Nuclear Reaction Code Development at LANL

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Introduction

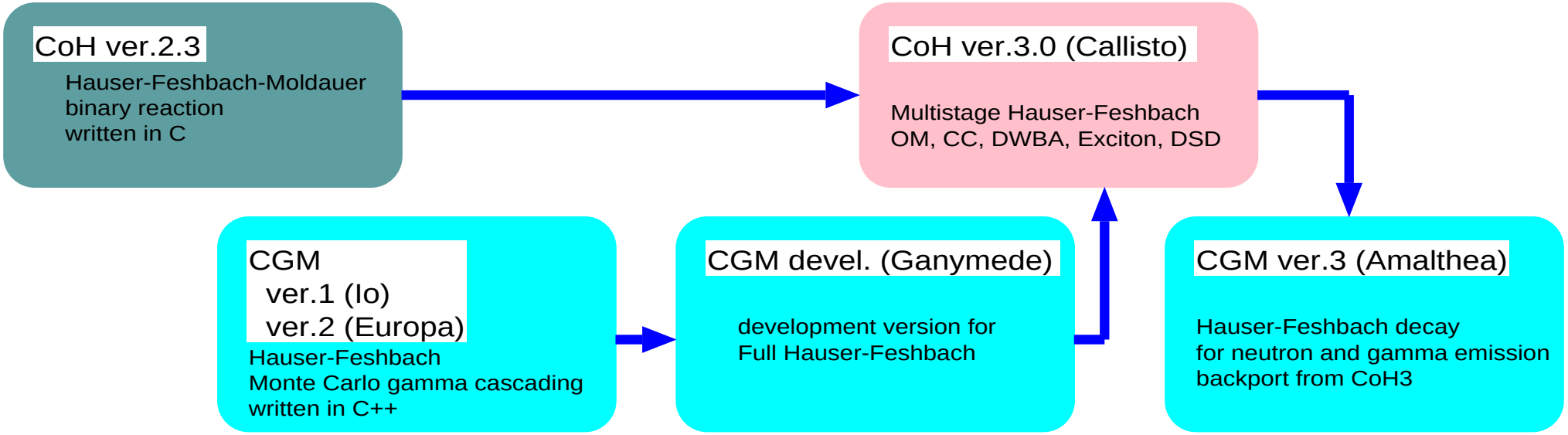
Theory and Model Code Development at LANL

- Hauser-Feshbach code development for nuclear data evaluation,
  - Coupled-Channels + Hauser-Feshbach calculations
  - Fission modeling, class-I class-II state coupling
- and other possible applications
  - β-delayed neutron and γ-ray emission
  - Monte Carlo technique
    - to understand nuclear reaction mechanisms
    - MC simulation for prompt fission neutron spectra
    - γ-ray emission event generator for transport simulations
- Nuclear reactions based on microscopic nuclear strucutre theory
  - Quantum mechanical pre-equilibrium process
  - Hartree-Foch BCS direct/semidirect capture process
    - proton capture, odd-Z target calculation

CoH: Optical Model and Hauser-Feshbach Model

New Hauser-Feshbach codes at Los Alamos

- CoH_3: C++ code with the spherical optical model, coupled-channels, DWBA, direct/semidirect capture, two-component exciton model, and multi-stage compound nucleus decay
- Internal T calculation (no ECIS contamination)
- A variant, CGM — Monte Carlo γ-ray cascading code available



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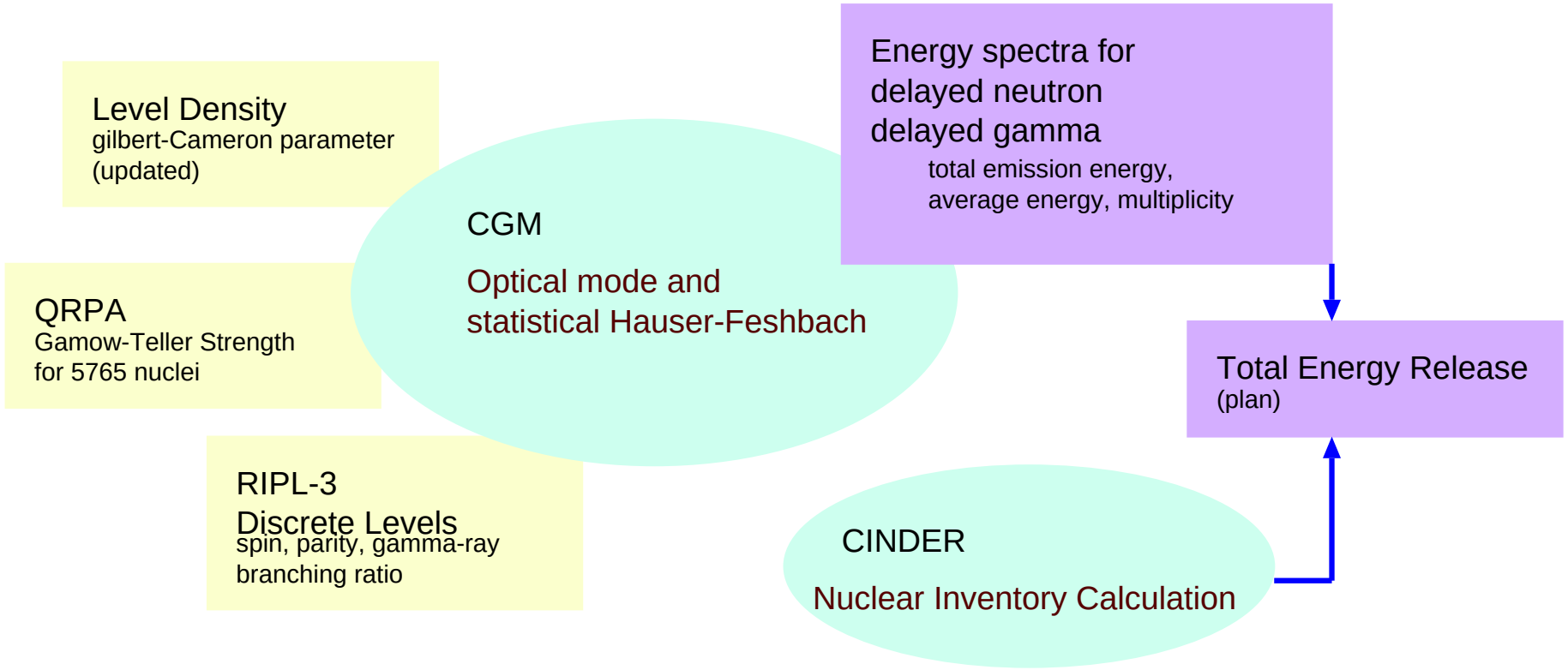
The CGM Codel

CGM: Cascading Gamma-ray and Multiplicity, ver.3.0 (Amalthea)



- Subset of CoH_3
- A portable code for combining with other code systems
  — CINDER, Monte Carlo prompt fission neutron spectrum

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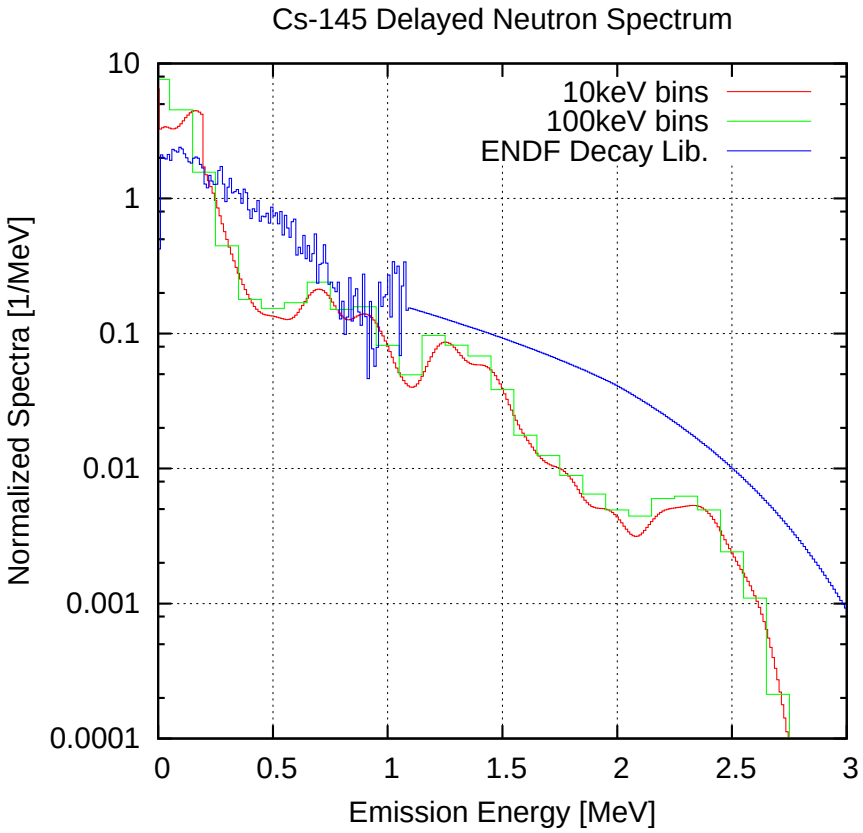
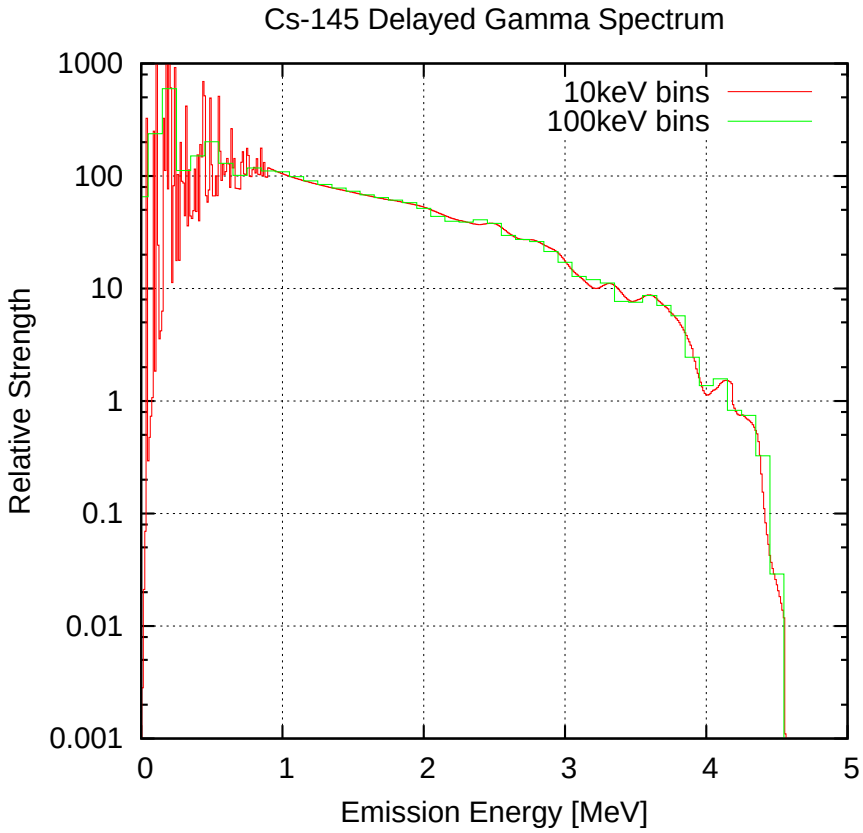
CGM Example: Neutron and Gamma Spectra

Beta-Delayed Neutron and Gamma Spectra: Cs-145





γ-ray multiplicity = 3.04

average γ energy = 973 keV

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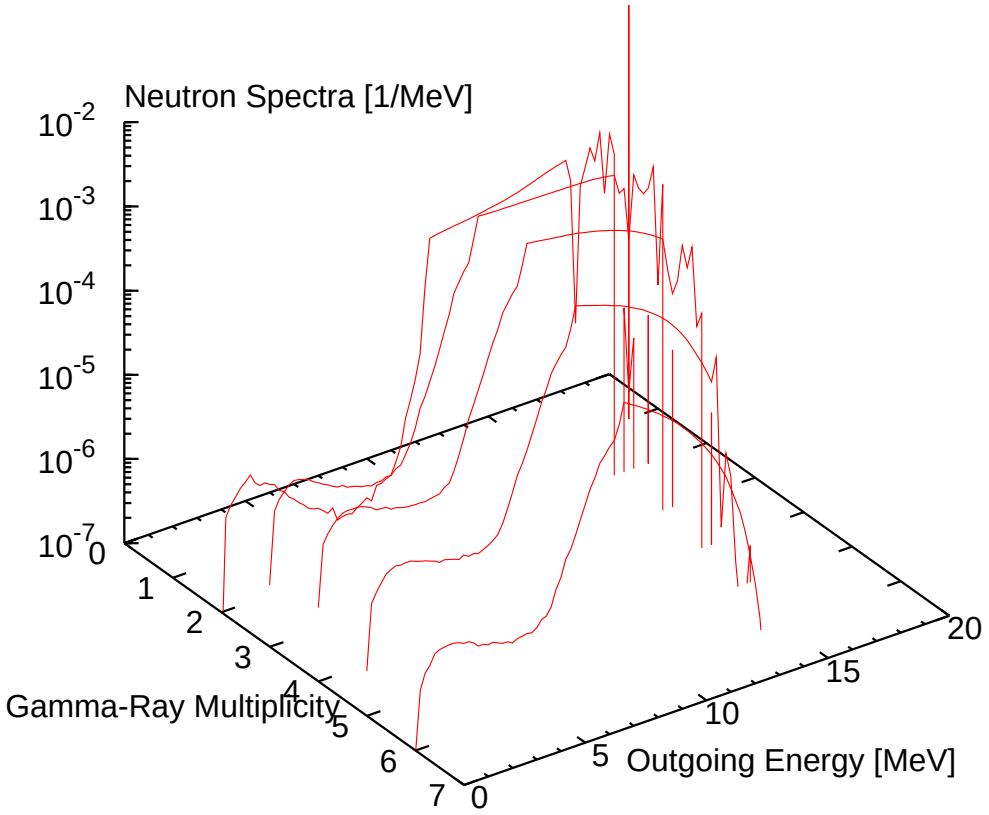
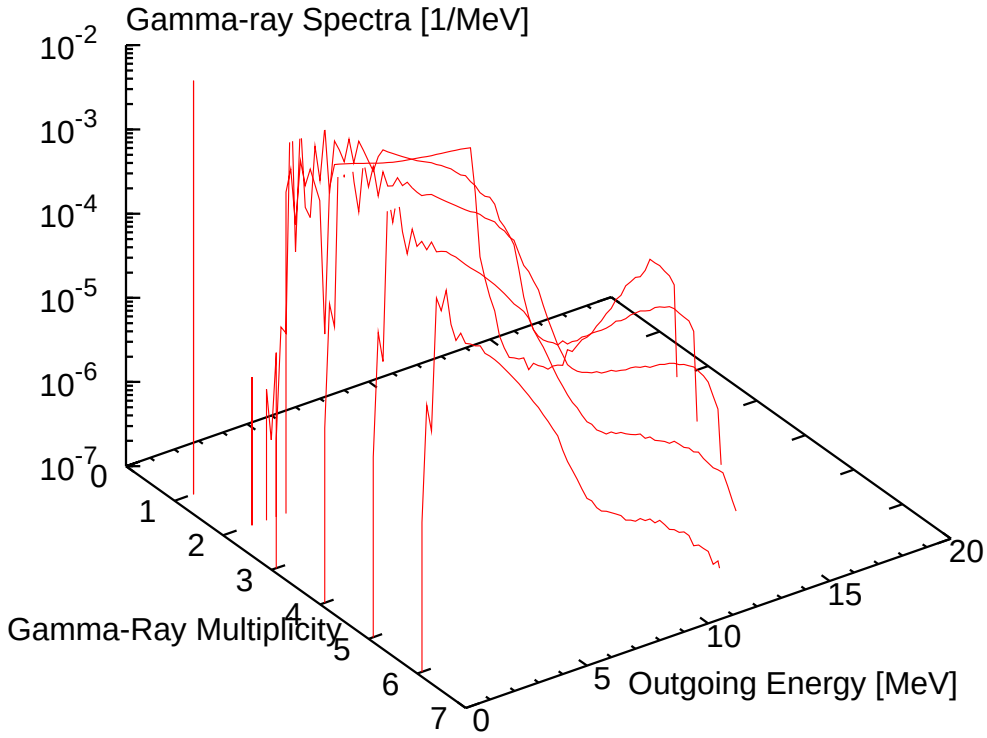
CoH Example: Monte Carlo Hauser-Feshbach

Neutron Emission as a Coincidence with a particular Gamma-ray

Neutron emissions gated on the $2^+ \rightarrow 0^+$ transition



Neutron Spectra



γ-ray Spectra

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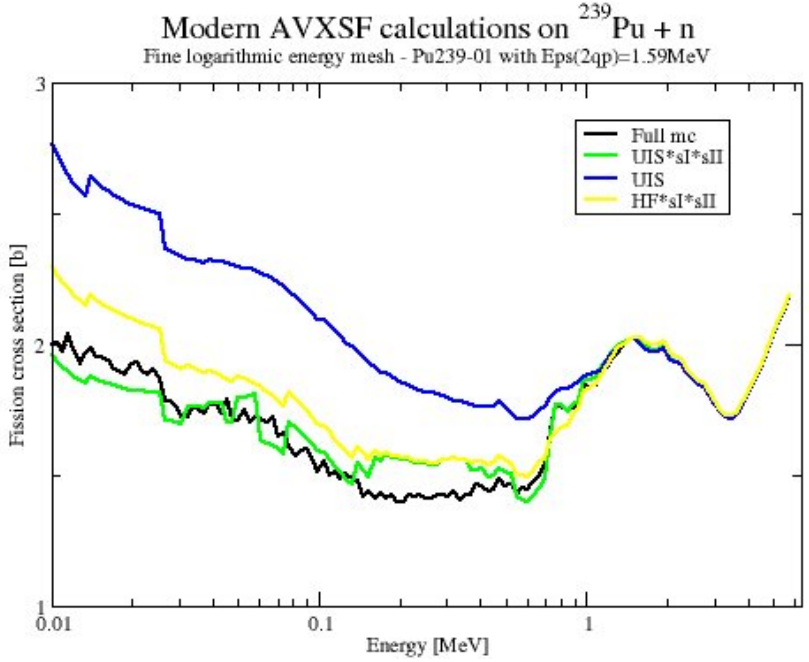
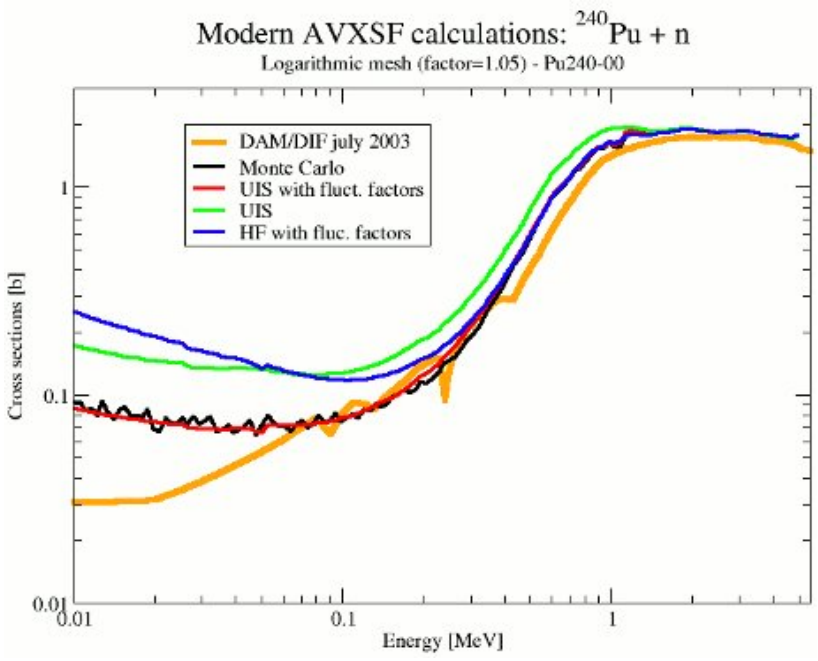
Treatment of Underlying Intermediate Structure (UIS)



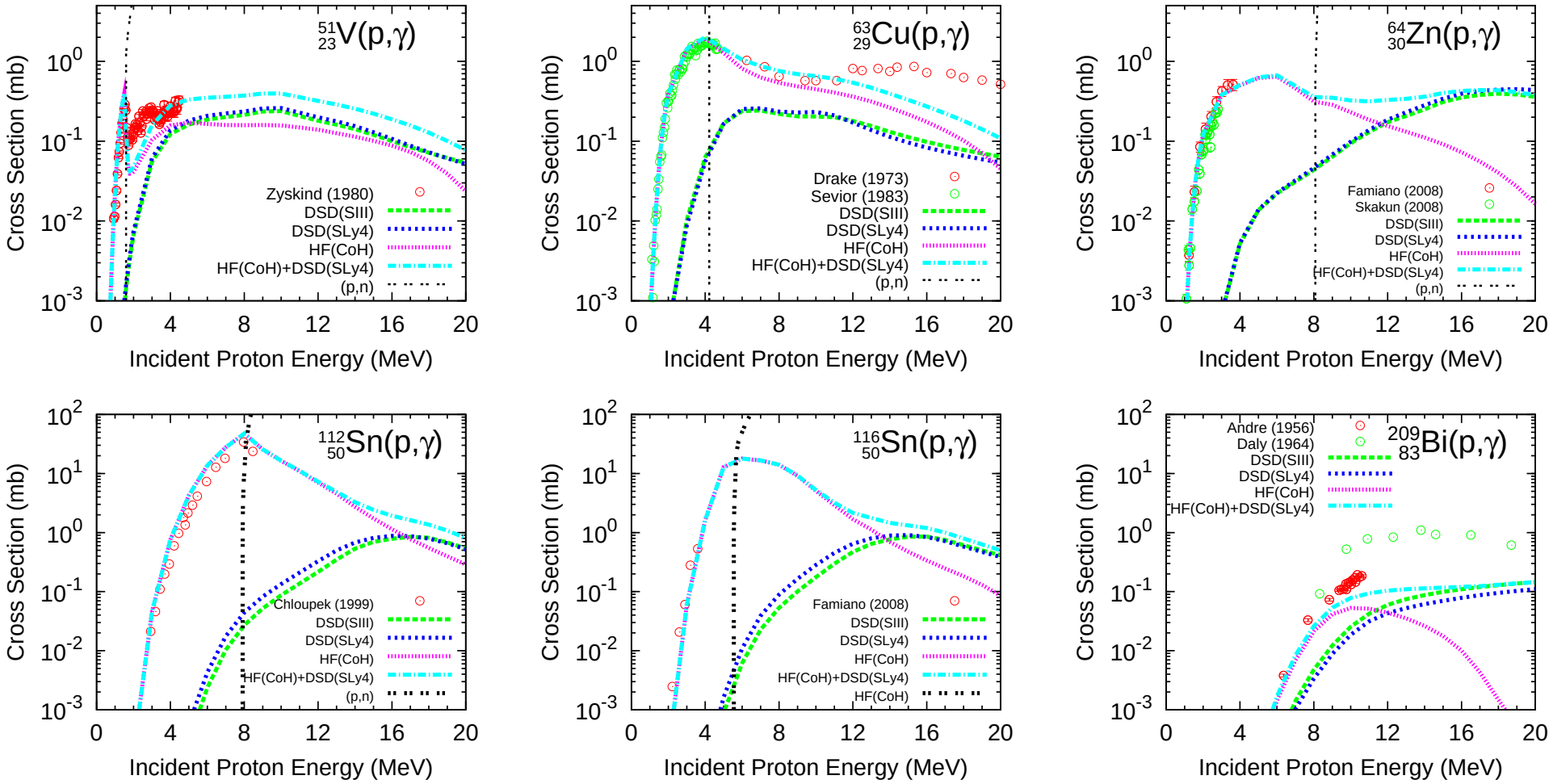


Accurate calculations of intermediate structure (IS) average cross section are now available using MC calculations based on the microsopic R-matrix theory with the underlying I.S (UIS).

UIS: Lower significantly the average fission cross section

HF-BCS and CoH for Proton Capture

Direct/Semidirect Capture based on Hartree-Fock BCS



CNR*09 talk by T. Watanabe

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Concluding Remarks

Model Code Development and Plans

- A new Hauser-Feshbach code, CoH_3
  - Monte Carlo approach to compound nucleus decay
  - ENDF-6 format conversion program (ETYPE under development)
- CGM, neutron and γ-ray emission from compound nucleus
  - β-delayed neutron and γ-ray emission
  - calculation of prompt γ-ray energy release
  - apply to decay heat calculation with CINDER
- Fission modeling
  - collaboration with LLNL under ARRA
- Proton capture — Hartree-Fock BCS
- Monte Calro prompt fission neutron spectrum calculation

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