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Research on neutron radiation-induced damage of diamond detector

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The High Luminosity Large Hadron Collider (HL-LHC) upgrade will increase instantaneous luminosity to more than five times its previous level, enhancing the precision of Higgs boson studies and expanding the potential for new physics discoveries. Synthetic single-crystal diamond (SCD), known for its superior radiation hardness, is a promising candidate for the proposed Mini-FCal in ATLAS detector.
In this study, SCDs were fabricated into detector modules and exposed to high-dose fast neutron irradiation up to 3.3×10^{17} n/cm^2, equivalent to the total radiation dose expected over ten years of operation in the forward region of ATLAS detector. Following the validation of the radiation resistance of SCDs, transmission electron microscopy (TEM) and electron energy loss spectroscopy (EELS) were employed to investigate crystal defects induced by high-dose neutron irradiation in high-quality SCDs.
Various irradiation-induced defects were directly imaged at the atomic scale, and their distribution was analyzed. EELS analysis further revealed the sp^3-to-sp^2 phase transition of diamond structures caused by irradiation, along with the spatial distribution of these transitions. Additionally, Monte Carlo and molecular dynamics simulations were used to investigate the dynamic processes of neutron-induced damage in diamond crystals.
This study deepens our comprehension of radiation damage in SCD and provides further references for applications in diamond detectors.

Primary experiment

LHC-ATLAS

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