Testing and verification of nuclear data with the GALILEE-1 processing code and the TRIPOLI-4 Monte Carlo code

DE LA RECHERCHE À L'INDUSTRIE

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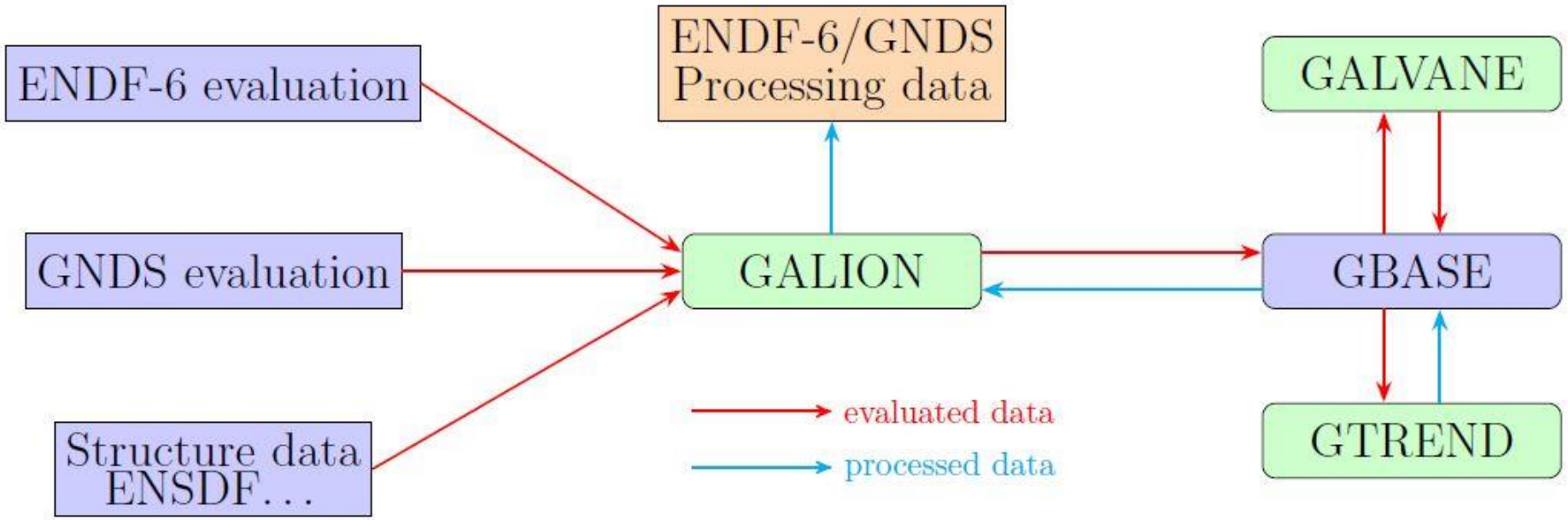
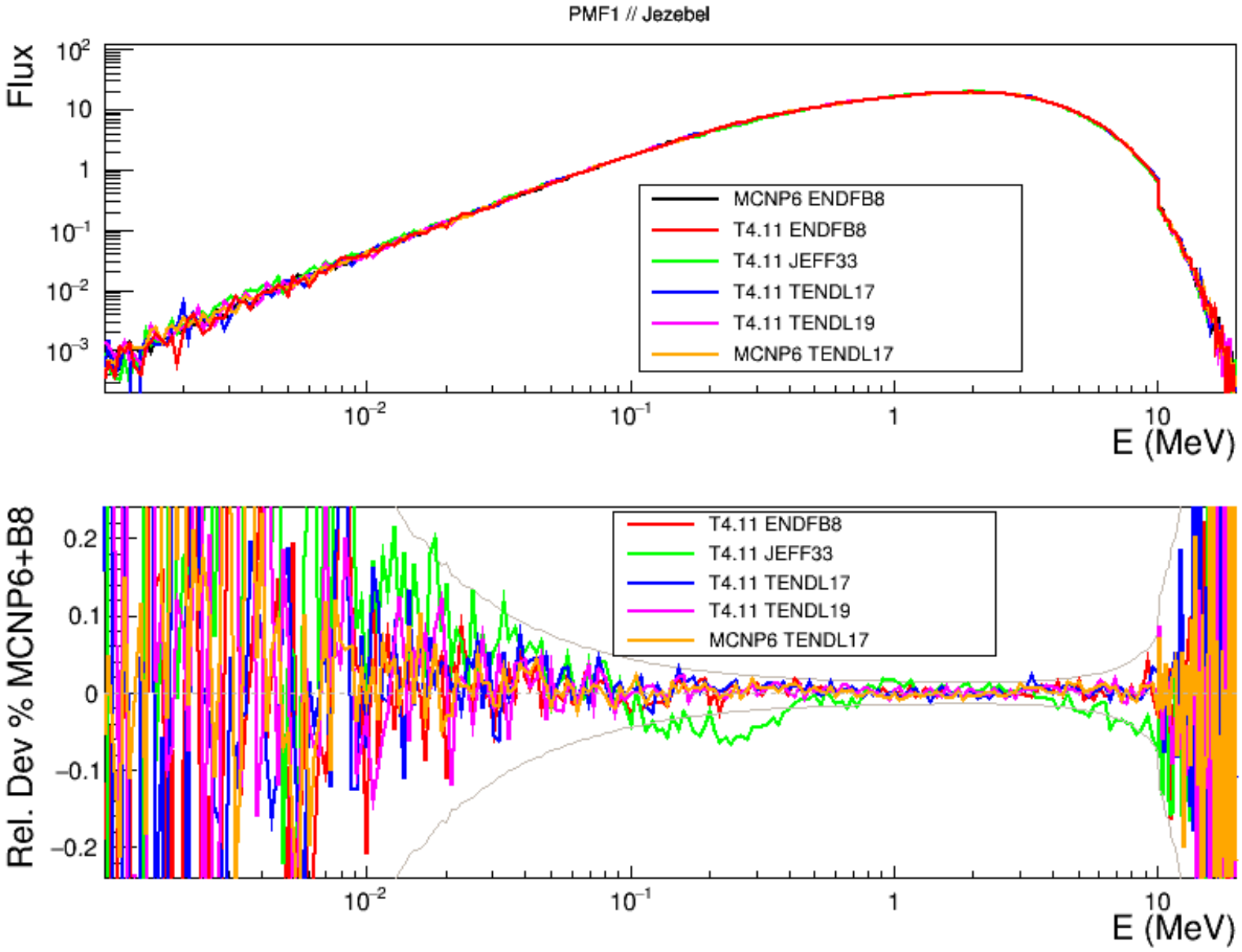
OUTLINES

1. Probability tables in URR
2. TSL reconstruction
3. Scattering angular distributions
4. Photonuclear reactions

GALILÉE-1 PROCESSING MODULES



PMF1 (Jezebel) : neutron flux in an inner sphere



PROBABILITY TABLES

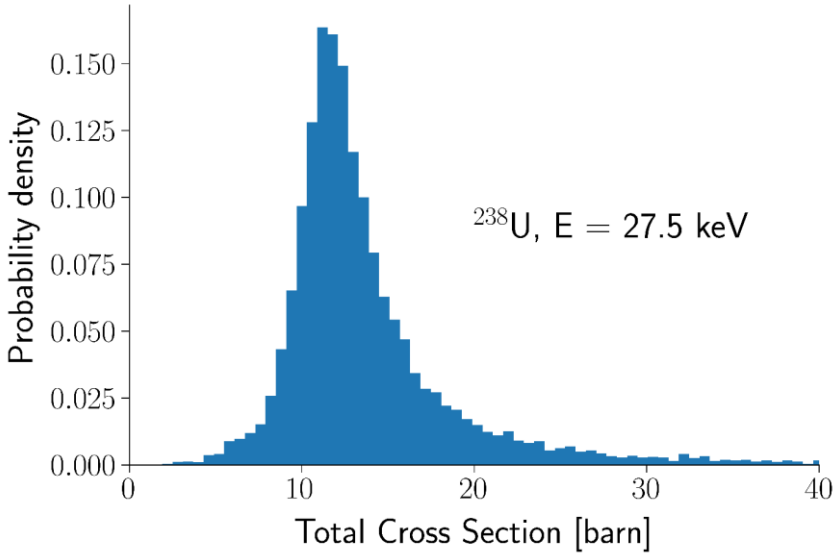
Monte-Carlo and deterministic codes developed at CEA have been using multi-group probability tables (PT) produced by CALENDF for many years :

- APOLLO2, APOLLO3® … : PT over the whole energy range
- TRIPOLI-4® : PT in URR

GTREND's specificities :

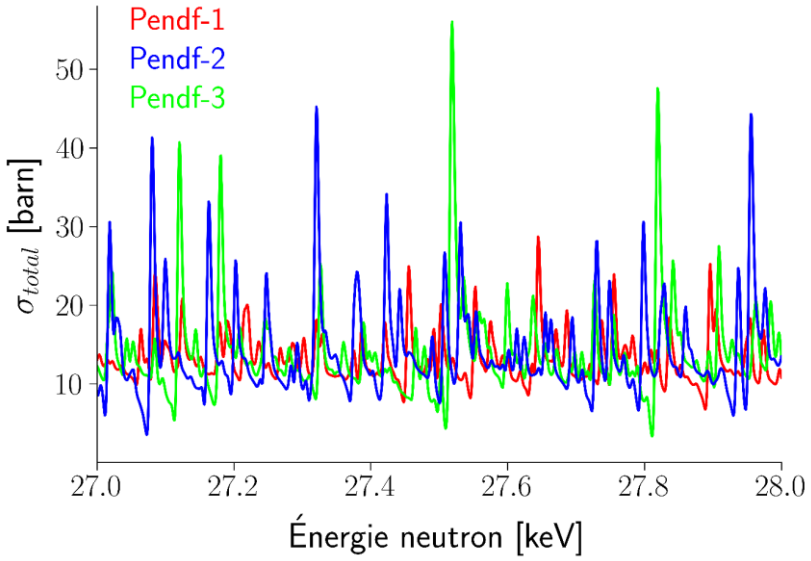
- PTs are multi-group on the energy mesh defined by the user
- Positive and negative moments of the cross sections are preserved (Gauss quadrature)
- The numbers of steps are not constant for all groups
- All cross sections can be calculated
- Competitive reactions can be calculated using resonance parameters
- SLBW and MLBW can be used in URR

Two methods to calculate GTREND multi-group PT



Discrete integration
→ Monte Carlo PT

Sampling
N resonances

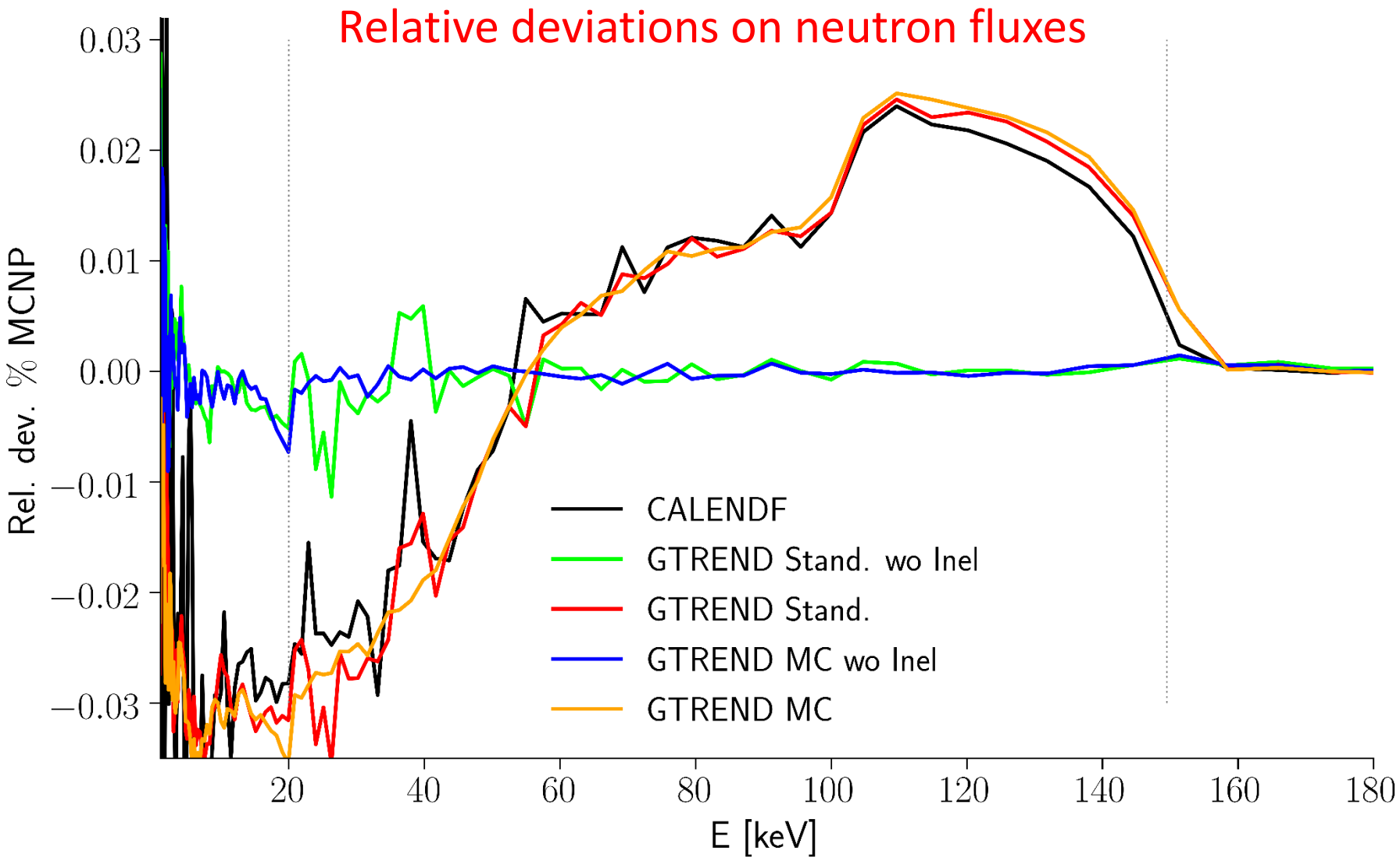


Continuous integration
→ Standard PT

IMF-007-TZH : Two homogenized nested cylinders
Nuclei : U234, U235, U236 and U238
Library : ENDF/B-VIII

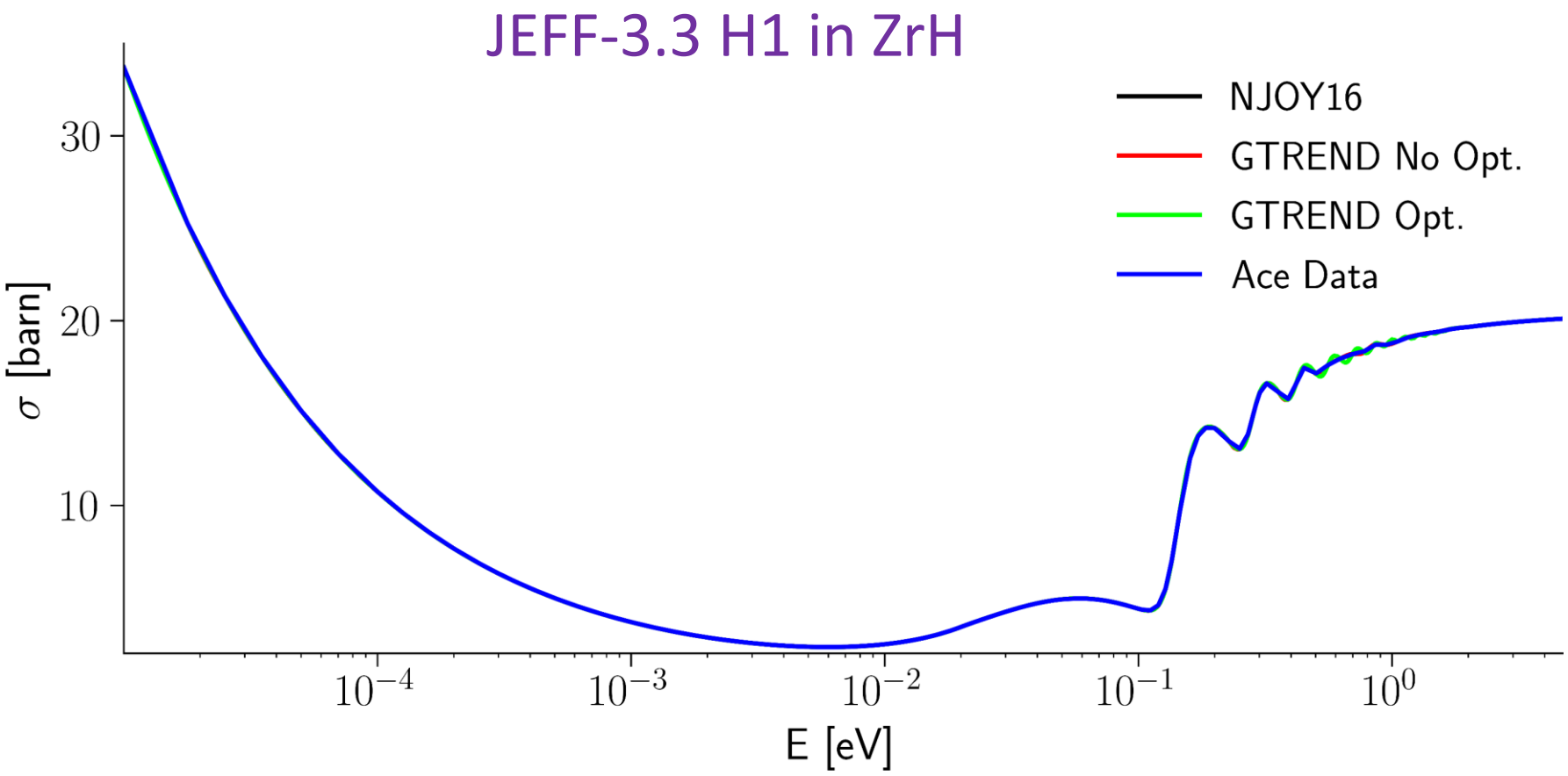
TRIPOLI-4® without Probability Tables (PT) :	0.99150 (3 pcm)
TRIPOLI-4® + CALENDF PT :	0.99524 (3 pcm)
TRIPOLI-4® + GTREND Standard PT :	0.99508 (3 pcm)
TRIPOLI-4® + GTREND Monte Carlo PT :	0.99509 (3 pcm)
MCNP-6 (PT calculation) :	0.99455 (3 pcm)
TRIPOLI-4® + GTREND Standard PT wo Inelastic :	0.99450 (3 pcm)
TRIPOLI-4® + GTREND Monte Carlo PT wo Inelastic :	0.99455 (3 pcm)

BigTen 2 Zones homogenized using ENDF-B/VIII library

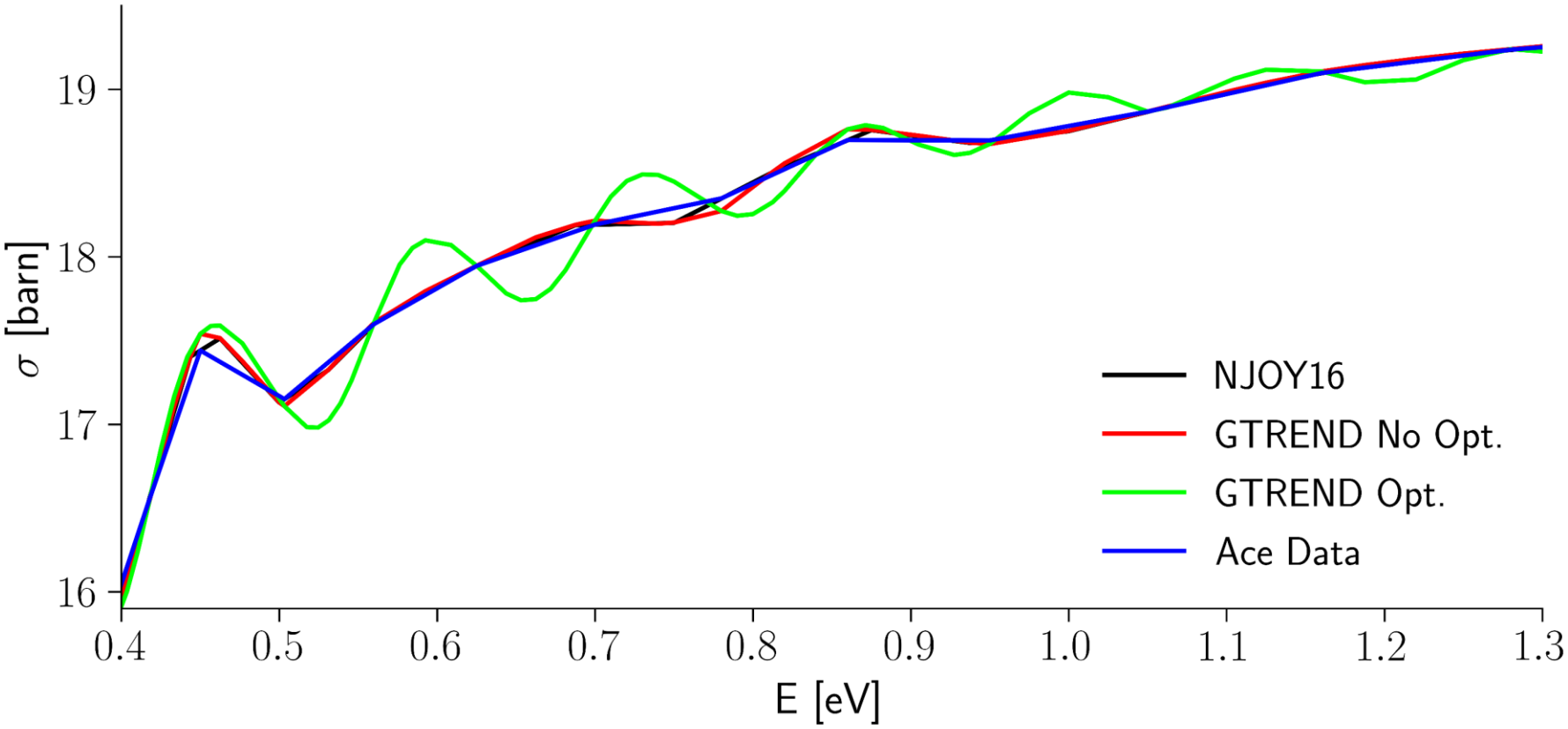


TSL Data : Incoherent inelastic cross section H1 in ZrH

GTREND is used to calculate TSL data : Cross section, energy and angular distribution
New Format (coherent and incoherent elastic) will be available soon
Optimized energy grid could be used in order to improve inelastic cross section



TSL Data : Incoherent inelastic cross section H1 in ZrH



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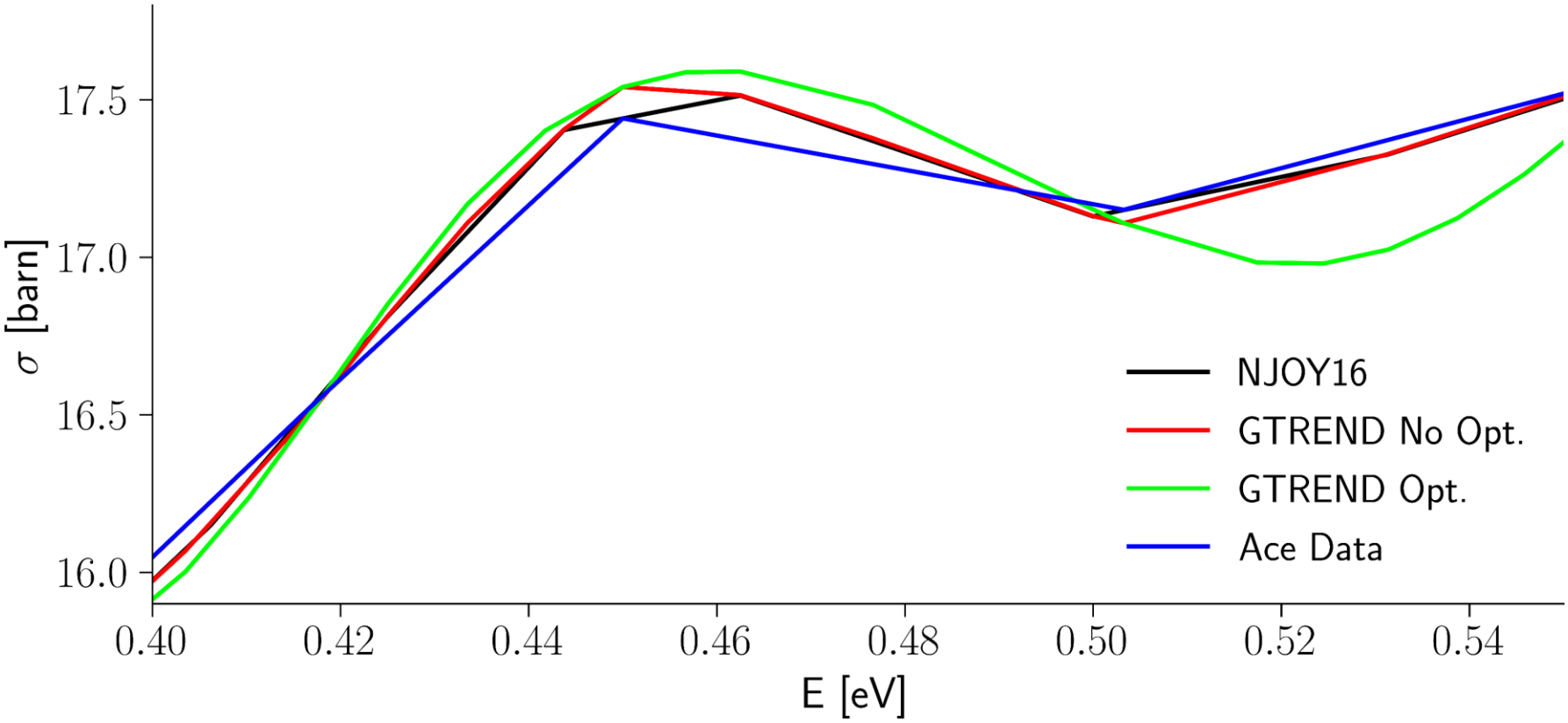
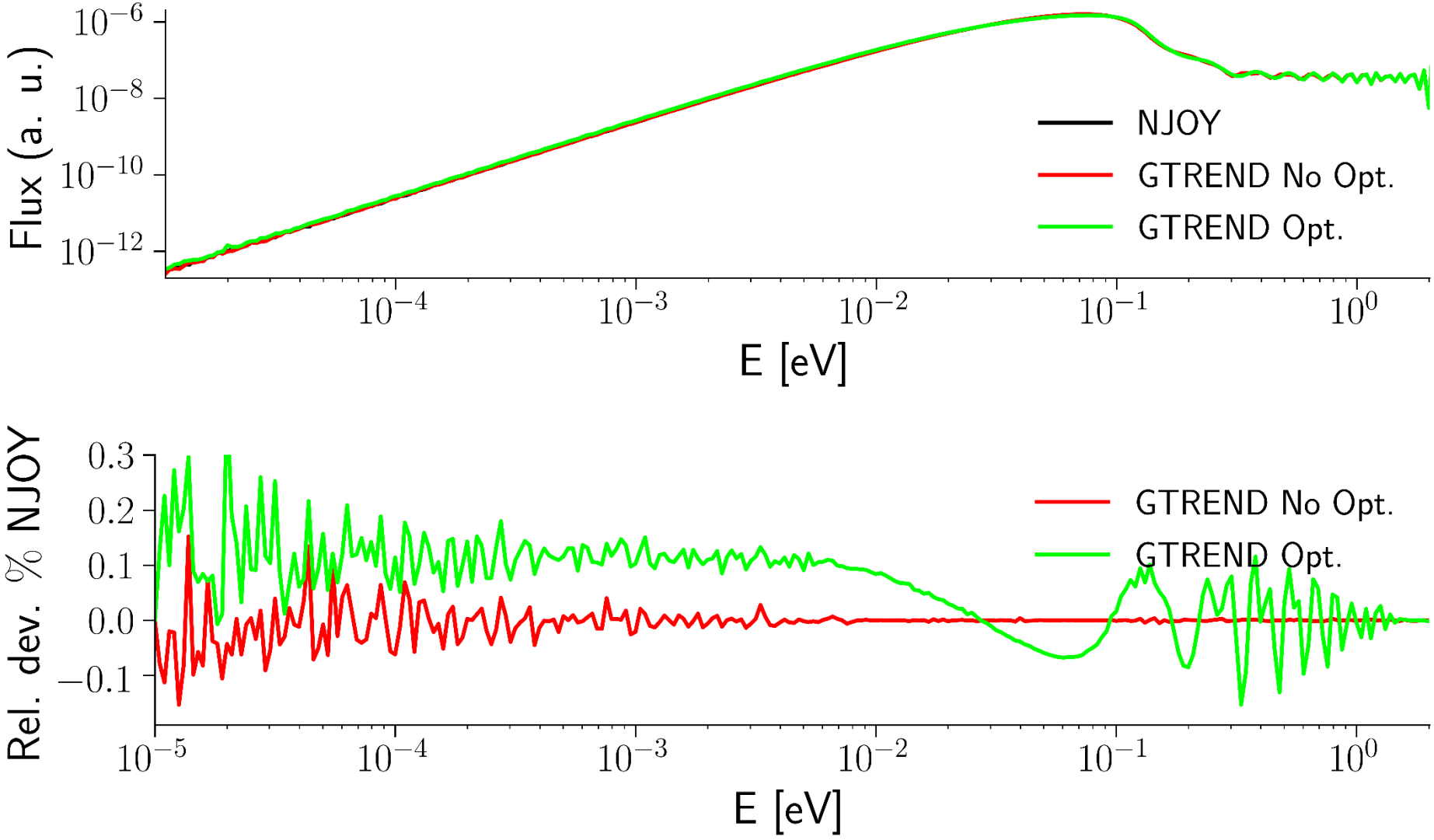


2 eV Neutron Source in ZrH sphere. TRIPOLI-4® calculations using various TSL data

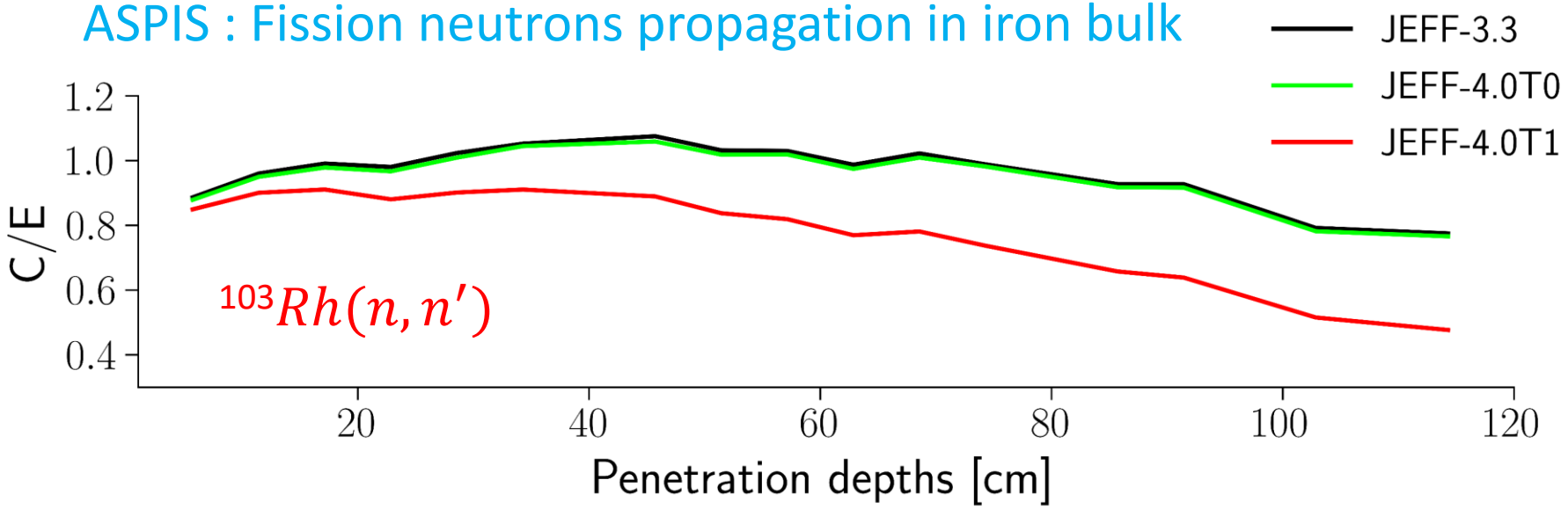


Criticality benchmarks

Bench	CEAV7.1	CEAV7.1 +TSL Gtrend No Opt	CEAV7.1 +TSL Gtrend Opt
LCT-006-1 (H2O)	1.00145 (6)	1.00138 (8)	1.00149 (8)
LCT-007-1 (H2O)	0.99919 (6)	0.99916 (9)	0.99899 (9)
ICT-003-1 (H2O+ZrH)	1.00740 (4)	1.00751 (6)	1.00783 (6)
ICT-003-2 (H2O+ZrH)	1.01162 (4)	1.01162 (6)	1.01210 (6)

Large discrepancies in shielding benchmarks and for many criticality benchmarks

ASPIS : Fission neutrons propagation in iron bulk



TRIPOLI-4® Results	HMF-014	PMF-028
JEFF-3.3	0.99670 (9)	0.99914 (20)
JEFF-4.0-T0	0.99747 (10)	0.99973 (17)
JEFF-4.0-T1	1.00048 (10)	1.00569 (17)

Angular distribution from resonance parameters

Blatt and Biedenharn formalism → Angular distributions reconstruction

- LRF=3 : Reich-Moore : Only elastic scattering
- LRF=7 : R-Matrix-Limited : All reactions (elastic and inelastic scattering)

NJOY2016 : Angular distributions reconstruction for LRF=7

GALILÉE-1 : Angular distributions reconstruction for LRF=3 and LRF=7

Analyzed cases :

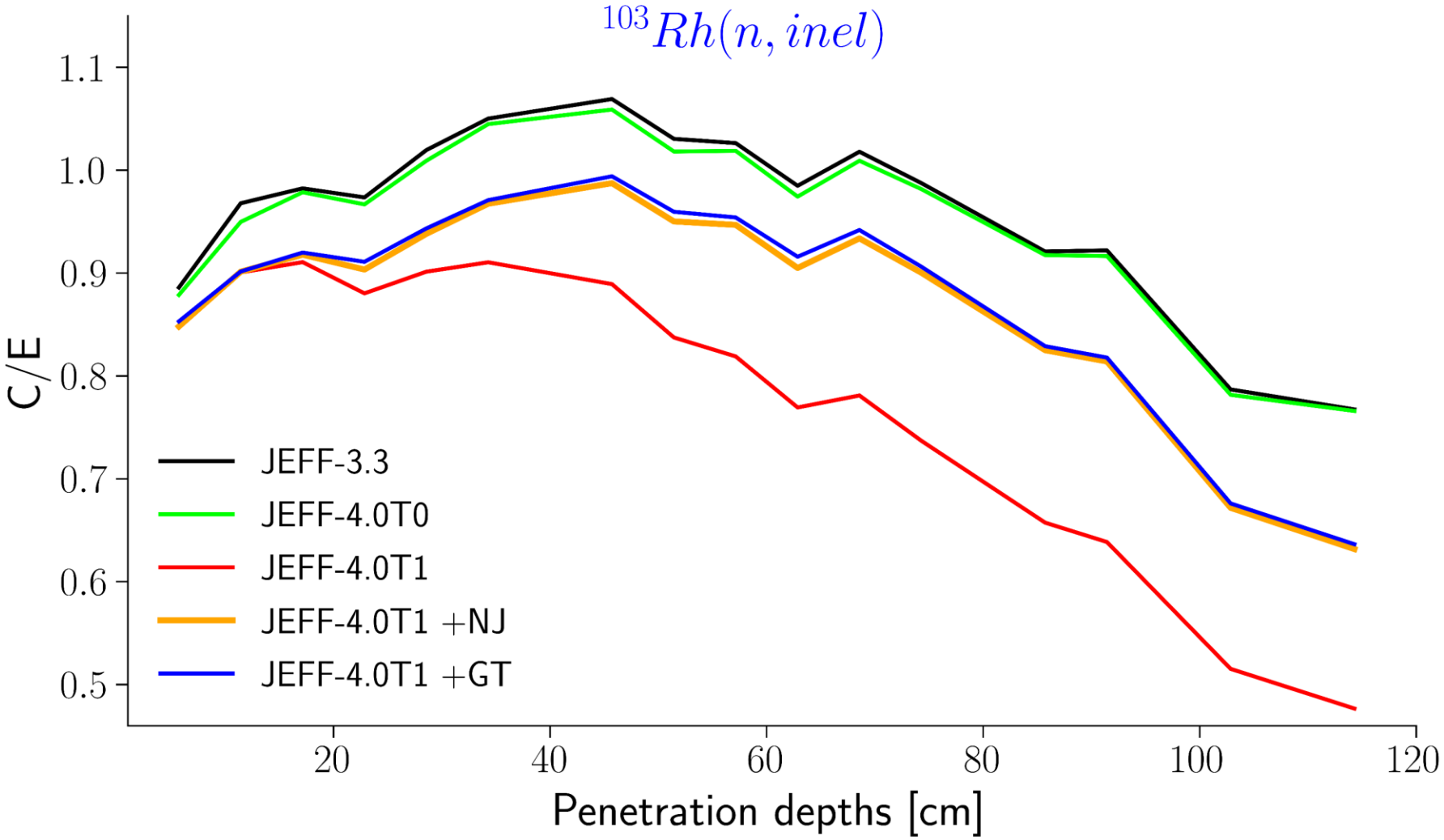
1/ Fe56/JEFF40T1 (LRF=7) and Fe56/JEFF-3.3 (LRF=3) :

Criticality,

shielding

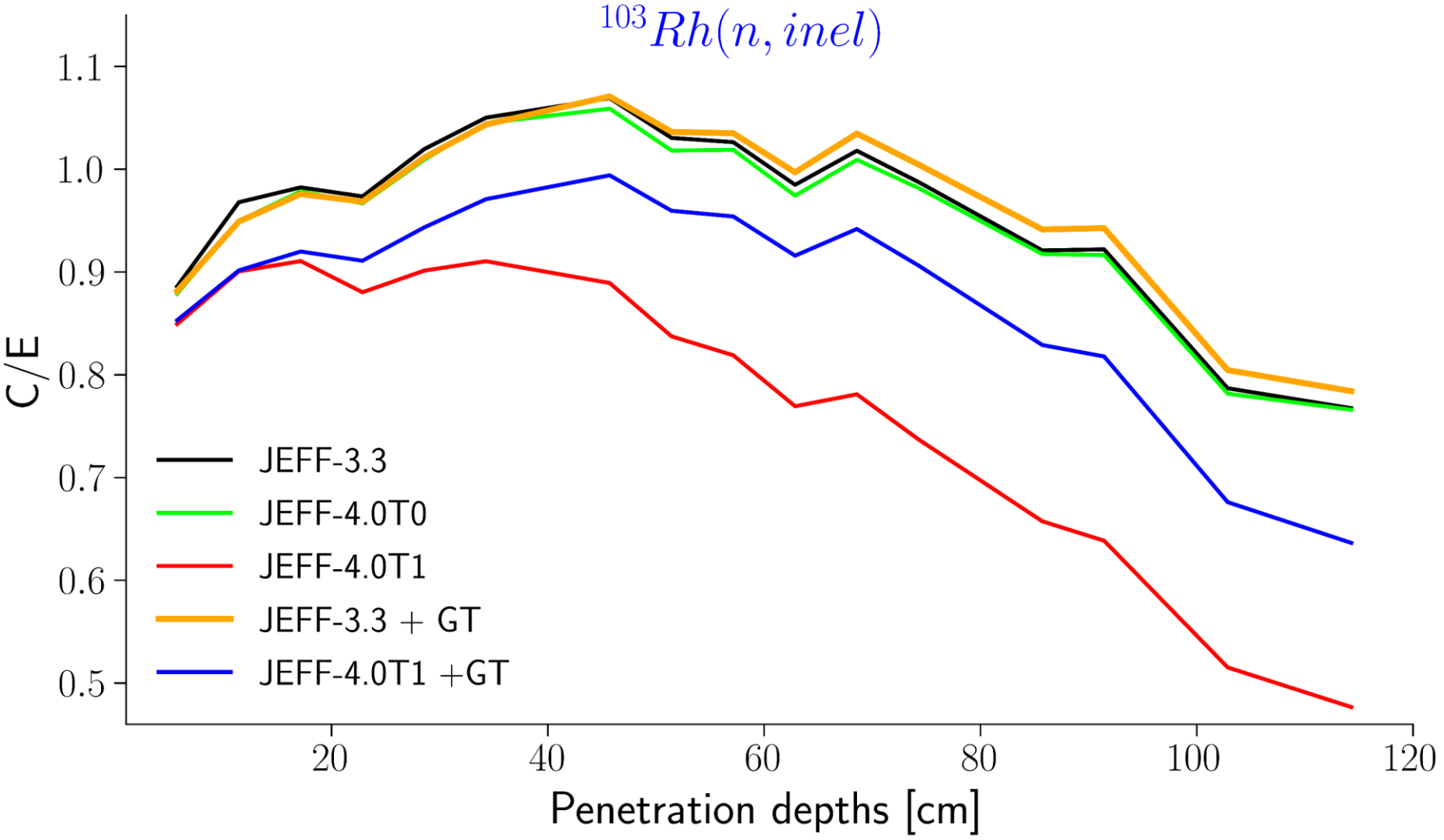
ASPIS Benchmark : Sensitivity to Fe56 angular distributions

^{56}Fe JEFF40T1 : LRF=7 R-Matrix Limited



ASPIS Benchmark : Sensitivity to Fe56 angular distributions

^{56}Fe JEFF-3.3 : LRF=3 Reich-Moore



Fe56 / Criticality benchmarks. Impact of anisotropy from resonance parameters

	HMF-014	PMF-028
JEFF-3.3	0.99670 (9)	0.99914 (20)
JEFF-4.0-T0	0.99747 (10)	0.99973 (17)
JEFF-4.0-T1	1.00048 (10)	1.00569 (17)
JEFF-40-T1 / Fe56 Aniso (NJOY)	0.99453 (10)	0.99893 (10)
JEFF-40-T1 / Fe56 Aniso (GTREND)	0.99450 (10)	0.99875 (10)

TRIPOLI-4 uses photonuclear evaluation file without any processing.

Issues in evaluation files :

- Non physical thresholds in laboratory frame

  → GALILÉE-1/TRIPOLI-4

- Total cross section is not equal to sum of partials

  → NJOY (RECONR)

- Reaction with threshold and non-zero cross section at threshold

  → NJOY (RECONR)

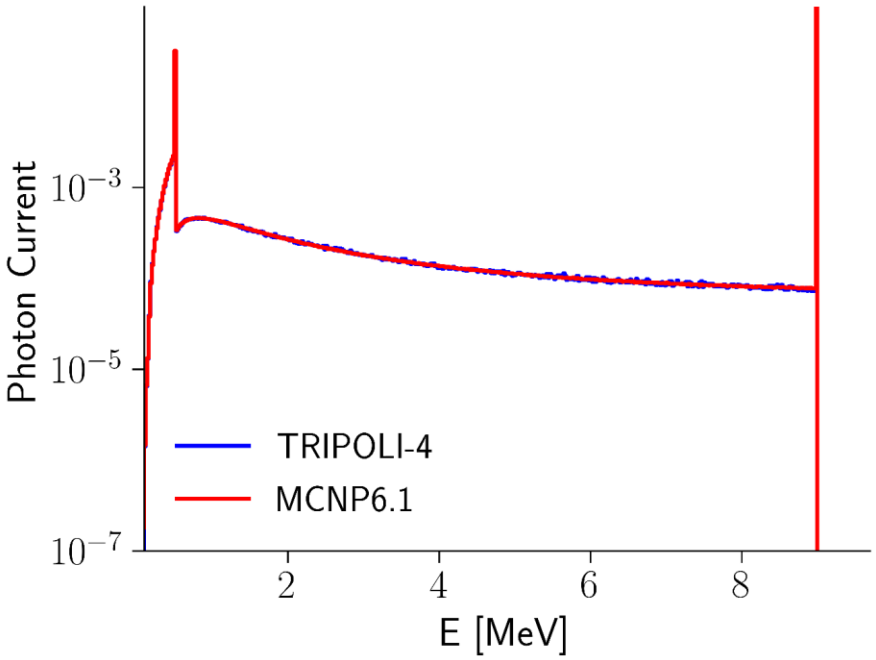
Tran Kim Tuyet & al. : Preliminary comparison of the TRIPOLI-4® and DIANE Monte Carlo codes on the Barber & George photonuclear benchmark (RPSD Conference)

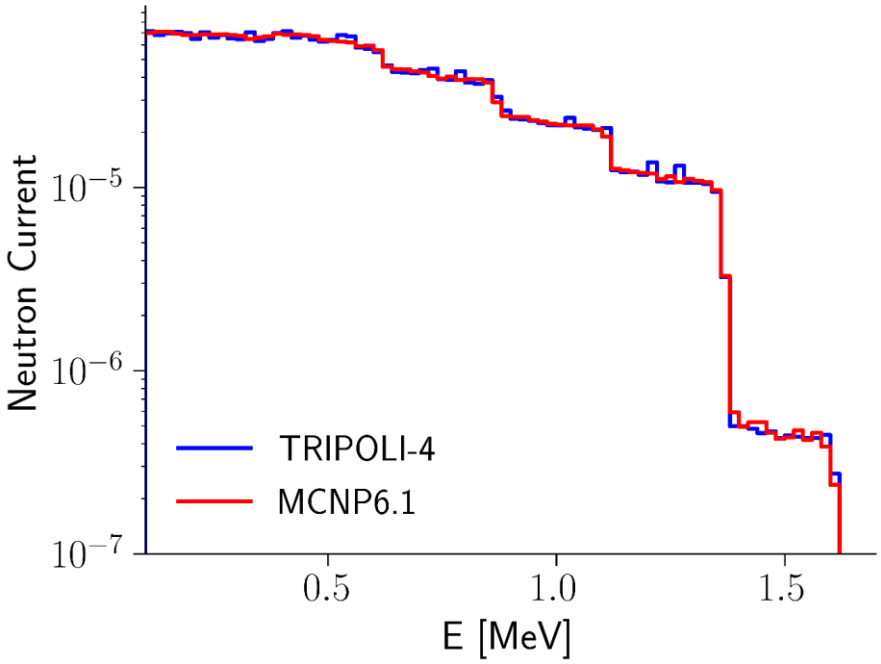
Neutron and Photon currents in a Ta181 Sphere (ϕ = 30cm ; ρ =16.6g/cm^3)

Photon source E= 9 MeV (Center of sphere)

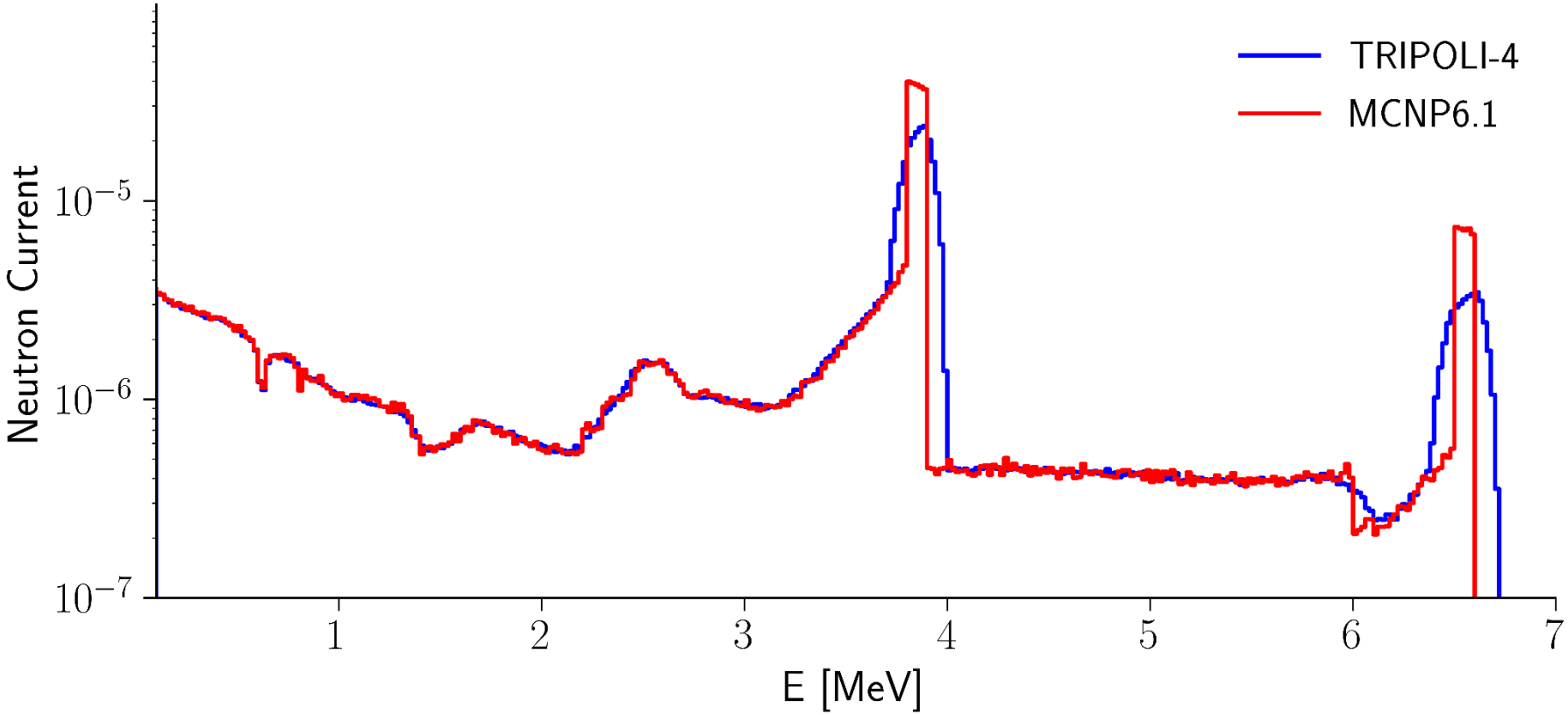
Neutron, Photonuclear : ENDF/B-VII.1

Photo-Atomic : EPDL97





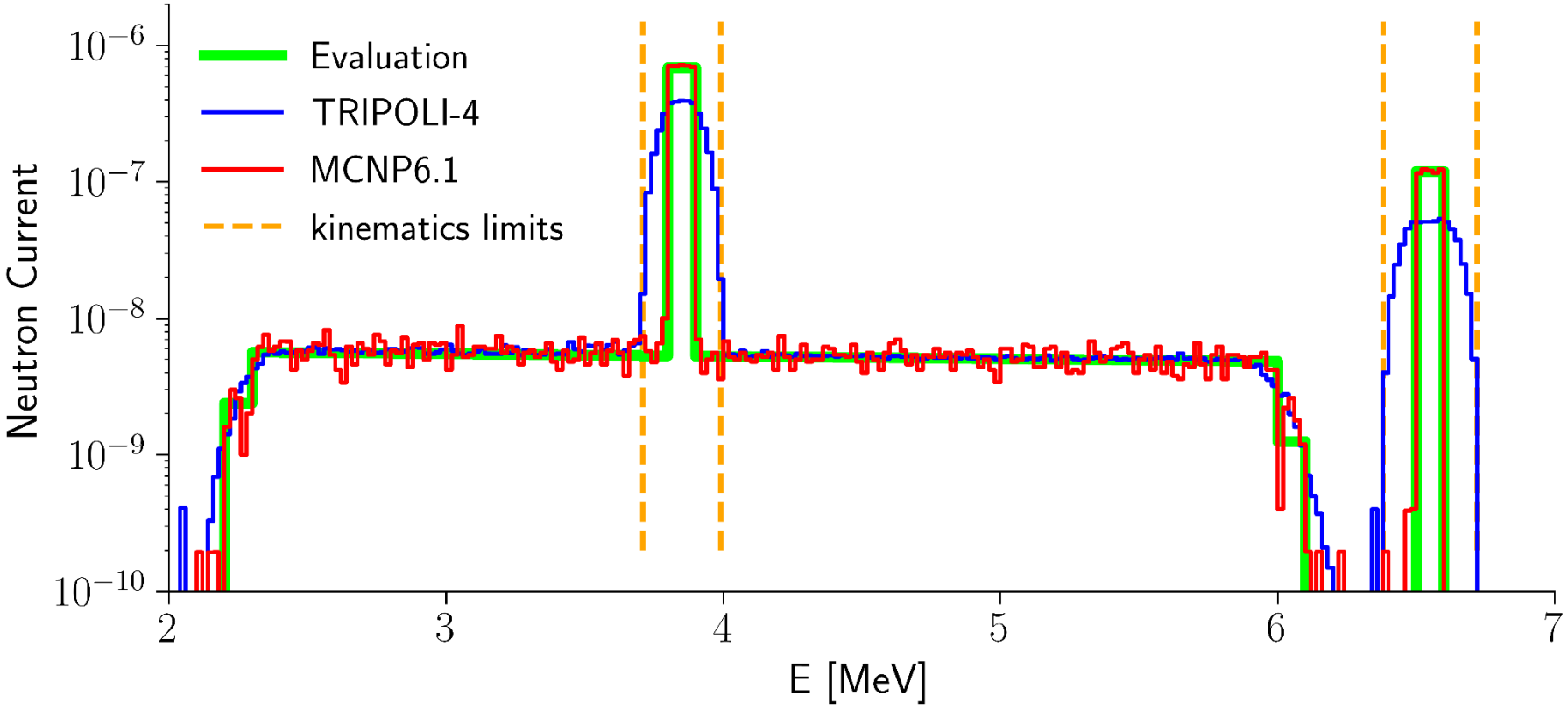
Neutron and Photon currents in a Be9 Sphere
(ϕ = 30cm ; ρ =1.85 g/cm^3)
Photon source E= 9 MeV (Center of sphere)



MF6 MT29 (γ,n2α) : Center of Mass distributions

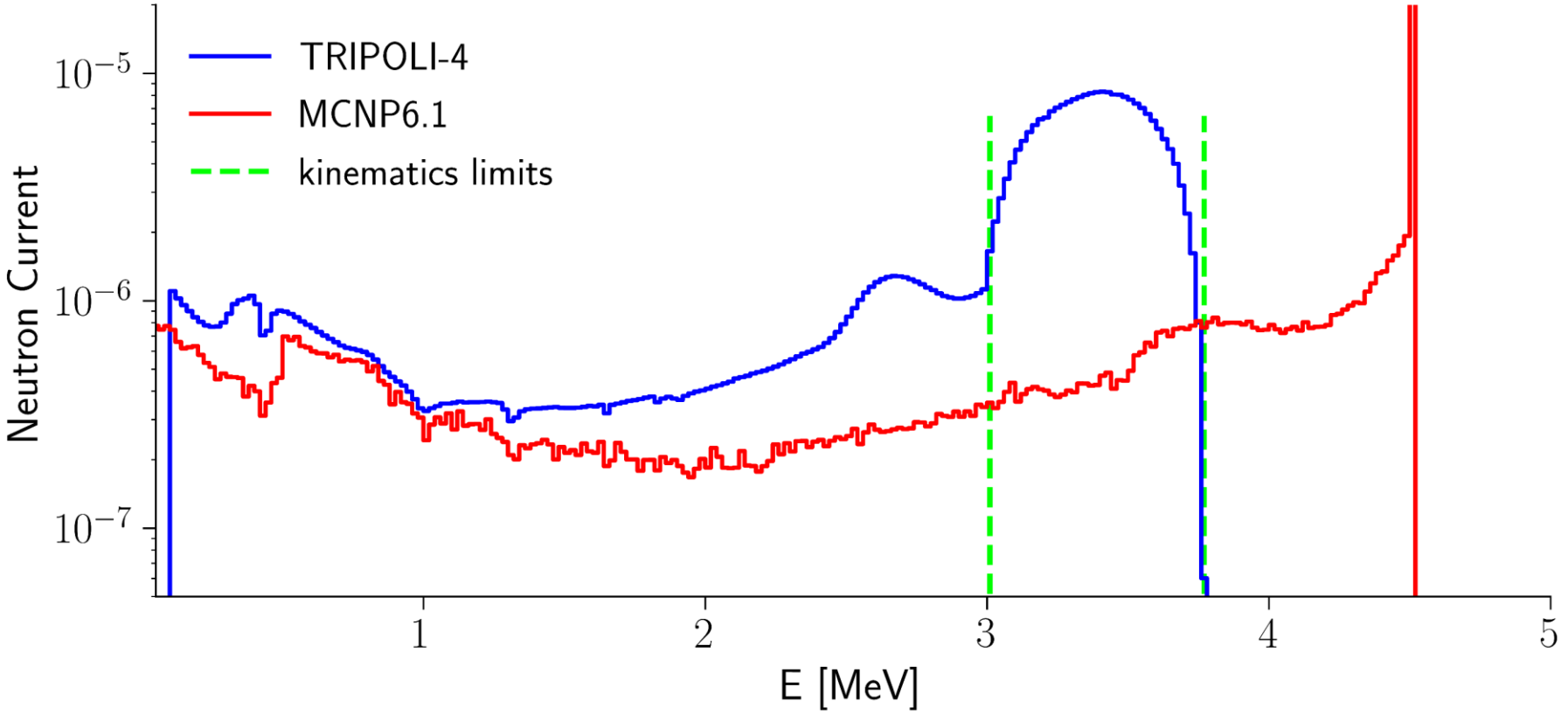
→ Transformation in laboratory frame

TRIPOLI-4 : Semi-classical transformation

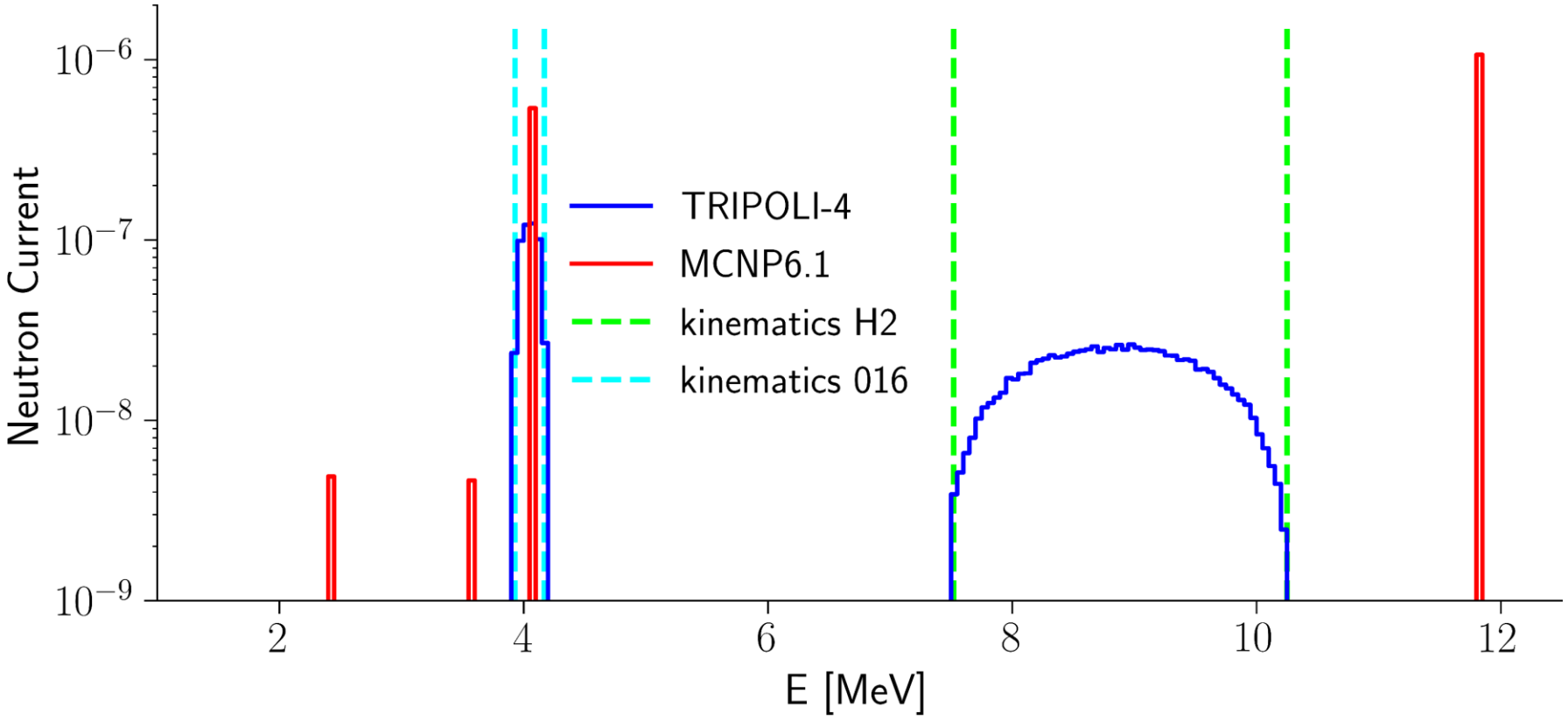


(γ,n) reaction : Two-body reaction

D2O : 1.1 g/cm^3. Source : 9 MeV. Threshold reaction O16 : 12.5 MeV



D2O target : ρ=0.01g/cm^3 ; ENDF/B-VII.1 neutron/photonuclear data
Gamma Source = 20 MeV
Kinematics limits : Semi-Classical calculation



GALILÉE-1 Processing Code :

Developments already completed :

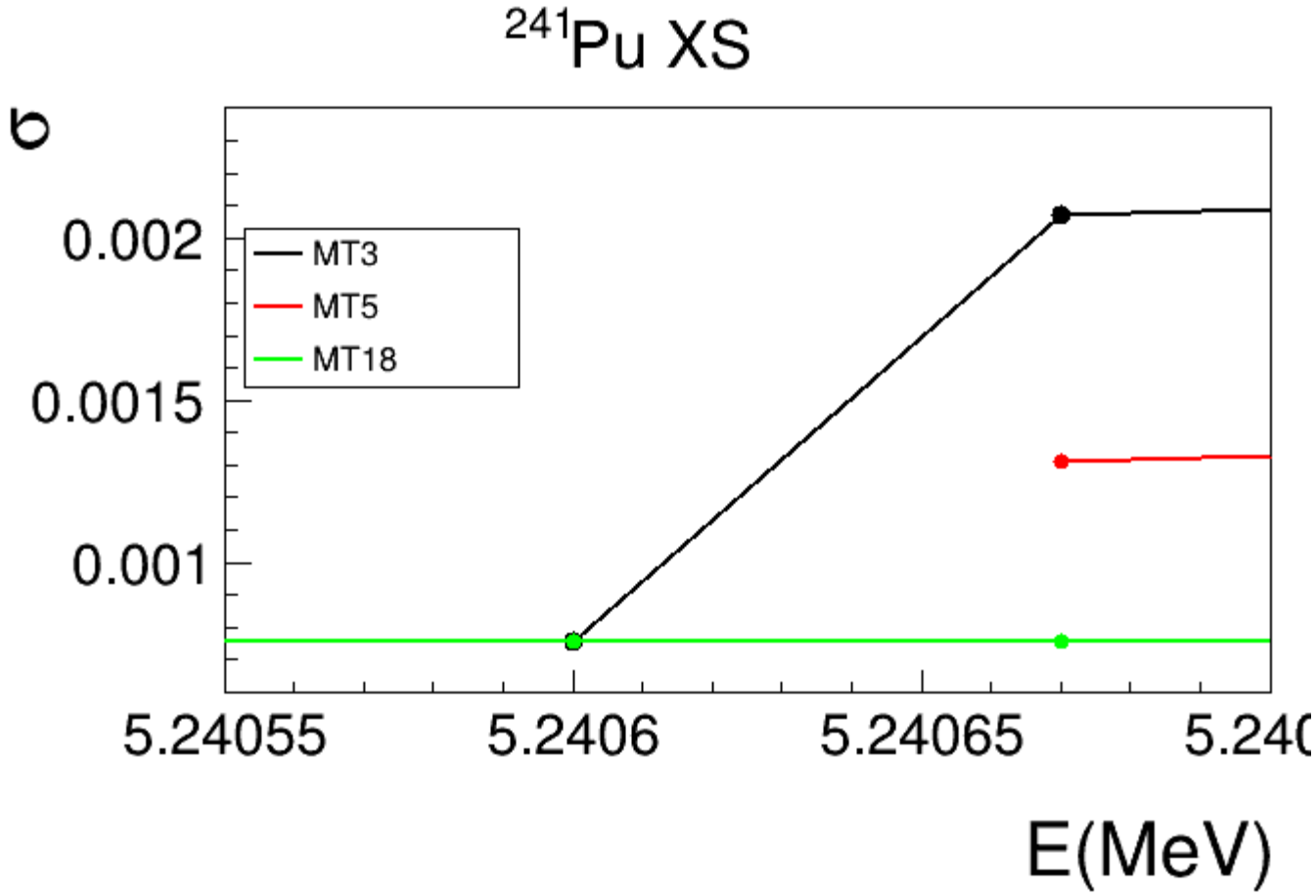
Cross section reconstruction, linearization and Doppler broadening
URR multi-group Probability Tables
TSL processing
Angular distribution from resonance parameters
TRIPOLI-4® Monte-Carlo neutron library

Future developments :

TSL : new representation (coherent and incoherent elastic)
Read/store RRR and URR parameters from GNDS Files
Kinematics of outgoing particles
Multi-group Cross sections and transfer matrices

Thank you for your attention

C. Jouanne


^{241}Pu XS
b
0.002
0.0015
0.001
MT3
MT5
MT18
5.24055
5.2406
5.24065
5.240
E(MeV)