LHCb 2003-154
November 5, 2003

A look at the interplay between L1 trigger and tagging

Stefano Villa

Université de Lausanne
E-mail: stefano.villa@cern.ch

Abstract

We investigate the interplay between L1 trigger and flavour tagging in LHCb, as simulated in DaVinci v8r3, by looking at some representative channels.

1 Introduction

The main goal of LHCb is the study of CP asymmetries. Triggering and tagging are two crucial steps in view of this aim. They accomplish the tasks of getting the interesting B events at high efficiency with the smallest possible background retention and of tagging the flavour of the two neutral B mesons in the event to allow the computation of the asymmetry. Triggering and tagging are not two independent processes, even though they are well separated in the chain of data acquisition and offline analysis. They are both very sensitive to similar characteristics of the events (such as the presence of high p_t tracks) and therefore we expect that the performance of the trigger can influence the behaviour of tagging. On the other hand tagging can influence the development of trigger algorithms. Trigger optimization has been based so far on the maximization of the efficiency over samples of offline selected events. In the future the option of optimizing the trigger over events which are not only selected but also tagged might be considered, since these events are the ones which will be used to extract physics measurements.

The development of LHCb software has now come to a point where realistic simulations of the trigger capabilities are possible, and a fully developed tagging package exists and can be used for physics studies and evaluation of efficiencies [1]. We also have for the first time very high statistics signal and background samples which were produced in the first part of the year 2003 to be used for the TDR studies. At this time a preliminary study of the interplay between trigger and tagging seems useful.

The software packages used to obtain the results reported in this note are: DaVinci v8r3 [2], L1Decision v2r0 and FlavourTagging v4r5 or v4r6 depending on the channel. The choice of channels has been limited by the availability of offline selections where information about both selection and tagging was available in the form of event lists [3], and where also list of MC files (oodst) used to obtain these results were given. Table 1 lists the MC samples used in this study, with the number of L0 accepted events (since we concentrated on correlations between tagging and L1 trigger, only events accepted by the L0 trigger were considered), the number of offline selected events (accepted at L0) and the number of events which were assigned a flavour tag (and were accepted at L0). The results shown in this note have been obtained by running DaVinci on each MC sample and by checking in the offline event lists which events were selected. If the event was selected, its tags (same-side kaon, opposite-side kaon, electron, muon, vertex and combined) were read off, the global L1 trigger variable (L1GLOB, as defined in [4]) was computed and all the information was stored in a root file. To study the correlations between L1 trigger and tagging, efficiencies were computed as a function of L1GLOB, as we will describe in the following sections.

The definitions of efficiencies which will be used in the rest of this note are based on the following abbreviations:

- TAG = event is tagged
- L0 = event is accepted by the L0 trigger

Table 1: MC samples used to evaluate the performance of trigger and tagging. The table lists channel description, channel number, number of L0 accepted events, number of offline selected (and L0 accepted) events and number of tagged (and L0 accepted) events.

channel description	channel number	N(L0)	N(SEL&&L0)	N(TAG&&L0)
$B_d \to \pi^+\pi^-$	412100	96718	8575	3255
$B_d \to J/\psi(\mu^+\mu^-)K_s(\pi^+\pi^-)$	411300	31738	2508	1145
$B_s \to K^+K^-$	612500	112549	14444	6666
$B_s \to J/\psi(\mu^+\mu^-)\phi(K^+K^-)$	611300	159146	14637	6722
Minimum Bias	61	6590	0	0

- L1 = event is accepted by the L1 trigger
- SEL = event is selected by the offline physics selection
- && = logical AND (à la C++)
- w = wrong tag fraction (number of events with a wrong tag divided by the number of events tagged).

Note that in this study if an event is tagged (TAG) it means that it was offline selected (SEL).

2 Efficiency of L1 trigger on tagged events

Figure 1 shows the retention of Minimum Bias (MB) versus the efficiency of the L1 trigger normalized to the sample of tagged events for several values of the L1GLOB variable. For comparison, the corresponding curves obtained by normalizing the efficiency to the number of selected events are shown as well. For all four channels, the L1 efficiency is always larger when computed on the tagged sample than on the selected sample. The relative difference at the 4% MB retention level (corresponding to the 40 kHz output rate foreseen for L1) varies between 6 and 10%.

3 Performance of tagging as a function of L1 trigger

The performance of the tagging algorithm on samples which are accepted by the L1 trigger as a function of the cut on L1GLOB has also been studied. Two quantities are normally considered when dealing with flavour tagging: the tagging efficiency (ϵ) and the wrong tag fraction w. From these quantities we derive the *effective efficiency*, defined as the product of the efficiency and of the dilution factor: $\epsilon_{\text{eff}} = \epsilon(1-2\text{w})^2$. In Fig. 2 the tagging efficiency (defined as N(L0&&L1&&TAG)/N(L0&&L1&&SEL)),

the wrong tag fraction and the effective efficiency are plotted as a function of L1GLOB for the four channels under study. In general the tagging efficiency and the tagging effective efficiency increase when the L1 cut is tighter, especially in the region around L1GLOB=0, close to the actual working point of the trigger.

4 Efficiency of L1 trigger and tagging on selected events

A way to combine L1 trigger and tagging efficiencies, as displayed in Fig. 1 and 2, is to compute the effective efficiency of tagging and L1 trigger. This quantity, defined as N(L0&&L1&&TAG)/N(L0&&SEL) $\times(1-2\mathrm{w})^2$, is plotted in Fig. 3 versus the MB retention rate for several values of the L1GLOB cut. The most striking feature of such plots is the presence of a saturation effect. The efficiency of trigger and tagging reaches a plateau, sometimes even before crossing the 4% MB-retention line, beyond which it is impossible to go no matter how much the L1 trigger cut is relaxed, accepting more and more MB. This behaviour can be explained by the fact that the events which are accepted by looser L1 cuts have "worse quality" and therefore the overall tagging effective efficiency does not increase. This effect is quite general for all channels analysed, but the rate at which the plateau is reached depends on the channel.

References

[1] M. Calvi, O. Dormond and M. Musy, *LHCb Flavour Tagging Performance*, LHCb/2003-115.

[2] DaVinci reconstruction program, for release notes see web page `http://lhcb-comp.web.cern.ch/lhcb-comp/Analysis/default.htm`

[3] Event lists and results of simulations of offline analyses are collected in `http://lhcb-phys.web.cern.ch/lhcb-phys/task_force/TDR_studies_2002-2003/event_lists_TDR_Dv8r2/`

[4] L1GLOB corresponds to the variable called Δ^{glob} in C. Jacoby and T. Schietinger *Level-1 decision algorithm and bandwidth division*, LHCb/2003-111; see also H. Dijkstra *et al.*, *The use of the TT1 tracking station in the level-1 trigger*, LHCb/2002-045.

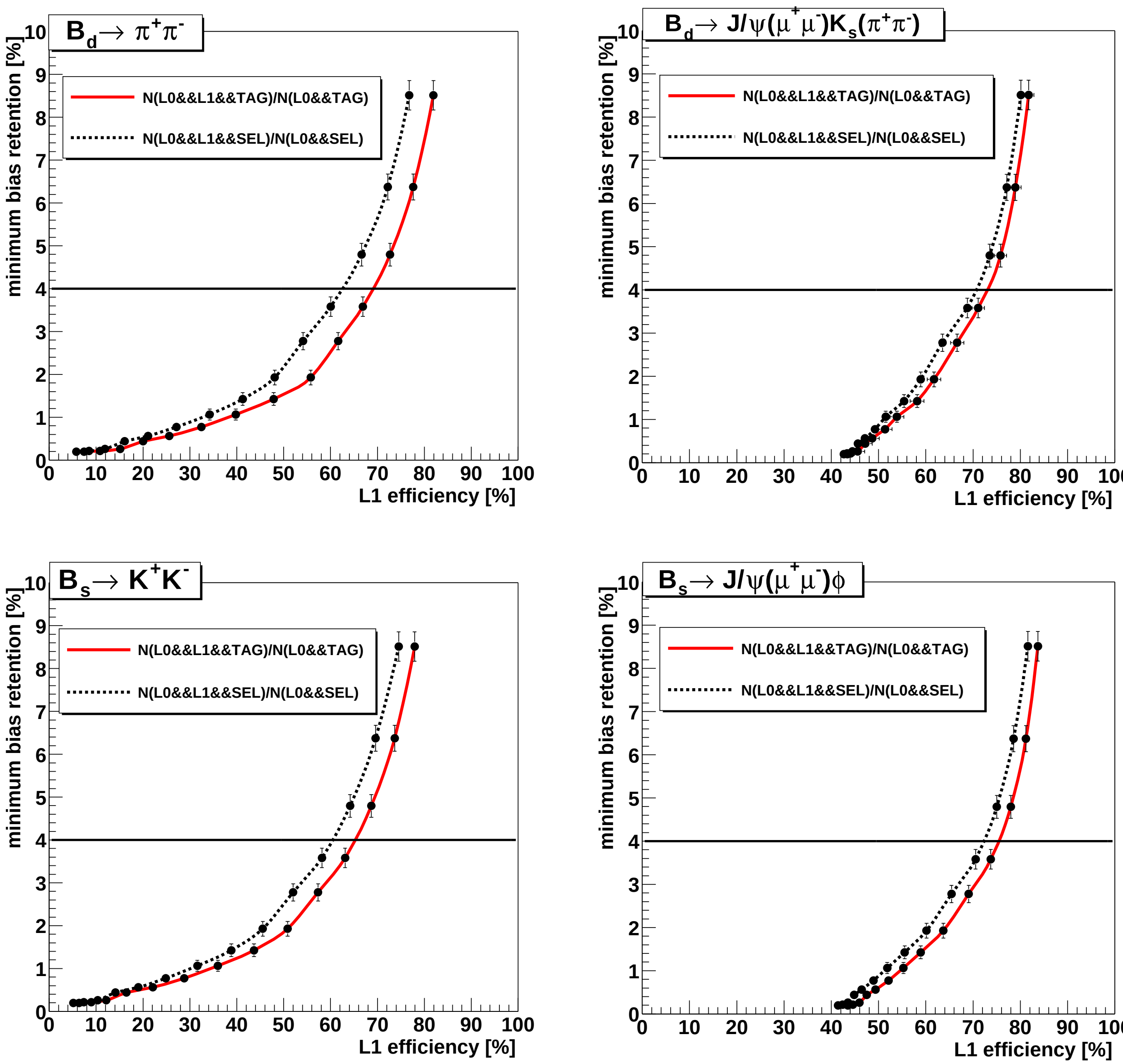

Figure 1: Efficiency of the L1 trigger on the sample of offline selected events (dashed line) and on the sample of tagged events (solid line) versus the MB retention rate for the four channels under study. Different points on the curves correspond to different values of the L1GLOB variable.

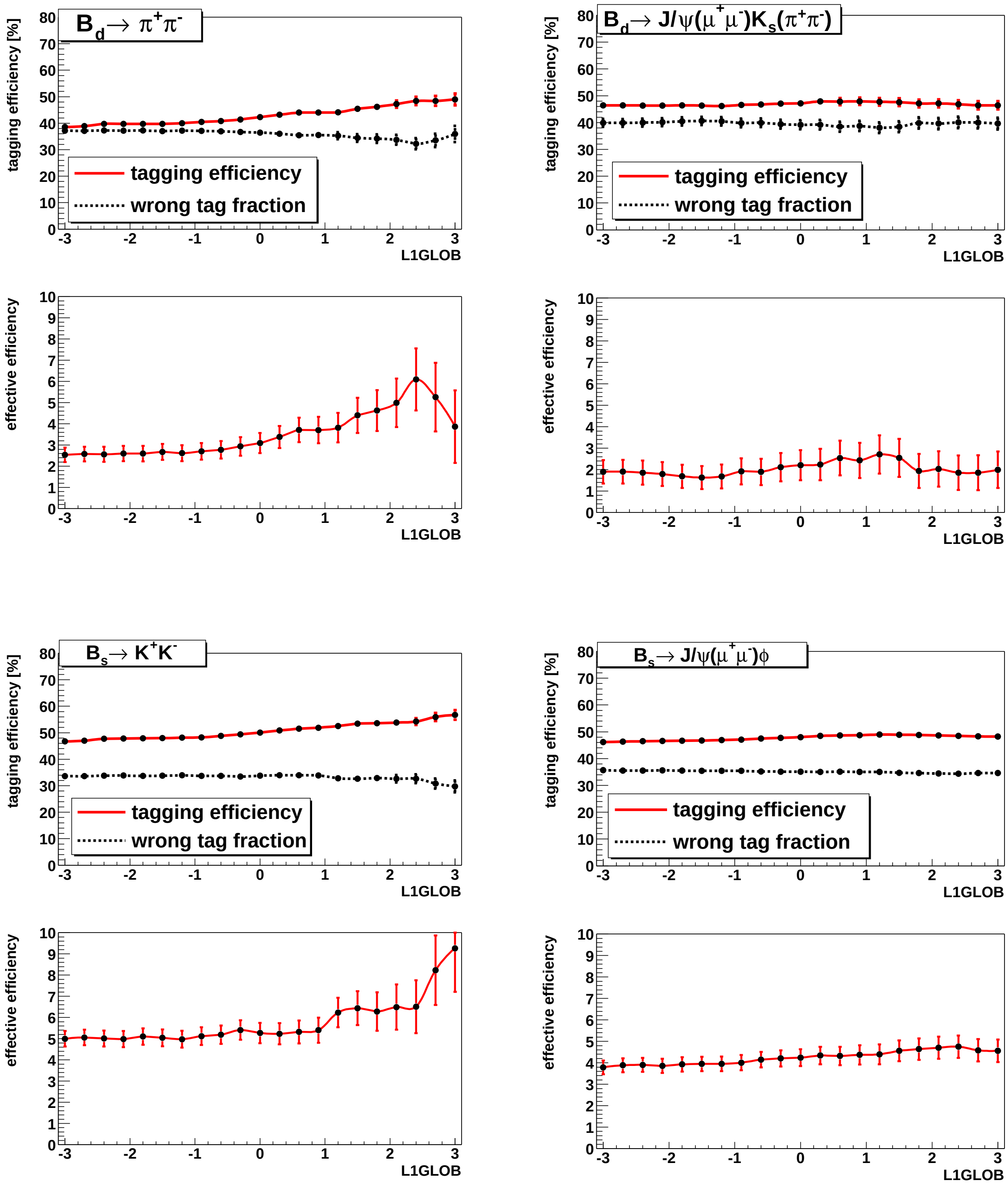

Figure 2: Tagging efficiency (defined as N(L0&&L1&&TAG)/N(L0&&L1&&SEL)) and wrong tag fraction (upper plots) and effective tagging efficiency (defined as N(L0&&L1&&TAG)/N(L0&&L1&&SEL) $\times(1-2\text{w})^2$, lower plots) as a function of L1GLOB, for the four channels under study.

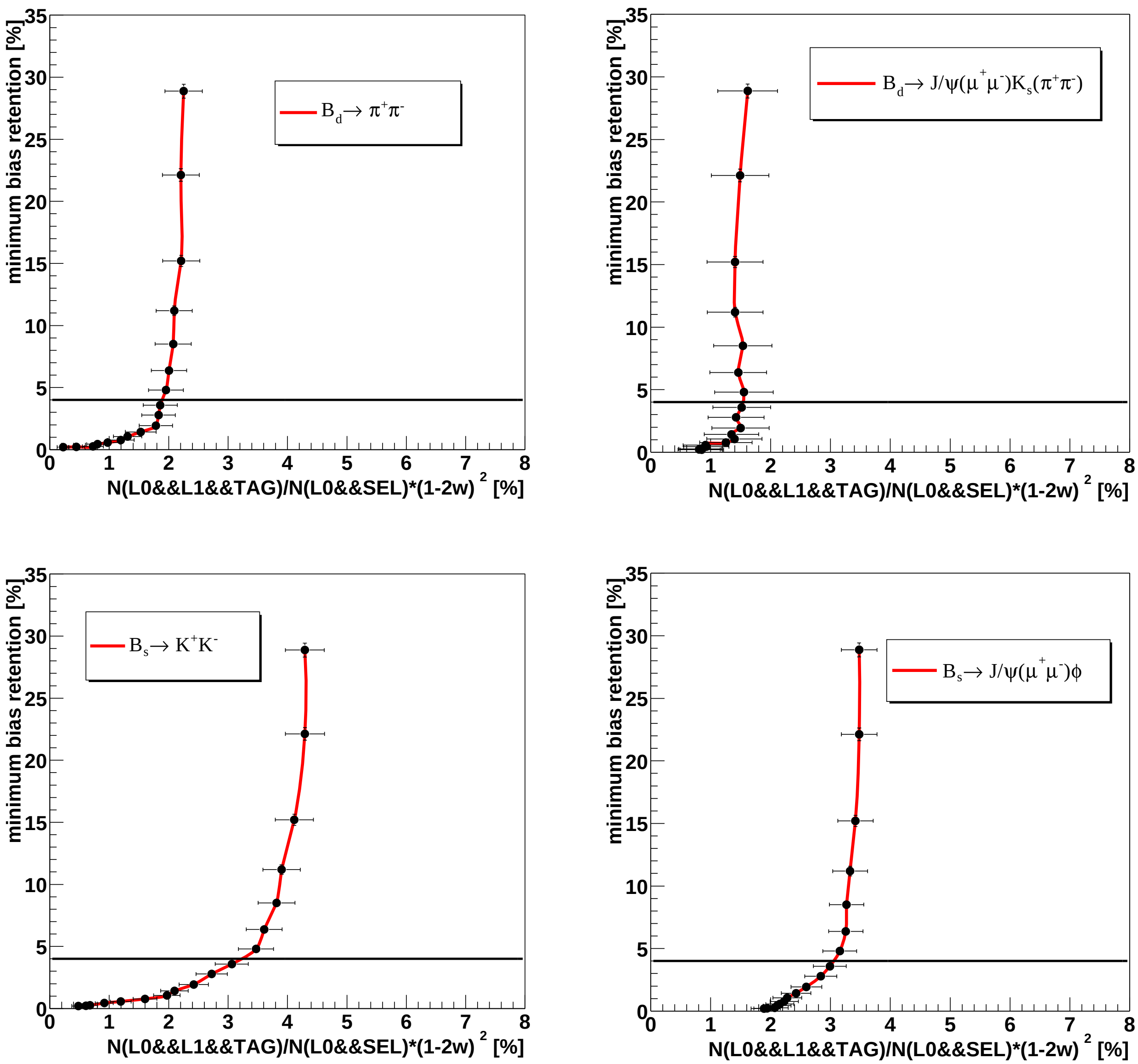

Figure 3: Trigger and tagging effective efficiency versus MB retention rate for the four channels under study. Different points on the curve correspond to different values of the L1GLOB variable.