CP Violation sensitivity at the Belle II Experiment

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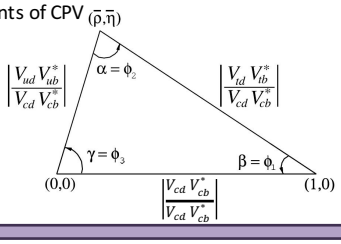
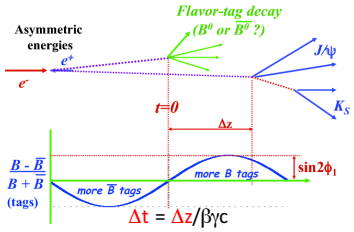
- The weak interactions of quarks are described by the CKM unitary matrix (V_{CKM}).
- V_{CKM} is expressed by three rotation angles and one phase (phase≠0 ↔ CP violation in the quark sector).
- Unitarity relations are represented by six triangles in the complex plane.
- The B^0 Unitarity Triangle (UT) is shown here
  - ✓ Sides ~ Branching fractions and $B\bar{B}$ mixing
  - ✓ Angles ~ amounts of CPV $(\bar{\rho},\bar{\eta})$



The β and γ of the UT are related to V_{td} and V_{ub}, respectively. The former is accessible through oscillations

Asymmetric B-factories @ Υ(4S)



- Resolution on Δt will be dominated by the resolution of the tagging side vertex

Δz:
Belle ~ 200 mm
Belle II ~ 130 mm

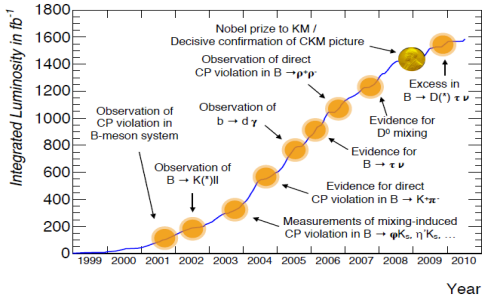
Δt resolution:
Belle ~ 0.92ps
Belle II ~ 0.77 ps

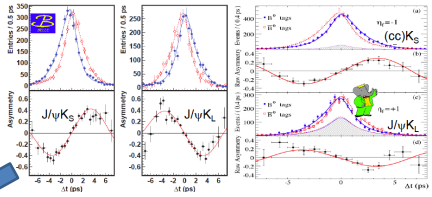
CPV asymmetry in the time-dependent rates for initial B meson decays to a CP eigenstate, f_{CP}

$$a_{f_{cp}}(\Delta t) \equiv \frac{\Gamma[B \to f_{cp}] - \Gamma[\bar{B} \to f_{cp}]}{\Gamma[B \to f_{cp}] + \Gamma[\bar{B} \to f_{cp}]} = -\xi_f \sin 2\phi_1 \sin \Delta M \Delta t$$

B Factories: a truly remarkable success story

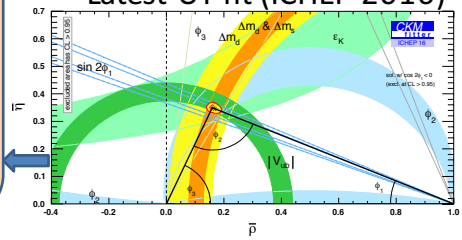
- Spectacular accelerator and detector performance.
- Discovery of CP violation in B decays.
- Confirmation of the CKM picture of flavor physics. → Nobel prize to Kobayashi and Maskawa.
- Discovery of several new particles.
- Probe of rare B decays.



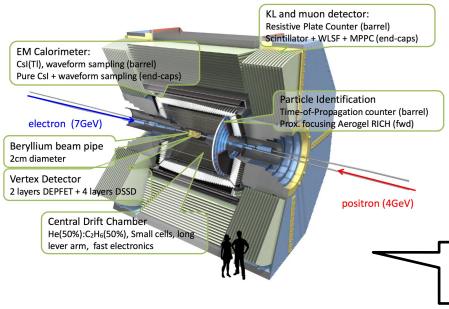


- The asymmetry shown on the top right two plots are related to the $a_{f_{cp}}(\Delta t)$ defined on the first part of this poster
- The two plots for J/ψ K_s and J/ψ K_L have different opposite ξ_f values, but give the consistent results
- The correlated neutral B-meson pair production at Upsilon(4S) leads to excellent tagging power
- Final results from Belle:
  sin 2ϕ_1 = 0.667 ± 0.023(stat.) ±0.012(sys.)
- Latest UT fit confirms the CKM mechanism to current experimental resolution

Latest UT fit (ICHEP 2016)

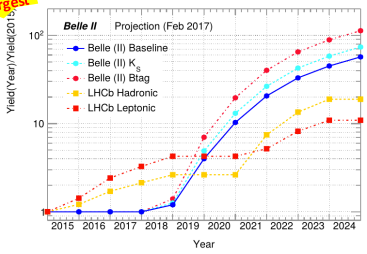


Belle II Detector on SuperKEKB



World Largest

Peak luminosity of SuperKEKB reach 40 times of KEKB!



Many upgrades needed in order to increase the performance and cope with much more severe background conditions

Main improvement in performance in two areas: Tracking and vertex determination; Particle ID

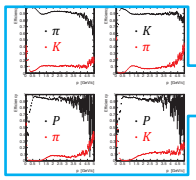
The global performance of the flavor tagger

r is the output of a multivariate combiner (FastBDT) of tag information.

r- bin	ε_l(%)	$\Delta\varepsilon_l$(%)	w_l(%)	Δw_l(%)	$\varepsilon_{\text{eff},l}$(%)	$\Delta\varepsilon_{\text{eff},l}$(%)
0.000 – 0.100	12.4	0.0	47.6	0.0	0.0	0.0
0.100 – 0.250	14.4	−0.1	41.4	0.0	0.4	0.0
0.250 – 0.500	21.0	−0.1	31.2	−0.1	3.0	0.0
0.500 – 0.625	11.5	0.3	21.8	0.0	3.7	0.2
0.625 – 0.750	12.0	0.4	15.6	0.1	5.7	0.4
0.750 – 0.875	11.8	−0.1	9.4	0.0	7.8	−0.1
0.875 – 1.000	16.9	−0.6	2.4	0.1	15.3	−1.2
Total	$\varepsilon_{\text{eff}} = \sum_l \varepsilon_l \cdot \langle 1-2w_l \rangle^2 = 35.8\%$				$\Delta\varepsilon_{\text{eff}} = -0.7\%$	

The FBDT combiner achieves a total effective efficiency of ε_{eff} = 35.8%

Combined charged PID performance of Belle II



The performance of Belle II PID

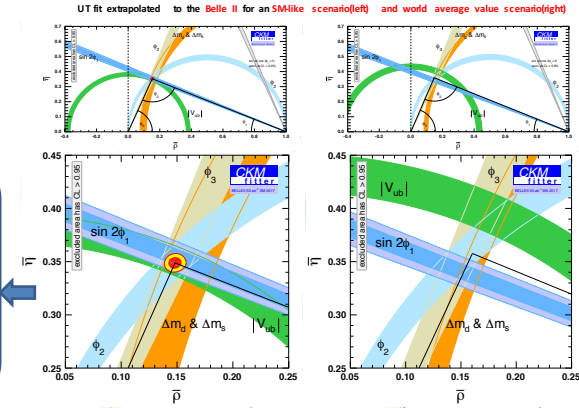
- Inclusive $c\bar{c}$ MC samples.
- Minimal track quality restrictions are applied
- $\mathcal{L}(\alpha:\beta) > 0.5$
- Black markers: selection eff. w/o background; red markers: fake rate
- Very good PID performance, especially in the low p region

Outlook for Belle II

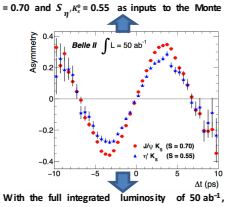
- Belle has been a successful B factory, especially for CPV.
- Major upgrades of KEKB and Belle.
- CKM mechanism will be tested at 1% level on Belle II.
- Some flavor variables still to be measured precisely → therefore a lot of room for discoveries at Belle II!

- Two key scenarios (World average (ca. 2016) central values and SM-like central values) in the Belle II era are considered when we estimate the expected measurement precision of ϕ_1, ϕ_2, ϕ_3, $|V_{ub}|$, Δm_d and Δm_s corresponding to 50 ab^{-1} data.
- Belle II will provide the most precise measurements of many key observables used in the determination of these parameters.
- The exceptions are ϕ_3, which will be of similar precision at LHCb, and B_s and B mixing, which will be measured with greater precision at LHCb.
- One of the most important inputs from Belle II will be the measurement of $|V_{ub}|$ from inclusive semi-leptonic decays.
- The charmless B decay measurements on Belle II will greatly benefit from the detector improvements

UT fit extrapolated to the Belle II for an SM-like scenario(left) and world average value scenario(right)



Time dependent CP asymmetries for the final states J/ψ K_S (red dots) and η'K_S (blue triangles), using $S_{J/\psi K^0_S}$ = 0.70 and $S_{\eta' K^0_S}$ = 0.55 as inputs to the Monte Carlo



With the full integrated luminosity of 50 ab^{-1}, these two modes would be unambiguously distinguishable, signifying the existence of New Physics

Channel	Event yield	$\sigma(S)$	$\sigma(S)_{2017}$	$\sigma(A)$	$\sigma(A)_{2017}$
$J/\psi K^0$	1.4×10^6	0.0052	0.022	0.0050	0.021
$\eta' K^0$	55900	0.015	0.12	0.011	0.14

Expected yields and uncertainties on the S and A parameters for the channels ($J/\psi K^0$ and $\eta' K^0$) with 50 ab^{-1} data. In the 5th and the last column we also give the present WA errors on each of the observables