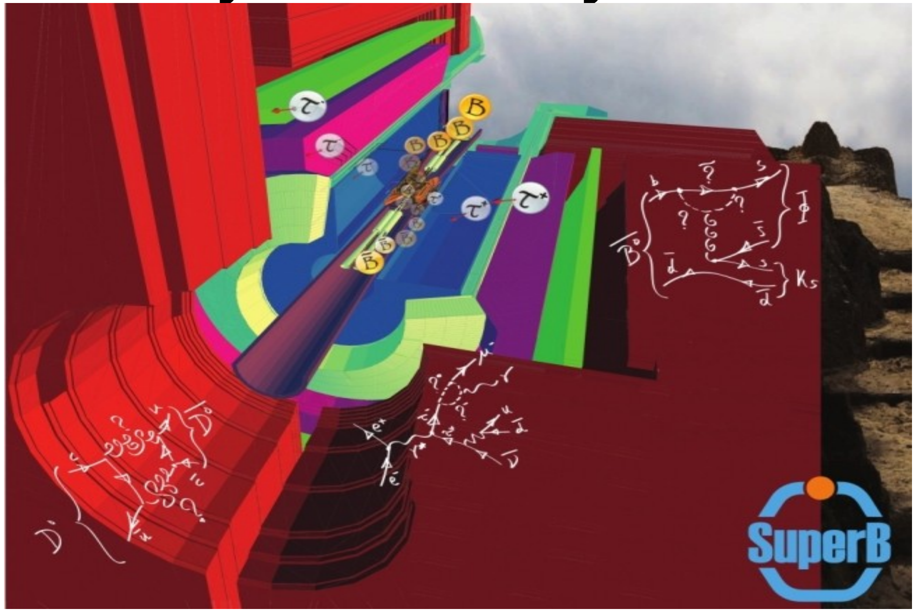
1st SuperB Collaboration Meeting

13-16 September 2011
Queen Mary, University of London (UK)



Time-Dependent CP Violation in Charm

Queen Mary
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SuperB

Q1. In the standard model, CP violation originates from the complex phase naturally occurring in the CKM matrix: is this the end of the story?

Q2. Is there a unique environment where to perform precision tests of the CKM mechanism and where to look for CP violation and new physics?

i) Theory + Experiments

ii) Numerical analysis

iii) FastSim and Charm

i) Theory + Experiments

...We explore Time-dependent CP asymmetries formalism in the charm sector for the first time...

Time-dependent *CP* asymmetries in *D* and *B* decays

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(Dated: July 19, 2011)

The measurement of time-dependent *CP* asymmetries in charm decays can provide a unique insight into the flavor changing structure of the Standard Model. We examine a number of different *CP* eigenstate decays of *D* mesons and describe a method that can be used to measure time-dependent *CP* asymmetries at existing and future experiments, with a preliminary assessment,

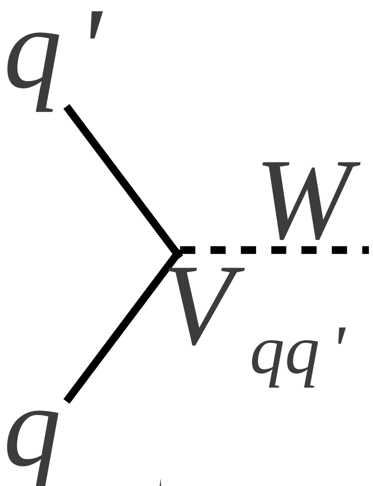
BEVAN - **INGUGLIA** - MEADOWS

Queen Mary University of London

ArXiv: 1106.5075v2

University of Cincinnati

Buras parametrization of the CKM matrix up to λ^5



$$V_{CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

PDG standard parametriazation with

$$s_{12} = \lambda, \quad s_{13} \sin\delta_{13} = A\lambda^3 \eta, \quad \bar{\eta} = \eta\left[1 - \frac{\lambda^2}{2} + O(\lambda^4)\right]$$

$$s_{23} = A\lambda^2, \quad s_{13} \cos\delta_{13} = A\lambda^3 \rho, \quad \bar{\rho} = \rho\left[1 - \frac{\lambda^2}{2} + O(\lambda^4)\right]$$

$$V_{CKM} = \begin{pmatrix} 1-\lambda^2/2-\lambda^4/8 & \lambda & A\lambda^3(\bar{\rho}-i\bar{\eta}) + A\lambda^5(\bar{\rho}-i\bar{\eta})/2 \\ -\lambda + A^2\lambda^5\left[1-2(\bar{\rho}+i\bar{\eta})\right] & 1-\lambda^2/2-\lambda^4(1+4A^2)/8 & A\lambda^2 \\ A\lambda^3\left[1-(\bar{\rho}+i\bar{\eta})\right] & -A\lambda^2 + A\lambda^4\left[1-2(\bar{\rho}+i\bar{\eta})\right]/2 & 1-A^2\lambda^4/2 \end{pmatrix} + O(\lambda^6)$$

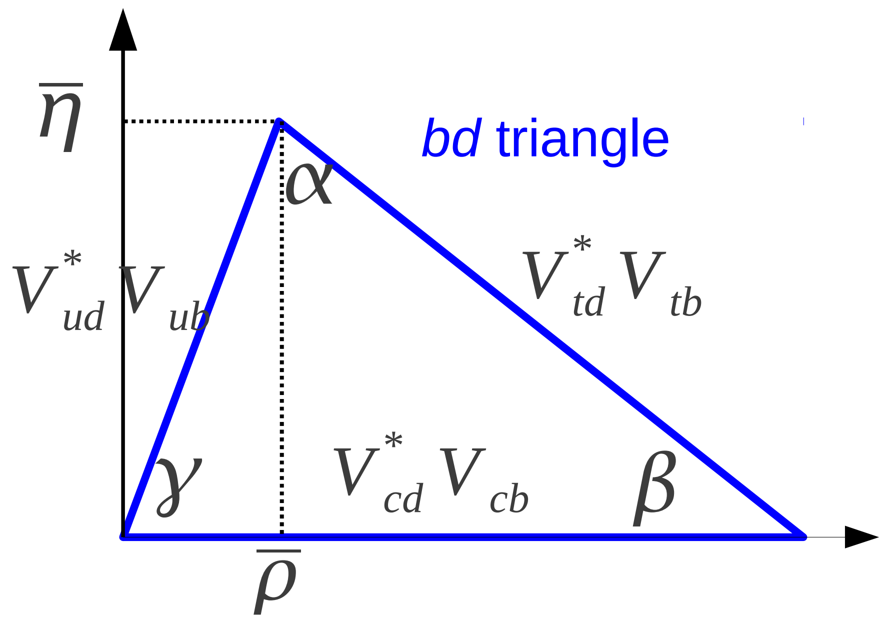
TAB 1

	UTFit	**CKM Fitter**
λ	0.22545 ± 0.00065	0.22543 ± 0.00077
A	0.8095 ± 0.0095	$0.812^{+0.013}_{-0.027}$
ρ	0.135 ± 0.021	————————————
η	0.367 ± 0.013	————————————
$\bar{\rho}$	0.132 ± 0.020	0.144 ± 0.025
$\bar{\eta}$	0.358 ± 0.012	$0.342 + 0.016$

Why do we express the matrix in terms of $\bar{\rho}\ \bar{\eta}$?

Unitarity triangles

Unitarity conditions of the CKM matrix are translated into 6 possible unitary triangles in the complex plane. We illustrate two here.



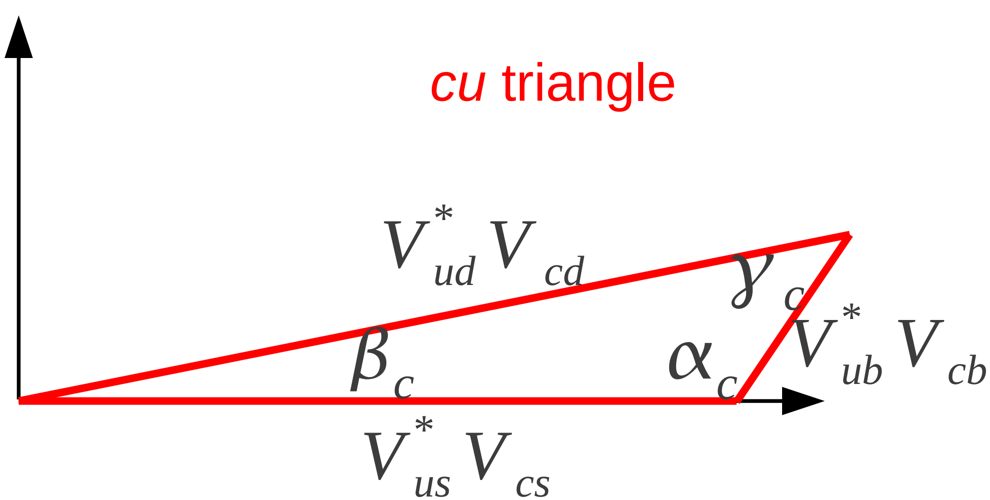
$$V_{ud}^{*}V_{ub}+V_{cd}^{*}V_{cb}+V_{td}^{*}V_{tb}=0$$

$$\alpha=arg[\frac{-V_{td}V_{tb}^{*}}{V_{ud}V_{ub}^{*}}]=(91.4\pm6.1)^{o}$$

$$\beta=arg[\frac{-V_{cd}V_{cb}^{*}}{V_{td}V_{tb}^{*}}]=(21.1\pm0.9)^{o}$$

$$\gamma=arg[\frac{-V_{ud}V_{ub}^{*}}{V_{cd}V_{cb}^{*}}]=(74\pm11)^{o}$$

FROM EXPERIMENTS



$$V_{ud}^{*}V_{cd}+V_{us}^{*}V_{cs}+V_{ub}^{*}V_{cb}=0$$

$$\alpha_{c}=arg[\frac{-V_{ub}^{*}V_{cb}}{V_{us}^{*}V_{cs}}]=(111.5\pm4.2)^{o}$$

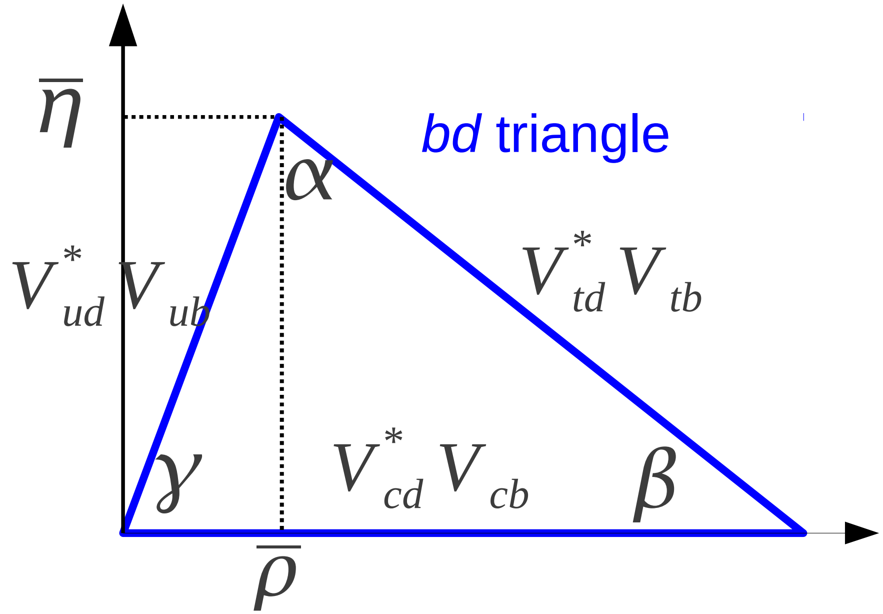
$$\beta_{c}=arg[\frac{-V_{ud}^{*}V_{cd}}{V_{us}^{*}V_{cs}}]=(0.035\pm0.0001)^{o}$$

$$\gamma_{c}=arg[\frac{-V_{ub}^{*}V_{cb}}{V_{ud}^{*}V_{cd}}]=(68.4\pm0.1)^{o}$$

AVERAGE OF VALUES IN TAB 1

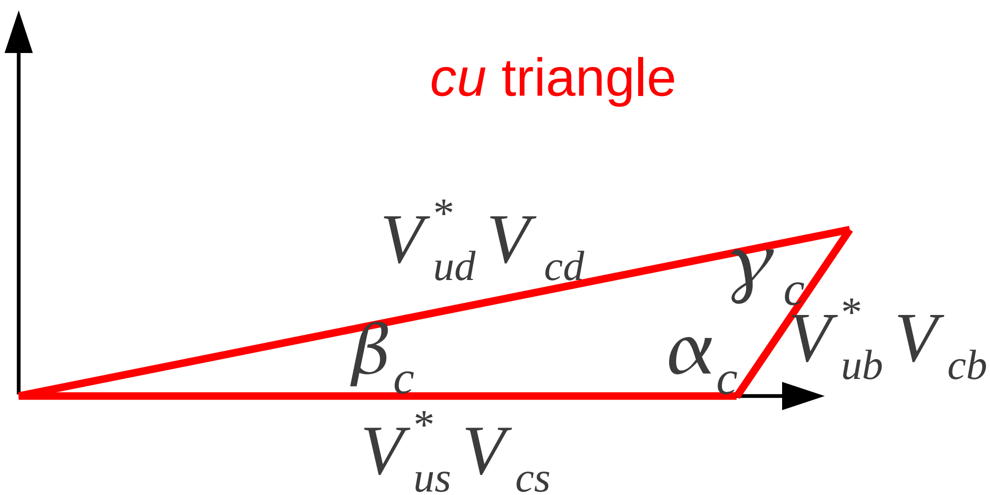
Unitarity triangles

Unitarity conditions of the CKM matrix are translated into 6 possible unitary triangles in the complex plane. We illustrate two here.



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

The value of sin(2β) differs from the predicted value (see paper) by 3.2 standard deviation: need to be checked!
CKM mechanism “maybe” is breaking down.. **arXiv: 1104.2117v2**



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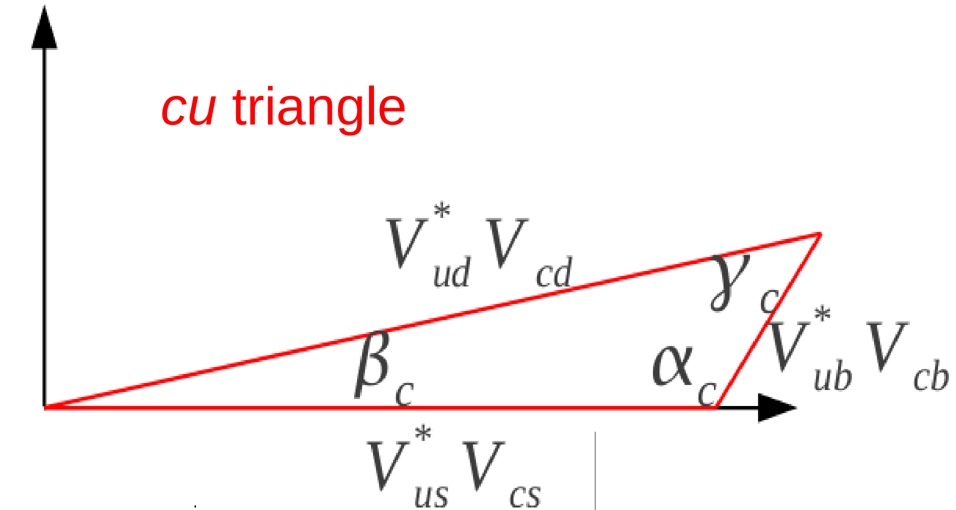
AVERAGE OF VALUES IN TAB 1

Constraint on the *cu* triangle

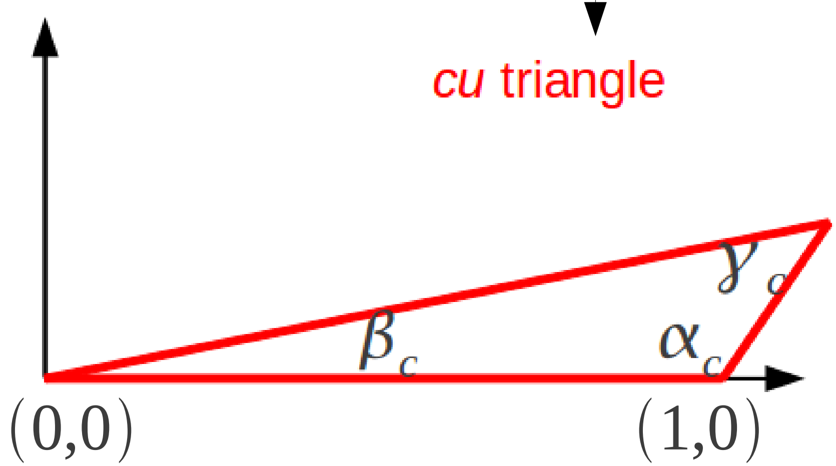


It is possible to constrain the apex of the *cu* triangle in two ways:

1) by constraining two internal angles
2) by measuring the sides

Normalizing the baseline to 1, so dividing by $V_{us}^{*}V_{cs}$

$$\gamma_c = (68.4 \pm 0.1)^o \quad \text{from } CKM\ prediction$$
$$+ any\ measurement\ of\ \beta_c \rightarrow constraint\ \ on\ \ the\ apex\ of\ the\ triangle$$



$$X + iY = 1 + \frac{A^2\lambda^5(\bar{\rho} + i\bar{\eta})}{\lambda - \lambda^3/2 - \lambda^5(1/8 + A^2/2)}$$

$$X = 1.00025$$
$$Y = 0.00062$$

Time-dependent formalism (i)

Neutral meson systems exhibit mixing of mass eigenstates $|P_{1,2}>$ where:

$$i\frac{d}{dt}\begin{pmatrix}|P_1>\\|P_2>\end{pmatrix}=\begin{pmatrix}M_{11}-\frac{i}{2}\Gamma_{11} & M_{12}-\frac{i}{2}\Gamma_{12}\\ M_{12}^{*}-\frac{i}{2}\Gamma_{12}^{*} & M_{22}^{*}-\frac{i}{2}\Gamma_{22}^{*}\end{pmatrix}\begin{pmatrix}|P^0>\\|\overline{P^0}>\end{pmatrix}=H_{eff}\begin{pmatrix}|P^0>\\|\overline{P^0}>\end{pmatrix}$$

$$|P_{1,2}>=p|P^0>\pm q|\overline{P^0}>$$

$$q^2+p^2=1 \quad normalize\ \ the\ \ wavefunction$$

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

$$H_{eff}=M-\frac{i}{2}\Gamma$$

$$M_{11}=M_{22},\Gamma_{11}=\Gamma_{22} \quad \leftarrow \quad CPT\ \ INVARIANCE$$

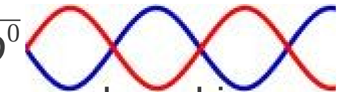
$$M_{11}=M_{22},\Gamma_{11}=\Gamma_{22},\Im[\frac{\Gamma_{12}}{M_{12}}]=0 \quad \leftarrow \quad CP\ \ INVARIANCE$$

$$\Im[\frac{\Gamma_{12}}{M_{12}}]=0 \quad \leftarrow \quad T\ \ INVARIANCE$$

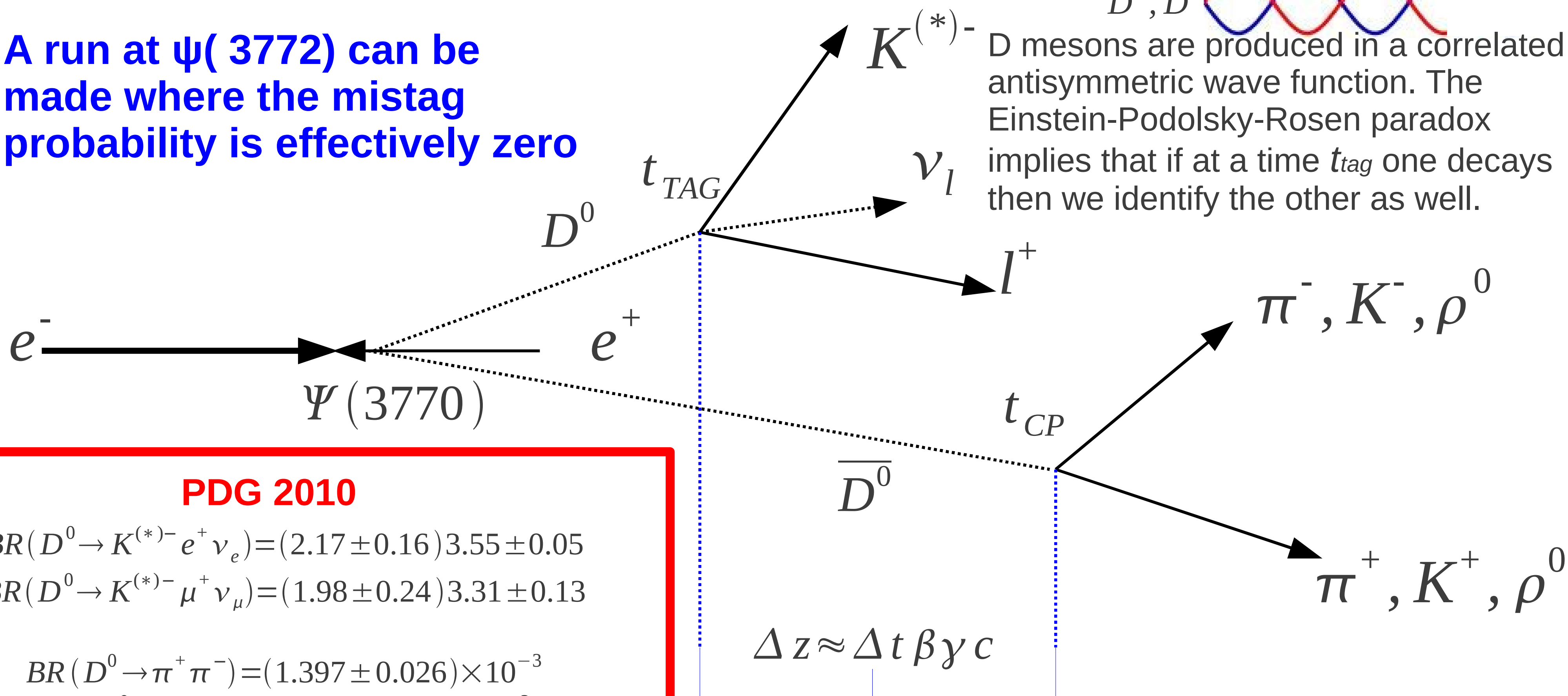
$$\boxed{\frac{d}{dt}\langle\Psi(t)|\Psi(t)\rangle=-\langle\Psi(t)|\Gamma|\Psi(t)\rangle}$$

Correlated mesons: semi-leptonic tagging

A run at ψ(3772) can be made where the mistag probability is effectively zero



D mesons are produced in a correlated antisymmetric wave function. The Einstein-Podolsky-Rosen paradox implies that if at a time t_{tag} one decays then we identify the other as well.



PDG 2010

$$BR(D^0 \rightarrow K^{(*)-} e^+ \nu_e) = (2.17 \pm 0.16) 3.55 \pm 0.05$$

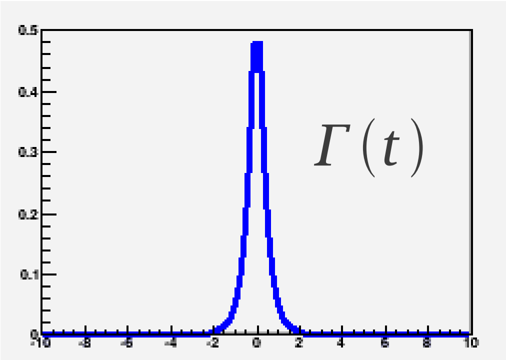
$$BR(D^0 \rightarrow K^{(*)-} \mu^+ \nu_\mu) = (1.98 \pm 0.24) 3.31 \pm 0.13$$

$$BR(D^0 \rightarrow \pi^+ \pi^-) = (1.397 \pm 0.026) \times 10^{-3}$$

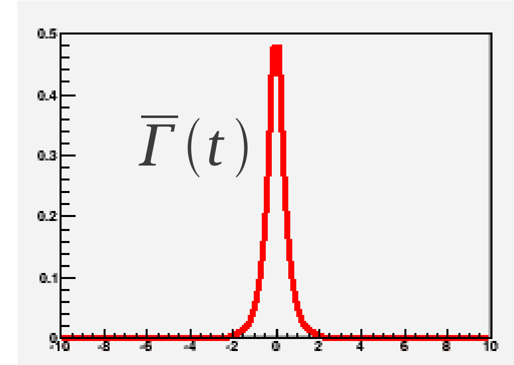
$$BR(D^0 \rightarrow K^+ K^-) = (3.94 \pm 0.07) \times 10^{-3}$$

At time t_{TAG} *the decays* $D \rightarrow K^{-(+)} l^{+(-)} \nu_l$ *account for* 11% *of all D decays and unambiguously assigns the flavour:* D^0 *is associated to a* l^+, $\overline{D^0}$ *is associated to a* l^-

Assuming PDG values for BR and CLEO_c efficiency for double tagging we expect with semi-leptonic tag ~158000 for $D^0 \rightarrow \pi^+ \pi^-$



Time-dependent formalism (ii)



The time-dependence of decays of P^0 (P^0) to final state |f > are:

$$\Gamma(P^0 \rightarrow f) \propto e^{-\Gamma_1|\Delta t|}\left[\frac{h_+}{2}+\frac{\Re(\lambda_f)}{1+|\lambda_f|^2}h_- + e^{[\Delta\Gamma|\Delta t|/2]}\left(\frac{1-|\lambda_f|^2}{1+|\lambda_f|^2}\cos\Delta M\Delta t-\frac{2\Im(\lambda_f)}{1+|\lambda_f|^2}\sin\Delta M\Delta t\right)\right]$$

$$\overline{\Gamma}(\overline{P^0} \rightarrow f) \propto e^{-\Gamma_1|\Delta t|}\left[\frac{h_+}{2}+\frac{\Re(\lambda_f)}{1+|\lambda_f|^2}h_- - e^{[\Delta\Gamma|\Delta t|/2]}\left(\frac{1-|\lambda_f|^2}{1+|\lambda_f|^2}\cos\Delta M\Delta t-\frac{2\Im(\lambda_f)}{1+|\lambda_f|^2}\sin\Delta M\Delta t\right)\right]$$

$$where: \quad h_{+-}=1\pm e^{\Delta\Gamma|\Delta t|}, \quad \lambda_f=\frac{q}{p}\frac{\overline{A}}{A}$$

λ_f very important!

We now obtain the time-dependent CP asymmetry

$$A^{Phys}(\Delta t)=\frac{\overline{\Gamma}^{Phys}(\Delta t)-\Gamma^{Phys}(\Delta t)}{\overline{\Gamma}^{Phys}(\Delta t)+\Gamma^{Phys}(\Delta t)}=-\Delta\omega+\frac{(D+\Delta\omega)e^{\Delta\Gamma|\Delta t|/2}(|\lambda_f|^2-1)\cos\Delta M\Delta t+2\Im(\lambda_f)\sin\Delta M\Delta t}{(1+|\lambda_f|^2)h_+/2+h_-\Re(\lambda_f)}$$

Where we included mistag probability effects

Uncorrelated D^0 mesons

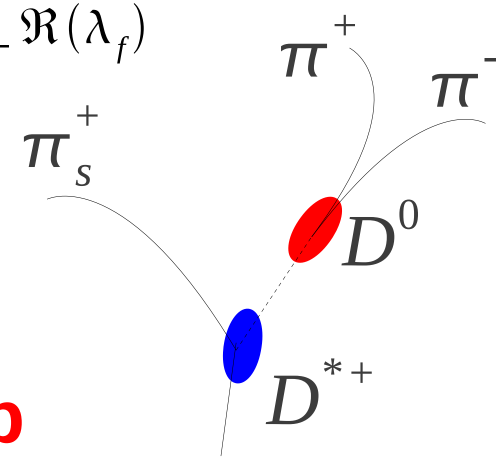
$$A(t)=\frac{\overline{\Gamma}(t)-\Gamma(t)}{\overline{\Gamma}(t)+\Gamma(t)}=2e^{\Delta\Gamma t/2}\frac{(|\lambda_f|^2-1)\cos\Delta M\, t+2\Im(\lambda_f)\sin\Delta M\, t}{(1+|\lambda_f|^2)(1+e^{\Delta\Gamma t})+2\Re(\lambda_f)(1-e^{\Delta\Gamma t})}$$

Mistag probability and dilution become important

$$A^{Phys}(t)=\frac{\overline{\Gamma^{Phys}}(t)-\Gamma^{Phys}(t)}{\overline{\Gamma^{Phys}}(t)+\Gamma^{Phys}(t)}=+\Delta\omega+\frac{(D-\Delta\omega)e^{\Delta\Gamma t/2}(|\lambda_f|^2-1)\cos\Delta M\, t+2\Im(\lambda_f)\sin\Delta M\, t}{(1+|\lambda_f|^2)h_+/2+h_-\Re(\lambda_f)}$$

The flavour tagging is accomplished by identifying a "slow" pion in the processes (CP and CP conjugated):

$$D^{*+}\to D^0\pi_s^+$$
$$D^{*-}\to\overline{D^0}\pi_s^-$$



SuperB at $\Upsilon(4S)$ and LHCb

D* from $e^+e^-\to c\overline{c}$ can be separated from those coming from B's by applying a momentum cut.
Clean environment.
More easier to separate prompt D* from B cascade than LHCb

D* mesons are secondary particles produced in the primary decay of a B meson.
High background level to keep under control.
Trigger efficiency.

Analysis of CP eigenstates (i)

When exploring CP violation, ignoring long distance effects, the parameter λ may be written as:

$$\lambda_f = \left|\frac{q}{p}\right| e^{i\phi_{MIX}} \left|\frac{\overline{A}}{A}\right| e^{i\phi_{CP}}$$

ϕ_{MIX} : phase of $D^0\overline{D^0}$ mixing

ϕ_{CP} : overall phase of $D^0 \to f_{CP}$ (eigenstate)

$$A = |T|\ e^{i(\phi_T+\delta_T)} + |CS|\ e^{i(\phi_{CS}+\delta_{CS})} + |W|\ e^{i(\phi_W+\delta_W)} + \sum_{q=d,s,b} |P_q|\ e^{(i\phi_q+\delta_q)}$$

The following processes, as we will see, are tree dominated

$$D^0 \to K^+K^-, \pi^+\pi^-, K^+K^-K^0, K^0\pi^+\pi^-$$

Assuming negligible the contribution due to P/CS/W amplitudes, then:

$$\boxed{\lambda_f = \left|\frac{q}{p}\right| e^{i\phi_{MIX}} e^{-2i\phi_T^W}}$$

Analysis of CP eigenstates (ii)

mode	η_{CP}	T	CS	P_q	W_{EX}
$D^0 \to K^+K^-$	$+1$	$V_{cs}V_{us}^*$		$V_{cq}V_{uq}^*$	
$D^0 \to K_S^0 K_S^0$	$+1$				$V_{cs}V_{us}^*$
$D^0 \to \pi^+\pi^-$	$+1$	$V_{cd}V_{ud}^*$		$V_{cq}V_{uq}^*$	$V_{cd}V_{ud}^*$
$D^0 \to \pi^0\pi^0$	$+1$		$V_{cd}V_{ud}^*$	$V_{cq}V_{uq}^*$	$V_{cd}V_{ud}^*$
$D^0 \to \rho^+\rho^-$	$+1$	$V_{cd}V_{ud}^*$		$V_{cq}V_{uq}^*$	$V_{cd}V_{ud}^*$
$D^0 \to \rho^0\rho^0$	$+1$		$V_{cd}V_{ud}^*$	$V_{cq}V_{uq}^*$	$V_{cd}V_{ud}^*$
$D^0 \to \phi\pi^0$	$+1$		$V_{cs}V_{us}^*$	$V_{cq}V_{uq}^*$	
$D^0 \to \phi\rho^0$	$+1$		$V_{cs}V_{us}^*$	$V_{cq}V_{uq}^*$	
$D^0 \to f^0(980)\pi^0$	-1		$V_{cs}V_{us}^* + V_{cd}V_{ud}^*$	$V_{cq}V_{uq}^*$	
$D^0 \to \rho^0\pi^0$	$+1$		$V_{cd}V_{ud}^*$	$V_{cq}V_{uq}^*$	$V_{cd}V_{ud}^*$
$D^0 \to a^0\pi^0$	-1		$V_{cd}V_{ud}^*$	$V_{cq}V_{uq}^*$	$V_{cd}V_{ud}^*$
$D^0 \to K_S^0K_S^0K_S^0$	$+1$				$V_{cs}V_{ud}^* + V_{cd}V_{us}^*$
$D^0 \to K_L^0K_S^0K_S^0$	-1				$V_{cs}V_{ud}^* + V_{cd}V_{us}^*$
$D^0 \to K_L^0K_L^0K_S^0$	$+1$				$V_{cs}V_{ud}^* + V_{cd}V_{us}^*$
$D^0 \to K_L^0K_L^0K_L^0$	-1				$V_{cs}V_{ud}^* + V_{cd}V_{us}^*$

Analysis of CP eigenstates (iii)

Amplitude to order λ^6:

$$V_{cs}V_{us}^* = \lambda - \frac{\lambda^3}{2} - \left(\frac{1}{8} + \frac{A^2}{2}\right)\lambda^5,$$

REAL

$$V_{cd}V_{ud}^* = -\lambda + \frac{\lambda^3}{2} + \frac{\lambda^5}{8} + \frac{A^2\lambda^5}{2}[1 - 2(\bar\rho + i\bar\eta)]$$

$$V_{cb}V_{ub}^* = A^2\lambda^5(\bar\rho + i\bar\eta),$$

COMPLEX

$$V_{cs}V_{ud}^* = 1 - \lambda^2 - \frac{A^2\lambda^4}{2} + A^2\lambda^6\left[\frac{1}{2} - \bar\rho - i\bar\eta\right]$$

$$V_{cd}V_{us}^* = -\lambda^2 + \frac{A^2\lambda^6}{2}[1 - 2(\bar\rho + i\bar\eta)].$$

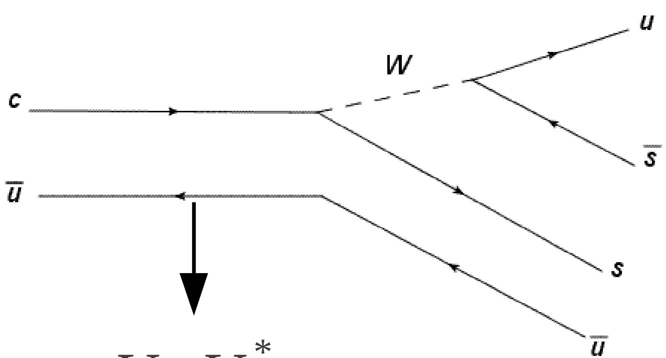
$V_{cb}V_{ub}^*$ *large phase* : $V_{ub} \rightarrow \gamma_c = \gamma$

$V_{cd}V_{ud}^*$ and $V_{cd}V_{us}^*$ *small phase* : $V_{cd} \rightarrow \beta_c$

$V_{cs}V_{ud}^*$ *small phase entering at* $O(\lambda^6)$

$D^0 \rightarrow K^+ K^-$

Tree topology

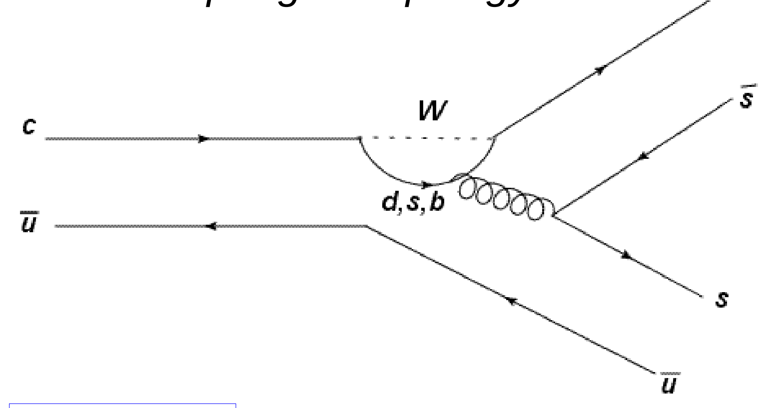


$$V_{cs} V^*_{us}$$

$$V_{cs}V^*_{us} = \lambda - \frac{\lambda^3}{2} - \left(\frac{1}{8} + \frac{A^2}{2}\right)\lambda^5$$

Real

Gluonic penguin topology



$$\boxed{V_{cd} V^*_{ud}} + V_{cs} V^*_{us} + V_{cb} V^*_{ub}$$

Real **Negligible**

$$\boxed{V_{cd}V^*_{ud} = -\lambda + \frac{\lambda^3}{2} + \frac{\lambda^5}{8} + \frac{A^2\lambda^5}{2}[1 - 2(\bar{\rho} + i\bar{\eta})]}$$

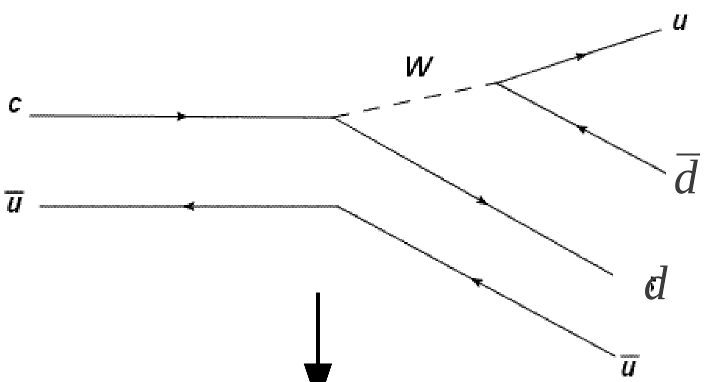
To first order one would expect to measure an asymmetry consistent with zero:

→ **cross check of detector reconstruction and calibration**

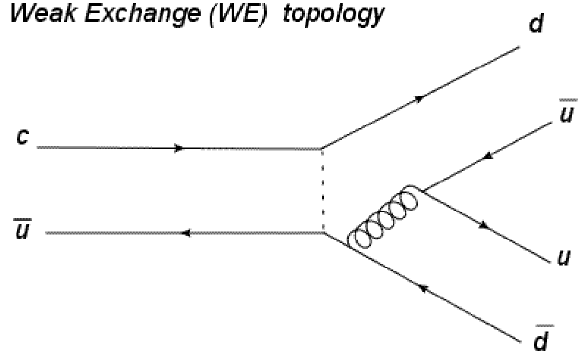
→ **ideal mode to use when searching for new physics (NP)**

$D^0 \rightarrow \pi^+ \pi^-$ (i)

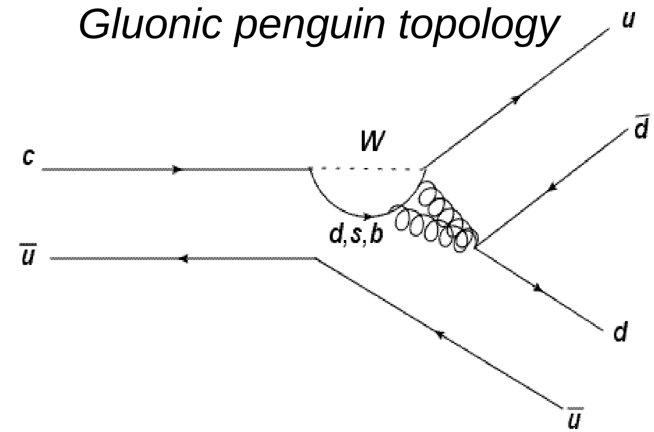
Tree topology



Weak Exchange (WE) topology



Gluonic penguin topology



$\boxed{V_{cd} V^*_{ud}}$

$\boxed{V_{cd} V^*_{ud}}$

$\boxed{V_{cd} V^*_{ud}} + V_{cs} V^*_{us} + V_{cb} V^*_{ub}$

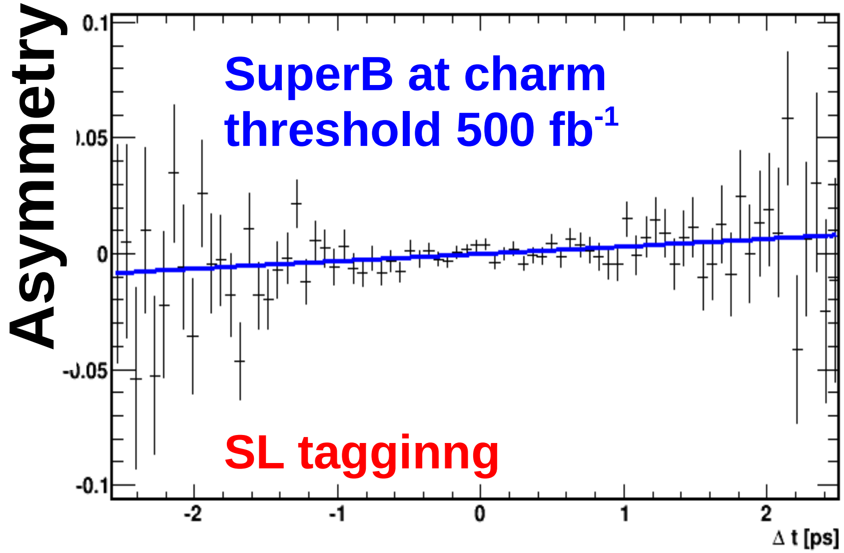
Real **Negligible**

$$\boxed{V_{cd}V^*_{ud} = -\lambda + \frac{\lambda^3}{2} + \frac{\lambda^5}{8} + \frac{A^2\lambda^5}{2}[1 - 2(\bar{\rho} + i\bar{\eta})]} \longrightarrow V_{cd} V^*_{ud} \rightarrow \beta_c$$

Penguin topologies are DCS loops while the Tree amplitude is CS
→ **Penguin contributions could in principle be ignored, but..**
→ **A complete theoretical analysis is necessary if one wants to extract the weak phase and disentangle the c→s→u penguin** (See A. Bevan talk)

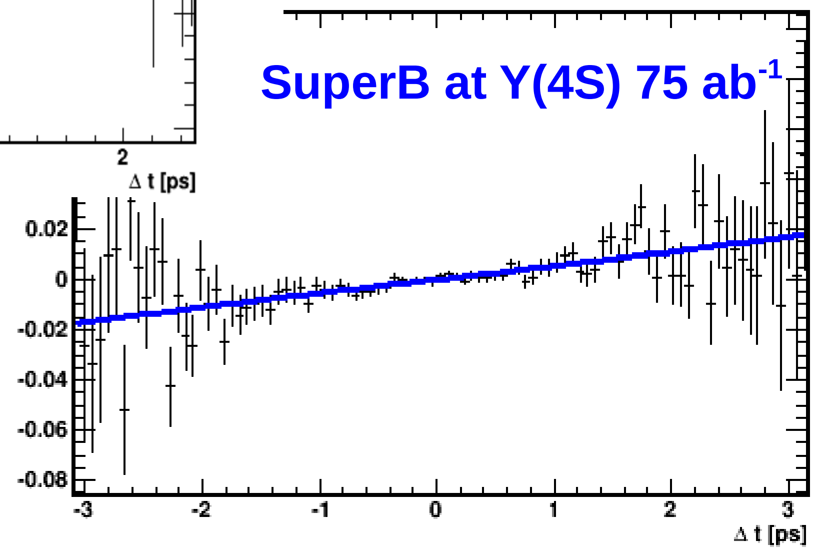
ii) Numerical analysis

TDCPV in charm: numerical analysis

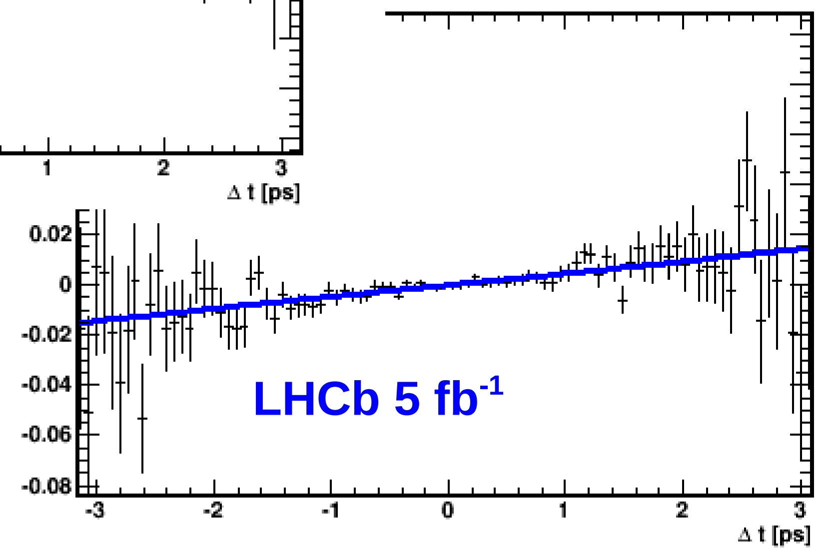


$$A^{Phys}(\Delta t) = \frac{\overline{\Gamma^{Phys}}(\Delta t) - \Gamma^{Phys}(\Delta t)}{\overline{\Gamma^{Phys}}(\Delta t) + \Gamma^{Phys}(\Delta t)}$$

$$D^0 \rightarrow f_{cp}$$



$$f_{cp} = \pi^+ \pi^-$$



TDCPV will be more clear to be observed at SuperB (or Belle2) running at $\Upsilon(4S)$ and at LHCb than at SuperB running at charm threshold, but...

Results: precision on $\beta_{c,eff}$

Parameter	Super$B$ SL	Super$B$ SL + K	Super$B$ $\Upsilon(4S)$	LHCb
$\phi = \arg(\lambda_f)$	8.0°	3.4°	2.2°	2.3°
$\phi_{CP} = \phi_{KK} - \phi_{\pi\pi}$	9.4°	3.9°	2.6°	2.7°
$\beta_{c,eff}$	4.7°	2.0°	1.3°	1.4°

Results: precision on $\beta_{c,eff}$

Parameter	Super$B$ SL	Super$B$ SL + K	Super$B$ $\Upsilon(4S)$	LHCb
$\phi = \arg(\lambda_f)$	8.0°	3.4°	2.2°	2.3°
$\phi_{CP} = \phi_{KK} - \phi_{\pi\pi}$	9.4°	3.9°	2.6°	2.7°
$\beta_{c,eff}$	4.7°	2.0°	1.3°	1.4°

With this same method we are also able to provide a measurement of the mixing phase by using the channel K^+K^- :

$\phi_{MIX} \approx 5^o$ at charm threshold using SL tagging

$\phi_{MIX} \approx 2.5^o$ at charm threshold using SL+K tagging

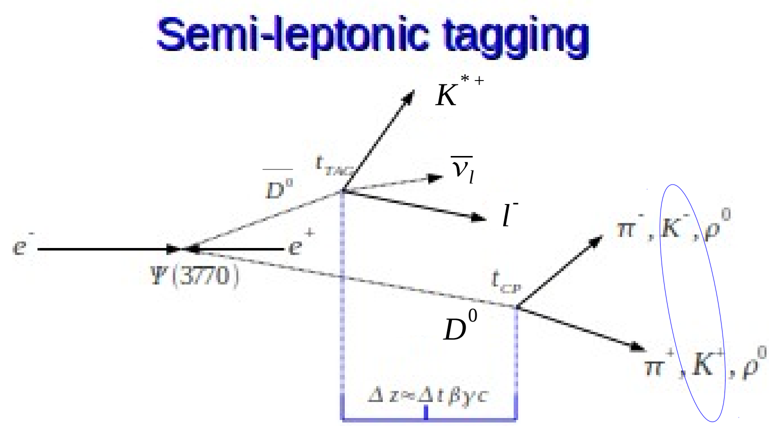
$\phi_{MIX} \approx 1.35^o$ at the Υ(4S)

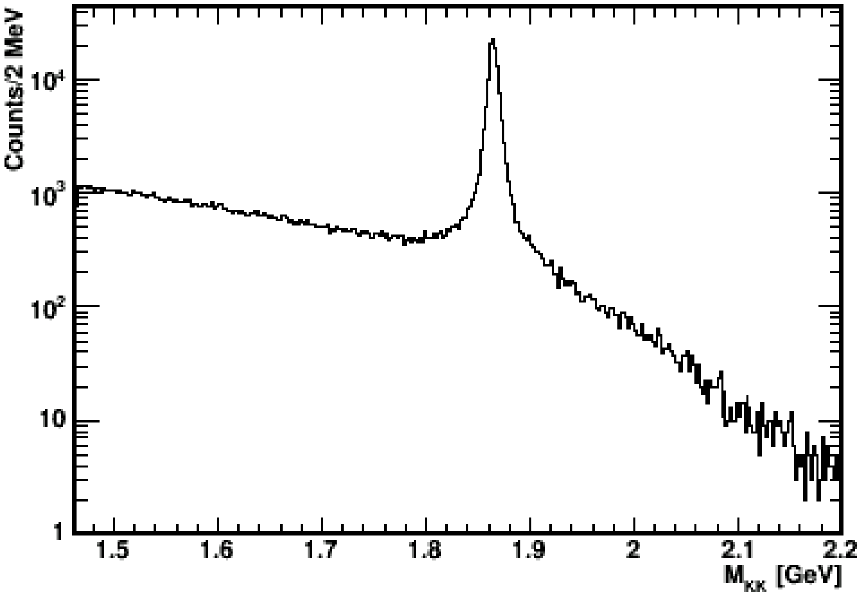
Niels Bohr: An expert is a man who has made all the mistakes which can be made, in a narrow field.

iii) FastSim

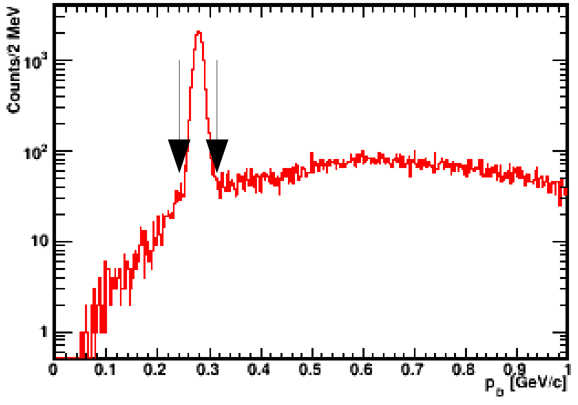
(see Matteo Rama talk/tutorial)

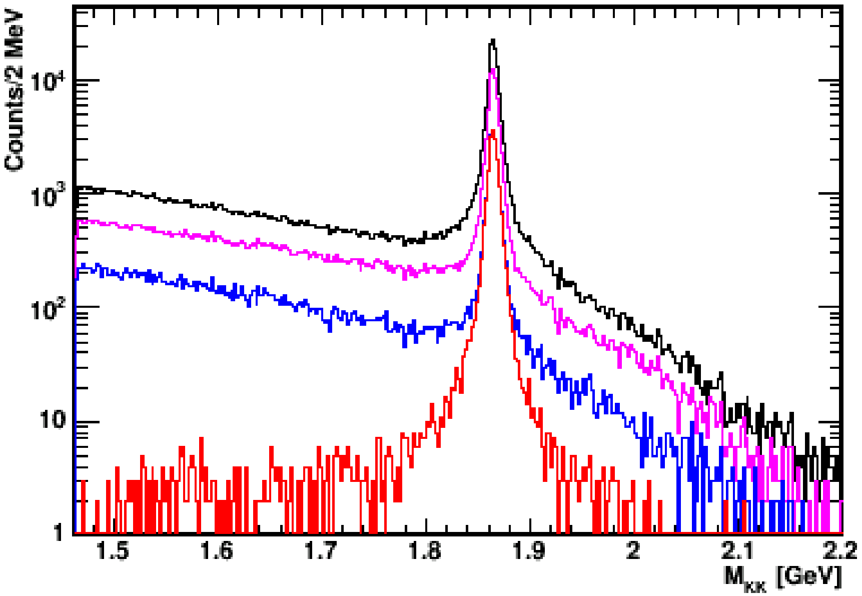
FastSim: Semi-Leptonic Tag at Charm Threshold ($D^0 \to K^+ K^-$)



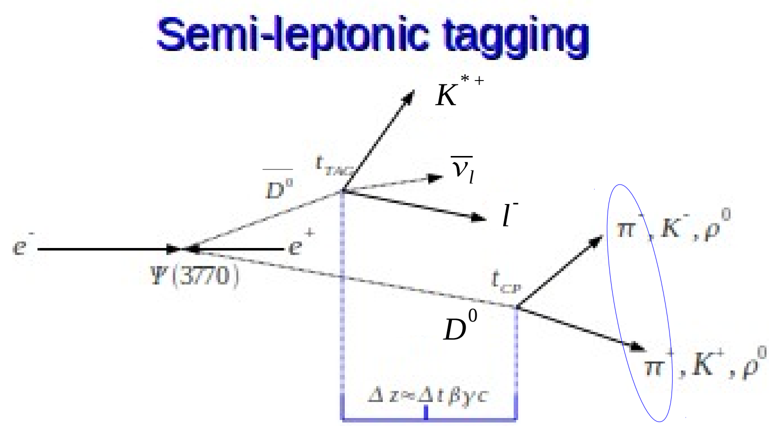


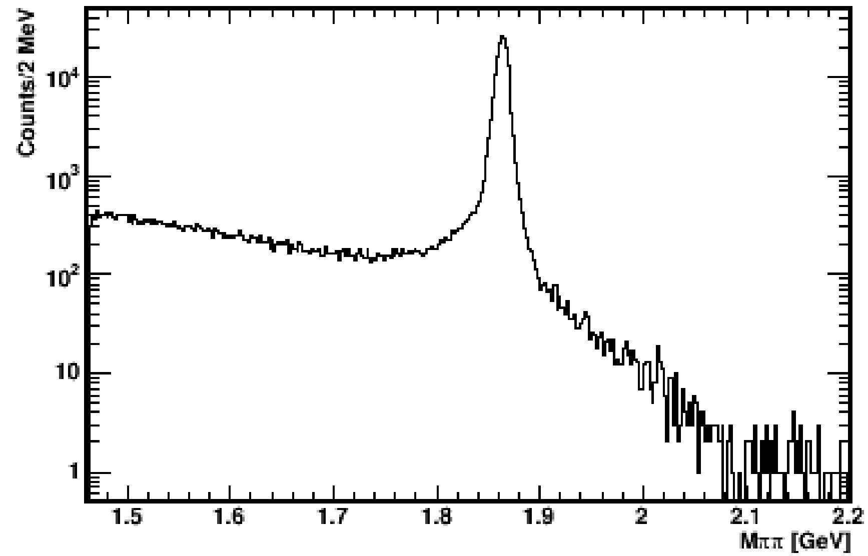
Black: signal generated with no cuts,
Magenta: 4 ch. tracks required,
Blue: 4 ch. Tracks + 3 Kaons,
Red: 4 ch. Tracks + 3 Kaons, and D^0 momentum constraints.





FastSim: Semi-Leptonic Tag at Charm Threshold ($D^0 \rightarrow \pi^+ \pi^-$)



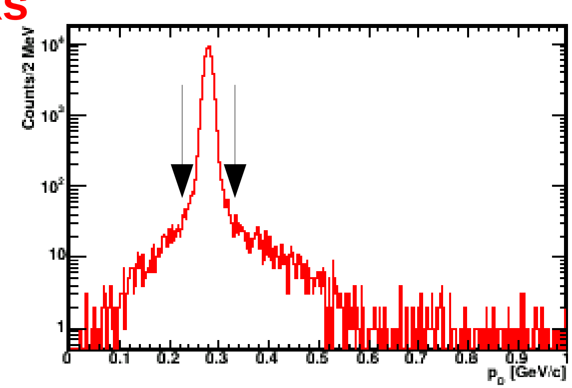


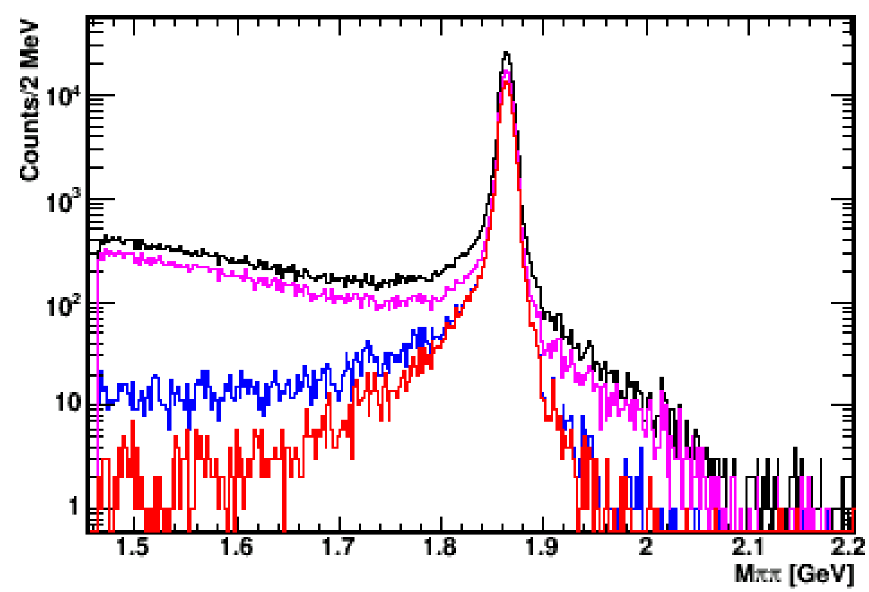
Black: signal generated with no cuts,

Magenta: 4 ch. tracks required,

Blue: 4 ch. Tracks + 2 Pions,

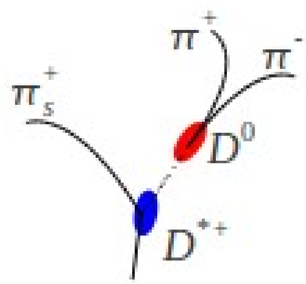
Red: 4 ch. Tracks + 2 Pions, and D^0 momentum constraints.

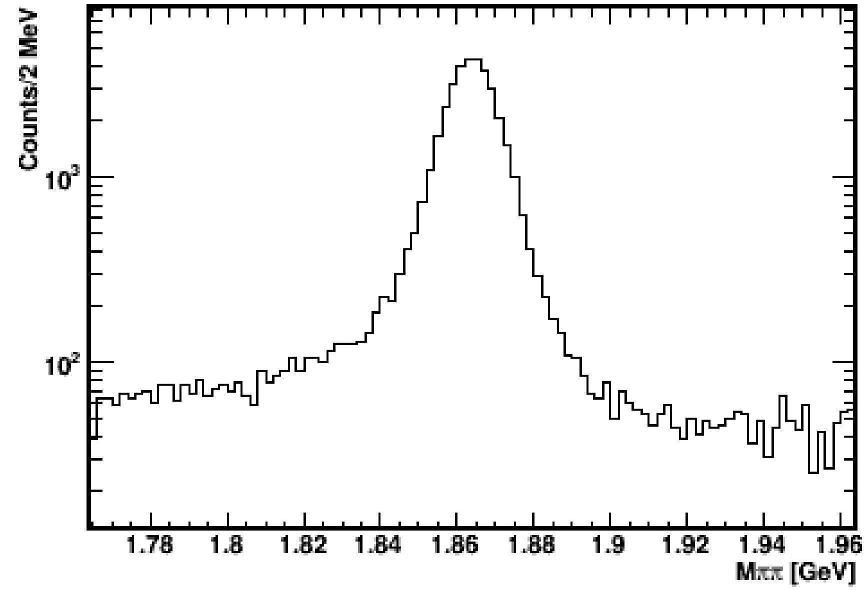




FastSim: Tagging at the $\Upsilon(4S)$, ($D^0 \rightarrow \pi^+ \pi^-$)

$$e^+ e^- \rightarrow \Upsilon(4S) \rightarrow B^0 \overline{B^0},$$
$$\overline{B^0} \rightarrow D^{*+} K^-,$$
$$D^{*+} \rightarrow D^0 \pi_s^+,$$
$$D^0 \rightarrow \pi^+ \pi^-$$
$$all \quad B.R. = 100$$

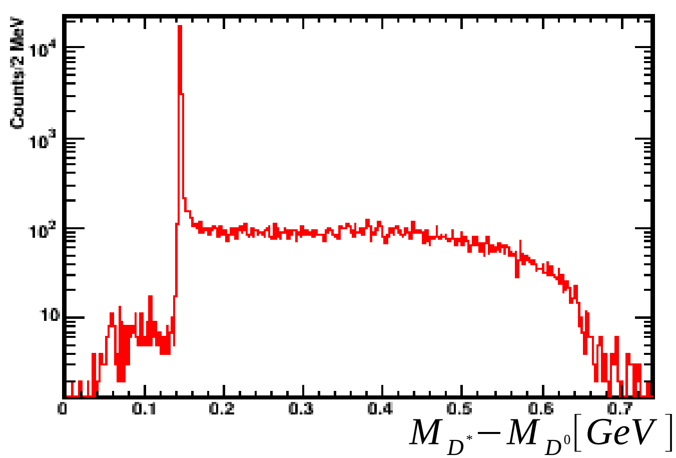


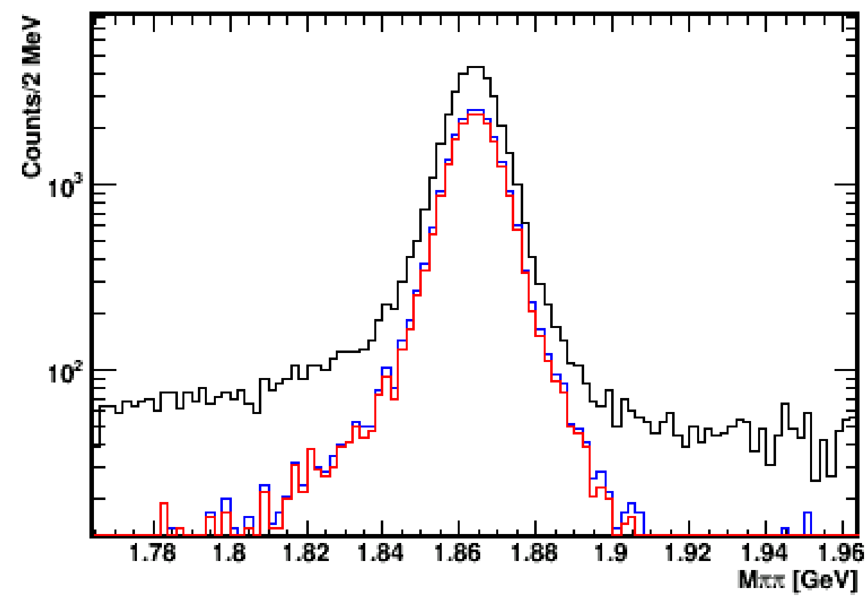


Black: signal generated with no cuts,

Blue: 4 ch. Tracks + 2 Pions,

Red: Mass difference for D mesons as shown in the histogram below





Conclusions

We are exploring time-dependent CP asymmetries in charm and we defined a measurement for the $\beta_{c,eff}$ angle in the charm triangle.

After defining the tagging for charm, we have studied a number of possible final states.

Using the developed formalism we simulated pseudo-experiments assuming SuperB luminosity and we have shown that a possible measurement for TDCP asymmetries will be reasonable.

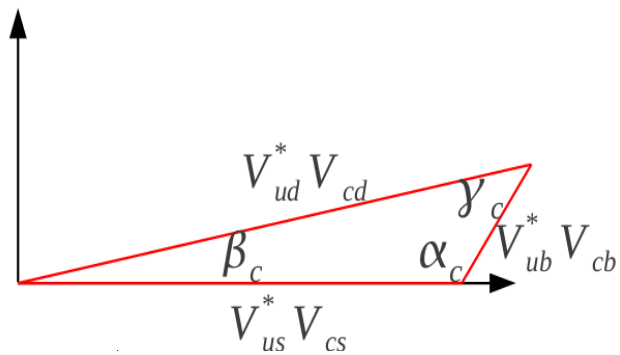
We simulated pseudo-experiments and applied the formalism for uncorrelated mesons for both SuperB and LHCb and we compared the obtained results. We highlight that a precision measurement of any time-dependent effect will require a detailed understanding of the background.

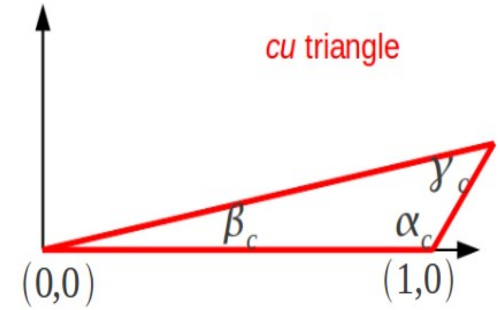
Our method may be used to measure the mixing phase in $D^0 \to K^+ K^-$.

We started to generate events with FastSim, and shown how to remove background(s) for both charm threshold and $\Upsilon(4S)$.

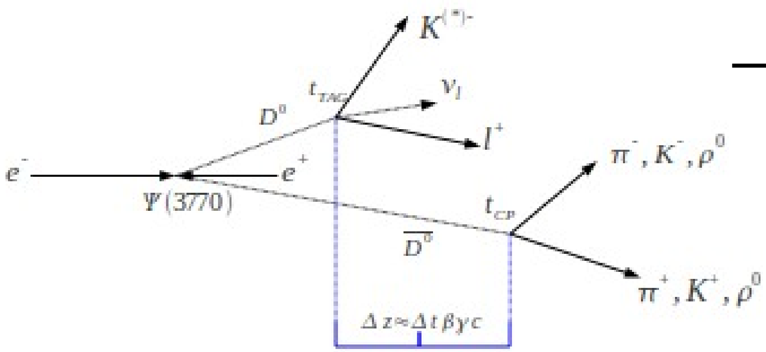
Conclusions: pictures

$$V_{CKM}=\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

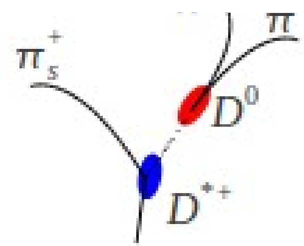




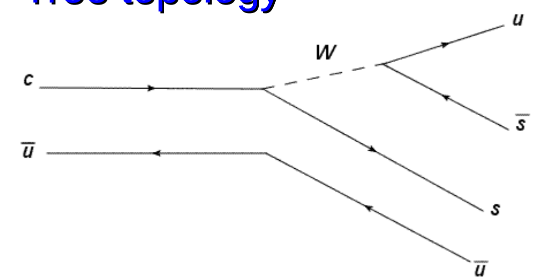
Semi-leptonic tagging



Uncorrelated mesons



Tree topology



$$A^{Phys}(\Delta t)=\frac{\overline{\Gamma}^{Phys}(\Delta t)-\Gamma^{Phys}(\Delta t)}{\overline{\Gamma}^{Phys}(\Delta t)+\Gamma^{Phys}(\Delta t)}=-\Delta\omega+\frac{(D+\Delta\omega)e^{\Delta\Gamma|\Delta t|/2}(|\lambda_f|^2-1)\cos\Delta M\Delta t+2\Im(\lambda_f)\sin\Delta M\Delta t}{(1+|\lambda_f|^2)h_+/2+h_-\Re(\lambda_f)}$$

Parameter	Super$B$ SL	Super$B$ SL + K	Super$B$ $\Upsilon(4S)$	LHCb
$\phi=\arg(\lambda_f)$	8.0°	3.4°	2.2°	2.3°
$\phi_{CP}=\phi_{KK}-\phi_{\pi\pi}$	9.4°	3.9°	2.6°	2.7°
$\beta_{c,eff}$	4.7°	2.0°	1.3°	1.4°

$\phi_{MIX}\approx 5^o$ at charm threshold using SL tagging

$\phi_{MIX}\approx 2.5^o$ at charm threshold using SL+K tagging

$\phi_{MIX}\approx 1.35^o$ at the Υ(4S)

Q1. In the standard model, CP violation originates from the complex phase naturally occurring in the CKM matrix: is this the end of the story?

Q2. Is there a unique environment where to perform precision tests of the CKM mechanism and where to look for CP violation and new physics?

Q1. In the standard model, CP violation originates from the complex phase naturally occurring in the CKM matrix: is this the end of the story?

A1. Who knows? Need to be checked...

Q2. Is there a unique environment where to perform precision tests of the CKM mechanism and where to look for CP violation and new physics?

A2. No, there are TWO unique environments where.. : SuperB and Charm..

Thank you

for your attention!