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INSTITUT
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ET DE SÛRETÉ NUCLÉAIRE

Nuclear Data Activities at IRSN

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Nuclear data activities at IRSN

- **No “pure” nuclear data but activities with strong ties to nuclear data**

- **Experimental programs: data & code validation**
  - Fission product experimental program
  - Plutonium temperature effect experimental program
  - Structural materials experimental program

- **Development of calculation tools: data related developments**
  - CRISTAL: criticality safety package
  - MORET: Monte Carlo calculations
  - VESTA: a generic interface for depletion calculations

MORET

- **Multi-group/continuous energy Monte Carlo for criticality and reactor calculations**
- **The distributed multi-group version: MORET 4**
  - 3D modular combinatorial geometry
  - Coupled with APOLLO2 deterministic code self-shielding and homogenization of cells in the CRISTAL standard calculation route
  - Source convergence, simulation strategies and weakly coupled systems
- **The future: MORET5**
  - Continuous energy mode (beta version at the end of 2007)
  - Woodcock tracking
  - Cross section libraries from any evaluation
  - Compatibility with various deterministic cell codes for the multi-group mode
- **Nuclear data needs**
  - Neutron transport data
  - Various formats: multi-group & continuous energy

VESTA

- **A generic Monte Carlo evolution interface**
  - Provide the normal MC accuracy for the smallest computing effort possible
  - Creating a generic interface for Monte Carlo depletion calculations
  - For now limited to MCNP(X) and a modified version of ORIGEN 2.2
  - Efficient, flexible and easy to use
  - A first version foreseen in 2008

- **VESTA has very specific nuclear data needs like any depletion code**
  - Cross section data read from ENDF files generated by NJOY which are also used by MCNP(X)
  - ENDF libraries contain additional data needed for depletion:
    - Fission yield data and radio-active decay data
    - Branching ratios for the production of isomeric states
    - Fission Q-value data

C++ software for nuclear data manipulation: ENDF++

- **Under developed and investigation in the framework of our main activities**
- **All the advantages of object oriented design**
  - Modularity, generality and reusability
  - Optimisation and maintenance
  - They can function as a standalone application or can be easily integrated into other dedicated applications
  - High level design with low level interface
- **ENDF++ is currently:**
  - An ENDF parser to read/format/write nuclear data
  - A number of function objects or functors:
    - Linearisation of point wise data
    - Integration of linearised functions
    - Unionisation of linearised functions

Parsing ENDF files with ENDF++

- **Read, write and extract ENDF data**
  - MF1: fission neutron yield, fission Q-values, etc.
  - MF2: resonance data
  - MF3/MF9/MF10/MF23: cross section and multiplicity data
  - MF7: thermal neutron scattering data
  - MF8: radioactive decay data, fission yield data, etc.

- **Format nuclear data in the ENDF format**
  - MF1: fission neutron yield, fission Q-values, etc.
  - MF3/MF9/MF10/MF23: cross section and multiplicity data
  - MF7 MT4: incoherent inelastic scattering data - $S(\alpha,\beta)$ data

- **Easily extendable to other data contained in the ENDF file**

Parsing ENDF files with ENDF++

- **The parser is currently used inside VESTA, to read the required nuclear data for a depletion calculation**
- **Future applications for this parser will include:**
  - Quality Assurance for basic evaluations
    - Test for formatting errors
    - Test for inconsistencies between various sub-libraries
  - Help in automated NJOY processing
    - Checks important parameters for nuclide tailored NJOY input
    - E.g. the temperature, wether or not the nuclide has resolved/unresolved resonances, etc.
  - Quality Assurance for processed evaluations
    - ENDF format is used by NJOY to pass on data between modules
    - Provide testing for undetected reconstruction errors (e.g. JEFF 3.1 ^{58}Co capture)
  - Merging data together into a single ENDF tape
  - Etc.

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Functors within ENDF++

- **Integrating linearised data**

$$f_g = \int_{E_{g-1}}^{E_g} f(E)\,dE \qquad f_g^h = \int_{E_{g-1}}^{E_g} h(E)\,f(E)\,dE$$

  - For simple integrals
  - For calculating group cross sections
  - For weighted integrals, like for instance isomeric production branching ratios

- **Linearise data**
  - Generate linearised data within a given tolerance
  - NJOY does not linearise and reconstruct all data from an ENDF file
  - For example: MF9 - multiplicities for radio-active isotope production

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Functors within ENDF++

- **Functors can be developed independently with relative ease in little time**
  - Tasks should be split up as much as possible
    - A functor that integrates data should not have to linearise it
  - The remaining tasks are thus very specific
  - Therefore easy to implement
  - Anybody can contribute!

- **Functors should have a basic and simple interface**
  - Only low level data is manipulated: integers, real values, arrays, etc.
  - No “advanced” concepts

- **Great optimisation potential**
  - Multiple implementations are possible and the best can be chosen
  - Gains the potential of automatic validation

Other R&D topics in the near and far future

- **The continous energy version of MORET will use a "universal" energy grid**
  - To avoid exploding the resulting energy grid, we will need to look into energy grid thinning
  - Study the different algorithms that can be used
  - Implement them for use in MORET 5

- **MORET 5 will use probability tables in the unresolved resonance region**
  - This is currently limited to probability tables from NJOY

- **These topics could all become basic functors in ENDF++**

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Conclusion and outlook

- **ENDF++ provides us with a software framework:**
  - For nuclear data testing and Quality Assurance
  - For easy access to data in the ENDF format
  - For basic operations on that data

- **Ultimately, ENDF++ will contain all the basic building blocks for a more complicated task like cross section reconstruction:**
  - Reading and extracting the basic data
  - Linearising the data
  - Thinning the resulting energy grid
  - Reconstructing resonance data

- **We are open for business and are willing to collaborate with all of you!**