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## Present Status of JENDL High Energy File Project

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and

High Energy Nuclear Data Evaluation WG,  
Photonuclear Data Evaluation WG  
and PKA Spectrum WG,  
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Nuclear data in the energy range up to a few GeV are necessary to many applications, such as accelerators used for physics research, radiation therapy, medical isotope production and transmutation of radioactive waste. The JAERI Nuclear Data Center has started evaluation work in cooperation with Japanese Nuclear Data Committee (JNDC) to produce files related high energy, which are JENDL High Energy File, JENDL PKA/KERMA File and JENDL Photonuclear Data File.

The JENDL High Energy File will include nuclear data for proton- and neutron-induced reactions. The evaluation work is separated into two phases. The energy range of the phase-I is up to 50 MeV, mainly for the International Fusion Material Irradiation Facility (IFMIF)<sup>1)</sup>. The energy range for the phase-II is up to 2 GeV mainly for a project of JAERI Neutron Science Research Center. Below 20 MeV, the data of JENDL Fusion File<sup>2)</sup> or JENDL-3.2<sup>3)</sup> are adopted basically. The elements included in the JENDL High Energy File are summarized in Table 1. In 1996, the evaluation work was concentrated into neutron data of the phase-I. SINCROS-II<sup>4)</sup> is mainly used for the phase-I evaluation. For light mass nuclei, SCINFUL/DDX<sup>5)</sup> code which considers break-up reactions with primary knock-on atom (PKA) spectra is used as well as EXIFON<sup>6)</sup> code which can calculate with correction of preequilibrium process. From the benchmark calculation<sup>7,8)</sup>, the ALICE-F<sup>9)</sup> and HETC/3-STEP<sup>10)</sup> code can be used in the phase-II evaluation. As an advanced evaluation method, an application of the quantum molecular dynamics (QMD) theory<sup>11,12)</sup> is investigated.

The JENDL PKA/KERMA File is generated to supply PKA spectra, damage energy spectra, DPA (displacement per atom) cross sections and kerma factors by neutron-induced reactions as basic information for estimation of material radiation damage in the energy region up to 50 MeV. The elements included in the file are listed in Table 2. It is often impossible to calculate PKA spectra exactly for reactions emitting two or more particles from evaluated nuclear data file. Then, a processing code system, ESPERANT<sup>13)</sup> was developed to calculate above quantities from evaluated nuclear data file by using effective single particle emission approximation (ESPEA). As a trial task of ESPERANT, a file of PKA spectra for 69 nuclides from F to Bi in the energy region up to 20 MeV has been generated for fusion application (FENDL-2 project<sup>14)</sup>) from the JENDL Fusion File.

For  $\gamma$ -ray induced reaction data up to 140 MeV, the JENDL Photonuclear Data File is

provided for applications such as electron accelerator shielding and radiation therapy. The photon absorption cross section is evaluated with the giant dipole resonance model and quasideuteron model, and the decaying processes are estimated with the statistical model with preequilibrium correction by using MCPHOTO and ALICE-F codes. The isotopes shown in Table 3 are included in the file. The evaluation work is now in a final stage.

The present status of the JENDL High Energy File, PKA/KERMA File and Photoneuclear Data File was reviewed. For these files, ENDF-6 format must be selected fundamentally.

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Table 1 The elements to be included in the JENDL High Energy File

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|---|
| Phase-I (for neutron, < 50 MeV)   |
| <u>H-1</u> , Li-6,7, Be-9, B-10,11, <u>C-12</u> , N-14, O-16, <u>Na-23</u> , <u>Mg-24,25,26</u> , <u>Al-27</u> , <u>Si-28,29,30</u> , Cl-35,37, <u>K-39,41</u> , <u>Ca-40,42,43,44,46,48</u> , <u>Ti-46,47,48,49,50</u> , <u>V-50,51</u> , <u>Cr-50,52,53,54</u> , <u>Mn-55</u> , <u>Fe-54,56,57,58</u> , Co-59, <u>Ni-58,60,61,62,64</u> , <u>Cu-63,65</u> , Ge-70,72,73,74,76, <u>Y-89</u> , Zr-90,91,92,94,96, Nb-93, <u>Mo-92,94,95,96,97,98,100</u> , <u>W-180,182,183,184,186</u> , Au-197, Pb-204,206,207,208, Bi-209                                |
| Phase-I (for proton, < 50 MeV)  |
| Li-6,7, C-12,13, Al-27, Si-28,29,30, Cr-50,52,53,54, Fe-54,56,57,58, Ni-58,60,61,62,64, Cu-63,65, Nb-93, Mo-92,94,95,96,97,98,100, W-180,182,183,184,186, Ta-181, Pb-204,206,207,208, Bi-209  |
| Phase-II (for neutron and proton, < 2 GeV)  |
| <u>H-1</u> , Li-6,7, Be-9, B-10,11, C-12,13, N-14, O-16, F-19, Na-23, Mg-24,25,26, <u>Al-27</u> , <u>Si-28,29,30</u> , Cl-35,37, Ar-35,38,40, K-39,41, Ca-40,42,43,44,46,48, V-51, Cr-50,52,53,54, Mn-55, Fe-54,56,57,58, Co-59, <u>Ni-58,60,61,62,64</u> , <u>Cu-63,65</u> , Zn-64,66,67,68,70, Y-89, Zr-90,91,92,94,96, Nb-93, <u>Mo-92,94,95,96,97,98,100</u> , W-180,182,183,184,186, Au-197, Hg-196,198,199,200,201,202,204, <u>Pb-204,206,207,208</u> , <u>Bi-209</u> , Th-232, U-235,238, Np-237, Pu-238,239,240,241,242, Am-241,243, Cm-243,244,245 |

Underline: evaluation finished (now in review stage)

Table 2 The elements to be included in the JENDL PKA/KERMA File

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| H-1, Li-6,7, Be-9, B-10,11, C-12, N-14, O-16, Na-23, Mg-24,25,26, Al-27, Si-28,29,30, Cl-35,37, K-39,41, Ca-40,42,43,44,46,48, Ti-46,47,48,49,50, V-51, Cr-50,52,53,54, Mn-55, Fe-54,56,57,58, Co-59, Ni-58,60,61,62,64, Cu-63,65, Zr-90,91,92,94,96, Ge-70,72,73,74,76, Nb-93, Mo-92,94,95,96,97,98,100, W-180,182,183,184,186, Pb-204,206,207,208, Bi-209 |
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Table 3 The nuclei to be included in the JENDL Photoneuclear Data File

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| H-2, C-12, N-14, O-16, Na-23, Mg-24,25,26, Al-27, <u>Si-28,29,30</u> , Ca-38,40, Ti-46,48, <u>V-51</u> , Cr-52, Mn-55, <u>Fe-54,56</u> , Co-59, <u>Ni-58,60,61,62,64</u> , <u>Cu-63,65</u> , <u>Zn-64</u> , Zr-90, <u>Nb-93</u> , Mo-92,94,96,98,100, <u>Cs-133</u> , <u>Gd-160</u> , <u>Ta-181</u> , <u>W-182,184,186</u> , Au-197, Pb-206,207,208, <u>Bi-209</u> , <u>U-235,238</u> |
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Underline: evaluation finished (now in review stage)