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The TENDL nuclear data library: for criticality calculations and more

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Summary

- The TENDL library: what is behind ?
- Criticality applications
- Uncertainties for criticality
- More

What is the TENDL project ?

- TENDL: TALYS evaluated nuclear data library,
- Goal: improve simulations for TENDL and/or other libraries, or solving

$$0 \leq \chi^2 \leq 1$$

$$\chi^2 = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{C_i - E_i}{\Delta E_i}\right)^2$$

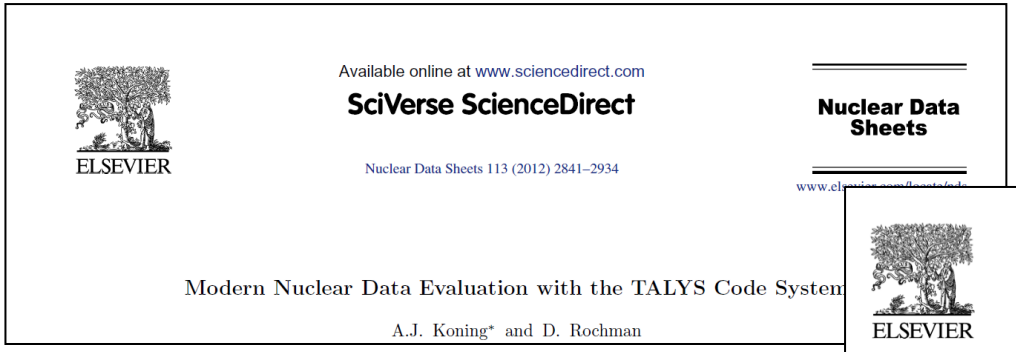
- Available at https://tendl.web.psi.ch/home.html
- Comes from T6 (software package)
- T6 leads to TENDL, TMC, BMC, HFR…
- See for instance NDS 113 (2012) 2841, ANE 51 (2013) 60, NDS 139 (2017) 1, NDS 155 (2019) 1

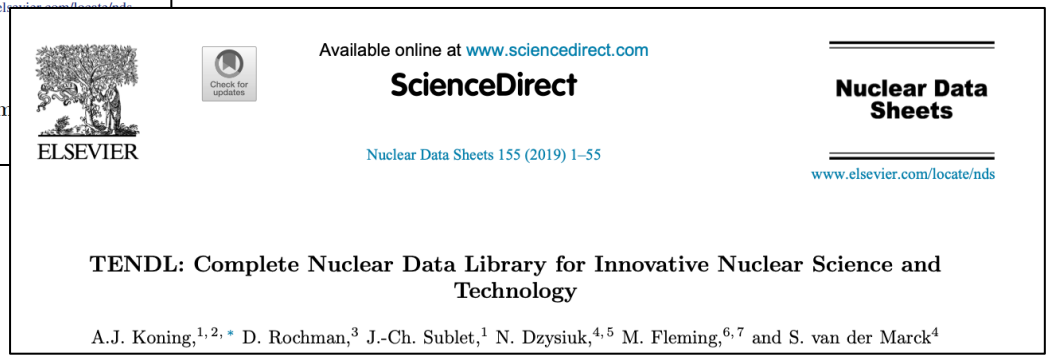
What is the TENDL project ?

- TENDL is in fact a by-product of a series of codes,
- This is one fundamental difference with other libraries (no manual work),
- It allows to perform „TMC“ for Total Monte Carlo (uncertainty propagation)
- Methods: reproductibility & completeness, development of a portable system, and making use of the knowledge included in other libraries (JEFF, ENDF/B, JENDL),
- Background: theoretical calculations (TALYS) with experimental inputs, with original resonance evaluations,
- Impact:
  - TENDL-2008 to 2023 releases (>2800 isotopes),
  - Neutrons, protons, deuterons, tritons, He3, alpha and gamma induced,
  - all isotopes, all cross sections with covariances, 0-200 MeV,
  - more than 300 isotopes in the NEA JEFF-3.3 library,
  - more than 50 isotopes in the US ENDF/B-VIII.0 library,
  - more than 450 publications using TENDL

TENDL: from MF-1 to MF-40, 200 MeV

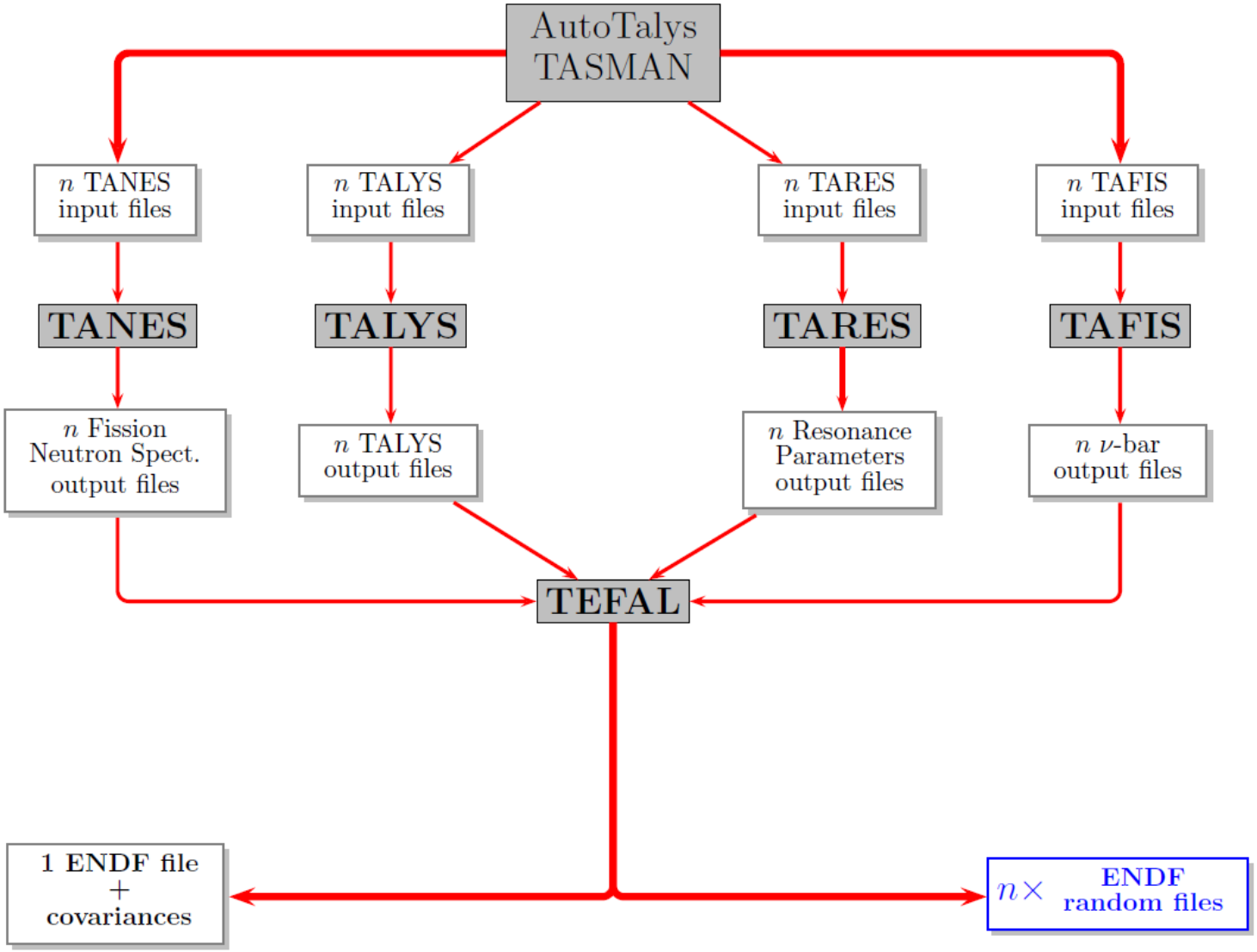
- MF-1: Description + fission parameters
- MF-2: Resonance parameters (Reich-Moore or Multi-level Breit Wigner)
- MF-3: Cross sections (n,tot), (n,el), (n,non), (n,inl$_i$), ..., (n,γ), (n,p$_i$), (n,α_i)
- MF-4: Elastic angular distribution (Legendre Polynomials)
- MF-5: Fission neutron spectrum
- MF-6: Double differential distributions and spectra for (n,2n), ..., (n,α_i)
- MF- 8-10: Isomeric cross sections
- MF- 12-15: Gamma yields, angular distributions and spectra
- MF- 31-32-33-34-35, 40: nubar, Resonance parameter, cross section, angular distribution and fission neutron spectrum, radionuclide production.





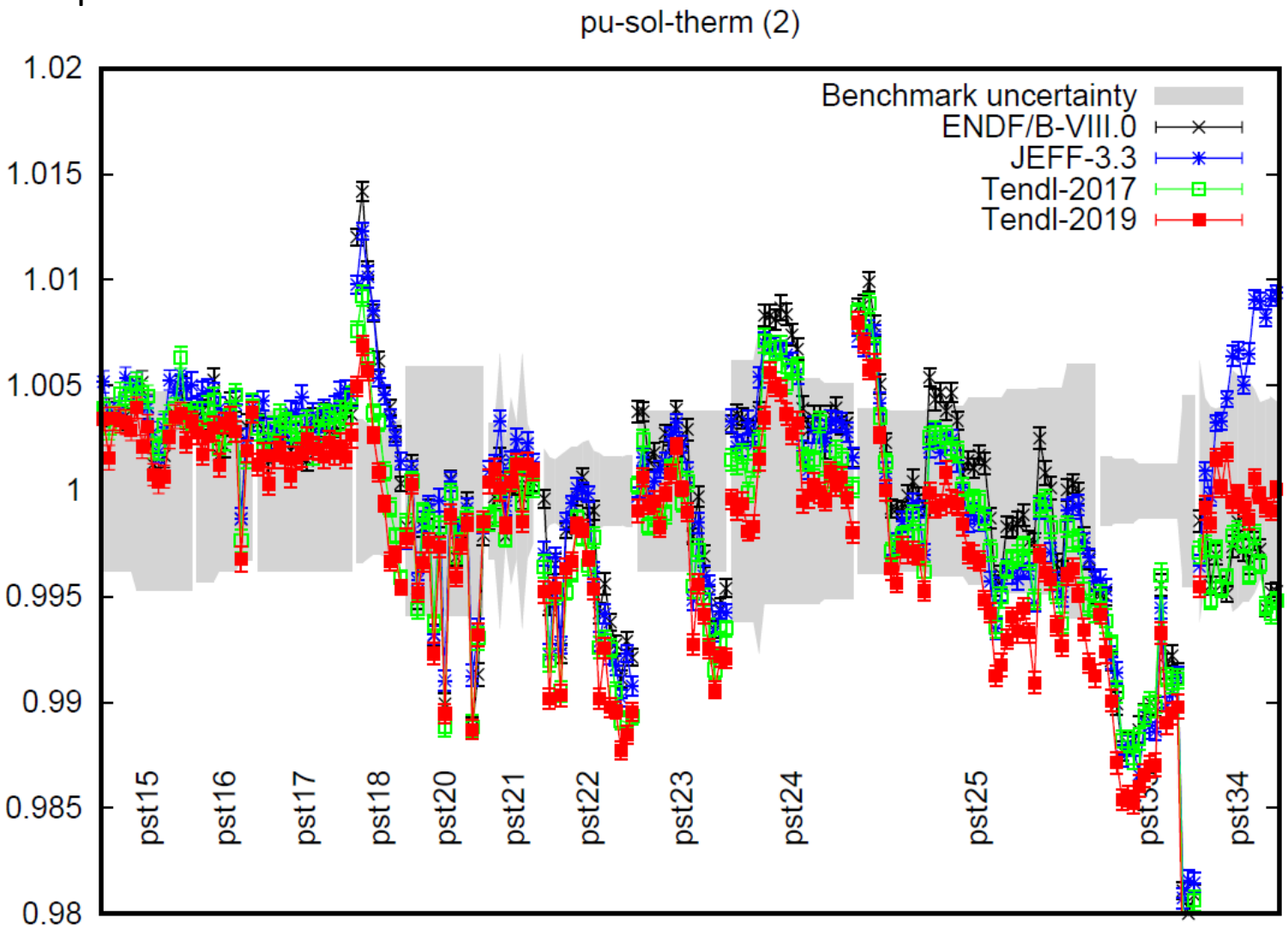
The TENDL library

- Method: Quality evaluation, production automation, open source



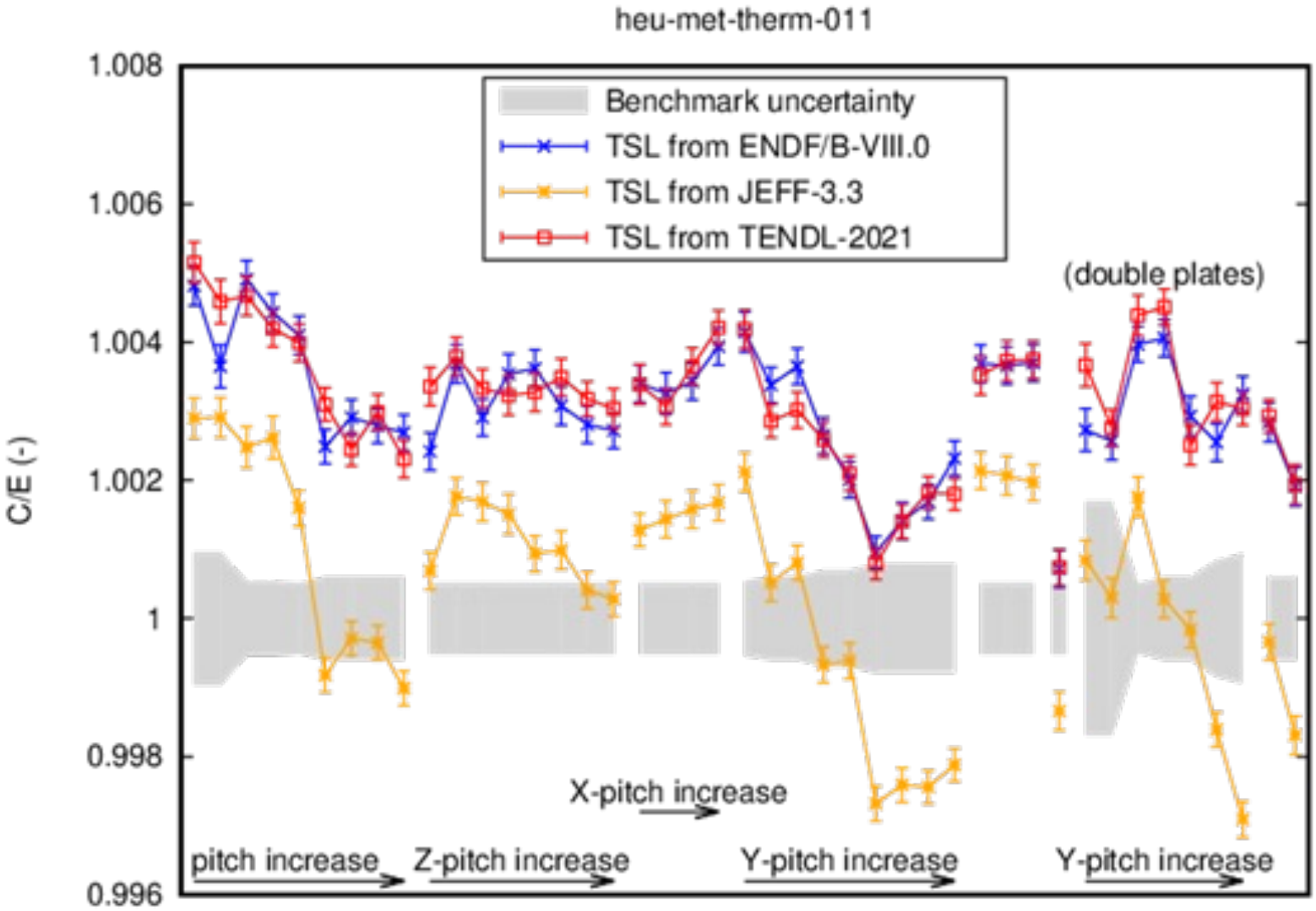
TENDL: validation for criticality benchmarks

- Example on PST cases



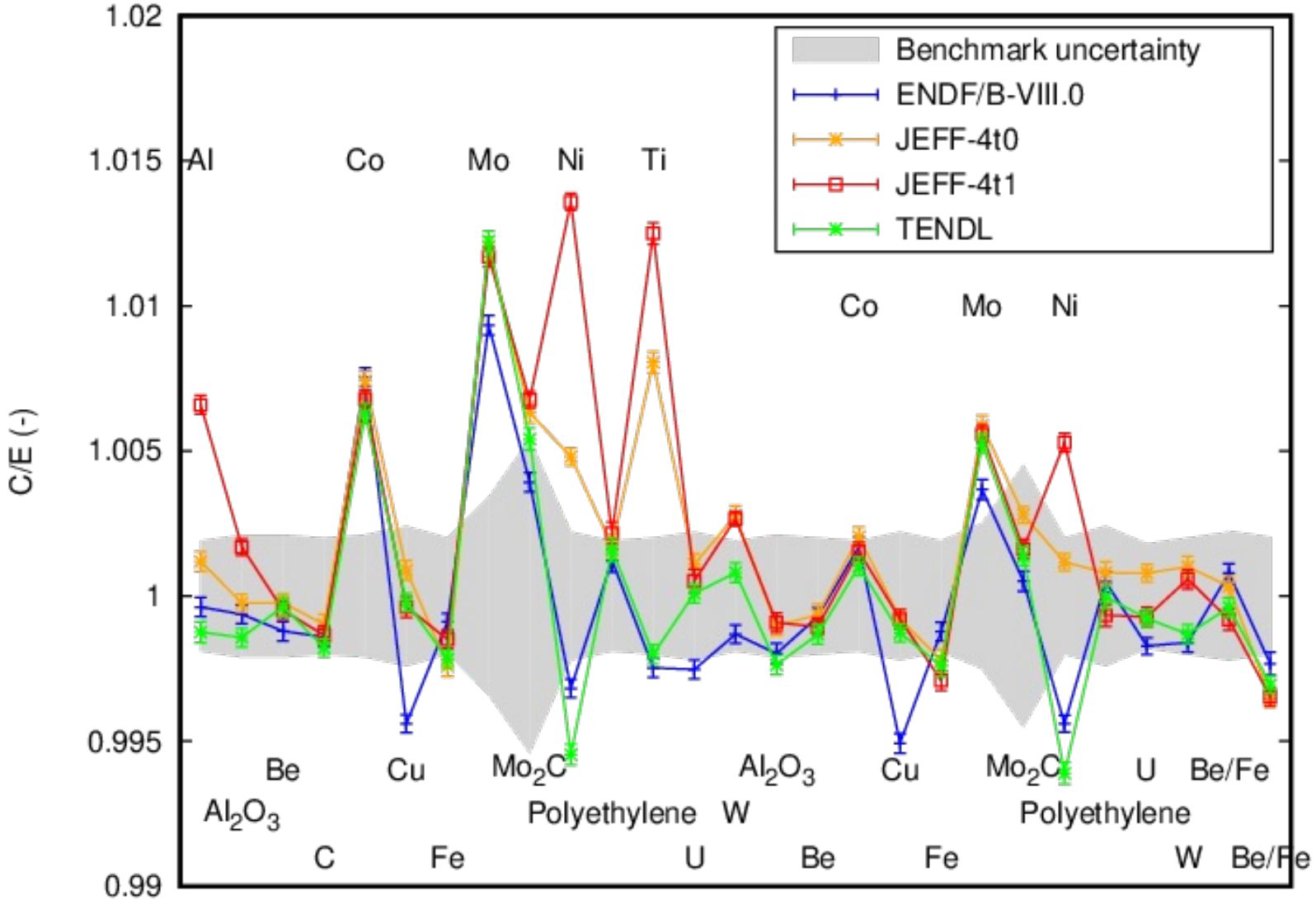
TENDL: validation for criticality benchmarks

- Example on HMT-11 cases



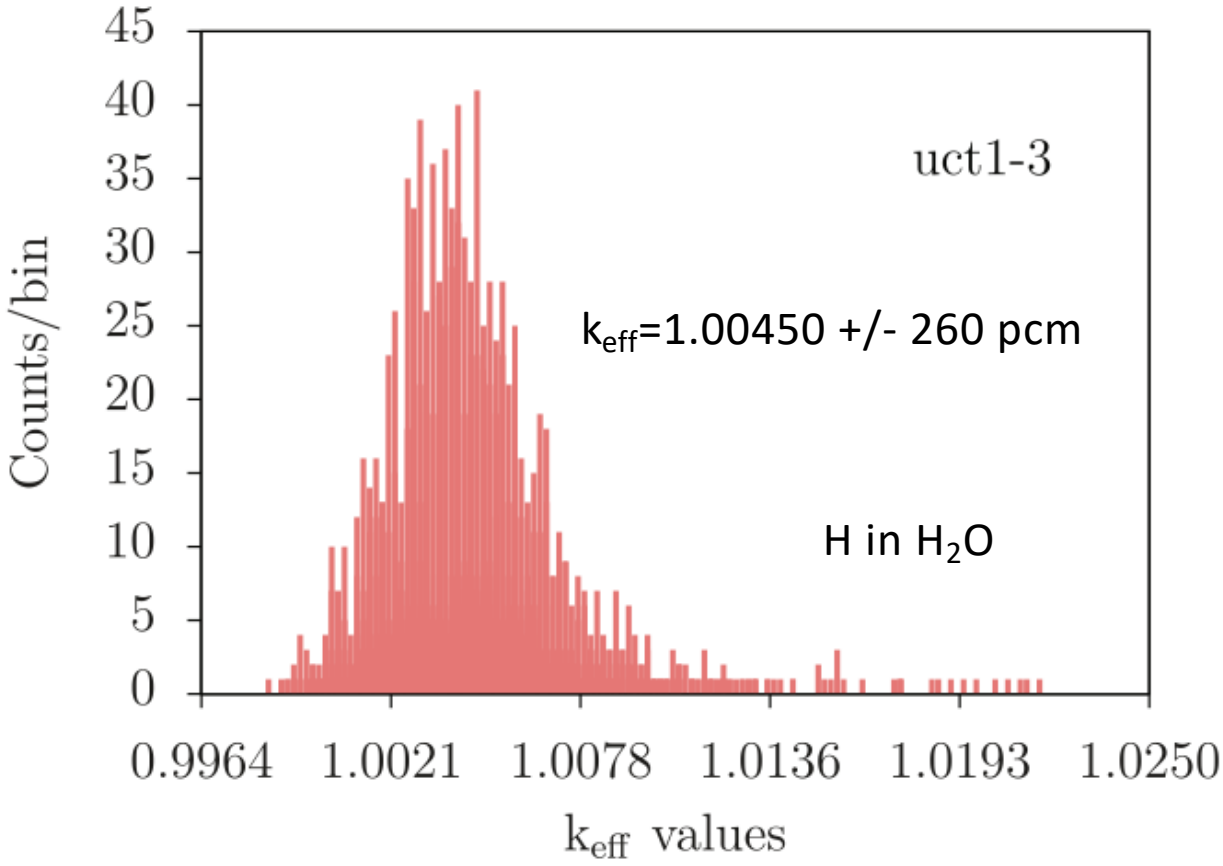
TENDL: validation for criticality benchmarks

- Example on HMF-84 cases



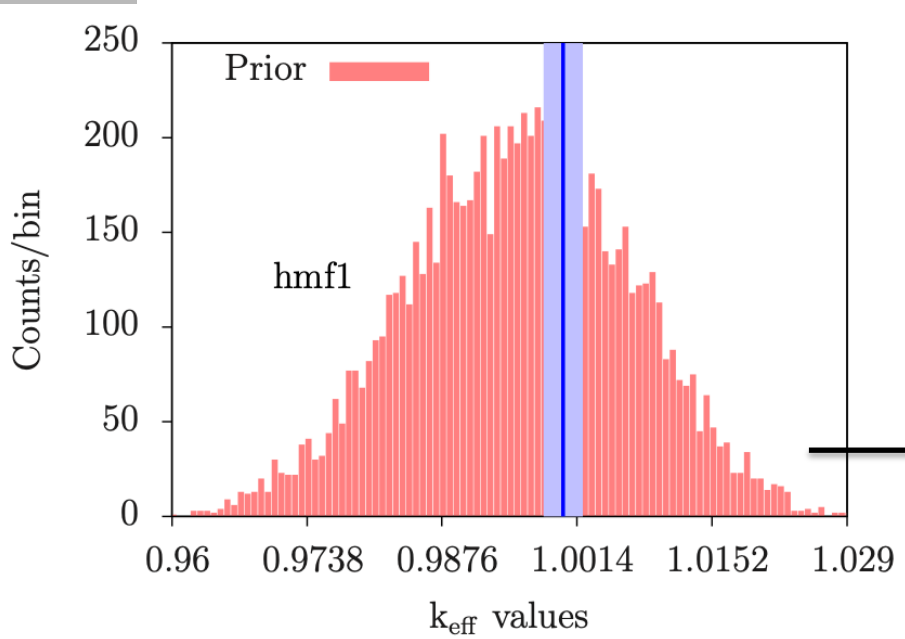
TENDL: uncertainties due to nuclear data

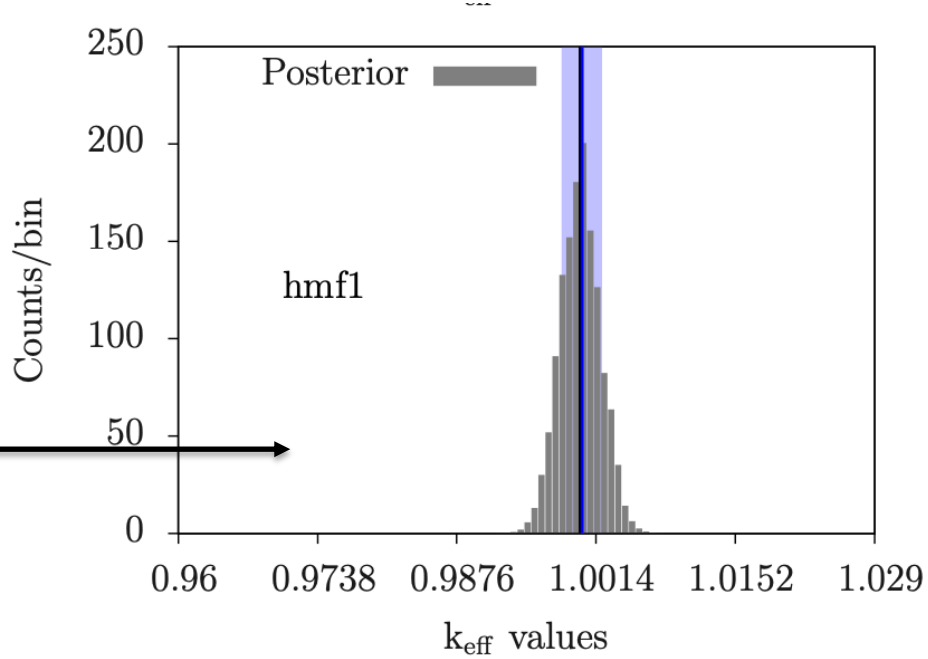
- Uncertainties for criticality benchmarks due to many aspects of nuclear data:
  - Cross sections, nubar, pfns
  - Angular distribution (shielding)
  - Thermal scattering data (TSL)
  - Based on covariances (sensitivity) or random files (TMC)



TENDL + ICSBEP = nuclide correlation

- Based on criticality benchmarks and the BMC method:
  - Posterior uncertainties
  - Correlations between isotopes





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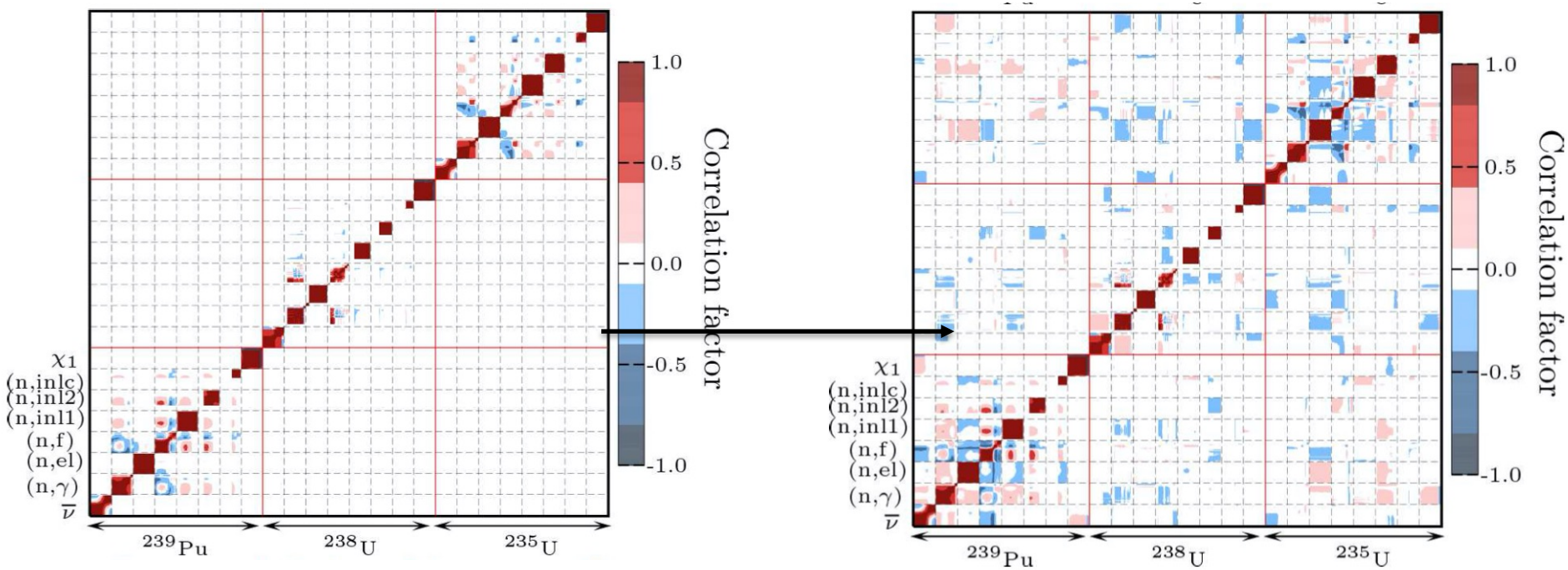
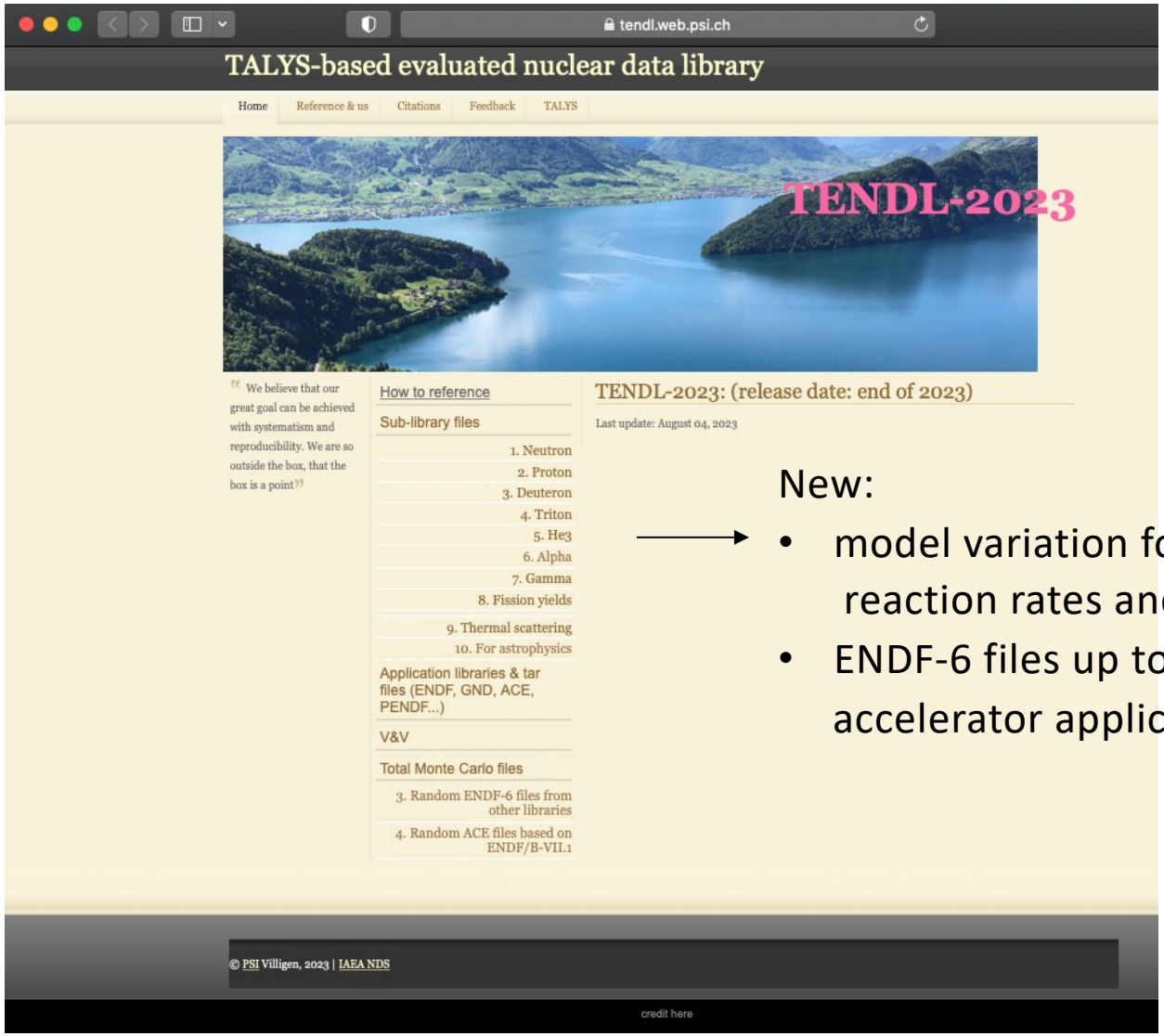


TENDL-2023: new library

- Method: Quality evaluation, production automation, open source

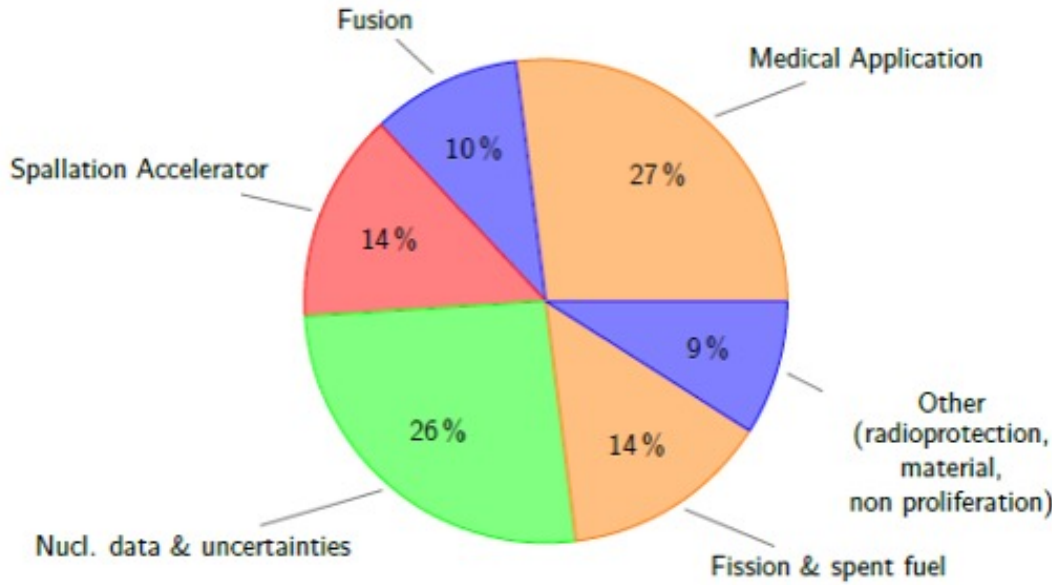


New:

- model variation for astrophysical reaction rates and MACS
- ENDF-6 files up to 600 MeV for accelerator application

Conclusions

- TENDL is performing well on criticality benchmarks
- Consistent format, processing, included information
- With covariance and random files for uncertainty propagation
- One unique information source for various applications
- Open-source software to produce the library
- Open unexpected opportunities



PAUL SCHERRER INSTITUT

PSI

Wir schaffen Wissen – heute für morgen