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Improving the precision of calibrating a large low-background proportional counter

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The fundamental difference between low-background nuclear-physical measurements and other types of studies of the characteristics of ionizing radiation sources is the extremely low total event count rate. Therefore, all recording devices in such experiments are oriented to work with individual signals. Spectrometric measurements of low-energy ionizing radiation using gas detectors are mainly carried out in the proportional amplification mode. The proportional counter is an excellent detector for the soft x-ray region because it is saturable, energy selective and has high-absorption efficiency as well as a very good signal to noise ratio. The search for such a rare nuclear decay as the simultaneous capture of two orbital electrons by the same noble gas isotope nucleus by recording x-rays and Auger electrons is possible using large proportional counters. The characteristics of these counters must satisfy a number of conditions, since the intrinsic radiation, a background of the detectors must be ultra-low and the spectrometric characteristics must be stable during sufficiently long measurements.

Modern equipment allows us to record the full shape of the signals in digital form from several channels simultaneously. Subsequent analysis with specially developed software algorithms allows obtain the desired dependencies and divide events into separate groups. Such information is of particular value when conducting low-background measurements, in which the useful effect is a small fraction of the total count rate. In this case, the selection of events with parameters corresponding to the effect can significantly increase the effect/background ratio. The quality of such a selection depends on the completeness of taking into account the features of the response function to the desired events inherent in a particular operating mode of the gas detector.

Experiments on the study of double decay processes with the capture of electrons of the inner atomic shell in different isotopes of high-purity noble gases are ongoing for a long time at the Baksan Neutrino Observatory of the INR RAS using several 10.93-liter copper proportional counters. The experience of long-term measurements related to a search of $2\nu 2$K capture with samples of different enriched for ^{78}Kr and ^{124}Xe using large proportional counters with a casing made of M1-grade copper showed that the spectrometric properties of the detector quite noticeably degrade over time.

In this report, we will focus on the analysis of changes in spectrometric properties overtime of a detector filled with xenon during long measurements, in contrast to krypton, which does not have long-lived radioactive isotopes that allow enough proper calibration from internal sources.

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