T 24: Standard Model Physics II

Time: Tuesday 16:15–18:15 Location: KH 00.014

T 24.1 Tue 16:15 KH 00.014

Hadronic Recoil in future high μ measurements — Fabrice Balli[1], •Tim Frederik Beumker[2], and Frank Ellinghaus[2] — [1]Université Paris-Saclay — [2]Bergische Universität Wuppertal

A precise calculation of the missing transverse momentum (E_T^{miss}) is crucial for many Standard Model measurements. In addition, the recently published measurement of charged-current Drell-Yan cross-sections at high transverse masses showed that uncertainties arising from the E_T^{miss} calculation dominate, in particular when determining fake lepton contributions.

The Hadronic Recoil provides an alternative method of calculating the E_T^{miss} by using the recoil of the vector boson. It has been successfully used in low-μ precision W measurements so far and an implementation of the Hadronic Recoil was moved to the central ATLAS reconstruction software, to make it accessible for future high-μ ($\hat{=}$ #interactions per bunch crossing) analyses. This talk presents the general procedure for calculating the Hadronic Recoil and its validation at high μ.

T 24.2 Tue 16:30 KH 00.014

Measuring the W Mass with the ATLAS low-$\langle\mu\rangle$ Dataset — •Mathias Backes — Heidelberg University

The measurement of the mass of the W-boson is one of the fundamental tests of the Standard Model. ATLAS (2024) and CMS (2024) published measurements presenting results for the W-mass which are in agreement with the Standard Model. These measurements are in more than 5σ tension with the value obtained by the CDF collaboration (2022). In order to investigate this tension ATLAS is currently performing an additional measurement.

The W mass is most accurately measured using the leptonic decay channel $W \rightarrow l\nu_l$ with $l \in (e, \mu)$. The low-pileup dataset of ATLAS (taken in Run-2) is especially useful because a central aspect of this analysis is the precise estimation of the hadronic recoil to infer the energy and direction of the neutrino. Since the W mass cannot be measured directly it has to be inferred through comparisons with Monte Carlo simulations in a Profile Likelihood Fit.

In this talk the current status of the analysis including the details of the Profile Likelihood Fit is presented.

T 24.3 Tue 16:45 KH 00.014

Impact of measuring the W boson mass in a combined analysis at several collision energies with the ATLAS experiment — Philip Bechtle[1], •Oliver But[1], Matthias Schott[1], and Chen Wang[2] — [1]Physikalisches Institut, Universität Bonn — [2]Deutsches Elektronen Synchrotron, Hamburg

The precision measurement of the W boson mass is an important consistency test of the standard model. To match the standard model fit uncertainty of the W boson mass of less than 10 MeV all sources of uncertainties have to be carefully controlled. One strategy is to include data taken at multiple proton proton collision energies and fit them simultaneously. As a consequence, systematic effects which act differently for different collision energies decorrelate from the parameter of interest and reduce their impact on the uncertainty.

In this talk, I introduce the concept of correlated parameters and demonstrate how combining a 5 TeV and 13 TeV dataset in the W mass measurement at the ATLAS experiment can help reduce the uncertainty coming from systematics.

T 24.4 Tue 17:00 KH 00.014

Study of electroweak production of $W(\ell\nu)\gamma\gamma$ events in the Run-2 and Run-3 proton-proton collision data of the ATLAS detector. — •Sina Aktas, Gia Khoriauli, Raimund Ströhmer, and Thomas Trefzger — Julius-Maximilians-Universität Würzburg, Würzburg, Germany

Production of electroweak vector bosons provides a sensitive probe of the gauge interactions of the Standard Model, especially through the study of heavy gauge boson polarisation. The longitudinal polarisation of the W and Z bosons is of particular interest. The electroweak production of the $W\gamma\gamma$ events in proton-proton collisions at the LHC is sensitive to triple and quartic electroweak gauge couplings and its study provides an opportunity to test the predictions of the electroweak theory.

We work on the development of analysis methods to measure differential cross sections and polarisation fractions of the W boson in the electroweak production of $W(\ell\nu)\gamma\gamma$ in the ATLAS detector. The analysis will use the full datasets of proton-proton collisions at the LHC at $\sqrt{s} = 13$TeV (Run-2) and $\sqrt{s} = 13.6$TeV (Run-3).

In this work, we discuss the current status of the study. The methods and preliminary results of the analysis based on Monte Carlo simulations are presented.

T 24.5 Tue 17:15 KH 00.014

Machine Learning Based Tagging of Vector Boson Polarization — •Lena Alshut, Erik Bachmann, Mareen Hoppe, and Frank Siegert — Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Germany

The longitudinal polarization of massive vector bosons (MVBs) is a direct consequence of electroweak symmetry breaking and serves as a sensitive probe of the Higgs mechanism and potential new physics. Because longitudinally polarized MVBs are rare, previous studies at the LHC have relied on neural-network classifiers trained to distinguish polarization states. However, this formulation depends on an nonphysical quantities with unknown distribution and assumes classes of purely longitudinal or transverse polarized MVBs.

In this work, the alternative strategy of polarization fraction regression is explored. These fractions at phase-space point level are physical observables with well-defined distributions. This enables a direct comparisons of model predictions and MC truth values, providing the opportunity for systematic improvement of polarization tagging.

We develop a Machine Learning-based tagger that predicts event level polarization fractions using the four-momenta of final-state particles. A MLP and a Transformer are trained on Standard Model expectations. In this talk, we present results for Z+jets in the leptonic decay channel at LO, LO+PS, and higher perturbative orders as a exemplary test case. The approach can directly be translated to the analysis of LHC pp colission data, where it allows for a more physical interpretation of polarization measurements.

T 24.6 Tue 17:30 KH 00.014

Probing vacuum dispersion with electron-laser interactions — •Anthony Hartin — LMU, Munich, Germany

Partice physics processes occurring in the strong field of an intense laser can only be fully described by a quantum field theory that is non-perturbative with respect to the strong field. Such a theory is provided by the Furry interaction picture where the strong field is included in exact solutions of the Dirac equation. These solutions describe a new particle, the bound fermion, which sees a structured space-time depending on where it is in relation to the kinematics and phase of the strong field. This theory predicts novel phenomenology, including a shift in rest mass of the bound fermion, a dispersive vacuum and consequently, novel resonances in the bound fermion propagator. We review the theory and phenomenology and propose an experiment which can detect these novel non-perturbative resonances.

T 24.7 Tue 17:45 KH 00.014

The gradient flow coupling of three- and four-dimensional QED — •Lars Georg, Robert Harlander, and Robert Mason — RWTH Aachen University

Connecting low-energy lattice results to high-energy continuum calculations is highly nontrivial, as they rely on fundamentally different regularizations. The gradient flow offers an elegant way to bridge this gap, since it can be implemented both on the lattice and in the continuum and naturally defines renormalized couplings and observables.

While the GF up to now has found most of its applications in QCD, I consider its implementations in other theories such as scalar QCD, or theories with U(1) gauge factor. I present explicit results for the perturbative gradient-flow coupling for QED in (3+1) and (2+1) dimensions. QED_4 serves as a clean Abelian testing ground and limiting case of QCD, while QED_3 shares important qualitative features with QCD such as chiral symmetry breaking and the presence of an infrared fixed point in the large-N_f expansion.

T 24.8 Tue 18:00 KH 00.014

Nonrelativistic reduction of relativistic effective field theories
— •Tobias Asano[1], Fabio Di Pumpo[2], Enno Giese[3], and Motoaki Bamba[1,4] — [1]Department of Physics, Graduate School of Engineering Science, Yokohama National University, Japan — [2]Institut für Quantenphysik, Universität Ulm, Germany — [3]Technische Universität Darmstadt, Institut für Angewandte Physik, Germany — [4]Institute for Multidisciplinary Sciences, Yokohama National University, Japan

The applications of effective field theories (EFTs) range from Standard Model EFT to nonrelativistic (NR) EFTs like NR quantum chromodynamics. A symmetry-based construction of relativistic EFTs, like Standard Model EFT is straightforward. In contrast, Lorentz invariance is not trivial in NR EFTs, making a construction more complicated. While construction rules are well understood for, e.g., NR quantum chromodynamics, there is no simple extension when one includes more fields, such as gravity.

In this work, we present an approach starting from the construction of a relativistic EFT, conceptually close to Standard Model EFT, and perform an NR reduction, centered on an extended Foldy-Wouthuysen transformation, leading to NR quantum chromodynamics, for instance. Such a treatment is highly suited for theories where NR construction rules are not straightforward, such as an EFT on curved spacetime.

This work is supported by the Japan Society for the Promotion of Science (JSPS) (Grant Nos. JP25KJ1313, JP24K21526, JP25K00012, JP25K01691, JP25K01694, JPJSJRP20221202) and the Research Foundation for Opto-Science and Technology.