中国原子能科学研究院
CHINA INSTITUTE OF ATOMIC ENERGY
中核集团 CNNC

2022/23 Status Report of China Nuclear Data Center

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China Nuclear Data Center
China Institute of Atomic Energy (CIAE)

Presentation for Technical Meeting on the International Network of Nuclear Reaction Data Centres, 8-9 May, 2023 Vienna, Austria

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2. Status of CENDL-3.2 and sub-libraries
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1. General Information of CNDC

China Nuclear Data Center (CNDC), established in 1975, located on the south-west of Beijing and about 40 km away from Beijing Tiananmen Square.

2 divisions （Evaluation and Experiment Divisions） and total 60 staffs.

Research fields: nuclear data related experiment, theory, evaluation, multi-group constant library generation and benchmark testing.

2. Status of CENDL-3.2 and sub-library

2.1 CENDL-3.2

was released in 2020, containing mainly the neutron data of 272 nuclides from neutron to ^{241}Am. 135 Nuclides were Newly Evaluated or Updated， 137 Nuclides were Inherited from CENDL-3.1 .

UNF is the main reaction program used in evaluation.

Newly Evaluated (58 nuclides):

n-1, H-1, Na-23, Al-27, S-32, S-33, S-34, S-36, Ca-40, Fe-56, Ni-58, Zn-64, Zn-66, Zn-67, Zn-68, Zn-70, Se-74, Se-76, Se-77, Se-78, Se-79, Se-80, Se-82, Kr-87, Kr-88, Mo-93, Mo-99, Sn-126, Sn-128, Sb-124, Sb-127, I-130, I-131, Xe-123, Xe-124^{b}, Xe-129, Xe-131, Xe-132^{b}, Xe-133, Xe-134^{b}, Xe-135^{b}, Xe-136, La-139^{b}, Ce-140, Ce-141^{b}, Ce-142, Ce-144^{b}, Ho-165, W-180, W-182, W-183, W-184, W-186, U-236, U-240, Np-236, Pu-238, Am-241.

The average values of C/E-1, standard deviation and χ^2

Type	Cases	Quantity	ENDF/B-VIII.0	JENDL-4.0	JEFF-3.2	CENDL-3.1	CENDL-3.2
U-235	686	Average	-20	26	62	182	-84
		STDEV	703	772	750	779	758
		χ2	**12.32**	**13.56**	**12.41**	**23.94**	**9.66**
Pu	376	Average	93	554	210	764	4
		STDEV	488	561	504	769	554
		χ2	**2.26**	**4.91**	**2.80**	**9.05**	**3.27**
U-233	164	Average	606	606	607	610	606
		STDEV	1127	1031	1091	1197	1139
		χ2	4.87	4.82	4.32	6.57	5.30

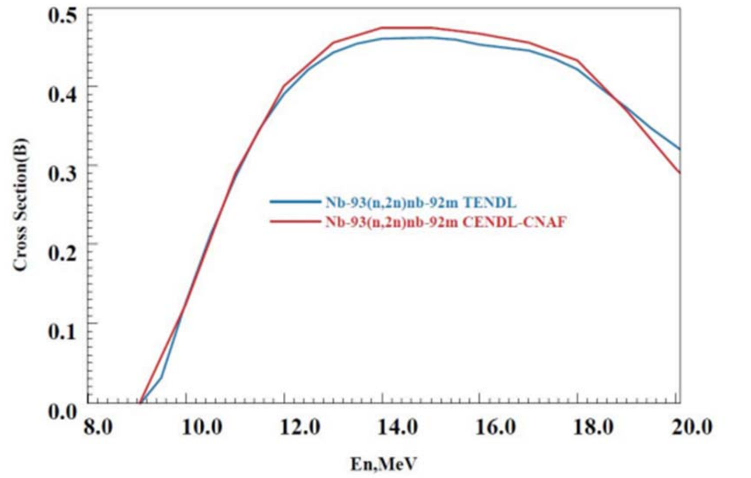
Benchmark test of was performed with ENDITS-1.0, an integrated benchmarking test system including 1261 criticality benchmark configurations. As shown in Table , the χ^2 value shoews that CENDL-3.2 has got good improvement for ^{235}U and Pu systems.

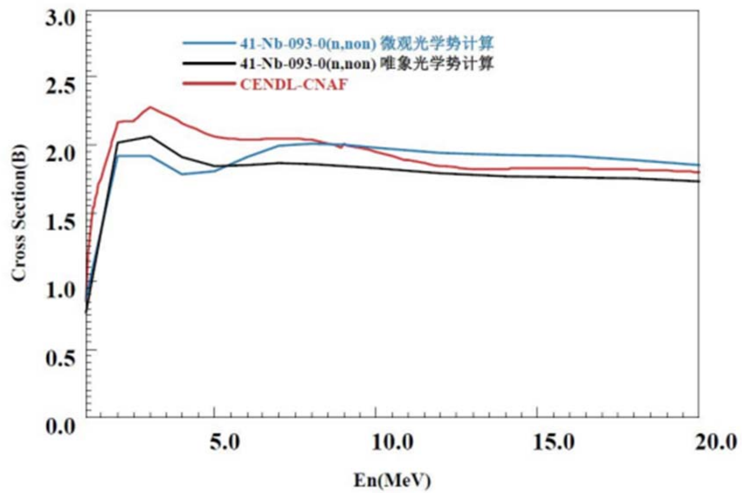
2.2 CENDL Sub-library:Neutron Activation File –CENDL/CNAF

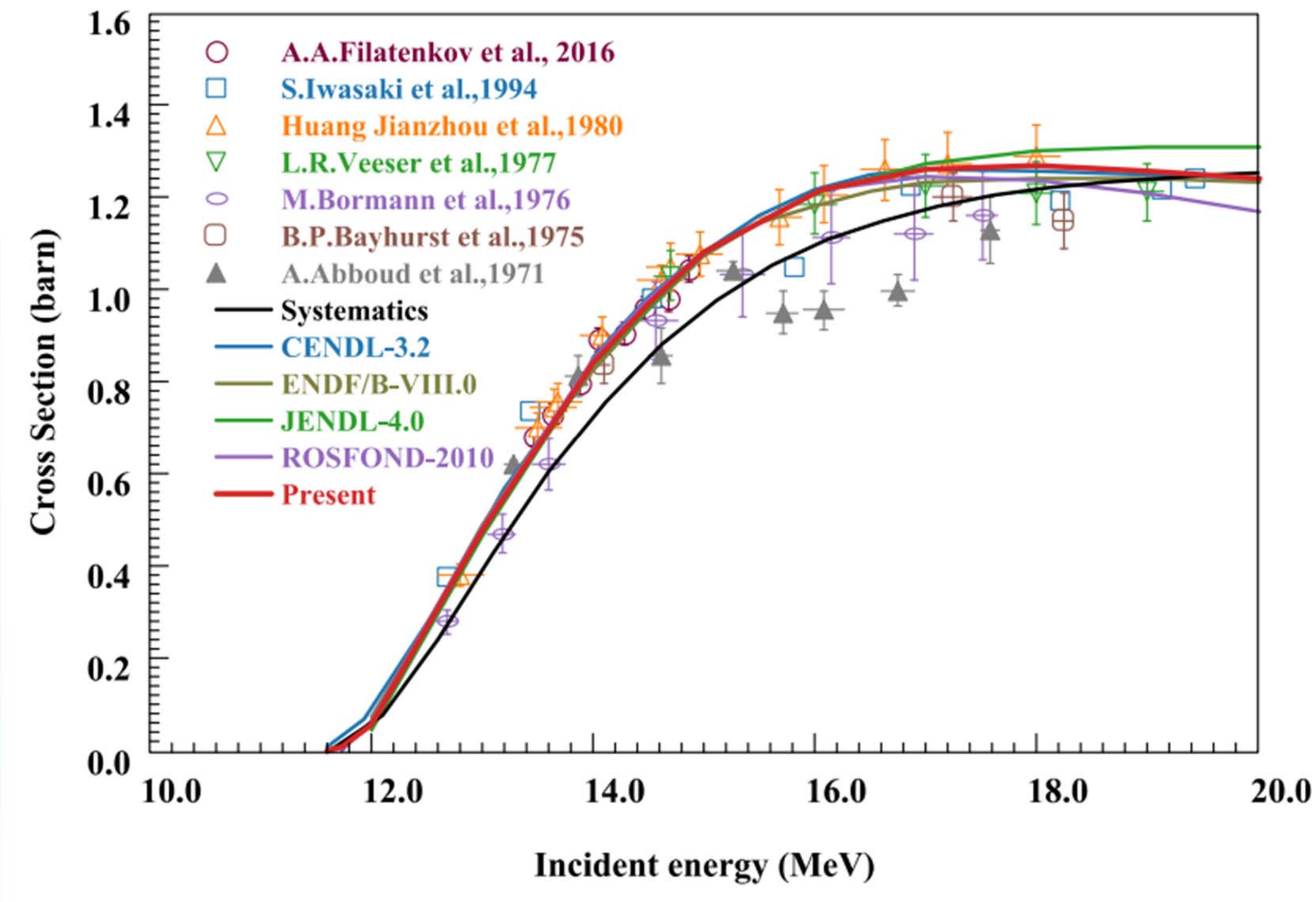
- CNAF includes 818 nuclei from 1H to 257Fm within the neutron energy range of 10^{-5} eV to 20 MeV.
- General information, comments (MF=1), reactions cross sections (MF=3), nucleus dictionary (MF=8), and split threshold reaction channels (MF=10) are included in the library.
- Evaluations were obtained 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.
- For convenient used in applications, all resonance parameters were converted into linearized point-wise format, and connected at the boundary energy. To calculate the point-wise cross, The ENDF/B Pre-processing codes (PREPRO) were used.

11 Nuclear reaction channels in activation data library

MT	File types
102	(n,γ) reaction
16	(n,2n) reaction
17	(n,3n) reaction
18	(n,f) reaction
103	(n,p) reaction
107	(n,α) reaction
105	(n,t) reaction
106	(n,^{3}He) reaction
104	(n,d) reaction
28	(n,n'p) reaction
22	(n,n'α) reaction







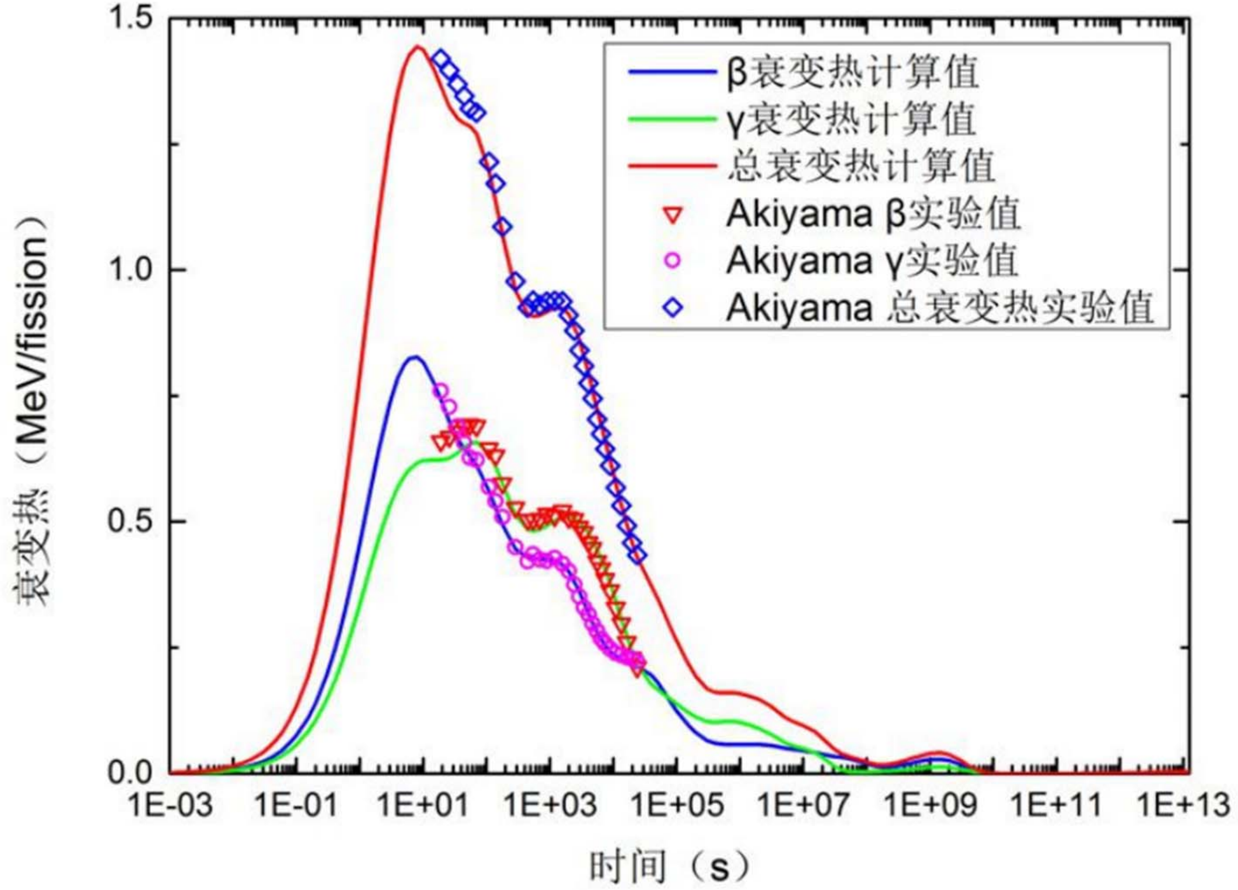
89Y(n,2n) 88Y reaction

2.3 Radioactive Decay Data File: CENDL- DDL

- The DDL included 2350 nuclei from A=66 to A=172 (FY region) with ENSDF and ENDF formats. Evaluations are taken from : (1) CNDC & Jilin Univ.: ~500 nuclei； (2) DDEP: ~200 nuclei; (3) ENSDF: ~1500 nuclei; (4) JEF3.2: ~150 nuclei (for stable nuclei);
- J 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 seems questionable.
- All T-half are revised by new measurements (2021,12).
- Mean energies for emitting beta & gamma by Jilin University : from TAGS measurements if available, otherwise from theoretical calculation. For even-even nuclides, from theoretical analysis where QRPA approach is employed based on CDFT.

  ORPA: the self-consistent quasi-particle random phase approximation;
  CDFT: covariant density functional theory.
- Beta-delayed n, p emitted are adopted from literatures and systematics or theoretical calculation. P1n, P2n from eva. of 2015Bi05, 2020Li32; P1p,P1 from eva. of 2020Ba07 when measurements available. Otherwise from systematics or theoretical calculation.

CENDL-DDL test



Decay heat after 235U fast neutron fission

2.4 The CENDL Sub-library: Photonuclear Data file:PD

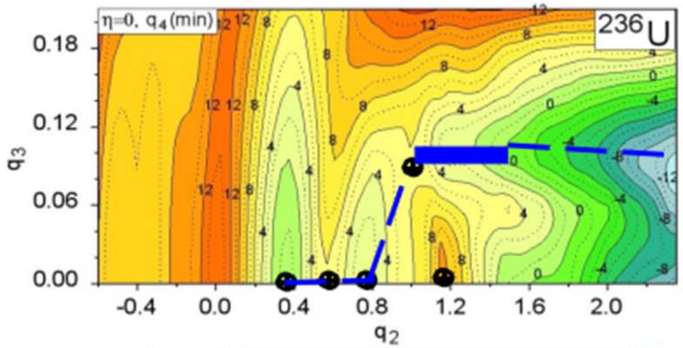
- Total of 264 materials are all newly evaluated and with ENDF-6 format.
- Mainly based on theoretical calculations with the Chinese photonuclear reaction codes GLUNF for the 6 light nuclei and MEND-G for the 264 medium-heavy nuclei.
- The incident photon energies for the medium-heavy nuclei are up to 200 MeV. 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.

Type	Nuclides	
Light	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-124,126,128-132,134,136, Cs-133, Ba-130,132,134-138,La-138,139,Ce-136,138,140,142,Pr-141, Nd-142-146,148,150,Sm-144,147-50,152,154,Eu-151,153, Gd-152,154-158,160,Tb-159,Dy-156,158,160-164,Ho-165, Er-162,164,166-168,170,Tm-169,Yb-168,170-174,176,Lu-175,176, Hf-174,176-180,Ta-180,181,W-180,182-184,186,Re-185,187, Os-184,186-190,Ir-191,193,Pt-190,192,194-196,198,Au-197, Hg-196,198,199-202,204,Tl-203,205,Pb-204,206-208, Bi-209	258

3. Progress of theory, evaluation and experiments
3.1 Fission Theory

- The **Langevin approach** is extendedly applied to study the dynamical process of nuclear fission within the **Fourier shape parametrization** **(method 1)**.

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



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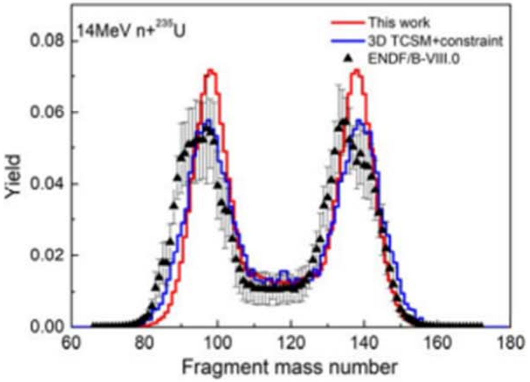
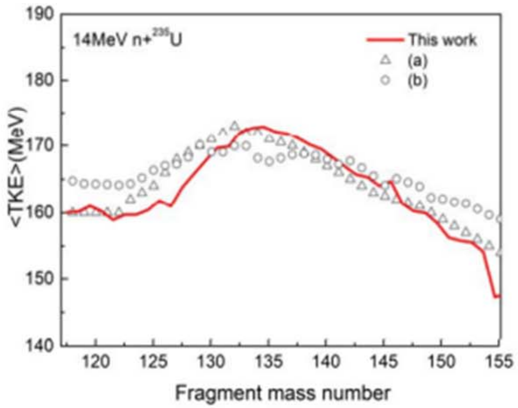
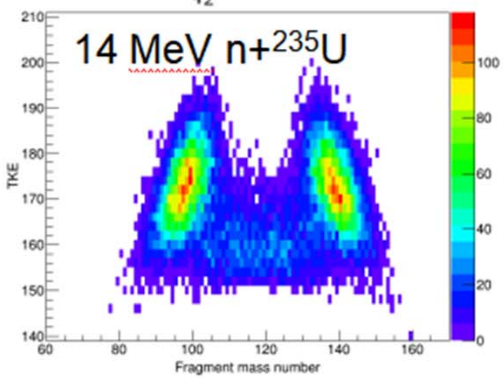
National Natural Science Foundation of China



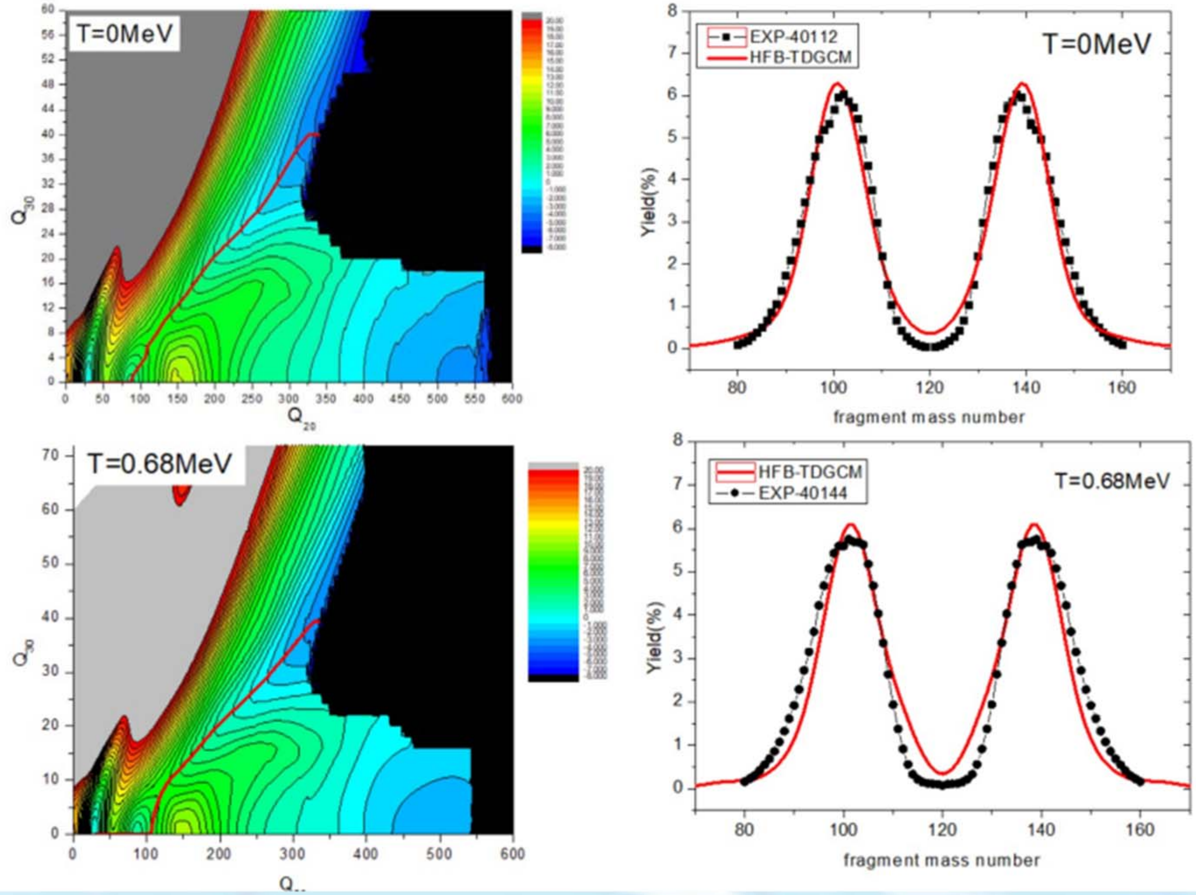




Phys. Rev. C 103, 044601 (2021)

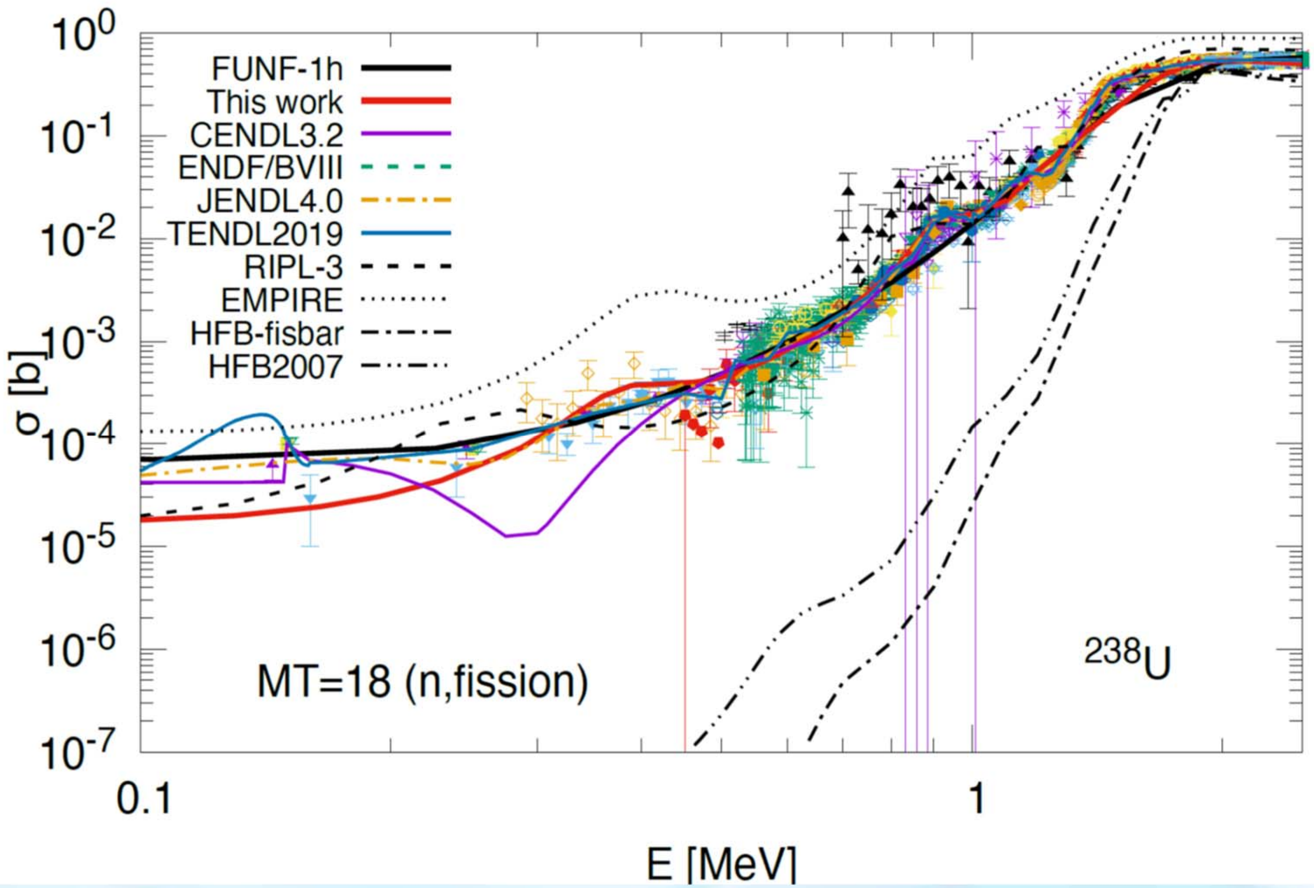
3. Progress of theory, evaluation and experiments
3.1 Fission Theory

The dynamics of induced fission of ^{240}Pu is investigated in a theoretical framework based on the finite temperature time-dependent generator coordinate method (TDGCM) in the Gaussian overlap approximation (GOA).



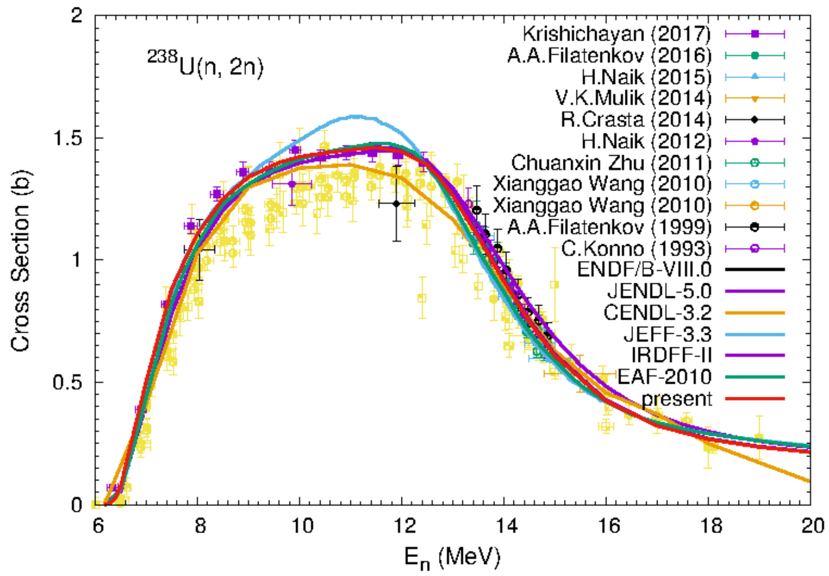
3.2 Progress of nuclear reaction theory: FUNF

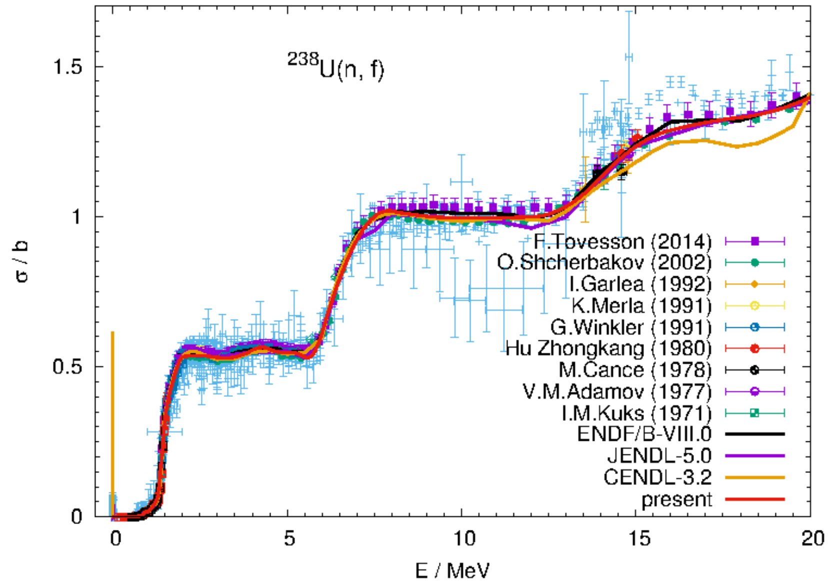
FUNF: multiple fission barriers model added, can calculate the fission cross-section with different kinds of fission barriers.
For the case of the n+238U reaction, the cross section calculated by the double fission barriers model is much better than the single fission barriers model, especially for the resonance structure in the low energy range.



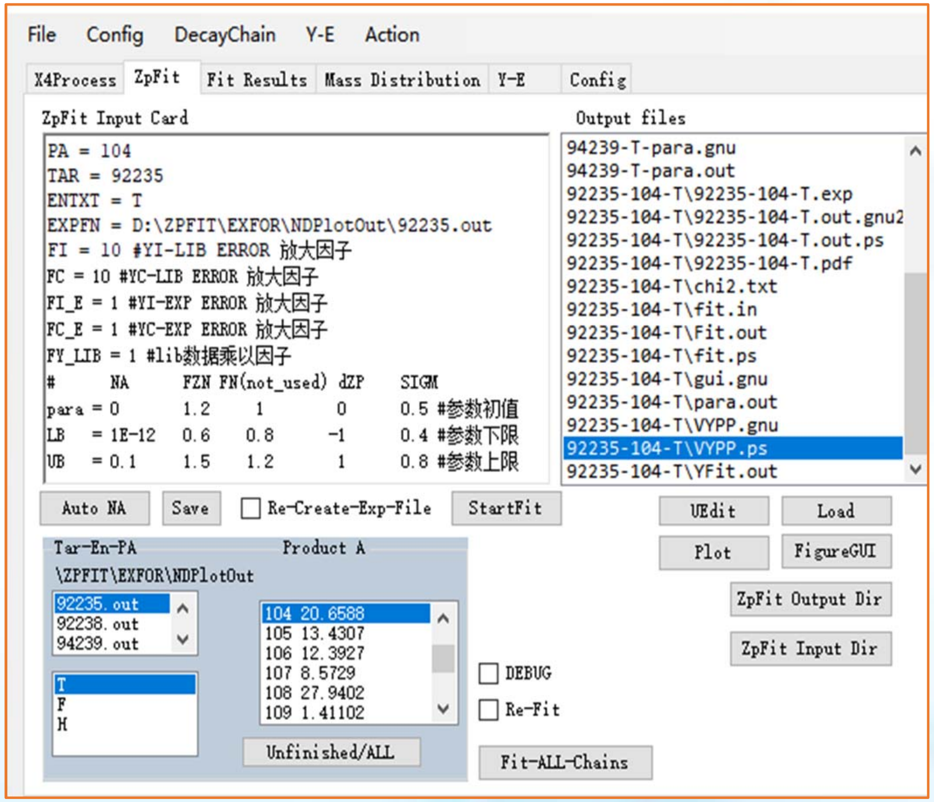
3.3 Evaluation

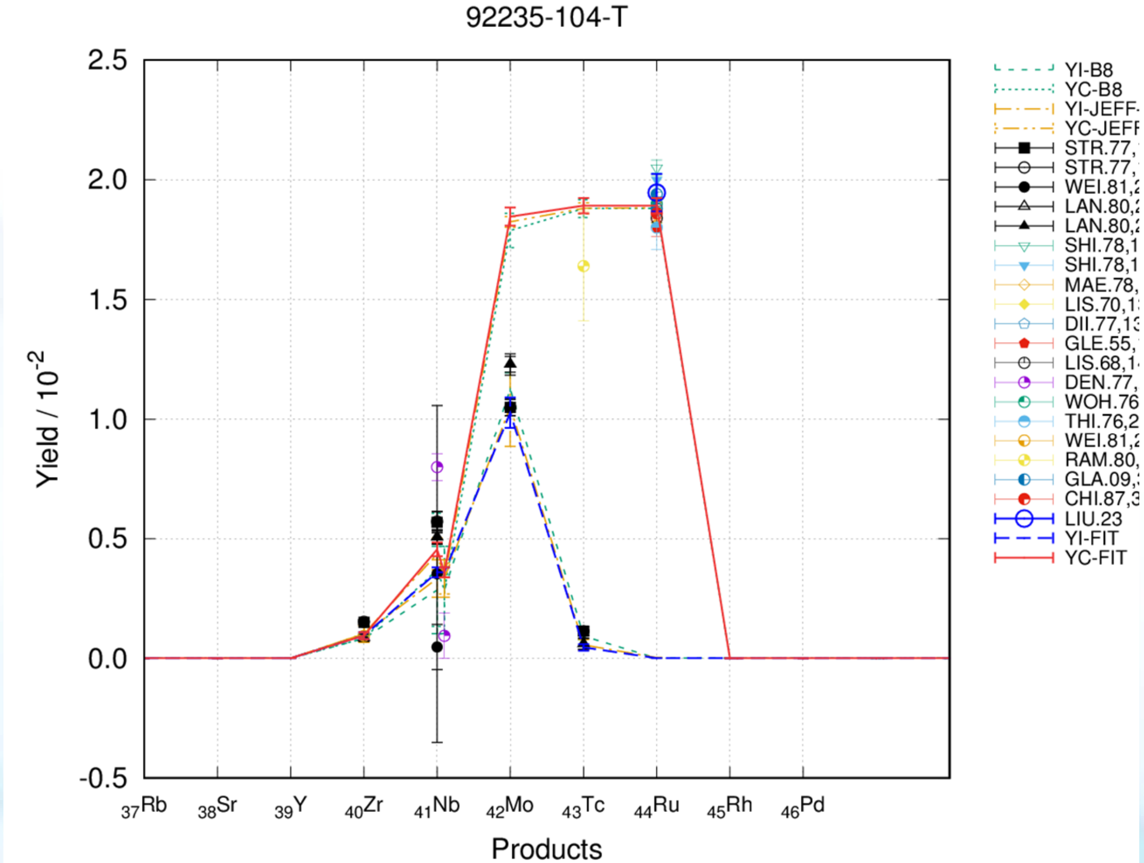
1) New evaluation for the complete set of neutron data of ^{238}U at the neutron energy En≤ 20 MeV was done recently，Including (n, tot), (n, 2n), (n, f), (n, 3n), (n, γ) cross sections and average number of fission neutrons NU.



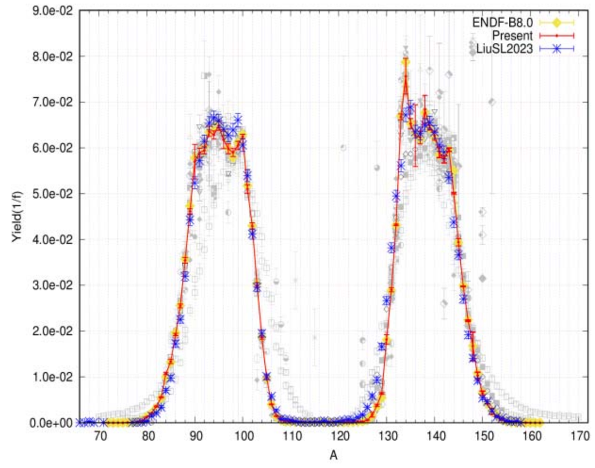


2) Fission yields of U235 U238 and Pu239 evaluated with the means of simultaneous evaluation for independent and cumulative yields based upon CENDL-3.2/DDL (Radioactive Decay Data File)

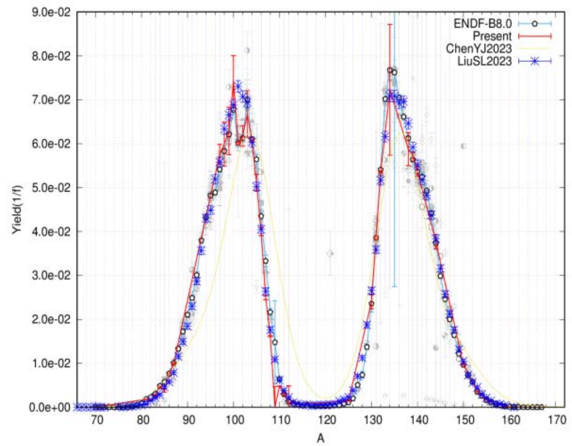




3) Thermal n+^{235}U, ^{239}Pu mass distribution were measured with E-V method



FF identification spectrum with mass resolution 1.0 amu



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EXFOR Activity at CNDC 2022-23

Wang Jimin, Tao Xi, Jin Yongli

China Nuclear Data Center (CNDC)

China Institute of Atomic Energy (CIAE)

Technical Meeting on the

International Network of Nuclear Reaction Data Centres

9 – 12 May, 2023, Vienna, Austria

CNDC X4 Group

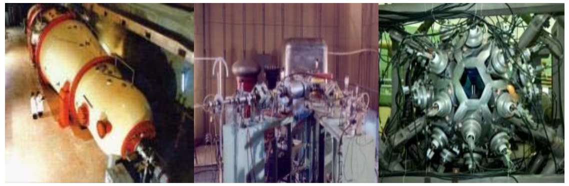
- **Compilers:** Jimin Wang, Xi Tao, Lile Liu, Yang Su
- **Software developer:** Yongli Jin
- **Steering Committee:** Nengchuan Shu, Zhigang Ge

Responsibility

- **Compilation** of nuclear reaction data induced by neutron and charged particle measured in China under the guidance of IAEA/NDS.
- **Revision** of the entries with issues in EXFOR compiled at CNDC.

Compilation status

■ Main Facilities in China



中国主要的核数据测量平台

中国科学院近代物理研究所 Institute of Modern Physics, Chinese Academy of Sciences

ADS related data (proton induced)

兰州大学 LANZHOU UNIVERSITY

Excitation function around 14 MeV

西北核技术研究院

Decay data

四川大學 SICHUAN UNIVERSITY

Excitation function

中国工程物理研究院 CHINA ACADEMY OF ENGINEERING PHYSICS

Integral experiments, other data measurement

中国原子能科学研究院 CHINA INSTITUTE OF ATOMIC ENERGY

Excitation function, FY, γ production yields, DX and DDX, benchmark experiments, etc

北京大学 PEKING UNIVERSITY

Charged reaction measurement (n,LCP)

中国科学院上海应用物理研究所 SINAP Shanghai Institute of Applied Physics, Chinese Academy of Sciences

Th-U cycle related data

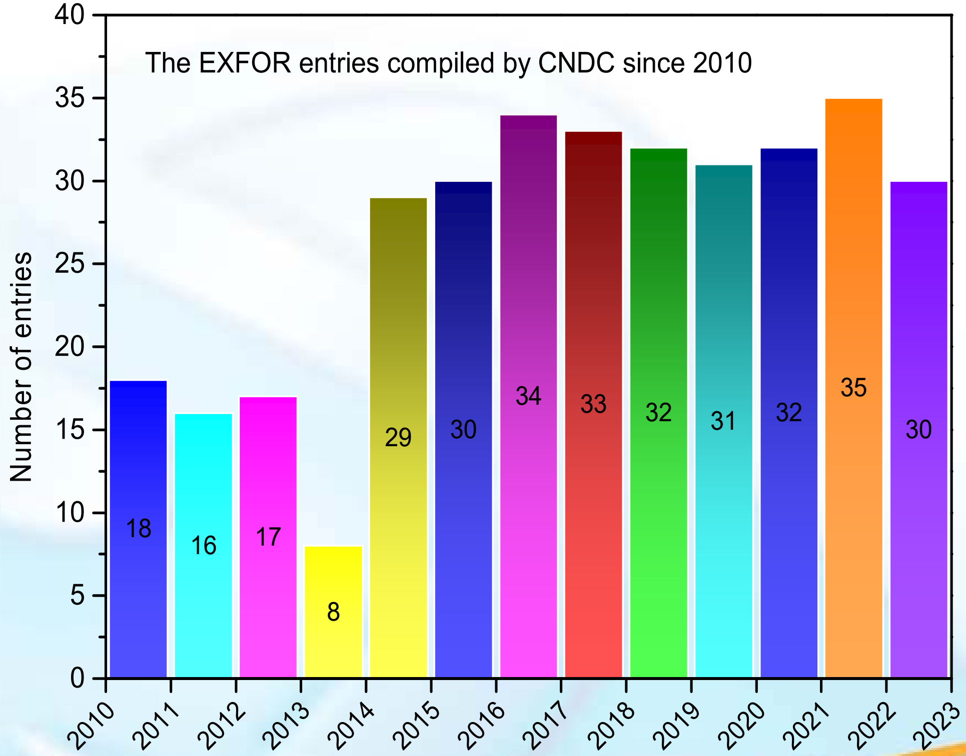
CSNS 中国散裂中子源 CHINA SPALLATION NEUTRON SOURCE

CS measurement for wide energy

Compilation status

- Since 2010, more than 345 entries were compiled at CNDC, which include 182 neutron and 163 charged particle entries.

- Since the last NRDC meeting (2022-06-01), 30 new entries have been finalized, which include 18 neutron and 12 charged particle entries.



Compilation status

No.	Entry No.	1st author	Reference	Status
1	32809	Luocheng Yang	J,ARI,164,109242,2020	Trans.3208
2	32810	X. X. Li	J,PR/C,106,065804,2022	Finalized
3	32811	Zhizhou Ren	J,PR/C,102,034604,2020	Trans.3208
4	32812	Junhua Luo	J,CPH/C,44,114002,2020	Trans.3208
5	32814	Yong Li	J,CPH/C,44,124001,2020	Finalized
6	32855	Junhua Luo	J,RCA,109,513,2021	Trans.3208
7	32856	Xin-Rong Hu	J,CNST,32,101,2021	Trans.3208
8	32857	S. Q. Yan	J,AJ,919,84,2021	Prelim.3209
9	32860	Luocheng Yang	J,ANE,165,108780,2022	Prelim.3209
10	32861	X. X. Li	J,PR/C,104,054302,2021	Finalized
11	32862	Zengqi Cui	J,EPJ/A,57,310,2021	Prelim.3209
12	32868	Zhang Jiang-Lin	J,ASI,71,052901,2022	Prelim.3209
13	32869	Wang De-Xin	J,ASI,71,072901,2022	Prelim.3209
14	32870	Jie Ren	J,CPH/C,46,044002,2022	Prelim.3209
15	32873	Yu.M.Gledenov	J,EPJ/A,58,86,2022	Prelim.3209
16	32886	Zhizhou Ren	J,EPJ/A,59,5,2023	Prelim.3209
17	32887	Yonghao Chen	J,PL/B,839,137832,2023	Finalized
18	32888	Chao Liu	J,NIM/A,1041,167319,2022	Finalized

Compilation status

No.	Entry No.	1st author	Reference	Status
1	S0087	Y.J.Li	J,PR/C,102,025804,2020	Trans.S031
2	S0235	F.F. Duan	J,PL/B,811,135942,2020	Trans.S031
3	S0249	Hua Wei	J,CNPR,34,138,2017	Trans.S031
4	S0261	Wang Tieshan	J,CST,35,496,2001	Trans.S031
5	S0262	Sun Xufang	J,CST,42,875,2008	Trans.S031
6	S0264	Su Xiaobin	J,CST,50,395,2016	Trans.S031
7	S0270	B.Liu	J,ARI,173,109713,2021	Trans.S031
8	S0273	W. H. Ma	J,PR/C,103,L061302,2021	Trans.S031
9	S0277	Y. Z. Sun	J,PR/C,104,014310,2021	Trans.S031
10	S0278	Hao Zhang	J,CPH/C,45,084108,2021	Trans.S032
11	S0279	Z. Y. Zhang	J,PRL,126,152502,2021	Trans.S032
12	S0295	B.Gao	J,PRL,129,132701,2022	Trans.S032

Revision

- **Since the last NRDC meeting (2022-06-01), 26 entries have been revised, which include 10 neutron and 16 charged particle entries.**

No.	Entry No.	1st author	Reference	Status
1	31454	Zhao Wenrong	J,CST,29,294,1995	Trans.3208
2	31463	Chen Zemin	J,CNPR,16,31,1999	Trans.3208
3	31506	Chen Zemin	J,CNPR,16,31,1999	Trans.3208
4	31507	Chen Zemin	J,CNPR,16,31,1999	Trans.3208
5	31609	Junhua Luo	J,NIM/B,265,453,2007	Trans.3208
6	32551	Zhao Wenrong	J,CST,33,415,1999	Trans.3208
7	32649	Ye Bangjiao	J,CST,33,193,1999	Trans.3208
8	32718	Feng Jing	J,CST,47,1473,2013	Prelim.3209
9	32786	Huaiyong Bai	J,PR/C,99,024619,2019	Trans.3208
10	32798	Jie Wen	J,ANE,140,107301,2020	Trans.3208
11	A0564	Liu Zuhua	J,CNPR,17,210,2000	Finalized
12	E2386	Wang Lichun	J,CNPR,30,107,2013	Finalized
13	E2517	Wang Lichun	J,CNPR,30,107,2013	Finalized

Revision

- **Since the last NRDC meeting (2022-06-01), 26 entries have been revised, which include 10 neutron and 16 charged particle entries.**

No.	Entry No.	1st author	Reference	Status
14	S0012	Long Xianguan	R,NST-001,198505	Trans.S032
15	S0013	Long Xianguan	R,NST-003,198903	Trans.S032
16	S0047	Guo Bing	J,CST,41,158,2007	Trans.S032
17	S0053	Guo Bing	J,CST,39,118,2005	Trans.S032
18	S0058	Li Yunju	J,CNPR,29,224,2012	Trans.S032
19	S0076	Y.Y.Yang	J,NIM/A,701,1,2013	Trans.S032
20	S0083	He Jianjun	J,CNPR,34,403,2017	Trans.S032
21	S0085	Y.Y.Yang	J,PR/C,87,044613,2013	Trans.S032
22	S0160	Zhu Yongtai	J,CTNP,10,26,1993	Trans.S032
23	S0183	He Jianjun	J,CNPR,34,403,2017	Trans.S032
24	S0203	Y.Y.Yang	J,PR/C,90,014606,2014	Trans.S032
25	S0206	Y.Y.Yang	J,PR/C,98,044608,2018	Trans.S032
26	S0265	K.Wang	J,PR/C,103,024606,2021	Trans.S032

Scanning of journals

- Currently CNDC is responsible for scanning of 8 journals published in 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. Submit the scanning results to IAEA/NDS every month.

- 26 experimental works

Journal	Vol.	Issue	Published	Page	1st author	Journal	Vol.	Issue	Published	Page	1st author
J,ASI	71	5	2022/3/5	052901	Zhang Jiang-Lin	J,CPH/C	46	7	2022/7/15	079001	A.Gandhi
		7	2022/4/5	072901	Wang De-Xin			8	2022/8/15	085001	Lin Zhao
		19	2022/10/5	192501	Zhu Chuan-Xin			9	2022/9/15	094003	Nguyen Van Do
J,CPH/C	46	1	2022/1/15	014001	O.S.Deiev			10	2022/10/15	104001	X.Y.Wang
		1	2022/1/15	014002	A.Gandhi			11	2022/11/15	111001	Xiao-Dong Xu
		1	2022/1/15	014003	Shu-Ya Jin			11	2022/11/15	114002	Yu.E.Penionzhkevich
		2	2022/2/15	024001	Haoyu Jiang			12	2022/12/15	124001	O.S.Deiev
		4	2022/4/15	044001	Junhua Luo	J,CST	56	1	2022/1/20	61	HU Jifeng
		4	2022/4/15	044002	Jie Ren			5	2022/5/20	798	LIU Chao
		5	2022/5/15	054001	Z.W.Tan			5	2022/5/20	805	REN Jie
		5	2022/5/15	054002	R.K.Singh			5	2022/5/20	816	SUN Qi
		5	2022/5/15	054003	Yong Li			5	2022/5/20	825	HU Yiwei
		6	2022/6/15	064002	O.S.Deiev			5	2022/5/20	835	LIANG Jianfeng

Scanning of journals

Chin. Phys. B Vol. 28, No. 10 (2019) 100701

Photoactivation experiment of ^{197}Au(γ, n) performed with 9.17-MeV γ-ray from ^{13}C(p, γ)^{14}N*

Yong-Le Dang(党永乐)[1,2], Fu-Long Liu(刘伏龙)[1,2], Guang-Yong Fu(付光永)[1,2], Di Wu(吴笛)[2], and Nai-Yan Wang(王乃彦)[1,2,†]

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[2] China Institute of Atomic Energy, Beijing 102413, China

(Received 29 May 2019; revised manuscript received 5 August 2019; published online 17 September 2019)

High energy γ-ray can be used for nuclear waste transmutation by using the giant dipole resonance (GDR). Th
tonuclear reaction ^{197}Au(γ,n) is known as a standard for studies on photoactivation experiments. The previous exper
on ^{197}Au(γ,n) have been performed with bremsstrahlung, positron annihilation in flight or laser Compton scattering
In this work, a new mono-energetic γ-ray source based on ^{13}C(p,γ)^{14}N reaction is used to measure the cross sec
^{197}Au(γ,n) and the measured value is compared with the results obtained with other ways.

Keywords: resonance reaction, high energy γ-ray, photonuclear reaction

PACS: 07.85.Fv, 24.30.–v, 25.20.–x **DOI:** 10.1088/1674-1056/ab3a8d

1. Introduction

Development of nuclear power is the strategic choice for solving the energy supply and ensuring the sustainable development of economy and society. However, nuclear reactor of 1-GW power products about 30-tons spent fuel per year, including long-lived fission product (LLFP) about 30 kg.[1] In this situation, the disposal of LLFP becomes much important. The prime ways such as deeply bury, transport to the space, and ice cover are unable to ensure absolute safety which is the fundamental requirement of long-lived radioactive wastes disposal. In 1990s, Accelerator Driven Sub-critical System (ADS) was known as an effective method.[2] For most radioactive wastes, the neutron cross sections are high enough so the coupling efficiencies of transmutation are considerable. However, for some nuclei, the neutron cross section is very low and there may be some new radioactive nuclei generated during the transmutation of ^{137}Cs. Another approach, photoneutron transmutation, due to the giant dipole resonance (GDR), may be a supplement of neutron transmutation, in which the largest cross section will be several hundreds millibarn in the high energy range.[3]

The high energy γ-ray is generated mainly by bremsstrahlung, positron annihilation in flight, laser Compton scattering, and nuclear excitation in nuclear reaction.[4] As a standard for studies on photonuclear reactions, ^{197}Au(γ,n) has been investigated to verify the ability of transmutation perform with γ-ray. In previous studies, photonuclear experiments were performed mainly by using the γ-ray source of positron annihilation in flight.[5] The photoactivation experiment on ^{197}Au was measured with bremsstrahlung facility on ELBE (electron lin-
ear accelerator of high brilliance and low emi
photoneutron cross section of ^{197}Au(γ,n) was
laser Compton scattering γ-ray at ring at AIS
The nuclear transmutation rate on ^{197}Au wa
New SUBARU.[8] While the γ-rays from positr
in flight, bremsstrahlung, and laser Compton sc
mono-energetic even continuous, so it is nec
the cross section or transmutation using mono-
and compare the result with the measured value
other methods.

Table 1 shows several (p, γ) resonance re
nuclei. In the present work, γ-ray from ^{13}C(p,
at $E_p = 1.75$ MeV has been used to measure th
of ^{197}Au(γ,n) at 9.17 MeV, by measuring t
from the reaction product, ^{196}Au. For the ac
surement, the depth distribution of ^{196}Au in
the attenuation of γ-ray from ^{196}Au inside the t
taken into account.

Table 1. Several resonance reactions.

Reaction	E_γ/MeV	E_R/M
^{19}F(p,$\alpha\gamma$)	6.1	≤ 0.
^{19}F(p,$\alpha\gamma$)	7.0	≤ 0.
^{13}C(p,γ)	9.17	1.7
^{7}Li(p,γ)	14.8	0.4
^{7}Li(p,γ)	17.6	0.4
^{3}H(p,γ)	19.8–30	–

2. Experiment

According to the previous investigation
threshold of ^{197}Au(γ,n) and ^{197}Au(γ,2n) are

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International Atomic Energy Agency
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Memo CP-D/1075

Date: 2023-03-16
To: Distribution
From: N. Otsuka, Jimin Wang

Subject: **Dictionary 5 (Journal) – CPH/B; Dictionary 22 – LABR3**

We propose the following two new codes for compilation of the 197Au(γ,n)196Au cross sections published in Yong-Le Dang et al., Chin. Phys. B 28 (2019) 100701.

Dictionary 5 (Journals)

CPH/B Chinese Physics B

Dictionary 22 (Detectors)

LABR3 LaBr3 scintillator

```
ENTRY            G0090   20230303
SUBENT        G0090001   20230303
BIB                 12         29
TITLE      Photonuclear reaction study with the (p,g) resonance
            gamma-source
AUTHOR     (Chuangye He, Yongle Dang, Fulong Liu, Guangyong Fu,
            Di Wu, Yangping Shen, Zhiyu Han, Qiwen Fan, Bing Guo,
            Naiyan Wang)
INSTITUTE  (3CPRAEP,3CPRBNU)
REFERENCE  (J,EPJ/CS,239,01014,2020)
           (J,CPH/B,28,100701,2019) Preliminary data given
FACILITY   (VDGT,3CPRAEP) 2x1.7-MV tandem accelerator
INC-SOURCE (MPH=(6-C-13(P,G)7-N-14))
           Proton beam (8 uA, 1.750 MeV) on 13C (100 ug/cm2)
            evaporated on Au (10 mm diam x 2 mm thick)
SAMPLE     Two air-cooled 197Au disks (purity of 99%, 10 mm diam.)
            coated with 13C foil (100 ug/cm2)
DETECTOR   (HPGE) Coaxial HPGe detector to measure 9.17 MeV gamma
            yields
           (LABR3) LaBr3(Ce) to measure 9.17 MeV gamma angular
            distribution
           (NAICR) NaI(Tl) to monitor 9.17 MeV gammas
           (HPGE) Anti-Compton HPGe to measure gamma-rays from
            activated samples
METHOD     (ACTIV) Irradiated for 6 hrs and 5.5 hrs, cooled for
            cooled for 3.6 hrs and 3.1 hrs, measured for 20.6 hrs
            and 94.2 hrs
CORRECTION Corrected for attenuation of 9.17 MeV and 355.7 keV
            gamma-rays in the gold sample
ERR-ANALYS (ERR-T) Total uncertainty
           (ERR-S) Statistical uncertainty
           (ERR-SYS) Systematic uncertainty
HISTORY    (20230303C) On
ENDBIB              29          0
```

Software development

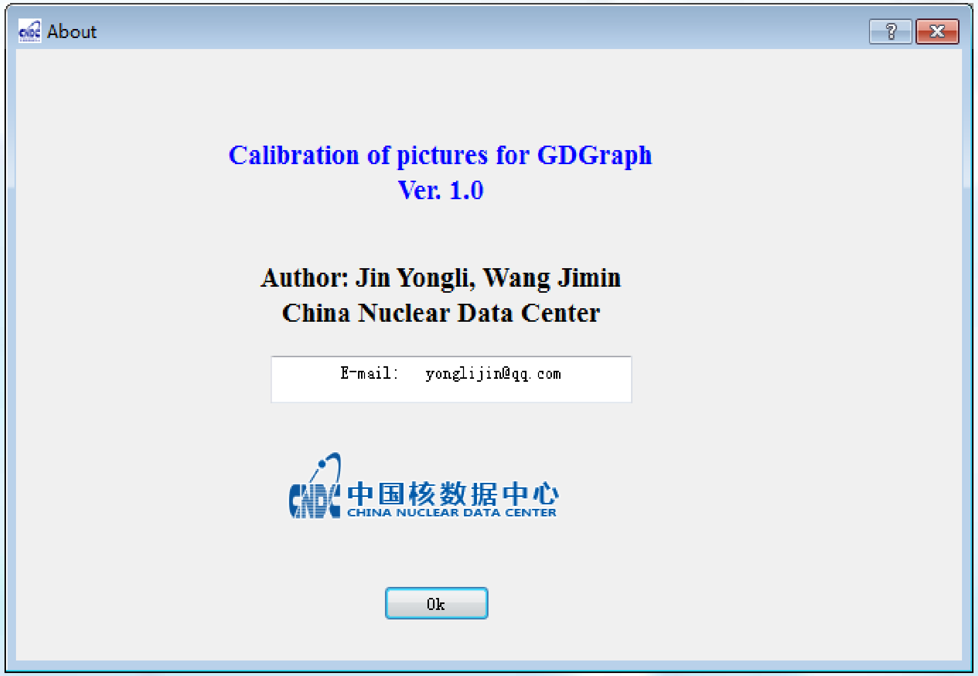
- **NDPlot**: a program Visually to analyze and process the nuclear data, developed by Dr. Yongli Jin (CNDC). The latest version 0.97 beta was released in Dec.20,2022, some new features were introduced, such as radioactive nuclides production cross sections plotting, more flexible legends settings, and so on.

- **GDGraph**: Visually convert graph to digit, developed by Dr. Yongli Jin (CNDC).

Software development

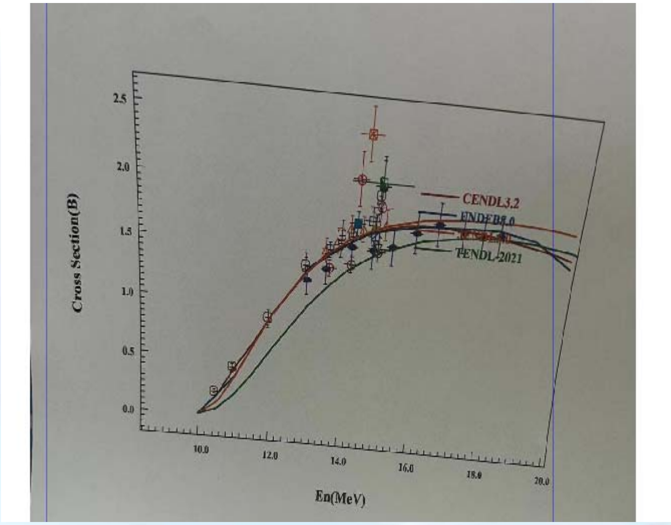
■ **2D calibration (correct for distorted figure)**

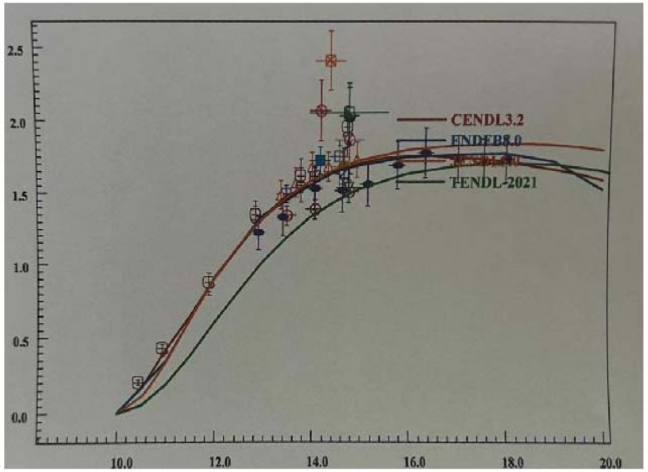
A83	Jin Suzuki Pikulina Zerkin	(Continuing action) Study problems in 2D calibration of original pictures, and process of approval of results of digitizing using plotting facilities.



Software development

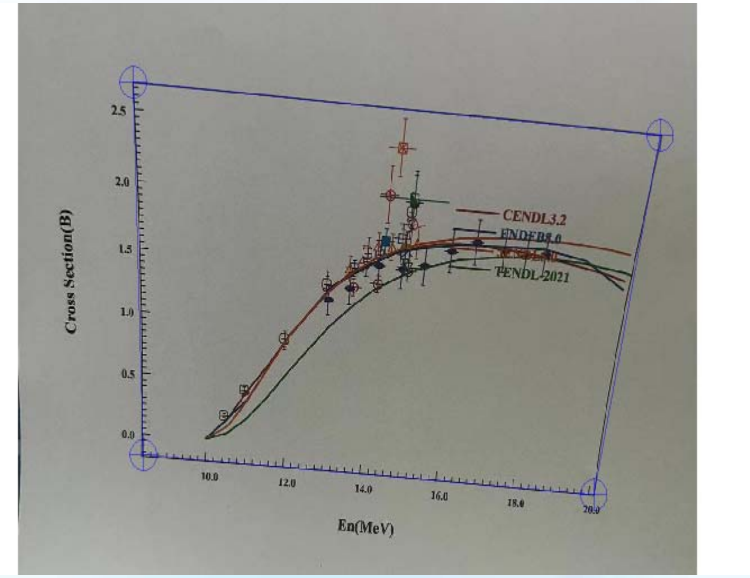
- Automatic calibration

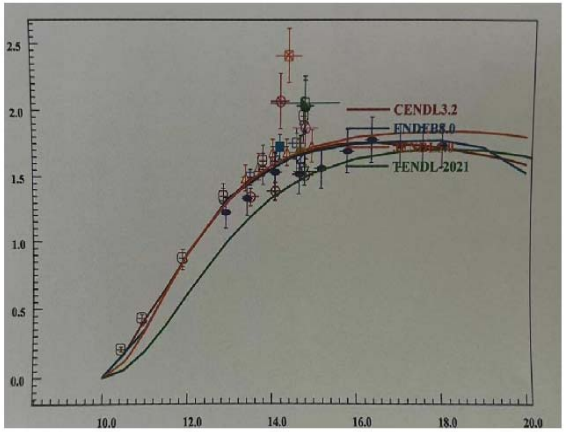




Software development

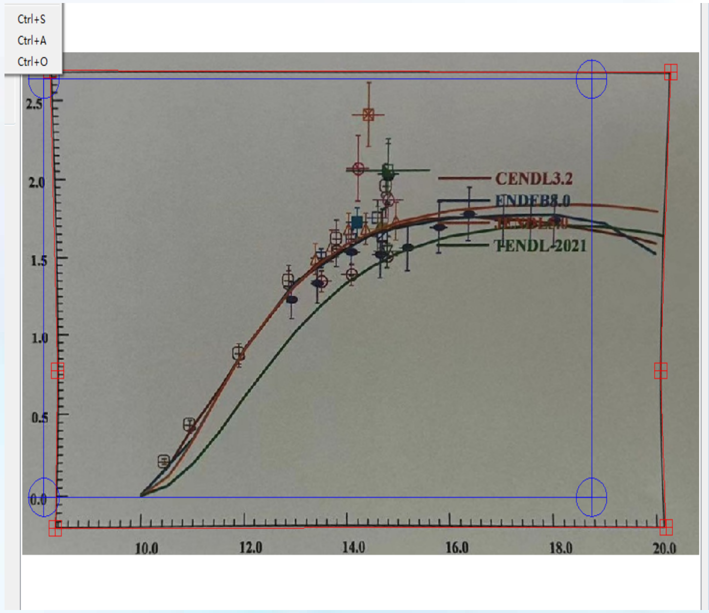
- Manual calibration

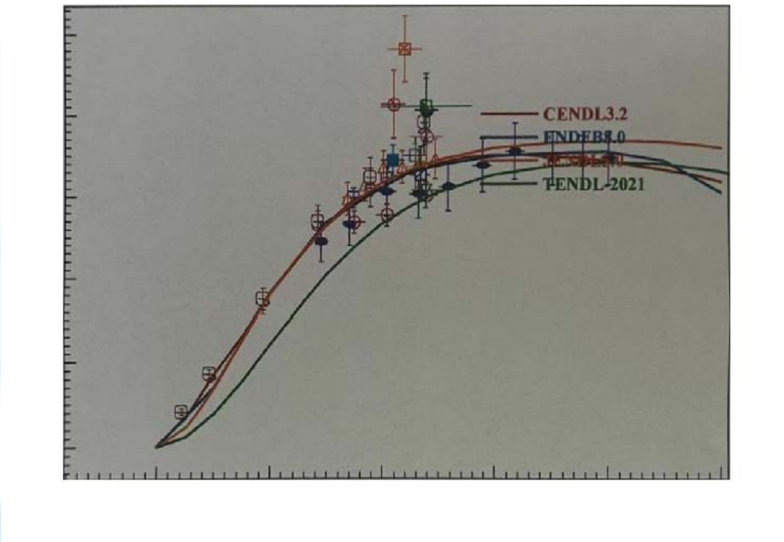




Software development

➢ Vertical distortion calibration





Thank you for your attention！

Comments and suggestion welcome！

Thank you for your attention！
Comments and suggestion are welcome！