Search for long-lived axion-like particles from flavour-changing neutral current exotic Top quark decays with the ATLAS experiment

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The Standard Model (SM), although confirmed with great precision experimentally, is still insufficient for giving answers to many fundamental questions. One prime example is the strong CP problem which axion-like particles (ALPs) are proposed to solve. One way to approach ALPs is to parameterise ALP couplings to Standard Model particles like top quarks. ALPs appear in flavour-changing exotic top decays where the top quark decays into an ALP and an up or charm quark. Within this decay mode, parts of the parameter space suggests ALPs to have lifetimes long enough to travel macroscopic distances before decaying. This search is dedicated to look for two kind of events: $t\bar{t}$ events with one SM decaying top quark and one exotically decaying top quark as shown in Figure 1 as well as single top quark events from the top and ALP production at the LHC as shown in Figure 2. In both of these topologies the focus is on ALPs decaying hadronically. ALPs are assumed electrically neutral and thus leave no energy deposits in the ATLAS tracking system. Moreover, the ratio of energy deposits in the electromagnetic calorimeter and hadronic calorimeter are used to suppress SM backgrounds. An event selection with ATLAS Run 2 simulations is presented that is specifically designed to fight simulated backgrounds, taking the significance as a figure of merit for cut optimisation. It makes use of a selection of standard kinematic cuts on leptons, on the missing transverse energy and the W boson and more, a cut on the required number of jets in the event and cuts on kinematic and topological features of the signal candidate jet. Finally, a modified χ^2 algorithm is developed to suppress SM $t\bar{t}$ events. This event selection paves the way for a data-driven background estimation method, called the ABCD method, used to account for non-simulated backgrounds, like e.g. beam-induced backgrounds. These backgrounds can mimic the special characteristics of ALPs from top quarks, however, they can hardly be simulated. With the ABCD method it is possible to arithmetically determine the number of events in a signal region. Knowing the expected number of events in the signal region defined in the ABCD plane, the expected 95% CL_s upper limits on branching ratio and coupling strength are calculated by constructing a profile likelihood function as a product of the Poisson distribution of each region. After performing a simultaneous fit of signal and background the limits can be obtained. The results of this fit outperform the limits of previous studies and therefore motivate an iteration of the analysis with more data and more efficient software tools for data processing. In addition to that, a new set of signal topologies including $t\bar{t}$+ALP or displaced top analyses would help to advance ALP searches in collider experiments. This talk presents the approach to searches for long-lived ALPs from exotic top decays at ATLAS developed in a previous study.

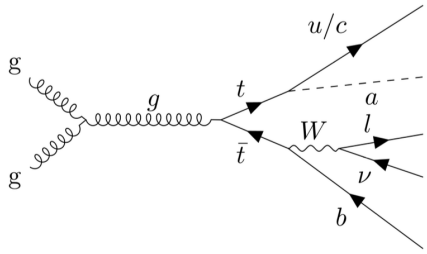

Figure 1: $t\bar{t}$ event with an ALP

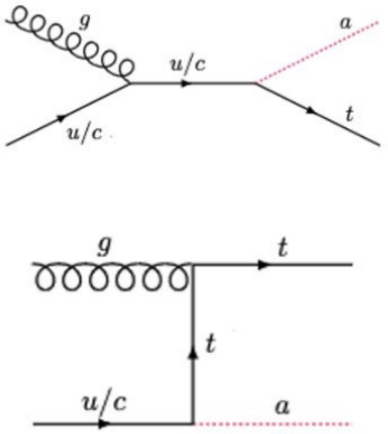

Figure 2: Single top event with an ALP