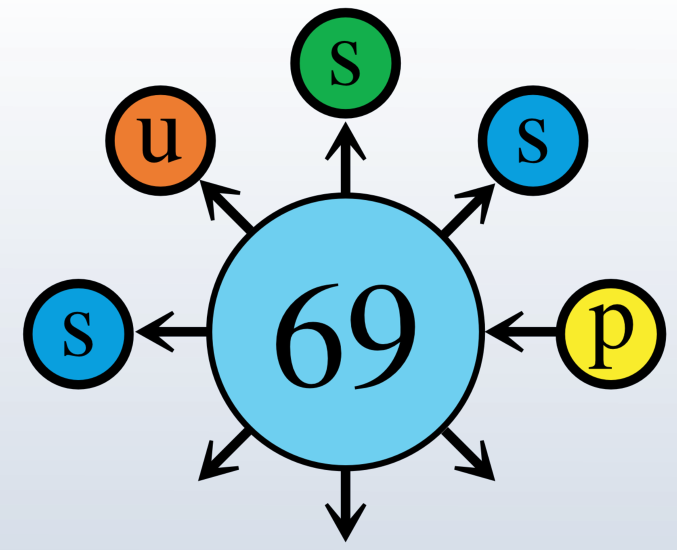
Flavour Tagging at LHCb

Katharina Kreplin, Heidelberg University



LHCb - the B physics experiment at the LHC

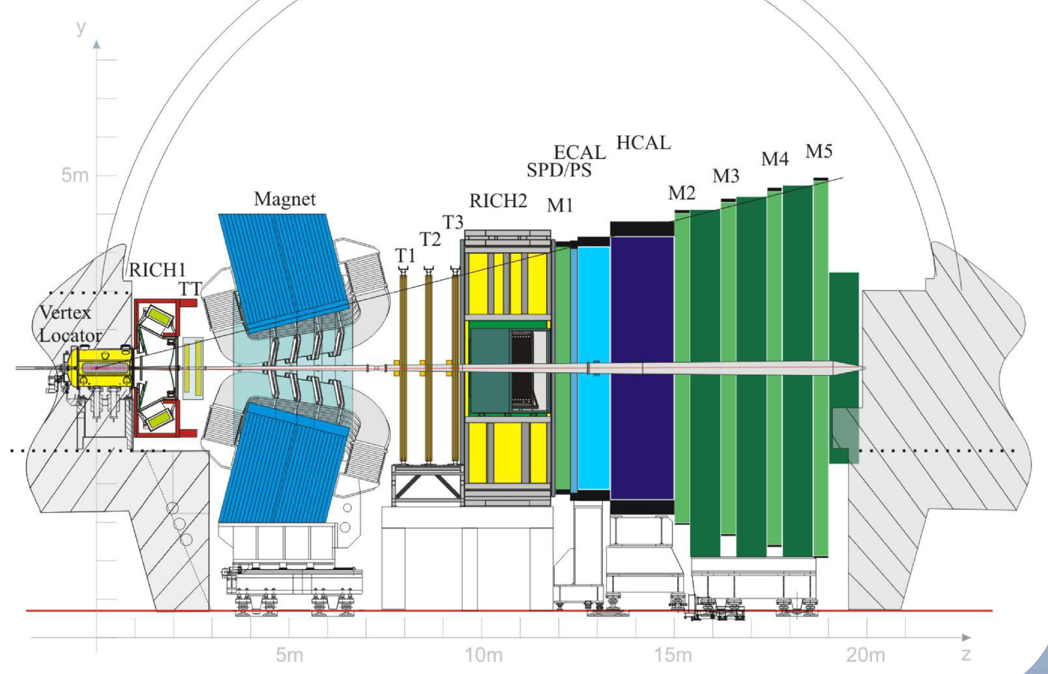
single arm forward spectrometer

excellent in:
- tracking
- vertexing
- particle id

proper time resolution: $\sim 45\text{fs}$

2011: $\mathcal{L} \sim 1\text{fb}^{-1}$ @7TeV

2012: $\mathcal{L} \sim 1\text{fb}^{-1}$ @8TeV

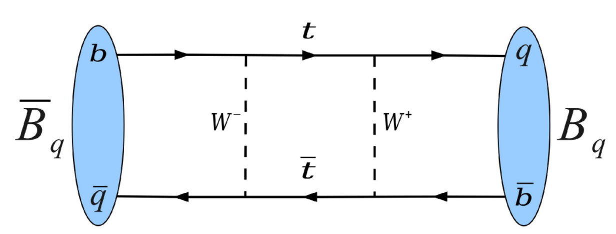


Neutral B meson mixing

mass eigenstate $\neq$ weak eigenstate

$|B_L\rangle = p|B_q\rangle + q|\bar{B}_q\rangle$, $|B_H\rangle = p|B_q\rangle - q|\bar{B}_q\rangle$

$\longrightarrow$ neutral mesons oscillate into their anti-particles



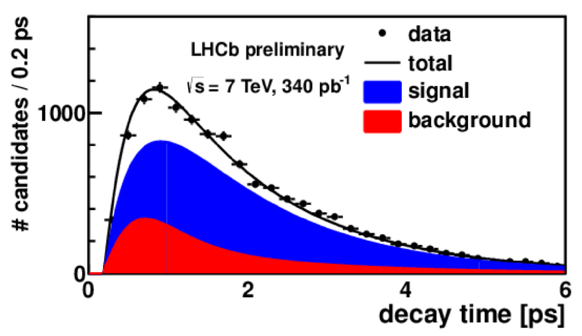
dominant Feynman diagram

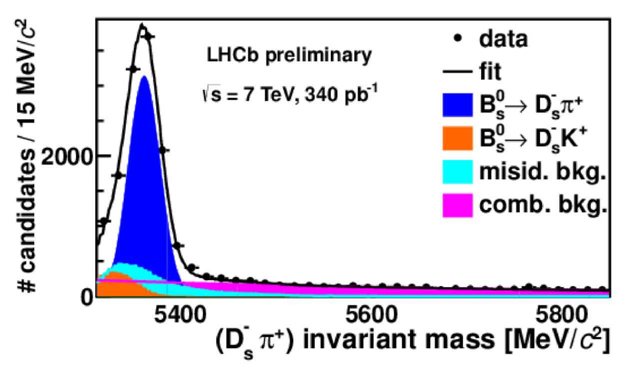
mixing frequency Δm corresponds to difference between mass eigenstates

Measurement of Δm_s in $B_s^0 \to D_s^- \pi^+$ decays

LHCb-CONF-2011-050

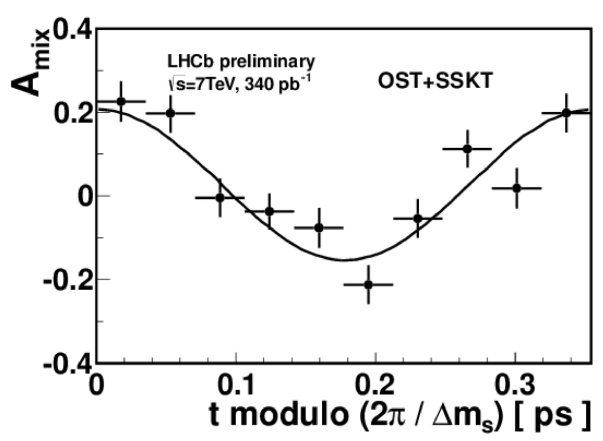
crucial ingredients:
- production flavour $\longrightarrow$ Flavour Tagging
- decay flavour $\longrightarrow$ Charge of the decay daughters
- excellent proper time resolution, due to fast mixing





9 k signal events

effective efficiency of:
- OS taggers $\epsilon\mathcal{D}^2 = (3.1 \pm 0.8)\%$
- SSK tagger $\epsilon\mathcal{D}^2 = (1.2 \pm 0.4)\%$



dominating systematics:
effects on the z and p scale (alignment)
B field calibration

$$\Delta m_s = 17.725 \pm 0.041(stat) \pm 0.026(syst)\text{ps}^{-1}$$

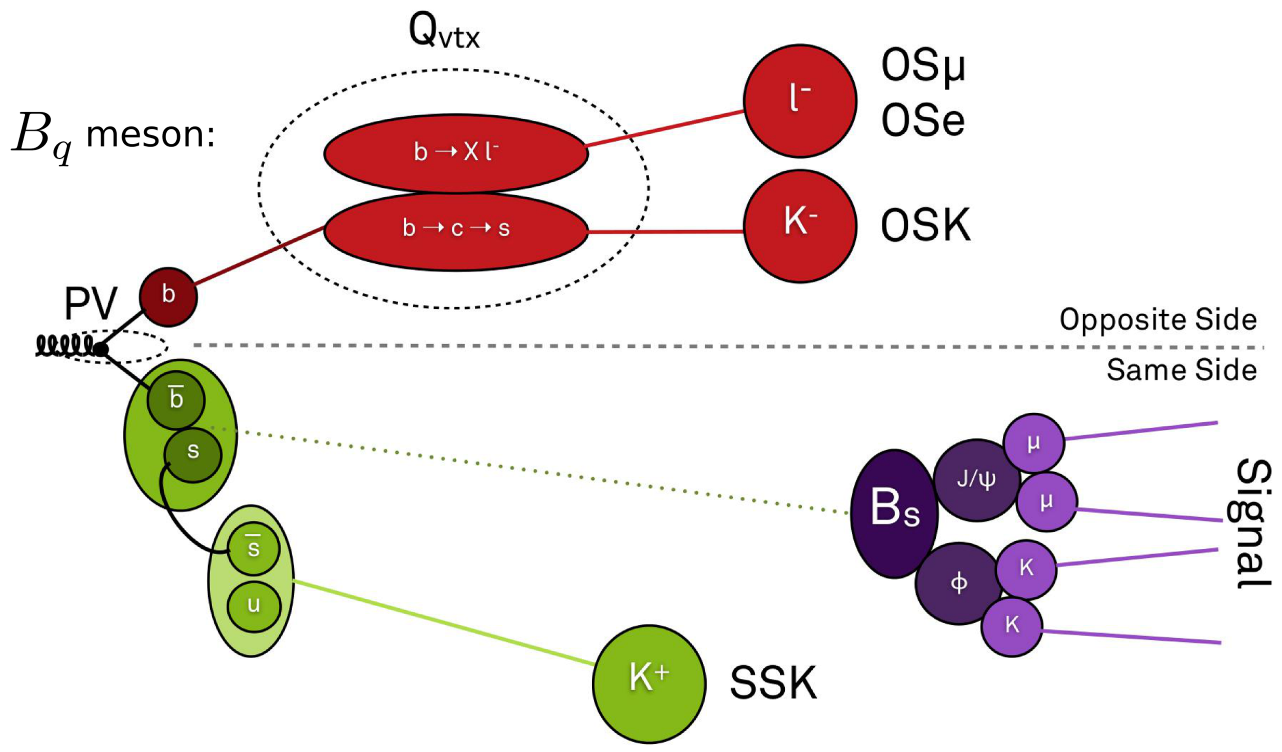
world best measurement

Flavour tagging

Two independent methods to tag the production flavour of the B_q meson:

Opposite side tagger (OS):
- exploit the second quark of the $b\bar{b}$ pair
  - OS kaon: $b \to c \to s$
  - OS muon, OS electron: semileptonic B decays
  - OS vertex: charge of the opposite B vertex

Same side tagger (SS):
- exploit the second quark of the $q\bar{q}$ pair
  - SS kaon: for B_s
  - SS pion: for $B_{u/d}$



Tagging algorithm: cut based selection of tagging particles in signal B events, if more than 1 tagging particle remains, take the one with the highest pt

Tagging parameters:

efficiency $\epsilon = \frac{N(\text{tagged})}{N(\text{all})}$

mistag probability $\omega = \frac{N(\text{tagged wrong})}{N(\text{tagged})}$

dilution $\mathcal{D} = (1 - 2\omega)$

effective efficiency $\epsilon_{\text{eff}} = \epsilon\mathcal{D}^2$ (figure of merit)

typical values $\epsilon\mathcal{D}^2 \sim 0.7 - 2.4\%$

due to hadronic environment

$\longrightarrow$ efficient tagging increases dramatically the size of data sample usable for CP measurements

This study: Optimization of the OS Kaon tagger

using the flavour specific channel $B^+ \to J/\psi K^+$

Aim: Understand the differences between data and MC to reoptimize the tagging algorithm on a corrected MC sample

Current status of the LHCb flavour tagging performance using 1fb^{-1} data, collected during 2011

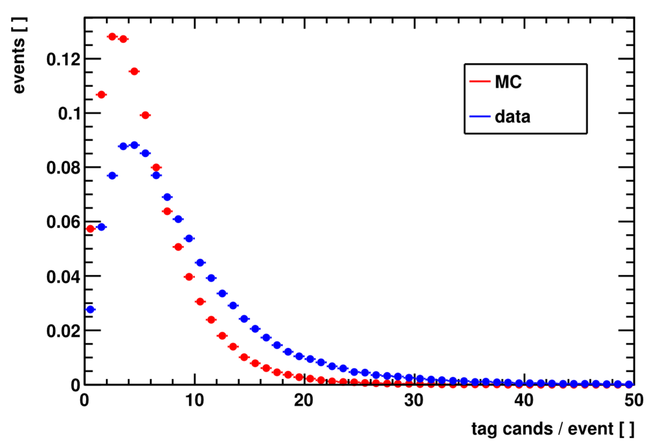
	ϵ %	ω %	$\epsilon\mathcal{D}^2$%
Data:	17.57 ± 0.08	39.33 ± 0.25	0.80 ± 0.04
MC:	15.76 ± 0.04	34.89 ± 0.13	1.44 ± 0.02

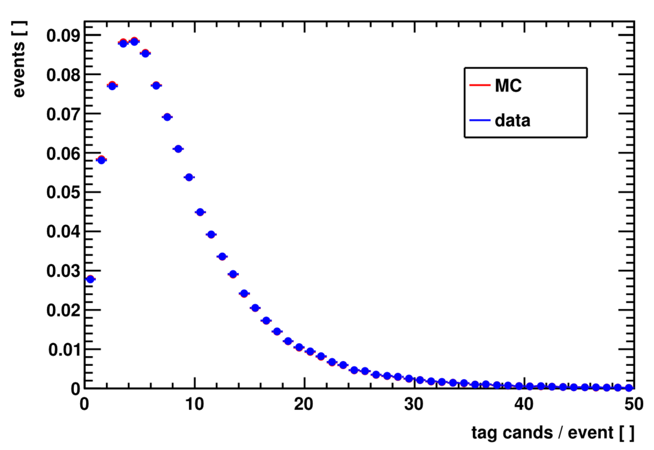
$\longleftarrow$ MC is significantly better!

	ϵ %	ω %	$\epsilon\mathcal{D}^2$%
MC corrected:	21.01 ± 0.06	39.84 ± 0.16	0.87 ± 0.03

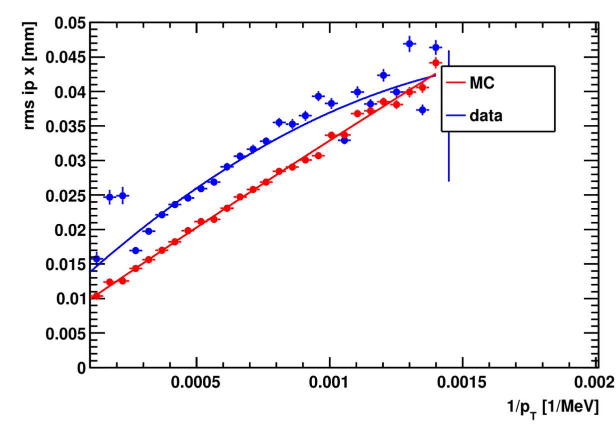
1. PID cut efficiency:
   checked on clean data samples $(D^*K, D^*\pi, \Lambda_0 p)$
   data-MC agreement in cut efficiency: 2 - 3 %
   $\longrightarrow$ $\Delta\epsilon$: 0.1 %, $\Delta\omega$: 0.01 %

2. MC underestimates track multiplicity:
   correct number of tracks per event in MC, depending on the number of primary vertices and the kinematic range of the tracks
   $\longrightarrow$ $\Delta\epsilon$: 3 %, $\Delta\omega$: 1.8 %



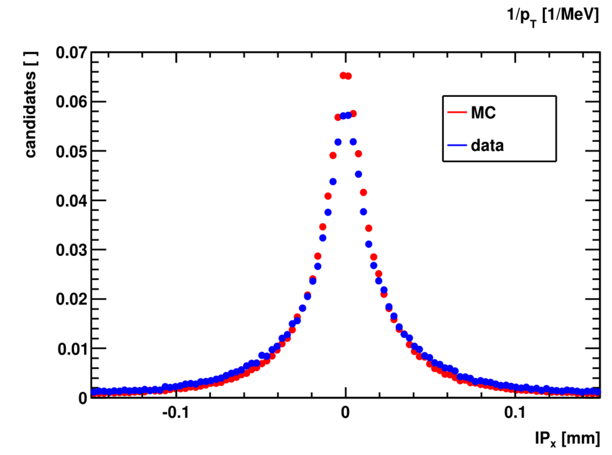


3. Impact parameter resolution:
   Impact parameter resolution too good in MC $\longrightarrow$ smear it



determine the IP x,y resolution in categories of the number of PVs per event

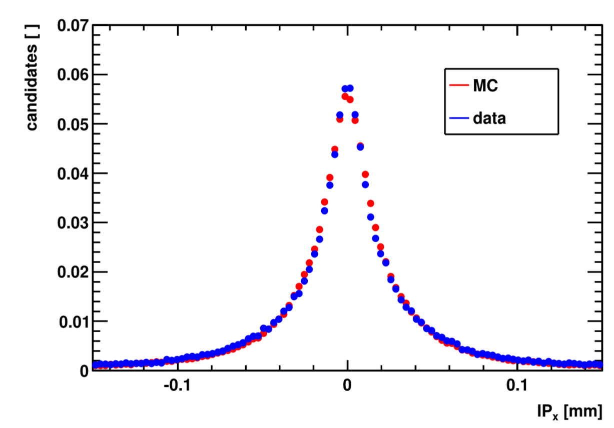
fit resolution in data and MC by polynomials (2. order)



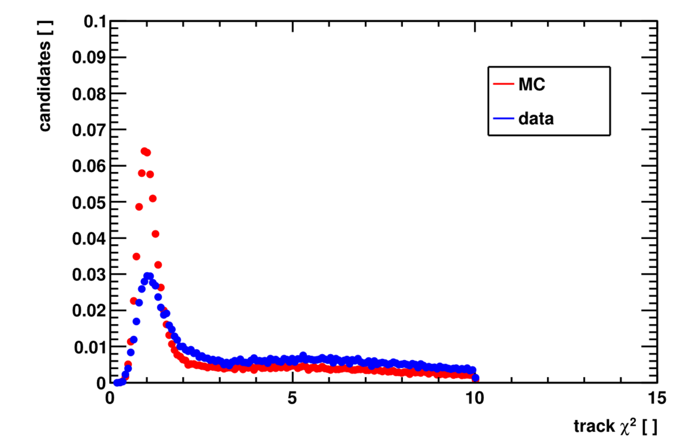
draw a random number with Breit-Wigner shape

recalculate the IP

$\longrightarrow$ $\Delta\epsilon$: 4 %, $\Delta\omega$: 0.8 %



4. Remaining discrepancy:
   track χ^2/ndf distribution



   adjust cut in MC, no distribution correction possible
   $\longrightarrow$ $\Delta\epsilon$: 1.8 %, $\Delta\omega$: 0.6 %

5. Mistag fraction still too low in MC:
   possible inefficiency in kaon from opposite B selection in data
   Replace $\sim 25\%$ MC truth kaons from opposite B by underlying event tracks
   $\longrightarrow$ $\Delta\epsilon$: 2.1 %, $\Delta\omega$: 1.6 %

$\Longrightarrow$ the differences between data and MC can be explained by these corrections