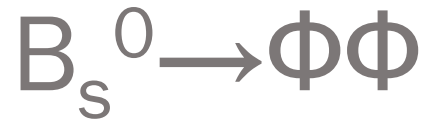


$B_s^0 \rightarrow \phi\phi$
A Probe for New Physics at the LHCb
Experiment



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IOP HEPP Conference 2008

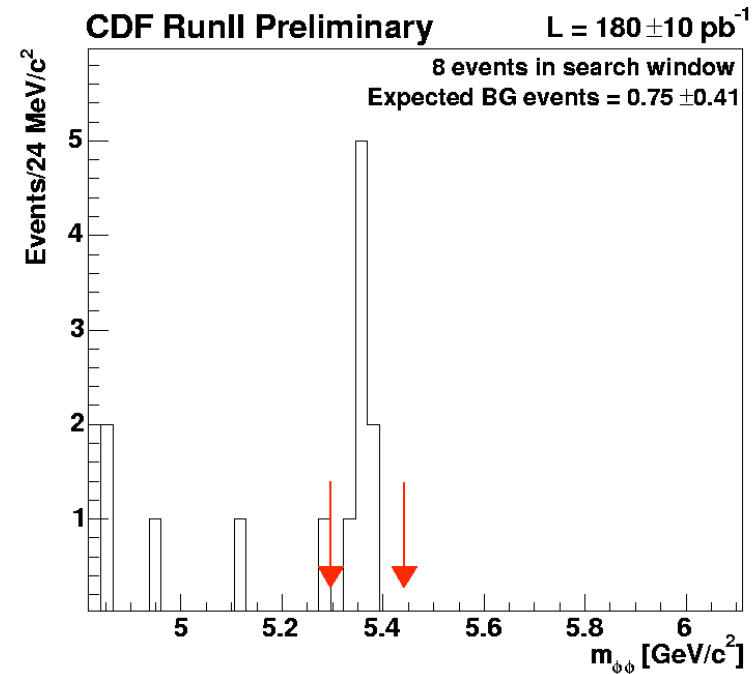
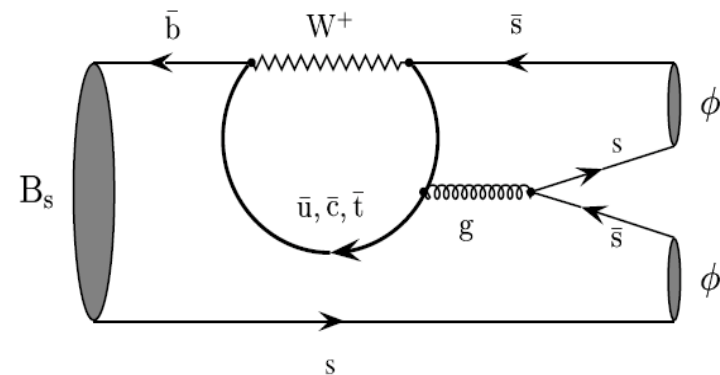




- Flavour-Changing Neutral Current process, decays via a gluonic $b \rightarrow s$ penguin
- Branching ratio measured by CDF:
- Look for 4 kaons ($\Phi \rightarrow K^+K^-$) in final state, total visible branching ratio:

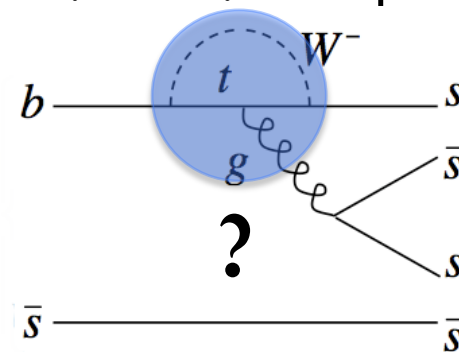
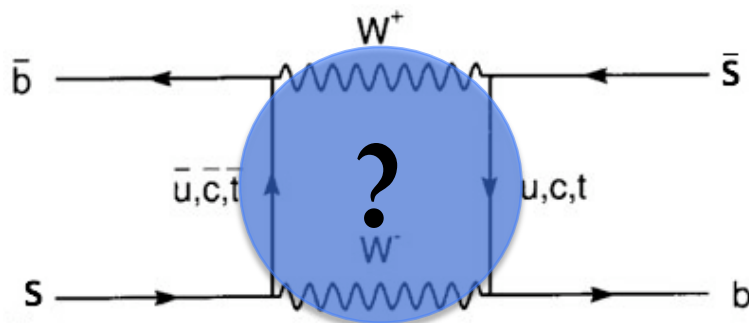
$$(14_{-5}^{+6} \pm 6) \times 10^{-6}$$

$$(3.4 \pm 2.1) \times 10^{-6}$$



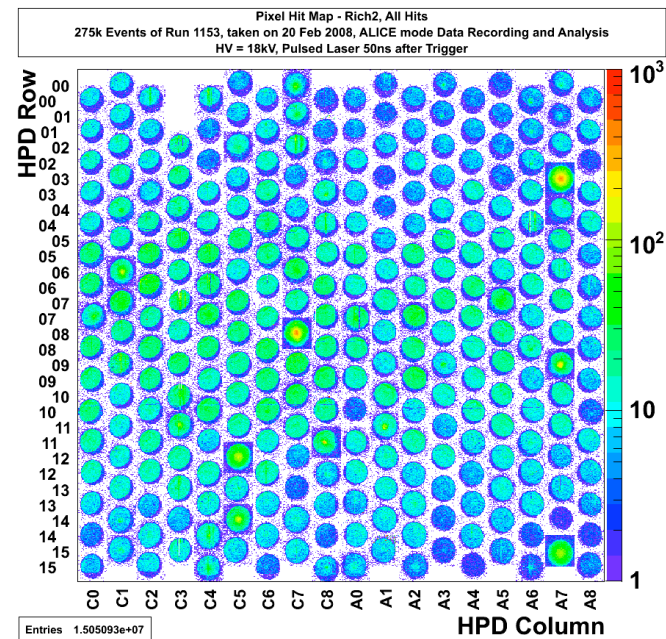
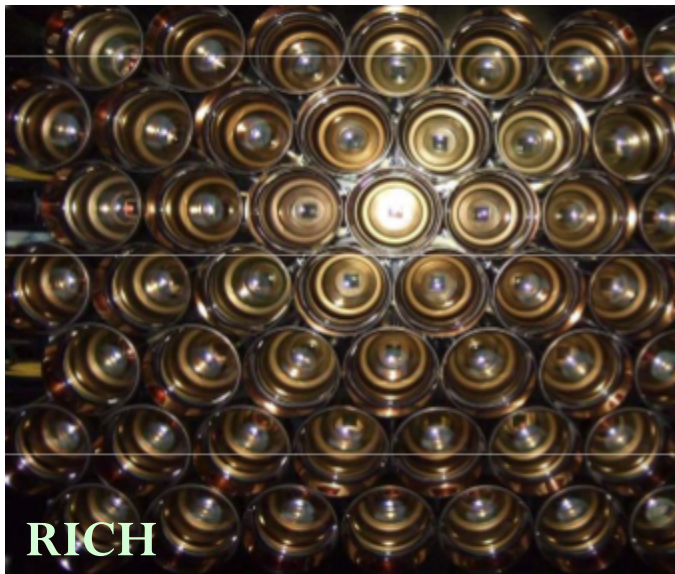
Motivation

- New Physics particles can enter penguin loop and B_s -mixing box diagram, causing deviations from Standard Model predictions for the total CP-violating weak phase, ϕ_s
- $\phi_s^{\text{SM}} \approx 0$, so a non-zero measurement of ϕ_s would be a signal of New Physics
- Interesting comparison with Tree process $B_s^0 \rightarrow J/\psi \Phi$
- Recent UTfit paper suggests a $>3\sigma$ deviation from SM in phase of B_s mixing amplitude [arXiv:0803.0659]



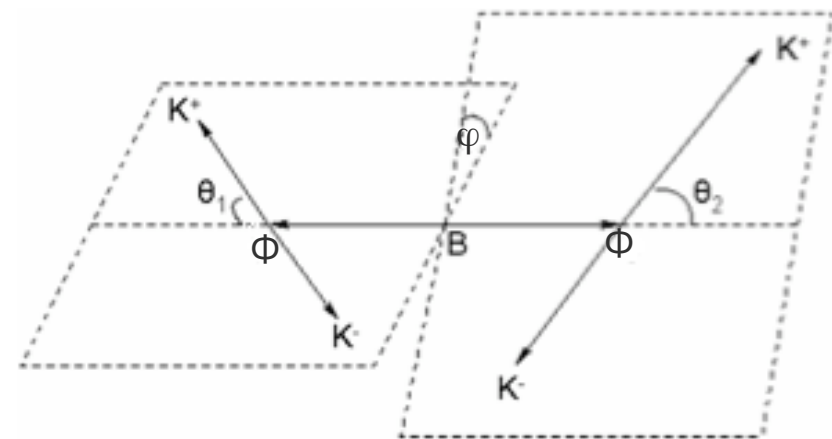
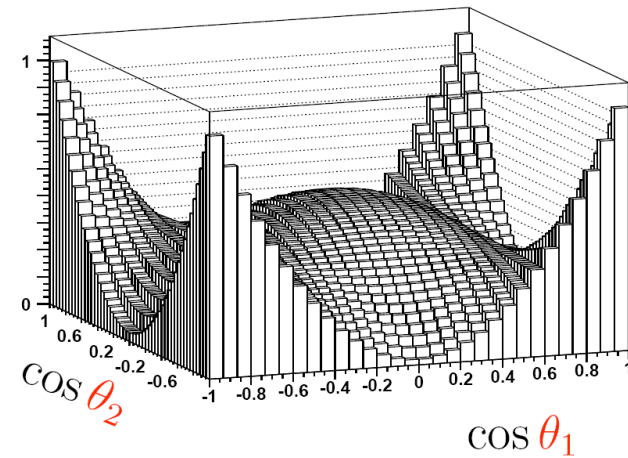
The LHCb Experiment

- Precision B-Physics experiment at the LHC
- Much greater luminosity for B_s events than has been achieved previously
- Excellent K/π separation thanks to RICH system
- Vertex Locator close to beam pipe allows for excellent proper time resolution



$B \rightarrow VV$ Decays

- Pseudoscalar meson decays to 2 vector mesons
- Mixture of CP-odd and CP-even eigenstates
- CP-odd and CP-even can be separated due to different angular distributions
- Measure angles in Helicity basis, since it treats the identical daughter particles symmetrically

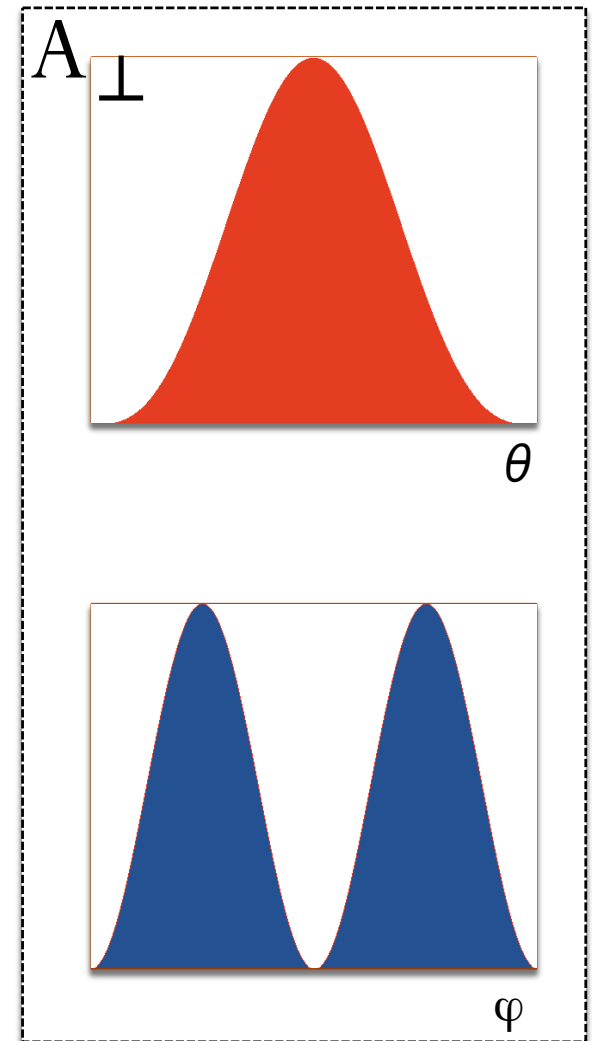
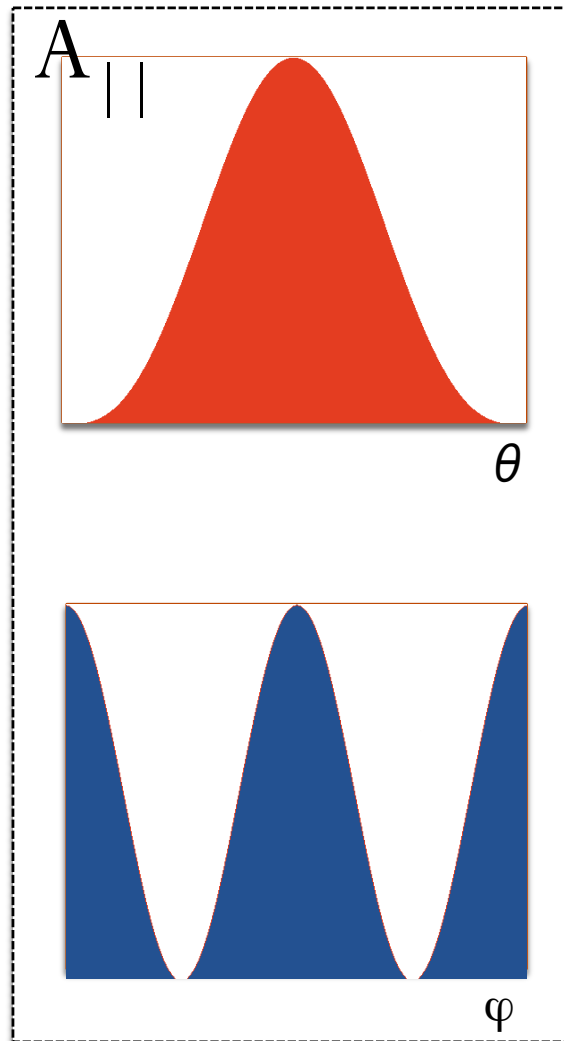
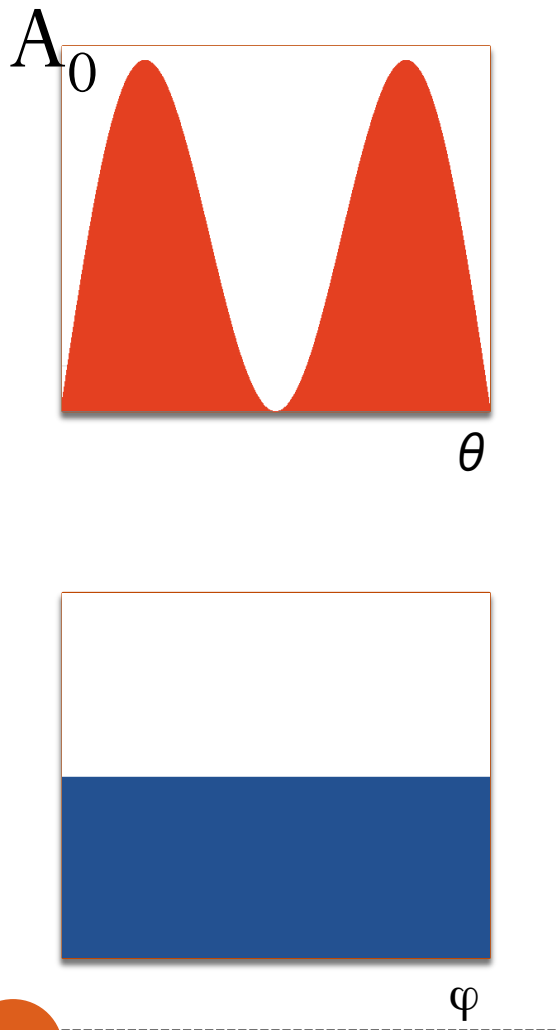


Differential Decay Rate

$$\frac{d\Gamma(t)}{d\cos\theta_1 d\cos\theta_2 d\varphi} \propto \sum_{j=1}^6 K_j(t) f_j(\theta_1, \theta_2, \varphi)$$

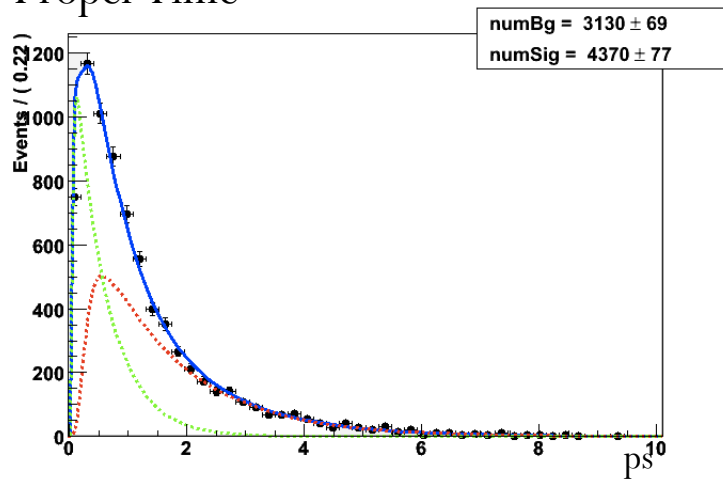
- Split differential decay rate into 6 angular (f_j) and 6 time-dependent (K_j) functions
- K_j functions can be expressed in terms of the complex linear polarisation amplitudes A_0 , $A_{||}$ and A_{\perp}
- A_0 and $A_{||}$ are CP-even amplitudes, A_{\perp} is CP-odd
- K_j functions encode ϕ_s dependence, f_j functions separate CP eigenstates

Angular Components

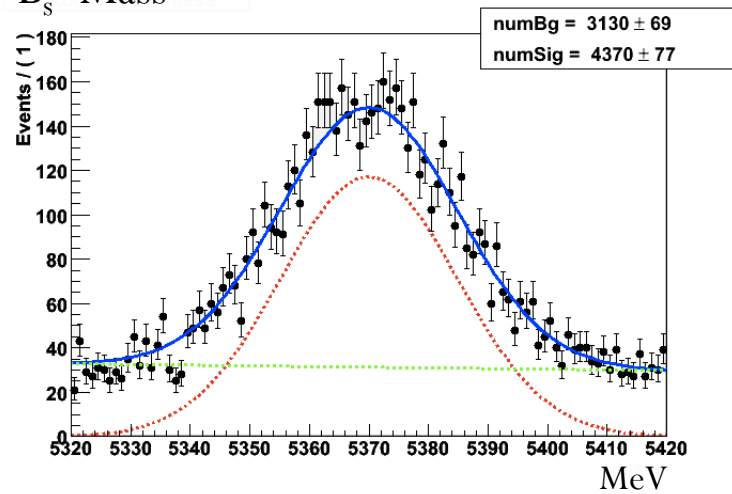


PDFs

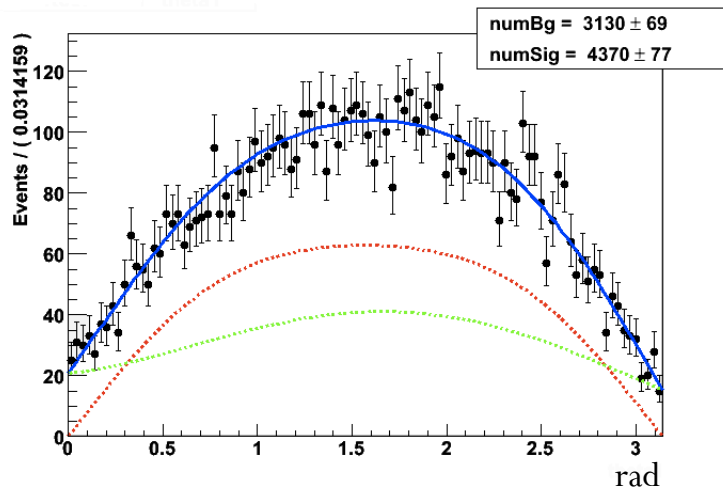
Proper Time



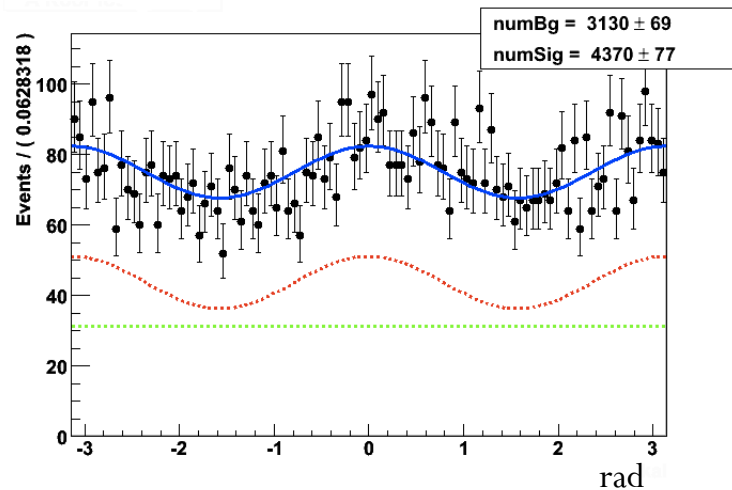
B_s^0 Mass



Angle $\theta_{1,2}$



Angle φ



Event Yields

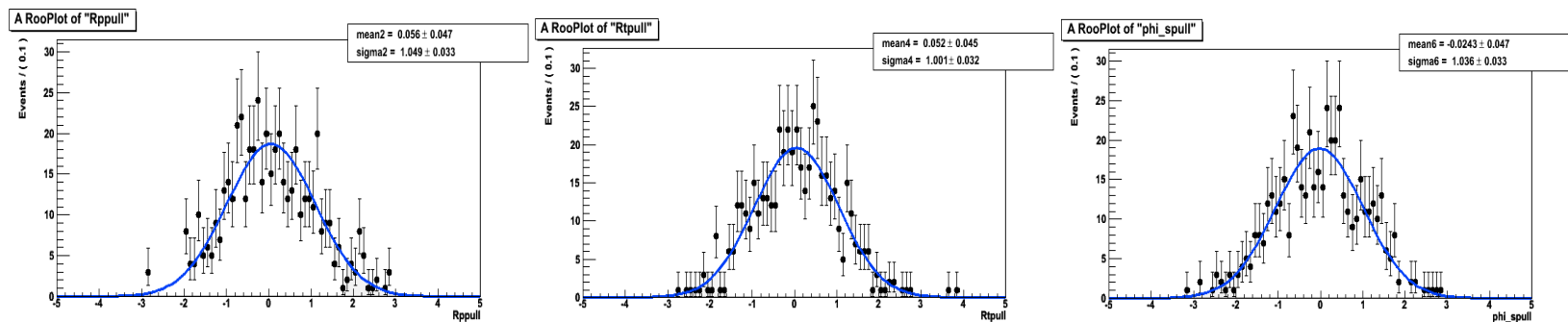
- Based on full LHCb simulation (DC06)
- Estimated signal events in 2fb^{-1} :

$$\begin{aligned} N_{\text{sig}} &= \mathcal{L} \times \sigma_{\text{bb}} \times 2 \times P(B_s^0) \times \text{BR}^{\text{vis}} \times \epsilon_{\text{acc}} \times \epsilon_{\text{trig}} \times \epsilon_{\text{sel}} \\ &= 2\text{fb}^{-1} \times 500 \mu\text{b} \times 2 \times 0.104 \times (3.4 \times 10^6) \\ &\quad \times 0.347 \times 0.183 \times 0.102 \\ &= 4390 \pm 76 \end{aligned}$$

- Tagging performance:
 - $\epsilon_{\text{tag}} = 0.600 \pm 0.01$
 - $\omega_{\text{tag}} = 0.359 \pm 0.012$
- B/S ratio between 0.715 and 3.4 (90% upper CL)

Sensitivity

- Preliminary toy studies performed based on expected yields
- After 1 year running (2fb^{-1}):
 - $\sigma(\phi_s) = 0.14$ at SM value ($\phi_s=0$), scales to ~ 0.06 in 10fb^{-1}
 - $\sigma(|A_{||}|^2) \approx \sigma(|A_{\perp}|^2) = 0.09$ at $|A_{||}|^2 = |A_{\perp}|^2 = 0.25$
 - No strong dependence on B/S observed
 - Studies ongoing...



Summary

- Intriguing signs of New Physics in $b \rightarrow s$ transitions
- NP effects may affect the total weak phase, ϕ_s , in the FCNC decay $B_s^0 \rightarrow \Phi \Phi$
- The LHCb experiment will have good sensitivity to this parameter
- Good complementary analysis to $B_s^0 \rightarrow J/\psi \Phi$

Backup slides

Preselection, Selection cuts and resolutions

Preselection

ΔLL between K and π hypotheses	> -5
IP significance of K with respect to PV	> 2
Invariant mass of Φ candidate (MeV)	$9970 < m_{\Phi} < 1070$
Φ vertex χ^2	< 25
Invariant mass of B_s^0 candidate (GeV)	$5 < m_B < 6$
B_s^0 vertex χ^2	< 40

Selection

- Table shows signal (25k events from full simulation) in blue and background (500k stripped b-inclusive events, equivalent to 13.8M unstripped events)
- Left hand columns show cuts applied sequentially, right hand columns show cuts applied individually

Preselected	3230	6181	-	-
$K P_t > 400 \text{ MeV}$	3093	545	3093 (96%)	545 (9%)
$\Phi P_t > 1200 \text{ MeV}$	2966	312	2967 (92%)	315 (5%)
$\Delta M(B_s^0) < 50 \text{ MeV}$	2876	24	3126 (97%)	546 (9%)
$\chi^2(B_s^0) < 25$	2792	17	3131 (97%)	3568 (58%)
$\Delta M(\Phi) < 20 \text{ MeV}$	2582	4	2990 (93%)	1591 (26%)
$D_z(B_s^0) > 0$	2578	3	3225 (99%)	3658 (59%)
$IP/\sigma(\Phi) > 2$	2571	2	3218 (99%)	3595 (58%)