

# Preliminary Results of Nuclear Data S&U Analysis for Benchmark Exercises Using DANTSYS/SUSD3D

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# I. Introduction



## Preparation of Cross Section Data

### ◆ Source ENDF

- ☞ ENDF/B-VII.0
- ☞ JENDL-4.0

### ◆ NJOY99 Code Processing

- ☞ Same NJOY processing options as KAFAX-libraries (NEA-1815, -1816, -1817) except for energy group structure (150 groups)
- ☞ MATXS-format
- ☞ Energy group structure: 33 groups of SG33 standard
- ☞ Weighting function: KALIMER-150 core spectrum



# Preparation of Covariance Data

## ◆ Source Covariance Data

- ☞ JENDL-4.0

## ◆ NJOY99 Code Processing

- ☞ COVFIL-format

- ☞ Energy group structure: 33 groups of SG33 standard

## ◆ Nuclides included

- ☞ Non-Actinides: B-10, B-11, O-16, Na-23, Mn-55, Fe-56, Co-59, Ni-58, Ni-60

- ☞ Actinides: U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Am-241

# Sn Transport Calculation by DANTSYS

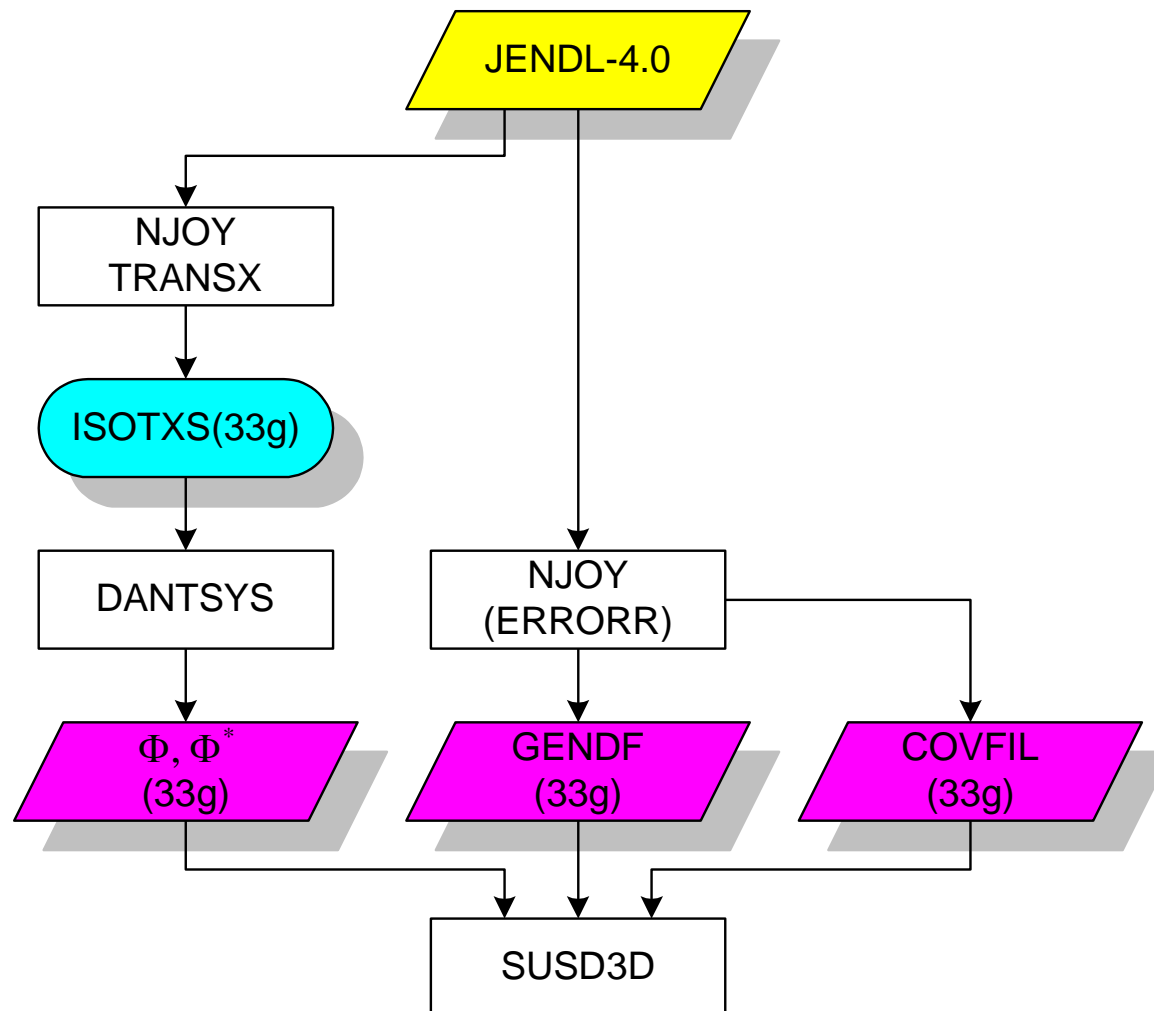
## ◆ Geometry

- ☞ 1-D Sphere model: JEZEBEL-Pu239, JEZEBEL-Pu240, FLATTOP-Pu
- ☞ 2-D Cylinder (R-Z) model: ZPR-6/7, ZPR-6/7 High-Pu240, JOYO Mk-I

## ◆ Angular Quadrature Sets

- ☞ S16, S8, S4: Traditional built-in  $P_n$  constants given by DANTSYS (IQUAD=1)
- ☞ S4: Quadrature set of SG33 standard (just for 1-D calculations)

# S&U Analysis by SUS3D



# II. Preliminary Benchmark Results



## This Study

- ◆ Benchmark calculations have been carried out for 7 benchmark exercises of WPEC SG33.
- ◆ Validation of Integral Parameters
  - ☞ k-eff, spectral indices, Na void reactivities (ZPPR-9)
  - ☞ DANTSYS calculations
    - ENDF/B-VII.0- and JENDL-4.0-based MATXS-format libraries
    - Options: P1-S4, P1-S8 (JEZEBEL-Pu239, ZPR-6/7), P3-S16
    - Same meshing and isotopic compositions as SG33 standard
    - Different angular quadrature sets (S4) from SG33 standard
  - ☞ Corrective Factors for homogeneous deterministic calculations (P1-S4, 33 groups)

# This Study

- ◆ Calculation of Nuclear Data Uncertainties to k-eff
  - ☞ Forward & Adjoint Fluxes: ENDF/B-VII.0 vs. JENDL-4.0
  - ☞ Same Covariance Data of JENDL-4.0 for both ENDF/B-VII.0- and JENDL-4.0-based DANTSYS runs
  - ☞ Considering
    - all nuclides with covariance data
    - all nuclear reactions of covariance file
    - inelastic scattering reactions with all discrete levels (MT=51-91, not MT=4)
    - normalized to sum of total nu sensitivities (MT=452) for all actinides

# Results with ENDF/B-VII.0-Based Library

No.	Core	Parameter	Experiment	ENDF/B-VII.0 (P1-S4, Quad. Set of DANTSYS)		ENDF/B-VII.0 (P1-S4, Quad. Set of SG33)	
				C/E	Uncertainty(%)	C/E	Uncertainty(%)
1	JEZEBEL-Pu239	keff	1.00000	1.003	0.48762	1.003	0.48809
2		F28/F25	0.2133	0.984		0.984	
3		F49/F25	1.4609	0.980		0.980	
4		F37/F25	0.9835	0.974		0.974	
5	JEZEBEL-Pu240	keff	1.00000	1.003	0.43217	1.003	0.43228
6	FLATTOP-Pu	keff	1.00000	1.010	0.48961	1.010	0.49039
7		F28/F25	0.1799	0.987		0.987	
8		F37/F25	0.8561	0.986		0.985	
9	ZPR-6/7	keff	1.00051	1.001	1.20620		
10		F28/F25	0.0223	0.988			
11		F49/F25	0.9435	1.013			
12		C28/F25	0.1323	1.024			
13	ZPR-6/7 High-Pu240	keff	1.00080	1.000	1.18180		
14	ZPPR-9	keff	1.00080	1.001	1.34660		
15		F28/F25	0.0207	0.991			
16		F49/F25	0.9225	0.989			
17		C28/F25	0.1296	1.027			
18		Na void (Step 3), pcm	106.0000	1.048			
19	Na void (Step 5), pcm	109.0000	1.075				
20	JOYO Mk-I	keff	1.00105	1.005	0.84874		

**NOTE:**

- ✓ failed to apply 2D quadrature set of SG33 standard
- ✓ might be inadequate for DANTSYS run

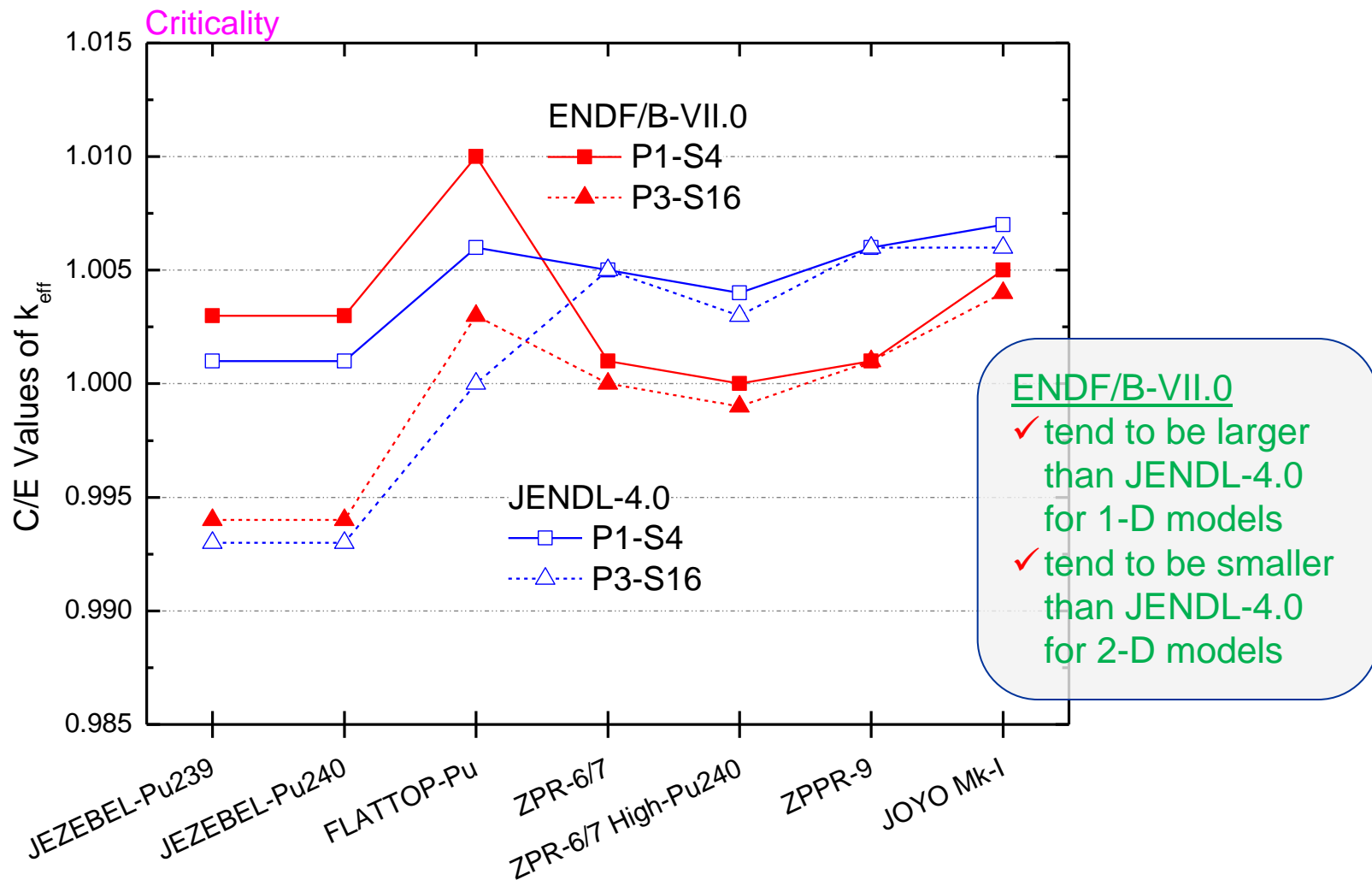
# Results with JENDL-4.0-Based Library



No.	Core	Parameter	Experiment	JENDL-4.0 (P1-S4, Quad. Set of DANTSYS)		JENDL-4.0 (P1-S4, Quad. Set of SG33)	
				C/E	Uncertainty(%)	C/E	Uncertainty(%)
1	JEZEBEL-Pu239	keff	<b>1.00000</b>	<b>1.001</b>	<b>0.48642</b>	<b>1.002</b>	<b>0.48697</b>
2		F28/F25	<b>0.2133</b>	<b>0.973</b>		<b>0.973</b>	
3		F49/F25	<b>1.4609</b>	<b>0.989</b>		<b>0.989</b>	
4		F37/F25	<b>0.9835</b>	<b>0.965</b>		<b>0.965</b>	
5	JEZEBEL-Pu240	keff	<b>1.00000</b>	<b>1.001</b>	<b>0.43031</b>	<b>1.002</b>	<b>0.43048</b>
6	FLATTOP-Pu	keff	<b>1.00000</b>	<b>1.006</b>	<b>0.48943</b>	<b>1.007</b>	<b>0.49027</b>
7		F28/F25	<b>0.1799</b>	<b>0.983</b>		<b>0.983</b>	
8		F37/F25	<b>0.8561</b>	<b>0.983</b>		<b>0.983</b>	
9	ZPR-6/7	keff	<b>1.00051</b>	<b>1.005</b>	<b>1.18440</b>		
10		F28/F25	<b>0.0223</b>	<b>0.992</b>			
11		F49/F25	<b>0.9435</b>	<b>1.027</b>			
12		C28/F25	<b>0.1323</b>	<b>1.031</b>			
13	ZPR-6/7 High-Pu240	keff	<b>1.00080</b>	<b>1.004</b>	<b>1.16110</b>		
14	ZPPR-9	keff	<b>1.00080</b>	<b>1.006</b>	<b>1.32050</b>		
15		F28/F25	<b>0.0207</b>	<b>0.997</b>			
16		F49/F25	<b>0.9225</b>	<b>1.003</b>			
17		C28/F25	<b>0.1296</b>	<b>1.033</b>			
18		Na void (Step 3), pcm	<b>106.0000</b>	<b>1.117</b>			
19		Na void (Step 5), pcm	<b>109.0000</b>	<b>1.151</b>			
20	JOYO Mk-I	keff	<b>1.00105</b>	<b>1.007</b>	<b>0.84486</b>		

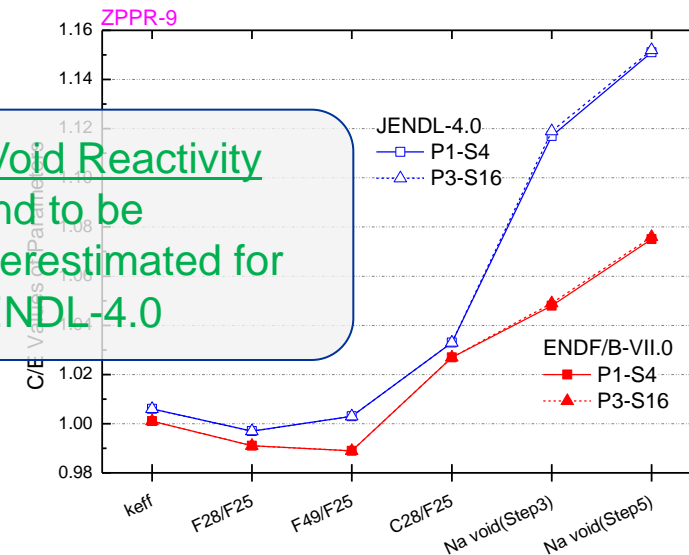
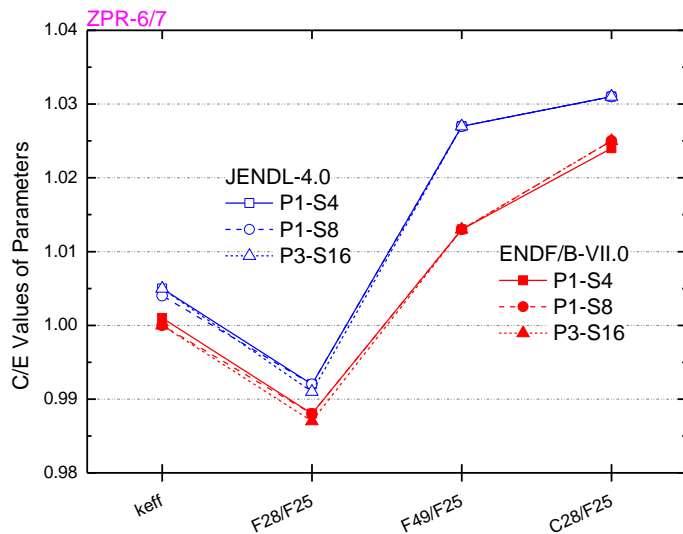
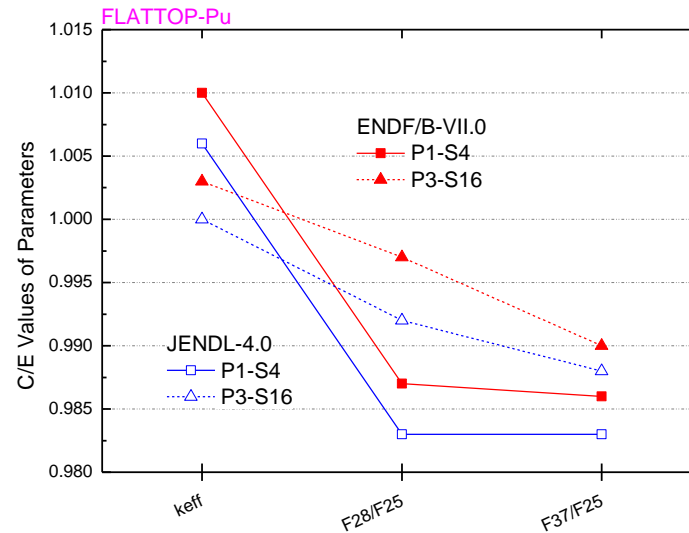
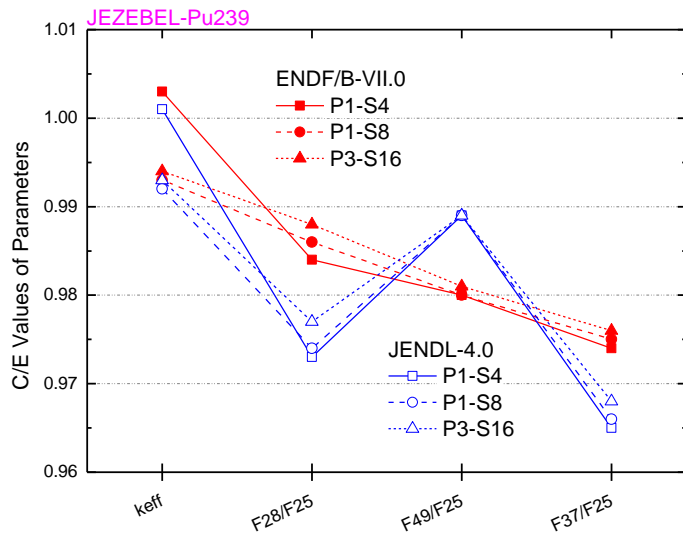
# Comparison of Criticality Results

## ENDF/B-VII.0 vs. JENDL-4.0



# Comparison of Integral Parameters

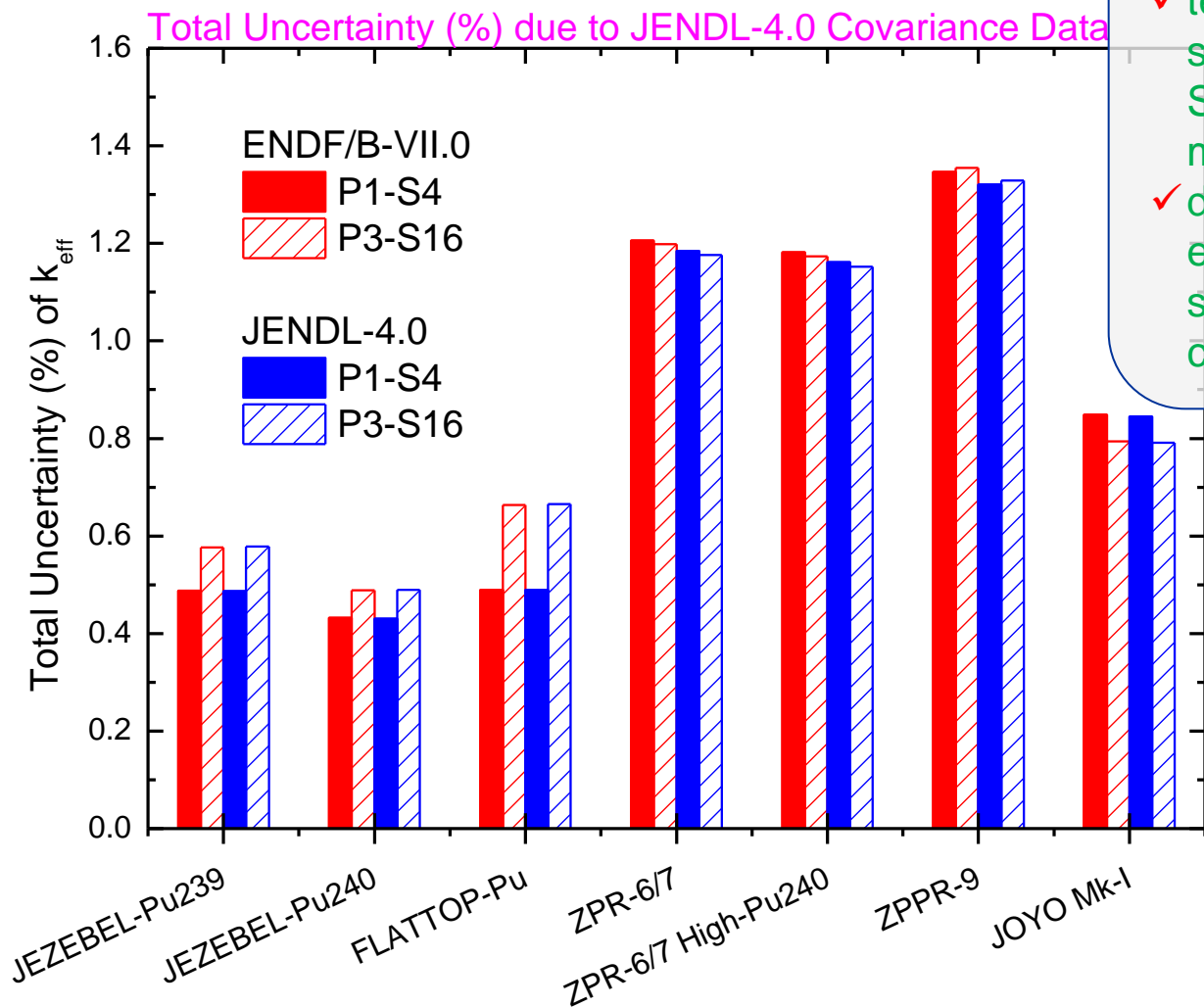
## ENDF/B-VII.0 vs. JENDL-4.0



Na Void Reactivity  
 ✓ tend to be overestimated for JENDL-4.0

# Comparison of Total Uncertainty

## ENDF/B-VII.0 vs. JENDL-4.0



Uncert. for P1-S4

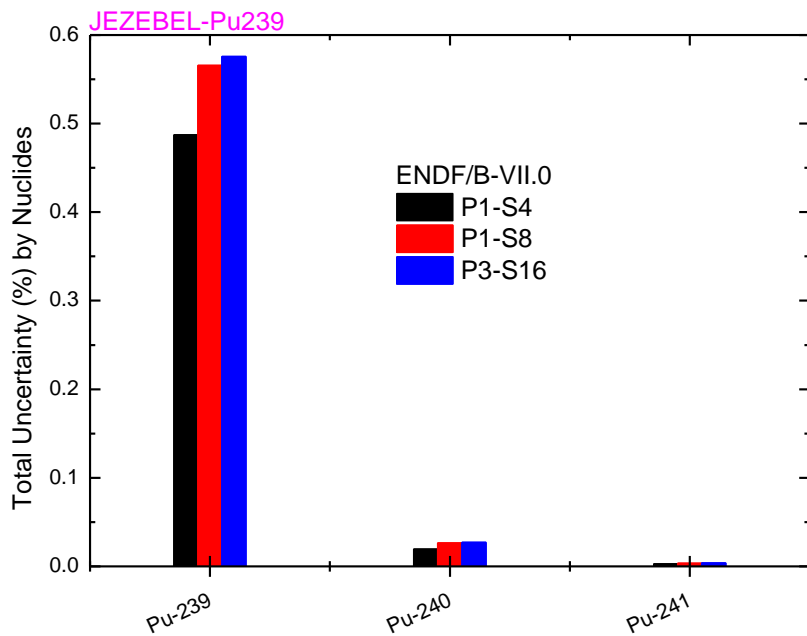
✓ tend to become smaller than P3-S16 for 1-D models

✓ due to changes in elastic & inelastic scattering contributions

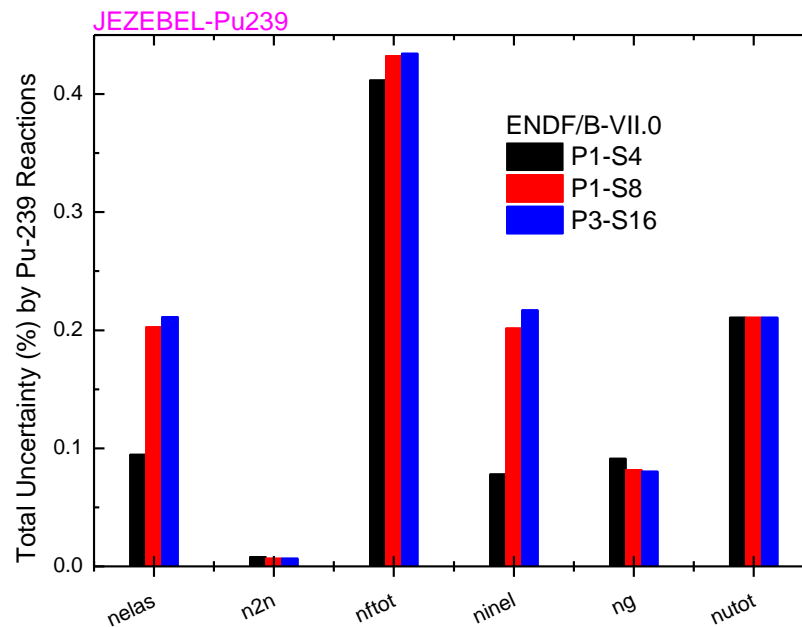
# Uncertainty Contribution by Nuclides & Reactions

## JEZEBEL-Pu239

< by Nuclides >



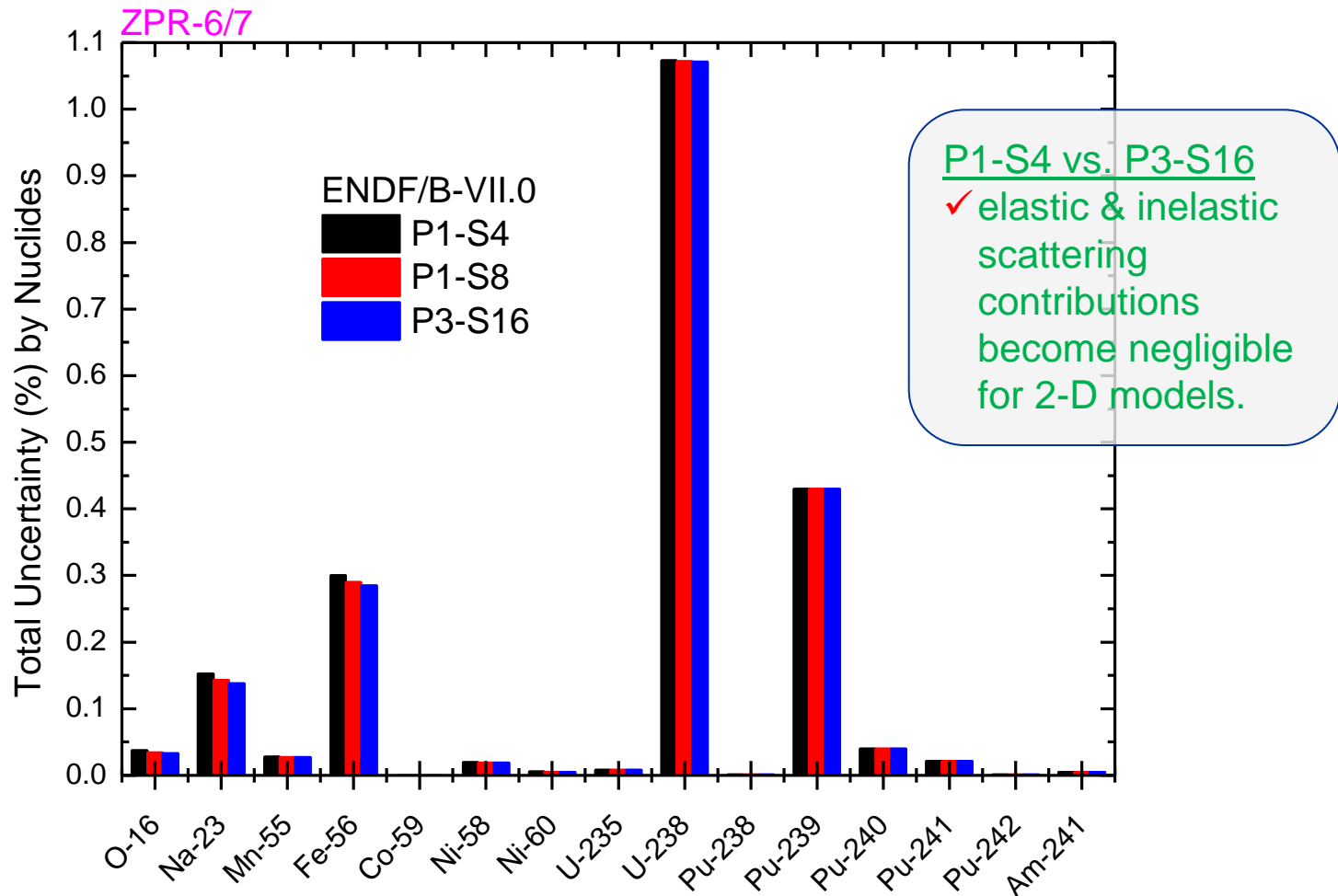
< by Reactions of Pu-239 >



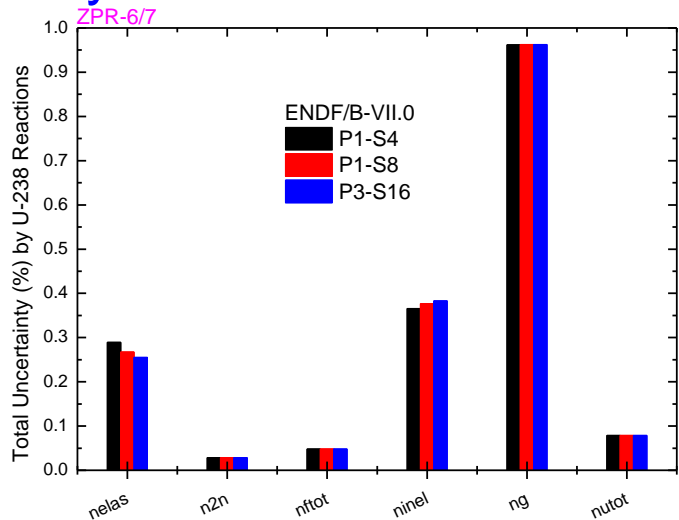
# Uncertainty Contribution by Nuclides & Reactions

ZPR-6/7

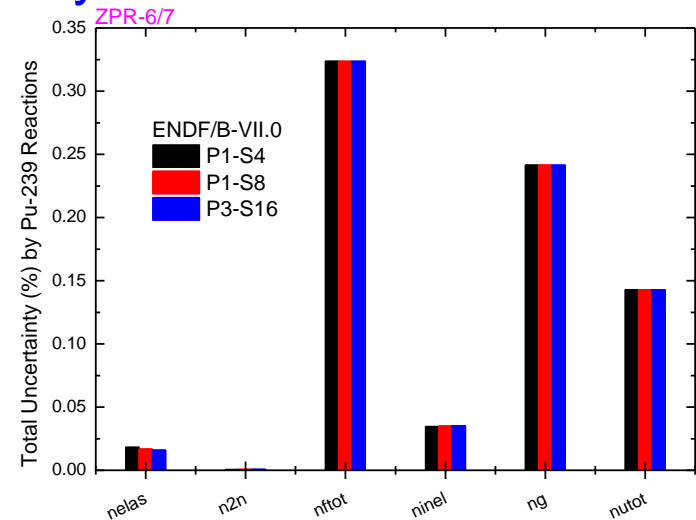
< by Nuclides >



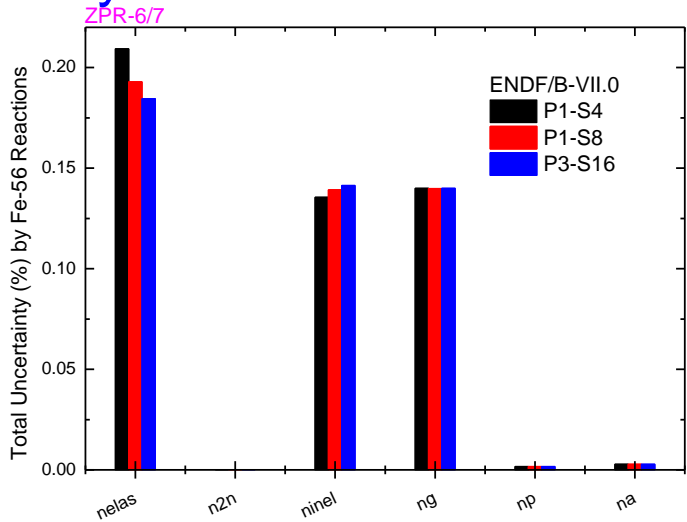
## < by Reactions of U-238 >



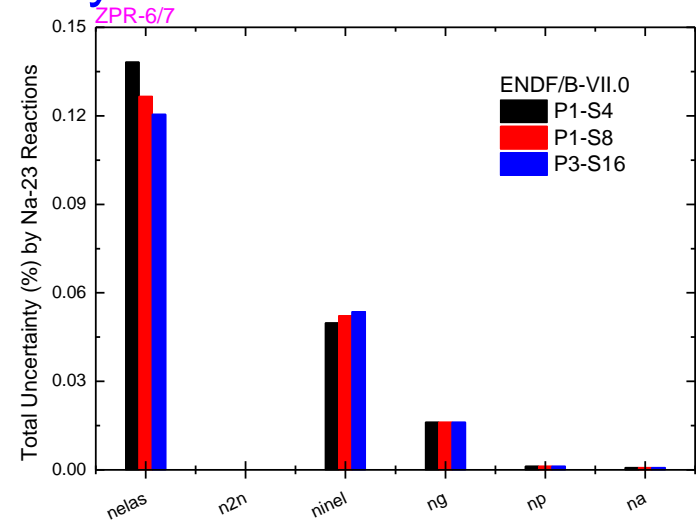
## < by Reactions of Pu-239 >



## < by Reactions of Fe-56 >

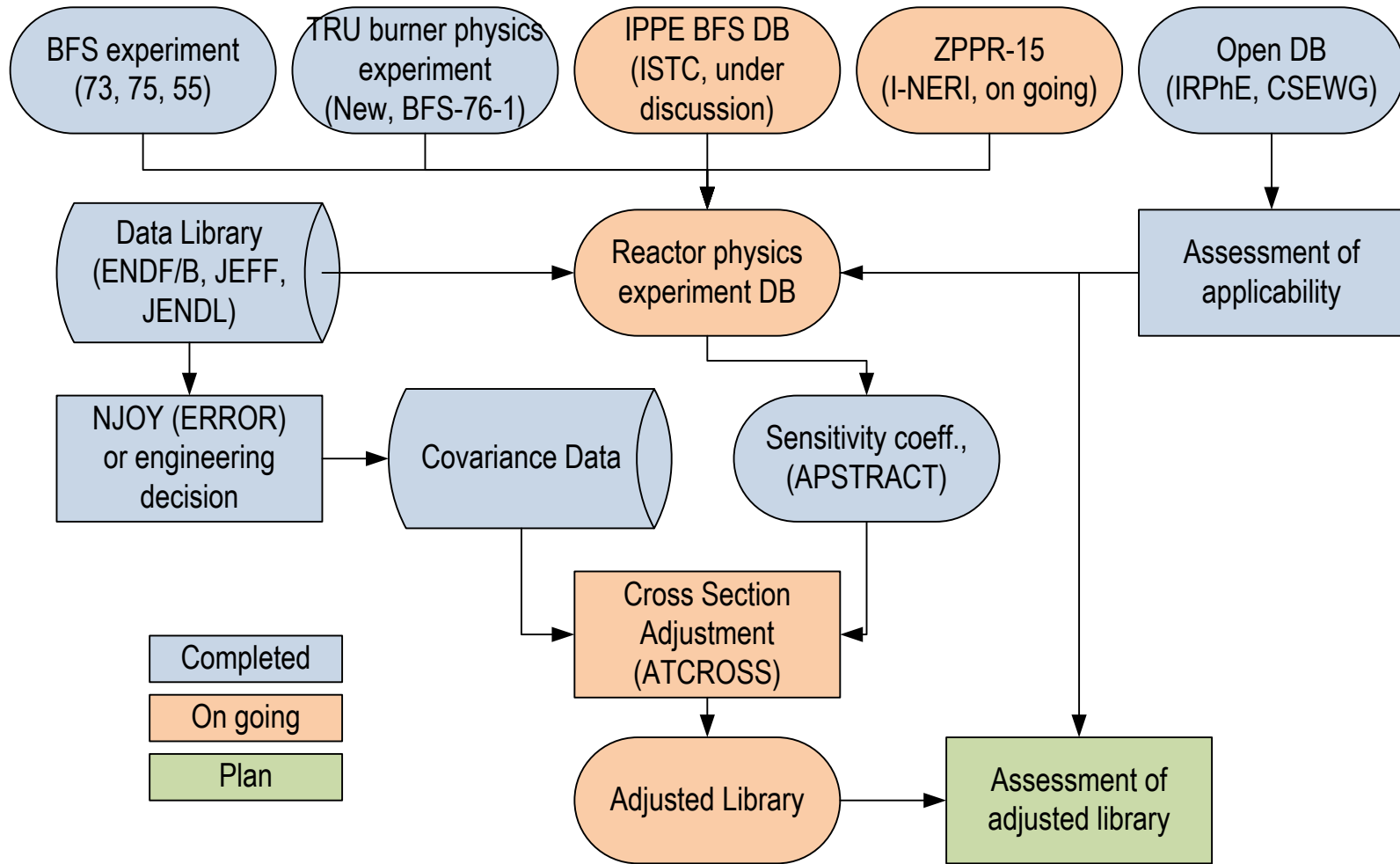


## < by Reactions of Na-23 >



# Status of V&V Activity at KAERI

## Work flow of V&V activity



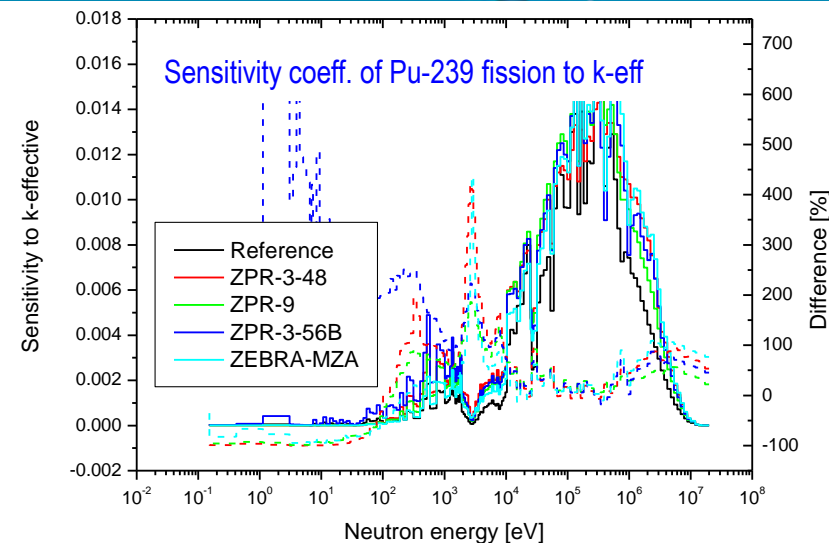
# Status of V&V Activity at KAERI

## Development of sensitivity analysis code (APSTRACT)

- ◆ Using perturbation theory based  $S_N$  transport theory
  - ☞ Forward and adjoint flux from TWODANT calculation
  - ☞ Using self-shielded cross section in ISOTXS

< Comparison of integral sensitivity coefficients of reactor physics exp. with reference core<sup>1)</sup>>

		Ref. <sup>1)</sup>	ZPR-3-48	ZPR-6-6A	ZPR-9	ZPR-3-56B	ZEBRA-MZA
Pu239	Fission	0.4382	0.5739-		0.5659	0.5913	0.5569
	Nu	0.6192	0.8219-		0.7859	0.8581	0.7830
	Capture	-0.0355	-0.0641-		-0.0517	-0.0714	-0.0478
U238	Fission	0.0574	0.0849	0.0726	0.0953	0.0652	0.0624
	Nu	0.0981	0.1454	0.1198	0.1599	0.1065	0.1033
	Capture	-0.1509	-0.2051	-0.2667	-0.2302	-0.1638	-0.1292
PU241	Fission	0.0419	0.0094-		0.0173	0.0187	0.0370
	Nu	0.0627	0.0138-		0.0251	0.0276	0.0531
	Capture	-0.0167	-0.0043-		-0.0072	-0.0102	-0.0123
Na	Capture	-0.0017	-0.0008	-0.0021	-0.0012	-0.0019	-0.0008
Fe	Capture	-0.0196	-0.0070	-0.0175	-0.0081	-0.0141	-0.0078



<sup>1)</sup> Reference core represents the TRU burner core for which BFS-76-1 experiment was performed

# Status of V&V Activity at KAERI

## Development of cross section adjustment technology

### ◆ Major Topics of Research

- ☞ Requirement of cross section adjustment
- ☞ Determination of target accuracy and selection of reactor physics experiment from open documents

### ◆ Methodology of adjustment

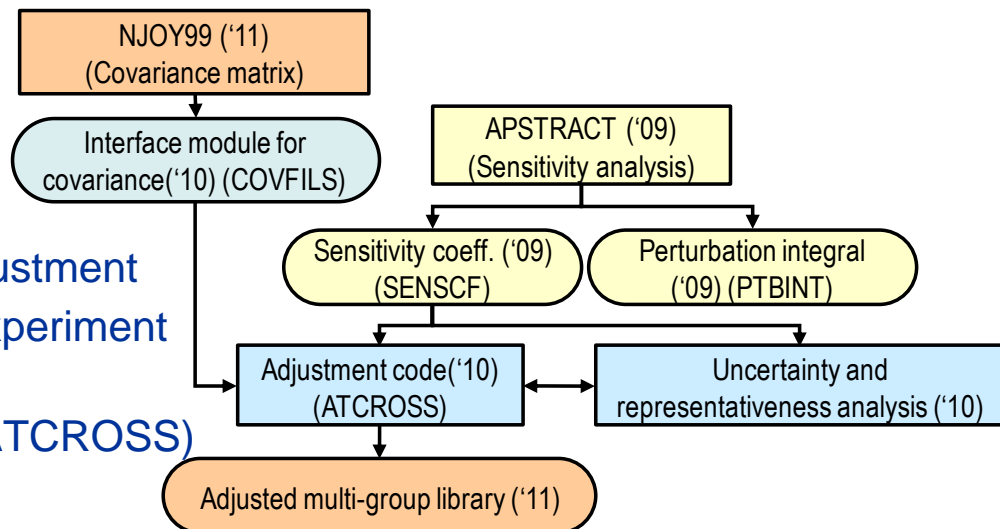
- ☞ Generalized least square method

### ◆ Development of XS adjustment code (ATCROSS)

- ☞ Interface with sensitivity analysis code
- ☞ Interface with NJOY code for covariance (COVFILS format)
- ☞ Uncertainty analysis and representativeness analysis

### ◆ Major Achievements and Further Utilization

- ☞ Requirement of cross section adjustment
- ☞ Selection of applicable physics experiment DB from open database
- ☞ Cross section adjustment code (ATCROSS)
- ☞ Utilization for producing adjusted multi-group library



# III. Summary

## ◆ First contribution to WPEC SG33 by KAERI

- ☞ Generation of MATXS-format cross section libraries based on ENDF/B-VII.0 and JENDL-4.0
- ☞ Generation of COVFIL-format covariance libraries based on JENDL-4.0
- ☞ Calculation of integral parameters for 7 benchmark exercises of WPEC SG33
- ☞ Estimation of nuclear data uncertainties to k-eff

## ◆ Future Works

- ☞ Estimate nuclear data uncertainties to remaining integral parameters (spectral indices, Na void reactivities)
- ☞ Apply COMMARA-2.0 or ENDF/B-VII.1 covariance data
- ☞ Nuclear data adjustment