# Research Proposal

## Effective field theory interpretation of tZq in ATLAS

My thesis is involved in the measurement of total cross-section of a single top quark production in association with a Z boson using 139 fb$^{-1}$ of proton-proton collision data collected by the ATLAS experiment at the LHC during Run II, at a center-of-mass energy of $\sqrt{s} = 13$ TeV with an aim of measuring tZq differential cross-section. In this production mechanism, the top quark is produced via the t-channel and the Z boson is either radiated off from one of the participating quarks or produced via W boson fusion leading to a signature of a single top quark, a Z boson and an additional quark. It includes tZ coupling as well as the coupling of the three vector bosons (WWZ), is a key irreducible background to the tHq process and is sensitive to new physics phenomena. Within the standard model (SM), any flavour-changing neutral current (FCNC) involving the top quark and the Z boson is forbidden at tree level and is suppressed at higher orders because of the GIM mechanism. Some SM extensions, such as R-parity violating supersymmetric models, top-colour assisted technicolour models, and singlet quark models, predict enhancements of the FCNC branching fraction, which could be as large as $\mathcal{O}(10^{-4})$. In absence of any distinct evidence of new physics phenomena at the LHC, an increasing number of experimental studies aim at probing anomalous effects with an effective field theory (EFT) that represents a comprehensive approach for interpretation of various experimental results. Because it is possible that new particles that are considered in many BSM theories have masses that are above the energy reach at the LHC. The presence of new heavy particles can potentially induce various anomalous interactions at the electroweak and these effects can be studied at the LHC. Possible deviations from the SM predictions can be parametrized in a general way with an effective field theory (EFT) approach that uses an extended SM lagrangian built on dimension-six operators (SMEFT). The details on EFT can be referred to Ref. [1], and Ref. [2].

A full classification of the EFT operators relevant to the processes with top quarks is given in Ref. [3]. The tZq differential cross-section measurement can also be expressed in terms of parameters within the EFT. The EFT operators relevant to this study are the electroweak dipole moments $(\mathcal{O}_{tZ}, \mathcal{O}_{tW})$ and anomalous tZ neutral-current interactions $(\mathcal{O}_{\phi t}, \mathcal{O}^{-}_{\phi Q})$. In addition to the EFT study, this analysis includes constraints on the vector and axial-vector current couplings, as well as the electroweak dipole moments. Thus, this interesting tZq process motivates me for the tZq differential cross-section measurement and it's EFT interpretation. Not only tZq, the processes with production of four top quarks is sensitive to the four fermion EFT operators $(\mathcal{O}^{1}_{tt}, \mathcal{O}^{1}_{QQ}, \mathcal{O}^{1}_{Qt}, \mathcal{O}^{8}_{Qt})$. The recent limits on EFT operators derived from measurements of the LHC top working group are given in Ref. [4].

[1] W. Buchmuller and D. Wyler, DOI: 10.1016/0550-3213(86)90262-2

[2] B. Grzadkowski et al., arXiv:1008.4884

[3] J. A. Aguilar-Saavedra et al., arXiv:1802.07237

[4] ATLAS Collaboration, https://cds.cern.ch/record/2792256