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Projects in Particle Physics for Bachelor and Master Students

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1 Master Thesis: $h \rightarrow gg, \gamma\gamma$ with Leptoquarks

Leptoquarks (LQs) are well motivated extensions of the Standard Model (SM) of particle physics since they are able to explain the intriguing hints from New Physics in semi-leptonic B decays and the anomalous magnetic moment of the muon. In general, there are 5 representations of scalar LQs under the SM gauge group. The LQs can also couple to the SM Higgs and mix with each other, once the Higgs acquires its vev. The aim of this master thesis is to calculate the loop corrections to $h\gamma\gamma$ and hgg couplings and determine the phenomenological relevance for the future colliders.

2 Bachelor Thesis: Lepton Flavour Violating Processes from Effective Operators

Lepton Flavour Violating (LFV) Processes (such as $\mu \rightarrow 3e$ and $m\mu \rightarrow e\gamma$ measured at PSI) are prime places to search for New Physics (NP) since lepton flavour is conserved in the SM. Therefore, any deviation from zero would prove the existence of physics beyond the Standard Model. LFV processes can be described using effective field methods which in which the effect of NP is parametrised via the coefficients of higher dimensional operators. The goal of this bachelor thesis is to calculate the decay rates of LFV processes as a function of these coefficients.

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3 Bachelor Thesis: Non-Resonant ALP's in Vector Boson Scattering at the HL-LHC

Axion-like particles (ALPs) and other pseudo-Goldstone bosons are ubiquitous in generic extensions of the Standard Model (SM). For instance in solutions to the strong CP problem or in models addressing the Higgs hierarchy problem as in Composite Higgs models. Recent works have shown that due to the derivative nature of the couplings of the ALP's to the SM particles, there is an enhanced sensitivity to new physics in the tails of the kinematic differential distributions. The goal of this bachelor thesis is to calculate the sensitivity of the HL-LHC in detecting or excluding ALP's in the Vector Boson Scattering process $pp \rightarrow jjWW$.