

Wonder-2023

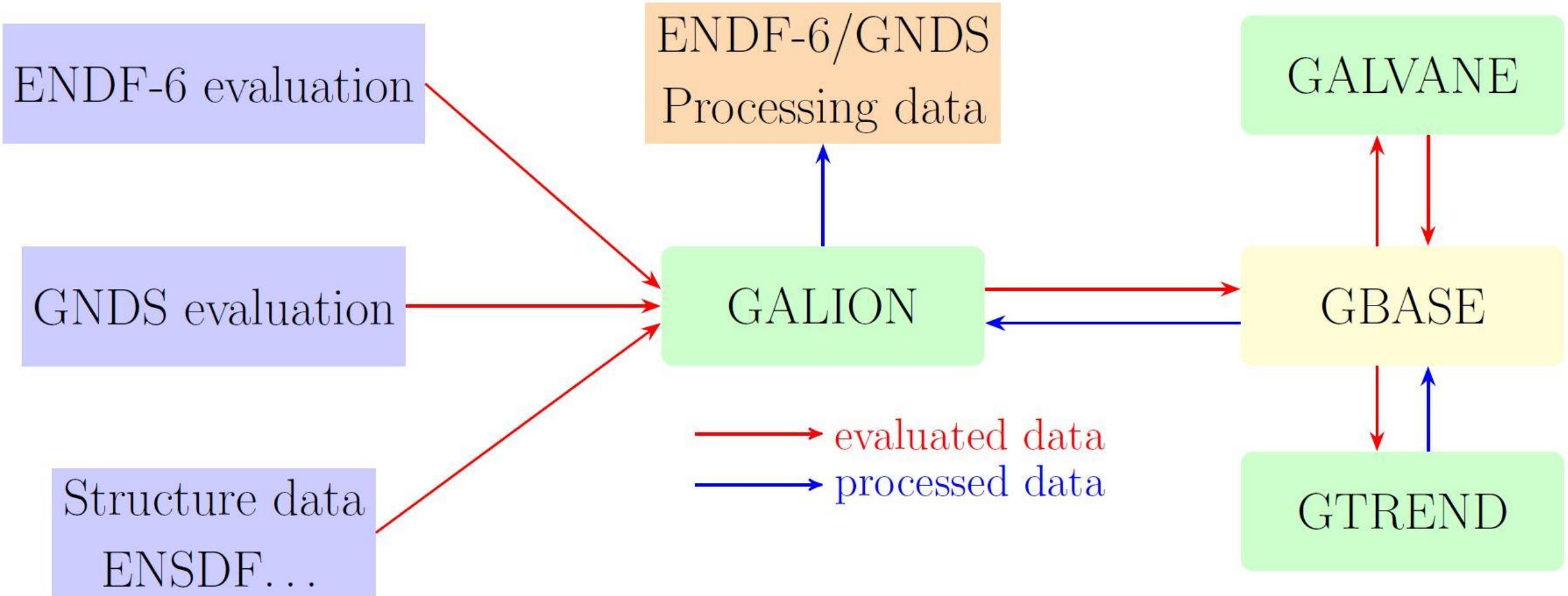
C. Jouanne, M. Coste-Delclaux (CEA/Saclay)

Wonder-2023, Aix en Provence, June 5-9, 2023

Outline

- Description of the GALILÉE-1 Code
- URR / Probability Tables
- Scattering angular distributions
- Conclusions and Perspectives

GALILÉE-1 system



GTREND Probability Tables (PT)



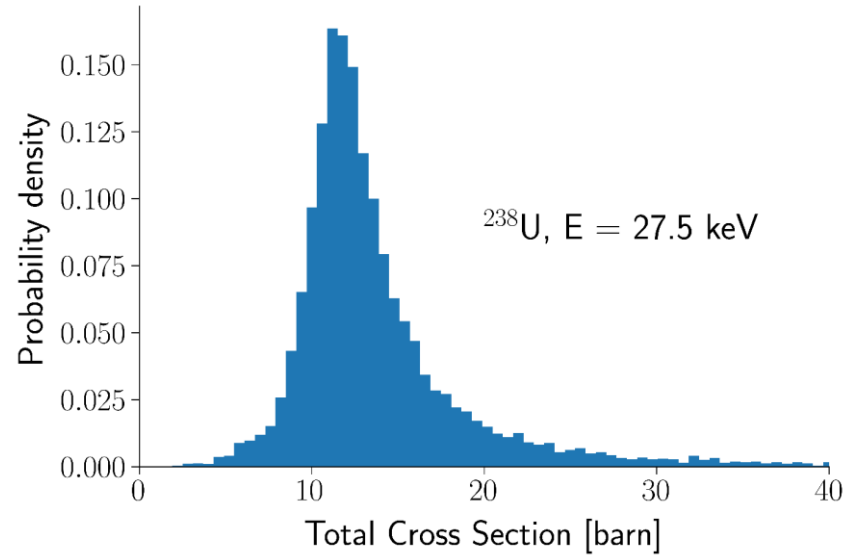
Monte-Carlo and deterministic codes developed at CEA have been using **multi-group** probability tables (PT) produced by CALENDF for many years :

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

GTREND PT specificities :

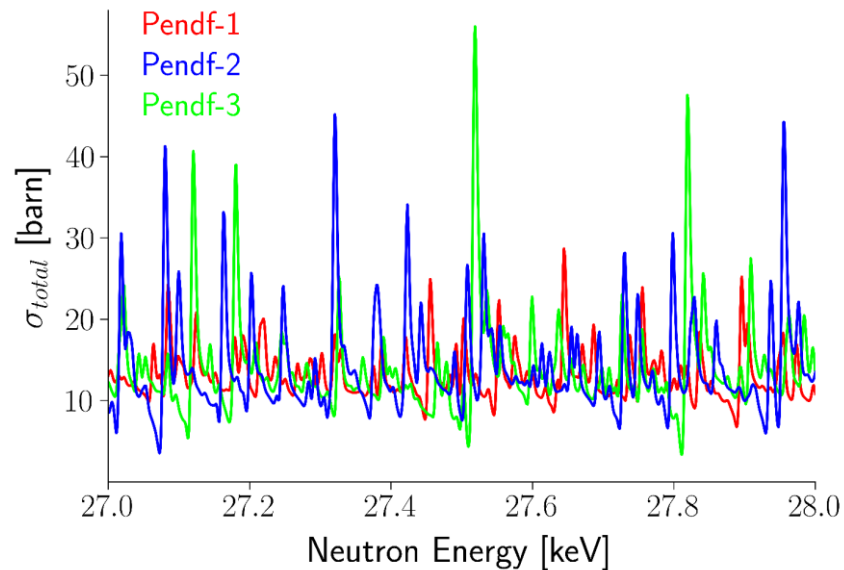
- All partial cross sections can be calculated
- Competitive reactions can be calculated using resonance parameters
- Two methods :
 - ✓ Moment-based PTs preserving positive and negative moments of the cross sections (Gauss quadrature)
 - Multigroup PTs calculated on a continuous or a discrete energy distribution
 - Pointwise PTs calculated on a discrete distribution
 - Number of steps not constant according to the group or the energy
 - ✓ ACE-like PTs
 - Pointwise Pts calculated on a discrete energy distribution
 - Constant number of steps for each energy

GTREND PT Calculation



Discrete integration
→ Monte Carlo PT
→ Pointwise or Multigroup

Sampling
N resonances



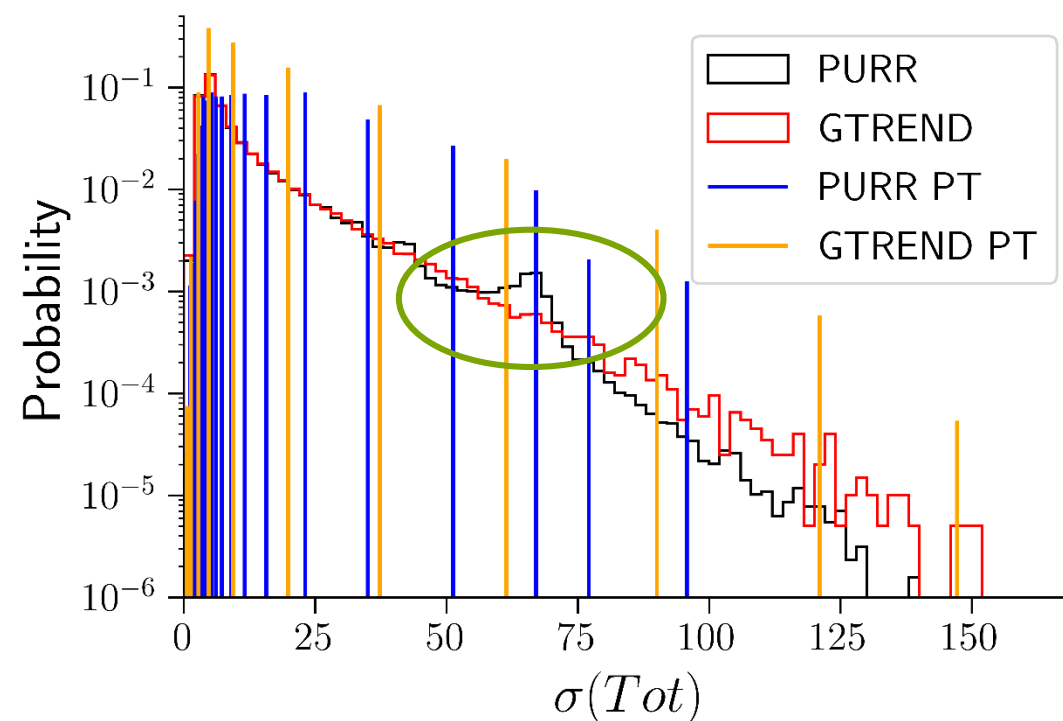
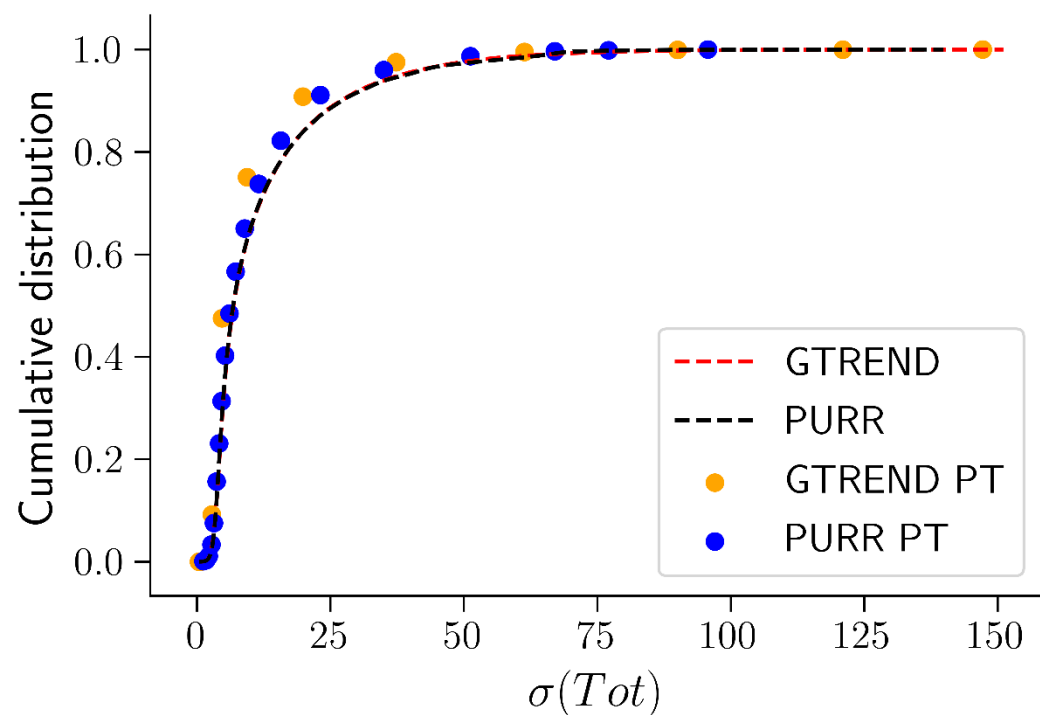
Continuous integration
→ Standard PT
→ Multigroup

PURR and GTREND Pointwise Monte-Carlo PTs

Candidate : Cs134 ENDF/B-VIII : LSSF=0 Elastic and Capture reactions in URR
PTs at 5keV (294 K)

GTREND : 14 Steps (Moments calculation) 100 000 randoms calculations

PURR : 20 Steps. 640 000 randoms calculations

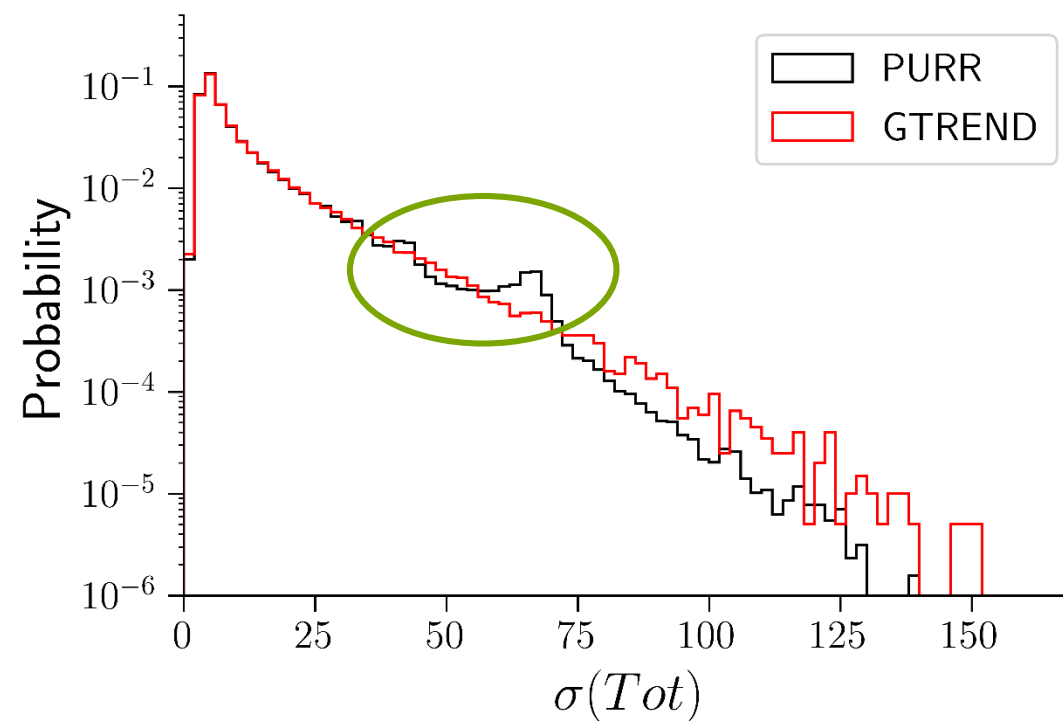
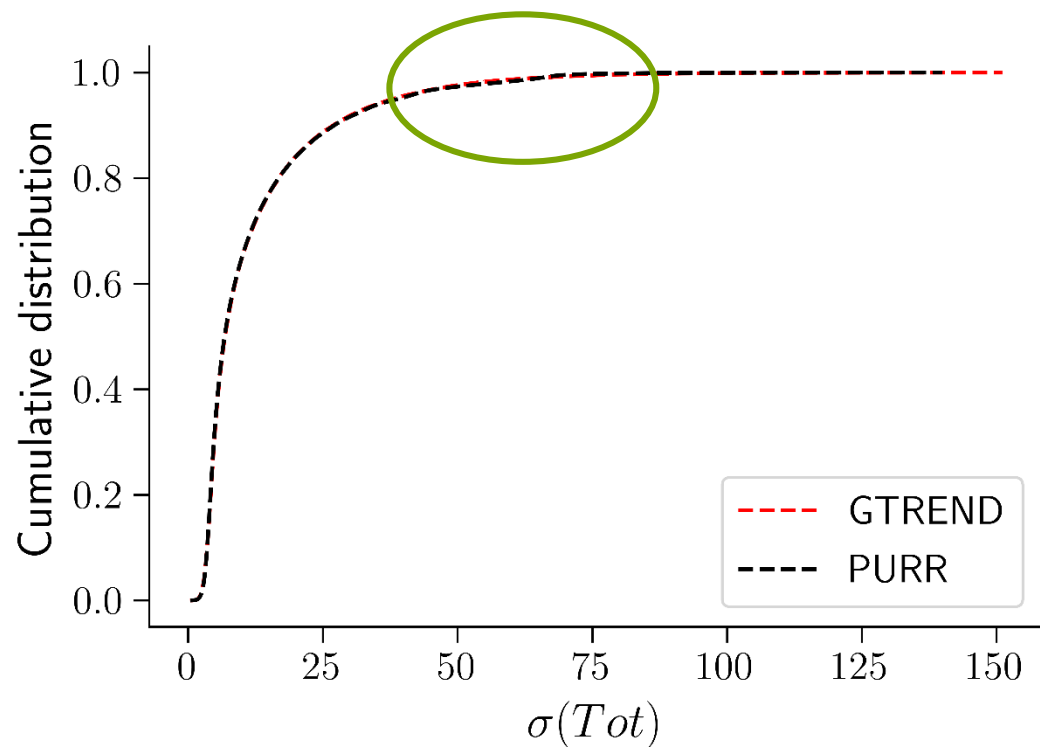


PURR and GTREND Pointwise Monte-Carlo PTs

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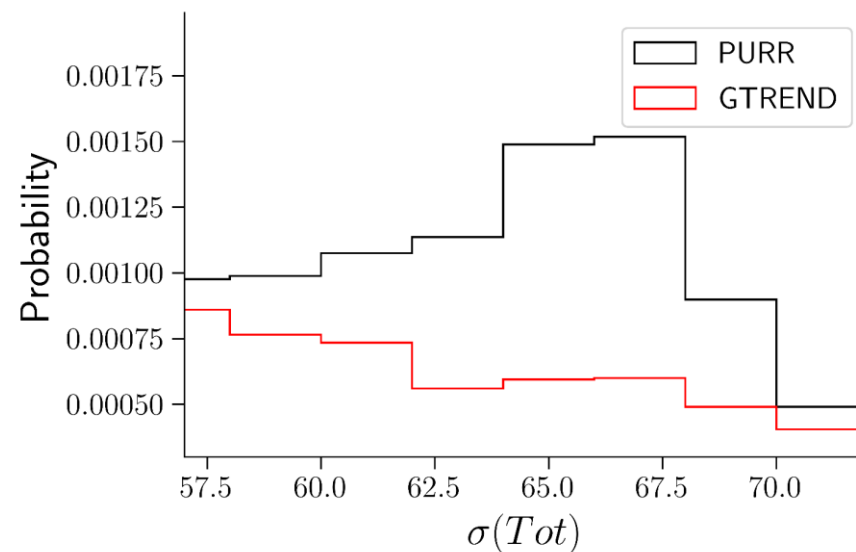
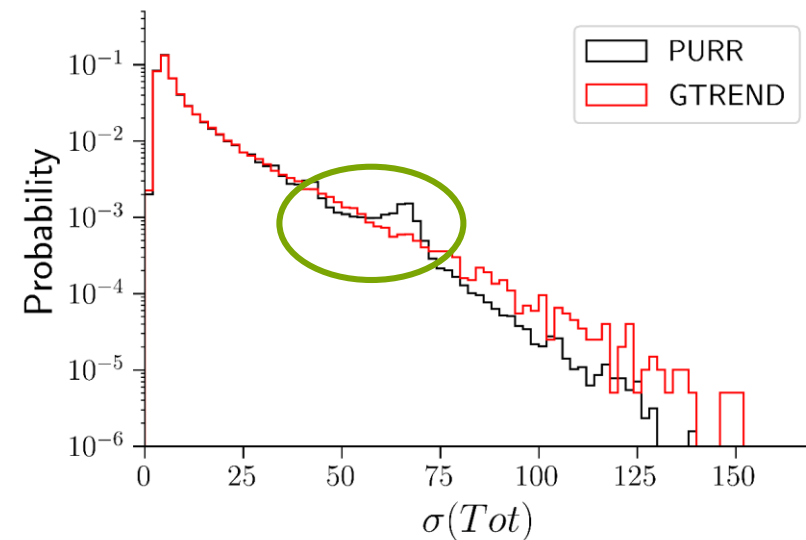
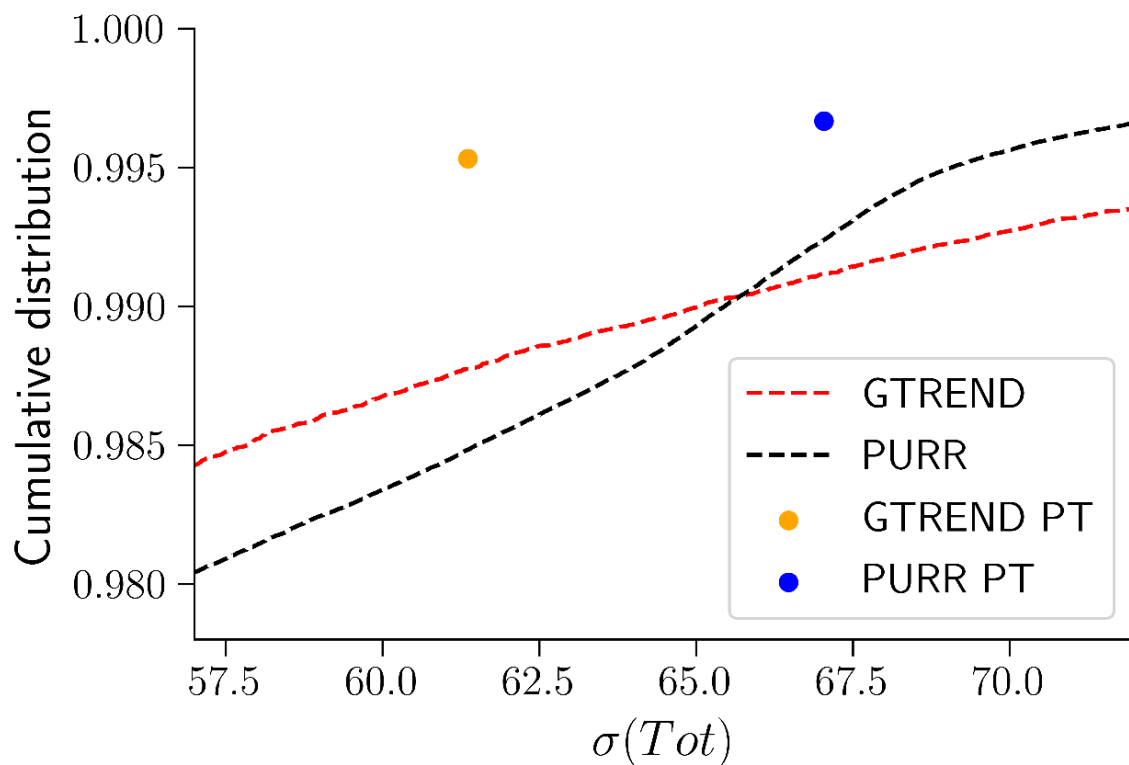


PURR and GTREND Pointwise Monte-Carlo PTs

Candidate : Cs134 : LSSF=0 Elastic and Capture reactions in URR
PTs at 5 keV (294 K)

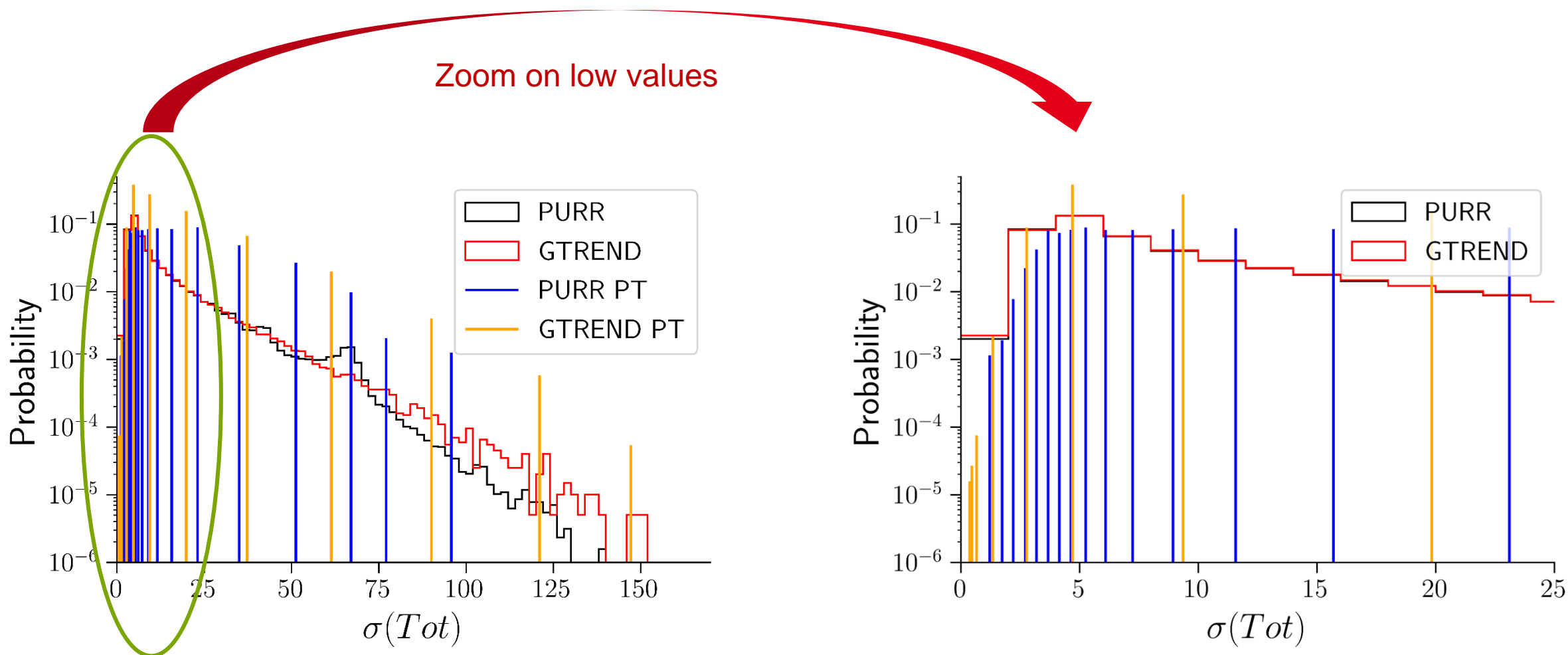
GTREND : 14 Steps (Moments calculation) 100 000 randoms calculations
28 Moments are preserved (From -13 to 14)

PURR : 20 Steps. 640 000 randoms calculations



PURR and GTREND Pointwise Monte-Carlo PTs

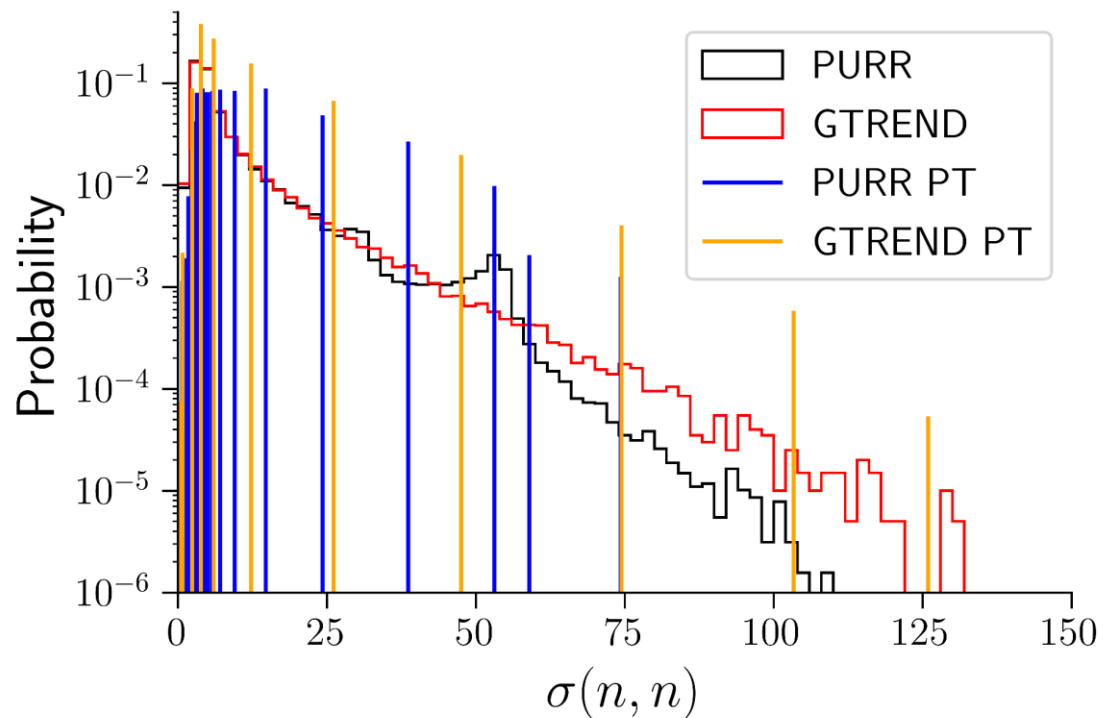
Candidate : Cs134 ENDF/B-VIII : LSSF=0 Elastic and Capture reactions in URR
PTs at 5 keV (294 K)



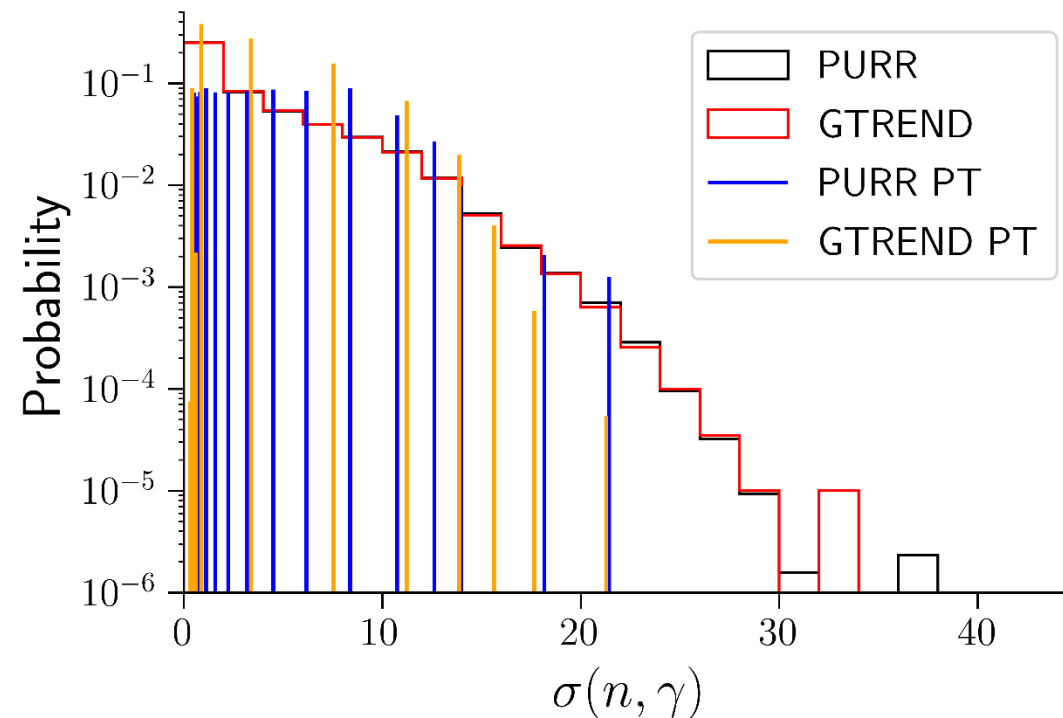
PURR and GTREND Pointwise Monte-Carlo PTs

Candidate : Cs134 ENDF/B-VIII : LSSF=0 Elastic and Capture reactions in URR
PTs at 5 keV (294 K)

Elastic scattering

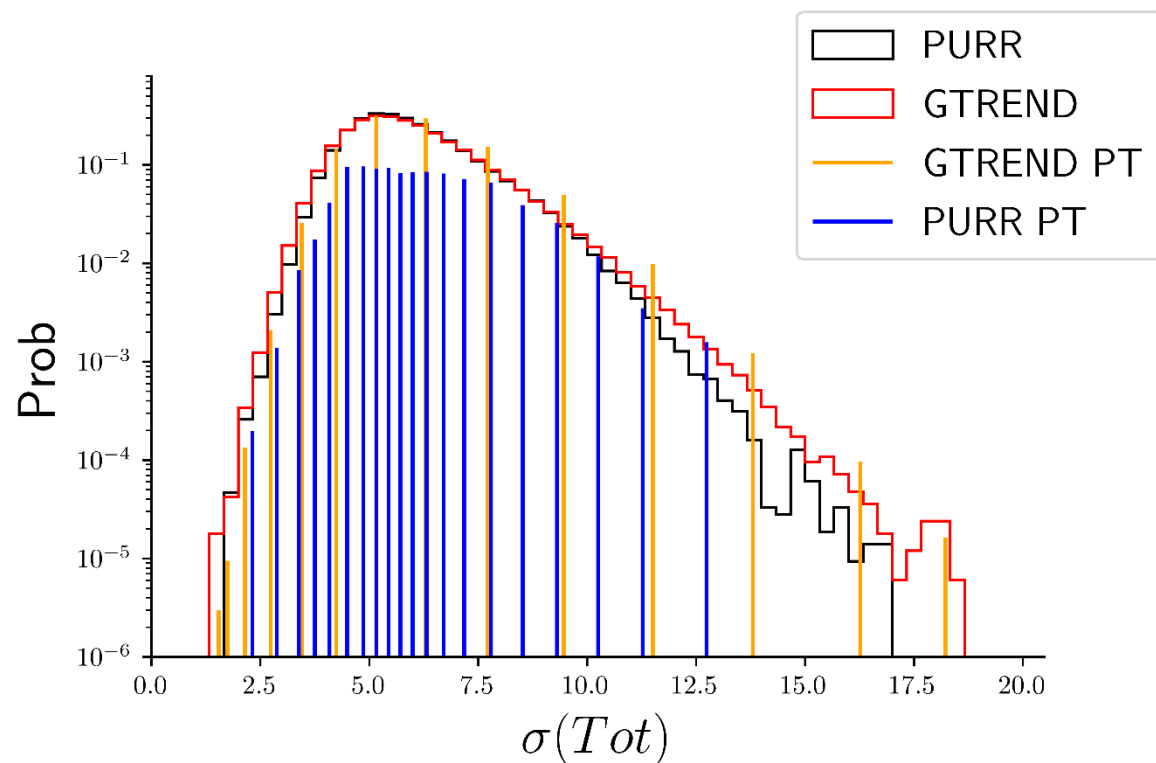
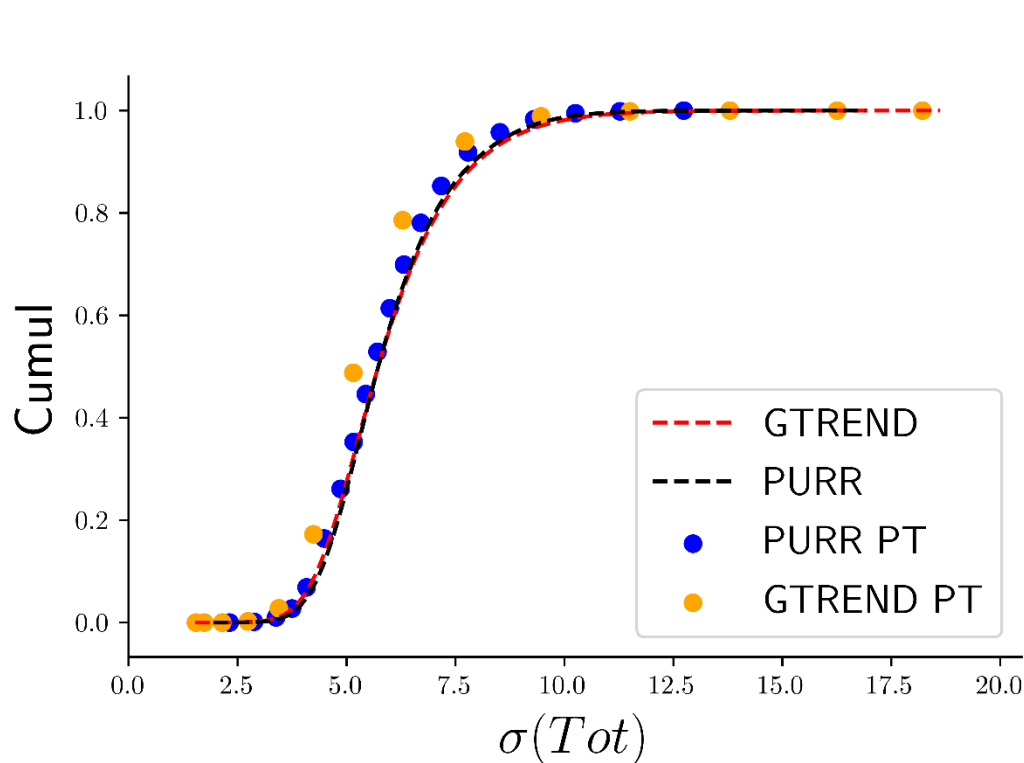


Radiative capture



PURR and GTREND Pointwise Monte-Carlo PTs

Candidate : Cs134 ENDF/B-VIII : LSSF=0 Elastic and Capture reactions in URR
PTs at 80 keV (294 K)

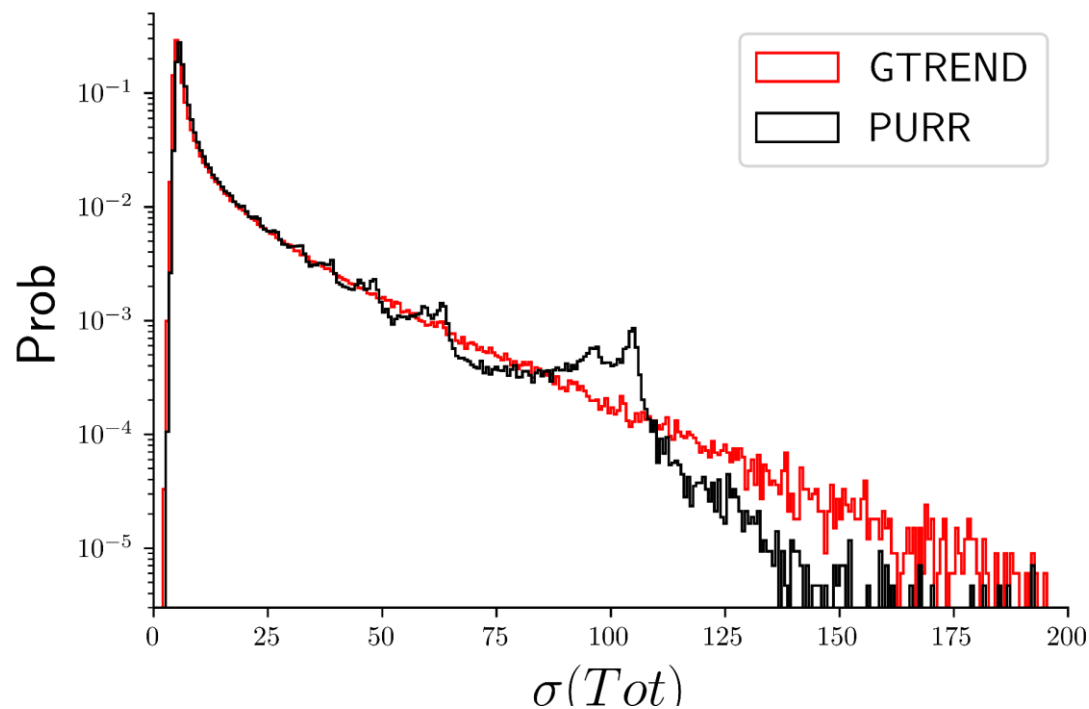


PURR and GTREND Pointwise Monte-Carlo PTs

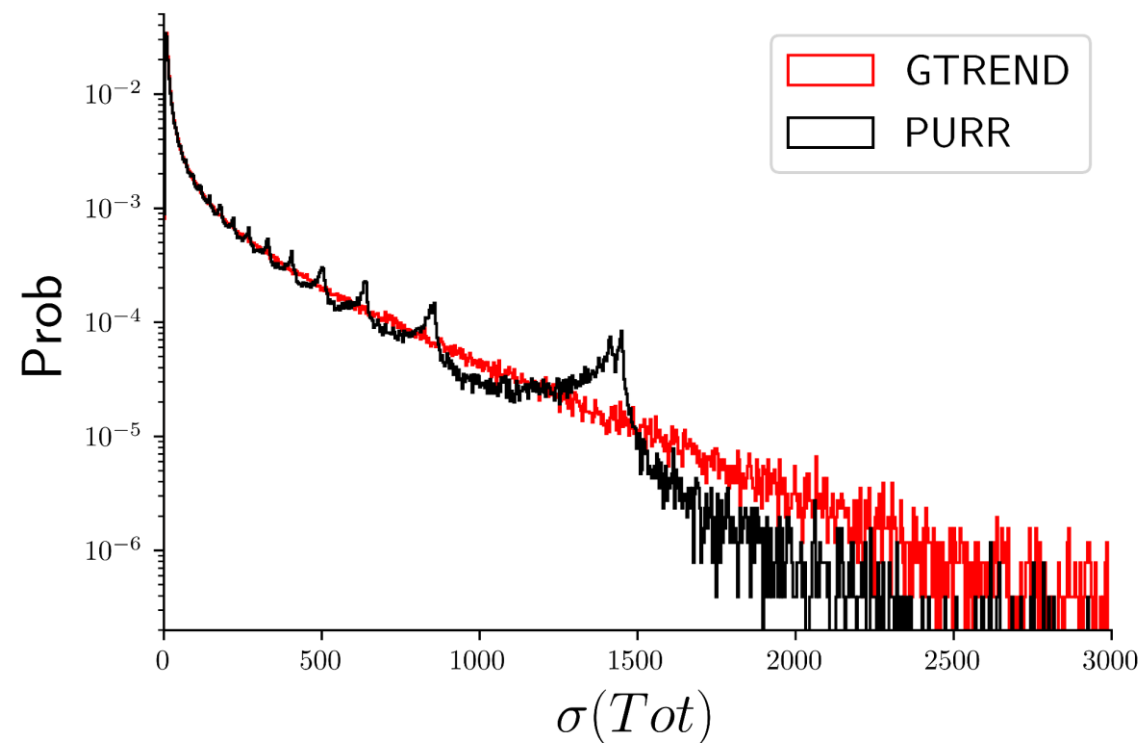


Structures in PURR random total cross sections. Explanations ?

Ag108 JEFF-3.3 at 1 keV (294 K)



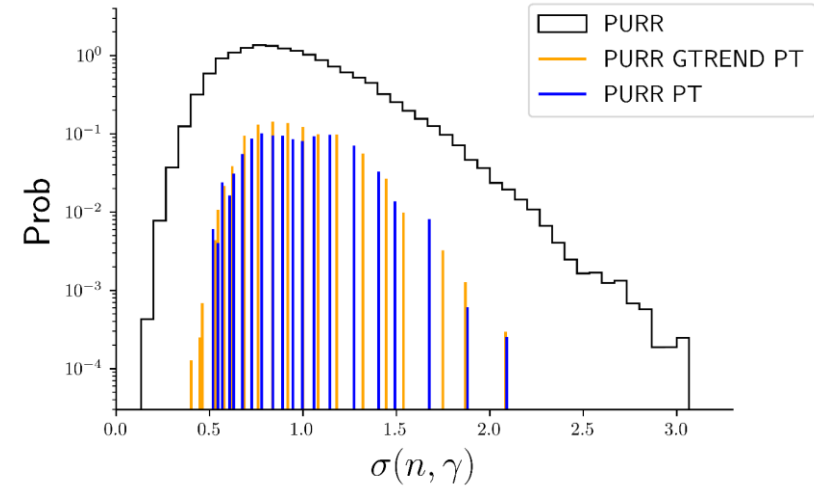
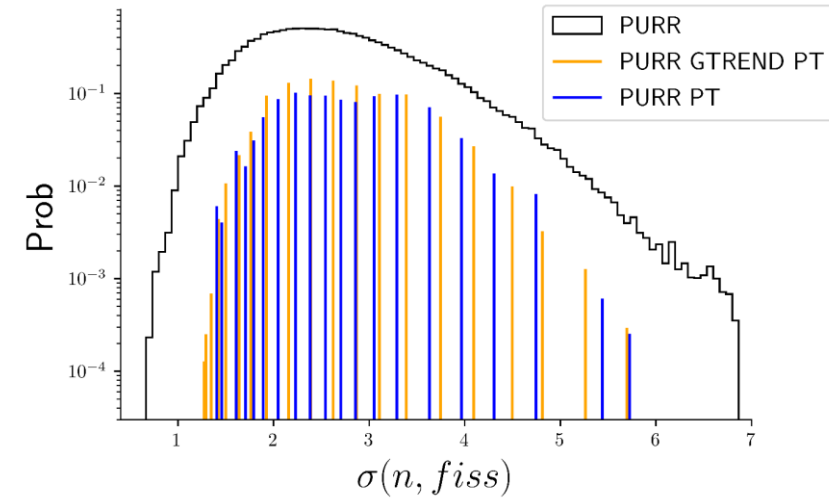
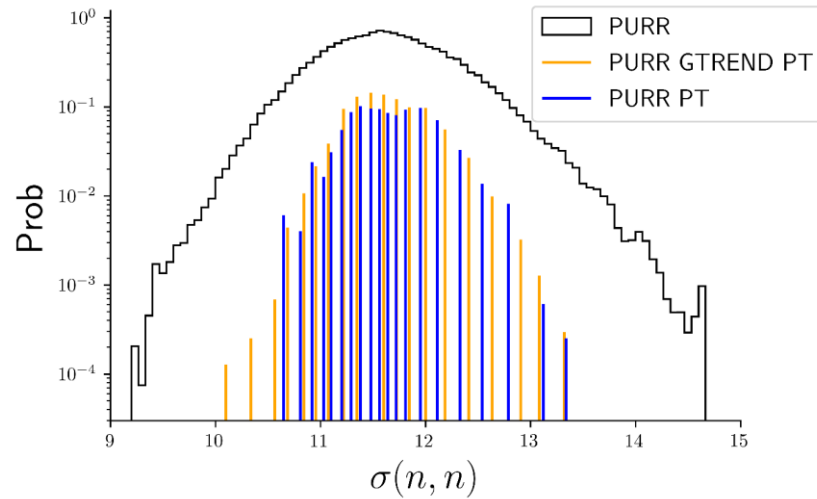
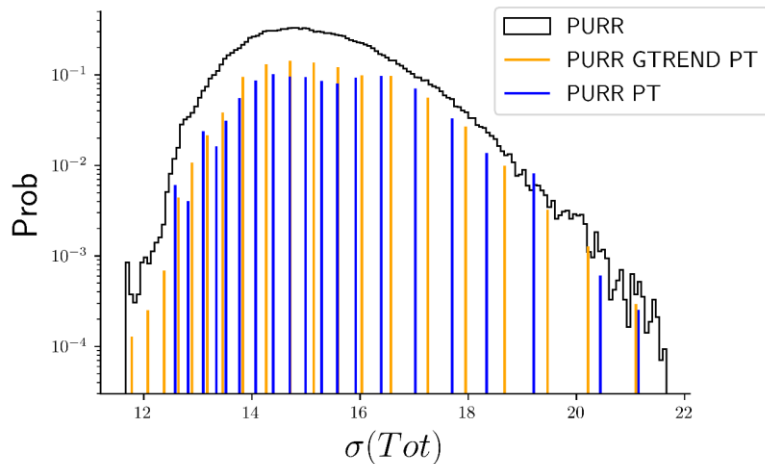
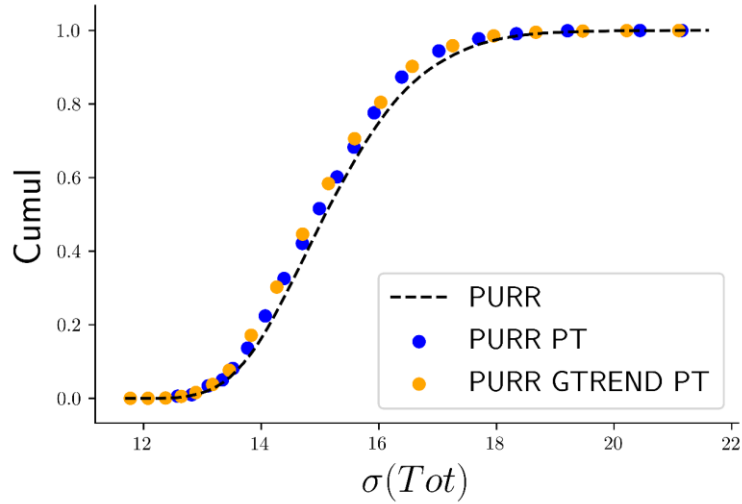
Eu153 JEFF-3.3 at 100 eV (294 K)



PURR Random Cross Sections \rightarrow Pointwise PTs

U235 ENDF/B-VIII. 13.1 keV (294 K). Overlay of distributions for partials cross sections.

PURR random σ distributions, PURR PTs (20 steps) and Ace-like GTREND PTs (20 steps)

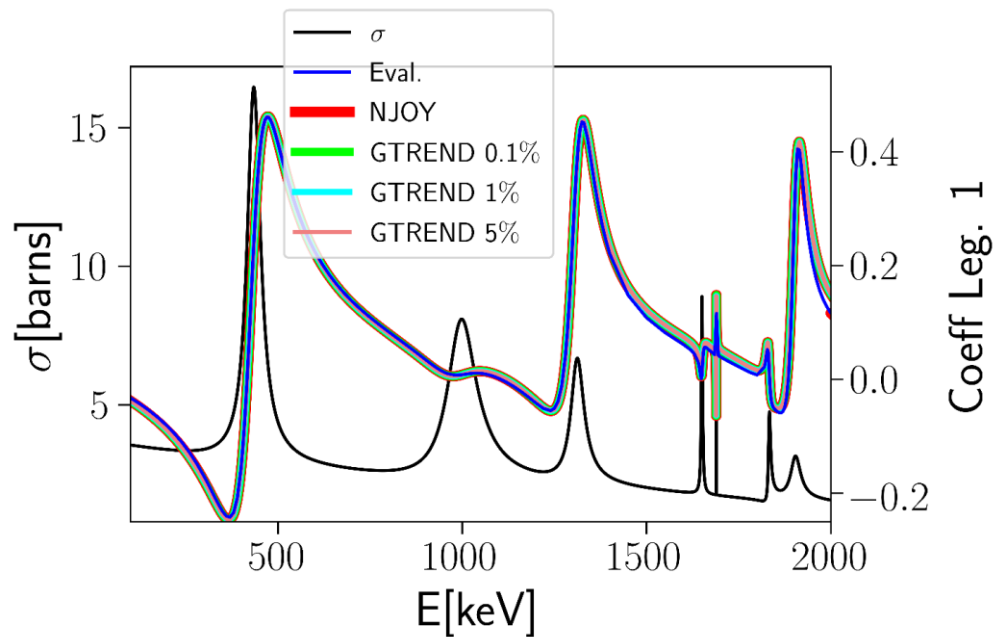


GTREND Anisotropy calculations in the Resolved Resonance Range

- Calculation from resonance parameters using Blatt-Biedenharn formalism
 - ✓ Reich-Moore formalism LRF=3 (elastic scattering)
 - ✓ R-Matrix-Limited formalism LRF=7 (all reactions)
- Linearization of all Legendre coefficients on the same incident energy grid
 - ✓ Pointwise or mixed linearization criteria
 - ✓ User accuracy
- Production of a new evaluation with modified files 4 in the resolved resonance range

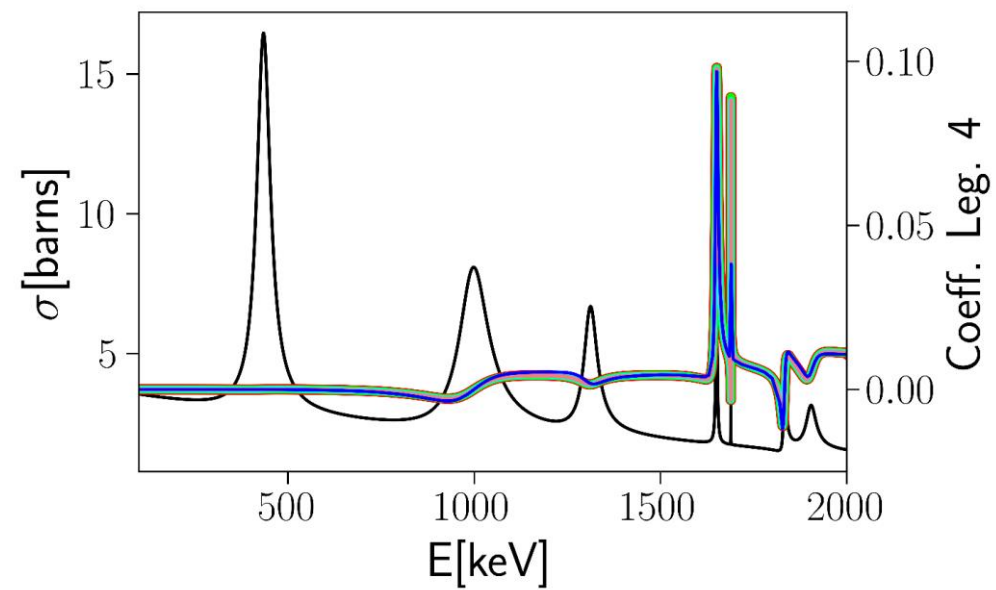
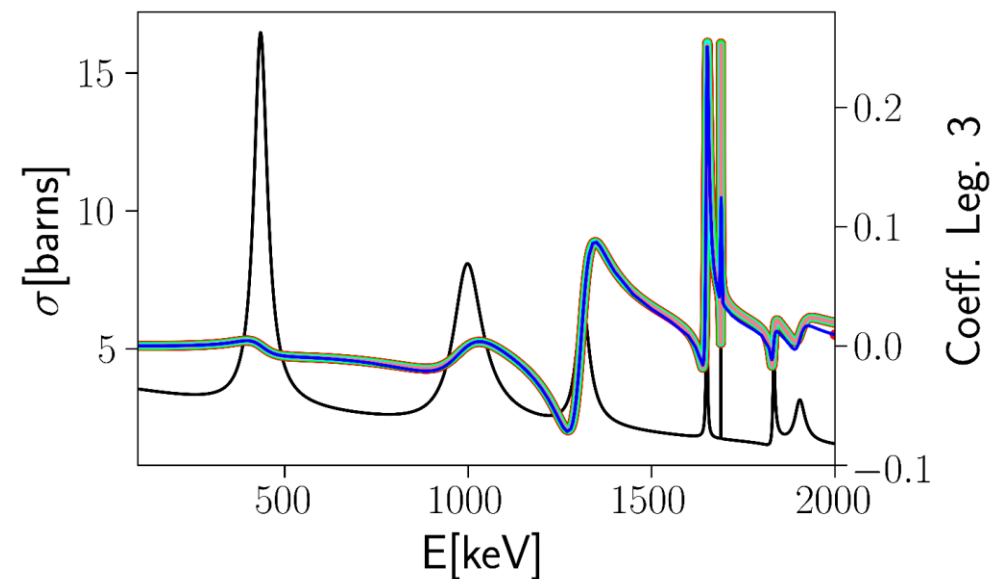
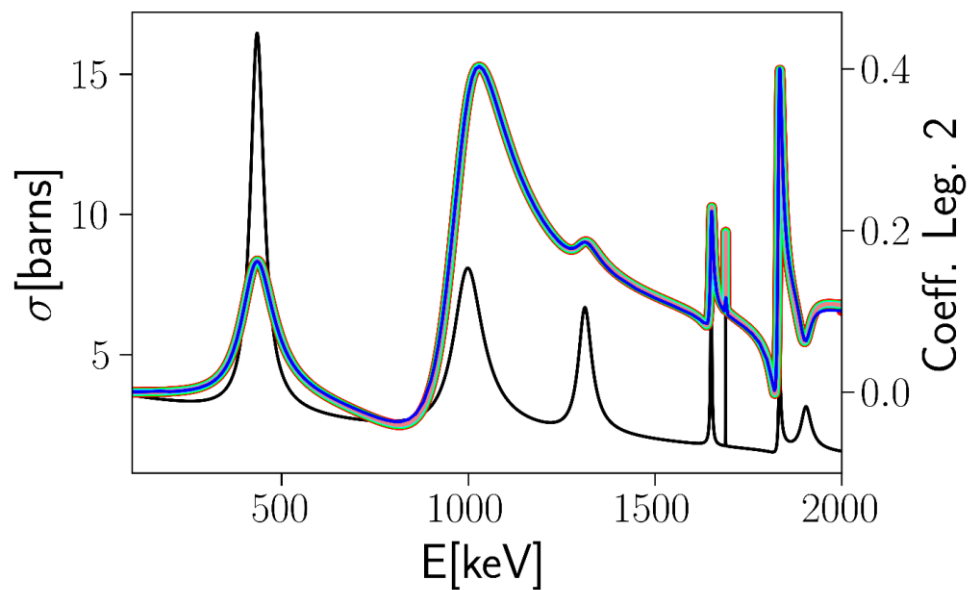
NJOY and GTREND Anisotropy calculations

O16 JEFF4T2 LRF=7 → reconstruction of elastic scattering anisotropy



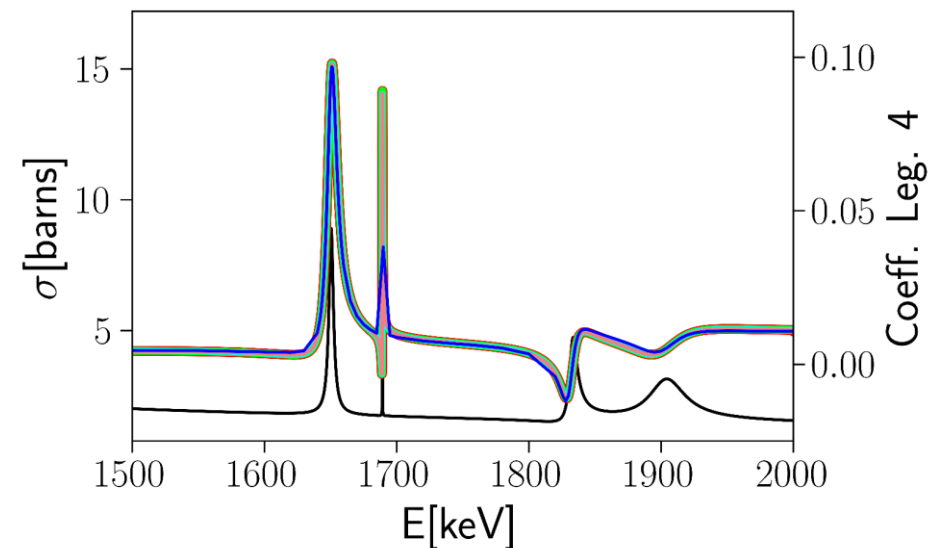
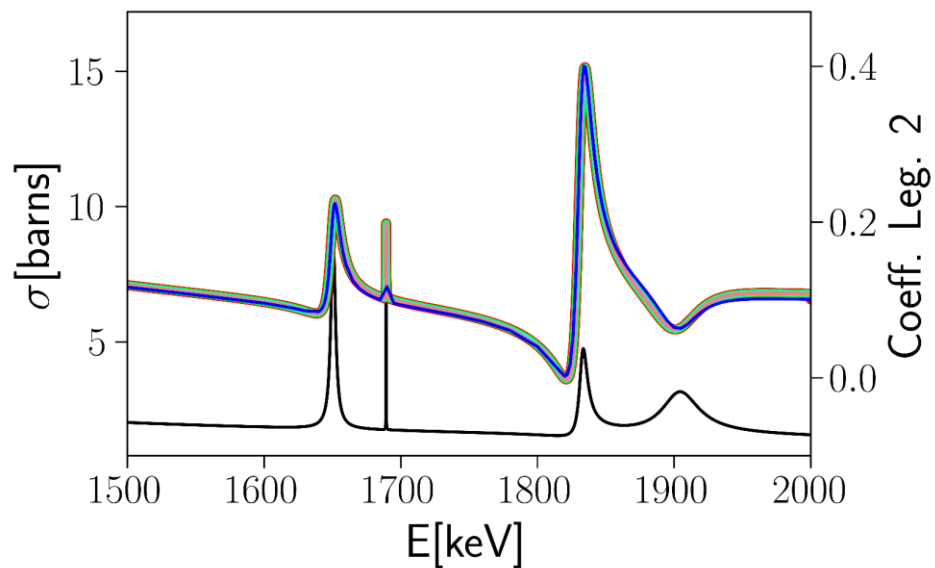
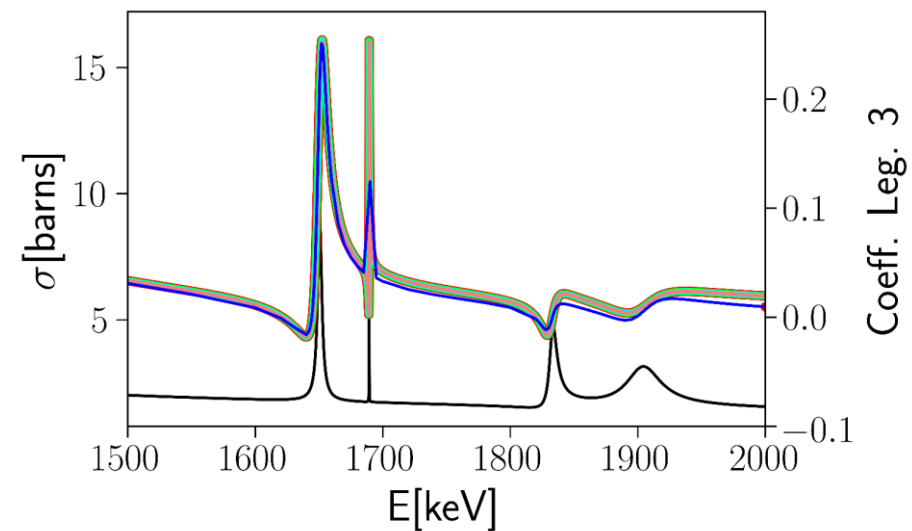
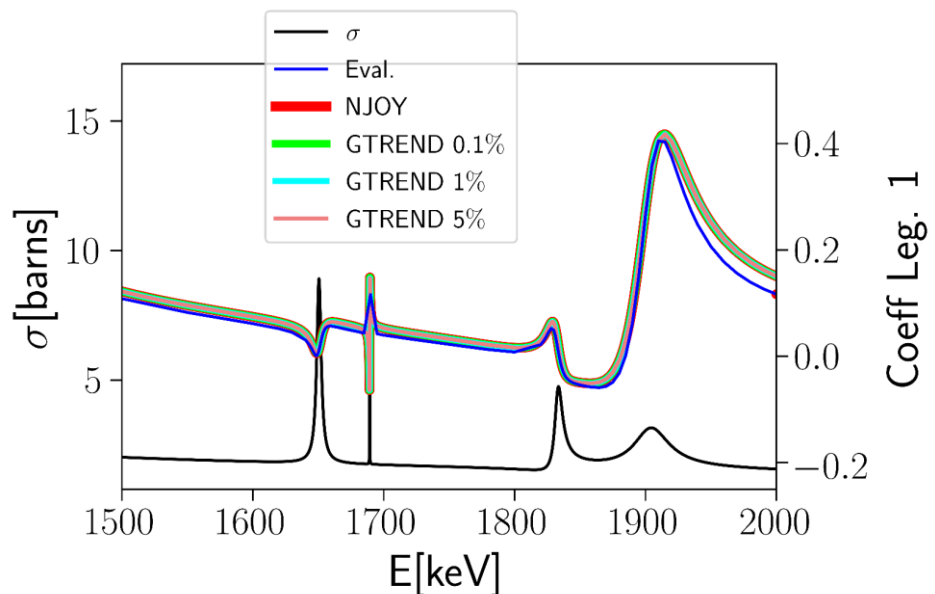
Between $1. 10^{-5}eV$
and 6 MeV

Aniso	Nb. Pts
Eval	1015
NJOY 0.1%	4735
GT 0.1%	4409
GT 1%	1685
GT 5%	1349



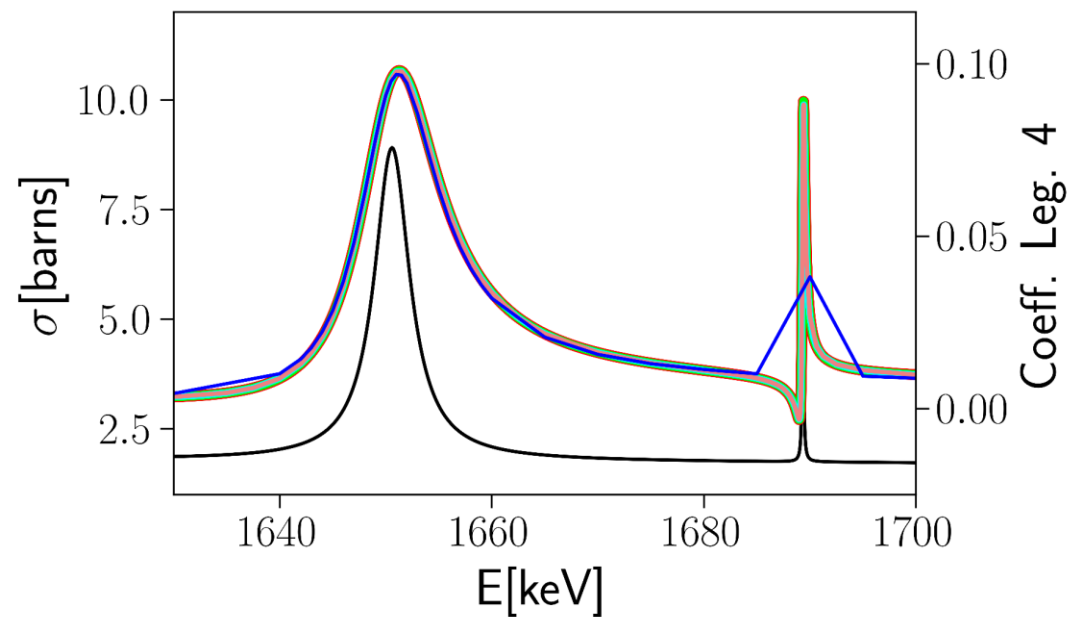
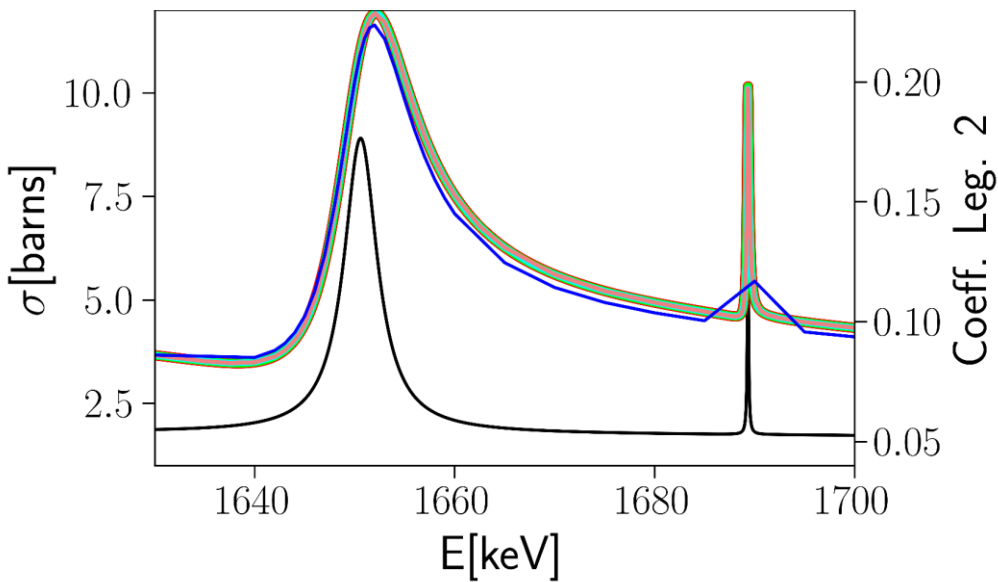
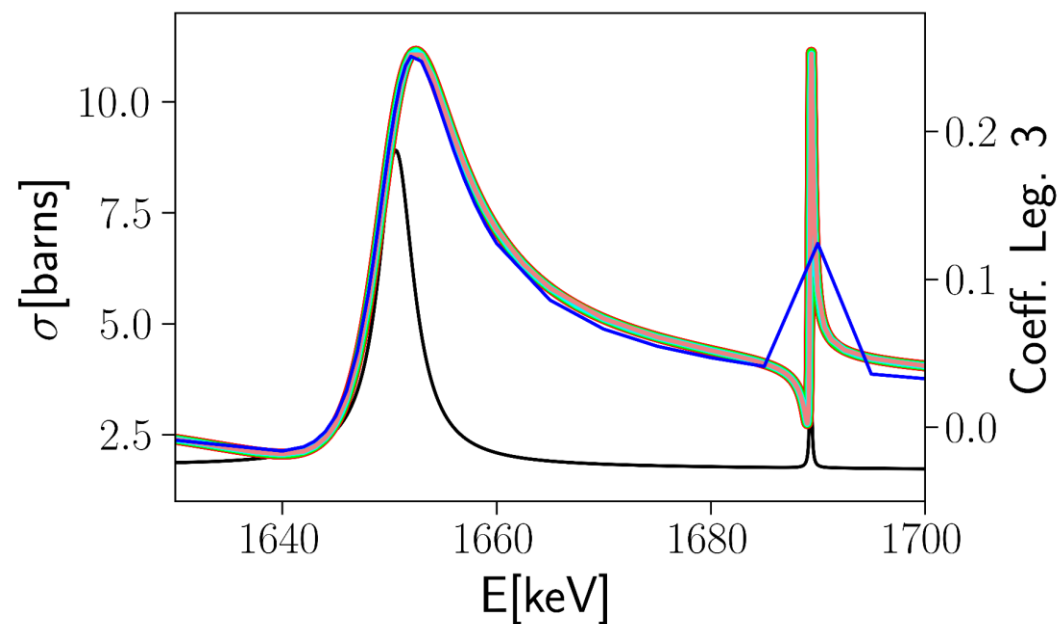
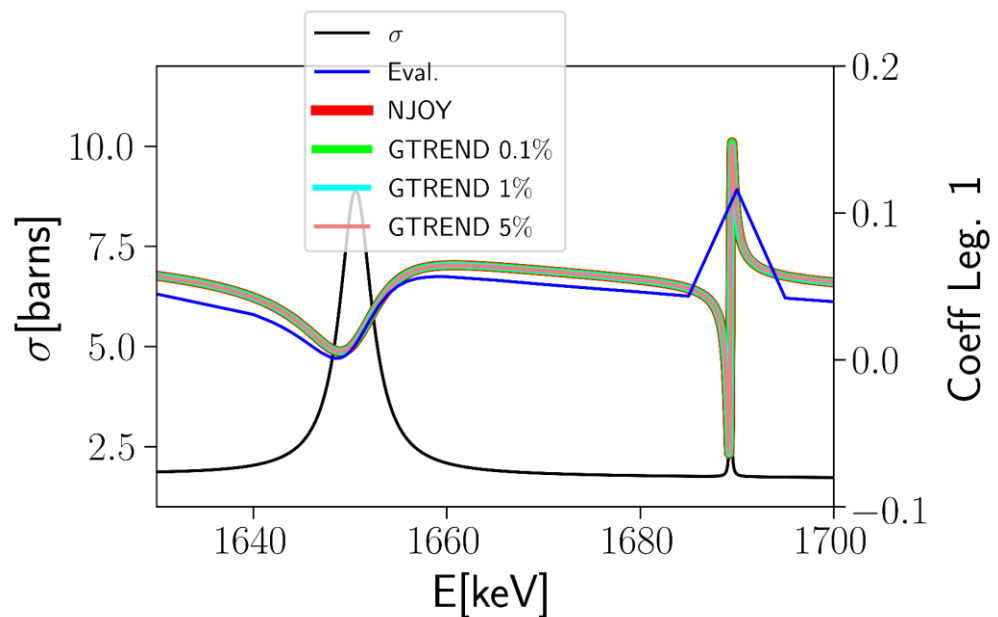
NJOY and GTREND Anisotropy calculations

O16 JEFF4T2 LRF=7 → reconstruction of elastic scattering anisotropy



NJOY and GTREND Anisotropy calculations

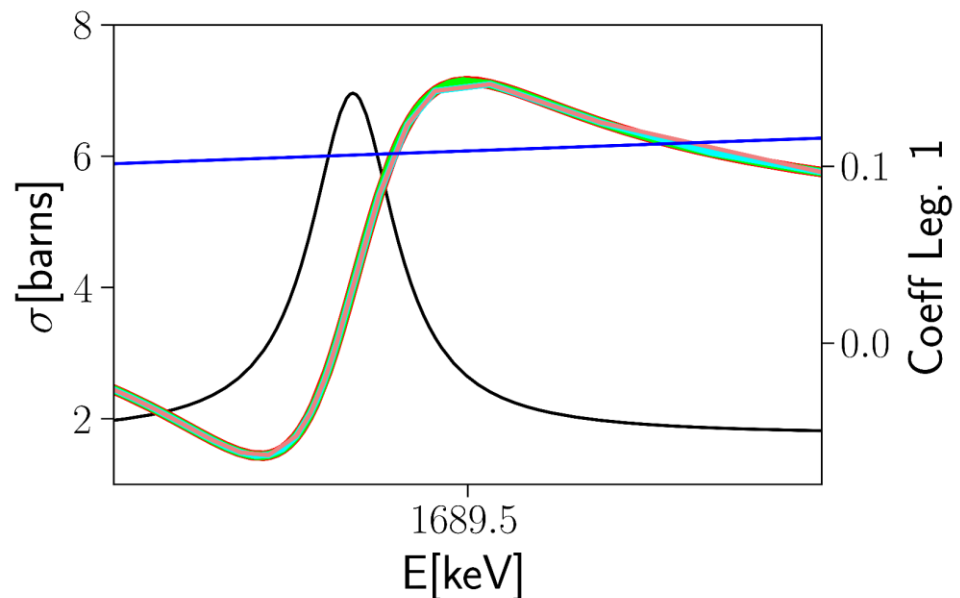
O16 JEFF4T2 LRF=7 → reconstruction of elastic scattering anisotropy



NJOY and GTREND Anisotropy calculations

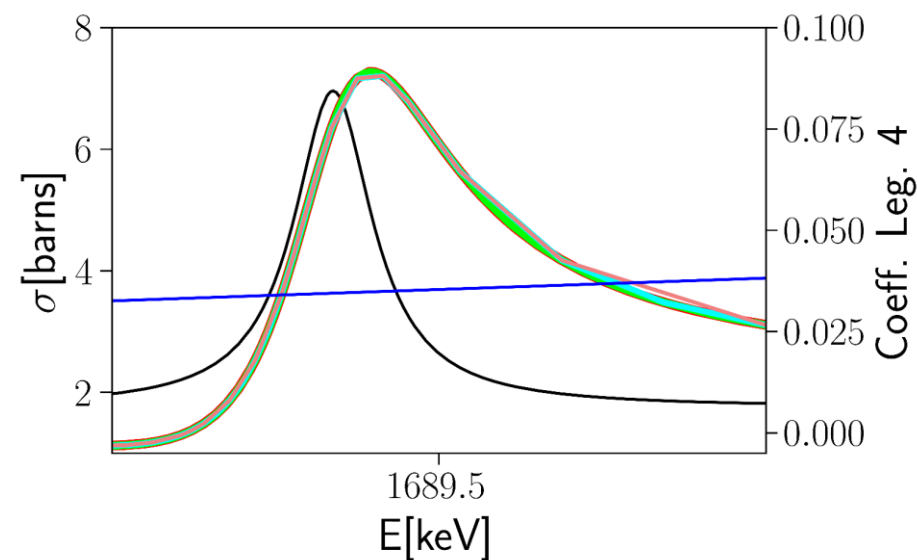
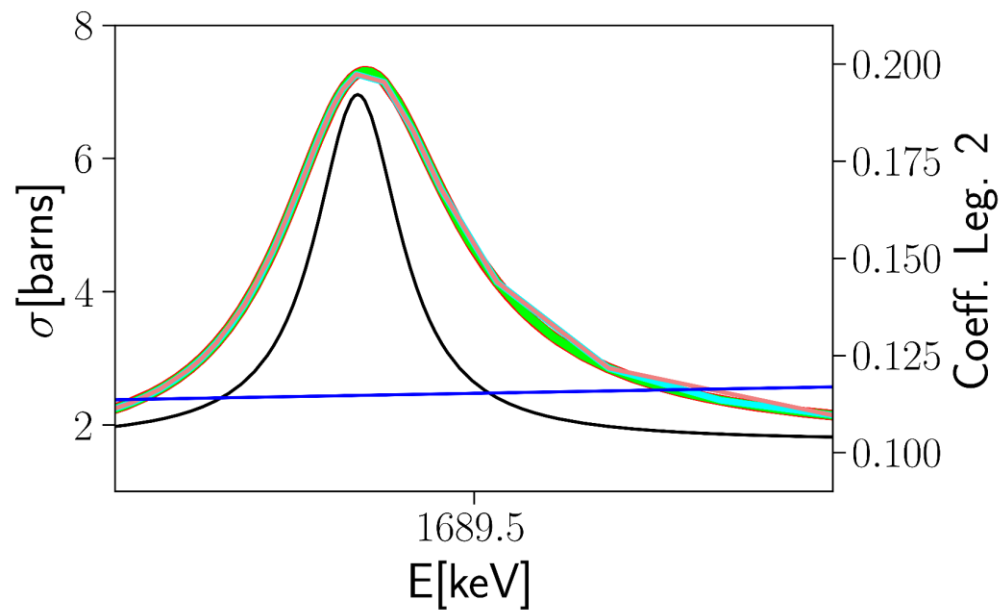
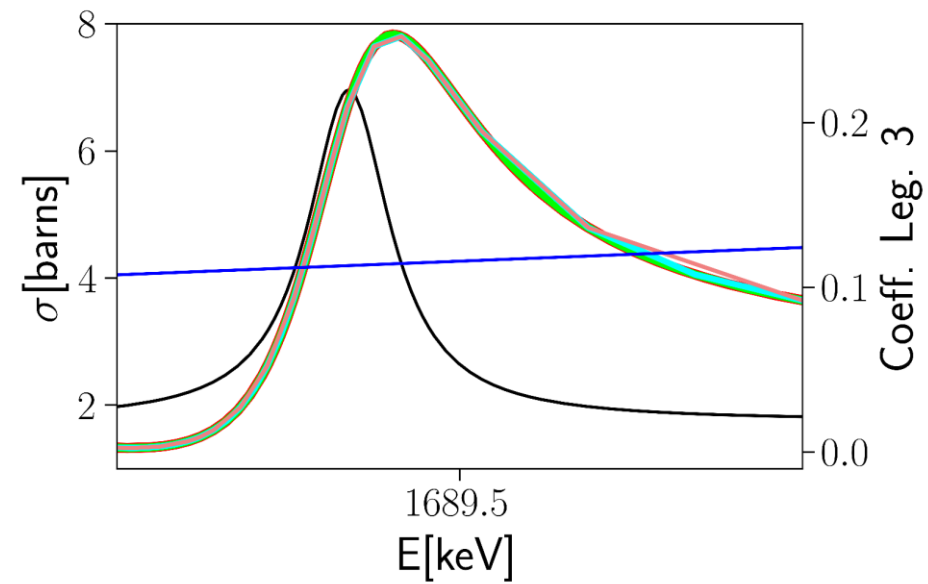


O16 JEFF4T2 LRF=7 → reconstruction of elastic scattering anisotropy



Between 1.689 MeV and 1.690 MeV

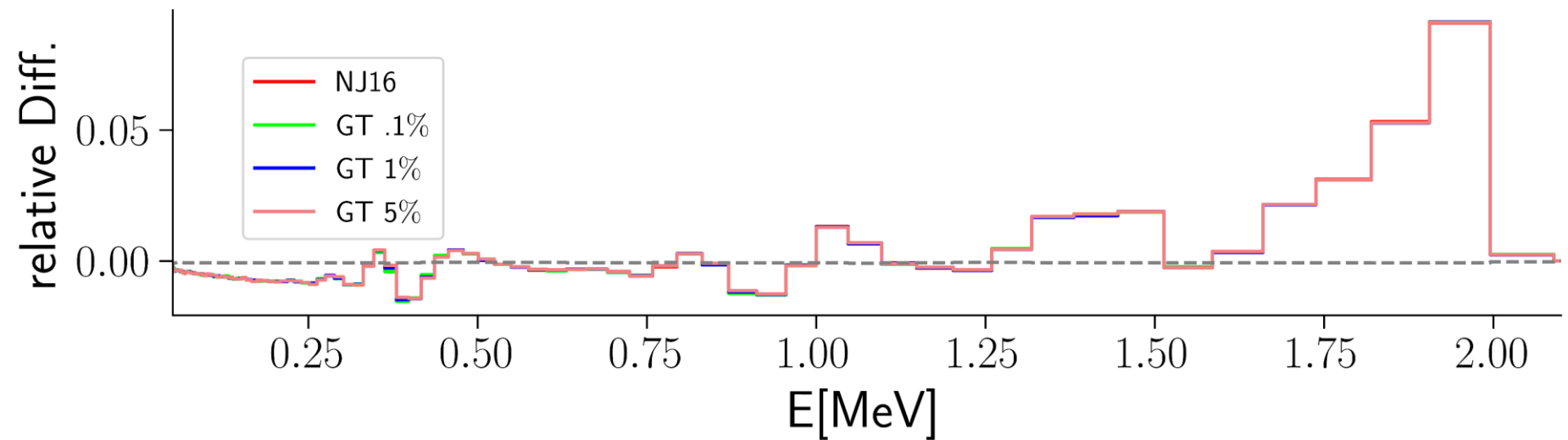
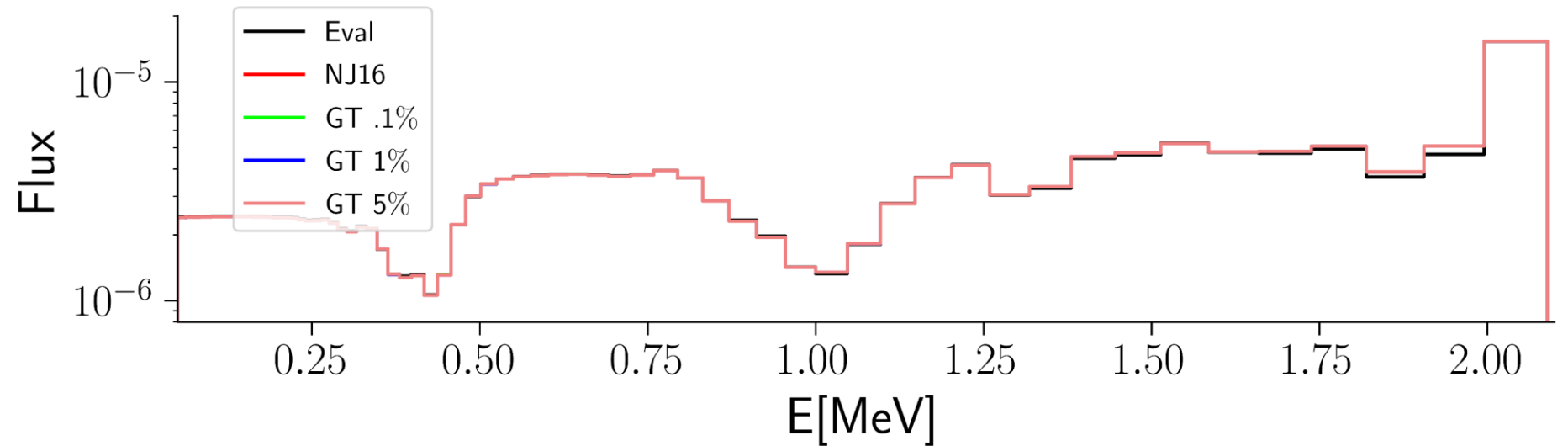
Aniso	Nb. Pts
Eval	0
NJOY 0.1%	59
GT 0.1%	99
GT 1%	31
GT 5%	21



NJOY and GTREND Anisotropy calculations

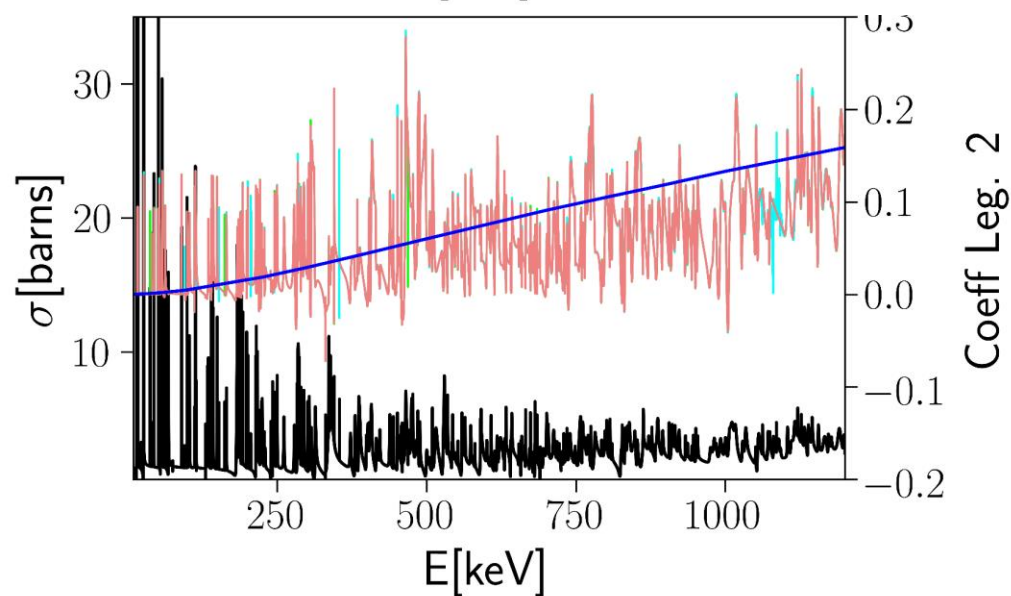
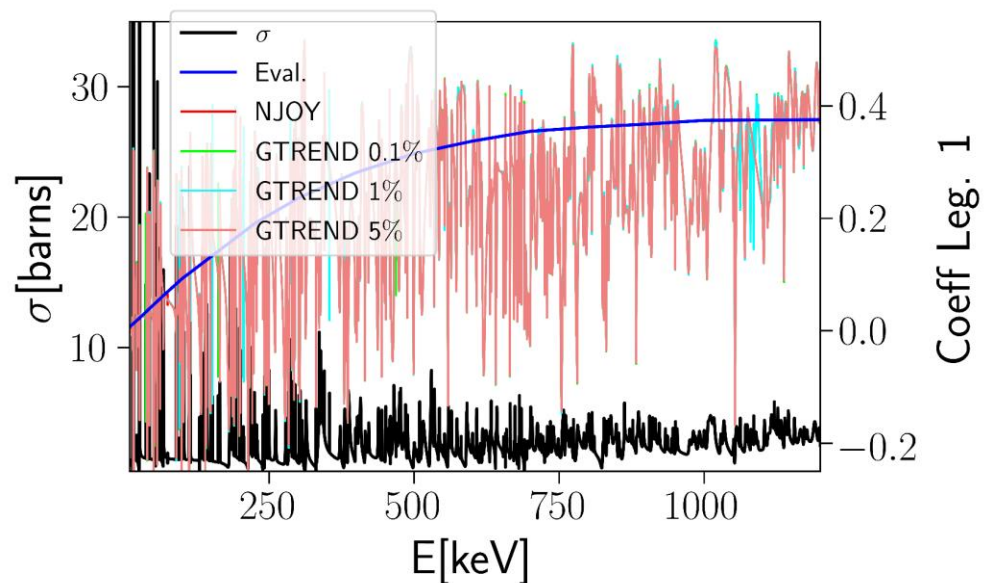
O16 JEFF4T2 LRF=7 → reconstruction of elastic scattering anisotropy

Slowing down in
O16 Sphere
Source = 2 MeV
→ Impact of anisotropy
reconstruction



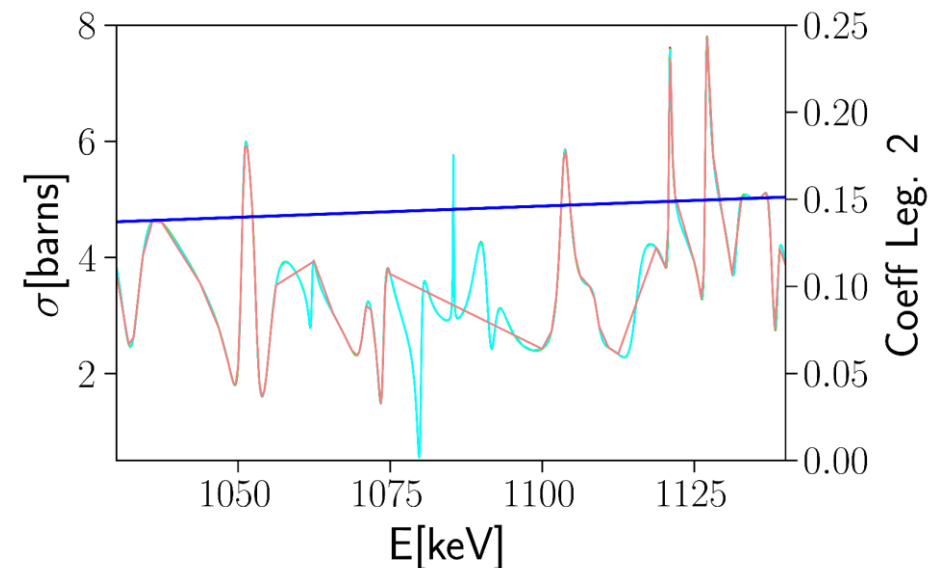
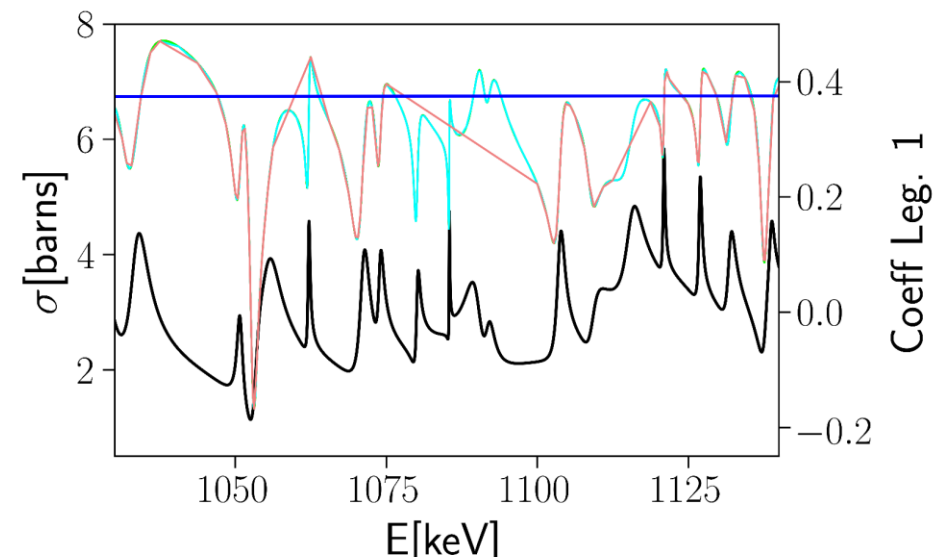
NJOY and GTREND Anisotropy calculations

CI35 ENDF/B-VIII.1 beta1 LRF=7 → reconstruction of elastic scattering anisotropy



Between 1.10^{-5} eV
And 1.2 MeV

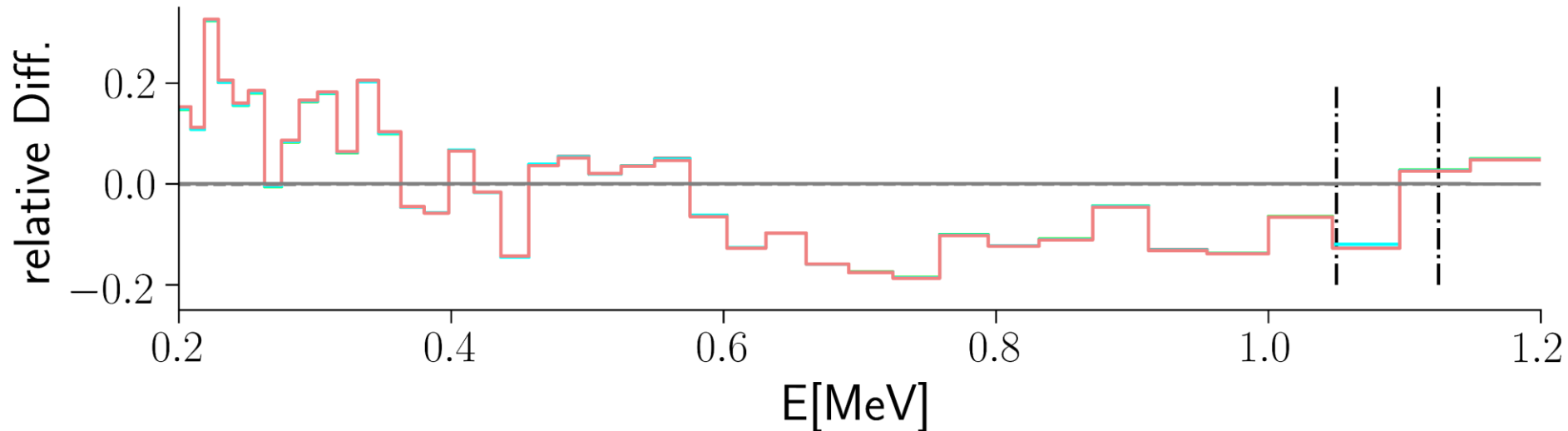
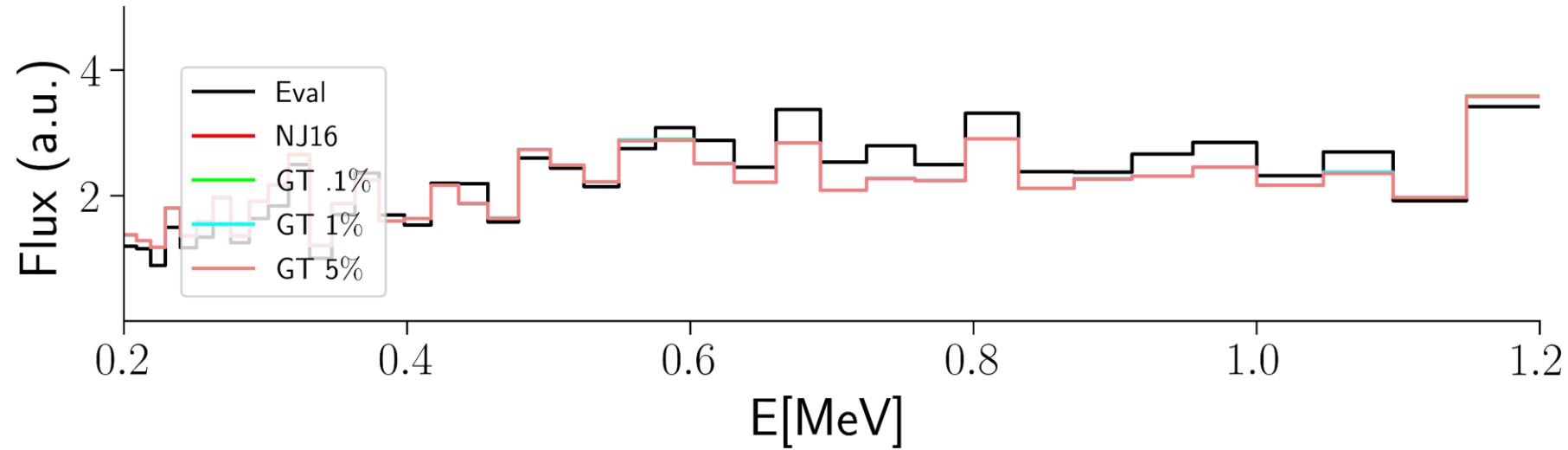
Aniso	Nb. Pts
Eval	20
NJOY 0.1%	25 788
GT 0.1%	18 022
GT 1%	6 411
GT 5%	3 613



NJOY and GTREND Anisotropy calculations

CI35 ENDF/B-VIII.1 beta1 LRF=7 → reconstruction of elastic scattering anisotropy

Slowing down in
CI35 Sphere
Source = 1.2 MeV
→ Impact of anisotropy
reconstruction
 $\Delta \sim 20\%$





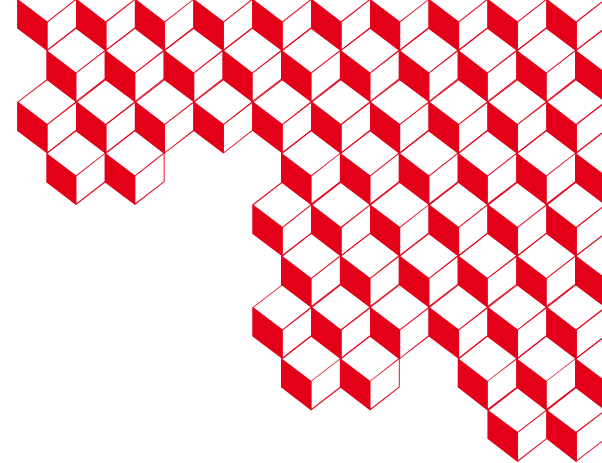
GALILÉE-1 Processing Code :

Developments already completed :

- Cross section reconstruction, linearization and Doppler broadening
- URR multi-group and Pointwise Probability Tables
- TSL processing
- Angular distribution from resonance parameters (R-Matrix Limited and Reich-Moore)
- 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

BigTen using ENDF-B/VIII library



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 using ENDF-B/VIII library



Relative deviations on neutron fluxes

