

Exp. Systematic Errors

Most CP measurements use time-dep rate asymmetries

$$a(t) = \frac{\Gamma(B_q^0(t) \rightarrow f) - \Gamma(\bar{B}_q^0(t) \rightarrow f)}{\Gamma(B_q^0(t) \rightarrow f) + \Gamma(\bar{B}_q^0(t) \rightarrow f)} \sim a_{dir} \cos(\Delta m_q t) + a_{mix} \sin(\Delta m_q t)$$

- $a_{dir, mix}$ = func's of unitarity angles
 - * + 4-quark operators if decay has contrib from >1 CKM amplitude
- requires tagging flavor of B at production & decay
- robust to 1st order in exp. unknowns

Categories of Syst. Error

- Generally, difference in B & B-bar hadrons
 - a. Production Asymmetries
 - b. Tagging Efficiencies
 - c. Mistag Rates
 - d. Final State Acceptance
 - e. Backgrounds

Understand w/ Control Samples

Sample	Checks	Accuracy*
$B^+ \rightarrow J/\psi K^+$	b,c	0.1% / yr
$B_d \rightarrow J/\psi K^{0*}$	a (f_0)	0.1% / yr
$B_s \rightarrow D_s \pi$	a (f_s)	?
* LHC study		

Theoretical Uncertainties

- Mainly when hadronic effects don't cancel in ratio
 - introduce depend. on hadr. matrix elem's (4-q op's)
 - occur when >1 diagrams contribute to decay

1. Penguins

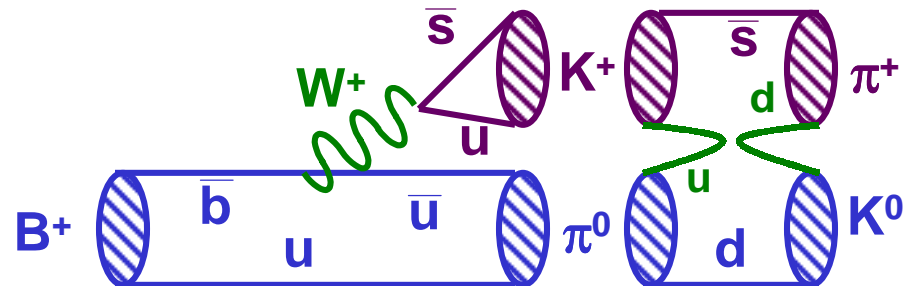
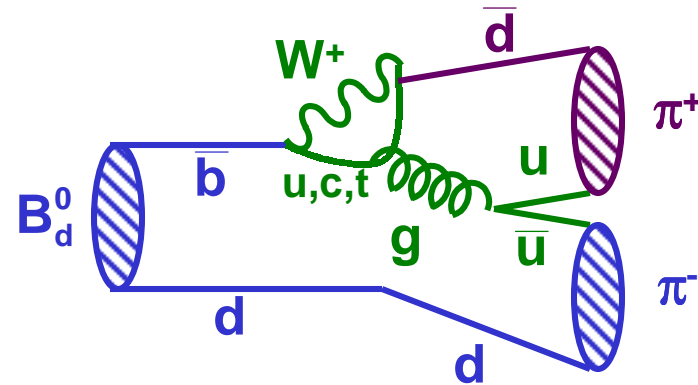
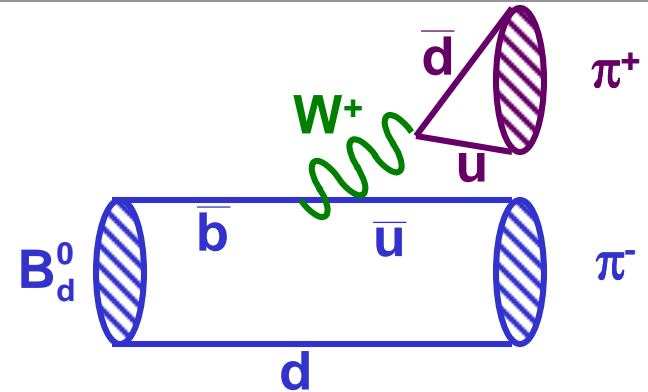
- calc. $|P/T|$

2. Strong Phases

- $\phi \rightarrow \phi + \delta$

3. Final State Interactions

- very hard to calc



Mode by Mode Breakdown

Mode	Meas	Experimental Syst	Theoretical Syst
$B_d \rightarrow J/\psi K_s$	β	* ctrl sample stat's	penguins few % unitarity of CKM
$B_d \rightarrow \pi^+ \pi^-$	α	π/K separation?	* $\delta P/T < 10\%$ required
$B_d \rightarrow \rho \pi$	α	* Dalitz sel. bias	—
$B_d \rightarrow D^* \pi$	$\gamma+2\beta$	$b \rightarrow u \ll b \rightarrow c$	hadr. M.E. & str phase
$B_s \rightarrow D_s K$	$\gamma-2\delta\gamma$	* $D_s \pi \sim 20 D_s K$	—
$B^- \rightarrow D^0 K^-$	γ	* BR $\sim O(10^{-7})$	—
$B_d \rightarrow D K^*$	γ	* small BR	—
$B^{0,-} \rightarrow K \pi$	γ	eff(trig & reco)	* SU(3) break & FSI
$B_s \rightarrow J/\psi K_s$	γ	* $B_d \rightarrow J/\psi K_s$ bgrd	SU(3) breaking
$B_d \rightarrow D^+ D^-$	γ	trig & bgrd	* penguins
$B_d \rightarrow \pi\pi, KK$	γ	* proper time res.	SU(3) breaking
* dominant systematic			

Beyond the SM

Beyond the SM effects:

- **Large?:** **Mixing, Penguins**
- **Small:** **Tree level decays**

CP Violation in Decays with & without Mixing

- $B_d \rightarrow J/\psi K_s$ $\sin 2\beta \rightarrow \sin (2\beta + \theta_{mix})$
- $B_d \rightarrow \phi K_s$ $\sin 2\beta \rightarrow \sin (2\beta + \theta_{mix} + \theta_{pen})$
- $K \rightarrow \pi VV$ $\epsilon_K(\text{meas}) \sim 10^{-3}$
- $D \rightarrow K\pi$ **mixing effect (~ 0 in SM)**
- **EDMs** **Flavor diagonal CP violation (~ 0 in SM)**

Supersymmetric Models

- **In general \Rightarrow 43 CP violating phases (c.f. 1 in SM)**
- **CP violation sensitive to $\Lambda(\text{flavor})$ & $\Lambda(\text{soft-susy-breaking})$**
 - * $\Lambda_F \gg \Lambda_S \Rightarrow$ **No new sources of flavor & CP violation**
 - * $\Lambda_F < \Lambda_S \Rightarrow$ **Flavor & CP violation beyond CKM**

Beyond the SM Effects*

Model	$d_N / 10^{-25} \text{ e cm}$	θ_{mix}	θ_{pen}	$a(D \rightarrow K\pi)$	$a(K \rightarrow \pi\nu\nu)$
SM	$< 10^{-6}$	0	0	0	$O(1)$
MSSM	$O(10^2)$?	?	?	$O(10^7)$
Exact Univ	$< 10^{-6}$	0	0	0	= SM
Approx Univ	$> 10^{-2}$	$O(0.2)$	$O(1)$	$O(1)$	\sim SM
Alignment	$> 10^{-3}$	$O(1)$	$O(1)$	$O(10^{-2})$	\sim SM
Heavy Squark	$\sim 10^{-1}$	$O(1)$	$O(1)$	$O(10^{-3})$	\sim SM

* stolen shamelessly from: Y. Nir, "CP Violation in and Beyond the SM"
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