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Tracking with timing: a system approach

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High Luminosities planned at colliders of the next decades pose very severe requirements on vertex detector systems in terms of space resolution (tens of μm), radiation hardness (5 to 10 x 10ˆ16 1 MeV neq cmˆ-2 and some Grad) and data throughput (nxTbit/s). Expected event pile-up (more than 100) introduces the need to add high resolution time measurements (better than 100 ps) already at the single pixel level, for both real-time and off-line track reconstruction.
This demand pushes towards a new concept of vertex detector system, where all these features must operate at the same time.
The TIMESPOT project (TIME and SPace real-time Operating Tracker), started in the end of 2017 is an R&D project whose strategy consists in facing this experimental challenge at system level. It consists of a research team gathering together state-of-the-art knowledges from different expertises and disciplines, in such a way to finalize existing technologies in the direction of an innovative tracking apparatus. This organic approach is a key point of the project. Our experience as experimentalists is that high performance is only possible by optimizing the details of a system as a whole, in particular considering the interplay of sensor and electronics.
The TIMESPOT activity is organized in several Work Packages (WP). Two WP are dedicated to sensor design and characterization (3D silicon and diamond sensors respectively). Their aim is a rad-hard device with optimized timing performance. One WP is dedicated to front-end design. Its target is the development of a high resolution time and space pixel read-out circuit. Other two WP are dedicated to the implementation of high speed, high density read-out boards, capable of real-time reconstruction of tracks. The final target is realizing a proto-tracker system demonstrator, having at least 4 fully equipped tracking layers, high speed data-taking and real-time processing.
Many intersting results are already available as an outcome of the TIMESPOT activity. In sensor development, a 3D trench-based geometry has been chosen to be the best one concerning high time resolution applications, desined and submitted for fabrication. Activity on the design of dedicated front-end in 28-nm CMOS has led to the submission of a complete pixel read-out circuit, also integrating a TDC with 15 ps r.m.s. resolution. A special care is being dedicated to the development of real-time reconstruction algorithms for tracking. Pre-processing is based on the concept of so-called stubs or tracklets, which are pre-constructed and combined already at the front-end level.
A full overview of the project will be given, covering its different aspects and activities. Results obtained during this first year, from sensor developments to front-end and back-end electronics, will be illustrated. Emphasis will be also given to real-time processing strategies and developments for real-time tracking, which concern both detailed simulation studies and first hardware demontrators.

Primary author: LAI, Adriano (Universita e INFN, Cagliari (IT))

Presenter: LAI, Adriano (Universita e INFN, Cagliari (IT))

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