New and Revised Benchmarks in the ICSBEP and IRPhEP Handbooks

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Idaho National Laboratory

Key Highlights Only

Nuclear Data Week 2020
(Pretend we're on Long Island)
30 November – 4 December 2020

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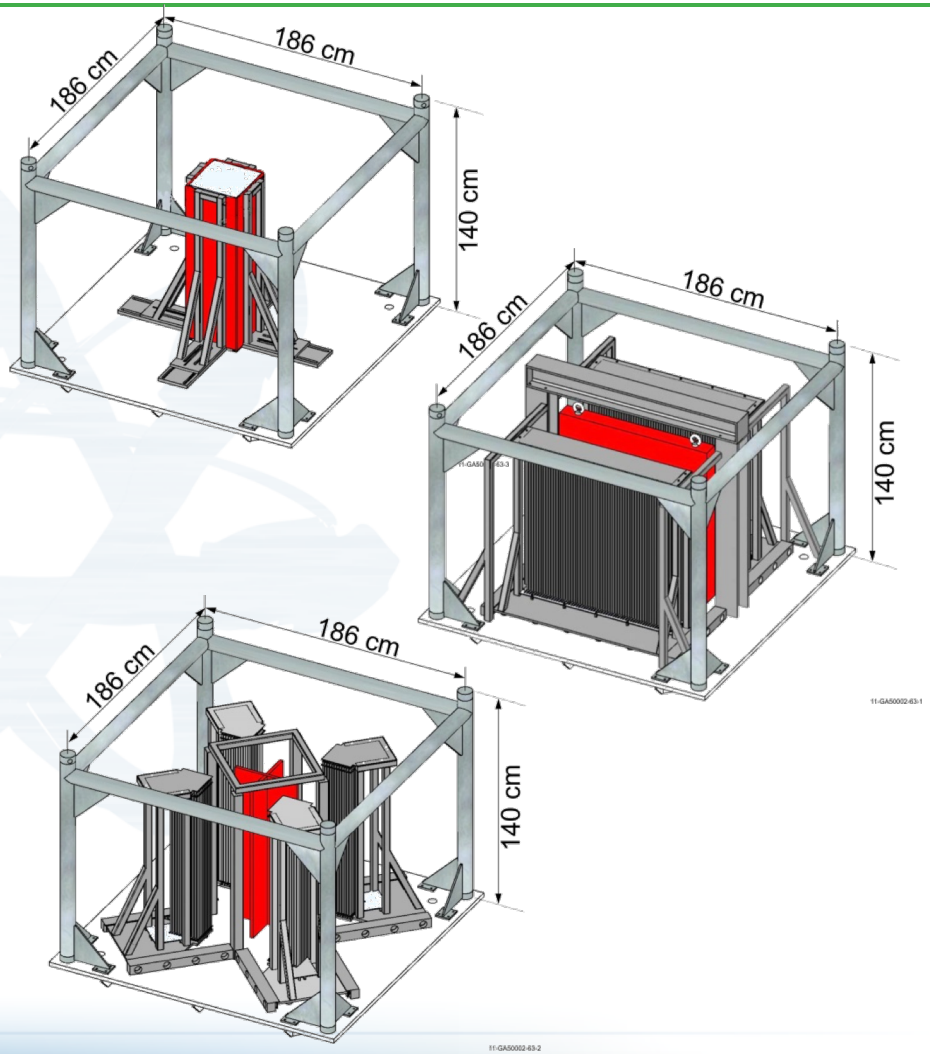
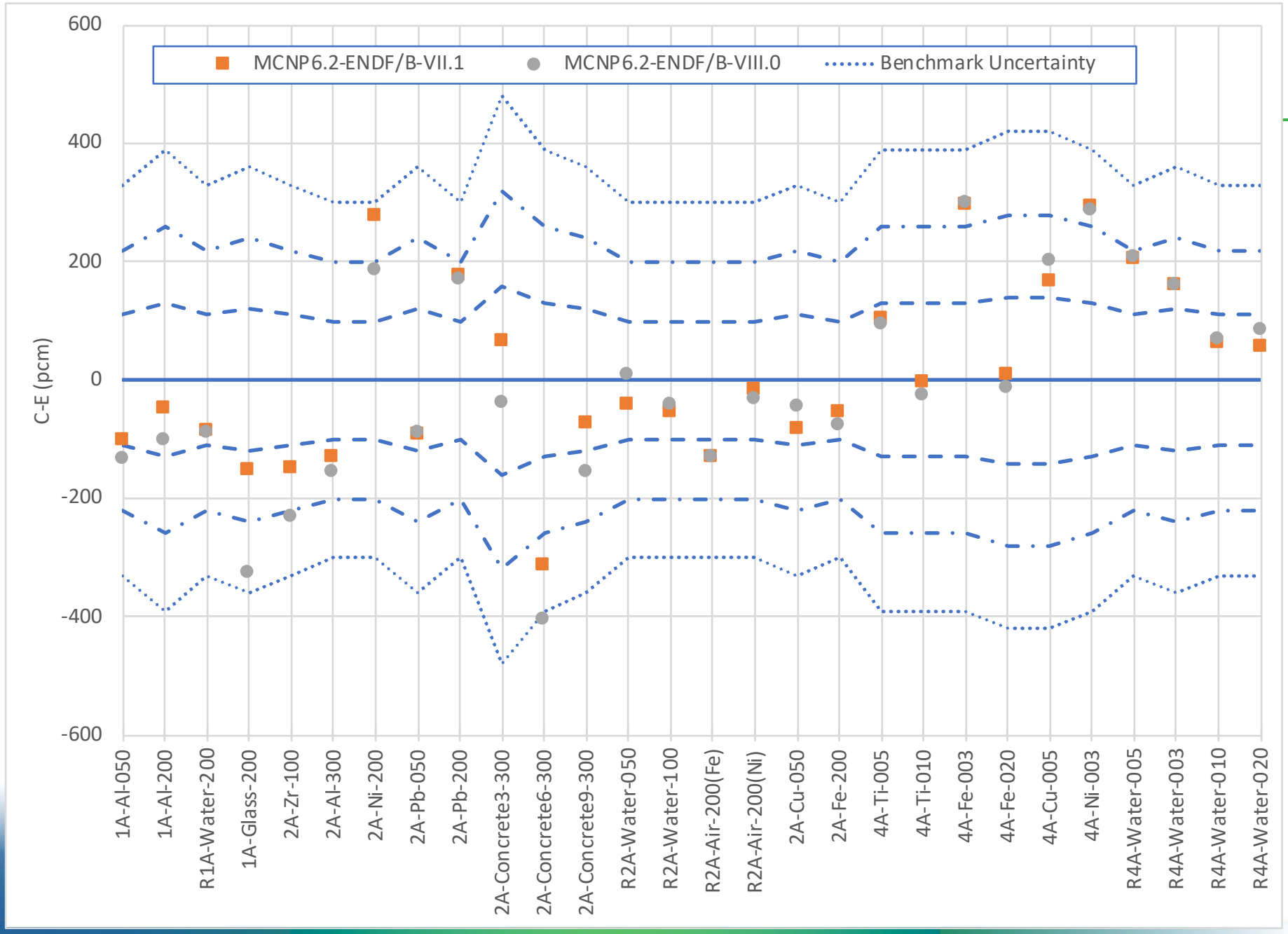
ICSBEP 2020 Handbook: LEU-COMP-THERM-074

- **MIRTE-1**
  - Valduc (CEA)
  - Complete series now available
  - 28 benchmark experiments
    - Screens
    - Al, concrete, Cu, glass, Fe, Pb, Ni, Ti, Zr
- **Most sample calculations within 3σ of benchmark values**

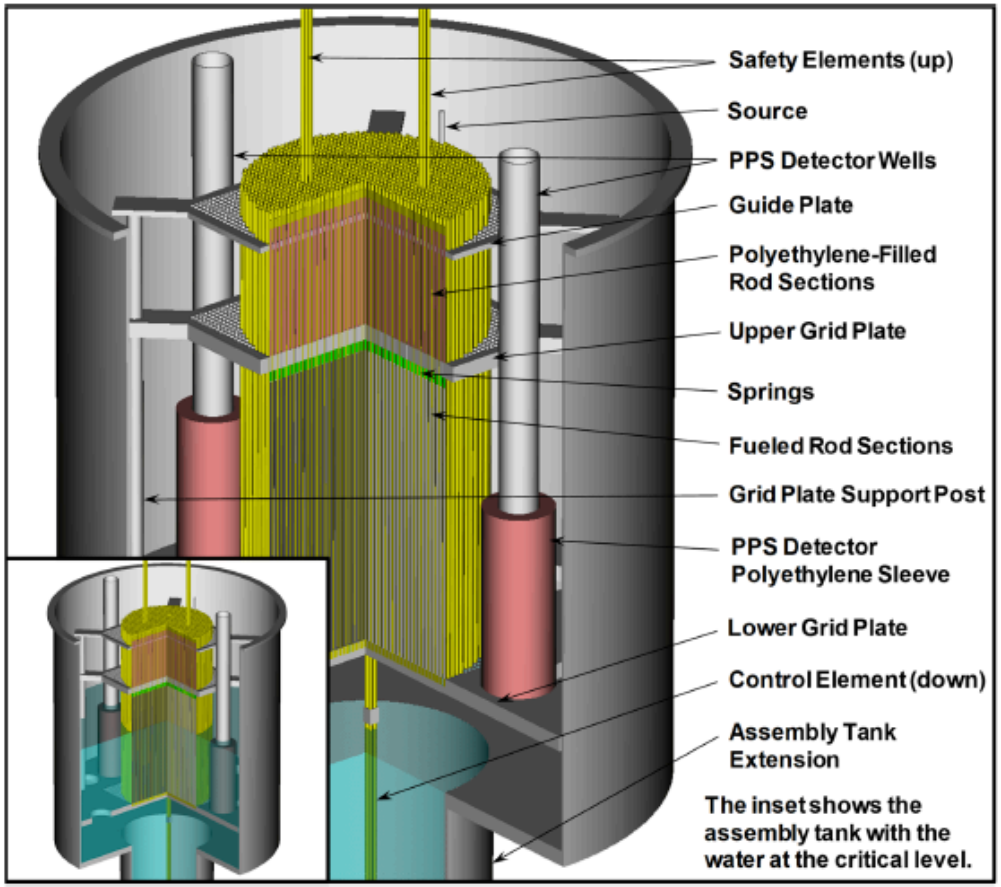


LEU-COMP-THERM-074 Sample Results



ICSBEP 2020 Handbook: LEU-COMP-THERM-101

- 7uPCX @ SNL
  - 22 experiments
  - 0.52 fuel-to-water volume ratio
    - 0.855 cm pitch
  - 6.90 % $^{235}UO_2$ rods
  - Evaluated critical water heights for various rod loadings
    - Including gaps between arrays



LEU-COMP-THERM-101 Sample Results

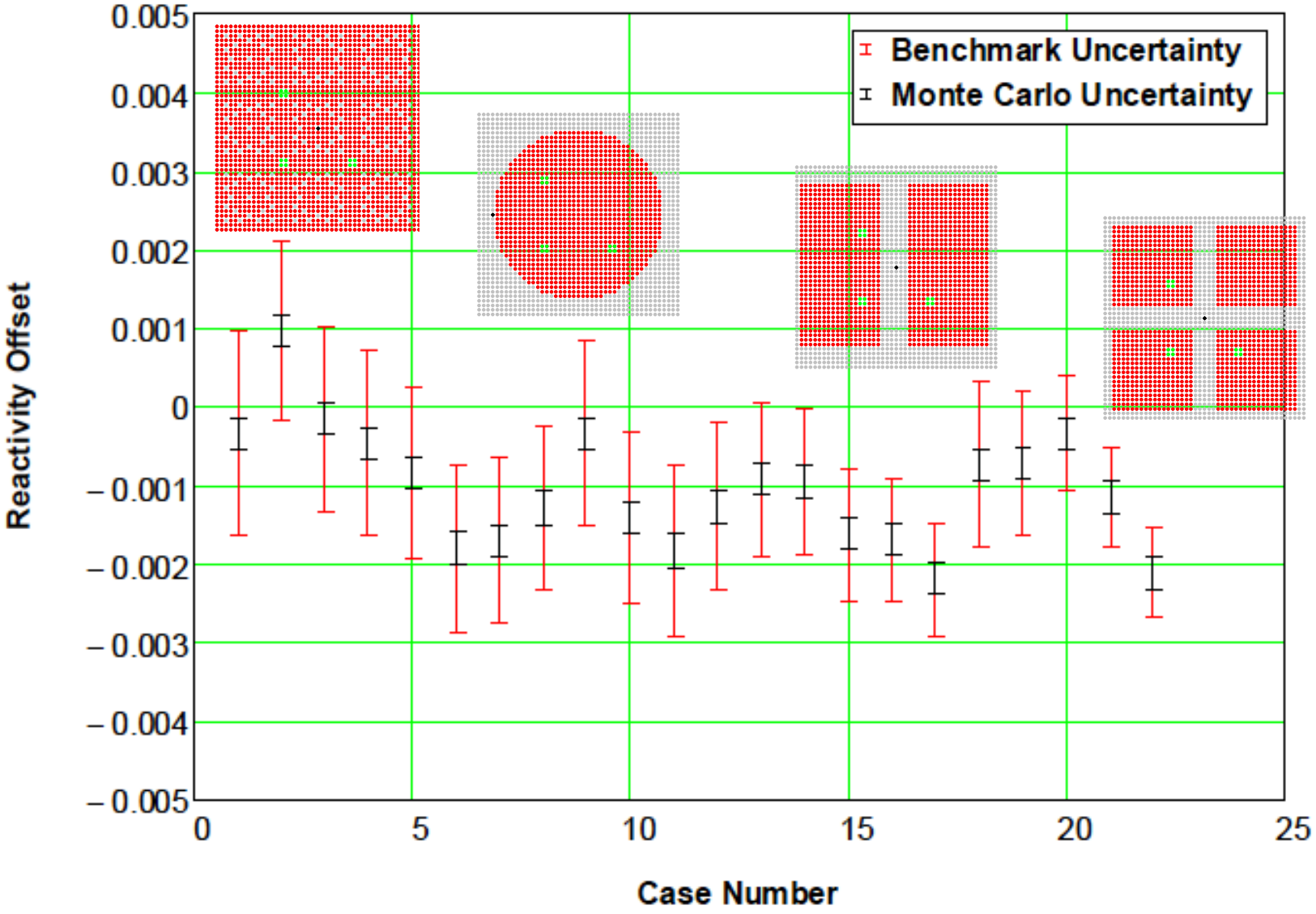
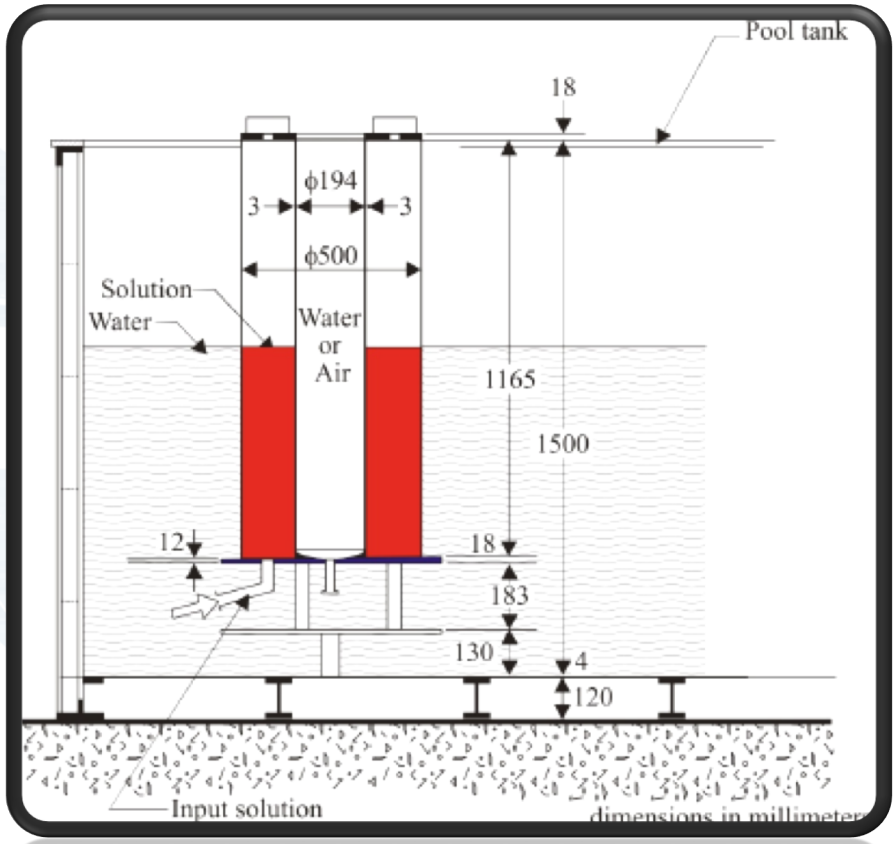


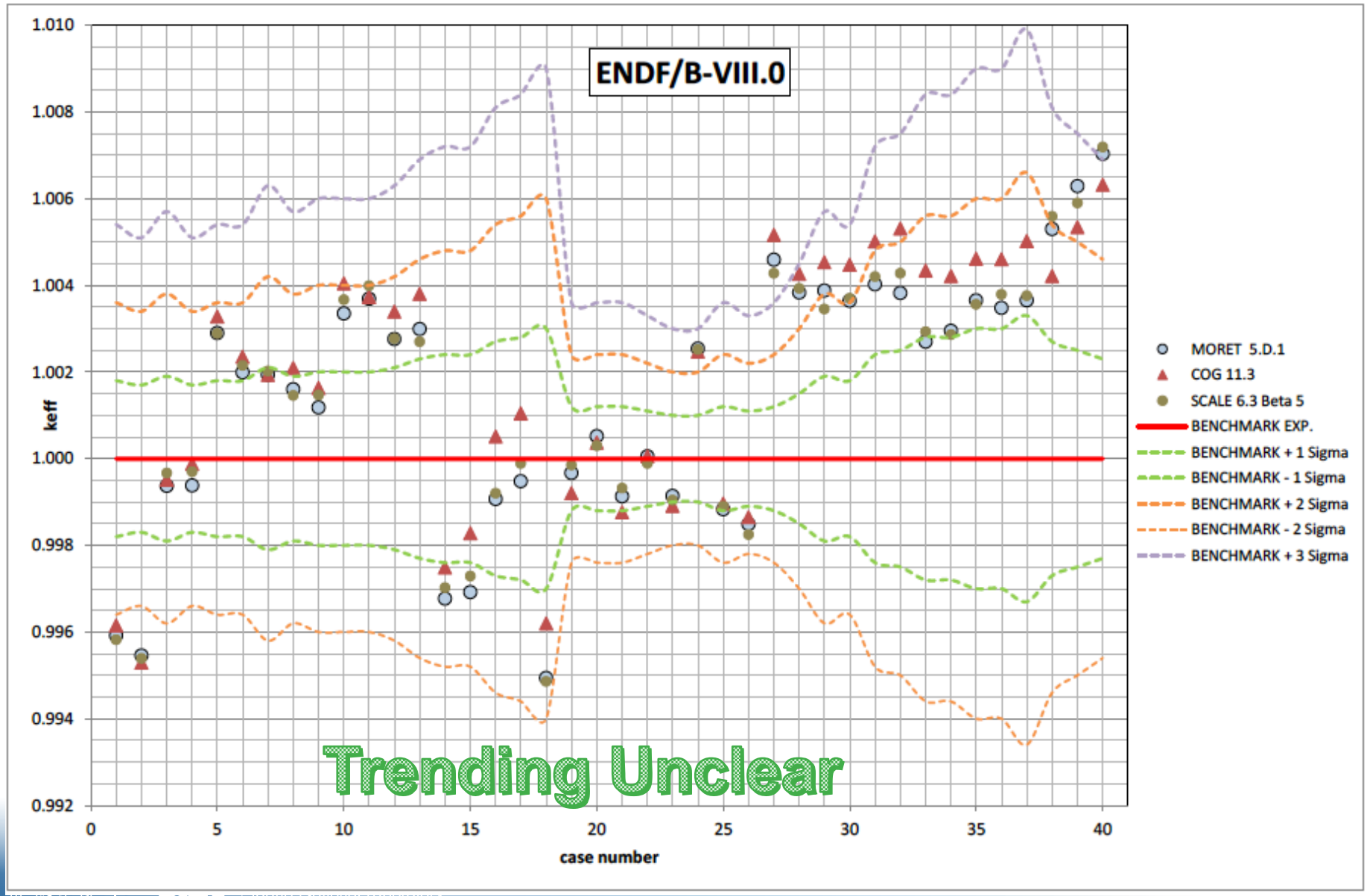
Figure 67. Reactivity Offset for MORET 5.D.1 Calculations using Continuous-Energy ENDF/B-VIII.0 Cross Sections.

ICSBEP 2020 Handbook: PU-SOL-THERM-041

- **Valduc (CEA)**
  - 40 configurations
  - 1964 – 1965
  - Annular cylinder
    - 50 (OD) & 20 (ID) cm
    - Central air or water
  - 20 – 190 g/L Pu
    - ~3 % ^{240}Pu
  - k_{eff} = 1.0000
    - 1σ: 110 – 330 pcm

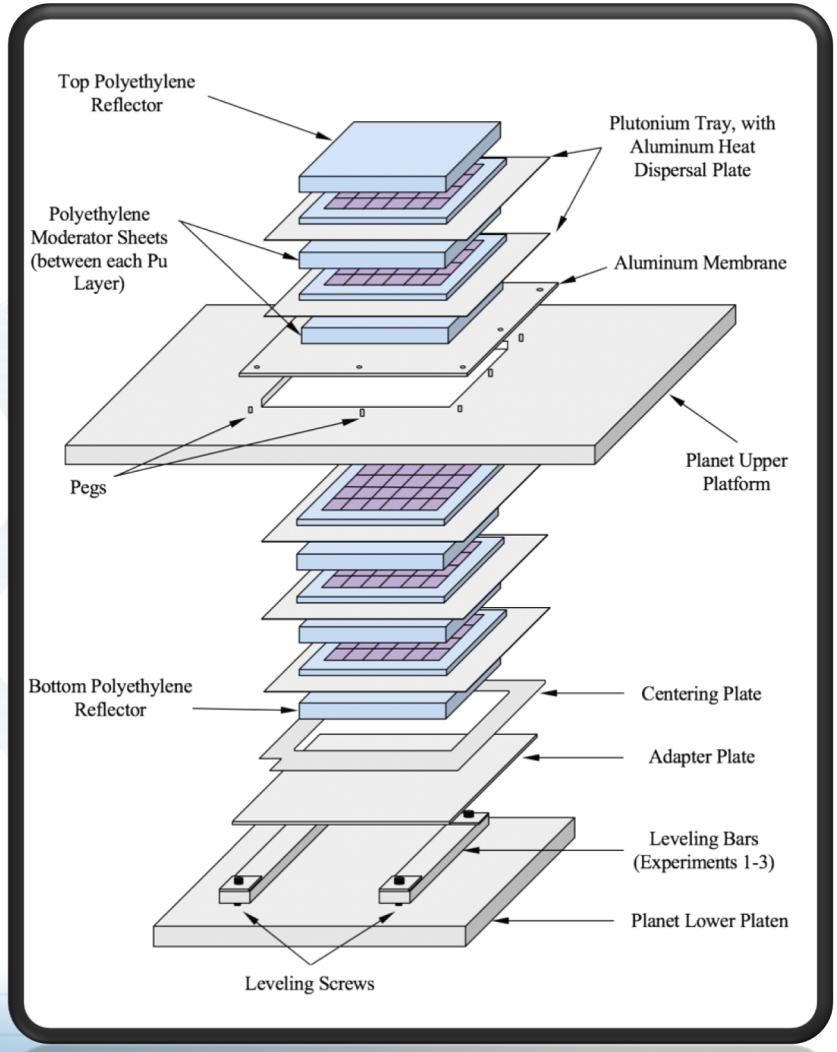


PU-SOL-THERM-041 Sample Results

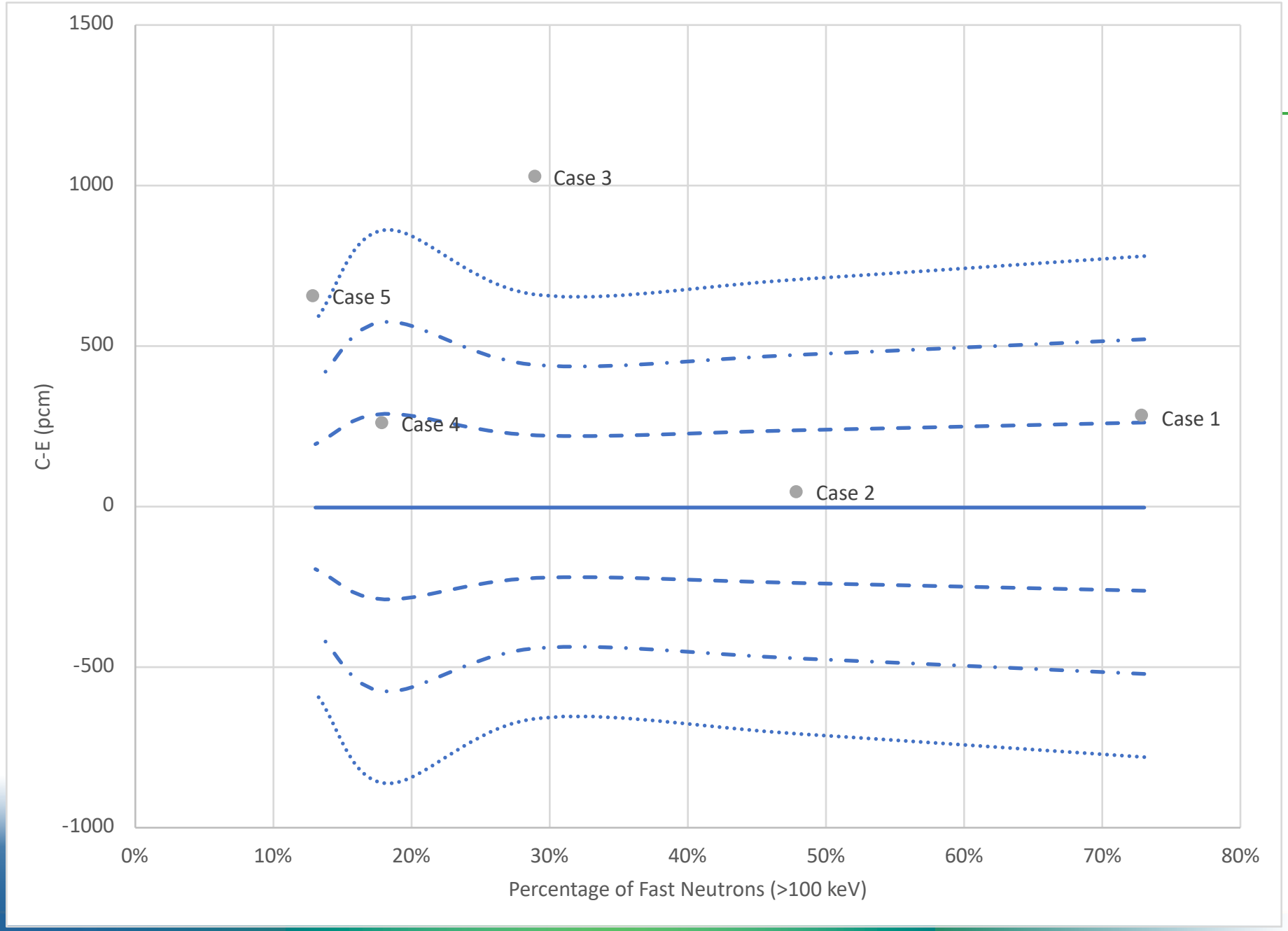


ICSBEP 2020 Handbook: PU-MET-MIXED-002, (PU-MET-THERM-002) & (PU-MET-FAST-048)

- Thermal/Epithermal eXperiments (TEX)
  - Planet (2017-2018) @ NCERC
  - ZPPR plates
  - 5 experiments
    - 1 case PMT002
    - 2 cases PMM002
    - 2 cases PMF048
- Most sample calculations within 2σ of the benchmark values

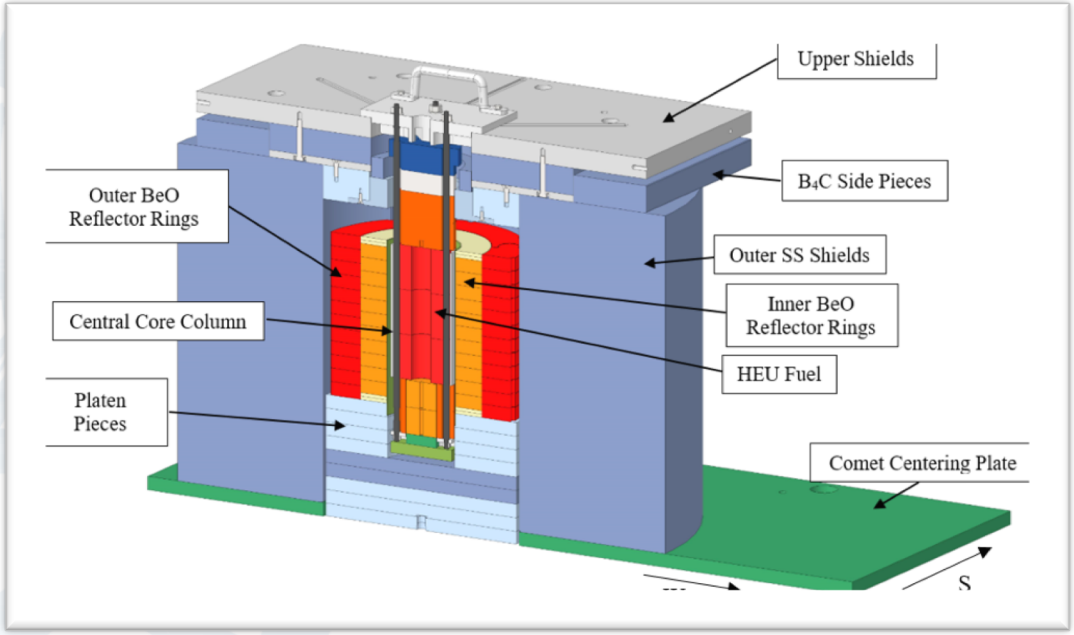


PU-MET-MIXED-002 Sample Results

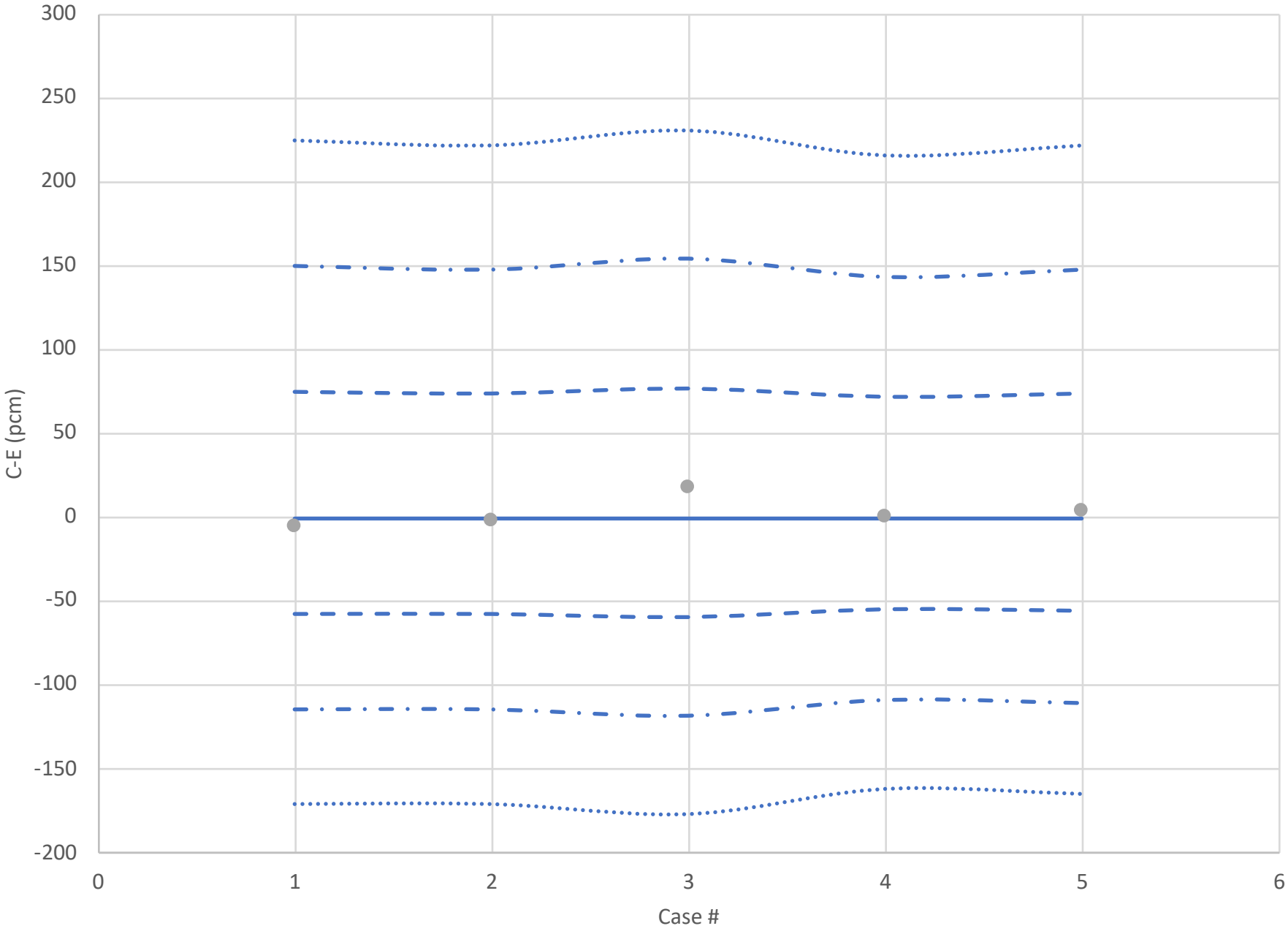


ICSBEP 2021 Handbook: HEU-MET-FAST-101 (Draft #'s)

- **Kilopower Reactor Using Stirling TechnologY (KRUSTY)**
  - **Comet (2017-2018) @ NCERC**
  - **HEU-Mo, BeO, SS**
  - **5 similar configurations**
- **Great sample calculation agreement**

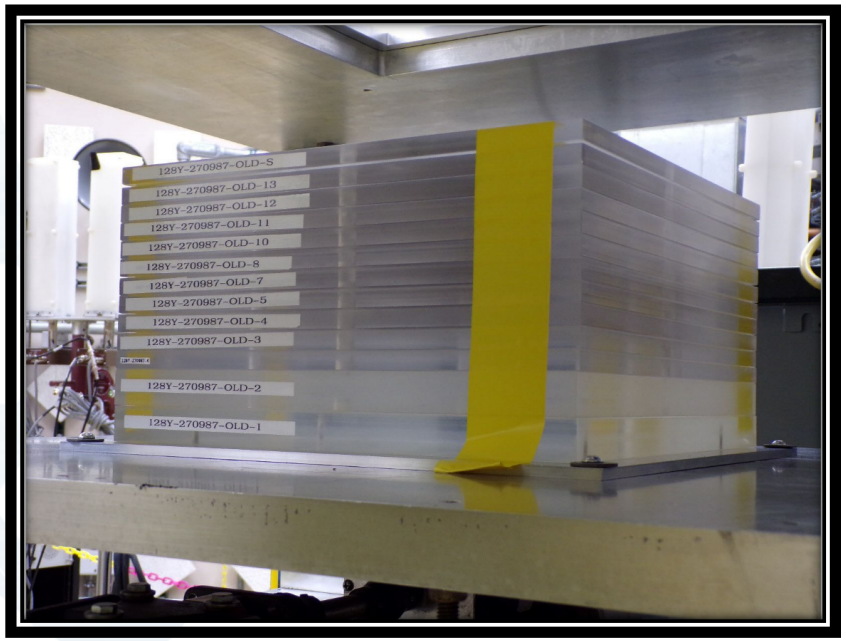


HEU-MET-FAST-101 Draft Results

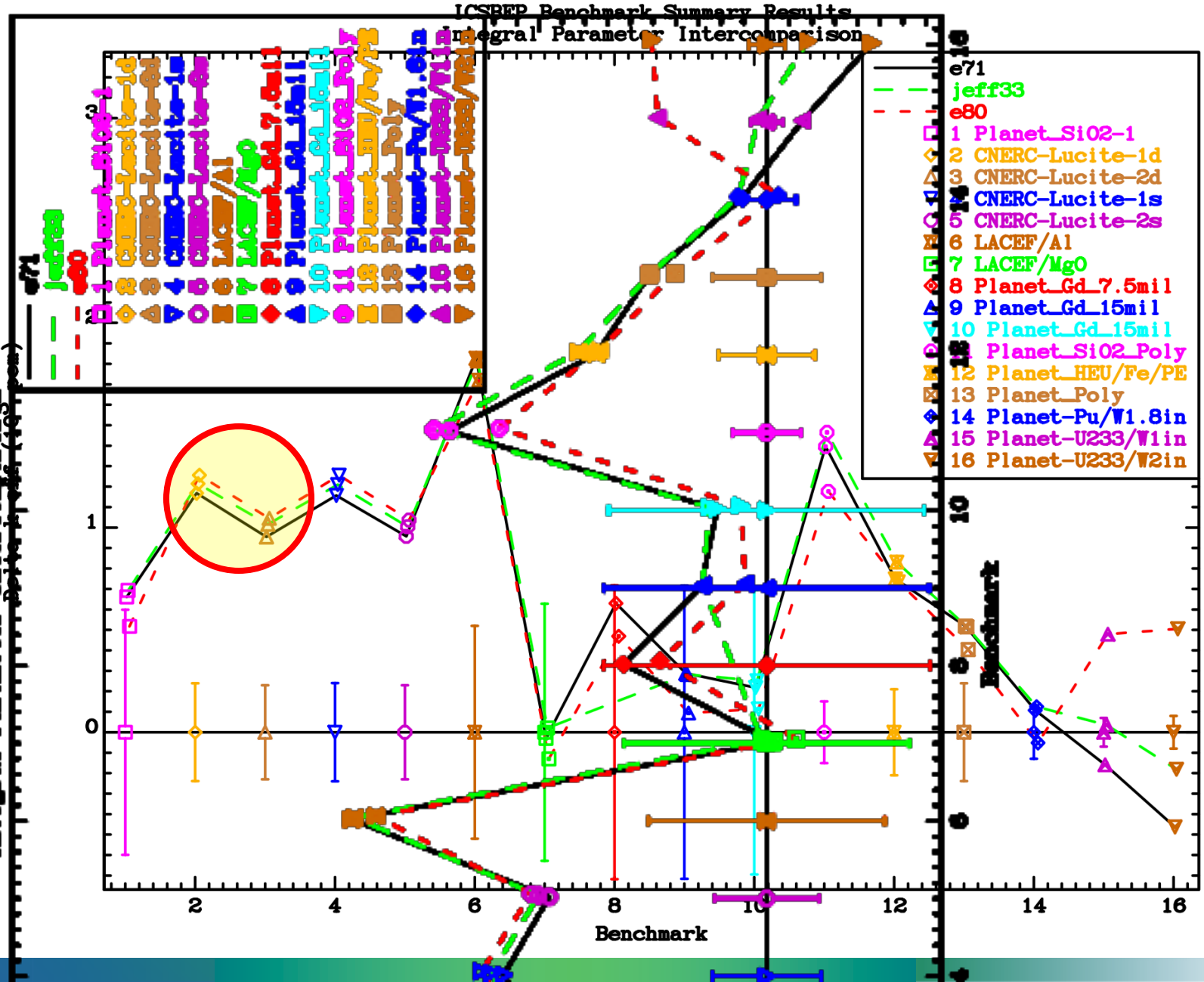


ICSBEP 2021 Handbook: HEU-MET-THERM-004 (Draft #'s)

- HEU foils moderated and reflected by Lucite
  - Planet (2019) @ NCERC
  - 2 configurations
- MCNP6.2 w/ ENDF/B-VIII.0 sample calculations are high by ~1.2 %, ~5σ

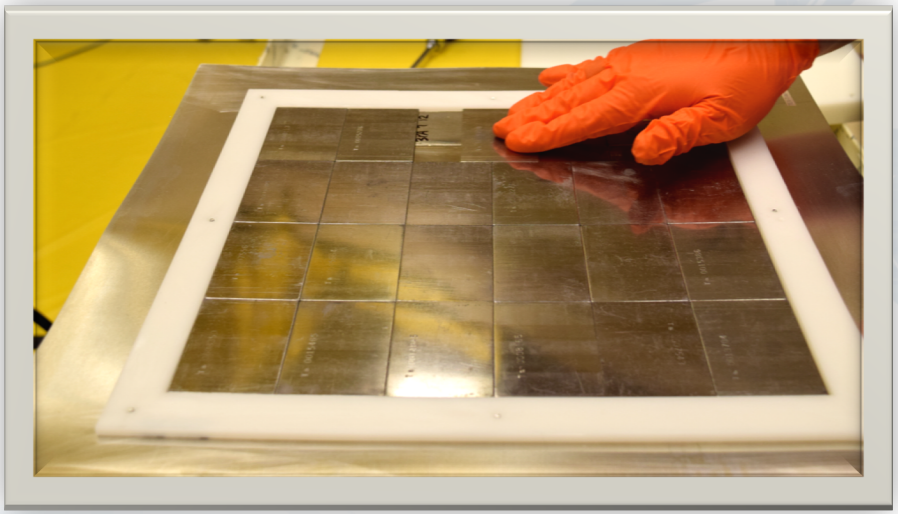


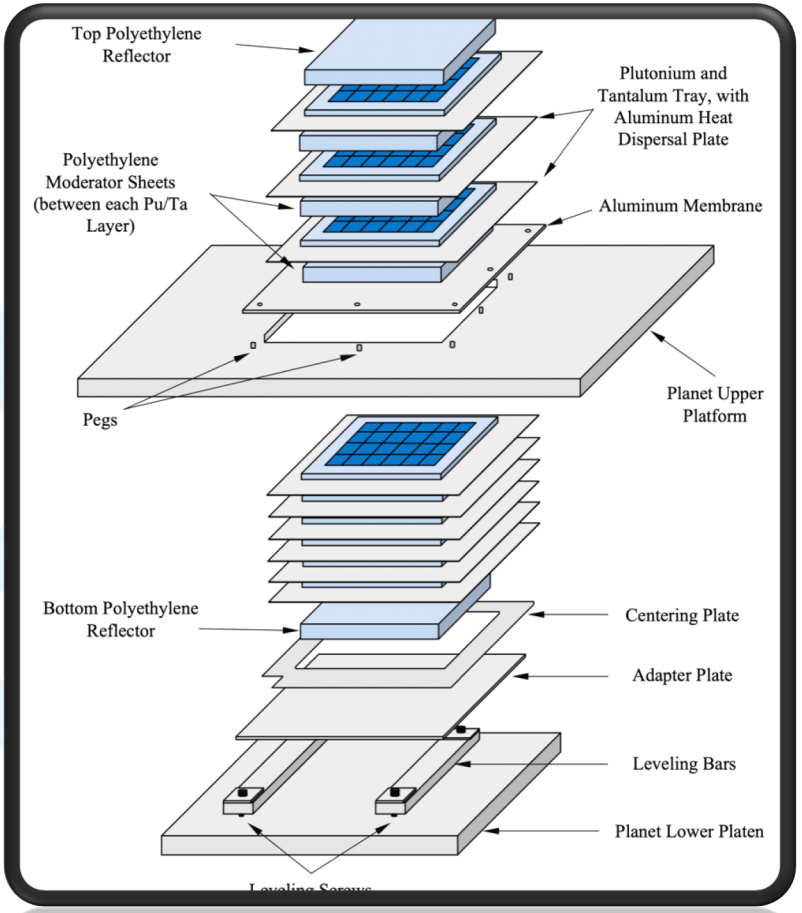
Comparison of Planet Benchmarks (Andre Trkov)



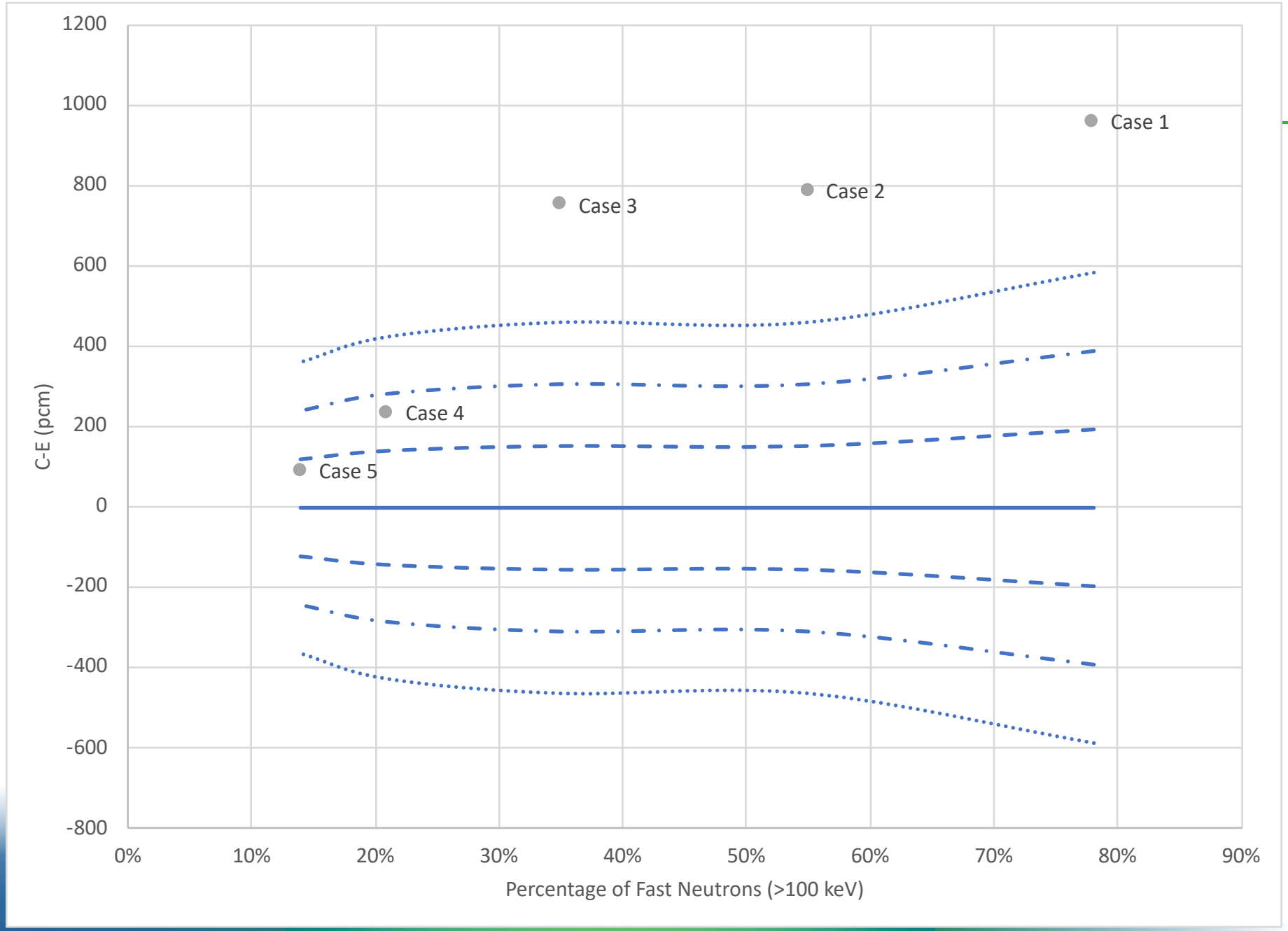
ICSBEP 2021 Handbook: PU-MET-MIXED-003 (PU-MET-FAST-049) & (PU-MET-THERM-003)

- TEX w/ Ta
  - Planet (2018) @ NCERC
  - 5 configurations



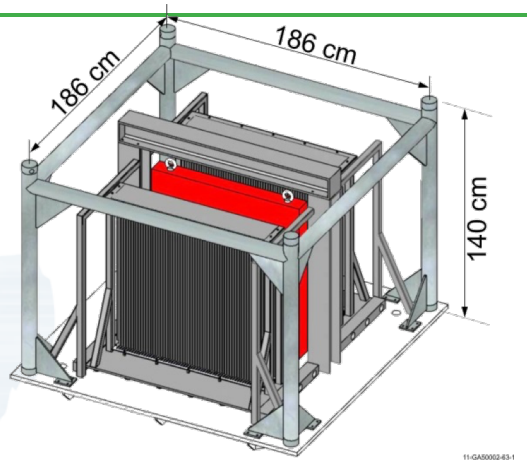


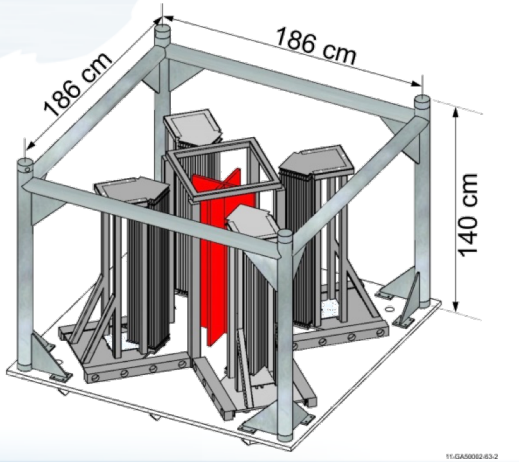
PU-MET-MIXED-003 Draft Results



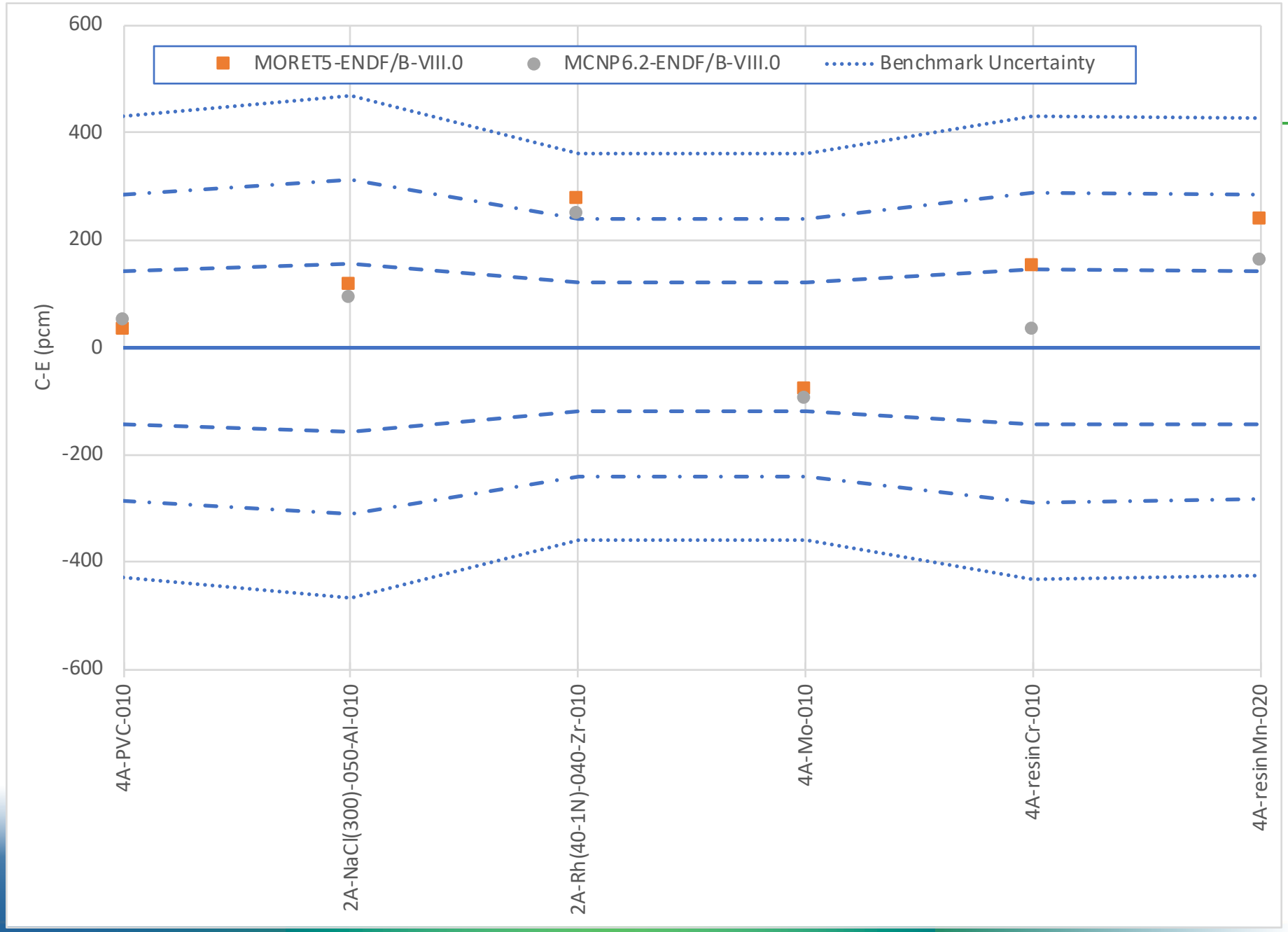
ICSBEP 2021 Handbook: LEU-COMP-THERM-106

- **MIRTE-2.2**
  - **Valduc (CEA)**
  - **28 benchmark experiments**
    - **Screens**
    - **NaCl**
    - **Rh (rhodium sulfate)**
    - **PVC (Cl)**
    - **Mo**
    - **Cr (chromium resin)**
    - **Mn (manganese resin)**





LEU-COMP-THERM-0106 Draft Results



¿Questions?

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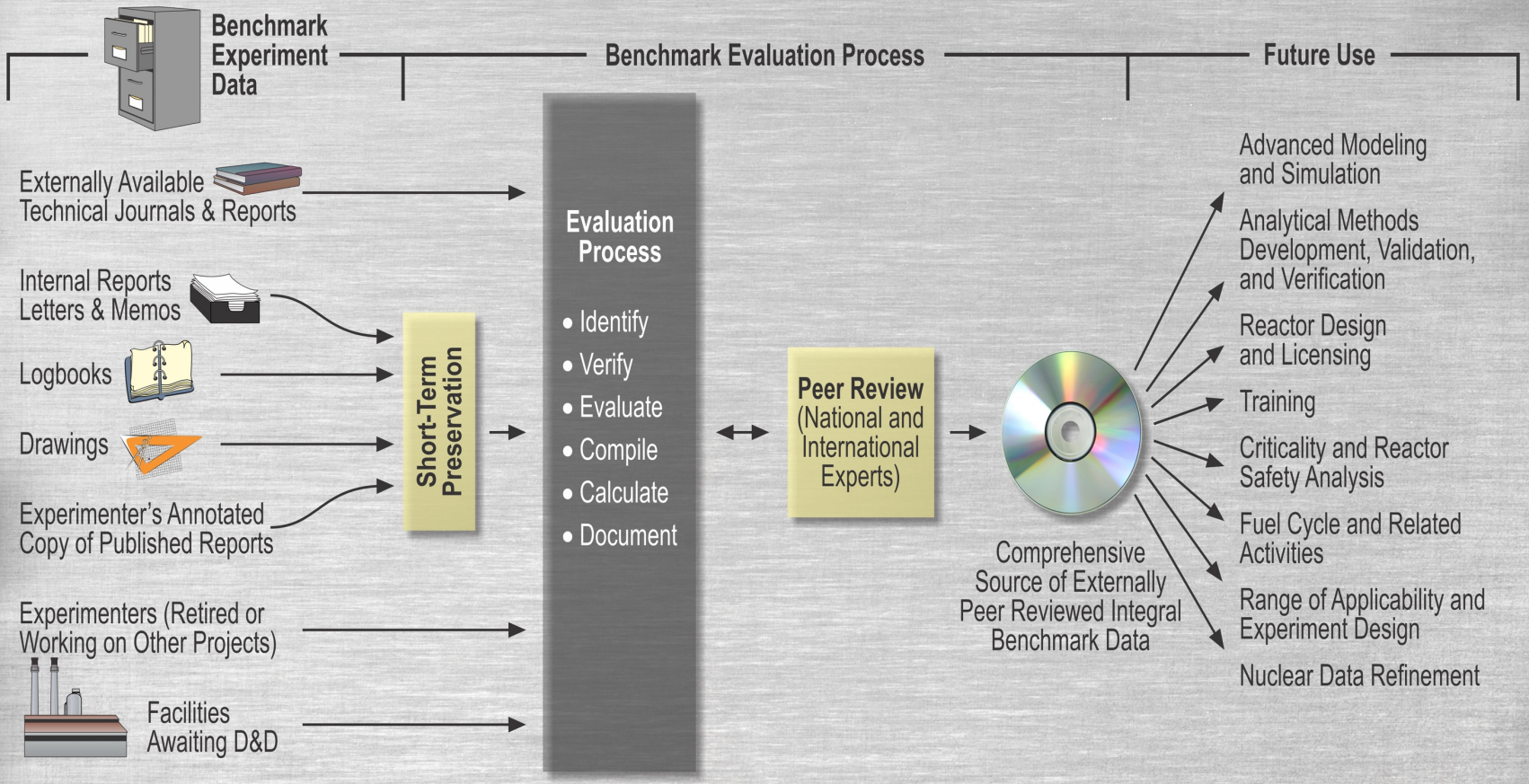
Extra Slides

INTERNATIONAL BENCHMARK PROGRAMS

NEA NUCLEAR ENERGY AGENCY

OECD BETTER POLICIES FOR BETTER LIVES

INL Idaho National Laboratory



Countries Participating in the ICSBEP & IRPhEP

- Argentina
- Belgium
- Brazil
- Canada
- People's Republic of China
- Czech Republic
- France
- Germany
- Hungary
- India
- Israel
- Italy
- Japan

- Kazakhstan
- Poland
- Republic of Korea
- Russian Federation
- Serbia
- Slovenia
- South Africa
- Spain
- Sweden
- Switzerland
- United Kingdom
- United States of America

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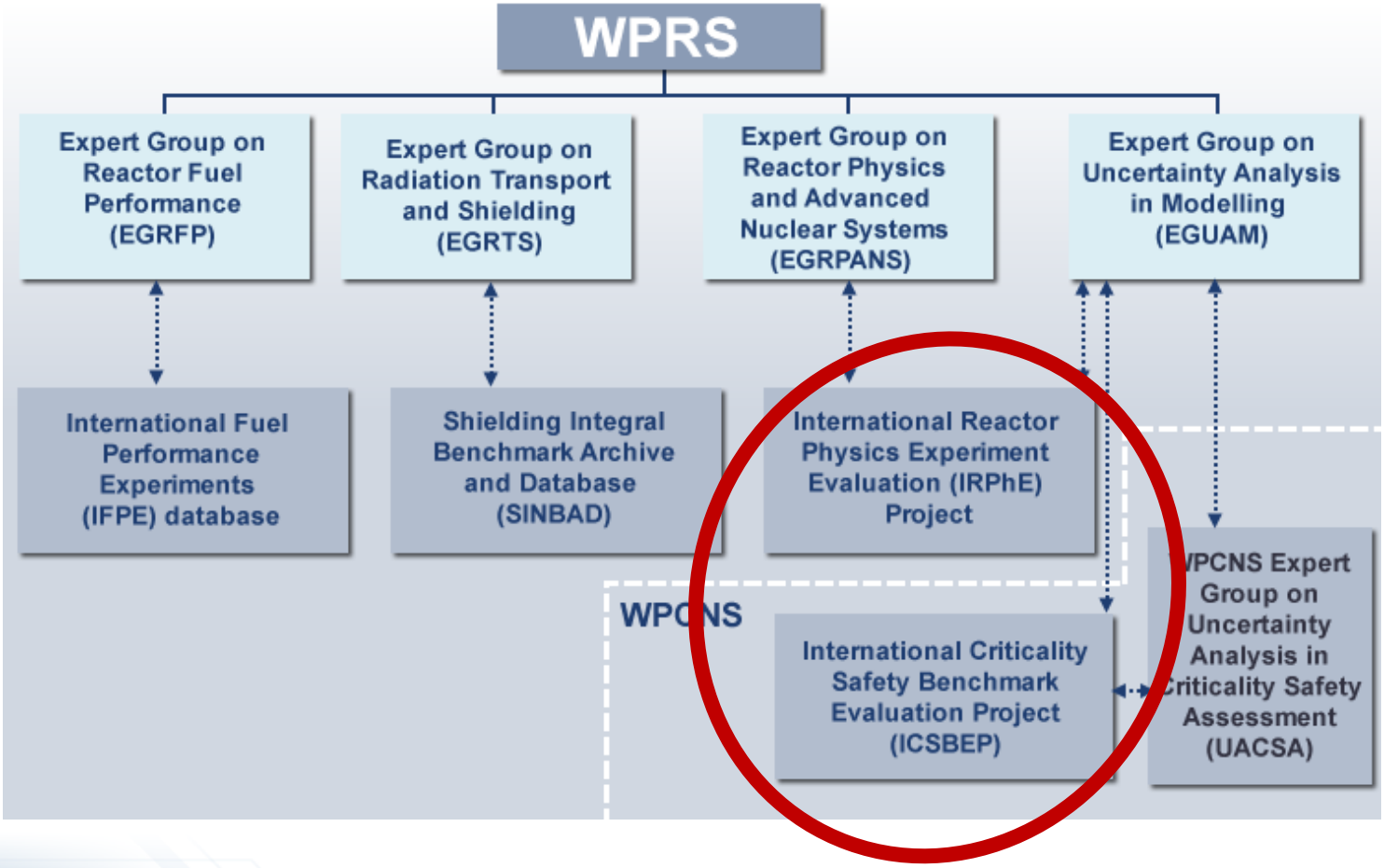


Managed by an Elected Chair

Current OECD/NEA Member Countries

Argentina	France	Latvia	Russia
Australia	Germany	Luxembourg	Slovak Republic
Austria	Greece	Mexico	Slovenia
Belgium	Hungary	Netherlands	Spain
Canada	Iceland	New Zealand	Sweden
Chile	Ireland	Norway	Switzerland
Czech Republic	Israel	Poland	Turkey
Denmark	Italy	Portugal	United Kingdom
Estonia	Japan	Romania	United States
Finland	Korea		

Available to Member Countries and Active Participating Facilities

Acknowledgments

- The ICSBEP and IRPhEP are a collaborative effort
  - Scientists, engineers, administrative support, program sponsors
  - 26 different countries have participated
    - 23 in ICSBEP
    - 23 in IRPhEP
  - Without these dedicated individuals, these benchmark projects would not exist.

IRPhEP, ICSBEP, & SINBAD Annual Technical Review Group (TRG) Meetings

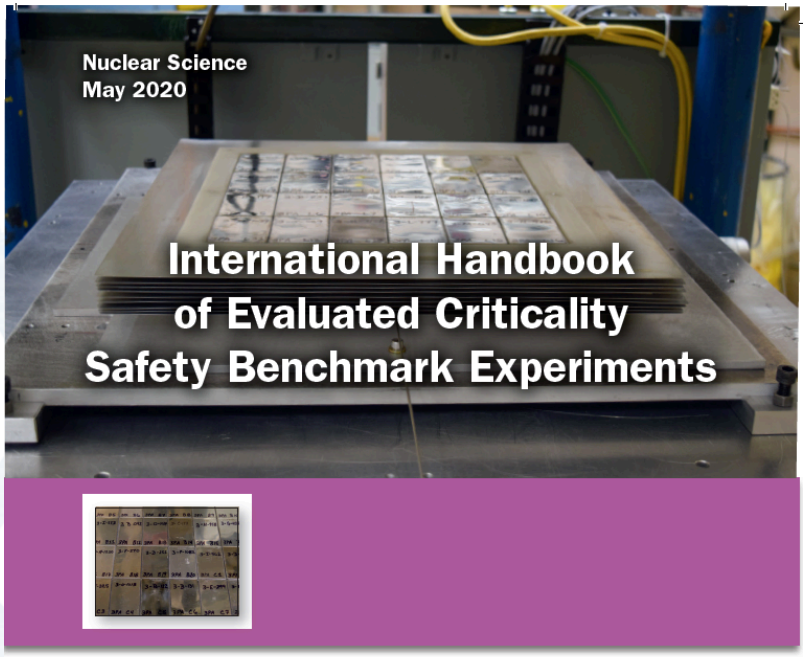
- ICSBEP Only
- 19-23 October 2020
- OECD NEA, Paris, France
- Virtual

- Ideally All Three
- 11-15 October 2021
- OECD NEA, Paris, France
- Hopefully In-Person

International Handbook of Evaluated Criticality Safety Benchmark Experiments

December 2020 Edition

- **23 Contributing Countries**
- **~70,000 Pages**
- **582 Evaluations**
  - **5,053 Critical, Near-Critical, or Subcritical Configurations**
  - **45 Criticality-Alarm-Placement/Shielding Configurations**
  - **237 Configurations with Fundamental Physics Measurements**
  - **838 Unacceptable Experiment Configurations**



NEA
NUCLEAR ENERGY AGENCY

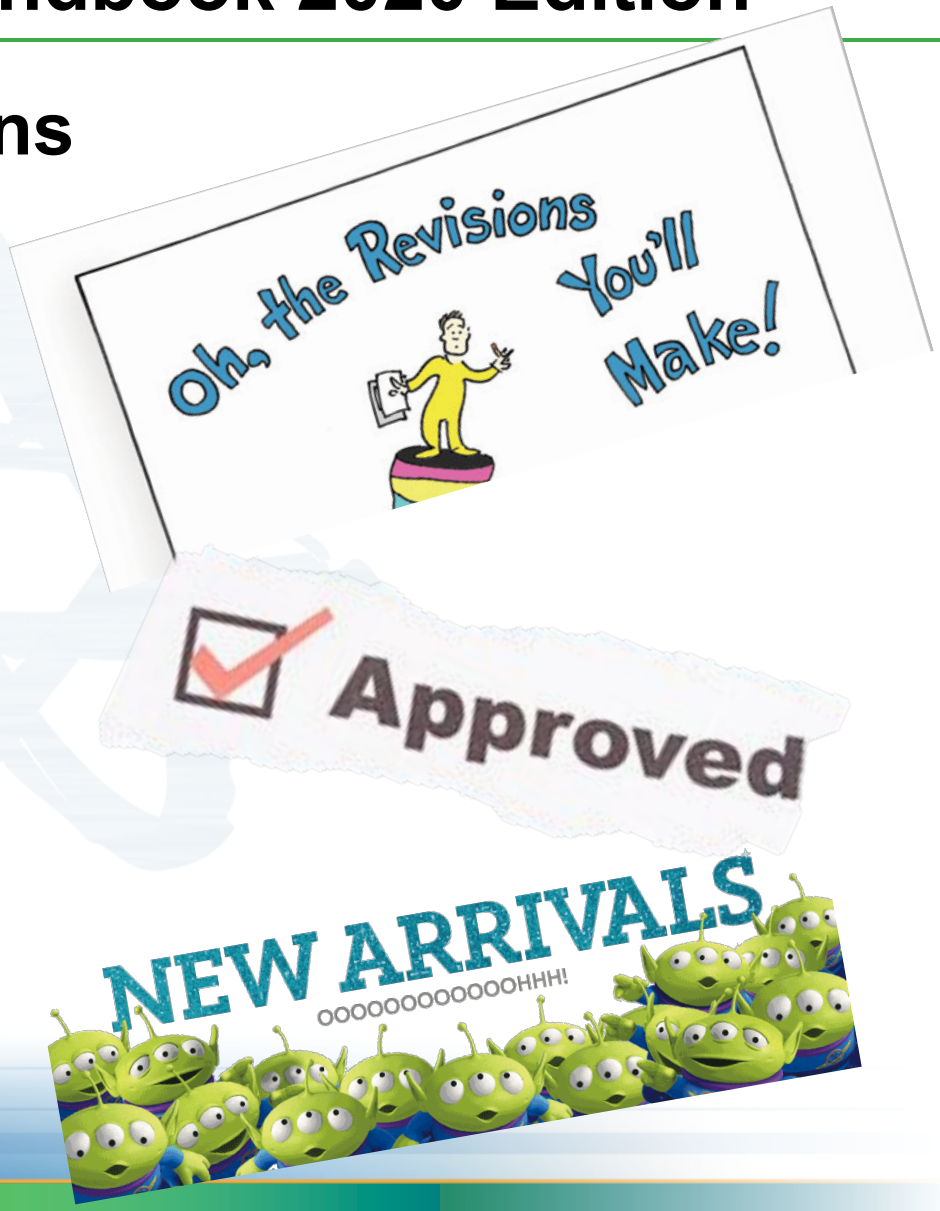
http://icsbep.inl.gov/
https://www.oecd-nea.org/science/wpncs/icsbep/

Breakdown of Current ICSBEP Benchmark Specifications

- 773 plutonium experiments
  - 36 compound
  - 128 metal
  - 609 solution
- 1426 highly enriched uranium experiments
  - 291 compound
  - 601 metal
  - 527 solution
  - 2 mixed compound/solution
  - 5 mixed metal/solution
- 274 intermediate- and mixed-enrichment uranium experiments
  - 156 compound
  - 53 metal
  - 65 solution
- 1780 low enriched uranium experiments
  - 1518 compound
  - 82 metal
  - 120 solution
  - 60 mixed compound/solution
- 244 ^{233}U experiments
  - 6 compound
  - 11 metal
  - 227 solution
- 536 mixed plutonium-uranium experiments
  - 301 compound
  - 52 metal
  - 86 solution
  - 76 mixed compound/solution
  - 21 mixed metal/compound
- 20 special isotope experiments
  - metal (^{237}Np, ^{238}Pu, ^{242}Pu, & ^{244}Cm)
- 7 criticality-alarm/shielding experiments
  - 45 unique configurations with numerous dose points
- 10 fundamental physics experiments
  - 237 unique measurements such as fission rates, transmission measurements, and subcritical neutron multiplication measurements

New Content in the Handbook 2020 Edition

- **11 Revised Evaluations**
  - **7 Minor**
  - **3 Significant**
  - **1 Replaced**
- **5 New Evaluations**



Minor Revisions to the Handbook 1-3:

- **LEU-COMP-THERM-104**
  - Evaluation report was missing from the 2019 release of the Handbook.
- **MIX-COMP-THERM-004**
  - MCNP sample input decks provided in benchmark subdirectory.
- **PU-MET-FAST-001**
  - On page 79, replaced the text defining full insertion of the rectangular part as being centered within the length of the channel within “upper part M2” to indicate correctly “upper part M3”.
  - Replaced the “-6” exponents with “6” in the EALF and AFGE columns of Table C.2.

Minor Revisions to the Handbook 4-6:

- **PU-SOL-THERM-023**
  - **MCNP input decks providing in the benchmark subdirectory were incorrect, and they have been removed.**
- **PU-SOL-THERM-028 and PU-SOL-THERM-029**
  - **On page 2, replaced "- 50/20 cm diam., 3.0 % ^{240}Pu : PU-SOL-THERM-041," with "- 50/20 cm diam., 19 % ^{240}Pu : PU-SOL-THERM-031,".**
  - **The hyperlink also points to the correct benchmark.**

Minor Revisions to the Handbook 7:

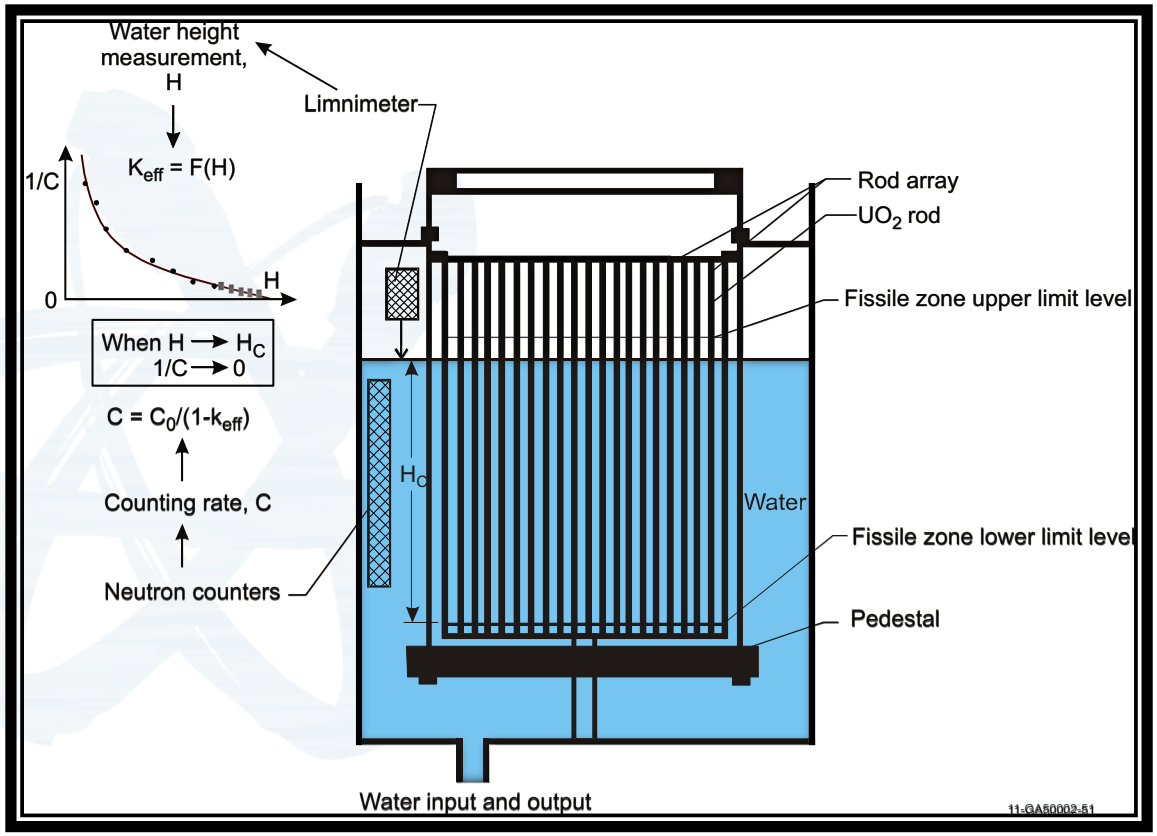
- **IEU-SOL-THERM-001**
  - Table 18 was added to Section 4 on page 30 to provide sample MCNP calculations attributed to Kermit Bunde (DOE-IE).
  - MCNP sample input decks now provided in the benchmark subdirectory.
- **Benchmark**
  - k_{eff} = 1.0000 ± 0.0052
- **MCU**
  - 0.9735 to 0.9855
  - ± 0.0014
- **MCNP**
  - 0.9834 to 0.9932
  - ± 0.0002

Significant Revisions to the Handbook 1-3:

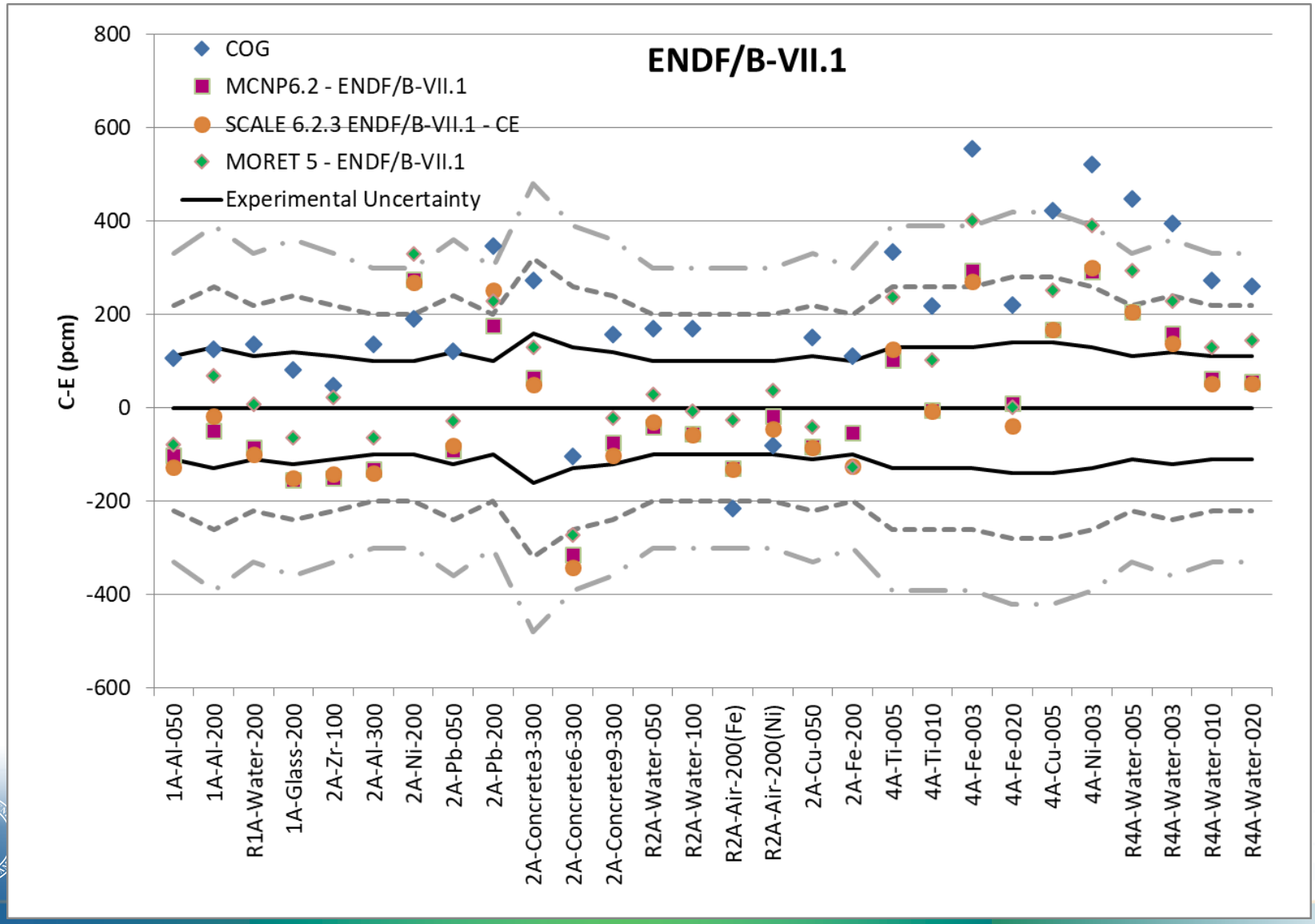
- **FUND-NCERC-PU-HE3-MULT-003**
  - Female polyethylene hemishell atom densities corrected in Table 113.
- **FUND-LLNL-ALPHAN-HE3-MULT-001**
  - Updated uncertainty analysis. Reduced uncertainty in aluminum components and total uncertainty.
- **LEU-SOL-THERM-012**
  - Errors in the tank geometry uncertainty analysis were identified during the review of LEU-SOL-THERM-013. They were found common to this evaluation and corrected.

Replaced Evaluation 1: LEU-COMP-THERM-074

- **MIRTE-1**
  - Valduc (CEA)
  - Complete experiment series now available
  - 28 benchmark experiments
    - Screens
    - Al, concrete, Cu, glass, Fe, Pb, Ni, Ti, Zr
- **Most sample calculations within 3σ of benchmark values**

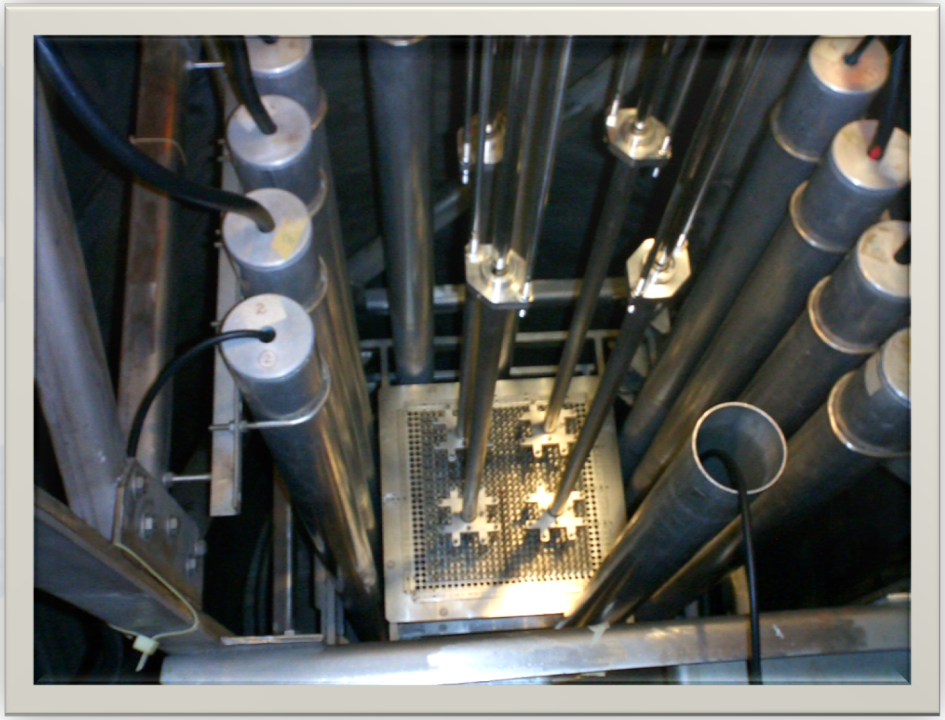


LEU-COMP-THERM-074 Sample Results



New Evaluation 1: SUB-LEU-COMP-THERM-003

- IPEN/MB-01 Reactor (Brazil)
  - Boric acid in water to achieve subcriticality
    - 50 – 300 ppm
  - 1 critical & 7 subcritical experiments
- Sample calculations within 2σ of the benchmark values
  - MCNP5
  - ENDF/B-VII.0



New Evaluation 2: LEU-COMP-THERM-101

- 7uPCX @ SNL
  - 22 experiments
  - 0.52 fuel-to-water volume ratio
    - 0.855 cm pitch
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  - Evaluated critical water heights for various rod loadings
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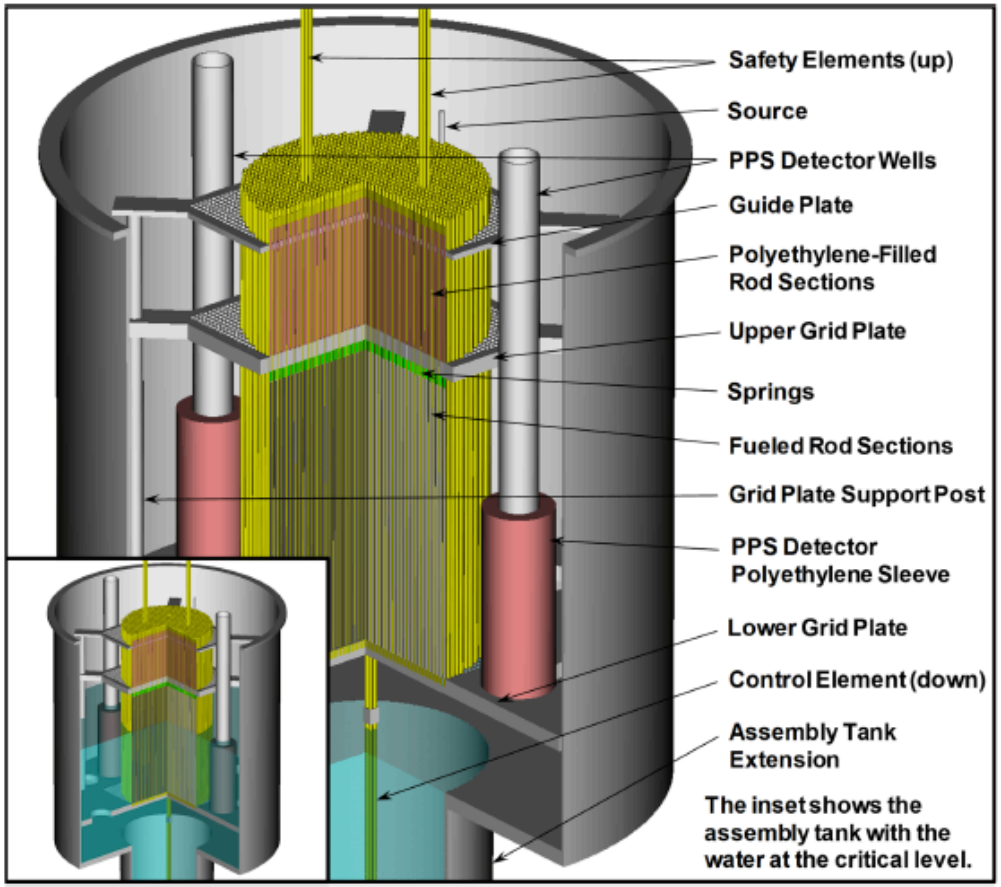


LEU-COMP-THERM-101 Sample Results – I

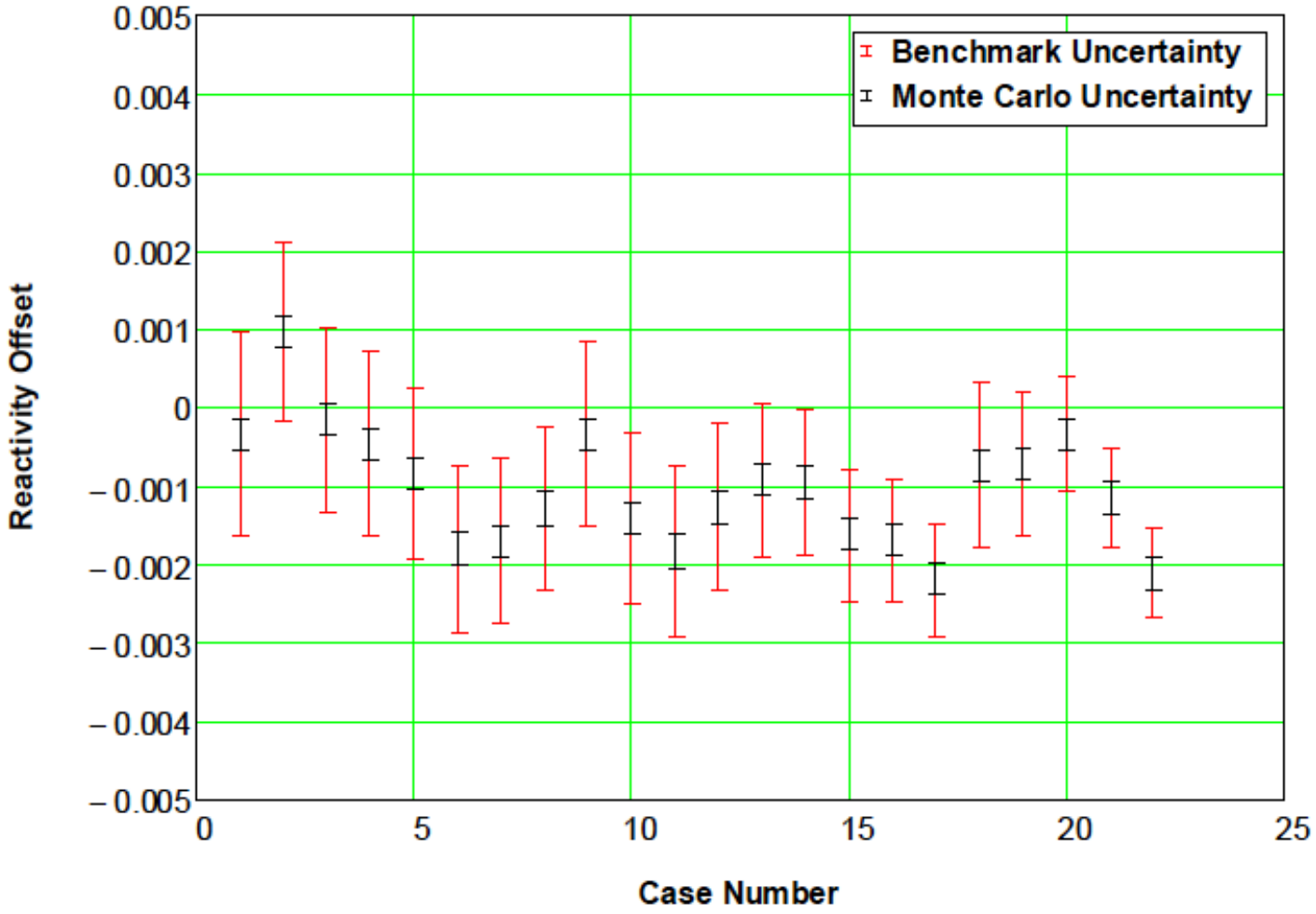


Figure 67. Reactivity Offset for MORET 5.D.1 Calculations using Continuous-Energy ENDF/B-VIII.0 Cross Sections.

LEU-COMP-THERM-101 Sample Results – II

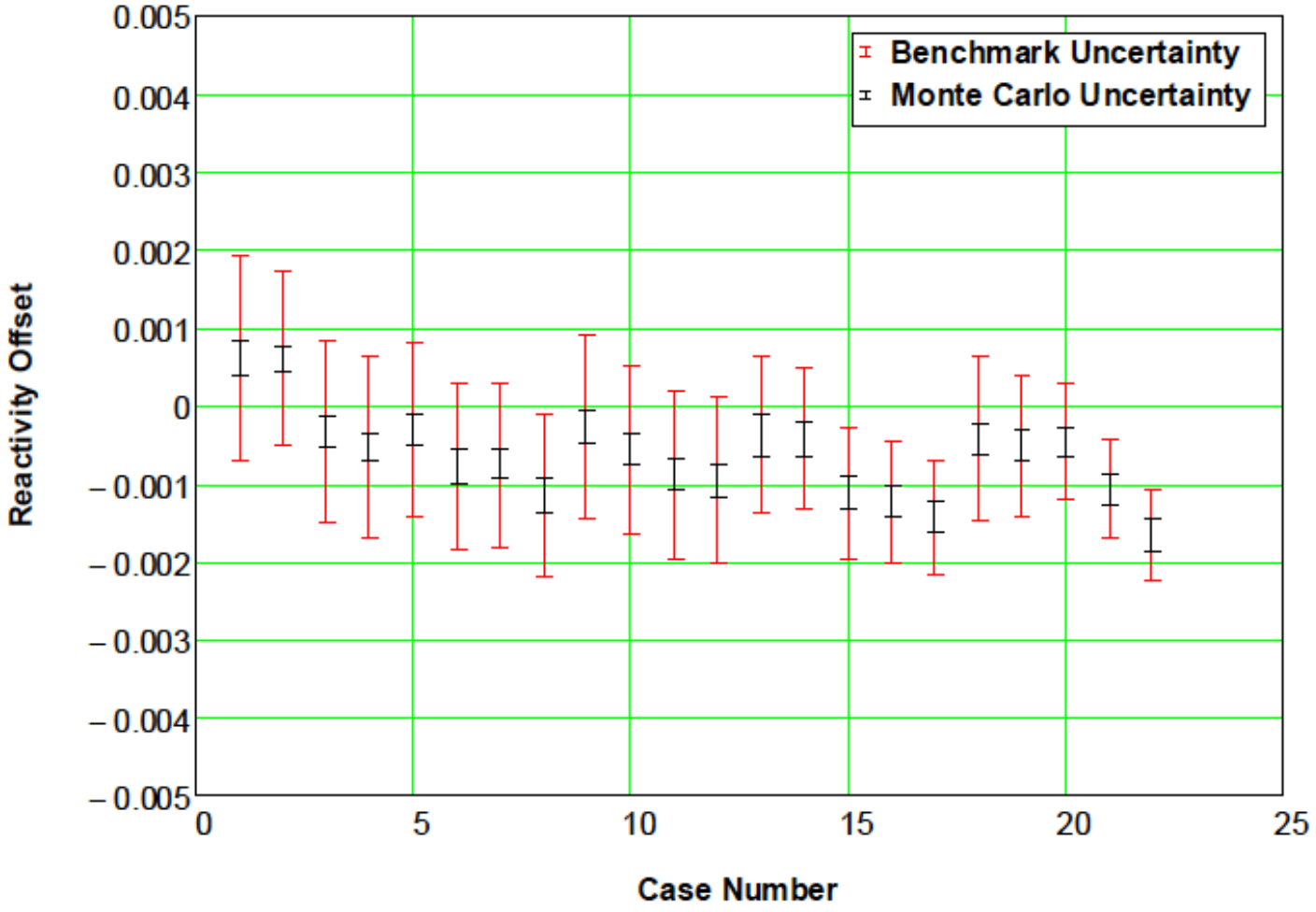
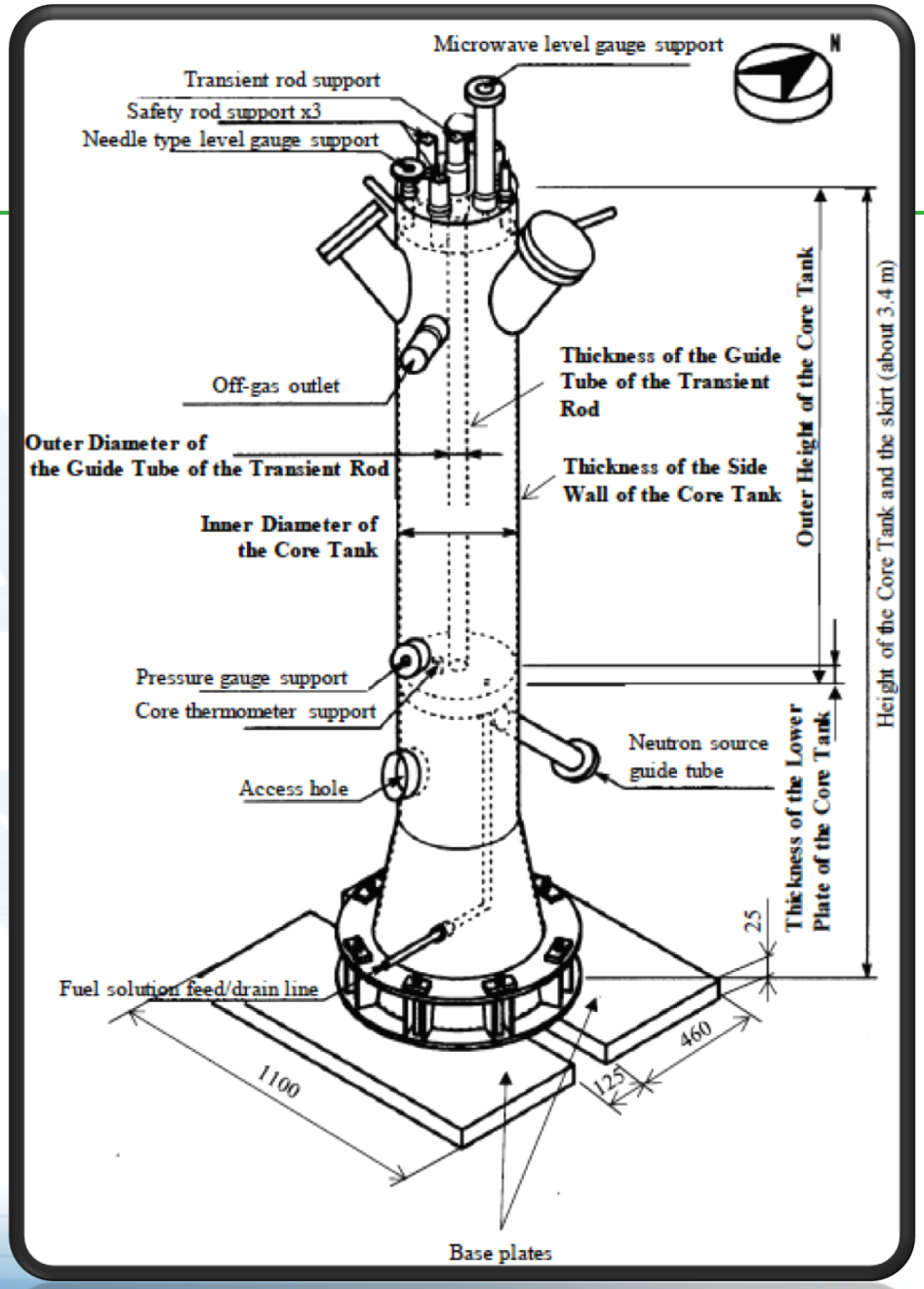


Figure 64. Reactivity Offset for KENO V.a Calculations Using Cross Sections from the Continuous-Energy ENDF/B-VII.1 SCALE6.2 Library.

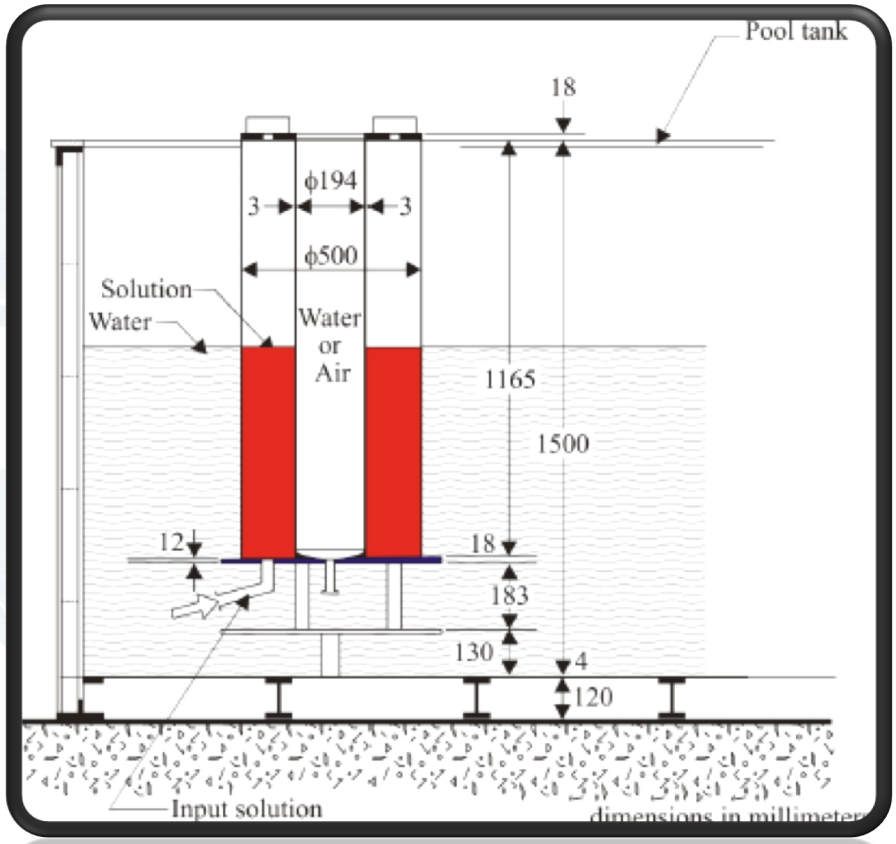
New Evaluation 3: LEU-SOL-THERM-013

- TRACY
  - Tokai Research Establishment (JAEA)
- Critical configuration supporting pulse withdrawal supercritical experiment
- Uranyl Nitrate
  - 10 % enriched
  - B_4C transient rod inserted
- All sample calculations overpredict by > 3σ
  - k_{eff} = 1.0024 ± 0.0007

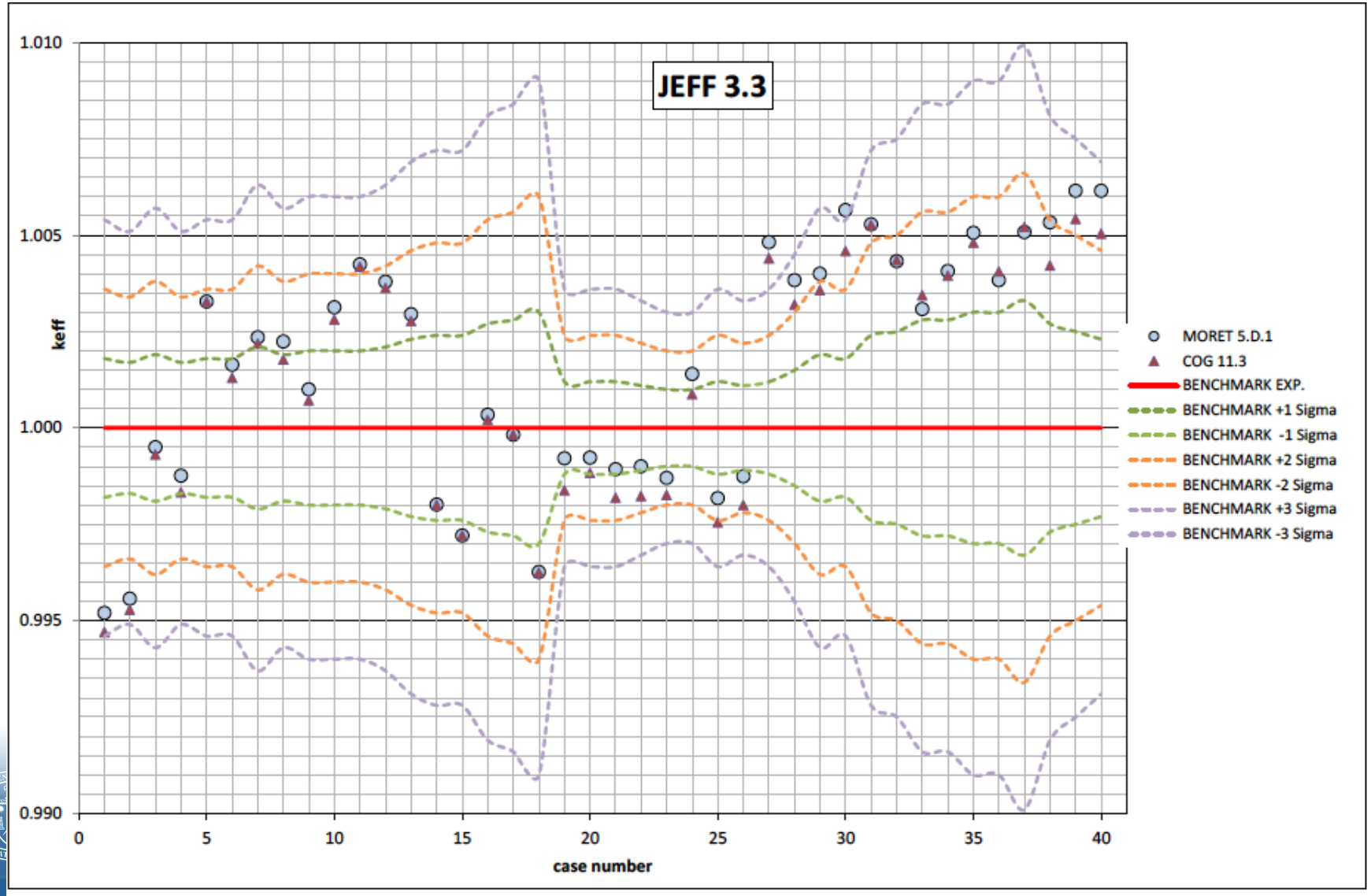


New Evaluation 4: PU-SOL-THERM-041

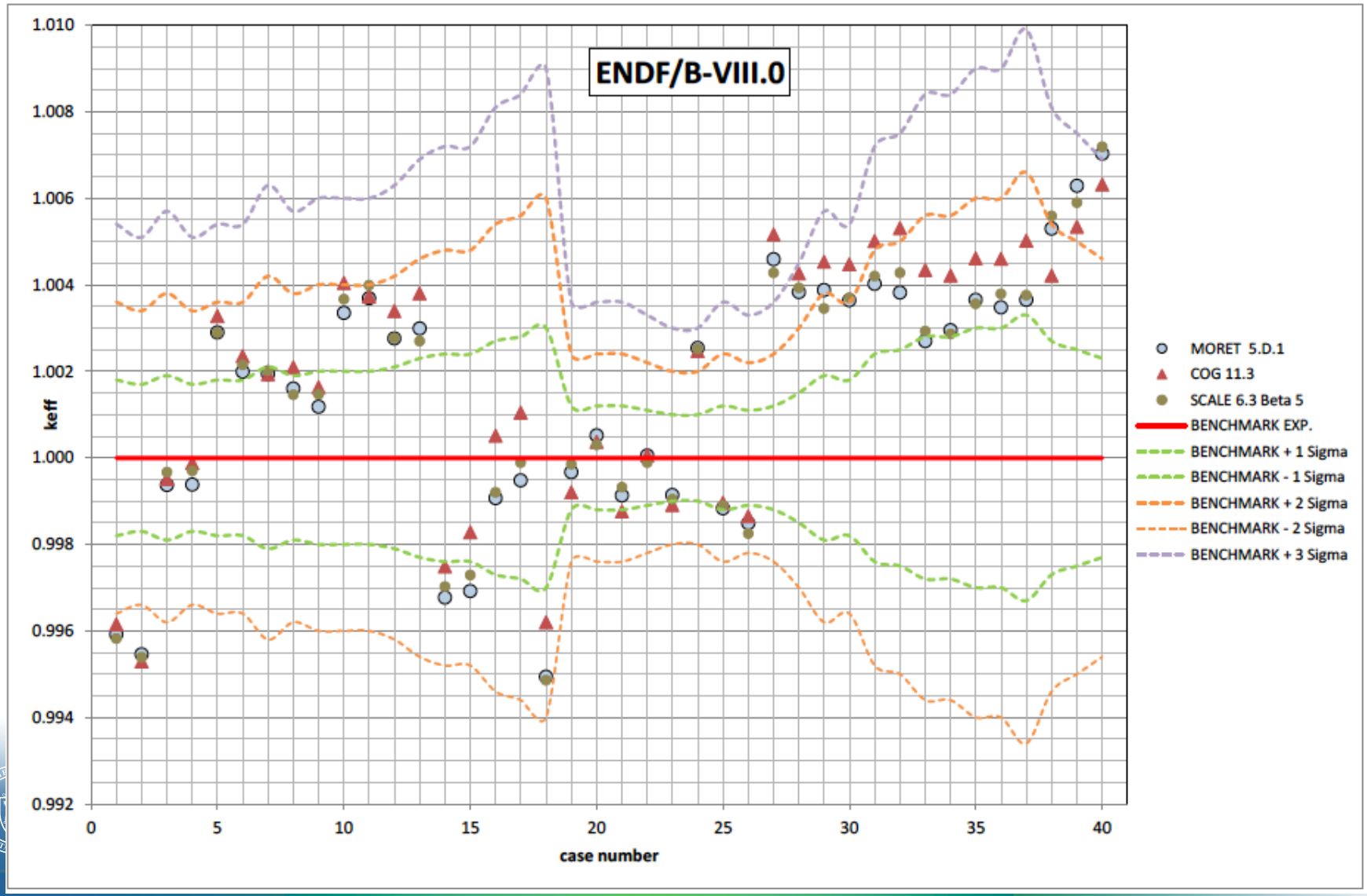
- **Valduc (CEA)**
  - 40 configurations
  - 1964 – 1965
  - Annular cylinder
    - 50 (OD) & 20 (ID) cm
    - Central air or water
  - 20 – 190 g/L Pu
    - ~3 % ^{240}Pu
  - k_{eff} = 1.0000
    - 1σ: 110 – 330 pcm



PU-SOL-THERM-041 Sample Results – I

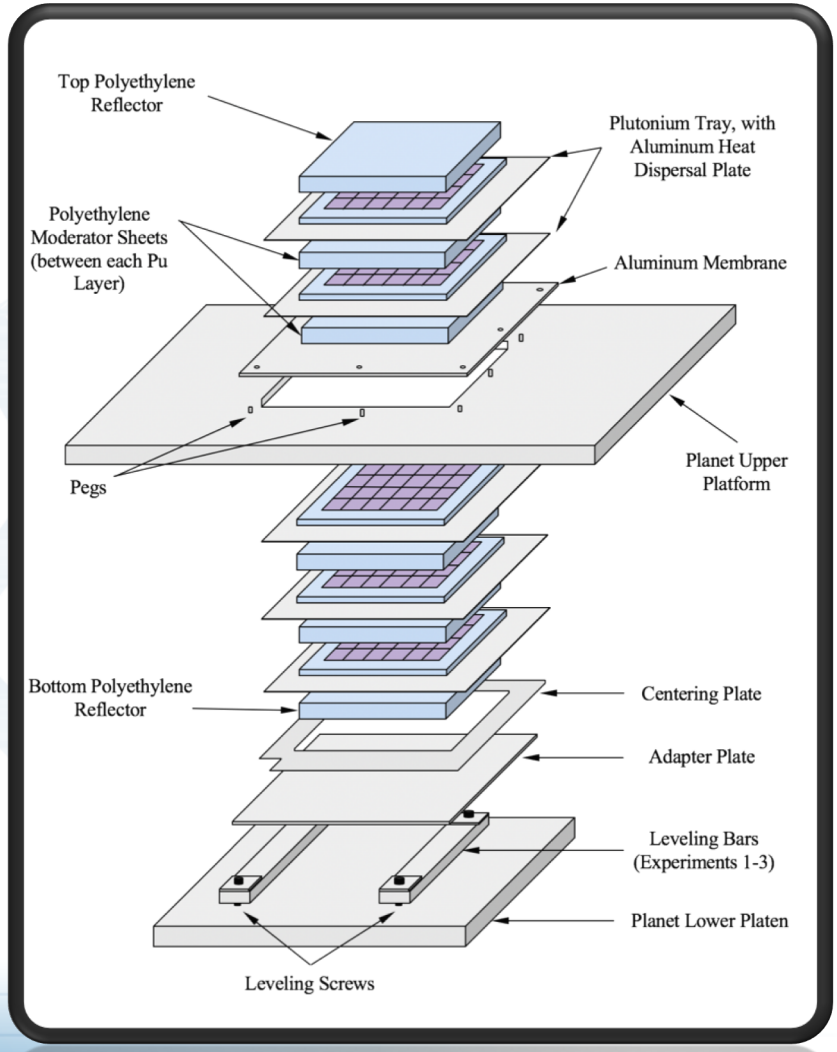


PU-SOL-THERM-041 Sample Results – II



New Evaluation 5: PU-MET-MIXED-002, (PU-MET-THERM-002) & (PU-MET-FAST-048)

- Thermal/Epithermal eXperiments (TEX)
  - Planet (2017-2018) @ NCERC
  - ZPPR plates
  - 5 experiments
    - 1 case PMT002
    - 2 cases PMM002
    - 2 cases PMF048
- Most sample calculations within 2σ of the benchmark values



Potential Future Benchmark Evaluations – I

- Belarus
  - GIACINT
- Brazil
  - IPEN/MB-01 with Boric Acid
- Czech Republic
  - Fast Neutron Leakage from Iron Spheres
  - SiO_2, Graphite, and Molten Salt Experiments
- France
  - MIRTE-2 w/ Fe & Cu Dleeves
  - UO_2 Rods in NaCl Solution
  - UO_2 Rod Lattices with Mo Dleeves
- Japan
  - TRACY Transients
  - Zeus LEU/Pb
  - DCA (Natural and LEU)
  - STACY w/ Debris
- Russia
  - BFS Fe with H_2O
- Slovenia
  - Lucite-Moderated and -Reflected HEU Foils
  - ASPIS-Fe shielding benchmark

Potential Future Benchmark Evaluations – II

- **United States**
  - 7UpCX Experiments
  - GODIVA-IV Revision
  - ISSA Lite
  - KRUSTY
  - Pulsed Spheres Experiments
  - BAPL Solution Criticals
  - Zeus HEU/Pb
  - Jupiter Pu/Pb
  - UNM & ISU AGN Reactors
  - NeSO: Subcritical Measurements
  - HOTBOX
  - TEX Pu with Ta, HEU, HEU with Hf, & ^{233}U
  - ORCEF HEU Experiments
  - HPRR Sulfur Fluence Measurements
  - BeRP Ball with CH_2/Ni Composite Reflector
  - TRX Critical Experiments
  - Fast Neutron Die Away Measurements
  - DCTF
  - ORELA Experiment
  - Organic-Moderated FFTF MOX Fuel Pins
  - New Flattop Evaluation
  - RPI RCF Neutron Clustering Experiments
  - Alpha Transport Shielding Benchmark
  - Music: Bare HEU
  - CURIE: ^{235}U Unresolved Resonance Region
  - ^{252}Cf Benchmark
  - MUSIC: Bare HEU Experiments
  - Hexagonal Ice TSL Evaluation

International Handbook of Evaluated Reactor Physics Benchmark Experiments

December 2020 Edition

- 23 Participating Countries
- 56 Reactor Facilities
- Data from 167 Experimental Series
  - 163 Approved Benchmarks
  - 4 DRAFT Benchmarks
- Available Late 2020

NEA
NUCLEAR ENERGY AGENCY

http://irphep.inl.gov/
http://www.oecd-nea.org/science/wprs/irphe/

New Content in the Handbook 2020 Edition

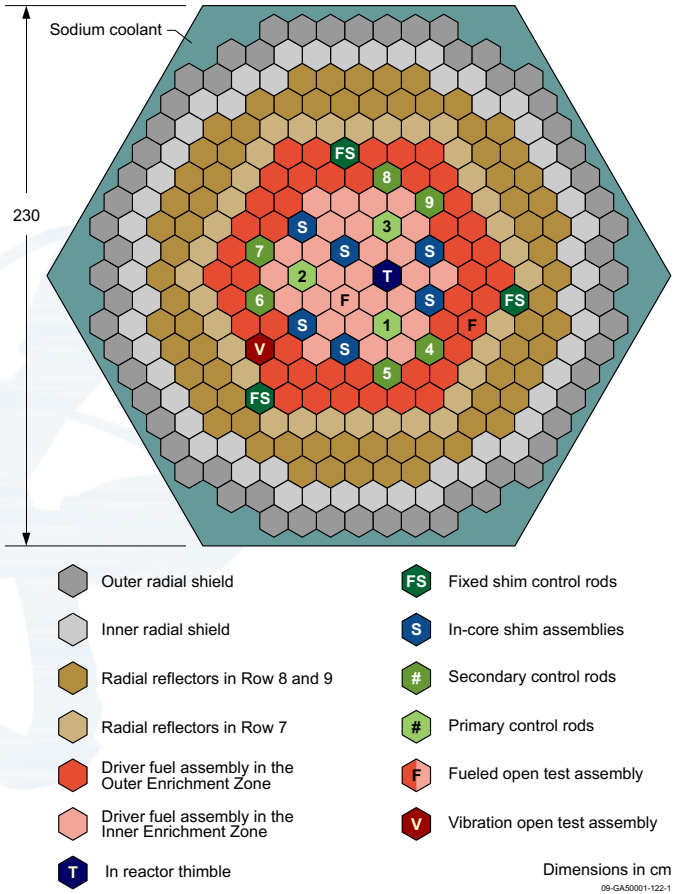
- 1 Revised Evaluation
  - FFTF-LMFR-RESR-001
    - Sample Spectral Calculations
- 1 New Evaluation
  - TREAT-FUND-RESR-003
    - Criticality
    - New graphite TSL x-sec
- New version of IRPhE Database and Analysis Tool (IDAT) released in 2019
  - Web application and version on IRPhEP DVD

Breakdown of Current Reactor Facilities on IRPhEP Handbook

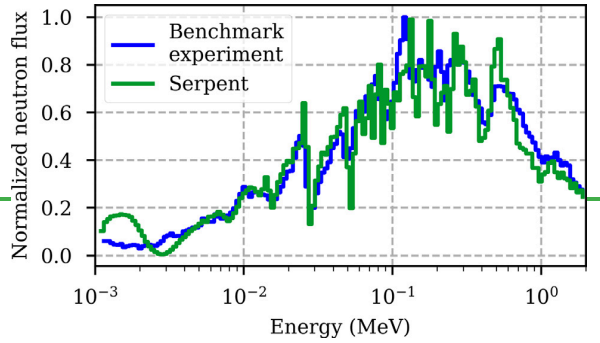
- 7 Pressurized Water Reactor (PWR)
  - BEAVRS, DIMPLE, DUKE, EOLE, OTTOHAHN, SSCR, VENUS
- 3 Vodo-Vodynaoi Energetichesky Reactor (VVER)
  - LR-0, P-Facility, ZR-6
- 0 Boiling Water Reactor (BWR)
- 10 Liquid Metal Fast Reactor (LMFR)
  - BFS-1, BFS-2, BR2, EBR-II, FFTF, JOYO, SNEAK, ZEBRA, ZPPR, ZPR
- 5 Gas Cooled (Thermal) Reactor (GCR)
  - ASTRA, HTR10, HTTR, PROTEUS, VHTRC
- 1 Gas Cooled Fast Reactor (GCFR)
  - PROTEUS
- 5 Light Water Reactor (LWR)
  - CROCUS, DIMPLE, IPEN(MB01), KRITZ, TCA
- 3 Heavy Water Reactor (HWR)
  - DCA, ETA, ZED2
- 1 Molten Salt Reactor (MSR)
  - MSRE
- 1 Reaktor Bolshoy Moshchnosti Kanalniy (RBMK)
  - RBMK(CF)
- 6 Space Reactor (SPACE)
  - ORCEF, SCCA, TOPAZ, UKS1M, ZPPR, ZPR
- 23 Fundamental Physics Reactor Measurements (FUND)
  - ATR, BFS-1, BFS-2, CORAL(1), FCA, FR0, HECTOR, IGR, KUCA, LAMPRE, LR-0, MINERVE, NRAD, ORCEF, ORSPHERE, PBF, RA-6, RB, RHF, TREAT, TRIGA, ZEBRA, ZPR

Revision: FFTF-LMFR-RESR-001

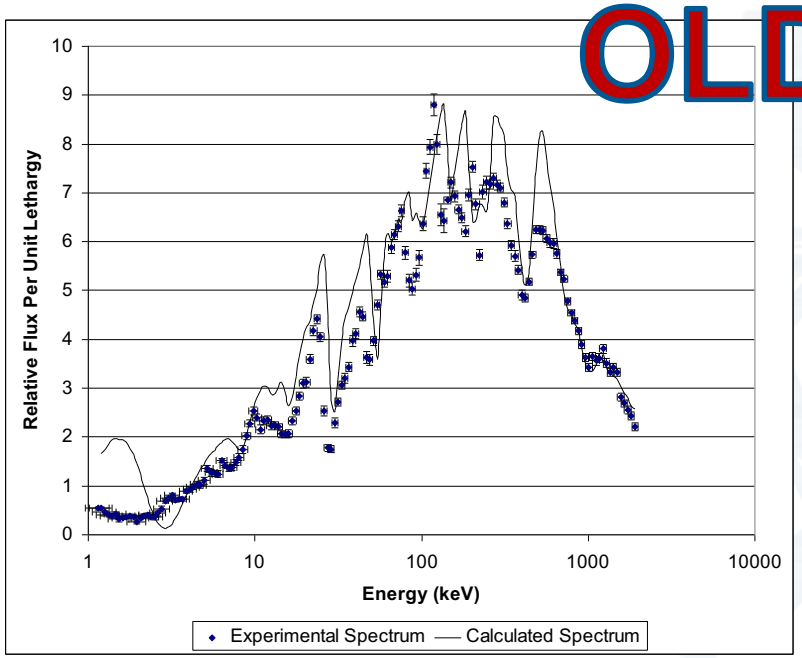
- Error in vertical and lateral placement of the simulated detectors for spectra measurements
- Fairly close to correct lateral positions within the models
- However, both neutron detectors were located in-core, whereas one should have been placed below the active fuel zone



Results: Midplane Neutron Spectra Measurements



OLD



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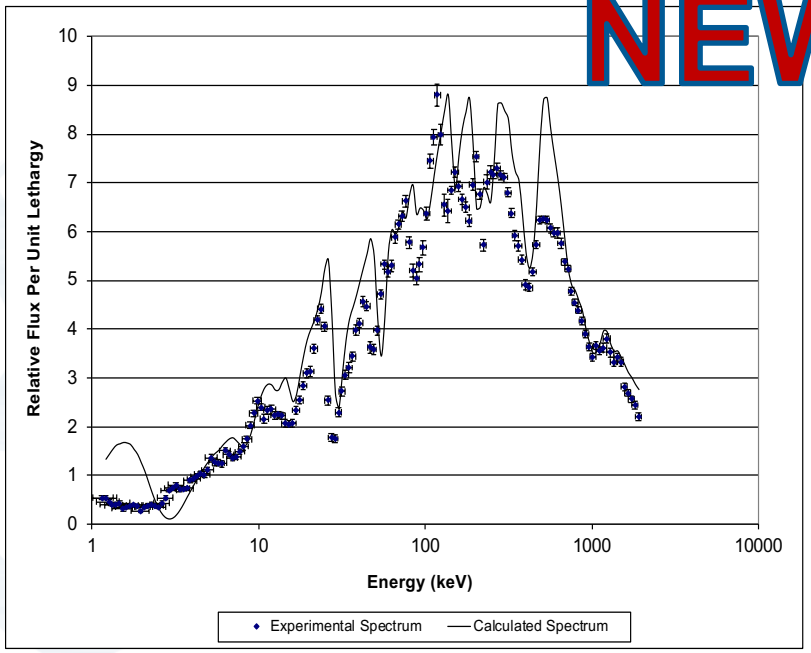
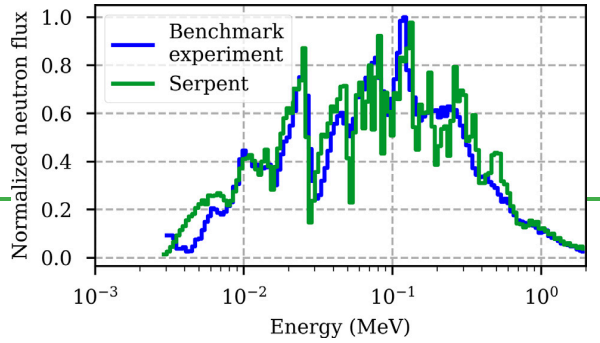


Excellent Agreement

Results: 80-cm Below Midplane Neutron Spectra Measurements



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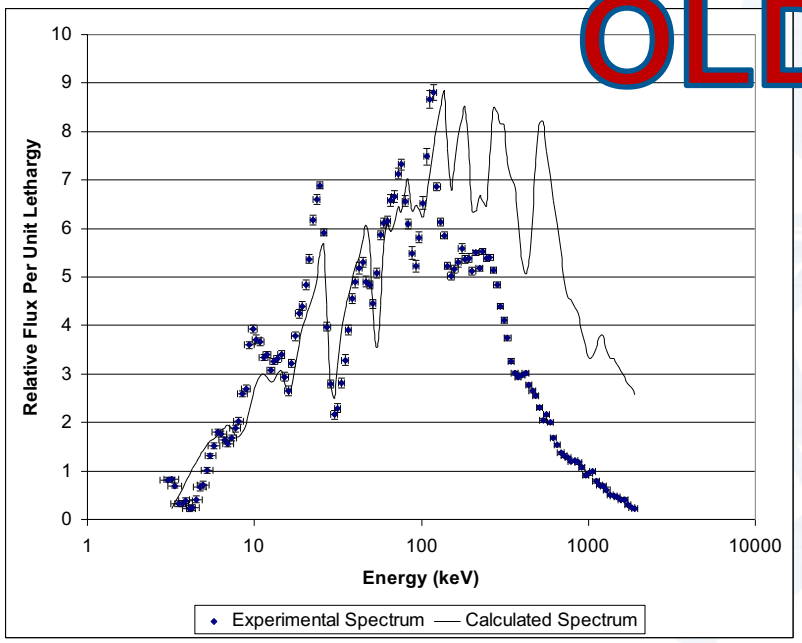
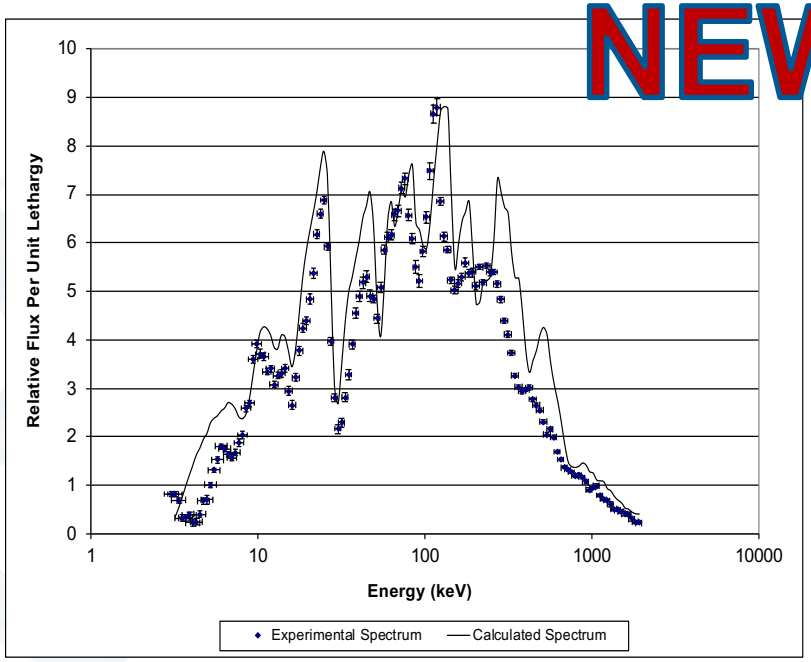
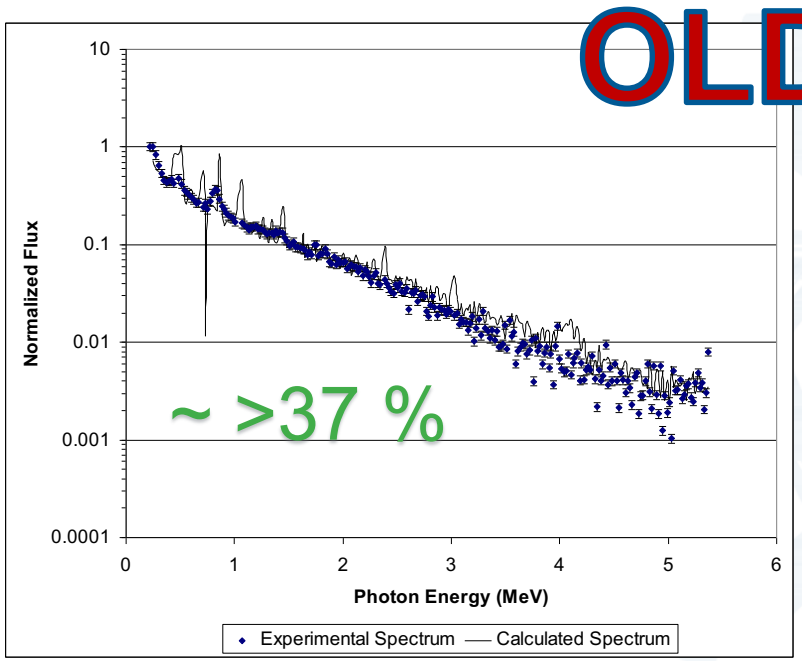


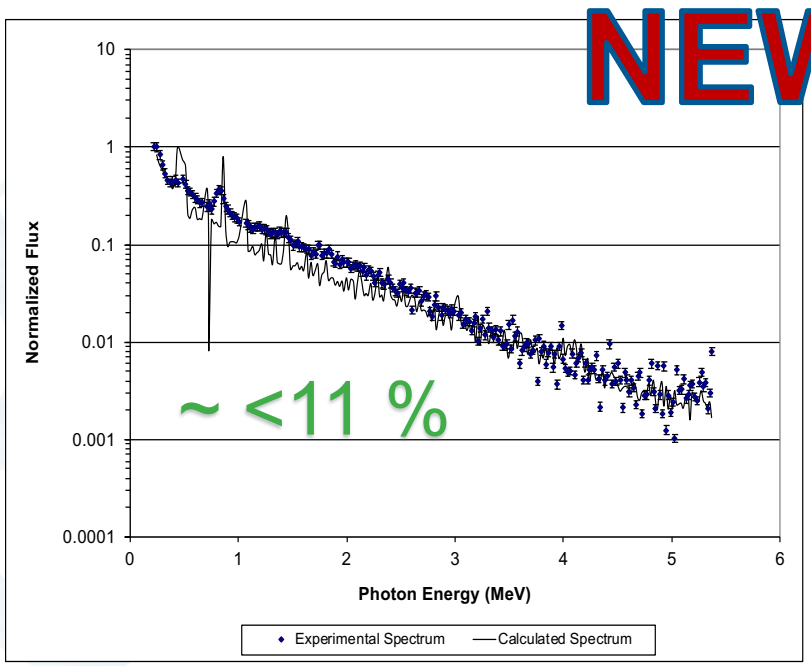
NEW



Improved Agreement

Results: Midplane
Gamma Spectra Measurements

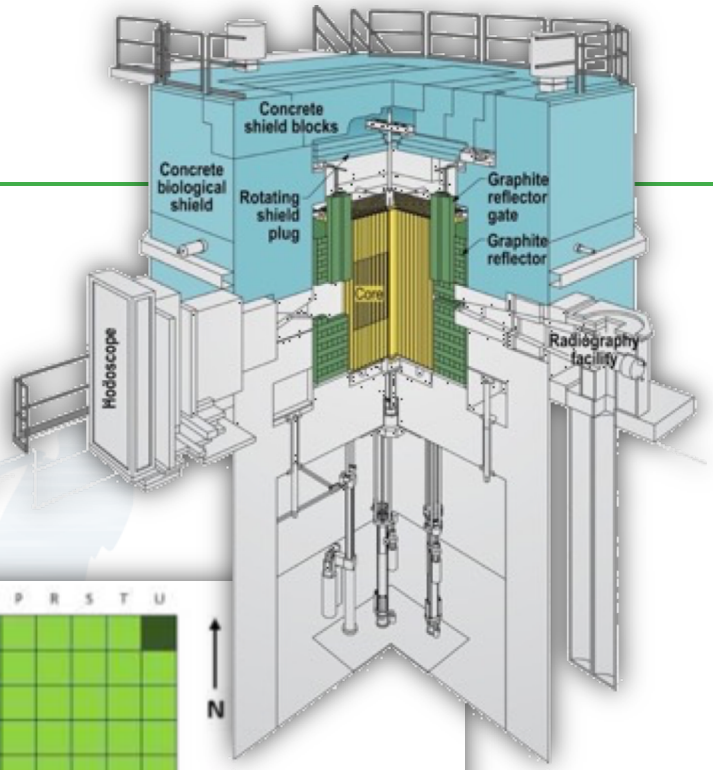


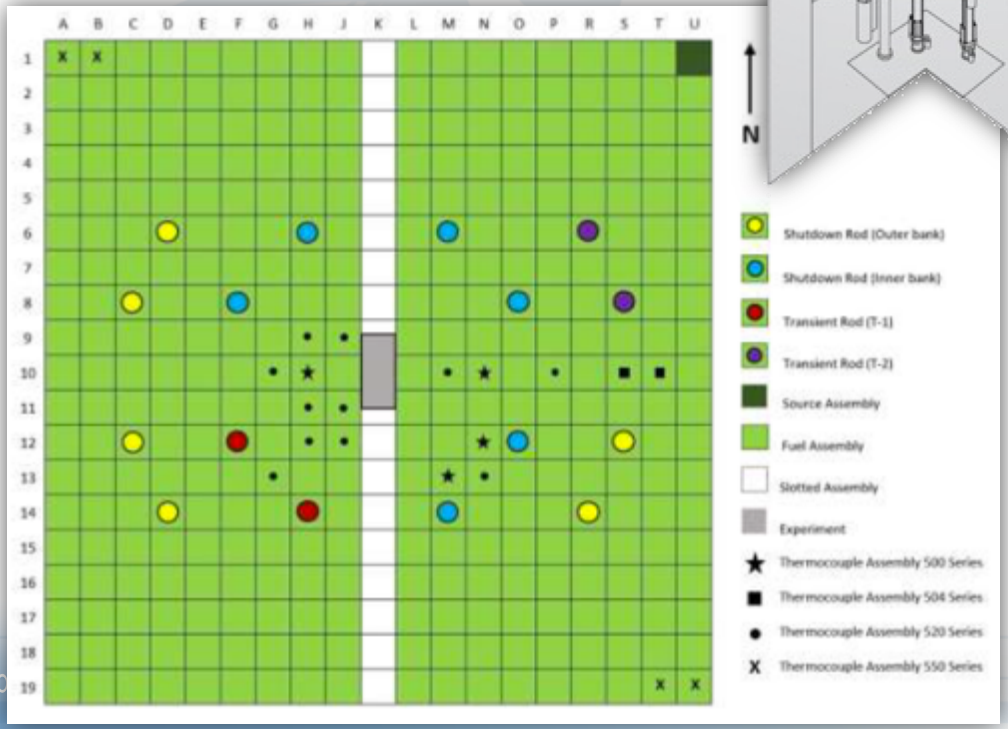


Improved Agreement

New: TREAT-FUND-RESR-003

- Transient Reactor Test Facility – INL
  - NCSU (US)
  - M2CAL Series
- Evaluated
  - Criticality





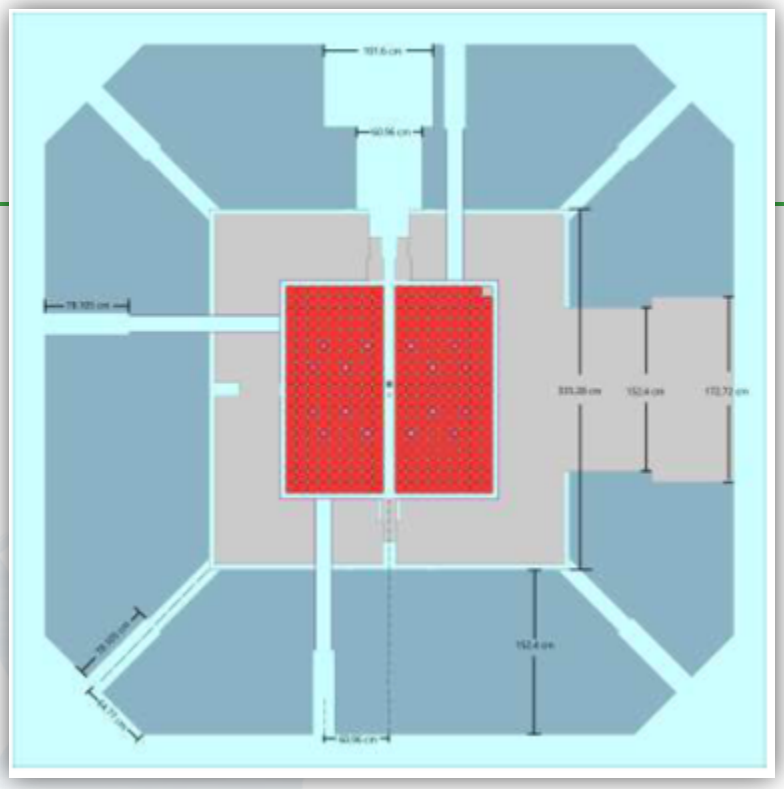
TREAT: Dominant Uncertainties

Final Values

Perturbed Parameter	Parameter Value	±1σ Uncertainty	Δkeff (±1σ)
Fuel U-mass Content (wt%)	0.211	0.004	0.00161
Fuel Density (g/cm^3)	1.73	0.01	0.00092
Fuel Fe Content (wt%)	0.0267	0.0077	-0.00045
Fuel V Content (ppm)	30	9	neg.
Fuel B Content (ppm)	7.53	1.16	-0.00988
Fuel H Content (ppm)	510	266	0.00795
Al-6063 Composition	Max/Min Al		0.00021
Al-6063 Density (g/cm^3)	2.685	0.01	neg.
Al-6061 Composition	Max/Min Al		neg.
Al-6061 Density (g/cm^3)	2.70	0.01	neg.
Al-1100 Composition	Max/Min Al		0.00023
Al-1100 Density (g/cm^3)	2.71	0.01	neg.
Zy-3 Composition*			0.00054
Zy-3 Density (g/cm^3)	6.53	0.01	neg.
CP-2 Graphite Composition	Max/Min C		0.00033
CP-2 Graphite Density (g/cm^3)	1.67	0.0255	0.00140
Total			**0.01296**

TREAT: Criticality

- **Serpent 2.1.29**
  - **ENDF/B-VII.1**
  - **ENDF/B-VIII.0 S(α,β) graphite**



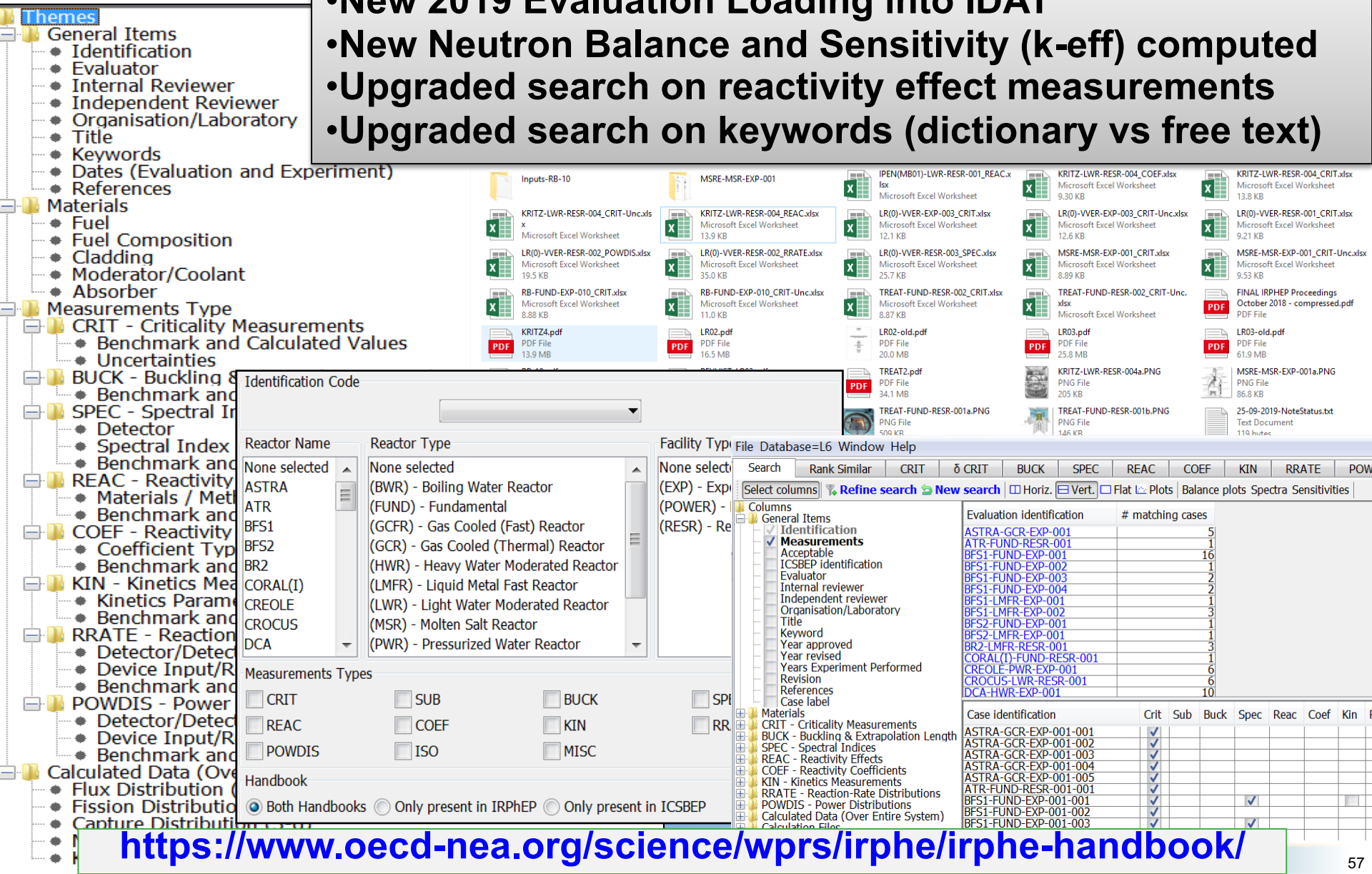
Final Values

Neutron Cross Section Libraries	Calculated* $k_{eff} \pm \sigma$	Benchmark $k_{eff} \pm \sigma$	(C-E)/E %	Difference (pcm)
ENDF/B-VII.1 with ENDF/B-VIII.0 30% porous graphite	1.02414 ± 0.00007	0.9993 ± 0.0130	2.49	2427

* Calculated k_{eff} standard deviation from Monte Carlo statistical error.

International Reactor Physics Handbook Database and Analysis Tool (IDAT)

- New 2019 Evaluation Loading into IDAT
- New Neutron Balance and Sensitivity (k-eff) computed
- Upgraded search on reactivity effect measurements
- Upgraded search on keywords (dictionary vs free text)

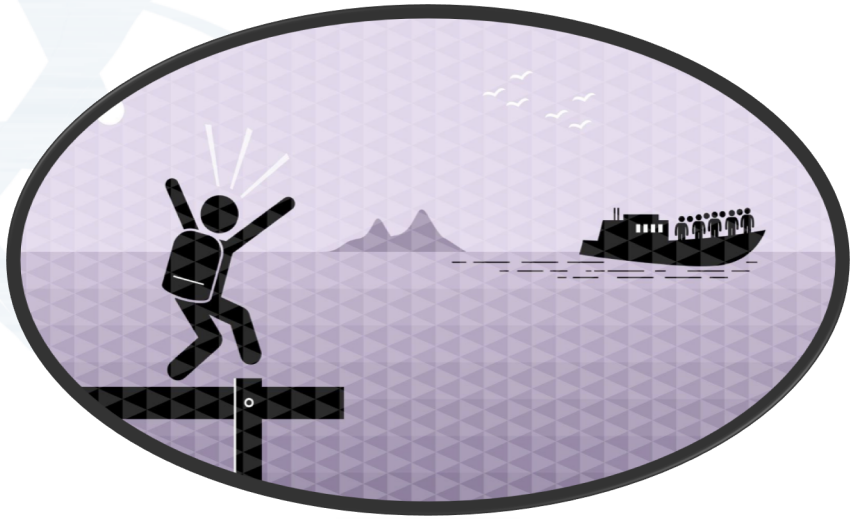


https://www.oecd-nea.org/science/wprs/irphe/irphe-handbook/

Benchmarks with Delayed Publication

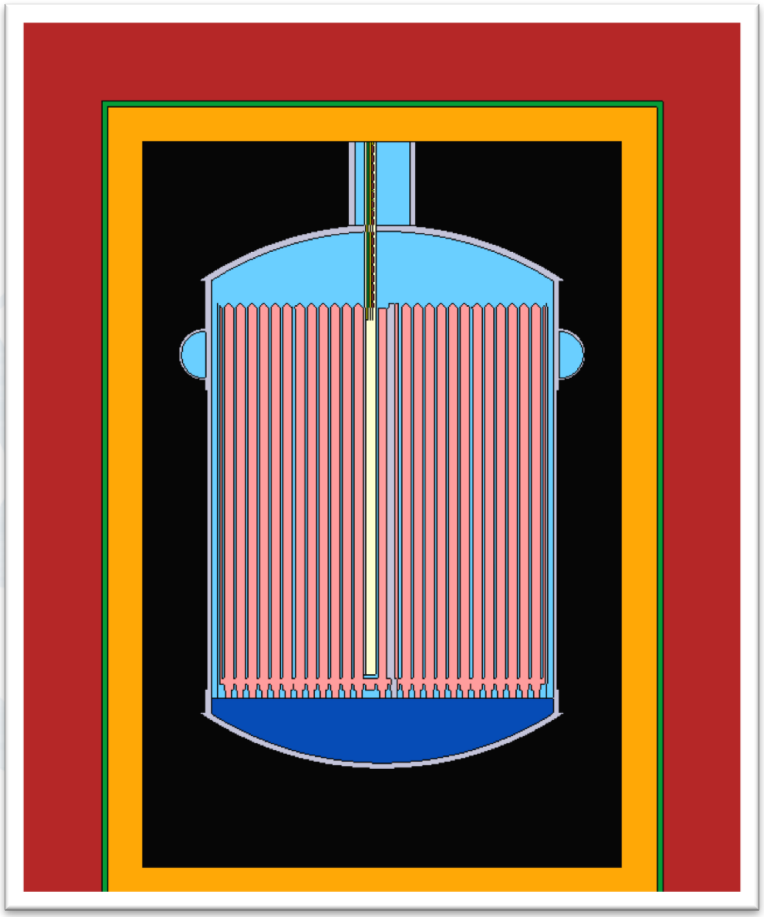
- 1 Revised Evaluation
  - MSRE-MSR-RESR-001
    - Control rod worths
    - Fuel coefficients
- 1 New Evaluations
  - ZPR-GCFR-EXP-001
    - Criticality
    - Neutron spectra
    - Control rod worths
    - Doppler sample worth

- To Be Published in 2021 Edition of the IRPhEP Handbook



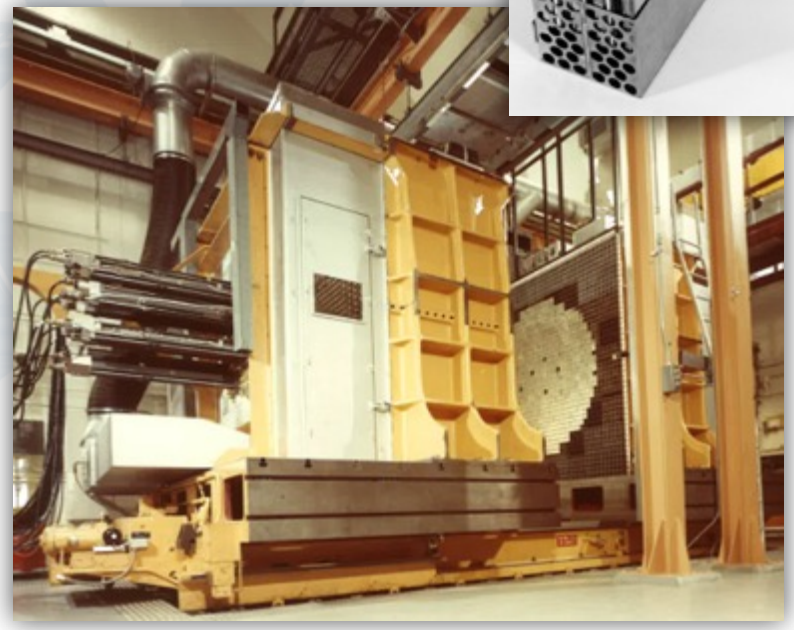
Revision 2021: MSRE-MSR-RESR-001

- **Molten Salt Reactor Experiment – ORNL**
  - U.C. Berkeley & ORNL (US)
  - 62.5LiF-31.6BeF_2-5.1ZrF_4-0.8UF_4
  - 1.408 wt.% ^{235}U
  - Graphite moderated
- **Additional measurements**
  - Reactivity effects measurements
  - Reactivity coefficient measurements



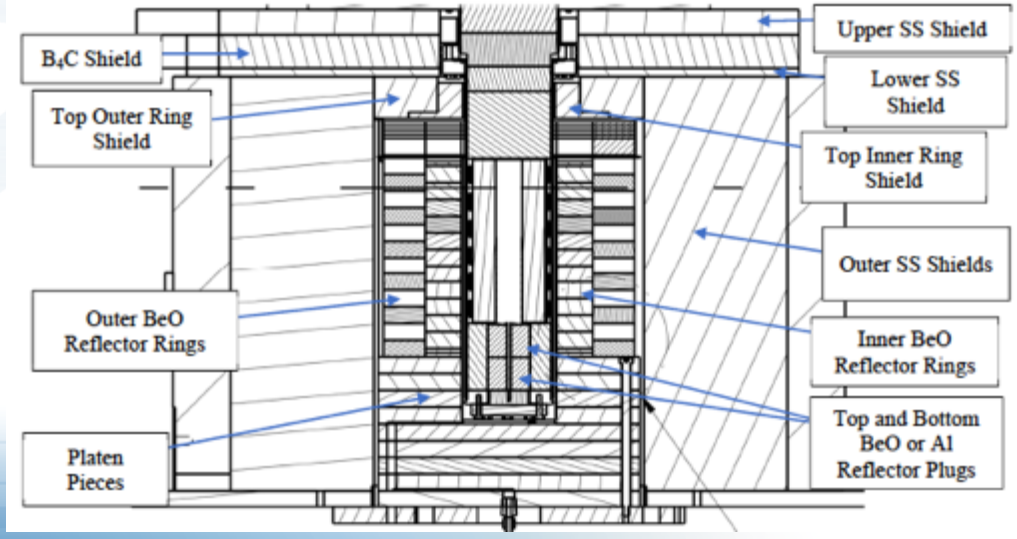
New 2021: ZPR-GCFR-EXP-001

- ZRP-9/29
  - GCFR – Phase II
  - ANL
- Evaluated
  - Criticality
  - Neutron spectra
    - Results within ~5%
  - Control rod worths
  - Doppler sample worth
    - Results pending

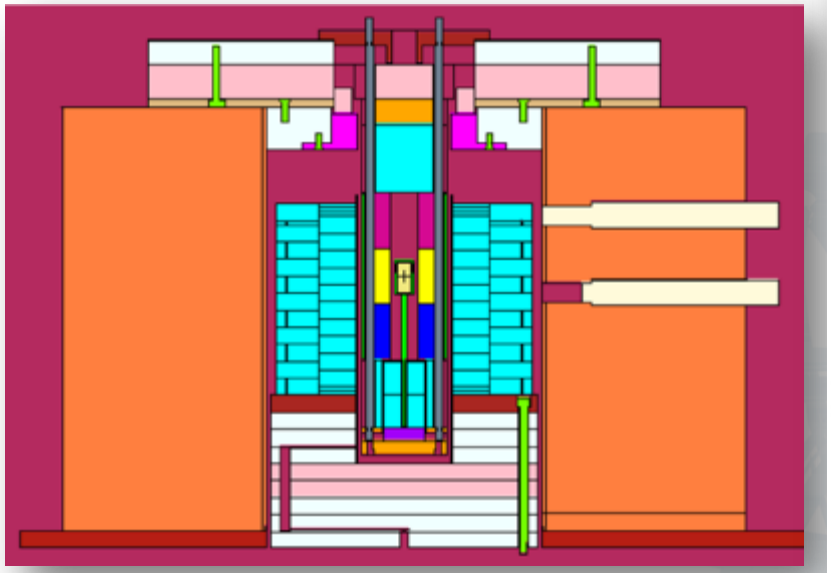


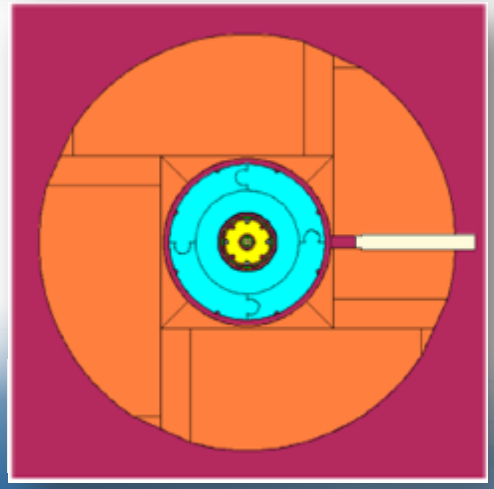
New ICSBEP 2021: KRUSTY (HEU-MET-FAST-101)

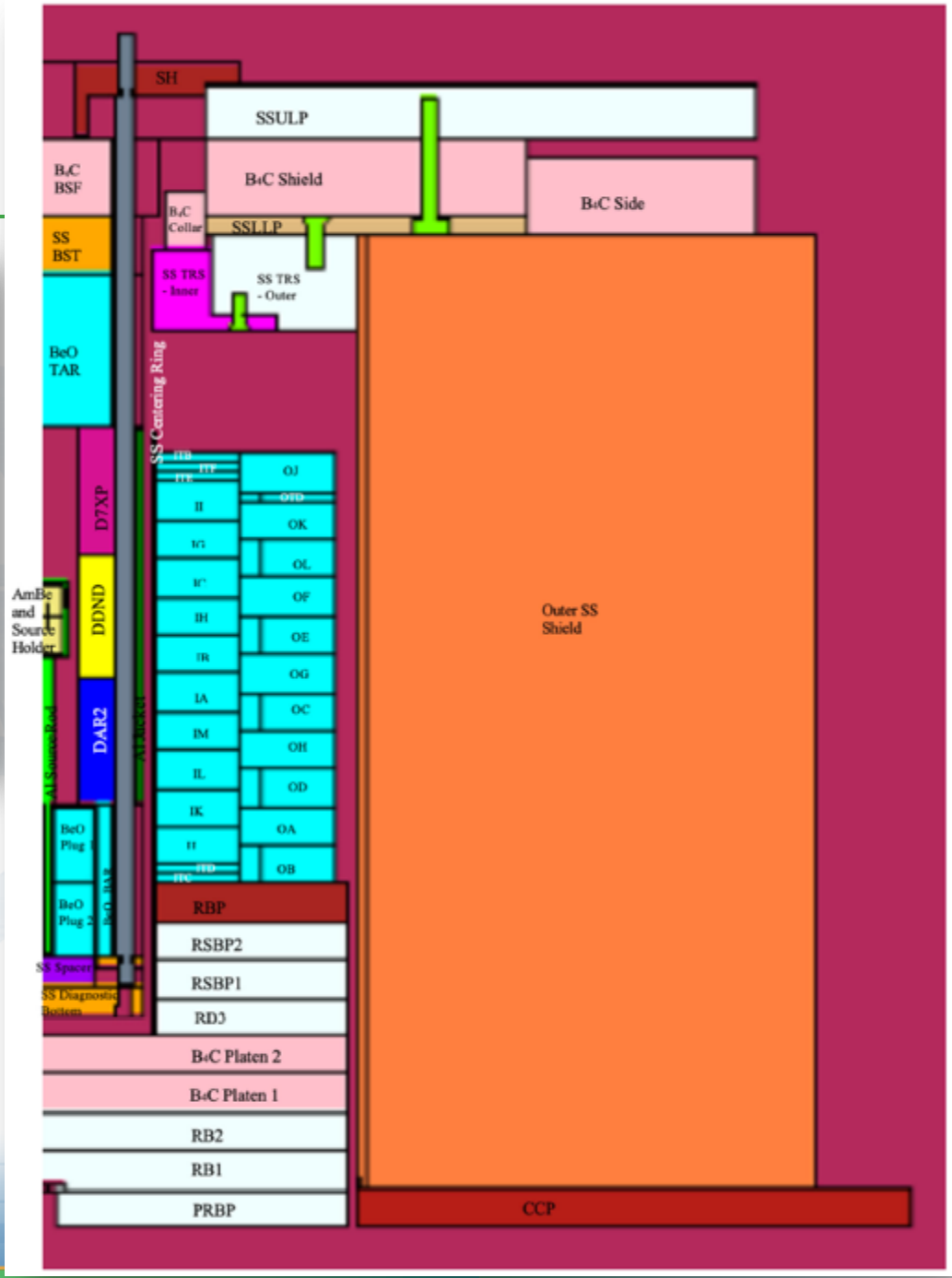
- Kilopower Reactor Using Stirling Technology (KRUSTY) demonstration
  - Nov 2017 – Jan 2018
  - HEU annulus
  - BeO reflected
  - Comet vertical lift assembly
  - NCERC/LANL
- First benchmarks for 5 critical configurations
  - Future benchmarks expected covering other aspects of experimental series



KRUSTY: MCNP Models







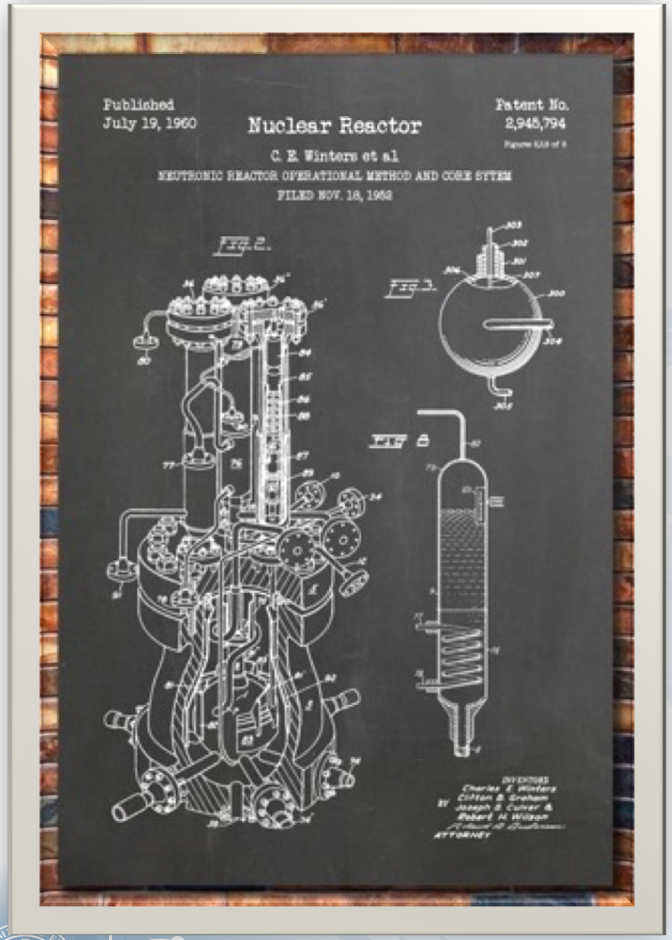
Potential Future Benchmark Evaluations – I

- **Brazil**
  - IPEN/MB-01 experiments to test delayed neutron data
- **Canada**
  - ZED-2 Experiments
- **China**
  - CEFR
- **Czech Republic**
  - N-transport Si-beam in Pb, or Fe
  - RPV configuration
  - VR1 with IRT-4M Fuel
  - VVER-1000 w/ SiO_2 or graphite core
  - SiO_2 space reactor
  - Molten salt
- **France**
  - BERENICE
  - ERMINE I-V
  - SEFOR
  - SNEAK 12A & 12B
- **Japan**
  - FCA IX-1 or IX-6 CRIT
  - FCA IX MA measurements
  - Pb/Void measurements
  - TCA Am-241
  - KUCA experiments
- **Russia**
  - ASTRA U-235 RRATE measurements

Potential Future Benchmark Evaluations – II

- Serbia
  - RB Reactor
- Slovenia
  - TRIGA Au(n,g) RRATE
- Sweden
  - KRITZ-1/-2 BWR data
- Switzerland
  - CROCUS measurements
  - HCLWR-PROTEUS
  - PETALE: SS
- UK
  - DIMPLE CERES II
  - PFR MA measurements
- US
  - AGN reactor
  - ATR CIC 2022
  - KRUSTY measurements
  - LWBR program
  - TREAT measurements
  - TRIGA 3D n-flux and temperature *
  - TSL FLiBe: TBD *
  - TSL Graphite: ORELA *
  - TSL Water: TBD *
  - TVA Watts Bar HZP ZPPT

Other IRPhEP Archives



Primary documentation and other benchmarks

Recently added primary documentation archives (Last update December 2008)

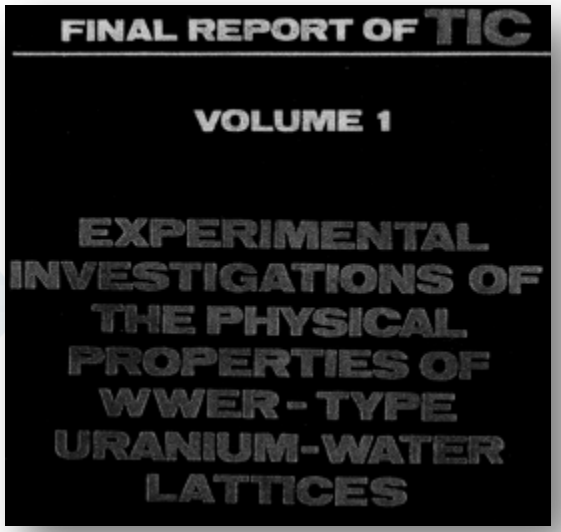
- IRPHE/B&W-SS-LATTICE, Spectral Shift Reactor Lattice Experiments
- IRPHE-JAPAN, Reactor Physics Experiments carried out in Japan
- IRPHE/JOYO MK-II, JOYO MK-II core management and characteristics database
- IRPhE/RRR-SEG, Reactor Physics Experiments from Fast-Thermal Coupled Facility
- IRPHE-SNEAK, KFK SNEAK Fast Reactor Experiments, Primary Documentation
- IRPhE/STEK, Reactor Physics Experiments from Fast-Thermal Coupled Facility
- IRPHE-ZEBRA, AEEW Fast Reactor Experiments, Primary Documentation
- IRPHE-DRAGON-DPR, OECD High Temperature Reactor Dragon Project, Primary Documents
- IRPHE-HTR-ARCH-01, Archive of HTR Primary Documents
- IRPHE/AVR, AVR High Temperature Reactor Experience, Archival Documentation
- IRPHE-KNK-II-ARCHIVE, KNK-II fast reactor documents, power history and measured parameters
- IRPhE/BERENICE, effective delayed neutron fraction measurements
- IRPhE-TAPIRO-ARCHIVE, fast neutron source reactor primary documents, reactor physics experiments

Other benchmarks in reactor physics (coupled neutronics/thermal-hydraulics - coupling core-plant)

- ZZ 3DLWRCT, 3-D LWR Rod Ejection and Rod Withdrawal Benchmarks
- ZZ BFBT, OECD/NEA-US/NRC NUPEC BWR Full-size Fine-mesh Bundle Tests Benchmark
- ZZ BWRSB-FORSMARKS, Stability Benchmark Data from BWR FORSMARKS 1 and 2
- ZZ BWRSB-RINGHALS1, Stability Benchmark Data from BWR RINGHALS-1
- ZZ BWRTT, BWR Turbine Trip Transient Benchmark Based on Peach-Bottom 2
- ZZ PBMR-400: PBMR Coupled Neutronics/Thermal Hydraulics Transient Benchmark
- ZZ PWR-MSLB, PWR Main Steam-Line Break Benchmarks, Coupled Neutronics Thermal-Hydraulics
- ZZ V1000CT-1 VVER-1000 Main Coolant Pump (MCP) Switching On Benchmark
- ZZ WPPR Pu Recycling Benchmark Results
- ZZ UAM-LWR Uncertainty Analysis in Modelling, Coupled Multi-physics and Multi-scale LWR analysis

TIC VVER Documents Will Also be Archived

- Temporary International Collective (TIC) for Joint Research into the Physics of VVER-Type Reactors
- Published in Budapest in 1985
- Primary reference for some of the VVER benchmarks
- 5 volumes, supplemental report, and journal article
- Recommended to create OECD NEA IRPhEP archive
  - https://www.oecd-nea.org/science/wprs/irphe/documentation.html



Conclusions

- The IRPhEP and ICSBEP continue to provide high-quality integral benchmark data
- Valuable for nuclear data testing, uncertainty reduction, criticality safety, reactor physics, advanced modeling and simulation
- Data contributed from 26 countries
- Enable current and future activities supported by experimental validation