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Optimization and calibration of the flavour tagging algorithms in the LHCb experiment

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Summary. — For precise CP violation and time-dependent asymmetries measurements it is necessary to determine the flavour of B mesons at production (*flavour tagging*). In what follows the *flavour tagging* performances of the LHCb experiment are summarized.

PACS 13.85 – Ni Inclusive production with identified hadrons.
PACS 12.15 – y Electroweak interactions.
PACS 14.40 – Nd Bottom mesons.

1. – Flavour tagging

One of the main goals of the LHCb experiment is the measurement of CP violation in B mesons decays and the study of some of their rare decays. To do this the LHCb spectrometer is designed to provide a very selective and efficient trigger, excellent track and vertex resolutions, good mass resolution and excellent identification of particles (pions, protons, kaons, and muons, electrons) in a large momenta interval.

For CP violation and time-dependent asymmetries measurements it is necessary to know if the reconstructed B meson contain a b or a $\overline{b}$ quark (*flavour tagging*).

LHCb flavour tagging algorithms can use particles that comes from the fragmentation of the b quark that produce signal B meson (*Same Side (SS)* algorithms) or particles from the decay chain of the accompayining B meson (*Opposite Side (OS)* algorithms). SS algorithms use π/K as tagger particle, while OS use $\mu/e/K$ and Q_{vtx} (weighted mean of track charges of the secondary inclusive vertex) the charge of the tagger is correlated to the flavour of the B meson [1].

The performances of each algorithm are measured in term of $\epsilon_{eff} = \epsilon_{tag}(1 - 2\omega)^2$ where ω and ϵ_{tag} are calculated in terms of right(R), wrong(W) and untagged events (U) according to

$$(1) \qquad \omega = \frac{W}{R+W}, \qquad \omega = \text{mistag}, \qquad \epsilon_{tag} = \frac{R+W}{R+W+U}, \qquad \epsilon_{\text{tag}} = \text{efficiency}.$$

TABLE I. – *Performance results.*

$B^+ \to J/\Psi K^+$	$B^0 \to J/\Psi K^{*0}$	$B^0 \to D^{*-}\mu^+\nu_\mu$
$(2.10 \pm 0.08 \pm 0.24)\%$	$(2.09 \pm 0.09 \pm 0.24)\pm$	$(2.53 \pm 0.10 \pm 0.27)\%$

These quantities can be measured for each tagger directly on data using flavour specific control channels that are: $B^+ \to J/\Psi K^+, B^0 \to J/\Psi K^{*0}, B^0 \to D^{*-}\mu^+\nu_\mu$. The development of each algorithm has been done studying MC events but they have been optimized on real data to maximize ϵ_{eff}.

The tagging algorithms provide also an estimate of the mistag probability event by event (η) based on the output of a neural network that is trained on MC to identify the correct response.

It uses geometrical and kinematical properties of the tagger particle as input to determine the tagging decision and the probability of wrong decision.

In case more than one tagging decision is available, these are combined according to the predicted mistag probability (η) to provide a single combined decision and probability. For a correct combination the predicted mistag has to be calibrated on data to match the measured mistag fraction. For this purpose it is used a control channel ($B^+ \to J/\Psi K^+$) that allows to directly measure ω. Using the hypothesis of linear calibration model $\omega(\eta) = p_0 + p_1(\eta - \langle\eta\rangle)$.

ω is calculated as a function of η. The results of the calibration are $p_0 = 0.392 \pm 0.002$, $p_1 = 1.035 \pm 0.021$ and $\langle\eta\rangle = 0.391$.

2. – Results

The results for the per-event ϵ_{eff} of the OS combined algorithms measured with the first data collected by LHCb in 2011 ($0.37\,\text{fb}^{-1}$) are reported in table I for the three control channels.

Some relevant phyisics measurements that use flavour tagging has been made in 2011 such as the mixing phase in $B_0 - \overline{B_0}$ [2-4] and the Δm_s [5].

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