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Study of the Single-Photoelectron Signal in Photomultiplier Tubes of the DANSS Detector

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The DANSS experiment at the Kalinin NPP measures the reactor antineutrino flux and spectrum in order to search for sterile neutrinos and to address a range of fundamental and applied physics problems. The readout of the detector's 1 m³ plastic scintillator array is based on a hybrid system including photomultiplier tubes (PMTs) and silicon photomultipliers (SiPMs). High-precision Monte Carlo (MC) simulations, which are essential for accurate energy reconstruction, require detailed modeling of the PMT response. This work focuses on the analysis of the single-photoelectron (SPE) signal characteristics in these PMTs. To extract these characteristics, the photocathodes were illuminated with low-intensity LED pulses of varying brightness. The measured amplitude spectra were approximated using a convolution of a Poisson distribution — accounting for electron emission statistics from the photocathode and first dynode — and a Gaussian function representing electronic noise. By analysis of the dependence of the fit parameters on light intensity, we derived characteristics for each individual PMT. The averaged key parameters of the readout system were determined and successfully implemented into the DANSS MC simulation framework.

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