2021/22 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 joined the nuclear data activities of IAEA as the national nuclear data center of China since 1984. As a window, CNDC has been open to the world since 1978 and CNDC has established a good cooperative relationship with the IAEA, OECD/NEA, and major nuclear data centers and institutions in the world.

1-1. The current main task of CNDC

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

1-2. Mainly Tasks of CNDC in 2021/2022

1) New Five Years Plan (2021-2025) for nuclear data (CENDL Project).
2) Data evaluation for next CENDL version and sub-library.
3) Methodological studies of nuclear data evaluation (incl. theoretical and experimental for fission process…).
4) Nuclear data measurements and related methodological studies.
5) The compilations for EXFOR.
6) Nuclear data services.

2. Nuclear Data Evaluation

2-1. Neutron Activation File - CNAF

The first release CENDL-CNAF included 818 nuclei from ^{1}H to ^{257}Fm within the neutron energy region of from 10^{-5} eV to 20 MeV. The ENDF/B-6 data format was adopted. The general information, comments (MF=1), reactions cross sections (MF=3), nucleus dictionary (MF=8), and split threshold reaction channels (MF=10) are included in the library. Evaluations were obtained using APMN, Unified Hauser-Feshbach and Exciton model (UNF series), Full and Diagonal Reduced R-matrix (FDRR) model calculations or systematic analysis based on available experimental data. When there have many experimental data for a reaction channel, the evaluated experimental data were selected for curve fitting by using a program of orthogonal polynomial fit or spline function fit from threshold to 20 MeV. The fitting results were adopted. For convenient used in applications, all resonance parameters are already converted into a linearized point-wise format, and reasonably connected at the boundary energy. To calculate the point-wise cross, The ENDF/B Pre-processing codes (PREPRO) were used.

2-2. Radioactive Decay Data File: DDL1.0

The CENDL-DDL included 2350 nuclei between A=66 to A=172 FY region. ENSDF and ENDF format were adopted. Evaluations taken from: (1) CNDC+ Jilin Univ.: ~500 nuclei; (2) DDEP: ~200 nuclei; (3) ENSDF: ~1500 nuclei; (4) JEF3.2: ~150 nuclei (only for stable nuclei). The Q-values of the decay modes are updated to the Atomic Mass Evaluation (AME) released in 2021Wa16. Jπ for g.s. (Jilin Univ.): by systematical comparison, physical analysis and theoretical calculation, spin for ground states is re-assigned for which lacks measurement or questionable. All

T1/2 are revised by new measurements (2021, 12). Mean energies for β & γ: from TAGS measurements when available, otherwise from theoretical calculation. For even-even nuclides, from theoretically analysis which employed the self-consistent quasi-particle random phase approximation (QRPA) approach based on covariant density functional theory (CDFT) in Jilin University. Beta-delayed n, p, α emitted are adopted: P1n, P2n from eva. of 2015Bi05, 2020Li32; P1p,P1α from eva. of 2020Ba07 when measurements available. Otherwise from systematics or theoretical calculation.

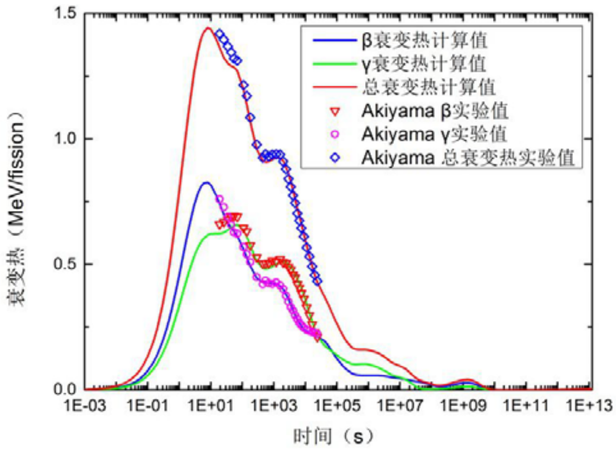

Fig.1 Decay heat after ^{235}U fast neutron fission.

2-3. The CENDL Sub-library: Photonuclear Data file:PD

The photonuclear data for a total number of 264 materials are all newly evaluated and outputted with the standard ENDF-6 format. All of the photonuclear data are mainly evaluated based on the theoretical calculations with the Chinese photonuclear reaction codes GLUNF for the light 6 nuclei and MEND-G for the medium-heavy 264 nuclei. The incident photon energies for the medium-heavy nuclei are up to 200MeV. In order to extend the incident energy to 200MeV, the n, p, d, t, He-3, α are considered to totally 18th particle emission reactions in the MEND-G code.

To ensure the availability and reliability of the PD file, nuclear data processing code system NJOY2016 and MCNP6 are used to verify and validate the PD library. The testing results show that the data structure of each nuclide is complete, the data content is reasonable, and can be applied to the simulation of Monte Carlo transport.

Table 1 Nuclides List for CENDL-3.2/PD

Light elements	Be-9,B-10,11,C-12,N-14,O-16	6
Medium-heavy elements	Mg-25,26,Al-27,Si-28,29,30,P-31,S-32,33,34,36,Cl-35,37,Ar-36,38,40,K-39,40,41,Ca-40,42,43,44,46,Sc-45,Ti-46,47,48,49,50,V-50,51,Cr-50,52,53,54,Mn-55,Fe-54,56,57,58,Co-59,Ni-58,60,61,62,64,Cu-63,65,Zn-64,66,67,68,70,Ga-69,71,Ge-70,72,73,74,76,As-75,Se-74,76,77,78,80,82,Br-79,81,Kr-78,80,82,83,84,86,Rb-85,87,Sr-84,86,87,88,Y-89,Zr-90,91,92,94,96,Nb-93,Mo-100,92,94,95,96,97,98,Ru-100,101,102,104,96,98,99,Rh-103,Pd-102,104,105,106,108,110,Ag-107,109,Cd-106,108,110,111,112,113,114,116,In-113,115,Sn-112,114,115,116,117,118,119,120,122,124,Sb-121,123,Te-120,122,123,125,126,128,130,I-127,Xe-124,126,128,129,130,131,132,134,136,Cs-133,Ba-130,132,134,135,136,137,138,La-138,139,Ce-136,138,140,142,Pr-141,Nd-142,143,144,145,146,148,150,Sm-144,147,148,149,150,152,154,Eu-151,153,Gd-152,154,155,156,157,158,160,Tb-159,Dy-156,158,160,161,162,163,164,Ho-165,Er-162,164,166,167,168,170,Tm-169,Yb-168,170,171,172,173,174,176,Lu-175,176,Hf-174,176,177,178,179,180,Ta-180,181,W-180,182,183,184,186,Re-185,187,Os-184,186,187,188,189,190,Ir-191,193,Pt-190,192,194,195,196,198,Au-197,Hg-196,198,199,200,201,202,204,Tl-203,205,Pb-204,206,207,208, Bi-209	258

3. Fundamental theory study for fission data

Method 1: The Langevin approach is extendedly applied to study the dynamical process of nuclear fission within the Fourier shape parameterization.

- macroscopic energy – Lublin-Strasbourg Drop model
- single-particle levels – Yukawa-folded potential
- shell correction – Strutinsky method
- pairing correction – BCS method

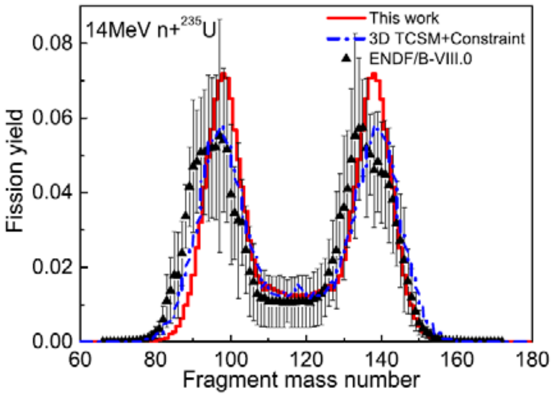

Fig. 2 The calculated fragment mass distribution in 14 MeV n + ^{235}U fission with the present model (red curve) compared with the result calculated with the 3D Langevin approach plus a constraint on the heavy fragment deformation based on the TCSM (blue dashed-dot curve) and the evaluated data from ENDF/B-VIII.0.

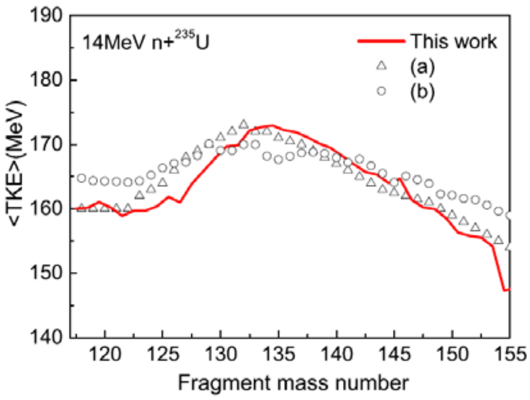

Fig. 3 The calculated TKE as a function of the heavy fragment mass in 14 MeV n + ^{235}U fission compared with the experimental data.

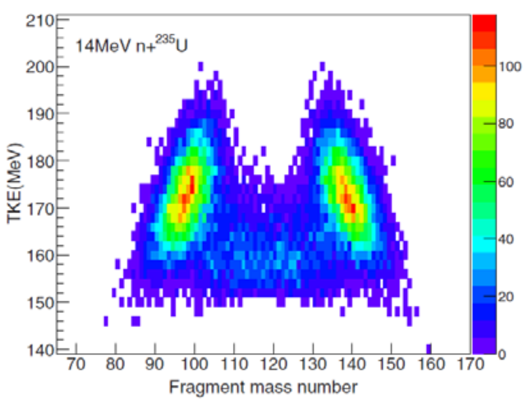

Fig. 4 The calculated mass-energy correlation of the fission fragments in 14 MeV n + ^{235}U fission.

Method 2: Using the 3D Langevin approach within the two-center shell model parameterization, the fission fragment mass distributions of U, Np and Pu isotopes are well reproduced and the systematic dependence of the averaged TKE on the Coulomb parameter is also well reproduced.

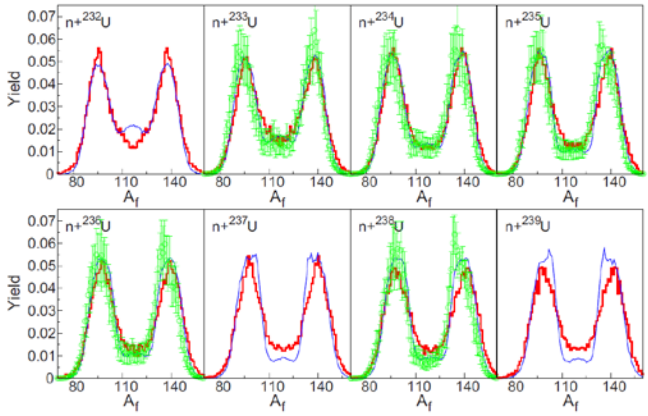

Fig.5 The calculated fragment mass distribution in 14 MeV n + $^{232-239}$U fission (red curve), compared with the primary fragment mass distribution calculated with the GEF model (blue curve) and the evaluated data from ENDF/B-VIII.0 (green circle).

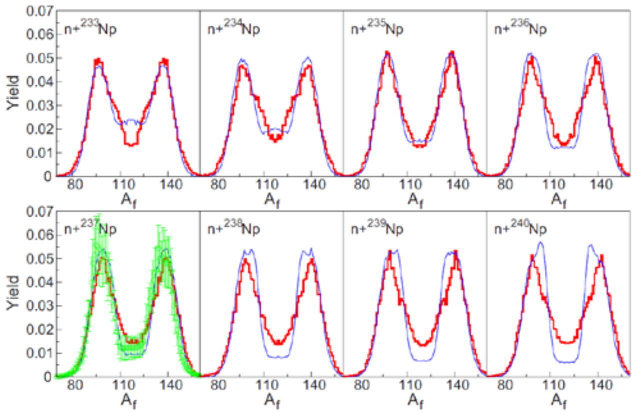

Fig.6 The calculated fragment mass distribution in 14 MeV n + $^{233-240}$Np fission (red curve), compared with the primary fragment mass distribution calculated with the GEF model (blue curve) and the evaluated data from ENDF/B-VIII.0 (green circle).

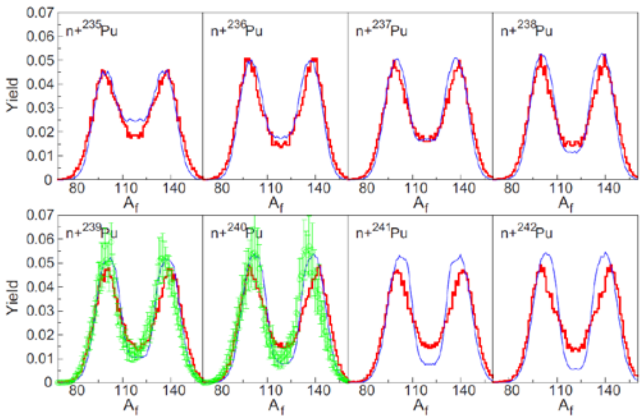

Fig.7 The calculated fragment mass distribution in 14 MeV n + $^{235-242}$Pu fission (red curve), compared with the primary fragment mass distribution calculated with the GEF model (blue curve) and the evaluated data from ENDF/B-VIII.0 (green circle).

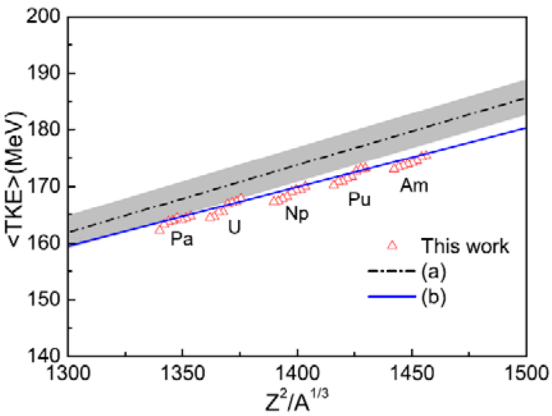

Fig.8 The calculated systematic dependence of the averaged TKE on the Coulomb parameter Z2/A1/3 of the fissioning systems.

4. EXFOR activities and nuclear data services

4-1. EXFOR Compilation

More than 445 entries were compiled at CNDC. Since 2010, more than 315 entries were finalized, which included 164 neutron and 151 charged particle entries. Feedback and correction performed for more than 110 entries. Since the last NRDC meeting (2021-04-14), 35 new entries have been finalized and 16 entries have been revised, more than 98 articles under compiling.

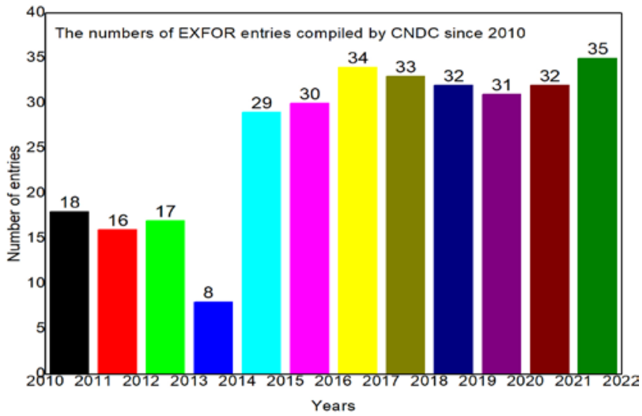

Fig. 9 The number of the finalized EXFOR entries

Table 2 New entries since the last NRDC meeting (2021-04-14)

No.	Entry No.	1st author	Reference	Status
1	32765	Changlin Lan	J,EPJ/A,53,131,2017	3200
2	32768	Qiang Wang	J,ARI,147,144,2019	3200
3	32770	S.Q.Yan	J,AJ,848,98,2017	3200
4	32778	Zhang Zhengwei	J,RPC,141,138,2017	3200
5	32784	Qiang Wang	J,RPC,152,125,2018	3206
6	32795	Fengqun Zhou	J,NIM/B,451,24,2019	3200
7	32797	Xiaojun Sun	J,CPL,36,112501,2019	3200
8	32799	Qiang Wang	J,NIM/B,469,28,2020	3200
9	32801	Chuanxin Zhu	J,CPH/C,44,034001,2020	3200
10	32802	Zhiling Yuan	J,JRN,324,277,2020	3200
11	32805	Junhua Luo	J,EPJ/A,56,125,2020	3200
12	32806	Su Shen	J,NIM/B,476,59,2020	3200
13	32811	Zhizhou Ren	J,PR/C,102,034604,2020	Finalized
14	32813	Haoyu Jiang	J,CPH/C,44,114102,2020	3206
15	32815	Nanru Ma	J,EPJ/CS,239,01007,2020	3206
16	32846	Shi Shuting	J,CNPR,24,29,2007	3206
17	32847	Jiang Jing	J,CNPR,32,435,2015	3207
18	32848	Wang Taofeng	J,CNPR,32,280,2015	3207

No.	Entry No.	1st author	Reference	Status
19	32851	Xinyi Chang	J,ARI,170,109588,2021	3206
20	32855	Junhua Luo	J,RCA,109,513,2021	Finalized
21	32856	Xin-Rong Hu	J,CNST,32,101,2021	Finalized
22	32858	Haoyu Jiang	J,EPJ/A,57,6,2021	3206
23	S0233	Yiming Duan	J,NIM/B,483,1,2020	S030
24	S0234	G. S. Li	J,PR/C,102,054607,2020	S030
25	S0235	F.F. Duan	J,PL/B,811,135942,2020	Finalized
26	S0250	Ma Nanru	J,CNPR,34,351,2017	S030
27	S0254	Li Junsheng	J,CNPR,34,545,2017	S030
28	S0255	Chen Zhijun	J,CNPR,34,705,2017	S030
29	S0261	Wang Tieshan	J,CST,35,496,2001	Finalized
30	S0262	Sun Xufang	J,CST,42,875,2008	Finalized
31	S0265	K. Wang	J,PR/C,103,024606,2021	S030
32	S0268	Jipeng Zhu	J,NIMB,494-495,23,2021	S030
33	S0269	C. H. Rong	J,EPJ/A,57,143,2021	S030
34	S0272	Wei Hua	J,CPH/C,45,044003,2021	S030
35	S0273	W. H. Ma	J,PR/C,103,L061302,2021	Finalized

4-2. Nuclear data services and dissemination

CNDC provides the nuclear data service for institutes, universities or other requirements in China. CNDC joined the developing of Chinese basic database and established the Website of “The Database of Nuclear Physics”. The Fission Yield (1.0beta) App was developed by CNDC. This App can retrieve the fission product yield data of neutron-induced fission and spontaneous fission from various evaluated data libraries: CENDL-TMSR, ENDF/B-VIII.0, JENDL-5.0, and JEFF-3.3 etc. The retrieved data can be shown as plot and saved in JPG and text formats for exchange.

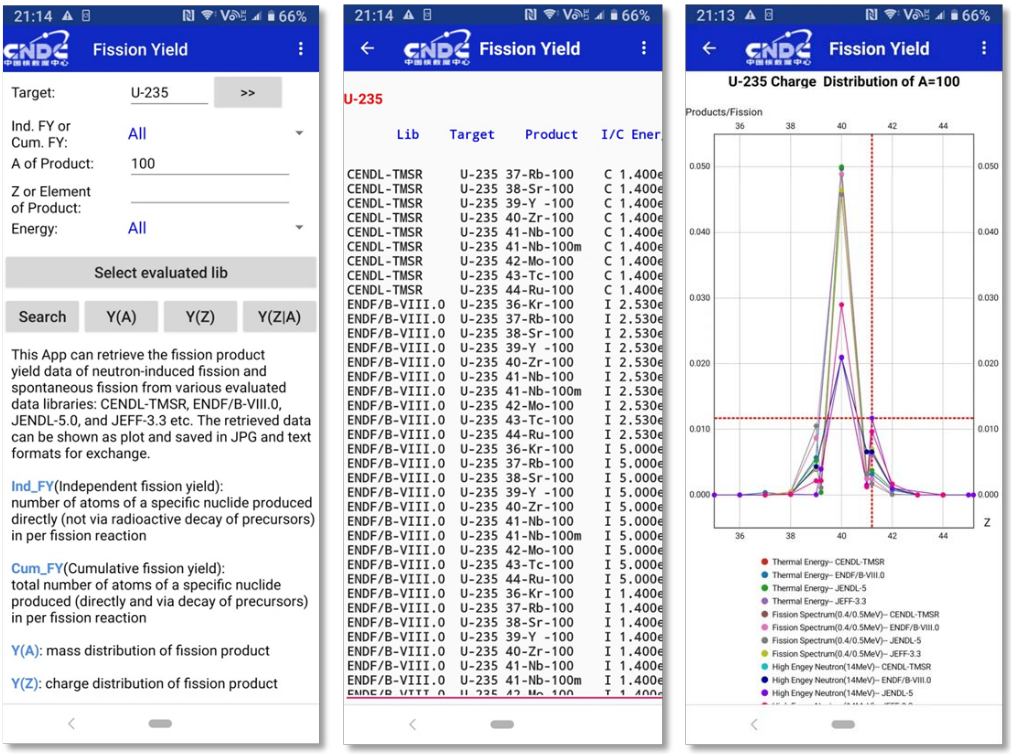

Fig.10 Interface of the Fission Yield (1.0beta) App