
Progress on Nuclear Data Adjustment

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- **Overview**
- **Changes made in Nuclear Data Preparation**
- **Methods and Procedures**
- **Updated Benchmark Results**
 - **Include sensitivity and uncertainty results for 1D benchmarks**
- **Summary**

- **Regenerate a set of multigroup XS library and covariance matrices.**
- **Developing S/U analysis code system**
 - **SEN1D can calculate S/U of k_{eff} , but not for reaction rate.**
 - **DOT3.5 was employed for 2D experiments analysis.**
 - **SUSD3D will be employed for 2D analysis.**
- **Do benchmark S/U analysis**
 - **1D/2D benchmark k_{eff} and reaction rates updated;**
 - **S/U analysis of k_{eff} for 1D benchmarks have been done;**
- **Adjustment exercise still have not started yet.**
 - **ZOTT-VL code will be employed;**
 - **Have to do some modification before adjustments.**

Changes made in Nuclear Data Preparation

■ Multigroup Cross Section Library

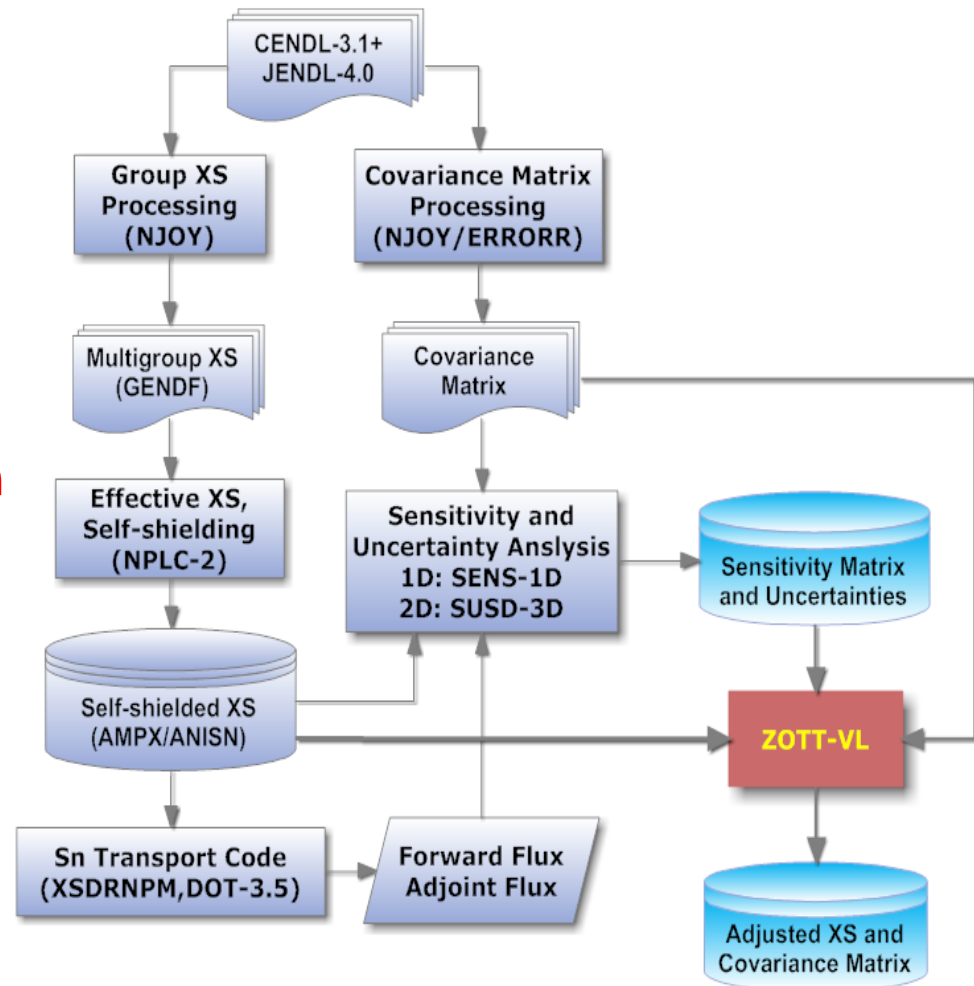
- Code: NPLC-2, preNPLC2.pl+NJOY99+PASC4
- Evaluation files(79 in total):
 - CENDL-3.1(with covariances): ^{56}Fe
 - JENDL-4.0(with covariances): ^{10}B , ^{23}Na , $^{235,238}\text{U}$, $^{239,240}\text{Pu}$.
 - CENDL-3.1: others.
- Weight function for group XS: iwt=8, 1/e + fast reactor + fission + fusion
- Self-Shielding: Bonami-II
- A mistake made in nuclear data processing corrected.

■ Multigroup Covariance

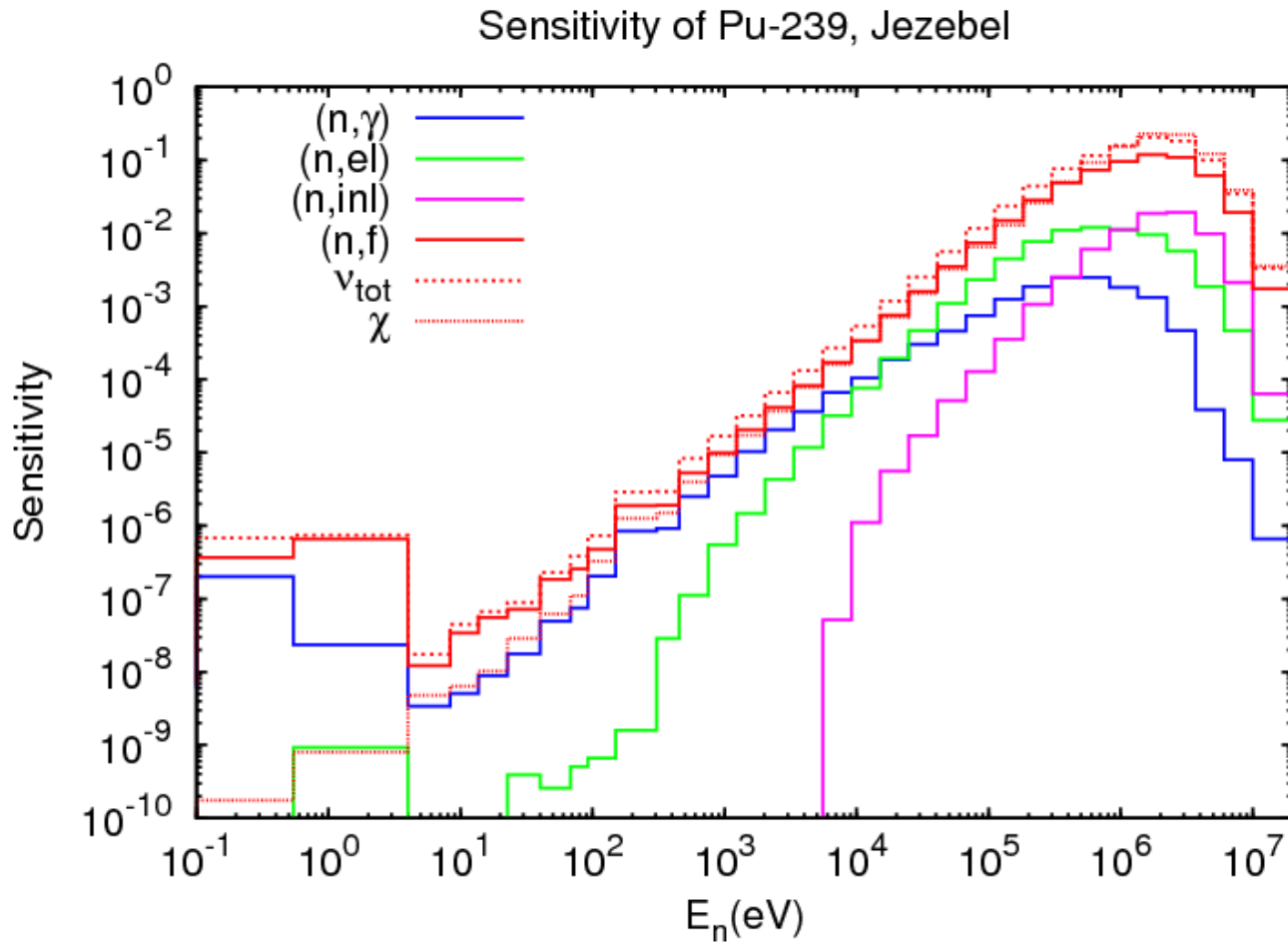
- Weight function: **changed to 1/E.**

Methods and Procedures

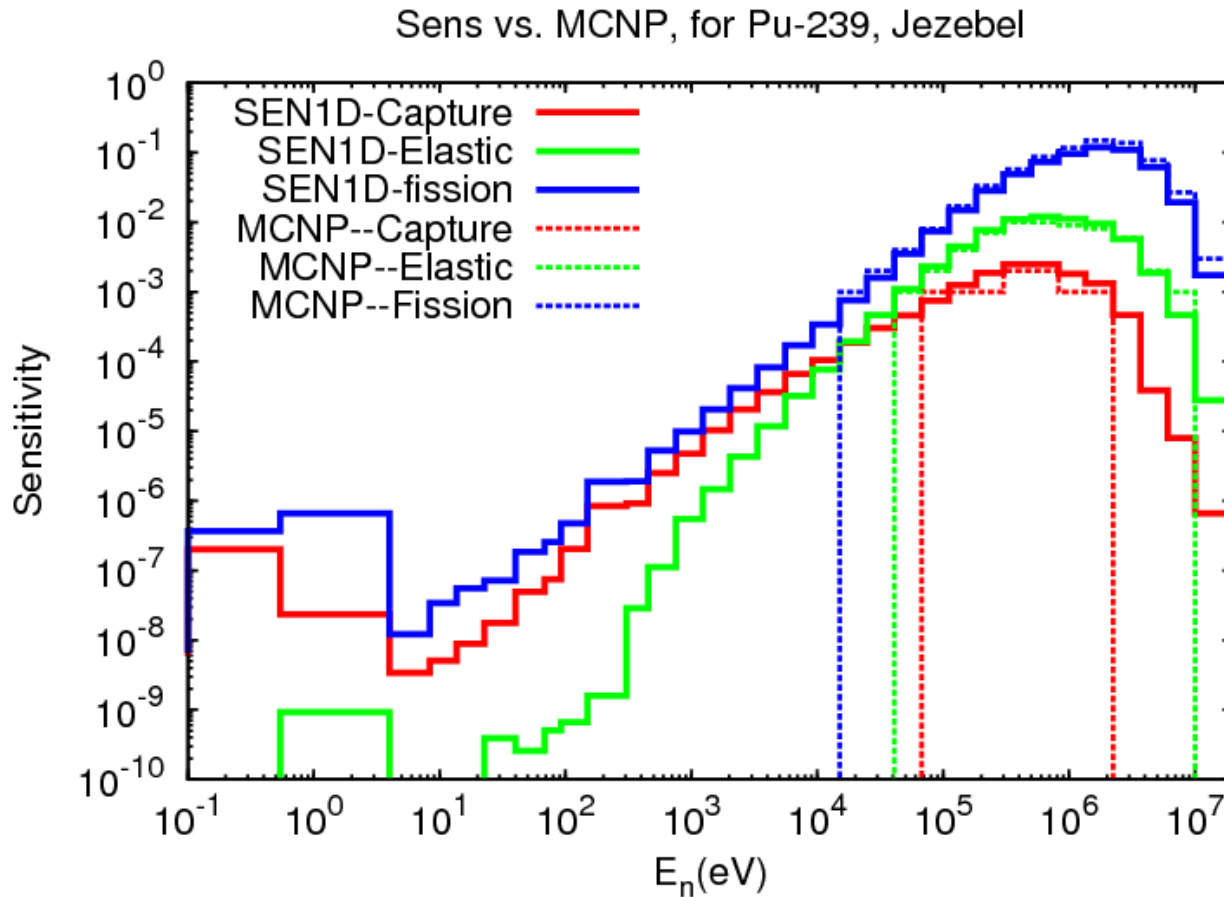
- SEN1D code is still under development
 - The code can calculate explicit sensitivities for 1D experiments.
 - **Self-shielded cross sections from AMPX work library were used in calculating sensitivities.**
- DOT3.5+SUSD3D will be employed for 2D S/U analysis.
- Modified ZOTT-VL will be employed as cross section adjustment code.



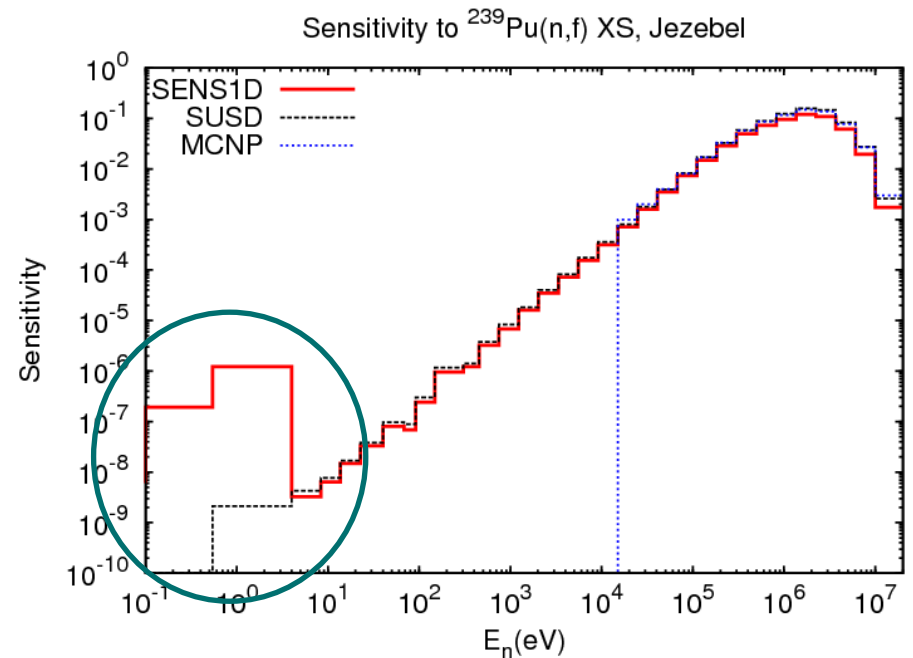
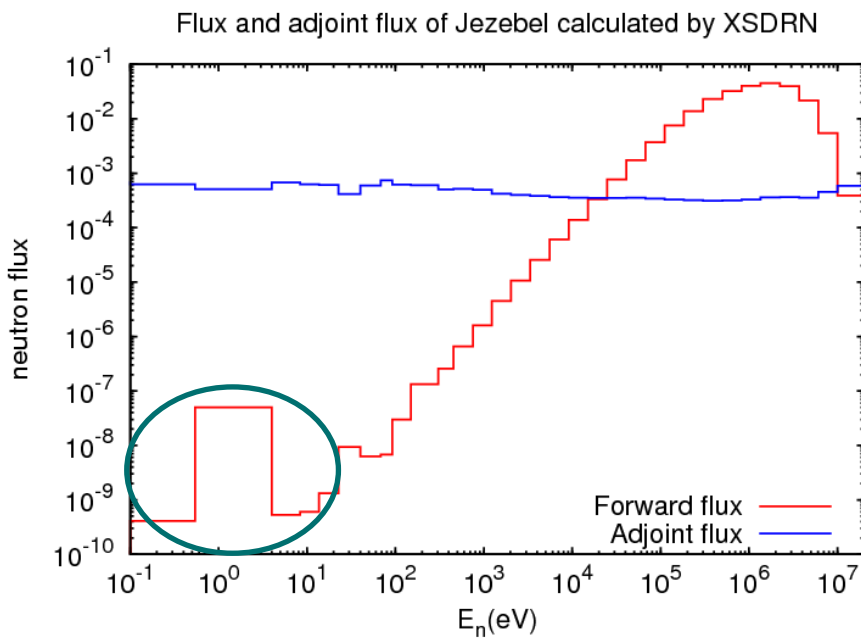
■ Sensitivities results for Jezebel calculated by SEN1D



■ SEN1D vs. MCNP



- **Comparison among SEN1D, MCNP and SEN1D**
 - **Unreasonable sensitivities calculated in low energy groups cause by wrong library.**
 - **General good for SEN1D.**



Updated Benchmark Results

■ Jezebel - ^{239}Pu

Parameters	MC Benchmark Model	S_4P_1	Corr. Fact.	Experiment
k_{eff}	0.9984	1.0040	0.9944	1.00000 \pm 200pcm
F28/F25	0.2069	0.2055	1.0068	0.2133 \pm 1.1%
F37/F25	0.9811	0.9808	1.0002	0.9835 \pm 1.4%
F49/F25	1.4374	1.4364	1.0007	1.4609 \pm 0.9%

Nuclide	(n,f)	(n, γ)	ν	(n,el)	(n,inl)	(n,tot)
Pu-239	3.49E-03	1.21E-03	2.10E-03	2.27E-03	5.61E-03	7.39E-03
	22.19%	2.67%	8.03%	9.44%	57.46%	99.79%
Pu-240	1.27E-04	7.21E-05	5.61E-05	1.73E-04	2.42E-04	3.36E-04
	0.03%	0.01%	0.01%	0.05%	0.11%	0.21%
					Total	0.0074

Most important contributions to the uncertainty of k_{eff} come from:
 $^{239}\text{Pu}(\text{n,inl})$ and (n,f)

Updated Benchmark Results

■ Jezebel - ^{240}Pu

Parameters	MC Benchmark Model	S_4P_1	Corr. Fact.	Experiment
k_{eff}	0.9985	1.0038	0.9947	1.00000 \pm 200pcm

Nuclide	(n,f)	(n, γ)	ν	(n,el)	(n,inl)	(n,tot)
Pu-239	3.00E-03	1.02E-03	1.76E-03	1.82E-03	4.87E-03	6.34E-03
	21.09%	2.43%	7.28%	7.75%	55.64%	94.18%
Pu-240	5.93E-04	3.38E-04	2.62E-04	7.73E-04	1.16E-03	1.57E-03
	0.82%	0.27%	0.16%	1.40%	3.16%	5.82%
					Total	0.0065

Most important contributions to the uncertainty of k_{eff} come from:
 $^{239}\text{Pu}(\text{n,inl})$ and (n,f)

Updated Benchmark Results

■ Flattop-Pu

Parameters	MC Benchmark Model	S_4P_1	Corr. Fact.	Experiment
k_{eff}	0.9988	0.9953	1.0035	1.00000 ± 300pcm
F28/F25	0.1759	0.1682	1.0458	0.1799 ± 1.1%
F37/F25	0.8645	0.8432	1.0252	0.8561 ± 1.4%

Nuclide	(n,f)	(n, γ)	v	(n,el)	(n,inl)	(n,tot)
Pu-239	3.36E-03	1.24E-03	1.73E-03	4.51E-04	2.76E-03	4.86E-03
	4.45%	0.61%	1.18%	0.08%	2.99%	9.31%
Pu-240	1.14E-04	7.67E-05	4.81E-05	4.20E-05	1.21E-04	1.94E-04
	0.01%	0.00%	0.00%	0.00%	0.01%	0.01%
U-235	3.22E-05	1.93E-05	2.51E-05	2.85E-05	9.86E-05	1.12E-04
	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
U-238	1.44E-04	9.44E-04	4.76E-04	3.44E-03	1.47E-02	1.52E-02
	0.01%	0.35%	0.09%	4.67%	85.43%	90.67%
					Total	0.0159

Most important contributions to the uncertainty of k_{eff} come from:
 $^{238}\text{U}(\text{n},\text{inl})$, (n,el) and $^{239}\text{Pu}(\text{n},\text{f})$

Updated Benchmark Results

■ Godiva

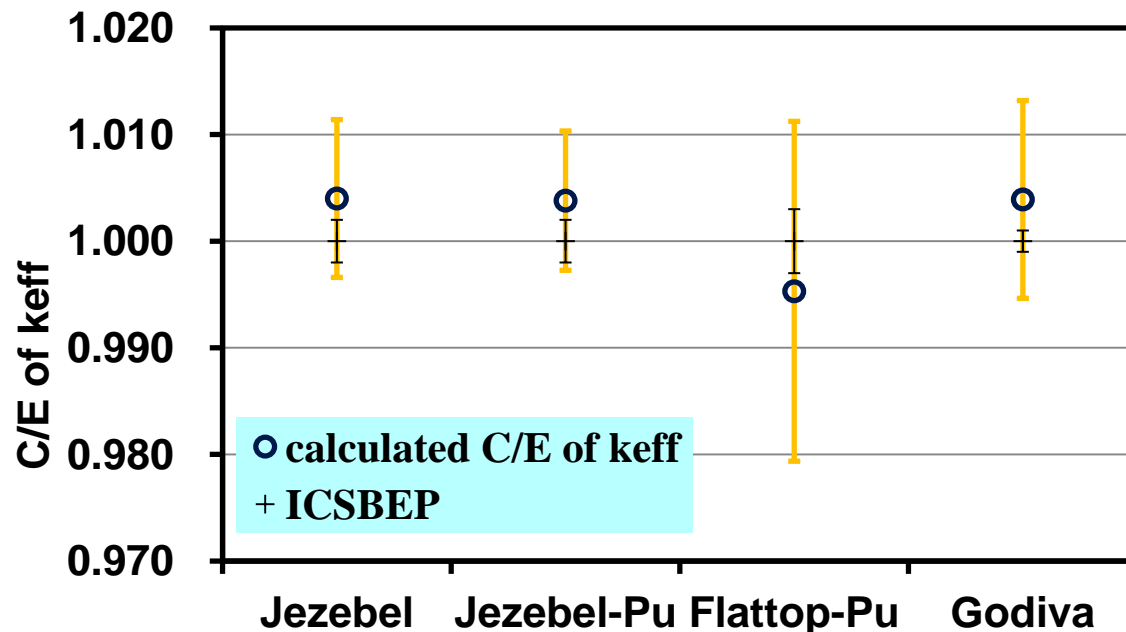
Parameters	MC Benchmark Model	S_4P_1	Corr. Fact.	Experiment
k_{eff}	0.9974	1.0039	0.9935	1.00000±100pcm
F28/F25	0.1589	0.1560	1.0187	0.1643 ±0.0018
F37/F25	0.8539	0.8391	1.0177	0.8516 ±0.0120
F49/F25	1.3977	1.3935	1.0030	1.4152 ±0.0140

Nuclide	(n,f)	(n, γ)	ν	(n,el)	(n,inl)	(n,tot)
U-235	2.62E-03	2.86E-03	2.74E-03	3.33E-03	7.22E-03	9.26E-03
	7.96%	9.49%	8.73%	12.87%	60.66%	99.74%
U-238	3.00E-05	5.19E-05	5.56E-05	1.42E-04	4.40E-04	4.70E-04
	0.00%	0.00%	0.00%	0.02%	0.22%	0.26%
Total					0.0093	

Most important contributions to the uncertainty of k_{eff} come from:
 $^{235}\text{U}(\text{n,inl}), (\text{n,el})$ and (n,γ)

Updated Benchmark Results

- **C/E values of k_{eff} and uncertainties for 1D benchmarks**
 - The calculated uncertainties of k_{eff} are much larger than those evaluated values of benchmarks.
 - Apparently, the covariance data of nuclear data need to be adjusted.



Updated Benchmark Results

■ ZPR6-7 standard

Parameters	MC Benchmark Model	S ₄ P ₁	Older data	Corr. Fact.	Experiment
k _{eff}	0.9902	0.9951	0.9467	0.9951	0.9866 ±0.00230
F49/F25	0.9159	0.9461	0.9633	0.968	0.9435 ±0.0198
F28/F25	0.0205	0.0232	0.0249	0.886	0.0223 ±0.0007
C28/F25	0.1393	0.1407	0.1693	0.990	0.1323 ±0.0032

■ ZPR6-7 high Pu240

Parameters	MC Benchmark Model	S ₄ P ₁	Corr. Fact.	Experiment
k _{eff}	0.9878	0.9937	0.9941	0.9874 ±0.00220

■ Joyo MK-I

Parameters	MC Benchmark Model	S ₄ P ₁	Corr. Fact.	Experiment
k _{eff}	-	1.00308	-	1.00105 ±0.00180

Updated Benchmark Results

■ ZPPR9

Parameters	S ₄ P ₁	Reactivity	Experiment	C/E
K _{eff}	0.99529		1.00080 ±0.00154	0.9945
S-Index (F28/F25)	0.0211		0.02210 ±0.00061	0.9551
S-Index (F49/F25)	0.9378		0.9295 ±0.0185	1.0090
S-Index (C28/F25)	0.1425		0.1379 ±0.0026	1.0334
Na void (Step 3)	0.99622	26.29 ¢	29.18 ¢ ±0.51 ¢	0.9010
Na void (Step 5)	0.99670	39.88 ¢	31.30 ¢ ±0.53 ¢	1.2740

- **The development of SEN1D code is still not finished**
 - To add the ability of calculating S-U of reaction rate;
 - Some verifications test still need to be done.
- **For ZPR6/7, ZPR6/7-High Pu240, ZPPR-9 and Joyo, k_{eff} and reaction rates calculations have been done.**
 - The mistake made in nuclear data processing has been corrected and the k_{eff} results for ZPR6/7 now is reasonable.
- **For Jezebel, Jezebel-Pu, Flattop-Pu and Godiva,**
 - Sensitivity and uncertainty are calculated and the results look reasonable.
 - The calculated uncertainties of k_{eff} are much larger than those evaluated values.

- **Next step**
- **Perform S/U analysis of 2D benchmarks.**
 - **How to deal with the implicit part of sensitivity?**

$$\begin{aligned} \left(S_{k, \Sigma_{x,g}^i} \right)_{total} &= \frac{\Sigma_{x,g}^i}{k} \frac{dk}{d\Sigma_{x,g}^i} = \frac{\Sigma_{x,g}^i}{k} \frac{\partial k}{\partial \Sigma_{x,g}^i} \\ &+ \sum_j \sum_h \frac{\Sigma_{y,h}^j}{k} \frac{\partial k}{\partial \Sigma_{y,h}^j} \times \frac{\Sigma_{x,g}^i}{\Sigma_{y,h}^j} \frac{\partial \Sigma_{y,h}^j}{\partial \Sigma_{x,g}^i} \\ &= S_{k, \Sigma_{x,g}^i} + \sum_j \sum_h S_{k, \Sigma_{y,h}^j} S_{\Sigma_{y,h}^j, \Sigma_{x,g}^i} \\ &\qquad \qquad \text{Explicit} \qquad \qquad \qquad \text{Implicit} \end{aligned}$$

- **Modify ZOTT-VL code and carry on adjustment test.**

Thank you for your attention!