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INTER-CODE COMPARISON OF TRIPOLI® AND MVP ON THE MCNP CRITICALITY VALIDATION SUITE

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ABSTRACT

This paper presents a joint work conducted at CEA Saclay and JAEA Tokai aimed at comparing the Monte Carlo codes TRIPOLI-4® and MVP on a selection of ICSBEP benchmarks. Our goal is to establish a common set of Monte Carlo input decks, as a basis for rigorous inter-code comparison in criticality-safety. As a reference, we will use the MCNP Criticality Validation Suite: other Monte Carlo developers might easily join this effort in the future. For the purpose of inter-code comparison, the TRIPOLI-4® and MVP input decks have been exactly translated from those of MCNP, without any further assumptions. Both TRIPOLI-4® and MVP have been run with the same ENDF/B-VII.0 evaluated nuclear data and, as far as possible, the same simulation options as in the original LANL work (same initial source, same number of active and discarded cycles and neutrons per cycle).

KEYWORDS
Criticality, Verification & Validation, MVP, TRIPOLI-4®, MCNP

1. INTRODUCTION

In this work, we will present the joint work conducted at CEA Saclay and JAEA Tokai with the aim of comparing the Monte Carlo codes TRIPOLI-4® [1] and MVP [2] on a selection of ICSBEP benchmarks [3]. Our goal is to establish a common set of Monte Carlo input decks, as a basis for rigorous inter-code comparison in criticality-safety. As a reference, we will use the MCNP [4] Criticality Validation Suite [5,6]: other Monte Carlo developers might easily join our effort in the future. For the purpose of inter-code comparison, the TRIPOLI-4® and MVP input decks have been accurately translated from those of MCNP, without any further assumptions. Both TRIPOLI-4® and MVP have been run with the same ENDF/B-VII.0 evaluated nuclear data and, as far as possible, the same simulation options as in the original LANL work (same initial source, same number of active and discarded cycles and neutrons per cycle).

This paper is organized as follows. In section 1, we briefly recall the main features of the TRIPOLI-4® and MVP Monte Carlo codes. Then, in section 2 we present the simulation results obtained on the MCNP Criticality Validation Suite benchmark. Conclusions will be finally drawn in section 3.

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2. TRIPOLI-4® AND MVP MONTE CARLO CODES

In this section, we provide an overview of TRIPOLI-4® and MVP Monte Carlo codes, illustrating their specific features.

2.1. TRIPOLI-4®

TRIPOLI® is the generic name of a Monte Carlo radiation transport codes family dedicated to shielding, reactor physics with depletion, criticality safety and nuclear instrumentation. Monte Carlo codes have been continuously developed at CEA since the mid-60s, at Fontenay-aux-Roses first, then at Saclay. The code TRIPOLI-4®, the fourth generation of the family, is the cornerstone of the CEA Radiation Transport Software Suite, which also includes the lattice and core family of deterministic codes dedicated to reactor physics analysis APOLLO2 and APOLLO3® [7], the depletion code MENDEL [8], the photon point-kernel code with buildup factors NARMER, the nuclear reaction analysis tool CONRAD [9,10] and the nuclear data processing system GALILEE [11]. TRIPOLI-4® is the reference industrial code for CEA (laboratories and reactors), EDF (operating 58 PWRs), and branches of AREVA. It is also the reference code of the CRISTAL Criticality Safety package [12] developed with IRSN and AREVA.

The code offers both fixed-source and criticality simulation modes. TRIPOLI-4® can simulate neutral particles: neutrons in the energy range from 20 MeV to 10^{-5} eV, and photons in the energy range from 20 MeV to 1 keV. Moreover, electrons and positrons can also be simulated down to 1 keV [13], mainly in the context of radiation detection problems and nuclear instrumentation. Neutron-photon coupling is handled by default. Photonuclear reactions may be simulated as well, if requested. The coupling between photons, electrons and positrons is taken into account by tracking the entire electro-magnetic shower. The particle transport in TRIPOLI-4® is performed in continuous-energy, and the necessary nuclear data (i.e., point-wise cross-sections, scattering kernels, secondary energy-angle distributions, secondary particle yields, fission spectra, and so on) are read by TRIPOLI-4® from any evaluation written in ENDF-6 [14] format, including (but not limited to) JEFF-3.1.1, ENDF/B-VII.1, JENDL-4.0 and FENDL-2.1 libraries. TRIPOLI-4® can directly access files in ENDF and PENDF format. The probability tables for TRIPOLI-4® for the unresolved resonance range, when present and requested, are generated by using the CALENDF code [15].

2.1.1. MVP

MVP is a general-purpose continuous-energy Monte Carlo code for neutron and photon transport calculations, which has been developed since the late 1980s at Japan Atomic Energy Agency (JAEA). The MVP code is designed for nuclear reactor applications such as reactor core design/analysis, criticality safety and reactor shielding. The main application field is reactor physics: analysis of critical experiments, calculation of reference solutions for reactor core design, etc. The code has been domestically used in Japan since the first release in 1994 [16]. The second version was released in 2005 with extended capabilities based on the advanced Monte Carlo methodology for reactor physics applications [2].

MVP implements fundamental Monte Carlo capabilities for neutron/photon transport based on the evaluated nuclear data. MVP can solve eigenvalue and fixed-source problems for neutron, photon and neutron-photon coupled transport. MVP can also solve time-dependent problems. MVP uses the specific cross section libraries, which are generated from the evaluated nuclear data in the ENDF-6 format with the LICEM code [17]. The neutron cross sections in the unresolved resonance region are described by the probability table method. The neutron cross sections at arbitrary temperatures are available for MVP by just specifying the temperatures in the input data. The resolved resonance cross sections are obtained with the SIGMA1 method. The thermal scattering data and the probability tables are obtained with the interpolation of pre-defined temperature points. These data are automatically prepared in prior to random walk.

3. TRIPOLI-4® AND MVP RESULTS ON THE MCNP CRITICALITY VALIDATION SUITE

In this section, we provide an overview of the simulation results obtained with TRIPOLI-4® and MVP on the MCNP Criticality Validation Suite.

3.1. Description of the MCNP Criticality Validation Suite

The MCNP Criticality Validation Suite collects 31 benchmarks taken from the International Handbook of Evaluated Criticality Benchmark Experiments [3]. This suite encompasses several kinds of nuclear fuels: Highly-Enriched Uranium (HEU), Intermediate-Enriched Uranium (IEU), Low-Enriched Uranium (LEU), Plutonium and U−233, each associated with a distinct neutron spectrum. Also, several kinds of geometries, moderators and reflectors are considered. All configurations are evaluated at room temperature and pressure. As such, this Criticality Validation Suite provides an excellent benchmark for the validation of the criticality calculations in Monte Carlo particle transport codes. In Table I, are summarized the identifiers of the 31 configurations (classified by fuel type), together with a short description for each case.

Table I. Description of the 31 configurations of the MCNP Criticality Validation Suite (from reference [5])

Benchmark name	ICSBEP identifier	Description
U233 configurations		
JEZ233	U233-MET-FAST-001	Bare sphere of ^{233}U
FLAT23	U233-MET-FAST-006	Sphere of ^{233}U reflected by normal U
UMF5C2	U233-MET-FAST-005, case 2	Sphere of ^{233}U reflected by beryllium
FLSTF1	U233-SOL-INTER-001, case 1	Sphere of uranyl fluoride solution enriched in ^{233}U
SB25	U233-COMP-THERM-001, case 3	Lattice of ^{233}U fuel pins in water
ORNL11	U233-SOL-THERM-008	Large sphere of uranyl nitrate solution enriched in ^{233}U
HEU configurations		
GODIVA	HEU-MET-FAST-001	Bare HEU sphere
TT2C11	HEU-MET-FAST-026, case 11	3x3x3 array of HEU cylinders reflected by paraffin
FLAT25	HEU-MET-FAST-028	HEU sphere reflected by normal U
GODIVR	HEU-MET-FAST-004	HEU sphere reflected by water
UH3C6	HEU-COMP-INTER-003, case 6	Reflected uranium hybride cylindrical assemblies
ZEUS2	HEU-MET-INTER-006, case 2	HEU platters, graphite moderator, Cu reflector
SB5RN3	U233-COMP-THERM-001, case 6	Triangular lattice of HEU fuel pins
ORNL10	HEU-SOL-THERM-032	Large sphere of HEU nitrate solution
IEU configurations		
IMF03	IEU-MET-FAST-003	Bare sphere of IEU (36 wt.%)
BIGTEN	IEU-MET-FAST-007	Cylinder of IEU (10wt.%) reflected by normal U
IMF04	IEU-MET-FAST-004	Sphere of IEU (36 wt.%) reflected by graphite
ZEBR8H	IEU-MET-FAST-008, case 7	Plate of IEU (37.5 w/o) reflected by U and steel
ICT2C3	IEU-COMP-THERM-002, case 3	Lattice of IEU (17 wt.%) fuel rods in water
STACY36	LEU-SOL-THERM-007, case 36	Cylinder of IEU (9.97 w/o) uranyl nitrate solution

LEU configurations		
BAWXI2	LEU-COMP-THERM-008, case 2	Large lattice of PWR fuel pins in borated water
LST2C2	LEU-SOL-THERM-002, case 2	Bare sphere of (4.9 wt.%) uranium oxyfluoride solution
Pu configurations		
JEZPU	PU-MET-FAST-001	Bare sphere of Pu
JEZ240	PU-MET-FAST-002	Bare sphere of Pu (20.1 at.% ^{240}Pu)
PUBTNS	PU-MET-FAST-003, case 3	3x3x3 array of small cylinders of Pu
FLATPU	PU-MET-FAST-006	Pu sphere reflected by normal U
THOR	PU-MET-FAST-008	Pu sphere reflected by Th
PUSH2O	PU-MET-FAST-011	Pu sphere reflected by water
HISHPG	PU-COMP-INTER-001	Infinite, homogeneous mix of Pu, hydrogen and graphite
PNL2	PU-SOL-THERM-021, case 3	Sphere of Pu nitrate solution
PNL33	MIX-COMP-THERM-002, case 4	Lattice of mixed-oxide fuel pins in borated water

3.2. Monte Carlo Simulation Results

In the following, we summarize our numerical simulation results for the effective multiplication factors of the 31 MCNP Criticality Suite configurations. The results have been organized as a function of the nuclear fuel type.

The experimental reactivities for each of the 31 configurations have been collected in reference [5] and are reported in the second column of Table II-Table VI. The effective multiplication factor computed with MCNP5-1.60 by using the ENDF/BVII.0 nuclear data library are summarized in reference [6] and have been reported in the third column of Table II-Table VI. The 31 MCNP input decks, including material description, geometry, and simulation parameters, are available from the CD-ROM of the MCNP5-1.60 release. All MCNP calculations from reference [6] have been performed by using 250 cycles of 5000 neutrons each, with 50 inactive cycles. All the configurations have been independently re-run by the TRIPOLI-4® and MVP teams by using MCNP5-1.60. Both teams have obtained rigorously the same results, which are reported in the fourth column of Table II-Table VI.

For the purpose of the TRIPOLI-4®-MVP inter-code comparison on the MCNP Criticality Suite benchmark, the TRIPOLI-4® and MVP input decks for the 31 configurations have been accurately translated from those of MCNP, without any further assumptions. Both TRIPOLI-4® and MVP have been run with the same ENDF/B-VII.0 evaluated nuclear data and, as far as possible, the same simulation options as in the original LANL work (same initial source, same number of active and discarded cycles and neutrons per cycle). TRIPOLI-4® and MVP results are reported respectively in the fifth and sixth columns of Table II-VI. TRIPOLI-4® calculations are performed by using the collision estimator, whereas MVP adopts the combined estimator. The effects of inter-cycle correlations on the statistical uncertainties are neglected.

Table II. Results for the ^{233}U configurations.

Benchmark name	Experiment k_{eff} (std)	MCNP k_{eff} (std)	MCNP k_{eff} (std)	TRIPOLI k_{eff} (std)	MVP k_{eff} (std)
JEZ233	1.0000 (0.0010)	0.9989 (0.0005)	0.99889 (0.00055)	0.99911 (0.00104)	1.00060 (0.00054)
FLAT23	1.0000 (0.0014)	0.9990 (0.0007)	0.99904 (0.00072)	0.99806 (0.00095)	0.99940 (0.00069)
UMF5C2	1.0000 (0.0030)	0.9931 (0.0005)	0.99307 (0.00064)	0.99117 (0.00108)	0.99292 (0.00062)
FLSTF1	1.0000 (0.0083)	0.9830 (0.0011)	0.98301 (0.00107)	0.98351 (0.00112)	0.98470 (0.00105)
SB25	1.0000 (0.0024)	1.0053 (0.0010)	1.00528 (0.00101)	1.00167 (0.00106)	1.00511 (0.00111)
ORNL11	1.0006 (0.0029)	1.0018 (0.0004)	1.00180 (0.00037)	1.00147 (0.00111)	1.00165 (0.00036)

Table III. Results for the HEU configurations.

Benchmark name	Experiment k_{eff} (std)	MCNP k_{eff} (std)	MCNP k_{eff} (std)	TRIPOLI k_{eff} (std)	MVP k_{eff} (std)
GODIVA	1.0000 (0.0010)	0.9995 (0.0005)	0.99946 (0.00059)	0.99813 (0.00093)	1.00021 (0.00066)
TT2C11	1.0000 (0.0038)	1.0008 (0.0007)	1.00100 (0.00077)	1.00263 (0.00103)	0.99968 (0.00083)
FLAT25	1.0000 (0.0030)	1.0034 (0.0007)	1.00343 (0.00066)	1.00335 (0.00091)	1.00272 (0.00066)
GODIVR	0.9985 (0.0011)	0.9990 (0.0007)	0.99899 (0.00069)	0.99942 (0.00104)	0.99983 (0.00077)
UH3C6	1.0000 (0.0047)	0.9950 (0.0008)	0.99500 (0.00081)	0.99580 (0.00106)	0.99554 (0.00068)
ZEUS2	0.9997 (0.0008)	0.9972 (0.0007)	0.99719 (0.00074)	0.99607 (0.00110)	0.99623 (0.00072)
SB5RN3	1.0015 (0.0028)	0.9985 (0.0013)	0.99847 (0.00131) 0.99774 (0.00092)†	0.99738 (0.00098)	0.99702 (0.00092)
ORNL10	1.0015 (0.0026)	0.9993 (0.0004)	0.99926 (0.00037)	0.99927 (0.00098)	0.99895 (0.00031)

† The input deck for SB5RN3 from the MCNP5-1.60 CD-ROM specifies 150 cycles. The former k_{eff} value has been obtained by running MCNP with the number of cycles as in the CD-ROM, whereas the latter value has been obtained running MCNP with 250 cycles. TRIPOLI-4® and MVP calculations have been performed using 250 cycles.

Table IV. Results for the IEU configurations.

Benchmark name	Experiment k_{eff} (std)	MCNP k_{eff} (std)	MCNP k_{eff} (std)	TRIPOLI k_{eff} (std)	MVP k_{eff} (std)
IMF03	1.0000 (0.0017)	1.0029 (0.0005)	1.00291 (0.00059)	1.00137 (0.00103)	1.00356 (0.00058)
BIGTEN	0.9948 (0.0013)	0.9945 (0.0005)	0.99450 (0.00047)	0.99451 (0.00087)	0.99591 (0.00051)
IMF04	1.0000 (0.0030)	1.0067 (0.0005)	1.00671 (0.00065)	1.00679 (0.00099)	1.00806 (0.00061)
ZEBR8H	1.0300 (0.0025)	1.0196 (0.0005)	1.01792 (0.00054) 1.01907 (0.00039)†	1.01983 (0.00080)	1.02069 (0.00035)
ICT2C3	1.0017 (0.0044)	1.0037 (0.0007)	1.00370 (0.00070)	1.00481 (0.00101)	1.00363 (0.00078)
STACY36	0.9988 (0.0013)	0.9994 (0.0005)	0.99942 (0.00058)	1.00021 (0.00103)	0.99841 (0.00060)

† The input deck for ZEBR8H from the MCNP5-1.60 CD-ROM contained a slight inconsistency in material definitions with respect to the original ICSBEP specifications [3]; moreover, the total number of cycles in the CD-ROM was 150, instead of 250 as customary for the other configurations. The former k_{eff} value has been obtained by running MCNP with the material specifications and the number of cycles as in the CD-ROM, whereas the latter value has been obtained running MCNP with the ICSBEP specifications and 250 cycles. TRIPOLI-4® and MVP calculations have been performed using the ICSBEP specifications and 250 cycles.

Table V. Results for the LEU configurations.

Benchmark name	Experiment k_{eff} (std)	MCNP k_{eff} (std)	MCNP k_{eff} (std)	TRIPOLI k_{eff} (std)	MVP k_{eff} (std)
BAWXI2	1.0007 (0.0012)	1.0013 (0.0007)	1.00133 (0.00069)	1.00312 (0.00096)	1.00074 (0.00054)
LST2C2	1.0024 (0.0037)	0.9940 (0.0005)	0.99401 (0.00062)	0.99477 (0.00096)	0.99648 (0.00054)

Table VI. Results of the Pu configurations.

Benchmark name	Experiment k_{eff} (std)	MCNP k_{eff} (std)	MCNP k_{eff} (std)	TRIPOLI k_{eff} (std)	MVP k_{eff} (std)
JEZPU	1.0000 (0.0020)	1.0002 (0.0005)	1.00024 (0.00059)	0.99899 (0.00106)	1.00135 (0.00050)
JEZ240	1.0000 (0.0020)	1.0002 (0.0005)	1.00019 (0.00055)	0.99896 (0.00094)	1.00064 (0.00063)
PUBTNS	1.0000 (0.0030)	0.9996 (0.0005)	0.99956 (0.00064)	0.99872 (0.00110)	0.99867 (0.00068)
FLATPU	1.0000 (0.0030)	1.0005 (0.0007)	1.00050 (0.00070)	1.00055 (0.00102)	0.99948 (0.00067)
THOR	1.0000 (0.0006)	0.9980 (0.0007)	0.99803 (0.00069)	0.99753 (0.00097)	0.99671 (0.00069)
PUSH2O	1.0000 (0.0010)	1.0012 (0.0007)	1.00121 (0.00072)	0.99942 (0.00108)	1.00062 (0.00078)
HISHPG	1.0000 (0.0110)	1.0118 (0.0005)	1.01179 (0.00055)	1.01280 (0.00092)	1.01163 (0.00031)
PNL2	1.0000 (0.0065)	1.0046 (0.0009)	1.00460 (0.00095)	1.00571 (0.00097)	1.00472 (0.00097)
PNL33	1.0024 (0.0021)	1.0065 (0.0007)	1.00646 (0.00074)	1.00737 (0.00093)	1.00544 (0.00066)

3.3. Discussion

The calculations performed with TRIPOLI-4® show a good agreement with respect to experiments; the multiplication factors of all configurations lie within 3 (combined) standard deviations, except for the ZEBR8H case. The MVP calculations also agree with the experimental values within 3 standard deviations except for ZEUS2, ZEBR8H and THOR. We suspect that for ZEBR8H probability tables might play an important role, which deserves to be further investigated. It should be remarked that the experimental uncertainties are quite large. For ZEUS2, the MVP result differs from that of TRIPOLI-4® by only 15 pcm; however, the difference from the experimental value is larger than 3 standard deviations. Observe nonetheless that statistical uncertainty might be underestimated due to inter-cycle correlations being neglected. For THOR, the MVP result significantly underestimates the experimental value; however, numerical analyses have shown that this underestimation is strongly affected by the number of simulated cycles: by taking a 1000 active cycles, the resulting multiplication coefficient would be keff = 0.99798 (1 standard deviation = 0.00029).

For the inter-code comparisons, we provide a summary of the absolute differences Δk in keff for T4-MCNP, MVP-MCNP and MVP-T4 in Tables VII-XI. Differences are expressed in pcm. Combined uncertainties in pcm are also given in parentheses and the number of asterisks expresses the discrepancies in terms of combined standard deviations as in reference [6]: * for Δk exceeding 1 combined standard deviation, ** for 2 combined standard deviations and *** for 3 combined standard deviations.

Table VII. Discrepancy analysis for the ^{233}U configurations.

Benchmark name	Δk(T4-MCNP) (std)	Δk(MVP-MCNP) (std)	Δk(MVP-T4) (std)
JEZ233	22 (118)	171 (77) **	149 (117) *
FLAT23	-98 (119)	36 (100)	134 (117) *
UMF5C2	-190 (126) *	-15 (89)	175 (125) *
FLSTF1	50 (155)	169 (150) *	119 (154)
SB25	-361 (146) **	-17 (150)	344 (153) **
ORNL11	-33 (117)	-15 (51)	18 (117)

Table VIIII. Discrepancy analysis for the HEU configurations.

Benchmark name	$\Delta k_{T4\text{-}MCNP}$ (std)	$\Delta k_{MVP\text{-}MCNP}$ (std)	$\Delta k_{MVP\text{-}T4}$ (std)
GODIVA	-133 (110) *	75 (88)	208 (114) *
TT2C11	163 (129) *	-132 (113) *	-295 (133) **
FLAT25	-8 (112)	-71 (93)	-63 (112)
GODIVR	43 (125)	84 (104)	41 (130)
UH3C6	80 (133)	54 (106)	-26 (126)
ZEUS2	-112 (133)	-96 (103)	16 (131)
SB5RN3	-36 (134)	-72 (130)	-36 (134)
ORNL10	1 (105)	-31 (49)	-32 (103)

Table IX. Discrepancy analysis for the IEU configurations.

Benchmark name	$\Delta k_{T4\text{-}MCNP}$ (std)	$\Delta k_{MVP\text{-}MCNP}$ (std)	$\Delta k_{MVP\text{-}T4}$ (std)
IMF03	-154 (119) *	65 (83)	219 (118) *
BIGTEN	1 (99)	141 (69) **	140 (101) *
IMF04	8 (118)	135 (89) *	127 (117) *
ZEBR8H	328 (133) **	162 (52) ***	86 (87)
ICT2C3	111 (123)	-7 (105)	-118 (128)
STACY36	79 (118)	-101 (83) *	-180 (119) *

Table X. Discrepancy analysis for the LEU configurations.

Benchmark name	$\Delta k_{T4\text{-}MCNP}$ (std)	$\Delta k_{MVP\text{-}MCNP}$ (std)	$\Delta k_{MVP\text{-}T4}$ (std)
BAWXI2	179 (118) *	-59 (87)	-238 (110) **
LST2C2	76 (114)	247 (82) ***	171 (110) *

Table XI. Discrepancy analysis for the Pu configurations.

Benchmark name	ΔkT4-MCNP (std)	ΔkMVP-MCNP (std)	ΔkMVP-T4 (std)
JEZPU	-125 (121) *	111 (78) *	236 (117) **
JEZ240	-123 (109) *	45 (84)	168 (113)*
PUBTNS	-84 (127)	-89 (93)	-5 (129)
FLATPU	5 (124)	-102 (97) *	-107 (122)
THOR	-50 (119)	-132 (98) *	-82 (119)
PUSH2O	-179 (130) *	-59 (106)	120 (133)
HISHPG	101 (107)	-16 (63)	-117 (97) *
PNL2	111 (136)	12 (136)	-99 (137)
PNL33	91 (119)	-102 (99) *	-193 (114) *

Concerning the T4-MCNP inter-code comparison, the keff values of the 31 configurations all lie within 3 (combined) standard deviations. As for the MVP-MCNP comparison, 29 out of 31 configurations lie within 3 (combined) standard deviations, and large discrepancies have been observed for ZEBR8H and LST2C2. To investigate the case of ZEBR8H, we have performed the criticality calculations without probability tables (i.e., infinite dilution calculations in the unresolved resonance region). Table XII shows the results obtained for MVP and MCNP with and without probability tables. Without probability tables, the MVP result agrees with that of MCNP within 1 standard deviation; the discrepancy can be thus reasonably attributed to the probability tables. To investigate the case of LST2C2, we have performed multiple criticality calculations for the same geometry starting with different random number seeds. Table XIII shows the results obtained for MVP and MCNP. The averaged result of MVP agrees with that of MCNP within 2 standard deviations; we might then argue that the discrepancy observed in Table X for LST2C2 may be due to the statistical fluctuations and the underestimation of the statistical uncertainty.

The agreement between the codes is globally satisfactory. However, it should be noted that the largest discrepancies in the inter-code comparisons are found in the IEU configurations; a relatively large number of asterisks is observed in the tables. This could be due to the impact of the probability tables in the intermediate-energy neutron spectrum, for which each code has a specific treatment (NJOY for MCNP, CALENDF for TRIPOLI-4® and U3R-J for MVP).

Table XII. Comparison between MCNP and MVP for ZEBR8H.

Case	MCNP k_{eff} (std)	MVP k_{eff} (std)
ZEBR8H (with probability tables)	1.01907 (0.00039)	1.02069 (0.00035)
ZEBR8H (without probability tables)	1.00887 (0.00038)	1.00917 (0.00035)

Table XIII. Comparison between MCNP and MVP for LST2C2.

Case	MCNP k_{eff} (std)	MVP k_{eff} (std)
MCNP Initial seed = 19073486328125	0.99401 (0.00062)	0.99648 (0.00054)
MCNP Initial seed = 1	0.99509 (0.00063)	0.99659 (0.00058)
MCNP Initial seed = 3	0.99693 (0.00060)	0.99562 (0.00053)
MCNP Initial seed = 5	0.99506 (0.00061)	0.99576 (0.00055)
MCNP Initial seed = 7	0.99626 (0.00062)	0.99536 (0.00059)
Average	0.99547 (0.00028)	0.99596 (0.00025)

4. CONCLUSIONS

In this work, we have presented some preliminary results aimed at extending the verification and validation database of the TRIPOLI-4® and MVP Monte Carlo codes for criticality calculations. As a reference, we have selected here the MCNP Criticality Validation Suite, which provides an ensemble of 31 reactor configurations covering a wide range of neutron spectra. Numerical simulations have shown a satisfactory agreement with respect to MCNP, although further investigations will be needed in order to fully assess the impact of probability tables in the IEU range.

For this work, we have strictly respected, as far as possible, the specifications provided in the MCNP reports concerning the Criticality Validation Suite [5, 6]. In particular, this means that the total number of cycles has been set to 250, which produces Monte Carlo uncertainties compatible with experimental error bars. Future work will focus on reducing the Monte Carlo uncertainties (with special emphasis on the Figure of Merit) and on re-evaluating the corresponding inter-code discrepancy analysis.

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