Summary Record of the 4th Meeting of WPEC Subgroup 39 on

Methods and approaches to provide feedback from nuclear and covariance data adjustment for improvement of nuclear data files

NEA, Issy-les-Moulineaux, France

19-20 May 2015

The subgroup co-ordinators, **M. Salvatores** and **G. Palmiotti**, welcomed the participants to the meeting (see list in Appendix 1). **O. Cabellos** acts as secretary. The proposed agenda was adopted (see Appendix 2).

1. **Review of actions**

M. Salvatores reminded the participants of the subgroup objectives and reviewed the actions agreed at the previous meeting.

Some participants were excused at this meeting (some actions, where they are involved, are still in progress):

- **E. Ivanov** (excused). The action on "Sensitivity coefficients (MC vs deterministic + comments of potential issues with MC)" and state-of-the-art of current methodologies: (KENO, SERPENT, MCNP6, TRIPOLI,…) should be consolidated.
- **Hoefer** (excused). The work done by AREVA to assess non-perturbative integral observable updating (MOCABA) and non-perturbative nuclear data updating (MOCABA) methodologies will be presented in this meeting by O. Cabellos.
- **Da Cruz** (excused). The action to release STEK model in MCNP is still under discussion at NRG.
- **A.X. Barnes** (excused). An action is still under way for providing small corrections to the Am241 model.

2. Presentations

K. Yokoyama reported the status of deliverable named "Methodology: summary". Draft deliverable is distributed in the meeting for comments. In the "Methodology: summary", it was emphasized the importance to describe compensation effects and how to avoid it during the adjustment process. It was recommended, to clarify and enlarge the content of the report, adding examples of real experiments. **G. Palmiotti** and **M. Salvatores** will collaborate in the report. A second draft will be presented in the next meeting.

K. Yokohama reported the status of deliverable named "Comments on covariance data". Draft deliverable is distributed in the meeting for comments. It was discussed the importance to include a short introduction of current methodologies in the report. And, review other important nuclear data to be analysed in the report (e.g. the nu-bar). **I. Kodeli** will provide additional comments on total nu-bar,

delayed nu-bar, correlation between ^{238}U elastic/inelastic and ^{56}Fe inelastic. A second draft will be presented in the next meeting.

M. Hursin reported on FDWR Experiments at PROTEUS done with support of FRAMATOME/SIEMENS/AREVA. He mentioned that PSI is willing to share data against in-kind contribution, and to provide C/E values, experimental uncertainties, sensitivity coefficients and infinitely dilute cross sections. These data (keff, spectral indexes,…) will be formatted according SG39 specifications. These data will be centralized, and distributed to SG39 participants in a password protected repository.

N. Touran reported on preliminary UQ efforts for Traveling Wave Reactor (TWR) design. The design is based on a "breed-and-burn" fast reactor without reprocessing. EGPT methodology has been used with COMMARA-2.0 covariance matrix. Preliminary uncertainties for keff (~1.2-1.7 %Δk/k) and reactivity coefficients were given. An overview of new steps (e.g. uncertainties in depletion,…) and needs (e.g. experiments to fill in gaps,…) for the project were presented.

It was agreed that TWR is a good example on how SG39 accounts for new industrial emerging needs, helping for data uncertainty reduction.

I. Kodeli presented the potential use of β_{eff} and other benchmarks (e.g. SINBAD, IRPhE) for adjustment. β_{eff} benchmarks are well consolidated, with exp. uncertainties < 3%. It was concluded that the β_{eff} uncertainty is in most cases (Jezebel, Skidoo, Topsy, Big-ten and Flattop 23) predominantly due to the uncertainties in delayed neutron yields (~90% uncertainty). In some cases (Popsy, SNEAK-7A, -7B and ZPPR-9) the inelastic and elastic scattering (contributing with few %), fission cross-sections (~0.2%) and prompt neutron yields (~0.2%), as well as prompt and delayed fission spectra (roughly 0.5%) play an important role. The high sensitivity and different shapes of sensitivity profiles the βeff experiments provide complementary information to critical experiments for the validation of nuclear data such as ^{238}U inelastic and elastic scattering (&fission, PFNS). Adjustment methodologies should take into account these βeff and spectral indexes measurements.

I. Kodeli reported on keff uncertainties for a simple case (sphere) of ^{241}Am using different codes and evaluated files. Differences in keff between ENDF/B-VII.0 and JENDL-4.0: ~ 3.5%. However, the sensitivities calculated using ENDF/B-VII.0 and JENDL-4.0 are in fair agreement. Large differences in keff (%Δk/k) were observed between uncertainties based on different covariance matrix evaluations: COMMARA-2: ~3%, SCALE-6.0: ~ 7.5% and JENDL-4.0: ~ 5.5%. The most important contributor in JENDL-4.0m and ENDF/B-VII.0 is PFNS, 5.1% and 5.8%, respectively. A clarification on PFNS covariance data is requested to JENDL project.

O. Cabellos reported on keff uncertainties for a simple test (sphere with graphite reflector) model of ^{241}Am using TSUNAMI code and ENDF/B-VII.0 with 238 groups. The relative standard deviation of keff (% Δk/k) due to cross-section covariance data is 7.7%, and the top contributors are ^{241}Am(n,n') and cross-correlation between ^{241}Am(n,elastic) and ^{241}Am(n,n').

It was concluded that this activity should continue: benchmark specification, comparison of codes, libraries,…

G. Palmiotti reported on experiments on ^{238}U (e.g. CALIBAN) and Fe transmission RPI experiments. New isotopes were introduced for future assessment: CIELO files, ^{23}Na, ^{241}Am and ^{105}Pd. Proposals were made in order to identify simple cases for testing purposes, and to determine compensating effects between capture and elastic/inelastic reaction cross-sections.

G. Palmiotti reported on the methodology still under development "REWIND: Ranking Experiments by Weighting to Improve Nuclear Data". This work tries to establish a methodology for ranking

experiments (using the factor "sharpe ratio") by looking at the potential gain they can produce in an adjustment. It is based on the formulation of the filtering technique, also known as linear quadratic estimation (LQE). Basically, it relies on a model with parameters that are progressively improved by measuring the actual data. REWIND is applied to CIELO files and SG33 set of experiments, then a ranking is provided. It seems that the selected "7" experiments by REWIND would produce similar adjustment results than using the whole set of "20" experiments.

Several issues were discussed: 1) assessing adjustment methodologies and ranking factors to be used, ranking factors based on physical considerations, 2) definition of a set of experiments to check the consistency of these methodologies, 3) developments to avoid compensating effects with these methodologies.

O. Cabellos (on behalf E. Castro and AREVA team) reported on the recent analysis on NUDUNA/MOCABA applications to reactor physics parameters using SEANAP system (System developed at Universidad Politécnica de Madrid for the analysis of PWR reactors). The exercise is to improve the predictions of a PWR cycle, based on the measurements and simulations of the previous cycle. It is only applied to Boron curve, and MOCABA improves mean values and leads to massive uncertainty reduction (before update uncert. of 45 ppm, and after 4 ppm). MOCABA is used to nuclear data library updating with equivalent results showing consistency in both calculations.

M. Salvatores commented the great interest of this methodology to be applied to SG33 set of experiments, and produce the generation of the adjusted library in ENDF or PENDF format.

M. Salvatores (on behalf H. Hummel) reported INL exploratory study for SEG experiments with some progress of the analysis. He introduced the SEG benchmark with a description of Pellet Unit Cells and the facility. Results obtained using MCNP6.1 with the ENDF/B –VII.I cross section library were shown. On-going and future work will consist in a verification of the adjoint energy shape and the review of experimental results and uncertainties.

H. Wu reported on the development of nuclear data adjustment code (NDAC) at CNDC. The methodology used at CNDC is based on Maximum Likelihood Method. NDAC was tested with 20 integral data. A preliminary study of input parameters was presented. This study replaces one kind of parameters at a time, try to find out the influence of covariance of group constants, sensitivities and covariance of integral quantities. It concluded that all ingredients in the adjustment affect the results and missing essential constraints lead to compensation errors.

3. Perspectives and review of pending actions.

- **Finalise deliverables**
  - Deliverable on covariance data to be finalized in 1-2 months. Feedback on covariance analysis expected. Action: Yokohama, Kodeli, Ishikawa
  - More on methodology (contributions expected on how to avoid compensations). New developments in continuous energy cross sections adjustment (AREVA) to be accounted for. Next version of deliverable by November 2015
  - A stress test on U-235 (n,f) using appropriate experiments is proposed by H.WU, in order to contribute to the issue of "avoiding compensations"; Action H.Wu, secretariat. Short paper describing the test is expected in the next month or two.
  - Sensitivity coefficients methods (MC vs deterministic, other issues) Pending Action: lead E.Ivanov. To be completed by next meeting.
  - Produce report by next meeting summarizing the status of uncertainties of Am-241 (for critical sphere). This should be done a) after benchmark model is consolidated and distributes

by end of August 2015 (Action A. Barnes); b) compiling corresponding calculated data. Action: O. Cabellos, I. Kodeli, G.Palmiotti

- **New experiments (separate effects) and their analysis:**
  - PROTEUS (link between epithermal and fast energy range: k- infinity, void coefficient, reaction rate ratios): U-238, Pu isotopes. Action to be finalized according to resources availability at PSI
  - β_{eff} experiments (new inelastic information, but need delayed nu-bar uncertainty). U-238, Pu-239, U-235. Action: I.Kodeli to summarize status and provide sensitivity coefficients in agreed format.
  - Variable adjoint experiments (e.g. SEG) to separate inelastic from absorption effects. Action: INL to analyse selected available experiments
  - Neutron leakage experiments (RPI, CALIBAN?) mostly for U-238 and Fe-56 inelastic. Action to be finalized. Secretariat to check with CEA availability of CALIBAN results
  - Selected neutron propagation experiments analysis (inelastic, elastic). Mostly Fe, also Na-23. Action: S.Pelloni
  - STEK experiments: Action to be reviewed in future. Secretariat to check with NRG availability of resources.

- **Account for new emerging needs:**
  - Industry driven needs (see TerraPower) for data uncertainty reduction or new target accuracies. Continuous action, to be reviewed at next meeting.
  - Provide feedback (including Am-241 issue) to be used in the frame of ND activities towards MA improvement requirements (NSC Expert group,). Action: Secretariat to suggest most appropriate form of communication.

- **Starting from CIELO new files (with uncertainties) attempt new adjustment:**
  - Selection of integral experiments (old and new ones)
  - Use of improved criteria for reliability (as result of methodology studies)
  - A-posteriori covariance data: proposals on how to use them in evaluation
  - Need more complete covariance information (e.g. U-235 data), possibly cross correlations

For this point, any future action should be agreed with the CIELO group, in order to check interest and to define a possible schedule

8. Next meeting

It is proposed to hold the next SG39 meeting in conjunction with JEFF meetings during the next Nuclear Data Week at the NEA, **November 30-December 4, 2015**.

Appendix 1

Participants to the 4th meeting of WPEC subgroup 39

NEA, Issy-les-Moulineaux, France

19-20 November 2015

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Appendix 2

Agenda of the 4th meeting of WPEC subgroup 39

WPEC SG39

"Methods and approaches to provide feedback from nuclear and covariance data adjustment for improvement of nuclear data files"

Agenda
NEA NEA Headquarters, Issy-les-Moulineaux May 19-20, 2015

	Tuesday, May 19, 2015 **NEA Room A**
14:00 - 14:15	Welcome, review of actions and introduction (O. CABELLOS, G. PALMIOTTI and M. SALVATORES)
14:15 - 15:00	Status of Deliverables, Kenji YOKOYAMA (and all for discussion) "1. Methodology" "2. Comments on covariance data."
15:00 - 15:30	"PROTEUS HCLWR Experiments", Mathieu HURSIN
15:30 - 16:00	"Preliminary UQ Efforts for TWR Design", Nicholas TOURAN
16:00 - 16:20	**Coffee break**
16:20 - 16:50	"Potential use of beta-eff and other benchmark for adjustment", I. KODELI
16:50 - 17:30	"keff uncertainties for a simple case of Am241 using different codes and evaluated files", I. KODELI, O. CABELLOS
	Information/discussion on: 1) U-238, Fe transmission RPI experiments G. Palmiotti 2) New isotopes to be considered in SG39. G. Palmiotti

	Wednesday, May 20, 2015 **NEA Room A**
09:00 - 09:50	"REWIND: Ranking Experiments by Weighting to Improve Nuclear Data", G. PALMIOTTI
09:50 - 10:15	"Recent analysis on NUDUNA/MOCABA applications to reactor physics parameters", E. CASTRO GONZALEZ, A. HOEFER, presented by O. CABELLOS
10:15 - 10:30	"INL exploratory study for SEG", A. HUMMEL, M.SALVATORES
10:30 - 10:45	**Coffee break**
10:45 - 11:15	'The Development of Nuclear Data Adjustment Code at CNDC', H.WU
11:15 - 11:35	Review of pending actions: ✓ Sensitivity coefficients (MC vs deterministic + comments of potential issues with MC). State-of-the-art (KENO, SERPENT, MCNP6, TRIPOLI, etc.), recommendations. E. Ivanov (leader) + I.Kodeli + PSI. Draft by May 2015 ✓ Neutron propagation experiments (FNS, FNG, JANUS): S.Pelloni, I.Kodeli, others (Analysis volunteers are needed)?? Experiment for O-16 to be analysed (I.Kodeli) ✓ Oscillation experiments (STEK, SEG). Sensitivity profiles, C/E with associated uncertainties. What could be made available by NRG for STEK? (Da Cruz). INL exploratory study for SEG, other contribution? ERMINE experiments: CEA contributions? (A summary on these actions to be discussed at next meeting)
11:35 - 12:00	Future plans and next meeting
12:30 - 14:00	**Lunch break**

	Wednesday , May 20, 2015 **NEA Room A+B**
14:00 - 18:00	**Joint Session SG38 + SG39 (Nuclear Data Adjustment) + SG40 (CIELO)**
14:00 - 14:20	SG38: "Overview of proposed new format, its similarities and differences compared to ENDF-6", Dave Brown
14:20 - 14:40	SG38: "Detailed view of how covariances and uncertainties are handled in the proposed new format", Caleb Mattoon
14:40 - 15:00	SG39: "Future plans for SG39", G. Palmiotti, M. Salvatores
15:00 - 15:20	SG39: "Summary of first 2 SG39 deliverables", K. Yokoyama
15:20 - 15:40	**Coffee Break**
15:40 - 16:00	SG40: "Perspectives on progress and future of CIELO", M. Chadwick
16:00 - 16:20	SG40:" Progress in CIELO on resonance range evaluations: Fe56, U235,238 and Pu239", L. Leal
16:20 - 16:40	"Development of a new Nuclear Data Evaluation Cycle at NEA Data Bank", C.J.Diez
16:40 - 17:00	"Using Sensitivity Data in DICE to identify CIELO benchmarks, and the Nuclear Data and Sensitivity Testing Tool", I. Hill
17:00 - 18:00	Feedback and discussion
18:00	Adjourn