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Working Party on International Nuclear Data Evaluation Co-operation

Meeting of the WPEC Subgroup 46 on the Efficient and Effective Use of Integral Experiments for Nuclear Data Validation

SUMMARY RECORD

25-26 June 2019
NEA Headquarters
Boulogne-Billancourt, France

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OECD/NEA Nuclear Science Committee

Working Party on International Nuclear Data Evaluation Co-operation (WPEC)

Meeting of Subgroup 46 on the Efficient and Effective Use of Integral Experiments for Nuclear Data Validation

NEA Headquarters Room BB12

46 quai Alphonse Le Gallo, 92100 Boulogne-Billancourt, France

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SUMMARY RECORD

1. Welcome

The Co-Chair, **G. Palmiotti**, welcomed the participants (see ***Appendix 1***) and the WPEC Secretariat, **M. Fleming**, noting that the other Co-chair, **M. Salvatores**, would be arriving for the second day of the meeting. **S. Pelloni** has announced his retirement. He will continue to be active and provide contributions to the subgroup, but will not be able to attend meetings. The participants noted that his enthusiasm and wide expertise in the field will be missed. His recent work on data adjustment has opened new perspectives to make adjustments more robust and unbiased

2. Adoption of the agenda

The presentation from **W. Haicheng** was removed from the agenda due to travel issues keeping him from participating in person. The Chair for Subgroup 44, **V. Sobes**, agreed to provide a presentation within the last agenda item. The agenda (see ***Appendix 2***) was otherwise adopted without modification.

3. Review of action items

Following the November 2018 meeting, all of the contributions for the Subgroup 39 final report were submitted to the NEA Secretariat, **M. Fleming**, and these were integrated into a report that was circulated to the participants. Comments have been received and the report draft has been submitted to the Nuclear Science Publications Assistant. It was noted that several reports have been submitted in the recent months and this is expected to increase the time required for full editing, submission to Central Secretariat and final publication.

4. Target Accuracy Issues

4.1. Guidelines for updated target accuracies

G. Palmiotti presented, on behalf of **M. Salvatores**, an introduction to the target accuracies exercise that has been proposed as two-phases. In 2019, data gathering will include a list of

systems, models, sensitivities, design parameters with requested accuracies and interested parties. This will be followed by an analysis phase where integral parameters are rigorously defined and weighted, and calculations are performed to provide feedback based on the target systems and accuracies. Several systems were shown with status of their models, sensitivities, and identified volunteers to perform calculations. Example/preliminary target accuracy requirements were shown for some ADS, VHTR, High BU PWR and MSR systems and a formula for minimisation was provided, requiring some weighting 'costs' to be separately defined in future analysis.

4.2. Proposal of Target Accuracy for ADS Neutronics Design

K. Yokoyama presented updated target uncertainties for ADS systems based on a publication in the *Annals of Nuclear Energy* 111, 449-459 (2018). The values given for the major and minor nuclide densities at the end of irradiation were identical to the WPEC subgroup 26 report, although various quantities such as BOL power peak, multiplication factor and reactivities had been revised. Additionally, β_{eff} (BOL and/or EOL), spallation neutrons and source efficiency, as well as heating from spallation were suggested as new integral parameters. These values were compared with those of the WPEC subgroup 26 report and the preliminary values from ***Section 4.1***.

4.3. The current ALFRED core design

D. M. Castelluccio reported on the current design activities for the ALFRED core. As a lead-cooled advanced demonstration reactor, ALFRED has been conceived to operate under multiple phases, as each will be used to qualify the following operational periods. Design details were provided, including complex axial configurations and loading patterns with a 5-year 5-batch loading scheme. Reactivity values were shown to for different scenarios.

4.4. ASTRID, ESFR, ALFRED and MYRRHA

P. Romojaro presented, on behalf of a joint CIEMAT/UPM work, an overview of systems that had been considered as part of past and continuing work funded in part through EU research under the Seventh Framework Programme or Horizon 2020, including ASTRID, ALFRED, MYRRHA and the ESFR. Models and sensitivity/uncertainty analysis tools were described, using well-known code packages and in-house Spanish tools. Summary data for some systems were shown, including ALFRED and MYRRHA integral parameter uncertainties. An integral assimilation process using DAWN was shown, with updated uncertainties shown to be significantly affected.

4.5. Sensitivity-Uncertainty Analysis of k_{eff} and β_{eff} for MYRRHA

I. Kodeli presented work done to perform β_{eff} sensitivity calculations for the MYRRHA reactor using a PARTISN/SUSD3D code system. It was shown that the two methods generated similar results, with either the Keepin or Bretscher formulae. Using the available nuclear data covariances, delayed neutron yields and ^{238}U inelastic scattering are the most important data for uncertainties in β_{eff}, with values based on the most recent nuclear data libraries showing 2-3% uncertainties.

4.6. High Priority Request List for Nuclear Data

E. Dupont, Chair of the EG-HPRL, provided an overview of the HPRL status, highlighting the major contributions from WPEC subgroup 26 in stimulating new measurements in the past 10

years. The entries proposed by WPEC subgroup 26 were reviewed, of which the majority are still classified as "work in progress". However, some have been completed and others have stimulated experiments, although they have not had their original request criteria fully met. Additional entries or revisions of the existing requests are always welcome and the potential for subgroup 46 to provide such information is greatly encouraged.

4.7. The JEFF Nuclear Data Library and the European nuclear data community

A. Plompen, Chair of the JEFF project, gave an overview of the activities within JEFF, reviewing many of the major European activities related to nuclear data and priorities for the JEFF project to address in the coming development of the next release. Highlights from the recent JEFF-3.3 release were shown, including new actinide and structural material evaluations, TSL, fission yields, decay and delayed neutron data. The library has undergone a significant benchmarking exercise but enhanced feedback from the target accuracy requirements activities are welcomed as part of the effort to identify priority evaluation areas for the next library.

4.8. Reminder on sensitivity profiles

M. Salvatores, on behalf of F. Gabrielli, presented two benchmarks involving a 1200 MW_{th} low void Sodium Fast Reactor (SFR) Minor Actinide Burner and the 2400 MW_{th} Molten Salt Advanced Reactor Transmuter (MOSART) critical reactor concept. These benchmarks aim to explore the performance of codes and nuclear data libraries, in particular any effects of minor actinide nuclear data uncertainties on design parameters. Several parameters of the benchmarks were described, including isotopic compositions, geometries and expected outputs.

4.9. NEA Tools to Support SG46 Work + WPRS Feedback

I. Hill presented an overview of the NEA tools including DICE, IDAT, JANIS and NDaST, which include sensitivity profiles for ICSBEP, IRPhE, as well as nuclear data (including covariances) and tools to utilise these to perform perturbation and uncertainty propagation calculations. The introduction of the limited 7-group structure for sensitivities was shown as a trivial manipulatino within DICE and IDAT. The reactivity worths and spectral indices measurements within IRPhE were reviewed, with nearly 3000 data immediately available from IRPhE within IDAT. Several benchmarks were reviewed, including a list from legacy NEACRP-L/A documents. The functionalities made available with NDaST were reviewed, reminding participants that fundamental issues with missing nuclear data uncertainties, limitations in the file format or processing capabilities remain the main issues preventing progress (e.g. PFNS, mubar/Legendre, etc.). In final comments, he reiterated other fundamental issues in performing adjustments without being able to consider all benchmarks, the lack of correlations between benchmarks and the fact that evaluators often utilise complex compensations within files that cannot be adjusted without critically impairing performance (e.g. energy-dependent PFNS).

5. Assimilation methods and issues

5.1. Trends on Major Actinides from an Integral Data Assimilation

G. Rimpault presented work done using integral benchmark assimilation with nuclear data libraries including JEFF-3.1.1 complemented with covariances from COMAC. It was shown that this effectively identified sources of error in the original data with new differential measurements

ultimately providing the evidence, as seen with ^{235}U capture, for example. Analyses suggest a 2.5% decrease for ^{238}U within the 3-60 keV region, 4-5% decrease for ^{238}U inelastic within 1-4 MeV. The assimilation also introduces significant reduction in the cross section uncertainties in these energy regions. Other integral assimilation results were shown for ^{239}Pu and ^{240}Pu, driven by simulation disagreements with PROFIL plutonium ratios that are broadly in the direction of the new ENDF/B-VIII.0 evaluations. It was remarked that complete uncertainty data (including PFNS and scattering angular data) and utilisation of these data within assimilation methods are expected to have a considerable impact on the results of future analyses and both data and methods development should be strongly encouraged.

5.2. Another Use of Integral Experiments for Nuclear Data Validation: Bias Factor Methods

G. Palmiotti presented work on bias factor methods that have been stimulated by a need for a simpler and clear methodology for taking into account cross section uncertainties in a preliminary design stage. Different bias factor methods were reviewed and applied to a set of experiments including ZPPR-15 A, CIRANO 2B, FFTF start-up and ZPR3-56B. The results are comparable with respect to bias factor and uncertainty reduction, although some methods can generate negative weights. Where representativity is relatively high, standard bias factor methods are still preferable.

5.3. New paradigm for nuclear data evaluation

M. Herman reviewed the state of current nuclear data evaluation practices and highlighted the major shortcomings that now must be addressed as the community attempted to improve upon the most recent evaluated libraries. The proposed ‘new paradigm’ is to store all evaluation input materials as a self-documented and reproducible repository (see WPEC subgroup 49 proposal made 27 June 2019) and to consistently adjust a full library in a reproducible and automated way. It was argued that the existing evaluations and most reaction model codes are robust enough and, potentially with the addition of some model defect handling methodologies (e.g. energy-dependent input parameters or ENDF-6 file-space Gaussian processes) we are ready to perform carefully documented and understood integral adjustment.

5.4. Treating inconsistent data in integral adjustment using Marginal Likelihood Optimization

H. Sjöstrand presented work done to address unreported systematic uncertainties (USU) that manifests as inconsistent data. Following previous work to address this issue, the technique of Marginal Likelihood Optimisation (MLO) has been employed to identify and correct erroneous experimental uncertainties in synthetic data studies. Results were shown when considering integral values from a subgroup 33 set of measurements and the corresponding reduction in nuclear data adjustments that would be proposed with the experimental data treated with MLO. Results coupling Bayesian Monte-Carlo nuclear data updates with and without MLO show a considerable improvement in the BMC updates, in part due to revised experimental uncertainties but also due to superior agreement between the BMC-updated files.

5.5. Adjusting GEF Model Parameters with Post Irradiation Examination Experiments

M. Hursin, on behalf of **D. Siefman**, presented the use of Marginal Likelihood Optimisation (MLO) to perform input model parameter optimisation with the GEF fission modelling code, which generates fission product yields, in response to post-irradiation experimental data. The simulation process uses CASMO-5 and thousands of prior FY samples from the GEF default parameter distributions to follow a 38 MWd/kg burnup of a UO_2 fuel with comparisons performed against 33 measured fission products. The resulting posterior data showed a much less biased comparison against the experimental data and reduced uncertainties. The posterior GEF model calculations are also in better agreement with evaluated fission mass distributions from ENDF/B-VIII.0.

6. Relation with other subgroups

6.1. WPEC Subgroup 44 Report

V. Sobes, Chair of the WPEC subgroup 44, reported on the meeting that took place on 24 June 2019, covering a range of domains including cross section evaluations, assimilation-based correlations, fission yield covariances and the handling of model defects. The subgroup is working now to prepare a summary report and has agreed participants for various sections, although more contributions are welcome. A final inter-comparison will be performed with the cross-correlation of fission and nu uncertainties.

7. Review of actions

The actions collected during the course of the meeting were discussed and agreed as included in ***Appendix 3***.

8. Next Meeting and any other business

The next meeting of the WPEC subgroup 46 will be 25-26 November 2019.

APPENDIX 1

List of participants to the 25-26 June 2019 Meeting of Subgroup 46 on the Efficient and Effective Use of Integral Experiments for Nuclear Data Validation

	First Name	Last Name	Country	Notes
1	Oscar	CABELLOS	SPAIN	Remote
2	Mario	CARTA	ITALY	
3	Donato-Maurizio	CASTELLUCCIO	ITALY	
4	Cyrille	DESAINTJEAN	FRANCE	
5	Marie-Anne	DESCALLE	UNITED STATES	
6	Isabelle	DUHAMEL	FRANCE	
7	Emmeric	DUPONT	FRANCE	
8	Luca	FIORITO	BELGIUM	
9	Michael	FLEMING	NEA	Secretariat
10	Zhigang	GE	CHINA	Remote
11	Michal	HERMAN	UNITED STATES	
12	Ian	HILL	NEA	
13	Andrew	HOLCOMB	UNITED STATES	
14	Mathieu	HURSIN	SWITZERLAND	
15	Raphaelle	ICHOU	FRANCE	
16	Osamu	IWAMOTO	JAPAN	
17	Nobuyuki	IWAMOTO	JAPAN	
18	Ivan-Alexander	KODELI	SLOVENIA	
19	Luiz Carlos	LEAL	FRANCE	
20	Nicolas	LECLAIRE	FRANCE	
21	Yi-Kang	LEE	FRANCE	
22	Denise	NEUDECKER	UNITED STATES	Remote
23	Giuseppe	PALMIOTTI	UNITED STATES	Chair
24	Chris	PERFETTI	UNITED STATES	
25	Arjan	PLOMPEN	EC	
26	Gerald	RIMPAULT	FRANCE	
27	Pablo	ROMOJARO	SPAIN	
28	Evgeny	ROZHIKHIN	RUSSIA	
29	Xichao	RUAN	CHINA	Remote
30	Massimo	SALVATORES	UNITED STATES	Chair
31	Stanislav	SIMAKOV	GERMANY	
32	Henrik	SJOSTRAND	SWEDEN	Remote
33	Vladimir	SOBES	UNITED STATES	
34	Andrej	TRKOV	AUSTRIA	
35	Morgan	WHITE	UNITED STATES	
36	Haicheng	WU	CHINA	Remote

37	Kenji	YOKOYAMA	JAPAN
38	Michael	ZERKLE	UNITED STATES

APPENDIX 2

OECD/NEA Nuclear Science Committee

Working Party on International Nuclear Data Evaluation Co-operation (WPEC)

Meeting of Subgroup 46 on the Efficient and Effective Use of Integral Experiments for Nuclear Data Validation

NEA Headquarters Room BB12

46 quai Alphonse Le Gallo, 92100 Boulogne-Billancourt, France

25-26 June 2019

AGENDA

1.	Welcome and introductions	Chair
2.	Adoption of the agenda	All
3.	Review of action items	Chair
4.	Target accuracy issues	
	4.1. Guidance for updated target accuracies	M. Salvatores
	4.2. Proposal for Target Accuracy for ADS Neutronics Design	K. Yokohama
	4.3. The current ALFRED core design	D.-M. Catelluccio
	4.4. ASTRID, ESFR, ALFRED and MYRRHA	P. Romojaro
	4.5. Sensitivity-Uncertainty Analysis of keff and βeff for MYRRHA	I. Kodeli
	4.6. High Priority Request List for Nuclear Data	E. Dupont
	4.7. The JEFF Nuclear Data Library and the European nuclear data community	A. Plompen
	4.8. Reminder on sensitivity profiles	F. Gabrielli
	4.9. NEA Tools to Support SG46 Work + WPRS Feedback	I. Hill
5.	Assimilation methods and issues	
	5.1. Trends on Major Actinides from an Integral Data Assimilation	G. Rimpault
	5.2. Another Use of Integral Experiments for Nuclear Data Validation: Bias Factor Methods	G. Palmiotti
	5.3. New paradigm for nuclear data evaluation	M. Herman
	5.4. Treating inconsistent data in integral adjustment using Marginal Likelihood Optimization	H. Sjöstrand

5.5. Adjusting GEF Model Parameters with Post Irradiation Examination Experiments
M. Hursin

6. Relation with other subgroups

6.1. WPEC Subgroup 44 Report V. Sobes

7. Review of actions All

8. Next meeting and any other business

APPENDIX 3

List of actions agreed at the 25-26 June 2019 Meeting of Subgroup 46 on the Efficient and Effective Use of Integral Experiments for Nuclear Data Validation

1. **K. Yokoyama, E Ivanov**: ADS target accuracies and integral parameters as proposed by JAEA to be coordinated with proposed target accuracies as proposed by **E. Ivanov** (see below). Revised values to be circulated before next meeting
2. Committed to provide models (possibly R-Z) by **next meeting** in November:
   a. **P. Romojaro** (MYRRHA, ESFR, ASTRID, and ALFRED)
   b. **ENEA** (ALFRED, LFR WESTINGHOUSE)
   c. **I. Kodeli** (MYRRHA)
   d. **JAEA** (ADS)

   Note: SG26 and SG33 data are available on reports and website

   Note: Available models from **F. Gabrielli** (benchmarks of SFRs and MSR)
3. **For those providing models**, it is requested that they provide a list of recommended integral parameters, associated sensitivities, and uncertainty analyses. Based on uncertainty analysis a recommended list of isotopes for TAR will be provided **by next meeting**.

   Note that the format for sensitivities should be those recommended by SG33. Uncertainty tables should also follow recommendations made in SG33.

   Note that the list of reactions for sensitivity is: capture (includes: (n,γ), (n,α), (n,p), etc.), fission, ν, χ, elastic, inelastic, μ
4. **I. Kodeli** to provide delayed neutron covariance data matrix by **next meeting**.
5. **All SG46** to provide enlarged list of benchmarks, upon request of **A. Plompen**. Strong interest in fuel cycle installation related target accuracies. Participants to provide feedback for **next meeting** where we will finalise the list of considered systems. It is reminded that in the SG26 exercise, a number of fuel cycle related parameters where already considered and could provide a basis also for the present exercise (to be expanded when needed)
6. **O. Cabellos, M. Hursin and A. Plompen** to circulate TAR tables to the wider community (code library developers, industry users, safety authorities), to get feedback to be finalised by the November 2019 meeting (as discussion point at the meeting).
7. **P. Romojaro** to verify (and provide feedback to the Secretariat before next meeting) interest of adding the low Na void ASTRID-like system provided by **F. Gabrielli**.
8. **P. Romojaro** to look at the SFR-UAM benchmarks to determine if they should be included in the TAR exercise. As above for action 6
9. Actions related to MSR:
   a. **I. Hill** circulate TAR material to parties interested in MSR

b. **C. Perfetti** to investigate ORNL comments on the TAR initiative. Suggest possibly which MOSART model could be put as priority and/or provide an extra benchmark closer to ORNL interest

c. **C. Perfetti** determine if he could take care of MSR system(s) for the SG46 TAR activity. Provide feedback to coordinators and Secretariat **before next meeting** in November

d. **M. Fleming** to ask **E. Ivanov** to specify if his comments come from MOSART team requirements and if he could contribute to the TAR exercise for the MSR part

10. **I. Hill** to circulate for comments, suggestions the TAR material for VHTRs to the groups participating to HTR benchmarks. Possible contributors to VHTR to be verified (**all, Secretariat**), **before next meeting**.
11. **M. Hursin** will provide methods used at PSI to provide uncertainties to regulators. To be discussed at the next meeting (discussion point on accuracy requirements, see action 6)
12. **All SG46** to consolidate commitments to contribute to the TAR exercise by **next meeting**.
13. **NEA** to provide feedback on interest of experiment correlation to IRPhE/ICSBEP.
14. **K. Yokoyama** to provide papers to **G. Palmiotti** which illustrate the equivalence of different bias factors methods and their equivalence to the extended adjustment method.
15. **M. Herman** to circulate a paper on the proposed new paradigm for evaluation for comments, suggestions (e.g. use of stress tests), criticism etc., in order to have a discussion at the next November SG46 meeting, aiming to the preparation of an agreed document with options, potential time scale for implementation, tools to be preferred etc.