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X-ray Detectors for the Unique Third Forbidden Decay of Potassium-40

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Enigmatic dark matter is responsible for 26% of the total mass-energy in the known universe. Since 1997, the DAMA/LIBRA experiment has claimed to have the first direct evidence for the observation of dark matter. One major source of background for this experiment is the 40K isotope. The chemical similarity between potassium and sodium is why trace amounts can be found in the NaI scintillators that DAMA/LIBRA uses as detectors. This contamination presents a challenging background that makes any interpretation of the dark matter signal difficult.

40K occurs in potassium (˜0.0117%), which is a contaminant even in ultra-pure NaI(Tl).

Two decay channels of 40K are of particular consequence. The first is the electron capture (EC*) into an excited state of 40Ar* which quickly de-excites to ground level. This releases a 2.95 keV x-ray or a 2.5 keV auger electron. A 1460 keV gamma ray is released in coincidence. There is also an electron capture (EC) directly to the ground state of 40Ar, which only releases a 2.95 keV x-ray (or 2.5 keV Auger Electron). Both decays contributes to the ˜3 keV bump seen in the data by DAMA/LIBRA and are a factor in their extraordinary claim. DAMA/LIBRA is able to remove a fraction of the decays to the excited state by tagging the 1460 keV gammas. However, the branching ratio to the ground state is not known. This branching ratio will help reduce and understand the background in the dark matter signal region of the DAMA/LIBRA experiment. In addition, this will be the first observation of a unique third forbidden decay.

We report on the performance of a Large Area Avalanche Photo Diode (LAAPD) for the direct measurement of the low energy x-rays and electrons. By observing multiple sources and x-ray fluorescence the LAAPD can be studied and characterised for the 40K energy range. Their viability for the use in a dedicated measurement of the EC branching ratio will then be determined.

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