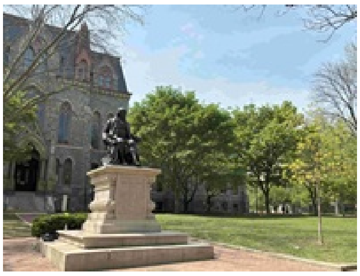

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Radiation-Hard Ga_2O_3 Solid-State Detectors for Extreme Environments in High-Energy Physics

Thursday 9 October 2025 11:40 (20 minutes)

The escalating radiation environment at next-generation colliders demands revolutionary advances in detector materials —and Ga_2O_3 emerges as a game-changing candidate poised to redefine innermost solid-state tracking through unparalleled radiation tolerance and thermal resilience. Future high-energy physics experiments will expose tracking layers to particle fluences exceeding 10^{15}–10^{16} n_eq/cm², multi-Mrad total ionizing doses, and stringent material budget constraints. Even the most advanced silicon detectors are nearing their fundamental performance limits under these extreme conditions, driving urgent exploration of alternative ultra-wide-bandgap semiconductors.

Ga_2O_3 combines an exceptional ultra-wide bandgap (˜4.9 eV), an extraordinarily high breakdown field (˜8 MV/cm), and intrinsic radiation hardness —enabling ultra-low leakage currents at elevated temperatures and the fabrication of ultra-thin, low-mass detector layers. These characteristics position Ga_2O_3 as an ideal platform for radiation-hard, long-lifetime solid-state tracking sensors capable of reliable operation with significantly reduced cooling demands in the harshest collider environments.

We report new experimental results from multiple Ga_2O_3 detector prototypes, featuring detailed electrical characterization, microstructural analysis, and rigorous ion irradiation testing. Our preliminary data reveal stable high-bias performance and robust structural integrity even after substantial radiation exposure, underscoring Ga_2O_3's potential as a radiation-immune detector material readily integrable with advanced low-noise readout electronics.

This work pioneers a new frontier for HEP tracking detectors, establishing Ga_2O_3 as a strong complement —and potential successor —to established wide-bandgap materials such as diamond and SiC. Our findings highlight the critical and timely need for coordinated R&D efforts to unlock Ga_2O_3's full potential and accelerate its path toward deployment in future collider tracking systems and other extreme-environment instrumentation.

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