Glueball 2-Track Analysis

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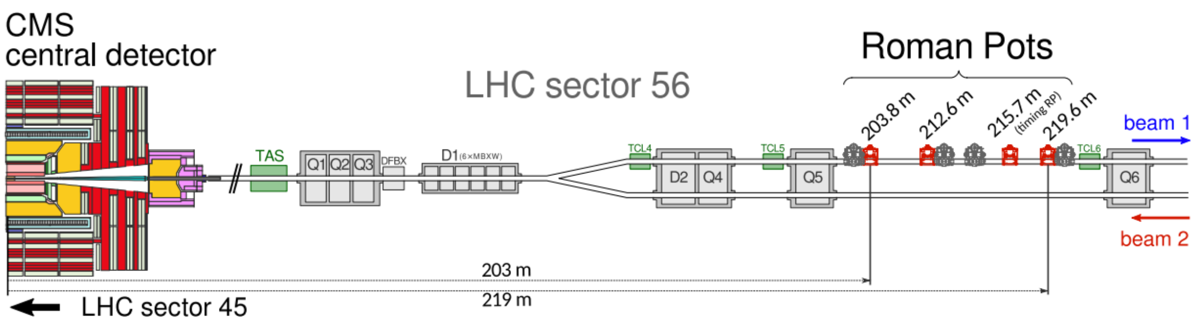
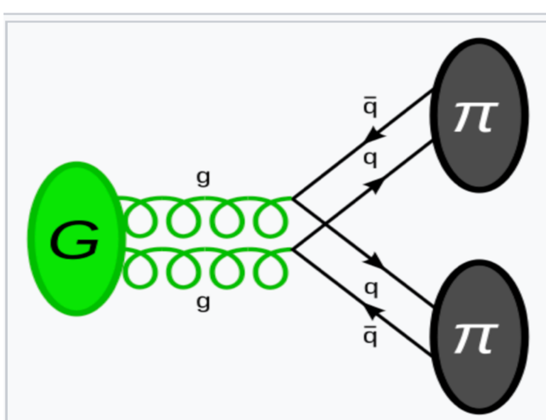
Introduction :

The Compact Muon Solenoid (CMS) is a large particle detector at the LHC. It can accurately measure the momentum of high-energy charged particles, even those with very low transverse momentum (pT), which helps detect low-mass particles. It is located at 220 from the CMS interaction point.



Background on Glueballs :

Glueballs are theoretical particles that scientists think might exist based on quantum chromodynamics (QCD), the theory explaining how the strong force holds particles like protons and neutrons together. Unlike other particles, glueballs are special because they are made only of gluons, which are the particles that carry the strong force, without any quarks. While QCD predicts the existence of glueballs, they have been hard to find in experiments because they mix with other particles, making them difficult to identify.



Objective of the Study :

The primary objective of this analysis is to explore various characteristics of two-track particle events in search of signatures indicative of glueball formation within the TOTEM and CMS experiments at CERN. By focusing exclusively on two-track events, this study aims to simplify the analysis and reduce background noise, thereby increasing the likelihood of identifying potential glueball candidates.

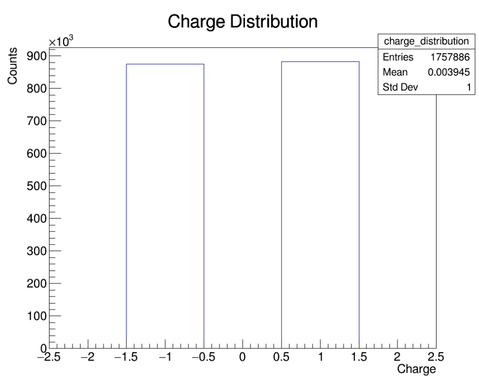
Data Analysis and Methodology :

Focus on Two-Track Analysis :

This analysis is specifically limited to events with exactly two particle tracks. The two-track selection criterion is crucial for isolating specific interactions that may be more likely to produce glueballs. By analyzing only these events, we can reduce the complexity associated with higher multiplicity events and focus on clearer, more interpretable signals.

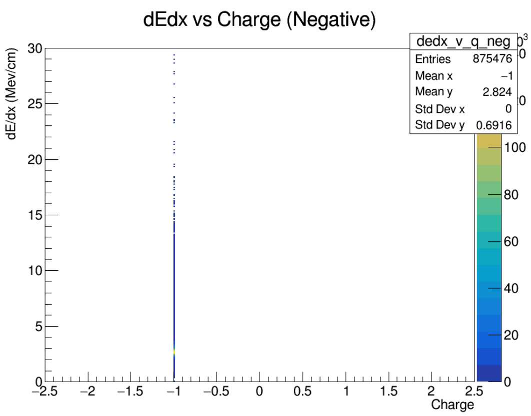
Charge Distribution :

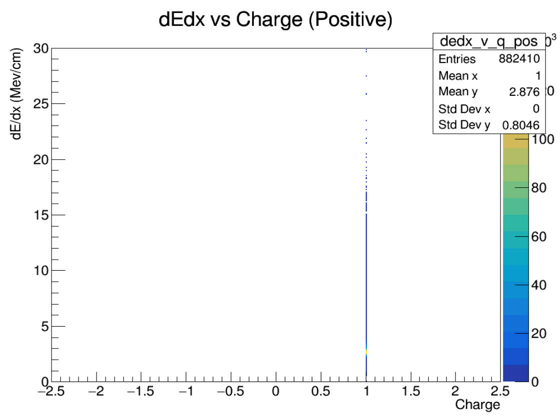
The charge distribution of the selected two-track events is a fundamental characteristic that provides insights into the types of particles produced in high-energy collisions. The histogram (Figure X) representing the charge distribution shows a clear separation between positively and negatively charged particles, which is essential for subsequent analysis where charge-dependent effects are considered.



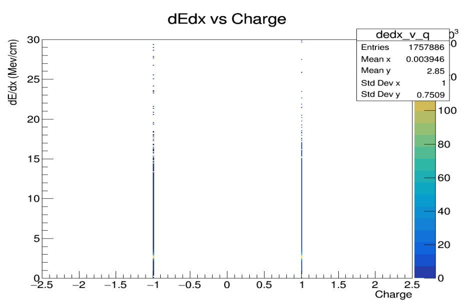
Energy Loss per Unit Length (dE/dx) vs Charge :

The relationship between the energy loss per unit length (dE/dx) and the charge of particles (Figures Y and Z) offers critical information about the ionization processes as particles traverse the detector. The distinct behavior observed for positive and negative charges is expected due to the difference in ionization characteristics between particles and antiparticles.



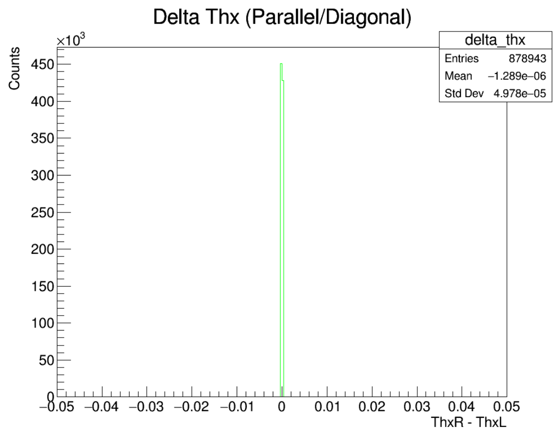


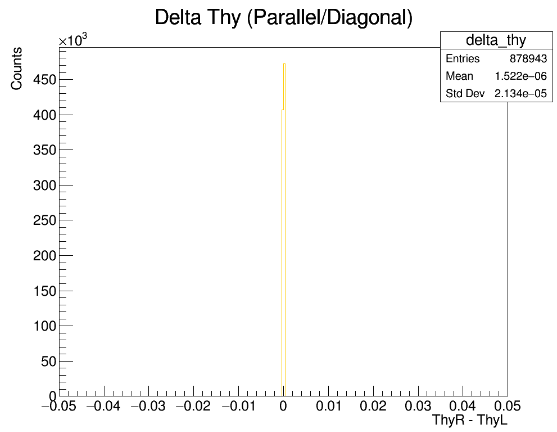
Combined :



Pseudorapidity (η) and Azimuthal Angle (φ) Asymmetry :

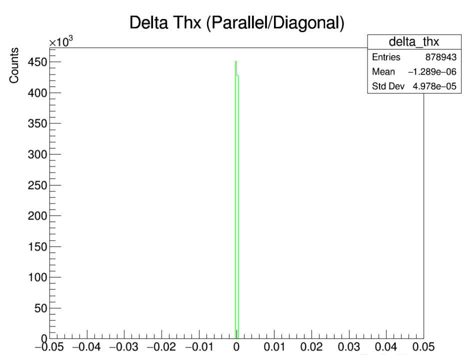
The asymmetry in pseudorapidity (η) and azimuthal angle (φ) between the two selected tracks (Figures A and B) is crucial for understanding the angular distribution of particles relative to the beam axis. The histograms show the application of cuts to focus on high-quality data, with η and φ asymmetry providing insights into the spatial distribution of particles.

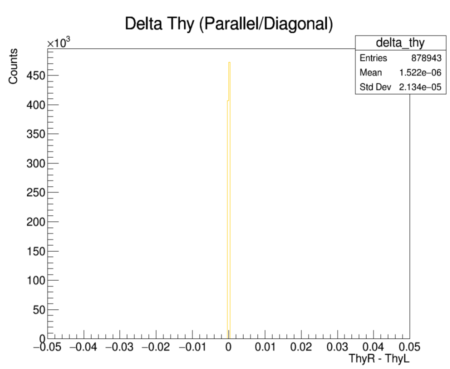




Delta Thx and Thy Distributions :

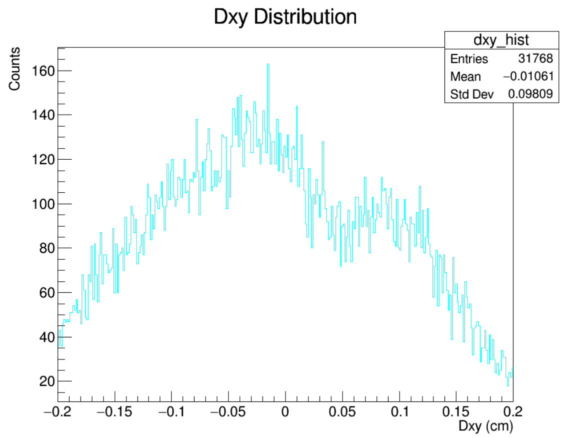
The Delta Thx (parallel/diagonal comparison for the x-direction) and Delta Thy (y-direction) histograms (Figures C and D) were refined by applying specific cuts to the two-track data ($-0.03 < ThxR < 0.03$ and $-0.03 < ThxL < 0.03$ for Thx; similarly for Thy).





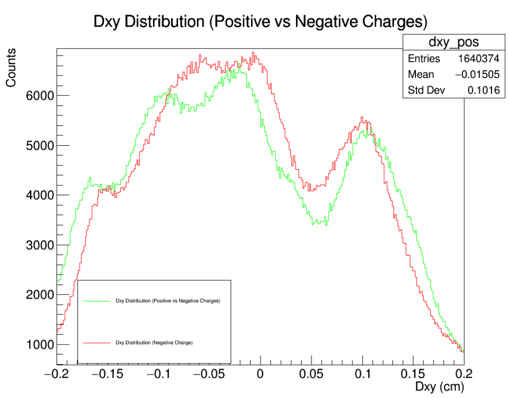
Dxy Distribution :

The Dxy distribution (Figure E) represents the transverse impact parameter, which is the distance of closest approach of a track to the collision point in the transverse plane. The applied cuts on pseudorapidity (trk_eta < 2.0) and energy loss (trk_dedx > 5.0) ensure that only high-quality two-track events are included, thereby enhancing the reliability of the data. This distribution is critical in understanding how far particle tracks are from the center.



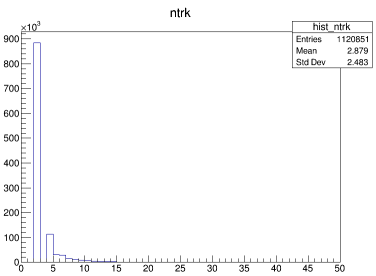
Dxy distribution for both positive and negative charges:

Dxy distribution for both positive and negative charges, showing how their transverse impact parameters (Dxy) are distributed. The distributions appear similar but with some differences in the central region, where positive charges seem to have a slight offset compared to negative charges.



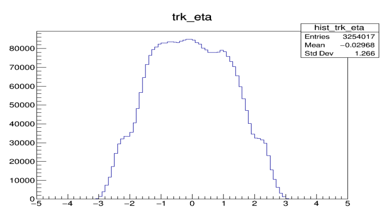
Track Multiplicity (ntrk) Distribution :

The ntrk distribution (Figure F) shows the frequency of events with different numbers of tracks. In this analysis, the distribution is focused on events where only two tracks are present.



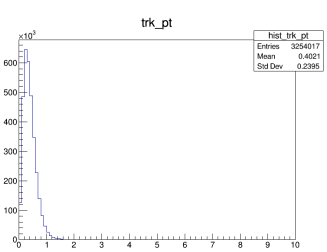
Pseudorapidity (trk_eta) Distribution :

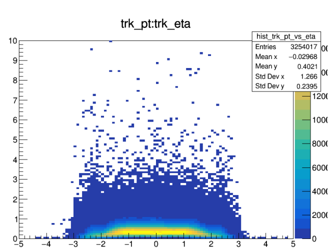
The trk_eta distribution (Figure G) illustrates the spread of track pseudorapidities, providing a view of the angular distribution of tracks relative to the beam axis. This distribution helps in understanding the overall event geometry and is critical for selecting events that are likely to contain glueball signatures, particularly in two-track events.



Transverse Momentum (trk_pt) Distribution :

The transverse momentum (trk_pt) distribution (Figure H) and its correlation with pseudorapidity (trk_pt vs. trk_eta, Figure I) offer insights into the momentum characteristics of the tracks. This information is essential for understanding the dynamics of two-track events and for identifying potential glueball candidates, which are expected to exhibit specific momentum distributions.





Conclusion :

Summary of Findings :

This study has provided valuable insights into the characteristics of two-track particle events that may be indicative of glueball production. The application of data cuts and the subsequent analysis of refined histograms have allowed for a clearer understanding of the potential signals associated with glueball formation. While further studies and more sophisticated analyses are necessary to conclusively identify glueballs.

References:

1. **Milieva, A.** *CERN Summer Student Report*. CERN, 2024. https://cds.cern.ch/record/2825437.

2. **Brüning, O. S., Collier, P., Lebrun, P., Myers, S., Ostojic, R., Poole, J., Proudlock, P. (eds.).** *LHC Design Report, Volume 1: The LHC Main Ring*. CERN, Geneva, 2004. CERN Yellow Reports: Monographs. DOI: 10.5170/CERN-2004-003-V-1 (cit. on pp. X).

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