2019/20 Status Report of China Nuclear Data Center

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CHINA NUCLEAR DATA CENTER

I. General Information of CNDC

1.1 About CNDC

CNDC

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.

The main task of CNDC:

- The nuclear data evaluations, libraries and relevant technique researches.
- Nuclear data measurements
- The exchange of nuclear data activities with IAEA, foreign nuclear data centers and agencies.
- The management of domestic nuclear data activities.
- The services for domestic and foreign nuclear data users.

1.2 Mainly tasks of CNDC in 2019/2020:

- New evaluations and re-evaluations for neutron data file for CENDL-3.2. and the benchmarking
- Photonuclear data modeling, evaluations, structure and decay data evaluation and library establishment
- Methodological studies of nuclear data evaluation.
- Nuclear data measurements and related methodological studies.
- The compilations for EXFOR.
- Nuclear data services is providing to all the nuclear data users.
- Propose the next Five Years Plan (2021-2025) of nuclear data
- ND2019 post tasks.

II. CENDL-3.2 and CENDL-PD

2.1 CENDL-3.2 released on June 12.2020

As a general purpose evaluated nuclear database, Chinese Evaluated Nuclear Data Library (CENDL) is not only an output of more-than-forty-year domestic cooperation under the name of CENDL Library Project via China Nuclear Data Coordination Network (CNDCN), but also a product of international collaborations, especially under the multi-lateral framework of IAEA and OECD/NEA/WPEC.

Coordinated by China Nuclear Data Center (CNDC) during 2015-2019, CENDL-3.2 is the latest release of CENDL. With ENDF-6 formatted neutron reaction data for a total number of 272 materials, CENDL-3.2 is expected to meet general requirements for diversified scenarios of peaceful use of nuclear power and nuclear technology application.

the data for 135 materials are totally new or partly updated evaluations, while the other 137 materials were inherited and adopted as it was from previous version, CENDL-3.1.

Table 1. Nuclides List and Major Updates for CENDL-3.2

Newly Evaluated and Partly Updated (135 Nuclides)

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.

Partly Updated (77 Nuclides):

H-2, Li-7, Ti-48, Ga-69[b], Ga-71[b], Ge-71[b], Ge-73[b], Ge-74[b], Ge-75[b], Ge-76[b], Ge-77[b], Ge-78[b], As-75[b], As-77[b], As-79[b], Sr-89[b], Y-89[b], Y-91[b], Zr-93[b], Zr-95[b], Nb-93, Nb-95[b], Tc-99[b], Ru-99[b], Ru-100[b], Ru-101[b], Ru-103[b], Ru-104[b], Ru-105[b], Rh-103[b], Rh-105[b], Pd-105[b], Pd-108[b], Cd-113[b], Sb-121[b], Sb-125[b], I-127[b], I-129[b], I-135[b], Cs-133[b], Cs-135[b], Cs-137[b], Ba-130[b], Ba-134[b], Ba-135[b], Ba-136[b], Ba-137[b], Ba-138[b], Pr-141[b], Nd-143[b], Nd-145[b], Nd-146[b], Nd-148[b], Pm-147[b], Pm-148[b], Pm-149[b], Sm-150[b], Sm-151[b], Eu-151[b], Eu-153[b], Eu-155[b], Gd-154[b], Gd-155[b], Gd-156[b], Gd-157[b], Gd-158[b], Gd-160[b], Th-232, U-233, U-235[c], U-237, U-238[c], U-239, Np-237, Np-239, Pu-240, Pu-241[c].

Inherited from CENDL-3.1 (137 Nuclides):

H-3, He-3, He-4, Li-6, Be-9, B-10, B-11, C-12, N-14, O-16, F-19, Mg-24, Mg-25, Mg-26, Si-28, Si-29, Si-30, P-31, Cl-0, K-0, Ca-0, Ti-46, Ti-47, Ti-49, Ti-50, V-0, Cr-50, Cr-52, Cr-53, Cr-54, Mn-55, Fe-54, Fe-57, Fe-58, Co-59, Ni-60, Ni-61, Ni-62, Ni-64, Cu-0, Cu-63, Cu-65, Ge-0, Ge-70, Ge-72, Kr-83, Kr-84, Kr-85, Kr-86, Rb-85, Rb-87, Sr-88, Sr-90, Zr-90, Zr-91, Zr-92, Zr-94, Zr-96, Mo-92, Mo-94, Mo-95, Mo-96, Mo-97, Mo-98, Mo-100, Ru-102, Ag-0, Ag-107, Ag-109, Cd-0, In-113, In-115, Sn-0, Sn-112, Sn-114, Sn-115, Sn-116, Sn-117, Sn-118, Sn-119, Sn-120, Sn-122, Sn-124, Sb-123, Te-130, Cs-134, Ba-132, Ce-136, Ce-138, Nd-142, Nd-144, Nd-147, Nd-150, Pm-148m, Sm-144, Sm-147, Sm-148, Sm-149, Sm-152, Sm-154, Eu-154, Gd-152, Dy-164, Hf-174, Hf-176, Hf-177, Hf-178, Hf-179, Hf-180, Ta-181, Au-197, Hg-0, Tl-0, Pb-204, Pb-206, Pb-207, Pb-208, Bi-209, U-232, U-234, U-241, Np-238, Pu-236, Pu-237, Pu-239, Pu-242, Pu-243, Pu-244, Pu-245, Pu-246, Am-240, Am-242, Am-242m, Am-243, Am-244, Bk-249, Cf-249.

a. Total data size of CENDL-3.2: 392MB.
b. Covariance added.
c. Beta-delayed fission gamma spectrum (MT=460) added.

In order to verify the physical rationality, systematic comparisons between CENDL-3.2 and other major evaluated libraries (ENDF, JENDL, BROND, JEFF and TENDL) as well as experimental data available have been implemented. Moreover, the benchmarking test of CENDL-3.2 was performed with ENDITS-1.0, an integrated benchmarking test system including 1233 criticality benchmark configurations.

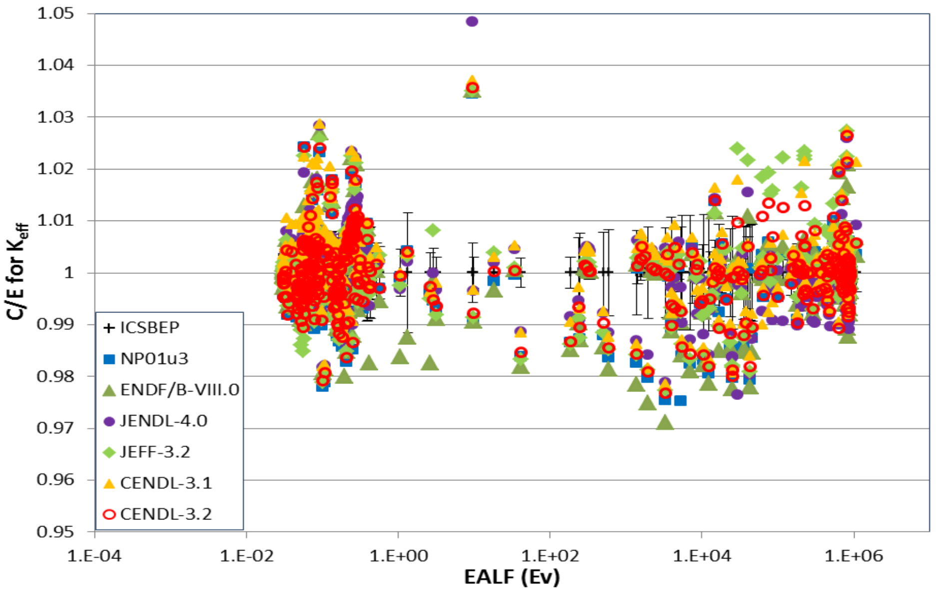

Fig. 1 Results for HEU systems

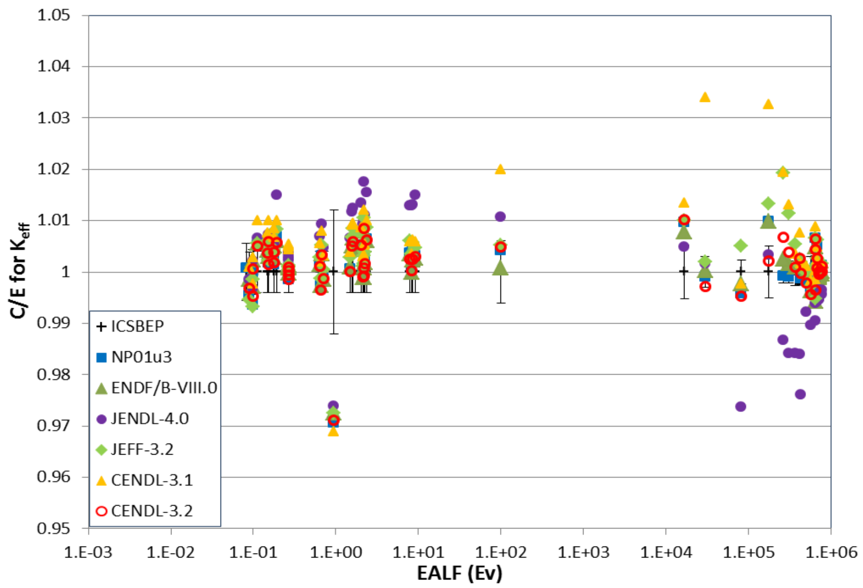

Fig. 2 Results for IEU systems

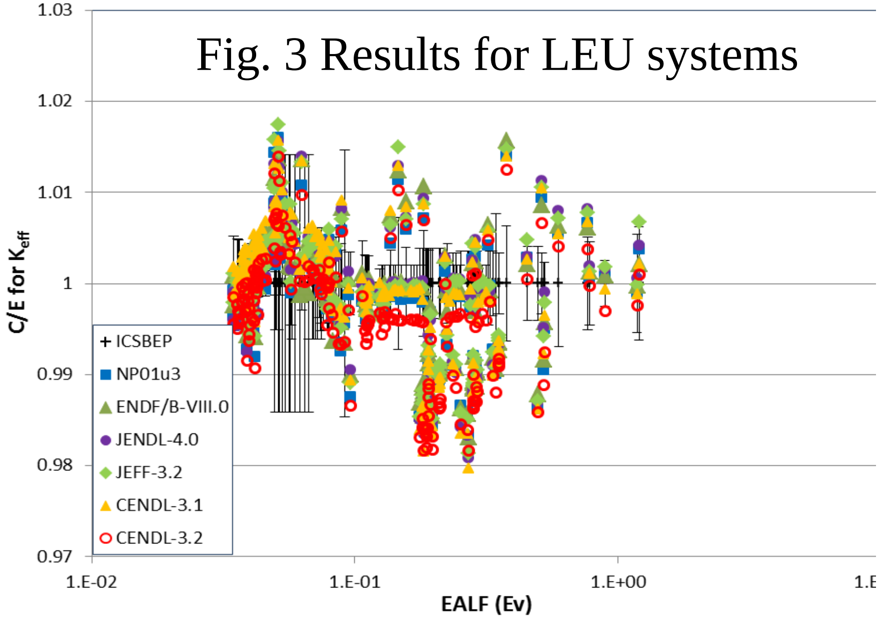

Fig. 3 Results for LEU systems

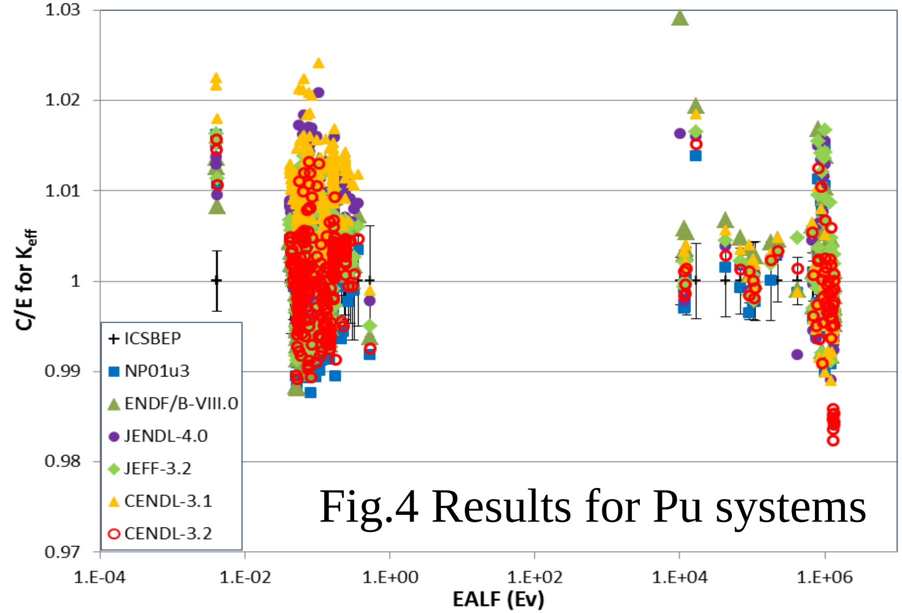

Fig.4 Results for Pu systems

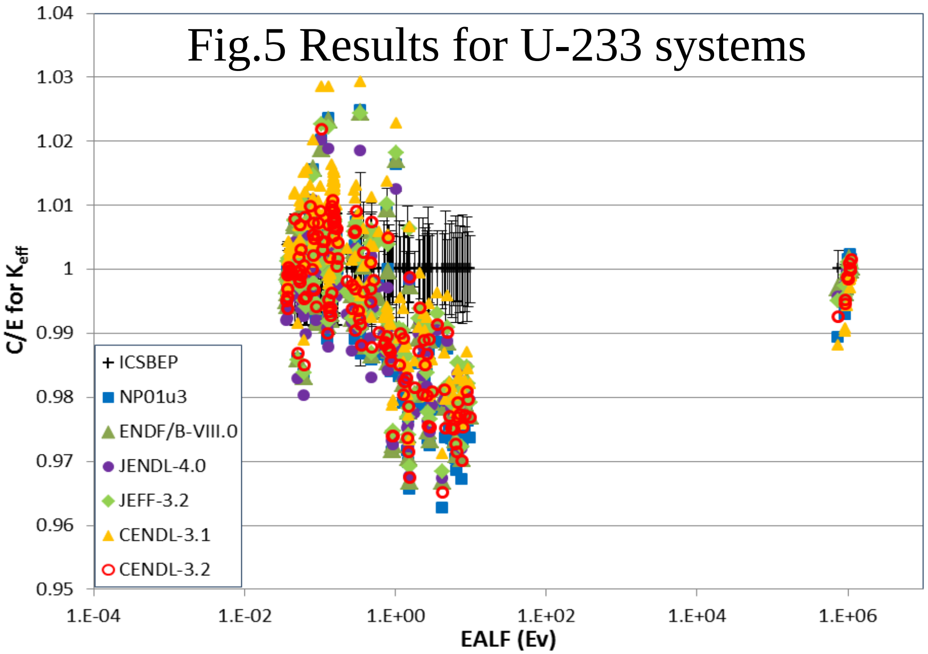

Fig.5 Results for U-233 systems

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

Type	Casess	Quantity	ENDF/B-VIII.0	JENDL-4.0	JEFF-3.2	CENDL-3.1	CENDL-3.2
U-235	686	C/E-1 (pcm)	-20	26	62	182	-84
		STDEV	703	772	750	779	758
		χ^2	12.32	13.56	12.41	23.94	9.66
U-Pu	7	C/E-1 (pcm)	-170	-1233	122	-36	88
		STDEV	225	572	414	285	283
		χ^2	5.89	249.26	35.51	11.89	16.81
Pu	376	C/E-1 (pcm)	93	554	210	764	4
		STDEV	488	561	504	769	554
		χ^2	2.26	4.91	2.80	9.05	3.27
U-233	164	C/E-1 (pcm)	-547	-653	-378	-42	-579
		STDEV	1127	1031	1091	1197	1139
		χ^2	4.81	4.77	4.27	6.49	5.30
All	1233	C/E-1 (pcm)	-56	89	49	328	-119
		STDEV	745	849	762	892	782
		χ^2	8.21	11.09	8.53	17.01	7.17

Progress in Nuclear Energy 136 (2021) 103727

Contents lists available at ScienceDirect

Progress in Nuclear Energy

journal homepage: http://www.elsevier.com/locate/pnucene

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Performance of CENDL-3.2 evaluated nuclear data library for the shielding benchmarks

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ARTICLE INFO

Keywords:
CENDL-3.2
Iron-88
PCA-Replica
HBR-2
NECP-Atlas
NECP-Hydra

ABSTRACT

The latest CENDL-3.2 evaluated nuclear data library was released in

Hindawi
Science and Technology of Nuclear Installations
Volume 2021, Article ID 6633366, 13 pages
https://doi.org/10.1155/2021/6633366

Hindawi

Research Article

Verification of CENDL-3.2 Nuclear Data on VENUS-3 Shielding Benchmark by ARES Transport Code

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...th China Electric Power University, Beijing 102206, China

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... 2021; Published 5 February 2021

...brary is deemed as an important achievement in the field of nuclear data research ...ry to the shielding calculation of PWR and analyze the influence of multigroup ...lation, ARES-MACXS module is used to process the MATXS format multigroup ...group working cross sections for PWR shielding calculation. VENUS-3 exper...y. It is often used to test the ability of the advanced transport calculation method ...uate the accuracy of cross-section library. Different cross-section parameters are ...ark, and equivalent neutron flux of ^{58}Ni(n,p)^{58}Co, ^{115}In(n,n′)^{115m}In and ^{27}Al(n,α) ...ata provided by the benchmark report. The numerical results demonstrate that ...lculated results and the experimental results are within 20%, which satisfies the

Annals of Nuclear Energy 158 (2021) 108238

Contents lists available at ScienceDirect

Annals of Nuclear Energy

journal homepage: www.elsevier.com/locate/anucene

ELSEVIER

Application of CENDL-3.2 and ENDF/B-VIII.0 on the reactor physics simulation of PWR

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ARTICLE INFO

Article history:
Received 1 December 2020
Received in revised form 27 February 2021
Accepted 3 March 2021

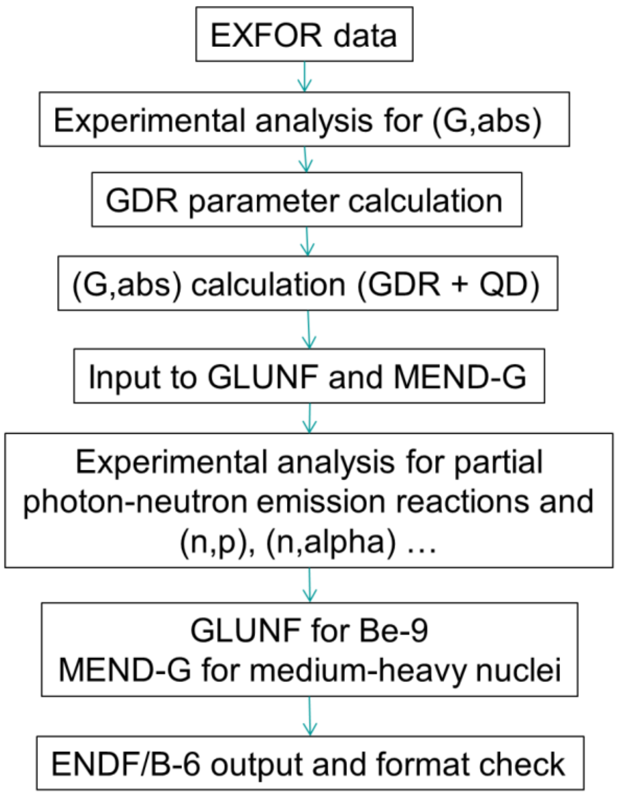
Keywords:
CENDL-3.2
ENDF/B-VIII.0
CNP-1000
NECP-Atlas
LOCUST/SPARK

ABSTRACT

The latest CENDL and ENDF/B evaluated nuclear data libraries was released in 2020 and 2018, respectively. To apply CENDL-3.2 and ENDF/B-VIII.0 in the reactor physic simulations of pressurized water reactor (PWR), the CNP-1000 PWR, which is an improved GEN-II PWR and operated in Fuqing Nuclear Power Plant in China, is simulated using these two libraries. The key parameters during the startup physics tests and power operation in the first three fuel cycles of the CNP-1000 reactor have been simulated and compared with corresponding measurement values. The numerical results show that ENDF/B-VIII.0 performs better in several parameters of the startup physics tests than ENDF/B-VII.0; the cross-section data in CENDL-3.2 is competent in the engineering application of PWR.

2.2 CENDL-PD for the photonuclear data will be released soon

1. CENDL-PD has been evaluated and it will be released soon,which contained photonuclear data for 266 nuclei.
2. The global estimation based on various Lorentzian model for all elements is performed;
3. The calculation for the competing photonuclear data is performed based on MEND-G and GUNF codes for light nuclei.



Scheme of photonuclear data evaluation at CNDC.

Reaction scheme

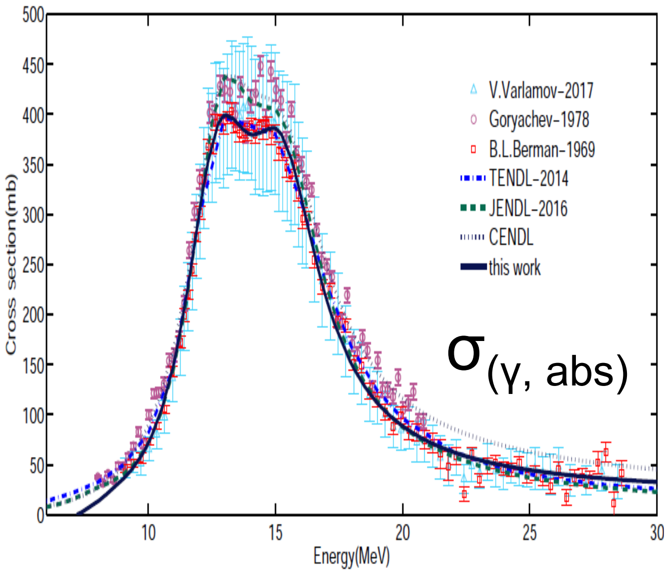
次数	Particles	Total reaction number
1	n,p,α,d,t,He-3	6
2	n,p,α,d,t,He-3	$6^2=36$
3	n,p,α,d,t,He-3	$6^3=216$
4	n,p,α,d,t,He-3	$6^4=1296$
5	n,p,α,d	$6^4X4=5184$
6	n,p,α,d	$6^4X4^2=20736$
7	n,p,α,d	$6^4X4^3=82944$
8	n,p,α	$6^4X4^3X3=248832$
9	n,p,α	$6^4X4^3X3^2=746496$
10	n,p,α	$6^4X4^3X3^3=2239488$
11	n,p	$6^4X4^3X3^3X2=4478976$
12	n,p	$6^4X4^3X3^3X2^2=8957952$
13	n,p	$6^4X4^3X3^3X2^3=17915904$
14	n,p	$6^4X4^3X3^3X2^4=35831808$
15	n,p	$6^4X4^3X3^3X2^5=71663616$
16	n,p	$6^4X4^3X3^3X2^6=143327232$
17	n,p	$6^4X4^3X3^3X2^7=286654464$
18	n,p	$6^4X4^3X3^3X2^8=573308928$

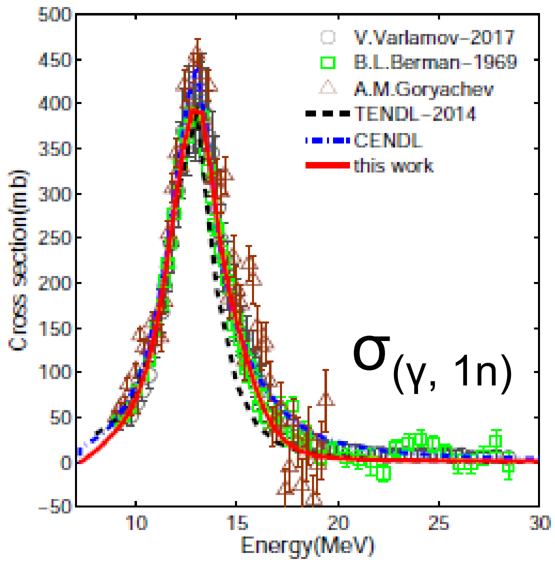
The evaluation for photonuclear data —W isotopes

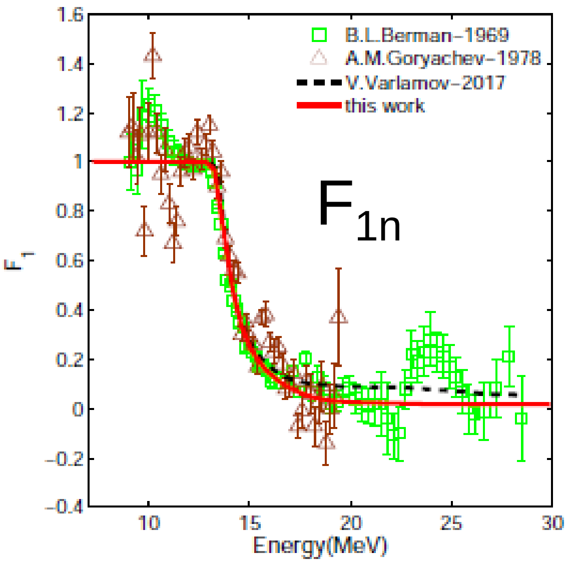
The experimental data of $\gamma + {}^{180,182,183,184,186}W$

Nuclide	Author/Ref.	Reaction Type	Energy(MeV)	Year
^{182}W	G.M.Gurevich+	(γ, abs)	8.53 - 20.7	1981
	A.M.Goryachev+	$(\gamma, n)+(\gamma, np)+(\gamma, 2n)$	8.02 - 20.8	1978
^{184}W	G.M.Gurevich+	(γ, abs)	8.53 - 20.7	1981
	A.M.Goryachev+	$(\gamma, x)n$	9.0 - 19.4	1973
	A.M.Goryachev+	$(\gamma, n)+(\gamma, np)+(\gamma, 2n)$	8.02 - 20.8	1978
^{186}W	Berman+	$(\gamma, x)n$	9.1 - 28.5	1969
		$(\gamma, x)n$,unw.	9.1 - 28.5	1969
		$(\gamma, n)+(\gamma, np)$	9.1 - 28.5	1969
		$(\gamma, 2n)+(\gamma, 2np)$	9.1 - 28.5	1969
		$(\gamma, 3n)$	9.1 - 28.5	1969
	A.M.Goryachev+	$(\gamma, x)n$	9.0 - 19.4	1973
		$(\gamma, x)n$,unw.,deriv.	9.0 - 19.0	1973
	A.M.Goryachev+	$(\gamma, n)+(\gamma, np)+(\gamma, 2n)$	8.02 - 20.8	1978
	G.M.Gurevich+	(γ, abs)	8.67 - 19.7	1981
	P.Mohr+	(γ, n)	7.26 - 10.9	2004

Experimental data for γ + W isotopes are measured mainly for ^{186}W below 30MeV.

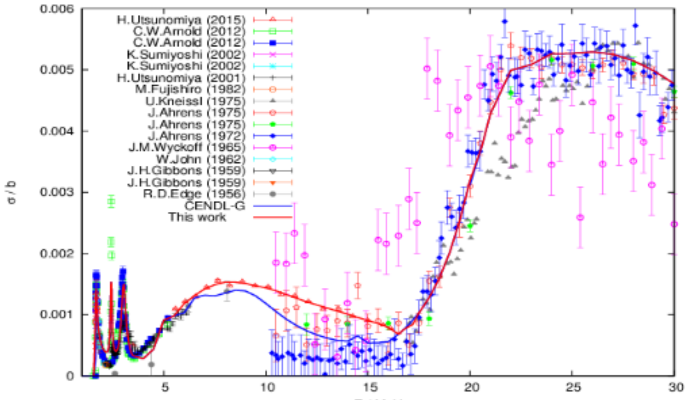




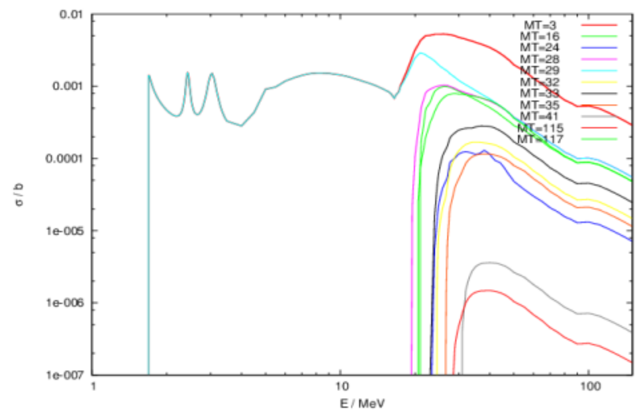


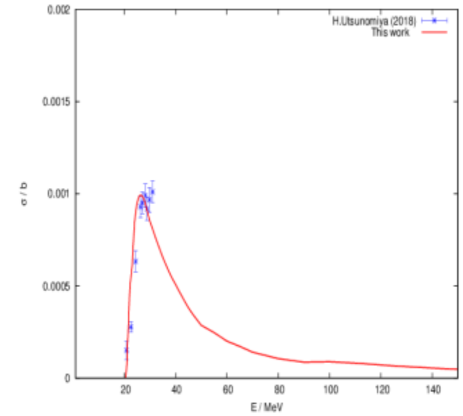
- The evaluated (γ, abs) with SMLO are based on the data by Berman and Varlamov's;
- The competing photonuclear reactions are calculated with MEND-G, and separate photon-neutron cross sections and physics criteria Fi are estimated.

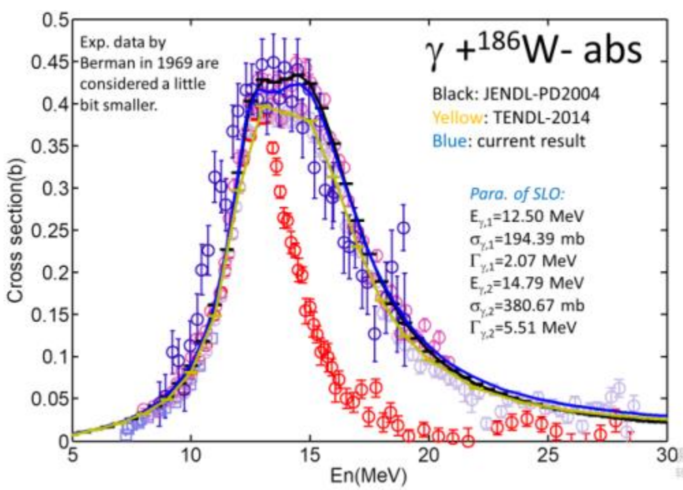
^{9}Be — ^{209}Bi 266 nuclei



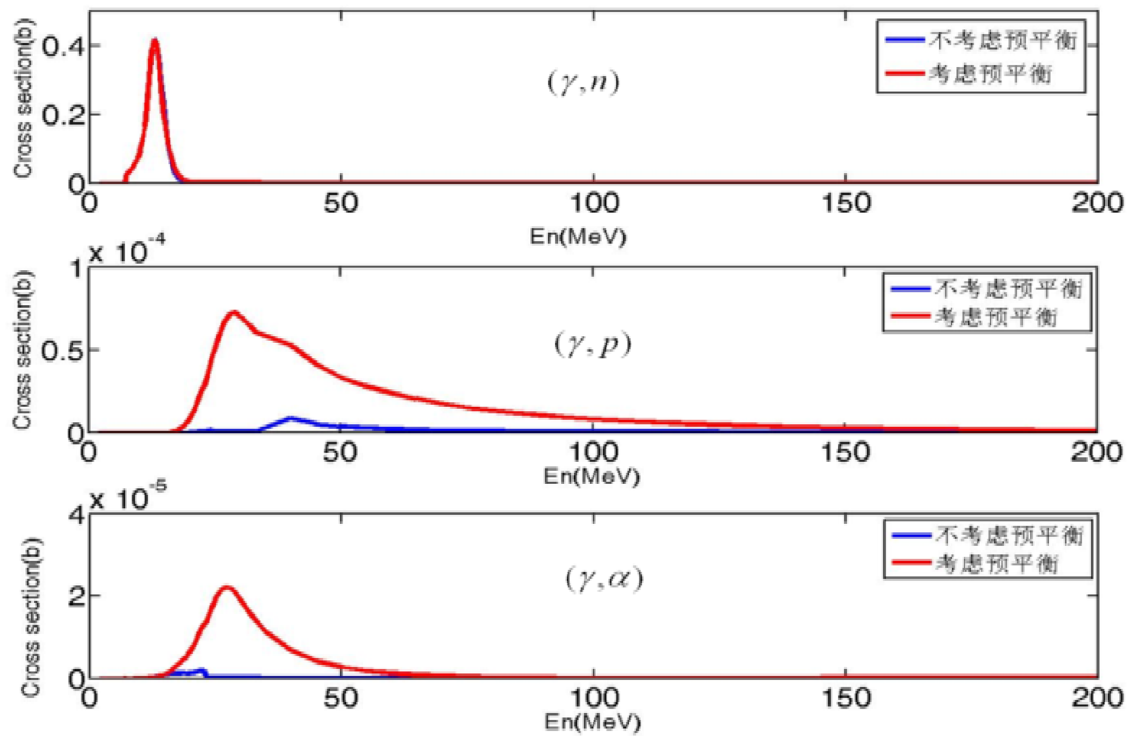
^{9}Be





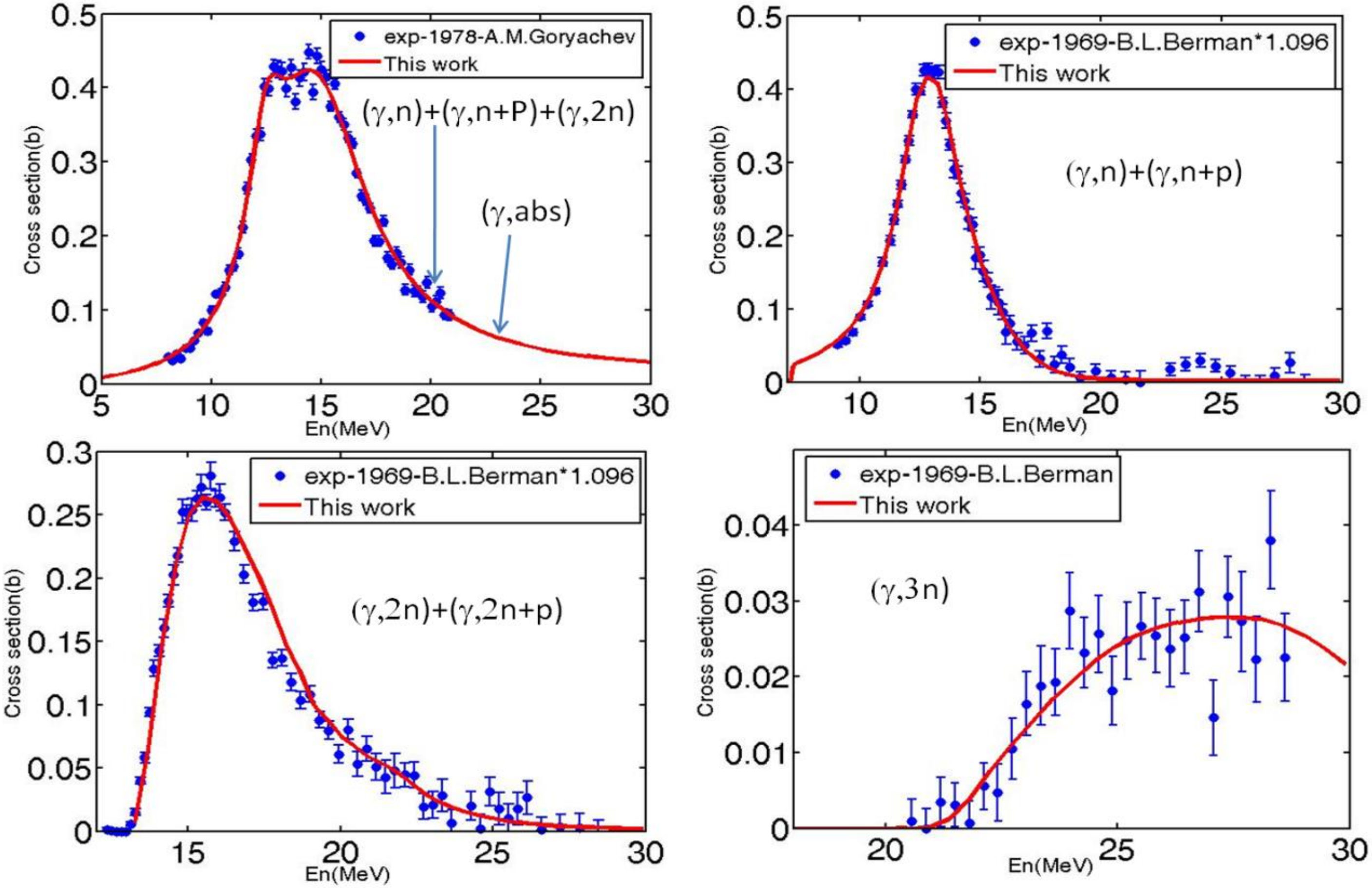


^{186}W



Single Lorentz formula+ GMEND parameters optimized

$\gamma + {}^{186}W$

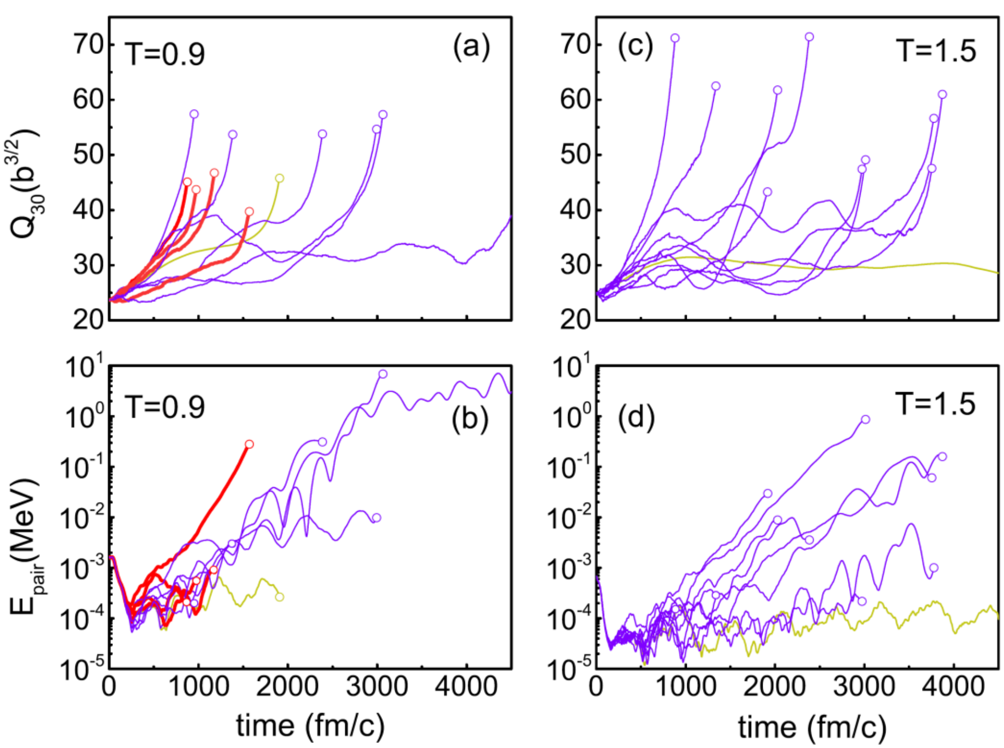


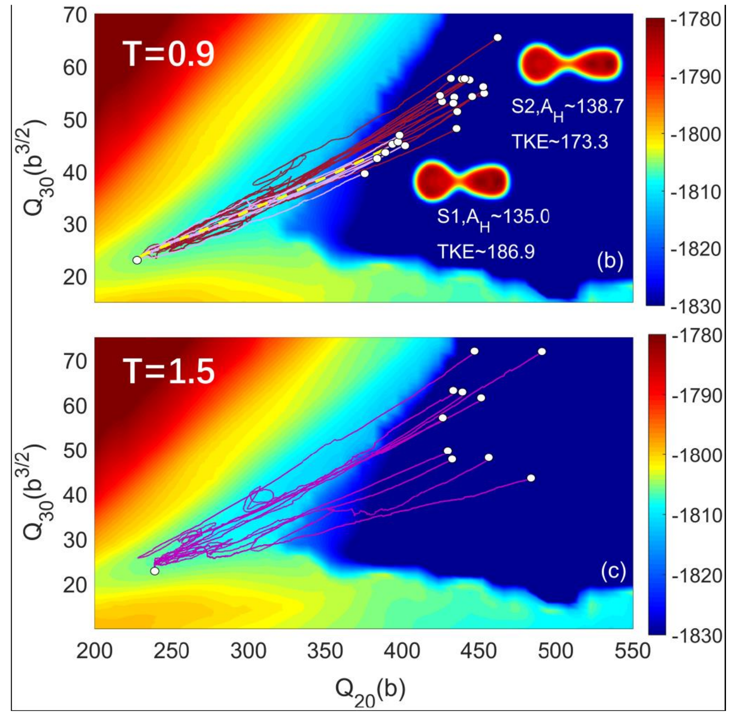
Main neutron outgoing cal. results

LD Par.	**p \ n**	**1**	**2**	**3**
	0	**25.999000**	**15.031723**	**19.108256**
Pair Par.	**p \ n**	**1**	**2**	**3**
	0	**0.988**	**0.869**	**0.89**

III. Fundamental theory and exp. study for fission data

The real-time fission dynamics from low-energy to high excitations in the compound nucleus ^{240}Pu with the TD-Hartree-Fock + BCS +thermal fluctuations was studied.





At high excitations, the random thermal fluctuations is indispensable to drive fission.

The obtained FY and TKE with fluctuations can be divided into two asymmetric scission channels, namely, S1 and S2, which explain well experimental results and give microscopic support to the Brosa model.

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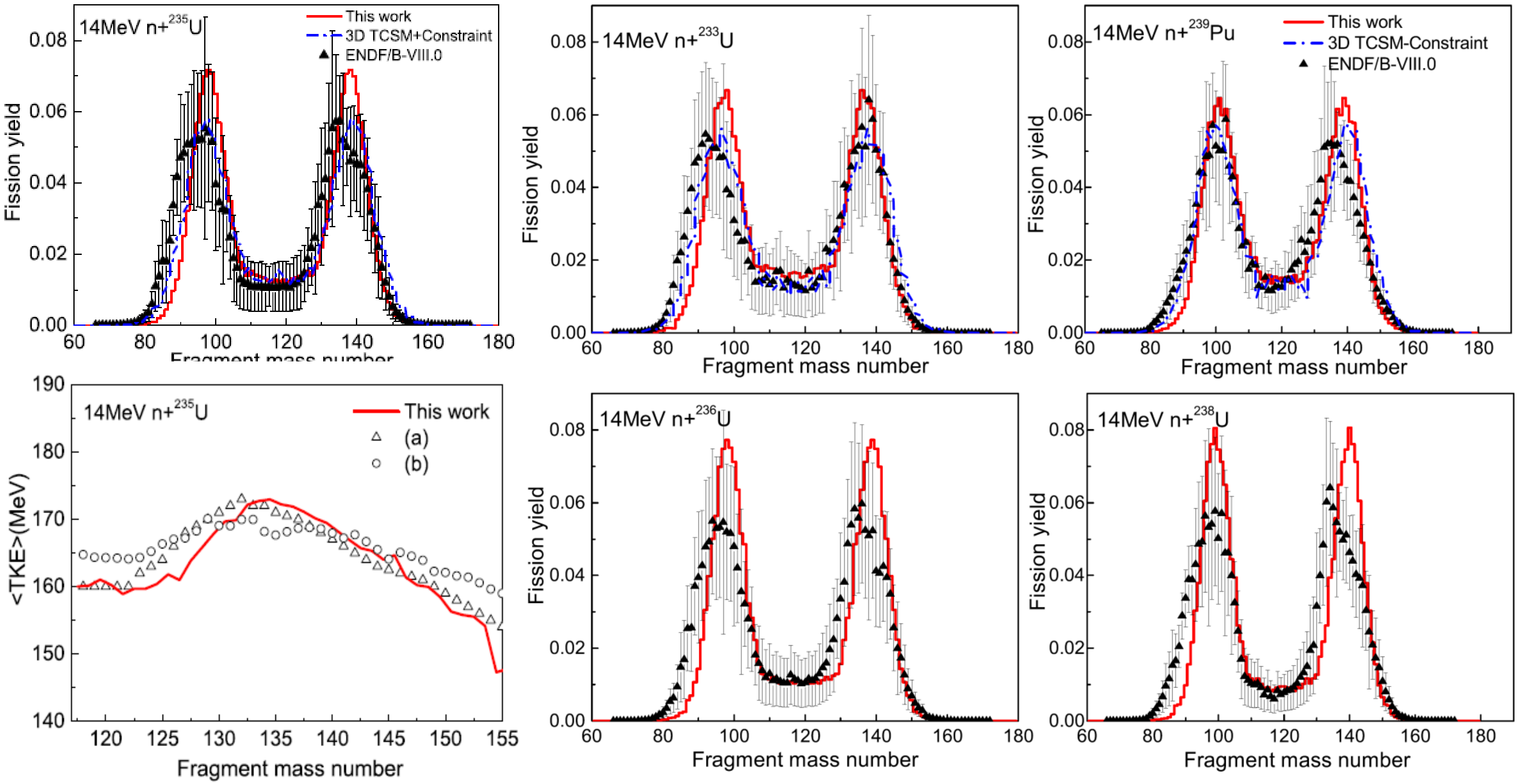
The Langevin approach is extendedly applied to study the dynamical process of nuclear fission within the Fourier shape parametrization.



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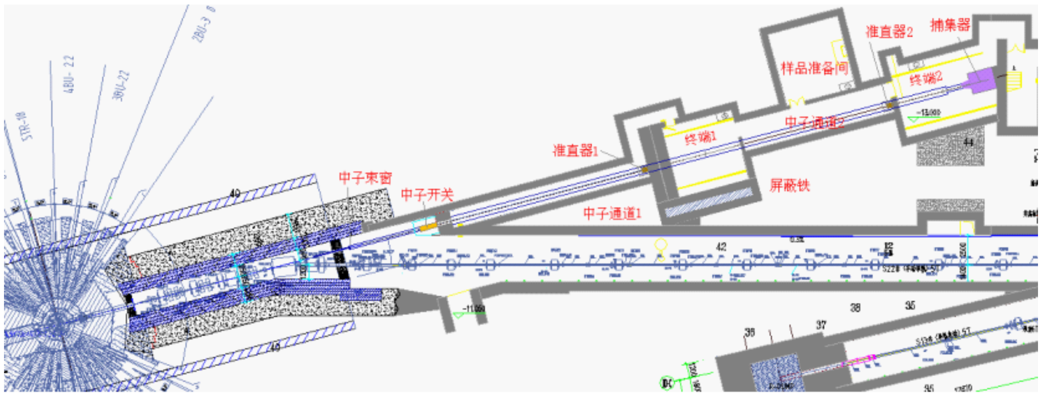
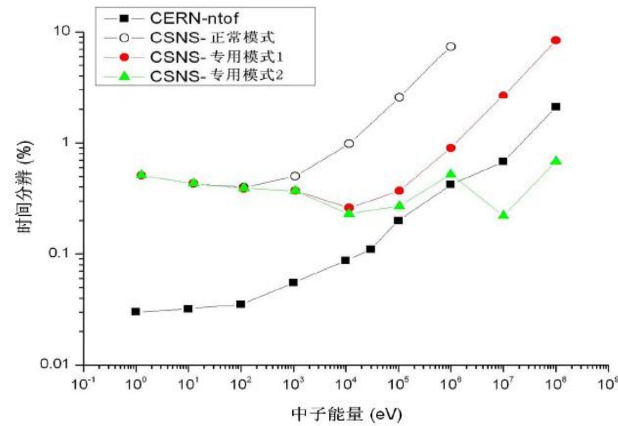
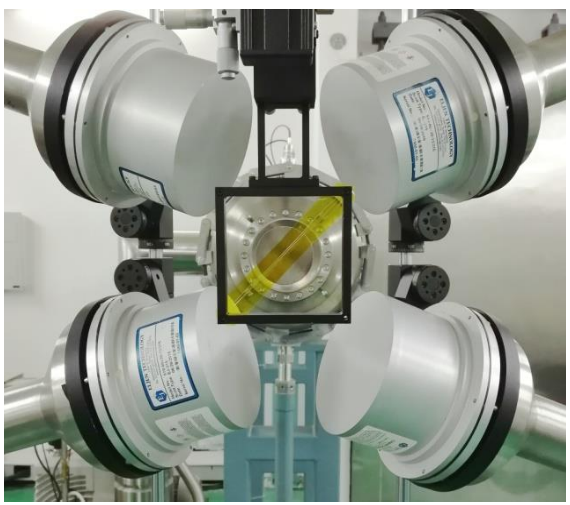
Experimental study of capture and fission cross sections for actinide

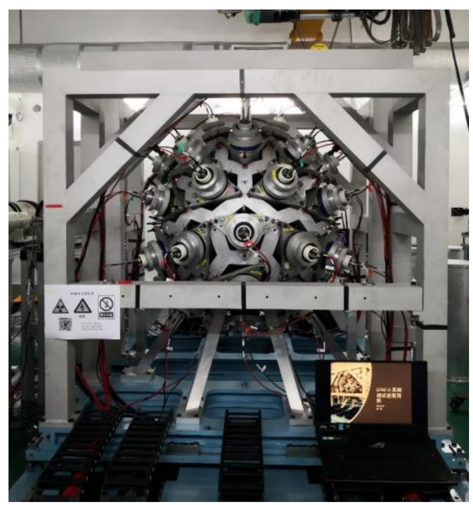
The platform and technology of neutron capture and fission cross section measurement based on CSNS were established, which makes China have the ability of nuclear data measurement in resonance region and wide neutron energy region for the first time.



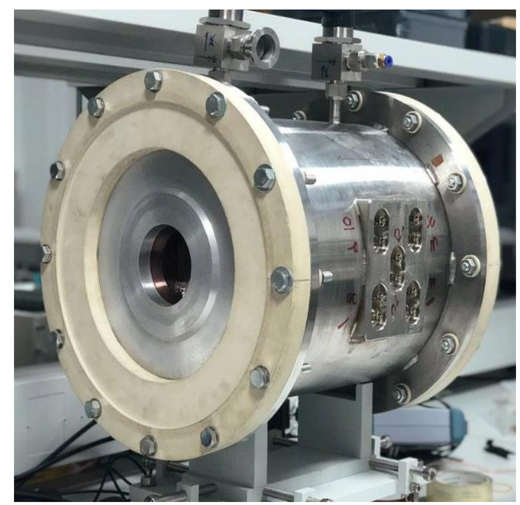




C6D6 detectors

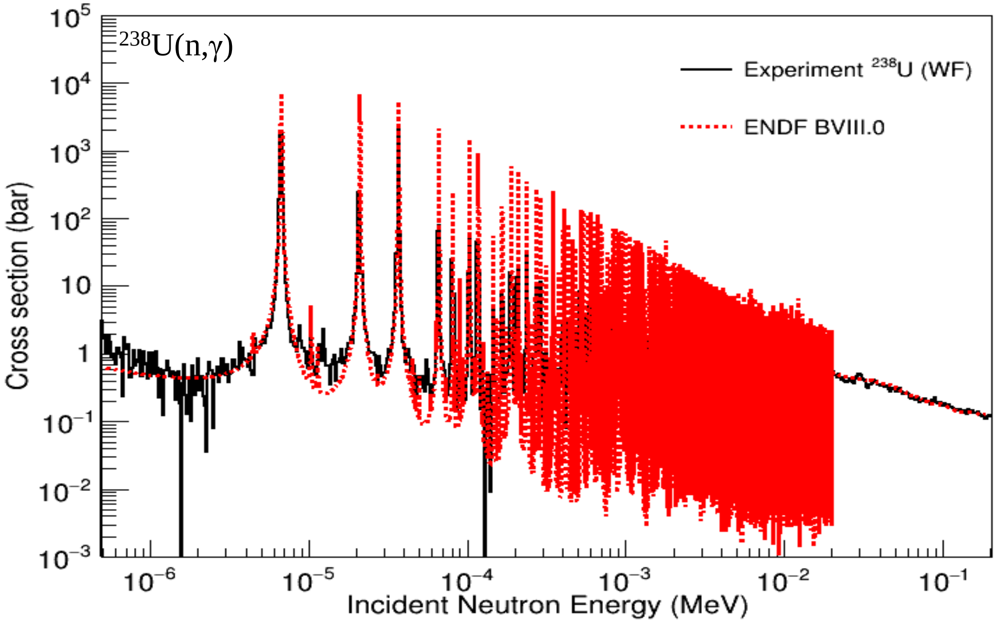


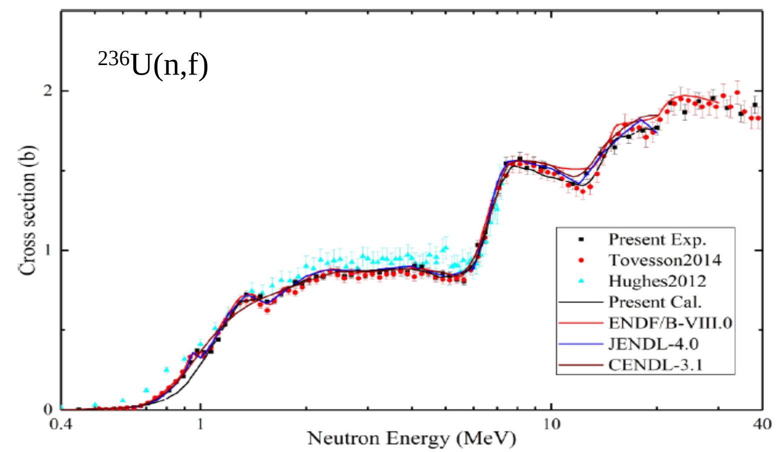
GTAF-II



FIXM

Many (n,γ) measurements and fission cross section ratio of ^{238}U to ^{235}U, as well as fission cross section of ^{236}U, have been performed.





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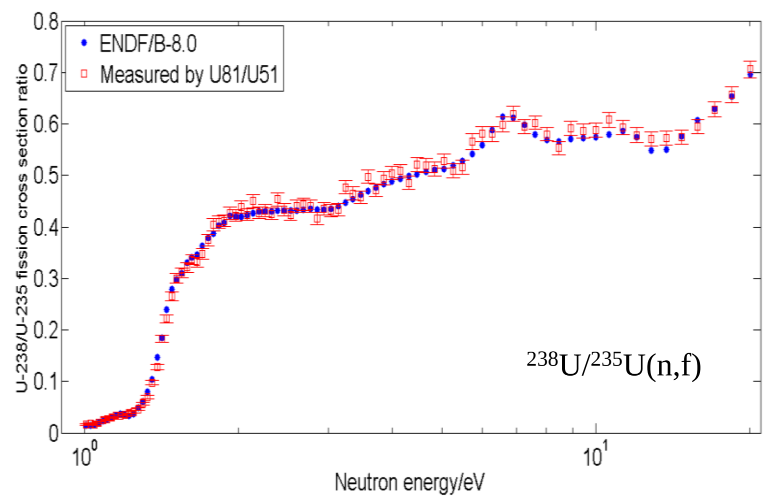
Time	Sample	Beam (h)	Institute
2018.04	^{169}Tm, ^{197}Au	122	CIAE
2018.11	^{57}Fe	130	CIAE
2019.01	^{nat}Se, ^{89}Y	180	Shanghai Advanced Research Institute
2019.01	^{232}Th	165	Shanghai Institute of Applied Physics,CAS
2019.04	^{238}U, ^{93}Nb	200	CIAE
2019.04	^{nat}Er, ^{nat}Yb, ^{nat}Sm	135	Shanghai Advanced Research Institute
2019.10	Lu	130	Inner Mongolia University for Nationalities
2020.06	Cu		Shanghai Advanced Research Institute
2020.10	$^{151,153}Eu$		Sun Yat-sen University



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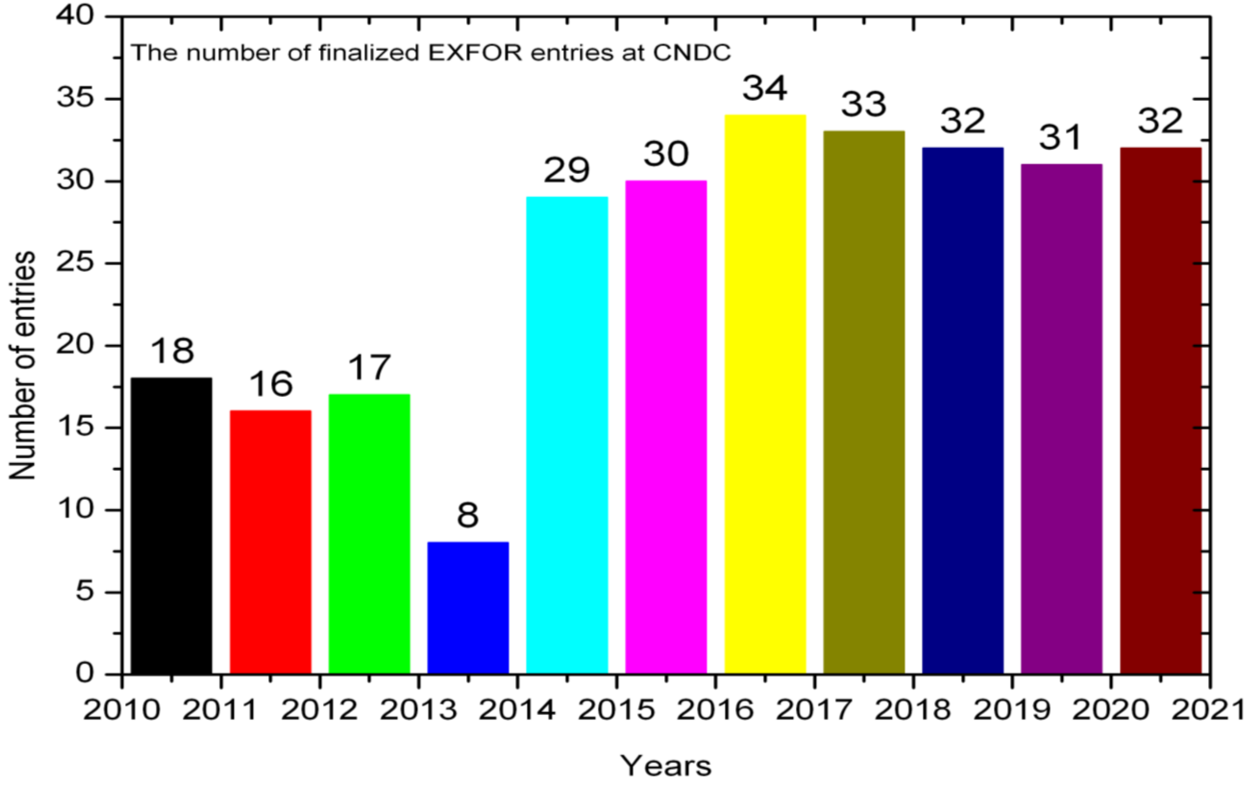
IV. EXFOR activities at CNDC

- **Compilation**

➢ more than 410 entries were compiled at CNDC. Since 2010, more than 280 entries were finalized, which included 142 neutron and 138 charged particle entries. Feedback and correction performed for more than 100 entries.

➢ Since the last NRDC meeting (April 2019), 63 new entries have been finalized and 26 entries have been revised, more than 87 articles under compiling.



• Tools used in Compilation

- ➢ Searching for material (analysis of papers, books, reports, dissertations, and proceedings), all work done by hand.
- ➢ Using **EXFOR-Editor software** developed by the CNPD for coding of the selected information in accordance with the rules of the EXFOR library, and checking for compliance with the EXFOR format to ensure the reliability and quality of the input data.
- ➢ Using **GDGraph software** developed by Yongli Jin (CNDC) for digitization. Article from old journals, in which the results of the experiments are presented in the form of graphical dependences without the tabular data used to plot these graphs.
- ➢ In addition, processing of an EXFOR entry or trans tape with the codes **CHEX** and **ORDER** have been developed by Victoria McLane (NNDC), and **JANIS** Trans Checker is maintained by Nicolas Soppera (NEA DB).

- # Scanning of Chinese Journals

➢ Currently, CNDC is responsible for scanning of 8 Chinese journals, 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. CNDC submit the scanning results to IAEA/NDS every month since January 2020.

➢ Memo CP-S/005, "Complete scanning of articles published in CST (Vols. 1 to 54)

➢ Memo CP-S/006, "Complete scanning of articles published in CTNP (Vols. 1 to 13) and CNPR (Vols. 14 to 37)

- # Institute codes

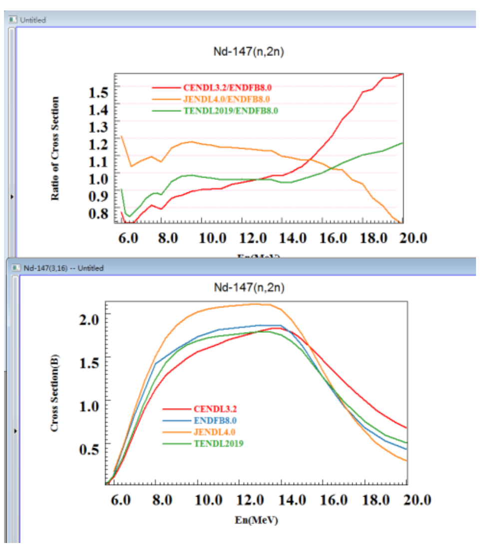
➢ Memo CP-S/007, "Dictionary 3 (Institute codes) – 3CPRSNU, 3CPRSZH"

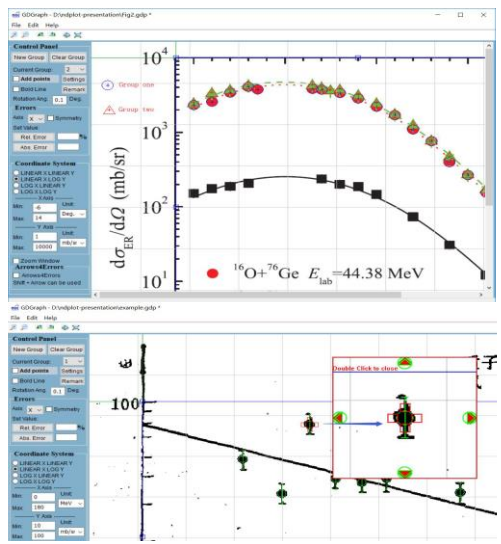
➢ Memo CP-S/008, "Dictionary 3 (Institute codes) – 3CPRSZN"

3CPRSNU	Shanxi Normal University, Linfen
3CPRSZH	Sun Yat-Sen University, Zhuhai
3CPRSZN	Shenzhen University, Shenzhen

• Development of Software

- **NDPlot**: a program designed to facilitate the visualization and manipulation of nuclear data, developed. The latest version 0.95 beta was released in Dec.14,2020, some new features were introduced, such as ratio with curves, more convenient for processing of natural nuclide data, and so on.
- **GDGraph**: a graph digitization tool, developed by Dr. Yongli Jin (CNDC). A friendly interface has been implemented by use of WxWidgets as the graphical user interface toolkit.
- Both software have been registered last year.





V. Nuclear data service

- CNDC provides the nuclear data service and receives feedback in China. Online service through the Website of "The Database of Nuclear Physics". Including experimental data (EXFOR), evaluated data (ENDF/B-VIII.0, JENDL-4.0, JEFF-3.3, BROND-3.1 and CENDL-3.2), nuclear structure and decay data, astrophysical data and nuclear data for medical applications, etc.
- The regular update and maintenance of IAEA/NDS mirror-site in China

Thank you for your attention !
Comments and suggestion welcome !