T 67: Top Physics III

Time: Thursday 16:15–18:00 Location: KH 00.011

T 67.1 Thu 16:15 KH 00.011

Towards a top quark mass measurement in the all-jets final state using full Run 2 data — •Lennert Griesing, Peter Schleper, Johannes Lange, Hartmut Stadie, Lukas Schaller, and Yannek Gruel — Institute of Experimental Physics, Hamburg University, Germany

A precise measurement of the top quark mass is important for testing the Standard Model of particle physics. While the CMS experiment has achieved high precision using a profile likelihood fit in the lepton+jets final state, it has not been applied to the all-jets final state, yet. This final state remains challenging due to the large QCD multijet background and the complexities of the event reconstruction.

A new measurement in this channel is being developed using data collected with the CMS experiment at the LHC during Run 2 at $\sqrt{s} = 13\,\text{TeV}$. The analysis strategy combines optimized event selection, data-driven background estimation, and systematic uncertainty studies tailored to the all-jets final state. A profile-likelihood fit is employed to extract the top quark mass while simultaneously constraining systematic uncertainties. Leveraging the full statistical power of the dataset, this analysis aims to provide a complementary, high-precision measurement of the top quark mass. We report on the current status of this analysis.

T 67.2 Thu 16:30 KH 00.011

Comparing Parton-Shower Models in Top-Quark Production and Reweighting Between Models with Machine Learning — •Arshil Shaikh[1,2], Roman Kogler[1,2], and Dominic Stafford[2] — [1]Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Deutsches Elektronen-Synchrotron (DESY), Notkestr.85, 22607 Hamburg, Germany

Accurate modeling of parton-shower dynamics is essential for precision studies of top-quark production. In our setup, next-to-leading-order matrix-element events are generated with POWHEG, which can be interfaced with different parton-shower approaches. These include the transverse-momentum-ordered dipole shower of Pythia8 and the antenna-based shower implemented in Vincia. Their distinct approximations can lead to notable differences in jet and jet-substructure observables.

In this work, we study $pp \to t\bar{t} \to$ semileptonic events produced with POWHEG+Pythia8 and POWHEG+Vincia, comparing the $t\bar{t}$ system kinematics, jet characteristics, and jet-substructure variables such as N-subjettiness, generalised angularities, and energy-correlation functions. Furthermore, we use the DCTR (Deep neural networks using Classification for Tuning and Reweighting) technique to reweight Pythia8 events such that they reproduce Vincia-like distributions, without requiring the computationally expensive step of re-running the full detector simulation. This study highlights key differences between parton-shower models and demonstrates the potential of machine-learning-based reweighting to efficiently bridge them.

T 67.3 Thu 16:45 KH 00.011

Investigation of boosted top quarks and overlapping jets in the all-jets top quark mass measurement — •Yannek Ruwen Gruel, Peter Schleper, Johannes Lange, Hartmut Stadie, Lennert Griesing, and Lukas Schaller — Universität Hamburg, Hamburg, Germany

At high momenta, the distances between the jets of top quark decay products are smaller due to the Lorentz boost. As a result, the jets may overlap or even merge. This study investigates the influence of these effects on the measurement of the top quark mass with a resolved selection in the all-jet channel with the CMS experiment. For the event reconstruction, a kinematic fit is used that operates on the hypothesis of non-overlapping jets. Due to the strict trigger cuts for p_T, a large number of top quarks with high p_T are expected. The number of events with overlapping and merged jets is quantified and the distortion of the event reconstruction is studied.

T 67.4 Thu 17:00 KH 00.011

Unfolding tops - using ATLAS to create detector-independent data — •Elia Schmidt, Richard Nisius, Changqiao Li, Xuewei Jia, and Dimbiniaina Rafanoharana — Max Planck Institute for Physics

The top-quark mass is an important fundamental parameter of the standard model. While its exact value has profound implications for Particle Physics, e.g. the stability of the QCD vacuum, its determination is hampered by theoretical ambiguities. The most precise measurements, performed by the big LHC Collaborations, are systematically limited and suffer from substantial modelling uncertainties.

In this presentation I will give a short overview of the theoretical issues associated with top-quark mass measurements and motivate the concept of data unfolding. The ongoing ATLAS analysis I am involved in has the goal of publishing an unfolded invariant mass distribution of lepton-jet pairs from $t\bar{t}$ decays. I use it as an example to show how data from ATLAS are processed to create a distribution which is essentially independent of detector-related uncertainties. The unfolded distribution can then be compared to all theoretical predictions, allowing conceptually sound top-quark mass determinations within a chosen model.

T 67.5 Thu 17:15 KH 00.011

Measurement of the top-quark mass using singly produced top-quarks in the t-channel — •Lukas Kretschmann, Dominic Hirschbühl, and Wolfgang Wagner — Bergische Universität Wuppertal, Germany

Almost all measurements of the top-quark mass have been performed using top-quark-antiquark pair-production events, measurements in other channels can be important inputs for a global combination. First studies for a measurement of the top-quark mass using t-channel single top-quark events are shown. This channel is statistically independent to the top-quark-antiquark pair-production measurements and has different systematic uncertainties associated to it, e.g. modelling uncertainties from Monte Carlo event generators. The high rate of background-events is a major challenge in this channel, for this a Graph Neural Network (GNN) is trained to enrich the selection in single top-quark t-channel events. For the determination of the top-quark mass the invariant mass of the charged lepton and the b-quark jet is used as a sensitive observable employing a maximum likelihood fit.

T 67.6 Thu 17:30 KH 00.011

Quark mass effects in the gradient flow observables — •Robert Mason and Robert Harlander — TTK, RWTH Aachen University, Aachen, Germany

The gradient flow provides a consistent scheme for matching perturbation theory and lattice field theory. In the continuum this has typically been done with the simplifying assumption that quarks are massless. However, this neither reflects lattice computations nor physical reality. In this talk we discuss the computation of three quantities fundamental to the gradient flow, the vacuum expectation values of the flowed fermion and gluon condensates and the fermion kinetic operator, and consider their quark mass effects to the three loop level. We then briefly discuss the idea of Takaura et. al. to use these mass effects with lattice data for precision estimates of the quark masses.

T 67.7 Thu 17:45 KH 00.011

New method for extracting the mass of valence quarks in protons — •Jianming Wang — Department of Physics, Lanzhou University, Lanzhou, China

In this paper, the extraction of the mass of valence quarks in protons no longer depends on the exact mass of each quark, but seeks the exact mass ratio of different valence quarks in the same system through experiments. By finding the exact ratio of the mass of the up quark and the down quark, the relationship among the three valence quarks can be found. Based on the experimental results of Seaquest carried out by Fermilab in 2021, through analysis, the accurate ratio of up quark to down quark mass ($mu/md = 0.707$) is obtained, and the mass triangle is established. It is deduced that the sum of squares of up quark mass in protons is equal to the square of down quark mass. The mathematical expression is: $mu^2 + mu^2 = md^2$.