Nuclear Reaction Modeling at LANL

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Overview

Development of Nuclear Reaction Theory

- Hauser-Feshbach theory for deformed nuclei
  - Transmission coefficients by Coupled-Channels model for the excited states
  - Cross section calculations on the excited states feasible
  - Width-fluctuation, need more work
- Monte Carlo technique for sequential particle emission
  - Prompt fission neutron spectrum calculation
  - Monte Carlo Hauser-Feshbach calculation
- Quantum mechanical pre-equilibrium process
  - Fully microscopic, Hartree-Fock-BCS, with RPA
- Model Codes
  - We continue developing McGNASH, though it slowed down somewhat.
  - New Hauser-Feshbach Monte Carlo code, CGM, underway.
  - CoH capable for calculating nuclear reactions on excited states.

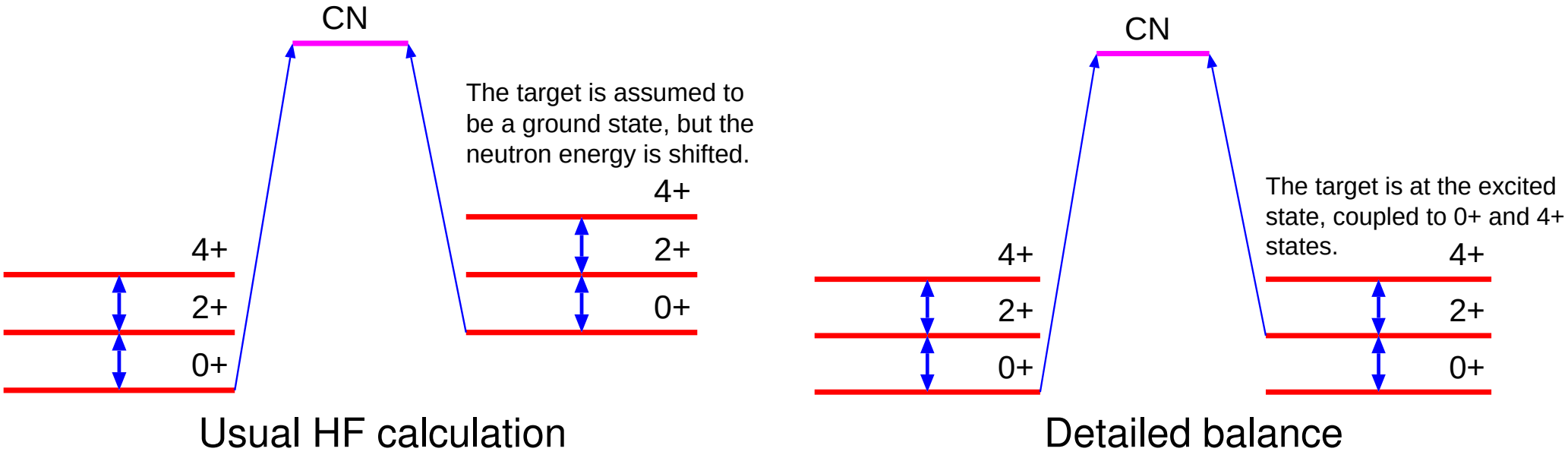
Introduction

Neutron Reaction on Deformed Nuclei at Low Energies

- Incorporate Coupled-Channels (CC) method into Hauser-Feshbach formula
  - Inverse channel problem
    - What is the appropriate transmission coefficient for the excited states ?
    - Replaced by the one for the ground state (historical)
    - Solve the CC equation for the excited state (detailed balance)
  - Width fluctuation correction when off-diagonal elements exist
    - Moldauer
    - Engelbrecht-Weidenmüller transformation
    - Kawai-Kerman-McVoy (KKM)
    - Nishioka-Weidenmuüller-Yoshida, GOE for coupled-channels
- I will report :
  - Coupled-Channels Hauser-Feshbach (CCHF) method
  - Apply to calculate neutron capture cross sections for deformed nuclei (no fissile)
  - Super-elastic calculation

Detailed Balance for Compound Reaction

Neutron Emission Probabilities $\propto$ Transmission



- The same transmission coefficients are used for both entrance and exit channels.
- Sometimes exit channels are corrected by a factor of $1 + \sigma_D/\sigma_R$.
- Solve the Coupled-Channels equations for the excited state, which couples to the negative energy states (super-elastic).

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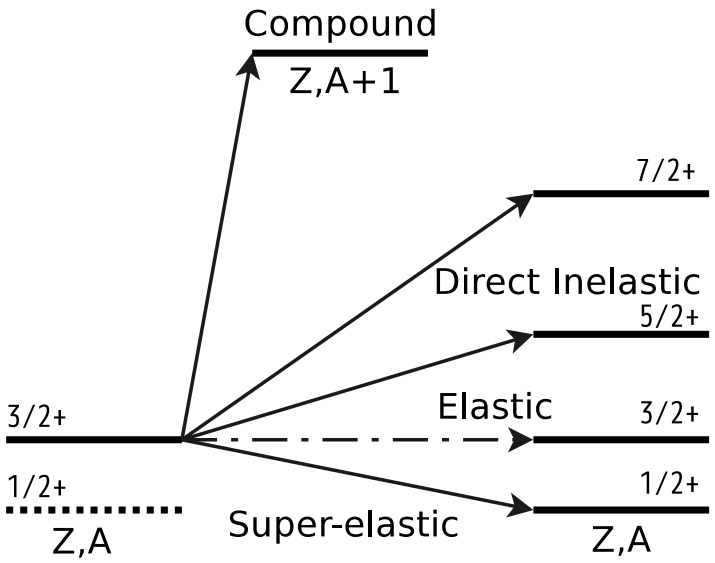
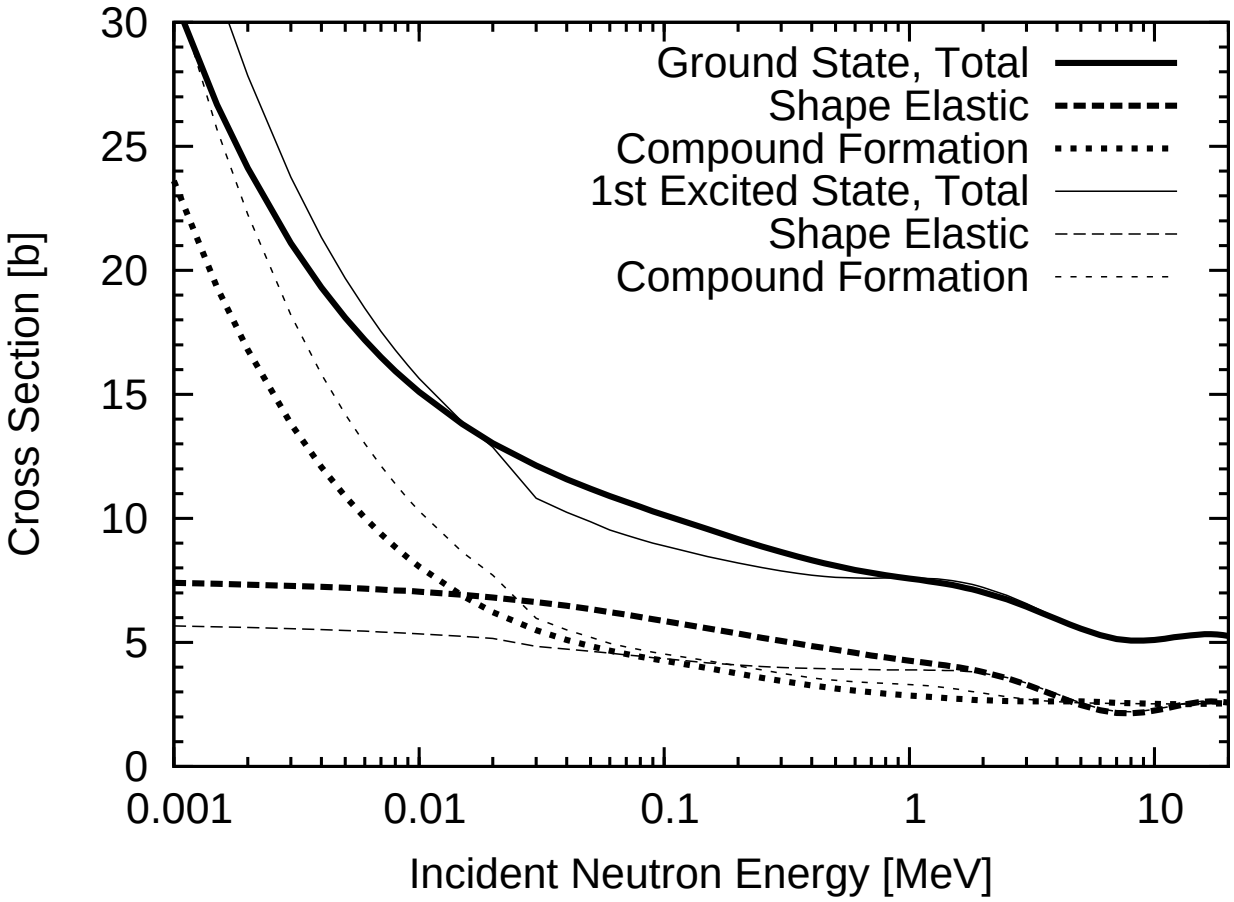
Direct Cross Sections

Coupled-Channels Calculations for the Excited States

Calculation for n + ^{169}Tm





Preliminary

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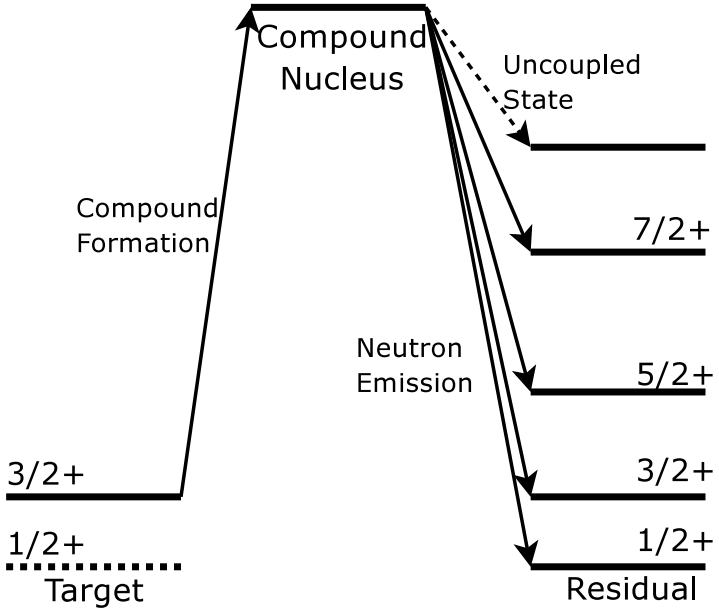
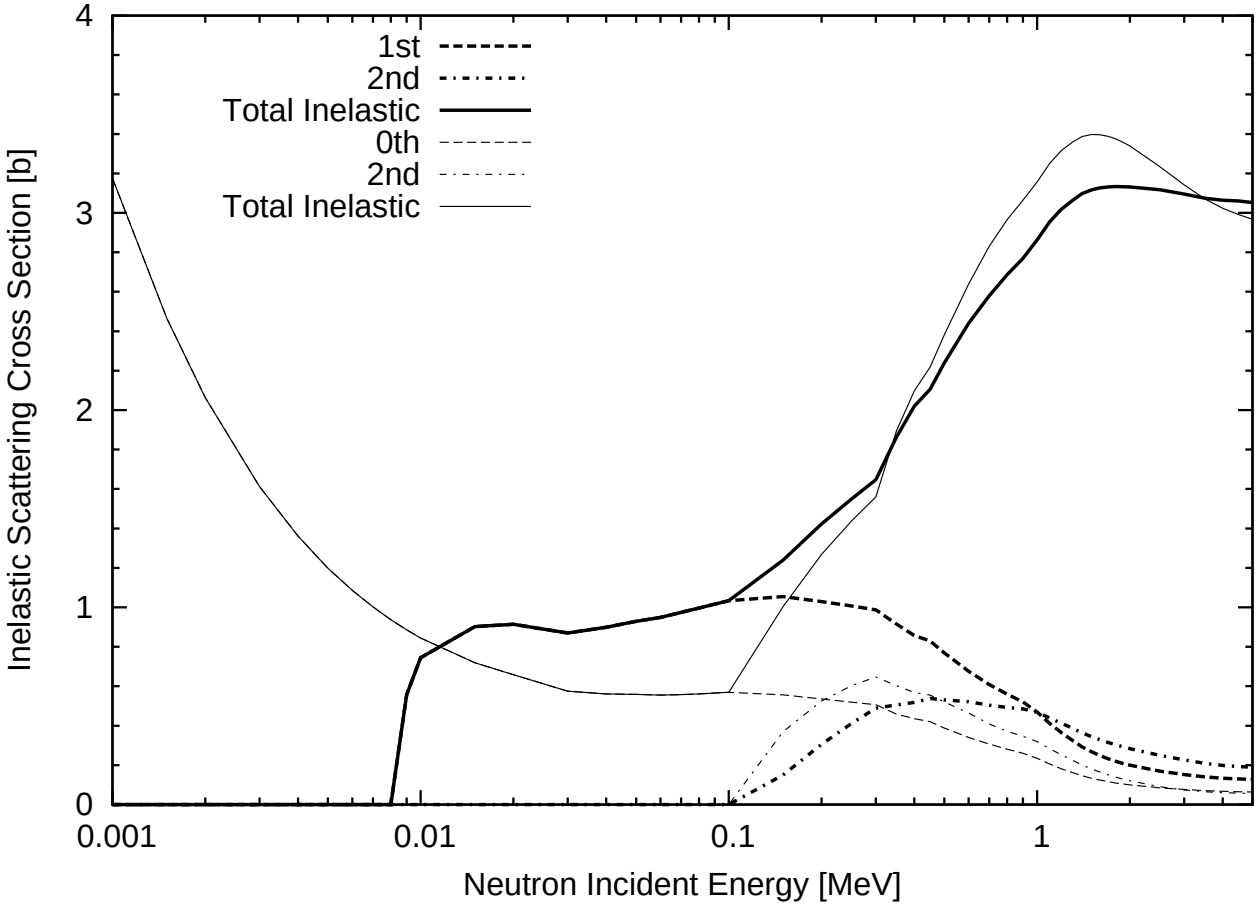
Inelastic Scattering Cross Sections

Hauser-Feshbach Calculations for the Excited States

Calculation for n + ^{169}Tm





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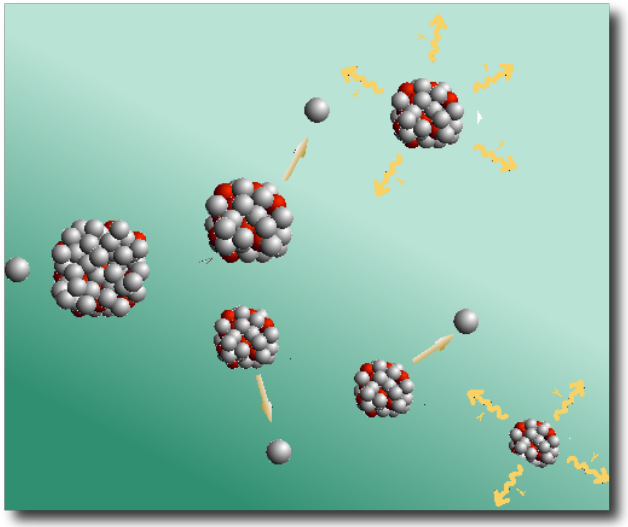
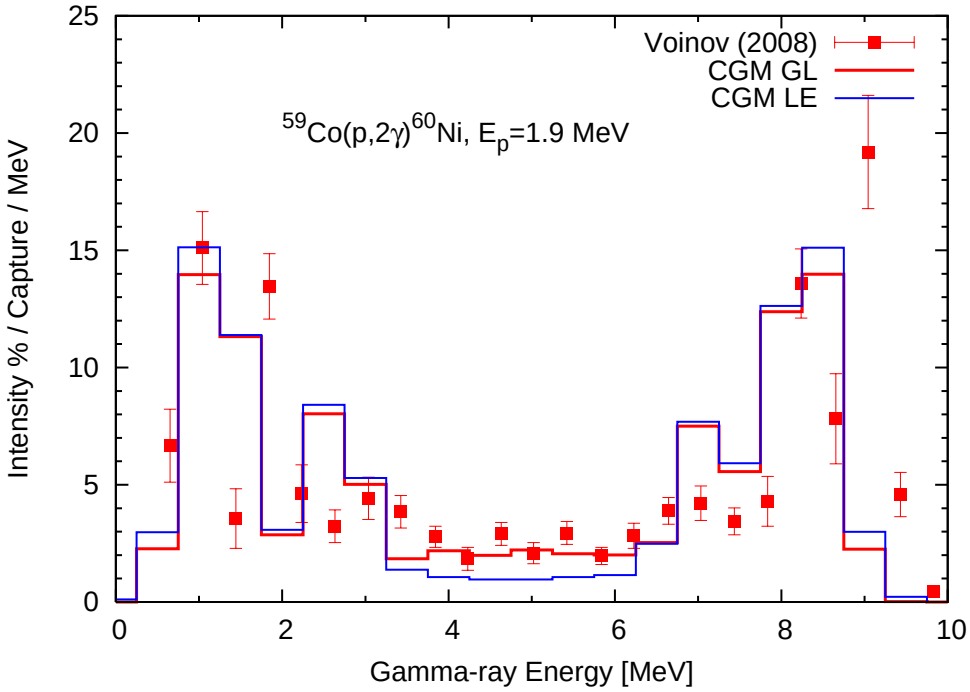
Monte Carlo Simulation for Particle Emission

Application of Monte Carlo to Hauser-Feshbach model at LANL

- prompt fission neutron spectra
  - correlation between n and γ
- β-delayed γ spectra
- γ-ray multiplicity distribution





- Internal MC gives all correlation between a specific reaction and observables.
- External MC gives target recoil in the laboratory frame.

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