The LHCb Experiment I
Physics

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1) A bit of history

Ideas to use LHC as a B factory: already in early 90's

Expressions of Interest presented at LHC Evian Workshop in March 1992: (Even three of them!)

- -Forward collider experiment
  - ☺ large $b\bar{b}$ cross section
- -Fixed target experiment with an extracted proton beam
  - ☺ B decays visible in the vertex detector (large boost)
- -Fixed target experiment with an internal gas jet target
  - ☺ a priori known small primary vertex

NB: e^+e^- B factory situation was still unclear at that moment

Europe:

- PSI, turned down by the CH authority in 1989
- No strong push by CERN (ISR-B) nor DESY (HELENA) managements
- Novosibirsk, transition from Soviet to Russia in 1991

US:

- SLAC versus Cornell during the SSC up and down era

Japan:

- KEK, no top found by the TRISTAN

After the Evian workshop in 1992...

PEP II and KEKB have been approved for FY 1994

- asymmetric e^+e^- colliders at $\Upsilon(4S)$
- using PEP and TRISTAN tunnels, respectively
- BABAR (PEP II) and BELLE (KEKB) detectors
  - general purpose e^+e^- detectors for comprehensive studies of heavy flavours (b, c, τ) including CP violation

Followed by

Internal metal wire targets in the HERA proton ring at DESY

- 900 GeV/c p beam hallow against Cu and Wu wires
- HERA-B detector
  - fixed target experiment with a primary goal to find CP violation in $B_d \rightarrow J/\psi\, K_S$ decays

The LHC front

- three Letters of Intent have been submitted in Nov 1993
- LHCC recommended none of them but asked to design a new collider mode experiment ⇒ The LHCb Experiment
  - Letter of Intent in Aug 1994
  - Technical Proposal in Feb 1995

$$\eta_{\pi\pi} = \frac{\langle \pi\pi | H | \mathrm{K_L} \rangle}{\langle \pi\pi | H | \mathrm{K_S} \rangle}$$

Physics background at that time:

$\not{C}\!P$ seen only in the neutral kaon system

$\not{C}\!P$ in K^0-$\overline{\mathrm{K}}{}^0$ oscillations: $|p/q| \neq 1$, i.e. $\mathrm{Im}(\Gamma_{12}/M_{12}) \neq 0$

$$\mathrm{K}^0 \;\substack{\nearrow M_{12} \searrow \\ \searrow i\Gamma_{12} \nearrow}\; \overline{\mathrm{K}}{}^0$$

$\mathrm{Re}\ \varepsilon_{\mathrm{K}} = \mathrm{Re}\ \eta_{\pi\pi} \neq 0$

$\not{C}\!P$ due to the interplay between the oscillations and decays

$$\mathrm{K}^0 \;\substack{\xrightarrow{p}\ \mathrm{K}^0\ \xrightarrow{A} \\ \xrightarrow[q]{}\ \overline{\mathrm{K}}{}^0\ \xrightarrow[\overline{A}]{}}\; \pi\pi$$

$$\mathrm{Im}\left(\frac{q\,\overline{A}}{p\,A}\right) \neq 0$$

$\mathrm{Im}\ \eta_{\pi\pi} \neq 0$

$\not{CP}$ in decays not established, $\mathrm{Re}(\varepsilon'/\varepsilon) = 0$, i.e. $|\eta_{+-}| = |\eta_{00}|$,

and $\mathrm{Im}\ \eta_{\pi\pi} = \mathrm{Re}\ \eta_{\pi\pi} \times 2\Delta m/\Delta\Gamma = \mathrm{Re}(\varepsilon_K) \times 2\Delta m/\Delta\Gamma$

Measurements are compatible with the CKM picture

i.e. $|V_{cb}|$, $|V_{ub}/V_{cb}|$, $|V_{td}|$ measurements and $\mathrm{Re}(\varepsilon_K)$ gives a consistent CKM parameter solution (λ, A, ρ, η), but

without $\mathrm{Re}(\varepsilon_K)$, $\eta = 0$ still possible:

i.e. $\not{CP}$ a la Superweak model

The major goal of the first generation "high statistics" B experiments includes

-to measure $\not{CP}$ violation outside of the K^0 system, i.e. the B meson systems, in particular $B_d^0 \to J/\psi K_S$,

-to determine (ρ, η) without $\not{CP}$

BABAR, BELLE, HERA-B and a B experiment at LHC

(LHC was supposed to start before 2000)

However for LHCb:

Starting of LHC slipped to 2005 (now 2007)

Emphasis of physics goal was also put for search for New Physics

For the final approval in 1995, a physics case with possible New Physics presented at LHC Committee

Then, two B factories and experiments working very well

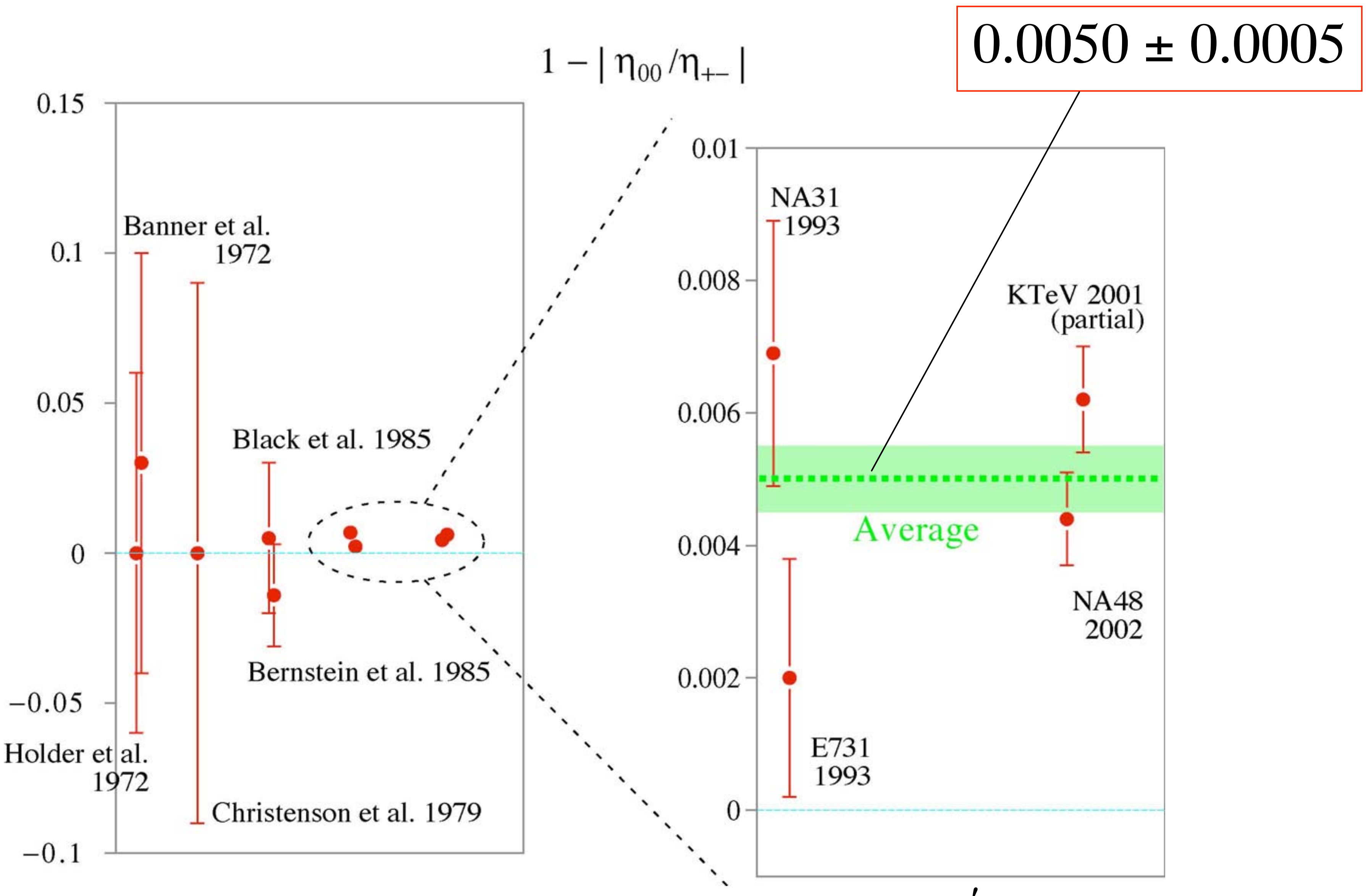
$\mathrm{Re}(\varepsilon'/\varepsilon) \neq 0$ well established (NA48, KTeV)

CDF and D0 exploring some B (importantly B_s) physics

further emphasis on New Physics for LHCb

$\Rightarrow$ a challenge for the detector...

After cancellation of BTeV, LHCb is the only approved dedicated B experiment >2009 (Super B factory?)

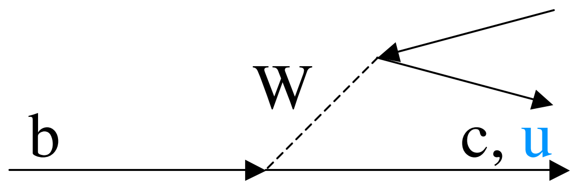


$$3\,\mathrm{Re}\,\frac{\varepsilon'}{\varepsilon} = |\eta_{+-}/\eta_{00}| - 1$$

2) Where are we and how do we continue?

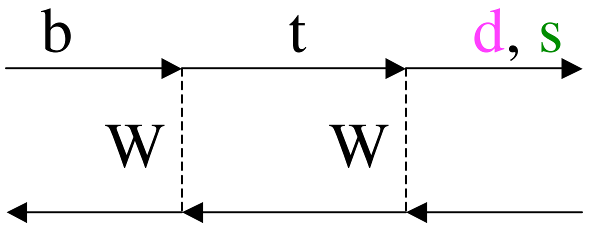
Assuming the Standard Model prescription...

Tree
$\Gamma(b \to c)$
$\Gamma(b \to u)$



$|V_{cb}|$
$|V_{ub}|$ $\rho^2 + \eta^2$

Box
$\omega(B_d\text{-}\bar{B}_d)$
$\omega(B_s\text{-}\bar{B}_s)$

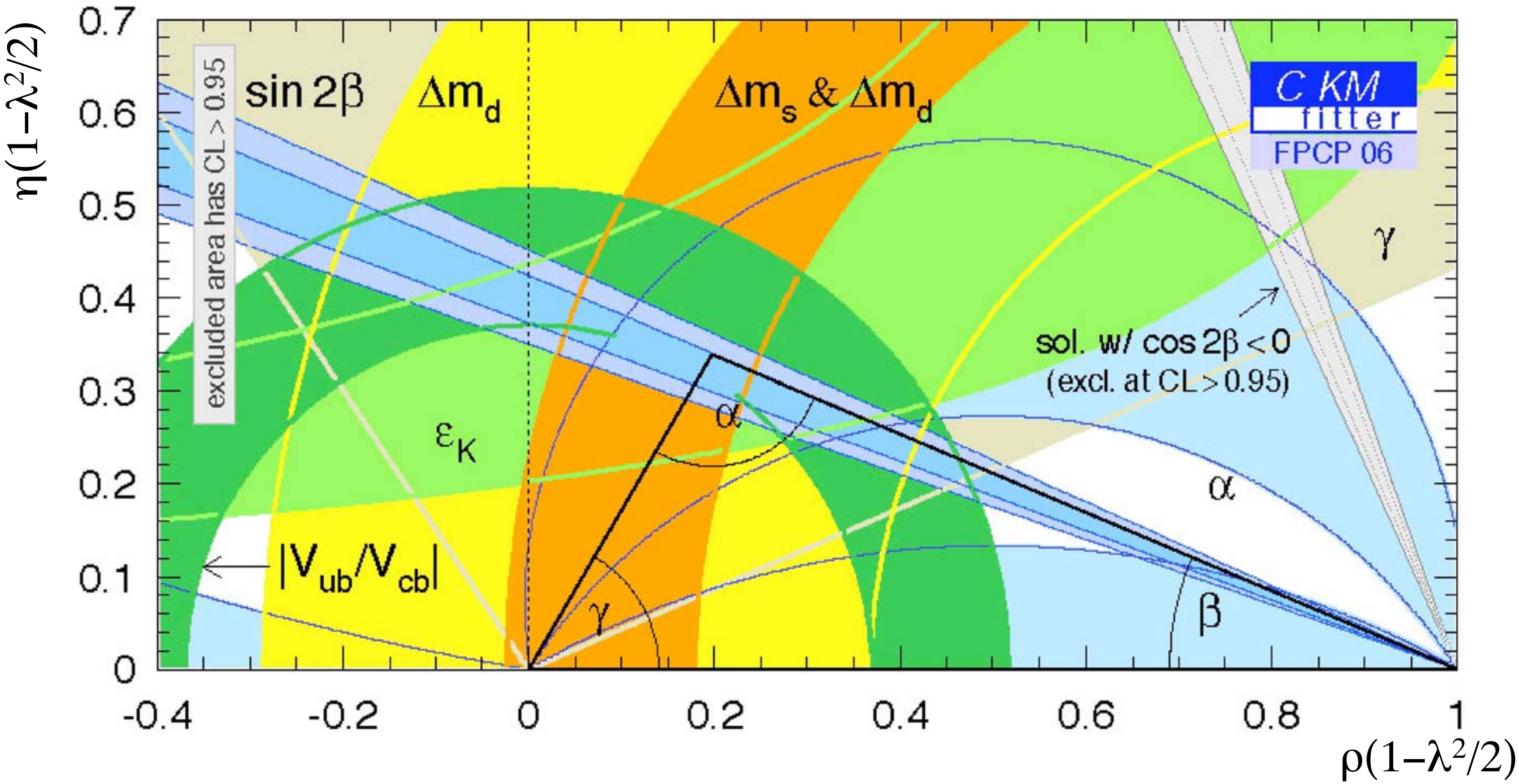


$|V_{td}|$ $(1-\rho)^2 + \eta^2$
$|V_{ts}|$

$\not{C}\not{P}$(Box⊗Tree) arg V_{td} + arg V_{cb} $\tan^{-1} \eta / (1 - \rho) \to \beta$

$\not{C}\not{P}$(Box⊗Tree) arg V_{td} + arg V_{ub} $\tan^{-1} \eta / (1 - \rho) + \tan^{-1} \eta / \rho \to \beta + \gamma$

$\not{C}\not{P}$(Tree⊗Tree) arg V_{cb} + arg V_{ub} $\tan^{-1} \eta / \rho \to \gamma$

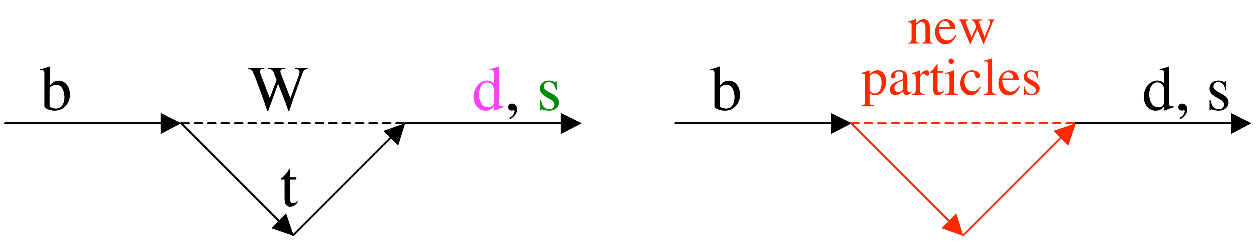


- remarkable agreement among all the measurements
- with new Δm_s, the side measurements exclude $\eta = 0$

$\not{CP}$ in the Standard Model is established without using $\not{CP}$ information!

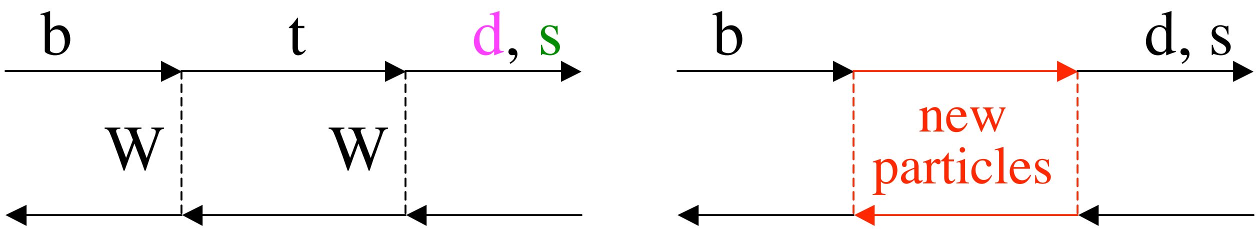
New Physics can contribute in the loop level, "virtual" i.e. box and penguin diagrams

Penguin
$\Gamma(b \rightarrow s)$
$\Gamma(b \rightarrow d)$



$|V_{td}| + \Delta_{peng(d)}$
$|V_{ts}| + \Delta_{peng(s)}$

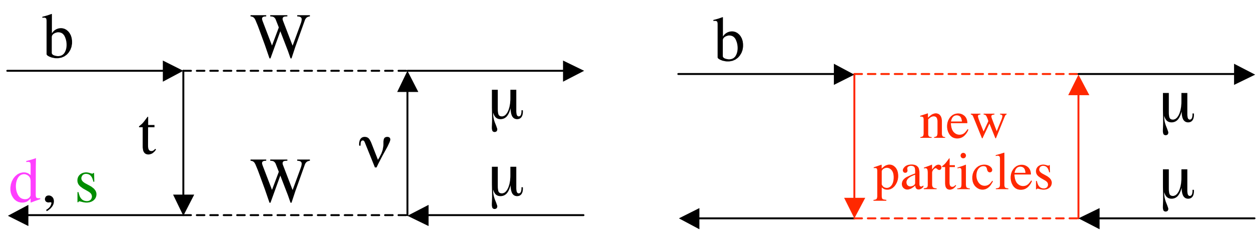
Box
$\omega(B_d\text{-}\bar{B}_d)$
$\omega(B_s\text{-}\bar{B}_s)$



$|V_{td}| + \Delta_{box(d)}$
$|V_{ts}| + \Delta_{box(s)}$

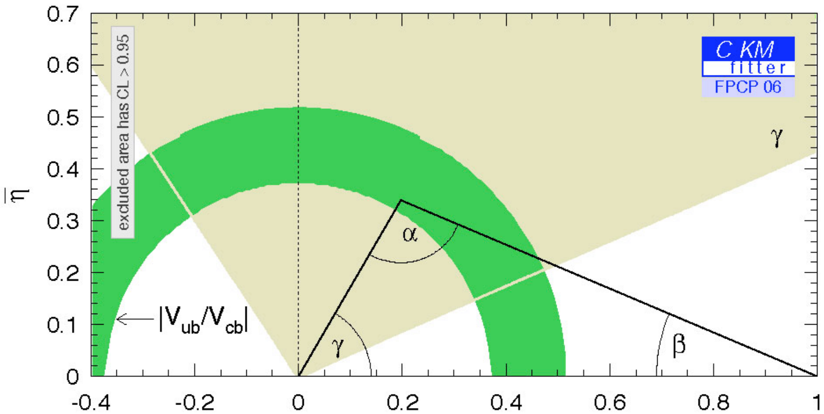
$\not{C}\not{P}$(Box⊗Tree) $\arg V_{td}\,(V_{ts}) + \arg V_{cb}\,(V_{ub}) + \Phi_{box(d)}\,(\Phi_{box(s)})$
$\not{C}\not{P}$(Box⊗Peng) $\arg V_{td}\,(V_{ts}) + \arg V_{td} + \Phi_{box(d)}\,(\Phi_{box(s)}) + \Phi_{peng(d)}$
$+ \arg V_{td} + \Phi_{box(d)}\,(\Phi_{box(s)}) + \Phi_{peng(s)}$

$\Gamma(B \rightarrow \mu\mu)$

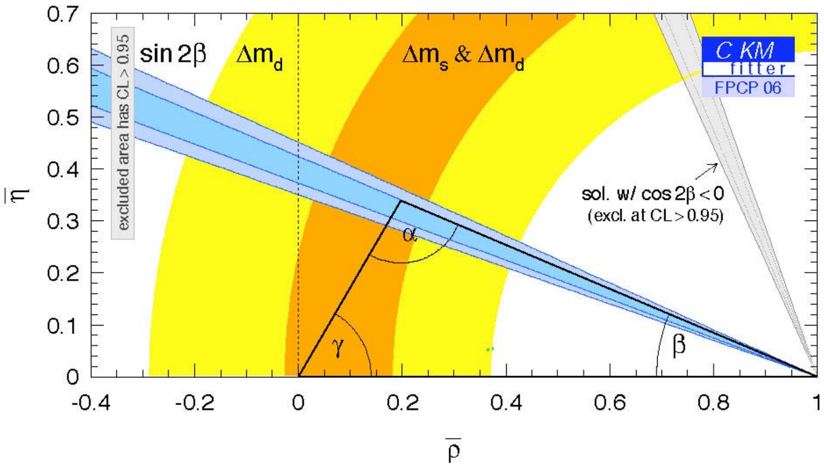


$|V_{td}| + \Delta_{\mu\mu(d)}$
$|V_{ts}| + \Delta_{\mu\mu(s)}$

An example of the next analysis steps...



a)
extracting (ρ, η) from the tree processes
⇒ true CKM (ρ, η)



b)
extracting (ρ, η) from the box processes
⇒ an effective (ρ, η)
with New Physics contaminations

a) + b) will disentangle the new physics contribution, but need

Much better measurements of γ, $\sigma_\gamma < 5°$ (currently $^{+35°}_{-25°}$)

Improving hadronic theory, $B_B \times f_B^2$ and $|V_{ub}|$

and a further improvement on CP in $b \to c\bar{c}s$

Or, measure angles in a different ways...

γ from tree only:

$B \to DK^{(*)}$, $B_s \to D_s K$

γ from tree+penguin

$B \to \pi\pi \oplus B_s \to KK \oplus$ U-spin

β from box only (almost)

$B \to J/\psi K_S$

$\beta + \gamma$ from tree+penguin+box

$B \to \pi\pi$, $\rho\pi$, $\rho\rho$

Or, look for $\not{CP}$ where Standard Model predict small effect

$B_d \rightarrow \rho^0\gamma$ box + $b \rightarrow d\gamma$ penguin

$B_s \rightarrow \phi\gamma$ box + $b \rightarrow s\gamma$ penguin

CP asymmetry = 0

if t quark dominates in the loop

$$\mathrm{Im}\left(\frac{q}{p}\frac{\bar{A}}{A}\right) = \mathrm{Im}\left[\frac{(V_{tb}V_{ti}^*)^2}{|V_{tb}V_{ti}^*|^2}\frac{V_{tb}^*V_{ti}}{V_{tb}V_{ti}^*}\right] = 0$$

i = d or s (B$_s$ better valid)

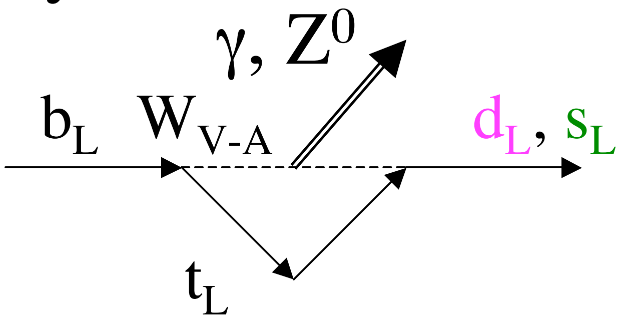
$B_s \rightarrow J/\psi\phi$ box + $b \rightarrow c$ tree

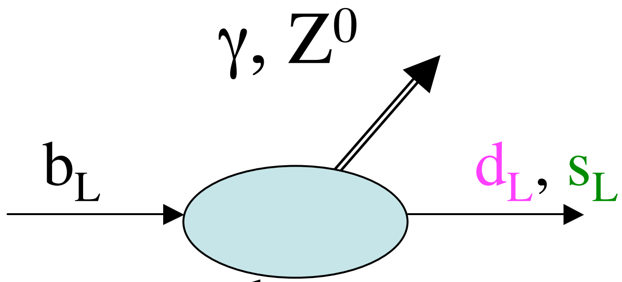
$$\mathrm{Im}\left(\frac{q}{p}\frac{\bar{A}}{A}\right) = \mathrm{Im}\left[\frac{(V_{tb}V_{ts}^*)^2}{|V_{tb}V_{ts}^*|^2}\frac{V_{cs}^*V_{cb}}{V_{cs}V_{sb}^*}\right] = 2\lambda^2\eta$$

but New Physics in loop may make them large...

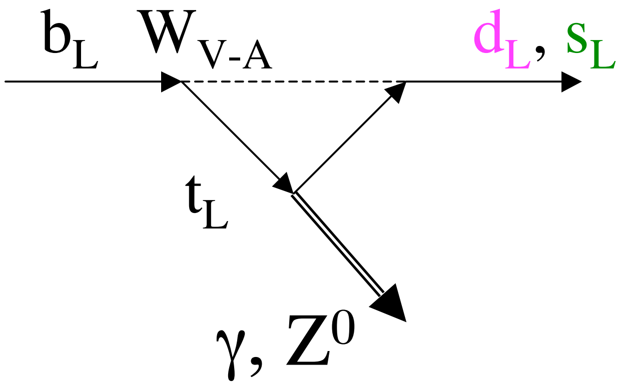
Or in a more subtle ways...

Study the Lorentz structure of the current in the loops





scaler,
right-handed spinor,
vector,
etc.



different γ, Z^0 polarization may appear

3) Some LHCb B physics sensitivity

Reconstruction of B **decay vertex with a good resolution**
is essential to **reduce combinatorial background**:

decay vertex: >1 well reconstructed tracks

well reconstructed track =

- charged particle seen by vertex detector
- reconstructed particle from tracks measured by vertex detector
  $D^0(\rightarrow K^-\pi^+)$, $D_s(K^+K^-\pi^+)$, etc.

examples are

$B_{(s)}{}^0 \rightarrow l^+l^-$, h^+h^-, ..., $B_s{}^0 \rightarrow D_s(\rightarrow K^+K^-\pi^-)\ \pi^+$

π^0 and γ may be **associated** to a reconstructed vertex (if not too many)

$B^0 \rightarrow K^{*0}(K^+\pi^-)\gamma$, $\rho^0(\rightarrow\pi^+\pi^-)\pi^0$, etc. are possible

but not

$B^0 \rightarrow K_S\pi^0$, $\rho^+(\rightarrow\pi^+\pi^0)\pi^0$, $\pi^0\nu\nu$, etc.

$B^+ \rightarrow \mu^+\nu$, $K^+\nu\nu$, $\tau^+\nu$

LHC is a b factory! ("b" not "B")

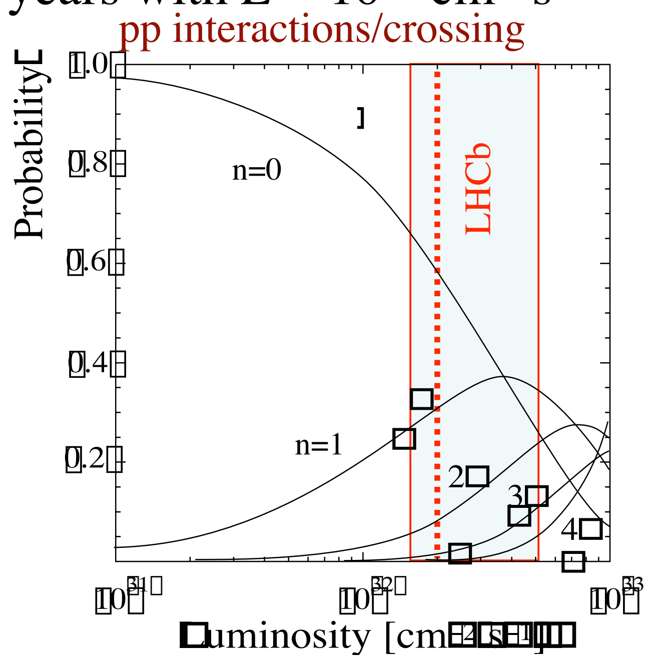
B^0, B^+, B_s, B_c, b-baryons:

Expected fractions ~ 40 : 40 : 10 : 0.1 : 10 %

	$e^+e^- \rightarrow \Upsilon(4S) \rightarrow B\bar{B}$ PEPII, KEKB	$pp \rightarrow b\bar{b}X$ ($\sqrt{s}$ = 14 TeV, Δt_{bunch}=25 ns) LHC (LHCb, ATLAS, CMS)	
Production $\sigma_{b\bar{b}}$	1 nb	~500 μb	☺
Typical $b\bar{b}$ rate	10 Hz	100–1000 kHz	
$b\bar{b}$ purity	~1/4	$\sigma_{b\bar{b}}/\sigma_{inel}$ = 0.6% Trigger is a major issue !	☹
Pileup	0	0.5–5	
b-hadron types	B^+B^- (50%) $B^0\bar{B}^0$ (50%)	B^+ (40%), B^0 (40%), B_s (10%) B_c (< 0.1%), b-baryons (10%)	☺
b-hadron boost	Small	Large (decay vertexes well separated)	
Production vertex	Not reconstructed	Reconstructed (many tracks)	
Neutral B mixing	Coherent $B^0\bar{B}^0$ pair mixing	Incoherent B^0 and B_s mixing (extra flavour-tagging dilution)	☹
Event structure	$B\bar{B}$ pair alone	Many particles not associated with the two b hadrons	

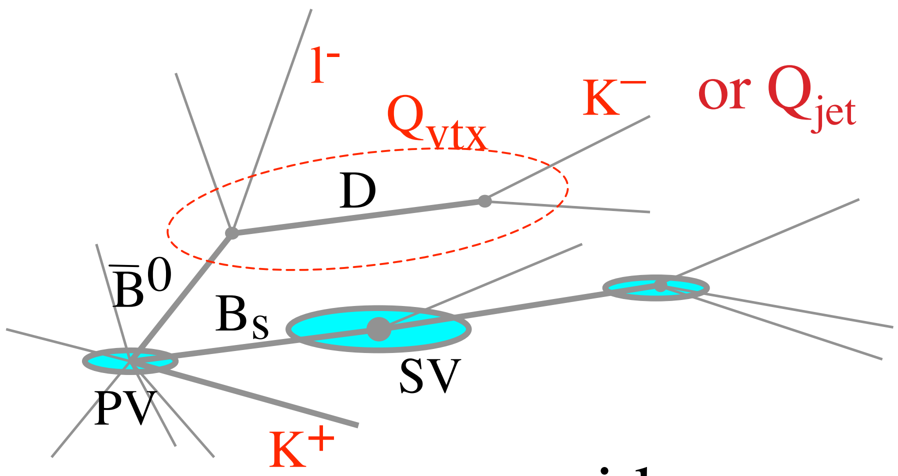
Luminosities

- LHC machine, pp collisions at $\sqrt{s}$ = 14 TeV:
  - design luminosity $L = 10^{34}$ cm^{-2}s^{-1}, bunch crossing rate = 40 MHz
  - average non-empty bunch crossing rate f = 30–32 MHz
  - Pileup:
    - n = number of inelastic pp interactions occurring in the same bunch crossing
    - Poisson distribution with mean $\langle n \rangle = L\sigma_{inel}/f$, with σ_{inel}= 80 mb
    - $\langle n \rangle$ = 25 at 10^{34} cm^{-2}s^{-1} → not good for B physics (except $B_s \to \mu\mu$?)
- ATLAS and CMS
  - B physics in the early stage of the LHC operation ~3 years with $L = 10^{33}$ cm^{-2}s^{-1}
- At LHCb:
  - L tuneable by adjusting final beam focusing
  - Choose to $\langle L \rangle \sim 2\times10^{32}$ cm^{-2}s^{-1} (max. ~5×10^{32})
    - Clean environment: $\langle n \rangle$=0.5
    - Less radiation damage
    - Will be available from “first” physics run



- A “standard” year
  - In one “nominal year” = 10^7 s:
    - At LHCb 2 fb^{-1} of data, 10^{12} bb pairs produced
    - At ATLAS/CMS 10 fb^{-1} of data

Flavour tag



LHCb

Tag	$\varepsilon D^2 = \varepsilon(1-2w)^2$
Opposite μ	0.7%–1.8%
Opposite e	0.4%–0.6%
Opposite K	1.6%–2.4%
Opposite Q_{vtx}	0.9%–1.3%
Same side π (B^0)	0.8%–1.0%
Same side K (B_s)	2.7%–3.3%
Combined (B^0)	4%–5%
Combined (B_s)	7%–9%

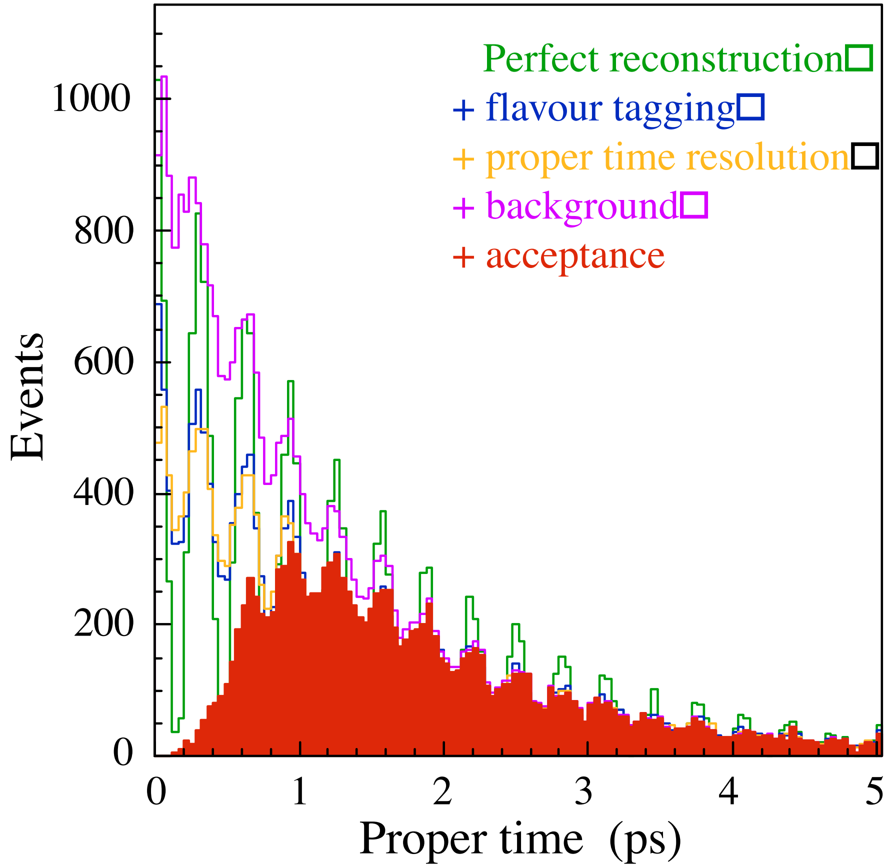
One of the first physics goals: Confirm the CDF observation of B_s–B_s oscillation with much higher significance!

$B_s \rightarrow D_s^{-}\pi^{+}$

Plot made for 1 year of data (80k selected events, LHCb) for $\Delta m_s = 20\ \text{ps}^{-1}$

$\Rightarrow$ a month of data is enough

Important input to control the flavour tag performance



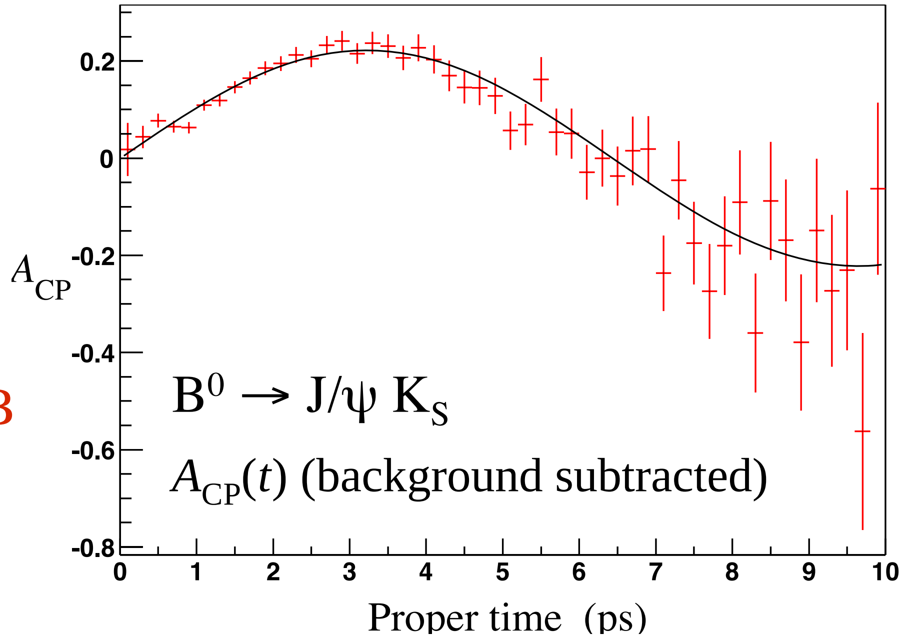
Measurement of sin 2β is not a central physics goal of LHCb (known well) but will be an important check of CP analyses e.g. tagging dilution, detector asymmetry...

+ can search for direct CP violating term $\propto \cos \Delta m_d t$

Expect 216k reconstructed $B^0 \to J/\psi K_S$ events/year

Precision $\sigma_{stat}(\sin 2\beta) \sim 0.02$, i.e. $\sigma_{stat}(\beta) \sim 0.6°$ in one year (10^7sec, 2fb^{-1})

B^0 mass resolution 10 MeV



$K \to \phi K_S$ is a difficult channel for LHCb: due to small p_0(K) from φ, small ε_{trig} and S/B

Annual yield: 0.8k, B/S<2.4 (preliminary)

Scaling of 1 year sensitivity from $J/\psi K_s$ $\sigma(\sin 2\beta_{eff})$~0.4.

$B_s \to J/\psi\,\phi$ is the B_s counterpart of $B^0 \to J/\psi K_S$

CP asymmetry measures ϕ_s, the phase of B_s oscillation

In Standard Model ϕ_s is small: $\phi_s = -2\lambda^2\eta \sim -0.04$

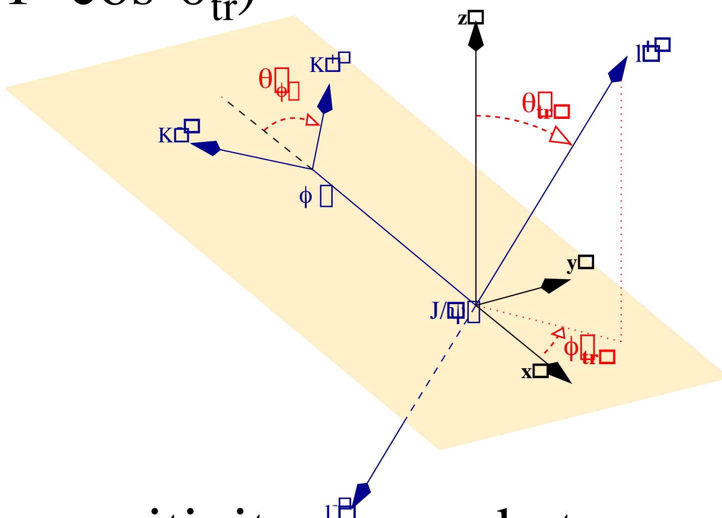
$\to$ sensitive probe for new physics

Final state is admixture of CP-even and odd contributions

$\to$ angular analysis of decay products required

$L(t) = (1-R_{-})\, L_{+}(t)\, (1+\cos^2\theta_{tr})/2 + R_{-}\, L_{-}(t)\, (1-\cos^2\theta_{tr})$

Fit for $\sin\phi_s$, R_{-} and $\Delta\Gamma_s/\Gamma_s$



131k signals/year (10^7sec) in LHCb

$\sigma_m = 14$ MeV/c^2, B/S = 0.12 $\sigma_\tau = 36$ fs

$\sigma(\sin\phi_s) \sim 0.023$, $\sigma(\Delta\Gamma_s/\Gamma_s) \sim 0.01$

($\Delta m_s = 17.5$ ps^{-1})

Including $B_s \to J/\psi\eta$, $\eta_c\phi$, D_sD_s will increase sensitivity somewhat: only ~ 21k events/year, but pure CP state

$B_s \to D_s^- K^+$ and $\bar{B}_s \to D_s^+ K^-$ (b→u transition, BR ~ 7 × lower)

both tree decays, which interfere via B_s mixing

CP asymmetry measures $\gamma + \phi_s$

Very little theoretical uncertainty, insensitive to new physics

ϕ_s will be determined using $B_s \to J/\psi\,\phi$ decays → extract γ

$B_s \to D_s^- \pi^+$ gives background to $D_s K$ (BR ~ 12 × higher)

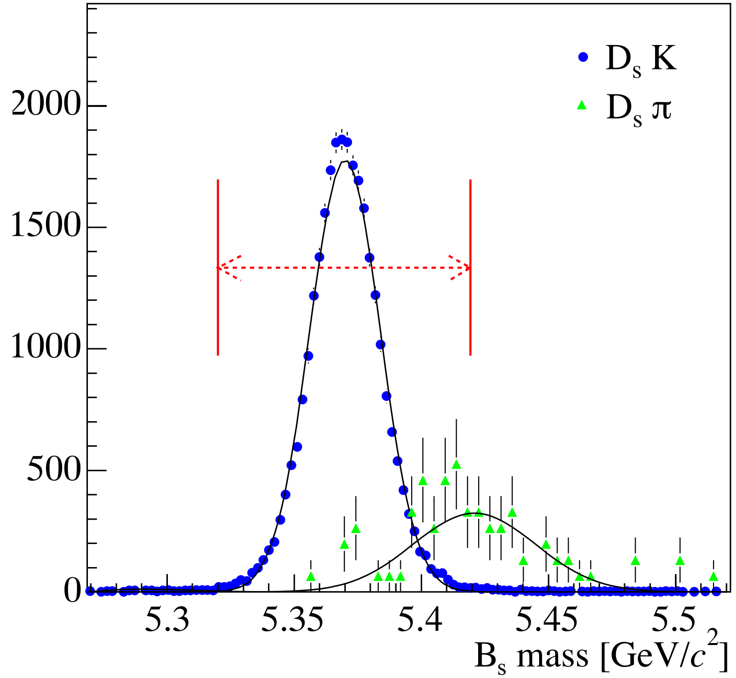
Suppress using PID

→ residual contamination only ~ 10%

5.4k signal/year (10^7sec, 2fb^{-1})

S/B (from bb) > 1 (at 90% CL)

(only 1 bkg event in wider M_B window)



Allow for strong phase difference Δ between the two diagrams

Fit two time-dependent asymmetries:

Phase of $D_s^+K^- = \Delta - (\gamma + \phi_s)$

Phase of $D_s^-K^+ = \Delta + (\gamma + \phi_s)$

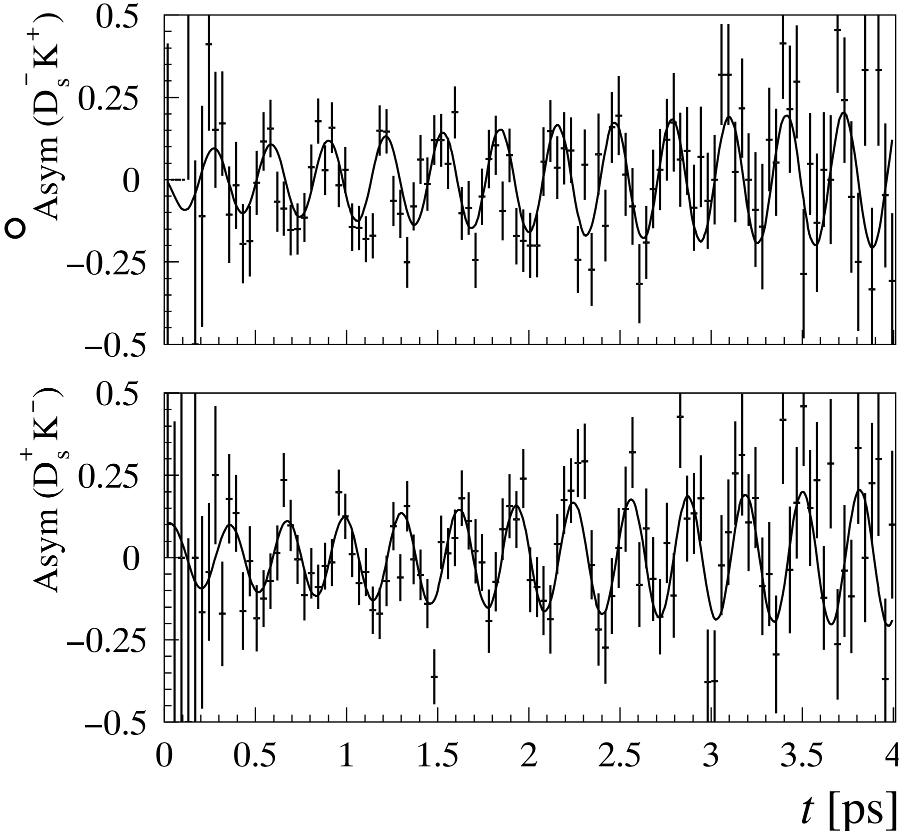
$\rightarrow$ extract both Δ and $(\gamma + \phi_s)$

$\sigma(\gamma) \sim 13°$ in one year

for $\Delta m_s = 17.3\ \mathrm{ps}^{-1}$, $-20° < \Delta < 20°$

statistically limited

Asymmetries (5 years data)



$B \rightarrow DK$ for γ measurement

$\bar{b} \rightarrow \bar{c} + W(\rightarrow u\bar{s})$ D^0 K

B $\quad$ D^0-$\bar{D}^0$ mixing, DCS decays, K^0-$\bar{K}^0$ mixing $\quad$ $|A + A' e^{i(\Delta+\gamma)}|^2$

$\bar{b} \rightarrow \bar{u} + W(\rightarrow c\bar{s})$ $\bar{D}^0$ K

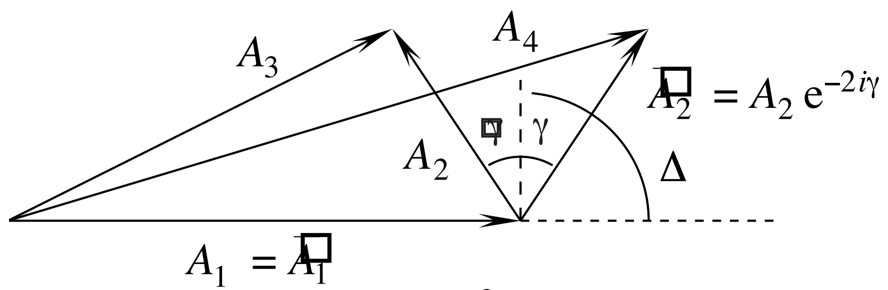
$b \rightarrow c + W(\rightarrow \bar{u}s)$ $\bar{D}^0$ $\bar{K}$

$\bar{B}$ $\quad$ D^0-$\bar{D}^0$ mixing, DCS decays, K^0-$\bar{K}^0$ mixing $\quad$ $|A + A' e^{i(\Delta-\gamma)}|^2$

$b \rightarrow u + W(\rightarrow \bar{c}s)$ $\bar{D}^0$ $\bar{K}$

Measure 6 decay rates: $B^0 \to \bar{D}^0 K^{*0}$, $D^0 K^{*0}$ and $D^0_{CP} K^{*0}$
+ CP conjugates, where $D^0_{CP} \to K^+K^-$ (or $\pi^+\pi^-$)

Appropriate construction of amplitudes allows both γ and strong phase Δ to be extracted [Gronau & Wyler, Dunietz]



Decays are self-tagging (through $K^{*0} \to K^+\pi^-$) and time integrated

No penguin diagram contributing to the decay

Mode	Yield	S/B
$B^0 \to \bar{D}^0\ (K^+\pi^-)\ K^{*0}$	3400	> 2.0
$B^0 \to D^0\ (K^-\pi^+)\ K^{*0}$	500	> 0.3
$B^0 \to D^0_{CP}\ (K^+K^-)\ K^{*0}$	600	> 0.3

LHCb annual yields
(for $\gamma = 65°$, $\Delta = 0$)

$\to \sigma(\gamma) \sim 8°$

($55° < \gamma < 105°, -20° < \Delta < 20°$)

Measure four decay rates, $B^+ \rightarrow (K^+\pi^-)_{D\text{-mass}} K^+$, $(K^-\pi^+)_{D\text{-mass}} K^+$ + CP conjugates

$$\Gamma(B^- \to (K^-\pi^+)_D K^-) \;\propto\; 1 + (r_B r_D^{K\pi})^2 + 2 r_B r_D^{K\pi} \cos\left(\delta_B - \delta_D^{K\pi} - \gamma\right), \quad (1)$$

$$\Gamma(B^- \to (K^+\pi^-)_D K^-) \;\propto\; r_B^2 + (r_D^{K\pi})^2 + 2 r_B r_D^{K\pi} \cos\left(\delta_B + \delta_D^{K\pi} - \gamma\right), \quad (2)$$

$$\Gamma(B^+ \to (K^+\pi^-)_D K^+) \;\propto\; 1 + (r_B r_D^{K\pi})^2 + 2 r_B r_D^{K\pi} \cos\left(\delta_B - \delta_D^{K\pi} + \gamma\right), \quad (3)$$

$$\Gamma(B^+ \to (K^-\pi^+)_D K^+) \;\propto\; r_B^2 + (r_D^{K\pi})^2 + 2 r_B r_D^{K\pi} \cos\left(\delta_B + \delta_D^{K\pi} + \gamma\right), \quad (4)$$

(1), (3): ~60k events

(2), (4): ~0.5k events

B decays

Weak phase diff.: γ

Magnitude ratio: r_B

Strong phase diff.: δ_B

D decays

Magnitude ratio: $r_D^{K\pi}$

Strong phase diff.: $\delta_D^{K\pi}$

hope to get information from CLEO-c

$\sigma(\gamma) \sim 4°$-$13°$ in 1 year

Using $(K_S\pi^+\pi^-)_{D\text{-mass}}$ under investigation

Time-dependent CP asymmetries for $B^0 \rightarrow \pi^+\pi^-$ and $B_s \rightarrow K^+K^-$

$$A_{CP}(t) = A_{dir} \cos(\Delta m\, t) + A_{mix} \sin(\Delta m\, t)$$

A_{dir} and A_{mix} depend on weak phases γ and ϕ_d (or ϕ_s), and on ratio of penguin to tree amplitudes = $d\, e^{i\theta}$

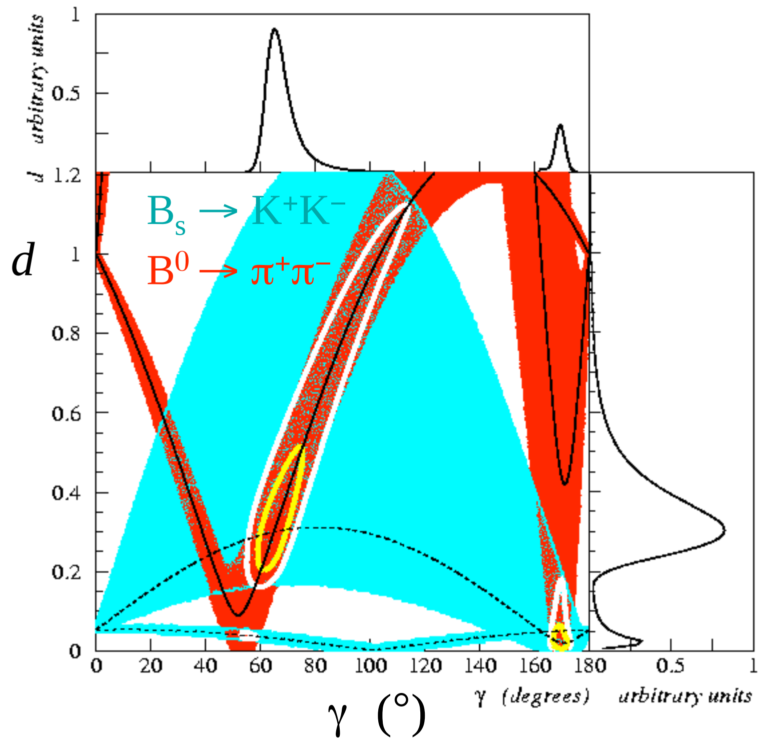
Under U-spin symmetry [Fleischer]
(interchange of d and s quarks)

$$d_{\pi\pi} = d_{KK} \text{ and } \theta_{\pi\pi} = \theta_{KK}$$

→ 4 measurements, 3 unknowns
(taking ϕ_s & ϕ_d from other modes)
→ can solve for γ

26k $B^0 \rightarrow \pi^+\pi^-$ events/year (LHCb)
37k $B_s \rightarrow K^+K^-$ → $\sigma(\gamma) \sim 5°$

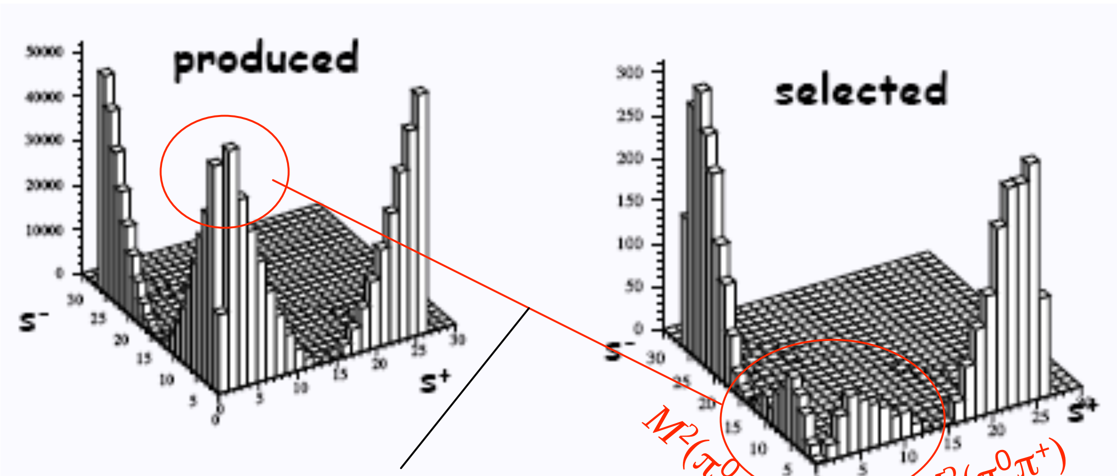
Uncertainty from U-spin assumption
Sensitive to new physics in penguins



Time-dependent Dalitz plot analysis of $B^0 \to \rho\pi \to \pi^+\pi^-\pi^0$ permits extraction of α along with amplitudes + strong phases [Snyder & Quinn]

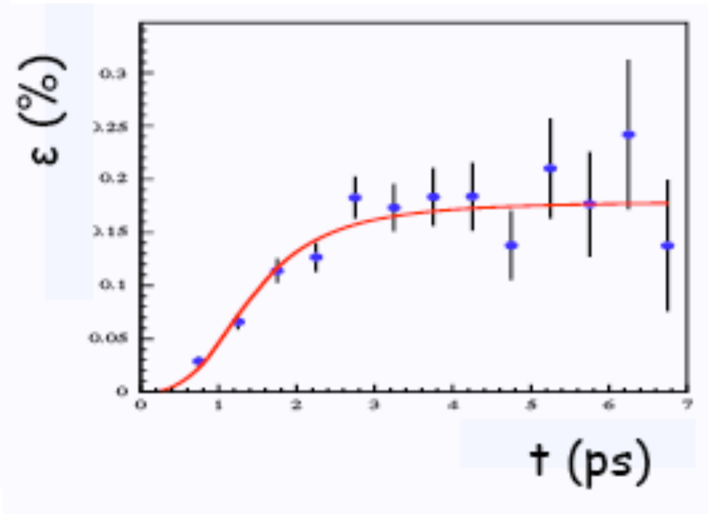
Annual yield ~ 14k events, B/S < 0.8 (90% CL)

Dalitz plot acceptance



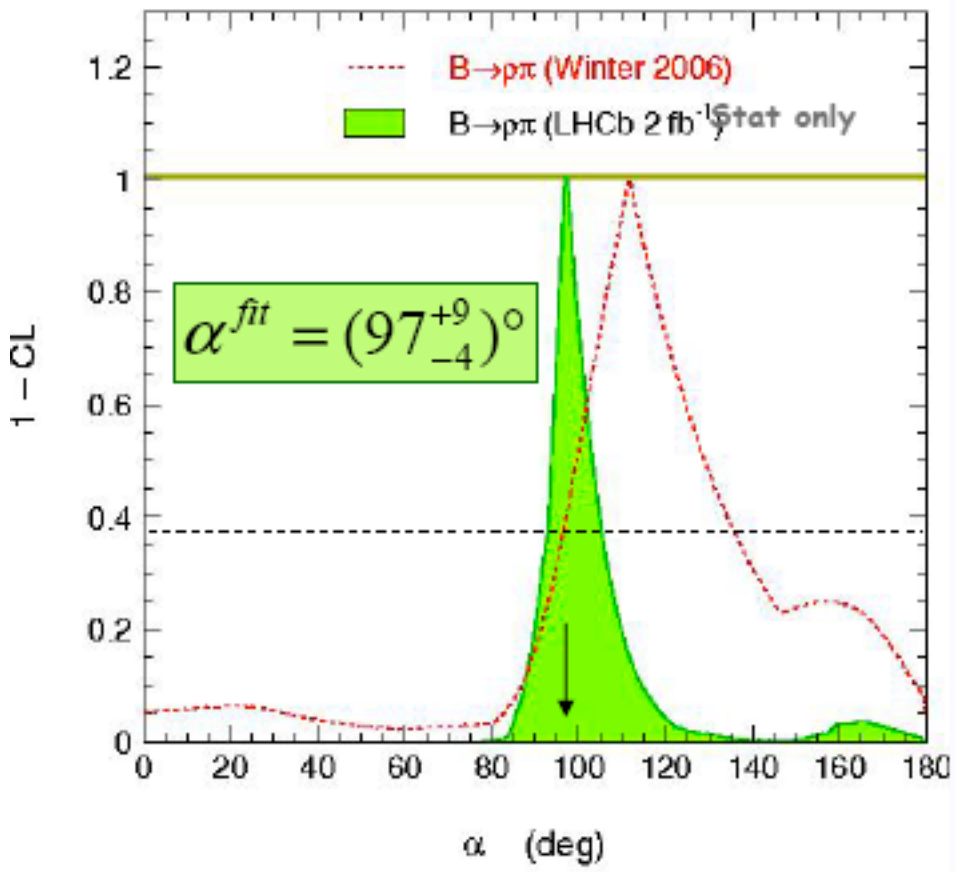
due to the π^0 energy cut

Proper-time acceptance



Complicated 11-parameter fit, studied with toy MC

Statistical precision of $\sigma(\alpha) \sim ^{+9°}_{-4°}$ achievable in one year



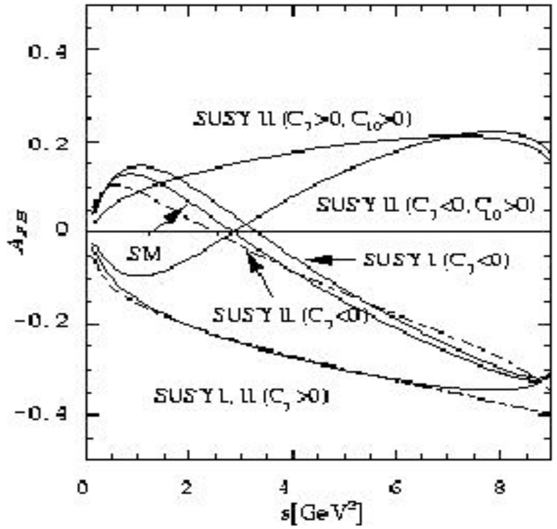
Assuming $Br(B^0 \rightarrow \rho^0\rho^0) = 5\times10^{-7} \Rightarrow \sigma(Br)/Br=0.2$ in one year

important input for $B\rightarrow\rho\rho$ studies

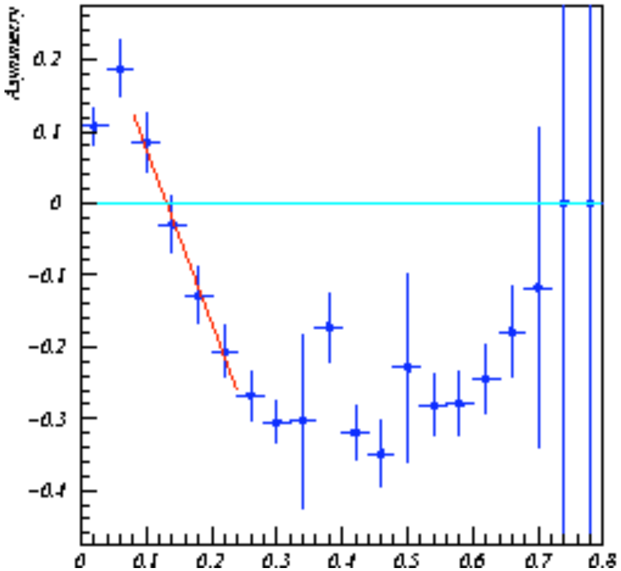
$B^0 \rightarrow K^{*0}\mu^+\mu^-$ suppressed decay (ΔB = 1 FCNC), BR~10^{-6}

Forward-backward asymmetry in the $\mu\mu$ rest-frame $A_{FB}(s)$ is sensitive probe of new physics [Ali *et al*]

$A_{FB}(s)$



$A_{FB}(s)$ ^



$\hat{s} = (m_{\mu\mu}/m_B)^2$

LHCb: 4400 events/year, S/B > 0.4

$A_{FB}(s)$ reconstructed using toy MC
(two years data, background subtracted)
Zero point located to ±0.04

31% error on C_7/C_9

(recent update expects 7700 events with a similar B/S)

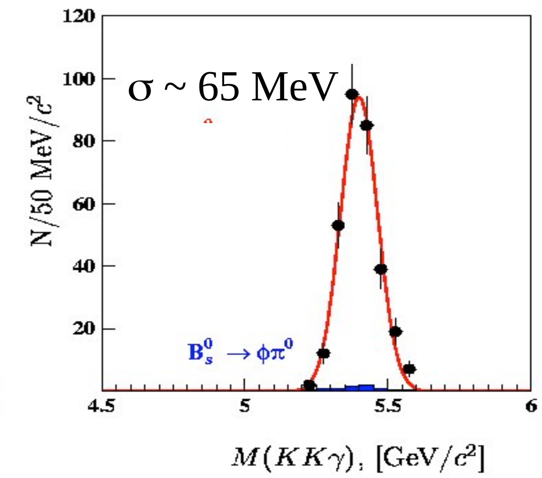
Rare decay: BR ($B_s \rightarrow \mu^+\mu^-$) = 3.5×10^{-9} in Standard Model
Sensitive to new physics, can be strongly enhanced in SUSY

LHCb expect ~30 selected signal events/year for SM BR
Problem to estimate the background:
no events selected from full background sample,
but only corresponds to B/S < 6 (90% CL)

Prospect of significant BR measurement, even for SM value

Other channels

$B_s \rightarrow \phi\gamma$



- some other interesting channels

	$N/2fb^{-1}$	B/S
$B \rightarrow K^{*0}\gamma$	35k	<0.7
$B_s \rightarrow \phi\gamma$	9.3k	<2.4
$B_s \rightarrow \phi\phi$	1.2k	<0.2

- Not yet systematically explored: B_c and b-baryon physics
- Recent assignment of high rate output streams from the HLT opens possibility of charm physics: > 10^8 reconstructed D*/year, and inclusive b trigger (*eg* on single μ) should give the equivalent of ~ 10^9 perfectly tagged b-hadron decays/year
- Although detector is under construction, still room to adjust trigger to select channels of topical interest

Systematics

Some potential sources of systematic uncertainty:

- B/B production asymmetry
- Charge-dependent detection efficiencies
- Background asymmetries
- Trigger bias (*eg* for flavour tag, proper-time acceptance)

Some experimental handles available:

- Control channels (*eg* $J/\psi K^*$ for $J/\psi K_S$, *etc*)
- Regular reversal of spectrometer B field
- Simultaneous fit of signal and background (*eg* $D_sK/D_s\pi$)
- Analysis of tagging performance in separate categories (*eg* triggered on B signal/triggered on other tracks)

High rate HLT unbiased samples will allow study using data