Status of the ENDF/B-VIII beta3 library

D. Brown
Beta0 highlights (2011-2015):

- **CIELO evaluations:**
  - $^{16}\text{O}$
  - $^{56}\text{Fe}$
  - $^{235}\text{U}$
  - $^{238}\text{U}$
  - $^{239}\text{Pu}$

- **Non-CIELO:**
  - $^{54}\text{Fe}$, $^{57}\text{Fe}$, $^{58}\text{Fe}$
  - n
  - Yb, Dy, Os (JENDL4)
  - $^{18}\text{O}$ (RUSFOND)
  - $^{63,65}\text{Cu}$
  - 182,183,184,186$\text{W}$

- **EPICS2014:**
  - photoat
  - electrons
  - atomic_relax

- **Decay data:**
  - $^{40}\text{Ar}$
  - $^{236m1}\text{Np}$
  - 58-61$\text{Ni}$
  - EGAF gammas
  - Bug fixes

- **Thermal Scattering:**
  - $^{90}\text{Kr}$
  - $^{140,141}\text{Cs}$
  - $^{143}\text{Ba}$
  - $^{143,144,145}\text{La}$
  - $^{134}\text{Sb}$
  - $^{138}\text{I}$

  - MAT fixes
  - $\text{SiO}_2$ (x2)
  - SiC
  - Lucite
  - $\text{H}_2\text{O}$
  - $\text{D}_2\text{O}$ (x2)
Beta1 highlights
(corrections after mini-CSEWG Apr. 2016)

- **CIELO:**
  - $^{56}\text{Fe}$
  - $^{235}\text{U}$
  - $^{238}\text{U}$

- **Non-CIELO:**
  - $^{7}\text{Be}$
  - $^{12,13}\text{C}$
  - $^{54,57}\text{Fe}$
  - Bug fixes
Beta2 highlights
(so we all have something to present at ND2016...)

- **CIELO:**
  - $^{56}$Fe
  - $^{235}$U
  - $^{238}$U
  - $^{239}$Pu

- **Non-CIELO:**
  - $^7$Be
  - $^{54}$Fe
  - $^{40}$Ca
  - Bug fixes

- **Thermal scattering:**
  - BeO (x2)
  - Polyethylene
Beta3 highlights

- **CIELO:**
  - $^{56}$Fe
  - $^{239}$Pu

- **Non-CIELO:**
  - $^{54,57}$Fe
  - $^{35,37}$Cl
  - $^{59}$Co
  - $^{73,74}$As
  - $^{78}$Kr
  - $^{132}$Te
  - $^{124}$Xe
  - 174, 176, 178, 179, 180 Hf

- **Charged particles:**
  - $^7$Be
  - RQ Wright’s nubars
  - $^7$Li, $p+a$, $p+^{13}$C
  - $d+7$Li
  - $t+a$, $t+^{7}$Li
  - $^3$He+$a$, $^3$He+$^3$He
  - $a+a$

- **Thermal scattering:**
  - $D_2O$ (x2) new temps
  - Be(metal)
  - $UO_2$ (x2)
  - Graphite
  - Reactor graphite
Late things

- $^{235}$U (arrived after beta3)
- $^{238}$U (arrived after beta3)
- Standards (not arrived yet)

- Working though bug lists supplied by
  - Kent Parsons (LANL)
  - Cedric Jouanne (CEA)
ADVANCE feedback available on all evaluations


- If you have questions about a report, I can walk you through it
ENDF Hackathon© 2016

D. Brown, T. Kawano,
S. Mughabghab, G. Nobre,
V. Sobes,
I. Thompson (remotely)
What’s all this about?

- Clean up as many ENDF evaluations as possible using whatever evaluation tools you have
- Donuts and coffee provided…
- Schedule:
  - Monday-Thursday — kill bugs
  - Friday — review changes, make sure OK
40% reduction in open trackers

Lots of old bugs have been fixed
This year’s winner of the golden bug, for most dead bugs

- **Champion: Toshihiko Kawano!**
  - 19 commits (including a 2 self-inflicted bug penalty)

- **Reserve champion: Dave Brown**
  - 9 commits + 1 bonus commit for being organizer and donut purchaser
Big Changes

- $^{63,65}$Cu finalized (VS+TK)
- R.Q. Wright’s nubar evaluations added to all MA (TK)
- Death to SLBW format, plus other minor RRR fixes (DB+GN)
- Proper extension of $^7$Be to 20 MeV, preserving Page’s evaluation (IT)
- $^{239}$U RRR (IT)
- Hf fixes (TK): new fast for 174,176-180
- $^{154}$Eu thermal cross section fix (TK+SM)
- $^{73,74}$As evaluations recalculated in fast region (TK)
- $^{93}$Nb RR updated (TK)
- $^{35,37}$Cl capture cross sections fixed (TK)
- $^{76}$Kr redo fast region, JENDL-4 RRR (TK)
- $^{124}$Xe redo fast region (TK)
- $^{132}$Te redo fast region (TK)
- ECPL translated to ENDF (IT)
SLBW format eliminated in ENDF library & messed up RRR $J^\Pi$ assignments corrected

Bad $J^\Pi$: $^{105}$Rh, $^{148m1}$Pm, $^{241}$U, $^{243}$Pu

SLBW->MLBW: $^{105}$Rh, $^{135}$Xe, $^{148m1}$Pm, $^{241}$U, $^{243}$Pu
Wish we could have gotten to these...

- $^{12}\text{C}$ discrete gamma’s added for use in assays
- $^{240}\text{Pu}$ thermal cross sections tweaked to resolve PU-SOL-THERM
- deuteron masses
- removal of all pseudo-levels
- energy balance
- Reduce signal/noise for FUDGE errors
Automated fixes?

- Zeros in Legendre moment data
- Norms of all PDFs set to 1.0000000000
- BR’s all sum to 1.0000000
- Tweak Q’s & Thresholds
“Minor tweak” to 240Pu?
Background

- We always do terrible with PU-SOL-THERM assemblies (some ZPRs too)
  - Is it 239Pu or 240Pu?
  - New CIELO evaluation of 239Pu did not fix

- In 2010 revision [#111] a new ORNL+LANL evaluation was submitted for 240Pu
  - It made PU-SOL-THERMs worse (See Skip’s 2010 CSEWG validation talk)
  - We reverted to ENDF/B-VII.0 RRR in revision [#175]

- JENDL-4.0 adopted new ORNL RRR
Tracker [#633]: $^{240}\text{Pu}(n,\text{el})$ thermal cross section is very low

Thanks Boris!
Here’s a similar plot, including the Atlas value
σ_s = 1.73 ± 0.10 b
=σ_{coh} = 4\pi(g_+a_++g_-a_-)^2 \text{ since } J^\Pi = 0^+

“Can be determined very accurately” – S. Mughabghab

Determined from pair of neutron diffraction experiments
- (ANL) G.H. Lander, M.H. Mueller, ACR/B 27, 2284 (1971)
- (LANL) J.L. Green et al., JNM, 34, 281 (1970)
Things we tried

- Rework bound levels to match Atlas values for thermal elastic, capture and fission (carefully, there is MT32 data to go with it)
- Reconstruct angular distribution using FUDGE (better physics, but doesn’t do anything to benchmarking)
Changed bound resonances
Fission lowered a little from B7.1

It was difficult to match Atlas exactly by hand.
ORNL resonances already agreed with Atlas
Testing

<table>
<thead>
<tr>
<th></th>
<th>ICSBEP</th>
<th>ENDF/B-VII.1 == ENDF/B-VIII.b2</th>
<th>ENDF/B-VIII.b2+rev111 (ORNL)</th>
<th>ENDF/B-VIII.b2+bd level fix</th>
<th>ENDF/B-VIII.b2+bd level fix, angDist</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMF002 (&quot;dirty Jezebel&quot;)</td>
<td>1.000(2)</td>
<td>0.999999(8)</td>
<td>0.99997(8)</td>
<td>1.00002(8)</td>
<td>0.99995(8)</td>
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<tr>
<td>MCF002 (ZPR6/7 &quot;high 240Pu&quot;)</td>
<td>0.9874(22)</td>
<td>0.98003(7)</td>
<td>0.97944(7)</td>
<td>0.97985(7)</td>
<td>0.97955(7)</td>
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<tr>
<td>PST18.2</td>
<td>1.0000(34)</td>
<td>1.01173(9)</td>
<td>1.01474(12)</td>
<td>1.01053(12)</td>
<td>1.01078(12)</td>
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<td>PST18.9</td>
<td>1.0000(34)</td>
<td>0.99815(10)</td>
<td>1.00223(10)</td>
<td>0.99836(10)</td>
<td>0.99830(10)</td>
</tr>
</tbody>
</table>

Performance comparable to B7.1