Library validation with the GALILÉE-1 and TRIPOLI-4® codes.

Cédric Jouanne – Mireille Coste-Delclaux – Odile Petit

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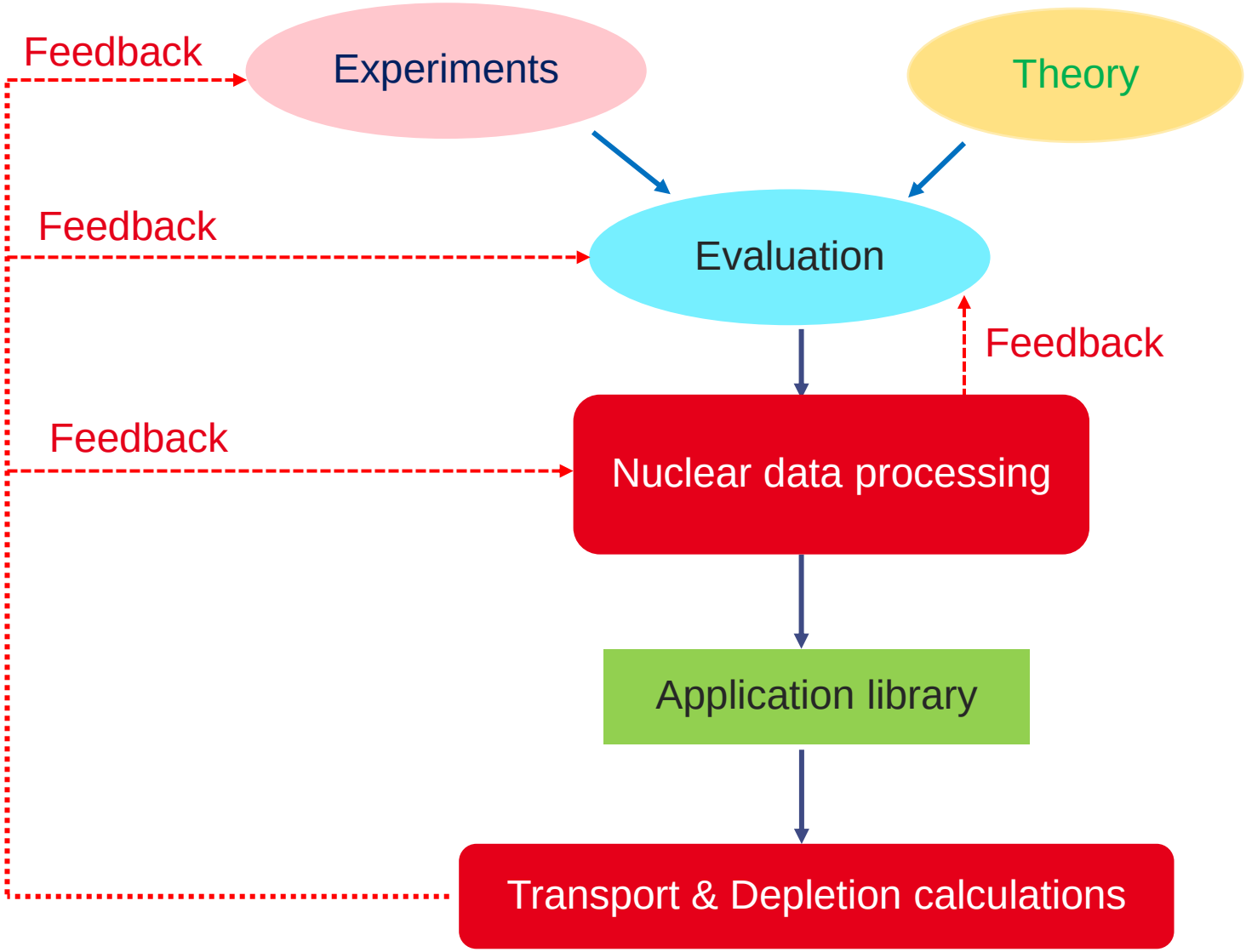
Outline

1 – Nuclear data Processing & Simulation
2 – GALILÉE-1 + TRIPOLI-4® : Tests + Validation of nuclear data
3 – Secondary particles (gamma production)
4 – Photonuclear data
5 – Conclusion

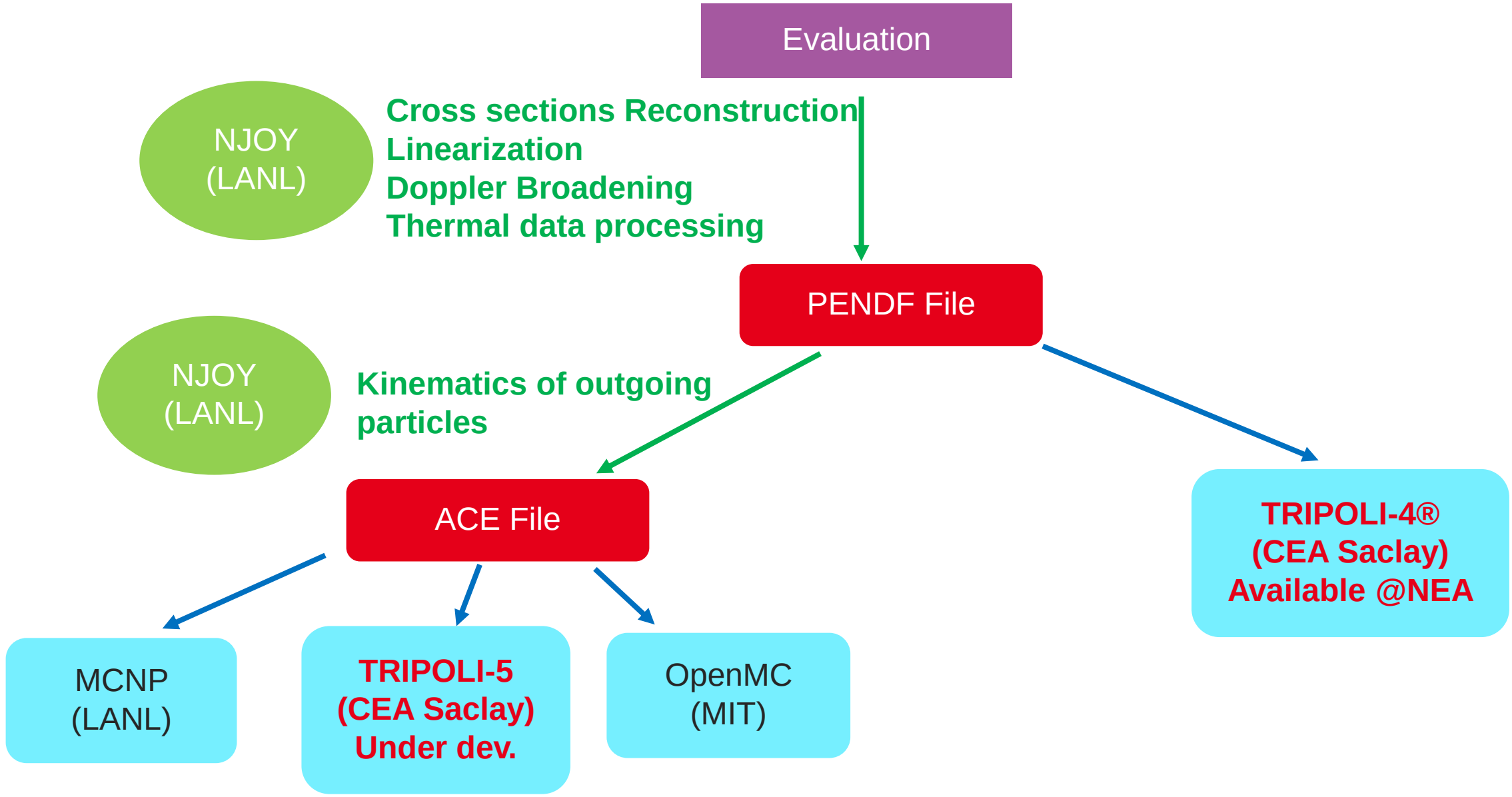
F. X. Hugot, O. Petit, et al. (2024). « Overview of the TRIPOLI-4 Monte Carlo code, version 12 ».
EPJ Nuclear Sciences & Technologies, *10*, 17. (2024)

M. Coste-Delclaux, et al. (2024). « Recent developments in the GALILÉE-1 processing code ».
EPJ Web of Conferences (Vol. 294, p. 06003). EDP Sciences. (2024)

Nuclear data – Processing - Simulation



Nuclear data processing for Monte Carlo codes



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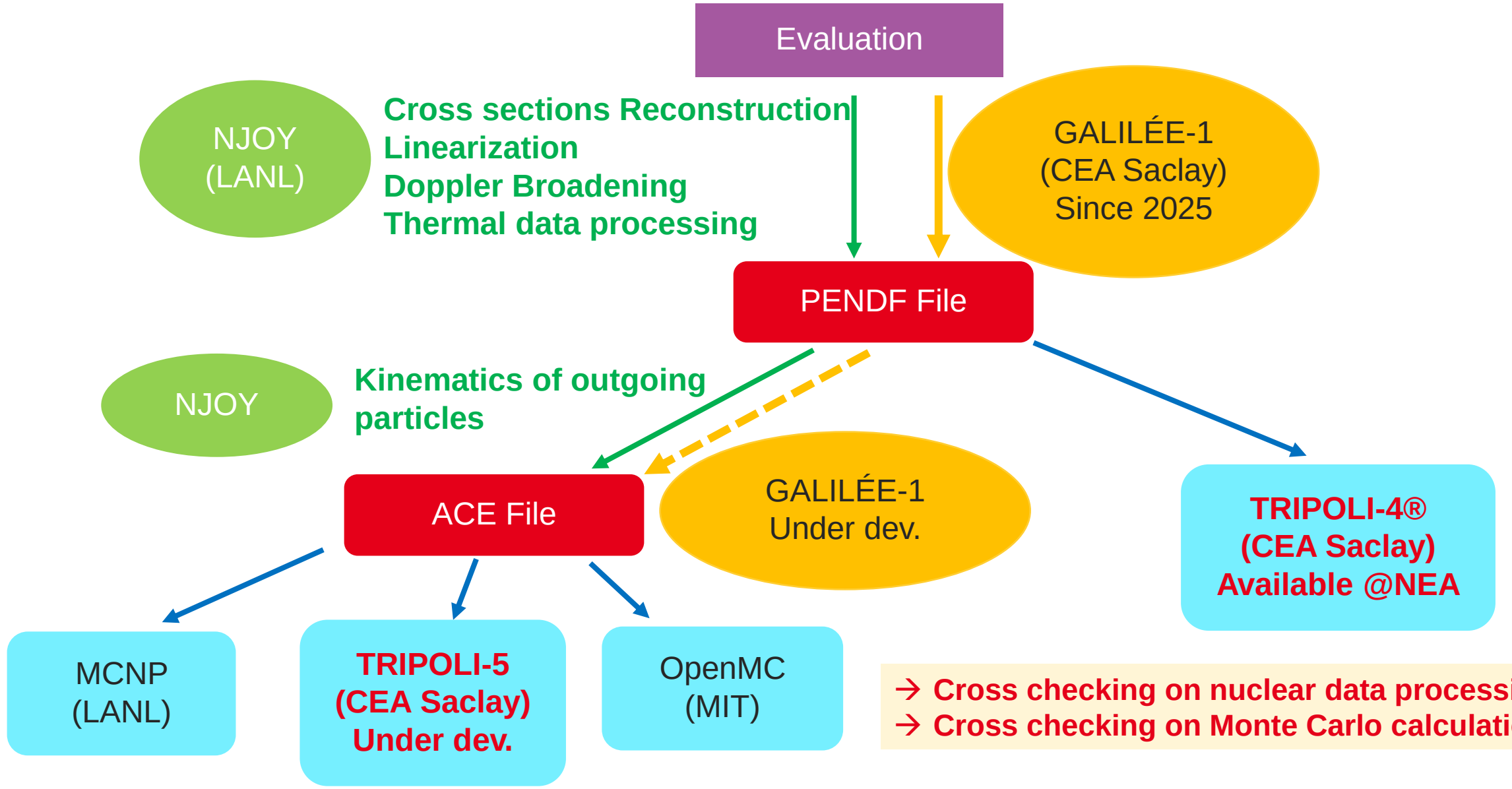


→ Cross checking on nuclear data processing
→ Cross checking on Monte Carlo calculations

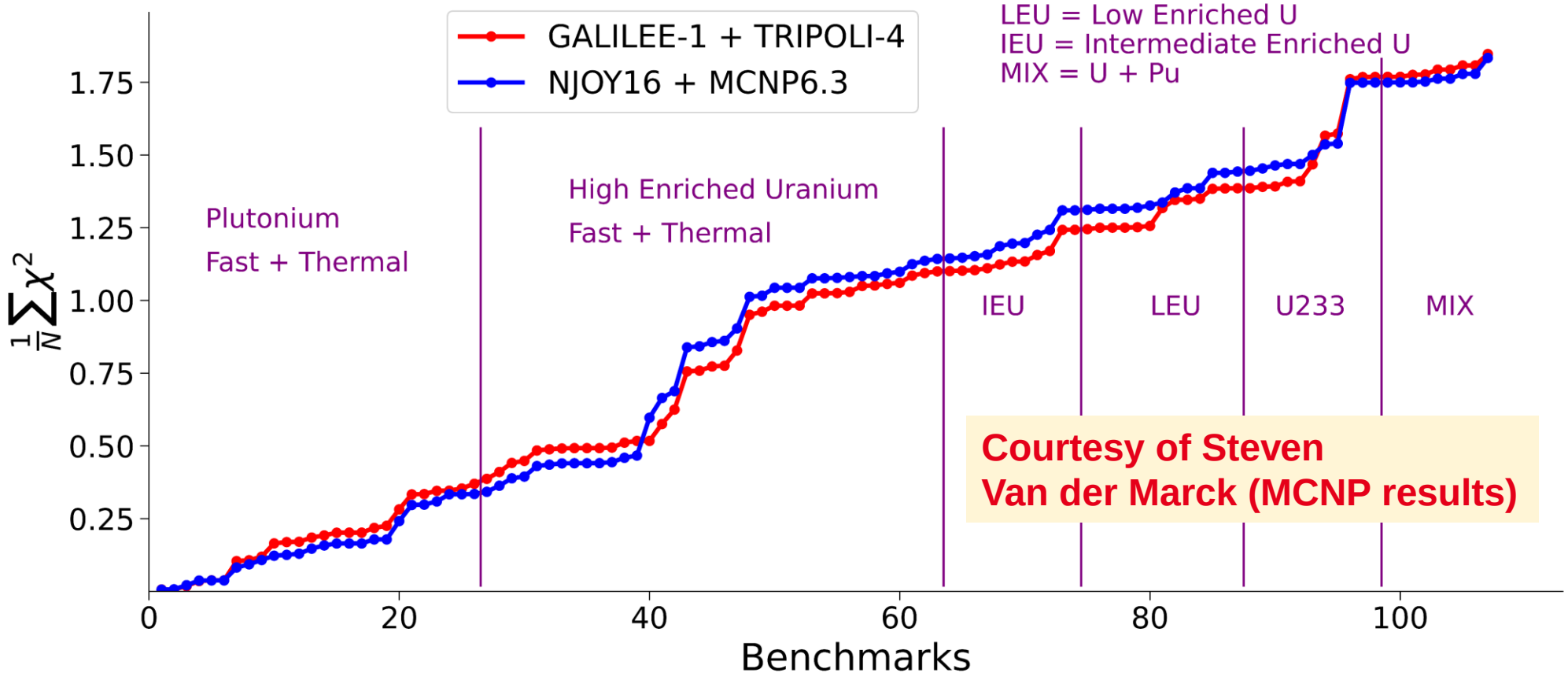
GALILÉE-1 + TRIPOLI-4 or NJOY16 + MCNP

Very good agreement between NJOY + MCNP and GALILÉE-1 + TRIPOLI-4 calculations

→ very high level of confidence in the use of the library

Example : ICSBEP criticality benchmarks using JEFF-4 Library

$$\chi_i^2 = \frac{(C_i - E_i)^2}{\sigma_{E_i}^2 + \sigma_{C_i}^2}$$



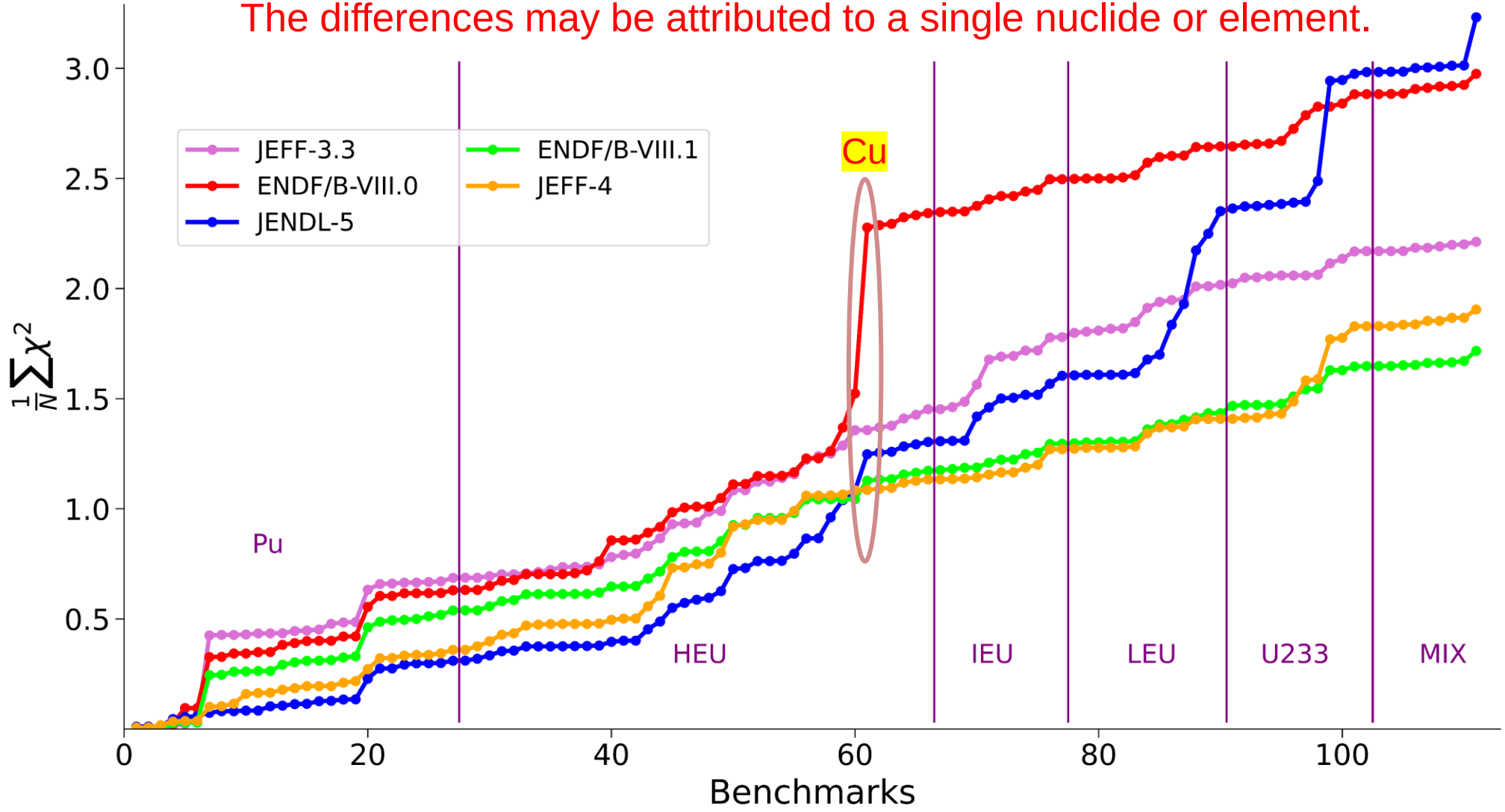
Courtesy of Steven Van der Marck (MCNP results)

The differences are mainly due to the definitions of the geometry.

Thanks to Oscar for sharing the MCNP files.

GALILÉE-1 + TRIPOLI-4 : Highlighting the impact of a nuclide

The differences may be attributed to a single nuclide or element.



Shielding benchmark: Effect of anisotropy

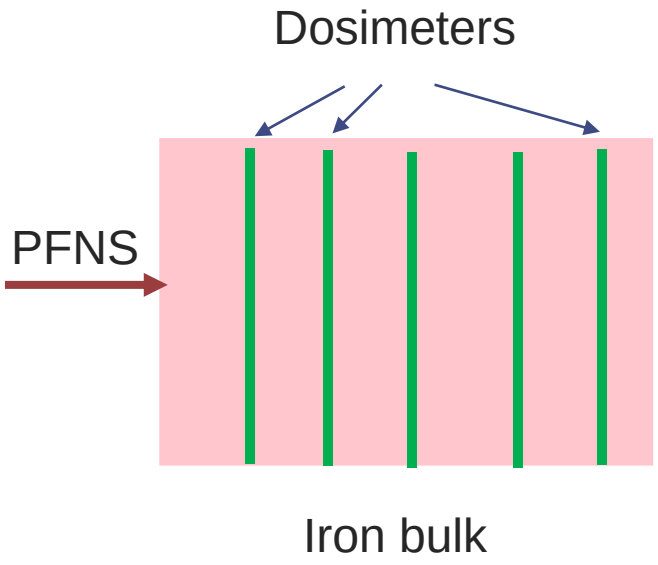
The TRIPOLI-4 library can be easily modified (cross sections, anisotropies, secondary particle kinematics)

ASPIS : Propagation of fission neutrons through an iron bulk

Dosimeters located at different penetration depths

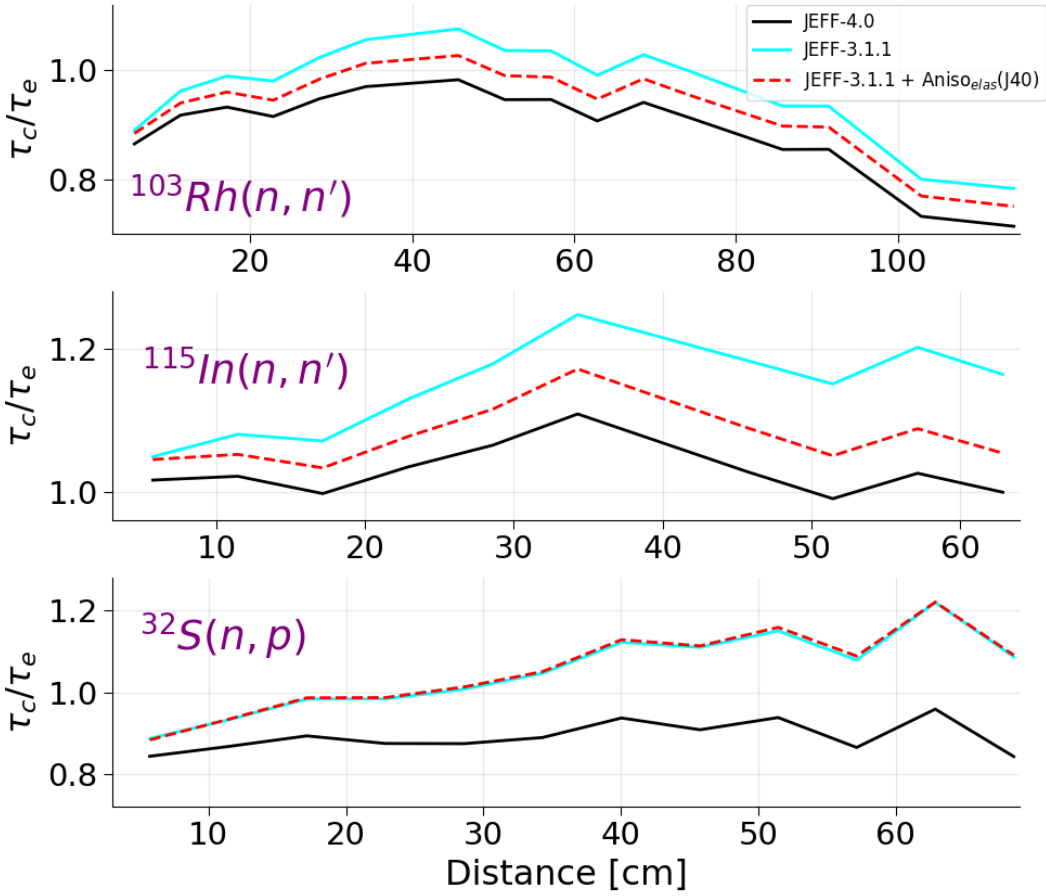
Impact of anisotropy in elastic scattering

All nuclei except Fe56 from JEFF-4.



^{103}Rh(n,n'): 40 keV
^{115}In(n,n'): 340 keV
^{32}S(n,p): 1.7 MeV

τ_c : calculated reaction rates
τ_e : experimental reaction rates



Photon production induced by radiative capture

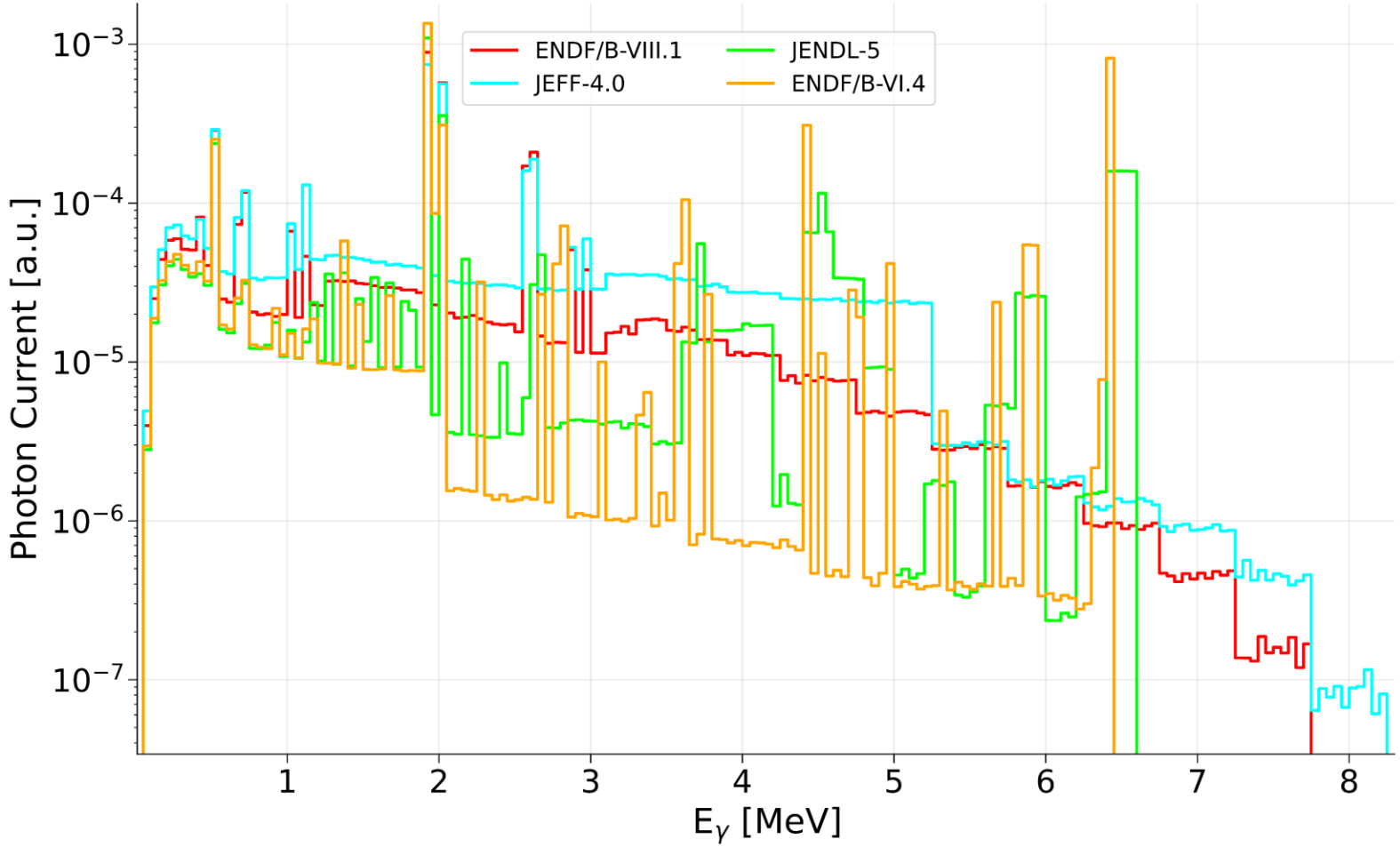
Significant effort has been devoted to the latest libraries.

	Nucleides	No gamma in (n,γ)
JEFF-3.3	562	1
JEFF-4	593	4
ENDF/B-VIII.0	557	140
ENDF/B-VIII.1	556	6
JENDL-4	406	45
JENDL-5	795	5

However, what is the quality of the gamma production data?

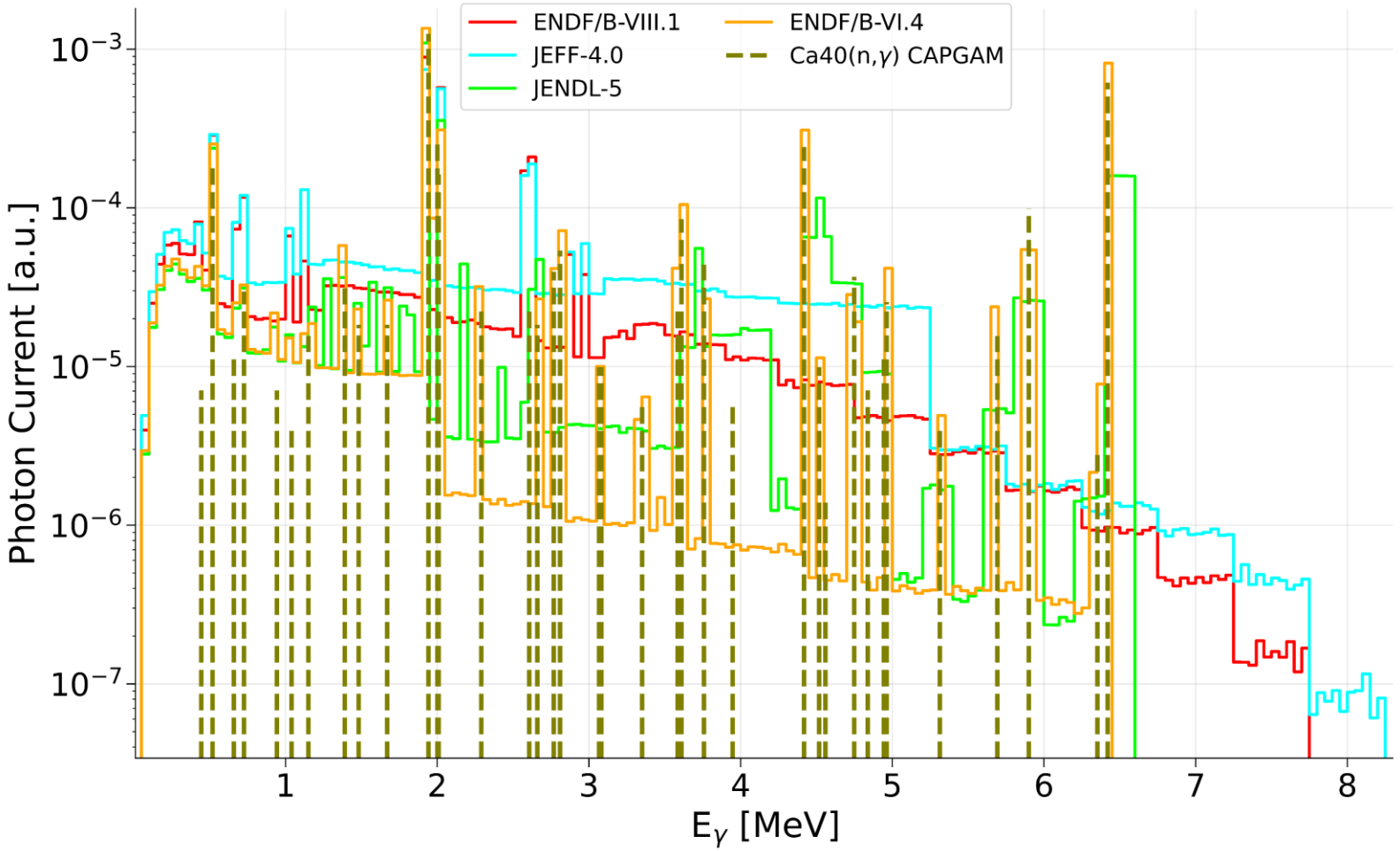
Photon production from radiative capture on ^{40}Ca

TRIPOLI-4 calculation: Photon production from a neutron source at 1 eV

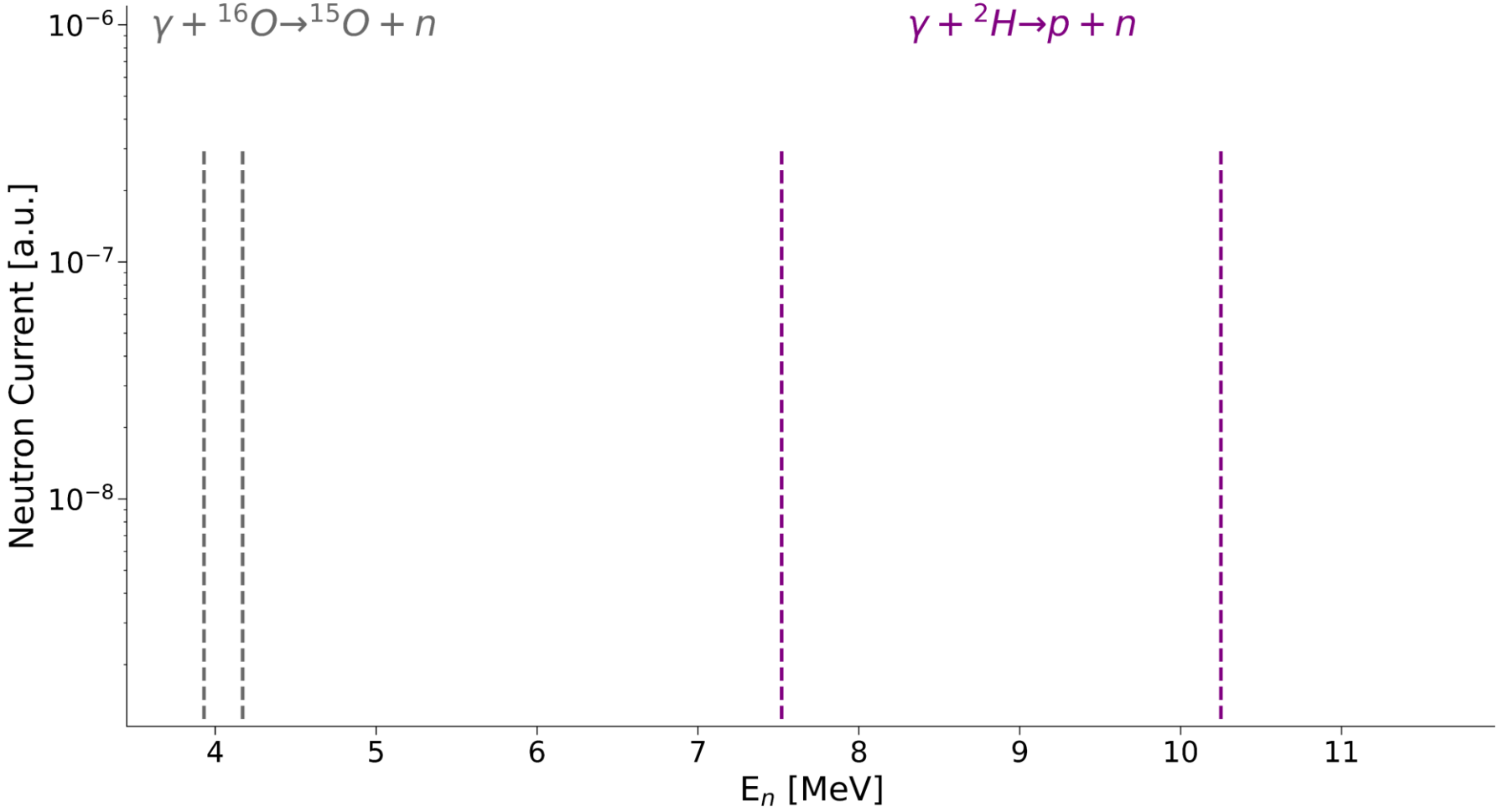


Photon production from radiative capture on ^{40}Ca

CapGam library: Discrete Photon library → High energy discrete Gamma



Photonuclear reactions
gamma source 20 MeV in D_2O (γ,n)



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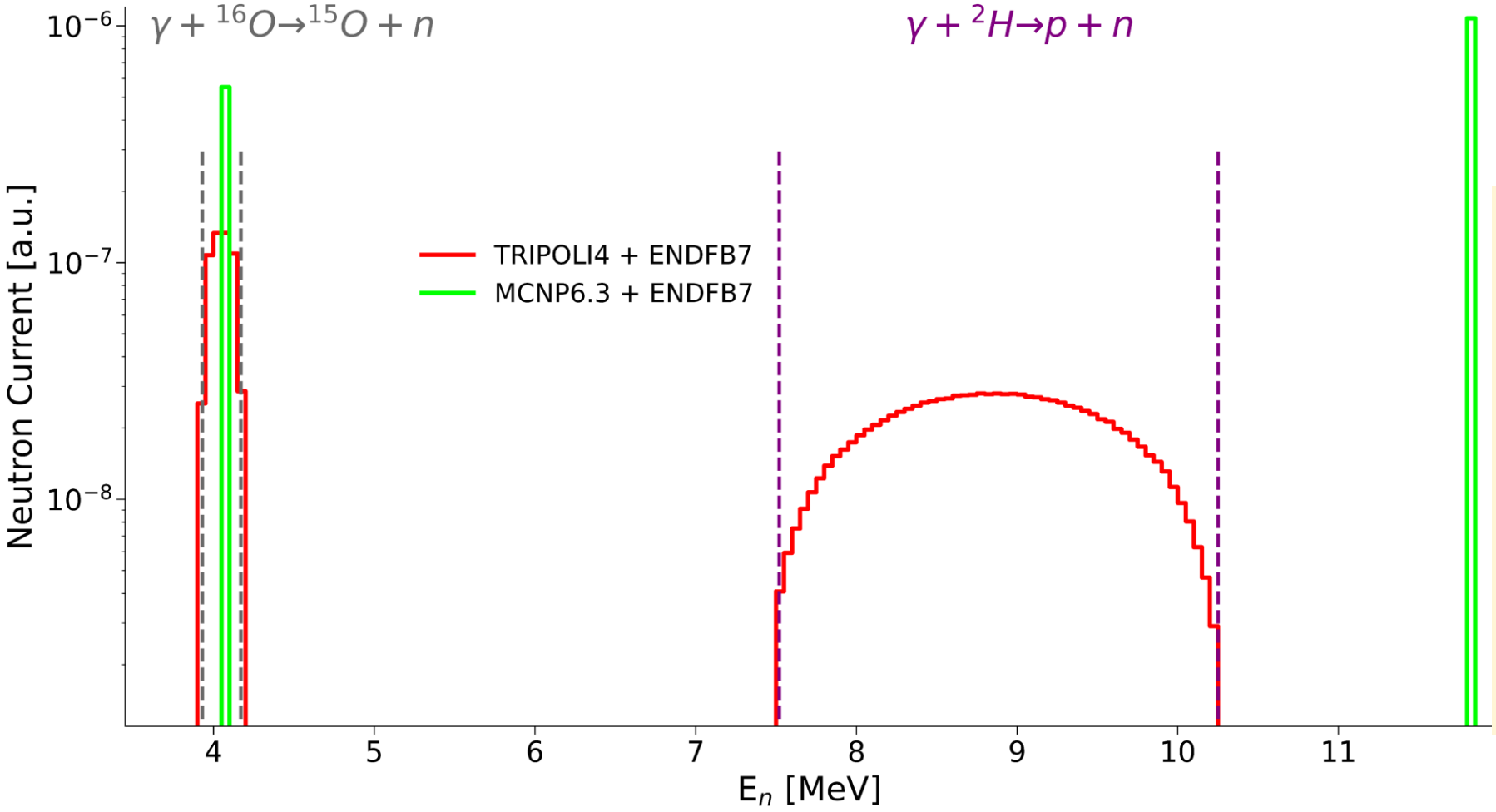


Tripoli4 : ✓
MCNP :
ACE File or Kinematics ?

→ Use of JENDL5

- H2(JENDL5) ~ H2(B7)

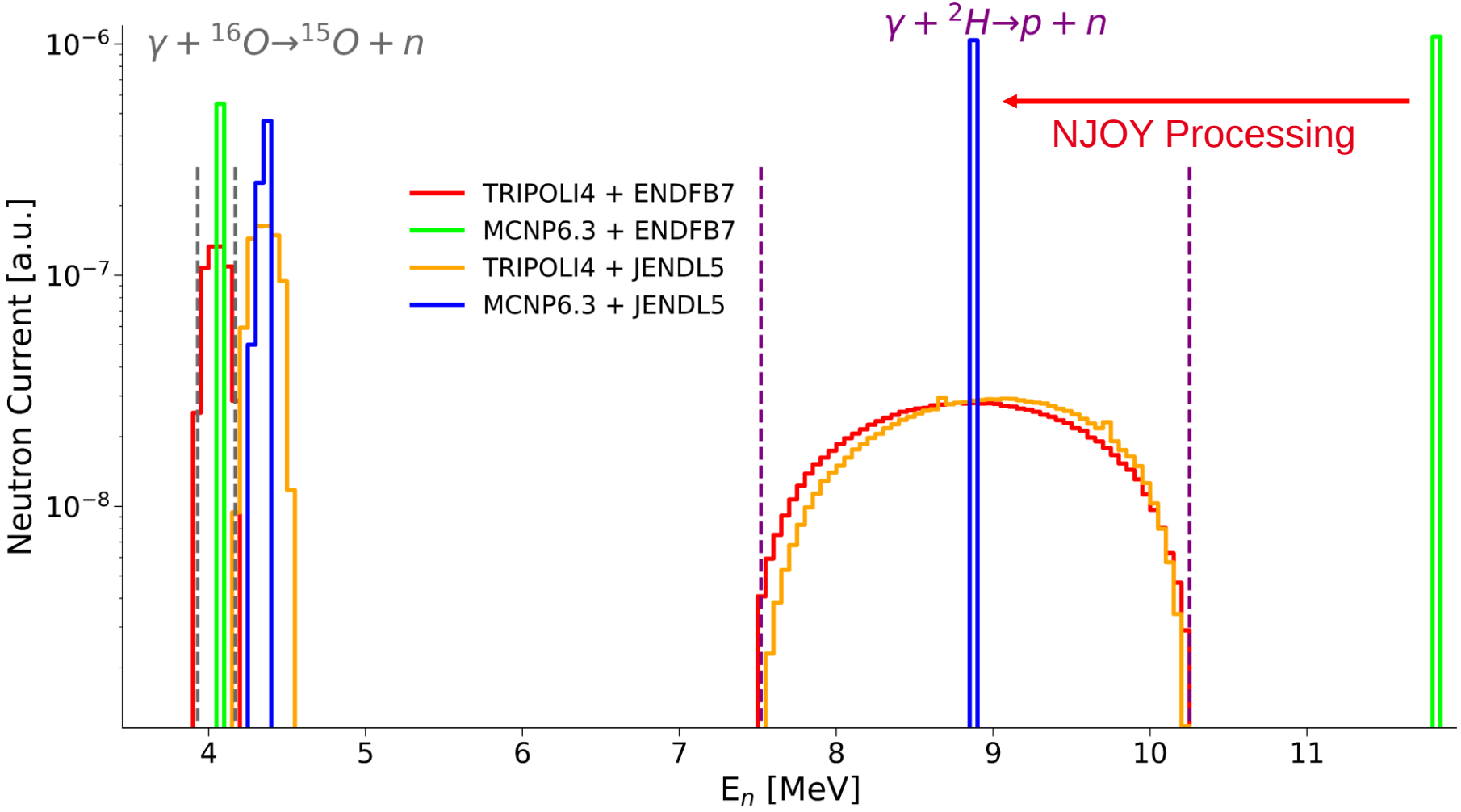
Diff. in anisotropy in CoM

- O16 (Use of only one

Reaction (gamma,anything)

JENDL5 library
processed by NJ16
(JAEA version)

Photonuclear reactions
gamma source 20 MeV in D_2O (γ,n)

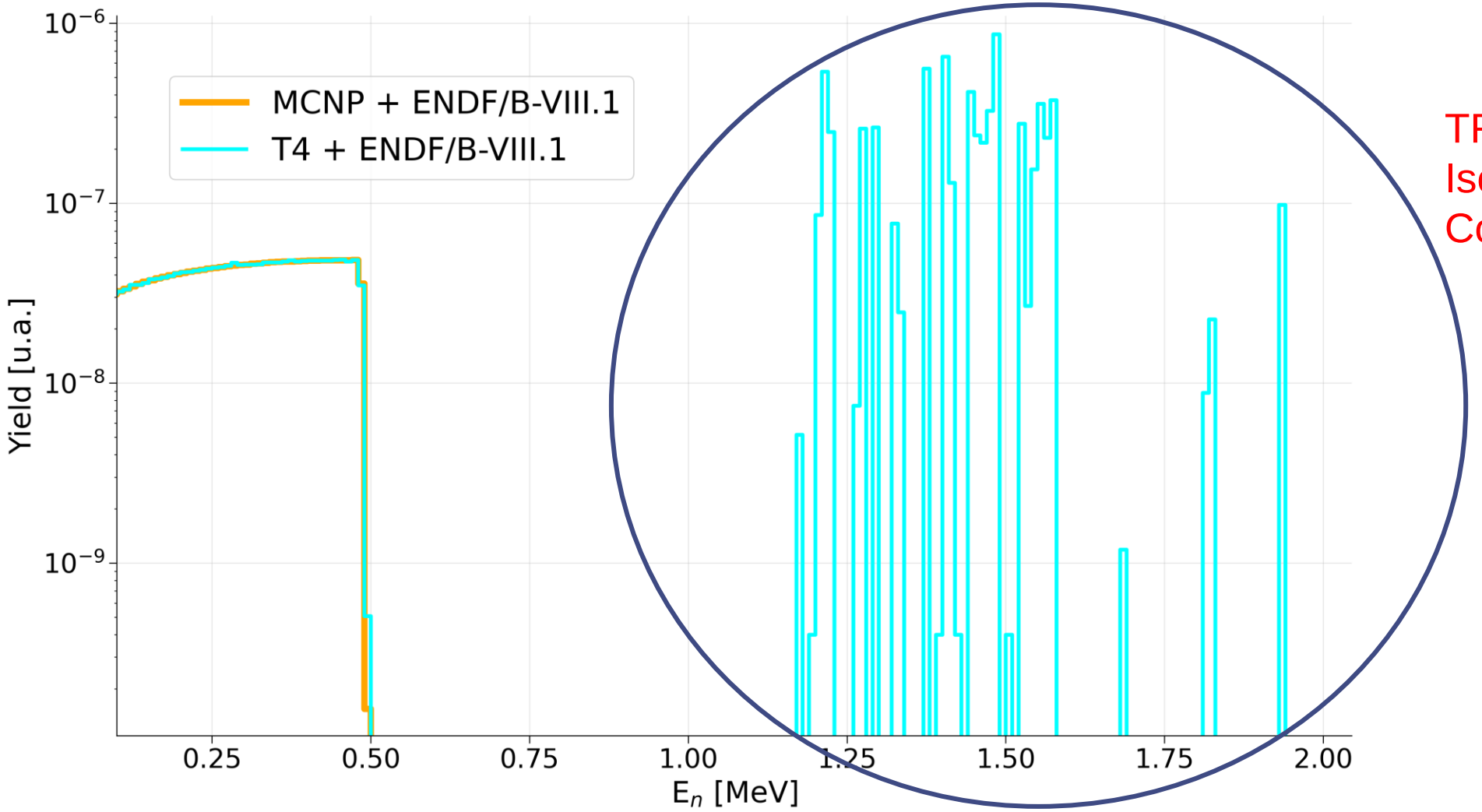


NJOY16 + MCNP:
Kinematics in Lab frame instead of CoM frame !

JENDL5:
Total kinetic energy is assigned to the neutron (All nuclei, except ^2H)

Photonuclear reactions
Lack of data

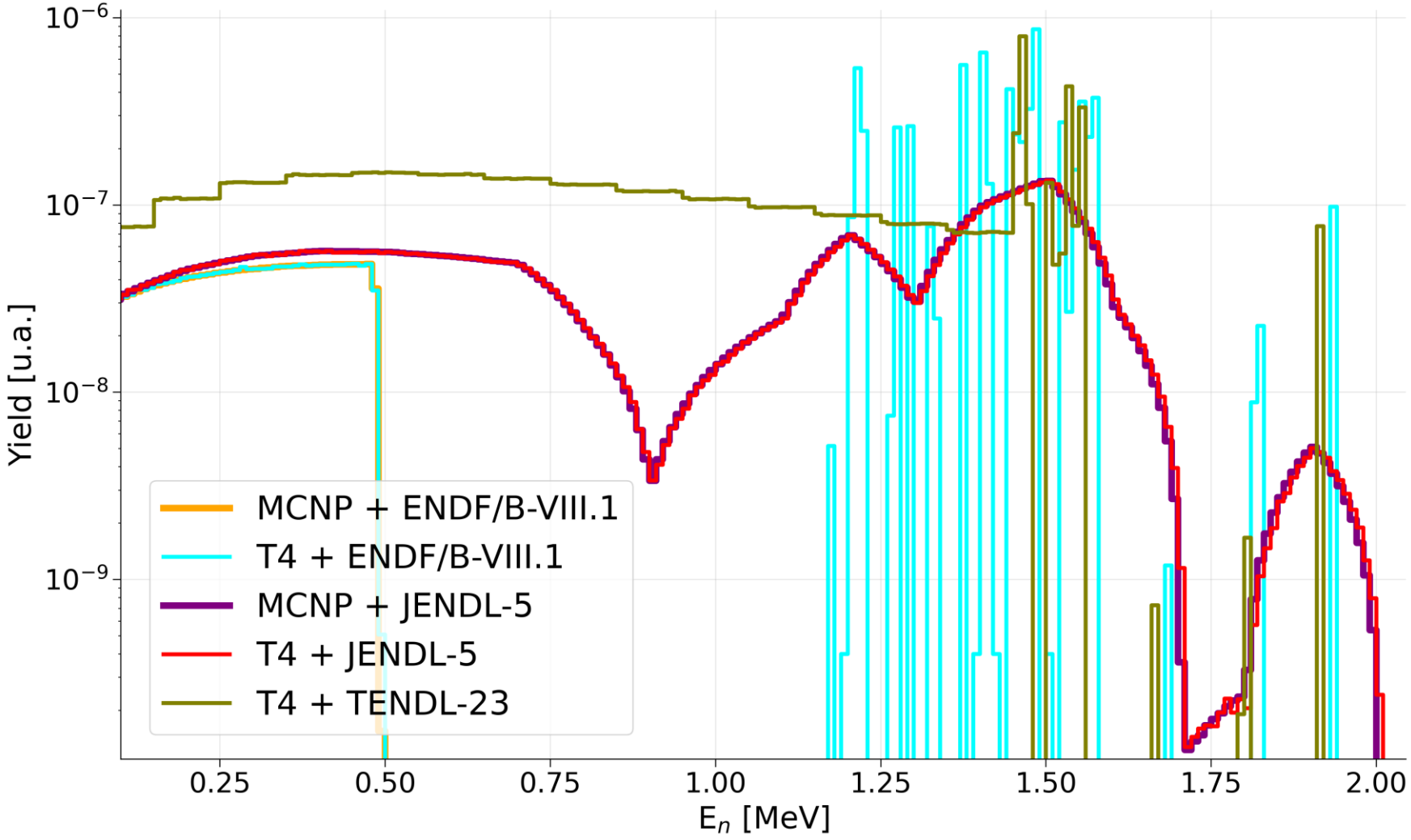
$^{182}W(\gamma,n)^{181}W^{*\ i=0,21}$ Cross sections available in evaluation without neutron kinematics data



TRIPOLI-4 Assumption:
Isotropic deviation in
CoM for neutron

Photonuclear reactions
Lack of data + Inconsistencies

$^{182}W(\gamma,n)^{181}W^{*\ i=0,21}$ Cross sections available in evaluation without neutron kinematics data



3 libraries ≡ 3 results

Conclusion

NJOY16 + MCNP ≡ GALILÉE-1 + TRIPOLI-4 for neutron transport
(Exception: Treatment of unresolved resonance range URR).

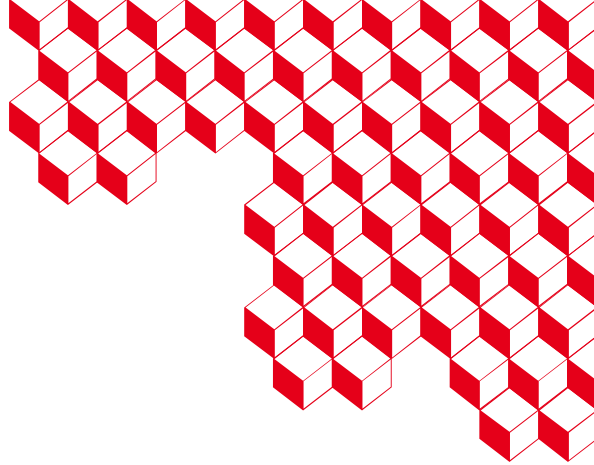
GALILÉE-1 + TRIPOLI-4 is used to check the consistency of the evaluation files.

Possible improvement: inclusion of gamma-ray data from the CAPGAM library.
Use of DICEBOX or FIFRELIN … ?

Improved description of primary gamma rays. Feasible in ENDF-6 format, likely easier in GNDS.

Primary gamma from radiative capture: Example ^{56}Fe in JENDL-5 Library.

Photonuclear Files: - Completion
- Kinematics for secondary particles



Thank You !

Cédric Jouanne
CEA Saclay
cedric.jouanne@cea.fr