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Sub-nanosecond charged particle detector with fast scintillator and hybrid photodetector

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We present here the concept and results of a charged particle detector based on a novel inorganic scintillator coupled to a hybrid photodetector (HPD). The newly developed inorganic scintillator has a decay time ≤ 0.5 ns, high photon yield and long-lifetime. Together with the HPD, the detector exhibits a single electron pulse width of ≤ 0.7 ns, while allowing for quantitative detection over a dynamic range of several orders of magnitude. Custom-designed electronics produce an output pulse without distortion or ringing. Overall gain of ˜10ˆ6 makes single particle detection possible without the need for an additional amplifier. Unlike traditional MCP-based detectors or electron multipliers, the optical decoupling between particle detection and gain enables the use of low-voltage electronics. Additionally, an ion-to-electron convertor can be coupled to the detector, thus enabling the detection of both positive and negative particles. A more compact version of this detector with Si-PM or PMT is also available, having the same advantages described above, with pulse width of a few ns. The use of long-lifetime scintillator and photo-sensor dramatically improves detector stability and lifetime, up to a total detector output charge of several tens of coulombs. Several implementations of this detector as a time-of-flight (TOF) detector for mass spectrometry have already demonstrated its outstanding combination of properties: time resolution, dynamic range, stability and lifetime. This concept can be applied in future exciting new applications in other fields, such as e-beam tools in semiconductor industry, medical instruments and particle physics.

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