Investigation of a direction sensitive sapphire detector stack at the 5 GeV electron beam at DESY-II

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For detectors in particle physics experiments and at accelerators extremely radiation hard sensors are needed in the region near the beam pipe. Examples are beam halo and beam loss monitoring systems at Large Hadron Collider or other accelerators. Characteristics of single crystal sapphire are comparable to diamond sensors, currently used for these purposes, and they are considered a promising alternative. Industrially grown sapphire wafers are available in large sizes, are low cost and, like diamond sensors, can be operated at room temperature. Currently sapphire sensors are used for a beam-loss monitor at FLASH. A multichannel direction-sensitive detector was designed for single particle detection using a stack of sapphire plates. The performance of the detector was studied in a 5 GeV electron beam. The charge collection efficiency of the sensors was measured as a function of the bias voltage. It rises with the voltage, reaching about 10% at 950 V. The signal size at this voltage was equivalent to about 22000 e^-. The detector was operated together with EUDET beam telescope, which allowed the reconstruction of the position of the hits at the detector, allowing to measure the signal size as a function of the position with respect to the metal electrodes. A dependence on the electrical field direction was found. The data confirms the prediction that mainly the electrons contribute to the signal. Also evidence for the presence of a polarization field was observed. Based on these results, the design of a next generation sapphire strip detector will be presented.

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