CLUSTERING EFFECTS IN TERNARY FISSION OF HEAVY AND SUPERHEAVY NUCLEAR SYSTEMS

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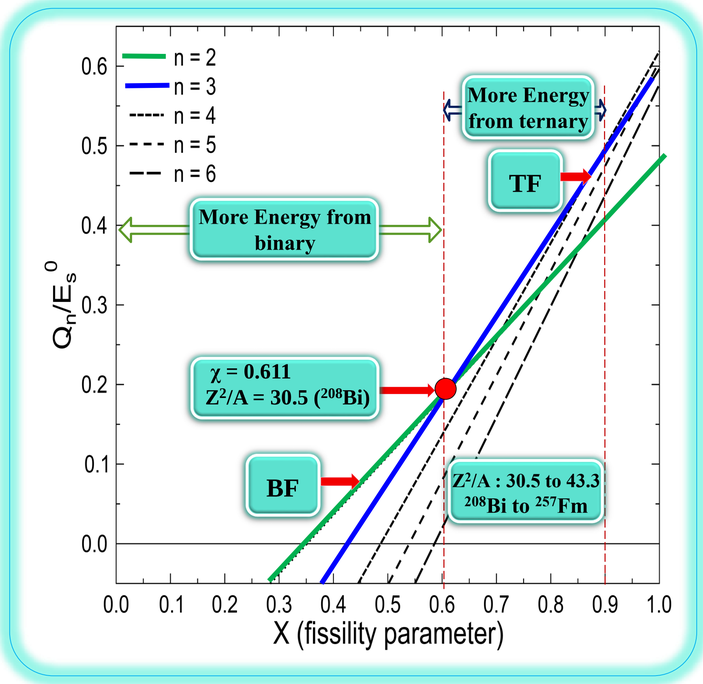
1. ABSTRACT

Clusterization, i.e., the process of forming compact pieces of nuclear matter due to the shell effect inside the nucleus, plays an important role in true ternary fission of super-heavy nuclear systems [1]. Experimental investigations show that during the reaction between medium mass nuclei and heavy mass target, three body clusterization (ternary fission) occurs into two heavy nuclei (doubly magic nuclei, i.e., ^{132}Sn, ^{208}Pb, etc.) and one light nucleus [2]. In ^{238}U + ^{238}U composite nuclear system, triple cluster decay is expected to occur possibly creating two Pb-like fragments (Z = 82 and N = 126) and a ^{60}Ca which is highly exotic. Using this concept, we have carried out a test experiment with the reaction between ^{238}U (with incident beam energy 6.2 MeV/u) and ^{238}U (target), in GANIL (Caen, France) with the CORSET [3] setup by an international collaborations. The aim was to measure the mass and energy distributions of the fragments and their angular correlations by a TOF-TOF-E technique. The data indicate mainly binary decay of fission fragments. Besides, there are many events that can indicate ternary decays. For the confirmation of two Pb-like and one ^{60}Ca nuclei, we have in progress further investigations.

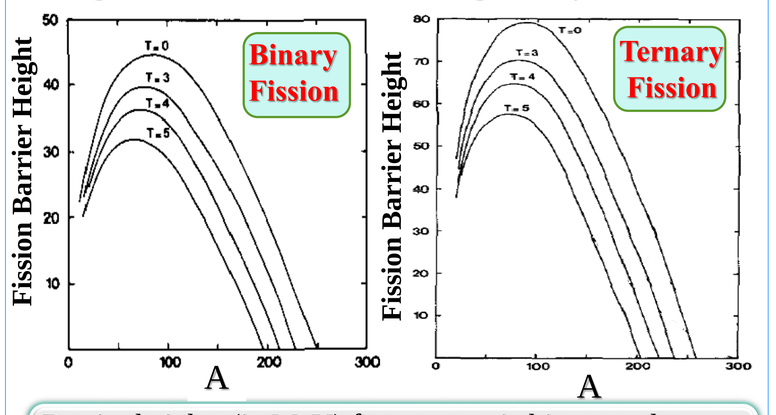
2. ENERGY RELEASE IN FISSION



Energy release of an ideal, electrically charged, liquid drop vs. the fissility parameter χ or Z^2/A [4]. The parameter ***n*** gives the number of equally sized fragments in the decay process.

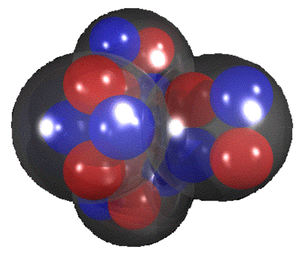
3. FISSION BARRIER HEIGHT

For larger masses, both barriers reach gradually similar values.

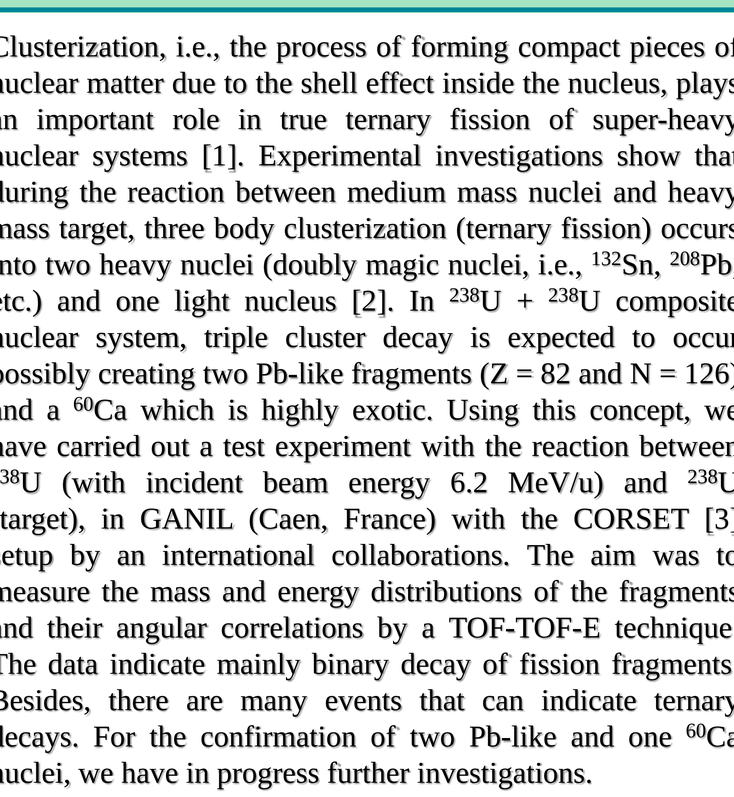


Barrier heights (in MeV) for symmetric binary and ternary fission as a function of temperature and mass number [5].

The arrangement of four alpha particle clusters in the nucleus ^{16}O

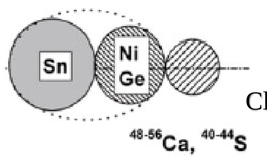


4. CLUSTER TRI-PARTITION



Mass Distribution from Spontaneous fission of ^{252}Cf [6].

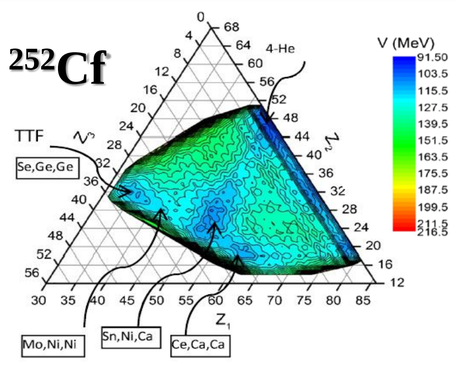
3 body decay occurs when there is a shell closure in the emerging fragments.



"CCT" -Ternary Cluster Decay ^{252}Cf

5. POTENTIAL ENERGY SURFACE

Landscape of potential energy of three body configurations formed in collision of ^{238}U+^{238}U [1].



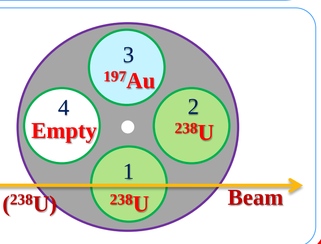
The potential energy surface of the three fragments for all the possible ternary split-ups of the parent nucleus ^{252}Cf [7].

6. MCP BASED DETECTORS

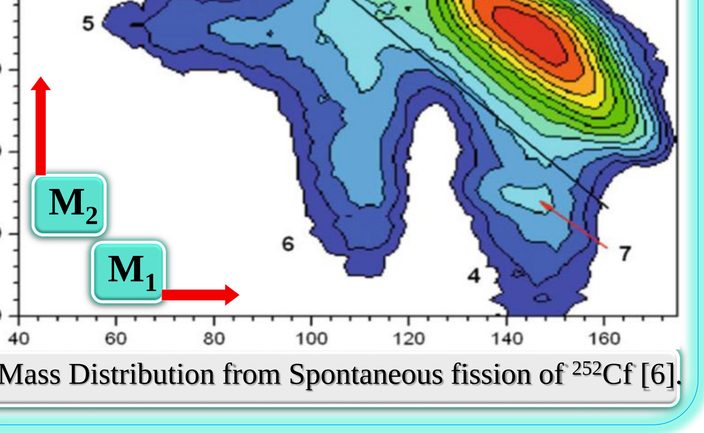
TOF Arm of CORSET With Start and Stop Detector.

8 Si-Detectors attached with Stop Detector.

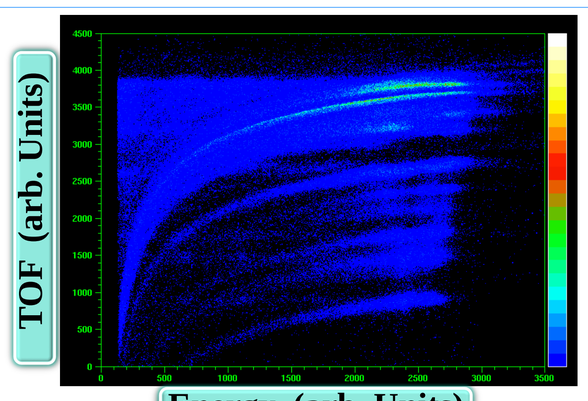
Thickness of Target:
1: 230 – 260 μg/cm²
2: 419 – 457 μg/cm²
3: 500 μg/cm²
Beam Energy: 6.2 MeV/A



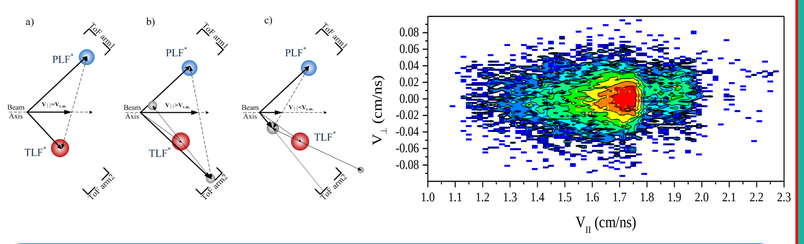
7. EXPERIMENTAL TECHNIQUE



Layout of the CORSET spectrometer



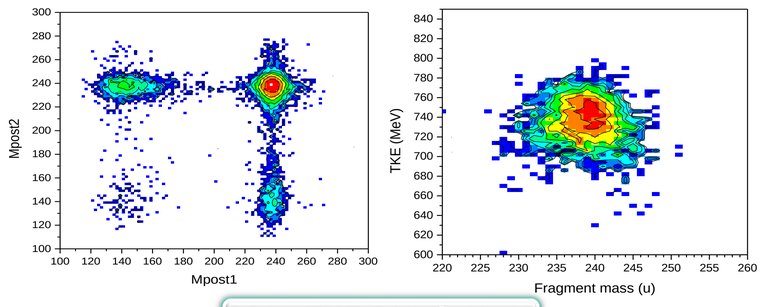
8. EXPERIMENTAL DATA



$V_{\parallel} = V_{c.m.}$: Binary fission, full momentum transfer.

$V_{\parallel} > V_{c.m.}$: Sequential fission, detected fragments in the forward (beam) direction.

$V_{\parallel} < V_{c.m.}$: Sequential fission, detected fragments in the backward (opposite to beam) direction.



Mass-TKE Distributions

9. CONCLUSIONS

All previous studies on ternary fission proof that superheavy systems can undergo 3 body decay. In this test experiment we found the signature of sequential ternary fission case. The physics of clusterization for which ternary fission occurs in superheavy systems is a very important phenomena also for the nucleogenesis in the r-process.

10. REFERENCES

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