Application of the experimental dataset in visualization for the BESIII experiment

Minghua Liao (廖明华), Zhengyun You (尤郑昀)

liaomh7@mail2.sysu.edu.cn

Sun Yat-sen University

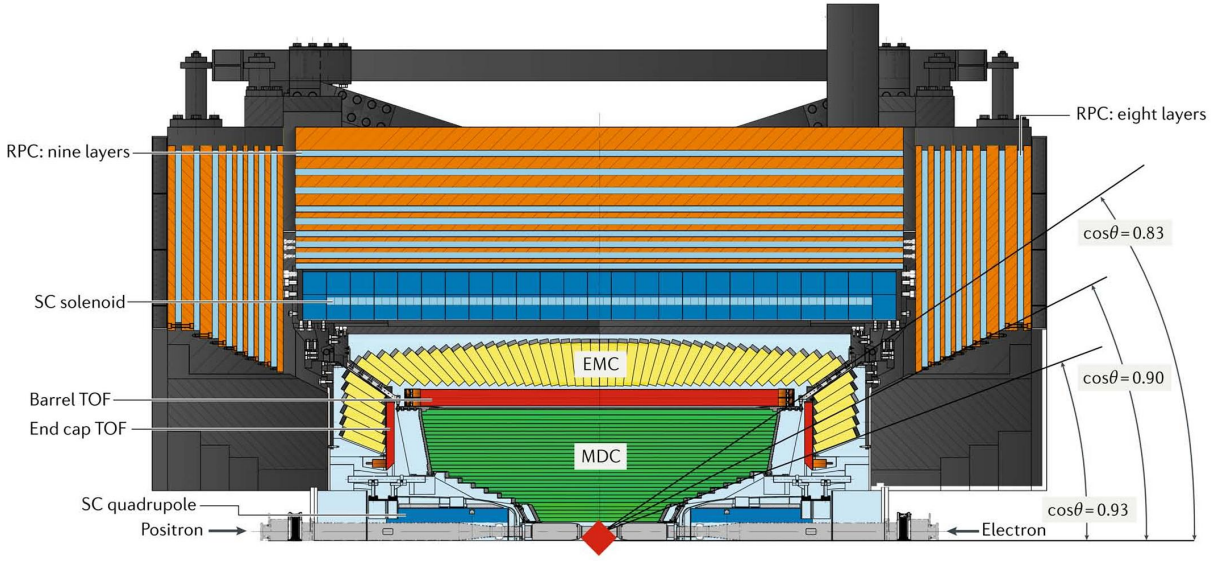
16 July 2026

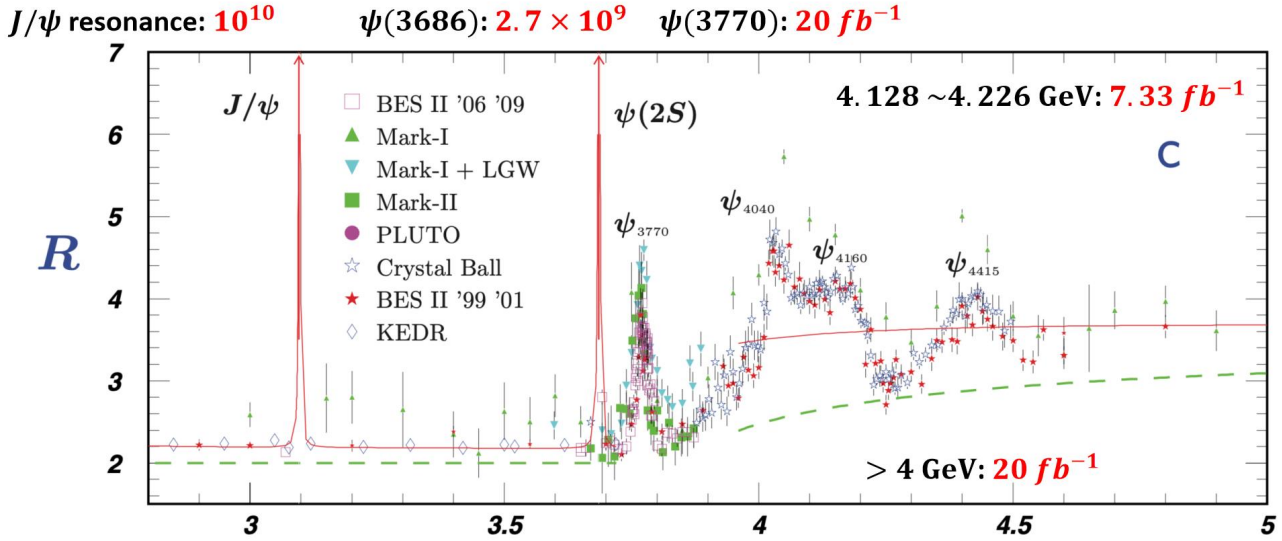
Outline

- BESIII experiment and ROOT-based visualization
- Experimental dataset from BESIII
- Application of dataset in Unity-based visualization
- Application of dataset in Phoenix-based Visualization
- Summary

BESIII experiment

- The BESIII experiment, a spectrometer operating at the Beijing Electron Positron Collider (BEPCII), can accurately record information on final state particles from e^+e^- collisions. BEPCII operates in the tau-charm energy region, with a beam energy range from 1.00 to 2.45 GeV and a peak luminosity of 1.1×10^{33} cm^{-2}s^{-1}.



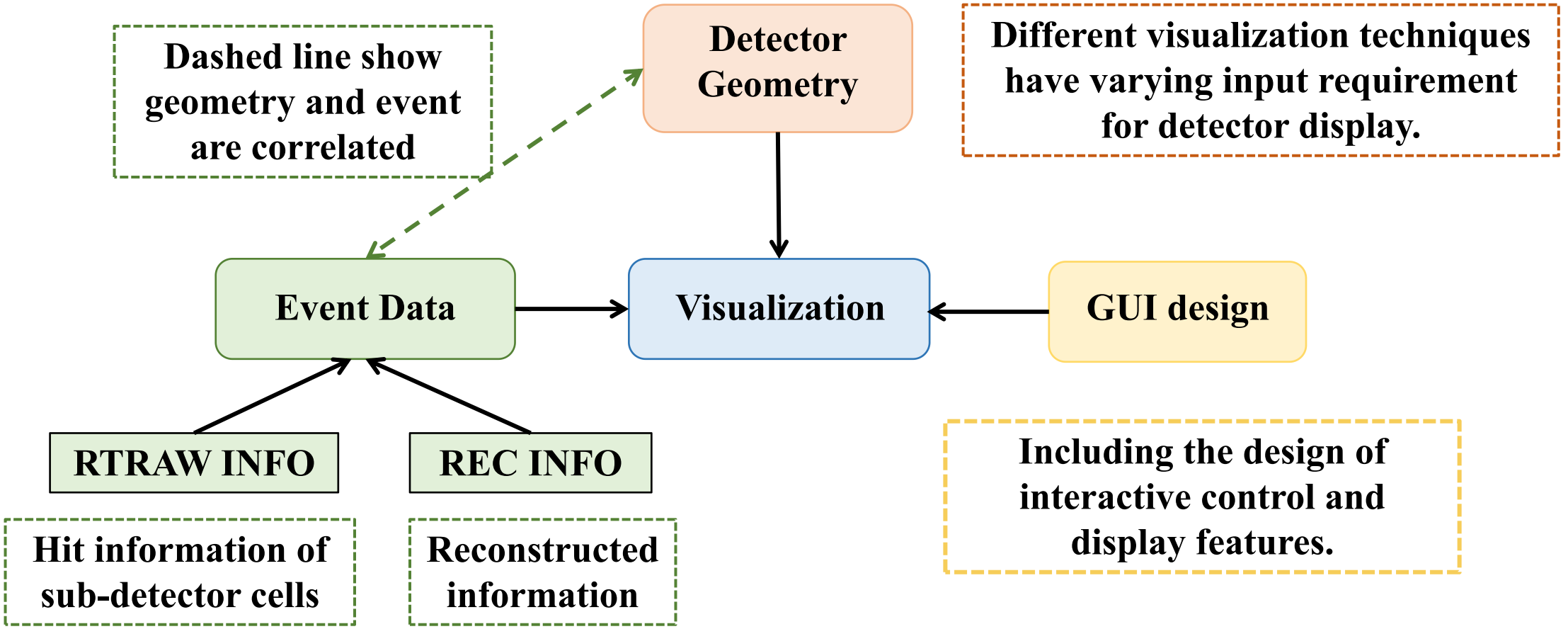


Currently, more data are being collected.

- BESIII has a broad physics program, including light hadron physics, charmonium physics, charm physics, R values, QCD and τ physics, as well as searches for exotic decays and new physics.

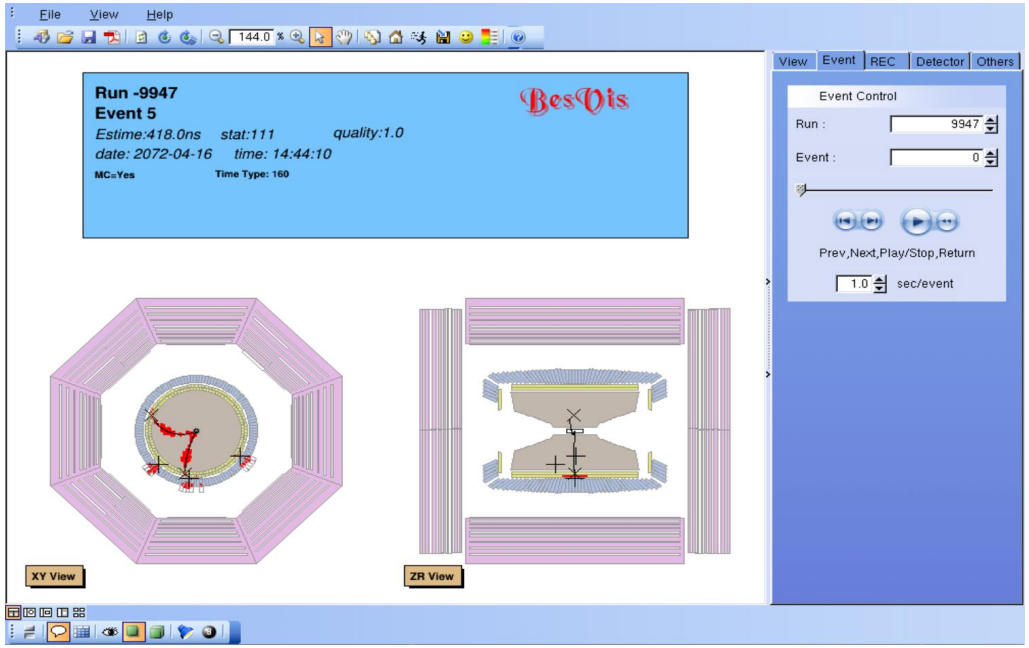
Event Display

- Event Display refers to the visualization of detector geometry and event information in 3D or 2D format, and the design of interactive features.



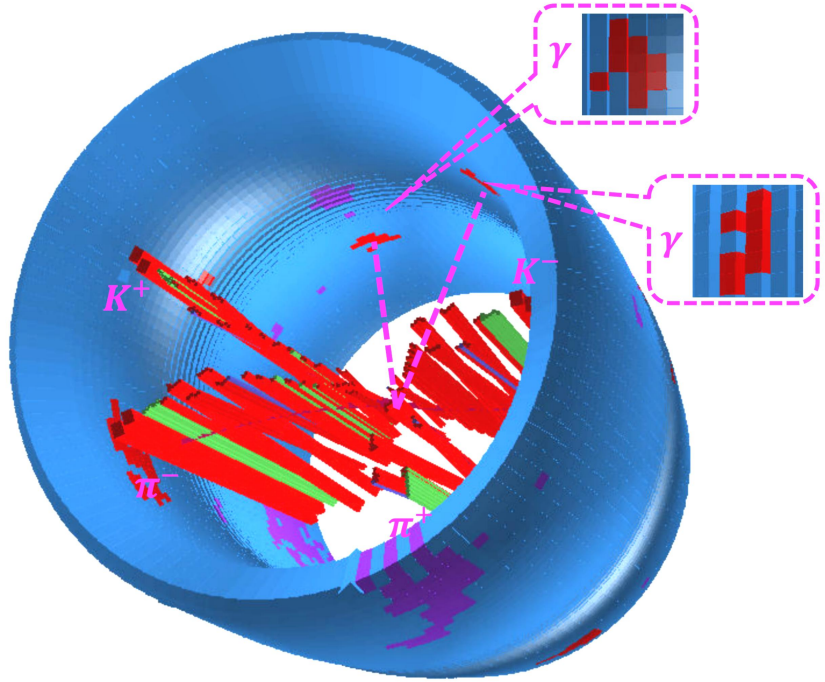
ROOT-based Event Display for BESIII

- ROOT-based event display has been applied in the BESIII experiment and integrated into the BOSS offline software system.
  - Display of event tracks and detector hits.
  - 3D and 2D visualization of the detector.
  - Detector view switching and event selection.



- Applications of ROOT-based Event Display:
  - Applied in the data acquisition system (DAQ).
  - Reconstruction algorithms tuning。
  - Applied in physics analysis, refer to:

Front.Phys.(Beijing) 19 (2024) 6, 64201



Workflow of open dataset

The open dataset is extracted from various types of data collected by BESIII. The workflow is as follows:

Particle Collision

↓ Data from e^+e^- collisions are recorded by the trigger system as RAW files.

RAW/RTRAW File

↓ The RAW data is reconstructed and saved as REC files.

REC File

↓ **Physical information** is extracted from the REC files and stored in ROOT files.

ROOT File

↓ Classic and interesting events are displayed with BesVis and saved as ROOT files.

Filtered ROOT File

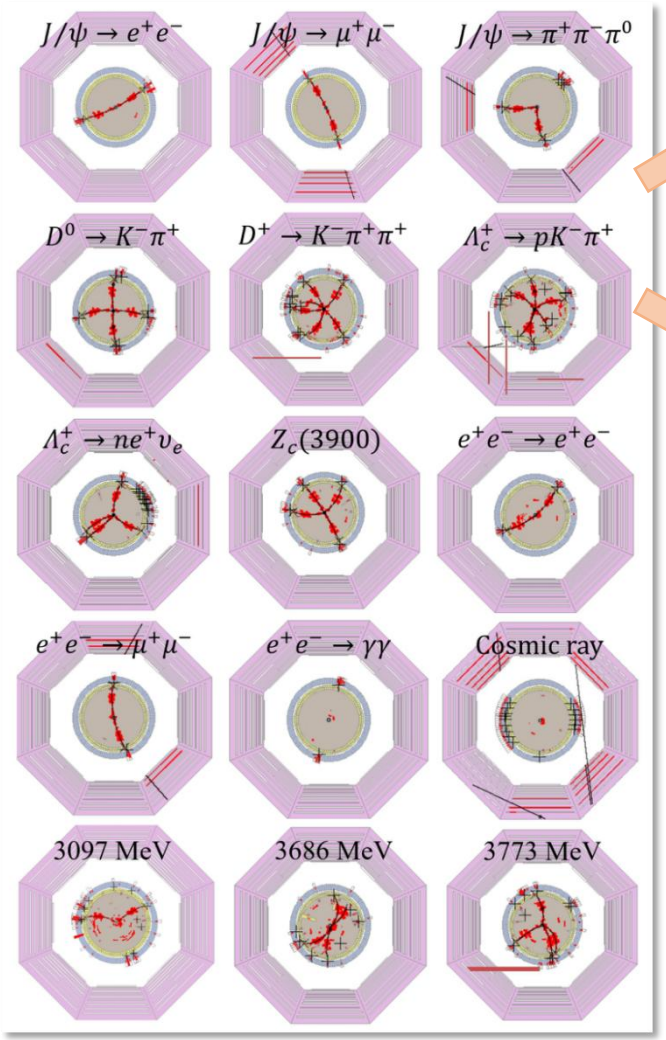
↓ Extract event information from ROOT files, including **Tracks and Hits** data, and save them **in txt files**.

TXT File

Nucl.Sci.Tech. 36 (2025) 11, 218

S.N	Physics processes	Events	Types
1	$J/\psi \to e^+e^-$	128	MC
2	$J/\psi \to \mu^+\mu^-$	126	MC
3	$J/\psi \to \pi^+\pi^-\pi^0$	155	MC
4	$D^0\bar{D}^0$, $D^0 \to K^-\pi^+, \bar{D}^0 \to K^+\pi^-$	122	MC
5	D^+D^-, $D^+ \to K^-\pi^+\pi^+$, $D^- \to K^+\pi^-\pi^-$	140	MC
6	$\Lambda_c^+\bar{\Lambda}_c^-$, $\Lambda_c^+ \to pK^-\pi^+$, $\bar{\Lambda}_c^- \to \bar{p}K^+\pi^-$	113	MC
7	$\Lambda_c^+ \to ne^+\nu_e$	104	MC
8	$e^+e^- \to \pi^+\pi^- J/\psi$ ($Z_c(3900)$)	10	Data
9	$e^+e^- \to e^+e^-$	141	Data
10	$e^+e^- \to \mu^+\mu^-$	121	Data
11	$e^+e^- \to \gamma\gamma$	150	Data
12	3097 MeV	150	Data
13	3686 MeV	150	Data
14	3773 MeV	144	Data
15	Cosmic ray	10	Data

Open dataset



runNo: 30038
EventNo: 2137001
MdcTrack

		x	y	z	r (cm)		px	py	pz	p (GeV)	
0 100 41.8664 39 24 0 0 42	-0.0465377	-0.0996479	0.335359	0.109979	1	1.20999	1.09632	-0.512006	0.550871	1.32948	1.14357

0.826455 0.335359 0.45527 0.000134338 6.26826e-06 -4.40381e-05 0.000376021 -5.38876e-06 3.1959e-07 -2.3583e-06 1.6225
1.80467e-05 -0.000104227 1.13901e-06 0.0219242 -0.000420368 9.21144e-06

MdcHit
1 1 0 1196 647.25
1 1 1 697 517.125
1 1 3 999 513.938
1 3 0 149 634.875
1 3 1 313 657

MdcHit:

Numerical order	Meaning
1	The type of wire
2	Layer level
3	Wire level
4	charge
5	time

Potential applications:

1. Study the detector response and develop data processing techniques.
2. Analyze characteristics of different physics events.
3. Develop visualization techniques for research, education, and outreach.

Unity

PHOENIX

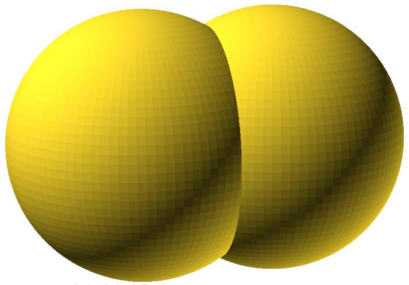
More.

Unity-based Event Display

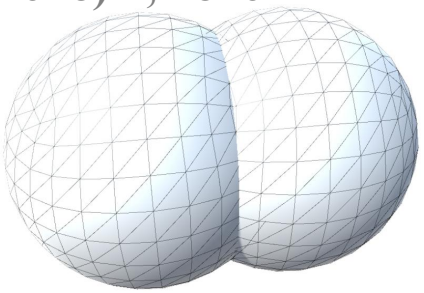
- Unity is a game engine that supports multiple platforms and offers rich display features.

- **Detector geometry:**
  - Use a Geant4->FBX geometry converter to generate detector in FBX format, as direct geometry input of Unity.
  - Independent of offline software system.

Front.Phys.(Beijing) 21 (2026) 2, 26201



CSG Format



FBX Format (Unity support)

- **Event Data:**
  - Support **TXT format file** for input.
  - Extract the event information from root file, and export the TXT file.

```
runNo: 30038
EventNo: 2137001          x        y        z        r  (cm)      px       py      pz     p  (GeV)
MdcTrack
0 100 41.8664 39 24 0 0 42 -0.0465377 -0.0996479 0.335359 0.109979 1 1.20999 1.09632 -0.512006 0.550871 1.32948 1.14357
0.826455 0.335359 0.45527 0.000134338 6.26826e-06 -4.40381e-05 0.000376021 -5.38876e-06 3.1959e-07 -2.3583e-06 1.6225
1.80467e-05 -0.000104227 1.13901e-06 0.0219242 -0.000420368 9.21144e-06
```

It can be used directly as input.

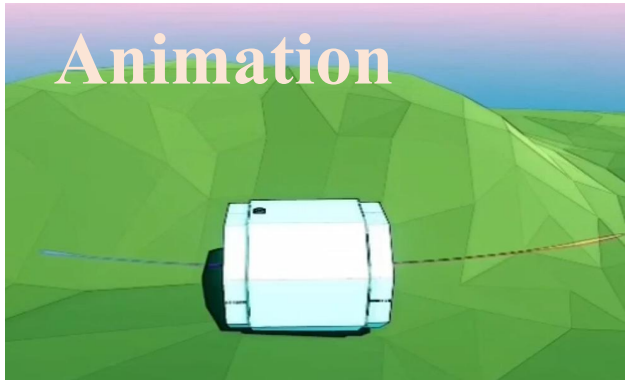
```
MdcHit
1 1 0 1196 647.25
1 1 1 697 517.125
1 1 3 999 513.938
1 3 0 149 634.875
1 3 1 313 657
```

MdcHit:

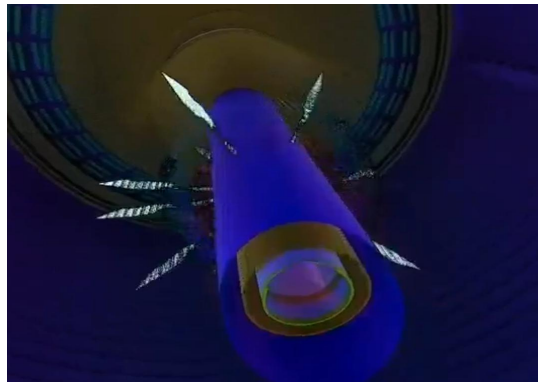
Numerical order	Meaning
1	The type of wire
2	Layer level
3	Wire level
4	charge
5	time

Unity-based Event Display

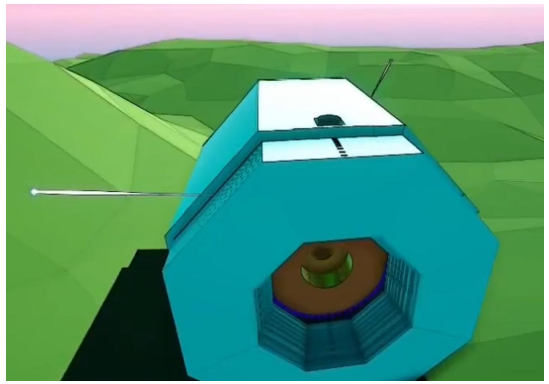
➢ The Unity-based visualization tool is under development.



Next



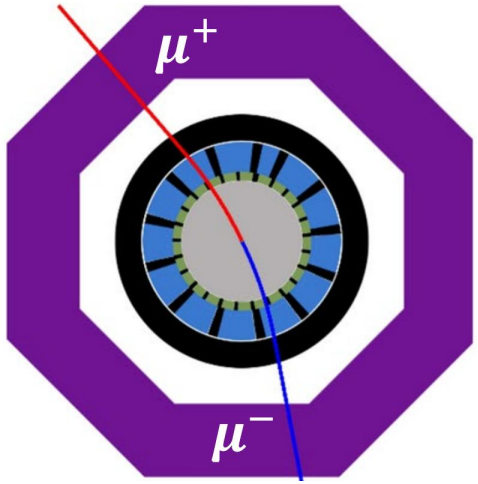
Next

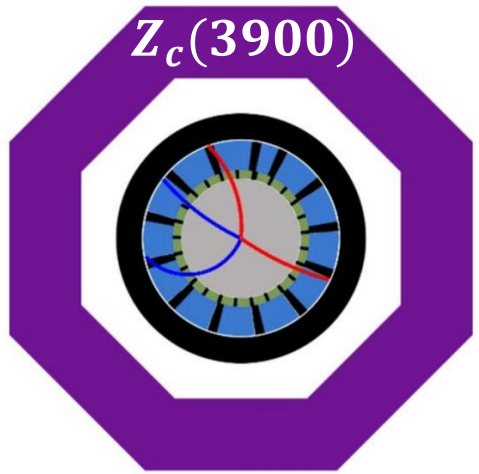


Electron and positron motion. **Electron-positron collision.** **Visualization of muon track.**

Features of Unity

1. Supports multi-platform operation
2. Rich display features
3. Better visual effects
4. Supports running locally without requiring the full offline software





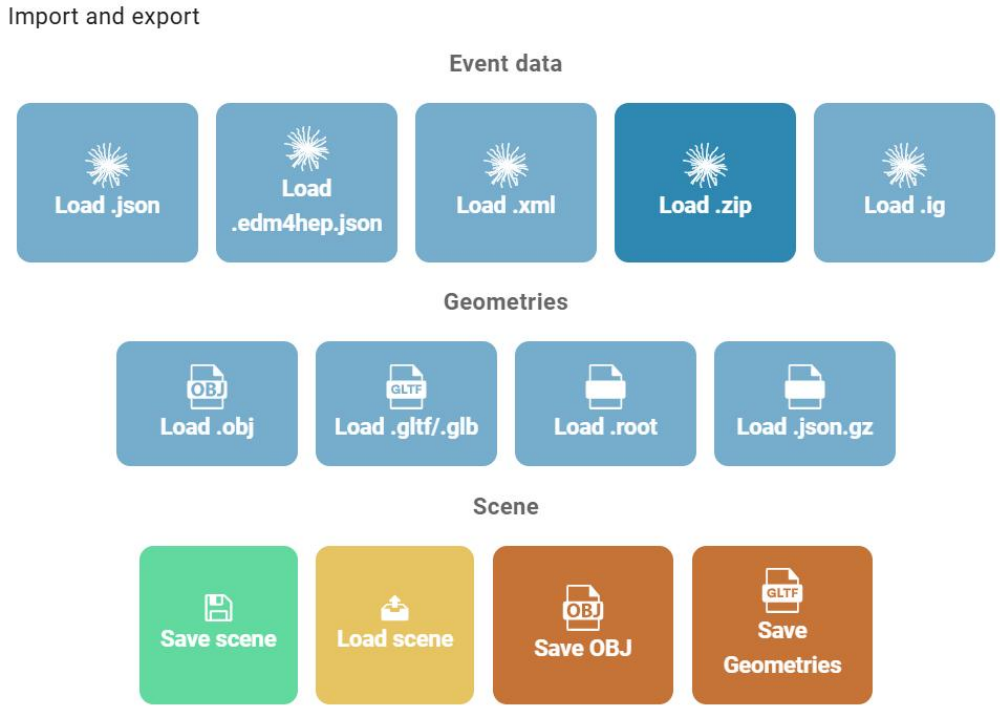
Phoenix-based visualization

- **Phoenix is a web-based visualization** framework for HEP, built on JSROOT and three.js libraries.

- **Supports importing detector geometry file in ROOT format.**
- **Support importing event in JSON format:**


```
"LongTracks": [
  {
    "charge": -1,
    "chi2": 51.32474511039702,
    "color": "0x777777",
    "dof": 38,
    "id": "pion",
    "pos": [
      [
        -0.13165841735161207,
        -0.04427468990441445,
        -28.34814622044968
      ],
```


Public access link:
https://hepsoftwarefoundation.org/phoenix/#/



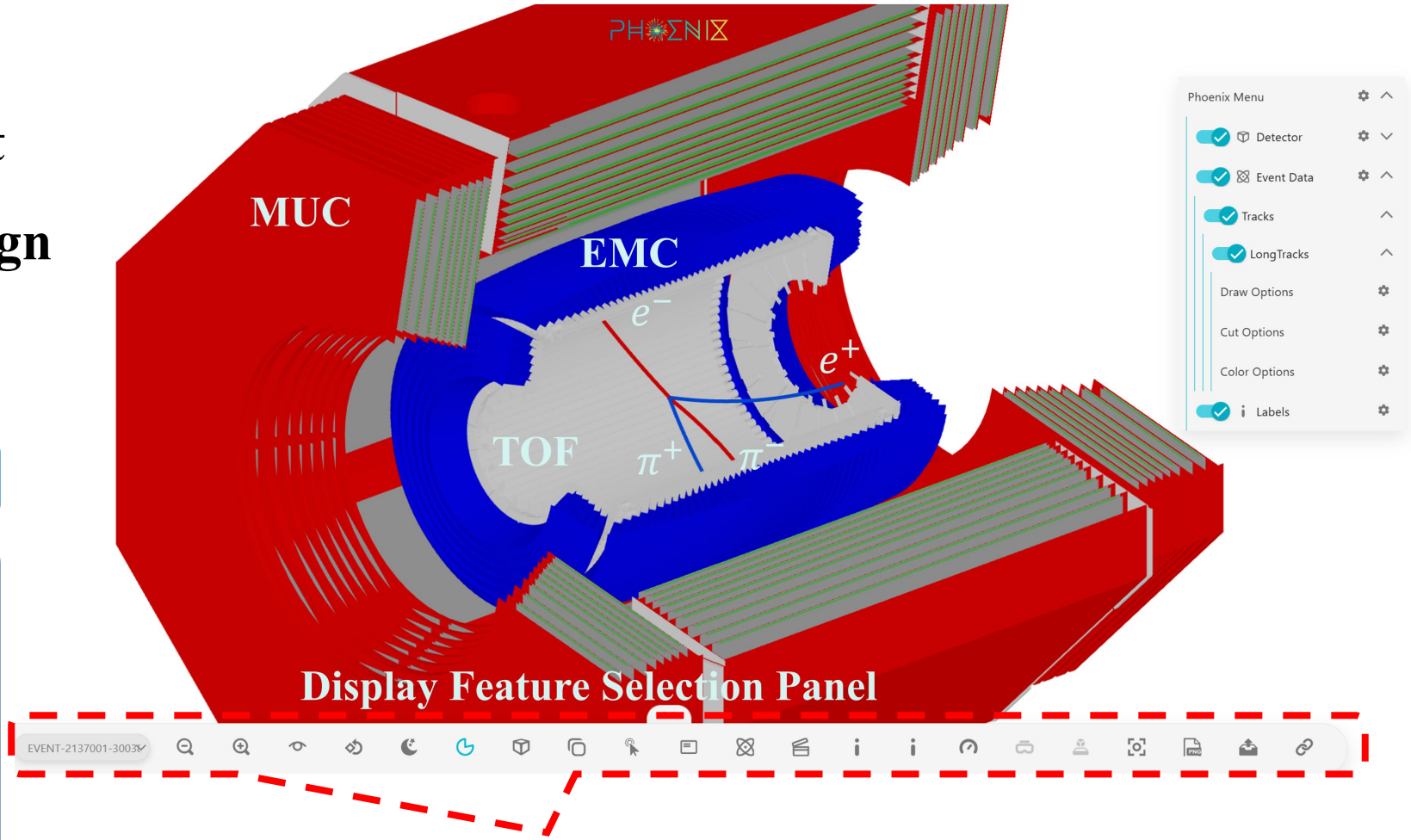
The display of detector geometry and event information is independent of each other.

Phoenix-based visualization

- Phoenix for BESIII includes **detector visualization, event track display, and GUI design with animation.**

Features of Phoenix

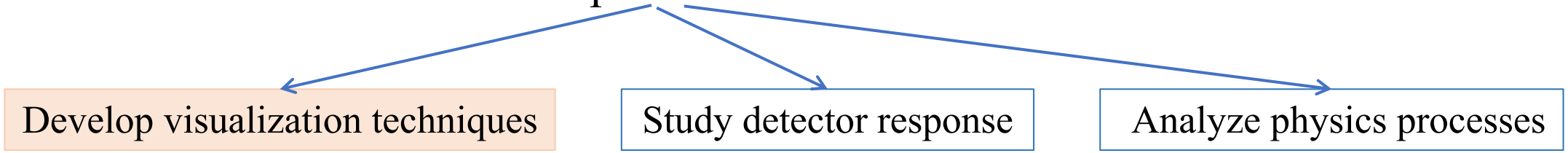
1. Browser access on any device.
2. Lightweight and No additional dependencies.
3. Fast, high-quality visuals.
4. Flexible features that can be extended or customized as needed.



- **Multiple visualization features configuration are available.**

Summary

- Based on the BESIII , we simulated some typical physics processes and collected some real data to serve as an open dataset.



- Unity: uses txt inputs and offers 2D/3D displays, animations, and track views.
- Phoenix: converts TXT files to JSON for detector geometry and event visualization with rich GUI features.

Thank you for listening!

Backup slides