SEARCH FOR COLLINEAR TRIPARTITION OF THE ^{252}Cf NUCLEUS AT THE MODIFIED FOBOS SPECTROMETER.

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1 Introduction.

Some preliminary results of the experiment aimed at the investigation of collinear cluster tripartition of the ^{252}Cf nucleus are presented below. The experiment is performed at the 4π spectrometer FOBOS installed at the FLNR of the JINR[1)], and it was inspired mainly by the previous results obtained at the FOBOS setup[2)]. Some unusual events with the yield of ~10^{-5}-10^{-6} with respect to those due to an ordinary spontaneous decay of the nuclei of ^{248}Cm and ^{252}Cf have been detected whose total mass of the two complimentary fragments amounted to about 70% of the initial mass of fissioning nuclei. These events lie far away of the sets of points F (fig.1) connected with conventional binary fission.

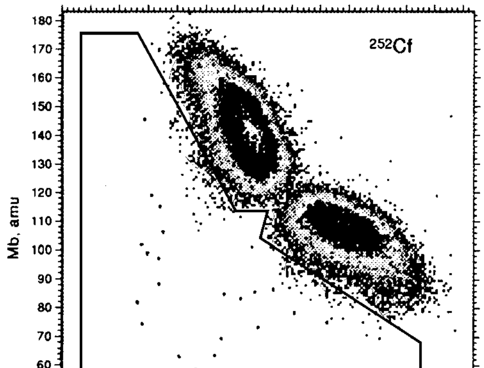

Fig.1. Fission fragments mass-yields matrix Y(Ma,Mb) for ^{252}Cf(s f) decay.

The mass-energy correlations for these rare events allow one to associate them with fission of the system via an elongated three-body chain–like configuration. In this case two fragments being at the utmost left and the utmost right positions fly apart along the chain axis, while the middle fragment can stay almost in rest. The results obtained have been treated as an indication of collinear cluster tripartition (CCT) of the heavy nuclei under study.

2 Experiment

The main method problem manifested in that experiments was a background of faulty events due to the partial lost of the energy of the fission fragments (FF) on supporting and coordinate grids of the FOBOS modules. In order to overcome this obstacle and to improve the quality of the data some modifications have been introduced into the experiment scheme. These modifications concerned the configuration of the detectors including the start detector, the electronics and also the data acquisition system. The most important tasks are discussed in following.

Two groups containing six FOBOS modules each are used as a double-armed spectrometer for measuring the FF velocities (V) by means of their time-of-flight and their energies (E). Thus both the «2-V» and the «V-E» methods are accessible for the calculation of the FF masses. When using the latter method one do not need to use any a-priori assumptions concerning the process to be exclusively binary.

According to the model of the CCT process proposed in Ref.[2] the middle fragment of the three-body pre-scission chain borrows almost the whole deformation energy of the system. Being presumably in rest it would be an isotropic source of post-scission neutrons of a high multiplicity (~10) in the lab system. On the contrary, the neutrons emitted from the moving fission fragments are focused along the fission axis. In order to exploit this phenomenon for revealing the CCT events the “neutron belt” was assembled in a plane being perpendicular to the symmetry axis of the spectrometer, which serves as the mean fission axis at the same time. The center of this belt coincides with the location of the FF source (fig.2).

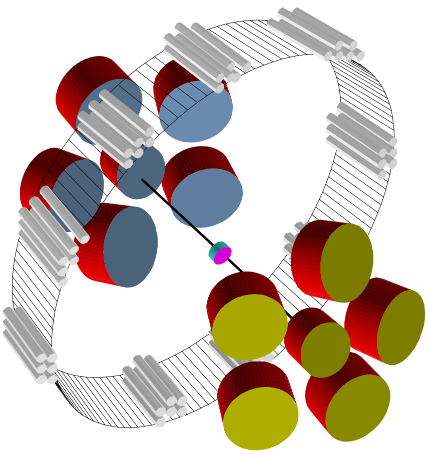

Fig.2 The general layout of the spectrometer.
The spontaneous source inside the start detector is in the middle.

The neutron detector consists of 140 separate hexagonal modules[3)] comprising a ^{3}He-filled proportional counter, a moderator, a high-voltage input and a preamplifier. The counters operate under a gas pressure of 7 bar, being 50 cm in length and 3.2 cm in diameter. The moderator is made of polyethylene. The spacing between the parallel planes of a module is 5 cm. The neutron counters are composed into 8 arrangements of 16 counters each and one of 12 counters and they cover altogether ~35% of the complete solid angle of 4π. Two such arrangements mounted at the main FOBOS vacuum chamber near the target node. The electronics of the "neutron belt" is operated in the slave mode being triggered by the event selector of the gas part of the FOBOS detector.

The registration efficiency for those neutrons emitted from an isotropic source was found to be very closed to its geometrical limit, while the registration efficiency for neutrons emitted from the fission fragments registered by the FOBOS modules amounted to ~4% because they are focused along the fission axis which is perpendicular to the plane of the neutron counter belt.

The typical spectrum of frequency versus number of the tripped neutron counters for registered fission events is presented in Fig. 3. The function obtained agrees well with the theoretical calculations based on the known probabilities for emitting a certain number of neutrons per fission meaning the total registration efficiency of about 4%.

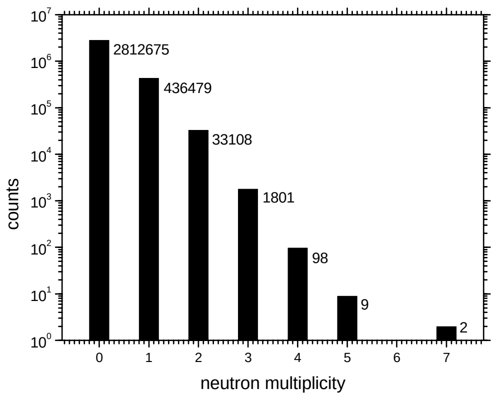

Fig.3 The spectrum of frequency versus number of tripped neutron counters for the recorded fission events.

The next test of the reliability of the CCT events is the low total charge of the both detected fragments, less than $Z_C/2$, where Z_C is a charge number of the fissioning nucleus. Unfortunately the Bragg-spectroscopy is out of rule for the heavy ions whose energy are typically less than 1 AMeV for the FF in spontaneous fission. In order to perform the test for the total charge an additional parameter was recorded for each fission fragment registered. This alternative method was proposed in Ref.[4)] It is based on measuring the delay between the time the fragments enter a Bragg ionization chamber (BIC) and the time the anode pulse crosses a given level, i.e. the parameter connected with the drift time of an electric charge in a BIC.

The distribution of FF energy versus drift time obtained in our experiment is shown in Fig. 4. The FF fall to the light and the heavy mass peaks, which are easily distinguished.

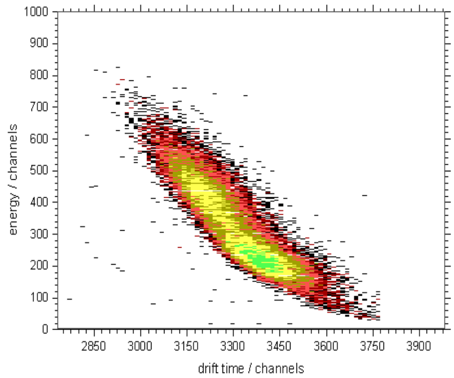

Fig. 4. The distribution of the FF energy versus drift time measured in a BIC.

The last modification of the spectrometer is a specially designed wide aperture start-detector with an internal FF source[5)]. The full simmetrization of the spectrometer arms achieved due to such a start−detector essentially improves the quality of the data.

3 Results and discussion .

Processing of the data obtained is in progress now but the first interesting result can be already discussed. Fig.5 depicts energy distribution Y(Ea,Eb) of the fragments detected in coincidence in two arms (labeled **a** and **b**) of the spectrometer on condition that simultaneously more than 4 neutron counters were fired.

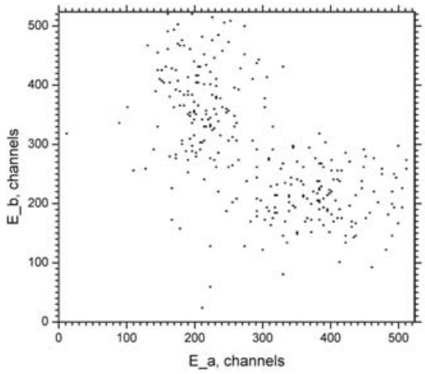

Fig.5. Energy distribution Y(Ea,Eb) of the complimentary fragments on condition that simultaneously more than 4 neutron counters were fired.

The statistics processed is about $1.4*10^7$ events. The set of points which looks like parabola (marked by the arrow) attracts attention. For comparison, similar plot obtained for the events fall inside the contour marked in the fig.1 is shown in fig.6.

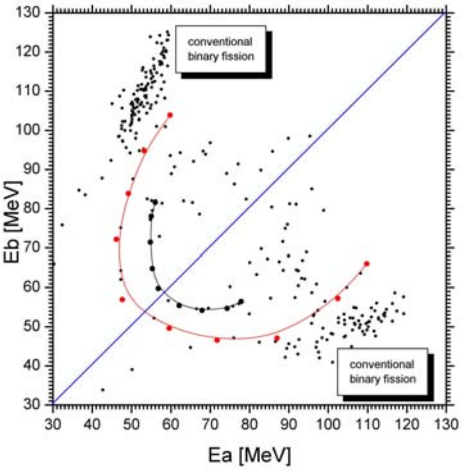

Fig.6. Energy distribution Y(Ea,Eb) of the complimentary fragments obtained for the events fall inside the contour marked in the fig.1.

The events forming an angle-like structure in fig.1, i.e. linked with tripartition, are connected by the parabolic curves.

Thus in fig.5 just in raw neutron gated data we observe the structure linked with collinear tripartition. This is the most inspiring result for the moment.

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4 References

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