Overview Of Unstable Nuclear State Studies In Dissociation Of Relativistic Nuclei

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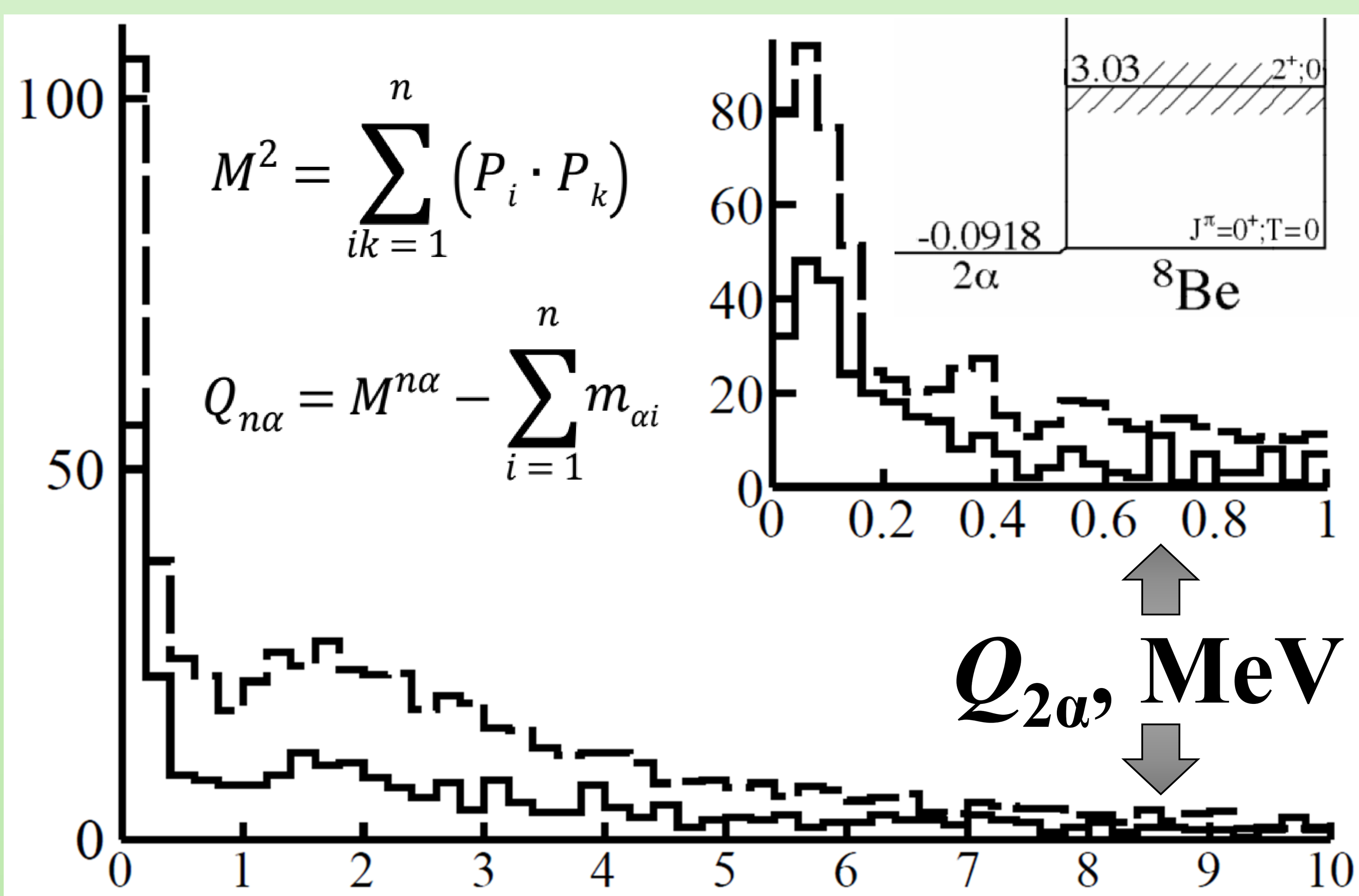
ABSTRACT

Results are presented on the identification of the unstable nuclei ^{8}Be and ^{9}B and the Hoyle state (HS) in the relativistic dissociation of the isotopes ^{9}Be, ^{10}B, ^{10,11,12}C, and ^{16}O in a nuclear track emulsion (NTE). The main motivation for the study is the prospect of using these states in the search for more complex unstable states that decay with their participation. It is shown that to identify relativistic decays ^{8}Be and ^{9}B and HS in NTE, it is sufficient to determine the invariant mass as a function of angles in pairs and triples of He and H fragments in the approximation of conservation of momentum per nucleon of the parent nucleus. The observed diversity enables us to assume universality in the formation of nuclear-molecular states near the bond thresholds as a consequence of coalescence of emerging α-particles and nucleons.

INTRODUCTION

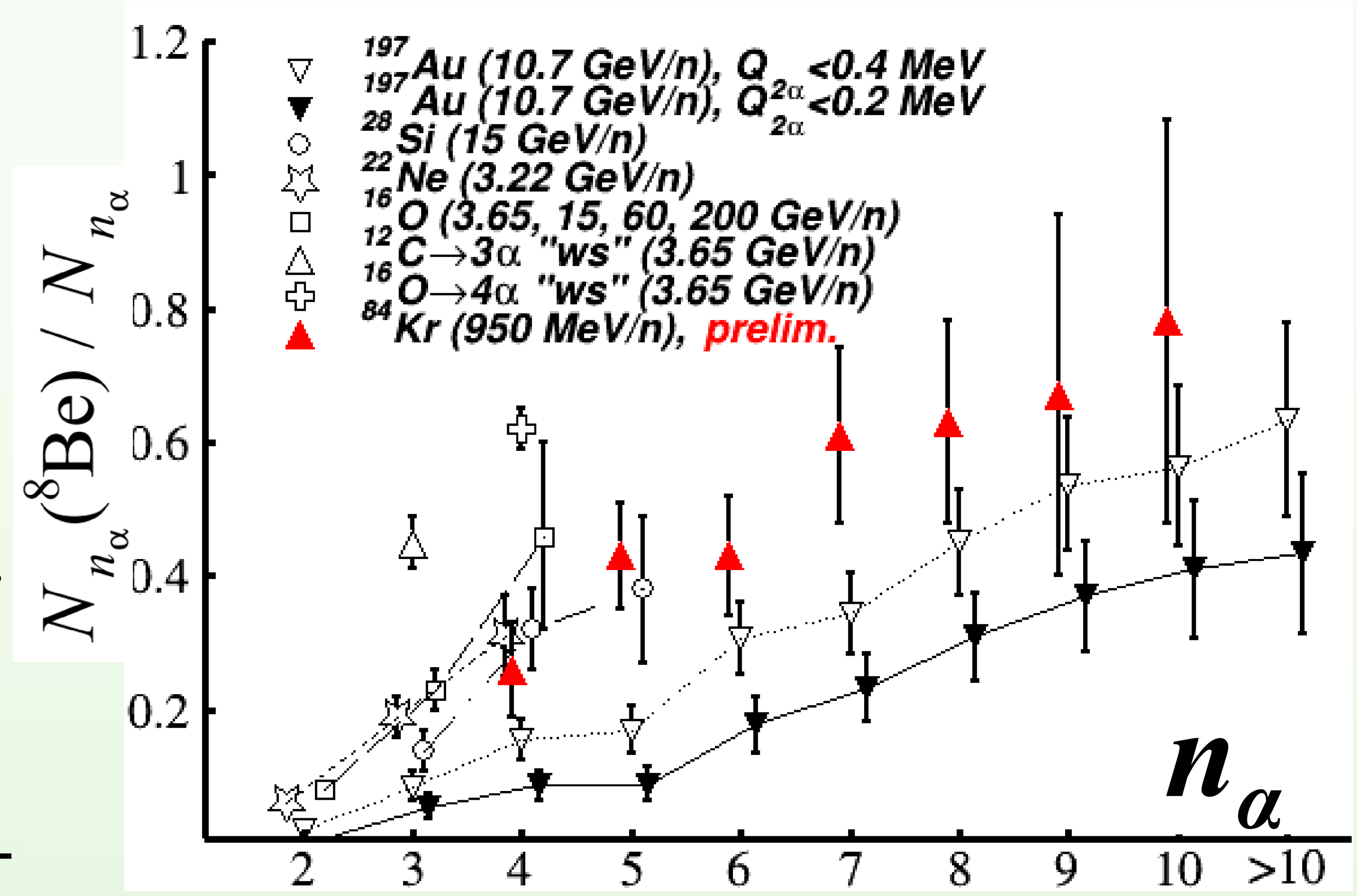
Currently, a research focus is on the theoretical concept of α-particle Bose-Einstein condensate (αBEC) - the ultra cold state of several S-wave α-particles near coupling thresholds. The unstable ^{8}Be nucleus is described as 2αBEC, and the $^{12}C(0^+_2)$ excitation or Hoyle state (HS) as 3αBEC. Decays $^{8}Be \to 2\alpha$ and $^{12}C(0^+_2) \to {}^{8}Be\alpha$ can serve as signatures for more complex αBEC decays. Thus, the 0^+_6 state of the ^{16}O nucleus at 660 keV above the 4α threshold, considered as 4αBEC, can sequentially decay $^{16}O(0^+_6) \to \alpha{}^{12}C(0^+_2)$ or $^{16}O(0^+_6) \to 2{}^{8}Be(0^+)$. Its search is being carried out in several experiments on fragmentation of light nuclei at low energies. Confirmation of the existence of this and more complex forms of αBEC could provide a basis for expanding scenarios for the synthesis of medium and heavy nuclei in nuclear astrophysics.

$^{8}Be_{gs}$ PRODUCTION IN FRAGMENTATION OF RELATIVISTIC NUCLEI

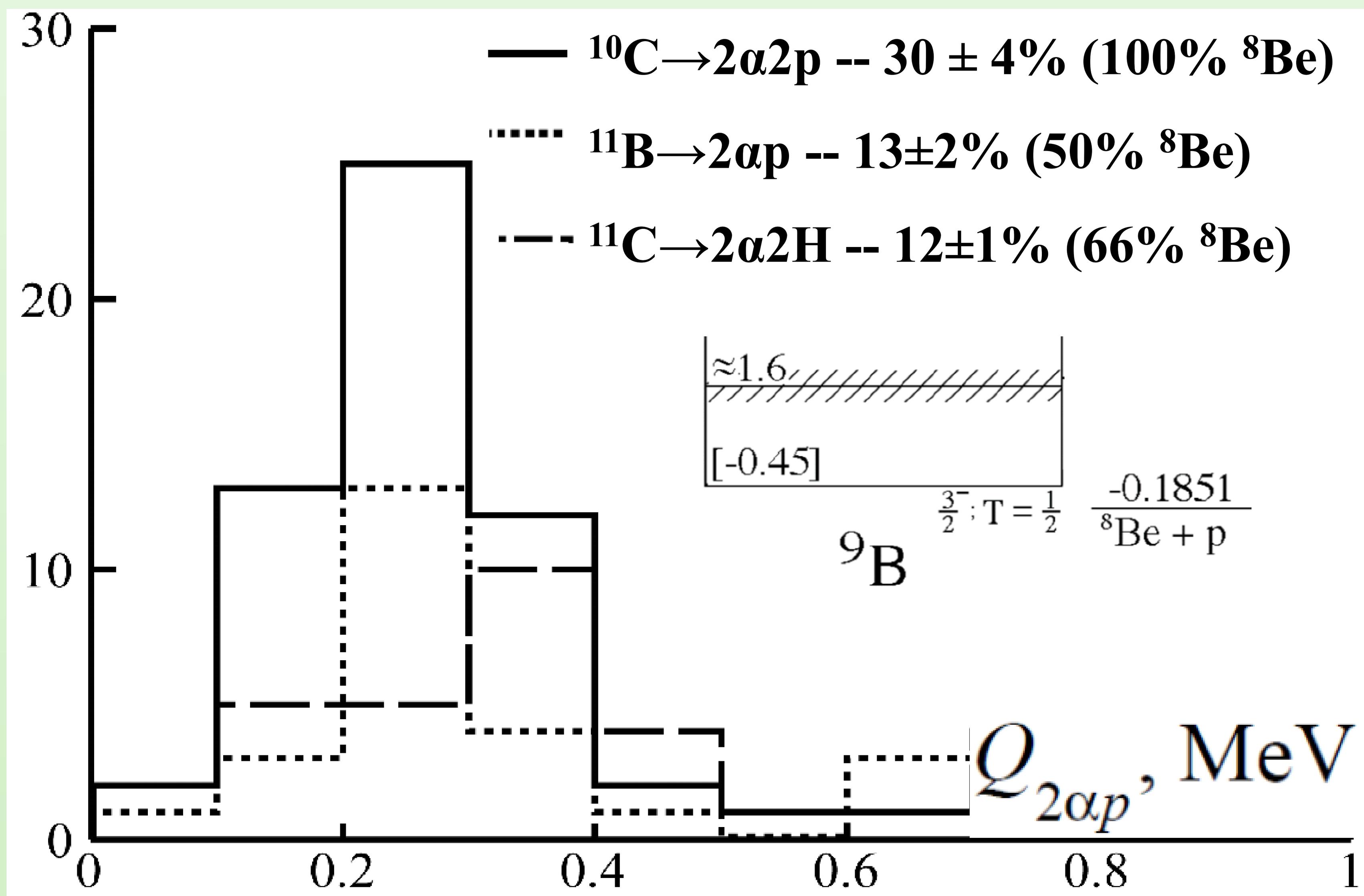


Number of 2α-pairs $N_{2\alpha}$ over the excitation energy $Q_{2\alpha}$ in the $^{12}C \to 3\alpha$ (solid line) and $^{16}O \to 4\alpha$ (dashed line) coherent dissociation at 3.65*A* GeV. The contribution of $^{8}Be_{gs}$ has been determined like 45 ± 4% in ^{12}C and 62 ± 3% in ^{16}O (6±1% 2^{8}Be).

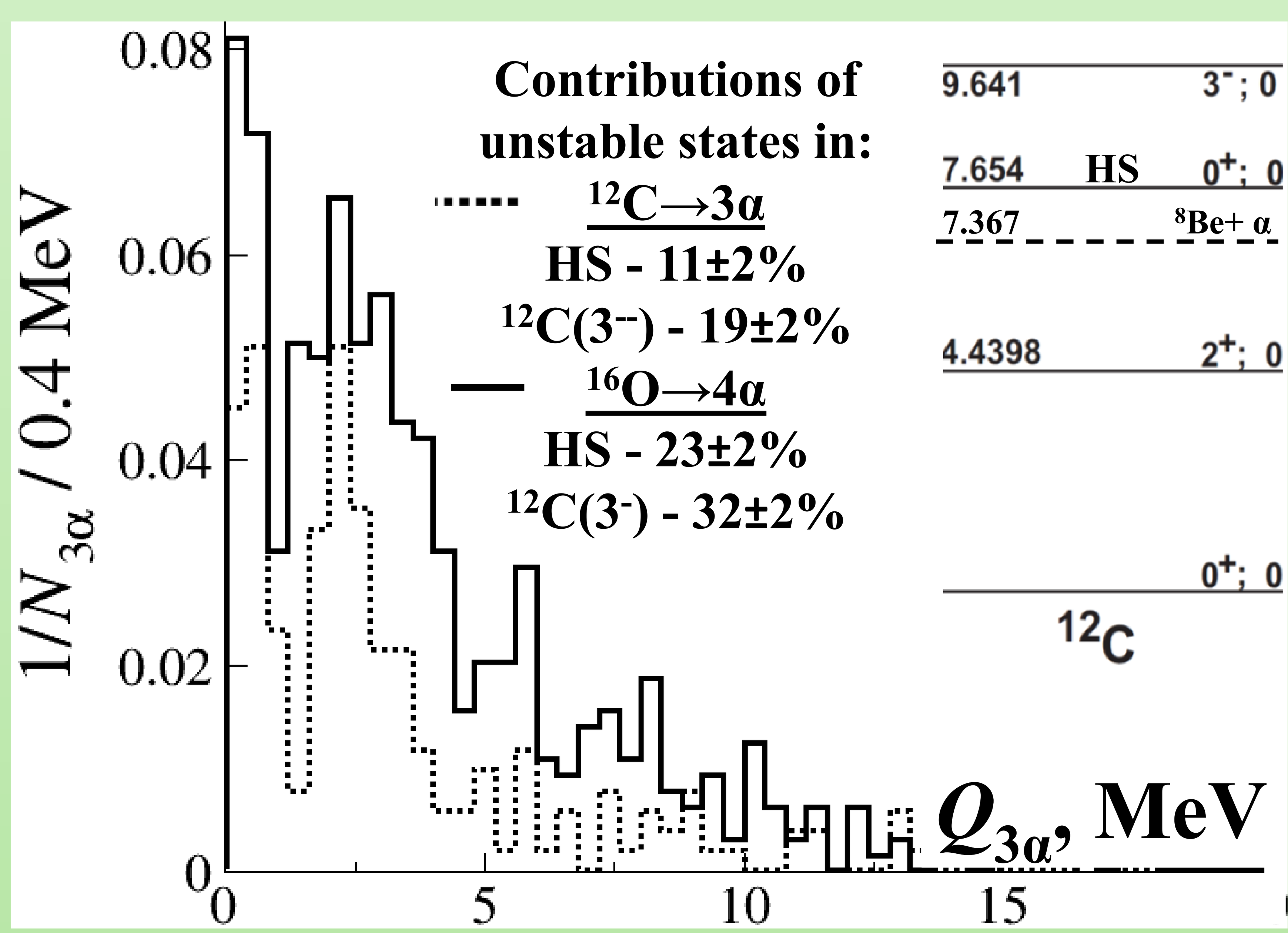
CORRELATION IN FORMATION OF ^{8}Be NUCLEUS WITH THE MULTIPLICITY OF α-PARTICLES IN FRAGMENTATION OF RELATIVISTIC NUCLEI



^{9}B (0.185 MeV) IN DISSOCIATION OF ^{10}C, ^{11}C AND ^{10}B



HOYLE STATE $^{12}C(0^+)$ AND $^{12}C(3^-)$ STATE IN DISSOCIATION OF $^{12}C \to 3\alpha$ AND $^{16}O \to 4\alpha$ AT 3.65*A* GeV



CONCLUSION

- **Productivity of the nuclear emulsion method in studies nuclear clustering and states of the lowest density and temperature is confirmed.**
- **Determination of the invariant masses from the fragment emission angles assuming conservation of momentum per nucleon of the parent nucleus allowed identifying the decays of $^{8}Be(0^+)$, $^{8}Be(2^+)$, ^{9}B, $^{12}C(0^+_2)$, and $^{12}C(3^-)$.**
- **The observations of $^{8}Be(0^+)$ and $^{12}C(0^+_2)$ points out that conditions of nuclear astrophysics can be reproduced in the relativistic fragmentation.**
- **Despite relativistic scale unstable states may emerge in final state interactions of lowest energy nuclear physics.**
- **Progress in microscope image analysis opens up new horizons to the method in nuclear structure studies.**

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