PROGRESS OF CENDL PROJECT AND RELATED ACTIVITIES 2014-2015

GE Zhigang

China Nuclear Data Center(CNDC)
China Nuclear Data Key Laboratory
China Committee of Nuclear Data(CCND)
China Institute of Atomic Energy(CIAE)
P.O.Box 275-41,Beijing 102413, P.R.China
E-Mail:gezg@ciae.ac.cn

CHINA NUCLEAR DATA CENTER

I. *Introduction of China Nuclear Data Activities*

- *The goal of China nuclear data activities is supplying the nuclear data to feed the needs of the nuclear peaceful applications; which contains the nuclear power plants design, science studies, nuclear medicine application and public education et al.*
- *The China nuclear data activities consists of nuclear data measurement and related measurement methods study, data evaluation and model study, data library establish and library management and nuclear data benchmark testing and validation.*
- *The mainly activities are being carried out at China Nuclear Data Center(CNDC), China Institute of Atomic Energy(CIAE) and China Nuclear Data Coordination Network(CNDCN) and more than 10 institutions and universities are involved CNDCN.*

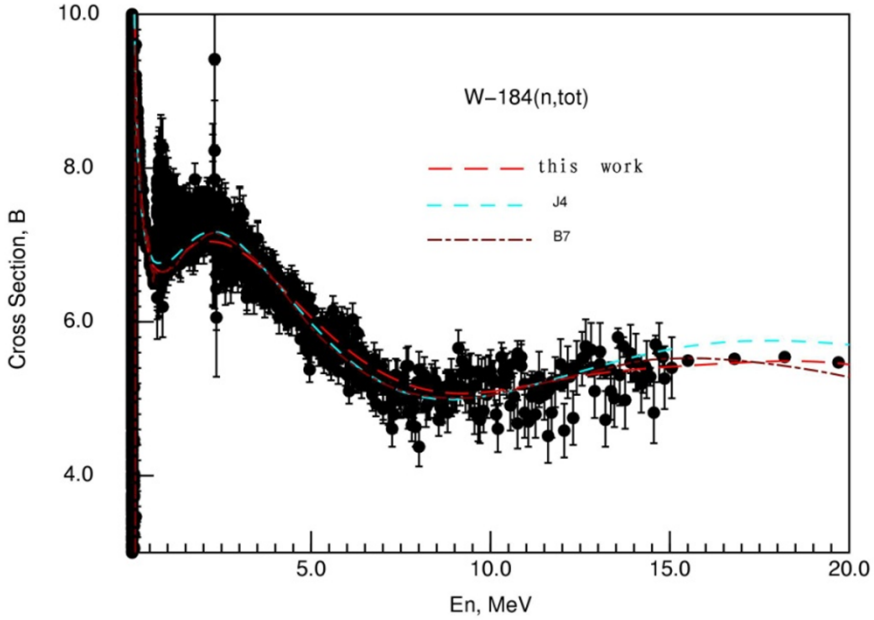
II. *Recent Progress of China Nuclear Data Project*

- *New evaluations of CENDL project.*
- *Fission yields, activation data and decay data evaluation*
- *Nuclear data methodology studies.*
- *The benchmark/validation of new evaluations.*
- *Neutron data library evaluations and data processing for Th-U fuel cycling studies(Chinese TMSR Project).*
- *Nuclear data evaluation and benchmark/validation for ADS needs (China ADS Project).*
- *EXFOR compilation.*

2. Nuclear Data Evaluation and Methodological Studies

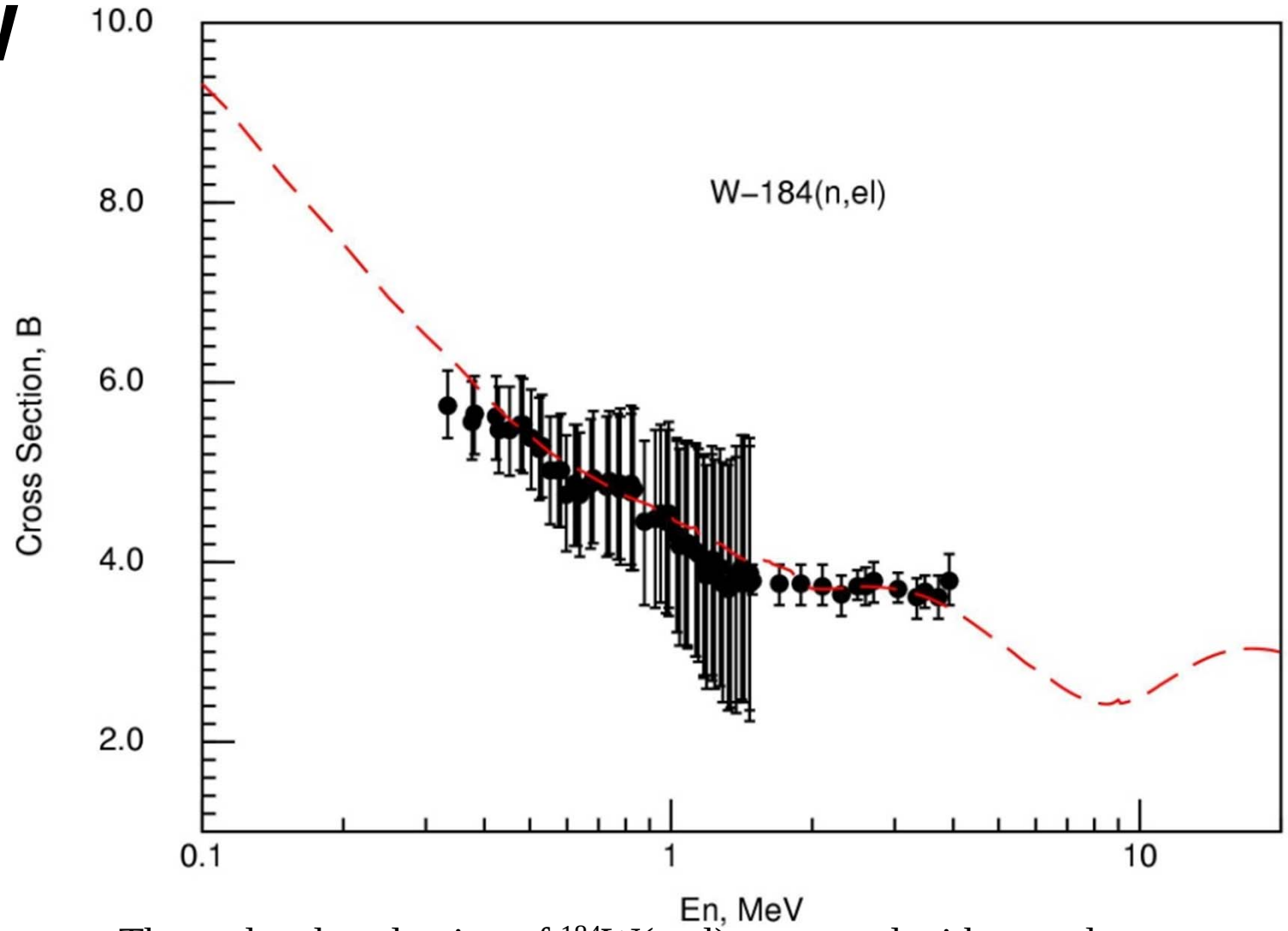
CENDL Project

●The evaluation activities are performing for the updating of CENDL, which contain the neutron reaction data, activation and fission yields files. As some examples, following are the new evaluations for the neutron files and activation of ^{184}W、^{237}U、^{56}Fe.

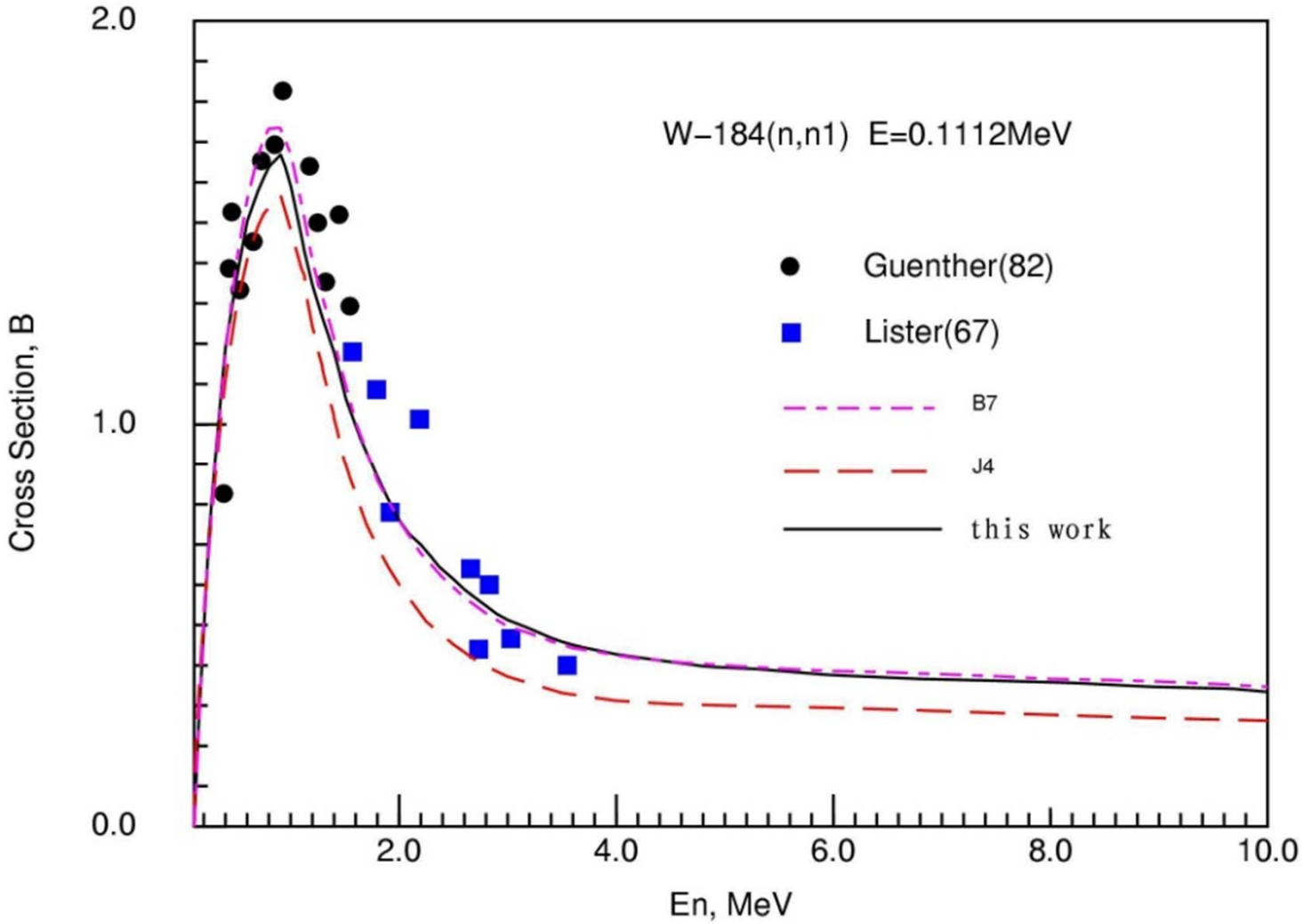


^{184}W(n, tot) new evaluation comparion with evaluated files ENDF/B7, JENDL-4 and CENDL-3.1. and exp.data. .

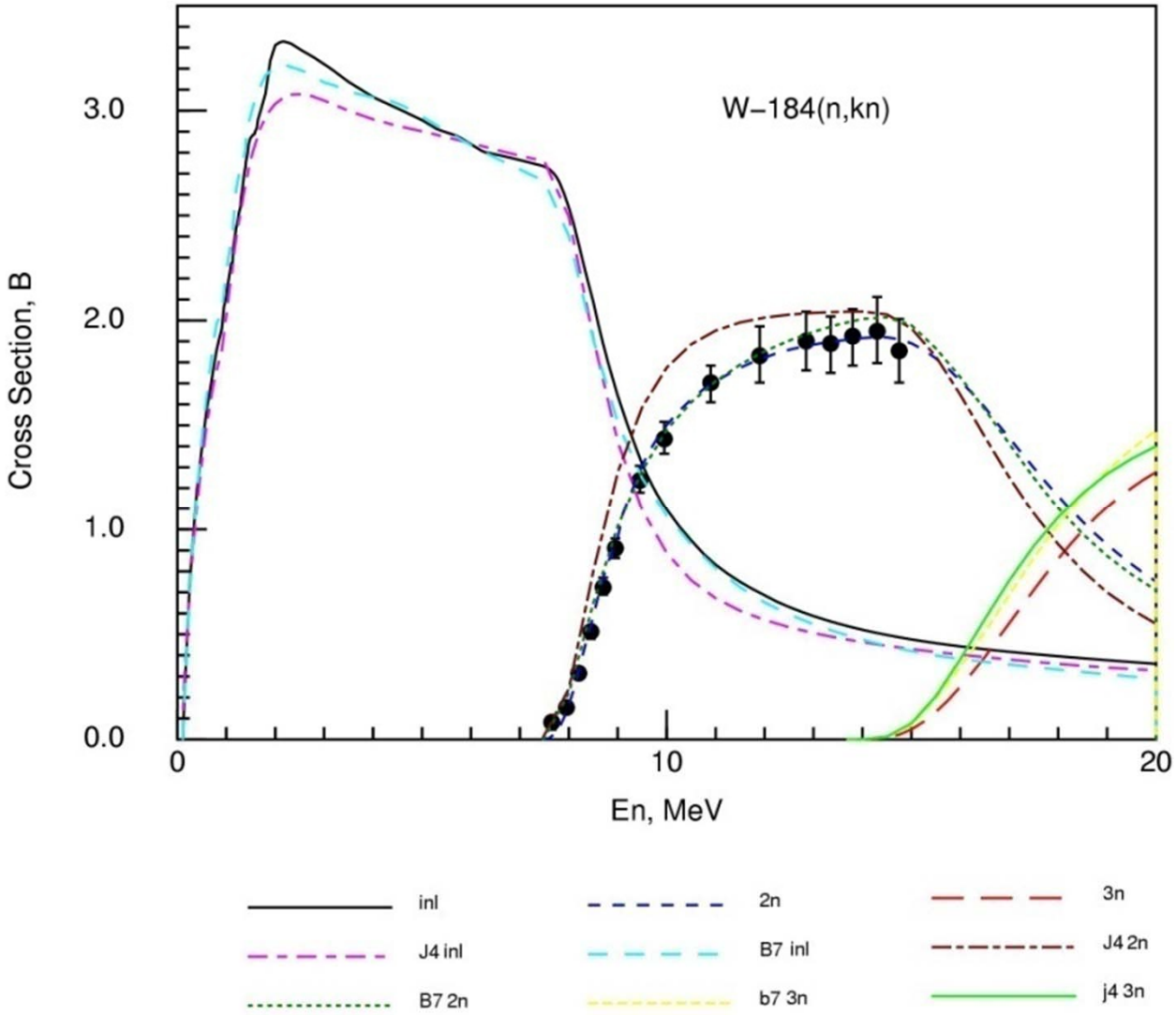
^{184}W



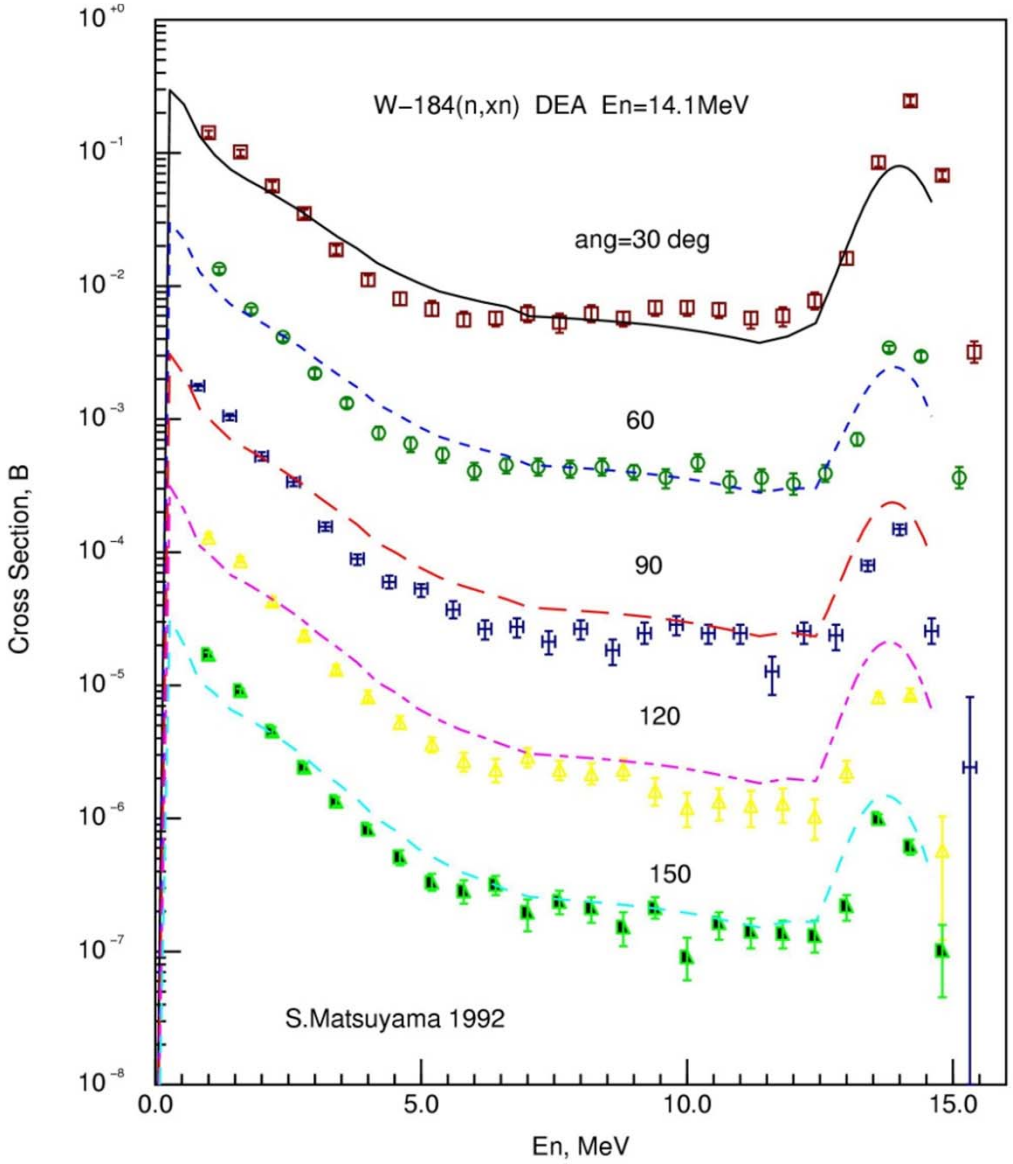
The updated evaluation of $^{184}W(n,el)$ compared with exp. data.



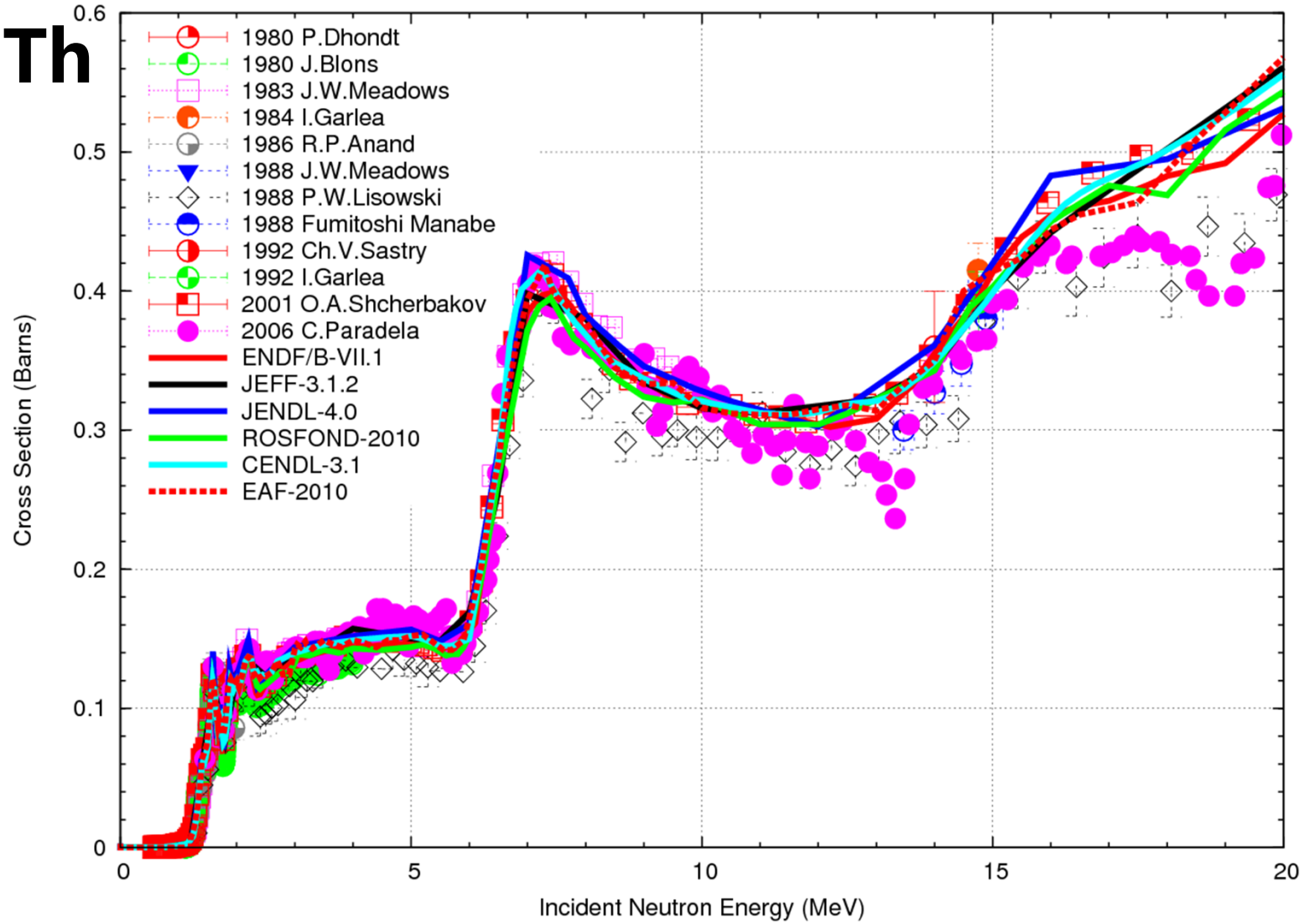
The updated evaluation of ^{184}W(n,n1) compared with exp. data.



The updated evaluation of ^{184}W(n,xn) compared with exp. data and other libraries.

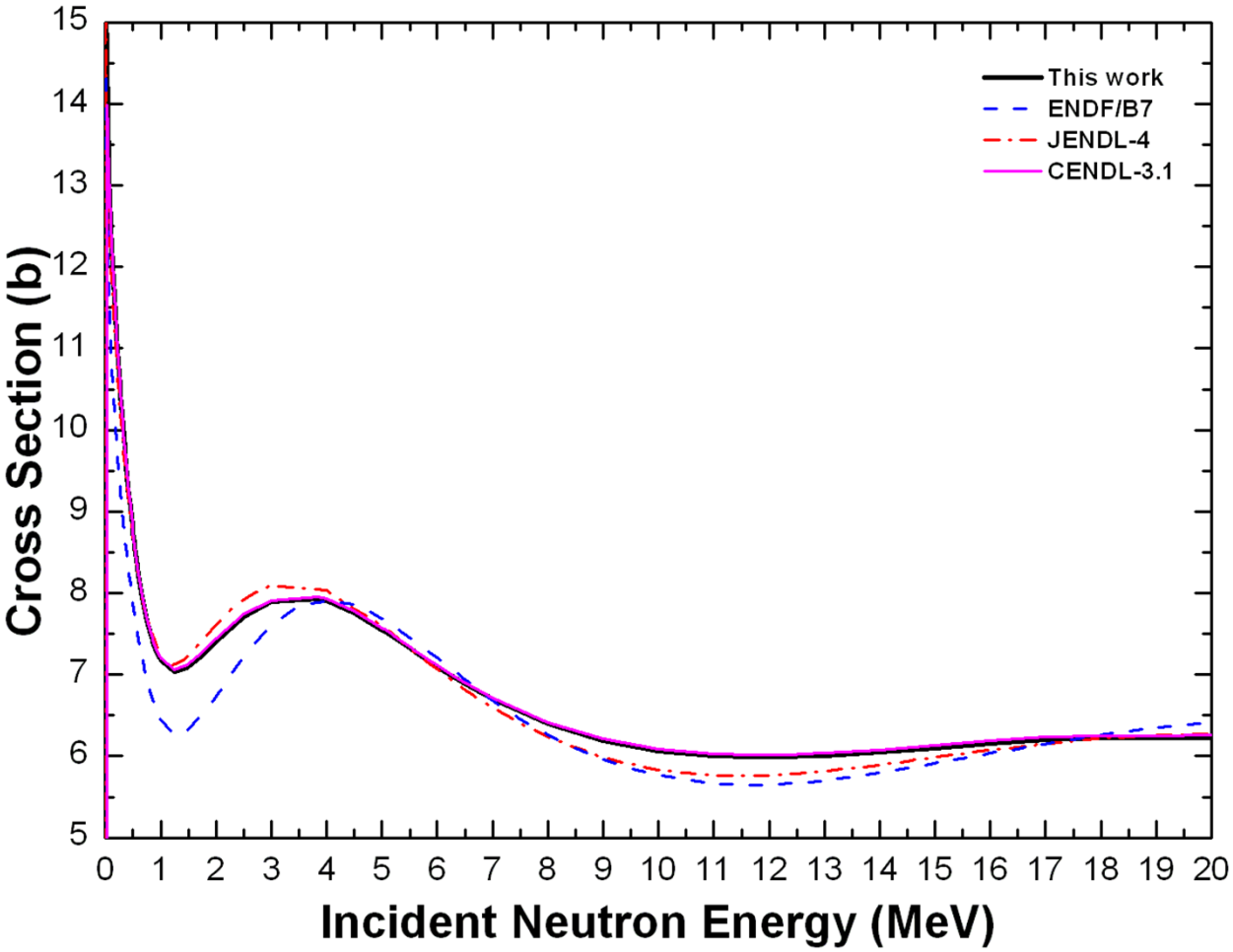


The updated evaluation DDX of ^{184}W(n,n1) compared with exp. data of ^{nat}W.

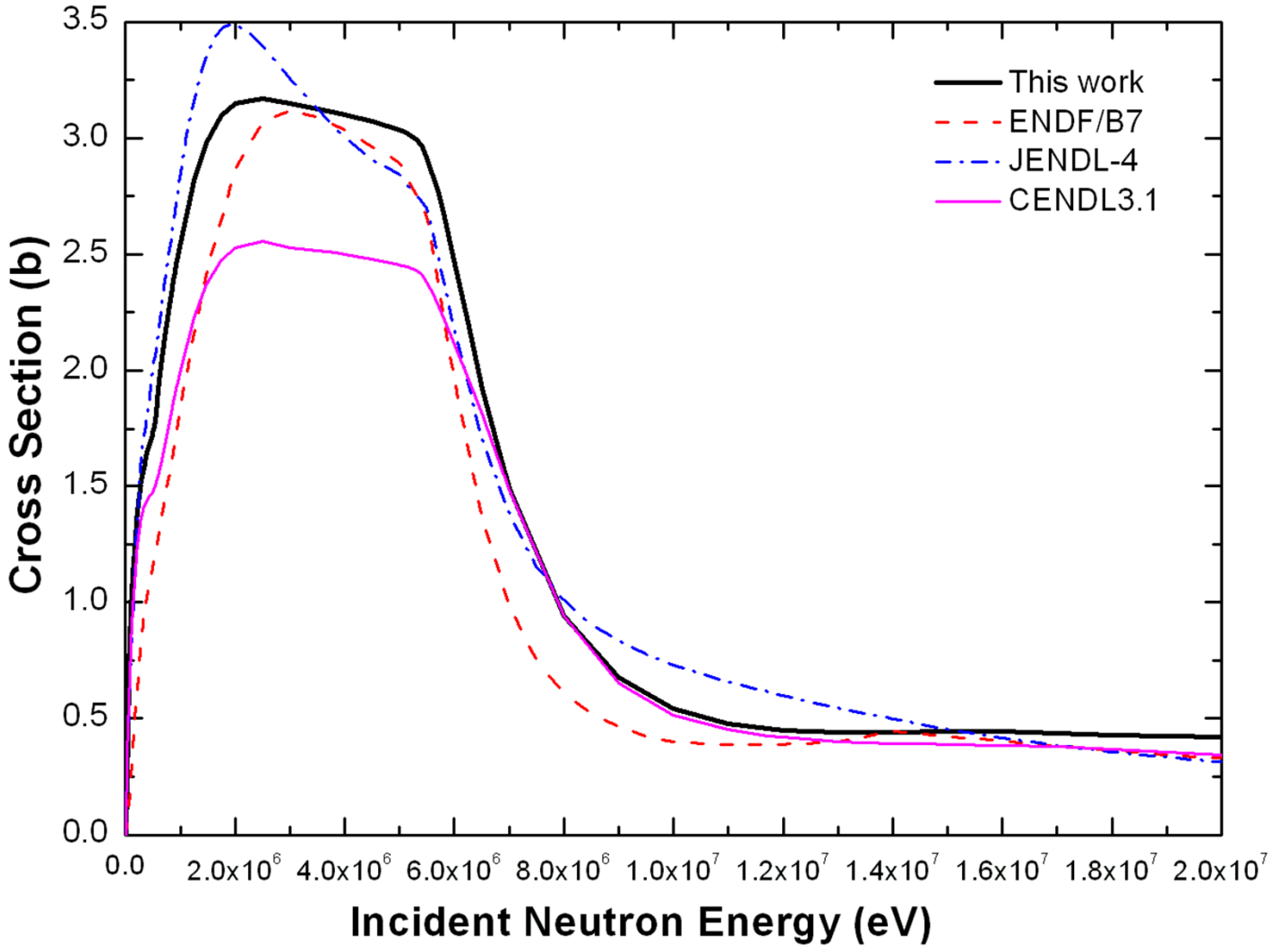


^{232}Th(n, f) new evaluation compared with other evaluated files and exp. data.

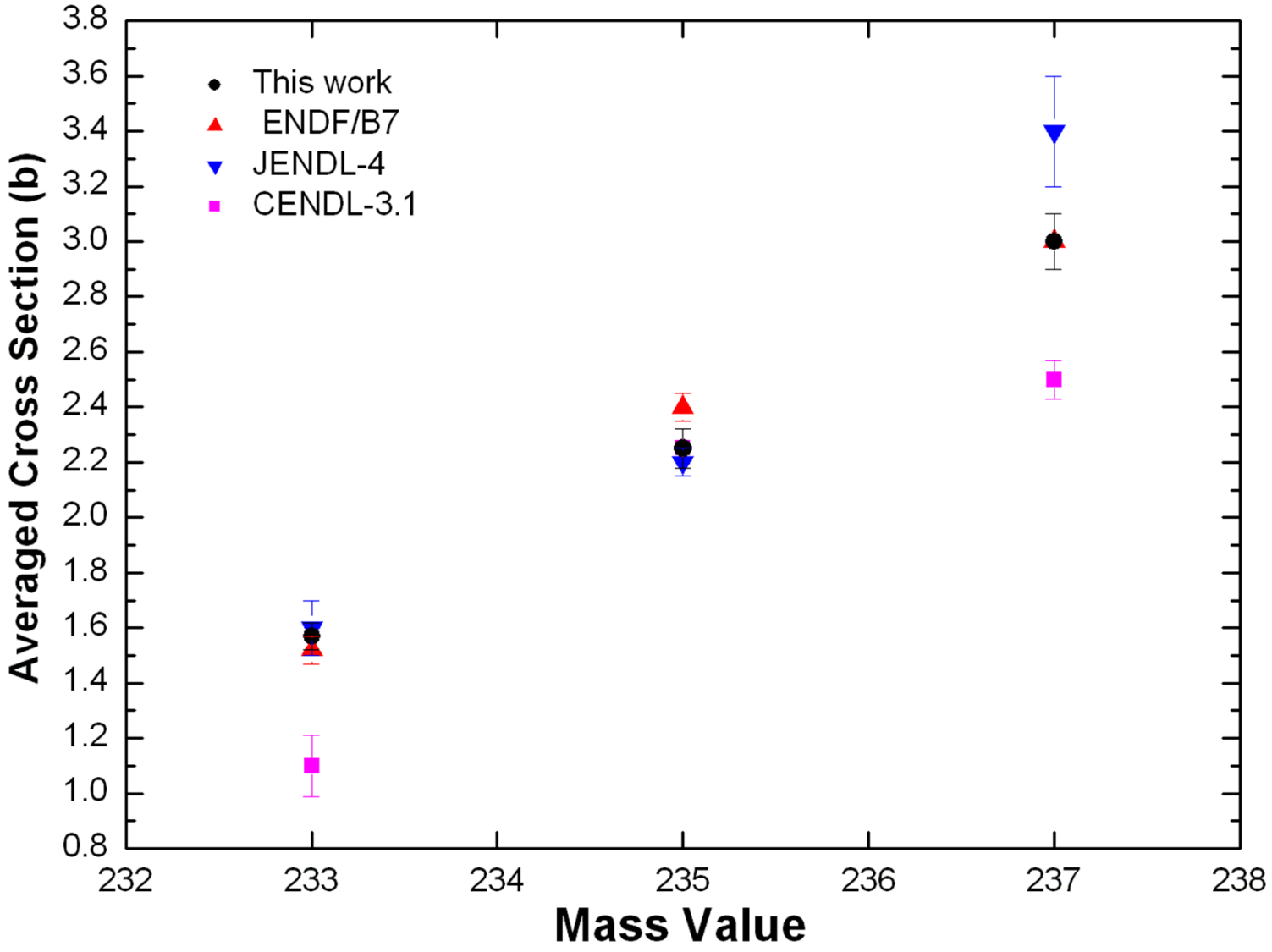
^{237}U



^{237}U(n, tot) new evaluation comparion with evaluated files ENDF/B7, JENDL-4 and CENDL-3.1.

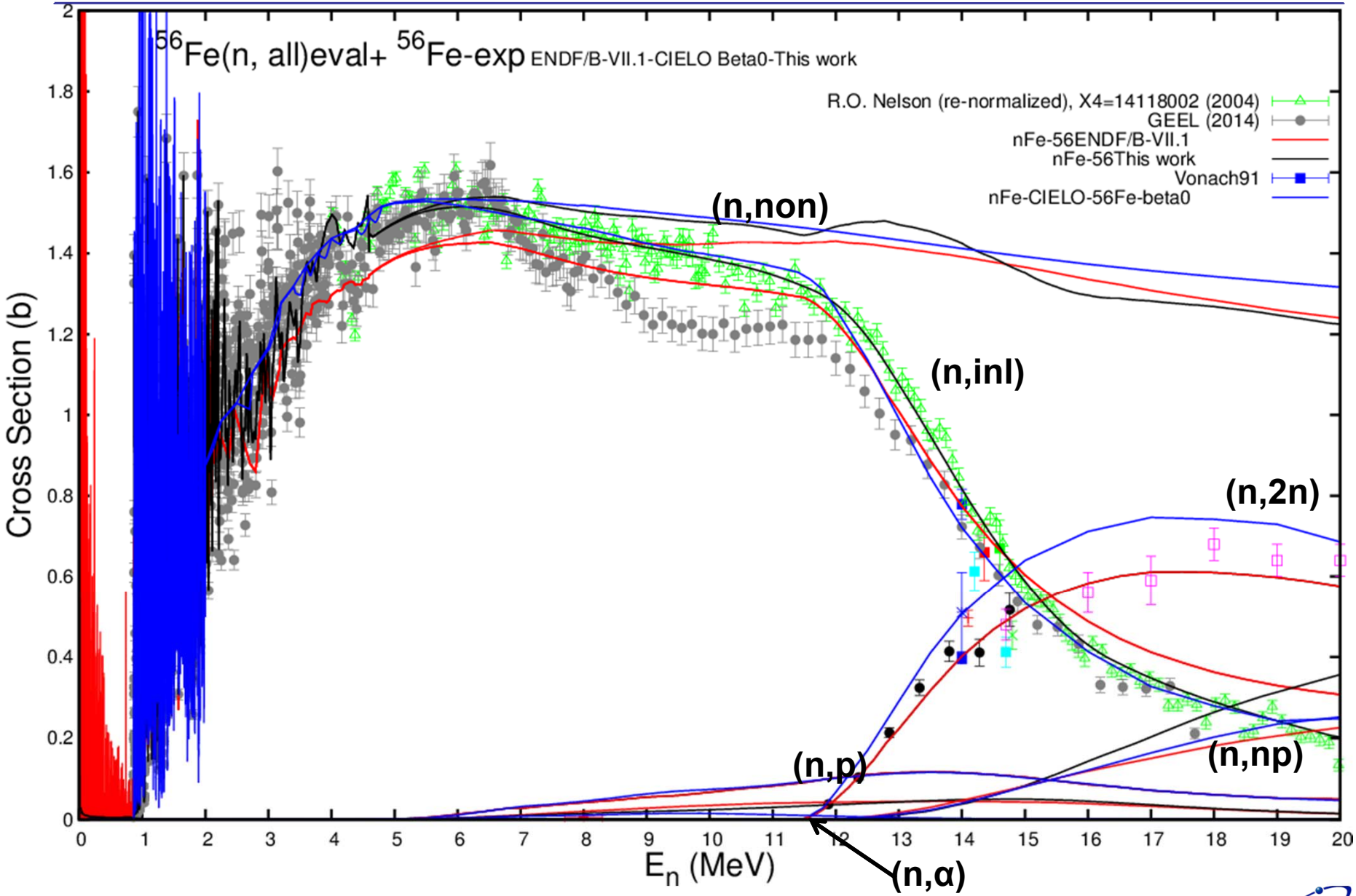


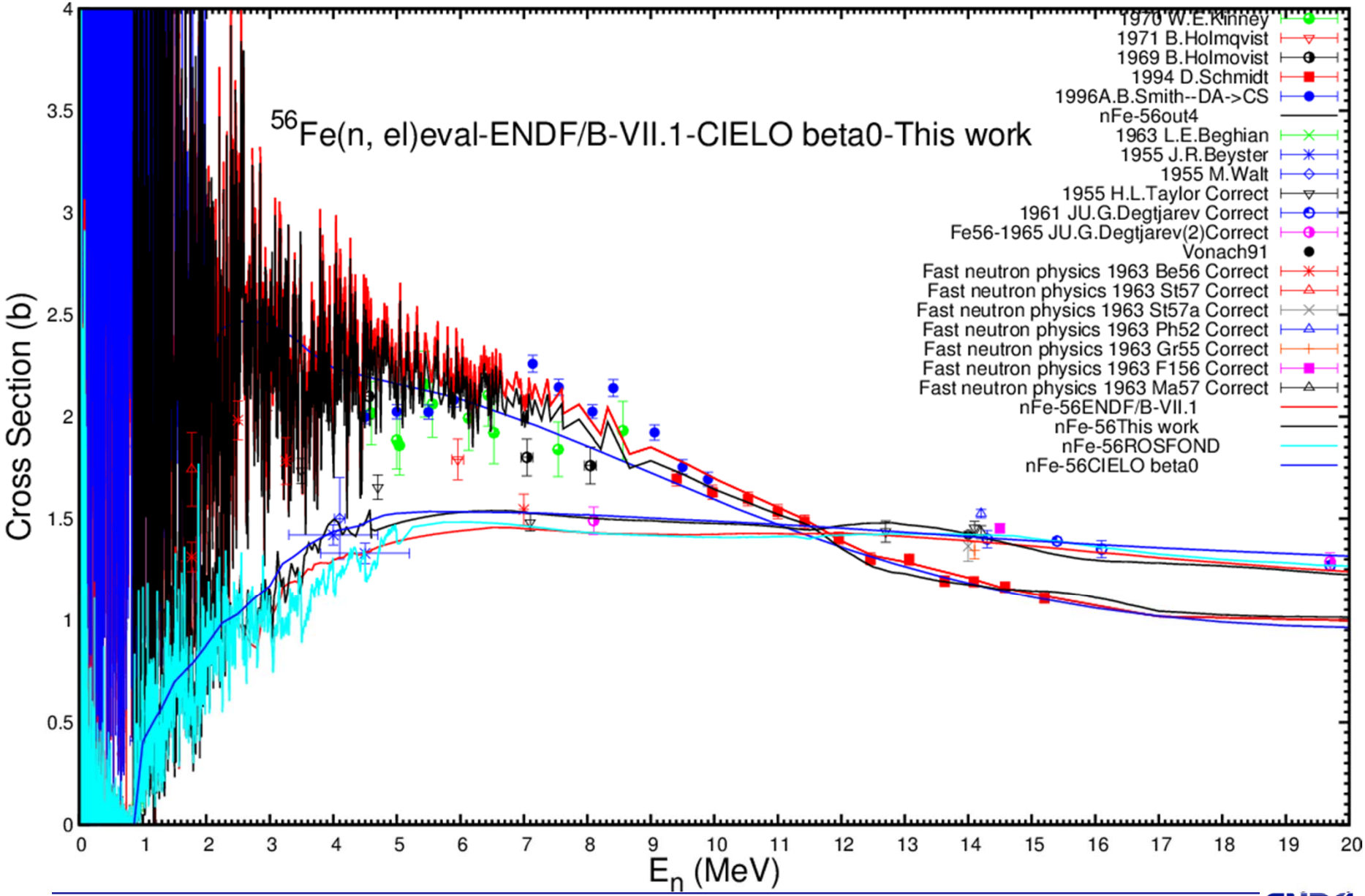
^{237}U(n, inl) calculations comparion with evaluated files ENDF/B7, JENDL-4 and CENDL-3.1.

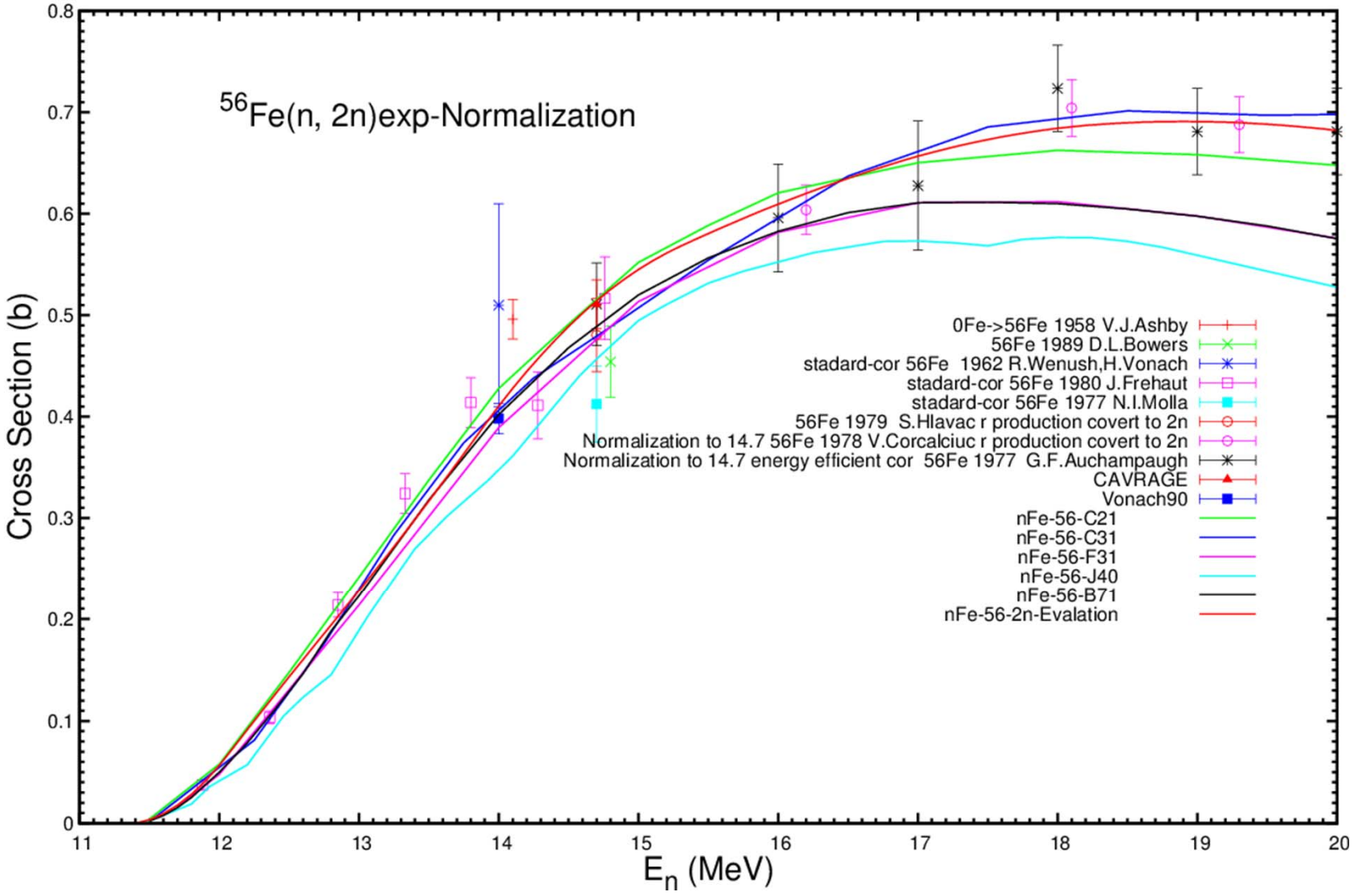


Average cross sections of 2~5 MeV for U(Odd A)

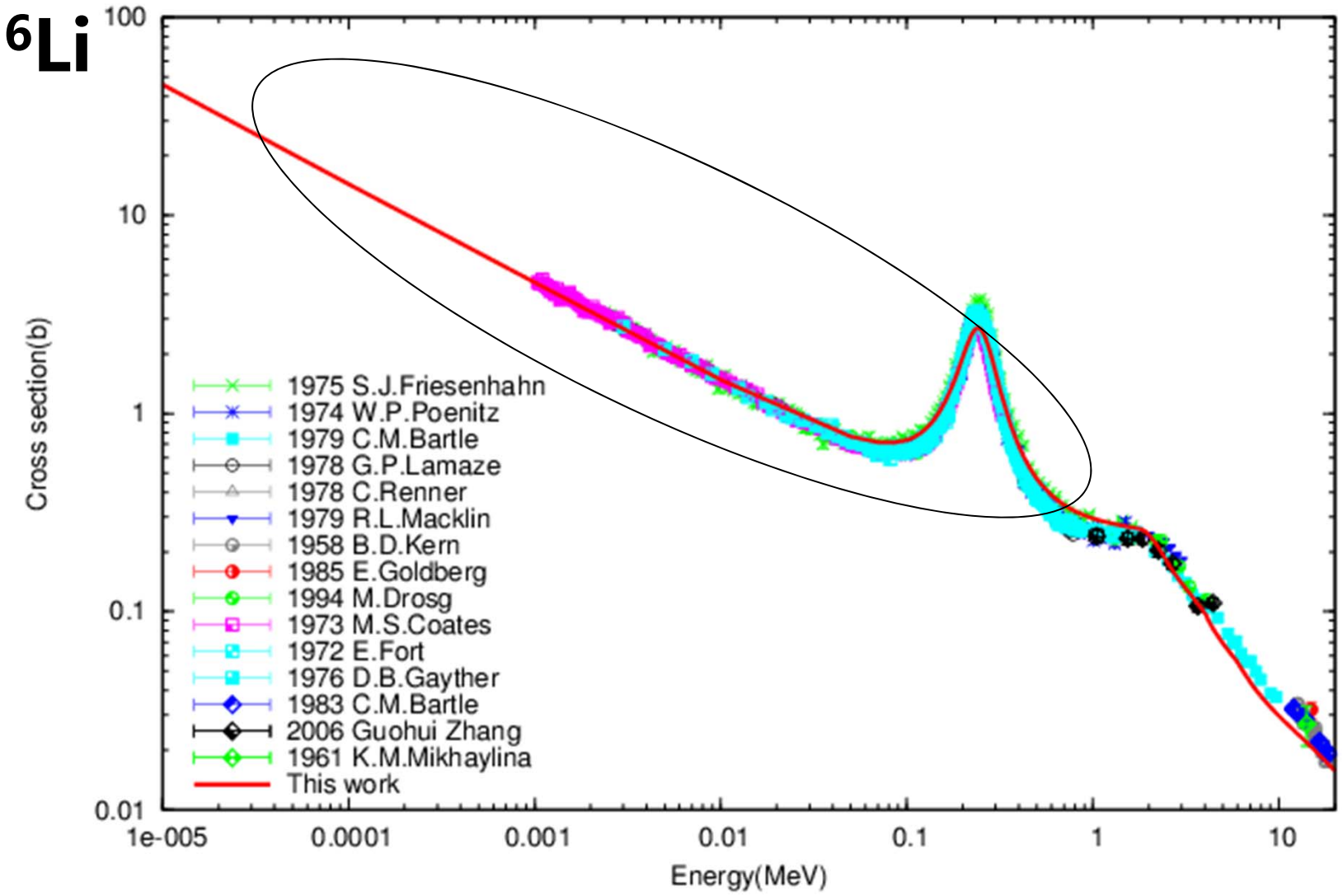
^{56}Fe


56Fe(n, all)eval+ 56Fe-exp ENDF/B-VII.1-CIELO Beta0-This work
R.O. Nelson (re-normalized), X4=14118002 (2004)
GEEL (2014)
nFe-56ENDF/B-VII.1
nFe-56This work
Vonach91
nFe-CIELO-56Fe-beta0
(n,non)
(n,inl)
(n,2n)
(n,np)
(n,p)
(n,α)
Cross Section (b)
En (MeV)

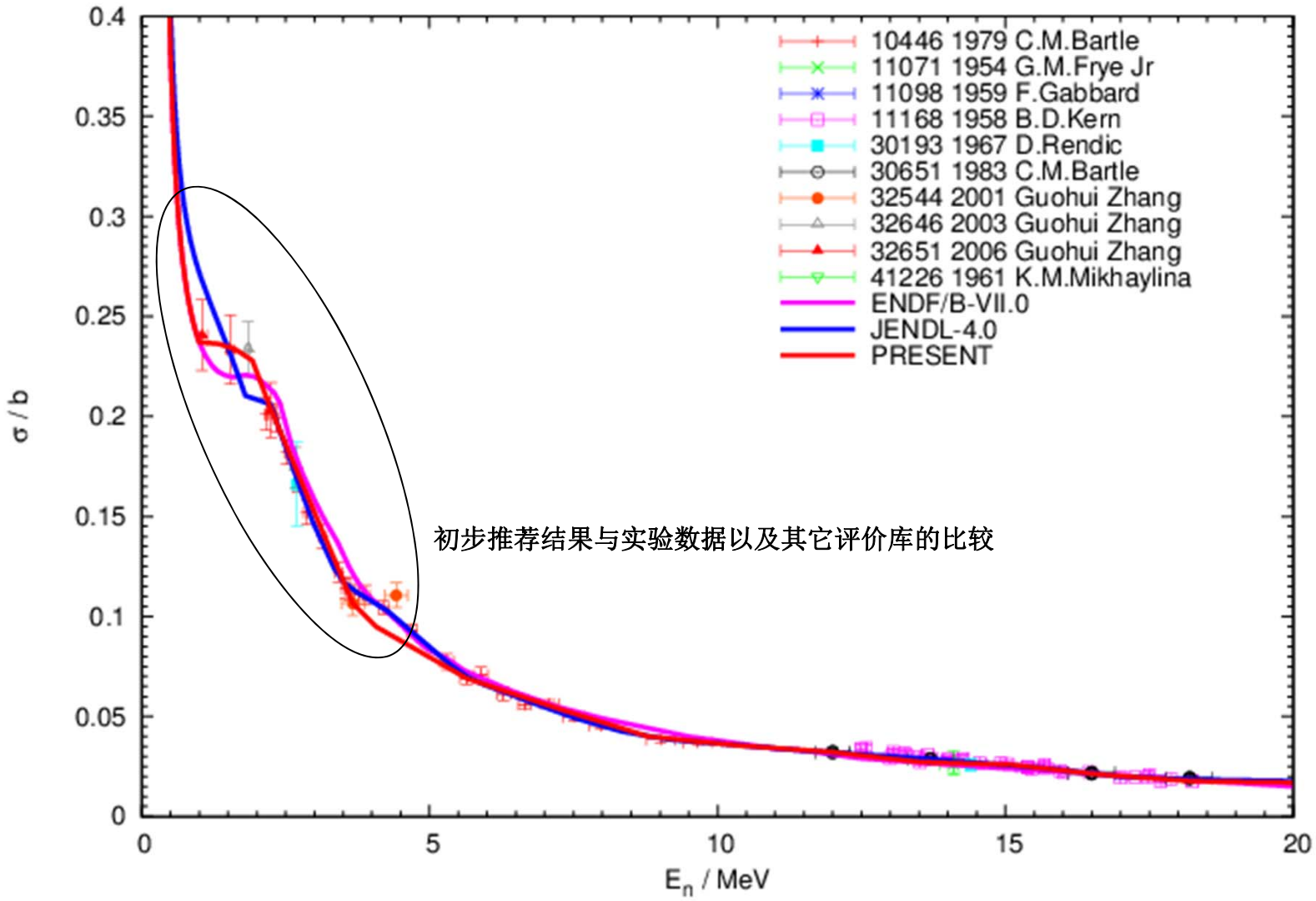

56Fe(n, el)eval-ENDF/B-VII.1-CIELO beta0-This work
Cross Section (b)
En (MeV)
1970 W.E.Kinney
1971 B.Holmqvist
1969 B.Holmovist
1994 D.Schmidt
1996A.B.Smith--DA->CS
nFe-56out4
1963 L.E.Beghian
1955 J.R.Beyster
1955 M.Walt
1955 H.L.Taylor Correct
1961 JU.G.Degtjarev Correct
Fe56-1965 JU.G.Degtjarev(2)Correct
Vonach91
Fast neutron physics 1963 Be56 Correct
Fast neutron physics 1963 St57 Correct
Fast neutron physics 1963 St57a Correct
Fast neutron physics 1963 Ph52 Correct
Fast neutron physics 1963 Gr55 Correct
Fast neutron physics 1963 F156 Correct
Fast neutron physics 1963 Ma57 Correct
nFe-56ENDF/B-VII.1
nFe-56This work
nFe-56ROSFOND
nFe-56CIELO beta0



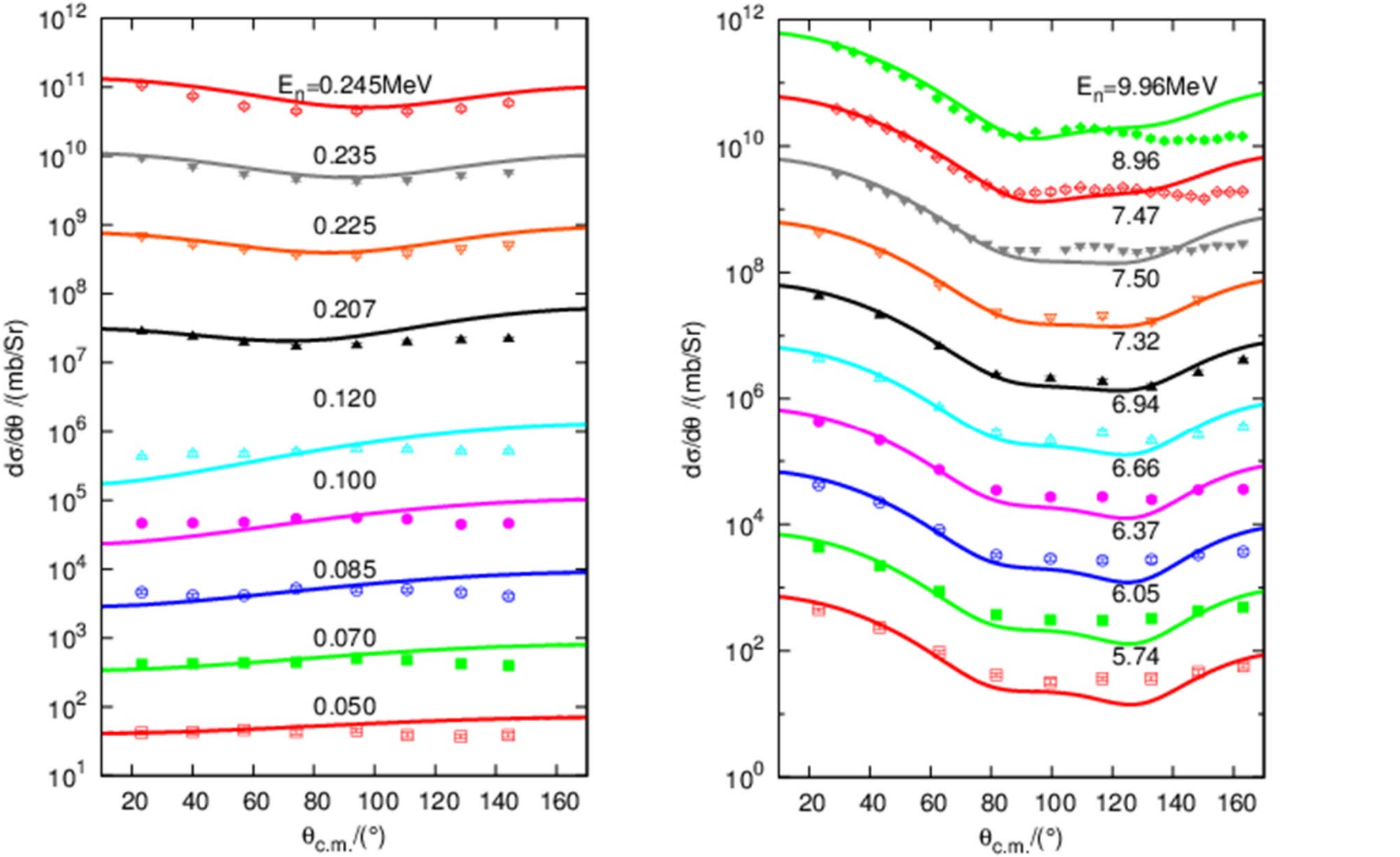
^{56}Fe(n, 2n) new evaluation compared with exp. data.



^{6}Li(n, t) cross sections calculated by FDRR compared with exp. data.



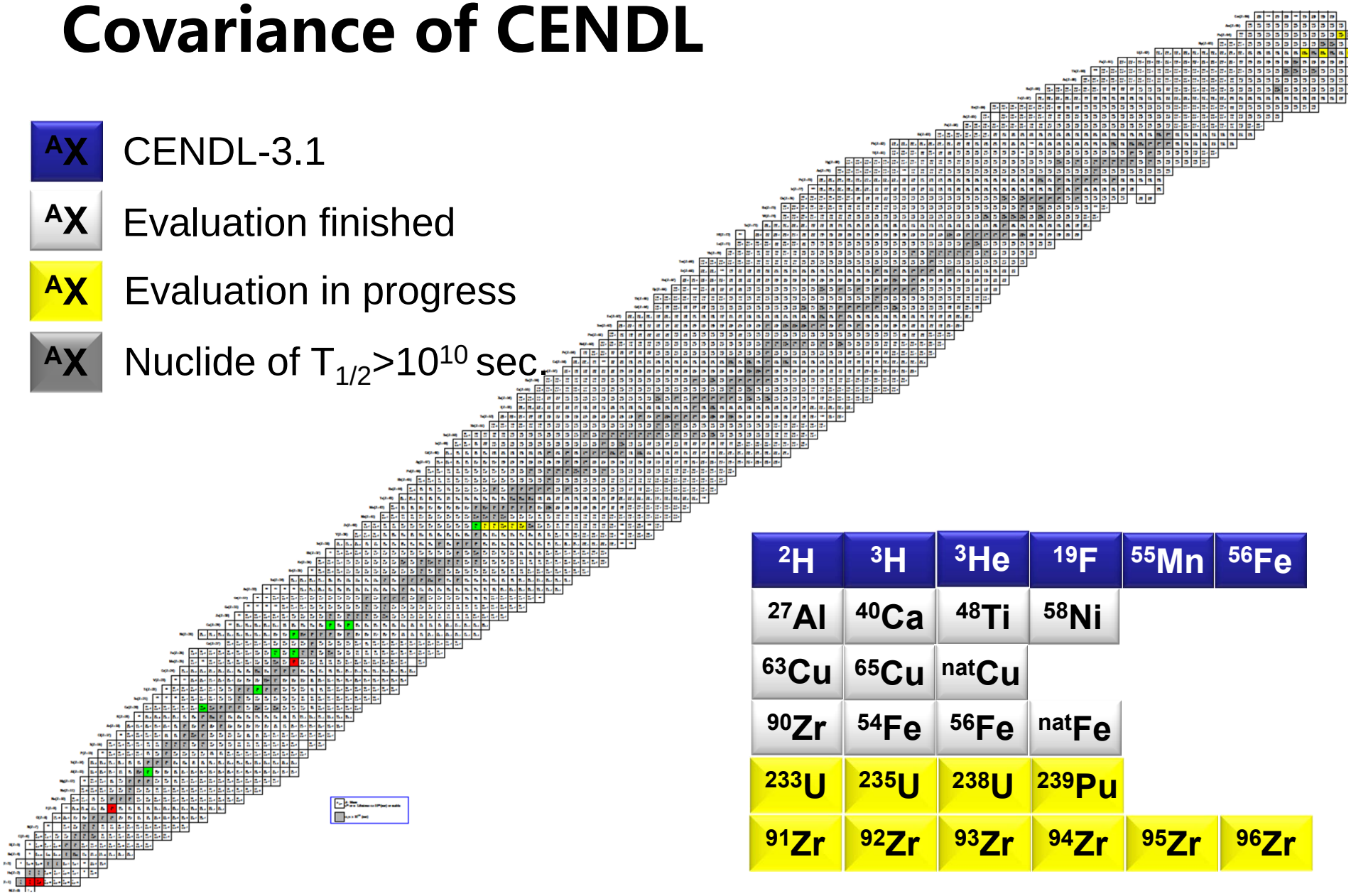
^{6}Li(n, t) cross sections calculated by FDRR compared with exp. data and other libraries.



Elastic scattering angular distribution ^{6}Li(n, t)

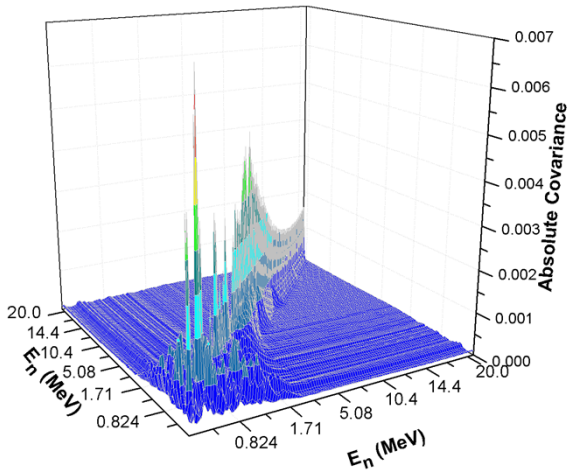
Covariance of CENDL

- ^{A}X CENDL-3.1
- ^{A}X Evaluation finished
- ^{A}X Evaluation in progress
- ^{A}X Nuclide of $T_{1/2}>10^{10}$ sec.

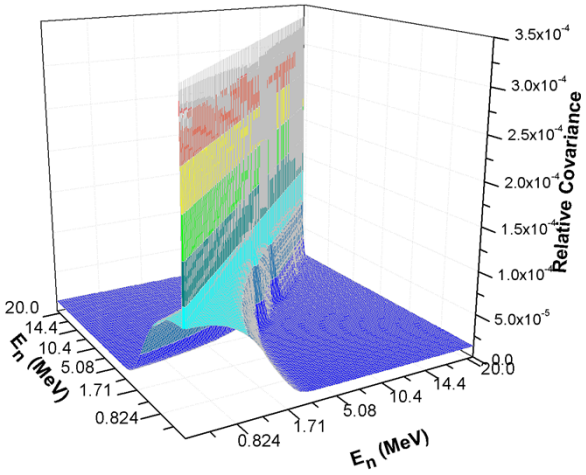


^{2}H	^{3}H	^{3}He	^{19}F	^{55}Mn	^{56}Fe
^{27}Al	^{40}Ca	^{48}Ti	^{58}Ni		
^{63}Cu	^{65}Cu	^{nat}Cu			
^{90}Zr	^{54}Fe	^{56}Fe	^{nat}Fe		
^{233}U	^{235}U	^{238}U	^{239}Pu		
^{91}Zr	^{92}Zr	^{93}Zr	^{94}Zr	^{95}Zr	^{96}Zr

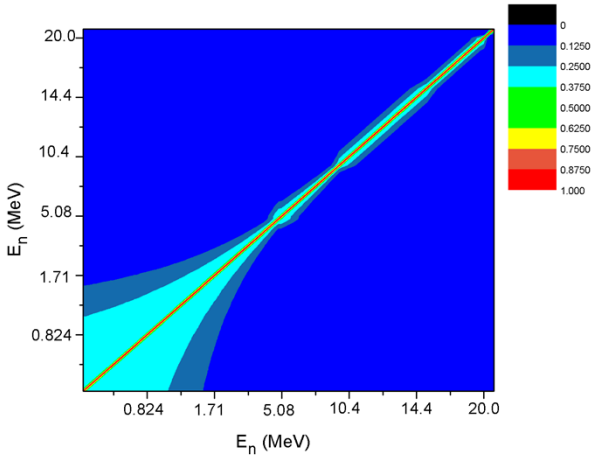
^{40}Ca(n, tot) cross section measurements (<20 MeV)



Absolute covariance coefficient



Relative covariance



correlation

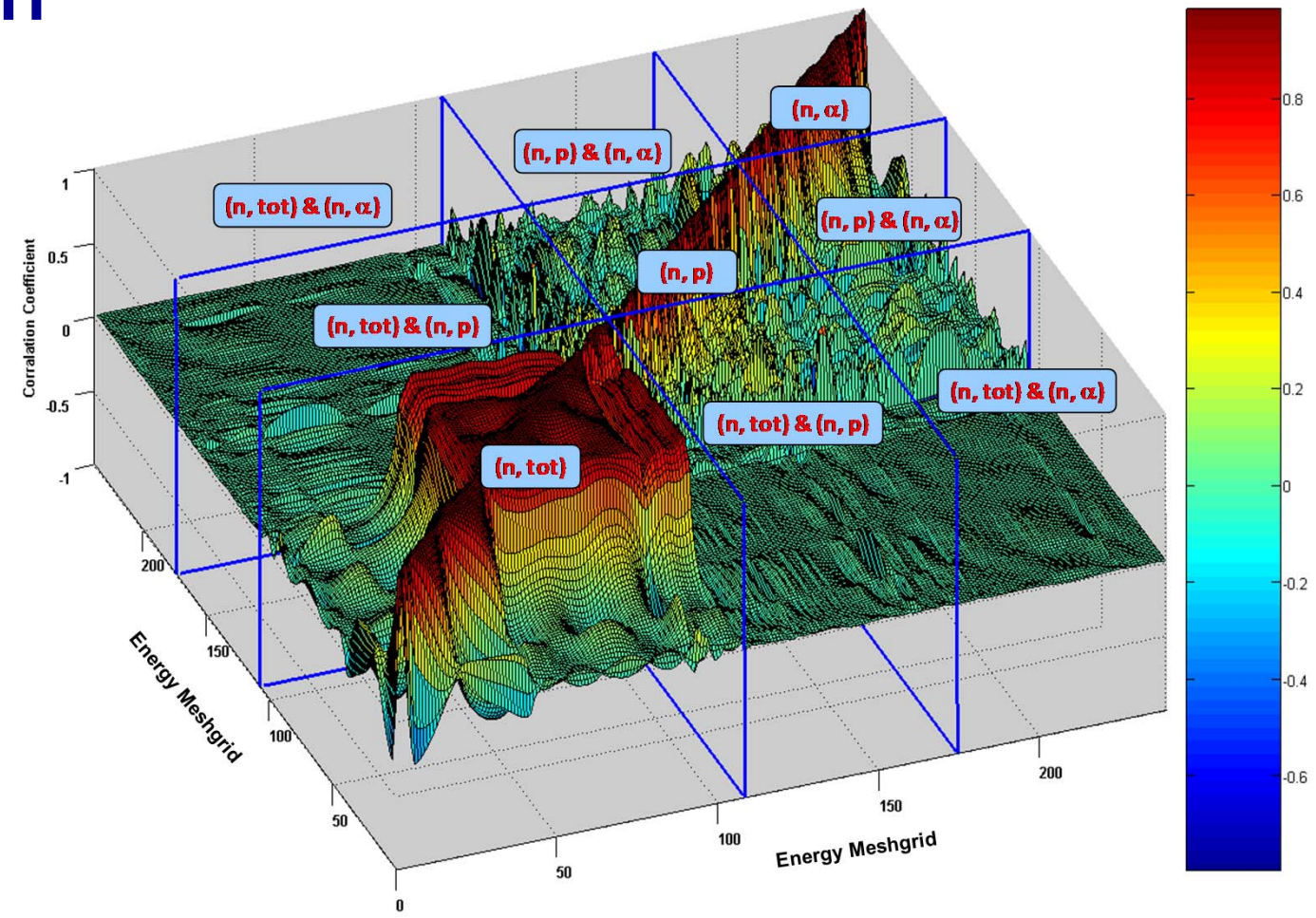
- **Errors and coefficient:**

Error source	Value(%)	correlation
statistic	1.5	no
background correction	0.6	middle-range
inscattering correction	0.5	middle-range
deadtime correction	0.6	middle-range
geometry	0.2	long-range
sample	0.3	long-range

■ **Analysis:**

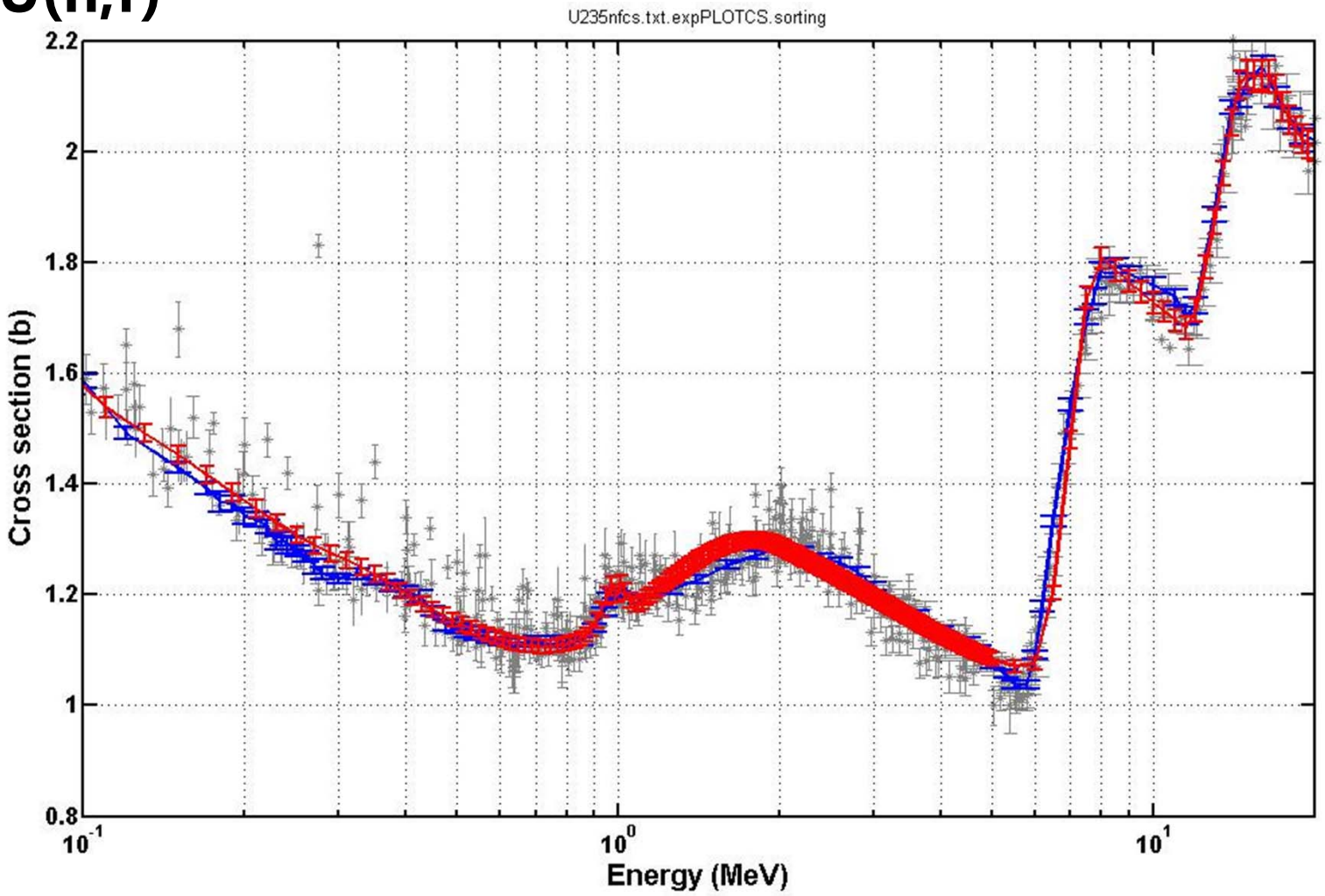
- **Fluctuation of absolute total errors caused by fluctuation of cross sections**
- **Bigger correlations near the diagonal elements, because of the middle-range correlations**
- **Below 5 MeV, the strong correlations caused by the strong structures and energy points density**

n+^{48}Ti



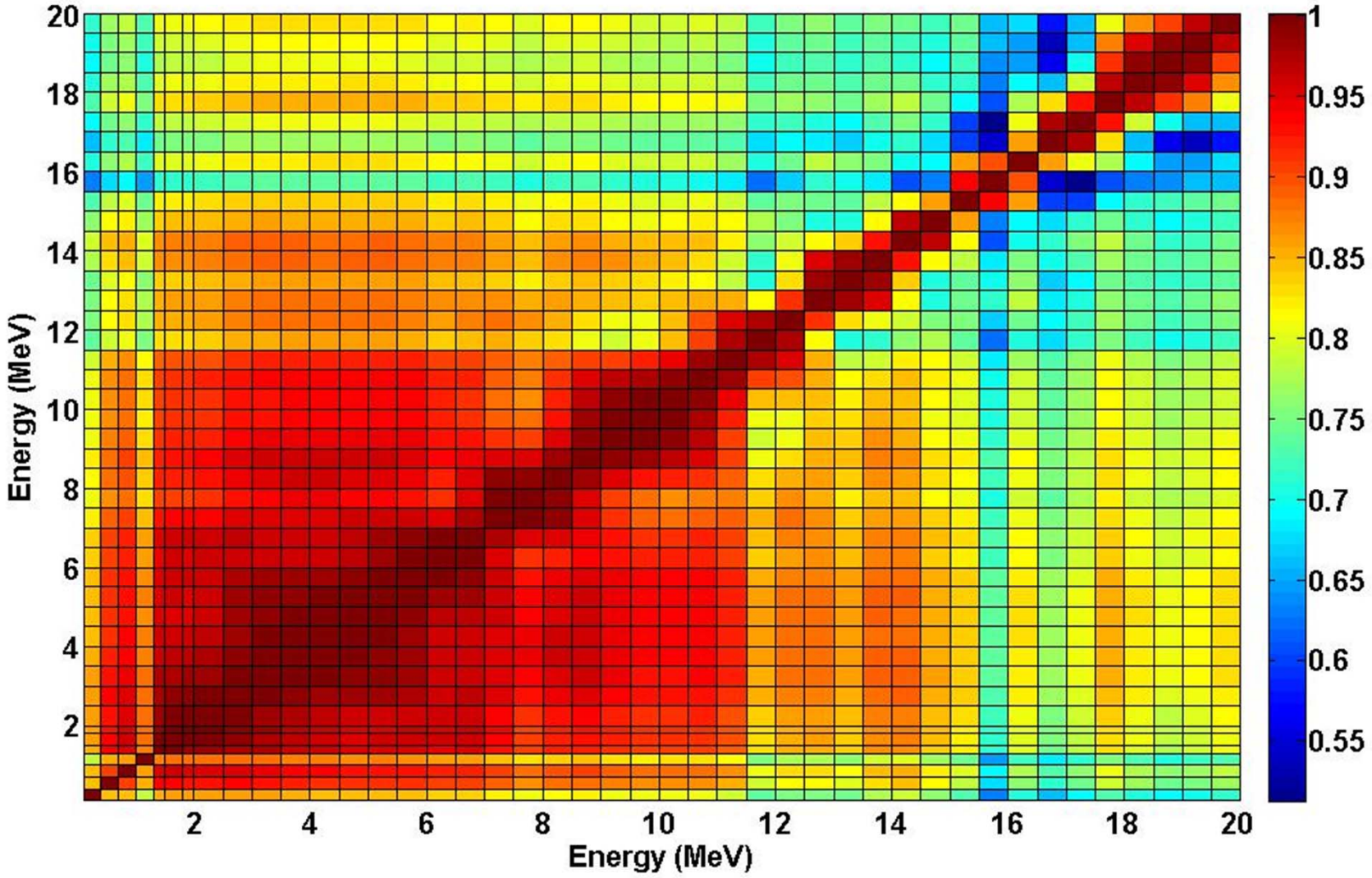
The updated covariance evaluations for the different reaction channels of n+^{48}Ti with COVAC system.

^{235}U(n,f)

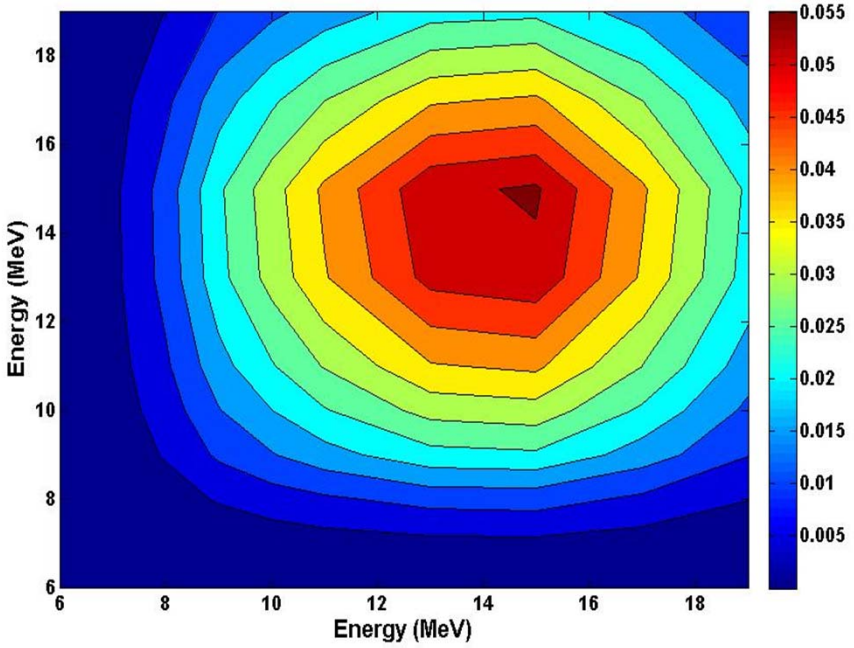


^{235}U裂变截面的SPCC拟合结果（红色曲线，带有误差范围）与文献[1]中列出的实验数据（灰色点）和标准截面推荐数据（蓝色曲线，带有误差）的结果比对

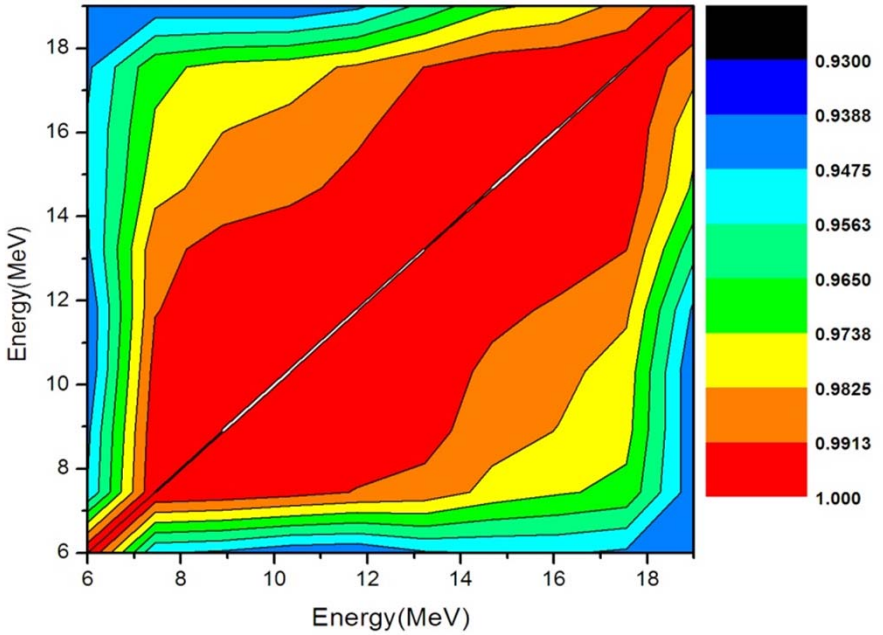
Correlated coefficient matrix of ^{235}U(n,f)



Evaluation of ^{233}U covariance



Absolute covariance matrix of ^{233}U(n,2n)



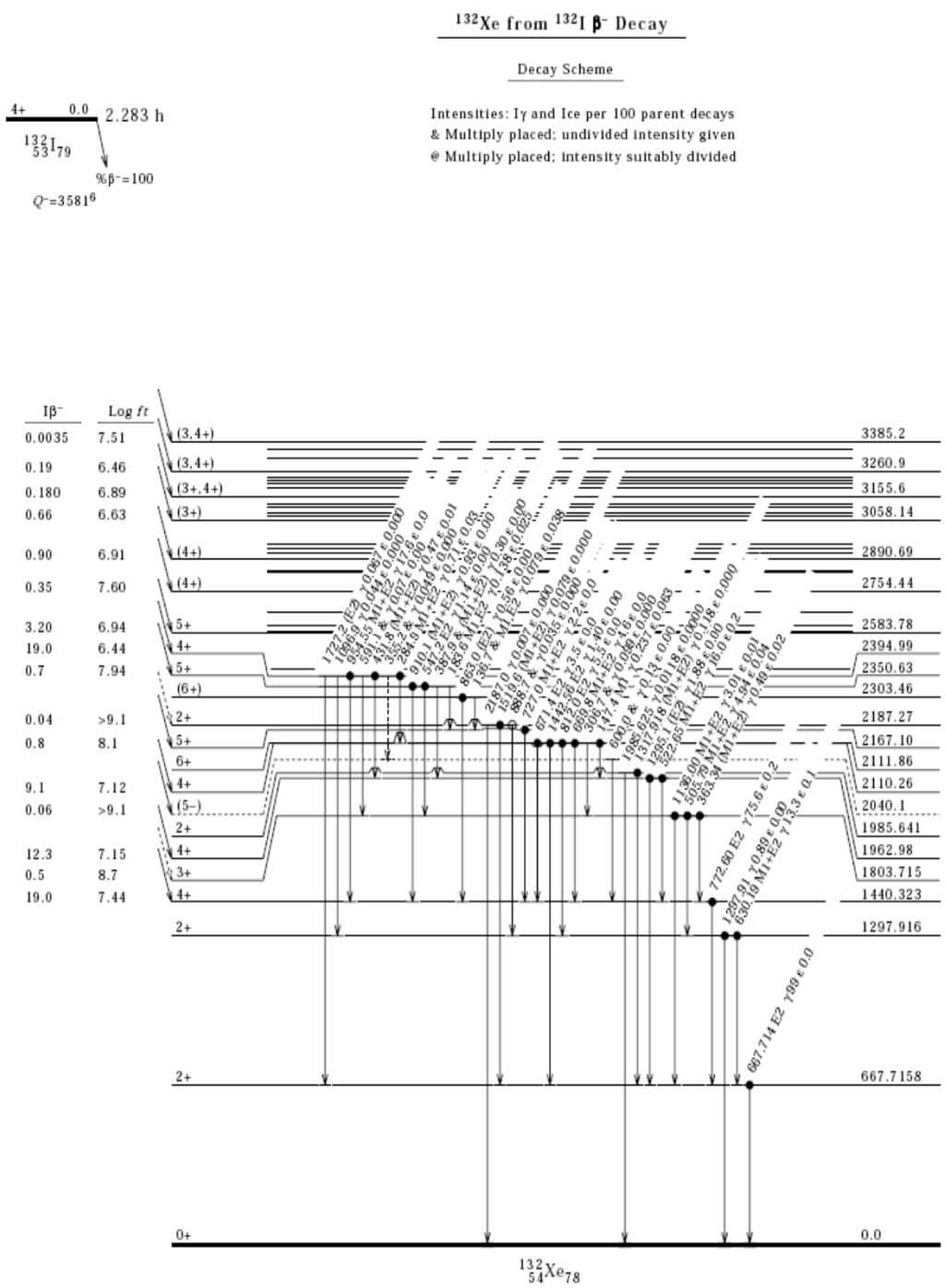
Correlated coefficient matrix of ^{233}U(n,2n)

Nuclear Structure and Decay Data Evaluation.

^{132}I decay data evaluation which contained half-life, decay type, data and level scheme et al., has been performed.

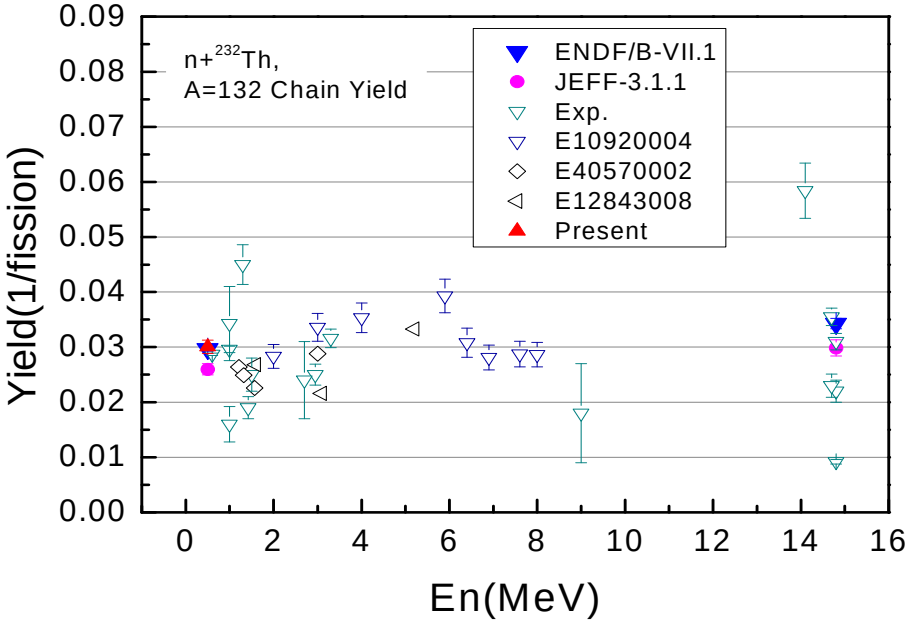
Decay Type	Energy/keV	Intensities (absolute)/%
e Au_L	3.430	1.07 4
e Au_K	24.60	0.129 4
e Ce_{2K}	102.1 4	0.014 16
e Ce_{3K}	112.84 10	0.057 6
e Ce_{3L}	141.95 10	0.0074 10
e Ce_{3M}	146.26 10	0.001499
e Ce_{4K}	149.0 3	0.021 7
e Ce_{10K}	220.54 20	0.014 4
e Ce_{12K}	228.34 10	0.064 6
e Ce_{15K}	250.34 10	0.029 3
e Ce_{12L}	257.45 10	0.0084 8

Decay Scheme of ^{132}I (partial)

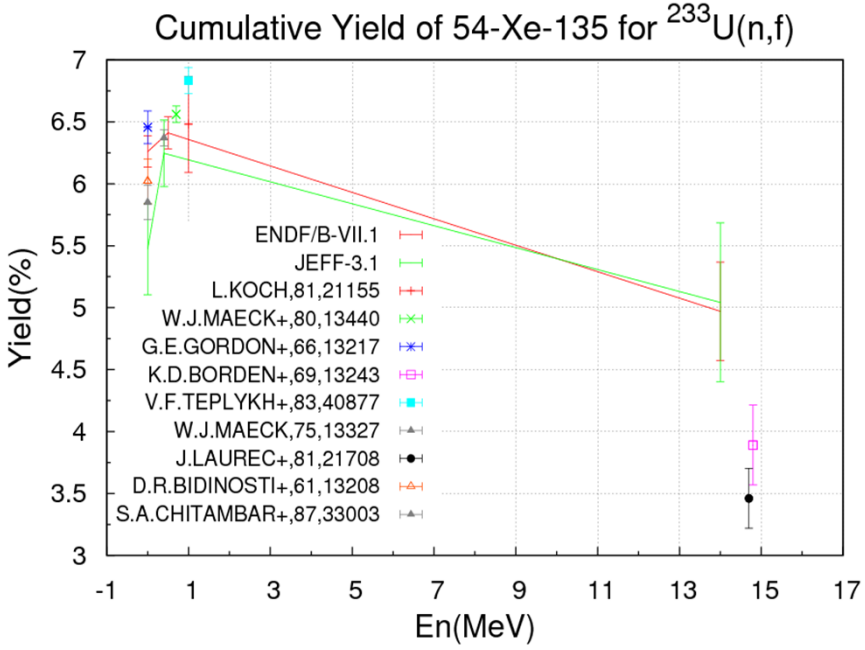


Fission Product Yields

- Evaluation of ^{232}Th
- Evaluation of ^{233}U



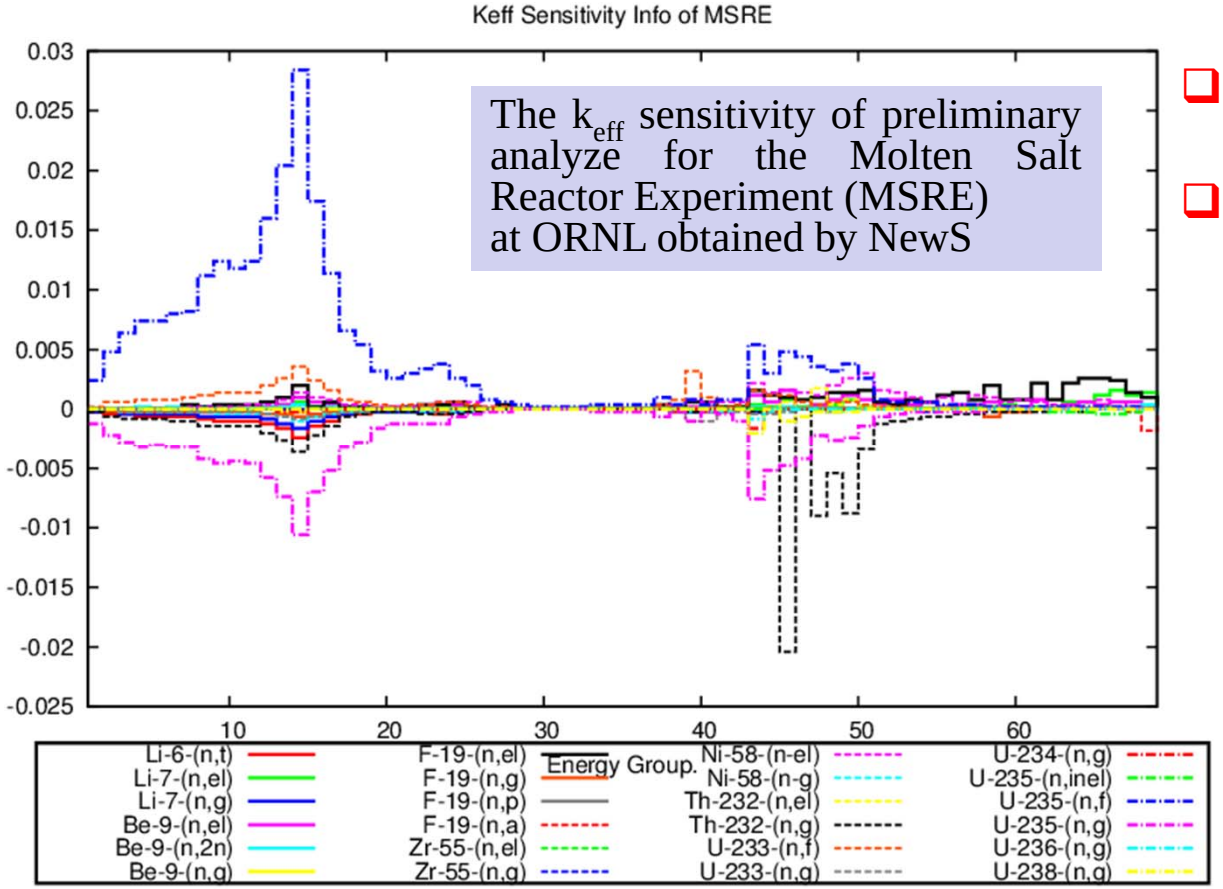
A=132 Chain Yield for ^{232}Th



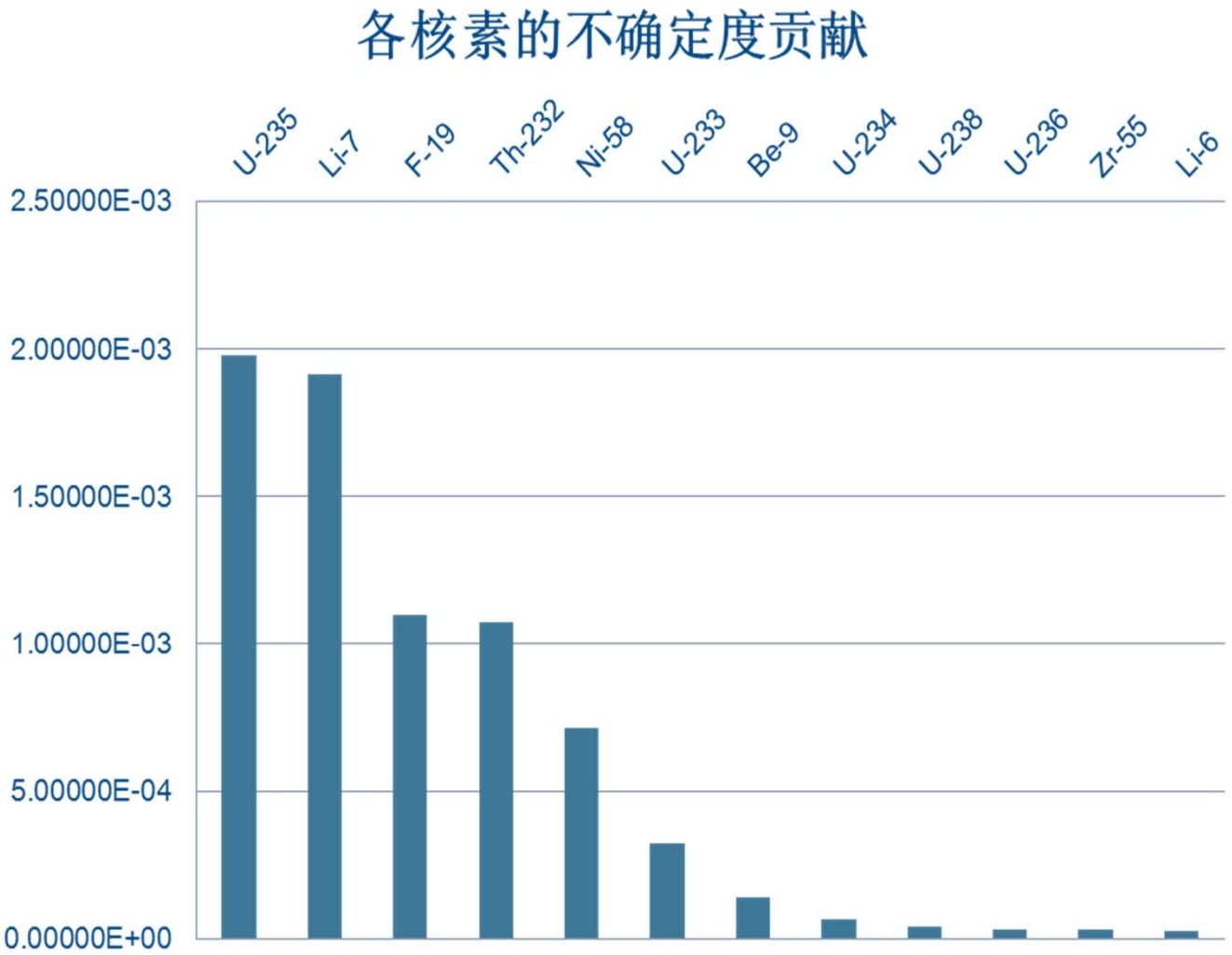
Cumulative Yield of ^{135}Xe for ^{233}U

Nuclear Data S/U Study

A analyze system NewS of nuclear data uncertainty /sensitivity is developing and some preliminary results has been obtained which show as following.



- Calculation of sensitivity with M-C method.
- Calculation of multi-group covariance with NJOY.



核素	不确定度
U-235	1.98011E-03
Li-7	1.91572E-03
F-19	1.09622E-03
Th-232	1.07537E-03
Ni-58	7.14507E-04
U-233	3.22334E-04
Be-9	1.39565E-04
U-234	6.44978E-05
U-238	4.18339E-05
U-236	3.20000E-05
Zr-55	2.83720E-05
Li-6	2.47993E-05
Total	3.25441E-03

Uncertainties of k_{eff} for MSRE

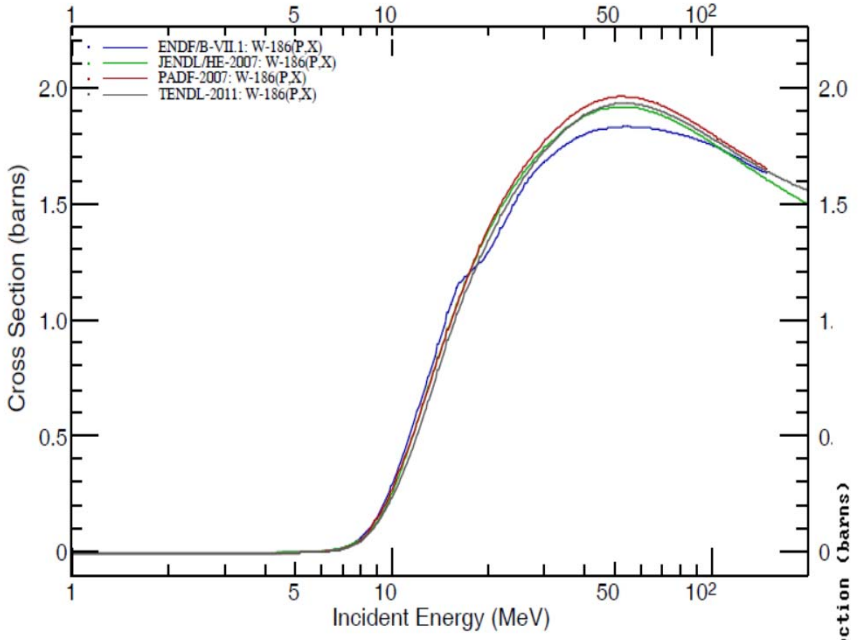
ADS

- The comparisons of high energy nuclear data for W and Ga.
- Validation of W.
- Integral Experiment and validation for Ga.
- Generating high energy library in ACE format

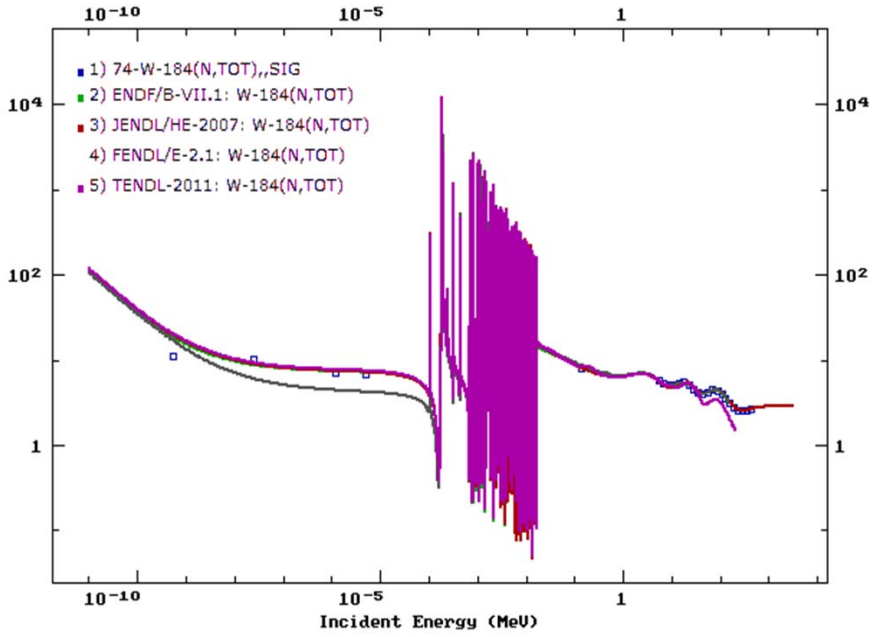
❑ Study on the method of processing for high energy evaluated data files

❑ Update of NJOY99

Comparisons of high energy nuclear data



Comparison of ^{186}W (P,X) cross section

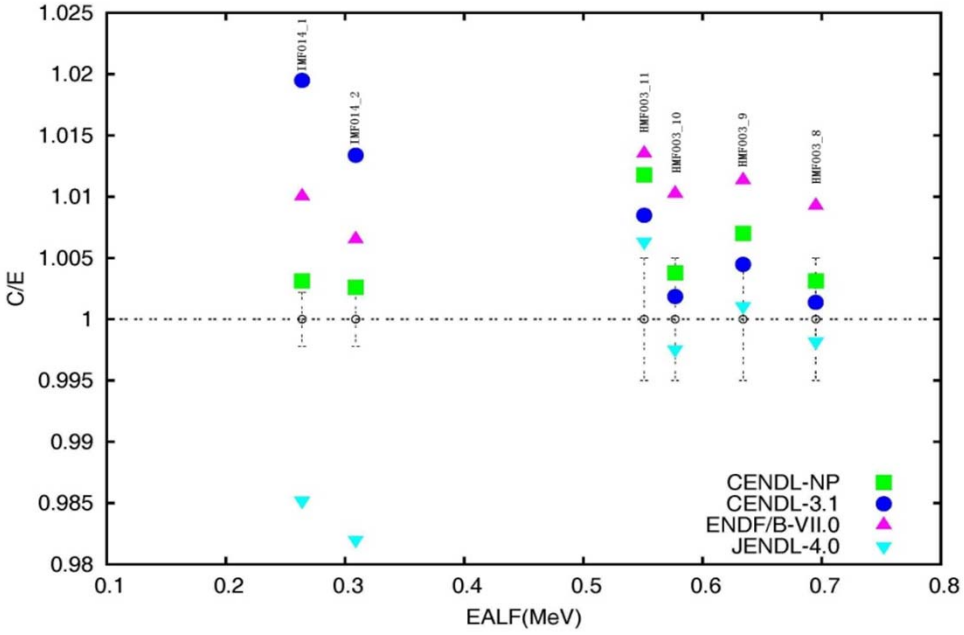


Comparison of ^{184}W(N,TOT) cross section

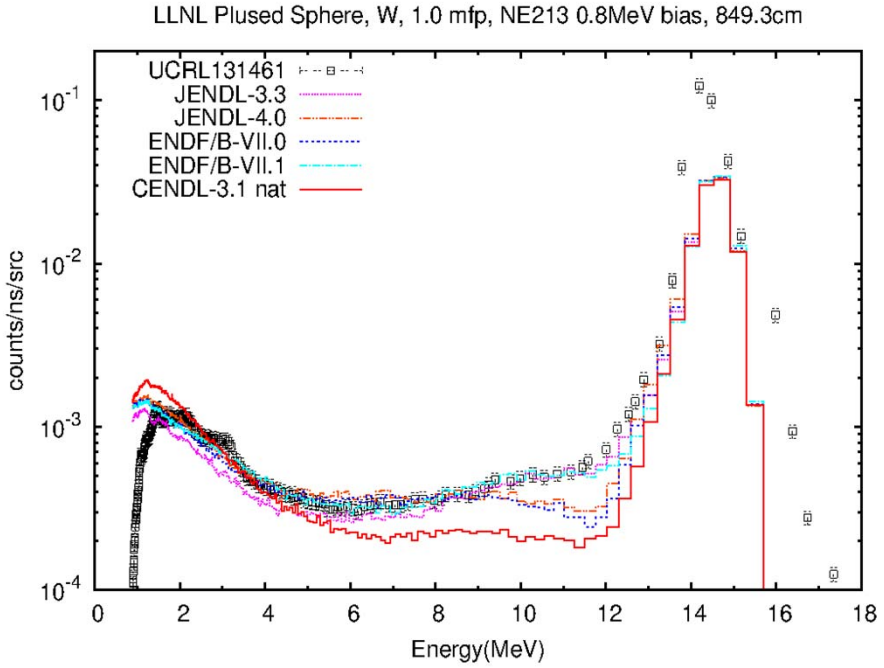
Validation of W

CENDL-NP shows good performance on IMF system. Over prediction of k_{eff} for IMF system from CENDL-3.1. CENDL-3.1 and ENDF/B-VII.0 show good performance on HMF system.

JENDL-3.3 and ENDF/B-VII.1 show good agreements with measured data.

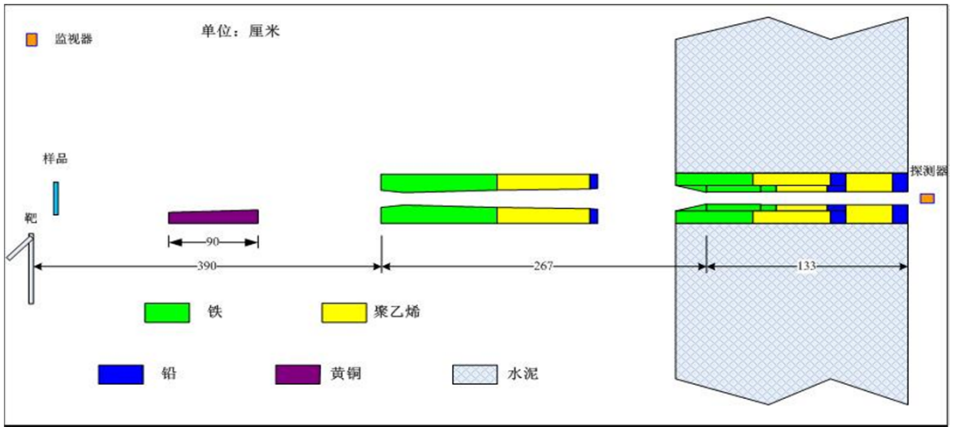


C/E values of k_{eff} for HMF and IMF system



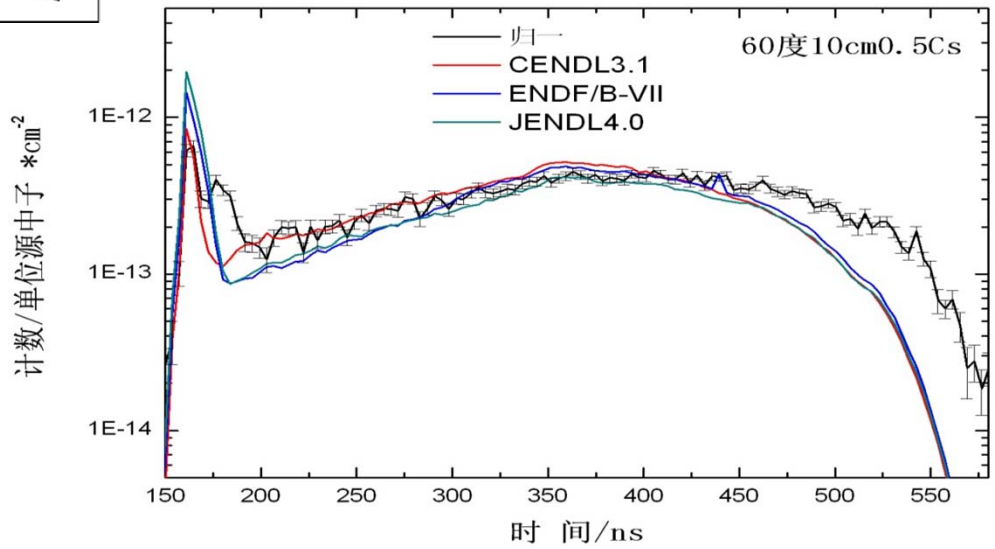
Neutron leakage spectrum from W pulsed Sphere

Integral Experiment and validation for Ga



Experimental layout of standard sample and Ga sample

The plate experiment of Ga has been performed and the flight time spectrum has been measured.



Comparison of calculated flight time spectrum with measured data

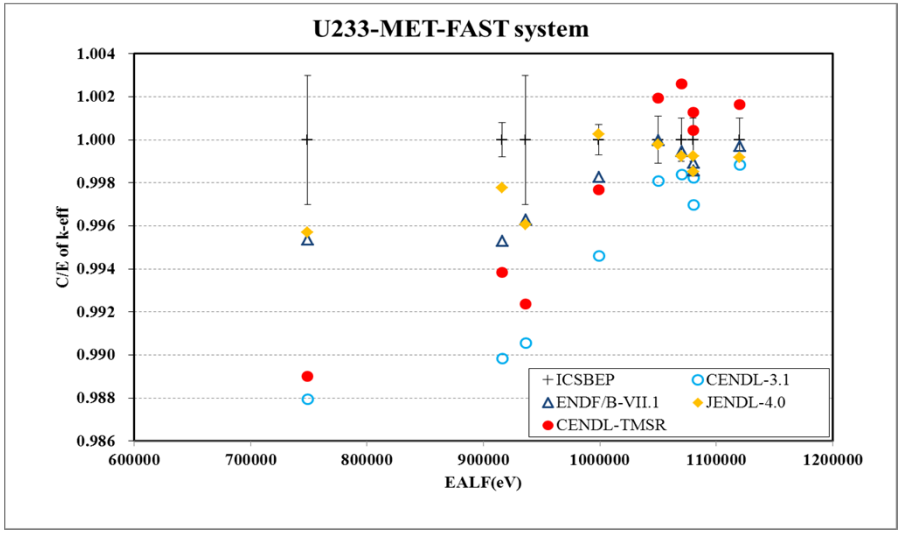
Th-U-Fuel Cycle

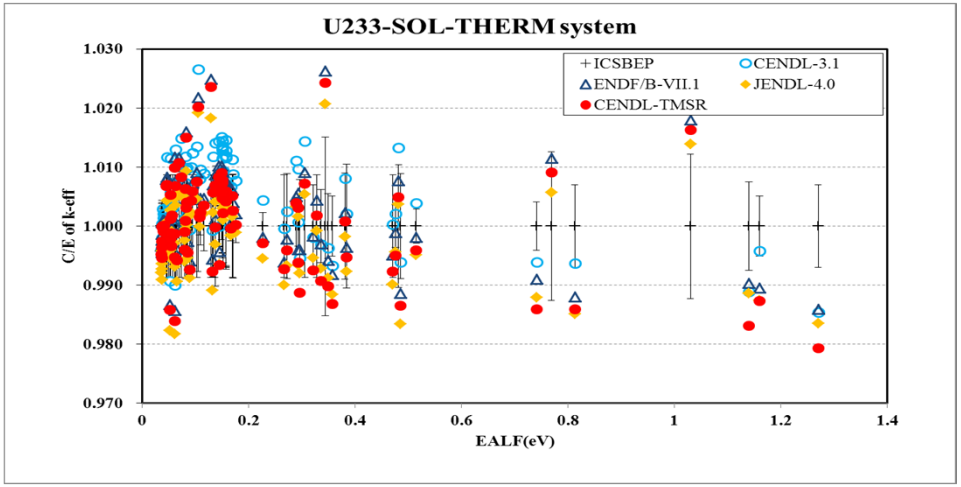
Production and testing of nuclear data library from CENDL-TMSR

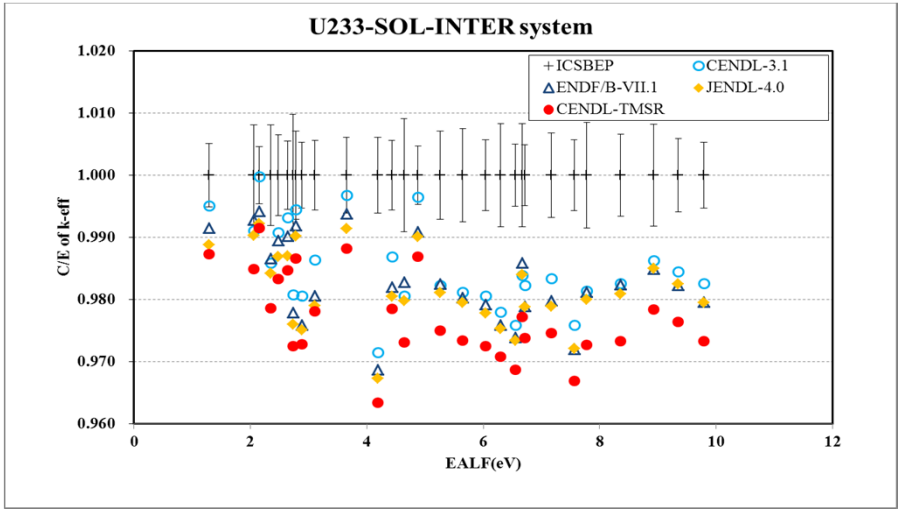
CENDL-TMSR: A hybrid library was recommended from CENDL-3.1、ENDF/B-VII.0、JENDL-4.0、JEFF-3.1.1 and IAEA/ADS-2.0

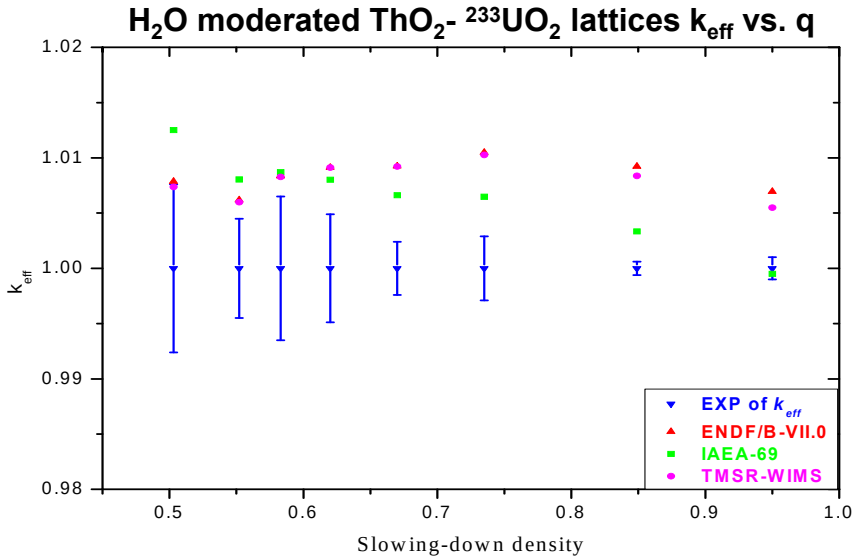
- Re-evaluation of ^{232}Th
- Recommendation of ^{235}Th、^{234,234m}Pa
- Production and testing of data libraries from CENDL-TMSR
  - Multi-group nuclear data library
  - ACE format data library

Nuclear Data Activities Related to Th-U-Fuel Cycle (cont.)









III. *Other Nuclear Data Activities Related to CENPL Project*

- ✓ 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.
- ✓ During the 2014/15 EXFOR compile group at CNDC have finished 11 entries and 36 entries is being compiling.
- ✓ A symposium of the fundamental study of nuclear data held in Beijing on 31, Oct. 2014. A proposal for the fundamental study of nuclear data has been submitted to the National Natural Science Foundation of China (NSFC) and a positive response has been received.

Thank you for your attention !
Comments and suggestion welcome !