5th UPM/CEIDEN Workshop on "Impact of recent nuclear data evaluations on energy and non-energy nuclear applications"

May 23, 2023
Universidad Politécnica de Madrid
Instituto de Fusión Nuclear "Guillermo Velarde"
ETS de Ingenieros Industriales de Madrid, Madrid, Spain

O. Cabellos (UPM/SP) opened the meeting and welcomed all participants (Agenda of the meeting is Appendix 1, a list of participants is in Appendix 2).

1. Welcome and introduction to the meeting.

J. Dies (CSN/SP) opened the meeting with an overview on the current status of the nuclear energy in the world. He highlighted the central role of nuclear data for validation and verification of codes and applications methods for design, operation and nuclear safety. In addition, he mentioned the importance of nuclear data for the back-end fuel cycle.

A. Plompen (JRC/BE) presented the status of the JEFF project. He pointed out the importance of this meeting for identifying nuclear data needs, completeness in current evaluations and improvements in methodologies. The JEFF-4.0 library is expected in December 2024.

2. Technical presentations.

- ***A. Jiménez-Carrascosa (PSI)**, "Assessment of nuclear data libraries performance for SFR simulation"*
  He concludes the importance of nuclear data adjustment for nuclear data assessment. This works has selected a suite of benchmarks from ICSBEP/IRPhEP with high similarity to SFRs not only keff but reactivity coefficients and control rod worths. TSURFER/SCALE tool is used **showing major adjustments for the following JEFF-3.3 nuclear reactions: U238(n,gamma), U238(n,n'), U238(n,fission) and Pu239/PFNS**. Finally, he pointed out as major task in the future an "Accurate estimation of correlations in experiment uncertainties" to be used in conjunction with assimilation techniques.

- ***P. Romojaro (SCK•CEN)**, "Nuclear data requirements for an accurate estimation of the neutron production rate of spent nuclear fuel".*

He started with an introduction on different PIE programs (ARIANE, MALIBU and REGAL) and importance for the validation of any characterisation scheme (e.g. neutron emission, decay heat, etc...) based on depletion calculations. Depletion codes (ALEPH, SCAle and SERPENT2.2.0) were introduced, and depletion calculations were performed for an irradiated segment sample (at 54.3 MWd/kg) with different nuclear data libraries (ENDF/B-VII.0, VII.1 and VIII.0, JEFF-3.1.2, JEFF-3.3 and JEFF-4T1 and T2, JENDL4.0u and JENDL-5.0). The impact of nuclear data is reviewed for the isotopic prediction of 137Cs, 244Cm and Burnup, and for the neutron emission. He concluded that:

- **Recommended decay and neutron emission data not always adopted in evaluated data libraries**
- **147Nd(n,g) cross section in JEFF-3.3 and ENDF/B-VIII.0 are too high (important for normalisation of PIE data)**
- **Fission yields for 148Nd in JENDL-5.0 are too low**
- **242Pu(n,g) and 243Am(n,g) cross sections require a re-evaluation (use of available experimental data)**

– ***C. Ratero (SCK·CEN)**, "Benchmarking of JENDL-5 and JEFF-4T2 in depletion calculations against isotopic inventories"*

She presented a depletion calculation for the MOX/GM1 sample(at 66.8 MWd/kgHM) from Gösgen Reactor (PWR), measured by PSI Laboratory. Calculations are performed with ALEPH code.
In general, JEFF-4T2 has a good C/E performance. Some discrepancies in C/E were investigated for the JENDL-5 library concluding that:

- **The 244Pu prediction by JENDL-5 can be improved by including files corresponding to:**
  - **243Pu neutron transport**
  - **244mAm radioactive decay data**
- **Discrepancies for Sm isotopes will be reduced with the inclusion of:**
  - **147Pm branching ratio for radiative capture.**

– ***F. Grimaldi (SCK·CEN)**, "Neutron data benchmarking at the VENUS-F zero power reactor for MYRRHA".*

He performed a sensitivity analysis for the VENUS-F and MYRRHA systems. The similarity between both systems is assessed using the representativity formula based on sensitivity profiles and covariance data. He concluded that:

- The keff Sensitivity profiles computed with different nuclear data libraries are rather consistent.
- Big differences from the evaluated covariance matrices and their availability.
- keff representativity of VENUS-F to MYRRHA v1.8: **0.96 (JEFF-3.3); 0.82 (ENDF/B-VIII.0); 0.92 (JENDL-4.0u). These differences may be attributed to the differences in the nuclear data covariances.**

– *C. Guerrero (US), "Neutron absorption in the Cr isotopes of structural materials affects the criticality of fast reactor assemblies"*

He presented the motivation of new measurements of 50,53Cr(n,gamma) isotopes for criticality safety issues which can be found at the OECD/NEA-HPRL (https://www.oecd-nea.org/dbdata/hprl). Additionally, discrepant data for the 53Cr(n.gamma) in MACS(30) is presented, as well. The differences between nuclear data evaluations are discussed. A summary of different experiments are shown, highlighting the new ones (thick and thin samples) at the nTOF. **Preliminary results are presented with a comparison of recent evaluations JEFF-3.3 and CENDL-3.2**. In addition, preliminary results for the experimental value of 50Cr(n,gamma)-MACS(30) measured at HISPANoS

@CNA are presented. **This 50Cr(n,gamma)/MACS(30) value shows a good agreement with the KADONIS value**.

– *Y. Huang (Xi'an Jiaotong University), "Uncertainty Quantification Comparisons in Different Evaluated Libraries Based on the ENDF-6 Formatted Sampling Method".*
The NECP-SOUL methodology is presented which is able to generate random ENDF-6 files based on original ENDF-6 file and covariance data. A comparison with SANDY tool is performed for the Jezebel benchmark, uncertainty results show a good agreement between NECP-SOUL and SANDY. He presented some uncertainty quantification analysis in JEZEBEL, GODIVA and PWR-Pin cell. In this exercise, covariance data are taken from: ENDF/B-VIII.0, JEFF-3.3, JENDL-5.0 and TENDL-2021. He concluded that:
  - **PWR-pin cell (TMI-1 HFP): Largest uncertainties are found using ENDF/B-VIII.0. JENDL-5 has shown the smallest uncertainties.**
  - **Godiva: JEFF-3.3 and TENDL-2021 have the similar results. Lower uncertainties in JENDL-5.**

  Large impact of uncertainties due to U-235/MF34 only provided in ENDF/B-VIII.0
  - **Jezebel: JEFF-3.3 and TENDL-2021 show similar uncertainties. As for ENDF-B/VIII.0, the uncertainty result of MF 33 is more large than other libraries.**

– *Y. Qiu (KIT), "Current status and urgent needs of nuclear data and experiments for the IFMIF-DONES design analysis"*
He introduced the IFMIF-DONES (International Fusion Material Irradiation Facility – Demo- Neutron Source) facility and the current issues with nuclear data and experiments. He concluded as main issues for IFMID/DONES:
  - **d-Li neutron production- discrepancies betweenFZK-2005 and JENDL-DEU 2020**
  - **d-Li activation (7Be, 3H): Li(d,x)7Be and Li(d,x)3H (see NEA/HPRL: https://www.oecd-nea.org/dbdata/hprl)**
  - **natCu(d,x)64Cu with break-model implemented by M. Avrigeanu in TENDL-2023?**
  - **Cu(d,Xn) angular distributions by P. Sauvan in TENDL-2023?**
  - **other deuteron transport/activation libraries/gas production/ heating**
  - **needs on integral experiments:**
    - **experimental benchmarks for the high-energy neutrons (DONES: 25% neutrons >14 MeV) are not still lacking. The only one performed is the TIARA shielding experiment for Iron and concrete.**
    - **activation cross section on the high neutron energy needs dedicated benchmarks for DONES application, which is important for safety-relevant evaluation, e.g. Shutdown dose.**

– *Sonia Panizo (CIEMAT) Impact of nuclear data library uncertainties in MYRRHA v1.8 with SUMMON. Library intercomparison*
She presented the SUMMON (Sensitivity and Uncertainty Methodology for MONte carlo codes) tool developed at CIEMAT which has been verified with SANDY code. The MYRRHA system is used to propagate uncertainties in keff for different nuclear data evaluations (JEFF-3.3, ENDF/B-VIII.0 and JENDL-4.0). Differences are shown in the presentation. It can be seen a large contribution in **JEFF-3.3 for the covariance Pu240(n,fission)**. Additionally, the **uncertainty propagation for the neutron multiplicity is presented.** Evaluations may provide only total and/or prompt or both, with or without correlations. She concluded that uncertainties associated with V_{total} and V_{prompt} should not

be dismissed a priori as redundant, in the cases where the correlation data between them exists. The contribution to the uncertainty could be distributed among the four terms of the covariance matrix.

Then, INGENIA/UPM activities were presented:

- *Blanca Aguado (INGENIA/UPM), "Overview of INGENIA activities: Course 2022-2023"*
  Activities of the INGENIA/NUCLEAR course are presented. This course is a CDIO course of the UPM. She gave an overview of the content of the course with special mention to our Guest lectures who have been participating this year. She also mentioned the GreatPioneer (https://great-pioneer.eu/) course on nuclear data life cycle. Finally social media activities are also mentioned via @IngeniaNuclear.

- *Antonio Silván (INGENIA/UPM), "EXFOR – Outlier identification (EXFOR - ENDF)"*
  He presented the Data Mining developed at UPM to search and process EXFOR entries and evaluated data which allow to perform a data analysis to identify potential outliers in EXFOR. The Assessing of Outlier Detection is presented. Different techniques are explored: DBSCAN, Multivariate normal distribution and Distance-based technique. In total, 207 599 EXFOR subentries for isotopes were reviewed (4 398 164 EXFOR energy-points) and 4 288 EXFOR Subentries for natural elements (1 125 858 EXFOR energy-points). This work has provided a total of 139 EXFOR subentries to be reviewed.

- *Alejandro Velasco (INGENIA/UPM), "Mapping of ND Evaluations. An example with JEFF-4T2.2"*
  He presented the UPM tool developed to trace and identify the origin (MF/MT) in nuclear data evaluations. JEFF-4.0T2.2 is analysed using a total of 29 previous nuclear data evaluation. This work shows that 172 files in JEFF-4.0T2.2 are new evaluations of a total of 564 files. Graphical examples are shown. Finally, a new tool has been developed to identify missing JEFF data in the JEFF-4T2.2, an example new JEFF-4T2.2 evaluation for 90Zr and 186W are presented. It shows a lack of data for MF12, MF14 and MF15 which were already in previous JEFF evaluations.

- *Álvaro Antón (INGENIA/UPM). "Processing & Benchmarking JEFF-4T2.2 – A comparison with other evaluations"*
  He presented the UPM processing tool for evaluated data into ACE format. Two suites of benchmarks are shown, the criticality Mosteller 123 benchmarks and the Oktavian/shielding suite. Calculations are performed with MCNP6.1 using JEFF-4T2.2. This work shows a deterioration in criticality benchmarks: U233, HMI6, LST7, PMF5, PST9. For shielding calculations in OKTAVIAN Benchmark the JEFF-4T2.2 shows a deterioration for Al, Mo, Cu and Zr at high energies.

- *José Miras (INGENIA/UPM), "Benchmarking & Validation JEFF-4T2.2 – A comparison with other evaluations"*
  He presented the results in two different calculations:
  - **The Benchmark Phase-VII (2008- WPNCS- Expert Group on Burnup Credit) with a good agreement for the JEFF-4T2.2.**
  - **A comparison with the critical boron let-down for the NNPP- Almaraz PWR, cycle1. The burnup issue (loss of reactivity along burnup) is shown for the JEFF-3.3 and JEFF-4T2.2. Better agreement is shown for ENDF/B-VII.1 within the +-50 ppm of the acceptance limit.**

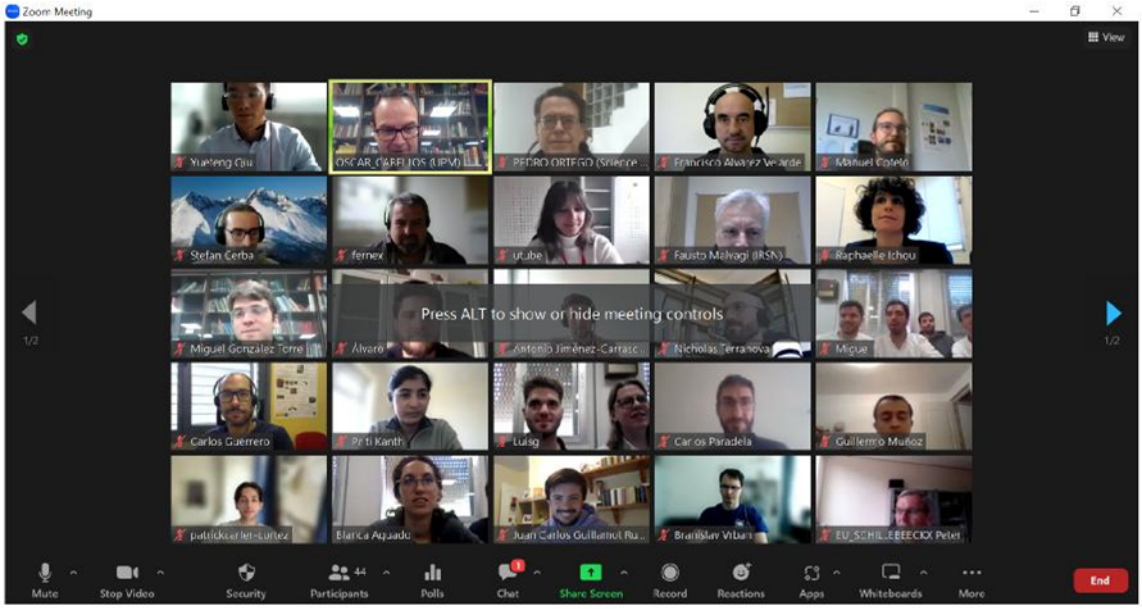
- ☐ *Miguel López (INGENIA/UPM), "Processing into JANIS format: Uncertainty Quantification with different evaluations using NDaST code".*
  He presented the UPM processing tool for evaluated data into HENDF format used in JANIS tool. This HENDF database for JEFF-4T2.2 and JENDL-5.0upd are freely available for the nuclear data community thanks to this INGENIA work (links are provided in the presentation). Finally, he also presented the uncertainty quantification for the ICSBEP/PU Benchmarks using NDaST tool for JENDL-5.0

Appendix I. Agenda

Start - End	Presenter (Institution)	Title
9:00 – 9:15	O. Cabellos (UPM) J. Dies (CSN) A. Plompen (JRC)	Welcome Introduction (VIDEO) Introduction: JEFF Project
9:15 – 9:30	A. Jiménez-Carrascosa (PSI)	Assessment of nuclear data libraries performance for SFR simulation
9:30 – 9:45	P.Romojaro (SCK·CEN)	Nuclear data requirements for an accurate estimation of the neutron production rate of spent nuclear fuel
9:45 – 10:00	C. Ratero (SCK·CEN)	Benchmarking of JENDL-5 and JEFF-4T2 in depletion calculations against isotopic inventories
10:00 – 10:15	F. Grimaldi (SCK·CEN)	Neutron data benchmarking at the VENUS-F zero power reactor for MYRRHA
10:15 – 10:30	C. Guerrero (US)	Neutron absorption in the Cr isotopes of structural materials affects the criticality of fast reactor assemblies
10:30 – 10:45	Y. Huang (Xi'an Jiaotong University)	Uncertainty Quantification Comparisons in Different Evaluated Libraries Based on the ENDF-6 Formatted Sampling Method
10:45 – 11:00	Y. Qiu (KIT)	Current status and urgent needs of nuclear data and experiments for the IFMIF-DONES design analysis
11:00- 11:15	**Coffee break and photo of participants**	
11:15 – 11:30	Sonia Panizo (CIEMAT)	Impact of nuclear data library uncertainties in MYRRHA v1.8 with SUMMON. Library intercomparison
11:30 – 11:40	Blanca Aguado (INGENIA/UPM)	Overview of INGENIA activities: Course 2022-2023
11:40 – 11:50	Antonio Silván (INGENIA/UPM)	EXFOR – Outlier identification (EXFOR - ENDF)
11:50 – 12:00	Alejandro Velasco (INGENIA/UPM)	Mapping of ND Evaluations. An example with JEFF-4T2.2
12:00 – 12:10	Álvaro Antón (INGENIA/UPM)	Processing & Benchmarking JEFF-4T2.2 – A comparison with other evaluations
12:10 – 12:20	José Miras (INGENIA/UPM)	Benchmarking & Validation JEFF-4T2.2 – A comparison with other evaluations
12:20 – 12:30	Miguel López (INGENIA/UPM)	Processing into JANIS format: Uncertainty Quantification with different evaluations using NDaST code
12:30 – 12:35	Closing the meeting	

Appendix II. List of Participants (deleted)

Appendix III. Participants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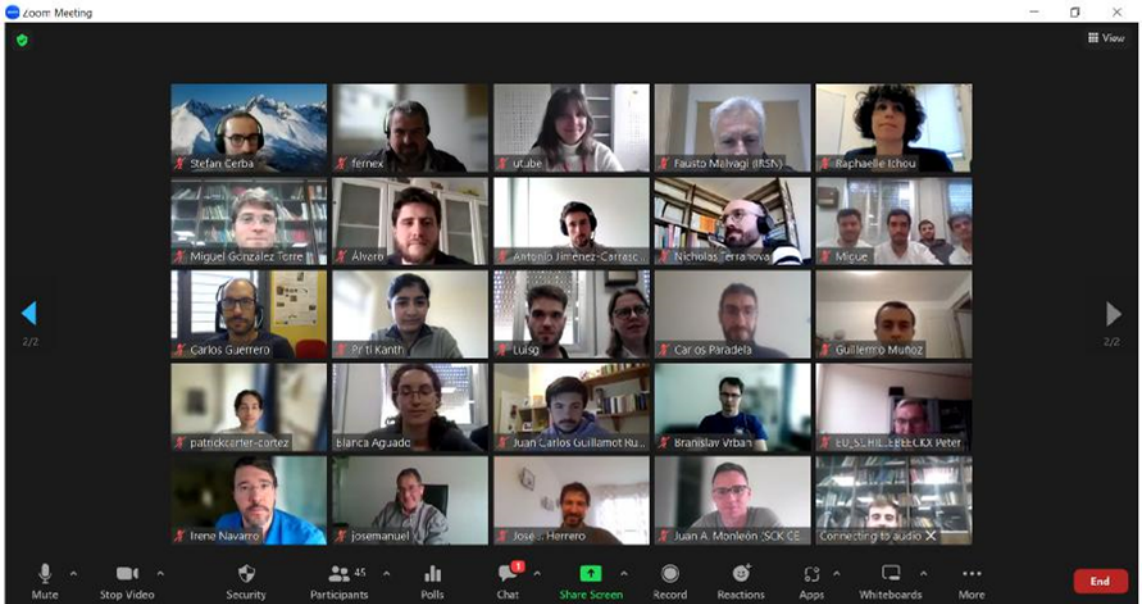
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