# Status Report of CENDL Project

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CHINA NUCLEAR DATA CENTER

# 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 tasks 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.

## Mainly activities of CNDC in 2018/2019:

- New evaluations and re-evaluations for neutron data file for CENDL-3.2.
- Nuclear structure and decay data evaluations.
- 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.

# Staff and Organization of CNDC

## 中国核数据中心组织 CNDC Organization

主任 Director

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 compilation

## 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。

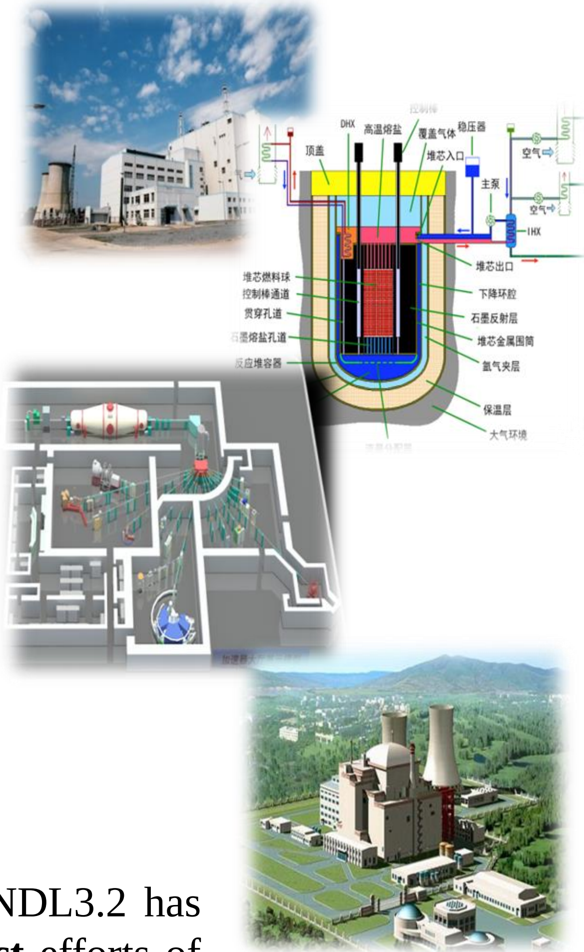
Head：Dr. Shu Nengchuan
- Data library setup/management
- Evaluation system of nucl. data setup
- Nucl. data service/user assistance

| | | |
|---|---|---|
| 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). Two will join us this fall.
- ✓ Planning to increase the official staff up to 25 in recently years.

# II. CENDL Project and CENDL library

Based on the measurements and evaluations collaborated with China Nuclear Data Coordination Network, the main output of CENDL project is the CENDL library.



Chinese Evaluated Nuclear Data Library (CENDL project)

CENDL-1, 1985version 36
CENDL-2, 1992version 68
CENDL-3, 2000version 214
CENDL-3.1 2009 version 245
**CENDL-3.2 2019 version 270**

Nuclear Structure and Decay Data Library (NSDD)
Fission Product Yield Data Library (FPYD)
Charged-Particle Nuclear Data Library (CPND)
Neutron Activation Dosimetry Data Library
Other Data Library

A new revision of Chinese Evaluated Nuclear Data Library, CENDL3.2 has been started under the joint **CENDL library and CENDL Project** efforts of CENDL working group since 2010, which will be released this year.

# II. CENDL library

| Nucl. | Content of Nuclei in CENDL-3.2 (270) |
|---|---|
| **Light Elements** | 0-n-1, $^{1-3}$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, $^{64,66-68}$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, $^{74,76-81}$Se, $^{83,84,85,86,87}$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, $^{127,129,130,131,135}$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, $^{165}$Ho |
| **Actinides** | $^{232}$Th, $^{233}$Pa, $^{232-240,241}$U, $^{236-239}$Np, $^{236-246}$Pu, $^{240-244,242m}$Am, $^{249}$Bk, $^{249}$Cf |

# CENDL-3.2 new evaluations comparison with previous CENDL-3.1

| Mass regions | The new evaluated and updation in CENDL-3.2 (77) |
|---|---|
| **Light Elements** | 0-n-1, $^{1,2}$H, $^{6,7}$Li |
| **Structural Materials** | $^{23}$Na, $^{27}$Al, $^{32,33,34,36}$S, $^{40}$Ca, $^{48}$Ti, $^{54,56-58}$Fe, $^{58}$Ni, $^{64,66-68}$Zn, $^{90}$Zr, $^{181}$Ta, $^{180,182,183,184,186}$W |
| **Fission Products & Medium Elements** | $^{74,76-81}$Se, $^{85,87}$Kr, $^{93}$Nb, $^{125}$Sb, $^{127,130,131}$I, $^{123,124,129,131-133,134-136}$Xe, $^{139}$La, $^{140-142,144}$Ce, $^{155,160}$Gd, $^{165}$Ho |
| **Actinides** | $^{232}$Th, $^{233}$Pa, $^{233,235-237,239-241}$U, $^{236,238,239}$Np, $^{237-239,241}$Pu, $^{241}$Am |

1、The total number of CENDL is 270 (240 elements in CENDL-3.1);

- ✓ 77 nuclides are newly evaluated and updated in CENDL-3.2;
- ✓ 14 nuclides are new members in CENDL;
- ✓ 42 nuclides are revised based on CENDL-3.1, including the key elements **$^{235}$U, $^{239}$Pu, $^{233}$U, $^{232}$Th, $^{56}$Fe, $^{1}$H;**
- ✓ Covariance are systematically updated for about 90 fission product nuclei and actinides.

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

3、MF contains 1, 2, 3, 4, 5, 6, 12, 14, 15, 32, 33;

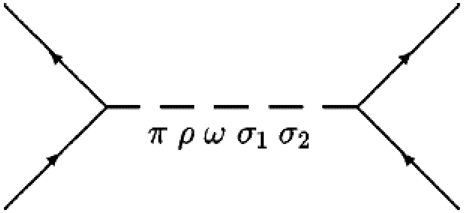
# 1. Light nuclei:

## n-n & n-p data based on the microscopic N-N interaction

High precision NN potential fits about 6000 pp and np data with $\chi^2 \sim 1.0$.

CD-Bonn meson exchange nuclear force is able to explain CIB and CSB.

Low energy pp, nn and np scattering in $^1S_0$ channel, their $a$ and $r$ almost identify.




$$a_{pp} = -17.3 \pm 0.4\ \text{fm} \quad a_{nn} = -18.9 \pm 0.4\ \text{fm} \quad a_{np} = -23.74 \pm 0.02\ \text{fm}$$
$$r_{pp} = 2.85 \pm 0.04\ \text{fm} \quad r_{nn} = 2.75 \pm 0.11\ \text{fm} \quad r_{np} = 2.77 \pm 0.05\ \text{fm}$$

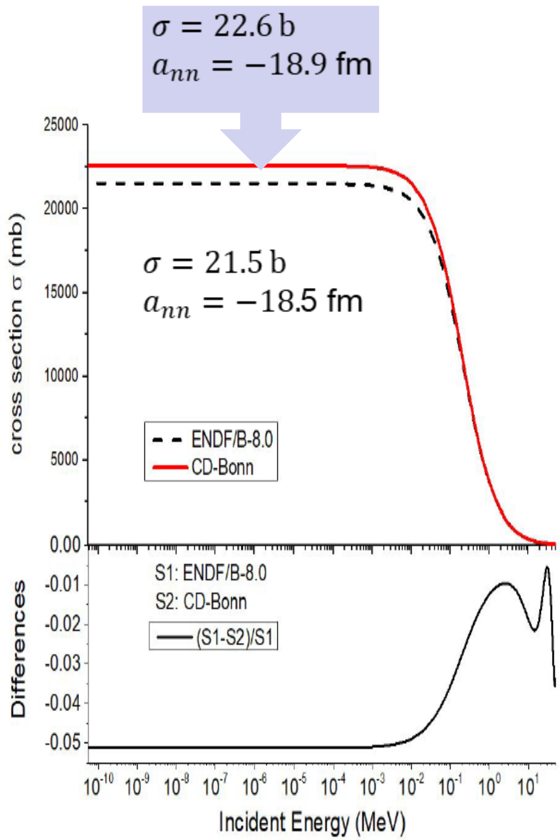
1. Solving Lippmann-Schwinger equation in momentum space to obtain phase shift $\delta_{lj}$.
2. For spin triplet $S = 1$, coupling orbit $L$ and spin $S$ to provide $J$. 6 summation must be taken into account.

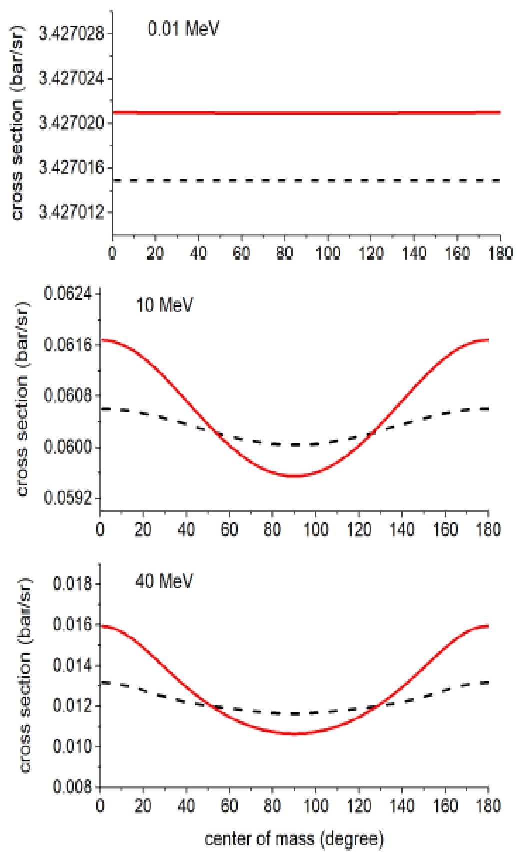
$$\frac{\mathrm{d}^3\sigma(\theta)}{\mathrm{d}\Omega} = \frac{1}{3k^2} \sum_{J_1} \sum_{l_1} \sum_{l_1'} \sum_{J_2} \sum_{l_2} \sum_{l_2'} \mathrm{i}^{-l_1 + l_1' + l_2 - l_2'} \left(1 - S_{l_1' l_1}^{J_1}\right)^* \left(1 - S_{l_2' l_2}^{J_2}\right) K(J_1 l_1 l_1', J_2 l_2 l_2', \theta)$$

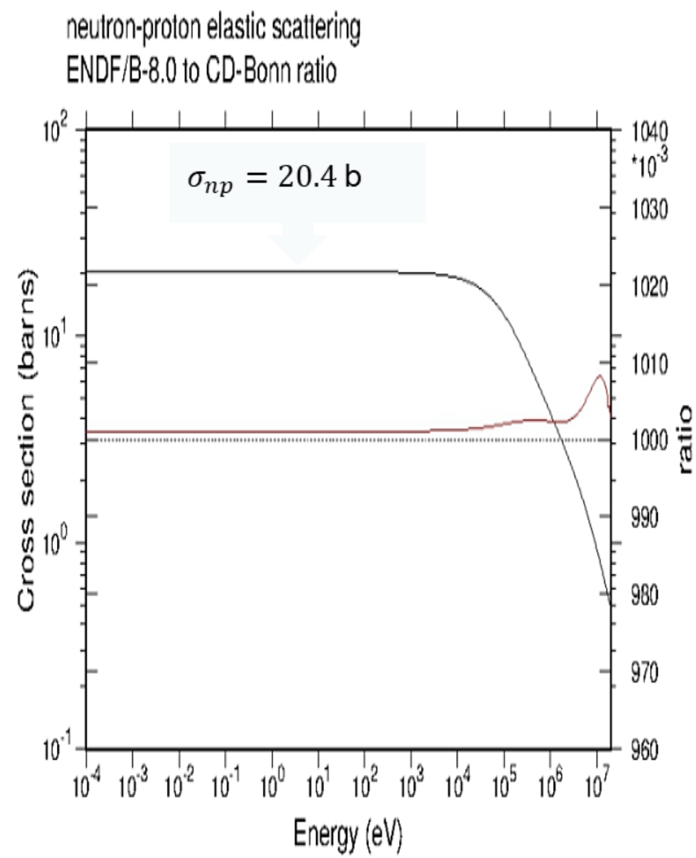
# 1. Light nuclei:

## nn and np data in CENDL3.2

Comparisons of nn and np scattering cross section between ENDF/B-8.0 and CENDL-3.2



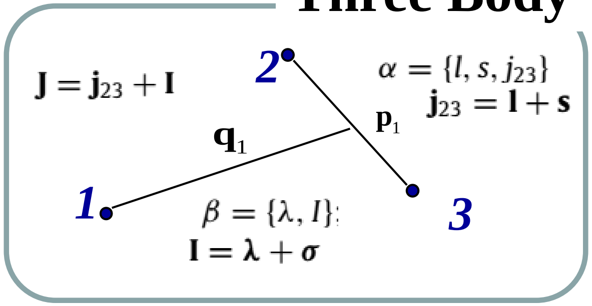



# 1. Light nuclei:

**new calculation for n-d data based on the Faddevv-AGS approach**

The wave packet method (wave packet continuum discretization)

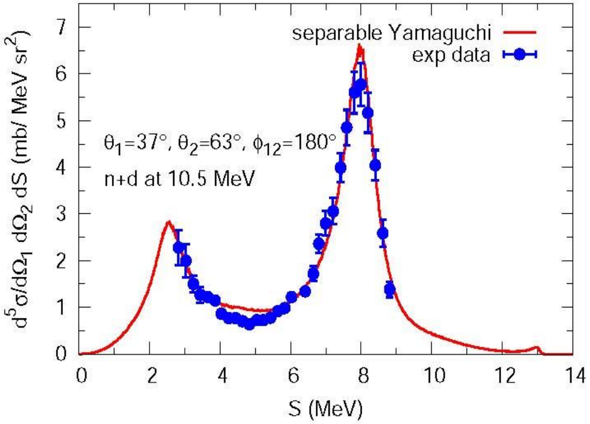
## Three Body

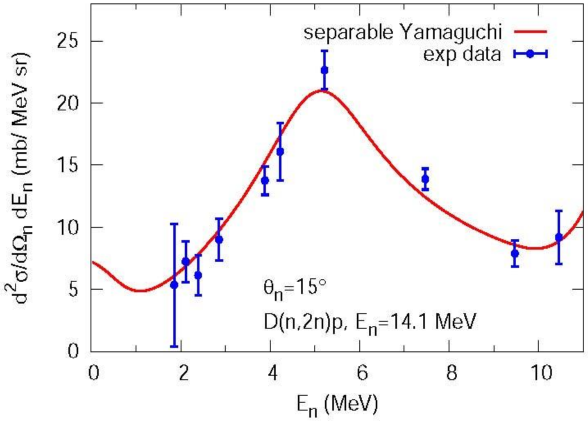


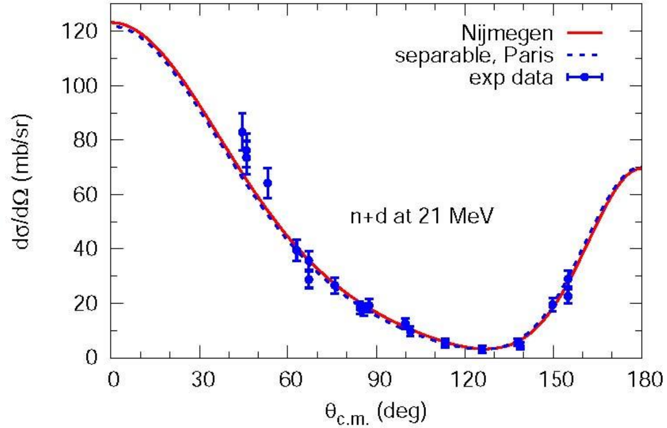

Three-body Hamiltonian: $$H = H_0 + \sum_{i=1}^{3} v_i$$

Channel Hamiltonian: $$H_1 = H_0 + v_1 = h^0_{q_1} \oplus h_1, \;\; h_1 = h^0_{p_1} + v_1$$

Three-body channel WP as direct product of two-body WPs: $$|\,Z^{\Gamma\alpha\beta}_{kj}\rangle = |z^{\chi}_{k}, x^{\lambda}_{j}; \alpha, \beta, : \Gamma\rangle, \; \Gamma = \{\mathbf{J}, \pi, T\}$$



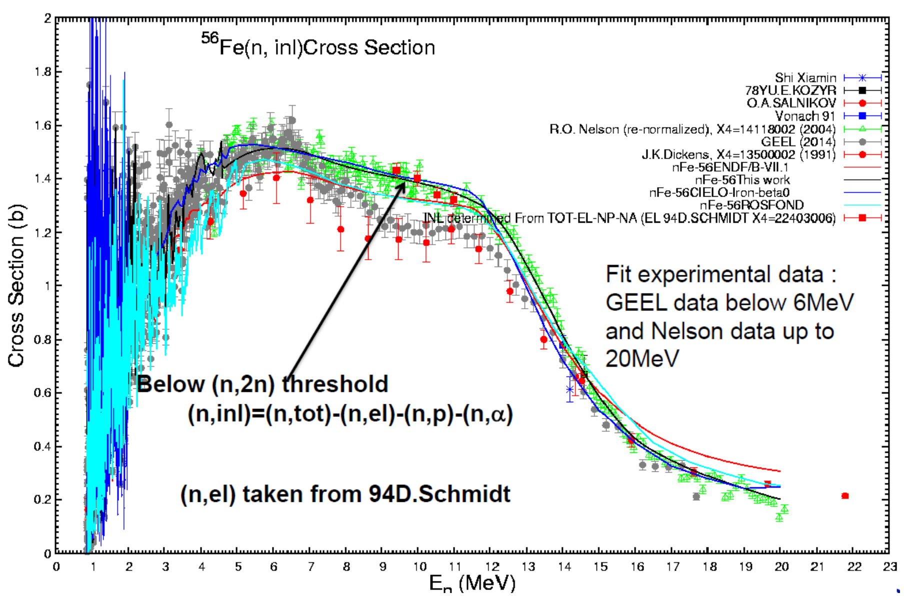



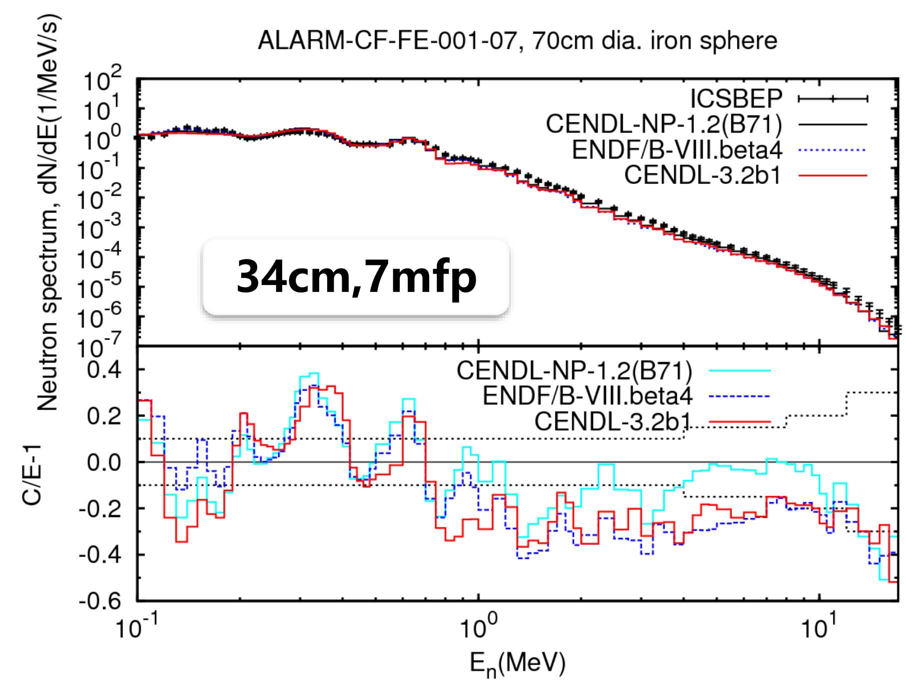



# 2. Medium-heavy nuclei:

## Re-evaluation of $^{56}$Fe(n,inl) reaction cross section

- The (n,inl) evaluation in smooth region for both B8b4 and C32b1 are based on the experimental data recommended by QIAN Jing in the CIELO project.
  - Above 6MeV, Nelson(2004) is recommended based on the (n,el) XS measured by Schmidt .
- The new evaluations of $^{56}$Fe leads to a serious under prediction of neutron leakage from IPPE iron sphere.

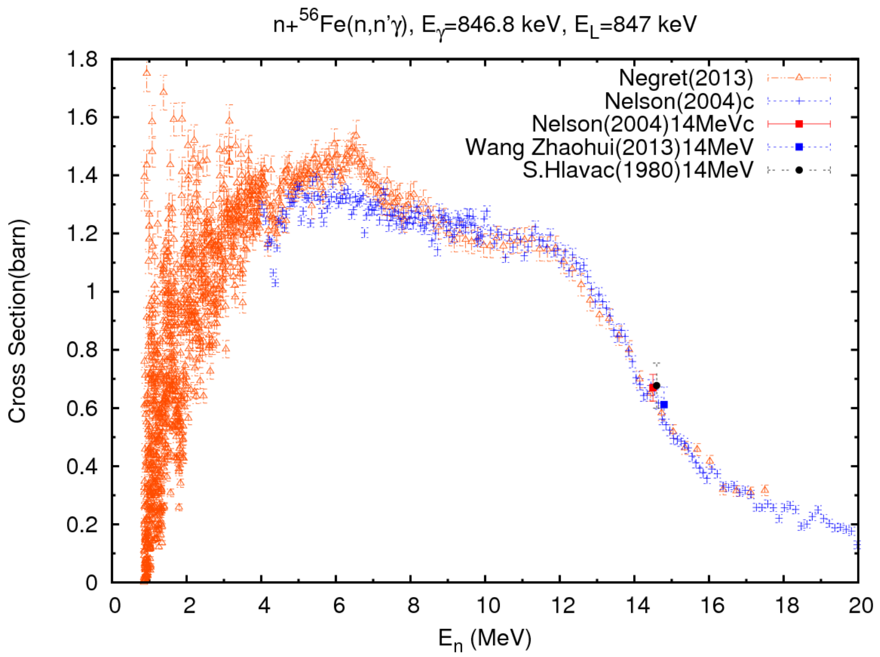


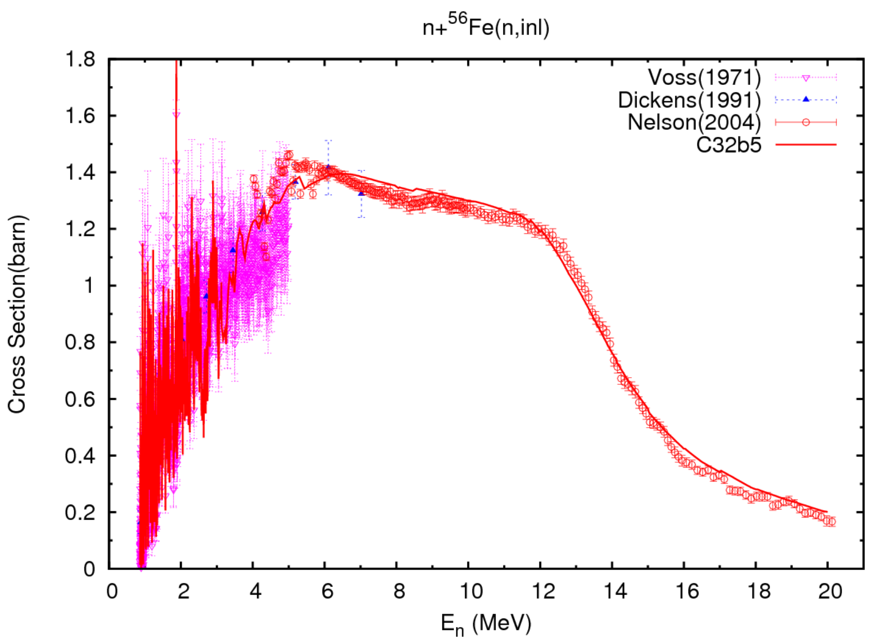



# 2. Medium-heavy nuclei:

## Re-evaluation of $^{56}Fe(n,inl)$ reaction cross section

- To solve the problem of under prediction neutron leakage in iron shielding, the experimental data of $^{56}Fe(n,inl)$ 847keV gamma production cross sections have been re-evaluated and a new curve for $^{56}Fe(n,inl)$ reaction has been evaluated.
  - Nelson(2004) was corrected based on the experiment data around 14MeV.

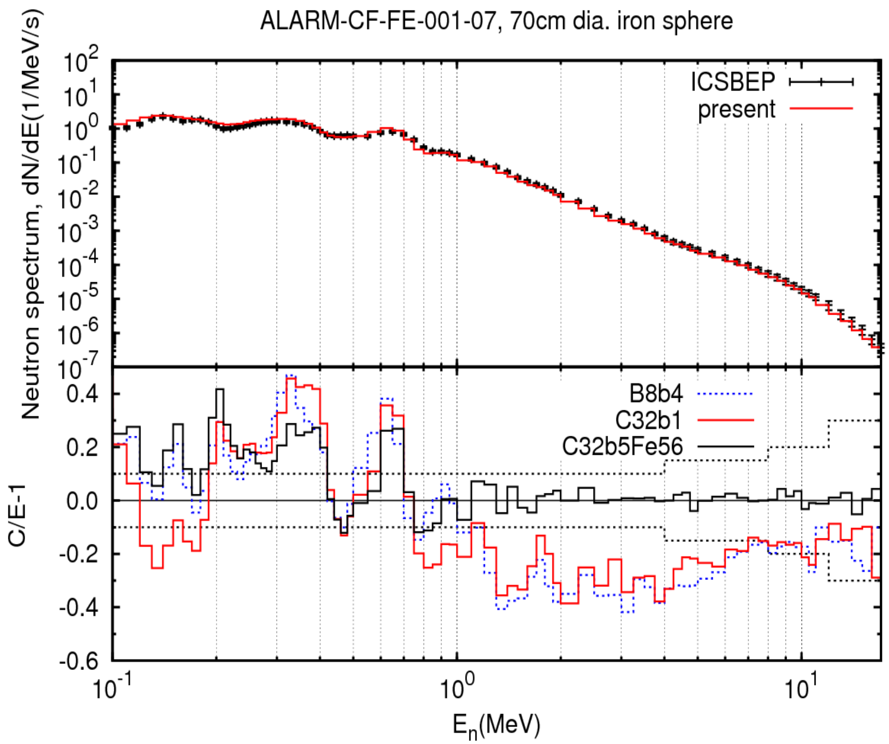


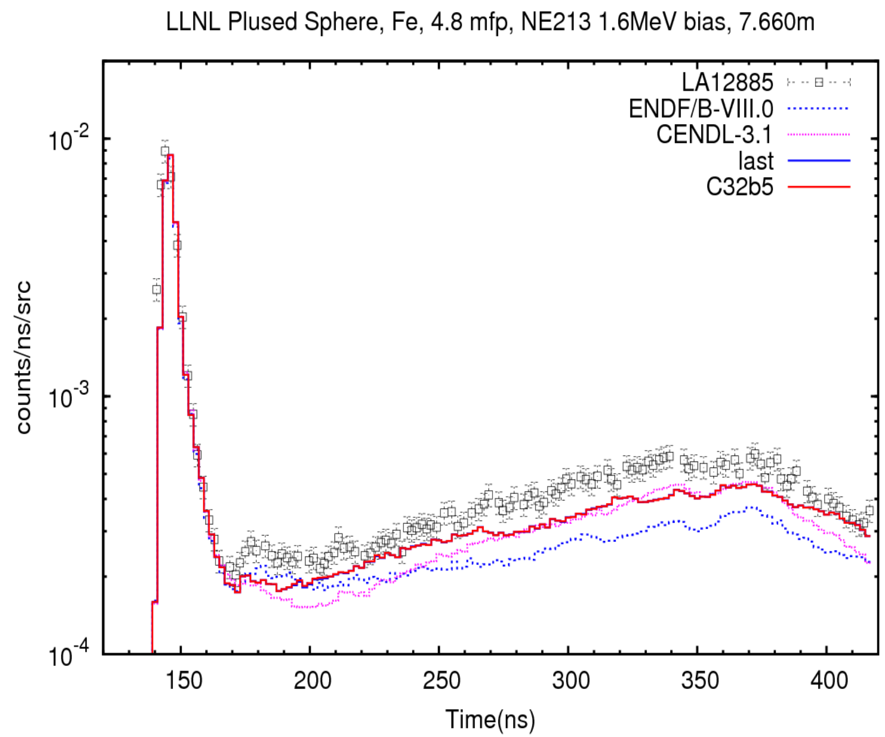



# 2. Medium-heavy nuclei:

## Re-evaluation of $^{56}$Fe(n,inl) reaction cross section

- Significant improvement of validation results have been achieved in testing with the 70cm dia. IPPE iron sphere and the LLNL pulsed iron sphere.



# 2. Medium-heavy nuclei:

The evaluation system for medium-heavy nuclei

| Calculation system for FP nuclei based on the UNF code system (CENDL-3.1 to 3.2) | |
|---|---|
| sunf2unf.pl | Convert sunf->unf |
| Batchcal | Produce unf.newunf |
| batchmincard.pl | Auto-produce inputs SEMAW.in, DPPMI.in, Min.in， sys.dat, exp |
| Correctmin | Correct the energy margin of min.in |
| get14MevCSInl | Produce the direct reaction cross section based on |
| batchmincard14.pl | Adjust DWUCK para. to fit 14MeV |
| NDPlot | Plot the figures for 10 reactions |

| 核素 | 输入卡 | 核素 | 输入卡 | 核素 | 输入卡 | 核素 | 输入卡 |
|---|---|---|---|---|---|---|---|
| 12-MG-24 | UNF | 32-GE-70 | UNF | 39-Y-89 | SUNF | 44-RU-102 | SUNF |
| 12-MG-25 | UNF | 32-GE-71 | UNF | 39-Y-91 | SUNF | 44-RU-103 | SUNF |
| 12-MG-26 | UNF | 32-GE-72 | UNF | 40-ZR-90 | UNF | 44-RU-104 | SUNF |
| 14-SI-28 | UNF | 32-GE-73 | UNF | 40-ZR-91 | UNF | 44-RU-105 | SUNF |
| 20-CA-40 | UNF | 32-GE-74 | UNF | 40-ZR-92 | UNF | 44-RU-99 | SUNF |
| 22-TI-46 | UNF | 32-GE-75 | UNF | 40-ZR-93 | SUNF | 45-RH-103 | SUNF |
| 22-TI-47 | UNF | 32-GE-76 | UNF | 40-ZR-94 | UNF | 45-RH-105 | SUNF |
| 22-TI-48 | UNF | 32-GE-77 | UNF | 40-ZR-95 | SUNF | 46-PD-105 | SUNF |
| 22-TI-49 | UNF | 32-GE-78 | UNF | 40-ZR-96 | UNF | 46-PD-108 | SUNF |
| 22-TI-50 | UNF | 33-AS-75 | UNF | 41-NB-93 | SUNF | 48-CD-113 | SUNF |
| 28-NI-58 | UNF | 33-AS-77 | UNF | 41-NB-95 | SUNF | 49-IN-113 | UNF |
| 28-NI-60 | UNF | 33-AS-79 | UNF | 42-MO-100 | UNF | 49-IN-115 | UNF |
| 28-NI-61 | UNF | 36-KR-83 | SUNF | 42-MO-92 | UNF | 51-SB-121 | SUNF |
| 28-NI-62 | UNF | 36-KR-84 | SUNF | 42-MO-94 | UNF | 51-SB-123 | SUNF |
| 28-NI-64 | UNF | 36-KR-85 | SUNF | 42-MO-96 | UNF | 51-SB-125 | UNF |
| 29-CU-63 | UNF | 36-KR-86 | SUNF | 42-MO-98 | UNF | 52-TE-130 | SUNF |
| 29-CU-65 | UNF | 38-SR-88 | SUNF | 43-TC-99 | SUNF | 53-I-127 | SUNF |
| 31-GA-69 | UNF | 38-SR-89 | SUNF | 44-RU-100 | SUNF | 53-I-129 | UNF |
| 31-GA-71 | UNF | 38-SR-90 | SUNF | 44-RU-101 | SUNF | 53-I-135 | SUNF |

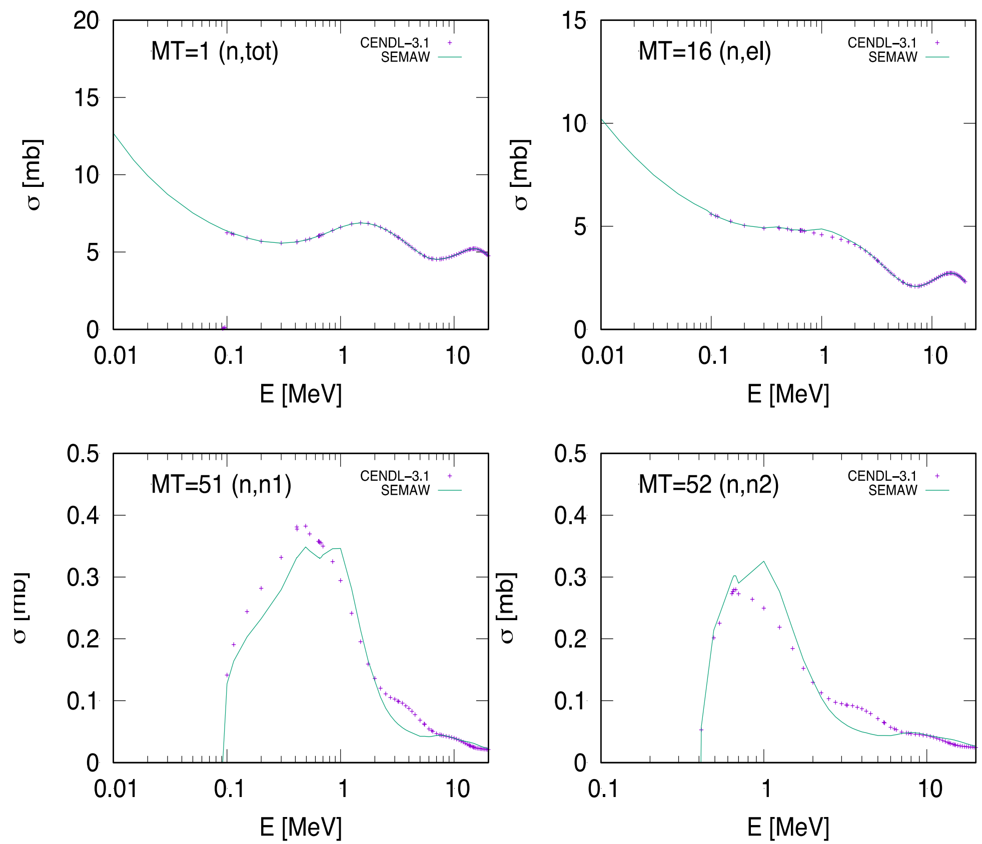
| 核素 | 输入卡 | 核素 | 输入卡 | 核素 | 输入卡 |
|---|---|---|---|---|---|
| 54-XE-123 | SUNF | 57-LA-139 | SUNF | 62-SM-149 | SUNF |
| 54-XE-124 | SUNF | 58-CE-141 | SUNF | 62-SM-150 | SUNF |
| 54-XE-129 | SUNF | 58-CE-144 | SUNF | 62-SM-151 | SUNF |
| 54-XE-131 | SUNF | 59-PR-141 | SUNF | 62-SM-152 | SUNF |
| 54-XE-132 | SUNF | 60-ND-142 | SUNF | 62-SM-154 | SUNF |
| 54-XE-134 | SUNF | 60-ND-143 | SUNF | 63-EU-151 | SUNF |
| 54-XE-135 | SUNF | 60-ND-144 | SUNF | 63-EU-153 | SUNF |
| 54-XE-136 | SUNF | 60-ND-145 | SUNF | 63-EU-154 | SUNF |
| 55-CS-133 | SUNF | 60-ND-146 | SUNF | 63-EU-155 | SUNF |
| 55-CS-134 | SUNF | 60-ND-147 | SUNF | 64-GD-152 | SUNF |
| 55-CS-135 | SUNF | 60-ND-148 | SUNF | 64-GD-154 | SUNF |
| 55-CS-137 | SUNF | 60-ND-150 | SUNF | 64-GD-155 | SUNF |
| 56-BA-130 | SUNF | 61-PM-147 | SUNF | 64-GD-156 | SUNF |
| 56-BA-132 | SUNF | 61-PM-148 | SUNF | 64-GD-157 | SUNF |
| 56-BA-134 | SUNF | 61-PM-148m | UNF | 64-GD-158 | SUNF |
| 56-BA-135 | SUNF | 61-PM-149 | SUNF | 64-GD-160 | SUNF |
| 56-BA-136 | SUNF | 62-SM-144 | SUNF | 66-DY-164 | SUNF |
| 56-BA-137 | SUNF | 62-SM-147 | SUNF | | |
| 56-BA-138 | SUNF | 62-SM-148 | SUNF | | |

# 2. Medium-heavy nuclei:

The evaluation system for medium-heavy nuclei

The comparison of CENDL-3.1 and CENDL-3.2 for n+$^{147}$Pm reactions

with the help of MINUIT, **we have adjusted the parameters of the UNF code**, such as the parameter of the level density, pairing interaction and Giant dipole resonance of (n, gamma) channel. As shown in Figure, the dotted line is the results of the CENDL3.1, the solid line is the cross sections we have calculated with the new parameter set. For the (n,n1) and (n,n2) channel, the new parameter set gives the reasonable cross section at 8 to 10 MeV.

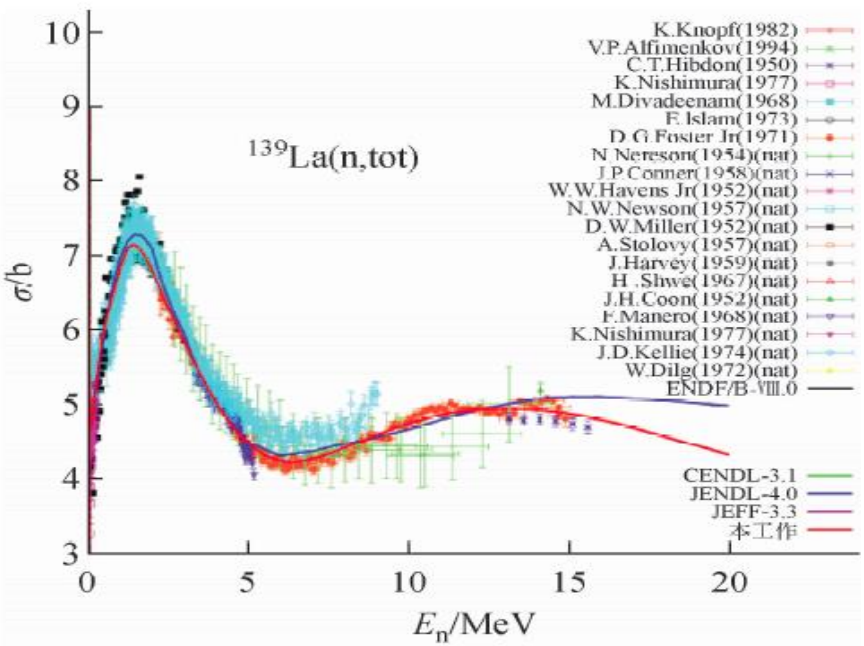


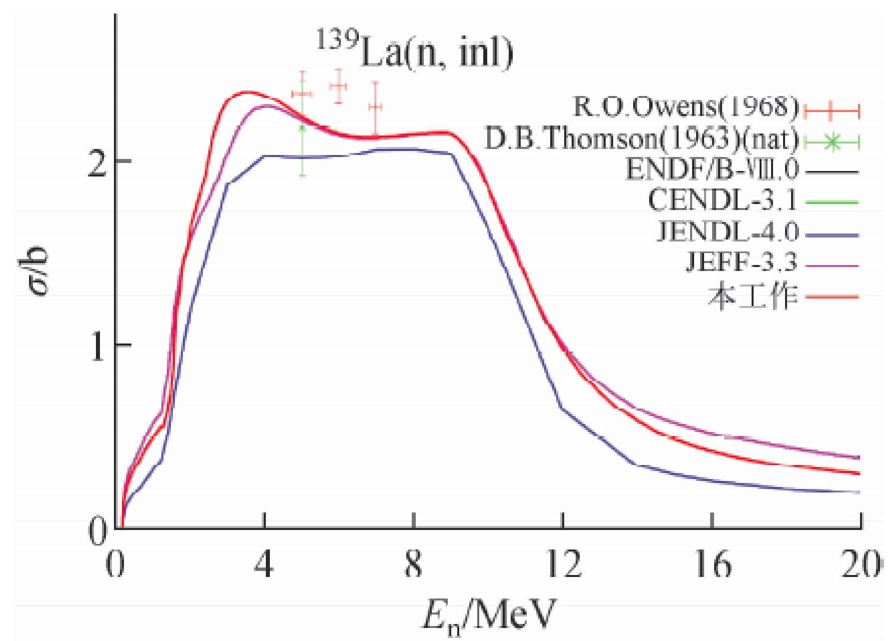
# 2. Medium-heavy nuclei:

## The evaluation system for medium-heavy nuclei

The neutron reaction data of medium-heavy nuclei (mass number around 100~200) are systematically updated in CENDL**. All the modifications are based on the calculations with the UNF code**. Parts of them are new evaluations concerning the latest measurements. The others are the systematic reproductions to the previous CENDL library, some odd structures are removed from previous CENDL.

The new evaluations for La-139 (n,tot),(n,inl)



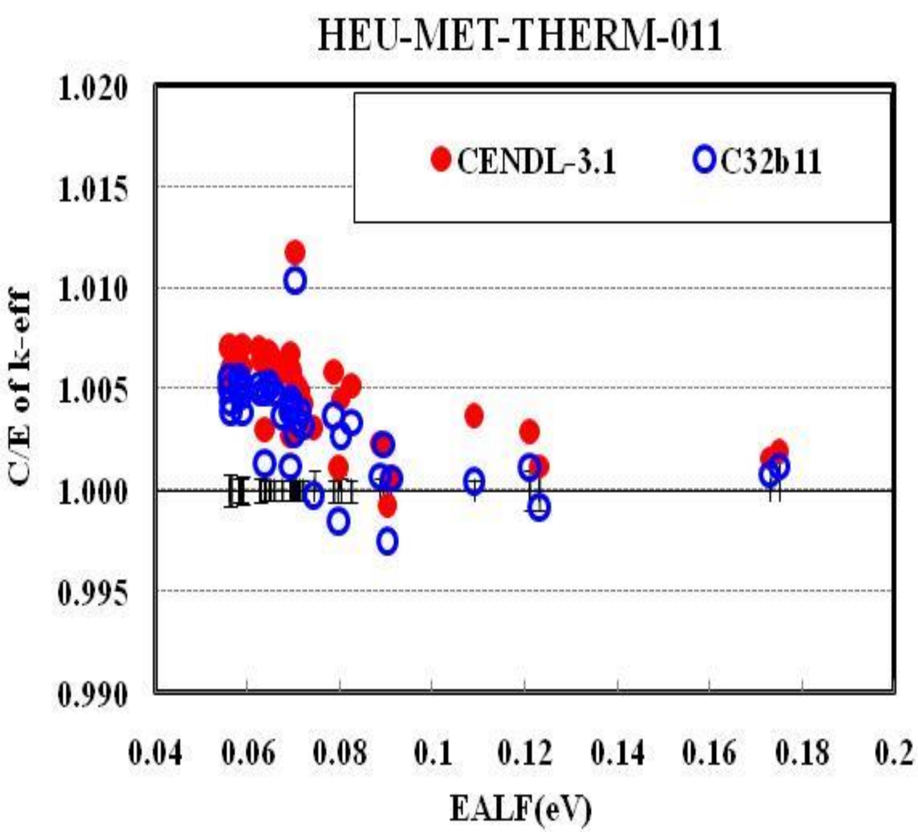



# 3. Fission nuclei:

## revision of U-235 data (part 1)

- Nubar and resonance parameters of $^{235}$U(rev.C32b11) which refer as CENDL-3.2 now, were modified to reproduce the thermal quantities of the IAEA 2006 standard, which improves the prediction of keff for the HMT system.

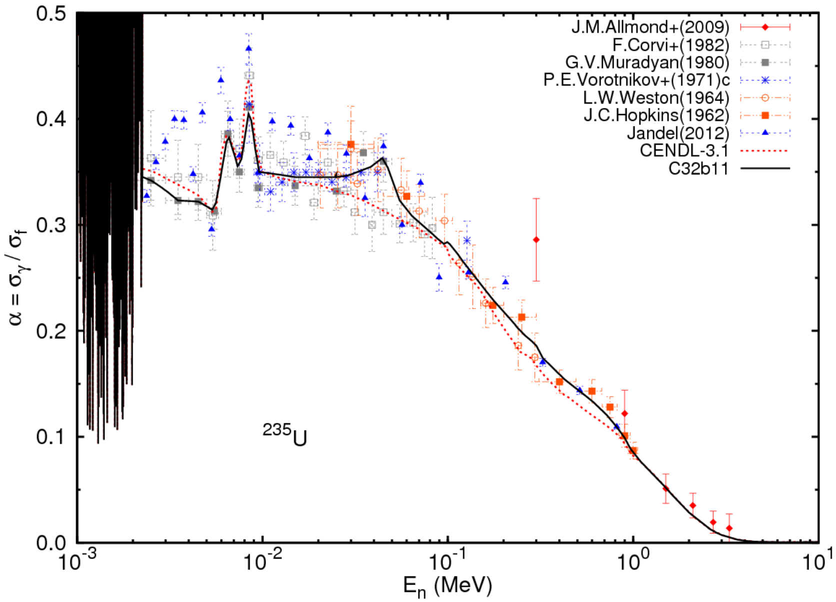
| Thermal quantities | IAEA2006 standard | C32b11 evaluation | C32b11 Eval./Std. | Δ |
|---|---|---|---|---|
| (n,f) | 584.33 | 5.84177E+02 | -0.03% | -0.15% |
| (n,γ) | 99.401 | 9.94001E+01 | 0.00% | 0.70% |
| (n,el) | 14.087 | 1.51081E+01 | 7.25% | -0.05% |
| (n,tot) | 697.818 | 6.98685E+02 | 0.12% | -0.03% |
| $G_f$ | 0.97729 | 0.97667 | -0.07% | 0.00% |
| $G_\gamma$ | | 0.99118 | | |
| $G_a$ | 0.97881 | 0.97878 | 0.00% | 0.00% |
| ν | 2.43550 | 2.4359 | 0.01% | -0.03% |
| η | 2.08143 | 2.0816 | 0.01% | -0.16% |
| α | 0.17011 | 0.17015 | 0.03% | 0.85% |

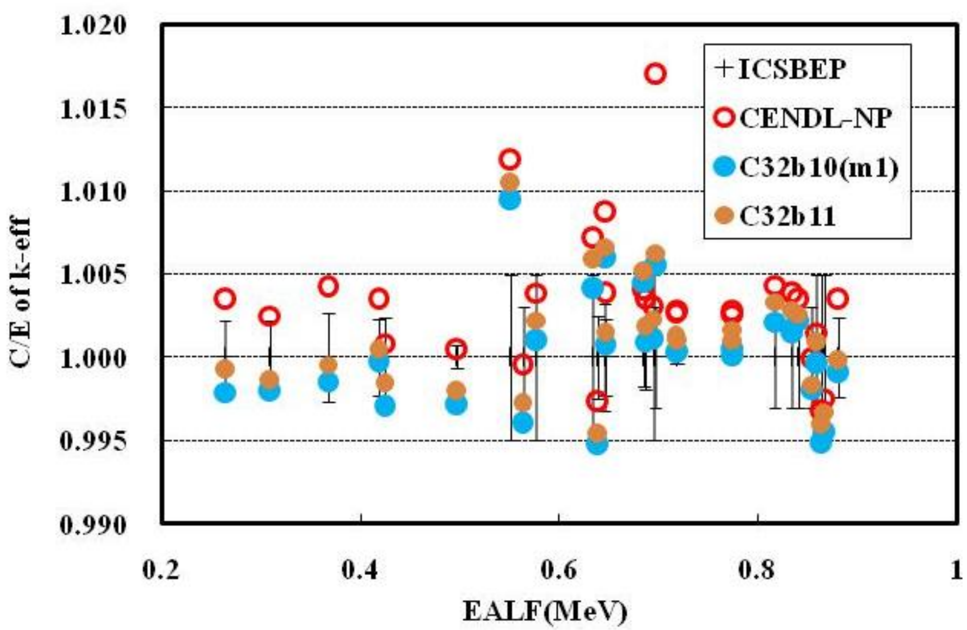


# 3. Fission nuclei:

revision of U-235 data (part 1)

- (n,γ) cross sections were revised based on (n,f) cross sections recommended by IAEA 2006 standard and re-evaluated alpha values.
- Benchmark testing with the selected HMF, IMF and HMI cores show that the prediction of keff gets closer to 1 than before.

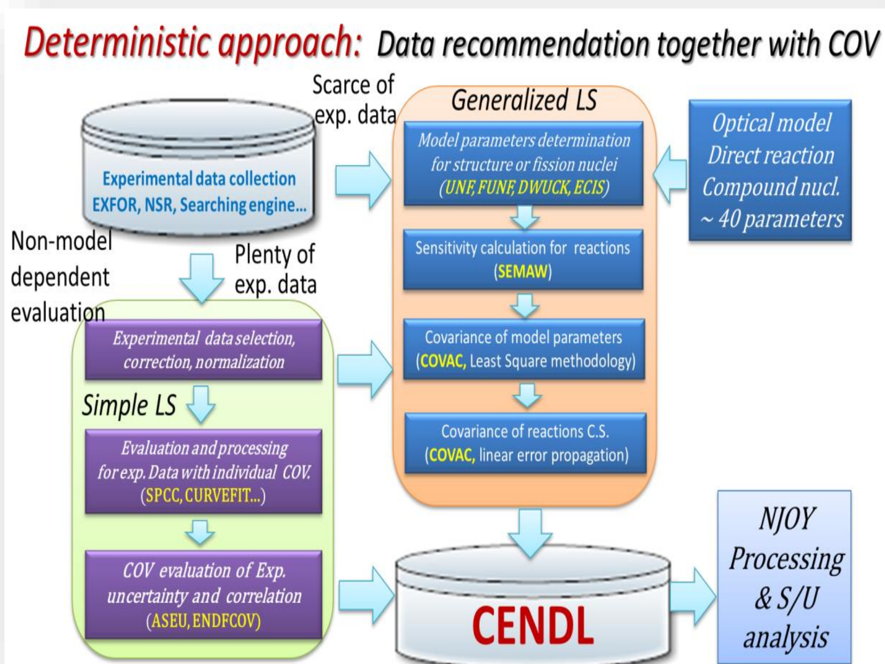


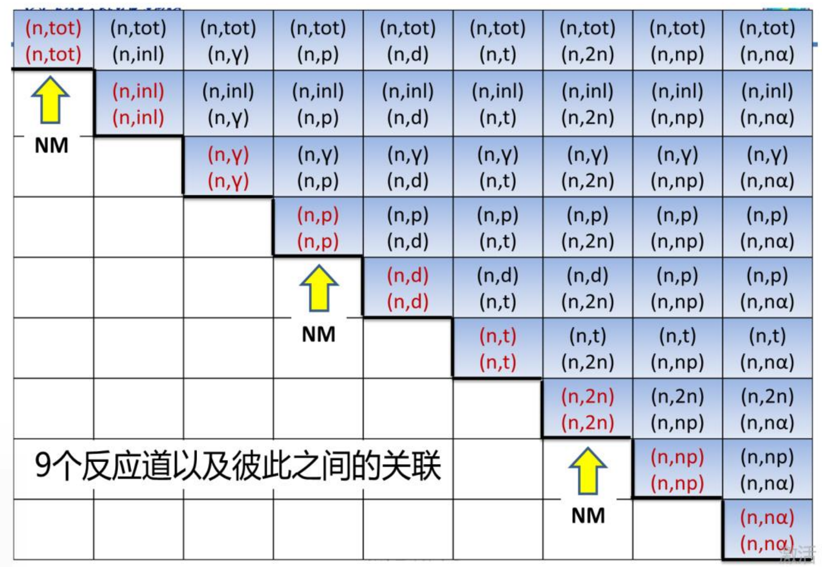



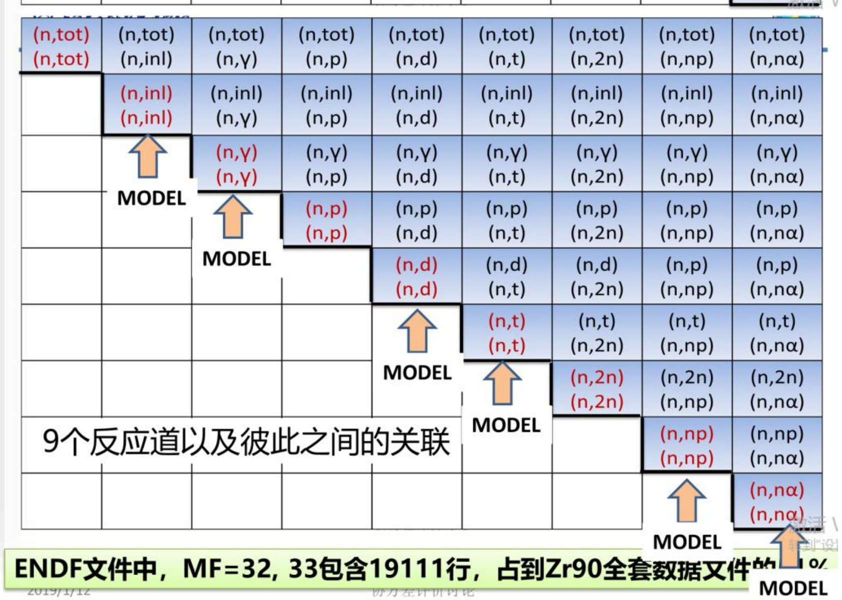
# 4. Covariance :

## Descriptions to COV scheme

①Tech. for non-model & model dependent
②Energies for structure & smooth regions
③COV data types for NI & NC
④Tech. deal with single & multiple measurements
⑤Tech. for parameter sensitivity selection
⑥COV matrix positive definition treatment



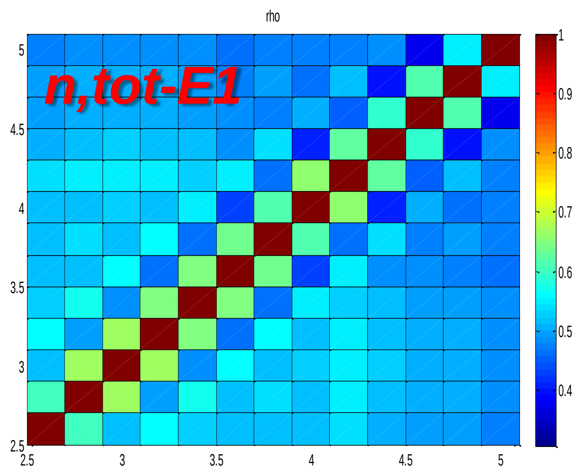



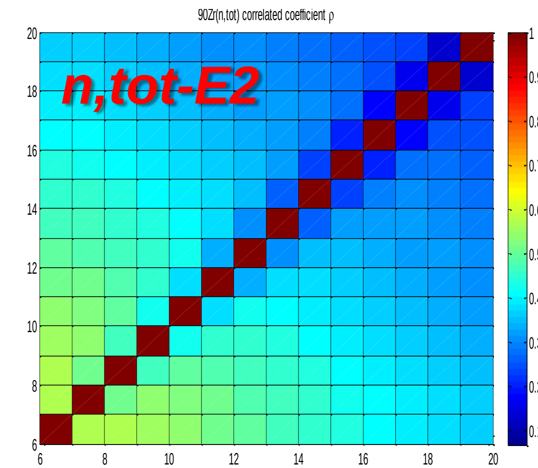



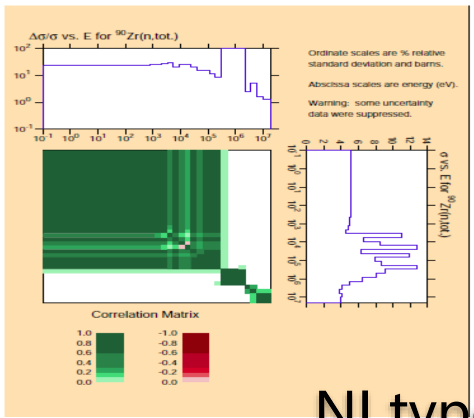

ENDF文件中，MF=32, 33包含19111行，占到Zr90全套数据文件的 1%

# 4. Covariance :

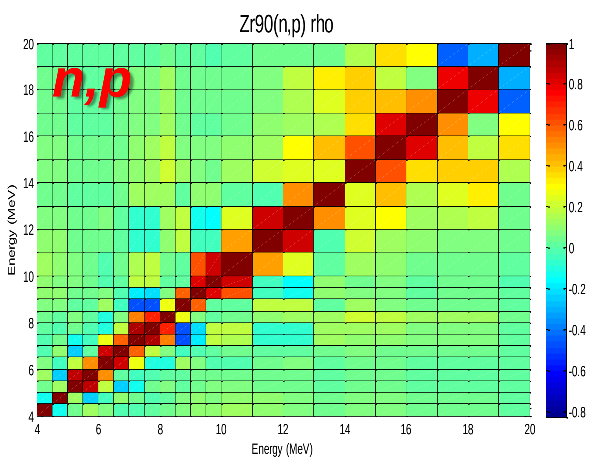
Covariance for n+$^{90}$Zr reaction cross sections

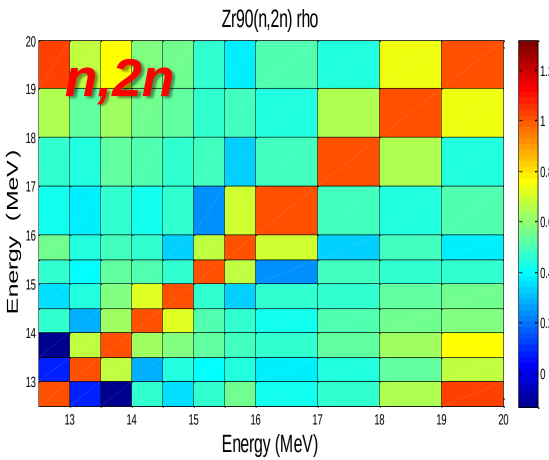


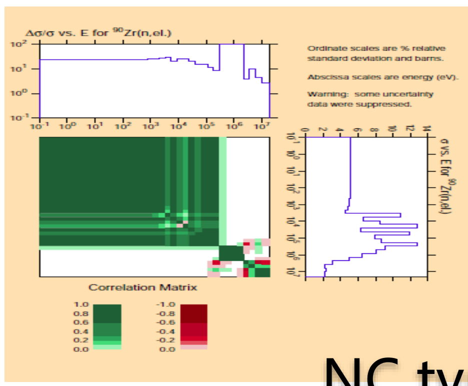




NI type




NC type

# III. CENDL Sub-library:

## 1. Fission yield sub-library :

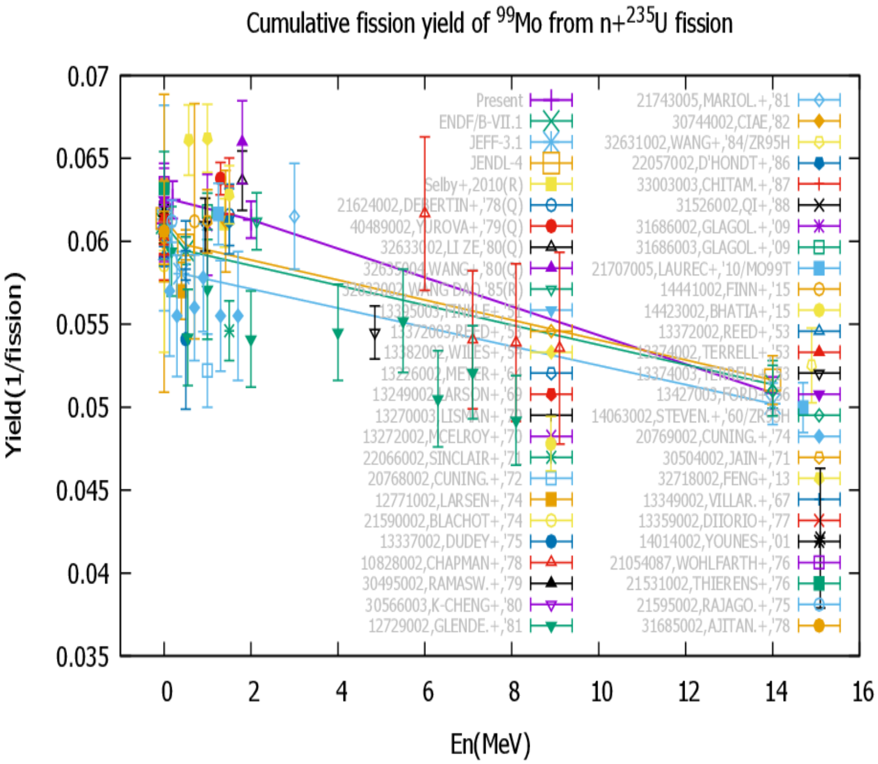
### Phenomenological Method of FY and Macro-benchmark Test

49 experimental yields of $^{99}$Mo, $^{99}$Tc and chain yield, from US, China and Europe.

The experimental data were modified by gamma ray intensity and standard yield. After weighted averaging, the yields at thermal energy is 6.12E-2 (7.38E-4), consistent with that of ENDF/V-II.1.

The yields at fission spectrum energy are quite different, ranging from 5.5 to 6.4%. Six of them are ratio, and have good consistency, which were adopted to deduced the yields, resulted 6.25 (1.8%) to 6.13 (1.8%) over the energy range of 0.2 MeV to 2 MeV, which are in accordance with the values of Selby 2011.

**The yield at 14 MeV has only measured datum 6.27%, and was corrected to 5.08E-2 (9.66E-4) by normalizing with its yield at thermal energy, which is consistent with ENDF/BVII-1 and JEFF-3.1 within the uncertainties.**

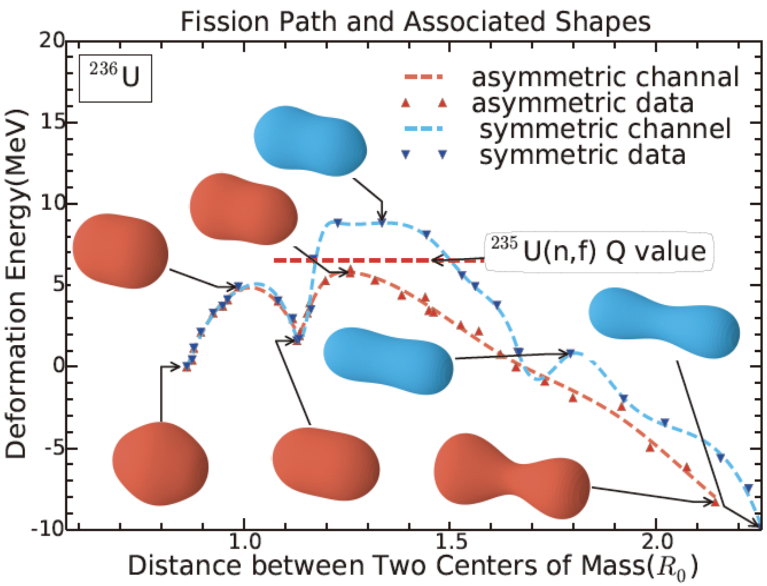


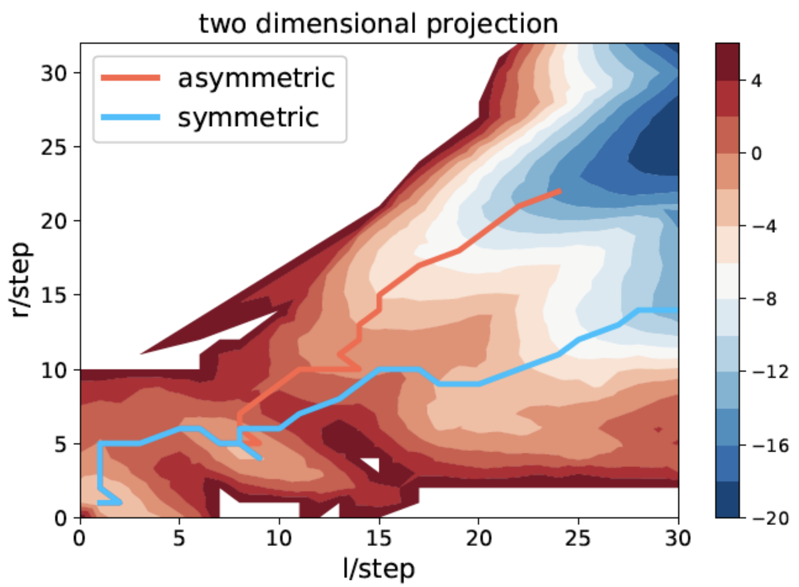
# 1. Fission yield sub-library :

## Calculations of multi-dimensional potential energy surfaces within a macroscopic-microscopic model and the study of fission dynamic processes

In the macroscopic-microscopic model, two sets of shapes are used to describe the nuclear shape. One is three-quadrature surface, which can independently describe the deformation of fragment. The other is the generalized Lawrence shape, and parameters have clearer meaning. Each of these two sets of shape parameters contains five independent variables.

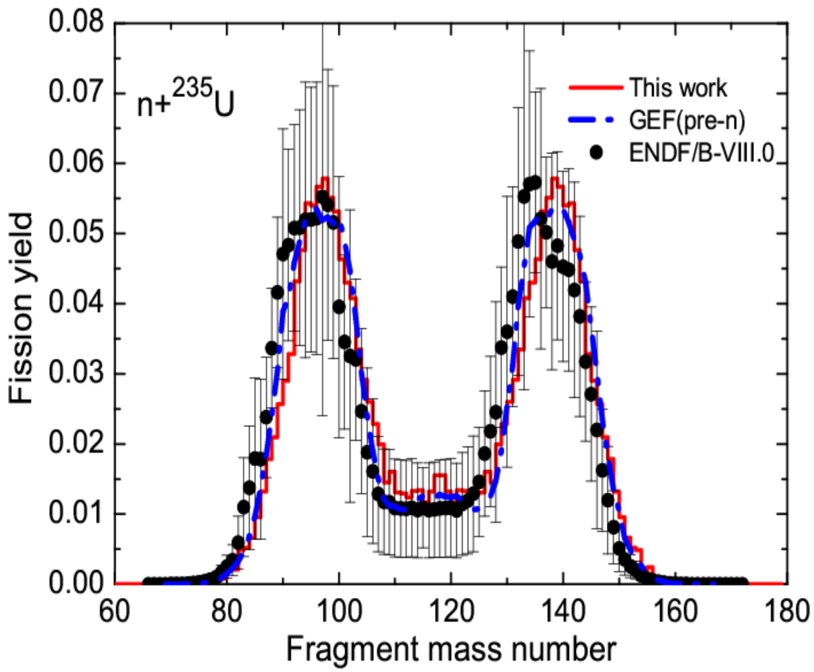
**Potential energy surfaces of isotopes of U and Pu elements were calculated in the five-dimensional deformation space. The asymmetric and symmetrical fission modes of actinide are obtained.**

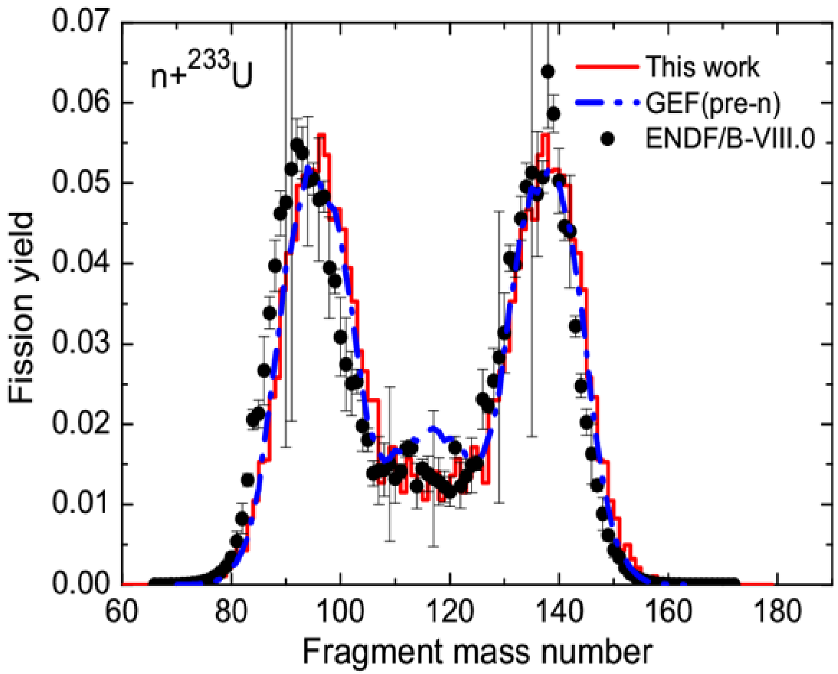


# 1. Fission yield sub-library :

The mass distributions of 14MeV neutron induced $^{233, 235, 238}$U and $^{239}$Pu fission were calculated with Langevin equation, and the results were compared with the evaluated data of ENDF/B-VII.0 library (post-neutron mass distribution) and the results of pre-neutron mass distribution calculated by GEF.



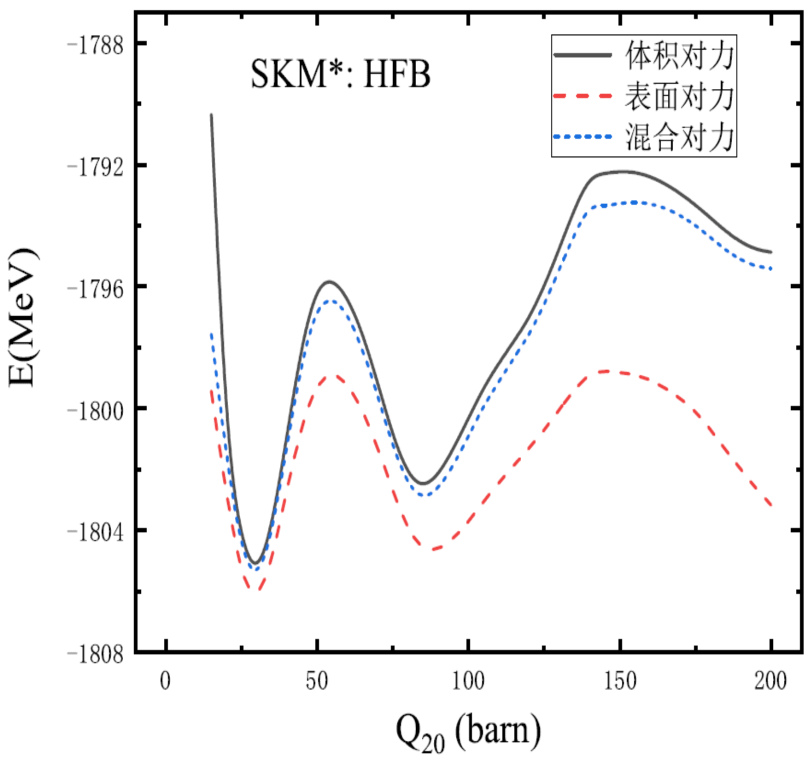



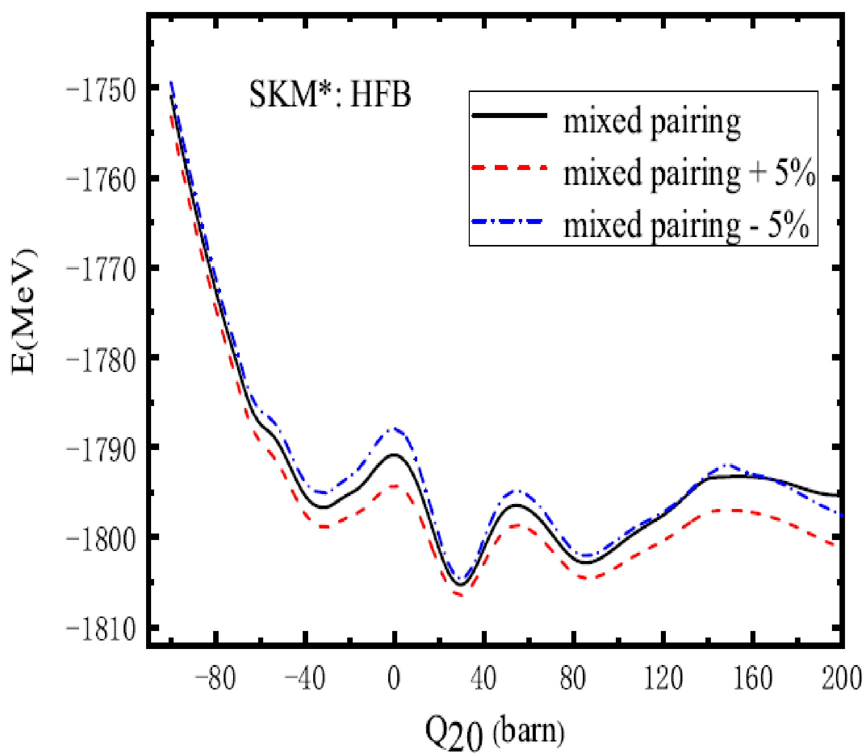

Simulation and evaluation results of n(14MeV) +$^{235,233}$U

# 1. Fission yield sub-library :

## Studies on the mechanism of nuclear fission in Actinide nuclei with microscopic theories

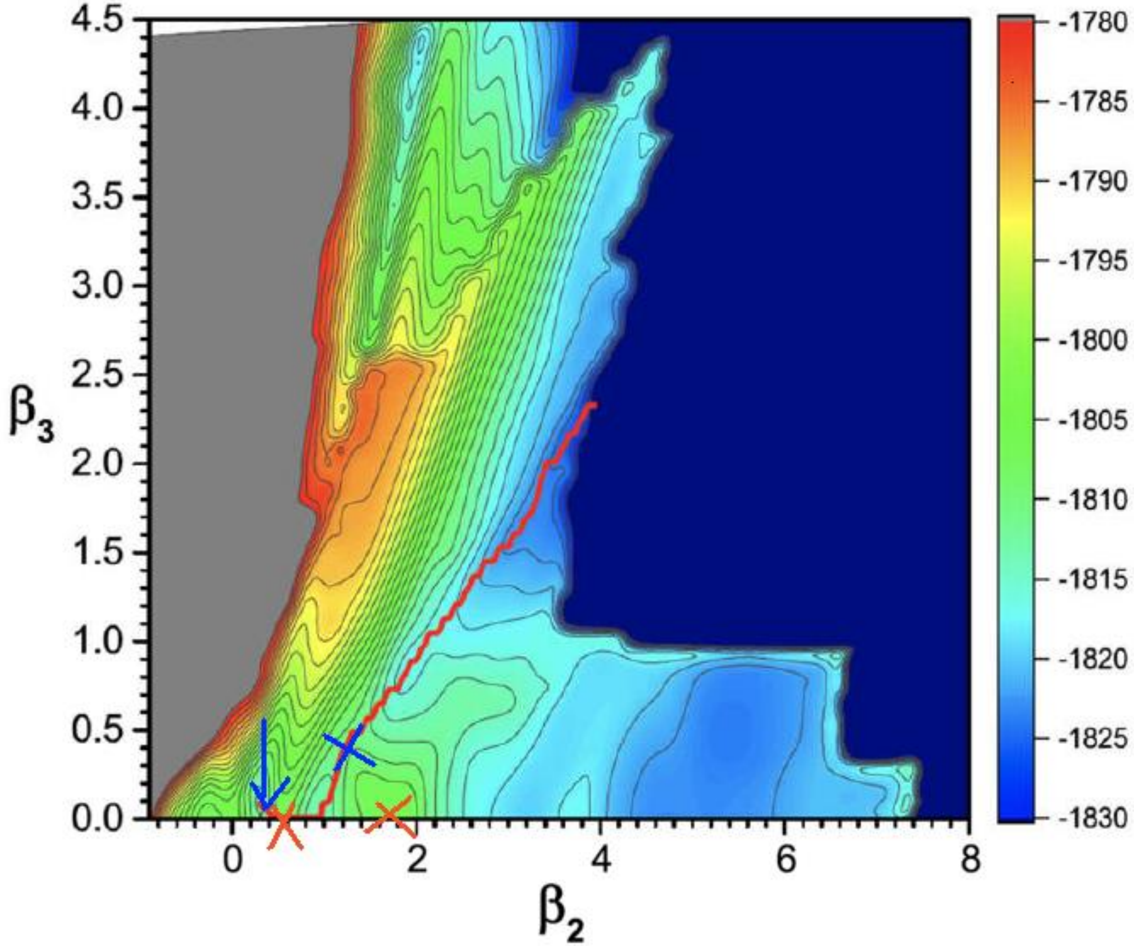
Using the Constrained Hartee-Fock-Bogoliubov (CHFB) method based on non-relativistic energy density functional, the method and program for calculating the multidimensional potential energy surface are developed. The effects of different paring models and different paring strength on the potential energy surface are analyzed.



# 1. Fission yield sub-library :

On the other hand, the time-dependent generated coordinate method (TDGCM) based on covariant density functional is used to study the dynamic properties of $^{240}$Pu fission. The multi-dimensional fission potential energy surface and fission barrier structure are given.




$^{240}$Pu potential energy surface in (β2,β3) plane calculated with self-consistent relativistic mean field + BCS

# 2. Decay data sub-library :

- Requirements of burn-up calculation, analysis neutrino spectra anomaly, CENDL/DDA for fission product was being developed
- About 1415 nuclides will be included
- CNDC has updated and compiled decay data for about 200 nuclides

Approach:

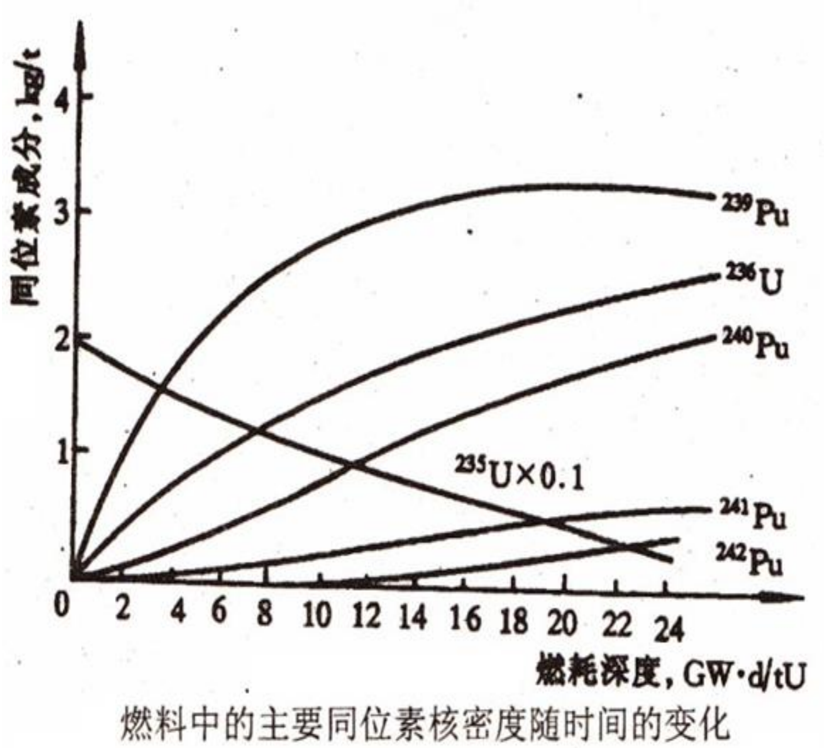
- Base library: adopt the AME (2017Wa10) in Lanzhou, and update the Q-value;
- Construction policy: contrast & comparison new exp. data and existing data library: CNDC,DDEP, IAEA-CRP,JEF-3.2, JENDL-DDF2015 and ENSDF;
- Test: part of the key elements have tested through in Chinese domestic user at present.

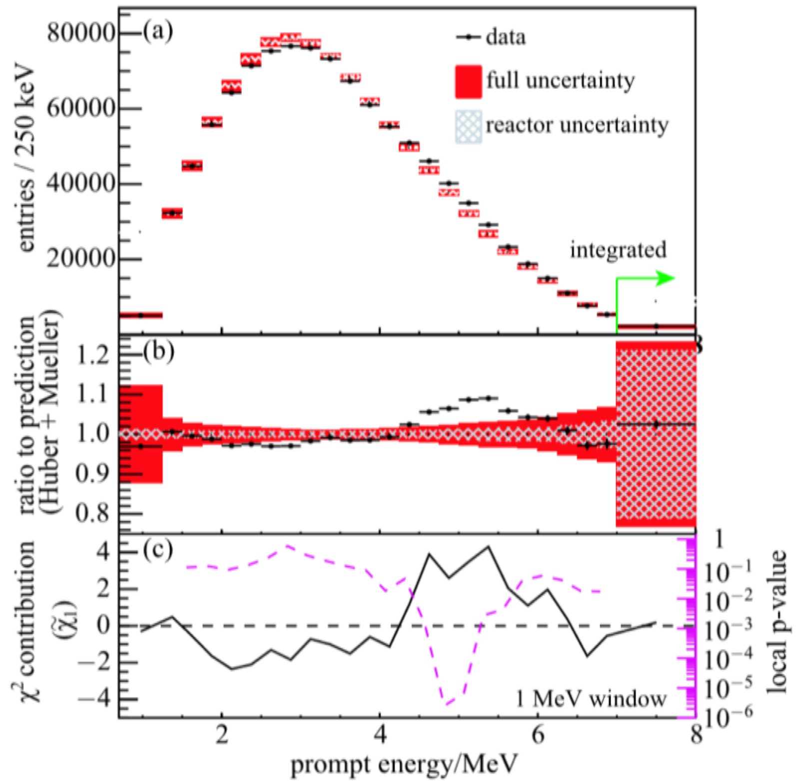
| Mode | CNDC | DDEP | ENSDF |
|---|---|---|---|
| %IT | 7.44(20) | 9.1(6) | 8.7(9) |
| %ε | 92.56(20) | 90.9(6) | 91.3(9) |

| Eγ/keV | CNDC | DDEP | ENSDF |
|---|---|---|---|
| 79.138(IT) | 5.68(18) | 6.9(5) | 6.6(5) |
| 433.937(ε) | 91.73(20) | 90.1(6) | 90.5 |
| 614.276(ε) | 92.3(22) | 90.5(16) | 89.8(19) |
| 722.907(ε) | 92.4(22) | 90.8(16) | 90.8(19) |

# 3. Activation sub-library :

- ✓ To meet the requirements of burn-up calculation, other nuclear application, the CENDL evaluated neutron activation cross section sub-library was being developed.
- ✓ About 200 target, 100 reaction channels will be included
- ✓ CNDC has updated and re-evaluated for about 150 target s firstly.
- ✓ Test: some important CS will be tested by systematics



# 3. Activation sub-library :

Chinese measurements： 94 neutron data

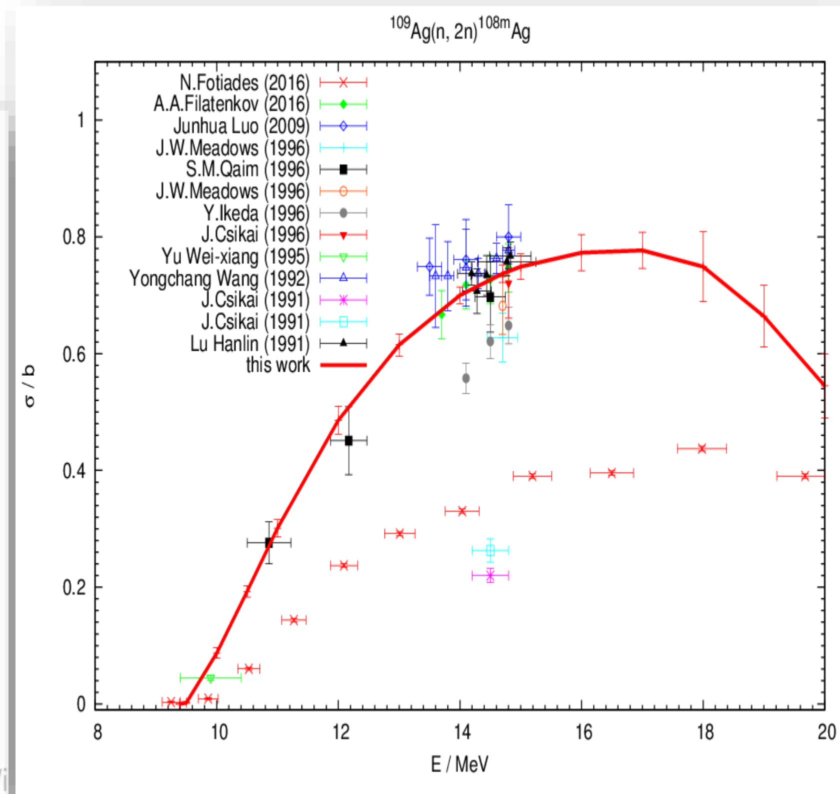
| | | | | | |
|---|---|---|---|---|---|
| $^{23}$Na(n,2n)$^{22}$Na | $^{24}$Mg(n,p)$^{24}$Na | $^{27}$Al(n, a)$^{24}$Na | $^{45}$Sc(n,2n)$^{44g,}$Sc | $^{45}$Sc(n,2n)$^{44m}$Sc | $^{45}$Sc(n,2n)$^{44m+g}$Sc |
| $^{46}$Ti(n,p)$^{46}$Sc | $^{47}$Ti(n,p)$^{47}$Sc | $^{48}$Ti(n,p)$^{46}$Sc | $^{51}$V(n,a)$^{48}$Sc | $^{55}$Mn(n,2n)$^{54}$Mn | $^{54}$Fe(n,p)$^{54}$Mn |
| $^{54}$Fe(n,a)$^{51}$Cr | $^{56}$Fe(n,p)$^{55}$Mn | $^{59}$Co(n,2n)$^{58}$Co | $^{59}$Co(n,p)$^{59}$Fe | $^{59}$Co(n,a)$^{56}$Mn | $^{58}$Ni(n,2n)$^{57}$Ni |
| $^{58}$Ni(n,p)$^{58}$Co | $^{58}$Ni(n,x)$^{57}$Co | $^{60}$Ni(n,p)$^{60}$Co | $^{62}$Ni(n,a)$^{59}$Co | $^{62}$Ni(n, a)$^{59}$Fe | $^{63}$Cu(n,a)$^{60}$Co |
| $^{66}$Zn(n,2n)$^{65}$Zn | $^{67}$Zn(n,p)$^{67}$Cu | $^{70}$Zn(n,2n)$^{69m}$Zn | $^{71}$Ga(n,r)$^{72}$Ga | $^{85}$Rb(n,2n)$^{84m}$Rb | $^{85}$Rb(n,2n)$^{84m+g}$Rb |
| $^{85}$Rb(n,p)$^{85m}$Kr | $^{85}$Rb(n, a)$^{82}$Br | $^{87}$Rb(n,2n)$^{86}$Rb | $^{87}$Rb(n,p)$^{87}$Kr | $^{89}$Y(n,2n)$^{88}$Y | $^{90}$Zr(n,2n)$^{89}$Zr |
| $^{89}$Zr(n,2n)$^{88}$Zr | $^{96}$Zr(n,2n)$^{95}$Zr | $^{92}$Mo(n,p)$^{92}$Nb | $^{98}$Mo(n,r)$^{99}$Mo | $^{93}$Nb(n,2n)$^{92m}$Nb | $^{93}$Nb(n,a)$^{90m}$ Y |
| $^{109}$Ag(n,2n)$^{108m}$Ag | $^{113}$In(n,2n)$^{112m}$In | $^{113}$In(n,n')$^{113m}$In | $^{115}$In(n,2n)$^{114m}$In | $^{115}$In(n,n’)$^{115m}$In | $^{115}$In(n,r)$^{116m}$In |
| $^{115}$In(n,p)$^{115}$Cd | $^{115}$In(n,a)$^{112}$Ag | $^{127}$I(n,2n)$^{126}$I | $^{124}$Xe(n,2n)$^{123}$Xe | $^{132}$Ba(n,2n)$^{131}$Ba | $^{134}$Ba(n,2n)$^{133m}$Ba |
| $^{134}$Ba(n,2n)1$^{33m+g}$Ba | $^{134}$Ba(n,p)$^{134m+g}$Cs | $^{134}$Ba(n,a)$^{131m}$Xe | $^{137}$Ba(n,p)$^{137}$Cs | $^{136}$Ba(n,p)$^{136}$Cs | $^{138}$Ba(n,a)$^{135}$Xe |
| $^{136}$Ce(n,2n)$^{135}$Ce | $^{138}$Ce(n,2n)$^{137m}$Ce | $^{140}$Ce(n,2n)$^{139}$Ce | $^{140}$Ce(n,p)$^{140}$La | $^{142}$Ce(n,2n)$^{141}$Ce | $^{151}$Eu(n,2n)$^{150m}$Eu |
| $^{151}$Eu(n,r)$^{152m}$Eu | $^{151}$Eu(n,r)$^{152g}$Eu | $^{153}$Eu(n,2n)$^{152g}$Eu | $^{153}$Eu(n,r)$^{154}$Eu | $^{159}$Tb(n,2n)$^{158}$Tb | $^{159}$Tb(n,r)$^{160}$Tb |
| $^{165}$Ho(n,r)$^{166m}$Ho | $^{169}$Tm(n,2n)$^{168m}$Tm | $^{169}$Tm(n,3n)$^{167}$Tm | $^{169}$Tm(n,r)$^{170}$Tm | $^{175}$Lu(n,2n)$^{174m+g}$Lu | $^{176}$Hf(n,2n)$^{175}$Hf |
| $^{180}$Hf(n,r)$^{181}$Hf | $^{179}$Hf(n,2n)$^{178m2}$Hf | $^{180}$Hf(n,2n)$^{179m2}$Hf | $^{181}$Ta(n,2n)$^{180m}$Ta | $^{181}$Ta(n,p)$^{181}$Hf | $^{182}$W(n,n’a)$^{178m2}$Hf |
| $^{185}$Re(n,2n)$^{184m}$Re | $^{185}$Re(n,2n)$^{184m+g}$Re | $^{187}$Re(n,2n)$^{186g}$Re | $^{187}$Re(n,2n)$^{186m}$Re | $^{193}$Ir(n,2n)$^{192m2}$Ir | Pt(n,x)$^{195m}$Pt |
| $^{198}$Pt(n,2n)$^{197}$Pt | $^{197}$Au(n.2n)$^{196}$Au | $^{197}$Au(n,3n)$^{195}$Au | $^{204}$Pb(n,2n)$^{203}$Pb | | |
| $^{51}$V(d,2n)$^{51}$Cr | $^{89}$Y(p,n)$^{89}$Zr | $^{89}$Y(p,2n)$^{88}$Zr | $^{89}$Y(p,pn)$^{88}$Y | $^{51}$V(p,n)$^{51}$Cr | Fe(p,x)$^{57}$Co |
| Fe(p,x)$^{54}$Mn | Fe(p,x)$^{55}$Co | Fe(p,x)$^{56}$Co | $^{27}$Al(d,pa)$^{24}$Na | Ti(p,x)$^{48}$V | Ti(d,x)$^{48}$V |
| Mo(p,x)$^{95m,g}$Tc | Mo(p,x)$^{96g}$Tc | Mo(p,x)$^{99}$Mo | Mo(d,x)$^{95m,g}$Tc | Mo(d,x)$^{96g}$Tc | Mo(d,x)$^{99}$Mo |

# 3. Activation sub-library :

## Example： $^{109}Ag(n,2n)^{108m}Ag$

- ✓ using new evaluated decay data to update the measured CS.
- ✓ data analysis with uncertainty evaluation
- ✓ Data Processing using SPCC from CNDC
- ✓ Recommendation and comparison

| YEAR | AUTHOR | INSTITUTE | REFERENCE | FACILITY | METHOD | DETECTOR | ENERGY |
|---|---|---|---|---|---|---|---|
| 2016 | N.Fotiades | 1USALAS | J,PR/C,94,044608,2016 | LINAC | TOF | HPGE | 9.25~33.35 |
| 2016 | A.A.Filatenkov | 4RUSRI | R,INDC(CCP)-0460,2016 | CCW | ACTIV | SCIN,GELI,HPGE | 13.70~14.80 |
| 2009 | Junhua Luo | 3CPRLNZ | J,ANE,36,718,2009 | CYCLO | ACTIV | HPGE | 13.50~14.80 |
| 1996 | J.W.Meadows | 1USAANL | J,ANE,23,877,199607 | CCW | ACTIV | GE-IN | 14.7 |
| 1996 | S.M.Qaim | 2GERJUL | J,ARI,47,(5/6),569,1996 | CYCLO,CYCLO | ACTIV | HPGE,GELI | 10.86~14.50 |
| 1996 | J.W.Meadows | 1USAANL | J,ANE,23,877,199607 | FNS | - | HPGE | 14.7 |
| 1996 | Y.Ikeda | 2JPNJAE | S,INDC(NDS)-342,19,199602 | CCW | STTA,GSPEC | NAICR | 14.10~14.80 |
| 1996 | J.Csikai | 3HUNKOS | R,INDC(NDS)-342,29,199602 | - | ACTIV | HPGE | 14.8 |
| 1995 | Yu Wei-Xiang | 3CPRAEP | J,CNP,17,(3),268,1995 | VDG | ACTIV | GELI | 9.9 |
| 1992 | Yongchang Wang | 3CPRLNZ | J,NSE,111,314,1992 | NGEN | ACTIV | HPGE | 13.60~14.80 |
| 1991 | J.Csikai | 2GERKIG | J,ANE,18,(1),1,1991 | NGEN | ACTIV | GELI | 14.5 |
| 1991 | Lu Hanlin | 3CPRAEP | J,CNP,13,(3),203,1991 | CCW,CCW | ACTIV | GELI | 14.19~14.83 |
| 1999 (Deriv) | A.A.Filatenkov | 4RUSRI | R,RI-252,199905 | CCW | ACTIV | SCIN | 14.1 |



# 4. Photo data sub-library :

270 new evaluations have been performed based on the new GLUNF、MEND-G systems.

EXFOR data

↓

Experimental analysis for (G,abs)

↓

GDR parameter calculation

↓

(G,abs) calculation (GDR + QD)

↓

Input to GLUNF and MEND-G

↓

Experimental analysis for partial photon-neutron emission reactions and (n,p), (n,alpha) …

↓

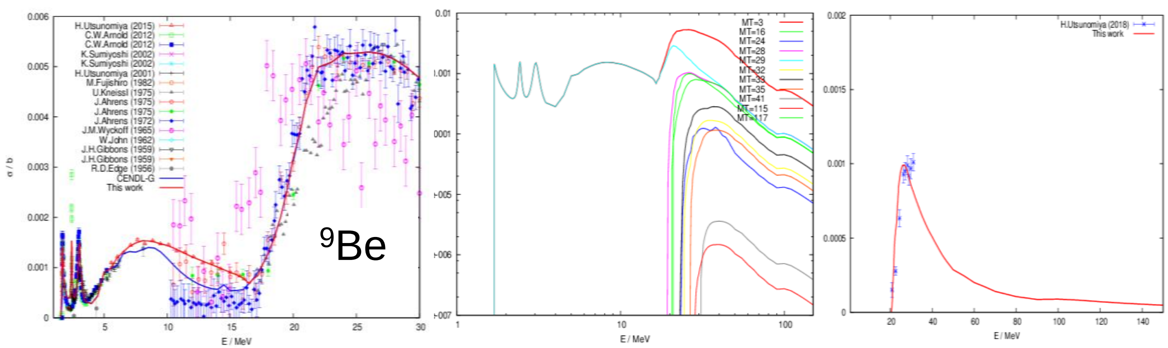
GLUNF for Be-9
MEND-G for medium-heavy nuclei

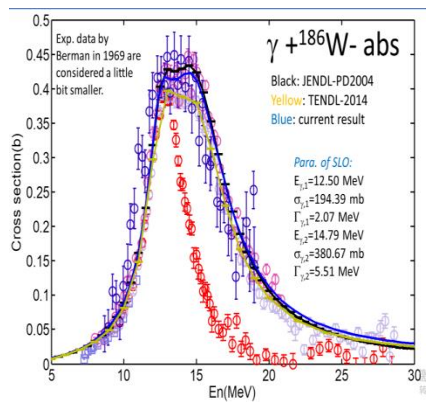
↓

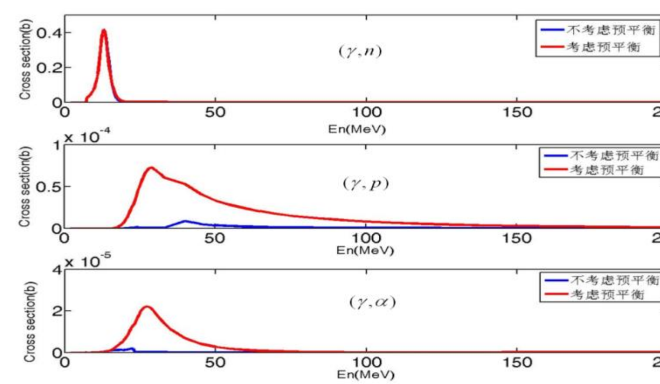
ENDF/B-6 output and format check

Evaluation Scheme for PD

$^{9}$Be — $^{209}$Bi 274 nuclei



# IV. Conclusion:

- ✓ As the main output of CENDL project, CENDL-3.2 library is built with the general purpose to provide high-quality nuclear data for the modern nuclear science， engineering and nuclear technology etc applications
- ✓ CENDL-3.2 library is constituted by neutron, fission yield, decay data, activation and photon files, which is difference comparison with previous CENDL libraries, and provide more nuclear reaction information for application.
- ✓ Comparing with previous CENDL library, the updated evaluation of nuclear reaction data for several key nuclides, such as U-235, Pu-239, U-233, Th-232, Fe-56 and et al. has been revised and improved.
- ✓ The library was tested with the criticality and shielding benchmarks with ENDITS-1.0, better results have been obtained, and used for applications for CEFR, TMSR, CAP1400, ADS, BIRF, JUNA, BiSoL etc projects.
- ✓ All CENDL project also benefit from the international cooperation such as NRDC network, IAEA/CRP, OECD/WPEC and et al;

# ND2019 Conference Summary

*GE Zhigang*

China Nuclear Data Center(CNDC)
China Committee of Nuclear Data(CCND)
China Institute of Atomic Energy(CIAE)
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E-Mail:gezg@ciae.ac.cn

CHINA NUCLEAR DATA CENTER


**May 19-23, 2019 Beijing China**



**Sept.16 2016, Bruges Belgium.**


## Organized by:

CNDC
CIAE
CNS

## Co-sponsored by:

OECD/NEA
IAEA

## Supported by:

CAEA
NSFC
CNNC
CCAST


# General Information of ND2019

## Participant Information:

| COUNTRY | No | RANK |
|---|---|---|
| China | 294 | 1 |
| United States | 34 | 2 |
| Japan | 28 | 3 |
| France | 24 | 4 |
| Switzerland | 15 | 5 |
| Korea | 14 | 6 |
| Czech Republic | 10 | 7 |
| Italy | 9 | 8 |
| Germany | 8 | 9 |
| Romania | 8 | 9 |
| Sweden | 8 | 9 |
| Austria | 7 | 10 |
| Belgium | 6 | 11 |
| Russia | 6 | 11 |
| United Kingdom | 6 | 11 |
| Spain | 5 | 12 |

| COUNTRY | No | RANK |
|---|---|---|
| Greece | 4 | 13 |
| South Africa | 3 | 14 |
| Argentina | 2 | 15 |
| Belarus | 2 | 15 |
| Canada | 2 | 15 |
| Poland | 2 | 15 |
| Slovenia | 2 | 15 |
| Australia | 1 | 16 |
| Finland | 1 | 16 |
| India | 1 | 16 |
| Iran | 1 | 16 |
| Malaysia | 1 | 16 |
| Mongolia | 1 | 16 |
| Turkey | 1 | 16 |
| Ukraine | 1 | 16 |
| Botswa | 1 | 16 |

**Country** 32 **Participant** 508 **Male:** 427 **Female:** 81

# Presentation Information:

| Topics | Files |
|---|---|
| **Data Dissemination and International Collaboration** | **9** |
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| > Evaluation Libraries | 5 |
| > Evaluation methodology | 18 |
| > Thermal Scattering Data | 14 |
| > Uncertainty Quantification and Covariances | 13 |
| **Experimental Facilities, Equipment Techniques and Methods** | **40** |
| **Fission Physics and Observables** | **40** |
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| **Nuclear Data Application** | **74** |
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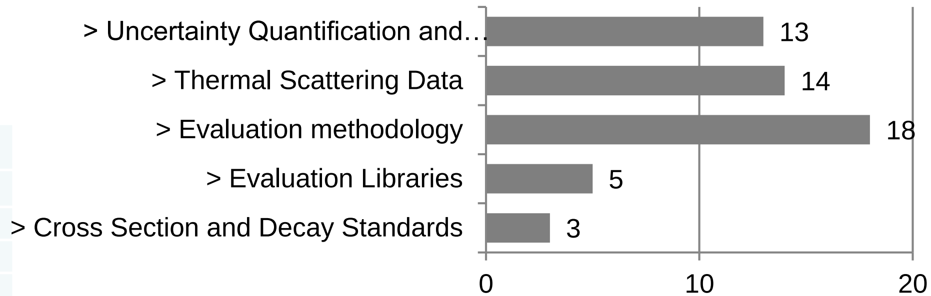
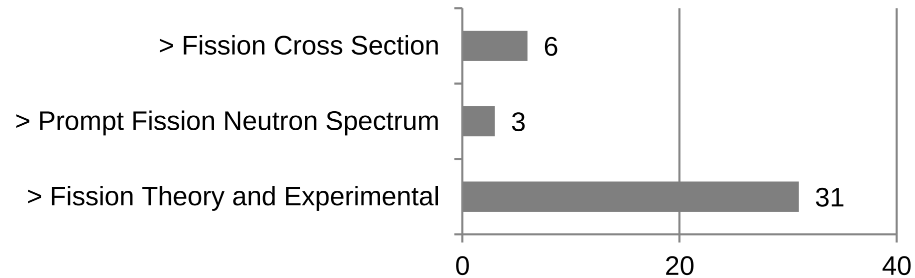
| > Nuclear Data for Medical Applications | 3 |
| > Nuclear Data in Accelerator Related Applications | 17 |
| > Nuclear Data in Fusion Application | 4 |
| > Particle Therapy and Radiotherapy | 6 |

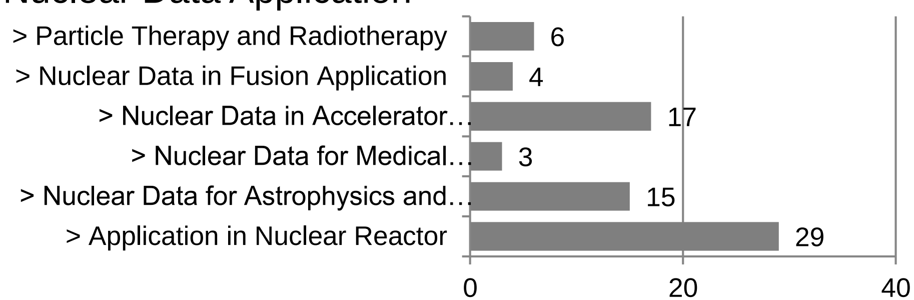
Evaluation




Fission Physics and Observables



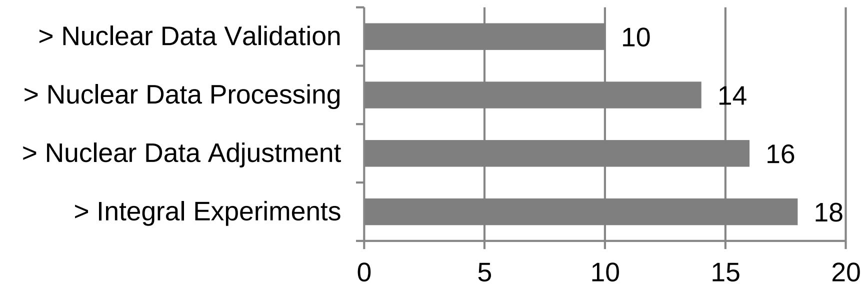

Nuclear Data Application



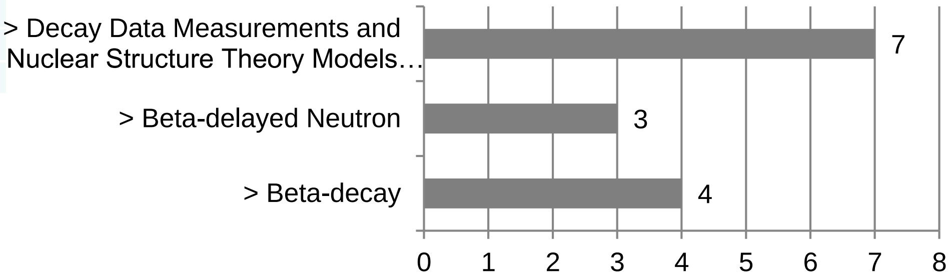

# Presentation Information:

| Topics | Files |
| --- | --- |
| **Nuclear Data Processing and Validation** | **58** |
| > Integral Experiments | 18 |
| > Nuclear Data Adjustment | 16 |
| > Nuclear Data Processing | 14 |
| > Nuclear Data Validation | 10 |
| **Nuclear Reaction Measurements** | **75** |
| **Nuclear Structure and Decay Data** | **20** |
| > Beta-decay | 4 |
| > Beta-delayed Neutron | 3 |
| > Decay Data Meas. and Nucl. Structure Theory Models and Codes | 7 |
| > Nuclear Masses and Decay Data Measurements | 6 |
| **Nuclear Theory, Model and Codes** | **37** |
| **Spallation, High and Intermediate Energy Reactions** | **10** |
| **Plenary 0520** | **7** |
| **Plenary 0524** | **6** |
| **keynote** | **5** |
| Total | **434** |

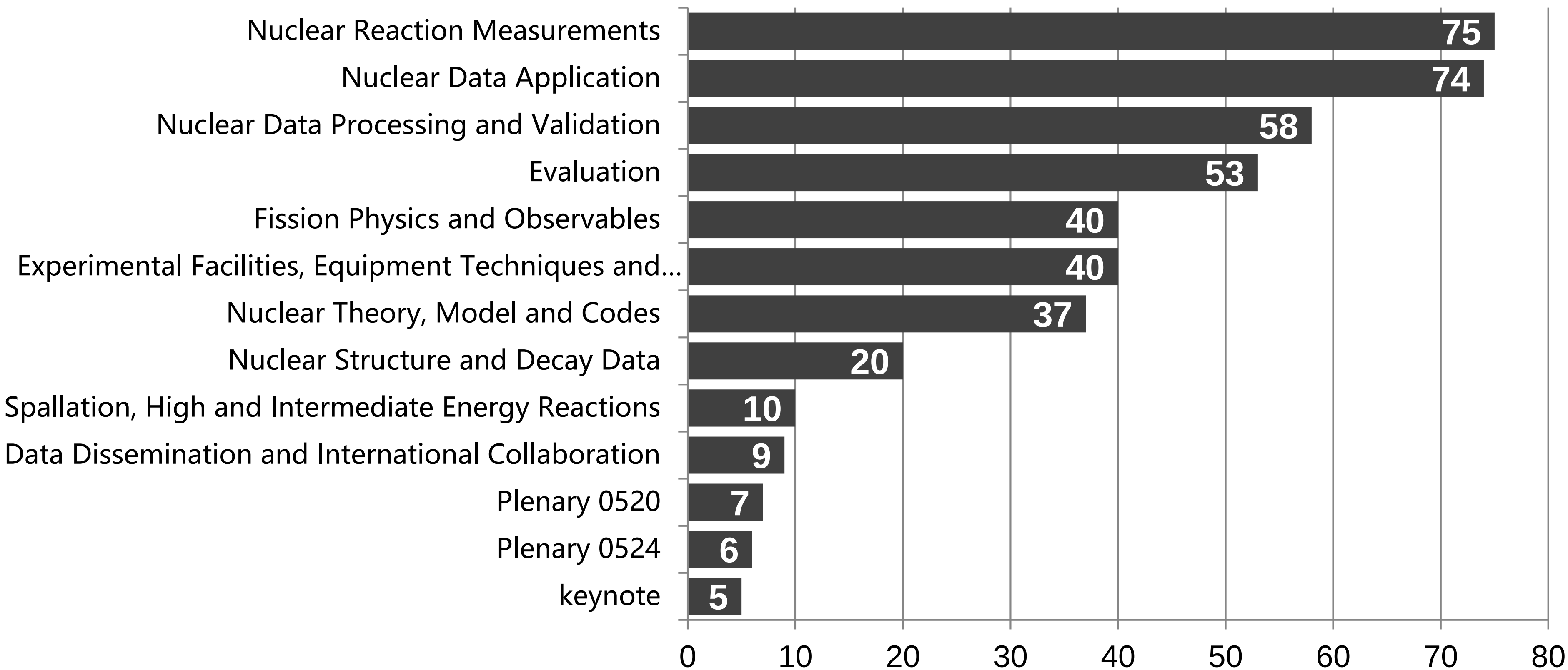
## Nuclear Data Processing and Validation




## Nuclear Structure and Decay Data



# Topic distribution of presentations:



# Others:

## Activities during the ND2019

a) Three bilateral Meetings: CIAE-NEA, CIAE-IAEA, JEFF-CENDL
b) Two side-meetings: WPEC-Subgroup 45 VaNDaL, EG-GNDS Subgroup
c) One workshop: Neutronics Experimental Facility HINEG and Simulation Code Super MC

## Conference presentations and photos :

After the agreements from the authors and participants received them will be upload to the conference website.

## Conference proceedings : Full-paper

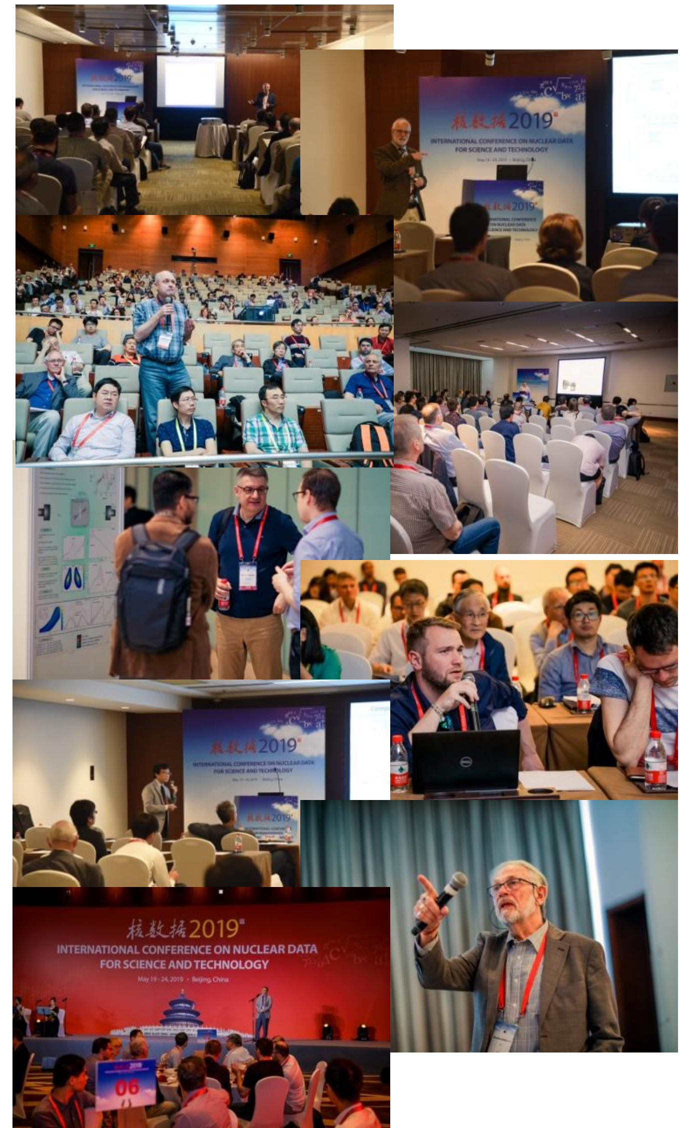
a) Limit 4 pages for regular, short presentations or posters
b) Limit 6 pages for invited/plenary presentations;
c) Paper must be written in latex format, and in two column type,
d) Paper will be published on EPJ web conference;
e) Full-paper submission deadline is Aug. 01, 2019;

# 核数据2019

# 2019 International Conference On Nuclear Data for Science and Technology

May 19 - 24, 2019 • China National Convention Center • Beijing





# Chinese media reports about ND2019

中华人民共和国中央人民政府
www.gov.cn

国际核数据大会首次在我国召开

国家原子能机构
CHINA ATOMIC ENERGY AUTHORITY

第十四届国际核数据大会在京开幕

中国核工业集团有限公司
China National Nuclear Corporation

国际核数据大会首次在中国召开

中国核数据中心成为国际五大核数据中心之一

新华社
05-20 18:04

新华社北京5月20日电（记者高敬）核科学研究、核设施建设以及核技术应用都离不开核数据。核数据精度与可靠性直接关系着各种与核相关的装置和产品的有效性、安全性和经济性。记者20日从正在北京举行的第十四届国际核数据大会获悉，中国核数据中心已成为国际五大核数据中心之一。

IT之家

国际核数据大会首次在我国召开

2019-05-21 10:16

科学网 新闻

国际核数据大会首次在我国召开

人民网 people.cn

人民网 >> 国际

国际核数据大会在中国召开

2019年05月21日08:29 来源：人民网－人民日报海外版 分享到：

第14届国际核数据大会5月20日-24日在北京国家会议中心举行。本次大会主题为"核数据——人类的共同资产"，来自45个国家、地区以及相关国际组织、机构的核数据、核科学与核工程领域学者专家以及国内各科研所、高校代表及关注核数据领域的各界人士等共计约500名代表参会。

据悉，国际核数据大会是国际核数据界规模最大、水平最高的学术交流会议。这是大会首次在中国召开，也是首次在OECD成员国之外的国家召开。

中国核数据中心已成为国际五大核数据中心之一。中国核学会理事长王寿君介绍，中国坚定不移地推动核能高质量发展。截至2019年4月，中国大陆在运核电机组达到45台，装机容量4590万千瓦；在建机组11台，装机容量1218万千瓦。（记者叶子）

国际核数据大会首次在我国召开

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