



Issues to the next FENDL

Japan Atomic Energy Agency

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**Consultancy Meeting on the Further Development
of the Fusion Evaluated Nuclear Data Library (FENDL)**

30 October to 2 November 2023

IAEA Headquarters, Vienna, Austria

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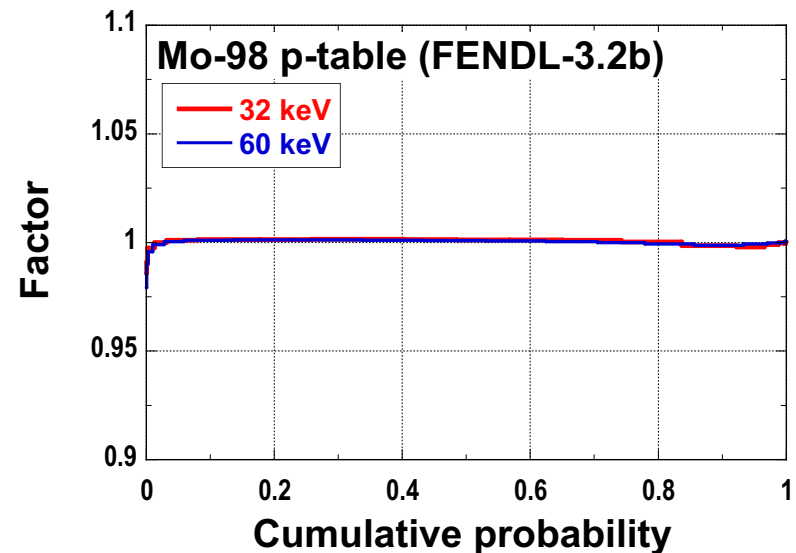
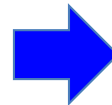
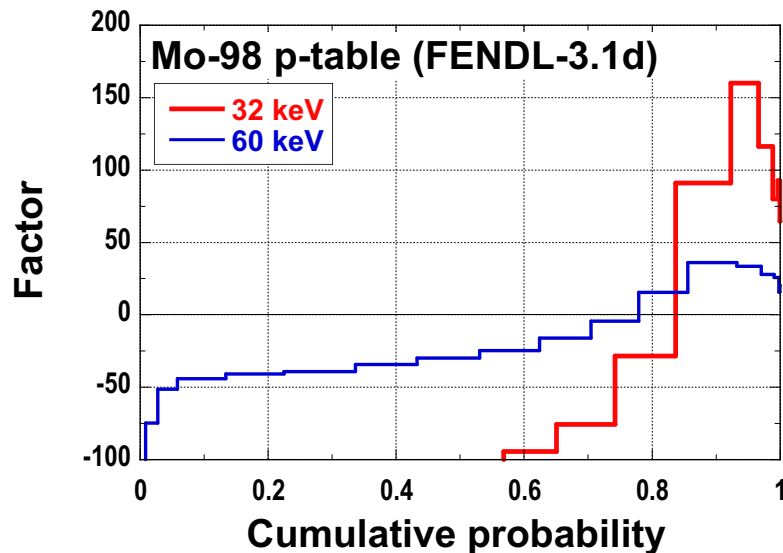
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Introduction -(1)

#4



- We examined FENDL-3.2b and its ACE file in detail and confirmed that the following problems in FENDL-3.1d ACE file which we had pointed out were solved in FENDL-3.2b ACE file.
- **Negative probability table (p-table) of heating number**

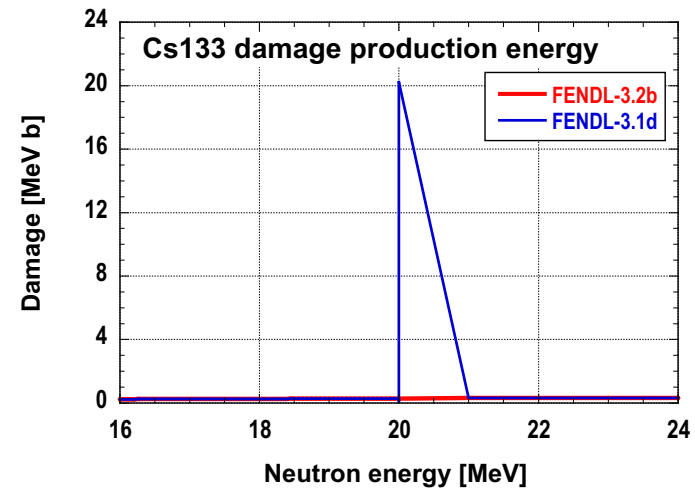
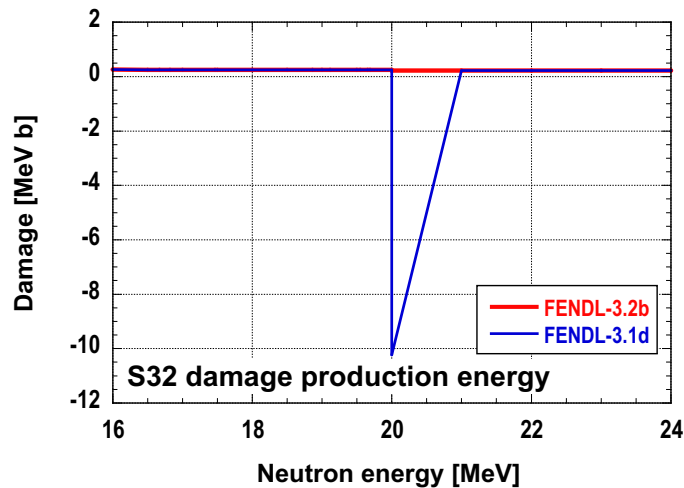
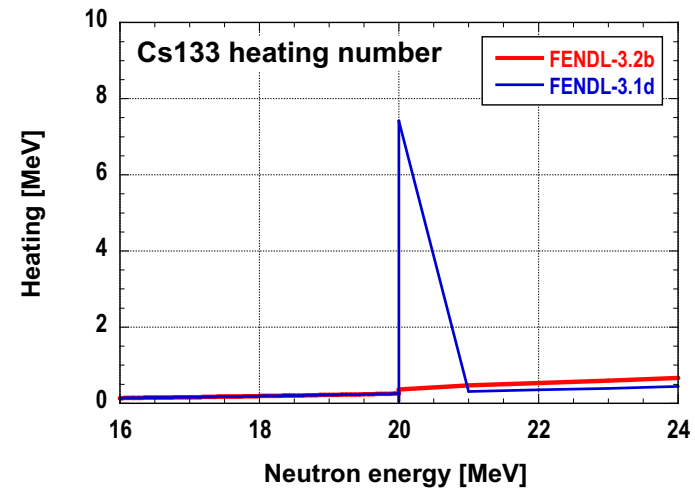
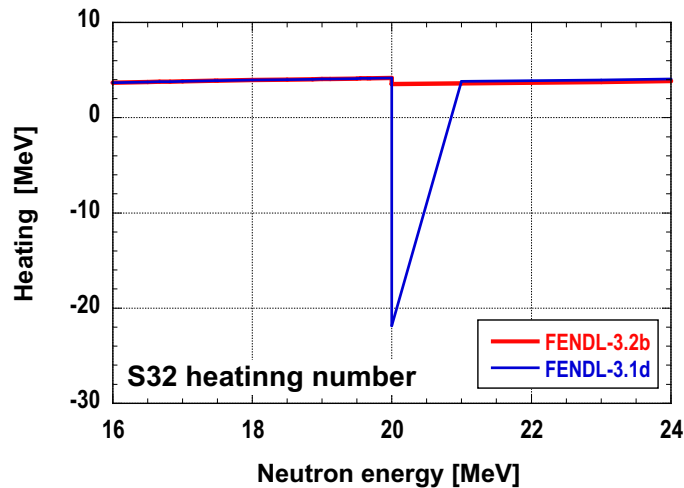


Introduction -(2)

#5



- Negative or too large heating number and damage production energy cross section



Introduction -(3)

#6



- However the following issues still remain and are newly found in FENDL-3.2b ACE files.
 - **Too small damage production energy cross section** above 20 MeV or a few MeV
 - **Inadequate ACE files** of proton sub-library
- **The above issues are explained here** (Dr. Nakayama and Dr. Kwon present other issues in this meeting).



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Nuclei from JENDL-4.0/HE -(1)

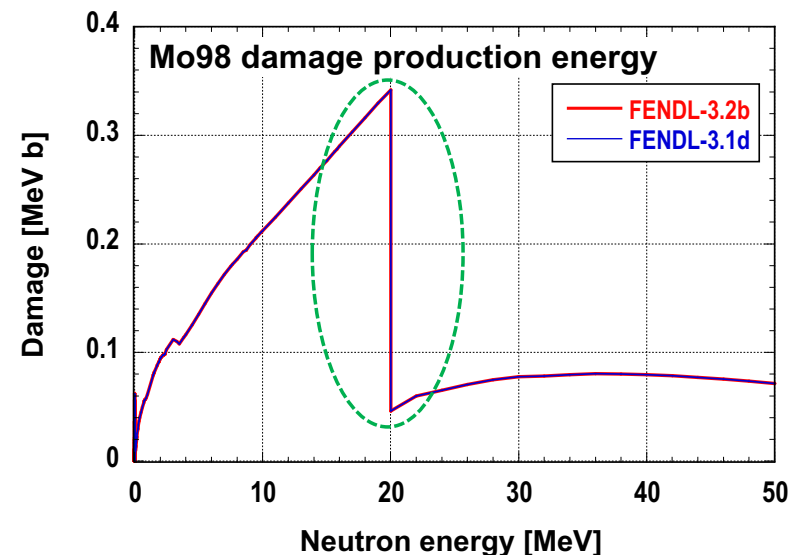
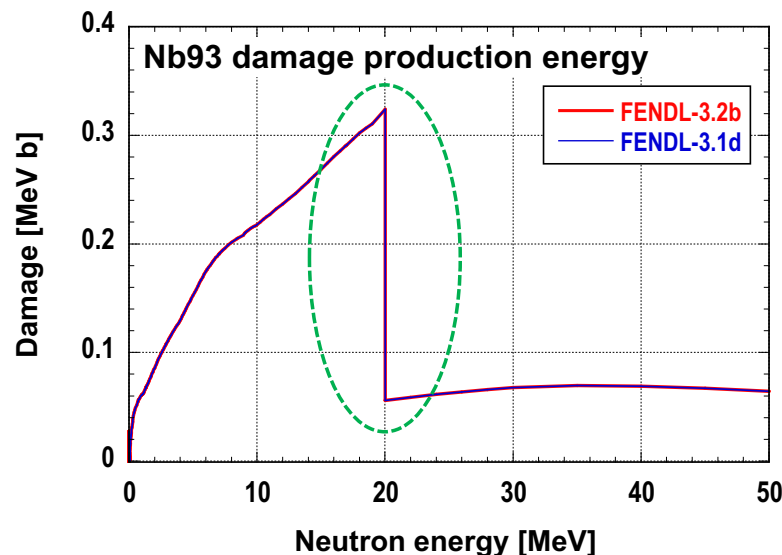
#8



- As pointed out in 2018 FENDL meeting, ACE files of nuclei from JENDL-4.0/HE in FENDL-3.1d have **sharply small** damage production energy cross section data above 20 MeV.

S. Kwon et al., Problems of DPA cross-sections above 20 MeV in FENDL-3.1d found in A-FNS neutronics analysis, J. Nucl. Sci. Technol., 57(2020), 344 – 351.

<https://doi.org/10.1080/00223131.2019.1661306>





- ❑ We specified that **no energy distribution data of several residual nuclei above 20 MeV** in JENDL-4.0/HE caused the problem.
- ❑ **This issue has not been improved in FENDL-3.2b** because it is impossible to add energy distribution data of several residual nuclei above 20 MeV to JENDL-4.0/HE.
- ❑ Recently we released **ACE files of JENDL-4.0/HE** (<https://rpg.jaea.go.jp/main/en/ACE-J40HE/index.html>), where damage production energy cross section data above 20 MeV were replaced with those of **TENDL-2019** etc. for this issue.

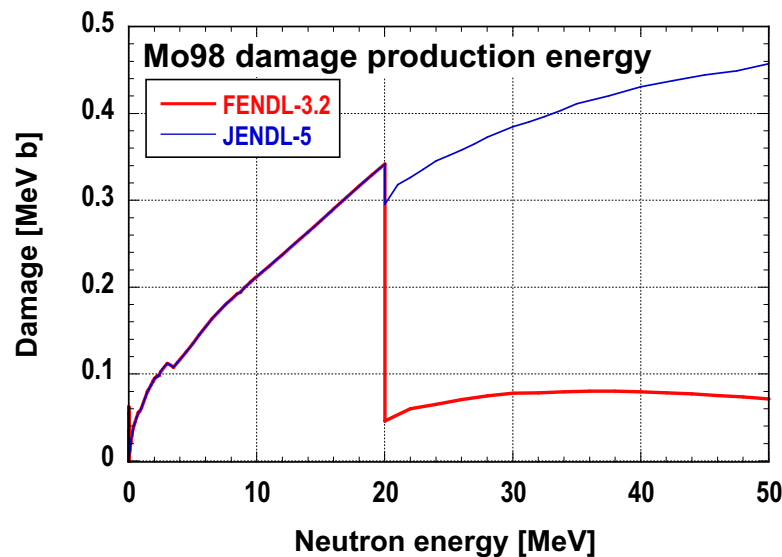
C. Konno, New JENDL-4.0/HE neutron and proton ACE files, J. Nucl. Sci. Technol. (online). <https://doi.org/10.1080/00223131.2023.2237970>

Nuclei from JENDL-4.0/HE -(3)

#10



- Recently **JENDL-5** and its ACE files were released (<https://rpg.jaea.go.jp/main/en/ACE-J50/>).
- JENDL-5 supersedes JENDL-4.0/HE and has **energy distribution data of all residual nuclei above 20 MeV**, which solves this issue.



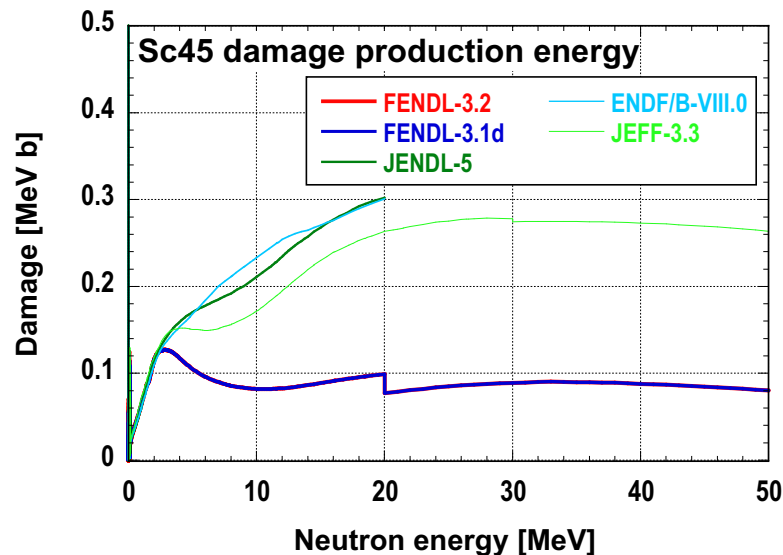
O. Iwamoto et al., Japanese evaluated nuclear data library version 5: JENDL-5, J. Nucl. Sci. Technol., 60 (2023), 1-60.

<https://doi.org/10.1080/00223131.2022.2141903>

- Thus we recommend to adopt data of JENDL-5 for nuclei from JENDL-4.0/HE in the next FENDL.



- As also pointed out in 2018 FENDL meeting, **damage production energy cross section data above several MeV of 13 nuclei (^{45}Sc , ^{58}Fe , $^{70,72-74,76}\text{Ge}$, ^{103}Rh , $^{204, 206-208}\text{Pb}$, and ^{209}Bi) from JEFF-3.1.1 were much smaller** than those in the other nuclear data libraries, which has not been resolved in FENDL-3.2b.



S. Kwon et al, Problems of DPA cross-sections above 20 MeV in FENDL-3.1d found in A-FNS neutronics analysis, J. Nucl. Sci. Technol., 57(2020), 344 – 351.
<https://doi.org/10.1080/00223131.2019.1661306>



- ❑ We specified that the problematic 13 nuclei from JEFF-3.1.1 have **incorrect energy distribution data of recoil nucleus in the inelastic scattering to continuum states (file=6, mt=91) and/or no energy distribution data of several residual nuclei above 20 MeV** such as JENDL-4.0/HE, which caused this issue.
- ❑ We recommended that the problematic nuclei from JEFF-3.1.1 should be replaced with those from **JEFF-3.3**, which do not have this issue
- ❑ However **FENDL-3.2b** is still the **same as FENDL-3.1d** for the nuclei.
- ❑ **The problematic 13 nuclei from JEFF-3.1.1 should be replaced with those from JEFF-3.3.**



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Proton files from JENDL/HE-2007 -(1) #14



- ❑ JENDL/HE-2007, JENDL-4.0/HE and JENDL/DEU-2020 adopt **LAW=7** (laboratory angle-energy law) for File 6 MT=5.
- ❑ Original NJOY2016 produces **ACE files of LAW=61** (tabular angular distribution) from ENDF-6 files with LAW=7.
- ❑ MCNP6.2 and earlier version MCNPs can treat neutron ACE files of LAW=61 correctly.
- ❑ However **they cannot do charged particle ACE files of LAW=61 correctly** while they can do them of LAW=67 (laboratory angle-energy law).

T. Sasa et al., Continuous Energy Cross Section Library for MCNP/MCNPX based on JENDL High Energy File 2007, JAEA-Data/Code 2008-022.

Proton files from JENDL/HE-2007 -(2) #15



- ❑ Dr. Kosako made a NJOY patch for NJOY99.259 to produce not ACE files of LAW=61 but those of LAW=67, but the patch is not available.
- ❑ The official ACE files of LAW=67 of JENDL/HE-2007, JENDL-4.0/HE and JENDL/DEU-2020 were produced by using NJOY with the patch.
- ❑ FENDL-3.2b proton and deuteron ACE files from JENDL-4.0/HE and JENDL/DEU-2020 produced with the patch were provided from JAEA to IAEA.
- ❑ However **FENDL-3.2b proton ACE files from JENDL/HE-2007** have angular distributions of **LAW=61**.

Proton files from JENDL/HE-2007 -(3) #16

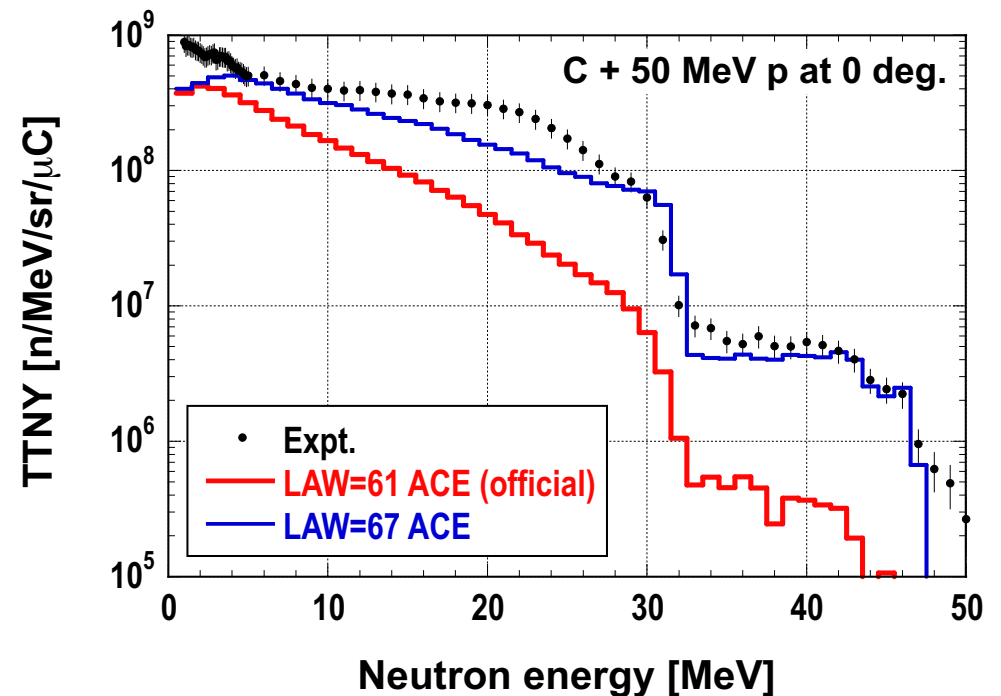
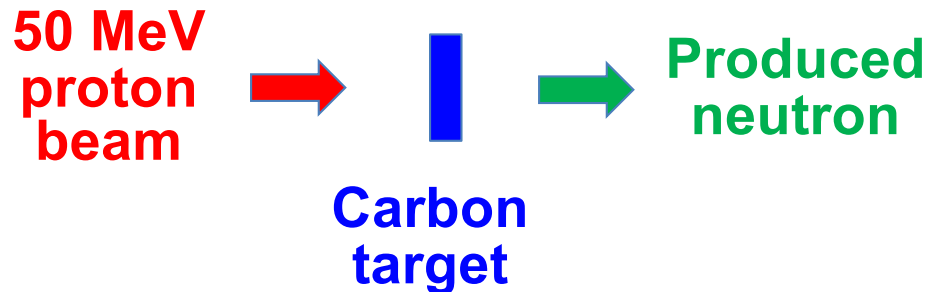


How different are MCNP6.2 calculation results with ACE files of LAW=61 and LAW=67?

→ Very large !

Carbon thick target yield expt. with 50 MeV proton

T. Aoki et al., Nucl. Sci. Eng. 146, 200–208 (2004).



Proton files from JENDL/HE-2007 -(4) #17



- ❑ JENDL-5 was released in 2021.
- ❑ We modified **NJOY2016.65** for JENDL-5 including charged particle sub-libraries.
- ❑ The **NJOY patch** is available with JENDL-5 ACE files from <https://rpg.jaea.go.jp/main/en/ACE-J50/>.
- ❑ The patch also has a function to produce not ACE files of LAW=61 but those of **LAW=67**.
- ❑ **FENDL-3.2b** proton files from JENDL/HE-2007 should be replaced with JENDL-5 and/or should be reprocessed by using NJOY2016.65 with the patch for JENDL-5, where LAW=67 is adopted.



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- We examined FENDL-3.2b in detail and found the following issues and countermeasures.
 - ACE files of nuclei from JENDL-4.0/HE in FENDL-3.2b have sharply small damage production energy cross section data above 20 MeV.
 - Files from JENDL-4.0/HE in FENDL-3.2b should be replaced with those of JENDL-5.
 - Damage production energy cross section data of 13 nuclei from JEFF-3.1.1 are too small above a few MeV.
 - Files from JEFF-3.1.1 in FENDL-3.2b should be replaced with those of JEFF-3.3.

Conclusion -(2)

#20



- **FENDL-3.2b proton ACE files from JENDL/HE-2007 have angular distributions of LAW=61.**

→ **FENDL-3.2b proton files from JENDL/HE-2007 should be replaced with JENDL-5 and/or should be reprocessed by using NJOY2016.65 with the patch for JENDL-5, where LAW=67 is adopted.**

□ **We hope that the above issues are solved in the next FENDL.**



Thank you for your attention!