Heavy quark Physics at FCC-ee, rare decays case study

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November 27, 2020

1 Abstract

The FCC-ee is a frontier Higgs, Top, Electroweak, and Flavour factory. It will be operated in a 100-km circular tunnel built in the CERN area, and will serve as the first step of the FCC integrated programme towards $\geq$ 100 TeV proton-proton collisions exploiting the same infrastructure [1]. With its huge luminosity at the Z-pole, $\sim 10^{12}$ $Z \to b\bar{b}$ decays will be collected at the currently foreseen two interaction points, which is a sample of b hadrons an order of magnitude larger than anticipated at the Belle II experiment. This enormous data set, the clean environment, the high boost of the b hadrons, and the production of the full spectrum of heavy-flavoured particles provides unique opportunities for Heavy Flavour physics at FCC-ee.

Of particular interest is the study of the inclusive and exclusive rare decays involving charged leptons in the final state. These include fully leptonic decays, for example $B_c^+ \to \mu^+\nu$ and $B_c^+ \to \tau^+\nu$, and dileptonic and semileptonic FCNCs that are driven by electroweak penguins and box diagrams in the Standard Model, such as $B_d \to \mu^+\mu^-$, $B_s \to \tau^+\tau^-$, $b \to s(d)\ell^+\ell^-$ and $b \to s(d)\tau^+\tau^-$, where ℓ represents either an electron or a muon. The study of these modes, together with radiative FCNCs, allow for stringent tests of the SM and have high discovery potential in probing for new physics extensions. The FCC-ee will be able to complement many of the studies performed at Belle II and LHCb, and significantly extend the measurement programme in several critical areas. Final states involving τ leptons can be singled out as especially promising in this regard. Experiments at the FCC-ee can greatly improve our knowledge of these decays if they are highly hermetic and have excellent resolution for reconstructing the production and decay vertices. Hadron particle identification will also be essential for analysing many of the exclusive decays of interest. The FCC-ee Conceptual Design Report began to address some of these questions through means of a fast simulation with parametric detector response [2]. In the next phase of physics studies the detector design must be optimised to maximise the physics performance for this very important category of decay channels.

References

[1] A. Abada et al. FCC-ee: The Lepton Collider: Future Circular Collider Conceptual Design Report Volume 2. *Eur. Phys. J. ST*, 228(2):261–623, 2019.

[2] A. Abada et al. FCC Physics Opportunities: Future Circular Collider Conceptual Design Report Volume 1. *Eur. Phys. J. C*, 79(6):474, 2019.