CoH_3 The Hauser-Feshbach code

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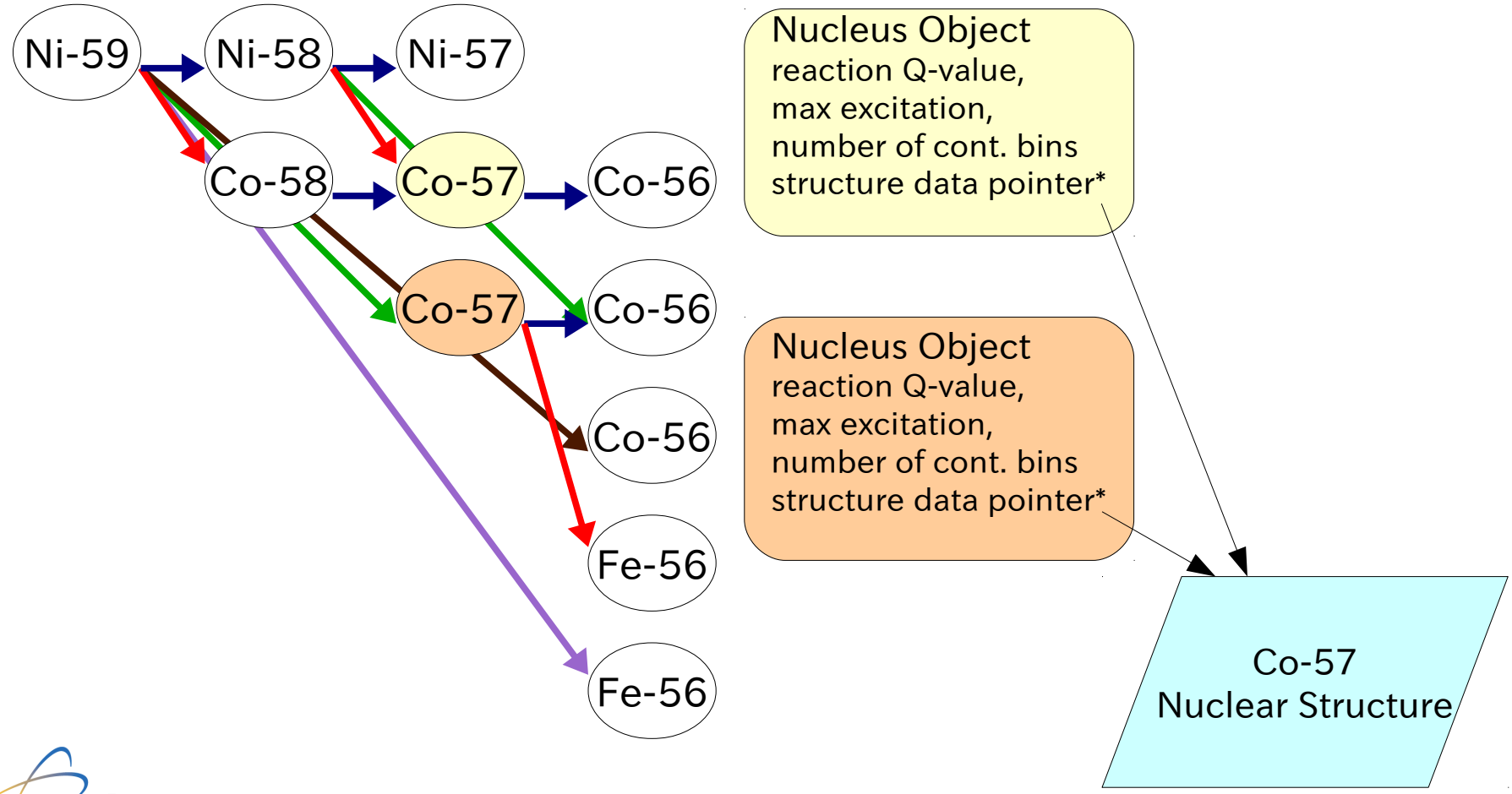
CoH_3 - ver.3.2 Umbriel, 3.3 Titania, and 3.4 Oberon

Code Name	Year	Lines	Main Feature
Umbriel	2012	27.0K	automated ENDF-6 file production with DeCE (talk at USNDP 2012)
Titania	2013/ 2014	28.5K	advanced memory management prompt fission neutron spectrum astrophysical rate calculation
Oberon (beta)	2014	38.4K	nuclear mean-field models Engelbrecht-Weidenmueller transformation beta-delayed neutron/fission module
Miranda	?	?	

Whats New in Titania and Oberon?

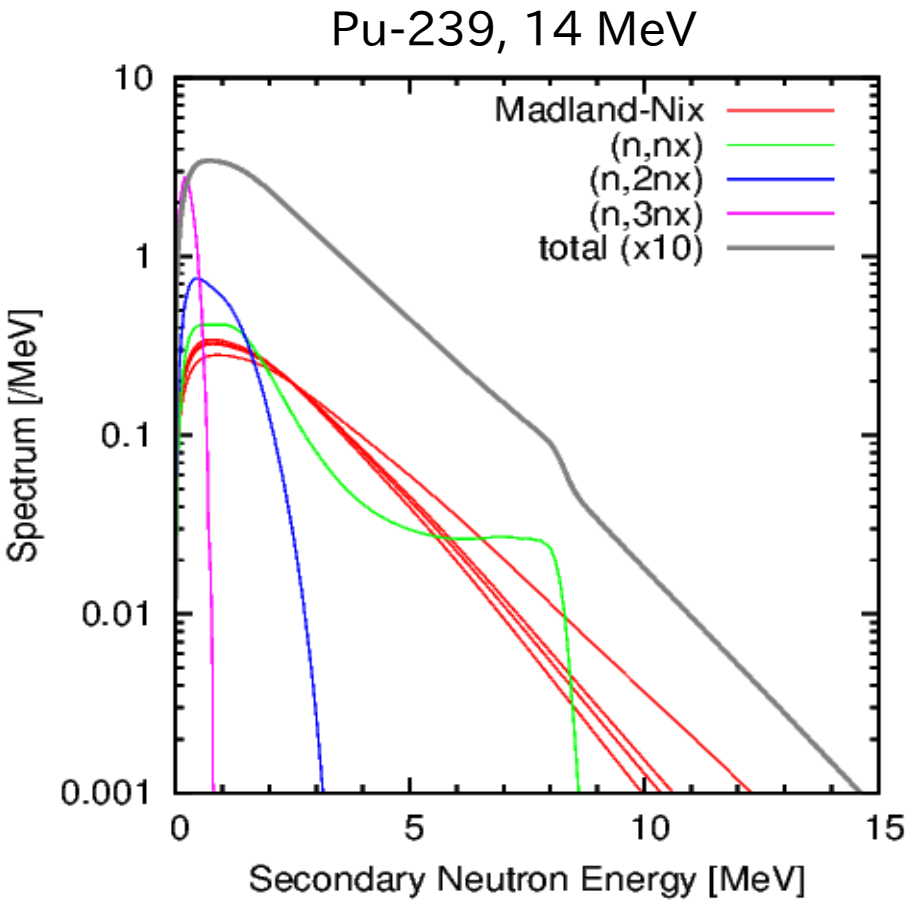
- **Memory Management**
  - Reduced memory size, especially for high energy calculations
  - New faster scheme of dynamical memory allocation
- **More Outputs**
  - Ground state and isomeric state production
- **New Functions / Physics**
  - Exclusive spectrum calculation (was ECLIPSE) merged
  - Madland-Nix model prompt fission neutron spectrum
    - including pre-fission neutron emission
  - Automatic production of Maxwellian-averaged cross sections
  - Nuclear mean-field models included
    - Hartree-Fock BCS and FRDM
  - Kunieda's optical potential for deformed nuclei
  - New width fluctuation parameterization
  - Rigorous treatment of nuclear deformation in the Hauser-Feshbach model with width fluctuation
  - Beta-delayed neutron/gamma/fission code supplemental

Automatic Reaction Chain Set Up and Data Pointers



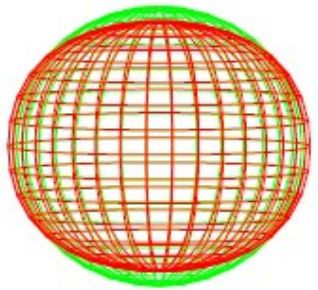
Prompt Fission Neutron Spectrum Calculation

- **Prompt fission neutron spectr**
  - Madland-Nix model
  - multi-chance fission
  - pre-fission evaporation neutron spectra
- **Exclusive prefission neutrons**
  - similar to the other exclusive spectrum calculations in CoH



Mean-Field Models Added To CoH_3

- **FRDM: Finite-Range Droplet Model**
- **HF-BCS: Skyrme Hartree-Fock BCS Model**
  - a la Bonneau, not French-free anymore
- **can be used for:**
  - direct/semidirect capture calculation
  - nuclear deformations for about 9,000 nuclei
  - single-particle state density in the pre-equilibrium process by Strutinsky's method
  - ... and so on



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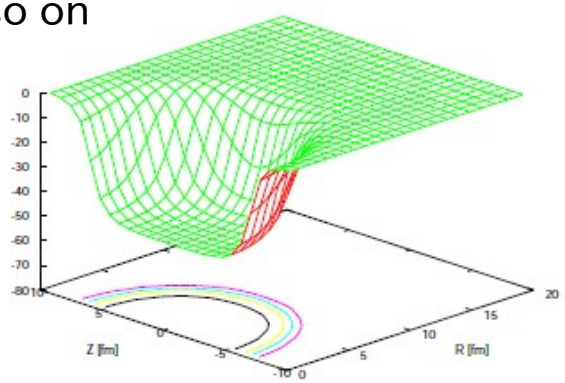
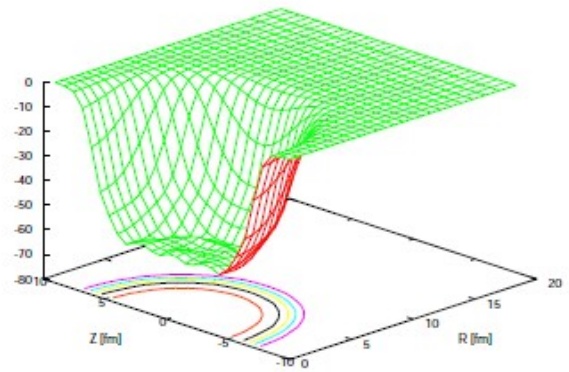


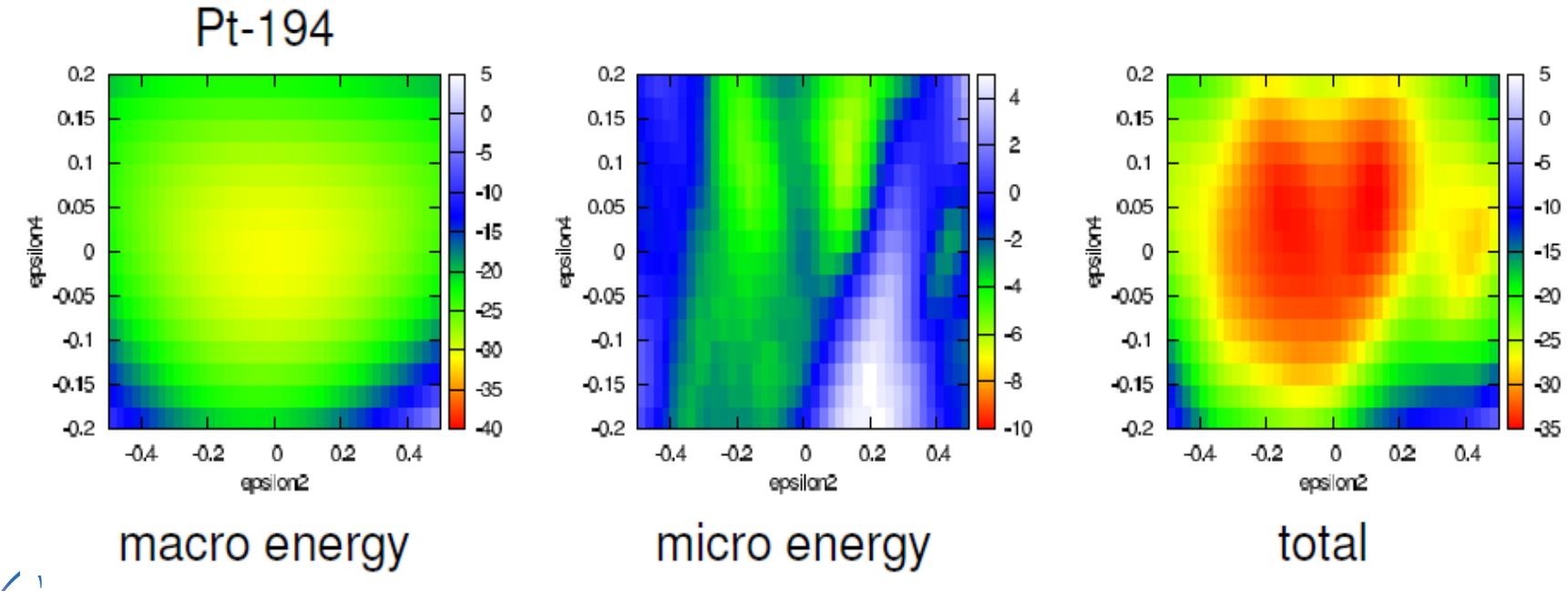
FRDM



HF-BCS

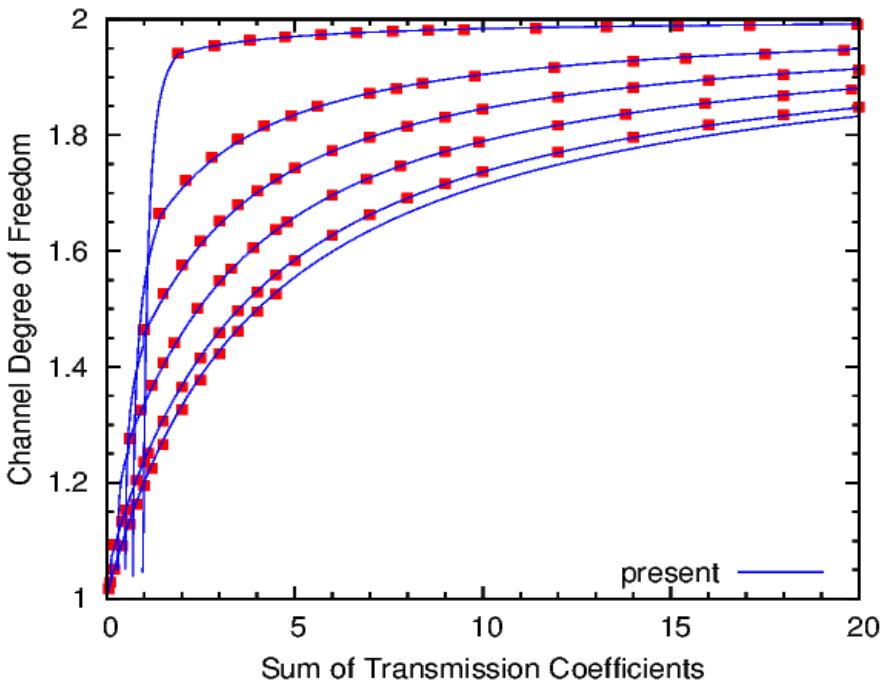
Combining FRDM and HF-BCS

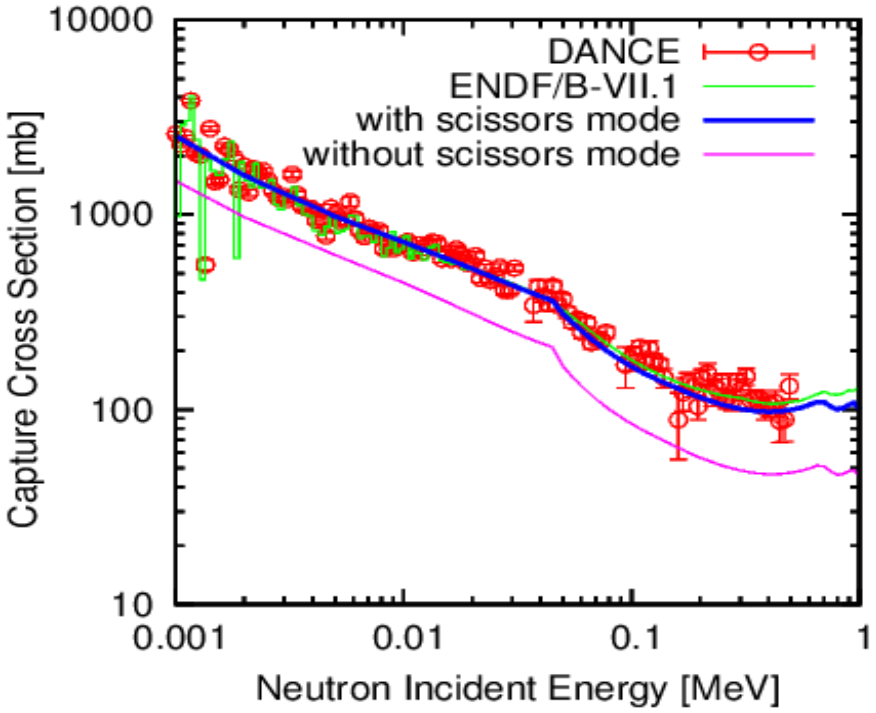
- **Use FRDM potential as an initial potential in the HF iteration**
  - iteration converges quickly
  - can avoid being trapped by local minima
  - if spherical WS is used, HF iteration can go to either prolate/oblate shape depending on the initial condition



Improved Statistical Model Calculation

- New width fluctuation model based on GOE
  - ND2013 paper, T. Kawano, P. Talou
- M1 scissors mode in the photon strength function

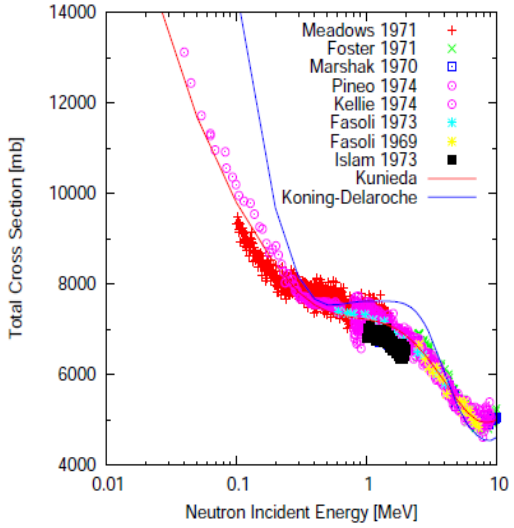


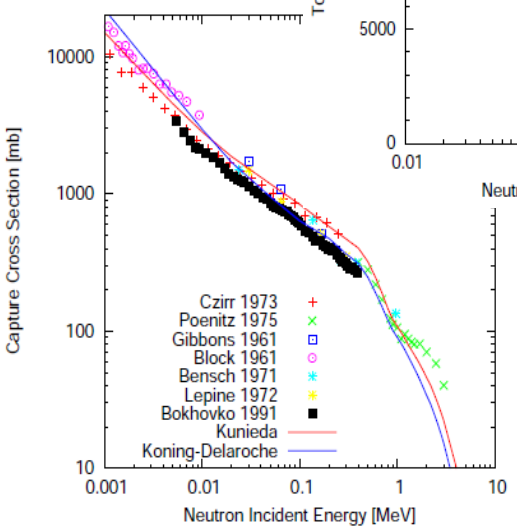


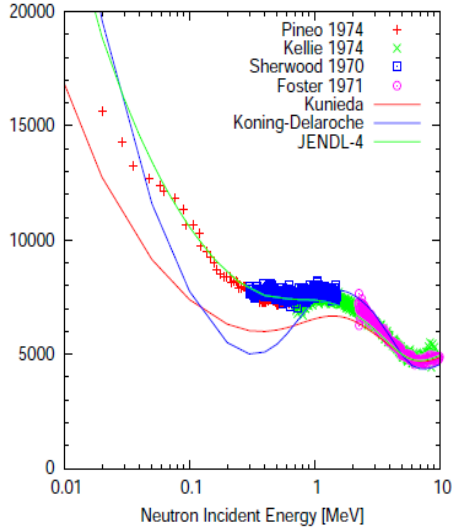
FRDM + Kunieda Potential Coupled-Channels Calculation

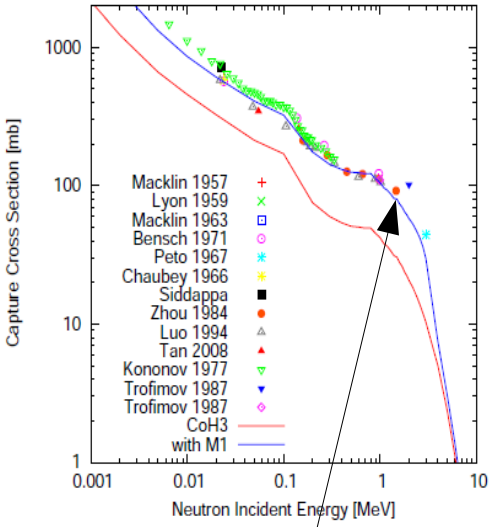
- **Deformation parameter (shape) taken from FRDM**
  - Spherical Harmonics expansion of FRDM potential for CC

Sm-152









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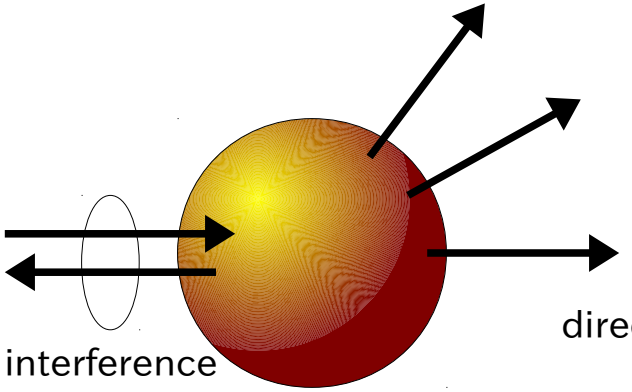
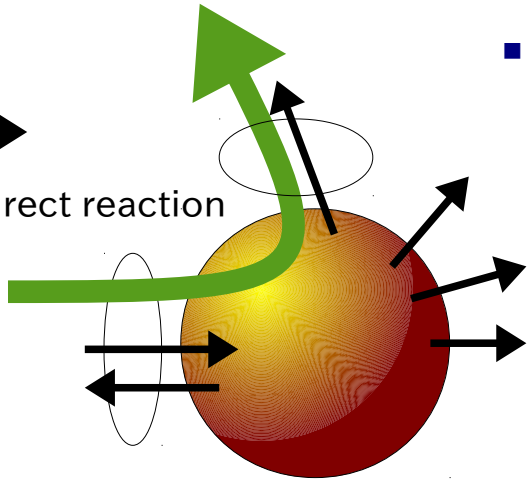
Small M1 added
E=3, Gamma=3, sigma=0.5mb

Hauser-Feshbach with Strongly Coupled Channels

- **Long standing issue: Statistical Model + CC**
  - Statistical Model = Hauser-Feshbach + width fluctuation

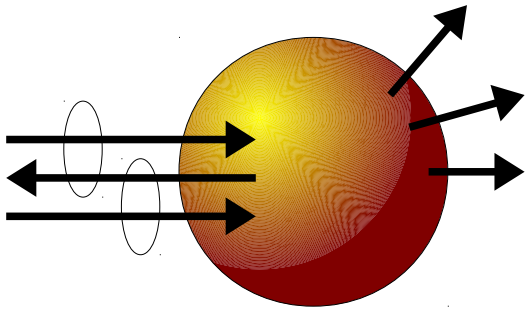


Spherical Case



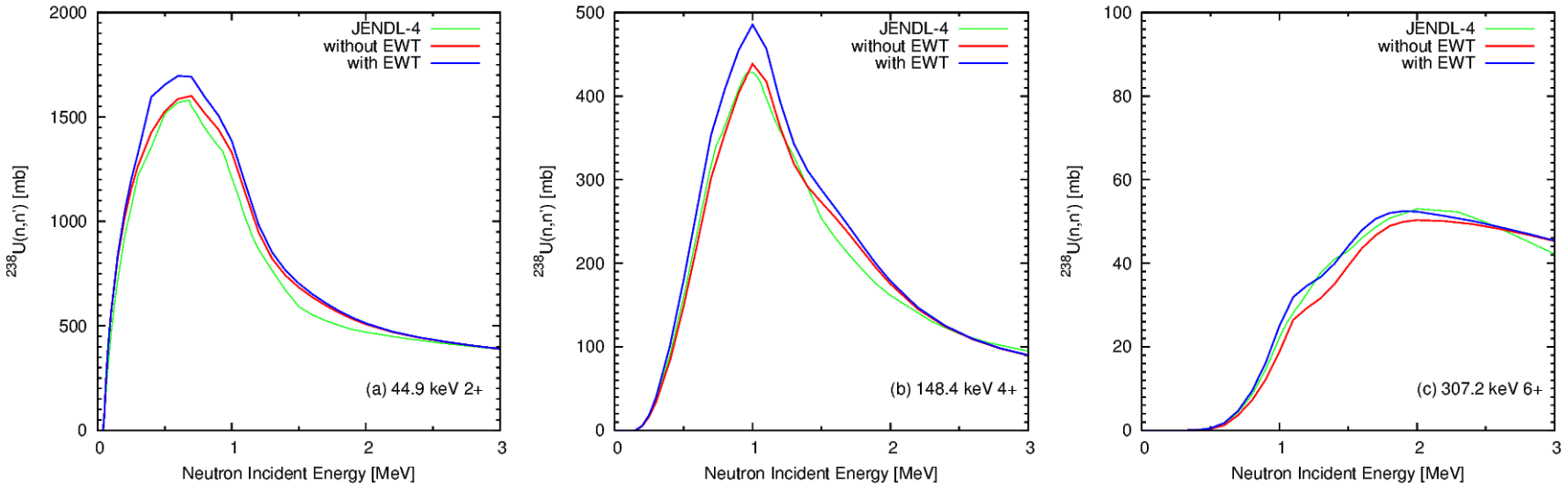
Deformed Case

- **Engelbrecht-Weidenmueller Transformation**
  - diagonalization of CC scattering matrix
  - fluctuation calculation in the channel space
  - back-transformation to cross section space



EW Transformation for Inelastic Scattering Cross Section

- U-238 + n
  - increase in the CN inelastic cross section, due to decrease in the elastic channel
  - similar results by Kawano (JENDL-3.3) and Capote with ECIS (talk at ND2013)
  - CoH calculation includes the all uncoupled-levels - fission and capture



Conclusions

- **CoH Statistical Model Code Development**
  - Improved physics
    - nuclear structure mean-field models unified
    - consistent treatment of nuclear deformation
  - ENDF evaluation
    - prompt fission neutron spectrum, including pre-fission neutrons
    - better calculation for deformed nuclei using Kunieda-potential and FRDM/HF-BCS
  - Technical development
    - advanced memory management
    - isotope production cross section automated
    - automatic MACS calculation