National Institute of Standards and Technology

Neutron Cross Section and Fluence Standards Program

PROGRESS REPORT

USNDP Meeting
Brookhaven National Laboratory
November 17, 2016

Activities

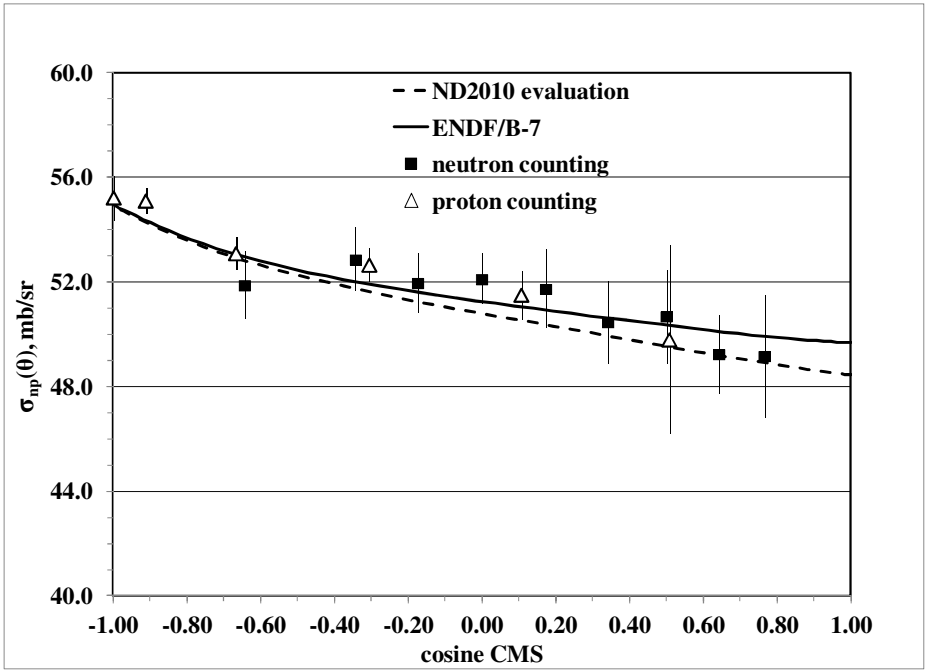
- **Measurements of Standards**
- **Evaluation of Standards**
- **Other work**

Nuclear Reaction Activities: H(n,n)H Standard Angular Distribution Work

This work was initiated to resolve problems with the hydrogen database.

- We previously made measurements at 10 and 14.9 MeV at the Ohio University accelerator facility. The data were obtained by detecting the recoil proton.
- New measurements at 14.9 MeV have been made detecting the neutron in coincidence with the associated proton so that data can be obtained at smaller CMS angles. The data were obtained at the Ohio University accelerator facility.
- The neutron detector efficiency was determined based on the ^{252}Cf spontaneous fission neutron spectrum using TOF between the fission fragment and a neutron.
- (collaboration of NIST with Ohio University, LANL and the University of Guelma)

Data shown at the ND2016 conference are shown here compared with data obtained using detection of the recoil proton. There is excellent agreement with the ENDF/B-VII standards evaluation within the uncertainties but there is a trend toward lower values at small CMS angles for both experiments.



Nuclear Reaction Activities: Standards Measurements

^{6}Li(n,t) Cross Section

- At the NIST Neutron Center for Neutron Research a measurement was made of the ^{6}Li(n,t) cross section standard. This is the first direct and absolute measurements of this cross section in this neutron energy range using monoenergetic neutrons.
  - A primary effort was focused on measuring the neutron fluence accurately. It was determined with an uncertainty of 0.06%.
  - A better determination of the mass must be made to improve the uncertainty of this measurement by about an order of magnitude. We are seeking support to do that work.

(collaboration of NIST with the University of Tennessee and Tulane University)

NBS-I Source Strength Determination Work

- Work continues on improvements in the determination of the source strength for NBS-I, the U.S. national fast-neutron source standard. This work will have an impact on many cross section measurements that have used this source as a standard and any future measurements made using this source.
  - Measurements have been made using a ^{252}Cf neutron source, based on its accurately known nu-bar. They are being analyzed

National Repository for Fissionable Isotope Mass Standards

- These are well characterized samples that have been obtained from various labs that no longer are in the nuclear measurement field. They are routinely monitored.
  - These samples available for loan in physics experiments

IAEA
International Atomic Energy Agency

INDC(NDS)-0641
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INDC International Nuclear Data Committee

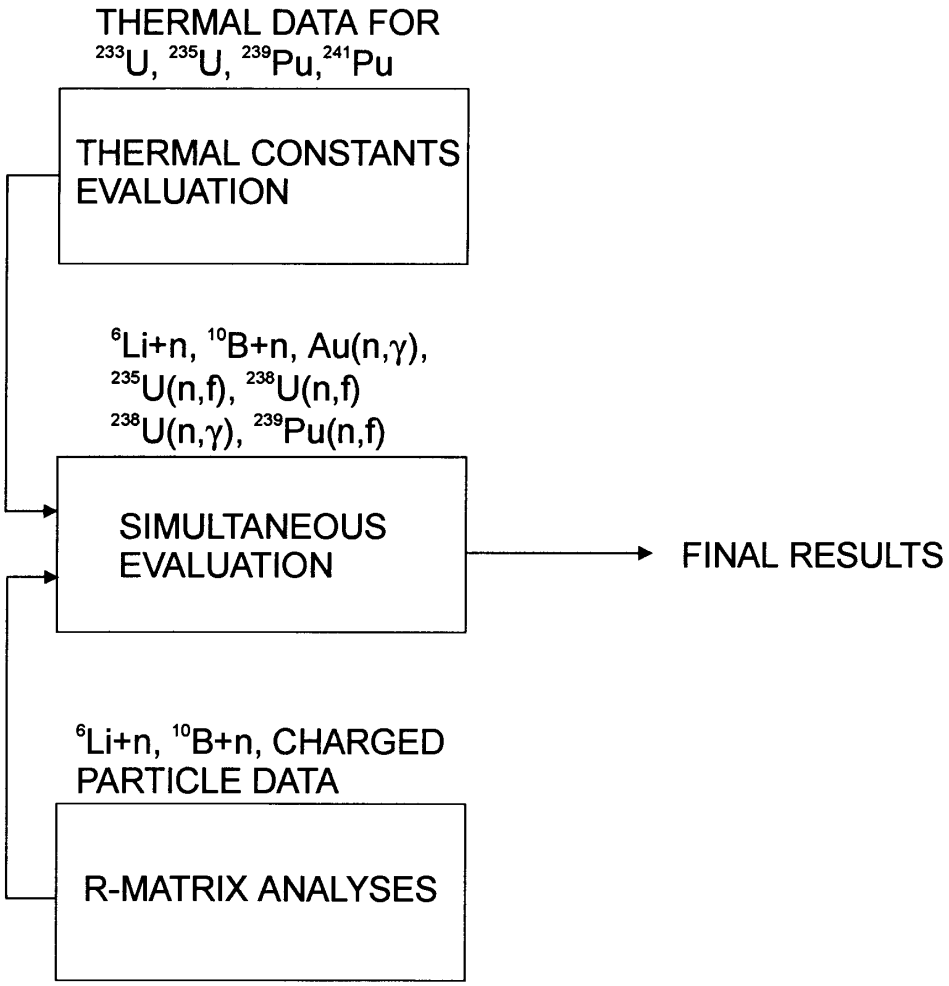
Summary Report from the Technical Meeting

Toward a New Evaluation of Neutron Standards

8 – 12 July 2013
IAEA, Vienna

Attendees of the IAEA Technical Meeting on a New Evaluation of the Neutron Standards

NEW STANDARDS EVALUATION PROCEDURE



Nuclear Reaction Activities: - Evaluations

- NIST has been actively involved in the entire process of evaluating the standards which will be used for the new ENDF/B-VIII evalution.
- The traditional neutron cross section standards are: H(n,n), ^{6}Li(n,t), ^{10}B(n,α), ^{10}B(n,α$_1$γ), C(n,n), Au(n,γ), ^{235}U(n,f), ^{238}U(n,f). Also cross sections for ^{239}Pu(n,f) and ^{238}U(n,γ) were evaluated in the process.
- Experimental data in the standards database have been improved as a result of NIST involvement or encouragement. These data were used in the evaluation of the neutron cross section standards.

Other Standards Related Work

- Work has been done on the gold cross section at low energies.
- Reference cross sections for prompt gamma-ray production in fast neutron-induced reactions have been studied and proposed.
- Very high energy fission reference cross sections for Bi and Pb have been evaluated.
- An effort was directed at improvement in the ^{235}U thermal neutron fission spectrum evaluation and some improvement in the ^{252}Cf spontaneous fission neutron spectrum.
- A new evaluation of the thermal constants is proposed.

Proposed Work

- Complete any additional work needed to finalize the standards data. Work on a draft of the work done on the standards for publication in Nuclear Data Sheets.
- Pursue improvements in the experimental database so they are available for the next evaluation of the standards.
- In an effort to continually improve the standards, continue to recommend and encourage new measurements and perform examinations of the data from them for use in future evaluations of the standards.
- Do diagnostic work involving symmetry of angular distributions to relate the fluence of lower energy neutrons to the fluence of higher energy neutrons. This should lead to measurements of the H(n,n)H angular distribution with the new deuterium gas target at smaller center-of-mass angles.
- Calibrate NBS-I using an absolutely calibrated source based on α-γ coincidences with the $^{10}B(n,\alpha_1\gamma)$ reaction.
- Continue to acquire and monitor samples in the National Repository for Fissionable Isotope Mass Standards. Make these samples available for loan in experiments
- Determine the mass of the ^{6}Li sample used for the $^{6}Li(n,t)$ cross section. Note the accompanying presentation.

Improving the ^{6}Li Thermal Neutron Absorption Cross Section With ID-ICP-MS*

Alan K. Thompson
Nuclear Data Week 2016

*Isotope Dilution Inductively Coupled Plasma Mass Spectrometry

The Problem

- The efficiency of conversion of a cold neutron beam to (detected) α particles using a ^{6}Li foil, $\varepsilon_0 = \rho\Omega\sigma_0$, was measured at NIST to ~0.1 %

- The efficiency was consistent with the density of the foil as specified by IRMM and the ENDF B/VII ^{6}Li thermal neutron absorption cross section

- IRMM published a paper that implies a 0.9 % correction to the amount of ^{6}Li in the NIST target foils (due to an adjustment of the isotopic ratios in IRMM-016, a lithium isotopic reference material)…

The problem (cont.)

- NIST found no problems with the determination of Ω
- IRMM staff have not explained the 0.9 % correction to us and the implications it might have for the NIST foil

A Possible Solution

- The Inorganic Chemical Science Group at NIST has offered to use their ICP-MS system (and a few person-weeks of staff time) to:
  - Analyze the adjustment to IRMM-016 and implications for the foils, and
  - Make a precise determination of the $^{6/7}$Li content of one of our foils to verify those implications
- ….for $35k.