Visualizing BESIII Events with Unity

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Abstract

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 3D animated format. Such visual representations of events effectively demonstrate the particle collisions and tracks with the detector. The development of the visualization system for event displays not only improves physics analysis, but also encourages cross-disciplinary applications and contributes to educational initiatives.

1. INTRODUCTION

- **Unity Real-Time Development Platform:**
  - Used for creating immersive 2D, 3D, AR, and VR experiences, offering extensive tools and a community for developers and support more than 20 platforms
- **Application in high energy physics based on Unity engine:**
  - Many high-energy experiments have attempted to use Unity for the display of detectors and events, such as:
  - ELAINA: JUNO Event Display based on Unity
  - CAMELIA: Cross-platform ATLAS Multimedia Education Lab for Interactive Analysis
- **BESIII and BEPCII:**
  - The BESIII detector records symmetric e^+e^- **collisions** provided by the BEPCII storage ring in the center-of-mass energy range from 2.0 to 4.95 GeV, with a peak luminosity of 1×10^{33} cm^{-2}s^{-1} achieved at $\sqrt{s}=$ 3.77 GeV.
  - BESIII consists of 4 sub-detectors: MDC (Main Draft Chamber), TOF (Time-Of-Flight System), EMC (Electromagnetic Calorimeter), MUC (Muon Chamber System)

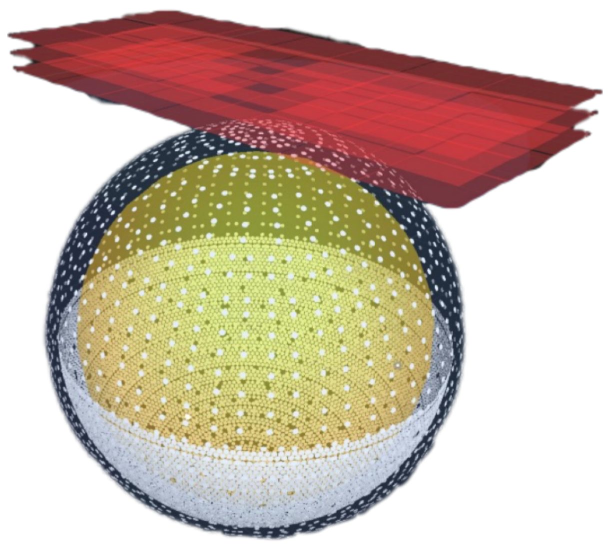

Fig.1 Visualization of the JUNO detector

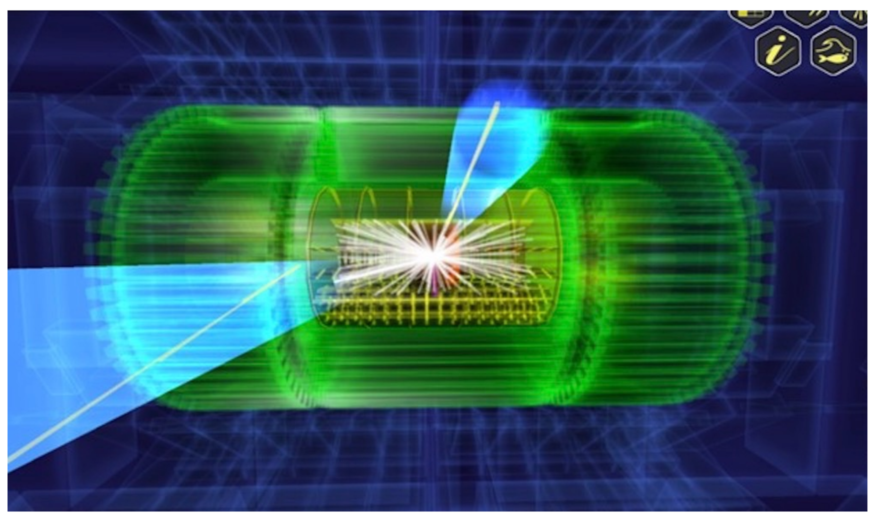

Fig.2 Event display of ATLAS experiment

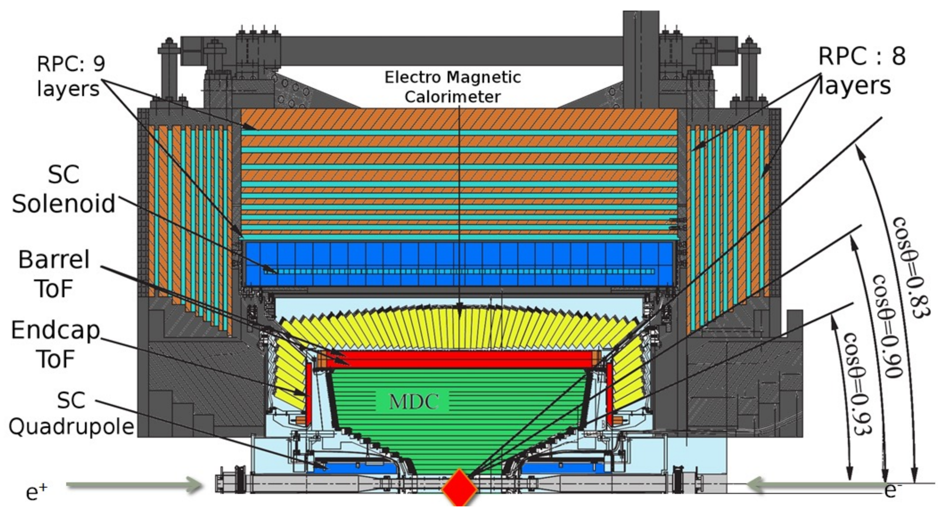

Fig.3 BESIII detector

2. EVENT INFORMATION TRANSFORMATION

ROOT → TXT → UNITY

- 1. Write an EventDisplay algorithm package in C++ to store the tracks and hits information for each sub-detector.
- 2. With the EventDisplay algorithm package, store the tracks and hits information in ROOT format.
- 3. Convert the tracks and hits information from ROOT to TXT format. The TXT should record the run and event numbers and detail the information for each track in every event sequentially.
- 4. Import the TXT file into Unity and use C# to visualize the particle tracks.

3. BESIII DETECTOR VISUALIZATION

- GDML, a detector description format, is converted through FreeCAD for visualizing the BESIII detector in Unity.

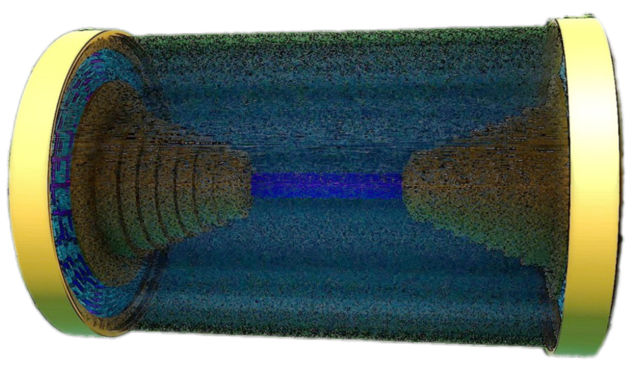

Fig.4 The MDC of BESIII detector with beam pipe inside in Unity

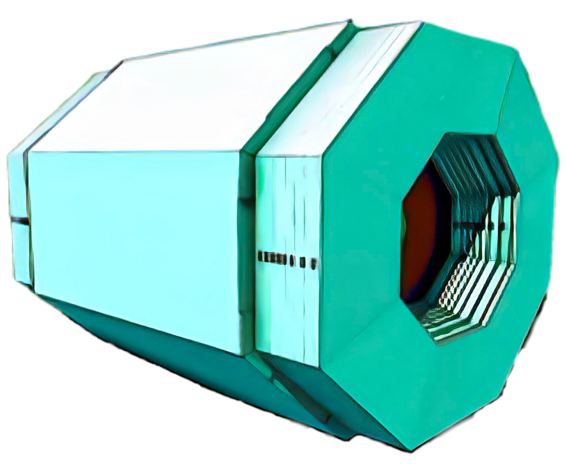

Fig.5 The MUC of BESIII detector in Unity

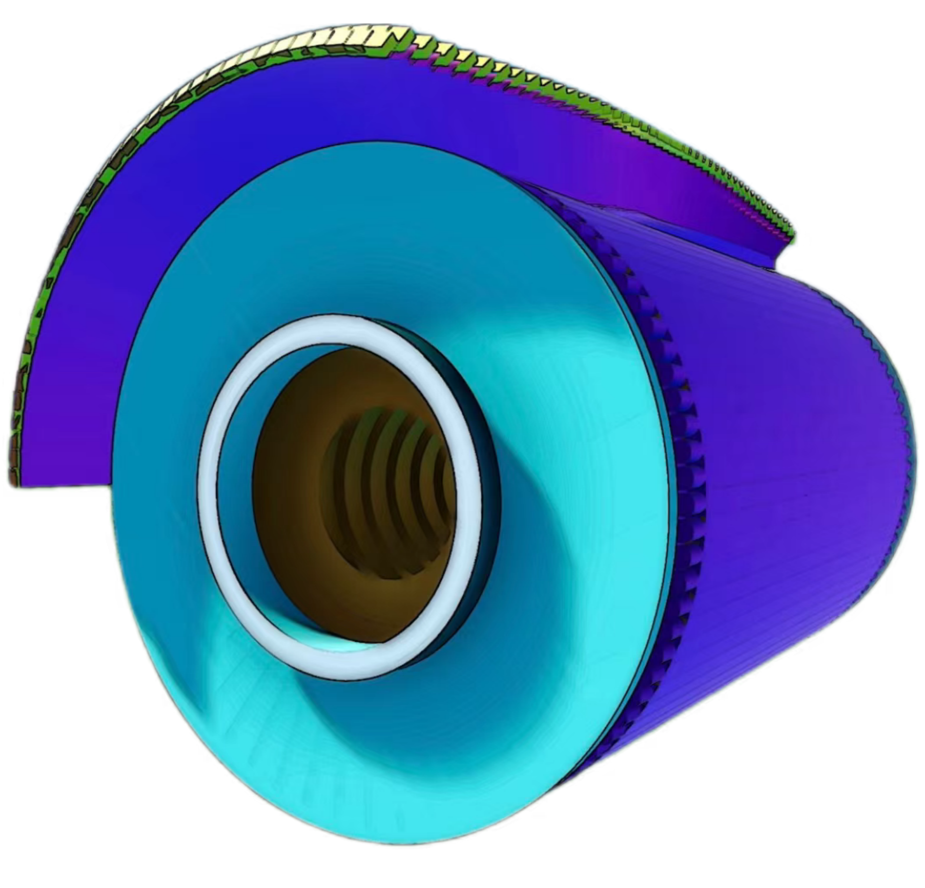

Fig.6 The TOF and MDC of BESIII detector in Unity

4. EVENTS VISUALIZATION

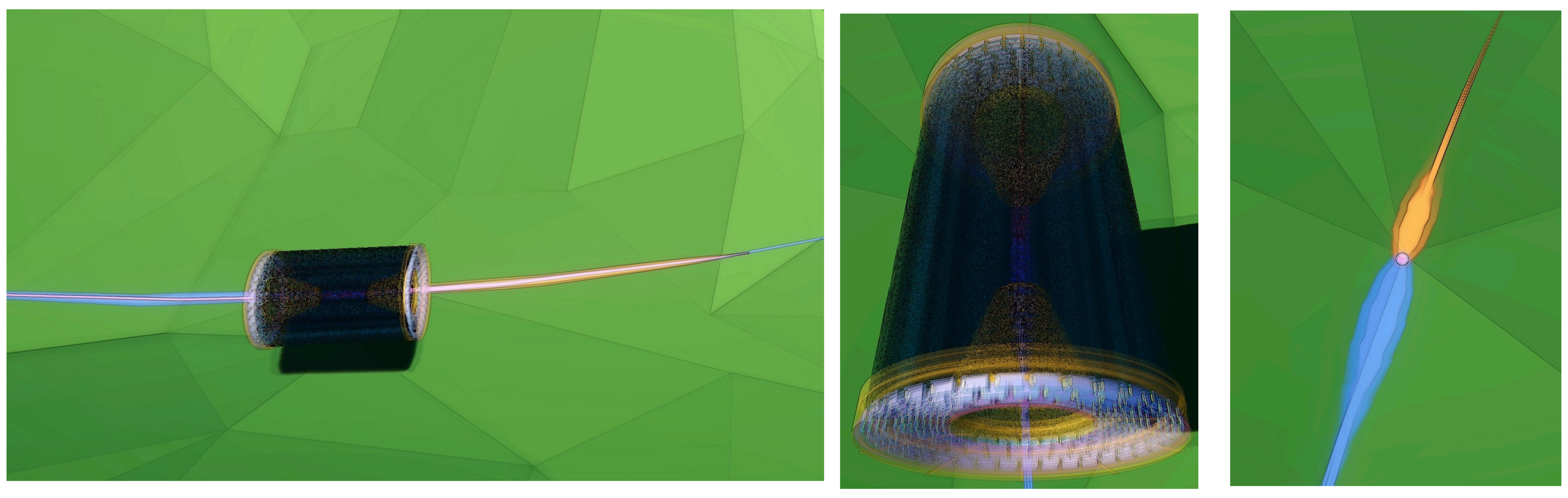

Fig.7 Visualization of e^+e^- collisions with/without MDC

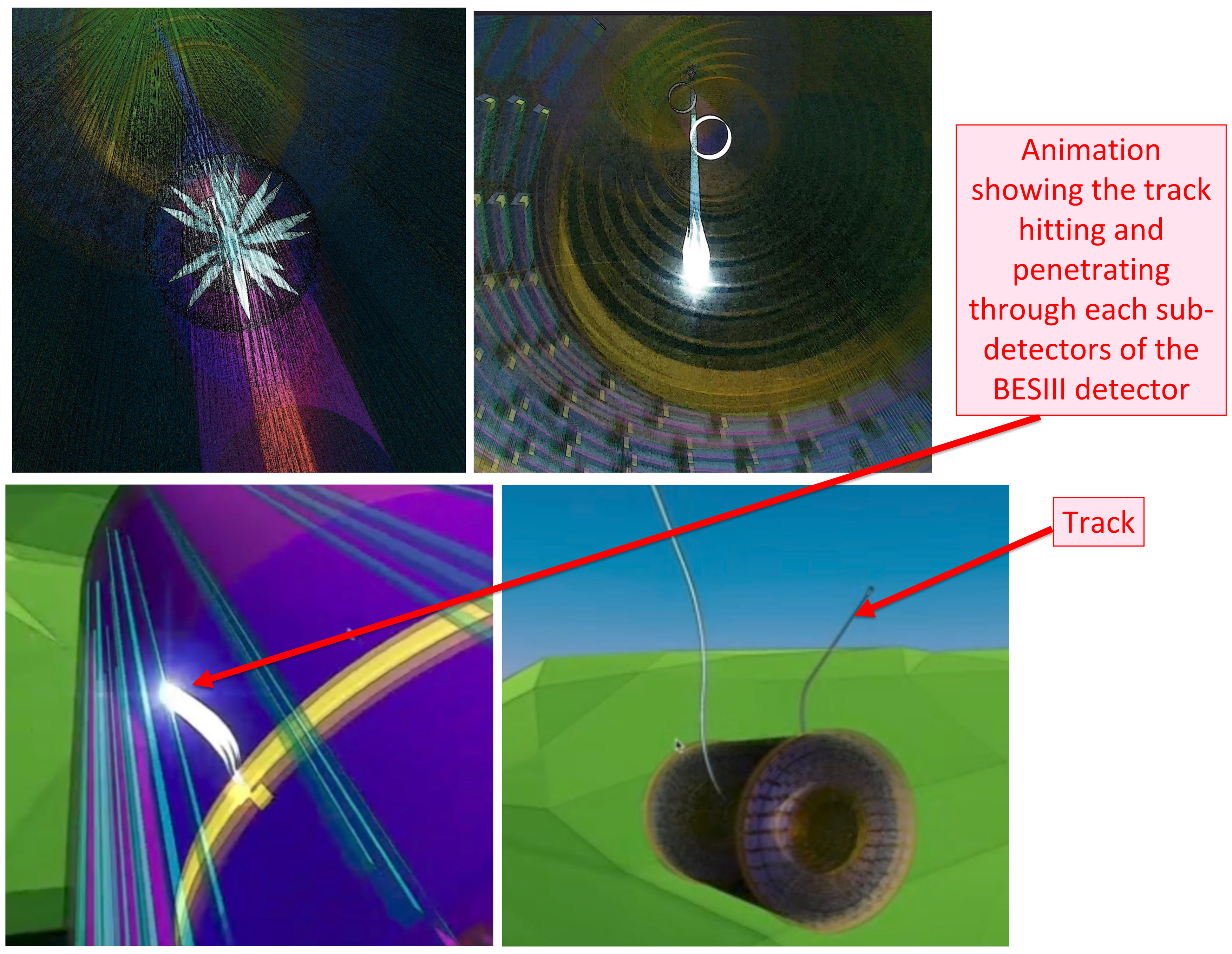

Fig.8 Visualization of a simulated BESIII event in search for $J/\psi \to e\mu$

- 1. The APP can display an annular collision of positrons and electrons.
- 2. Can simultaneously display the tracks event display and each part of the detector, as well as the position of the tracks within the detector. Additionally, it can also display the tracks event display separately.

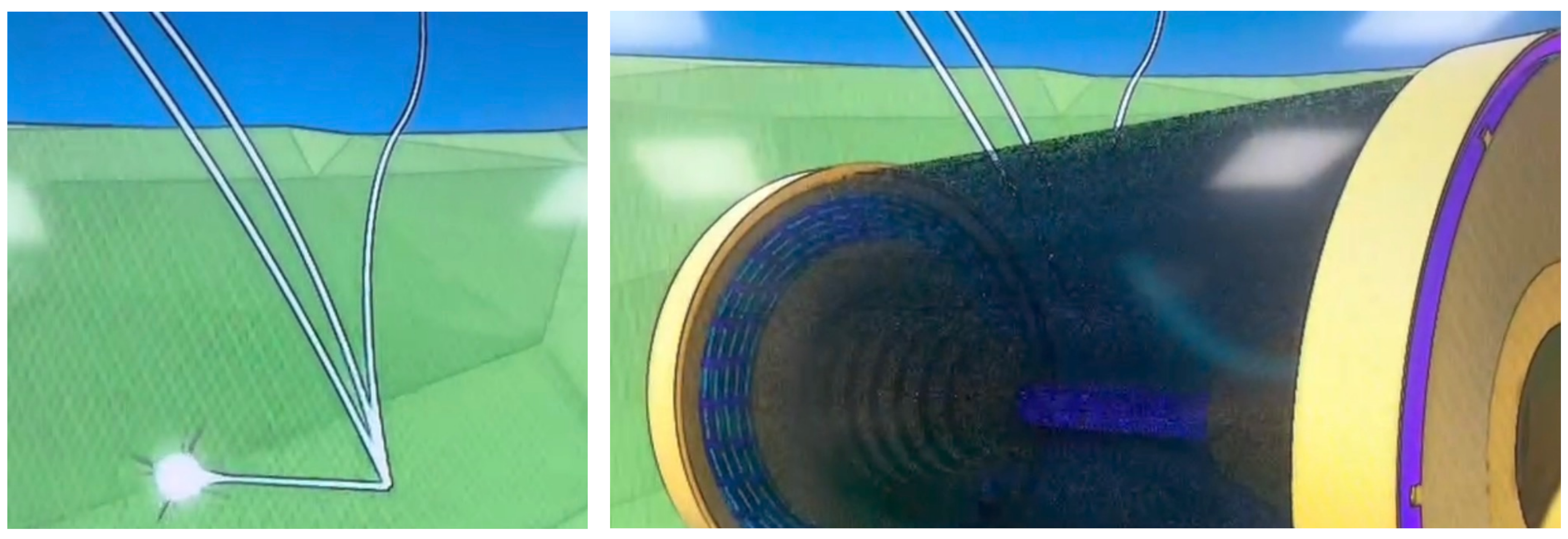

Fig.9 Visualization of 4 Λ_c tracks without/with the MDC.

5. EVENTS SWICTHING SYSTEM

- 1. After importing the event data to this APP, can directly input the run and event number to observe the corresponding event's 3D event display.
- 2. The "last" and "next" buttons allow for quickly viewing the previous or next event's display.
- 3. Boundaries have been set, tracks will not diverge indefinitely.

Reference

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