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Construction of the KAPAE Phase II Detector in the Underground Laboratory

The KAPAE Phase II detector was developed to investigate the invisible decay of positronium, with a focus on exploring theoretical phenomena such as milli-charged particles, mirror worlds, new light X-bosons, extra dimensions, and dark photons. As the first step, this study focuses on the search for dark photons through the decay of para-positronium. The detector is maintained at -30°C and built in the Yemi underground laboratory located 1,000 m below ground to obtain stable data with ultra-low background. The detector consists of a 5×5 array of Bismuth Germanate (BGO) scintillation crystals, each with dimensions of $30 \times 30 \times 150 \text{ mm}^3$, coupled with silicon photomultipliers (SiPMs) for enhanced light collection efficiency and energy resolution. The BGO crystals were optimized for high gamma-ray detection efficiency, while the SiPMs provide precise timing and energy measurements. Additionally, the detector is shielded by layers of lead and oxygen-free copper to suppress environmental background radiation further, effectively reducing interference from cosmic rays and other radiation sources. In this presentation, we will share preliminary results obtained from both surface and underground environments, focusing on the performance evaluation of the KAPAE Phase II detector under varying experimental conditions.

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