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Improvements on directional nuclear recoil measurements with BEAST TPCs

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We report on the performance of compact, high definition Time Projection Chambers (TPCs) with pixel chip readout as part of the BEAST II beam background measurement project at SuperKEKB. The TPCs detect fast neutrons by measuring the three dimensional (3D) ionization distribution of nuclear recoils in ^{4}He:CO_2 gas at atmospheric pressure. We use these detectors to characterize the fast-neutron flux near the Belle II detector at the SuperKEKB electron–positron collider in Tsukuba, Japan. The results highlight the mobility of the TPCs by measuring the fast-neutron flux at new locations. We also showcase new machine learning techniques that can provide accurate head-tail assignment even at low energies, significantly improving directional capabilities. Scaled-up detectors based on the detection principle demonstrated here may be suitable for directional dark matter searches, measurements of coherent neutrino–nucleus scattering, and other experiments requiring precise detection of neutrons or nuclear recoils.

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