Quasifission of superheavy composite systems in reactions with heavy ions

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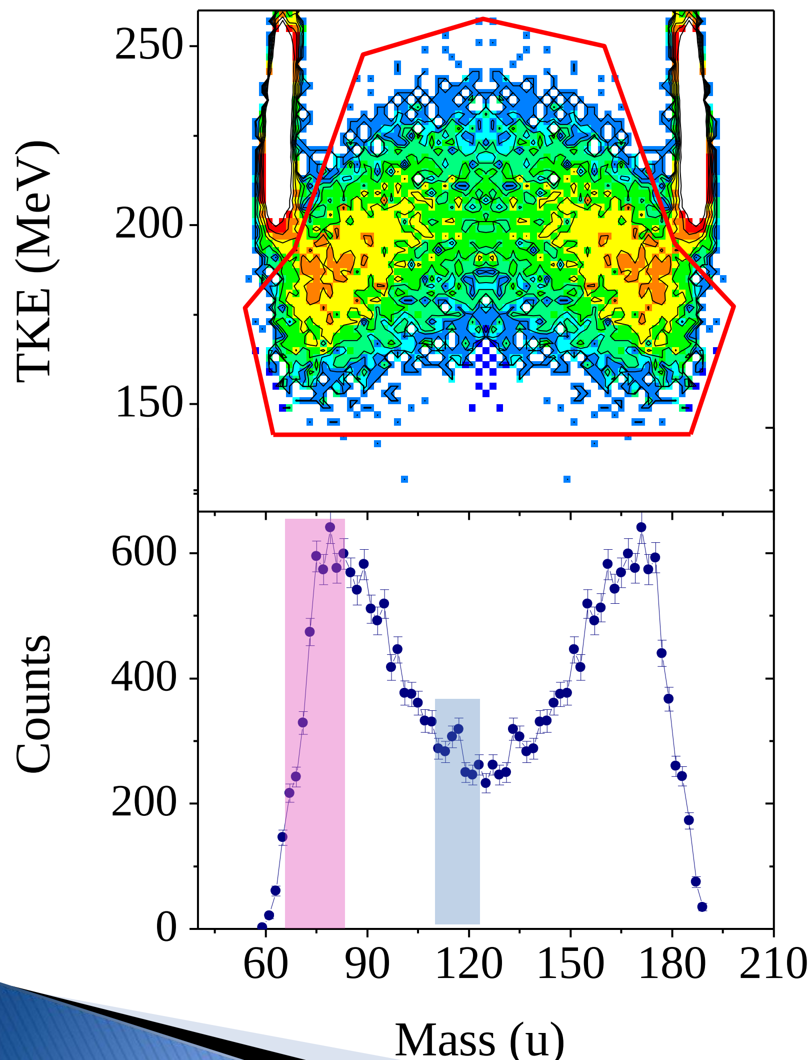
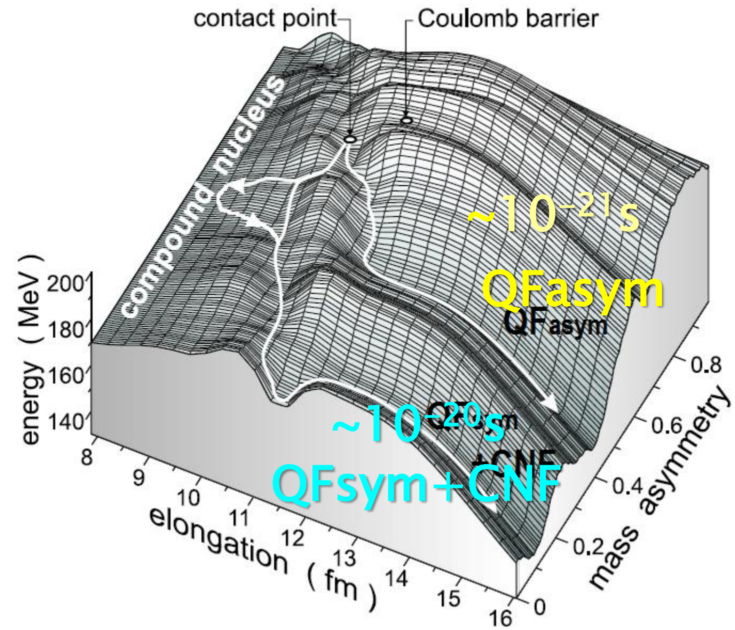
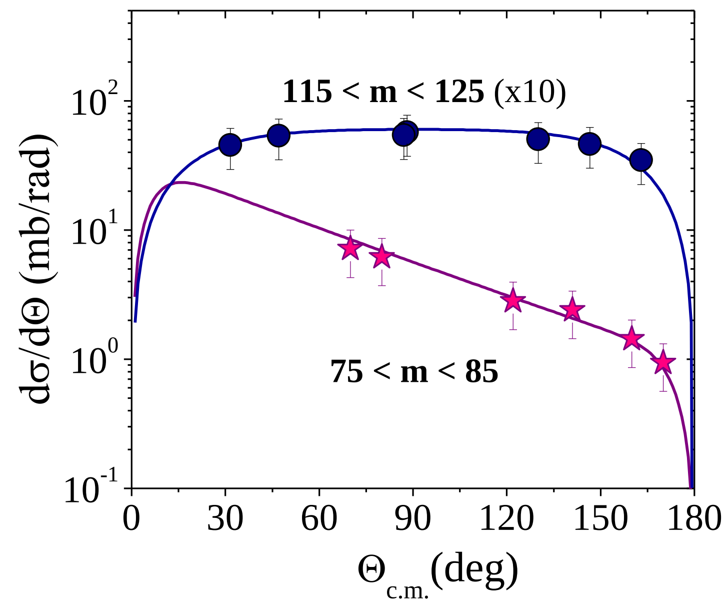
Heavy ion-induced reactions: binary channel

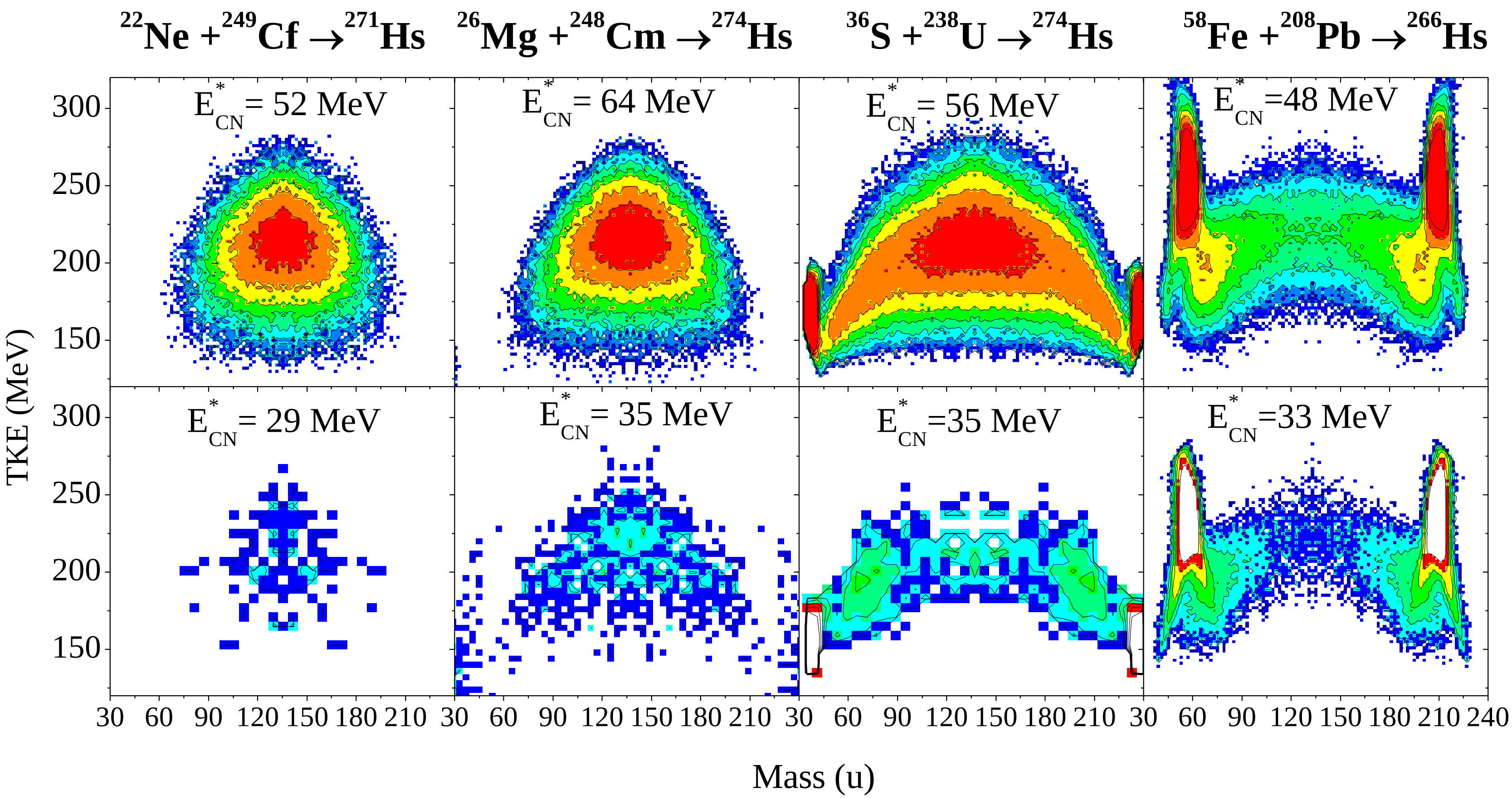
$^{64}Ni+^{186}W \rightarrow ^{250}No^{*}$ $E^{*} \cong 40$ MeV





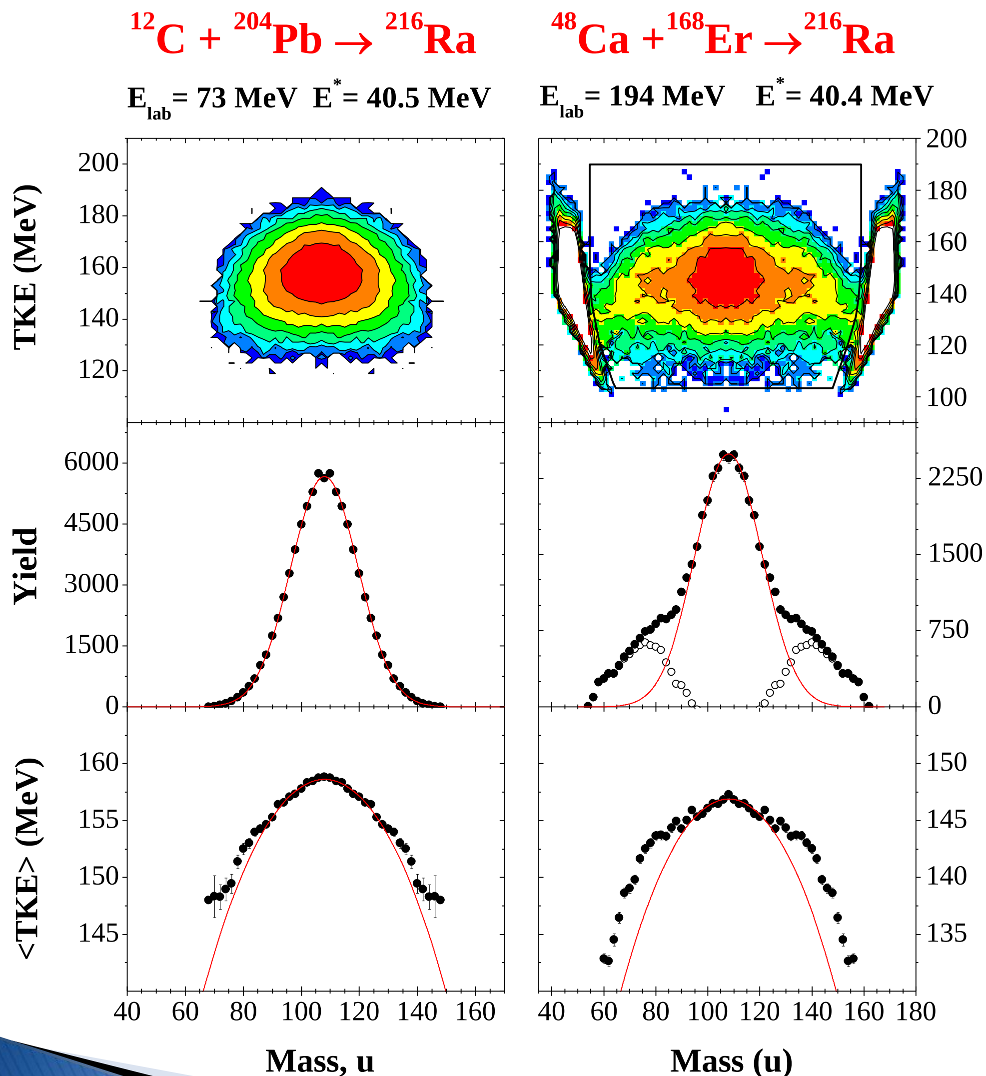


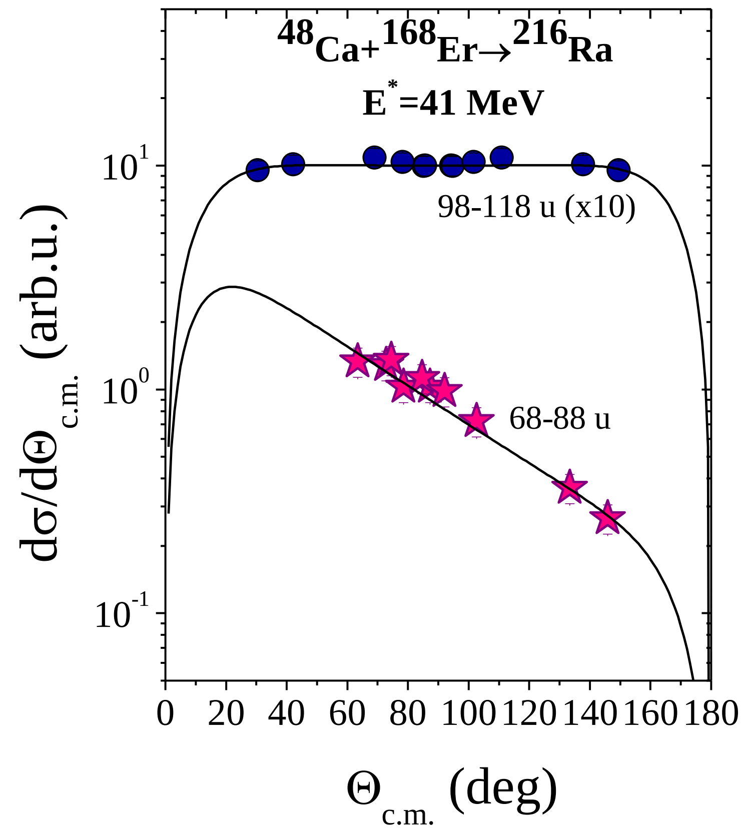
Competition between fusion and QF processes: Hs (Z=108) composite systems



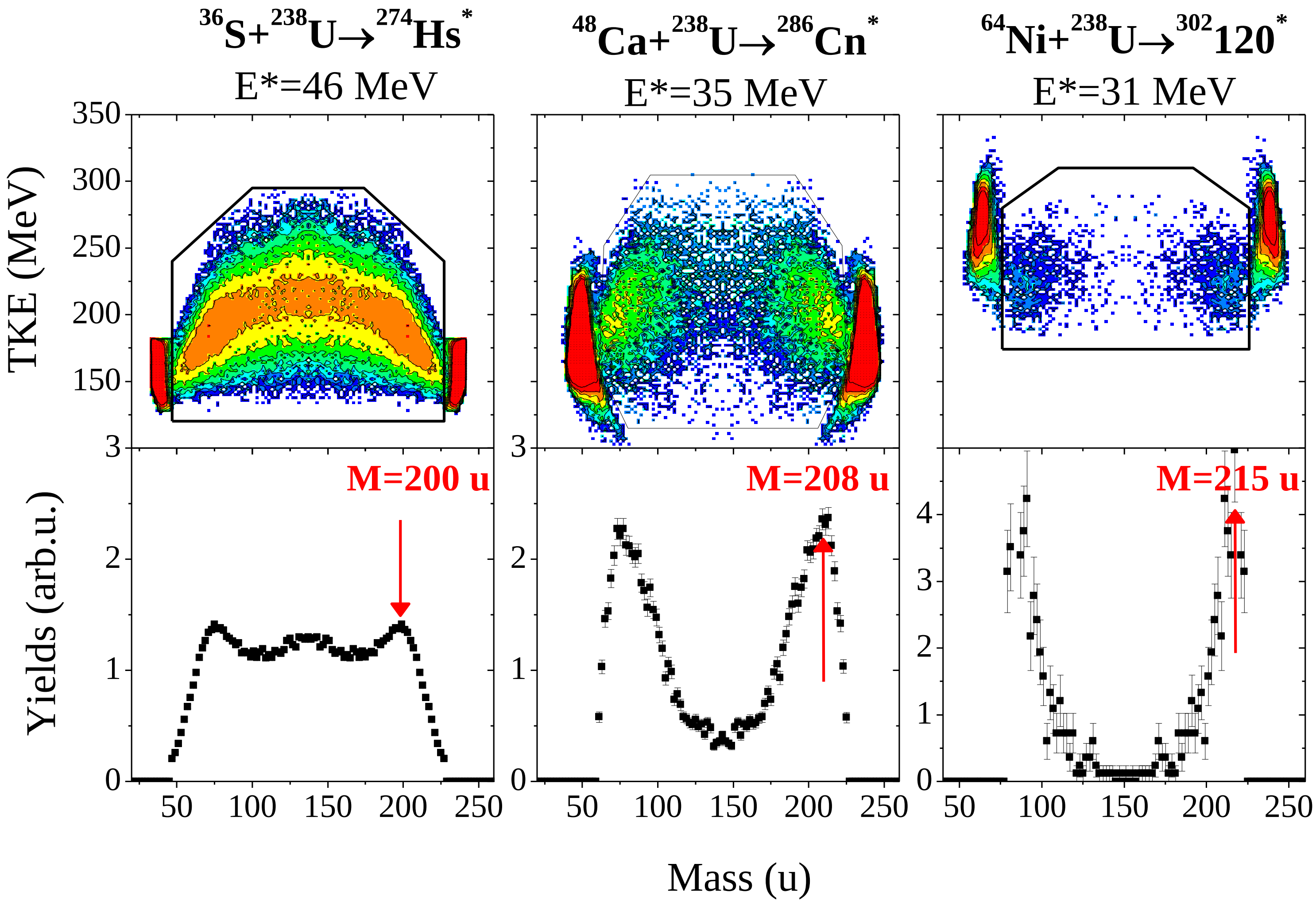
Z_1Z_2=980 1152 1472 2132

Presence of Qfasym in the medium composite systems (A~190-230u)





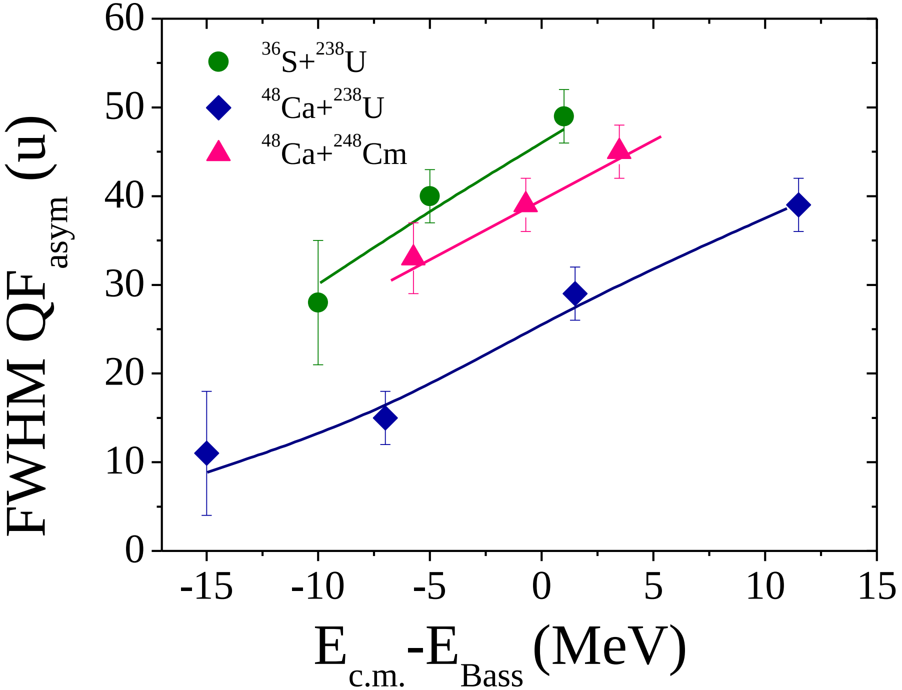
QFasym in the syperheavy composite systems

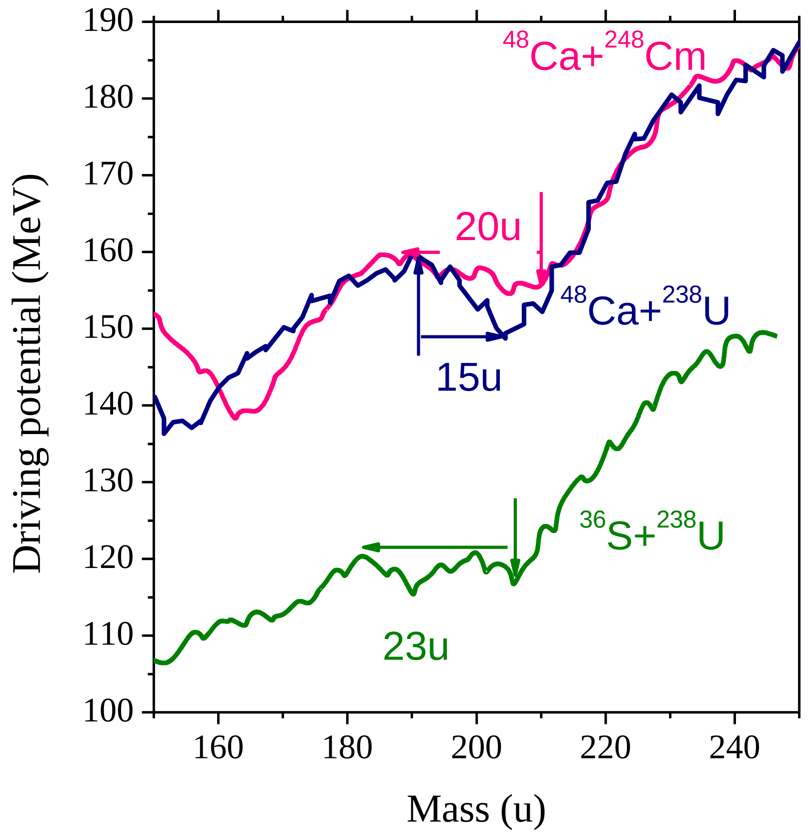


The positions of heavy peaks in the primary mass distributions of QFasym fragments in reactions with heavy ions

Reactions	Z_1Z_2	$<M_H>$	$<M_H shells>$	Reference
$^{30}Si+^{238}U$	1288	178	199,3	Nishio et al. (EXON09)
$^{36}S+^{238}U$	1472	200 ± 3	202,5	Nishio, Itkis(PRC83)
$^{40}Ar+^{238}U$	1656	204	204,5	Nishio et al. (EXON09)
$^{48}Ca+^{238}U$	1840	208 ± 3	208,5	Kozulin et al.(PLB683)
$^{48}Ca+^{244}Pu$	1880	210 ± 3	211,8	Itkis et al. (NPA787)
$^{48}Ca+^{248}Cm$	1920	211 ± 3	213,8	Itkis et al. (NPA787)
$^{64}Ni+^{238}U$	2576	215 ± 3	216,5	Kozulin et al.(PLB686)

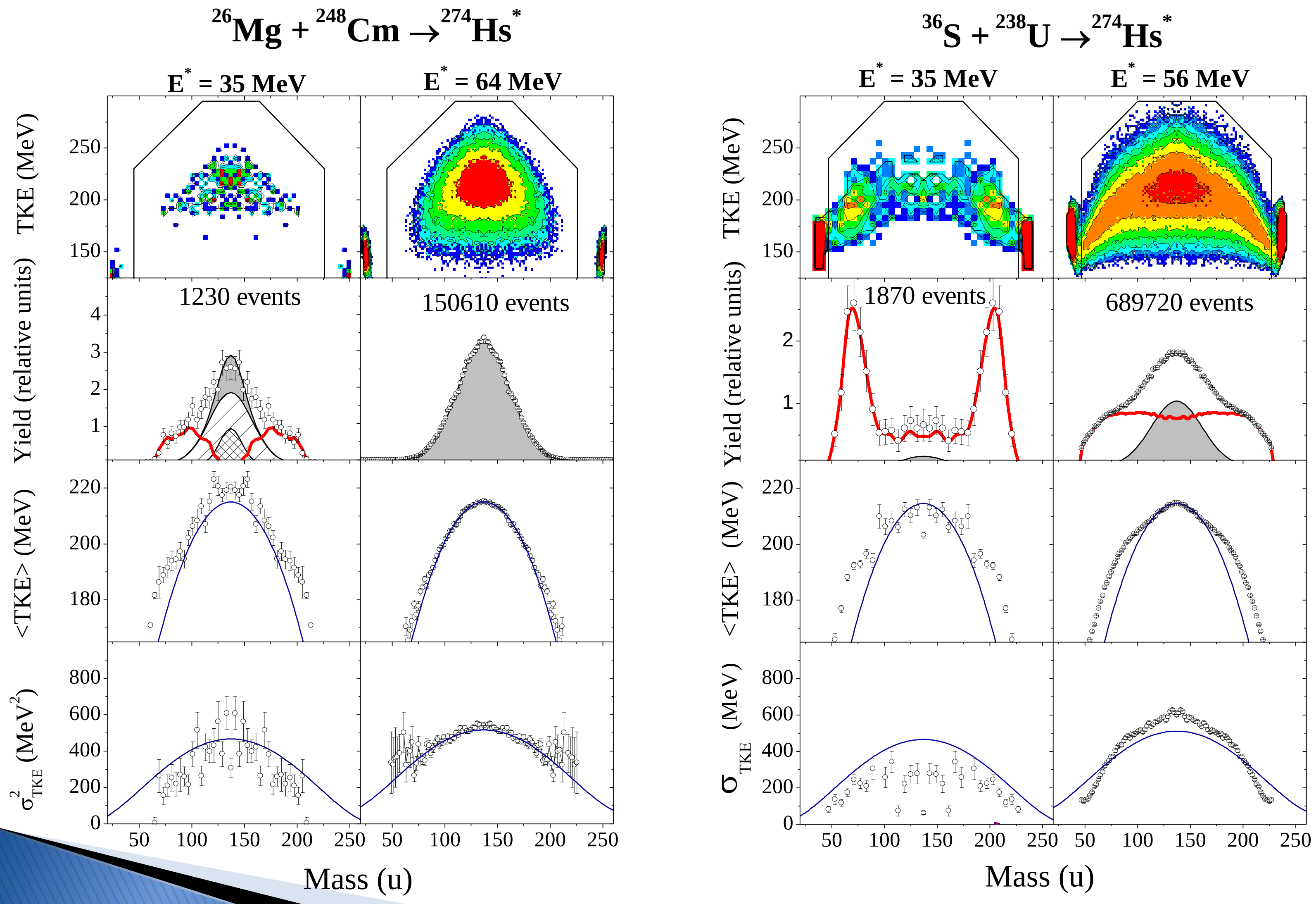
The widths of Qfasym mass distributions



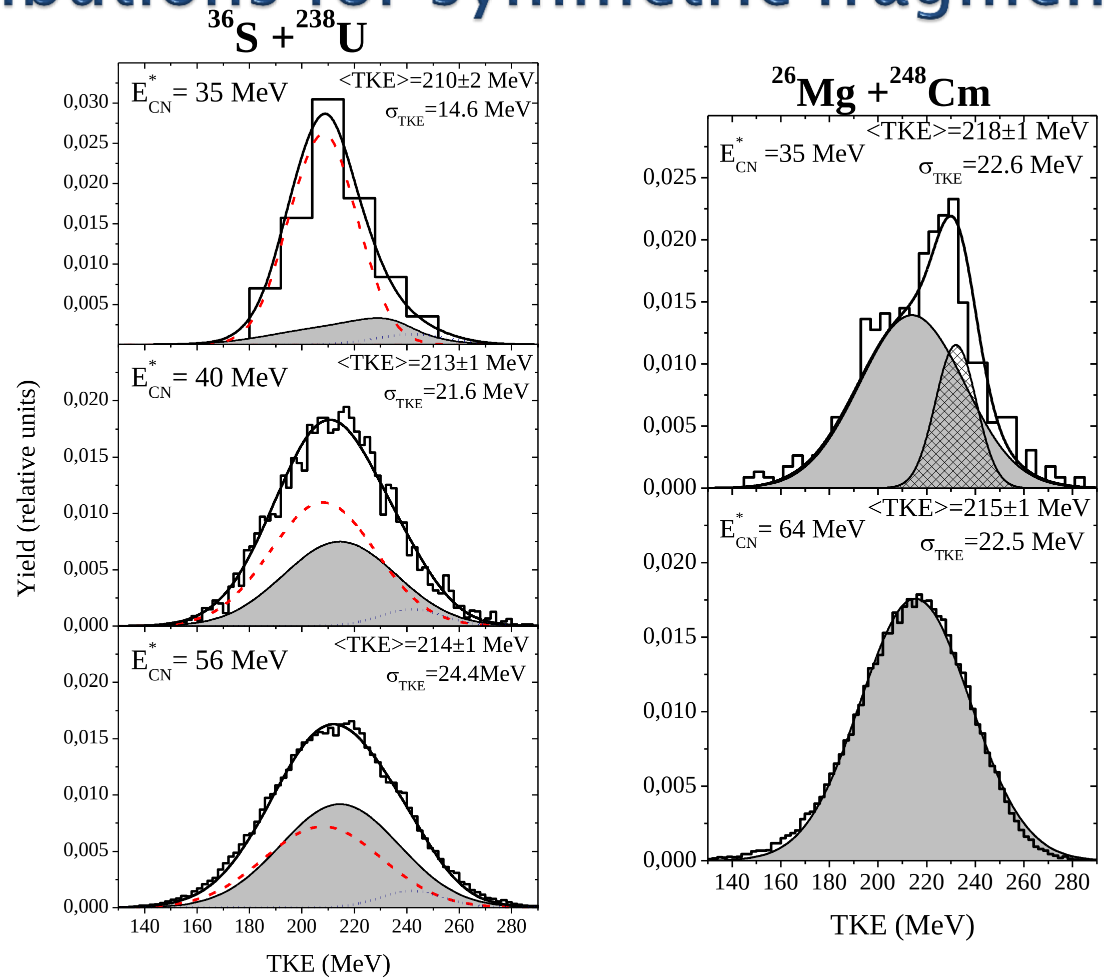


While the relative contribution of QF to the capture cross section mainly depends on the reaction entrance channel properties, such as mass-asymmetry, collision energy, deformation of interacting nuclei and the Coulomb factor Z_1Z_2, the features of asymmetric QF are determined essentially by the driving potential of composite system.

Qfsym versus CNF

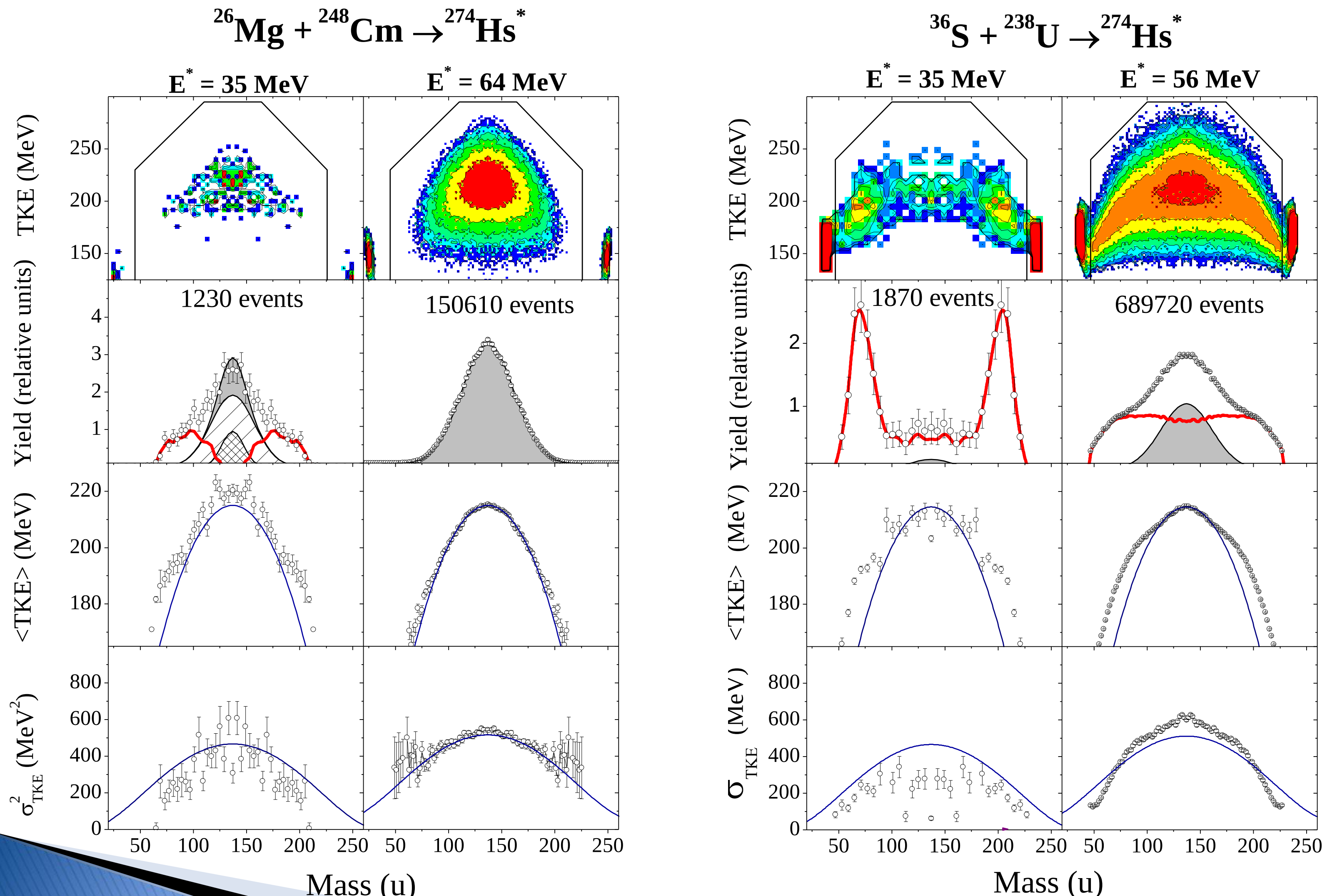


TKE distributions for symmetric fragments



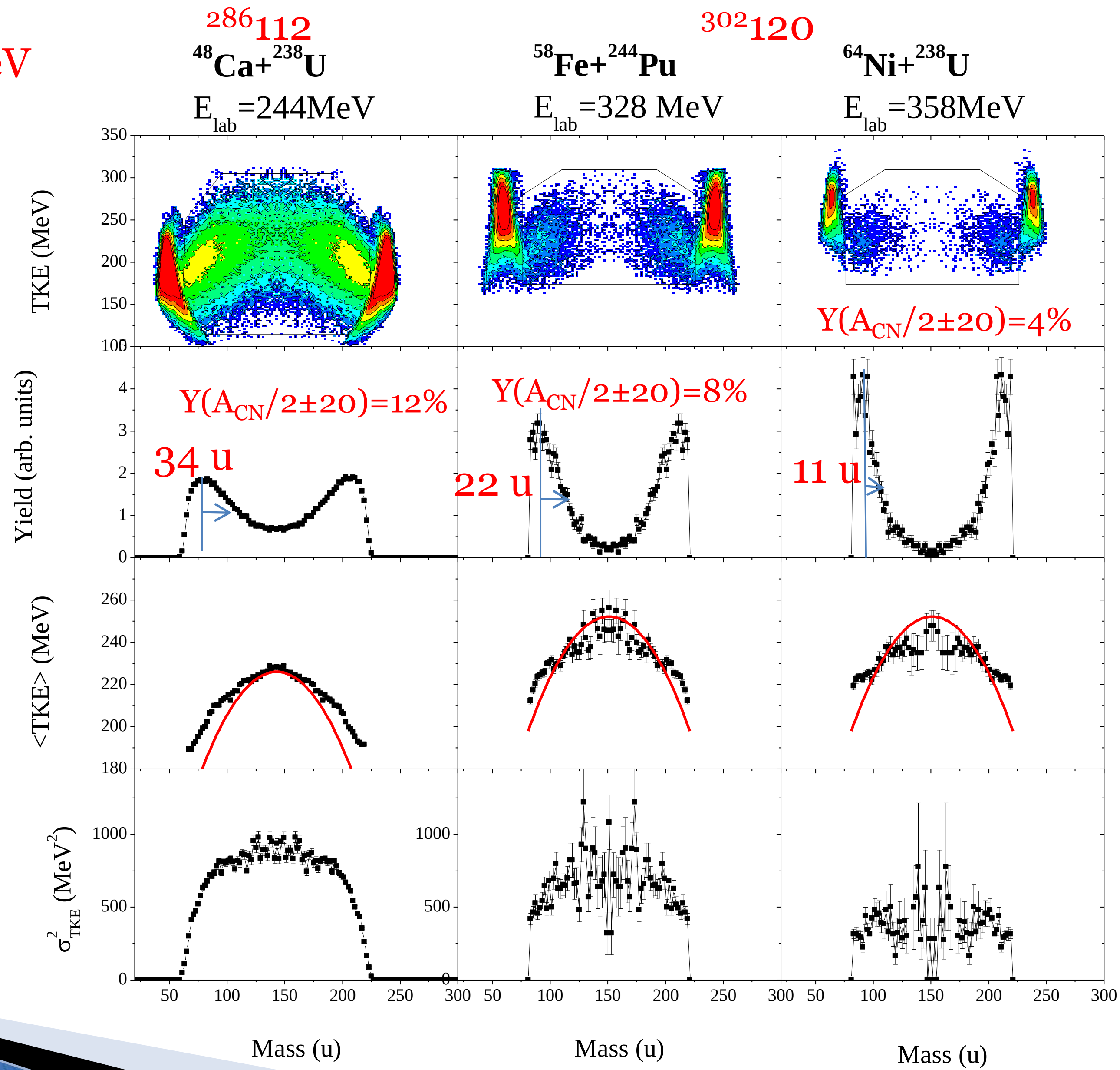
At excitation of CN larger than 40 MeV (when the shell in CN-fission is practically disappeared) broadening of the TKE distribution point to the presence of the both QF and CN-fission processes. Narrowing of the TKE distribution indicate that QF is a dominant process.

Qfsym versus CNF



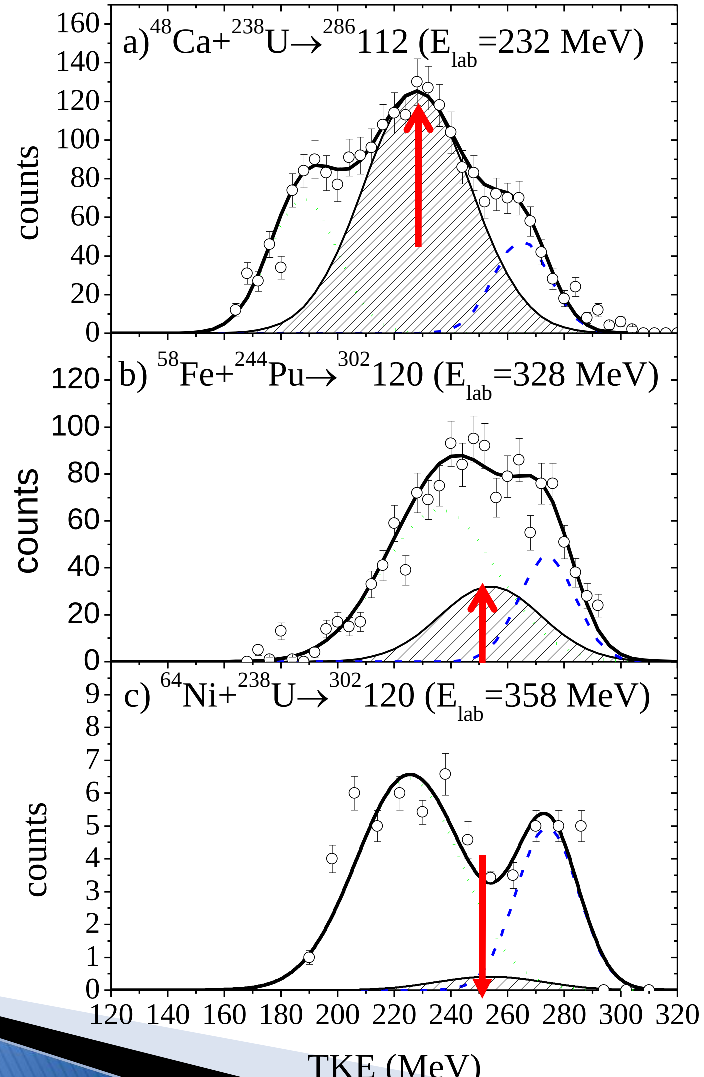
Transition from ^{48}Ca to ^{58}Fe and ^{64}Ni

$E_{CN}^{*} \approx 45$MeV



TKE distributions for symmetric fragments

Viola systematics



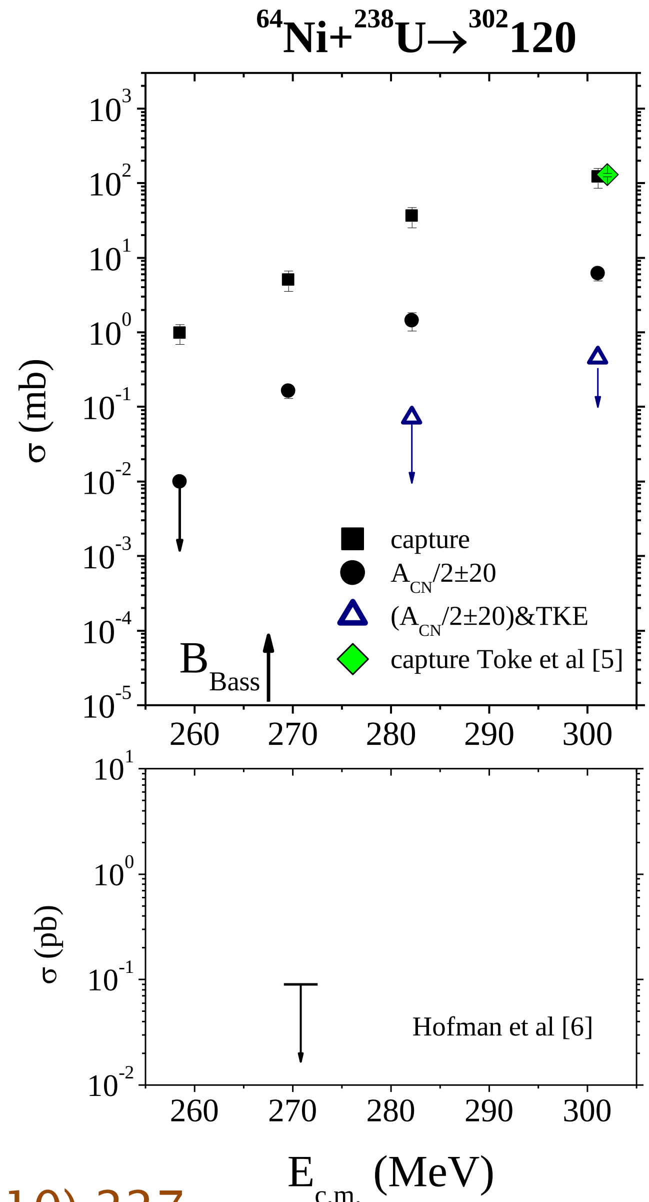
68%

≤2%

≤0.2%

Cross section for the $^{64}Ni+^{238}U$ reaction

- The capture cross section is about a few hundred millibarns at energy above the Coulomb barrier (about 4-5 times less than for the reaction $^{48}Ca+^{238}U$).
- The formation cross section of fragments with masses $A_{CN}/2\pm20$ u is one order of magnitude less compare with Ca-induced reactions.
- The estimated value of formation probability of compound nucleus formed in the reaction $^{64}Ni+^{238}U$ drops three orders of magnitude with respect to the $^{48}Ca+^{238}U$ reaction. This is unfortunately a limiting factor.
- Thus, we conclude that the reaction $^{64}Ni+^{238}U$ is not suitable for the synthesis of the synthesis of element Z=120.



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Conclusion

- While the relative contribution of QF to the capture cross section mainly depends on the reaction entrance channel properties, such as mass-asymmetry, collision energy, deformation of interacting nuclei and the Coulomb factor Z_1Z_2, the features of asymmetric QF are determined essentially by the driving potential of a composite system.
- The major part of the QF fragments peak around the region of the Z=82 and N=126 (double magic lead) and (Z=28 and N=50) shells, and the maximum of the yield of the QF component is a mixing between all these shells. Hence, shell effects are everywhere present and determine the basic characteristics of fragment mass distributions.
- Previously for separation of QF and CN-fission the angular and mass distributions of fissionlike fragments were used. The present analysis of the TKE distributions of fragments with mass $A_{CN}/2\pm20$ u for different reactions studied shows that the variance of the TKE distribution is sensitive to the presence of the QF process. At excitation of CN larger than 40 MeV (when the shell in CN-fission is practically disappeared) broadening of the TKE distribution point to the presence of the both QF and CN-fission processes. Narrowing of the TKE distribution indicate that QF is a dominant process.
- At the transition from Ca to Ni projectiles the formation of symmetric fragments is suppressed sharply by Qfasym and deep-inelastic reactions and Ni ions is not suitable for the synthesis of element Z=120 in the complete fusion reactions. Alternative way for further progress in SHE can be achieved using hot fusion reactions with ^{50}Ti, ^{54}Cr, ^{58}Fe ions or using the deep-inelastic and QF reactions.

Collaboration

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