Disappearance of channel coupling effects in $^{12}C + ^{24}Mg$ fusion far below the barrier

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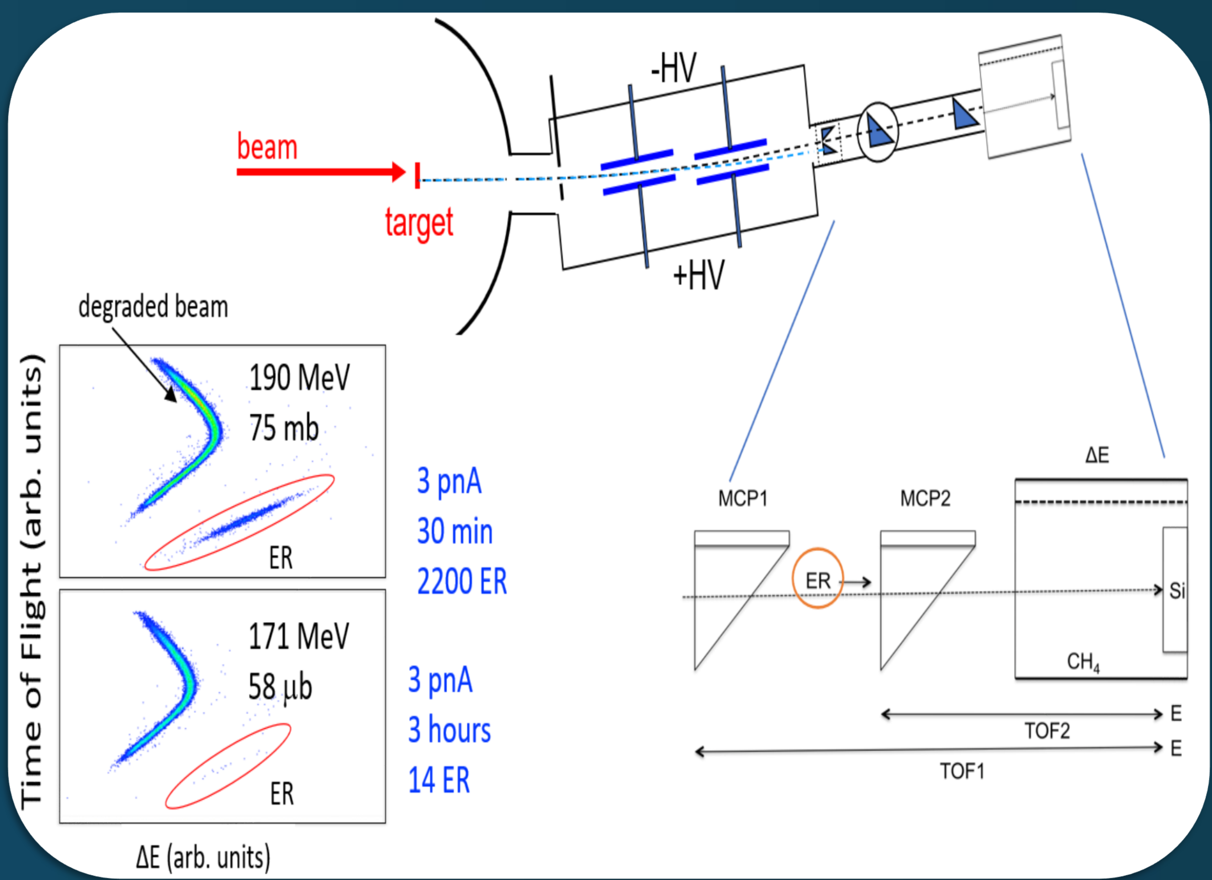
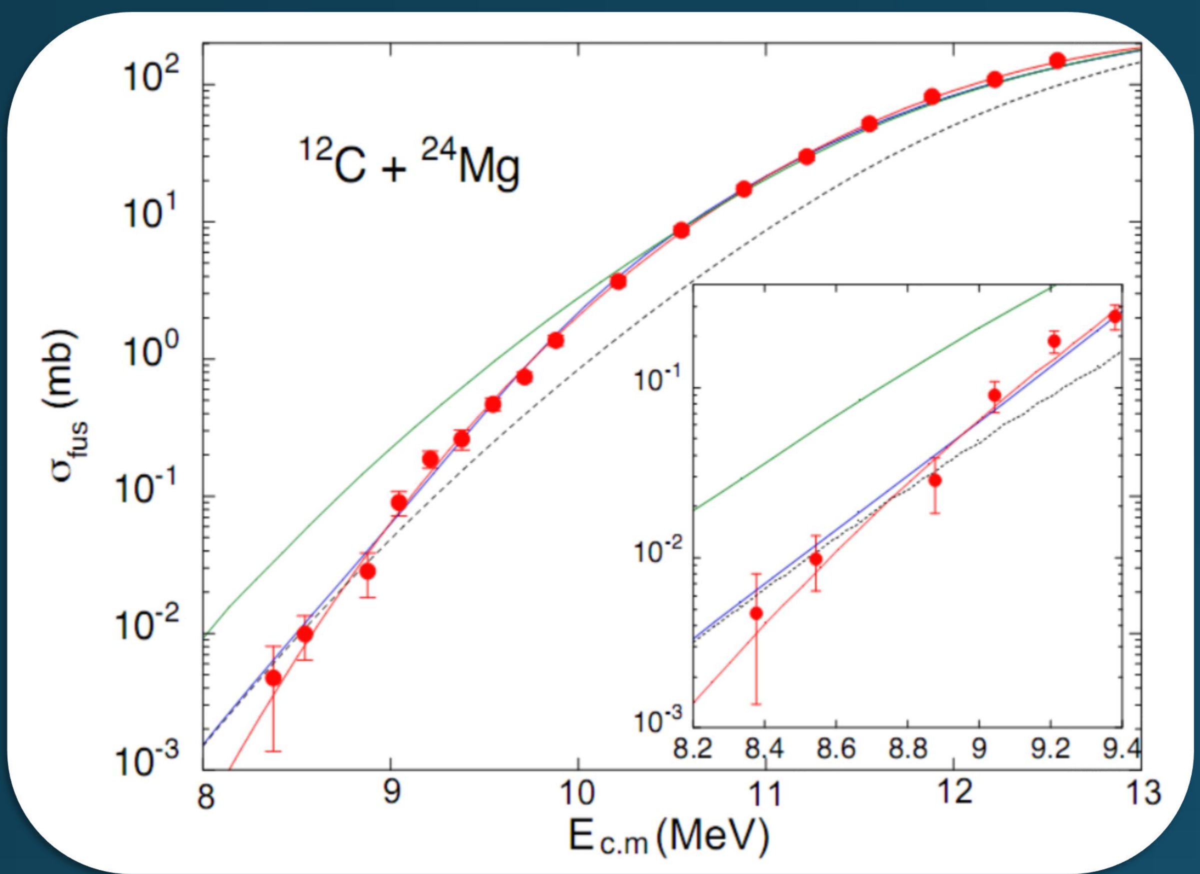
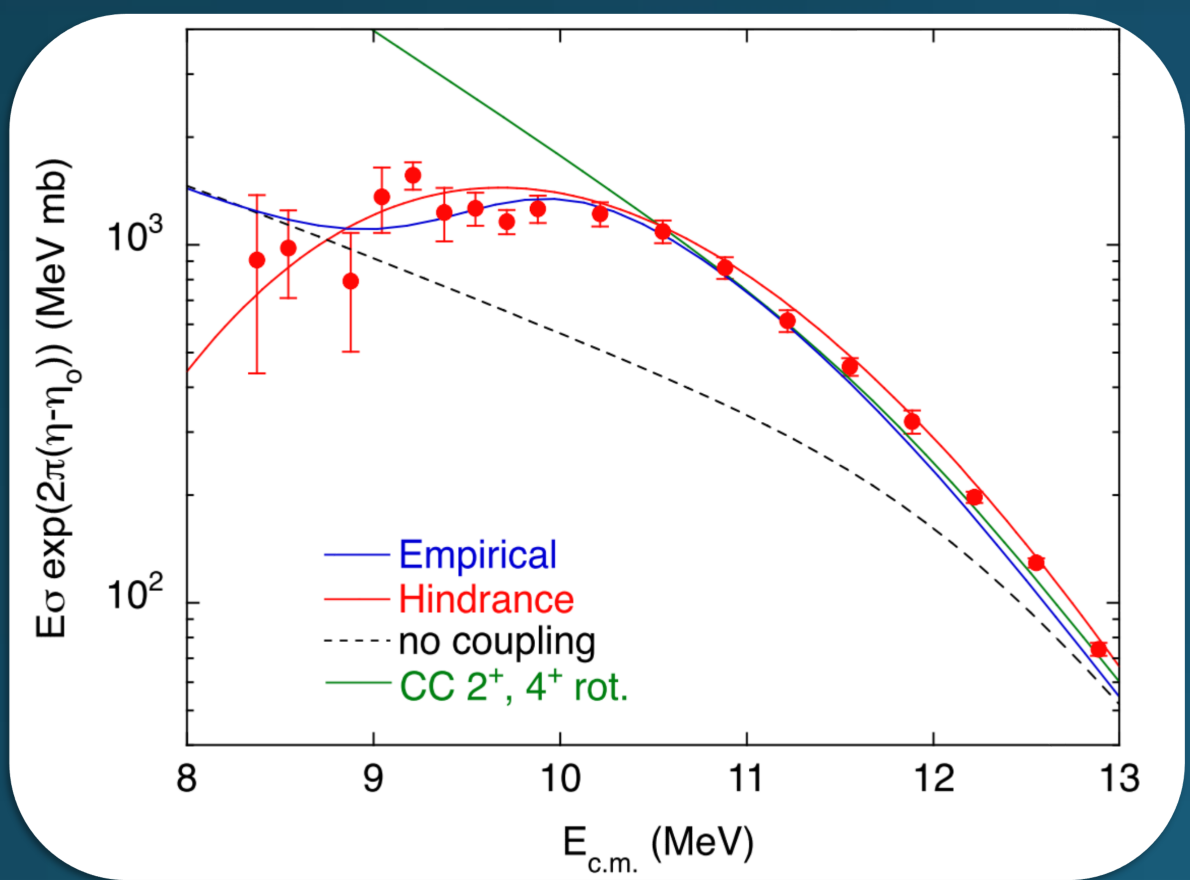
The behavior of the $^{12}C + ^{24}Mg$ system far below the barrier suggest that the coupling strengths gradually decrease and vanish, so that the excitation function seems to be well reproduced by a simple one-dimensional tunnelling through the potential barrier in that energy range.

The excitation function of $^{12}C + ^{24}Mg$ has been measured down to 4 μb, using ^{24}Mg beams from the XTU Tandem accelerator of LNL, thus completing a previous experiment on that system[1] On the right we report the set-up used for the measurement of fusion cross sections, where the fusion-evaporation residues (ER) were detected at small angles by an E-Δ E-ToF detector telescope following a beam electrostatic deflector. Also shown are two experimental Δ E-ToF matrices, where the ER are clearly separated from beam-like particles and identified.

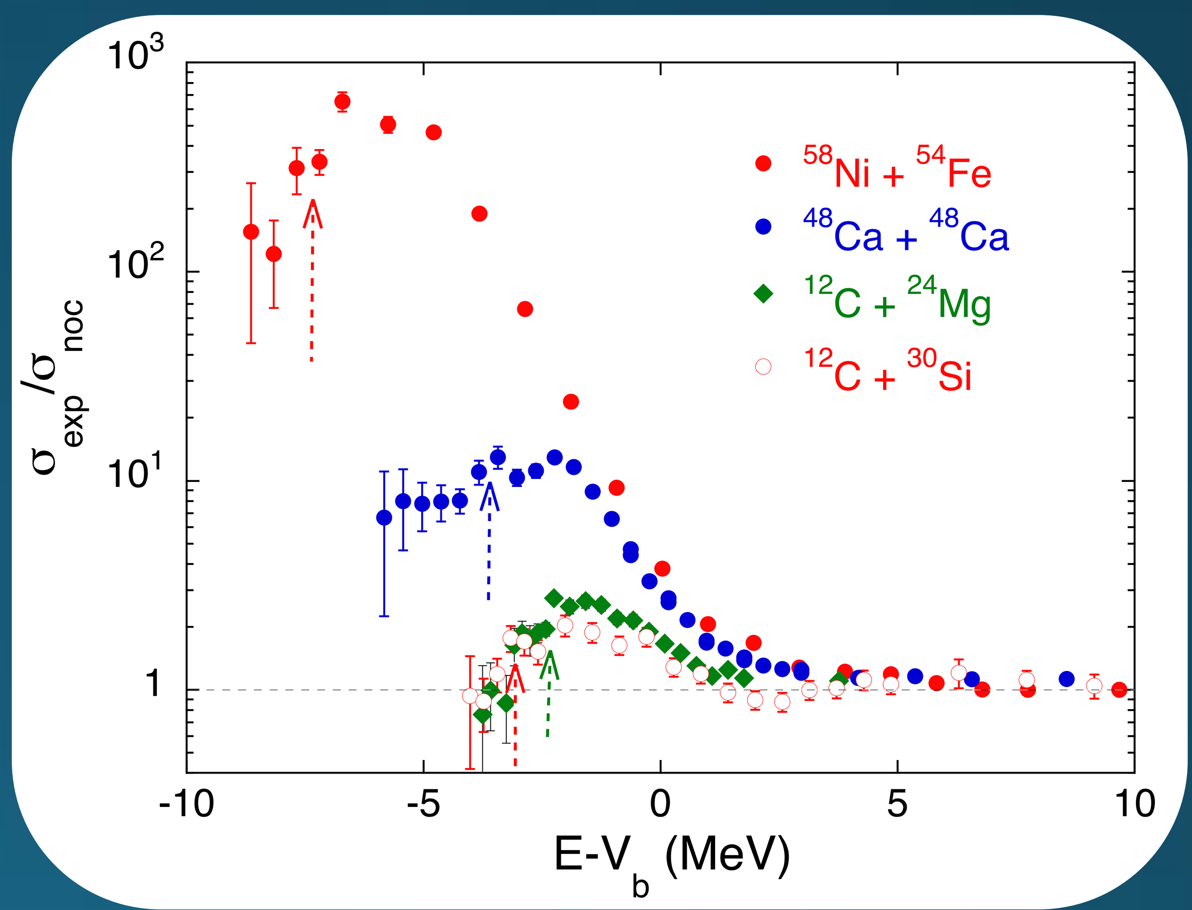




Coupled-channels calculations have been performed using a Woods-Saxon potential. The results over-predict the cross sections at very low energies, thus clearly showing the presence of hindrance. Also the astrophysical S-factor (left, below) shows a clear maximum vs energy. Furthermore we see that the cross section is remarkably large at the hindrance threshold (~1 mb), and that the no-coupling limit fits the lowest-energy cross sections.



The cross sections and the shape of the S factor are both well reproduced using an empirical interpolation[2] in the spirit of the adiabatic model, and the hindrance parametrization[3] . This suggests that discriminating between the two approaches would require further precise cross section measurements at lower energies.



The panel on the right shows a systematics of the trend of $^{12}C + ^{24}Mg$ and $^{12}C + ^{30}Si$ fusion, compared to two heavier systems $^{48}Ca + ^{48}Ca$ and $^{58}Ni + ^{54}Fe$. The ratio of measured fusion cross sections to the calculated ones in the no-coupling limit is plotted vs the energy distance from the barrier. It is seen for the two lighter systems (in particular for $^{12}C + ^{24}Mg$) that the ratio decreases to one (no enhancement) at the lowest energies, i.e. the enhancement produced by couplings to the low-energy collective modes disappears. This suggests that the coupling strengths are strongly damped at those energies.

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[2] T. Ichikawa, K. Hagino, and A. Iwamoto, Phys. Rev. C 75 (2007) 057603
[3] C.L.Jiang, K.E.Rehm, B.B.Back and R.V.F.Janssens, Phys. Rev. C 79 (2009) 044601