Reaction cross sections and prompt neutron emission and spectra calculations for $^{238}U(n,f)$ and $^{237}Np(n,f)$

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Introduction

- **Model prediction of mass distributions**

- **Investigate the predictive power of the model**

Introduction

Mono-energetic neutron source

- 7 MV Van-de-Graaff accelerator
  - ^{7}LiF(p,n)^{7}Be, TiT(p,n)^{3}He, D_2(d,n)^{3}He, TiT(d,n)^{4}He
  - DC ($I_{p,d}$ < 50 µA), pulsed beam available
  - 4 + 1 non-T beam line
- $\Phi_n < 10^9$ /s/sr
- *NEPTUNE* isomer spectrometer
- ionisation chambers, NE213 neutron/gamma-ray detectors, BF_3 counters, HPGe detectors
- Bonner spheres
- fast rabbit systems ($T_{1/2}$ > 1s) for activation studies

GELINA neutron TOF spectrometer

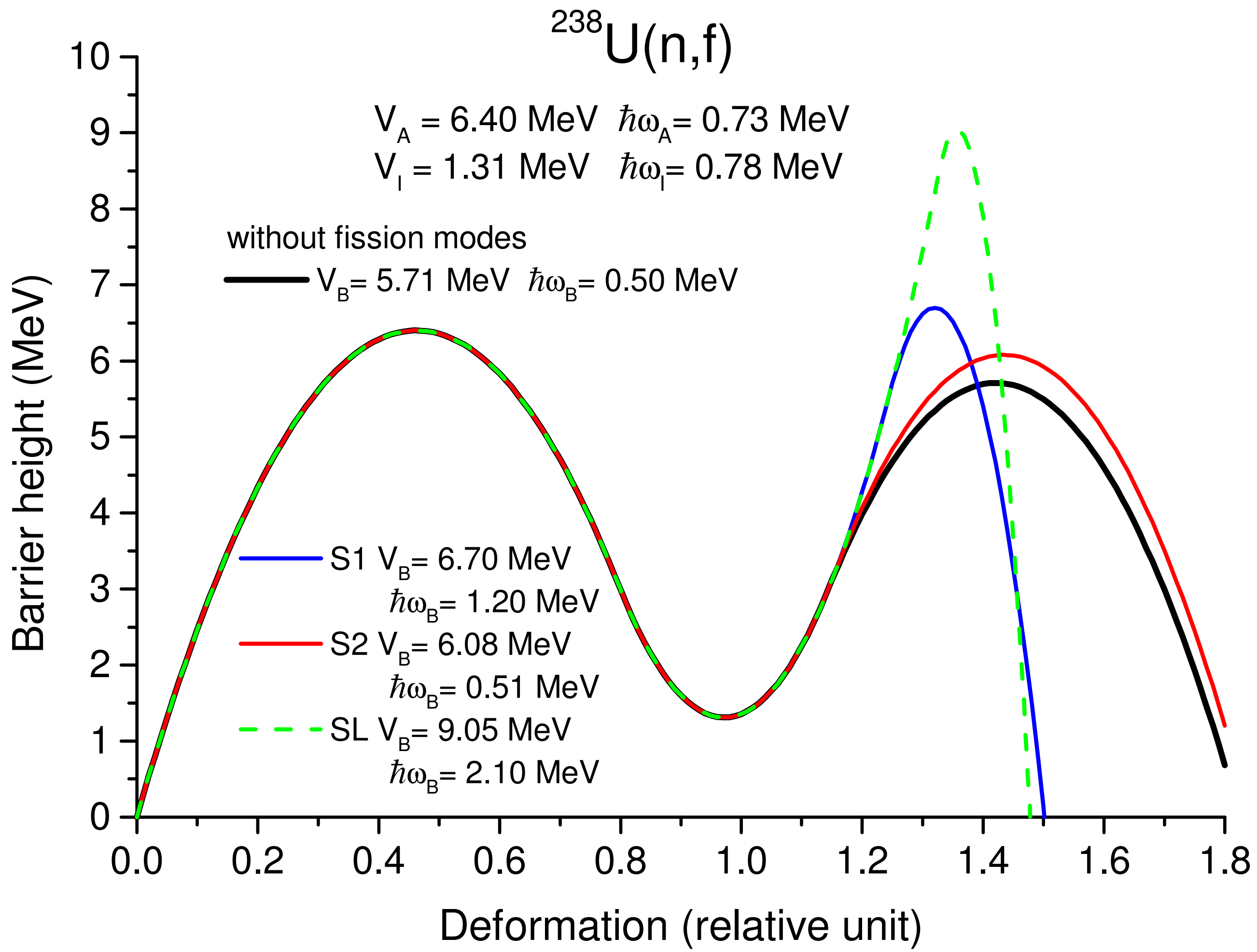
- 70 - 140 MeV electron accelerator
- repetition frequency: 40 - 800 Hz
- neutron pulse: 2 µs - 1 ns @ FWHM
- $\Phi_n = 3.4\ 10^{13}$/s @ 800 Hz
- 12 different flight paths with a length between 8 and 400 m
- ionisation chambers, C_6D_6 detectors
- high-resolution γ-ray detectors
- fission chambers for flux monitoring

Theoretical modeling of reaction cross sections and prompt neutron multiplicity and spectra

Concept of the model calculations

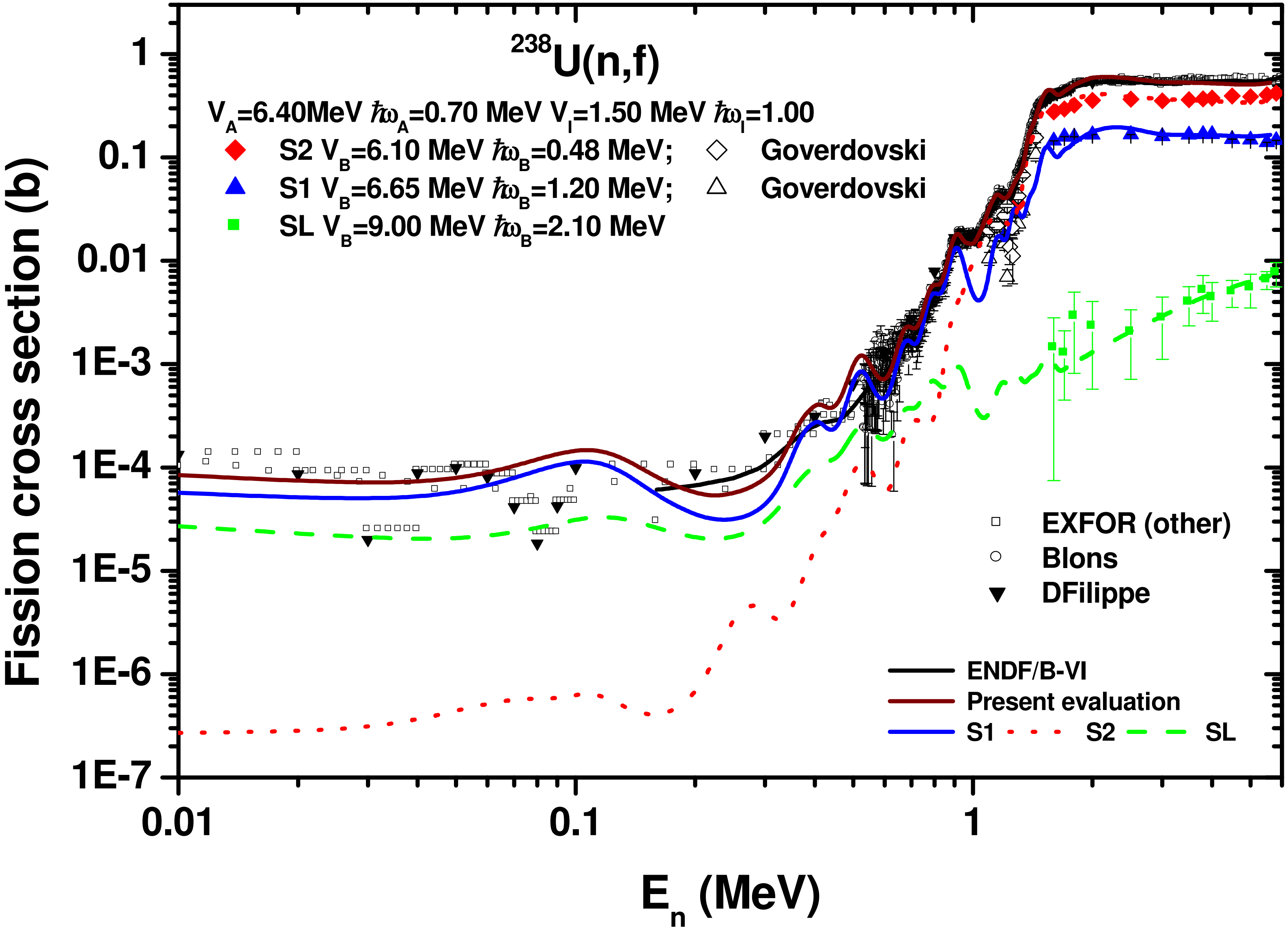
- Experimental input: fission-mode branching ratio (w_m) as a function of the incident neutron energy
  ENDF/B-VI fission cross section data
- Statistical treatment of the CN mechanism within the code
  STATIS extended for MM-RNR model (*NP A707 (2002) 32*)
  - one CN (incident neutron energies below 2nd chance fission)
  - 3 most dominant fission modes : asymmetric S1, S2 and symmetric SL
  - parabola-shaped inner and outer barriers
  - elastic and inelastic neutron scattering, radiative capture, fission
- Direct interaction with ECIS code (coupled channel method, *Raynal CEA-N-2772, 1994*):
  - total cross-section, partial direct scattering cross-sections for the first four rotational bands and the neutron transmission coefficients

Multi-modal fission barrier

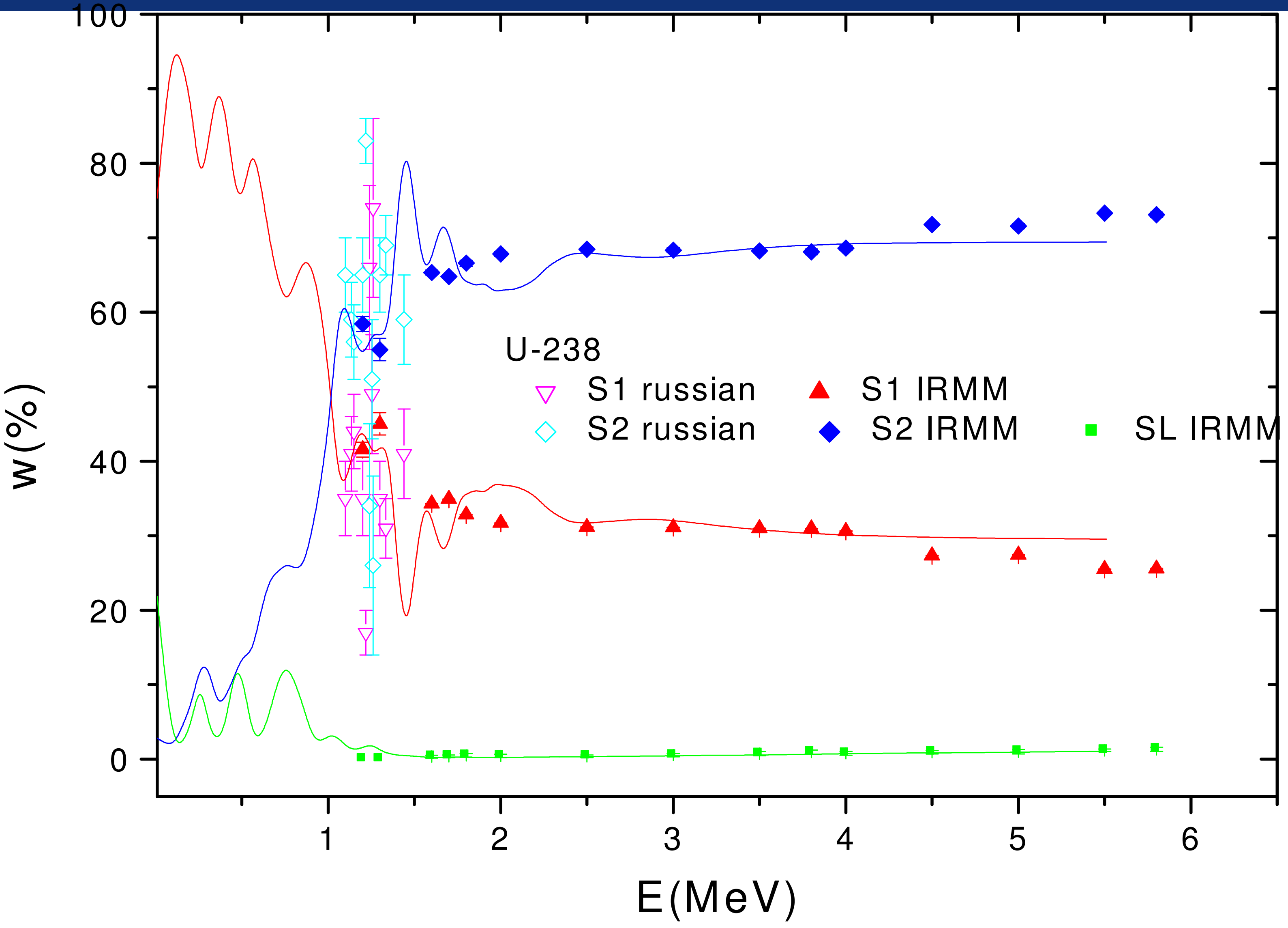


$^{238}U(n,f)$

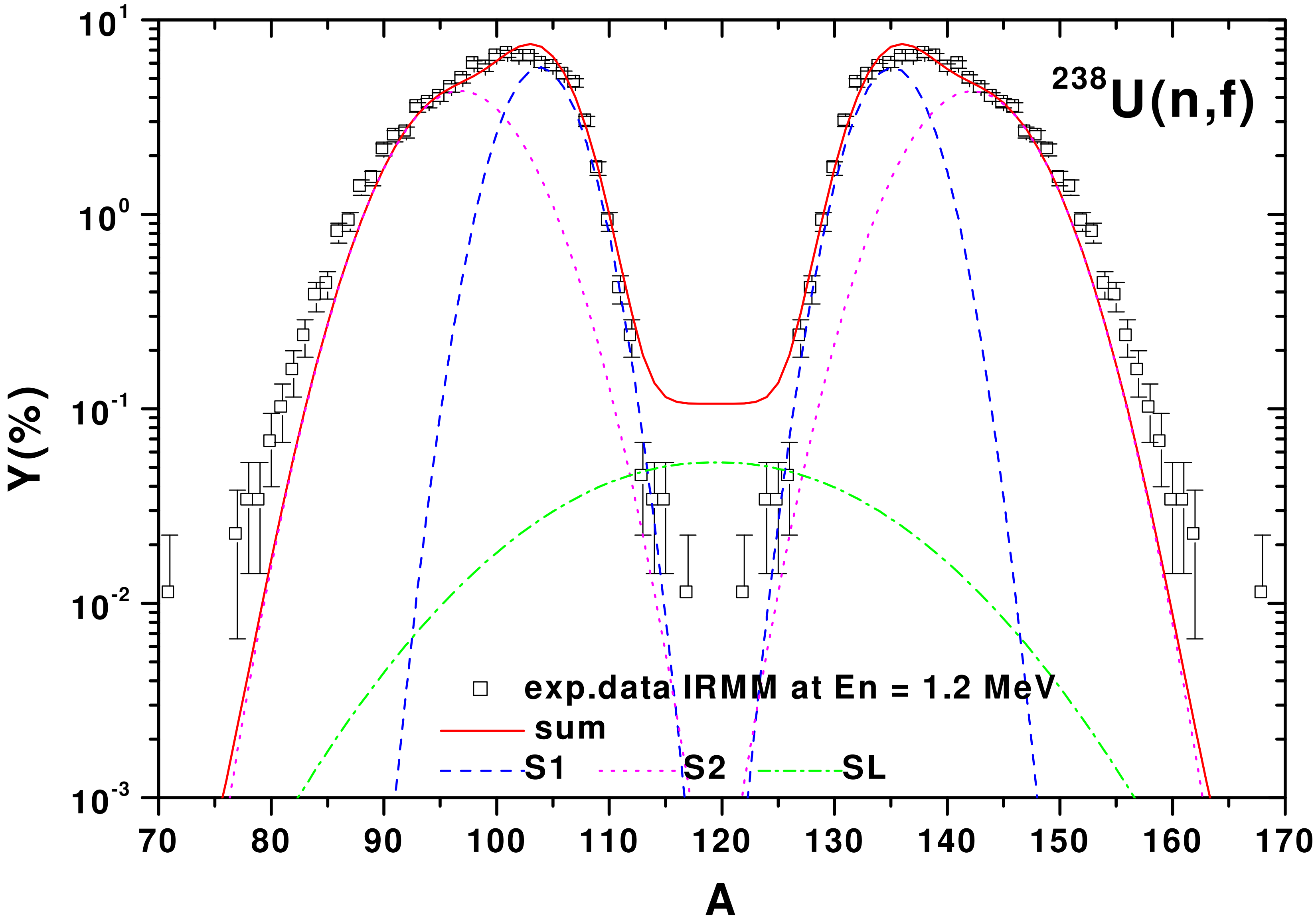
Fission Cross-section for $^{238}U(n,f)$



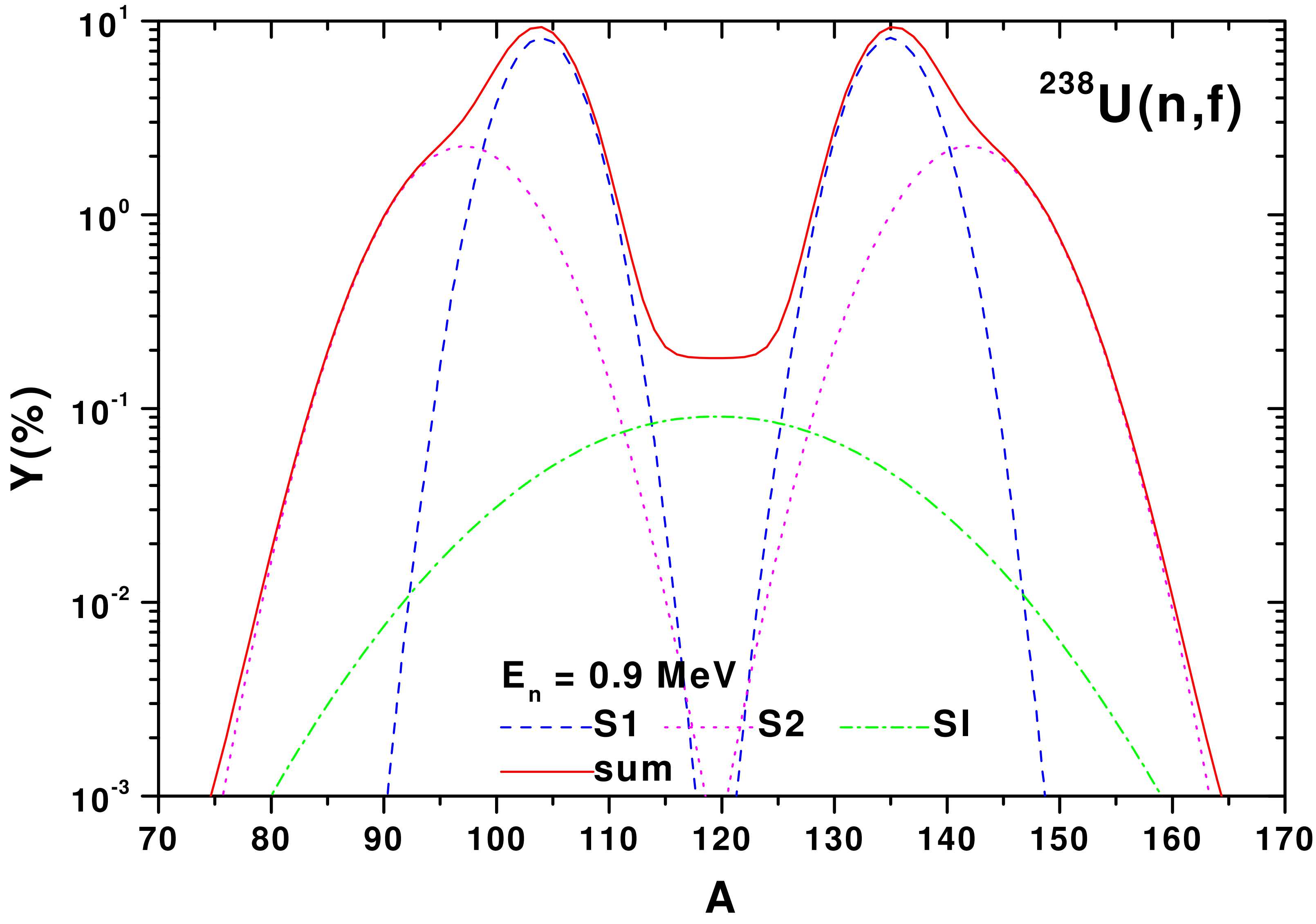
Branching Ratio for $^{238}U(n,f)$



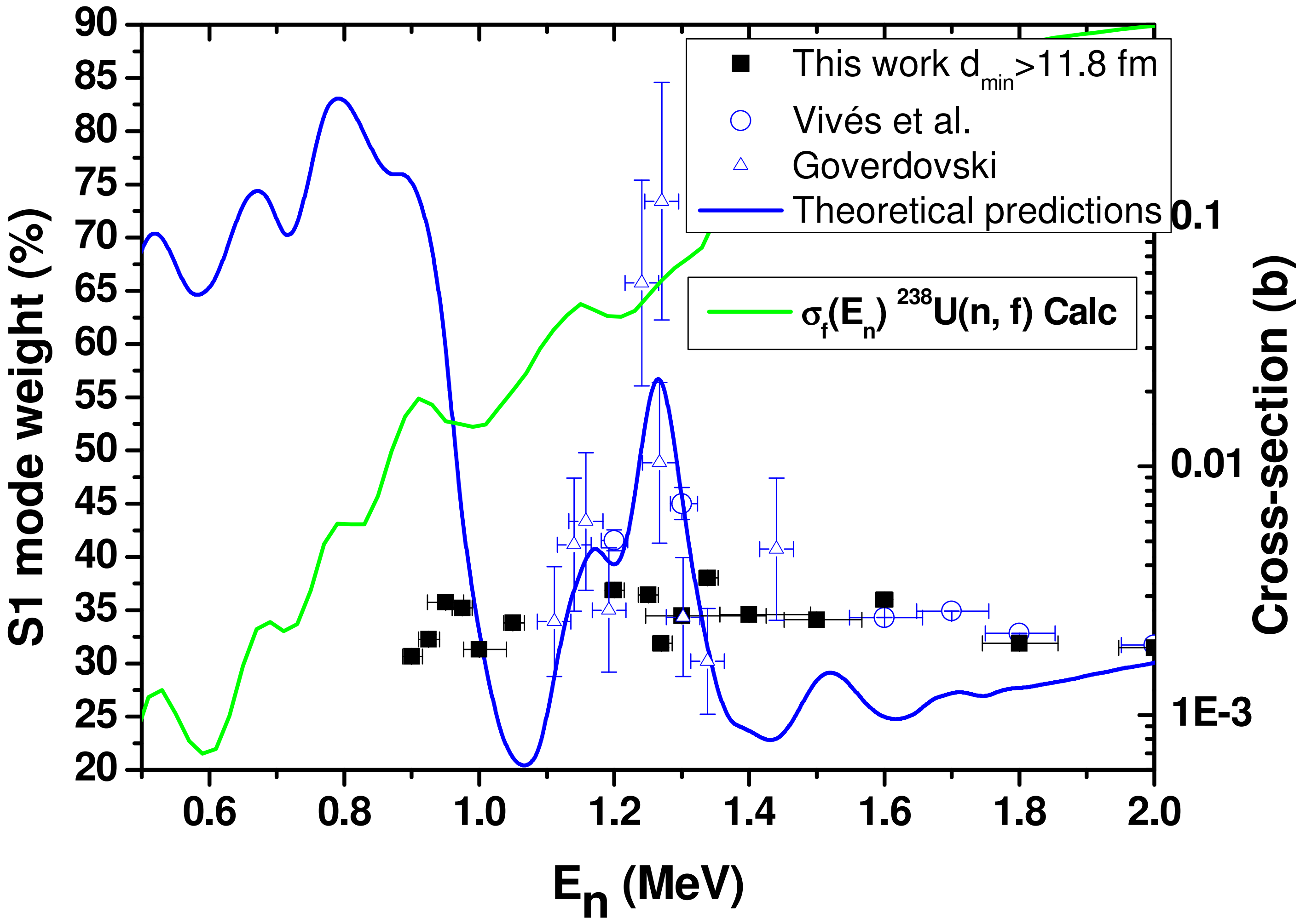
^{238}U Mass Distribution at E_n=1.2 MeV



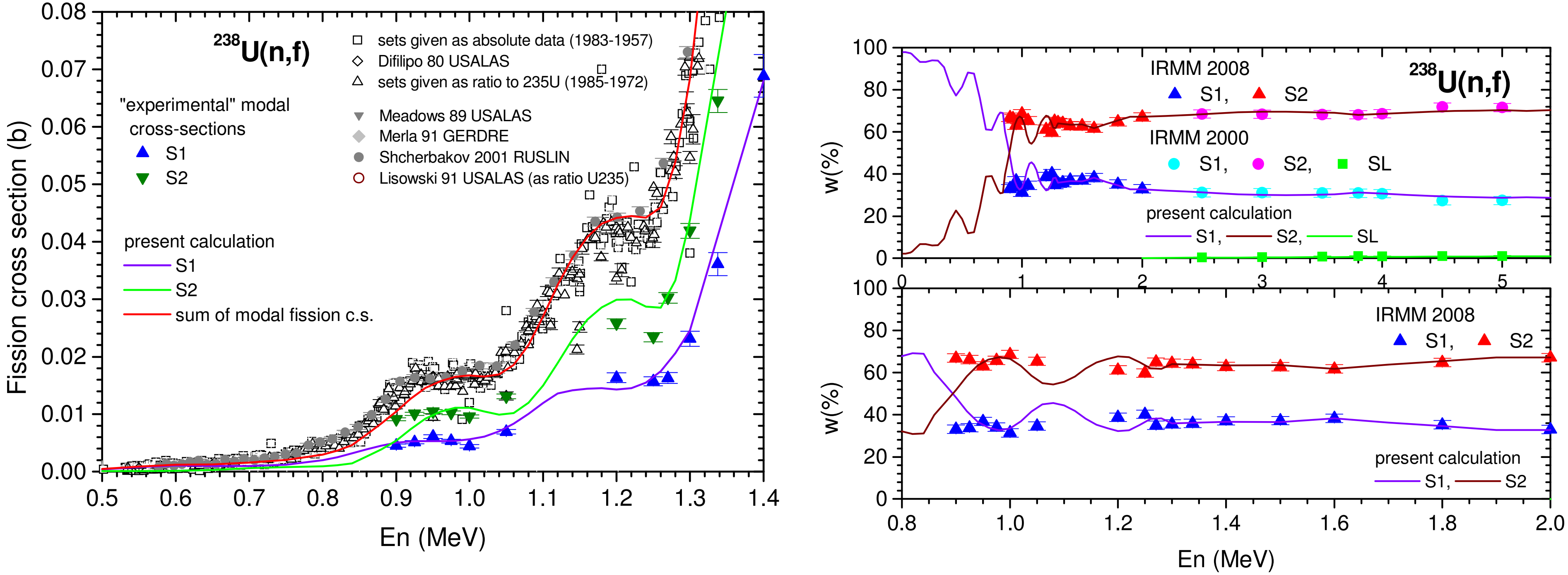
^{238}U Mass Distribution at E_n=0.9 MeV



Fission mode weights



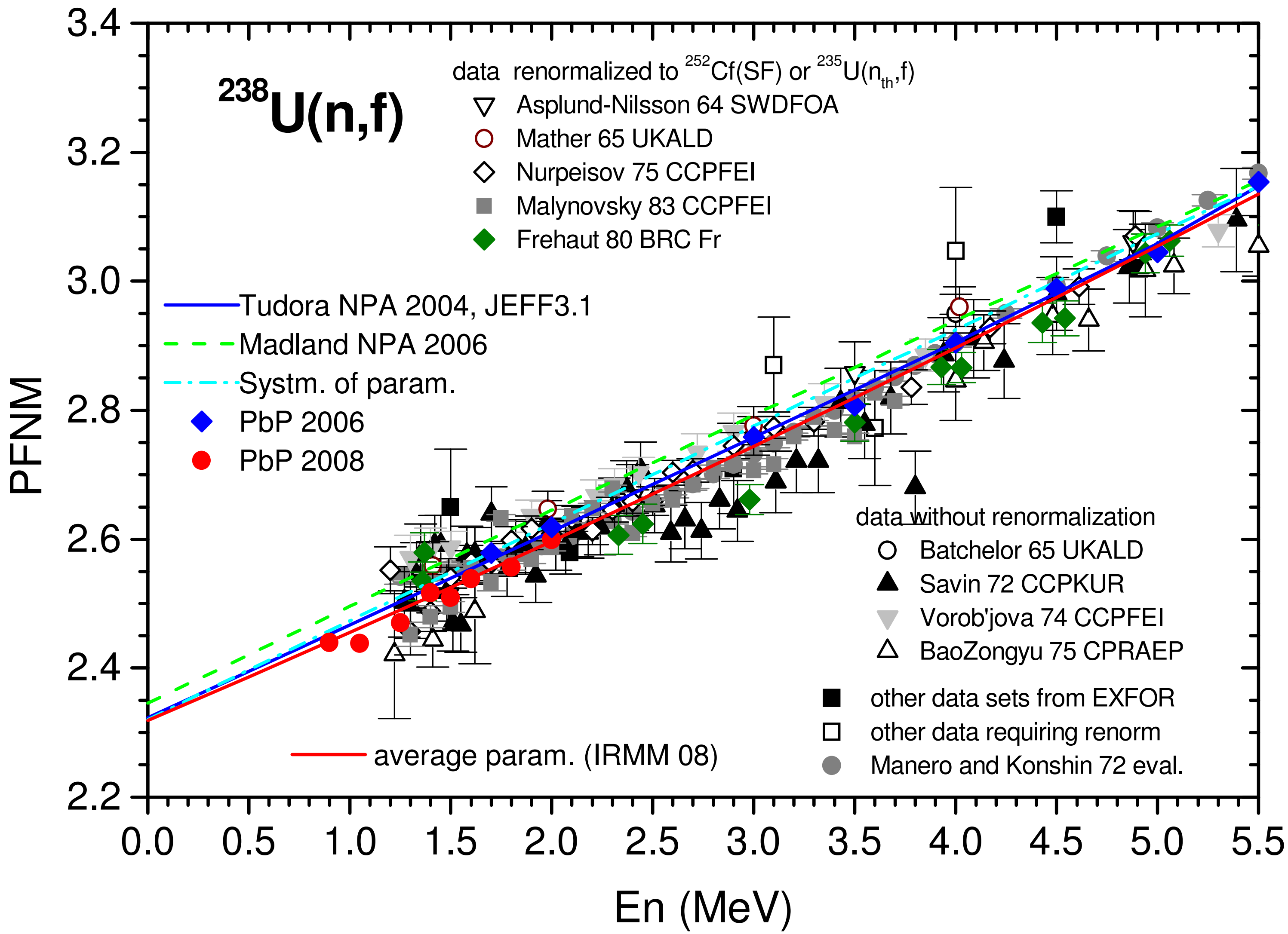
Improved barrier parameters



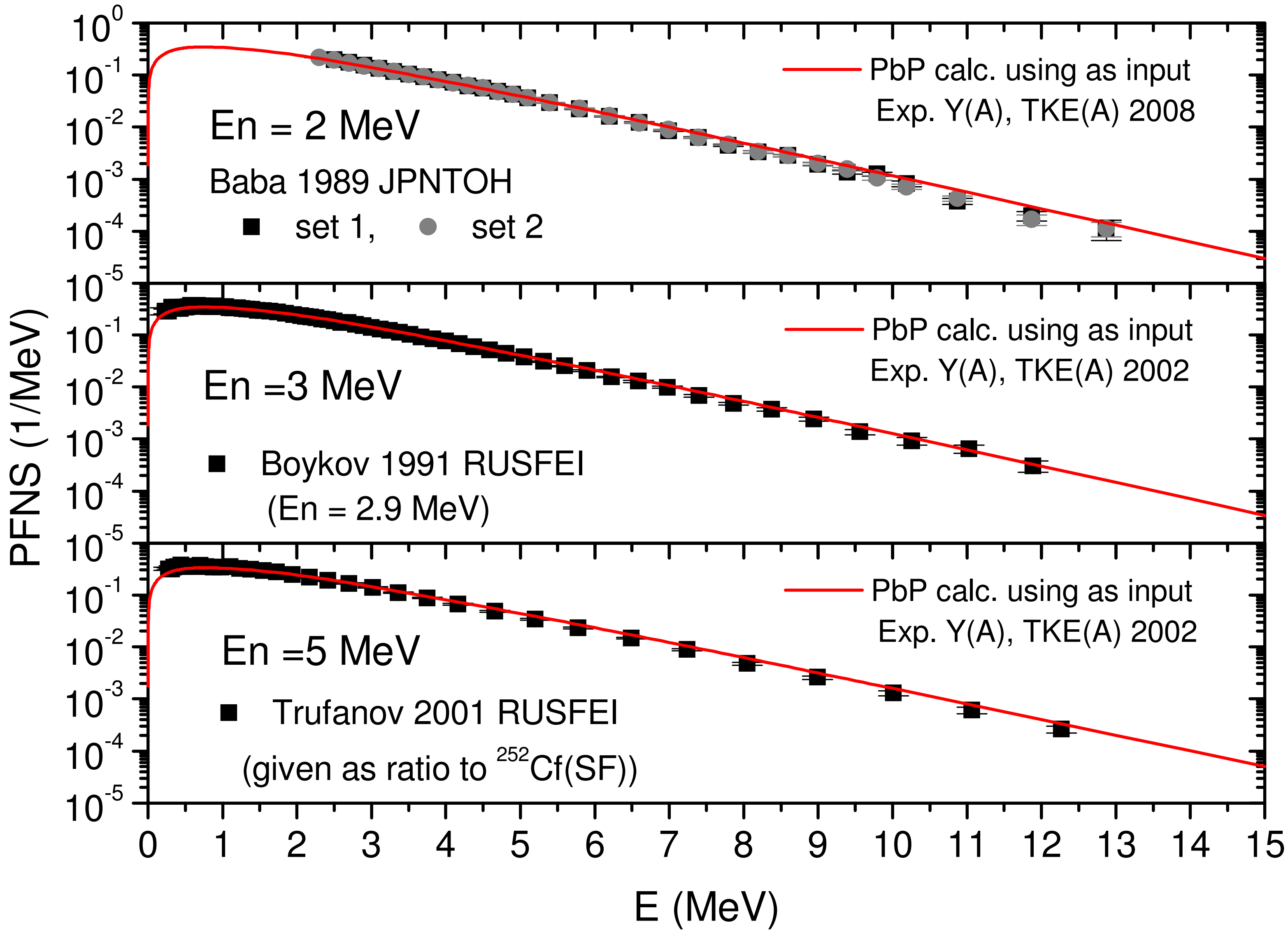
Point by point (PbP) calculations

- Assumption: Neutron evaporation from fully accelerated fission fragments (Los Alamos model)
- PbP takes into account the full range of possible fragmentations of the fissioning nucleus
- FF mass and total kinetic energy distributions are input quantities for the PbP calculations
- above the second chance threshold only most probable fragmentation used
- split of the total excitation energy between the two fragments of each pair is based on ν_H/ν_{pair} ratio
- mass excesses are based on Audi and Wapstra

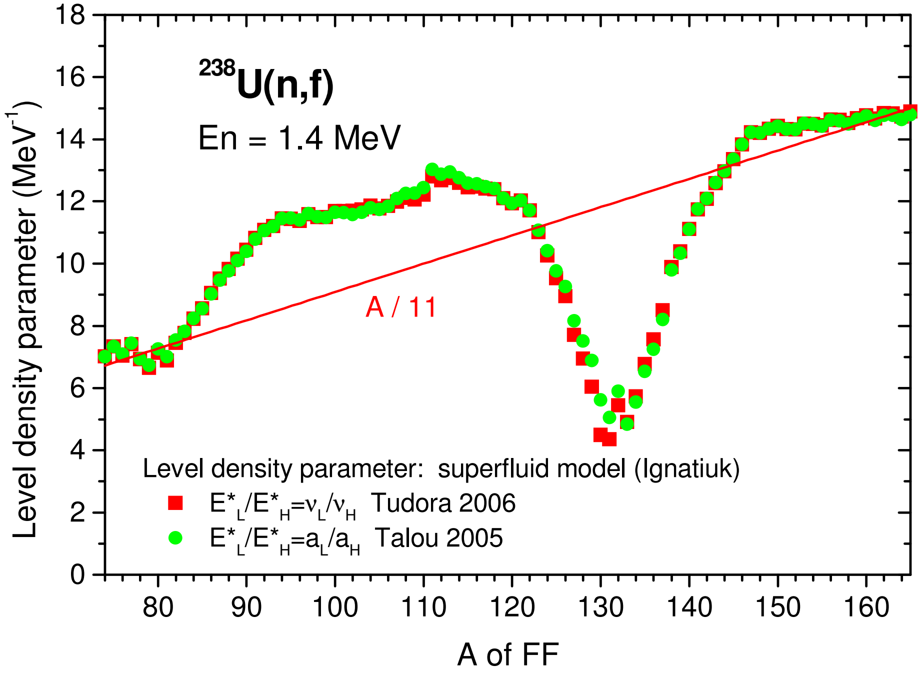
Prompt neutron multiplicity

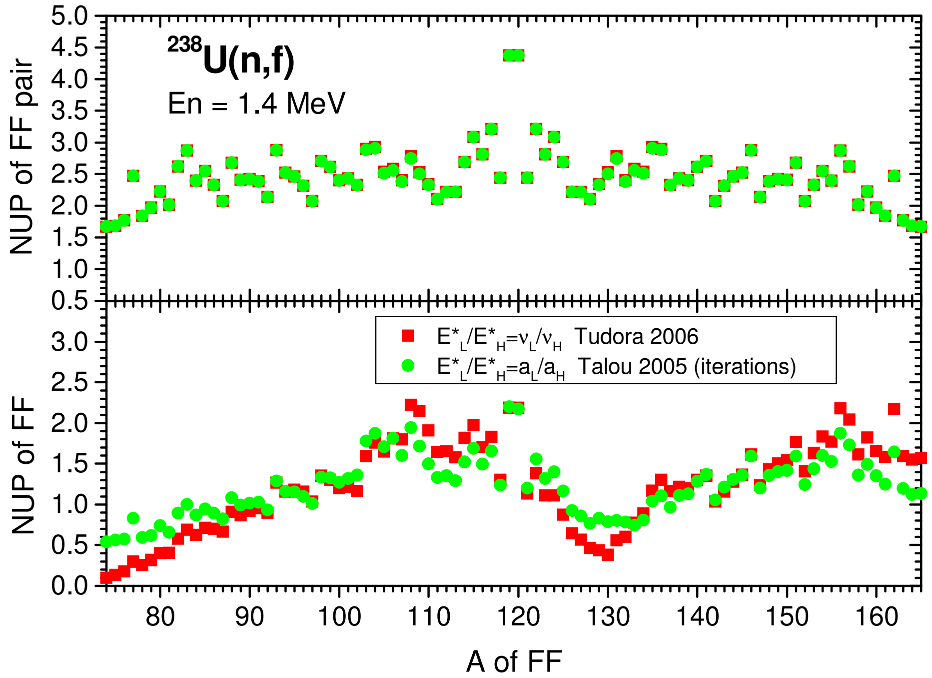


Prompt fission neutron spectrum



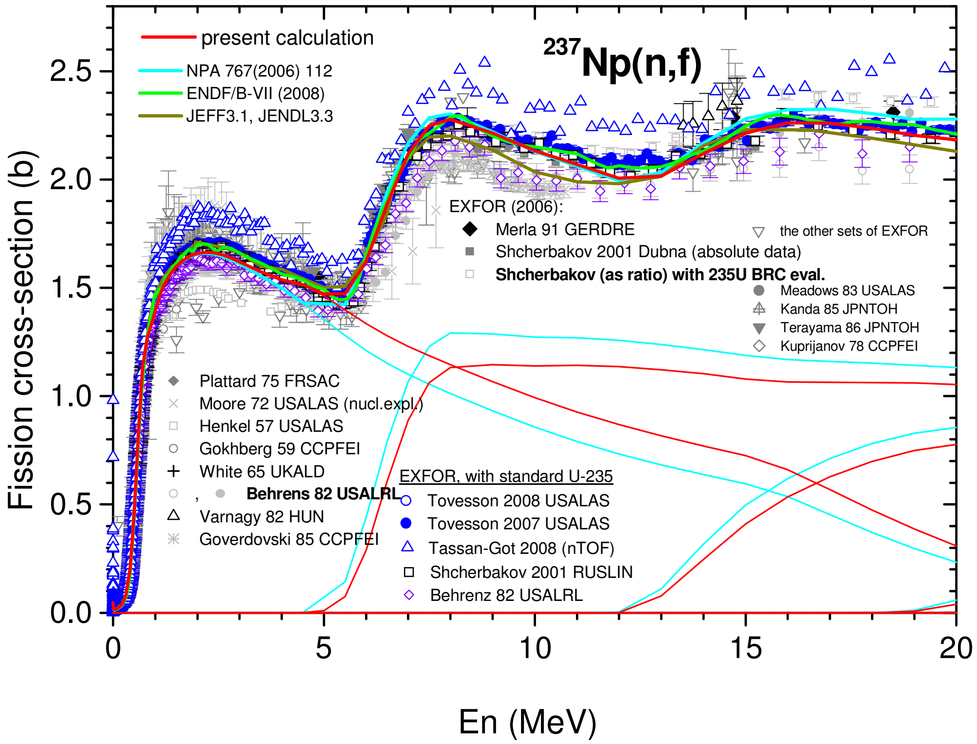
Level densities and share of TXE

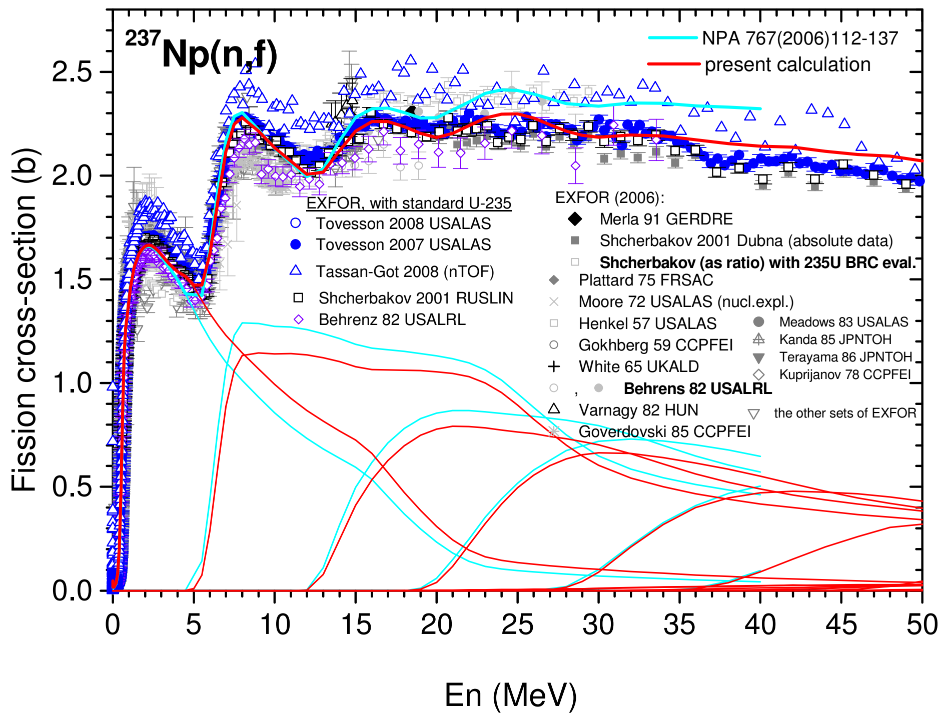




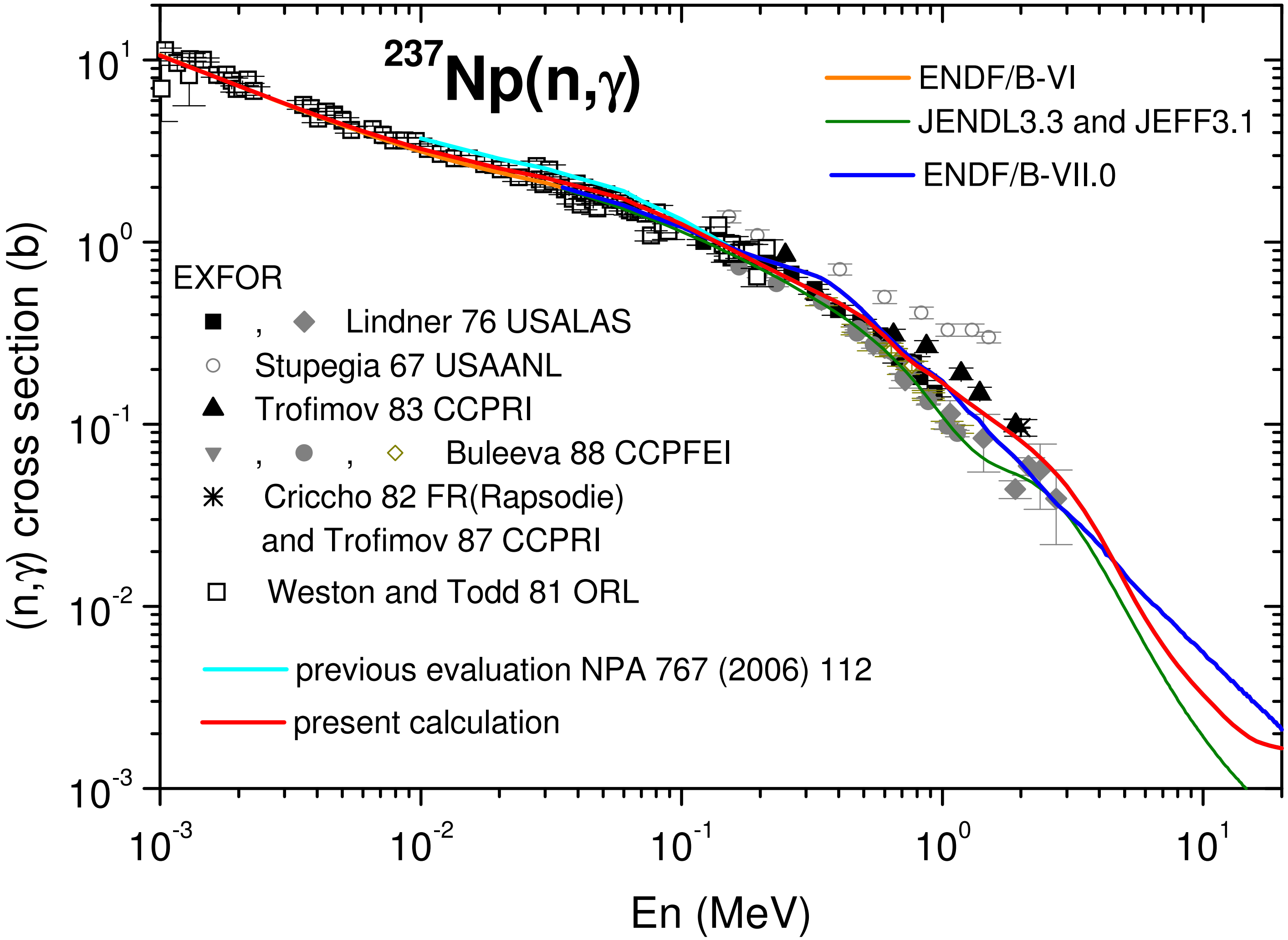
$^{237}Np(n,f)$

^{237}Np fission cross section up to 50 MeV

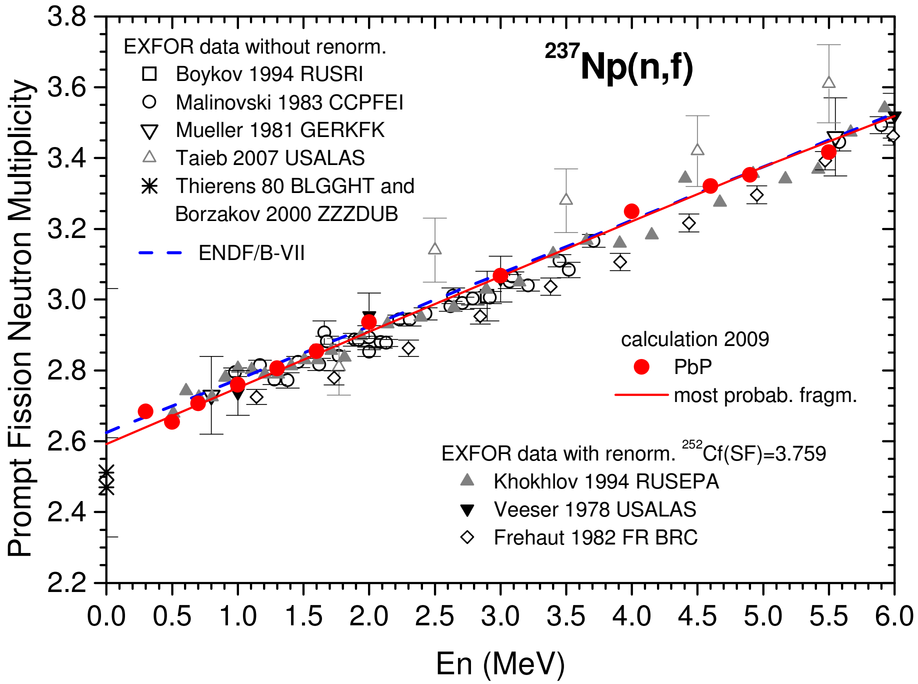


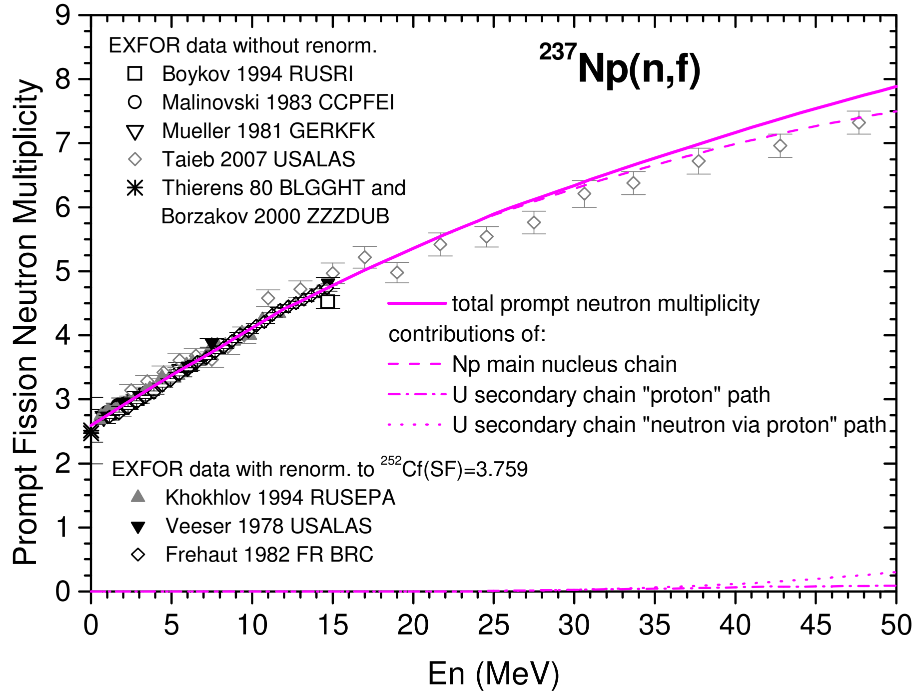


Capture cross section

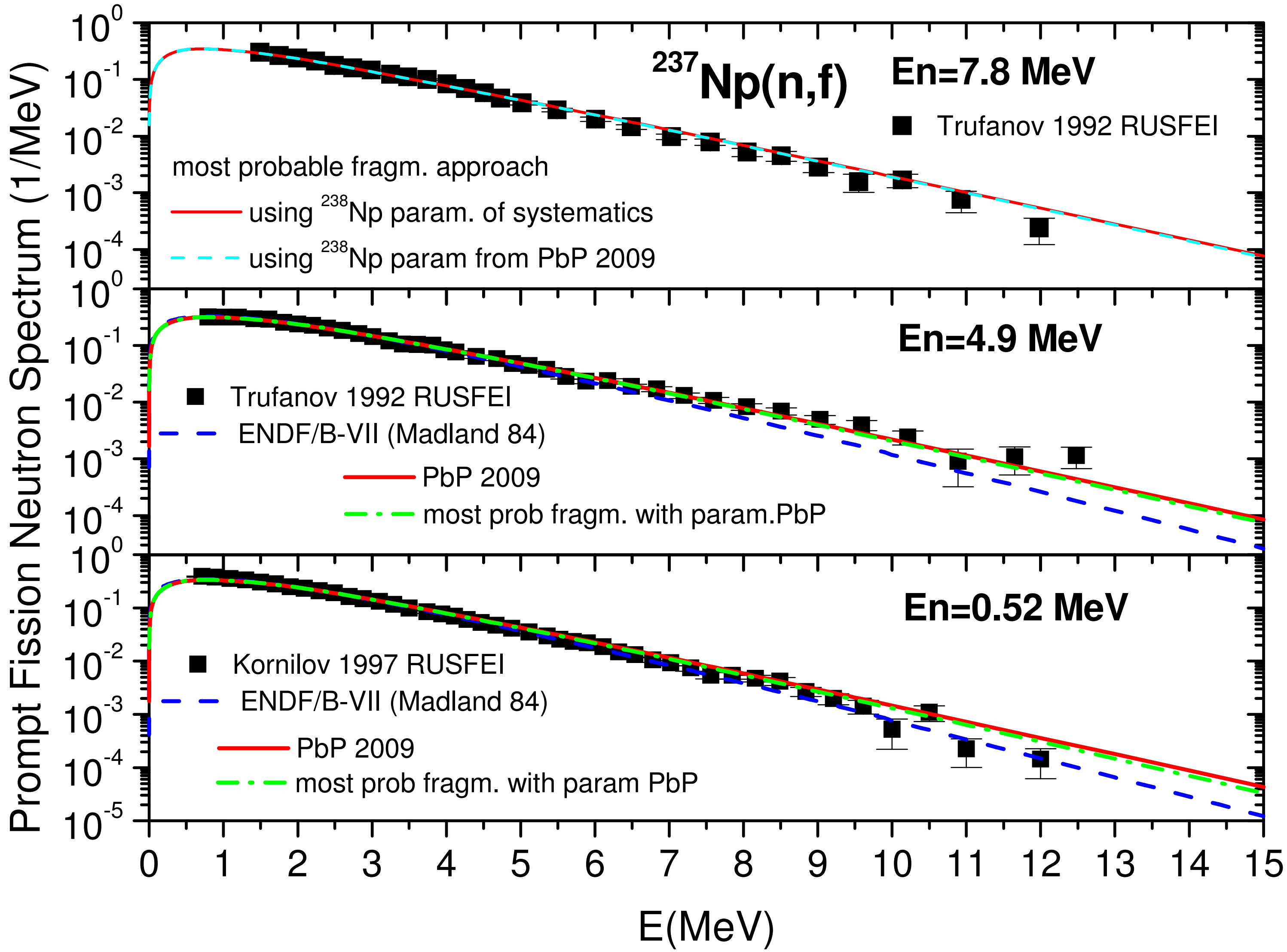


Prompt neutron multiplicities





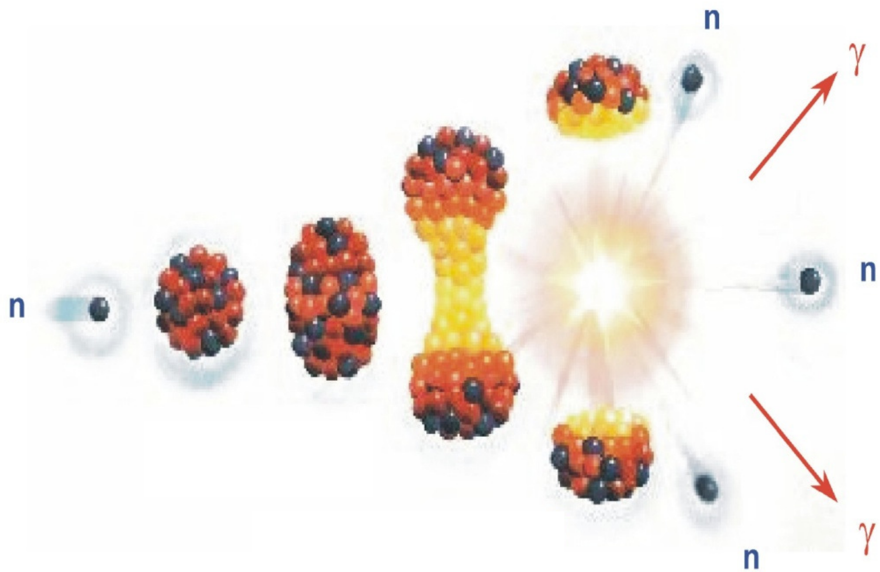
Prompt fission neutron spectra



Conclusions

- Model calculations within a statistical model in good agreement with many experimental results, but predictive power of the model is limited.

- Point by point calculation of the prompt fission neutron multiplicities and spectra gives good agreement with experimental data.



Thank you for your attention ☺