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Characterisation and Simulation of Photomultiplier Tube (PMT) Response in the SABRE South Experiment

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Photomultiplier Tubes (PMTs) are central to the SABRE South experiment's ability to detect rare, low-energy events, such as potential dark matter interactions in ultra-pure NaI(Tl) crystals. To correctly interpret what the detector sees, we need simulations that faithfully reproduce how our PMTs respond to real signals. This work presents the comparison of the simulated PMT waveforms from our custom simulation framework with actual SABRE South PMT data.

Key properties such as gain, dark rate, timing response, and afterpulsing are studied in PMT tests to build a clear picture of how the PMTs behave under real experimental conditions. Alongside this, we develop and refine simulated PMT waveforms that aim to capture the key physical and electronic effects shaping the signal. By comparing these simulations directly with data, discrepancies are identified and used to refine the simulation framework. This iterative process helps to improve the accuracy of the detector response simulation, which is crucial for reliable event reconstruction and background rejection.

The major output from this work will be a realistic PMT response simulation framework tailored to SABRE South, built on detailed characterisation of PMT performance from calibration and background runs. Our goal is to bridge the gap between simulation and data, so we can confidently interpret the signals SABRE South observes

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