Determination of $\frac{B(\overline{B}^0_s \to D^0 K^{*0})}{B(\overline{B}^0 \to D^0 \rho^0)}$ at LHCb

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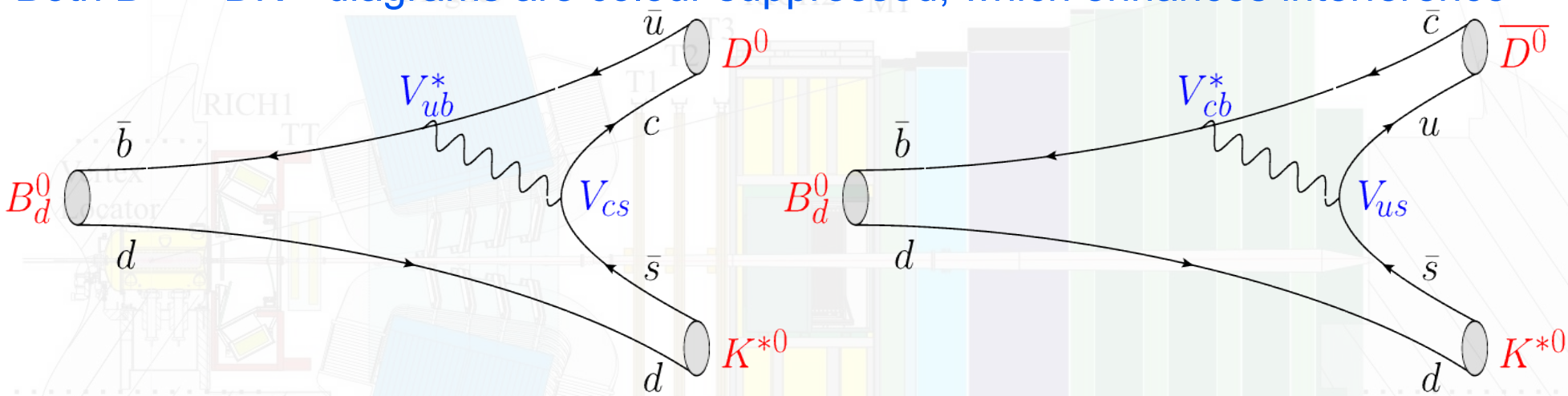
(On behalf of the LHCb collaboration)

IOP – Glasgow – 2011

Introduction (I)

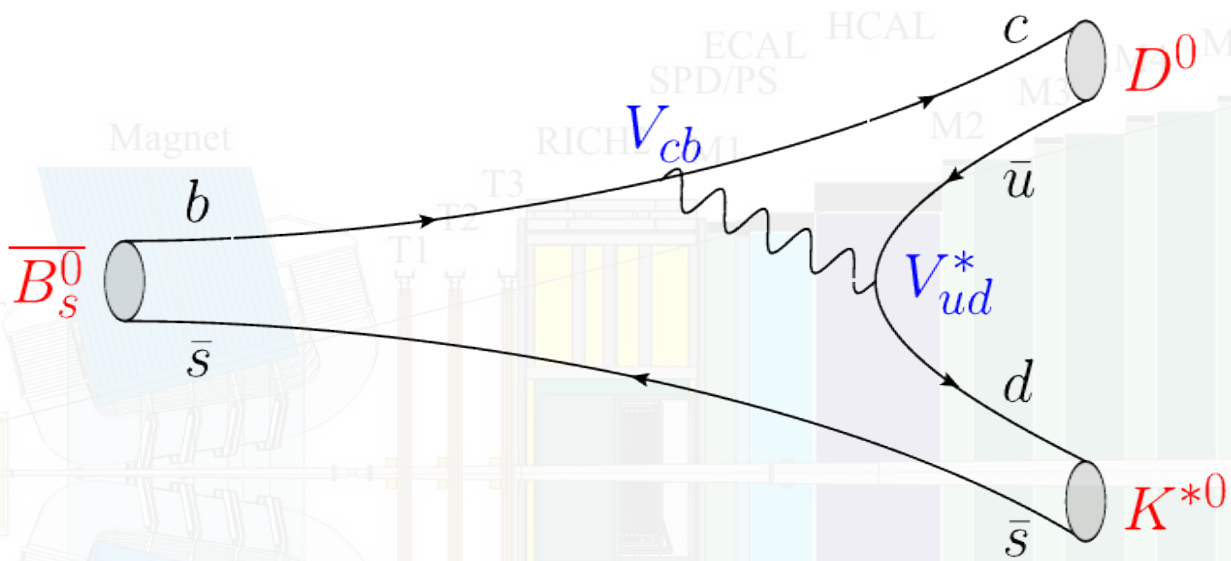
- Why study $B \rightarrow DK^*$?
  - $B^0 \rightarrow DK^{*0}$ provides a method of extracting the unitarity triangle angle, γ
  - Sensitivity to γ from interference of diagrams with $b \rightarrow u$ and $b \rightarrow c$ transitions
  - Both $B^0 \rightarrow DK^{*0}$ diagrams are colour suppressed, which enhances interference



- Signal or Background?
  - Today's signal, $\overline{B}^0_s \rightarrow D^0K^{*0}$, a potentially serious background to $B^0 \rightarrow D^0K^{*0}$
  - Observation and study of the $\overline{B}^0_s$ decay mode is just the first step

Introduction (II)

- Would like to measure the ratio: $\frac{B(\overline{B}_s^0 \to D^0 K^{*0})}{B(B^0 \to \overline{D}^0 K^{*0})}$



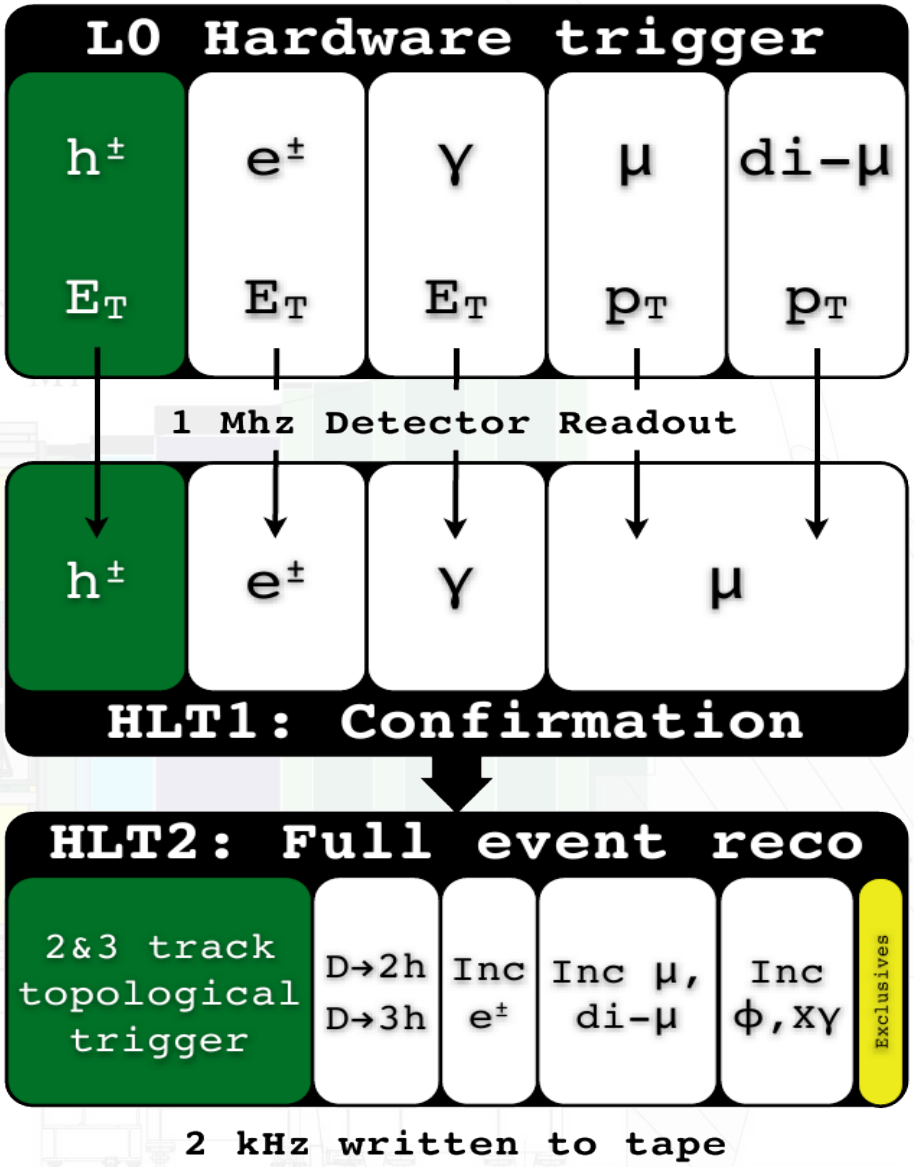
- B^0 suppressed w.r.t. B_s^0, so low yield in current sample
- Replace $B^0 \to \overline{D}^0 K^{*0}$ with $\overline{B}^0 \to D^0 \rho^0$: $\frac{B(\overline{B}_s^0 \to D^0 K^{*0})}{B(\overline{B}^0 \to D^0 \rho^0)}$
- Similar topology with a vector particle but different final state

Data Samples

- Performed on the full 2010 data sample from LHCb
  - ~36 pb^{-1}
- Two data samples, $\bar{B}^0 \rightarrow D^0\rho^0$ and $B^0_{(s)} \rightarrow D^0K^{*0}$
- Selections kept as similar as possible:
  - Allows systematics to be cancelled in the ratio of branching fractions
  - Differences due to the vector meson mass window and daughter PID
- Example cuts:
  - χ^2 of the impact parameter to the primary vertex for the B candidate.
  - PID on all K and π
  - Cuts on all vertices (B, D and the vector particles)

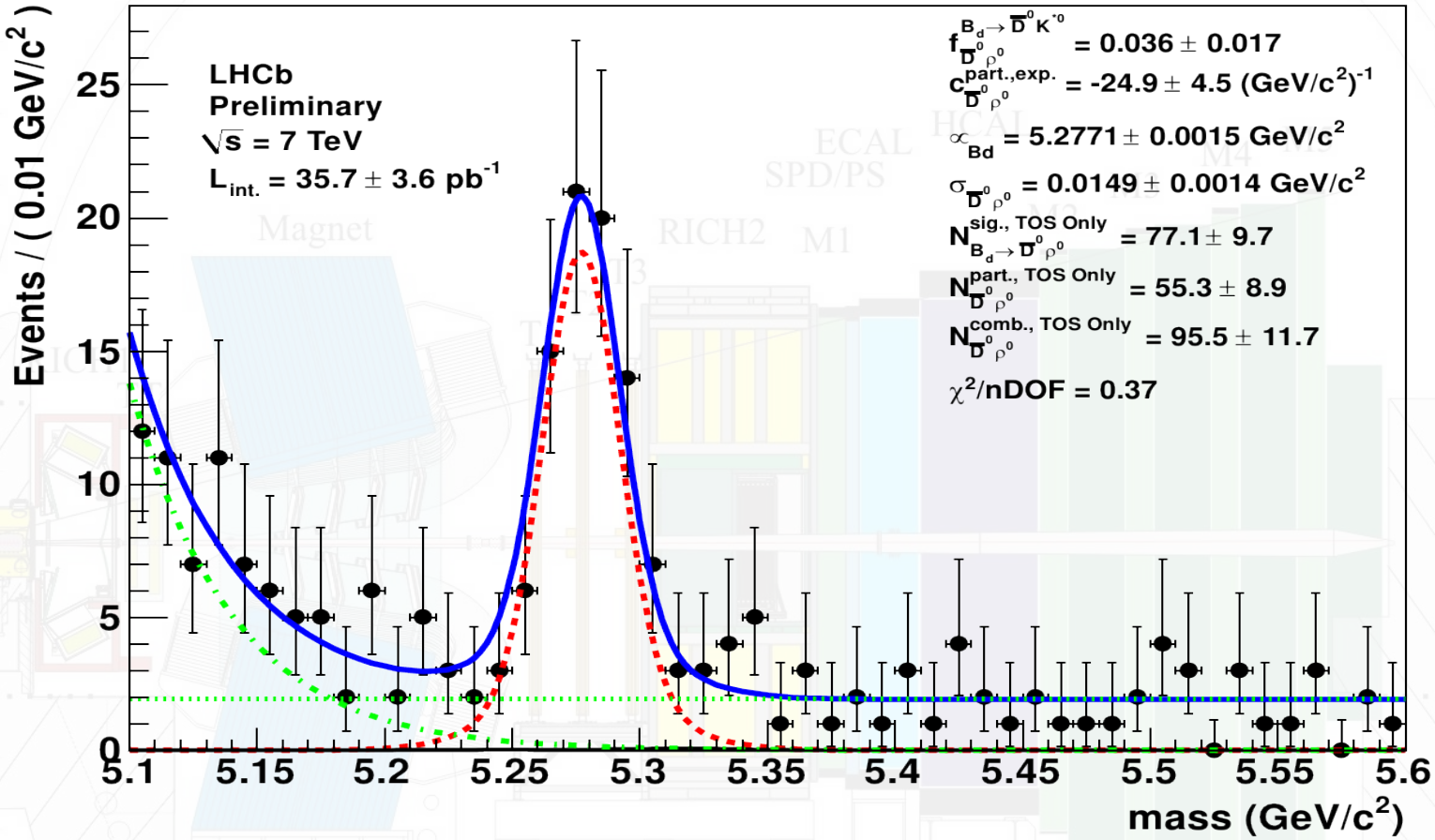
Trigger

- $\bar{B}^0 \rightarrow D^0\rho^0$ sample split
- TOS – Events triggered On the Signal in the Level 0 (L0) Hadronic trigger (green)
- OtherB – Events triggered independently of the B candidate decay at L0



$\overline{B}^0 \rightarrow D^0 \rho^0$

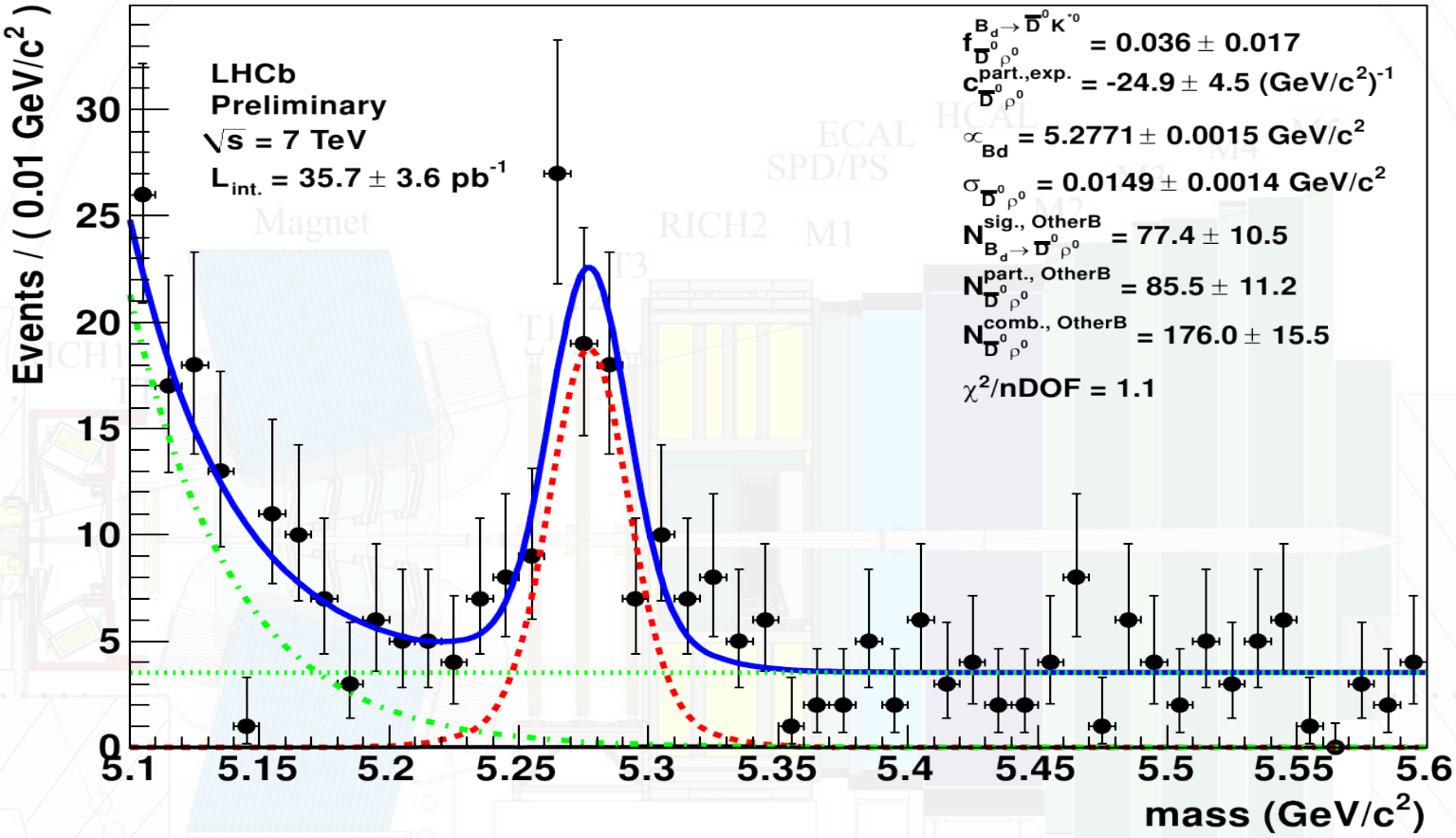
- TOS data only, the signal peak is clearly visible



- Fit – a double Gaussian for signal, an exponential for the partially reconstructed background and a flat distribution for the combinatorial background.

$\overline{B}^0 \rightarrow D^0 \rho^0$

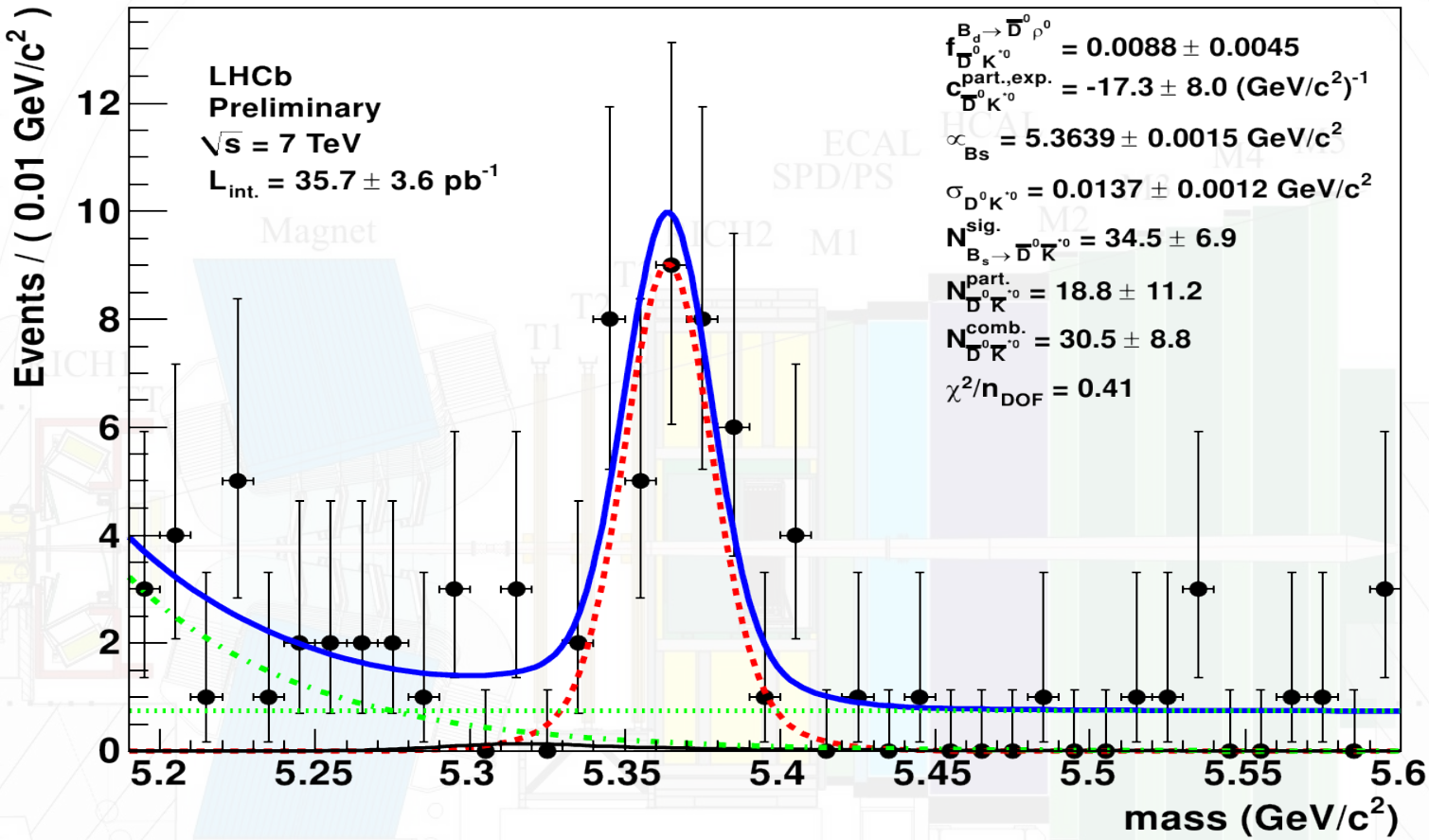
- OtherB data only, with a clear signal peak



- Fit - the same as the TOS data fit

$\overline{B}_s^0 \rightarrow D^0 K^{*0}$

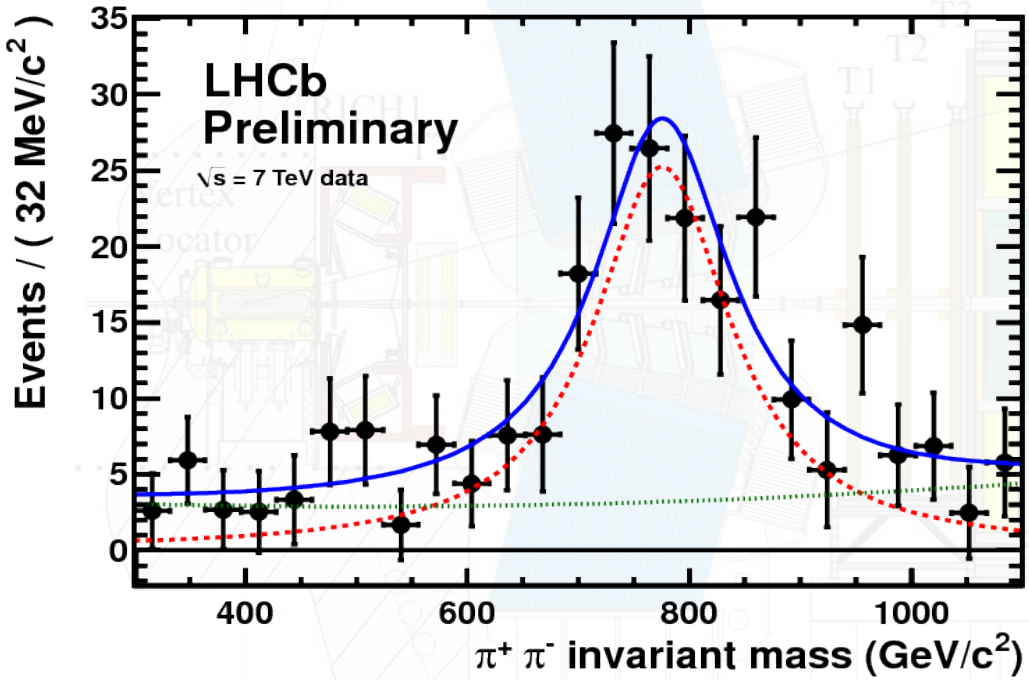
- The worlds first observation, signal peak very clear (greater than 9σ)

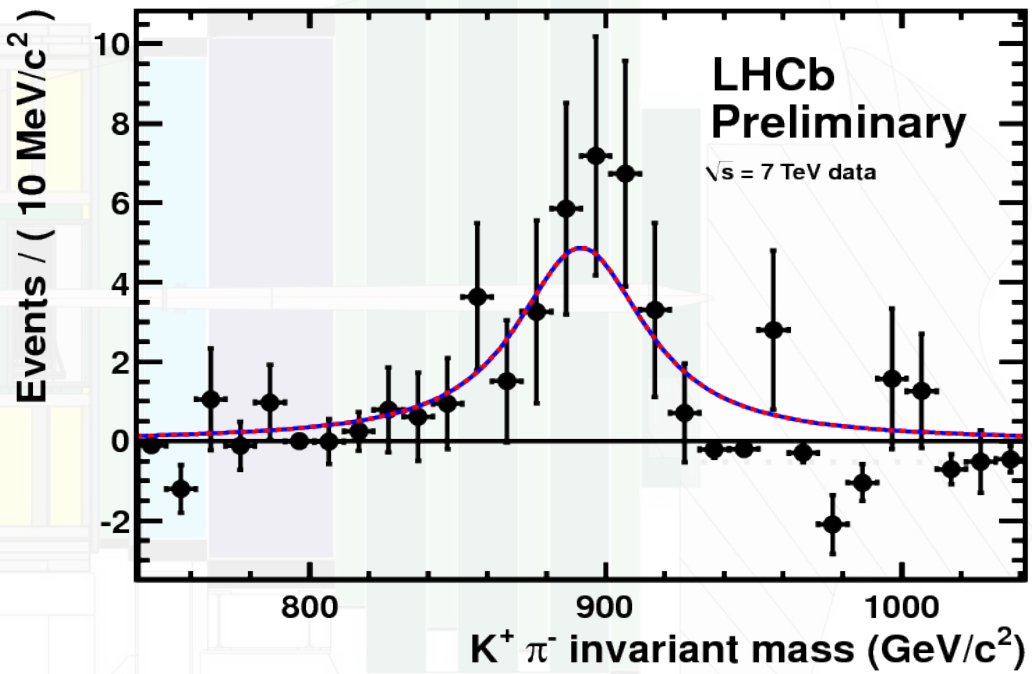


- Fit – the same as for $\overline{B}^0 \rightarrow D^0\rho^0$ but with an addition cross feed PDF to allow for $\overline{B}^0 \rightarrow D^0\rho^0$ mis-ID.

Non resonant effects

- $\bar{B}^0 \rightarrow D^0\rho^0$ sample contains a non-resonant contribution
  - Left: Background subtracted $\pi^+\pi^-$ mass distribution from $D\pi\pi$ data
  - Right: Background subtracted $K\pi$ mass distribution from $DK\pi$ data





Systematic uncertainties

- Currently lower than statistical uncertainty
  - This will not be the case with the 2011 data
- Main sources
  - PID performance ~ 6.8%
  - PDF parametrisation ~ 6.4%
  - Non-ρ^0 events ~ 6.8%
  - Total ~ 12.3%
- HFAG average of $f_d/f_s = 3.71 \pm 0.47$
  - Gives an addition uncertainty ~12.7%
  - LHCb already has a measurement: CERN-LHCb-CONF-2011-013

Results

- Signal yields from the fits:
- $\overline{B}^0 \to D^0\rho^0$ (combined) = 154.5 ± 14.3 events
- $\overline{B}^0_s \to D^0K^{*0}$ = 34.5 ± 6.9 events
- "non-ρ^0" = 30.1 ± 7.9 events

$$\frac{B(\overline{B}^0_s \to D^0K^{*0})}{B(\overline{B}^0 \to D^0\rho^0)} = 1.39 \pm 0.31 \pm 0.17 \pm 0.18$$

- Uncertainties: statistical, systematic, hadronisation fraction f_d/f_s

$$B(\overline{B}^0_s \to D^0K^{*0}) = (4.44 \pm 1.00 \pm 0.55 \pm 0.56 \pm 0.69)\times10^{-4}$$

- Uncertainties: statistical, systematic, hadronisation fraction f_d/f_s and $B(\overline{B}^0 \to D^0\rho^0)$
- Using $B(\overline{B}^0 \to D^0\rho^0) = (3.2 \pm 0.5)\times10^{-4}$ from the PDG

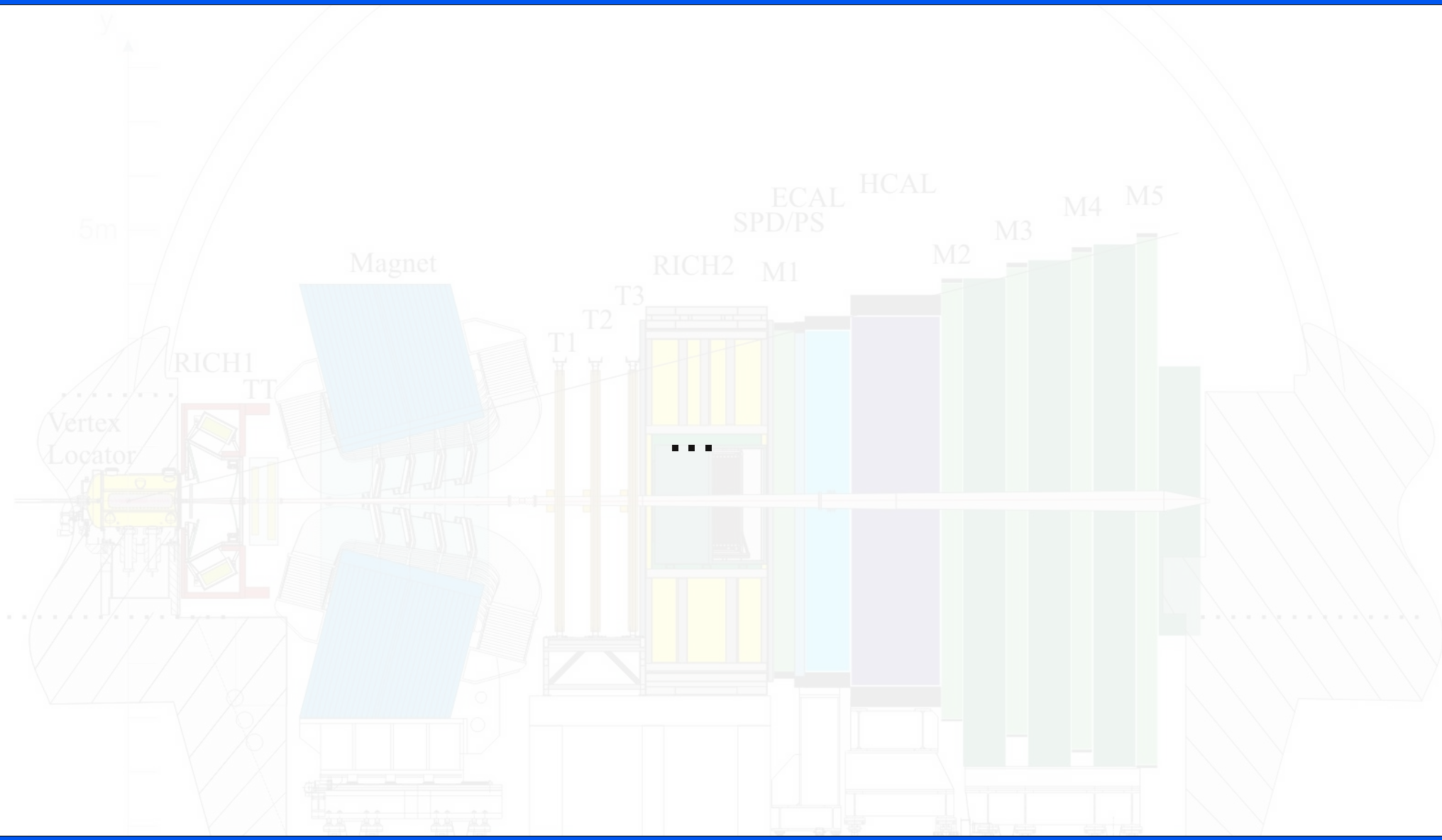
Plans for 2011 data and beyond

- $B \rightarrow DK^*$
  - Improve the measurement of $B(\overline{B}_s^0 \rightarrow D^0K^{*0})$
  - See the $B^0 \rightarrow D^0K^{*0}$ decay mode
  - Measurement of γ from $B^0 \rightarrow D^0K^{*0}$
- Dalitz plot analyses
  - $B^0 \rightarrow D\pi\pi$
  - $B^0 \rightarrow DK\pi$
  - $B_s^0 \rightarrow DK\pi$
- Other
  - $B_s^0 \rightarrow D\varphi$

Summary

- Excellent progress so far on a limited data sample
  - Analysis methods in place for future measurements
  - First observation of $\overline{B}_s^0 \to D^0 K^{*0}$: $(4.44 \pm 1.00 \pm 0.55 \pm 0.56 \pm 0.69) \times 10^{-4}$
  - Systematic uncertainties improving regularly
- Exciting year to come at LHCb
  - Data sample to be increased dramatically during 2011
  - Progress should be possible on all of points from the previous slide
- For more details see:
  - LHCb-CONF-2011-008

Backup


y
5m
Magnet
RICH1
TT
Vertex
Locator
T1
T2
T3
RICH2
M1
SPD/PS
ECAL
HCAL
M2
M3
M4
M5
...

Cuts

particle	variable	threshold
$K_{K^{*0}}$	$\Delta_{K-\pi}\mathcal{L}$	> 3
	p_T	> 300 MeV/c
	$\min_{\mathrm{PVs}} \chi^2_{\mathrm{IP}}$	> 4
$\pi_{K^{*0}}$ or π_{ρ^0}	$\Delta_{\pi-K}\mathcal{L}$	> -3
	p_T	> 300 MeV/c
	$\min_{\mathrm{PVs}} \chi^2_{\mathrm{IP}}$	> 4
V	$\lvert\cos\theta_{\mathrm{Helicity}}\rvert$	> 0.4
	$\min_{\mathrm{PVs}} \chi^2_{\mathrm{IP}}$	> 25
	$(\chi^2/n_{\mathrm{D.O.F.}})$ vertex	< 12
	p_T	> 1 GeV/c
K^{*0}	$\lvert m^{\mathrm{reconstructed}}_{K^{*0}} - m^{\mathrm{PDG}}_{K^{*0}}\rvert$	< 50 MeV/c^2
ρ^0	$\lvert m^{\mathrm{reconstructed}}_{\rho^0} - m^{\mathrm{PDG}}_{\rho^0}\rvert$	< 150 MeV/c^2

Cuts

K_{D^0}	$\Delta_{K-\pi}\mathcal{L}$	> 0
	p_T	> 400 MeV/c
	$\min_{\mathrm{PVs}} \chi^2_{\mathrm{IP}}$	> 4
π_{D^0}	$\Delta_{\pi-K}\mathcal{L}$	> -4
	p_T	> 250 MeV/c
	$\min_{\mathrm{PVs}} \chi^2_{\mathrm{IP}}$	> 4
D^0	$(\chi^2/n_{\mathrm{D.O.F.}})$ vertex	< 5
	$\min_{\mathrm{PVs}} \chi^2_{\mathrm{IP}}$	> 4
	$\left\lvert m_{D^0}^{\mathrm{reconstructed}} - m_{D^0}^{\mathrm{PDG}} \right\rvert$	< 20 MeV/c^2
B^0 or B^0_s	$\frac{z_{D^0\ \mathrm{vertex}} - z_{V\ \mathrm{vertex}}}{\sqrt{\sigma^2_{z,\ D^0\ \mathrm{vertex}} + \sigma^2_{z,\ V\ \mathrm{vertex}}}}$	> -2
	$\cos(\theta_{\mathrm{Flight}})$	> 0.99995
	$(\chi^2/n_{\mathrm{D.O.F.}})$ vertex	< 4
	$\min_{\mathrm{PVs}} \chi^2_{\mathrm{IP}}$	< 9

Systematics

Source of the uncertainty	σ_R/R
MC statistics $r_{\text{acceptance}} = 0.955 \pm 0.004$	0.4 %
Change in the central value of the vector mass window $r_{\text{V}} = 1.02 \pm 0.01$	1.0 %
MC statistics	1.0 %
Difference in p_T distributions of tracks between data vs MC $r_{\text{sel.}} = 0.802 \pm 0.020$	2.5 %
Use of the unweighted data calibration sample to compute $r_{\text{PID}} = 1.03 \pm 0.07$	6.8 %
L0 Hadron threshold influence on $r_{\texttt{TOSOnly}} = 1.20 \pm 0.08$	3.0 %
`OtherB` triggering efficiency independent on the mode $r_{\texttt{OtherB}} = 1.03 \pm 0.03$	1.6 %
PDF parametrizations	6.4 %
Statistical uncertainty on the " non ρ^0 " component $= 30.1 \pm 7.9$	6.8 %
Overall relative systematical uncertainty	12.3 %
HFAG average [6] for $\frac{f_d}{f_s} = 3.71 \pm 0.47$	12.7 %