# T 76: Search for Dark Matter 3

Time: Wednesday 16:15–18:30 Location: T-H35

T 76.1 Wed 16:15 T-H35

**Search for dark matter production in association with a single-top and w-boson with the ATLAS experiment** — •Alvaro Lopez Solis — DESY-Zeuthen, Zeuthen, Germany

Measurements at large scales suggest that Dark Matter (DM) constitutes around 27% of all the energy available in the Universe and around 85% of all the available mass. However, its nature remains a mystery. Several theories try to address this problem by suggesting the existence of new weakly interacting particles that would constitute most of this new type of energy. This talk will present a search using the ATLAS experiment at LHC for these weakly interacting particles. It is motivated by the hypothesis that DM particles would couple to the Standard Model (SM) particles via a pseudo-scalar mediator within an extended two-Higgs-doublet model (2HDM+a). Among all the possible signatures predicted by this model, this talk will present the search for DM production in association to a single-top quark and a W-boson in channels where both, top and W-boson, are assumed to decay hadronically (0L channel) or either one of them decay leptonically (1L channel).

T 76.2 Wed 16:30 T-H35

**Search for Dark Matter at the ATLAS detector with a W-boson and a top-quark in the final state** — •Paul Moder[1], Alvaro Lopez Solis[2], Ben Brüers[2], and Claudia Seitz[1] — [1]DESY Hamburg — [2]DESY Zeuthen

The Standard Model (SM) is one of the most robust models in particle physics containing all observed elementary particles and their interactions. Over the years, its predictions were tested and proven in a number of experiments. However, there are still observations that can not be explained by the SM with one of the most prominent ones being the existence of Dark Matter (DM). While the existence of DM was first theorised through astronomical observations, extensions of the SM allow for a search of DM at the Large Hadron Collider (LHC) as well. Since DM can not be detected directly, final states analysing its existence at the LHC are always designed around high missing transverse energy. This talk will present such a search at the ATLAS detector based on an extended two-Higgs-doublet model (2HDM+a) where the pseudo-scalar mediator allows the production of DM in the final state. In addition to the DM, a top-quark and a W-boson are produced in the final state, where the W-boson of this signal process can be expected to have high momentum. This allows for a unique technique by tagging these W-bosons through large-radius jets increasing the sensitivity of the signal process. This talk presents the cut-based definitions for an analysis with zero leptons in the final state as well as the most recent results.

T 76.3 Wed 16:45 T-H35

**Search for Dark Matter in a tW+MET signature with the ATLAS experiment** — •Ben Brüers — Deutsches Elektronen Synchrotron DESY, Zeuthen, Germany

Dark Matter (DM) remains one of the unrevealed mysteries of the universe. Even though it constitutes $\sim 80\%$ of the matter, considerably little is known about DM, despite it significantly influences the dynamics of galaxies and the expansion of the universe. The search for DM at colliders, probing mainly a particle nature of the unknown matter, marks an important pillar in exploring all possible realisations of DM. This talk will present a search for DM with the ATLAS experiment, where the DM is coupled to the Standard Model (SM) via a pseudo-scalar mediator within an extended two-Higgs-doublet model (2HDM+a). The associated production of DM with a W-boson and a top-quark is considered. As the DM deposits no energy in the detector, the experimental signature includes high missing transverse energy ($E_{\mathrm{T}}^{\mathrm{miss}}$). To reconstruct highly energetic W-bosons, expected for signals with a heavy $\mathrm{H}^{+}$, large-radius jets are employed. The talk will give an introduction to the analysis and present the most recent results.

T 76.4 Wed 17:00 T-H35

**Search for dark matter produced in association with two top quarks and missing energy in the final state using ATLAS 13 TeV pp collision data** — •Marco Rimoldi — DESY, Hamburg, Germany

The hypothesis of the existence of non-baryonic dark matter (DM) comes from gravitational evidence across a wide range of astrophysical and cosmological systems. Of the many types of DM candidate proposed, weakly interacting massive particles (WIMP) are believed to be a theoretically convincing candidate. WIMPs must interact weakly with electromagnetic radiation and be consistent with the expected DM density. If WIMPs are the manifestation in nature of DM, then it may be possible to produce it directly at the LHC.

Results of the combination of four analyses are presented, selecting final state events with two top quarks and invisible particles. Proton proton collisions data collected by the ATLAS experiment at a centre-of-mass energy of 13 TeV during the Run-2 data-taking are used. Results are interpreted in terms of dark matter simplified models considering a spin-0 mediator to dark sector.

Upper limits on the Higgs boson invisible branching ratio, where the Higgs is produced according to the Standard Model in association with a pair of top quarks are also reported.

T 76.5 Wed 17:15 T-H35

**Search for new physics in $t\bar{t}$+$\mathrm{E}_T^{miss}$ final states in pp collisions at 13 TeV with the ATLAS experiment.** — •Simran Gurdasani — Albert-Ludwigs-Universität, Freiburg, Germany

This talk will present the developments of an ongoing search for Beyond Standard Model (BSM) signatures that can be probed using the $t\bar{t}$+$\mathrm{E}_T^{miss}$ final state at the Large Hadron Collider (LHC). Neural Networks are used for the search which is performed on data collected with the ATLAS detector between 2015 and 2018, corresponding to 139 $fb^{-1}$ of pp data at 13 TeV. Models specifically targeted include DM production via scalar or pseudo-scalar mediators, SUSY stop pair production and Higgs decays to new invisible particles. A two-fold implementation of neural nets is designed, where the first step aims to efficiently reconstruct the hadronically decaying top quarks in a given event. This is designed to specifically target mid-pt range tops decaying to resolved jets. The second step aims to exploit full kinematic correlations of the $t\bar{t}$+$\mathrm{E}_T^{miss}$ system and tag a given event to one of the targeted BSM processes while providing background rejection against both major (ttbar and Wjets) and non-major SM processes. The talk will give an overview of the strategy developed and the status of ongoing optimization studies.

T 76.6 Wed 17:30 T-H35

**Combining Dark Matter searches with top quarks with the ATLAS detector** — •Marianna Liberatore — Deutsches Elektronen-Synchrotron DESY, Hamburg and Zeuthen, Germany

A motivation to WIMP dark matter (DM) searches at the LHC, and in particular in ATLAS, is the especially promising possibility that interactions between ordinary matter and DM are mediated by new spin-0 particles. Such particles would extend the SM with a potential dark sector, to which DM particles belong. Similarly to the Higgs boson, these new mediators interact strongest with the heaviest particles via Yukawa-type couplings, making them more prone to associated production with heavy-flavour quarks.

To test those models, two recently released search channels are considered within ATLAS: DM with top quark pairs[1] or a single top quark[2], with a focus on the two charged leptons final states. This talk will motivate how the statistical combination of these two results in simplified models could significantly enhance the sensitivity to DM signals, and the first results of these combined studies will be presented.

[1] JHEP04(2021)165
[2] Eur.Phys.J.C(2021)81:860

T 76.7 Wed 17:45 T-H35

**Searching for Dark Matter in top quark production with the CMS experiment** — Danyer Perez Adan, Afiq Anuar, Alexander Grohsjean, Laurids Jeppe, Jonas Rübenach, Christian Schwanenberger, •Dominic Stafford, and Nicole Stefanov — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

Astronomical observations provide strong evidence that a large proportion of the matter in the universe is "Dark Matter" (DM), which is currently not included in the Standard Model (SM) of particle physics. Furthermore, many cosmological models suggest Dark Matter should couple to the SM around the 100 GeV scale, and hence may be pro-

duced at the LHC, appearing as missing transverse momentum. We present a search for Dark Matter produced in association with top quarks, via a spin-0 mediator, with a focus on the dileptonic channel. This analysis will be part of the upcoming CMS result with the full Run-2 dataset, and will be the first to combine the top quark pair + DM and single top + DM processes for dileptonic, semileptonic and full hadronic final states, which greatly aids sensitivity to the highest mediator masses in the search.

The dileptonic channel poses an interesting challenge due to a large amount of missing transverse momentum in the SM $t\bar{t}$ background, and an irreducible $t\bar{t}Z(Z \to \nu\nu)$ background. This analysis therefore uses novel variables and machine learning techniques in the signal extraction, and new control regions to constrain the irreducible backgrounds.

T 76.8 Wed 18:00 T-H35

**Performance of different MET reconstruction methods in a monotop DM analysis** — •Jost von den Driesch[1], Sebastian Wieland[1], Michael Wassmer[1], Nikita Shadskiy[1], Ulrich Husemann[1], Matteo Cremonesi[2], Lindsey Gray[3], and Yihui Lai[4] — [1]Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT) — [2]University of Notre Dame (ND) — [3]Fermilab — [4]University of Maryland (UMD)

Missing transverse momentum (MET) is an important quantity in many analyses at hadron colliders. Especially Dark Matter (DM) analyses often make use of this quantity as DM particles leave the detector without interactions and therefore create large amounts of MET. However, due to its origin from non-detectable particles, MET cannot be measured directly, but must be estimated from the transverse momentum of all reconstructable particles.

Over the years, various MET reconstruction methods have been developed and applied at CMS. The latest approaches use machine learning methods, e.g. Convolutional Neural Networks (DeepMET) or Graph Neural Networks (GraphMET). Monte Carlo studies show an improvement of MET reconstruction performance by these novel reconstruction methods compared to the older ones. Yet, it remains unclear how large this effect will be in a full analysis.

This talk will introduce the aforementioned MET reconstruction methods and compare their expected impact on a monotop analysis, aimed at the search for Dark Matter in events with a single top quark and large MET.

T 76.9 Wed 18:15 T-H35

**Search for axion-like particles (ALPs) at Belle II experiment.** — •Awais Bin Zahid, Pablo Goldenzweig, and Torben Ferber — Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

One possible extension of the Standard Model (SM), which may contribute in solving the mystery of Dark Matter (DM) and/or explain some astrophysical anomalies, are Axion-Like Particles (ALPs). The model taken into consideration in this search is of an ALP interacting with SM photons with a coupling strength $g_{a\gamma\gamma}$ and having mass $m_a$. The search for the direct production of such an ALP via the process (ALP-Strahlung) $e^+e^- \to \gamma a(a \to \gamma\gamma)$, is performed in the mass range $0.2 < m_a < 9.8$ GeV/$c^2$. Given that the final state of the $e^+e^- \to \gamma a(a \to \gamma\gamma)$ process is fully neutral, being made up of three photons, a proper kinematic fit with neutral particles is a powerful tool to improve signal resolution. In this talk, I will present the status of sensitivity evaluation based on Monte Carlo simulation which corresponds to the data of almost 500 $fb^{-1}$ that will be collected by Belle II at the end of summer 2022.