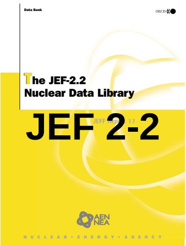

QUALIFICATION OF THE JEF2.2 CROSS-SECTIONS IN THE EPITHERMAL AND THERMAL RANGES USING A STATISTICAL APPROACH

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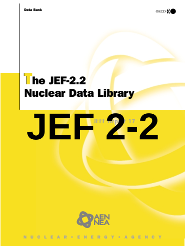

BUT : *Current cross-sections do not satisfy safety design parameter accuracy requirements*

For Example

- +/- 600 pcm on K_{eff} for PWR-UO_2 lattice
- +/- 1000 pcm on K_{eff} for PWR-MOx lattice

Due to Cross-Sections Uncertainties

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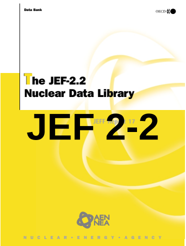
- Physicists built *Specific Integral Experiments* (fundamental or mock-up types) to measure Neutronic Parameters with improved accuracies : for example +/- 300 pcm (1σ) on K_{eff} or +/- 1 % (1σ) on fission rate distributions

⇒A Statistical Approach is used to combine informations coming from these integral experiments and those coming from microscopic cross-section measurements (traditionnaly used for fast reac-tors libraries but not for THERMAL reactors)

Maximum Likelyhood Principle and the BAYES Theorem



Try to use this statistical technique to qualify thermal cross-section libraries based on the JEF2.2 basic nuclear data set.

- ^{235}U, ^{238}U, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{16}O
- Natural Zr, ^{56}Fe, ^{58}Ni, ^{52}Cr, ^{27}Al
- ^{10}B, Natural Gd
- ^{12}C, H_2O
- Capture, Fission, ν, elastic and inelastic

Data Needed to apply this statistical approach

- Measurement of Fundamental Neutronic Parameters
- Variance/covariance Matrix relative to these Experiments
- Sensitivity Coefficients Matrix of the integral parameters to the cross-sections.
- Variance/covariance matrix relative to the cross-sections

Analyzed Integral Experiments

- ***4 International Experimental Benchmarks***
  - TRX-1 ; TRX-2 ; ORNL and PNL spheres
- ***10 UO_2 Experiments***
  - EPICURE-1 ; CAMELEON ; DIMPLE ; VVER and BNL Lattices
- ***9 $UPuO_2$ Experiments***
  - ERASME ; JAERI ; EPICURE-2
- ***1 Spent fuel analysis***
  - SHERWOOD

↳ 23 K_{eff}

↳ 27 Spectral indices

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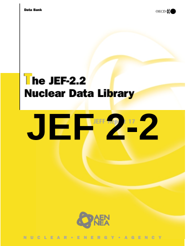
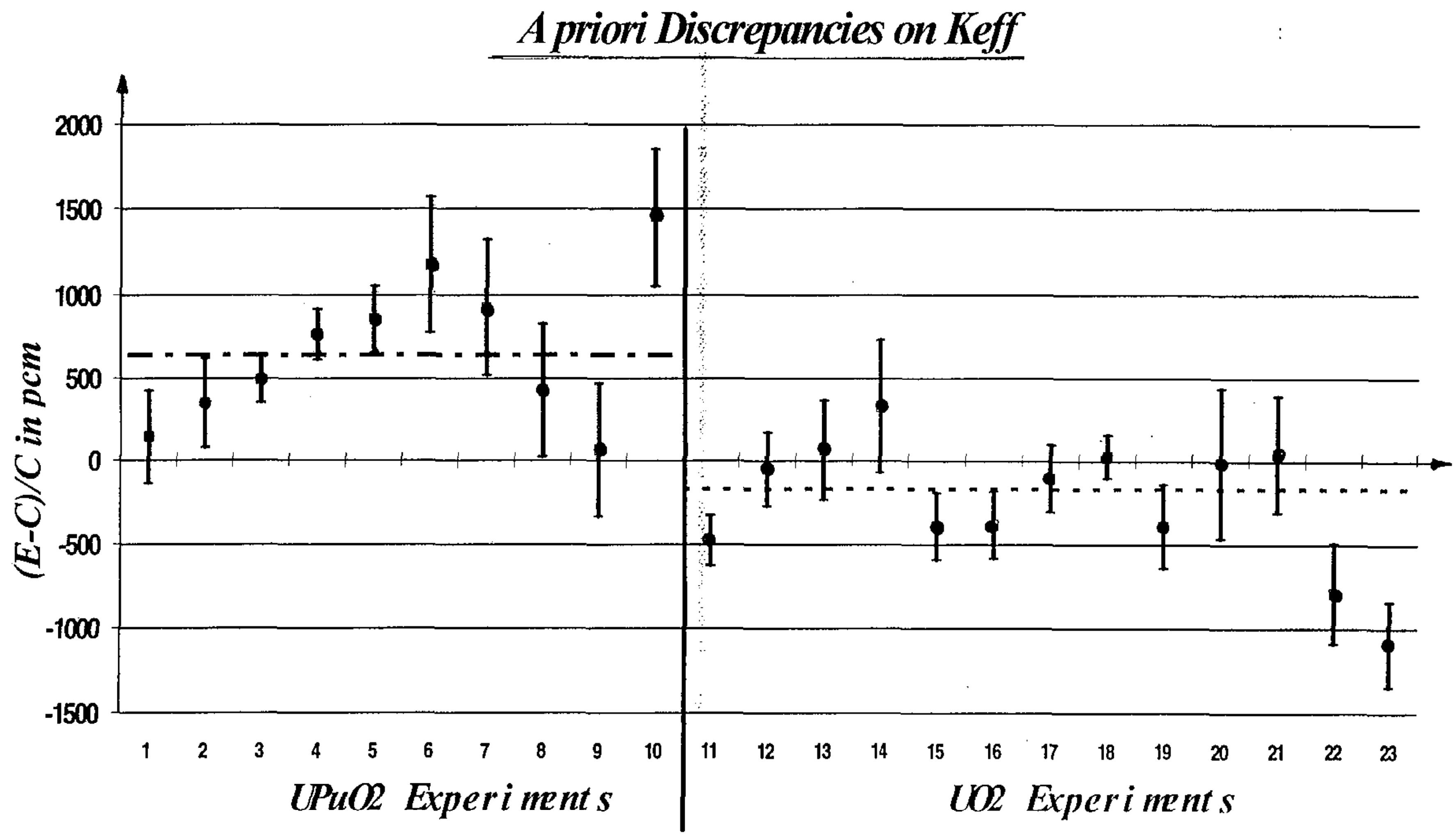
Results of the Adjustments

- *A Priori Dispersion Factor* $\chi^2 = 5.00$
- *A Posteriori Dispersion Factor* $\chi^2 = 0.95$

↳ *Consistent with the statistical enhancement factor, which must be :*

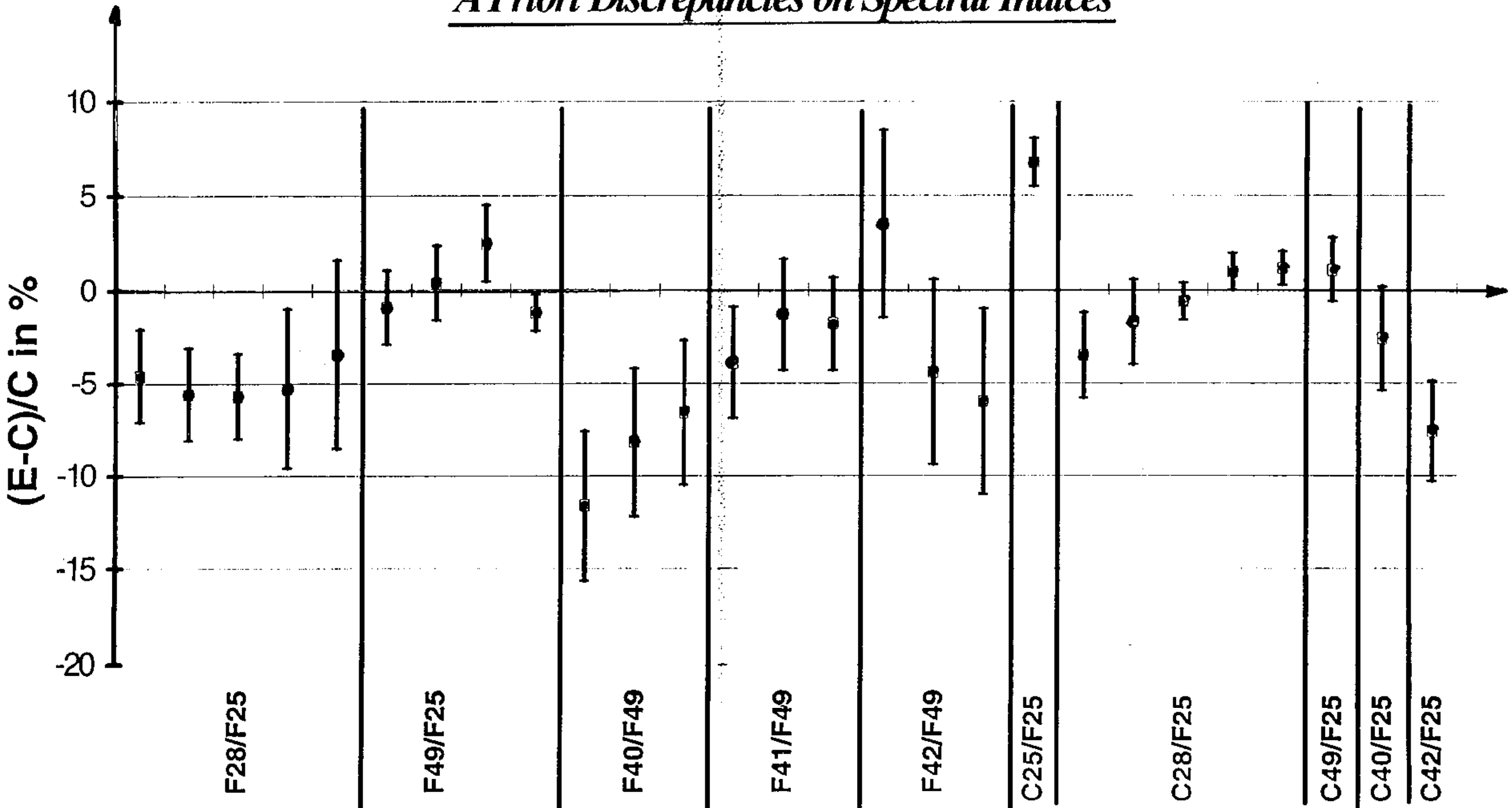
$$1-\sqrt{\frac{2}{N}} \leq \chi^2 \leq 1+\sqrt{\frac{2}{N}}$$


The JEF-2.2 Nuclear Data Library
JEF 2-2


A priori Discrepancies on Keff
(E-C)/C in pcm
2000
1500
1000
500
0
-500
-1000
-1500
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
UPuO2 Experiments
UO2 Experiments

14C80149

A Priori Discrepancies on Spectral Indices



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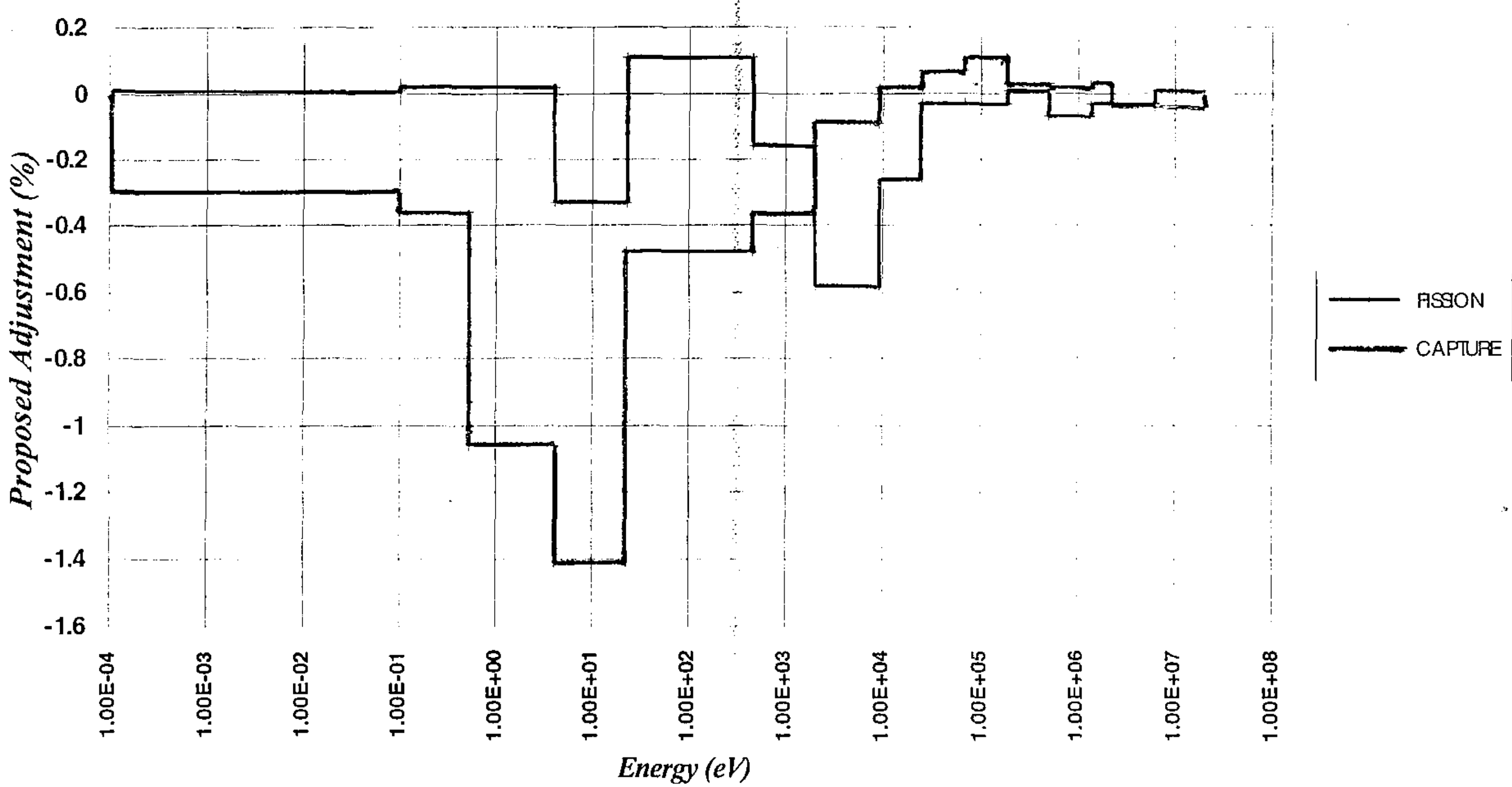
Cross-Sections of 239Pu



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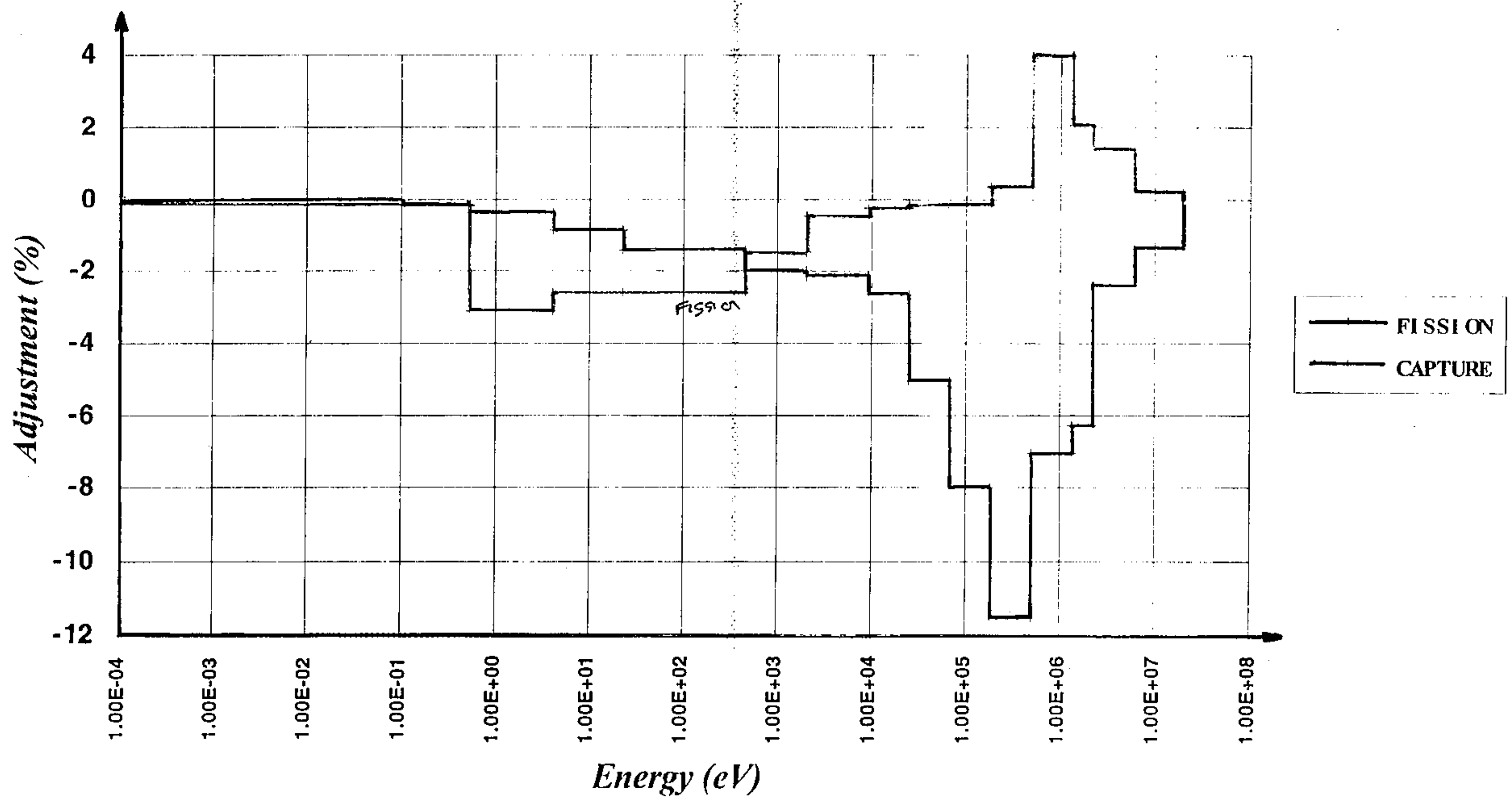
Cross-Section of 240Pu



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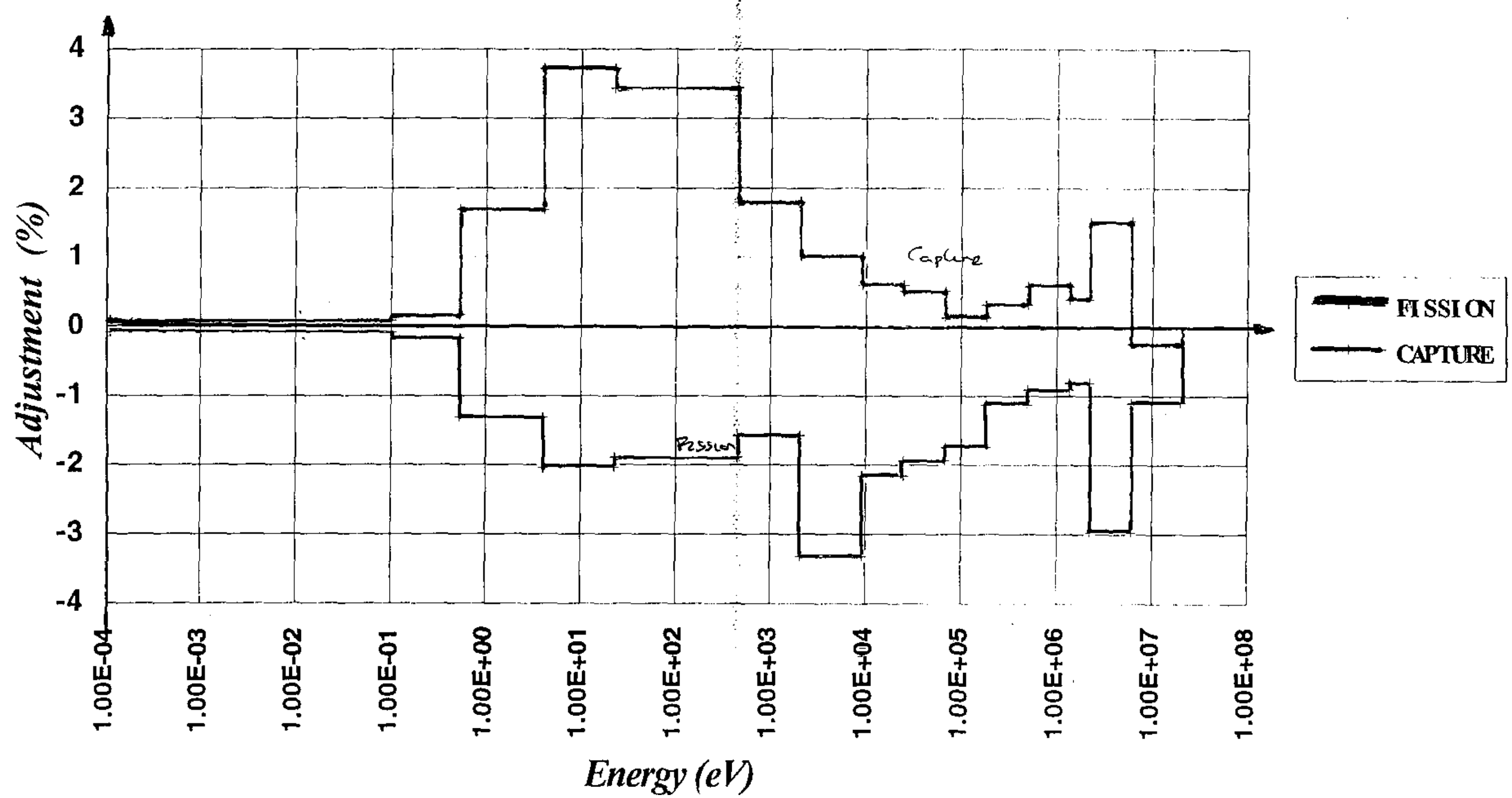
Cross-Sections of 241Pu



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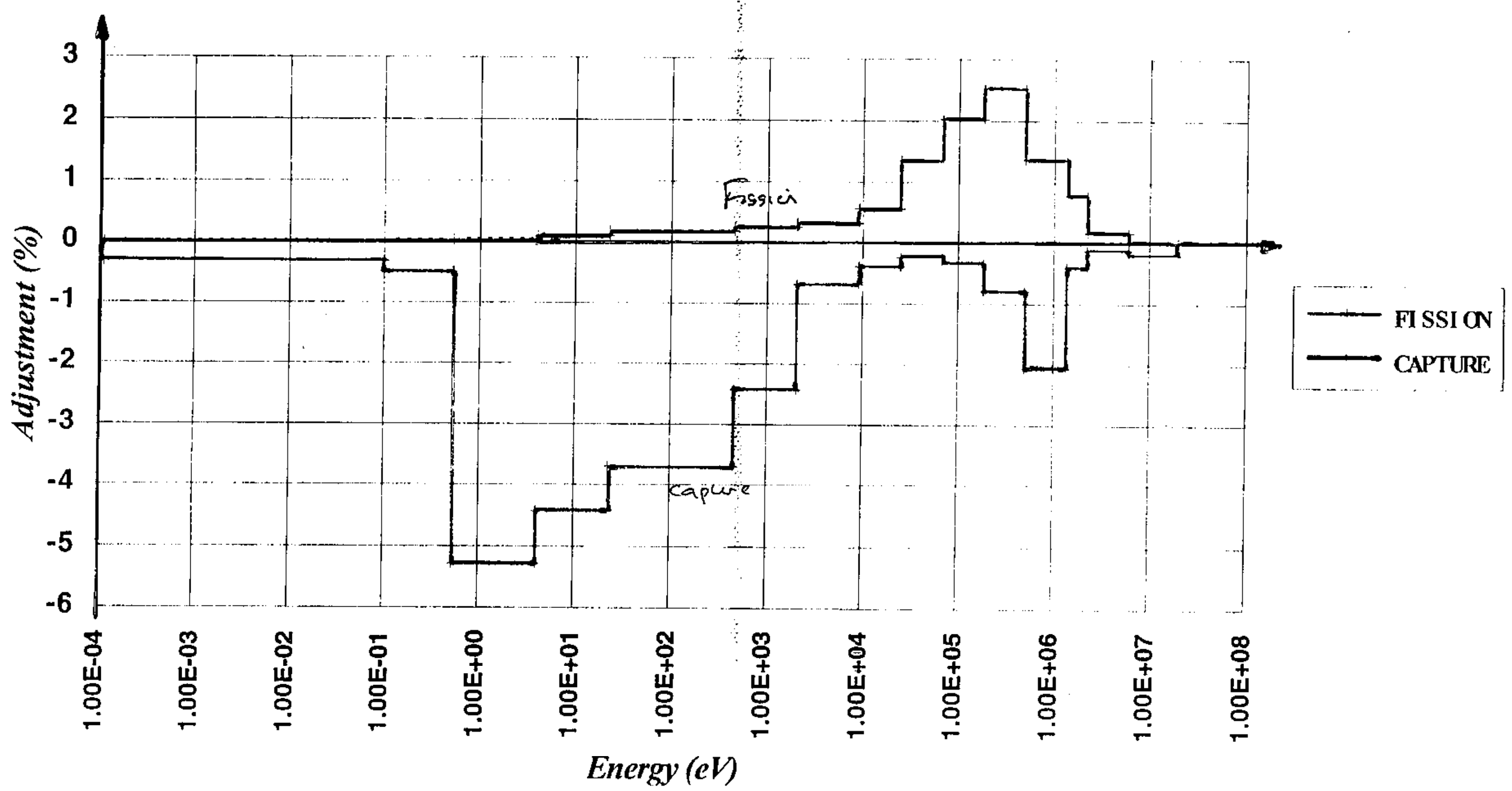
Cross-Section of 242Pu



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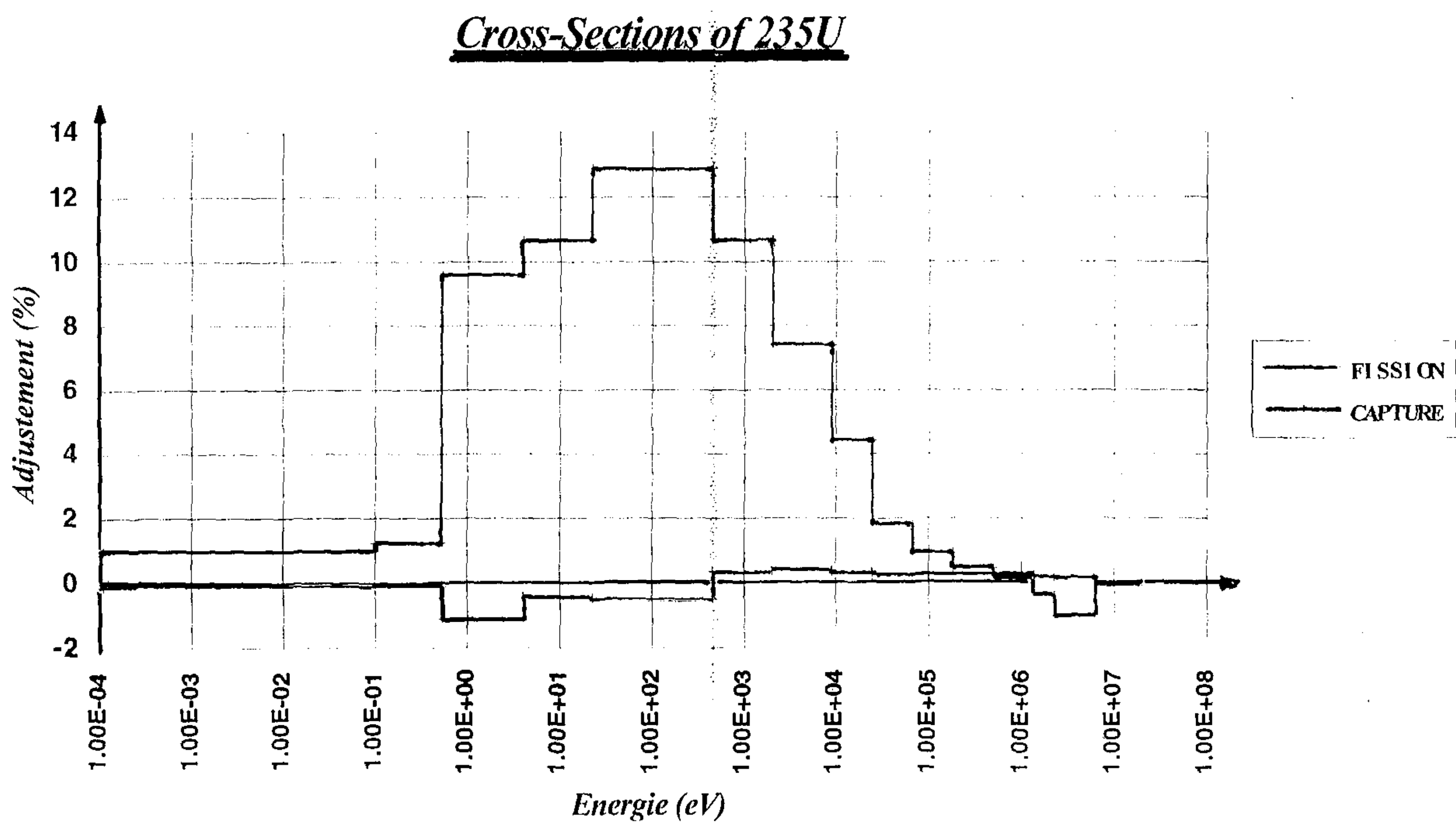
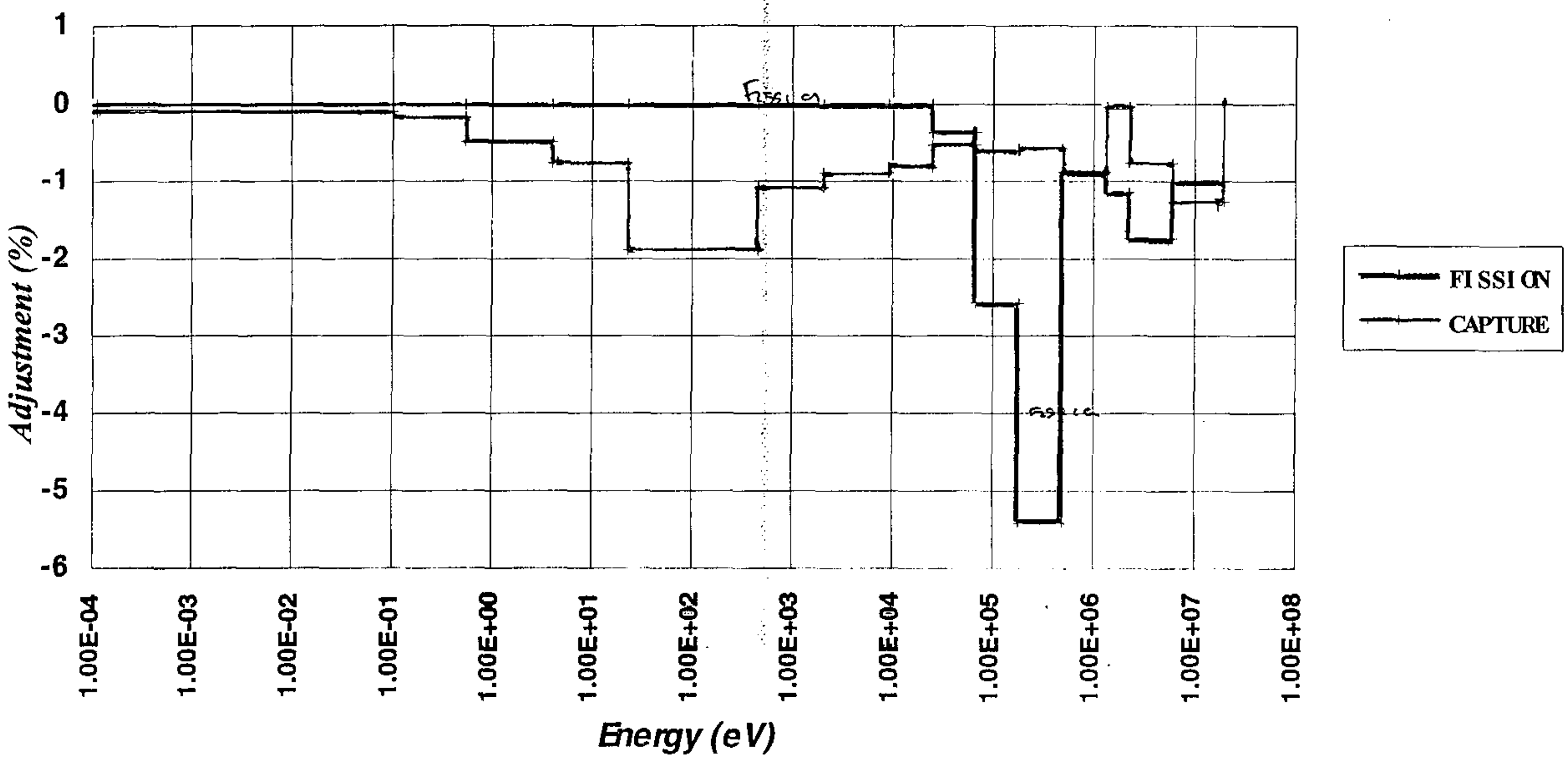

Cross-Sections of 235U
Adjustement (%)
14
12
10
8
6
4
2
0
-2
1.00E-04
1.00E-03
1.00E-02
1.00E-01
1.00E+00
1.00E+01
1.00E+02
1.00E+03
1.00E+04
1.00E+05
1.00E+06
1.00E+07
1.00E+08
Energie (eV)
FISSION
CAPTURE

14080155

Cross-Sections of 238U



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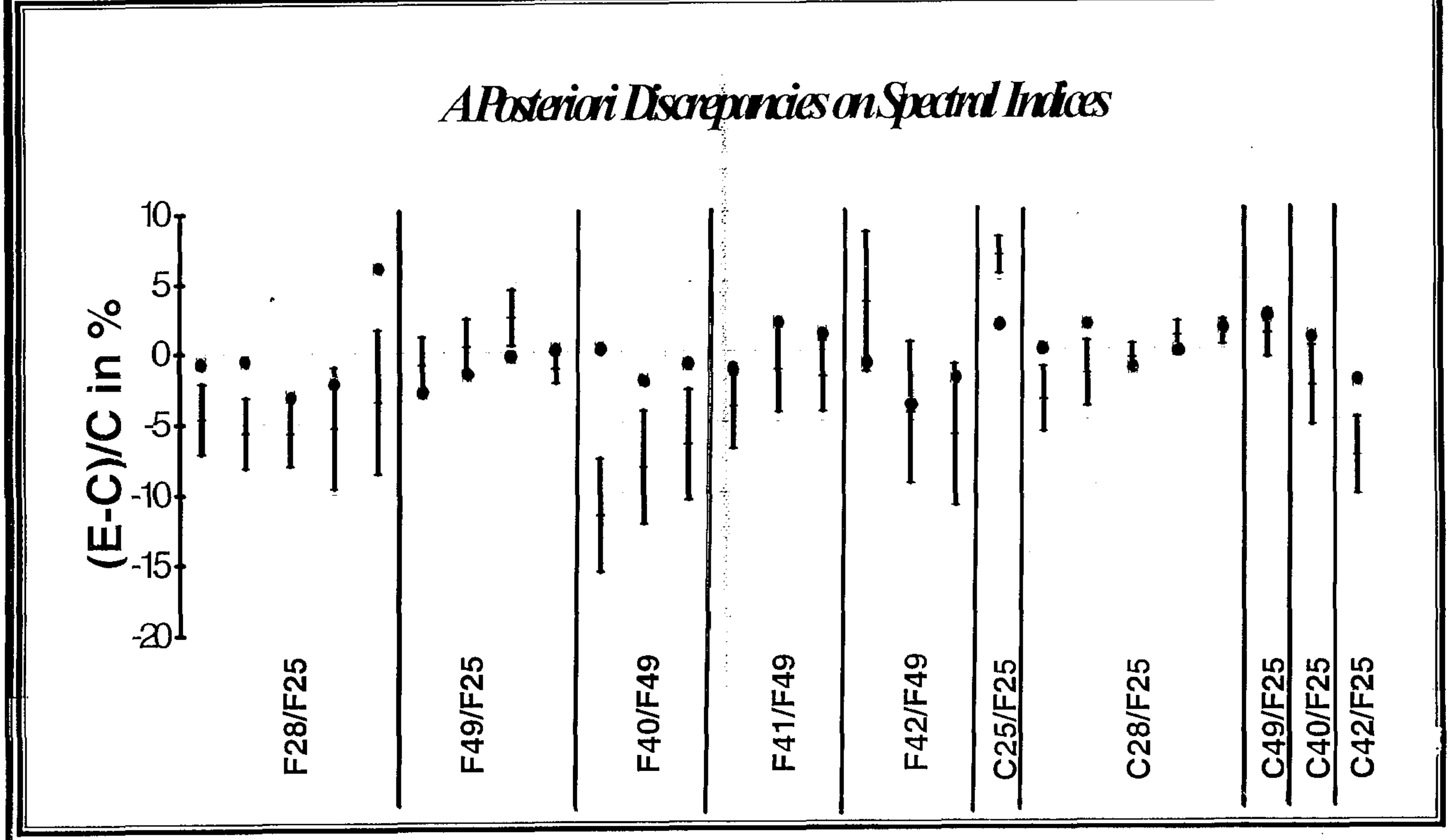
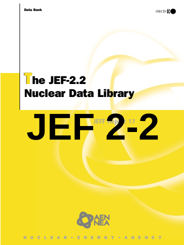

A Posteriori Discrepancies on Spectral Indices
(E-C)/C in %
10
5
0
-5
-10
-15
-20
F28/F25
F49/F25
F40/F49
F41/F49
F42/F49
C25/F25
C28/F25
C49/F25
C40/F25
C42/F25

14080157



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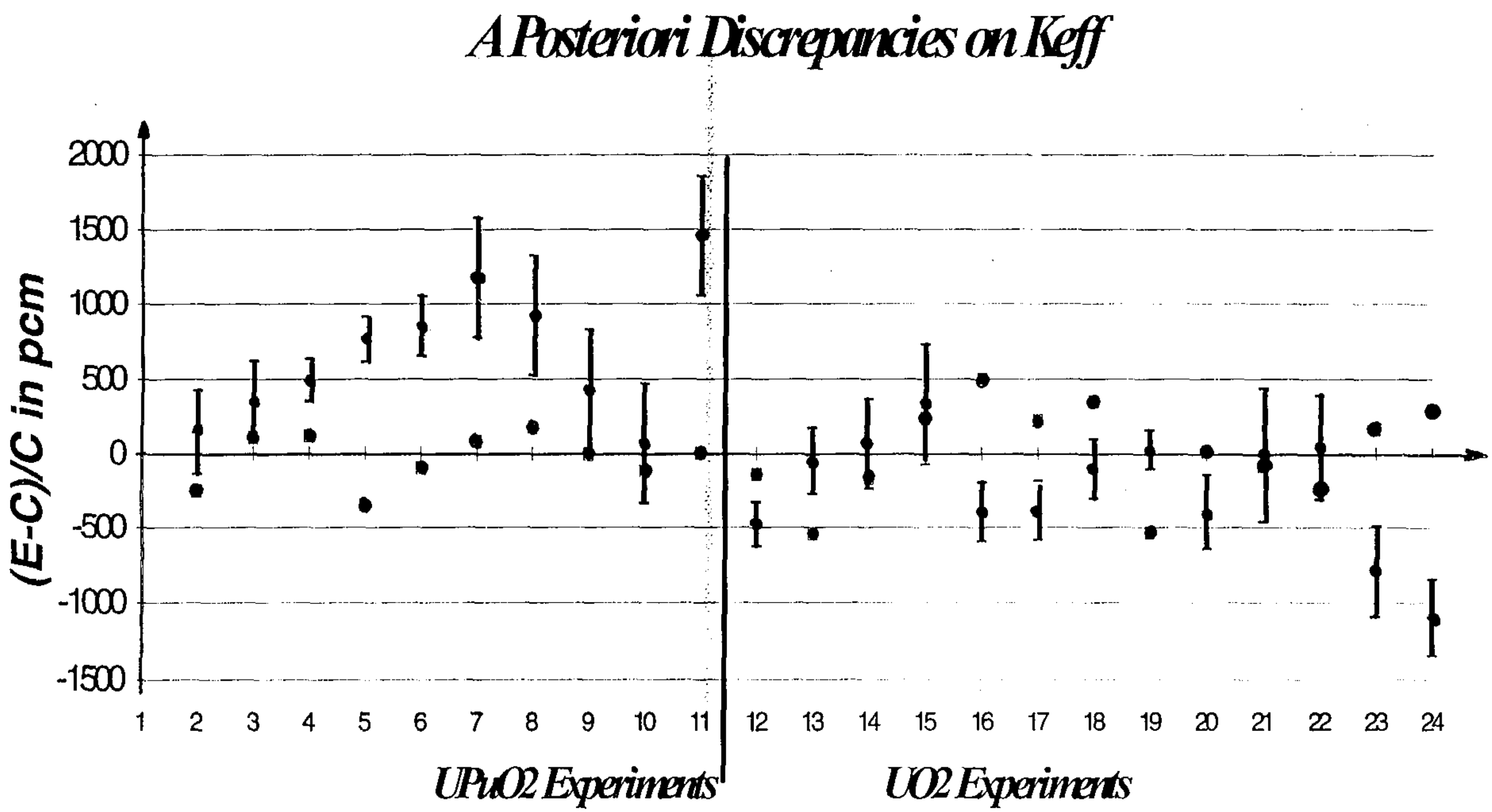

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Synthesis of the adjutments (1)

- ^{239}Pu
  - No significant trend except for a slight decrease (1.5%) of the Capture in the resonance range
- ^{240}Pu
  - Large decrease of the fission (11%) and slight decrease of Capture (3.5%) in the first resonance at 1.054 eV.
- ^{241}Pu
  - Slight decrease of the fission (3%) and increase (2%) of capture above 0.5 eV.
- ^{242}Pu
  - Large decrease (5%) of the capture in the first resonance at 2.67 eV
- ^{238}U
  - Large decrease of the fission near the threshold (weighting flux problems)

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Synthesis of the adjutments (2)

↳ ^{235}U (JEF2.2 and ENDF-BVI)

- Fission very wellknown but very large increase (up to 12 % !) of the capture cross-section in the resonance energy range.

⇒Self-shieding calculations in the APOLLO-2 code (resonance overlapping effect for example)

⇒Evaluation : Mean capture width of around $\Gamma\gamma = 33$ meV was used where the usually accepted value is $\Gamma\gamma = 37$ +/- 2 meV. The discrepancy is about the same than the recommanded adjustment

⇒ **NEW EVALUATION ?**