ENDF/B-VIII: What has changed so far?

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presented by M. Herman
So, what has changed and what hasn’t?

- CIELO evaluations
- TSL evaluations
- Many other ENDF evaluations
- V&V, QA
- New format

This is what gets us the amazing performance
So, what has changed and what hasn’t?

- CIELO evaluations
- TSL evaluations
- Many other ENDF evaluations
- V&V, QA
- New format

But many other applications need these
So, what has changed and what hasn’t?

- CIELO evaluations
- TSL evaluations
- Many other ENDF evaluations
- V&V, QA
- New format

This is how we insure good performance
So, what has changed and what hasn’t?

- CIELO evaluations
- TSL evaluations
- Many other ENDF evaluations
- V&V, QA
- New format

This is how we prepare for the future
CSEWG is a long standing collaboration between data users who, incidentally, are also the biggest content providers.
ENDF/B-VIII highlights

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

- **Neutron standards**
  - $^{1}\text{H}$
  - $^{6}\text{Li}$
  - $^{10}\text{B}$
  - $^{197}\text{Au}$

- **Structural materials:**
  - $^{12,13}\text{C}$
  - $^{40}\text{Ca}$
  - $^{54}\text{Fe}$, $^{57}\text{Fe}$, $^{58}\text{Fe}$
  - $^{58-61}\text{Ni}$
  - Yb, Dy, Os (JENDL4)
  - $^{63,65}\text{Cu}$
  - $^{182,183,184,186}\text{W}$
  - $^{174,176,178,179,180}\text{Hf}$
  - $^{132}\text{Te}$

- **Other non-CIELO:**
  - n
  - $^{7}\text{Be}$
  - $^{18}\text{O}$ (RUSFOND)
  - $^{35,37}\text{Cl}$
  - $^{59}\text{Co}$
  - $^{73,74}\text{As}$
  - $^{78}\text{Kr}$
  - $^{124}\text{Xe}$
  - RQ Wright’s nubars
  - $^{40}\text{Ar}$
  - $^{236m}\text{Np}$
  - $^{240}\text{Pu}$
  - EGAF gammas
  - Bug fixes
Bug fixes

- **Beta4**
  - 35,37Cl
  - 74As
  - 241Am

- **Beta5 (ENDF/A)**
  - 48Ti
  - 10Be
  - 180,181Ta
  - 185,187Re
Serious changes

- **Beta4**
  - 63,65Cu Covariances
  - 240Pu
  - Standards
  - CIELO

- **Beta5 ??**
  - Standards
  - CIELO
  - 53Cr?
240Pu

- **Resonances**
  - 2010 ORNL evaluation did not perform well, was rejected, but minor fix to bound level needed, V. Sobes made correction

- **Fast Region**
  - Fission cross section updated: Replaced by Tovesson 2009 data from 5.7keV to 40 keV (URR), Weston 40keV - 190keV.
  - Capture cross section taken from ENDF/B-VII.0 (=ENDF-B/VI.8), with an additional 2% reduction above 42 keV to improve
  - Elastic cross section taken from ENDF/B-VII.0 (=ENDF-B/VI.8). IAEA noted problem in URR, ave. capture restored to VI.1
Capture in URR
### Final thermal constants

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Atlas</th>
<th>ENDF/B-VIII.0</th>
<th>ENDF/B-VII.1</th>
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</thead>
<tbody>
<tr>
<td>$\sigma_\gamma$</td>
<td>289.5 ± 1.4 b</td>
<td>289.4 b</td>
<td>287.5 b</td>
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<tr>
<td>$\sigma_s$</td>
<td>1.73 ± 0.10 b</td>
<td>1.73 b</td>
<td>0.95 b</td>
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<tr>
<td>$\sigma_f$</td>
<td>0.056 ± 0.030 b</td>
<td>0.056 b</td>
<td>0.064 b</td>
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<td>$\sigma_B$</td>
<td>18.8 b</td>
<td>17.96 b</td>
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<td>Wescott’s $g$-factor</td>
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ENDF/B-VIII highlights, continued

- **Charged particles:**
  - p+d, p+\(^7\)Li, p+a, p+\(^{13}\)C, p+\(^{207}\)Pb
  - d+\(^7\)Li
  - t+a, t+\(^7\)Li
  - \(^3\)He+a, \(^3\)He+\(^3\)He
  - a+a

- **Decay data:**
  - \(^{93,95,96}\)Rb
  - \(^{95}\)Sr
  - \(^{82,83}\)Ge
  - \(^{95,98,98m,99}\)Y
  - \(^{88,89,90,91}\)Br
  - \(^{90}\)Kr
  - \(^{140,141}\)Cs
  - \(^{143}\)Ba
  - \(^{143,144,145}\)La
  - \(^{134}\)Sb
  - \(^{138}\)I

- **Thermal Scattering:**
  - Be(metal)
  - UO\(_2\) (x2)
  - Regular & reactor graphite
  - BeO (x2)
  - Polyethylene
  - SiO\(_2\) (x2)
  - SiC
  - Lucite
  - UN
  - Water: H\(_2\)O & D\(_2\)O (x2)
  - Water Ice Ih (x2)
  - YH\(_2\) (x2)

- **EPICS2014:**
  - photoat
  - electrons
  - atomic relax
Bug fixes

- **Beta4**
  - Be(metal)

- **Beta5 (ENDF/A)**
  - p+2H
  - D2O (D, O)
  - H2O (H)
Serious changes

- **Beta4**
  - Light charged particles
  - UN

- **Beta5 ??**
  - nothing planned
UN: New TSL evaluation from NCSU

- LEAPR from NJOY99.396
- 7 temps. (296K-120K)
- Inelastic uses Incoherent approx.
- Elastic uses generalized coherent approx. with modified LEAPR
# Light charged particle evaluations

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<th>Target:</th>
<th>p</th>
<th>d</th>
<th>t</th>
<th>h</th>
<th>α</th>
<th>$^6$Li</th>
<th>$^7$Li</th>
<th>Projectile:</th>
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- Keep ENDF/B-VII.0
- Recommend ECPL in future
- Here ECPL to ENDF/B-VIII.0
p+\(^7\)Li

P. Navratil merged ECPL cross sections with fits in literature;
D. Brown added outgoing distributions from ECPL using inverse kinematics when needed.
$d + ^7\text{Li}$

$^7\text{Li}(d,2n)^7\text{Be}$

$^7\text{Li}(d,n+\alpha)^4\text{He}$

$^7\text{Li}(d,p)^6\text{Li}$

$^7\text{Li}(d,t)^6\text{Li}$
$t + ^7\text{Li} \ & \ ^3\text{He} + ^3\text{He}$

Graphs showing the cross-sections and S-factors for reactions involving $^7\text{Li}$ and $^4\text{He}$.
Criticality Data Testing – Legacy LANL Assemblies

• Previous (e71) good bare assembly results are retained with e80β4 cross sections.

• Reflected assembly results are significantly improved.
Summary

- With E80β4 we have retained the good ENDF/B-VII.1 eigenvalue performance.
- The long-standing PST eigenvalue bias has been eliminated.
- Benchmarks with significant quantities of iron are calculated more accurately.
- Small trends in calculated eigenvalues over large energy intervals remain (HMF7, PMF suite).
- Reaction rate C/E values at high energy (e.g., n,2n reactions) remain poor.
ENDF/B-VIII planned for late FY17

6 year timeline
not to scale

Mini CSEWG Apr. 2016

WPEC May. 2016


ENDF Hackathon© 2016

CSEWG Nov. 2016

Mini-CSEWG 4-5 May 2017

WPEC 15-19 May 2017

beta5: covariance late spring 2017

beta6: release candidate summer 2017

ENDF/B-VIII.0 late summer 2017

ENDF/B-VII.0 contains 393 neutron evaluations;
1644 citations since 2006
(Google Scholar)

ENDF/B-VII.1 contains 423 neutron evaluations;
945 citations since 2011
(Google Scholar)
ENDF/B Quality Assurance

Pen-n-paper “Days of yore” (pre-2003)

Automated with ADVANCE (2011-present)

Where to find the link to ADVANCE

www.nndc.bnl.gov

Reactions tab

The link
ADVANCE quality assurance system for ENDF

- On every commit of every evaluation automatically:
  - Run it through a battery of tests, including customer codes
  - Generate comparison plots
  - Generate HTML report

- New in FY17:
  - Update Fudge-4.2.1 add PREPRO/GROUPIE
  - Aesthetic improvements (AJAX & MathJax)
  - Full library ACE file tarballs
  - Per-isotope error reports
  - Covariance and ACE overview
  - Rewrote INTER using FUDGE
To find out detailed lists of problems, go to ADVANCE, find your library’s release notes.

The link

ADVANCE