Mu2e Event Display Development – Using the TEve Framework

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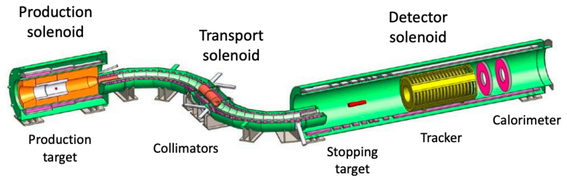
Mu2e : Objective and Overview

- Aim : Search for the charged Lepton Flavour Violating (cLFV) neutrinoless, coherent conversion of muons into electrons, in the field of a nucleus by measuring the ratio,

$$R_{\mu e} = \frac{\mu^- N \rightarrow e^- N}{\mu^- N \rightarrow all\ muon\ captures}$$

- Signal : 105 MeV electron
- Background :
  1. Intrinsic background : Decay of muons in the atomic orbit in the stopping target (DIO)
  2. Radiative Pion Capture
  3. Cosmic Rays

- Mu2e will use an 8 GeV proton beam, which creates pions during the collision with the Tungsten Production target in the Production Solenoid (PS).
- The backward-going pions decay into muons which spiral through the Transport Solenoid (TS) into the Detector Solenoid (DS).
- The muon beam collides with the Al stopping target in the DS creating electrons.
- These electrons are detected and their tracks are reconstructed using the Straw tube Tracker and the Crystal Calorimeter.



Mu2e Solenoid system

Event Display using TEve

- Motivation : A 3-D visual interface useful for experts as well as the general users; A framework to aid the Mu2e development discussions and the public engagement about the experiment.

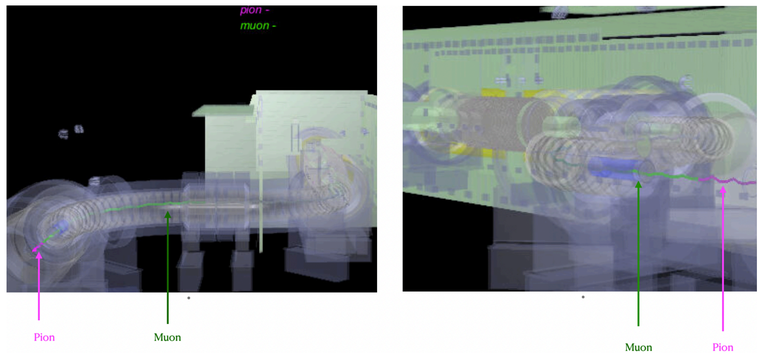
- TEve is a ROOT based 3-D event visualisation framework. It provides ready-made GUI which allows the geometry to be imported from a basic GDML. It maintains access to the raw art file making it convenient to go between the raw and reconstructed data in the browser. It provides a highly sophisticated display with in-built zoom and rotation functionalities.

- The objectives mentioned below are part of the on-going development of the Mu2e event display :
  1. Addition of upstream visuals and user defined track selection feature using the particle ID.
  2. Improvement of the MC truth and reconstructed helices alignment.
  3. Enhancement of the 2-D display of the hits and the tracker.

Upstream visualisation and User defined track selection

- The upstream MC trajectory was added into the display. This enables the user to view the tracks in the PS as well as TS making it convenient to follow the trajectory of the muon beam from the Production region to the muon stopping target, where the conversion may take place.

- An array called “particles” listing the particle IDs was added. It provides the user a selection panel of the tracks to be displayed.
- This feature is functional in all the solenoids, for both the MC truth and the reconstructed trajectories.
- The tracks are colour coded and labelled according to their particle ID.



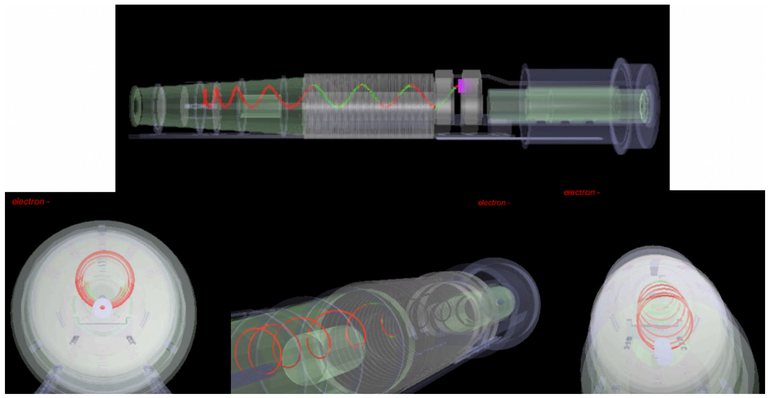
Pion to muon decay, Upstream Event Display

```
    addCosmicSeedFit          : false
    addClusters               : true
    addTrkExtTrajs            : false
    addMCTraj                 : true
  }
  particles :   [-11,11,13,-13,2212,2112,211,22,212]
}
```

Particle selection array

Matching of the MC truth and reconstructed helices

- The alignment of the MC truth and reconstructed helices has been improved. This was achieved by using a module called the KalSegment which gives the Kalman filtered, segment by segment co-ordinate information of the reconstructed helix.
- The method initially followed was an approximation technique which utilised the position and the momentum direction vectors to draw the reconstructed helix.



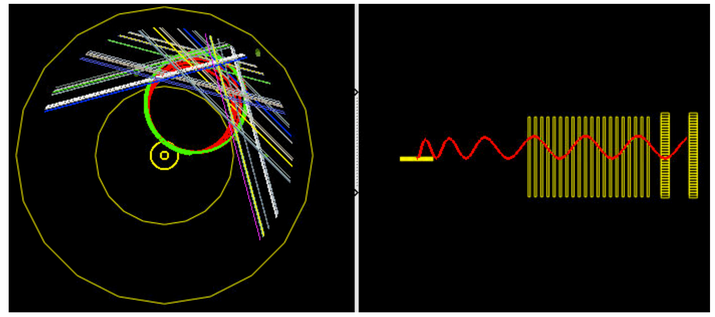
Conversion electron event display
Red : MC truth track, Green : Reconstructed track

Enhancement of the 2-D Projection

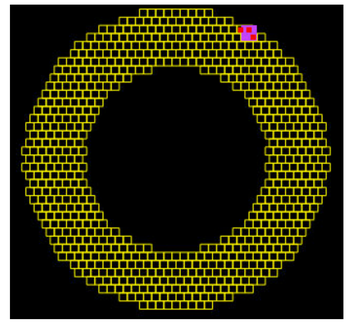
- The 2-D Tracker view was improved with the addition of the stopping target, tracker planes and the calorimeter disk geometries.

- The straws which have been hit are highlighted along with a label which can be visualised when the pointer is placed on the straw. The label contains the straw, panel and plane information.

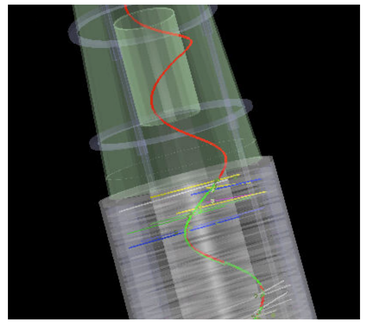
- The straws are highlighted and labelled in the 3-D view as well.



2-D XY and XZ Tracker views with the highlighted “hit” straws



Calorimeter disk with the crystal hits



3-D view of the helix and “hit” straws

Future steps

- Addition of the 2-D projections of the Cosmic Ray Veto (CRV) system.
- Addition of the hit “residuals” histogram into the display.