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Photomultiplier Characterisation and its Impact on Background for SABRE South

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The DAMA experiments have detected a modulating signal compatible with dark matter for 20 years with a combined significance of 12.9 sigma. A result in tension for a spin independent WIMP with null results from large noble gas experiments. This is the motivation for NaI(Tl) based replication studies of the DAMA experiment.
One of the biggest challenges facing these experiments is the low number of photoelectrons detected at the 1 keV$_{ee}$ lower threshold. This reduces the efficiency of the detector and makes distinguishing scintillation events from photomultiplier noise difficult. This noise is a significant component of the low energy background model that is difficult to include in time dependent background models as it cannot be modelled in Monte Carlo simulations. This makes accurate measurement of the low energy noise important for both understanding and minimising its contribution to the overall background.
We report on the photomultiplier characterisation test bench developed for the crystal detector photomultipliers for the SABRE (Sodium iodide with Active Background Rejection) South experiment, a detector designed to test the DAMA modulation. This includes studies of the single photon response, quantum efficiency, dark noise and detector linearity. A specific focus is on correlated dark noise between two photomultipliers above the random coincidence rate, due to its significant contribution to the low energy background. We have also begun development of signal vs. noise classifiers for low energy scintillation events base on a selection of pulse shape variables.
We present the results of the photomultiplier characterisation and its impact on the low energy performance of the SABRE South experiment. We also present initial measurements of the first SABRE South test crystal grown from Astro-Grade NaI powder, which has undergone direct background counting.

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