2017/18 Status Report of China Nuclear Data Center

GE Zhigang

China Nuclear Data Center(CNDC)
China Committee of Nuclear Data(CCND)
China Institute of Atomic Energy(CIAE)
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I. General Information of 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.
- 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.

1.1 Information of CNDC

中国核数据中心组织 CNDC Organization

主任 D

葛智刚 博士
Dr. Ge Zhigang

副主任 Deputy Directors

钱 晶 博士
Dr. Qian Jing

吴海成 博士
Dr. Wu Haicheng

评价组 Evaluation Unit

组长： 黄小龙 博士

- 实验核数据的编纂和评价工作
- 实验数据评价方法研究
- 建立实验核数据库（EXFOR）

Head: Dr. Huang Xiaolong

- Exp. data evaluations
- Methodological studies of exp. data eval.
- EXFOR compilation

理论组 Theory Unit

组长：续瑞瑞 博士

- 核数据的核反应理论基础研究。
- 中子/带电粒子核反应程序研制。
- 核数据模型计算任务。

Head: Dr. Xu Ruirui

- Nucl. data model study
- Development of nucl. data code.
- Nul. data calculation

宏观组 Macroscopic Data Unit

组长：刘　　萍 博士

- 评价核数据库群常数加工制作。
- 评价核数据基准检验。
- 群常数制作和宏观检验方法研究。

Head: Dr. Liu Ping

- Nucl. data processing
- Nucl. data benchmarking/validation
- Methodological of bechmarking/ processing

数据库组 Data Library Unit

组长：舒能川 博士

- 数据评价方法研究/评价系统建立。
- 建立计算机化中国评价核数据库。
- 计算机网络系统/用户服务。

Head: Dr. Shu Nengchuan

- Data library setup/management
- Evaluation system of nucl. data setup
- Nucl. data service/user assistance

Evaluation Unit	Head: Dr. Huang Xiaolong	3 official staff
Theory Unit	Head: Dr. Xu Ruirui	6 official staff
Macroscopic Data Unit	Head: Dr. Liu Ping	5 official staff
Data Library Unit	Head: Dr. Shu Nengchuan	4 official staff
Secretary Office		1 official staff

- ✓ 19 official staff + 6 students(Master 2, Ph.D 4).
- ✓ Planning to increase the official staff up to 25 in recently years.

1.2 Mainly tasks of CNDC in 2017/2018:

- New evaluations and re-evaluations for neutron data file for CENDL-3.2β0.
- Nuclear structure and decay data evaluation.
- Update photonuclear data modeling and evaluations.
- Methodological studies of nuclear data evaluation.
- The compilations for EXFOR.
- The regular update and maintenance of IAEA/NDS mirror-site in China.
- Nuclear data services is providing to all the nuclear data users.
- ND2019 preparation.

II. CENDL-3.2β0 and Methodology Study

2.1 CENDL-3.2b0

CENDL-3.2β0 will be the updated library as the main fruit of the CENDL project recent years.

Various kinds of nuclear data are involved in CENDL library, which mainly include the complete set of neutron data, activation data, decay data, fission yield data files.

Therefore, the massive activities are carried out and going on to develop our methodologies of nuclear data evaluation to fulfill the mission, including microscopic nuclear model, covariance evaluation scheme, theory of fission product… …

Nucl.	*Content of Nuclei in CENDL-3.2β0 (250)*
Light Elements	$^{1-3}$H, ^{3,4}He, ^{6,7}Li, ^{9}Be, ^{10,11}B, ^{12}C, ^{14}N, ^{16}O, ^{19}F
Structural Materials	^{23}Na, $^{24-26}$Mg, ^{27}Al, $^{28-30}$Si, ^{31}P, ^{32,33,34,36}S, ^{0}Cl, ^{0}K, ^{40}Ca, $^{46-50}$Ti, ^{0}V, $^{50,52-54}$Cr, ^{55}Mn, $^{54,56-58}$Fe, ^{59}Co, $^{58,60-62,64}$Ni, ^{0,63,65}Cu, ^{0}Zn, ^{0}Ge, $^{90-92,94,96}$Zr, $^{92,94-98,100}$Mo, ^{0,107,109}Ag, ^{0}Cd, ^{0}Sn, $^{174,176-180}$Hf, ^{181}Ta, ^{180,182,183,184,186}W, ^{197}Au, ^{0}Hg, ^{0}Tl, $^{204,206-208}$Pb, ^{209}Bi
Fission Products & Medium Elements	^{69,71}Ga, $^{70-78}$Ge, ^{75,77,79}As, ^{83,84,85,86,87}Kr, ^{85,87}Rb, $^{88-90}$Sr, ^{89,91}Y, ^{93,95}Zr ^{93,95}Nb, ^{99}Tc, $^{99-105}$Ru, ^{103,105}Rh, ^{105,108}Pd, ^{113}Cd, ^{113,115}In, $^{112,114-120,122,124}$Sn, ^{121,123,125}Sb, ^{130}Te, ^{127,129,135}I $^{123,124,129,131,132,133,134-136}$Xe, $^{133-135,137}$Cs, $^{130,132,134-138}$Ba, ^{139}La $^{136,138,140-142,144}$Ce, ^{141}Pr, $^{142-148,150}$Nd, ^{147,148,148m,149}Pm $^{144,147-152,154}$Sm, $^{151,153-155}$Eu, $^{152,153,154-158,160}$Gd, ^{164}Dy
Actinides	^{232}Th, $^{232-240,241}$U, $^{236-239}$Np, $^{236-246}$Pu, $^{240-244,242m}$Am, ^{249}Bk, ^{249}Cf

Nucl.	***New evaluated and updated nuclei in CENDL-3.2b0 (57)***	
Light Elements	**^{1}H, ^{6,7}Li**	**3**
Structural Materials	**^{23}Na, ^{32,33,34,36}S, ^{27}Al, ^{40}Ca, ^{56}Fe, ^{58}Ni, ^{181}Ta, ^{180,182,183,184,186}W**	**15**
Fission Products	**^{87,88}Kr, ^{93}Nb, ^{125}Sb, ^{123,124,129,131,133,134,135}Xe, ^{140,141,142}Ce, ^{152,153,154,155,156,157,158,160}Gd**	**22**
Actinides	**^{232}Th, ^{233,235,236,237,239,240}U, ^{236,237,238,239}Np, ^{237,238,241}Pu, ^{241}Am**	**15**

1、The total materials of CENDL3.2β0 is 250 (240 in CENDL3.1);

- 56 nuclides are newly evaluated and updated in CENDL3.2 β0;
- 14 nuclides are new members in CENDL3.2 β0;
- 42 nuclides are revised based on CENDL3.1;
- Covariance for 16 nuclides (^{2,3}H, ^{3}He, ^{19}F, ^{40}Ca, ^{48}Ti, ^{55}Mn, ^{63,65,0}Cu, ^{90,91,92,93,94,95,96}Zr, ^{180,182,183,184,186}W, ^{233,235}U) with high fidelity based on CENDL3.1

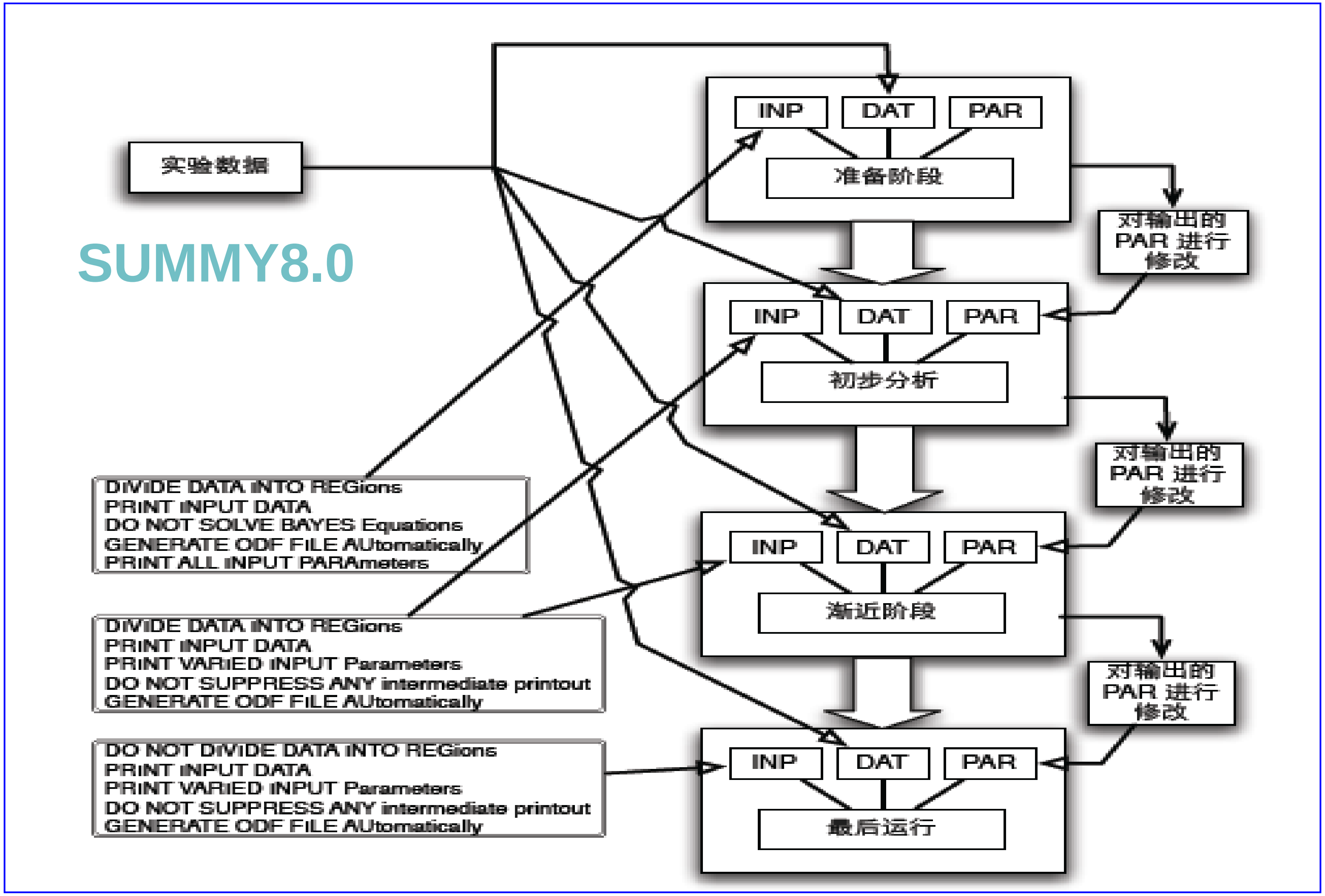
2、The incident neutron energy $E_n \leq$ 20MeV;

3、MF = 1, 3, 4, 5, 6, 12, 14, 15, 33.

2.2 Methodology Study

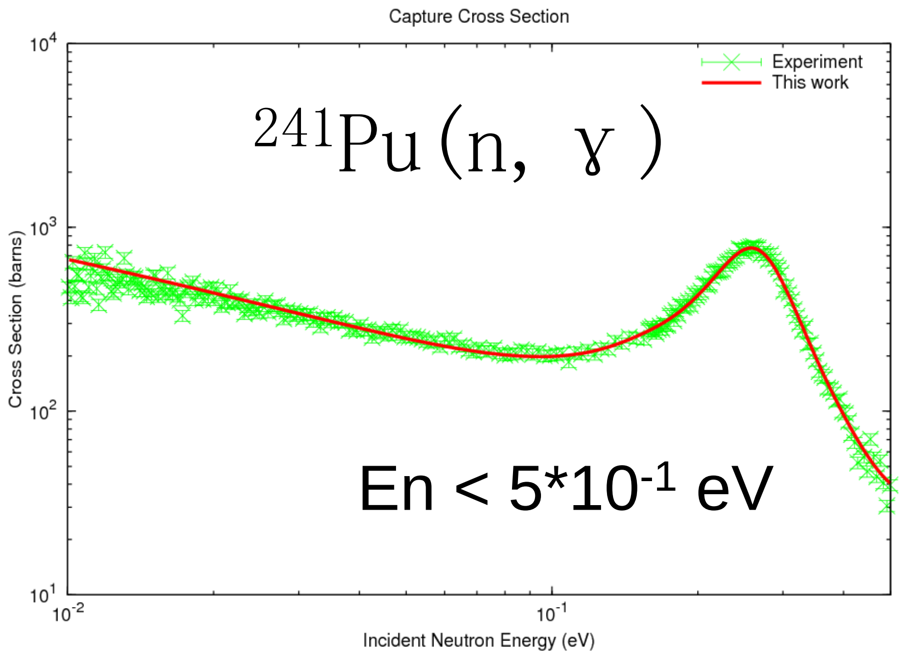
The evaluation scheme for resonance at CNDC

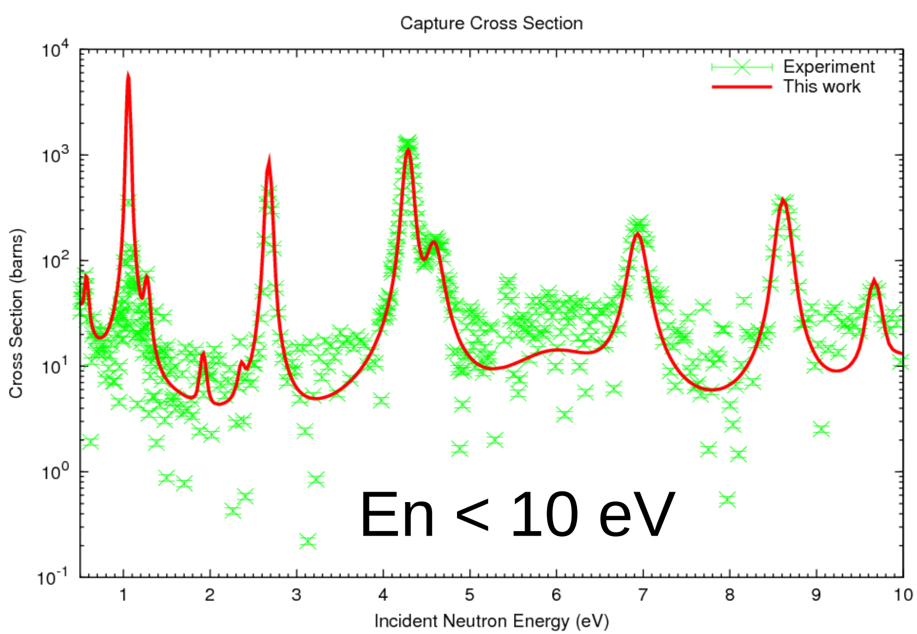
Analysis Scheme at CNDC



The concerned experimental data for 241Pu (n, tot), (n, γ), (n, fission)

Energy Region（eV）	Data accepted
0.001-0.5	**TOT:** Schwartz, Simpson, Craig, Young, Smith **FIS:** Adamchuk, Richmond, Seppi, Raffle, Watanabe(1964,1966), James, Wagemans(1975,1991), Weston, Tovesson CAP: Weston
0.5-20	**TOT:** Harvey, Kolar, Pattenden, Simpson, Craig **FIS:**Adamchuk, Richmond,Moore, Watanabe(1964), James, Migneco, Blons, Wagemans(1976,1991), Weston, Tovesson **CAP:** Weston
20-45	**TOT:** Harvey, Kolar, Pattenden, Craig, **FIS:** Moore, Watanabe(1964), James, Simpson, Migneco, Blons, Wagemans(1976), Weston, Tovesson **CAP:** Weston
45-100	**TOT:** Harvey, Kolar, Pattenden ,Craig, **FIS:** Moore, Watanabe(1964), James, Simpson, Migneco, Blons, Weston, Tovesson
100-200 200-300	**TOT:** Harvey, Kolar, Pattenden, Craig **FIS:** Watanabe(1964), James, Simpson, Migneco, Blons, Weston, Tovesson





1. The total cross section, the fission cross section and the capture reaction are considered simultaneously in our work to achieve more consistent results;

2. The experimental data reported by L. W. Weston et al in 1978 are adopted after our evaluation;

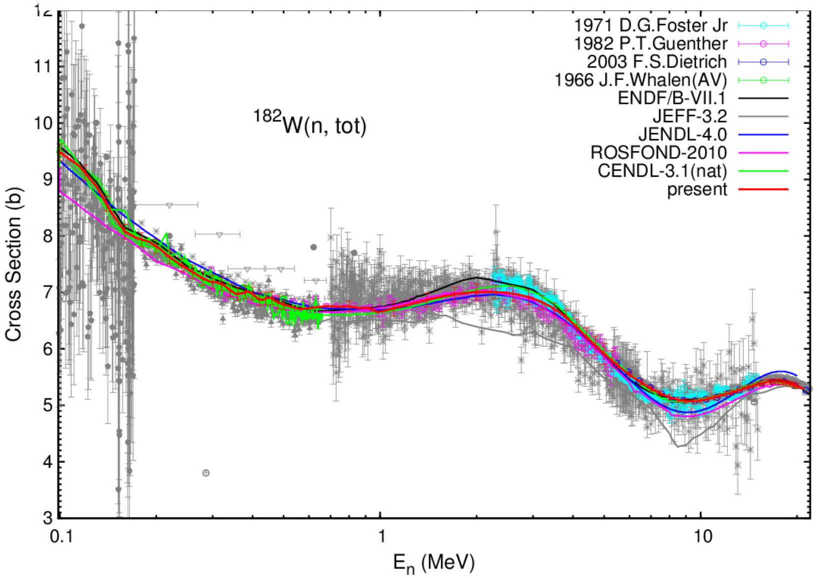
3. In the resolved resonance region (En<300eV), 274 RPs are adopted in our final evaluation, including 4 minus RPs and 5 RPs beyond 300eV;

4. The current evaluation contains additional 29 RPs in total than that in ENDF/B-VIII.beta5.

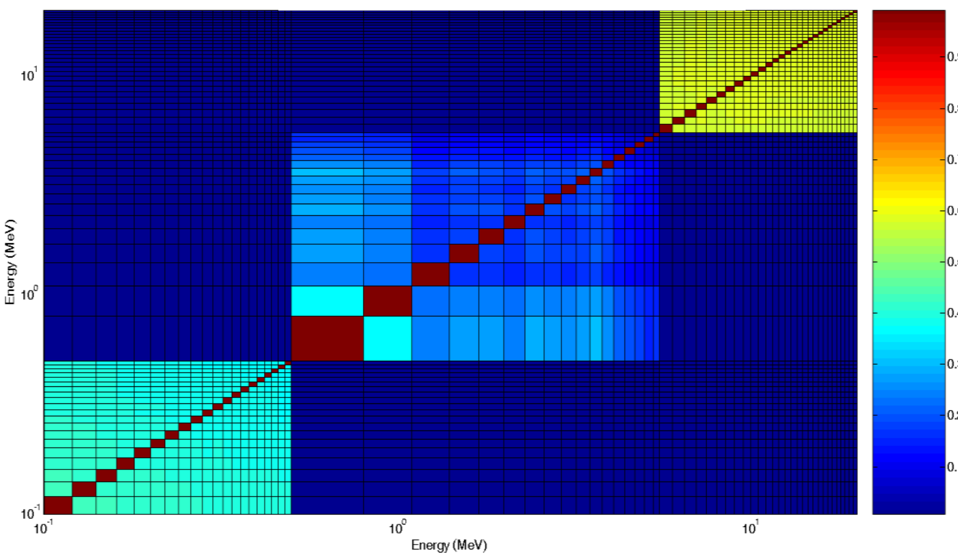
The covariance evaluation of CENDL

The non-model dependent evaluation for 182W(n, tot) cross section measurements (<20 MeV)

recommended data with uncertainties



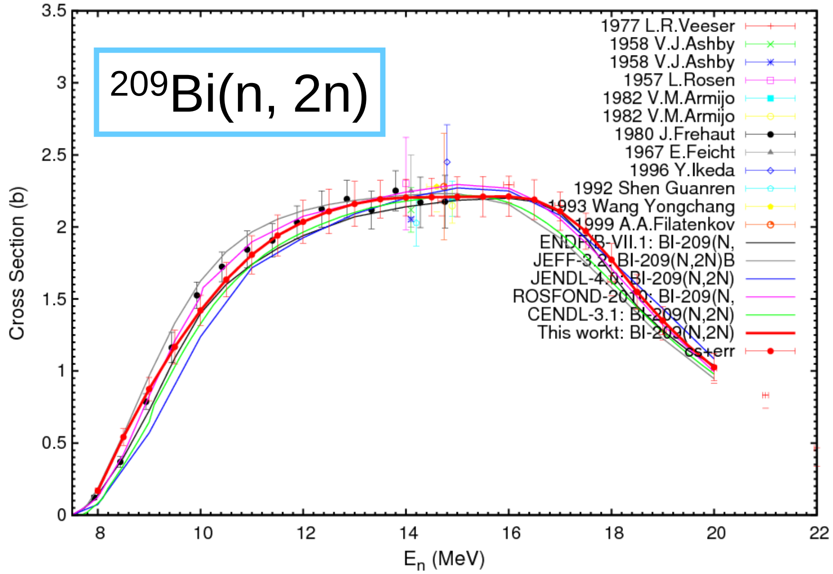
correlation coefficient

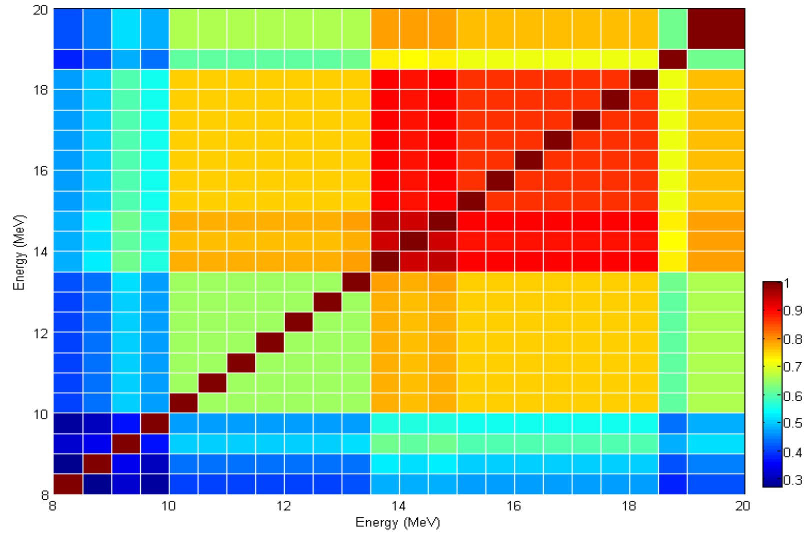


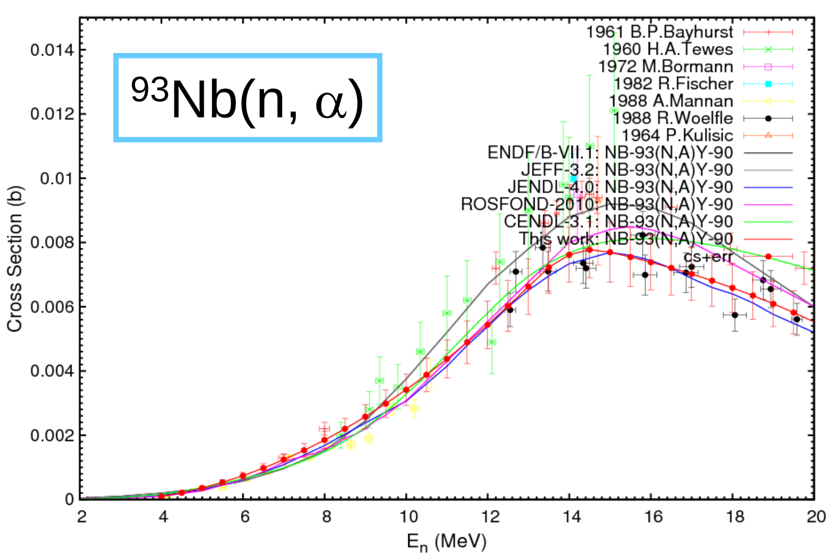
Uncertainty source ->		statistic	background	inscattering correction	deadtime correction	Energy drift	geometry	sample
correlation->		no	middle-range	middle-range	middle-range	middle-range	long-range	long-range
Section I [0.1, 0.5]	valua	original	0.006	0.006	0.005	0.005	0.003	0.008
	Coefficient factor	0	0.2	0.3	0.3	0.1	1	1
Section II [0.5, 5.45]	valua	original	0.005	0.005	0.0045	0.005	0.002	0.006
	Coefficient factor	0	0.2	0.3	0.3	0.1	1	1
Section III [5.45, 20]	valua	original	0.003	0.004	0.003	0	0.002	0.005
	Coefficient factor	0	0.2	0.3	0.3	0.1	1	1

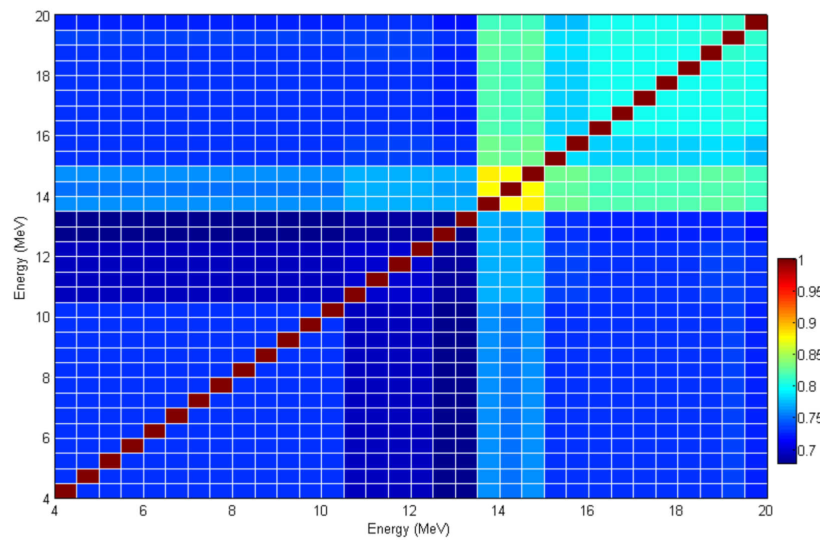
The discussion on the correlated factors and the covariance.

The covariance evaluation from CNDC and the cooperative network

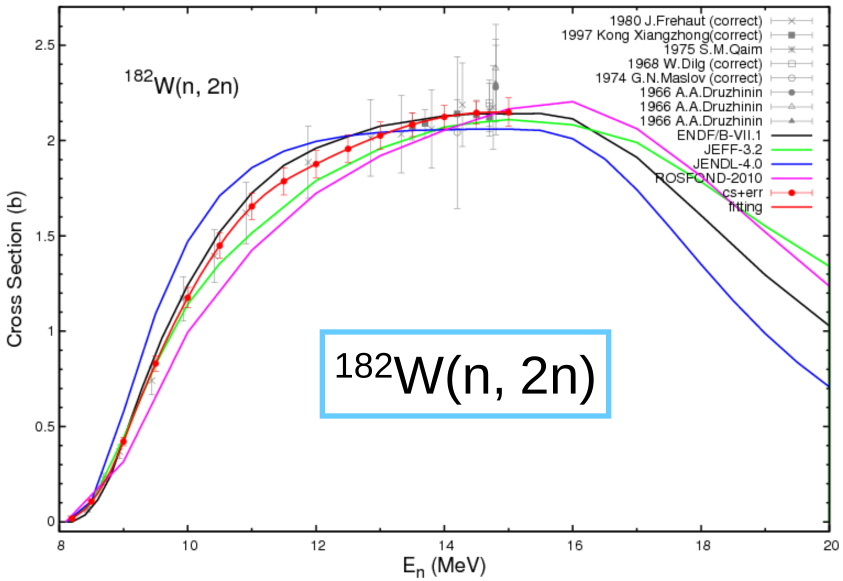


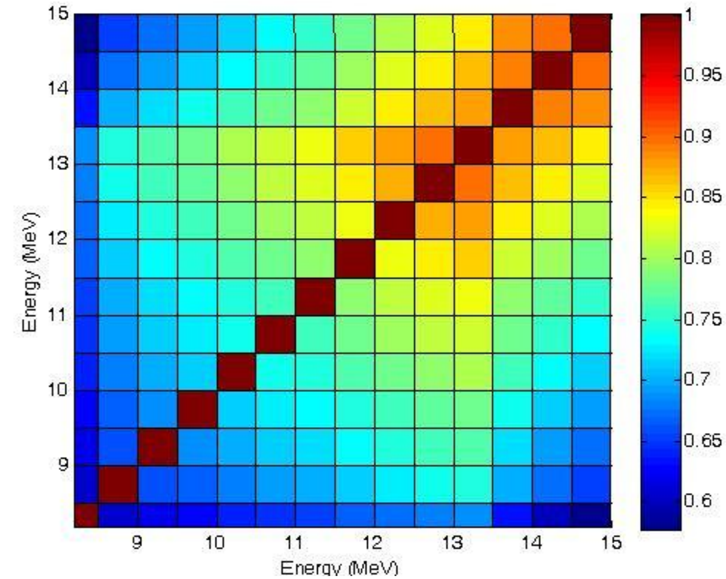


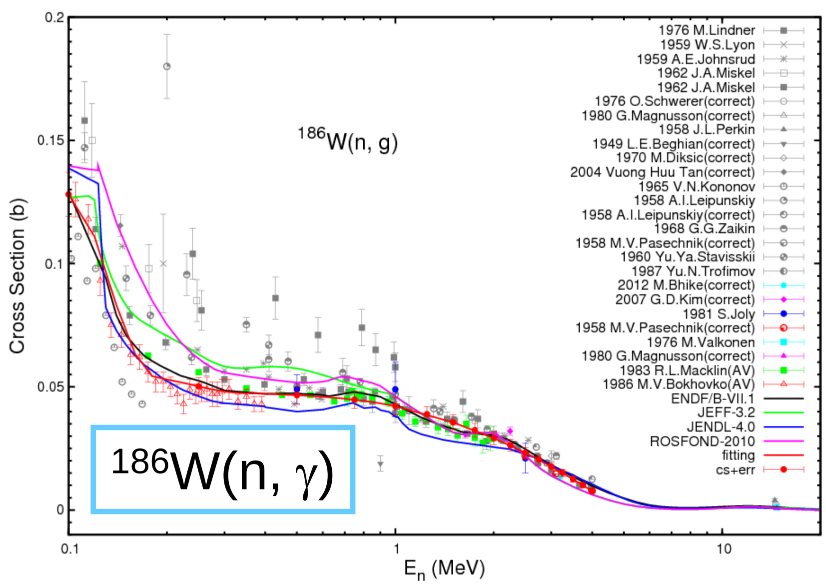


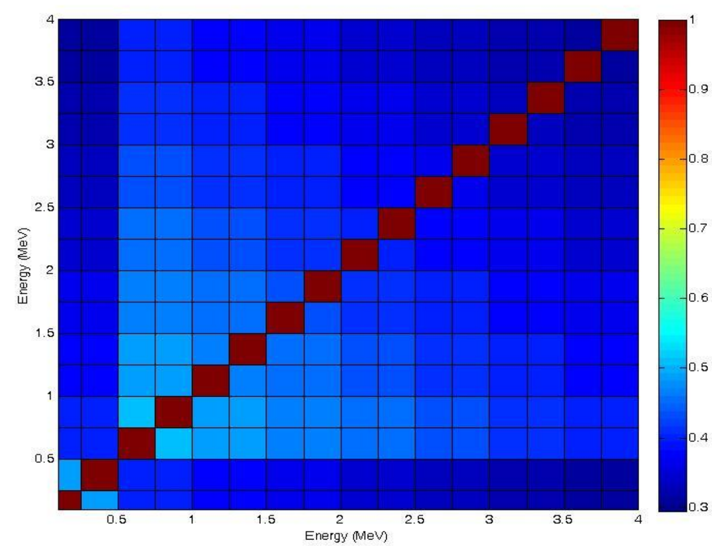


The covariance evaluation from CNDC and the cooperative network



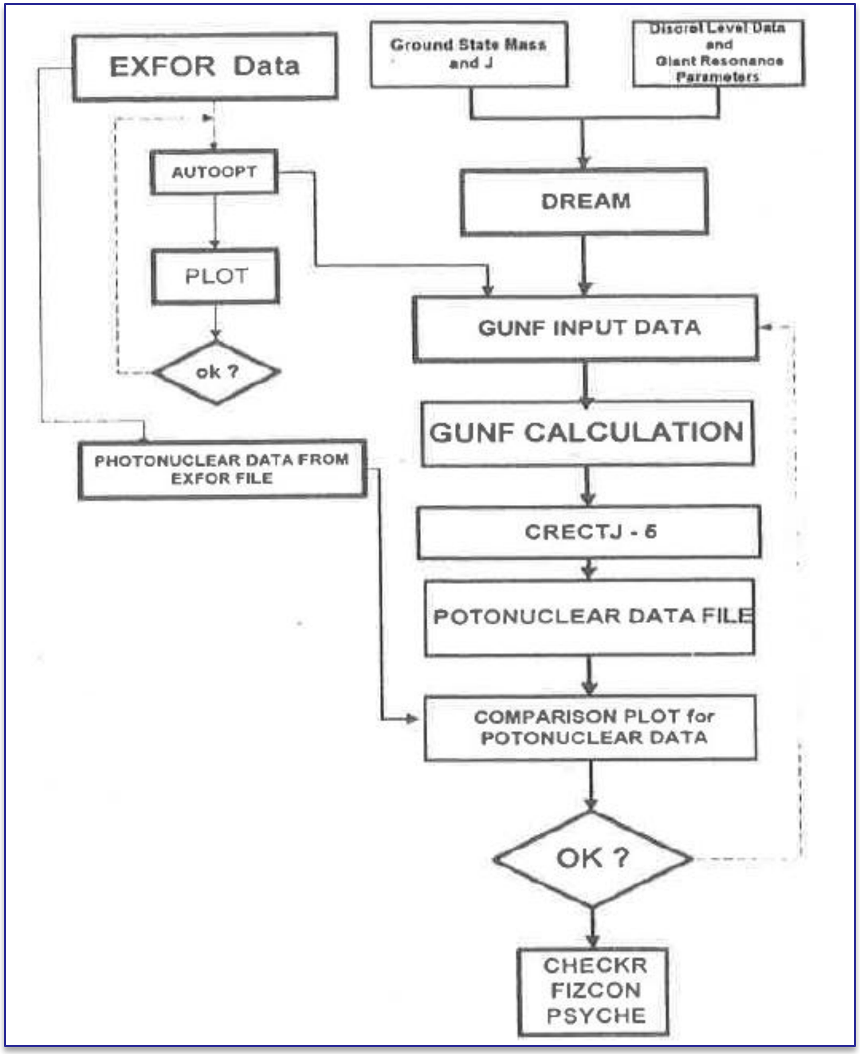






The evaluation for photonuclear data at CNDC

Methods during 1996-1999,
B. S. Yu, J. S. Zhang, Y. L. Han



What is new in the current technique from 2016-to now ?

1. New codes for more light nuclei besides ^{9}Be, and middle-heavy nuclei：
- MEND-G for middle-heavy nuclei up to 200MeV
- GLUNF for ^{6,7}Li, ^{9}Be, ^{10,11}B, ^{12}C up to 150MeV

2. Combine 7 kinds of approaches in PSF calculation, adjust new parameters for each isotopes;

3. Discussion of the theoretical calculated transitional multiplicity function Fi;

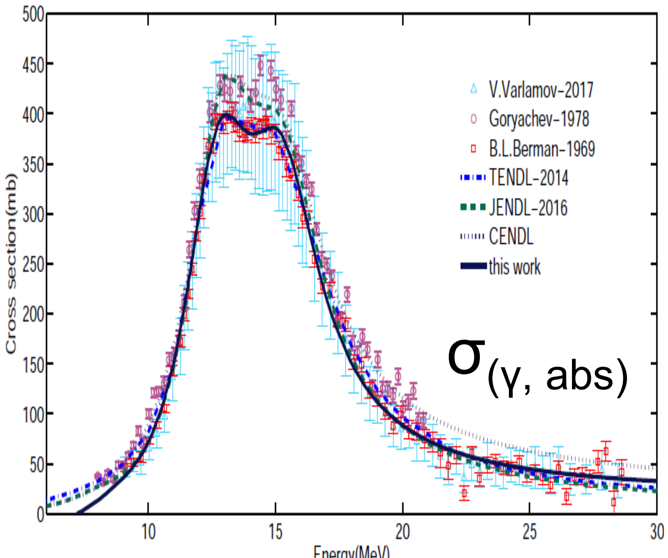
4. This work is building on more:
   latest experimental data
   latest evaluation data
   latest concentration in ENDF format

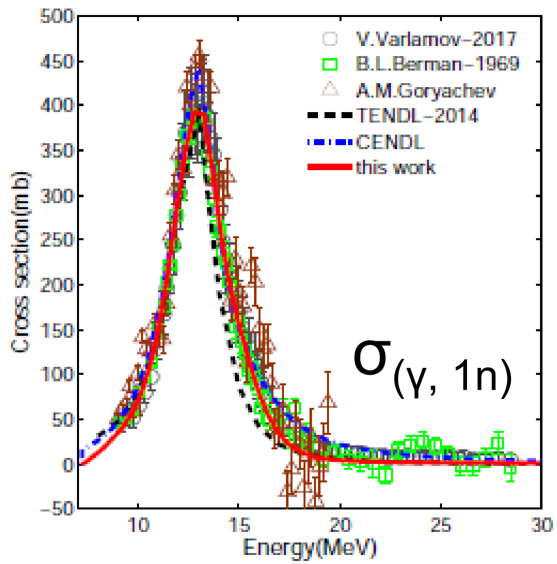
The evaluation for photonuclear data —W isotopes

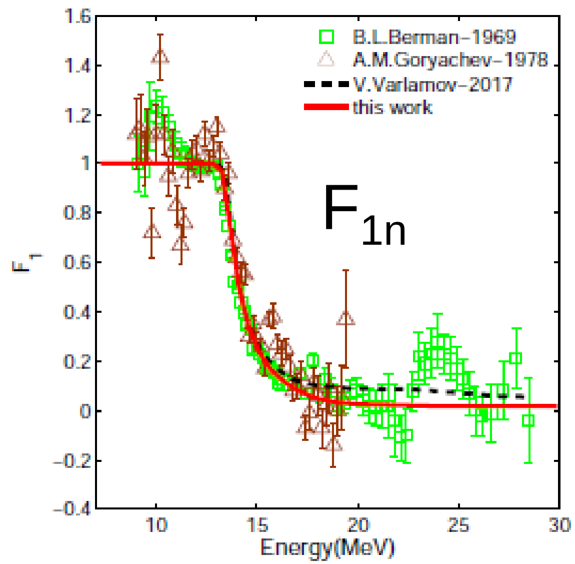
The experimental data of $\gamma + {}^{180,182,183,184,186}W$

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

The sub-library of CENDL for the photonuclear data is under study:

1. Near to 270 nucleus will be obtained;
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.

IAEA
Atoms For Peace

International Atomic Energy Agency
Agence internationale de l'énergie atomique
Organismo Internacional de Energía Atómica

Vienna International Centre, P.O. Box 100, A-1400 Vienna, Austria
Phone: (+43 1) 2600 • Fax: (+43 1) 26007
E-mail: Official.Mail@iaea.org • Internet: http://www.iaea.org

IAEA Research Contract No: 20466

Research Contract

This Research Contract is entered into between the International Atomic Energy Agency (hereinafter referred to as the "IAEA"), an intergovernmental organization established by its Statute, whose address is Vienna International Centre, P.O. Box 100, 1400 Vienna, Austria; and the China Institute of Atomic Energy CIAE (hereinafter referred to as the "Contractor") whose address is:

China Institute of Atomic Energy CIAE
PO Box 275-59
102413 Beijing
China.

Hereinafter, the IAEA and the Contractor will also be referred to individually as a "Party" and collectively as the "Parties"

Whereas, the IAEA is authorized under its Statute and the decisions of its competent organs to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world, and this mandate includes the encouragement and assistance to research on, and the development of, practical applications of atomic energy for peaceful purposes throughout the world by, inter alia, entering into contracts for research and development; and

Whereas, the Contractor is able and willing to carry out the Research Project in cooperation with the IAEA under this Research Contract (hereinafter referred to as the "Contract").

Now, therefore, the Parties hereby agree as follows:

Article 1
Scope of the Research Project

1. The Contractor undertakes to perform the Research Project entitled "Calculation and Evaluation of Photonuclear Cross Sections and Y-Ray Strenght Functions for Light and Medium Heavy Nuclei" (hereinafter referred to as the "Research Project") which forms a part of the IAEA's Coordinated Research Project "F41032", entitled "Updating Photonuclear Data Library and Generating a Reference for Photon Strength Functions".

2. The Chief Scientific Investigator shall be Ms Ruirui Xu.

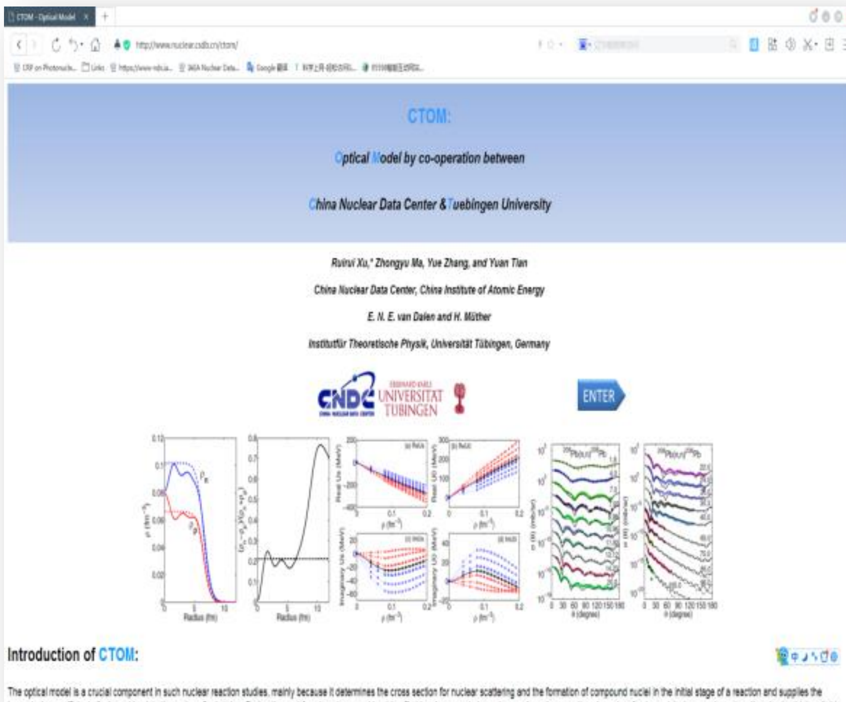
3. The programme of work to be performed under this Research Project shall be:

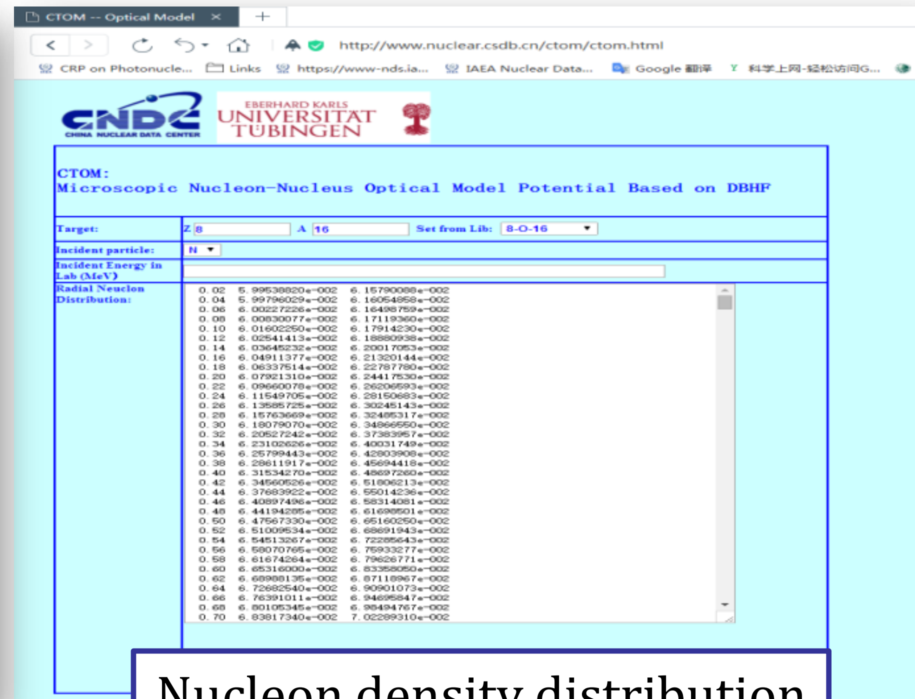
IAEA Contract with
CNDC-[20466]

Semi-Microscopic nucleon-nucleus OMP – CTOM

CTOM based on the DBHF model is released in 2017.6

The nucleon density distributions of 88 nucleus base on HFB calculation are available.



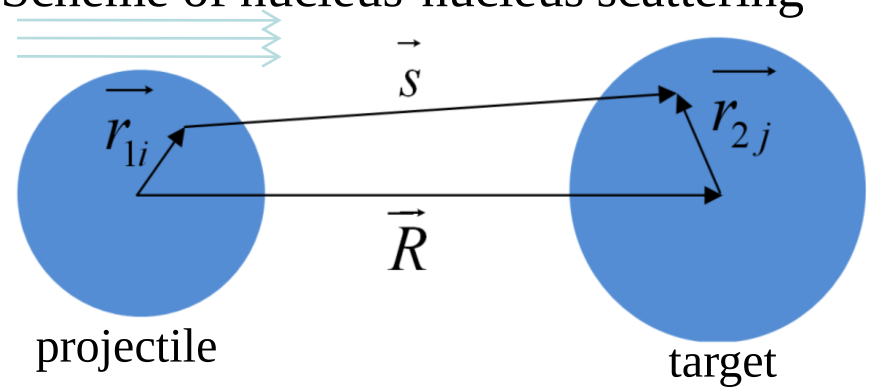


Nucleon density distribution

http: www.nuclear.csdb.cn/ctom

Microscopic OMP for nucleus - nucleus scattering

Scheme of nucleus-nucleus scattering



Double folding model

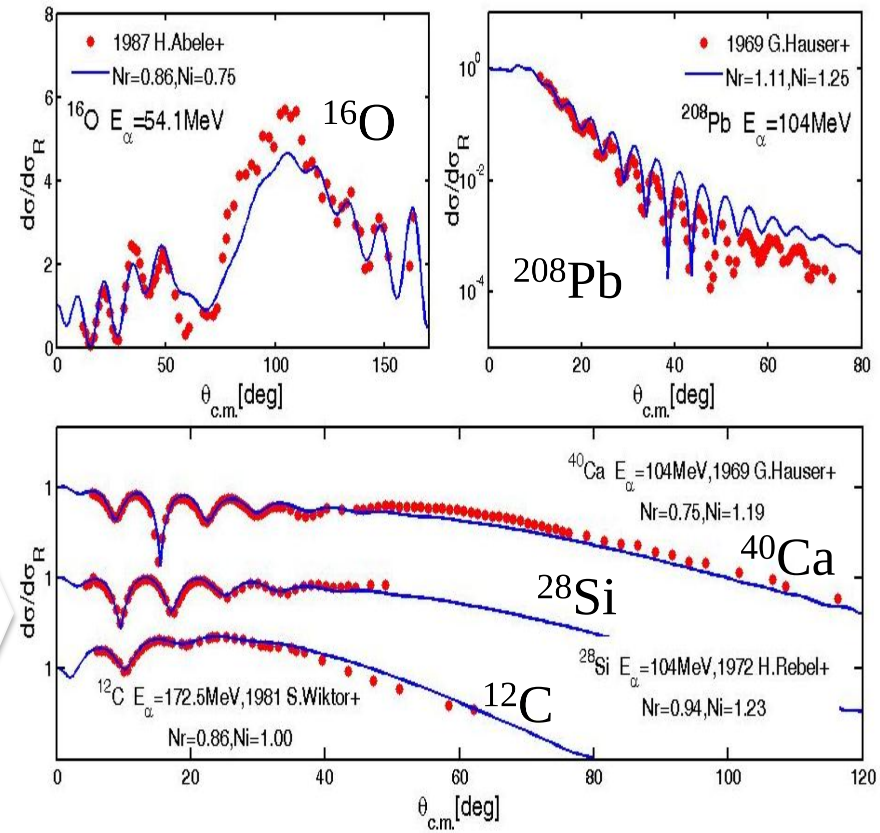
$$U(R)=\int \rho_1(\vec{r}_1)\rho_2(\vec{r}_2)V(\varepsilon,\rho,\vec{s})d\vec{r}_1 d\vec{r}_2$$

$$U(R)=\int \rho_{1p}(\vec{r}_1)\rho_2(\vec{r}_2)V_p(\varepsilon,\rho,\beta)d\vec{r}_1 d\vec{r}_2 +\int \rho_{1n}(\vec{r}_1)\rho_2(\vec{r}_2)V_n(\varepsilon,\rho,\beta)d\vec{r}_1 d\vec{r}_2$$

Fourier transform， six-fold integral

Scattering from the isospin asymmetric nucleus

Isospin dependency nucleus-nucleus potential

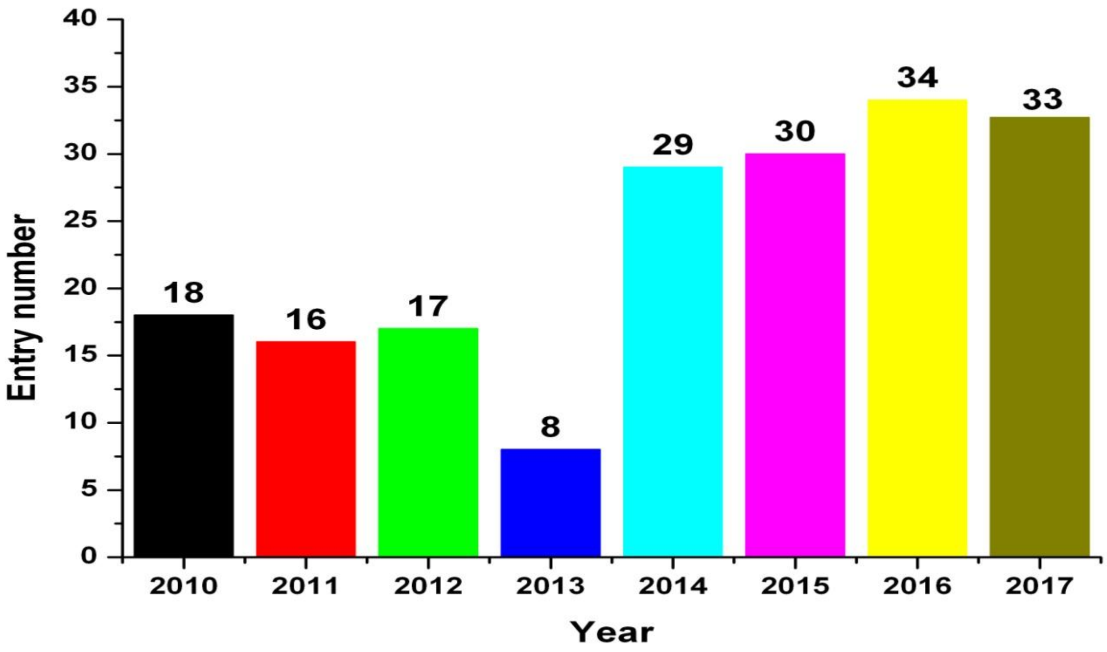


The prediction power of our nucleus-nucleus potential based on CTOM is satisfactory.

III. EXFOR activities at CNDC during 2017/2018

3.1 Compilation activities of EXFOR

- Since 2010, CNDC has compiled 185 EXFOR entries, which included 84 neutron and 101 charged particle entries, feedback & correction performed for more than 40 entries.
- From NRDC-2017 to now, 33 entries have been finalized and 11 entries have been updated, more than 35 articles under compiling and more than 5 entries under checking.

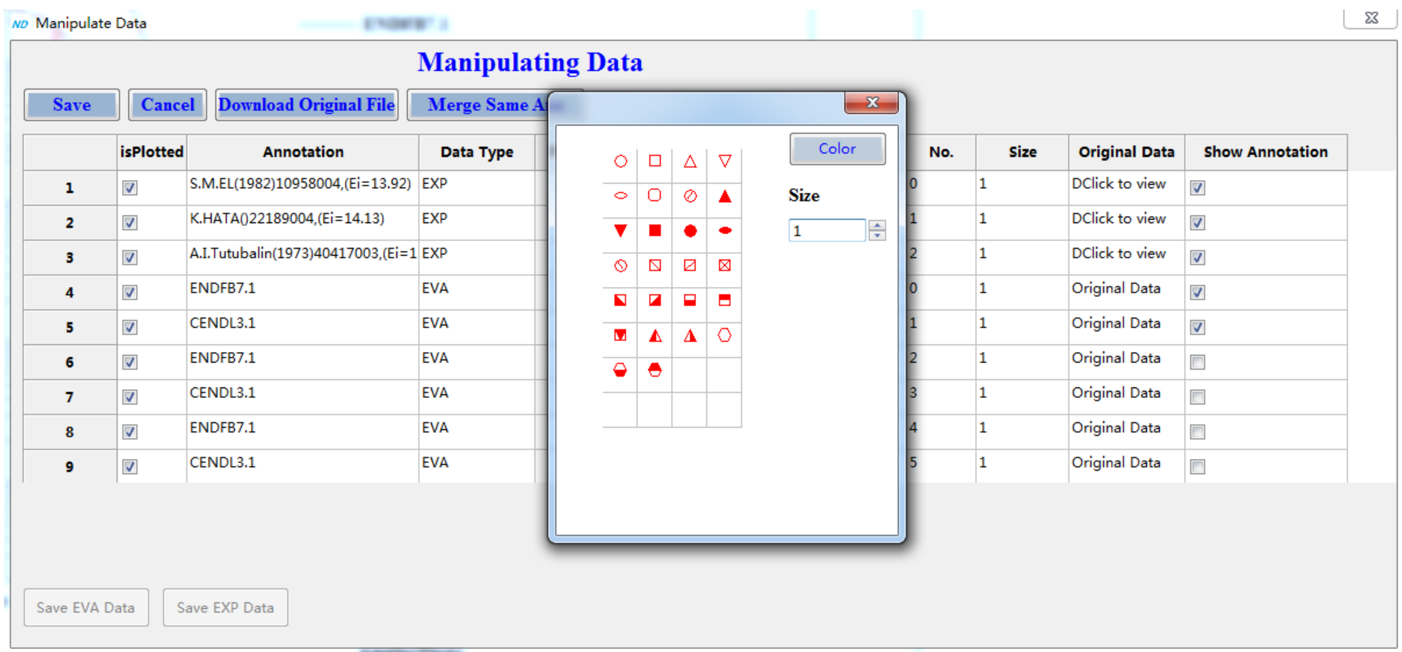


The number of the finalized EXFOR entries

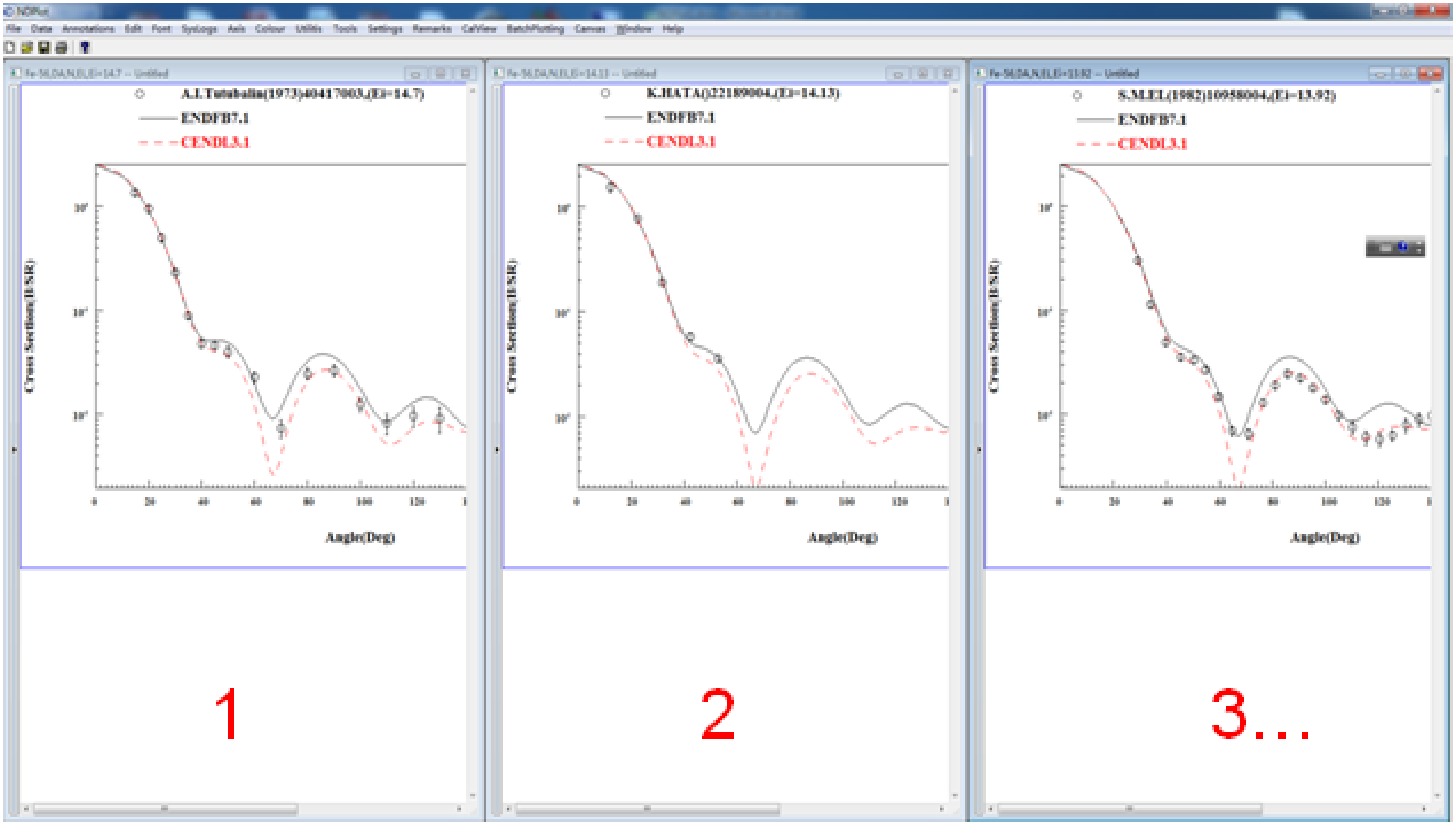
3.2 Software NDPlot

Nuclear data plotting software NDPlot was developed by Dr. Yongli Jin in 2017. Features of NDPlot as follows:

1. Treatments of CS, DA, DE, DAE etc.
2. Using EXFOR, ENDF, and user-defined format data (free format).
3. Saving project file.
4. Exporting figures as jpg, eps, pdf, etc.
5. Supporting Windows clipboard (inserting picture into MS Word, PowerPoint).
6. Online retrieve & transfer the exp. and eval. data from the database.



Changing the point style



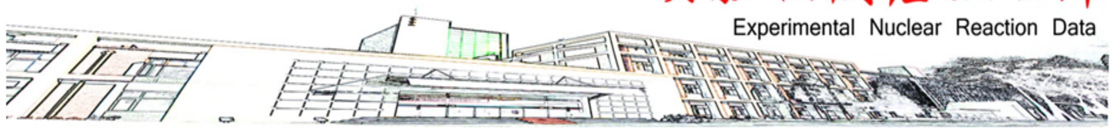
Multiple windows for plotting

3.2 Management Software

EXFOR compilation managed Website has been a definite improvement, can be better managed the compilation process.

中国核数据中心

实验核反应数据库
Experimental Nuclear Reaction Data



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欢迎taoxi!

	No.	Title	Ref.	Vol.	Issue	Page	Publish date	Author	Action	Compiler	Entry	Memo
修改 详情	1	Measurement of neutron-removal cross section of neutron-rich nucleus 8He by using the transmission method	J,HEN	31	1	52	200701	李琛(Li Chen)	Finalized	Youxiang ZHUANG	S0110	1) Assigned and compiled it during N.Otsuka visit (16-22 Nov. 2014).
修改 详情	2	Rotation and decay of the dinuclear system formed in dissipative reaction of 19F + 27Al	J,HEN	29	12	1142	200512	韩建龙(Han Jianlong)	Finalized	Youxiang ZHUANG	S0108	1) Assigned and compiled it during N.Otsuka visit (16-22 Nov. 2014).
修改 详情	3	Measurement of total reaction cross sections for neutron-rich nucleus 8He on 28Si	J,HEN	29	10	944	200510	李琛(Li Chen)	Finalized	Youxiang ZHUANG	S0107	1) Assigned and compiled it during N.Otsuka visit (16-22 Nov. 2014).
修改 详情	4	Experimental study of the exotic-nuclei	J,HEN	28	12	1256	200412	李加兴(Li Jiaxing)	Finalized	Xi TAO	S0105	1) Assigned and compiled it during N.Otsuka visit (16-22 Nov. 2014).
修改 详情	5	Measurement of total cross section of nuclei produced by 20Ne bombing at 9Be target	J,HEN	26	7	683	200207	李加兴(Li Jiaxing)	Finalized	Xi TAO	S0102	1) Assigned and compiled it during N.Otsuka visit (16-22 Nov. 2014).
修改 详情	6	Reaction time in the 19F + 93Nb dissipative collision	J,HEN	26	3	239	200203	田文栋(Tian Wendong)	Finalized	Youxiang ZHUANG	S0099	1) Assigned and compiled it during N.Otsuka visit (16-22 Nov. 2014).
修改 详情	7	Alpha fragment emission in 25MeV/u 6He+9Be break-up reaction	J,HEN	27	3	206	200303	李智焕(Li Zhihuan)	Finalized	Jimin WANG	S0103	1) Assigned and compiled it during N.Otsuka visit (16-22 Nov. 2014).
修改 详情	8	Angular distribution of elastic scattering of l7F and 18Ne on proton	J,HEN	26	6	594	200206	卢朝晖(Lu Zhaohui)	Finalized	Jimin WANG	S0101	1) Assigned and compiled it during N.Otsuka visit (16-22 Nov. 2014).
修改 详情	9	Measurements of reaction cross section for F isotopes and possible proton skin structure for 17F	J,HEN	26	1	35	200201	张虎勇(Zhang Huyong)	Finalized	Jimin WANG	S0097	1) Assigned and compiled it during N.Otsuka visit (16-22 Nov. 2014).
修改 详情	10	Measurement of total reaction cross sections for 8B and 9C on silicon target	J,HEN	25	12	1165	200112	王全进(Wang Quanjin)	Finalized	Guochang CHEN	S0086	1) Assigned and compiled it during N.Otsuka visit (16-22 Nov. 2014).

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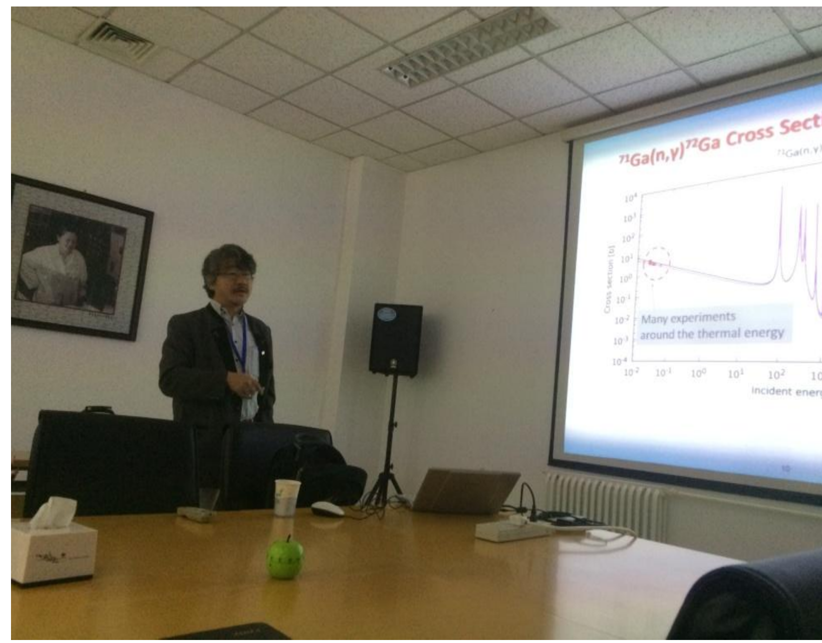
3.3 EXFOR Activity

In the autumn of 2017, Three people from CNDC have attended the AASPP-2017 in Mongolia and then Dr. Otsuka visited CNDC. During two-week collaboration with Otsuka-san in Ulaanbaatar and Beijing, we finalized 12 EXFOR entries and fixed the problem in 30997.

AASPP-2017



Dr. Otsuka at CNDC

IV. Nuclear Data Service

CNDC provides the nuclear data service in China for different institutes, schools or other requirements. CNDC joined the developing of Chinese basic database and established a “The Database of Nuclear Physics” Website including experimental data (EXFOR), evaluated data, nuclear structure and decay data, astrophysical data and nuclear data for medical applications.


ND2019
See you in Beijing!

Thank you for your attention !
Comments and suggestion welcome !