

# ICNC Workshop: DICE and NDaST Hands on Demonstration

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ICNC2019 Paris, France  
September 19<sup>th</sup> 2019

## 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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Received December 23, 2002  
Accepted January 26, 2003

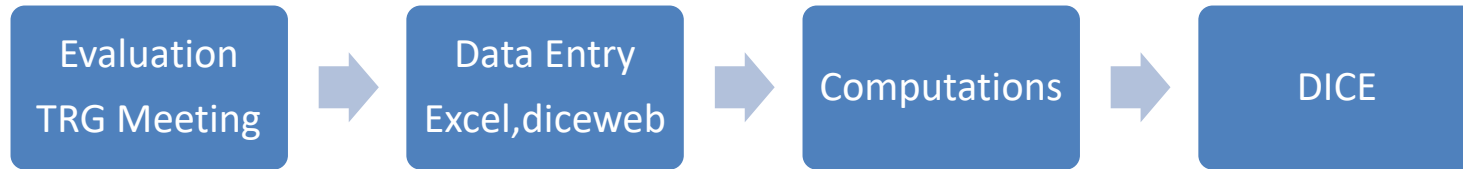
**Updates to the Database for ICSBEP (DICE)+ Using DICE For V&V**

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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)

DICE

File Database=NEA Personal-Keff Window Help

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

Themes

- 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

Fissile material

- None selected
- Compound
  - MOX (Mixed U and Pu Oxides)**
  - Plutonium Oxide
  - Thorium Oxide
  - Uranium Hexafluoride
  - Uranium Hydride
  - Uranium Oxide
  - Uranium Silicide
  - Uranium Tetrafluoride
  - Uranium-233 Oxide
- Metal / Alloy
  - Curium

Combine with AND     Combine with OR

Fuel concentration (g/L)

Value :  +/- :

OR >=  <=

Query

Acceptable = Acceptable  
and Fissile material = MOX (Mixed U and Pu Oxides)

Number of cases Case label  
Title

Clear

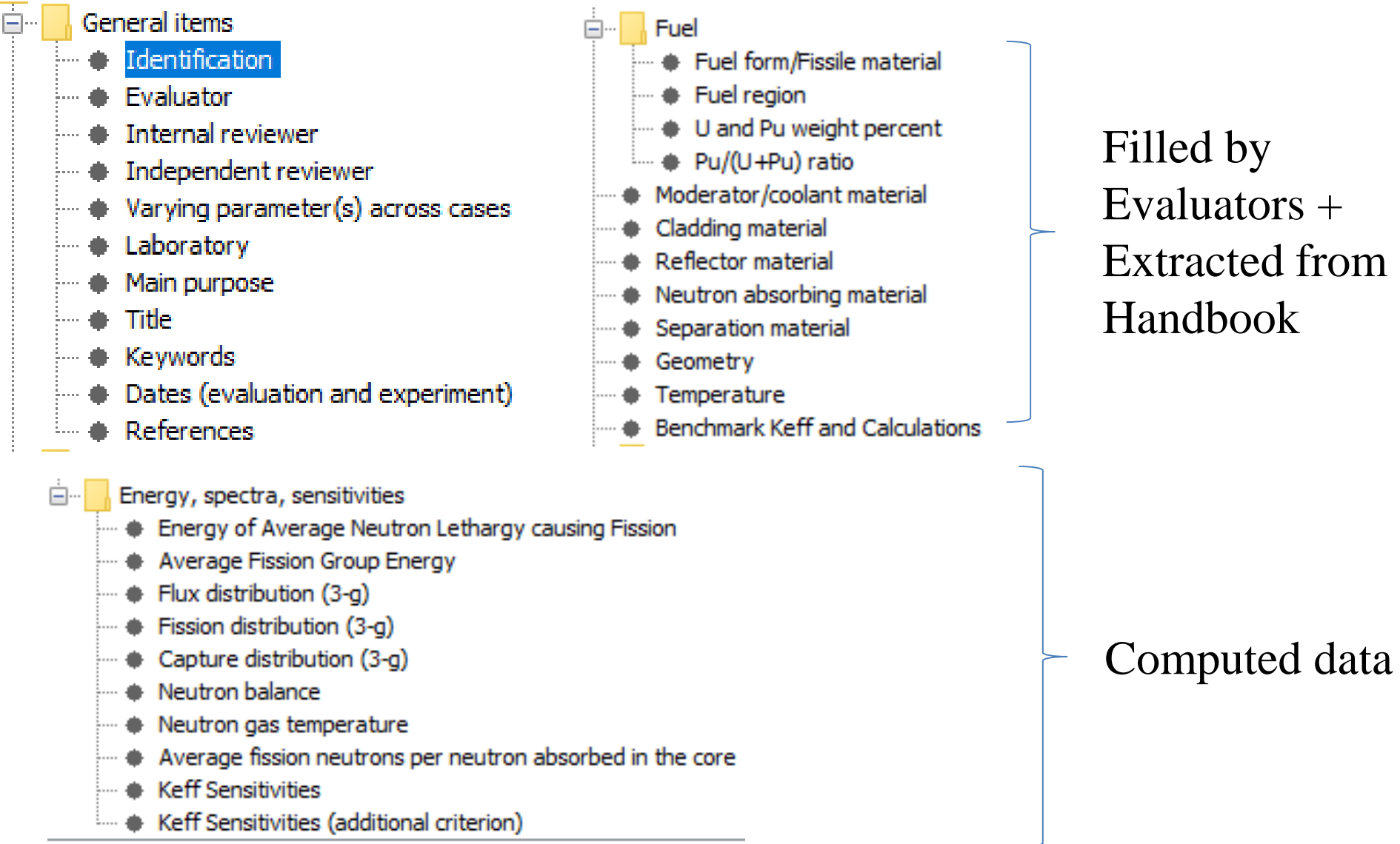
**Search !**

History :

26 Evaluations, 371 Cases

41M of 247M

## Search (2/2)



## Results

DICE

File Database=NEA Personal-Keff Window Help

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

Select columns Refine search New search Horiz. Vert. Flat Plots ParPlots Spectra plots Sensitivity plots PDF HT

**Columns**

- General items
  - Identification
  - Acceptable
  - Evaluator
  - Internal reviewer
  - Independent reviewer
  - Varying parameter(s) across cases
  - Laboratory
  - Main purpose
  - Title
  - Pictures
  - Keyword
  - Year approved
  - Year revised
  - Years experiment performed
  - Revision
  - References
  - Number of cases
  - Case label
- Fuel
  - Fuel form/Fissile material
  - Fuel concentration (g/L)
  - Fuel composition (isotope wt%)
  - Pu/(U+Pu) ratio
- Moderator/coolant
  - Moderator/coolant
  - Moderation ratio type
  - Moderation ratio
  - Moderator to fuel ratio
  - Moderator to fissile ratio

Uncheck all  
Apply

Evaluation identification	Number of cases	Title
PU-MET-FAST-001	4	BARE SPHERE OF PLUTONIUM-239 MET
PU-MET-FAST-002	1	240 Pu JEZEBEL: BARE SPHERE OF PLU
PU-MET-FAST-003	5	UNMODERATED PLUTONIUM METAL BU
PU-MET-FAST-004	9	UNMODERATED PLUTONIUM METAL CY
PU-MET-FAST-005	1	BENCHMARK CRITICAL EXPERIMENT OF
PU-MET-FAST-006	1	PLUTONIUM SPHERE REFLECTED BY NO
PU-MET-FAST-008	1	BENCHMARK CRITICAL EXPERIMENT OF
PU-MET-FAST-009	1	BENCHMARK CRITICAL EXPERIMENT OF
PU-MET-FAST-010	1	BENCHMARK CRITICAL EXPERIMENT OF
PU-MET-FAST-011	1	BENCHMARK CRITICAL EXPERIMENT OF
PU-MET-FAST-012	1	URANIUM-REFLECTED ARRAY OF PLUTO

Case identification	Case label
PU-MET-FAST-001-001	Configuration A
PU-MET-FAST-001-002	Configuration B
PU-MET-FAST-001-003	Configuration C
PU-MET-FAST-001-004	Configuration D
PU-MET-FAST-002-001	
PU-MET-FAST-003-001	Case no. 101
PU-MET-FAST-003-002	Case no. 102
PU-MET-FAST-003-003	Case no. 103
PU-MET-FAST-003-004	Case no. 104
PU-MET-FAST-003-005	Case no. 105
PU-MET-FAST-004-001	Case 207
PU-MET-FAST-004-002	Case 208
PU-MET-FAST-004-003	Case 209
PU-MET-FAST-004-004	Case 210
PU-MET-FAST-004-005	Case 211
PU-MET-FAST-004-006	Case 212
PU-MET-FAST-004-007	Case 213
PU-MET-FAST-004-008	Case 214

Evaluations

Cases

## Results: What are the Buttons/Tabs?

Critical / Subcritical

Alarm / Shielding

Fundamental Physics

Correlation Matrix

Rank Similar

Keff trends plots

Handbook Volumes

Specialised Information

 Refine search  New search

Keep or Clear previous filters when returning to search page

Horiz.  Vert.  Flat

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

Plots  ParPlots  Spectra plots  Sensitivity plots

Plot DICE data, or computed data retrieved from search

PDF HTML XML

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



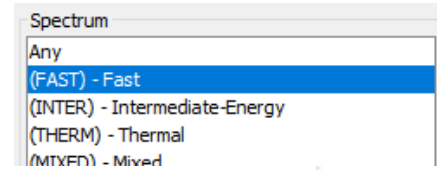
## DICE is Strongly Linked to Handbook Structure and Classifications

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	# cases
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 URANIUM	

Evaluation identification	Number of cases	Title	Case	Year(s) experiments performed
HEU-MET-MIXED-009	43	URANIUM METAL SLABS MODERATED WITH POLYETHYLENE, PLEXIGLAS,	HMF048-001	1965 - 1967
HEU-MET-MIXED-010	7	LATTICES OF ORALLOY CUBES IN WATER	HMF048-002	1965 - 1967
HEU-MET-MIXED-011	17	OIL-REFLECTED SPHERES AND HEMISPHERES OF HIGHLY ENRICHED URANIUM	HMM011-003	1965 - 1967
			HMM011-004	1965 - 1967
			HMM011-005	1965 - 1967
			HMF048-006	1965 - 1967

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

## 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

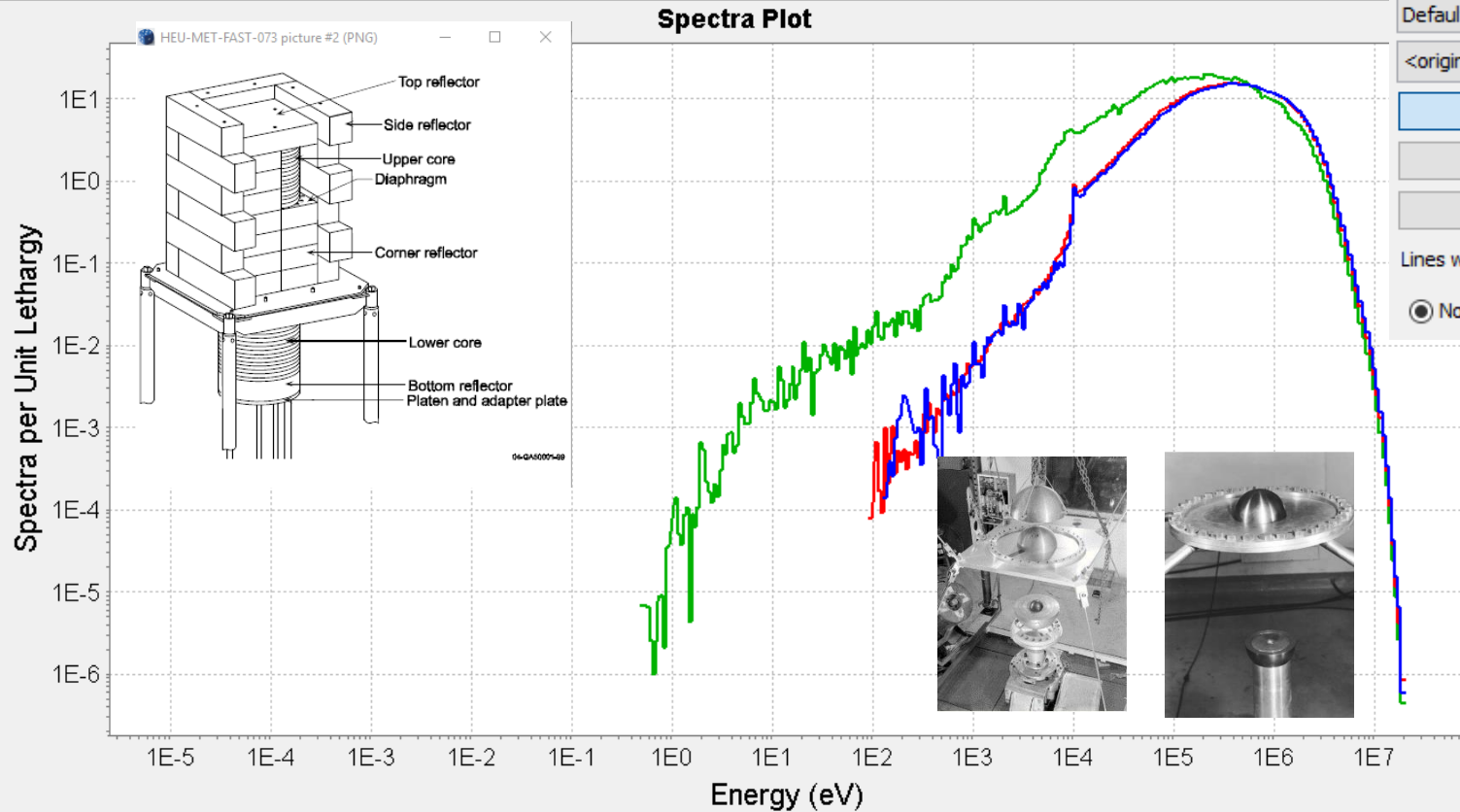
## Spectra Plots

DICE

File Database=NEA Personal=Keff Window Help

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

Select Refine search New search Horiz. Vert. Flat Plots ParPlots Spectra plots Sensitivity plots PDF HTML XML



■ HEU-MET-FAST-001-001 KENO ABBN-93 / 299-Group CAPTURE ■ HEU-MET-FAST-057-001 KENO ABBN-93 / 299-Group CAPTURE  
 ■ HEU-MET-FAST-073-001 KENO ABBN-93 / 299-Group CAPTURE

Representation

Y axis log

Per unit lethargy bin

Default normalization

<original>

Plots Table

Clear

Load own data...

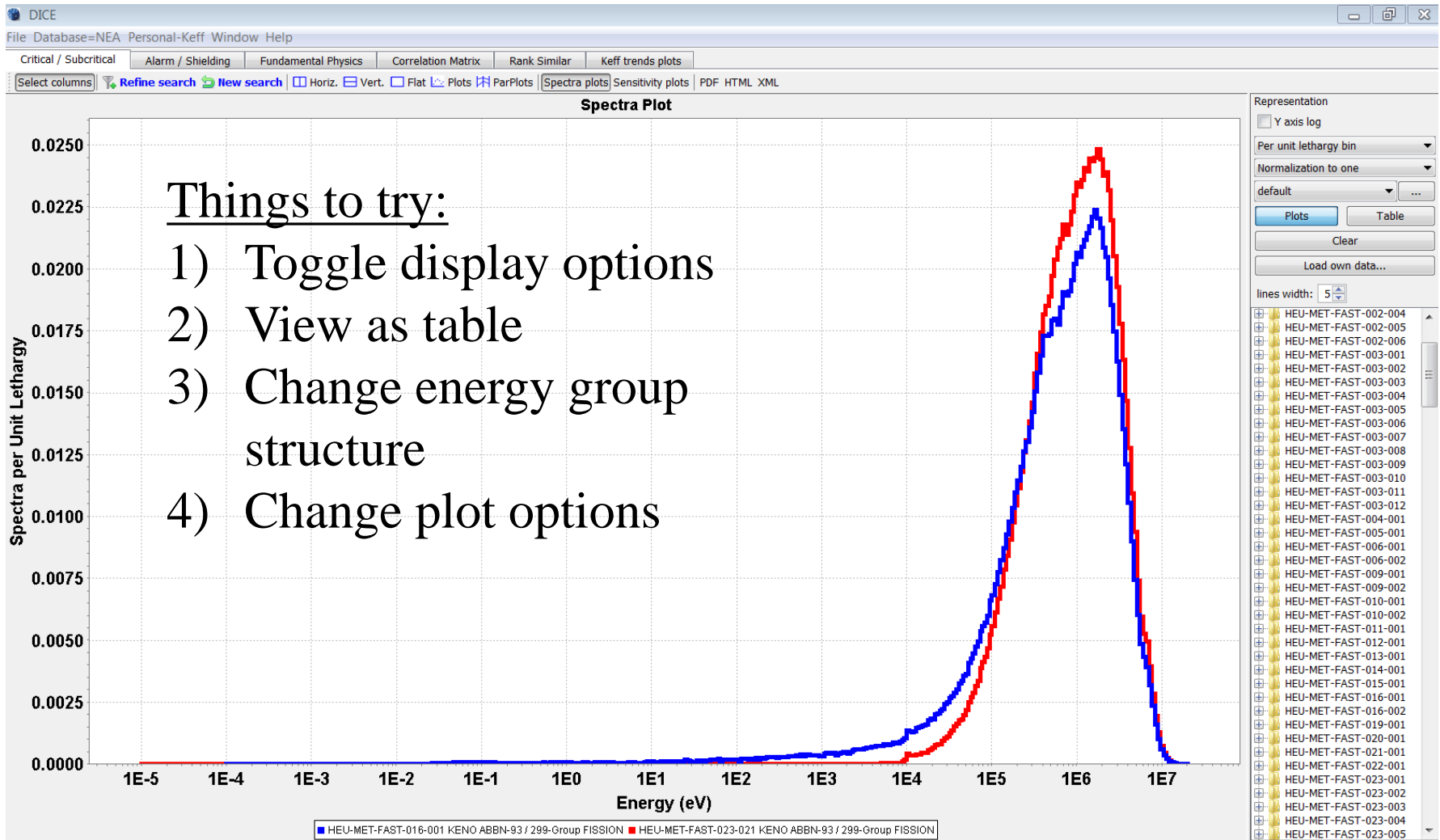
Lines width: 3

Black & white

No comparison  Ratio  Difference

- HEU-MET-FAST-071-022
- HEU-MET-FAST-071-023
- HEU-MET-FAST-071-024
- HEU-MET-FAST-071-025
- HEU-MET-FAST-071-026
- HEU-MET-FAST-071-027
- HEU-MET-FAST-072-001
- HEU-MET-FAST-072-002
- HEU-MET-FAST-072-003
- HEU-MET-FAST-073-001
- KENO ABBN-93 / 299-Group
  - FLUX
  - CAPTURE
  - FISSION
  - (N,2N)
  - PRODUCT
- HEU-MET-FAST-074-001
- HEU-MET-FAST-074-002
- HEU-MET-FAST-074-003
- HEU-MET-FAST-074-004
- HEU-MET-FAST-075-001
- HEU-MET-FAST-076-001

## Fission Spectrum Plot Example



## Balance Data + Calculation Files

- Calculation Files
  - Inputs
  - Balances**
  - Sensitivities
  - Spectra
- Correlation Matrices
- Uncertainties Evaluation

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
HEU-MET-FAST-007-002	KENO	ABBN-93 / 299-Group	Balance

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

$$(\text{PRODUCT} + (n, 2n)) / (\text{CAPTURE} + \text{FISSION} + \text{LEAKAGE}) = \text{KEFF}$$

### BALANCE TABLE

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

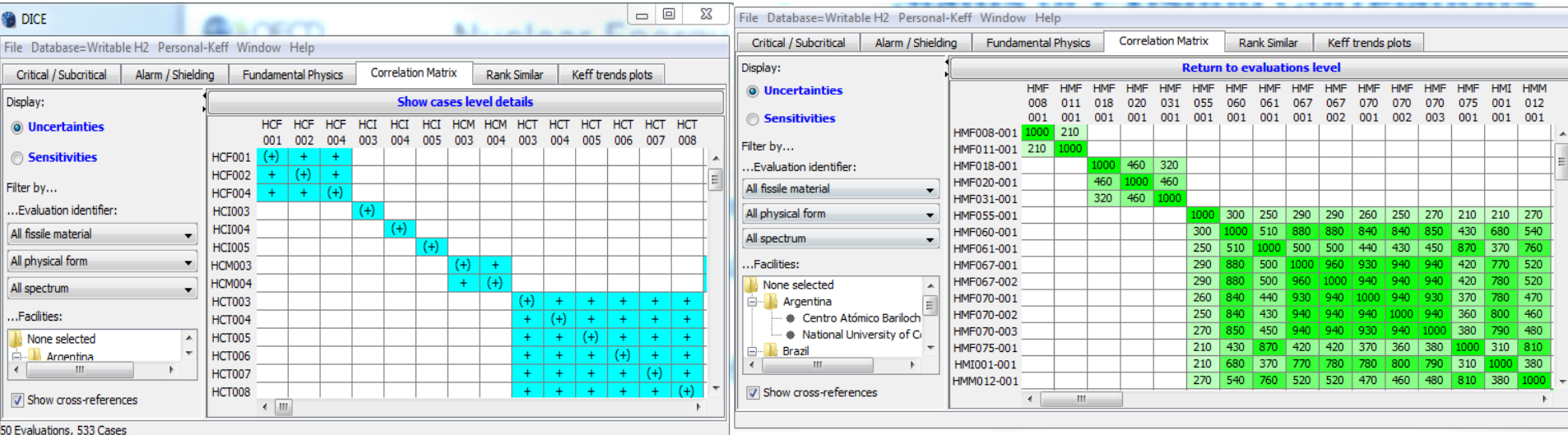
ISOTOP	CONC	MASS	CAPTURE	FISSION	(n, 2n)	PRODUCT	Sig-C	Sig-F	Sig-2N	NU
U234	5.3678E-04	0.246	1.39	2.58	0.00	6.82	0.513	0.955	0.001	2.639
U235	4.7033E-02	21.645	59.62	388.66	1.91	992.78	0.252	1.640	0.008	2.554
U236	9.5896E-05	0.044	0.18	0.20	0.00	0.53	0.364	0.408	0.004	2.683
U238	4.7782E-04	0.223	0.55	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.



The screenshot displays two windows from the DICE software. The left window shows the 'Correlation Matrix' for 'Uncertainties' with a grid of '+' signs indicating correlations between cases like HCF001, HCI003, HCM003, etc. The right window shows a similar matrix for 'Sensitivities' with numerical values in green cells, such as 1000, 210, 460, 320, etc., representing the correlation coefficients between cases like HMF008-001, HMF011-001, etc.

## Different Case Response to Nuclear Data

Case  
Level

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:

IDs in alphabetical order

Filter by...

...Evaluation identifier:

HEU

MET

FAST

...Facilities:

LLNL

Show cross-references

**Return to evaluations level**

	HMF 057 001	HMF 057 002	HMF 057 003	HMF 057 004	HMF 057 005	HMF 057 006	HMF 057 007	HMF 057 008	HMF 058 001	HMF 058 002	HMF 058 003	HMF 058 004	HMF 058 005	HMF 058 006	HMF 058 007	HMF 058 008
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

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:

IDs in alphabetical order

**Show cases level details**

	HMF 057	HMF 058	HMF 066
HMF057	999	940	888
HMF058	940	985	973
HMF066	888	973	989

$$E \equiv \begin{matrix} S_a^T & S_e \\ \hline S_a & S_e \end{matrix}$$

## New: Order by Similarity Clusters



DICE

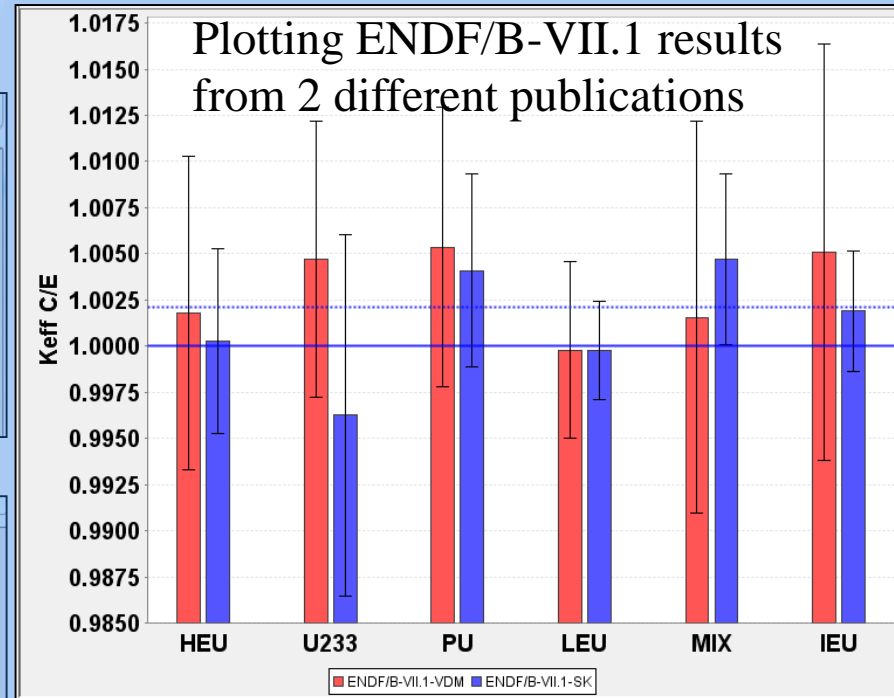
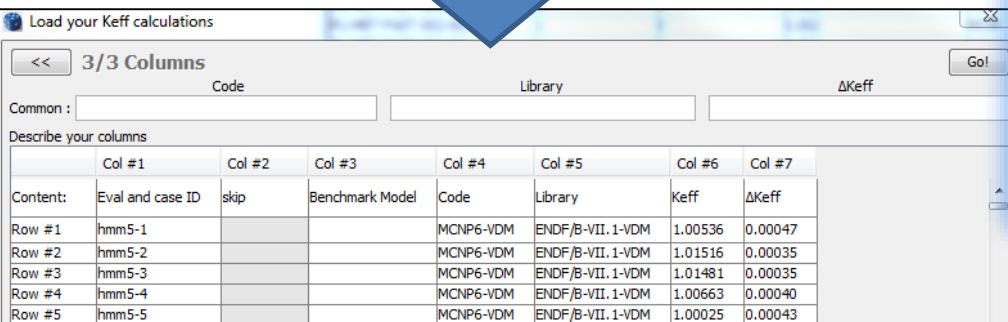
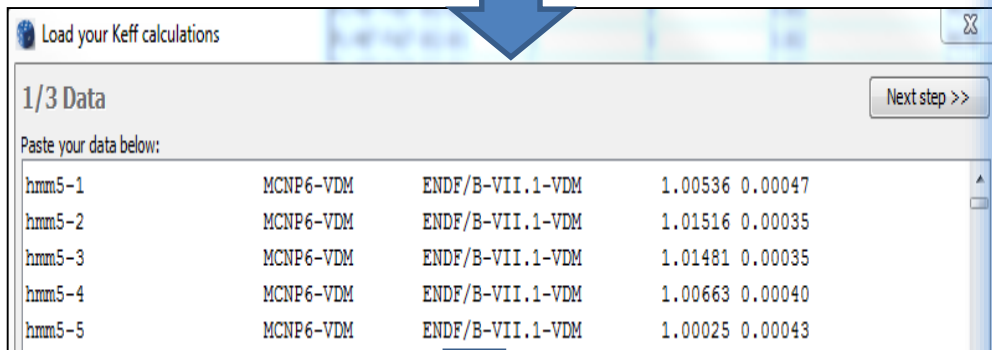
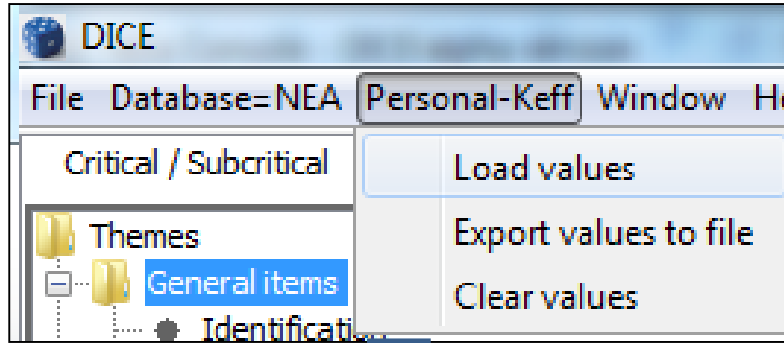
File Database=NEA Personal-Keff Window Help

	Critical / Subcritical	Alarm / Shielding	Fundamental Physics	Correlation Matrix	Rank Similar	Keff trends plots								
Display:							Show c							
<input type="radio"/> Uncertainties														
<input checked="" type="radio"/> Sensitivities														
Order by:														
Similarity clusters														
Filter by...														
...Evaluation identifier:														
All fissile material														
All physical form														
All spectrum														
	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

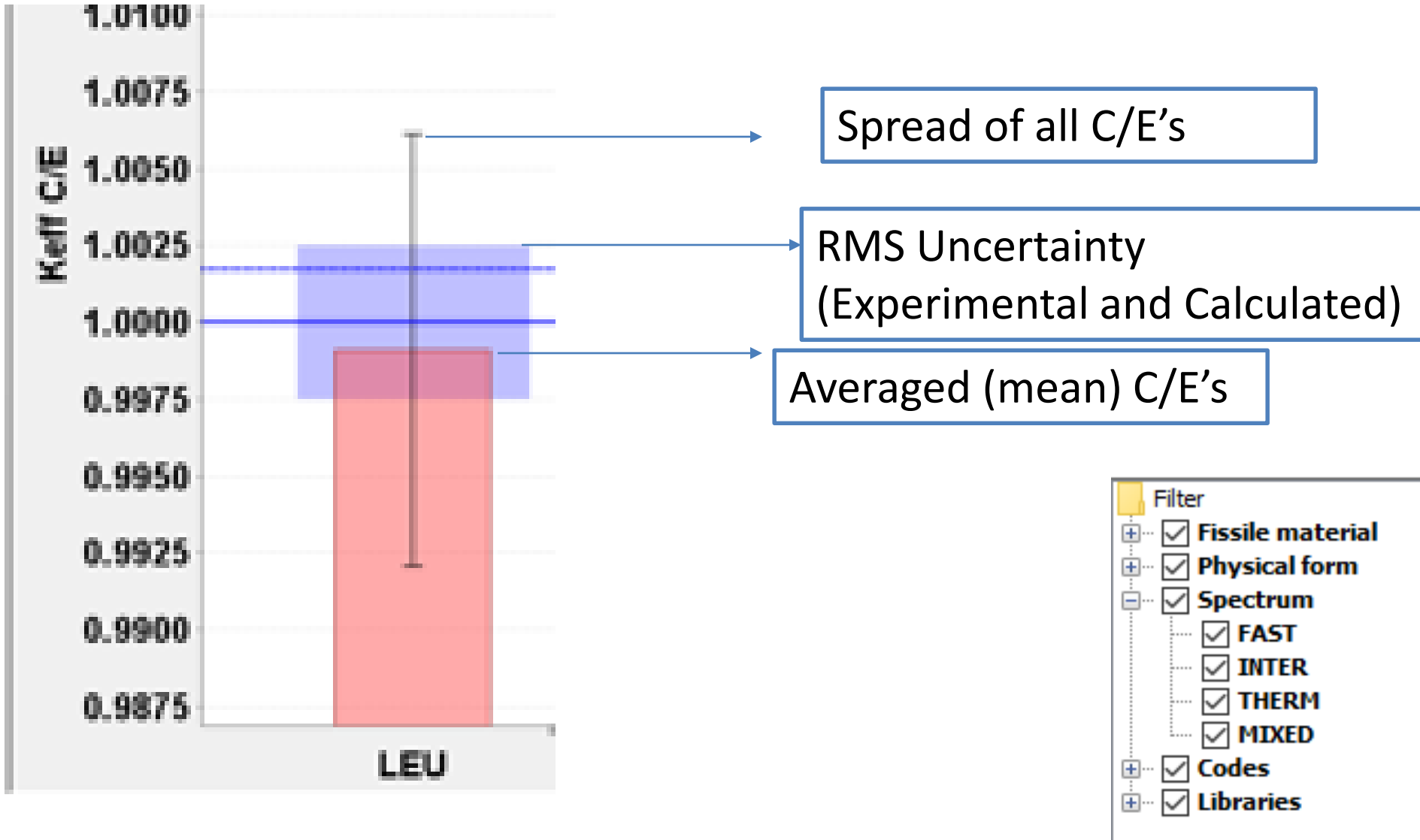
# Personal Keff in Local Database + Trend Plots

## Storing $K_{eff}$ from external calculations

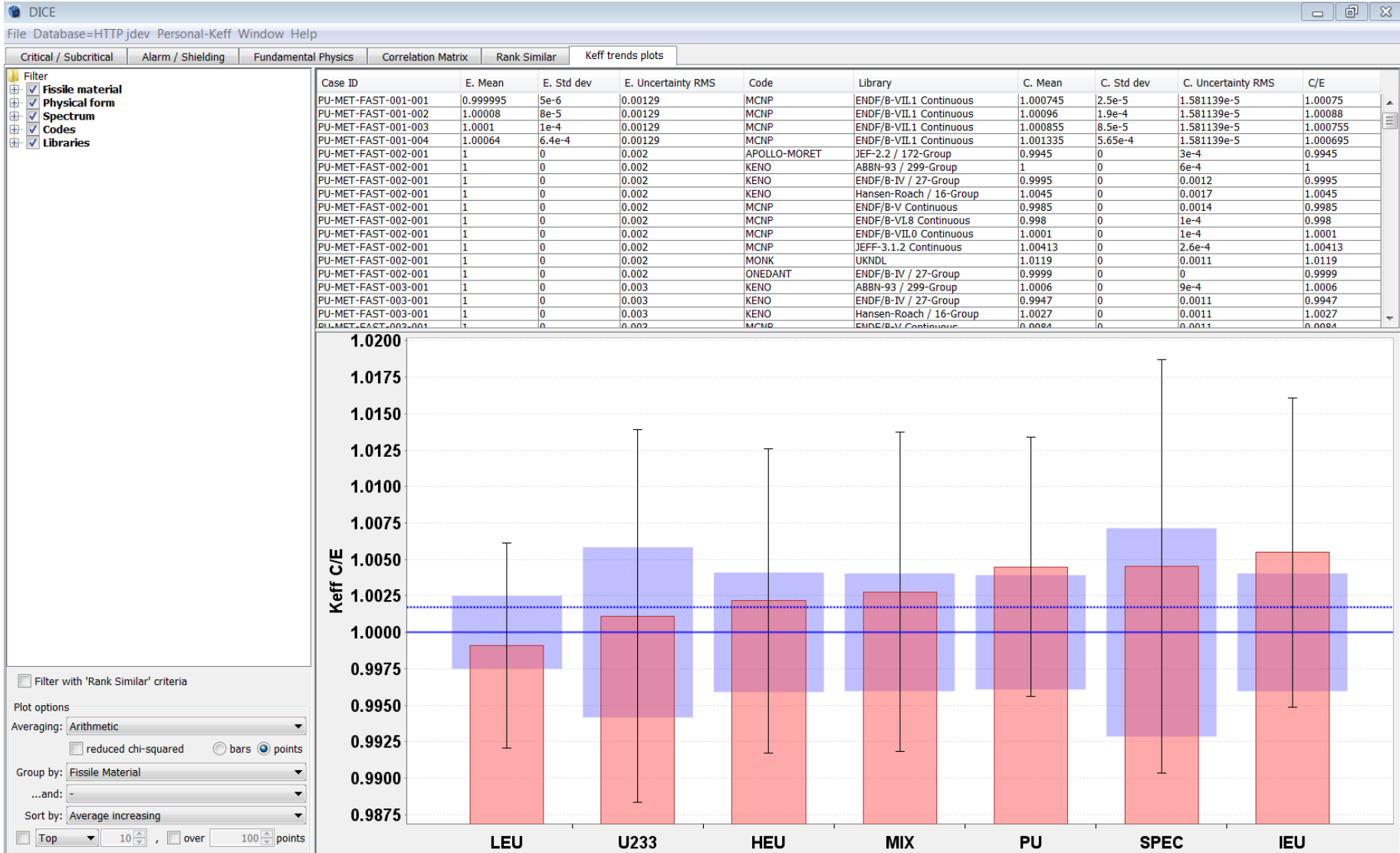
Available only with local database (need to copy DICE to a writeable area)



## How to Interpret Trend Plots



## Trend Plots



## Trend Plots Options

Filter with 'Rank Similar' criteria

### Plot options

Averaging: Arithmetic

reduced chi-squared  bars  points

Group by: Fissile Material

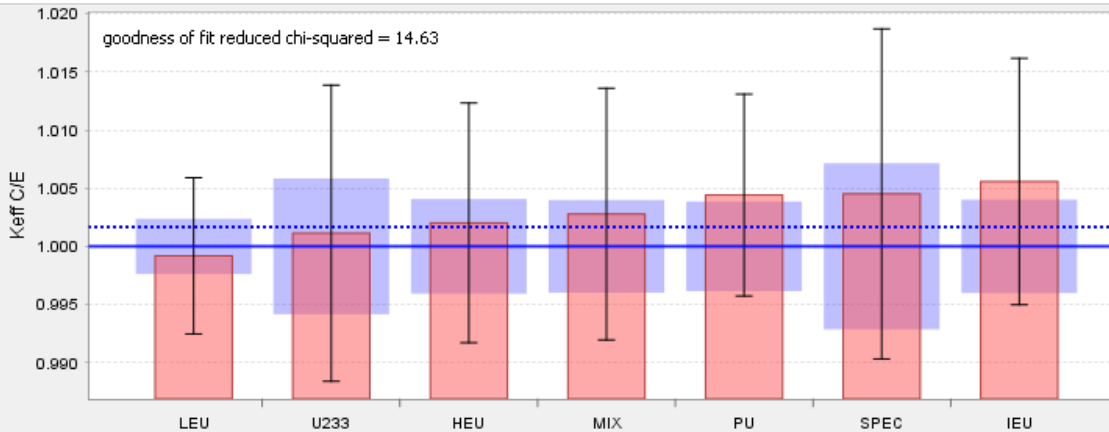
...and: -

Sort by: Average increasing

Top 10,  over 100 points

- Fissile Material
- Physical Form
- Spectrum
- Evaluation ID
- Case ID
- Code
- Library

- Average increasing
- Average decreasing
- Group
- Number of points
- Other value
- Similarity





## Find Cases With Similar Spectrum/Balance/Sensitivity Data

DICE

File Database=NEA Personal=Keff Window Help

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

3-groups percent spectra Coverage: 94.4% (4673 / 4952)

Type:  Thermal:  Intermediate:  Fast:  (in %) ≤

Neutron balance Coverage: 94.4% (4673 / 4952)

3-groups sensitivities Coverage: 87.5% (4332 / 4952)

Sensitivity Coverage: 87.5% (4334 / 4952)

Search

Show cases with no data

Case ID	Code	Library	3-Groups Spectra Ranking
LEU-COMP-THERM-068-006	KENO	ABBN-93 / 299-Group	1.000
LEU-COMP-THERM-068-007	KENO	ABBN-93 / 299-Group	1.000
MIX-COMP-THERM-016-003	KENO	ABBN-93 / 299-Group	1.000
MIX-COMP-THERM-016-018	KENO	ABBN-93 / 299-Group	0.999
MIX-COMP-THERM-016-019	KENO	ABBN-93 / 299-Group	0.999
IEU-COMP-THERM-001-028	KENO	ABBN-93 / 299-Group	0.999
LEU-COMP-THERM-066-005	KENO	ABBN-93 / 299-Group	0.999
MIX-COMP-THERM-016-005	KENO	ABBN-93 / 299-Group	0.999
IEU-COMP-THERM-001-010	KENO	ABBN-93 / 299-Group	0.999
IEU-COMP-THERM-001-011	KENO	ABBN-93 / 299-Group	0.999
IEU-COMP-THERM-001-002	KENO	ABBN-93 / 299-Group	0.999

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

The screenshot shows the DICE software interface with the following components:

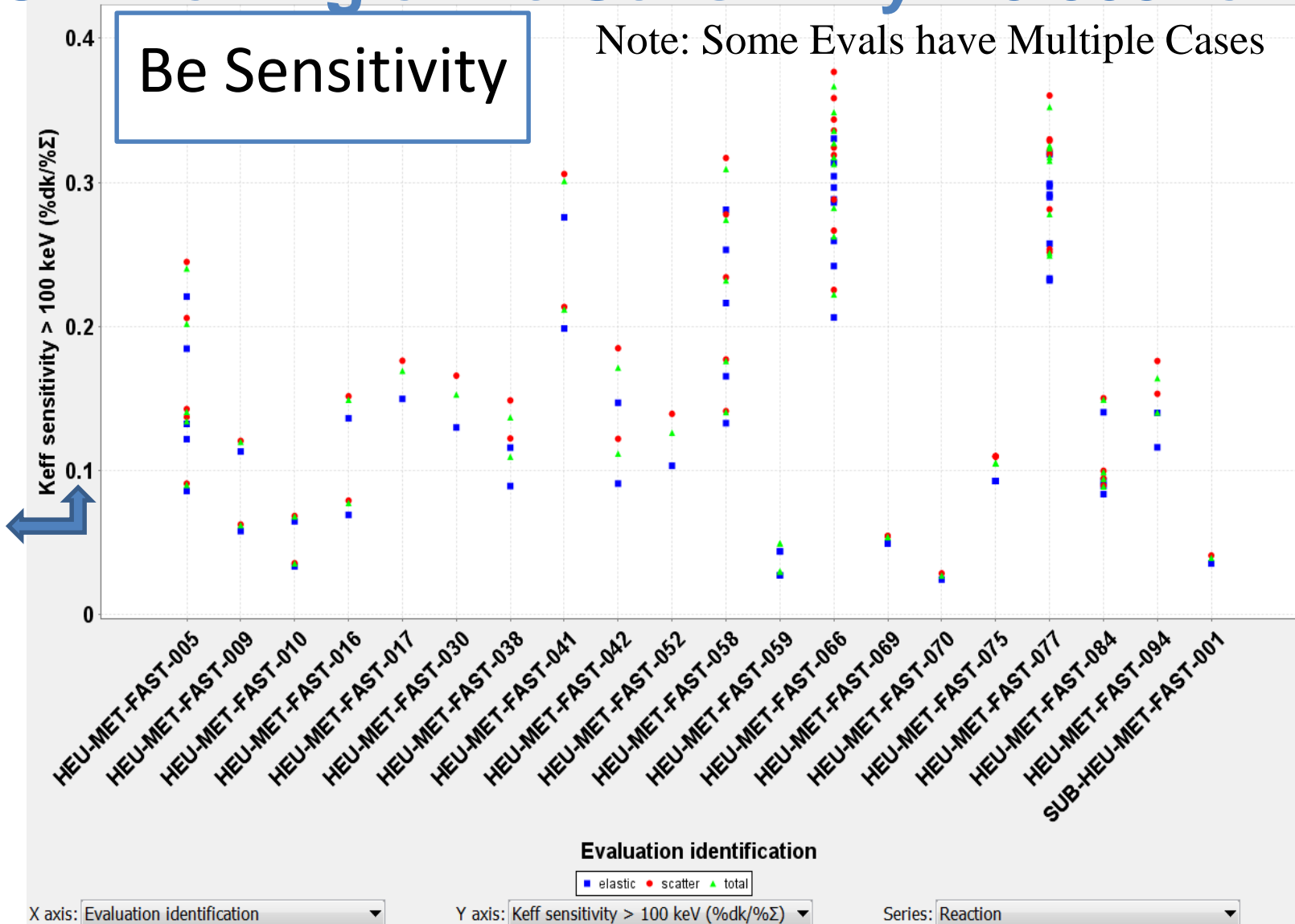
- Menu Bar:** File Database=NEA Personal-Keff Window Help
- Navigation Tabs:** Critical / Subcritical, Alarm / Shielding, Fundamental Physics, Correlation Matrix, Rank Similar, Keff trends plots
- Left Panel (Tree View):**
  - Pu/(U+Pu) ratio
  - Moderator/coolant material
  - Cladding material
  - Reflector material
  - Neutron absorbing material
  - Separation material
  - Geometry
  - Temperature
  - Benchmark Keff and Calculations
  - 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** (highlighted)
    - Keff Sensitivities (additional criterion)
- Isotope Selection:**
  - Any
  - 1 - H - Hydrogen
  - 2 - He - Helium
  - 3 - Li - Lithium
  - 4 - Be - Beryllium
- Reaction Selection:**
  - Any
  - capture
  - elastic
  - elastic-P1
  - fission
- Logic:**  Combine with AND  Combine with OR
- Total Keff sensitivity over all energy range:**
  - Value :  +/- :   Abs
  - OR >=  <=
- Energy Group Sensitivity:**
  - Keff sens. < 0.625 eV:** Value :  +/- :   Abs; OR >=  <=
  - Keff sens. 0.625 eV - 100 keV:** Value :  +/- :   Abs; OR >=  <=
  - Keff sens. > 100 keV:** Value :  +/- :   Abs; OR >=  <=
- Footer:** Values between -1 and 1, in %dk/%Σ - Keff Sensitivities are currently available for about 88% of cases

Set Threshold



## DICE Plotting of Be Sensitivity > 0.005 for HMF

Can also read as 100 pcm/1% change in  $\Sigma$

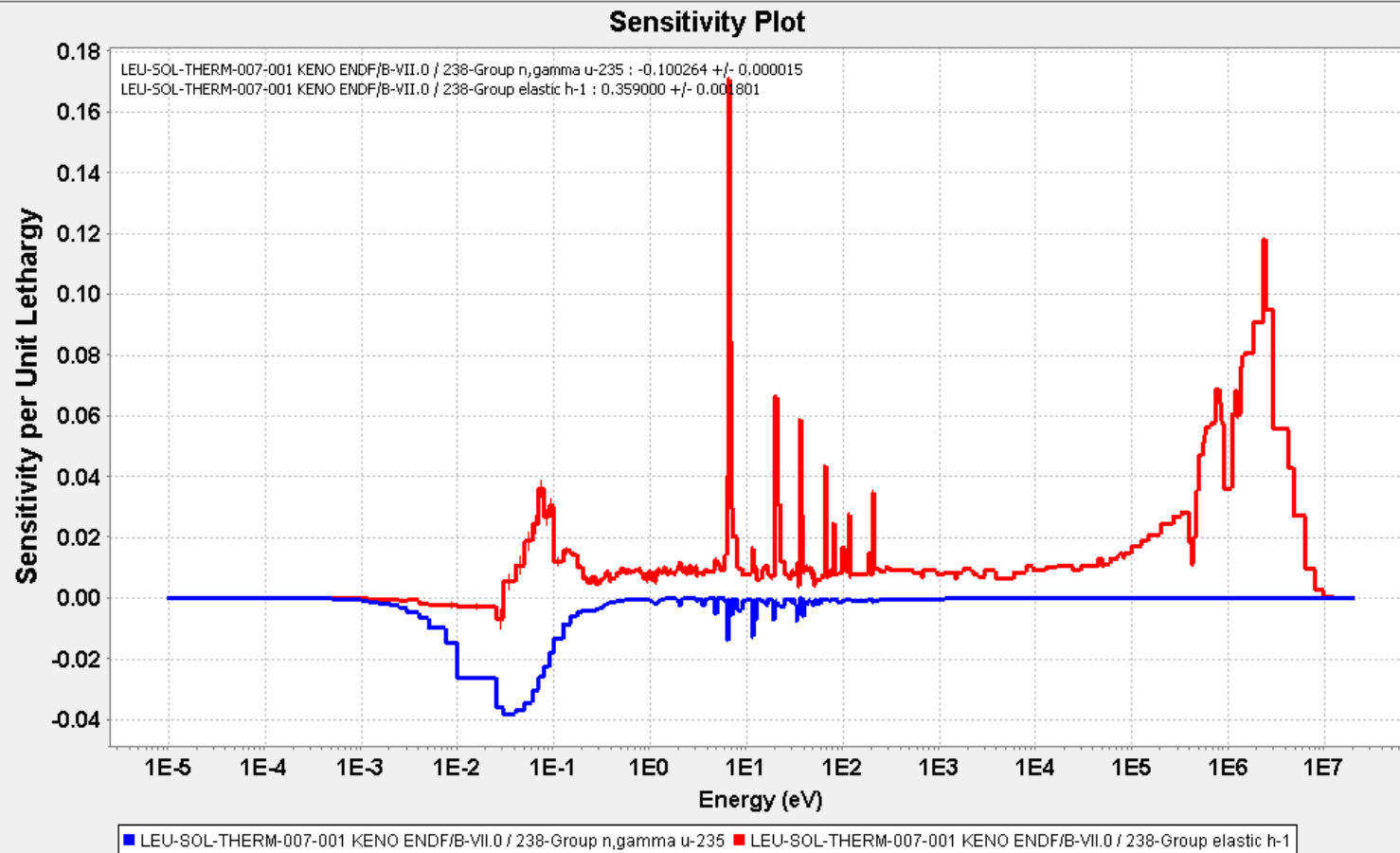


## Sensitivity Viewer

DICE

File Database=NEA Personal=Keff Window Help

Critical / Subcritical Alarm / Shielding Fundamental Physics Correlation Matrix Rank Similar Keff trends plots  
Select Refine search New search Horiz. Vert. Flat Plots ParPlots Spectra plots Sensitivity plots PDF HTML XML



Representation  
Per unit lethargy bin  
<original>  
Plots Table  
Clear  
Load own data...  
Lines width: 3 Black & white  
 No comparison  Ratio  Difference

Root  
LEU-SOL-THERM-007-001  
KENO ENDF/B-VII.0 / 238-Group  
c  
cr-50  
cr-52  
cr-53  
cr-54  
fe-54  
fe-56  
fe-57  
fe-58  
h-1  
total  
 elastic  
scatter  
n,gamma  
mn-55  
n-14  
ni-58  
ni-60  
ni-61  
ni-62  
ni-64  
o-16

## Sensitivity Viewer

The image shows a software interface for the Sensitivity Viewer. On the left is a control panel with the following elements:

- Representation:** A dropdown menu currently showing "Per unit lethargy bin". Below it is another dropdown menu showing "<original>".
- Plots:** A button that is currently selected.
- Table:** A button.
- Clear:** A button.
- Load own data...:** A button.
- Lines width:** A spinner box set to "3".
- Black & white:** An unchecked checkbox.
- Comparison options:** Three radio buttons: "No comparison" (selected), "Ratio", and "Difference".

On the right is a detailed view of the "Representation" dropdown menu, showing a list of options:

- Per unit lethargy bin
- <original> (highlighted in blue)
- <original>
- ABBN 30-group
- ABBN93 299-group
- Hansen-Roach 16-group
- ICSBEP 3-group
- SCALE 27-group
- SCALE 44-group
- SCALE 238-group
- Straker-Morrisson 22-group
- WPEC SG46 7-group

Below the list is a "Format:" section with radio buttons:

- Auto-detect
- ABBN
- TSUNAMI1D/SUSD3D
- TSUNAMI3D (selected)
- MCNP Output
- WPEC SG33
- Binary

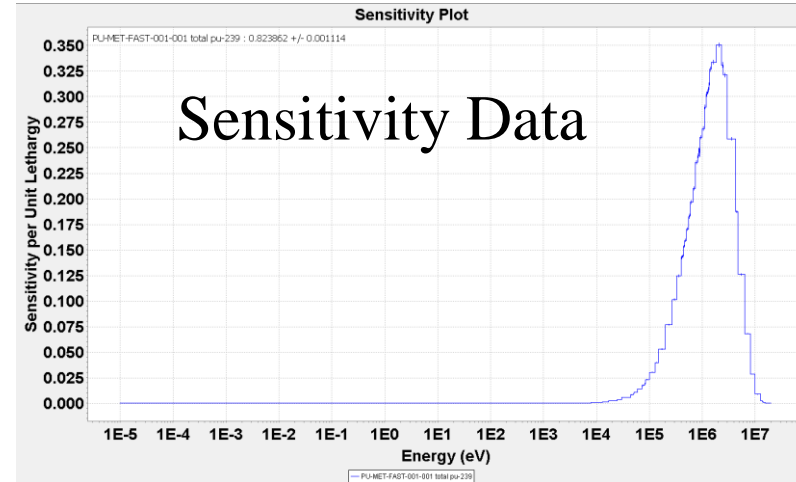
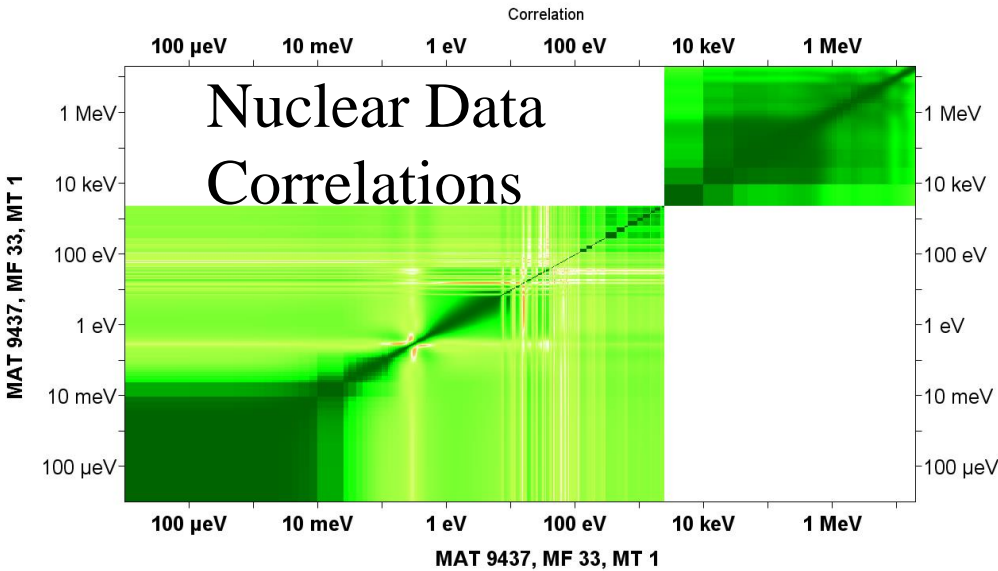
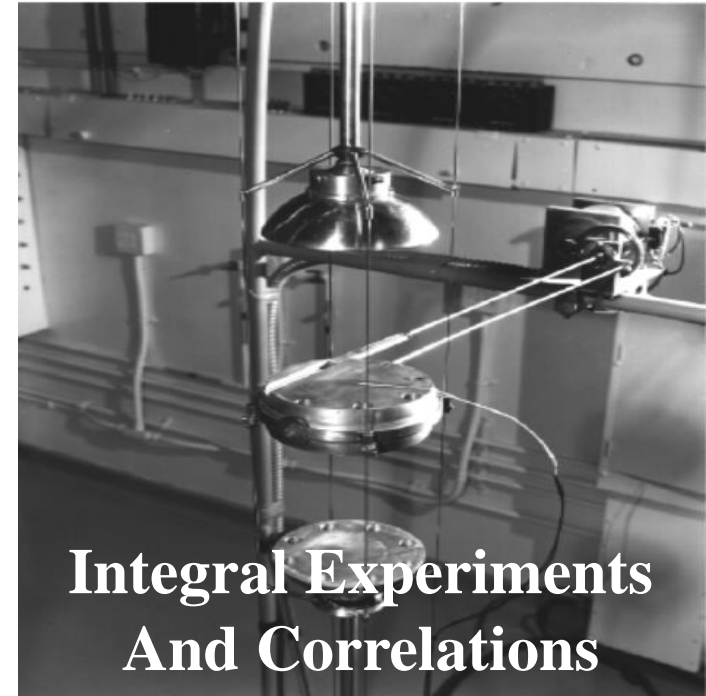
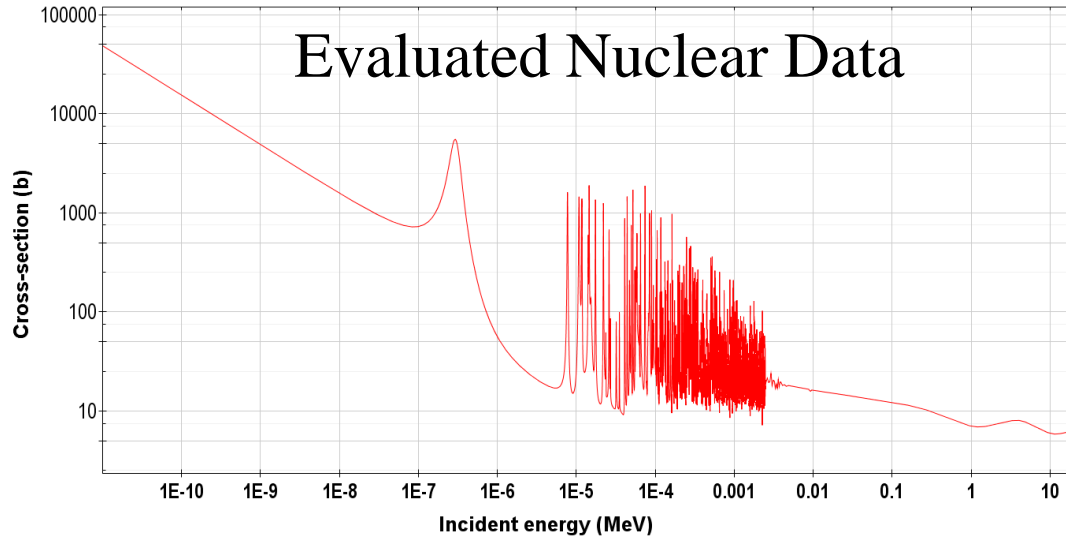
Two blue arrows point from the control panel to the detailed view: one from the "<original>" dropdown to the top of the list, and another from the "Plots" button to the "Format:" section.

# The NEA Nuclear Data Sensitivity Tool NDaST

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



Incident neutron data / ENDF/B-VII.1 / Pu239 / MT=1 : (n,total) / Cross section



## 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  $\Delta k_{\text{eff}}$  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



- Automated 3D uncertainty calculations can easily be performed for all (benchmark) problems for which MCNP inputs exist
- Method works well for both shielding and  $k_{\text{eff}}$  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



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.*

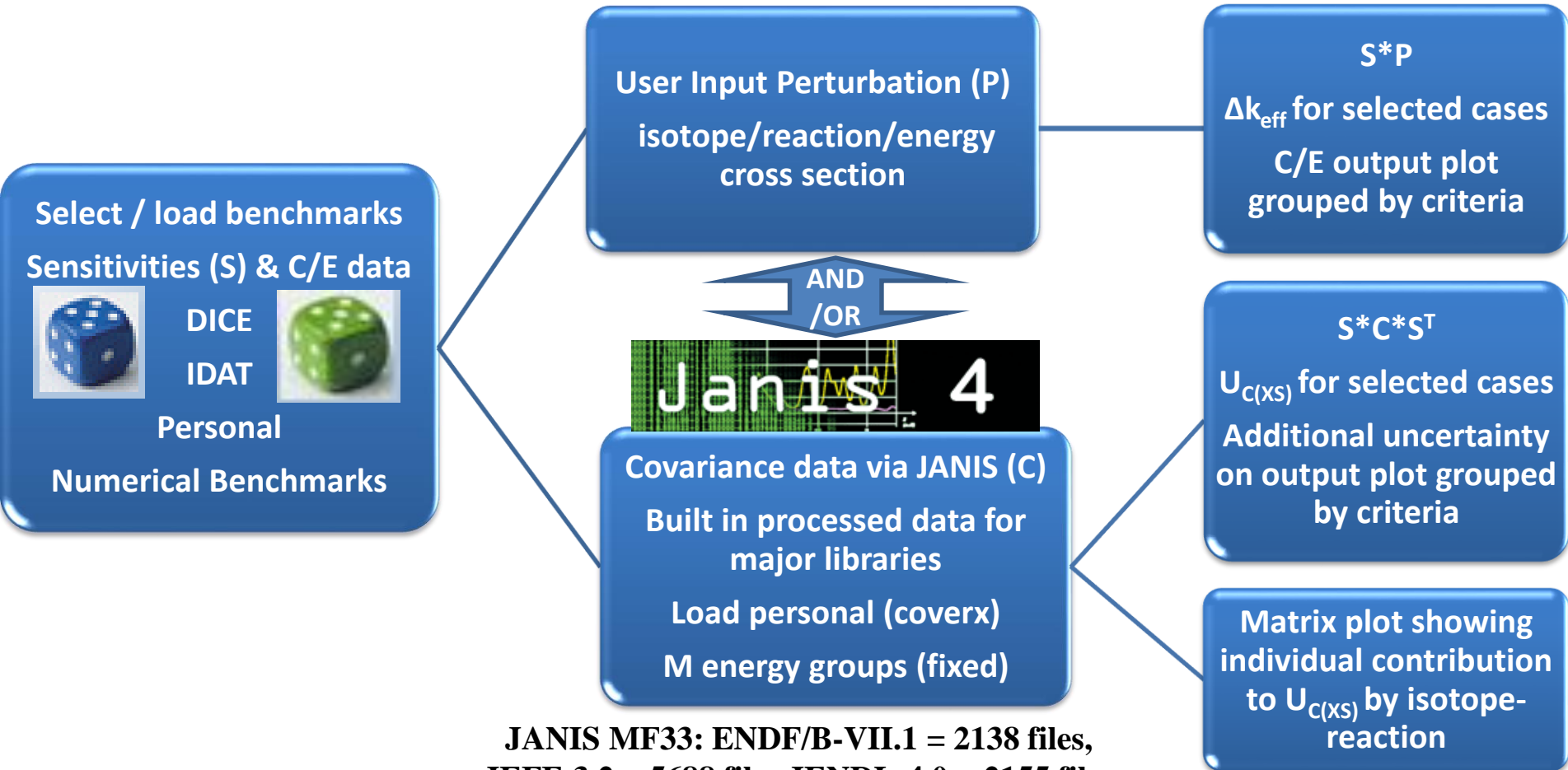
*James Dyrda*

*Nicolas Soppera*

*Ian Hill*

## Nuclear Data Sensitivity Tool (NDaST) Flowchart

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



**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,  $k_{\text{eff}}$  5 pcm

**To assess the impact of each reaction on the benchmarks**

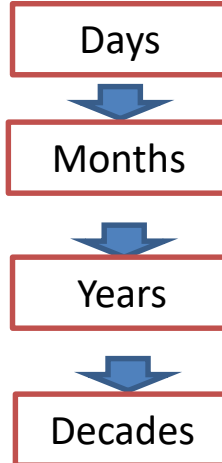
→ 600 X #Reactions [Look what is driving the  $k_{\text{eff}}$  change]

**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

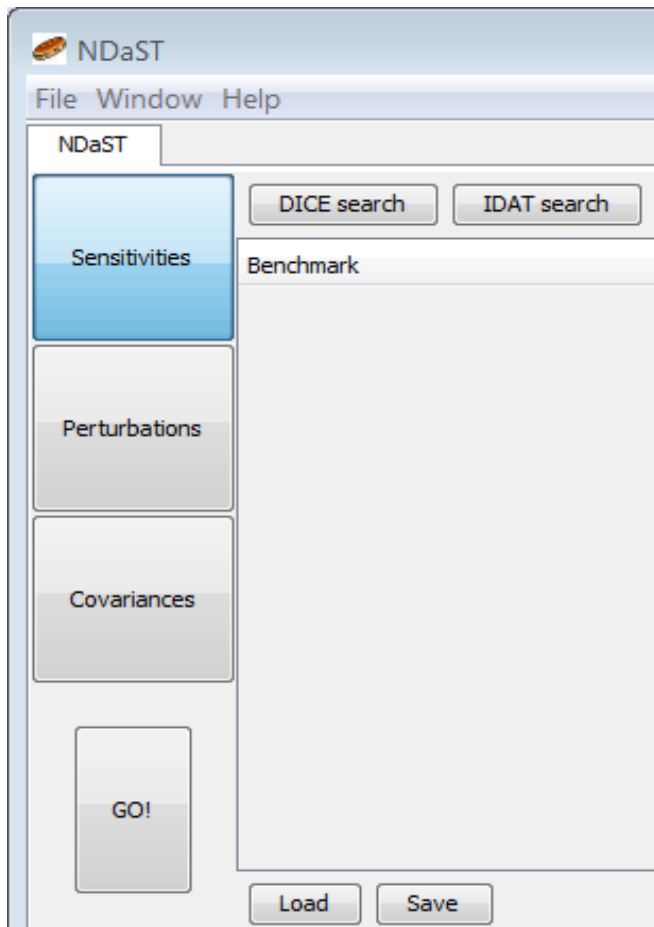
You will see approximated results, suitable for general trending and broad conclusions – more data, of lower accuracy can help to focus more precise efforts

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.



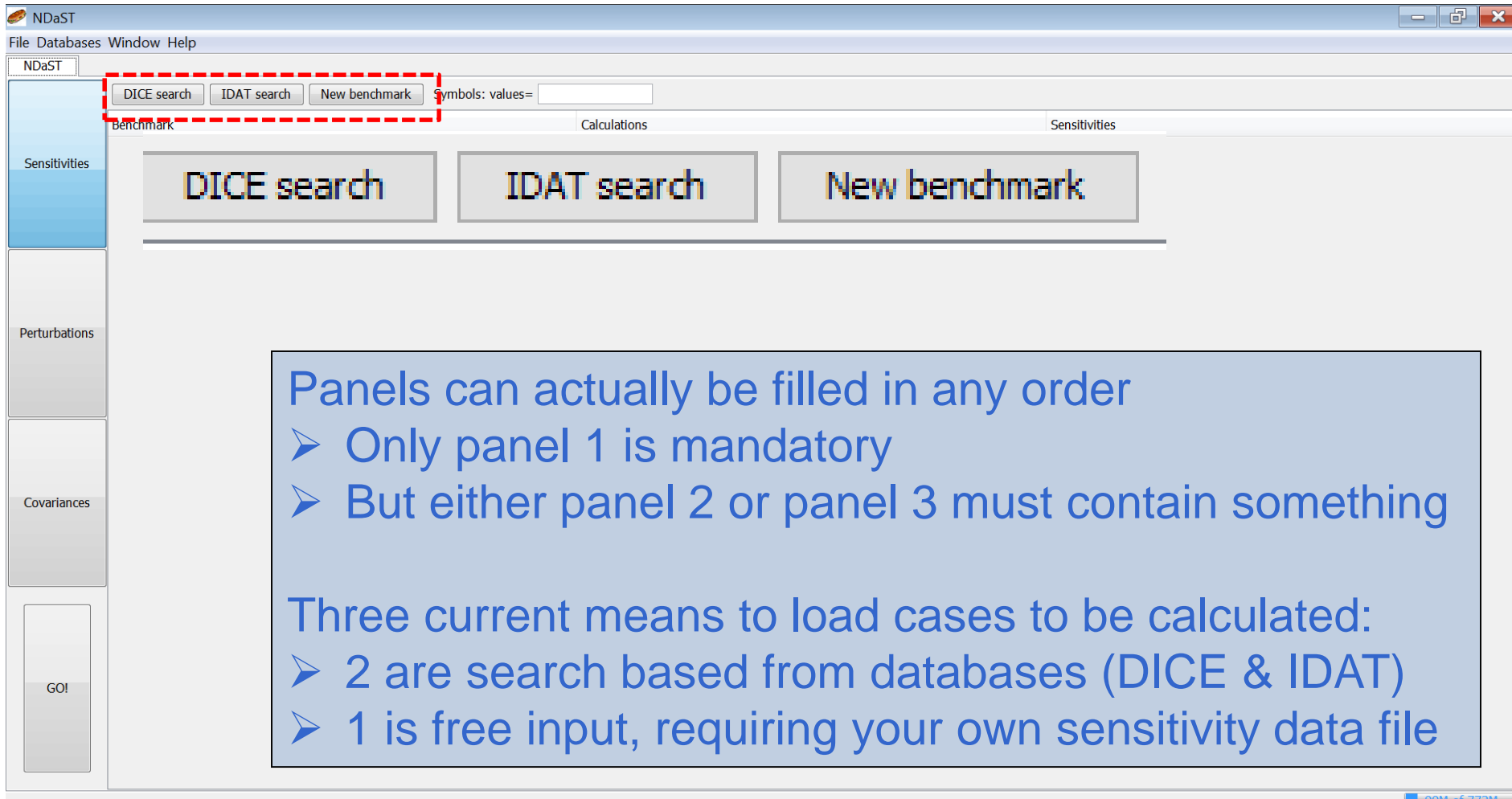
- Search using all the usual DB attributes
- Modify the results or add personal case results & sensitivity data
- 'Create' your own personal benchmark
- Save/load custom benchmark suite e.g. CSEWG
- Enable sharing of editable xml file datasets for collaborators / inter-comparisons



The screenshot shows a detailed view of the 'Sensitivities' section. The title bar reads 'NDaST - NDaST'. The menu bar includes 'DICE search' and 'IDAT search'. The main area is a table with two columns: 'Benchmark' and 'Calculations'. The table lists various benchmarks and their corresponding calculation counts.

Benchmark	Calculations
LST002-001	8 calc(s)
HMF032-002	6 calc(s)
PMF012-001	4 calc(s)
MCF005-001	3 calc(s)
HMF002-005	5 calc(s)
LMT015-004	2 calc(s)
IMF004-001 (Detailed Model)	5 calc(s)
HMF003-004	6 calc(s)
IMF003-001 (Detailed Model)	5 calc(s)
LCT043-004	6 calc(s)
LMT015-014	2 calc(s)
LCT043-003	6 calc(s)
HMF014-001	6 calc(s)
LMT015-012	2 calc(s)
HMF002-006	5 calc(s)

## Panel 1: Select Benchmark Sensitivity Data



NDaST

File Databases Window Help

NDaST

DICE search IDAT search New benchmark Symbols: values=

Benchmark Calculations Sensitivities

DICE search IDAT search New benchmark

Sensitivities

Perturbations

Covariances

GO!

99M of 773M

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

Select columns [Refine search](#) [New search](#)  Horiz.  Vert.  Flat [Plots](#) [ParPlots](#) [Spectra plots](#) [Sensitivity plots](#) [PDF](#) [HTML](#) [XML](#)

**Sensitivities**

- Columns
- General items
  - Identification
  - Acceptable
  - Laboratory
  - Title
  - Pictures
  - Keyword
  - Year approved
  - Year revised
  - Years experiment performed
  - Revision
- Number of cases**
- Case label**

**Perturbations**

- Energy, spectra, sensitivities
  - EALF (eV)
  - AFGE (eV)
  - Flux < 0.625 eV
  - Flux 0.625 eV - 100 keV
  - Flux > 100 keV
  - Fission < 0.625 eV
  - Fission 0.625 eV - 100 keV
  - Fission > 100 keV
  - Capture < 0.625 eV
  - Capture 0.625 eV - 100 keV
  - Capture > 100 keV
  - Keff Sensitivity < 0.625 eV (%dk/%Σ)
  - Keff Sensitivity 0.625 eV - 100 keV (%dk/%Σ)
  - Keff Sensitivity > 100 keV (%dk/%Σ)
  - Total Keff Sensitivity over all energy (%dk/%Σ)

**Covariances**

- Fuel

Evaluation identification	Number of cases	Title
U233-MET-FAST-001	1	233U JEZEBEL: A BARE SPHERE OF URANIUM-233 METAL
U233-MET-FAST-002	2	BENCHMARK CRITICAL EXPERIMENTS OF URANIUM-233 SPHERES SURROUNDED BY URANIUM-235
U233-MET-FAST-003	2	BENCHMARK CRITICAL EXPERIMENTS OF HIGHLY ENRICHED URANIUM-233 SPHERES REFLECTED BY NORMAL URANIUM
U233-MET-FAST-004	2	BENCHMARK CRITICAL EXPERIMENTS OF HIGHLY ENRICHED URANIUM-233 SPHERES REFLECTED BY TUNGSTEN
U233-MET-FAST-005	2	BENCHMARK CRITICAL EXPERIMENT OF HIGHLY ENRICHED URANIUM-233 SPHERES REFLECTED BY BERYLLIUM
U233-MET-FAST-006	1	BENCHMARK CRITICAL EXPERIMENT OF A URANIUM-233 SPHERE REFLECTED BY NORMAL URANIUM WITH FLATTOP

Case identification	Model	Benchmark Keff	Benchmark Keff uncertainty (1 σ)	Code name	Library	Calculation label	Calculated
U233-MET-FAST-001-001	-	1.000	0.001	KENO	ABBN-93 / 299-Group	-	0.9976
U233-MET-FAST-001-001	-	1.000	0.001	KENO	ENDF/B-IV / 27-Group	-	0.9625
U233-MET-FAST-001-001	-	1.000	0.001	KENO	Hansen-Roach / 16-Group	-	1.0068
U233-MET-FAST-001-001	-	1.000	0.001	MCNP	ENDF/B-V Continuous	-	0.9970
U233-MET-FAST-001-001	-	1.000	0.001	MCNP	ENDF/B-VI.8 Continuous	-	0.9926
U233-MET-FAST-001-001	-	1.000	0.001	MCNP	ENDF/B-VII.0 Continuous	-	0.9996
U233-MET-FAST-001-001	-	1.000	0.001	MCNP	JEFF-3.1.2 Continuous	-	1.00423
U233-MET-FAST-001-001	-	1.000	0.001	MONK	UKNDL	-	1.0011
U233-MET-FAST-001-001	-	1.000	0.001	ONEDANT	ENDF/B-IV / 27-Group	-	0.96
U233-MET-FAST-002-001	-	1.0000	0.0010	KENO	ABBN-93 / 299-Group	-	0.9959
U233-MET-FAST-002-001	-	1.0000	0.0010	KENO	ENDF/B-IV / 27-Group	-	0.9739
U233-MET-FAST-002-001	-	1.0000	0.0010	KENO	Hansen-Roach / 16-Group	-	1.0010

Add selected search results to your benchmark selection

Return to benchmark selection

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

DICE search

IDAT search

New benchmark

Symbols: values=

	Benchmark	Calculati...	Sensitivities	ICBEVALS.NUMBER_CASES	ICBCALCS.C_OVER_E
<b>Sensitivities</b> 8 benchmarks 8 profiles	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

NDaST

File Databases Window Help

NDaST

Label: PCT001-001

Experimental value: 1.0

Experimental uncertainty: 0.011

Calculations

Label	Value	Uncertainty
<input checked="" type="checkbox"/> MONK JEF-2.2 Continuous	0.997	0
<input checked="" type="checkbox"/> MCNP ENDF/B-V Continuous	1.002	0
<input checked="" type="checkbox"/> MCNP ENDF/B-VI.4 Continuous	1.01	0.001
<input checked="" type="checkbox"/> KENO ENDF/B-V / 238-Group	0.998	0
<input checked="" type="checkbox"/> MCNP JEFF-3.1.2 Continuous	1.008	0
<input checked="" type="checkbox"/> TRIPOLI JEF-2.2 Continuous	0.993	0.001
<input checked="" type="checkbox"/> APOLLO JEF-2.2 / 172-Group	0.991	0
<input checked="" type="checkbox"/> KENO ABBN-93 / 299-Group	1.008	0
<input checked="" type="checkbox"/> WWMC JEF-2.2 / 172-Group	0.994	0
<input checked="" type="checkbox"/> MCNP ENDF-7.1 continuous	0.992	0

Sensitivities

Add sensitivities

Sensitivity

KENO ENDF/B-VII.0 / 238-Group

Ok Cancel

6 Evaluations. 10 Cases

IBM of 773M

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

Label	Value	Uncertainty
My code	1.004	2.0E-4

7 benchmark(s) selected

80M of 773M

## Save and Load Options

NDaST

File Databases Window Help

NDaST

DICE search IDAT search New benchmark Symbols: values= Keff

Benchmark	Calculations	Sensitivities	ICBSENS_G3.ISOTOPE	ICBSENS_G3.INTER	ICBEVALS.N
PCI001-001	9 calc(s)	1 sensitivity(ies)	Pu239	0.5996	1
PCM002-006	3 calc(s)	1 sensitivity(ies)	Pu239	0.2039	29
PCM002-008	3 calc(s)	1 sensitivity(ies)	Pu239	0.2001	29
PMI001-001	6 calc(s)	1 sensitivity(ies)	Pu239	0.3118	6
PMI001-002	6 calc(s)	1 sensitivity(ies)	Pu239	0.2982	6
PMI002-001	11 calc(s)	1 sensitivity(ies)	Pu239	0.3402	1
PMM001-004	6 calc(s)	1 sensitivity(ies)	Pu239	0.2116	6

Sensitivities

Perturbations

Covariances

Save as

Look in: SavedFiles

- MCNP6\_VnV\_Exp
- SavedFiles - Shortcut
- @b,p,c.ndast
- @b,p,c\_results.ndast
- @b,p,c\_results\_RESAVED.ndast
- @results\_DEV.ndast
- @results\_DEV\_resaved.ndast
- @test\_filter.ndast
- @test\_save\_categories.ndast
- aef.ndast
- CSEWG.ndast
- CSEWG\_expanded.ndast
- CSEWG\_expanded\_senonly.ndast
- CSEWG\_senonly.ndast
- DICE1.ndast
- DICE2.ndast
- DICE3.ndast
- error\_test53.ndast

File name: GENTLE\_PuInter\_example

Files of type: NDaST Parameters (\*.ndast)

Parts to save:

- benchmarks
- perturbations
- covariances
- results

Save as Cancel

## 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="ICBSSENS_G3.ISOTOPE">Pu239</category>
        <category key="ICBSSENS_G3.INTER">0.3118</category>
        <category key="ICBEVALS.NUMBER_CASES">6</category>
        <category key="ICBSSENS_G3.REACTION">fission</category>
      </benchmark>
    </benchmarks>
  </params>
</ndast>
```

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

NDaST

File Databases Window Help

NDaST

**Sensitivities**  
8 benchmarks  
8 profiles

**Perturbations**  
1 perturbation

Covariances

GO!

All isotopes From sensitivities

Isotopes

- 75 - Re - Rl
- 77 - Ir - Iric
- 79 - Au - Gi
- 80 - Hg - M
- 82 - Pb - Le
- 83 - Bi - Bis
- 90 - Th - Tf
- 91 - Pa - Pr
- 92 - U - Ura
- 93 - Np - Ni
- 94 - Pu - Pl
- Pu238
- **Pu239**
- Pu240
- Pu241
- Pu242

Reactions

- TOTAL
- ELASTIC
- INELASTIC
- N\_2N
- FISSION
- CAPTURE
- N\_GAMMA
- N\_P
- N\_D
- N\_T
- N\_ALPHA

**Perturbations**

E=  eV Add energy group bound(s)

Energy group	<Pu239,FISSION>
10 μeV	
20 MeV	

Paste perturbations Calculate ratios Clear

● solid

○ density

<Pu239,FISSION>

8 benchmark(s) selected 82M of 3618M

## Add Energy & Perturbation Manually

NDaST

File Databases Window Help

**Sensitivities**  
8 benchmarks  
8 profiles

**Perturbations**  
2 perturbations

Covariances

GO!

All isotopes From sensitivities

Isotopes

- 75 - Re - Rl
- 77 - Ir - Iric
- 79 - Au - Gi
- 80 - Hg - M
- 82 - Pb - Le
- 83 - Bi - Bis
- 90 - Th - Th
- 91 - Pa - Pr
- 92 - U - Ura
- 93 - Np - Ni
- 94 - Pu - Pl
- Pu238
- Pu239
- Pu240
- Pu241
- Pu242
- 95 - Am - A
- 96 - Cm - C

Reactions

- TOTAL
- ELASTIC
- INELASTIC
- N\_2N
- FISSION
- CAPTURE
- N\_GAMMA
- N\_P
- N\_D
- N\_T
- N\_ALPHA
- ELASTIC\_P1
- NUBAR

Perturbations

E=  eV

Energy group	<Pu239,FISSION>	<Pu239,CAPTURE>
10 µeV	1.1	0.6
625 meV	1.2	0.8
200 eV	1.3	0.9
20 MeV	1.4	1.1

Mix and delete energies – code will logically extend or unionise

● solid  
○ density

<Pu239,FISSION>  
<Pu239,CAPTURE>

Energy (eV)

■ <Pu239,FISSION>  
■ <Pu239,CAPTURE>

8 benchmark(s) selected 259M of 3618M

## Paste Energies & Perturbations

NDaST

File Databases Window Help

NDaST

**Isotopes**

- 68 - Er - Erbium
- 69 - Tm - Thulium
- 71 - Lu - Lutecium
- 72 - Hf - Hafnium
- 73 - Ta - Tantalum
- 74 - W - Tungsten
- 75 - Re - Rhenium
- 77 - Ir - Iridium
- 79 - Au - Gold
- 80 - Hg - Mercury
- 82 - Pb - Lead
- 83 - Bi - Bismuth
- 90 - Th - Thorium
- 91 - Pa - Protactinium
- 92 - U - Uranium
- 93 - Np - Neptunium
- 94 - Pu - Plutonium
  - Pu238
  - **Pu239**
  - Pu240
  - Pu241
  - Pu242
- 95 - Am - Americium
- 96 - Cm - Curium
- 98 - Cf - Californium

**Reactions**

- TOTAL
- ELASTIC
- INELASTIC
- N\_2N
- FISSION
- CAPTURE
- N\_GAMMA
- N\_P
- N\_D
- N\_T
- N\_ALPHA
- NUBAR
- CHI

**Perturbations**

E=  eV Add energy group bound(s) Paste perturbations JANIS ratio

Energy...	<Pu23...	<Pu23...	<Pu23...
1E-5 - ...	1.103	1.004	
1E-4 - ...	1.103	1.004	
1E-3 - ...	1.103	1.002	
1E-2 - ...	1.105	1.002	
1E-1 - ...	1.065	0.999	
1E0 - 1...	1.062	1.028	
1E1 - 1...	1.031	0.995	
1E2 - 1...	1.005	0.993	
1E3 - 1...	0.984	1.018	
1E4 - 1...	1.001	1.006	
1E5 - 1...	1.02	1	
1E6 - 1...	1.006	1.001	
1E7 - 2...	1.094	0.993	

Perturbation label:

**Paste perturbations - NDaST**

lower energies  
 (upper bound of 2E7 eV assumed if not given)

upper energies  
 (lower bound of 1E-5 eV assumed if not given)

```

1E-5
1E-4 ; 1.012
1E-3 ; 1.011
1E-2 ; 1.01
1E-1 ; 0.999
1E0 ; 0.998
1E1 ; 0.957
1E2 ; 1.017
1E3 ; 0.974
1E4 ; 0.97
1E5 ; 1.026
1E6 ; 1.109
1E7 ; 2.364
2E7 ; 0.365
  
```

Label:

**Covariances**

0.0000000

Energy (eV)

**GO!**

## Computation of Ratios in JANIS

Calculate perturbations from nuclear data

### 1 Nuclear data

JANIS libraries  Own files ...

NEA>BROND-2.2	NEA>ENDF/B-VII.0	NEA>IRDF-1.0
NEA>BROND-3.1	NEA>ENDF/B-VII.1	NEA>IRDF-1.0-6
NEA>CENDL-2.1	NEA>ENDF/B-VIII.0	NEA>IRDF-1.05
NEA>CENDL-3.1	NEA>FENDL-2.1	NEA>JEF-2.2
NEA>EAF-2007	NEA>FENDL-2.1 MG	NEA>JEFF-3.0
NEA>EAF-2010	NEA>FENDL-3.1b	NEA>JEFF-3.0/A
NEA>ENDF/B-VI.8	NEA>IRDF-2002	NEA>JEFF-3.1
NEA>ENDF/B-VI.8-HF	NEA>IRDF-2002 MG	NEA>JEFF-3.1.1

Numerator(s)  
NEA>JENDL-4.0

Denominator  
NEA>ENDF/B-VII.1

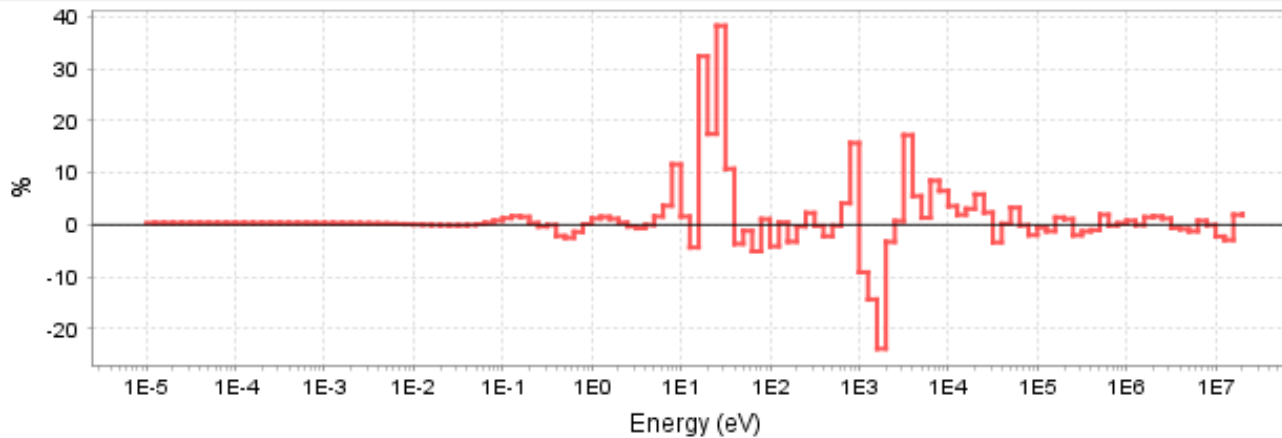
### 2 Nuclide(s)/Reaction(s)

Isotope(s)	Reaction(s)	Selected
Np238	TOTAL	<Pu239,FISSION>
Np239	ELASTIC	
Pu236	INELASTIC	
Pu237	N_2N	
Pu238	FISSION	
Pu238	CAPTURE	
Pu239	N_GAMMA	
Pu240	N_P	
Pu241	N_D	
Pu241		

3: Group 10 groups/decade

Spectrum Constant spectrum

Compute energy groups of continuous XS ratios



— Pu239 FISSON JENDL-4.0 / ENDF/B-VII.1

Perturbation label: JENDL-4.0 / ENDF/B-VII.1

Ok

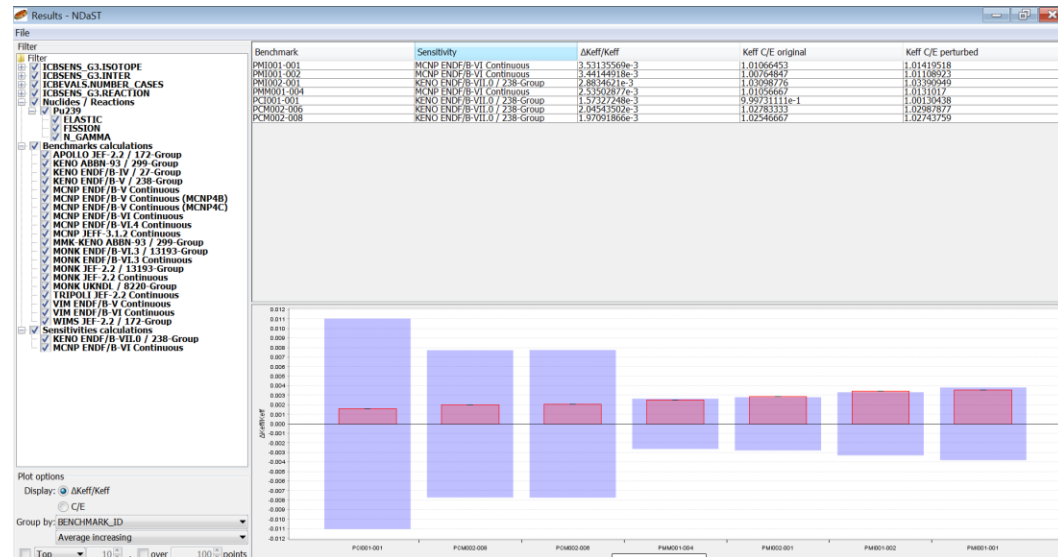
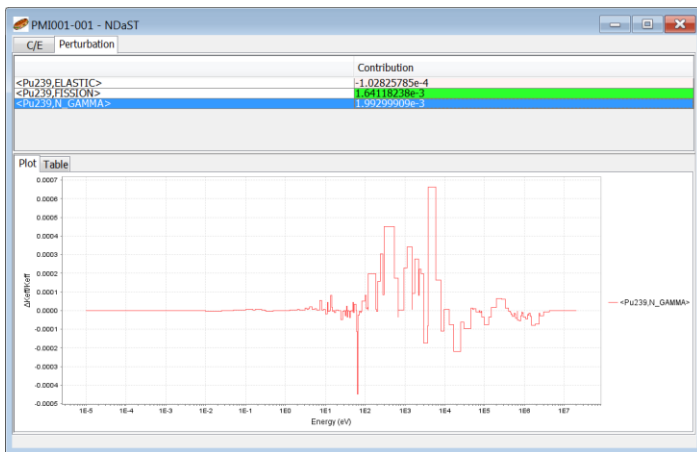
Cancel

## Launch Perturbation Calculation

The screenshot displays the NDaST software interface. A dialog box titled "NDaST" is centered on the screen, prompting the user to "Launch Perturbation calculation with: 7 benchmark(s), 3 perturbation(s)". The dialog box includes "OK" and "Cancel" buttons. In the background, the NDaST main window is visible, showing a list of isotopes (e.g., Pu238, Pu239, Pu240, Pu241, Pu242) and reaction types (e.g., ELASTIC, FISSION, CAPTURE). The right-hand pane, titled "Results - NDaST", displays a list of perturbation results, including DICE and UNCR values for various cases and benchmarks.

## Output Window and Plots (1)

- Window with results table of  $\Delta k_{\text{eff}}/k_{\text{eff}}$ , original & perturbed mean C/E
- Filter tree to the side – dynamic inclusion by nuclide, reaction, fuel, code...
- Grouped plot below – toggle either  $\Delta k_{\text{eff}}$  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  $\Delta k_{\text{eff}}$
  - Individual C/E for all results loaded to that case
  - Energy breakdown of  $\Delta k_{\text{eff}}$



## Delta $k_{eff}$ Output and Plot

File Edit View Help

Filter

- ICBEVALS.NUMBER\_CASES
- Nuclides / Reactions
  - Pu239
  - FISSION
- Benchmarks calculations
- Sensitivities calculations

Plot options

Display:   $\Delta K_{eff}/K_{eff}$   
 C/E

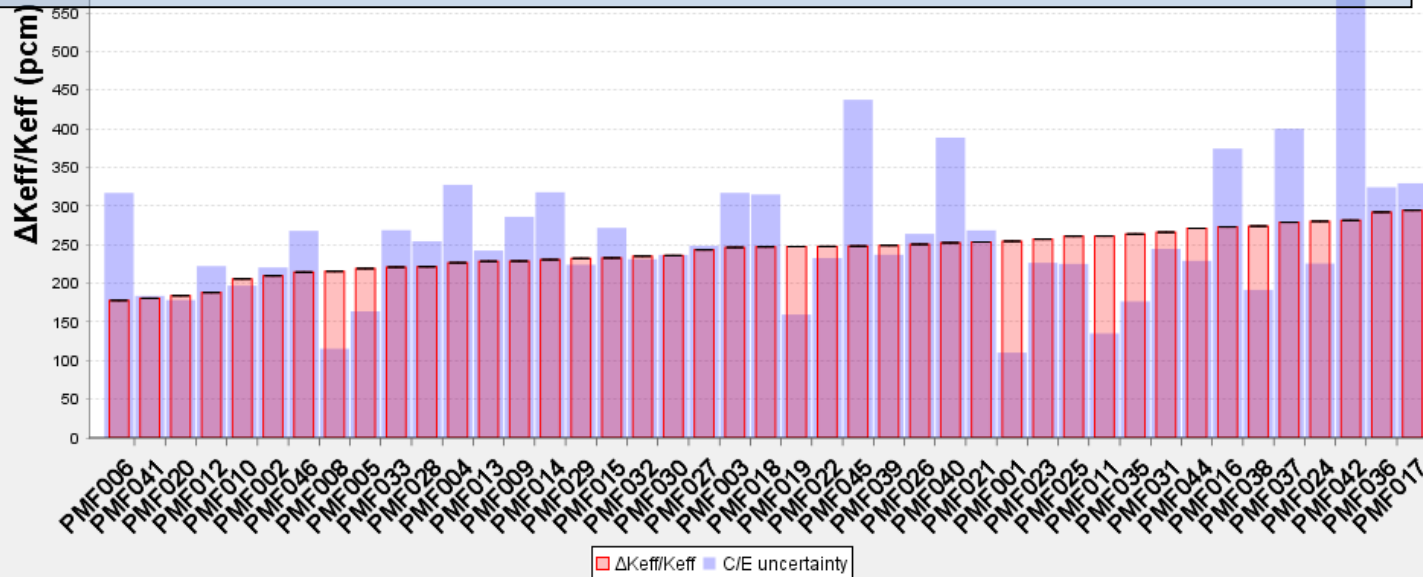
Group by: EVAL\_ID

Average increasing

Top 10 Over 100 points

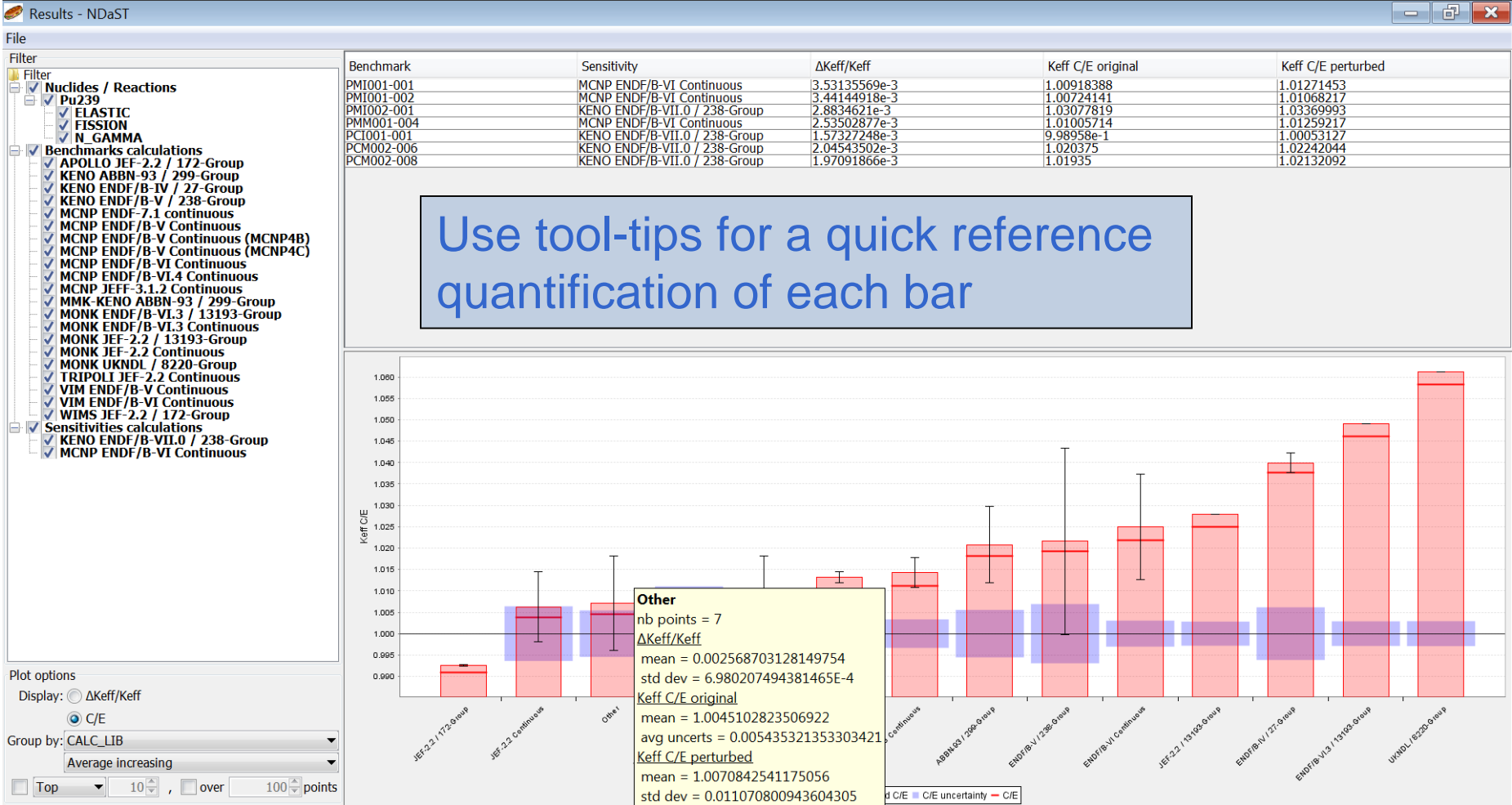
Benchmark	Sensitivity	$\Delta K_{eff}/K_{eff}$	Keff C/E original	Keff C/E perturbed
PMF001-001 (Detailed Model)	KENO ENDF/B-VII.0 / 238-Group	254.8	1.00068001	1.00322798
PMF001-001 (Simplified Model)	KENO ENDF/B-VII.0 / 238-Group	254.8	1.001408	1.00395595
PMF001-002 (Detailed Model)	KENO ENDF/B-VII.0 / 238-Group	254.4	1.00106983	1.00361374
PMF001-002 (Simplified Model)	KENO ENDF/B-VII.0 / 238-Group	254.4	1.001408	1.00395232
PMF001-003 (Detailed Model)	KENO ENDF/B-VII.0 / 238-Group	254.4	1.00071986	1.00326308
PMF001-003 (Simplified Model)	KENO ENDF/B-VII.0 / 238-Group	254.4	1.001408	1.00395174
PMF001-004 (Detailed Model)	KENO ENDF/B-VII.0 / 238-Group	253.6	1.00062919	1.00316176
PMF001-004 (Simplified Model)	KENO ENDF/B-VII.0 / 238-Group	253.6	1.001408	1.00394381
PMF002-001	KENO ENDF/B-VII.0 / 238-Group	209.6	1.00123667	1.00333298

Remove / include branches or leaves of the filter tree; table and plot update dynamically so you can copy & paste the individual results you need





## C/E Output Plot: Calculation Library + Tooltips



## Output Table: Detail Popup (C/E)

PMI001-001 - NDaST

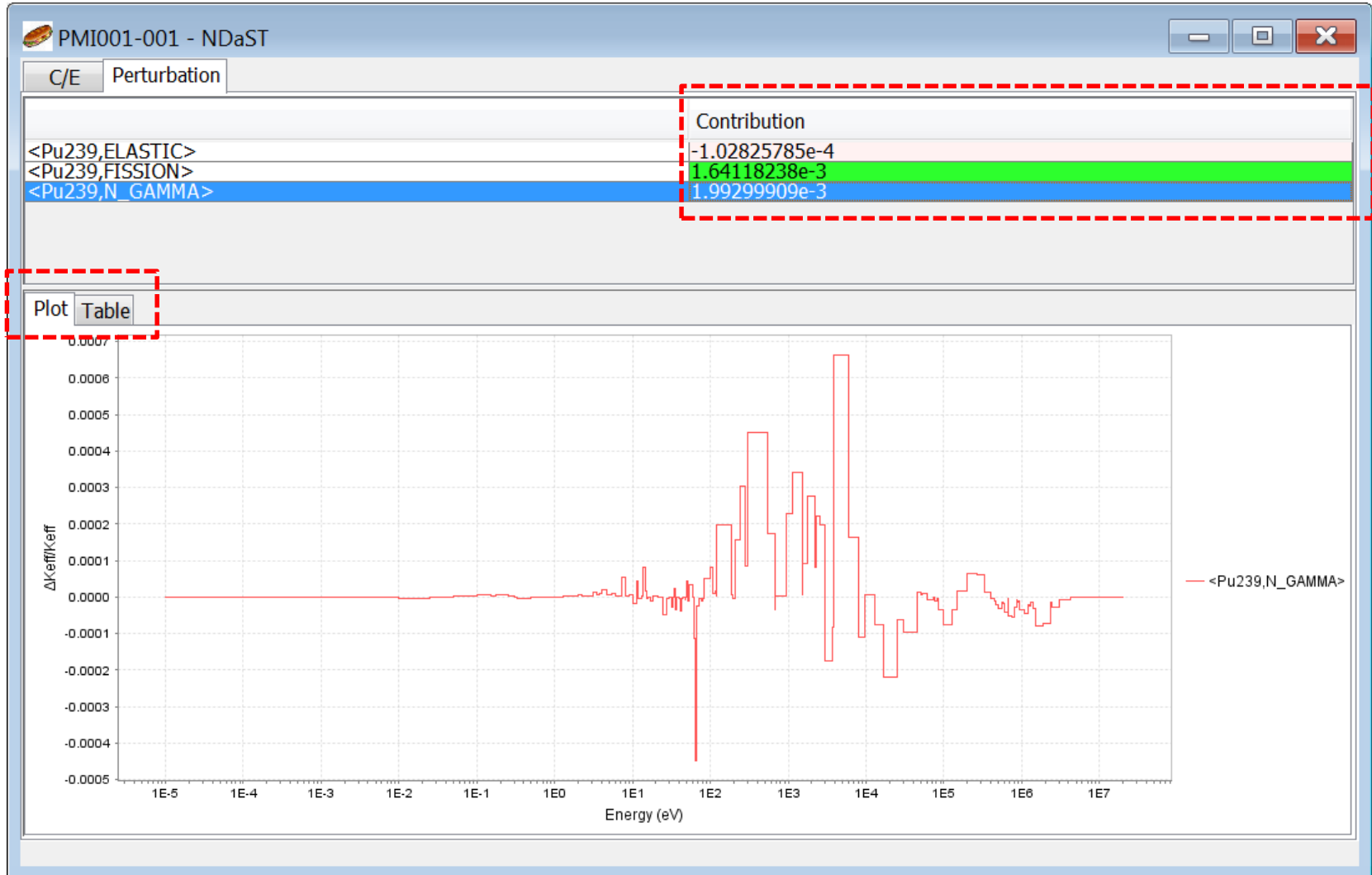
C/E Perturbation

Benchmark Keff = 1.0002  
 Benchmark Keff uncertainty = 0.0037  
 Perturbation  $\Delta K_{eff}/K_{eff}$  = 3.53135569e-3

Calculation	Keff	Keff unc.	Keff C/E original	Keff C/E unc.	Keff C/E perturbed
MCNP ENDF/B-VI.4 Continuous	1.012		1.011798	3.777679e-3	1.015328
MMK-KENO ABBN-93 / 299-Group	1.011	0.00	1.010498	3.787683e-3	1.014029
MCNP ENDF/B-V Continuous	1		0.999400	3.731391e-3	1.002931
MONK JEF-2.2 Continuous	1.012	0.00	1.012198	3.879504e-3	1.015728
MCNP ENDF/B-VI Continuous	1.015	0.00	1.014597	3.803048e-3	1.018128
MONK ENDF/B-VI.3 Continuous	1.016	0.00	1.015497	3.892149e-3	1.019028

Double click a table entry to see the detail behind the average values i.e. complete breakdowns

## Output Table: Detail Popup (Perturbation)



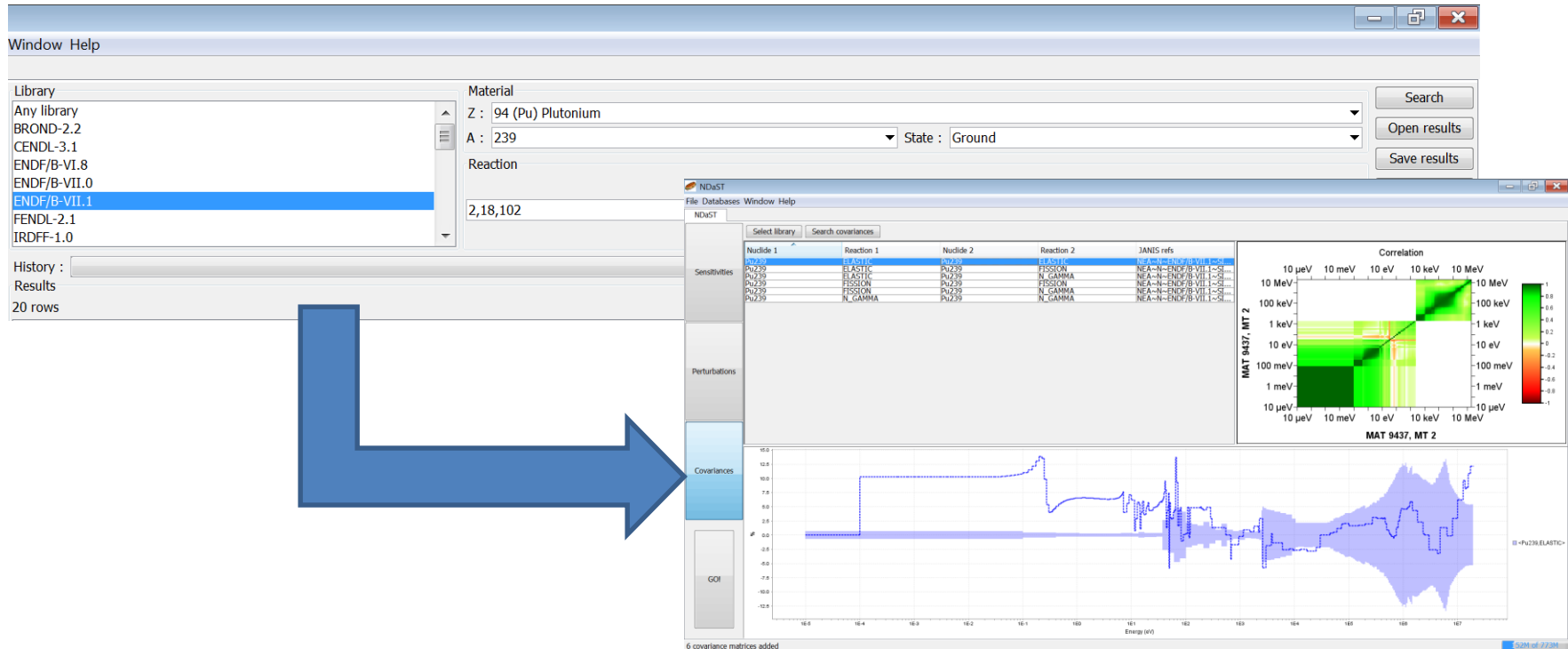
## Exercise 1 - Perturbations

- I. Choose BMs based on some sensitivity criteria to Pu239
  - Select top cases (max ~10)
- II. Edit the cases with 'personal'  $k_{\text{eff}}$  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

NDaST  
File Databases Window Help

NDaST

**Sensitivities**  
4 benchmarks  
4 profiles

**Perturbations**  
3 perturbations

**Covariances**

GO!

Library

- Any library
- BROND-2.2
- BROND-3.1
- CENDL-3.1
- ENDF/B-VI.8
- ENDF/B-VII.0
- ENDF/B-VII.1**
- ENDF/B-VIII.0

Format:  BOXER  ENDF

Material #1  
Z: 94 (Pu) Plutonium  
A: 239 State:   
Reaction #1

Material #2  
Z:   
A: State:   
Reaction #2

History:   
Results

18 rows

Search	Evaluation	Format	Material1	MF1	MT1	Material2	MF2	MT2
NEA	ENDF/B-VII.1	BOXER	Pu239	MF=33	MT=1 : (n,total)	Pu239	MF=33	MT=1 : (n,total)
NEA	ENDF/B-VII.1	BOXER	Pu239	MF=33	MT=1 : (n,total)	Pu239	MF=33	MT=2 : (z,elastic)
NEA	ENDF/B-VII.1	BOXER	Pu239	MF=33	MT=1 : (n,total)	Pu239	MF=33	MT=18 : (z,fission)
NEA	ENDF/B-VII.1	BOXER	Pu239	MF=33	MT=1 : (n,total)	Pu239	MF=33	MT=102 : (z,y)
NEA	ENDF/B-VII.1	BOXER	Pu239	MF=33	MT=2 : (z,elastic)	Pu239	MF=33	MT=2 : (z,elastic)
NEA	ENDF/B-VII.1	BOXER	Pu239	MF=33	MT=2 : (z,elastic)	Pu239	MF=33	MT=4 : (z,n')
NEA	ENDF/B-VII.1	BOXER	Pu239	MF=33	MT=2 : (z,elastic)	Pu239	MF=33	MT=16 : (z,2n)
NEA	ENDF/B-VII.1	BOXER	Pu239	MF=33	MT=2 : (z,elastic)	Pu239	MF=33	MT=17 : (z,3n)
NEA	ENDF/B-VII.1	BOXER	Pu239	MF=33	MT=2 : (z,elastic)	Pu239	MF=33	MT=18 : (z,fission)
NEA	ENDF/B-VII.1	BOXER	Pu239	MF=33	MT=2 : (z,elastic)	Pu239	MF=33	MT=37 : (z,4n)
NEA	ENDF/B-VII.1	BOXER	Pu239	MF=33	MT=2 : (z,elastic)	Pu239	MF=33	MT=102 : (z,y)
NEA	ENDF/B-VII.1	BOXER	Pu239	MF=33	MT=4 : (z,n')	Pu239	MF=33	MT=4 : (z,n')

Ready

Search

Open results

Save results

Print

Reset

Interrupt

Maximize

OK Cancel

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

## View Selected Covariance Files

NDaST File Databases Window Help

NDaST

Search covariances Select library Clear

Nuclide 1	Reaction 1	Nuclide 2	Reaction 2	JANIS refs
Pu239	TOTAL	Pu239	TOTAL	NEA~N~ENDF/...
Pu239	ELASTIC	Pu239	ELASTIC	NEA~N~ENDF/...
Pu239	INELASTIC	Pu239	INELASTIC	NEA~N~ENDF/...
Pu239	FISSION	Pu239	FISSION	NEA~N~ENDF/...

**Sensitivities**  
147 benchmarks  
159 profiles

**Perturbations**  
1 perturbation

**Covariances**  
4 matrices

Rel. std dev  
 filled  
 outline  
 Perturbations  
 display  
 solid  
 density

GO!

4 covariance matrices added

161M of 3618M

### Correlation

MAT 9437, MT 18

MAT 9437, MT 18

Rel. std dev

Energy (eV)

<Pu239,FISSION>

## Launch Uncertainty Calculation

NDaST
File Databases Window Help

Search covariances

Select library

Nuclide 1	Reaction 1	Nuclide 2	Reaction 2	JANIS refs
Pu239	ELASTIC	Pu239	ELASTIC	NEA~N~ENDF/...
Pu239	INELASTIC	Pu239	INELASTIC	NEA~N~ENDF/...
Pu239	FISSION	Pu239	FISSION	NEA~N~ENDF/...
Pu239	N_GAMMA	Pu239	N_GAMMA	NEA~N~ENDF/...

Clear

**Sensitivities**  
4 benchmarks  
4 profiles

**Perturbations**

**Covariances**  
4 matrices

GO!

NDaST

Launch Uncertainty propagation calculation with:

4 benchmarks (4 sensitivity profiles),  
4 covariance matrices

compute off-diagonal terms (cases/sensitivities representativity, aka 'Ck')

OK
Cancel

Perturbations

display

solid

density

■ <Pu239,FISSION>

MAT 9437, MT 18

**Correlation**

Clear

**MAT 9437, MT 18**

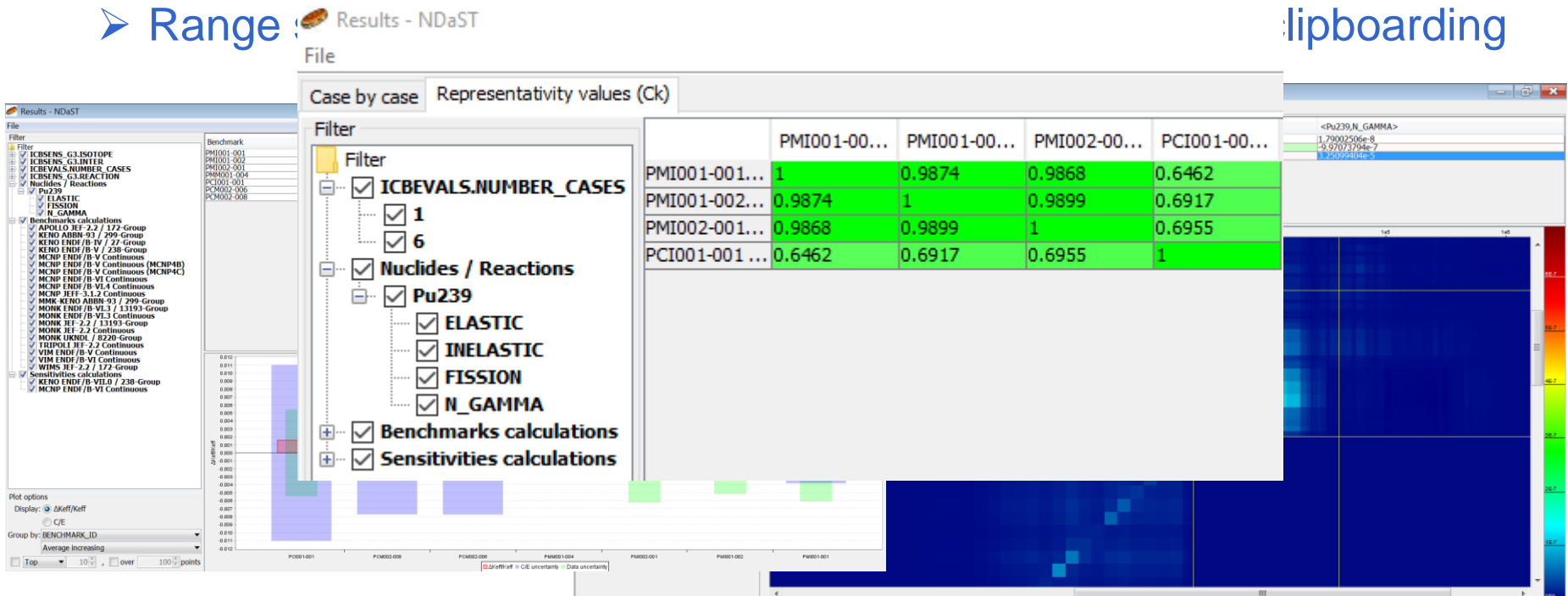
4 covariance matrices added

396M of 3618M

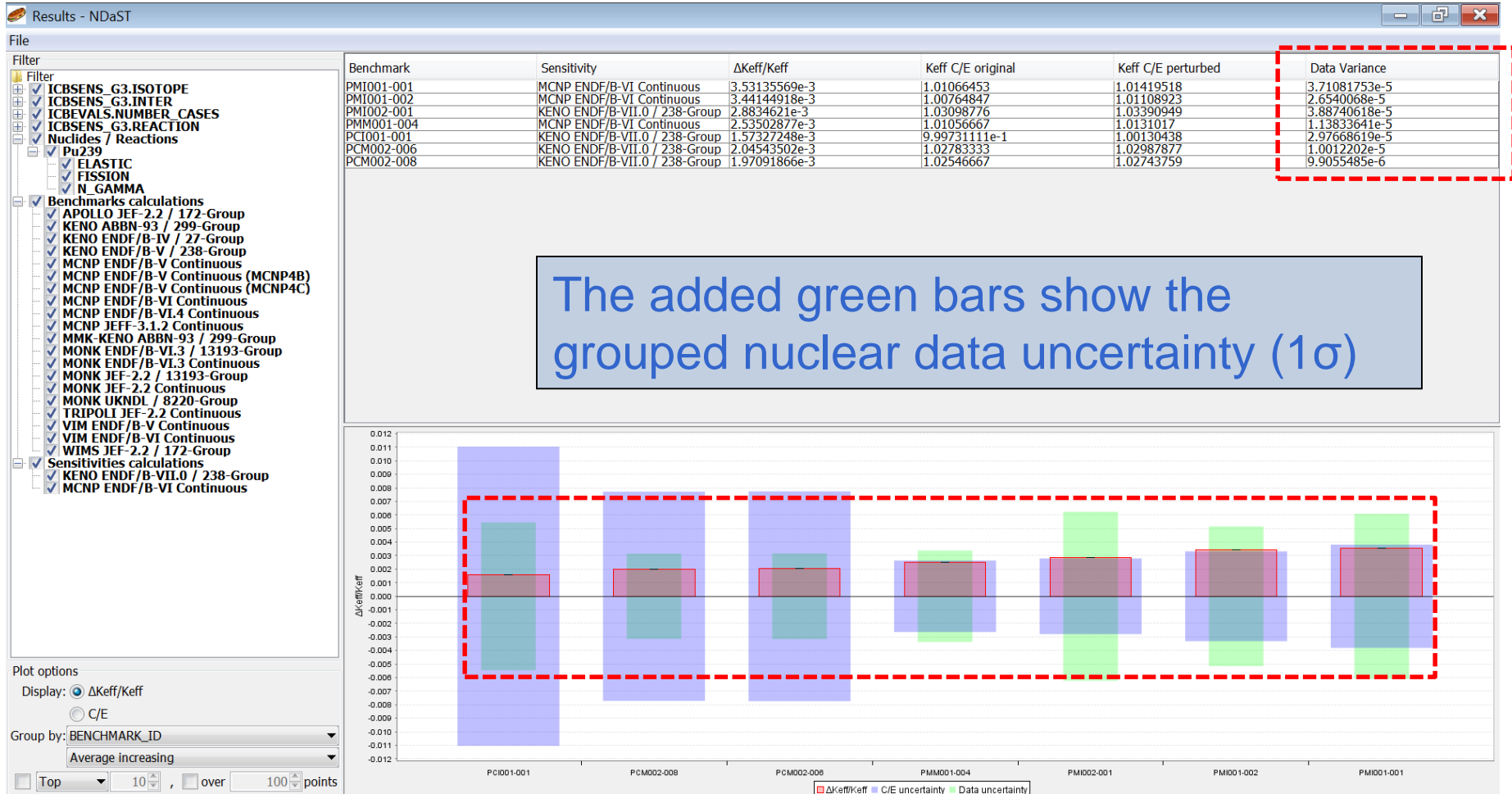


## Output Window and Plots (2)

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



## Delta $k_{eff}$ Output and Plot

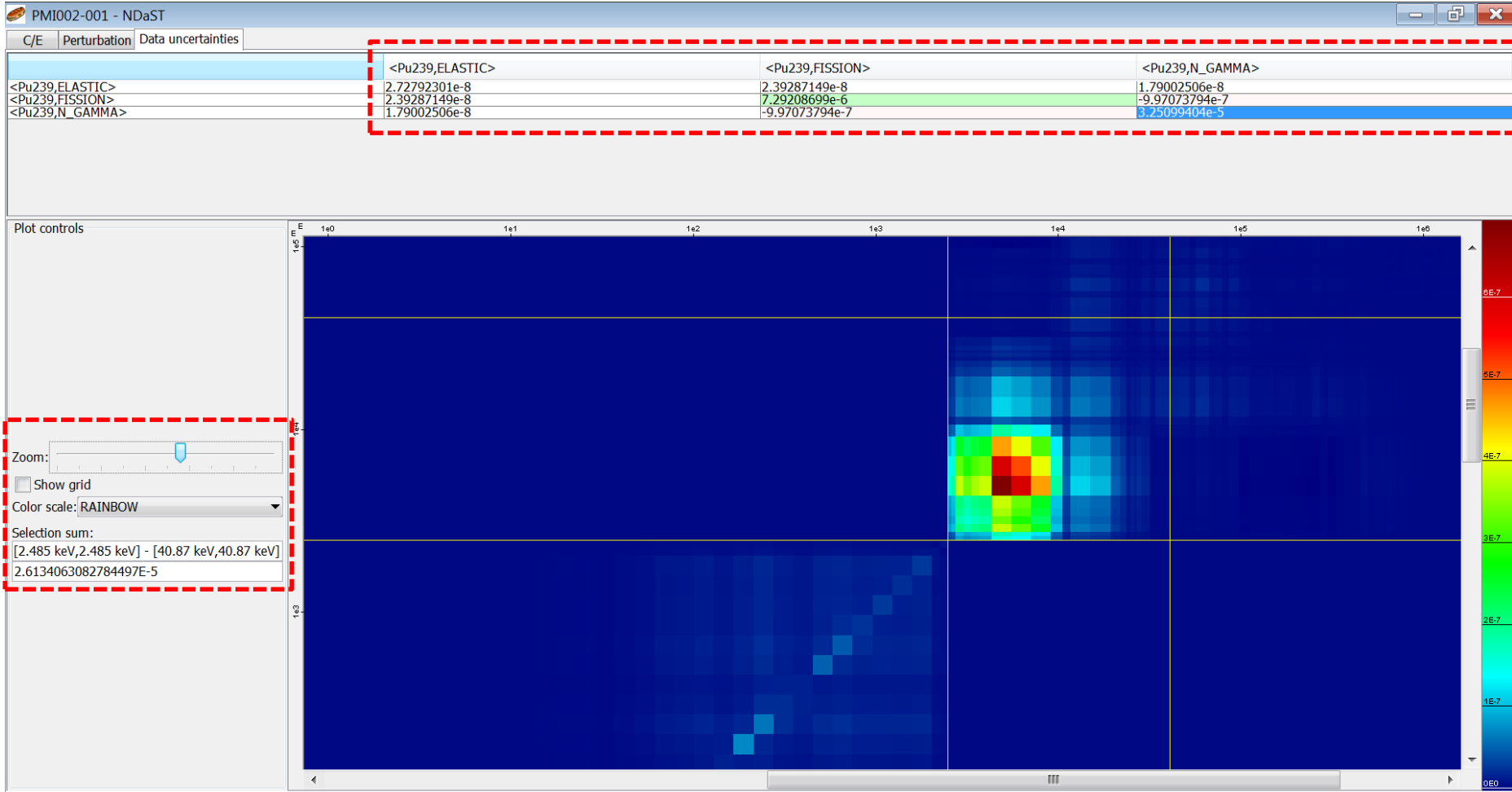


## Save Output Data

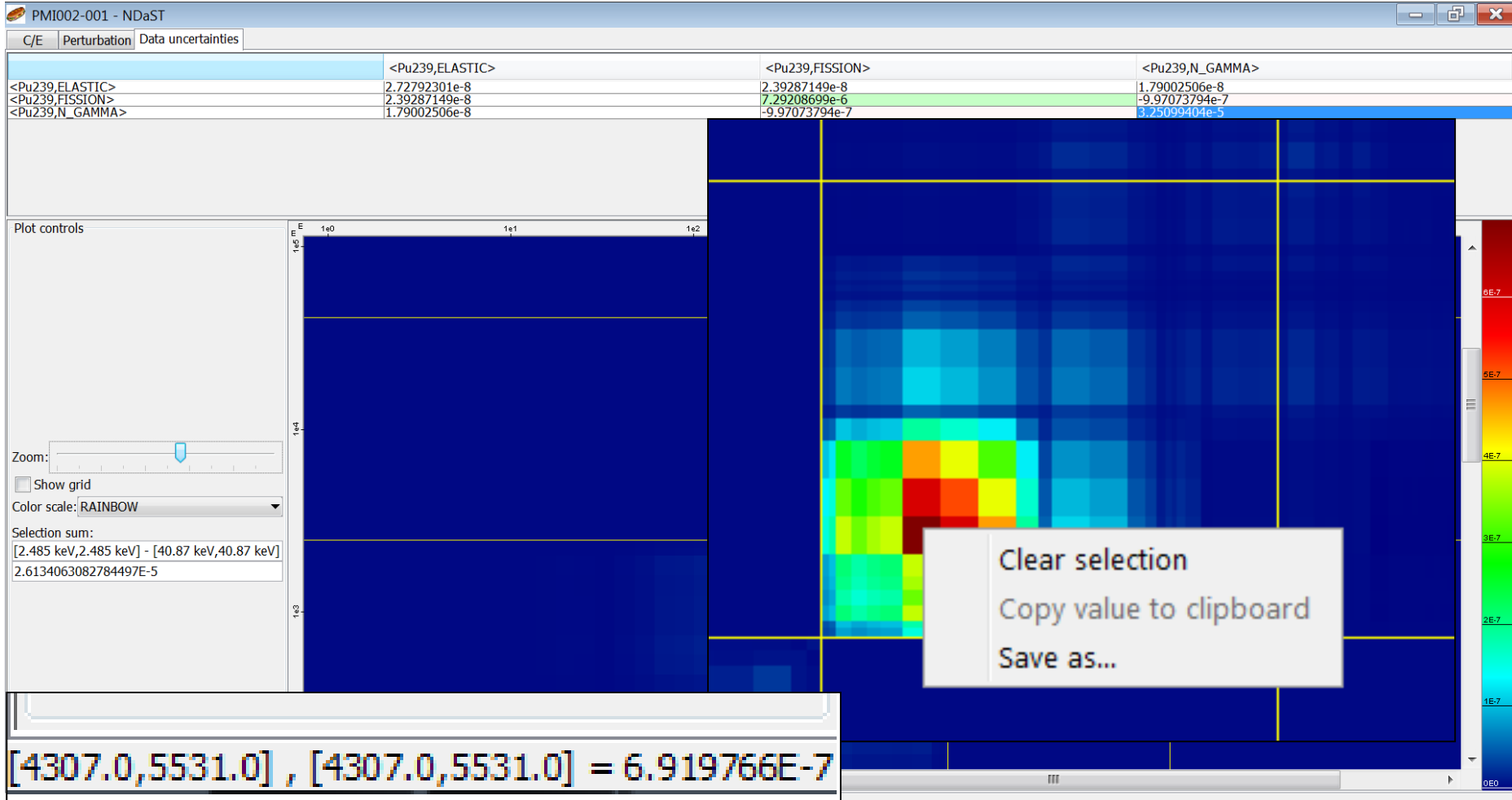
The screenshot shows the 'Results - NDAST' application window. A 'File' menu is highlighted in the top-left corner. A 'Save as' dialog box is open in the center, showing the file 'GENTLE\_PuInter\_example.ndast' being saved to the 'SavedFiles' directory. The 'Parts to save' section on the right of the dialog has 'benchmarks', 'perturbations', 'covariances', and 'results' checked. Below the dialog, a table displays benchmark data, and a bar chart at the bottom visualizes the data variance for various benchmarks.

Benchmark	Sensitivity	$\Delta K_{eff}/K_{eff}$	Keff C/E original	Keff C/E perturbed	Data Variance
PM1001-001	MCNP ENDF/B-VI Continuous	3.53135569e-3	1.00918388	1.01271453	3.71081753e-5
PM1001-002	MCNP ENDF/B-VI Continuous	3.44144918e-3	1.00724141	1.01068217	2.6540068e-5
PM1002-001	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

## 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/](http://www.oecd-nea.org/ndast/)

Email: [ndast@oecd-nea.org](mailto:ndast@oecd-nea.org)

## Thank you for your attention



All NEA publications and institutional documentation available at  
[www.oecd-nea.org](http://www.oecd-nea.org)

