T 83: Methods in Particle Physics IV (Lepton Reconstruction)

Time: Thursday 16:15–18:45 Location: VG 4.101

T 83.1 Thu 16:15 VG 4.101

Electron Reconstruction Efficiencies in Run 2 and Run 3 at ATLAS — •Marius Melcher, Asma Hadef, and Arno Straessner — Technische Universität Dresden

Before particles detected by the ATLAS experiment can be used in physics analyses, their measured signatures undergo several analysis steps, e.g. reconstruction and identification. It is crucial that these steps and their performances are well understood. This talk will focus on the electron reconstruction and the measurement of its efficiency.

For electron reconstruction, information from different parts of the detector needs to be connected: a track from the Inner Detector is matched to energy deposits in the EM calorimeter by reconstruction algorithms. To estimate how many real electrons successfully pass these algorithms the tag-and-probe method is used for $Z \to ee$ decays to measure efficiencies both for data and Monte Carlo simulation in dependence of p_T and η. These results are then used to derive scale factors which are applied to correct MC predictions in subsequent analyses with electrons in the final state. In addition to the scale factors also their uncertainty is passed to the analyses. Understanding and controlling the systematic uncertainties of the efficiency measurement is therefore crucial.

After introducing the method and its data-driven approach for background estimation, recent results for the full Run 2 and already available Run 3 datasets are discussed.

T 83.2 Thu 16:30 VG 4.101

Likelihood Tuning for LHC Run 3 — •Max Fusté Costa[1], Martina Laura Ojeda[2], and Sarah Heim[1] — [1]DESY, Hamburg, Germany — [2]CERN, Geneva, Switzerland

A likelihood-based identification (LH ID) is used to identify the reconstructed electrons in the ATLAS detector and to reject hadronic jets and electrons from heavy flavor decays. Due to differences between Run 2 and 3 at the LHC, the LH ID needs to be retuned. The transverse momentum range of the tuning will be extended as well. This is done using Run 3 Monte Carlo samples, with observables adjusted using the Shift and Stretch (S&S) method to match the data. The performance of the tuning and the fudging are evaluated through efficiency measurements.

T 83.3 Thu 16:45 VG 4.101

Photon identification at the CMS experiment using particle flow candidates and individual calorimeter energy deposits — •Caio Daumann and Johannes Erdmann — III. Physikalisches Institut A, RWTH Aachen University

Many physics processes under study at the Large Hadron Collider are characterized by the presence of photons in the final state. Consequently, the performance of photon identification algorithms is crucial for the physics reach of the CMS experiment. Currently, the photon identification algorithm is based on a Boosted Decision Tree that utilizes high-level variables as input, such as shower shapes and isolation variables. Instead of relying on high-level variables, we investigate the performance of a photon classifier trained on low-level quantities, such as individual energy deposits in the calorimeter and particle-flow candidates surrounding the photon, from which high-level information is typically derived. Modern machine learning architectures are well-known for their ability to extract informative features directly from raw training data, often outperforming classifiers based on high-level variables. In this study, we report the performance of a classifier trained using such low-level information.

T 83.4 Thu 17:00 VG 4.101

Measurement of photon identification efficiency with the inclusive photon method using 2022 CMS data — Johannes Erdmann, •Nitish Kumar, and Jan Lukas Späh — III. Physikalisches Institut A, RWTH Aachen University

The measurement of the photon identification efficiency is an essential component of all analyses using photons. Conventionally, the CMS collaboration uses the tag-and-probe technique to measure the photon identification efficiencies up to photon p_T of 500 GeV. This method is limited by small event yields in the high-p_T region and the extrapolation beyond 500 GeV is associated with additional uncertainties, which is relevant for analyses involving high-p_T photons.

The inclusive photon method, also known as the matrix method, allows a precise measurement of the photon identification efficiencies at high photon p_T. This method uses an inclusive photon sample selected with single photon triggers. It utilizes isolation criteria to obtain the fraction of prompt photons in the whole sample and the subsample meeting the identification criteria. This allows the extraction of the photon identification efficiency in a data-driven way. In this talk, we present the preliminary measurement results of photon identification efficiencies with the inclusive photon method using data collected by the CMS experiment in 2022, including the associated systematic uncertainties.

T 83.5 Thu 17:15 VG 4.101

Determination of Universal Tau Fake Factors for the Run 3 Data Taking Period of ATLAS — •Christian Schmidt, Arno Straessner, and Asma Hadef — Institut für Kern- und Teilchenphysik, Technische Universität Dresden

Tau leptons are an important product in collision events at the LHC; they primarily decay into a hadronic final state. Hadronic jets can easily produce similar signatures inside the ATLAS detector, i.e. fake taus, so it becomes necessary to estimate the fake tau background. The Fake Factor (FF) method estimates this background from data events with non-isolated tau candidates using a correction factor which depends on the transverse momentum of the tau candidate. In addition, the FF depends on the origin of the fake-producing jets, such as quark or gluon jets. Instead of measuring the FFs in a separate control region for each physics analysis, the Universal Fake Factor (UFF) method uses an estimate of the jet composition to linearly interpolate the FFs.

This talk will present the general principles of the UFF method, the process of calculating parameters to be used for determining the UFF parameters in ATLAS Run 3 data, and current results.

T 83.6 Thu 17:30 VG 4.101

Measurement of Tau Identification Scale Factors in the $W \to \tau\nu$ Channel Using LHC Run 3 Data — •Luka Vomberg, Christian Grefe, Philip Bechtle, and Klaus Desch — Physikalisches Institut Bonn

Measurement of Tau Identification Scale Factors in the $W \to \tau\nu$ Channel Using LHC Run 3 Data

Scale factors are necessary to calibrate the selection efficiency for the identification of hadronic tau-lepton decays in simulation to the observed efficiencies in data. These factors are determined for all ATLAS analyses in dedicated tag-and-probe studies.

A measurement of tau identification (ID) scale factors using 2022 data from LHC Run 3 is presented, focusing on the $W \to \tau\nu$ channel. This channel offers a higher transverse momentum reach than $Z \to \tau\tau$ or $t\bar{t}$ due to the W-boson recoiling from a jet, and allows tight missing energy cuts because of the neutrino in the final state. The primary challenge is the large dijet QCD background, addressed using the data-driven ABCD method.

The entire measurement workflow is implemented with Snakemake, providing a novel and systematic solution to ensure easy reproducibility and interoperability - an essential but often overlooked aspect of such measurements. Additionally, new strategies for improving fake tau estimation are proposed to enhance the measurement's precision and reliability.

T 83.7 Thu 17:45 VG 4.101

Inference of the Neutral Four-Momentum of Hadronic τ-Leptons using Neural Networks in ATLAS — •Simon Thiele[1], Lukas Cieslik[1], Christian Grefe[1], Alessandra Betti[2], Philip Bechtle[1], and Klaus Desch[1] — [1]Rheinische Friedrich-Wilhelms Universität Bonn — [2]Sapienza Università di Roma

Reconstructing the four-momenta of neutral decay products of hadronically decaying τ-leptons, which are almost exclusively π^0's, allows to infer the spin of the τ. This allows for example to measure the CP of the Higgs boson. Therefore it is desirable to reconstruct this momentum as accurately as possible, which is challenging since the photons from the π^0 decays are only measured in the electromagnetic calorimeter.

Currently these neutral decay products are reconstructed in ATLAS using the Tau-Particle-Flow algorithm, which also performs a decay mode identification, classifying the tau jets by the number of charged and neutral hadrons they contain. In recent years a new neural network based decay mode classifier has been developed. This new classifier has a higher efficiency than the current algorithm. But since it is only a classifier without a reconstruction of the neutral four-momentum, this gain in efficiency is not accessible to these Higgs CP studies. Therefore we are currently working on developing a neural network based solution for that also provides inference of the neutral four-momentum.

In this talk I will first go over this motivation and the current state of the art algorithms and then discuss the performance of the new neural network solution.

T 83.8 Thu 18:00 VG 4.101

Muon Momentum Scale and Resolution Calibration for CMS — •Dorian Guthmann, Markus Klute, and Jost von den Driesch — Karlsruher Institut für Technologie, Karlsruhe, Deutschland

Many analyses conducted with the CMS experiment at the LHC rely on a precise description of muon momenta. However, deviations between data and simulation arise due to mismodeling of the detector, such as misalignment and limited magnetic field precision. To address this, scale and resolution corrections are applied to the transverse momentum of muons, mitigating biases and aligning the theoretical description of muons with their experimental counterpart. This presentation will provide an overview of the progress made over the past year in refining and enhancing these corrections.

T 83.9 Thu 18:15 VG 4.101

Reconstruction of Stand-Alone Muons in Run 3 of ATLAS — •Celine Stauch[1], Otmar Biebel[1], Valerio D'Amico[1], Stefanie Götz[1], Lars Linden[1], Bao Tai Le[1], Tim Rexrodt[1], and Giorgia Proto[2] — [1]LMU Munich — [2]MPI Munich

The identification and reconstruction of muons is an essential aspect for precise measurements of processes including muons in the final states of the ATLAS experiment at the LHC and HL-LHC. Various important physics processes produce muons which are detected by the Muon Spectrometer with almost 100 %-efficiency and good momentum resolution. Muons in the very forward region of the detector are called stand-alone muons. These muons are outside the reach of the Inner Track detector and are reconstructed solely using the Muon Spectrometer.

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 behavior and is then used to correct the simulation in physics analyses.

T 83.10 Thu 18:30 VG 4.101

Estimation of Non-Prompt Lepton Backgrounds with Classical and Machine Learning Techniques — Korn Steffen, Quadt Arnulf, and •Schiel Nico — II. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Non-prompt leptons are a significant background in many particle physics analyses, for example $t\bar{t}$ and HWW^* analyses. These processes depend on the modelling of parton showers and are therefore challenging to predict theoretically. Consequently, data-driven approaches are utilised to model backgrounds arising from non-prompt leptons. Often, classical methods such as the fake-factor method are used. However, machine learning based methods such as normalising flows also show promising results for modelling non-prompt leptons. In this talk, both approaches are compared with respect to their performance.