2023/24 Status Report of China Nuclear Data Center

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1. General Information of China Nuclear Data Center

China Nuclear Data Center (CNDC) was established in 1975 and has been participating in the International Atomic Energy Agency's nuclear data activities as the National Nuclear Data Center of China since 1984. As a window, CNDC has been open to the world since 1978 and has established good cooperative relationships with the International Atomic Energy Agency, OECD/National Energy Agency, as well as major nuclear data centers and institutions around the world.

1.1 The current main task of CNDC

1) Management of domestic nuclear data activities.
2) Nuclear data evaluations, libraries and relevant methodology studies.
3) Nuclear data measurements and methodology studies
4) Exchange of nuclear data activities with IAEA, foreign nuclear data centers and agencies.
5) Services for domestic and foreign nuclear data application users.

1.2 Mainly Tasks of CNDC in 2023/2024

1) Five-Year-Plan (2021-2025) for nuclear data (CENDL Project).
2) Data evaluation for next CENDL version and sub-library.
3) Methodology studies of nuclear data evaluation (incl. theoretical and experimental for fission process…).
4) Nuclear data measurements and related methodology studies.
5) Compilations for EXFOR.
6) Nuclear data services.

2. Nuclear Data Evaluation

2.1 CENDL Photonuclear Data file: CENDL-3.2/PD-beta

The Chinese Evaluated Photonuclear Data Library - Test Version (CENDL/PD-beta1) includes a total of 266 isotopes within the nuclear region from Beryllium-9 (^{9}Be) to Bismuth-209 (^{209}Bi) (see Table 1). The photon incident energy covers a range from neutron separation energy to 200 MeV, of which 15 isotopes (marked with an asterisk in Table 1 have been included in the IAEA/PD-2019 database by the International Atomic Energy Agency (IAEA).

Table 1. Nuclides List of CENDL-3.2/PD-beta

4-Be-9*, 5-B-10, 5-B-11, 6-C-12*, 7-N-14*, 8-O-16*, 11-Na-23, 12-Mg-24 ,12-Mg-25, 12-Mg-26, 13-Al-27*, 14-Si-28, 14-Si-29, 14-Si-30, 15-P-31, 16-S-32, 16-S-33, 16-S-34, 16-S-36, 17-Cl-35, 17-Cl-37, 18-Ar-36, 18-Ar-38, 18-Ar-40, 19-K-39, 19-K-40, 19-K-41, 20-Ca-40, 20-Ca-42, 20-Ca-43, 20-Ca-44, 20-Ca-46, 21-Sc-45, 22-Ti-46, 22-Ti-47, 22-Ti-48, 22-Ti-49, 22-Ti-50, 23-V-50, 23-V-51, 24-Cr-50*, 24-Cr-52, 24-Cr-53*, 24-Cr-54*, 25-Mn-55, 26-Fe-54, 26-Fe-56, 26-Fe-57, 26-Fe-58, 27-Co-59, 28-Ni-58, 28-Ni-60, 28-Ni-61, 28-Ni-62, 28-Ni-64,29-Cu-63, 29-Cu-65, 30-Zn-64, 30-Zn-66, 30-Zn-67, 30-Zn-68, 30-Zn-70, 31-Ga-69, 31-Ga-71, 32-Ge-70, 32-Ge-72, 32-Ge-73, 32-Ge-74, 32-Ge-76, 33-As-75, 34-Se-74, 34-Se-76, 34-Se-77, 34-Se-78,
34-Se-80, 34-Se-82, 35-Br-79, 35-Br-81, 36-Kr-78, 36-Kr-80, 36-Kr-82, 36-Kr-83, 36-Kr-84, 36-Kr-86, 37-Rb-85, 37-Rb-87, 38-Sr-84, 38-Sr-86, 38-Sr-87, 38-Sr-88, 39-Y-89, 40-Zr-90*, 40-Zr-91, 40-Zr-92, 40-Zr-94, 40-Zr-96, 41-Nb-93, 42-Mo-92, 42-Mo-94,42-Mo-95,42-Mo-96,42-Mo-97,42-Mo-98,42-Mo-100,44-Ru-96,44-Ru-98,44-Ru-99,44-Ru-100,44-Ru-101,44-Ru-102,44-Ru-104,45-Rh-103, 46-Pd-102,46-Pd-104,46-Pd-105,46-Pd-106,46-Pd-108,46-Pd-110,47-Ag-107,47-Ag-109,48-Cd-106,48-Cd-108,48-Cd-110,48-Cd-111,48-Cd-112,48-Cd-113,48-Cd-114, 48-Cd-116,49-In-113,49-In-115,50-Sn-112,50-Sn-114,50-Sn-115,50-Sn-116,50-Sn-117,50-Sn-118*,50-Sn-119,50-Sn-120,50-Sn-122,50-Sn-124,51-Sb-121,51-Sb-123,52-Te-120,52-Te-122, 52-Te-123,52-Te-125,52-Te-126,52-Te-128,52-Te-130,53-I-127,54-Xe-124,54-Xe-126,54-Xe-128,54-Xe-129,54-Xe-130,54-Xe-131,54-Xe-132,54-Xe-134,54-Xe-136,55-Cs-133,56-Ba-130,56-Ba-132,56-Ba-134,56-Ba-135,56-Ba-136,56-Ba-137,56-Ba-138,57-La-138,57-La-139,
58-Ce-136,58-Ce-138,58-Ce-140,58-Ce-142,59-Pr-141,60-Nd-142,60-Nd-143,60-Nd-144,60-Nd-145,60-Nd-146,60-Nd-148,60-Nd-150,62-Sm-144,62-Sm-147,62-Sm-148,62-Sm-149,62-Sm-150,62-Sm-152,62-Sm-154,63-Eu-151,63-Eu-153,64-Gd-152,64-Gd-154,64-Gd-155,64-Gd-156,64-Gd-157,64-Gd-158,64-Gd-160,65-Tb-159,66-Dy-156,66-Dy-158,66-Dy-160,66-Dy-161,66-Dy-162,66-Dy-163,66-Dy-164,67-Ho-165,68-Er-162,68-Er-164,68-Er-166,68-Er-167,68-Er-168,68-Er-170,69-Tm-169,70-Yb-168,70-Yb-170,70-Yb-171,70-Yb-172,70-Yb-173,70-Yb-174,70-Yb-176,71-Lu-175,71-Lu-176,72-Hf-174,72-Hf-176,72-Hf-177,72-Hf-178, 72-Hf-179,72-Hf-180,73-Ta-180,73-Ta-181,74-W-180*,74-W-182*,74-W-183*,74-W-184*,74-W-186*,75-Re-185,75-Re-187,76-Os-184,76-Os-186,76-Os-187,76-Os-188,76-Os-189,76-Os-190,77-Ir-191,77-Ir-193,78-Pt-190,78-Pt-192,78-Pt-194,78-Pt-195,78-Pt-196,78-Pt-198,79-Au-197,80-Hg-196,80-Hg-198,80-Hg-199,80-Hg-200,80-Hg-201,80-Hg-202,80-Hg-204,81-Tl-203, 81-Tl-205,82-Pb-204,82-Pb-206,82-Pb-207,82-Pb-208,83-Bi-209

2.2 Fission yield evaluation with Zp model and machine learning

An evaluation platform (named ZpFit) based on the Zp model has been developed to evaluate the independent and cumulative yields simultaneously, which decay branching data is from CENDL/DDP. NDPLOT is used to retrieved the experimental data from EXFOR library. Fig. 2 shows the evaluation result of products of A = 140 for nth + ^{235}U fission, where the increasing lines stand for the cumulative yields, and decreasing lines from ^{140}Xe stands for the independent yields. Fig. 3 is the yields correlation coefficient of the above products.

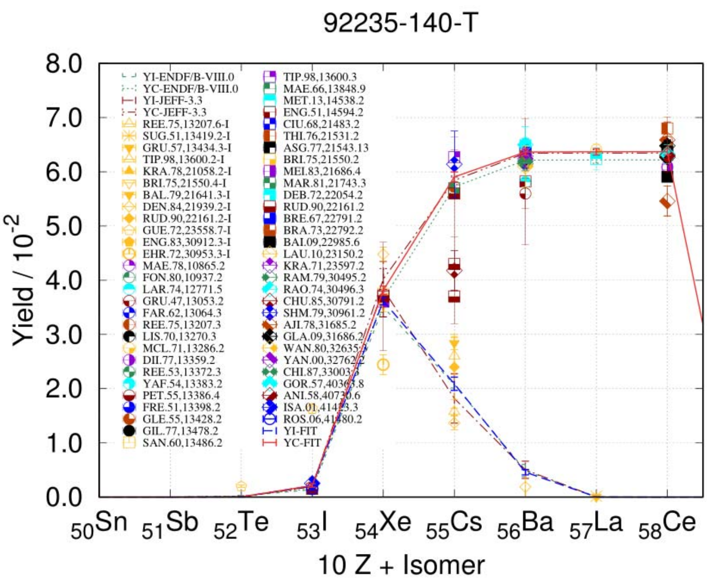

Fig. 1 Yield evaluation for nth + ^{235}U, A = 140

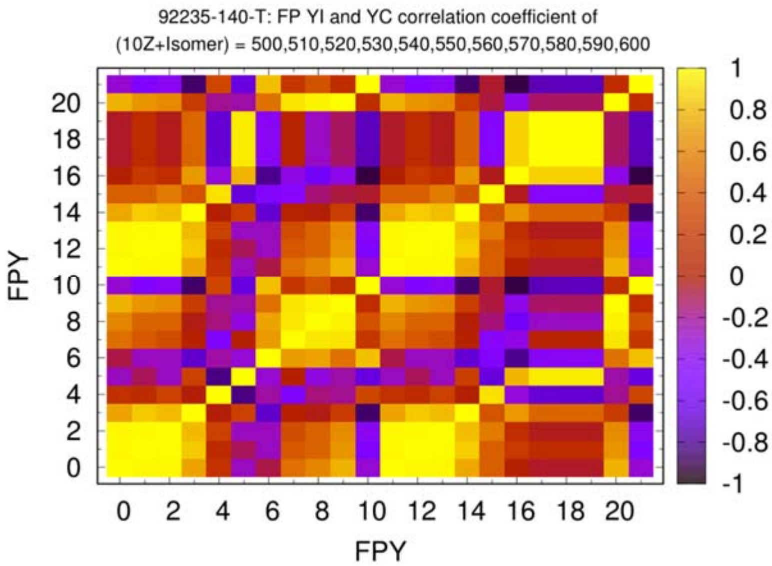

Fig. 2 The yields correlation coefficient of the products of A =140 for nth + ^{235}U fission

The Gaussian Process Regression (GPR) model is used to learn from experimental data on the neutron-induced fission yield of ^{235}U. The results show that the machine learning prediction are consistent well with the with experimental data.

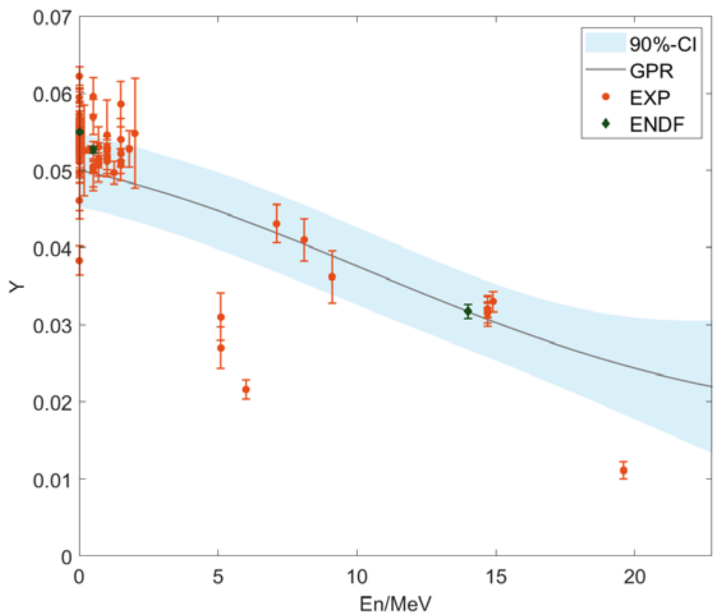

Fig. 3 The chain yield - energy relation of A = 140 of n + ^{235}U fission

3. Progress of nuclear structure theory

Study of U-isotope ground state properties with covariant

We have systematically analyzed the ground state of uranium isotopes from 225 to 240. By comparison with experimental data and Hartree-Fock-Bogoliubov calculations with Gogny D1S, the ground state of the uranium isotopes is always preferred to reflection-asymmetric deformation with our calculation. Fig.4 are the results of the binding energies.

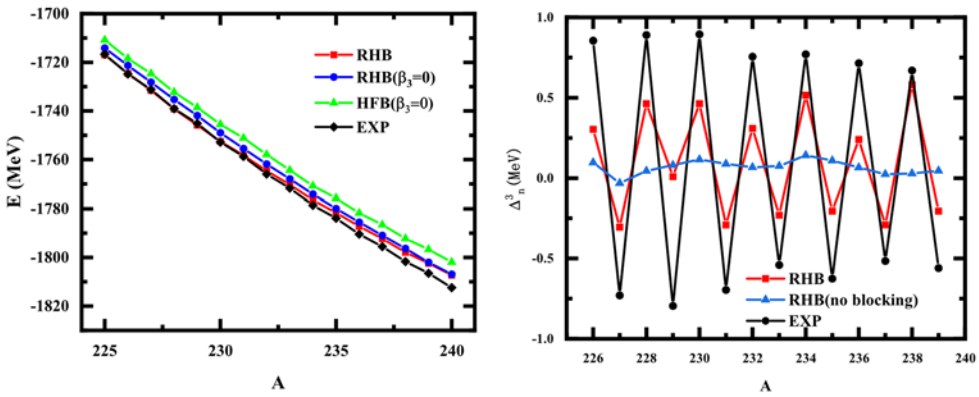

Fig. 4 (Left) Comparison of ground state binding energies of U-isotopes. A represents the mass number of uranium. The red curve is the result of the RHB calculation including the octupole deformation, the blue curve is the result of the RHB calculation considering only the symmetric cases, the green curve is the result of the non-relativistic Hartree-Fock-Bogoliubov calculation, and the black curve represents the experimental values. (Right) Comparison of three-point pairing energy of U-isotopes. The red curve is the result of the RHB calculation with blocking, the blue curve is the result of the RHB calculation without blocking, and the black curve represents the experimental values.

4. EXFOR activities and nuclear data services

4.1. Compilation and Scanning

Since the last NRDC meeting, we have compiled 35 new entries (summarized in Table 2), 31 neutron entries of which are contained in 2 final TRANS tapes (3209 and 3210), 4 CNPD entries of which are contained in final TRANS S033. The 3209 and 3210 have been transmitted by NDS, and S033 has been transmitted by CNDC.

Currently CNDC is responsible for scanning of 8 journals of China, namely ASI, CNPR, CNST, CPH/C, CPL, CST, HFH and NTC. The ASI is semimonthly, the HFH is bimonthly, the CNPR is quarterly and others are monthly. The scanning results are transmitted to NDS every month.

Table 2 New entries since the last NRDC meeting

No.	Entry No.	1st author	Reference	Status
1	32857	S. Q. Yan	J,AJ,919,84,2021	TRANS 3209
2	32860	Luocheng Yang	J,ANE,165,108780,2022	TRANS 3209
3	32862	Zengqi Cui	J,EPJ/A,57,310,2021	TRANS 3209
4	32868	Zhang Jiang-Lin	J,ASI,71,052901,2022	TRANS 3209
5	32869	Wang De-Xin	J,ASI,71,072901,2022	TRANS 3209
6	32870	Jie Ren	J,CPH/C,46,044002,2022	TRANS 3209
7	32873	Yu.M.Gledenov	J,EPJ/A,58,86,2022	TRANS 3209
8	32886	Zhizhou Ren	J,EPJ/A,59,5,2023	TRANS 3209
9	32810	X. X. Li	J,PR/C,106,065804,2022	TRANS 3210
10	32814	Yong Li	J,CPH/C,44,124001,2020	TRANS 3210
11	32819	Group	J,CST,2,1,1960	TRANS 3210
12	32820	Huang Shengnian	J,CST,3,585,1961	TRANS 3210
13	32822	Liang Qichang	J,CST,3,199,1961	TRANS 3210
14	32824	Li Guanhua	J,CST,3,106,1961	TRANS 3210
15	32825	Hu Ji'an	J,CST,6,554,1964	TRANS 3210
16	32826	Hu Xuanwen	J,CST,6,368,1964	TRANS 3210
17	32827	Ye Chuntang	J,CST,6,349,1964	TRANS 3210
18	32828	Yuan Harong	J,CST,6,127,1964	TRANS 3210
19	32832	Wang Yusheng	J,CST,6,1,1964	TRANS 3210
20	32833	Ruan Jinghui	J,CST,7,108,1965	TRANS 3210

21	32834	Group	J,CST,9,285,1975	TRANS 3210
22	32835	Chen Ying	J,CST,10,146,1976	TRANS 3210
23	32837	Ruan Jinghui	J,CST,11,335,1977	TRANS 3210
24	32840	Li Ze	J,CST,14,98,1980	TRANS 3210
25	32841	Ma Weiyi	J,CST,16,4,1982	TRANS 3210
26	32844	Huang Ruiliang	J,CST,31,55,1997	TRANS 3210
27	32845	Yuan Junqian	J,CTNP,11,65,1994	TRANS 3210
28	32861	X. X. Li	J,PR/C,104,054302,2021	TRANS 3210
29	32887	Yonghao Chen	J,PL/B,839,137832,2023	TRANS 3210
30	32888	Chao Liu	J,NIM/A,1041,167319,2022	TRANS 3210
31	32889	Ren	J,CNST,34,115,2023	TRANS 3210
32	S0239	Chen Zhiqiang	J,CNPR,19,387,2002	TRANS S033
33	S0240	Li Gongping	J,CNPR,19,39,2002	TRANS S033
34	S0247	Yang Lei	J,CNPR,30,117,2013	TRANS S033
35	S0259	Wu Meizhen	J,CST,3,701,1961	TRANS S033

2. Visits and Cooperation

Nengchuan SHU, Jimin WANG and Xi TAO visited IAEA from 9 to 12 May 2023 to attend the NRDC 2023 meeting. Naohiko OTSUKA visited CNDC from 18 to 22 September 2023 to discuss finalization of EXFOR entries compiling data measured in China.