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Electroweak precision physics via angular distributions in τ decays to two pseudoscalars

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Hadronic tau decays provide a unique low-energy laboratory for the charged-current interaction between quarks and leptons. Their use as an electroweak precision sector is, however, limited by nonperturbative QCD dynamics in the resonance region, encoded in hadronic form factors. In this work we show that angular information in two-hadron tau decays can be used to construct observables in which these form factors cancel, leading to first-principles Standard Model predictions up to light-quark-mass and radiative corrections. We derive the fully differential distributions for arbitrary two-pseudoscalar final states, including tau polarization, and extend them to the Weak Effective Field Theory at linear order in new-physics couplings. We then illustrate our strategy with several benchmark observables, for both unpolarized and polarized taus, whose Standard Model predictions can be obtained without modelling the dominant hadronic form factors and which receive characteristic beyond-the-Standard-Model corrections, in particular from tensor currents. These results provide concrete targets for Belle II, polarized-tau proposals such as Chiral Belle, and future high-statistics facilities, including super-tau-charm factories and FCC-ee, to test the electroweak structure of hadronic tau decays.

Academic position of the presenting author

Ph.D. Student

Primary authors: PAZ CASTRO, Santiago (IFIC (CSIC-UV)); ESTRADA, Emilio (Universitat de Barcelona); PASSEMAR, Emilie (IFIC (CSIC-UV)); RODRÍGUEZ SÁNCHEZ, Antonio (Universidad de Castilla-La Mancha); ROIG, Pablo (Cinvestav)

Presenter: PAZ CASTRO, Santiago (IFIC (CSIC-UV))

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