Search for Light Pseudoscalar Bosons from Higgs Boson Decays in the Four-Kaon Final State with the CMS Detector

Johannes Hornung
KIT

Since the discovery of the Higgs boson h_{125} in 2012 by the CMS and ATLAS collaborations at the Large Hadron Collider (LHC) at CERN, its properties have been extensively measured. Precision measurements of the Higgs boson's width and couplings, across various production and decay modes, show remarkable consistency with the predictions of the Standard Model of Particle Physics (SM). However, the results can also be used to infer upper limits on branching ratios of yet undetected decay modes of the Higgs boson, with a current value of 0.16 at 95 % confidence level (CL). This branching ratio encompasses immediate decays into SM particles that are not detectable, as well as decays into particles predicted by theories beyond the Standard Model (BSM). These findings have driven further searches for exotic final states in Higgs boson decays.

This talk presents a search for exotic Higgs boson decays into two light pseudoscalar bosons a, each subsequently decaying into a pair of charged kaons. Light pseudoscalar bosons coupling to the Standard Model Higgs boson are suggested by various BSM theories, including Axion-Like Particles (ALPs) or additional Higgs bosons, as suggested for example by the Next-to-Minimal Supersymmetric Standard Model (NMSSM).

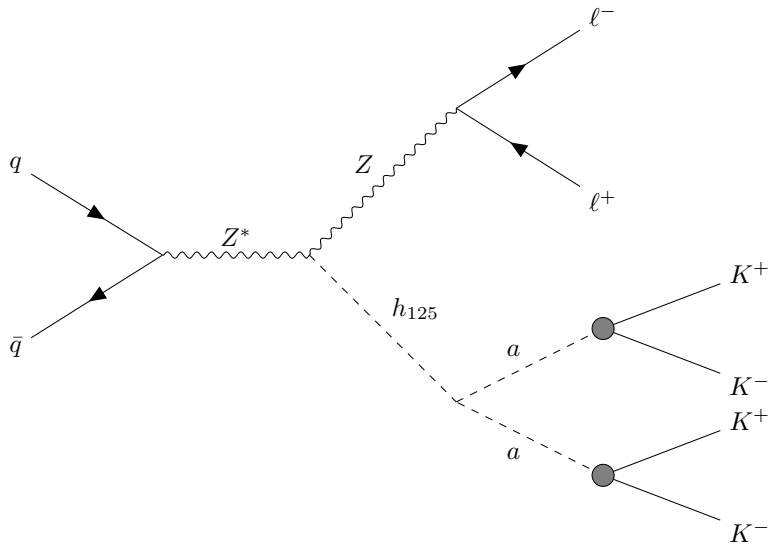

Figure 1: Simplified Feynman diagram of the Zh_{125} production and decay of an SM-like Higgs boson h_{125} into two pseudoscalar bosons a. The a bosons decay further into pairs of charged kaons $K^{\pm}$. The Z boson is assumed to decay into two leptons $\ell^{\pm}$ ($e^{\pm}$ or $\mu^{\pm}$).

The four-kaon final state is chosen, because high-energy kaons are long-lived and are expected to reach the detector before decaying further. In CMS, such particles are reconstructed as so called Particle Flow candidates, which combine information from multiple subdetectors to identify and measure individual particles in the event. High-energy kaons from the signal decay thus appear as distinct, trackable objects that can be used to reconstruct the full Higgs boson decay chain.

To suppress the overwhelming QCD multijet background, the analysis focuses on the associated production of the Higgs boson with a Z boson. The clean signature of $Z \to \ell^+\ell^-$ ($\ell = e, \mu$) provides the necessary experimental handle for event selection and allows a sensitive search for this rare decay mode.

Results from this analysis will provide first constraints on the $h_{125} \to aa \to 4K^{\pm}$ decay channel and pave the way for expanded searches with Run 3 data.