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General conversion interface for high energy physics detector description to FBX format and visualization development

高能物理探测器描述到FBX建模的通用转化接口与可视化开发

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Abstract: Detector description is an important part of off-line software for high energy physics experiments. Professional visualization platforms such as Unity can help realize the visualization of complex detectors, and bring convenience to the detector design, simulation reconstruction, case display and other work in the experiment. The focus of this work is to develop a general automatic interface, which can efficiently convert the detectors currently described in GDML, DD4hep, ROOT, Geant4 and other formats in high energy physics experiments into FBX format, which is popular in the industry, and import them into Unity to realize automatic detector modeling.

Introduction

The visualization of detectors is an integral aspect throughout the entire process of HEP experiments, including detector design, assembly and commissioning, experiment operation and maintenance, data quality monitoring, simulation and reconstruction, as well as physics analysis. Moreover, detector visualization implies the possibility of achieving event display, which may hold significant implications for physics analysis.

Fig. 1 Advantages of visualization technology from industry

Currently, there are several software and platforms for detector visualization in HEP experiment field. But in comparison, visualization technology from industry has more advantages. **Unity** is a professional video and game production engine, which can help to visualize HEP detectors.

- Professional 3D software.
- Provide access to VR or AR.
- Supports more than 20 platforms.

Although several HEP experiments have made targeted visualization software, such as ELAINA for JUNO and CAMELIA for ATLAS, based on Unity, we hope to complete the HEP experiment detector universal visualization interface.

Fig. 2 Platforms Unity supports

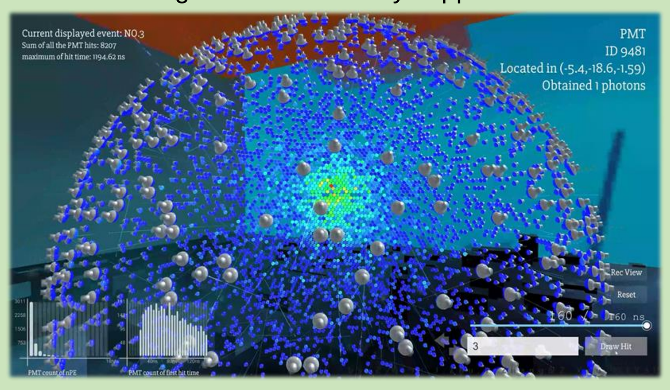


Fig. 3 JUNO event display - ELAINA

Detector Description

HEP experiment detectors are usually large-scale, complex and precise, and their internal detection units often need to be optimized and upgraded. As a result, if we want to implement the detector visualization based on Unity, it is almost impossible to reconstruct a complete and accurate model for each HEP detector in Unity.

Detector description in HEP now:

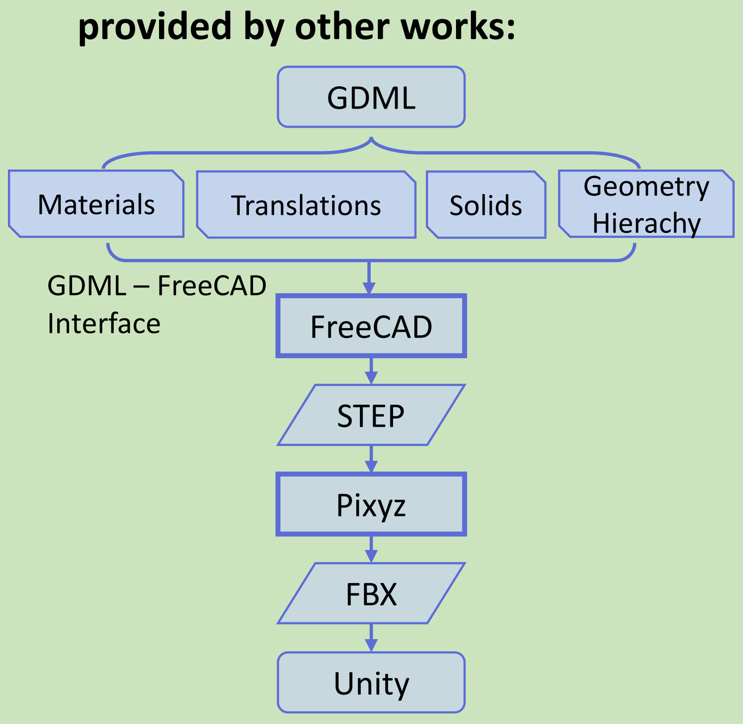
- **GDML**
- **ROOT**
- **DD4hep**
- **Geant4**

⇒ None of them can be directly imported into Unity ⇒ **Develop a method for automatic detector transformation!**

The method should work for all detectors and all formats, while keeping consistency.

Methodologies

- **A feasible transformation method provided by other works:**

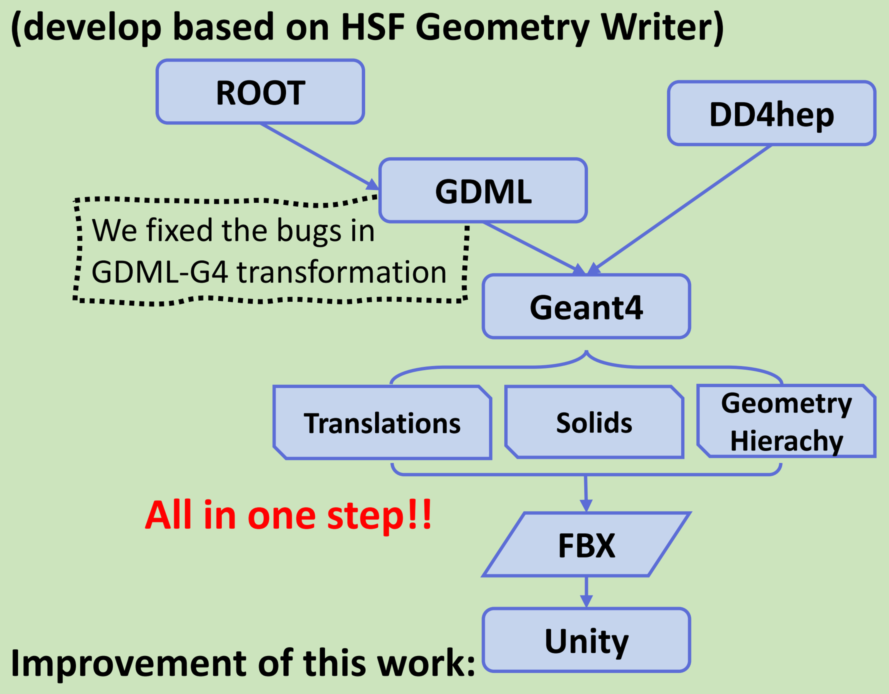


Result of previous work:

- Maintain the unique identifier of each detector unit.
- Provides rich visualization properties.

BUT: Complicated & time consuming.

- **A new method provided by this work: (develop based on HSF Geometry Writer)**



Improvement of this work:

- Fine tuning of configuration to solve crash caused by complicated geometry.
- Self-defined shapes and geometry classes.
- The steps are easier and faster.
- Is able to assist all four detector descriptions.
- Running in Geant4, it's totally free

Visualization in Unity

The interface provided in this work is capable of converting all four detector descriptions (including ROOT, GDML, Geant4 and DD4hep) into FBX-formatted files, and we will show them in Unity in this part.

1. **ROOT to Unity with EicC detector**

The Electron-Ion Collider in China (EicC) is a proposed high-energy facility, aims for precision studies of nucleon structure, partonic interactions in nuclei, and exploration of exotic heavy quark states, supported by an advanced detector system.

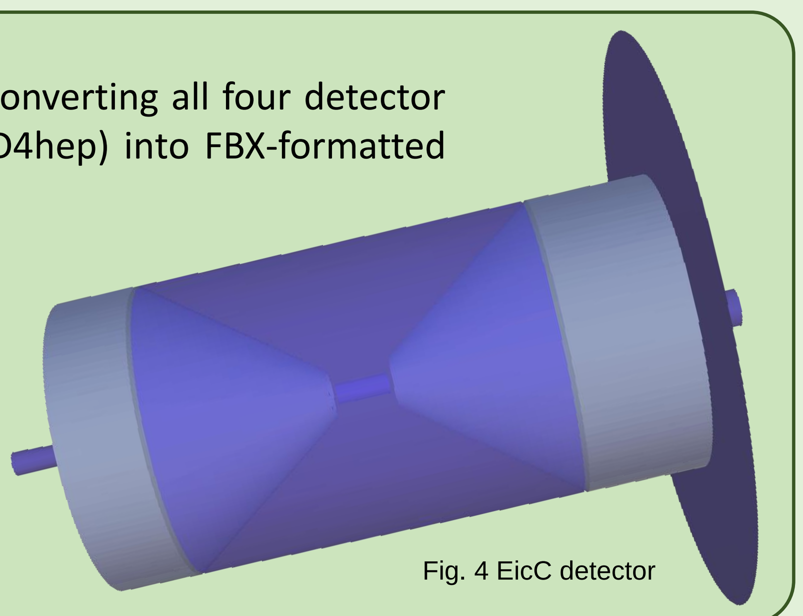


Fig. 4 EicC detector

Visualization in Unity

2. **GDML to Unity with BESIII detector**

The Beijing Spectrometer Experiment (BESIII detector) at the BEPCII accelerator is a major upgrade of BESIII at the BEPC for the studies of hadron physics and τ-charm physics with the highest accuracy achieved until now.

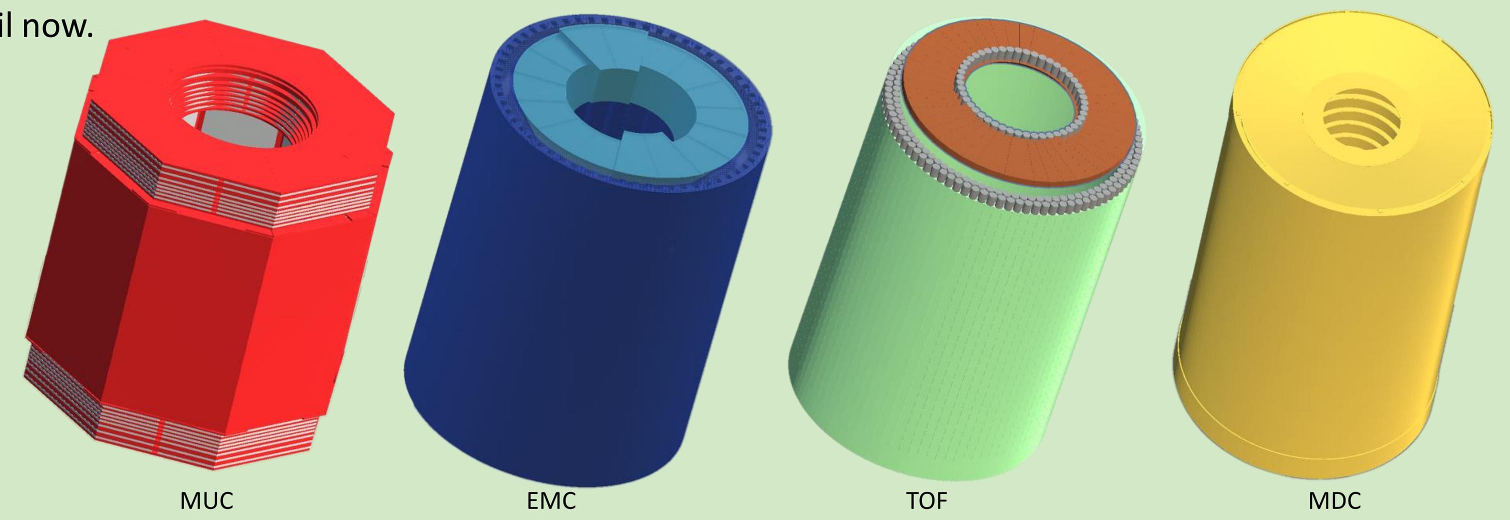


Fig. 5 BESIII Subdetectors

3. **Geant4 to Unity with JUNO detector**

The Jiangmen Underground Neutrino Observatory (JUNO) is an neutrino experiment station, aimed at determining the neutrino mass hierarchy, precisely measuring neutrino mixing parameters, and conducting various cutting-edge scientific research.

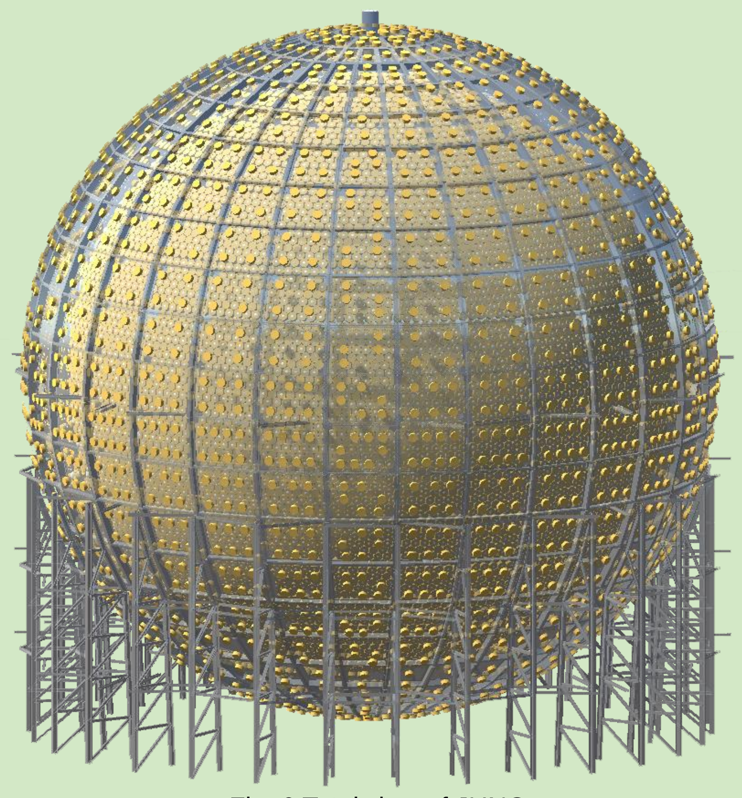


Fig. 6 Total view of JUNO

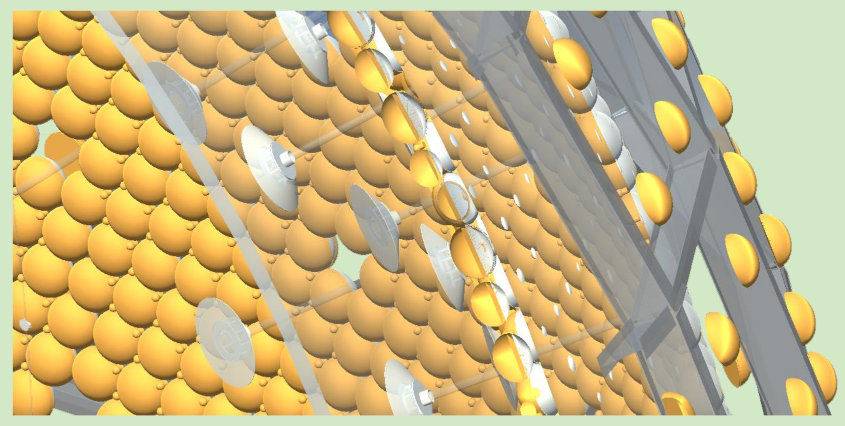


Fig. 7 Inner/outer PMT and holder

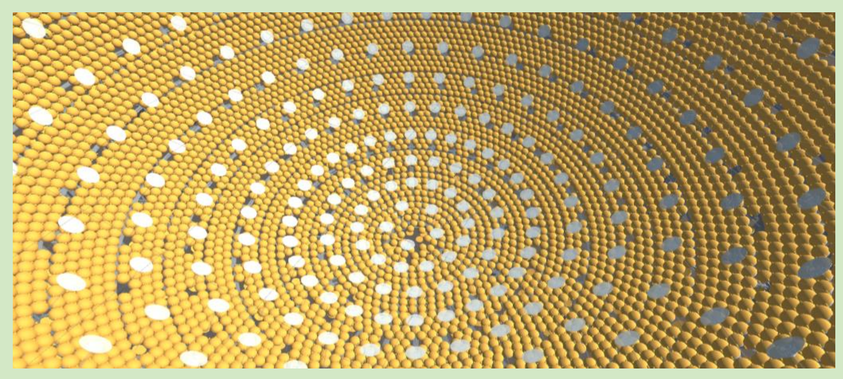


Fig. 8 Inner view of JUNO

4. **DD4hep to Unity with CEPC**

The CEPC (Circular Electron-Positron Collider) is a proposed high-energy particle accelerator for precision Higgs boson and physics beyond the Standard Model research.

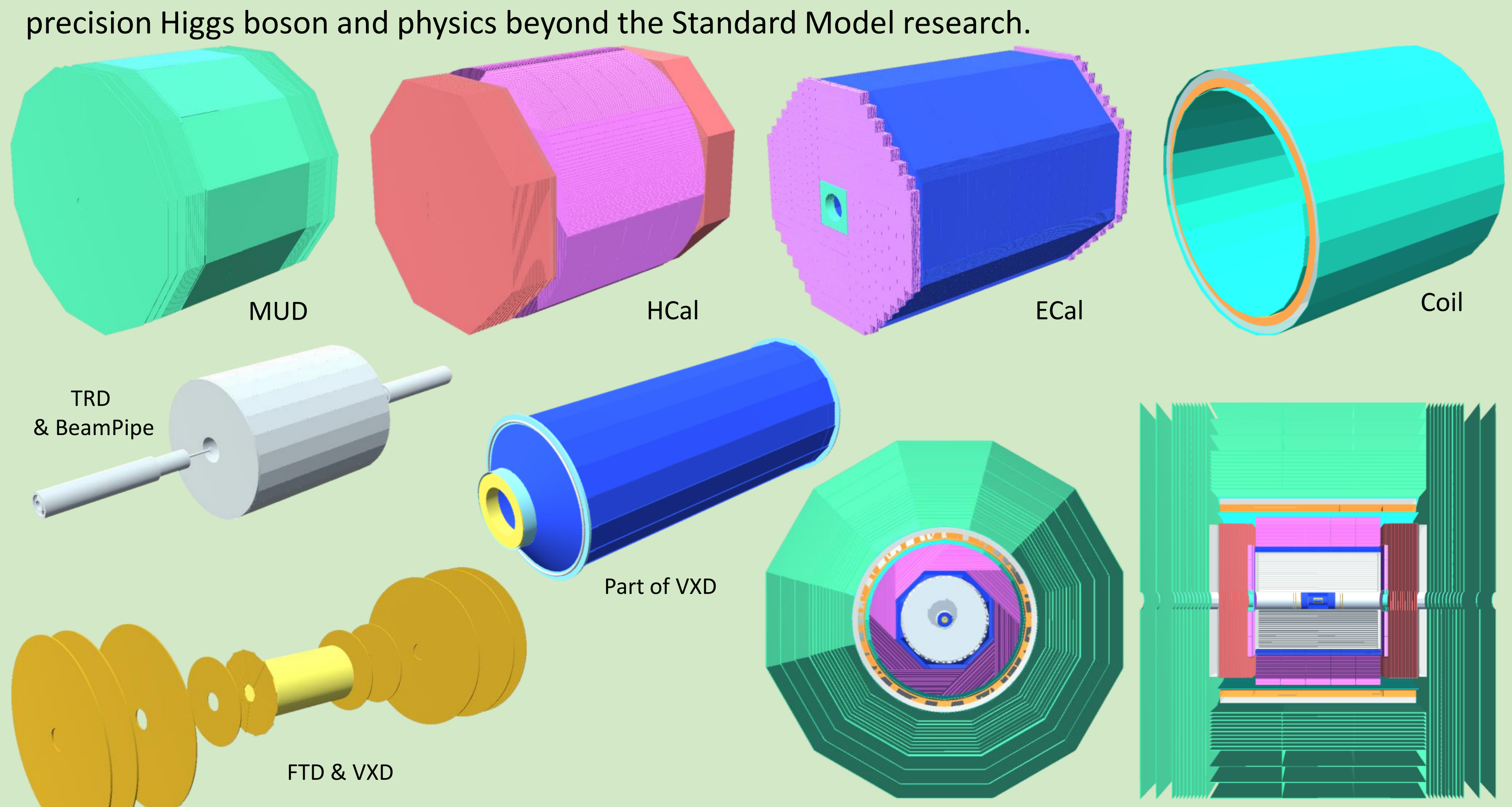


Fig. 9 CEPC Subdetectors and cross section

Further applications

With the FBX files converted from GDML, we can visualize detectors in Unity directly, which means we can develop more technology based on Unity. Which is promising for us in the future:

- **Event Display**

This figure is the event display shown in Besvis, which is based on ROOT. In the future, we can develop event display software for various detectors based on Unity more conveniently. In addition, we can develop real-time event display, 3D example display video production technology.

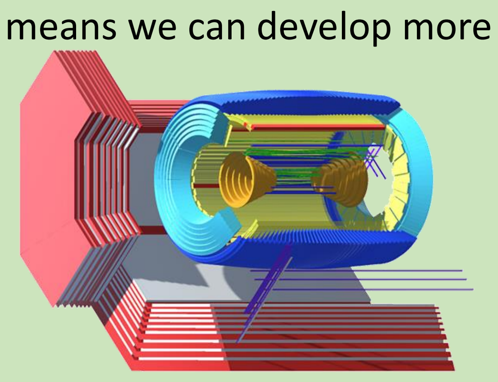


Fig. 10 Visualization result of BESVIS

- **Virtual Reality (VR) / Augmented Reality (AR)**

Unity provides a direct interface to AR or VR, where we can upgrade to more and richer interactive content. The figure on the left shows how the JUNO detector behaves in VR interactions, which can assist in the design, assembly and operational supervision of the detector.

Fig. 11 Interactive interface in Unity

Reference

[1] HEP Software Foundation Community White Paper Working Group---Visualization[J]. Bellis M, Bianchi R M, Binet S, et al., arXiv:1811.10309, 2018.
[2] Method for detector description transformation to Unity and application in BESIII[J]. Huang K X, Li Z J, Qian Z, et al., Nuclear Science and Techniques, 2022, 33(11): 142.
[3] Ric-bianchi, tpmccauley, et al., (2018) Visualization[source code].https://github.com/HSF/Visualization.

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