Analyses of JAEA/FNS iron in-situ experiment with latest nuclear data libraries

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ND2022 online
2022 July 27

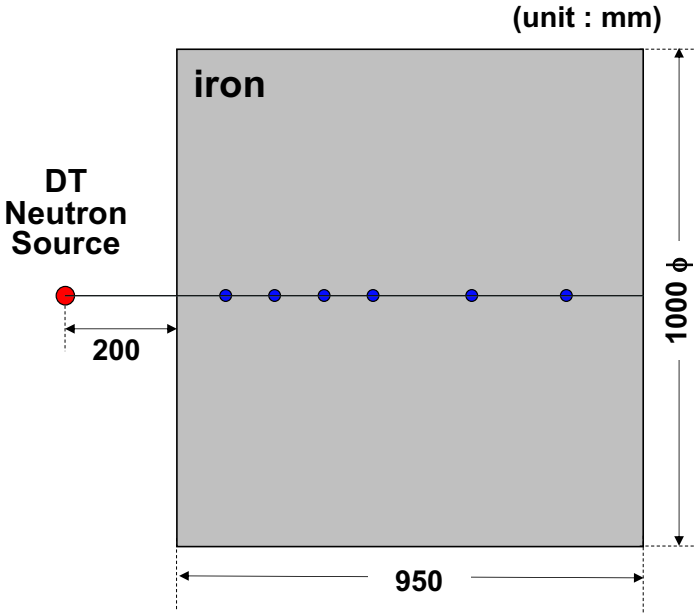
Introduction

- For the JENDL-5 development, we analyzed the iron in-situ experiment at the DT neutron source facility FNS in JAEA with the two-dimensional Sn code DORT and the latest nuclear data libraries in 2020: JENDL-4.0, ENDF/B-VIII.0 and JEFF-3.3.
- The calculation results with JENDL-4.0 and JEFF-3.3 agreed with the measured data well.
- On the contrary, the calculation result with ENDF/B-VIII.0 differed from the measured data most.
- Here we investigate the reasons of this ENDF/B-VIII.0 issue.

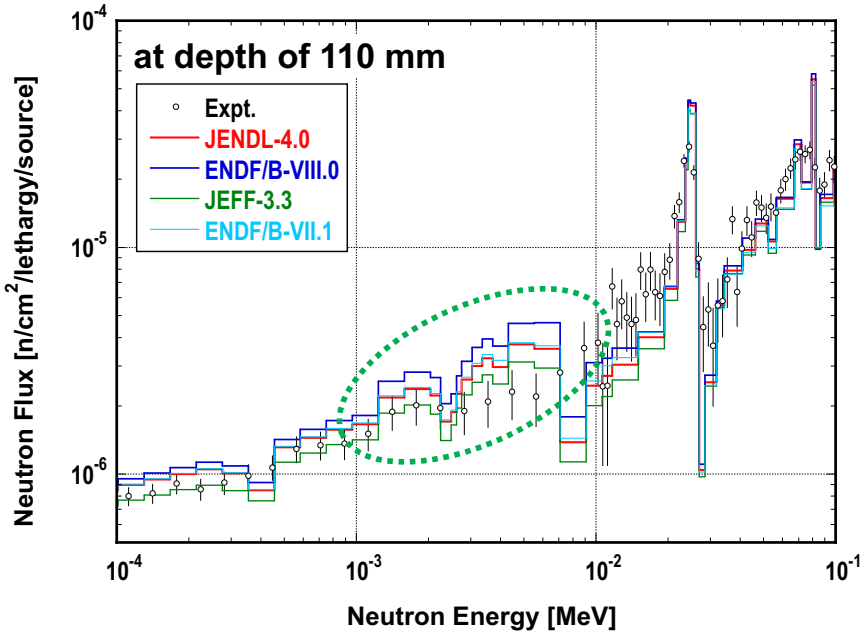
Analysis method

- **Code** : Two-dimensional Sn code **DORT**
  - **Short calculation time**
  - **No statistical error**
  - **Similar results** to those with MCNP
  - P_5-S_{16} approximation
- **Multigroup library**
  - Nuclear library : **JENDL-4.0**, **ENDF/B-VIII.0**, **JEFF-3.3** and additionally **ENDF/B-VII.1** because of better than ENDF/B-VIII.0
  - **MATXS** files (neutron:199 groups) were produced with **NJOY2016**.
  - A multigroup library for the experiment was generated from the MATXS files with **TRANSX** code.

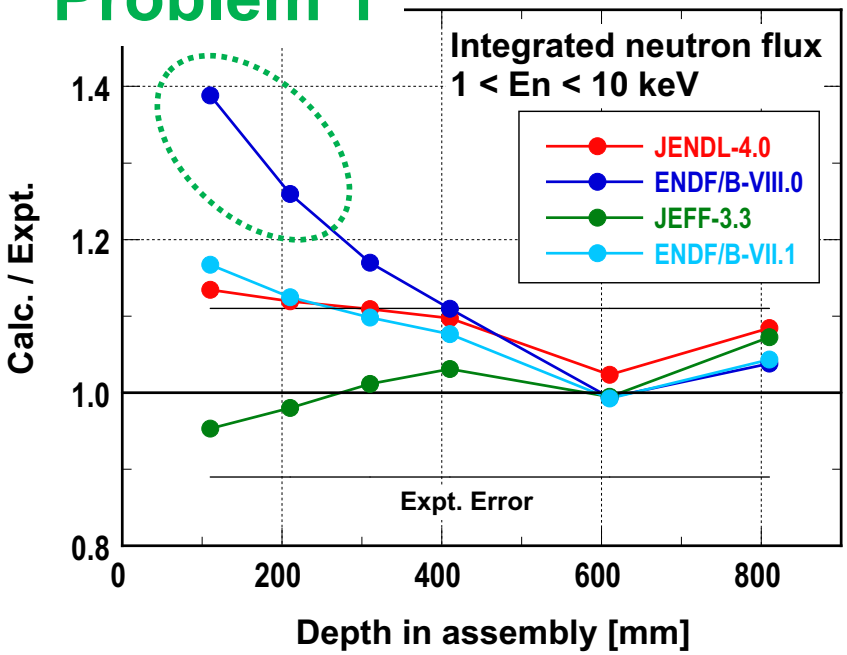
FNS iron experiment and results -(1)



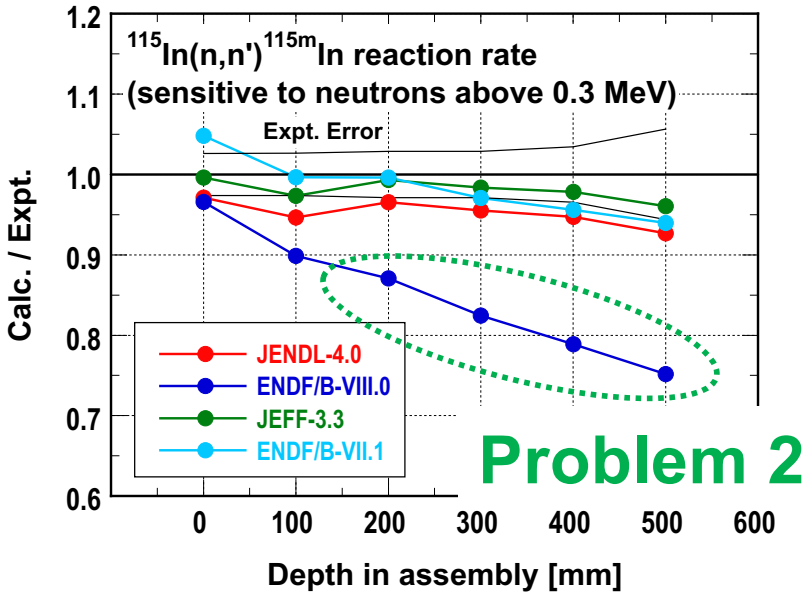
Neutron spectra over almost the whole energy and reaction rates of several reactions were measured inside the iron assembly 30 years ago.

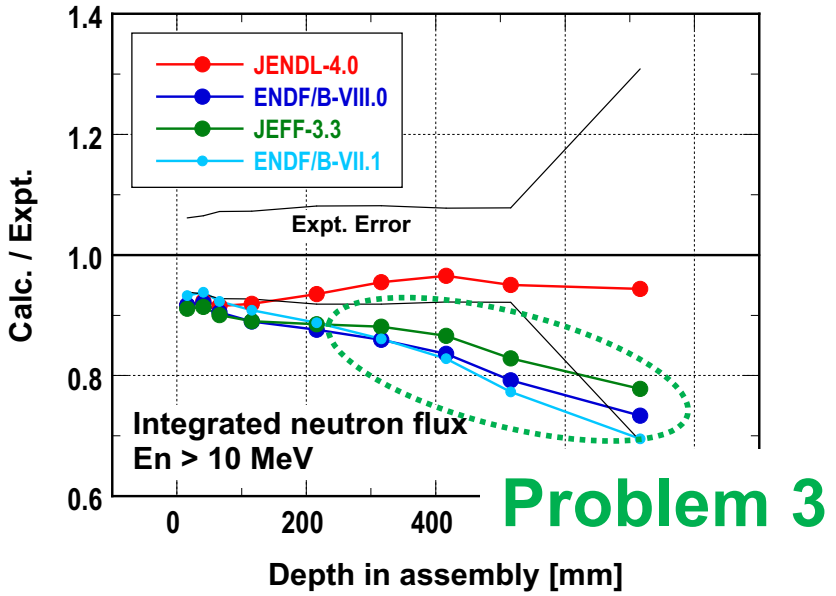


Problem 1



FNS iron experiment and results -(2)

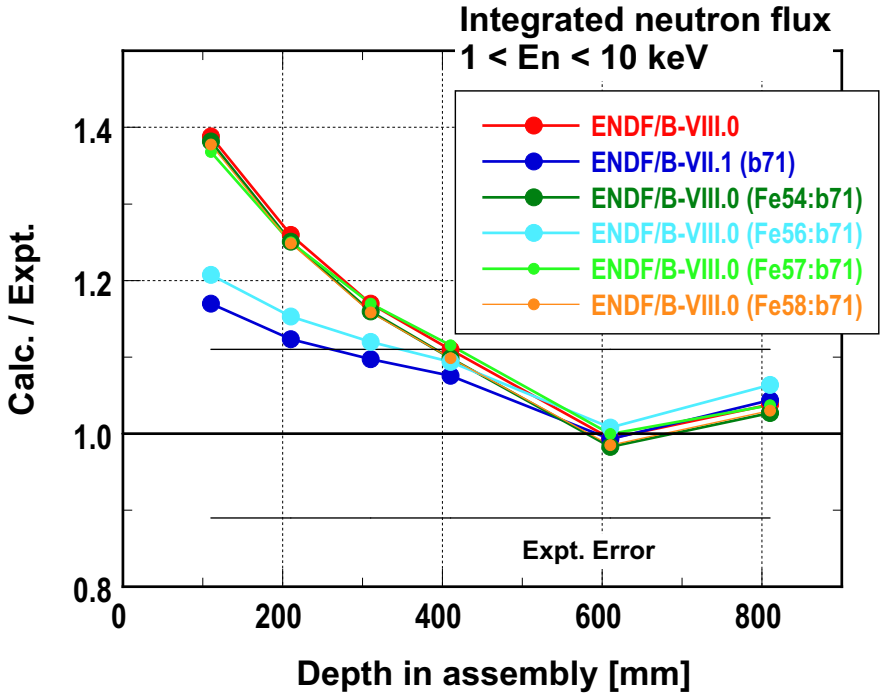


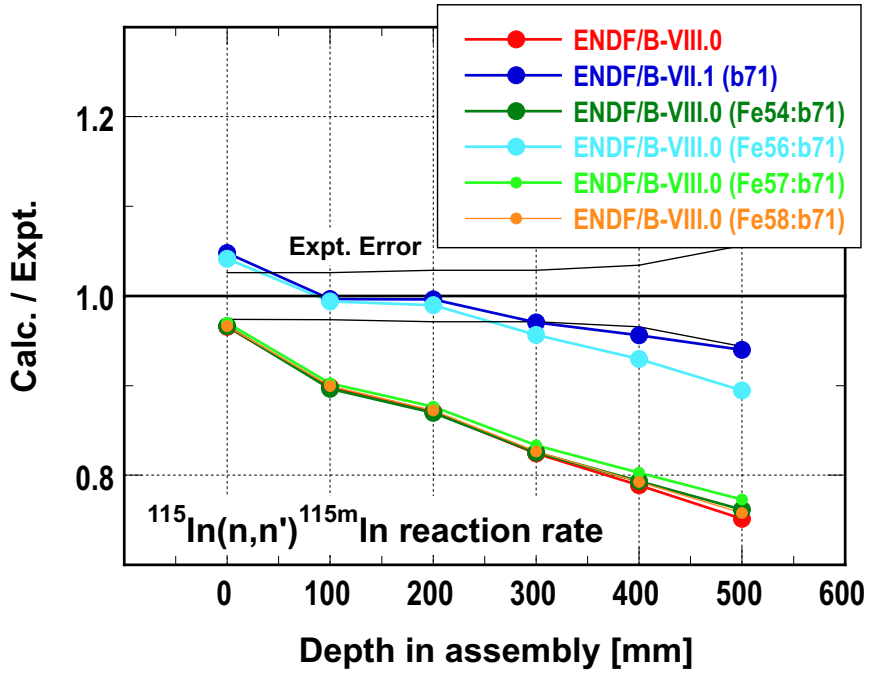


- **ENDF/B-VIII.0 causes the following problems.**
  - **Problem 1 : Overestimation of neutron flux of 1 - 10 keV at the shallower region**
  - **Problem 2 : Underestimation of reaction rate of ^{115}In(n,n')^{115m}In at the deeper region**
  - **Problem 3 : Underestimation of neutron flux above 10 MeV at the deeper region (this is also true of ENDF/B-VII.1 and JEFF-3.3)**

Problems 1 and 2 -(1)

- In order to specify which iron isotope causes Problems 1 and 2, we replaced the iron isotope files one by one from ENDF/B-VIII.0 to ENDF/B-VII.1 because ENDF/B-VII.1 did not cause the Problems and analyzed the experiment.

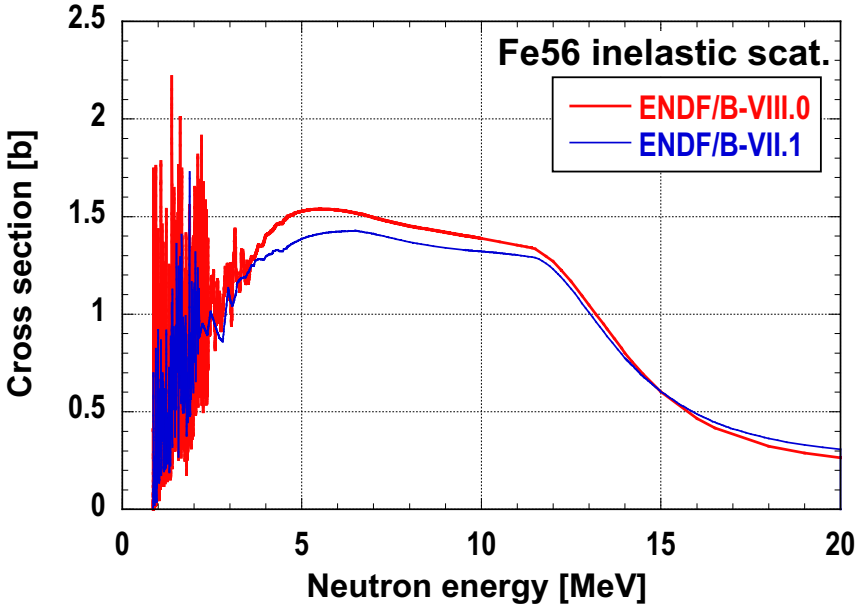


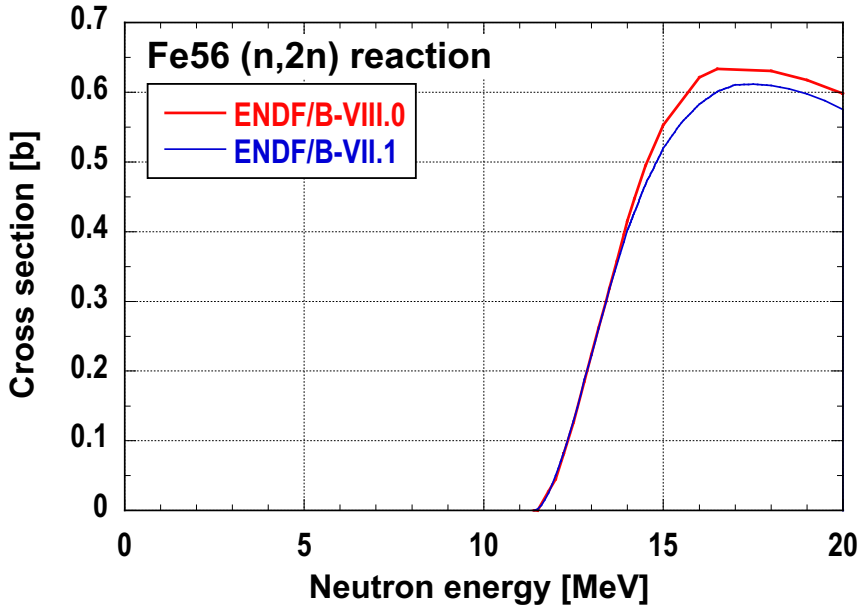


- Mainly ^{56}Fe causes Problems 1 and 2.

Problems 1 and 2 -(2)

- We compared each reaction data of ^{56}Fe in ENDF/B-VIII.0 with those in ENDF/B-VII.1.

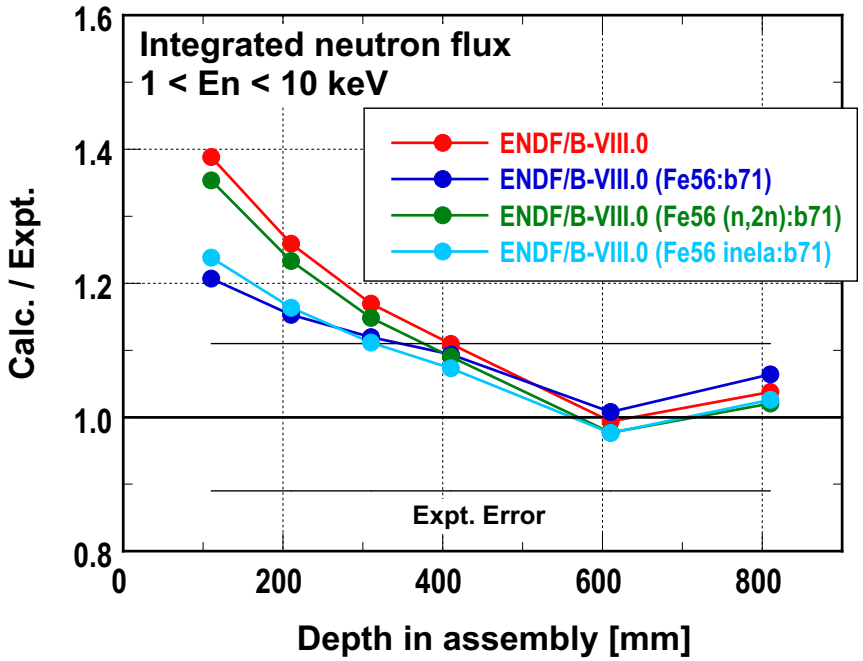


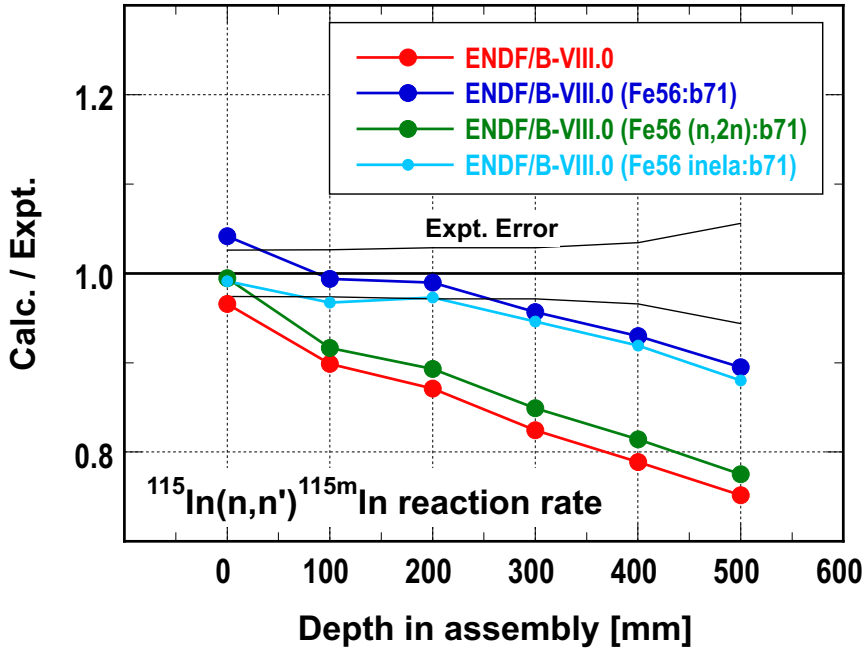


→ inelastic scattering and (n,2n) reaction are different between ENDF/B-VIII.0 and -VII.1.

- We replaced inelastic scattering data or (n,2n) reaction data in ^{56}Fe from ENDF/B-VIII.0 to ENDF/B-VII.1 and analyzed the experiment.

Problems 1 and 2 -(3)

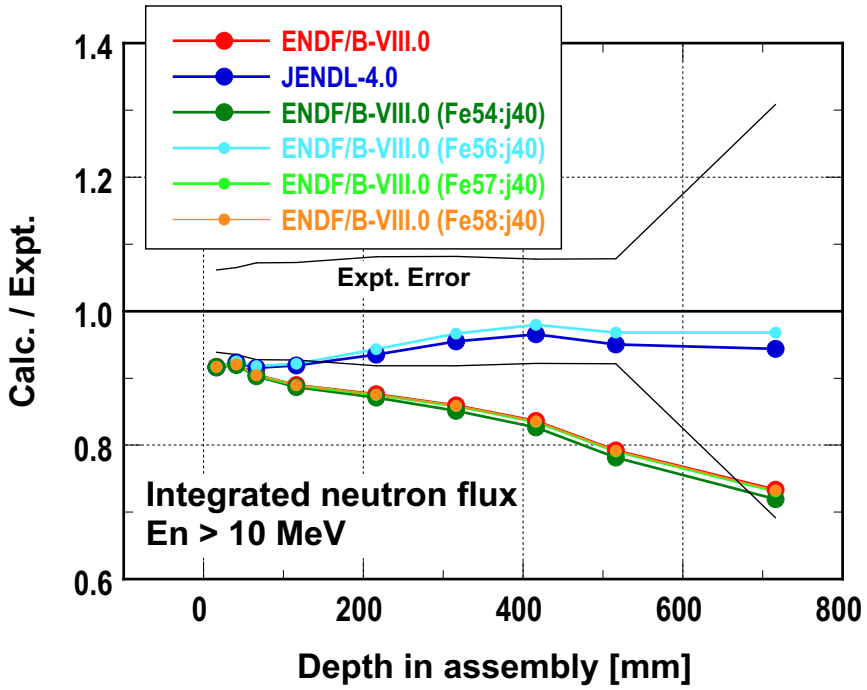




- It is considered that inelastic scattering data of ^{56}Fe in ENDF/B-VIII.0 mainly cause Problems 1 and 2.

Problem 3 -(1)

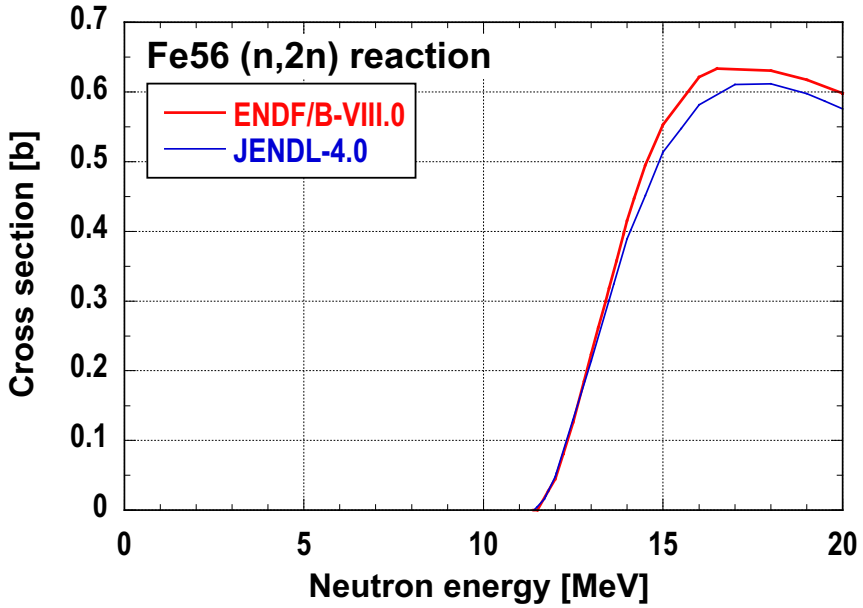
- In order to specify which iron isotope causes Problem 3, we replaced the iron isotope files one by one from ENDF/B-VIII.0 to JENDL-4.0 because only JENDL-4.0 did not cause Problem 3 and analyzed the experiment.

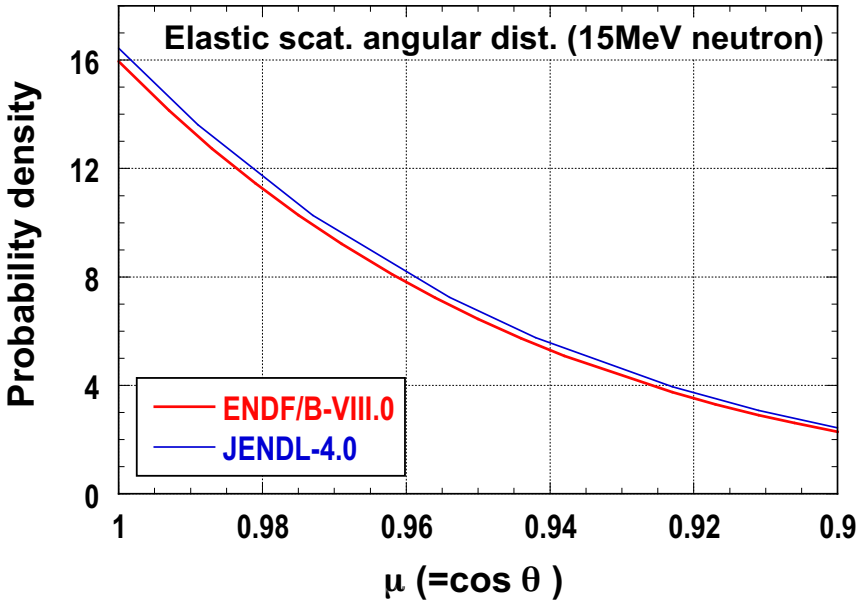


- Mainly ^{56}Fe also causes Problem 3.

Problem 3 -(2)

- We compared ^{56}Fe reaction data above 10 MeV in ENDF/B-VIII.0 with those in JENDL-4.0.

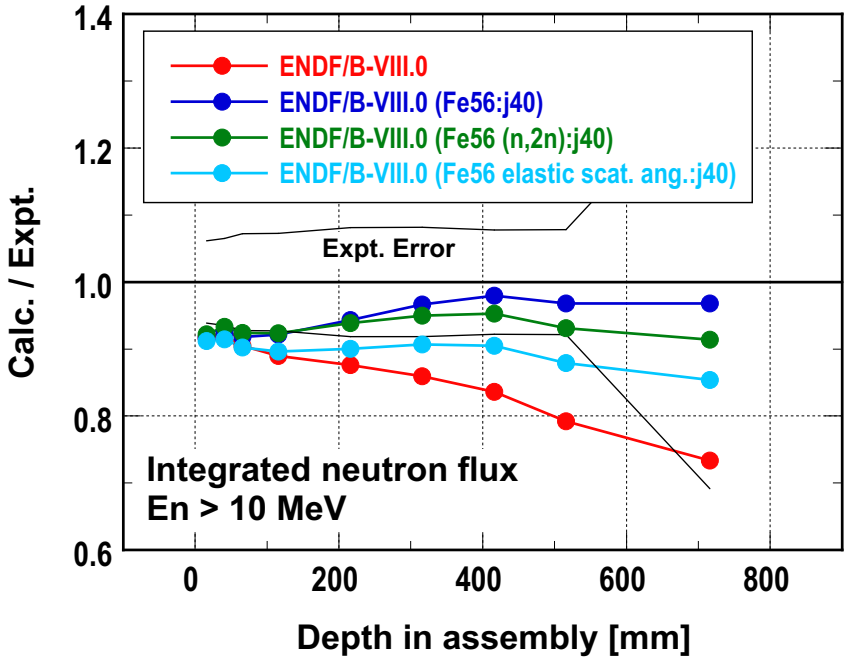




→ (n,2n) reaction cross section and angular distribution of elastic scattering around 0 degree are different between ENDF/B-VIII.0 and JENDL-4.0.

Problem 3 -(3)

- We replaced (n,2n) reaction cross section or angular distribution data of elastic scattering above 10 MeV in ^{56}Fe from ENDF/B-VIII.0 to JENDL-4.0 and analyzed the experiment.



- It is found out that both the data of ^{56}Fe in ENDF/B-VIII.0 mainly cause Problem 3.

Summary

- We found ENDF/B-VIII.0 caused the following problems through our analyses of iron in-situ experiment at JAEA/FNS.
  1. The neutron flux of 1 - 10 keV is overestimated more at shallower region.
  2. The reaction rate of ^{115}In(n,n')^{115m}In sensitive to neutrons above 0.3 MeV is underestimated more at deeper region.
  3. The neutron flux above 10 MeV is underestimated more at deeper region.
- This study specified reasons of the problems.
  - Problems 1 and 2 : inelastic scattering data of ^{56}Fe
  - Problem 3 : (n,2n) reaction data and angular distribution data of elastic scattering of ^{56}Fe

Thank you for your attention!