

WPEC Subgroup Proposal *Robert W. Mills, NNL (JEFF)*

Title

"Improved Fission product yield evaluation methodologies"

Justification for a Subgroup

The current evaluated fission product yield files (ENDF, JEFF, JENDL etc.), like all nuclear data evaluations, are based upon a combination of experimental data, theory and empirical models. These are combined to produce sets of complete data that are consistent with both experiment and the physical constraints, in this case, of the fission process. These files have undergone developments over the last 40 years, but, with the reduction of experimental measurement activities in the 1980's and 1990's, and little demand for improvements from existing applications, few researchers have remained active in this area.

In the last few years improved models of the fission process (References 1 to 12) have given greater insight into the fission fragmentation process and allowed the development of a general description of the process that offers new insights to predicting fission product yields using a small set of underlying physics parameters rather than empirical fitting. These ideas could be very helpful in the development of a new generation of fission product yield evaluations.

Also, over the last decade, the budding renaissance of nuclear power and increasing interest in fast spectra reactors (GEN-IV, Thorium fuel cycles, P&T, plutonium fuel cycles/waste management etc.) have drawn attention to the limitation of current files and their underpinning experimental and theoretical understanding. These new applications' requirements for fission product yields (Reference 13) include improved accuracy and covariance data (to allow accurate estimates of error in engineering parameters) for fast neutron fissioning systems with much fewer measurements than thermal neutron fission reactor applications which are dominated by the well measured thermal fission of ^{235}U and ^{239}Pu . These requirements, including fast spectra fission of ^{232}Th , $^{233,235,238}\text{U}$ and ^{239}Pu , have already lead to a reevaluation of historic measurements (References 14-18) and will be aided by a wide range of planned and ongoing new measurements (References 19-25). Some of these new measurements include data obtained from direct fission product particle identification whose methods lack the resolution to determine the particle's mass and charge uniquely to within the ± 1 mass or charge unit. These novel measurements will require new evaluation methods to be included in analyses with existing databases. These new evaluations will also need to produce covariance data if they are to be used in uncertainty and target accuracy assessment exercises such as that in WPEC-26 (Reference 26). Covariances will need to include effects from experimental measurement (methods, ratio techniques etc), parameter fitting (Wahl Zp, five Gaussian model, etc) and the statistical analysis and processing involved in the production of the evaluated files (measurements of yields around splitting and recombination of decay chains, calculation of cumulative yields from independent yields etc).

Fission product yields have become a current topic of much interest, for experiments, evaluations, and theory/models, as evidenced by the many recent references in this proposal and the investments many countries are making in new measurements.

Subgroup Monitor

M.B. Chadwick, LANL (ENDF)

Subgroup Coordinator

R.W. Mills, NNL (JEFF)

Subgroup Participants (Proposal, to be revised, updated etc)

M.B. Chadwick, T. Kawano, J.P. Lestone, ... (ENDF);

Prof. Tadashi Yoshida, T. Tachibana, K. Oyamatsu, ... (JENDL);

R.W. Mills, NNL, K-H. Schmidt, GSI, O. Serot, E. Bauge, ... (JEFF);

(Note: The names are preliminary and the data projects will need to identify appropriate participants from their communities.)

Definition of the project and proposed activities

There are new developments in the theory and measurement of fission product yields that are expected to result in new evaluated files in the next 5 years. These files are expected to include considerably more accurate yields including neutron energy dependence combined with new covariance information that will for the first time allow realistic error estimates of many engineering parameters to be determined within the calculation code rather than only being justified by comparison with limited benchmark experiments. To gain maximum benefit for modellers these groups need to exchange and discuss their new experimental data, as well as their ideas and plans so that common data formats for the improved yields and new covariance data can be developed.

It is proposed that this new WPEC subgroup will work on improving fission product yield evaluation methods to include both the existing and new measurement types and consider adoption of new models of fission product production replacing the current models such as the five-Gaussian and Wahl Z_p models. In addition, the new evaluation methodologies should allow the definition and evaluation of the covariance terms to improve estimations of errors in applied calculations. The goal is for the experts in this field to develop improved methodologies for future evaluations that are consistent with the new theoretical knowledge and experimental measurements, and include common covariance methods that will allow calculations with both improved accuracy and the generation of uncertainties on calculated engineering parameters.

Relevance to Evaluated Data Files

The results of this work are intended to be a resource advising future evaluators in new fission fragmentation models, evaluation methodologies and the treatment of fission yield covariances.

Tasks:

1. *Document and compare the current methodologies used to produce the ENDF, JEFF and JENDL files.*
2. *Through insights amongst the subgroup participants, together with new measurements being made, the participants will strive to better understand and reconcile existing fission product yield discrepancies. Tasks will include:*

Analyze the implications of new measurements techniques which offer a qualitative and potentially a quantitative leap forward, for updating the current evaluated files.

Examine the existing and planned fission product yield measurements and consider how to improve the current evaluation methodologies to gain maximum benefit from these new sources of data.

Examine the use of the new theoretical methods to model yield distributions compared to existing models and the measurements, including for example, the recently published Lohengrin measurements of thermal fission of ^{239}Pu (Ref .27) and the LANL/CEA fast and 14 MeV plutonium measurements (Ref 14-16).

3. *Recommend revised fission product data formats including covariance data.*

Time-Schedule and Deliverables:

It is anticipated that the experts of this SG could complete and document the activities (mandate) listed above within 2 years starting from January 2013.

<u>Date</u>	<u>Deliverables</u>
June, 2013	Review of current evaluation methods and new requirements
January, 2014	Proposal for new fission yield format including covariance.
December, 2014	Present Final Report of Subgroup activities, including documentation and recommendations of new data analysis methods and models.

Other background:

It is not intended that this work will determine a single recommended method for fission product yield evaluations, but rather allow the different projects to develop their own methods using the newly available theoretical understanding and experimental measurements to improve the files.

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