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NUDUNA - Nuclear Data Uncertainty Analysis

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  - **Comparison to Existing Methods**
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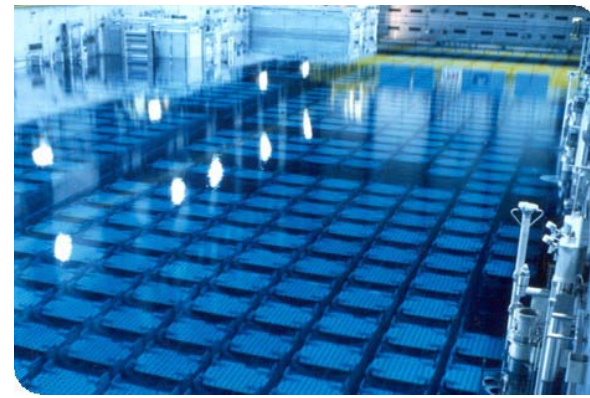
  - **Comparison to TSUNAMI tool by Oakridge National Lab**

Chapter 1

Motivation

Motivation



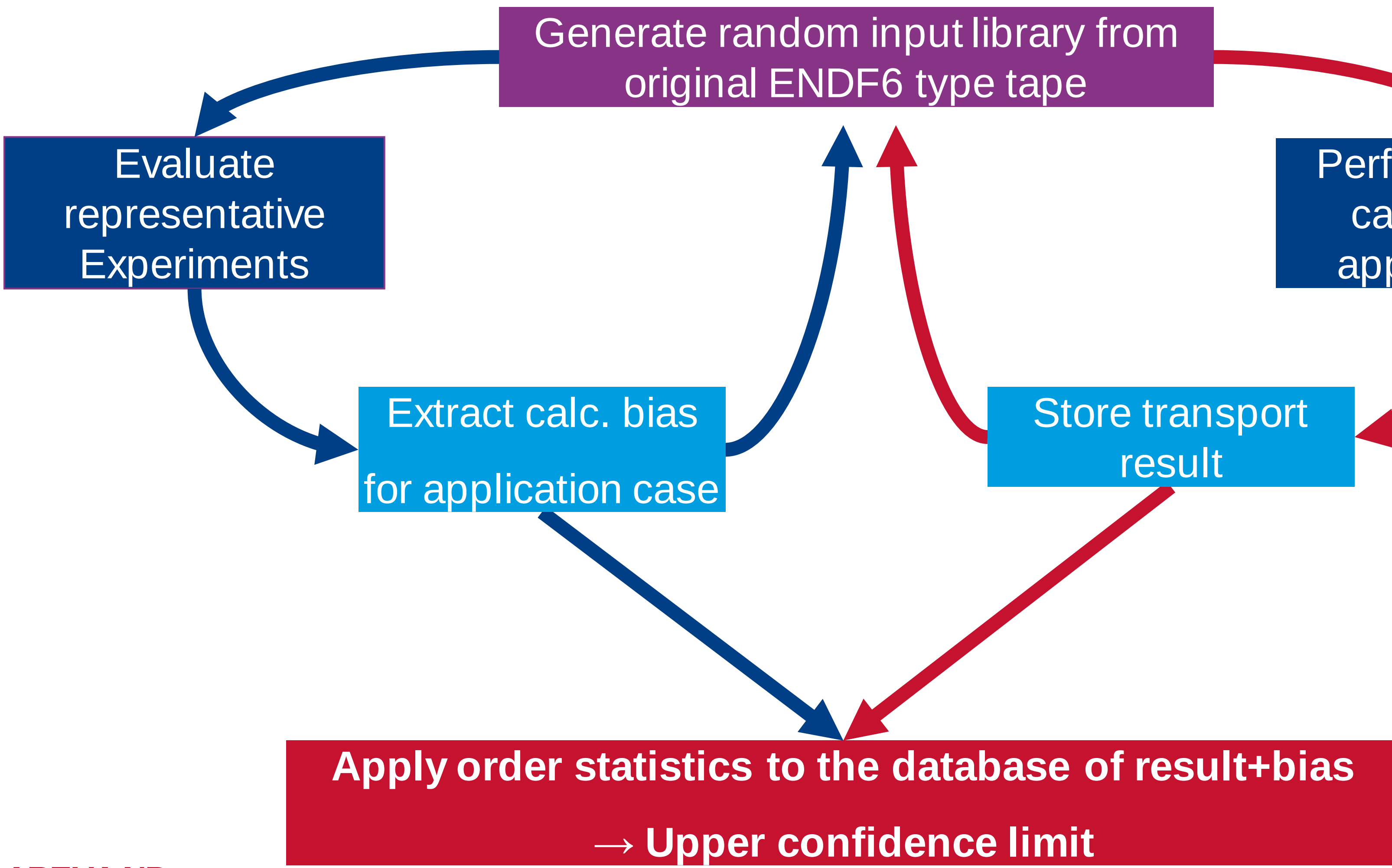
- Criticality safety evaluations for (re-) processing, storage, transport and final disposal of nuclear fuel
- Analyses rely on transport codes (e.g. MCNP, SCALE)
- Types of uncertainties of analyses:
    1. Geometrical and material data uncertainties
    2. Burn-up and decay uncertainties
    3. Systematic uncertainties in the transport algorithms (Calc. Bias)
    4. Nuclear data uncertainties (expressed in terms of covariance data)
- Status of nuclear data uncertainty estimation
    - Only US and French authorities demand estimates of nuclear data uncertainties
    - Otherwise nuclear data uncertainties considered by the safety margin (which includes errors not accounted for)

- **We aim to provide a proper estimate for nuclear data uncertainties**
    - **Ensure conservatism in safety margins**
    - **Reduce conservatism in safety margins**

Chapter 2

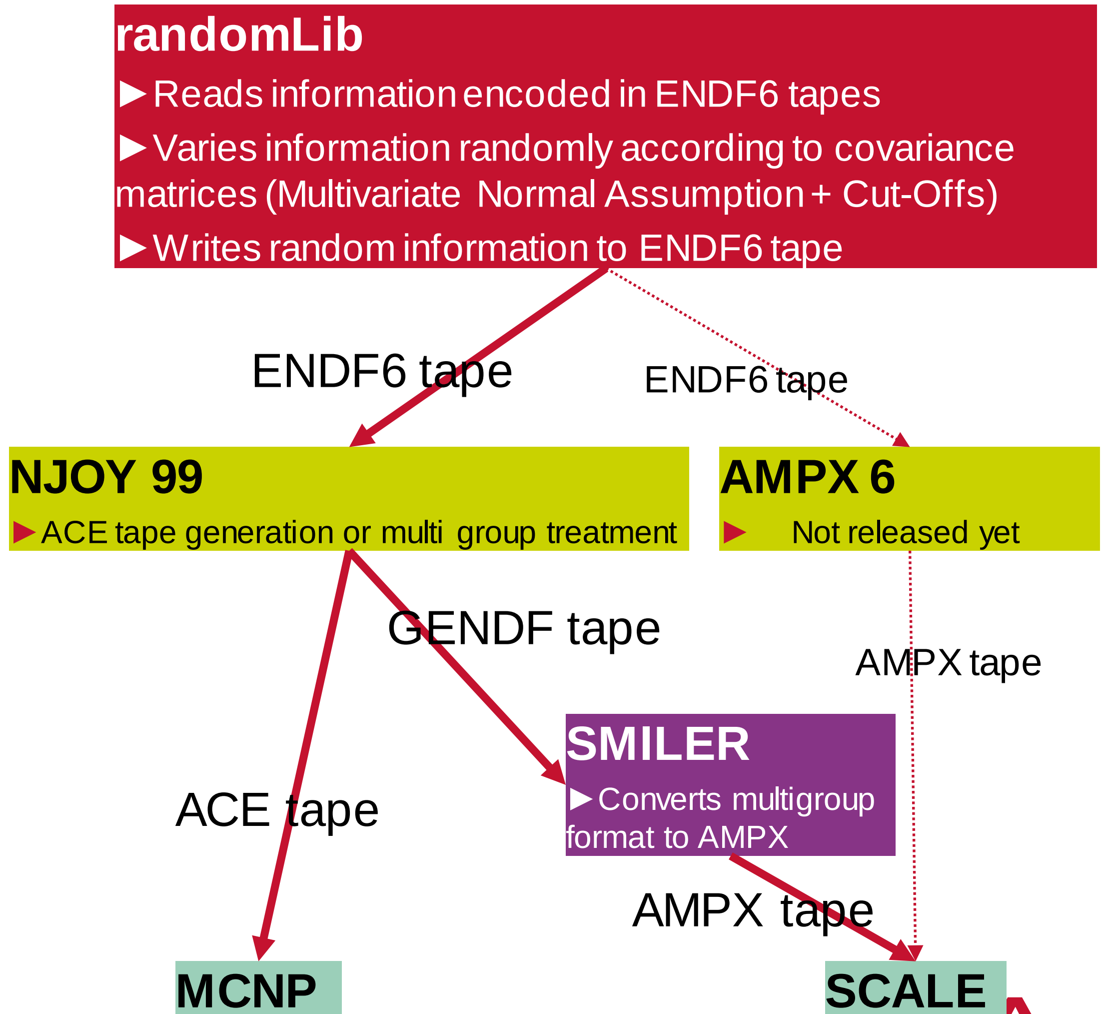
NUDUNA Details

NUDUNA Details I:
How to estimate nuclear data uncertainties



NUDUNA Details II: How to generate random input libraries

- **Nuduna Scope: Provide libraries for SCALE and MCNP transport suites → Need to generate AMPX and ACE formatted input files**
- **NUDUNA makes use of:**
  - **New „randomLib“ tool which creates random ENDF6 type libraries**
  - **„NJOY 99“ tool by Los Alamos National Lab (LANL)**
  - **SMILER included in PUFF IV tool by Oakridge National Lab (ORNL)**
- **Challenges**
  - **Numerical treatment of large covariance matrices**
  - **Memory management**



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Comparison to Other Approaches

- **TSUNAMI by Oakridge**
  - Works only with group wise cross sections
  - Very fast method
  - First order perturbation theory

- **Total Monte Carlo based on TALYS (Koning et al., NRG)**
  - Approach is directly based on the fits of the original experimental data
  - No perturbation theory, but full Monte-Carlo approach

- **NUDUNA by Areva**
  - Compatible to all libraries provided by the international data groups
  - Automated generation of group and point wise cross sections
  - No perturbation theory, but full Monte-Carlo approach

- …

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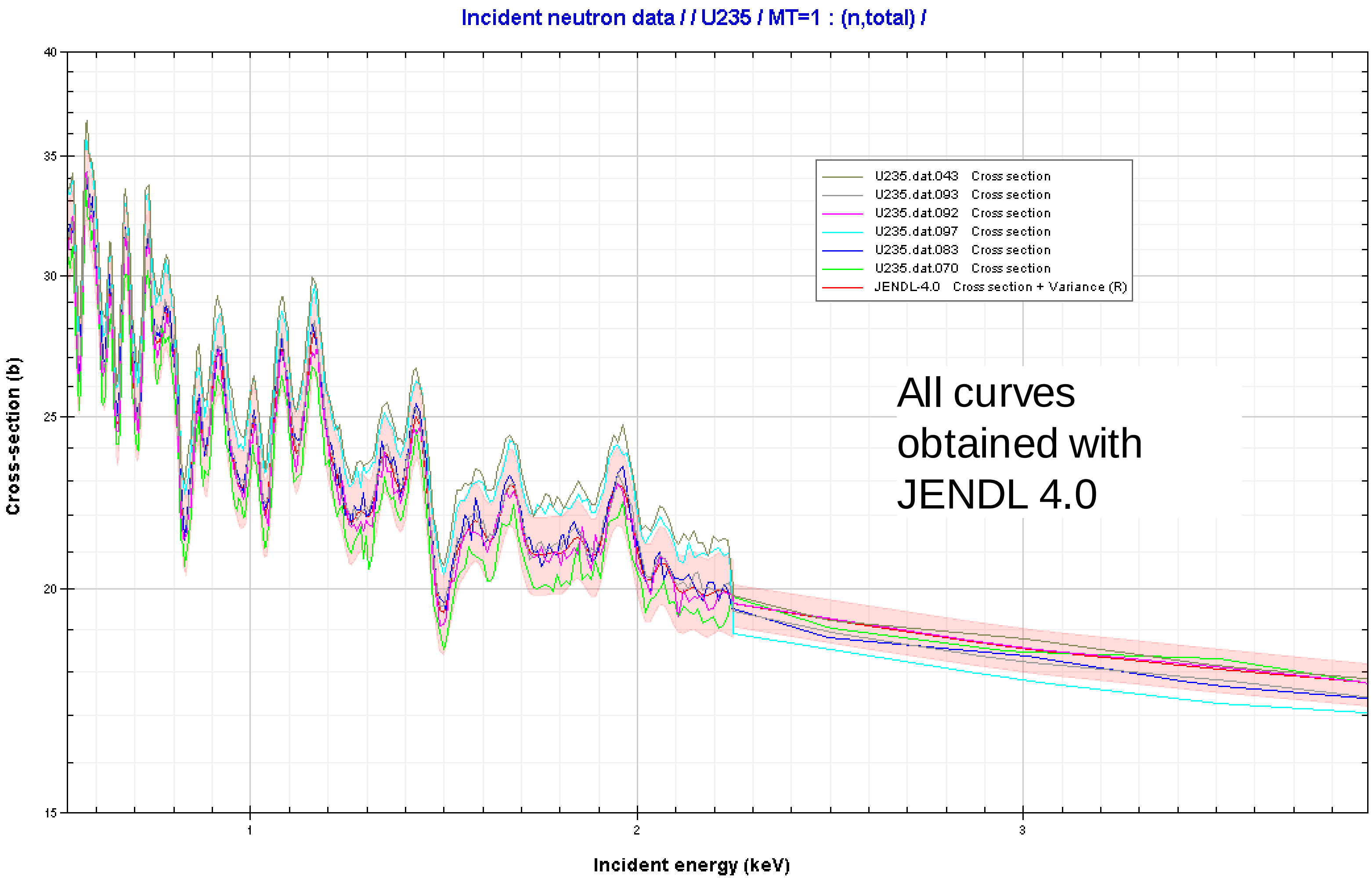
Chapter 3

Results

Results I:
Total cross section for neutron scattering off ^{235}U



- Database: JENDL 4.0 library
- Plot shows 6 different random cross sections together with the variance band
- NUDUNA procedure includes the strong correlations among data points of different energies

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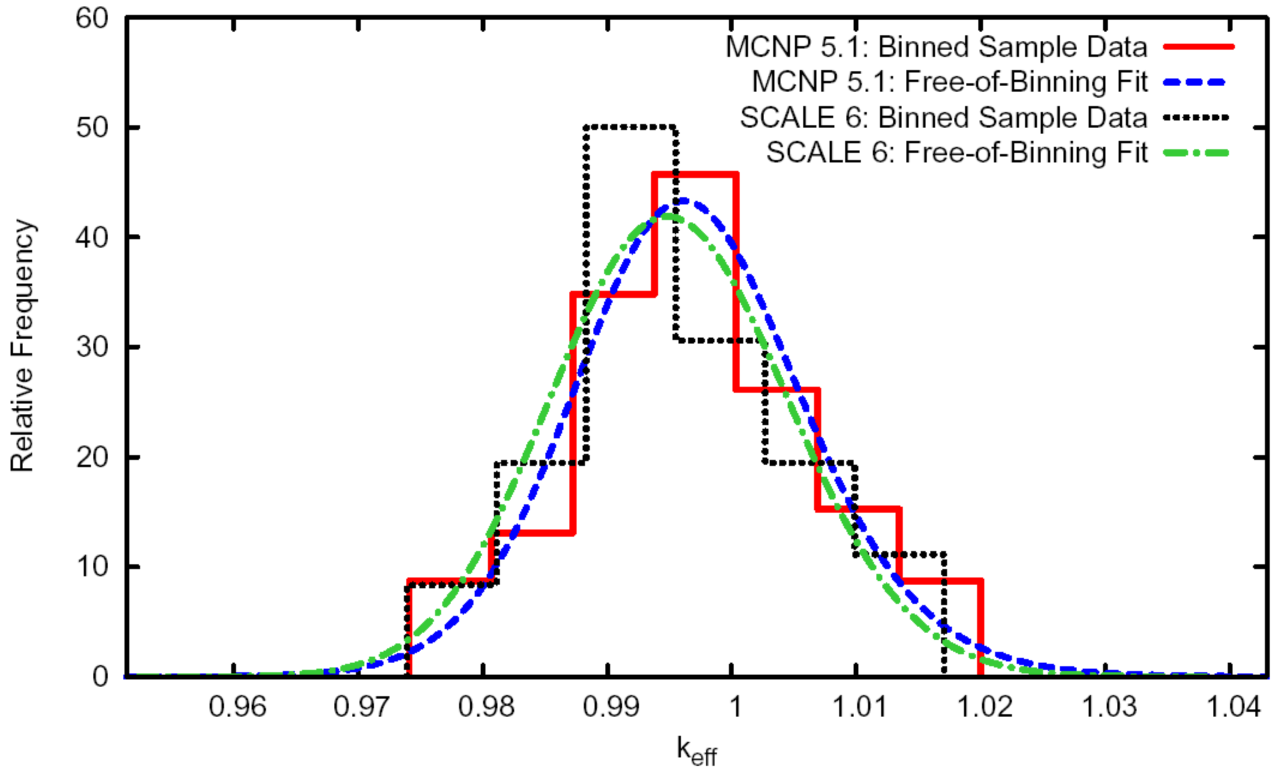
Results II: Comparison to TSUNAMI



k_{eff} results obtained for Godiva experiment (HEU-MET-FAST 001)

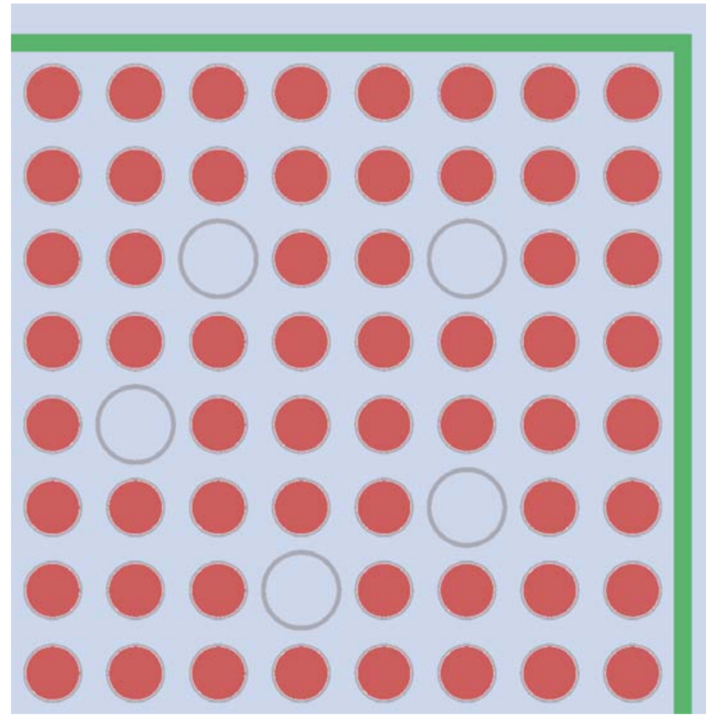
- 70 different random libraries
- JENDL 4
- No calculational bias considered

- **NUDUNA based k_{eff} standard deviation due to nuclear data covariances:**
  SCALE (238 groups): 970 pcm, MCNP (cont. energy) : 940 pcm
- **TSUNAMI (most widespread competitive tool) k_{eff} standard deviation :**
  930 pcm
  - **NUDUNA delivers compatible result, full support of both SCALE and MCNP**

Resolved resonances

- **LWR fuel element benchmark**
  - **Study optimal moderation**

2nd order effects dominate



- **Problem**
  - **Huge impact of resonance uncertainties cited by JENDL 4.0**
  - **How to interpret these uncertainties?**

Summary and Outlook

Summary & Outlook

- **NUDUNA provides a tool to estimate nuclear data uncertainties for transport codes**
- **AMPX and ACE support fully implemented**
- **NUDUNA is compatible to TSUNAMI, which is the presently most wide spread tool for nuclear data uncertainty estimation**
- **NUDUNA improves on the TSUNAMI methodology by not relying on first order perturbation theory**
- **NUDUNA allows for uncertainty estimation using point-wise cross section libraries**

- **Outlook**
  - **Need ENDF/B-VII covariance data to compare directly to TSUNAMI**
  - **Thermal Systems: study resolved resonance covariance matrices**

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End of presentation

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Appendix I

Introduction to Nuclear Data Uncertainties

Nuclear Data

- Nuclear data are provided by several working groups
  - E.g. ENDF/B, JEFF, JENDL, TENDL libraries
- Data are encoded in *ENDF6* standard
  (ENDF-6 Formats Manual, Editors: M. Herman and A. Trkov*, CSEWG Document ENDF-102, Report BNL-90365-2009*, June 2009)
  - Data organized in so-called *files*
- Several types of data
  - multiplicities of produced secondary particles, especially of produced neutrons (included in file 1 of ENDF6 standard) ,
  - resonance parameters (file 2),
  - cross sections of background contributions (file 3),
  - angular distributions of final state particles (file 4),
  - energy distributions of final state particles (file 5),
  - data on thermal neutron scattering off molecules, i.e. so-called S(α,β) data (file 7),
  - radioactive decay data and fission product yields.

Data NUDUNA focuses on

Uncertainties of Nuclear Data

- **ENDF6 standard provides means to encode covariance matrices of data**
  - **File 31: Covariances for multiplicity data**
  - **File 32: Covariances for resonance parameters**
  - **File 33: Covariances for background cross section data**
  - **File 34: Covariances for angular distribution data**
  - **File 35: Covariances for energy distribution data**

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End of presentation

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