Evaluated neutron data libraries for GEANT4

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- The following ENDF-6 format libraries have been translated into the GEANT4 format:
  - ENDF-VII.0 (USA) – 385 isotopes
  - ENDF-VI.8 (USA) – 317 isotopes
  - JEFF-3.0 (EU) – 373 isotopes
  - JEFF-3.1 (EU) – 334 isotopes
  - JENDL-4.0 (Japan) – 400 isotopes
  - JENDL-3.3 (Japan) – 332 isotopes
  - BROND-2.2 (Russia) – 120 isotopes
  - CENDL-3.1 (China) – 239 isotopes

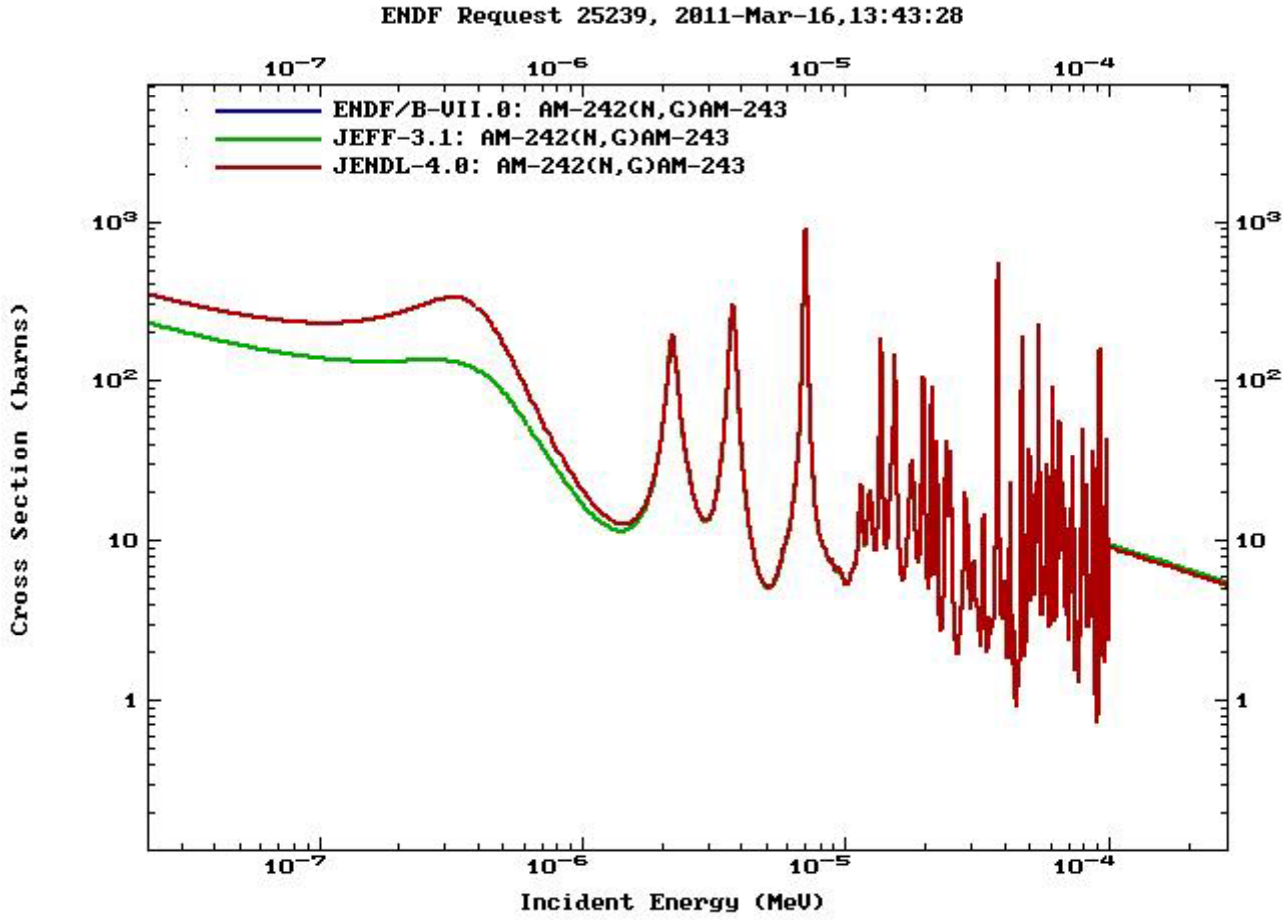
  - G4NDL-3.14 (GEANT4) – 181 isotopes

Why different neutron libraries?

Conf.	k_{eff}		
	ENDF-VII.0	JEFF-3.1	JENDL-3.3
SC0	0.97565±0.00012	0.97606±0.00011	0.97652±0.00011
SC3a	0.94873±0.00011	0.94905±0.00004	0.94908±0.00011
SC3b	0.94851±0.00011	0.94909±0.00011	0.94908±0.00011
SC6	0.85070±0.00012	0.85133±0.00012	0.85180±0.00010

k_{eff} obtained with MCNPX simulations for different configurations in the same reactor, using different libraries

Why different neutron libraries?



Procedure to create the GEANT4 libraries

- The ENDF-6 format data libraries can be download, for example, from:
  - http://www.nea.fr/dbdata/eva/
  - http://www-nds.iaea.org/exfor/endf.htm
  - http://www.nndc.bnl.gov/exfor/endf00.jsp
- They have to be pre-processed before translating them into the GEANT4 format, in order to convert the resonance contribution into cross section data points, and also to transform all cross section data points into linear-linear interpolable form, which is required by the GEANT4 code.
- There are some programs available to do this pre-processing, such as NJOY and PREPRO. The PREPRO package has been used:
  - http://www-nds.iaea.org/ndspub/endf/prepro

Procedure to create the GEANT4 libraries

- By looking at the ENDF-6 format manual:
  - http://www.nndc.bnl.gov/csewg_members/ENDF-102/ENDF-102.pdf

  and to the GEANT4 code a program has been developed which translates the information contained into the ENDF-6 format files into the GEANT4 format files.

Comments

1- Some angular distributions of outgoing particles are described in ENDF-6 with Legendre coefficients. The maximum allowed number of coefficients in the ENDF-6 format is 64, whereas in GEANT4 is 29-30. Because of this, for some isotopes, the coefficients of order grater than 30 have been omitted.

2- Capture photon production is usually described with MF=12,13,14 and 15. However, for some isotopes (more as newer is the library), photons are described with MF=6. GEANT4 do not accept the photon description in this format for capture, but it do for other reactions, so the libraries have been translated as usual, using the MF=6 format, and the GEANT4 code has been modified to read capture data in this format.

Comments

3- For some few isotopes (^{232}Th, ^{231}Pa and ^{233}Pa in the ENDF-VII.0 library), neutrons emitted after fission are described using MF=6. GEANT4 do not allow this format. In this case PREPRO was used to transform those information in MF=4 and MF=5 formats.

4- There is sometimes in the MF=6 format information concerning the recoil nucleus. GEANT4 are not well prepared to manage this information, so this information has been omitted.

List of isotopes with Capture photons in MF=6

ENDF/B-VI.8: None

JENDL-3.3: None

CENDL-3.1: 2_3_Helium 58_136_Cerium

JEFF-3.0: 9_19_Fluorine

BROND-2.2: 1_1_Hydrogen 1_2_Hydrogen 2_3_Helium 3_6_Lithium

JEFF-3.1: 20_40_Calcium 20_42_Calcium 20_43_Calcium 20_44_Calcium 20_46_Calcium 20_48_Calcium 21_45_Scandium 22_46_Titanium 22_47_Titanium 22_48_Titanium 22_49_Titanium 22_50_Titanium 26_54_Iron 26_57_Iron 26_58_Iron 32_70_Germanium 32_72_Germanium 32_73_Germanium 32_74_Germanium 32_76_Germanium 43_99_Technetium 82_204_Lead 82_206_Lead 82_207_Lead 82_208_Lead 83_209_Bismuth

ENDF/B-VII.0: 1_1_Hydrogen 20_40_Calcium 20_42_Calcium 20_43_Calcium 20_44_Calcium 20_46_Calcium 20_48_Calcium 32_70_Germanium 32_72_Germanium 32_73_Germanium 32_74_Germanium 32_76_Germanium 33_74_Arsenic 33_75_Arsenic 36_85_Krypton 37_86_Rubidium 38_84_Strontium 39_89_Yttrium 39_90_Yttrium 40_90_Zirconium 42_95_Molybdenum 3_99_Technetium 44_101_Ruthenium 45_103_Rhodium 46_105_Palladium 47_109_Silver 47_111_Silver 50_113_Tin 50_125_Tin 51_126_Antimony 52_132_Tellurium 53_130_Iodine 54_131_Xenon 55_133_Cesium 56_133_Barium 57_140_Lanthanum 58_136_Cerium 58_138_Cerium 58_139_Cerium 58_143_Cerium 59_141_Praseodymium 59_142_Praseodymium 60_142_Neodymium 60_143_Neodymium 60_144_Neodymium 60_145_Neodymium 60_146_Neodymium 60_147_Neodymium 60_148_Neodymium 60_150_Neodymium 61_151_Promethium 62_144_Samarium 62_147_Samarium 62_148_Samarium 62_149_Samarium 2_150_Samarium 62_151_Samarium 62_152_Samarium 62_153_Samarium 62_154_Samarium 63_153_Europium 63_157_Europium 64_152_Gadolinium 64_153_Gadolinium 64_154_Gadolinium 64_155_Gadolinium 64_156_Gadolinium 64_157_Gadolinium 64_158_Gadolinium 64_160_Gadolinium 65_160_Terbium 66_156_Dysprosium 66_158_Dysprosium 66_160_Dysprosium 66_161_Dysprosium 66_162_Dysprosium 66_163_Dysprosium 66_164_Dysprosium 77_191_Iridium 77_193_Iridium 82_204_Lead 82_206_Lead 82_207_Lead 90_232_Thorium 91_231_Protactinium 91_233_Protactinium

JENDL-4.0: 1_1_Hydrogen 14_28_Silicon 14_29_Silicon 14_30_Silicon 20_40_Calcium 20_42_Calcium 20_43_Calcium 20_44_Calcium 20_46_Calcium 20_48_Calcium 23_50_Vanadium 23_51_Vanadium 24_50_Chromium 24_52_Chromium 24_53_Chromium 24_54_Chromium 30_64_Zinc 30_65_Zinc 30_66_Zinc 30_67_Zinc 30_68_Zinc 30_70_Zinc 32_70_Germanium 32_72_Germanium 32_73_Germanium 32_74_Germanium 32_76_Germanium 46_102_Palladium 6_104_Palladium 46_105_Palladium 46_106_Palladium 46_107_Palladium 46_108_Palladium 46_110_Palladium 47_107_Silver 47_109_Silver 47_111_Silver 50_112_Tin 50_114_Tin 50_115_Tin 50_116_Tin 50_117_Tin 50_118_Tin 50_119_Tin 50_120_Tin 50_122_Tin 50_123_Tin 50_124_Tin 50_126_Tin 55_133_Cesium 55_134_Cesium 55_135_Cesium 55_136_Cesium 55_137_Cesium 60_142_Neodymium 60_143_Neodymium 60_144_Neodymium 60_145_Neodymium 60_146_Neodymium 60_147_Neodymium 60_148_Neodymium 60_150_Neodymium 61_147_Promethium61_148_Promethium 61_149_Promethium 61_151_Promethium 62_144_Samarium 62_147_Samarium 62_148_Samarium 62_149_Samarium 62_150_Samarium 62_151_Samarium 62_152_Samarium 62_153_Samarium 62_154_Samarium 63_151_Europium 63_152_Europium 63_153_Europium 63_154_Europium 63_155_Europium 63_156_Europium 63_157_Europium 64_152_Gadolinium 64_153_Gadolinium 64_154_Gadolinium 64_155_Gadolinium 64_156_Gadolinium 64_157_Gadolinium 64_158_Gadolinium 64_160_Gadolinium 65_159_Terbium 65_160_Terbium 66_154_Dysprosium 66_156_Dysprosium 66_158_Dysprosium 66_159_Dysprosium 66_160_Dysprosium 66_161_Dysprosium 66_162_Dysprosium 66_163_Dysprosium 66_164_Dysprosium 69_169_Thulium 74_180_Tungsten 74_182_Tungsten 74_183_Tungsten 74_184_Tungsten 74_186_Tungsten 76_184_Osmium 76_186_Osmium 76_187_Osmium 76_188_Osmium 76_189_Osmium 76_190_Osmium 76_192_Osmium 79_197_Gold 82_204_Lead 82_206_Lead 82_207_Lead 82_208_Lead 89_225_Actinium 89_226_Actinium 89_227_Actinium 90_227_Thorium 90_228_Thorium 90_229_Thorium 90_230_Thorium 90_231_Thorium 90_232_Thorium 90_233_Thorium 90_234_Thorium 91_229_Protactinium 91_230_Protactinium 91_231_Protactinium 91_232_Protactinium 91_233_Protactinium 92_230_Uranium 92_231_Uranium 92_232_Uranium 92_233_Uranium 92_234_Uranium 92_235_Uranium 92_236_Uranium 92_237_Uranium 92_238_Uranium 93_234_Neptunium 93_235_Neptunium 93_236_Neptunium 93_237_Neptunium 93_238_Neptunium 93_239_Neptunium 94_236_Plutonium 94_237_Plutonium 94_238_Plutonium 94_239_Plutonium 94_240_Plutonium 94_241_Plutonium 94_242_Plutonium 94_244_Plutonium 94_246_Plutonium 95_240_Americium 95_241_Americium 95_242_Americium 95_243_Americium 95_244_Americium 96_240_Curium 96_241_Curium 96_242_Curium 96_243_Curium 96_244_Curium 96_245_Curium 96_246_Curium 96_247_Curium 96_248_Curium 96_249_Curium 96_250_Curium 97_245_Berkelium 97_246_Berkelium 97_247_Berkelium 97_248_Berkelium 97_249_Berkelium 97_250_Berkelium 98_246_Californium 98_248_Californium 98_249_Californium 98_250_Californium 98_251_Californium 98_252_Californium 98_253_Californium 98_254_Californium 99_251_Einsteinium 99_252_Einsteinium 99_253_Einsteinium 99_254_Einsteinium 99_255_Einsteinium 100_255_Fermium