Status of the ENDF Project

P. Obložinský

National Nuclear Data Center
Brookhaven National Laboratory
Major Events Since WPEC 2004

- October 2004: ND2004, Santa Fe
  - Status of Preliminary ENDF/B-VII reviewed in a series of invited talks

- November 2004: CSEWG Meeting
  - Review and validation of Preliminary ENDF/B-VII

- March 2005: ENDF/B-VII beta0 released
ENDF/B-VII beta0

Neutron sublibrary released March 11, 2005

• 340 neutron evaluations (85 new/revised, 255 from ENDF/B-VI.8)
• revised LA150 files (March 10, 2005)
• revised actinides from LANL (March 9, 2005)
• new delayed-neutron time constants and fractions in actinides
• extensive benchmarking at Petten in March 2005, JEFF-3.1, also ENDF/B-VII

www.nndc.bnl.gov/endf7/b0/ - single file
www.nndc.bnl.gov/exfor7/endf00.htm - retrieval
ENDF/B-VII beta0 Retrieval

Cross Section Evaluation Working Group
ENDF/B-VIIb0: New Evaluations

265 new or improved evaluations

**Neutrons**: 85 materials (16 actinides, revised LA150, etc.)

- $^1$H, $^7$Be, $^{27}$Al, $^{28,29,30}$Si, $^{31}$P, $^{40}$Ca, $^{50,52,53,54}$Cr, $^{54,56,57}$Fe, $^{58,60,61,62,64}$Ni, $^{63,65}$Cu, $^{93}$Nb, $^{182,183,184,186}$W, $^{196,198,199,200,201,202,204}$Hg, $^{206,207,208}$Pb, $^{232,233,234,235,236,237,238,240,241}$U, $^{241,242,242}$Am, $^{239}$Pu, $^{237}$Np (LANL, mostly up to 30 MeV, with $^{232,233,234,235,238}$U and $^{241}$Pu resonances by ORNL)

- $^{19}$F, $^{35,37}$Cl (ORNL, resonance region)

- $^{70,72,73,74,76}$Ge (JAERI-BNL); $^{95}$Mo, $^{99}$Tc, $^{101}$Ru, $^{103}$Rh, $^{105}$Pd, $^{109}$Ag, $^{131}$Xe, $^{133}$Cs, $^{141}$Pr, $^{143,145}$Nd, $^{147,149,150,151,152}$Sm, $^{153}$Eu, $^{155,157}$Gd, $^{160,161,162,163,164}$Dy (KAERI-BNL)

**Photonuclear**: 160 materials (LANL, mostly from IAEA project)

**Charged particles**: 20+ materials (all LANL, revised LA150 to be processed)
ENDF/B-VII: Standards

New evaluations for 5+3+2 reactions

- Light nuclei: $^1$H(n,n), $^3$He(n,p), $^6$Li(n,t), $^{10}$B(n,$\alpha$), $^{10}$B(n,$\alpha_1$)
- Heavy nuclei: $^{197}$Au(n,$\gamma$), $^{235}$U(n,f), $^{238}$U(n,f)
- Associated: $^{238}$U(n, $\gamma$), $^{239}$Pu(n,f)

Neutron cross-section standards: Complex international activity

- CSEWG, NEA Working Party, IAEA CRP on Standards
- Cross sections provided in 2004
- Covariances expected in 2005
ENDF/B-VII: Covariances

- No new covariances submitted so far
- Covariances taken over from ENDF/B-VI (47 materials)
- New covariances expected for 7 isotopes of Gd (ORNL, LANL – criticality safety)
- New covariances expected for $^{235,238}\text{U}, ^{239}\text{Pu}$ (ORNL, LANL - criticality safety and AFCI)
LANL: Actinides, improved \((n,n')\)

- New LANL \(^{238}\text{U}(n,xn)\) evaluation
- Improved treatment of direct reactions
- Excellent description of neutron spectrum below elastic peak
- Supported by LLNL 14 MeV pulsed-sphere benchmark
LANL: Actinides, improved (n,2n)

- New LANL $^{239}$Pu(n,2n) evaluation
- Recent data from GEANIE
- Improved modeling

![Graph showing $^{239}$Pu(n,2n) Reaction]
LANL: Actinides, improved (n,f)

- Modern treatment of direct reactions at high energies
- Reflected in evaluation of $^{233}$U(n,f)
LANL: Actinides, improved capture

- New evaluation of branching ratio for $^{242\text{g}}\text{Am}/^{242\text{tot}}\text{Am}$ in $^{241}\text{Am}(n,\gamma)$
- Based on integral data, improved modeling
- Kawano, LANL
ORNL: Resonances, $^{233}$U

- $^{233}$U+n total and fission
- ORELA measurement (Guber et al, NSE 2000)
- Fit by SAMMY (Reich-Moore formalism)
ORNL: Resonances, $^{\text{nat}}$Cl

- Transmission for $^{\text{nat}}$Cl+n
- ORELA measurement (Guber et al, PRC 2002)
- Fit by SAMMY (Reich-Moore formalism)
ENDF/B-VII: Data Testing

Phase 1: Data verification (NNDC)

Phase 2: Data validation (LANL, ANL, KAPL, ORNL, Bechtel Bettis)
NNDC: New/revised files processed by checking codes, plotted against other evaluations and experimental data

- ENDF/B-VII
- CENDL-2
- JEF-3.0
- BROND-2.2
- JENDL-3.3
- ENDF/B-VI.8
- CHECKR
- FIZCON
- PSYCHE
- ENDVER
- PLOTC4
- ZVView
- CSISRS

- html

- check format
- compare with other libraries
- compare with experimental data
- provide easy access

Cross Section Evaluation Working Group
NNDC: New/revised neutron evaluations processed by NJOY-2003.0 modules:

- moder
- reconr
- broadr
- unresr
- heatr
- purr
- gaspr
- moder
- viewr
- acer
- viewr

acer files are tested in simple MCNP runs (GODIVA)
Data Validation (fast criticals)

**LANL k-eff calculations performed by MCNP5 code:**
- ENDF/B-VII and ENDF/B-VI.8
- Benchmark models CSEWG, also ICSBEP 2003

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Description</th>
<th>Experiment</th>
<th>B-VII</th>
<th>B-VI.8</th>
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<tbody>
<tr>
<td>Godiva</td>
<td>$^{235}$U sphere</td>
<td>1.0000(10)</td>
<td>0.99970(19)</td>
<td>0.99665(19)</td>
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<td>Jezebel</td>
<td>$^{239}$Pu sphere</td>
<td>1.0000(20)</td>
<td>1.00051(18)</td>
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<td>Flattop-25</td>
<td>$^{235}$U, reflector U</td>
<td>1.0000(10)</td>
<td>1.00299(21)</td>
<td>1.00193(19)</td>
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<td>Flattop-Pu</td>
<td>$^{239}$Pu, reflector U</td>
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<td>1.00194(23)</td>
<td>1.00282(22)</td>
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<td>Jezebel-23</td>
<td>$^{233}$Pu sphere</td>
<td>1.0000(14)</td>
<td>0.99883(18)</td>
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<td>1.0000(10)</td>
<td>1.00059(22)</td>
<td>1.00239(23)</td>
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<td>Bigten</td>
<td>$^{235}$U/U, reflector U</td>
<td>0.9960(30)</td>
<td>0.99708(16)</td>
<td>1.00950(17)</td>
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</tbody>
</table>

- Dramatic improvement for $^{233}$U
- Reflector bias for $^{235}$U and $^{239}$Pu largely reduced (Flattop versus unreflected k-eff)
- Dramatic improvement for Bigten (due to new inelastic $^{238}$U)
- But: Flattops too high
Data Validation (ENDF/B-VIIb0)

LANL data testing ENDF/B-VI.8 and VII

- Calculated by R. MacFarlane, LANL, March 2005
- Plot created by R. Perel, Jerusalem University, March 2005
Data Validation (ENDF/B-VIIb0)

LANL data testing ENDF/B-VI and VII

- exp uncert
- exp uncert
- VI release 8
- prevII May04
- prevII Mar05

- Calculated by R. MacFarlane, LANL, March 2005
- Plot created by R. Perel, Jerusalem University, March 2005
Data Validation (ENDF/B-VIIb0)

LANL data testing ENDF/B-VI.8 and VII

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Data Validation (thermal lattices)

Thermal data testing at LANL focused on high-enriched and low-enriched uranium-water systems, MCNP5 code

**HEU lattices**
ENDF/B-VI.8 was considered to be very good
ENDF/B-VII shows similar performance

**Water moderated LEU lattices**

ENDF/B-VI.8 - **Issue:** substantial under-prediction of $k_{\text{eff}}$ (0.9936), thought to result from $^{238}\text{U}$, also addressed by WPEC

ENDF/B-VII - Current result for LCT006 $k_{\text{eff}} = 0.9991$
- Improvement supported by LCT001 series due to:
  - High energy inelastic scattering in LANL $^{238}\text{U}$ eval.
  - New resonance parameters and lower thermal capture evaluations by ORNL
- But: LCT002 series indicates possible enrichment bias
Further Development

• **Further improvements expected**
  - Iterative improvement process for actinides will continue, LANL
  - Possibly new spectra for the delayed neutrons, LANL
  - Update 29 FPs (inelastic, capture photon production, EMPIRE-2.19), BNL
  - Bulk of FPs may be replaced, depends on WPEC SG23 progress

• **Data testing**
  - Systematic data verification, format errors corrected, BNL
  - **Extensive validation will continue**, LANL and others

• **Covariances**
  - Covariance data for 10 materials expected (Gd, U, Pu), ORNL & LANL
Future Events

• July 12, 2005 – CSEWG validation meeting at ORNL

• Nov 8-10, 2005 – CSEWG annual meeting, final review at BNL

• Dec 2005 – release of ENDF/B-VII