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Radiation length imaging with high resolution telescopes

The construction of low mass vertex detectors is of high interest for next generation collider experiments like Belle II. Test beam experiments with multi GeV particle beams and high resolution tracking telescopes provide an opportunity to obtain precise 2D images of the radiation length X/X_0 of thin planar targets like detector modules. The method developed to measure the radiation length uses hits from the reference telescope and requires no readout of the detector module under study.

At the heart of a spatially resolved X/X_0 measurement is a precise reconstruction of the particle's hit position and scattering angle at the target plane. The main challenges are the alignment of the reference telescope and the calibration of its angular resolution. Systematical uncertainties can be minimized by conducting a calibration measurement, where the module under study is replaced by an aluminium target with a well known thickness profile.

In order to demonstrate the capabilities of X/X_0 imaging, a test beam experiment with the AIDA telescope has been conducted at the DESY test beam facility. The device under test was a mechanical prototype of a DEPFET pixel module for the Belle II vertex detector. A data sample of 25 million tracks at $4\,\mathrm{GeV}$ has been collected with a rate of $700\,\mathrm{Hz}$ within three hours. The data is sufficient to resolve bump bonds below the readout ASICs and to measure the thickness profile of the all-silicon DEPFET module.

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