T 3: Flavour Physics 1

Time: Monday 16:15–18:35 Location: T-H16

T 3.1 Mon 16:15 T-H16

Measurement of the ratios $\mathcal{R}(\mathrm{D}^{(*)})$ with leptonic τ and hadronic tag at Belle — •Felix Metzner[1], Florian Bernlochner[2], Michael Feindt[1], and Pablo Goldenzweig[1] for the Belle-Collaboration — [1]Karlsruhe Institute of Technology — [2]University of Bonn

The discrepancy observed for the ratios $\mathcal{R}(\mathrm{D}^{(*)})$ of the decays $\mathrm{B} \to \mathrm{D}^{(*)}\tau\nu_\tau$ relative to the normalisation modes $\mathrm{B} \to \mathrm{D}^{(*)}\ell\nu_\ell$ ($\ell = \mathrm{e}, \mu$) between the experimental results and the Standard Model (SM) prediction is one of few longstanding tensions of the SM. The new Belle II software framework and the therein included conversion tool B2BII allows to reevaluate the Belle data set of 772 million $\mathrm{B\bar{B}}$-pairs recorded from 1999 until 2010 using the improved algorithms of the modern framework. With this approach a new measurement of the ratios $\mathcal{R}(\mathrm{D}^{(*)})$ with an improved hadronic tagging algorithm — the Full Event Interpretation (FEI) — is carried out. Profiting from a higher reconstruction efficiency, due to the new tagging algorithm, this analysis aims to provide new insights into these semileptonic B-decays. In this talk, the procedure and the current status of the analysis will be presented.

T 3.2 Mon 16:30 T-H16

Inclusive B-meson tagging for an $R(D^{(*)})$ measurement at Belle II — Thomas Kuhr, Thomas Lück, and •Sofia Palacios Schweitzer — Ludwig-Maximilians-Universität, München

The world average of previous measurements of $R(D^{(*)})$, defined as $R(D^{(*)}) = \frac{\mathcal{B}\left(B\to D^{(*)}\tau\nu_\tau\right)}{\mathcal{B}\left(B\to D^{(*)}l\nu_l\right)}$, shows a 3.4σ deviation from Standard Model predictions, which could indicate some new physics phenomena, such as the existence of Leptoquarks. This analysis uses data and simulations from the Belle II experiment at the SuperKEKB electron-positron collider to measure $R(D^{(*)})$. To account for the challenge of multiple neutrinos as final state particles, an approach is considered, where besides the signal B-meson decay kinematical and topological properties of the other B-meson are reconstructed fully inclusively. In contrast to exclusive tagging used for previous measurements of $R(D^{(*)})$ by the B-factories, this inclusive tagging approach suffers from a larger background, but also offers a higher reconstruction efficiency. The current status of the analysis will be presented.

T 3.3 Mon 16:45 T-H16

Probing the $R(D^{(*)})$ discrepancy with inclusive $B \to X\tau\nu$ decays at Belle II — Jochen Dingfelder, Florian Bernlochner, •Henrik Junkerkalefeld, and Peter Lewis — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

Excesses in the $R(D)$ and $R(D^*)$ ratios measured by multiple experiments have caused large interest in recent years and align with other measurements in the flavor sector that may hint at non-universality of lepton flavor. Exclusive decays of B mesons into τ leptons ($B \to D^{(*)}\tau\nu$) seem to appear more frequently compared to the respective decays into light leptons than expected by theory.

The Belle II experiment in Japan enables a complementary test of these measurements. Due to the precise knowledge of the initial state of the collision and the controlled production of $B\bar{B}$ pairs, an inclusive measurement of $B \to X\tau\nu$ becomes possible. Here, the hadronic system X is not explicitly reconstructed, i.e. all possible hadrons contribute. This approach offers a better statistical precision than exclusive measurements at the expense of larger backgrounds.

In this talk, the current status of the inclusive $R(X)$ measurement is presented. The event selection, the signal extraction strategy and the most important systematic uncertainties are discussed.

T 3.4 Mon 17:00 T-H16

Measuring $R(D^*)$ in hadronic one-prong τ decays at Belle II — Florian Bernlochner, William Sutcliffe, and •Ilias Tsaklidis for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

In this work we are measuring the $R(D^*)$ ratio with hadronically decaying τ leptons. The Belle II experiment is producing exact $B\bar{B}$ pairs and it greatly benefits from the clean experimental environment of e^+e^- collisions. In this study we tag one of the two B mesons using the Full Event Interpretation algorithm in fully hadronic modes, in order to kinematically constrain the second B meson. We reconstruct $B \to D^*\tau\nu$ decays with a single charged track originating from the τ decay and two missing neutrinos. This gives us a unique access to quantities, sensitive to New Physics, such as the τ lepton polarization besides the $R(D^*)$ ratio. In this talk the reconstruction strategy, the current status and future targets of the analysis will be presented.

T 3.5 Mon 17:15 T-H16

Measurement of R(D*) with semileptonic tagging at Belle II — Florian Bernlochner, Jochen Dingfelder, Peter Lewis, and •Alina Manthei for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

The Belle II experiment at the SuperKEKB asymmetric-energy electron-positron collider is able to collect a large number of events with $B\overline{B}$ pairs. The analysis of semitauonic decays of these B mesons allows for tests of lepton flavour universality. Existing experimental results on the ratios of the branching fractions $\mathcal{R}(D^{(*)} = \mathcal{B}(\overline{B} \to D^{(*)}\tau^-\overline{\nu})/\mathcal{B}(\overline{B} \to D^{(*)}l^-\overline{\nu})$, where l denotes an electron or muon, are in tension with the Standard Model (SM) predictions, which might hint at physics beyond the SM, such as the presence of charged Higgs bosons or leptoquarks. A combined analysis of $\mathcal{R}(D)$ and $\mathcal{R}(D^*)$ with measurements from Belle, BaBar and LHCb yields a divergence from the SM prediction by approximately 3.8σ, where σ indicates the standard deviation. Thus, further investigations of these decays with the recently collected data by Belle II are necessary. This talk will present the current status and plans for a measurement of $\mathcal{R}(D^{(*)})$ using this data, while reconstructing the respective other B meson in the event in semileptonic modes.

T 3.6 Mon 17:30 T-H16

$m_b(m_Z)$ revisited with Zedometry — •Stefan Kluth — MPI für Physik, Föhringer Ring 6, 80805 München

Precision measurements of Z^0 boson properties can allow a determination of the mass of the b quark at the scale of the Z^0 boson mass $m_b(m_Z)$. The dependence of Standard Model predictions by the programs zfitter and Gfitter on the b quark mass are studied. The precision of the currently available measurements by the LEP experiments and SLD, together with measurements from the LHC experiments for the mass of the top quark and the Higgs boson, is not sufficient for a relevant measurement. The predicted precision of Z^0 boson resonance measurements at future $\mathrm{e}^+\mathrm{e}^-$ colliders will allow a competetive determination of $m_b(m_Z)$.

T 3.7 Mon 17:45 T-H16

From sWeights to COWs: News about the sWeight method — •Hans Dembinski[1], Matt Kenzie[2], Christoph Langenbruch[3], and Michael Schmelling[4] — [1]TU Dortmund, Germany — [2]University of Warwick, United Kingdom — [3]RWTH Aachen, Germany — [4]MPIK Heidelberg

A common problem in experimental flavour physics is the separation of signal and background, when the background is difficult to parameterise. We revisit the foundation of the popular method known as sWeights (or sPlot), which allows one to calculate estimates from the signal density in a control variable (for example, the decay time of a particle) using a fit of a mixed signal and background model to a discriminating variable (typically the invariant mass of decay candidates). sWeights are a special case of a larger class of Custom Orthogonal Weight functions (COWs), which can be applied to a more general class of problems in which the discriminating and control variables are not necessarily independent and still achieve close to optimal performance. We present new insights into the properties of parameters estimated from fits to sWeighted data, and provide closed formulas for the asymptotic covariance matrix of these parameters. To illustrate our findings, we show practical applications of these techniques.

T 3.8 Mon 18:00 T-H16

Normalization of the rare $K^+ \to \pi^+\nu\bar{\nu}$ decay by a $K^+ \to \pi^+\pi^0/K^+ \to \mu\nu$ measurement with NA62 — •ATAKAN TUĞBERK AKMETE — JOHANNES GUTENBERG UNIVERSITÄT, MAINZ

The ultra-rare $K^+ \to \pi^+\nu\bar{\nu}$ decay has a precisely predicted Standard Model branching ratio of $8.4 \pm 1.0 \times 10^{-11}$ which is almost free from

theoretical uncertainties. Therefore, this SM limit can be tested by a precision measurement. Further, the very high sensitivity of this decay also makes it one of the most suitable candidates to investigate indirect effects of new physics in the flavour sector.

The NA62 experiment at the CERN SPS was proposed and designed to measure this branching ratio by using a decay-in-flight technique. NA62 took data of the $K^+ \to \pi^+\nu\bar{\nu}$ decay in 2016, 2017, 2018 and 2021. The previous analyses yielded the most precise branching-ratio measurement of the decay. In those analyses, the $K^+ \to \pi^+\pi^0$ was used as normalization in order to extract the number of kaon decays for the $K^+ \to \pi^+\nu\bar{\nu}$ branching ratio measurement.

However, it is also possible to use another normalization mode, $K^+ \to \mu\nu$, which can be useful for eliminating undesirable effects that were considered in the previous analyses such as photon and multiplicity rejections. In this talk, I will be discussing the results of this $K^+ \to \mu\nu$ normalization mode and representing a new measurement on $K^+ \to \pi^+\pi^0/K^+ \to \mu\nu$.

Group Report T 3.9 Mon 18:15 T-H16

Towards a Super Charm-Tau Factory in Russia — •Mustafa Schmidt, Simon Bodenschatz, Lisa Brück, Michael Düren, Jan Niclas Hofmann, Sophie Kegel, Jhonatan Pereira de Lira, Marc Strickert, Chris Takatsch, Leonard Welde, and Vincent Wettig — II. Physikalisches Institut, Justus-Liebig-Universität Gießen

The Super Charm-Tau Factory (SCTF) is a future electron-positron collider that is planned to be built in Sarov, Russia. Its center-of-mass energy can be tuned between 2 and 6 GeV for studying a large variety of physics programs. The crab-waste method, a novel collision scheme for particle beams, makes it possible to reach an exceptionally high luminosity up to a value of $\mathcal{L} = 10^{35}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$ which is 3–4 orders larger than in previous accelerators. In combination with longitudinally polarized lepton beams in the interaction point and an excellent Particle Identification (PID), SCTF will offer the unique possibility to study open questions in the field of particle physics and to find new physics beyond the standard model (SM). Prominent examples are the investigation of CP-violation in the open-charm sector or Charged Lepton Flavor Violation (CLFV) in decays of τ-leptons. This talk will present some highlights of the physics program and the detector design. Our working group in Giessen focuses on the PID design using RICH and DIRC detectors.