

ENDF/B-VII Energy Balance

R. E. MacFarlane

Presented to the Cross Section Evaluation Working Group

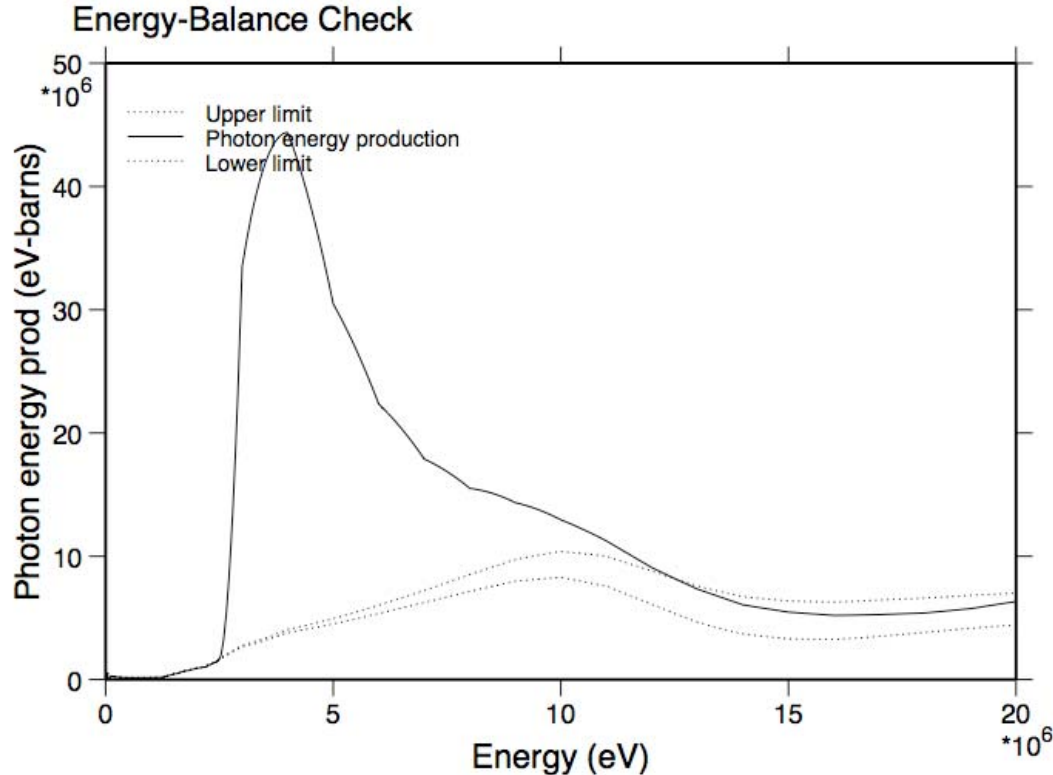
Nov. 6 – 8, 2007

Brookhaven National Laboratory

Energy Balance Testing

- Nuclear heating comes from the charged particles produced by a nuclear reaction, including the recoil nucleus.
- The charged product energy is equal to the energy available from $E+Q$ minus the energy carried away by neutrons and photons.
- If the neutron or photon energy production is off, you can get bad results for the heating, such as negative values.
- The NJOY HEATR module includes a capability to calculate reasonable bounds for the heating and photon production, and to graphically compare the values computed from the evaluation with these bounds.

Example of Photon Energy Check for ENDF/B-VII.0 ^{47}Ti



- The solid curve should lie between the dashed curves.
- The problem is unreasonable photon production yields in MF12/MT91 (values in the hundreds).
- This overestimate of photon production results in extremely negative heating values between 2.5 MeV and 12 MeV.

The Energy Balance Web Page for ENDF/B-VII.0

- Go to <http://t2.lanl.gov/data/ebalVII/summary.html>.
- There is a list of all the non-fissionable isotopes from ENDF/B-VII with a link to the testing plots and short comments about the quality of the energy balance for that evaluation.
- Materials with no gamma production are also included for completeness and to give a hint of what the results for heating would be if the evaluation were upgraded to include photon production.

Priorities for Improvements

- Improve materials that rate “poor” on the list, emphasizing metals that might occur in realistic systems. Heating and photon production problems are less important for things like fission products.
- Energy balance is difficult to achieve for the heavier materials, so occasional negative heating values can be accepted there. Photons tend to stay close to their point of origin, canceling out much of the problem.

Some Examples of Evaluations with Energy Balance Problems

- ^{11}B above 11 MeV.
- ^{23}Na above 10 MeV.
- ^{31}P between 2 MeV and 20 MeV.
- ^{36}S above 5 MeV.
- ^{46}Ti above 3 MeV, ^{47}Ti from 3 to 12 MeV, ^{50}Ti from 1 MeV to 15 MeV.
- natV from 10 MeV to 17 MeV.
- $^{91,92,94,96}\text{Zr}$ above 3 MeV.

More Examples

- $^{92,94,96,97,98}\text{Mo}$ above 500 keV.
- $^{153,154,155,157}\text{Gd}$ above 10 MeV.
- $^{162-170}\text{Er}$ above 1.5 MeV.
- ^{181}Ta above 10 keV.
- ^{184}W from 1 MeV to 20 MeV.
- ^{208}Pb between 3 MeV and 10 MeV.