

## 分離変換技術開発と核データ研究の展望

# (6) 関連する核データ及び その現状と展望

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## History of JENDL

Version	JENDL-1	JENDL-2	JENDL-3.1	JENDL-3.2	JENDL-3.3	JENDL-4.0
Purpose	FR	LWR+FR	General	General	General	General
Released	1977	1982	1990	1994	2002	2010
Max. E	15 MeV	20 MeV	20 MeV	20 MeV	20 MeV	20 MeV
No of Nuclides*	66 + 6	173 + 8	305 + 19	318 + 22	335 + 2	405 + 1
Gamma Data	0	0	59	66	114	354
DDX Data	0	0	0	0	60	318
Cov.	0	0	1	1	20	95

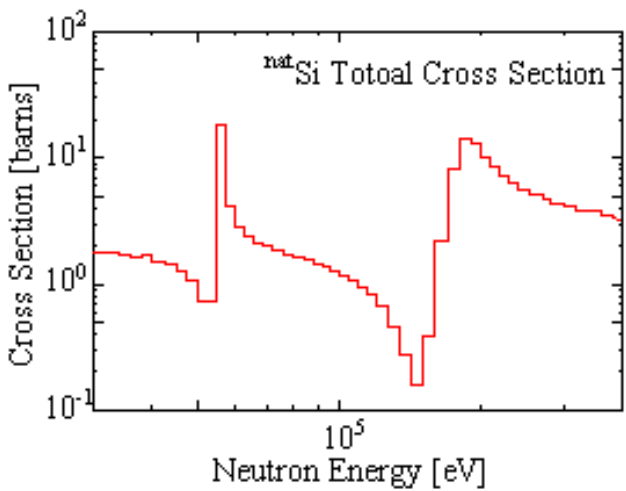
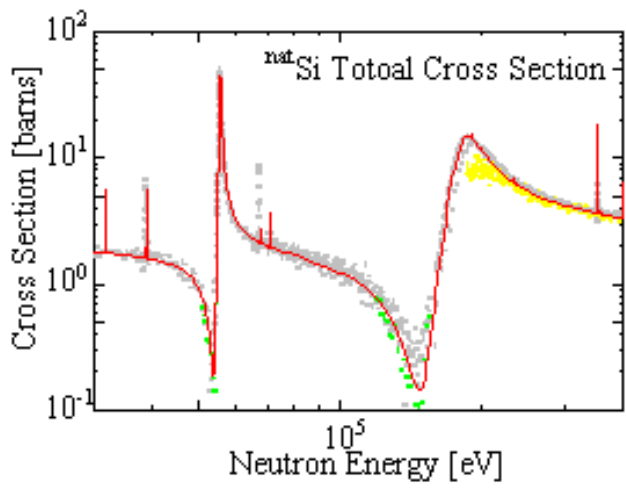
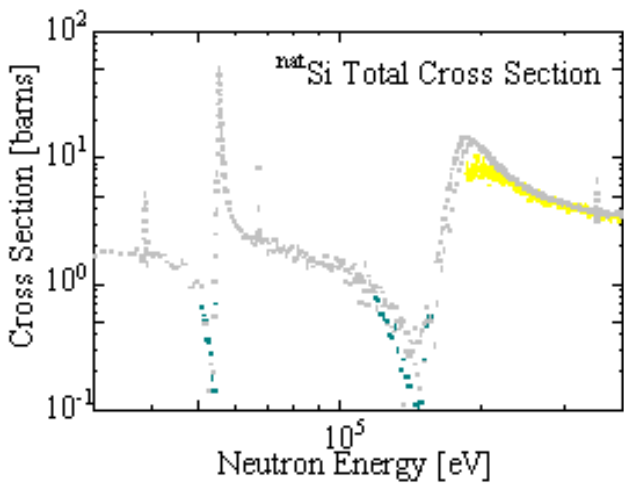
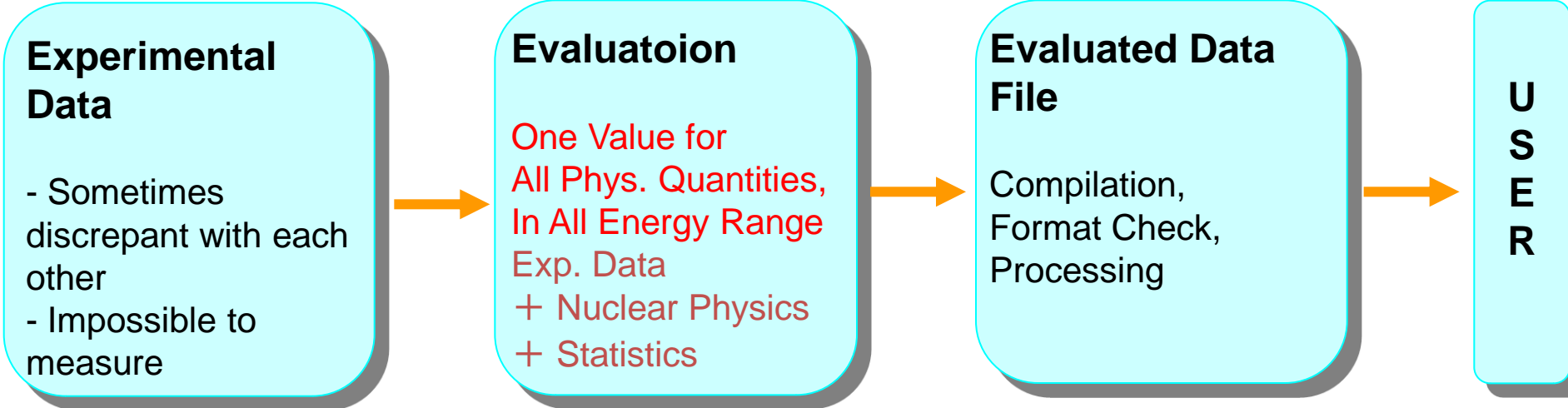
\* : Isotopes + Natural Elements

## Comparison of Three Major Libraries

Library	ENDF/B-VII.1/0	JEFF-3.1.2/1	JENDL-4.0
Developed by	US	EU	Japan
Released Year	2011/2006	2012/2009	2010
No. of Nuclides	423/393	381/381	406
No. of Nuclides with Gamma-ray Data	286/206	216/136	354
No. of Nuclides With DDX	255/171	161/83	319
No. of Nuclides with Covariances	190/26	36/36	95
Main Evaluation Code(s)	GNASH EMPIRE	TALYS	CCONE POD
<b>Self-Sufficiency</b>	<b>51%/60%</b>	<b>12%/20%</b>	<b>96%</b>

Researched by N. Iwamoto (JAEA)

## Why is “Nuclear Data Evaluation” necessary?



## *Cooperation for Data Collection*

### **Bibliographic Database**

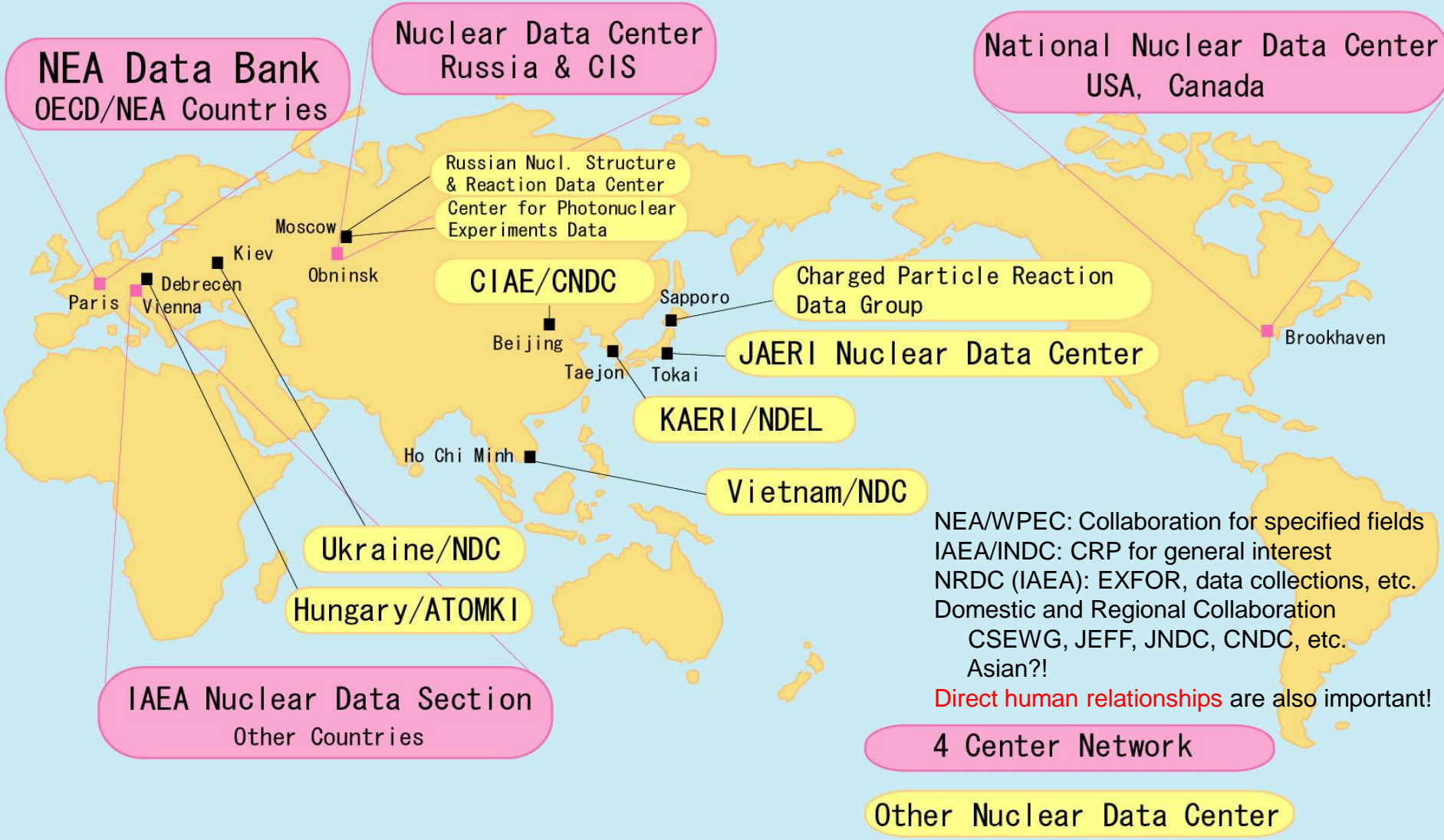
**CINDA**: Computer Index for Neutron Data

### **Experimental Database**

**EXFOR**: Exchange Format

Both above are compiled by **4 Center Network (→ Next Page)**

# Trends of International Collaboration



## *NEA/Working Party on International Nuclear Data Evaluation Cooperation (WPEC)*

First Meeting of the

### WORKING GROUP ON INTERNATIONAL EVALUATION COOPERATION

Oak Brook, USA, 9th October 1989

**Present:**

C. Dunford	(ENDF)	Chairman
H. Gruppelaar	(EFF)	
Y. Kikuchi	(JENDL)	
<u>R. McKnight</u>	(NEACRP)	
<u>H. Küsters</u>	(NEACRP)	
C. Nordborg	(NEA)	Secretary
<u>M. Salvatores</u>	(JEF)	
A. Smith	(NEANDC)	
M. Sowerby	(NEANDC)	

Second Meeting of the

### WORKING GROUP ON INTERNATIONAL EVALUATION COOPERATION

Marseille, France, 30th April and 1st May 1990

**Present:**

C. Dunford	(ENDF)	Chairman
E. Fort	(NEANDC)	
H. Gruppelaar	(EFF)	
Y. Kanda	(JENDL)	
Y. Kikuchi	(JENDL)	
<u>H. Küsters</u>	(NEACRP)	
D. Larson	(ENDF)	
E. Menapace	(JEF)	
C. Nordborg	(NEA)	Secretary
<u>M. Salvatores</u>	(JEF)	
M. Sowerby	(JEF)	
<u>H. Takano</u>	(JENDL)	

## NEA/NSC/WPEC

Report of the NEACRP/NEANDC Task Force  
on  
Evaluation Cooperation

J. Rowlands, C. Nordborg

6 October 1989

### 1 Members of the Task Force

J. Rowlands (NEANDC) chairman,

C. Nordborg (NEA) secretary,

C. Dunford (ENDF), T. Fukahori (JENDL),

S. Igarasi (JENDL), Y. Kikuchi (JENDL),

D. Larson (ENDF), R. McKnight (NEACRP),

S. Pearlstein (ENDF), M. Salvatores (JEF),

H. Vonach (NEANDC).

H. Gruppelaar (EFF),

H. Küsters (NEACRP),

T. Nakagawa (JENDL),

M. Sowerby (JEF).



## *NEA/NSC/WPEC Subgroups (SG)*

### Long-term subgroups

Three long-term subgroups had been created in 1993.

SG-A: Experimental Activities

← WP on Int. ND Measurement Activities (WPMA)

SG-B: Evaluated Data Formats and Processing for Application Libraries

SG-C: High Priority Request List (HPRL)

Co-ordinator: A. Plompen (EC/JRC/IRMM)

### Short-term subgroups

SG-1: Comparison of evaluated data for  $^{52}\text{Cr}$ ,  $^{56}\text{Fe}$  and  $^{58}\text{Ni}$  (1992, C.Y. Fu)

SG-2: Generation of covariance files for  $^{56,\text{nat}}\text{Fe}$  (1994, H. Vonach)

SG-3: Actinide data in the thermal range (1994, H. Tellier and H. Weigmann)

SG-4:  $^{238}\text{U}$  capture and inelastic cross-sections (1999, M. Baba)

SG-5:  $^{239}\text{Pu}$  fission cross-section between 1 and 100 keV (1994, E. Fort)

SG-6: Delayed neutron data (2002, A. d'Angelo)

SG-7: Nuclear data standards (2006, A. Carlson)

## *NEA/NSC/WPEC Subgroups (SG)*

### **Short-term subgroups**

**SG-8: Present status of minor actinide data (1999, T. Nakagawa and H. Takano)**

SG-9: Fission neutron spectra (2003, D. Madland)

SG-10: Eval. method of inelastic scattering cross-sections for weakly absorbing fission-product nuclides (2001, M. Kawai)

SG-11: Subgroup cancelled

**SG-12: Nuclear models to 200 MeV for high-energy data eval. (1998, M. Chadwick)**

**SG-13: Intermediate energy data (1998, A. Koning and T. Fukahori)**

**SG-14: Processing and validation of intermediate energy data files (2000, A. Koning)**

SG-15: Cross-section fluctuations and self-shielding effects in the unresolved resonance region (1995, F. Frohner)

SG-16: Effects of shape differences in the level densities of three formalisms on calculated cross-sections (1998, C.Y. Fu and M. Chadwick)

SG-17: Status of pseudo-fission product cross-sections for fast reactors (1998, H. Gruppelaar)

SG-18: Epithermal capture of  $^{235}\text{U}$  (1999, C. Lubitz)

SG-19: Activation cross-sections (2005, A. Plompen)

**SG-20: Covariance matrix eval. and processing in the resonance region (2006, T. Kawano)**

## *NEA/NSC/WPEC Subgroups (SG)*

### **Short-term subgroups**

SG-21: Assessment of neutron cross-section evals. for the bulk of fission products (2005, P. Oblozinsky)

SG-22: Nucl. data for improved LEU-LWR reactivity predictions (2006, A. Courcelle)

SG-23: Evaluated data library for the bulk of the fission products (2009, P. Oblozinsky)

SG-24: Covariance data in the fast neutron region (2011, M. Herman)

SG-25: Assessment of FP decay data for decay heat calculations (2007, T. Yoshida)

SG-26: Uncertainty and target accuracy assessment for innovative systems using recent covariance data evals. (2008, M. Salvatores)

SG-27: Prompt photon production from FPs (R. Jacqmin)

SG-28: Processing of covariance data in the resonance region (M. Dunn)

SG-29:  $^{235}\text{U}$  capture cross section in the keV to MeV energy region (2011, O. Iwamoto)

SG-30: Improvement of accessibility and quality of the EXFOR database (2011, A. Koning)

SG-31: Meeting nuclear data needs for advanced reactor systems (2014, H. Harada)

SG-32: Unresolved resonance treatment for cross section and covariance representation (2011, L. Leal)

## *NEA/NSC/WPEC Subgroups (SG)*

### Short-term subgroups

SG-33: Methods and issues for the combined use of integral experiments and covariance data (2013, G. Palmiotti and M. Salvatores)

SG-34: Coordinated eval. of  $^{239}\text{Pu}$  in the resonance region (2014, C. De Saint-Jean)

SG-35: Scattering angular distribution in the fast energy range (T. Kawano)

SG-36: Eval. of exp. data in the resolved resonance region (P. Schillebeeckx)

SG-37: Improved fission product yield eval. methodologies (R.W. Mills)

SG-38: Beyond the ENDF format: A modern nucl. database structure (D. McNabb)

SG-39: Methods and approaches to provide feedback from nucl. and covariance data adjustment for improvement of nucl. data files (G. Palmiotti and M. Salvatores)

SG-40: Collaborative International Evaluated Library Organisation (CIELO) Pilot Project (M. Chadwick)

SG-41: Improving nucl. data accuracy of  $^{241}\text{Am}$  and  $^{237}\text{Np}$  capture cross-sections (H. Harada)

SG-42: Thermal Scattering Kernel  $S(\alpha,\beta)$ : Measurement, Eval. and Application (G. Noguere)

## *IAEA/Coordinated Research Project (CRP)*

- Nuclear Data for Production of Therapeutic Radionuclides (2002-2006)
- Parameters for Calculation of Nuclear Reactions of Relevance to Non-energy Nuclear Applications (**Reference Input Parameter Library**: Phase III) (2003-2007)
- Reference Database for Neutron Activation Analysis (2005-2009)
- Updated Decay Data Library for Actinides (2005-2009)
- Development of a Reference Database for Ion Beam Analysis (2005-2009)
- Heavy Charged-particle Interaction Data for Radiotherapy (2007-2010)
- Minor Actinide Neutron Reaction Data (**MANREAD**) (2007-2011)
- Nuclear Data Libraries for Advanced Systems: Fusion Devices (**FENDL**) (2007-2012)
- Prompt Fission Neutron Spectra of Actinides (2010-2014)
- Development of a Reference Database for Particle-Induced Gamma-ray Emission (PIGE) (2011-2015)
- Nuclear Data for Charged-particle Monitor Reactions and Medical Isotope Production (2012-2016)
- Testing and Improving the IAEA International Dosimetry Library for Fission and Fusion **IRDFF** (2013-2017)
- Primary Radiation Damage Cross Sections (2013-2017)
- Reference Database for Beta-Delayed Neutron Emission (2013-2017)

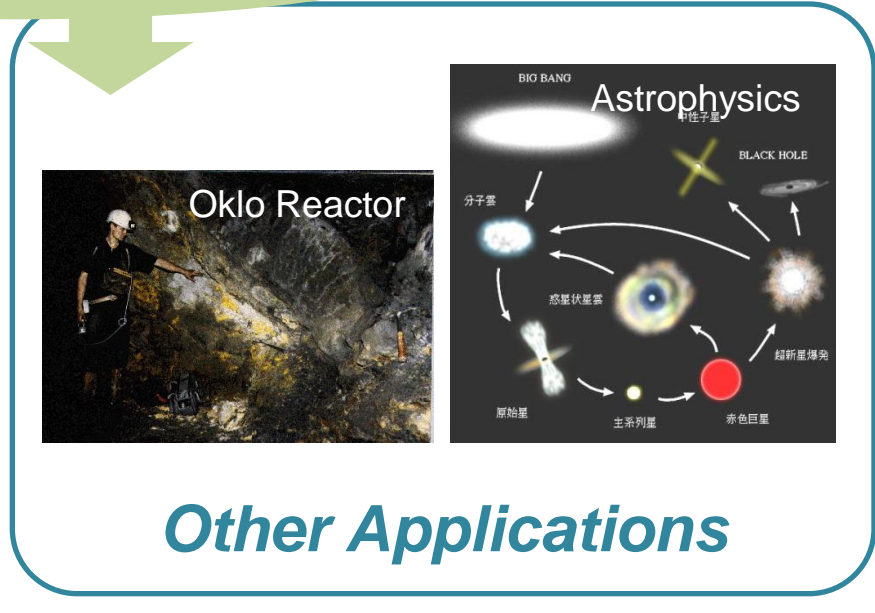
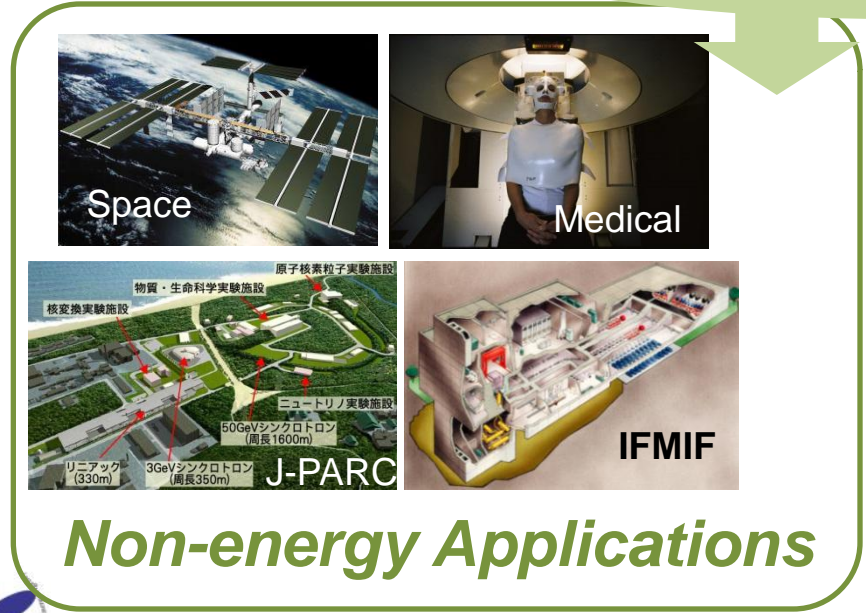
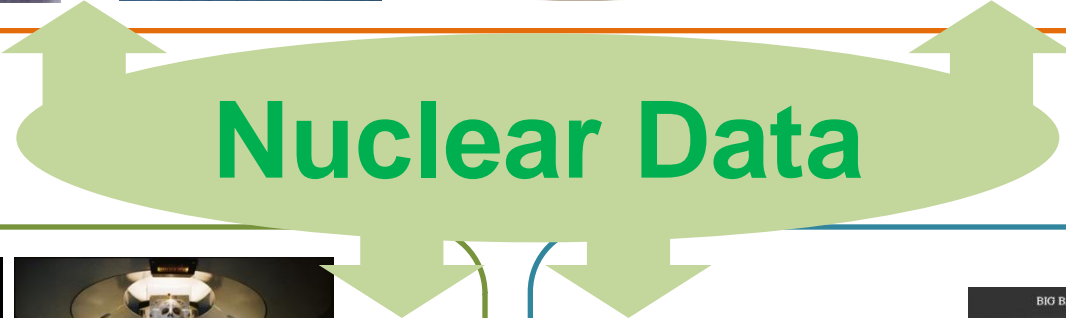
## World Trends

- “Nuclear Energy Renaissance” ← Energy Security → NPP
- International Projects (GIF, INPRO, GNEP, etc.)  
→ Researchers of Institutes & Industries
- Medical, Industrial, Agricultural Applications → Radiation Users
- IAEA/Nuclear Knowledge Management (Jun. 2007)
- Summer Institute (World Nuclear Univ., IAEA, OECD/NEA, WNA, etc.)  
US (2005), Sweden & France (2006), Korea (2007), Canada (2008)
- EU Training by INSTN (France) , CEA, Univ., EDF, Nuclear Industries
- University Program by US/DOE/NE

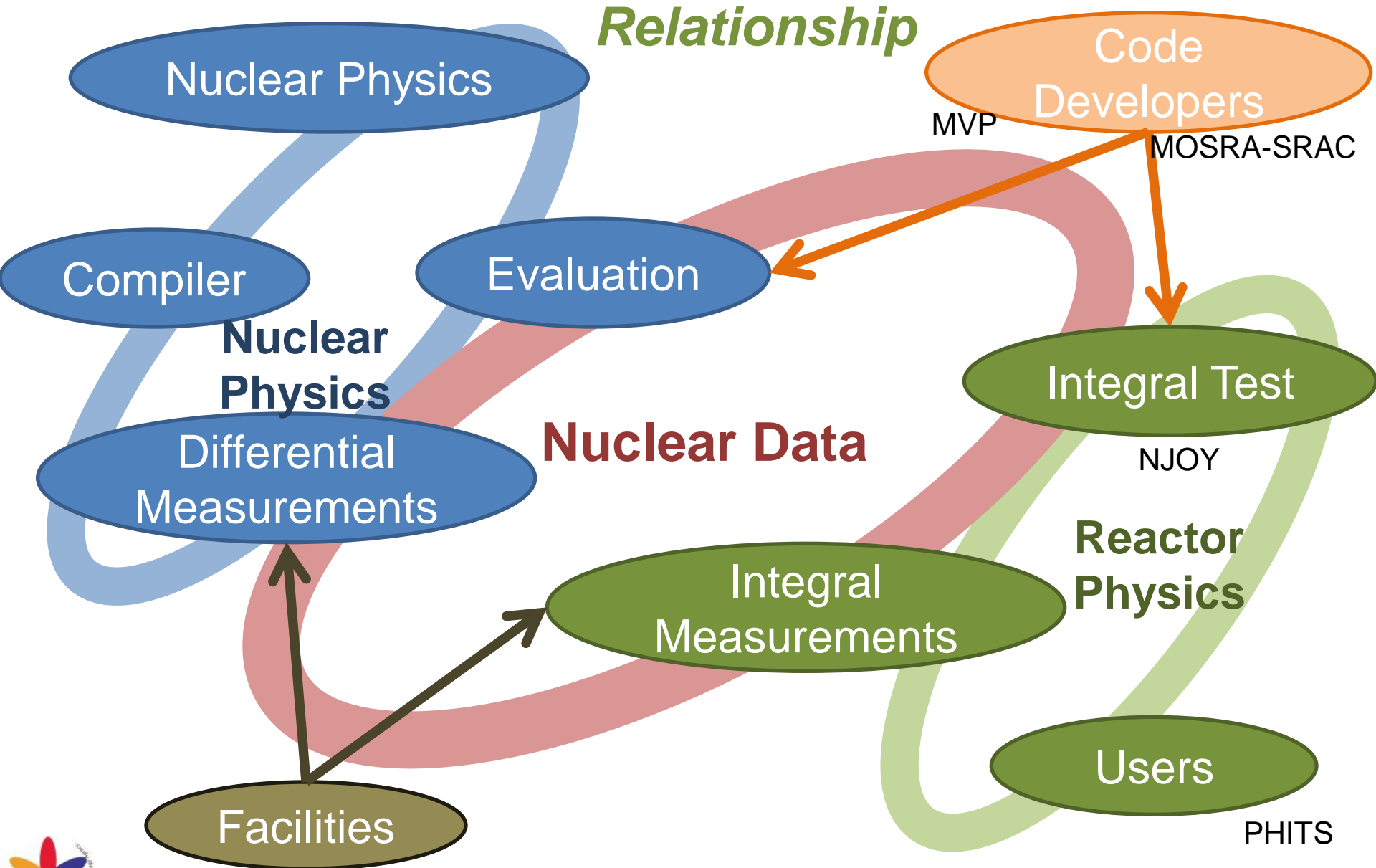
## Asian Trends

- KAERI/Training Center → Training for Electric Company,  
Regulation Agents, Industry, Universities, Institutes
- CIAE/Training Center → OJT, Simulator Training
- OAP & TINT (Thailand), MINT (Malaysia), VAEC (Vietnam) → Training
- IAEA → Remote Education System (KAERI),  
→ Training Material Preparation (JAEA)

## Nuclear Data Needs (General)



# Nucl. Data Needs and Relationship with R-Phys.






## *Current Environment Condition of Nuclear Data*

### **Nuclear Data Needs**

- Main Needs → Reactor Characteristics
- Down-stream → Burn-up, Criticality, Decay Heat
- SA Management
- LWR Safety

### **Quality Assurance**

- Best Estimate and Uncertainty Analysis
  - Covariance and Error Data
- Validation & Verification (V&V)
- Maintenance Strategy of Databases and Codes



International  
Standard

## *Nuclear Data Needs for SA Management*

= **Source Term** of Radiation and Heating

- **Burn-up** Calculation for Inventory Estimation
  - FP & MA Productions (FPY, Activation)
- **Decay Heat** Calculation
  - FP & MA Productions (FPY, Activation)
  - Decay Data
- **Shielding** Calculation for Fuel Cask
  - FP & MA Productions (FPY, Activation)
  - Neutron and Gamma-ray Productions, ( $\alpha, n$ )
- Calculation on **Re-criticality Potential**
  - FP & MA Productions (FPY, Activation)
  - Neutron Production
- **LWR Safety Foundation**
  - Thermal Cross Section,  $S(\alpha, \beta)$
  - Resonance Data

## Required Accuracy for Decay Heat Calculation

	Phase	Cooling Time [s]				
		1 – 20	20 – 10 <sup>4</sup>	10 <sup>4</sup> – 10 <sup>6</sup>	10 <sup>6</sup> – 10 <sup>7</sup>	10 <sup>7</sup> – 10 <sup>8</sup>
U-235	I	10%	5%	10%	10%	< 5%
	II	5%	2%	5%	5%	
Pu-239	I	10%	5%	10%	10%	< 5%
	II	5%	2%	5%	5%	
Pu-241	I	30%	15%	30%	30%	< 5%
	II	5%	2%	5%	5%	
U-238	I	30%	30%	30%	30%	< 15%
	II	15%	15%	15%	15%	

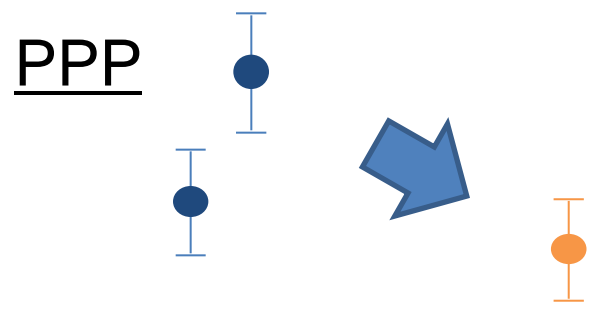
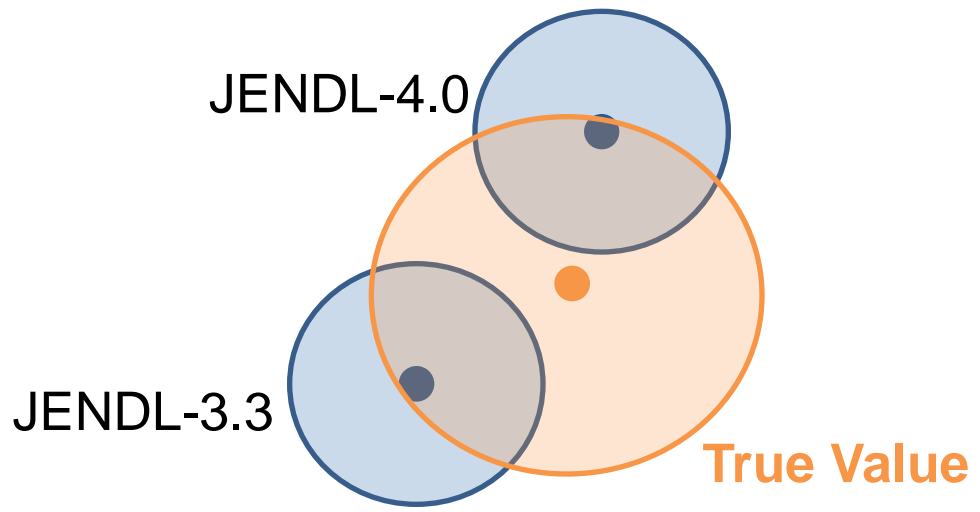


Now 10% (Uncertainty of Decay Energy)

## What is Uncertainty?

### Origins of Uncertainty

- ✓ Data: Nuclear Data, Material Compositions, etc.
- ✓ Modeling: Geometry, Homogenization, Numerical Approximation
- ✓ Calc. Method: Monte Carlo, Deterministic Method



	Data 1	Data 2	Ave.
Value	1.0	1.5	0.88
Stat. Err.	10%	10%	25%
Correlation	20%		

- Many exp. data with same methods
  - reducing statistical error, but not systematic one
  - exp. data with many methods
- Reducing both statistical and systematic errors
  - improving uncertainty of V&V

## *Collaborative consideration is necessary.*

### **V&V**

- What level is necessary for V&V achievement?
  - user needs research
  - deep discussion with users
- Verification → differential test
- Validation → integral (benchmark) test

### **Strategic Plan for Code Maintenance System**

- Financial, Physical, Psychological Supports
- Information from applied fields
- Research and dissemination of user needs

### **Quality Assurance and Standardization**

- Collaboration with AESJ
- Solving export control problem

## *Recover from Endangered Species*

### **Status Yellow**

- Nuclear Data Evaluator
  - To keep evaluation capability → CCONE
  - To keep specialists for light mass nuclides
- Covariance
  - Evaluation Code + KALMAN?
- Resolved Resonance Parameter
  - REFIT, SAMMY

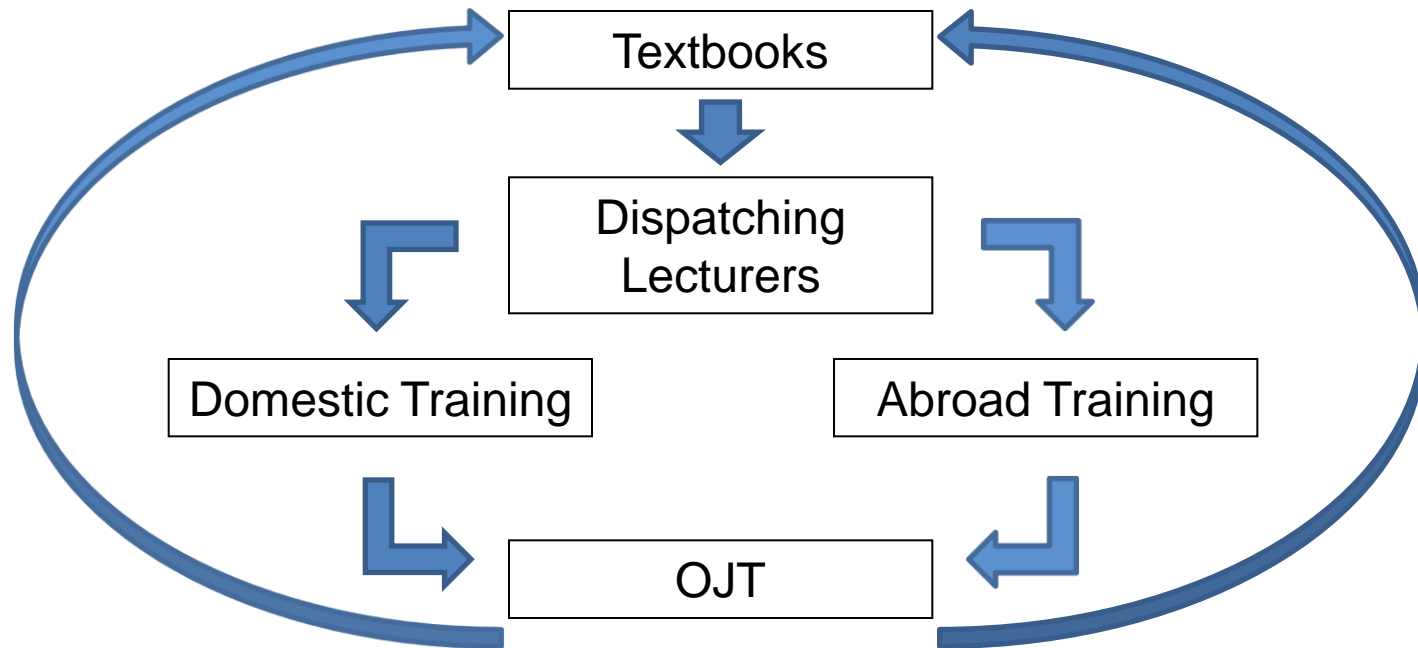
### **Status Red**

- Fission Product Yield
- Structure and Decay Data
- Thermal Scattering Kernel  $S(\alpha, \beta)$

*“Many professionals on individual components, but very few professional looking down whole system”, Tomio Kinoshita (International Institute for Advanced Studies), ATOMOS 57[3], 2011*

## *Example of Human Resource Developments*

- Textbooks
- Tutorial and Training System
- Cooperative Work with Universities
- International Collaboration



## *What I have often heard are ...*

When finish to produce nuclear data files?

Nuclear data are an important database for research and developments of nuclear applications. **Target materials and kinds of nuclear data are different** application by application. So new nuclear data is always necessary.

Is it necessary to be done by Japan?

**It is necessary** for proper usage of nuclear data **to know about the origin and background**. In the case of nuclear data being produced in abroad, it has some difficulty to see it.

Why do not consider the world-unified nuclear data file?

Since nuclear data are a kind of physical quantities, it must **converge into certain values**. However, it needs much more time to be fixed.



**Thank you for your attention!**

**JENPL**  
is your good choice.