Current Status of CIAE Activities on Nuclear Data Adjustment

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Outline

- Introduction
- Methods and Procedures
- Nuclear Data Preparation
- Preliminary Benchmark Results
- Summary
Introduction

- History
  - No *Nuclear Data Adjustment* on multi-group cross-section (XS) library had been done before.
  - Fe, $^{235,238}\text{U}$, $^{239}\text{Pu}$ and et al. of CENDL-2.1 were adjusted according several benchmark results.
  - The total cross sections of $^{63,65}\text{Cu}$ for CENDL-3.1 were evaluated based on trend and sensitivity analysis of selected benchmarks.
Introduction

- Our plan
  - Generate a set of multigroup XS library.
  - Generate a set of covariance matrices.
  - Do benchmark exercise.
  - Develop a S/U analysis code – 1/D
  - Perform S/U analysis.
  - Develop a nuclear data adjustment code for multigroup library?
  - Do adjustment exercise.
  - Others?
Methods and Procedures

- **Maximum Likelihood Method** is going to be used in our practice.
  - The vector of adjusted constant is given by
    
    \[ C' = C + M H^T \left( V + H M H^T \right)^{-1} \left( I_e - I_p \right) \]
  - The best estimated results for integral quantities are given by
    
    \[ I' = I_c + H M H^T \left( V + H M H^T \right)^{-1} \left( I_e - I_c \right) \]
Methods and Procedures

- Some criteria in applying the nuclear data adjustment
  - The benchmarks sequence used for adjustment should be clean and able to define a trend of a integral parameter ($k_{eff}$, reaction rate, and so on.) for one material (an isotope or an element) explicitly.
  - The chosen of the material to be adjusted should be based on trend and sensitivity analysis.
  - Reserve human judgments to avoid unreasonable adjustment occurred.
Methods and Procedures

- **NPLC-2**
  - Resonance self-shielded XS library in AMPX/ANISN format

- **XSDRN-PM**
  - 1D transport calculations

- **DOT-3.5**
  - 2D transport calculations

- **SENS-1D**
  - $S_N$ based XS sensitivity and uncertainty
  - First-order perturbation theory
Nuclear Data Preparation

- Multigroup Cross Section Library
  - Code: NPLC-2, preNPLC2.pl+NJOY99+PASC4
  - Evaluation files (78 in total):
    - CENDL-3.1 (with covariances): $^{56}\text{Fe}$
    - JENDL-4.0 (with covariances): $^{10}\text{B}$, $^{23}\text{Na}$, $^{235,238}\text{U}$, $^{239,240}\text{Pu}$.
    - CENDL-3.1: others.
  - GRP. Structure: 33g
  - Weight function: iwt=8, thermal+ 1/e + fast reactor + fission + fusion
  - Self-Shielding: Bonami-II
  - Effective XS: XSDRN-PM
Nuclear Data Preparation

- Covariance Matrix
  - Different weight function -- different multigroup covariance
  - The same weight function was used both in our multigroup XS and covariance matrix preparing.

![Graph showing energy ratio and differential energy ratio for two different weight functions: iwt8 (Thermal + 1/E + fast reactor + fission + fusion) and iwt3 (1/E). The graph illustrates the behavior of the ratio across different energy ranges.]
Nuclear Data Preparation

- $^{239}\text{Pu}(n,f)$ -- Different weight func. and group structure?
Nuclear Data Preparation

$$^{235}\text{U}(n,f)$$

- Correlation Matrix
- Ordinate scales are % relative standard deviation and barns.
- Abscissa scales are energy (eV).

CNDC

IJS
Nuclear Data Preparation

- $^{238}\text{U}(n,\gamma)$

- $\Delta\sigma/\sigma$ vs. $E$ for $^{238}\text{U}(n,\gamma)$
  - Ordinate scales are % relative standard deviation and barns.
  - Abscissa scales are energy (eV).

- Correlation Matrix
  - CNDC
  - IJS

2011-05-11
WPEC Meeting/SG33, NEADB, France
Preliminary Benchmark Results

- **Jezebel – $^{239}$Pu**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>MC Benchmark Model</th>
<th>$S_4P_1$</th>
<th>Corr. Fact.</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>$k_{\text{eff}}$</td>
<td>0.9984</td>
<td>1.0040</td>
<td>0.9945</td>
<td>1.00000 ± 200pcm</td>
</tr>
<tr>
<td>F28/F25</td>
<td>0.2069</td>
<td>0.2056</td>
<td>1.0066</td>
<td>0.2133 ± 1.1%</td>
</tr>
<tr>
<td>F37/F25</td>
<td>0.9811</td>
<td>0.9809</td>
<td>1.0002</td>
<td>0.9835 ± 1.4%</td>
</tr>
<tr>
<td>F49/F25</td>
<td>1.4374</td>
<td>1.4364</td>
<td>1.0007</td>
<td>1.4609 ± 0.9%</td>
</tr>
</tbody>
</table>

- **Jezebel – $^{240}$Pu**

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</tr>
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<tr>
<td>$k_{\text{eff}}$</td>
<td>0.9985</td>
<td>1.0037</td>
<td>0.9948</td>
<td>1.00000 ± 200pcm</td>
</tr>
<tr>
<td>F28/F25</td>
<td>0.1759</td>
<td>0.1685</td>
<td>1.0438</td>
<td>0.1799 ± 1.1%</td>
</tr>
<tr>
<td>F37/F25</td>
<td>0.8645</td>
<td>0.8447</td>
<td>1.0234</td>
<td>0.8561 ± 1.4%</td>
</tr>
</tbody>
</table>

- **Flattop-Pu**

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<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>$k_{\text{eff}}$</td>
<td>0.9988</td>
<td>0.9939</td>
<td>1.0050</td>
<td>1.00000 ± 300pcm</td>
</tr>
<tr>
<td>F28/F25</td>
<td>0.1759</td>
<td>0.1685</td>
<td>1.0438</td>
<td>0.1799 ± 1.1%</td>
</tr>
<tr>
<td>F37/F25</td>
<td>0.8645</td>
<td>0.8447</td>
<td>1.0234</td>
<td>0.8561 ± 1.4%</td>
</tr>
</tbody>
</table>
Preliminary Benchmark Results

- **ZPR6-7 standard**
  - The result of deterministic code is unreasonable 😞
  - Insufficient resonance self-shielding for $^{238}$U?

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</tr>
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<tr>
<td>$k_{eff}$</td>
<td>0.9902</td>
<td>0.9467</td>
<td>1.0460</td>
<td>0.9866 ± 230pcm</td>
</tr>
<tr>
<td>F49/F25</td>
<td>0.9159</td>
<td>0.9633</td>
<td>0.9510</td>
<td>0.9435 ± 2.1%</td>
</tr>
<tr>
<td>F28/F25</td>
<td>0.0205</td>
<td>0.0249</td>
<td>0.8250</td>
<td>0.0223 ± 3.0%</td>
</tr>
<tr>
<td>C28/F25</td>
<td>0.1393</td>
<td>0.1693</td>
<td>0.8230</td>
<td>0.1323 ± 2.4%</td>
</tr>
</tbody>
</table>

- **To be done**
  - ZPR6-7 High Pu-240
  - ZPRR-9
  - Joyo MK-1
Summary

- A 33g AMPX library has been generated for nuclear data adjustment.
- Covariance matrices are also generated with .
  - Additional uncertainties can be imported during processing.
- Benchmark exercises have not been finished yet。
- Develop a S/U analysis code – 1D
  - Dr. Wang will give a talk later.
- Work has not be done
  - Perform S/U analysis with SENS-1D.
  - Develop an adjustment code.
  - Do adjustment exercise.
Thank you for your attention.