

Glueball Physics and Search for Candidates in the CMS-TOTEM Experiment

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Quantum Chromodynamics (QCD) is the theory describing the strong interaction. QCD is a well-established quantum field theory (QFT) that successfully explains phenomena such as quark confinement. However, several questions remain open.

A primary challenge in studying QCD is the breakdown of perturbative methods at low energies, where the strong coupling constant becomes large. This occurs because gluons, the bosons that mediate the strong interaction, carry color charge. This self-interaction allows for the formation of bound states composed entirely of gluons, known as glueballs. Although these particles were first hypothesized over fifty years ago, definitive experimental evidence of their existence has not been established.

This work seeks to address this gap by searching for the first excited Glueball state $J^{CP} = 2^{++}$, which Lattice QCD calculations predict to have a mass of approximately $2200 \text{ MeV}/c^2$. Because this particle is a resonance, it is too short-lived for direct detection; therefore, we analyze the decay channel $X \rightarrow \rho\rho \rightarrow \pi^+\pi^-\pi^+\pi^-$.

We use data from the CMS-TOTEM experiment collected via Central Exclusive Production (CEP). In a CEP event, the protons interact through Pomeron exchange while remaining intact. While previous searches have yielded null results, the increased luminosity and proton-tagging capabilities of the TOTEM detector provide a new opportunity to observe this state. To isolate the potential signal, we must suppress the background due to non-resonant $\rho\rho$ and $\pi^+\pi^-\pi^+\pi^-$ production, a task facilitated by using Monte Carlo simulations to optimize our cuts.

To date, no definitive glueball signal has been identified within the experimental data. However, the production and analysis of the simulated datasets is ongoing, and we are currently developing selection criteria to improve background rejection.