Nuclear Data Pipeline, Part II

From ENDF to Application

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Nuclear Data Pipeline

1. Measurement
2. Theory
3. Evaluation
4. Processing
5. Verification and Validation
6. Applications
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# Forms of Nuclear Data

**Evaluated Data**
Data as produced by an evaluator  
- ENDF  
- GNDS

**Processed Data**
Some (or all) processing is complete

**Application Data**
Processed data in a form application codes can use  
- ACE—Monte Carlo  
- NDI—deterministic
Nuclear Data Processing

Processing code:
- Read evaluated data
- Perform physics calculations
- Generate code-specific application data
Physics Calculations in Processing Codes

- Resonance reconstruction
- Doppler Broadening
- Secondary particle generation
- Calculate energy deposition (KERMA) and radiation damage cross section
- Produce probability tables from unresolved resonance range
- Produce self-shielded cross sections in unresolved resonance range
- Calculate multi-group cross sections
Other Processing Tasks

• Generation of covariance matrices
• Plotting data
  – Cross sections
  – Secondary angle and energy distributions
  – Covariance matrices
  – etc.
• Formatting data for application codes
  – Monte Carlo
  – Deterministic
US Nuclear Data Processing Codes

There are three major processing codes being used in the United States:

- Los Alamos
  - NJOY
- Oak Ridge
  - AMPX
- Livermore
  - FUDGE

All codes are undergoing major modernization efforts
- Adapting for the use of GNDS and ENDF
- Simplifying and automating the generation of application data from evaluated data
Number of evaluations is increasing
Quantity of data is increasing
We can't continue to process/consume data as we once did.
**ENDF Releases**

- Number of evaluations is increasing
- Quantity of data is increasing

![Graph showing the increase in Neutron Evaluations and Size Neutron Sublibrary (MB) over time from 1968 to 2018.](image.png)
ENDF Releases

- Number of evaluations is increasing
- Quantity of data is increasing
- We can’t continue to process/consume data as we once did.
Verification and Validation of Processed Data

Once the processing has been completed, the data must be verified and validated

- Verify that data fits appropriate format
- Validate that data accurately describes Mother Nature
- Indirectly check that the application codes are using data correctly

Imperfections

- Evaluated data
- Processing codes
- Application codes
Verification and Validation of Processed Nuclear Data

Verification:
• Are cross section values positive?
• Do partial cross sections sum to total?
• Are PDFs positive and normalized?
• $P_0 \geq 0$
• $|P_n| < P_0$, $n = 1, \cdots, n_{\text{max}}$
• etc.

Validation of data against experimental benchmarks
• 1000+ MCNP models of critical assemblies
• Compare calculated $k_{\text{eff}}$ to experimental $k_{\text{eff}}$
• Plot change in results with changing input parameters
  – e.g., leakage vs. reflector thickness
• LLNL pulsed spheres
US Application Codes

Los Alamos
- MCNP
- Partisn

Oak Ridge
- SCALE

Livermore
- Mercury
- ARDRA
New Data from Evaluations

- $P(\nu)$ data introduced in ENDF/B-VIII.0 for $^{235}\text{U}$, $^{238}\text{U}$, $^{239}\text{Pu}$.
  - Funded in part from NA-22, ASC-PEM, and NCSP
- Processing codes must be updated
- Application formats must be updated
- Application codes must be updated
- New data is (slowly) moving through the pipeline as capabilities are improved and updated
Conclusion

• The quality and quantity of nuclear data is improving.
• In order to take advantage of this increase in knowledge and understanding, we need to make sure that all pieces of the Nuclear Data Pipeline are working together.
• Adding new capabilities to our processing and application codes will help us to better utilize the nuclear data available to us.
Improving the efficiency of the entire Nuclear Data Pipeline