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#6-69 HV effect on neutron coincidence counting

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Neutron detection is important in the field of Nuclear Safeguards, Homeland Security, and CBRN (Chemical, Biological, Radiological, and Nuclear) defense. In these areas, precise as well as efficient detection and analysis of neutron emissions are necessary for identifying nuclear material or monitoring radioactive sources. On the one hand, neutrons are very difficult to shield and, taking into account the very low intrinsic background for neutrons, even weak sources can be detected. On the other hand, neutrons only interact weekly with the detector material and in most cases, they need to be moderated, making the detection a veritable challenge. Therefore, specialized materials and technologies, such as neutron-sensitive gases, are employed to facilitate detection.
Normally, a count rate measurement is sufficient to determine that a neutron source is present, but other techniques must be used for more specific identification. In neutron coincidence counting, the temporal correlation of neutrons is considered to distinguish between the prompt emission of a bunch of neutrons, which often indicates the presence of nuclear material, and a random emission of neutrons from industrial sources like Am/Be. This approach therefore is particularly valuable in nuclear security or safeguards, as it enhances the detection capabilities for spontaneous fission and nuclear chain reactions. Neutron Multiplicity Counting goes further by analyzing the frequency of single, double, triple, or higher-order coincidences, which provides even more detailed information concerning the fissile material.
Although many alternative materials have been developed in recent years due to Helium-3 (He 3) shortages, He-3 detectors still remain the standard. The He-3 isotope is highly effective for neutron capture due to its high cross-section for neutron capture, which allows these detectors to operate with high efficiency and even at low neutron flux levels. A configuration of multiple He-3 detectors within a detection array can improve overall detection efficiency, and allows for more accurate coincidence analysis. This technique has found widespread application in nuclear monitoring and control, particularly in identifying and quantifying fissile materials, assessing radioactive sources, and ensuring compliance with international regulatory standards.
Measurements of a commercial neutron multiplicity counter using a set of 30 He-3 tubes were performed. Depending on the applied high voltage (HV), the count rate, Feynman variance (Y2F), and Rossi-α values are examined. With increasing HV, the measured count rate rises, making a higher HV desirable for an increased efficiency of the detector. However, this increase also affects the Feynman variance and Rossi-α value in such a way that above a given HV value the measurement no longer qualifies for accurate analysis. In this case, the instrument can only be used for count rate measurements, and successful multiplicity measurements are no longer possible.
To distinguish nuclear, and in particular fissile, material from industrial neutron sources, the detector must be accurately calibrated and appropriately set to ensure reliable and valid results. This will be demonstrated in the presentation.

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