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Directional distributions of prompt fission neutrons from $^{252}\text{Cf}(\text{sf})$

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The study of particle (n , p , α , and γ) emission in fission phenomena is crucial to understand the involved timescales, the energy dissipation, and the underlying mechanisms of the process. Among these, neutron emission is one of the most experimentally exploited process. Earlier studies of neutron-fragment (n -f), neutron-neutron (n - n) correlations were primarily focused on scission neutrons. More recent measurements have explored the average energy of neutrons detected in coincidence with others of specific energies, analyzed as a function of the angle between them [1,2]. These investigations offer indirect insights into the partitioning of excitation energy between the fission fragments during the splitting without measuring the fragments. In addition, three-neutron angular correlations have been examined under various energy and angular conditions [3]. Currently, efforts are being made to understand the effect of fragment spin on the neutron and γ -ray emission [4]. To gain a deeper understanding of the neutron generation in the fission process, a dedicated experiment was carried out to examine the energy and angular correlations of emitted neutrons with respect to the direction of the fission fragments in the spontaneous fission of the ^{252}Cf nucleus.

The measurement was performed using the ELIGANT-GN [5] array at ELI-NP. In contrast to previous measurements with this setup, where the trigger was provided by prompt fission γ -rays, the array was complemented with a vacuum chamber in order to detect fission fragments. A ^{252}Cf spontaneous fission source was placed inside the vacuum chamber at the center of the array. The 16×16 double-sided silicon strip detector (DSSSD) was mounted at a distance of 9 cm from the source for the detection of fission fragments. The neutrons emitted in the fission were measured in coincidence with the fission fragments using thirty-six EJ-301 liquid scintillators or the detection of fast neutrons as well as twenty-five ^6Li -glass detectors for the detection of low-energy neutrons. The distance between the source and detectors was 150 cm and 100 cm, respectively. All neutron detectors were arranged in the upper hemisphere and provide high efficiency with excellent timing resolution for time-of-flight energy calculations. The lower hemisphere of the array houses thirty-four large-volume $\text{LaBr}_3:\text{Ce}$ and CeBr_3 detectors mounted at a distance of 30 cm to measure the γ -rays emitted in a fission event. Data were collected over a period of six months in order to achieve sufficiently good statistics.

The angular distribution of neutrons relative to the detected fission fragments confirms the kinematical focusing of neutrons in the direction of the emitting source. The energy-angular distributions of the neutrons correlated with light fission fragments show good agreement with literature. Moreover, the data are consistent with FREYA model [5] calculations for the fission of the ^{252}Cf nucleus. The analysis is further extended to investigate two-neutron correlations with respect to the light fragment. A detailed description of the experimental setup, along with an investigation of neutron generation in fission focusing on one- and two-neutron energy-angle correlations relative to the detected fission fragment, will be presented and discussed in the framework of the FREYA model.

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