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

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presented by M. Herman

BROOKHAVEN NATIONAL LABORATORY
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U.S. DEPARTMENT OF ENERGY | Office of Science

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

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} But many other applications need these

So, what has changed and what hasn't?

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} 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
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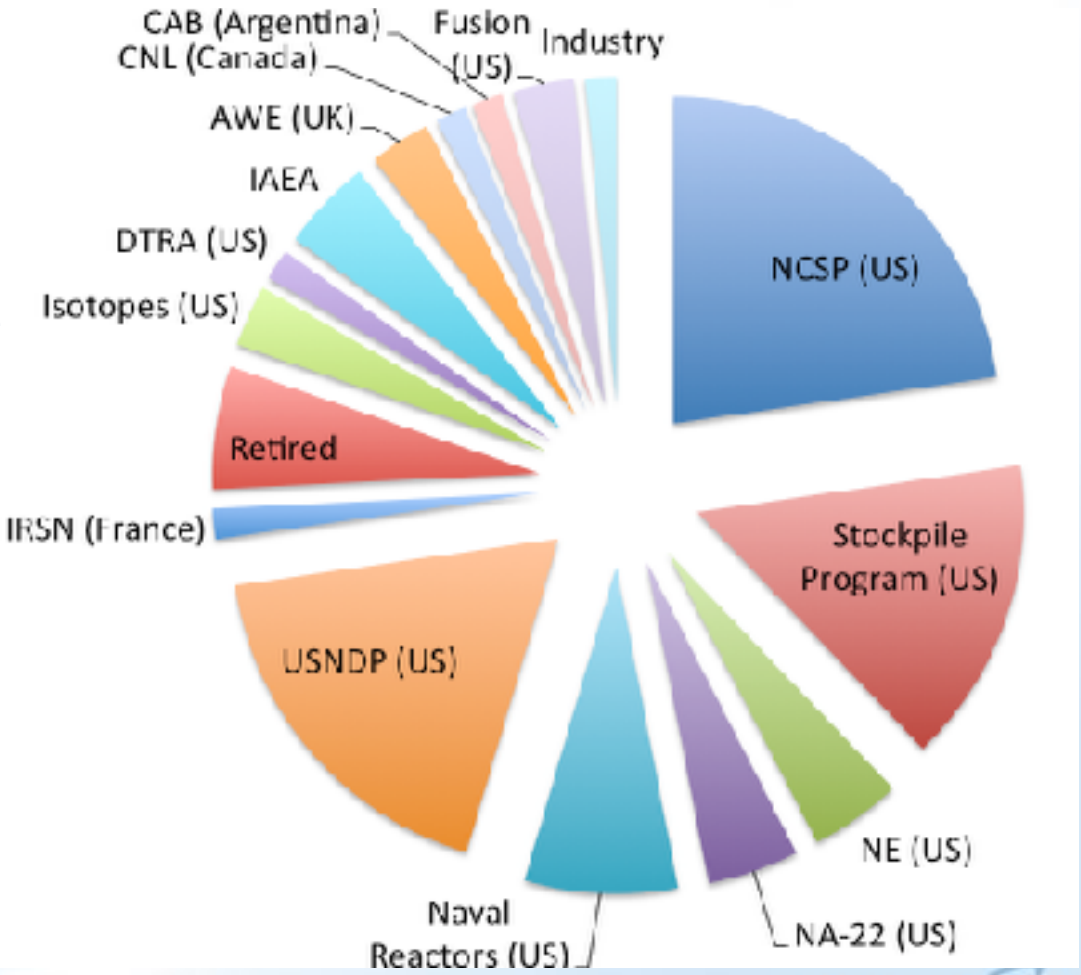
} This is how we prepare for the future

CSEWG is a long standing collaboration between data users who, incidentally, are also the biggest content providers

Fraction of evaluations provided for ENDF/B-VIII



ENDF/B-VIII highlights

- **CIELO:**
  - ^{16}O
  - ^{56}Fe
  - ^{235}U
  - ^{238}U
  - ^{239}Pu
- **Neutron standards**
  - ^{1}H
  - ^{6}Li
  - ^{10}B
  - ^{197}Au
- **Structural materials:**
  - $^{12,13}C$
  - ^{40}Ca
  - ^{54}Fe, ^{57}Fe, ^{58}Fe
  - $^{58\text{-}61}Ni$
  - Yb, Dy, Os (JENDL4)
  - $^{63,65}Cu$
  - $^{182,183,184,186}W$
  - $^{174,176,178,179,180}Hf$
  - ^{132}Te
- **Other non-CIELO:**
  - n
  - ^{7}Be
  - ^{18}O (RUSFOND)
  - $^{35,37}Cl$
  - ^{59}Co
  - $^{73,74}As$
  - ^{78}Kr
  - ^{124}Xe
  - RQ Wright's nubars
  - ^{40}Ar
  - $^{236m1}Np$
  - ^{240}Pu
  - EGAF gammas
  - Bug fixes

Bug fixes

- **Beta4**
  - 35,37Cl
  - 74As
  - 241Am
- **Beta5 (ENDF/A)**
  - 48Ti
  - 10Be
  - 180,181Ta
  - 185,187Re

Serious changes

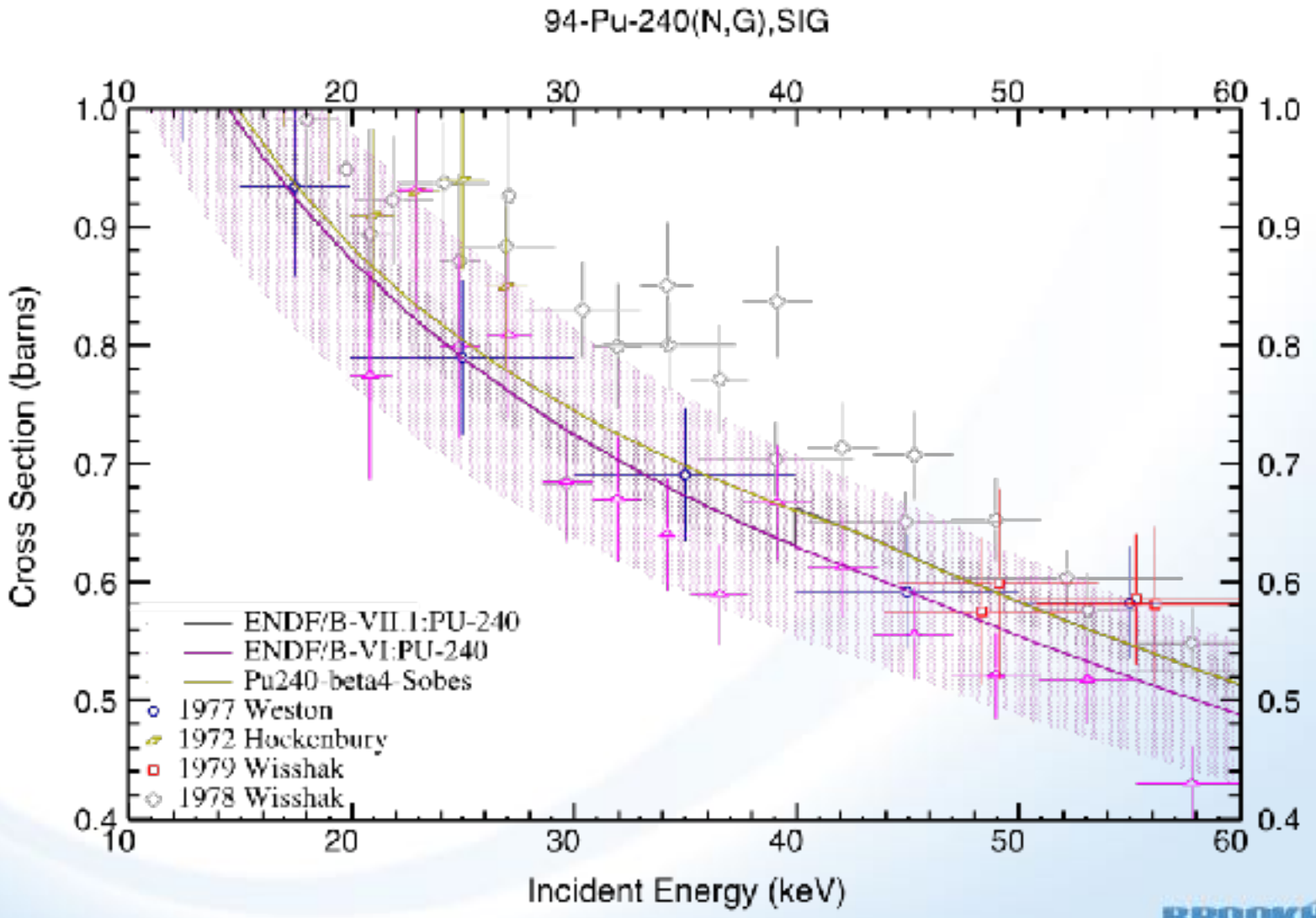
- **Beta4**
  - 63,65Cu Covariances
  - 240Pu
  - Standards
  - CIELO
- **Beta5 ??**
  - Standards
  - CIELO
  - 53Cr?

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

Quantity	Atlas	ENDF/B-VIII.0	ENDF/B-VII.1
σ_γ	289.5 ± 1.4 b	289.4 b	287.5 b
σ_s	1.73 ± 0.10 b	1.73 b	0.95 b
σ_f	0.056 ± 0.030 b	0.056 b	0.064 b
σ_B	18.8 b	17.96 b	3.02
Wescott's g-factor	1.0264	1.0259	1.0278

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
- **EPICS2014:**
  - photoat
  - electrons
  - atomic_relax
- **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_2O & D_2O (x2)*
  - Water Ice Ih (x2)
  - YH_2 (x2)

Bug fixes

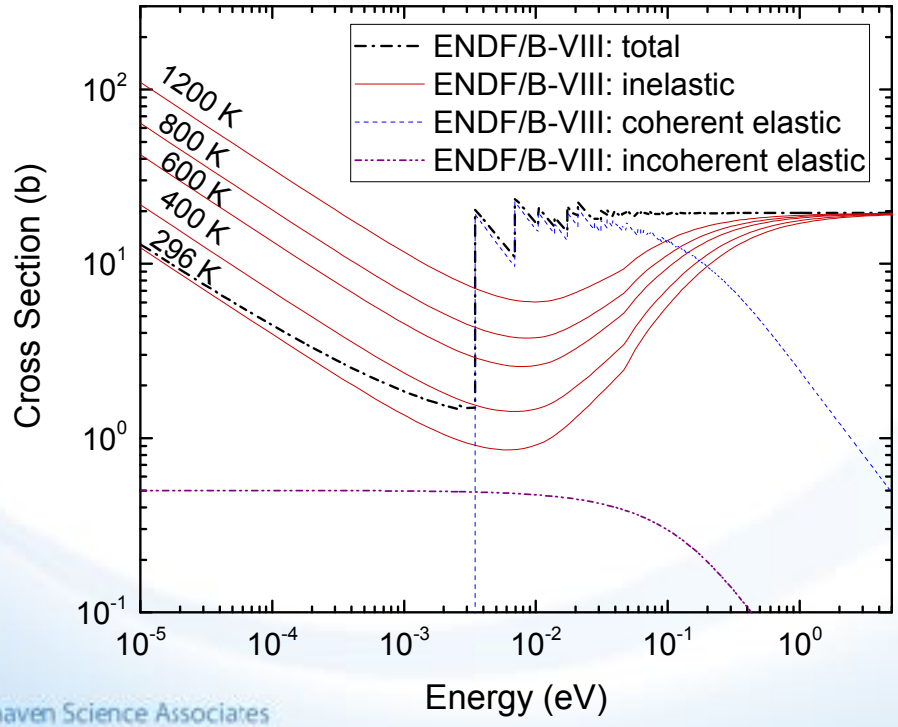
- **Beta4**
  - Be(metal)
- **Beta5 (ENDF/A)**
  - p+2H
  - D2O (D, O)
  - H2O (H)

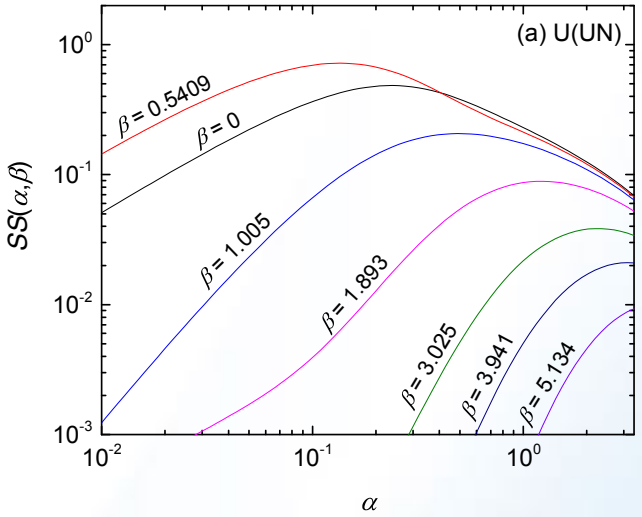
Serious changes

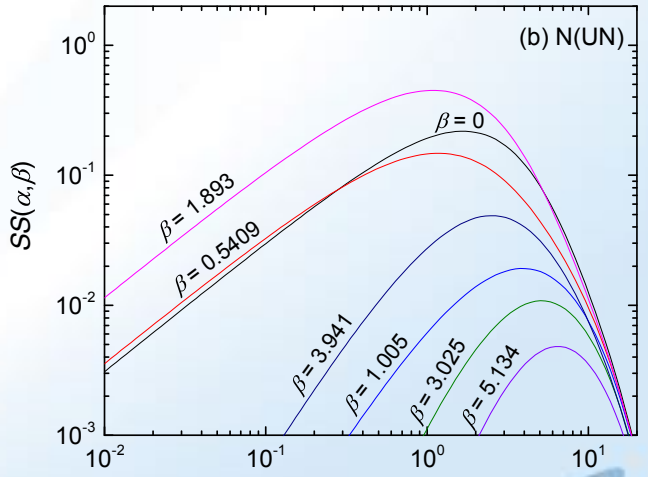
- **Beta4**
  - Light charged particles
  - UN
- **Beta5 ??**
  - nothing planned

UN: New TSL evaluation from NCSU

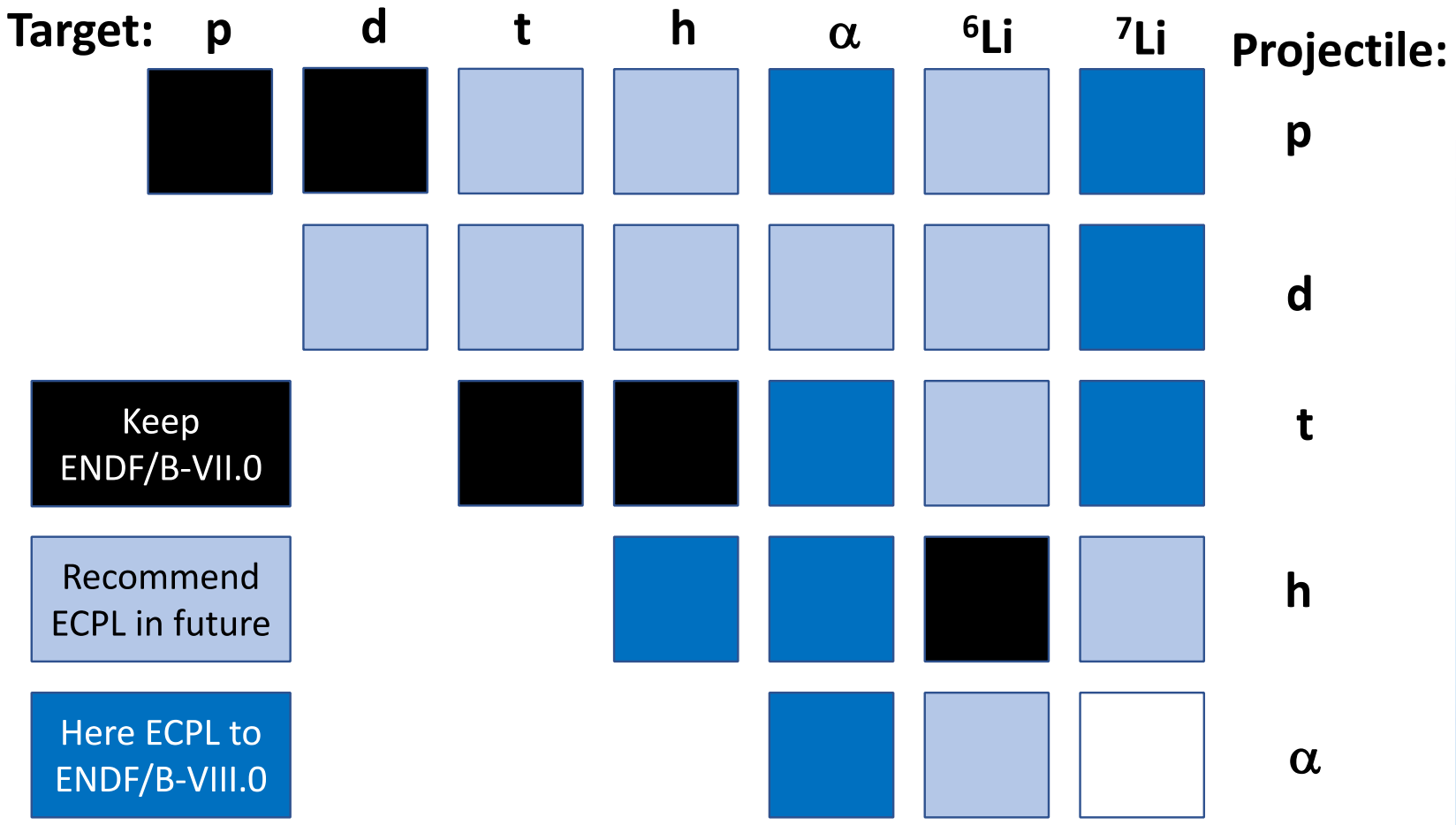
- LEAPR from NJOY99.396
- 7 temps. (296K-120K)
- Inelastic uses Incoherent approx.
- Elastic uses generalized coherent approx. with modified LEAPR



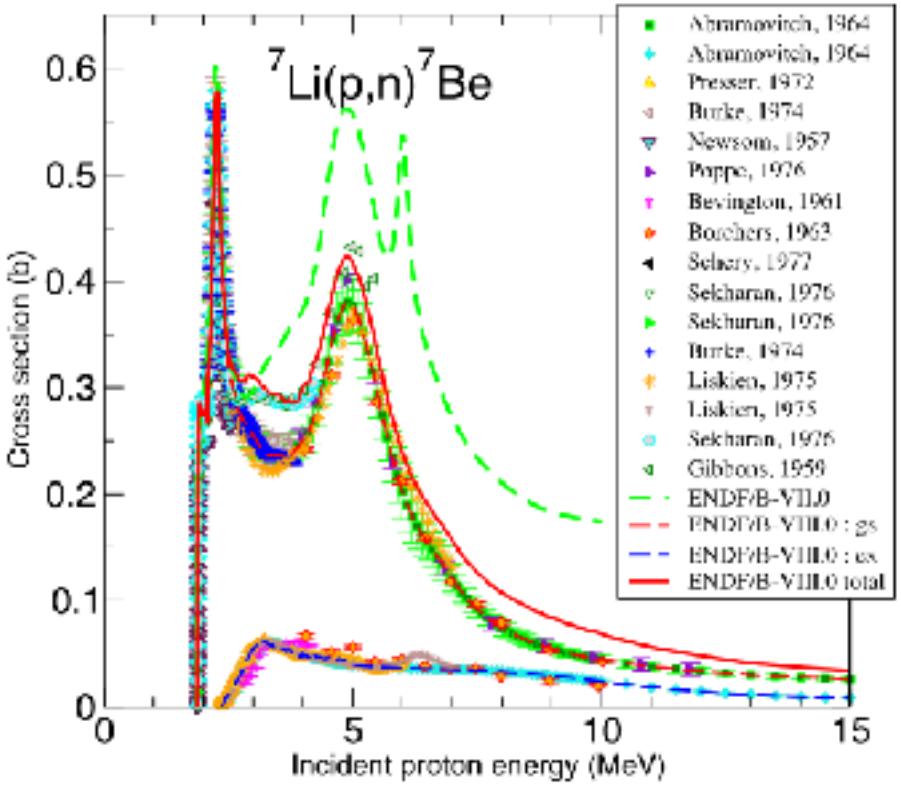


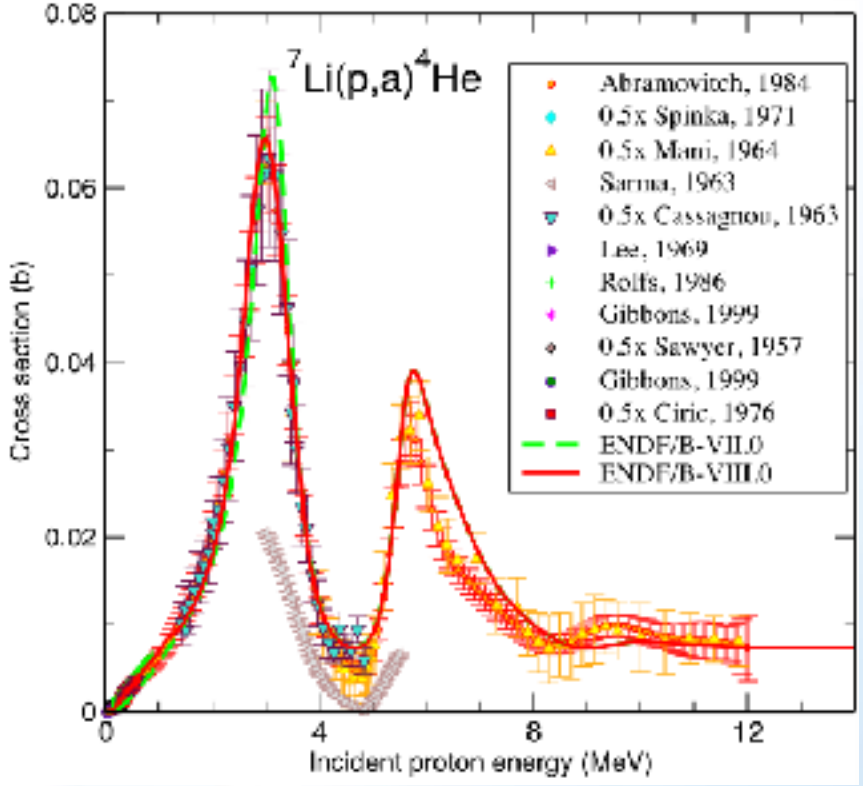


Light charged particle evaluations



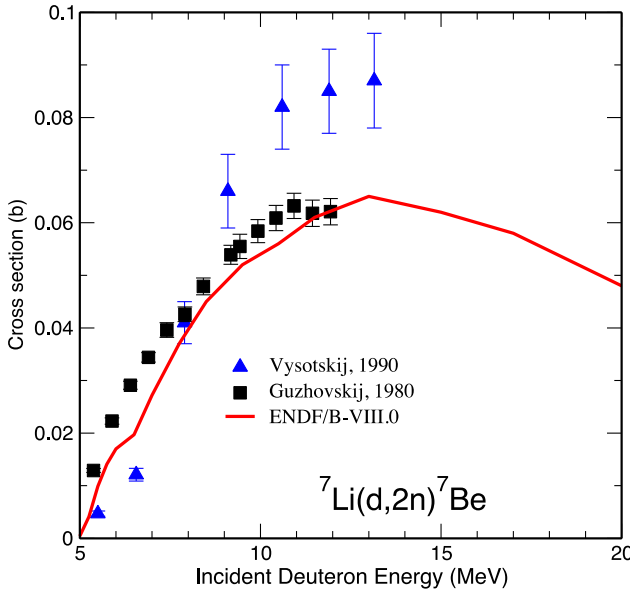
p+^{7}Li

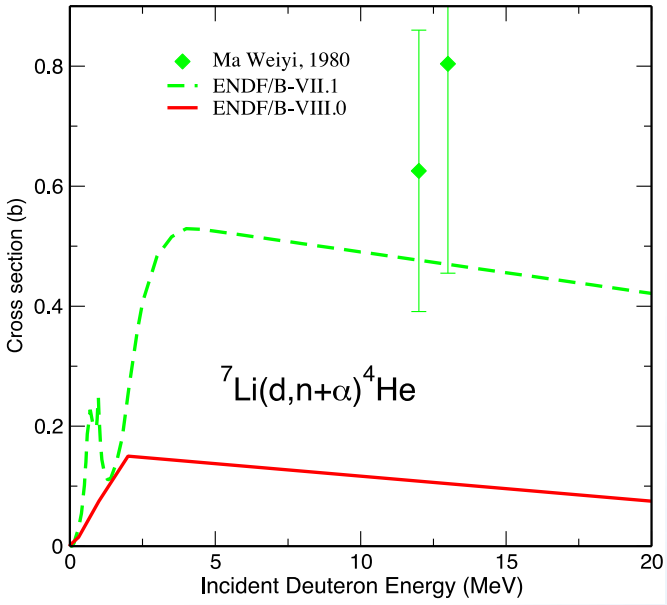


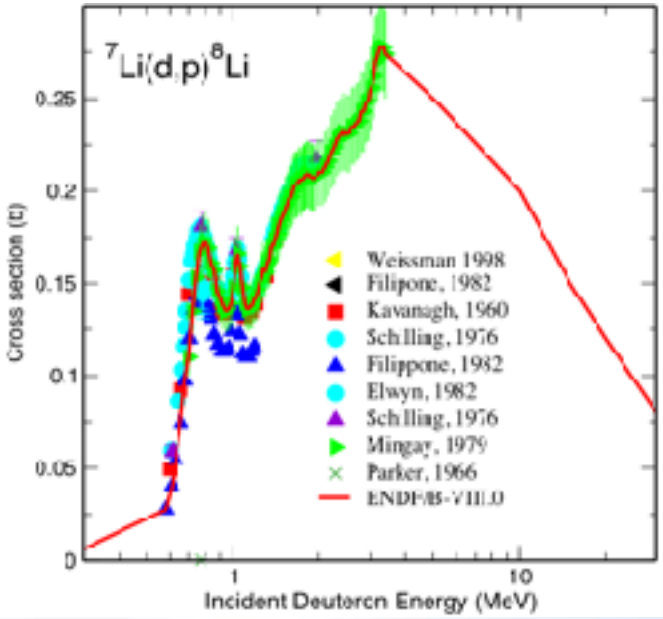


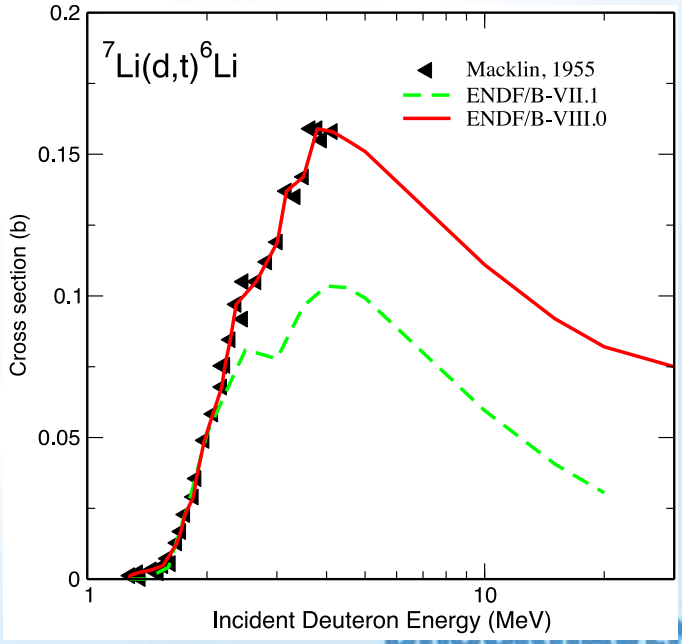
P. Navratil merged ECPL cross sections with fits in literature;
D. Brown added outgoing distributions from ECPL using inverse kinematics when needed

d+^{7}Li

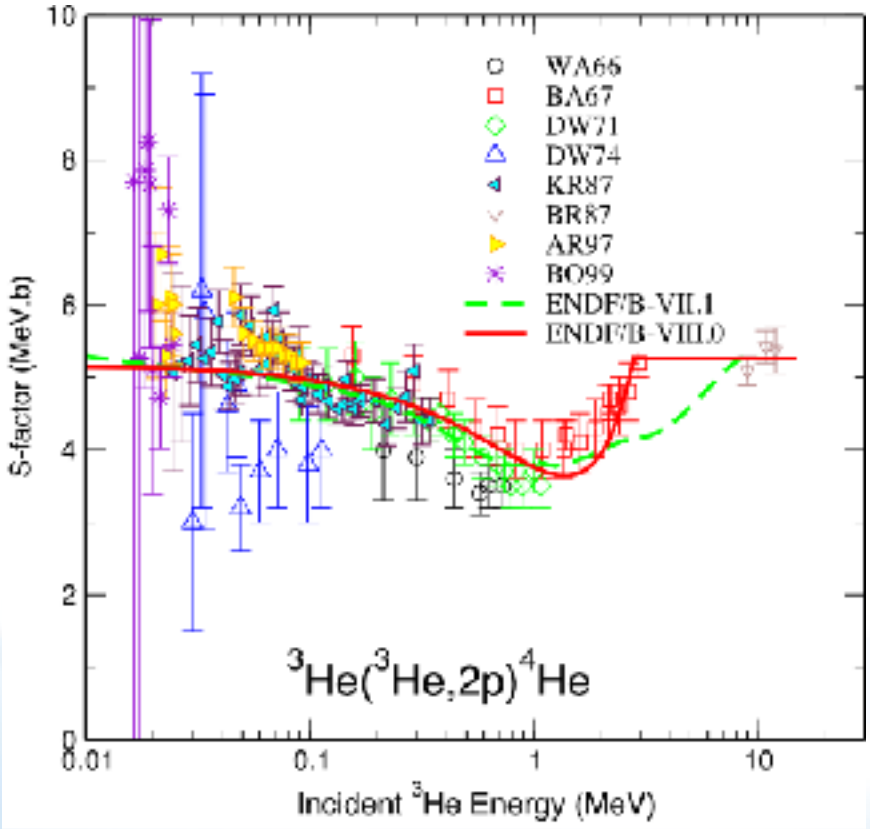

Cross section (b)
Incident Deuteron Energy (MeV)
Vysotskij, 1990
Guzhovskij, 1980
ENDF/B-VIII.0
^{7}Li(d,2n)^{7}Be

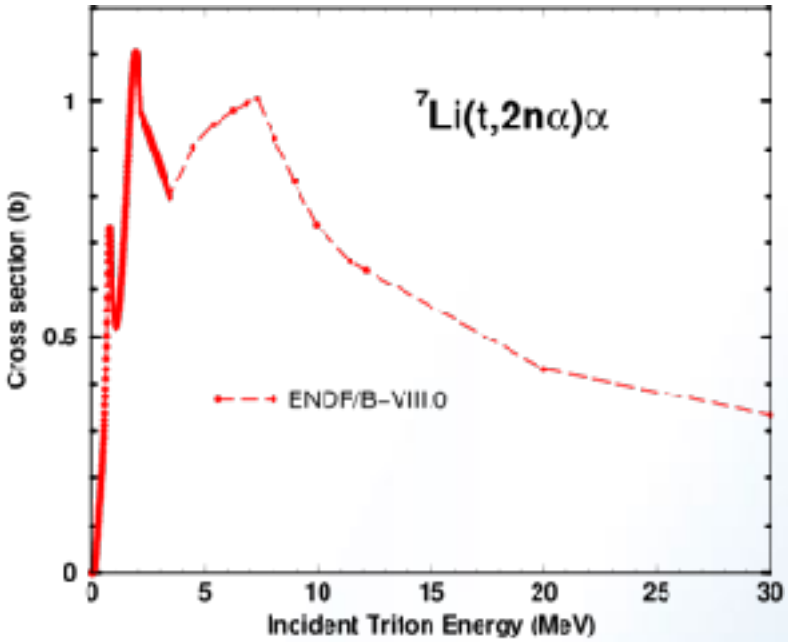

Cross section (b)
Incident Deuteron Energy (MeV)
Ma Weiyi, 1980
ENDF/B-VII.1
ENDF/B-VIII.0
^{7}Li(d,n+α)^{4}He

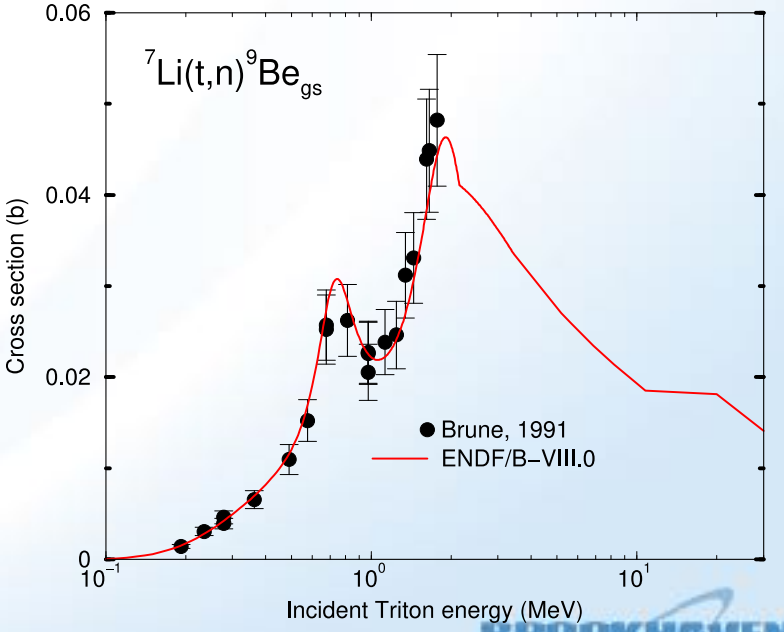

Cross section (b)
Incident Deuteron Energy (MeV)
^{7}Li(d,p)^{8}Li
Weissman 1998
Filipone, 1982
Kavanagh, 1960
Schilling, 1976
Filippone, 1982
Elwyn, 1982
Schilling, 1976
Mingay, 1979
Parker, 1966
ENDF/B-VIII.0


Cross section (b)
Incident Deuteron Energy (MeV)
^{7}Li(d,t)^{6}Li
Macklin, 1955
ENDF/B-VII.1
ENDF/B-VIII.0

t+^{7}Li & ^{3}He+^{3}He

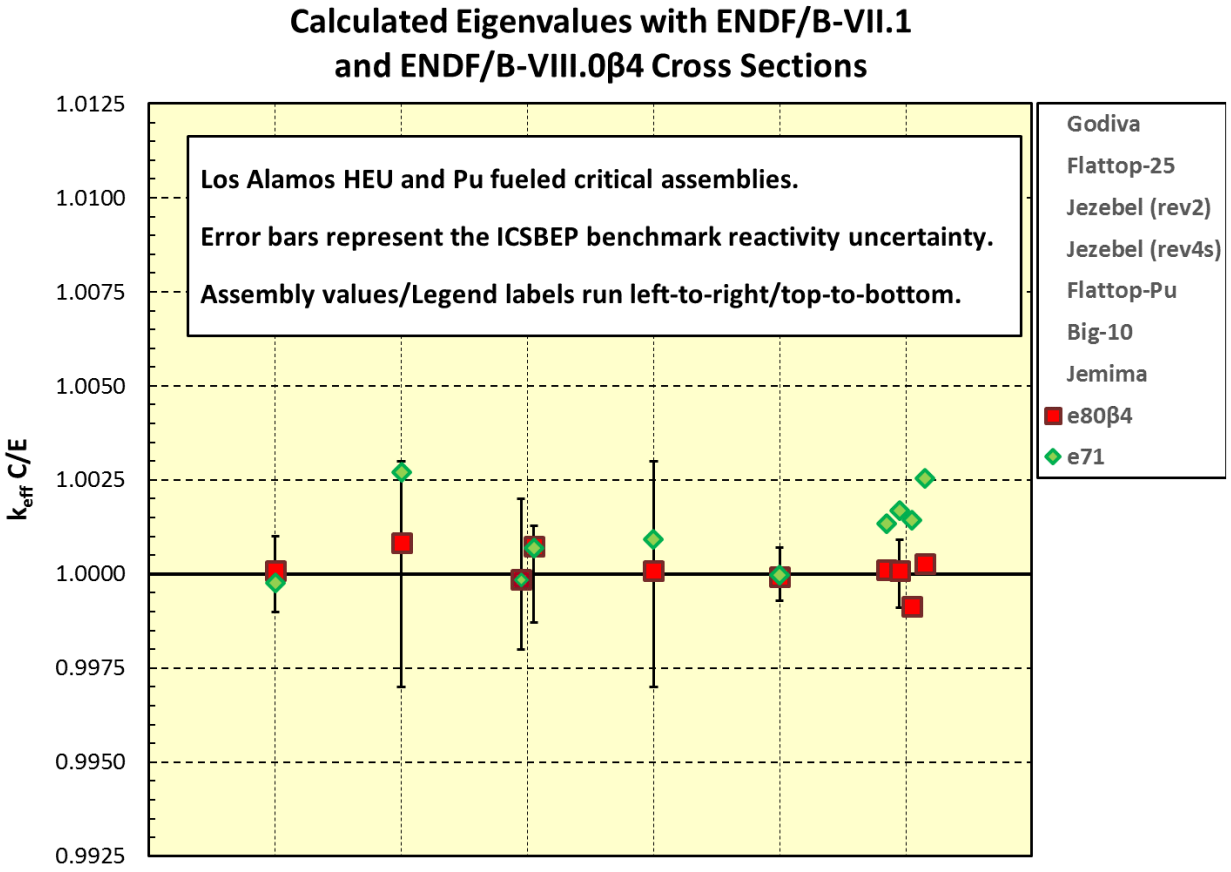






Criticality Data Testing – Legacy LANL Assemblies

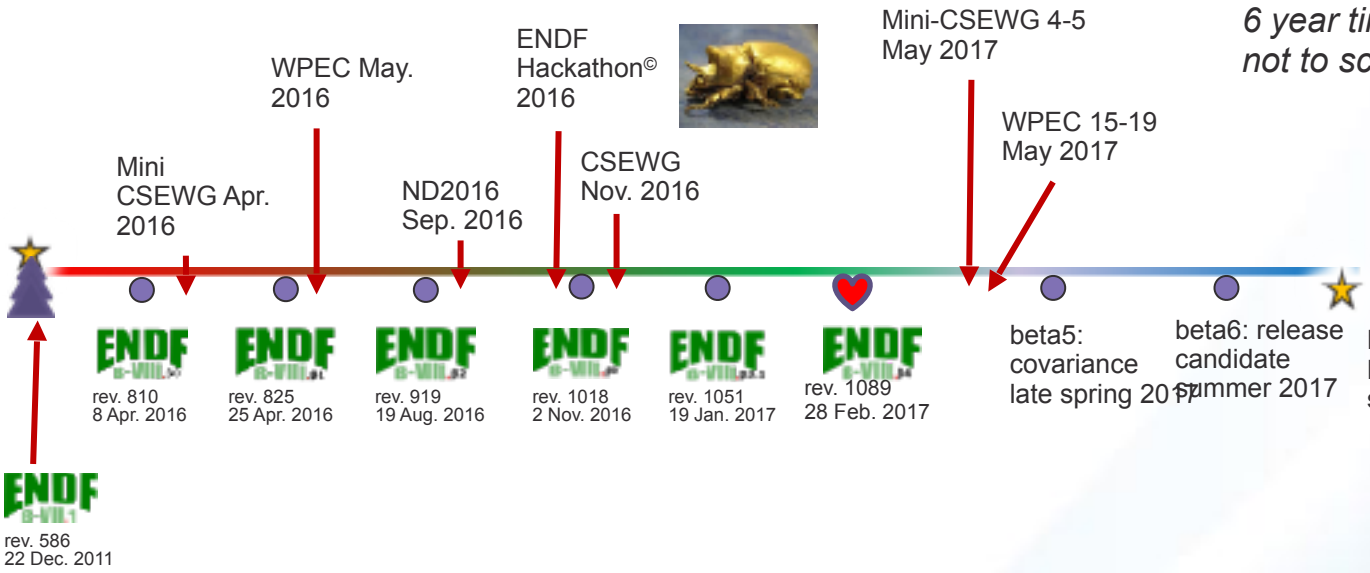
- **Previous (e71) good bare assembly results are retained with e80β4 cross sections.**
- **Reflected assembly results are significantly improved.**

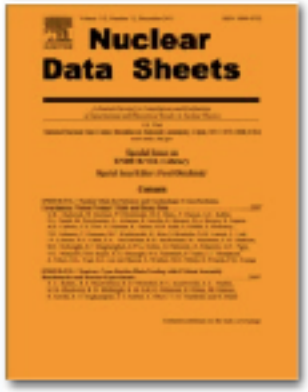


Summary

- **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

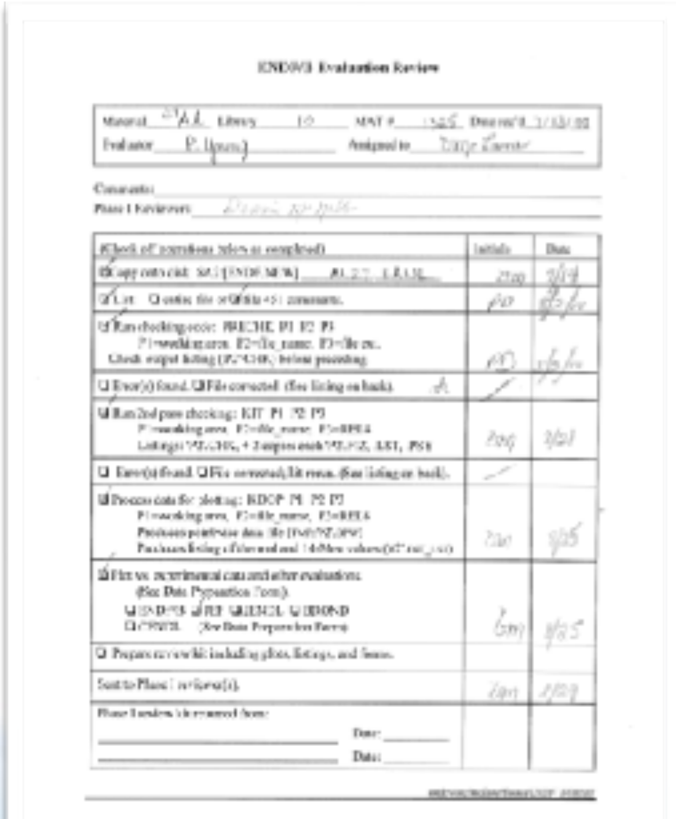




ENDF/B-VII.0 contains 393 neutron evaluations;
1644 citations since 2006 (Google Scholar)
ENDF/B-VII.1 contains 423 neutron evaluations;
945 citations since 2011 (Google Scholar)

ENDF/B Quality Assurance

Pen-n-paper "Days of yore" (pre-2003)



Sample PHASE I review packet cover page (June 2000)

Automated with ADVANCE (2011-present)

http://www.nndc.bnl.gov/endf/b7.dev/qa/index.html

Where to find the link to ADVANCE

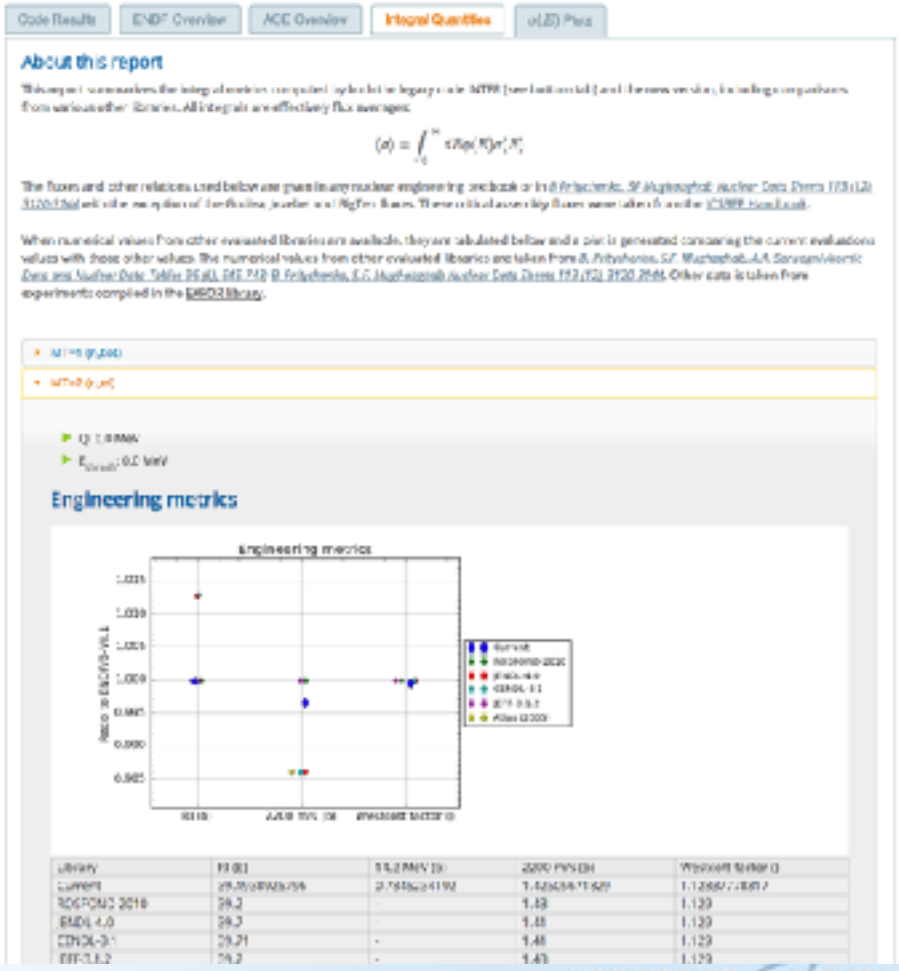
www.nndc.bnl.gov

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