Update on Standards Activities

Allan D. Carlson
Ionizing Radiation Division
National Institute of Standards & Technology

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IAEA Consultants' Meeting

- In order to improve the standards on a continuing basis, an IAEA Nuclear Data Development Project "Maintenance of the Neutron Cross Section Standards" was initiated.
  - This project will pursue improvements in the experimental database, consider additional standards, maintain evaluation codes and periodically update the standards so they are available for new versions of data libraries.
  - The first meeting was held in October of 2008 and the second meeting was held in October 2010.

Second IAEA Consultants' Meeting on The Nuclear Data Development Project "Maintenance of the Neutron Cross Section Standards"

Summary of the Second IAEA Consultants' Meeting (Oct. 2010) on the Nuclear Data Development Project "Maintenance of the Neutron Cross Section Standards".

The topics of the meeting were:

- Updating the standards experimental database.
- Update for an evaluation of the ^{252}Cf spontaneous fission neutron spectrum.
- Update for an evaluation of the ^{235}U(n_{th},f) neutron spectrum.
- Adding "Reference" cross section to our evaluation effort. These do not have the quality of the standards but they are convenient for certain applications.
    - Reference cross sections for measurements of prompt gamma-ray production cross sections.
    - Au(n,γ) reference cross section for capture cross section measurements for astrophysics (below the standards energy region).
- Use of models to smooth cross sections, spectra and covariances.

THE NEUTRON CROSS SECTION STANDARDS

Reaction	Energy Range
H(n,n)	1 keV to 20 MeV
^{3}He(n,p)	thermal to 50 keV
^{6}Li(n,t)	thermal to 1 MeV
^{10}B(n,α)	thermal to 1 MeV
^{10}B(n,$\alpha_1\gamma$)	thermal to 1 MeV
C(n,n)	thermal to 1.8 MeV
^{197}Au(n,γ)	thermal, 0.2 to 2.5 MeV
^{235}U(n,f)	thermal, 0.15 to 200 MeV
^{238}U(n,f)	2 to 200 MeV

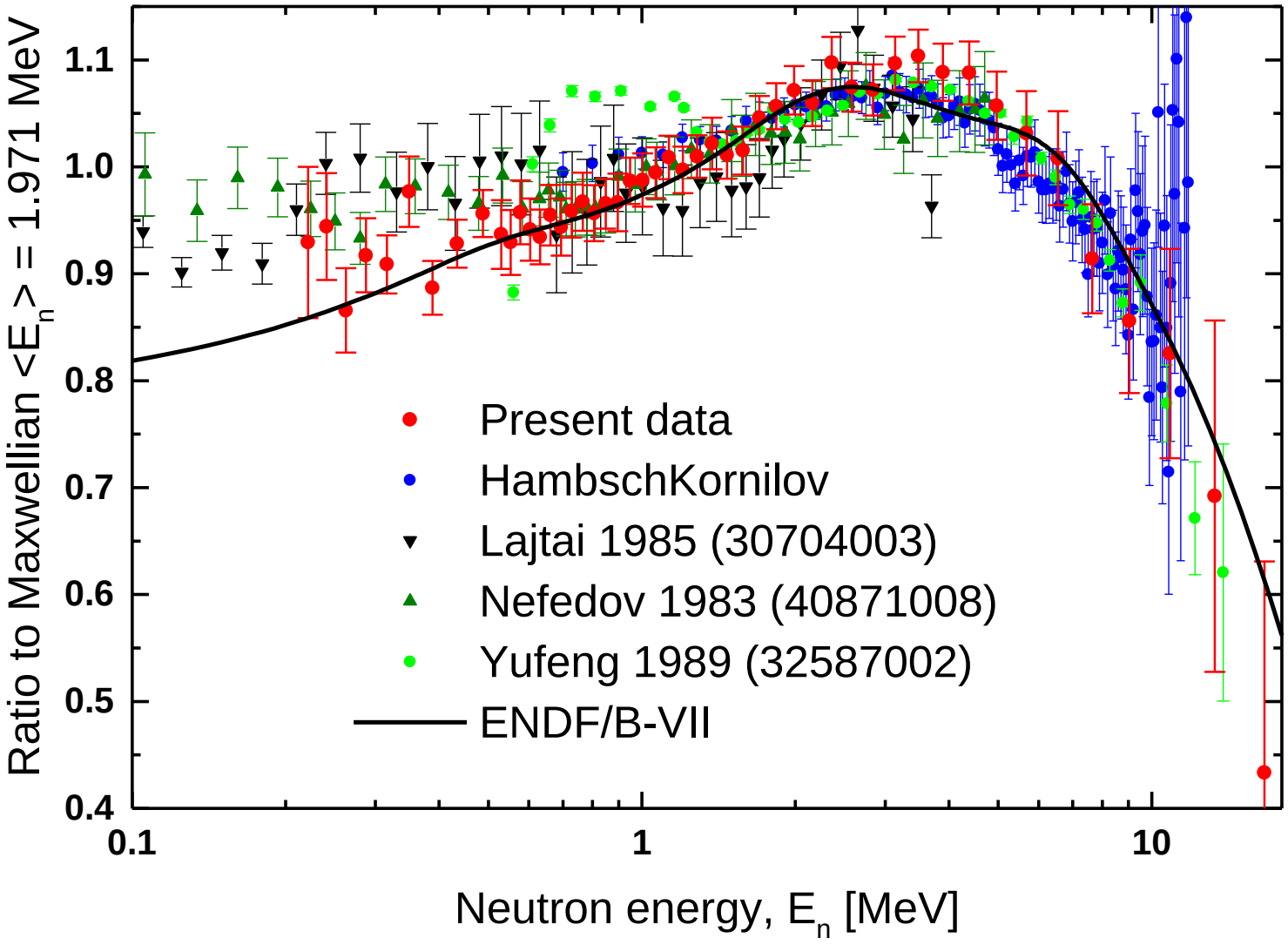
Summary of the Second IAEA Consultants' Meeting (Oct. 2010) on the Nuclear Data Development Project "Maintenance of the Neutron Cross Section Standards".

- Updating of the standards database.
  - The experiments completed or underway since the completion of the standards evaluation were reviewed.
    - The experiments suggest improvements have been made for the H(n,n), Li(n,t), ^{10}B(n,α), Au(n,γ), and ^{238}U(n,γ) cross sections.
    - There are inconsistencies for the ^{3}He(n,p), C(n,n), ^{238}U(n,f) and ^{239}Pu(n,f) cross sections.
    - These experiments will be discussed in the Measurements Committee session

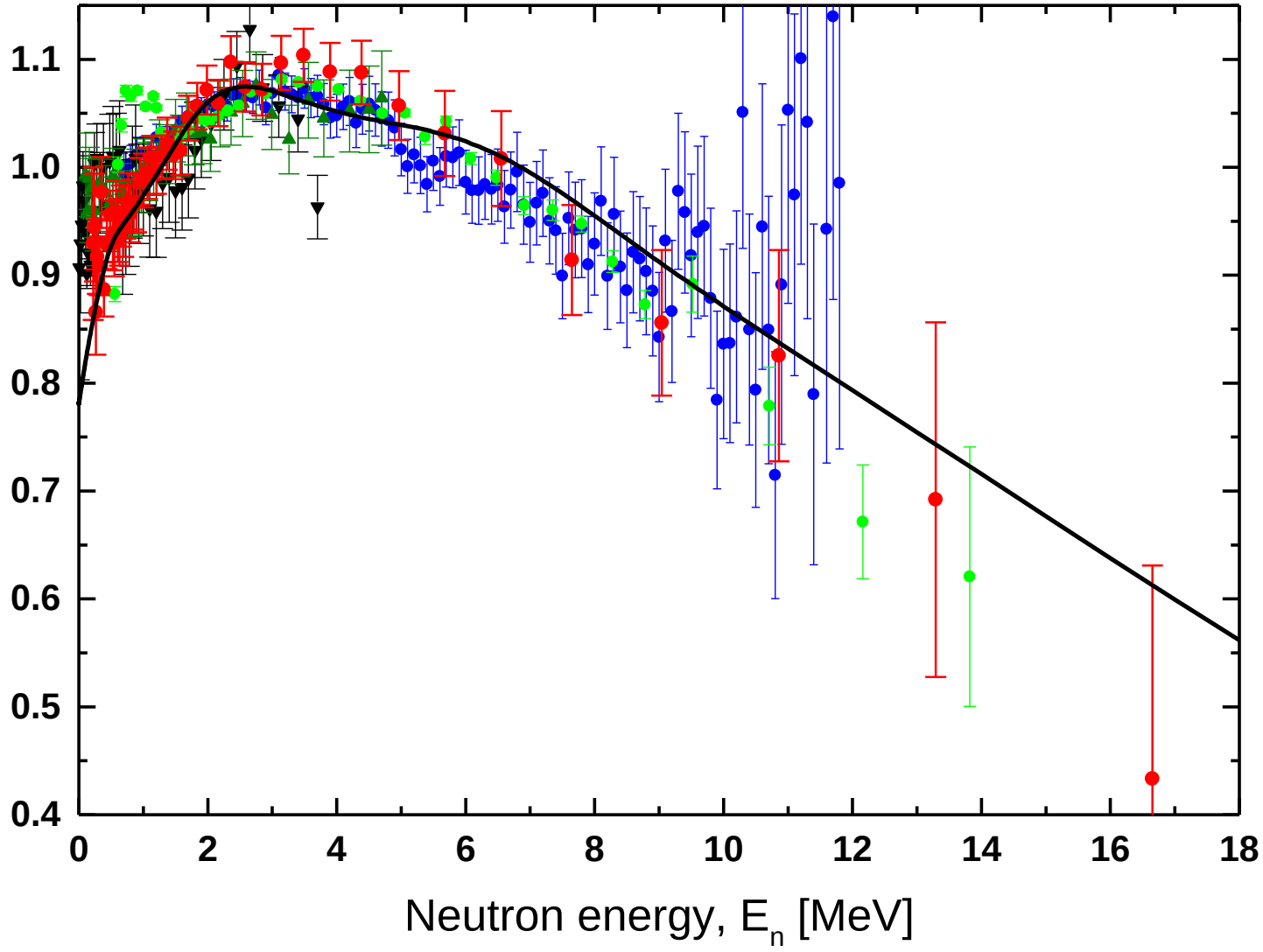
Summary of the Second IAEA Consultants' Meeting

- Neutron spectra
  - No new measurements have been made of the ^{252}Cf spontaneous fission neutron spectrum. There are new measurements of the $^{235}U(n_{th},f)$ neutron spectrum made by Kornilov (Hambsch) et al. and Vorobyev et al.

$^{235}U(n_{th},f)$ neutron spectra, "Present data" is Vorobyev et al.



$^{235}U(n_{th},f)$ neutron spectra, "Present data" is Vorobyev et al.



Summary of the Second IAEA Consultants' Meeting

- Neutron spectra (cont.)
  - The most recent measurements of the $^{235}U(n_{th},f)$ neutron spectrum have been made with a ^{252}Cf source located outside the beam. Thus ratio measurements of these spectra were obtained.
  - For the standards evaluation the GMA code was used to properly evaluate ratio data. Then there was an impact on both quantities in the ratio.
  - It seemed reasonable to use the GMA code for a simultaneous evaluation of these two fission spectra. This was done and it included smoothing using a model. There were some problems with the preliminary results of the work. There was a critical review of the process with many helpful suggestions for the next set of calculations.

Summary of the Second IAEA Consultants' Meeting

- Neutron spectra (cont.)

  - An IAEA Coordinated Research Project (CRP) was recently initiated to provide new evaluations of prompt fission neutron spectra of major actinides including covariance matrices. The work of this CRP will be utilized in the present studies of fission neutron spectra. The CRP will include new experimental data on the energy and angular correlations of fission fragments from ^{235}U thermal fission and the measurements of ^{235}U(n,f) spectra.

  - Theoretical efforts are underway to provide improved spectra fits and data evaluation in the whole energy range. These include an approach to data evaluation based on model calculations and experimental data using a Unified Monte Carlo method and Generalized Least Squares. Validation of the resulting data against integral critical assembly and dosimetry data is foreseen.

Summary of the Second IAEA Consultants' Meeting

- Reference cross sections for measurements of prompt gamma-ray production cross sections.
  - Several candidates were investigated taking into account factors such as structure and magnitude of the cross section, status of the database, sample properties, and evaluations performed.
  - Both (n,n'γ) and (n,2nγ) reactions were considered.
  - Fe(n,n'γ)
    - LANL corrected data are now in good agreement with the ENDF/B-VII.0 evaluation.
    - IRMM data have been determined to need fission chamber efficiency corrections. The corrections are in the direction to give improved agreement with evaluations.

Summary of the Second IAEA Consultants' Meeting

• Reference cross sections for measurements of prompt gamma-ray production cross sections. (cont.)

- Cr(n,n'γ)
  - •LANL data analysis is continuing.
  - •IRMM data have the same problem with fluence determination as their Fe(n,n'γ) data, i.e.they need fission chamber efficiency corrections. The corrections are in the direction to give improved agreement with evaluations.

- Other nuclides investigated-Nb, Au and Ti.
  - • Nb-problems due to a long-lived isomer.
  - • Au-problems due to the gamma-ray close to strong background lines, also an isomer is present.
  - • Ti-appears to be the **most suitable**. It has better physical properties than Cr and is less abundant in shielding than Fe. But the database needs to be improved.

Summary of the Second IAEA Consultants' Meeting

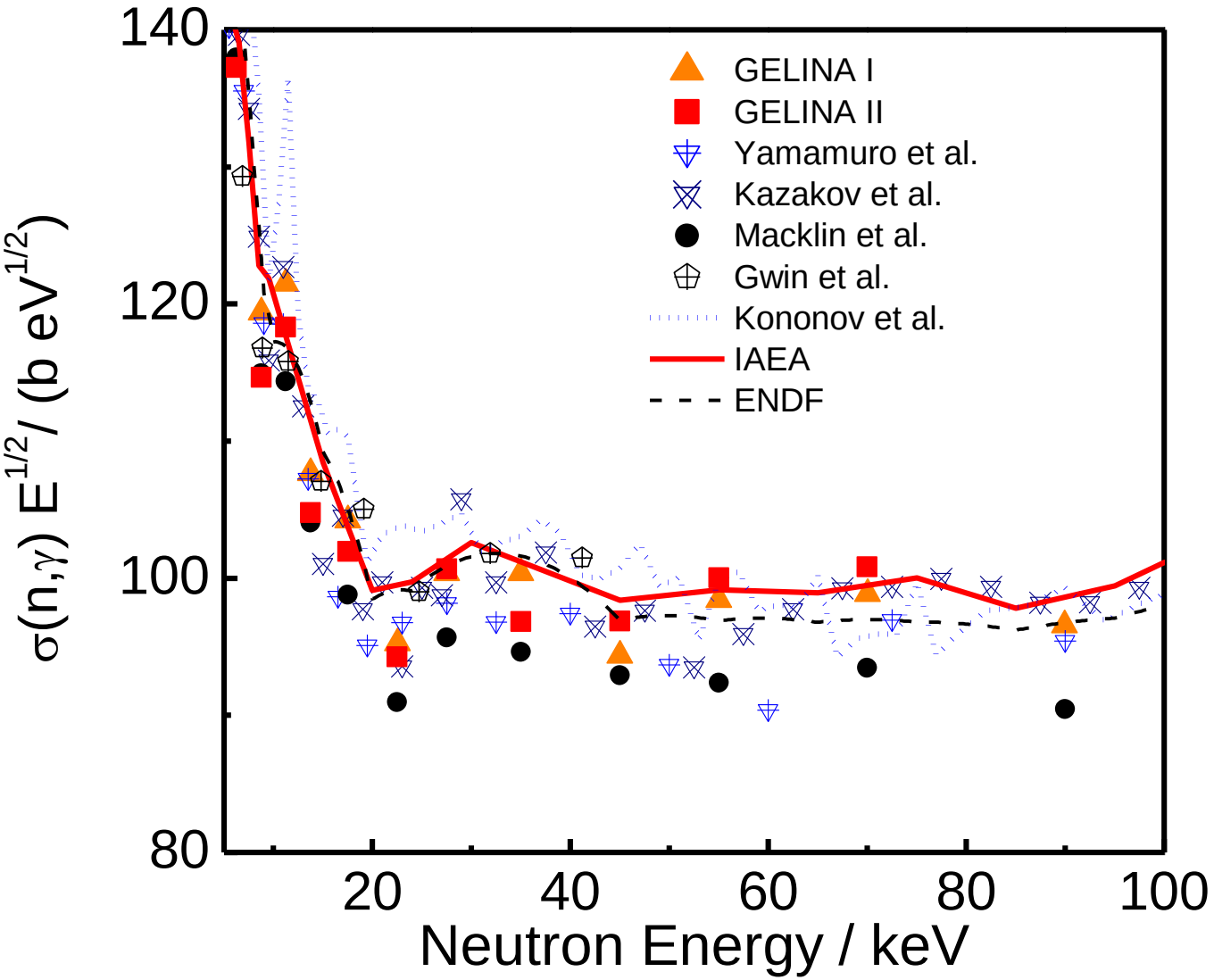
- Au(n,γ) reference cross section for capture cross section measurements for astrophysics (below the standards energy region).
  - Due to the evaluation process used for the standards evaluation, data for the Au(n,γ) cross section were obtained for energies below 200 keV (below the standards energy region).
  - These results are consistently higher than the Ratynski evaluation (by about 5-7% from 15 to 25 keV) which is used in astrophysics applications.
  - The Ratynski evaluation relies on Macklin capture data and Ratynski-Käppeler Karlsruhe pseudo-Maxwellian capture data.
  - The standards evaluation uses a large database of various types of data.
  - The results of WPEC Subgroup 4 support the standards evaluation.

Summary of the Second IAEA Consultants' Meeting

•Au(n,γ) reference cross section for capture cross section measurements for astrophysics (below the standards energy region) (cont.).

- New experiments were reported at the Consultants' Meeting.
  - Wallner using AMS with a simulated Maxwellian neutron source spectrum of 25 keV mean energy obtained a ratio to the standards evaluation for gold capture of 1.04 ± 0.05
  - Lederer reanalyzed n_TOF gold capture data of Massimi and folded a simulated Maxwellian neutron source spectrum of 25 keV mean energy into that data. The result was 564 ± 23 mb compared with the standards evaluation of 575 mb. That is a 2% difference with an uncertainty of 4%.
  - The Au(n,γ) cross section measurements of Borella et al. support the standards evaluation. Schillebeeckx repeated that experiment of Borella et al. with considerable concern about corrections to the data. The new results support the standards results and the Borella et al. data.

Gold Capture Measurements and Evaluations, GELINA I = Borella et al., GELINA II= Schillebeeckx, IAEA=the Standards Evaluation



Summary of the Second IAEA Consultants' Meeting

- Developing a procedure to improve the smoothing process.

  - The objective is to remove non-physical fluctuations (statistical structure) and maintain real structure such as the cusps that occur from competition with inelastic scattering. In the standards evaluation, a 3-point smoothing was used. The present effort used statistical model calculations for the Au(n,γ) and ^{238}U(n,γ) cross sections as shape data, with high correlation between neighboring points, in the GMAP code. The procedure appears to have been successful. As noted previously work is also being done on spectra evaluations.

  - Future work may be done using a similar procedure for fission cross section evaluations.

Recommendations

• Though the international evaluation of the standards has been completed, maintaining an active program of measurements and evaluation activities is essential for improvement of the standards. Some of the evaluation activities are being done under the IAEA Nuclear Data Development Project "Maintenance of the Neutron Cross Section Standards". This project is important since it allows improvements in the experimental database, considerations for additional standards, the maintenance of evaluation codes and periodic updates of the standards so they are available for new versions of nuclear data libraries.