Utilities of nuclear data library at CNDC

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Nuclear Reaction Theory(R matrix) and FDRR Code – light nuclei

FDRRi.dat: control the key paras.

```
 input data 2: FDRRi.dat
!***np, DST, NDX ***
   111   15.0   -1
! Wt:chi2-ntot, Wcs(0-Nreta)
1 0 1 1 0
! Wang(1-Nang)
0.1
! WPoL(1-NPoL)
0
! ((WCSc(Ic,k),k=2,Ncreta(Ic)),Ic=1,Nchar)
0 0 0
! ((WcAng(Ic,k),k=1,Ncang(Ic)),Ic=1,Nchar)
0
!WcPoL(Ic,k)
!
!
11.92980498
17.76847541
10.76207089
-7.909062971
-8.466772771
6.091134544
```

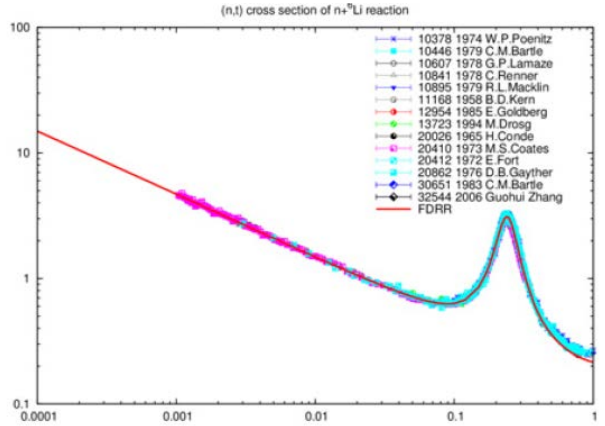
Para. Num., steps

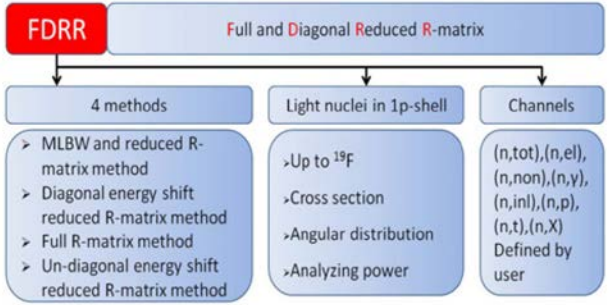
Weights for channels

Different projectiles

FDRRk.dat: levels and exp. data

```
输入文件FDRRk.dat
 Kcal    Kred     Kdel   Nchar   Nlevt   Nlevp  IEcL
 4       1        1      1       3       3      1
 Eclam(1-Nlevt)
 ELamL(1-Nlevt)
 11.92980498
 17.76847541
 10.76207089
 AJJc(1-Nlevt)
 0.5
 1.5
 2.5
 NJPi
 3
 NJPip
 3
 AJJ(1-NJPi)
 0.5    1.5     2.5
 IJP(1-Nlevt)
 1
 2
 3
 Nang和Nang1
 1     3
 NPoL极化数据
 0
 Nreta  保留道数（1至Nreta为保留道，Nang+1至Nreta道只有积分截面）
 3
 Nchant 总粒子道数（Nreta+1至Nchant为约化粒子道，第0道为γ光子道），目前设定最大为20
 3
 IZp(1-Nchant)各(αn)道出射粒子的电荷数(整型)
           0          1          1
 IAp(1-Nchant)各(αn)道出射粒子的质量数(整型)
           1          3          2
```





Nuclear Reaction Theory and LUNF Code – light nuclei

LUNF can be used for all CS cal. of n+ ^{6,7}Li, ^{9}Be, ^{10,11}B, ^{12}C etc. with ENDF/B6 output. En ≤ 20/30MeV, double-differential CS.

```
C=============================================================C
C@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@C
C@                                                           @C
C@      LL          UU      UU     NNN      NN     FFFFFFFFFF  @C
C@      LL          UU      UU     NNNN     NN     FFFFFFFFFF  @C
C@      LL          UU      UU     NN NN    NN     FF          @C
C@      LL          UU      UU     NN  NN   NN     FFFFFFFFF   @C
C@      LL          UU      UU     NN   NN  NN     FFFFFFFFF   @c
C@      LL          UU      UU     NN    NN NN     FF          @c
C@      LL          UUUUUUUUUU     NN     NNNN     FF          @c
C@      LLLLLLLLL   UUUUUUUU       NN      NNN     FF          @c
C@                                                           @c
C@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@C
C=============================================================C
C                                                             C
C                        FOR (N+Li6)                          C
C                                                             C
C                   AUTHORS:     ZHANG JING-SHANG             C
C                                                             C
C                          作者        张竞上                 C
C                                                             C
C                 CHINA INSTITUTE OF ATOMIC ENERGY            C
C                                                             C
C                     中国原子能科学研究院                    C
C                                                             C
C                  (CNDC, BEIJING 102413)  2006               C
C                                                             C
C                 中国核数据中心，北京102413，2006版          C
C                                                             C
C=============================================================C
C                                                             C
C       THIS CODE IS USED FOR CALCULATING OF FAST NEUTRON REACTION   C
C                 DATA OF N+Li6 BELOW 20 OR 30 MeV.           C
C                                                             C
C             INCLUDING ALL KINDS OF CROSS SECTIONS           C
C       TOTAL, ELASTIC SCATTERING AND NON-ELASTIC SCATTERING  C
C        AND ALL KINDS OF REACTION CHANELLS                   C
```

```
KTEST KOPP KDDCS KCOMP KENDF
  0    0     1     0     1
 A     Z      AT        K     EF    CE1   CM1  CE2
 6     3   6.01512075  100.   30.   0.8   0.1  0.1
MATERIAL NUMBER
 325
NUMBER OF INCIDENT ENERGIES  'NOE' AND ENERGIES 14MeV=83
103                          0
  1.E-11  0.0010  0.0025  0.0050  0.0075  0.0100  0.0200  0.0300  0.0400  0.0500
  0.0600  0.0700  0.0800  0.0900  0.1000  0.1500  0.2000  0.3000  0.4000  0.5000
  0.6000  0.7000  0.8000  0.9000  1.0000  1.2500  1.5023  1.7223  2.0000  2.0435
  2.0500  2.3354  2.5000  2.5528  2.7431  2.7674  2.9192  3.0000  3.1820  3.2111
  3.5031  3.7950  4.0000  4.0500  4.0869  4.1603  4.2000  4.3180  4.3204  4.5000
  4.6708  4.8300  5.0000  5.2546  5.4000  5.7000  6.0000  6.5000  6.8000  7.0500
  7.4700  8.0000  8.1738  8.5000  8.9600  9.0000  9.3415  9.5000  9.9253 10.0000
  10.1000 10.750 11.0000 11.5000 11.6770 12.0400 12.2610 12.5000 12.9400 13.0000
  13.5000 13.940 14.0000 14.1000 14.2000 14.6000 15.0000 15.1800 15.4000 15.7640
  16.0000 16.500 16.7500 16.9310 17.0000 17.5000 17.5520 18.0000 18.0990 18.5000
  19.0000 19.5000 20.000
INPUT MET(I), I=1,MEL
 1  0  0  0  0  0  0  0  0  0
 0  0  0  0  0  0  0  0  0  0
 0  0  0  0  1  0  0  0  1  0
 0  0  0  0  0  0  0  1  0  0
 0  0  1  0  0  0  0  0  0  0
 0  0  1  0  0  0  1  0  0  1
 0  1  0  1  0  1  0  1  0  1
 0  0  1  0  0  1  0  0  0  1
 0  0  1  0  0  0  1  0  0  0
 1  0  0  0  1  0  0  1  0  0
 1  0  1
INPUT COEFFICIENT OF THREE BODY BREAK-UP OF Li7
 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.35714 0.39544 0.40269
 0.40373 0.44216 0.45843 0.47619 0.48523 0.48848 0.49405 0.49474 0.49916 0.50003
 0.49917 0.49882 0.49853 0.49790 0.49751 0.49624 0.49621 0.49397 0.49159 0.48922
```

Nuclear Reaction Theory and UNF Code – medium heavy and FP

Optical model potential

Phenomenological method

Koning-Dec(2003)
CH89 (1989)
Becchetti-Greenlees (1969)
Coupled channel (in research)

Microscopic method

CT Potential (2016)
Pot. via SHF (2014)
JLM model (1977,1998)

Unified Hauser-Feshbach & exiton model

Hauser-Feshbach
Fluctuation
Fission
γ emission
Level density
GC + Ignatyuk
HFB approach (in Re.)
Giant resonance
recoil

Jπ dependent pre-equilibium theory
Exciton model
Kalbach syst.
Comp. particle emis.
… …

Dirac reaction

Spherical DWBA
Deformed/coupled channel
Rotation(soft, hard) (in Research)
Vibration

- Incident energy of projectile: E ≤ 20MeV;
- Incident particle: n, p, gamma(50MeV);
- Target: stable and unstable nuclei near to beta valley
- Output: ENDF-6 format; MF = 1-6,12-15;

MEND for incident energy E ≤ 200MeV is also parallel being developed by Nankai University.

Reaction channels considered in UNF code

No.	Channels	KOP	KTYP1	KTYP2	KGD	KCH
0	(n,γ)		0	0	0	0
1	(n,n')	1	1	1	1	1
2	(n,p)	2	2	2	2	2
3	(n,α)	3	3	3	3	3
4	(n,^{3}He)	4	4	4	4	4
5	(n,d)	5	5	5	5	5
6	(n,t)	6	6	6	6	6
7	(n,2n)	1	1	1	7	7
8	(n,np)	2	1	2	5	8
9	(n,nα)	3	1	3	8	9
10	(n,pn)	7	2	1	5	8
11	(n,2p)	8	2	2	9	10
12	(n,αn)	9	3	1	8	9
13	(n,3n)	1	1	1	10	11

Input：

UNF: input files

Target:ground state/iso state

No.of En.

Calculate the special En. point

```
 1 KTEST KOPP KDDCS KGYD KENDF KCOV KOUT
 2   0    0     1     1    1     0    1
 3 THE STATUS OF TARGET 1: GROUND STATE  >1: ISOMERIC STATE
 4 1
 5 THE NUMVER OF ISOTOPES
 6 1
 7 THE CHARGE NUMBER OF THE NUECLEUS
 8 28
 9 MASS NUMBERS OF EACH ISOTOPE
10 58
11 ABUNDANCE OF EACH ISOTOPE
12 1.000000
13 MATERIAL NUMBER
14 2825
15 NUMBER OF INCIDENT ENERGIES, 'NOE','EL(I),I=1,MEL AND MET(I),I=1,MEL
16       225          0
17 1.0E-11      2.52e-8      0.005       0.010       0.050
18 0.0639       0.100        0.200       0.300       0.400
19 0.4995       0.500        0.600       0.6567      0.6609

62      3           1           1           3           1
63      1           3           1           2           1
64      1           3           1           1           1
```

KTEST: single En or multiple(1/0)
KOPP: OMP output (1/0)
KDDCS: DDX output(1/0)
KGYD: g production(1/0)
KENDF: ENDF/B format(1/0)
KCOV: COV cal(1/0)
KOUT: output all the details besides results

Incident En.

Paras. for output control
1:only XS
2:XS and DA
3:XS and DA and DDS, g-production

Nuclear Reaction Theory and UNF Code – medium heavy and FP

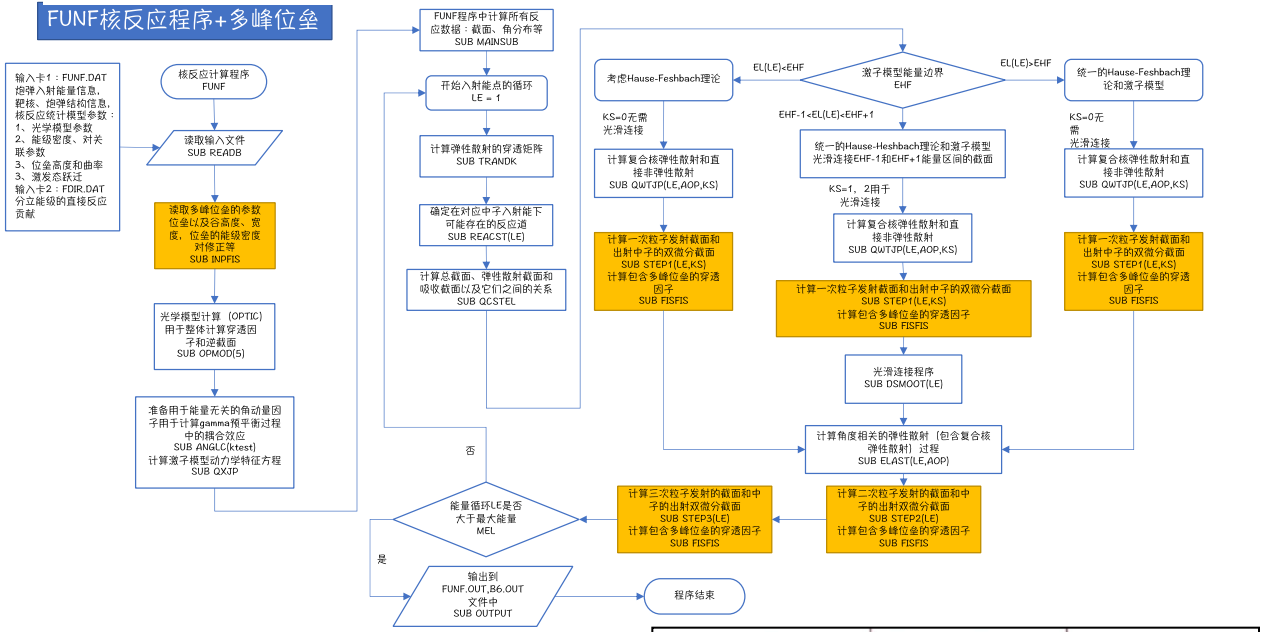
Calculation system for FP nuclei (CENDL-3.1 to 3.2)	
sunf2unf.pl	Convert sunf->unf
Batchcal	Produce unf.newunf
batchmincard.pl	Auto-produce inputs SEMAW.in, DPPMI.in, Min.in , sys.dat, exp
Correctmin	Correct the energy margin of min.in
get14MevCSInl	Produce the direct reaction cross section based on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

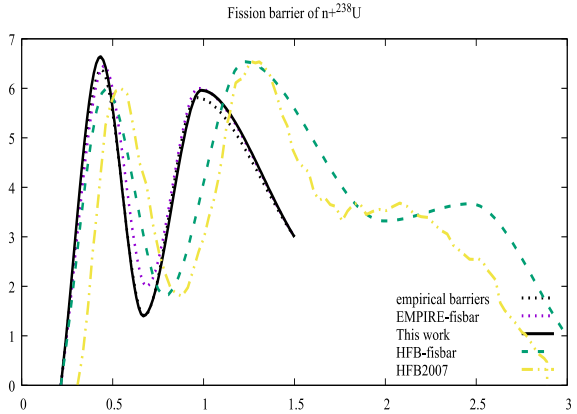
核素	输入卡	核素	输入卡	核素	输入卡	核素	输入卡
12-MG-24	UNF	32-GE-70	UNF	39-Y-89	SUNF	44-RU-102	SUNF
12-MG-25	UNF	32-GE-71	UNF	39-Y-91	SUNF	44-RU-103	SUNF
12-MG-26	UNF	32-GE-72	UNF	40-ZR-90	UNF	44-RU-104	SUNF
14-SI-28	UNF	32-GE-73	UNF	40-ZR-91	UNF	44-RU-105	SUNF
20-CA-40	UNF	32-GE-74	UNF	40-ZR-92	UNF	44-RU-99	SUNF
22-TI-46	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

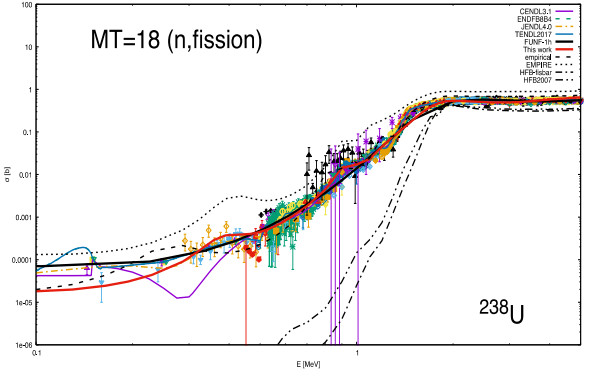
核素	输入卡	核素	输入卡	核素	输入卡
54-XE-123	SUNF	57-LA-139	SUNF	62-SM-149	SUNF
54-XE-124	SUNF	58-CE-141	SUNF	62-SM-150	SUNF
54-XE-129	SUNF	58-CE-144	SUNF	62-SM-151	SUNF
54-XE-131	SUNF	59-PR-141	SUNF	62-SM-152	SUNF
54-XE-132	SUNF	60-ND-142	SUNF	62-SM-154	SUNF
54-XE-134	SUNF	60-ND-143	SUNF	63-EU-151	SUNF
54-XE-135	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		

New fission reaction code — FUNF-2020

+ Multi-humped fission







No.	Channels	No.	Channels	No.	Channels
0	(n,γ)	4	(n,d)	8	(n,f)
1	(n,n')	5	(n,t)	9	(n,nf)
2	(n,p)	6	(n,2n)	10	(n,2nf)
3	(n,α)	7	(n,3n)		

Reaction channels considered in FUNF

Input：

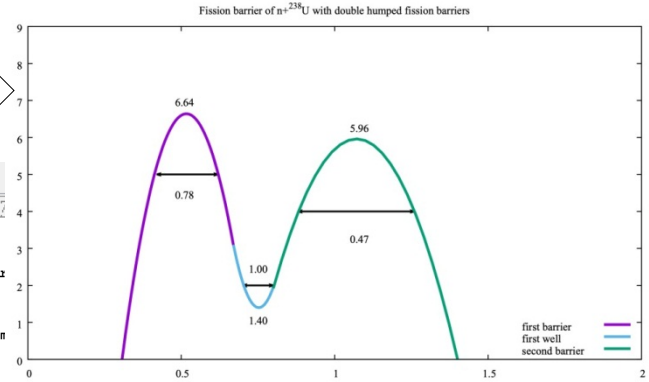
FUNF: input files

fisbar.dat | fis.inp | FUNF.DAT

```
KTEST, KENDF, KFI, KSEN, KSYS, ifisty
   0   1   0   0   0   1
A, Z, AMT, CK, EF, CE1, DGMA, alink
 235  92    235.0439240  2000.000    35.000     0.080     0.150     1.000
MATERIAL NUMBER
1235
THE STATUS OF TARGET 1: GROND STATE            >1: ISOMORIC STATE
   1
NUMBER OF INCIDENT ENERGIES AND ENERGIES
  56   0
  0.100000E-10  0.100000E-01  0.200000E-01  0.300000E-01  0.400000E-01  0.500
  0.600000E-01  0.700000E-01  0.800000E-01  0.900000E-01  0.103440E+00  0.226
  0.334230E+00  0.416580E+00  0.512090E+00  0.610710E+00  0.700000E+00  0.800
  0.900000E+00  0.100000E+01  0.150000E+01  0.200000E+01  0.250000E+01  0.300
  0.350000E+01  0.400000E+01  0.450250E+01  0.500000E+01  0.550000E+01  0.560
  0.570000E+01  0.580000E+01  0.600000E+01  0.650000E+01  0.700000E+01  0.750
  0.800000E+01  0.850000E+01  0.900000E+01  0.950000E+01  0.100000E+02  0.105
  0.110000E+02  0.115000E+02  0.120000E+02  0.125000E+02  0.130000E+02  0.135
  0.140000E+02  0.145000E+02  0.150000E+02  0.160000E+02  0.170000E+02  0.180
  0.190000E+02  0.200000E+02
  3   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1   1   1   1   1   3
ENERGY BOUND OF HF CALCULATION
  4.3200
ANGLES
  30.0  60.0  90.0 120.0 150.0      0.01
BINDING ENERGIES (0:7)
        0.00000       6.54582       7.17830      -4.57246      11.02910
        5.29761       6.84576
LEVEL DENSITY PARAMETERS (0:10)
       28.143800     28.624360     18.437017      7.249584     27.226789     17.
       30.798336     32.587002     29.112480     30.165726     31.675702
PAIR CORRECTION VALUES (0:10)
        1.098686      0.085980     -0.011141      1.129761      1.265677      1.
        0.114416     -0.669505     -0.097520     -0.162096     -0.269447
PARAMETERS OF GIANT RESONANSE MODEL (0:7)          CSG, EE, GG
    0.2218    0.7100    0.4146    0.4235    0.6800    0.3521    0.3281    0.3485
    0.7649    0.0595    0.4954    0.4582    0.0283    0.0777    0.2952    0.6227
   10.8227    9.0997   13.2292   11.0470   13.1051   13.1891   11.1200   11.2843
   13.5810   13.8500   13.4922   13.8617   13.1530   13.2167   15.0596   10.5099
    3.4369    2.4271    5.1327    2.5944    4.9889    5.0255    2.5170    2.0552
    4.5560    4.6766    5.0847    4.7374    4.9671    4.9727    4.6233    4.1960
INPUT THE RESIDUAL EXCITATION ENERGY "EREXCIT"
   16.5000
BIN SIZE IN GAMMA PRODUCTION
    0.1000
FISSION BARRIER (3) AND CURVATURE PARAMETER (3)
       6.625940      5.621008      6.282088
       0.654993      0.668938      1.159844
COEFFICIETS OF FISSION LEVEL DENSITY CKF(3)
       1.385468      4.197341      2.652831
DATA OF FISSION CROSS SECTIONS
       0       0       0
DISCRETE LEVEL NUMBER FOR ALL  RESIDUAL NUCLEI    (0:7)
  20  40   1  20   2   6   1   1
FOR  92  U 238
```

fisbar.dat | fis.inp | FUNF.DAT

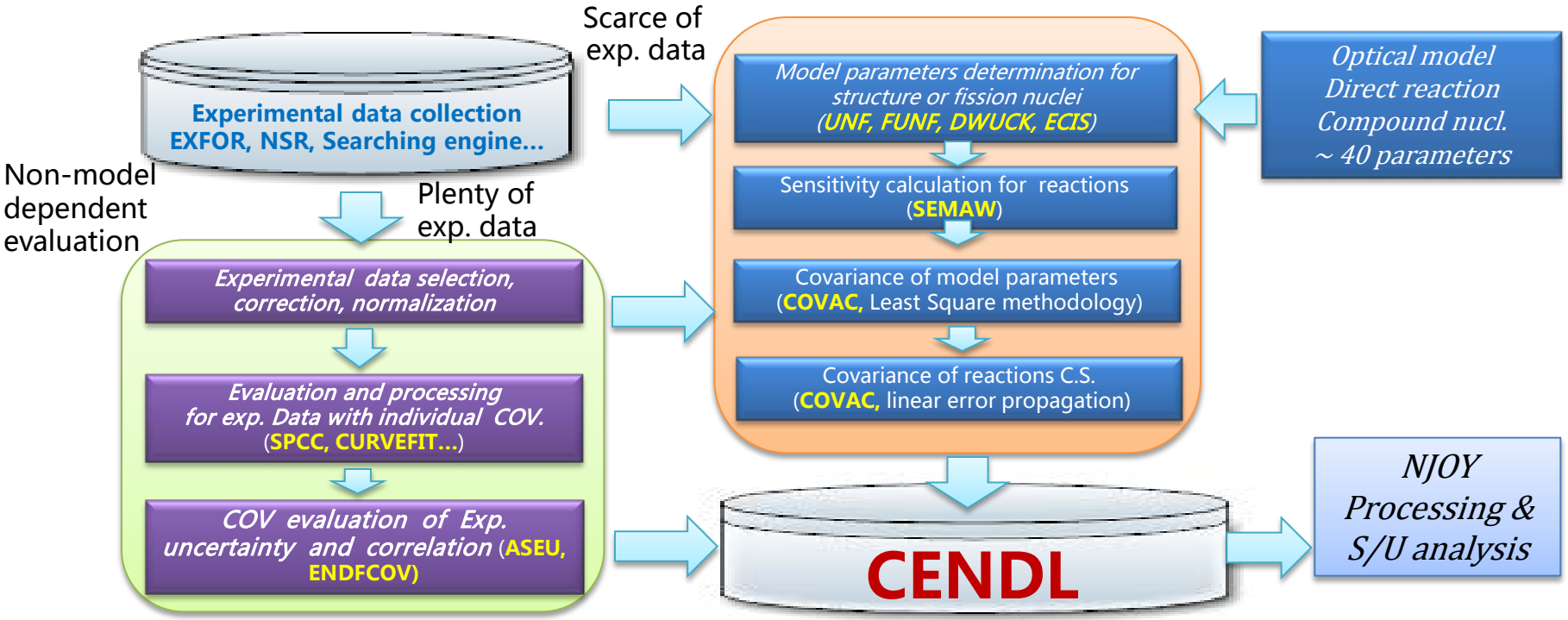
```
92 239 3 1 6.64 0.78 5.96 0.47 1.40 1.00
```



fisbar.dat | fis.inp | FUNF.DAT

```
# FISSHI  FISOPT  FISBAR  FISDEN  FISDIS  FISMOD  FISTGA
     0       1      -1       1       1       0       0
#FISSHI: controls treatment of the fission channel for nucleus
         0 advanced low-energy fission treatment with multi-humped bar
#FISOPT: controls subbarrier effects for nucleus
         0 no subbarrier effects
         1 subbarrier effects considered
         2 subbarrier effects considered including isomeric fission and gamm
#FISBAR: controls origin of fission barrier data for nucleus
        -1 fission barrier given by 'fisbar.dat'
         0 internal EMPIRE fission barrier library
         1 RIPL-3 empirical fission barrier
         2 Parabolic approximation derived from numerical RIPL-3 HFB
         3 one-dimension non-parabolic numerical RIPL-3 HFB
         4 one-dimension non-parabolic numerical SKYAX
#FISDEN: controls level density at saddle points for nucleus
         0 EGSM
         1 Gilbert-Cameron
         3 HFB microscopic calculations
#FISDIS: controls discrete transitional states
         0 no discrete states above fission barrier
         1 discrete states above fission barrier
#FISMOD: controls multi-modality of fission for nucleus
         0 single modal fission
         1 2 modes multimodal fission
         2 3 modes multimodal fission
#FISTGA: Gamma transition probability for the isomeric gamma cascade in the second well.
```

For evaluation of cross section, the orthogonal polynomial fitting code SPF developed in CNDC or GMA were used if there are enough measurements. While only a few data were found, the evaluation was performed by means of theoretical calculations using APMN+UNF/FUNF or EMPIRE/TALYS. Sometime the systematic analysis codes developed by CNDC were also considered.



Correlations among single (or multiple) set(s) of experimental data are vital elements to get an 'honest' covariance.

Non-model dependent evaluation：Experimental COV construction via considering all the uncertainties sources.

ASEU2.0 ：多家数据、多反应截面不确定度源项分析的程序

改进功能：可用来构建相同（or不同）核反应截面之间实验协方差矩阵，考虑同一个测量数据内部各能点信息；考虑不同测量间各能点信息；

输入卡：ASEU2.0 共包含card1、card2、card3 共三部分；

```
========= CARD 1 ==========
#n+90Zr
7
========= CARD 2 ==========
#ASEU items  % 程序自动判断unc源项的总数，第一行列为统计误差
*unc 01  statistics   - counting
*unc 02  neutron flux - differential cs of T(d,n)4He
*unc 03  neutron flux - background correction from D-D and other nuclei
*unc 04  neutron flux - correction for neutron multiple scattering
*unc 05  sample       - sample weighting
*unc 06  sample       - isotopic abundance
*unc 07  sample       - gamma self-absorption
*unc 08  monitor      - cross sections of monitor
*unc 09  detector     - efficiency of detector
*unc 10  irradiation  - decay data
*unc 11  others       - time of irradiation
#Peep inside various sources % 检测感兴趣的源项对总不确定度的贡献(对象：多项求和、单项)
2 3 4
#CC between data sets  (总行数=Iexp*(Iexp+1)/2-Iexp)  % unc-i：规定为统计误差，当该数值为1.0，表示这两家数据来自同一个测量有少量源项不同,两者之间
      unc-1   unc-2   unc-3   unc-4   unc-5   unc-6   unc-7   unc-8   unc-9   unc-10  unc-11
1  2  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1  3  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1  4  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1  5  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1  6  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
1  7  0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
```

Card 1：输入待研究反应截面信息；总测量家数

Card 2：列出不确定度源项 **unc-i**；
各类**unc-i**引起不同测量家间的关联系数；
rho(i,j) = exp[-(Ei-Ej)/w]

ASEU2.0 ：多家数据、多反应截面不确定度源项分析的程序

改进功能：可用来构建相同（or不同）核反应截面之间实验协方差矩阵，考虑同一个测量数据内部各能点信息；考虑不同测量间各能点信息；

输入卡：ASEU2.0 共包含card1、card2、card3 共三部分；

```
========= CARD 3 ==========所有不确定度为相对误差
#======Data Set: 1
17
   8.0000E+00 1.2200E-02  5.0E-01
   1.2130E+01 3.5400E-02  5.0E-01
   1.3330E+01 4.3500E-02  5.0E-01
   1.3400E+01 4.2900E-02  5.0E-01
   1.3520E+01 4.4000E-02  5.0E-01
   1.3690E+01 4.4100E-02  5.0E-01
   1.3880E+01 4.5400E-02  5.0E-01
   1.4010E+01 4.5100E-02  5.0E-01
   1.4090E+01 4.4500E-02  5.0E-01
   1.4310E+01 4.8000E-02  5.0E-01
   1.4500E+01 4.6400E-02  5.0E-01
   1.4680E+01 4.5000E-02  5.0E-01
   1.4810E+01 4.4900E-02  5.0E-01
   1.4930E+01 4.4400E-02  5.0E-01
   1.6500E+01 4.5900E-02  5.0E-01
   1.7950E+01 4.3600E-02  5.0E-01
   1.9760E+01 4.9300E-02  5.0E-01
#energy      unc-1     unc-2     unc-3     unc-4     unc-5     unc-6     unc-7     unc-8     unc-9     unc-10    unc-11
8.0000E+00   2.0E-01   1.5E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01
1.2130E+01   2.0E-01   1.5E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01
1.3330E+01   2.0E-01   1.5E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01
1.3400E+01   2.0E-01   1.5E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01
1.3520E+01   2.0E-01   1.5E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01   2.0E-01
```

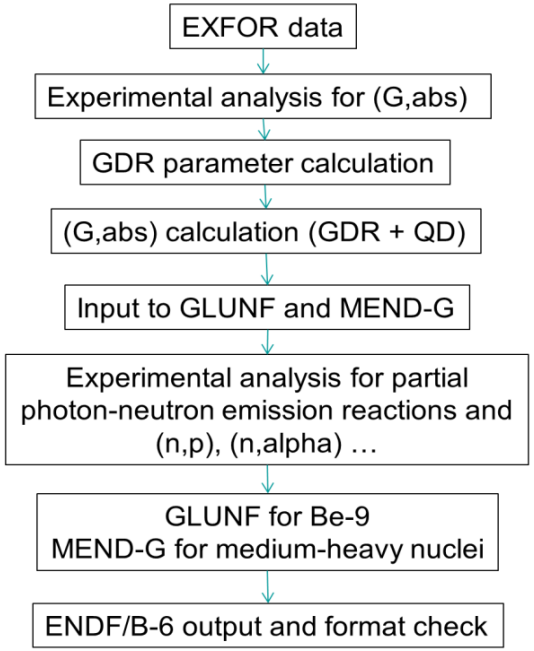
Card 3：逐家输入测量结果（含不确定度）
各类**unc-i**引起不同能量点的不确定度信息
各类**unc-i**引起不同能量点的关联系数**CC**

注：长程、中程、短程影响能量区域不同

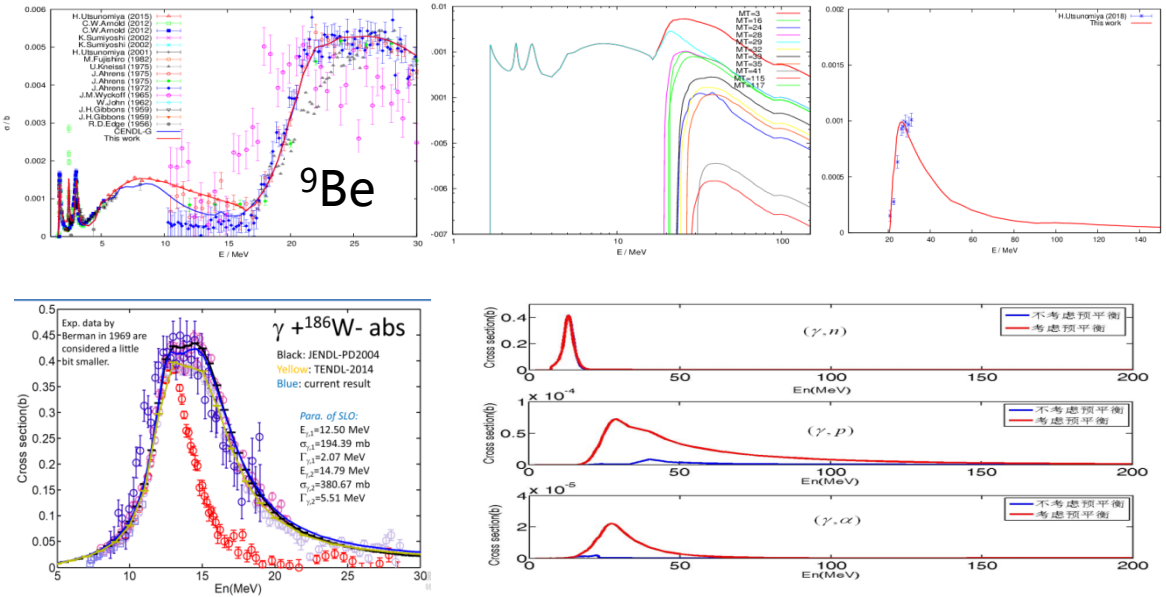
CENDL photon data — MEND-G & GLUNF

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

Evaluation Scheme for PD



^{9}Be — ^{209}Bi 274 nuclei



GLUNF： theoretical model code for the photon – light nuclei reaction system

Items	Content
Theory	(1) Light nucl: GLUNF (150MeV) (2) Middle-heavy nucl: GMEND (200MeV) (3) Updating PSF parameters： GDR parameter
Evaluation for Experimental data	(1) analyze the consistency of experimental data of different channels (2) Evaluate the details of experimental data (3) Recommend the final data list used in our work
Library compilation	Data recommendation and ENDF-6 format compilation

- MEND-G for middle-heavy nuclei up to 200MeV
- GLUNF for ^{6,7}Li, ^{9}Be, ^{10,11}B, ^{12}C up to 150MeV

GLUNF: Model code for the photon/light nuclei reaction system

- 7 models including the microscopic RQRPA, SLO, MLO et al. are utilized to estimate the photon strength function and derive the gamma absorption, Quasi-Deutron (QD) is included to describe the (g,abs) in the larger energy region;
- OMPs of n, p, a, ^{3}He, d, t were obtained from RIPL in GLUNF code;
- The pre-equilibrium and equilibrium emission are included;
- Recoil effect in multi-stage emission processes are included for the light nuclei;
- The 2nd particle emission is considered: ^{6}Li(12), ^{7}Li(12), ^{9}Be(26), ^{10}B (24), ^{11}B(35), ^{12}C(143).

Be-9(g,*) reactions in GLUNF

```
C=================================================================C
C              CLASSIFIED REACSTION SITUATION                     C
C=================================================================C
C  IB IVP   CHANNEL          KTP1 KTP2 KOP KGD KCH  REACTION    MT  C
C   0  0  (G,G)Be9             0         0   0   0  (G,G)Be9    102  C
C   1  1  (G,N)Be8             1         1   1   1  (G,N2A)      29  C
C   2  2  (G,P)LI8(K=1,2)      2         2   2   2  (G,P)LI8    601  C
C   3  3  (G,A)He5             3         3   3   1  (G,N2A)      29  C
C   4  4  (G,He3)He6(K=1)      4         4   4   3  (G,He3)He6  750  C
C   5  5  (G,D)Li7(K=1,2)      5         5   5   4  (G,D)Li7    650  C
C   6  6  (G,T)Li6(K=1,3)      6         6   6   5  (G,T)Li6    700  C
C-----------------------------------------------------------------C
C   1  7  (G,2N)Be7(K=1,2)     1    1    1   7   6  (G,2N)Be7    16  C
C   1  8  (G,NP)Li7(K=1,2)     1    2    2   5   7  (G,NP)Li7    28  C
C   1  9  (G,NA)A(K=1)         1    3    3   8   1  (G,N2A)      29  C
C              (K>1)A=P+T      1    3    3   8   8  (G,NPTA)     33  C
C              (K>1)A=N+He3    1    3    3   8   9  (G,2NHe3)A   24  C
C              (K>1)A=D+D      1    3    3   8  10  (G,N2D)A     35  C
C   1 10  (G,NHe3)He5(N+A)     1    4    4   3   9  (G,2NHe3)A   24  C
C   1 11  (G,ND)Li6(K=1,3)     1    5    5   6  11  (G,ND)Li6    32  C
C        (K=2,4,5)Li6=D+A      1    5    5   6  10  (G,N2D)A     35  C
C   1 12  (G,NT)Li5(P+A)       1    6    6   9   8  (G,NPTA)     33  C
C-----------------------------------------------------------------C
C   2 13  (G,PN)Li7(K=1,2)     2    1    1   5   7  (G,NP)Li7    28  C
C         (K>2)Li7=T+A         2    1    1   5   8  (G,NPTA)     33  C
C   2 14  (G,PD)He6(K=1)       2    5    5   4  12  (G,PD)He6   115  C
C                (K>1)         2    5    5   4  13  (G,2NPD)A    41  C
C   2 15  (G,PT)He5(N+A)       2    6    6   3   8  (G,NPTA)     33  C
C-----------------------------------------------------------------C
C   3 16  (G,AN)A(K=1)         3    1    1   8   1  (G,N2A)      29  C
C              (K>1)A=P+T      3    1    1   8   8  (G,NPTA)     33  C
C              (K>1)A=N+He3    3    1    1   8   9  (G,2NHe3)A   24  C
C              (K>1)A=D+D      3    1    1   8  10  (G,N2D)A     35  C
C   3 17  (G,AD)T              3    5    5  10  14  (G,DT)A     117  C
C-----------------------------------------------------------------C
C   4 18  (G,He3N)He5(N+A)     4    1    1   3   9  (G,2NHe3)A   24  C
C-----------------------------------------------------------------C
C   5 19  (G,DN)Li6(K=1,3)     5    1    1   6  11  (G,ND)Li6    32  C
C        (K=2,4,5..)Li6=D+A)   5    1    1   6  10  (G,N2D)A     35  C
C   5 20  (G,DP)He6(K=1)       5    2    2   4  12  (G,PD)He6   115  C
C                (K>1)         5    2    2   4  13  (G,2NPD)A    41  C
C   5 21  (G,DD)He5(N+A)       5    5    5   3  10  (G,N2D)A     35  C
C   5 22  (G,DT)A(K=1)         5    6    6   8  14  (G,DT)A     117  C
C-----------------------------------------------------------------C
C   6 23  (G,TN)Li5(P+A)       6    1    1   9   8  (G,NPTA)     33  C
C   6 24  (G,TP)He5(N+A)       6    2    2   3   8  (G,NPTA)     33  C
C   6 25  (G,TD)A(K=1)         6    5    5   8  14  (G,DT)A     117  C
C=================================================================C
```

Input file：GLUNF.dat

```
KTEST KENDF
  0     1
NUMBER OF INCIDENT ENERGIES AND "NOE"
228                    0
 1.5721  1.6900  1.7000  1.7100  1.7200  1.7300  1.7400  1.7500  1.7600  1.7700
 1.7800  1.7900  1.8000  1.8100  1.8200  1.8300  1.8400  1.8500  1.8600  1.8700
 1.8800  1.8900  1.9000  1.9100  1.9200  1.9300  1.9400  1.9500  1.9600  1.9700
 1.9800  1.9900  2.0000  2.0100  2.0200  2.0300  2.0400  2.0500  2.0600  2.0700
 2.0800  2.0900  2.1000  2.1100  2.1200  2.1300  2.1400  2.1500  2.1600  2.1700
 2.1800  2.1900  2.2000  2.2100  2.2200  2.2300  2.2400  2.2500  2.2600  2.2700
 2.2800  2.2900  2.3000  2.3100  2.3200  2.3300  2.3400  2.3500  2.3600  2.3700
 2.3800  2.3900  2.4000  2.4100  2.4200  2.4300  2.4400  2.4500  2.4600  2.4700
 2.4800  2.4900  2.5000  2.5100  2.5200  2.5300  2.5400  2.5500  2.5600  2.5700
 2.5800  2.5900  2.6000  2.6500  2.7000  2.7500  2.8000  2.8500  2.9000  2.9500
 3.0000  3.0500  3.1000  3.1500  3.2000  3.2500  3.3000  3.3500  3.4000  3.4500
 3.5000  4.0000  4.5000  5.0000  5.5000  6.0000  6.5000  7.0000  7.5000  8.0000
 8.5000  9.0000  9.5000 10.000  10.500  11.000  11.500  12.000  12.500  13.000
13.500  14.000  14.500  14.750  15.000  15.500  15.721  16.000  16.500  16.713
16.904  17.000  17.191  17.500  17.707  17.887  18.000  18.500  18.941  19.000
19.185  19.250  19.500  19.898  20.000  20.588  21.000  21.203  21.278  21.352
21.414  22.000  22.189  22.500  23.000  23.004  23.077  23.370  23.408  23.979
24.000  24.189  24.500  24.750  25.000  25.250  25.458  25.500  25.750  26.000
26.250  26.406  26.587  26.712  27.000  27.500  27.690  27.981  28.000  28.500
29.000  29.500  30.000  31.000  32.000  33.000  34.000  35.000  36.000  37.000
38.000  39.000  40.000  41.000  42.000  43.000  44.000  45.000  46.000  47.000
48.000  49.000  50.000  55.000  60.000  65.000  70.000  75.000  80.000  85.000
90.000  95.000 100.00  110.00  120.00  130.00  140.00  150.00
INPUT "MET" (=0 ONLY OUTPUTING C.S; =1 OUTPUTING NEUTRON SPECTRA)
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  1  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0
0  0  1  0  0  0  0  0  0  0
```

Incident energies

```
NUMBER OF INCIDENT ENERGIES for absorbtion cross section
177
 1.5721  1.6700  1.6800  1.6900  1.7000  1.7100  1.7200  1.7300  1.7400  1.7500
 1.7600  1.7700  1.7800  1.7900  1.8000  1.8100  1.8200  1.8300  1.8400  1.8500
 1.8600  1.8700  1.8800  1.8900  1.9000  1.9100  1.9200  1.9300  1.9400  1.9500
 1.9600  1.9700  1.9800  1.9900  2.0000  2.0100  2.0200  2.0300  2.0400  2.0500
 2.0600  2.0700  2.0800  2.0900  2.1000  2.1100  2.1200  2.1300  2.1400  2.1500
 2.1600  2.1700  2.1800  2.1900  2.2000  2.2100  2.2200  2.2300  2.2400  2.2500
 2.2600  2.2700  2.2800  2.2900  2.3000  2.3100  2.3200  2.3300  2.3400  2.3500
 2.3600  2.3700  2.3800  2.3900  2.4000  2.4100  2.4200  2.4300  2.4400  2.4500
 2.4600  2.4700  2.4800  2.4900  2.5000  2.5100  2.5200  2.5300  2.5400  2.5500
 2.5600  2.5700  2.5800  2.5900  2.6000  2.6500  2.7000  2.7500  2.8000  2.8500
 2.9000  2.9500  3.0000  3.0500  3.1000  3.1500  3.2000  3.2500  3.3000  3.3500
 3.4000  3.4500  3.5000  4.0000  4.5000  5.0000  5.5000  6.0000  6.5000  7.0000
 7.5000  8.0000  8.5000  9.0000  9.5000 10.000  10.500  11.000  11.500  12.000
12.500  13.000  13.500  14.000  14.500  15.000  15.500  15.721  16.000  16.500
16.713  17.000  17.191  17.500  17.707  18.000  18.500  18.941  19.000  19.500
20.000  20.100  20.588  21.000  21.202  22.000  23.000  24.000  25.000  26.000
27.000  28.000  29.000  30.000  35 40 50 60 70 80 90 100 110 120 130 140 150
Be-9 CS(G,ABS) mb
0 0.000306824 0.0011196 0.0014134 0.001414 0.0013344 0.0012431 0.0011582
0.0010834 0.0010183 0.000961523 0.000911833 0.000868013 0.000829102 0.000794322
0.000763022 0.000734712 0.000708962 0.000685442 0.000663872 0.000644012 0.000625471 0.000608081
0.000591881 0.000576771 0.000562621 0.000549361 0.000536911 0.000525201 0.000514171 0.00050378
0.00049398 0.00048473 0.00047599 0.00046774 0.00045995 0.0004526 0.00044567 0.00043915 0.00043302
0.00042727 0.00042183 0.00041677 0.00041193 0.00040753 0.00040348 0.0003998 0.00039651 0.00039361
0.00039112 0.00038908 0.00038751 0.00038645 0.00038596 0.0003861 0.00038695 0.0003886 0.00039117
0.00039483 0.00039976 0.0004062 0.00041438 0.00042468 0.00043769 0.00045409 0.00047478 0.00050094
0.00053418 0.00057662 0.00063105 0.00070107 0.00079093 0.00090478 0.0010445 0.0012048 0.0013661
0.0014908 0.0015368 0.0014874 0.0013651 0.0012117 0.0010604 0.00092792 0.00081895 0.00073166
0.00066245 0.00060761 0.00056402 0.0005292 0.00050125 0.00047873 0.00046056 0.00044591 0.00043417
0.00042485 0.00040451 0.00041467 0.00045231 0.00052479 0.00064859 0.00084856 0.0011366 0.0014292
0.0015033 0.0012954 0.0010089 0.00077892 0.00062022 0.00051364 0.00044115 0.00039074 0.00035494
0.00032914 0.00028274 0.00043535 0.00091038 0.00098003 0.00118 0.00131 0.00142 0.00149 0.00153
```

Incident energies and absorption XS

```
DISCRETE LEVEL NUMBER FOR ALL   RESIDUAL NUCLEI (0:10)
 19   22   10   12   5   9   7   9   16   12   1
0: FOR (G,G) Be-9  NDL=19
0.0000 1.6850 2.4294 2.7800 3.0490 4.7040 6.7600 7.9400 11.283 11.810
13.790 14.392 14.400 15.100 15.970 16.671 16.975 17.298 17.493
1.5000 0.5000 2.5000 0.5000 2.5000 1.5000 3.5000 0.5000 1.5000 0.5000
3.5000 1.5000 0.5000 2.5000 2.5000 1.5000 0.5000 2.5000 3.5000
 -1     1    -1    -1     1     1    -1    -1     1     1
 -1    -1    -1     1    -1     1    -1    -1     1
1: FOR (G,N) Be-8  NDL=22
 0.000 3.0400 11.400 16.626 16.922 17.640 18.150 18.910 19.070 19.240
19.400 19.860 20.100 20.200 20.900 21.500 22.000 22.200 24.000 25.200
25.500 27.4941
   0.0    2.0    4.0    2.0    2.0    1.0    1.0    2.0    3.0    3.0
   1.0    4.0    2.0    0.0    4.0    3.0    1.0    2.0    1.0    2.0
   4.0    0.0
   1      1      1      1      1      1
  -1      1      1      1     -1      1
   1      1
2: FOR (G,P) Li-8   NDL=10
   0.0000 0.9808 2.2550 3.2100 5.4000 6.1000 6.530 7.1000 9.6700 10.8222
   2.0000 1.0000 3.0000 1.0000 0.0000 3.0000 4.000  1.000 1.0000  0.0000
```

Levels of residuals

```
INPUT OPTICAL POTENTIAL PARAMETERS (N,P,A,HE-3,D,T)
   1.584148   0.63680    0.39000    0.52000    0.37740    0.38655
   1.193309   0.31020    0.25000    0.30000    0.30272    0.29400
   1.434096   0.78710    0.39000    0.50000    0.14500    0.29400
   1.533548   0.55000    0.39000    0.52000    0.35500    0.48600
   1.15589    1.21910    0.90000    1.20000    1.01550    1.42101
   1.55255    1.11530    0.90000    0.90000    1.31320    0.73599
   1.69357    1.02810    0.90000    0.90000    1.63770    1.29200
   1.15589    1.25000    0.90000    1.20000    1.64000    1.21500
   1.50000    1.50000    0.90000    1.30000    1.05000    1.40000
  -1.68278   -2.70850    0.00000    0.00000    3.69990   12.00002
   0.30853    0.30850    0.00000    0.00000    0.30032    6.09004
   0.00562   -0.50       0.00000    0.00000    0.15999   -0.12900
  60.29005   53.95910  133.00000  101.90000  150.75999  139.04668
  -0.28640   -0.31940   -0.30000   -0.50000   -0.58920   -0.63000
   0.01760   -0.00049    0.00100    0.00000   -0.13748    0.63100
 -24.00000   24.00000    0.
   0.00330    0.40000    0.
   6.24281    6.20000    0.00000    2.50000    7.00000    3.61000
   7.93996   16.99000   15.00000    4.00000   17.64150   22.49991
  -0.33296   -0.05824   -0.25000   -0.15000   -0.17434    4.00000
 -12.00000   12.00000    0.00000    0.00000    0.00021    0.00000
      0.70000       0.70000
```

OMPs for particle emission

MEND-G：Model code for the photon/medium heavy nuclei reaction system

Control parameters & incident energies

```
MENDG INPUT FILE
Ntest,IGAP,IENDF,MAT,IaDL,INCS,ispe,NFIS,IZ0,IA,    NC,NOP,NCL,  DK,   ALPHA,BETA, ce1, dgama,sgmin
   0   1   1    2328   1   1   1   0  23  51   0   4   1  1900.0     1.0     0.0     1.0     1.0 0.2E-05
Np0,Nh0 for photonuclear data
   2   2
order of particle emission
   0
LEL,EL(LET),NANG(LET)
  70
     2.00      2.80      3.60      4.40      5.20      6.00      6.80      7.60      8.40      9.20
    13.00     13.39     13.78     14.17     14.56     14.94     15.33     15.72     16.11     16.50
    18.00     18.50     19.00     19.50     20.00     20.50     21.00     21.50     22.00     23.00
    24.00     25.00     25.50     26.00     26.50     27.00     27.50     28.00     28.50     29.00
    30.00     30.50     31.00     31.50     32.00     32.50     33.00     34.00     35.00     36.00
    37.00     38.00     39.00     40.00     41.00     41.50     42.00     42.50     43.00     43.50
    44.00     45.00     45.50     46.00     46.50     47.00     47.50     48.00     49.00     50.00
    51.00     52.00     53.00     54.00     55.00     56.00     57.00     58.00     59.00     60.00
    62.00     64.00     66.00     68.00     70.00     72.00     74.00     76.00     78.00     80.00
    82.50     85.00     90.00     95.00    100.00    130.00    150.00    180.00    200.00
        0         0         0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0         0         0
R(6),W2N,W3N,WPN,ALPH,BET,ALPA
```

Levels of residuals

```
KMM(0:6): numbers of discrete levels                in 7 channels KMM(I,J), J=0,6
       40        40        40        28        40        40        35
FOR  51V    Z= 23   A= 51
  0.000000  0.320084  0.470000  0.928640  1.010000  1.190000  1.609236
  1.910000  2.410750  2.546400  2.600000  2.677460  2.699631  2.790000
  3.083520  3.150000  3.215500  3.264390  3.279990  3.310000  3.320000  3.372000
  3.377680  3.381100  3.383200  3.385587  3.395020  3.412800  3.443910  3.454090
  3.516940  3.555500  3.562600  3.568200  3.576780  3.614065  3.623100  3.632030
       3.5       2.5       1.5       1.5       3.5       0.5       5.5       4.5
       4.5       1.5       0.5       2.5       1.5       7.5       2.5       1.5
       2.5       1.5       1.5       2.5       2.5       3.5       4.5       1.5
       4.5       2.5       4.5       6.5       6.5       3.5       2.5       4.5
       4.5       3.5       3.5       2.5       1.5       4.5       1.5       2.5
        -1        -1         1        -1         1         1        -1        -1
         1        -1         1         1         1        -1         1         1
        -1        -1        -1        -1        -1         1         1        -1
        -1        -1        -1        -1        -1         1        -1        -1
                            -1        -1        -1        -1        -1        -1
```

MENDI.dat for g+V-51

```
R(6),W2N,W3N,WPN,ALPH,BET,ALPA
      1.00      1.00      0.75      0.75      0.75
      1.00      1.00      1.00      0.00      0.00      1.00
EFLM1,EFLM2,RFLM(3:6)
    100.00    150.00      0.30      1.00      0.30      0.30
ASS,   UC,   UA,   facud   Uxpd, estar,  a10, a11  , a12,   EHFPE,EDEL
0.0088    1.40  263.00    0.90    0.00 2000.00  1.0000  0.0000  0.0000   6.5   5.0
OM paramwters(n,p,alpha,d,t,He-3)
AR,AS,AVV,AS0,XR,XS,XV,XS0,XC,U0,U1,U2,V0,V1,V2,   V3,V4,VS0,W0,W1,W2,EW,W1h As1,Av1
   0.6584900000   0.5187700000   0.6578000000   0.8092396900   0.6578000000   0.6578000000
   0.6315300000   0.7127100000   0.6359000000   0.7315233000   0.6359000000   0.6359000000
   0.7644700000   0.3025500000   0.5587000000   0.9666246500   0.5587000000   0.5587000000
   0.7500000000   0.7500000000   0.8500000000   0.8130024100   0.8500000000   0.8500000000
   1.2287300000   1.3212300000   1.3421000000   1.1736277300   1.3421000000   1.3421000000
   1.1446200000   0.9732200000   1.2928000000   1.3275184600   1.2928000000   1.2928000000
   1.1758000000   1.5902700000   1.4259000000   1.5628659700   1.4259000000   1.4259000000
   1.0100000000   1.0100000000   1.2686000000   1.2335057300   1.2686000000   1.2686000000
   1.2500000000   1.2394400000   1.3500000000   1.6977314900   1.3500000000   1.3500000000
  -1.8033000000   0.4510000000  -4.0174000000   2
   0.1281900000   0.0000160000   0.1409000000   0
  -0.0002650000  -0.0100000000   0.0000000000   0
  53.1012200000  45.3857300000 175.0881000000  82.1783218400 175.0881000000 175.0881000000
  -0.2955300000  -0.3310100000  -0.6236000000  -0.1480910900  -0.6236000000  -0.6236000000
   0.0006148000   0.0007100000   0.0006000000  -0.0008857100   0.0006000000   0.0006000000
 -24.0000000000   8.5043900000  30.0000000000 -34.8110160800  30.0000000000  30.0000000000
   0.0000000000   0.0668600000  -0.2360000000   1.0584393700  -0.2360000000  -0.2360000000
```

OMP of emission particles

```
                                  fused=0.0 vs. GCC/Su,      fused=.05 vs. Ignatyuk.
                                  fused,   faif(6)
                    0.0200    0.0800    0.0600    0.0950
   0.1375  0.84E-04    0.0500
   1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
!fpse(6),          fpe1(6)
     0.0       0.0       0.0       0.0       0.0       0.0
     0.0       0.0       0.0       0.0       0.0       0.0
! if NOP=4, read in the following KD's              (A.J.Koning & J.P.Delaroche) OM parameters.
!ark,ask,avk,asok,rrK,rsK,rvK,rsoK,rcK,V1k,V2K,     V3K,V4K,D1K,D2K,D3K,W1K,W2K,Vso1,Vso2,Wso1,Wso2
!for particle n(left)    and          p(right).
  0.6778  -0.149E-03          0.6778  -0.149E-03
  0.5446  -0.166E-03          0.5187   0.521E-03
  0.6778  -0.149E-03          0.6778  -0.149E-03
  0.59                        0.59
  1.3039  -0.405E+00          1.3039  -0.405E+00
  1.3424  -0.158E-01          1.3424  -0.158E-01
  1.3039  -0.405E+00          1.3039  -0.405E+00
  1.1854  -0.647E+00          1.1854  -0.647E+00
                              1.1980    0.6970   12.9940
 59.30 -21.00  -0.02          59.30  21.00   -0.02
  0.007228  -0.148E-05        0.007067   0.423E-05
  0.1994E-04 -0.2000E-07      0.1729E-04  0.1136E-07
  0.70E-08                    0.70E-08
 16.0 -16.0                   16.0  16.0
  0.0180 0.003802 156.0 8.0   0.0180 0.0038
 11.5                         11.5
 12.195  0.016700            14.667  0.009629
 73.550  0.079500            73.550  0.079500
  5.922  0.003000             5.922  0.003000
    0.0040                      0.0040
   -3.1000                     -3.1000
160.0000                    160.0000
```

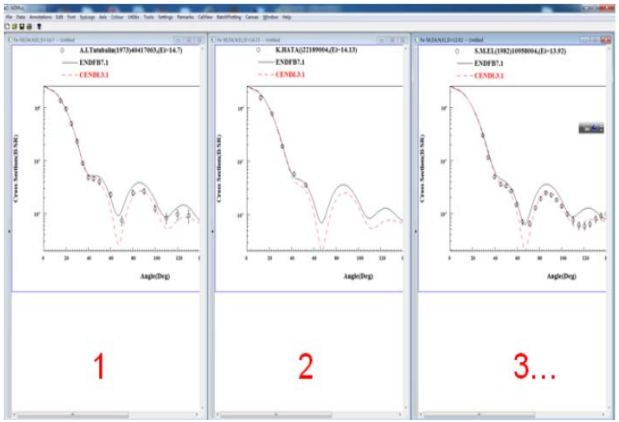
OMP of neutron and proton with KD potential

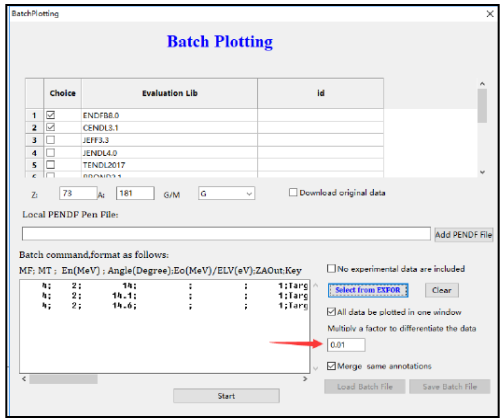
NDPlot

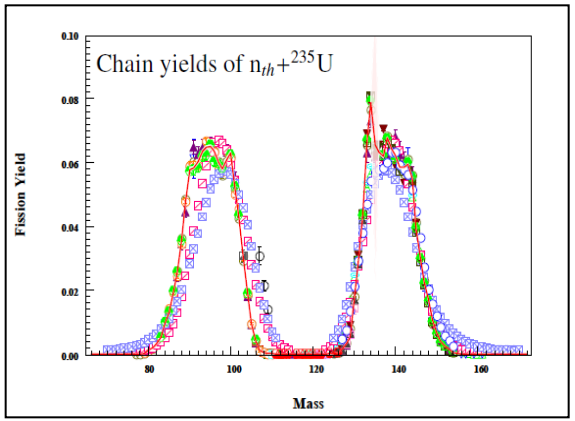
An efficient plotting tool NDPlot for nuclear data. It is not only a plotting tool for nuclear data, but also integrated application system.

NDPlot can manage experimental and evaluated data of nuclear reaction cross sections, angular distributions of secondary particles, energy distributions of secondary particles and product energy-angle distributions etc.

It also provides data processing functions such as curves summation capability to meet users' requirements.



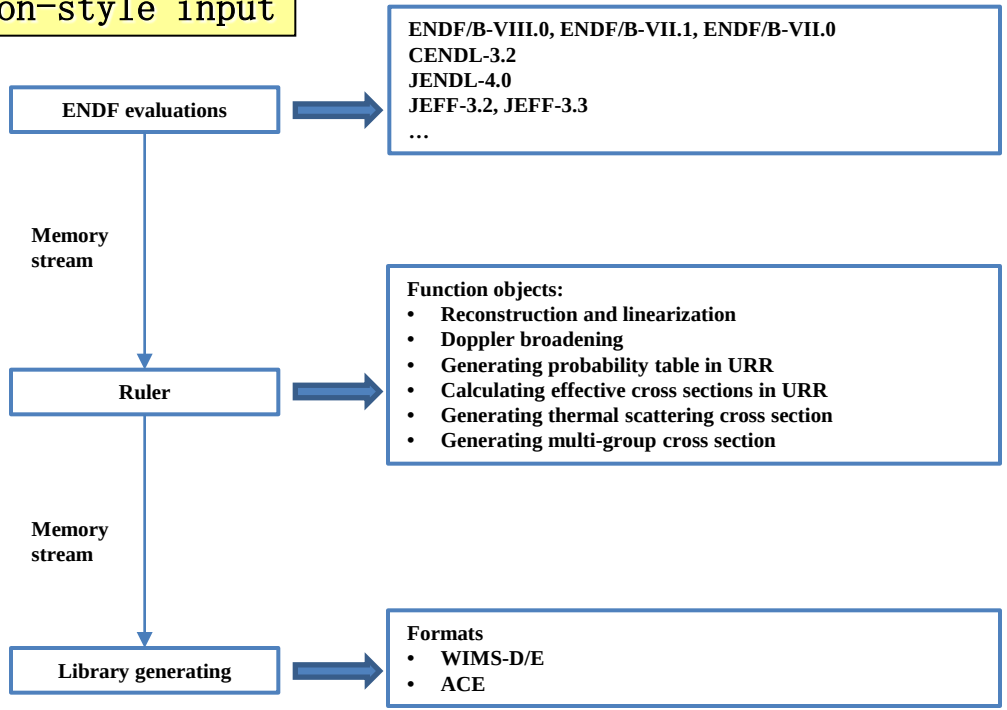




Nuclear Data Processing Code - Ruler

```
{
    "module":"ResonanceReconstruction",
    "inFile":"n_092-U-235.endf",
    "outFile":"tape21",
    "tolerance":0.001
}
{
    "module":"DopplerBroadening",
    "inFile":"tape21",
    "outFile":"tape22",
    "temperature":293,
    "ergMax":22500,
    "tolerance":0.002
}
{
    "module":"ProbabilityTable",
    "endf":"n_092-U-235.endf",
    "inFile":"tape24",
    "outFile":"tape25",
    "sigmaZeros":[1e10, 3e2],
    "ladderCount":100,
    "binCount":20
}
```

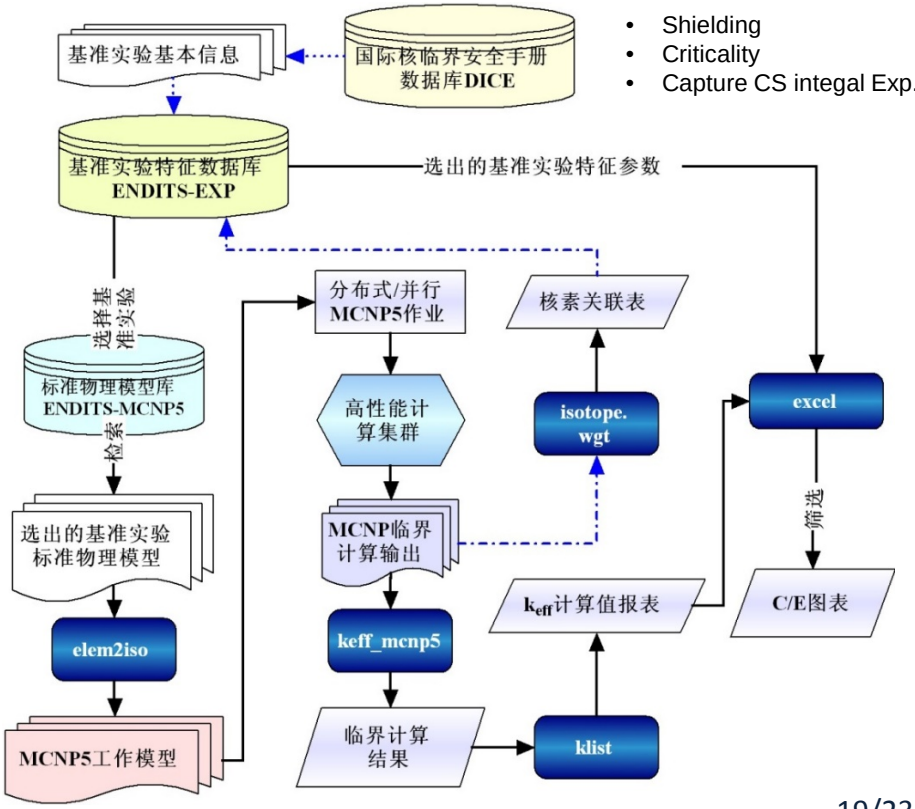
Json-style input



Auto. Testing System for Verification/Validation of ND – ENDITS

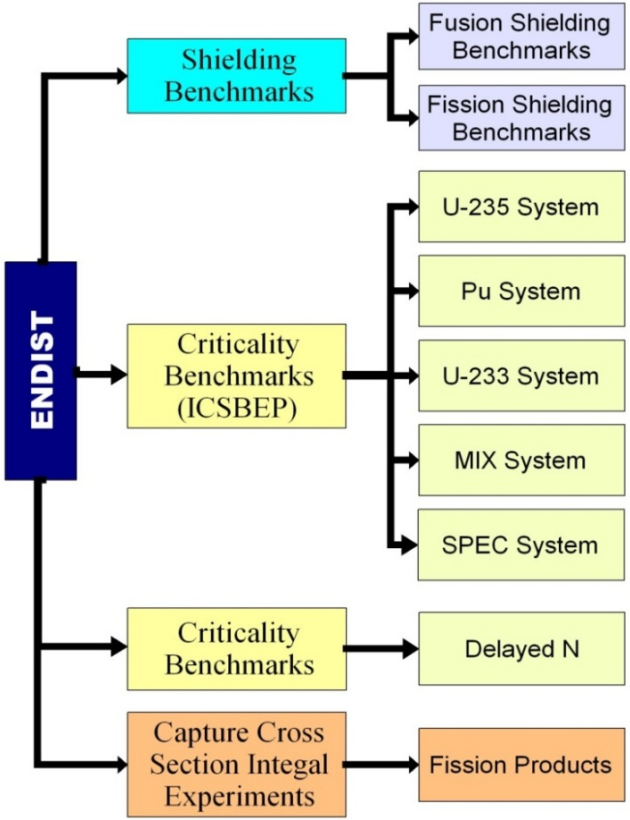
Auxiliary programs of ENDITS

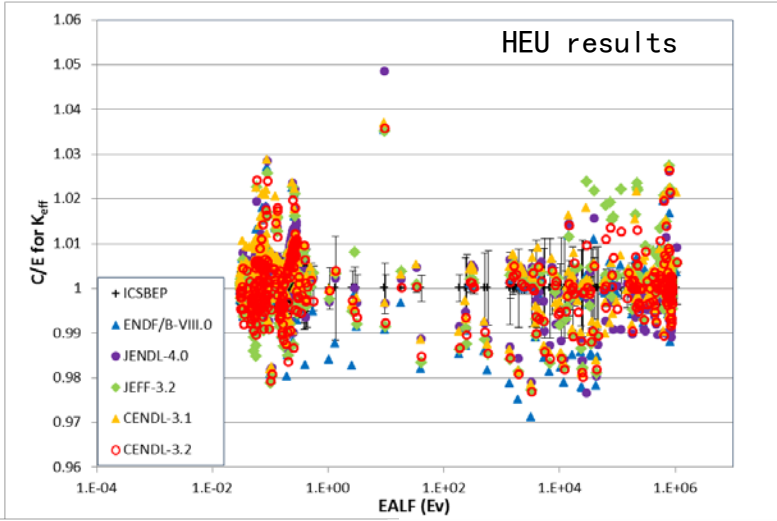
elem2iso	Convert natural nuclide -> isotopes
keff_mcnp	Auto-extract keff values
isotope.wgt	Auto-extract neutron reaction weights
klist	Extract results and generate reports

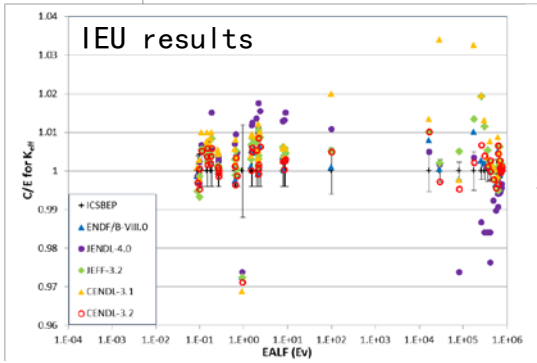


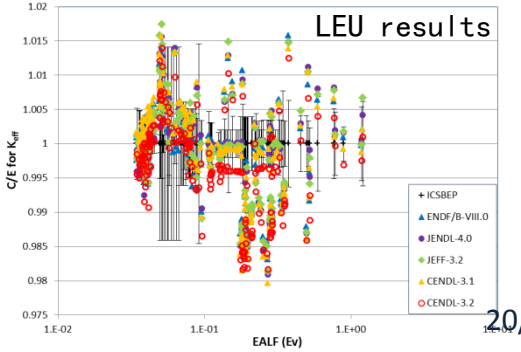
- Shielding
- Criticality
- Capture CS integal Exp.

Auto. Testing System for Verification/Validation of ND – ENDITS









Nuclear Data Adjustment Code - NDAC

NDAC: input file

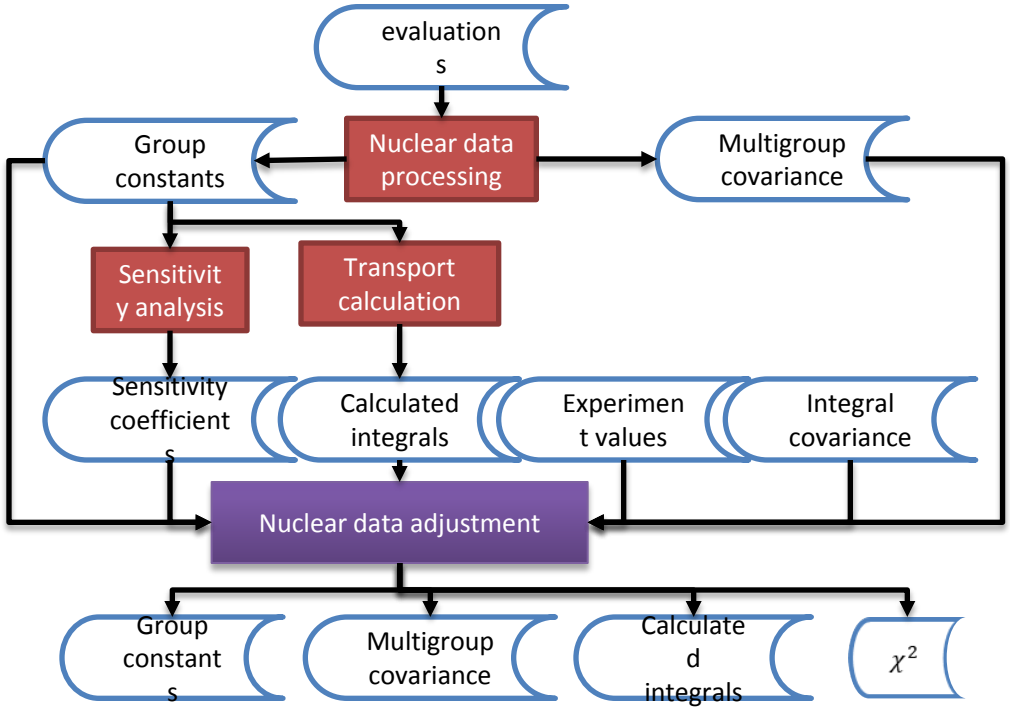
```
Card1
11 8 20

Card2
5010 8016 11023 24052
26056 28058 92235 92238
94239 94249 94241

Card3
3 2 3 4 3 101 3 251
3 18 1 452 5 18 1 455

Card4
sensitivity.txt
```

num. of isotopes, reactions, integrals

isotopes

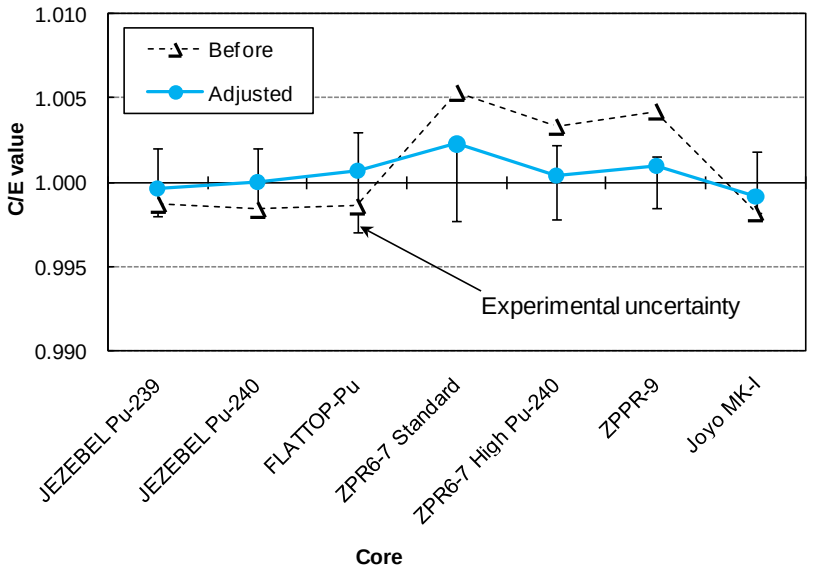
reactions

sensitivity profiles

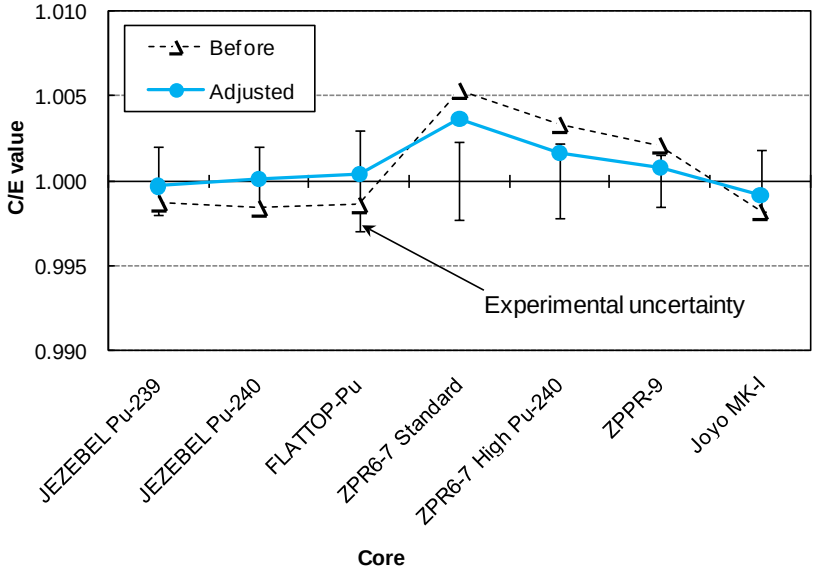


Nuclear Data Adjustment Code - NDAC

(Case 0: SG33 Standard Monte Carlo method (2D MC + INL's Corrective factors))



(Case 1: As-built Monte Carlo results)



Summary :

- Many utilities/codes and methodologies have been formed to accomplish the CENDL library, which contains of codes involving ND of reaction/structure modeling, exp. data eval., lib making/checking, benchmark/validation, etc. Many other excellent utilities from IAEA/other laboratories are also used.

- Various/complex codes, parameters, input/out formats used in the ND modeling, evaluation, checking and lib. establishing etc. it' s very inefficiency, fallibility for evaluators. Modern techniques (AI, ML and Big data etc.) should be introduced into the ND produce process to improve the efficiency and to guarantee the ND qualities.

- Efficient, friendly ND tools/methodologies for applications community are very importance, existing traditional tools/methodologies should be improved with modern techniques, so that the user could get correct ND and make the correct application with very convenient way. It will be benefit for both sides of ND researches and applications.

END