

Detailed Geometric Simulation of the Zero-Degree Calorimeter for the Spin Physics Detector Using Geant4

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Accurate geometric modeling of detector components is essential for optimizing performance and ensuring the reliability of experimental setups in high-energy physics. This report details the geometry simulation of the Zero-Degree Calorimeter (ZDC) which is an important component of the Spin Physics Detector (SPD) at the Nuclotron-based Ion Collider facility (NICA) currently under construction at the Joint Institute for Nuclear Research (JINR), Dubna. Using the latest version of the Geant4 toolkit, this work aims to replicate the particular design of the ZDC, which was engineered to be located at 13 m from the Interaction Point (IP) and placed in between the two beam pipes that are not parallel in that specific position. A precise ZDC geometry description was first created as a GDML solid in a FreeCAD workbench with the aim of being imported in Geant4. The main function of the ZDC consists of detecting neutral particles. Its finely segmented calorimeter design ensures to take part in polarimetry determination and luminosity measurements with high precision. This meticulous modeling of the ZDC's geometry takes into account its electromagnetic and hadronic modules, material composition, and the innovative "growing" design that enhances particle containment. The study also evaluates the detector's response to photons and neutrons with different energies. These results are benchmarked against the specifications outlined in the Technical Design Report (TDR) of the SPD collaboration.

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