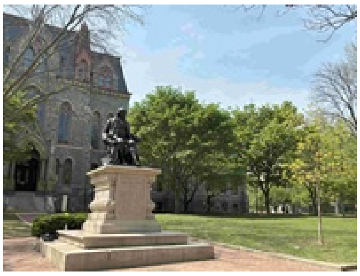

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InAs/GaAs Semiconductor Quantum Dot Scintillation Detector: Real and Projected Performance for 4D Tracking

Thursday 9 October 2025 11:20 (20 minutes)

The high speed and efficiency of the novel semiconductor InAs/GaAs quantum dot (QD) scintillator make it a promising alternative competitor to direct-ionization drift detectors for 3D tracking and other high-energy physics and medical applications. In this detector, self-assembled epitaxial QDs serve as artificial luminescent centers, converting the kinetic energy of incoming charged particles into photons, which are then collected by a monolithically integrated p-i-n photodiode. Starting with evaluating the expected performance of the scintillation tracking detector and comparing it to a prospective Si LGAD tracker, we identify key physical factors, such as device thickness, QD radiative efficiency and waveguiding losses, that govern the detector's time resolution.

Recent measurements on a 26-micron-thick scintillator demonstrated a yield of 34000 electrons/MeV (or 14% of the achievable maximum), an energy resolution of 4.4%, and decay time 270 ps, resulting in a time resolution of 20 ps for 4.5 MeV deposited energy. Timing performance can be improved in thicker detectors (unlike drift-based counterparts) and at higher efficiency. A recently observed hybrid response, where the ionization track is shared between the scintillator and a few-micron-thick photodiode, achieved over 60000 electrons/MeV yield and enabled detection of 60 keV photons. Consequently, the expected tracking performance under hybrid response was evaluated. Radiation hardness was assessed using a 1.5 MeV proton beam at 10^{14} protons/cm^2, corresponding to equivalent 1 Mev neutron fluence of 2×10^{15} cm^{-2}.

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