PROGRESS REPORT OF CENDL PROJECT 2015-2016

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OUTLINE

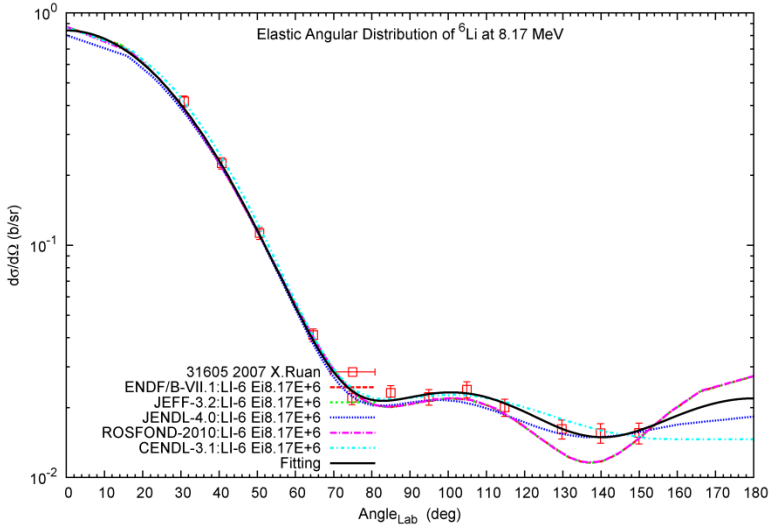
I. New evaluation for neutron data file for CENDL

II. Methodological studies of nuclear data evaluation

III. Nuclear data processing code development

IV. Other Information

I. New evaluation of neutron file for CENDL



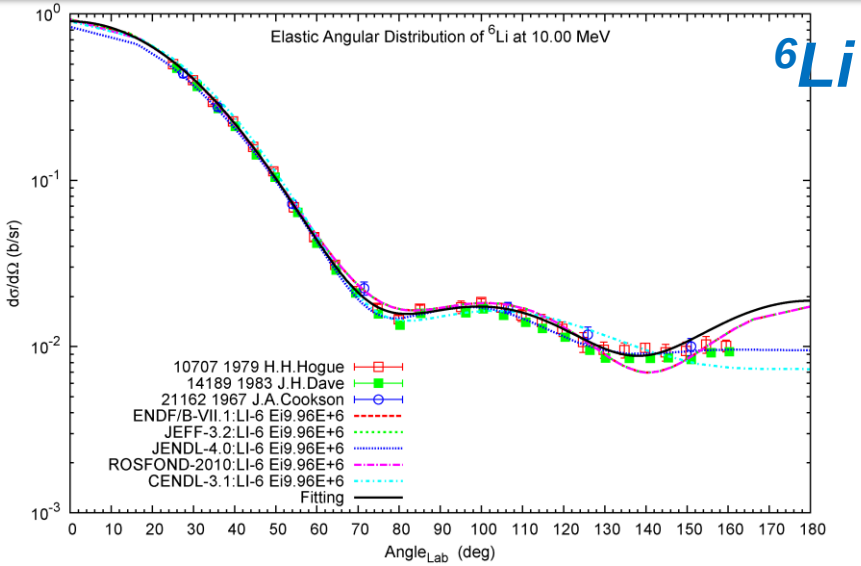
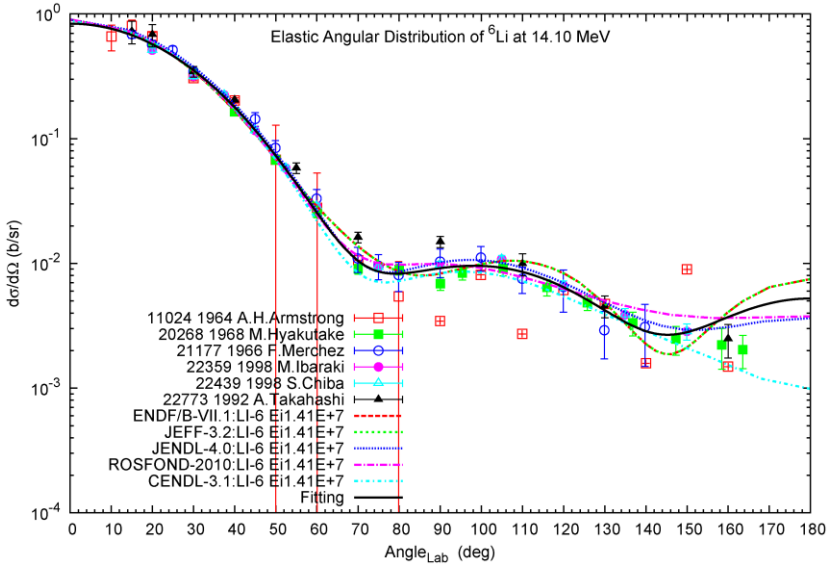
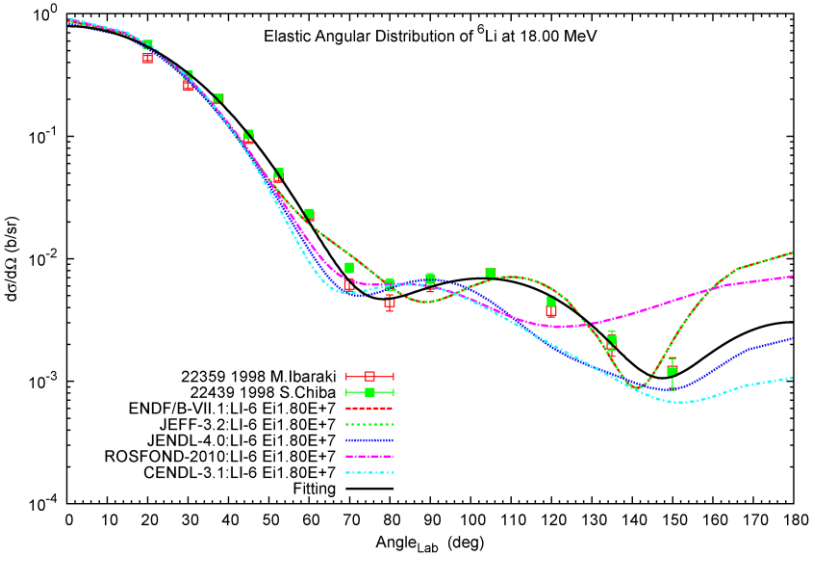


图 1 ^{6}Li弹性散射微分截面与实验数据及评价数据对比





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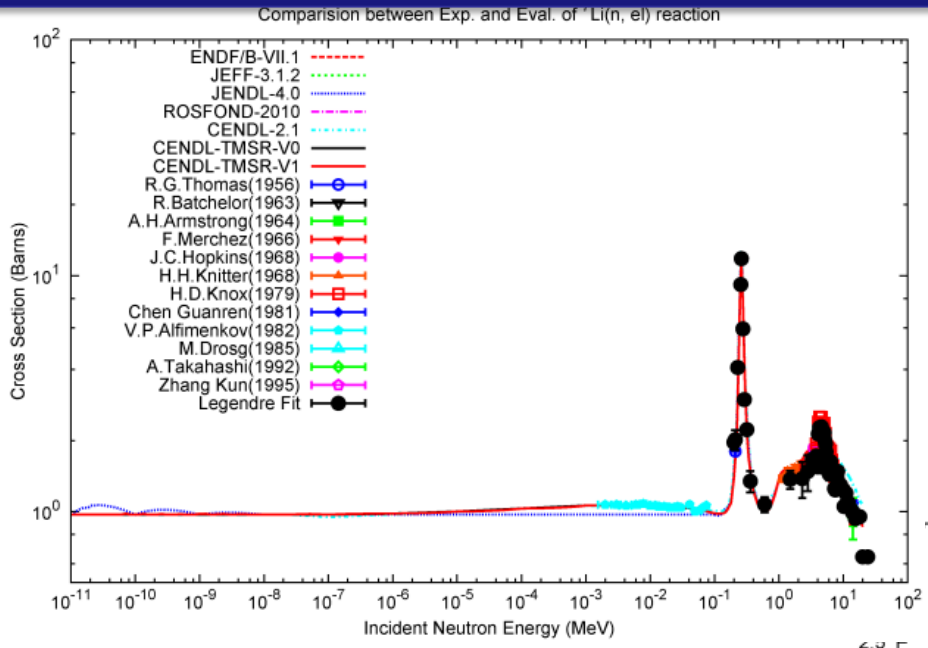
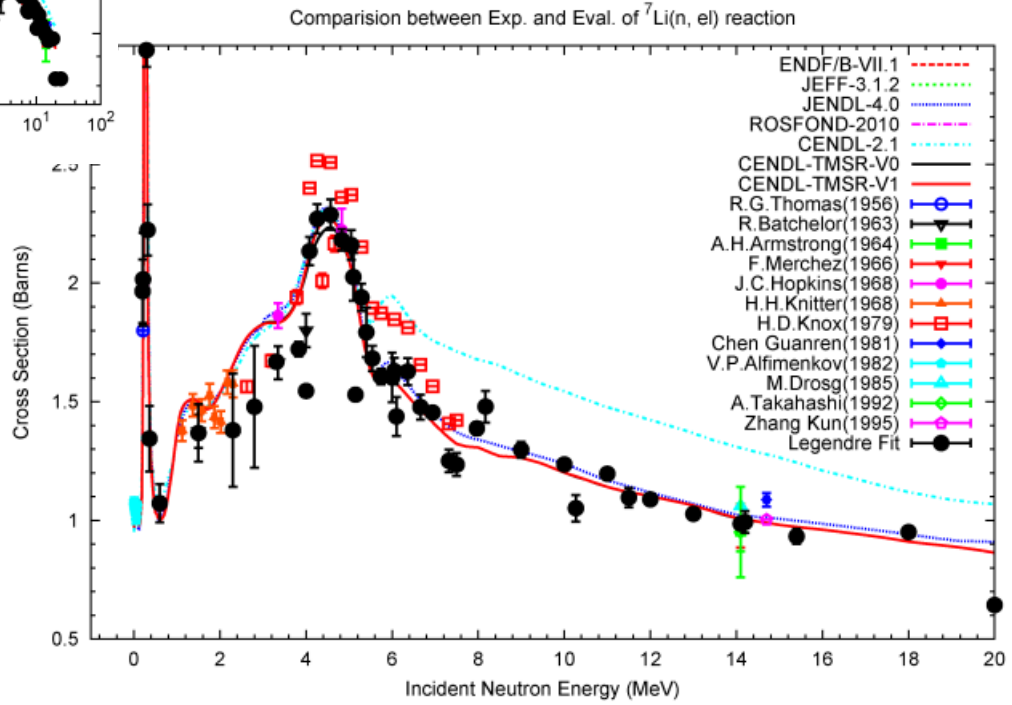
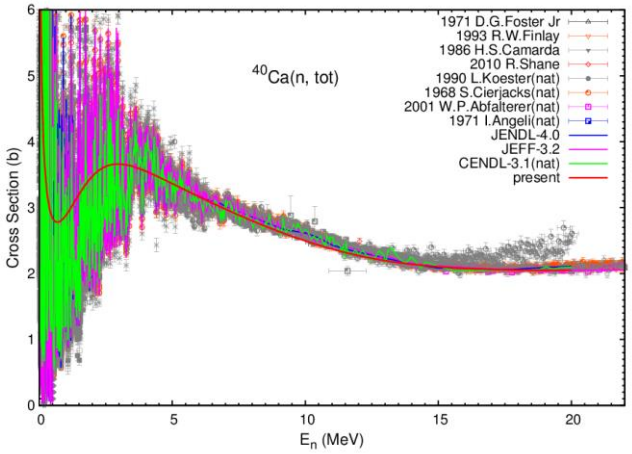


^{7}Li



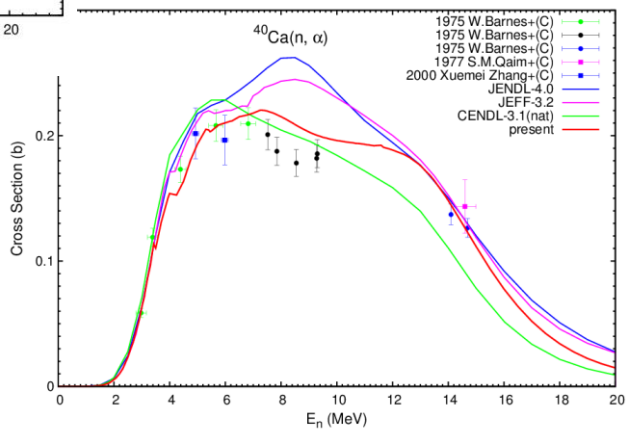
1. New evaluation of neutron file for CENDL

- New evaluation and covariance based on the experimental data for (n,tot) and (n, α)
- Koning-Delaroche potential is utilized to calculate the neutron scattering. This function is incorporated in the latest UNF2015
- The discrete levels are adopted as the data JENDL-4



^{40}Ca(n,tot)

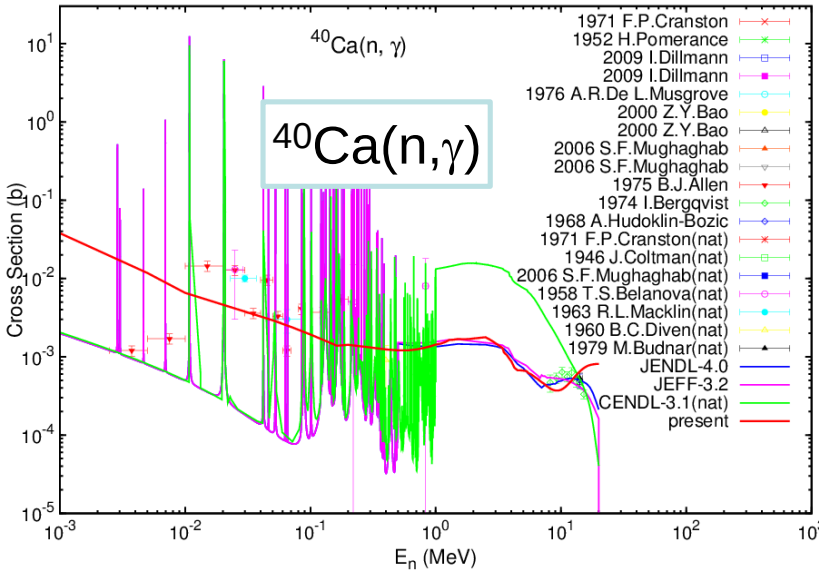
^{40}Ca(n,α)

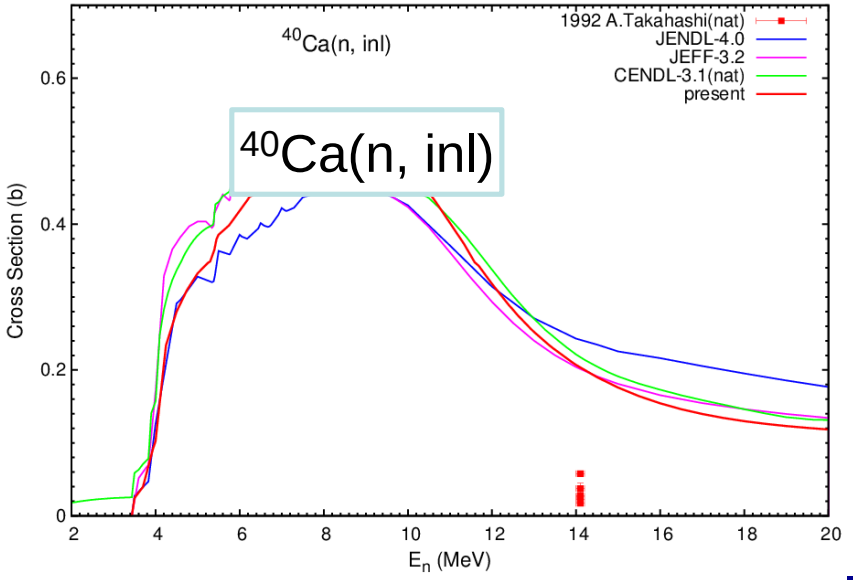


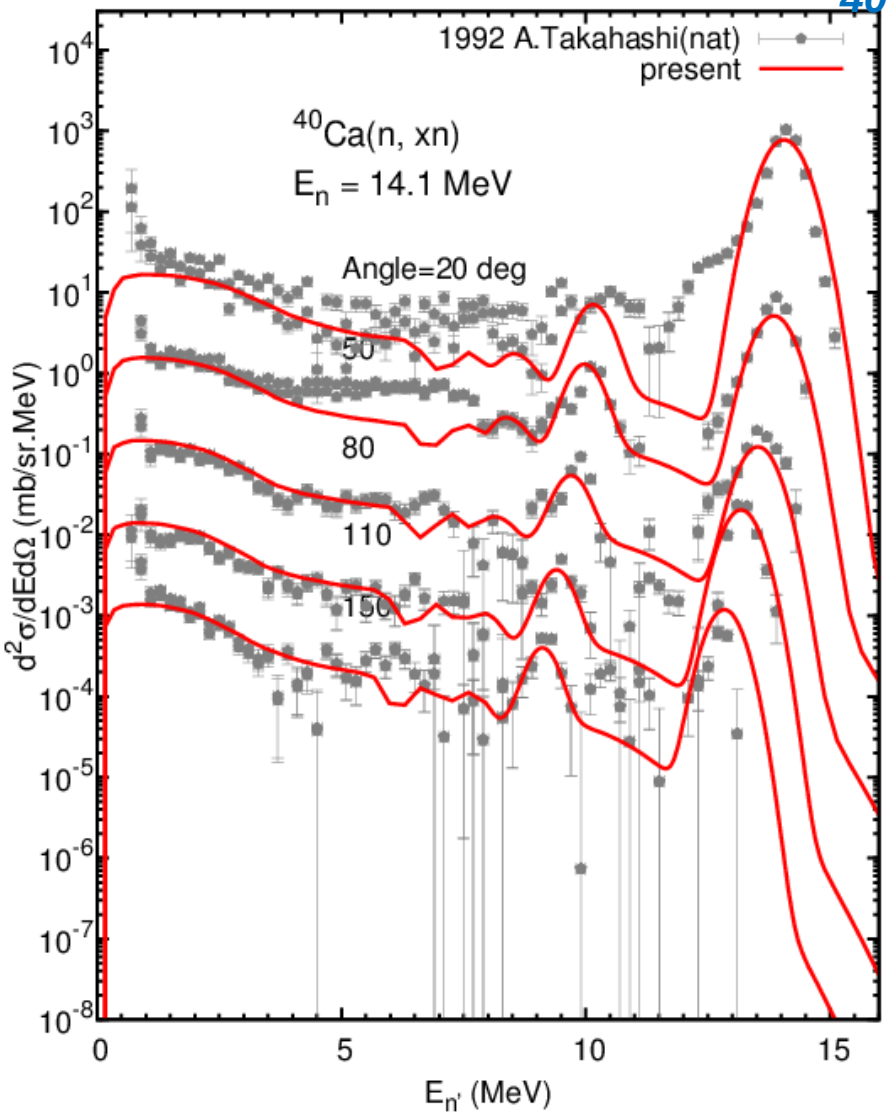
^{40}Ca

Level	Spin	Parity	DWBA
ground	0	1	0
3.35262	0	1	0
3.73669	3	-1	1
3.90438	2	1	1
4.49143	5	-1	1
5.21156	0	1	0
5.24879	2	1	1
5.2788	4	1	1
5.61352	4	-1	0
5.62941	2	1	1
5.90263	1	-1	0
6.025471	2	-1	0
6.02971	3	1	0
6.28515	3	-1	1
6.4224	2	1	1
6.50787	4	1	0
6.5428	4	1	1
6.58247	3	-1	0
6.750411	2	-1	1
6.9087	2	1	1

1. New evaluation of neutron file for CENDL

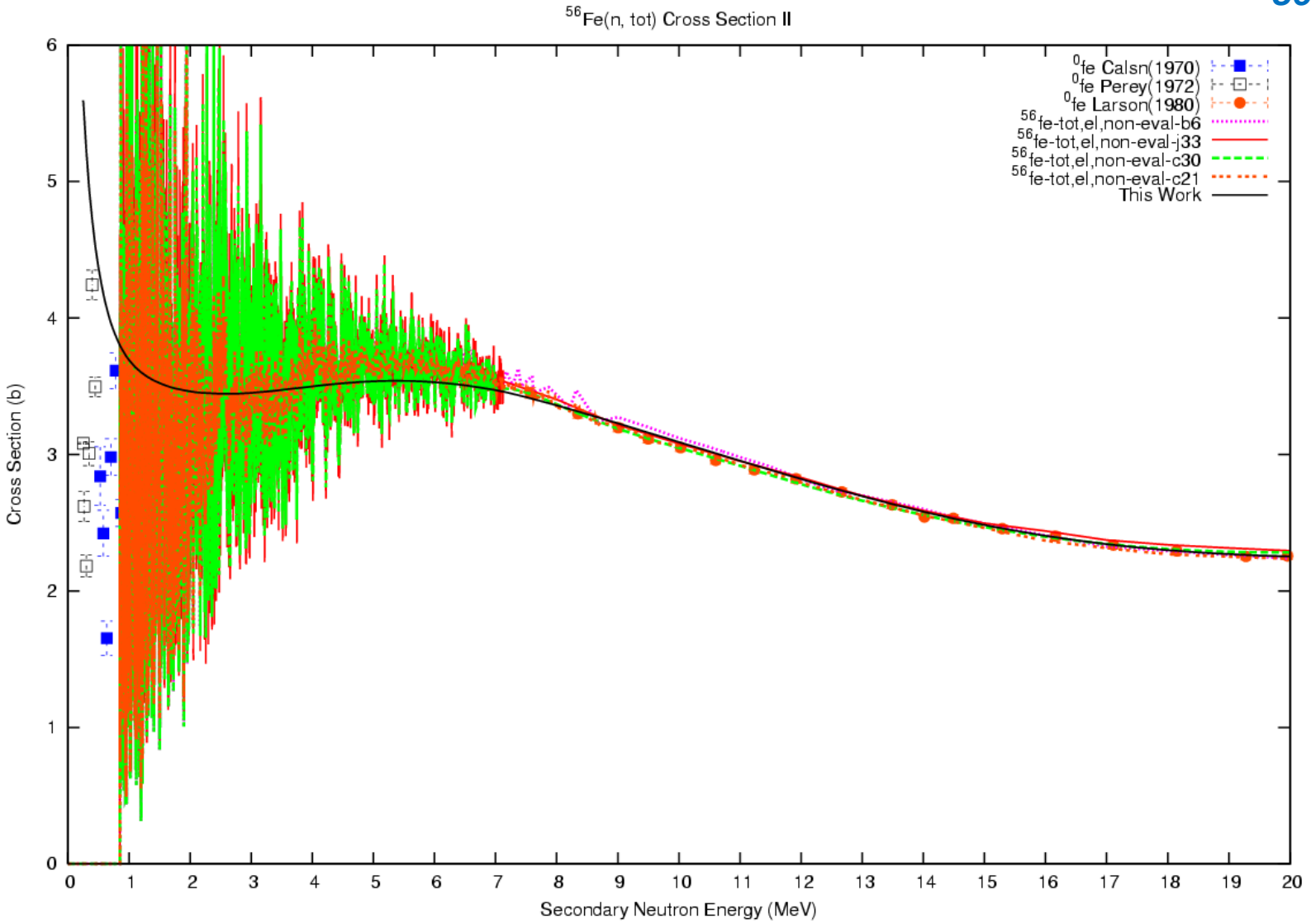






1. New evaluation of neutron file for CENDL

^{56}Fe



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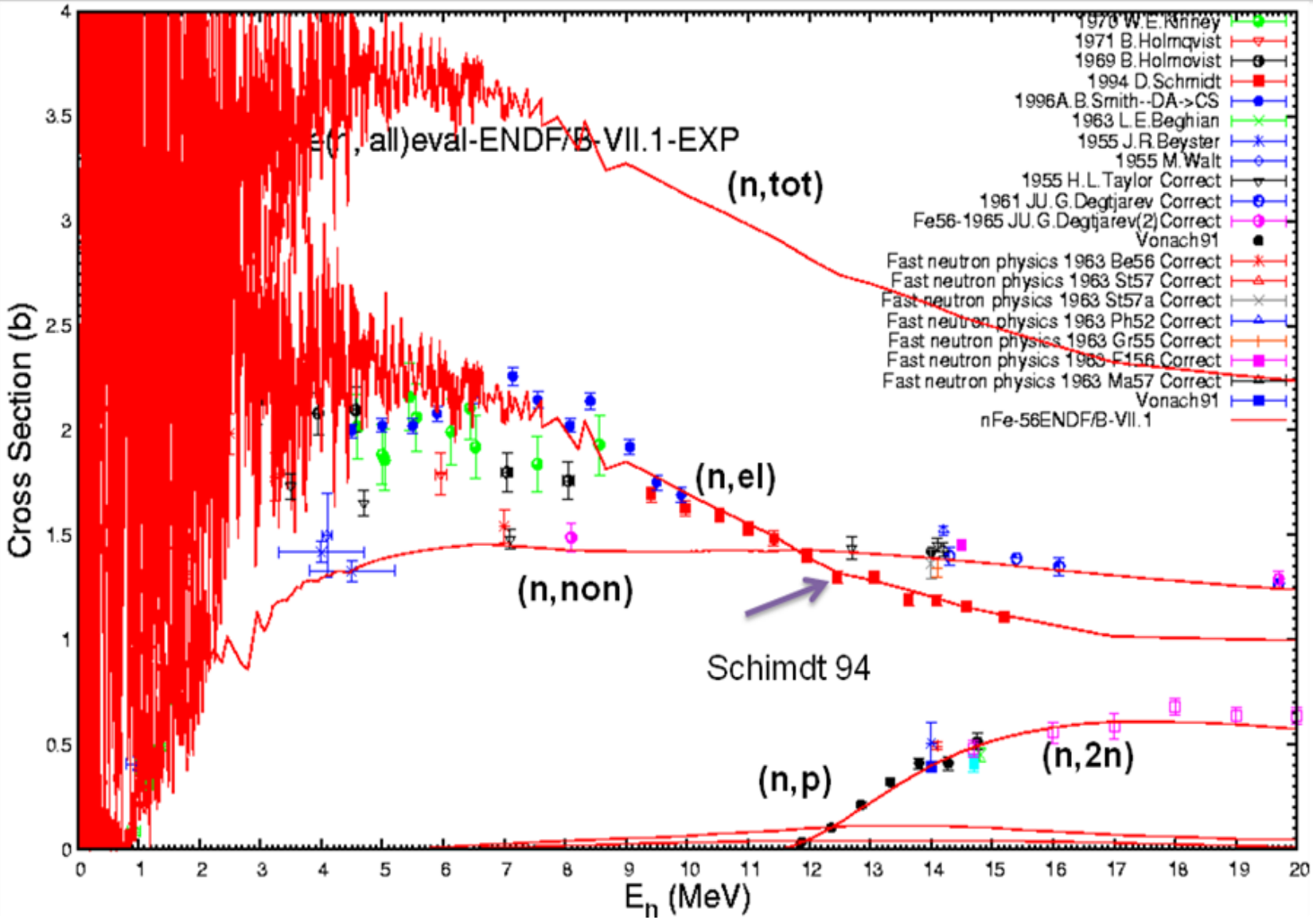

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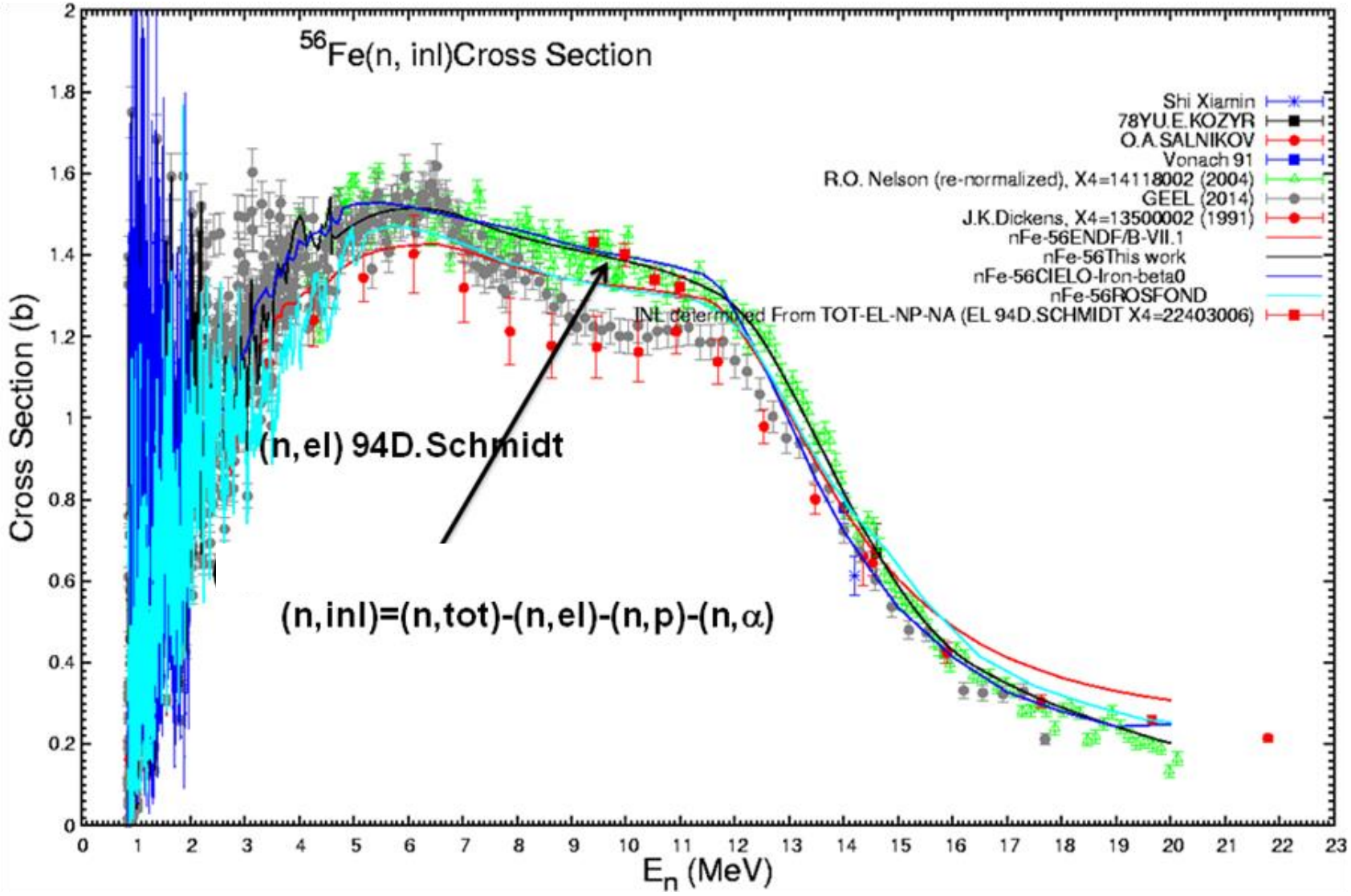

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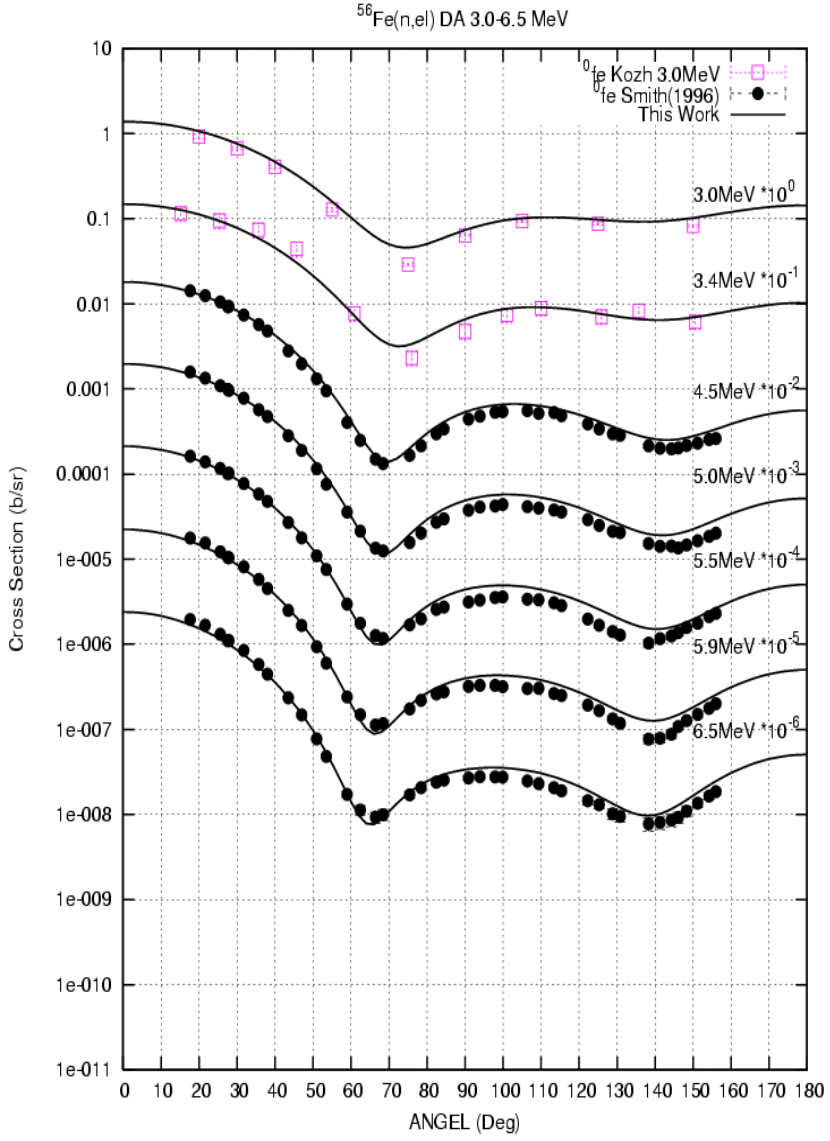

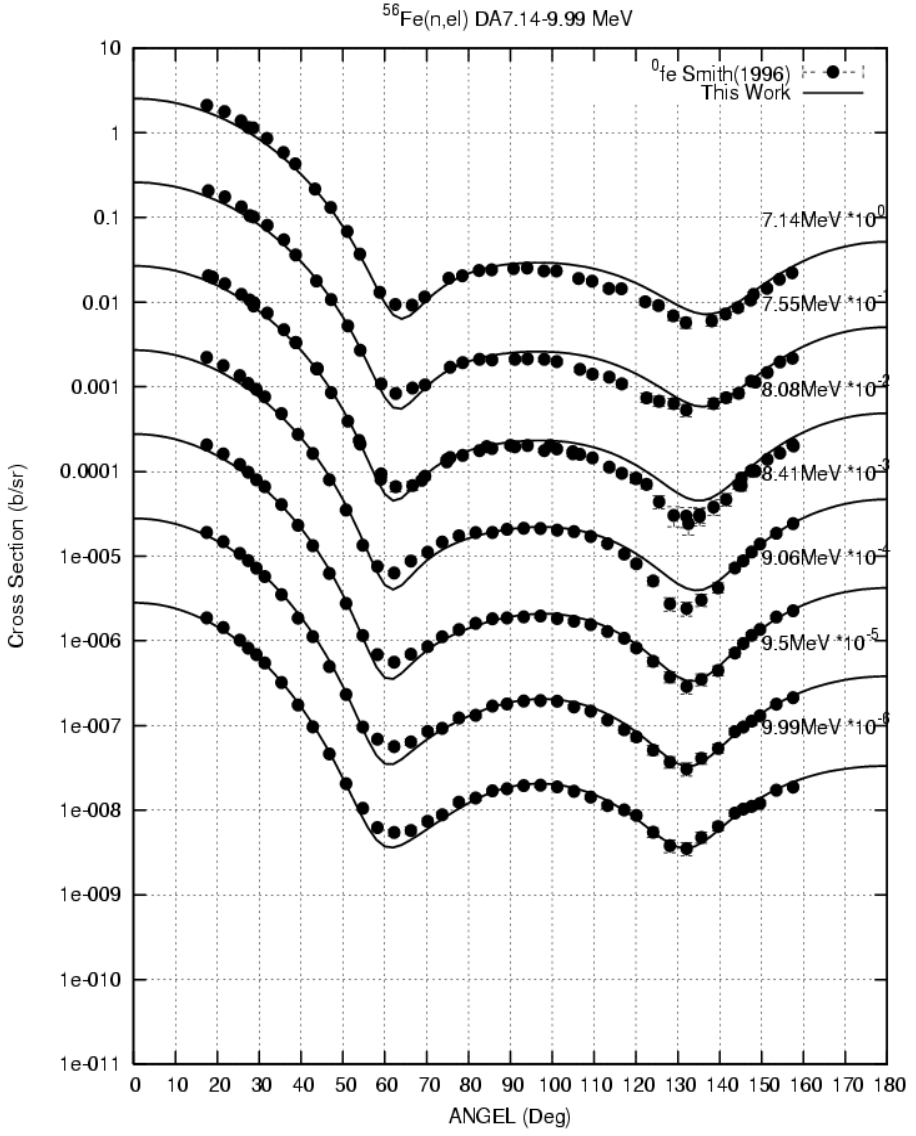

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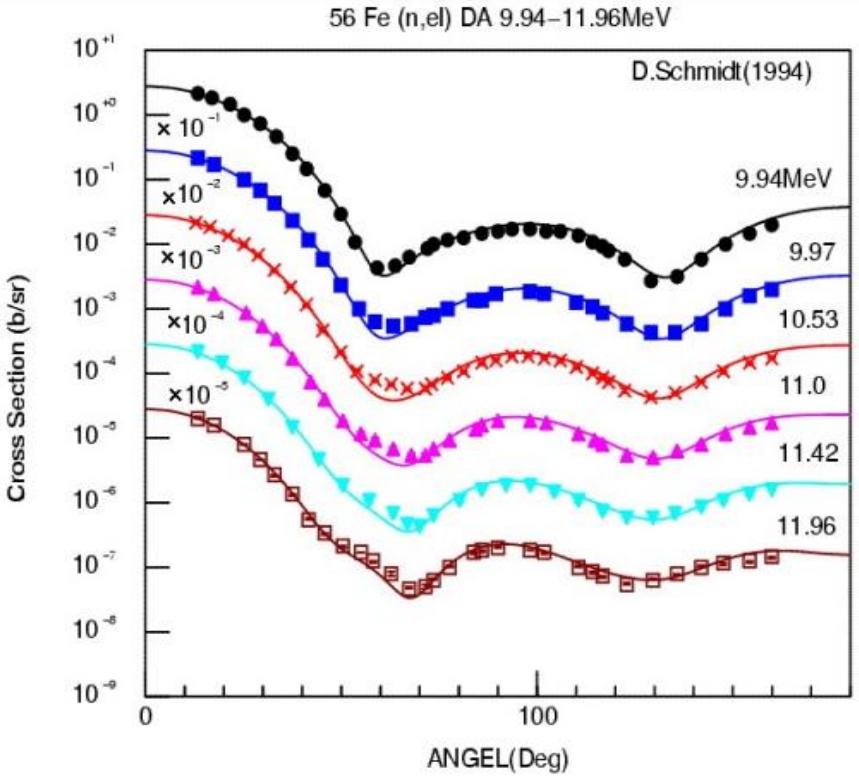

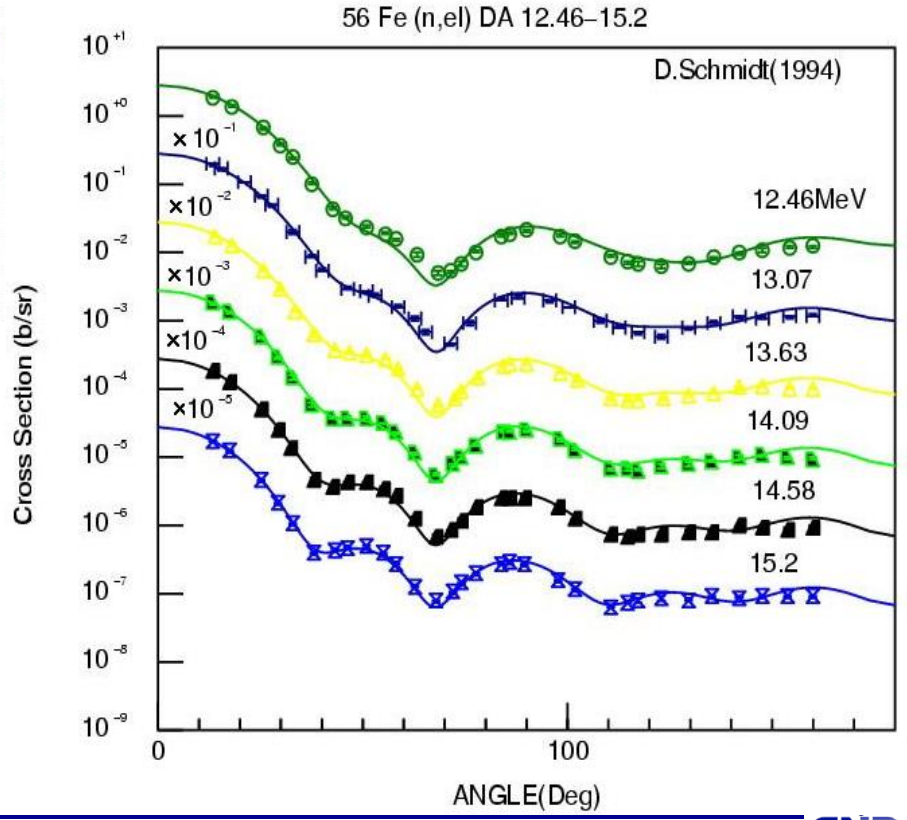

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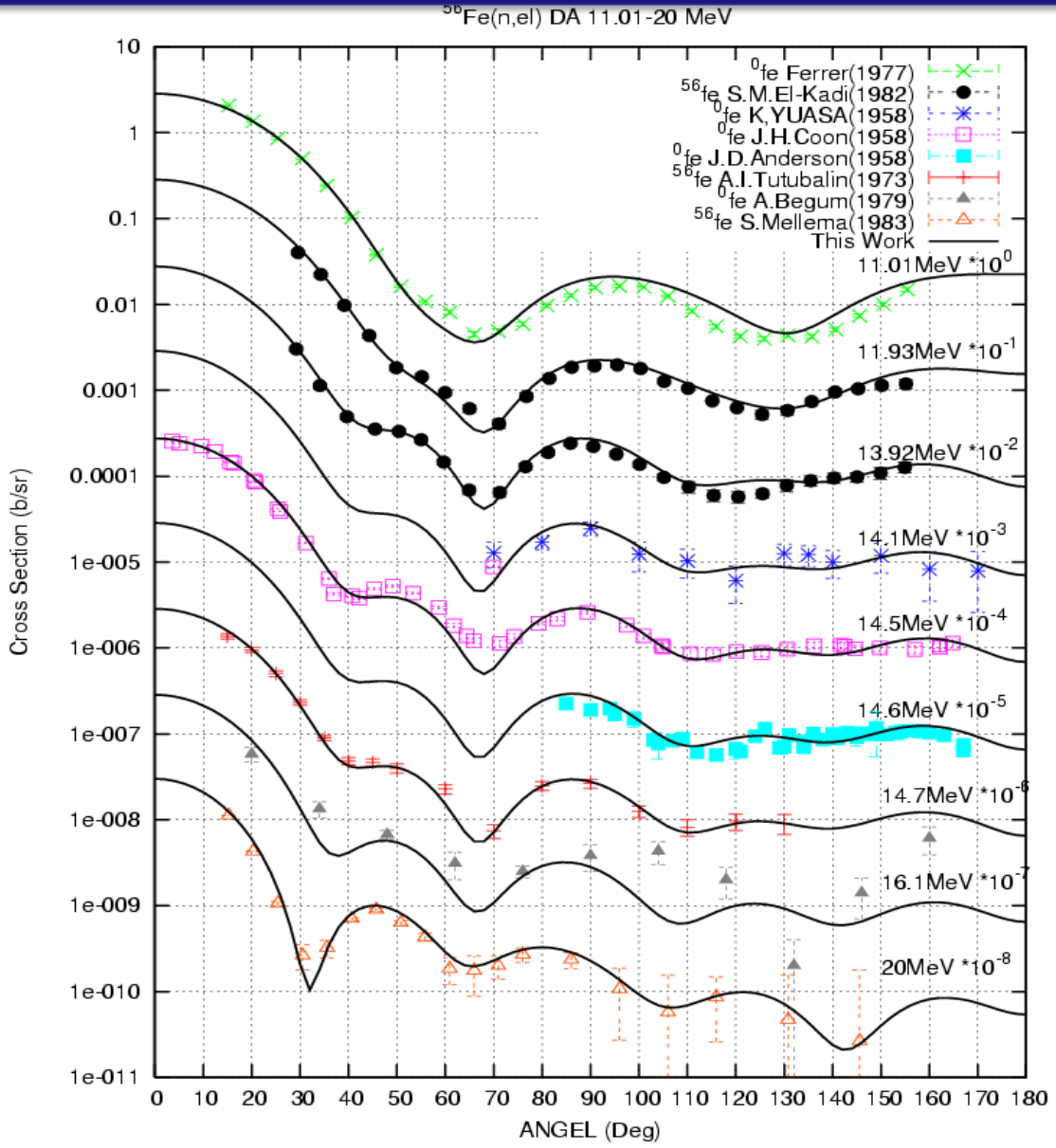

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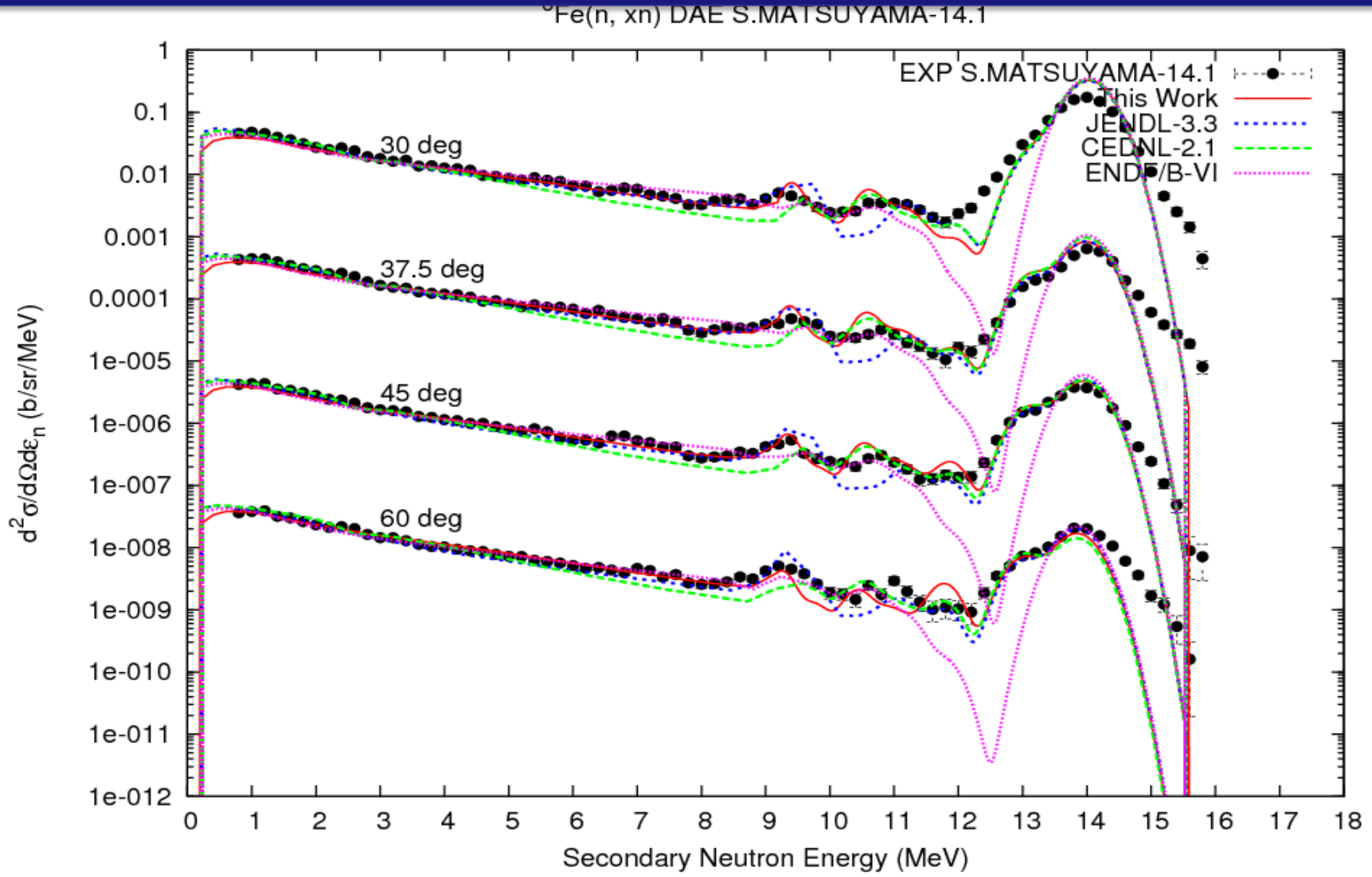

双微分截面理论计算数据与天然Fe实验数据的比对S.Matsuyama（1992

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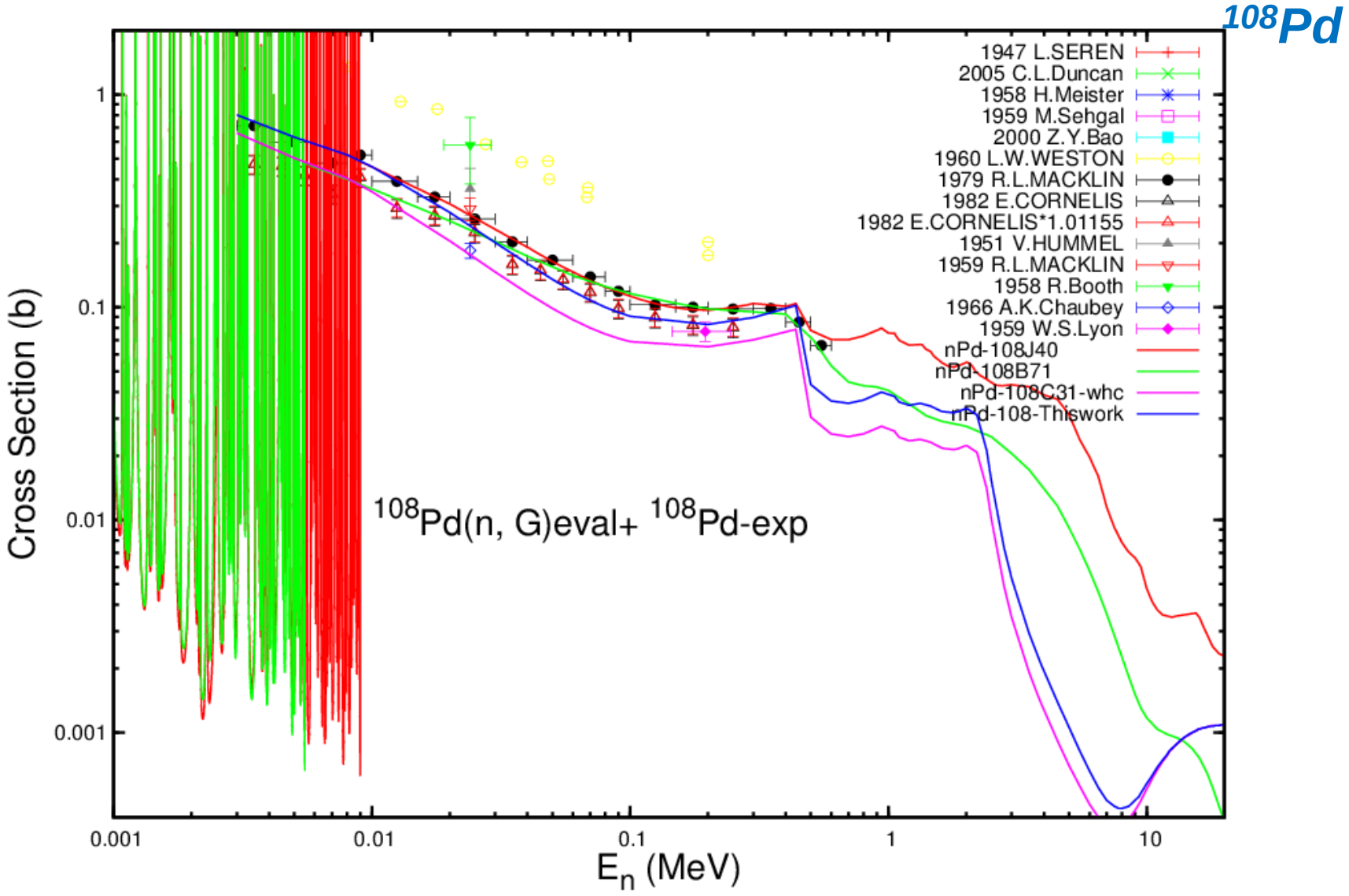

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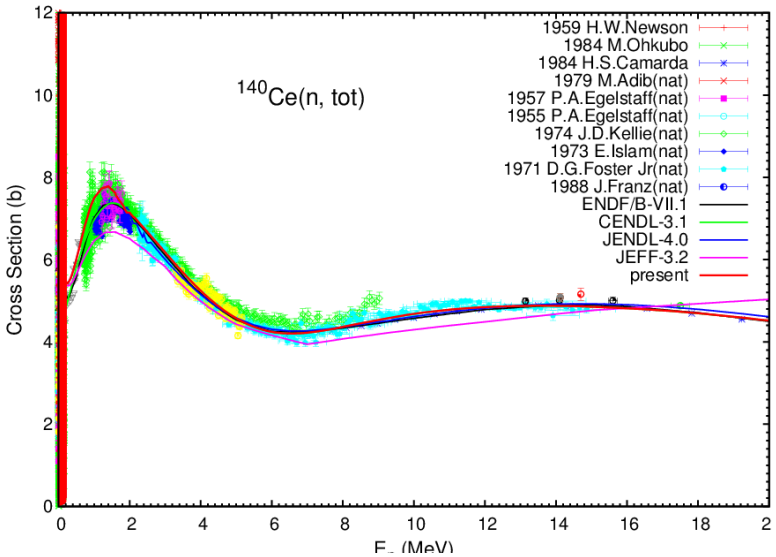
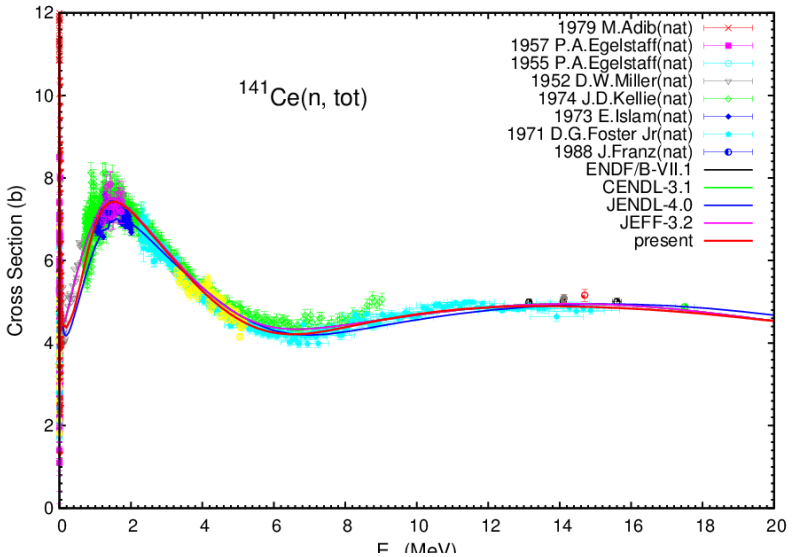
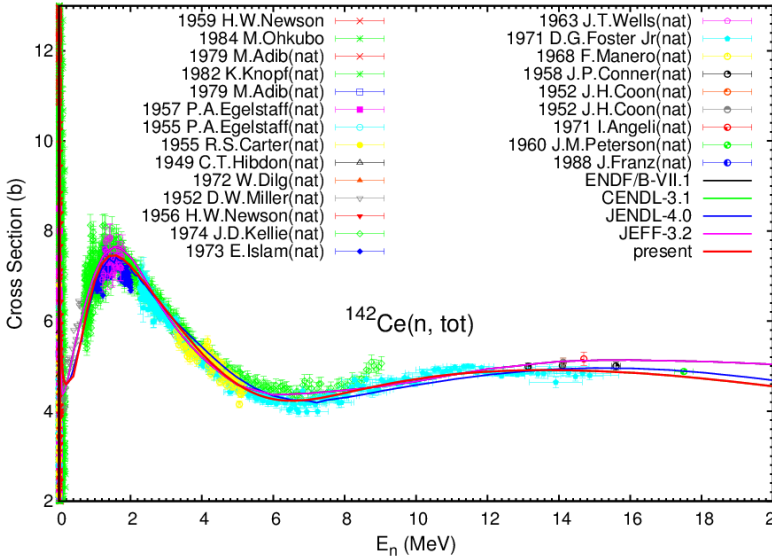
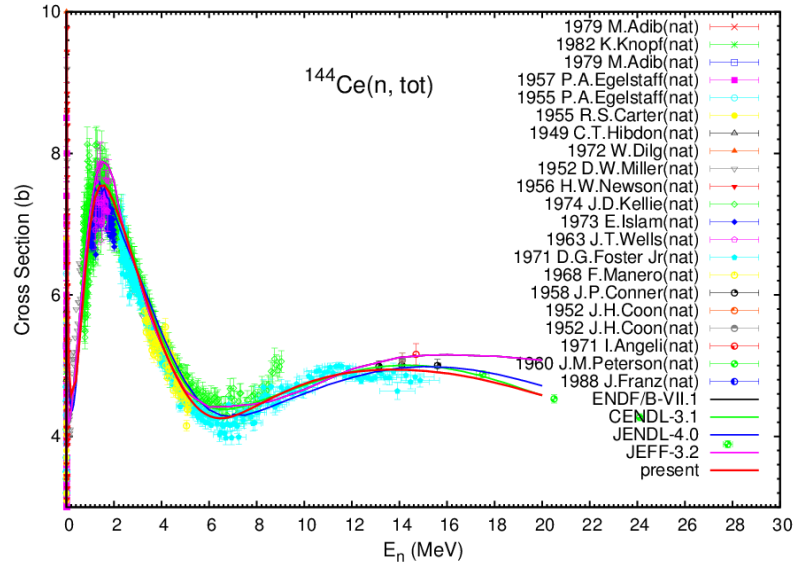
^{140,141,142,144}Ce



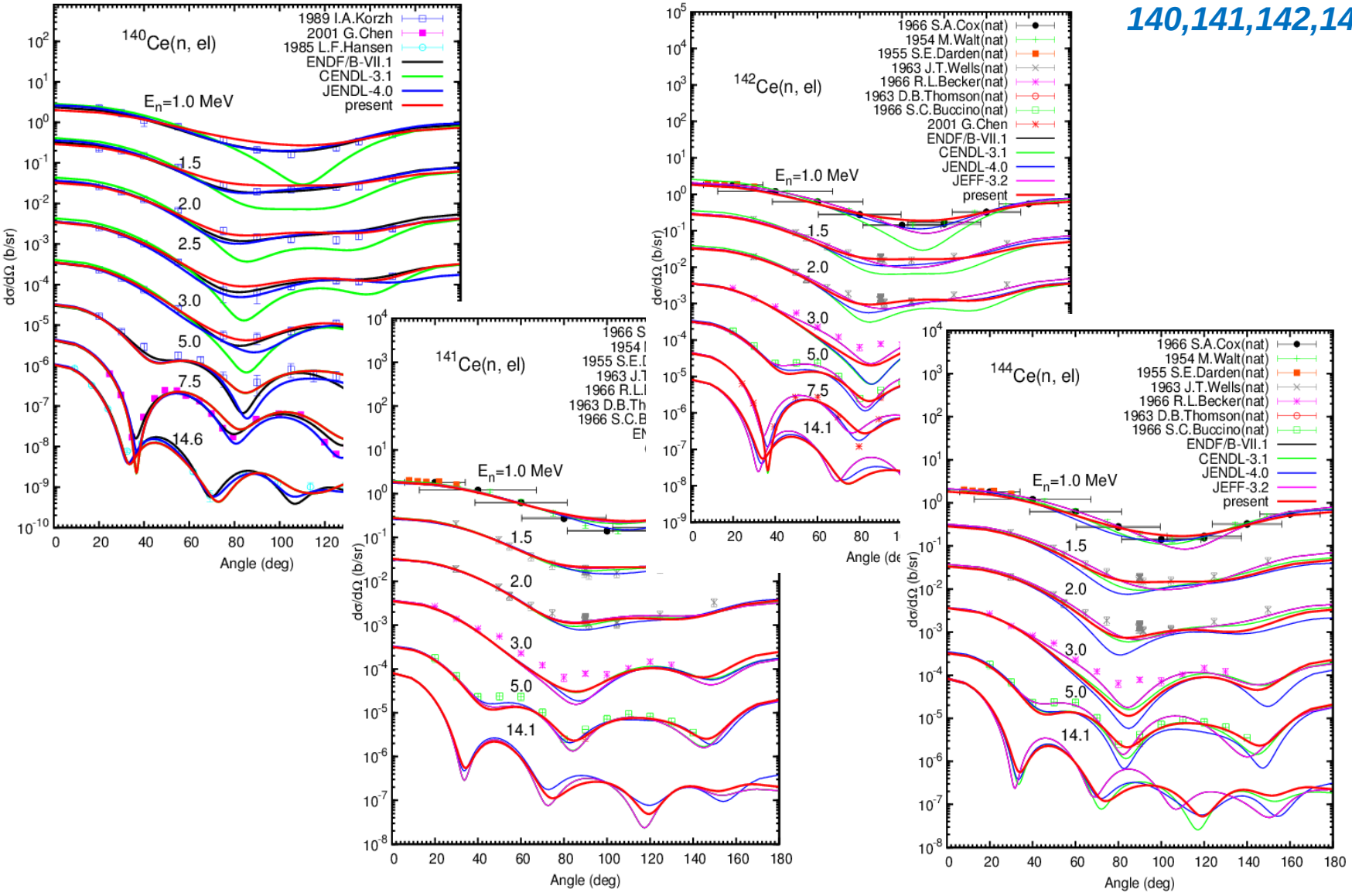






CNDC
CHINA NUCLEAR DATA CENTER

1. New evaluation of neutron file for CENDL



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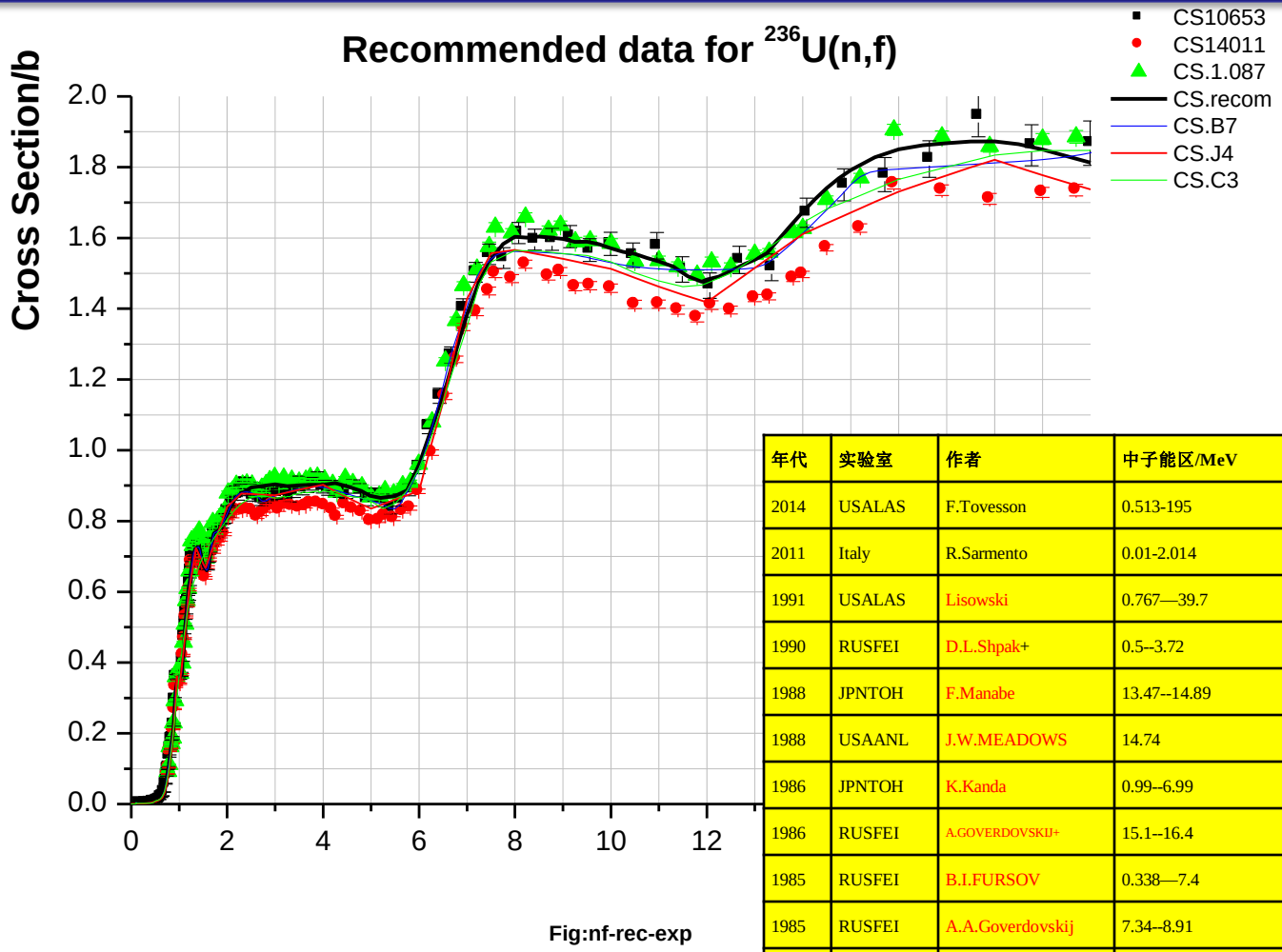


Fig:nf-rec-exp

年代	实验室	作者	中子能区/MeV	能点	装置	方法	其它实验条件
2014	USALAS	F.Tovesson	0.513-195	130	SPALL	TOF	(IOCH)14402
2011	Italy	R.Sarmento	0.01-2.014	70	SPALL	(TOF)-A	(FISCH)23131002
1991	USALAS	Lisowski	0.767—39.7	**177**	LINAC	**(TOF)-R**	(IOCH)14011003
1990	RUSFEI	D.L.Shpak+	0.5--3.72	77	(VDG)	^{235}U (n,f)	(GLASD)41096002
1988	JPNTOH	F.Manabe	13.47--14.89	4	(DYNAM)	^{235}U (n,f)	(FISCH)222820051
1988	USAANL	J.W.MEADOWS	14.74	1	D-T	^{235}U (n,f)	(IOCH)13134004
1986	JPNTOH	K.Kanda	0.99--6.99	27	DYNAM	^{235}U (n,f)	(FISCH)22024002
1986	RUSFEI	A.GOVERDOVSKIJ+	15.1--16.4	2	VDG	^{235}U (n,f)	(IOCH)40885004
1985	RUSFEI	B.I.FURSOV	0.338—7.4	66	(VDG)	^{235}U (n,f)	(IOCH)40836003
1985	RUSFEI	A.A.Goverdovskij	7.34--8.91	3	(D-D)	^{235}U (n,f)	(IOCH)40832002
1985	RUSFEI	A.A.Goverdovskiy	4.24—10.7	39	(VDG)	^{235}U (n,f)	40921002
1978	USAANL	J.W.Meadows	0.596-9.905	57	(DYNAM)	^{235}U (n,f)	(IOCH)10654002
1978	SWDUPP	C.NORDBORG	3.21-- 8.62	**40**	**(VDG)**	**(TOF)-R**	(IOCH) 20844003
1977	USALRL	J.W.Behrens	0.1723-	**136**	**LINAC**	**(TOF)-R**	(IOCH)10653003

1. New evaluation of neutron file for CENDL

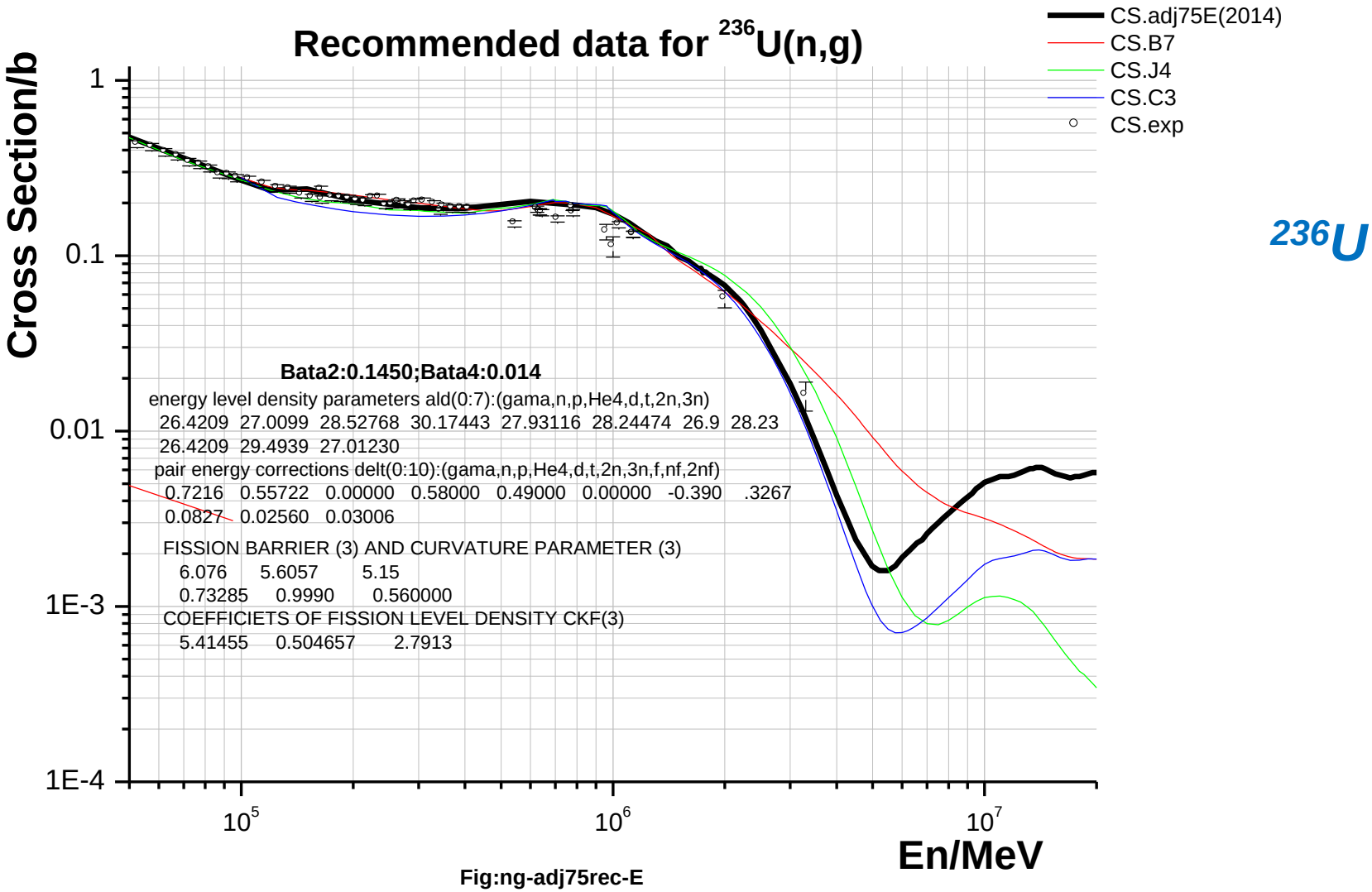
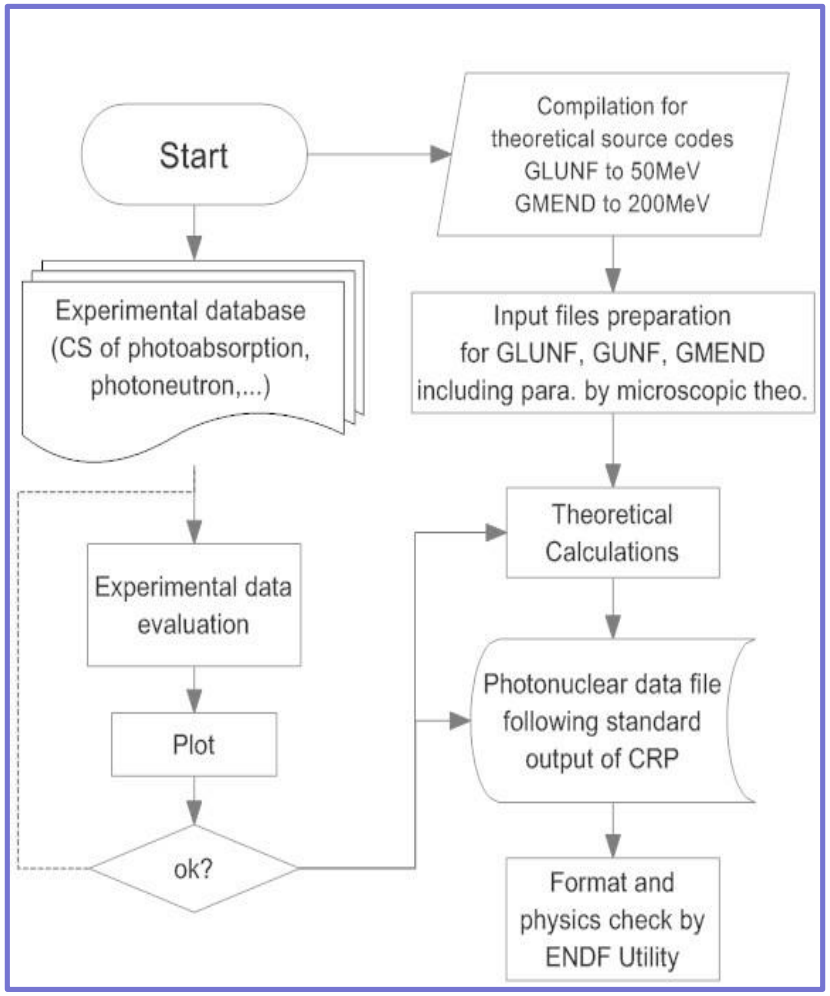


Fig:ng-adj75rec-E

1. Update photonuclear data at CNDC

Program of photonuclear data study



- CNDC attends the latest CRP of IAEA from 2016
- The photonuclear data of light and middle-heavy nuclei are being evaluated recently, and the new experimental data evaluation and theoretical source codes compilation are being carried out so as to fulfill the requirement of CRP;
- The recommended data files would be include the calculation results by:

  GLUNF for light nuclei;

  GUNF and GMEND for middle-heavy nuclei;
- 28 nuclei are planned to involve in this CRP (nuclei in red are in this contract):

  Update ^{9}Be, ^{27}Al, ^{51}V, ^{50,52,53,54}Cr, ^{54,56,57,58}Fe, ^{63,65}Cu, ^{90,91,92,94,96}Zr, ^{180,182,183,184,186}W, ^{209}Bi;

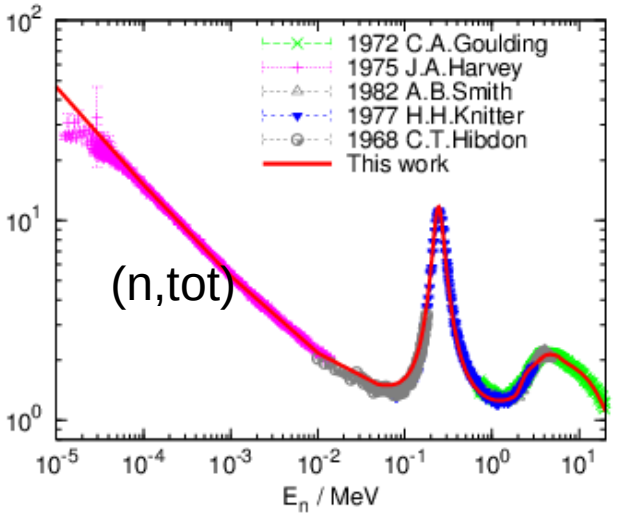
  New evaluations for ^{6,7}Li,^{10,11}B;
- The microscopic prediction for the photon strength function are performed by QRPA simultaneously.

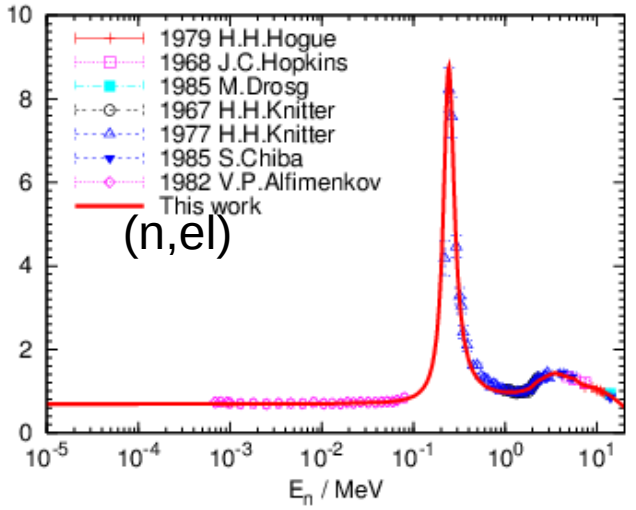
II. Methodological Studies of Nuclear Data Evaluation

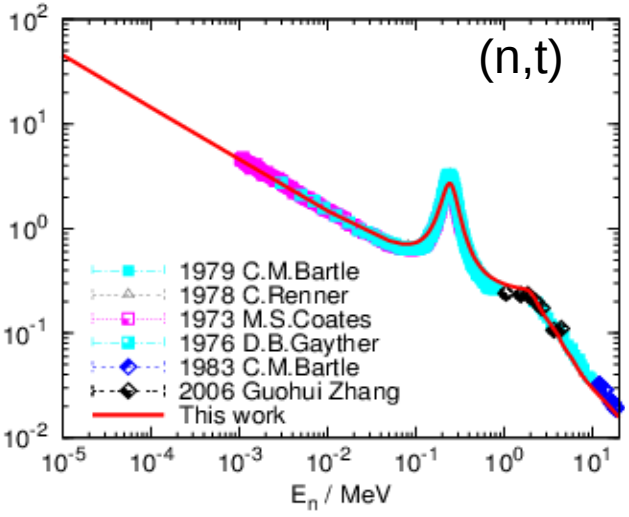
2-1. The evaluation of neutron data for light nuclei

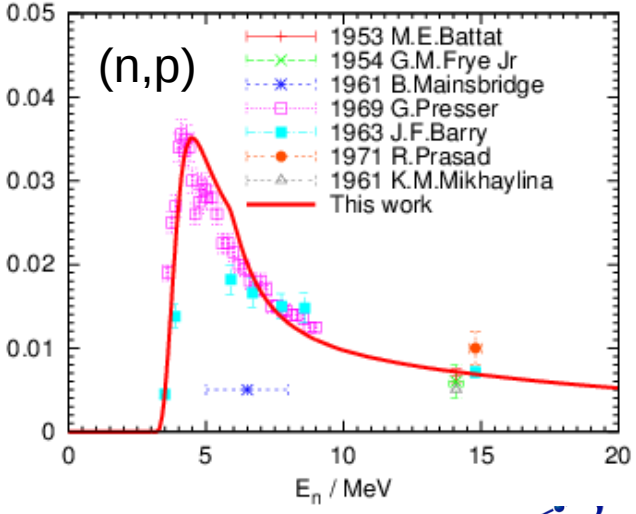
- ✓ Full and Diagonal Reduced R-matrix theory (FDRR code) is under development at CNDC to generate cross sections.
- ✓ LUNF code is planned to apply in producing the double differential cross section.

n+^{6}Li





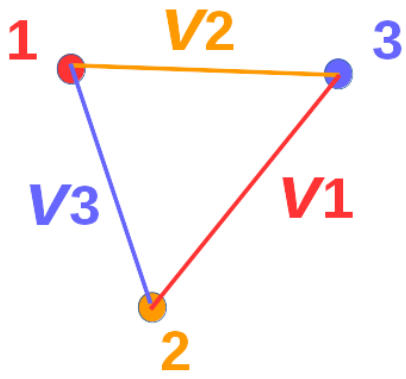




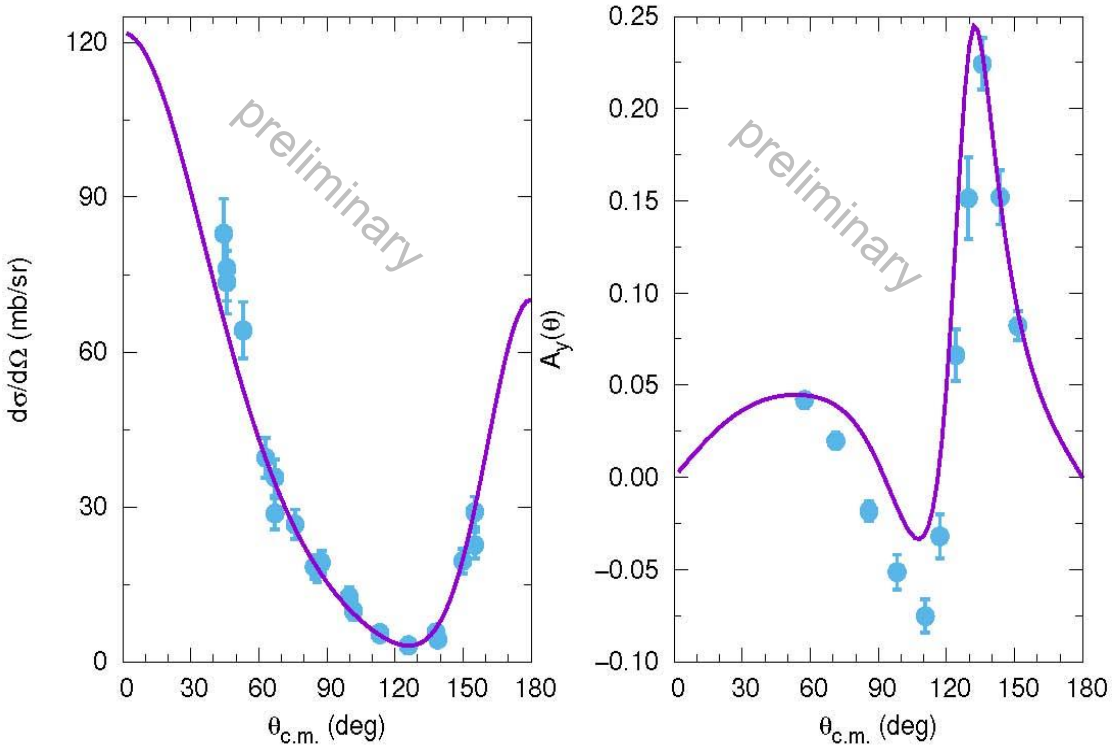
II. Methodological Studies of Nuclear Data Evaluation

2-2. Few body theory in the nuclear data evaluation

Faddeev method for 3N reactions



n+d scattering, elastic scattering and analyzing power, E_n=21 MeV, comparison with experimental data



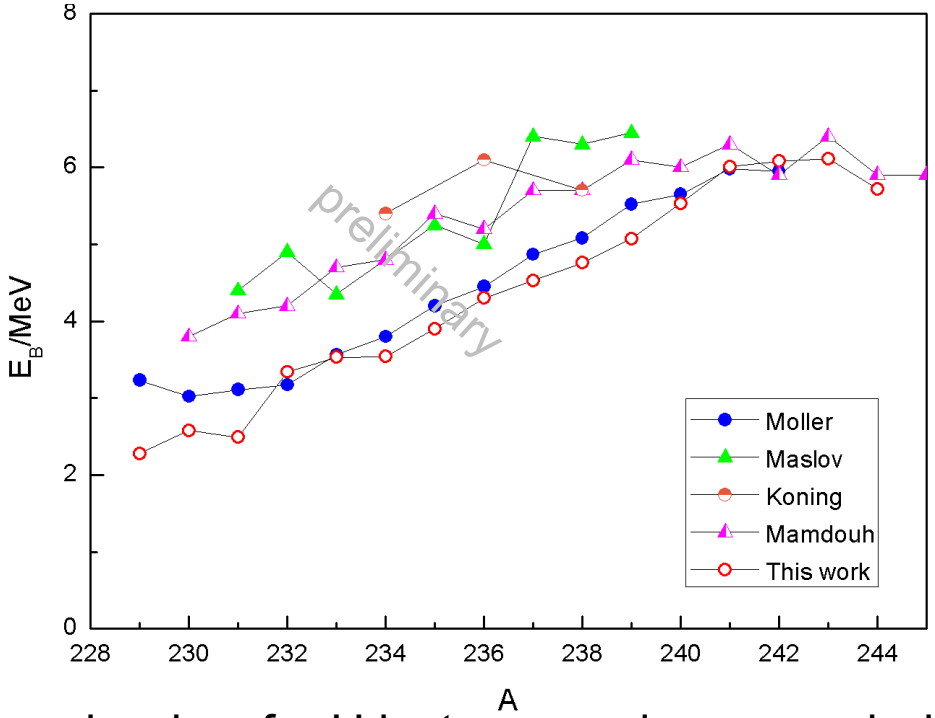
In our present scheme:

- Two-body NN interactions are adopted
- Three Jacobi coordinates are considered
- calculate elastic scattering, exchange and breakup processes on the same footing

II. Methodological Studies of Nuclear Data Evaluation

2-3. Fission Model Study

A primary code has been created for computing the potential surface. Improved Strutinsky shell correction model was adopted. And the Myser-Swiatechi and LSD formulae were used in the macro model; the Woods-Saxon and Folded-Yukawa potential were used in micro model. We calculated the surfaces for U and Pu isotopes, the fig 1 showed the preliminary results of fission barriers.

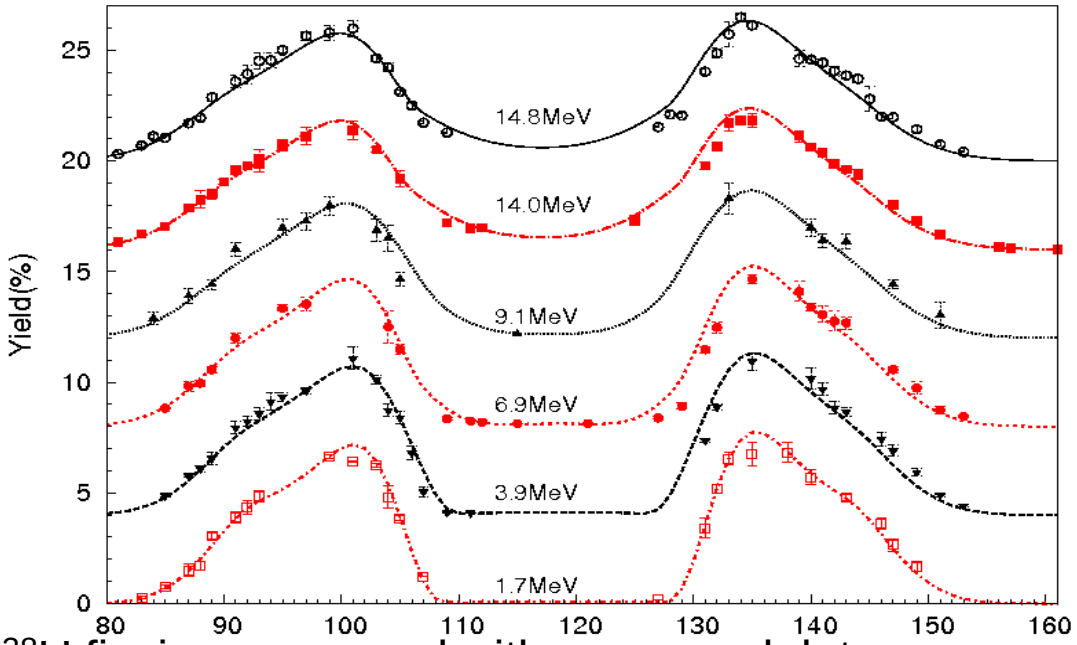


The calculated inner barriers for U isotopes and compared with other works'. Roughly, our results are close to other's except that of Koning

II. Methodological Studies of Nuclear Data Evaluation

2-4. Semi-empirical Model for FYD

A semi-empirical model is developed for calculating the yield mass distributions and energy dependence of n+^{238}U fission. The system potential energy included the macro-energy and 2 shell corrections, corresponding to the SL, SI and SII fission channels. Multi-chance fissions of (n,nf) and (n,2nf) were considered. The yield was expressed with a five-Gaussian-like formula with 13 parameters, which were determined by fitting to experimental. The results showed the model could well describe the mass distribution with variant incident energy and some of the yield energy-dependences .



Mass distribution of n+^{238}U fission compared with measured data

II. Methodological Studies of Nuclear Data Evaluation

2-4. Semi-empriical Model for FYD

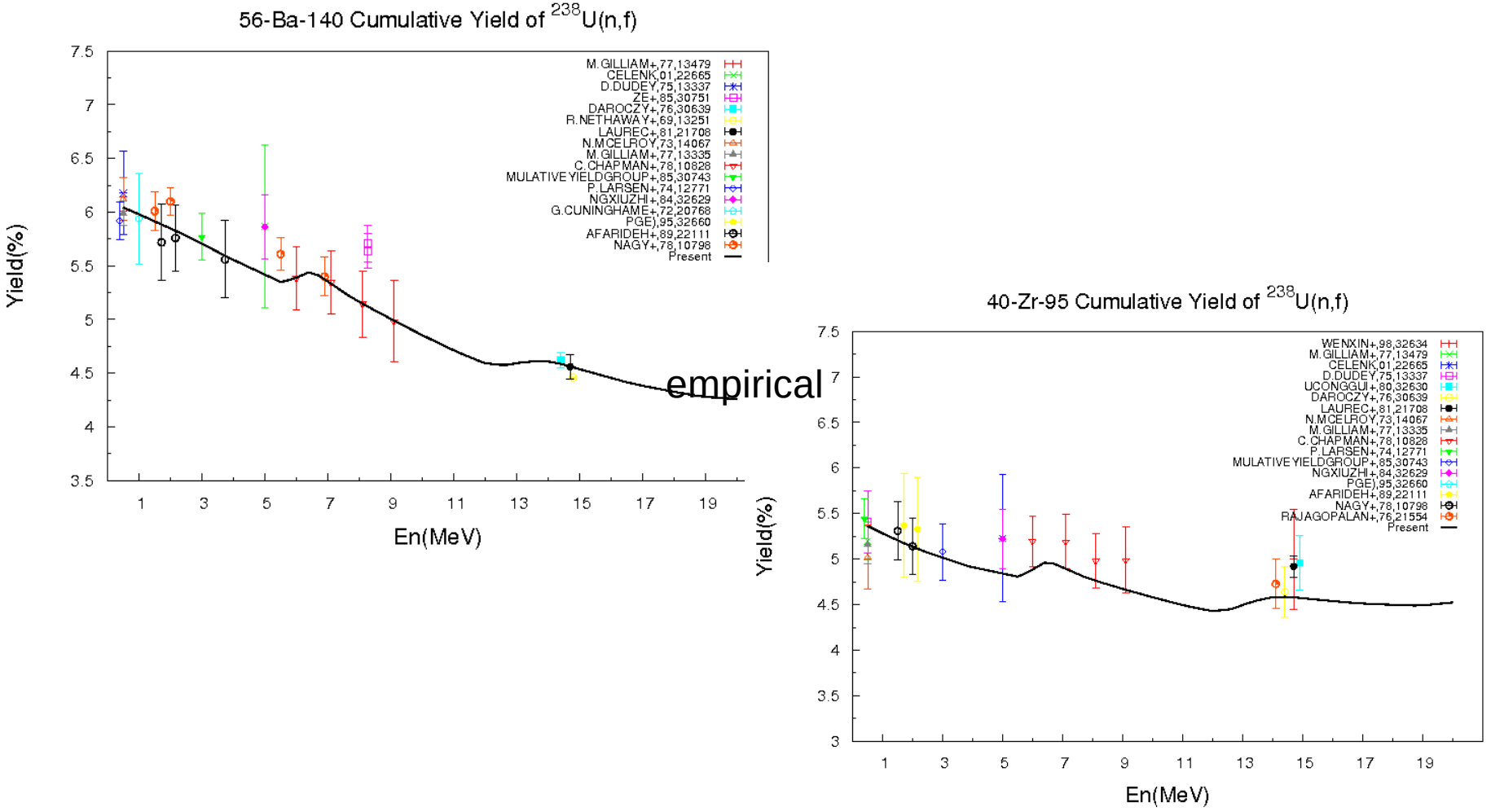


Fig. ^{140}Ba, ^{95}Zr yield energy-dependence of n+^{238}U fission

II. Methodological Studies of Nuclear Data Evaluation

2-5. Study of global prediction of microscopic optical potential

Isospin dependent MOP in DBHF approach

n, p -> ^{12}C-^{208}Pb below 200MeV

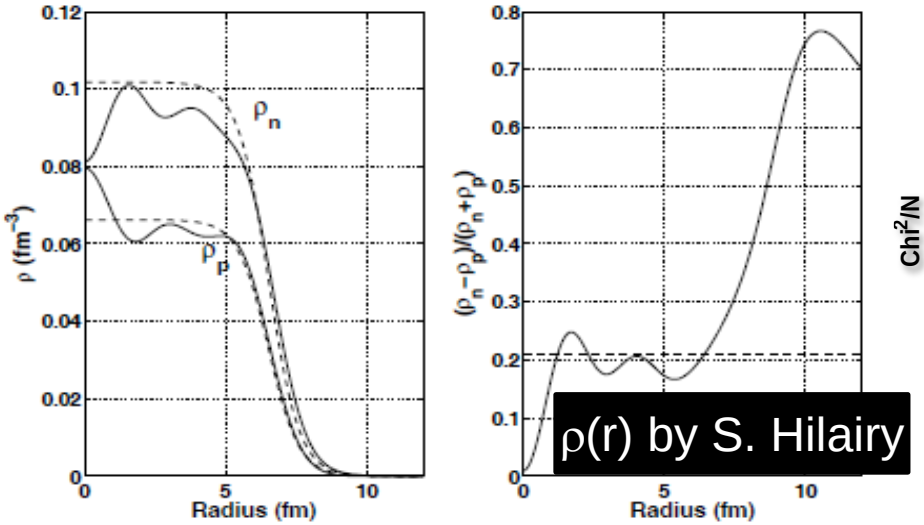
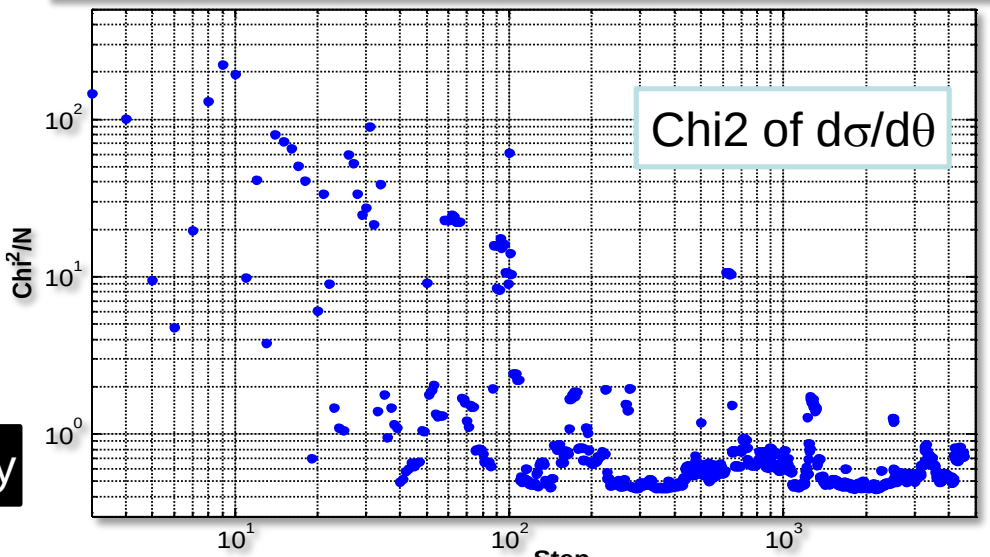
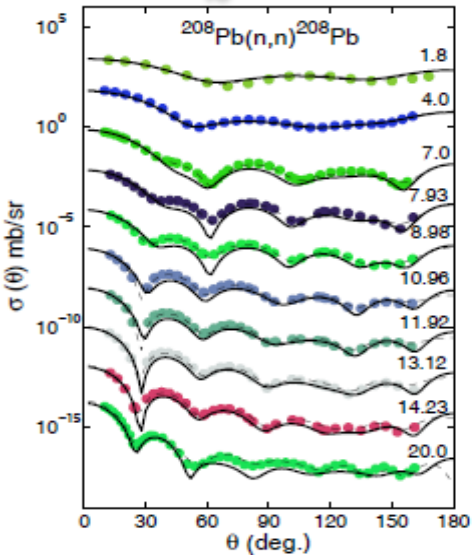


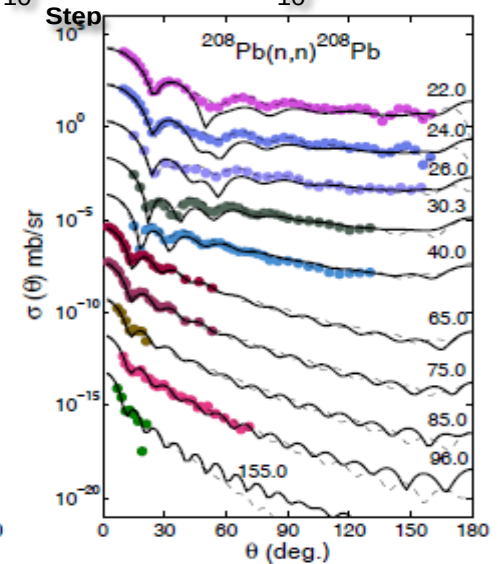
TABLE V: The χ^2/N of $d\sigma/d\Omega$ for n+^{12}C - ^{40}Ca reactions

Nuclide	Point num. of exp.	MOP	KD
^{12}C	293	3.35	2.43
^{14}N	336	0.21	0.22
^{16}O	309	0.91	0.66
^{23}Na	221	0.31	0.22
^{24}Mg	270	0.56	0.19
^{27}Al	426	0.068	0.069
^{28}Si	391	0.24	0.15
^{32}S	388	0.22	0.07
^{40}Ca	399	0.22	0.075

Potential optimization through 5000 times in the global simulated annealing algorithm







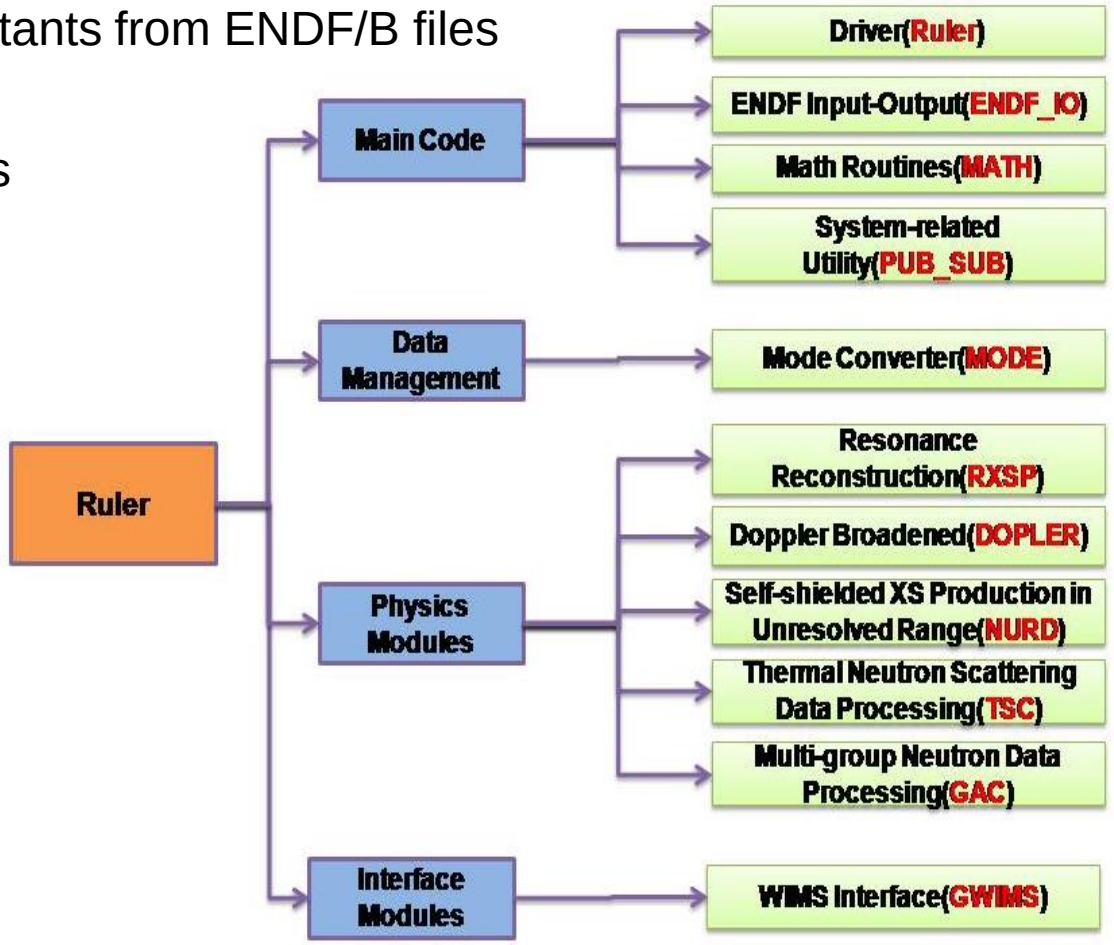
Current status of Ruler

- Ruler function

  Producing multi-group constants from ENDF/B files

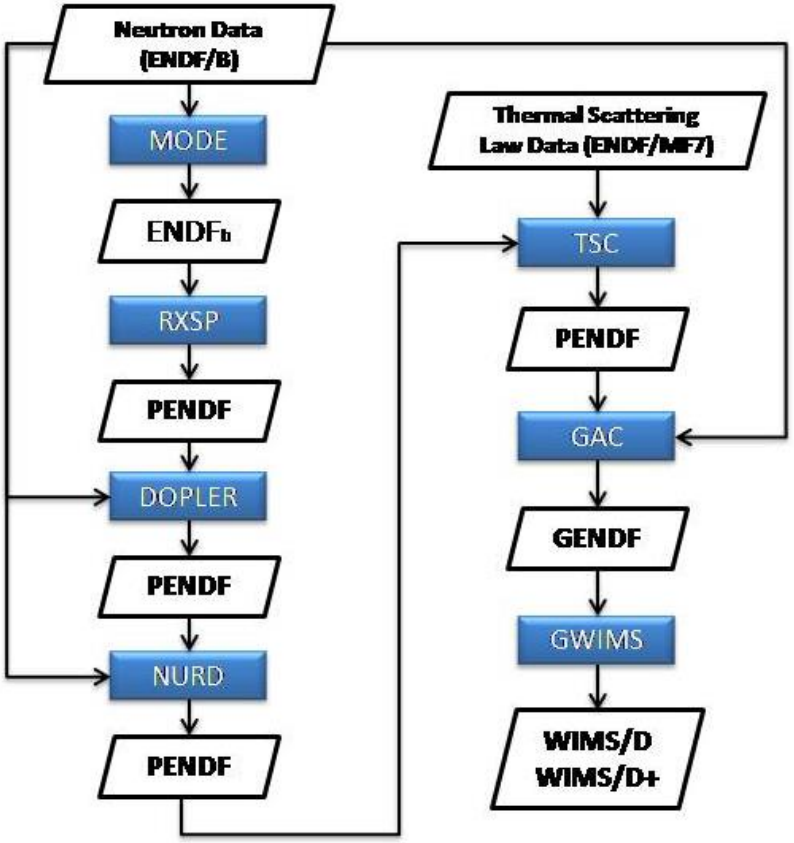
- Ruler structure

  Ruler consists of 11 modules



Current status of Ruler

- The characteristics of Ruler
  - Independent ENDF I/O module/library
  - Easy for maintenance and extension
  - Less computation time



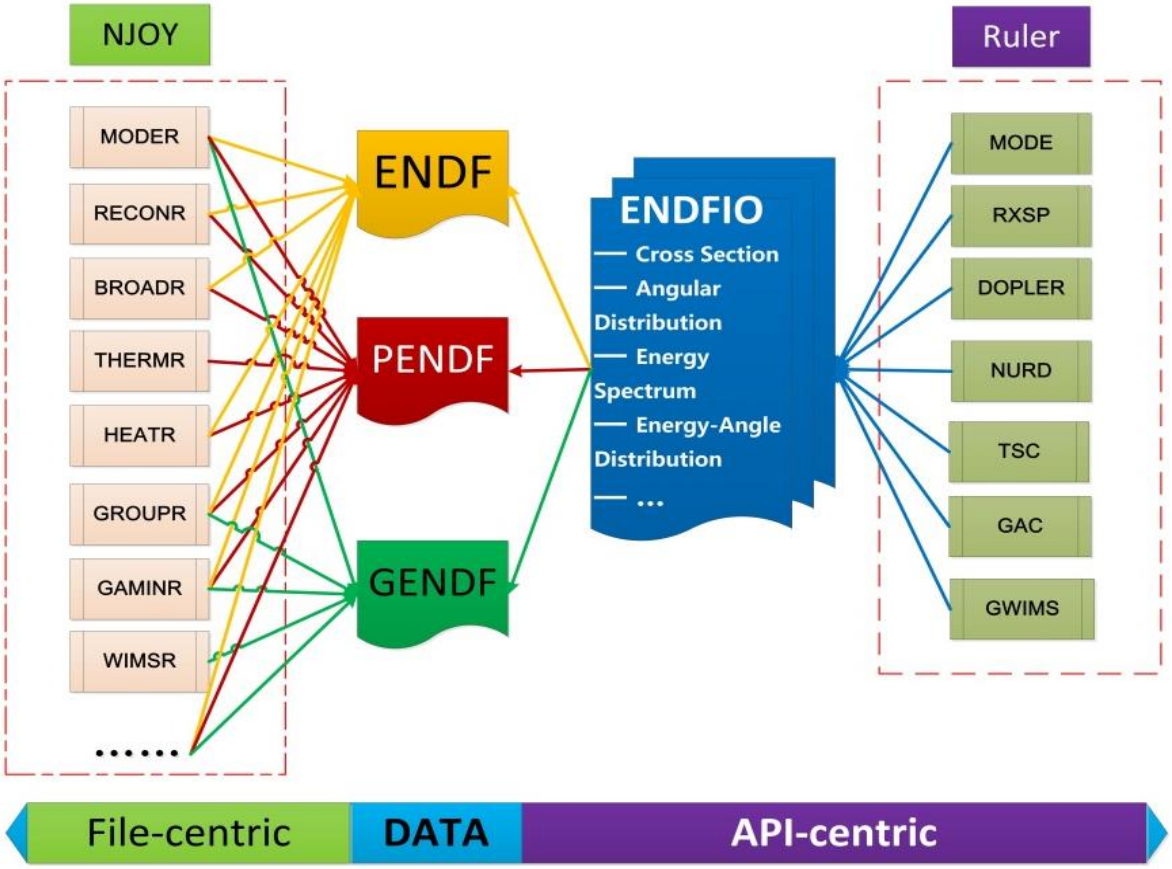
- Ruler physics

  Ruler can be used for

  - Generating WIMS-D/WIMS-D$^+$ format data files

Current status of Ruler

- Comparison between Ruler and NJOY
  - Processing way
    - Ruler: API-centric
    - NJOY: File-centric



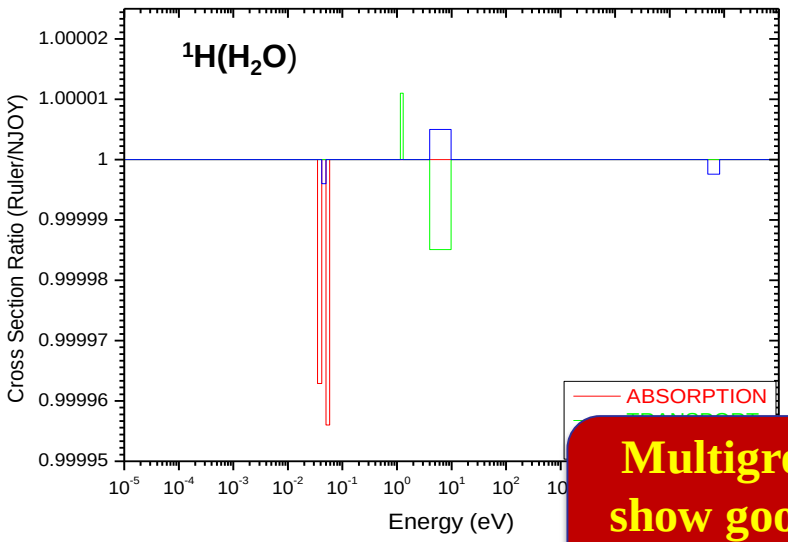
Current status of Ruler

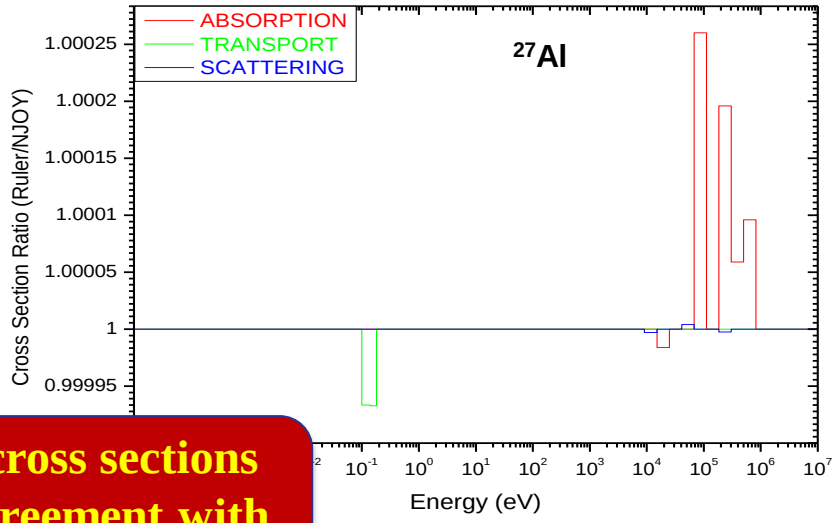
- Computation time

Nuclide	Running time (s)		Speed-up ratio
	NJOY	Ruler	NJOY/Ruler
1-H-H_2O	152.7	104.2	1.47
1-H-ZrH	410.2	365.9	1.12
1-D-D_2O	157.6	101.6	1.55
6-C	84.4		1.37
8-O-16	25.9		1.74
13-Al-27	7.0	4.3	1.63
26-Fe-56	23	19.9	1.16
36-Kr-83	5.7	3.1	1.84
42-Mo-95	7	5.7	1.23
92-U-235	247.3	187.0	1.32
92-U-238	448.6	225.3	1.99
94-Pu-239	136.7	67	2.04

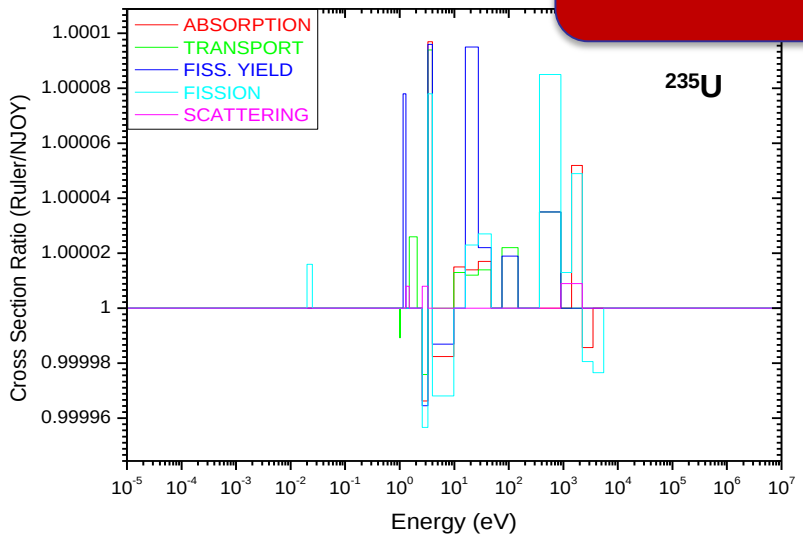
Less computation time is required for Ruler

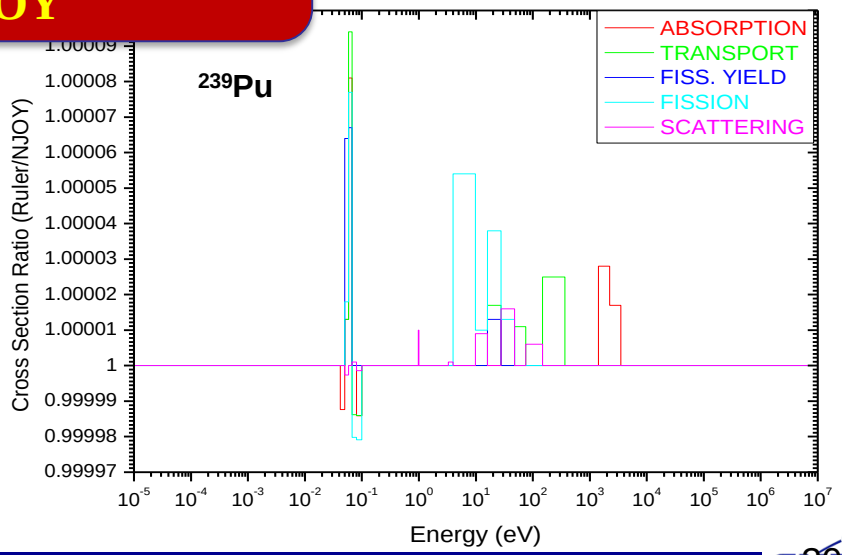
III. Nuclear Data Processing Code Development





Multigroup cross sections show good agreement with NJOY





Current status of Ruler

- Possible work to be made
  - Function extension of Ruler
    - Add photon processing module
    - Add heating processing module
    - Add more interface modules
  - Modification of ENDF_IO module for new data format

IV. Other Information

- ✓ The mainly evaluations of the CENDL project are being carried out by China Nuclear Data Center(CNDC), China Institute of Atomic Energy(CIAE) and China Nuclear Data Coordination Network(CNDCN).
- ✓ 21 staff at CNDC (permanent 21, Master 3, Ph.D 2). >10 Institutions including into the CNEDL project.
- ✓ The regular update and maintenance of IAEA/NDS mirror-site in China with the support of NDS.
- ✓ Nuclear data services is providing to all the nuclear data users in China and other regions by CNDC.
- ✓ A symposium of the key fundamental study of nuclear data organized by the National Natural Science Foundation of China (NSFC) in Beijing on 8-9 last year. More than 90 nuclear physicists attend this symposium. A proposal of establishing a long-term program for supporting the fundamental studies of nuclear data has been submitted.

Thank you for your attention !
Comments and suggestion welcome !