User's View on the ENDF Formats and Data Processing

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Overview

- History of Evaluated Nuclear Data Formats
- New Format Requirements
- Relation between old and new format
- Processing
  - Covariances, Sensitivity/Uncertainty
- Conclusions

History

Historic formats:

- KEDAK in Germany
- UKNDL in the UK
- ENDL at LANL
- ENDF rest of USA
- SOKRATOR former Soviet Union

→ ENDF format survived (Version ENDF-6)

New Format Requirements

ENDF: old fashioned, cumbersome, but thoroughly validated

- What can the new format do that the old one can not?
- How much effort is needed by the users to switch to the new format?
- Does it add value?

Specific ENDF Features

- Sequence numbers:
  - Useful as a pointer in a sequential file
  - Nuisance for archival in databases
  - Can be re-generated automatically, if needed

  → Should be optional
- MAT numbers:
  - Assignment is not rigid (ENDF/B library convention only)
  - Needed in sequential files for ordering materials
  - Legacy codes require them (but some can search by ZA/LIS0 designation)

Specific ENDF Features

- MT reaction numbers:
  - True limitation of the ENDF format
  - Adequate for most applications (main reaction channels accounted for, radionuclide production can be accomodated)
  - Short for special purposes (e.g. storing detailed results of model calculations)

Specific ENDF Features

- Fixed floating point representation
  - Standard 7 digits, up to 9 digits (6 for very small/big numbers), sufficient in most cases
  - Requires care at intermediate stages of evaluation
  - Needs customised reading routines in some programming languages (other than Fortran)
  - Covariance matrix representation (?)

ENDF Formats for Cross Section Covariances

- ***MF*=31:** covariance of average number of neutrons per fission (ν - MT=452, 455, 456)
- ***MF*=32:** Shape and area of individual resonances
- ***MF*=33:** covariance of neutron cross section
- ***MF*=34:** covariance of angular distribution of secondary neutron (currently MT=2/P_1 only, no X-correlations)
- ***MF*=35:** covariance of energy distribution of secondary particles (MT=18 only, no incident energy correlations)
- ***MF*=30:** Covariances obtained from parameter covariances and sensitivities (no processing available)
- ***MF*=40**: Covariances for production of radioactive nuclei

Processing available (NJOY-ERRORR)

ENDF Formats for Cross Section Covariances

- Covariances of correlated energy/angle distributions (File-36)
  - Adds one more dimension to the covariance matrix (increased volume of data)
  - Problem can be circumvented by the separability assumption using File-34 and File-35 for sensitivity/uncertainty
  - Priority – correlations between incident energies, P_L coefficients

→ **No urgent need for File-36**

MF=30

$$\left(\frac{\Delta R}{R}\right)^2 = S_R^t \cdot M_\chi \cdot S_R = S_R^t \cdot (\tilde{S}_\chi^t \cdot M_\varphi \cdot \tilde{S}_\chi) \cdot S_R$$

$$= (\tilde{S}_\chi \cdot S_R)^t \cdot M_\varphi \cdot (\tilde{S}_\chi \cdot S_R) = S_{RN}^t \cdot M_\varphi \cdot S_{RN}.$$

- MF=30 is particularly suited to evaluations produced with nuclear model codes and allows the inclusion of sensitivity profiles.
  - MacFarlane: hydrogen elastic scattering data
  - Shibata: Fe and Mn evaluations available from NEA DB
  - Badikov : Mn evaluation
  - Kodeli: fission spectra covariances based on Watt formula, suitable for uncertainty & adjustment analysis
- → **None of known computer codes (NJOY, FIZCONI, CHECKER) processes File30**
- **Valid for 1st order sensitivities → Extention to 2nd order ??**

Compact data representation

- ENDF: dense data packing on account of clarity
- Increased storage capacity available, but also more complex evaluated data → new format will face similar problems
- Indexing would contribute to clarity and visibility
- Redundancy in ENDF: separation of distributions from cross sections, covariances, some redundancy allowed for the convenience of the users; new technology should reduce this further

Outlooks for a New Format

- Backward compatibility (temporary)
  - Automatic translation codes (to and from ENDF)
  - Allows legacy codes to be used until new ones are fully operational and validated
- Assess added value
- Adopt (if justified)

Data Processing

NJOY99 main processing tool

- Input from international community increases reliability
- Clear long-term strategy on code distribution
- Development focusing on cavariances

Conclusions

- New Format
  - Smooth transition
  - Thorough validation
- Processing
  - Cross sections AND covariance data processing; opportunity to propose new solutions.