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First Steps Towards Four-Dimensional Tracking: Timing Layers at the HL-LHC

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The projected proton beam intensity of the High Luminosity Large Hadron Collider (HL-LHC), slated to begin operation in 2026, will result in between 140 and 200 concurrent proton-proton interactions per 25 ns bunch crossing. The scientific program of the HL-LHC, which includes precision Higgs coupling measurements, measurements of vector boson scattering, and searches for new heavy or exotic particles, will benefit greatly from the enormous HL-LHC dataset. However, particle reconstruction and correct assignment to primary interaction vertices presents a formidable challenge to the LHC detectors that must be overcome in order to reap that benefit. Time tagging of minimum ionizing particles (MIPs) produced in LHC collisions with a resolution of 30 ps provides further discrimination of interaction vertices in the same 25 ns bunch crossing beyond spatial tracking algorithms. The Compact Muon Solenoid (CMS) and ATLAS Collaborations are pursuing in total two technologies to provide MIP time tagging for the HL-LHC detector upgrade: LYSO:Ce crystals read out by silicon photomultipliers (SiPMs) for low radiation areas (CMS only) and silicon low gain avalanche detectors (LGADs, CMS and ATLAS) for high radiation areas. This talk will motivate the need for a dedicated timing layer in the CMS and ATLAS upgrades, describe the two technologies and their performance, and present simulations showing the improvements in reconstructed observables afforded by four dimensional tracking.

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