

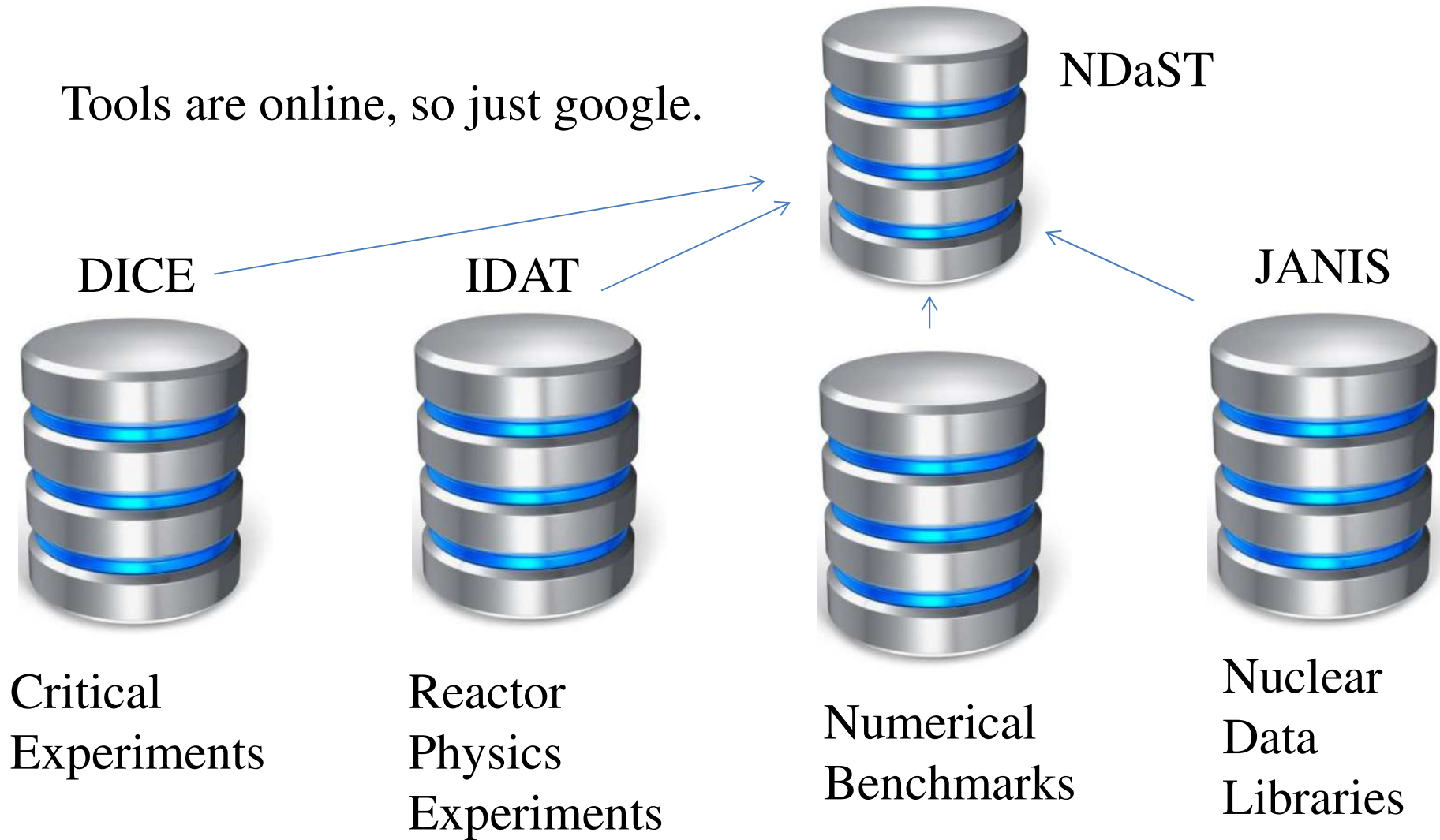
# NEA Tools: Availability and Use of Sensitivity Coefficients

**NEA Nuclear Science and Data Bank (\*UPM)**  
I.Hill, J.Dyrda, O.Cabellos\*

SG39/46  
November 20<sup>th</sup> 2017

## Collections

Tools are online, so just google.



## Tools: (CRIT,RP,ND,GLUE)

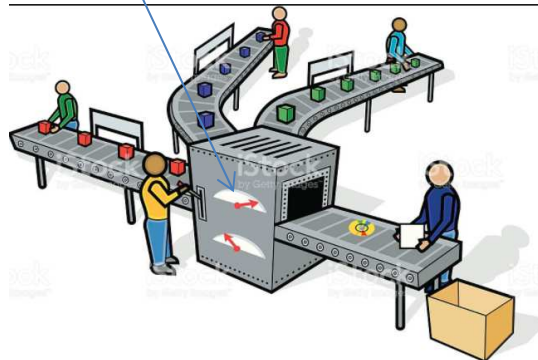
*Brief Overview of the Tools Available*

*DICE, IDAT, JANIS, NDaST*

SG46: **Efficient and Effective** Use of Integral Experiments for Nuclear Data Validation

## Applications:

*Summary of recent applications of the tools*



**Industrial engineering**: is a branch of [engineering](#) which deals with the optimization of complex [processes](#), [systems](#), or [organizations](#). **Industrial engineers** work to eliminate waste of time, money, materials, person-hours, machine time, energy and other resources that do not generate value. According to the [Institute of Industrial and Systems Engineers](#), they create engineering processes and systems that improve quality and productivity.<sup>[1]</sup>

# Collection: 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]   |
| 2017             | ~4200                  | Previous+P1 Sensitivities [~700 cases]                 |

**Isotopes**

- 83 - Bi - Bismuth
- 90 - Th - Thorium
- 92 - U - Uranium
- 93 - Np - Neptunium
- 94 - Pu - Plutonium
  - Pu238
  - Pu239
  - Pu240
  - Pu241
  - Pu242
- 95 - Am - Americium

Combine with AND  Combine with OR

**Reactions**

- None selected
- capture
- elastic
- elastic-P1
- fission
- inelastic
- nubar
- total

Combine with AND  Combine with OR

DB search: 3 group plot, distributed:238 group  
Can read in N group sensitivities and perform comparisons

**Sensitivity Plot**

PU-MET-FAST-001-001 KENO ENDF/B-VII.0 / 238-Group nubar pu-239 : 0.966329 +/- 0.000021

**Representation**

Per unit lethargy bin

<original>

Plots  Table

Clear

Load own data...

Lines width: 5  Black & white

No comparison  Ratio  Difference

- pu-239
- nubar
- total
- fission
- elastic-P1
- scatter
- chi
- elastic
- n,n'
- n,gamma
- n,2n

I.Hill, J.Gulliford, N.Soppera, M. Bossant, "DICE2013 New Capabilities and Features", PHYSOR2014

## Using DICE Sensitivities <sup>238</sup>U Example

European Commission

JRC TECHNICAL REPORT

Status of Evaluated Data Files for <sup>238</sup>U  
in the Resonance Region

Stefan Kopecky  
Ivan Sirakov  
Do Heon Kim  
Andrey Trkov  
Pascal Archier  
Bjorn Becker  
Oscar Cabellos  
Cyrille De Saint Jean  
Jan Heyse  
Hyeonng Il Kim  
Luiz Leal  
Young Duk Lee  
Gilles Noguere  
Carlos Paradela  
Vladimir Pronyaev  
Peter Schillebeeckx  
Gašper Žerovnik

2015

Report EUR 27504 EN

**Appendix B**  
Integral benchmark experiments with a high sensitivity to the cross section of <sup>238</sup>U in the energy region between 10 keV and 20 keV

| ICSBEF Id              | Common name      | Reaction | Sensitivity*<br>[(Δk/k)/(Δσ/σ) x 10 <sup>5</sup> ] |
|------------------------|------------------|----------|--|
| MIX-MISC-FAST-001-009  | BFS-31-4         | (n,tot)  | -56  |
| MIX-MISC-FAST-001-009  | BFS-31-4         | (n,γ)    | -39  |
| IEU-COMP-INTER-005-001 | ZPR-6/6A         | (n,γ)    | -36  |
| IEU-COMP-INTER-005-001 | ZPR-6/6A         | (n,tot)  | -31  |
| MIX-COMP-FAST-001-001  | ZPR-6/7          | (n,γ)    | -31  |
| MIX-COMP-FAST-006-001  | ZPPR-2           | (n,γ)    | -29  |
| MIX-COMP-FAST-005-001  | ZPR-9 Ass 31     | (n,γ)    | -29  |
| MIX-MISC-FAST-002-001  | BFS-49/1A        | (n,γ)    | -  |
| MIX-COMP-FAST-001-001  | ZPR-6/7          | (n,tot)  | -27  |
| MIX-COMP-FAST-006-001  | ZPPR-2           | (n,tot)  | -26  |
| MIX-COMP-FAST-005-001  | ZPR-9 Ass 31     | (n,tot)  | -26  |
| MIX-MISC-FAST-002-001  | BFS-49/1A        | (n,tot)  | -  |
| IEU-MET-FAST-017-001   | BFS-35-1         | (n,γ)    | -20  |
| MIX-MISC-FAST-001-011  | BFS-42           | (n,γ)    | -20  |
| IEU-MET-FAST-022-006   | 9-S              | (n,γ)    | -  |
| IEU-COMP-FAST-004-001  | ZPR-3/12 Load 10 | (n,γ)    | -20  |
| IEU-MET-FAST-017-001   | BFS-35-1         | (n,tot)  | -20  |
| MIX-MISC-FAST-001-011  | BFS-42           | (n,tot)  | -20  |
| IEU-MET-FAST-022-006   | 9-S              | (n,tot)  | -  |
| MIX-MISC-FAST-003-001  | BFS-97/1         | (n,γ)    | -17  |
| MIX-MISC-FAST-003-001  | BFS-97/1         | (n,tot)  | -12  |
| IEU-MET-FAST-022-005   | 8-S              | (n,γ)    | -  |
| MIX-MET-INTER-004-001  | ZPR-3/53         | (n,γ)    | -15  |
| IEU-MET-FAST-010-001   | ZPR-6/9 Load11   | (n,γ)    | -15  |
| IEU-COMP-FAST-004-001  | ZPR-3/12 Load 10 | (n,tot)  | -15  |
| IEU-MET-FAST-022-005   | 8-S              | (n,tot)  | -  |
| IEU-MET-FAST-022-007   | 10-S             | (n,γ)    | -  |
| IEU-MET-FAST-012-001   | ZPR-3/41         | (n,γ)    | -14  |
| IEU-MET-FAST-010-001   | ZPR-6/9 Load11   | (n,tot)  | -13  |

## IAEA Is a User

[https://www-nds.iaea.org/CIELO/Trkov\\_On%20the%20Use%20of%20Sensitivities%20to%20Identify%20Compensating%20Effects%20of%20Nuclear%20Data%20in%20Integral%20Benchmarks.pdf](https://www-nds.iaea.org/CIELO/Trkov_On%20the%20Use%20of%20Sensitivities%20to%20Identify%20Compensating%20Effects%20of%20Nuclear%20Data%20in%20Integral%20Benchmarks.pdf)



### Sensitivities in the DICE package of ICSBEP

#### DICE search for the selected nuclide

The first step in the process is to identify benchmarks that are most sensitive to the reactions of the nuclide of interest (i.e. the  $^{235}\text{U}$  in the present study) with the help of DICE. The process is as follows:

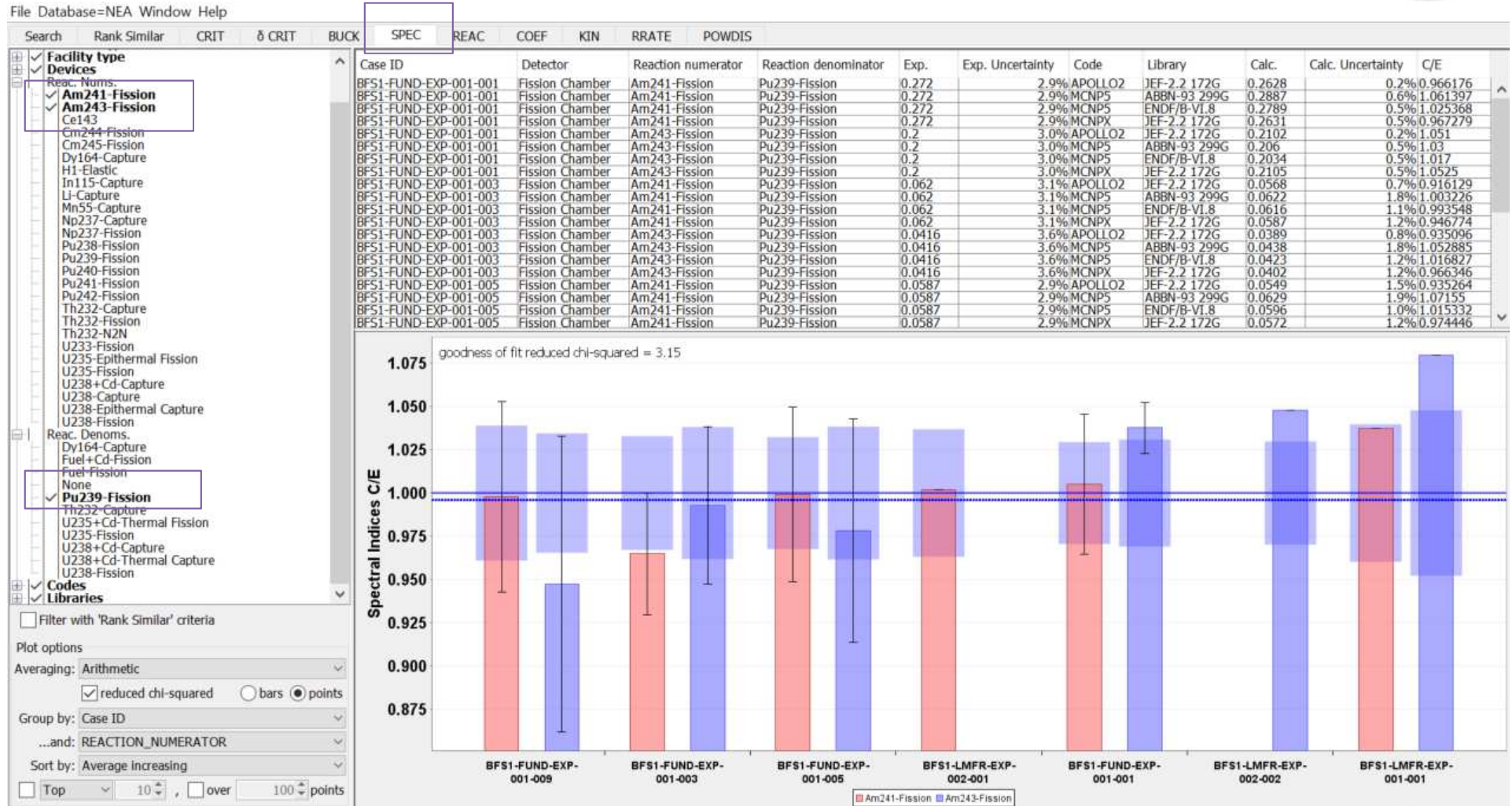
1. In the "Energy, spectra, sensitivities" select the Energy of average neutron causing fission, "Average fission group energy" and all sensitivities to  $k_{\text{eff}}$ .
2. Select the nuclide for which the sensitivities are required (e.g.  $^{235}\text{U}$ )
3. Select reactions (e.g.: capture, elastic, fission inelastic; it is probably unnecessary to select nu-bar, since practically all benchmarks are directly sensitive to it. Likewise, it is not necessary to select the total, since all the major partial reactions are included).
4. Sort the selected benchmarks by thermal  $k_{\text{eff}}$  sensitivities, then by reaction.
5. Select six (or otherwise) benchmarks most sensitive to thermal capture of U-235; be careful not to double-count benchmarks with multiple entries in the database. Save the selection to an Excell spreadsheet (or otherwise).
6. Similarly, select six (or otherwise) benchmarks most sensitive to thermal scattering cross section; be sure to check the negative as well as positive sensitivities. Add the selection to an Excell spreadsheet (or otherwise).
7. Repeat the procedure for thermal fission cross section.
8. Repeat steps 4 to 7 for epithermal  $k_{\text{eff}}$  sensitivities, including the inelastic cross sections.
9. Repeat steps 4 to 7 for fast  $k_{\text{eff}}$  sensitivities, including the inelastic cross sections.

Ian,

Do you have by any chance the sensitivity profiles for the remaining benchmarks of the HMF007 series? There is a group of discrepant benchmarks with EALF near 3 keV that correspond to cases 37-40, but the sensitivities are given only for the cases up to 35.

Cheers, Andrej

## IRPhEP Database and Analysis Tool (IDAT), equivalent for DICE for Reactor Physics Measurements



## Library Testing Perspective: What is Current Status, What is Required

### To assess the impact on all PU-SOL-THERM

→ Run 600 Benchmarks,  $k_{\text{eff}} \sim 10$  pcm

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

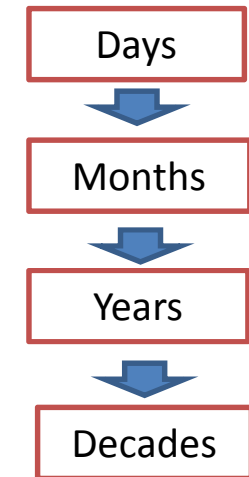
→ 600 X #Reactions [Look what is driving the  $k_{\text{eff}}$  change]

### 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




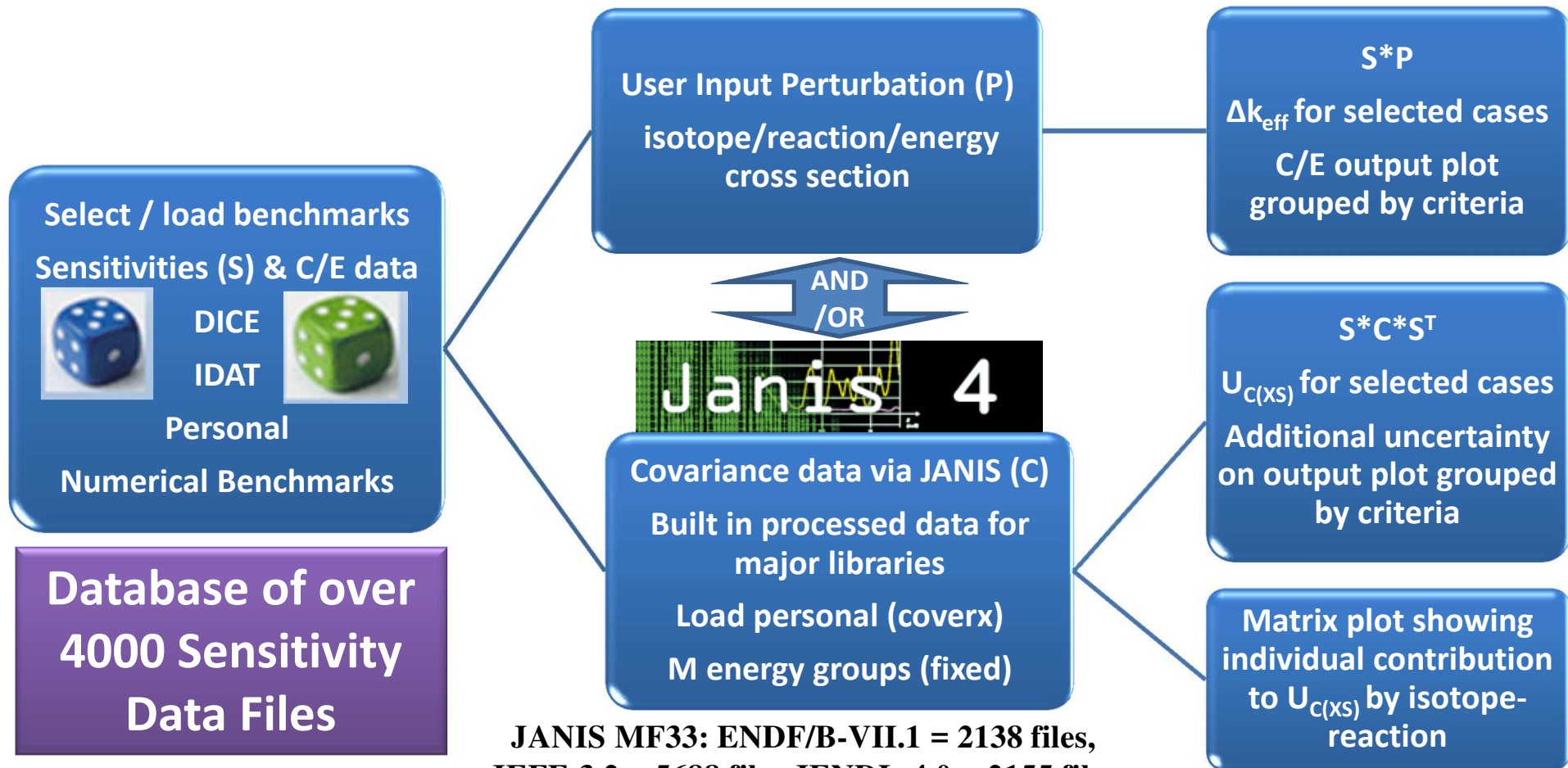
**Example:** 10 h per run, 5 reactions, 10 energy groups, 5 options

= 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! See Next Slide

## 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, SCALE6.2**

## NDaST: Perturbations or JANIS Computations

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

- Or choice a perturbation/s in an arbitrary group structure.

Group structure

Group type : **Uniform in log**

Lower energy :  in eV

Upper energy :  in eV

Subdivision :  in groups/decad

NDaST

File Databases Window Help

NE DICE=HTTP jdev

NE IDAT=HTTP jdev

JANIS=(4)

Sensitivities

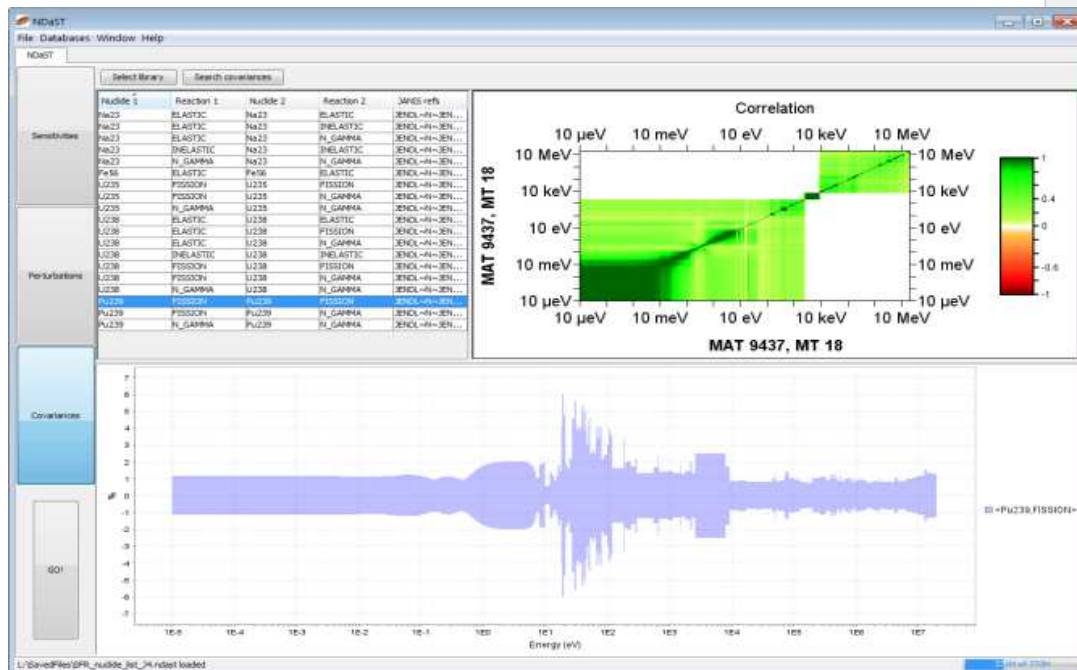
ENDF

JENDL

NEA

JEFF

IDAT search



Spectrum

Spectrum type : **PWR spectrum**

Emax,th :  in eV

Emax,epi :  in eV

theta,th :  in eV

theta,fis :  in eV

Constant spectrum

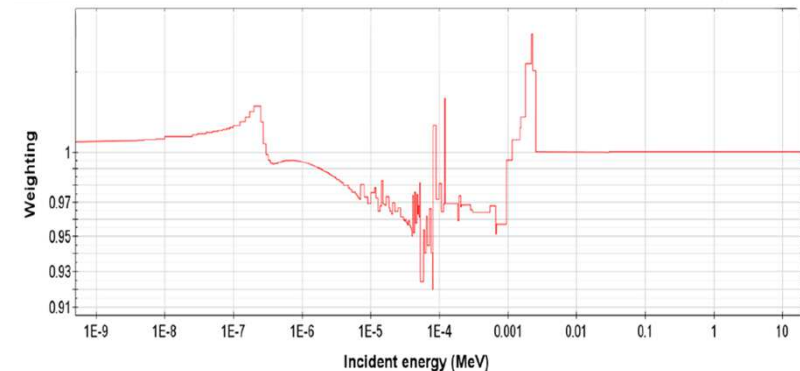
XY spectrum

PWR spectrum

General spectrum

Maxwellian spectrum

Fission spectrum



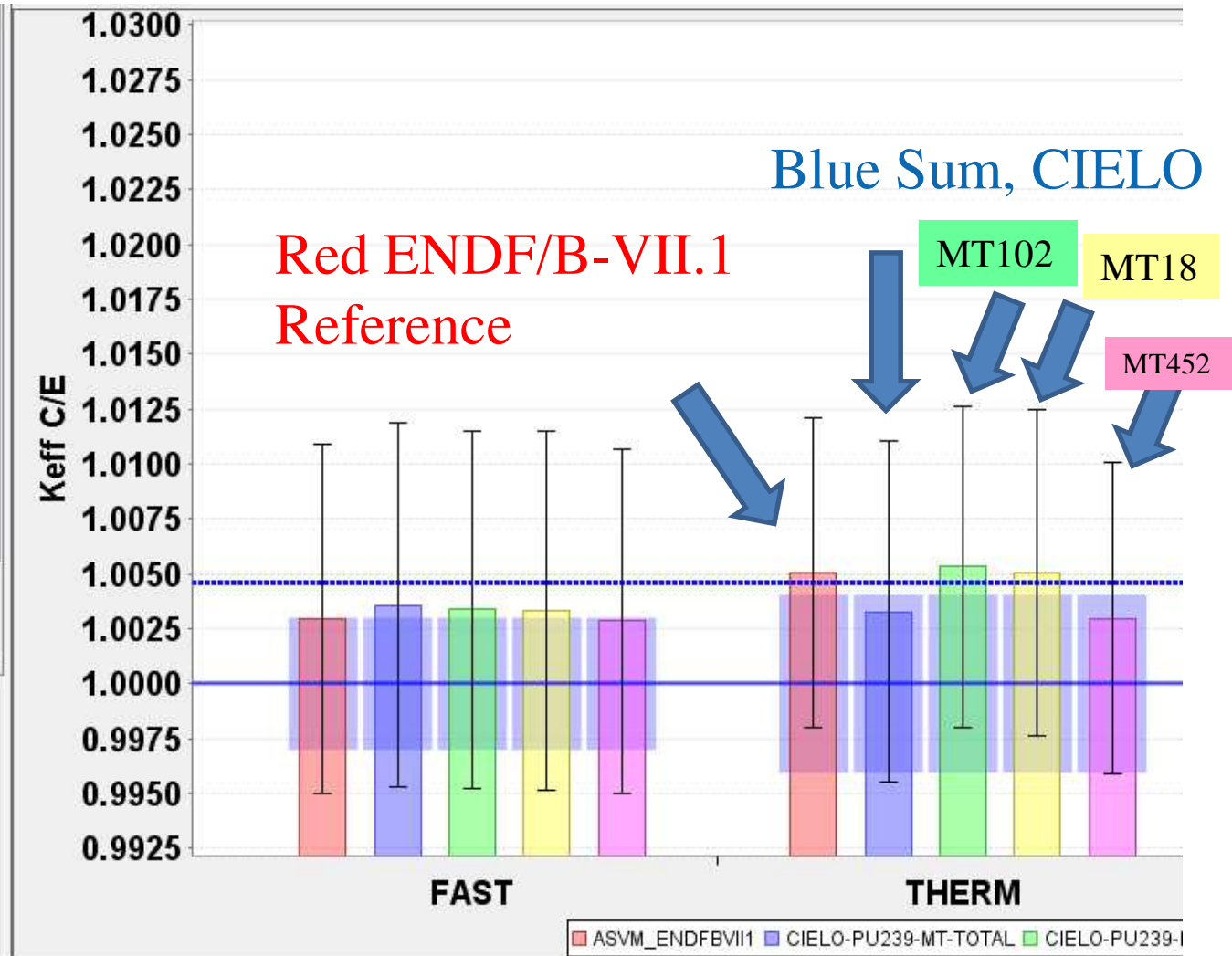
## NDaST Application Example 1: Rapid Test New Pu239 CIELO, Sum of MF18,MT102,MF452

ASVM\_ENDFBVII1  
BAS  
BNAB+LIPAR+TEPCON  
CENDL-3.1 Continuous  
CIELO-PU239-MT-TOTAL

ICSBEP has  
Approximately  
750 Pu and 500  
Mixed  
Benchmarks

Capture  
Fission  
Nubar

Filter  
Fissile material  
PU  
HEU  
LEU  
U233  
MIX  
SPEC  
Physical form  
HET  
SOL  
COMP  
MISC  
Spectrum  
FAST  
INTER  
THERM  
MIXED



## Application Example 2: Helping ENDF/B-VIII.0, DICE/NDaST

Ian

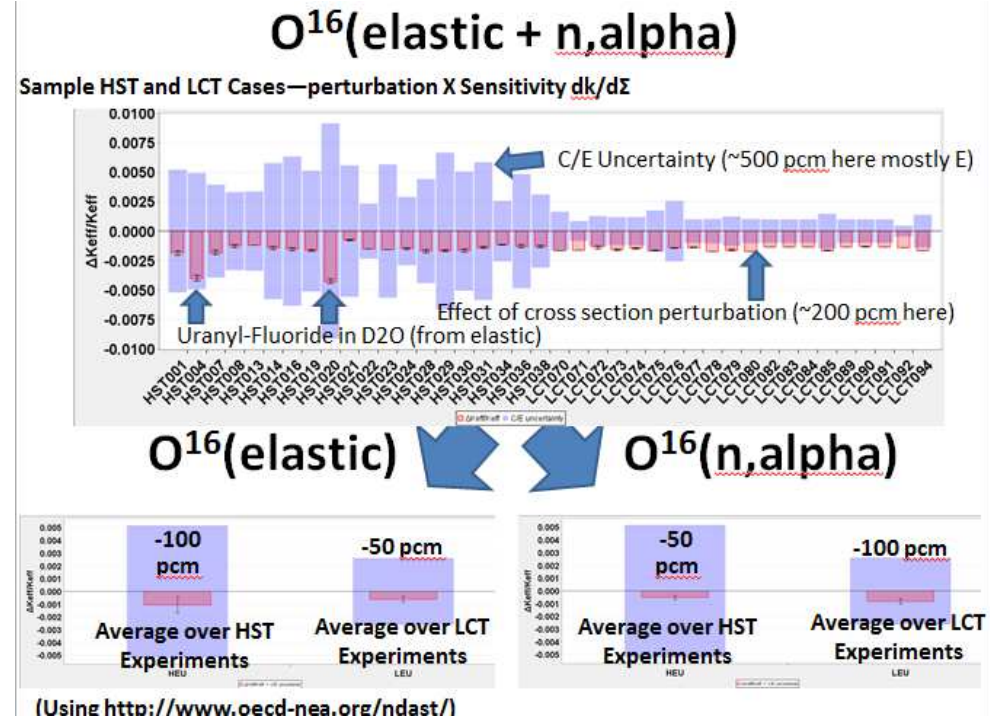
....

It would be great if we could get a few pics that diagnose the effects of the oxygen changes. Some of the main changes can be summarized :

- lower elastic at low energies thermal
- bigger n,a in the 3-6 and above region
- total cross section better understood in the few MeV range (though perhaps the total xs did not change much)

....

Mark



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### (elastic)

Regarding the O16 elastic reaction.

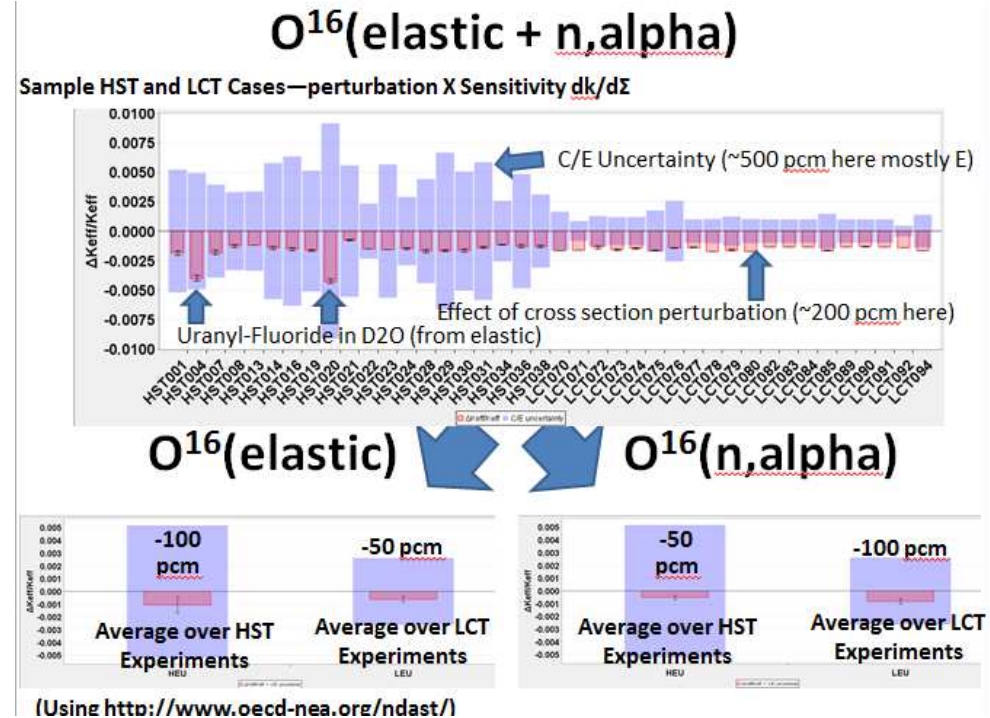
The impact for **LEU-COMP-THERM** experiments is of the order **-50 pcm**. However for some **heavy water benchmarks the impact is more like -150 to -200 pcm**.

It appears the magnitude seems to hinge on the degree of moderation (under or over) rather than the leakage for these experiments; these also tend to be low leakage experiments.

In most of these experiments decreasing the elastic scattering, decreases reactivity, so the systems are undermoderated.

Some experiments that are overmoderated (LCT060, an RBMK benchmark) show an increase in reactivity **~+20 pcm**.

While for **HEU-SOL-THERM** experiments it appears that the effect is **-100 pcm for low leakage systems [moderation effect]** and up to **-300 pcm for high leakage systems**. [For maximum HST leakage systems]. I think this aligns with your expectations.



## Application Example 2: Helping ENDF/B-VIII.0, DICE/NDaST

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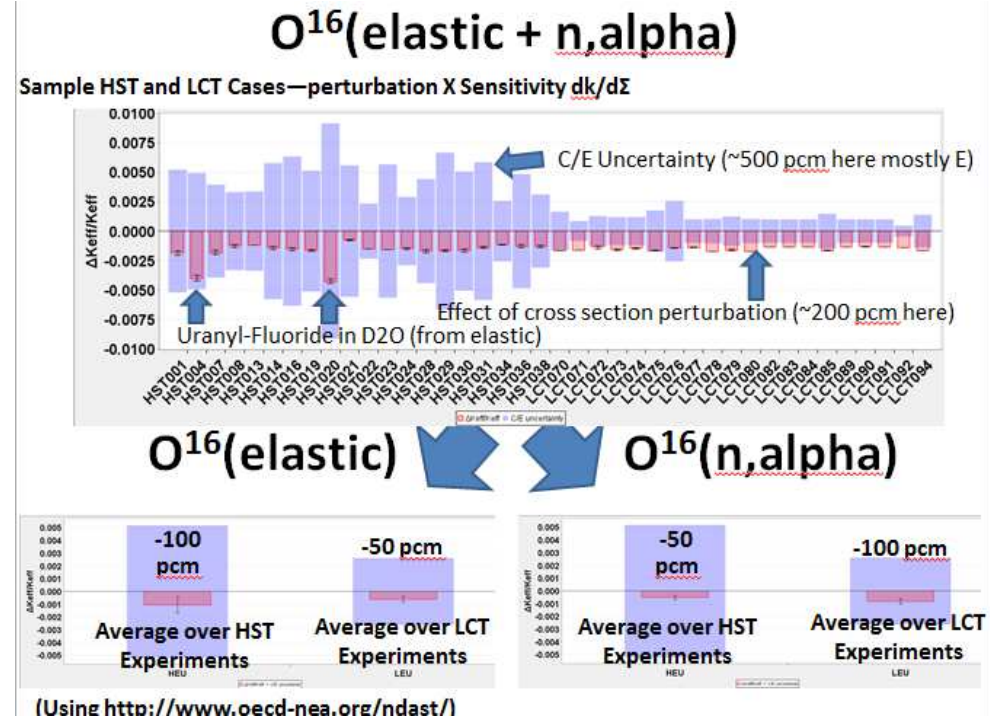
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Mark,

Ian - thanks so much. A very helpful and fascinating summary.

If I may I will show a viewgraphs on this at nd2016 to illustrate the value of your NDaST tools. It really helps point to which benchmarks are most sensitive, and to which cross section changes (eg n,alpha versus scattering) impact things most. I will also integrate a few sentences on this into the Cielo nd2016 paper.

I am copying some others who will be interested in your analysis.

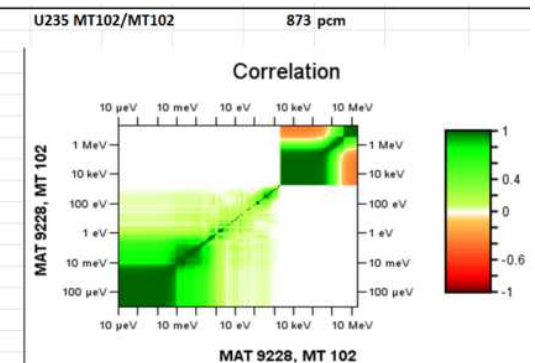
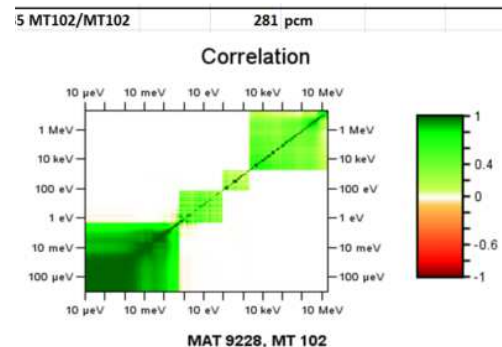
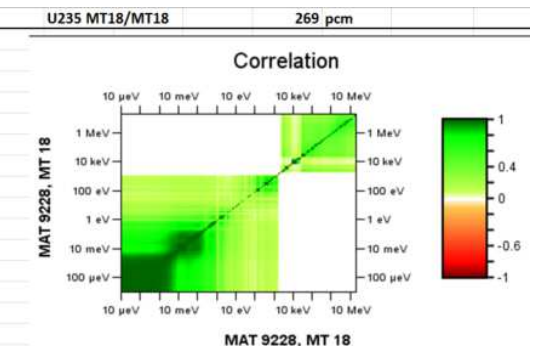
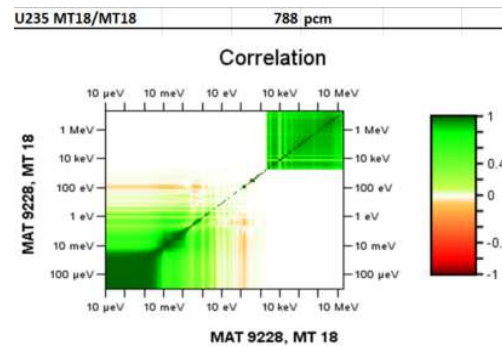
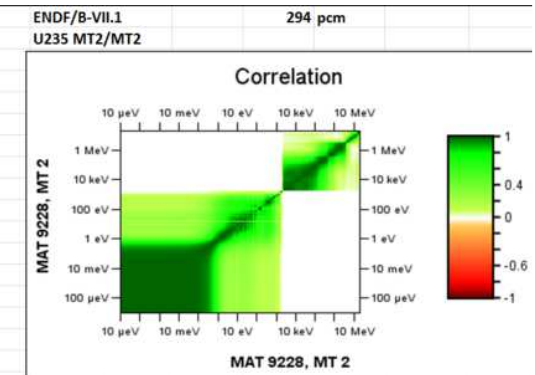
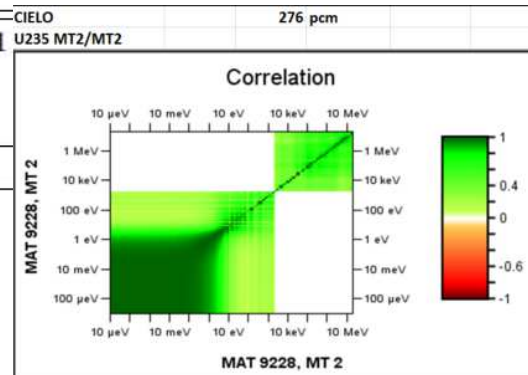
Best

Mark

## Application Example 3: CIELO Big Paper

|               | CIELO-1<br>Godiva<br>k-eff Unc.<br>(pcm) | B-VII.1<br>Godiva<br>k-eff Unc.<br>(pcm) | JEFF3.3<br>Godiva<br>k-eff Unc.<br>(pcm) | JENDL4.0u1<br>Godiva<br>k-eff Unc.<br>(pcm) |
|---------------|--|--|--|---|
| fission       | 788                                      | 269                                      | 648                                      | 320   |
| nubar         | 540                                      | 545                                      | 510                                      | 274   |
| PFNS $E_{av}$ | 151                                      | 276                                      | 364                                      | 176   |
| elastic       | 276                                      | 294                                      | 109                                      | 426   |
| inelastic     | 698 (est.)                               | 616                                      | 698                                      | 681   |
| capture       | 281                                      | 873                                      | 375                                      | 269   |
| Summed        | 1042 (est.)                              | 1220                                     | 1342                                     | 962   |
| Exp. unc.     | 100                                      | 100                                      | 100                                      | 100   |
| C-E           | 6  | 8  | 23                                       | 167   |

|               | CIELO-1<br>Jezebel<br>k-eff Unc.<br>(pcm) | B-VIL1<br>Jezebel<br>k-eff Unc.<br>(pcm) | JEFF3.3<br>Jezebel<br>k-eff Unc.<br>(pcm) | JENDL4.0u1<br>Jezebel<br>k-eff Unc.<br>(pcm) |
|---------------|---|--|---|--|
| fission       | 903                                       | 331                                      | 305                                       | 434  |
| nubar         | 241                                       | 81                                       | 413                                       | 209  |
| PFNS $E_{av}$ | 185                                       | 186                                      | 443                                       | 286  |
| elastic       | 463                                       | 438                                      | 90  | 198  |
| inelastic     | 797                                       | 797                                      | 150                                       | 250  |
| capture       | 67  | 74                                       | 30  | 59   |
| Summed        | 1025                                      | 562                                      | 645                                       | 648  |
| Exp. unc.     | 200                                       | 200                                      | 200                                       | 200  |
| C-E           | 15  | 12                                       | 38  | 185  |



## Application Example 4: Testing New Covariance for JEFF-3.3 T3 vs T1

### Selected Example Benchmarks

| Case label                     | Sensitivity Code              | 1 $\sigma$<br>JEFF-3.3<br>T3 | 1 $\sigma$<br>JEFF-3.3<br>T1 | Diff<br>J33T3 – J33T1<br>(pcm) | 1 $\sigma$<br>ENDF/B-VII.1 | 1 $\sigma$<br>JENDL-4.0 | Ratio<br>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<br>(Godiva)         | KENO ABBN-93 / 299-Group      | 0.014788                     | 0.014788                     | 0                              | 0.006302                   | 0.008816                | 2.34                  |
| IMF003-001<br>(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                     | +210                           | 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<br>(Detailed Model) | KENO ENDF/B-VII.0 / 238-Group | 0.002943                     | 0.003036                     | -9                             | 0.007796                   | 0.005421                | 0.38                  |

# App 5: Covariance Testing Industrial Scale

- The scale of the number of calculations is difficult for people to comprehend. Everything is there, but to distil to a slide or even a journal paper is difficult.

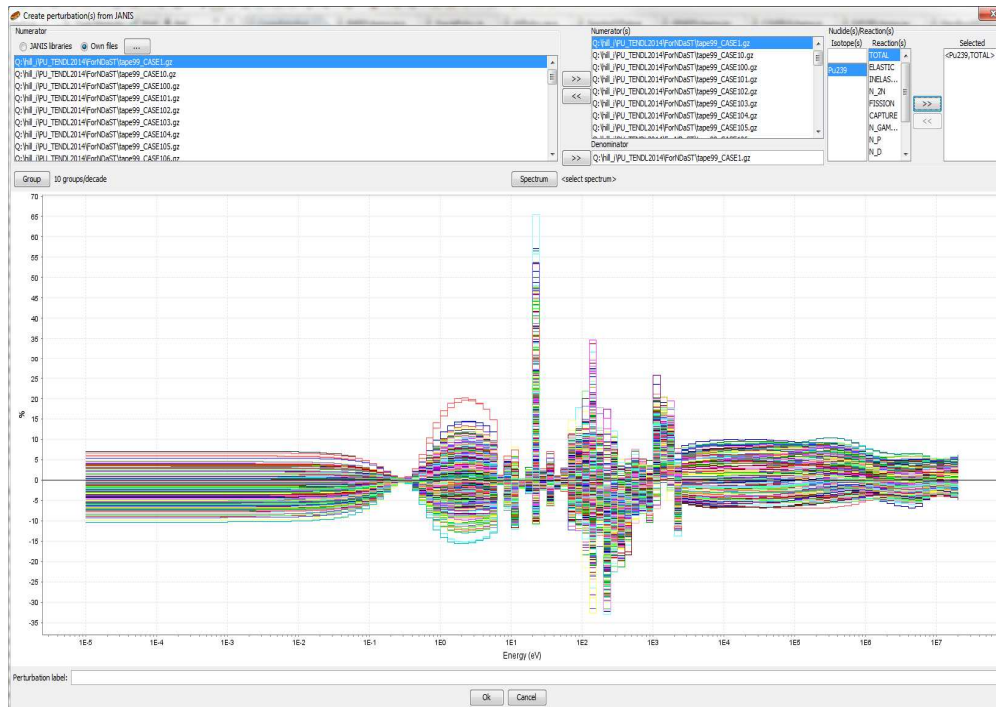
- Impact of different ND covariances in ICSBEP suite (4501 Benchmarks!!!)

| FISSILE<br>MAT. | Benchm.<br># | Exp. uncert<br>(pcm) | JENDL-4.0u   | ENDF/B-VII.1 | SCALE-6.2rev8 |             |              | JEFF-3.3T4   |             |              |
|-----------------|--------------|----------------------|--------------|--------------|---------------|-------------|--------------|--------------|-------------|--------------|
|                 |              |                      | XSs<br>(pcm) | XSs<br>(pcm) | XSs<br>(pcm)  | Nu<br>(pcm) | CHI<br>(pcm) | XSs<br>(pcm) | Nu<br>(pcm) | CHI<br>(pcm) |
| HEU             | 1364         | 379                  | 523          | 717          | 660           | 252         | 443          | 597          | 542         | 219          |
| IEU             | 215          | 391                  | 521          | 871          | 827           | 302         | 667          | 698          | 526         | 343          |
| LEU             | 1500         | 254                  | 380          | 425          | 412           | 361         | 279          | 389          | 537         | 127          |
| MIX             | 411          | 434                  | 611          | 467          | 543           | 154         | 220          | 598          | 419         | 460          |
| PU              | 766          | 405                  | 638          | 422          | 485           | 153         | 241          | 538          | 453         | 535          |
| SPEC            | 6            | 333                  | 754          | 646          | 429           | 24          | 108          | 642          | 146         | 63           |
| U233            | 239          | 583                  | 284          | 322          | 271           | 414         | 823          | 267          | 411         | 1            |
| Total           | 4501         |                      |              |              |               |             |              |              |             |              |

## NDaST: Automated JANIS Computations

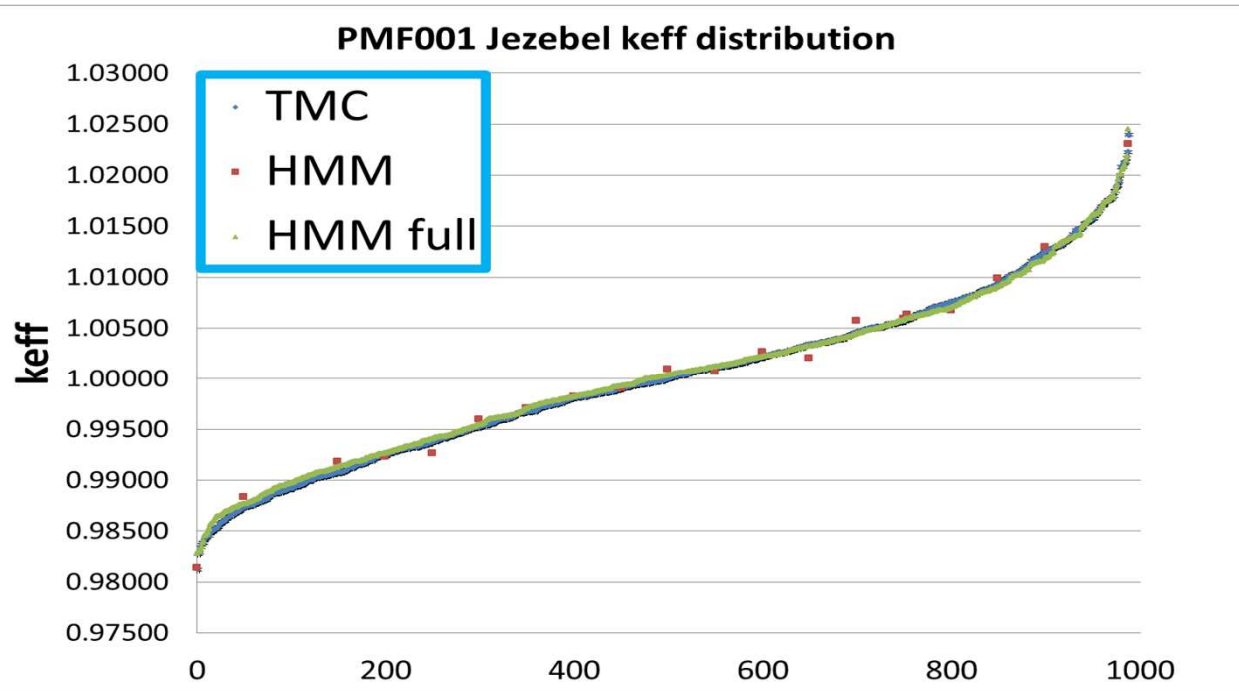
- An automated link has been introduced to the JANIS nuclear data software to generate the perturbation ratios between two evaluations.

- Upload 1000 Trial Evaluations



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

# Half Monte Carlo Method (HMM) Results

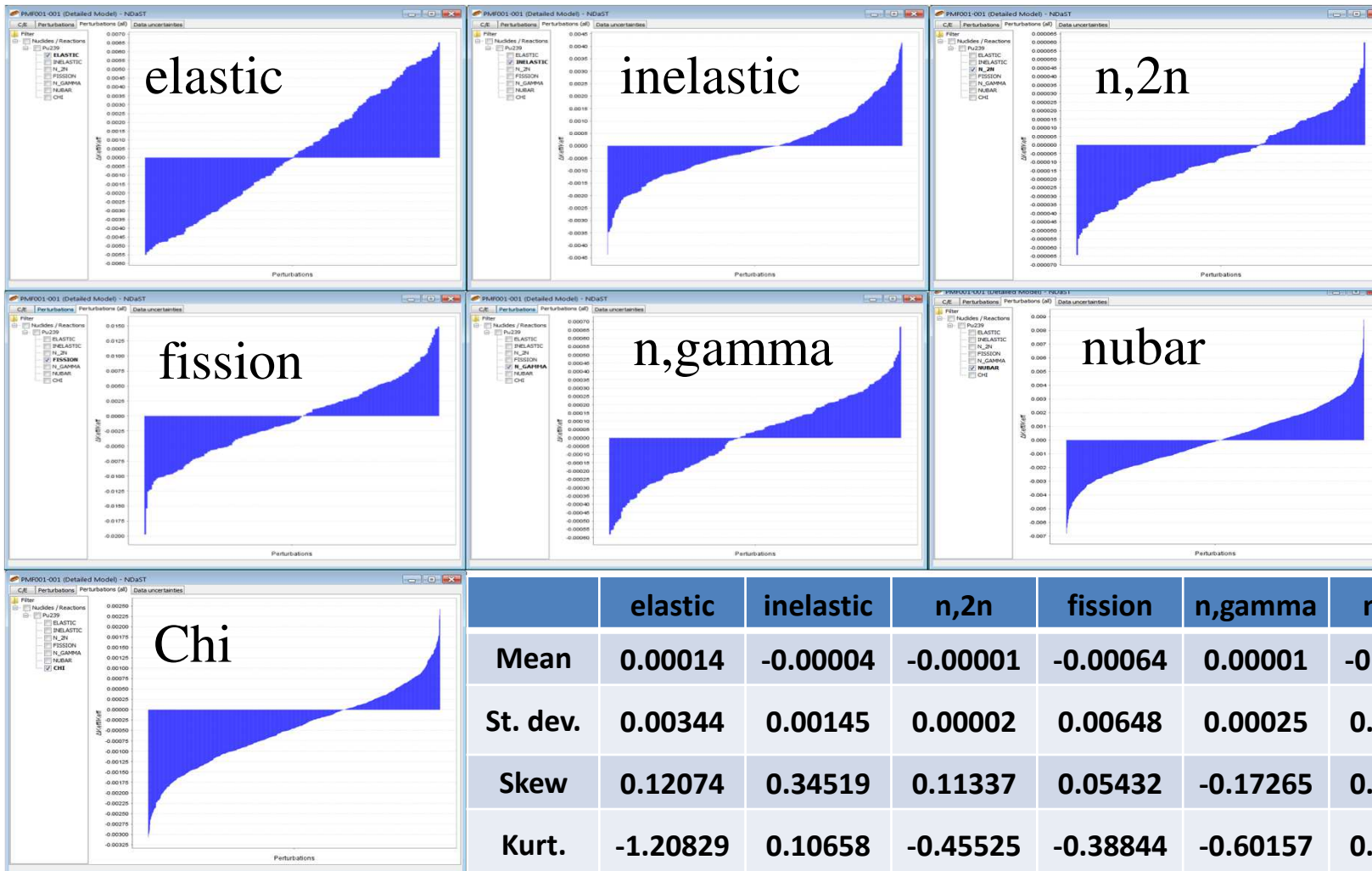


$k_{eff}$  distribution, sorted lowest  $k_{eff}$  to highest, plotted with the HMM  $k_{eff}$  predictions for 20 samples and full automated set

Example breakdown by reaction for 20 sample cases

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

## Delta $k_{eff}$ Distributions by Reaction



## V.2 Verifying CHI Covariance Data

### The Jezebel case

Figure. Jezebel (PMF1-1) neutron fission spectrum

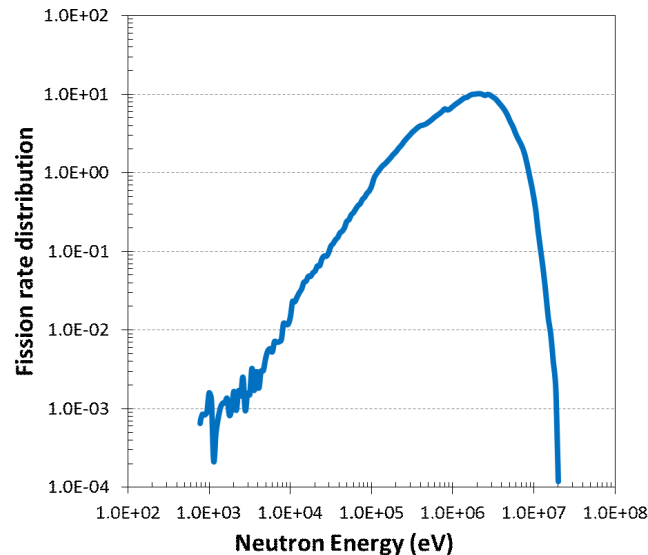
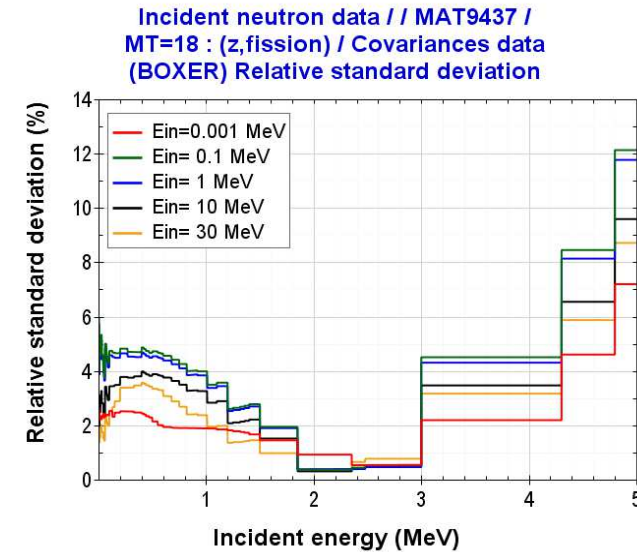


Figure. CHI rel.error(%) as a function of  $E_{in}$



| $E_{in}$ (eV) | Energy distribution of Jezebel spectrum (%) | Relative error in $K_{eff}$ as a function of $E_{in\_mean}$ (calculated with NDaST) (pcm) | Relative contribution to the total uncertainty (pcm) |
|---------------|---|---|--|
| 1.00E-05      | 0.0   | 256   | 0  |
| 1.00E+03      | 0.0   | 256   | 0  |
| 1.00E+05      | 2.3   | 455   | 10   |
| 1.00E+06      | 35.4  | 443   | 157  |
| 5.00E+06      | 57.0  | 399   | 227  |
| 1.00E+07      | 5.3   | 380   | 20   |

**Total uncertainty (pcm) due to CHI uncertainty**

**assuming Full correlated =**

**415**

## Addition of Personal Benchmarks

**New benchmark**

Can act as a repository for sensitivity files. Not just keff.

Symbols for axis values set here

Give at least:

- Case label
- Experimental value & uncertainty
- Sensitivity file

Plus N Calculation results:

- Code/data label
- Value & uncertainty

| Benchmark    | Calculations | Sensitivities      |
|--------------|--------------|--------------------|
| My benchmark | 1 calc(s)    | 1 sensitivity(ies) |
| HMF028-001   | 8 calc(s)    | 1 sensitivity(ies) |
| HCI003-001   | 5 calc(s)    | 1 sensitivity(ies) |
| HMF003-004   | 6 calc(s)    | 1 sensitivity(ies) |
| IMF008-001   | 3 calc(s)    | 1 sensitivity(ies) |
| HMF002-001   | 6 calc(s)    | 1 sensitivity(ies) |
| HMF032-003   | 6 calc(s)    | 1 sensitivity(ies) |
| HMF003-003   | 6 calc(s)    | 1 sensitivity(ies) |
| HMF003-002   | 6 calc(s)    | 1 sensitivity(ies) |
| HMF002-006   | 5 calc(s)    | 1 sensitivity(ies) |
| HMF014-001   | 6 calc(s)    | 1 sensitivity(ies) |
| HMF032-002   | 6 calc(s)    | 1 sensitivity(ies) |
| HMF084-012   | 4 calc(s)    | 1 sensitivity(ies) |

## Rank Similar

**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: 91.1% (4489 / 4930)

Neutron balance Coverage: 90.9% (4483 / 4930)

3-groups sensitivities Coverage: 85.0% (4191 / 4930)

Sensitivity Coverage: 85.1% (4193 / 4930)

Select sensitivity file: ED-002-006\_KENO\_ENDF-B-VII.0--238-Group\_SENS.1.gz ...

Search

Show cases with no data

| Case ID            | Code | Library                  | Sensitivity Ranking |
|--------------------|------|--------------------------|---------------------|
| PU-COMP-MIXED-0... | KENO | ENDF/B-VII.0 / 238-Group | 1.000               |
| PU-COMP-MIXED-0... | KENO | ENDF/B-VII.0 / 238-Group | 0.981               |
| PU-COMP-MIXED-0... | KENO | ENDF/B-VII.0 / 238-Group | 0.960               |
| PU-COMP-MIXED-0... | KENO | ENDF/B-VII.0 / 238-Group | 0.955               |
| PU-COMP-MIXED-0... | KENO | ENDF/B-VII.0 / 238-Group | 0.889               |
| PU-COMP-THERM-0... | KENO | ENDF/B-VII.0 / 238-Group | 0.887               |
| PU-COMP-MIXED-0... | KENO | ENDF/B-VII.0 / 238-Group | 0.884               |
| PU-COMP-MIXED-0... | KENO | ENDF/B-VII.0 / 238-Group | 0.876               |

| PMF    | PMF   | PMF   | PMF   | PMF   | PMF   | PMF   | PMF   | PMF   | PMF   | PMF   | PMF   | PMF   |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 001    | 002   | 003   | 004   | 005   | 006   | 008   | 009   | 010   | 011   | 012   | 013   |       |
| PMF001 | 0.999 | 0.985 | 0.907 | 0.905 | 0.972 | 0.931 | 0.969 | 0.988 | 0.971 | 0.768 | 0.938 | 0.945 |
| PMF002 | 0.985 | 1.000 | 0.988 | 0.984 | 0.964 | 0.925 | 0.962 | 0.978 | 0.963 | 0.756 | 0.930 | 0.936 |
| PMF003 | 0.997 | 0.988 | 0.999 | 0.997 | 0.974 | 0.933 | 0.971 | 0.992 | 0.972 | 0.768 | 0.941 | 0.948 |
| PMF004 | 0.995 | 0.984 | 0.997 | 0.999 | 0.973 | 0.932 | 0.969 | 0.987 | 0.971 | 0.765 | 0.940 | 0.947 |
| PMF005 | 0.972 | 0.964 | 0.974 | 0.973 | 1.000 | 0.947 | 0.970 | 0.974 | 0.970 | 0.749 | 0.957 | 0.963 |
| PMF006 | 0.931 | 0.925 | 0.933 | 0.932 | 0.947 | 1.000 | 0.945 | 0.938 | 0.988 | 0.717 | 0.994 | 0.944 |
| PMF008 | 0.969 | 0.962 | 0.971 | 0.969 | 0.970 | 0.945 | 1.000 | 0.971 | 0.967 | 0.746 | 0.953 | 0.957 |
| PMF009 | 0.988 | 0.978 | 0.992 | 0.987 | 0.974 | 0.938 | 0.971 | 1.000 | 0.971 | 0.760 | 0.946 | 0.953 |
| PMF010 | 0.971 | 0.963 | 0.972 | 0.971 | 0.970 | 0.988 | 0.967 | 0.971 | 1.000 | 0.747 | 0.984 | 0.955 |
| PMF011 | 0.768 | 0.756 | 0.768 | 0.765 | 0.749 | 0.717 | 0.746 | 0.760 | 0.747 | 1.000 | 0.723 | 0.731 |
| PMF012 | 0.938 | 0.930 | 0.941 | 0.940 | 0.957 | 0.994 | 0.953 | 0.946 | 0.984 | 0.723 | 1.000 | 0.956 |
| PMF013 | 0.945 | 0.936 | 0.948 | 0.947 | 0.963 | 0.944 | 0.957 | 0.953 | 0.955 | 0.731 | 0.956 | 1.000 |

**DICE**

File Database=NEA Personal-Keff Window Help

| Critical / Subcritical | Alarm / Shielding | Fundamental Physics | Correlation Matrix       | Rank Similar | Keff trends plots        |
|------------------------|-------------------|---------------------|--------------------------|--------------|--------------------------|
| Filter                 | Fissile material  | MCNP                | ENDF/B-VI Continuous     | MCNP         | ENDF/B-VI Continuous     |
|                        | PU                | KENO                | ENDF/B-VII.0 / 238-Group | KENO         | ENDF/B-VII.0 / 238-Group |
|                        | HEU               | KENO                | ENDF/B-VII.0 / 238-Group | KENO         | ENDF/B-VII.0 / 238-Group |
|                        | LEU               | KENO                | ENDF/B-VII.0 / 238-Group | KENO         | ENDF/B-VII.0 / 238-Group |
|                        | MIX               | KENO                | ENDF/B-VII.0 / 238-Group | KENO         | ENDF/B-VII.0 / 238-Group |
|                        | SPEC              | KENO                | ENDF/B-VII.0 / 238-Group | KENO         | ENDF/B-VII.0 / 238-Group |
|                        | Physical form     | KENO                | ENDF/B-VII.0 / 238-Group | KENO         | ENDF/B-VII.0 / 238-Group |
|                        | MET               | KENO                | ENDF/B-VII.0 / 238-Group | KENO         | ENDF/B-VII.0 / 238-Group |
|                        | SOL               | KENO                | ENDF/B-VII.0 / 238-Group | KENO         | ENDF/B-VII.0 / 238-Group |
|                        | COMP              | KENO                | ENDF/B-VII.0 / 238-Group | KENO         | ENDF/B-VII.0 / 238-Group |
|                        | MISC              | KENO                | ENDF/B-VII.0 / 238-Group | KENO         | ENDF/B-VII.0 / 238-Group |
|                        | Spectrum          | KENO                | ENDF/B-VII.0 / 238-Group | KENO         | ENDF/B-VII.0 / 238-Group |
|                        | FAST              | KENO                | ENDF/B-VII.0 / 238-Group | KENO         | ENDF/B-VII.0 / 238-Group |

Filter with 'Rank Similar' criteria

Edit rankings and thresholds

Plot options

Averaging: Arithmetic

reduced chi-squared  bars  points

Group by: Case ID

...and: -

Sort by: Similarity

Top 10 over 100 points

goodness of fit reduced chi-squared = 3.17

## Conclusion

5 years ago how long would it have taken to

- a) Find the benchmarks most sensitivity to intermediate energy elastic scattering.
- b) Predict the impact of changing Oxygen (n,alpha) reactions.
- c) Predict the keff impact of changes to chi on various classes of benchmarks
- d) Find the nuclear data uncertainty of thousands of ICSBEP benchmarks
- e) Evaluate the impact of thousands of nuclear data files. Examine the variations in each reaction and energy group

**These operations take a few minutes up to 1 hour now. The tools are already being used to help evaluate and test nuclear data. But we can still do better. Lots of room to improve, hopefully using the experiences of SG39/SG46**

# Extra Slides

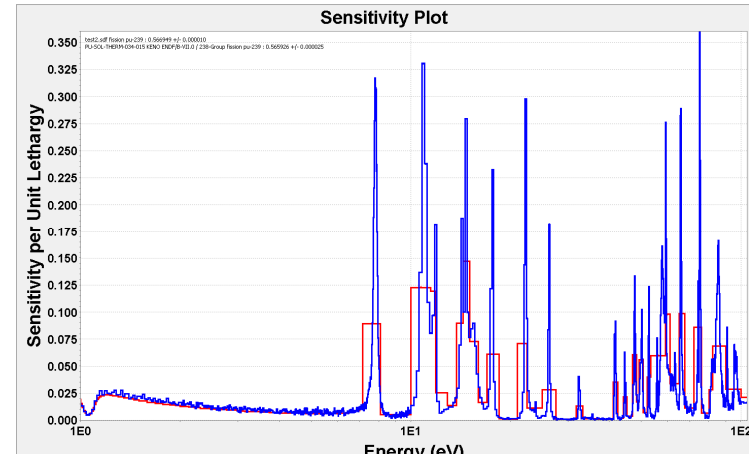
## PST034-015 NDaST Assumptions/Data

### Effect of Cross Section Group Structure

| Nuclear Data | Sensitivity | NDaST           |
|--------------|-------------|-----------------|
| <b>238G</b>  | <b>238G</b> | <b>+398 pcm</b> |
| 640G         | 238G        | +438 pcm        |
| 13072G       | 238G        | +399 pcm        |

### Effect of Sensitivity Group Structure

| Nuclear Data  | Sensitivity  | NDaST           |
|---------------|--------------|-----------------|
| 238G          | 238G         | +398 pcm        |
| 238G          | 5450G        | +477 pcm        |
| <b>13072G</b> | <b>5450G</b> | <b>+317 pcm</b> |



| Energy (eV)    | 238/238     | 13072/5450   |
|----------------|-------------|--------------|
| 0.00-0.01      | -9.0        | -6.5         |
| 0.01-0.1       | +30.5       | +30.5        |
| 0.1-1.0        | -156        | -155         |
| <b>1.0-5.0</b> | <b>+316</b> | <b>+369</b>  |
| 5.0-10.0       | +84         | +73          |
| <b>10-100</b>  | <b>+160</b> | <b>+28.4</b> |
| 100-2.0e6      | -28.1       | -16.7        |

Direct  
**+234 pcm**

