KAERI 한국원자력연구원 Korea Atomic Energy Research Institute

Nuclear Data Related Activities at KAERI

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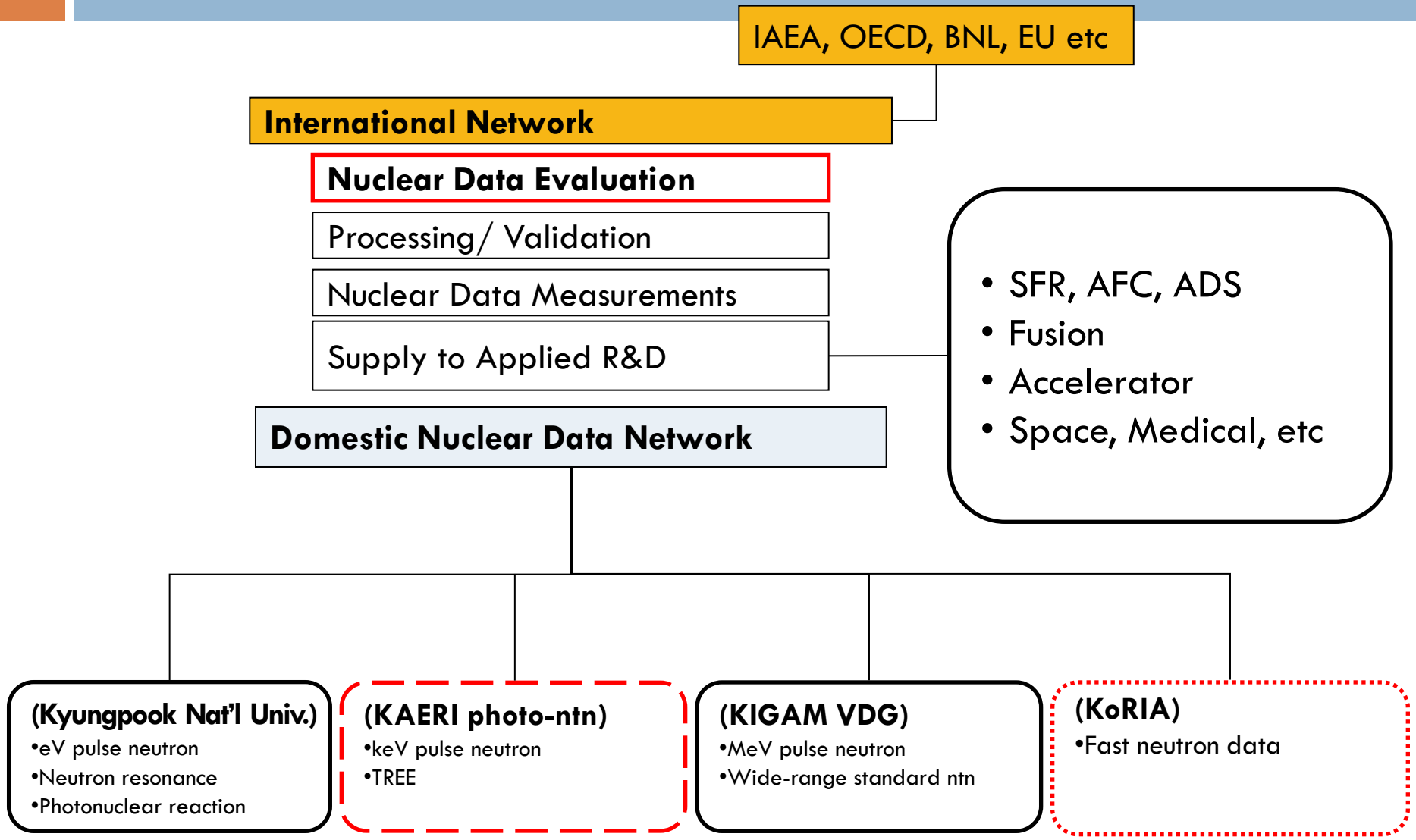
Contents

- Introduction to Nuclear Data Center at KAERI
- Evaluation activities
  - Covariance evaluations at resonance region
    - (n,el), (n,) and (n,f) based on MLBW formalism
    - Sample calculations for ^{237}Np
  - Evaluations at high energy region
    - XS/Covariance evaluations with EMPIRE-KALMAN
    - Results for Fe, Cr and W
- Processing and validation
  - Benchmark results for ^{240}Pu
- Measurement activities
  - Design of fast neutron source and various measurement activities
- New website for providing the nuclear data
  - Nuclear properties such as mass excess and decay mode, and evaluated nuclear data are provided

Nuclear Data Network in Korea



Nuclear Data Center @ KAERI

- Performs the measurement, evaluation, processing and validation of nuclear data which are requested by the various fields.
- Comprises 1 director, 11 permanent staffs (2 in evaluation, 1 in theory, 2 in processing and validation, 4 in measurements and application, 2 in atomic and molecular data), 1 PhD student, 1 post master's researcher and 1 secretary.
- Mission of KAERI/NDC is disseminating outcomes of international network as well as promoting domestic nuclear data activities and related applications.

COVRES Code

- Evaluates neutron c/s uncertainties in the resolved resonance region.
  - Extended from KERCEN
  - Based on a transparent formalism (using MLBW or kernel approximation) using the resonance parameter uncertainties from the *Atlas of Neutron Resonances*.
  - Handles scattering radius uncertainty explicitly.
  - Accepts the correlation coefficients as input.
- Uncertainty of average cross section

$$< \delta\bar{\sigma}\delta\bar{\sigma} >= \sum_{i,r,i',r'} \frac{\partial\bar{\sigma}}{\partial p_{i,r}} < \delta p_{i,r}\delta p_{i',r'} > \frac{\partial\bar{\sigma}}{\partial p_{i',r'}},$$

where $< \delta p_{i,r}\delta p_{i',r'} >$ is covariance of resonance parameters.

- Sensitivity

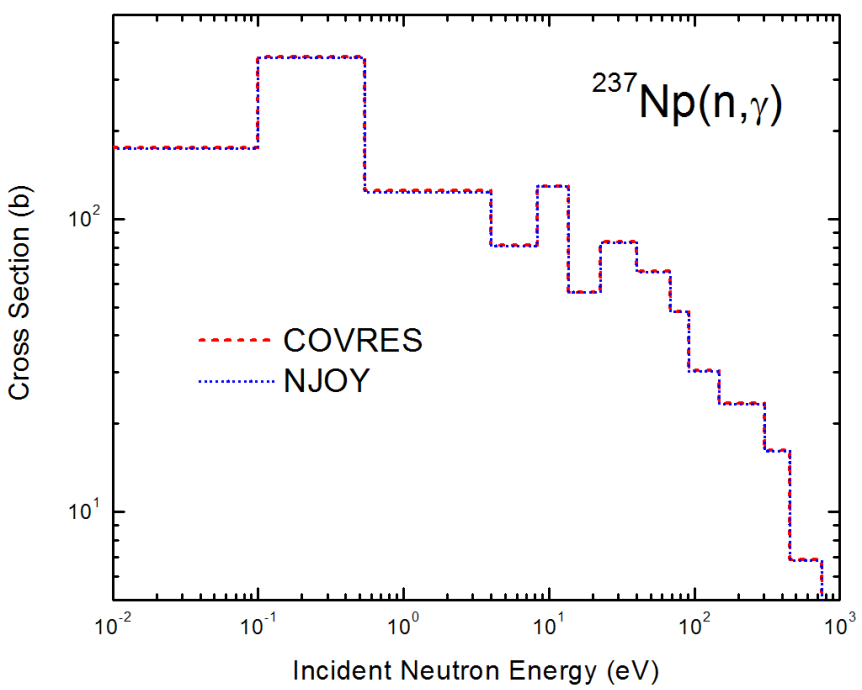
$$\frac{\partial\bar{\sigma}}{\partial\Gamma_i} = \frac{1}{\Delta E}\int_{E_1}^{E_2} \frac{\partial\sigma(E)}{\partial\Gamma_i} dE \qquad \text{where } i = \gamma, n$$

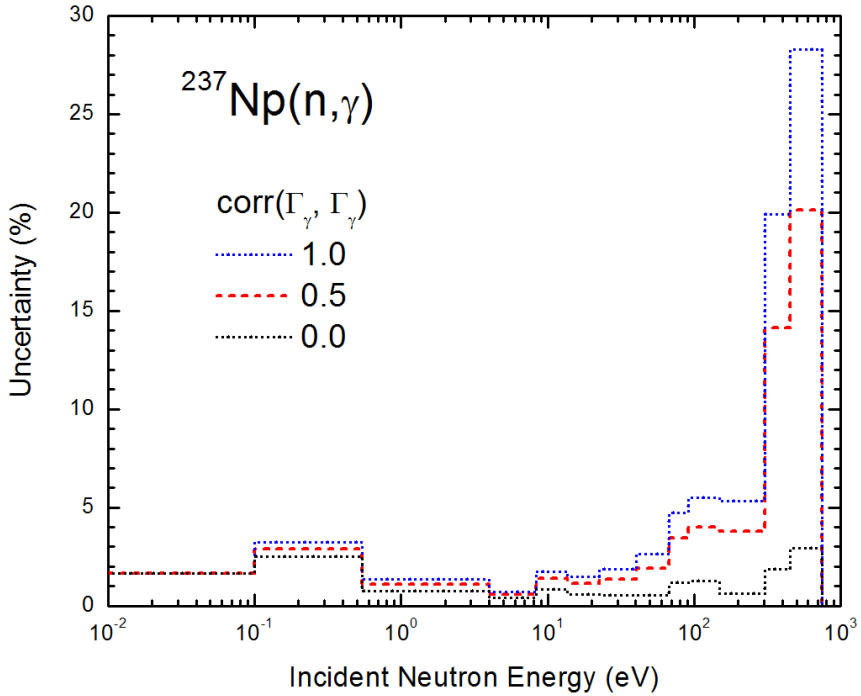
$\frac{\partial\bar{\sigma}_n}{\partial R'}$? by observing variation of average scattering cross section due to deviation of R'

$$\frac{\partial\bar{\sigma}_n}{\partial R'}\delta R' \approx \delta\bar{\sigma}_n \; (R' \rightarrow R' + \delta R')$$

Resonance region

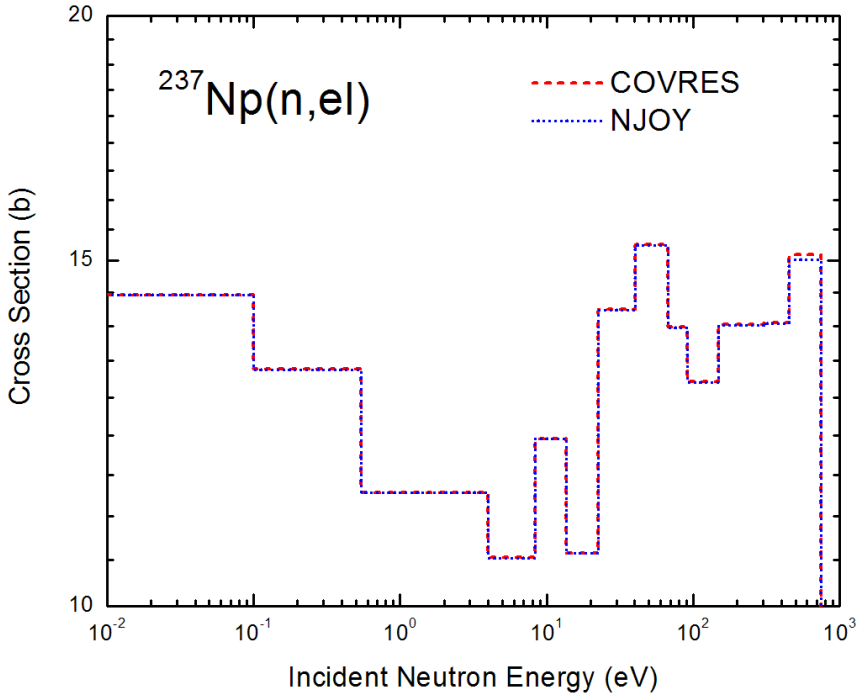
^{237}Np, capture

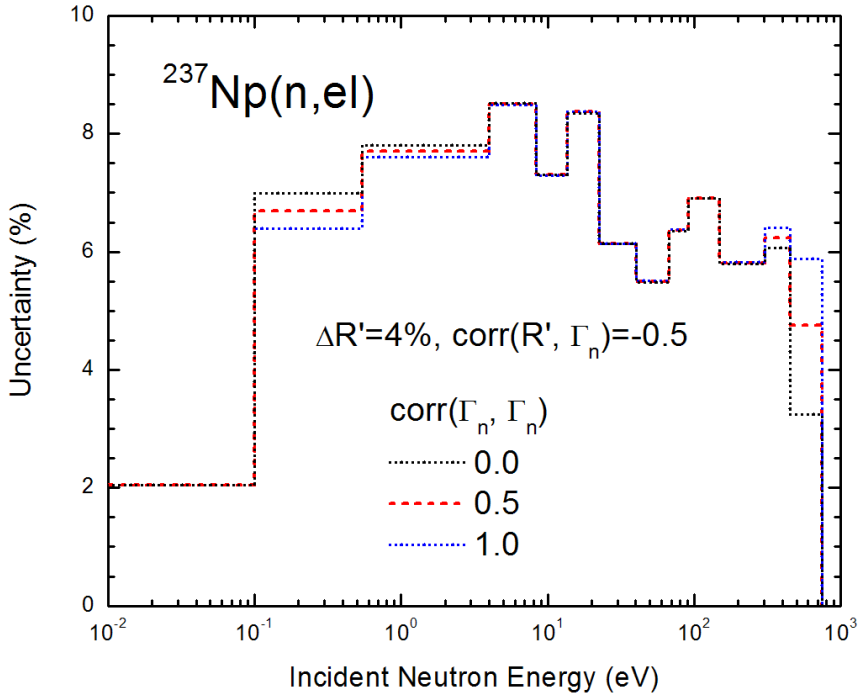




Resonance region

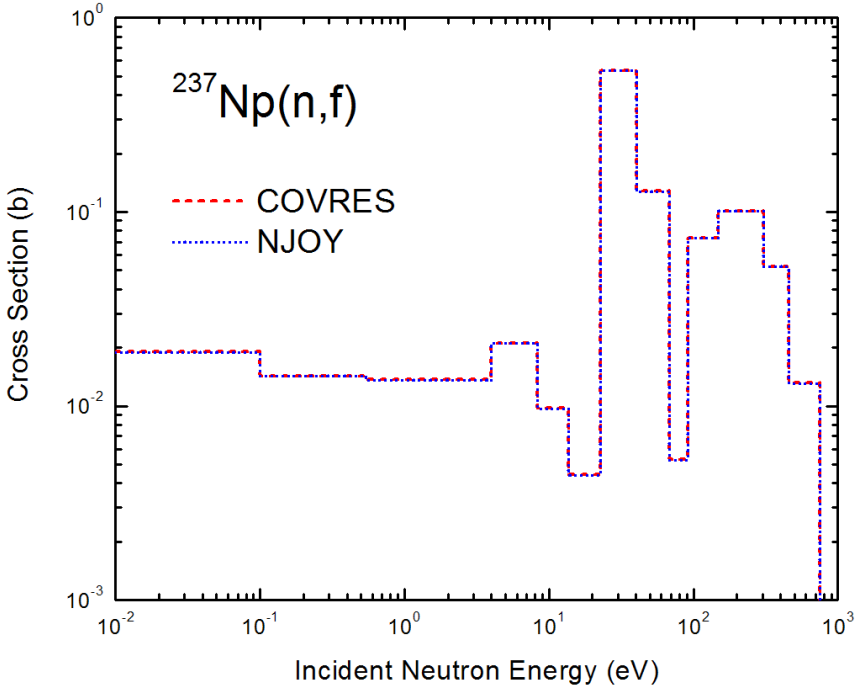
^{237}Np, scattering

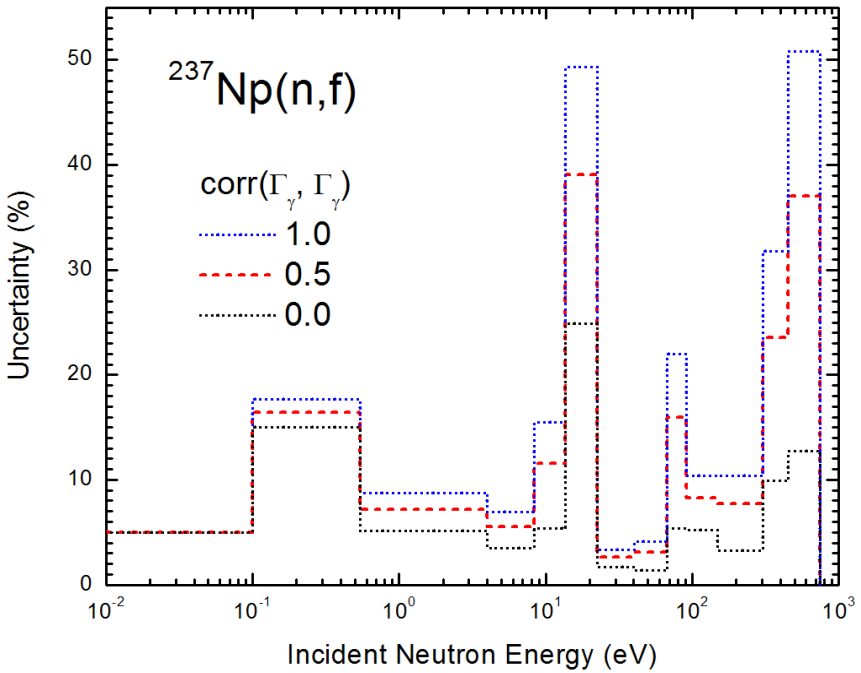




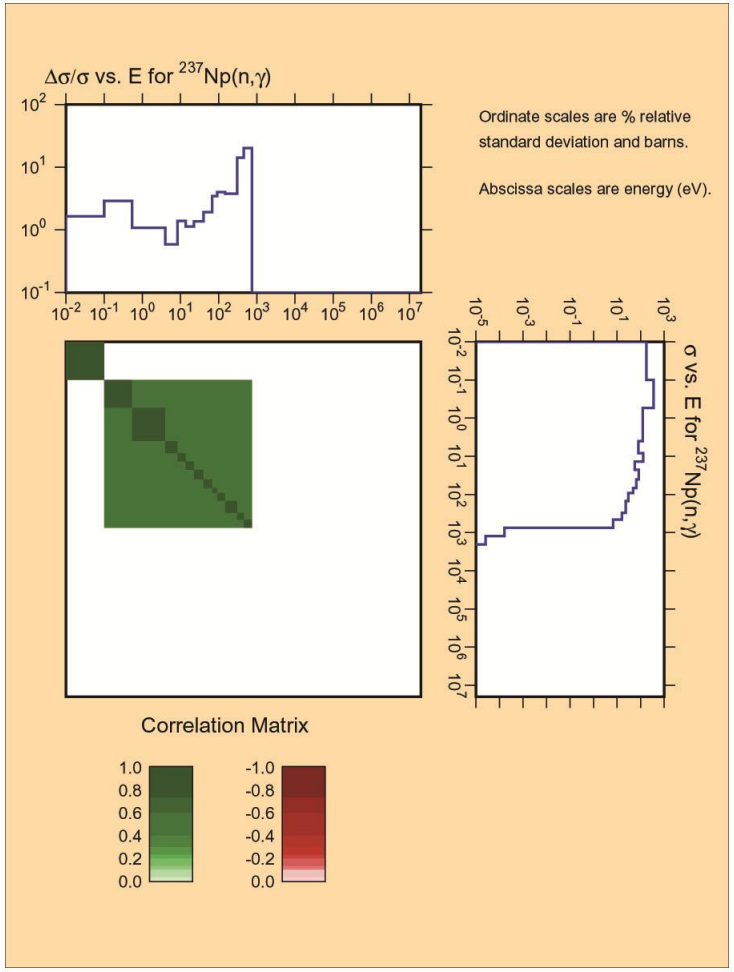
Resonance region

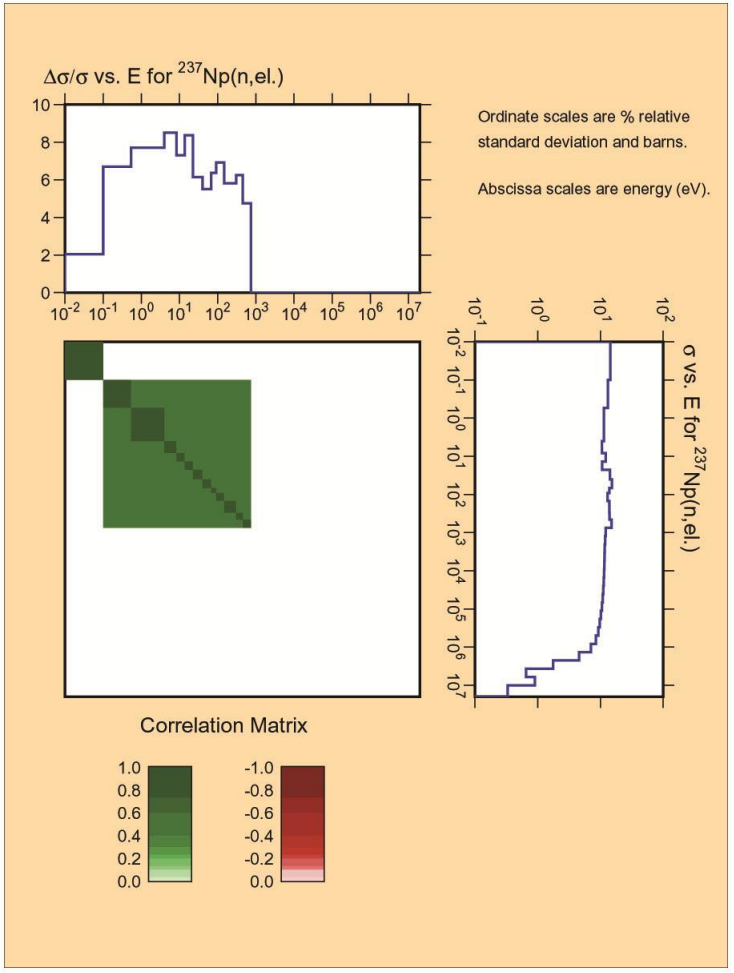
^{237}Np, fission



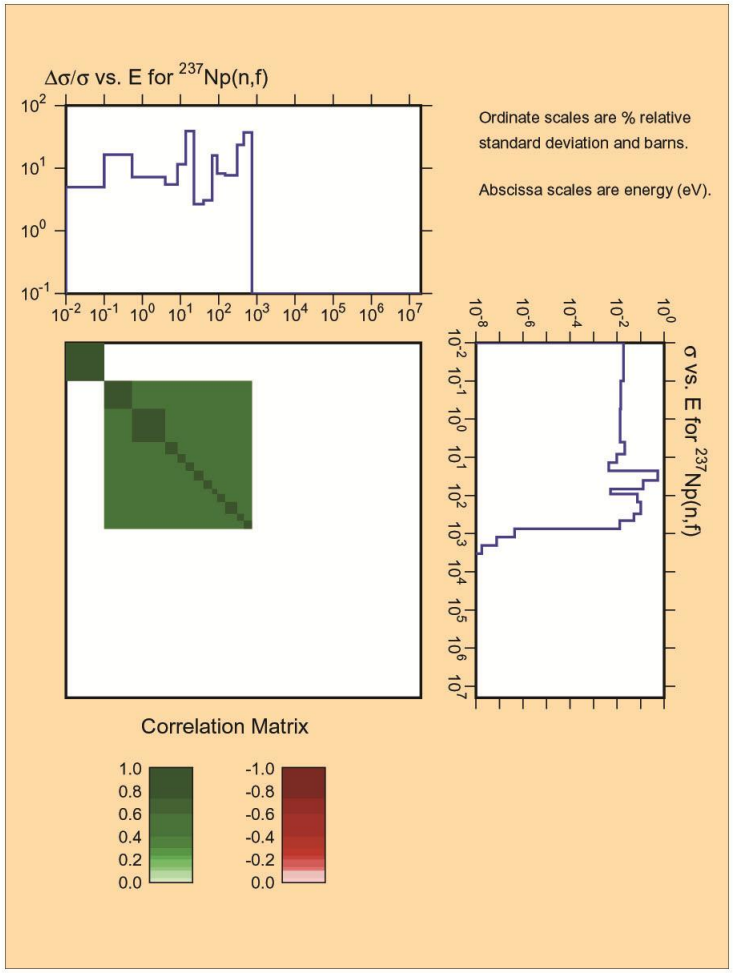


Covariances for ^{237}Np





Covariances for ^{237}Np



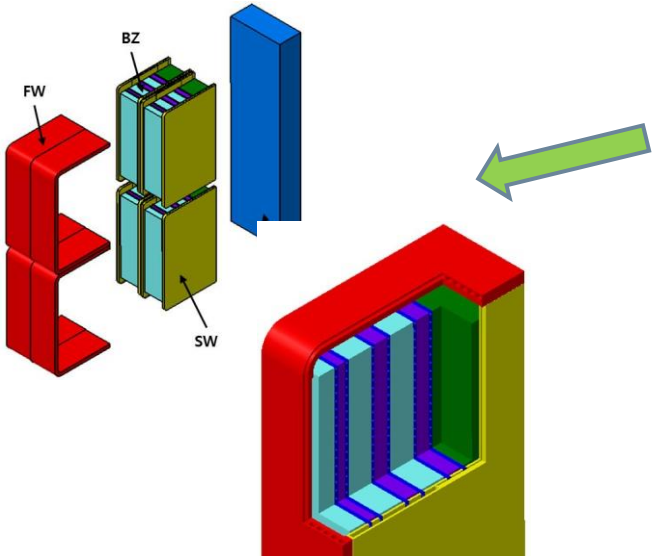
Evaluation Method

- Code
  - EMPIRE-3
  - Parallel computing used in order to reduce a computing time due to covariance matrices and a thousand incident energies
- OMP adjustment
  - Tool for optimization of OMP developed by KAERI/NDC
- Models
  - Hauser-Feshbach with HRTW
  - DEGAS for gamma and PCROSS for others in pre-equilibrium
  - Empire specific level densities
  - Gamma strength function by plujiko(MLO1)
- Covariance
  - EMPIRE-KALMAN used
  - Sensitivity matrices by variations of model parameters around optimal value
  - Using uncertainties of measurements if available
  - Scaling up or down the uncertainty if extremely low or high

Ko HCCR TBM

- A Mission of KAERI/NDC to Ko HCCR TBM
  - The neutronics analysis to obtain the optimal design parameters
  - Provision of the most reliable nuclear data
    - Recommendation of the evaluated nuclear data from the existing libraries
    - Production of the evaluated nuclear data

HCCR TBM configuration



Projection view of HCCR TBM sub-module

Materials used in the Ko HCCR TBM

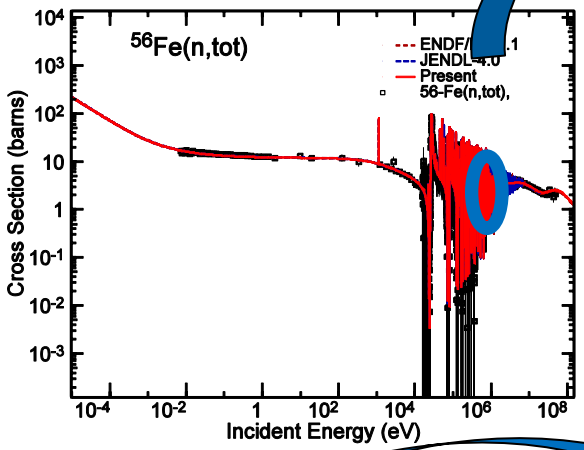
Material	Element
RAFM Steel* (Structural Material)	W, Ta, Fe, Cr, Zr, Mn, Mo, Nb, Cu, Ni, Co, V, Ti, S, P, Al, O, C, N, B, H
Li_4SiO_4 (Breeder)	Co, Fe, Ti, Ca, K, Si, Al, Na, O, Li-6, Li-7
Beryllium (Multiplier)	Fe, Si, Al, Mg, O, C, Be
SiC Coated Graphite (Reflector)	Pb, Zn, Cu, Ni, Co, Fe, Mn, Cr, V, Ti,Ca, K, Si, Al, Mg, Na, C, Li, B

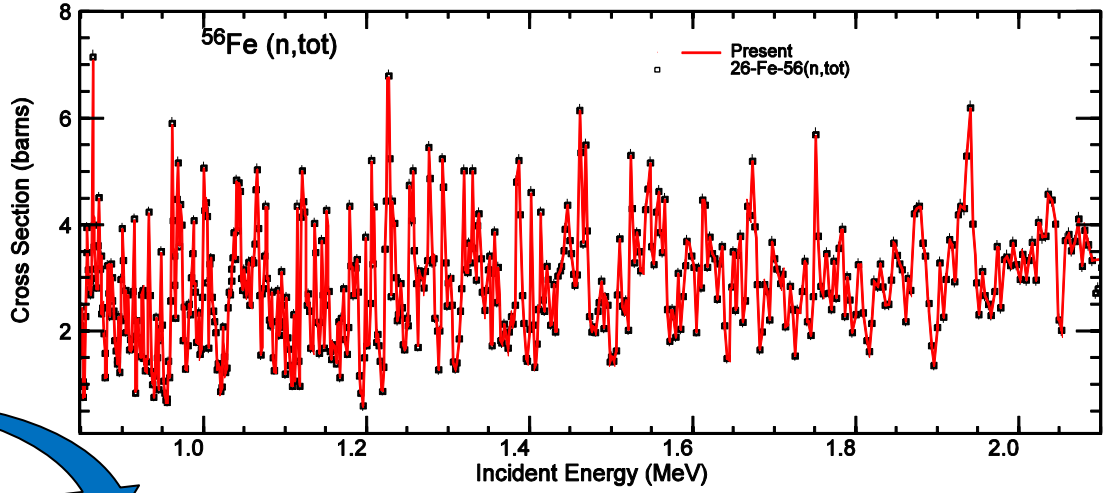
*Reduced Activation Ferritic/Martensitic (RAFM)

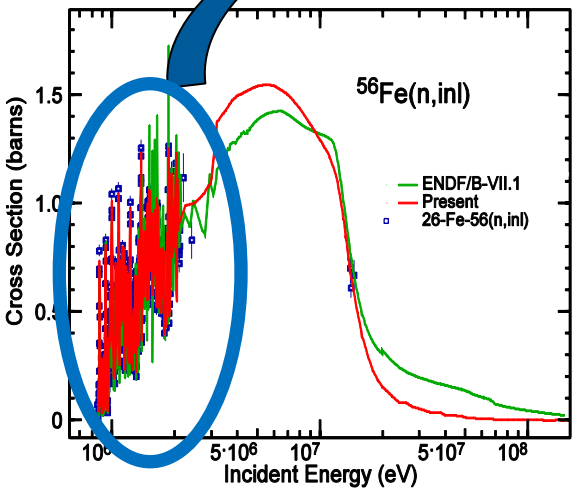
Red : this year

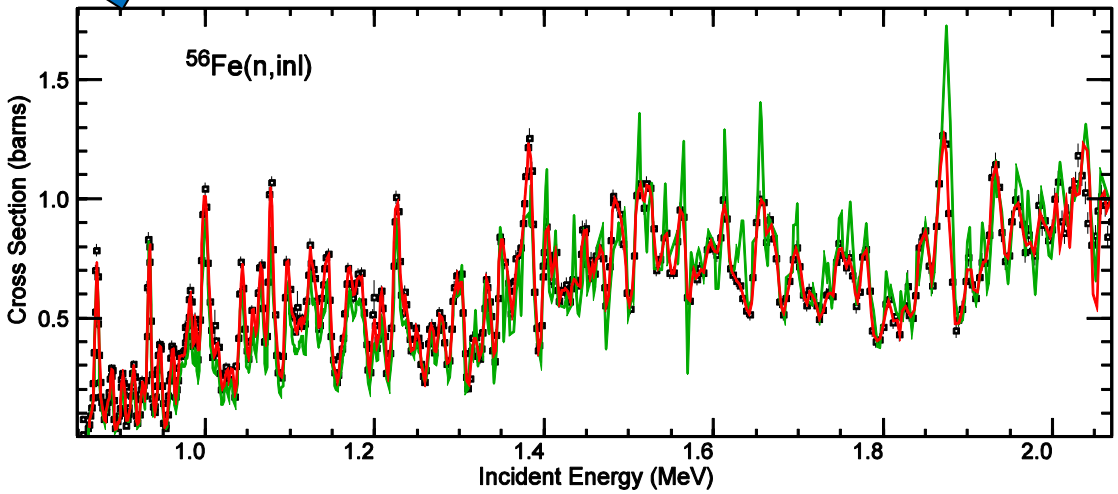
Remaining: 2016

Reproductions of a Resonance-like Structure (1)

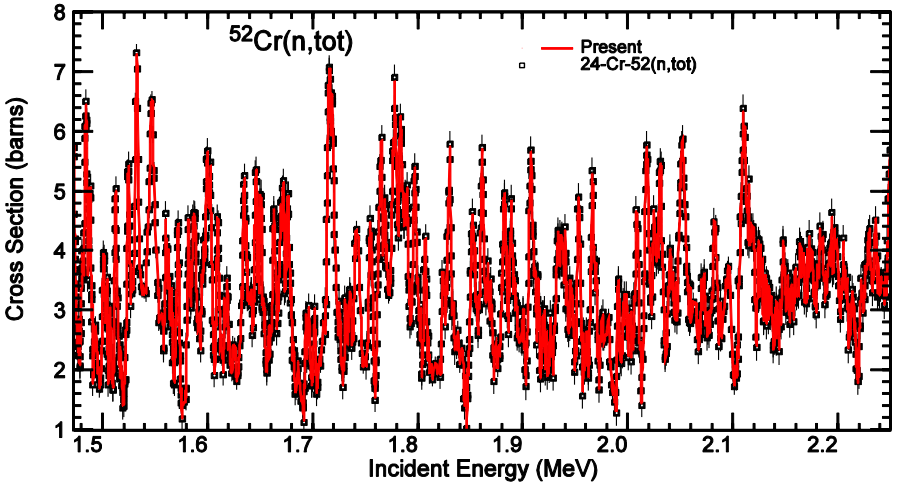


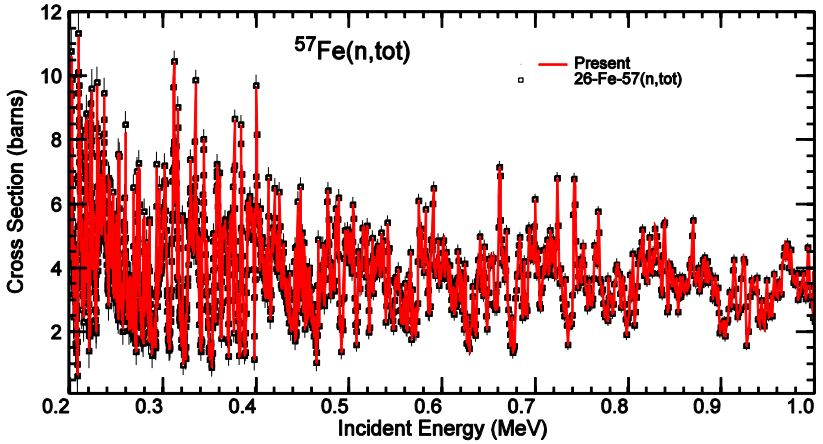


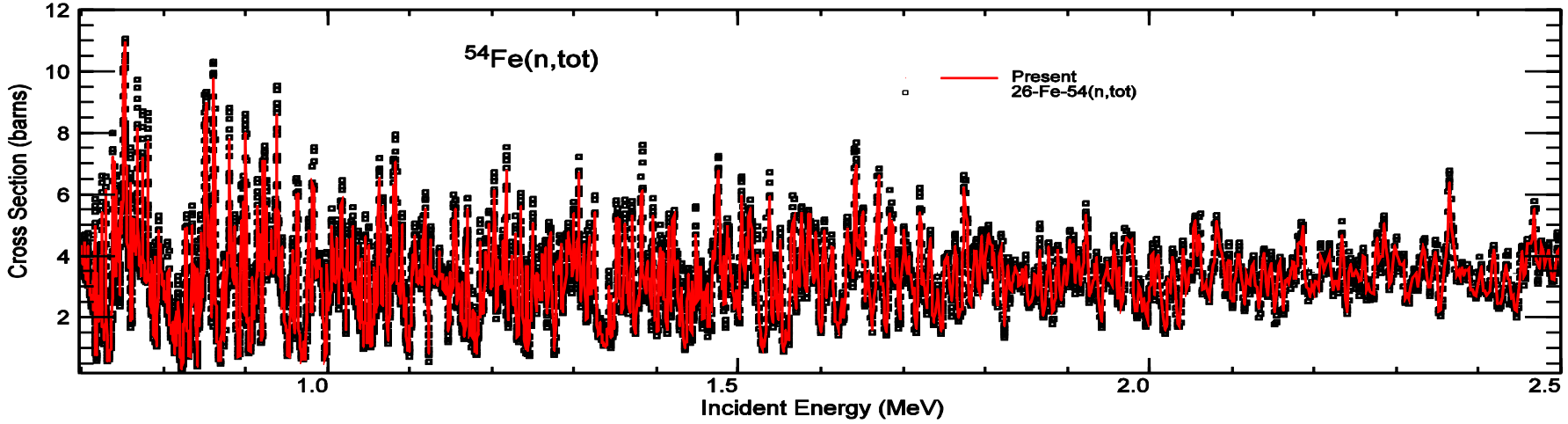




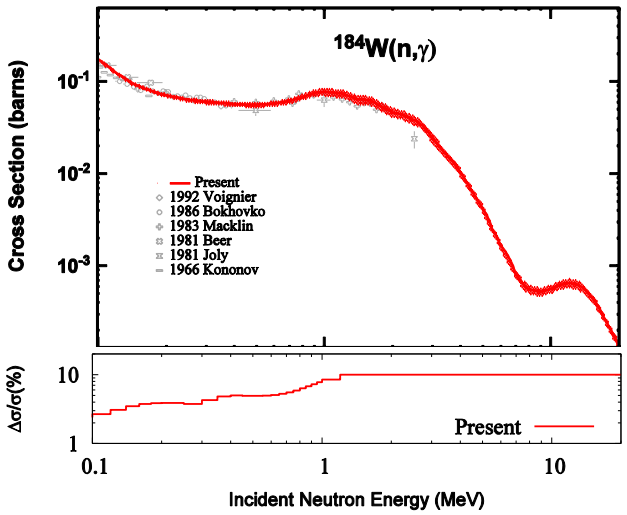
Reproductions of a Resonance-like Structure (2)

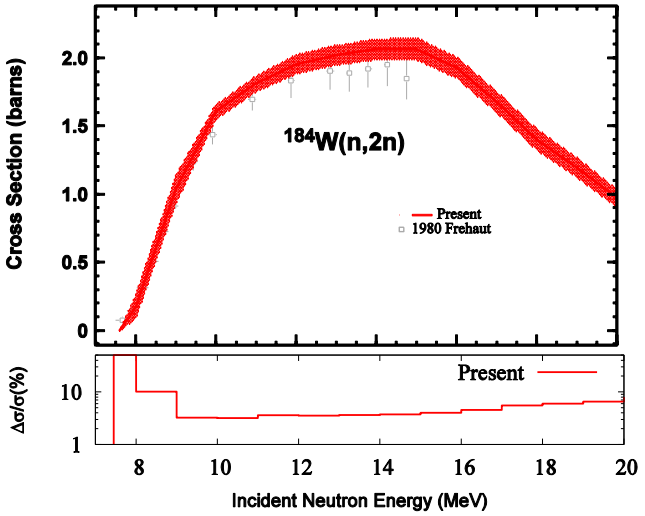


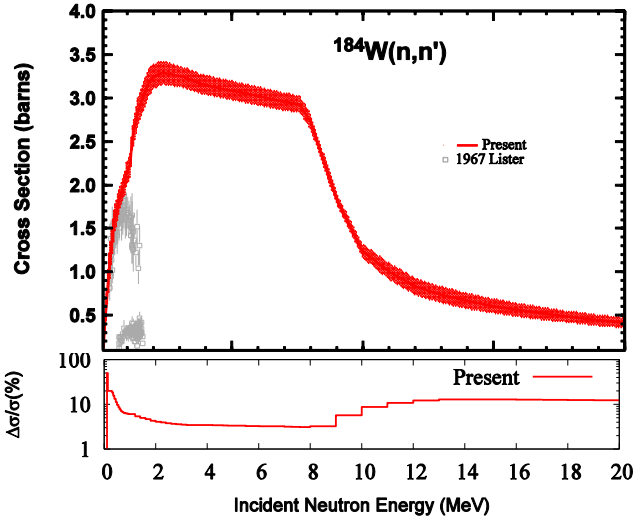


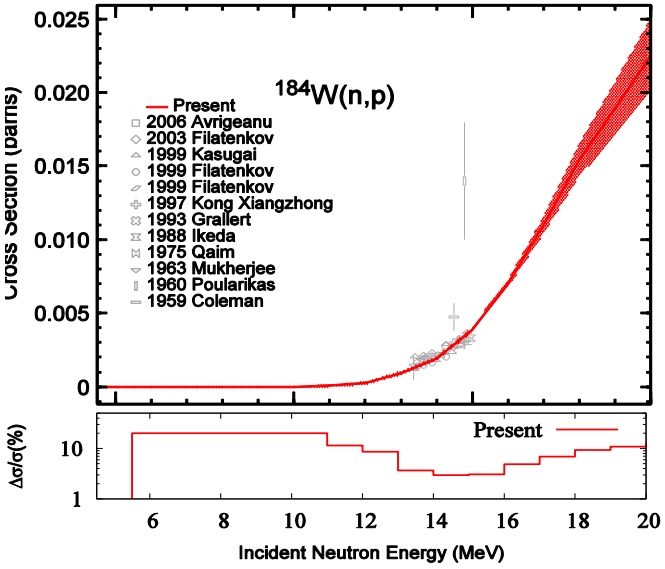


Cross Section and Uncertainties of W



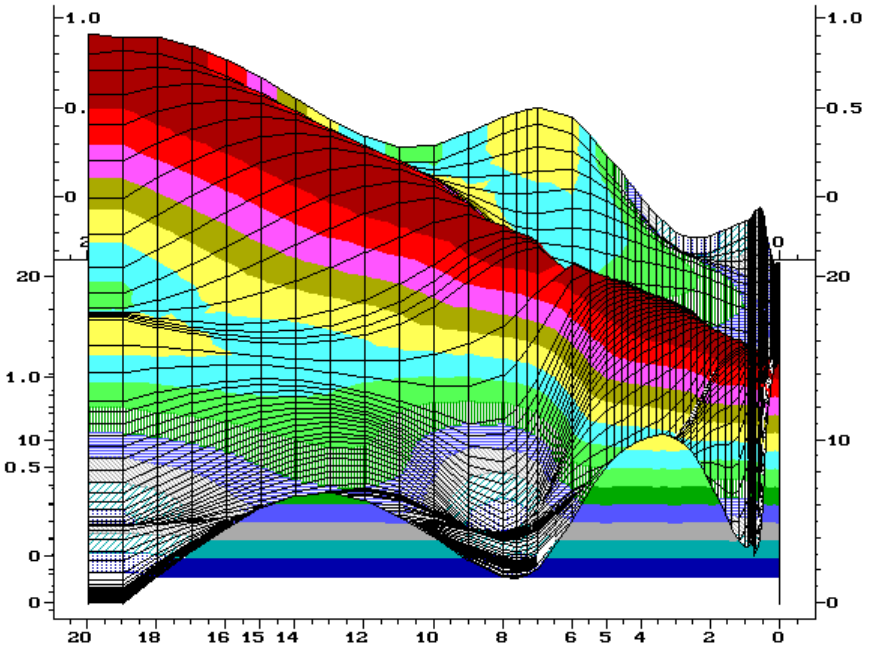


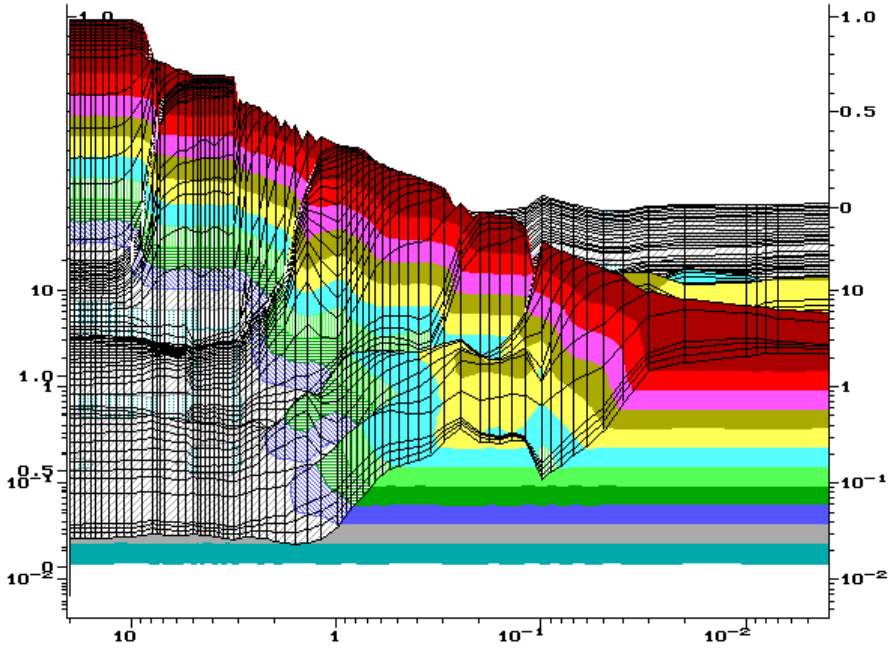


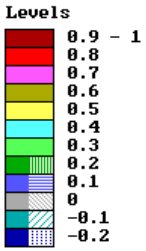


High energy region

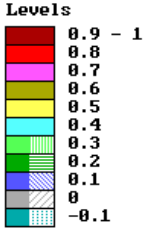
Correlations of ^{184}W







Total cross section

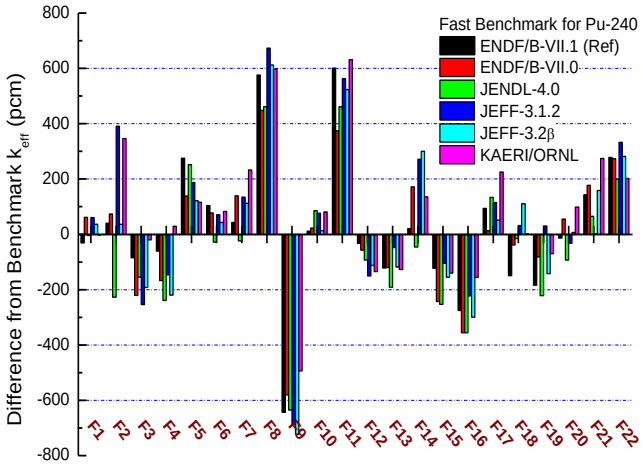


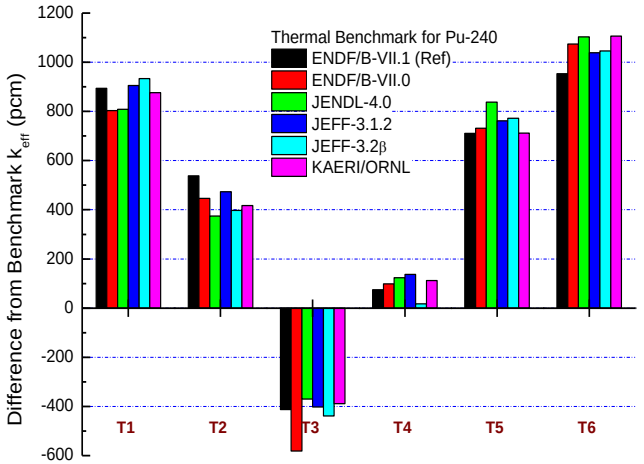
Capture cross section

Benchmark Study for Pu-240

- Benchmark problems taken from the ICSBEP/CSEWG
- X^2 obtained from 22 benchmark results for fast reactor and 6 for thermal reactor

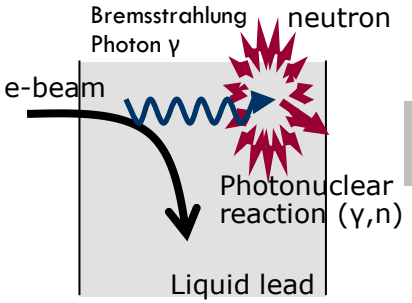
Bencharmk	ENDF/B-VII.1	ENDF/B-VII.0	JENDL-4.0	JEFF-3.1.2	JEFF-3.2(β)	KAERI/ORNL
Fast reactor	**1.481E-04**	1.160E-04	1.392E-04	1.837E-04	**1.659E-04**	**1.481E-04**
Thermal reactor	**2.679E-04**	2.880E-04	2.866E-04	2.883E-04	**2.911E-04**	**2.835E-04**
Overall	**4.159E-04**	4.040E-04	4.257E-04	4.720E-04	**4.570E-04**	**4.317E-04**



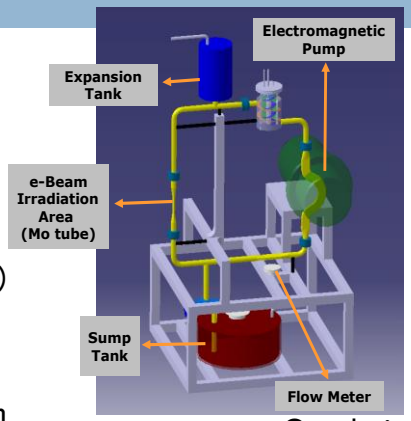


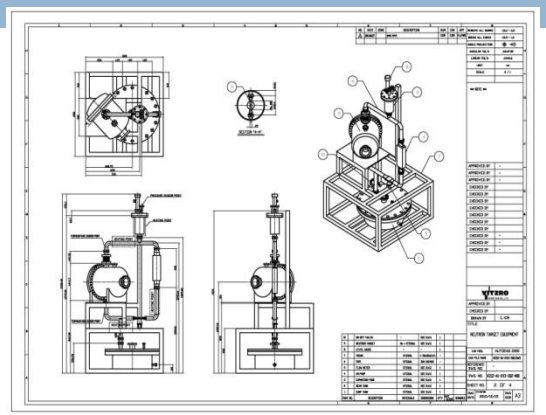
Design of KAERI Fast Neutron Source

Photo-neutron source at HZDR

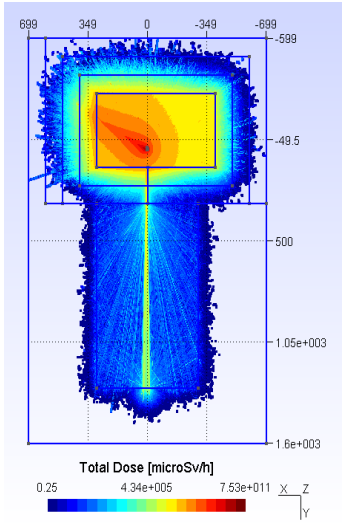


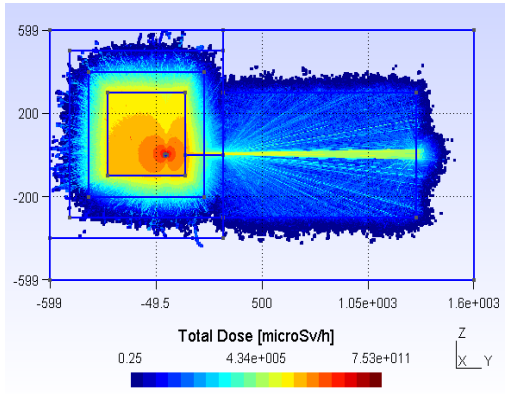
Neutron generation mechanism





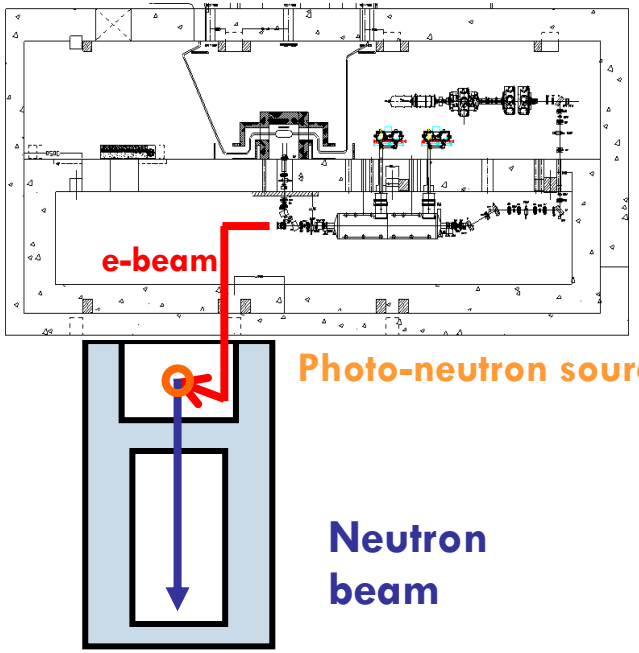
Our design of photo-neutron source





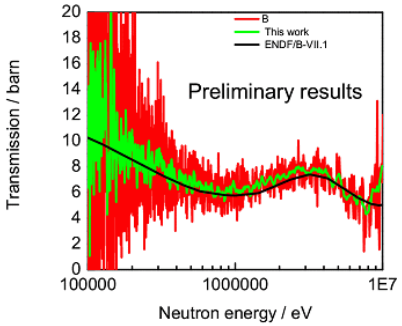
Optimum thickness of concrete shield:
3.4 m (x) x 2.8 m (y)

Shielding calculation for TOF facility

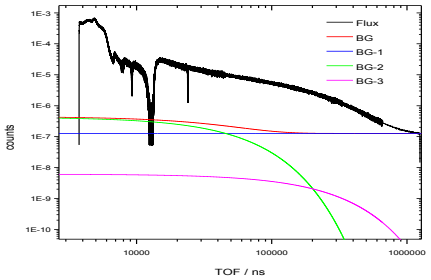


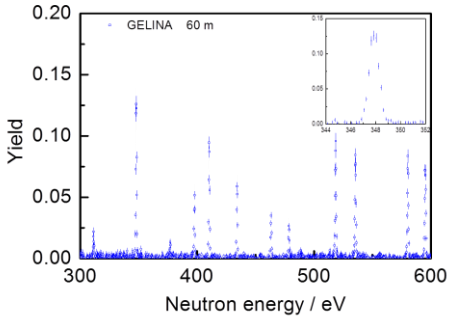
Measurement Activities

- Measurement of total cross section of W at HZDR

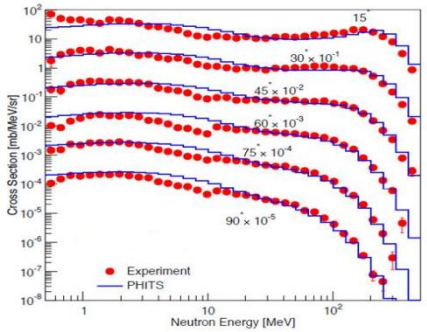


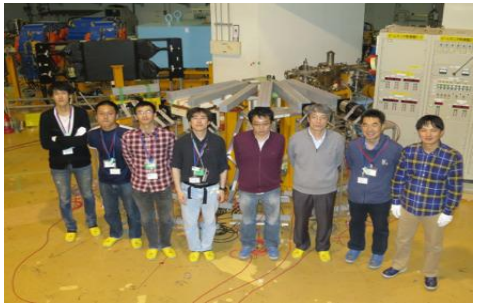
- Measurement of capture cross section of U-238 at IRMM





- Measurement of neutrons by high energy heavy ion reactions at HIMAC



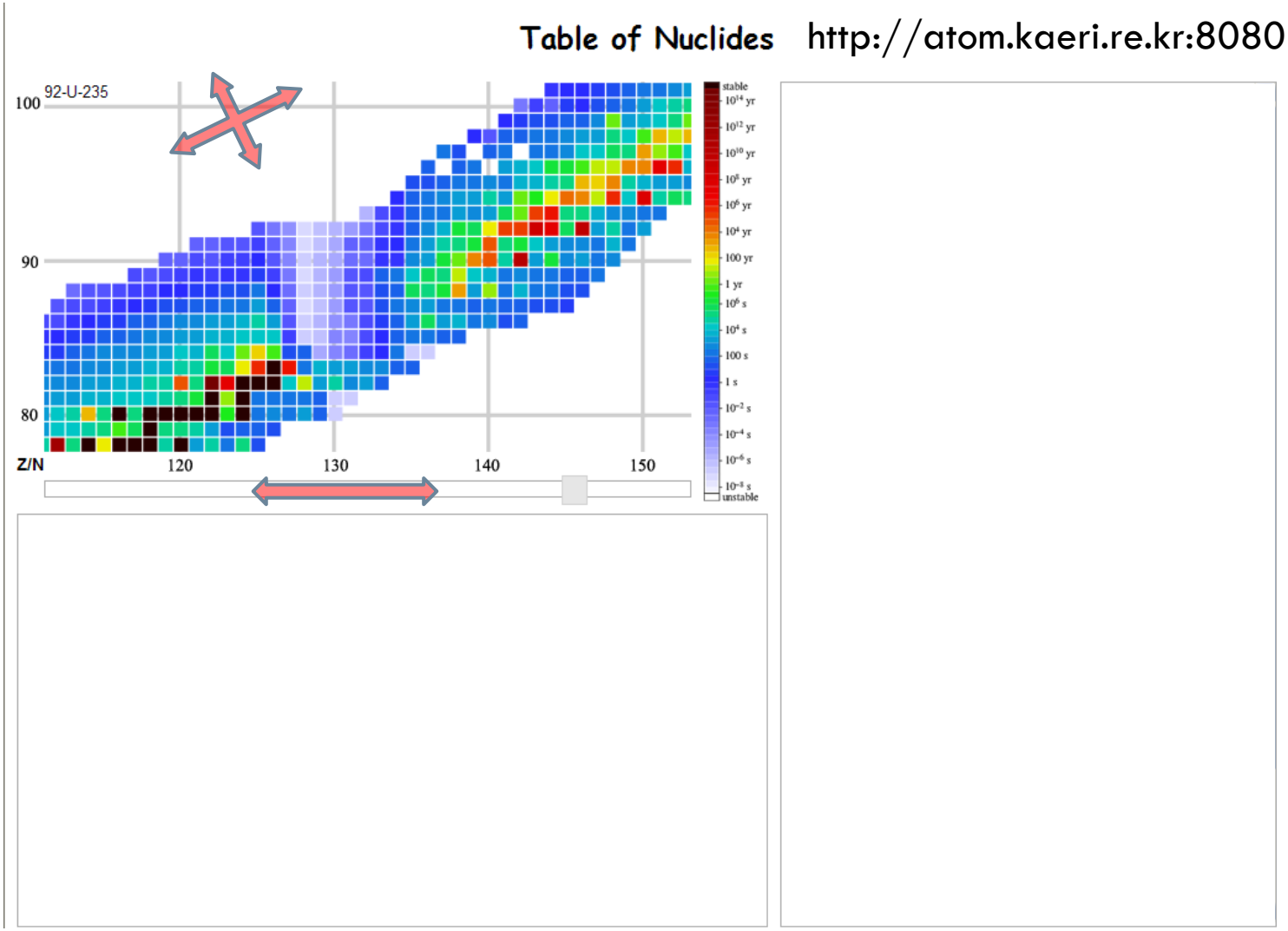


Development of a New Website

- Goal
  - As much information as possible is accessible from one page
  - Portable and easily migratable to new platform
- Development platform
  - Fedora, Java and MySQL (free of charge)
- Information provided now
  - Atomic mass, mass excess, binding energy, beta-decay energy, abundance, half-life and decay mode
  - Nuclear data evaluations including ENDF/B-VII.1, JENDL-4.0, CENDL-3.1 and JEFF-3.1 along with their plots
- Future plan
  - Other useful data including the resonance property and EXFOR will be added.
  - Comparison plot of evaluations and measurements will be provided.

Website

Table of Nuclides



Summary

- COVRES has been developed to accommodate the MLBW formalism, extending the previous work based on the kernel approximation, and has been tested for computing cross section uncertainties for the ^{237}Np.
- Fluctuations observed in Fe and Cr were reproduced, and covariance matrices for W were generated.
- Benchmark study for ^{240}Pu was carried out.
- Various measurement activities were performed.
- New website for providing the nuclear properties and the current evaluations are being developed.

Thank you !