OAK RIDGE National Laboratory

Introduction: Nuclear Data Needs for Nuclear Energy Applications

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Leader, Modeling and Simulation Integration

Presented to:
Workshop on Applied Nuclear Data Activities
George Washington University
January 23, 2019

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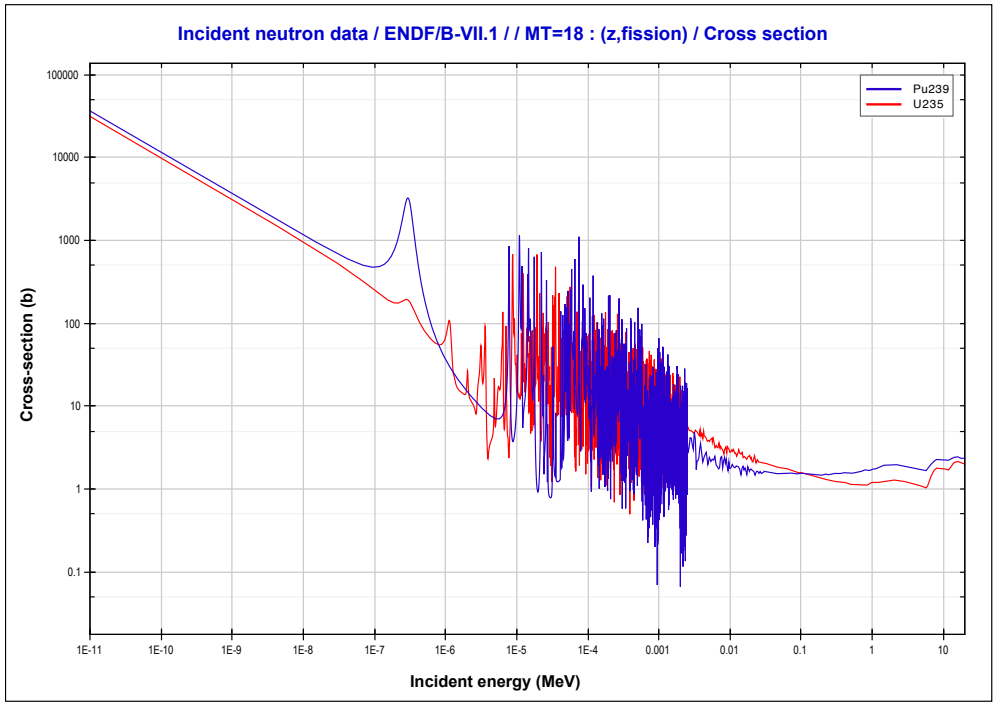
U.S. DEPARTMENT OF ENERGY

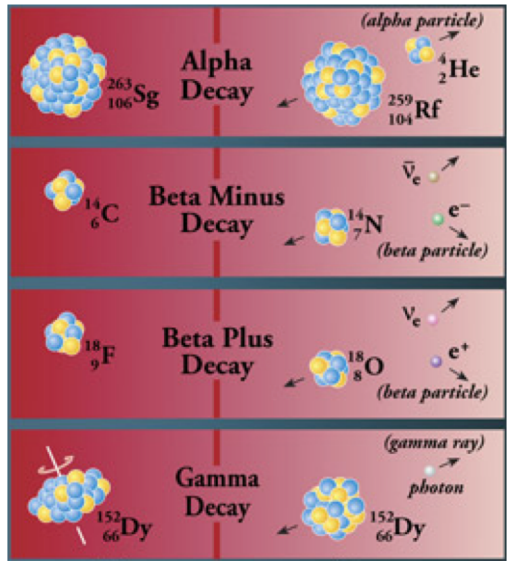
Goals of Nuclear Energy Roadmapping Session

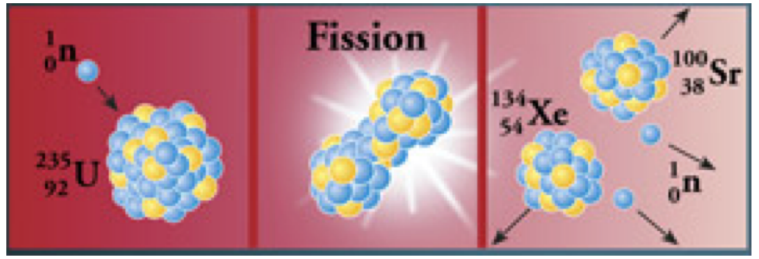
- Educate the community about the importance of nuclear data to the nuclear energy enterprise
- Determine priority needs for design, licensing, and operation of current and future nuclear energy systems
- Generate ideas for scope for a future Funding Opportunity Announcement

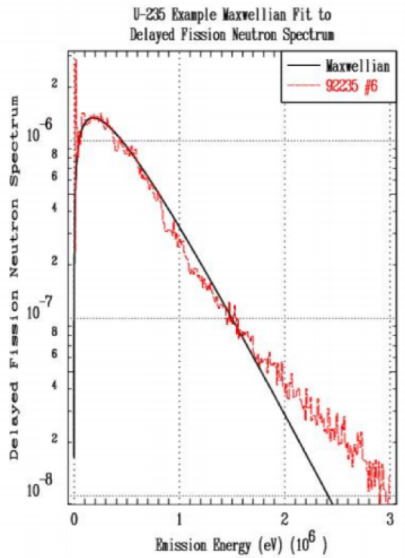
Nuclear data is of fundamental importance in nuclear science and engineering

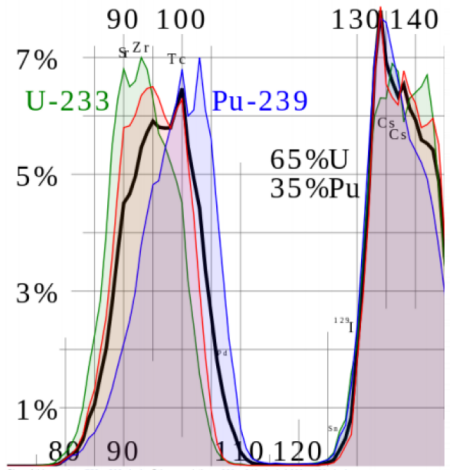
Neutronics calculations rely on nuclear data for criticality, reactivity, power distributions, depletion, decay heat, and more.











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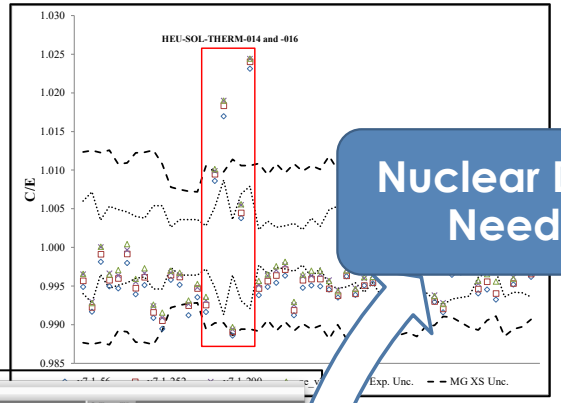
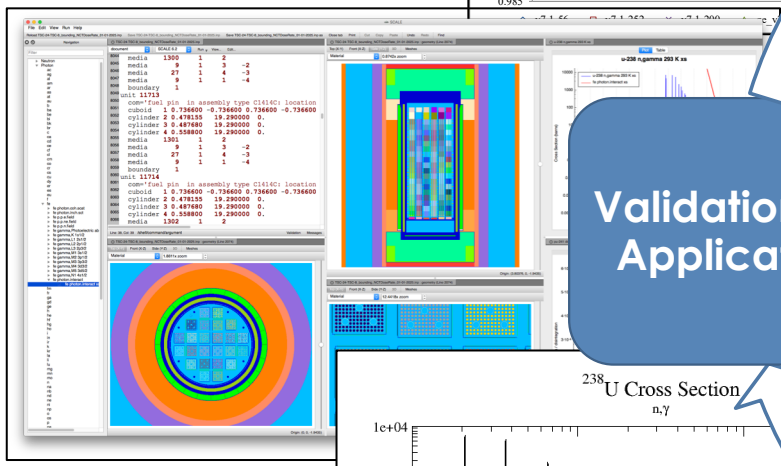
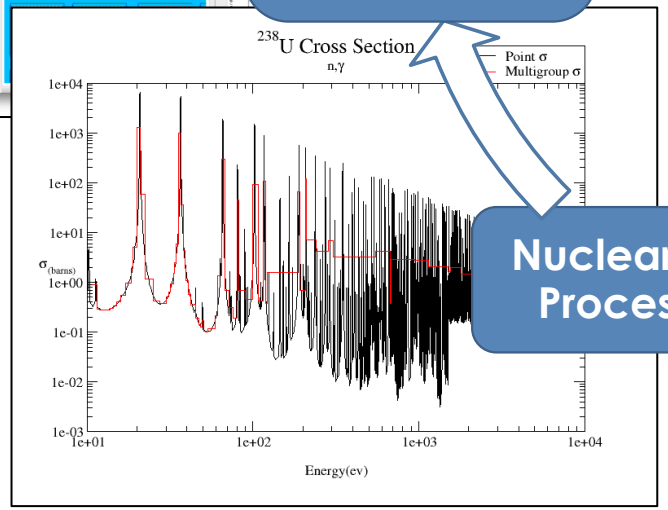
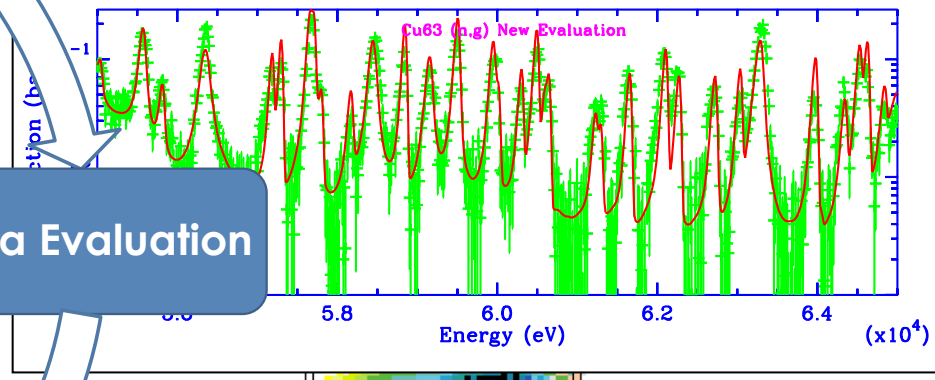
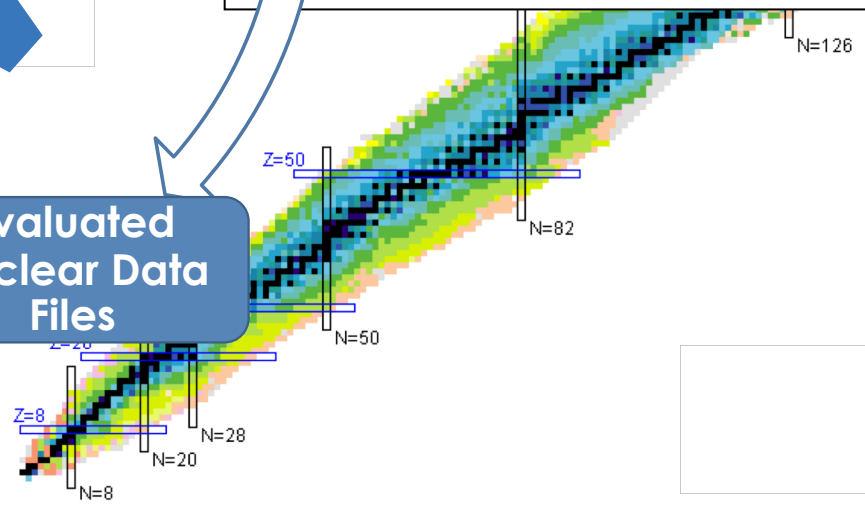
Nuclear Data Lifecycle











Nuclear Data Needs

Differential Data Measurements

Data Evaluation

Evaluated Nuclear Data Files

Nuclear Data Processing

Validation and Applications

Nuclear Data

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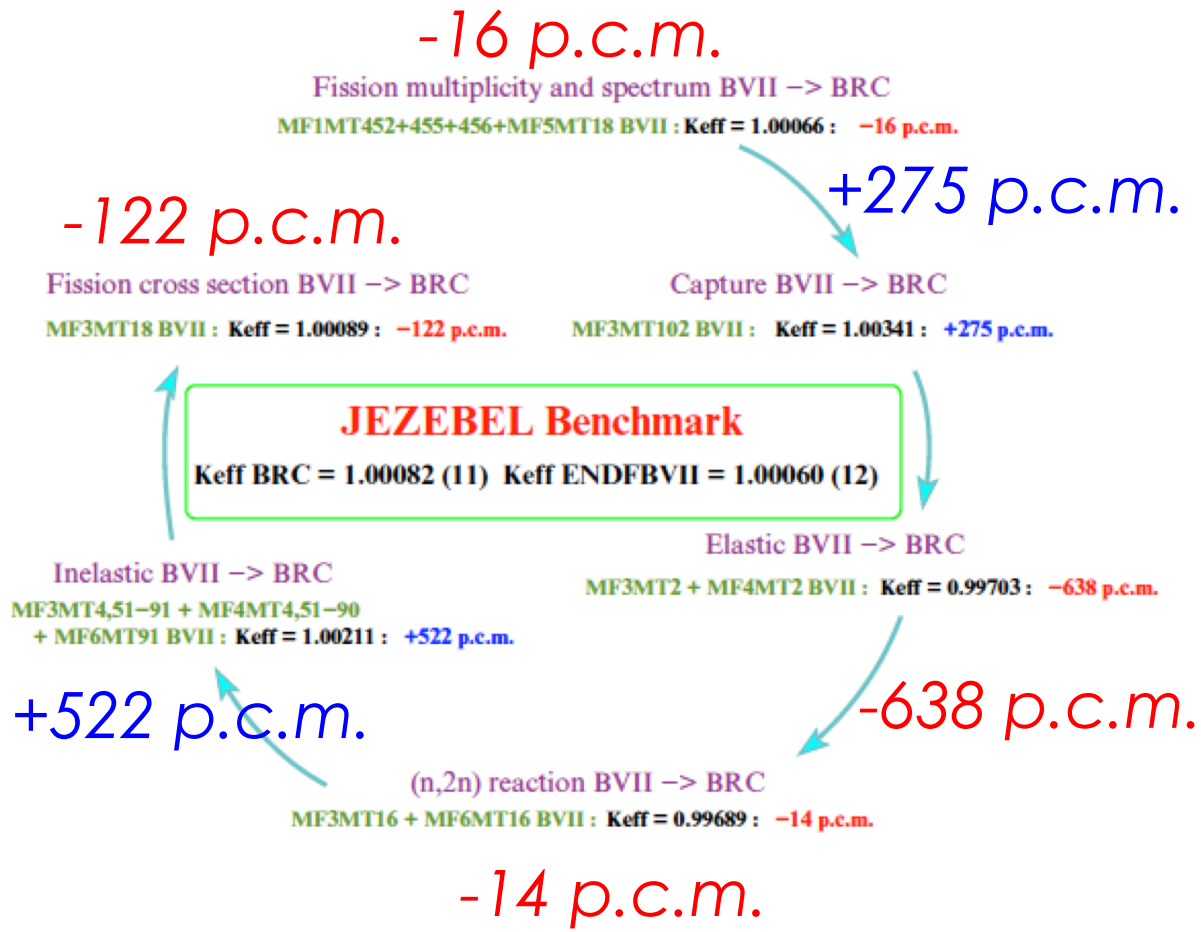
How are these "general purpose" libraries generated?

- A specific program (DOE-NP, NNSA/NCSP, NNSA/NA-22, DOD, international participant) funds an update in a nuclear data evaluation
  - New differential physics experiments
  - Data processing
  - Comparison to and **optimization with applications in their interest**
- National Nuclear Data Center - Cross Section Evaluation Working Group (CSEWG)
  - Updates are exchanged through a beta repository for ENDF and reviewed by a global team
  - Meets twice annually, with participation from IAEA, OECD/NEA, and others to review proposed updates
  - If changes benefit, or do not disrupt, applications of interest to these teams, the new evaluation is approved
- Only intermittent representation for Nuclear Energy applications
- Union of Concerned Scientist representative asked about nuclear data needs at December 13, 2018 NRC Advanced Reactor Stakeholder Meeting

Compensating Errors in the Jezebel experiment k_{eff}

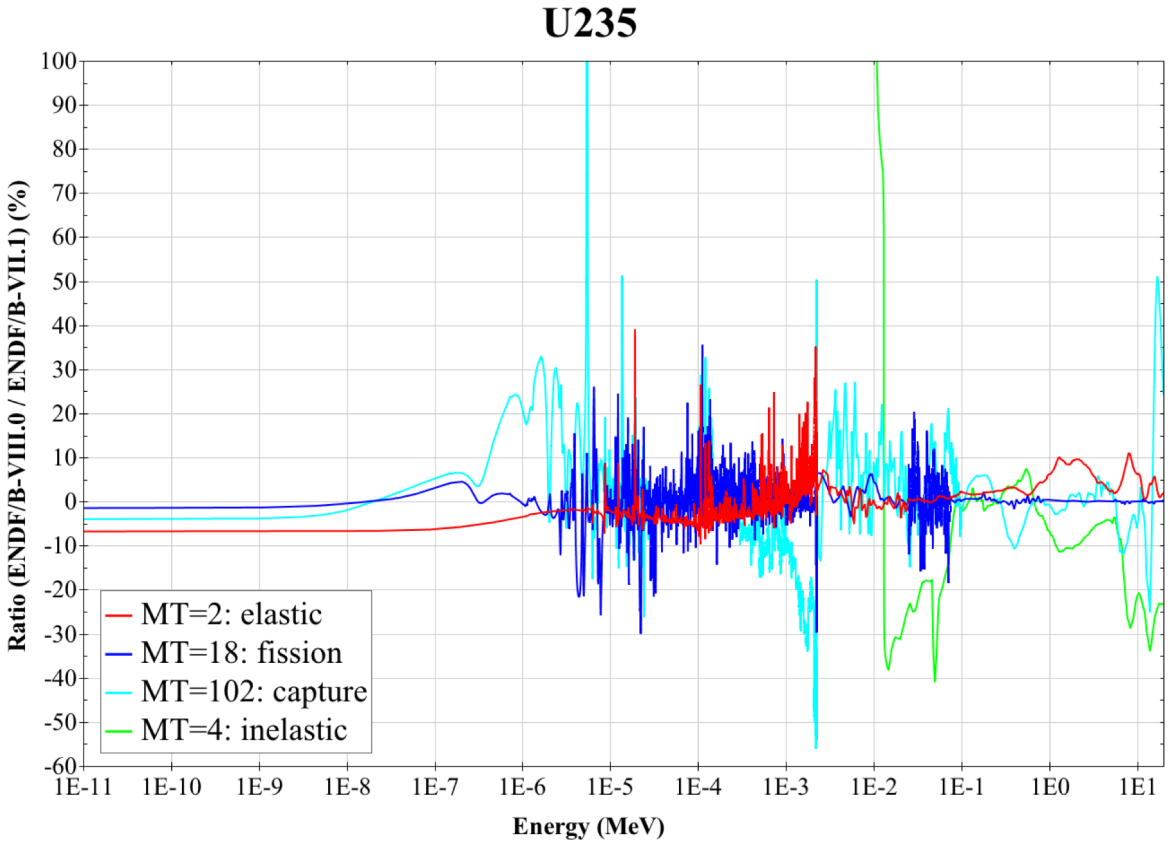
^{239}Pu metallic sphere at Los Alamos

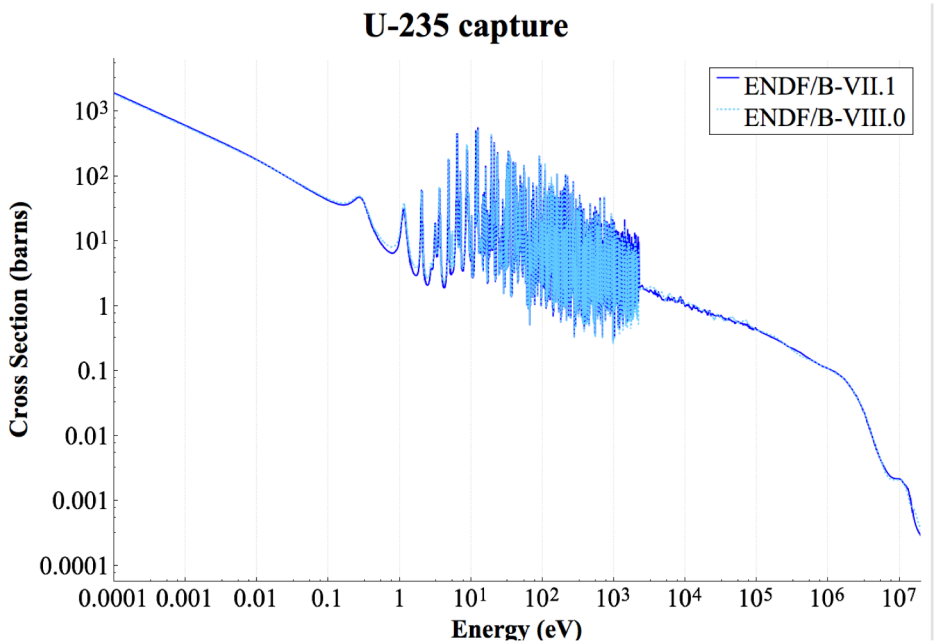
- Eric Bauge* reported on an analysis where components of the Bruyères-le-Châtel (BRC) ^{239}Pu evaluation were replaced with those from ENDF/B-VII.1.
- *We do not know if either evaluation is "correct" but both get the "correct" answer.*

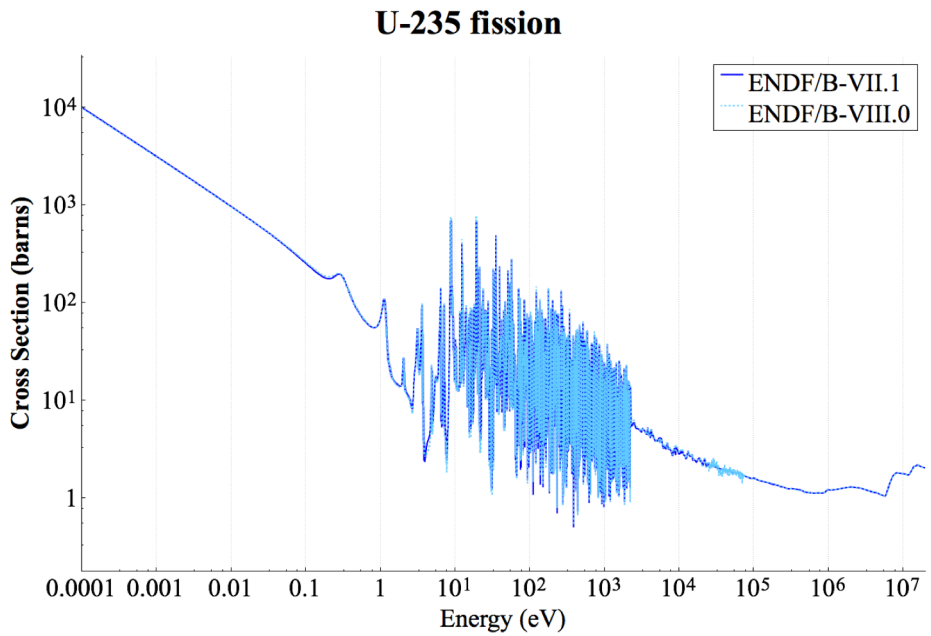


*E. Bauge *et al.*, Eur. Phys. J. A (2012) 48: 113

Cross section changes ENDF/B-VII.1 to ENDF/B-VIII.0







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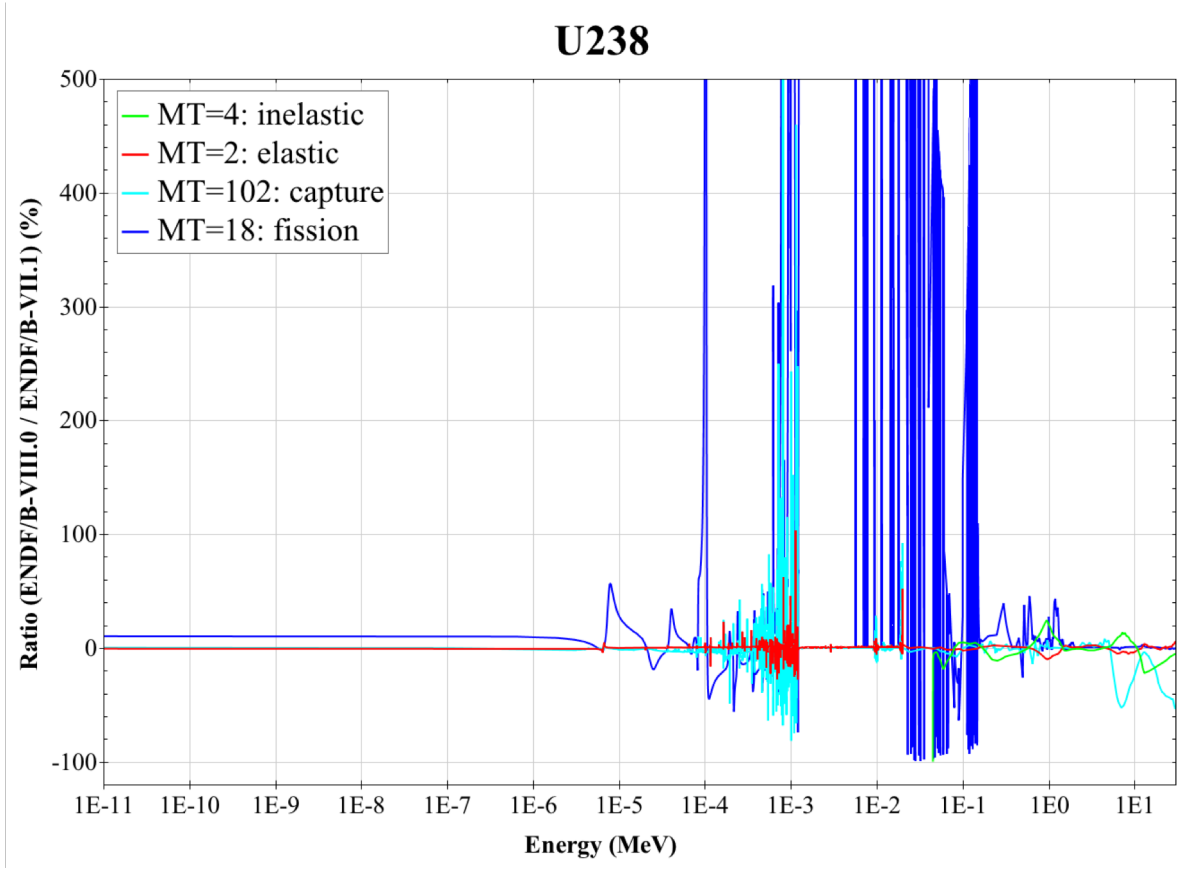

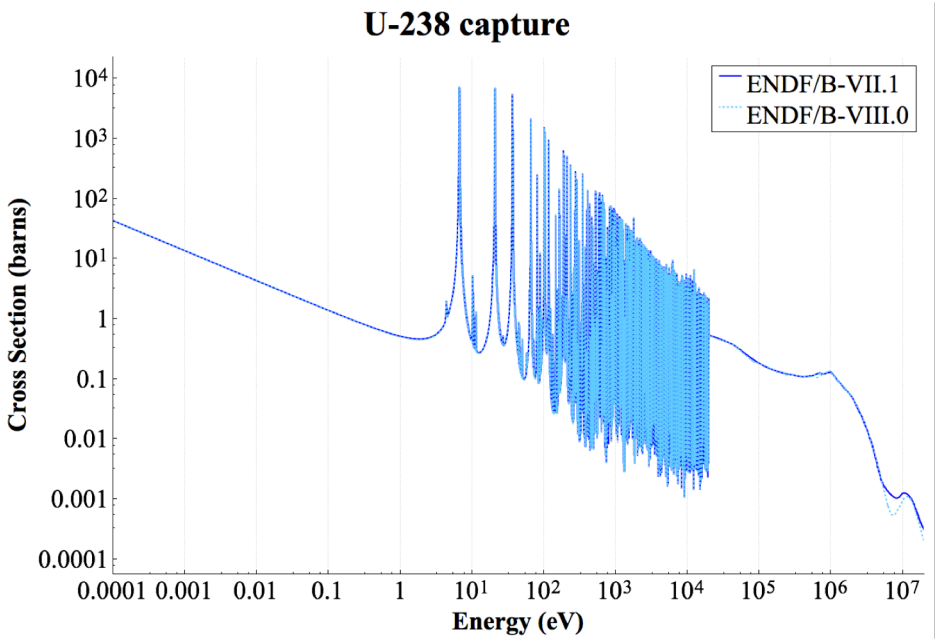

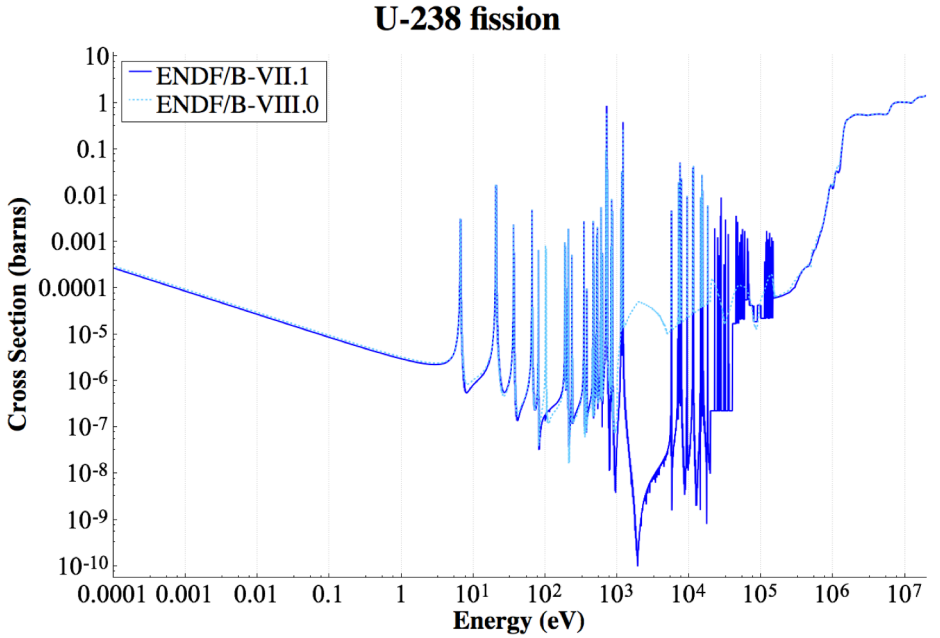

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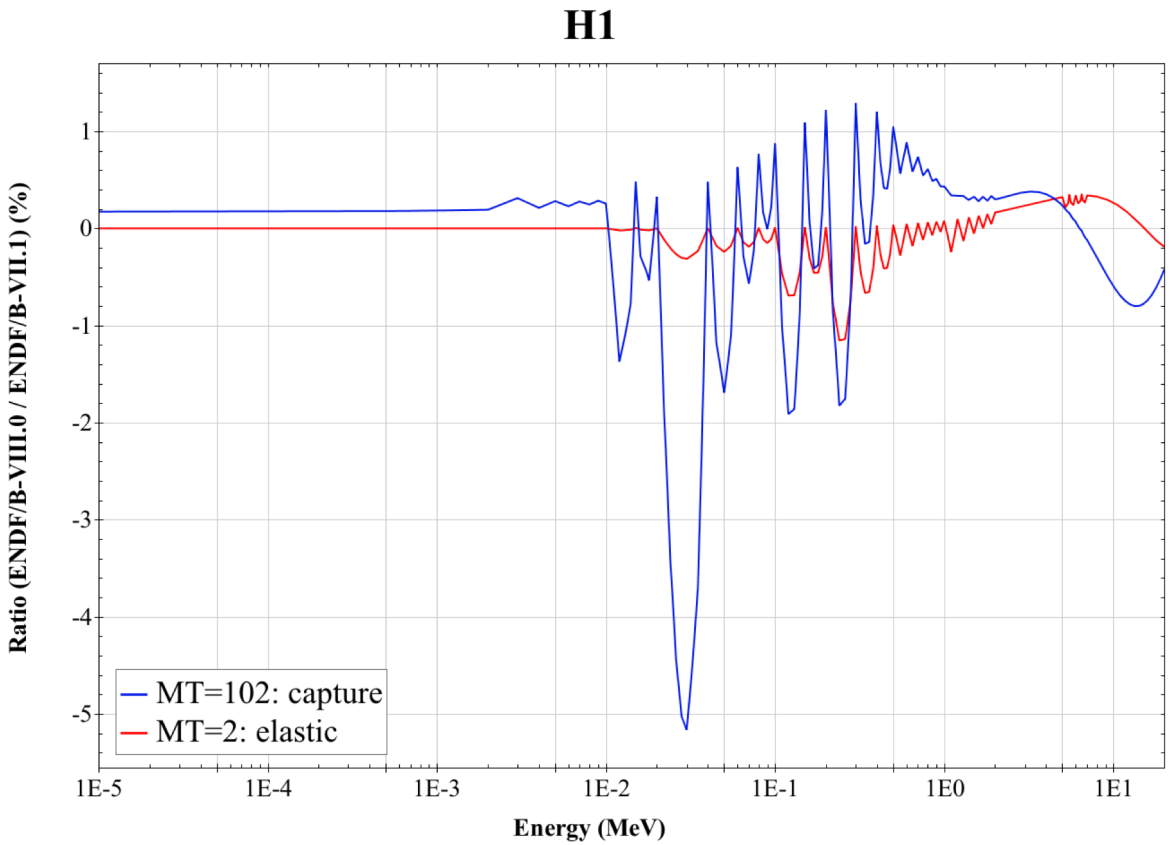

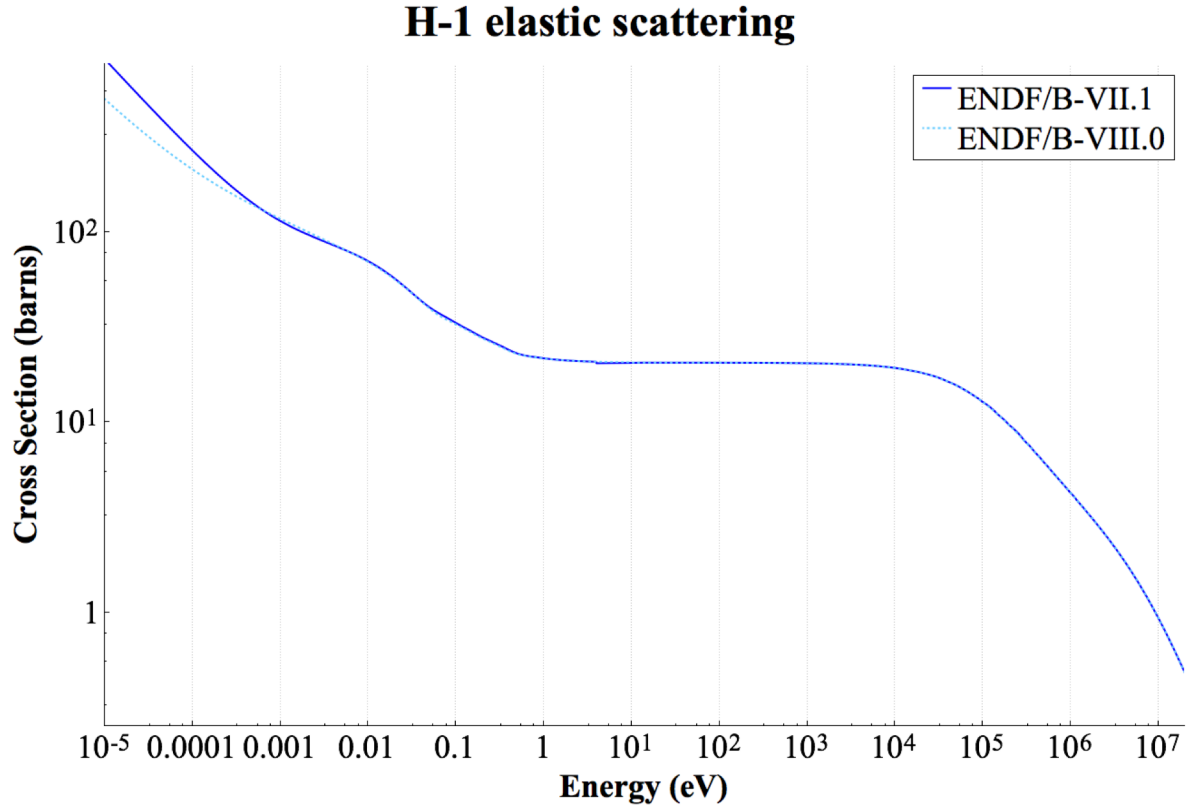

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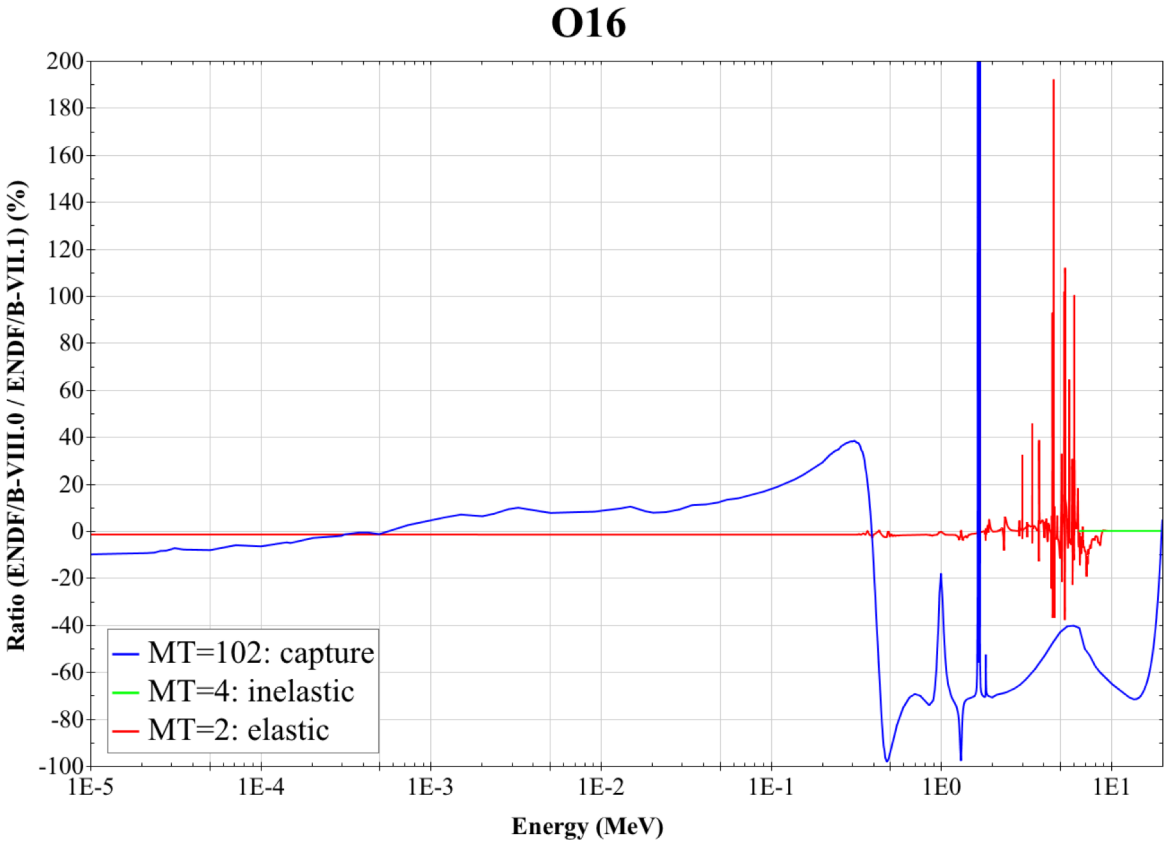

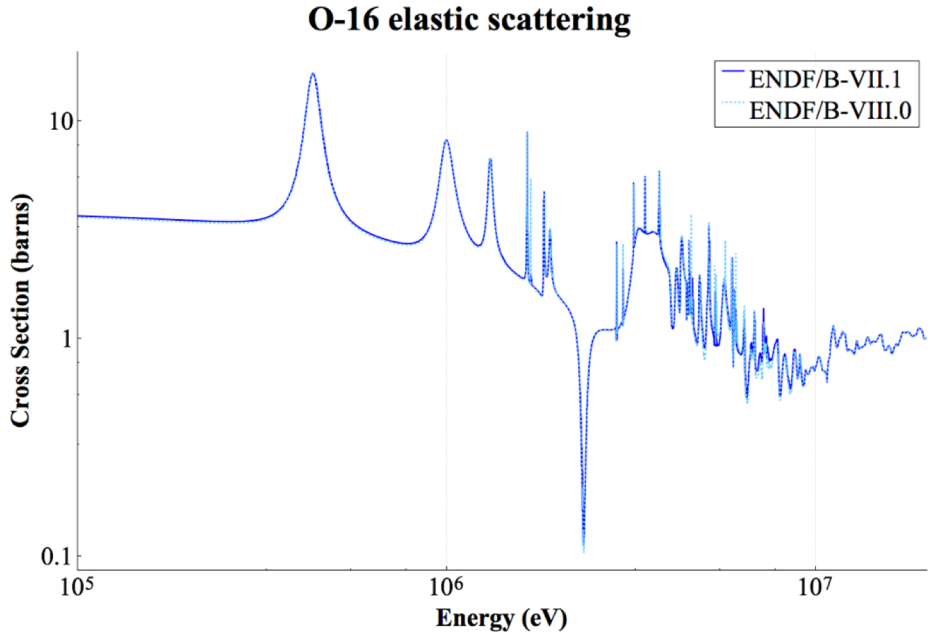

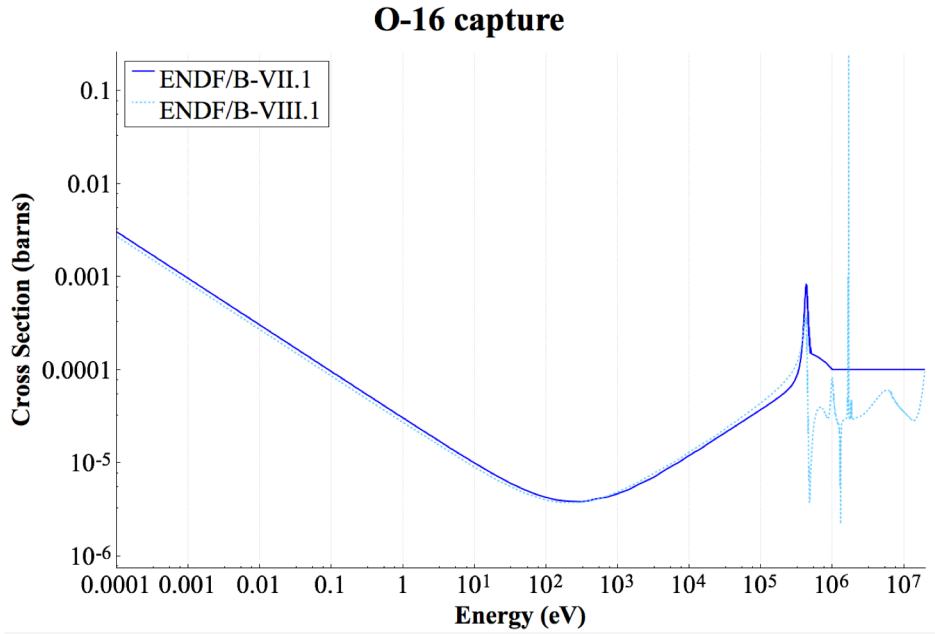

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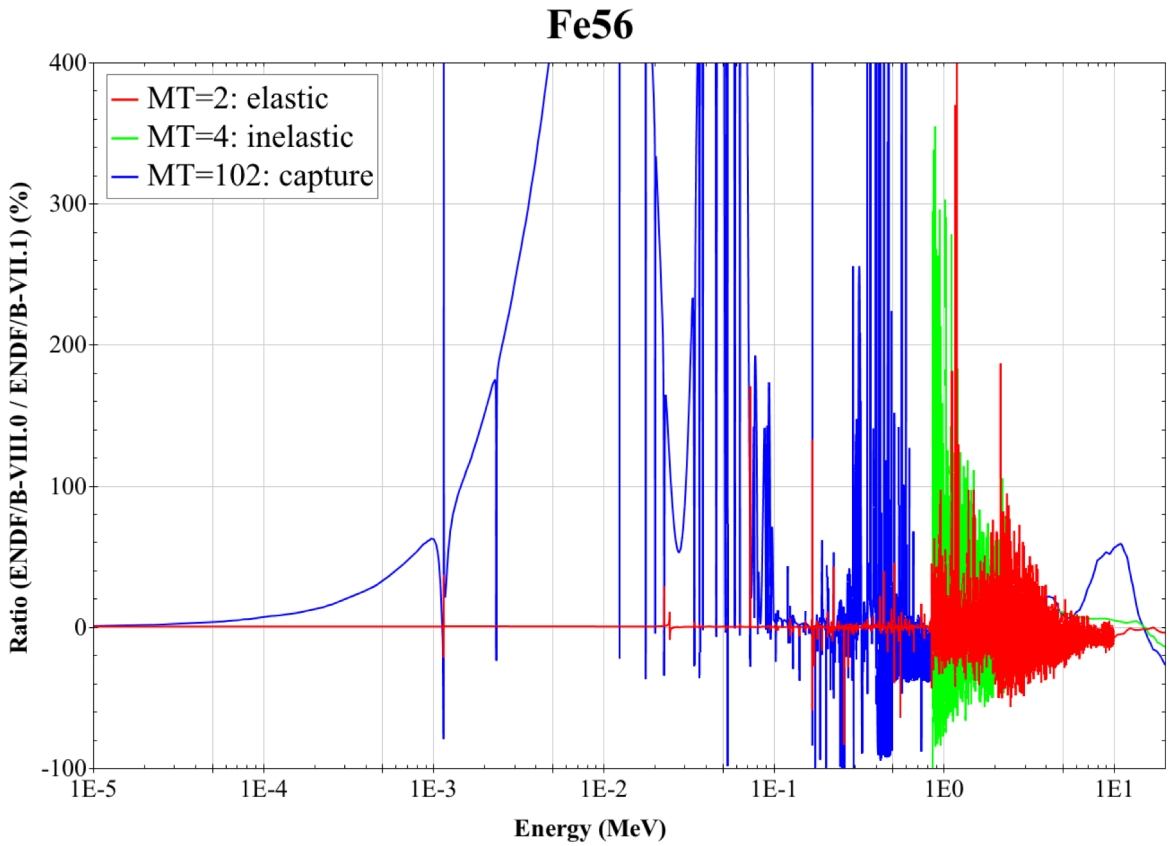
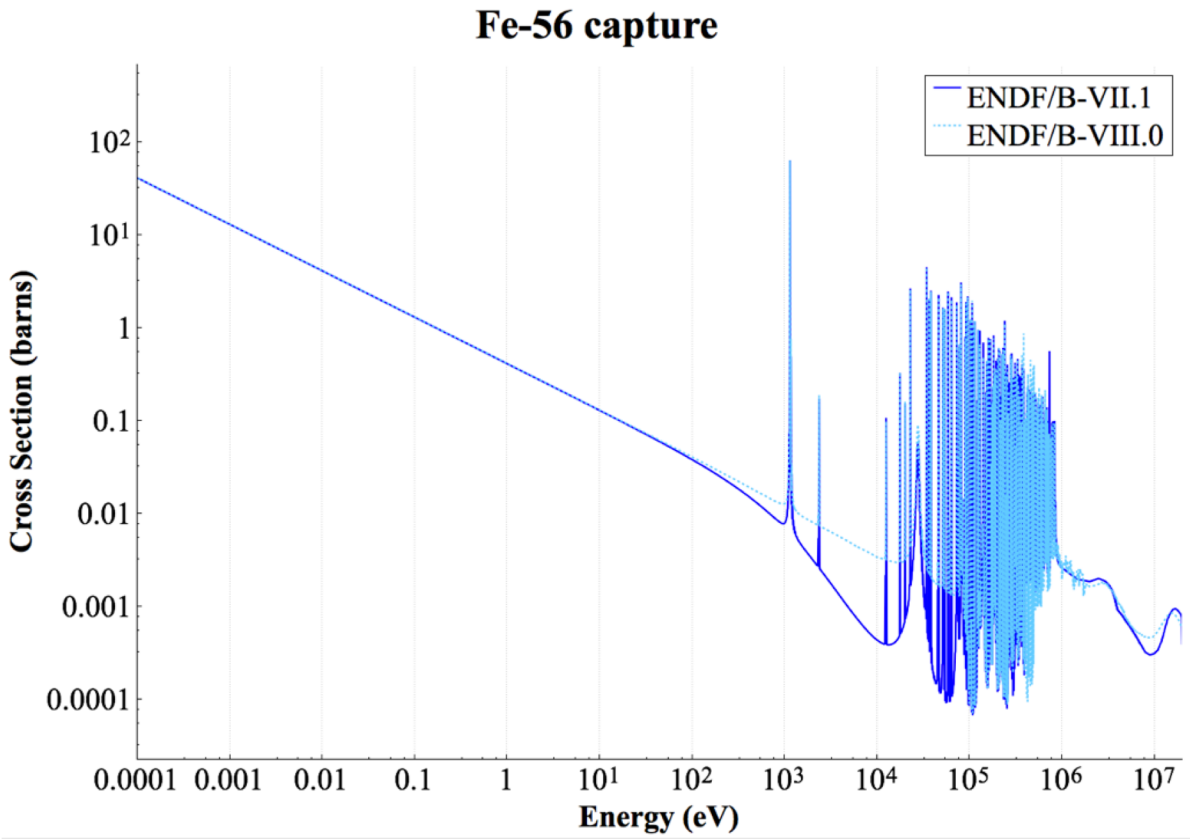
Cross section changes ENDF/B-VII.1 to ENDF/B-VIII.0





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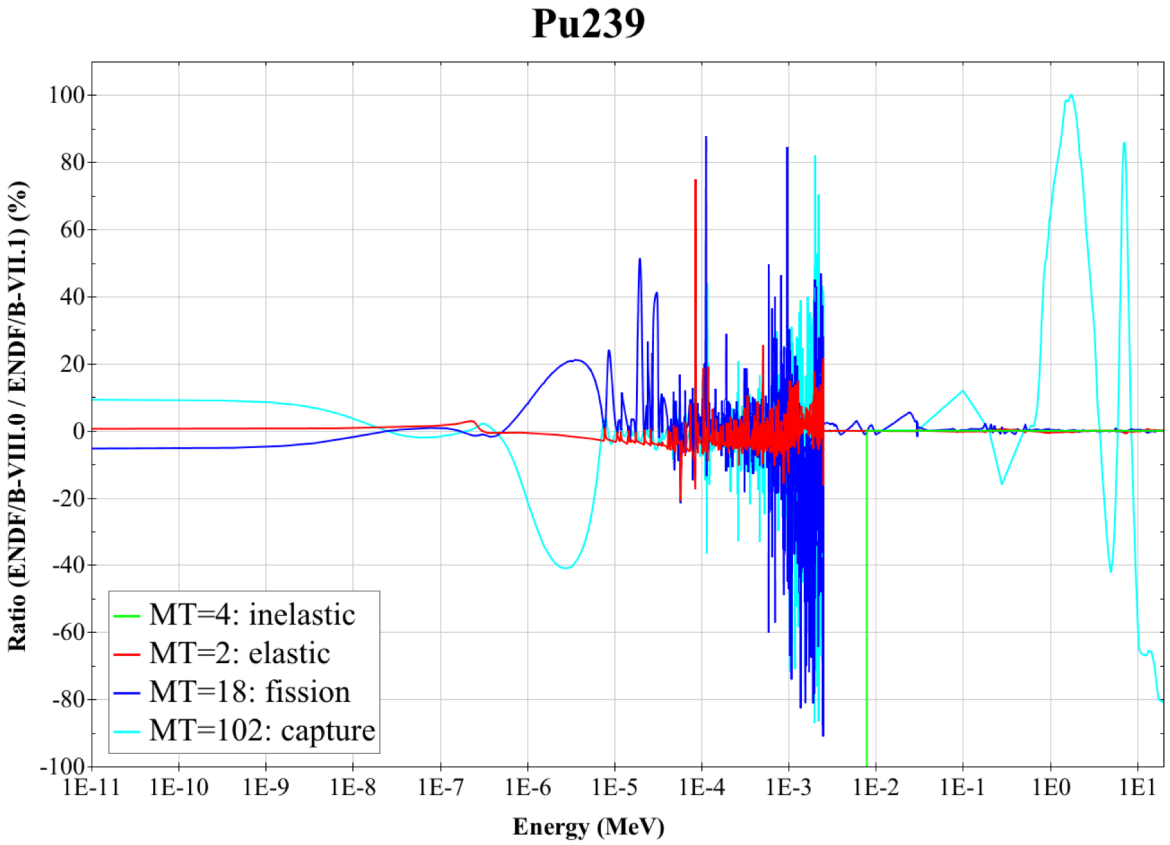

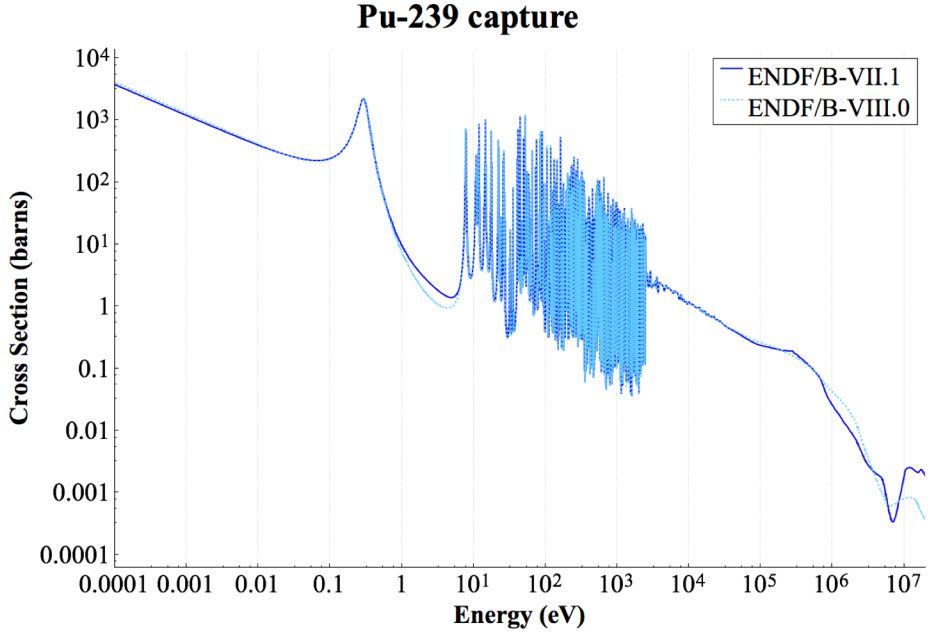

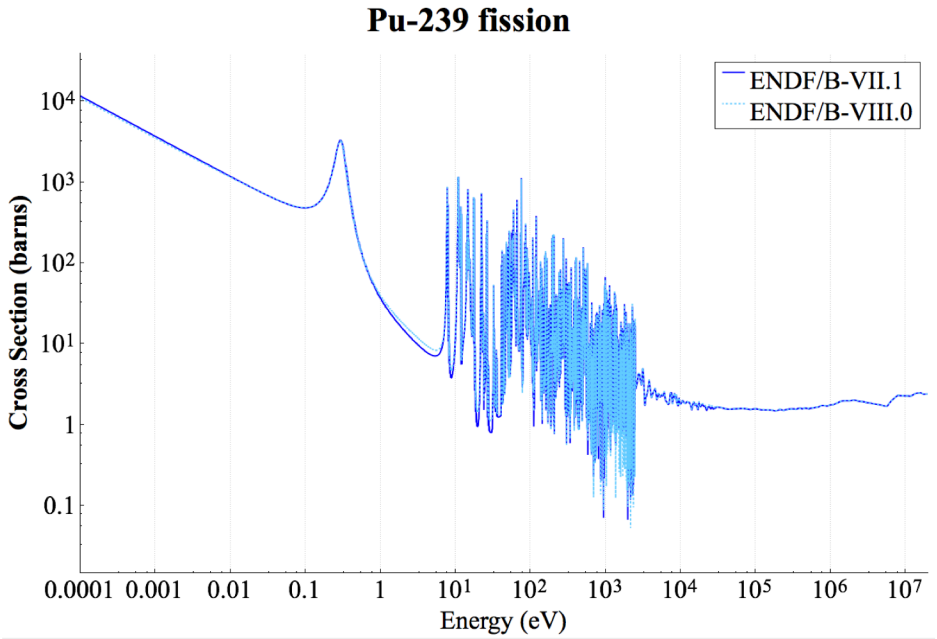

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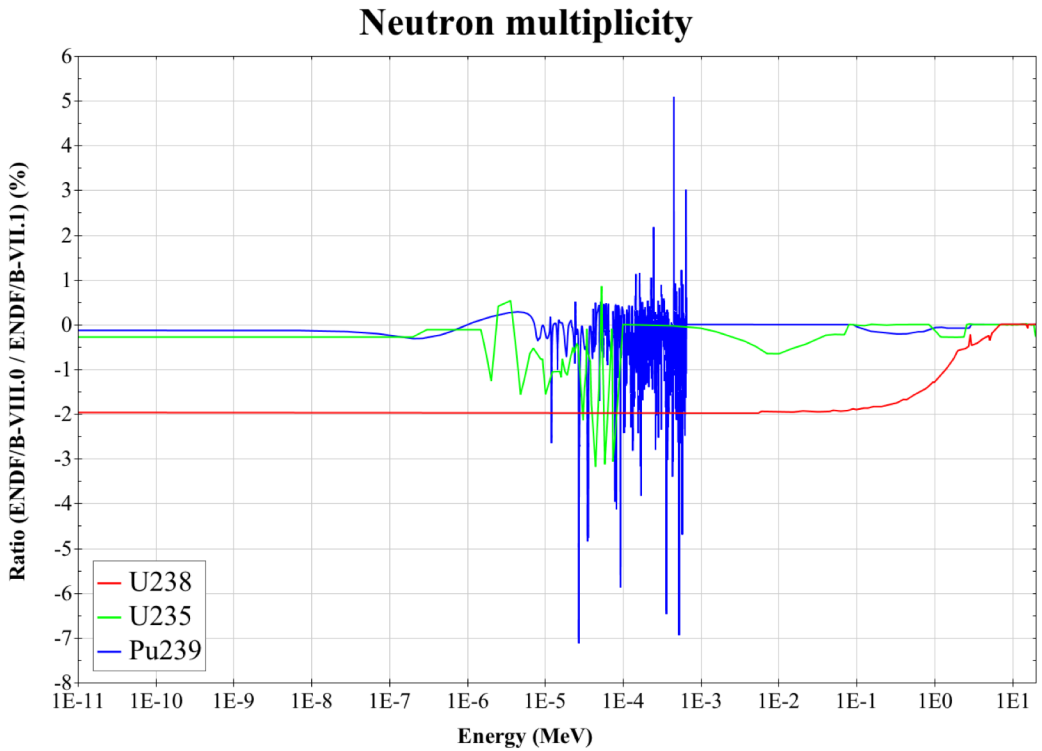
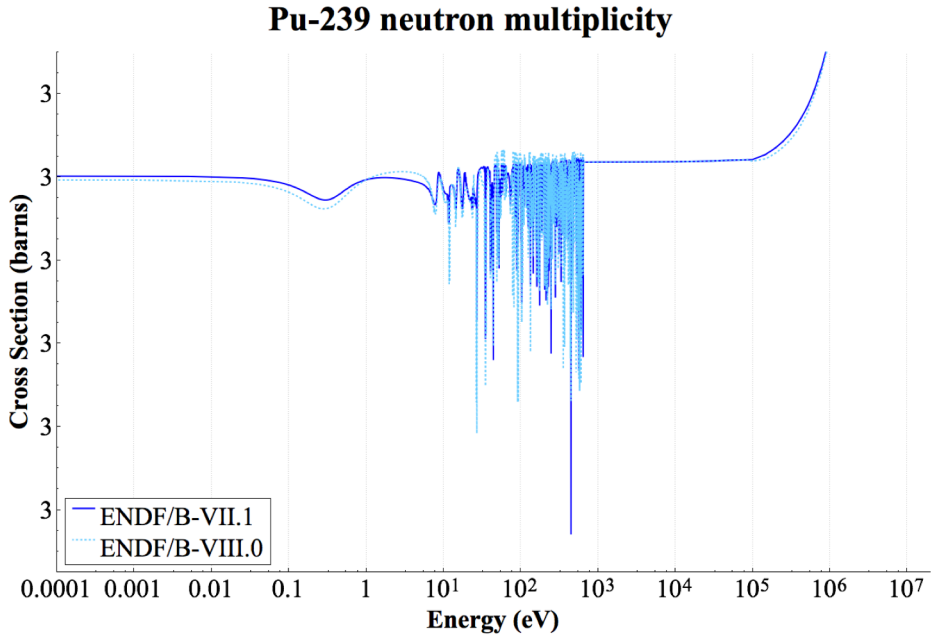
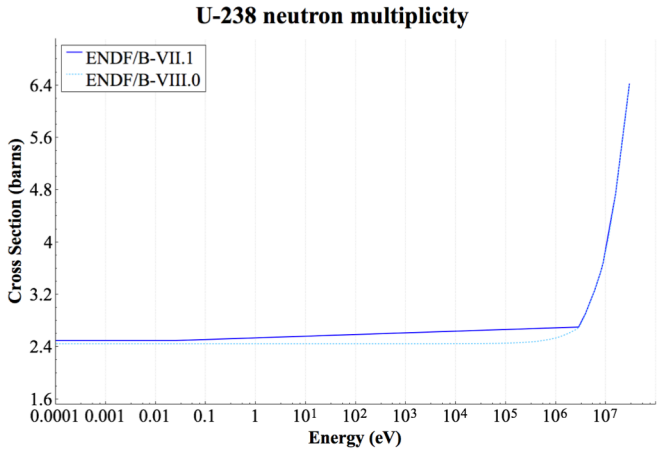
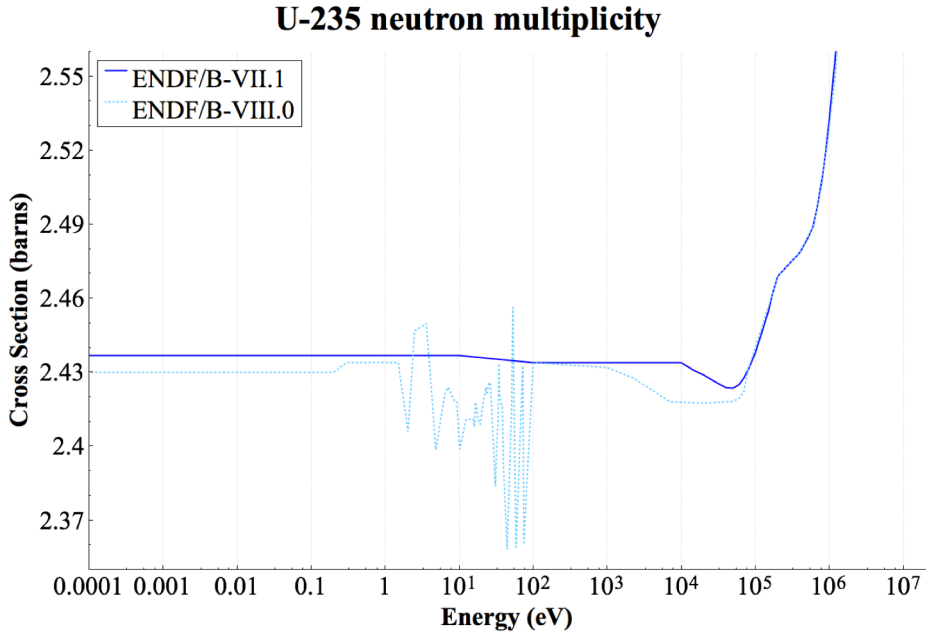






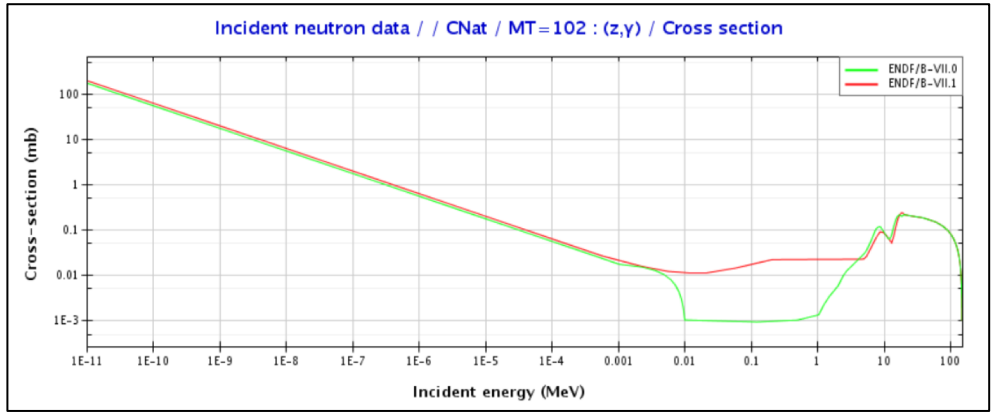


Changes in graphite data

ENDF/B-VII.0 (2006) to ENDF/B-VII.1 (2011)

- Capture cross section increased from 3.36 mb to 3.86 mb: ~1,000 pcm

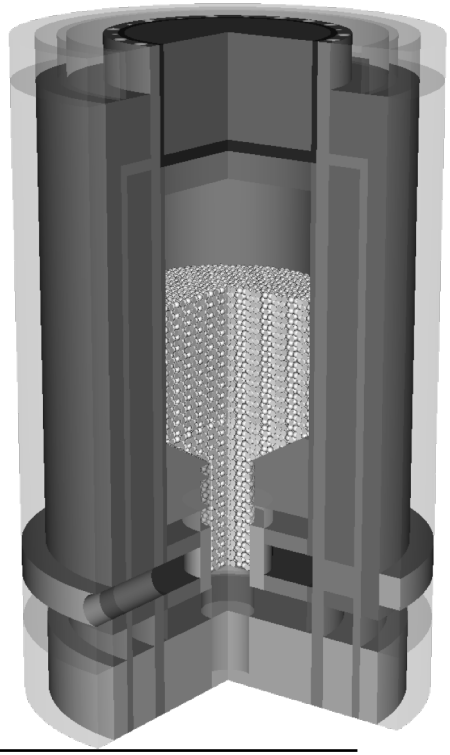
HTTR loading	ENDF-VII.0 C/E	ENDF-VII.1 C/E
Initial criticality	1.0165	1.0011
Full core	1.0097	1.0015



ENDF/B-VIII.0 (2018)

- New evaluations for thermal scatter based on molecular dynamics models from North Carolina State

HTR-10 Configuration	ENDF-VII.1 C/E	ENDF-VIII.0 C/E
First core	1.00267	1.00582



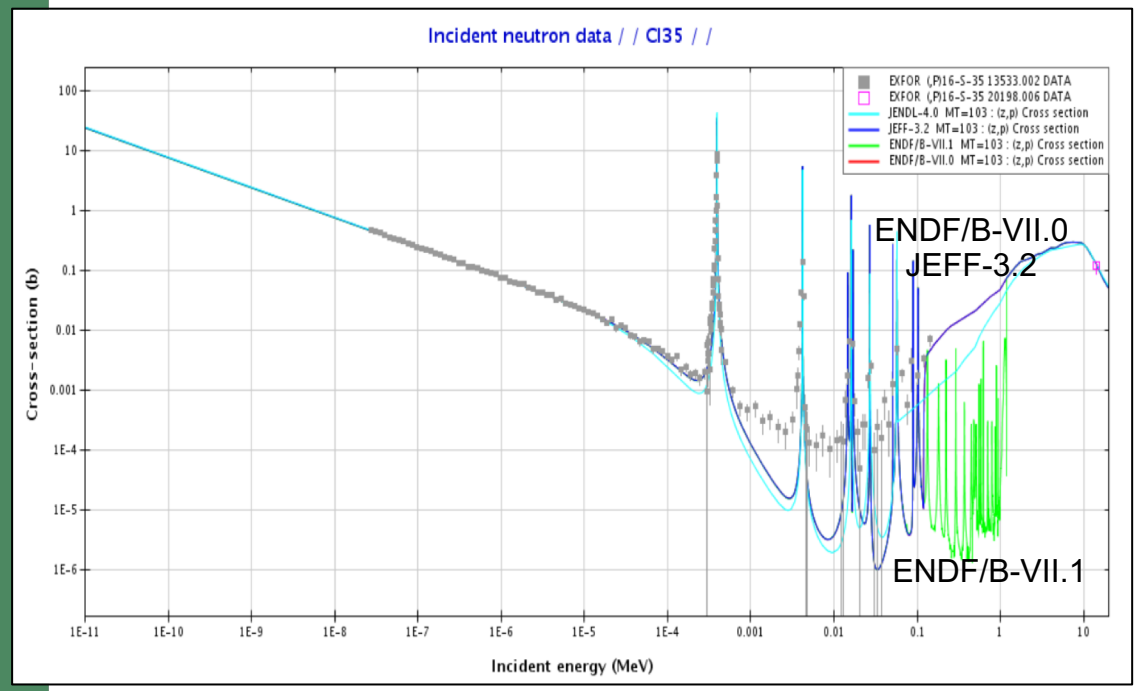
Library	Code	XS lib	k_∞	Δk (pcm)
ENDF/B-VII.1	KENO	CE	1.6770(4)	(ref)
ENDF/B-VIII.0	KENO	CE	1.6722(4)	−438(57)

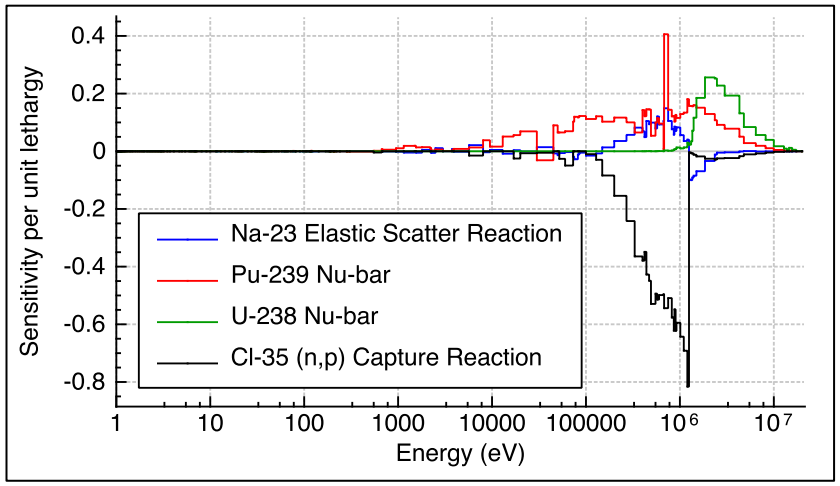
HTR-10 Pebble Analysis	Δk to all ENDF 7.1 (pcm)
But: graphite from ENDF 8.0	−7
But: ^{235}U from ENDF 8.0	−702
But: ^{238}U from ENDF 8.0	239
All ENDF 8.0	−438

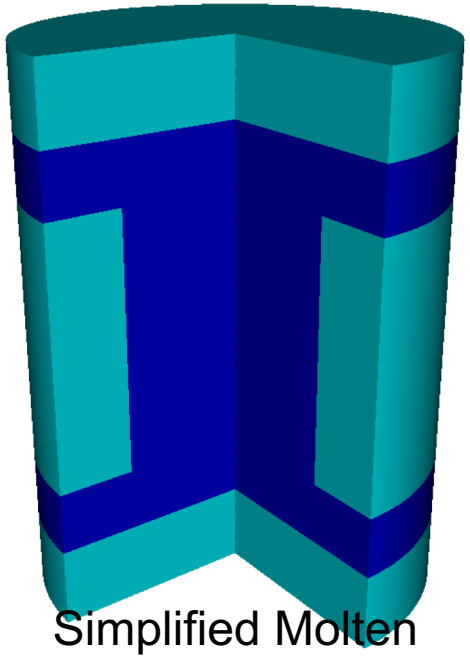
Nuclear data for molten salts

Changes in $^{35}Cl(n,p)$ cross section from ENDF/B-VII.0 to VII.1

Data Library	k_{eff}
ENDF/B-VII.0	1.02993 ± 0.00002
ENDF/B-VII.1	1.04924 ± 0.00002





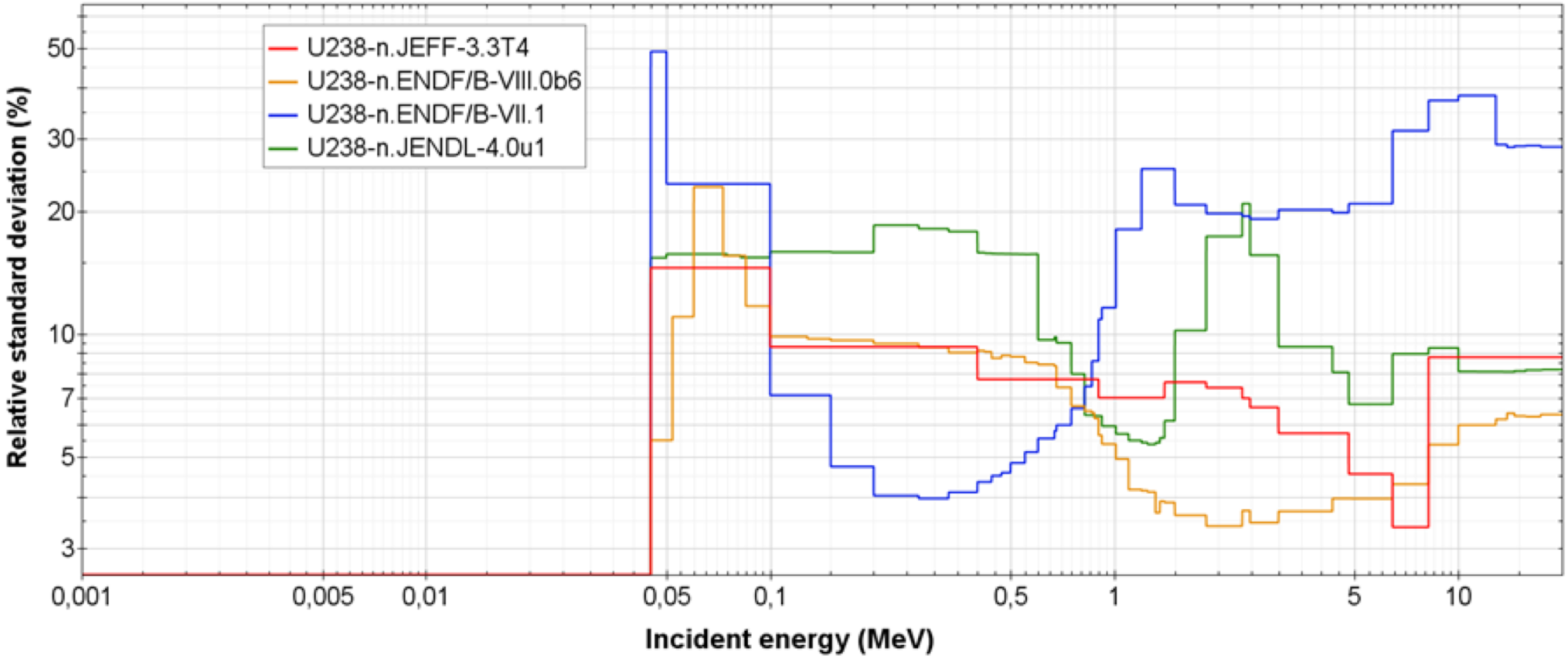


Simplified Molten Chloride Fast Reactor

Reaction	Sensitivity
Cl-35 (n,p) Capture Reaction	-0.958
Pu-239 Nu-bar	0.603
U-238 Nu-bar	0.281
Na-23 Elastic Scatter Reaction	0.114

No data for FLiBe / FLiNaK thermal scattering
Possible 2% Δk impact for thermal spectrum

^{238}U inelastic scattering cross section uncertainty differences between international libraries



ENDF/B-VII.1

Europe

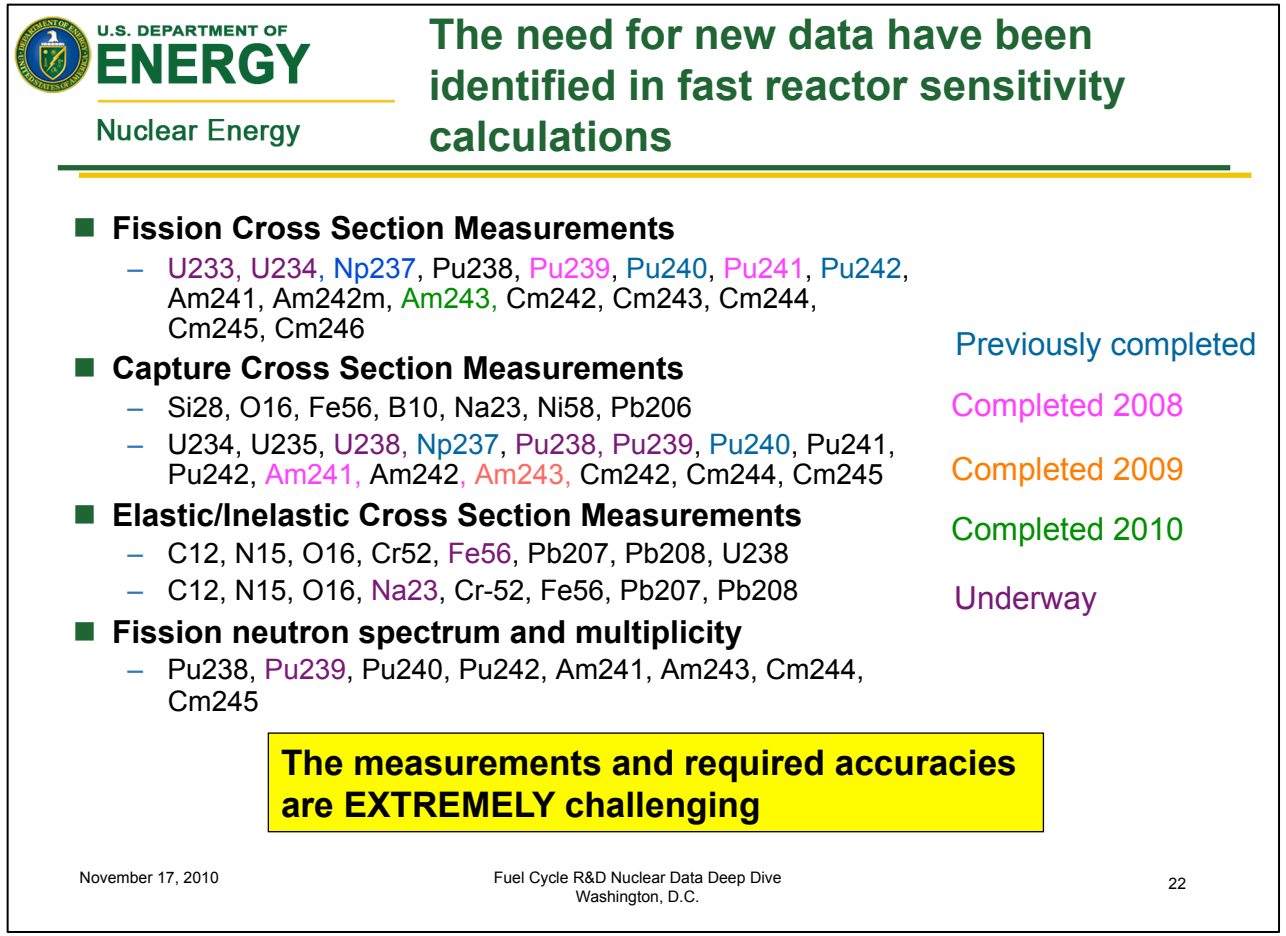
Japan

ENDF/B-VIII.0

Previous DOE-NE activities in nuclear data

Nuclear data cross-cut activity in Fuel Cycle R&D Program

- c. 2008–2013
- ~$5M/yr FCR&D and ARC
  - Nuclear theory and nuclear data
  - Nuclear data sensitivity studies
  - measurement program and challenges
  - Advanced detector development effort



T. Hill, “Nuclear Data Deep Dive,” Fuel Cycle R&D Program, Washington, D.C., November 17, 2010

Nuclear Data and Benchmarking Program

May–November 2018

U.S. DEPARTMENT OF ENERGY | Office of Nuclear Energy

- Nuclear Energy Enabling Technology (NEET) Crosscutting Program
- Partner with industry, NRC, and other programs to:
  - Identify priority needs for nuclear data and benchmarking
  - Perform new data measurements and evaluations
  - Support integral experiments and handbooks
  - Participate in application benchmark studies

- Nuclear data and validation studies:
  - Gap analysis for nonLWR (ORNL – Sobes/Bostelmann)
  - Investigation of HA-LEU transportation validation basis (ORNL – Rearden/Scaglione/Marshall/Clarity/Holcomb)
- Nuclear data generation:
  - Investigation and generation of application driven covariance data (ORNL – Sobes)
  - Improvements of nuclear data for depletion, activation, and decay (ORNL – Wieselquist)
  - New measurement of ^{238}U (n,n') with associated uncertainties (LBNL – Bernstein)
- International benchmarking activities:
  - Multi-Physics Experimental Data, Benchmark, and Validation (ORNL - Valentine)
  - International Physics Benchmark Programs: ICSBEP and IRPhEP (INL - Bess)
- University projects:
  - Generation of thermal scattering data for graphite (N.C. State, X-energy, ORNL)
  - Generation of thermal scattering sensitivity/uncertainty capabilities (U. Michigan, ORNL)

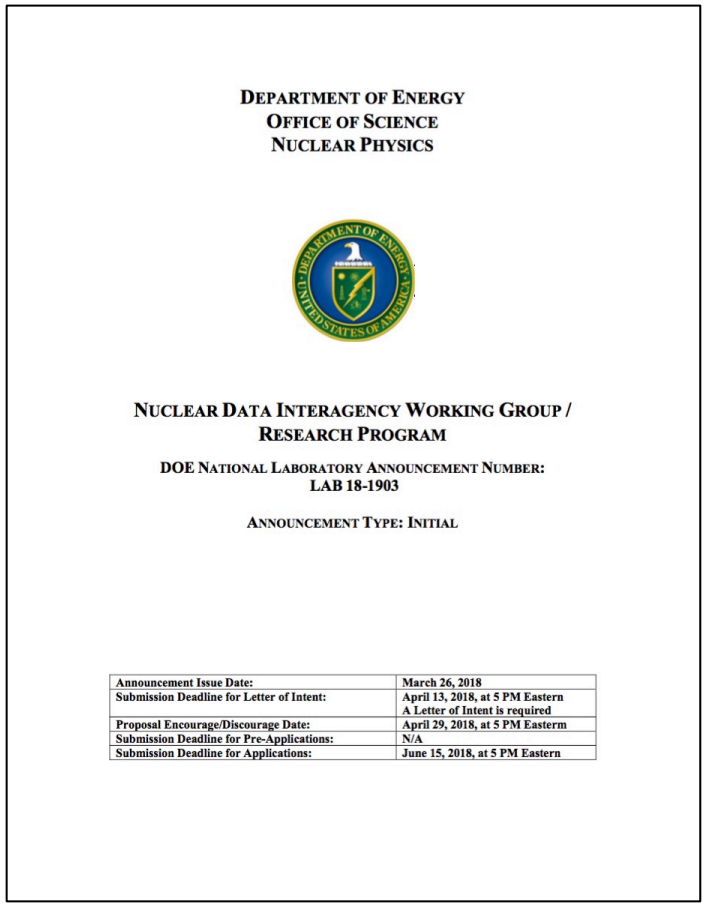
2018 Funding Opportunity Announcement

NE is interested in proposals that address nuclear data needs in these mission areas, provided that these needs are clearly demonstrated to be a limiting factor in nuclear fuel and reactor design, analysis, safety, and licensing calculations. Use of sensitivity and uncertainty analysis methods in proposed efforts is encouraged to demonstrate these needs. Some nuclear data needs for NE may be found in the NEA Nuclear Data High Priority Request List [5]. Recent studies of key safety and operational parameters highlight areas of nuclear data needs relevant to NE's mission.

Precisely determined differential cross section data and associated uncertainties are needed for certain high-priority nuclides and reactions, including:

- ^{238}U inelastic scattering
- ^{235}U capture in the intermediate energy range
- ^{23}Na and ^{56}Fe elastic scattering
- ^{35}Cl(n,p) in the intermediate and fast energy range
- Thermal neutron scattering kernels for fluorine-based molten salts

For the near term, ^{238}U inelastic scattering is the highest priority need for advanced reactor studies, as well as for several other NE program areas. The generation of new nuclear data, covariance data, and associated computational methodologies to address additional needs are also of interest to NE. All proposals must clearly demonstrate relevant application within NE's research scope.



DEPARTMENT OF ENERGY
OFFICE OF SCIENCE
NUCLEAR PHYSICS

NUCLEAR DATA INTERAGENCY WORKING GROUP / RESEARCH PROGRAM

DOE NATIONAL LABORATORY ANNOUNCEMENT NUMBER: LAB 18-1903

ANNOUNCEMENT TYPE: INITIAL

Announcement Issue Date:	March 26, 2018
Submission Deadline for Letter of Intent:	April 13, 2018, at 5 PM Eastern A Letter of Intent is required
Proposal Encourage/Discourage Date:	April 29, 2018, at 5 PM Easterm
Submission Deadline for Pre-Applications:	N/A
Submission Deadline for Applications:	June 15, 2018, at 5 PM Eastern

Nuclear Energy Roadmapping Session

- NRC Presentations:
  - Fuel cycle, transportation, and storage (NMSS)
  - Current Fleet (NRR/RES)
  - New Reactors (NRO)
- Industry Presentations
  - New Reactors
  - Current Fleet
- Laboratory and University Presentations
  - Ongoing R&D to quantify needs and make improvements