Event Display Development for Mu2e using Eve-7

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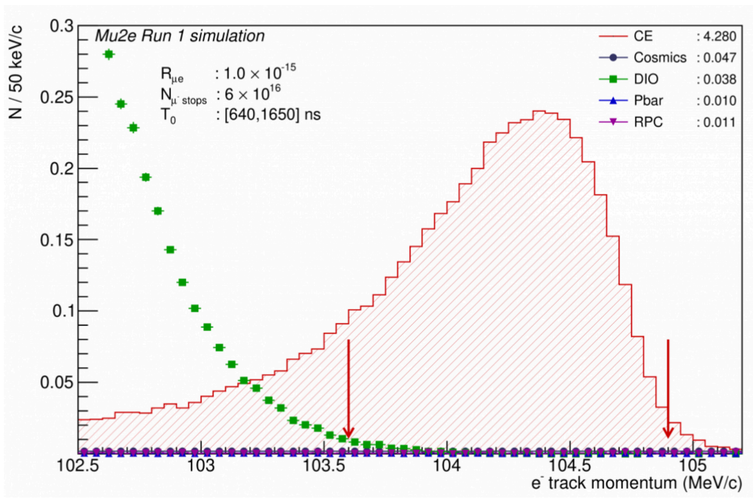
Mu2e : An overview

- A search for charged lepton flavour violating neutrinoless, coherent conversion of $\mu^- \rightarrow e^-$, in the field of an Al nucleus by measuring the ratio,

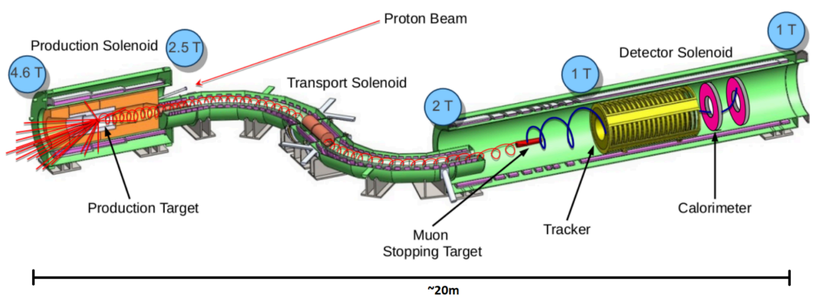
$$R_{\mu e} = \frac{\Gamma(\mu^- + N(Z,A) \rightarrow e^- + N(Z,A))}{\Gamma(\mu^- + N(Z,A) \rightarrow \nu_\mu + N(Z-1,A))}$$

- $E_{signal} = 105\ MeV$



Signal and Background PDFs for $R_{\mu \rightarrow e} = 10^{-15}$ [1]

- Mu2e will use a **Pulsed** 8 GeV proton beam to reduce the beam related background.
- The 3-part solenoid system with the negative **B** gradient guides the particles from the **Production Solenoid**, through the S-shaped **Transport Solenoid** to the **Detector Solenoid**.
- $\approx 3.9 \times 10^7$ protons per pulse will collide with the Tungsten "Production Target" and produce pions. The backward-going pions decay into muons which spiral through the S-shaped **Transport Solenoid**. The μ^- beam will collide with the stopping target in the **Detector Solenoid,** where the conversion process to e^- may occur.



Mu2e Schematic Setup [2]

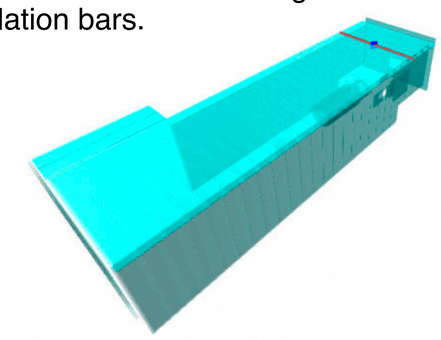
Mu2e Offline

- The core of Mu2e's software environment. It contains code used for GEANT4 based simulation of the entire Mu2e geometry and the reconstruction, analysis algorithms.
- It uses C++ and is based on **ART [3]**, an Event Processing Framework, developed at Fermilab.
- All the reconstructed objects (e.g. straw hits, calorimeter clusters) are stored as art data products. These objects are accessed and created in C++ modules.
- The Offline Event Display runs from a single analyser module.

Work in progress

- Upstream visualisation : Production and Transport solenoids have been added to the display enabling a complete illustration of the Mu2e world.
- Visibility of the true MC trajectory of particles traversing the muon beam line in all the solenoid regions would help the user to follow the MC trajectory of muons from the production region to the muon stopping target, where the conversion may occur.
- A GUI "ShowCRV" option is added which lets the user view the CRV geometry and the cosmic muon tracks and hits.
- The 2-D projections of the CRV will be added to get a better view of the "hit" CRV scintillation bars.

PS, TS and DS displayed

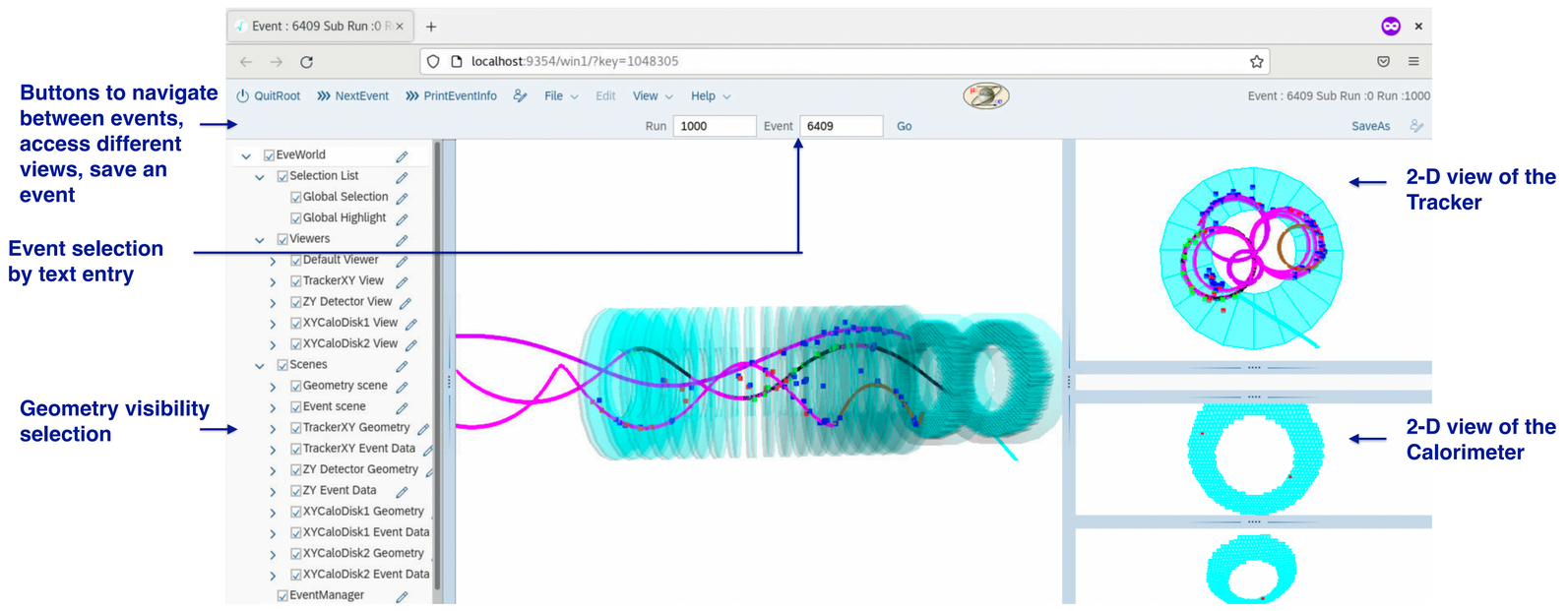


CRV display : "hit" scintillation bars highlighted in red, hits are shown in blue

Event display using Eve-7

- Event display is the top layer of a robust framework. It helps to visualise the physics in each event.
- Crucial for monitoring and debugging during live data taking, offline analysis as well as public outreach.

- A custom, offline display prototype was developed first using **TEve [4]**, a ROOT based 3-D event visualisation framework.
- The online display is being developed using **Eve-7 [5]**, an upgraded version of TEve which allows remote access for live data taking.
- Eve-7 has direct counterparts to most TEve objects making the translation easy.
- It allows users to remotely access the display from anywhere (provided FNAL VPN).
- Multiple Users can simultaneously view and interact with display.

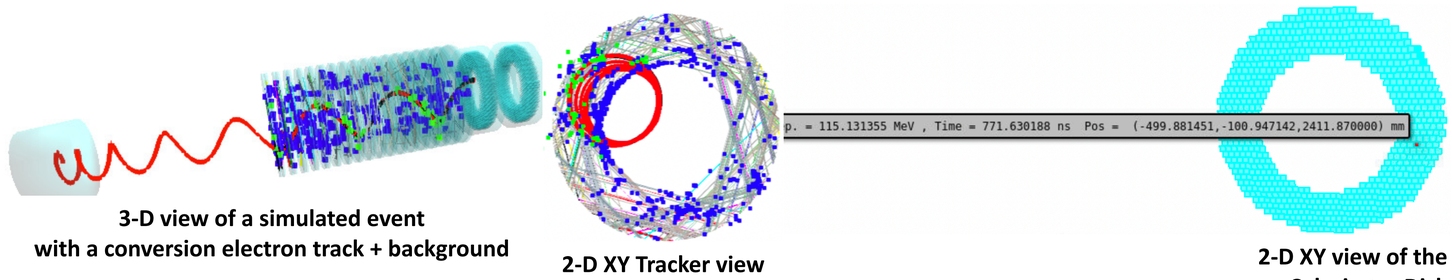


Main window of the online event display
Given here is an example event of $p\bar{p}$ annihilation at the Stopping Target in the Detector Solenoid

- A custom GUI was developed specifically for Mu2e.
- A GDML containing the Mu2e geometry can be created in Mu2e Offline and directly imported for 3D visualisation.
- The offline TEve display maintains access to the raw art file making it convenient to go between the raw and reconstructed data within the TEve Browser.
- Being ROOT based, Eve-7 fits in perfectly with the Mu2e environment with access to all the Mu2e objects. It can run directly on the .art files, outputs generated in Mu2e.

Features of the online display

- Reconstructed data like the tracks, hits and clusters can be displayed within the detector geometries upon GUI request.
- User defined track selection and colour coding feature, utilising the particle ID. For example : **e-**, μ^-, π
- The "hits" used in the track reconstruction are highlighted in **green** while the unused hits are in **blue**.
- Relevant information about the simulated particle, reconstructed track, straw and calorimeter crystal "hits" can be obtained on tool-tip.



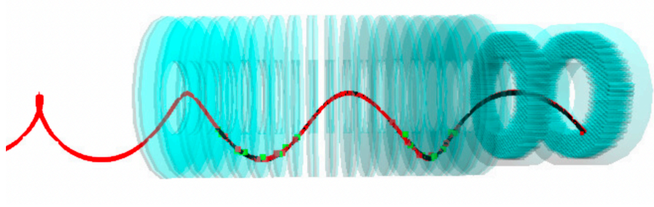
3-D view of a simulated event with a conversion electron track + background

Shown in red is the CE track

2-D XY Tracker view

2-D XY view of the Calorimter Disk

- The MC truth and reconstructed tracks can be displayed together, allowing visualisation of the track resolution.
- The reconstructed helix is formed using the segment by segment information provided by the "KalSegment" module which provides the Kalman filtered co-ordinate information.



Conversion electron event
Red : MC true track, Black : Reconstructed track
Green : Hits used in reconstruction

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References

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