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High Precision Timing and High Rate Detectors in Energy Frontiers

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High precision timing is becoming an important issue in particle physics especially in Energy Frontiers. Signals with FW10%-10% Max < 25ns and segmentation to handle >200 pileup(PU) are advantageous in many future Colliders and upgrades The high track density and pile-up in high luminosity particle colliders are challenges for event reconstruction and analysis. MIP (minimum ionizing particle) pileup is a few percent in ˜1x1 cm2, 1200 cm radially along h=0.The case for adding a timing 4th dimension to calorimetry and tracking is becoming compelling. Timing detectors must withstand 50 MRad and neutrons >3x1015n/cm2. Timing has been shown by CMS and ATLAS to improve ETmiss resolution, and tag secondary vertices to ±few mm. Precise timing of calorimeter deposits and vertexes enable rejection of spurious data inconsistent with the primary vertex time. We discuss detectors for MIPs capable of timing precision to ±10's ps, and rate capabilities exceeding 100's of MHz.Issues for defining a Figure of Merit for timing scales as tdecay/√Nelectrons. The rate capability scales inversely as tdecay. For optical transducers (SiPM, PMT, MCP-PMT), the timing precision is dominated by Trise and inversely by S/N. Noise in the experiments from low energy photons/x-rays scales inversely with Xo. SiPM and MCP-based detectors have risetimes shrinking to ˜100-20ps. Optical signals include scintillators with decay constants less than 2ns,Cherenkov radiators, and secondary emission detectors. Scintillators with high FOM include ZnO:Ga(GZO) (0.7ns decay), CdS:In (0.2ns decay) and organic solid and liquid (with rad resistance) scintillators with decays less than 1ns. We discuss scintillators, Cherenkov radiators(aerogels, quartz, Teflon AF, water, oils) and direct secondary emission MIP detectors as precision timing and high rate detectors.

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