AMPX Status Report and ENDF/B-VIII.0 Data Testing

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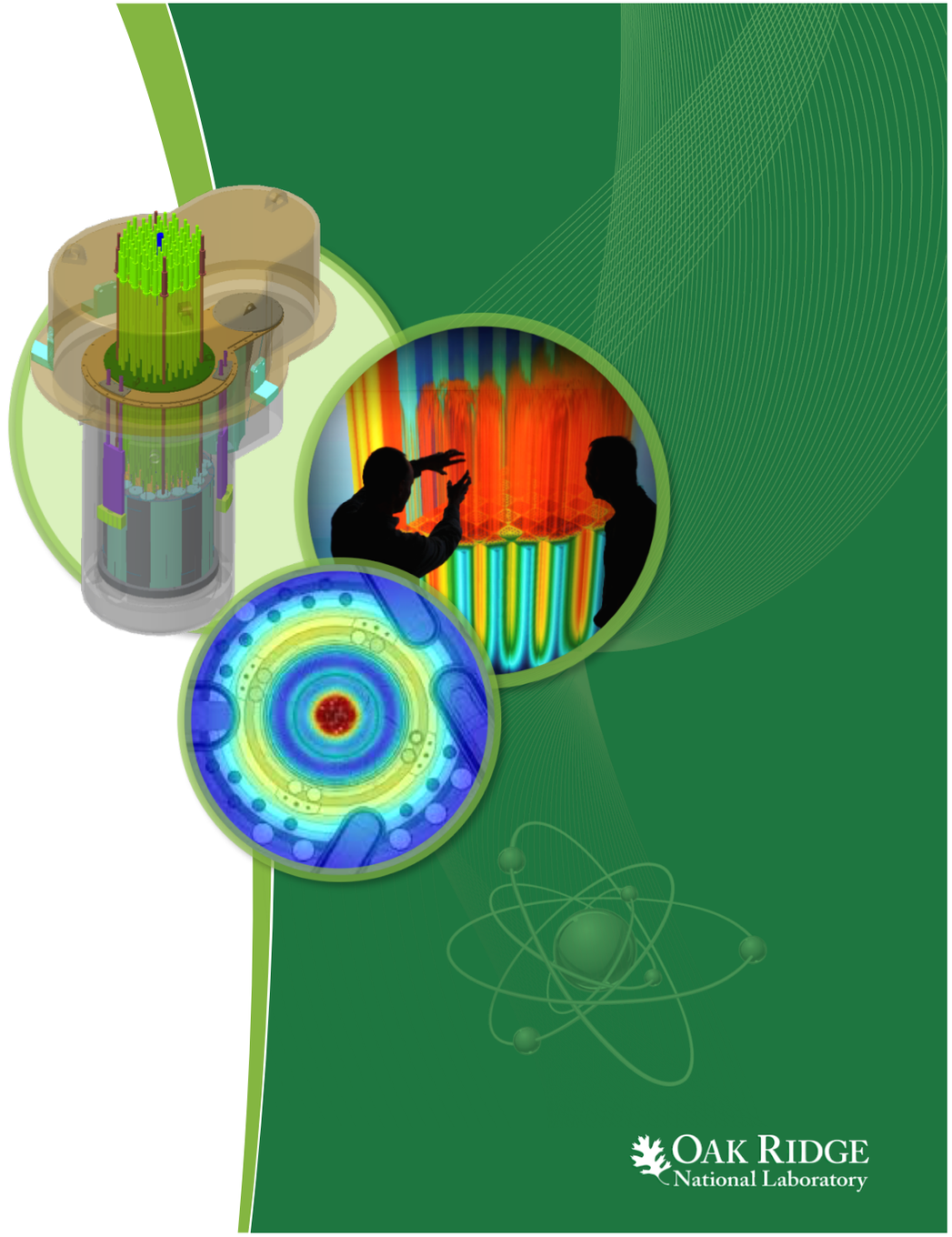

NCSP TPR

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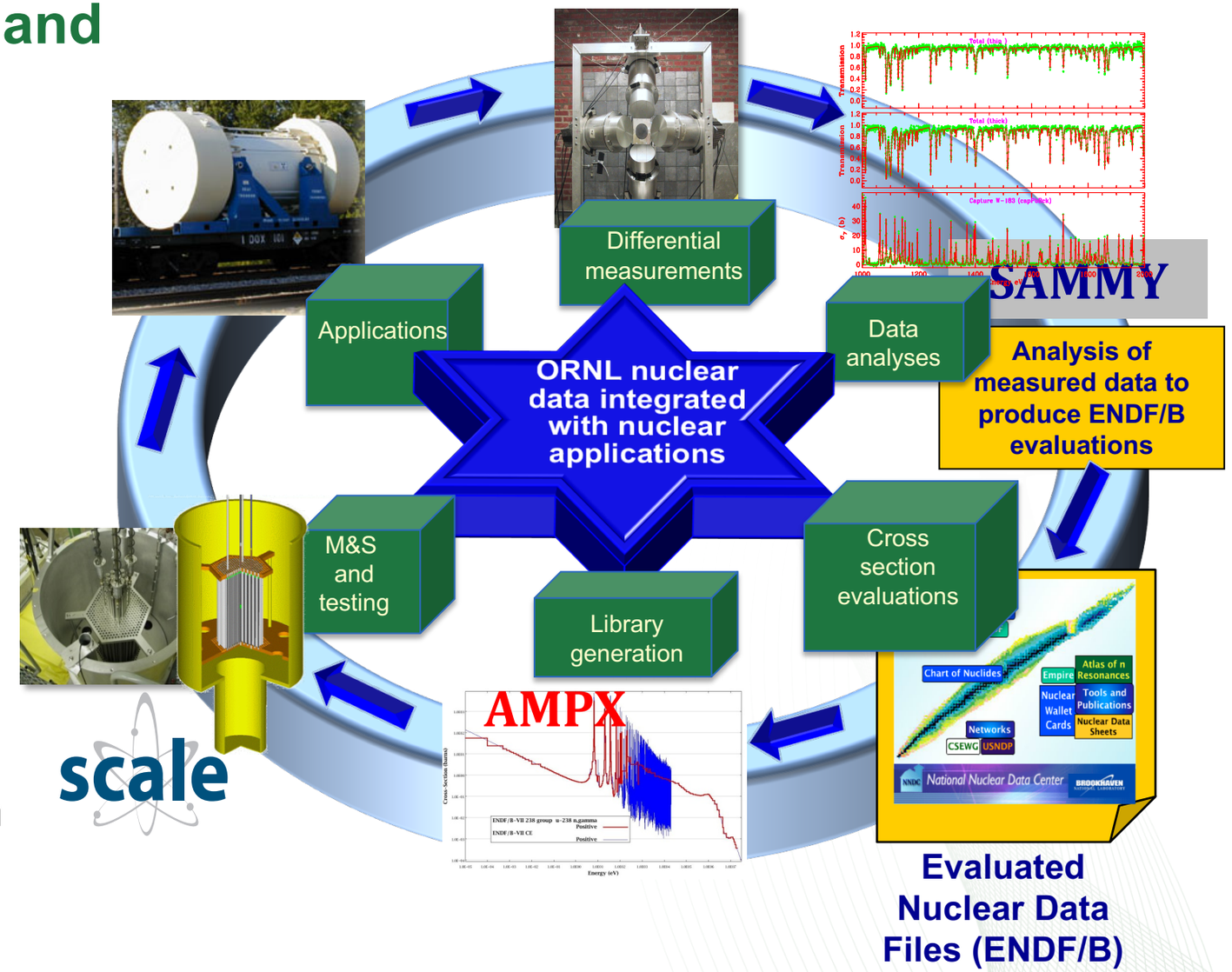
Introduction

- Brief AMPX overview
- New continuous energy (CE) library resources
- Status of general nuclear database structure (GNDS) in AMPX
- Support for new evaluated nuclear data file (ENDF) formats
- PURM Update
- ENDF VIII.0 data and covariance Testing

ORNL Nuclear Data Capabilities Tightly Coupled with M&S and Nuclear Applications

- Cross-section measurements for resonance region (Data from facilities: IRMM, RPI, and ORELA)
- Nuclear data analysis methods development (SAMMY)
- Cross-section evaluation and preparation of ENDF/B nuclear data files
- Cross-section processing methods development for generating nuclear data libraries (AMPX)
- Identification of data needs through application to real-world problems



AMPX - Capabilities

- Modular code system that takes basic cross section data in Evaluated Nuclear Data File (ENDF) format to provide:
  - Multigroup (MG) libraries
    - Requires point cross section data, weighting functions, energy bounds, etc
  - Continuous energy (CE) libraries
    - In resolved resonance region, 1-D data comes from POLIDENT
      - Supports single-level Breit-Wigner (SLBW), multilevel Breit-Wigner (MLBW), Adler-Adler (AA), Reich-Moore (RM), and R-Matrix Limited (RML) formats
    - In unresolved resonance region, PRUDE or PURM
      - Only SLBW in unresolved resonance region (only ENDF supported format)

AMPX – Capabilities (cont)

- Cross section uncertainty or covariance data
  - Used in SCALE sensitivity and uncertainty analysis tools
- Depletion and decay libraries
  - Used by ORIGEN
- In short, if you are using SCALE, you are using AMPX processed libraries

- Greatly simplified input file generation
  - Exsite provides templates to generate all input files needed for successful library build
  - Exsite also allows for user defined templates

CE Resource

- SCALE is moving to a new binary on-disk format (HDF5 based) for the CE libraries.
- A new in-memory C++ resource for the library was developed (ROBUS), to be used throughout SCALE.
- The resource and the on-disk format is extendable to accommodate new types of data.
- Unfortunately, the resource cannot be used as-is in AMPX, as it does not allow changing of the data.
- Added an in-memory layer (CEResource) that transfers from and to ROBUS but allows updates
- Currently, existing CE libraries must be converted to new format (in new PLATINUM)
- The plan is to convert new format libraries into current CE library format; development of this capability is near completion.

Iterator classes in AMPX

FillObject: basic class that must be implemented for all supported types. For example, 1-D adds a function returning the function value

FillObject

getE
setE
getInter
setInter

FillList: list of FillObject objects over which one can iterate. Supported types must implement the *interpolate* and *canInterpolate* functions

FillList

getNew(e)
getCurrent
Interpolate(e)
canInterpolate
start
advance
backspace
isEnd
insert
remove

FillAdvanceMultiple: a list of FillList objects over which one can iterate. Discontinuities are preserved and added at the beginning and end of the range of each FillList

FillAdvanceMultiple

start
advance
backspace
isEnd
getCurrentE

Union grid

- For the SCALE CE libraries:
  - Cross section data for all temperature independent reaction (51, 52, ..) are on the same energy grid. However, on-disk, a sub-set of that grid sufficient for the given reaction is stored
  - Cross section data for all reactions for a given temperature are on the same grid. This grid must include all energy points from the union grid of the temperature-independent cross section data
  - In the CEResource, all reaction data are given for each temperature. If data are the same across temperatures or reactions, C++ smart pointers are used
- For the 1-D data in the CEResource, an implementation of the iterator classes was provided
- This makes it easy to generate the union grids. Additional functionality was added to allow data thinning on the union grid and to require certain points on the union grid

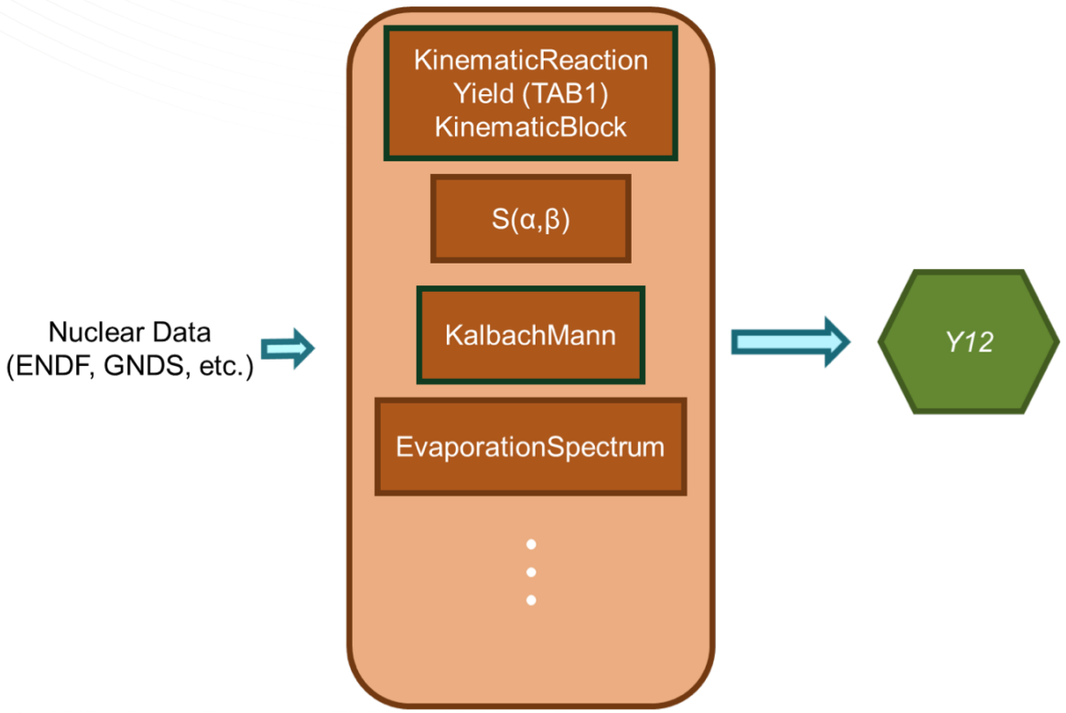
Calculation of redundant cross section data

- SCALE and AMPX share a ReactionResource class
  - contains an mt value for each reaction
  - Includes multiplicity if applicable
  - if redundant, reactions to be added to calculate the redundant cross section
- A template class allows for calculating the redundant cross section. Implementing classes need to provide:
  - exist(mt): checks whether the reaction exists
  - getCross(mt): obtains the data for the desired reaction
  - addCross(mt): adds the new reaction data
  - remove(mt): removes the reaction data

A class was added to recalculate the redundant cross section data in the CEResource. This assumes that the cross section data are on the correct union grid.

GNDS

- AMPX has code for low-level containers
- Work continues to add the GNDS on top of that
  - GNDS not yet finalized, so the reading is not finalized either (but reading of resonance data and 1D data are complete)



- GNDS data will be read into existing in-memory AMPX structures for further processing
- Most AMPX codes that read ENDF data already use those in-memory structures instead of reading ENDF directly

Fission Energy Release

- AMPX does not yet store the fission energy release in any library
- However, the code must be changed to jump over the TAB1 record if present.
- AMPX reads the entire File 1 information into memory, so even codes that do not use the energy release section in File 1 may fail.

New P(nu) format

- No space is available for the data on any SCALE library
- ENDF reading routines have been changed to add a distribution with -1800n (n= 0,1,..) for neutron and gamma containing:
  - Yield data
  - Double differential data either copied from File 5, File 15, or as given in File 6 if LAW is not equal to -5 or -15
- All processing codes ignore kinematic data if corresponding 1-D are not present (current version of Platinum had to be changed to not write it to the library)
- Added routines that check yields of all -1800n reactions sum up to 1. If the exit particle is a neutron, then the total nubar must be checked to ensure that it is consistent with the yields
- If distributions for the total are not given in the ENDF file, then the total must be recalculated

Probability tables

- MET-1000
  - single cube, homogenized assembly with reflected BCs
  - room temperature
  - fast spectrum
- Codes
  - MCNP v6.1
  - KENO v6.2

ENDF	Model	MCNP	KENO-STD	ΔKENO-STD (pcm)
VII.1	MET1000 – Add. – C1	2.11970	2.12569	-599
	MET1000 – Add. – C3	1.00518	1.00580	-62
	MET1000 – Hom.	1.29718	1.30185	-467
	MET1000 – Het.	1.29523	1.29941	-418
	MOX3600 – Hom.	1.15822	1.16436	-614
	MOX3600 – Het.	1.14381	1.14964	-583

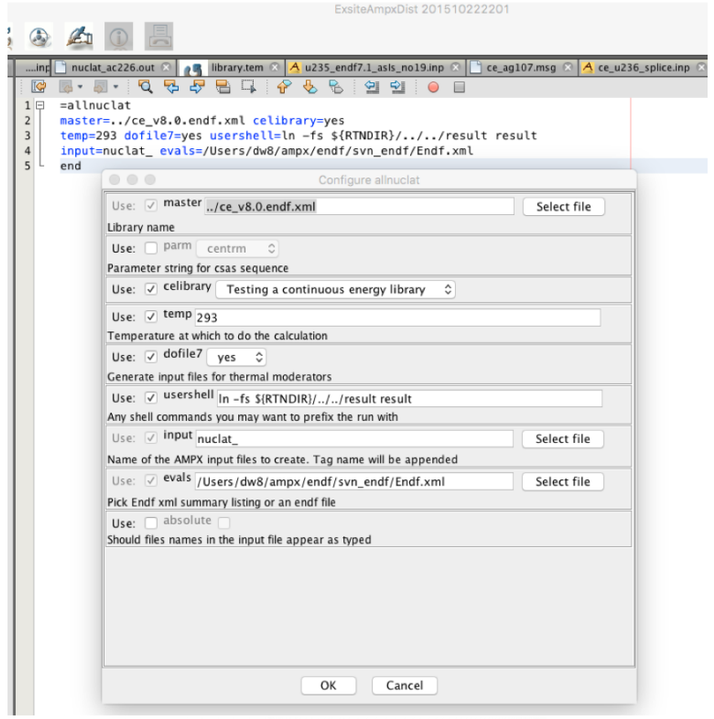
Probability tables (continued)

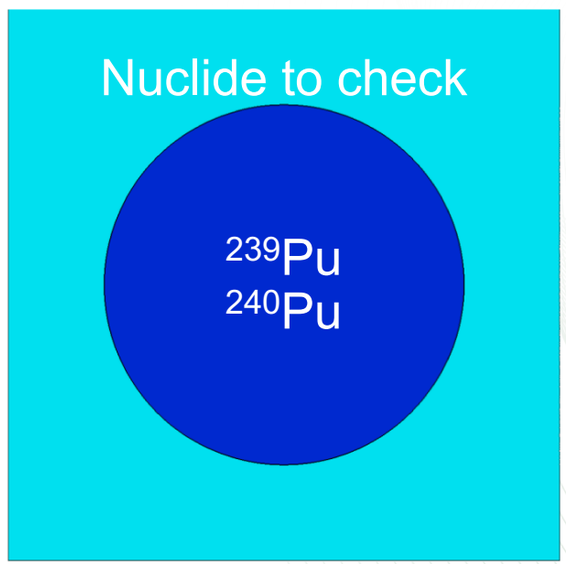
- The ENDF prescription for URR reconstruction:
  - Multiplicative: results from probability table construction are meant to give cumulative distribution function (CDF) shapes only, and so they are to be normalized and then scaled by a smooth cross section (given in File 3)
  - Additive: a background cross section (from File 3) is to be added to probability table values
- NJOY renormalizes **additive** tables to values calculated with J-functions
- An option was added to PURM to renormalize

ENDF	Model	MCNP	KENO-STD	KENO-NEW	ΔKENO-STD (pcm)	ΔKENO-NEW (pcm)
VII.1	MET1000 – Add. – C1	2.11970	2.12569	2.11905	-599	65
	MET1000 – Add. – C3	1.00518	1.00580	1.00467	-62	51
	MET1000 – Hom.	1.29718	1.30185	1.29706	-467	12
	MET1000 – Het.	1.29523	1.29941	1.29473	-418	50
	MOX3600 – Hom.	1.15822	1.16436	1.15793	-614	29
	MOX3600 – Het.	1.14381	1.14964	1.14346	-583	35

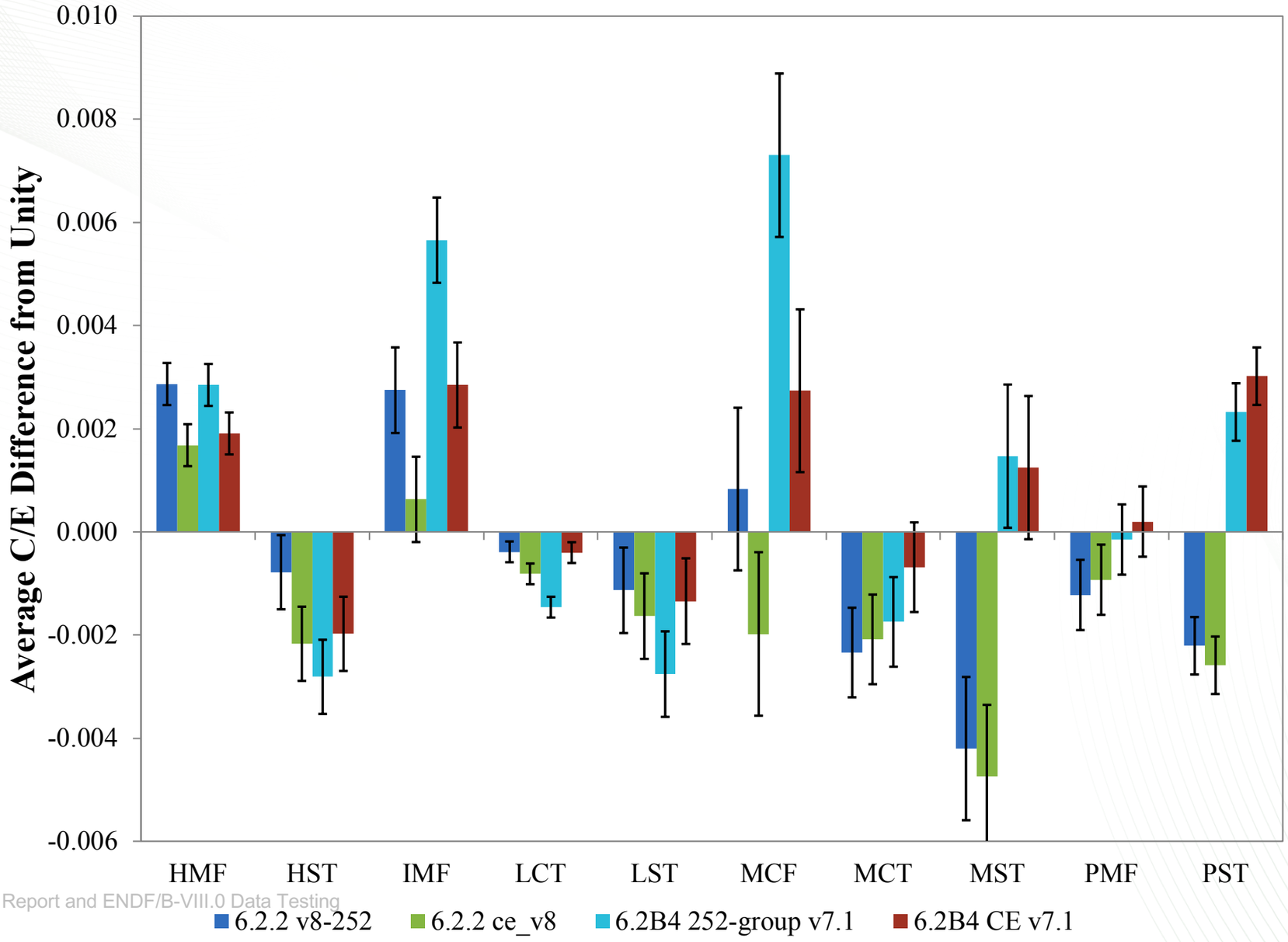
Testing of ENDF Data

- Generate ENDF/B-VIII.0 libraries with AMPX (MG & CE)
- Run KENO for a pin-cell with a moderator substituted by each nuclide in the library (ExSite can generate the input files)
- Note that the hard spectrum for most nuclides allows testing for anomalies for the threshold reactions
- Run the VALID suite
- Compare results to ENDF/B-VII.1





VALID ENDF/B-VIII.0 vs ENDF/B-VII.1



Summary

- CE Library resources have been implemented
- GNDS support is implemented as much as possible
- Initial support for the new fission release format has been added, but data are not yet used in any SCALE library
- PURM has been updated
- ENDFV/B-VIII.0 (and previous betas) has been tested