DE LA RECHERCHE À L'INDUSTRIE

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CURRENT STATUS OF THE VERIFICATION AND PROCESSING SYSTEM GALILÉE-1 FOR EVALUATED DATA

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OUTLINES

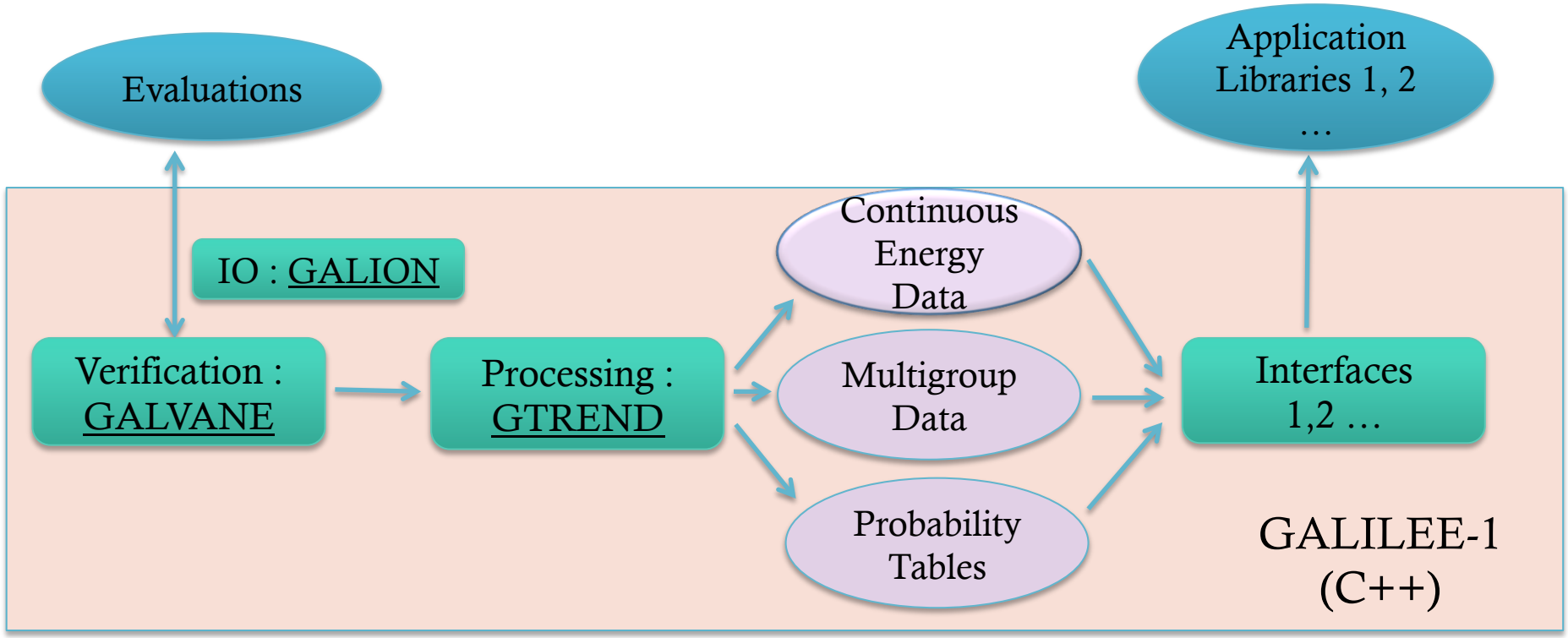
1. Code description
2. Cross Section Reconstruction
3. Doppler Broadening
4. Verification
5. Conclusions

GALILÉE-1 INTEGRATED RUNNING WAY

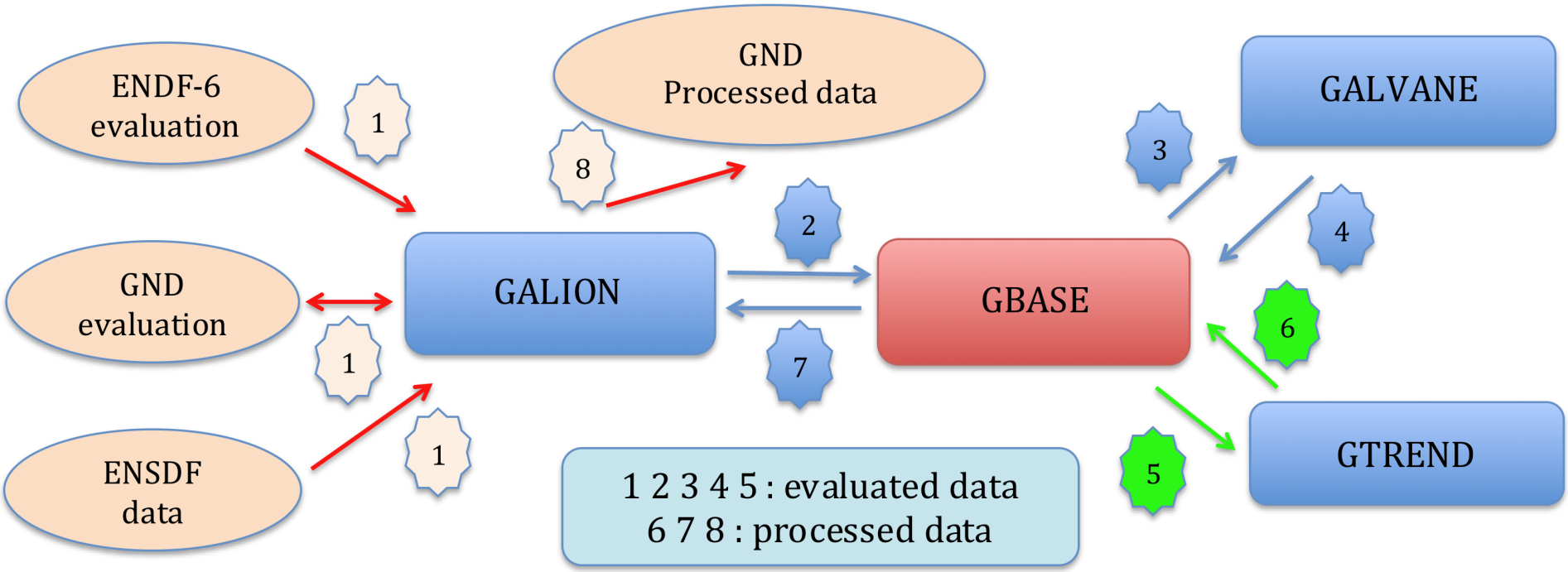
GALION: GALilée Input Output for Nuclear data

GALVANE : GALilée Verification of the Accuracy of Nuclear Evaluations

GTREND: GALilée TReatment of Evaluated Nuclear Data



DATA FLUXES


ENDF-6 evaluation
GND evaluation
ENSDF data
1
1
1
GND Processed data
8
GALION
2
7
GBASE
3
4
6
5
GALVANE
GTREND
1 2 3 4 5 : evaluated data
6 7 8 : processed data

CROSS SECTION RECONSTRUCTION

GTREND : Reconstruction at 0 K on NJOY / PREPRO energy grids

Comparisons between : NJOY99, NJOY2012, PREPRO and GTREND

$$|\Delta| = \left| \frac{\sigma(NJOY) - \sigma(GTREND)}{\sigma(NJOY)} \right|$$

Application : JEFF-3.2 Library (470 nuclei) NJOY2012 / GTREND

$|\Delta| > 5.\ 10^{-6}$ (0.001%) : 20 nuclei

SLBW, MLBW, RM, RML : Very good agreement NJOY2012/PREPRO15/GTREND

DOPPLER BROADENING

SIGMA1 method is implemented in GTREND

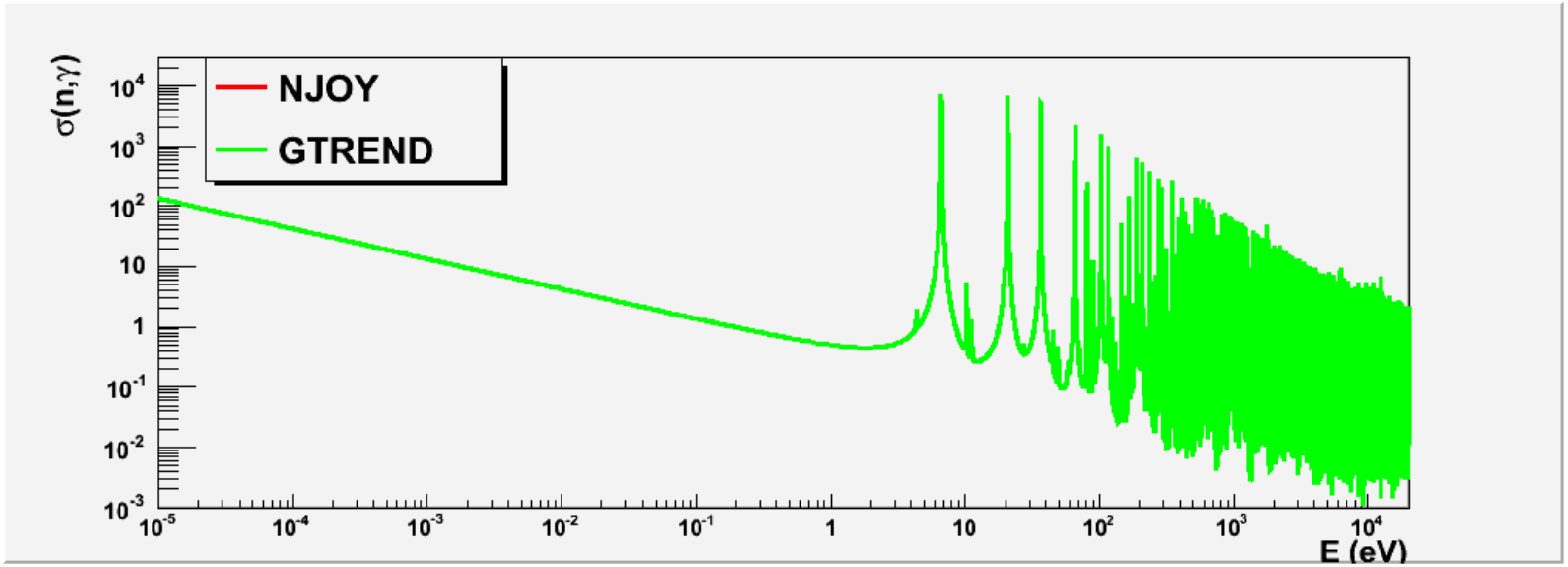
GTREND: Calculations at all energy points in a PENDF File
provided by NJOY/BROADR

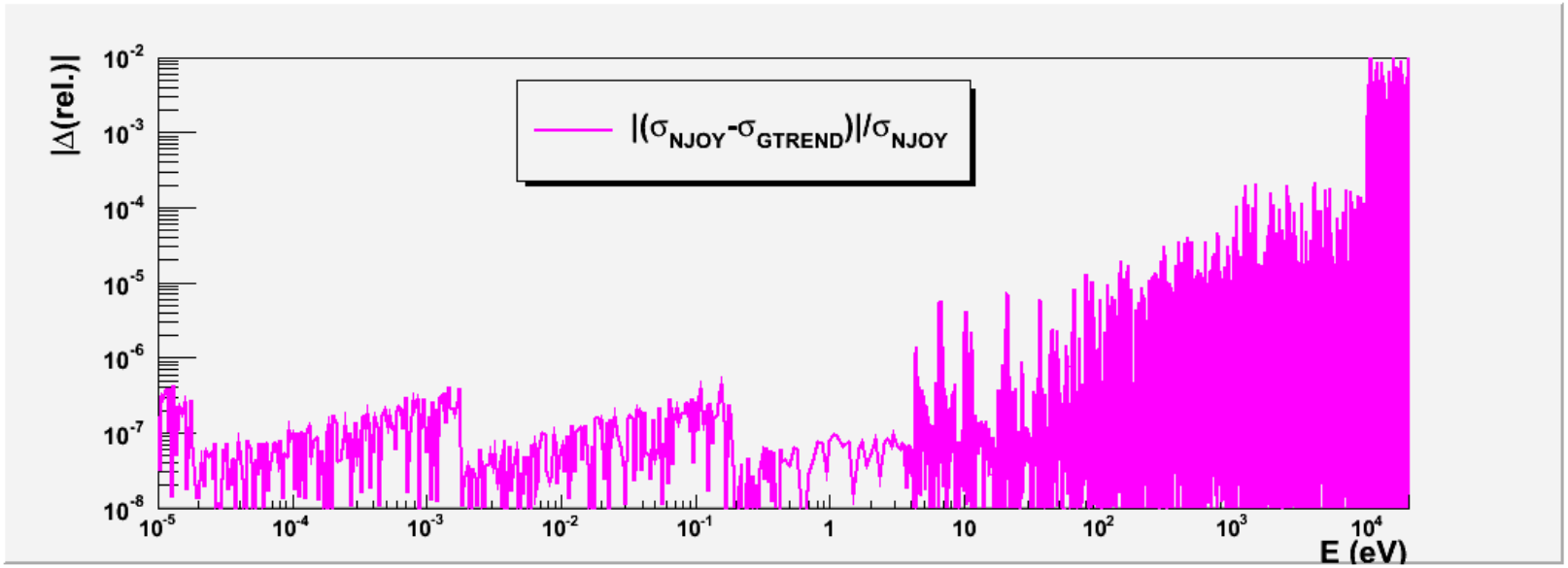
GTREND: Use of linear reconstruction at 0 K from NJOY/RECONR

Comparisons to NJOY99/BROADR and NJOY2012/BROADR

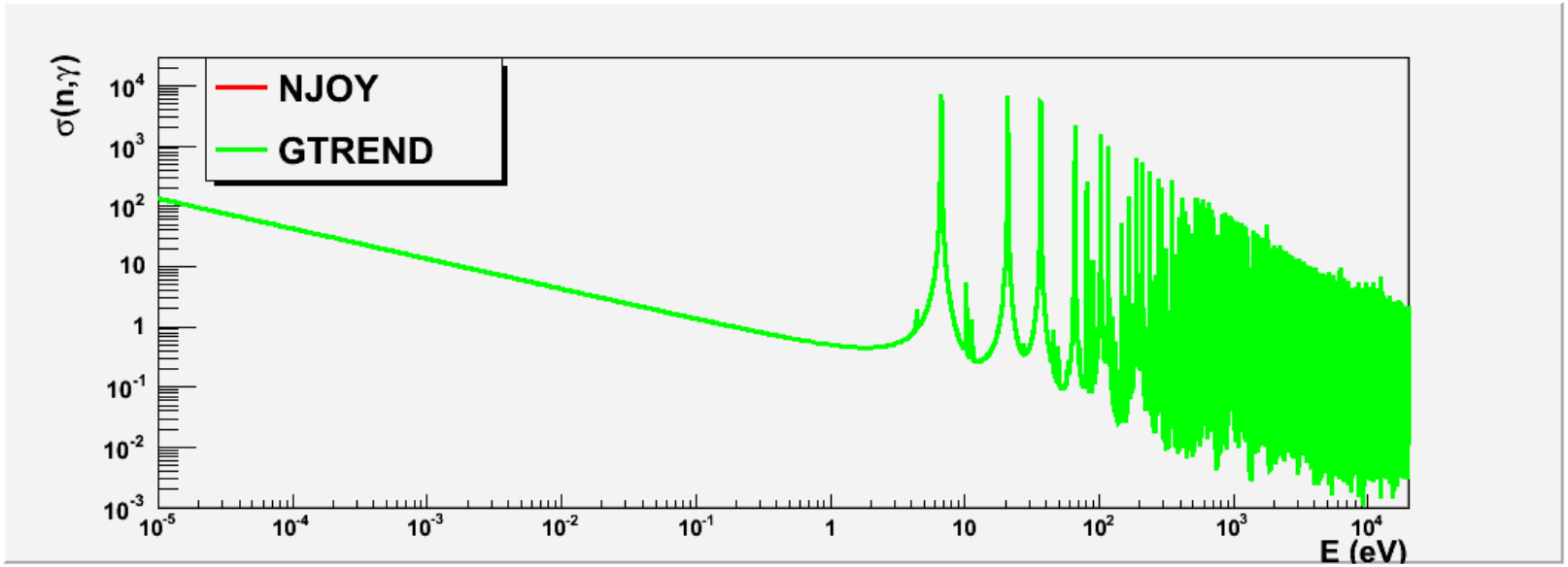
Example : 238U (n, γ) reaction

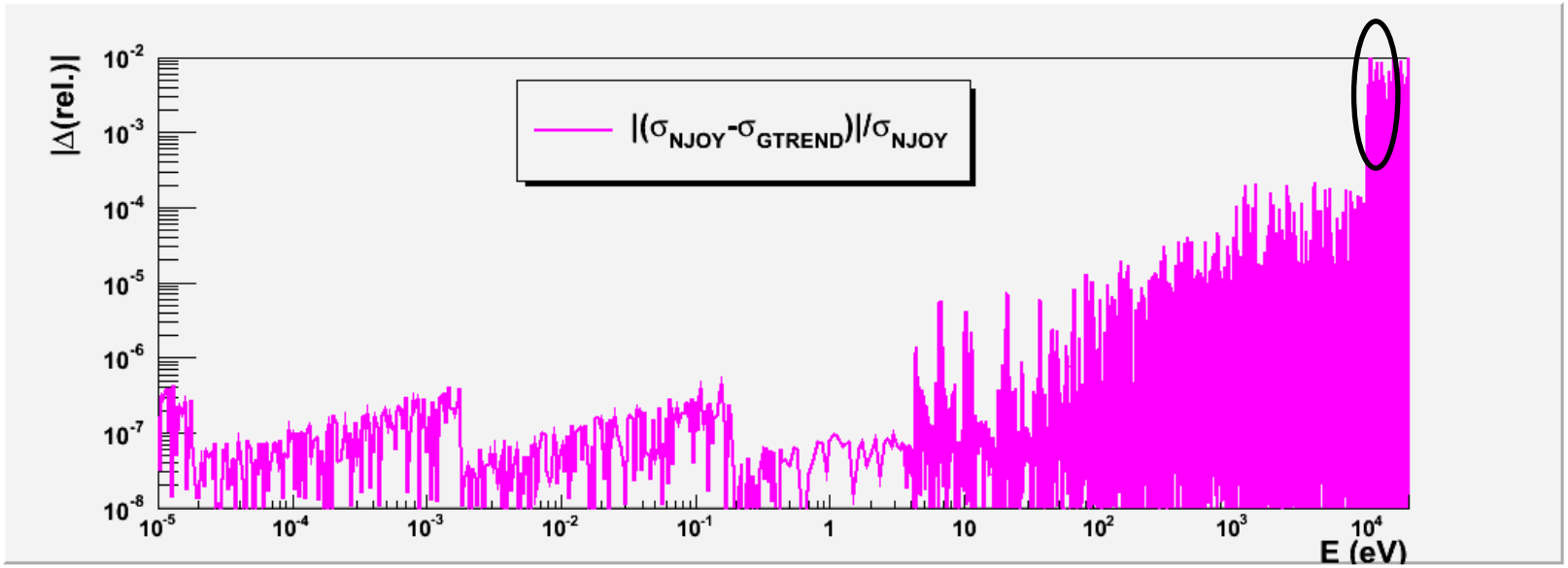
U238 RADIATIVE CAPTURE T=294 K



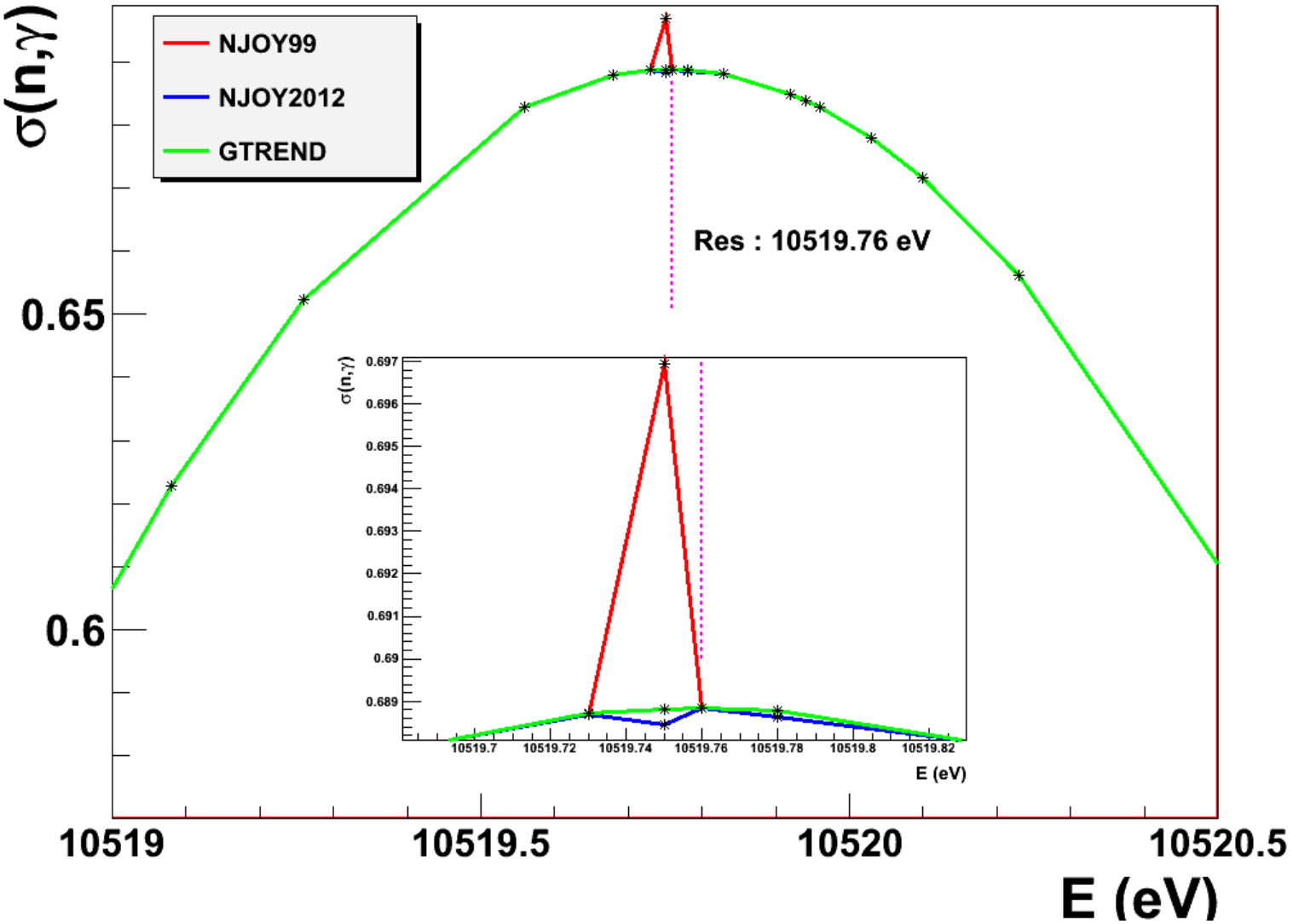


U238 RADIATIVE CAPTURE T=294 K





U238 RADIATIVE CAPTURE T=294 K



VERIFICATION

Library (# nuclei / #nuclei with Radioactive Data production) Inconsistencies	JENDL40 (406 / 3)	JEFF32 (472 / 169)	JEFF33T2 (559 / 320)	JEFF33T3 (566 / 325)	ENDFB7R1 (423 / 41)	ENDFB8B4 (447 / 43)
Mass comparison (> 1 MeV)	4	24	13	11	27	26
Resonance parameters	0	9	5	4	3	2
Q-reactions (> 500 keV)	5	53	32	32	92	97
Anisotropy	5	35	17	6	39	39
Radioactive production	1	41	97	99	14	12
Missing gamma production for radiative capture	139	104	44	1	138	142

GENERAL INFORMATIONS

RIPL-3, ENSDF, Nubase …
- Masses
- Lifetimes
- Excited states : Energy, decay modes

GENERAL INFORMATIONs (MF1) :

- Mass comparisons (spin, parity)

RESONANCE PARAMETERS (MF2) :

- J=L+S in RRR and URR (not always verified) : Evalution value (NJOY) or physical value ?
- level spacing in RRR and URR
- correlations (spacing)
- average widths

REACTIONS

CROSS SECTIONS (MF3):

- Q reactions, decay mode (LRFLAG)
- Energy thresholds
- Total = sum of partial reactions (MT=600…)
- Threshold in agreement with MF4, MF5, MF6…. thresholds

ANGULAR DISTRIBUTIONS (MF4) :

- Tab1 distribution : Norm = 1 ? (NJOY99/MCNP : Lin-log == Lin-Lin)
- Legendre polynomials : Negative values ?

ENERGY DISTRIBUTIONS (MF5) :

- Distribution normalizations ?
- Yield : implicit, explicit, right values (ex : n,2n : Yield = 2 or 1.999)
- Energy limit of distributions in agreement with available energy ?
- Interpolation between incident energy (unit base instead of lin-lin). NJOY/MCNP Always considers unit base lin-lin (except histogram)

REACTIONS

ENERGY-ANGLE DISTRIBUTION (MF6) :

- Yields ?
- Normalization of distributions
- Gamma : Discrete + continuous == 1
- Limits of energy distributions in agrement with available energy
- Sum of Average energies in agreement with available energy

Comment on MF6 and Discrete Inelastic scatterings :

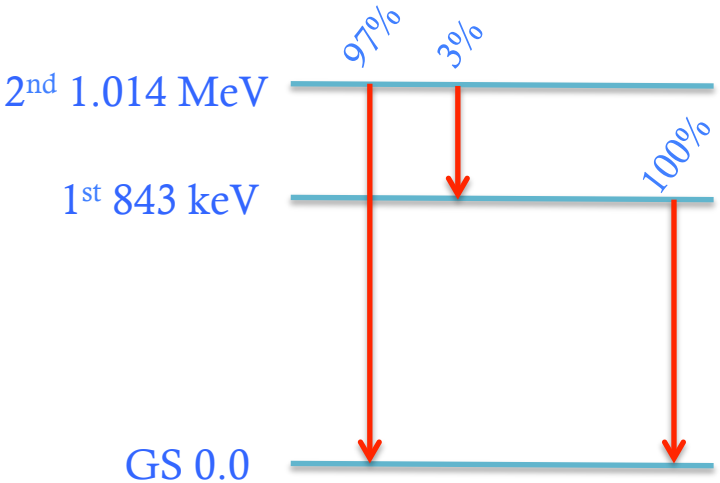
JEFF-3.2 : 95 nuclei. Gamma production in MF6 or MF12

➔ Better solution : MF4 (neutron angular distribution) + MF12 (gamma production)

INELASTIC SCATTERING IN MF6

Ex : Al27 (JEFF33T2, correction in JEFF33T3)

1st excited state : E=843 keV. 100% to GS
2nd excited state : E:1.014 MeV.
3% to 1st excited state : gamma cascade 843 keV and 171 keV
97% to GS. Gamma 1.014 MeV



MF6 (JEFF33T2) for 2nd Exc :

Yield gamma : 1.029 (multiplicity)
Proba : 94.3 % 1.014 MeV
2.8 % 843 keV
2.8 % 171 keV

→ no correlation between 843 and 171 keV

1.029 = 1* 0.97+ 2 * 0.03
0.943 = 0.97 / 1.029

INELASTIC SCATTERING IN MF6 → MF12

Solution : use of MF12 / MF14 files

1/ use SIXPAK (PREPRO) to generate MF4 from MF6 (neutron angular distributions)

2/ use ENSDF data to define gamma cascade for each excited state in agreement with excited state used in evaluation file

3/ add new MF4, MF12 and MF14 for discrete inelastic scatterings in evaluation file

Al27 is included in JEFF-3.3 T3

Submission of 30 nuclei :

Eu153, Eu156, I127, I129, In113, In115, Mo92, Mo94, Mo96, Mo97,
Mo98, Nd148, Pb206, Pb207, Pb208, Pd104, Pd106, Pd108, Rh103,
Sn112, Sn114, Sn115, Sn116, Sn117, Sn118, Sn119, Sn120, Xe128, Xe129, Xe133

VERIFICATION / RADIOACTIVE PRODUCTION (MF8)

JEFF-3.3 T3 : 325 Nuclei with Radioactive Production

- Inelastic scattering (MT4) :
  Final state with Exc > 0 MeV and LFS = 0 (GS identification) : 85 evaluations
  TALYS correction ?

- Inconsistencies between GP data and JEFF311/DD, JEFF32/DD or ENSDF
  for ID state (Energy Level) or Excitation Energy value

Delta ID STATE GP / J311 : 99
Delta ENER STATE GP / J311 : 5

Delta ID STATE GP / J33 : 94
Delta ENER STATE GP / J33 : 5

Delta ID STATE GP / ENSDF : 29
Delta ENER STATE GP / ENSDF : 5

→ Source of inconsistencies for depletion calculations

MF12 / MF13 / MF15 : GAMMA PRODUCTION

- Verification of the coherence of decay schemes
- Limits of energy distributions in agreement with available energy
- Sum of energies for all outgoing particles in agreement with available energy
  → sum of MF5, MF12, MF13 and MF15 energies

CONCLUSIONS

Important steps completed :

- Evaluation verification
- RRR Reconstruction
- Doppler Broadening
- Probability Tables : temperature interpolation, mixture, condensation on energy grids

Next steps :

- URR Calculations (2017)
- Thermal scattering treatment (2017)
- Production of TRIPOLI-4 libraries (2018)
- Release of GALION/GBASE/GALVANE at NEA (2018)

VERIFICATION / ENERGY BALANCE

Energy balance for emitted particles :

JEFF-3.2 / W isotopes :

(n,inel cont) MT91 : Egamma > Ein (neutron)
(n,gamma) MT102 : gamma multiplicity up to 200;
Ein= 10 MeV; Egamma= 87 MeV (Q=5.7 MeV)

JEFF-3.2 Ni62 :

(n,gamma) MT102 : Egamma = 9 MeV for 10^{-5} eV < Ein < 750 keV (Q=6.8 MeV)

ENDF/B-VII.1 Pb208 :

(n,inel) Exc= 3.47 MeV. Egamma = 2.39 MeV

VERIFICATION / RESONANCE PARAMETERS

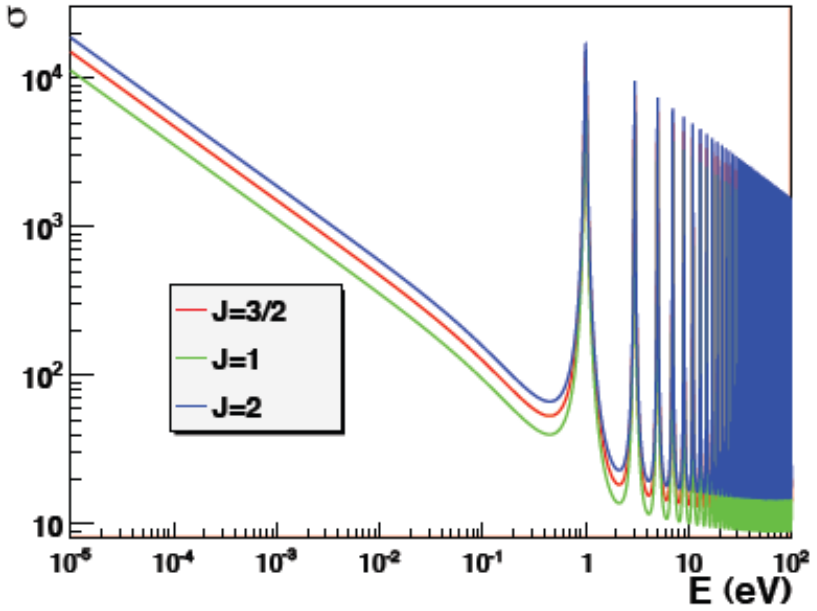
Angular momentum of a resonance state

Channel spin s sum of the spins of the two particles
l : orbital angular momentum
j : total angular momentum

$$\vec{j} = \vec{l} + \vec{s}$$

JEFF-3.2, Bk247 : Nucleus spin :3/2. l value : 0.
→ Theoretical: J=1 or J=2
but, Evaluation:J=3/2

JEFF-3.2, Np237 : Nucleus spin : 5/2. l value : 0.
→ Theoretical: J=2 or J=3
but, Evaluation: J=2, 3/2, 3

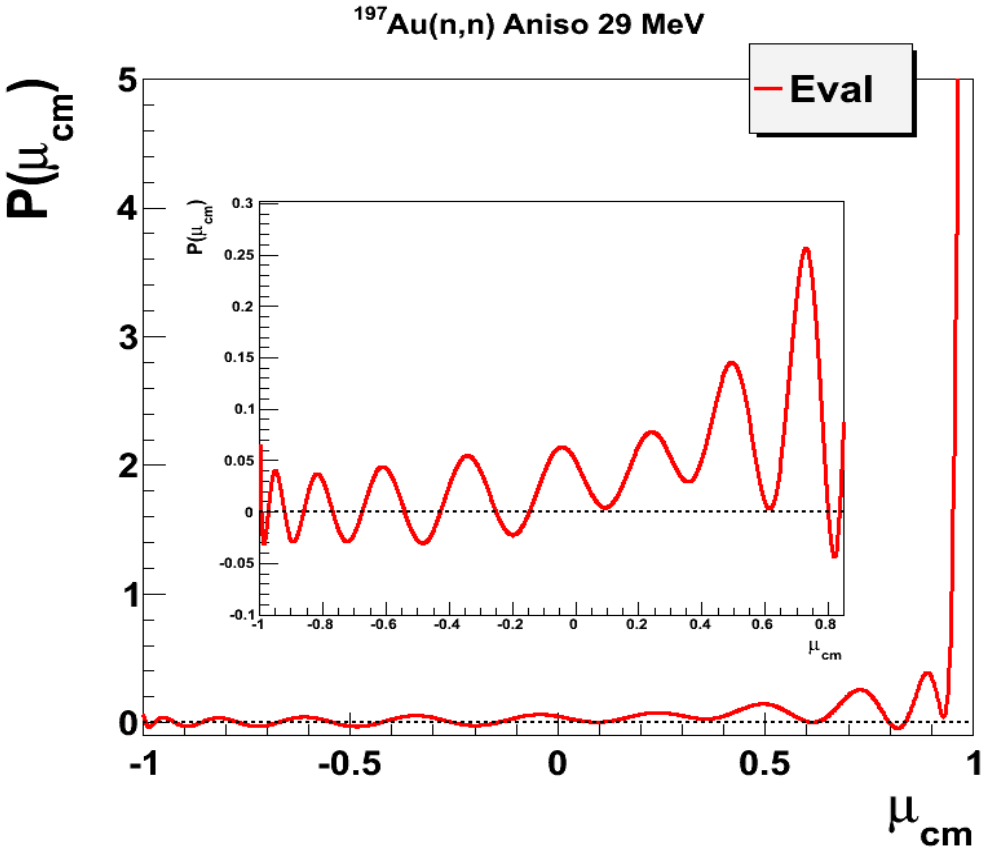


ANGULAR DISTRIBUTION

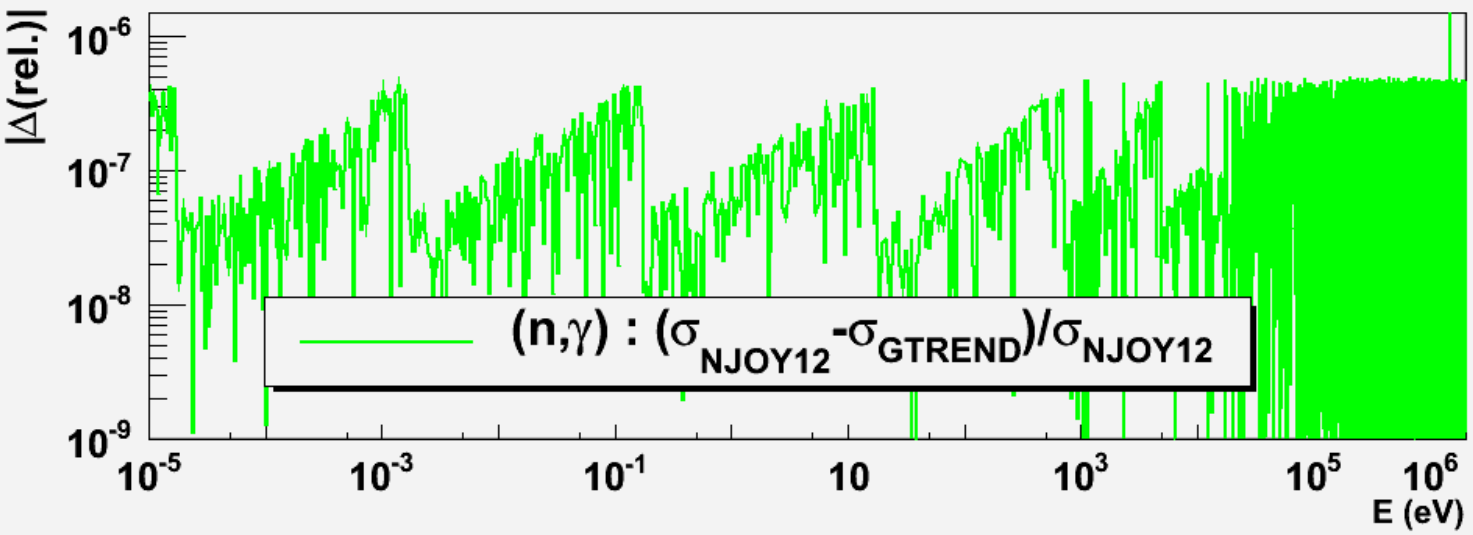
Negative angular distributions

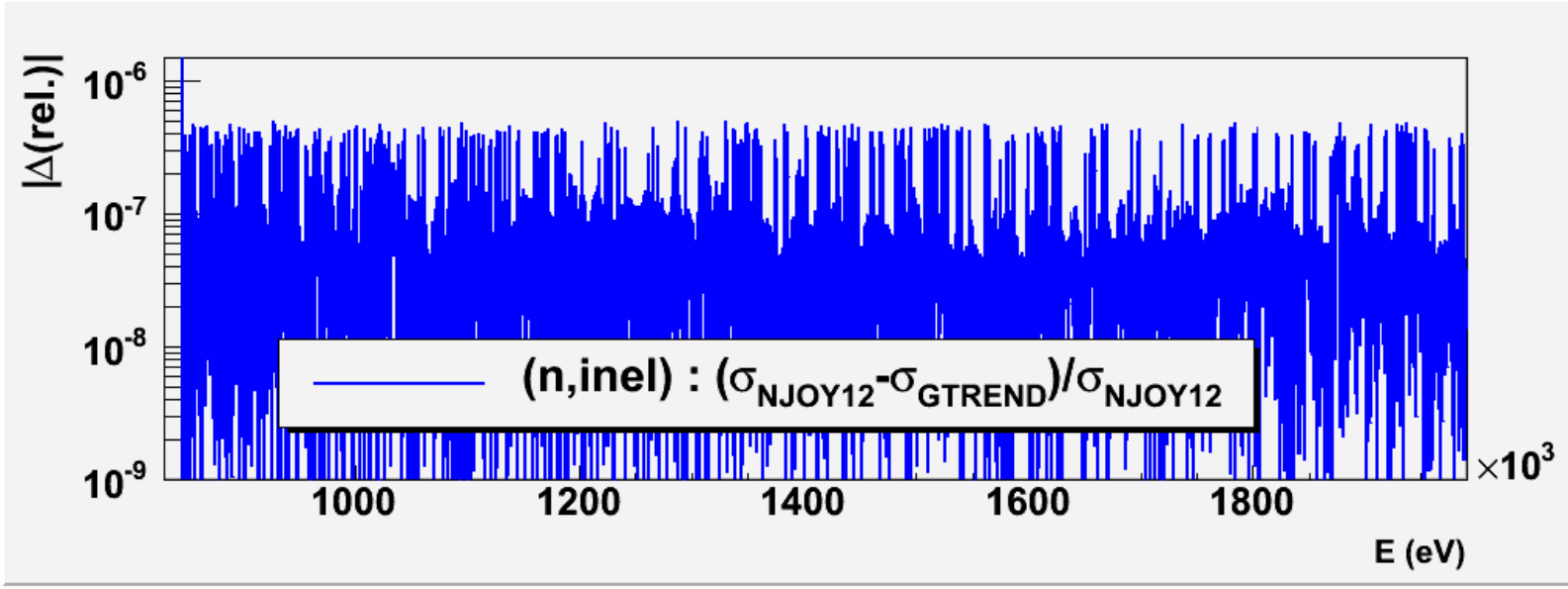
Legendre Polynomial coefficient :
Truncation at a given order
→ Negative probabilities (n,n), (n,n')

Cumulative density function (CDF) is not continuously growing.
→ Monte Carlo sampling ?



FE56 , R MATRIX LIMITED RECONSTRUCTION GTREND / NJOY2012





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