T 40: Experimental methods II

Time: Tuesday 16:00–18:30 Location: To

T 40.1 Tue 16:00 To

Track reconstruction for the Mu3e experiment — •Alexandr Kozlinskiy for the Mu3e-Collaboration — Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, Johann-Joachim-Becher-Weg 45, 55128 Mainz, Germany

The *Mu3e* experiment will search for the lepton flavour violating decay $\mu^+ \to e^+e^-e^+$ with the aim to reach a branching ratio sensitivity of 10^{-16}. The first phase the experiment will be performed at an existing beam line providing 10^8 muons per second at the Paul-Scherrer Institute (Switzerland) which will allow to reach a sensitivity for the branching fraction of 10^{-15}. The muons will stop on a target and decay at rest. The decay products (positrons and electrons) with energies below 53 MeV are measured by a tracking detector consisting of two double layers of 50 μm thin High-Voltage Monolithic Active Pixel Sensors (HV-MAPS). The high granularity of the pixel detector with a pixel size of 80×80 μm allows for a precise track reconstruction in the high occupancy environment of the *Mu3e* experiment. The *Mu3e* track reconstruction uses a novel fit algorithm that in the simplest case takes into account only the uncertainty due to multiple scattering, which allows fast online tracking on a GPU based filter farm. The implementation of the 3-dimensional multiple scattering fit based on hit triplets is described. An extension of the fit that takes into account energy losses and pixel size is used for offline track reconstruction. The algorithm and performance of the offline track reconstruction based on a full Geant4 simulation of the *Mu3e* detector are presented.

T 40.2 Tue 16:15 To

Status and outlook of the CMS fast Monte Carlo simulation chain (FastSim) — •Samuel Bein — Universitaet Hamburg, Hamburg, Germany

The High Luminosity LHC is expected to deliver a total integrated luminosity of 3 fb^{-1} to the CMS detector by the end of the next decade, a data set roughly 30 times larger than that obtained before the current date. This significant ramp up will enhance the importance of fast Monte Carlo simulation programs, both to satisfy computing budget requirements, and to provide analysis teams with accurate simulated event samples in a timely manner. The CMS experiment plans to develop its existing fast simulation program (FastSim), a factor of 10 faster than the Geant4-based full simulation, in order to fulfill a larger fraction of the collaboration's needs. The current performance of FastSim is highlighted, and the status of various developments, including the use of generative models to improve the accuracy of high-level physics observables, is discussed.

T 40.3 Tue 16:30 To

Direct-photon plus jets production in Powheg — •Yanwen Hong, Thomas Peiffer, Arnulf Quadt, and Elizaveta Shabalina — II. Physikalisches Institut, Georg-August-Universität Göttingen

Photons and photons-plus-jets production play an important role in high-energy collisions. Theoretical predictions for final-state photon production in pp, pPb, and PbPb collisions have been available at leading order (LO) and next-to-leading-order (NLO), and have been implemented in Monte Carlo generators like Sherpa. For direct-photon production, NLO samples are available only with the Sherpa generator and have been shown to provide a good description of data. An alternative sample, generated using the matrix element Monte Carlo generator Powheg, would help to provide an estimate of the systematic uncertainties in the modelling and to have a better understanding of these final states. The talk covers the following. A setup at NLO using the Powheg direct-photon process is studied. Configuration for di-photon plus jets samples with MadGraph5 interfaced with Pythia8 at NLO using the FxFx merging scheme is prepared, and a validation against the Sherpa setup and unfolded data using Rivet is performed. Finally, the effects of changing certain MC parameters and merging scale variations are studied.

T 40.4 Tue 16:45 To

Track reconstruction with ACTS — Florian Bernlochner, Jochen Dingfelder, and •Ralf Farkas for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

The reconstruction of trajectories of charged particles is a crucial task for most HEP experiments. The ACTS (A Common Tracking Software) aims to be a generic, framework and experiment-independent toolkit for track reconstruction, initially started from the ATLAS tracking software. My talk will summarize recent developments of a Combinatorial Kalman Filter (CKF) for the ACTS project, and the possibilities of integrating ACTS with the Belle II software framework.

T 40.5 Tue 17:00 To

Studies of parameter uncertainty correction methods in unbinned maximum likelihood fits to events weighted by the SPlot technique — Peter Buchholz, Mazuza Ghneimat, •Tim-Philip Hücking, Iskander Ibragimov, and Wolfgang Walkowiak — Universität Siegen, Siegen, Deutschland

The sPlot technique is used in HEP to e.g. separate signal and background events in control variable distributions on a statistical basis. This separation is achieved by applying sWeights as event weights. The sWeights are calculated based on a discriminating variable fit. In case of fitting the sWeighted distributions using an unbinned maximum likelihood approach, the covariance matrix, defined as the inverse Hessian matrix of the likelihood function, needs to be corrected.

Uncertainty correction methods proposed by Eadie et al. and Langenbruch are studied, utilizing RooFit. The studies are based on pseudo experiments employing a simple statistical model. The uncertainty correction method proposed by Eadie et al. is found to be sufficient only in few cases. Langenbruch proposed two uncertainty correction methods: The first one accounts for the presence of the sWeights in the fit and the second one additionally for the uncertainties of the sWeights. This second method is found to work best.

For certain distributions of the control variable, fits to sWeighted distributions may still show some problematic behavior, as observed for the case of two Gaussian distributions.

T 40.6 Tue 17:15 To

Estimating the fake lepton contribution in the framework of Bayesian statistics — Johannes Erdmann, Cornelius Grunwald, Kevin Kröninger, Salvatore La Cagnina, and •Lars Röhrig — TU Dortmund, Experimentelle Physik IV

In a particle detector, the signature of prompt leptons like electrons and muons can be faked by other objects, such as jets or non-prompt leptons from hadron decays. Huge amounts of simulated events would be needed to estimate the fake lepton background contribution due to the small fake probability, thus data-driven techniques like the matrix method are commonly used instead. The method is based on the definition of two identification criteria, referred to as loose and tight and the probabilities of a real or fake lepton to pass either one of these criteria.

Known limitations of the classical matrix method are the possible prediction of negative fake rates and the approximation of Poisson distributed counting rates as Gaussian distributions. A Bayesian approach is presented, facing these restrictions and leading to a stable fake rate estimation in cases, in which the classical matrix method has limited validity. Several studies and comparisons to alternative methods are presented.

T 40.7 Tue 17:30 To

Neural network background estimation for Higgs boson pairs decaying to $b\bar{b}b\bar{b}$ final state — •Marta Czurylo and André Schöning — Physikalisches Institut Universität Heidelberg

Monte Carlo (MC) simulations and data-driven techniques are commonly used for the background estimation in ATLAS analyses. An advantage of data-driven methods over more traditional MC simulations is observed when MC is unreliable, for example, in case of QCD processes.

One of such techniques is background reweighting from control to signal regions which is firstly discussed in general. A novel approach uses neural network machinery for the reweighting. The idea and preliminary performance of the neural network reweighting are presented for the Vector Boson Fusion production of Higgs boson pairs decaying to $b\bar{b}b\bar{b}$ final state. The studies are performed based on ATLAS datasets collected between 2016 and 2018 with total integrated luminosity of $126.7 fb^{-1}$.

T 40.8 Tue 17:45 To

Combinatorial Kalman Filter for the Belle II Experiment — Florian Bernlochner[1], Jochen Dingfelder[1], Alexander Glazov[2], Simon Kurz[2], and •Christian Wessel[1] for the Belle II-Collaboration — [1]Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, Bonn — [2]Deutsches Elektronen-Synchrotron DESY, Hamburg

Kalman filters are a widely used tool in HEP to identify charged particle trajectories with a high efficiency and purity. The Belle II Combinatorial Kalman Filter (CKF) implementation is instrumental in achieving the physics goals of the experiment and is successfully being used in first emerging physics measurements. In this talk, I will summarize the key elements of the CKF implementation, show first results with data and give an outlook on future optimizations and extensions we have been working on.

T 40.9 Tue 18:00 To

Performance and calibration of the semileptonic Full Event Interpretation at Belle II — Florian Bernlochner, Jochen Dingfelder, Peter Lewis, •Alina Manthei, and William Sutcliffe for the Belle II-Collaboration — Physikalisches Institut, Universität Bonn, Germany

The Belle II experiment is located at the SuperKEKB collider in Japan, where electrons and positrons collide at the $\Upsilon(4S)$ resonance to produce $B\overline{B}$ pairs. The analysis of the decays of these B mesons allows for precise tests of the Standard Model. In order to investigate properties of B meson decays with missing energy as precisely as possible, one relies on the accurate reconstruction of the second B meson in the event. For this purpose, a reconstruction algorithm has been developed, named the Full Event Interpretation (FEI). As not all of the features of the detector are modelled precisely by Monte Carlo simulation, differences in efficiencies of the FEI in data and MC may occur. Therefore, a careful calibration of the tagging efficiency is required to account for such mismatches in efficiencies. In this talk, the strategy for obtaining such a calibration in a data-driven way for semileptonically tagged events is presented and first results are shown.

T 40.10 Tue 18:15 To

Hadronic Tagging at the Belle II experiment — Florian Bernlochner, Lu Cao, Jochen Dingfelder, Maximilian Graf, •Gianna Mönig, William Sutcliffe, and Ilias Tsaklidis for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

The Belle II experiment, located at the SuperKEKB accelerator complex in Japan, recently started its first physics runs. Belle II aims to record B meson-pairs at unprecedented luminosities produced through electron-positron annihilation at the $\Upsilon(4S)$ resonance.

One key experimental method to carry out measurements with missing final state particles, such as neutrinos, is the reconstruction of one of the two B mesons in fully hadronic decay modes. The clean laboratory of electron-positron annihilation in combination with this approach allows one to infer flavor and momentum of the other B meson in the event. This method is called "hadronic tagging" and Belle II employs a machine learning based algorithm called the Full Event Interpretation (FEI) for an efficient reconstruction.

In this presentation, I review the current status and efficiency of hadronic tagging with early Belle II data. In addition, I present promising extensions that rely on the semi-inclusive reconstruction of the tag-side B meson or graph networks that are under study and summarize the calibration strategy of the tagging efficiency that was developed.