

# KAERI 핵데이터 연구 현황 (Nuclear Data Research Activities at KAERI)



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K N D C - P r o g r e s s   R e p o r t

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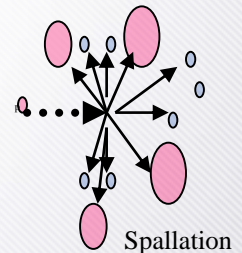
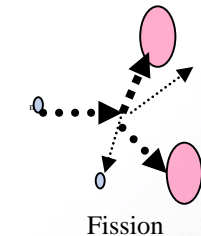
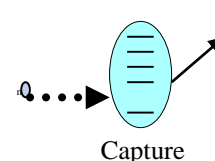
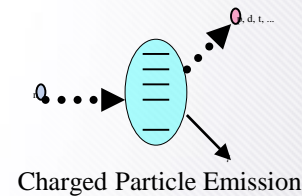
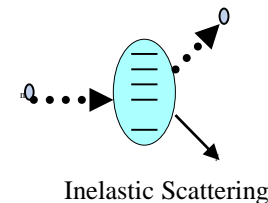
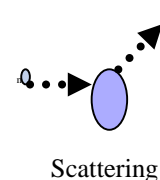
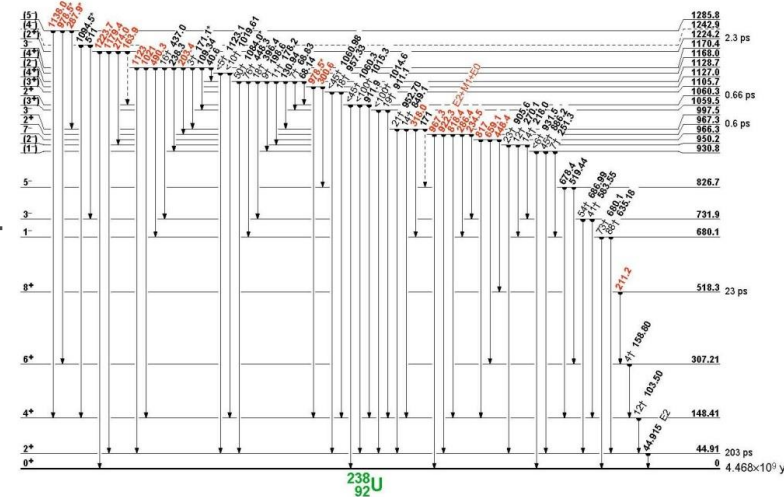
## 05 ND Processing/Validation

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# 01 Nuclear Data

## » What is Nuclear Data?

- Nuclear Structure Data (ENSDF)
  - Mass, excitation level, decay mode, half-lives, etc. (> 3000 nuclides)
  - **IAEA NSDD** (Int. Network of Nuclear Structure and Decay Data Evaluators)
  - KAERI, KRISS (Korea Research Institutes of Standards and Science)
- Nuclear Reaction Data (ENDF)
  - Reaction cross section, double differential cross section
  - **IAEA NRDC** (Int. Network of Nuclear Reaction Data Centers)
  - KAERI, a few Universities (measurement)

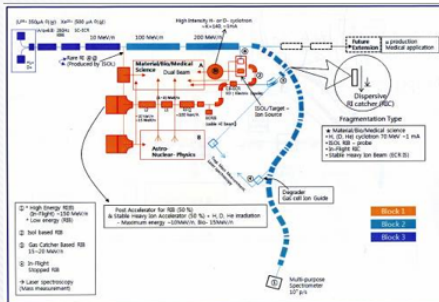


# 01 Nuclear Data

## » Nuclear Data Production

### 핵데이터 측정

- 가속기 이용
- 이론 미비/측정의 불일치
- 불가능한 에너지 및 반응



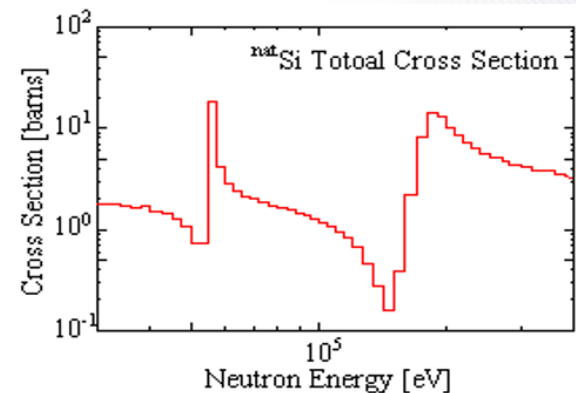
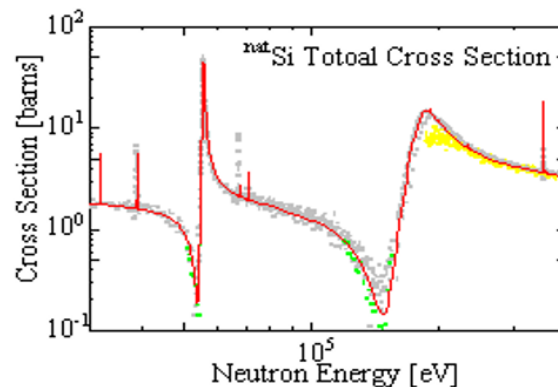
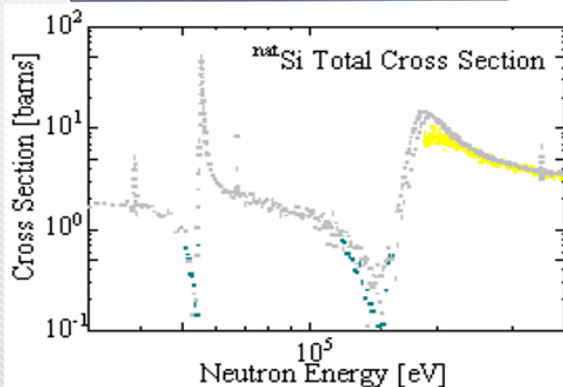
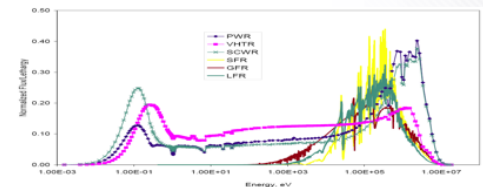
### 핵데이터 평가

- 실측치 분석
- 이론모형 도입
- 전구간 및 모든 반응 생산

$$\sigma_A = \frac{\pi}{k^2} \sum_{L=0}^{\infty} (2L+1)(1 - |S_L|^2) = \frac{\pi}{k^2} \sum_{L=0}^{\infty} (2L+1)T_L$$

### 핵데이터 처리/검증

- 군정수집 생산
- 검증 계산
- 불확실도 해석



# 02 Nuclear Data Center

## » Nuclear Data Centers



International Atomic Energy Agency

### Nuclear Data Services

Provided by the Nuclear Data Section



Databases » EXFOR | ENDF | EEView | CINDA | IBANDL | Medical | LiveChart

(<https://www-nds.iaea.org>)

### International Network of Nuclear Reaction Data Centres (NRDC)

Coordinator: Naohiko Otsuka (IAEA NDS)

#### Objectives and Tasks

The primary goal of the Network is the dissemination of nuclear reaction data and associated documentation to users. The following specific tasks must be carried out in order to accomplish this important aim:

- Compilation of relevant bibliographic information (CINDA),
- Compilation of experimental nuclear reaction data (EXFOR),
- Collection of evaluated nuclear reaction data (ENDF),
- Exchange of nuclear reaction data of all types,
- Promotion of the development of special purpose evaluated data files,
- Development of common formats for computerized exchange of nuclear data,
- Coordinated development of computer software for managing and disseminating nuclear data,
- Coordination of the development and dissemination of end user software for both on line and local access to nuclear data,
- Documentation of current and future data needs in order to be able to meet changing user demands.

#### Active Centres

#### Discontinued Centres

Country	Centre	Joined
Hungary	Nuclear Data Group (ATOMKI) Institute for Nuclear Research, Debrecen	1992
Russia	Centre for Photonuclear Experiments Data (CDFE) Moscow State University, Moscow	1982
Russia	Russian Nuclear Data Center (CJD) Institute of Physics and Power Engineering, Obninsk	1966
China	China Nuclear Data Center (CNDC) China Institute of Atomic Energy Beijing	1987
Russia	Center of Nuclear Physics Data (CNPD) All Russian Scientific Research Institute of Experimental Physics, Sarov	1997
Japan	Nuclear Data Center (JAEA/NDCC) Japan Atomic Energy Agency, Tokai-mura, Naka-gun, Ibaraki	1991
Japan	Hokkaido University Nuclear Reaction Data Centre (JCPRG) Hokkaido University, Sapporo	1975
Korea	Korea Nuclear Data Center (KNDC) Korea Atomic Energy Research Institute (KAERI), Yuseong, Daejeon	2000
India	Nuclear Data Physics Centre of India (NDPCI) Bhabha Atomic Research Centre (BARC), Trombay, Mumbai	2008
IAEA	IAEA Nuclear Data Section (NDS) Vienna	1966
OECD	OECD NEA Data Bank (NEA DB) Boulogne-Billancourt	1966
U.S.A	US National Nuclear Data Center (NNDC) Brookhaven National Laboratory, Upton, NY	1966
Ukraine	Ukrainian Nuclear Data Center (UkrNDC) Institute for Nuclear Research, Kyiv	1998




# 02 Nuclear Data Center

## » Nuclear Data Centers & Evaluated Nuclear Data Files



# 02 Nuclear Data Center

## » Evaluated Nuclear Data Files

Center (Country)	Nuclear Data File	Webpage
NNDC/BNL (USA)	 (557 nuclides, 2018)	<a href="http://www.nndc.bnl.gov/endl-b8.0/">www.nndc.bnl.gov/endl-b8.0/</a>
NEA/OECD (Europe)	JEFF-3.3 (562 nuclides, 2017)	<a href="http://www.oecd-nea.org/dbdata/jeff/jeff33">www.oecd-nea.org/dbdata/jeff/jeff33</a>
PSI/IAEA NDS (Switzerland)	 (2800 nuclides, 2021)	<a href="http://tendl.web.psi.ch/tendl_2021/tendl2021.html">tendl.web.psi.ch/tendl_2021/tendl2021.html</a>
NDC/JAEA (Japan)	 (795 nuclides, 2021)	<a href="http://wwwndc.jaea.go.jp/jendl/j5/j5.html">wwwndc.jaea.go.jp/jendl/j5/j5.html</a>
CNDC (China)	CENDL-3.2 (272 nuclides, 2020)	<a href="http://www.nuclear.csdb.cn/cendl32.htm">www.nuclear.csdb.cn/cendl32.htm</a>
CJD/IPPE (Russia)	BROND-3.1 (372 nuclides, 2016) ROSFOND-2010 (686 nuclides, 2008-2010)	<a href="http://vant.ippe.ru/en/brond-3-1.html">vant.ippe.ru/en/brond-3-1.html</a> <a href="http://www-nds.iaea.org/public/download-endl/ROSFOND-2010/">www-nds.iaea.org/public/download-endl/ROSFOND-2010/</a>
NDS/IAEA	FENDL-3.2 (192 nuclides, 2021), IRDFF-II (2020)	<a href="http://www-nds.iaea.org/fendl_library/websites/fendl32/">www-nds.iaea.org/fendl_library/websites/fendl32/</a>

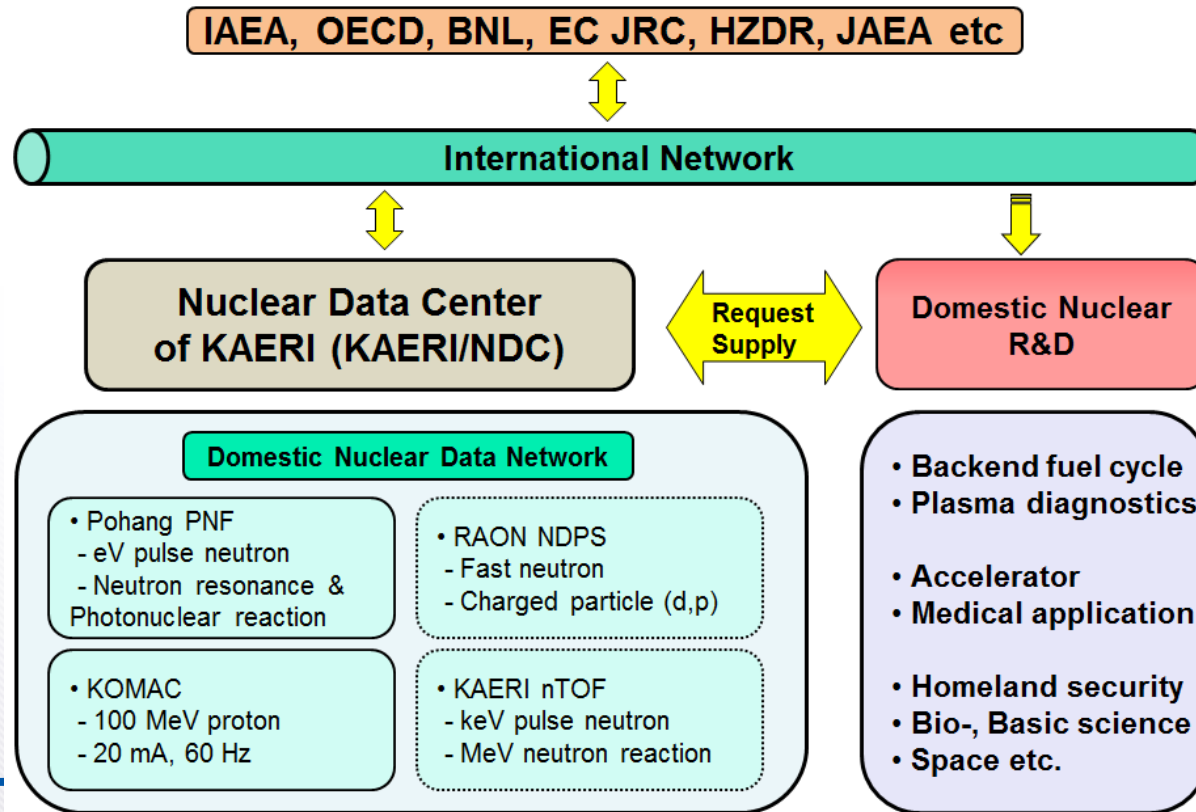


No.	NSUB	Sublibrary name	Short name	VIII.0	VII.1	VII.0	VI.8
1	0	Photonuclear	g	163	163	163	-
2	3	Photo-atomic	photo	100	100	100	100
3	4	Radioactive decay	decay	3821	3817	3838	979
4	5	Spont. fis. yields	sfy	9	9	9	9
5	6	Atomic relaxation	atom_relax	100	100	100	100
6	10	Neutron	n	557	423	393	328
7	11	Neutron fis. yields	nfy	31	31	31	31
8	12	Thermal scattering	tsl	34	21	20	15
9	19	Standards	std	10	8	8	8
10	113	Electro-atomic	e	100	100	100	100
11	10010	Proton	p	49	48	48	35
12	10020	Deuteron	d	5	5	5	2
13	10030	Triton	t	5	3	3	1
14	20030	<sup>3</sup> He	he3	3	2	2	1
15	20040	<sup>4</sup> He	a	1	-	-	-

# 02 Nuclear Data Center

## » KNDC

- Established in 1997 to start research on nuclear data in Korea (formerly, 'Nuclear Data Evaluation Lab.')
- Joined the International Network of NRDC in 2000



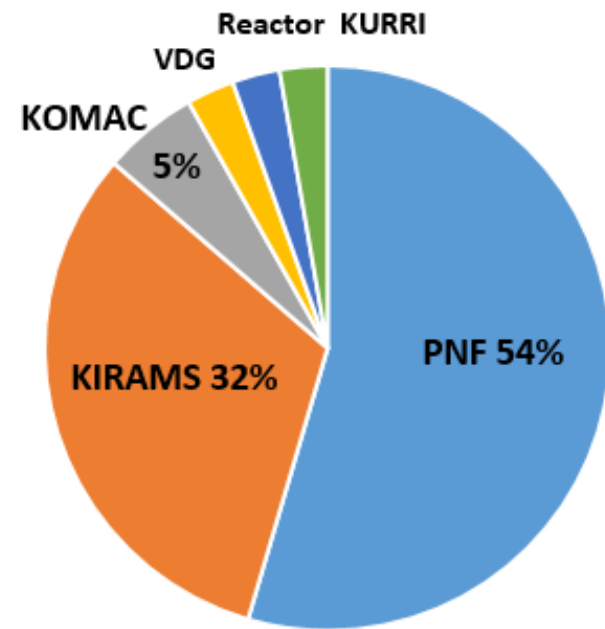
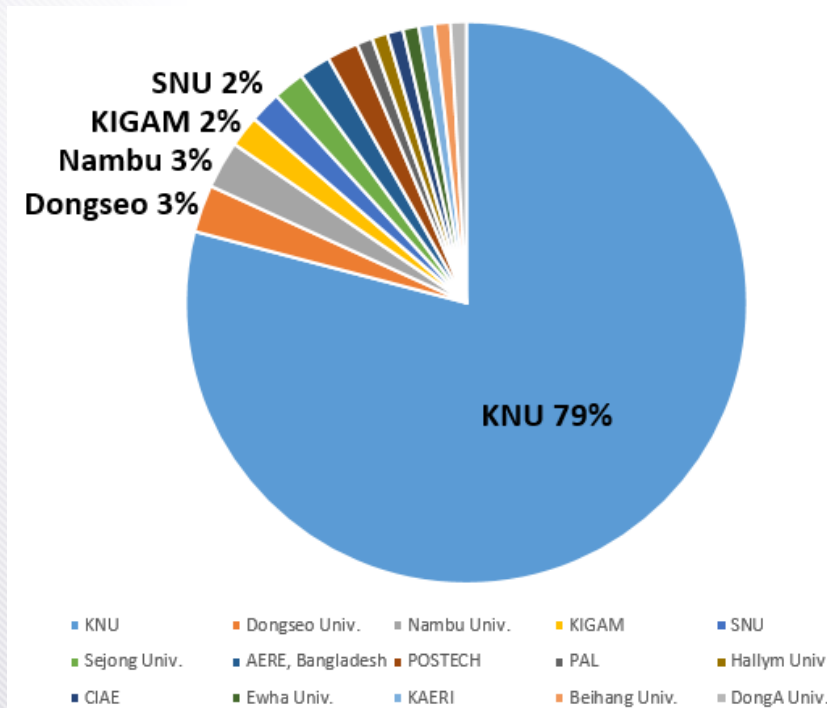
# 03 Measurement

## » Contribution to EXFOR DB

- As of 2023, a total of 115 entries were registered.
- Compilation: ~8.2 per year

- Institute (corresponding author)

- Facility (for experimental work)



# 03 Measurement

## » Existing Facilities

Facility	Characteristics	Measurements
Electron Linear Accelerator (PAL)	<ul style="list-style-type: none"> <li>100 MeV, 2.5 GeV linacs</li> <li>Neutron production by 100 MeV linac</li> <li><math>\gamma</math> production by 100 MeV and 2.5 GeV linacs</li> </ul>	<ul style="list-style-type: none"> <li>Total cross section</li> <li><math>(n, \gamma)</math> by neutron activation method</li> <li>Isomeric yield ratio</li> <li>Photo fission</li> </ul>
Cyclotron (KIRAMS)	<ul style="list-style-type: none"> <li>p : 20- 50 MeV / 40 <math>\mu</math>A</li> <li>d : 10- 25 MeV / 20 <math>\mu</math>A</li> <li><math>\alpha</math> : 20- 50 MeV / 1 <math>\mu</math>A</li> </ul>	<ul style="list-style-type: none"> <li>Activation cross section</li> </ul>
Proton Linear Accelerator (KOMAC, KAERI)	<ul style="list-style-type: none"> <li>p : 20 &amp; 100 MeV (linac)</li> </ul>	<ul style="list-style-type: none"> <li>Activation cross section</li> </ul>
Cyclotron (Jeongeup, KAERI)	<ul style="list-style-type: none"> <li>p : 30 MeV / 100 <math>\mu</math>A</li> </ul>	<ul style="list-style-type: none"> <li>Activation cross section</li> </ul>



## » Foreign Facilities

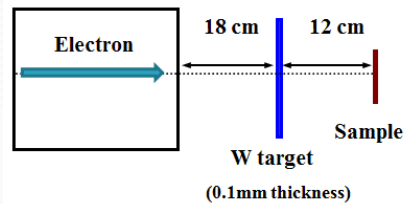
- nELBE (Germany) – Neutron total XS
- GELINA (Belgium) – Neutron capture XS
- HIMAC (Japan) – Neutron double differential XS



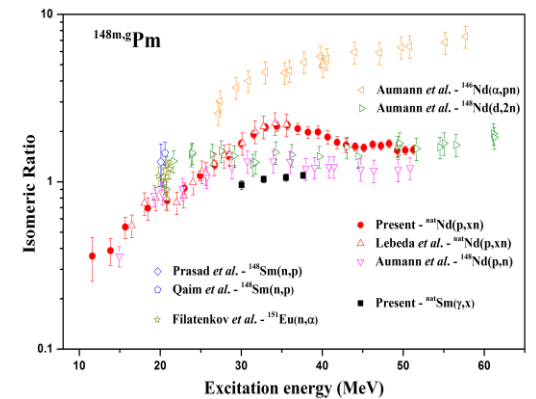
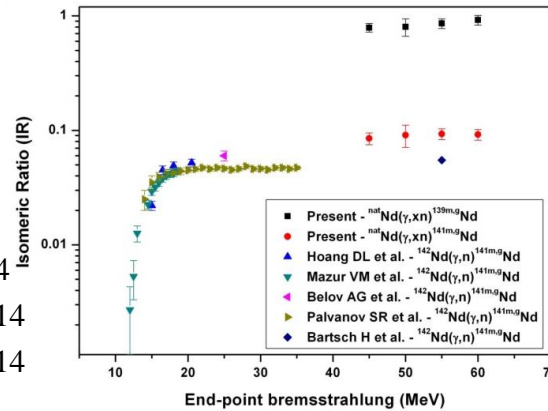
# 03 Measurement

## ND Measurements : Domestic

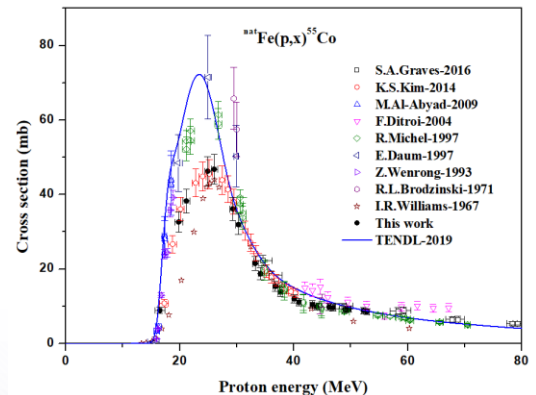
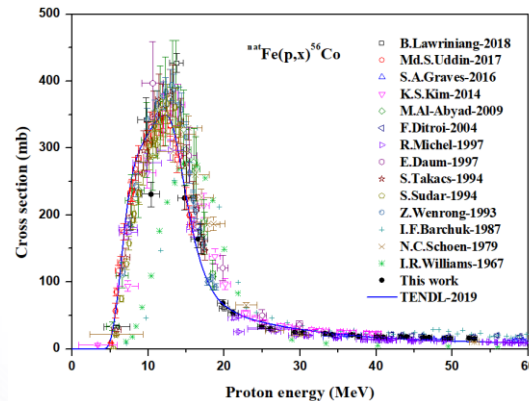
### ✓ PNF: Isomeric ratio



- S.C. Yang *et al.*, NDS 119, 314, 2014
- S.C. Yang *et al.*, JRNC 300, 367, 2014
- S.C. Yang *et al.*, JRNC 302, 467, 2014



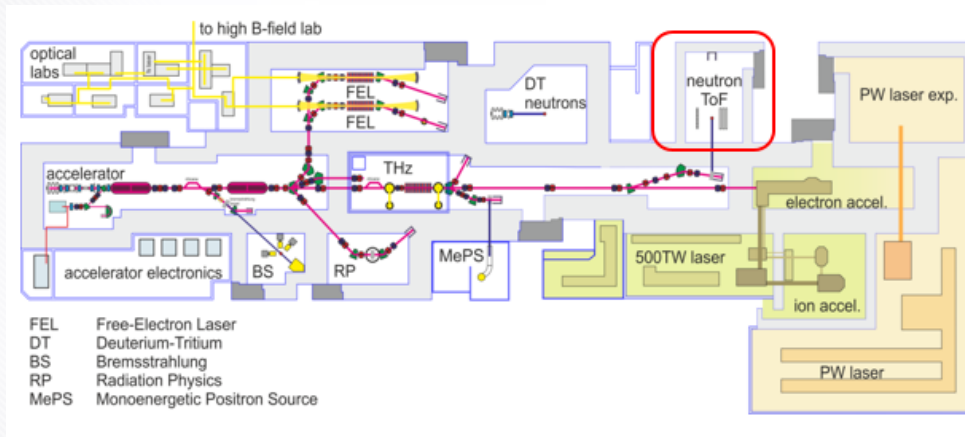
### ✓ KOMAC: DAQ system, Proton activation cross section



# 03 Measurement

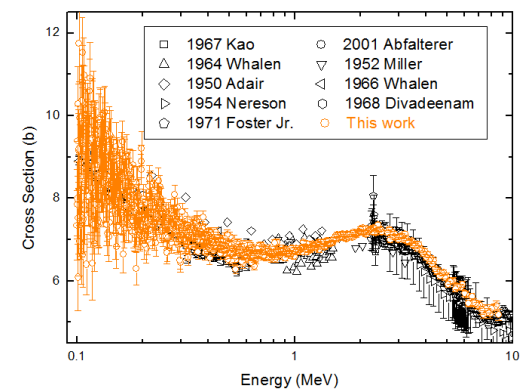
## » ND Measurements : Foreign

### ✓ nELBE: Neutron total cross section

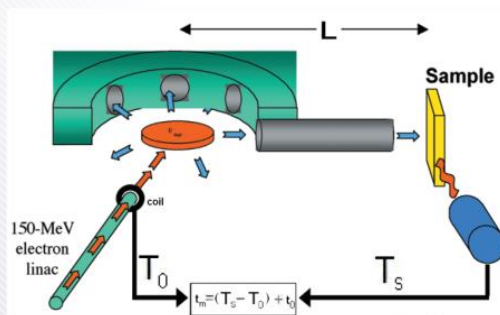


▪ T.Y. Song *et al.*, ND2016

▪ R.Beyer *et al.*, EPJA 54, 81, 2018

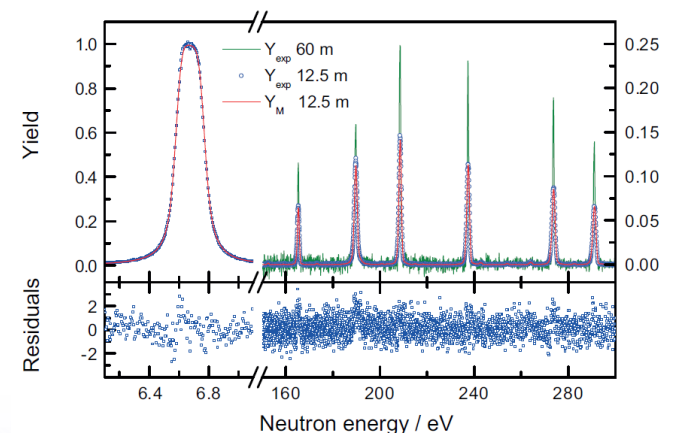


### ✓ GELINA: Neutron capture cross section @ resonance range



▪ H.I. Kim *et al.*, EPJ/A 52,170,2016

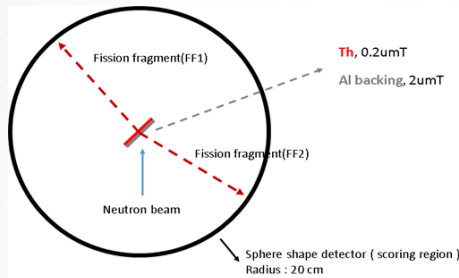
▪ ENDF/B-VIII.0 upload



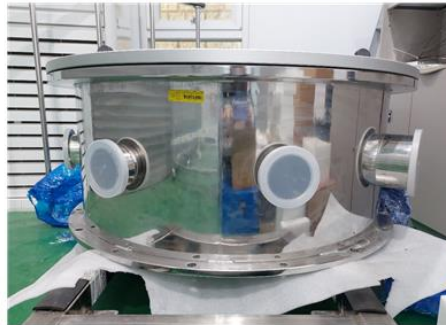
# 03 Measurement

## » Planned Facilities

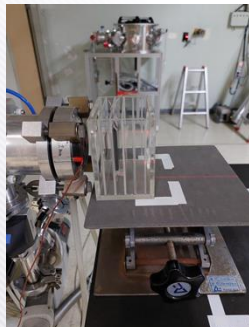
### ✓ NDPS/IBS: Fast neutron fission reaction



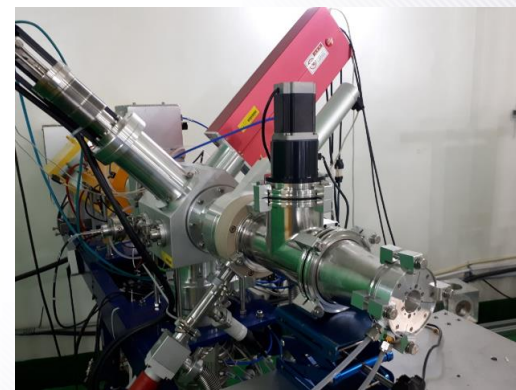
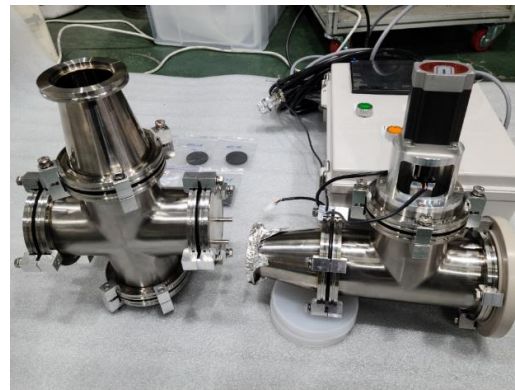
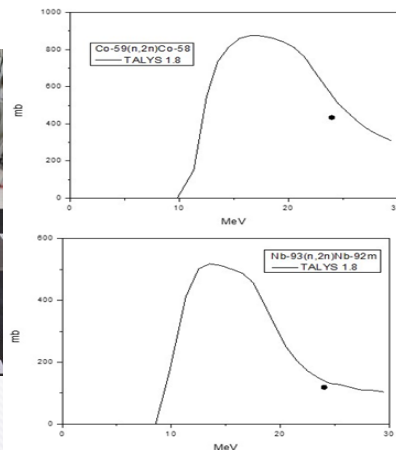
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### ✓ Cyclotron/Jeongeup: Neutron activation cross section

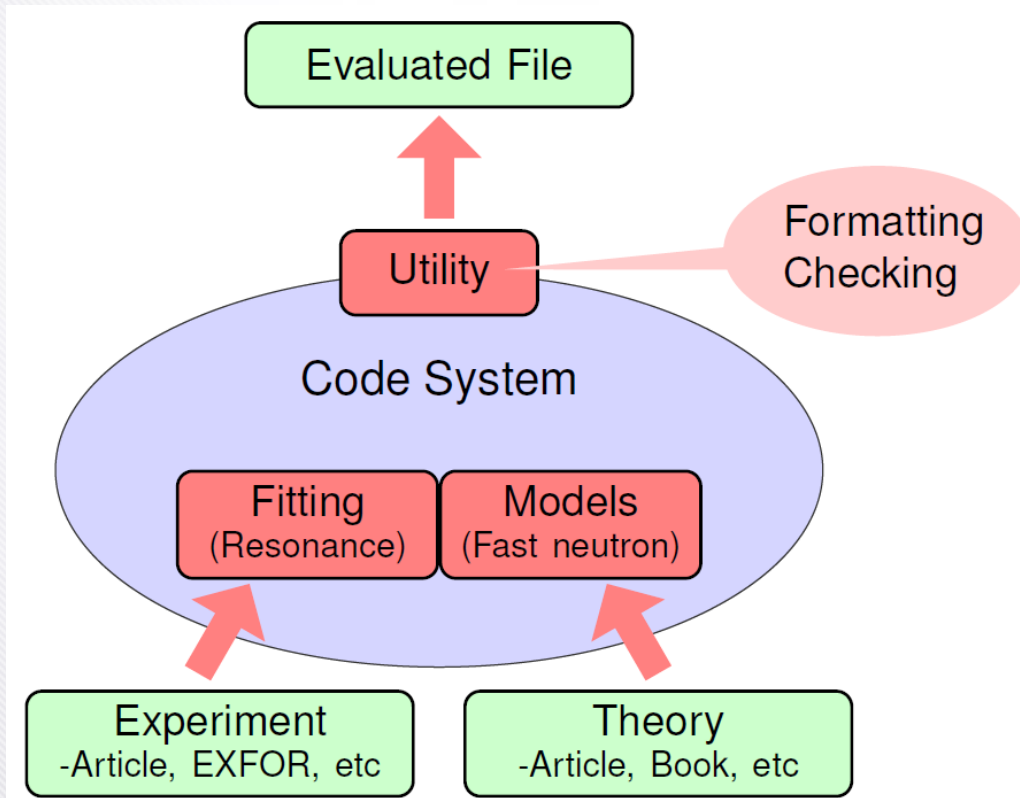


KIRAMS

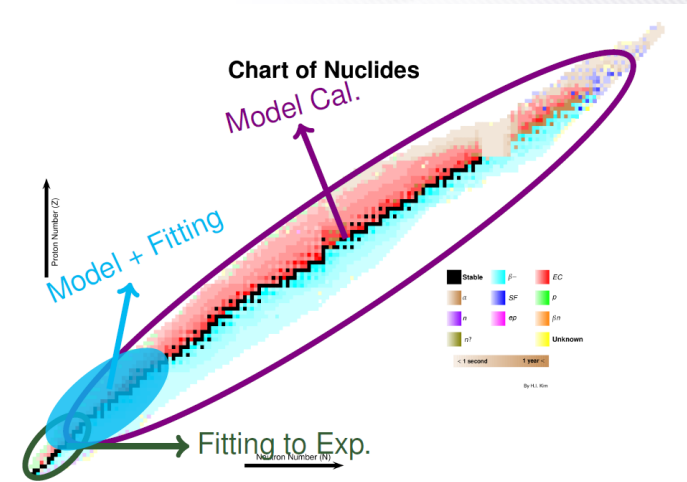


# 04 Evaluation

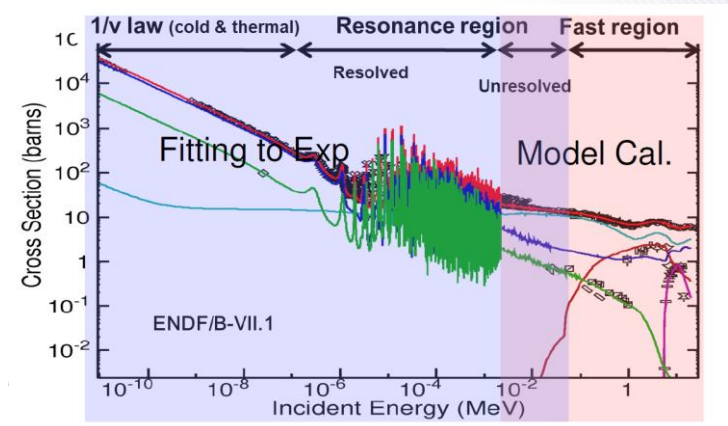
## » ND Evaluation Methodology



### Evaluated Nuclear Data Production



### According to Nuclear Mass

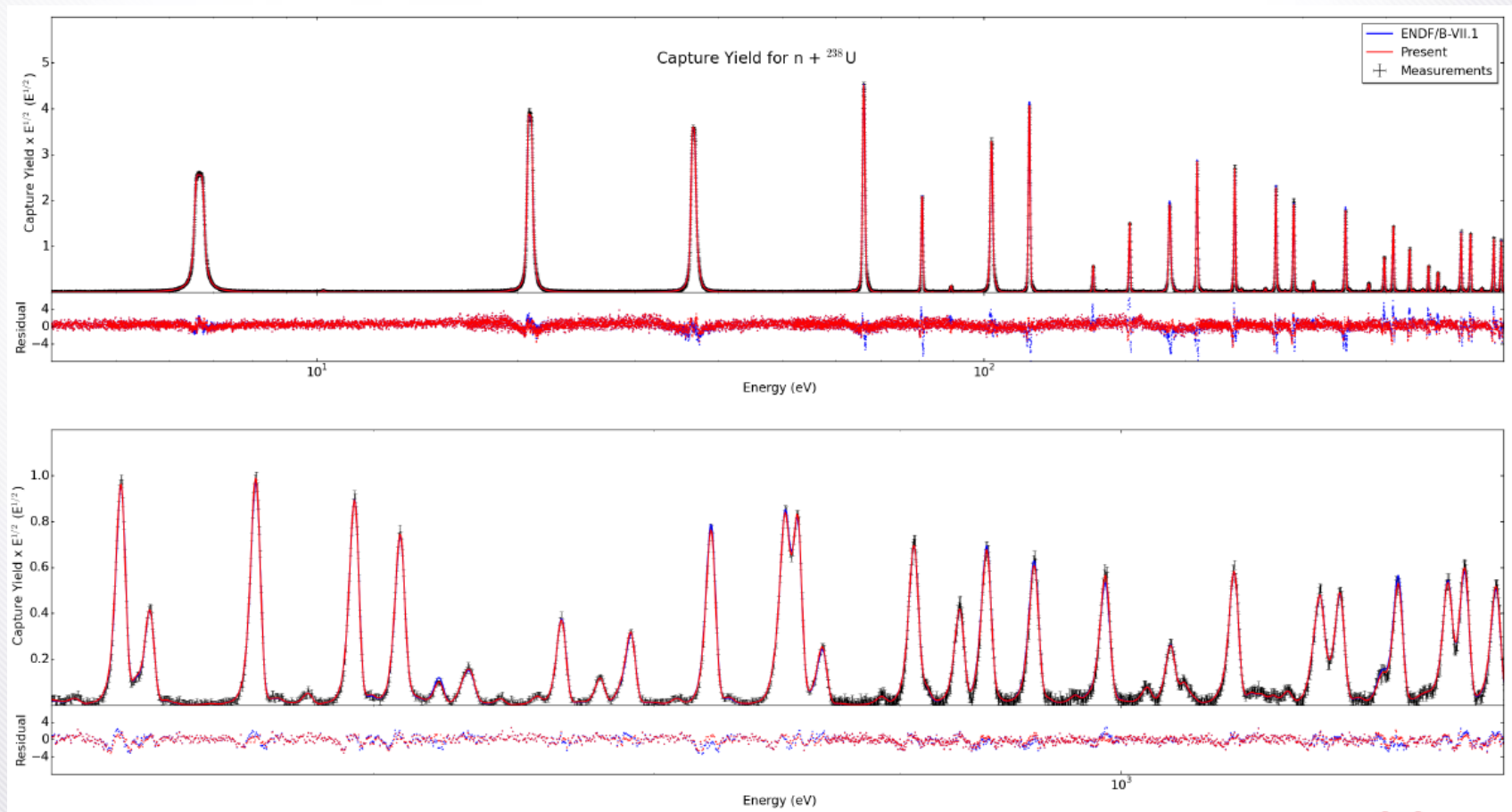


### According to Neutron Energy

# 04 Evaluation

## » ENDF/B-VIII.0

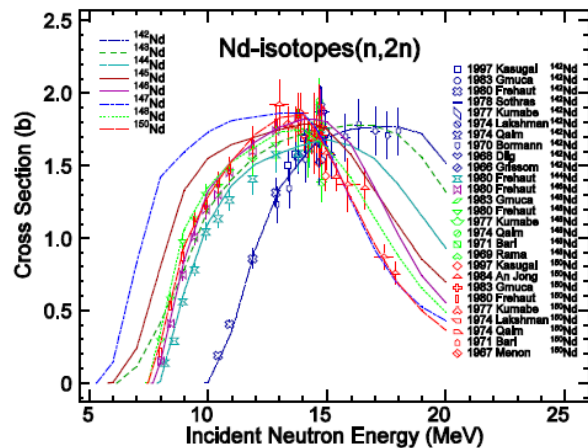
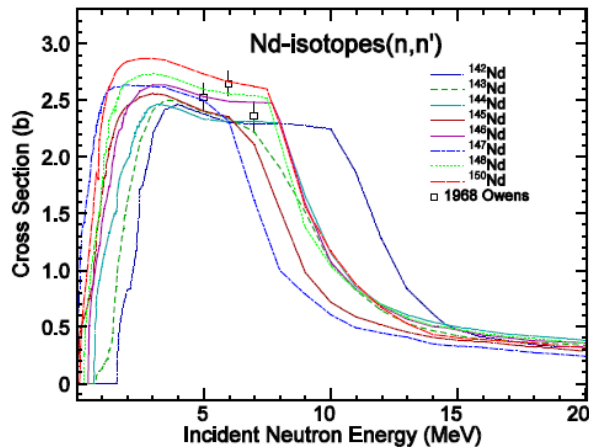
### ✓ U-238 Capture Cross Section: CIELO Project with IAEA



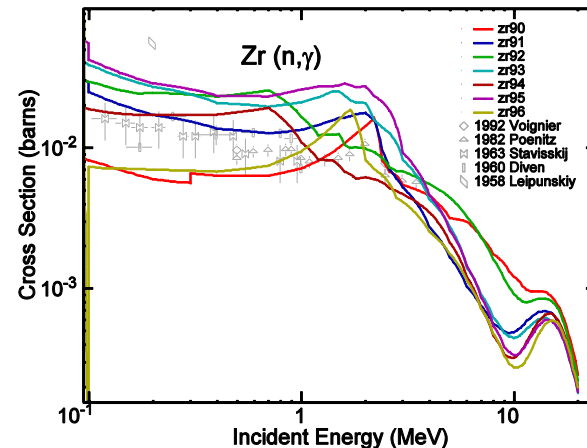
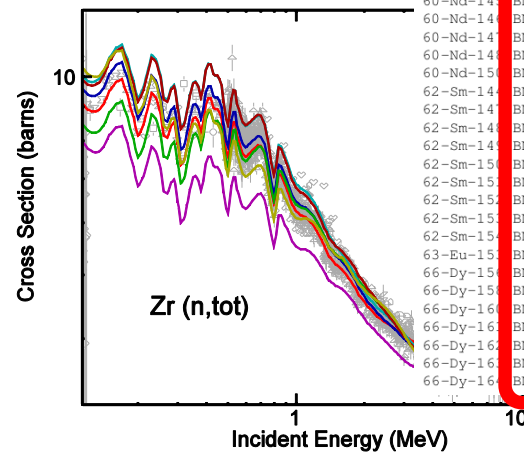
# 04 Evaluation

## » ENDF/B-VIII.0

### ✓ Nd-isotopes



### ✓ Zr-isotopes



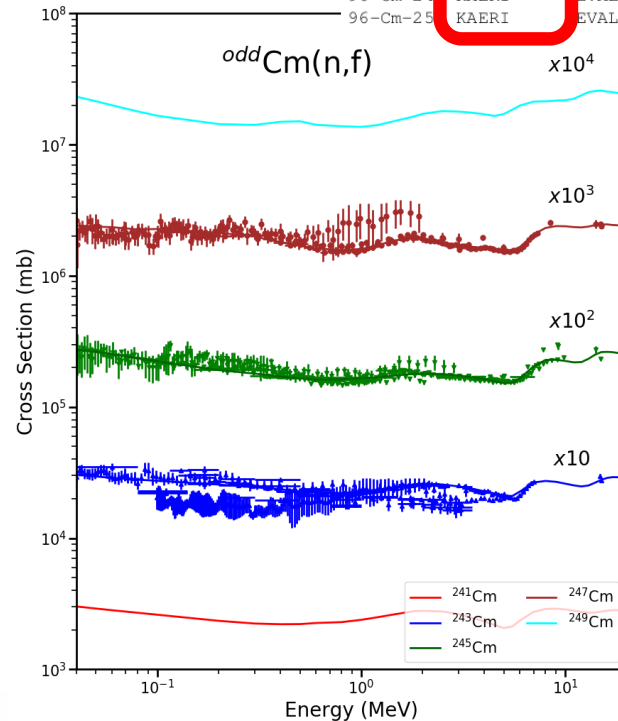
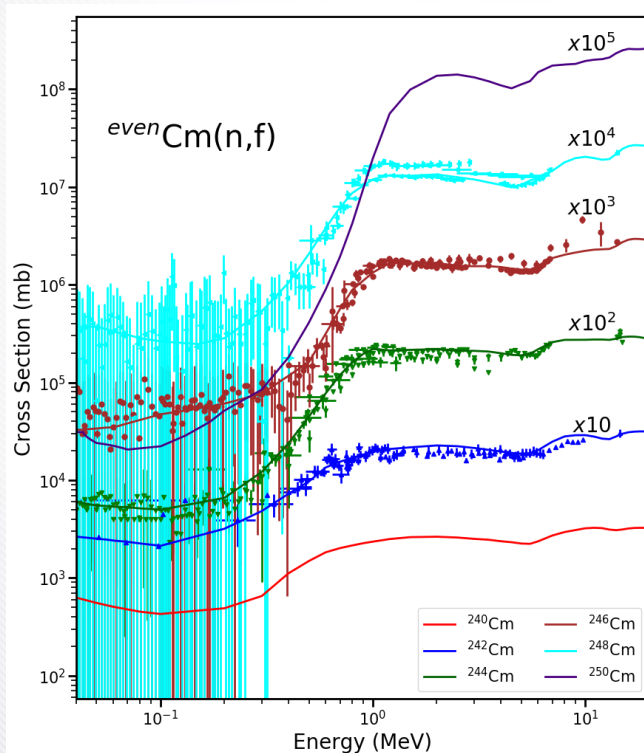
Material	Lab.	Date	Authors	Mat
27-Co-5	BNL	EVAL-MAY11	Mughabghab, BNL, Kim, KAERI+	2722
40-Zr-90	BNL, KAERI+	EVAL-SEP11	H. I. Kim, S. Mughabghab, R. Capote	4025
40-Zr-90	BNL, KAERI+	EVAL-SEP11	H. I. Kim, S. Mughabghab, R. Capote	4028
40-Zr-90	BNL, KAERI+	EVAL-SEP11	H. I. Kim, S. Mughabghab, R. Capote	4031
40-Zr-90	BNL, KAERI+	EVAL-SEP11	H. I. Kim, S. Mughabghab, R. Capote	4034
40-Zr-90	BNL, KAERI+	EVAL-SEP11	H. I. Kim, S. Mughabghab, R. Capote	4037
40-Zr-90	BNL, KAERI+	EVAL-SEP11	H. I. Kim, S. Mughabghab, R. Capote	4040
40-Zr-90	BNL, KAERI+	EVAL-SEP11	H. I. Kim, S. Mughabghab, R. Capote	4043
42-Mo-92	BNL, KAERI	EVAL-DEC10	Kim, Herman, Mughabghab+	4234
44-Ru-100	BNL, KAERI	EVAL-FEB06	Kim, Herman, Oh, Mughabghab+	4440
45-Rh-101	BNL, KAERI	EVAL-FEB06	Mughabghab, Kim, Herman, Oblozinsky	4525
46-Pd-105	BNL, KAERI	EVAL-FEB06	Kim, Herman, Oh, Mughabghab+	4634
47-Ag-107	BNL, KAERI	EVAL-FEB06	Mughabghab, Kim, Herman, Oblozinsky	4731
54-Xe-135	BNL, KAERI	EVAL-FEB06	Kim, Herman, Oh, Mughabghab+	5446
55-Cs-135	BNL, KAERI	EVAL-FEB06	Mughabghab, Kim, Herman, +	5525
59-Pr-141	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	5925
60-Nd-142	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6025
60-Nd-142	BNL, KAERI	EVAL-FEB06	Kim, Herman, Chang, Mughabghab+	6028
60-Nd-142	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6031
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60-Nd-142	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6049
62-Sm-144	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6225
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62-Sm-144	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6249
62-Sm-144	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6252
62-Sm-144	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6255
63-Eu-153	BNL, KAERI	EVAL-Sep02	Mughabghab, Oblozinsky, Herman+	6331
66-Dy-156	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6625
66-Dy-156	BNL, KAERI	EVAL-FEB06	Kim, Herman, Oh, Oblozinsky	6631
66-Dy-156	BNL, KAERI	EVAL-FEB06	Kim, Herman, Oh, Oblozinsky	6640
66-Dy-156	BNL, KAERI	EVAL-FEB06	Kim, Herman, Oh, Oblozinsky	6643
66-Dy-156	BNL, KAERI	EVAL-FEB06	Kim, Herman, Oh, Oblozinsky	6646
66-Dy-156	BNL, KAERI	EVAL-FEB06	Kim, Herman, Oh, Oblozinsky	6649

ENDF/B-VIII.0 : 42

# 04 Evaluation

## » JEFF-3.3

### ✓ Cm-isotopes



JEFF-3.3 : 27

Material	Lab.	Date	Authors	Mat
40-Zr-9	BNL, KAERI+	EVAL-SEP11	H.I. Kim, S.Mughabghab, R.Capote	4034
42-Mo-9	BNL, KAERI	EVAL-DEC10	Kim, Herman, Mughabghab+	4234
46-Pd-10	BNL, KAERI	EVAL-FEB06	Kim, Herman, Oh, Mughabghab+	4634
55-Cs-13	BNL, KAERI	EVAL-FEB06	Mughabghab, Kim, Herman, +	5525
59-Pr-14	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	5925
60-Nd-14	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6031
60-Nd-14	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6037
60-Nd-14	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6040
62-Sm-14	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6225
62-Sm-14	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6237
62-Sm-14	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6240
62-Sm-15	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6252
62-Sm-15	BNL, KAERI	EVAL-FEB06	Kim, Mughabghab, Herman, Oblozinsky	6255
66-Dy-16	BNL, KAERI	EVAL-FEB06	Kim, Herman, Oh, Oblozinsky	6640
66-Dy-16	BNL, KAERI	EVAL-FEB06	Kim, Herman, Oh, Oblozinsky	6643
66-Dy-16	BNL, KAERI	EVAL-FEB06	Kim, Herman, Oh, Oblozinsky	6646
96-Cm-24	KAERI	EVAL-NOV12	H.I. Kim, C.S.Gil, D.H.Kim, Y.O. Lee	9625
96-Cm-24	KAERI	EVAL-NOV12	H.I. Kim, C.S.Gil, D.H.Kim, Y.O. Lee	9628
96-Cm-24	KAERI	EVAL-NOV12	H.I. Kim, C.S.Gil, D.H.Kim, Y.O. Lee	9631
96-Cm-24	KAERI	EVAL-NOV12	H.I. Kim, C.S.Gil, D.H.Kim, Y.O. Lee	9634
96-Cm-24	KAERI	EVAL-NOV12	H.I. Kim, C.S.Gil, D.H.Kim, Y.O. Lee	9637
96-Cm-24	KAERI	EVAL-NOV12	H.I. Kim, C.S.Gil, D.H.Kim, Y.O. Lee	9640
96-Cm-24	KAERI	EVAL-NOV12	H.I. Kim, C.S.Gil, D.H.Kim, Y.O. Lee	9643
96-Cm-24	KAERI	EVAL-NOV12	H.I. Kim, C.S.Gil, D.H.Kim, Y.O. Lee	9646
96-Cm-24	KAERI	EVAL-NOV12	H.I. Kim, C.S.Gil, D.H.Kim, Y.O. Lee	9649
96-Cm-24	KAERI	EVAL-NOV12	H.I. Kim, C.S.Gil, D.H.Kim, Y.O. Lee	9652
96-Cm-25	KAERI	EVAL-NOV12	H.I. Kim, C.S.Gil, D.H.Kim, Y.O. Lee	9655

# 04 Evaluation

## » IAEA Photonuclear Data Library

- IAEA CRP (1999)
  - ✓ 164 nuclides → ENDF/B-VII.0 (163 nuclides) → ENDF/B-VIII.0
  - ✓ KNDC-evaluation: 124 nuclides
- IAEA CRP (2019)
  - ✓ 219 nuclides → KNDC-evaluation: 30 nuclides

$^{100}\text{Mo}(g,n)^{99}\text{Mo} \rightarrow ^{99m}\text{Tc}$

### IAEA Photonuclear Data Library 2019

T. Kawano,<sup>1,\*</sup> Y. S. Cho,<sup>2</sup> P. Dimitriou,<sup>3</sup> D. Filipescu,<sup>4</sup> N. Iwamoto,<sup>5</sup> V. Plujko,<sup>6</sup> X. Tao,<sup>7</sup> H. Utsunomiya,<sup>8</sup> V. Varlamov,<sup>9</sup> R. Xu,<sup>7</sup> R. Capote,<sup>3</sup> I. Gheorghe,<sup>4</sup> O. Gorbachenko,<sup>6</sup> Y.L. Jin,<sup>7</sup> T. Renstrom,<sup>10</sup> K. Stopani,<sup>9</sup> Y. Tian,<sup>7</sup> G. M. Tveten,<sup>10</sup> J.M. Wang,<sup>7</sup> T. Belgva,<sup>11</sup> R. Firestone,<sup>12</sup> S. Gorily,<sup>13</sup> J. Kopecky,<sup>14</sup> M. Krückel,<sup>15</sup> R. Schwengner,<sup>16</sup> S. Siem,<sup>10</sup> and M. Wiedeking<sup>17</sup>

<sup>1</sup>Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM 87545, USA

<sup>2</sup>Nuclear Data Center, Korea Atomic Energy Research Institute, Daejeon-Daero 989-111, Yuseong-gu, Daejeon, Korea

<sup>3</sup>NPAC-Nuclear Data Section, International Atomic Energy Agency, P.O. Box 100, 1400 Vienna, Austria

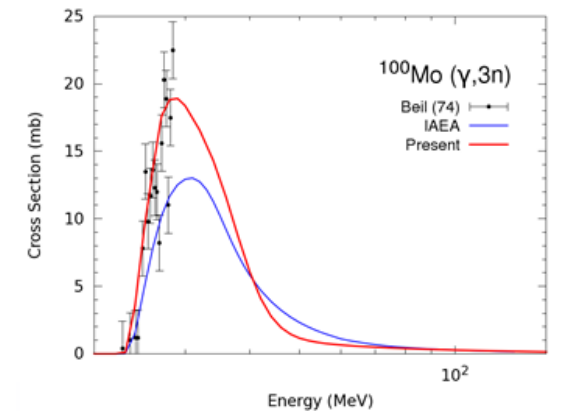
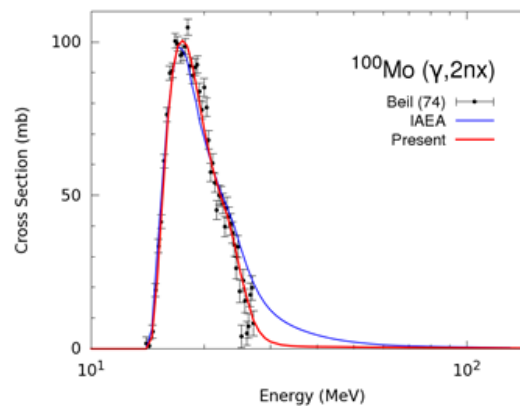
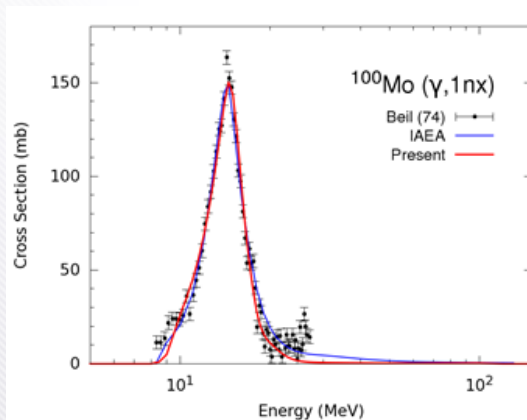
<sup>4</sup>Horia Hulubei National Institute for Physics and Nuclear Engineering (IFIN-HH), 30 Reactorului, Bucharest-Magurele 077125, Romania

<sup>5</sup>Nuclear Data Center, Japan Atomic Energy Agency, Tokai-mura, Ibaraki 319-1195, Japan

<sup>6</sup>Nuclear Physics Department, Taras Shevchenko National University, Kyiv, Ukraine

<sup>7</sup>China Nuclear Data Center, China Institute of Atomic Energy, P.O. Box 275(41), Beijing 102413, China

<sup>8</sup>Department of Physics, Konan University, Okamoto 8-9-1, Higashinada, Kobe 658-8501, Japan

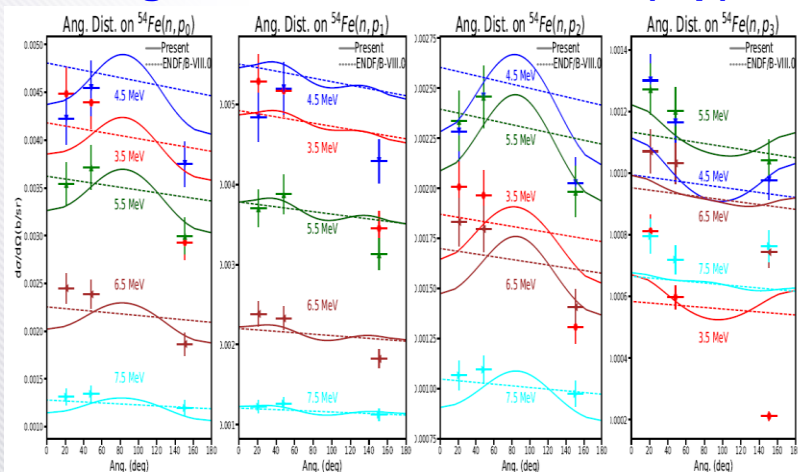


# 04 Evaluation

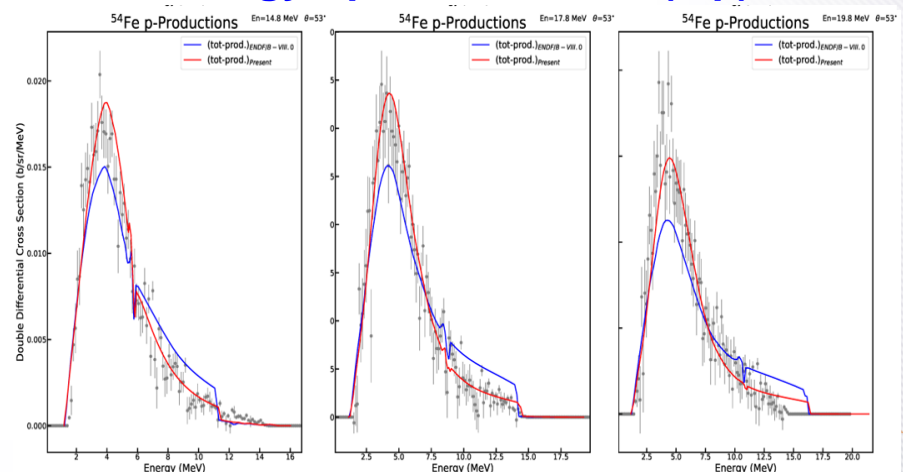
## » Neutron-induced charged particle data : On-going

- Completed in 2022 through I-NERI project with LANL
- Evaluate angular distributions and energy spectra for Fe, Ni, and Zn based on the experimental (n,p) and (n,a) reaction cross sections
- Predict angular distributions and energy spectra of (n,p) and (n,a) reactions for unmeasured nuclides, such as Cr, Mn, Co, Cu, and so on
- New evaluations have been submitted for ENDF/B-VIII.1- $\beta$ 1.

### Angular Distribution of $^{54}\text{Fe}(n,p)$



### Energy Spectrum of $^{54}\text{Fe}(n,p)$



# 04 Evaluation

## » Neutron-induced charged particle data : On-going

### ● List of 58 Nuclides Submitted for ENDF/B-VIII.1-β1 (2022.12.19)

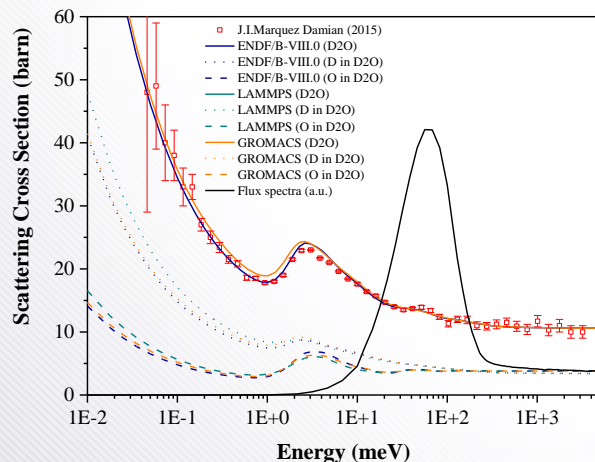
nucleus	# of discrete levels		nucleus	# of discrete levels		nucleus	# of discrete levels	
	p	a		p	a		p	a
Al-27	20	20	Cr-50	10	10	Zn-67	10	10
Si-28	14	16	Cr-51	10	10	Zn-68	8	10
Si-29	16	20	Cr-52	10	10	Zn-69	17	18
Si-30	6	12	Cr-53	10	10	Zn-70	1	1
Si-31	1	15	Cr-54	10	10	As-73	10	10
Si-32	1	1	Co-58	40	40	As-74	10	10
Cl-35	30	21	Co-59	10	10	Zr-90	12	9
Cl-36	16	32	Ni-58	10	10	Zr-91	6	40
Cl-37	10	6	Ni-59	10	10	Zr-92	1	40
K-39	10	10	Ni-60	10	10	Zr-93	17	27
K-40	10	10	Ni-61	10	10	Zr-94	10	40
K-41	10	10	Ni-62	10	10	Zr-95	16	9
Ti-46	10	10	Ni-63	26	10	Zr-96	3	10
Ti-47	10	10	Ni-64	10	10	Ag-107	10	10
Ti-48	10	10	Cu-63	10	10	Ag-109	31	2
Ti-49	10	10	Cu-64	40	40	Ta-180	10	10
Ti-50	10	10	Cu-65	10	10	Ta-181	10	10
V-49	40	40	Zn-64	10	10	Au-197	10	10
V-50	10	10	Zn-65	10	10			
V-51	10	10	Zn-66	10	10			

# 04 Evaluation

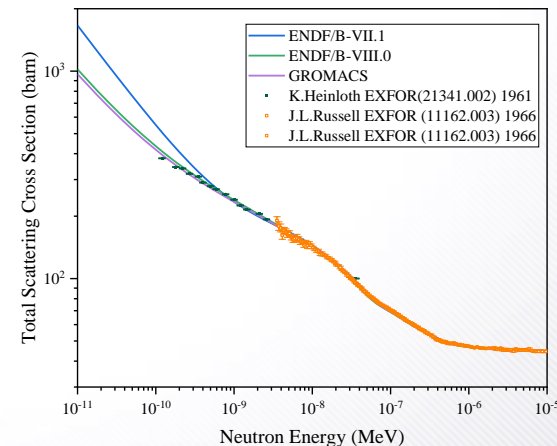
## » Thermal neutron scattering data production: On-going

- To produce, validate, and support TSL data of coolant/moderator materials for future advanced nuclear reactor R&Ds in Korea
- Preliminary TSL data of  $D_2O$  and  $H_2O$ 
  - ✓ Frequency spectrum and/or Sköld correction factor obtained by MD simulations
  - ✓ GROMACS and LAMMPS codes with TIP4P/2005f or SPC/E water models

### Scattering Cross Sections for $D_2O$



### Scattering Cross Sections for $H_2O$



# 05 Processing/Validation

## 핵데이터 처리/검증 및 응용

평가  
핵데이터

핵데이터  
처리

핵데이터  
검증

군정수  
배포/응용

핵반응데이터

- ENDF/B, JEFF, JENDL 등
- KAERI New

공분산데이터

- ENDF/B, JEFF, JENDL 등

핵구조데이터

- 악티나이드 핵분열생성물 수율, 붕괴 데이터

처리 코드

- NJOY, AMPX, PREPRO 등
- 개별 코드 (ORIGEN-S 수율, 붕괴)

처리 포맷

- ACE, MATXS, WIMS-D 등

검증 코드

- MCNP, DANTSYS, SCALE 등

검증 자료

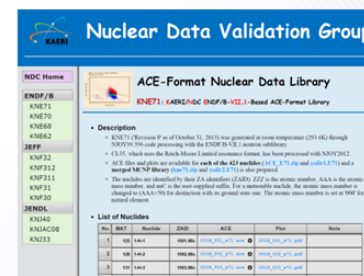
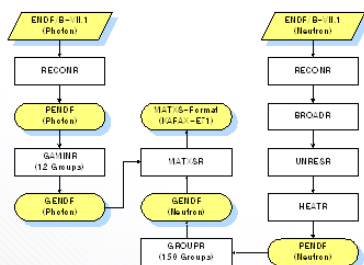
- ICSBEP, IRPhEP, SINBAD 등

군정수 배포

- NEA DB, KAERI Web., 국내외 RD 등

군정수 응용

- 원자력, 방사선, 의료 등

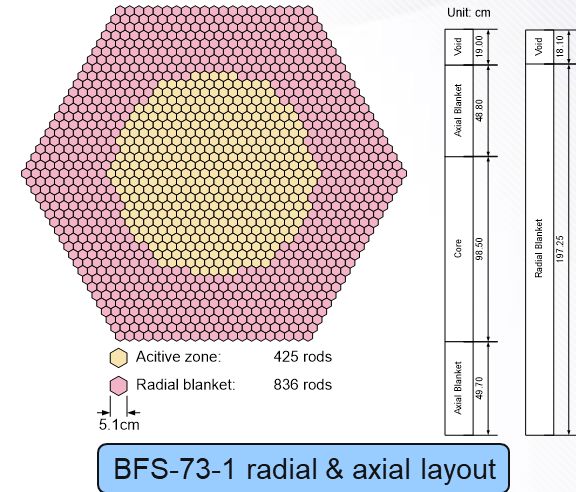


<sup>1</sup>IAEA representative at OECD/NEA Data Bank, 12 bd. des Iles, 92130 Issy-les-Moulineaux, France  
<sup>2</sup>OECD Nuclear Energy Agency, 12 bd des Iles, 92130 Issy les Moulineaux, France  
<sup>3</sup>RESCC, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831-6162, USA

# 05 Processing/Validation

## » Application Libraries

### ✓ KAFAX: Fast reactor core analysis



KAERI/TR-842/97

**KAFAX-F22 : JEF-2.2를 이용한 고속로용  
다군 단면적 라이브러리 생산 및 검증**  
- 중성자 80군 및 광자 24군 -

KAFAX-F22 : Development and Benchmark of Multi-group Library  
for Fast Reactor Using JEF-2.2  
- Neutron 80 Group and Photon 24 Group -

**KAERI**

한국원자력연구소

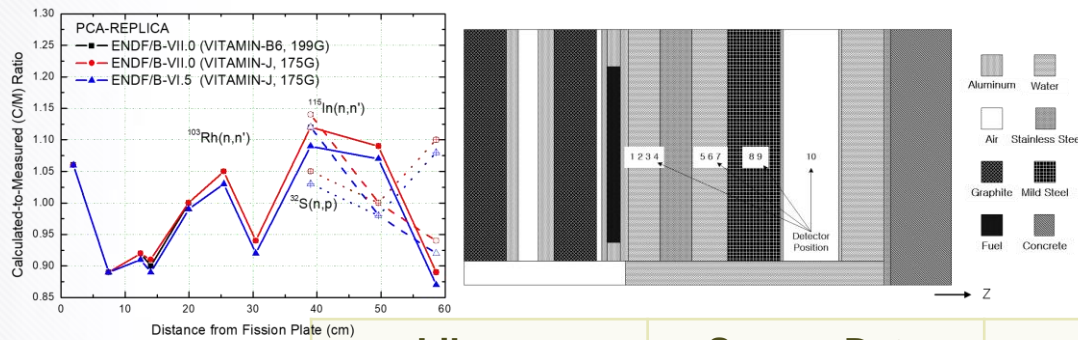
Library	Source Data	Energy Group	Note
KAFAX-F22	JEF-2.2	Neutron 80G, Photon 24G	NEA-1650
KAFAX-E66	ENDF/B-VI.6	Neutron 150G, Photon 12G	
KAFAX-E70	ENDF/B-VII.0	Neutron 150G, Photon 12G	NEA-1815
KAFAX-E71	ENDF/B-VII.1	Neutron 150G, Photon 12G	
KAFAX-F31	JEFF-3.1	Neutron 150G, Photon 12G	NEA-1816
KAFAX-J33	JENDL-3.3	Neutron 150G, Photon 12G	NEA-1817
KAFAX-JAC08	JENDL/AC-2008	Neutron 150G, Photon 12G	

# 05 Processing/Validation

## » Application Libraries

### ✓ KASHIL: Radiation shielding analysis

#### (1) PCA-REPLICA

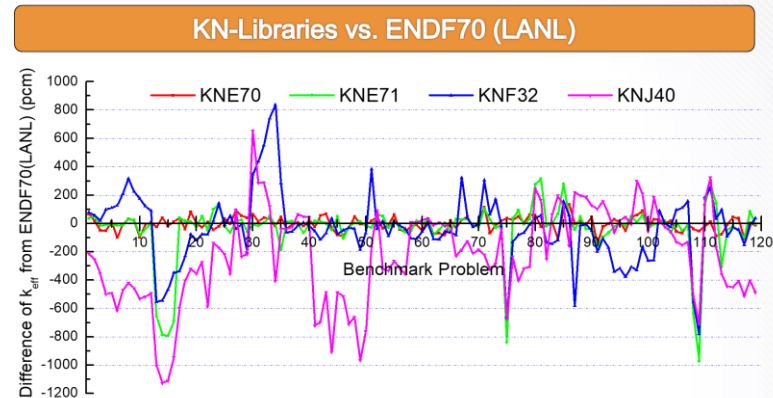


Library	Source Data	Energy Group	Note
KASHIL-E6	ENDF/B-VI.5	Neutron 175G, Photon 42G	NEA-1649
KASHIL-E68	ENDF/B-VI.8	Neutron 199G, Photon 42G	
KASHIL-E70	ENDF/B-VII.0	Neutron 199G, Photon 42G Neutron 175G, Photon 42G Neutron 80G, Photon 24G Neutron 47G, Photon 20G Neutron 44G, Photon 18G Neutron 30G, Photon 12G	NEA-1818
KASHIL-F31	JEFF-3.1.1	Neutron 199G, Photon 42G	
KASHIL-J33	JENDL-3.3	Neutron 199G, Photon 42G	

# 05 Processing/Validation

## » Application Libraries

### ✓ KN-Series ACE Library: MCNP



- ✓ KNE70 library shows good agreements with the results of ENDF70 while maintaining differences within about  $\pm 100$  pcm except for several benchmark problems.
- ❖ Confirms the validity of generation procedures for KN-libraries
- ✓ Other KN-libraries show relatively large differences in comparison with ENDF70.

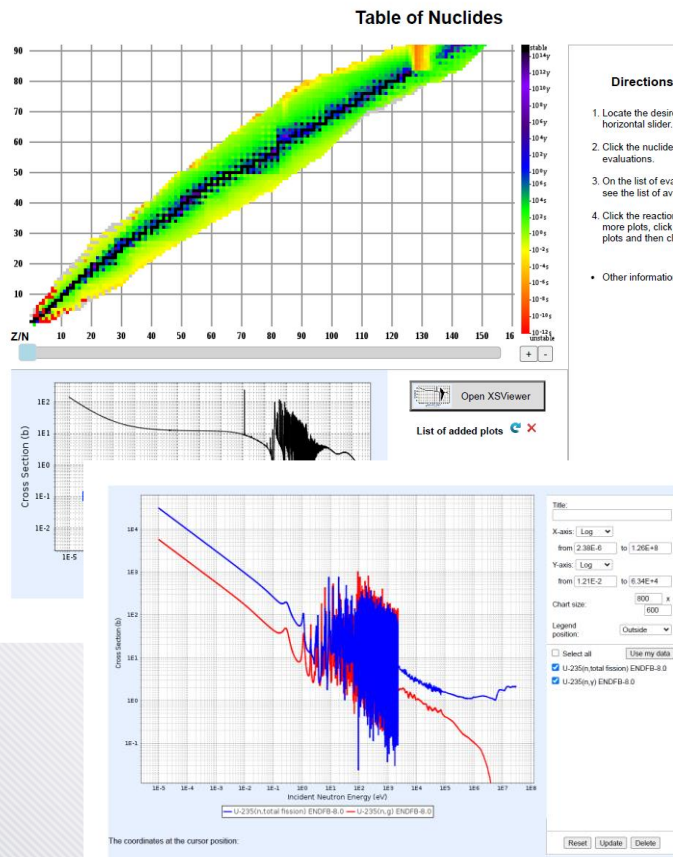
KN Library	Source Data	Temperature	Note
MCLIB-E6	ENDF/B-VI.5	300K, 600K, 900K	NEA-1651
KNE62, KNE68, KNE70, KNE71, KNE80	ENDF/B-VI.2, VI.8, VII.0, VII.1, VIII.0	293.6K	
KNF30, KNF31, KNF311, KNF312, KNF32, KNF33	JEFF-3.0, 3.1, 3.1.1, 3.1.2, 3.2, 3.3	293.6K	
KNJ33, KNJ40, KNJ40u, KNJAC08	JENDL-3.3, 4.0, 4.0u, JENDL/AC-2008	293.6K	

# 05 Processing/Validation

## » Web Service

### Nuclear Data Chart

(<http://atom.kaeri.re.kr/nuchart/>)



### Application Library

(<http://atom.kaeri.re.kr/NDVG/>)

Nuclear Data Validation Group

ACE-Format Nuclear Data Library

KNE71: KAERI/NDG ENDF/B-VII.1-Based ACE-Format Library

Description

- KNE71 (Revision 0 as of October 31, 2013) was generated at room temperature (293.15K) through NJOY99.396 code processing with the ENDF/B-VII.1 neutron sublibrary.
- C1-35, which uses the Reich-Moore Limited resonance format, has been processed with NJOY2012.
- ACE files and plots are available for each of the 423 nuclides ([ACE\\_001.jpg](#) and [code1.0.71](#)) and a merged MCNP library ([code1.0.71.jpg](#) and [code1.0.71](#)) is also prepared.
- The nuclides are identified by their ZA identifiers (ZAID), ZZZ is the atomic number, AAA is the atomic mass number, and mnc is the user-applied suffix. For a metastable nuclide, the atomic mass number is changed to (AAA+50) for distinction with its ground state one. The atomic mass number is set at '000' for a natural element.

List of Nuclides

No.	MAT	Nuclide	ZAID	ACE	Plot	Note
1	126	1-1-1	0018.001.001	0018.001.001.pdf		
2	126	1-1-2	0018.002.001	0018.002.001.pdf		
3	131	1-1-3	0018.003.001	0018.003.001.pdf		
4	225	2-11-3	0028w003.001	0028w003.001.pdf		
5	228	2-11-4	0028w004.001	0028w004.001.pdf		
6	326	3-11-1	0036.001.001	0036.001.001.pdf		
7	328	3-11-2	0036.002.001	0036.002.001.pdf		
8	419	4-11-7	0048w007.001	0048w007.001.pdf		
9	426	4-11-8	0048w008.001	0048w008.001.pdf		
10	826	6-8-10	0018.010.001	0018.010.001.pdf		
11	828	6-8-11	0018.011.001	0018.011.001.pdf		
12	800	6-0-0	0000.000.000	0000.000.000.pdf		

Validation Results

- D.H. Kim, C.-S. Gil, and Y.-O. Lee, "Current Status of ACE Format Libraries for MCNP at Nuclear Data Center of KAERI," BORD-8: 8th International Symposium on Radiation Safety and Detection Technology, Jeju, Korea, July 14-16, 2015.
- D.H. Kim, H.I. Kim, C.-S. Gil, Y.-O. Lee, and P. Schillebeekx, "Validation Study on G-versions of U-238 Evaluations for JEFF," Working Party on International Nuclear Data Evaluation Co-operation Subgroup Meeting, Paris, France, May 18-22, 2015.
- D.H. Kim, H.I. Kim, C.-S. Gil, and Y.-O. Lee, "Validation of New KAERI Evaluations of Actinides for JEFF," JEFF-Measurement, Evaluation, Processing and Benchmarking Working Group, Paris, France, November 25-29, 2013.

Nuclear Data Center, Korea Atomic Energy Research Institute, 989-111 Daedeok-daero, Yuseong-gu, Daejeon, 305-707, KOREA  
Tel: +82-42-866-8651, Fax: +82-42-866-2636, E-mail: [ndc@kaeri.ac.kr](mailto:ndc@kaeri.ac.kr)

### Atomic Data

(<http://pearl.kaeri.re.kr/pearl/>)

Photonic Electronic  
Atomic Reaction Laboratory

Atomic Data Center in KAERI

Access the Atomic Databases

Database on Photoionization/Electron Impact Ionization/Dielectronic Recombination Cross Sections and Rate Coefficient (periodic.jsp)

Go →

Database on CR-Model for Helium

Electron Impact Excitation Rate Coefficient (crmodel/atomicdata2.jsp)

Go →

Line Ratio

(crmodel/linratio2.jsp)

Go →

Nuclear Data Center at KAERI

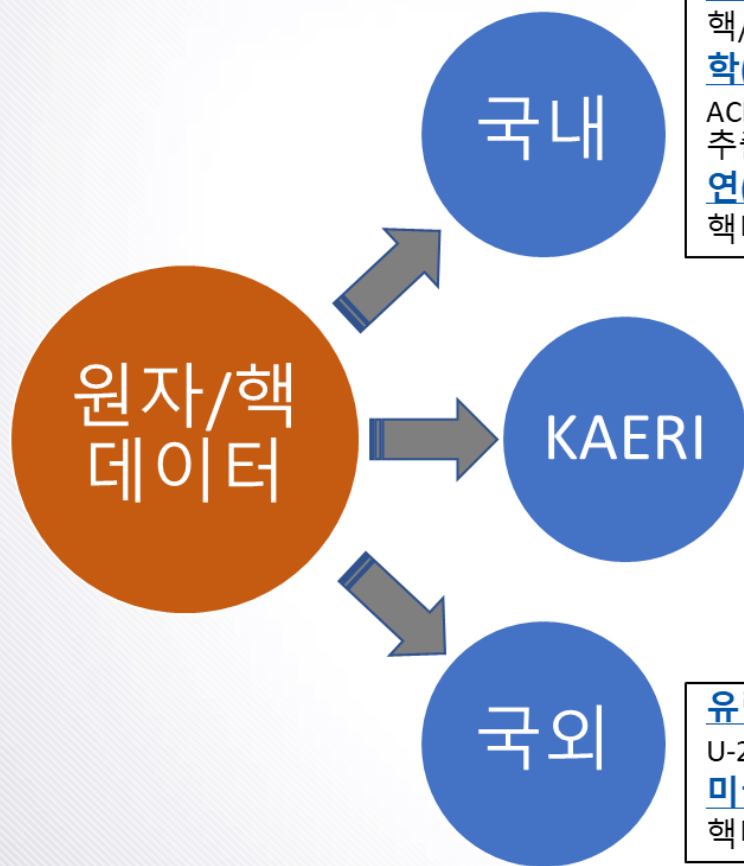
(<http://atom.kaeri.re.kr/>)

Korea Atomic Energy Research Institute

(<http://www.kaeri.ac.kr/>)

# 05 Processing/Validation

## » Nuclear/Radiation R&D Support



### 산(KNF 등):

핵/공분산 데이터 처리/검증

### 학(KAIST, 한양대, 성균관대, 부산대, 전북대, KINGS 등):

ACE, MATXS, TSL 라이브러리 처리/검증, 핵반응 및 핵구조 데이터 추출/이용, 텅스텐/헬륨/아르곤 분광 분석 원자데이터/모델링 제공 등

### 연(IBS, KINS 등):

핵데이터 추출/이용, 가속기 빔덱 설계, 고밀도레이저 유도 분광 분석

### 고속로:

KAFAX 라이브러리, 구조재 Damage XS, 임계불확도 등

### 연구로:

ENDF-7 ACE & TSL 온도 라이브러리(요르단), ENDF-8 ACE & TSL 온도 라이브러리(기장로), 지발중성자 XS 등

### VHTR:

ENDF-7.1 ACE & TSL 온도라이브러리

### 기타:

해양원전, 핵융합, 중수로, 토륨주기, Oyster 등 연구 지원

### 유럽(NEA, IAEA, 프랑스, 벨기에):

U-238 핵데이터 생산/검증, JEFF 임계 성능 검증 등

### 미국(LLNL, LANL, GA):

핵데이터 임계 성능 검증, 하전입자 반응 스펙트럼 등