INPUTS FOR PROSPECTIVE STUDIES IN THE HL-LHC/BELLE II ERA

Preliminary

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Abstract

This document provides the collection of inputs used by the CKMfitter collaboration to perform prospective works at the end of 2018. The statistical method employed is the frequentist approach *R*fit. Detailed background information on the methodology and the treatment of experimental and theoretical uncertainties is provided in:

CP VIOLATION AND THE CKM MATRIX:
ASSESSING THE IMPACT OF THE ASYMMETRIC *B* FACTORIES
By CKMfitter Group
Eur. Phys. J. **C41**, 1-131, 2005 [hep-ph/0406184]

OPPORTUNITIES IN FLAVOUR PHYSICS AT THE HL-LHC AND HE-LHC,
By A. Cerri *et al.*,
arXiv:1812.07638 [hep-ph].

http://ckmfitter.in2p3.fr

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HL-LHC will naturally provide an improvement in the determination of several flavour observables crucial for the determination of the CKM parameters. We can then consider two phases for the HL-LHC projections: in Phase I, we assum that the colleceted data amount for LHCb to 23 fb^{-1} and for CMS/ATLAS to 300 fb^{-1}, whereas for Phase II, we have for LHCb 300 fb^{-1} and for CMS/ATLAS 3000 fb^{-1}. A significant source of information is the HL-LHC yellow book [1] that also provides projections for the lattice computations at the horizon of Phase 1. Further observables will be measured at a higher precision thanks to Belle II, and we will assume that the uncertainties reached on these observables correspond to the projections for 50 ab^{-1} [3]. We also take into account the projected increase in the measurement of D and D_s semi-leptonic decay by BESIII, with an experimental accuracy of 1.2% on $|V_{cd}|$ and $|V_{cs}|$ combined with the lattice QCD projections of the YR for the decay constants of charmed mesons) [2]. Since we are interested in the future sensitivity for Phase I and Phase II, we choose the central values of future measurements to coincide with their SM predictions using the current best-fit values of $\bar{\rho}$ and $\bar{\eta}$.

The inputs used for the fits are shown in Tab. 1. For an easier comparison with the current situation, we have added a column "Current" corresponding to the current situation concerning uncertainties, but taking central values corresponding to a perfect agreement of the various constraints in the SM. Indeed, the current global fit exhibits slight discrepancies which increase the accuracy of the determination of the CKM parameters. In order to determine the increase in accuracy on the CKM parameters in a fair way, we therefore compare the three scenarios presented in Tab. 1 with the same central values taken to have perfect agreement rather than the results for the Summer 2018 update.

References

[1] A. Cerri *et al.*, "Opportunities in Flavour Physics at the HL-LHC and HE-LHC," arXiv:1812.07638 [hep-ph].

[2] Private communication from H. Li and H. Ma in preparation for the *White Paper on BES-III Experiment*

[3] E. Kou *et al.* [Belle II Collaboration], "The Belle II Physics Book," arXiv:1808.10567 [hep-ex].

[4] CKMfitter Summer 2018 update available on http://ckmfitter.in2p3.fr/

[5] Y. Amhis *et al.* [HFLAV Collaboration], Eur. Phys. J. C **77** (2017) no.12, 895 doi:10.1140/epjc/s10052-017-5058-4 [arXiv:1612.07233 [hep-ex]]. and updates on https://hflav.web.cern.ch

	Current	Phase I	Phase II	Ref.
$\lvert V_{ud}\rvert$	± 0.00021	± 0.00021	± 0.00021	[4]
$\lvert V_{us}\rvert f_+^{K\to\pi}(0)$	± 0.0004	± 0.0004	± 0.0004	[4]
$\lvert\epsilon_K\rvert \times 10^3$	± 0.011	± 0.011	± 0.011	[4]
$\lvert V_{cd}\rvert$	± 0.005	± 0.003	± 0.003	[2]
$\lvert V_{cs}\rvert$	± 0.016	± 0.014	± 0.014	[2]
Δm_d [ps^{-1}]	± 0.0019	± 0.0019	± 0.0019	[5]
Δm_s [ps^{-1}]	± 0.021	± 0.021	± 0.021	[5]
$\lvert V_{ub}\rvert \times 10^3$ ($b \to u\ell\bar{\nu}$)	± 0.23	± 0.04	± 0.04	[3]
$\lvert V_{cb}\rvert \times 10^3$ ($b \to c\ell\bar{\nu}$)	± 0.7	± 0.5	± 0.5	[3]
$\lvert V_{ub}/V_{cb}\rvert$ (Λ_b)	± 0.0050	± 0.0025	± 0.0008	[1]
$\sin 2\beta$	± 0.017	± 0.005	± 0.003	[1] and [3]
α [°]	± 4.4	± 0.6	± 0.6	[3]
γ [°]	± 5.6	± 1	± 0.35	[1] and [3]
β_s [rad]	± 0.031	± 0.014	± 0.004	[1]
$\mathcal{B}(B \to \tau\nu) \times 10^4$	± 0.21	± 0.04	± 0.04	[3]
$\mathcal{B}(B \to \mu\nu) \times 10^6$	–	± 0.03	± 0.03	[3]
$\mathcal{B}(B_s \to \mu\mu) \times 10^9$	± 0.66	± 0.34	± 0.17	[1]
$\mathcal{B}(B_d \to \mu\mu) \times 10^{11}$	–	± 3.5	± 1.0	[1]
$\frac{\mathcal{B}(B_d\to\mu\mu)}{\mathcal{B}(B_s\to\mu\mu)}$	–	± 0.010	± 0.003	[1]
$\bar{m}_c$ [GeV]	± 0.012 (0.9 %)	± 0.005 (0.4 %)	± 0.005 (0.4 %)	[1]
$\bar{m}_t$ [GeV]	± 0.73 (0.4 %)	± 0.35 (0.2 %)	± 0.35 (0.2 %)	[4]
$\alpha_s(m_Z)$	± 0.0011 (0.9 %)	± 0.0011 (0.9 %)	± 0.0011 (0.9 %)	[4]
$f_+^{K\to\pi}(0)$	± 0.0026 (0.3 %)	± 0.0012 (0.12 %)	± 0.0012 (0.12 %)	[1]
f_K	± 0.0006 (0.5 %)	± 0.0005 (0.4 %)	± 0.0005 (0.4 %)	[1]
B_K	± 0.012 (1.6 %)	± 0.005 (0.7 %)	± 0.004 (0.5 %)	[1]
f_{B_s} [GeV]	± 0.0025 (1.1 %)	± 0.0011 (0.5 %)	± 0.0011 (0.5 %)	[1]
B_{B_s}	± 0.034 (2.8 %)	± 0.010 (0.8 %)	± 0.007 (0.5 %)	[1]
f_{B_s}/f_{B_d}	± 0.007 (0.6 %)	± 0.005 (0.4 %)	± 0.005 (0.4 %)	[1]
B_{B_s}/B_{B_d}	± 0.020 (1.9 %)	± 0.005 (0.5 %)	± 0.003 (0.3 %)	[1]

Table 1: Uncertainties for the CKMfitter projections.