Evaluation Work at LANL

LA-UR-06 7890

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Preview

Cross Section Evaluation

- For ENDF/B-VII, we have upgraded several nuclear reaction data
  - ^{237}Np(n,f), ^{234}U(n,γ), ^{241}Am$(n,2n)$, ...
  - Resonance parameters for ^{237}Np and ^{234}U
- Nuclear reaction model calculations were made for many nuclides
  - Close collaboration with LANSCE / GEANIE, DANCE, and fission measurements
  - ^{191,193}Ir(n,n'), ^{197}Au(n,n'), ^{48}Ti(n,n'), $(n,2n)$, ^{150}Sm

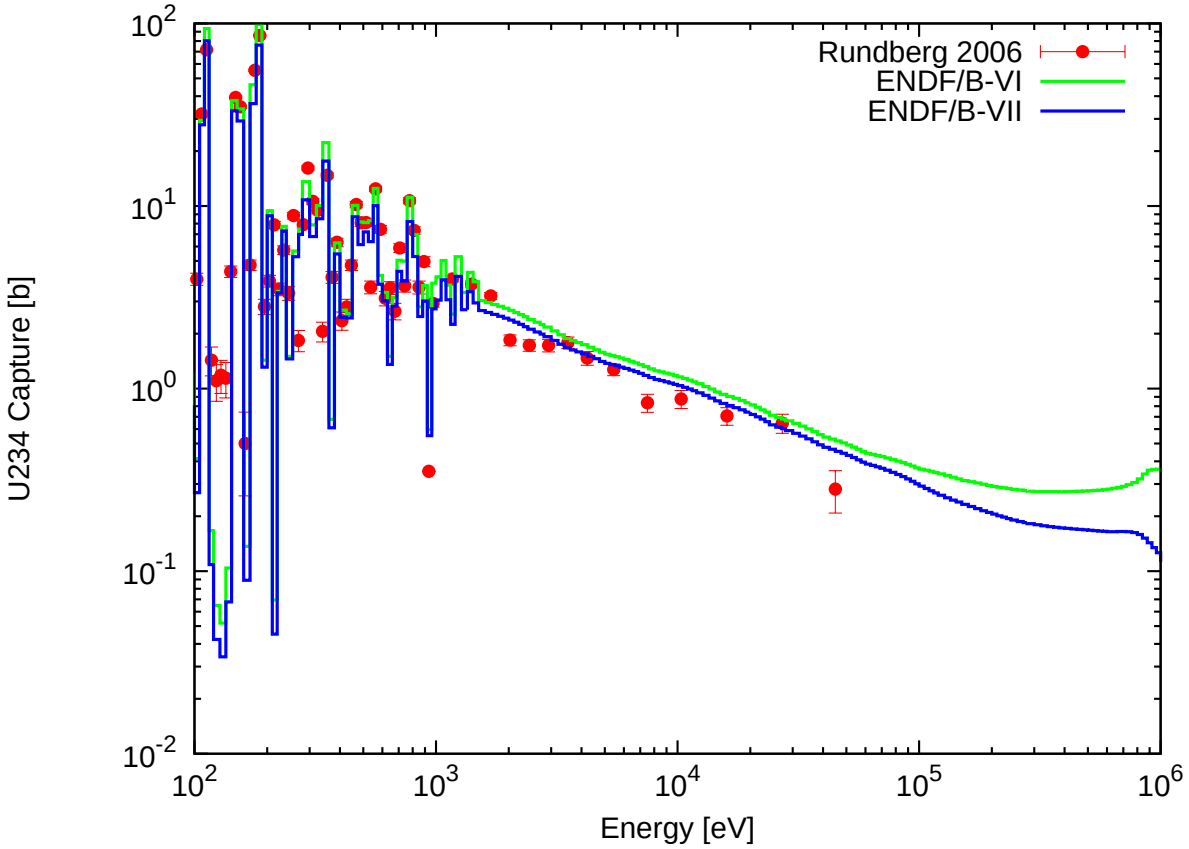
Covariance Evaluation

- ^{235}U, ^{238}U, ^{239}Pu covariance data finalized
- collaboration with BNL — EMPIRE-KALMAN

Code / Theoretical Development

- New McGNASH development — we will be able to release the code soon
- Hartree-Fock calculation for capture and pre-equilibrium
- Hauser-Feshbach theory with strongly coupled channels

U-234 Capture Cross Section - DANCE Data



The DANCE detector at LANSCE Lujan Center measured ^{234}U capture cross sections at low energies. These new data were analysed with the GNASH code for ENDF/B-VII.

- Resonance parameters at low energies were modified to reproduce the Mughabghab's latest values
- Γ_γ in the resolved resonances were changed from 0.04 eV to 0.026 eV

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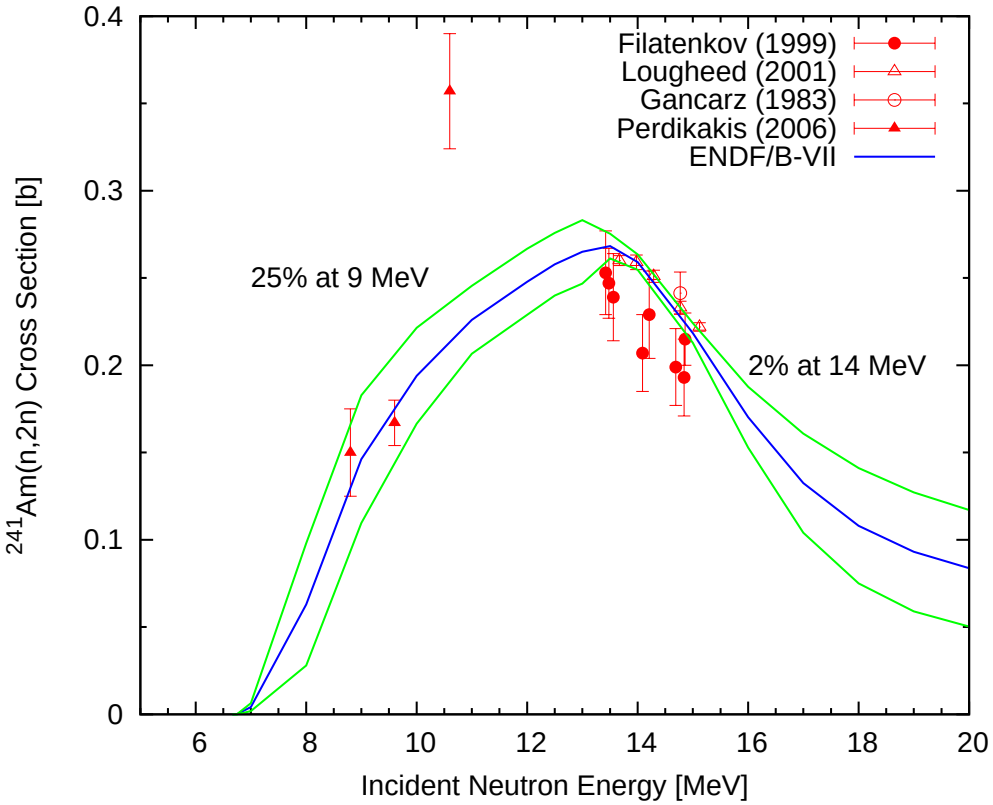
Am-241(n,2n) Reaction Cross Section



- Strong correlation appears below 12 MeV, due to model predictions
- Uncertainties near 14 MeV become small, because of measurements

With the Bayesian method, the covariance data of evaluated cross section are obtained. The covariance data include information of both experimental and theoretical uncertainties.

- supports LDRD/DR on americium
- needed in stockpile stewardship and threat reduction applications

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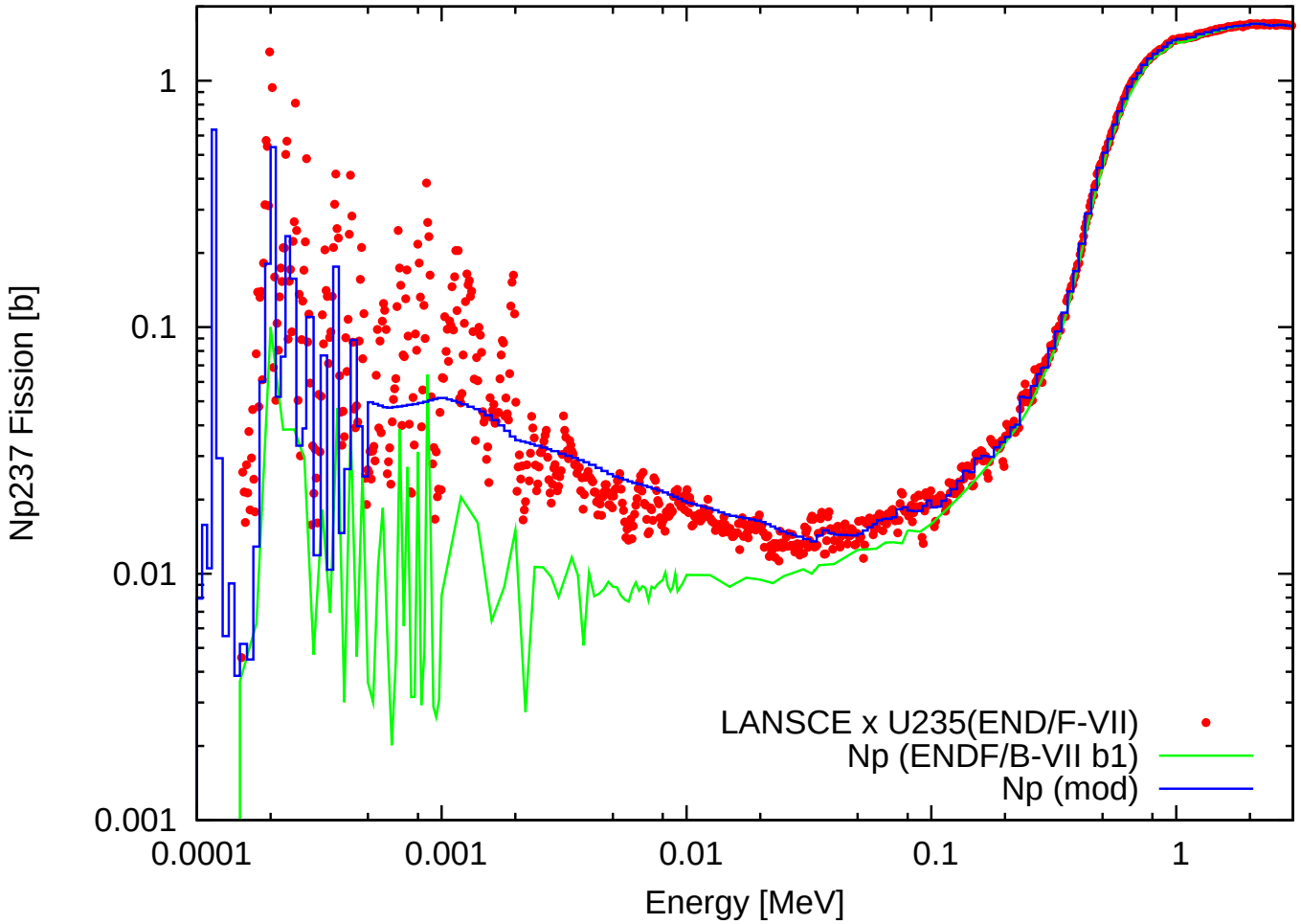
Np-237 Sub-threshold Fission



- We adopted the JENDL-3.3 resonance parameter evaluated by Nakagawa
- Unresolved parameters were slightly modified to match the LANSCE data

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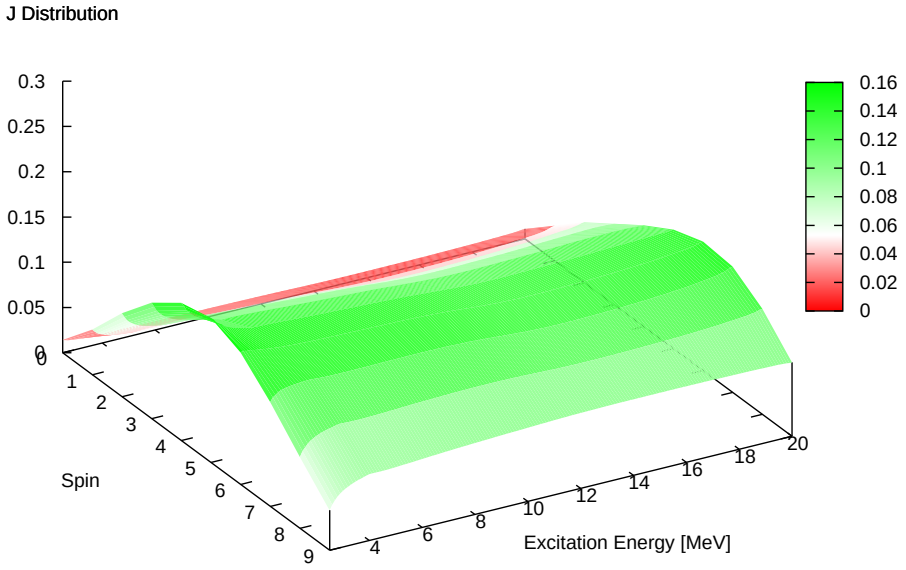
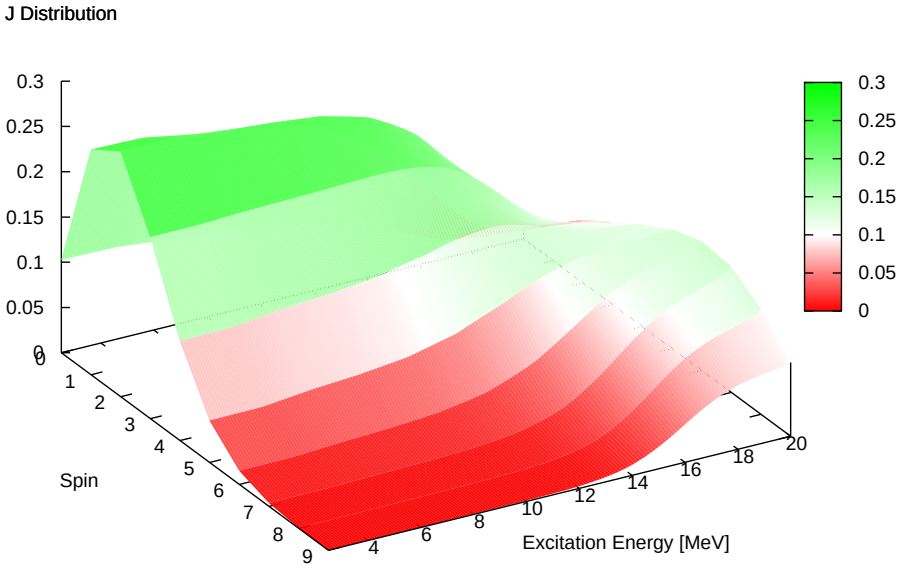
Spin Distribution in the Continuum

Analysis of GEANIE Data Requires a New Spin Physics in HF

CN Reaction Only



CN + FKK



- The FKK calculation suppresses the high-spin state population in the continuum because its angular momentum transfer is not so large.
- We expect that transitions from the higher spin-state become smaller.

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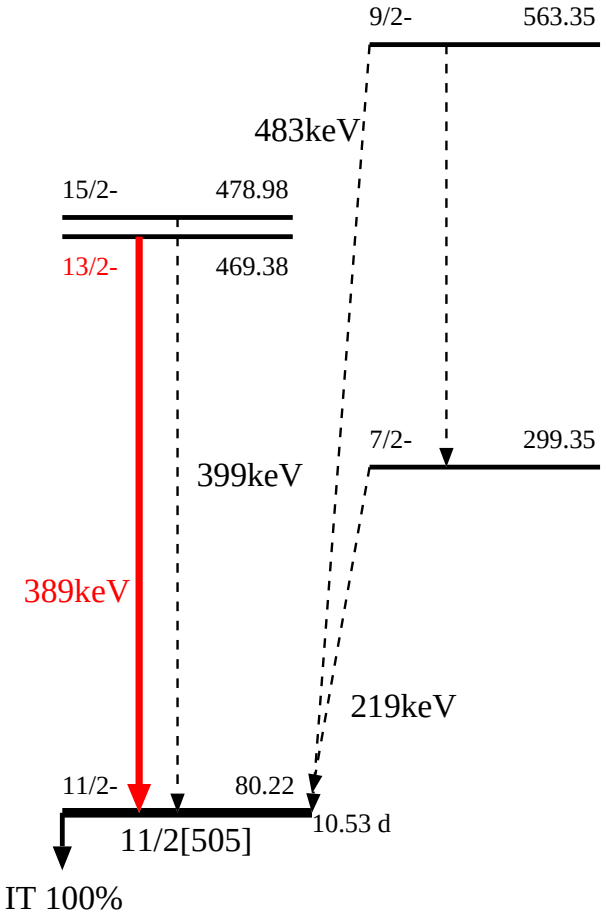
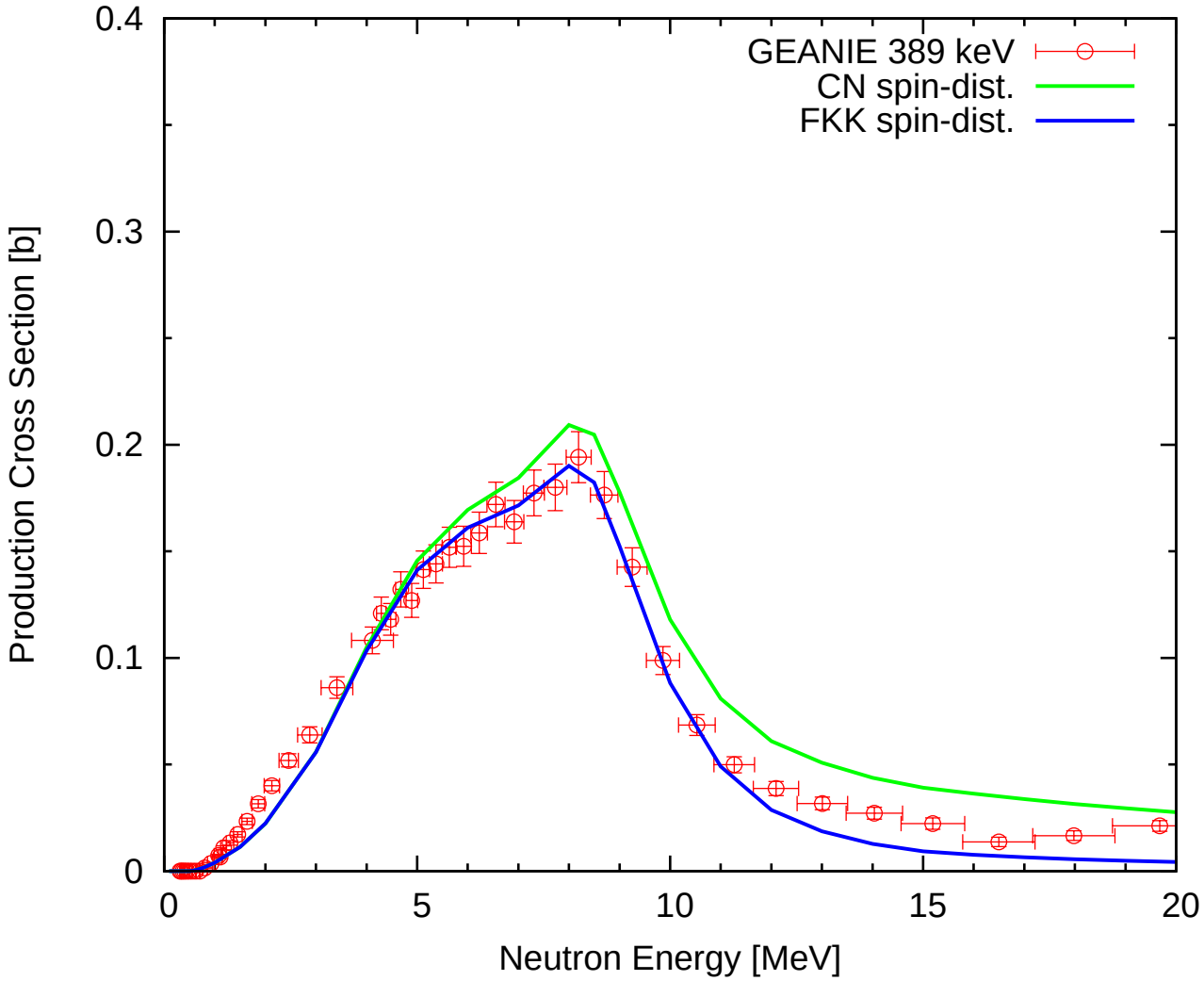
Ir-193, Gamma-ray to the Isomeric State, 389 keV

469.38 keV $13/2^-$ → **80.22 keV** $11/2^-$





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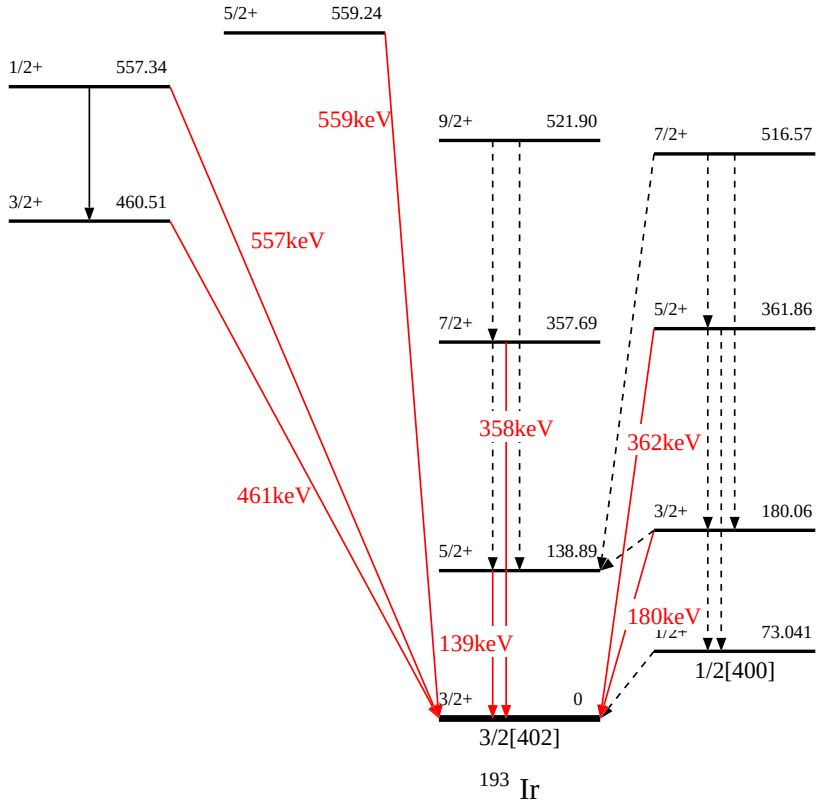
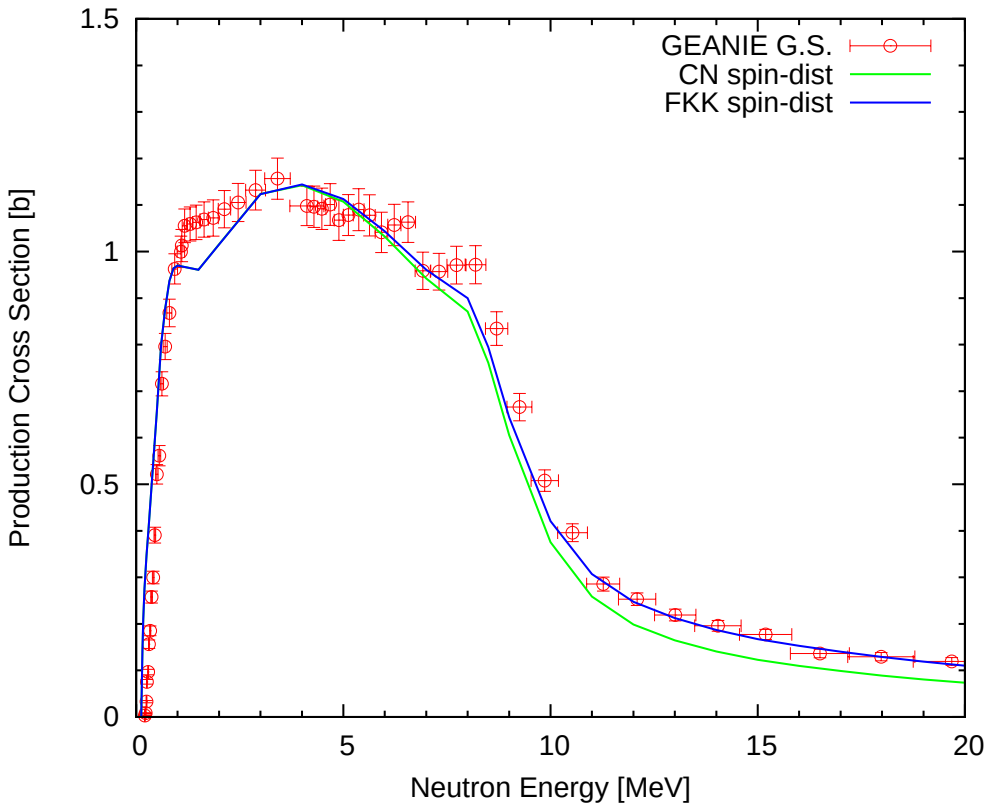
Ir-193, Ground State Production

Sum of Seven Gamma-rays





The calculations are for the partial γ-ray production, and we have evaluated a total meta-state production cross section. This partial evaluation was completed by Rochman et al., and included in ENDF/B-VII.

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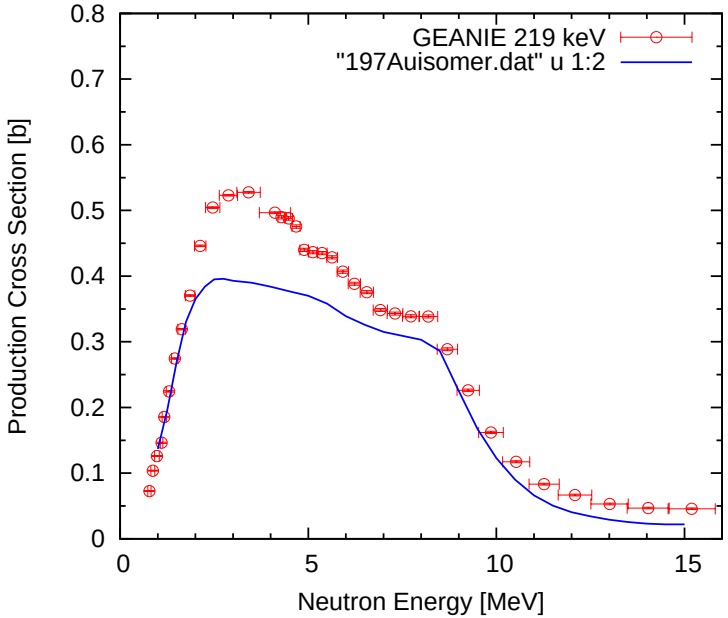
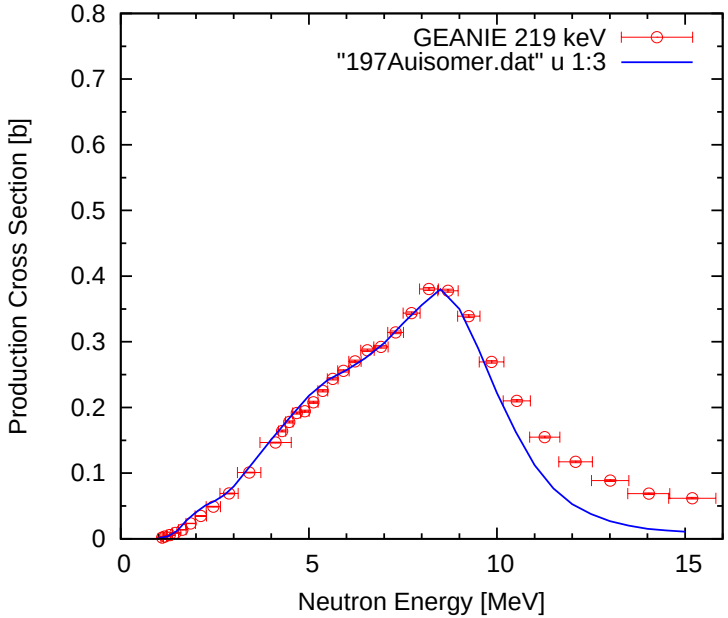
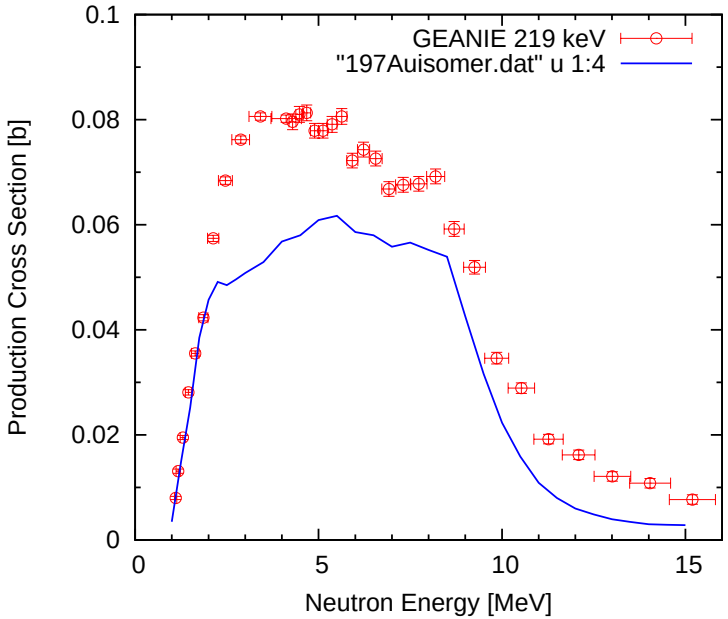
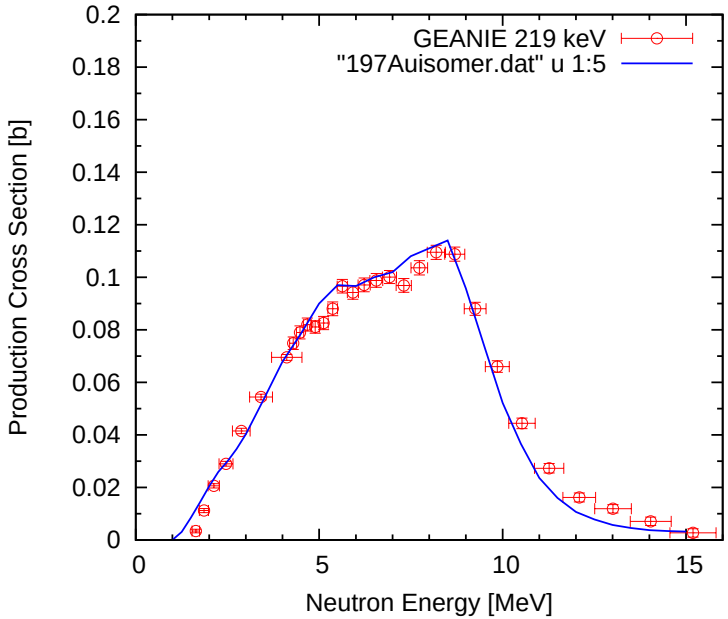
Au-197 Inelastic Scattering









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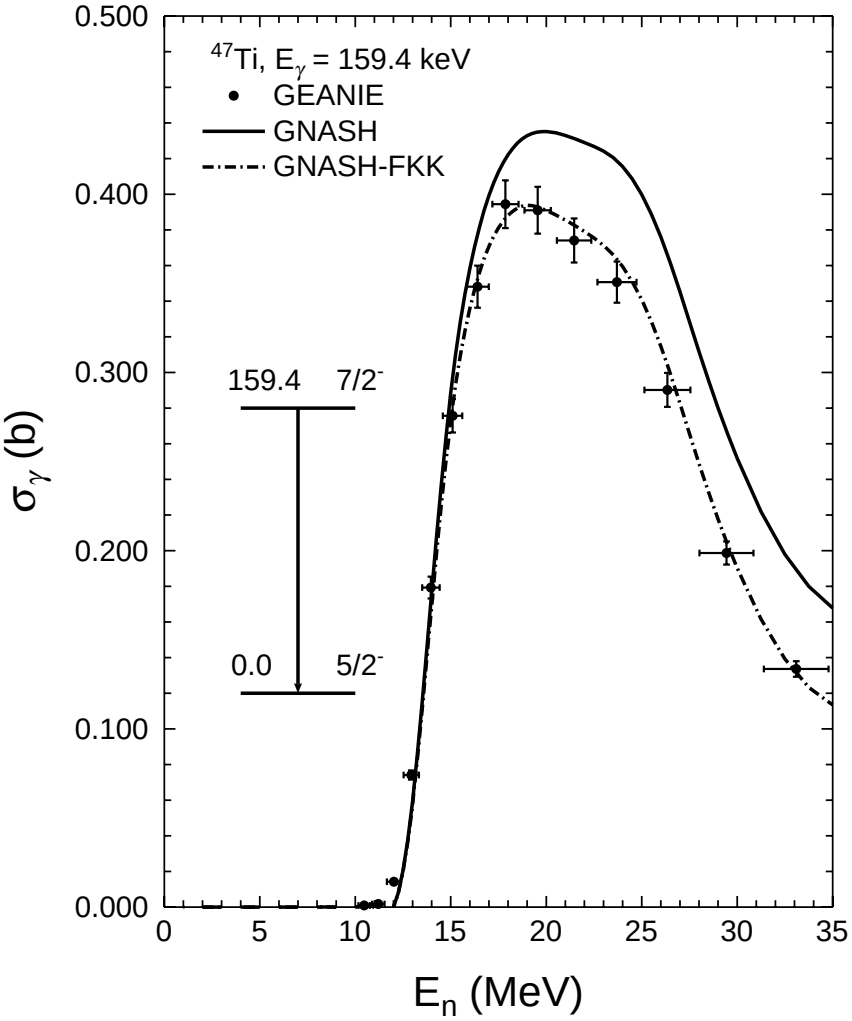
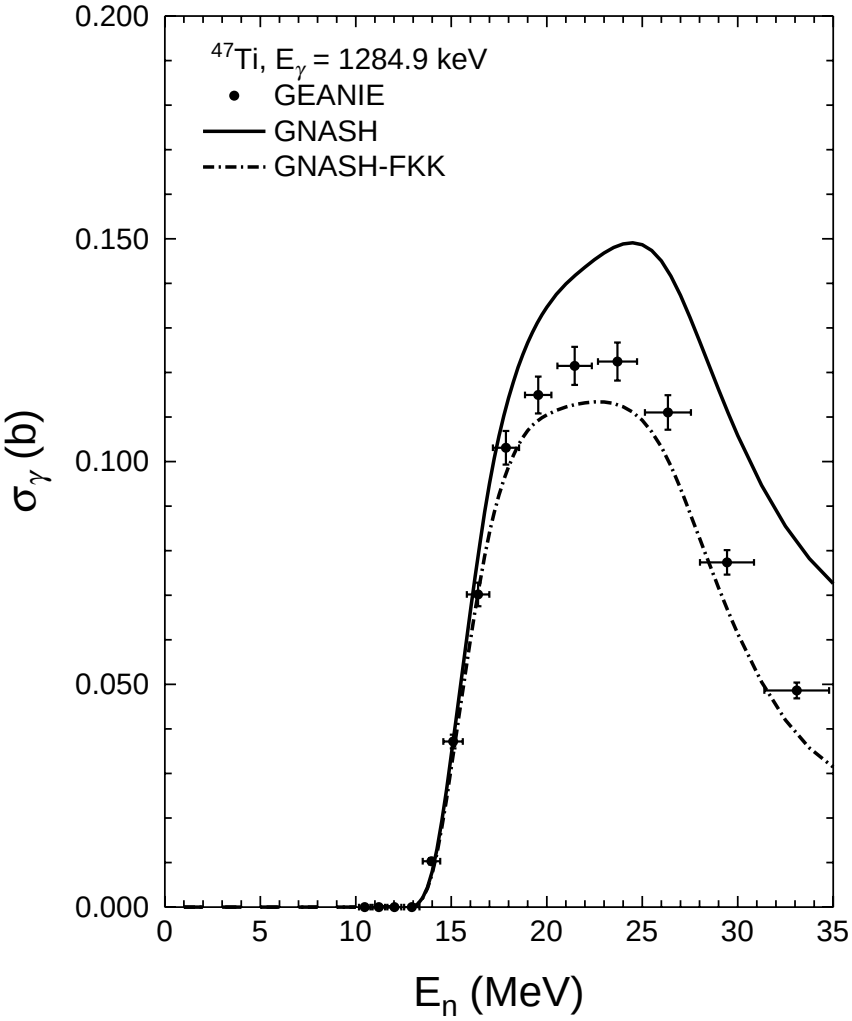
Ti-48 (n,2n)

Dugersuren Dashdorj (NCSU, LLNL)



159.4 keV $(7/2^-)$ to GS



1444.3 keV $(11/2^-)$ to 159.4 keV $(7/2^-)$

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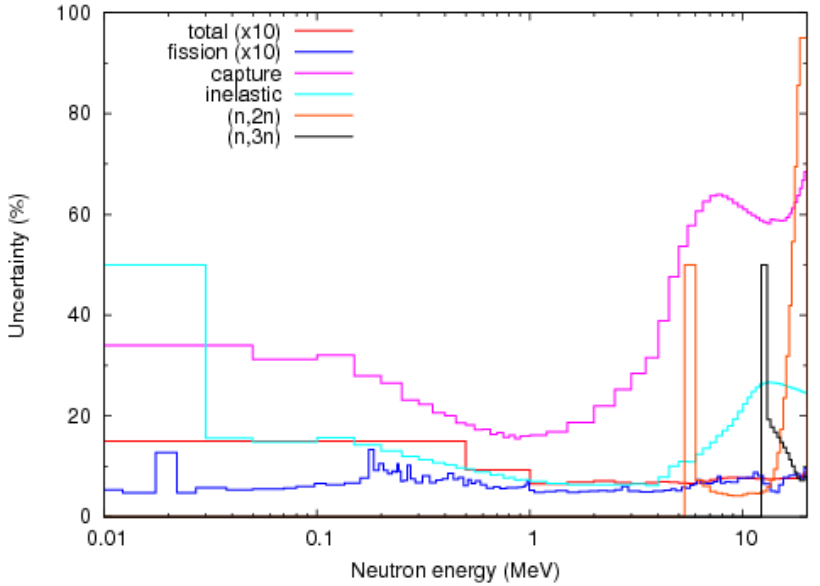
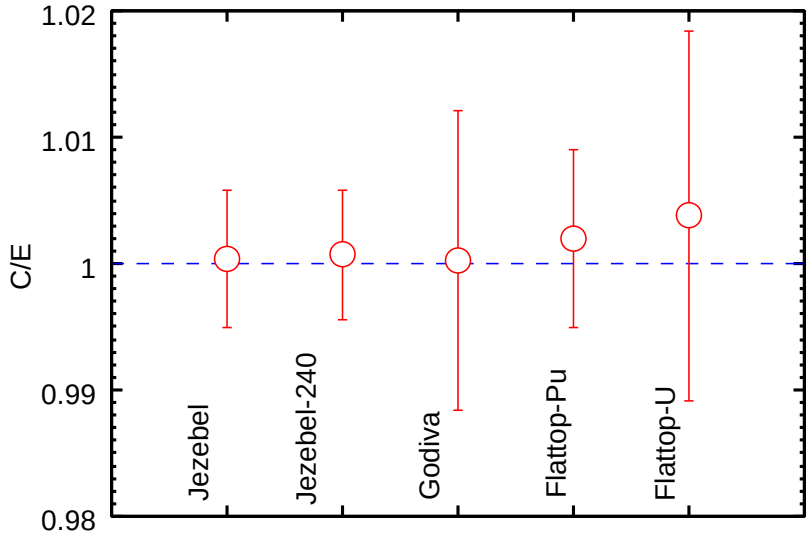
Calculated Uncertainties in k_{eff} for Critical Assemblies

Evaluation of Covariance Data for ENDF/B-VII

- Above the resonance range, LANL provided covariances for ^{235,238}U and ^{239}Pu
- Resonance parameter covariance data come from collaboration with ORNL
- The combined data are processed with NJOY+ERRORJ
- Figures below demonstrate our ability to create ENDF covariance data, process them, and appy in a transport calculation





Jezebel (Pu sphere) k_{eff} uncertainty is ~0.6%. Next We will describe how this can be reduced through use of integral data, using KALMAN.

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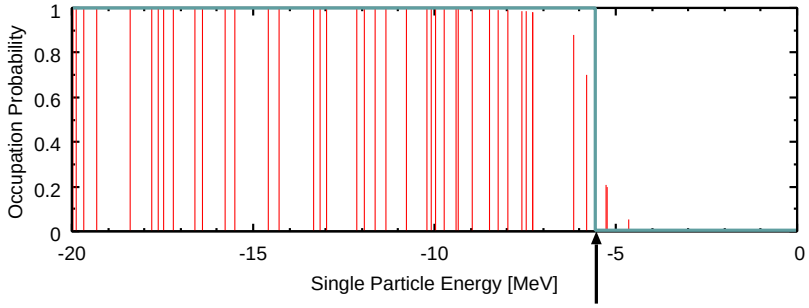
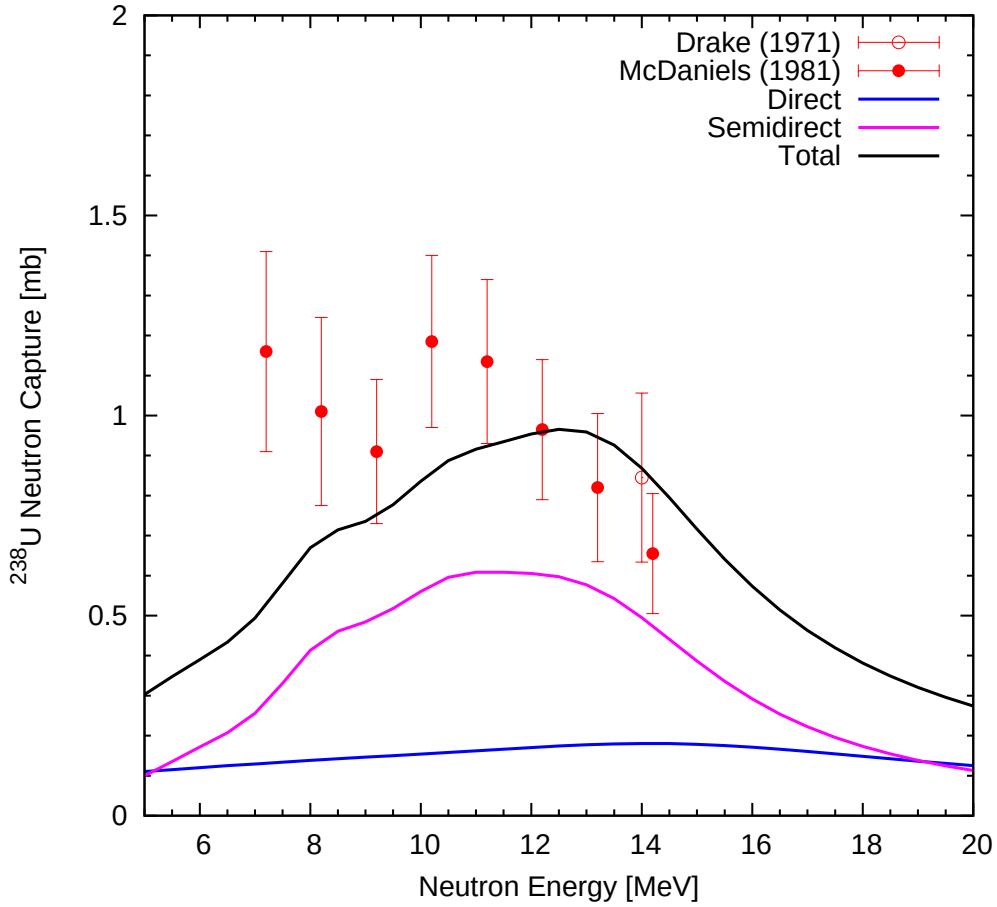
HF-BCS Calculation for U-238 Capture

McGNASH Code Development with HF-BCS Theory

- McGNASH capture cross section calculations were extended to utilize a modern nuclear structure theory.
- Single particle state wave-functions and occupation probabilities are calculated with the Hartree-Fock BCS theory.
- Direct/Semidirect capture model is extended to deformed nuclei.





$$\sigma_c^{th} = 2.9 \text{ mb}$$

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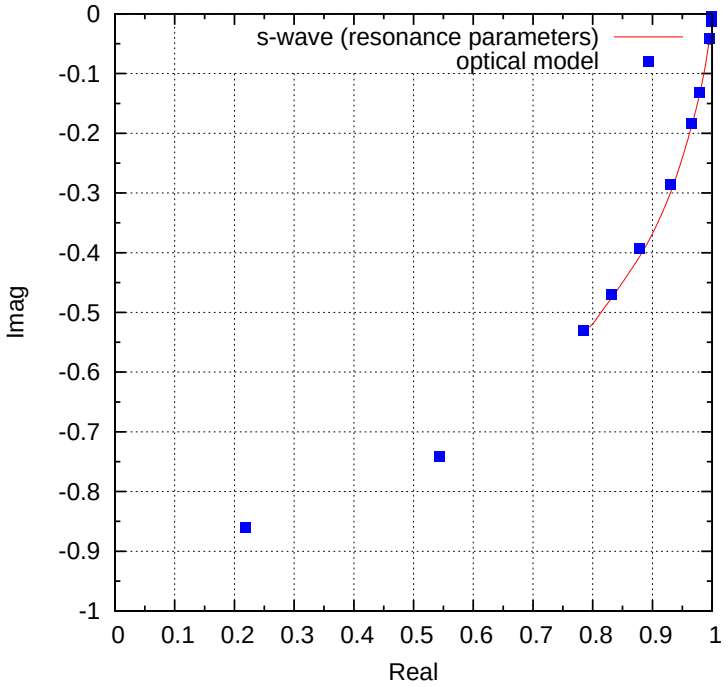
CC Potential in Resonance Region

Modification to the Global CC Potential of Soukhovitskiĭ, et al.

- E. Sh. Soukhovitskiĭ, et al., J. Phys. G: Nucl. Part. Phys. **30**, 905 (2004).
- Adjust the imaginary potential to match the energy averaged S-matrix elements from resonance parameters (TK, F.H. Fröhner, NSE, **127**, 130 (1997)).
- When the S-matrix elements (resonance and optical model) are obtained, total and reaction cross sections are automatically reproduced.



W_s = 2.59 MeV for $E_n < 1.13$ MeV

R' = 9.606 fm (9.6$\pm$ 0.1 in Atlas, Mughabghab)

S_0 = 1.13 $\times 10^{-4}$ ((1.29$\pm$ 0.13) $\times 10^{-4}$, ibid)

S_1 = 2.07 $\times 10^{-4}$ ((2.17$\pm$ 0.19) $\times 10^{-4}$, ibid)

Original SoukhovitskiĭPotential (in the paper)

R' = 9.57 fm

S_0 = 0.95 $\times 10^{-4}$

S_1 = 1.80 $\times 10^{-4}$

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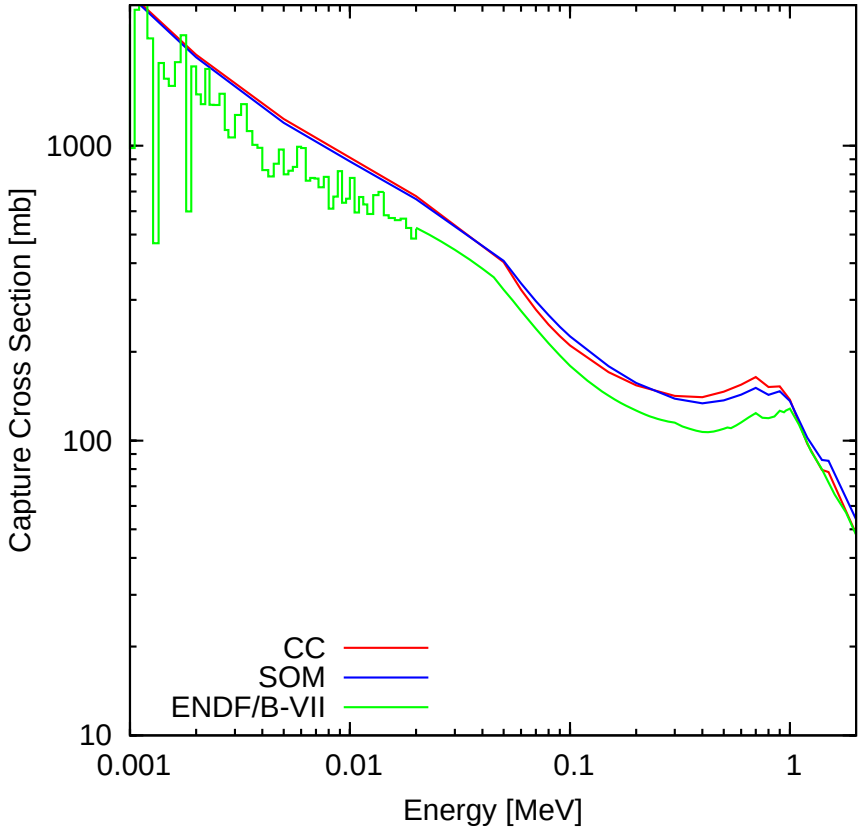
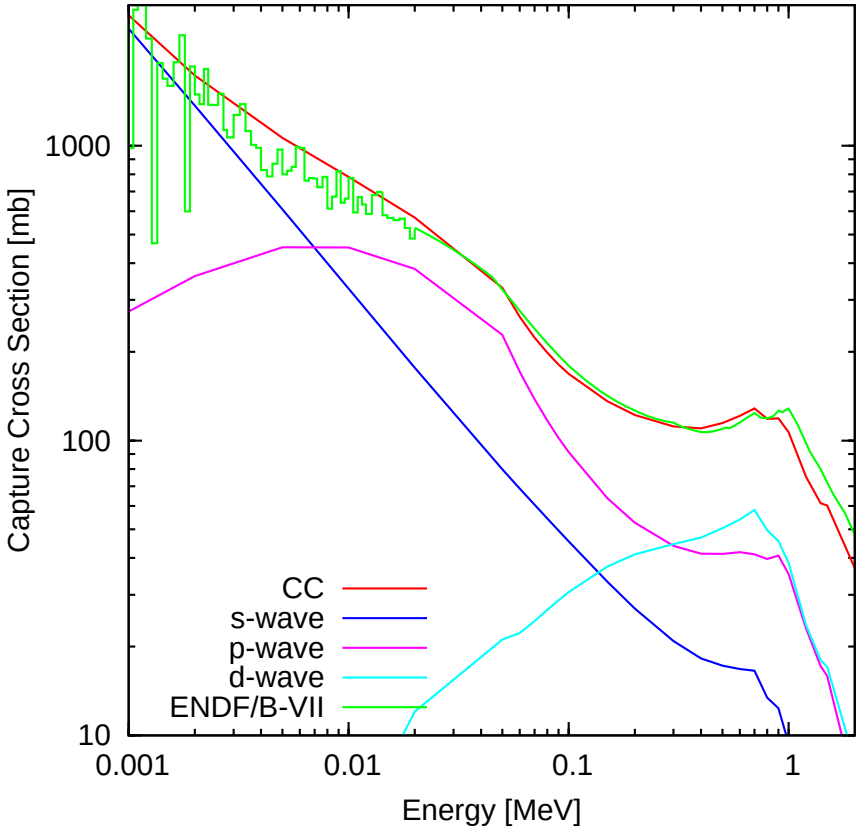
U-238 Capture Cross Section

Comparison with ENDF/B-VII



$\langle \Gamma_\gamma \rangle$=23.36 eV



$\langle \Gamma_\gamma \rangle$=17.83 eV

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Concluding Remarks

Evaluations at LANL

- Some actinides data were upgraded, and they were included in ENDF/B-VII
  - Results of ^{237}Np, ^{234}U, and ^{241}Am were shown
- We have developed a nuclear reaction theories for better agreement with the recent LANSCE experimental data
  - Spin-distribution in the pre-equilibrium process: ^{193}Ir, ^{197}Au, ^{48}Ti, and ^{150}Sm
- Covariance evaluation for major actinides was finished
- We will be able to use McGNASH for nuclear data production soon

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