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4D real-time tracking for high luminosity LHC experiments

The full exploitation of the physics potential of the high luminosity LHC is a big challenge. Experiments will have to cope with very high data rates, huge amount of data to process and store, and severe radiation damage for the innermost detectors. This requires new instrumentation and innovative solutions.

State of the art tracking pixel detectors with precise time-tagging show a time resolution of about 200ps. We aim to reduce this by one order of magnitude. Crucial aspects to achieve the ultimate time resolution are the optimisation of pixel sensor geometries (in both 3D and planar technologies) to achieve the most uniform electric field, and the design of fast and low noise dedicated front-end ASIC. This front-end will incorporate a fast current amplifier followed by a discriminator and a time-to-digital converter, and will be developed in 65nm CMOS technology with fault tolerant architecture which matches the radiation hardness requirements.

In this R&D project, we propose to build an innovative tracking detector with superior time (˜10ps) and position (˜10μm) hit resolutions, to be used in very harsh radiation environments (up to a total fluence exceeding 10^{16} 1 MeV neutrons equivalent per cm^2), capable of performing 4D and real-time tracking for fast trigger decisions. The precise measurement of the time of the hit is the key feature to operate an effective pattern recognition that guarantees a high tracking efficiency while enhancing the ghost track rejection, and to perform selective track triggering [1].

A conceptual design for a detector solution has been recently proposed and simulated [2]. The system consists of fast timing pixel sensors and a fast track finding system based on a massively parallel algorithm implemented in commercial FPGAs [3]. According to simulations the system allows a precise real-time determination of the track parameters (including time) while maintaining a low fraction of reconstructed fake tracks. New results at 40MHz event rate and with thousand tracks per event are promising and will be presented.

We ultimately aim to exploit this detector in flavour physics experiments, in conditions of a high event pile-up, where sensors and front-end electronics are required to continuously operate in a harsh radiation environment (up to a total flux of 10^{17} 1-MeV neutrons equivalent per cm^2). The proposed detector will allow to perform flavour physics at instantaneous luminosities more than one order of magnitude larger than current ones.

Bibliography

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