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Search for an Ultra Light Higgs Boson in the Rare Decay $K_L \rightarrow \pi^0 \pi^0 \mu^+ \mu^-$

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Using data collected by the KTeV Experiment at Fermi National Accelerator Laboratory in Batavia, Illinois, this study will be the first experimental analysis of $K_L \rightarrow \pi^0 \pi^0 \mu^+ \mu^-$. Although this decay mode is possible within the Standard Model, it is limited to a very narrow band of phase space. The HyperCP Experiment has recently observed three $\Sigma^+ \rightarrow p \mu^+ \mu^-$ events within a narrow dimuon mass range of 213.8 MeV/ c^2 to 214.8 MeV/ c^2 . This suggests that the process could occur via a neutral intermediary particle, $\Sigma^+ \rightarrow p X^0 \rightarrow p \mu^+ \mu^-$, with an X^0 mass of $214.3 \text{ MeV}/c^2 \pm 0.5 \text{ MeV}/c^2$. Since the X^0 has a light mass and a low interaction probability, then it is most likely a new neutral boson that exists beyond the Standard Model; potentially an ultra light higgs boson in the Next-to-Minimal Supersymmetric Standard Model (NMSSM). Recent theoretical predictions suggest that the decay mode $K_L \rightarrow \pi^0 \pi^0 \mu^+ \mu^-$ can also occur via the aforementioned neutral boson: $K_L \rightarrow \pi^0 \pi^0 X^0 \rightarrow \pi^0 \pi^0 \mu^+ \mu^-$. Therefore, in addition to a Standard Model measurement, the search for $K_L \rightarrow \pi^0 \pi^0 \mu^+ \mu^-$ is also carried out in an effort to address the viability of X^0 in explaining the HyperCP phenomena.

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