# 17th International Workshop on Top Quark Physics (TOP2024)

# Report of Contributions

https://indico.cern.ch/e/top2024

Contribution ID: **4** Type: **YSF talk**

# Encoding off-shell effects in top pair production in direct diffusion networks

Promoting predictions for top quark production to include off-shell effects comes at an exceptionally high computational cost. On an example of $l^+\nu l^-\bar{n}ub\bar{b}$ process, dominated by top quark pair production and decay in the dilepton channel, we show how to reliably encode off-shell effects in a generative neural network based on direct diffusion. This network, constructed using POWHEG/bb4l and POWHEG/hvq samples, can be applied to new or existing POWHEG/hvq samples at almost no computational cost.

**Primary authors:** BUTTER, Anja; KUSCHICK, Mathias; KLASEN, Michael; PALACIOS SCHWEITZER, Sofia (ITP, University Heidelberg); PLEHN, Tilman; JEZO, Tomas (WWU ITP)

**Presenter:** KUSCHICK, Mathias

Contribution ID: **6** Type: **Poster**

# Rare and exclusive few-body decays of the top quark

We will report on an extensive survey of rare and exclusive few-body decays of the top quark, defined as those with branching fractions BR⊠$10^{-5}$ and two or three final particles [[1]]. Such rare decays probe physics beyond the Standard Model (BSM), constitute a background for exotic decays into new BSM particles, and provide precise information on quantum chromodynamics factorization with small nonperturbative corrections. We tabulate the theoretical BR values for almost 40 rare decay channels of the heaviest elementary particle, indicating the current experimental limits in their observation. Among those, we have computed for the first time semiexclusive top-quark decays into a quark plus a meson, while updating predictions for a few other rare partial widths. The feasibility of measuring each of these unobserved decays is estimated for p-p collisions at the high-luminosity Large Hadron Collider (HL-LHC), and for e+e− and p-p collisions at the future circular collider (FCC).

[[1]] David d'Enterria, Van Dung Le, "Rare and exclusive few-body decays of the Higgs, Z, W bosons, and the top quark", arXiv:2312.11211 \[hep-ph\] DOI:10.1088/1361-6471/ad3c59 (JPG to appear)

**Primary authors:** D'ENTERRIA, David (CERN); LE, Van Dung

**Presenter:** LE, Van Dung

Contribution ID: **8** Type: **YSF talk**

# Complete NLO corrections to off-shell ttZ production at the LHC

The comparison of theory predictions and experimental measurements is one of the main roads for discovering physics beyond the Standard Model. The tremendous amount of data that has been and will be further collected at the LHC already demands a high level of precision from the theory predictions.
In this talk I will focus on ttZ production, whose phenomenological interest is well-established. The intricate resonance structure and the high multiplicity of the final state make the achievement of theory results for this process extremely challenging. I will present how we took another step forward to predict this process at high accuracy by computing for the first time the complete set of fully off-shell QCD and EW corrections.

**Primary authors:** DENNER, Ansgar (Julius Max. Universitaet Wuerzburg (DE)); LOMBARDI, Daniele (Universität Würzburg); PELLICCIOLI, Giovanni (Max-Planck-Institut für Physik)

**Presenter:** LOMBARDI, Daniele (Universität Würzburg)

Contribution ID: **10** Type: **YSF talk**

# Two-loop QCD corrections to pp->ttj

In this talk, I will discuss the status of the calculation of the two-loop QCD corrections to the production of a top-quark pair associated with a jet at hadron colliders. This is the main bottleneck for achieving NNLO predictions. I will review recent progress in calculating the required Feynman integrals using the method of differential equations. I will also present the cutting-edge computational techniques that allow us to tackle the extreme algebraic complexity of the two-loop multi-scale helicity amplitudes and the presence of complicated special functions.

**Primary authors:** BRANCACCIO, Colomba; HARTANTO, Heribertus Bayu (Asia Pacific Center for Theoretical Physics); BECCHETTI, Matteo (University of Bologna); BADGER, Simon David (Universita e INFN Torino (IT)); ZOIA, Simone (CERN)

**Presenter:** BRANCACCIO, Colomba

Contribution ID: **11** Type: **Poster**

# ALP-ine quests at the LHC: hunting axion-like particles via peaks and dips in top-antitop-quark production

We present an analysis of the sensitivity of LHC searches for a new spin-0 particle decaying into top-antitop-quark ($t\bar{t}$) final states to generic axion-like particles (ALPs) coupled to top quarks and gluons. As a first step, we derive new limits on the effective ALP Lagrangian in terms of the respective Wilson coefficients based on the results of a CMS search using 35.9 $\mathrm{fb}^{-1}$ of data, collected at $\sqrt{s} = 13$ TeV.
Making use of the invariant $t\bar{t}$ mass distribution and angular correlations of leptons, we then investigate how an ALP, featuring an additional explicit coupling to gluons in its effective Lagrangian, can be distinguished from an extended Higgs sector pseudoscalar boson that exclusively couples to gluons via a top-quark loop.
Focusing on the mass of 400 GeV, motivated by a local $3.5\sigma$ excess observed in the CMS search, we present prospects for the sensitivity to an ALP using the data collected during Run 2 as well as the high-luminosity phase of the LHC.

**Primary authors:** ANUAR, Afiq Aizuddin (CERN (CH)); GROHSJEAN, Alexander (Hamburg University (DE)); BIEKOETTER, Anke (JGU Mainz); SCHWANENBERGER, Christian (Deutsches Elektronen-Synchrotron (DE)); WEIGLEIN, Georg Ralf (Deutsches Elektronen-Synchrotron (DE)); JEPPE, Laurids (Deutsches Elektronen-Synchrotron (DE)); HEINEMEYER, Sven (CSIC (Madrid, ES)); BIEKOETTER, Thomas

**Presenter:** JEPPE, Laurids (Deutsches Elektronen-Synchrotron (DE))

Contribution ID: **12** Type: **not specified**

# Welcome drink

*Sunday, 22 September 2024 19:00 (1h 30m)*

Contribution ID: **13** Type: **not specified**

# Welcome for the local authorities

*Monday, 23 September 2024 09:00 (10 minutes)*

**Session Classification:** Introduction

Contribution ID: **14** Type: **not specified**

# Introductory information

*Monday, 23 September 2024 09:25 (10 minutes)*

**Session Classification:** Introduction

Contribution ID: **15** Type: **not specified**

# Keynote

*Monday, 23 September 2024 09:35 (45 minutes)*

**Presenter:** SERVANT, Geraldine (Deutsches Elektronen-Synchrotron (DE))

**Session Classification:** Introduction

Contribution ID: **16** Type: **not specified**

# Run 3 object reconstructions in ATLAS

*Monday, 23 September 2024 11:00 (20 minutes)*

**Presenter:** GILLES, Geoffrey (Nikhef National institute for subatomic physics (NL))

**Session Classification:** Cross sections

Contribution ID: **17** Type: **not specified**

# Run 3 object reconstructions in CMS

*Monday, 23 September 2024 11:30 (20 minutes)*

**Session Classification:** Cross sections

Contribution ID: **18** Type: **not specified**

# Machine learning for top

*Monday, 23 September 2024 12:00 (20 minutes)*

**Presenter:** KOMM, Matthias (Deutsches Elektronen-Synchrotron (DE))

**Session Classification:** Cross sections

Contribution ID: **19** Type: **not specified**

# Inclusive top cross sections in CMS

*Monday, 23 September 2024 14:00 (20 minutes)*

**Presenter:** DEL RIEGO BADAS, Javier (Universidad de Oviedo (ES))

**Session Classification:** Cross sections

Contribution ID: **20** Type: **not specified**

# Inclusive top cross sections in ATLAS

*Monday, 23 September 2024 14:30 (20 minutes)*

**Presenter:** CHEN, Charlie (University of Victoria (CA))

**Session Classification:** Cross sections

Contribution ID: **21** Type: **not specified**

# Differential top cross section in ATLAS and CMS

*Monday, 23 September 2024 15:00 (20 minutes)*

**Presenter:** BEHNKE, Olaf (Deutsches Elektronen-Synchrotron (DE))

**Session Classification:** Cross sections

Contribution ID: **22** Type: **not specified**

# Resonance-aware NLOPS matching for off-shell tt+tW production with semileptonic decays

*Monday, 23 September 2024 15:30 (20 minutes)*

**Presenter:** JEZO, Tomas (WWU ITP)

**Session Classification:** Cross sections

Contribution ID: **23** Type: **not specified**

# Complete NLO corrections to top-quark pair production with isolated photons

*Monday, 23 September 2024 16:30 (20 minutes)*

**Presenter:** STREMMER, Daniel (RWTH Aachen University)

**Session Classification:** Associated top production

Contribution ID: **24** Type: **not specified**

# Photon production in top quark events at ATLAS and CMS

*Monday, 23 September 2024 17:00 (20 minutes)*

**Presenter:** RIBEIRO LOPES, Beatriz (CERN)

**Session Classification:** Associated top production

Contribution ID: **25** Type: **not specified**

# Top quark production in association with vector bosons at ATLAS and CMS

*Monday, 23 September 2024 17:30 (20 minutes)*

**Presenter:** VAN DER LINDEN, Jan (Ghent University (BE))

**Session Classification:** Associated top production

Contribution ID: **26** Type: **not specified**

# tt+HF (bb/cc) measurements from ATLAS and CMS

*Tuesday, 24 September 2024 09:00 (20 minutes)*

**Presenter:** ANTIPOV, Egor (Stony Brook University (US))

**Session Classification:** top-Higgs interplay

Contribution ID: **27** Type: **not specified**

# Higgs synergies with top in ATLAS and CMS

*Tuesday, 24 September 2024 09:30 (20 minutes)*

**Presenter:** VARRIALE, Lorenzo (Univ. of Valencia and CSIC (ES))

**Session Classification:** top-Higgs interplay

Contribution ID: **28** Type: **not specified**

# Five-flavour scheme predictions for ttbb at next-to-leading order accuracy

*Tuesday, 24 September 2024 10:00 (20 minutes)*

**Presenter:** MOSKALETS, Tetiana (Southern Methodist University (US))

**Session Classification:** top-Higgs interplay

Contribution ID: **29** Type: **not specified**

# ATLAS EFT results in the top quark sector

*Tuesday, 24 September 2024 11:00 (20 minutes)*

**Presenter:** KIM, Dongwon (Stockholm University (SE))

**Session Classification:** EFT

Contribution ID: **30** Type: **not specified**

# CMS EFT results in the top quark sector

*Tuesday, 24 September 2024 11:30 (20 minutes)*

**Presenter:** VAN DEN BOSSCHE, Niels (Ghent University (BE))

**Session Classification:** EFT

Contribution ID: **31** Type: **not specified**

# Indirect constraints on top quark operators from a global SMEFT analysis

*Tuesday, 24 September 2024 12:00 (20 minutes)*

**Presenter:** RODRIGUEZ SANCHEZ, Antonio

**Session Classification:** EFT

Contribution ID: **32** Type: **not specified**

# Four top final states with NLO accuracy in perturbative QCD: 4 lepton channel

*Tuesday, 24 September 2024 14:00 (20 minutes)*

**Presenter:** DIMITRAKOPOULOS, Nikolaos (Central Michigan University)

**Session Classification:** Searches with tops in decay

Contribution ID: **33** Type: **not specified**

# Measurement and searches of four-top quark production with the ATLAS and CMS

*Tuesday, 24 September 2024 14:30 (20 minutes)*

**Presenter:** QIN, Quake (Institut de Fisica d'Altes Energies (IFAE))

**Session Classification:** Searches with tops in decay

Contribution ID: **34** Type: **not specified**

# Top-philic ALP phenomenology at the LHC: the elusive mass-window

*Tuesday, 24 September 2024 15:00 (20 minutes)*

**Presenter:** MIMASU, Ken

**Session Classification:** Searches with tops in decay

Contribution ID: **35** Type: **not specified**

# Searches for scalar particles in top quark topologies in ATLAS and CMS

*Tuesday, 24 September 2024 15:30 (20 minutes)*

**Presenter:** JONES, Eleanor (Deutsches Elektronen-Synchrotron (DE))

**Session Classification:** Searches with tops in decay

Contribution ID: **36** Type: **not specified**

# Precise tests of the axion coupling to tops

*Tuesday, 24 September 2024 16:30 (20 minutes)*

**Presenter:** PHAN, Anh Vu ((1) Radboud University, (2) Nikhef)

**Session Classification:** top and BSM search

Contribution ID: **37** Type: **not specified**

# Searches for top associated DM production at the LHC

*Tuesday, 24 September 2024 17:00 (20 minutes)*

**Presenter:** STAFFORD, Dominic William (Deutsches Elektronen-Synchrotron (DE))

**Session Classification:** top and BSM search

Contribution ID: **38** Type: **not specified**

# Quantum detection of new physics in top-quark pair production at the LHC

*Tuesday, 24 September 2024 17:30 (20 minutes)*

**Presenter:** VRYONIDOU, Eleni (University of Manchester (GB))

**Session Classification:** top and BSM search

Contribution ID: **39** Type: **not specified**

# Hadronic Top Quark Polarimetry

*Wednesday, 25 September 2024 09:00 (20 minutes)*

**Presenter:** GONÇALVES, dorival (Oklahoma State University)

**Session Classification:** FCNC and lepton flavor violation

Contribution ID: **40** Type: **not specified**

# Comparisons of FCNC results from ATLAS and CMS

*Wednesday, 25 September 2024 09:30 (20 minutes)*

**Presenter:** ANDREA, Jeremy (Centre National de la Recherche Scientifique (FR))

**Session Classification:** FCNC and lepton flavor violation

Contribution ID: **41** Type: **not specified**

# Probes of flavor symmetry and violation with Top quarks in ATLAS and CMS

*Wednesday, 25 September 2024 10:00 (20 minutes)*

**Presenter:** WATSON, Miriam (University of Birmingham (GB))

**Session Classification:** FCNC and lepton flavor violation

Contribution ID: **42** Type: **not specified**

# YSF theory 1

*Wednesday, 25 September 2024 11:00 (10 minutes)*

**Session Classification:** Young Scientist Forum

Contribution ID: **43** Type: **not specified**

# YSF CMS 1

*Wednesday, 25 September 2024 11:15 (10 minutes)*

**Session Classification:** Young Scientist Forum

Contribution ID: **44** Type: **not specified**

# YSF ATLAS 1

*Wednesday, 25 September 2024 11:30 (10 minutes)*

**Session Classification:** Young Scientist Forum

Contribution ID: **45** Type: **not specified**

# YSF theory 2

*Wednesday, 25 September 2024 11:45 (10 minutes)*

**Session Classification:** Young Scientist Forum

Contribution ID: **46** Type: **not specified**

# Status of top-quark mass measurement

*Thursday, 26 September 2024 09:00 (30 minutes)*

**Presenter:** VOS, Marcel (IFIC Valencia (ES))

**Session Classification:** Theory mini workshop

Contribution ID: **47** Type: **not specified**

# Electroweak metastability and Higgs inflation

*Thursday, 26 September 2024 09:45 (20 minutes)*

**Presenter:** MASINA, Isabella (Universita e INFN, Ferrara (IT))

**Session Classification:** Theory mini workshop

Contribution ID: **48** Type: **not specified**

# The collider landscape: which collider for establishing the SM instability ?

**Presenter:** FRANCESCHINI, Roberto (Rome 3 U.)

**Session Classification:** Theory mini workshop

Contribution ID: **49** Type: **not specified**

# Vacuum Stability in the Standard Model and Beyond

*Thursday, 26 September 2024 11:45 (20 minutes)*

**Presenter:** STEUDTNER, Tom

**Session Classification:** Theory mini workshop

Contribution ID: **50** Type: **not specified**

# Higgs potential criticality beyond the Standard Model

*Thursday, 26 September 2024 11:15 (20 minutes)*

**Presenter:** STEINGASSER, Thomas (MIT)

**Session Classification:** Theory mini workshop

Contribution ID: **51** Type: **not specified**

# Theory talk missing 1

**Session Classification:** Theory mini workshop

Contribution ID: **52** Type: **not specified**

# The magic of entangled top quarks

*Thursday, 26 September 2024 14:00 (20 minutes)*

**Presenter:** WHITE, Chris (Queen Mary University of London)

**Session Classification:** Spin and entanglement

Contribution ID: **53** Type: **not specified**

# Full quantum tomography of top quark decays

*Thursday, 26 September 2024 14:30 (20 minutes)*

**Presenter:** AGUILAR SAAVEDRA, Juan Antonio (Consejo Superior de Investigaciones Científicas (ES))

**Session Classification:** Spin and entanglement

Contribution ID: **54** Type: **not specified**

# CMS results on top spin and entanglement

*Thursday, 26 September 2024 15:00 (20 minutes)*

**Presenter:** NEGRO, Giulia (Purdue University (US))

**Session Classification:** Spin and entanglement

Contribution ID: **55** Type: **not specified**

# ATLAS results on top spin and entanglement

*Thursday, 26 September 2024 15:30 (20 minutes)*

**Presenter:** LYSAK, Roman (Czech Academy of Sciences (CZ))

**Session Classification:** Spin and entanglement

Contribution ID: **56** Type: **not specified**

# CMS Joker talk 1

*Thursday, 26 September 2024 16:30 (20 minutes)*

**Session Classification:** Joker talks

Contribution ID: **57** Type: **not specified**

# ATLAS Joker talk 1

*Thursday, 26 September 2024 17:00 (20 minutes)*

**Session Classification:** Joker talks

Contribution ID: **58** Type: **not specified**

# ATLAS Joker talk 2

*Thursday, 26 September 2024 17:30 (20 minutes)*

**Session Classification:** Joker talks

Contribution ID: **59** Type: **not specified**

# CMS Joker talk 2

*Thursday, 26 September 2024 18:00 (20 minutes)*

**Session Classification:** Joker talks

Contribution ID: **60** Type: **not specified**

# YSF ATLAS 2

*Friday, 27 September 2024 09:00 (10 minutes)*

**Session Classification:** Young Scientist Forum

Contribution ID: **61** Type: **not specified**

# YSF CMS 2

*Friday, 27 September 2024 09:15 (10 minutes)*

**Session Classification:** Young Scientist Forum

Contribution ID: **62** Type: **not specified**

# YSF CMS 3

*Friday, 27 September 2024 09:45 (10 minutes)*

**Session Classification:** Young Scientist Forum

Contribution ID: **63** Type: **not specified**

# YSF ATLAS 3

*Friday, 27 September 2024 10:00 (10 minutes)*

**Session Classification:** Young Scientist Forum

Contribution ID: **64** Type: **not specified**

# Mapping the SMEFT at High-Energy Colliders: from LEP and the (HL-)LHC to the FCC-ee

**Presenter:** CELADA, Eugenia

**Session Classification:** Future

Contribution ID: **65** Type: **not specified**

# Theory Summary

*Friday, 27 September 2024 10:45 (45 minutes)*

**Presenter:** Prof. CZAKON, Michal Wiktor (Rheinisch Westfaelische Tech. Hoch. (DE))

**Session Classification:** Summaries

Contribution ID: **66** Type: **not specified**

# Experimental Summary

*Friday, 27 September 2024 11:30 (45 minutes)*

**Presenter:** JAFARI, Abideh (Isfahan University of Technology (IR))

**Session Classification:** Summaries

Contribution ID: **67** Type: **not specified**

# Top2025 announcement

*Friday, 27 September 2024 12:15 (10 minutes)*

**Session Classification:** Last words

Contribution ID: **68** Type: **not specified**

# Closing remarks

*Friday, 27 September 2024 12:25 (10 minutes)*

**Session Classification:** Last words

Contribution ID: **69** Type: **not specified**

# YSF theory 3

*Friday, 27 September 2024 09:30 (10 minutes)*

**Session Classification:** Young Scientist Forum

Contribution ID: **70** Type: **not specified**

# Mapping the SMEFT at High-Energy Colliders: from LEP and the (HL-)LHC to the FCC-ee

*Tuesday, 24 September 2024 18:00 (20 minutes)*

**Presenter:** CELADA, Eugenia

**Session Classification:** top and BSM search

Contribution ID: **71** Type: **not specified**

# The collider landscape: which collider for establishing the SM instability ?

*Thursday, 26 September 2024 10:45 (20 minutes)*

**Presenter:** FRANCESCHINI, Roberto (Rome 3 U.)

**Session Classification:** Theory mini workshop

Contribution ID: **72** Type: **not specified**

# Outreach talk at the mediathèque

*Thursday, 26 September 2024 18:20 (1 hour)*

Contribution ID: **73** Type: **Poster**

# CP-sensitive simplified template cross-sections for $t\bar{t}H$

The CP structure of the Higgs boson is a fundamental property which has not yet been constrained with high precision. CP violation in the Yukawa coupling between the Higgs boson and top quark pair can be probed directly at the Large Hadron Collider by measuring top-quark-associated Higgs production. Multivariate analysis techniques commonly developed so far by the experiments are designed for a specific signal model and, therefore, complicate reinterpretations and statistical combinations. With this motivation in mind, we propose a CP-sensitive extension of the simplified template cross-section (STXS) framework. Considering multiple Higgs decay channels, we perform an in-depth comparison of CP-sensitive observables and combinations thereof. Our resulting proposal is to extend the existing binning in the transverse momentum of the Higgs boson $p_{T,H}$ by either the pseudorapidity difference of the two top-quarks $\Delta\eta_{t\bar{t}}$, or a variable that is based on the top quark momenta, namely $b_2$ or the Collins-Soper angle $|\cos\theta^*|$. We demonstrate that this variable selection provides close to optimal sensitivity to the CP mixture in the top Yukawa coupling for an integrated luminosity of 300 fb$^{-1}$, by comparing it to the results of a multivariate analysis. Our results also suggest a benefit of the two-dimensional STXS extension at 3000 fb$^{-1}$.

**Primary authors:** CARNELLI, Alberto (Université Paris-Saclay (FR)); KOTSOKECHAGIA, Anastasia (CERN); FUCHS, Elina (Leibniz Universitaet Hannover (DE)); DELIOT, Frederic (Université Paris-Saclay (FR)); BAHL, Henning; SCHOEFFEL, Laurent Olivier (Université Paris-Saclay (FR)); MENEN, Marco (Leibniz Universität Hannover); SAIMPERT, Matthias (CEA - IRFU - Université Paris-Saclay (FR))

**Presenter:** CARNELLI, Alberto (Université Paris-Saclay (FR))

Contribution ID: **74** Type: **not specified**

# Welcome from the French institute representatives

*Monday, 23 September 2024 09:10 (15 minutes)*

**Session Classification:** Introduction

Contribution ID: **75** Type: **Poster**

# Application of Machine Learning Top and W Jet Tagging to Hadronic Four-Top Final States

We present an application of the gradient boosting machine learning technique for tagging top quark and W jets in hadronic four-top final states induced by both Standard Model (SM) and Beyond the Standard Model (BSM) processes. Our approach utilizes classical subjettiness variables within the framework of the Delphes common parameterized detector simulation package. Jets produced in simulated proton-proton collisions at sqrt(s) = 14 TeV are identified as consistent with the hypothesis of originating from the decay of a top quark or a W boson and are used to reconstruct the mass of a hypothetical scalar resonance decaying into a pair of top quarks in events where four top quarks are produced. To evaluate the performance of our machine learning-based approach, we compare the results with those obtained using a simple cut-based tagging technique. Stacked histograms of a mixture of SM and BSM processes are analyzed, and the mass peak of the scalar resonance within the four-top final state is fitted to evaluate the performance of the ML and cut-based approaches. The application of these ML techniques enhances our ability to discern top quarks and W jets, contributing to a better understanding of the underlying physics processes. The results provide valuable insights for future experimental analyses, enabling the exploration of both SM and BSM physics scenarios.

**Primary authors:** KVITA, Jiri (Palacky University (CZ)); BARON, Petr (Palacky University (CZ)); PRIVARA, Radek (Palacky University (CZ))

**Presenter:** BARON, Petr (Palacky University (CZ))