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Übungen zu Teilchenphysik I

Wintersemester 2023/24

Exercise 5

To be worked on until January 11, 2024

B-Meson Decays at Belle II

Semileptonic decays of B-mesons into charmed final states play an important role in the measurement of the CKM-matrix element V_{cb} , but also in the search for new physics beyond the Standard Model. In the Standard Model, the decays occur at tree level via the emission of a virtual W boson that changes the bottom quark into a charm quark. Figure ?? shows the Feynman diagram of a $\bar{B} \rightarrow D^* \ell \bar{\nu}_\ell$ decay, with ℓ denoting either an electron or a muon.

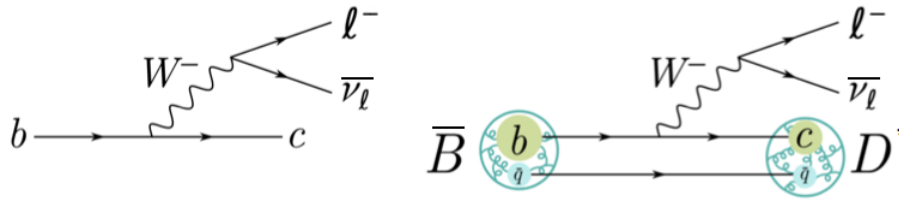


Figure 1: The semileptonic $\bar{B} \rightarrow D^* \ell \bar{\nu}_\ell$ decay at quark level (left) and in terms of mesons (right). The strong interaction influences the B-meson decay via the constant emission and absorption of, for instance, soft gluons. These non-perturbative effects depend on the four-momentum transfer from the $\bar{B}$ -meson system to the D^* -meson system, denoted as $q^2 = (p_B - p_{D^*})^2$.

The $\bar{B} \rightarrow D^* \ell \bar{\nu}_\ell$ decay is very abundant: more than 10% of all B-meson decays occur in this channel. Therefore, they are an ideal probe to search for new physics: for instance, the coupling of first- and second-generation leptons in the decay can be probed against the coupling of the third-generation τ lepton, or the decay topology can be used to search for massive neutrinos.

This exercise is inspired by two analyses made by the [Belle Collaboration](#):

- Measurement of the decay $B \rightarrow D \ell \nu_\ell$ in fully reconstructed events and determination of the Cabibbo-Kobayashi-Maskawa matrix element $|V_{cb}|$ [?].
- Search for the $B^+ \rightarrow \mu^+ \nu_\mu$ and $B^+ \rightarrow \mu^+ N$ with inclusive tagging [?].

Please feel free to have a closer look at these publications, if you are interested in the topics touched in this exercise.

As usual, you can find the corresponding Jupyter Notebook in the [tp1_forstudents](#) repository. For this exercise it is sufficient to use the standard `Datenanalyse` container on the [jupytermachine](#).