NEUP Nuclear Energy University Programs
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Nuclear Physics and Transmutation Science Breakout Session #12

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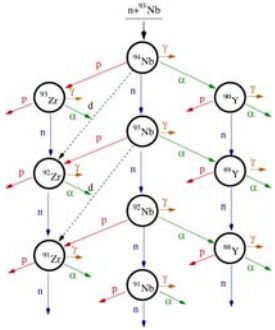
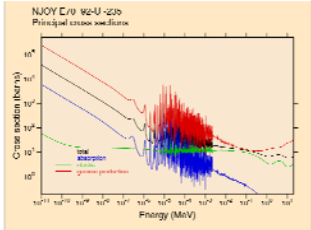
Nuclear Data Libraries: "best estimates" for the nuclear physics needed by nuclear applications





(Differential) Data

Theory & Modeling

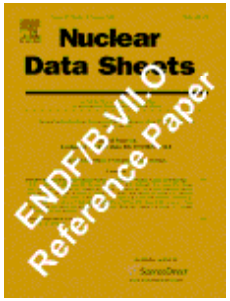
Uncertainty Quantification

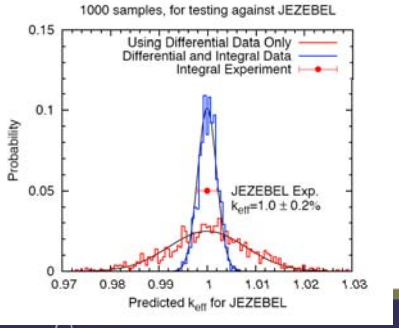
(Integral) Data

→ Nuclear Data Evaluation → NJOY Processing → MCNP/X Simulations

Reactor Simulations

Sensitivity Calculations →





Collaborations (LANSCE, X, TA-18, other labs, …)

T16, LANL playing a major role

Uncertainty Quantification

Nuclear Physics is the foundation of nuclear application simulations

Advancing the nuclear fuel cycle requires improvements in basic nuclear physics

- Nuclear physics plays an important role in many calculations performed throughout the fuel cycle
  - Reactor core and fuel design
  - Safety parameter assessment
  - Criticality safety
  - Shielding
  - Material damage in structures
  - Decay heat at reactor shut-down
  - Decay heat in the repository
  - Mass flow in the fuel cycle
  - Material detection
- Uncertainties in the nuclear data libraries propagate to uncertainties in calculated integral quantities, driving margins and costs in advanced system designs

Nuclear Physics Customers

- Reactor & Transmutation needs:
  - Sensitivity studies
  - List of high-priority isotopes and reactions needing improvements
  - Covariance data improvements are needed

- MPACT needs accurate and precise nuclear data to support advanced instrumentation and improved detection.
  - Some sensitivity capabilities exist, some are at an early stage
  - A balanced portfolio of investment and investigation are needed

- Nuclear Instrumentation activity (NEET)
  - In situ fuel monitoring and specialized instrumentation

Nuclear Physics Customers (cont'd)

- Separations and Wasteforms campaign needs are not limited to chemistry and materials
  - President's budget includes advanced instrumentation for future separation plants
  - President' budget includes advanced research for waste-stream minimization, which should include R&D for fission product transmutation
- Systems Analysis & Engineering:
  - Sensitivity studies are required to determine impact of nuclear data uncertainties on Modified Open Cycle

Nuclear Physics Customers (contd)

- **Modeling and Simulation**
  - Nuclear data is foundational in many calculations
  - Spanning the decades of time and length scales will require close integration
  - Fuel dynamics measurements (in-pile) at the grain level will requires M&S and detector system development

- **Criticality Safety needs are being developed**
  - Uncertainties in Burn-up credit calculations are driven in part by uncertainties in nuclear data
  - Broader scope sensitivity analyses are needed

Many measurements have been identified in the fast reactor sensitivity calculations

- Fission Cross Section Measurements
  - Np237, Pu238, Pu239, Pu240, Pu241, Pu242, Am241, Am242m, Am243, Cm244, Cm245

Previously completed

- Capture Cross Section Measurements
  - Si28, Fe56, B10
  - Np237, U238, Pu239, Pu240, Pu242, Am241, Am242, Am243, Cm242, Cm244, Cm245

Completed 2007

Completed 2008

- Inelastic Cross Section Measurements
  - Na23, U238, Fe56

Completed 2009

- fission neutron spectrum and multiplicity
  - Pu238, Pu239, Pu240

The measurements and required accuracies are EXTREMELY challenging

FY11 Nuclear Data to be joint funded by FCR&D and Office of Advanced Reactor Concepts (ARC)

- Transmutation–related work packages will be in FCRD:
  - Program will determine those data that have the largest impact on the program and provide specific target accuracies for improved data
  - Provide experimental strategies, methodological approaches and cost estimates to obtain nuclear data that meet the target accuracy requirements

- Reactor Design-related work packages will be in ARC:
  - Provide those data that support core design, and hardware/structural materials design

Work Scope 1 – Nuclear Theory and Modeling

- Comprehensive theoretical treatment
  - *inclusive multi-channel nuclear physics evaluations*, capable of delivering *inter-reaction covariance data as a function of incident neutron energy*.
  - Improved nuclear models – developed and validated in collaboration with the nuclear physics working group.
  - *evaluate and construct new data sets for key fuel cycle nuclides*.
  - *Systematic evaluation of how advanced measurement techniques* can be used to help guide improved nuclear theory and modeling, resulting in a strategic plan at the end of the first year. The following years will focus on *nuclear model development with periodic reporting on validation and cross-section evaluation studies*.

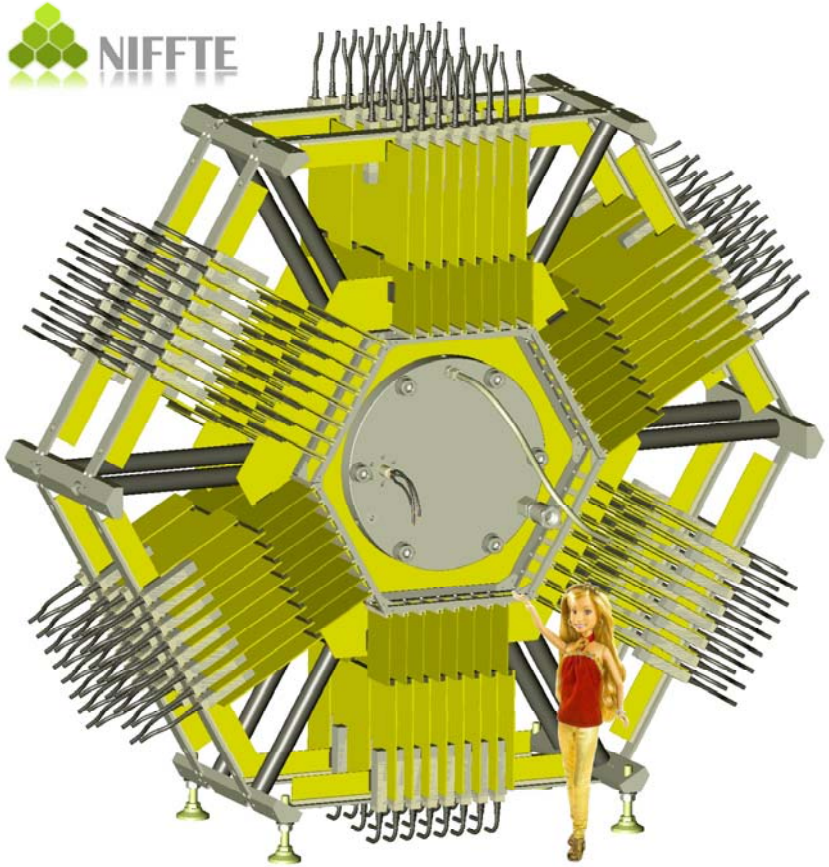
Work Scope 2 – Improved Measurement Techniques

- **Pursue advanced measurement techniques that could complement the ongoing measurement program**
  - fission multiplicity and fission neutron spectrum measurements as a function of incident neutron energy
  - Innovative ideas for detector development and testing for high fidelity requirements of the nuclear physics effort. University teams will develop new measurement systems to address the data needs noted above.
  - Candidate systems will be reviewed and refined in conjunction with the nuclear physics working group. The following years will focus on construction and testing of a prototype device.

Work Scope 3 – Revolutionary Transmutation Concepts

- **Innovative methods for fission product transmutation**
  - Nuclear physics may be able to play a role in the reduction of highly radioactive waste by transmutation or other means. Novel methods are being sought to help minimize the heat load from fission products in separated, processed waste. Such methods *could* include techniques other than neutron irradiation.

Final Slide



DOE Nuclear Energy
Fuel Cycle R&D
Excellence Award
GRAPHITE FROM CP-1
FIRST NUCLEAR REACTOR
DECEMBER 2, 1942
STAGG FIELD - THE UNIVERSITY OF CHICAGO