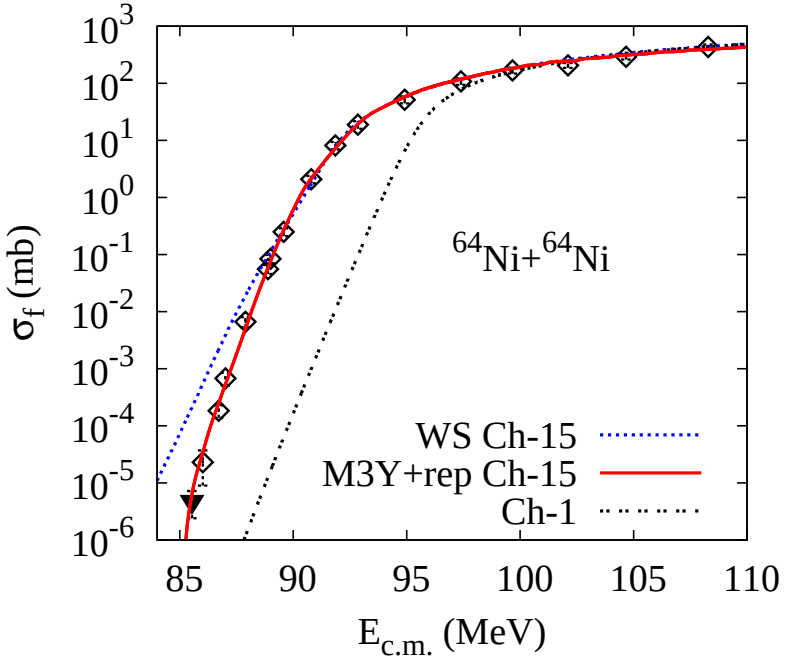
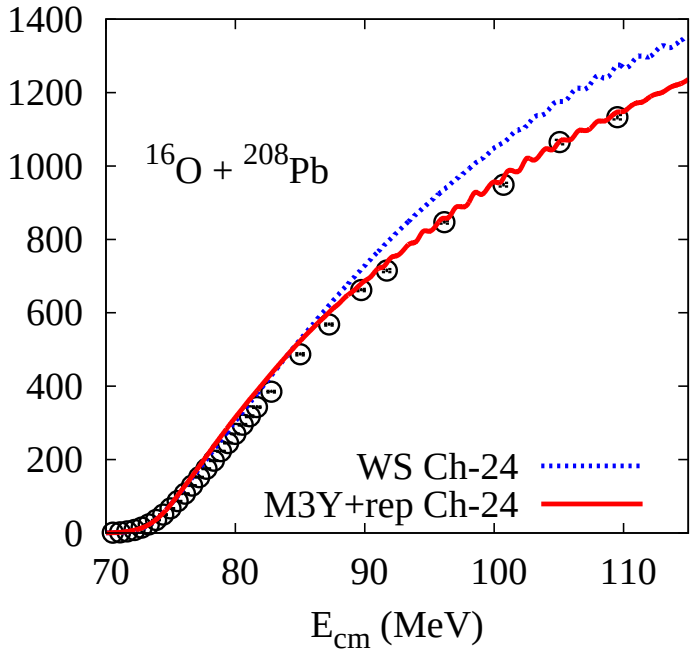
Challenges in coupled-channels calculations of heavy-ion fusion reactions.

- The goal is to develop a coupled-channels description that explains
  - the enhancement of fusion at sub-barrier energies,
  - the hindrance of data at extreme sub-barrier energies,
  - and the suppression of data far above the Coulomb barrier.
- The basic description should include couplings to the low-lying 2^+ and 3^- states, and two-phonon & mutual excitations of these states.
- Consider multi-phonon excitations and transfer reactions.
- The description should rely on a predictable ion-ion potential and realistic form factors for excitations and transfer.

Construction of the ion-ion potential.

- An ion-ion of the double-folding type is very useful. It must include a strong repulsion due to the nuclear incompressibility and Pauli blocking, e. g., the M3Y+rep potential. The repulsion can explain
  - the fusion hindrance a extreme subbarrier energies (see Ni+Ni), and
  - the suppression of data at high energies (see O+Pb), compared to calculations that use a ‘standard’ Woods-Saxon (WS) potential.





Uncertainties in the structure input.

- Multi-phonon and mutual excitations, for example, of the 2^+ and the 3^- states in the same nucleus, are not necessarily harmonic. Microscopic or Experimental Structure information is needed.
- The form factors for nuclear excitations need not be simple derivatives of the ion-ion potential. A description based on microscopic transition densities may be more realistic.
- Transfer and excitations are assumed to be independent degrees of freedom. Develop a description of transfer from excited states.
- A serious problem is the limitation in the number of channels. Calculations that include transfer reactions are usually simplified by lumping many channels together into a few effective channels. Develop a better description of the Q-value distribution for transfer that is consistent with measurements.