NRG/CCFE proposal: Towards a consistent transport and activation library for fusion

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Work plan

① History/introduction

② NRG/CCFE* Goal for the F4E Nuclear Data Grant

③ Methods

- Tools
- Knowledge/experience
- Method

④ Deliverable: Unified general purpose activation/transport/dosimetry library dedicated for fusion

⑤ Conclusion

* CCFE: Culham Centre for Fusion Energy, ex-UKAEA

History - Introduction

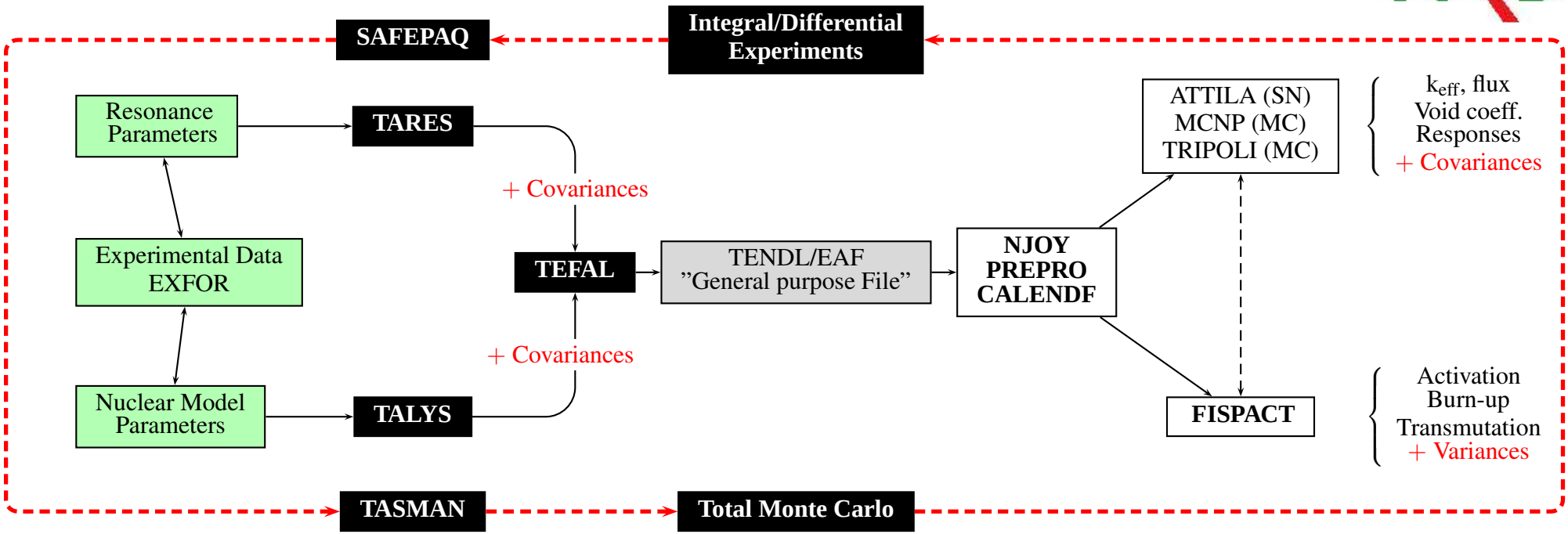
- In the past
  - EAF library: global approach for $\simeq$ 800 nuclides
  - Transport library: focus on 1 element at the time
  - Specific fusion libraries in Europe: EFF-2.4 and EFF-3.0 (1990-2000)
- Now
  - Fusion relevant evaluations adopted in JEFF, but JEFF is not the best Fusion library
  - TENDL-2008 was the first attempt to unify this.
- In the future
  - This proposal

Goals

- Combine the effort entering the
  - validated EAF-2010 neutron activation cross section library with
  - the TENDL-2010 neutron transport library

  to create a single truly general purpose file aimed at satisfying all radiation transport-dosimetry and activation-transmutation requirements for fusion and other devices.
  - Complete and Consistent (internally and with transport library)
  - Includes previous knowledge of EFF evaluators
  - Includes covariances
- High Quality Assurance (reproducibility, verification)
- Benchmarks with shielding (FNS, Oktavian, LLNL...), ICSBEP and ITER
- Uncertainties tested with perturbation methods, Total Monte Carlo and decay heat experiments

Tools: An approach from basic nuclear data to tests/benchmarking for fusion applications

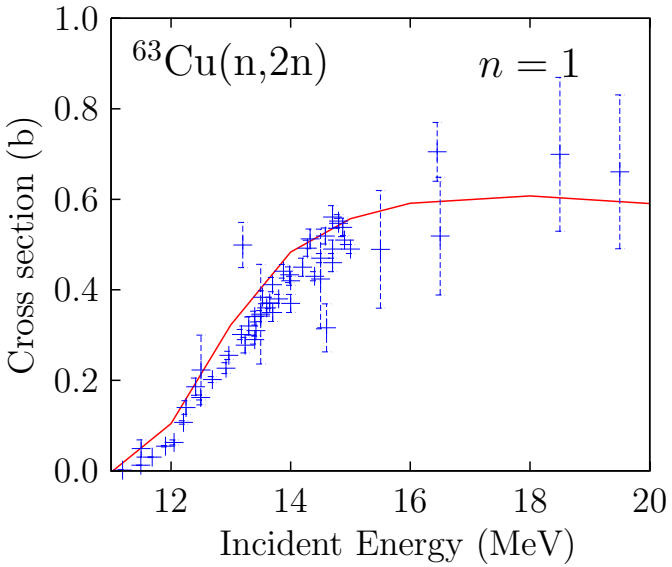


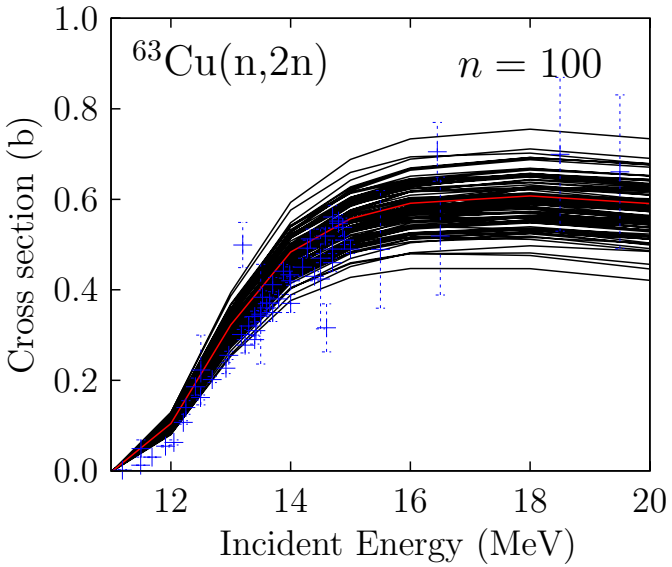
1. Theoretical nuclear model system: TALYS (T4).
2. Approach: activation-transmutation methodologies for fusion technology requirements: SAFEPAQ.
3. Outcome 1: nuclear data evaluations (+ file production and with associated uncertainty/covariances).
4. Outcome 2: library processing with NJOY, PREPRO and CALENDF

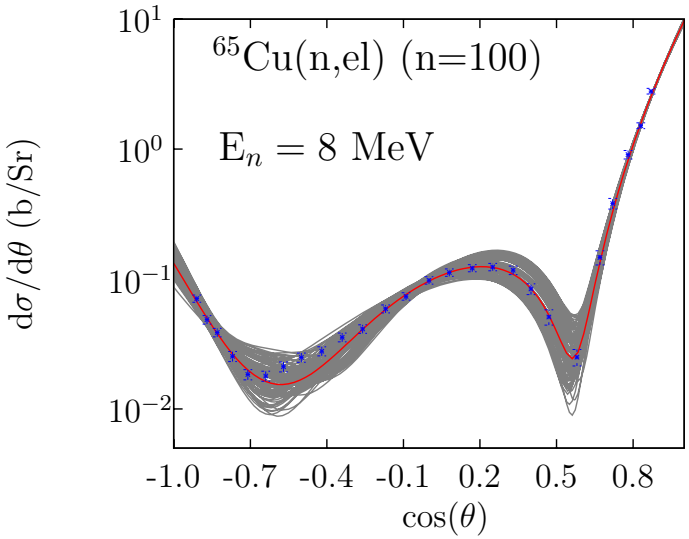
Method - Knowledge/experience

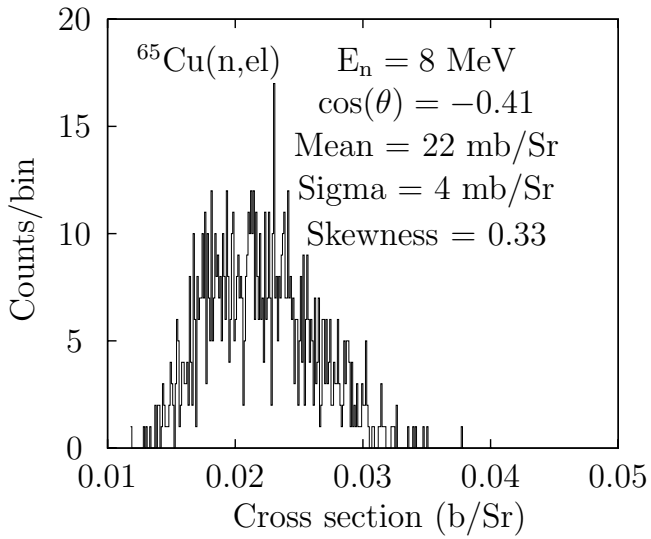
- Knowledge on file production (automation, format, testing) from the transport and activations communities (TALYS & SAFEPAQ)
- Knowledge of previous EFF and EAF evaluations (EAF-2010) and UKAEA (CCFE) experience
- Method already applied for Oktavian, FNS and LLNL benchmarks (Al, Si, Cu, Ti, Cr, Mn, Co, Fe, Mo, Zr, W, Mg), submitted to Fus. Eng. & Design
- Experience in running ITER and fusion relevant calculations with ITER-NL and F4E contracts at NRG.

Method - Examples with ^{63}Cu(n,2n) and ^{65}Cu(n,el)

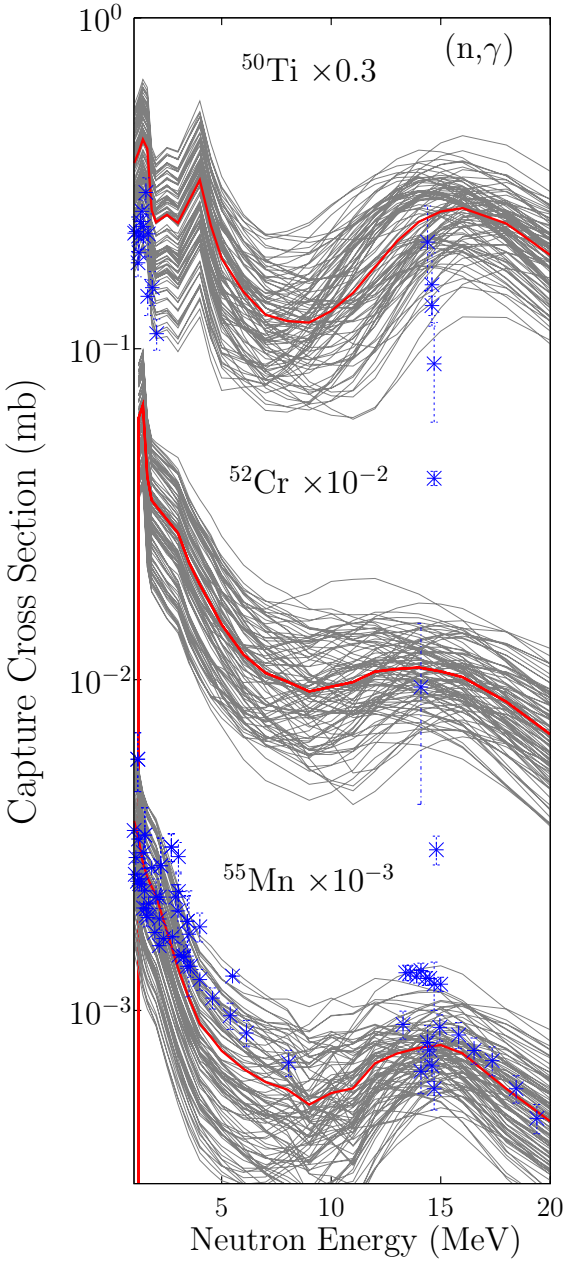


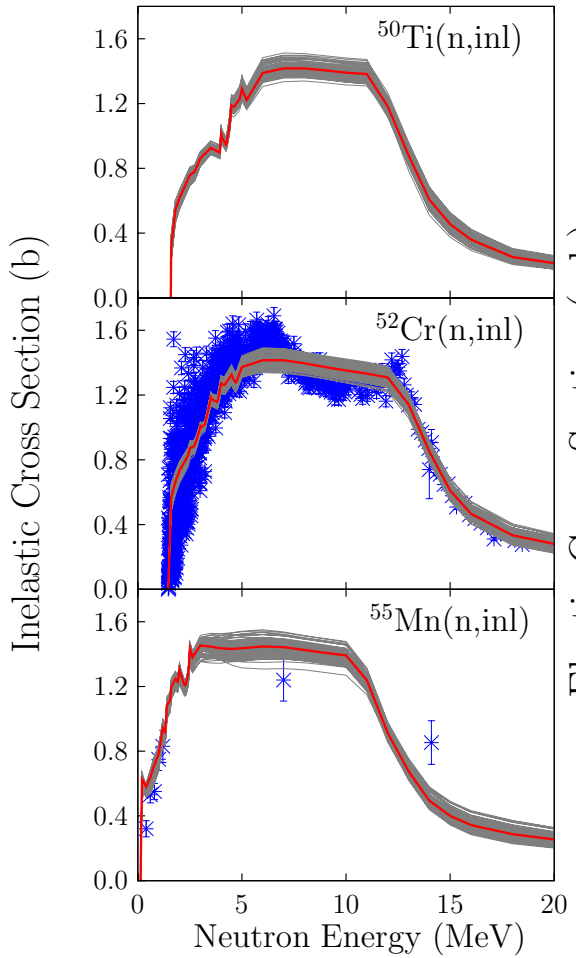


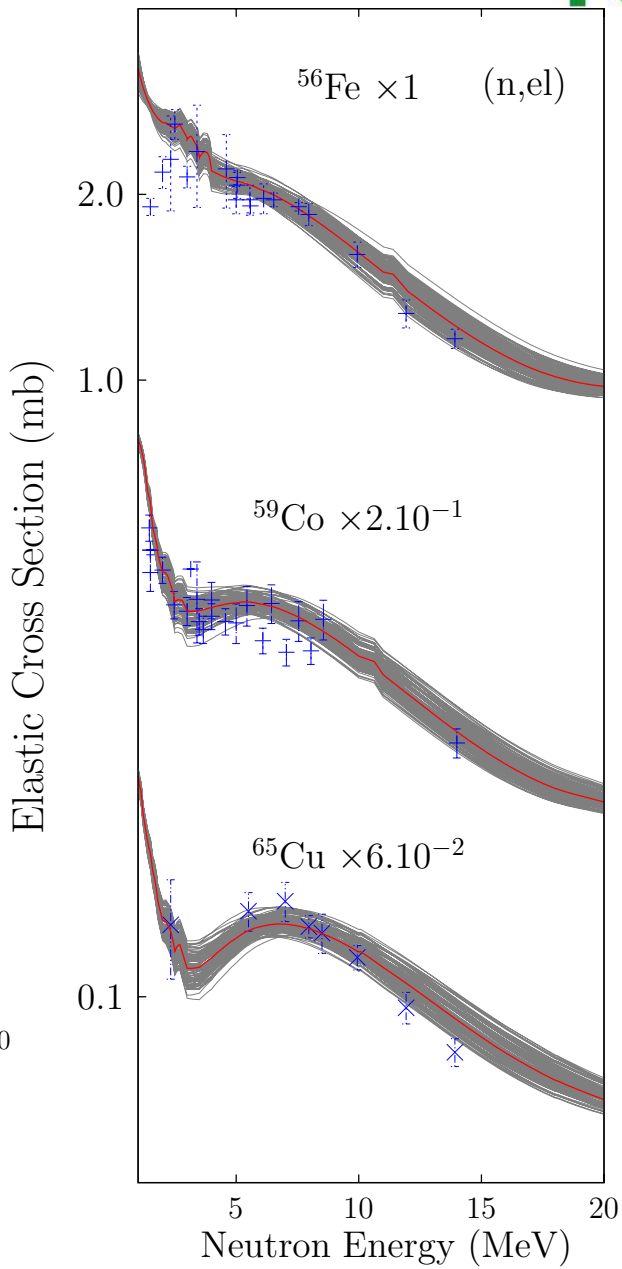




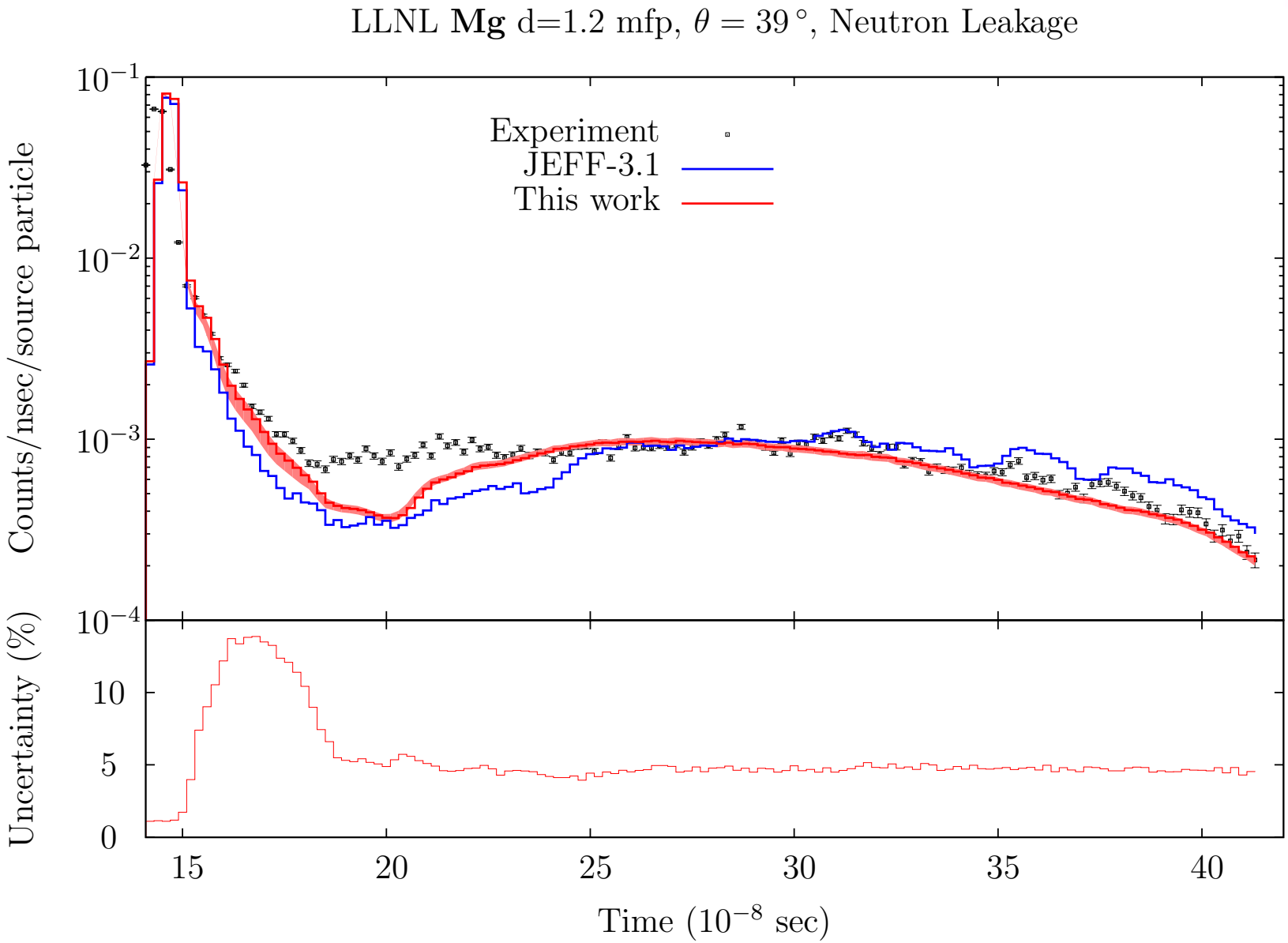
Method - Examples with (n,γ), (n,inl) and (n,el)



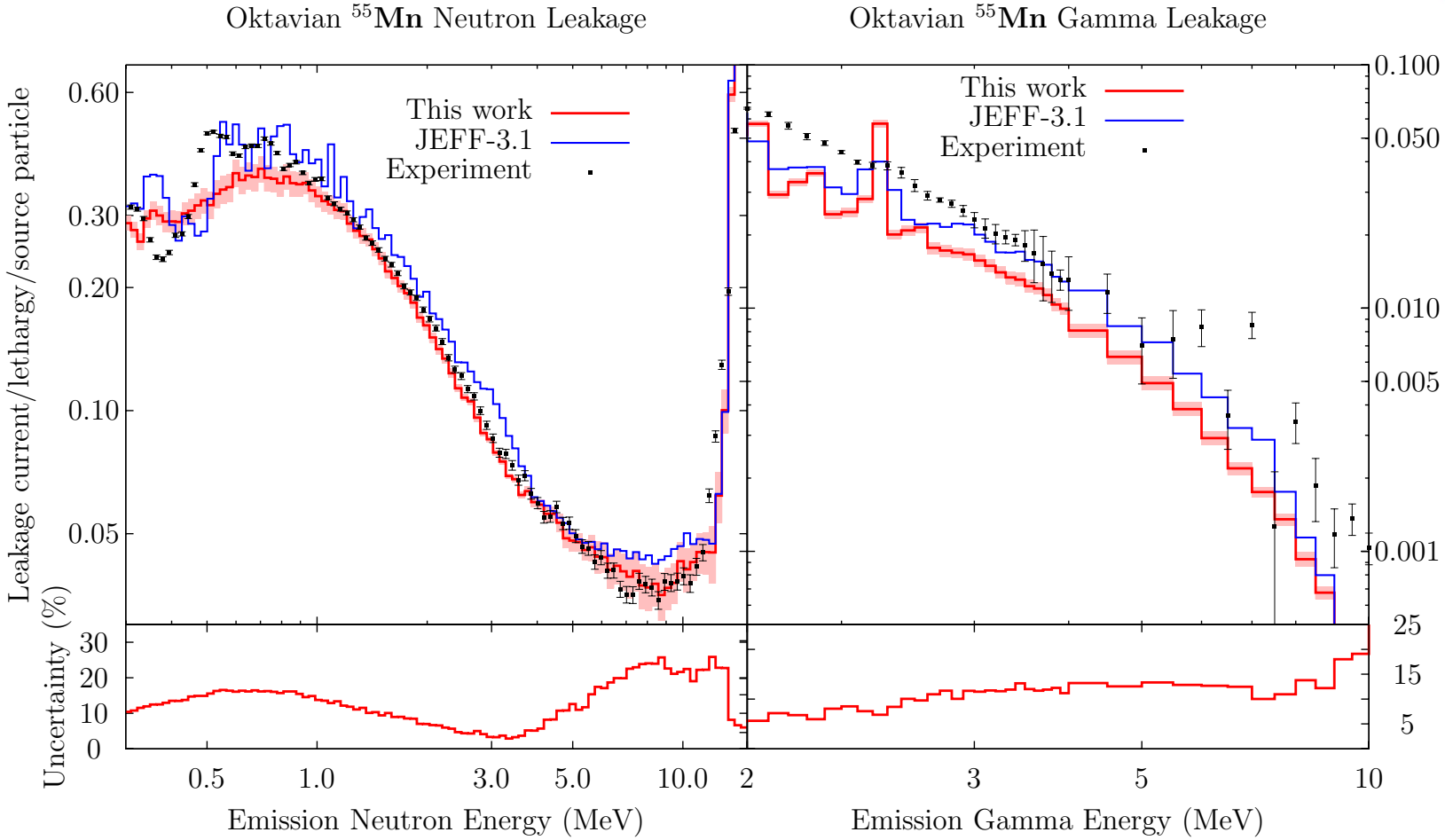




Method - Benchmark examples 1

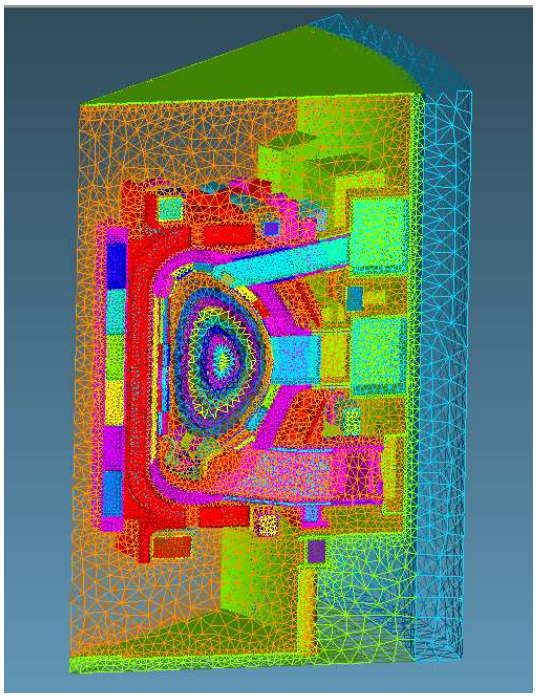


Method - Benchmark examples 2



Method - Benchmark with ITER at NRG and CCFE

ATTILA full ITER model

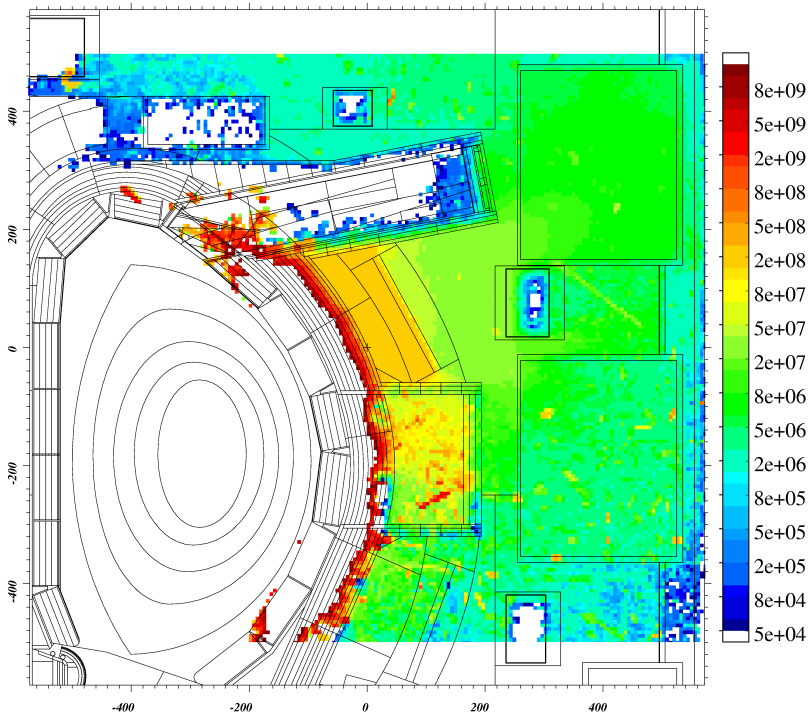


average size = 20cm
45’ to produce the mesh
RAM 6 Gb
elements ~ 2,200,000

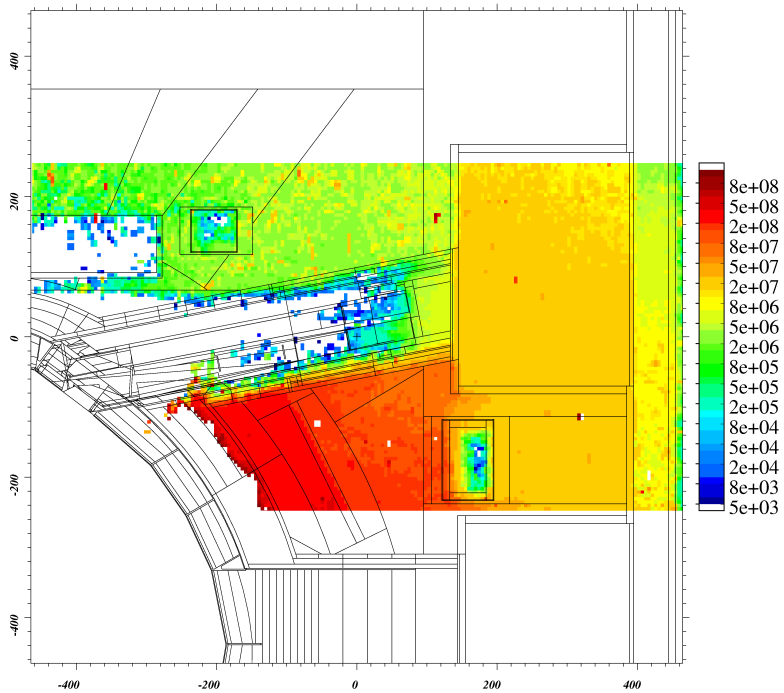
Method - Benchmark with ITER at NRG and CCFE

Equatorial port contribution

FEAT/Alite comparison



Neutron flux distribution



Method: No more delocalization

Experiments → Evaluation 1 → Evaluation 2

(integral, differential) (basic quantities)

(uncertainties)

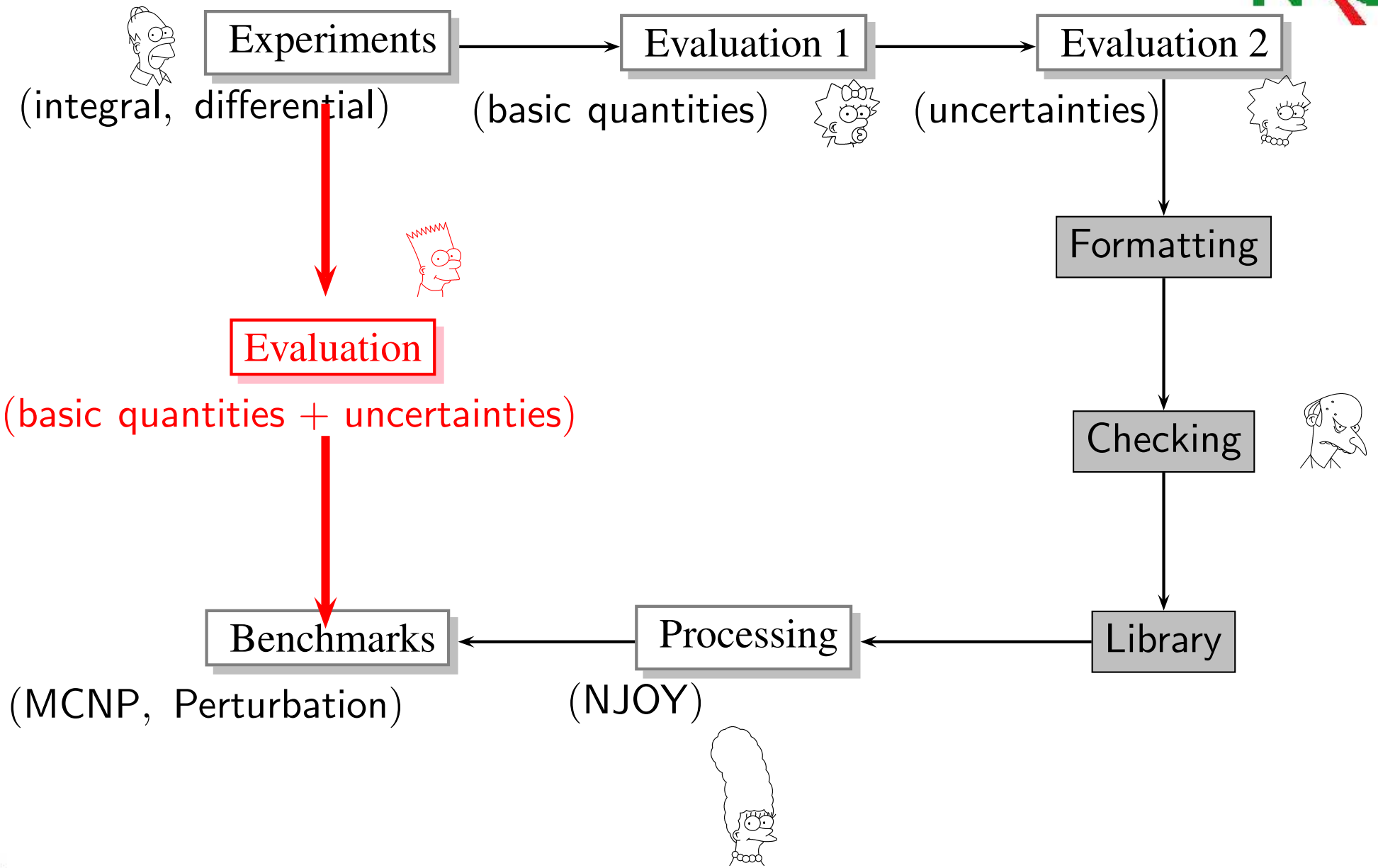
Formatting

Checking

Library → Processing → Benchmarks

(NJOY) (MCNP, Perturbation)

Method: No more delocalization



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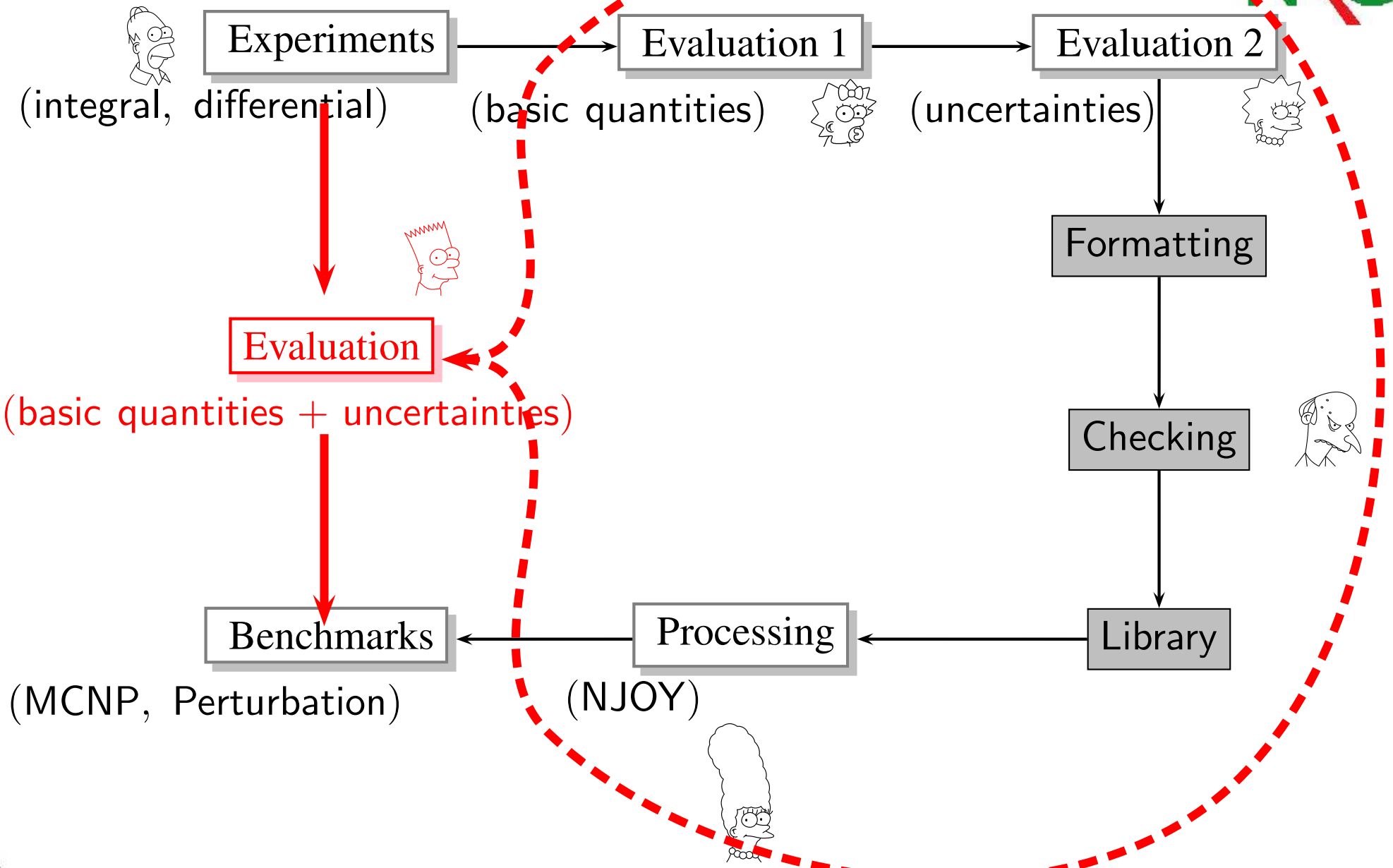

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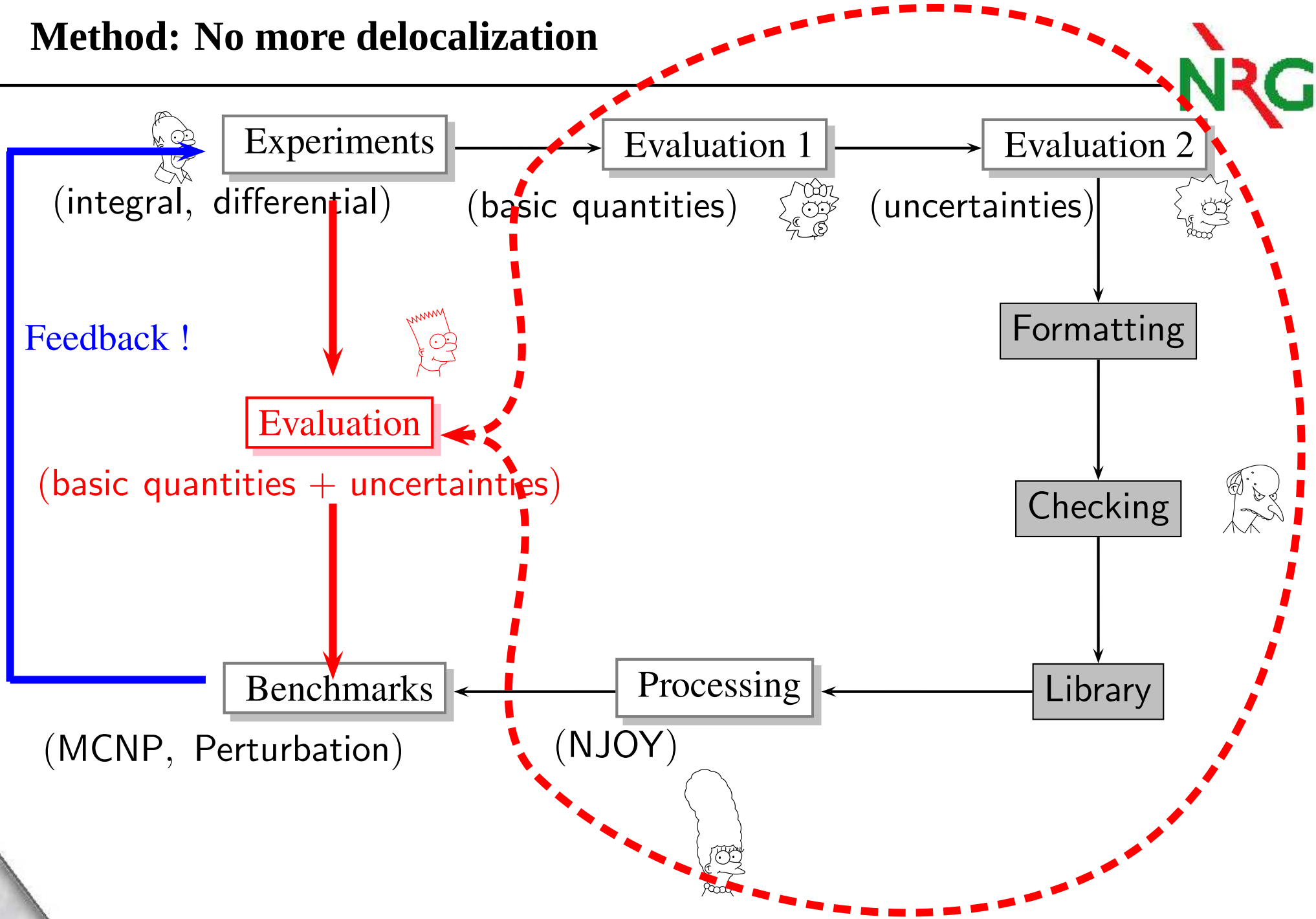

Method - Advantages

- ☺ This library will arise from a unique source (TENDL & EAF-2010) that encompasses twenty years of European fusion related nuclear data research within the EAF and EFF project.
- ☺ For the first time, all fusion-related experimental data and nuclear models will be transferred to technology in a consistent manner.
- ☺ Include other people's work (preferable with TALYS input files, but not necessarily)
- ☺ Automatic benchmarking
- ☺ Only essential info for an evaluation is stored
- ☺ Feedback of extensive validation and benchmark activities will automatically be taken into account.
- ☺ QA
- ☹ Needs discipline, team work and robust codes to (re)produce

Deliverable

- A neutron library dedicated for fusion application
- For all fusion relevant materials (Al, Si, Cu, Ti, Cr, Mn, Co, Fe, Mo, Zr, W, Mg and many others, in fact nearly all materials)
- Transport and EAF files MF-1,2,3,4,5,6,8,9,10,12,14,15,32,33,34
- Variances and covariances
- Tabular (partial) cross sections
- ENDF formatted files
- Processed files (NJOY, PUFF, PREPRO, CALENDF)

Conclusion: Welcome to the 21st century !

- Generation and delivery of new neutron transport libraries for the Monte Carlo codes MCNP, TRIPOLI and SN code ATTILA and activation libraries for the FISPACT code.
- In 2012: Unified activation and transport library based on EAF/TENDL
- Unique source (TENDL & EAF-2010).
- If required, inclusion of any other evaluation.
- No targeting on a few materials: the method will be applied to all fusion-relevant materials at the same time !

A high quality library for all fusion-relevant materials will be produced