Heavy Quarks & Leptons 08
Melbourne 5-9 June 2008

Status and Physics reach of LHCb

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On behalf of the LHCb collaboration

The Large Hadron Collider

LHC start up is approaching:

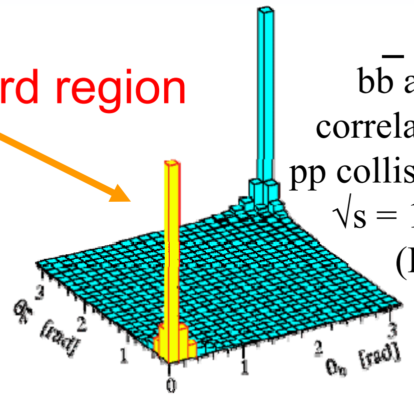
- Cooling down proceeding well, aiming for machine cold in the first half of July.
- Beam injected end July - early August. First collision 1-2 months later.
- Luminosity $\sim 10^{31}$ $cm^{-2}s^{-1}$

LHCb @ LHC

Huge $b\bar{b}$ production in pp collisions at $\sqrt{s}$=14TeV, in the forward region

σ_{bb} = 500 μb → N ~10^{12} $b\bar{b}$ events in L_{int} =2 fb^{-1}

σ_{inel} = 80 mb



$b\bar{b}$ angular correlation in pp collisions at $\sqrt{s}$ = 14 TeV (Pythia)

A possible running scenario:

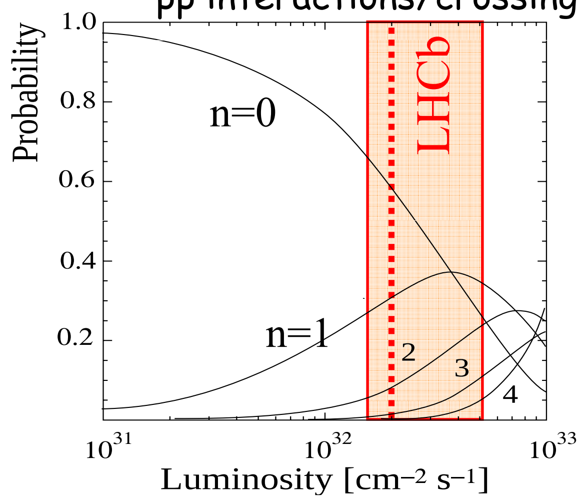
2008 Expect ~50 days of data taking with limited efficiency, L~10^{31} $cm^{-2}s^{-1}$
Calibration and Trigger commissioning / First results for non-CP physics

2009 Expect ~140 days of data taking, L~2x10^{32} $cm^{-2}s^{-1}$
First results on rare decays and CP physics ~ 0.5 fb^{-1}

2010- Stable running. Expect ~ 2 fb^{-1}/ year

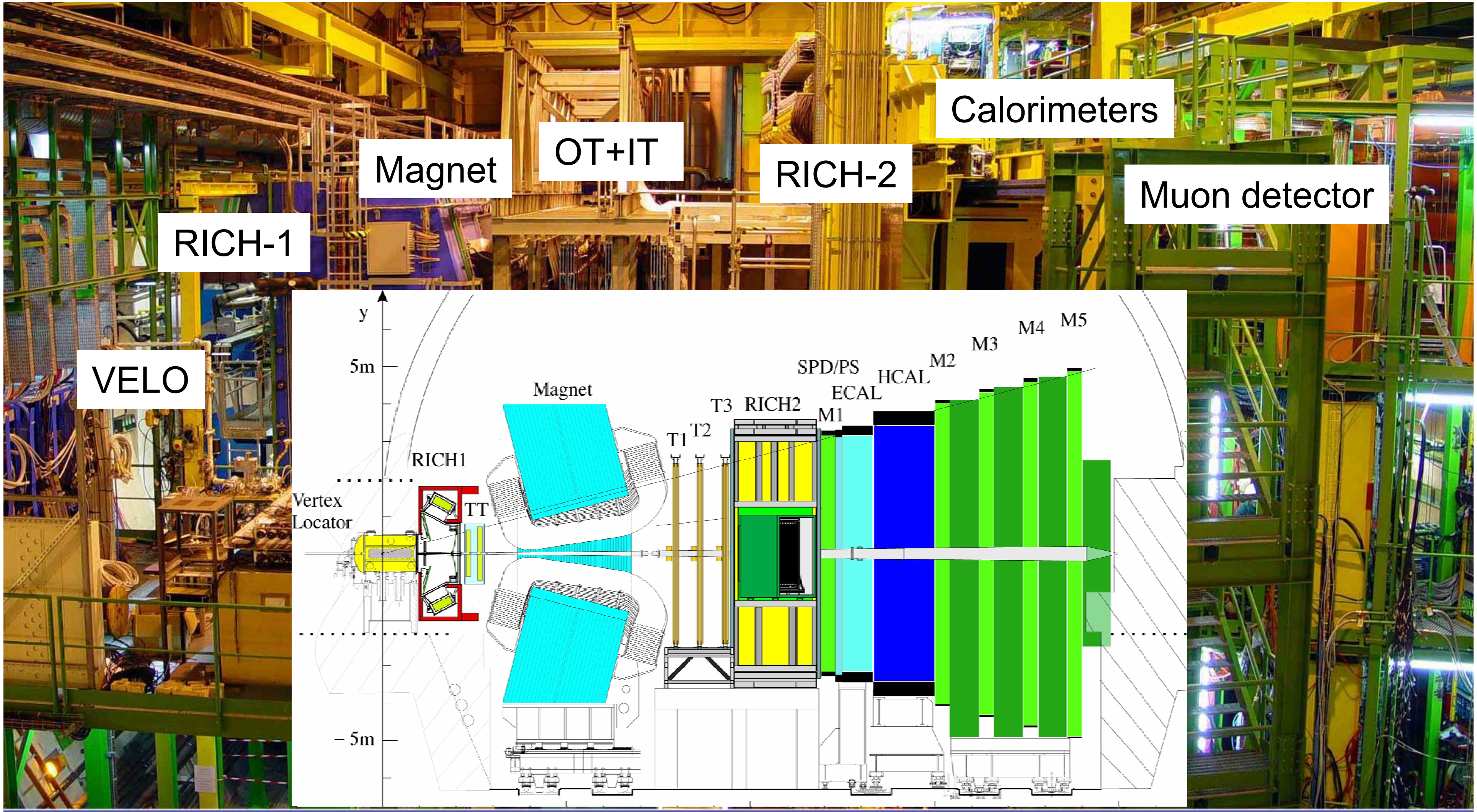
LHCb planes to collect an integrated luminosity of 10 fb^{-1} for year ~2013

pp interactions/crossing

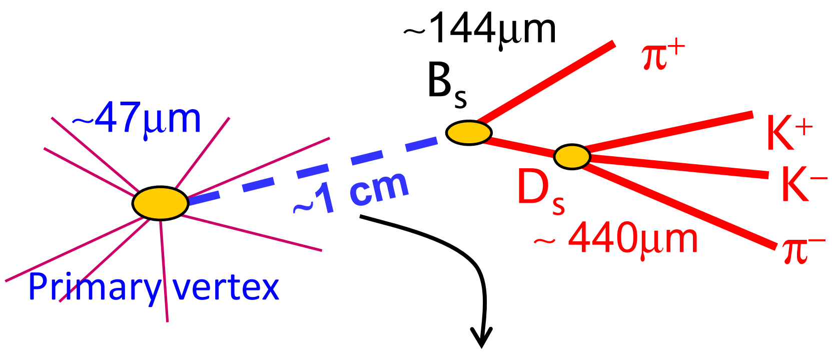


LHCb Detector in place

Detector installed, going to close and be ready for data-taking.
Commissioning with cosmics on-going.



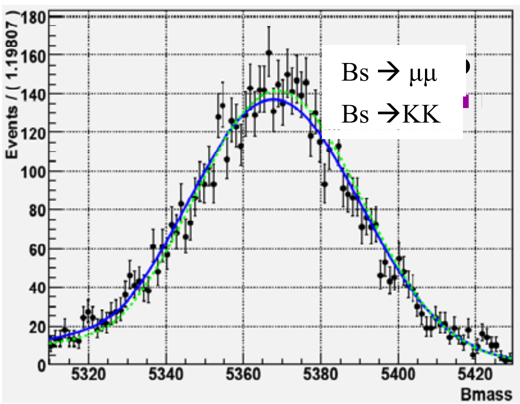
LHCb expected performance (I)
B vertex and mass measurement



B proper time resolution ~40 fs

From full tracking system (TT+ IT + OT):

Momentum resolution $\sigma(p)/p$ ~0.3%-0.5% increasing with p



B mass resolution ~15-20 MeV/c^2

All results obtained from full Detector (GEANT4) MC simulation

LHCb expected performance (II) Particle IDentification

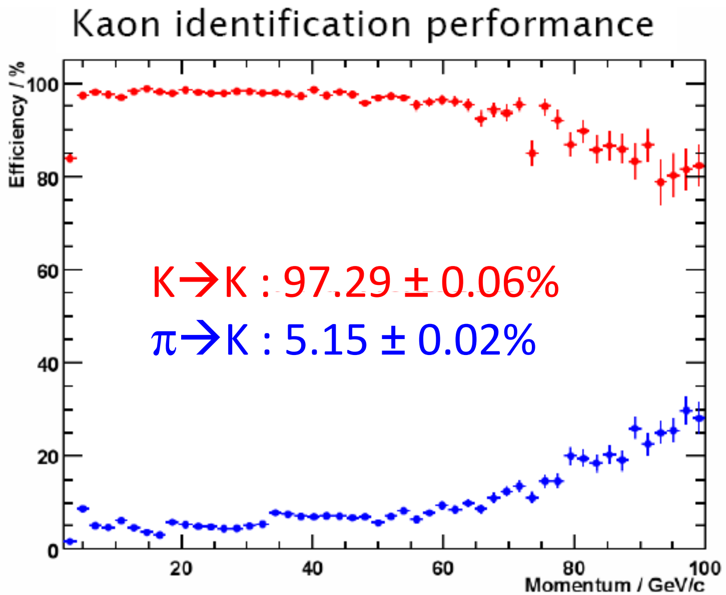
RICH1:

5cm aerogel n=1.03

$4m^3$ C_4F_{10} n=1.0014

RICH2:

$100m^3$ CF_4 n=1.0005



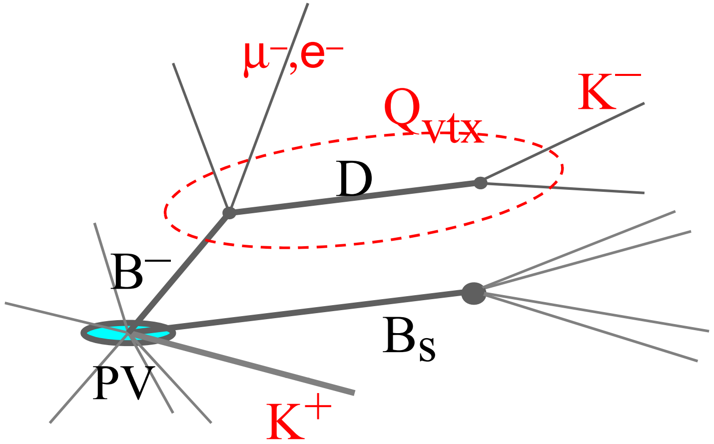
Flavour Tagging performance

from combination of several methods

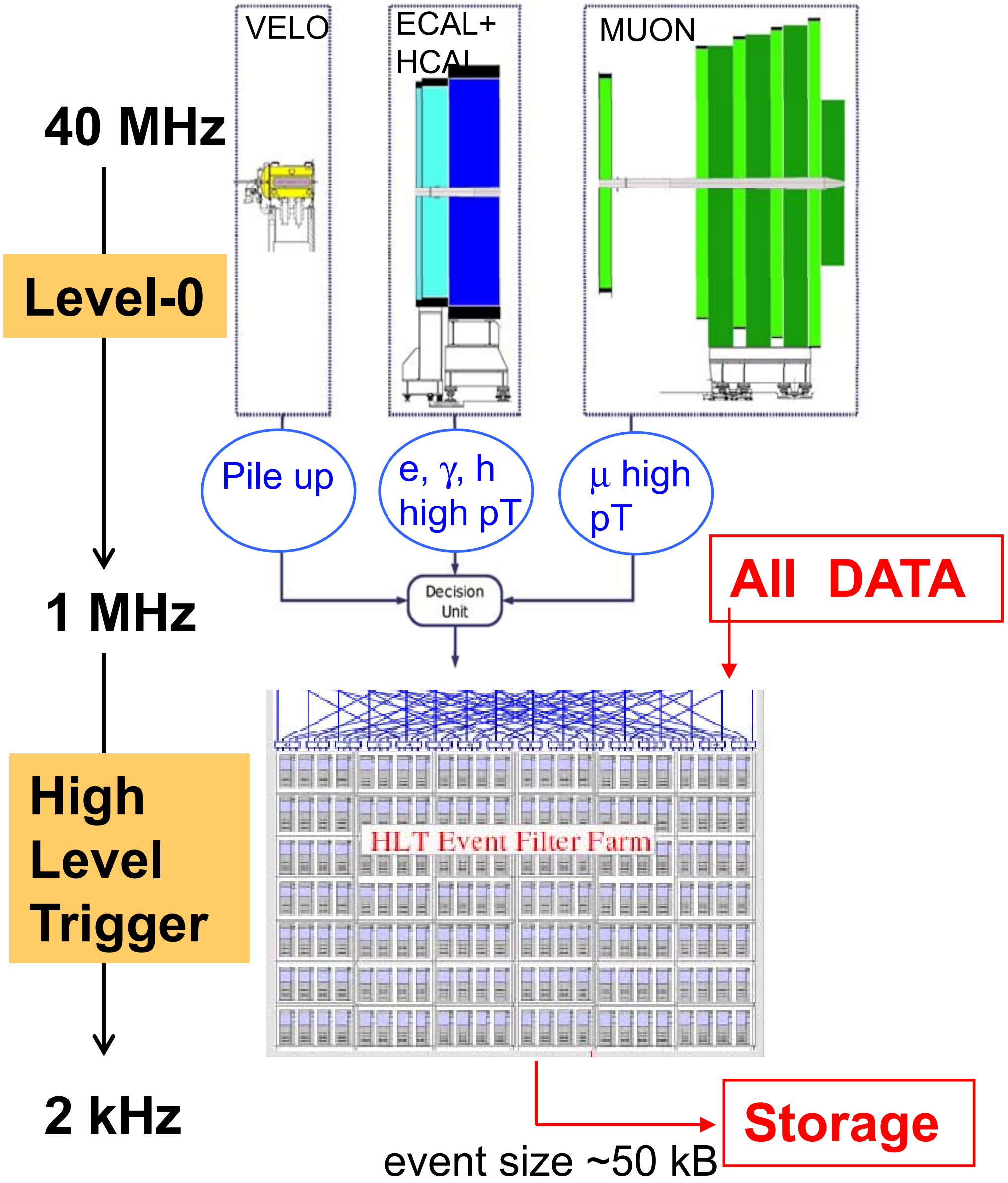
(electron, muon, kaon, pion, inclusive vertex):

εD^2 =4–5% for B_d

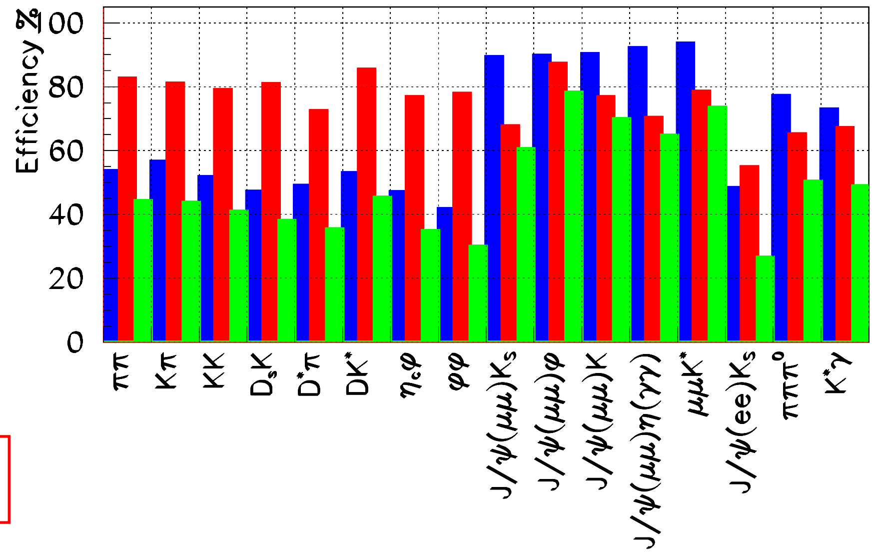
εD^2 =7– 9 % for B_s depending on channel



LHCb Trigger



L0, **HLT** and **L0×HLT** efficiency



HLT rate	Event type	Physics
200 Hz	Exclusive B selec.	B (core program)
600 Hz	High mass μμ	J/ψ, b→J/ψX
300 Hz	D* candidates	Charm
900 Hz	Inclusive b (b→μ)	B (data mining)

LHCb: motivation and Physics Program

LHCb is a 2nd generation precision experiment coming after B-Factories and Tevatron:

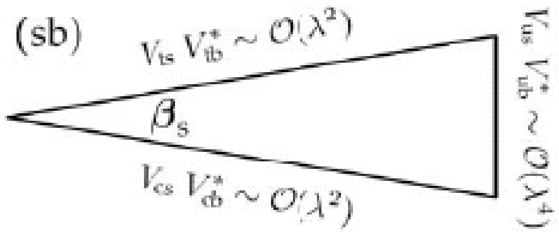
- $b \to d$ transitions: broadly studied, in general good agreement with SM.
- $b \to s$ transitions: still limited knowledge, space for NP effects.
- Strong constraints to SM available from precision measurements of CKM parameters, but γ angle still poorly known.
- High statistics production of all kind of b- (and c-) hadrons at LHC allows extensive studies in wide set of channels.

→ Improve precision on γ and other CKM parameters, search for NP from comparison between tree and box / penguin contributions.
Examples: β_s from $B_s \to J/\psi\phi$, γ from $B_{(s)} \to D_{(s)}K$, penguins in $B_s \to \phi\phi$

→ Search for NP in rare decays, with high precision measurements of BRs and time dependent CP asymmetries.
Examples: $B_s \to \mu\mu$, $B_d \to K^{0*}\mu\mu$, $B_s \to \phi\gamma$

B_s Mixing phase β_s with $b \to c\bar{c}s$ (I)

- The sin $2\beta_d$ analogous in the B_s sector.
- The phase arising from interference between B decays with and without mixing is a sensitive probe to new physics.



$$\beta_s = \arg\left(-\frac{V_{ts}V_{tb}^*}{V_{cs}V_{cb}^*}\right)$$

In the SM

$\Phi^{SM} = -2\beta_s = -0.0368 \pm 0.0017$

- Could be much larger if New Physics contributes to B_s-$\overline{B}_s$ transitions.

  From $B_s \to J/\psi\phi$ we measure $\Phi^{meas} = \Phi^{SM} + \Phi^{NP}$

- Tevatron results:

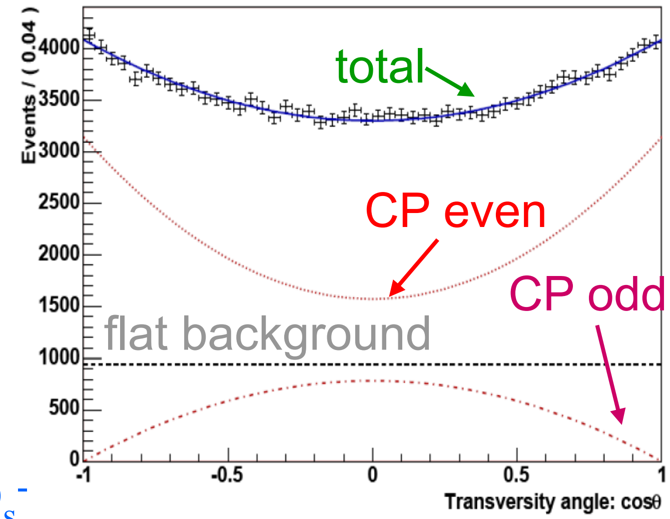
	D0	$2\beta_s = -0.57\,^{+0.24}_{-0.30}$	with 2.8 fb^{-1}
could be a hint of NP?	CDF	$2\beta_s = [0.32, 2.82]$ @ 68%CL	with 1.35 fb^{-1}

- Time-dependent asymmetry in decay rates:

$$A_{CP}(t) = -\frac{\eta_f \sin 2\beta_s \sin(\Delta m_s t)}{\cosh\left(\frac{\Delta\Gamma_s t}{2}\right) - \eta_f \cos 2\beta_s \sinh\left(\frac{\Delta\Gamma_s t}{2}\right)}$$

B_s Mixing phase β_s with $b \to c\bar{c}s$ (II)

- $B_s \to J/\psi(\mu^+\mu^-)\phi(K^+K^-)$ is the golden channel, requires angular analysis to disentangle the mixture of CP-even (η_f= -1) and CP odd (η_f=+1)
- Use flavour tagged and untagged events.
- Need very good proper time resolution to resolve B_s oscillations.



- Can add pure CP modes: $J/\psi\eta$, $J/\psi\eta'$, $\eta_c\phi$, $D_s^+D_s^-$ but much lower statistics.

Decay Channel	*Yield (2fb^{-1})*	*$\sigma(2\beta_s)$*
$B_s \to J/\psi(\mu\mu)\ \phi(KK)$	130k	0.023
Pure CP modes	~25k total	0.048
All modes		0.021

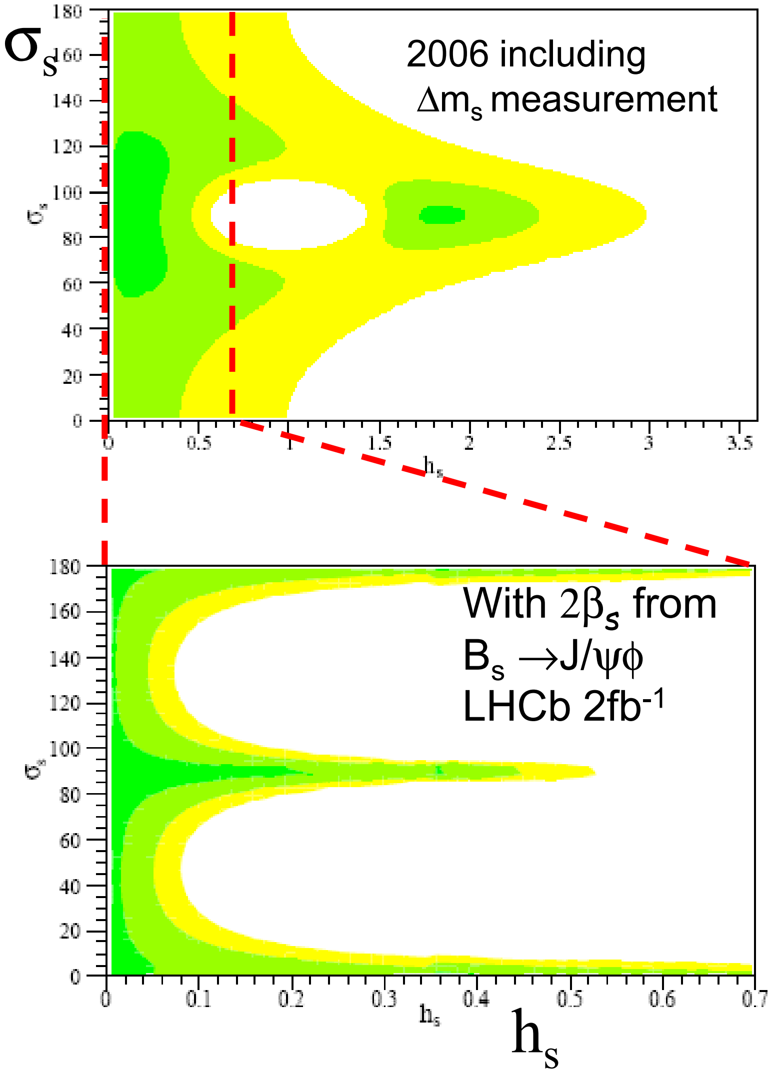
With 0.5 fb^{-1} $\sigma(2\beta_s)$~0.046

With 10 fb^{-1} $\sigma_{stat}(2\beta_s)$~ 0.009
> 3σ evidence of non-zero β_s even if only SM

Sensitivity to other fit parameters (*with 2 fb^{-1}*):
$\sigma(\Delta\Gamma_s/\Gamma_s)$=0.0092, $\sigma(R_T)$=0.0040

New Physics in B_s mixing

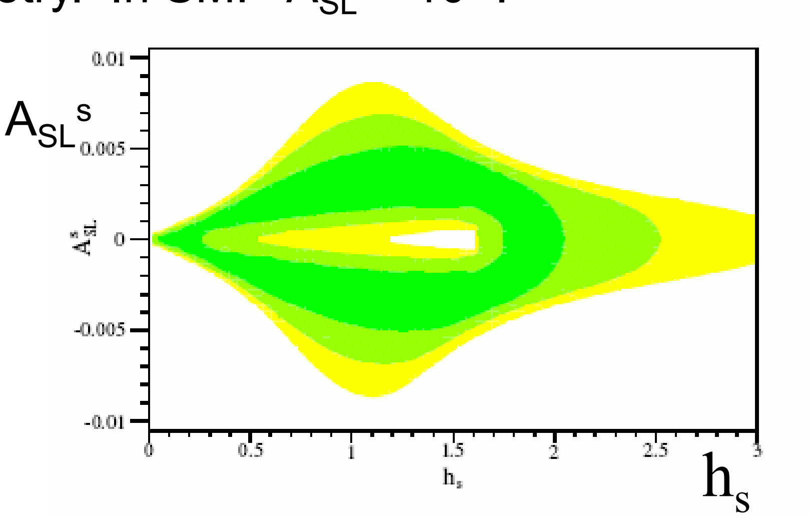
Ligeti, Paucci,Perez, hep-ph/0604112



New Physics in B_s mixing amplitude M_{12} parameterized with h_s and σ_s:

$$M_{12} = (1 + h_s \exp(2i\sigma_s))\, M_{12}^{SM}$$

Additional constraints can come from semileptonic Asymmetry. In SM: $A_{SL}^{s} \sim 10^{-5}$.



Preliminary results on the LHCb measurement of time dependent charge asymmetry in $B_s \to D_s \mu\nu$

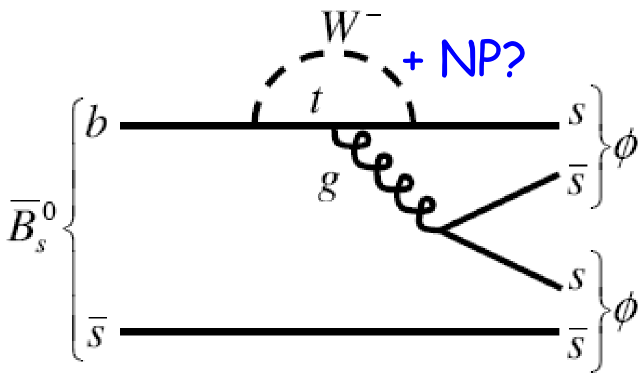
Expect ~10^9 events/ 2fb^{-1} → $\delta(A_{SL}^{s}) \sim 2\times10^{-3}$ in 2fb^{-1}

$b \to s\bar{s}s$ hadronic penguin decays

$B_s \to \phi\phi$

- In SM CP violation < 1% due to cancellation of the mixing and penguin phase:

$\phi_{Bs \to \phi\phi}^{SM} \approx 2\arg(V_{ts}^{*}V_{tb}) - \arg(V_{ts}V_{tb}^{*}) = 0$



- In presence of NP expect different contributions in boxes and in penguins:

$\phi_{Bs \to \phi\phi}^{NP} = \phi_M^{NP} - \phi_D^{NP}$

Channel	Yield (2 fb^{-1})	B/S (90%CL)
$B_s \to \phi\,\phi$	3100	< 0.8
$B_d \to \phi\, K_S$	920	< 1.1

- From the time dependent angular distribution of flavour tagged events, in 2 fb^{-1}

$\sigma_{stat}(\phi^{NP}) = 0.11$

- Less statistics on $B_d \to \phi\, K_S$, expected precision: $\sigma(\sin(2\beta_{eff})) \approx 0.23$

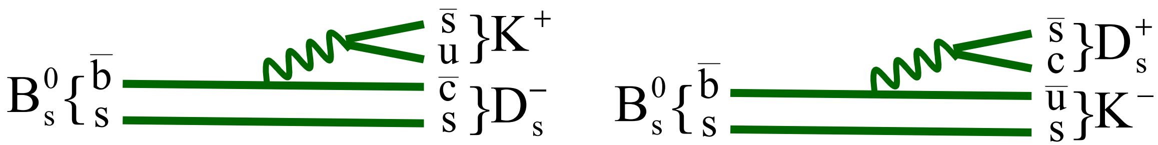
Different ways to γ at LHCb

tree decays only (first five rows):

B mode	D mode	Method	Parameter
$B_s \to D_s K$	$K K \pi$	tagged, $A^{CP}(t)$	$\gamma - 2\beta_s$
$B^+ \to D K^+$	$K\pi, KK/\pi\pi$	counting, ADS+GLW	γ
$B^+ \to D K^+$	$K_s \pi\pi$	Dalitz, GGSZ	γ
$B^+ \to D K^+$	$KK\pi\pi$	4 body Dalitz	γ
$B^0 \to D K^{*0}$	$K\pi, KK, \pi\pi$	counting, ADS+GLW	γ
$B \to \pi\pi, KK$	–	Tagged, $A^{CP}(t)$	$\gamma / \beta_d / \beta_s$

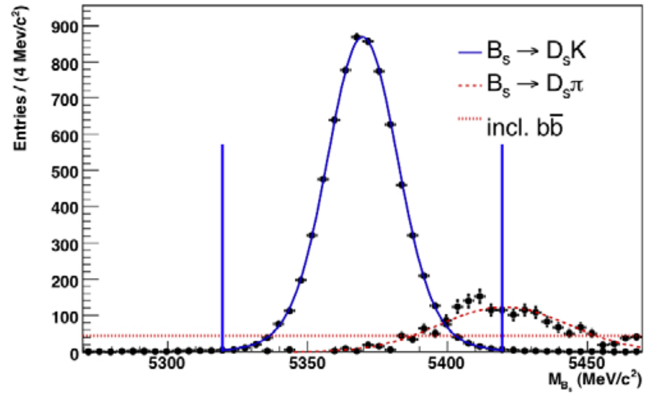
And several additional modes under study: $B^+ \to D^* K^+$ ($D \to K\pi, KK, \pi\pi$), $B^+ \to D K^+$ ($D \to K\pi\pi\pi$) …

γ from $B_s \to D_s K$

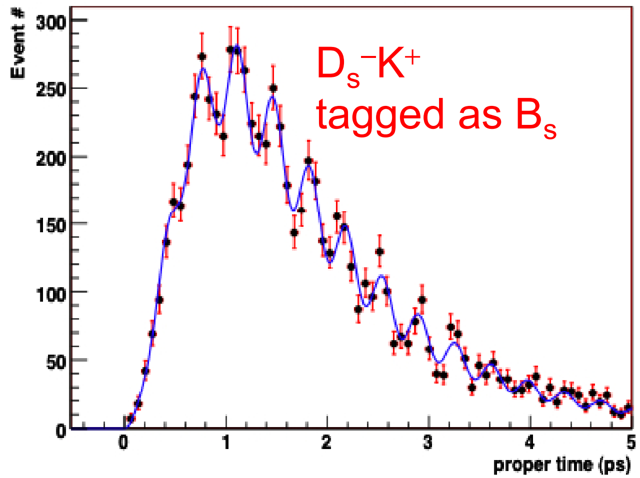


- Two tree decays which interfere via B_s mixing → determine γ in a very clean way

Channel	Yield (2 fb^{-1})	B/S (90%CL)
$B_s \to D_s K$	6200	< 0.2
$B_s \to D_s \pi$	140 k	0.4



- Fit time-dependent rates of $B_s \to D_s K$ and $B_s \to D_s \pi$
  - Including $B_s \to D_s \pi$ to constrain Δm_s and mistag
  - Use tagged and untagged $B_s \to D_s K$ samples



Sensitivity with $2fb^{-1}$:

$2\beta_s + \gamma$	9°-12°
Δm_s	0.007 ps^{-1}

Different ways to γ at LHCb

B mode	D mode	Method	Parameter	$\sigma(\gamma)$ 2fb^{-1}
$B_s \to D_s K$	$KK\pi$	**tagged, $A^{CP}(t)$**	γ-$2\beta_s$	9°-12°
$B^+ \to D K^+$	$K\pi$,KK/$\pi\pi$	**counting, ADS+GLW**	γ	11°-14°
$B^+ \to D K^+$	$K_s\pi\pi$	**Dalitz, GGSZ**	γ	7°-12°
$B^+ \to D K^+$	$KK\pi\pi$	**4 body Dalitz**	γ	18°
$B^0 \to D K^{*0}$	$K\pi$,KK,$\pi\pi$	**counting, ADS+GLW**	γ	9°
$B \to \pi\pi$,KK	–	**tagged, $A^{CP}(t)$**	$\gamma / \beta_d / \beta_s$	10°

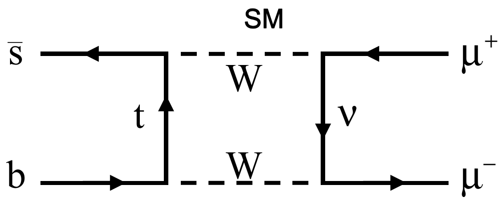
- Global fit combining χ^2 from the different ADS/GLW rates and Dalitz:

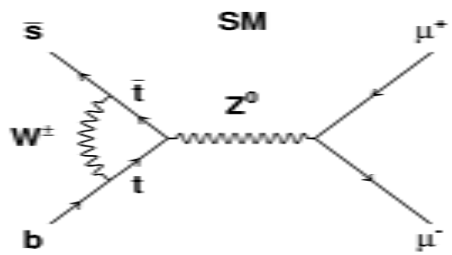
$\sigma(\gamma)$ 2fb^{-1}

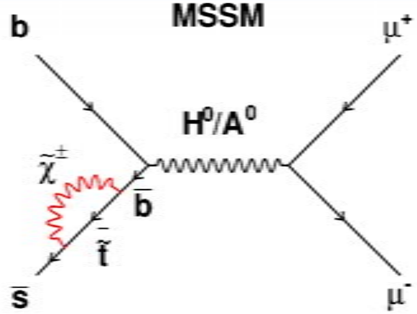
δ_{B° (°)	0	45	90	135	180
Combined B^+/B^0 (ADS+GLW)	**4.6°**	**7.6°**	**6.3°**	**7.1°**	**4.6°**
+ model independent Dalitz	**4.2°**	**5.7°**	**5.3°**	**5.7°**	**4.2°**

- Combining with time dependent measurements (D_sK and $D\pi$) gives a global LHCb sensitivity to γ with tree decays only: $\sigma(\gamma) \sim 4°$ with 2 fb^{-1}

$B_s \to \mu\mu$







- Highly suppressed in SM: $BR(B_s \to \mu\mu) = (3.35 \pm 0.32) \times 10^{-9}$
- Could be strongly enhanced by SUSY: $BR(B_s \to \mu\mu) \propto \tan^6\beta / M_H^2$

- Current limits from Tevatron ~2 fb^{-1}:

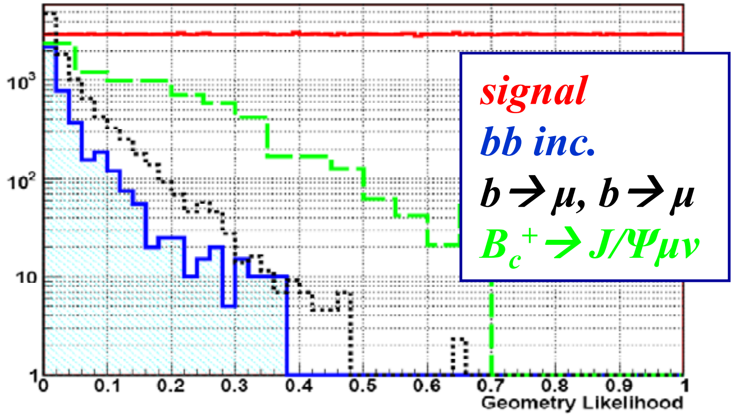
CDF	$BR < 4.7 \times 10^{-8}$	90% CL
D0	$BR < 7.5 \times 10^{-8}$	90% CL

LHCb: high stat. & high trigger efficiency for signal, main issue is background rejection.
Largest background is $b \to \mu$, $b \to \mu$.
Specific background dominated by $B_c^{\pm} \to J/\psi(\mu\mu)\, \mu^{\pm}\nu$
Exploit good mass resolution and vertexing, and good particle ID.

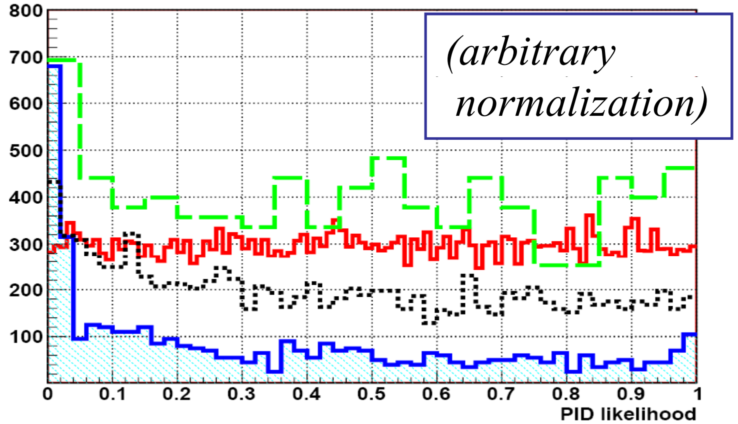
$B_s \to \mu\mu$

Analysis in a Phase Space with 3 axis:

- Geometrical Likelihood (GL) (impact parameters, distance of closest approach between $\mu\mu$, B_s lifetime, vertex isolation)
- Particle-ID Likelihood
- Invariant mass window around B_s peak



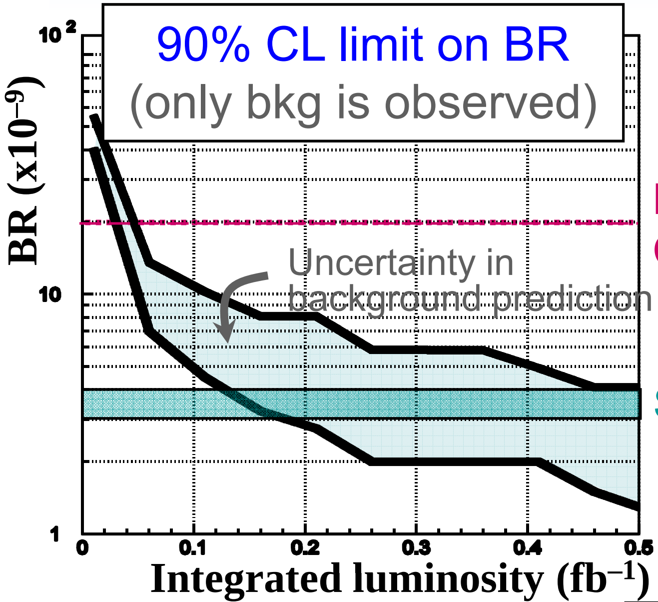
- Sensitive Region: GL > 0.5
- Divide in N bins
- Evaluate expected number of events for signal/background in each bin.

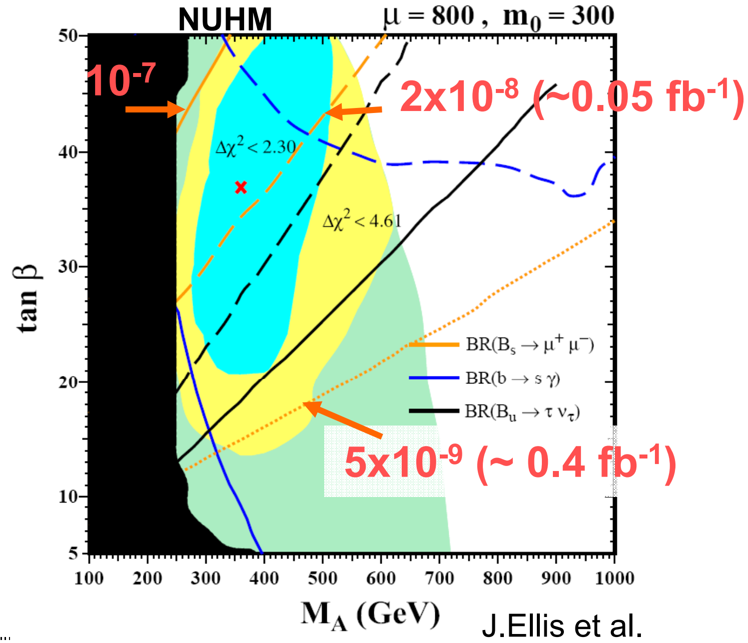


Assuming SM BR, in $2fb^{-1}$ ~30 signal events
~83 background events

- Normalization from $B^+ \to J/\psi K^+$ events. Dominant uncertainty on BR from relative B_s,B^+ hadronization fractions ~14%.

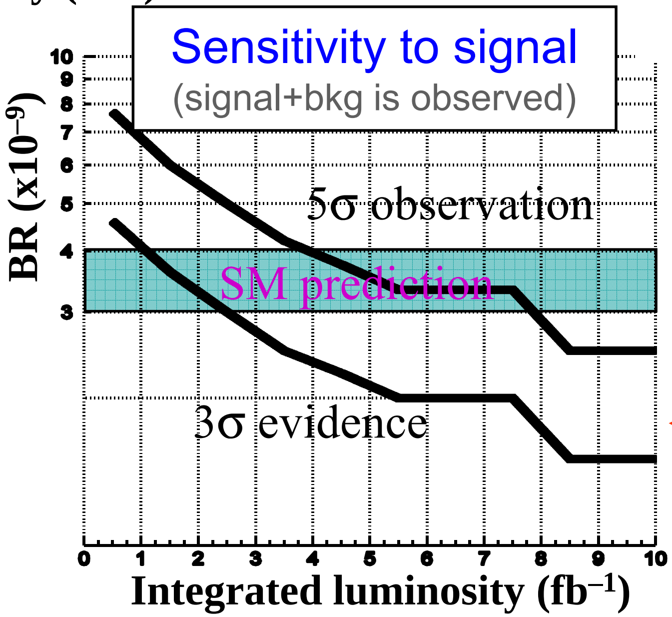
$B_s \to \mu\mu$





J.Ellis et al. arXiv:0709.0098v1 [hep-ph] (2007)

Exclusion: 0.5 $\text{fb}^{-1} \Rightarrow$ < SM



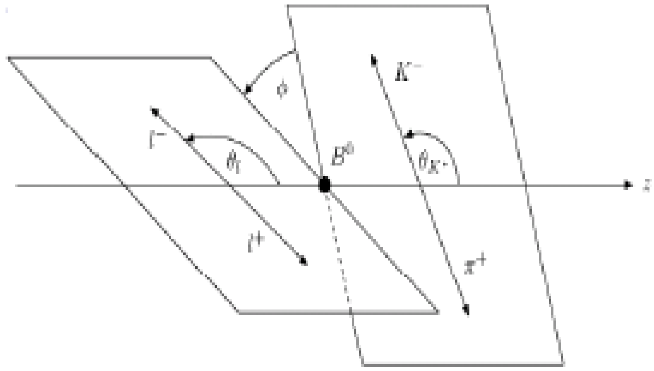
Within SM BR:
2 $\text{fb}^{-1} \Rightarrow$ 3σ evidence
6 $\text{fb}^{-1} \Rightarrow$ 5σ observation

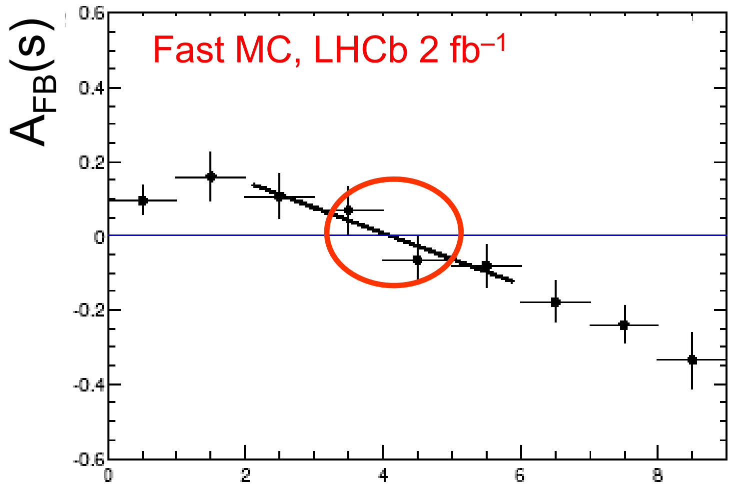
$B_d \to K^*\mu\mu$

- BR measured at B-factories, in agreement with SM: $BR(B_d \to K^*\mu\mu) = (1.22^{+0.38}_{-0.32}) \times 10^{-6}$
- Decay described by three angles (θ_μ, ϕ, θ_{K^*}).

- Zero crossing point of forward-backward asymmetry A_{FB} in θ_μ angle, as a function of $m_{\mu\mu}$, precisely computed in SM: $s_0^{SM}(C_7,C_9) = 4.39^{+0.38}_{-0.35}$ GeV^2

hep-ph/0412400





Channel	Yield (2 fb^{-1})	B/S
$B_s \to K^*\mu^+\mu^-$	7200	~0.5

Ignoring non-resonant $K\pi\mu\mu$ events

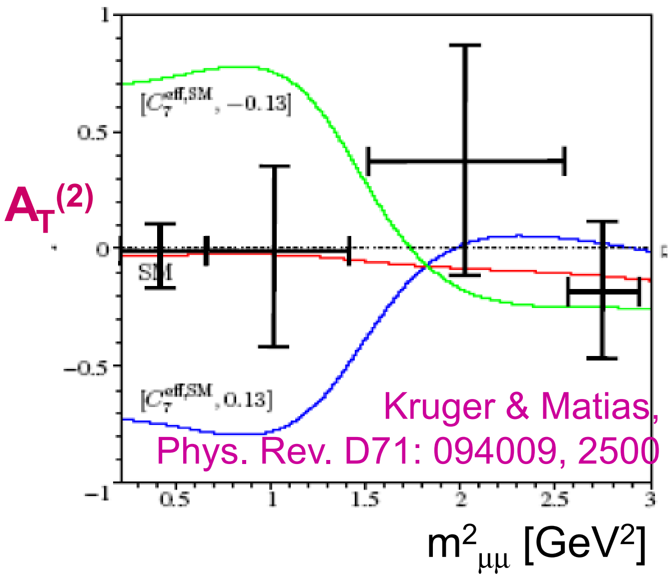
- Simple linear fit suggests precision:

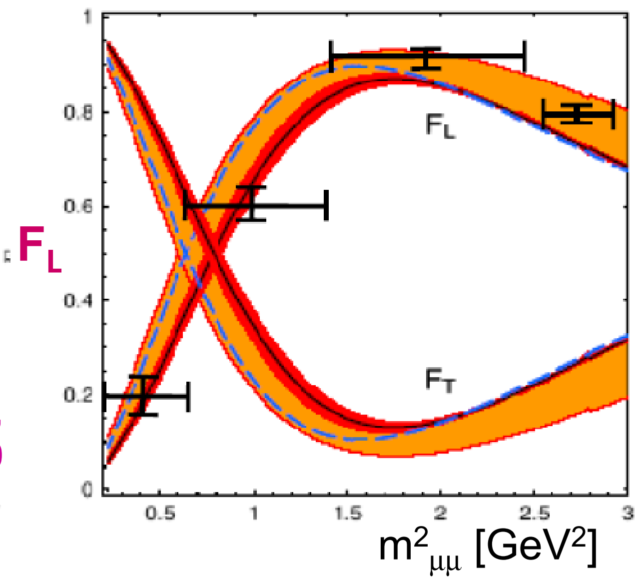
	0.5 fb^{-1}	2 fb^{-1}	10 fb^{-1}
$\sigma(s_0)$	0.8 GeV^2	0.5 GeV^2	0.3 GeV^2

$B_d \to K^* \mu\mu$ transverse asymmetries

- Fitting projections of θ_μ, ϕ, θ_{K^*} angular distributions can measure the fraction of longitudinal polarization F_L and the transverse asymmetry $A_T^{(2)}$:

Points LHCb 2 fb^{-1}





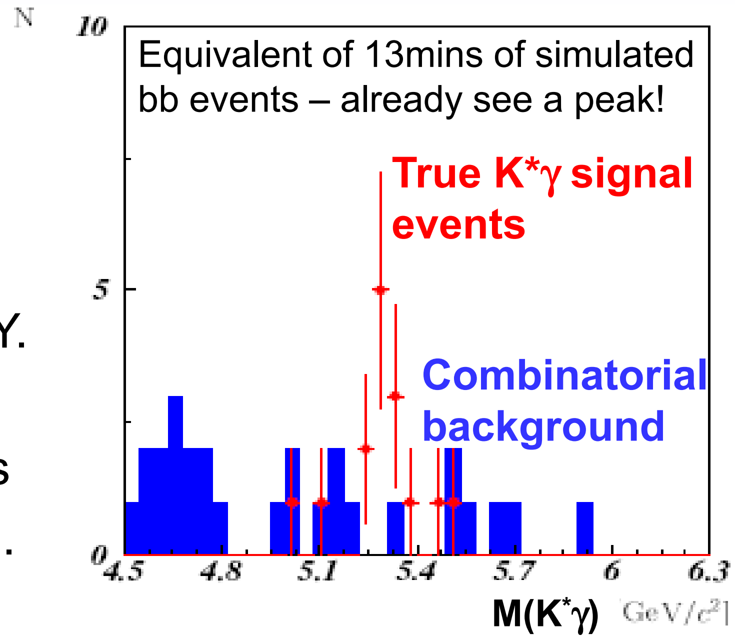
Stat. precisions in the region $s = m^2_{\mu\mu} \in [1, 6]$ (GeV/c²)² where theory calculations are most reliable

	Sensitivity with	
	2 fb^{-1}	10 fb^{-1}
$A_T^{(2)}$	±0.42	±0.16
F_L	±0.016	±0.007
A_{FB}	±0.020	±0.008

Under investigation also full angular fit in terms of transversity amplitudes $A_\perp^{L,R}$, $A_{//}^{L,R}$, $A_0^{L,R}$. Will improve precision on A_{FB}.

Radiative decays

Channel	Yield (2 fb^{-1})	B/S
$B_d \to K^*\gamma$	68000	~0.6
$B_s \to \phi\gamma$	11500	<0.5



$B_d \to K^*\gamma$ A^{dir}_{CP} < 1% in SM, up to 40% in SUSY.

$B_s \to \phi\gamma$ Time dependent CP asymmetry allows to test the helicity structure of the emitted photon. In SM $b \to s\gamma$ predominantly left-handed.

$$A_{CP}(t) = -\frac{A^{dir}\cos(\Delta m_q t) + A^{mix}\sin(\Delta m_q t)}{A^{\Delta}\sinh(\Delta\Gamma_q t/2) - \cosh(\Delta\Gamma_q t/2)}$$

In SM: A^{dir}=0 (direct CPV)
A^{mix}=sin 2ψ sin φ
A^{Δ} = sin 2ψ cos φ
with tanψ = $|b \to s\gamma_R| / |b \to s\gamma_L|$

As $\Delta\Gamma_s \neq 0$ $B_s \to \phi\gamma$ probes A^{Δ}, as well as A^{dir} and A^{mix}

For cosφ≈ 1 A^{Δ} ~sin 2ψ determines the fraction of "wrongly" polarized photon.

With 2fb^{-1}: σ (A^{Δ}) = 0.22 σ (A^{dir}, A^{mix})= 0.11

Charm physics

- LHCb will collect a large tagged $D^* \rightarrow D^0\pi$ sample (also used for PID calibration).

  A dedicated D* trigger is foreseen for this purpose.
  - Tag D^0 or anti-D^0 flavour with pion from $D^{*\pm} \rightarrow D^0 \pi^\pm$

D*-tagged signal yield in 2 fb^{-1} (from b hadrons only)	
$D^0 \rightarrow K^-\pi^+$ right sign	12.4 M
$D^0 \rightarrow K^+\pi^-$ wrong sign	46.5 k
$D^0 \rightarrow K^+K^-$	1.6 M

- Performance studies not as detailed as for B physics.

- Interesting (sensitive to NP) & promising searches/measurements:
  - Time-dependent D^0 mixing with wrong-sign $D^0 \rightarrow K^+\pi^-$ decays

    $\sigma_{stat}(x'^2)$ ~0.14 $\times10^{-3}$, $\sigma_{stat}(y')$ ~2 $\times10^{-3}$ with 2 fb^{-1}
  - Direct CP violation in $D^0 \rightarrow K^+K^-$
    - $A_{CP} \leq 10^{-3}$ in SM, up to 1% with New Physics
    - Expect $\sigma_{stat}(A_{CP})$ ~ 0.001 with 2 fb^{-1}
  - $D^0 \rightarrow \mu^+\mu^-$
    - $BR \leq 10^{-12}$ in SM, up to 10^{-6} with New Physics
    - Expect to reach down to $\sim 5\times10^{-8}$ with 2 fb^{-1}

LHCb beyond 10 fb^{-1}

- Several measurements limited by stat. precision after 10 fb^{-1}: investigating upgrade of detector to handle luminosity $2x10^{33}$ $cm^{-2}s^{-1}$ and integrate up to ~100 fb^{-1}
  - Not directly coupled to SLHC machine upgrade since luminosity already available, but may overlap in time with upgrades of ATLAS and CMS.

- Technical solutions under study (increase trigger efficiency for hadronic modes, fast vertex detection, electronics, radiation dose, pile-up, higher occupancy etc.)
  → Expression of Interest for an LHCb upgrade submitted to LHCC.

- Physics case:

- CPV in B_s mixing (tree and penguins)

- γ angle with ~1° precision

- Chiral structure of $b \to s$ from $B \to \phi\gamma$ and $B \to K^* \mu^+ \mu^-$

Observable	Sensitivity
$S(B_s \to \phi\phi)$	$0.01 - 0.02$
$S(B_d \to \phi K_S^0)$	$0.025 - 0.035$
ϕ_s $(J/\psi\phi)$	0.003
$\sin(2\beta)$ $(J/\psi K_S^0)$	$0.003 - 0.010$
γ $(B \to D^{(*)}K^{(*)})$	$< 1°$
γ $(B_s \to D_s K)$	$1 - 2°$
$\mathcal{B}(B_s \to \mu^+\mu^-)$	$5 - 10\%$
$\mathcal{B}(B_d \to \mu^+\mu^-)$	3σ
$A_T^{(2)}(B \to K^{*0}\mu^+\mu^-)$	$0.05 - 0.06$
$A_{FB}(B \to K^{*0}\mu^+\mu^-)$ s_0	0.07 GeV^2
$S(B_s \to \phi\gamma)$	$0.016 - 0.025$
$A^{\Delta\Gamma_s}(B_s \to \phi\gamma)$	$0.030 - 0.050$
charm x'^2	2×10^{-5}
mixing y'	2.8×10^{-4}
CP y_{CP}	1.5×10^{-4}

Expected sensitivity for 100 fb^{-1} assuming a factor 2 in hadronic trigger efficiency and same reconstruction efficiency

Conclusions

- LHCb is ready for data taking at LHC start-up.

- Very interesting results will come already with first 0.5 fb^{-1} of data:

$B_s \to J/\psi\phi$	$2\beta_s$ measurement with ~0.05 precision
$B_s \to \mu\mu$	BR limit down to SM value
$B_d \to K^{0*}\mu\mu$	~1800 events, overtaking B-Factories statistics

- LHCb results will provide in the coming years a strong improvement to flavour physics, in particular to the knowledge of all B_s sector.

- Actively preparing for analysis of several channels with high potential for indirect NP discovery.

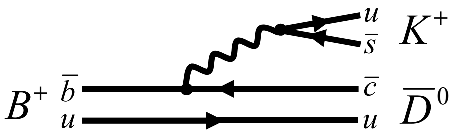
Looking forward next HQ&L Conference to show all that!

BACK-UP

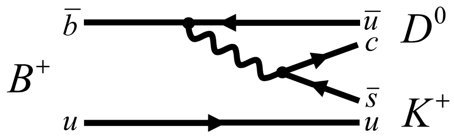
γ from $B^{\pm} \rightarrow D^0 K^{\pm}$ (ADS+GLW) (I)

Atwood, Dunietz and Soni, Phys. Rev. Lett. 78, 3257 (1997)
Gronau, London, Wyler, PLB. 253, 483 (1991)

- **Charged *B* decay**



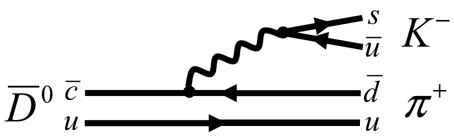
colour favoured



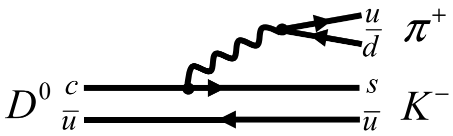
colour suppressed

Weak phase difference $-\gamma$
Strong phase difference δ_B
Amplitude ratio $r_B \sim 0.08$

- ***D^0* and *$\overline{D}^0$* can both decay into *$K^-\pi^+$* (or *$K^+\pi^-$*)**



doubly Cabibbo suppressed



Cabibbo favoured

Strong phase difference $\delta_D^{K\pi}$
Amplitude ratio $r_D^{K\pi}$
$=0.060\pm0.003$

$$\Gamma(B^- \rightarrow (K^-\pi^+)_D K^-) = N^{K\pi}(1 + r_B r_D + 2 r_B r_D \cos(\delta_B - \delta_D^{K\pi} - \gamma))$$

$$\Gamma(B^- \rightarrow (K^+\pi^-)_D K^-) = N^{K\pi}(r_B^2 + r_D^2 + 2 r_B r_D \cos(\delta_B + \delta_D^{K\pi} - \gamma))$$

$$\Gamma(B^+ \rightarrow (K^+\pi^-)_D K^+) = N^{K\pi}(1 + r_B r_D + 2 r_B r_D \cos(\delta_B - \delta_D^{K\pi} + \gamma))$$

$$\Gamma(B^+ \rightarrow (K^-\pi^+)_D K^+) = N^{K\pi}(r_B^2 + r_D^2 + 2 r_B r_D \cos(\delta_B + \delta_D^{K\pi} + \gamma))$$

right sign, lower sensitivity to γ

wrong sign, high sensitivity to γ

$$\Gamma(B^- \rightarrow (h^-h^+)_D K^-) = N^{hh}(1 + r_B^2 + 2 r_B \cos(\delta_B - \gamma))$$

$$\Gamma(B^+ \rightarrow (h^-h^+)_D K^+) = N^{hh}(1 + r_B^2 + 2 r_B \cos(\delta_B + \gamma))$$

Add CP eigenstate decays
$D^0 \rightarrow K^+K^-$, $\pi^+\pi^-$

γ from $B^{\pm} \to DK^{\pm}$ (ADS+GLW) (II)

6 decay rates and 7 parameters (r_B, r_D, δ_B, δ_D, γ , N^{hh}, $N^{K\pi}$) . r_D well-measured and δ_D constrained by CLEO-c (from final statistics expect $\Delta\cos\delta_D$~20%)

Can solve for unknowns, including the weak phase γ.
Add constraint on the relative D^0 two body BR and selection efficiencies (know to better than 3%)

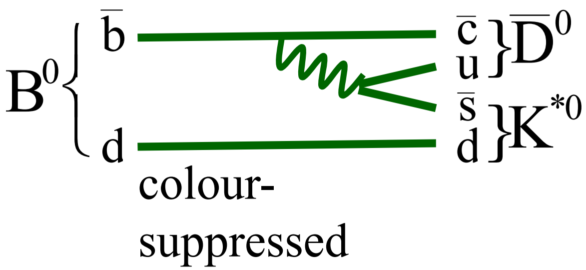
Channel	Yield 2 fb^{-1}	B/S
$B\to D(K\pi)K$ favoured	56k	0.6
$B\to D(K\pi)K$ suppressed	~400	~ 2
$B\to D(hh)K$	7.8k	1.8

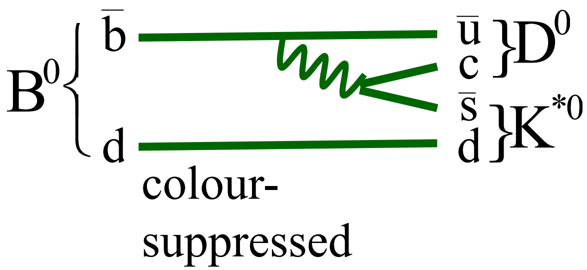
$\sigma(\gamma)$ = 11–14° with 2 fb^{-1}

depending on D strong phases

(Inputs:
γ=60°, r_B =0.1, δ_B =130°,
$\delta^{K\pi}$ from Cleo-c)

γ from $B^0 \rightarrow D^0K^{*0}$ (ADS+GLW)





Weak phase difference = γ
Magnitude ratio = $r_B \sim 0.4$

- Treat with same ADS+GLW method as charged case:
  - So far used only D decays to $K^-\pi^+$, $K^+\pi^-$, K^+K^- and $\pi^+\pi^-$ final states

$\sigma(\gamma)$ = 9° with 2 fb^{-1}

- Envisage also GGSZ analysis

Decay mode (+cc)	2 fb^{-1} yield	B/S
$B^0 \rightarrow (K^+\pi^-)_D K^{*0}$	3400	0.4–2.0
$B^0 \rightarrow (K^-\pi^+)_D K^{*0}$	540	2.2–13
$B^0 \rightarrow (K^+K^-)_D K^{*0}$	470	< 4.1
$B^0 \rightarrow (\pi^-\pi^+)_D K^{*0}$	130	< 14

(Inputs: γ=60°, r_B =0.4, δ_B =10°)

γ from $B^{\pm} \rightarrow D^0(K_s\pi^+\pi^-)K^{\pm}$ (GGSZ)

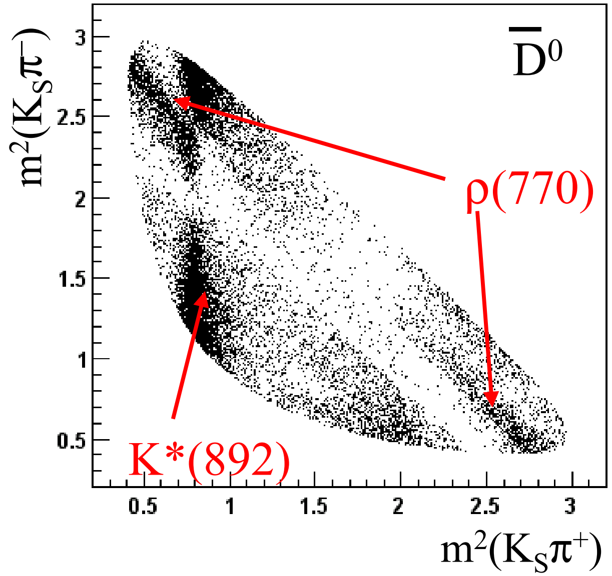
Giri, Grossman, Soffer, Zupan, PRD 68, 050418 (2003).

Amplitude analysis of the D - Dalitz plots for B^+ and B^- decays allows the extraction of © and r_B, δ_B. Assume no CP violation in D^0 decays

B decay amplitudes:

$A(B^- \rightarrow DK^-) \propto A_D(m_{K\pi-}^2, m_{K\pi+}^2) + r_B e^{i(\delta_B - \gamma)} A_D(m_{K\pi+}^2, m_{K\pi-}^2)$

$A(B^+ \rightarrow DK^+) \propto A_D(m_{K\pi+}^2, m_{K\pi-}^2) + r_B e^{i(\delta_B + \gamma)} A_D(m_{K\pi-}^2, m_{K\pi+}^2)$



Channel	Yield (2 fb^{-1})	B/S (90%CL)
$B \rightarrow D(K_s\pi^+\pi^-)K$	**5000**	**< 0.7**

Mode	$\sigma(\gamma)$ 2 fb^{-1}	Systematic error
$B \rightarrow D(K_s\pi^+\pi^-)K$ model-dependent	7°-12°	~5-10° (model dependence)
$B \rightarrow D(K_s\pi^+\pi^-)K$ model-indep.	9°-13°	3°-4° (Cleo-c statistics)

Sensitivity spread due to different background scenarios

γ from $B^0 \to \pi^+\pi^-$ and $B_s \to K^+K^-$

Sensitive to NP in penguins. Measure:

$$A_{CP}(t) = \frac{A_{dir}\cos(\Delta m\, t) + A_{mix}\sin(\Delta m\, t)}{\cosh(\Delta\Gamma\, t/2) - A_{\Delta\Gamma}\sinh(\Delta\Gamma\, t/2)}$$

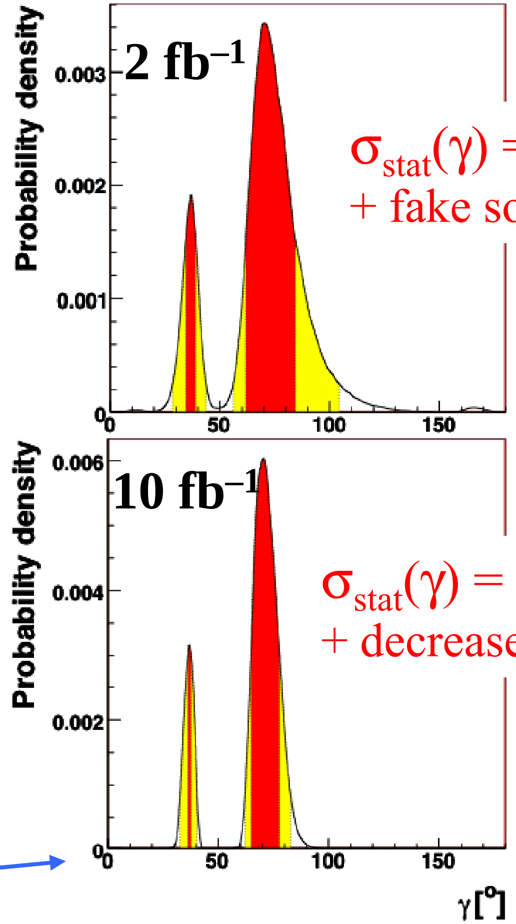
Channel	Yield 2 fb^{-1}	B/S
$B^0 \to \pi^+\pi^-$	36k	~ 0.5
$B_s \to K^+K^-$	36k	~0.15

Competitive with final Tevatron luminosity already for $L=0.5 fb^{-1}$

Advantage of strong PID system to separate $B \to h^+h^-$ modes.

2 fb^{-1}

$\sigma(\mathcal{A}_{\pi\pi}^{dir})$	0.043	$\sigma(\mathcal{A}_{KK}^{dir})$	0.042
$\sigma(\mathcal{A}_{\pi\pi}^{mix})$	0.037	$\sigma(\mathcal{A}_{KK}^{mix})$	0.044



- A_{dir} and A_{mix} depend on β_d, β_s, γ, $de^{i\theta}$ (P/T ratio)
- Exploit U-spin symmetry (Fleischer):

Assume: $d_{\pi\pi}=d_{KK}$ and $\theta_{\pi\pi}=\theta_{KK}$: 4 meas. and 3 unknowns
$\to$ can solve for γ (taking β_d, β_s from other modes)

- Can relax U-spin requirements:

$0.8<d_{KK}/d_{\pi\pi}<1.2$, $\theta_{\pi\pi}$,θ_{KK} free

R_K in $B^+ \to K^+\ell\ell$

$$R_K = \frac{\int_{4m_\mu^2}^{q_{max}^2} \frac{d\Gamma(B \to K\mu^+\mu^-)}{ds} ds}{\int_{4m_\mu^2}^{q_{max}^2} \frac{d\Gamma(B \to Ke^+e^-)}{ds} ds} = 1 \pm 0.001 \text{ in SM}$$ (Hiller,Krüger PRD69 (2004) 074020)

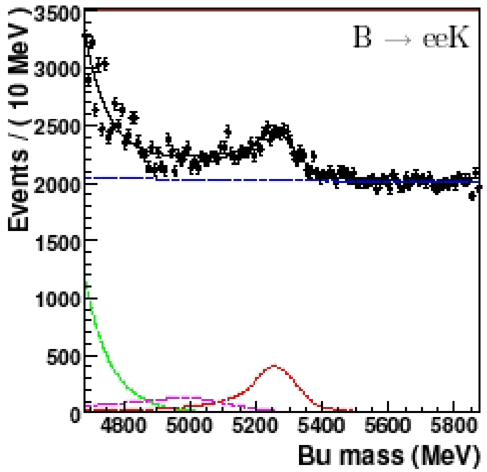
- Large corrections O(10%) possible in models that distinguish between lepton flavours (eg.MSSM at large tanβ). Constraints to NP also from R_K and BR($B_s \to \mu\mu$) combined.

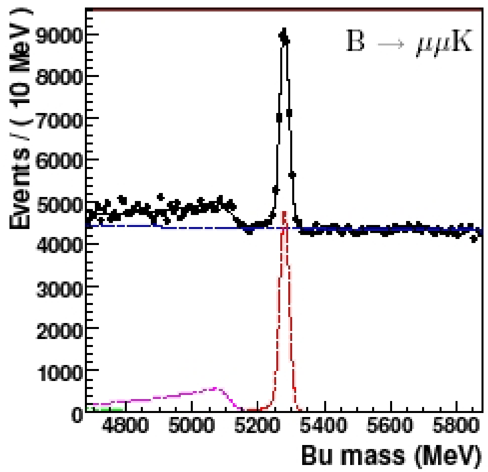
LHCb 10 fb^{-1}

$B_u \to eeK$ 9.2 k events

$B_u \to \mu\mu K$ 19 k events

$\sigma_{stat}(R_K) = 0.043$





$4m_{\mu\mu}^2 < m_{ll}^2 < 6$ $(GeV/c^2)^2$

- Trigger eff ~70% on ee channel under study - not included.
- Similar sensitivity expected for $R_{K^*} = B_d \to \mu\mu K^* / B_d \to eeK^*$.