Summary of the dissertation

“Electroweak heavy flavour precision observables: connecting open dots with the FCC-ee”

The heaviest third-generation fermions are expected to be most sensitive to effects from Beyond the Standard Model (BSM) physics, which will be probed with very high precision at a possible Future Circular Collider as electron-positron collider (FCC-ee).

In this thesis, a novel approach to measuring Electroweak Precision Observables in the beauty-quark sector is pioneered using exclusively reconstructed beauty-hadrons as hemisphere-flavour taggers for the partial decay-width ratio R_b and the forward-backward asymmetry $A^b{}_{FB}$, which receive virtual contributions from the heaviest states of the Standard Model (SM): top quarks, Higgs, and $W^{\pm}$ boson. This approach effectively eliminates the contamination from light-quark physics events and reduces leading systematic uncertainties; arising from background contamination, tagging-efficiency correlations, and radiated gluon corrections by exploiting the geometric and kinematic properties of beauty hadrons. This results in a total relative uncertainty of the order of $0{,}01\%$ for both observables. From $A^b{}_{FB}$, the weak mixing angle can be determined with a relative precision of $0{,}002\%$.

Building on this innovative methodology, the thesis is extended to the top-quark sector by extracting the sensitivity of top-quark observables to SM Effective Field Theory operators, which describe the effects of BSM physics by extending the SM with higher-dimensional operators on energy scales that are currently inaccessible.

In a FCC-ee environment, top-quark pairs are reconstructed, and the expected observational precision is used to derive constraints on the Wilson coefficients that are up to a factor of five and three more stringent than those derived from top-quark measurements at LHC and HL-LHC, respectively.