Extended adjustment using a wider integral data base

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Adjustment

- In the past 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 was 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, etc.). Later on added 5 more experiments (more sensitivity to isotope of interest), reaction covariance, and isotopes (to avoid compensations).
- 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

43 COMMARA-2.0 nuclei with covariances used in adjustment

- **Light Nuclei:**

  ^{10}B, ^{16}O, ^{12}C

- **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, ^{54}Fe, ^{57}Fe, ^{50}Cr, ^{53}Cr, ^{50}Cr, ^{60}Ni, ^{62}Ni, ^{55}Mn

- **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

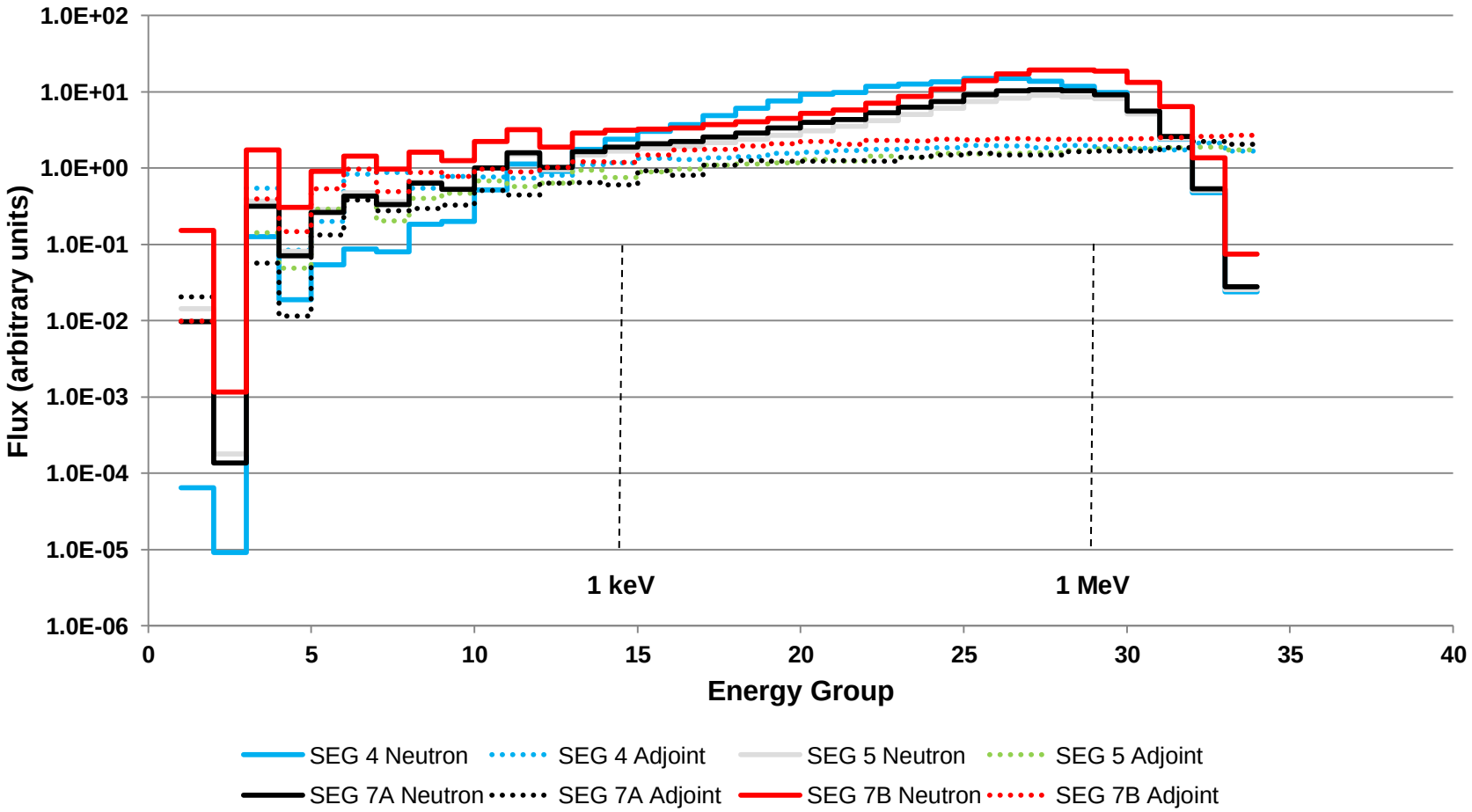
Extended Adjustment

- **An approach has been envisaged that expands as much as possible the use in the adjustment procedure of selected integral experiments that provide information on "elementary" phenomena, on separated individual physics effects related to specific isotopes or on specific energy ranges.**
- **In order to complement the "classical" set of integral experiments (criticality, reaction rates, reactivity coefficients) in the fast energy range, new more focused experiments are used, in particular:**
  - **New selective information on inelastic, elastic, fission and capture data (e. g. SEG experiments, FCA-IX)**
  - **Enhanced sensitivity to the actinide cross sections in the energy range ≤ 1 keV ($k\infty$, reaction rates, void reactivity effects performed at the PROTEUS facility)**
  - **Enhanced capture sensitivity in the range from few hundred eV to 1 eV (MANTRA irradiation experiments)**
  - **Specific feedbacks on elastic and inelastic structural materials (e. g. ASPIS-88 experiment for Fe-56)**
  - **β_{eff} experiments (problems for lack of delayed data covariance)**

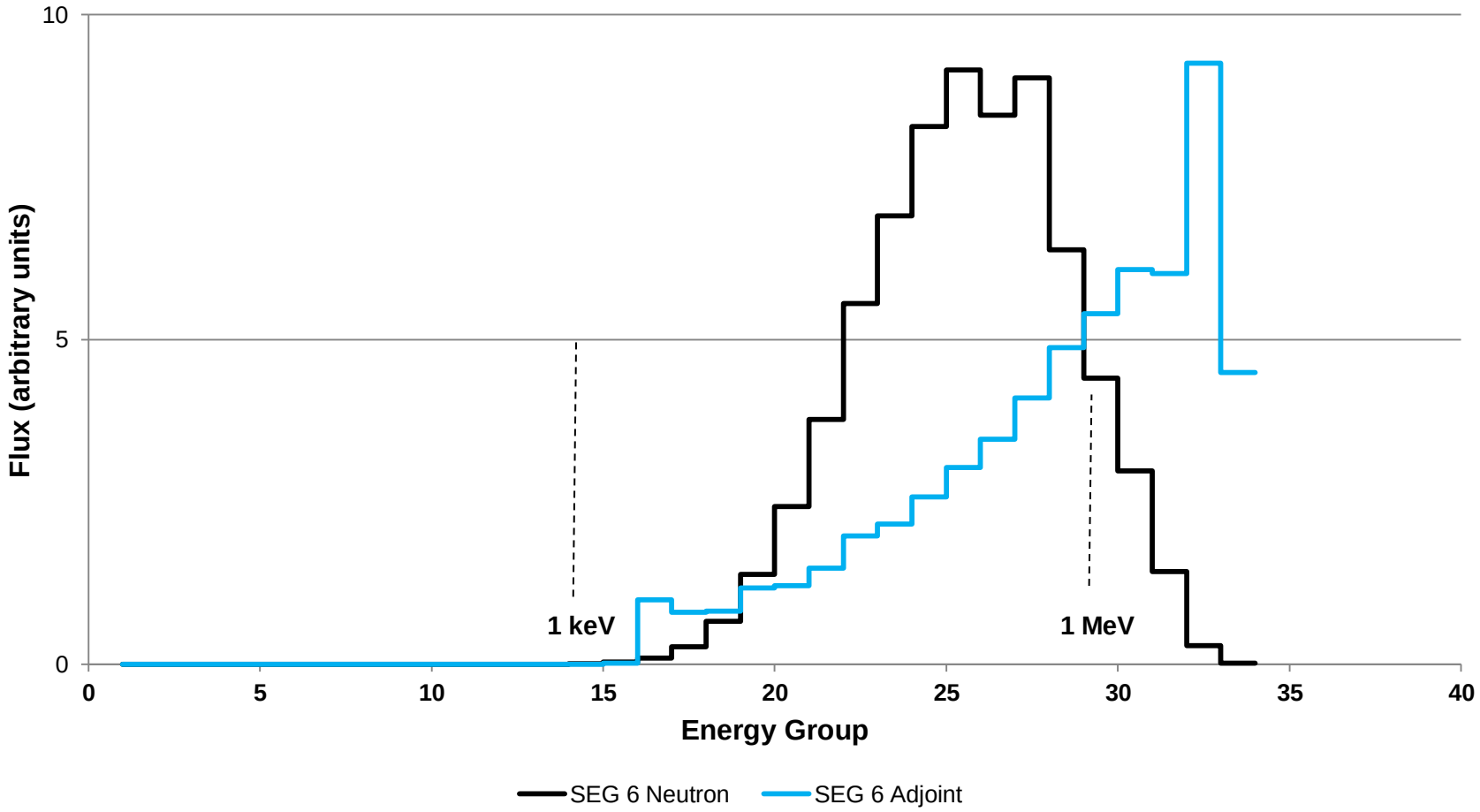
Extended Adjustment

- **Besides adding new experiments, also a new adjustment strategy is adopted (PIA, Progressive Incremental Adjustment) in order to avoid, if possible, compensations .**
- **PIA give priority to the utilization of experiments of elemental type (those sensitive to a specific cross section), following a definite hierarchy on which type of experiment to use:**
  - **Fission spectral indices**
  - **Irradiation experiments**
  - **Sample oscillation experiments**
  - **Critical masses**
  - **Reactivity variations**
- **The results of the adjustment will change, with respect to a traditional global one, only if there are correlations among experiments.**
- **Also, under consideration is to use another recent development, REWIND, for establish a prioritization inside each category of experiments.**

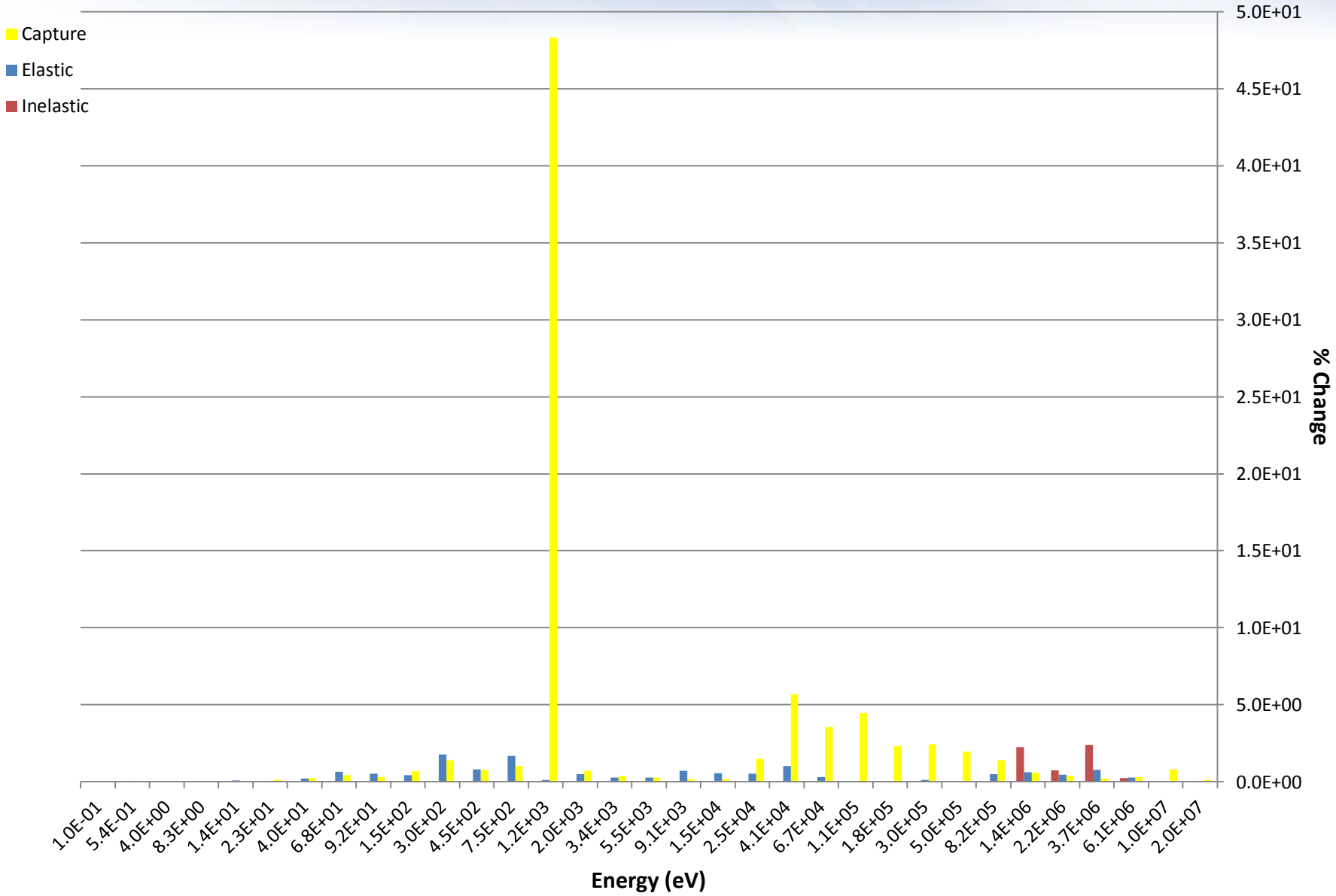
MCNP6.1 Calculated Flux and Adjoint Spectrums



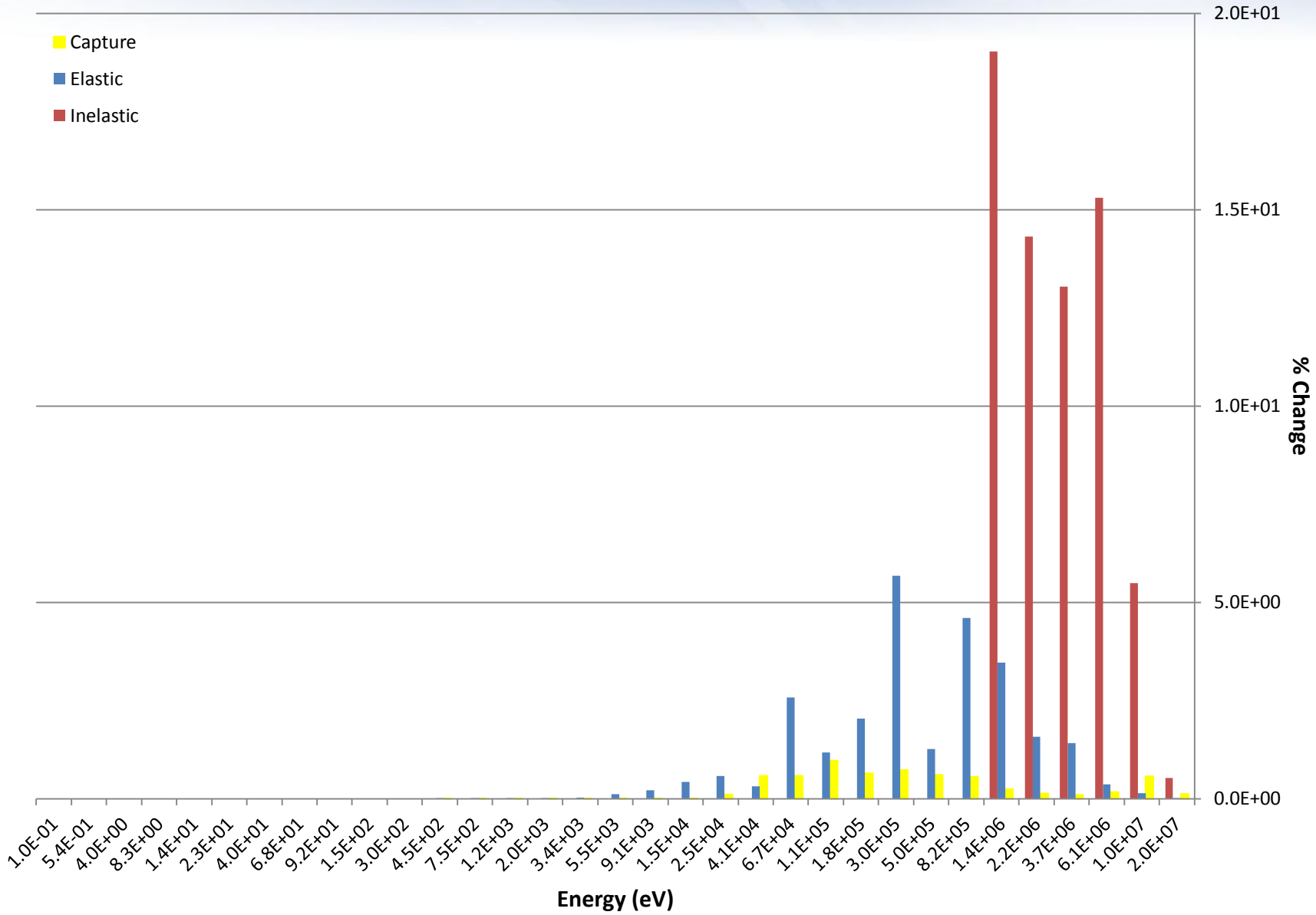
MCNP6.1 Calculated Flux and Adjoint Spectrums



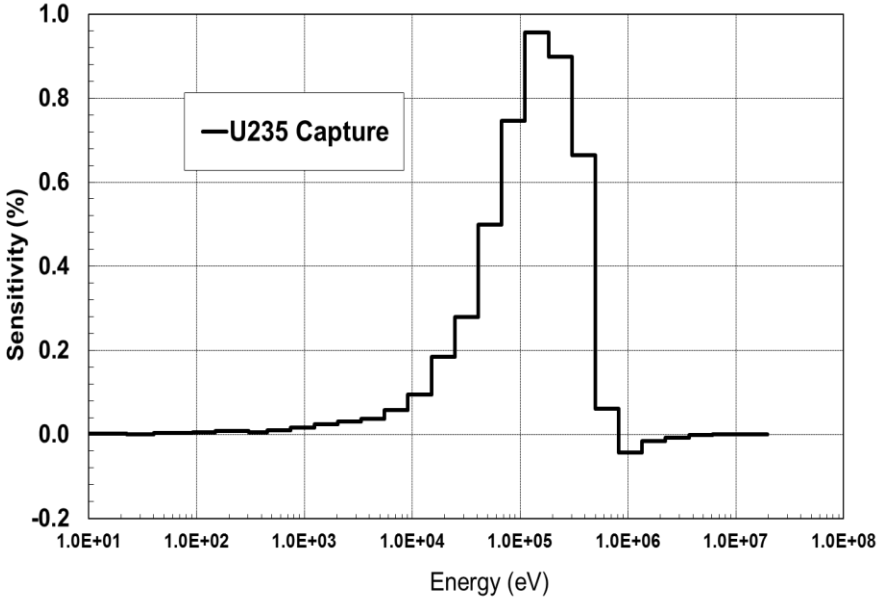
Fe-56 Sensitivities in SEG5 (JEF-2.2/ECCO/ERANOS)

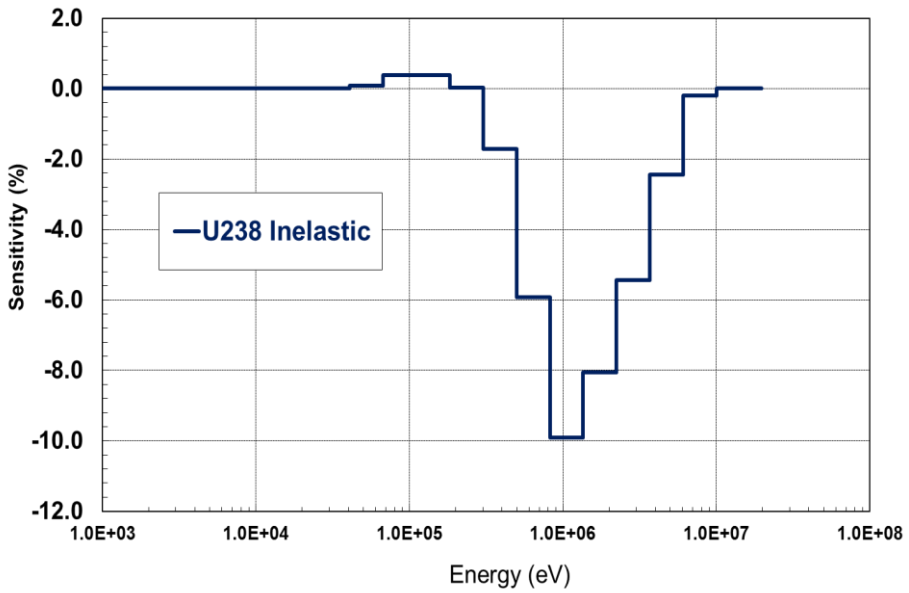


Fe-56 Sensitivities in SEG6_EK45 (JEF-2.2/ECCO/ERANOS)



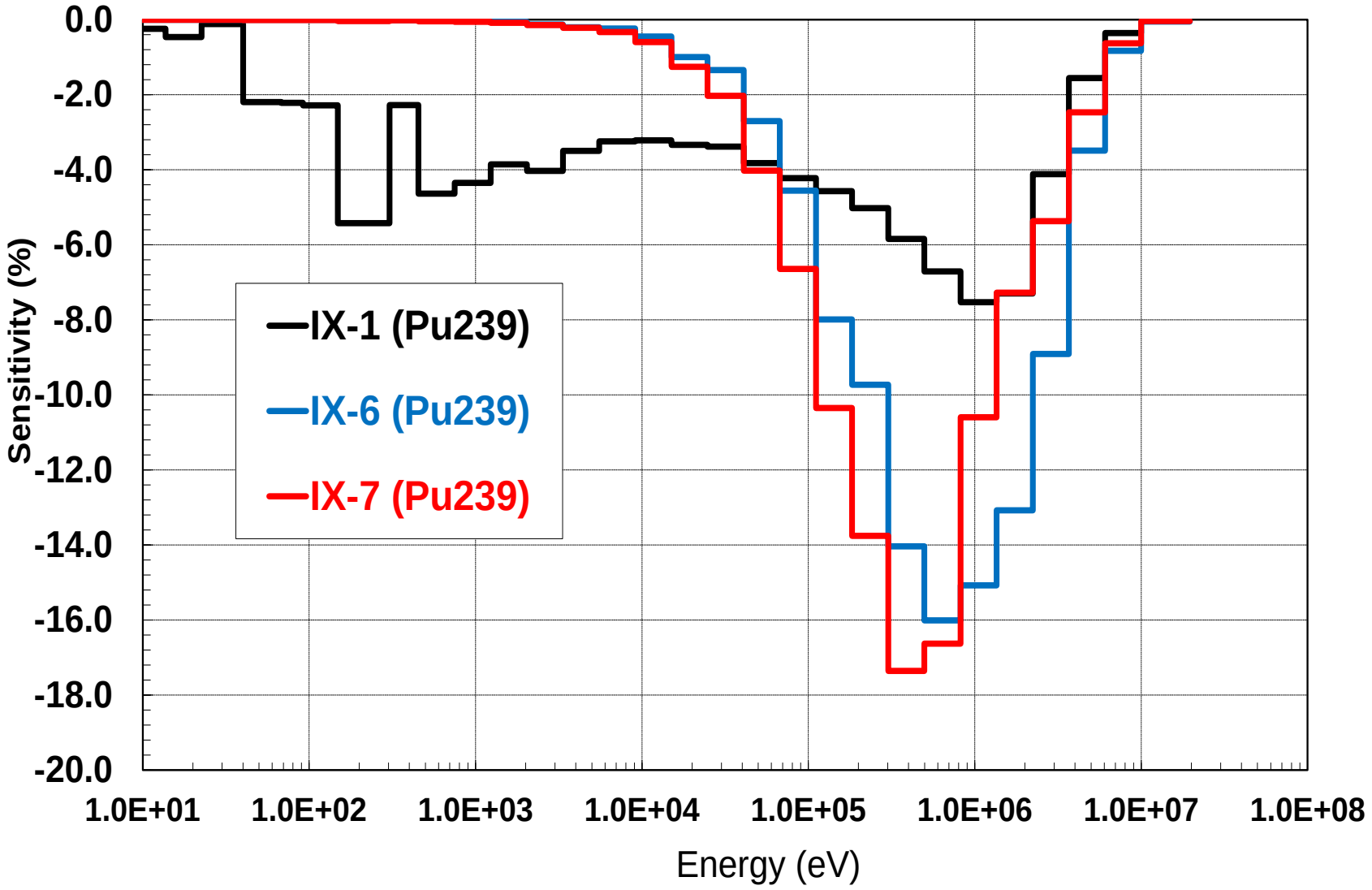
IX-7: Sensitivity of Np-237/Pu-239 spectrum index to ^{235}U σ_{cap} and ^{238}U σ_{inel}





- **IX-7 spectrum is the hardest. Inelastic cross sections sensitivity is high (and negative) at energies above the Np-237 fission threshold: the elastic/inelastic x-section increase in this energy region will reduce the high energy neutron contribution to the numerator**
- **Sensitivity to U-235 capture is still relatively high and positive in the high energy region: any increase of U-235 high energy capture will slightly reduce the high energy neutron contribution to the denominator.**

Sensitivity of ^{239}Pu σ_{fiss} (direct effect on spectrum index denominator)



Sensitivity Coefficients

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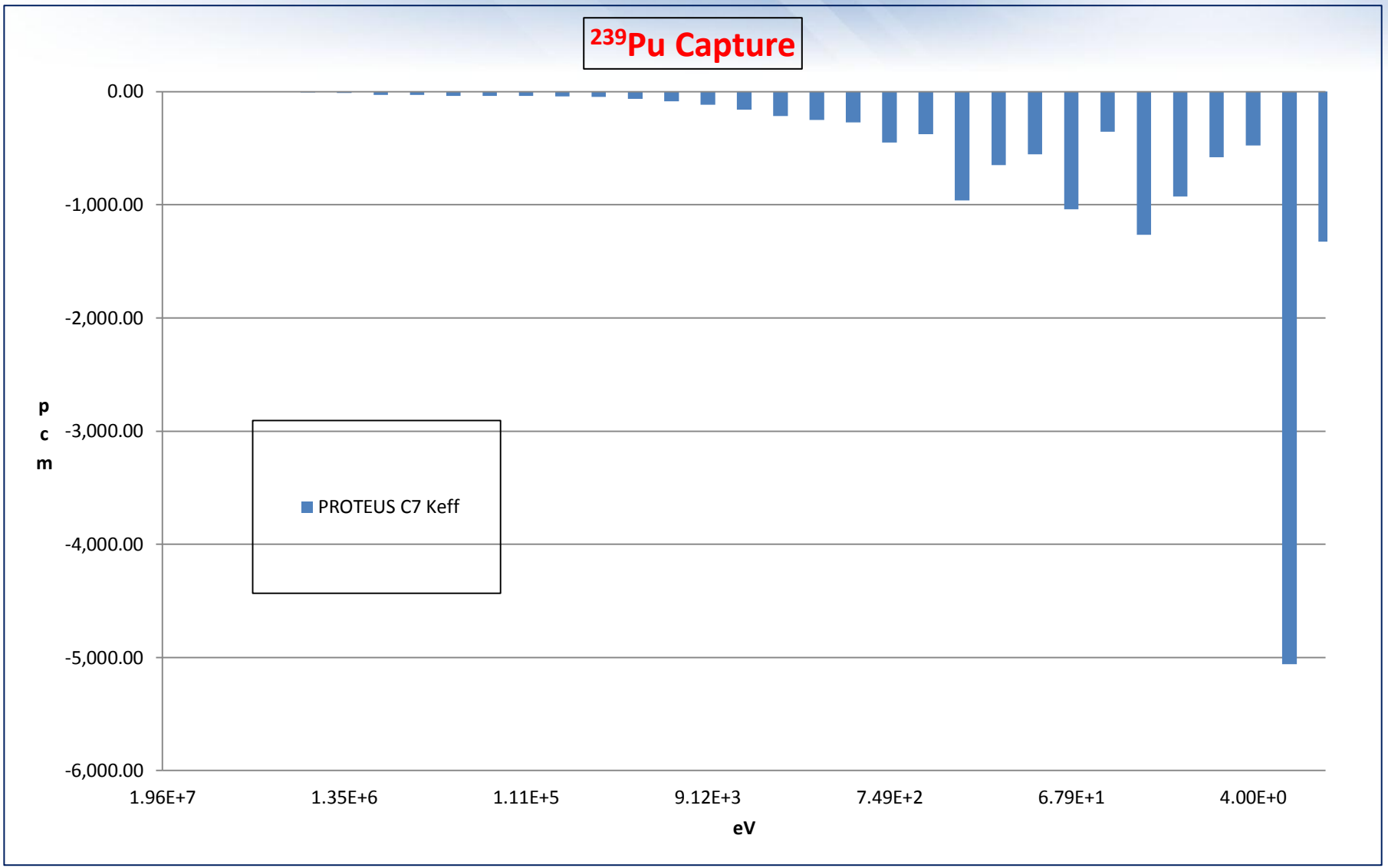

Sensitivity Coefficients

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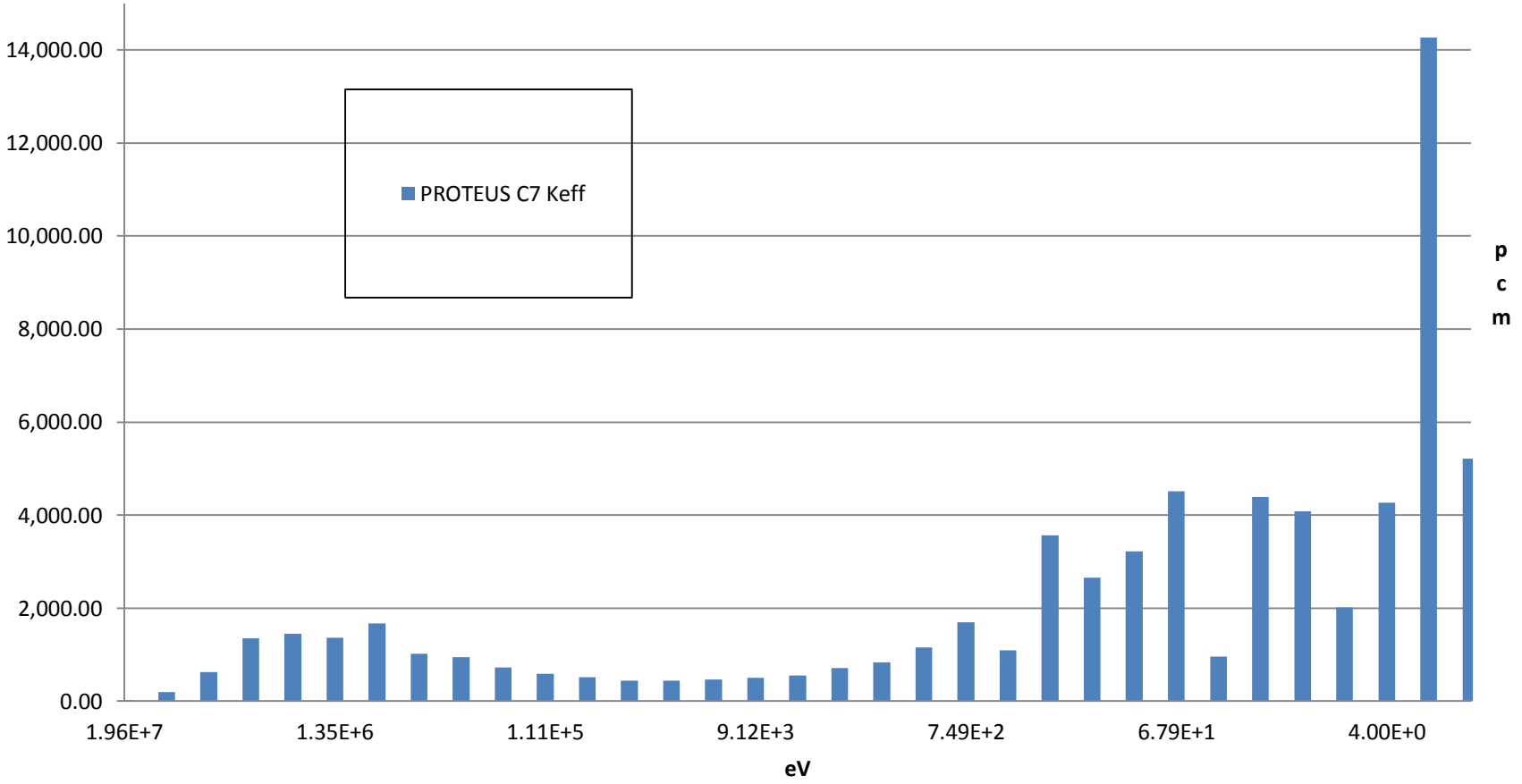
^{239}Pu Nubar



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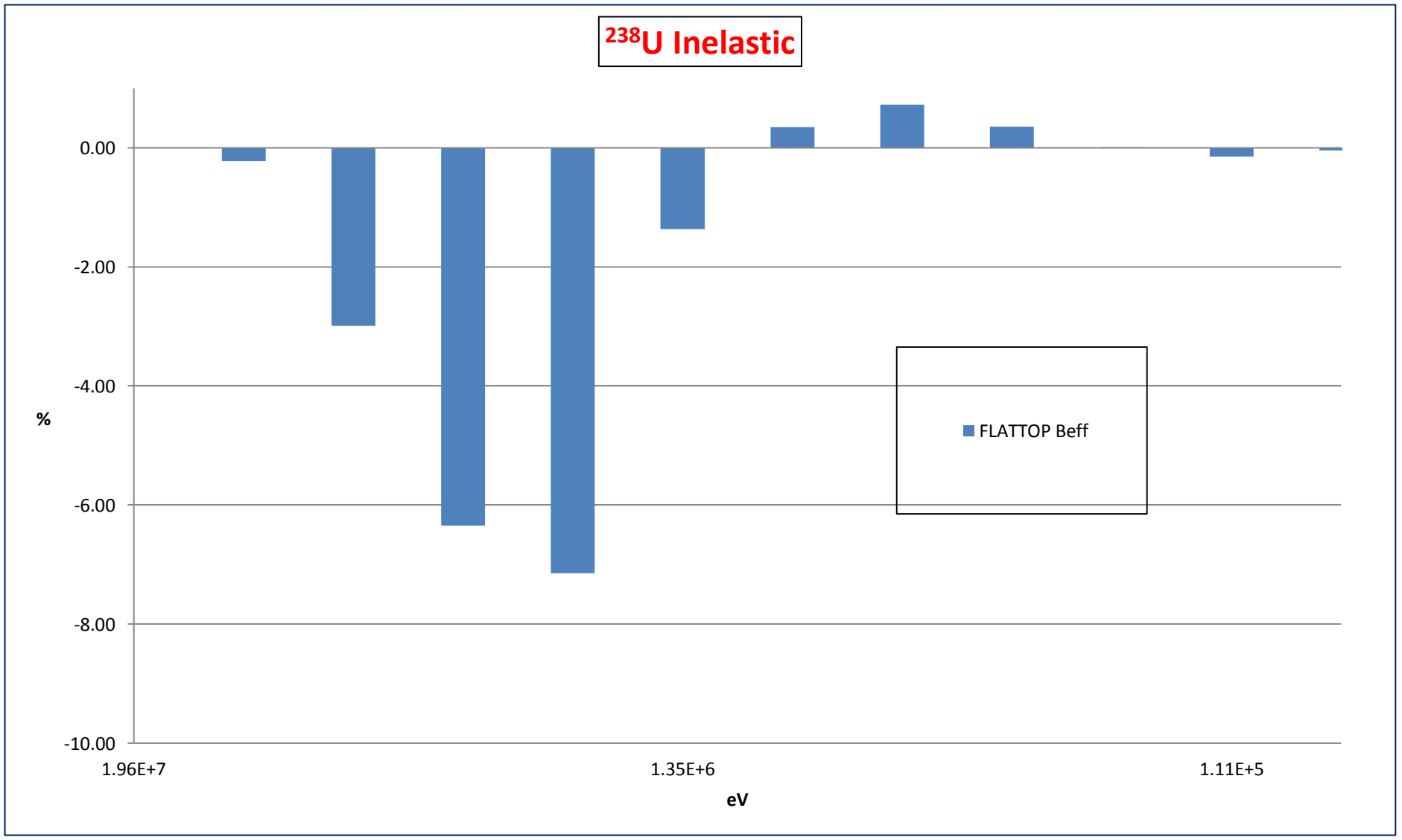

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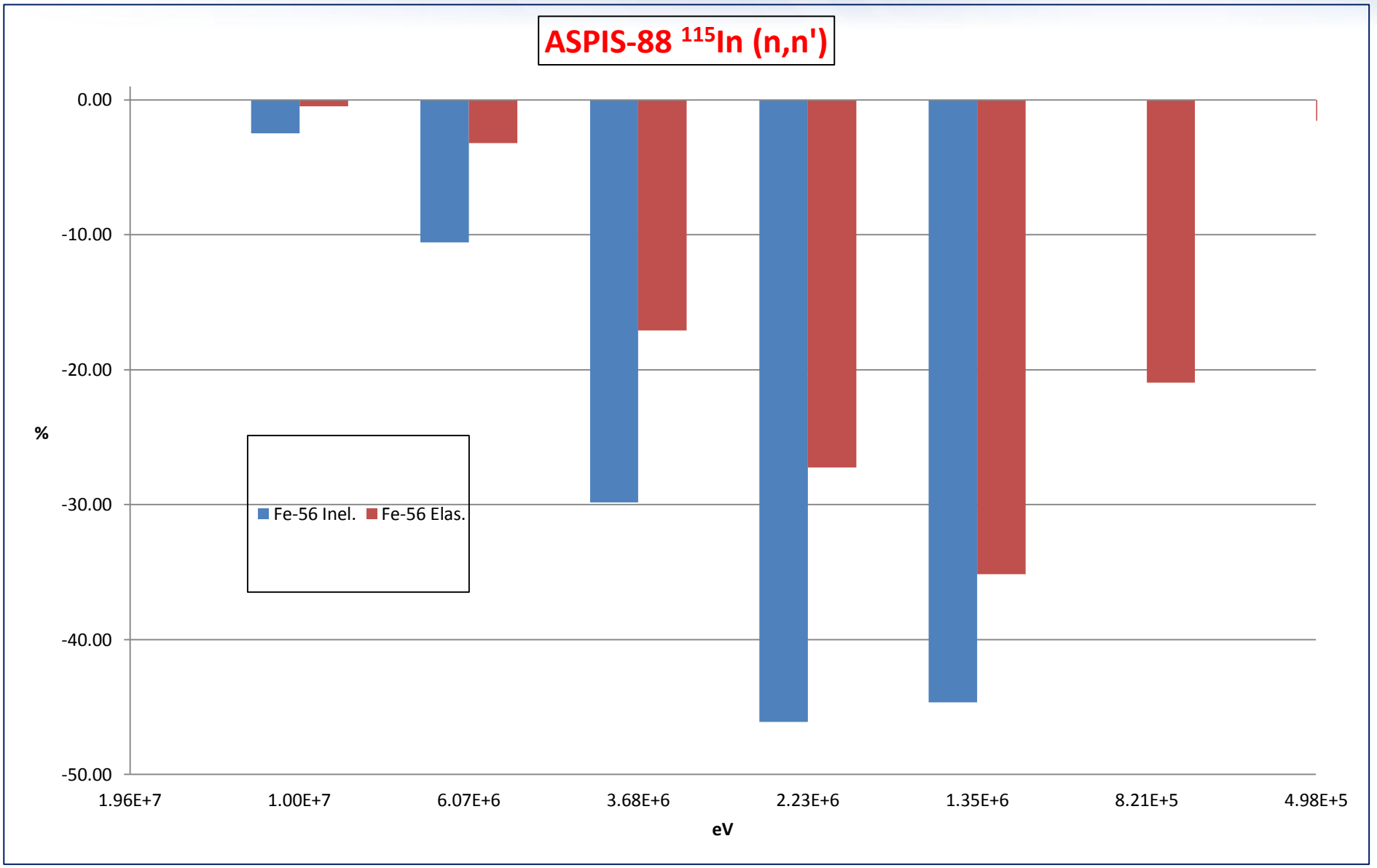

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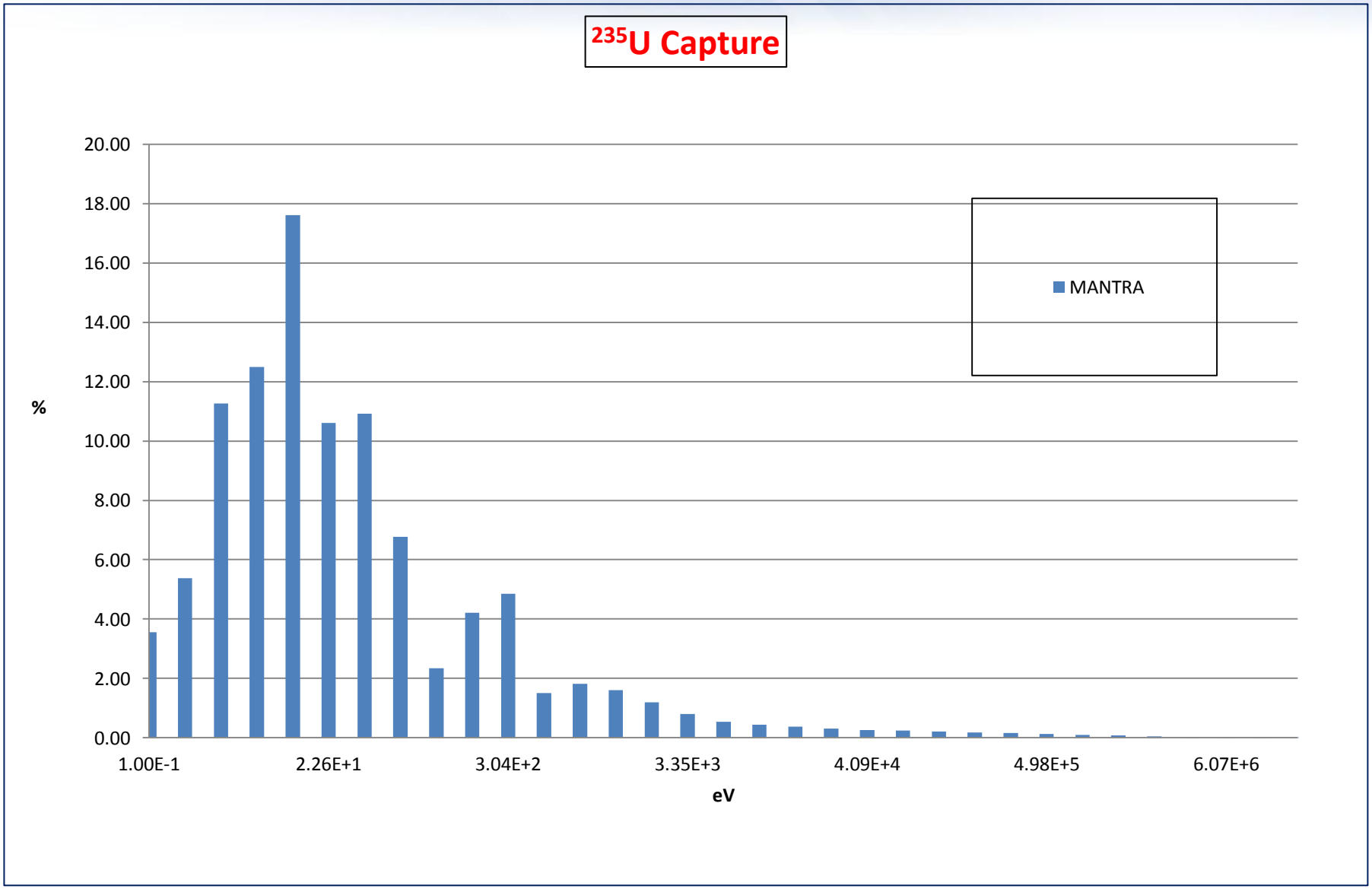

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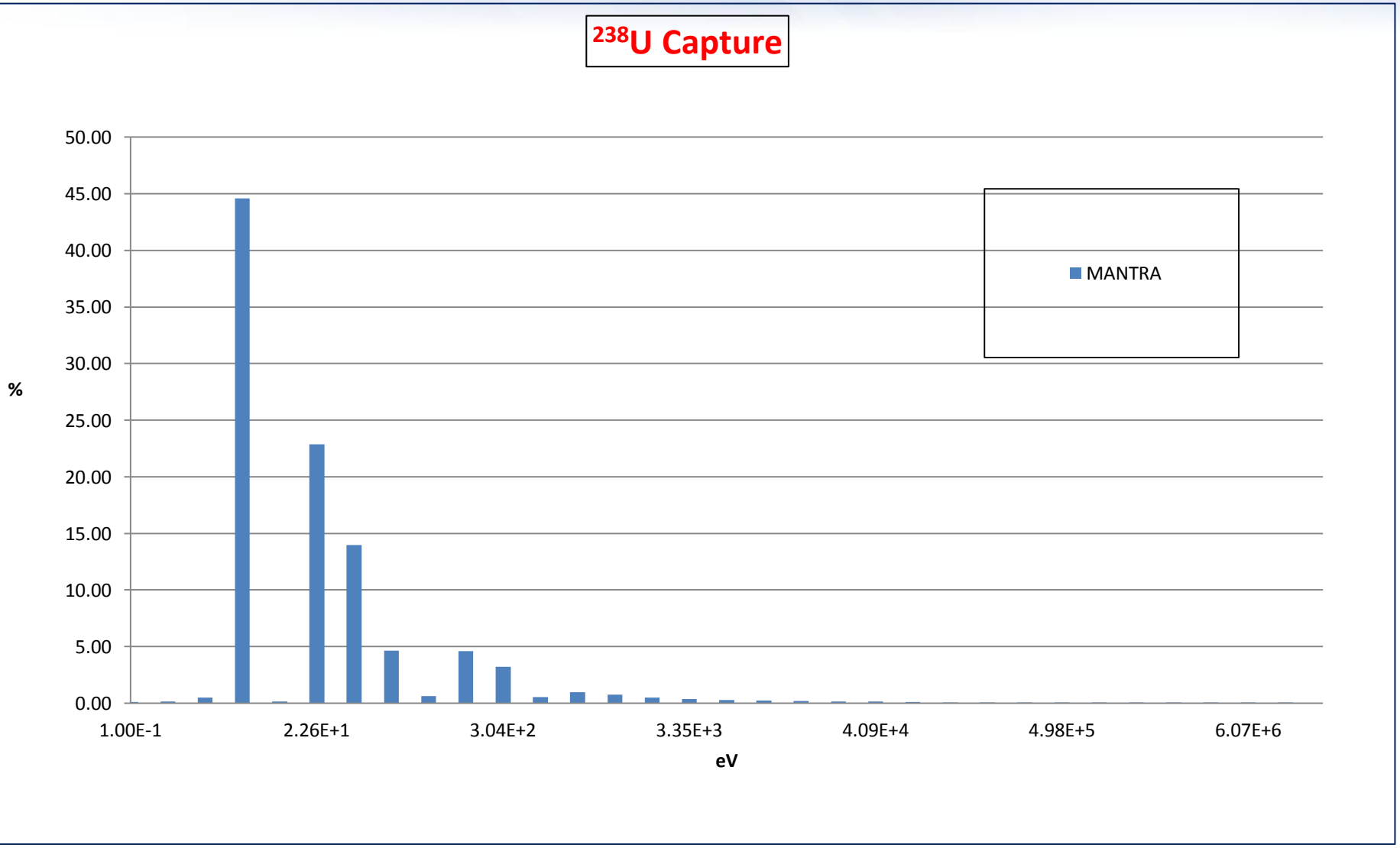

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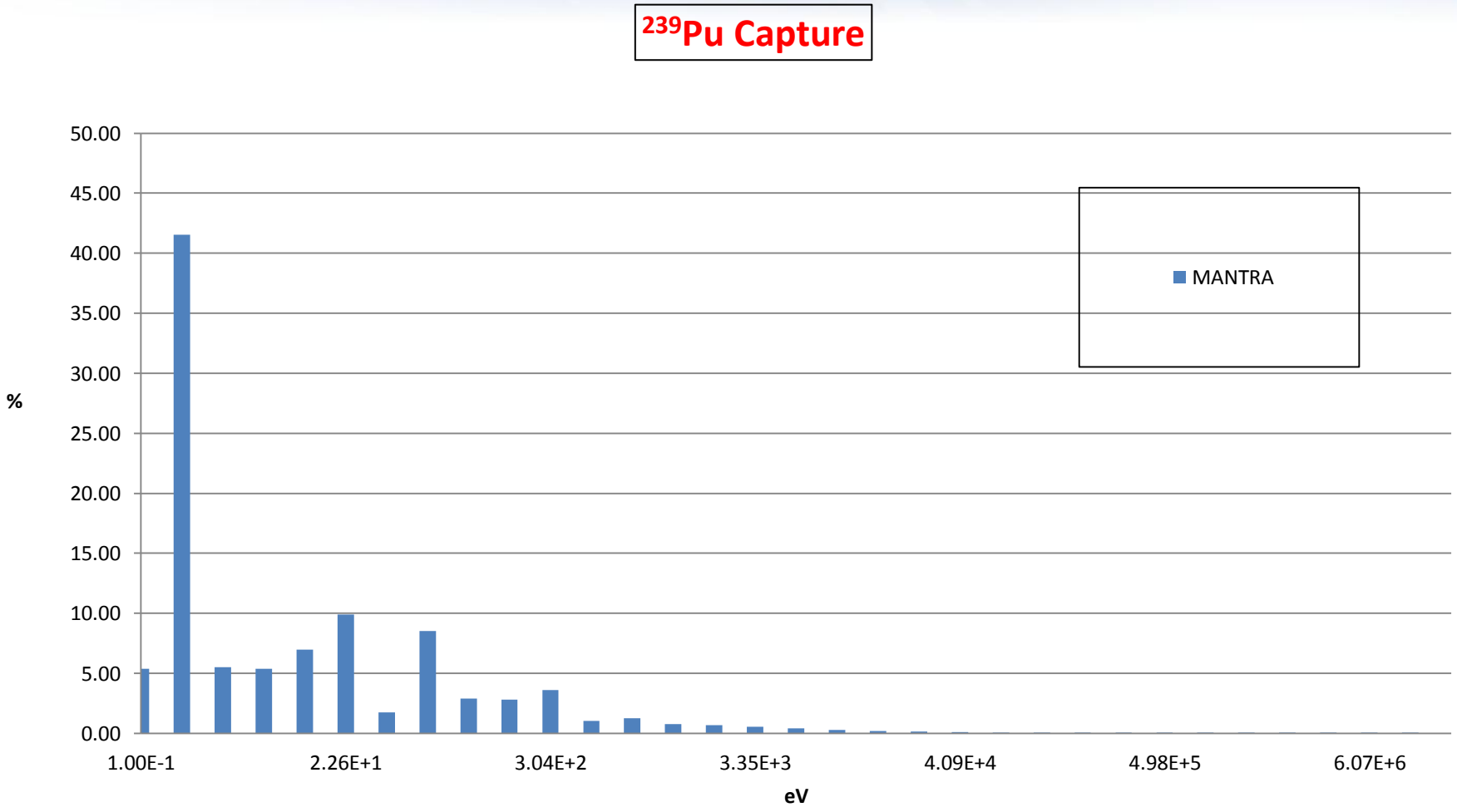

Conclusions

- **An extended adjustment has been proposed. In the future we will show the impact of these new experiments, in terms of added value in order to provide credible indications on major actinides and structural materials cross section nominal values, their energy behavior and associated uncertainties that could be used in the most advanced new nuclear data evaluations.**
- **However, especially in view of new method development (e.g. continuous energy adjustment), and most importantly for avoiding, as far as possible, compensations is very important that reliable and improved covariance data are provided by the evaluation community. Among the improvements:**
  - **Missing data in covariance matrix: fission spectra, P_1 elastic, secondary energy distribution for inelastic cross sections (multigroup transfer matrix), cross correlations (reactions and isotopes), delayed data (nubar and fission spectra).**
  - **If possible use the same cross section energy grid for covariance data, provide directly the angular information for anisotropy together with P_n expansion, and covariances for resonance parameters and nuclear radius.**
  - **Using SVD to minimize amount of data is welcome with, possibly, no negative eigenvalues.**