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Test results from the NA62 Gigatracker prototype: a high rate and sub-ns time resolution hybrid silicon pixel detector

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The NA62 experiment is aimed at studying ultra-rare kaon decays at the CERN SPS, and its beam spectrometer has to sustain high and non-uniform particle rate (0.8-1.0 GHz in total). Three Gigatracker (GTK) stations will precisely measure momentum and angles for each track of the high intensity NA62 hadron beam, with a time resolution of 150 ps. In order to keep background events at acceptable levels, multiple scattering and hadronic interactions of beam particles in the spectrometer have to be minimized. Therefore the total material budget of a single GTK station is fixed to 0.5% X0. In addition, the calculated fluence for 100 days of running is 2 × 10ˆ14 1 MeV neq/cmˆ2, a comparable value to the one expected in the inner trackers of LHC detectors during 10 years of operation. To comply with these tight requirements, an efficient and low-mass cooling system is being developed and the read-out chips will be thinned down to 100 microns or less.
Specifications of this detector are very challenging, especially the one on time resolution. The main issues that have been addressed in order to achieve the required resolution are compensation of the discriminator time-walk and time measurement with such a high channel density. Two complementary read-out architectures have been designed and produced as small-scale prototypes: one is based on the use of a Time-over-Threshold circuit followed by a TDC shared by a group of pixels, while the other makes use of a constant-fraction discriminator followed by an on-pixel TDC. The readout pixel ASICs are produced in 130 nm IBM CMOS technology and bump-bonded to 200 micron thick silicon sensors.
Recent experimental results obtained from laboratory and beam tests of prototype bump-bonded assemblies are presented, in addition to a general description of the Gigatracker detector system. These results show a time resolution of less than 200 ps for single hits from minimum ionizing particles.

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