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Timing and Position Measurements with Ultra-Fast Silicon Detectors

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We report on the design and performance of UFSD (Ultra-Fast Silicon Detectors) and their challenge for electronics systems. UFSD are segmented thin Low-gain Avalanche Detectors (LGAD) with measured time resolution of 30ps.
The combined accurate measurement of time and position for charged particle in UFSD offers unique physics capabilities such that they are being considered for use in the HL-LHC by ATLAS and CMS because of their ability to suppress backgrounds from high-luminosity pile-up.
We describe the status of the R&D involving three manufacturers (CNM, FBK, HPK) and radiation campaigns up to a neutron fluences of 6e15 n/cmˆ2 permits and assess the special challenges their use in HL-LHC would entail.

Summary

1. Description of Low-gain Avalanche Detector (LGAD) technology We are describing the basics of the LGAD, which are ordinary silicon sensors with an added p-layer to generate internal charge multiplication.
2. Simulation program Weightfield 2 (WF2) The design, operation and future development is aided by WF2, (presented in another TWEPP contribution). WF2 permits prediction of sensor performance as a function of geometry (area, thickness) and radiation levels and different readout options.
3. Production of UFSD The production program of three manufacturers is described and their product compared. The results of an irradiation campaign with fluences up to 6e15 n/cm2 have permitted to quantify the radiation damage and start a mitigation program.
4. Gain and Timing resolution We show that the doping profile of the p-layer determines the gain, and identify the gain as the parameter ruling the timing resolution. The gain and timing resolution have been measured in many beam and β-source tests for a variety of LGAD doping levels, geometries and radiation levels.
5. Challenges for the readout electronics Challenges for the readout electronics and options for the application at the HL-LHC are discussed briefly (they are presented in another TWEPP contribution).

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