β3 Comparison of Integral Data

B. Pritychenko

National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY 11973-5000, USA

BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

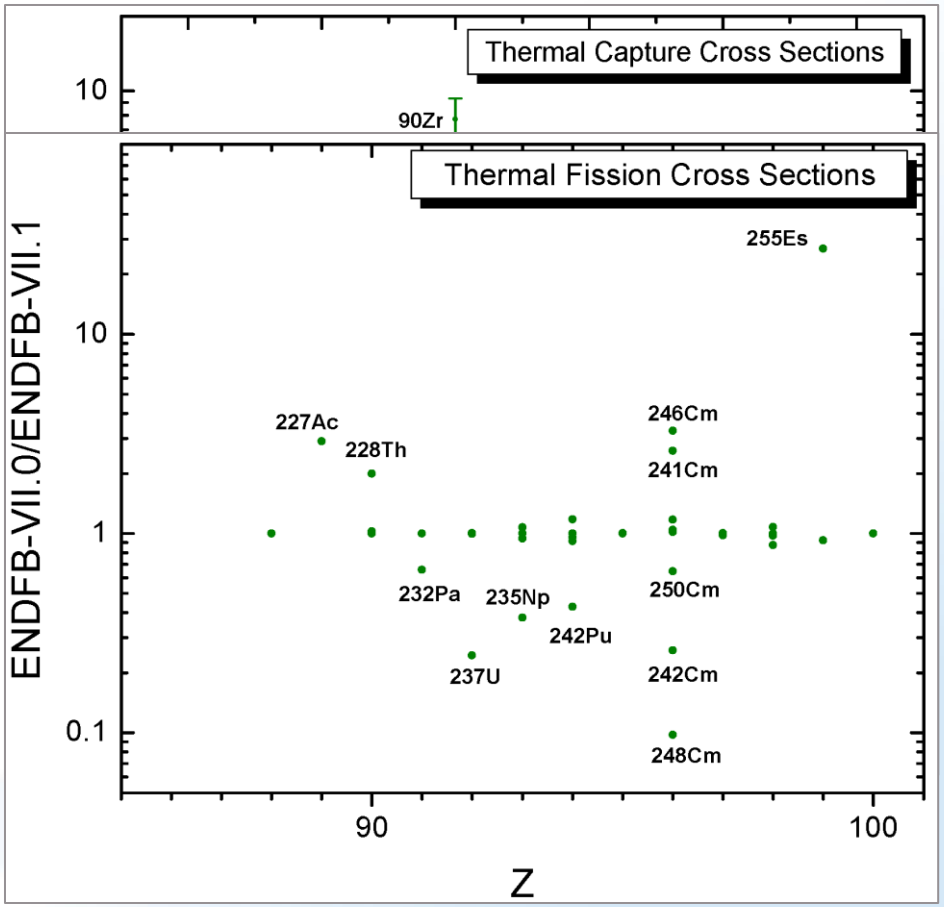
U.S. DEPARTMENT OF ENERGY | Office of Science

Introduction

- Previously presented integral tests often completely insensitive to deficiencies in materials with small isotopic abundances or “unimportant” for nuclear industry
- We need complementary testing approach
- Individual approach for ENDF/B-VII. 1 β3:
  - 418 ENDF/B-VII.1 materials
  - Four integral quantities: RI, Thermal and Maxwellian cross sections, Westcott factors
  - Comparisons with Atlas of Neutron Resonances, KaDONiS, …

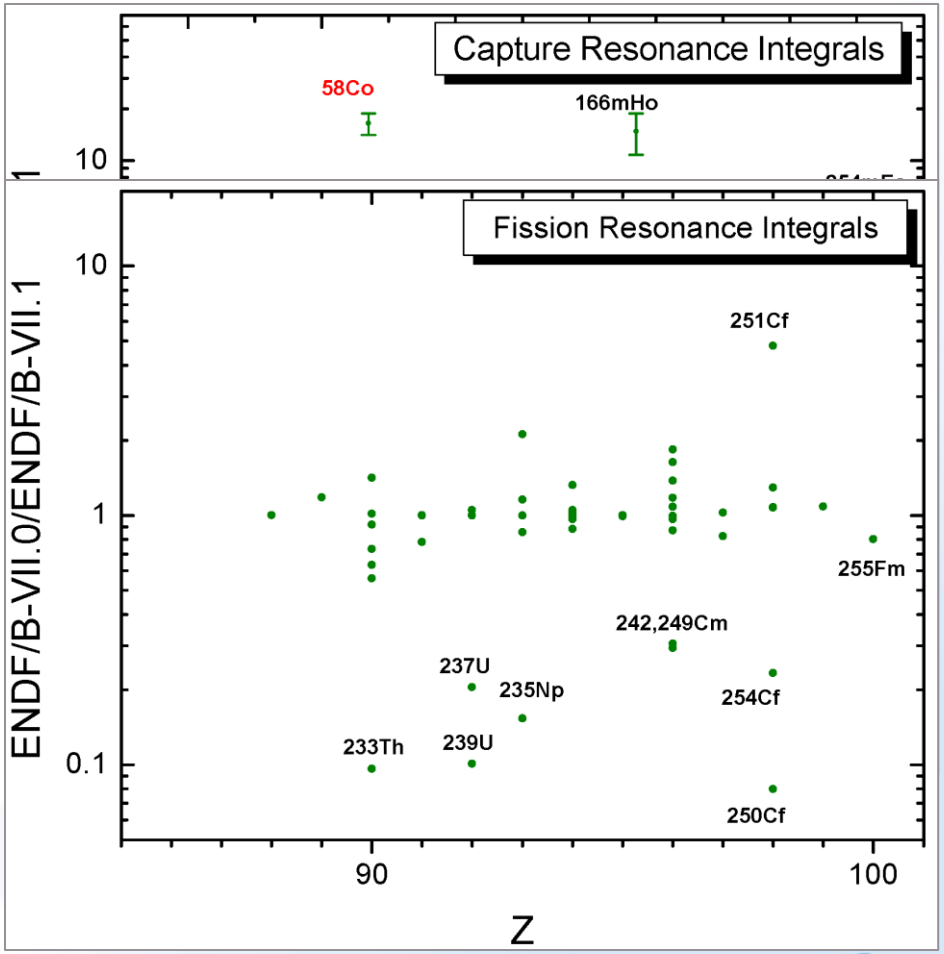
Thermal Cross Sections

- ENDF/B-VII.1 β3 MT=102,18
- Several data outliers in this case could be traced to the lack of measurements and incomplete overlap of experimental and theoretical data for 17O,103Ru,166mHo and 46Ca, 58Co,135Cs, 204Hg, respectively



Resonance Integrals

- ENDF/B-VII.1 β3 MT=102,18
- 16O,58Co are fixed in β4
- Resonance integrals for neutron capture and fission were calculated for 0.5 eV - 20 MeV incident neutron energy range
- Fission or Actinide region differences are due to adoption of Actinoid file from JENDL-4



Maxwellian-averaged Cross Sections

- ENDF/B-VII.1 β3 MT=102
- Use KADONIS to find deficiencies
- Theoretical values were adopted for 38Ar, 82Se, 115mCd, 141Ce, 143Pr and148m,149Pm.
- Improvements for: 3He, 9Be,C-0, 16O, 58Co, …, Nd region
- "*Long, Cold, Early r Process? …*", Phys. Rev. Lett. 106, 201104 (2011)

KADONIS/ENDFB-VII.1

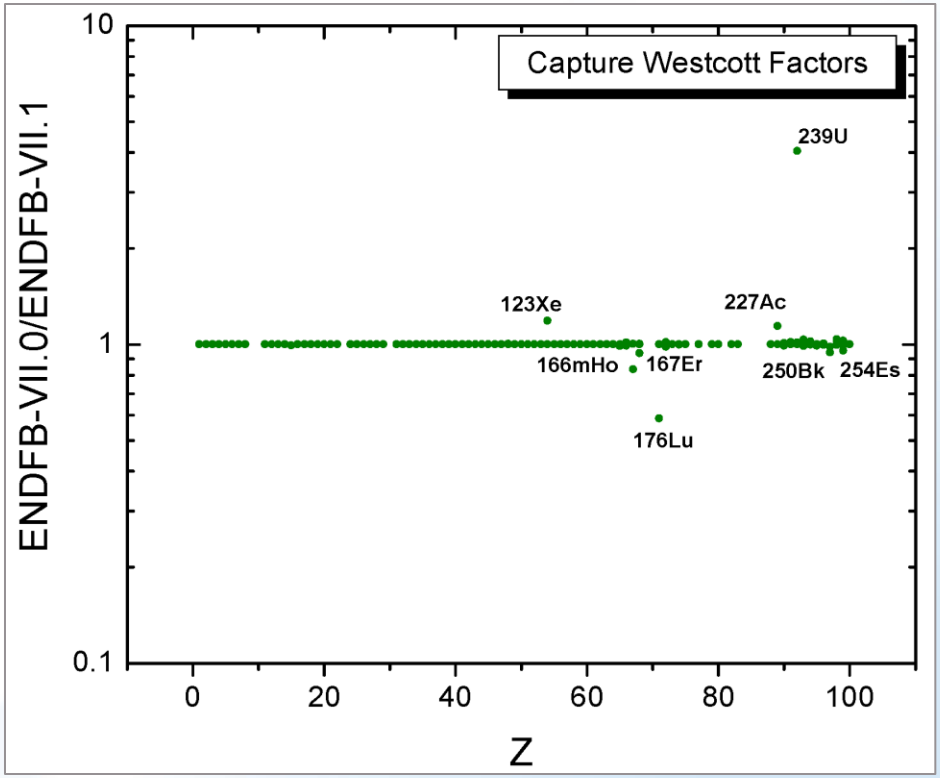
PRL 106, 201104 (2011) PHYSICAL REV

studies should use a complete network for both neutron-capture and ν interactions.

The effects of shock passage through the He shell have not been included, though we argued that r nuclei will survive the associated heating. Other consequences may be beneficial, extending the range for interesting nucleosynthesis. The density of shocked material jumps to ~7 times the preshock value and then decreases slowly on time scales $\sim\tau_{sh}$. So while larger explosion energies, $E_{50} \sim 12$, might appear to limit the duration of the r process to $\tau_{sh} \sim 7$ s, in fact there may be a postshock phase where densities higher than those of Fig. 2 aid the nucleosynthesis. Another potentially beneficial effect of the shock may come from neutrons released by $^{13}C(^{4}He, n)^{16}O$ and $^{17}O(^{4}He, n)^{20}Ne$: ^{12}C and ^{16}O are the principal neutron sinks in the inner He shell. If shock heating to $\gtrsim 5 \times 10^{8}$ K could liberate these neutrons without increasing the abundance of seeds, one might exploit both the more favorable $1/r^2$ of the inner He zone and NC ν channels in neutron production (which in the outer He zone lead to ^{7}Li). One source of uncertainty comes from the ^{12}C and ^{16}O (n, γ) cross sections, which differ by factors of ~3 and 45 (10 and 160) at $T_8 \sim 0.85$ (3) between the Evaluated Nuclear Data File and the Japanese Evaluated Nuclear Data Library [17]. The differences reflect the energy range over which s-wave capture is assumed to dominate. Pending resolution of this discrepancy, parametric studies will be needed [16].

Westcott Factors

- ENDF/B-VII.1 β3 MT=102
- In ENDF/B-VII.1 library Westcott factors evolved from 3.997 to 0.989 and from 1.002 to 1.711 for 239U and 176Lu, respectively. 176Lu agrees with the recommended value of 1.75.
- Small deviations in 123Xe are due to adoption of new evaluation and lack of experimental data



Conclusion & Outlook

- Thermal CS, RI, Westcott Factors, MACS have been calculated for ENDF/B-VII.1 β3 library
- Several deficiencies have been identified and fixes requested
- Current results will be extensively analyzed, compared with all available benchmarks to understand the origin of deficiencies
- Extensive exchange of ideas between ENDF and nuclear astrophysics communities
- Many thanks to M.W. Herman, M.B. Chadwick, S.F. Mughabghab for help and support