The LHCb detector

The LHCb detector is dedicated to the study of CP violation, flavour oscillation and rare decays in the B meson sector. It is a forward spectrometer, with a 0.3 rad polar angle acceptance. This geometry is well suited to the forward correlated production of B mesons.

The nominal operating luminosity at LHCb will be tuned to optimise the number of single interaction events.

Tagging principles

The Flavour Tagging is the procedure which determines the flavour at the production of the reconstructed B meson, i.e. whether the meson contained a b or a $\bar{b}$ quark. Tagging algorithms are usually classified into two groups: same side (SS) and opposite side (OS) algorithms. SS algorithms exploit the correlation of the charge of mesons produced in the fragmentation chain of the original flavour of the B signal. OS algorithms exploit the anti-correlation between the B hadrons produced in the same event, by looking at the decay products of the opposite B (the tagging B).

Opposite side tags

The selection of tagging leptons and kaons is based on kinematical and topological cuts and particle identification, all tuned to maximize $r_\omega$ (Table below). If several candidates tracks exist of the same type, the one with highest $p_t$ is selected.

The opposite side B meson is also exploited by reconstructing an inclusive secondary vertex, weighting the tracks exist of the same type, the one with highest $p_t$ selected.


c|p_{p_t} |
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The opposite side B meson is also exploited by reconstructing an inclusive secondary vertex, weighing the change of the tracks according to their $p_t$ assuming that the vertex charge corresponds to that of the b quark.

Same side

In the fragmentation cascade, the accompanying quark in the B meson gives rise to a quark with opposite charge, which tends to form a pion (kaon) for B$^0$ ($\bar{B}^0$). The selection of pions and kaons requires cuts on $p_t$, impact parameter ($\Delta$), as well as rapidity and azimuthal angle cuts to select particles produced close in momentum space to the signal B hadron.

Taggers

The Flavour Tagging procedure is in general not perfect, the observed CP-asymmetry will be diluted with respect to the true asymmetry.

Combination

The final decision is taken combining all the individual tagger decisions. For each event, a wrong tag probability is computed for each of the tagger candidates using a Neural Net (NN). The NN takes as input several properties of the tagger and it is trained to output for each tagger, and obtain a combined probability per event, to obtain the dependence of the mistag rate on the neural net output for each tagger, and obtain a combined probability per event used to subdivide $B^0 \rightarrow J/\psi K^0$ and $\bar{B}^0 \rightarrow J/\psi K^0$ events into 5 categories. The flavour oscillations in the B$^0 \rightarrow J/\psi K^0$ channel will be fitted as a function of proper time, in each of the 5 categories, in order to measure the mass rates which can then be used for the $B^0 \rightarrow J/\psi K_S$ CP channel.

Example: measurement of $\beta$

For the evaluation of the mistag rate, we will use $B^0 \rightarrow J/\psi K^0$ to obtain the dependence of the mistag rate on the neural net output for each tagger, and obtain a combined probability per event used to subdivide $B^0 \rightarrow J/\psi K^0$ and $\bar{B}^0 \rightarrow J/\psi K^0$ events into 5 categories. The flavour oscillations in the B$^0 \rightarrow J/\psi K^0$ channel will be fitted as a function of proper time, in each of the 5 categories, in order to measure the mass rates which can then be used for the $B^0 \rightarrow J/\psi K_S$ CP channel.

The expected precision in the measurement of sin(2$\beta$) at LHCb will be $\sigma(2\beta)$ = 0.03 for 28fb$^{-1}$ of data.