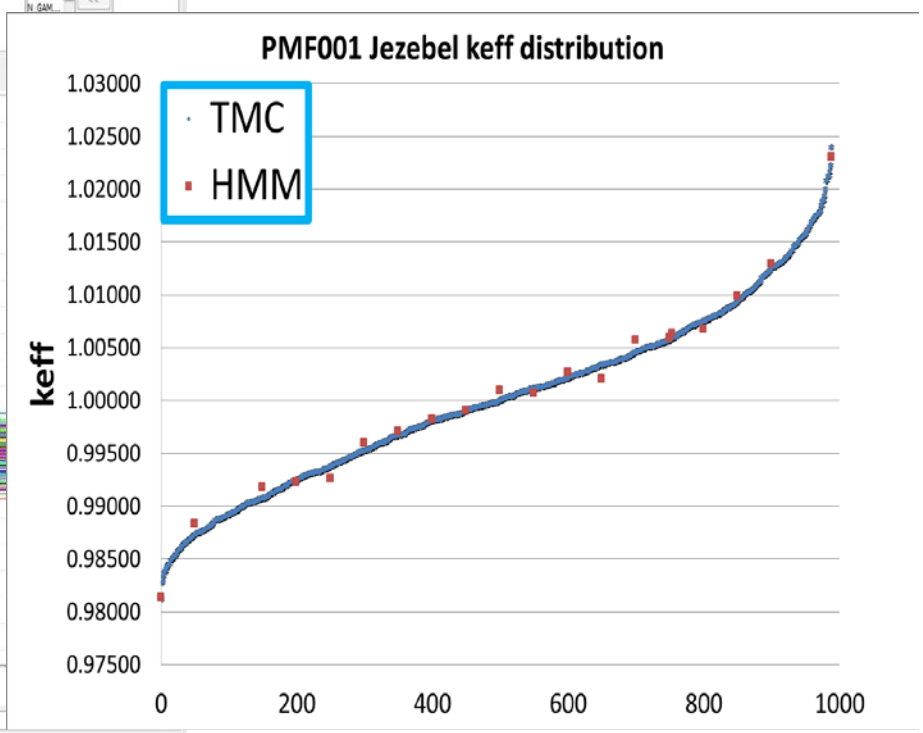
	Delta keff (pcm)																			
	Case Number																			
	24	34	38	170	431	436	455	476	494	527	558	591	643	670	680	710	738	772	782	993
Elastic	606	-217	-157	-441	513	59	-520	59	216	-47	606	-222	-490	-348	42	364	629	-481	393	-253
Inelastic	110	252	-19	75	-190	139	119	132	384	-9	-130	219	1	-206	81	-192	69	-14	-143	-45
N,2N	-3	-1	-4	-3	-4	1	-6	1	2	-6	-3	-4	-3	-3	-4	-4	-1	-6	-7	2
Fission	-800	120	780	566	1488	486	-272	485	-877	16	827	-940	-974	-537	541	-1258	-767	314	-486	-367
N,Gamma	-29	3	13	22	19	-30	-27	-30	10	-18	-22	-10	21	-42	-51	-28	-22	23	5	34
nubar	-249	113	126	-27	610	225	-175	-48	-189	138	-221	272	-428	-2	-230	315	482	-200	221	207
Chi	144	-129	-187	-219	-254	-15	-62	-129	-76	-130	111	-208	-117	-154	130	-61	55	59	95	1
Total	-221	141	552	-27	2183	865	-943	470	-530	-56	1170	-893	-1989	-1291	508	-864	444	-305	79	-421

Half Monte Carlo Results

PMF001 Jezebel 1000 SERPENT runs with different random TENDL-2014 Pu239 files, plotted with the HMM k_{eff} predictions for 20 samples



k_{eff} distribution, sorted lowest k_{eff} to highest



Summary

- ✓ ~4200 cases (~85%) have 3 group sensitivity data and full sensitivity profiles within DICE – similar also in IDAT
- ✓ An open web-based JAVA tool named NDaST is now available to take advantage of these data
- ✓ Enable rapid scoping of changes to nuclear data and to propagate nuclear covariance data uncertainties
- ✓ It also gives access to JANIS for automation of computations and use of processed nuclear covariance data; Half Monte Carlo Method
- ✓ Complement to ‘knowledge machine’ and more specific V&V calculations e.g. via the NEA Nuclear Data Evaluation Cycle (NDEC)
- ✓ Full release in 2016 following a beta testing period, with updates following this expected on an annual basis

EXTRA VIEWGRAPHS
for
How to Use NDaST

Contents

1. Introduction, means of use, benefits & limitations…

2. Loading benchmark sensitivities and results
3. Inputting nuclear data perturbations
4. Launch, visualise and interpret results

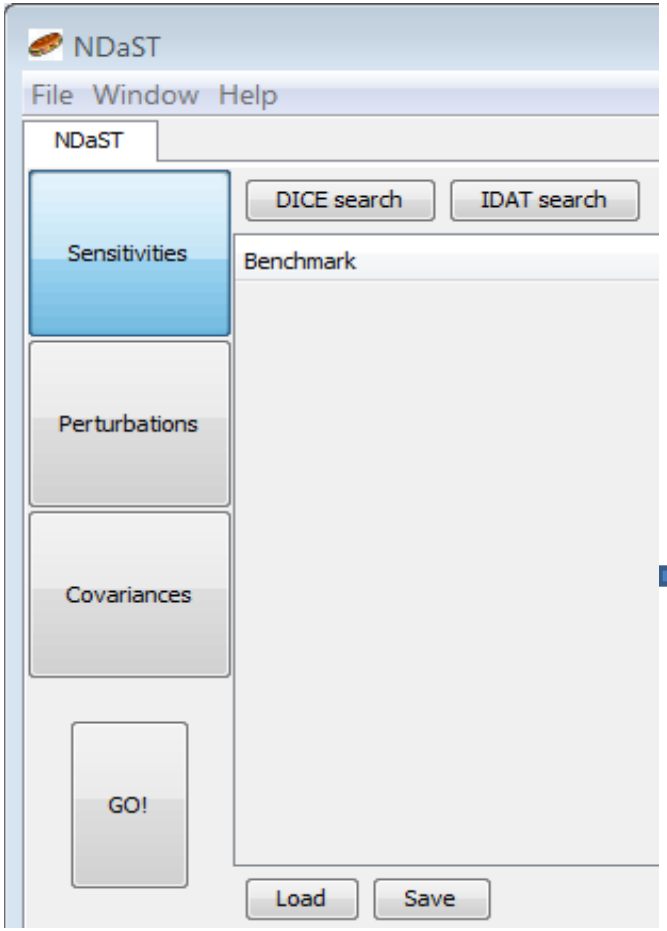
Class exercise 1 – steps 2, 3 & 4

5. Adding covariance matrices to the calculation
6. More visualisation possibilities
7. Future developments to be made

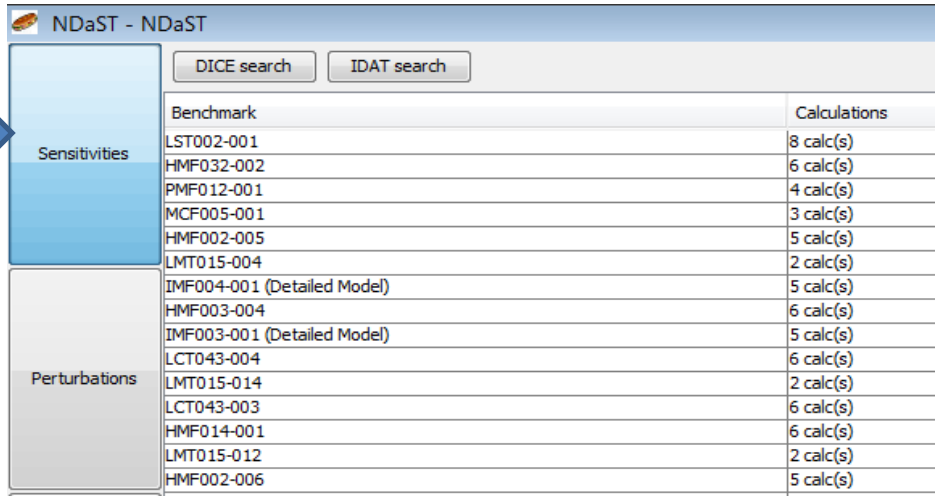
Class exercise 2 – try out steps 5 & 6

Panel 1: Select Benchmark Sensitivity Data

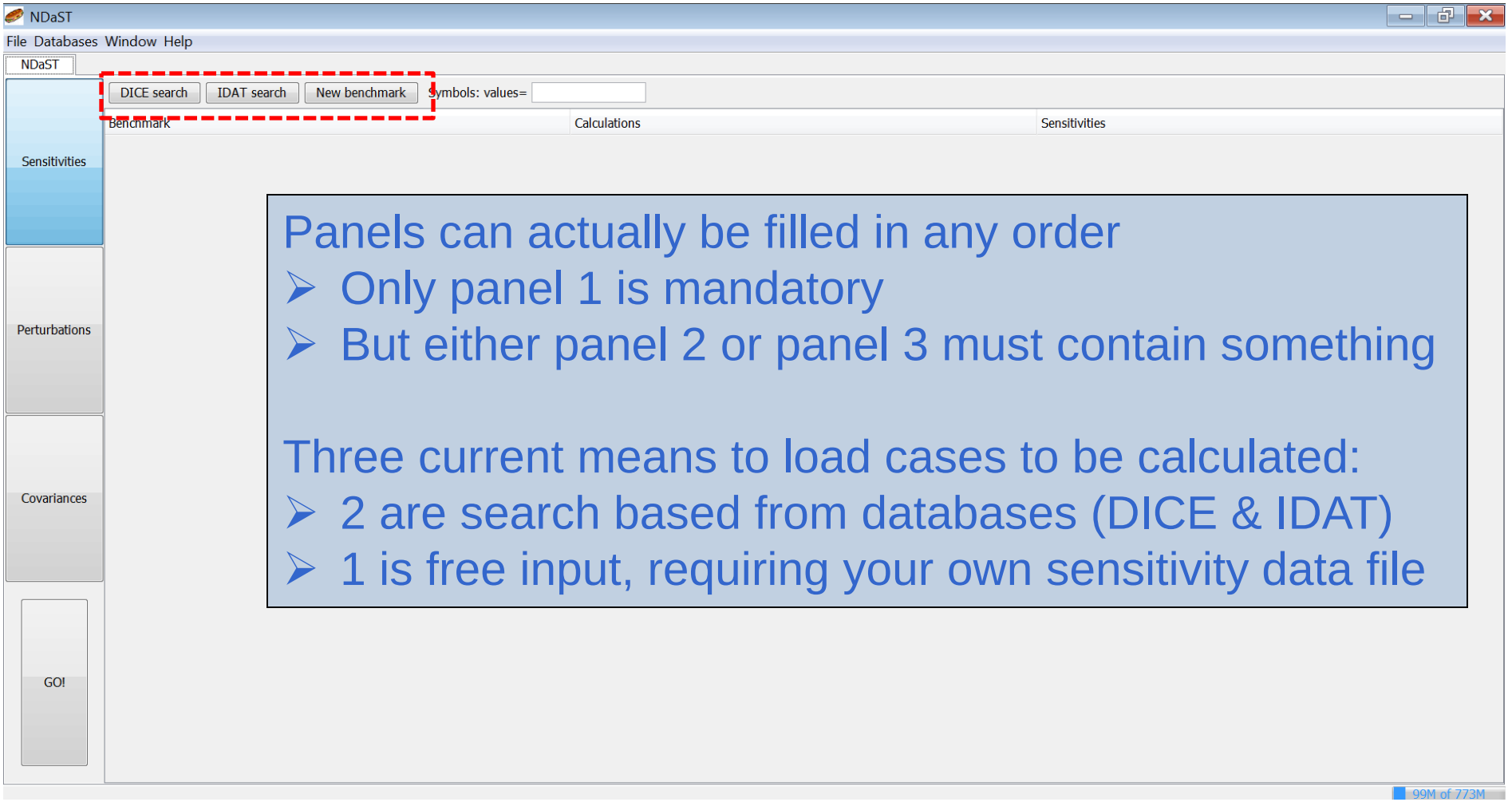
Currently can select benchmarks via DICE and IDAT plug-ins.



- 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



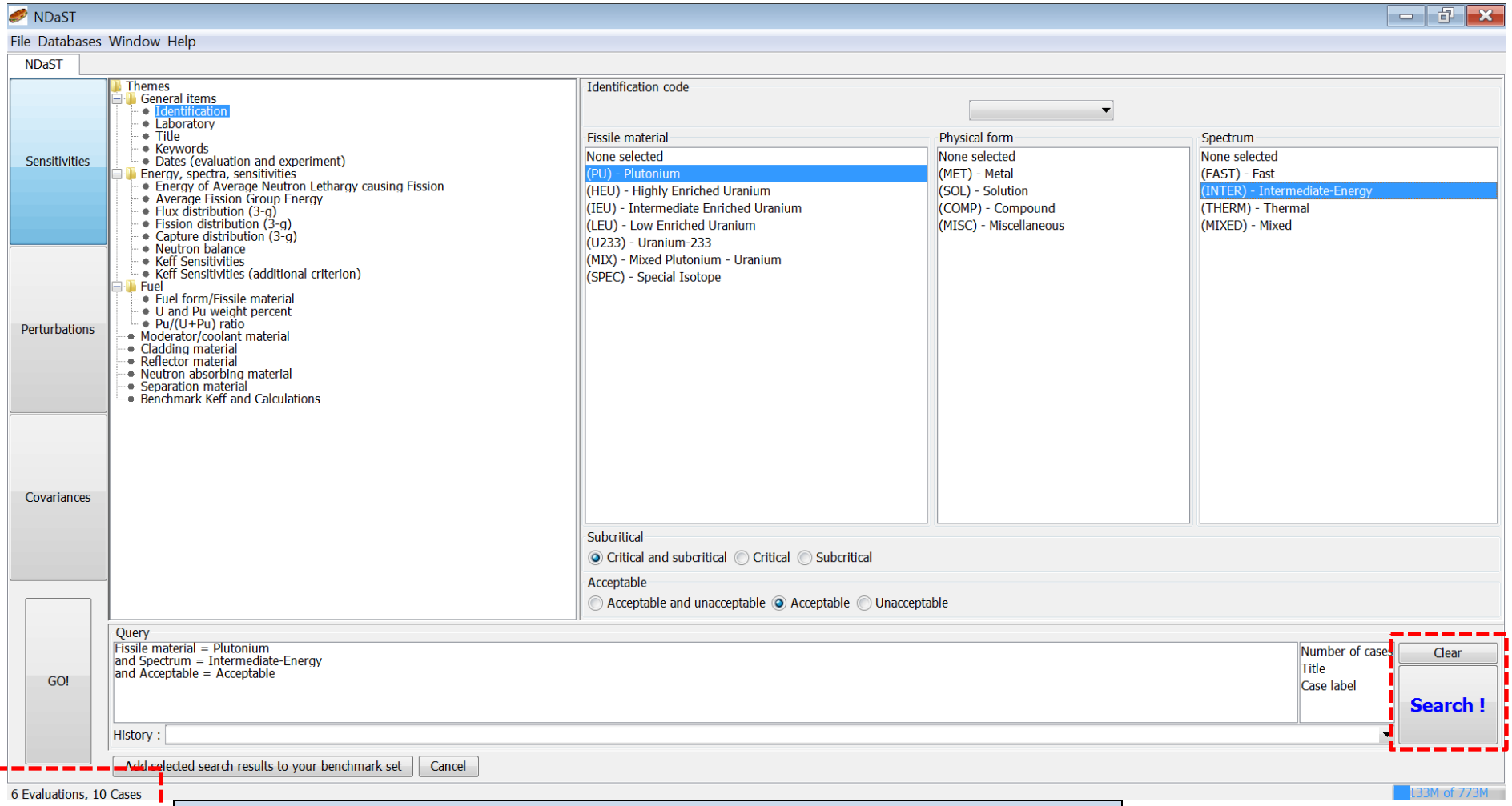
Panels can actually be filled in any order

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

Three current means to load cases to be calculated:

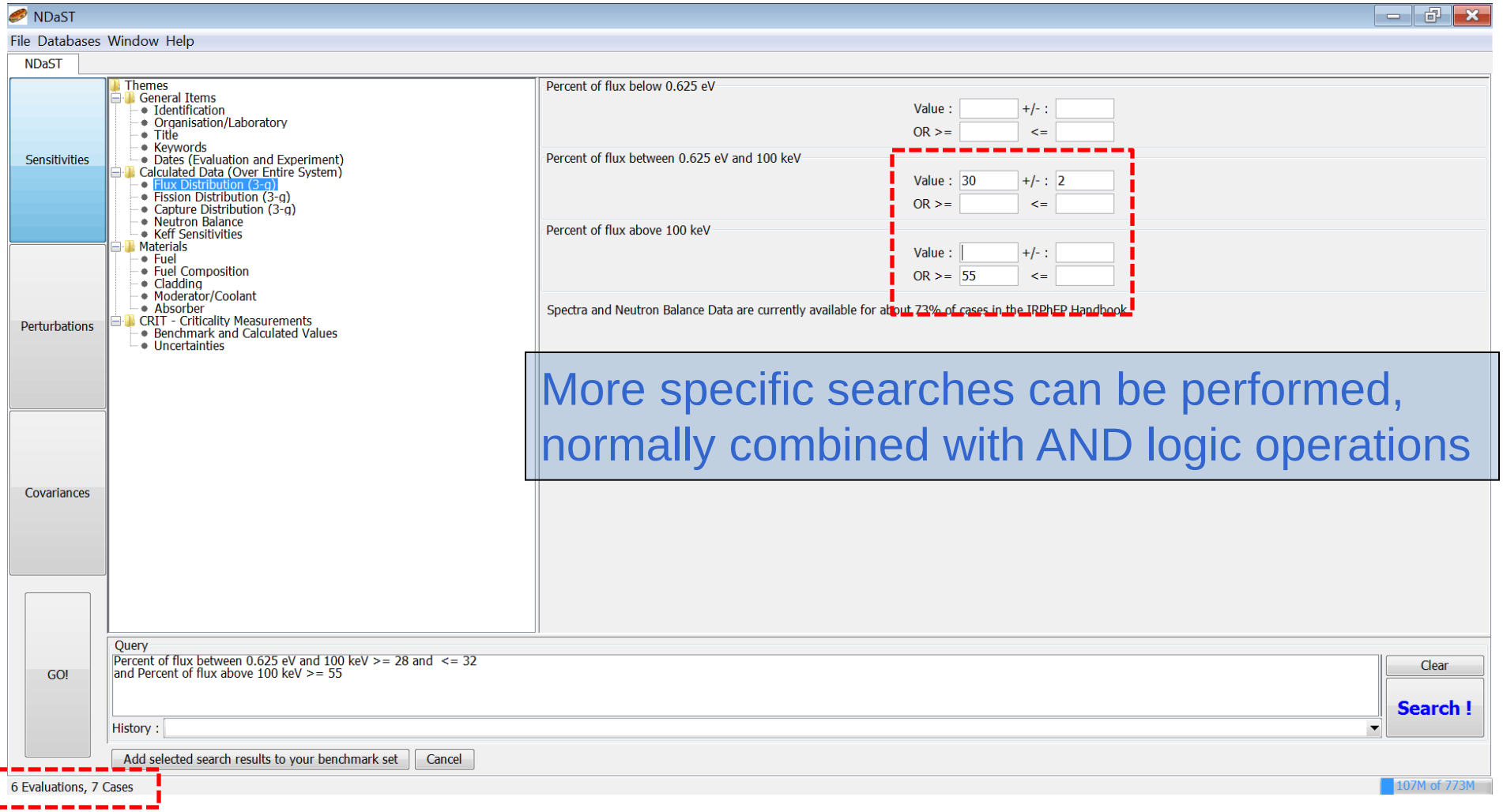
- 2 are search based from databases (DICE & IDAT)
- 1 is free input, requiring your own sensitivity data file

Simple Benchmark Selection - ID



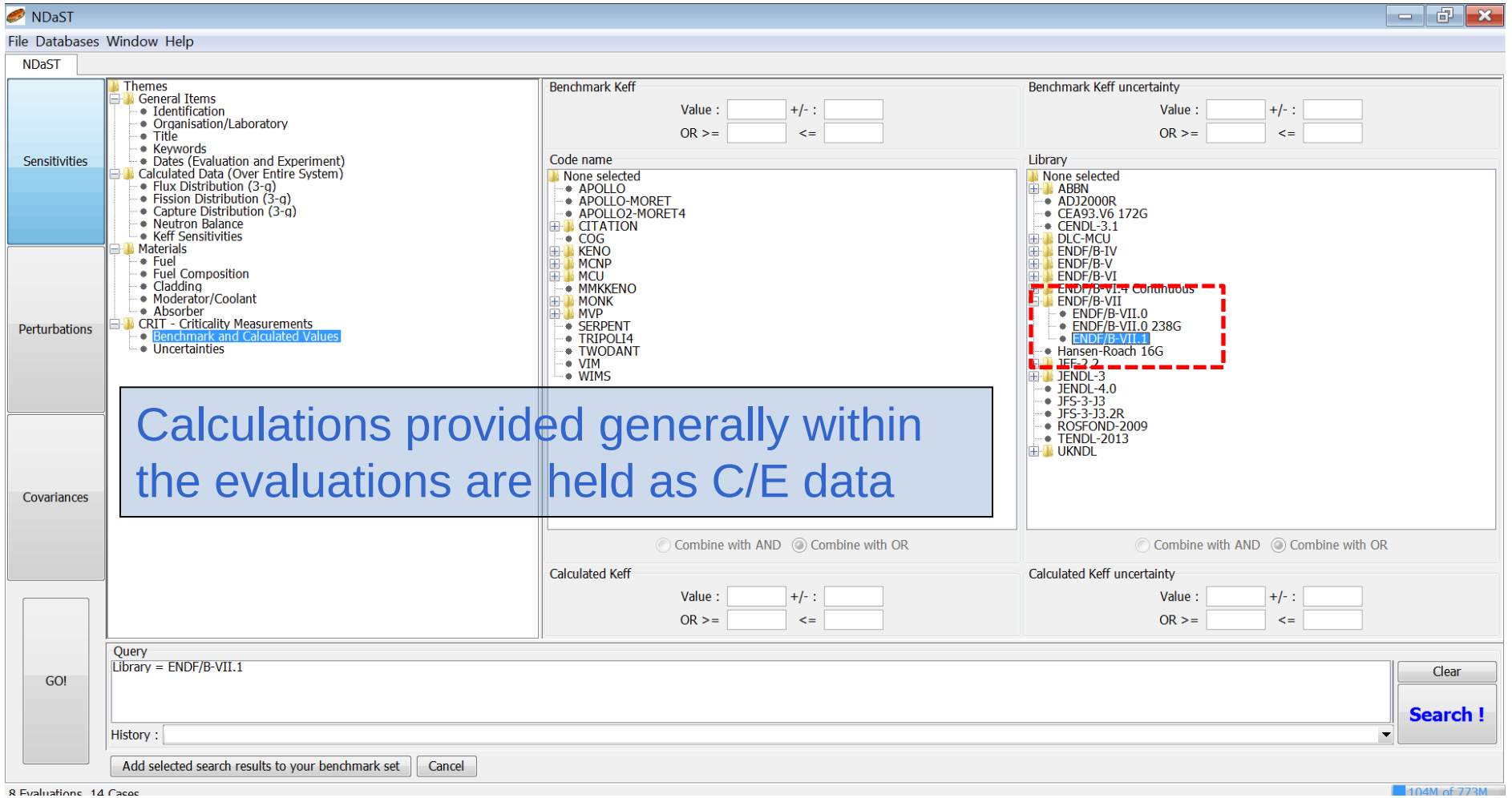
Counter is live before you hit Search button

Simple Benchmark Selection - Flux



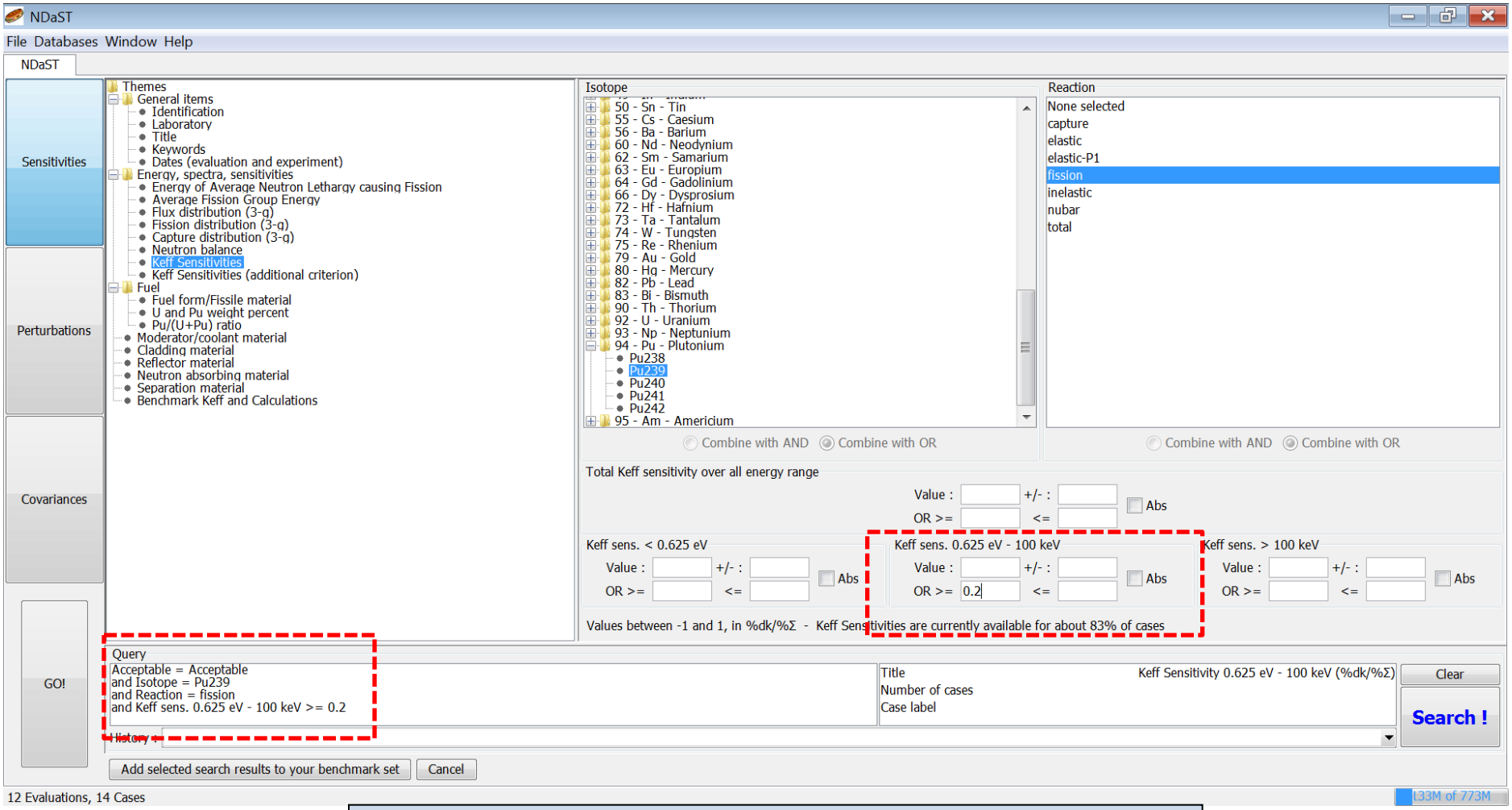
More specific searches can be performed, normally combined with AND logic operations

Simple Benchmark Selection - Library



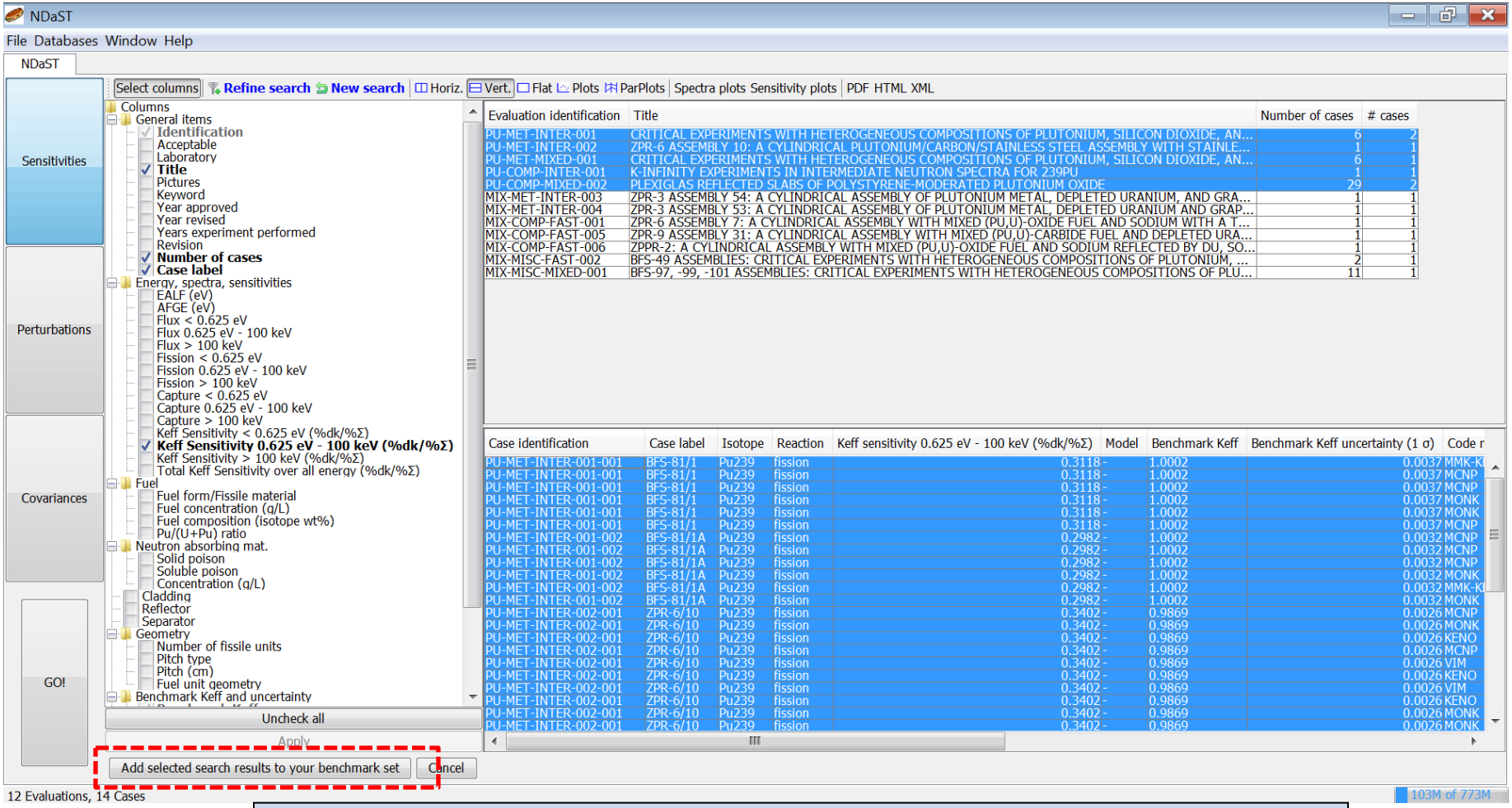
Calculations provided generally within the evaluations are held as C/E data

Sensitive Benchmark Search



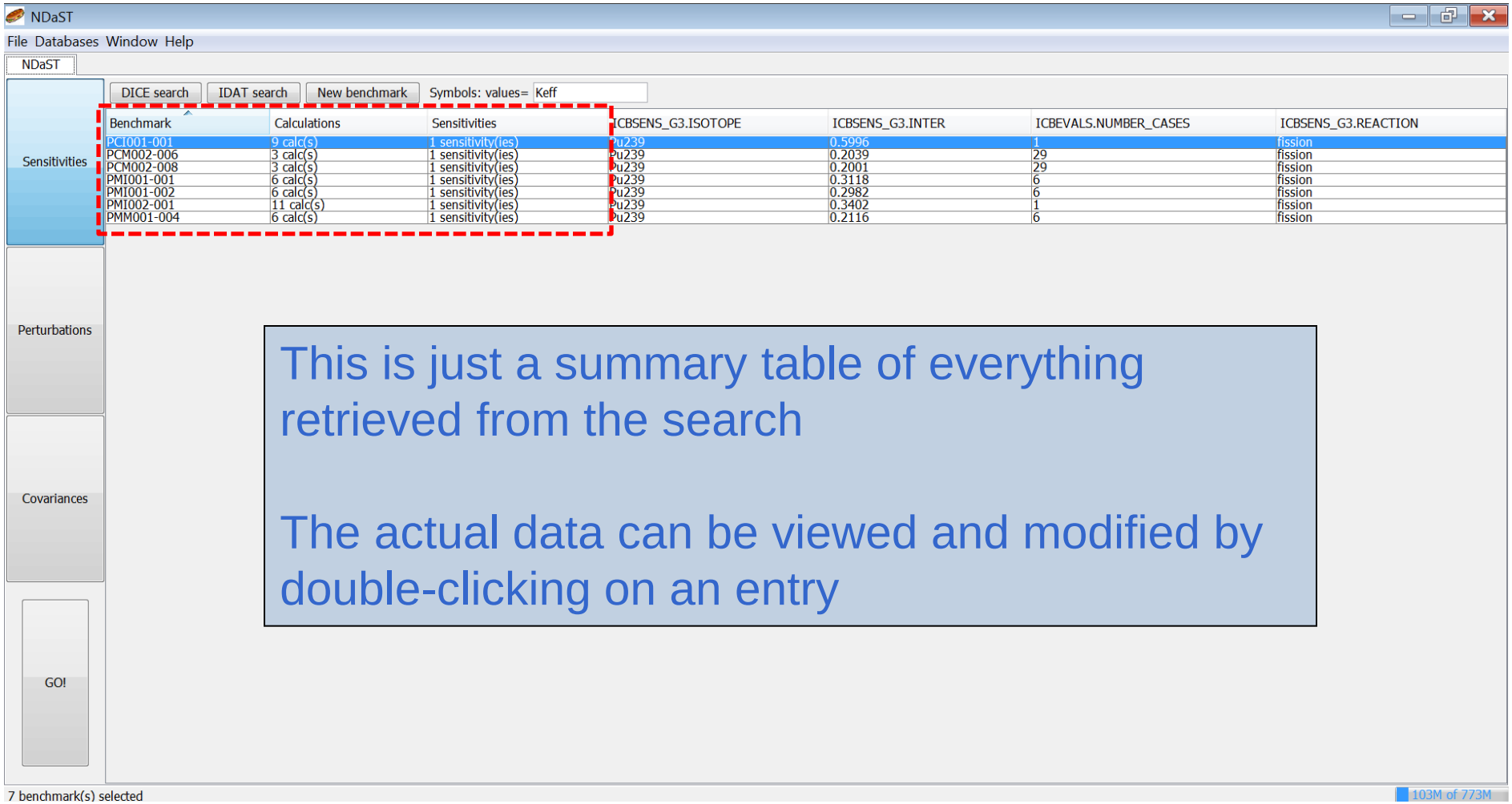
This is where NDaST is really focused!

Addition of Benchmarks to Set



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

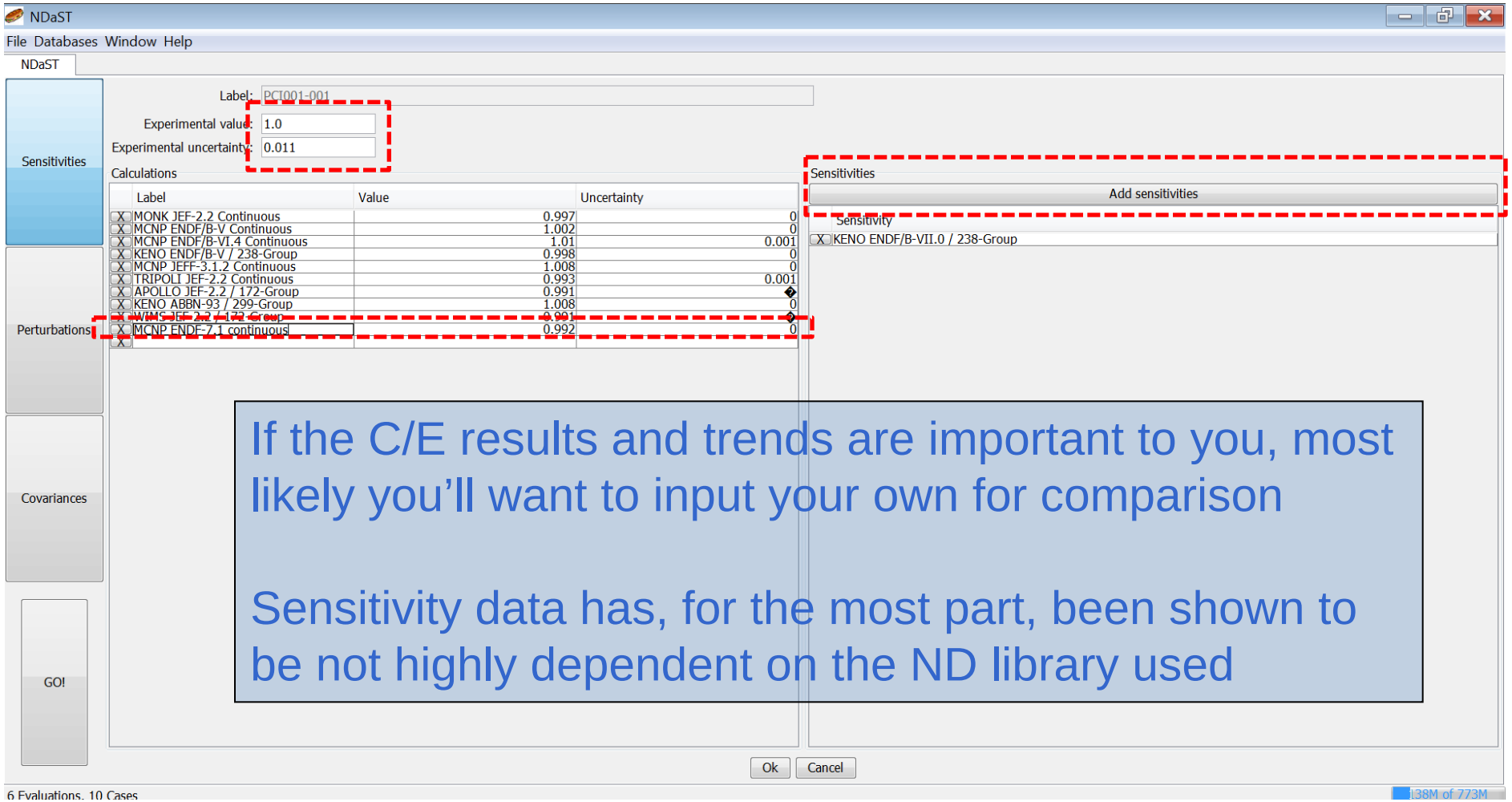
Addition of Benchmarks to Set



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

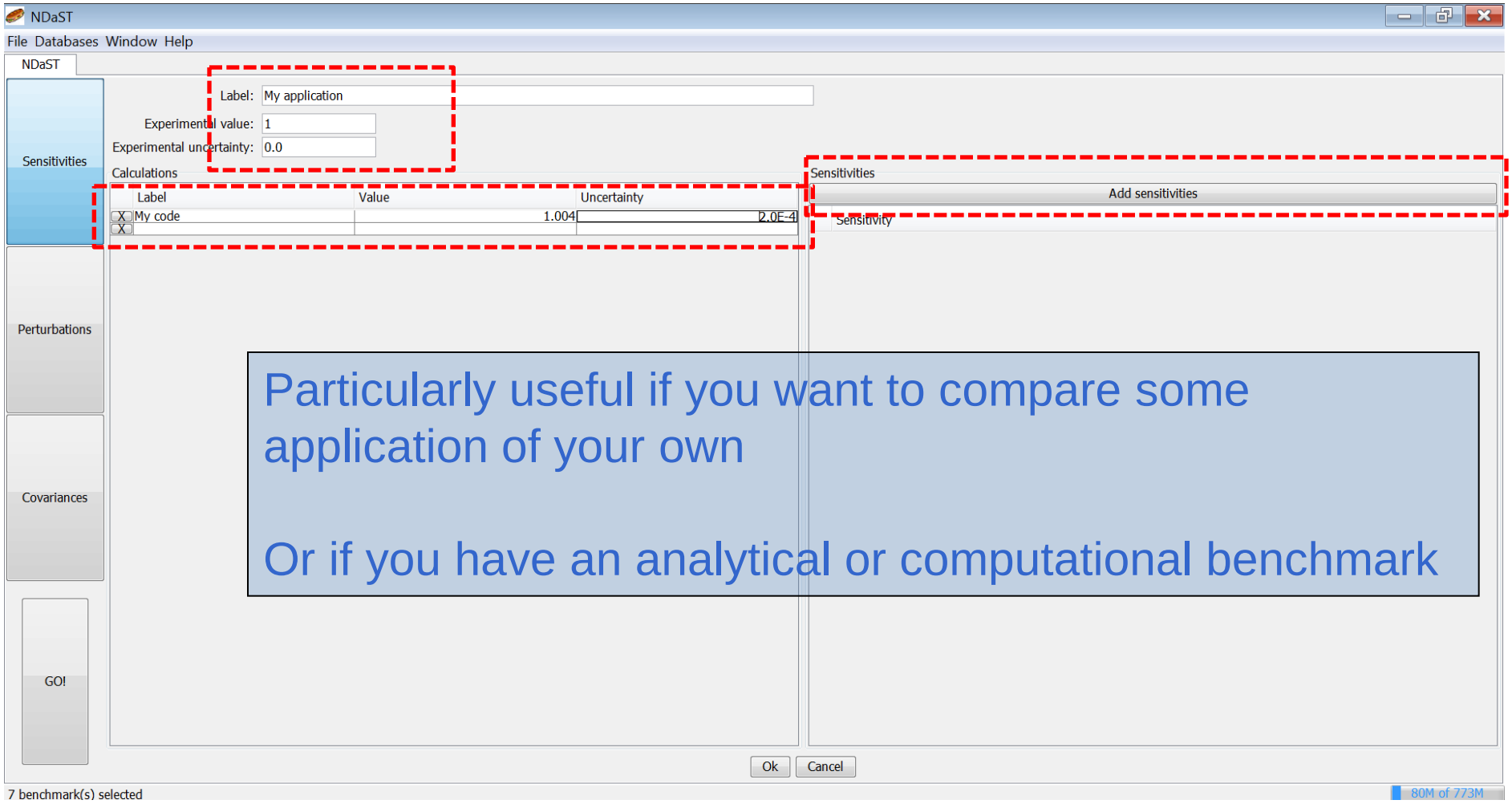
Edit Benchmark Data



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

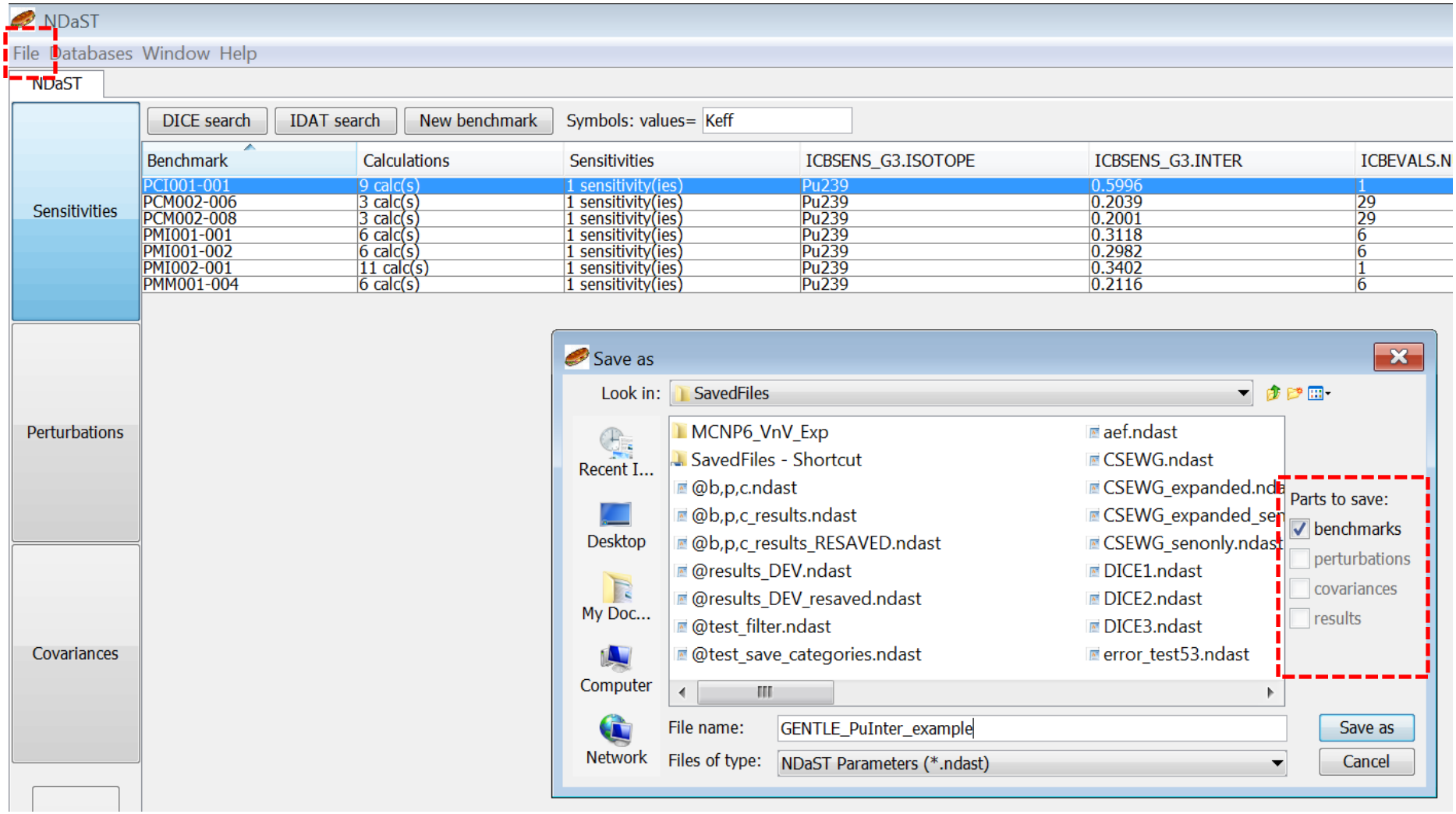
Add ‘New Benchmark’



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
Continuous" freetext="" val="1.0157" unc="0.001"/>
        <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

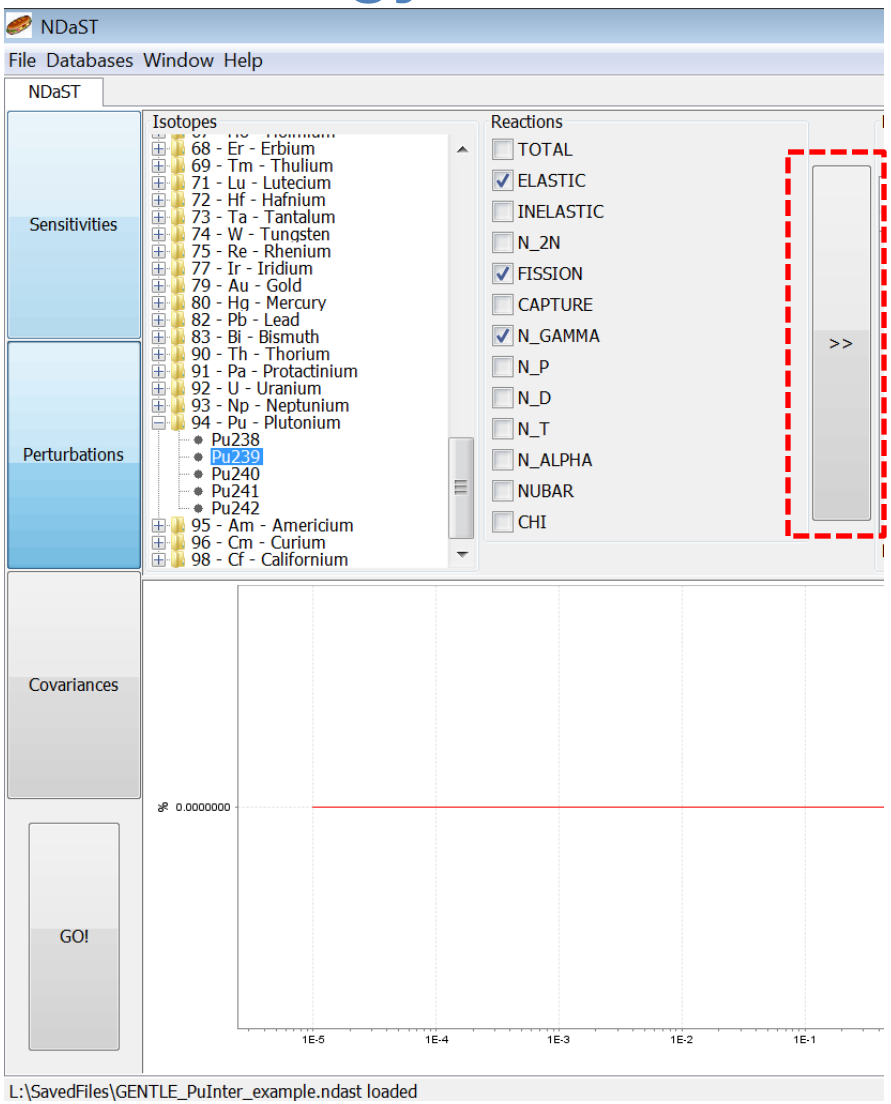
Each isotope-reaction represented by a column with N energy group rows

<u>Loading Options:</u>

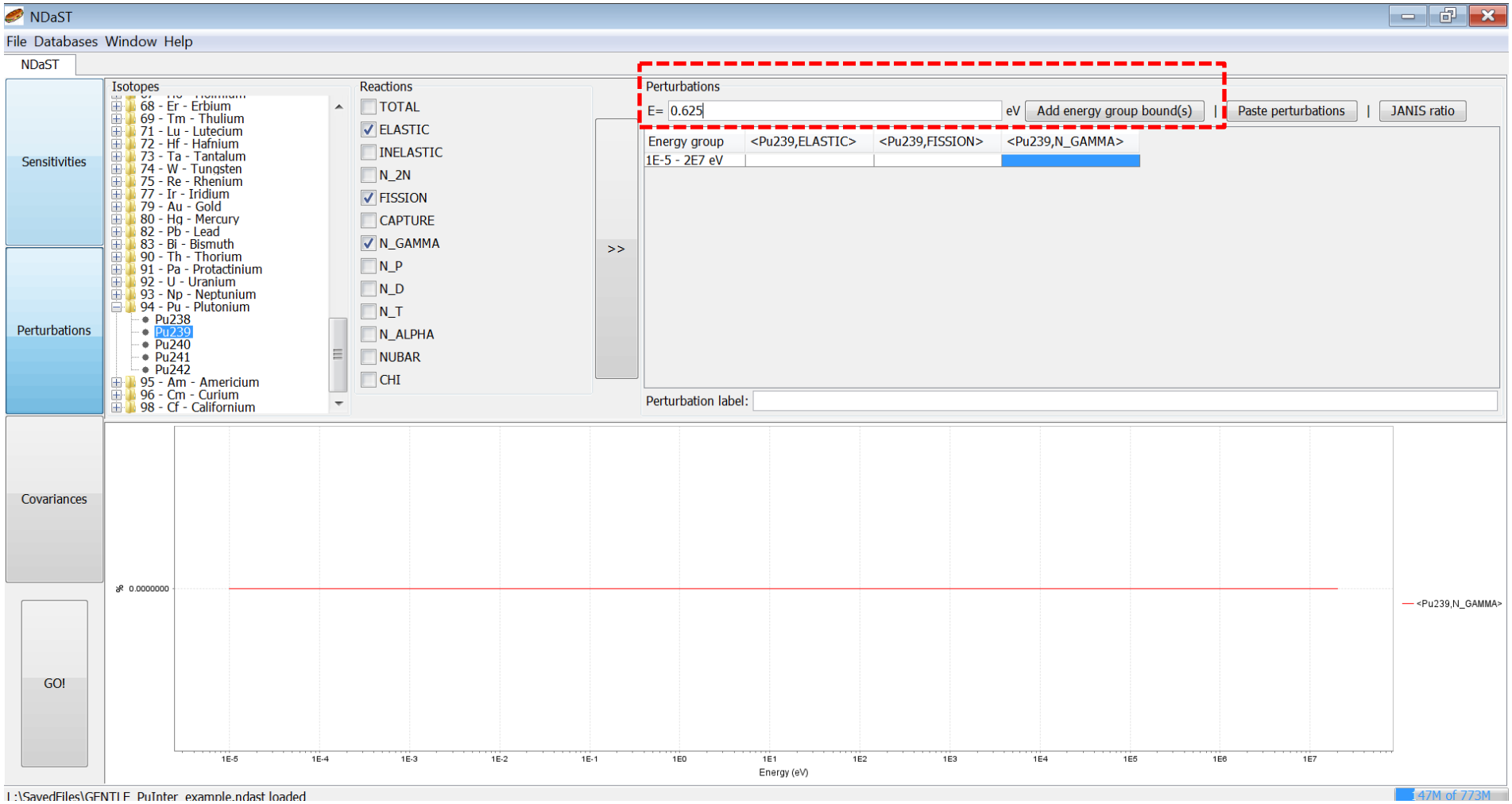
- Manually
- Copy/paste e.g. from file
- Auto-computed by dividing 2 evaluated files (via JANIS) Example:

CIELO ÷ ENDF/B-VII.1

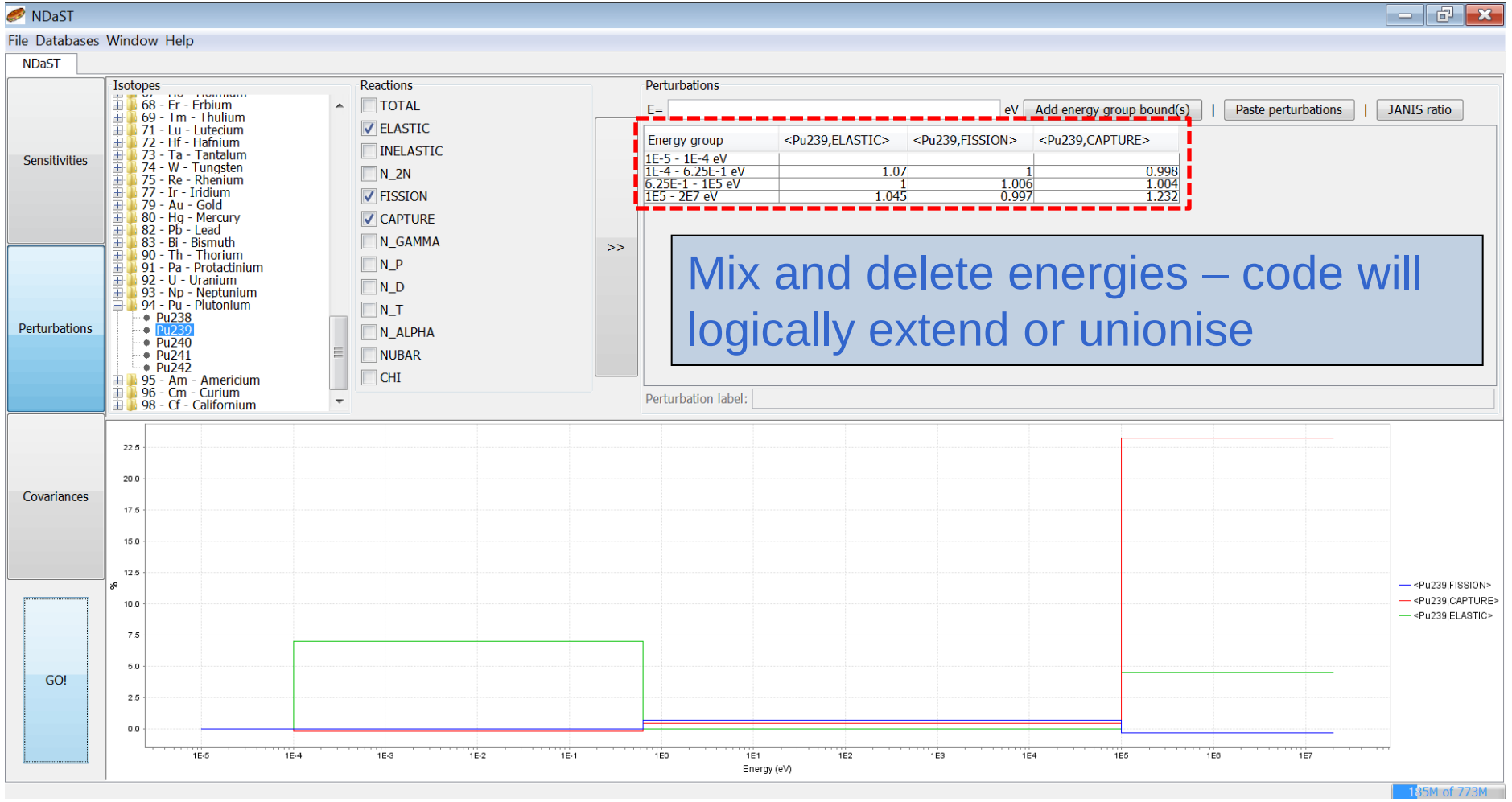
- Save in isolation or with panel 1 benchmarks



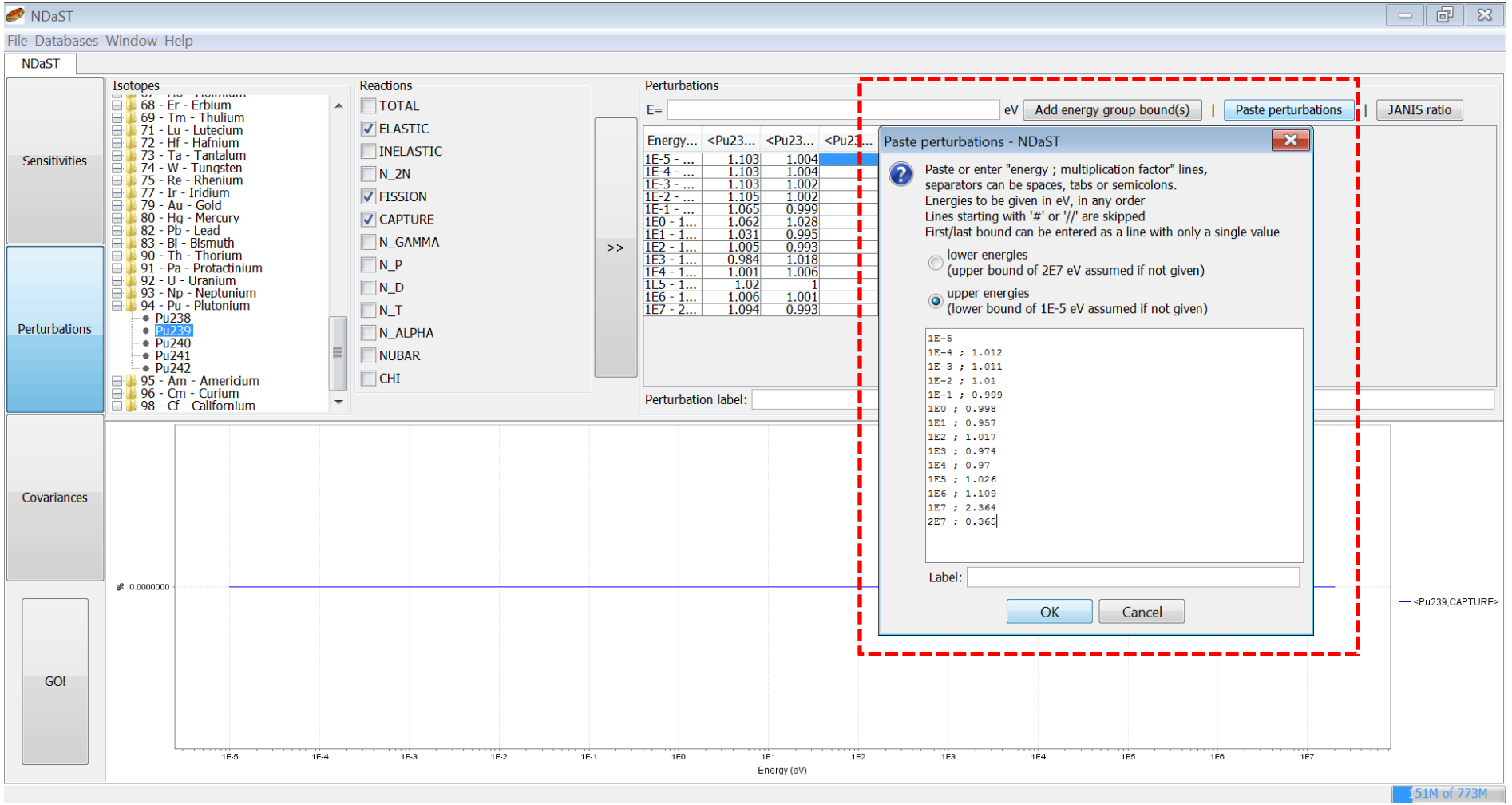
Add Energy & Perturbation Manually



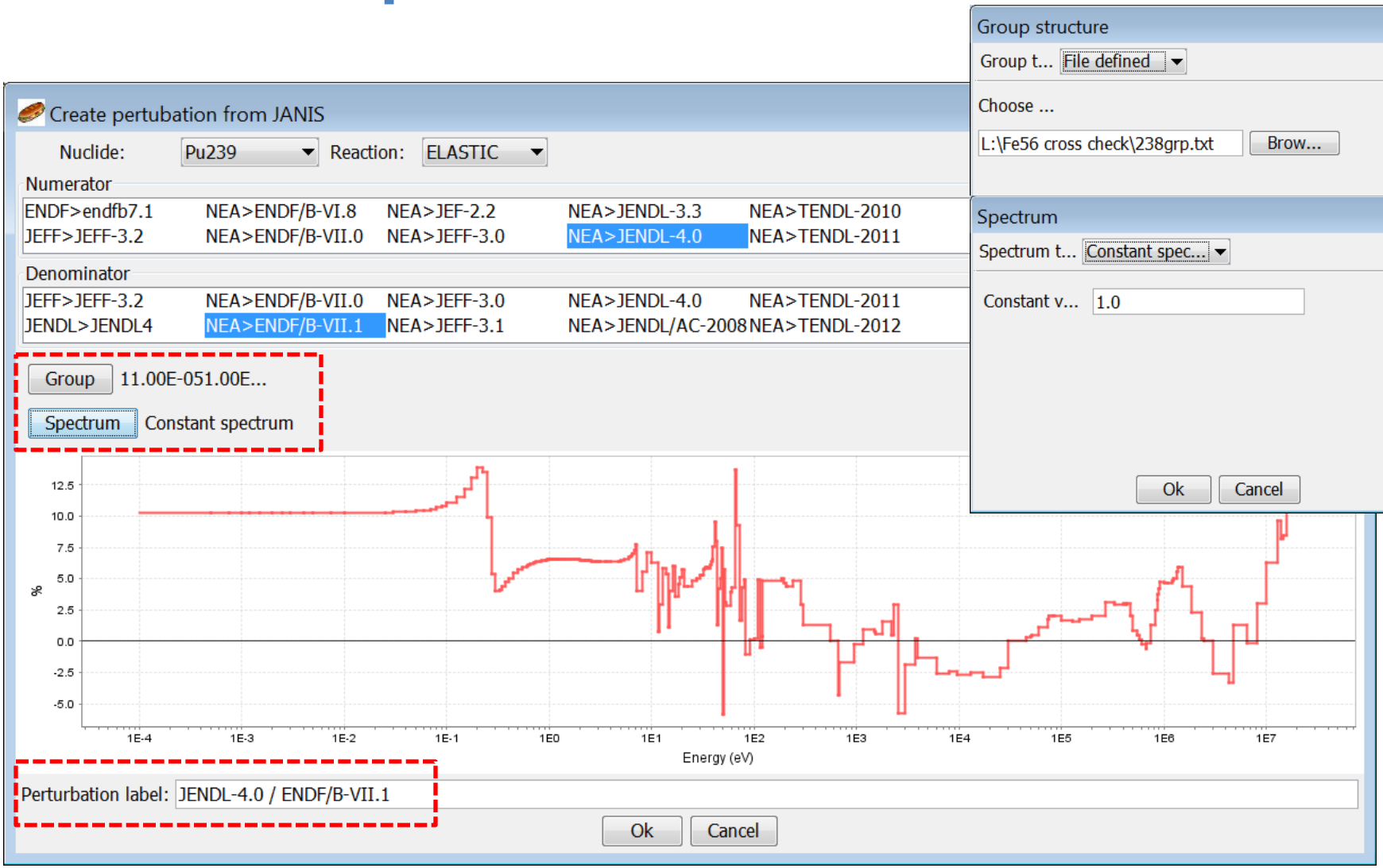
Add Energy & Perturbation Manually



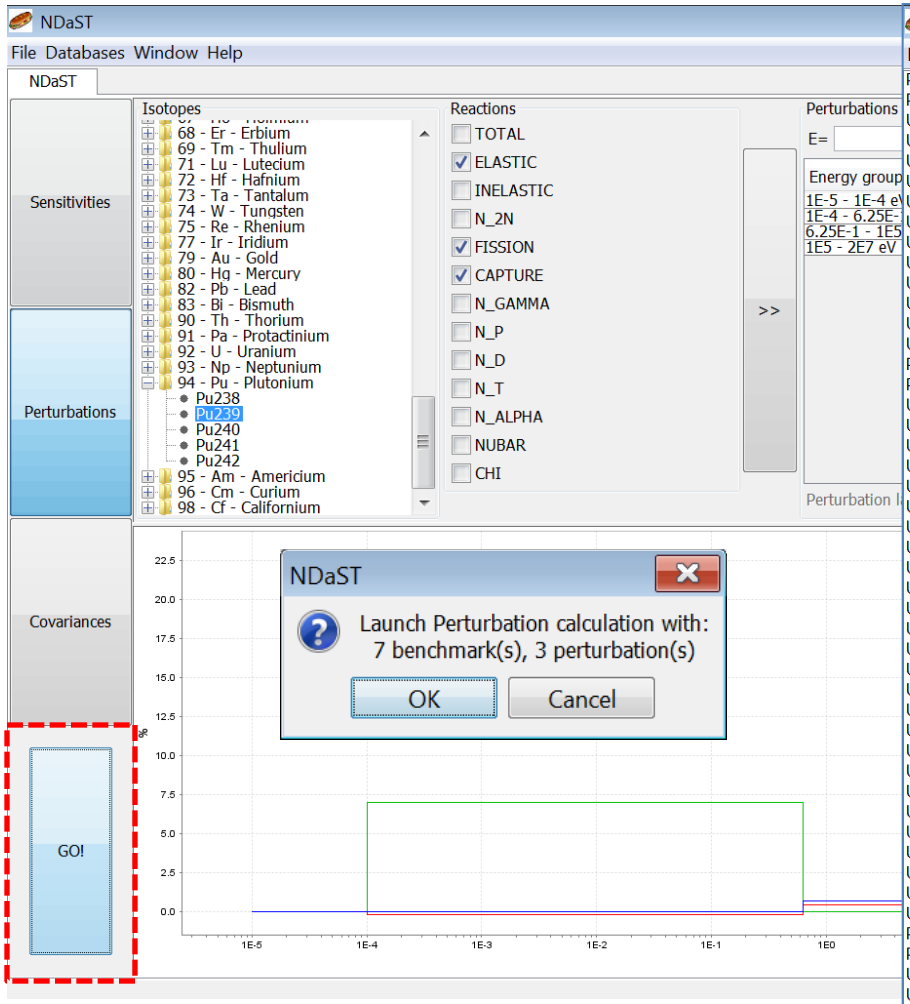
Paste Energies & Perturbations

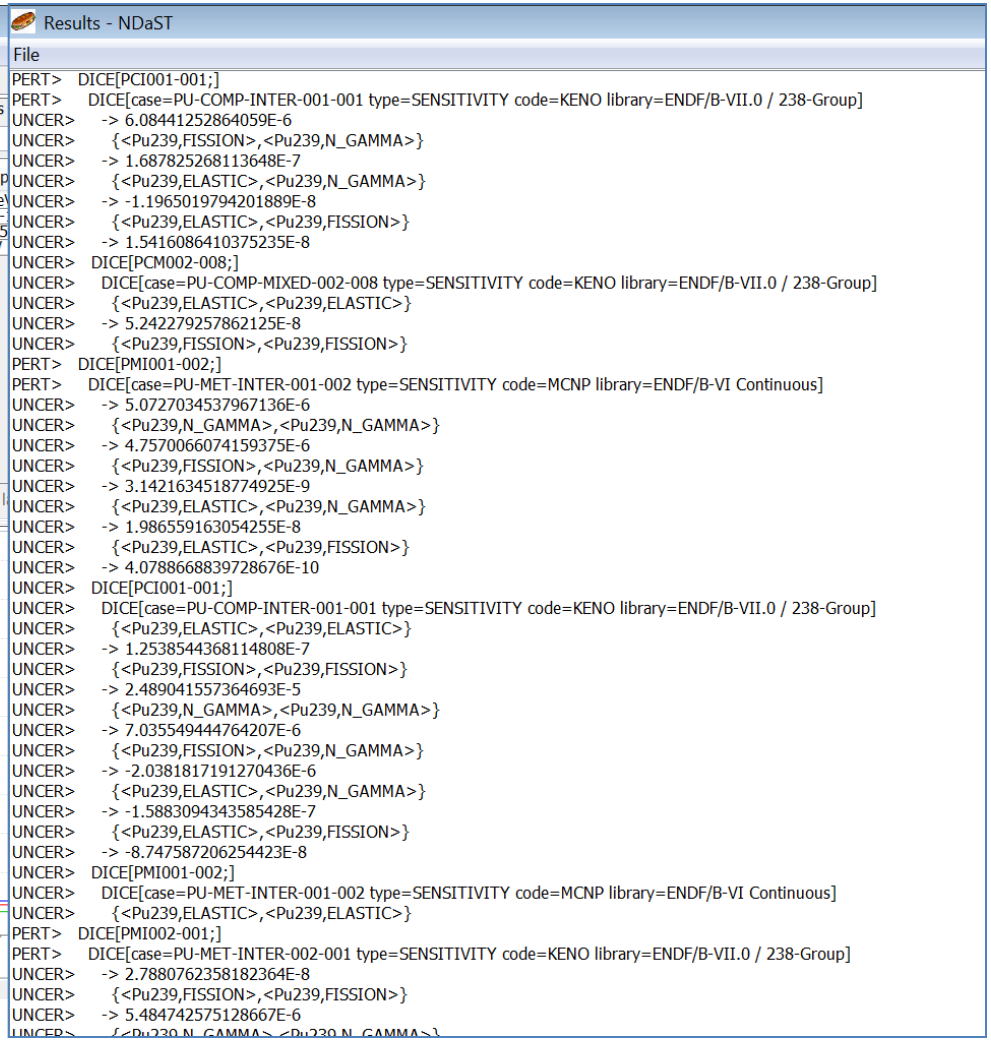


Computation of Ratios in JANIS



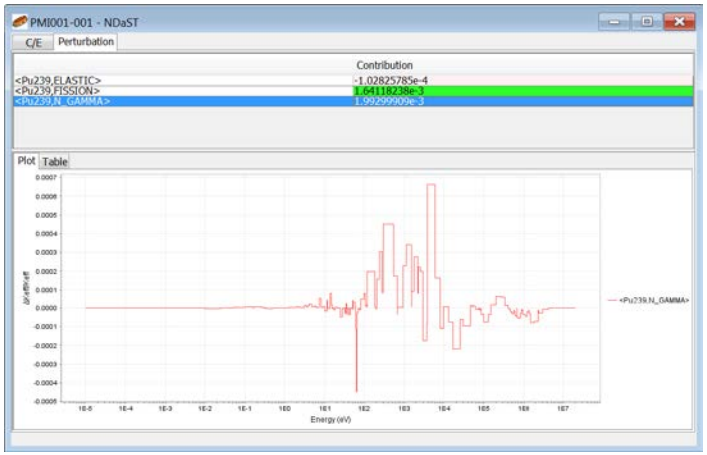
Launch Perturbation Calculation

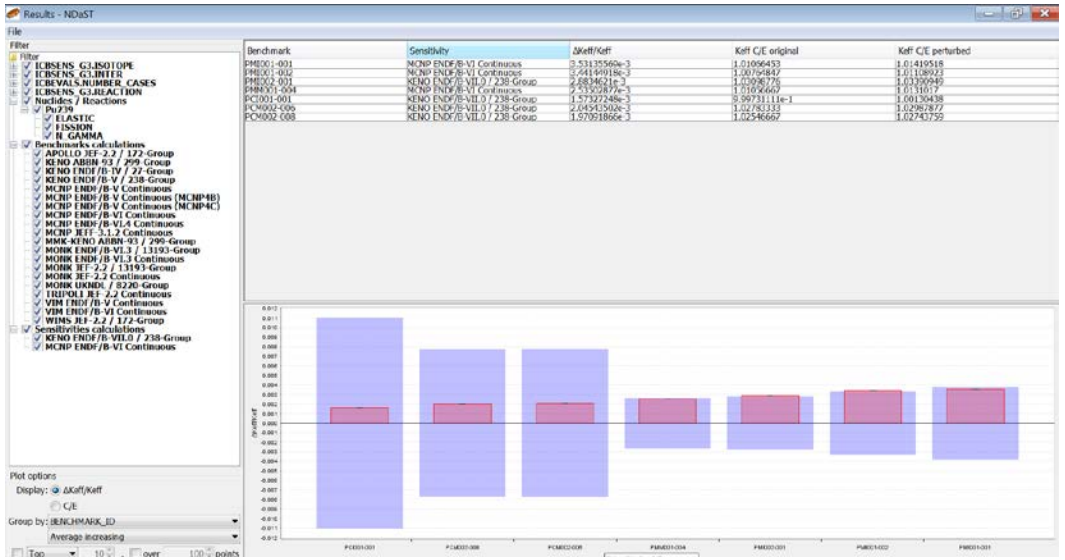




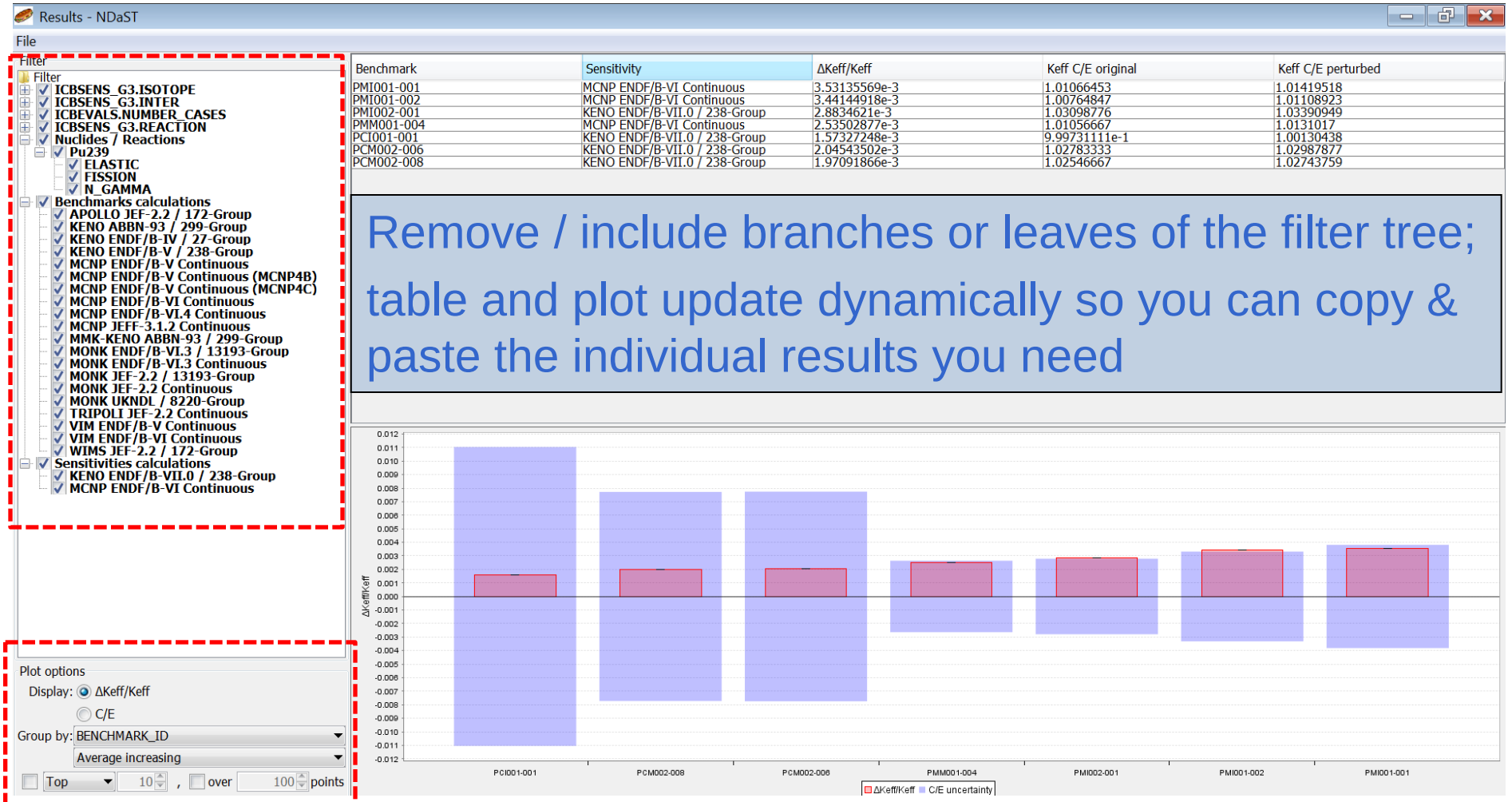
Output Window and Plots (1)

- 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



Delta k_{eff} Output: Physical Form

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

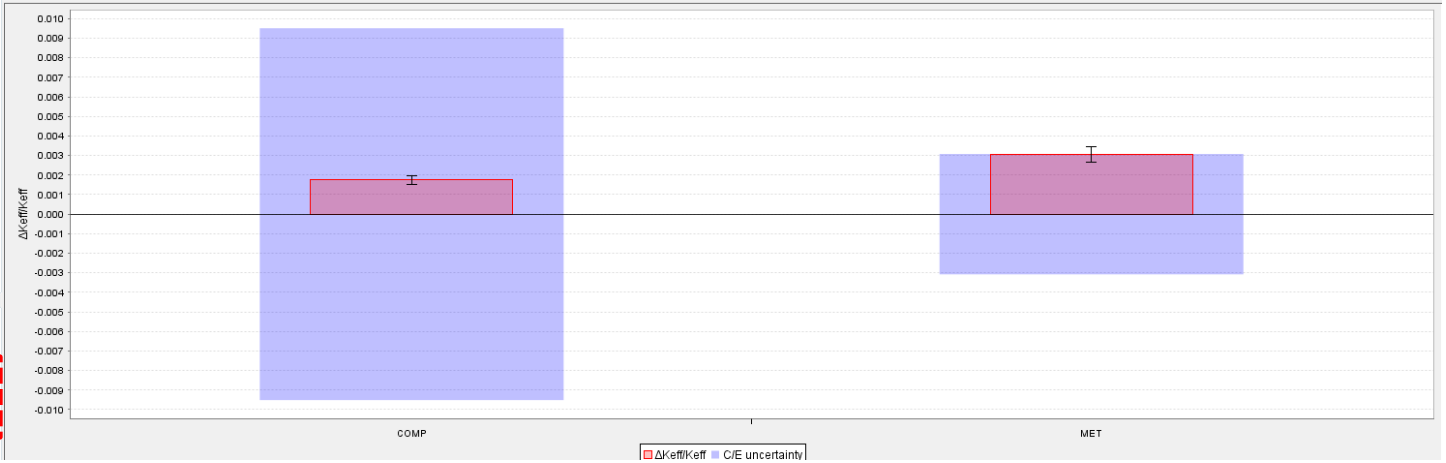
Group by: EVAL_ID_PHYSICAL_FORM

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	1.01066453	1.01419518
PMI001-002	MCNP ENDF/B-VI Continuous	3.44144918e-3	1.00764847	1.01108923
PMI002-001	KENO ENDF/B-VII.0 / 238-Group	2.8834621e-3	1.03098776	1.03390949
PMM001-004	MCNP ENDF/B-VI Continuous	2.53502877e-3	1.01056667	1.0131017
PCI001-001	KENO ENDF/B-VII.0 / 238-Group	1.57327248e-3	9.99731111e-1	1.00130438
PCM002-006	KENO ENDF/B-VII.0 / 238-Group	2.04543502e-3	1.02783333	1.02987877
PCM002-008	KENO ENDF/B-VII.0 / 238-Group	1.97091866e-3	1.02546667	1.02743759

Plot bars can be grouped by a fixed set of shared attributes – to be expanded in future



C/E Output Plot: BM ID

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

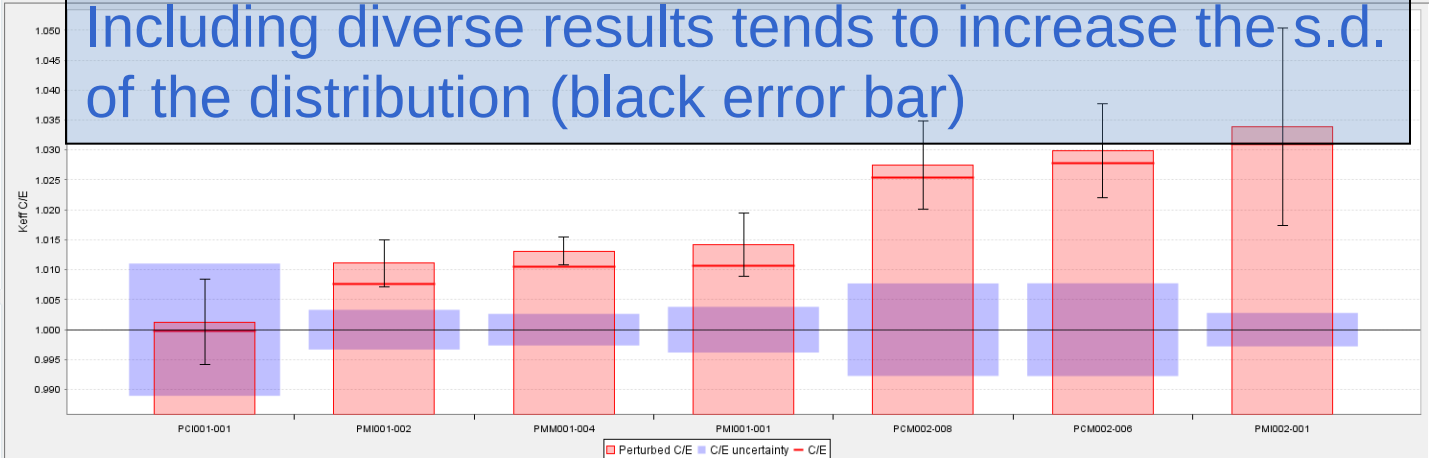
Average increasing

Top 10 , over 100 points

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

C/E plot shows not just the change, but the new expected values of calculations

Including diverse results tends to increase the s.d. of the distribution (black error bar)



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

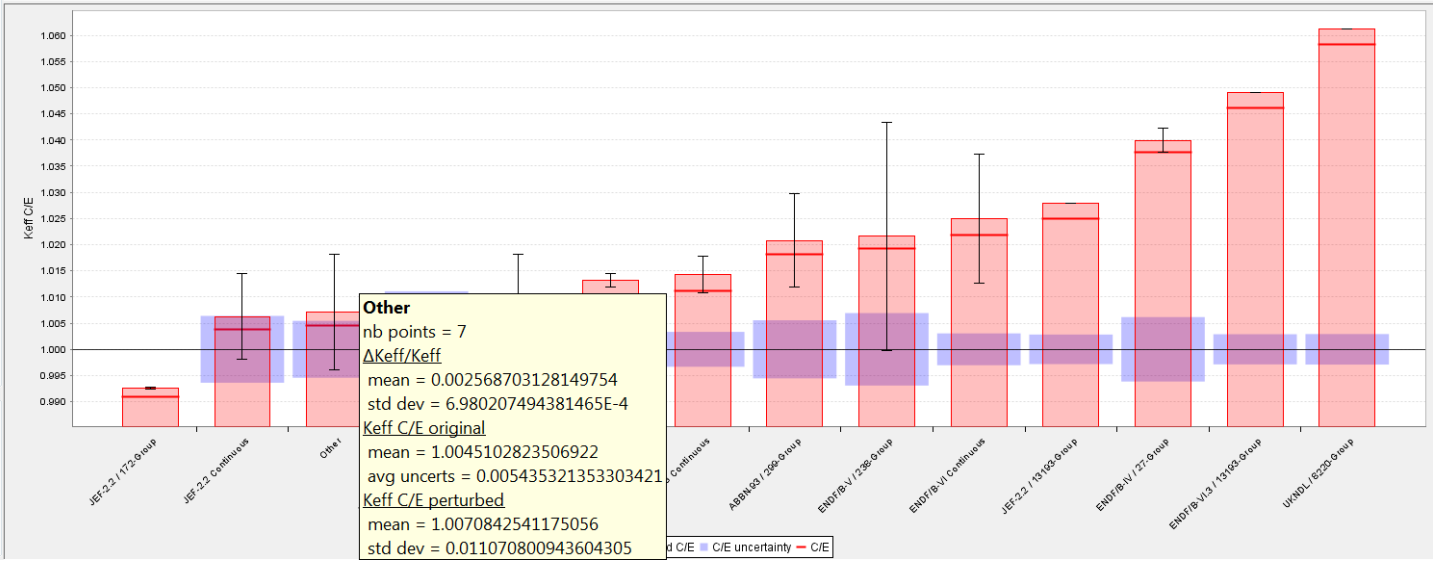
Group by: CALC_LIB

Average increasing

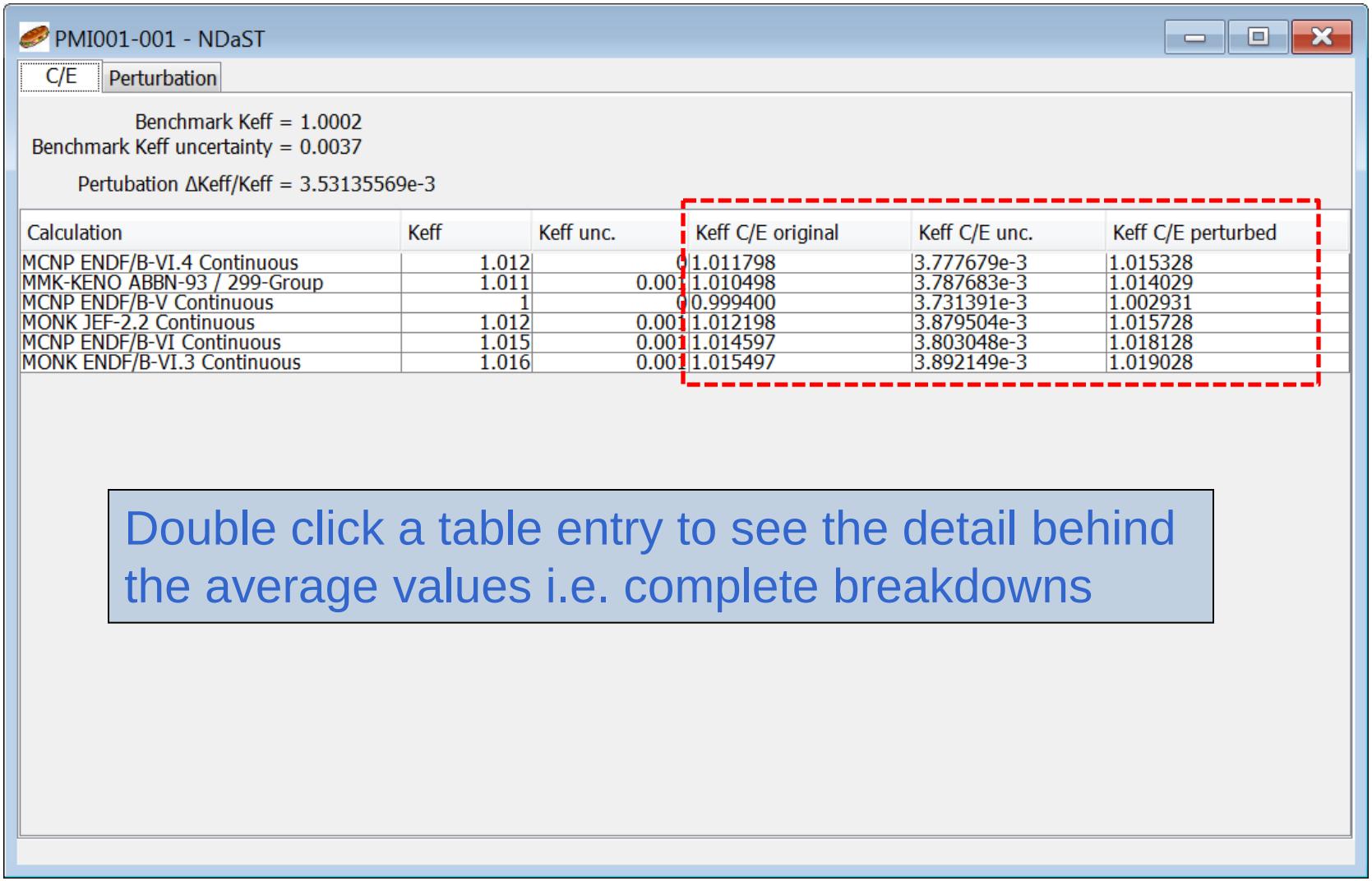
Top 10 , over 100 points

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	2.53502877e-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

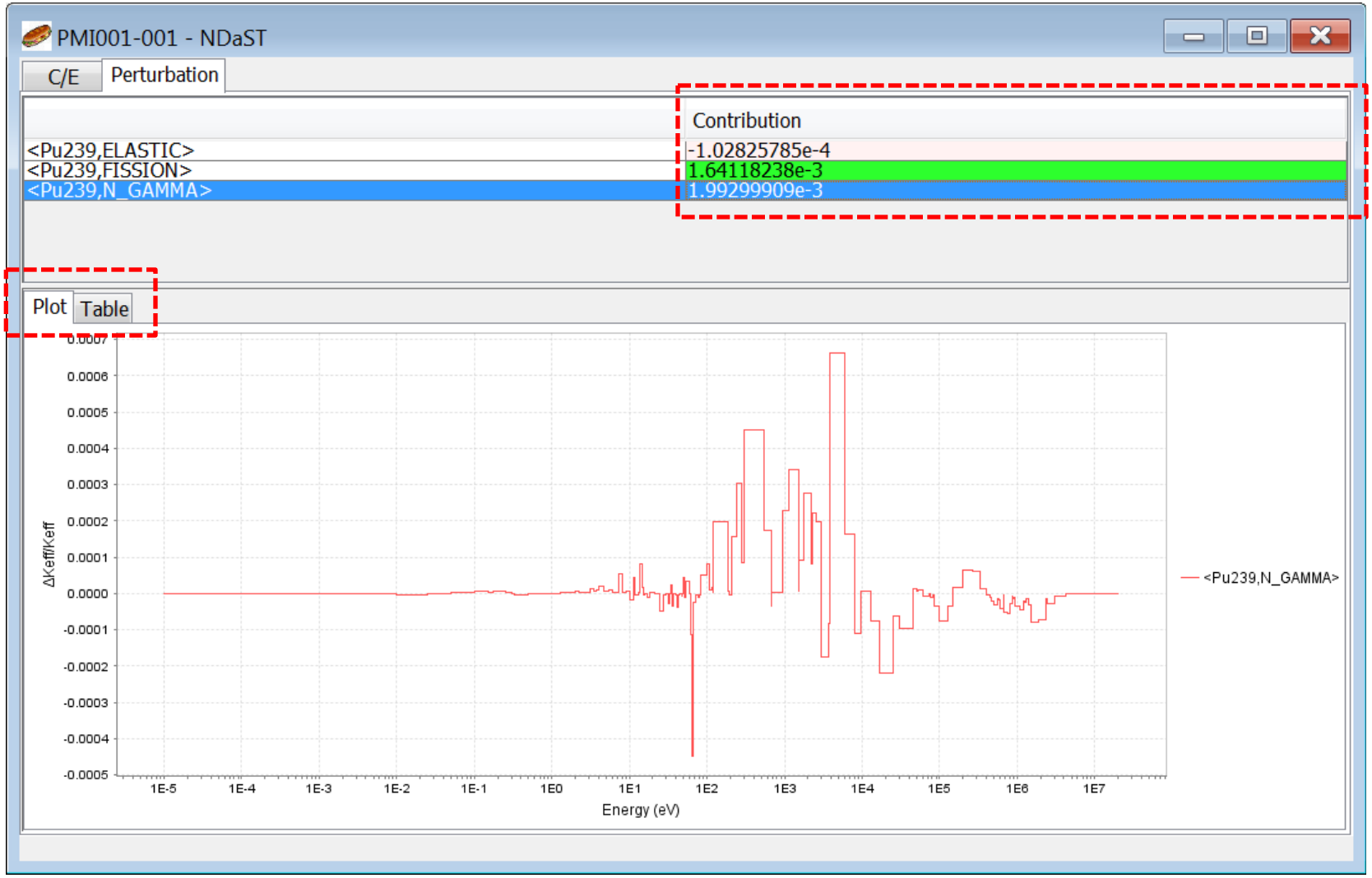
Use tool-tips for a quick reference quantification of each bar



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

Exercise 1 – Example Perturbations

Search DICE for
- Pu fuel cases

sensitive to intermediate fission
- >= 0.2 %dk/%dΣ

- Add data from these tables →

Predict effect of replacing JENDL-4.0 / ENDF/B-VII.1

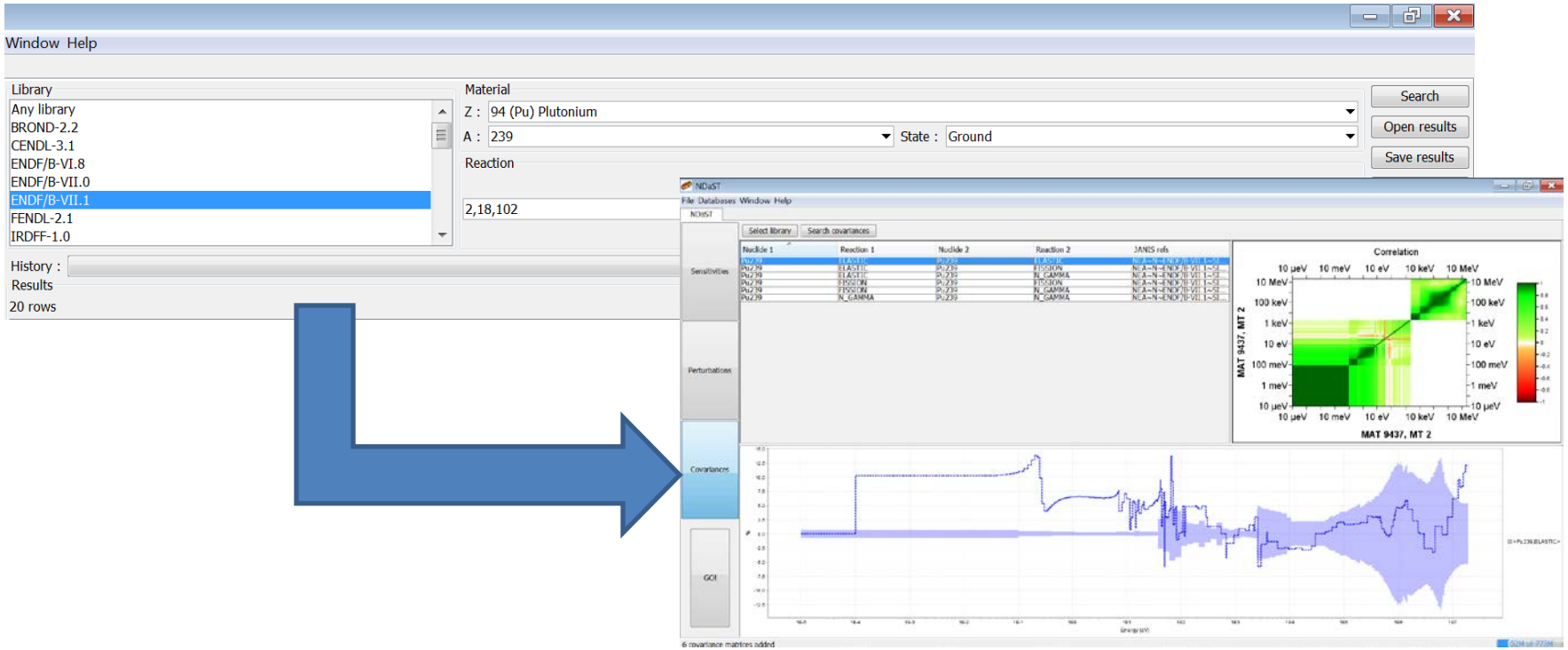
Benchmark	ENDF/B-VII.1 Calculation
PCI001-001	1.0095 ± 0.0002
PCM002-006	1.0150 ± 0.0002
PCM002-008	1.0180 ± 0.0002
PMI001-001	0.9970 ± 0.0002
PMI001-002	0.9980 ± 0.0002
PMI002-001	1.0050 ± 0.0002
PMM001-004	1.0120 ± 0.0002

	Pu239 elastic	Pu239 fission	Pu239 capture
1E-4 - 0.625 eV	1.070	1.000	0.998
0.625 - 100 keV	1.000	1.006	1.004
100 keV - 20 MeV	1.045	0.997	1.232

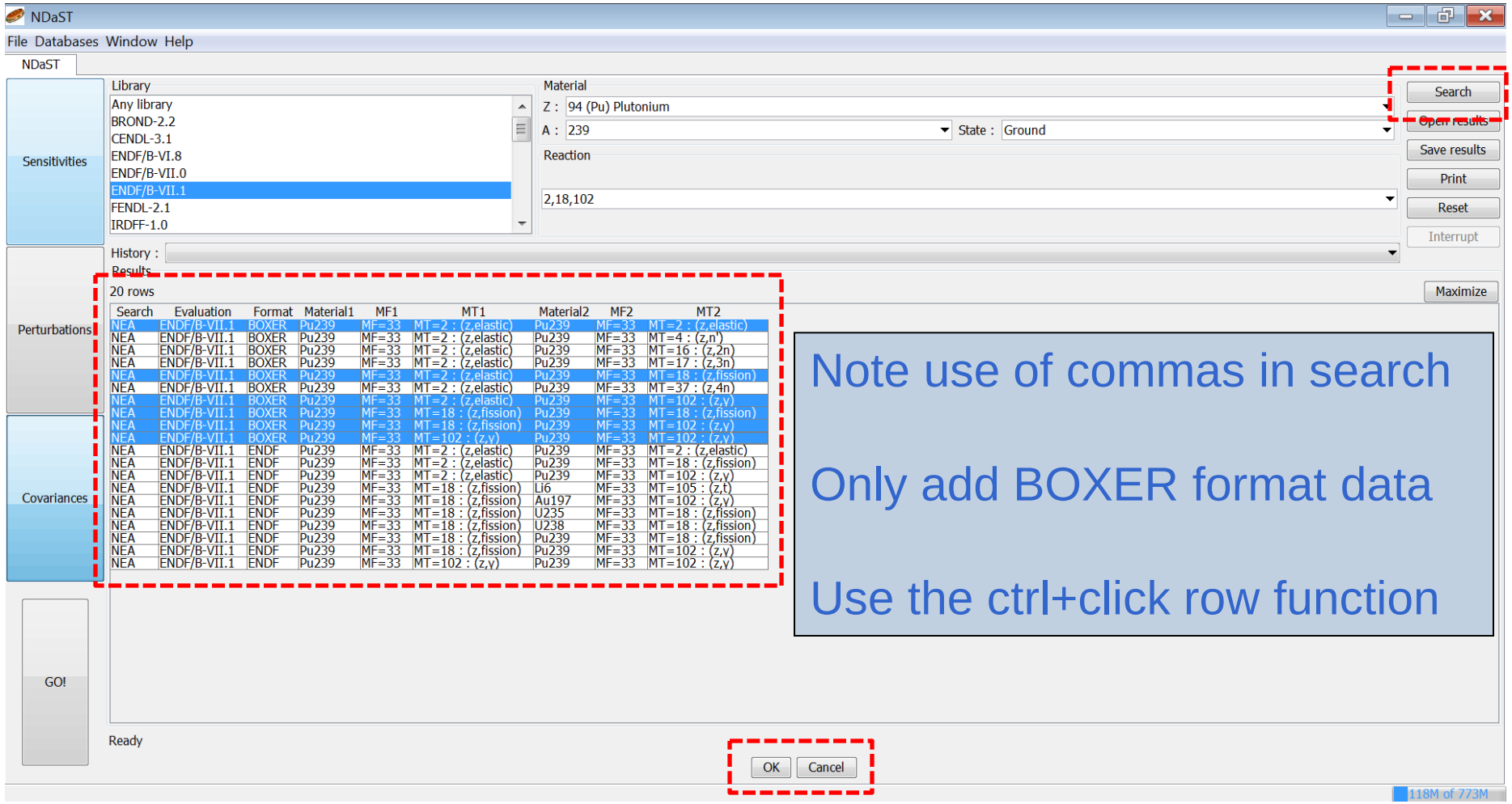
Panel 3: Select XS Covariance Data

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

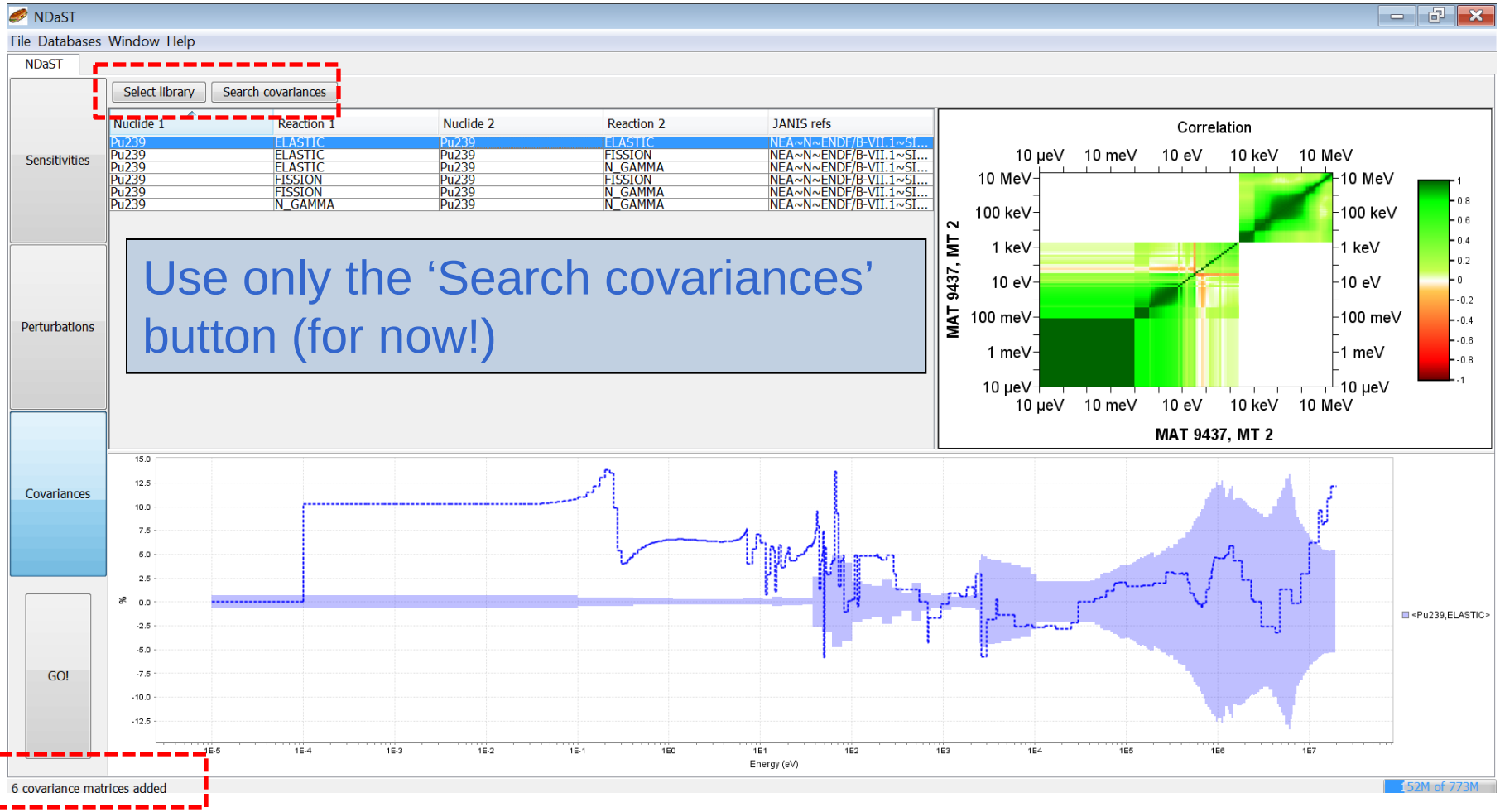


Note use of commas in search

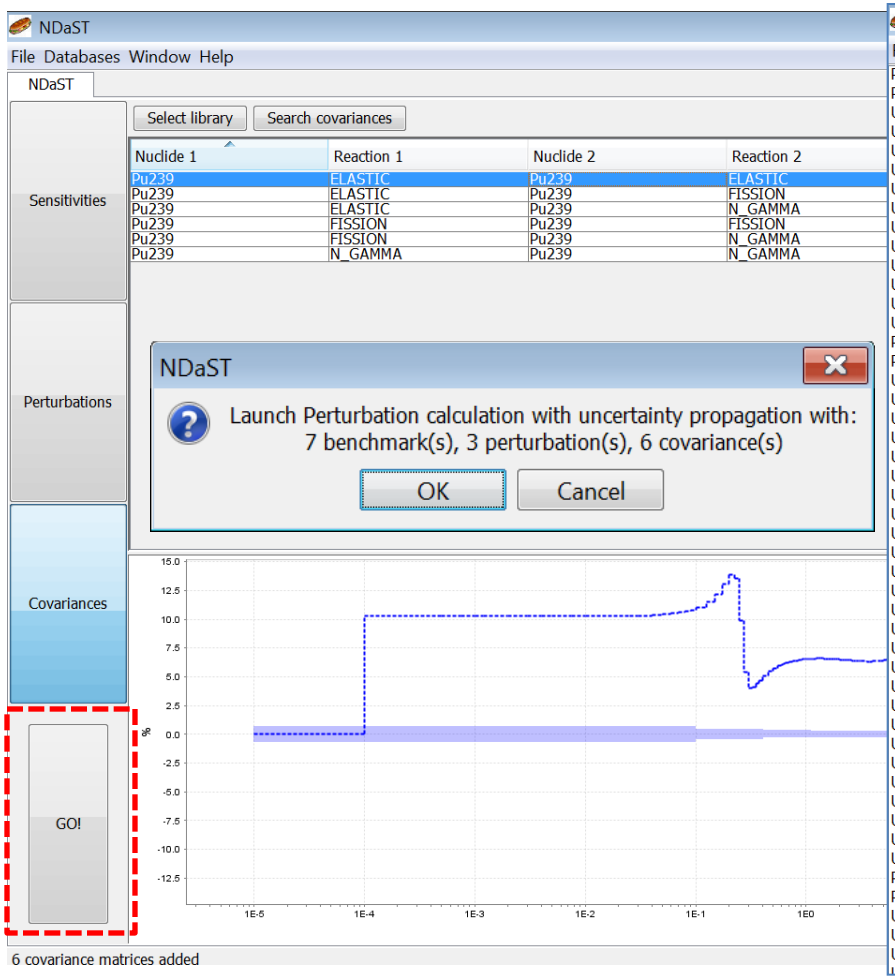
Only add BOXER format data

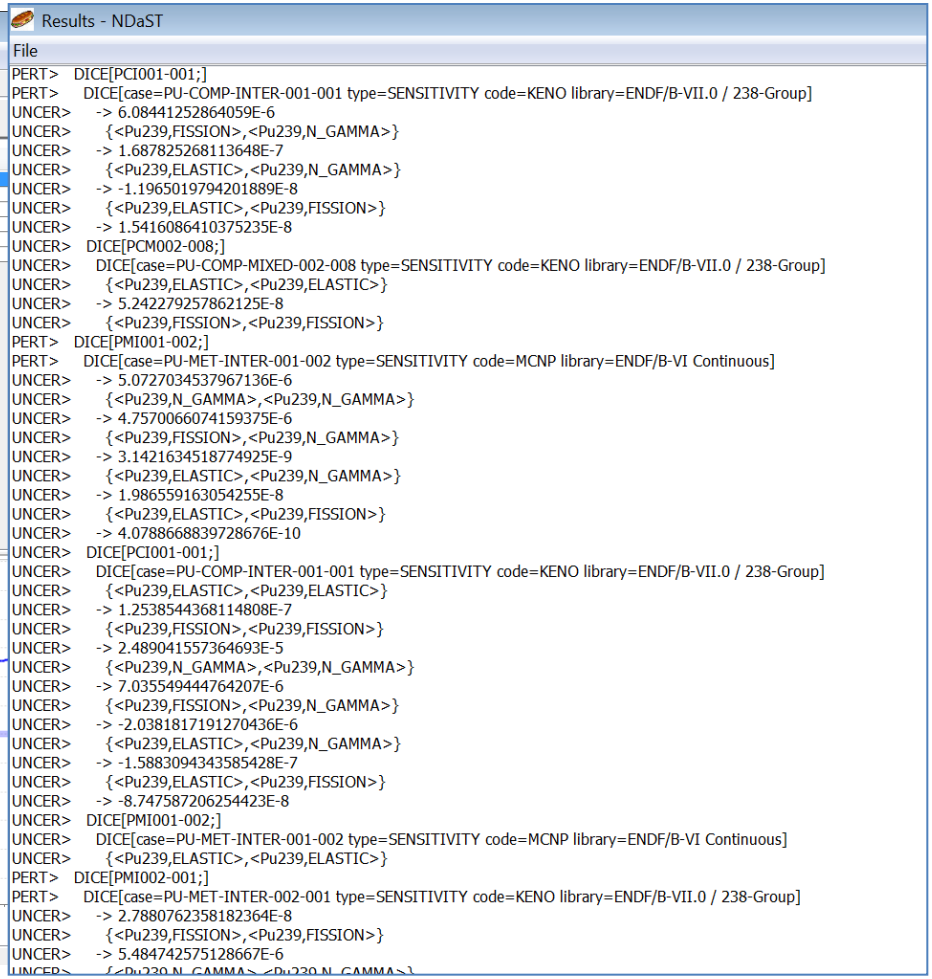
Use the ctrl+click row function

View Selected Covariance Files



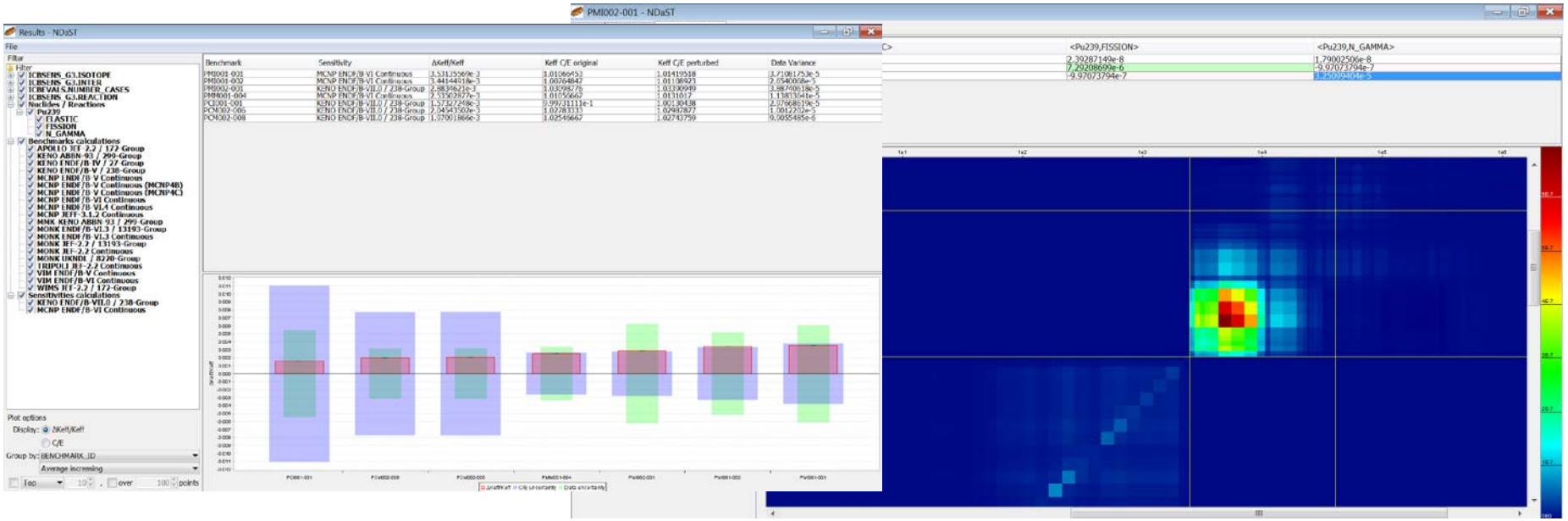
Launch Uncertainty Calculation





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 selection of heat map to quantify contributions + clipboarding



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

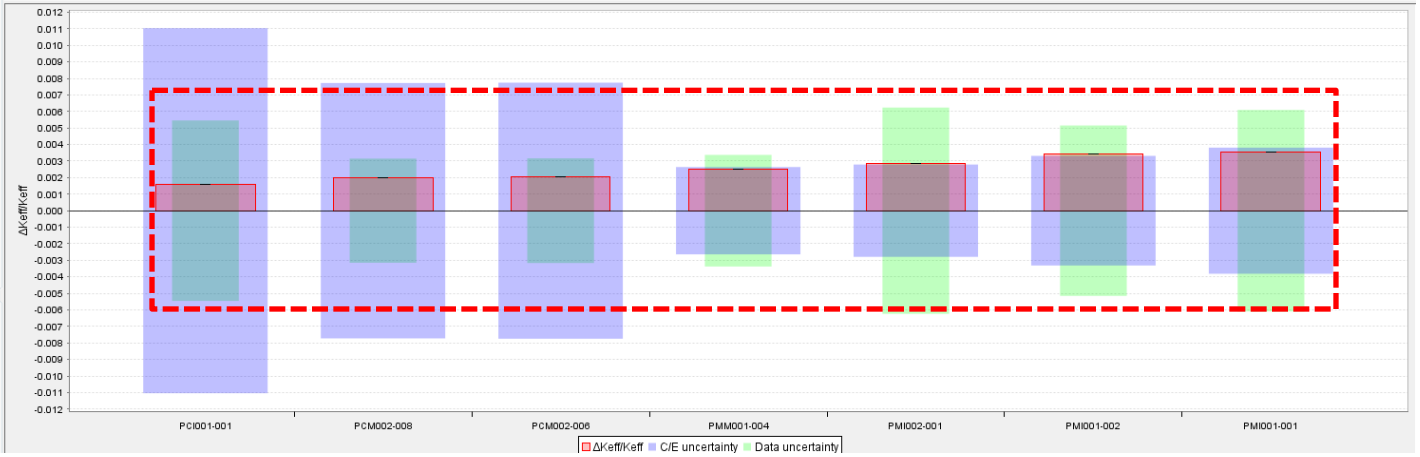
Group by: BENCHMARK_ID

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)



Delta k_{eff} Output: Tooltips

Results - NDaST

File

Filter

Filter
- ICBSENS_G3.ISOTOPE
- ICBSENS_G3.INTER
- ICBEVALS.NUMBER_CASES
- ICBSENS_G3.REACTION
- Nuclides / Reactions
- Benchmarks calculations
- Sensitivities calculations

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

Again, tool-tips can give access to the values stored behind

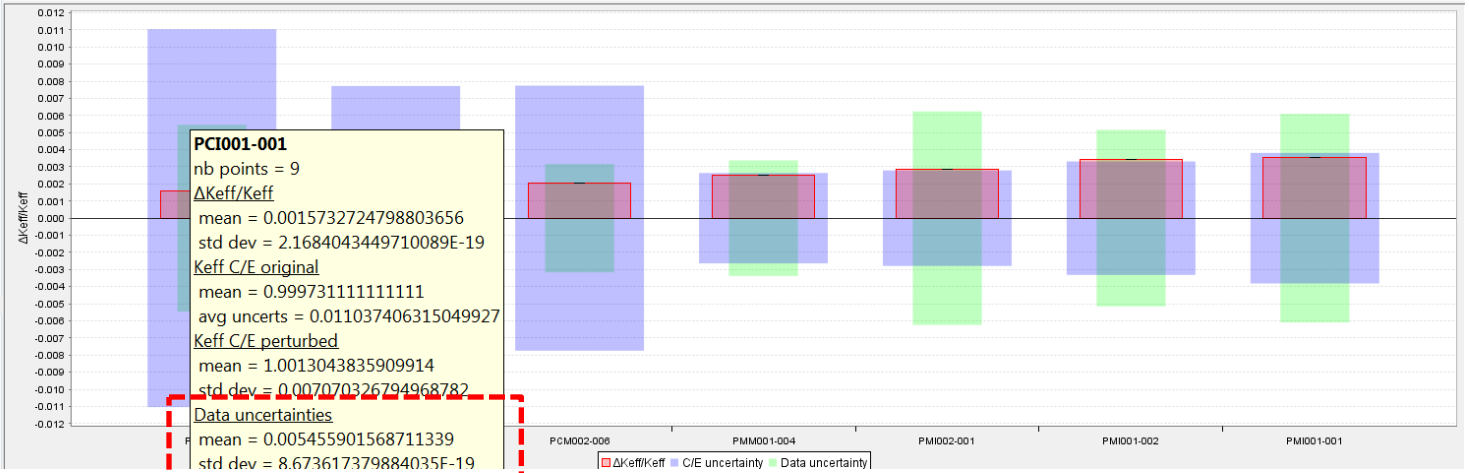
Plot options

Display: ΔKeff/Keff
C/E

Group by: BENCHMARK_ID

Average increasing

Top 10 , over 100 points



C/E Output Plot: BM ID

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

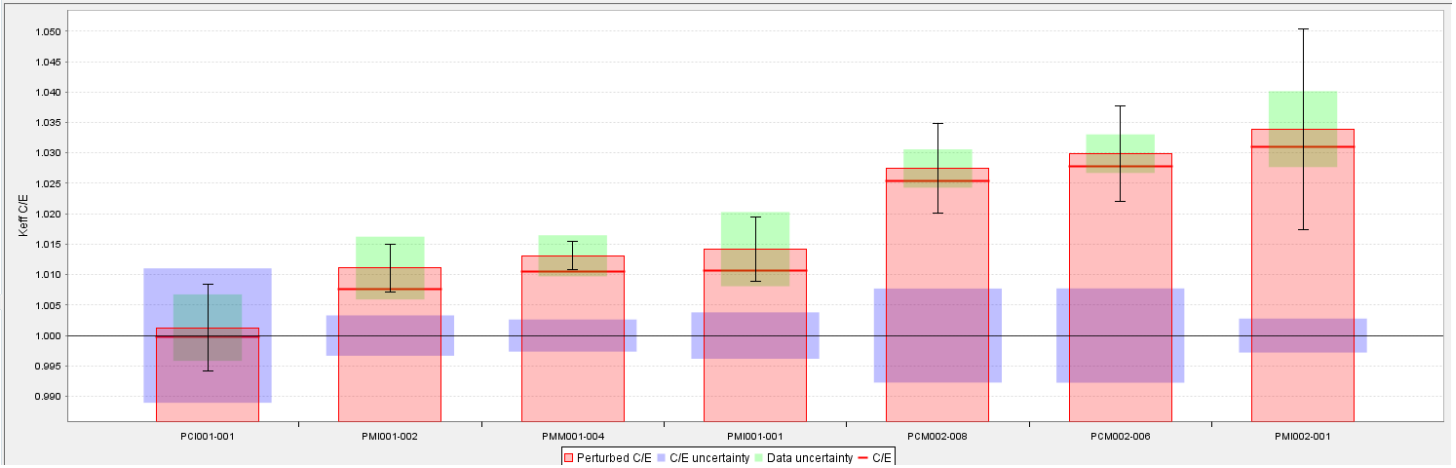
Group by: BENCHMARK_ID

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

For the C/E plot, green bars were chosen to be centred on the red bar height as they are an uncertainty associated with the input data



C/E Output Plot: BM ID Filtered

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

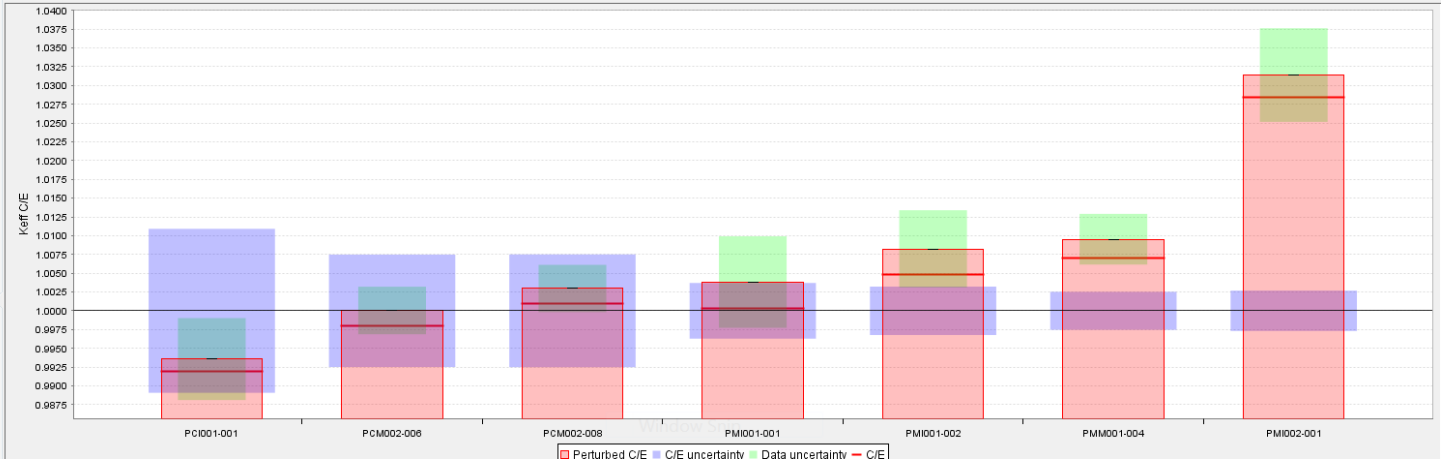
Group by: BENCHMARK_ID

Average increasing

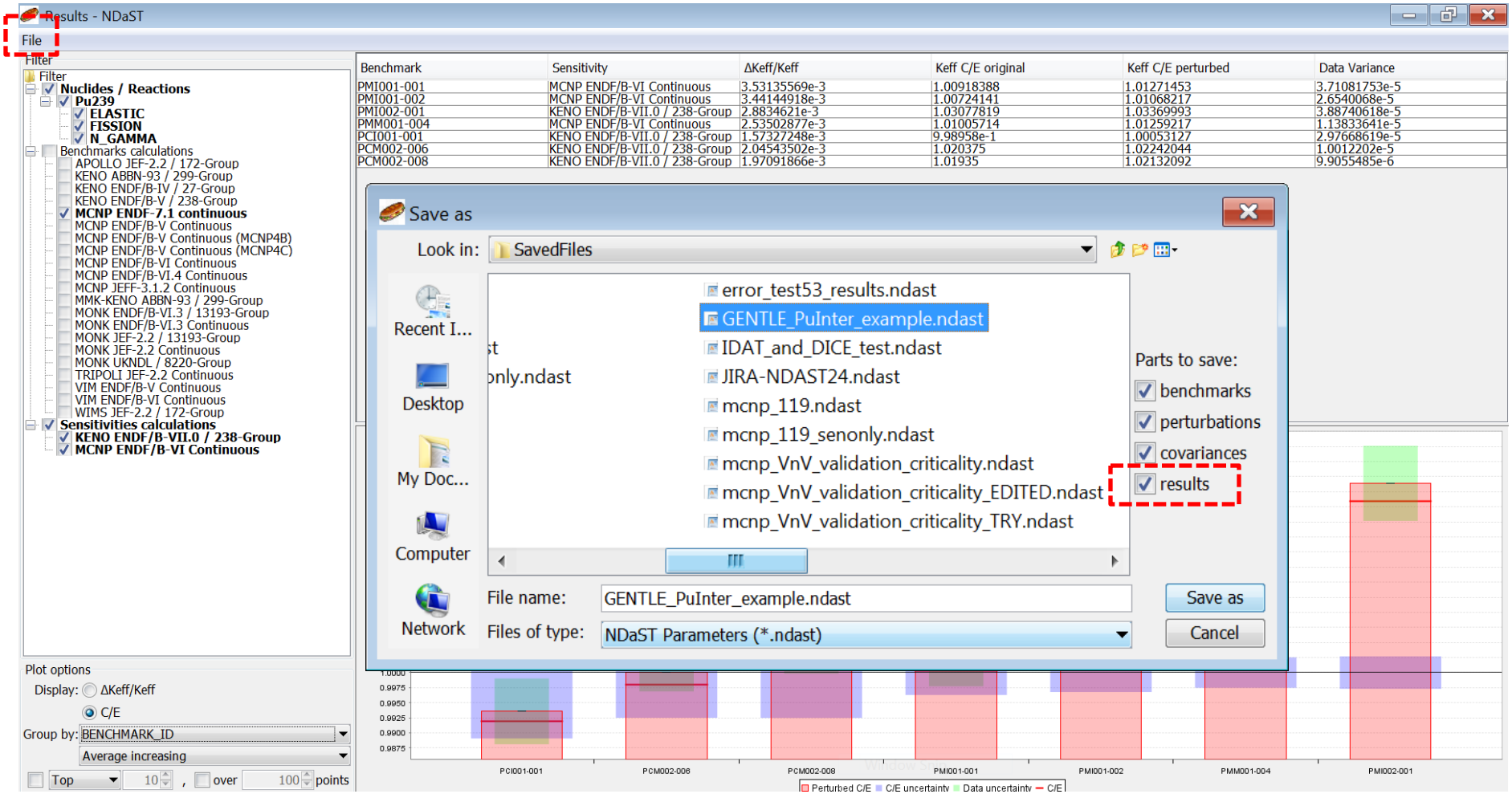
Top 10 , over 100 points

Benchmark	Sensitivity	ΔKeff/Keff	Keff C/E original	Keff C/E perturbed	Data Variance
PMI001-001	MCNP ENDF/B-VI Continuous	3.53135569e-3	1.00918388	1.01271453	3.71081753e-5
PMI001-002	MCNP ENDF/B-VI Continuous	3.44144918e-3	1.00724141	1.01068217	2.6540068e-5
PMI002-001	KENO ENDF/B-VII.0 / 238-Group	2.8834621e-3	1.03077819	1.03369993	3.88740618e-5
PMM001-004	MCNP ENDF/B-VI Continuous	2.53502877e-3	1.01005714	1.01259217	1.13833641e-5
PCI001-001	KENO ENDF/B-VII.0 / 238-Group	1.57327248e-3	9.98958e-1	1.00053127	2.97668619e-5
PCM002-006	KENO ENDF/B-VII.0 / 238-Group	2.04543502e-3	1.020375	1.02242044	1.0012202e-5
PCM002-008	KENO ENDF/B-VII.0 / 238-Group	1.97091866e-3	1.01935	1.02132092	9.9055485e-6

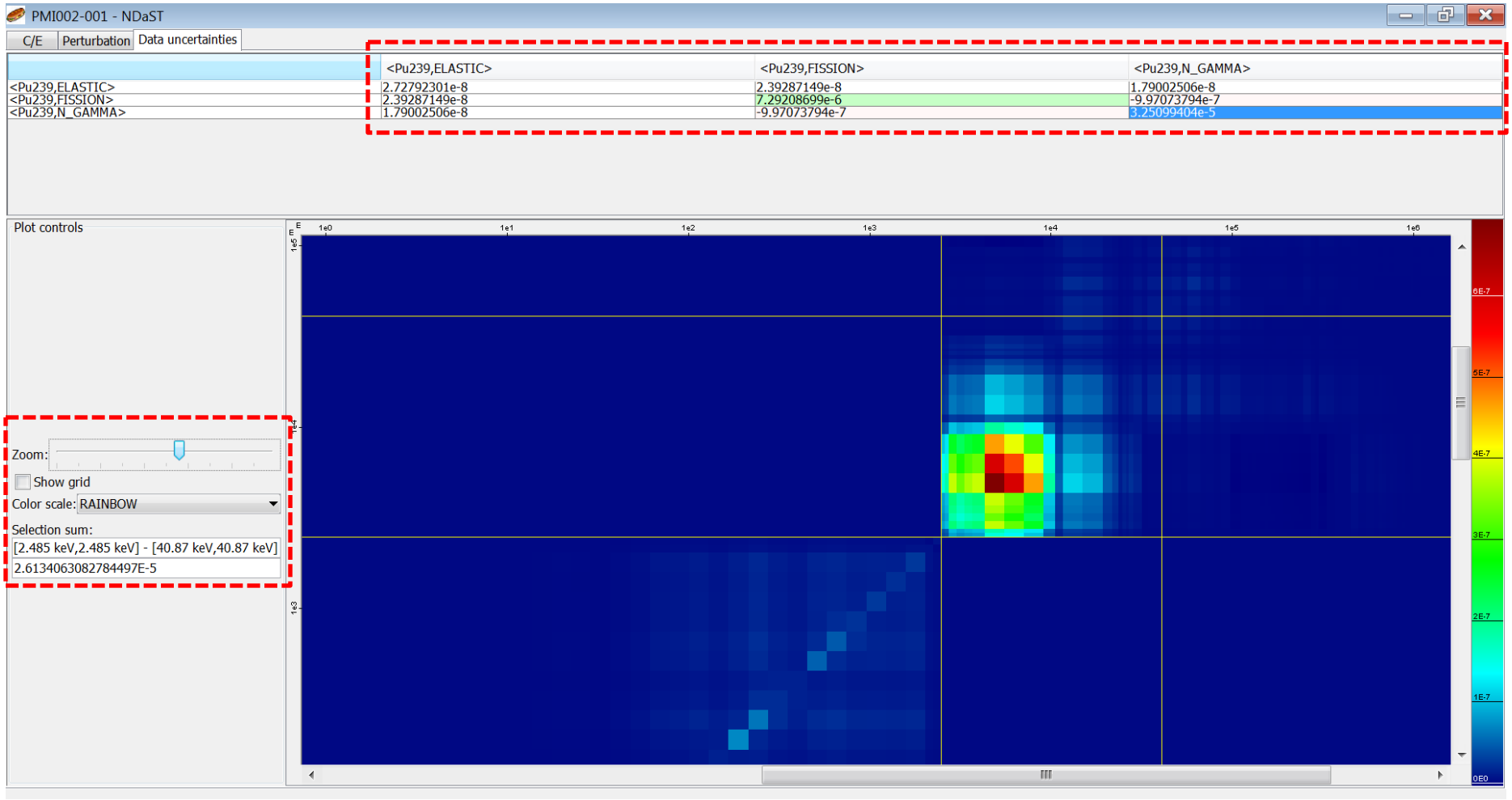
Filtering to a single series of calculational results allows some real validation judgement



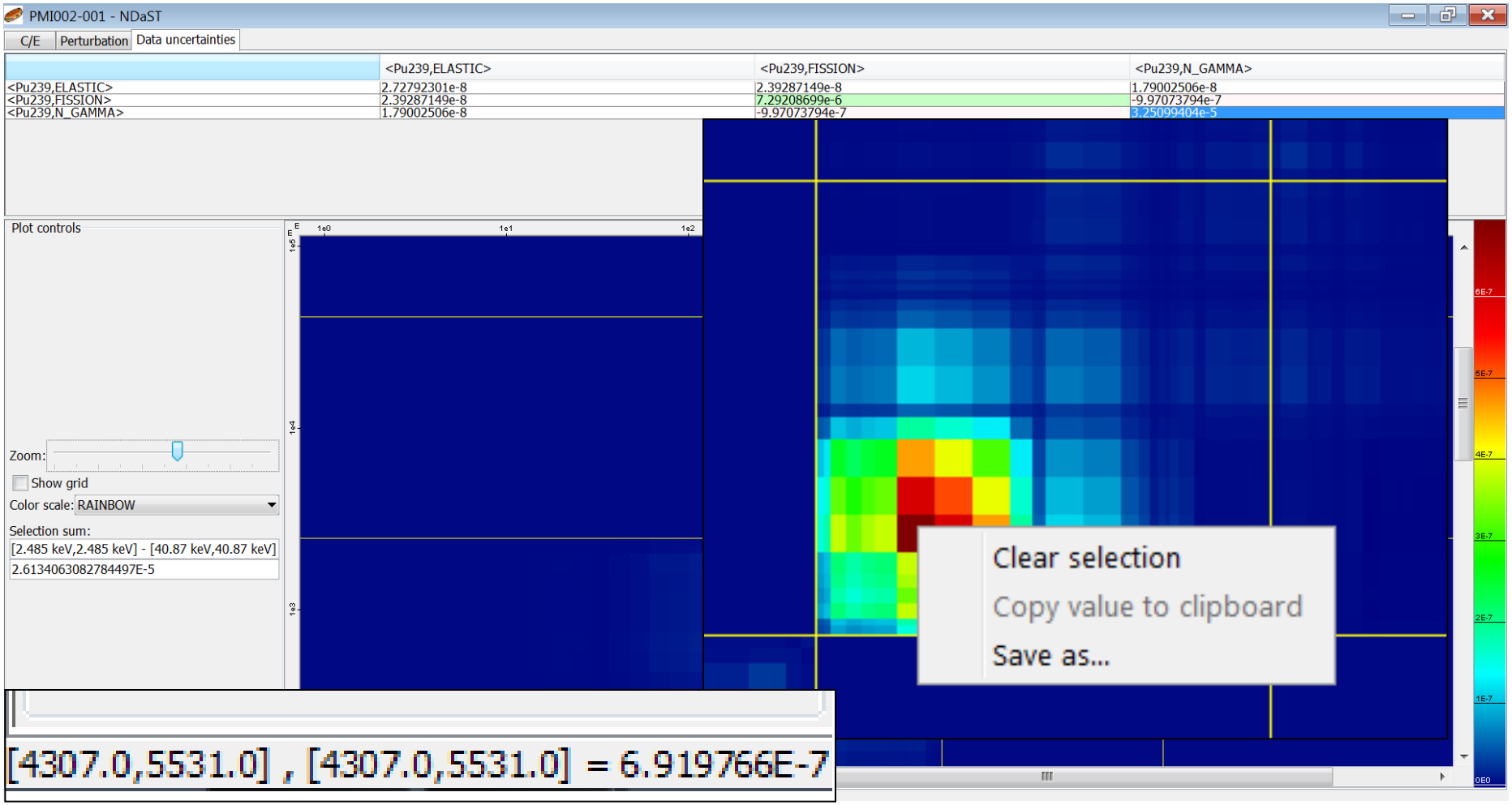
Save Output Data



Output Table: Detail Popup (Uncertainty)



Output Table: Detail Popup (Uncertainty)



Future NDaST Plans

NDaST principles: 1. Fast 2. Provides Insight 3. Integrates NEA Tools

Applications / End results (features for users higher up the application chain)

- Phase 2:
  - Continue to improve GUI features – e.g. automatically fill available nuclides
  - Provide useful statistical metrics – represenativity (Ck), chi-square values, adjustment based quantities
  - Total NDaST – multiple files randomly generated + statistical analysis of distribution
  - Link to NDEC – automatic perturbation generation from checking cycle
- Phase 3+:
  - With access to correlation coefficients, a full adjustment / GLS tool is possible.
  - Application specific features e.g. parameters to trend criticality safety / burn-up credit analyses.

Future NDaST Plans

NDaST principles: 1. Fast 2. Provides Insight 3. Integrates NEA Tools

Physics / Fundamentals (features for users closer to the basic data)

- Phase 2:
  - Compensating effect analysis – automatically preserve well known values e.g. total cross-section.
  - Incorporation of further sensitivity and covariance data formats.
  - Make available additional covariance data – allow comparison of all major modern libraries.
  - Handling of angular sensitivity data and MF34 uncertainty propagation.
- Phase 3+:
  - Generation / comparison of analytical models – e.g. Maxwellian & Watt PFNS representations. Analytical covariances?
  - Re-fitting experimental data to make fundamental ENDF-format file perturbations.

Exercise (2) – Add Covariances

I. Find covariance data for the 3 reactions
II. Add these + cross-nuclide matrices (Find all 6)
III. Check the perturbations against the s.d. values
IV. Re-run and look at the plot with green bar added
    - Check consistency of perturbation against uncertainty
V. Look at the diagonal / off-diagonal breakdown
    - View energy breakdown
    - Use region selection and clipboarding
VI. Try replacing with another library's covariances and re-run
    - Put the two output plots side-by-side

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