WPEC sub-group proposal: “Investigation of Covariance Data in General Purpose Nuclear Data Libraries”

Subgroup Monitor:
Cyrille de Saint Jean, CEA, France, (JEFF)

Subgroup Coordinator:
Vladimir Sobes, ORNL, USA, (ENDF)
WPEC sub-group proposal

(Cyrille de Saint Jean, CEA, France) and Vladimir Sobes (OREIL, USA)

Title: Investigation of Covariance Data in General Purpose Nuclear Data Libraries

Justification for a Subgroup

The motivation for the subgroup is to bring together the international covariance community to understand how the covariance data can be so different between the different evaluated nuclear data files, ENDF, JEFF, JENDL, CENDL, etc., while the mean values (cross sections, ratios, etc.) are generally very similar. Many questions have emerged from the groups applying covariance data for analyses, such as the Working Party on Nuclear Criticality Safety (WPNS) Expert Group on Uncertainty Analysis for Criticality Safety Assessment (UACSA), on how the use of different covariance libraries (e.g. ENDF, JEFF, JENDL, etc.) affect uncertainty quantification and Shirley assessment. Further, significant differences in covariance libraries leads to differences in the adjustment of parameters for fast reactors, which is an important topic for WPEC subgroup (JG 39).

The CIELO project, WPCE SG 49, established an international effort of nuclear data evaluations from different nuclear data projects to produce nuclear data evaluations that will be commonly accepted by all major nuclear data projects. This work has certainly driven the progress towards minimizing the disagreement in the mean values (cross sections, ratios, etc.) between different nuclear data libraries. However, with that project coming to a close the coming years, there has not yet been a concerted effort on providing consistent covariance evaluations across the different nuclear data libraries. The maturity of the nuclear data evaluation process is such, at this time, that it is warranted to create an international collaboration on cross section covariance evaluation methodologies.

This sub-group will be linked to the goal to investigate covariance data for a broad range of system types, not just fast reactors as in the scope of WPEC SG 49. This sub-group will leverage the work of previous sub-groups which investigated the generation of covariance data for specific physical regions, such as WPEC SG 24 and SG 39, which focused on evaluations of fast neutron region and the resolved resonance region as well as WPEC SG 42 which focused on the evaluation and covariance generation for thermal scattering. This sub-group will put an emphasis on providing guidance to the community on methods for systematic and consistent evaluation of covariance data for the whole energy range, paying special attention to the resolved resonance region (resolved resonance continuum). The group will also define examples of the application of the proposed methodology on a few selected isotopes. The ultimate goal of the subgroup is to provide an overview of the best practices of how to generate more consistent covariance data sets.

Subgroup Mentor:

Cyrille de Saint Jean, CEA, France, (JEF)

Subgroup Coordinator:

Vladimir Sobes, OREIL, USA, (ENDF)

Relevance to Evaluated Data Files

Recommendations for generating nuclear data covariance evaluations.

Time Schedule and Deliverables

2017-2018: The first period will be devoted to collect and review existing evaluations and to identify the major discrepancies between different projects as well as the major issues driving the discrepancies in the propagated nuclear data uncertainties in applications.

2018-2019: The second period will be devoted to the exploration of systematic and consistent methodologies for generating covariance data.

2019-2020: The third period will address the representation of nuclear data covariance in evaluated nuclear data files and their interpretation. Of particular interest will be the representation and interpretation of covariance data for non-cross section data (e.g. prompt neutron fission spectra, angular distributions, cross-correlations).

Subgroup Participants

The persons listed below already expressed some interest in the proposed activities, pending confirmation by the data projects and/or their home institutes.

ENDF


JEFF

G. Napier (CEA), P. Anfani (CEA), E. Bange (CEA), L. Lund (ISIS), S. Roney (ISIS), S. Eeo (ISIS), E. Leung (ORNL), W. Haack (ORNL), E. Franco (ORNL), D. Butch-Rochon (ORNL), T. Ivanova (NC), G. Cebello (NC), P. Tschirsky (NC), M. Salabas (Consultant), D.H. Kim (IAEA), E. Mills (NNI), Holmea Locht (TU Wien, Austria)

JENDL

O. Misunato (JAEA), G. Chiba (Hokkaido U.)

BROAD

A. Spokyn

CENDL

Z. Gu, S. Ramesh

IAEA/NDS

Rebecca Caputo

Other (non NEA)


Other Activities

Project Definitions and proposed activities

The implications for the propagation of nuclear data uncertainty through current modelling and simulation capabilities to the safety of nuclear installations around the world justify the creation of a new subgroup. An international collaboration through a NEA/WPEC subgroup will be essential to leverage efforts allowing the sharing of information needed for achieving the project goal.

The project will be divided in the following phases:

1) Evaluation of the differences between different covariance data evaluations in different evaluated nuclear data libraries
2) Assessment of the methodologies for generating covariance data utilized by the different data projects
3) Documentation and evaluation of the current state-of-the-art methodologies for covariance data generation
4) Discussion of the representation and interpretation of nuclear data uncertainty (covariance) in evaluated nuclear data files
5) Definition of a dedicated benchmark to test various covariance evaluation methodologies: this benchmark will propose a limited set of input data (microscopic/onedimensional measurements) with detailed uncertainties description for one isotope to be defined (e.g. "Pu-233", "Pu-239")

Detailed time schedule (preliminary version)

<table>
<thead>
<tr>
<th>Year</th>
<th>Period</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>May</td>
<td>Start of the activities at the NEA</td>
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<tr>
<td></td>
<td></td>
<td>Review of the motivation by WPCEC IAEA Expert group</td>
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<td></td>
<td></td>
<td>Review of the previous work of WPCEC SG 24, WPCEC SG 39, WPCEC SG 49</td>
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<tr>
<td>May</td>
<td></td>
<td>Collect evaluated nuclear data files for different covariance evaluations</td>
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<tr>
<td>June</td>
<td></td>
<td>Inter-comparison of available data</td>
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<tr>
<td>May</td>
<td></td>
<td>Begin to put together justifications for existing covariance data</td>
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<td></td>
<td>Review of existing data</td>
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<td></td>
<td></td>
<td>Preparation of anomaly activity</td>
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<tr>
<td></td>
<td></td>
<td>Set of activities at the NEA</td>
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<tr>
<td></td>
<td></td>
<td>Review of the existing differences in the covariance of different evaluated nuclear data libraries</td>
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<td></td>
<td></td>
<td>Review of various covariance generation methodologies</td>
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<tr>
<td></td>
<td></td>
<td>Collect justifications for existing covariance data</td>
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<tr>
<td>July</td>
<td></td>
<td>Collect report on current status of the art covariance data generation methodologies</td>
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<tr>
<td></td>
<td></td>
<td>Review of existing covariance data</td>
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<td></td>
<td></td>
<td>Study of the interface activities between different covariance generation methodologies</td>
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<tr>
<td>2019</td>
<td>May</td>
<td>Review of the ongoing activities</td>
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<tr>
<td></td>
<td></td>
<td>Set of the various activities</td>
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<tr>
<td></td>
<td></td>
<td>Review of the interface activities</td>
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<td></td>
<td>Review of the existing data</td>
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<td></td>
<td>May</td>
<td>Collect data for the subgroup for covariance data evaluation and recommended recommendations for nuclear data covariances storage and interpretation</td>
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<tr>
<td></td>
<td></td>
<td>Prepare report that includes a review of a systematic and consistent methodologies for covariance evaluation and recommendations for nuclear data covariances storage and interpretation</td>
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</tbody>
</table>


Justification for a Subgroup

• How can the covariance data be so different while the mean values are generally very similar between different evaluated nuclear data files?
• Different covariance libraries affect uncertainty quantification and similarity assessment.
• CIELO project driven the progress towards minimizing the disagreement in the mean values but no dedicated work towards covariance.
• Previous WPEC Subgroup with specific energy regions/applications: SG-24 (fast energy region), SG-36 (RRR), SG-39, SG-42 (S(α,β)).

This group:

• Methods for systematic and consistent evaluation of covariance data for the entire energy range.
• Deliver examples of the application of the proposed methodology on a few selected isotopes.
• Ultimate goal: provide an overview of the best practices of how to generate more consistent covariance data sets.
Subgroup Participants (Tentative)

**ENDF:**  B. Beck (LLNL), C. Mattoon (LLNL), E. Jurgenson (LLNL), M. Zerkle (NNL), D. Barry (NNL), D. Brown (BNL), M. Herman (BNL), D. Smith (ANL, retired), B. Rearden (ORNL), M. Dunn (ORNL), M. Williams (ORNL), D. Wiarda (ORNL), K. Guber (ORNL), P. Talou (LANL), D. Neudecker (LANL), M. White (LANL), M. Chadwick (LANL), G. Palmiotti (INL), Y. Danon (RPI)

**JEFF:**  G. Noguere (CEA), P. Archier (CEA), E. Bauge (CEA), L. Leal (IRSN), S. Pignet (IRSN), S. Evo (IRSN), E. Letang (IRSN), W. Haeck (IRSN), E. Ivanov (IRSN), Dimitri Rochman (PSI), T. Ivanova (NEA), O. Cabellos (NEA), P. Schillebeeckx (JRC), M. Salvatores (Consultant), D.H. Kim (KAERI), R. Mills (NNL), Helmut Leeb (TU Wien, Atominstitut)

- **JENDL**  O. Iwamoto (JAEA), G. Chiba (Hokkaido U.), K. Yokoyama (JAEA)

**BROND**  A. Ignatyuk

**CENDL**  Z. Ge, X. Ruirui

**IAEA-NDS**  R. Capote

**Other (non-NEA)**  ?
Proposed activities

• Evaluation of the differences between discrepant covariance data evaluations in different evaluated nuclear data libraries

• Assessment of the methodologies for generating covariance data utilized by the different nuclear data projects

• Documentation and evaluation of the current state-of-the-art methodologies for covariance data generation

• Demonstration of the state-of-the-art covariance evaluation methodologies on a limited set of input data (microscopic/integral measurements) with detailed uncertainties description for one isotope to be defined (e.g. $^{239}$Pu, $^{235}$U, $^{238}$U);

• Discussion of the representation and interpretation of nuclear data uncertainty (covariance) in evaluated nuclear data files.
Time Schedule and Deliverables

2017-2018: The first period will be devoted to collect and review existing evaluations and to identify the major discrepancies between different projects as well as the major issues driving the discrepancies in the propagated nuclear data uncertainties in applications.

2018-2019: The second period will be devoted to the exploration of systematic and consistent methodologies for generating covariance data.

2019-2020: The third period will address the representation of nuclear data covariance in evaluated nuclear data files and their interpretation. Of particular interest will be the representation and interpretation of covariance data for non-cross section data (i.e. prompt neutron fission spectra, angular distributions, cross-correlations).
**Detailed time schedule (preliminary version)**

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<th>Period</th>
<th>activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>May</td>
<td>Start of SG activities at the NEA:</td>
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<tr>
<td></td>
<td></td>
<td>• Review of the motivation by WPNCS UACSA Expert group</td>
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<td></td>
<td></td>
<td>• Review of the previous work of WPEC SG-24,36,39,42.</td>
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<td></td>
<td>May-June</td>
<td>Collect evaluated nuclear data files for discrepant covariance evaluations</td>
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<td></td>
<td>June-Dec.</td>
<td>Status/performance of available data</td>
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<td>Jan-May</td>
<td>Begin to put together justification for existing covariance data</td>
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<td></td>
<td>May</td>
<td>Status of the one-year activity:</td>
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<tr>
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<td></td>
<td>• Review of the existing differences in the covariance in different evaluated nuclear data libraries</td>
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<td></td>
<td></td>
<td>• Review of the existing covariance generation methodology</td>
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<td>May-July</td>
<td>Collect justification for of existing covariance data</td>
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<td></td>
<td>July-Dec.</td>
<td>Collate report on current state-of-the-art covariance data generation methodology</td>
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<tr>
<td>year</td>
<td>Period</td>
<td>activities</td>
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<tr>
<td>2019</td>
<td>May</td>
<td>Status of the two-year activities:</td>
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<tr>
<td></td>
<td></td>
<td>• Review of the systematic and consistent covariance generation methodologies</td>
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<tr>
<td></td>
<td></td>
<td>• Discuss the representation and interpretation of nuclear data covariance in evaluated nuclear data files</td>
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<td>May-Dec.</td>
<td>Study of the effects of different representation of nuclear data covariance in evaluated nuclear data files</td>
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<td></td>
<td>Jan-May</td>
<td>Document the recommendations of the sub-group for covariance data representation in evaluated nuclear data files</td>
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<tr>
<td>2020</td>
<td>May</td>
<td>Status of the three-years activities</td>
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<tr>
<td></td>
<td></td>
<td>• Proposal for a draft version of the final report that includes a review of systematic and consistent methodologies for covariance evaluation and recommendations for nuclear data covariance storage and interpretation</td>
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</tbody>
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