Feedback on CIELO Isotopes from ENDF/B-VII.0 Adjustment

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Adjustment

- A comprehensive multigroup neutron cross section adjustment has been carried out using ENDF/B-VII.0 data files and COMMARA 2.0 covariance matrix.
- An initial set of 148 integral experimental quantities has been analyzed (using the best calculational tools available) in order to provide C/E and associated calculational and experimental uncertainties and correlations.
- The initial set was reduced to 87 experimental values based on several considerations (duplications, some covariance data not available, experiments reserved for Fe and Na adjustment not included, etc.).
- A 33 energy group structure was adopted and sensitivity coefficients were calculated. Generalized Perturbation Theory (by ERANOS system) was used for static integral parameters and Depletion Perturbation Theory for time dependent parameters (done at ANL).

Type of experiments used in adjustment

	keff	Reactivity Coefficients	Spectral index	Irradiation	total # cases
Jezebel	2		3		5
Flattop	1		2		3
ZPPR-6/7,9	3	2	6		11
JOYO	1				1
Godiva	1		3		4
BigTen	1		3		4
Np Sphere	1				1
ZPPR-10,15	3	5			8
COSMO			9		9
PROFIL				26	26
TRAPU				15	15

34 COMMARA-2.0 nuclei with covariances used in adjustment

- **Light Nuclei:**

  ^{10}B, ^{16}O

- **Structural materials and fission fragments:**

  ^{23}Na, ^{52}Cr, ^{56}Fe, ^{58}Ni, ^{95}Mo, ^{97}Mo, ^{101}Ru, ^{105}Pd, ^{106}Pd,
  ^{133}Cs, ^{143}Nd, ^{145}Nd, ^{149}Sm, ^{151}Sm, ^{153}Eu

- **Major actinides:**

  ^{235}U, ^{238}U, ^{239}Pu

- **Minor actinides:**

  ^{234}U, ^{236}U, ^{237}Np, ^{238}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu
  ^{241}Am, ^{242m}Am, ^{243}Am, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{245}Cm

Eight types of parameters included in the adjustment

- (n,f):
  - cross section
  - nubar
  - PFNS (3 cases)
- (n,el):
  - cross section
  - P_1 (2 cases)
- (n,inel): cross section
- (n,γ): cross section
- (n,2n): cross section

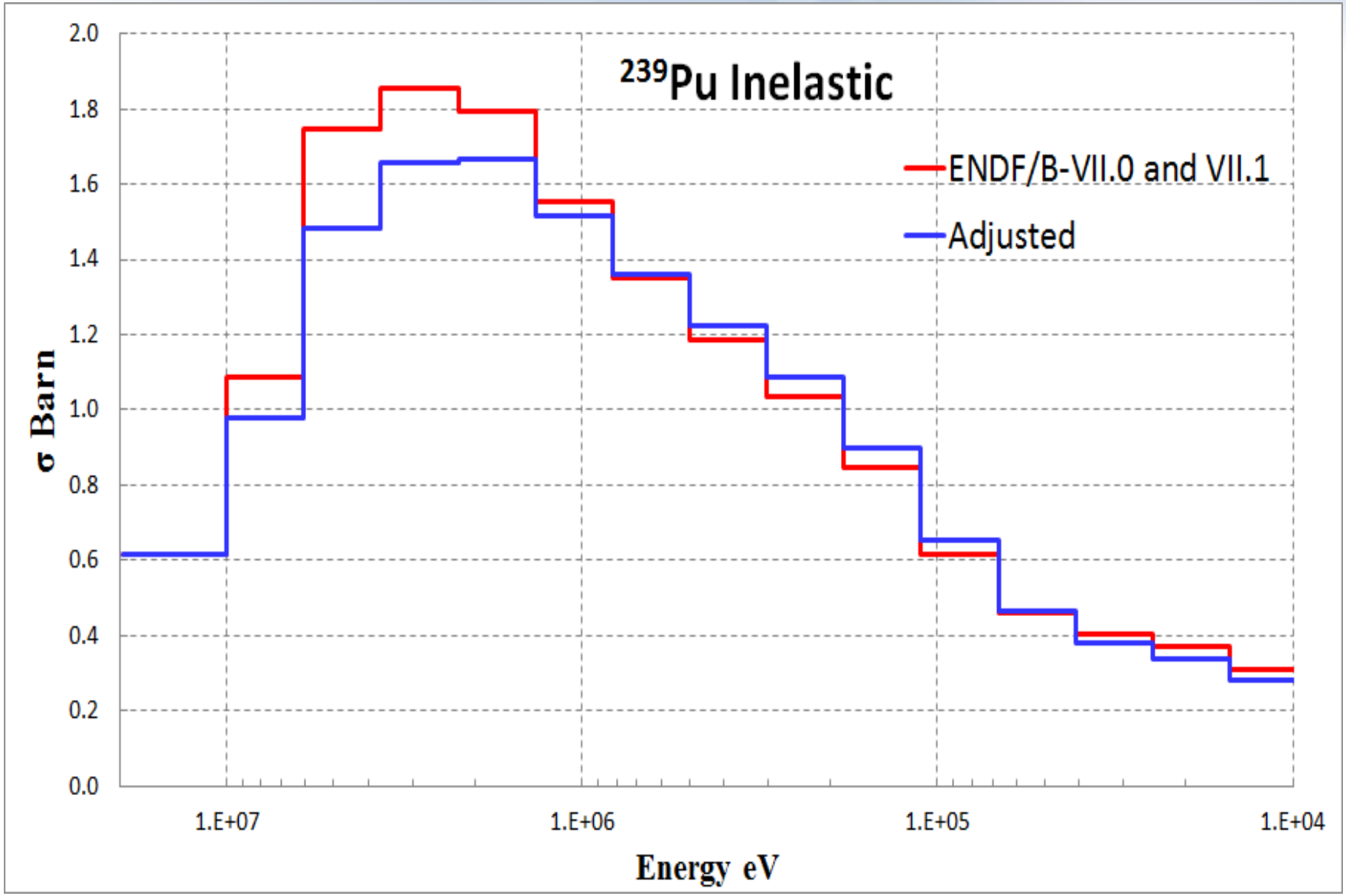
In all, 8976 points could have been adjusted, but only 1126 most important kept:

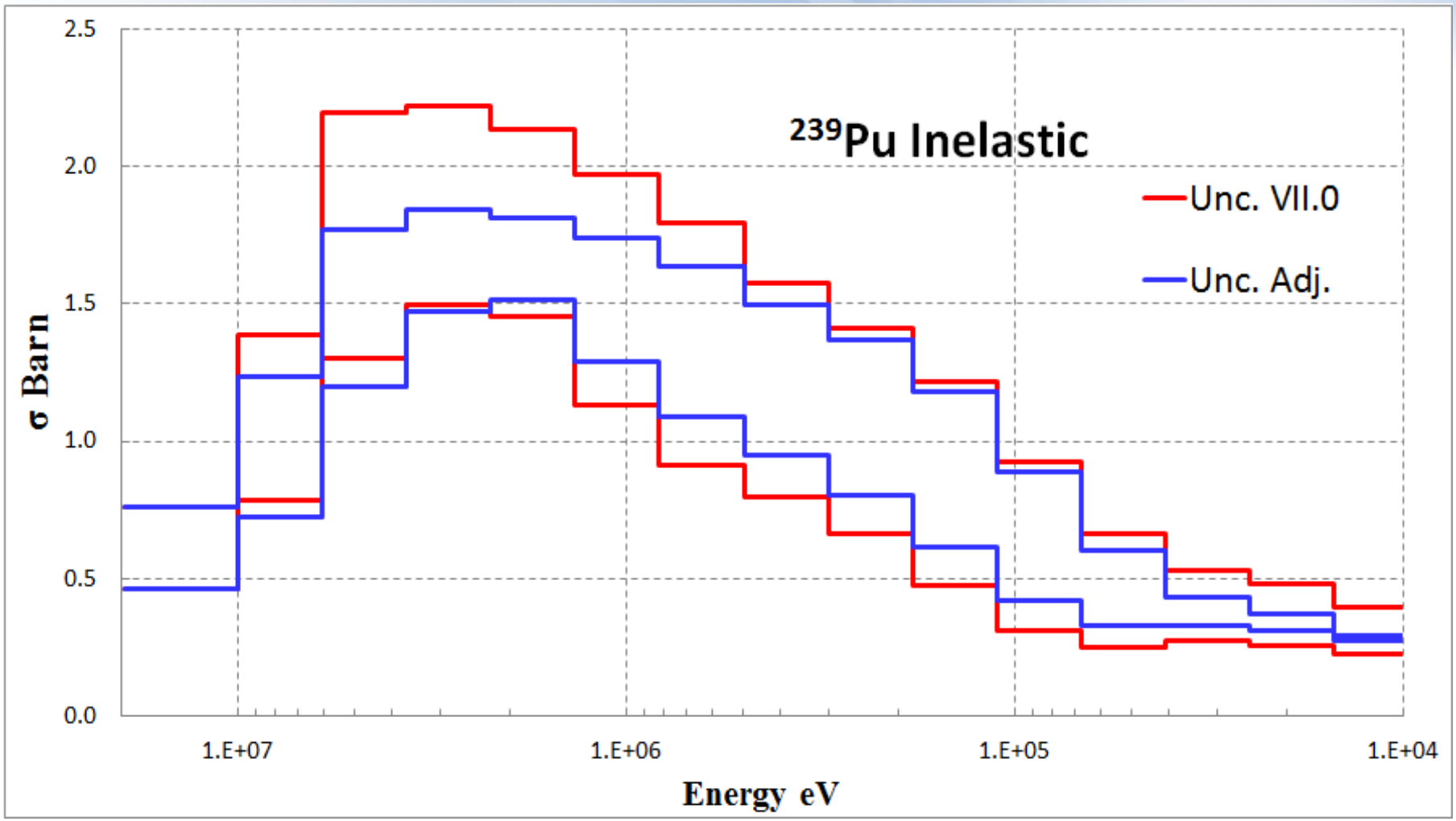
$$\left|\Delta R_{ip}^{1}\right| - \left|S_R^{+} DS_R\right| \geq \varepsilon^{1}$$

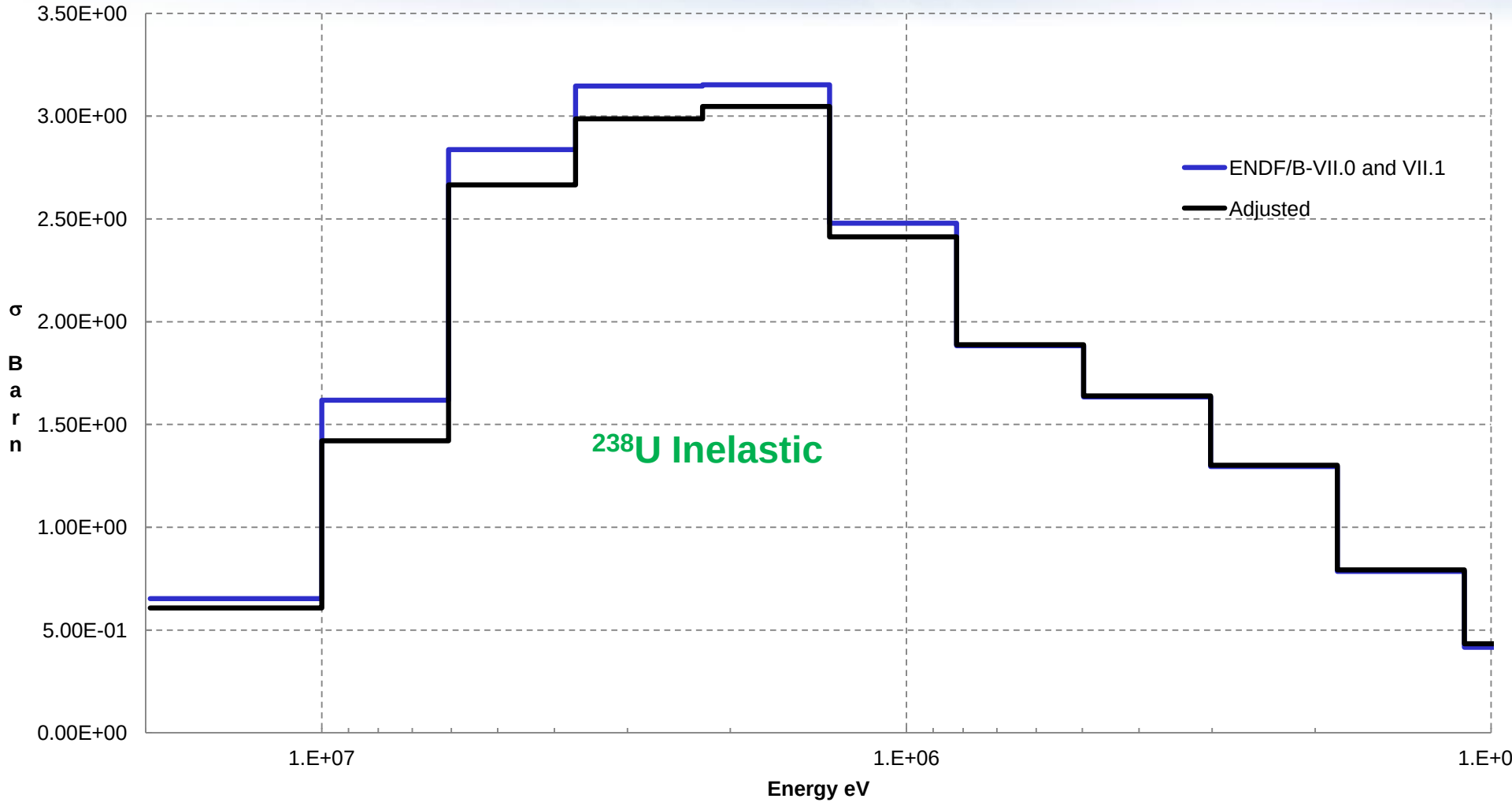
$$\mathbf{S}_{\mathbf{R}pj} = \frac{\Delta R_p}{\Delta \sigma_j}$$

Analysis of CIELO specific cross section adjustments

- **Inelastic cross section adjustments for the "Big Three" actinides:**
  - **^{238}U, ^{239}Pu and ^{235}U inelastic cross sections are all reduced in the range ~1-5 MeV. Their adjustments can be coupled to significant uncertainty reduction.**


239Pu Inelastic
ENDF/B-VII.0 and VII.1
Adjusted
σ Barn
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1.E+07
1.E+06
1.E+05
1.E+04
Energy eV


239Pu Inelastic
Unc. VII.0
Unc. Adj.
σ Barn
2.5
2.0
1.5
1.0
0.5
0.0
1.E+07
1.E+06
1.E+05
1.E+04
Energy eV


3.50E+00
3.00E+00
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
σ
B
a
r
n
1.E+07
1.E+06
1.E+0
Energy eV
ENDF/B-VII.0 and VII.1
Adjusted
238U Inelastic

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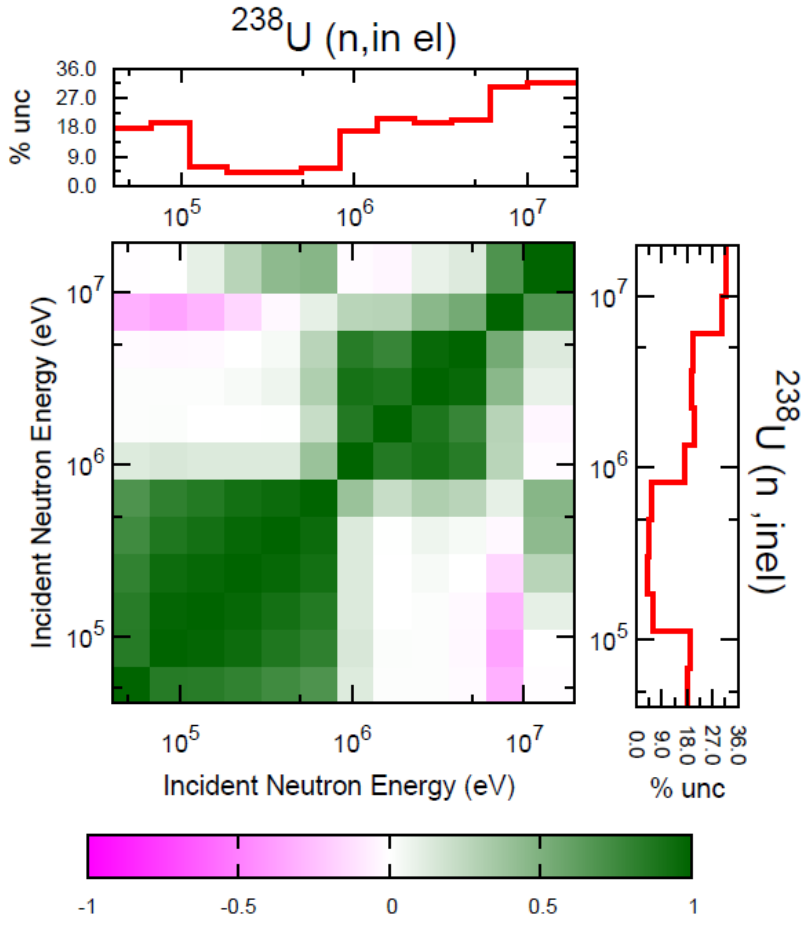
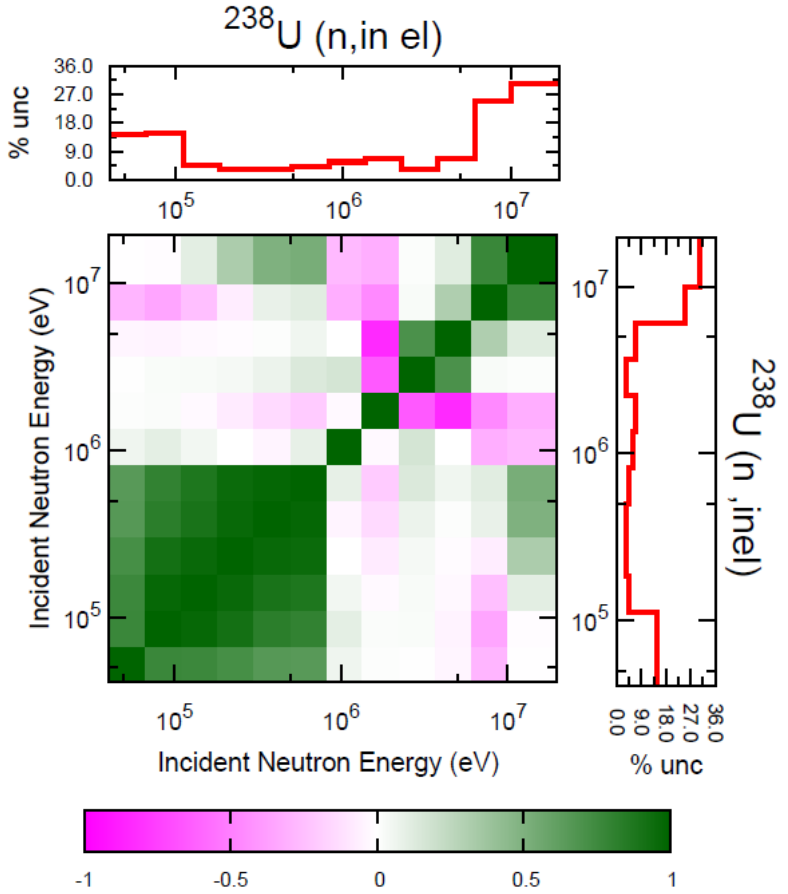
COMMARA 2.0



Adjusted



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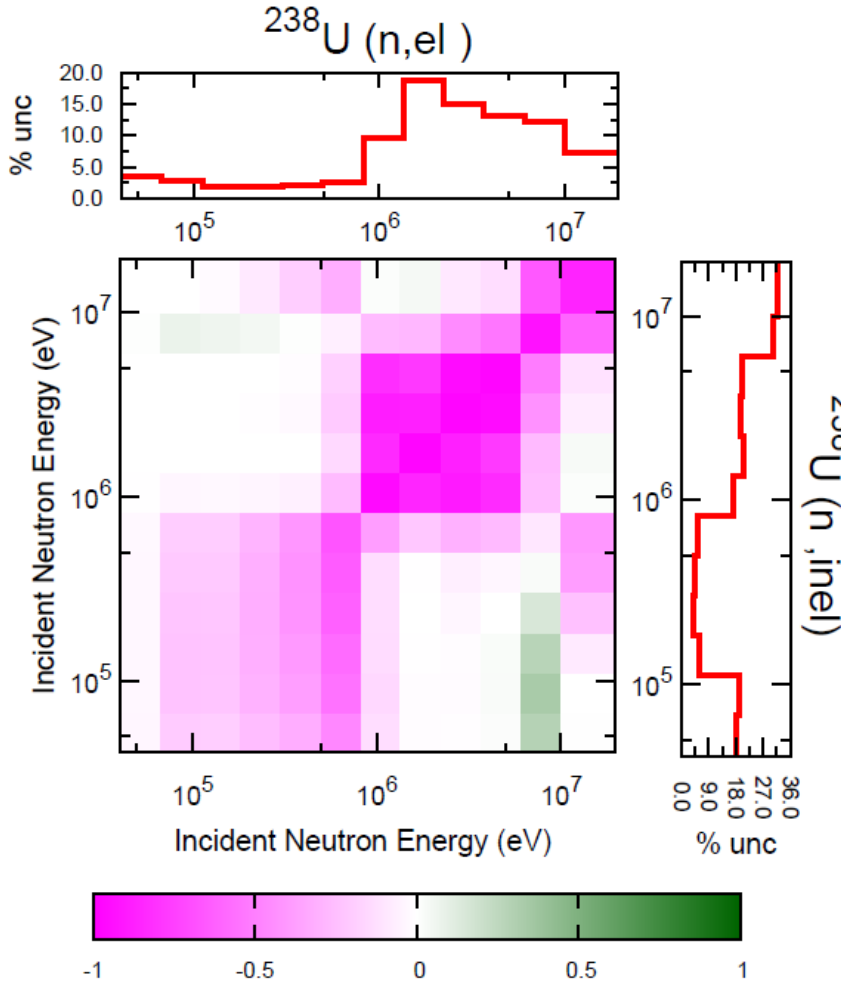
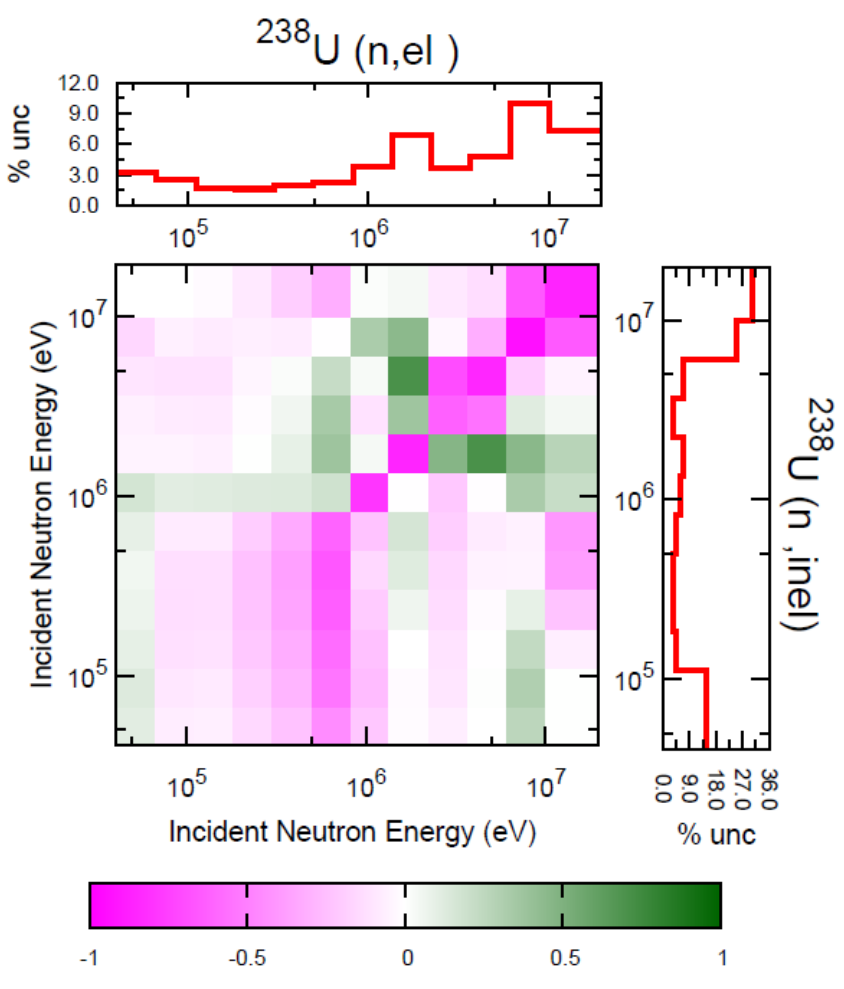
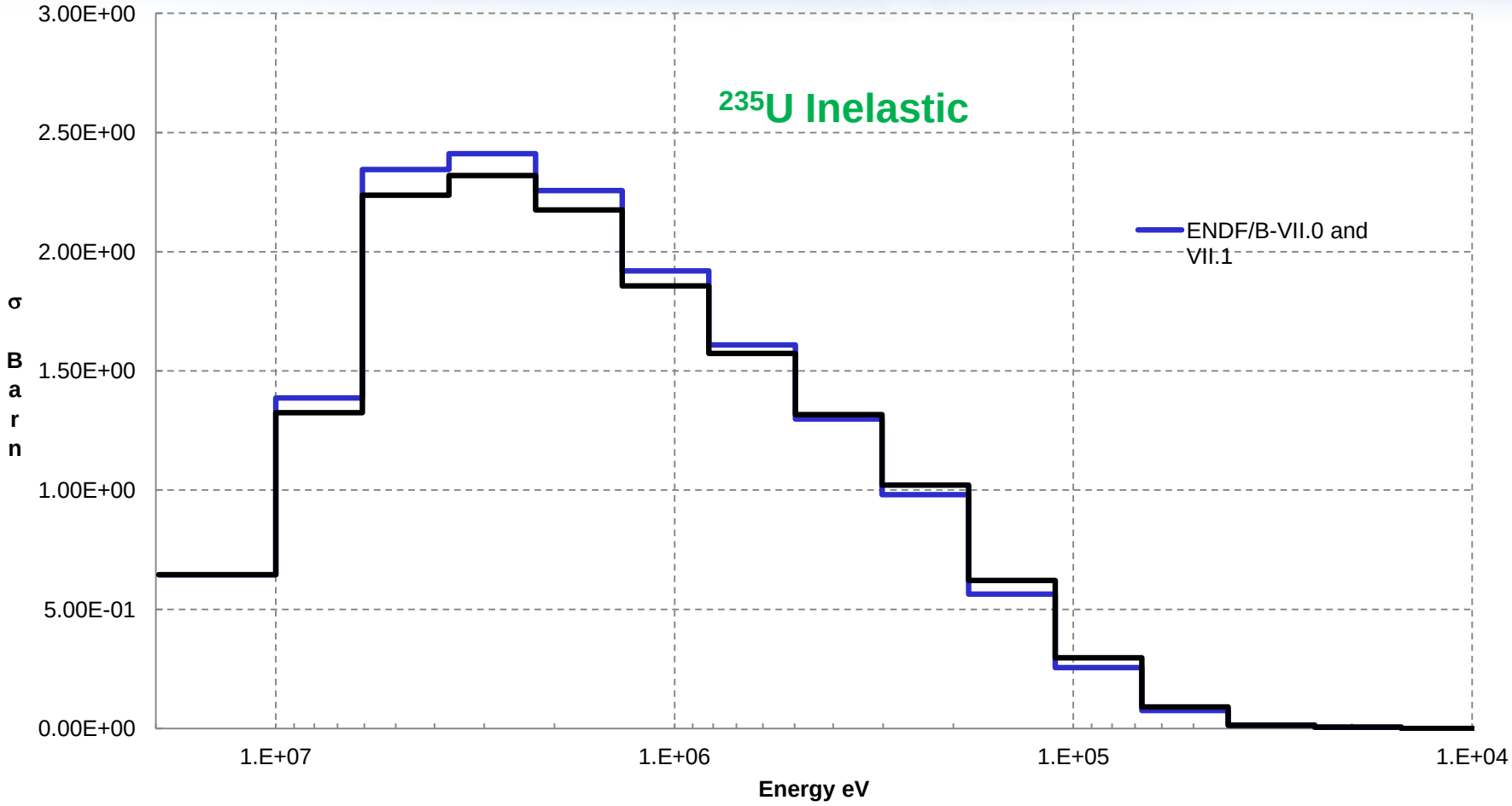
COMMARA 2.0

Adjusted






235U Inelastic
ENDF/B-VII.0 and VII.1
σ
B
a
r
n
3.00E+00
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
1.E+07
1.E+06
1.E+05
1.E+04
Energy eV

CORRELATIONS

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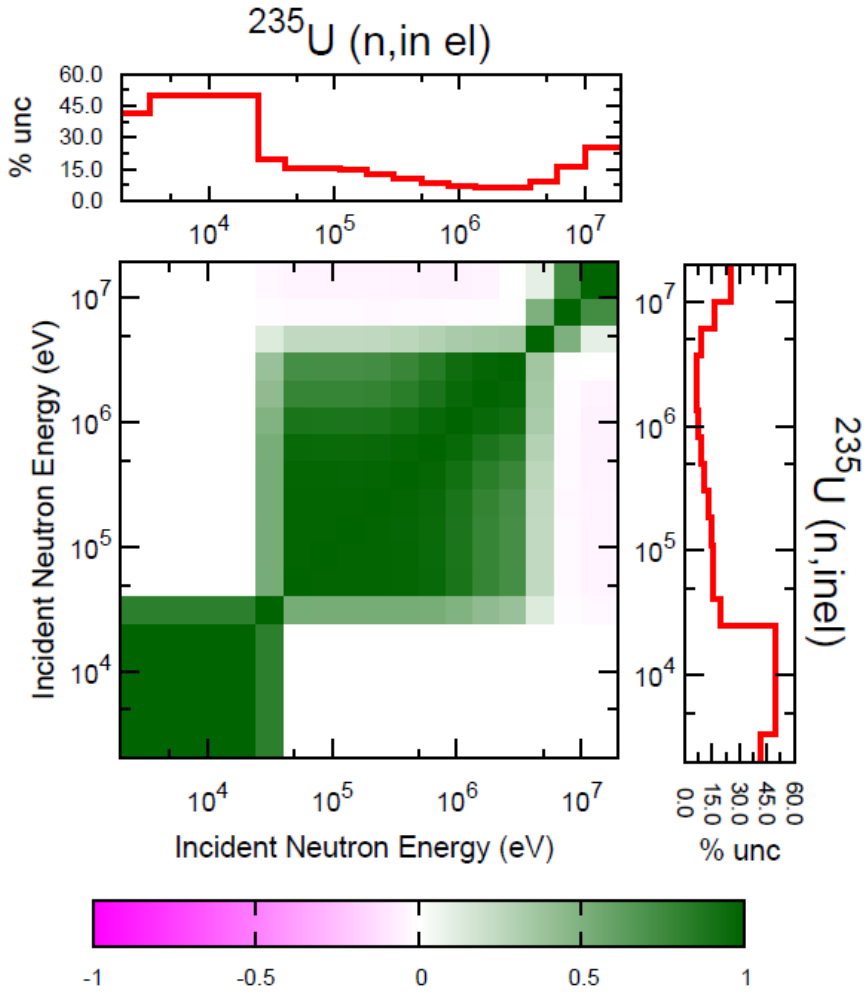
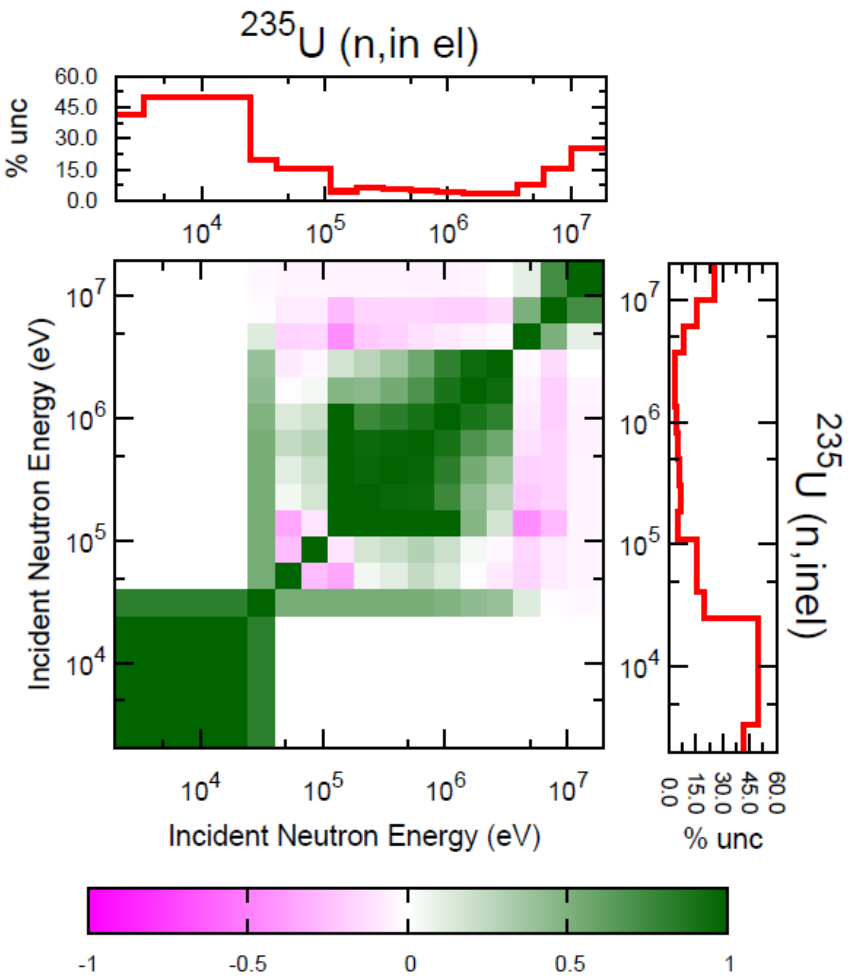
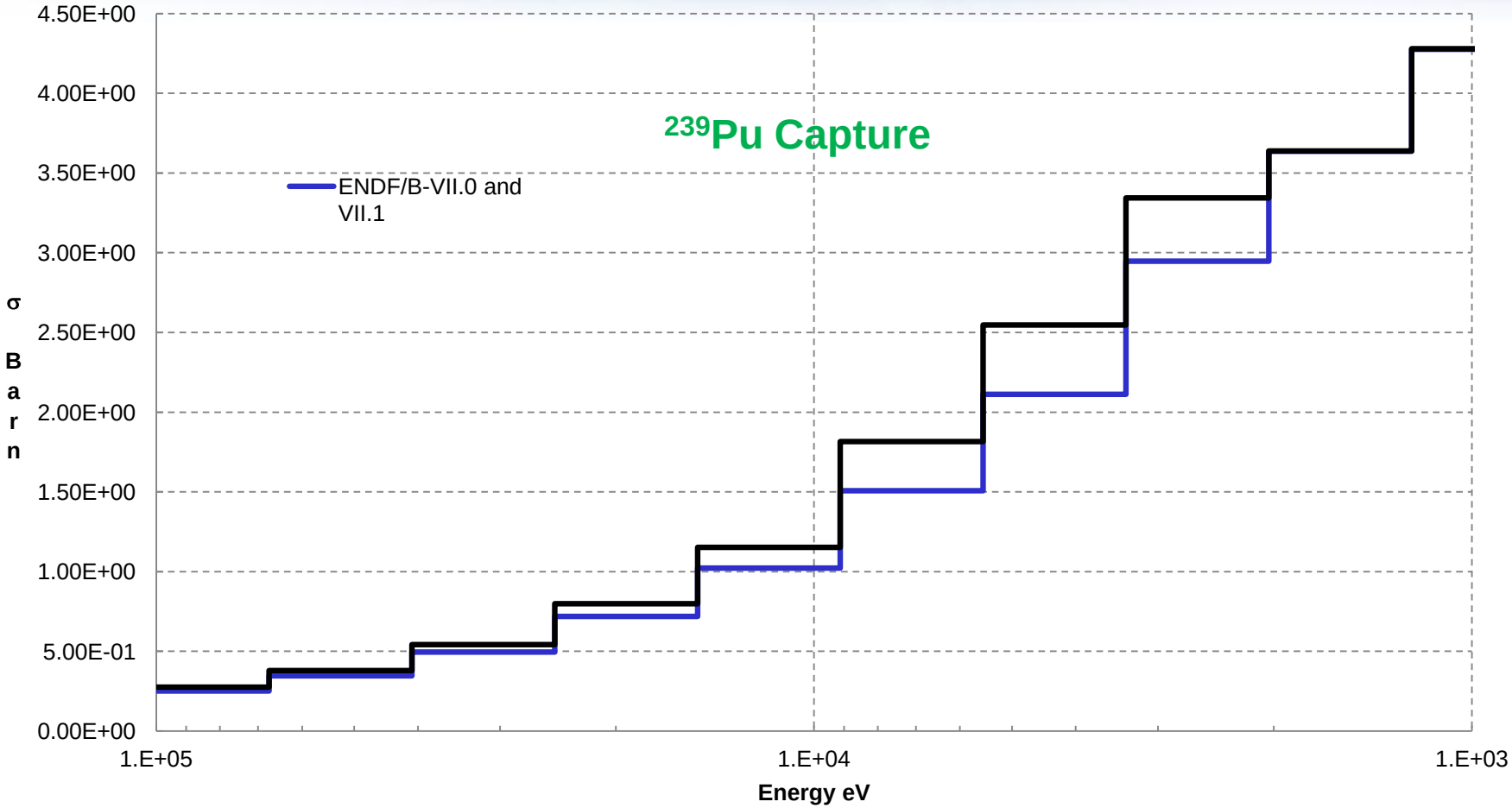


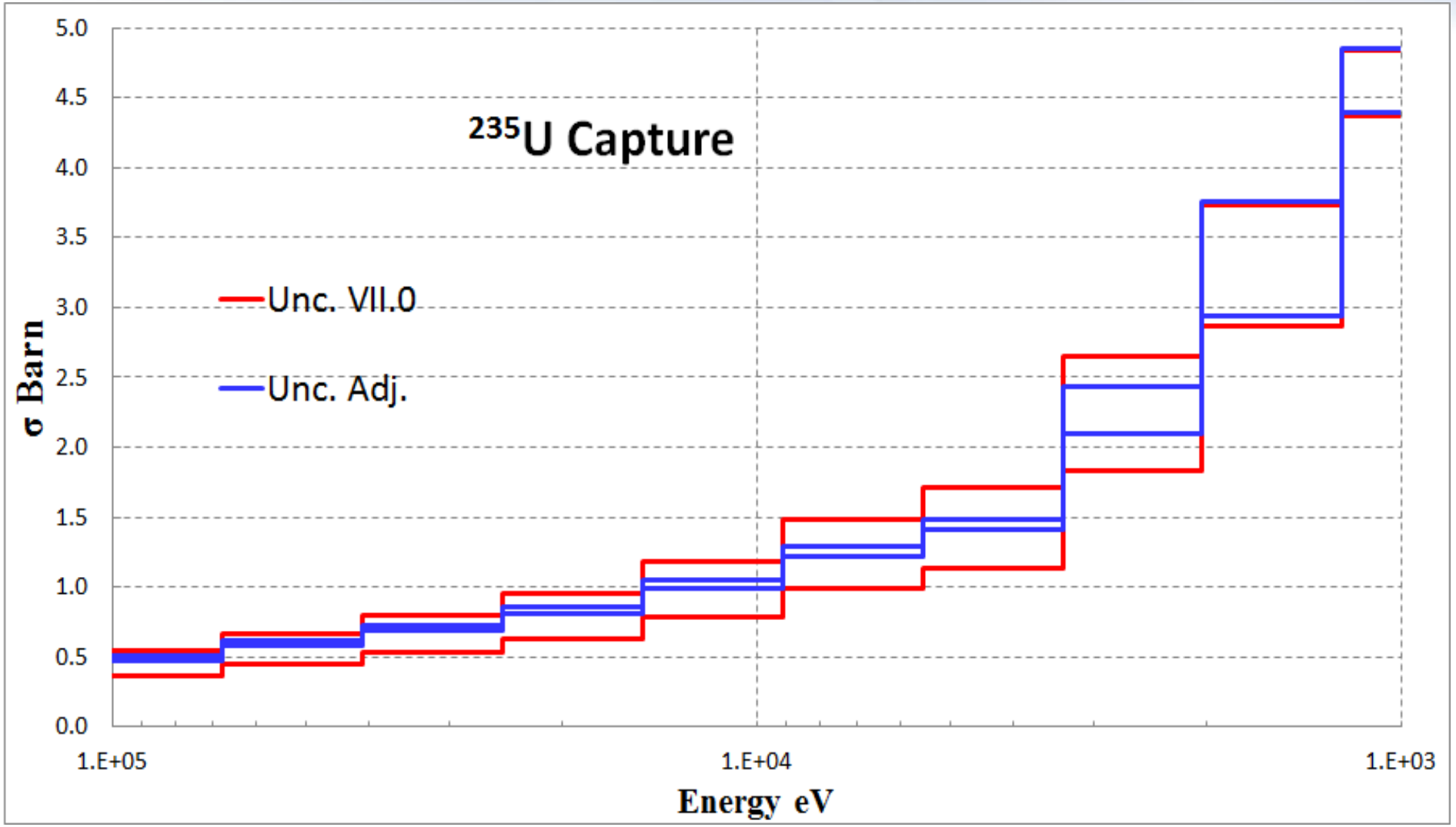
Adjusted



Analysis of CIELO specific cross section adjustments

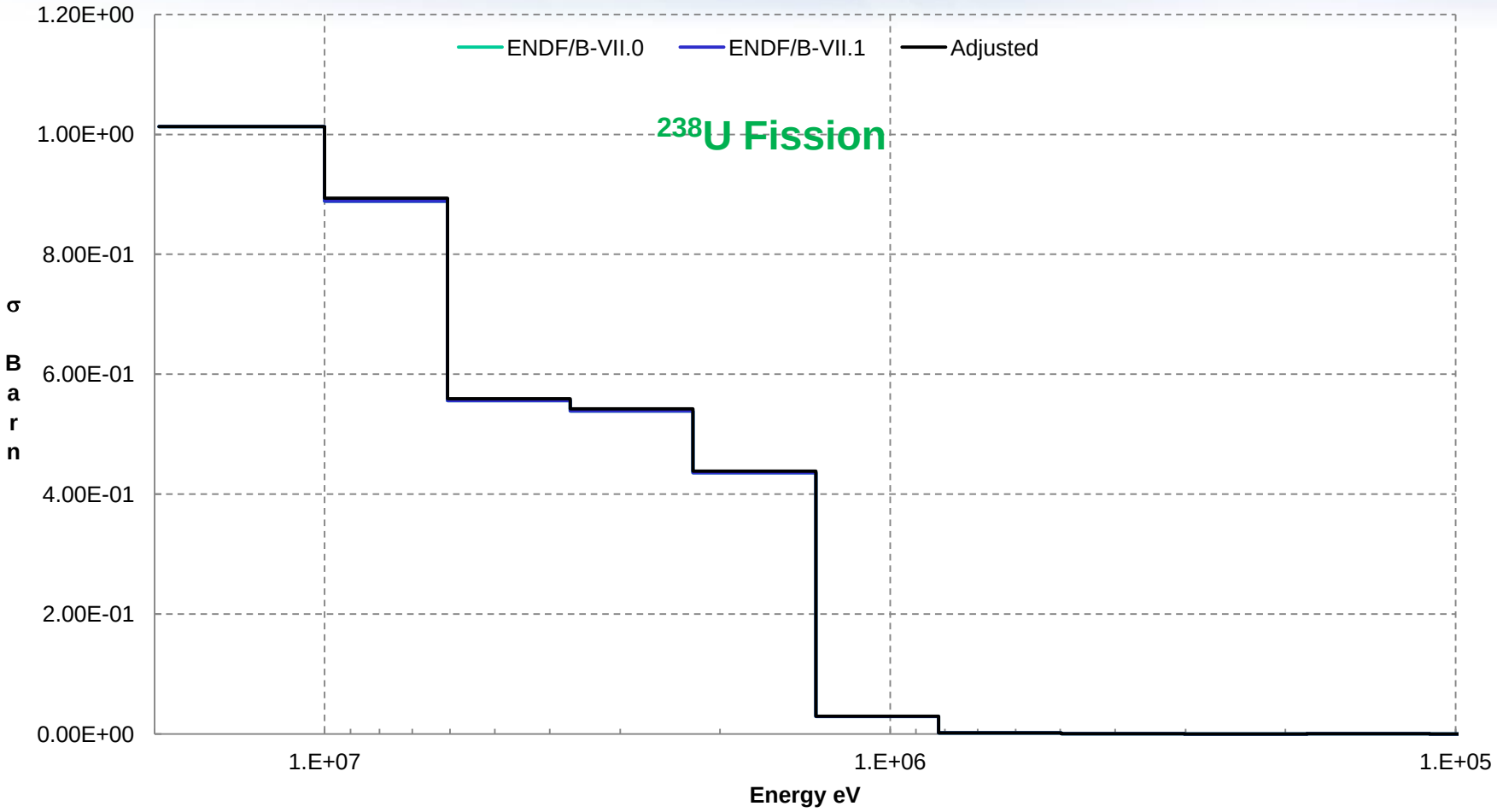
- **Capture cross section adjustments for the "Big Three" actinides:**
  - **The ^{239}Pu capture cross section is significantly reduced (5 to 10%) in the 1 Kev to 10 Kev.**
  - **The ^{235}U and ^{238}U capture cross section does not change too much but the ^{235}U adjustment is coupled to a very significant uncertainty reduction.**

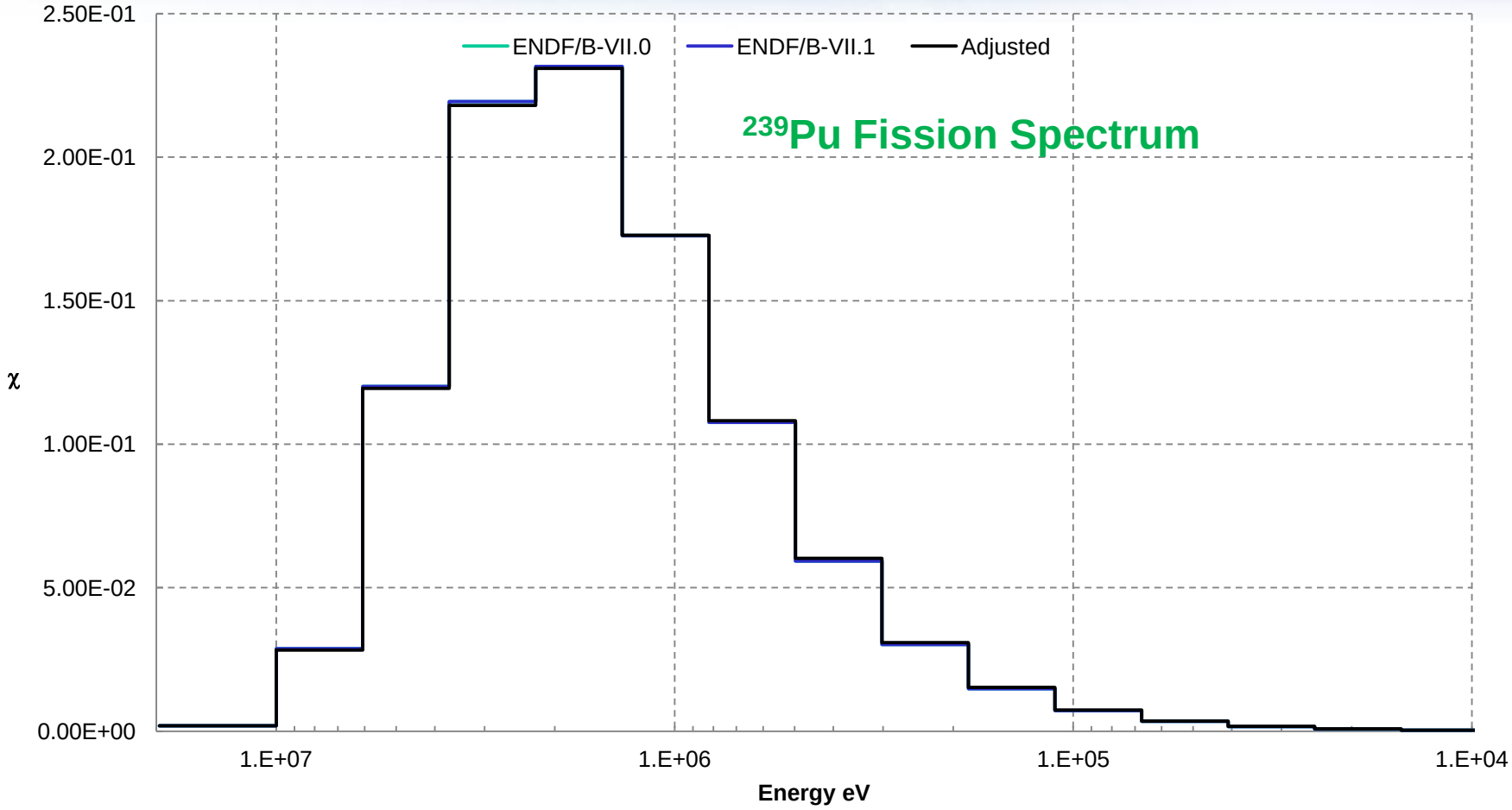

239Pu Capture
ENDF/B-VII.0 and VII.1
σ Barn
4.50E+00
4.00E+00
3.50E+00
3.00E+00
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
1.E+05
1.E+04
1.E+03
Energy eV


^{235}U Capture
Unc. VII.0
Unc. Adj.
σ Barn
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.E+05
1.E+04
1.E+03
Energy eV

Analysis of CIELO specific cross section adjustments

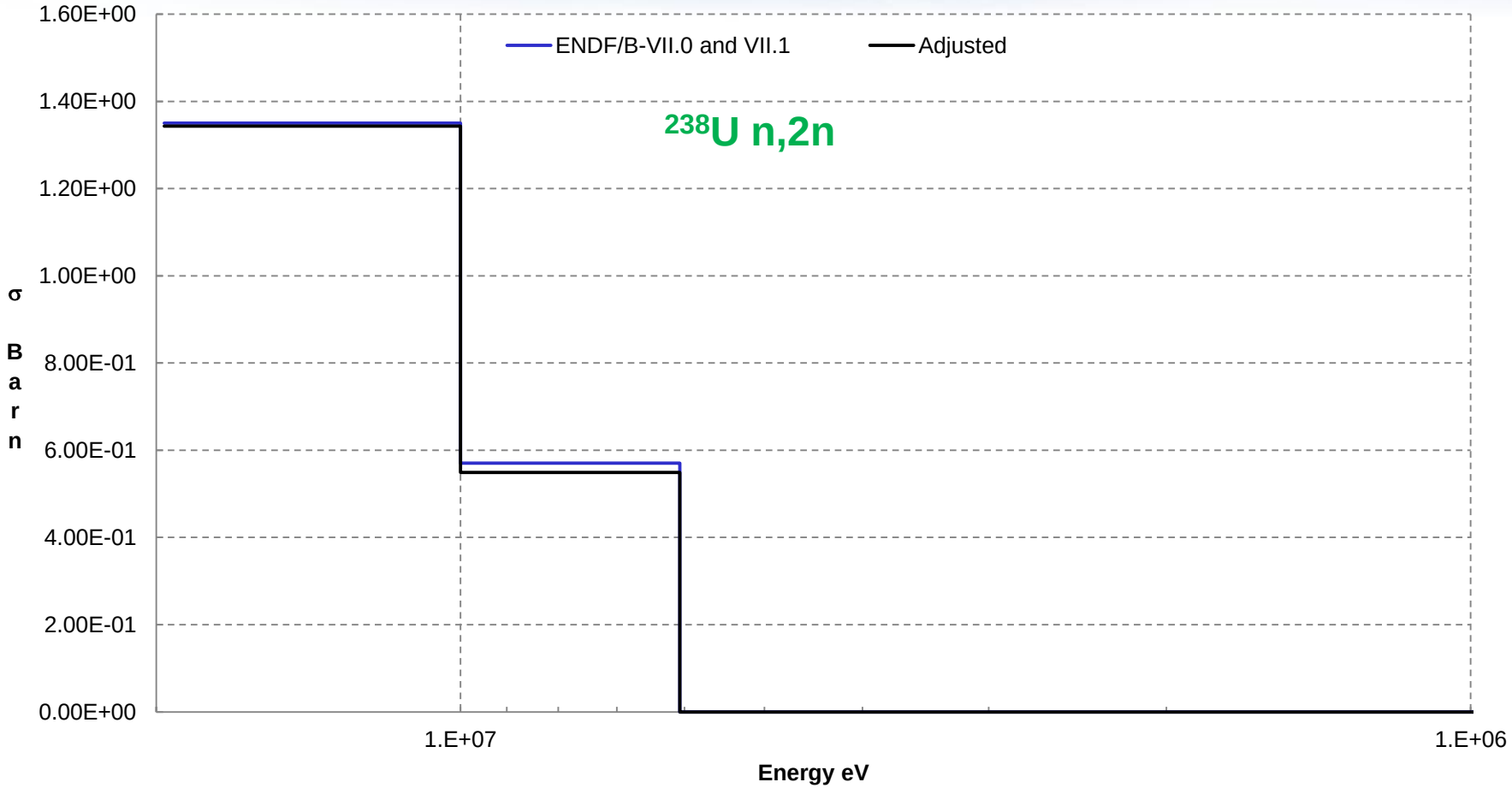
- **Fission cross sections and fission spectrum adjustments for the "Big Three" actinides:**
  - **No major adjustment because initial standard deviation is very low**
  - **Very low modification for ^{239}Pu fission spectrum (only one available in COMMARA 2.0)**

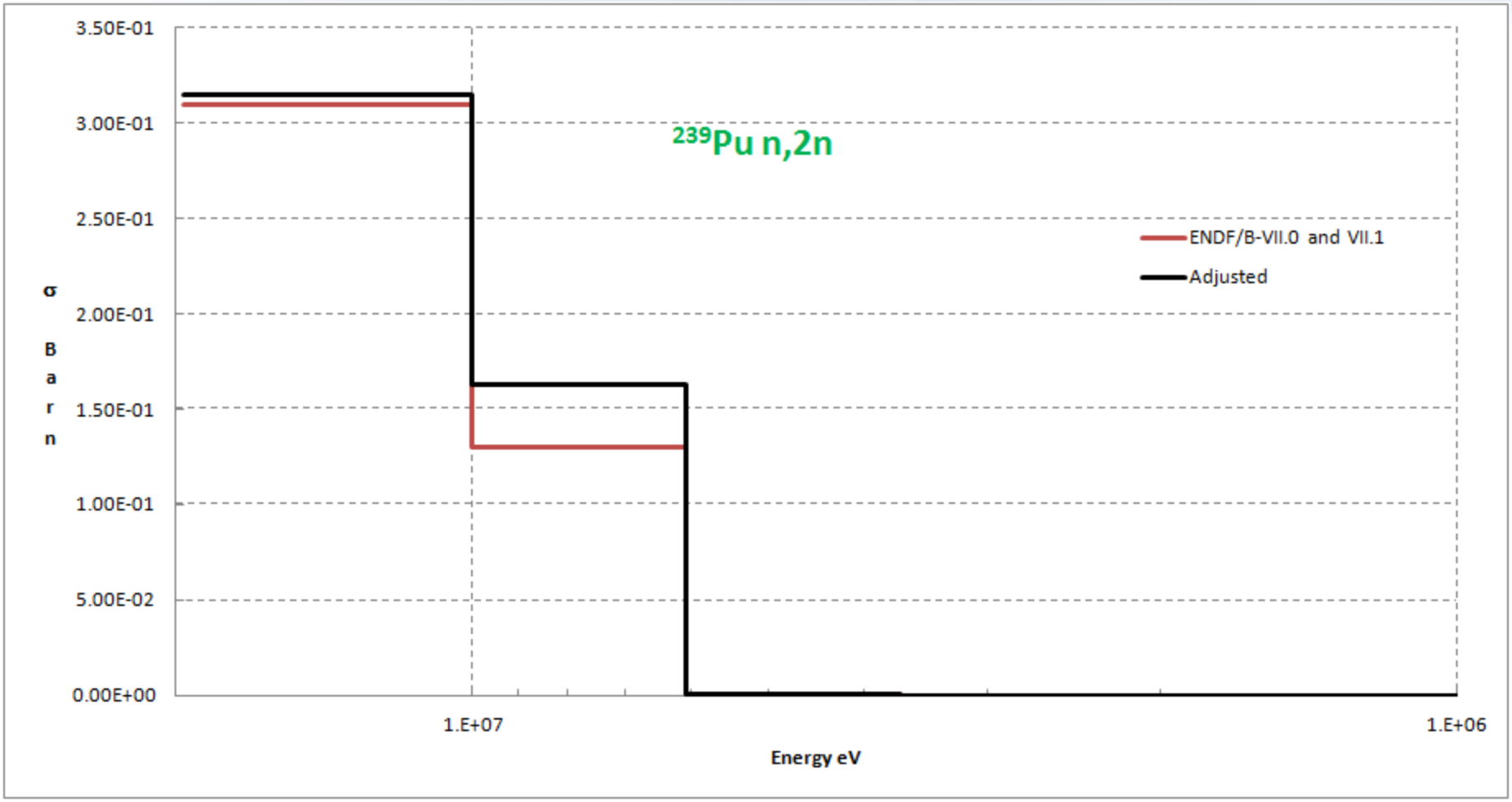

ENDF/B-VII.0
ENDF/B-VII.1
Adjusted
238U Fission
1.20E+00
1.00E+00
8.00E-01
6.00E-01
4.00E-01
2.00E-01
0.00E+00
σ
B
a
r
n
1.E+07
1.E+06
1.E+05
Energy eV

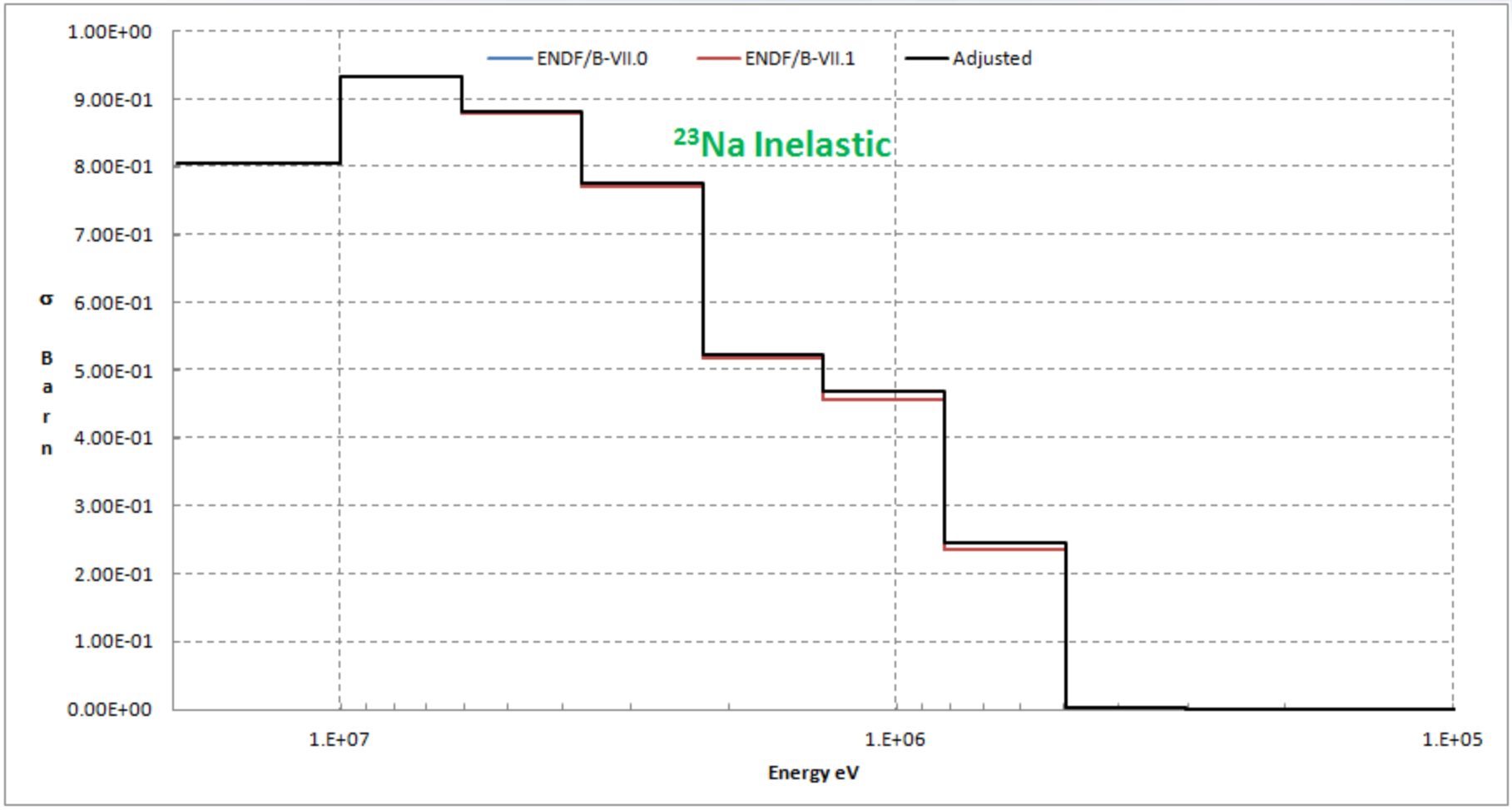

ENDF/B-VII.0
ENDF/B-VII.1
Adjusted
239Pu Fission Spectrum
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
χ
1.E+07
1.E+06
1.E+05
1.E+04
Energy eV

Analysis of CIELO specific cross section adjustments

- **(n,2n) cross section adjustments for the "Big Three" actinides:**
  - **The ^{238}U (n,2n) is reduced.**
  - **The ^{239}Pu (n,2n)) is significantly increased**
  - **For the ^{235}U (n,2n) there is no sensitivity in the experiments.**


ENDF/B-VII.0 and VII.1
Adjusted
238U n,2n
1.60E+00
1.40E+00
1.20E+00
1.00E+00
8.00E-01
6.00E-01
4.00E-01
2.00E-01
0.00E+00
σ
Barn
1.E+07
1.E+06
Energy eV


239Pu n,2n
ENDF/B-VII.0 and VII.1
Adjusted
σ
B
a
r
n
3.50E-01
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
1.E+07
1.E+06
Energy eV


ENDF/B-VII.0
ENDF/B-VII.1
Adjusted
23Na Inelastic
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
σ
Barn
1.E+07
1.E+06
1.E+05
Energy eV

ABR Ox. K_{eff} Uncertainty (pcm)

COMMARA 2.0

Isotope	σ_{cap}	σ_{fiss}	ν	σ_{el}	σ_{inel}	χ	P_1^{el}	Total
U238	278	29	112	105	547	0	0	633
PU239	308	223	71	30	79	161	0	428
FE56	170	0	0	172	147	0	44	287
PU240	61	45	82	5	17	24	0	116
NA23	4	0	0	20	80	0	69	107
CR52	21	0	0	38	18	0	0	47
O16	5	0	0	45	2	0	0	46
PU241	10	7	3	0	2	0	0	13
Total	453	229	156	213	578	163	82	834

ADJUSTED

Isotope	σ_{cap}	σ_{fiss}	ν	σ_{el}	σ_{inel}	χ	P_1^{el}	Total
U238	-56	-12	-17	-20	-43	0	0	-76
PU239	37	43	17	4	7	-30	0	52
FE56	92	0	0	100	41	0	33	146
PU240	11	14	23	3	11	11	0	33
NA23	5	0	0	-9	-12	0	-34	-37
CR52	7	0	0	15	-11	0	0	12
O16	5	0	0	49	2	0	0	49
PU241	-1	6	4	0	2	0	0	7
Total	84	44	22	111	-15	-28	-10	143

Conclusions

- There were no real targeted experiments for Na and Fe
- We can add ZPR-3 54 (reaction rates slopes), propagation experiments in Na and Fe, and more sodium void reactivity experiments.
- For ^{238}U inelastic it would nice to add transmission experiments with only ^{238}U
- More experiments targeted to ^{235}U are needed.
- There is a significant danger of compensation: low standard deviation for fission, lack of covariance data for certain reactions (fission spectra, anisotropic scattering)
- In any case, it would be useful to compare what are the central values and associated standard deviations obtained in different adjustments (JAEA, and CEA). This can be done for the infinite dilution cross section in the 33 group energy structure (as done for SG33), and see where we stand.
- Open problem: what to do with the new correlation matrix after adjustment?