where the overall sign is given by the CP eigenvalue, ±1, of the final state f_{CP}. The mixing phase ϕ_M and the decay phase ϕ_D are each convention dependent, that is their value can be changed by redefining the phases of some of the quark fields. However Im $r_{f_{CP}}$ depends on convention-independent combinations of CKM parameters only, and thus from Eq. (19) one can directly relate the measured CP-violating asymmetry to the phase of particular combination of CKM-matrix elements in the Standard Model.

In an e^+e^- B collider running at the $\Upsilon(4S)$ resonance, the initial B system is produced in a coherent state which remains $B^0\overline{B}^0$ until such time as one of the particles decays. The time evolution of the second particle thus begins at the time of the decay of the first. Events where one B decays to a flavor-tagging mode while the other decays to a CP-study mode can be used to reconstruct the dependence of the asymmetry on the time between the tagging decay and the CP-study mode decay. The tagging decay may be later, in which case the event is assigned a negative time. Note that the measurement of time dependence is essential at such a machine since, in the interesting cases where Eq. (19) applies, the time-integrated CP asymmetry vanishes.

Hadronic machines on the other hand produce uncorrelated B and $\overline{B}$ mesons; the time in the above equations is the time between production and decay, and thus is always positive. Time-integrated asymmetries do not vanish in this case. The time evolution of the tagging particle occurs independently and will contribute to wrong sign tags. Such machines produce many more B's than will an e^+e^- B factory. For modes with a clean signature, such as those with a final state $J/\psi(1S)$ or ϕ, hadronic machines can compete with a B factory in measuring CP asymmetries, but for modes such as $\pi\pi$ or $\rho\pi$ the problems of triggering and of backgrounds make such measurements extremely challenging in a hadronic environment.

Extracting CKM parameters from measured asymmetries: In order to relate the measured asymmetries to the CKM-matrix parameters one looks at the CKM elements that appear in the relevant decay amplitudes and in the mixing diagrams. Table 1 gives the result for the various b-quark decay channels. For the penguin contributions the CKM factors given here are obtained by assuming CKM unitarity and neglecting small corrections due to the difference between charm and up quark masses in the loop for $b \to d$ processes, and those due

Table 1: B decay modes for CP studies.

Quark Process	Tree CKM	Leading Penguin CKM	Sample B_d Modes	B_d Angle	Sample B_s Modes	B_s Angle	Comments
$b \to c\bar{c}s$	$V_{cb}V_{cs}^* = A\lambda^2$	$V_{cb}V_{cs}^* = A\lambda^2$	$J/\psi(1S)K_S$	β	$J/\psi(1S)\eta', D_s\overline{D}_s$	0	(a)
$b \to s\bar{s}s$	0	$V_{cb}V_{cs}^* = A\lambda^2$	ϕK_S	β	$\phi\eta'$	0	(b)
$b \to u\bar{u}s$	$V_{ub}V_{us}^* = A\lambda^4(\rho - i\eta)$	$V_{cb}V_{cs}^* = A\lambda^2$	$K_S\pi^0, K_S\rho^0$	–	$\phi\pi^0, K^+K^-$	–	(c)
$b \to d\bar{d}s$	0	$V_{cb}V_{cs}^* = A\lambda^2$	$K_S\pi^0, K_S\rho^0$	–	$\phi\pi^0, K_S\overline{K}_S$	–	(c)
$b \to c\bar{c}d$	$V_{cb}V_{cd}^* = -A\lambda^3$	$V_{tb}V_{td}^* = A\lambda^3(1-\rho+i\eta)$	$D^+D^-, J/\psi(1S)\pi^0, D^0\overline{D}^0(\dagger)$	β	$J/\psi(1S)K_S$	0	(d)
$b \to s\bar{s}d$	0	$V_{tb}V_{td}^* = A\lambda^3(1-\rho+i\eta)$	$\phi\pi^0, K_S\overline{K}_S$	–	ϕK_S	β	(c)
$b \to u\bar{u}d$ $b \to d\bar{d}d$	$V_{ub}V_{ud}^* = A\lambda^3(\rho - i\eta)$ 0	$V_{tb}V_{td}^* = A\lambda^3(1-\rho+i\eta)$	$\pi\pi, \pi\rho, \pi a_1$	α	π^0K_S, ρ^0K_S	γ	(e)
$b \to c\bar{u}s$ $b \to u\bar{c}s$	$V_{cb}V_{us}^* = A\lambda^3$ $V_{ub}V_{cs}^* = A\lambda^3(\rho - i\eta)$	0	$D^0_{CP}K^*(892)$	γ	$D^0_{CP}\phi$	–	$(f), (g)$
$b \to c\bar{u}d$ $b \to u\bar{c}d$	$V_{cb}V_{cd}^* = A\lambda^2$ $V_{ub}V_{cd}^* = A\lambda^4(\rho - i\eta)$	0	$D^0_{CP}\pi^0, D^0_{CP}\rho^0$	–	$D^0_{CP}K_S$	–	(g)

(a) Tree and penguin contribute with same weak phase.
(b) Penguin only, rare decays.
(c) Tree and penguin compete. Isospin analysis may allow extraction of α, β, for B_d channels, γ, 0 for B_s, where these angles come from tree and penguin contributions respectively. $K_S\overline{K}_S$ penguin only, except 0 asymmetry.
(d) Ignoring penguin relative to tree.
(e) Ignoring penguin relative to tree, or using isospin analysis.
(f) Self-tagging $K^*(892)$ decay modes can give γ when data from $B_d \to D^0_{CP}$, *i.e.* decays to CP eigenstates, and D^0- or $\overline{D}^0$-identified modes are combined. Similar results for charged $B \to DK$.
(g) Asymmetry in $D^0_{CP}\pi$, $D^0_{CP}K_S$, *etc.* modes is difficult to relate to CKM angles.
$(\dagger)$ $D^0\overline{D}^0$ from rescattering only, rate expected to be small.