Measurement perspectives of the top-antitop energy asymmetry in the production with an additional jet in the resolved topology with ATLAS

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The top quark is the heaviest particle in the Standard Model (SM) of particle physics and the only quark which decays before hadronization can happen. It decays into a real W boson and with a very high probability a bottom quark. The top quark is suitable for the search of physics beyond the SM of particle physics (BSM). There could be even heavier particles and they might become observable at higher center-of-mass energies, and the top quark could potentially interact with them. At the currently reachable center-of-mass energies, however, the impact of BSM physics might only be indirectly observable via the variation of properties of the production or decay of SM particles.
At the production of a top-antitop pair in proton-proton collisions, the charge asymmetry can be measured. This observable is introduced via next-to-leading order (NLO) interference, for example between the initial state and final state radiation. With the ATLAS detector the charge asymmetry is measured as a rapidity difference. In the top-antitop pair production with an additional jet the energy asymmetry, an observable complementary to the charge asymmetry, can be measured. The additional jet increases the sensitivity to possible new top quark interactions. Moreover the energy asymmetry can already be measured at leading order as an energy difference between the top quark and antitop quark. In proton-proton collisions the quark-gluon production channel gives the highest contribution to the energy asymmetry. After a first publication about the measurement of the energy asymmetry in the topology with a collimated hadronic top decay and a semileptonic decay with the ATLAS experiment, the future goal is to measure the observable in the full phase space. The event reconstruction in the "resolved" topology, in which the hadronic decaying top quark is reconstructed with several small-R jets, must be optimized in order to achieve the necessary sensitivity to the observable. Due to the (mostly) three small-R jets producing the hadronic decaying top quark, a lot permutations are available per event. The goal is to determine the permutation which optimizes the energy reconstruction of the mother particle. So far one of the studied reconstruction methods is the Kinematic Likelihood Fitter (short KLFitter) for the reconstruction on detector level. The KLFitter uses the measured 4-vectors of the considered objects. A fit is used to infer the 4-vectors of the decay products at parton level based on parameterized analytical transfer functions from parton to detector level. The measured detector level distributions are unfolded to the particle level to correct for experimental effects such like a limited acceptance and efficiency. Therefore a reconstruction method on particle level must be introduced. The transfer functions are not available at particle level and therefore a second reconstruction method was studied. A χ^2-algorithm is used to reconstruct the events on particle level. This algorithm constraints the reconstructed

masses of the top quarks and the W boson in the $t\bar{t}$ system.
The presentation will showcase the results of the optimized reconstruction using the KLFitter and the χ^2-algorithm. Currently, a new approach for handling permutations is being studied: a Symmetry Preserving Attention Neural Network (SPANet), which is primarily designed to address the jet-parton assignment problem. This network accounts for the symmetries present in an event, significantly reducing the number of permutations that need to be considered. Although this reconstruction method still requires optimization, a comparison of the so far studied reconstruction methods with a simple configuration of SPANet will also be included in the presentation.