PROCEEDINGS OF SCIENCE

Event Visualization with Unity in BESIII experiment

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In the realm of high-energy physics experiments, the ability of software to visualize data plays a pivotal role. It supports the design of detectors, aids in data processing, and enhances the potential to refine physics analysis. The integration of complex detector geometry and structures, using formats such as GDML or ROOT, into systems like Unity for 3D modeling is a key aspect of this process. This research employs Unity to render BESIII spectrometer and events in three-dimensional animated format. Such visual representations of events effectively demonstrate the particle collisions and trajectory interactions with the detector. The development of the visualization system for event displays through software not only improves physics analysis, but also encourages cross-disciplinary applications and contributes to educational initiatives.

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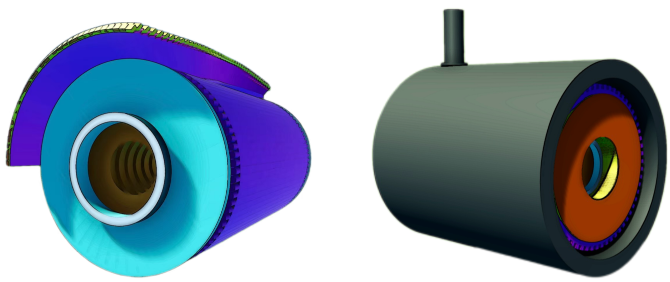
1. Introduction

In high-energy physics (HEP) experiments, visualization tools like event display systems are vital for interpreting particle interactions and optimizing detector designs [1, 2]. Advanced three-dimensional visualization, such as using Unity [3], allows detailed modeling of detector geometries [4, 5] with GDML or ROOT formats [6, 7], enhancing the analysis of experimental data by vividly illustrating particle collisions and tracks [8]. Unity has already been employed in some HEP experiments for visualizing detector geometry and events, such as Jiangmen Underground Neutrino Observatory experiment [9, 10]. This approach not only supports data analysis but also aids in software development, interdisciplinary applications, and educational outreach.

2. BESIII Event Visualization with Unity

The BESIII detector description is formatted in GDML and converted for visualization in Unity. This process allows the detailed geometric layout of the BESIII detector, including components of the Main Drift Chamber (MDC), Time-Of-Flight System (TOF), Electro-magnetic Calorimeter (EMC), and Muon Chamber system (MUC), to be accurately depicted, as shown in Figure 1.



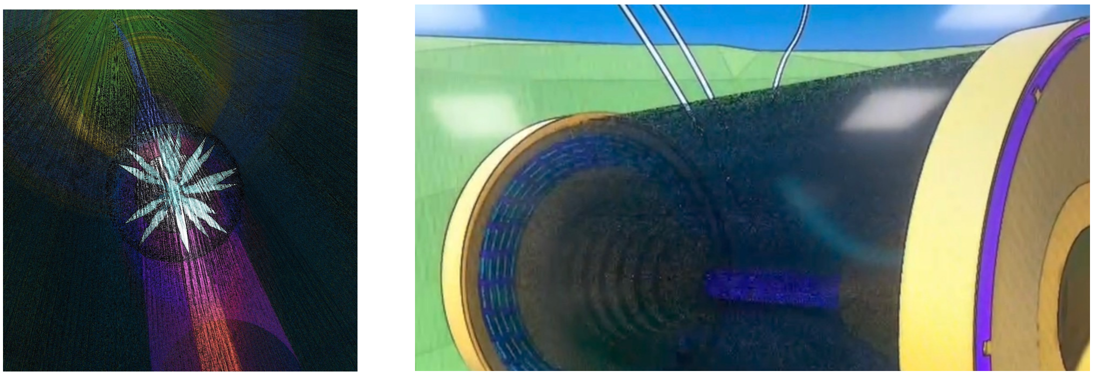
(a) **(b)**

Figure 1: The MDC and TOF (a) and the magnet (b) of BESIII detector visualized in Unity.

To visualize event information in Unity, a C++ package is employed to export data from the BESIII offline software. This data is stored in ROOT format using an event display algorithm and then converted into a text format, which includes details such as run and event numbers and sequential information. The text file is subsequently imported into Unity, where a C# module is used to render the particle tracks, enhancing the visualization capabilities for physics analysis in high-energy physics experiments.

An application was developed in Unity to visualize BESIII events, such as the collisions of positrons and electrons in the Beijing Electron Positron Collider (BEPCII). The visualization includes detailed animations that illustrate particle trajectories, hits, and their penetrations through each sub-detector. For example, Figure 2b shows a Monte Carlo event simulating the Λ_c decay in BESIII [11]. The application can display tracks alongside each part of the detector, allowing users to observe the exact positions of tracks within the detector. It also provides the capability to view the tracks individually, facilitating a thorough understanding of detector performance.

The application also features an event switching system that allows users to efficiently browse and examine data event by event. Users can input specific run and event numbers to access a 3D



(a) **(b)**

Figure 2: Visualization of BESIII events in Unity.

display of the corresponding event. The system also includes "previous" and "next" buttons for smooth navigation between events, ensuring seamless transitions during analysis. Additionally, boundaries are in place to prevent tracks from diverging, maintaining the integrity and accuracy of the visualizations within the BESIII detector. This system significantly enhances the application's functionality, making it a powerful tool for detailed and organized event analysis.

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