Flavor Physics

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- Introduction
- Recent results
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Keys to probing new physics

- $K\text{-}\bar{K}$ and $B\text{-}\bar{B}$ mixing
- CP violation
- Loop induced rare decays

Mixing

$$K \Rightarrow \pi\pi \Rightarrow \overline{K}$$

Mixing probes 2nd order Weak effects

$$\begin{pmatrix} M_{11} - \frac{i}{2}\Gamma_{11} & M_{12} - \frac{i}{2}\Gamma_{12} \\ M_{21} - \frac{i}{2}\Gamma_{21} & M_{22} - \frac{i}{2}\Gamma_{22} \end{pmatrix} = \left(M - \frac{i}{2}\Gamma\right)\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} + \begin{pmatrix} 0 & M_{12} - \frac{i}{2}\Gamma_{12} \\ M_{12}{}^{*} - \frac{i}{2}\Gamma_{12}{}^{*} & 0 \end{pmatrix}$$

$$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}\begin{pmatrix} 1 \\ \pm 1 \end{pmatrix} = \pm\begin{pmatrix} 1 \\ \pm 1 \end{pmatrix}$$

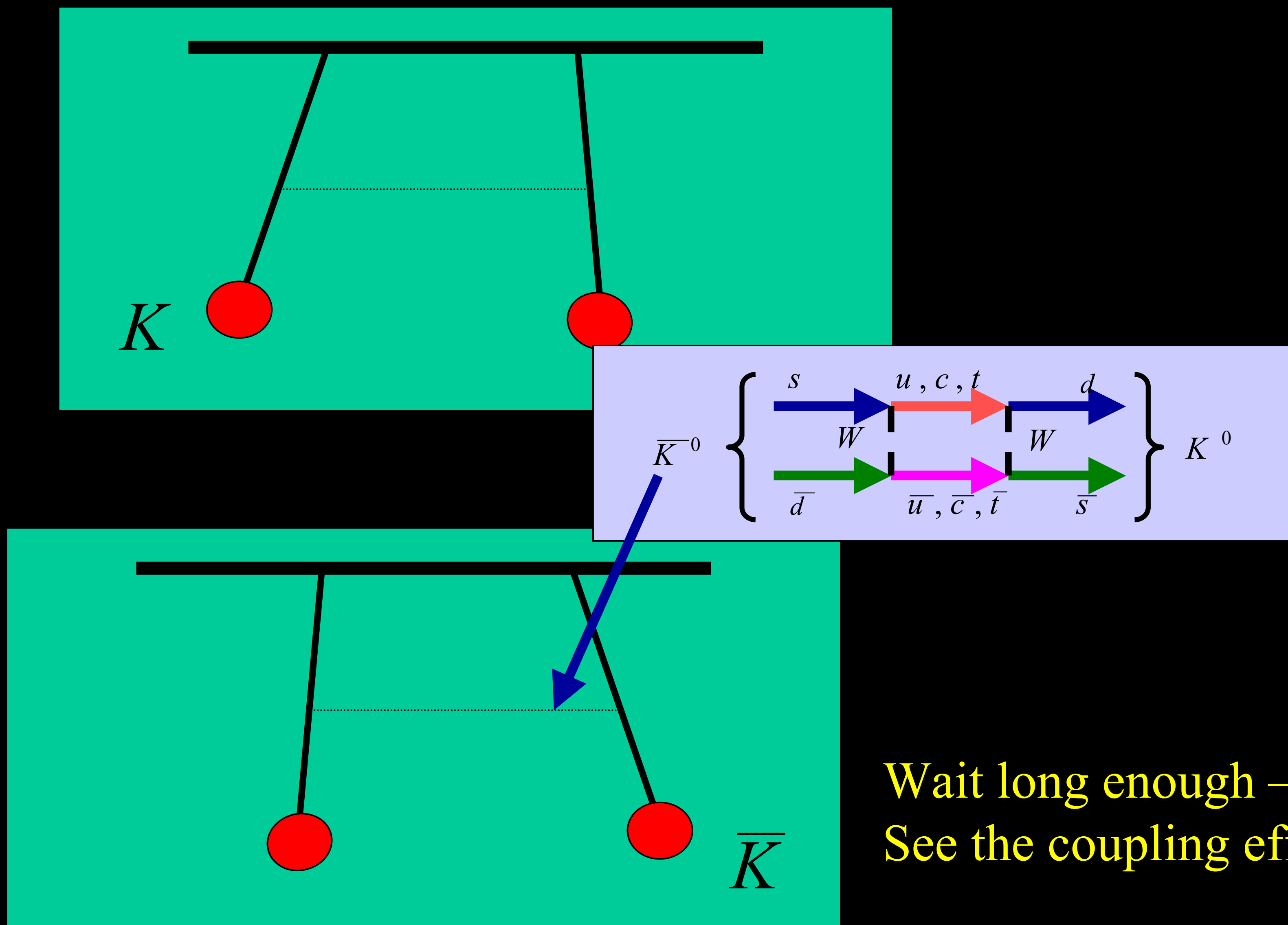
$$|K_{\pm}\rangle = \frac{1}{\sqrt{2}}\left[|K_0\rangle \pm |\overline{K_0}\rangle\right]$$

CP eigenstate

No matter how small the off diagonal elements are, the solution is same

Dynamics of double pendulum

Sensitive microscope for the coupling



Wait long enough – you will
See the coupling effect

Quantum mechanics tells us that

To make it hermitian

$$H = c\, h + c^*\, h^\dagger$$

$$CP\, h\, CP^\dagger = h^\dagger$$

$$CP\, H\, CP^\dagger = c\, h^\dagger + c^* h$$

$$\neq H \quad \text{unless } c = c^*$$

So, the phase is crucial in CPV

$$\begin{pmatrix} 0 & M_{12} - \frac{i}{2}\Gamma_{12} \\ M_{12}^{*} - \frac{i}{2}\Gamma_{12}^{*} & 0 \end{pmatrix} \begin{pmatrix} p \\ \pm q \end{pmatrix}$$

$$= \pm\sqrt{\left(M_{12} - \frac{i}{2}\Gamma_{12}\right)\left(M_{12}^{*} - \frac{i}{2}\Gamma_{12}^{*}\right)} \begin{pmatrix} p \\ \pm q \end{pmatrix}$$

$$CP \quad \left[p\left|K_0\right\rangle + q\left|\overline{K_0}\right\rangle\right] = \left[p\left|\overline{K_0}\right\rangle + q\left|K_0\right\rangle\right]$$

$$\frac{q}{p} = \sqrt{\frac{M_{12}^{*} - \frac{i}{2}\Gamma_{12}^{*}}{M_{12} - \frac{i}{2}\Gamma_{12}}}$$

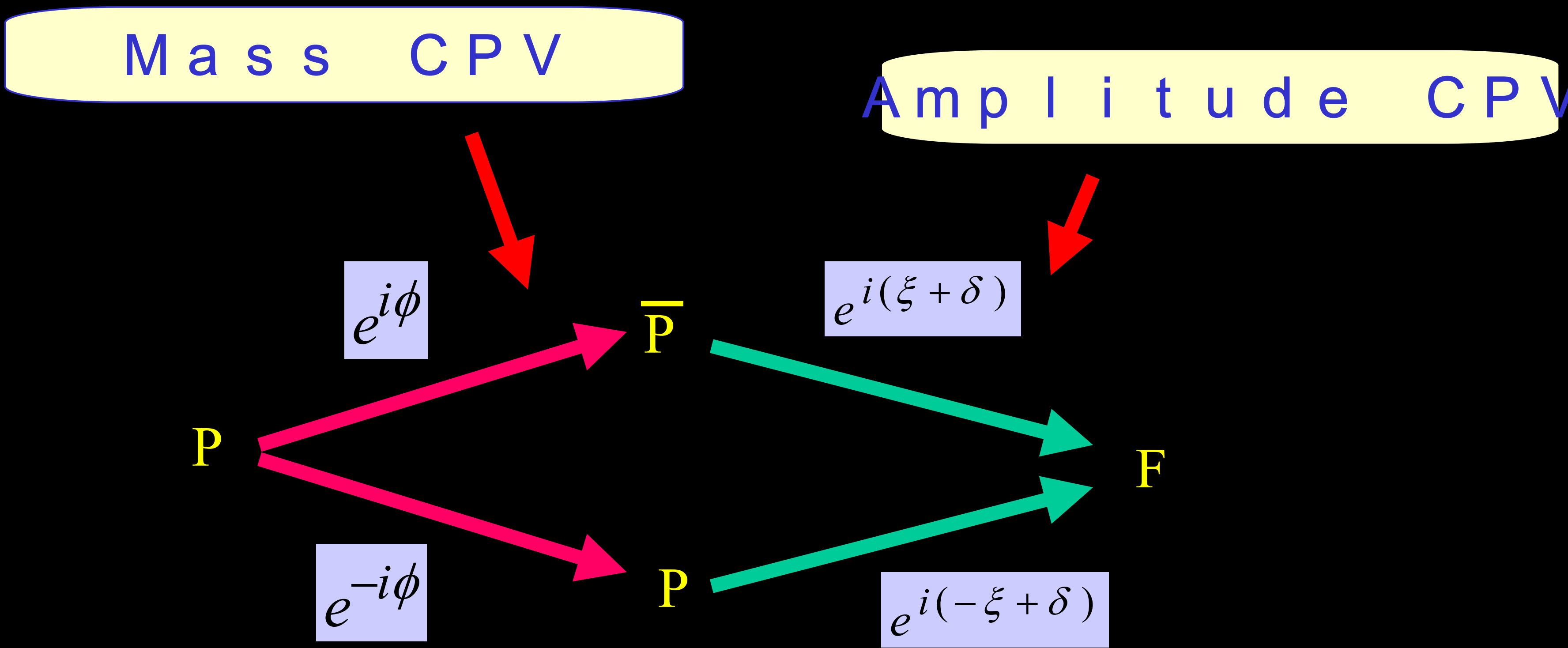
complex

It is sensitive to the hidden phase!

Not CP eigenstate

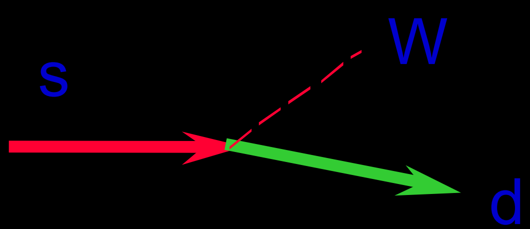
It must come from new physics
– sheds new light toward understanding quark masses!

Two sources of CPV



CPV ⇒ $$\left|A(P \to F)\right|^2 \neq \left|A(\overline{P} \to F_{CP})\right|^2$$

KM scheme of CPV



$$\begin{pmatrix} u \\ c \\ t \end{pmatrix} \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix} W$$

Phases of the KM matrix

3x3 unitary matrix has 9 real parameters

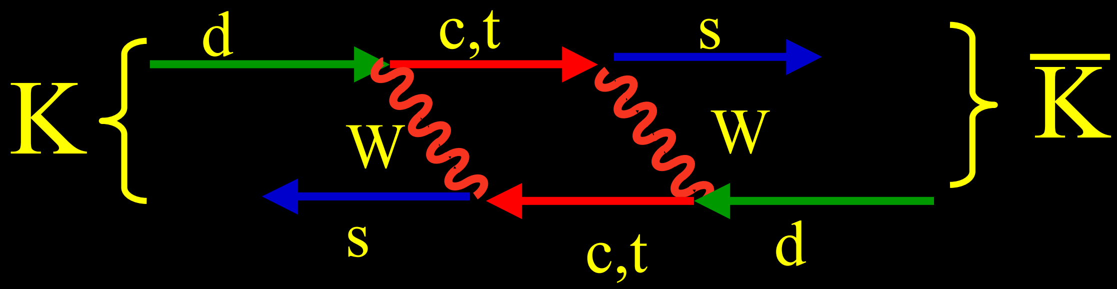
$$q_i \rightarrow e^{i\phi_i} q_i$$

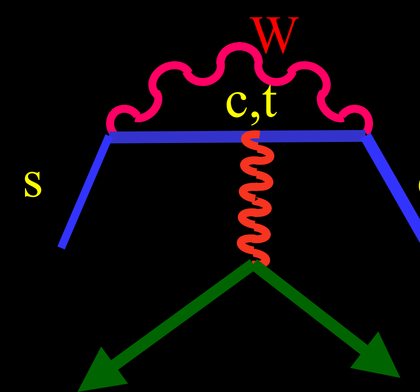
For 6 quarks, there are 5 phases
We xcan adjust

KM matrix has 4 parameters

1 CPV phase

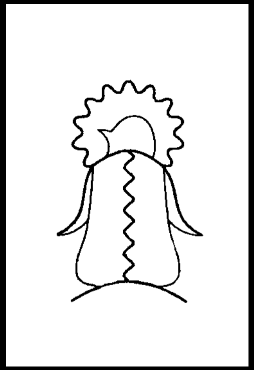
3 rotation angle

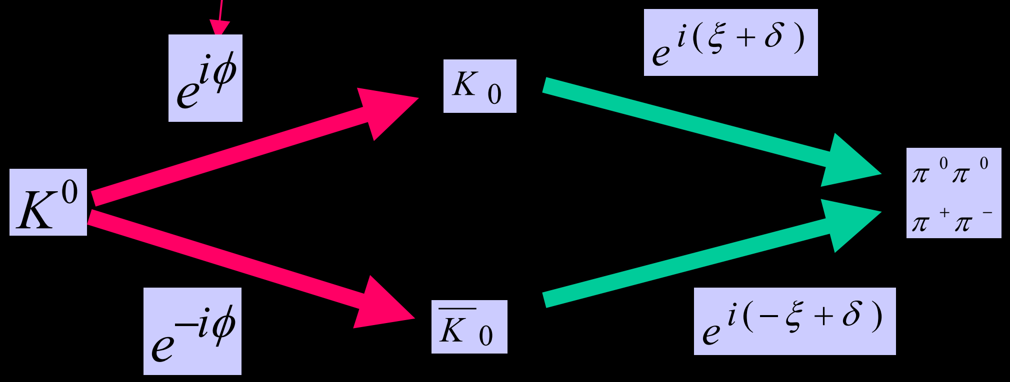




M$_{12}$ becomes complex

A(K --› ππ) amplitude becomes complex





$$\frac{\varepsilon'}{\varepsilon} \neq 0$$

Penguins and me in Cape Town, Jan., 1999

Experimental result

$$\frac{\varepsilon'}{\varepsilon} = \begin{cases} (15.3 \pm 2.6) \times 10^{-4} & NA48 \\ (20.7 \pm 2.8) \times 10^{-4} & KTeV \end{cases}$$

Theory:

$$\frac{\varepsilon'}{\varepsilon} = 13 \times \mathrm{Im}(V_{ts} V_{td}^{*}) \left(\frac{110 MeV}{m_s(2GeV)} \right)^2 \left[B_6^{(1/2)} (1 - \Omega_{IB}) - 1.4 B_8^{(3/2)} \left[\frac{m_t}{165 GeV} \right]^{2.5} \right]$$

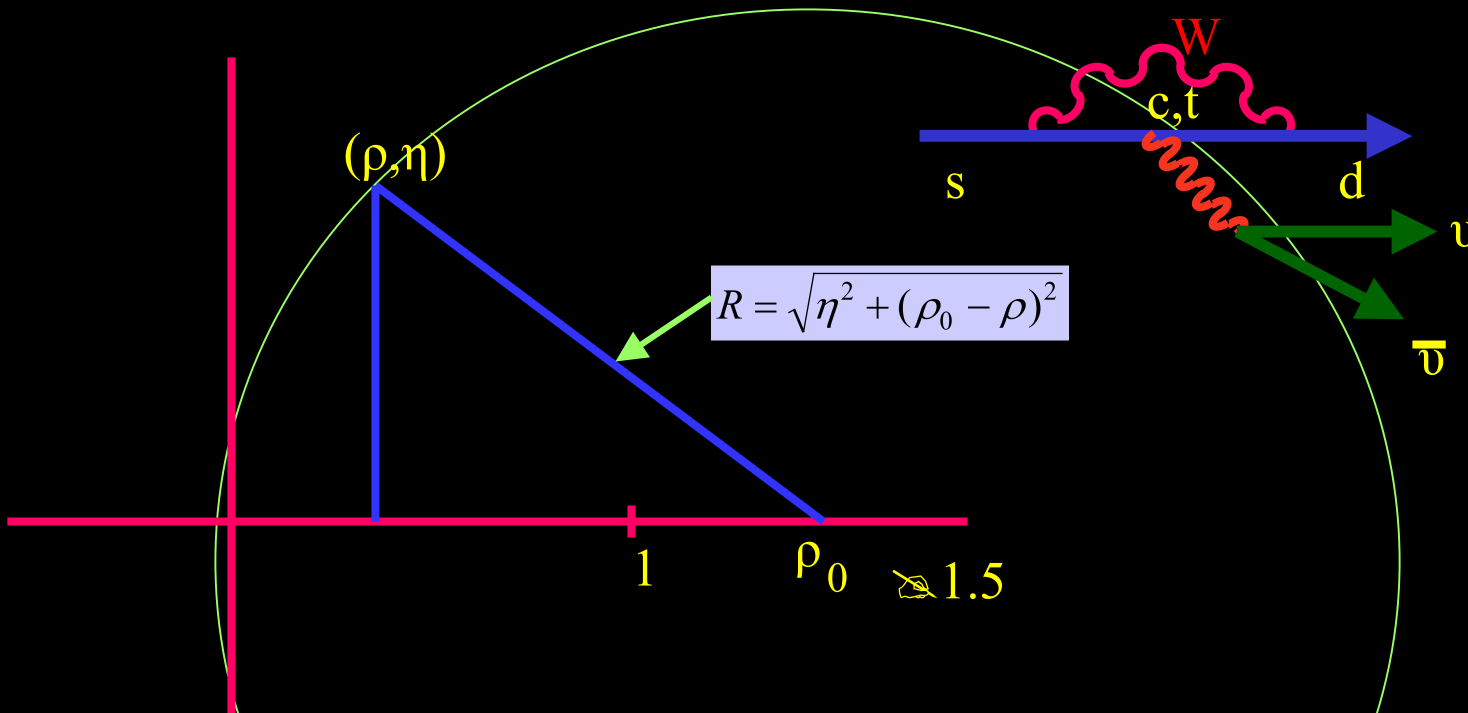
QCD penguin

EW penguin

Matrix elements are poorly known
And they cancel! So, for now there
is no constraint

Experimental value can be understood
with B's =1

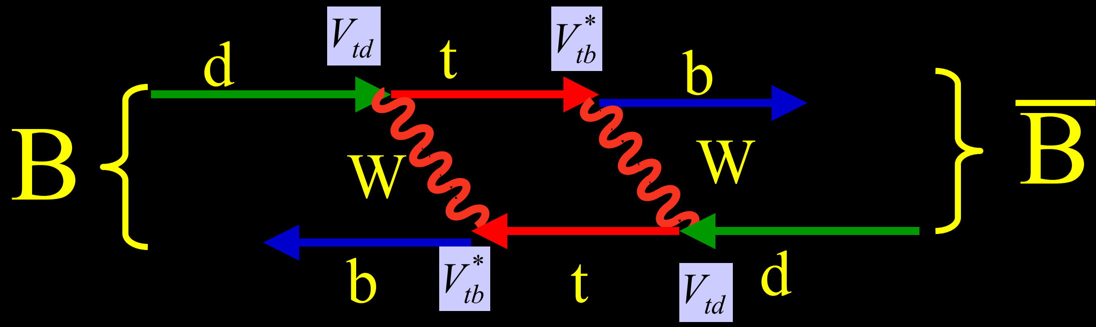
Second candidate for $K^+ \rightarrow \pi^+ + \nu + \overline{\nu}$



AGS E787 $Br(K^+ \rightarrow \pi^+ \nu \overline{\nu}) = (1.57^{+1.75}_{-0.82}) \times 10^{-10}$

Theory $(0.72 \pm .21) \times 10^{-10}$

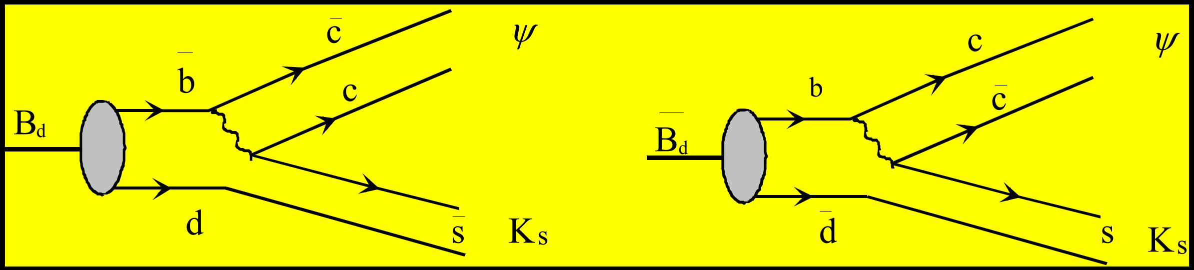
Mixing and CPV in B decays

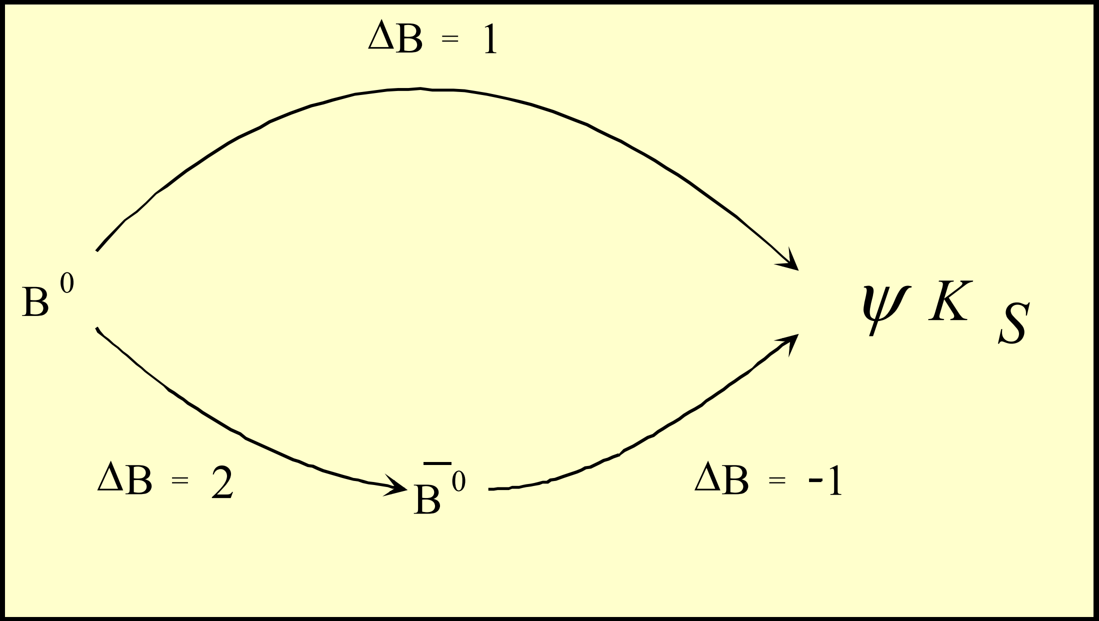


Predicts $B - \overline{B}$ mixing

M_{12} becomes complex

Gold plated decays

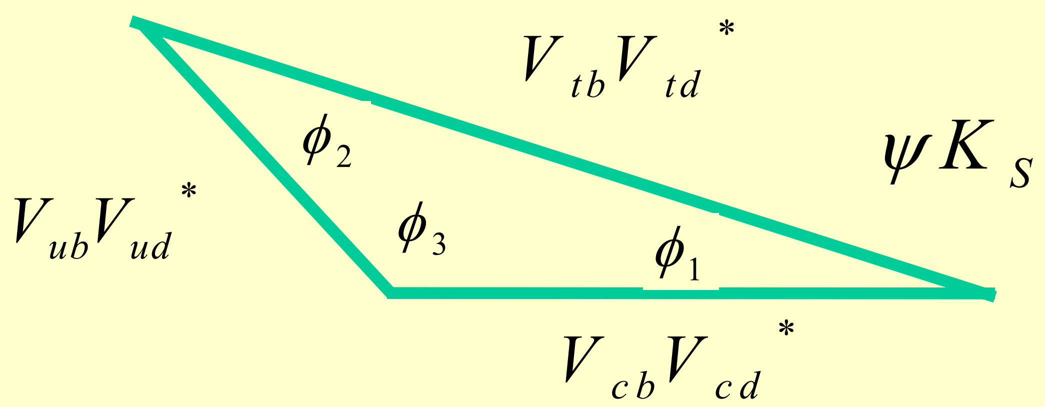




CPV in B decays

$$\frac{\Gamma(\bar{B}(t)\to\psi K_S)-\Gamma(B(t)\to\psi K_S)}{\Gamma(\bar{B}(t)\to\psi K_S)+\Gamma(B(t)\to\psi K_S)} = \sin(2\phi_1)\sin(\Delta M t)$$

$$\sin(2\phi_1) = \mathrm{Im}\left[\frac{V_{tb}V_{td}^{*}V_{cb}^{*}V_{cd}}{V_{tb}^{*}V_{td}V_{cb}V_{cd}^{*}}\right]$$



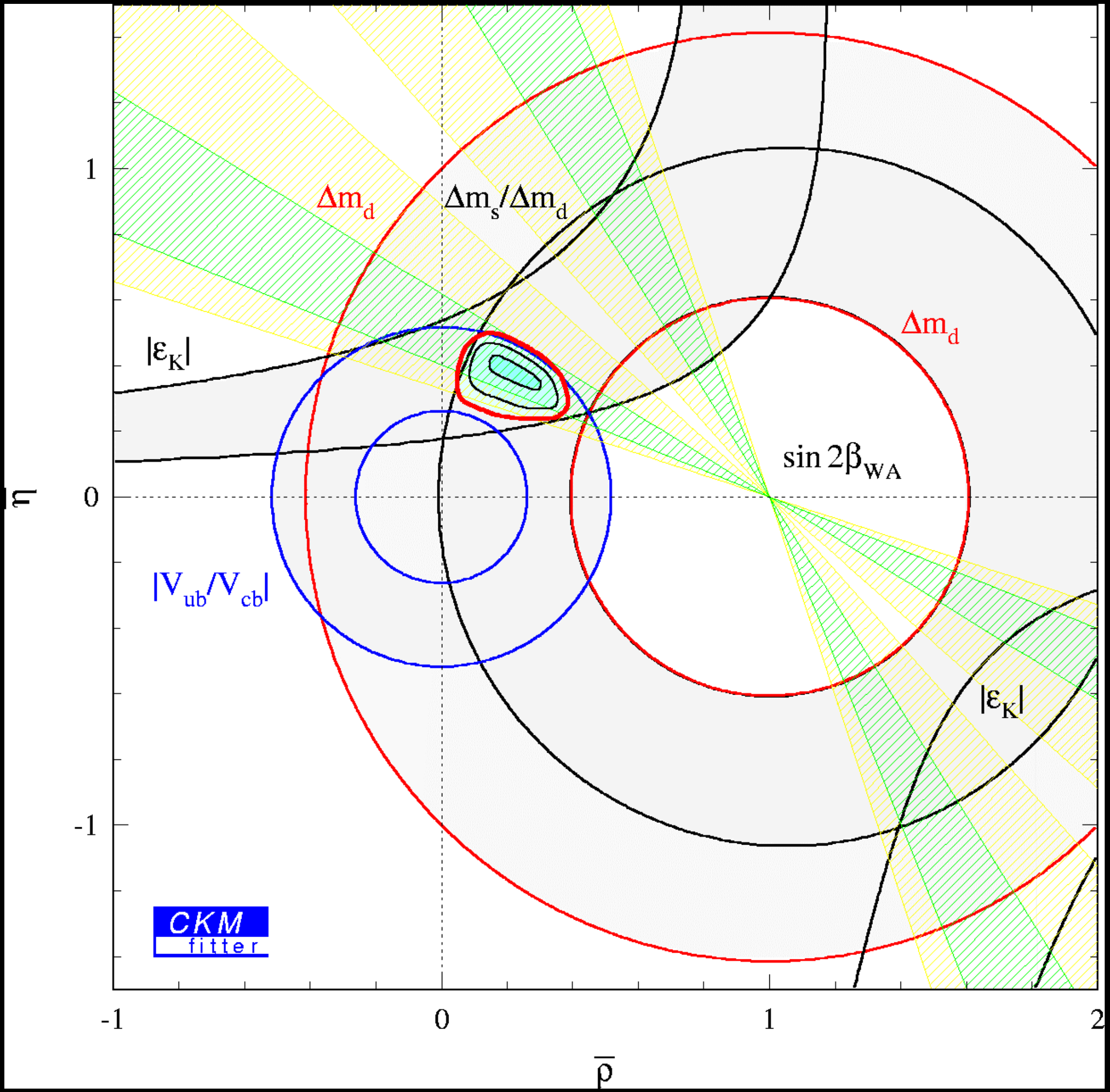
$$V_{cb}V_{cd}^{*} + V_{ub}V_{ud}^{*} + V_{tb}V_{td}^{*} = 0$$

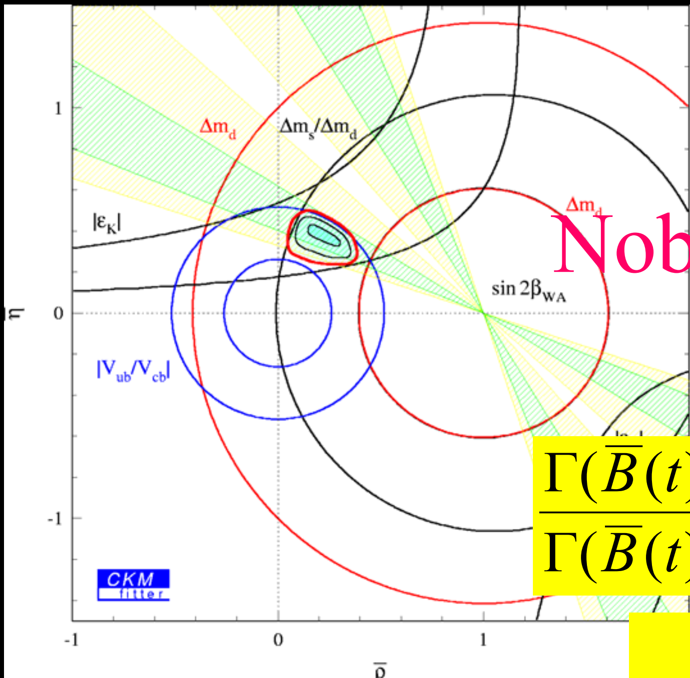
Discovery of CP violation in B decay

$$\sin(2\phi_1) = \begin{cases} (0.99 \pm 0.14 \pm 0.06)(Belle) \\ (0.59 \pm 0.14 \pm 0.05)(Babar) \end{cases}$$

GLOBAL FIT: RESULTS

Global fit including sin2β:





Nobody measured the sign of ΔM

$$\frac{\Gamma(\overline{B}(t)\to\psi K_S)-\Gamma(B(t)\to\psi K_S)}{\Gamma(\overline{B}(t)\to\psi K_S)+\Gamma(B(t)\to\psi K_S)}=\sin(2\phi_1)\sin(\Delta M t)$$

$$\Delta M = B_B\overline{\xi}_{td}^{\,2}\frac{G_F^2 F_B^2 M_B M_W^2 \eta_t^B E(x_t)}{6\pi^2}$$

$$\overline{\xi}_{td}^{\,2} = sign((1-\rho)^2-\eta^2)\,|\,\xi_{td}^2\,|$$

$$\frac{\Gamma(\overline{B}(t)\to\psi K_S)-\Gamma(B(t)\to\psi K_S)}{\Gamma(\overline{B}(t)\to\psi K_S)+\Gamma(B(t)\to\psi K_S)}=\sin(2\phi_1)\sin(\Delta M t)$$

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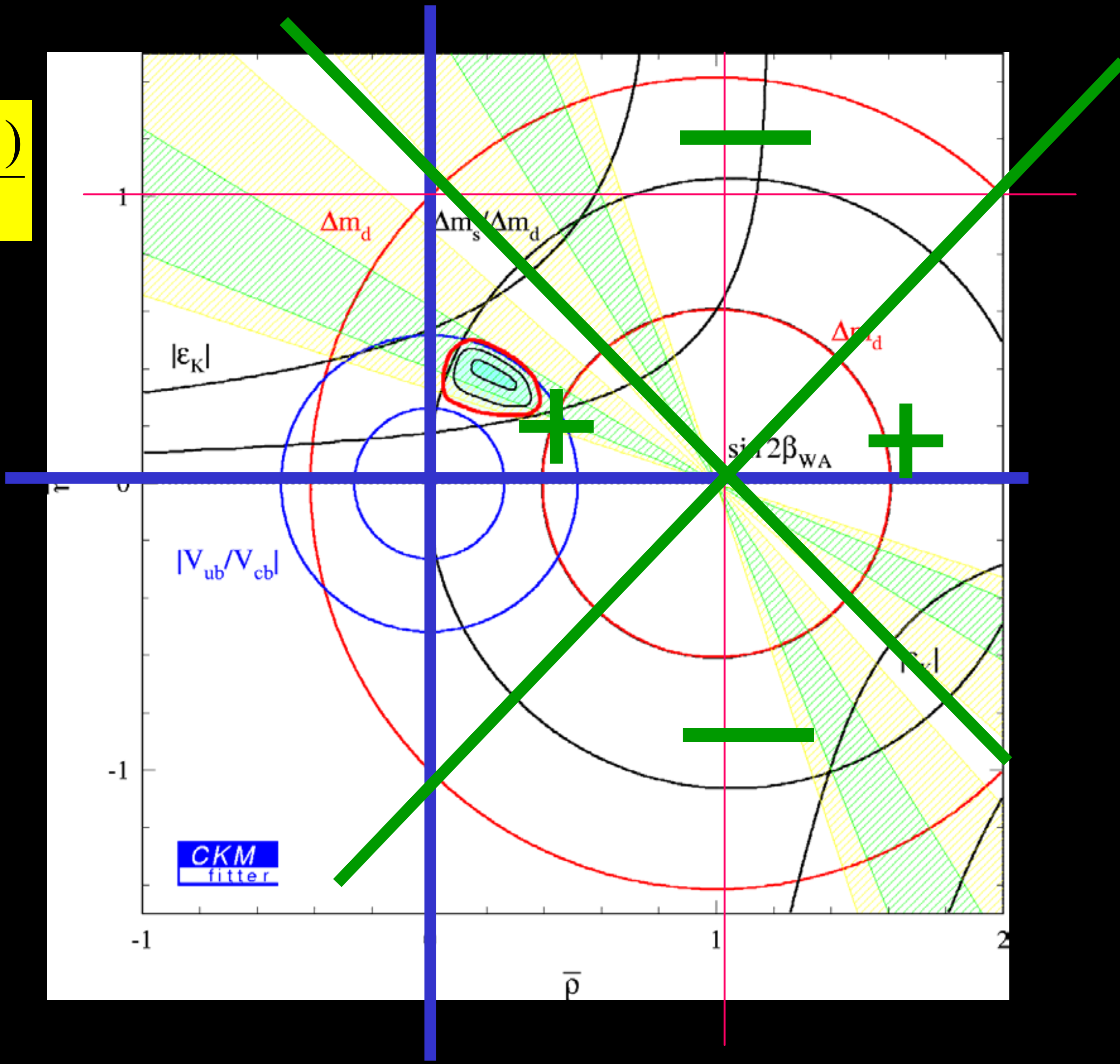
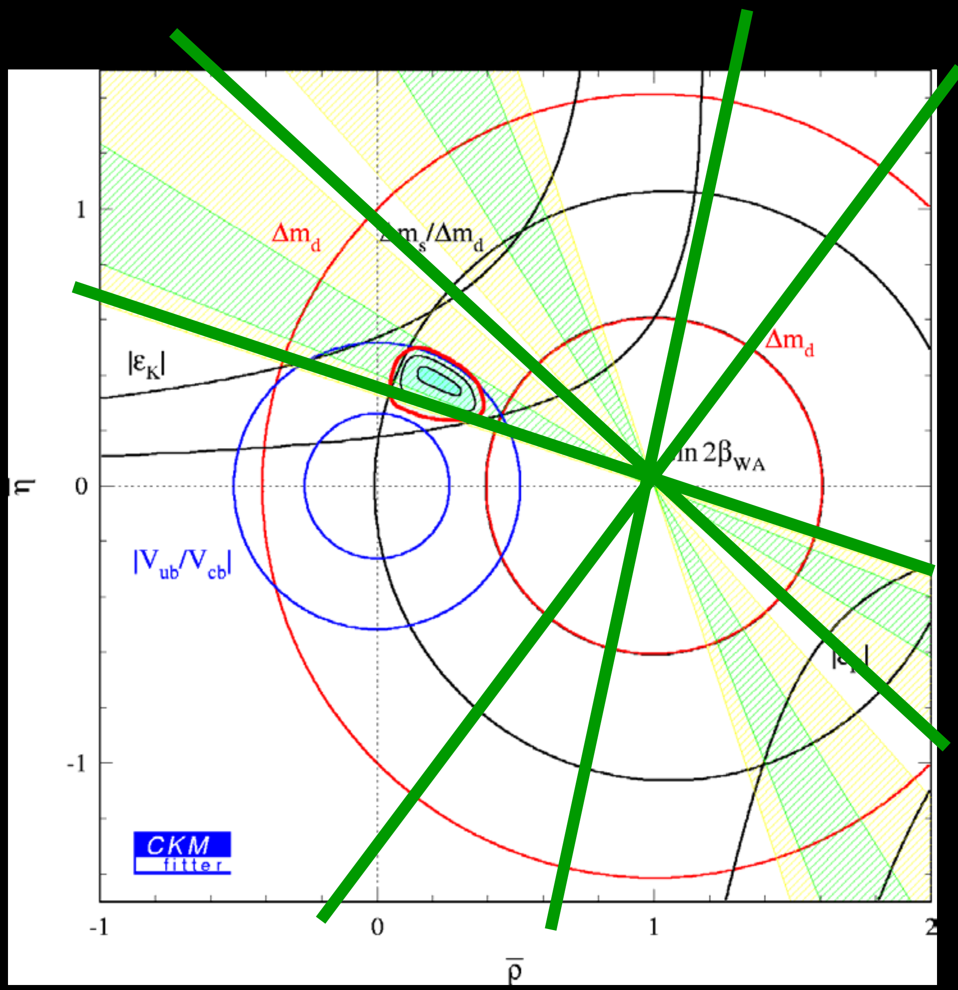
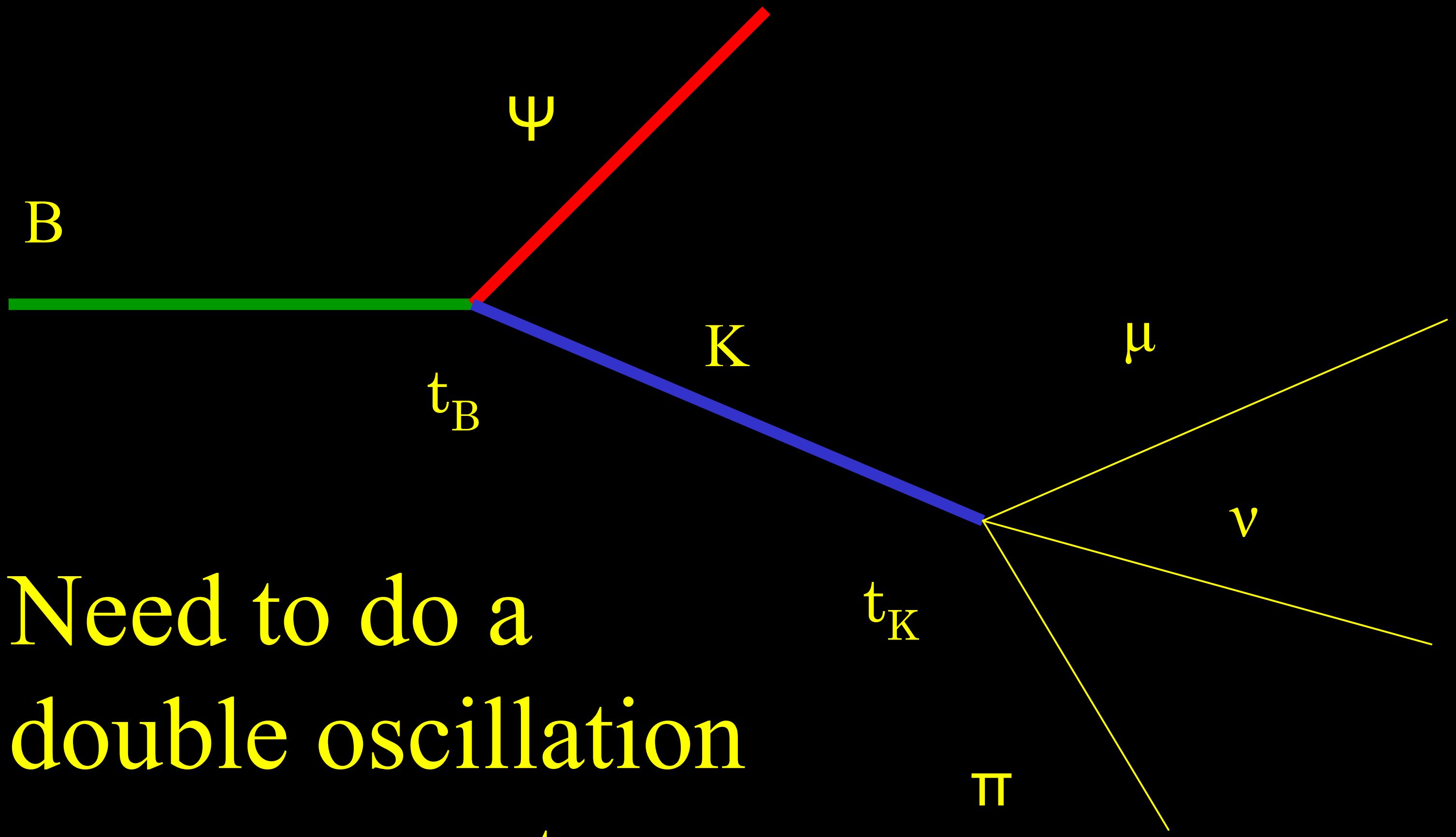


Correct allowed region on the ρ–η plane



How do we determine the sign of ΔM



Need to do a double oscillation measurement

$$\Gamma(\overline{B}(t_B) \to [\mu^- \pi^+ \overline{\nu}]_{\overline{K}} \psi) \propto [A + B + C + D]$$

$$\Gamma(\overline{B}(t_B) \to [\mu^+ \pi^- \nu]_{K} \psi) \propto [A - B + C - D]$$

$$\Gamma(B(t_B) \to [\mu^- \pi^+ \overline{\nu}]_{\overline{K}} \psi) \propto [A - B - C - D]$$

$$\Gamma(B(t_B) \to [\mu^+ \pi^- \nu]_{K} \psi) \propto [A + B - C + D]$$

$$A = \tfrac{1}{4} e^{-\Gamma_S t_K - \Gamma_B t_B} [1 + e^{\Delta\Gamma t_K}]$$

$$B = \tfrac{1}{2} e^{-\Gamma_S t_K - \Gamma_B t_B} e^{\Delta\Gamma t_K} \cos(\Delta M_B t_B) \cos(\Delta M_K t_K)$$

$$C = \tfrac{1}{4} e^{-\Gamma_S t_K - \Gamma_B t_B} [1 - e^{\Delta\Gamma t_K}] \sin(\Delta M_B t_B) \sin(2\phi_1)$$

$$D = \tfrac{1}{2} e^{-\Gamma_S t_K - \Gamma_B t_B} e^{\Delta\Gamma t_K} \sin(\Delta M_B t_B) \cos(2\phi_1) \sin(\Delta M_K t_K)$$

Detailed simulation is needed to understand the best strategy

$$\frac{\Gamma(\overline{B}(t_B) \to \psi[\mu^- \overline{\nu} \pi^+]_{\overline{K}(t_K)}) - \Gamma(\overline{B}(t_B) \to \psi[\mu^+ \nu \pi^-]_{K(t_K)})}{\Gamma(\overline{B}(t_B) \to \psi K_S) + \Gamma(B(t_B) \to \psi K_S)}$$

$$= \frac{\Gamma(K_S \to \mu \nu \pi)}{\Gamma(K_S \to \pi^+ \pi^-)} e^{\frac{1}{2}\Delta\Gamma t_K} [\cos(\Delta M_B t_B)\cos(\Delta M_K t_K) + \sin(\Delta M_B t_B)\sin(\Delta M_K t_K)\cos(2\phi_1)]$$

Penguin pollution

$$\frac{\Gamma(\overline{B}(t)\to\pi\pi)-\Gamma(B(t)\to\pi\pi)}{\Gamma(\overline{B}(t)\to\pi\pi)+\Gamma(B(t)\to\pi\pi)}=\mathrm{Im}\left(\frac{q}{p}\frac{A(\overline{B}\to\pi\pi)}{A(B\to\pi\pi)}\right)\sin(\Delta M t)$$

$$\left(p\ A(B\to\pi\pi)\right) \qquad \left(M_{12}\ Te^{i(-\phi_T+\delta_T)}+Pe^{i(-\phi_P+\delta_P)}\right)$$

Two clean possibilities:

$$\mathrm{Im}\left(\frac{M_{12}^*}{M_{12}}\frac{Te^{i(\phi_T+\delta_T)}+Pe^{i(\phi_P+\delta_P)}}{Te^{i(-\phi_T+\delta_T)}+Pe^{i(-\phi_P+\delta_P)}}\right)=\begin{cases}\mathrm{Im}\left(\dfrac{M_{12}^*}{M_{12}}\dfrac{e^{i\phi}}{e^{-i\phi}}\right) & \text{If } \phi=\phi_P=\phi_T \\ \mathrm{Im}\left(\dfrac{M_{12}^*}{M_{12}}\dfrac{e^{i\phi_T}}{e^{-i\phi_T}}\right) & \text{If } P=0\end{cases}$$

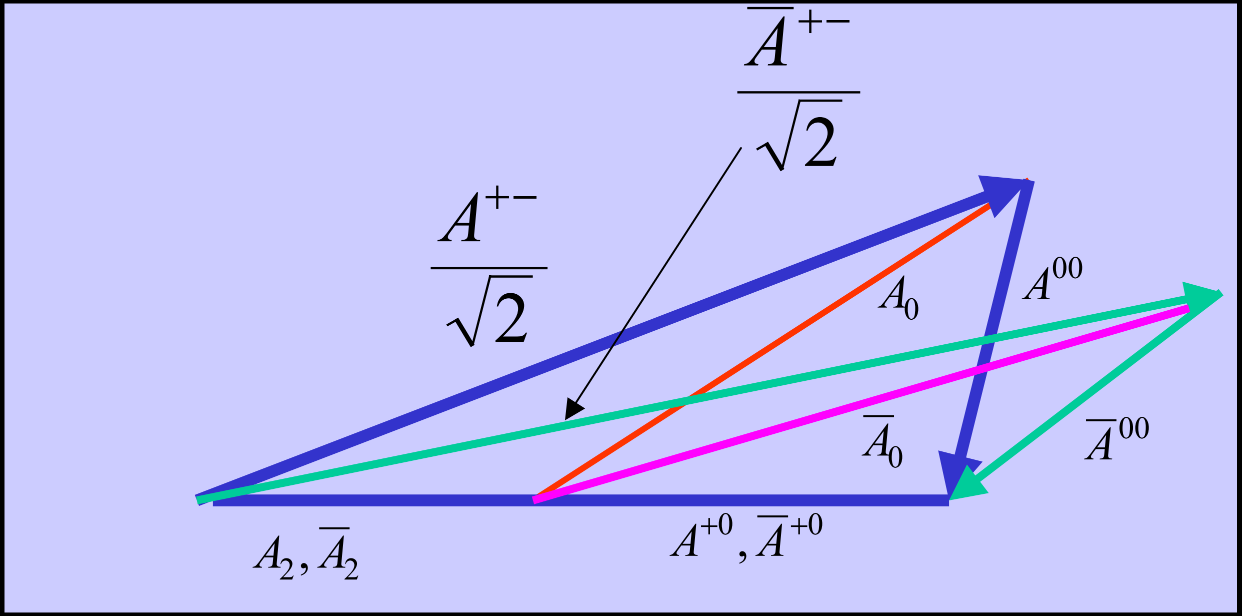
Penguins are larger than we thought

$$Br(B \to K\pi) \geq Br(B \to \pi\pi)$$

Implies that

$$\frac{P}{T} = \mathrm{O}(\lambda) \approx 0.23$$

Isospin Analysis



$$asym = \left|\frac{1+\bar{z}}{1+z}\right| \sin\left[2\phi_2 + \arg\left(\frac{1+\bar{z}}{1+z}\right)\right]$$

$$z = \frac{\sqrt{2}A_0}{A_2} \qquad \bar{z} = \frac{\sqrt{2}\overline{A}_0}{\overline{A}_2}$$

$$\frac{\Delta\phi_2}{\phi_2} = \sqrt{\begin{matrix}(0.1\sigma_{+-})^2 + (0.16\sigma_{00})^2 + (0.5\sigma_{+0})^2 \\ + (1.26\,\overline{\sigma}_{+-})^2 + (0.28\,\overline{\sigma}_{00})^2 + (0.11\sigma_{asym})^2\end{matrix}}$$

$$\sigma_{+-} = \frac{\Delta A(B\to\pi^+\pi^-)}{A(B\to\pi^+\pi^-)}$$

$$\overline{\sigma}_{+-} = \frac{\Delta A(\overline{B}\to\pi^+\pi^-)}{A(\overline{B}\to\pi^+\pi^-)}$$

To get 1% error on ϕ_2

$\sigma_{+-} = 4\%$ $\sigma_{00} = 2.5\%$ $\sigma_{+0} = .8\%$

$\overline{\sigma}_{+-} = .3\%$ $\overline{\sigma}_{00} = 1.4\%$ $\sigma_{asym} = 4\%$

$$\left(\frac{1.26}{.28}\right)^2 \approx 20 \geq \frac{Br(B\to\pi^+\pi^-)}{Br(B\to\pi^0\pi^0)}$$

Need 4.4×10^5 $B\to\pi^+\pi^-$

With $Br(B\to\pi^+\pi^-) = 4.3\times10^{-6}$

$10^{11}\,B's$

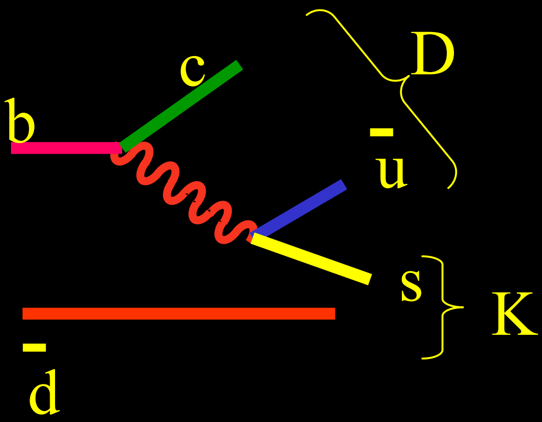
Luminosity 10^{37}

where do we go from here

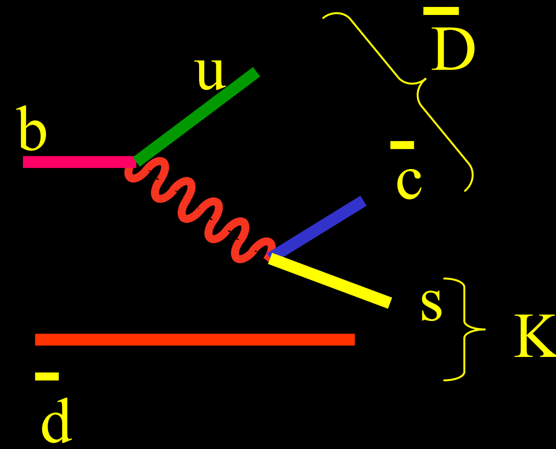
It is often implied: any asymmetry which does not lead to a clean determination of the KM element is not worth measuring.

This is a wrong attitude! Just keep at it. We will learn how to extract new physics as we go along.

$$asym = \frac{Br(B^- \to D_{1,2}K^-) - Br(B^+ \to D_{1,2}K^+)}{Br(B^- \to D_{1,2}K^-) + Br(B^+ \to D_{1,2}K^+)}$$



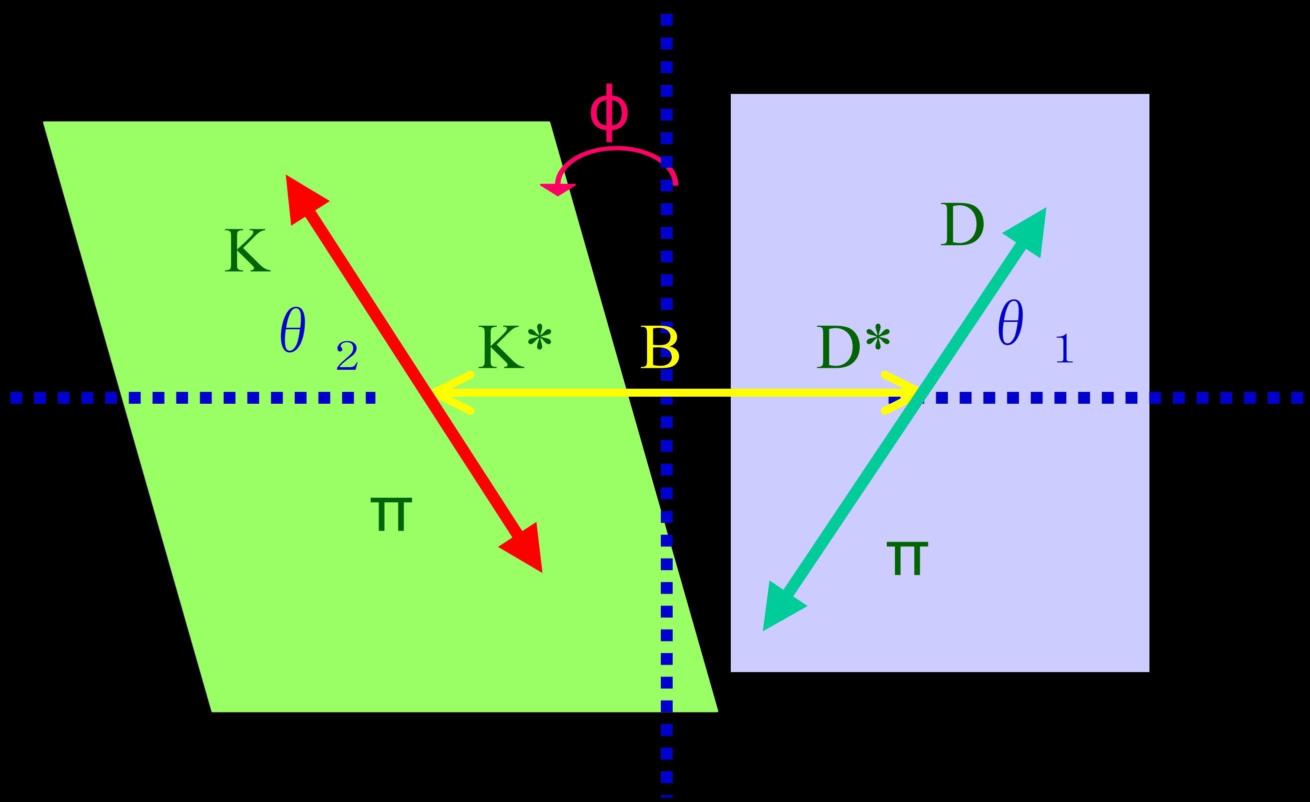
$$V_{cb}V_{us}^{*}ae^{i\delta}$$



$$V_{ub}V_{cs}^{*}be^{i\delta'}$$

$$asym = -\frac{2ab\sin\phi_3\sin(\delta'-\delta)}{a^2+b^2+2ab\cos\phi_3\cos(\delta'-\delta)}$$

B → K*+D* helicity analysis



B → K*D* has 3 helicity amplitudes: 00, +-, -+

$$A_\lambda = Amp(B \to f)_\lambda = a_\lambda e^{i\delta_\lambda^a} e^{i\phi_a}$$

$$A'_\lambda = Amp(\overline{B} \to f)_\lambda = b_\lambda e^{i\delta_\lambda^b} e^{i\phi_b}$$

$$\overline{A}'_\lambda = Amp(B \to \bar{f})_\lambda = b_\lambda e^{i\delta_\lambda^b} e^{-i\phi_b}$$

$$\overline{A}_\lambda = Amp(\overline{B} \to \bar{f})_\lambda = a_\lambda e^{i\delta_\lambda^a} e^{-i\phi_a}$$

$$6 - a_\lambda e^{i\delta_\lambda^a}$$

$$6 - b_\lambda e^{i\delta_\lambda^b}$$

$$2 - \phi_a, \phi_b$$

14 parameters

$$A(B \to K^* D^*) \propto A^0 \cos\theta_1 \cos\theta_2 + \frac{A^{\parallel}}{\sqrt{2}} \sin\theta_1 \sin\theta_2 \cos\phi - i \frac{A^{\perp}}{\sqrt{2}} \sin\theta_1 \sin\theta_2 \sin\phi$$

$g_0(\theta_1,\theta_2,\phi)$ $g_{\parallel}(\theta_1,\theta_2,\phi)$ $g_{\perp}(\theta_1,\theta_2,\phi)$

$$|A(B \to K^* D^*)|^2 \propto \sum_{\lambda\sigma} g_\lambda(\theta_1,\theta_2,\phi) g_\sigma(\theta_1,\theta_2,\phi)[\Lambda_{\lambda\sigma} + \Sigma_{\lambda\sigma}\cos(\Delta M t) - \Xi_{\lambda\sigma}\sin(\Delta M t)]$$

$$\begin{pmatrix} 00 & 0\parallel & 0\perp \\ & \parallel\parallel & \parallel\perp \\ & & \perp\perp \end{pmatrix}$$

6x3=18 observables

$6 - a_\lambda e^{i\delta_\lambda^a}$

$6 - b_\lambda e^{i\delta_\lambda^b}$

$2 - \phi_a, \phi_b$

14 parameters

Nonleptonic 2 body

$$
\begin{aligned}
B \;\rightarrow\; & \pi^+\pi^-,\ \pi^0\pi^0,\ \eta'\eta',\ \eta\eta',\ \pi^0\eta',\ \pi^0\eta \\
& K_S\pi^0,\ K_S\eta',\ K_S\eta,\ \rho^0 K_S,\ \phi K_S, \\
& K^0\bar{K}^0,\ K^+K^-,\ K^{*0}\bar{K}^{*0},\ K^{*+}K^{*-} \\
& \rho^0\pi^0,\ \omega\pi^0,\ \rho^0\eta,\ \rho^0\eta',\ \omega\eta,\ \omega\eta', \\
& \phi\pi^0,\ \phi\eta,\ \phi\eta',\ \rho^+\rho^-,\ \omega\omega,\ \rho^0\omega,\ \rho^0\phi',
\end{aligned}
$$

Over 70 decay modes

History of pQCD approach

- Brodsky Lepage PR D22,2157(80)

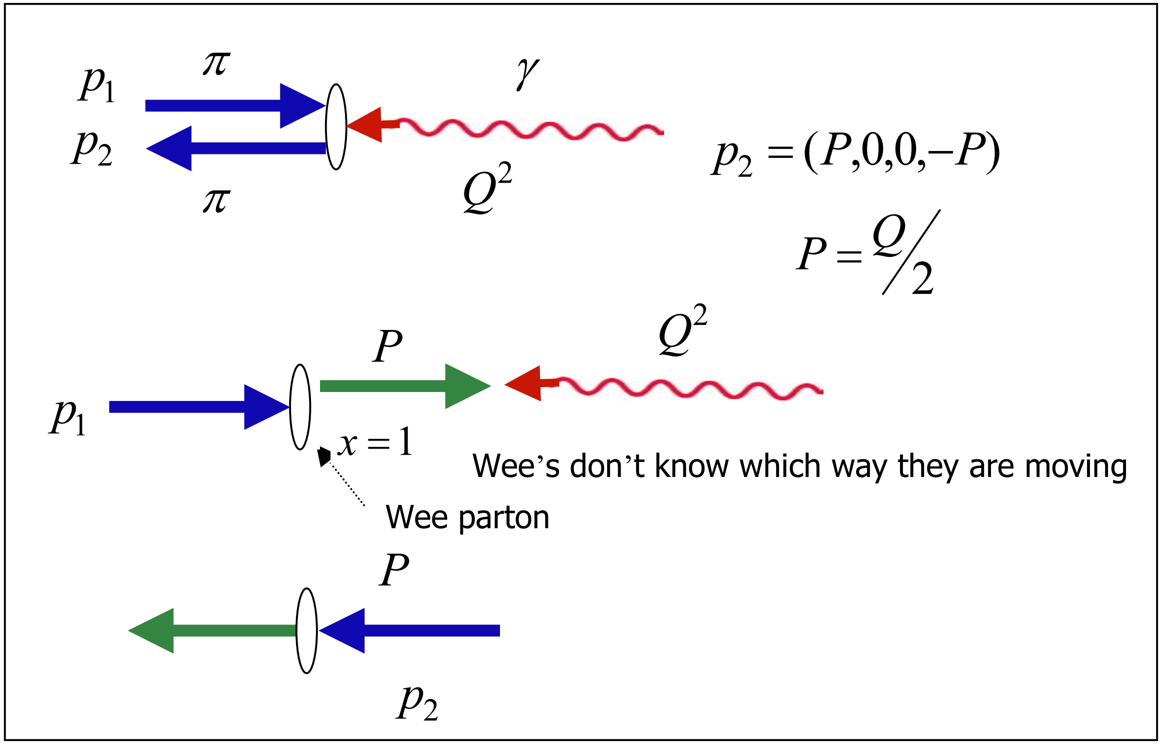
- Isgar Llewellynsmith NPB317,526(89)
- Botts Sterman NP B325, 62(89)

- Li and his collaborators

- Kroll Eur.Phys.J.C12,99(00)

- Li, Keum, AIS hep-ph/0004173 PR

Feynman's Mistake?
Pion form factor

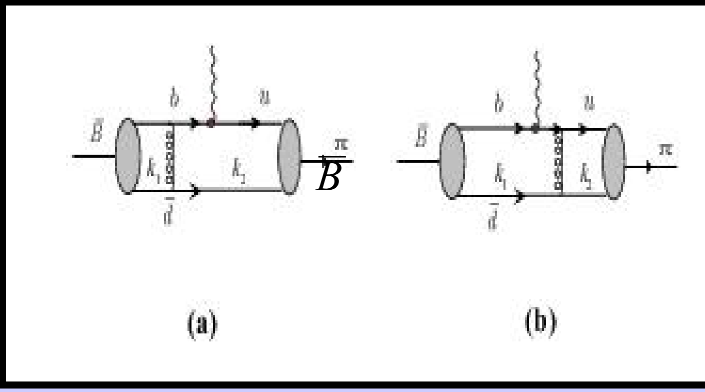


$F(Q^2)$

Depends on wee dynamics

Cannot be computed by perturbative QCD

Feynman's reasoning – Naive QCD



$$\left\langle \pi(p_2)\,|\,J_\mu(0)\,|\,\pi(p_1)\right\rangle = g^2 \int \frac{d^4k_1 d^4k_2 d^4x_1 d^4x_2}{(2\pi)^4(2\pi)^4} e^{-ik_2 y} \left\langle \pi \middle| \overline{u}_\gamma(0) d_\beta(y) \middle| 0 \right\rangle$$

$$\times\, e^{ik_1 x} \left\langle 0 \middle| \overline{d}_\alpha(x) u_\delta(0) \middle| \pi \right\rangle T_H^{\gamma\beta;\alpha\delta}$$

$$T_H^{\gamma\beta;\alpha\delta} = [\gamma_\sigma]^{\alpha\beta} \frac{1}{(k_2-k_1)^2} \left[\gamma_\mu \frac{\not{P} - \not{k}_2}{(P-k_2)^2} \gamma^\sigma\right]^{\gamma\delta} .$$

$$(k_2-k_1)^2 \propto x_1 x_2,$$

Infrared singularity! Infrared singularity!

◇Isgar Llewellynsmith NPB317,526(89) Isgar Llewellynsmith

Feynman says small x and small $k_\perp$ dominates

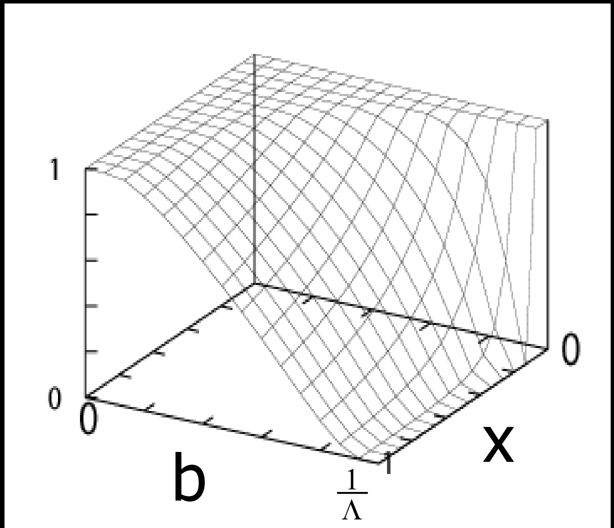
This is not so in QCD

When quark and anti-quark are far apart in space they radiate gluons

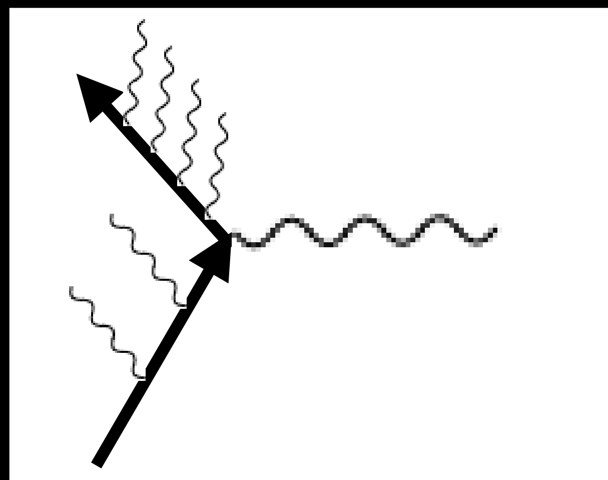
Small $x \Rightarrow$ large longtudinal separation

Small $k_\perp \Rightarrow$ large transverse separation

Probability of not emitting any gluon:
Sudakov factor suppress these regions



Sudakov Factor in QED

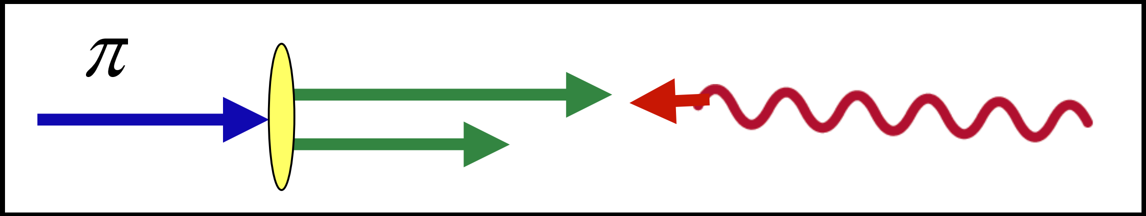


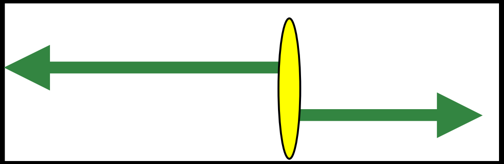
$$\left(\frac{d\sigma}{d\Omega}\right)_{measured} = \left(\frac{d\sigma}{d\Omega}\right)_0 \times \left| exp\left[-\frac{\alpha}{2\pi}\log\left(\frac{-q^2}{m^2}\right)\log\left(\frac{-q^2}{E_l^2}\right)\right]\right|^2$$

Remember!

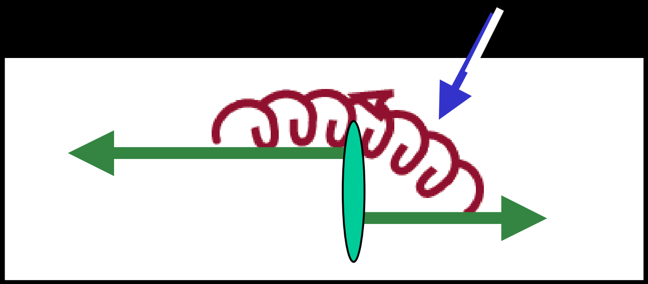
Even if you emit one gluon,
you don't get $B \rightarrow \pi\pi$

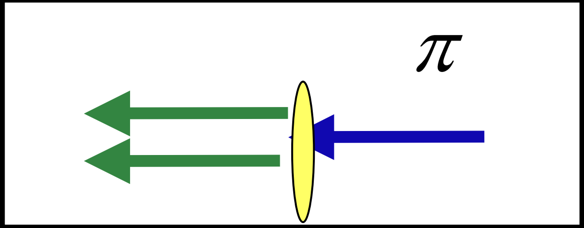
PQCD approach to pion form factor

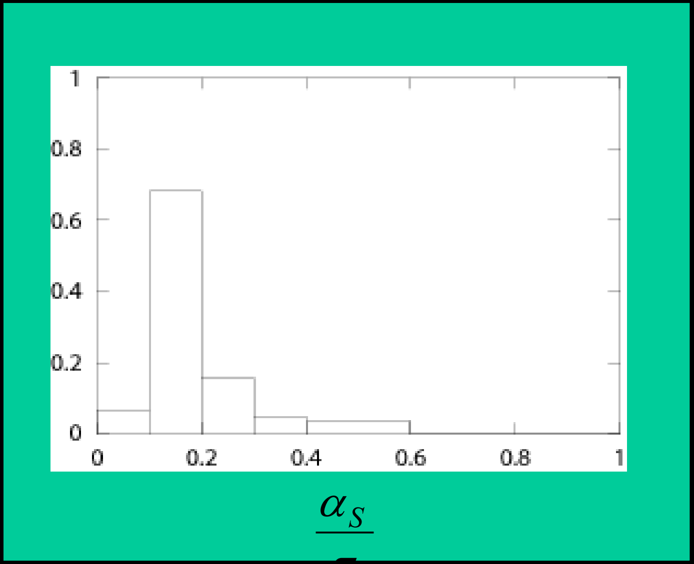




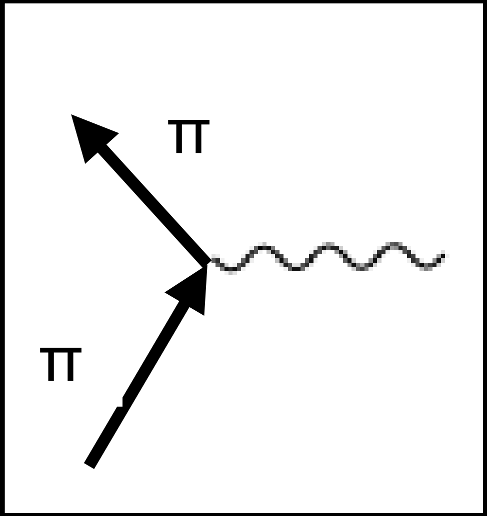
$\pi + "\gamma" \rightarrow X$

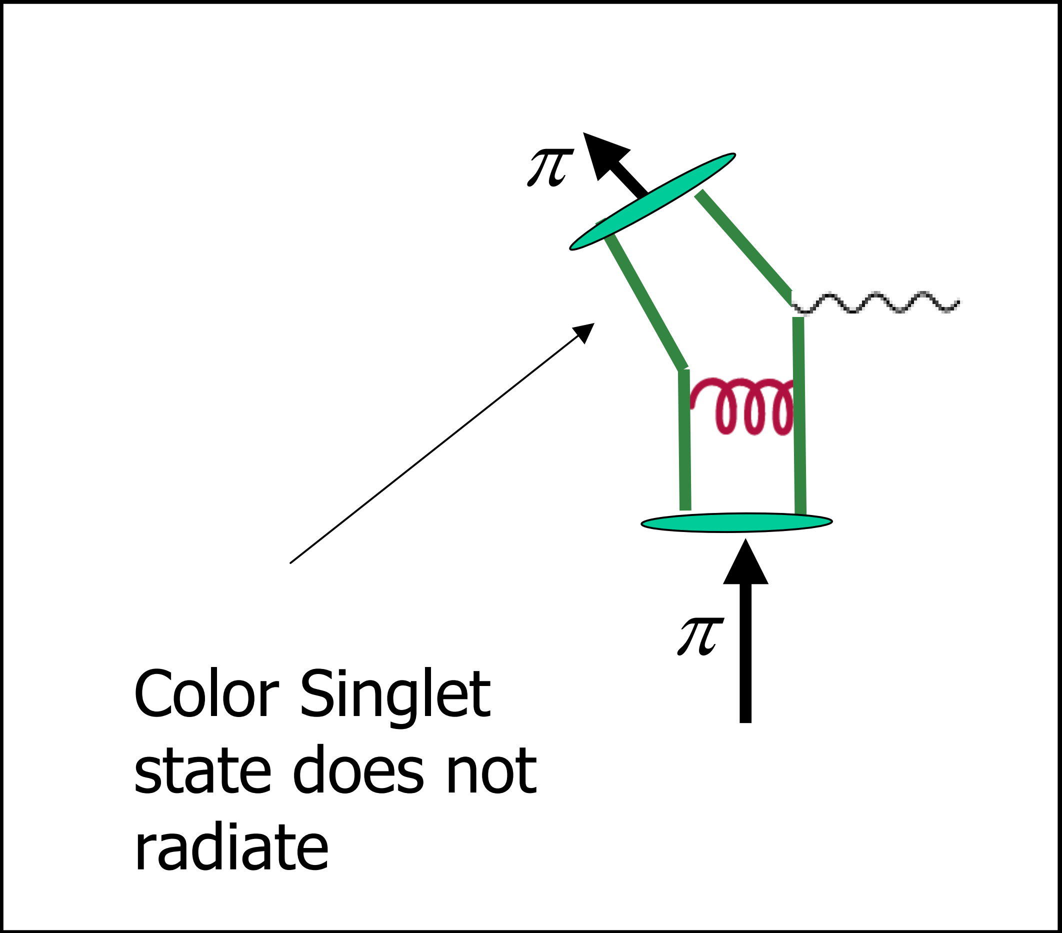






Pion form factor

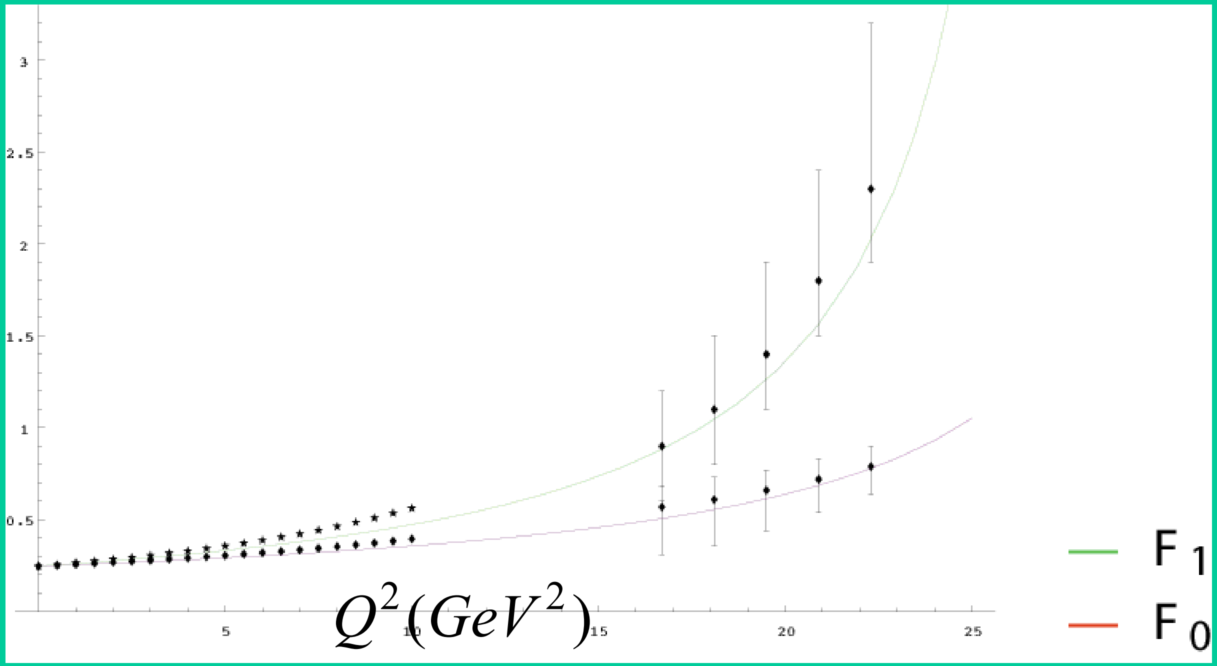


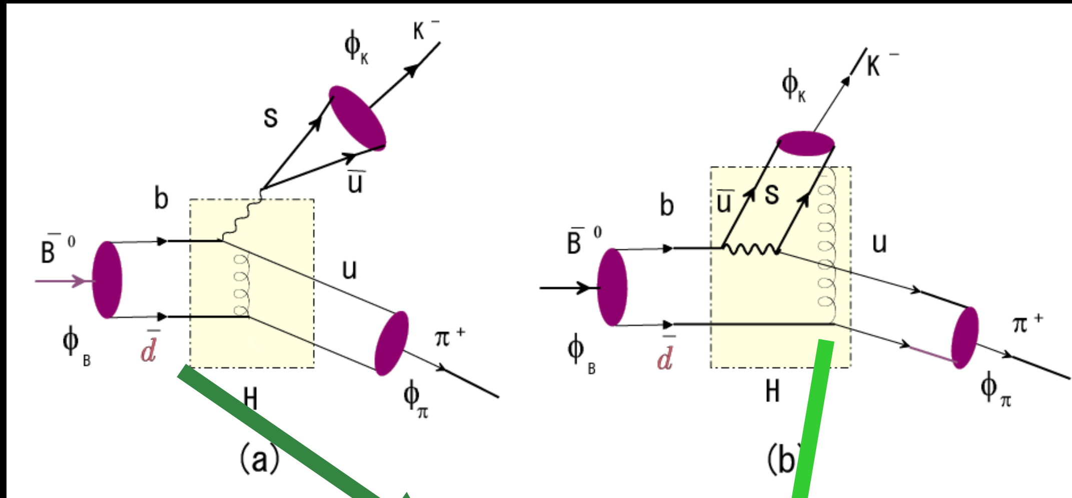


Sudakov factor

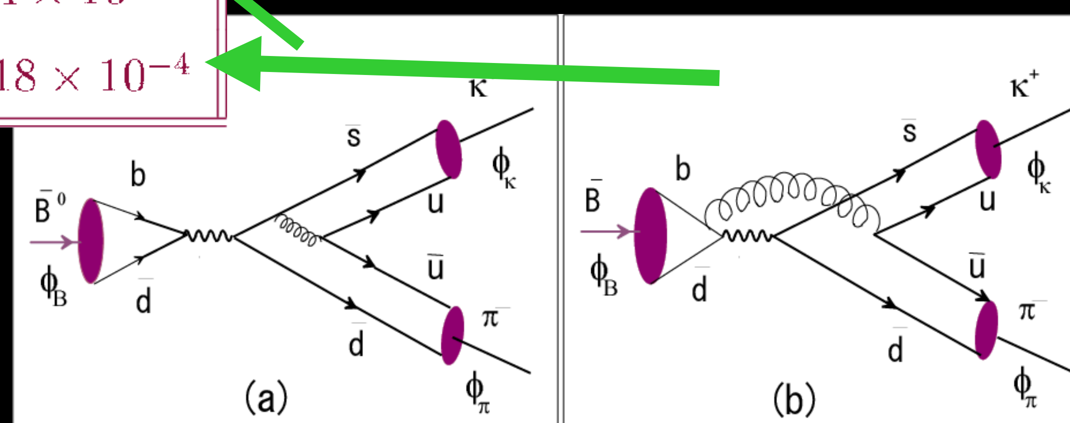
$B \to \pi$ transition form factor

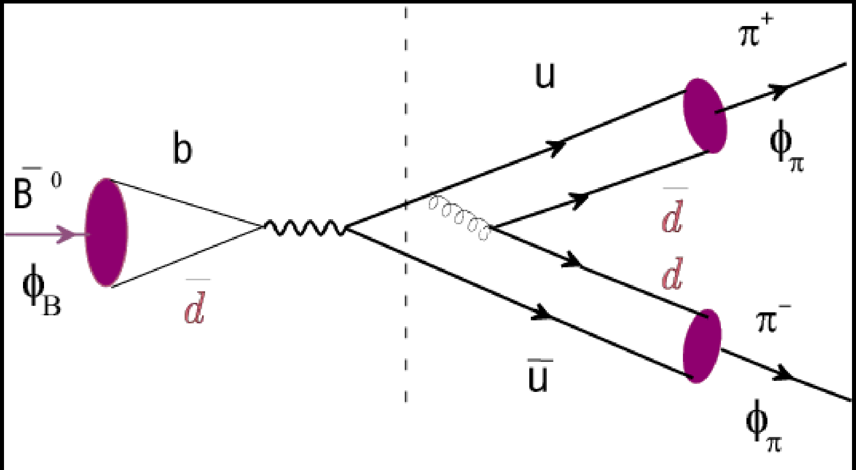
$$\int \frac{d^4y}{(2\pi)^4} e^{ik_1 y} \langle 0|\bar{b}_\beta(0) d_\gamma(y)|B(P_1)\rangle = -\frac{i}{\sqrt{2N_c}} \left[(\not{P}_1 + M_B)\gamma_5(\phi_B(k_1) + (\not{n}_+ - \not{n}_-)\bar{\phi}_B(k_1))\right]_{\gamma\beta} ,$$



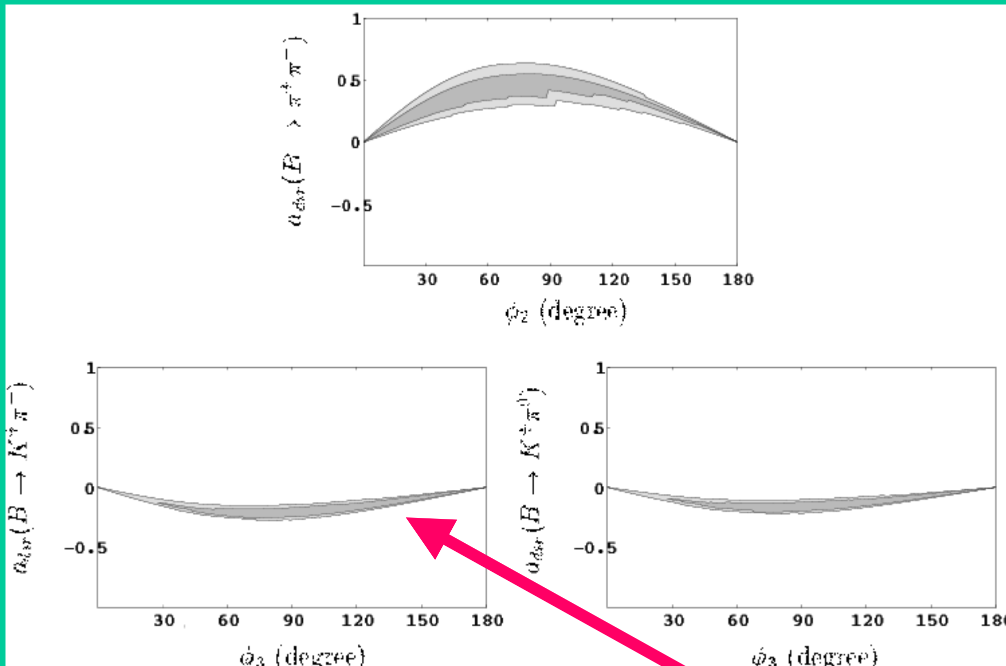


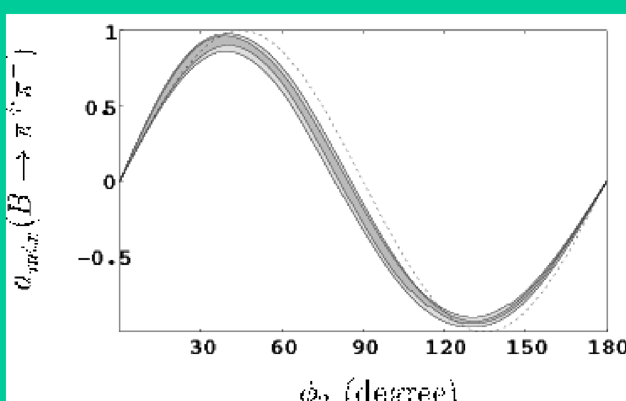
F_e	5.577×10^{-1}
F_e^P	-5.537×10^{-2}
F_a^P	$3.333 \times 10^{-3} + i\, 3.181 \times 10^{-2}$
M_e	$-0.942 \times 10^{-3} + i\, 3.385 \times 10^{-3}$
M_e^P	$2.931 \times 10^{-5} - i\, 1.304 \times 10^{-4}$
M_a^P	$-9.397 \times 10^{-5} - i\, 1.918 \times 10^{-4}$





The diagram which produces strong interaction phase -> CP violation





I can't make it small.
Non-leading effects?

CP averaged branching ratios
Experimental data & PQCD

final state	exp. data(10^{-5})	min.	max.
$\pi^+\pi^-$	$0.43^{+0.16}_{-0.14} \pm 0.05$(CLEO)	0.67	1.14
	$0.56^{+0.23}_{-0.20} \pm 0.04$(BELLE)	0.67	1.14
	$0.41 \pm 0.10 \pm 0.07$(BABAR)	0.67	1.14
$\pi^0\pi^0$		0.010	0.028
$\pi^+\pi^0$		0.44	0.50
$K^+\pi^-$	$1.72^{+0.25}_{-0.24} \pm 0.12$(CLEO)	1.26	2.64
	$1.93^{+0.34}_{-0.32}{}^{+0.15}_{-0.06}$(BELLE)	1.26	2.64
	$1.67 \pm 0.16 \pm 0.13$(BABAR)	1.26	2.64
$K^+\pi^0$	$1.16^{+0.30}_{-0.27}{}^{+0.14}_{-0.13}$(CLEO)	0.88	1.70
	$1.63^{+0.35}_{-0.33}{}^{+0.16}_{-0.18}$(BELLE)	0.88	1.70
	$1.08^{+0.21}_{-0.19} \pm 0.10$(BABAR)	0.88	1.70
$K^0\pi^+$	$1.82^{+0.46}_{-0.40} \pm 0.16$(CLEO)	2.03	2.06
	$1.37^{+0.57}_{-0.48}{}^{+0.19}_{-0.18}$(BELLE)	2.03	2.06
	$1.82^{+0.33}_{-0.30} \pm 0.20$(BABAR)	2.03	2.06
$K^0\pi^0$	$1.46^{+0.59}_{-0.51}{}^{+0.24}_{-0.33}$(CLEO)	0.74	0.77
	$1.60^{+0.72}_{-0.59}{}^{+0.25}_{-0.27}$(BELLE)	0.74	0.77
	$0.82^{+0.31}_{-0.27} \pm 0.12$(BABAR)	0.74	0.77
$\pi^+\rho^-$	$2.76^{+0.84}_{-0.74} \pm 0.42$(CLEO)	2.39	3.37
	$2.89 \pm 5.4 \pm 0.43$(BABAR)	2.39	3.37
$\pi^+\rho^0$	$1.04^{+0.33}_{-0.34} \pm 0.21$(CLEO)	0.48	0.59
$\pi^0\rho^+$		0.64	1.01
$\pi^0\rho^0$		0.008	0.011
$\pi^+\omega$	$1.13^{+0.33}_{-0.29} \pm 0.14$(CLEO)	0.43	0.81
	$0.66^{+0.21}_{-0.18} \pm 0.07$(BABAR)	0.43	0.81
$\pi^0\omega$		0.010	0.028
ϕK^+	$0.55^{+0.21}_{-0.18} \pm 0.06$(CLEO)	1.01	
	$1.06^{+0.21}_{-0.19} \pm 0.22$(BELLE)	1.01	
	$0.77^{+0.16}_{-0.14} \pm 0.08$(BABAR)	1.01	
ϕK^0	$0.87^{+0.38}_{-0.30} \pm 0.15$(BELLE)	0.943	
	$0.81^{+0.31}_{-0.25} \pm 0.08$(BABAR)	0.943	

Summary

- Dreams become reality over 20 yers.
- What used to be a dream is being realized in rare K decays.
- Detecting large CPV in B decay has been a dream for a long time.
- Lets hope that our dreams in B decays will also become reality.
- $K_L \to \pi^0 \nu\bar{\nu}$ will be measured eventually.