T 31: Methods in particle physics 3 (lepton reconstruction)

Time: Tuesday 16:00–18:00 Location: Geb. 20.30: 2.066

T 31.1 Tue 16:00 Geb. 20.30: 2.066

Measurement of the tau lepton identification efficiencies using LHC Run 3 data with the ATLAS detector — •Baktash Amini, Christian Weiser, Karsten Köneke, and Karl Jakobs — Albert-Ludwigs-Universität Freiburg

Final states with tau lepton decays are crucial components of the ATLAS physics program at the LHC. Efficient and precise reconstruction and identification of tau leptons are required in order to obtain the best possible measurements of processes containing tau leptons. This talk presents measurements of the identification efficiencies of tau leptons that decay to a single neutrino and hadrons (τ_{had}), using LHC data recorded with the ATLAS detector during proton-proton collisions at $\sqrt{s} = 13.6$ TeV. The so-called Tag-and-Probe method is employed using Z boson decays into two tau leptons, where the “Tag” is the tau lepton that decays to two neutrinos and an electron or muon (τ_{lep}), while the “Probe” is the τ_{had} decay of interest ($Z \to \tau_{lep}\tau_{had}$).

T 31.2 Tue 16:15 Geb. 20.30: 2.066

Reconstruction of boosted di-tau topologies with CMS — •Olha Lavoryk, Markus Klute, Roger Wolf, Günter Quast, Sebastian Brommer, and Artur Gottmann — Karlsruhe Institute of Technology(ETP), Karlsruhe, Germany

The precise measurement of the Higgs boson properties remain pivotal in understanding the fundamental principles of particle physics. For the CMS experiment, the reconstruction of boosted Higgs bosons presents unique challenges, demanding innovative techniques for accurate identification and analysis. We explore novel approaches leveraging graph neural networks (GNNs) to enhance the reconstruction of boosted Higgs bosons within the CMS experiment, particularly focusing on the Higgs decay channel into a pair of tau leptons. This channel holds significant promise owing to the strong Yukawa coupling between the Higgs boson and the tau lepton. The proposed GNN-based methodologies are targeted for the reconstruction of boosted Higgs boson decays within the Run-2 dataset of the CMS experiment.

T 31.3 Tue 16:30 Geb. 20.30: 2.066

ML4Taus: Tau decay mode classification using CNNs on Calorimeter Data — •Jonathan Pampel[1], Jochen Dingfelder[1], Tatjana Lenz[1], Christina Dimitriadi[1], and Duc Bao Ta[2] — [1]Rheinische Friedrich-Wilhelms-Universität, Bonn, Germany — [2]Johannes Gutenberg Universität, Mainz, Germany

The tau-lepton is the heaviest charged lepton with a mass of about twice the mass of the proton. It can decay leptonically into two neutrinos and another lepton or hadronically into one neutrino and some hadrons, the latter being mostly pions. In the ATLAS collaboration at CERN, there are already several algorithms for the decay mode classification of hadronically decaying tau-leptons (tau-jets).

This talk presents a novel technique based on convolutional neural networks to classify the hadronic tau-lepton decay modes. The goal is to determine the number of neutral and charged pions in a tau-jet using calorimeter information. To do this, for each calorimeter layer, an ‘image’ of the tau-jet is generated. These ‘images’ are used as input for a neural network built from several 2D convolution and pooling layers and a flattening layer followed by a number of dense layers.

The talk includes an introduction to tau decay mode classification as well as a visualization of the preprocessed data which is fed into the neural network. Finally, the best performing neural network*s architecture and its performance will be presented. All performance evaluation is done using ATLAS Run 2 $\gamma^* \to \tau\tau$ Monte Carlo samples.

T 31.4 Tue 16:45 Geb. 20.30: 2.066

Muon Momentum Scale and Resolution Corrections for CMS — •Dorian Guthmann[1], Jost von den Driesch[1], Markus Klute[1], and Filippo Errico[2] — [1]Karlsruhe Institute of Technology — [2]Istituto Nazionale di Fisica Nucleare Roma

In the context of the Compact Muon Solenoid (CMS) Experiment at the LHC, a precise measurement of muon momenta plays a crucial role. Muons hold significant importance in various particle physics analyses. However, deviations between recorded data and simulation arise due to detector effects. To address this challenge, scale and resolution corrections are applied to the transverse momentum of muons. These corrections aim to mitigate biases, aligning the theoretical description of muons with their experimental counterpart. This presentation will provide an overview of the current standard method in CMS and outline possible improvements to the procedure for run 3.

T 31.5 Tue 17:00 Geb. 20.30: 2.066

Muon reconstruction and identification efficiency in ATLAS with run-3 pp collision data — •giorgia proto and davide Cieri — Max Planck Institute Fur Physik

The identification and precise measurement of processes with muons in the final state is one of the main goal of the ATLAS experiment at the LHC and HL-LHC. Muons are produced in many important physics processes and are detected by the Muon Spectrometer with almost 100%-efficiency and good momentum resolution. Muon reconstruction and identification efficiencies are measured using the tag-and-probe method using $Z \to \mu\mu$ sample in the bulk of the space-phase. In the low-p_T region, the same method is applied on $J/\Psi \to \mu\mu$ sample.
The measured efficiency in Monte Carlo (MC) samples is then compared with that obtained from dataset. The agreement between the efficiency measured in data and the corresponding efficiency in MC is called Scale Factor and is used to quantify the deviation of the simulation from the real detector behaviour and is then used to correct the simulation in physics analyses.
This presentation reports the muon reconstruction and identification efficiency and the relative scale factors measurements in ATLAS during the Run 3 data taking for pp collisions at $\sqrt{s} = 13.6$ TeV collected in 2022 and 2023.

T 31.6 Tue 17:15 Geb. 20.30: 2.066

Investigating Shower Generator Dependence of Muon Isolation Efficiency for the ATLAS Collaboration — •Lars Linden[1], Stylianos Angelidakis[2], Christoph Ames[1], Youn Jun Cho[1], Stefanie Götz[1], Edis Hrustanbegovic[1], Celine Stauch[1], Lukas von Stumpfeldt[1], and Otmar Biebel[1] — [1]Ludwig-Maximilians-Universität, München — [2]National and Kapodistrian University, Athens

Muons originating from bosons are of vital importance for various physics analyses, therefore exact knowledge of the expected efficiencies of both the detectors and algorithms is important. In ATLAS simulations, the isolation efficiency exhibits a dependency on the parton shower generator model used. The corresponding differences for the PYTHIA and Sherpa generators used in simulation contribute a significant systematic uncertainty in muon isolation efficiency measurements. Because of this, the generator dependence is investigated using $Z \to \mu\mu$ samples generated using POWHEGBOX + PYTHIA 8 and Sherpa 2.2.11 Monte Carlo generators This talk presents the results of studies investigating the effect of shower generator differences on variables relevant for muon isolation algorithms.

T 31.7 Tue 17:30 Geb. 20.30: 2.066

Development of the Prompt Lepton Improved Veto — Arnulf Quadt, Baptiste Ravina, and •Tim Schlömer — I. Physikalisches Institut, Georg-August-Universität Göttingen

Prompt leptons originate from decays of heavy bosons like the W- and Z-boson, produced in the hard scattering process. These leptons originate from the primary vertex, due to the short lifetime of the bosons. In contrast, non-prompt, or fake leptons are mostly produced in semileptonic decays of c- or b-hadrons, which are characterised by a longer lifetime and therefore of a distinct secondary vertex.

The selection is mostly based on isolation observables like the measured energy activity around the lepton candidates. It is very important to select the prompt leptons, and fake leptons are important backgrounds in many multi-lepton analyses. In multi-lepton analyses, like $t\bar{t}H$, $t\bar{t}W$ or $t\bar{t}t\bar{t}$, fake leptons are the dominant background, even with the tightest isolation criteria.

One of the algorithms used in the ATLAS Collaboration that identify prompt leptons and veto fake leptons is the "Prompt Lepton Improved Veto" (PLIV), using several isolation, and additionally lifetime observables to distinguish between prompt and fake leptons. The most important input is a lifetime observable constructed from track information. Other important inputs are isolation observables such as ΔR between lepton and track jet, and the transverse momentum in a cone around the lepton.

For the improvement of PLIV, studies on new Neural Network architectures and calibration are performed.

T 31.8 Tue 17:45 Geb. 20.30: 2.066

Prompt Lepton Improved Veto (PLIV) Muon Studies and Application for Multi-Lepton Final States — •Stephen Eggebrecht, Steffen Korn, Arnulf Quadt, Baptiste Ravina, and Tim Schlömer — II Physikalisches Institut, Georg August Universität Göttingen

Prompt leptons originate from decays of electroweak bosons, like W and Z, or from Higgs bosons and are associated with tracks matching with the primary collision vertex. In contrast, non-prompt or fake leptons may be produced in c- or b-hadron decays and are usually associated with secondary vertices. In multi-lepton $t\bar{t}H$ or four top analyses, fake-leptons are a major background even with tight standard isolation and impact parameter requirement. Other multivariate techniques which identify prompt-leptons while veto non-prompt are needed.

The prompt lepton improved veto (PLIV) uses several input features such as standard isolation variables. Using additional isolation variables constructed with calorimeter information and lepton lifetime information from the combination of direction and impact parameter variables of reconstructed lepton tracks, the performance is improved. In this talk, new neural network techniques for PLIV for non-prompt muon rejection are presented and discussed. Furthermore, the first steps of calibration and application for multi-lepton final states are shown.