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InAs/GaAs Quantum Dot Scintillator for 4D Tracking Applications

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An InAs/GaAs quantum dot (QD) detector is a novel GaAs semiconductor-based scintillation detector utilizing artificial luminescent centers - epitaxial InAs QDs, combined with a monolithically integrated photodiode (PD) to collect the QD emission. To assess its feasibility for future tracking applications, we compare the parameters of this detector against a perspective Si Low Gain Avalanche Detector (LGAD) projected to have ~10 ps and 10 μm "4D resolution". Parameters of 25 μm thick QD scintillators with a 3 μm thick integrated PD are extracted from experimental studies supported by GEANT4 simulations. These parameters are compared to an LGAD sensor simulated using Weightfield2. For a QD luminescence decay time of 300 ps, the break-even point for 10 ps time resolution between this detector and LGAD falls within a thickness range of 20 to 50 μm, where the Ramo current in silicon becomes comparable to the peak optical flux produced by the QDs. Fast and efficient optical collection of deposited energy is the enabling factor for the fast risetime of the scintillator. The QD detector parameters were obtained from the response to 60 keV and 122 keV gamma photons. The collected charge exceeds 90 photoelectrons per keV of the deposited energy, which contained a small contribution from direct ionization in the PD. The material's radiation resistance has been tested with 1 MeV H^+ fluxes of up to 10^{14} cm^{-2}. This enhanced radiation resistance is shown to result from the improved electron confinement in the QDs when higher barriers of wider bandgap semiconductor, AlGaAs instead of GaAs is used.

Early Career

No

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