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A high angular resolution silicon microstrip beam telescope for crystal channeling studies

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A charged particle telescope has been developed for data taking by the UA9 collaboration at high rates in the CERN H8 beam line using protons and other particles at up to 400 GeV/c. It uses ten planes of silicon microstrip sensors, arranged as five pairs each measuring two coordinates, with an active area of 3.8 x 3.8 cm2. It provides excellent angular and spatial resolution for measuring trajectories of incident and outgoing particles. The apparatus has a baseline of approximately 10 m in each arm, and achieves an angular resolution of 5.2 μrad, limited by multiple scattering in the sensor layers. The sensors are instrumented by a system based on the electronic readout chain developed for the CMS Tracker and a simplified version of the data acquisition software, to provide almost deadtime-free operation at trigger rates of up to 9 kHz.

The telescope was developed to characterize silicon crystals used in channeling experiments with a primary objective to validate them for use in a future LHC beam collimation system. Channeling is a well-established phenomenon whereby a charged particle is confined by the strong electrostatic potential well between crystalline planes; by bending the crystal a parallel particle beam, or its halo, can be steered in a selected direction and hence used for efficiently reducing the LHC beam halo. A series of measurements of such crystals have been carried out over several years, and a prototype beam collimation system was installed in the LHC in 2016. Meanwhile, the telescope has also been used for other studies of fundamental phenomena associated with the channeling process.

The telescope will be described, including sensors, readout, electronic hardware and software, and its measured performance, referring to results from channeling measurements. The application of crystals to LHC beam collimation will be summarized and other innovative results from measurements reported.

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