

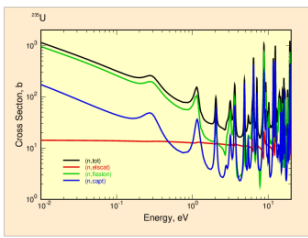
A periodic table of elements with various properties listed for each element. The table is color-coded and includes columns for atomic number, element symbol, name, and other properties. The title is "PERIODIC TABLE Atomic Properties of the Elements" and it is attributed to NIST.

ICSBEP ... more than just k_{eff}

Dr. A. C. (Skip) Kahler
Kahler Nuclear Data Services, LLC

Presented at the
IAEA Consultant's Meeting on
International Radiation Characterization Benchmark Experiment
Project (IRCBEP)

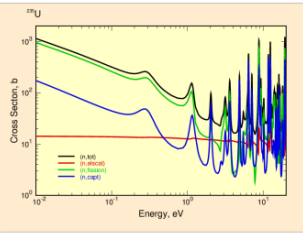
August 6 – 8, 2018
Vienna, Austria



ICSBEP ... a brief review

- ICSBEP = International Criticality Safety Benchmark Evaluation Project.
 - Evaluated benchmark experiment descriptions are distributed via DVD, or the web at <https://www.oecd-nea.org/science/wpncs/icsbep/handbook.html>.
- Started in 1992 by the US Department of Energy ... CSBEP at that time.
- Expanded to include International partners in 1994; affiliated with the OECD/NEA in 1995.
- The original Handbook was published in hardcopy form ... seven 3" 3-ring binders.
- Virtually all evaluated experiments are identified using a XXX-YYY-ZZZ-###.# nomenclature.
 - XXX defines the fuel ... HEU, IEU, LEU, Pu, MIX (Pu-U), 233U, SPEC ... one volume per fuel system.
 - HEU is $\geq 60\%$ ^{235}U ; LEU is $\leq 10\%$ ^{235}U ; rest is INTERmediate.
 - YYY is fuel form ...
 - MET=metal; COMP=compound (e.g., UO_2); SOL=solution; MISC if a mixture of forms.
 - ZZZ is a average spectrum energy indicator ...
 - FAST is 50% or more greater than 100 keV, THERM is 50% or more less than 0.625 eV; rest in INTERmediate; MIXED is no category is greater than 50%.
- The Handbook is updated ~annually.

ICSBEP ... a brief review



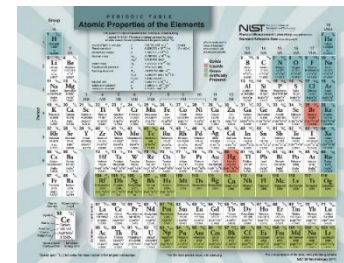
➤ ICSBEP = International Criticality Safety Benchmark Evaluation Project.

➤ Web site at <https://www.oecd-nea.org/science/wpncs/icsbep/handbook.html>.

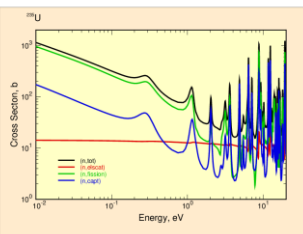
➤ Some Handbook statistics ...

➤ Now nine volumes

- Criticality alarm/Shielding (beginning in 2004).
- Fundamental Physics (beginning in 2006).



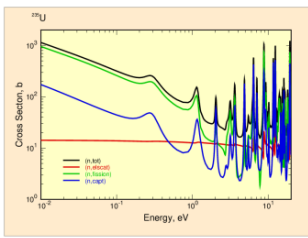
ICSBEP ... a brief review



- Nine volumes, 70,000+ pages ... how can you find what you want?

- (1) The old fashioned way ... if you're in this meeting I'm not the first person to call you a "nerd" ... and nerds love to read ... so settle into comfortable chair and eNJOY yourself ...

- (2) Our friends at the OECD NEA Data Bank have developed a ICSBEP database search tool ... DICE.
 - DICE = Database of International Criticality Experiments



DICE ...

➤ DICE is packaged with the ICSBEP DVD, or ...

➤ DICE is available online at <https://www.oecd-neo.org/science/wpncs/icsbep/dice.html>.

Home About Us News Work Areas Data Bank Publications Delegates' Area

NEA NUCLEAR ENERGY AGENCY

Nuclear science » WPNCs » ICSBEP

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

[Launch DICE](#)

DISCLAIMER: this online version does not include PDF evaluation files nor calculated data files. If you have received a DVD, please modify the Settings paths to point to your local files.

The ICSBEP released the first version of the Database for the International Handbook of Evaluated Criticality Safety Benchmark Experiments (DICE) in 2001. This database and corresponding user interface is included in the ICSBEP Handbook allowing easier access to information. Selected information from each configuration was entered into DICE, providing a synthetic description of the experiments. These include geometry, fuel composition, moderation and reflection conditions and spectrum characteristics.

DICE accomplishes two main objectives:

1. It provides a summary description of each experimental configuration where the main characteristics of the experiments are displayed in a uniform format.
2. It allows users to search the handbook for experimental configurations that satisfy their unique input criteria.

DICE provides the user with access to several categories of data, including:

- Detailed 1-group neutron balance data for each configuration with individual isotope contributions in different regions of the geometry.
- Flux and other reaction rates spectra in a 299-group energy scheme. Plotting capabilities were implemented into DICE allowing the user to compare the spectra of selected configurations in the original fine energy structure or on any user-defined broader energy structure.
- Sensitivity coefficients (percent changes of k-effective due to elementary change of basic nuclear data) for the major nuclides and nuclear processes in a 30-group and 238-group energy structure. These data are currently only available for about 80% of experimental configurations.

DICE is still in the development phase and is subject to data entry errors and omissions. The International Handbook remains the primary source of criticality safety benchmark data.

To learn more about DICE, consult the user's manual ([DICE User's manual 1.8 MB](#)) or watch the following demonstration videos:

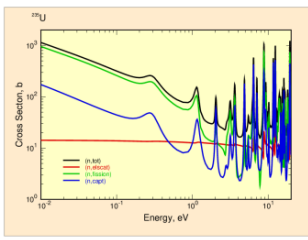
- [Sensitivity Search \[MP4\]](#)
- [Trend Plots \[MP4\]](#)

ICSBEP

- About
- International Participants
- ICSBEP Handbook
- ICSBEP Database (DICE)
- [Request a copy](#)

Useful links

- Computer Program Service abstract
- NEA International Reactor Physics Benchmark Experiments (IRPHE) Project
- NEA Databank
- ICSBEP Technical Review Group
- IRPHE-IDAT IDAT Prototype Test Group
- NDAeST (Nuclear Data Sensitivity Tool)



DICE ...



➤ What you see when DICE starts up ...

➤ Search categories include ...

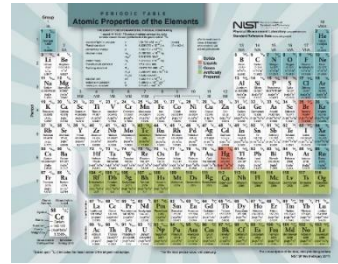
- Critical/Subcritical (shown here)
- Alarm/Shielding
- Fundamental Physics

➤ Lots of subcategories ...

The screenshot shows the DICE software interface. The 'Critical / Subcritical' tab is selected and circled in red. The interface is divided into several sections:

- Left Panel (Tree View):** A hierarchical list of search categories. The 'Critical / Subcritical' category is highlighted. Other categories include 'General Items', 'Fuel', 'Moderator/coolant material', 'Geometry', and 'Energy, spectra, sensitivities'.
- Top Panel (Tabs):** A row of tabs including 'Critical / Subcritical', 'Alarm / Shielding', 'Fundamental Physics', 'Correlation Matrix', 'Rank Similar', and 'Keff trends plots'. The 'Critical / Subcritical' tab is active and circled in red.
- Main Content Area:** Three columns of search results:
 - Fissile material:** Lists options like (PU) - Plutonium, (HEU) - Highly Enriched Uranium, (IEU) - Intermediate Enriched Uranium, (LEU) - Low Enriched Uranium, (U233) - Uranium-233, (MDX) - Mixed Plutonium - Uranium, and (SPEC) - Special Isotope.
 - Physical form:** Lists options like (MET) - Metal, (SOL) - Solution, (COMP) - Compound, and (MISC) - Miscellaneous.
 - Spectrum:** Lists options like (FAST) - Fast, (INTER) - Intermediate-Energy, (THERM) - Thermal, and (MIXED) - Mixed.
- Bottom Panel:** A 'Query' field with a 'Search !' button. There are also radio buttons for 'Subcritical' (Critical and subcritical, Critical, Subcritical) and 'Acceptable' (Acceptable and unacceptable, Acceptable, Unacceptable).

DICE ... reaction rate ratio measurements



➤ Fundamental Physics ...

➤ Reaction rate ratio ...

DICE
File Database=LocalShared Personal-Keff Windows Help

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

Themes

- General Items
 - Identification
 - Evaluator
 - Internal reviewer
 - Independent reviewer
 - Main purpose
 - Title
 - Keywords
 - Dates (evaluation and experiment)
 - References
- Target
 - Target
- Source
 - Particle & strength
 - Time dependency
 - Geometry
- Detector
 - Type
 - Efficiency

Identification code

Facility	Source type	Target material	Experiment type
None selected	None selected	None selected	None selected
(NIST) - National Institute of Standards and Technology	(1/E) - Slowing Down	(U235) - Uranium-235	(FISS) - Fission
(LLNL) - Lawrence Livermore National Laboratory	(DT) - Fusion	(U238) - Uranium-238	(CAPT) - Capture
(OU) - Osaka University (Oktavian)	(ALPHAN) - Alpha-n	(NP237) - Neptunium-237	(NTOF) - Neutron Time of Flight
(VNIITF) - Russian Federal Nuclear Research Center	(CF) - Californium Fission	(PU239) - Plutonium-239	(TRANM) - Transmission
(IPPE) - Institute of Physics and Power Engineering	(AM) - Americium Fission	(BE) - Beryllium	(RRR) - Reaction Rate Ratios
(JINR) - Joint Institute for Nuclear Research	(VDG) - Van de Graaf Accelerator	(PB) - Lead	(MULT) - Multiple
(NCERC) - National Criticality Experiment	(FR) - Fast Reactor	(MG) - Magnesium	(HE3) - Helium-3
	(PU) - Plutonium Fission	(MGO) - Magnesium Oxide	
		(MULT) - Multiple	
		(HE3) - Helium-3	

Query

Number of cases
Title
Case label

Clear

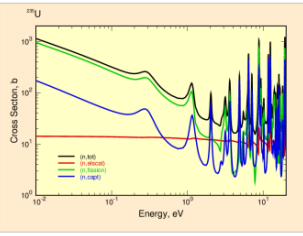
Search !

History :

8 Evaluations, 137 Cases

48M of 494M

DICE ... reaction rate ratio measurements



➤ Fundamental Physics ...

➤ Reaction rate ratio ...

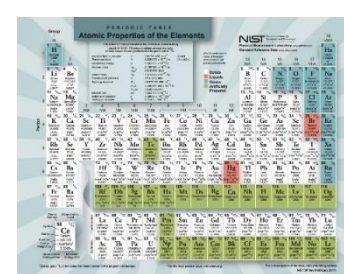
➤ Seems like only one experiment ...

➤ But additional data are available when searching beyond the official ICSBEP database ...

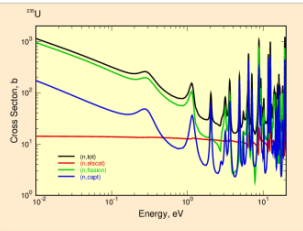
The screenshot shows the DICE software interface with the following components:

- Menu:** File, Database=LocalShared, Personal=Jeff, Window, Help
- Navigation:** Critical / Subcritical, Alarm / Shielding, Fundamental Physics (selected), Correlation Matrix, Rank Similar, Keff trends plots
- Search Tools:** Select columns, Refine search, New search, Horiz., Vert., Flat, Plots, ParPlots, PDF, HTML
- Columns Panel:**
 - General Items: Identification (checked), Evaluator, Internal reviewer, Independent reviewer, Main purpose, Title (checked), Keyword, Year approved, Year revised, Years experiment performed, Revision, References, Number of cases (checked), Case label (checked)
 - Target: Material
 - Source: Particle, Time dependency, Frequency (Hz), Strength, Geometry
 - Detector: Type, Size, Efficiency
- Table:**

Evaluation identification	Number of cases	Title	Case identification	Case label
FUND-IPPE-FR-MULT-RRR-001	45	CROSS SECTION RATIOS FOR MANY NUCLIDES MEASURED IN T	FUND-IPPE-FR-MULT-RRR-001-001	Th-232(n,f)
			FUND-IPPE-FR-MULT-RRR-001-002	U-233(n,f)
			FUND-IPPE-FR-MULT-RRR-001-003	U-234(n,f)
			FUND-IPPE-FR-MULT-RRR-001-004	U-236(n,f)
			FUND-IPPE-FR-MULT-RRR-001-005	U-238(n,f)
			FUND-IPPE-FR-MULT-RRR-001-006	Np-237(n,f)
			FUND-IPPE-FR-MULT-RRR-001-007	Pu-239(n,f)
			FUND-IPPE-FR-MULT-RRR-001-008	Pu-240(n,f)
			FUND-IPPE-FR-MULT-RRR-001-009	Pu-241(n,f)
			FUND-IPPE-FR-MULT-RRR-001-010	Pu-242(n,f)
			FUND-IPPE-FR-MULT-RRR-001-011	Am-241(n,f)
			FUND-IPPE-FR-MULT-RRR-001-012	Th-232(n,y)
			FUND-IPPE-FR-MULT-RRR-001-013	U-236(n,y)
			FUND-IPPE-FR-MULT-RRR-001-014	U-238(n,y)
			FUND-IPPE-FR-MULT-RRR-001-015	Np-237(n,y)
			FUND-IPPE-FR-MULT-RRR-001-016	Th-232(n,2n)
			FUND-IPPE-FR-MULT-RRR-001-017	U-238(n,2n)
			FUND-IPPE-FR-MULT-RRR-001-018	Nb-93(n,2n)Nb-92-M
			FUND-IPPE-FR-MULT-RRR-001-019	Al-27(n,a)Cr-51
			FUND-IPPE-FR-MULT-RRR-001-020	Fe-54(n,a)Cr-51
			FUND-IPPE-FR-MULT-RRR-001-021	Co-59(n,a)Mn-56
			FUND-IPPE-FR-MULT-RRR-001-022	Mo-92(n,a)Zr-89
			FUND-IPPE-FR-MULT-RRR-001-023	Nb-93(n,a)Y-90-M
			FUND-IPPE-FR-MULT-RRR-001-024	Mg-24(n,p)Na-24
			FUND-IPPE-FR-MULT-RRR-001-025	Al-27(n,p)Mg-27
			FUND-IPPE-FR-MULT-RRR-001-026	Ti-46(n,p)Sc-46
			FUND-IPPE-FR-MULT-RRR-001-027	Ti-47(n,p)Sc-47
			FUND-IPPE-FR-MULT-RRR-001-028	Ti-48(n,p)Sc-48
			FUND-IPPE-FR-MULT-RRR-001-029	Fe-54(n,p)Mn-54
			FUND-IPPE-FR-MULT-RRR-001-030	Fe-56(n,p)Mn-56
			FUND-IPPE-FR-MULT-RRR-001-031	Ni-58(n,p)Co-58
			FUND-IPPE-FR-MULT-RRR-001-032	Co-59(n,p)Fe-59
			FUND-IPPE-FR-MULT-RRR-001-033	Mo-92(n,p)Nb-92-M
			FUND-IPPE-FR-MULT-RRR-001-034	Cr-50(n,y)Cr-51
			FUND-IPPE-FR-MULT-RRR-001-035	Mn-55(n,y)Mn-56
			FUND-IPPE-FR-MULT-RRR-001-036	Fe-58(n,y)Fe-59
			FUND-IPPE-FR-MULT-RRR-001-037	Co-59(n,y)Co-60
			FUND-IPPE-FR-MULT-RRR-001-038	Ni-64(n,y)Ni-65
			FUND-IPPE-FR-MULT-RRR-001-039	Cu-63(n,y)Cu-64
			FUND-IPPE-FR-MULT-RRR-001-040	Cu-65(n,y)Cu-66
			FUND-IPPE-FR-MULT-RRR-001-041	Mo-98(n,y)Mo-99
			FUND-IPPE-FR-MULT-RRR-001-042	Zr-94(n,y)Zr-95
			FUND-IPPE-FR-MULT-RRR-001-043	Zr-96(n,y)Zr-97
			FUND-IPPE-FR-MULT-RRR-001-044	In-115(n,n)In-115-M
			FUND-IPPE-FR-MULT-RRR-001-045	Au-197(n,y)Au-198
- Footer:** 1 Evaluation, 45 Cases | 42M of 494M



Reaction Rate Ratio Measurements



➤ But additional data are available when searching beyond the official ICSBEP database ...



Available online at www.sciencedirect.com

ScienceDirect

Nuclear Data Sheets 118 (2014) 1–25

Nuclear Data Sheets

www.elsevier.com/locate/nds

➤ From the ND2013 Conference ...

➤ All measured data were recently re-analyzed/updated to modern nuclear data

- Godiva (central region)
- Jezebel (central region)
- Flattop-25 (central and radial)
- Flattop-Pu (central and radial)

The CIELO Collaboration: Neutron Reactions on ^1H , ^{16}O , ^{56}Fe , $^{235,238}\text{U}$, and ^{239}Pu

M.B. Chadwick,^{1,*} E. Dupont,² E. Bauge,³ A. Blokhin,⁴ O. Bouland,⁵ D.A. Brown,⁶ R. Capote,⁷ A. Carlson,⁸ Y. Danon,⁹ C. De Saint Jean,⁵ M. Dunn,¹⁰ U. Fischer,¹¹ R.A. Forrest,⁷ S.C. Frankle,¹ T. Fukahori,¹² Z. Ge,¹³ S.M. Grimes,¹⁴ G.M. Hale,¹ M. Herman,⁶ A. Ignatyuk,⁴ M. Ishikawa,¹² N. Iwamoto,¹² O. Iwamoto,¹² M. Jandel,¹ R. Jacqmin,¹ T. Kawano,¹ S. Kunieda,¹² A. Kahler,¹ B. Kiedrowski,¹ I. Kodeli,¹⁵ A.J. Koning,¹⁶ L. Leal,¹⁰ Y.O. Lee,¹⁷ J.P. Lestone,¹ C. Lubitz,¹⁸ M. MacInnes,¹ D. McNabb,¹⁹ R. McKnight,²⁰ M. Moxon,²¹ S. Mughabghab,⁶ G. Noguere,⁵ G. Palmiotti,²² A. Plompen,²³ B. Pritychenko,⁶ V. Pronyaev,⁴ D. Rochman,¹⁶ P. Romain,³ D. Roubtsov,²⁴ P. Schillebeeckx,²³ M. Salvatores,⁵ S. Simakov,⁷ E.Sh. Soukhovitskii,²⁵ J.C. Sublet,²⁶ P. Talou,¹ I. Thompson,¹⁹ A. Trkov,¹⁵ R. Vogt,¹⁹ and S. van der Marck¹⁶

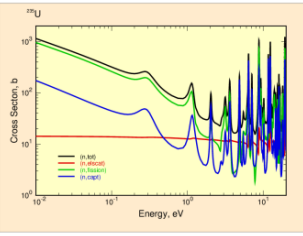
The CIELO Collaboration ...

NUCLEAR DATA SHEETS

M.B. Chadwick *et al.*

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		E. $^{252}\text{Cf}(sf)$ Cross Sections 20
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2. Elastic Scattering	5	
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1. Summary of the Evaluations	5	

Supplemental Experimental Measurements



➤ Additional data may also be found that are not categorized in DICE ...

➤ Back to Option (1) on how to search 9 volumes and 70,000+ pages ...

➤ From Section 1.4 (Supplemental Experimental Measurements) in LEU-COMP-THERM-008 ...

➤ ... and Appendix B ...

1.4 Supplemental Experimental Measurements

In addition to determination of the critical soluble boron concentration, several other

NEA/NSC/DOC(95)03/IV
Volume IV

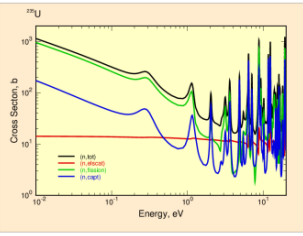
LEU-COMP-THERM-008

APPENDIX B: MEASUREMENTS OF ROD-BY-ROD POWER DENSITIES

In addition to measurements of the critical boron concentrations, measurements of the fission rates were made in some fuel rods in some of the experiments. In particular, "[t]he midplane relative power density over one-eighth of the central element was obtained for selected loadings. . . by using a sodium iodide (thallium activated) scintillation counter to count collimated fission product gammas from activated fuel rods" (Reference 1, p. 5). Such measurements were made for loadings 2 through 9, loading 11, and loadings 16 and 17 of Core XI. The results for a symmetric octant of the central assembly for loadings 2 through 9 are shown in Figures B.1 through B.8, and the results for loading 11 are shown in Figure B.9. The upper number in each location is the power density for that rod relative to the average for all the rods in the central assembly, and the numbers in parentheses are "... standard deviations obtained from two or more measurements" (Reference 1, p. 5).

Reference 1 also reports relative power density measurements for selected locations in loadings 16 and 17. Those results are shown in Tables B.1 and B.2, which are taken directly from Tables 13 and 14, respectively, in Reference 1.

IRPhEP ... an under-utilized resource



➤ IRPhEP = International Reactor Physics Experiment Evaluation Project.

➤ Web site at <https://www.oecd-nea.org/science/wprs/irphe/>.

➤ ... corresponding database search tool is “IDAT”.

➤ Nothing else to add at this time ... I’m as guilty as others in not taking advantage of this work, ☹️.

File Edit View History Bookmarks Tools Help

CNN - Breaking News, Latest N X Nuclear Energy Agency - Intern: X +

← → ↻ 🏠 🔒 https://www.oecd-nea.org/science/wprs/irphe/ 🔍 IRPhEP, NEA

Home About Us News **Work Areas** Data Bank Publications Delegates' Area

anniversary 40th NEA NUCLEAR ENERGY AGENCY Search OECD BETTER POLICIES FOR BETTER LIVES

Nuclear science > Working Party on Scientific Issues of Reactor Systems (WPRS) > IRPhE

WPRS

WPRS Expert Groups

- Expert Group on Reactor Fuel Performance (EGRFP)
- Expert Group on Reactor Physics and Advanced Nuclear Systems (EGRPANS)
- Expert Group on Radiation Transport and Shielding (EGRTS)
- Expert Group on Uncertainty Analysis and Modelling (EGUAM)

Databases under WPRS

- International Fuel Performance Experiments (IFPE) database
- Shielding Integral Benchmark Archive and Database (SINBAD)
- International Reactor Physics Experiment Evaluation (IRPhE) Project

International Reactor Physics Experiment Evaluation (IRPhE) Project

The International Reactor Physics Experiment Evaluation (IRPhE) Project aims to provide the nuclear community with qualified benchmark data sets by collecting reactor physics experimental data from nuclear facilities, worldwide. More specifically the objectives of the expert group are as follows:

- maintaining an inventory of the experiments that have been carried out and documented;
- archiving the primary documents and data released in computer-readable form;
- promoting the use of the format and methods developed and seek to have them adopted as a standard.

For those experiments where interest and priority is expressed by member countries or working parties and executive groups within the NEA provide guidance or co-ordination in:

- compiling experiments into a standard international agreed format;
- verifying the data, to the extent possible, by reviewing original and subsequently revised documentation, and by consulting with the experimenters or individuals who are familiar with the experimenters or the experimental facility;
- analysing and interpreting the experiments with current state-of-the-art methods;
- publishing electronically the benchmark evaluations.

The expert group will:

- identify gaps in data and provide guidance on priorities for future experiments;
- involve the young generation (Masters and PhD students and young researchers) to find an effective way of transferring know-how in experimental techniques and analysis methods;
- provide a tool for improved exploitation of completed experiments for Generation IV reactors;
- co-ordinate closely its work with other NSC experimental work groups in particular the International Criticality Safety Benchmark Evaluation Project (ICSBEP), the Shielding Integral Benchmark Experiment Data Base (SINBAD) and others, e.g. knowledge preservation in fast reactors of the IAEA, the ANS Joint Benchmark Activities;
- keep a close link with the working parties on scientific issues of reactor systems (WPRS), the expert group on reactor-based plutonium disposition (TFRPD), now integrated into WPRS, scientific issues of the fuel cycle (WPFC) and the working party on international evaluation co-operation (WPEC).

IRPhE home

- Contents
- IRPhE Handbook
- IRPhE Database (IDAT)
- Request a copy

Next meeting

TBD

Useful links

- Primary documentation and other benchmarks
- ICSBEP
- Format for submissions [467KB]
- Format template [256KB]
- ICSBEP Guide to the Expression of Uncertainties [5.22MB]
- Overview of ANL Fast Critical Experiments [7.3MB]
- IRPhE Listserv
- Presentations for IRPhE evaluators and reviewers
- IRPhE-IDAT IDAT Prototype Test Group
- NDaST (Nuclear Data Sensitivity Tool)