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Title: Improved Photon-Production Data for Thermal Neutron Capture in ENDF

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Improved Photon-Production Data for Thermal-Neutron Capture in ENDF

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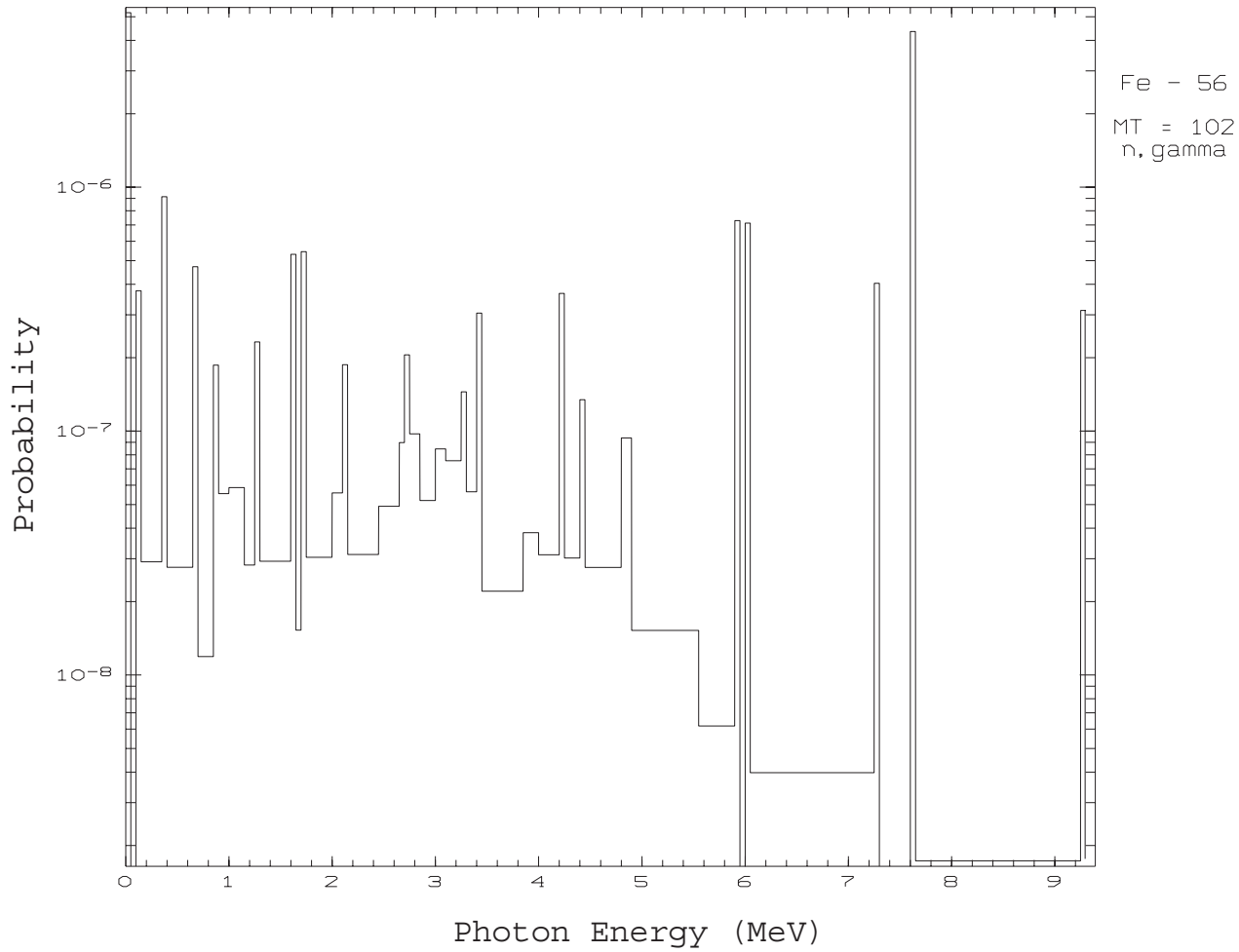
Representation of Photon Production in ENDF

- Continuous photon energy spectrum in File 15, with a total yield specified in File 12
  - » Usually 10-500 keV wide energy bins (example Fe in Figure 1)
- Discrete energy gamma-rays in File 12 - both gamma-ray energy and yield specified.
- Combination of File 12 and File 15

Figure 1: Thermal-Capture Spectrum for the Fe Isotopes

Note that there are no discrete gamma rays. The ^{56}Fe doublet at 7.6312 and 7.6456 MeV is contained in one energy bin from 7.60 to 7.65 MeV.

The same spectrum is used for each isotope of Fe.



Photon-Production Data in ENDF for Radiative Capture

- Elemental data used in isotopic evaluations
  - » examples include Cr, Fe, Ni, Cu
- Often based on outdated experimental data or compilations
  - » examples include Al, Cl, K

Improved Photon-Production Data for Thermal-Neutron Capture

- Based on Reedy and Frankle work - see neighboring poster
- Isotopic
- Normalized observed energy to the Q-value if within 10%
  - » Exceptions to date are ^{43}Ca, ^{47,49}Ti, ^{61}Ni, and ^{182,182,184,186}W

Incorporating Improved Data into ENDF

- Minimize impact on original evaluation
  - » We used the most recent ENDF evaluation.
  - » We used the same incident neutron energy range for the thermal spectrum as in the original evaluation.
  - » We specified a neutron energy-dependent yield when thermal spectrum used for all incident neutron energies to conserve energy.
  - » We updated Q-value for (n,γ) reaction.

Improving Elemental ENDF Evaluations

- Elemental evaluations to date: Mg and K.
- Incorporating only the most important gamma rays in File 12 - there is a limit on number of discrete photons in MCNP
  - » most intense gamma-ray (I) through I/100 (top 2 orders of magnitude in intensity)
- Using remaining gamma rays for File 15 background spectrum (usually 100 keV bins)
- We may use same technique for isotopes with > 500 discrete gamma-rays in the future.

Modified ENDF Evaluations

- We have completed modifications to the ENDF evaluations for
  - » ^{9}Be, ^{14}N, ^{19}F, Na, Mg, ^{27}Al, K, ^{45}Sc, ^{55}Mn, ^{50,52,53,54}Cr, ^{54,56,57,58}Fe, ^{58,60,61,62,64}Ni, ^{63,65}Cu
- We have performed new evaluations for ^{35,37}Cl, replacing the previous ENDF evaluation for natural Cl.

New ENDF Evaluations for $^{35,37}Cl$

- Based on JENDL3.2 for resonance region
- Incorporates improved photon-production data
- Data above resonance region based on a new evaluation for all reactions using GNASH

Improvements to Cl Photon-Production Data

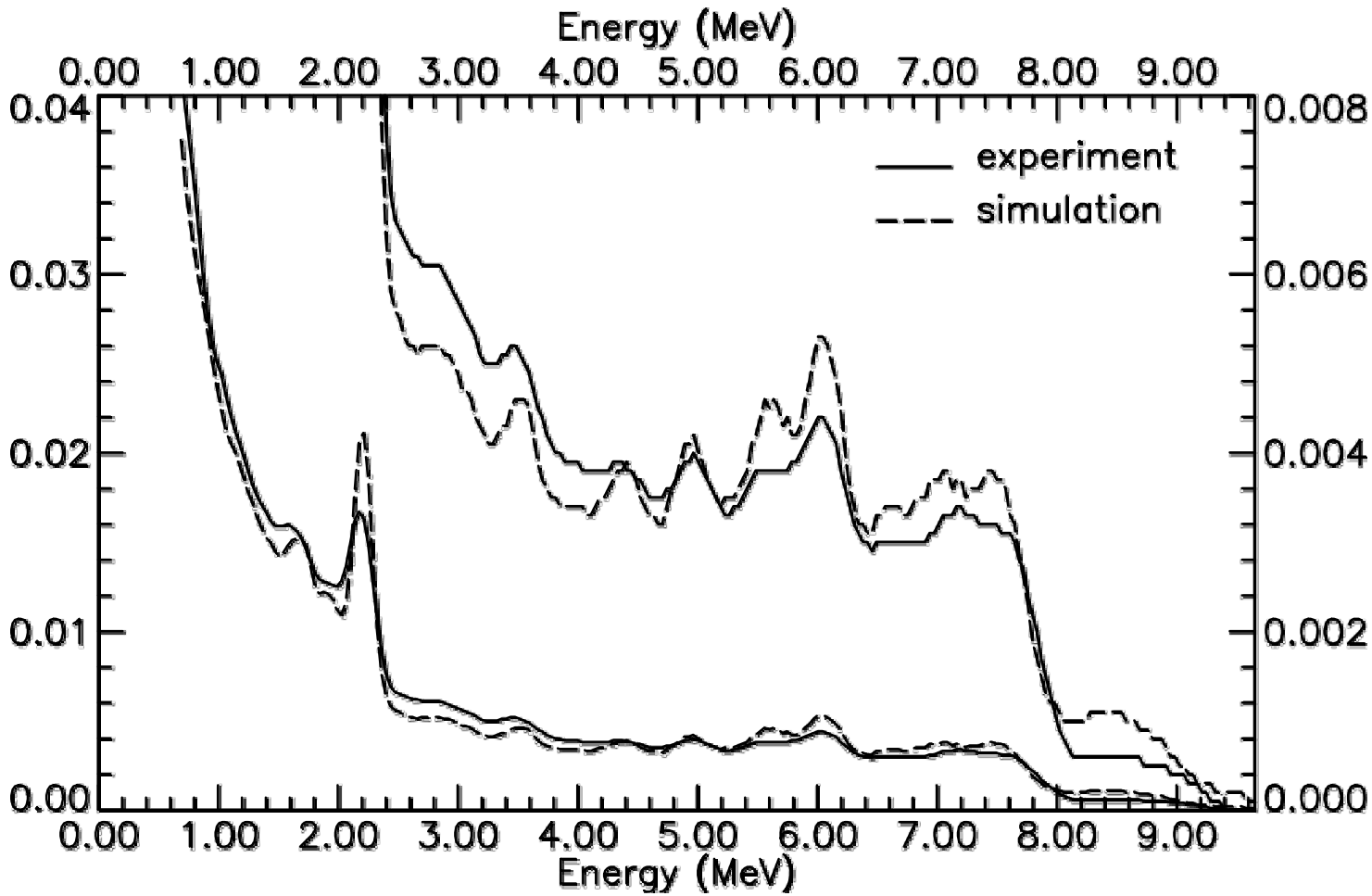
- Original ENDF
  - » Elemental, 1967
  - » 31 discrete gamma-rays in File 12
  - » Account for 73% of Q-value
  - » Thermal spectrum used up to E_n=20 MeV
- Improved ENDF
  - » Isotopic
  - » 482 gamma-rays
    - 403 for ^{35}Cl
    - 79 for ^{37}Cl
  - » Account for 99.6% of Q-value before normalization
  - » Thermal spectrum used up to E_n=0.1 MeV

Comparison of Natural Cl Data

Orphan (1970)	Lone (1981)	Original ENDF	Improved ENDF
0.5183; 14.29	0.5167; 18.50	0.5200; 24.53	0.5171; 24.47
0.7886; 13.46	0.7884; 15.00	0.0790; 20.17	0.7863; 10.59
			0.7884; 16.43
1.1654; 14.16	1.1647; 19.93	1.1640; 11.29	1.1649; 27.39
		1.6490; 14.72	1.6483; 0.528
1.9513; 27.77	1.9509; 21.72	1.9570; 12.52	1.9511; 19.52
1.9845; 19.66	1.9591; 14.62		1.9594; 12.65
6.1111; 20.50	6.1109; 20.00	6.1080; 25.03	6.1108; 20.72
6.6201; 12.99	6.6195; 8.01	6.6200; 12.95	6.6196; 7.88
	6.6276; 4.54		6.6278; 4.72
7.4138; 11.07	7.4138; 10.42	7.4130; 7.77	7.4140; 10.59
7.7900; 8.61	7.7902; 8.55		7.7903; 8.37
8.5787; 2.99	8.5784; 2.91	8.5770; 2.59	8.5786; 2.76

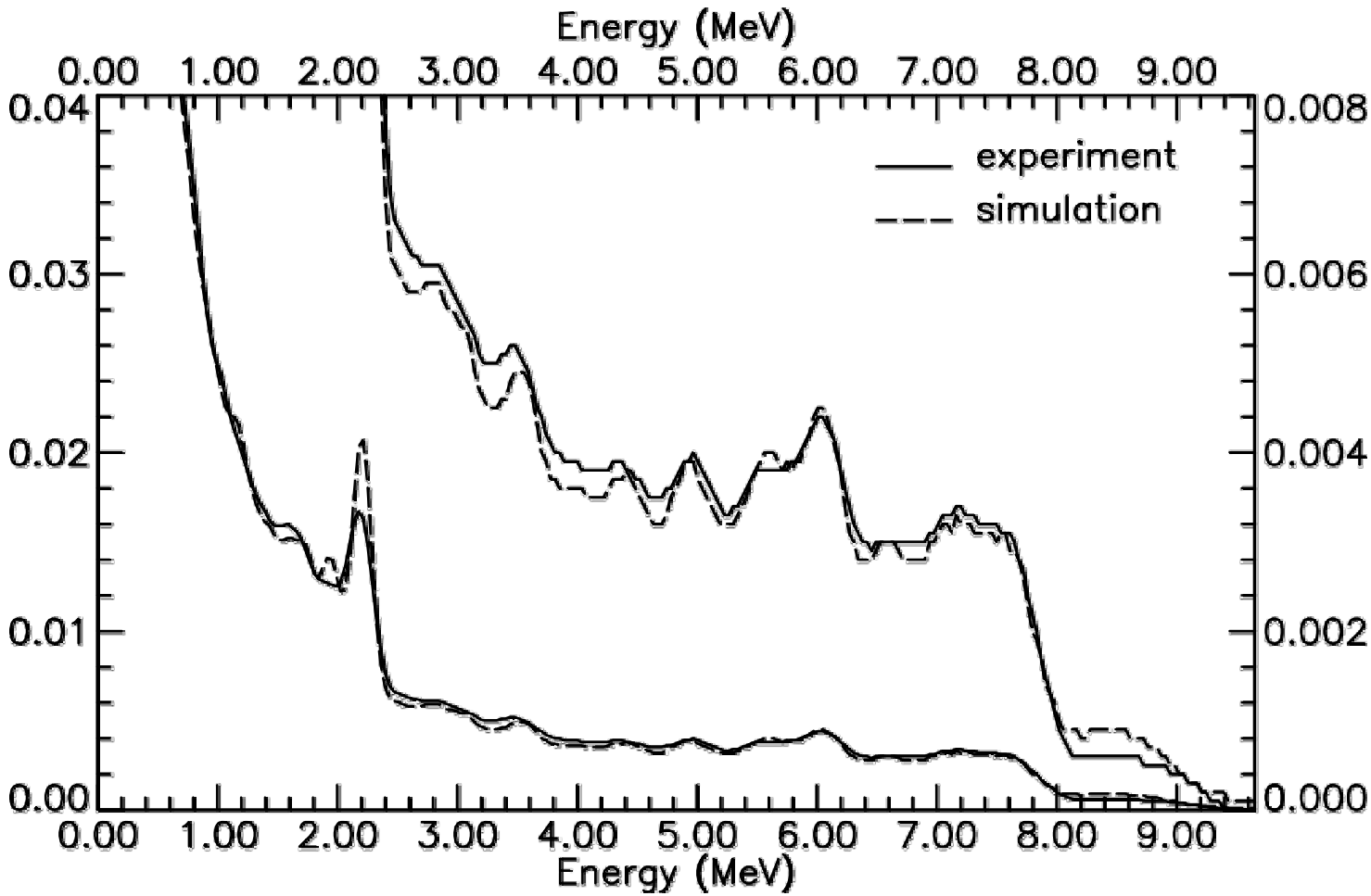
Gamma-ray Energy (MeV); Intensity (#/100 captures)

Capture Spectrum for 35pu Saltwater - Saturated (140Kppm) Sandstone Using ENDF/B-V Cl data in MCNP



The same data are shown on two vertical scales.

Capture Spectrum for 35pu Saltwater - Saturated (140Kppm) Sandstone Using Improved Cl data in MCNP



The same data are shown on two vertical scales.

WWW Site for Improved Thermal-Capture Data

- We will continue to incorporate improved data into the ENDF evaluations.
- A report is being written on the work that has been done for improving the photon-production data.
- As the improved photon-production data becomes available, we are providing the spectrum at the following WWW address:

http://www-xdiv.lanl.gov/XCI/PROJECTS/DATA/nuclear/photon/thermal.html