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Mass Resolution and Track Fit Performance

M. Needham
Laboratoire de Physique des Hautes Energies,
École Polytechnique Fédérale de Lausanne

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Abstract

The influence of the detector performance on the mass resolution for J/ψ, K_s and Λ decays is investigated. It is shown that the mass resolution is insensitive to the precise details of the material distribution assumed in the fit and also to the Outer Tracker hit resolution. On the other hand the information provided by the Tracker Turicensis is important.

1 Introduction

In this note the dependence of the mass resolution on the detector parameters and settings used in the track fit is studied using data from the DC06 Monte Carlo production [4]. The aim is to understand how the mass resolution is degraded if performance of the detector is worse than expected or incorrectly modeled by the track fit.

The following scenarios were considered:

Default: The standard track fit and settings used for the DC '06 reprocessing [1, 2]. This version of the fit is known to give close to optimal performance.

Fast Transport Service: A version of the track fit where the simplified description of the detector material described in [3] is used.

No drift information: The drift-time information for the Outer Tracker is is ignored in the fit. This worsens the resolution of the OT from 0.2 to $5/\sqrt{12} \sim 1.5$ mm.

No TT: The hits in the TT station are removed from the track prior to fitting.

No TT and drift information: The hits in the TT station are removed from the track prior to the fit and the drift time information in the Outer Tracker is ignored.

The mass resolution for the decays $J/\psi \rightarrow \mu^+\mu^-, K_S \rightarrow \pi^+\pi^-$ and $\Lambda \rightarrow p^+\pi^-$ has been studied using the selections described in [5]. In addition, for the J/ψ case the mass resolution with a more recent version of Geant4 has been investigated [6]. The results of these studies are described in the following section.

2 Results

Fig. 1 shows the di-muon mass resolution for selected J/ψ decays. As in [5] to disentangle the effect of radiative corrections the difference between the reconstructed and true invariant mass of the di-muon pair is plotted. It can be seen that:

- Using the fast transport service the mass resolution is degraded by 2 % at high momentum. This means that the mass resolution is relatively insensitive to the details of the detector modeling in the track fit [1].
- Turning off the drift information in the track fit the resolution degrades by 2 % at all momenta. This is consistent with the observation [1] that the momentum resolution of the spectrometer is dominated by multiple scattering up to 80 GeV.
- With the data generated with the more recent version of Geant4 the mass resolution is improved by 10 %. This effect is attributed to improvements in the multiple scattering model used in Geant4 [6].
- The information provided by the TT station is relatively important in determining the mass resolution. If the TT hits are ignored the resolution degrades by $\sim$ 20 %. This is consistent with the studies of the impact of TT hits on the momentum resolution made in [1].
- If the TT hits are ignored and the Outer Tracker drift information is not used the resolution is worsened by a factor of 1.5-2. The shape of the curve is explained by the fact that high momentum tracks tend to pass through the Inner Tracker and are therefore not effected by the removal of the Outer Tracker drift information. In addition, for tracks passing through the Inner Tracker the loss of the TT hits is compensated by the higher intrinsic resolution of the detector.

Fig 2 and Fig 3 show the mass resolution for selected K_s and Λ candidates respectively. Taking into account the compressed scale due to the lower Q-value compared to the J/ψ case similar trends are seen.

3 Summary

In this note the influence of the detector performance on mass resolution has been studied. It has been shown the mass resolution is relatively insensitive to the details of the material distribution in the detector and to the resolution of the Outer Tracker. On the other hand the TT hits have been shown to have a large impact on the performance. Ignoring the TT information the mass resolution is degraded by 20 %. In addition, with a later version of Geant4,

[1] The fit also allows the uncertainty on the mass estimate to be determined. The quality of this estimate may be more sensitive to the details of the material model in the track fit.

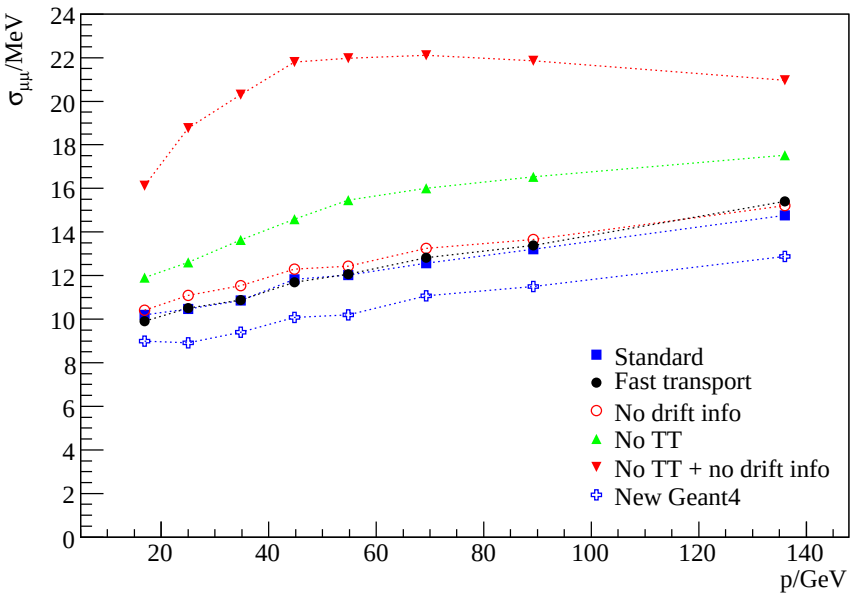

Figure 1: Di-muon mass resolution for selected J/ψ candidates versus p/GeV for the scenarios discussed in the text. The mean momentum of the candidates is 60 GeV.

where the multiple scattering model used is considered more realistic, the mass resolution is improved by 10 %.

References

[1] M. Needham. Performance of the LHCb Track Reconstruction Software. LHCb-note 2007-144.

[2] Gauss v25r7, Boole v12r10, Brunel v31r11, XmlDDDB v30r14.

[3] W. Hulsbergen. Update on simplified material. Trigger and Reconstruction Meeting 17/9/2007.

[4] Gauss v25r7, Boole v12r10, Brunel v30r14, XmlDDDB v30r14.

[5] M. Needham. Momentum scale calibration using resonances. LHCb-note 2008-037.

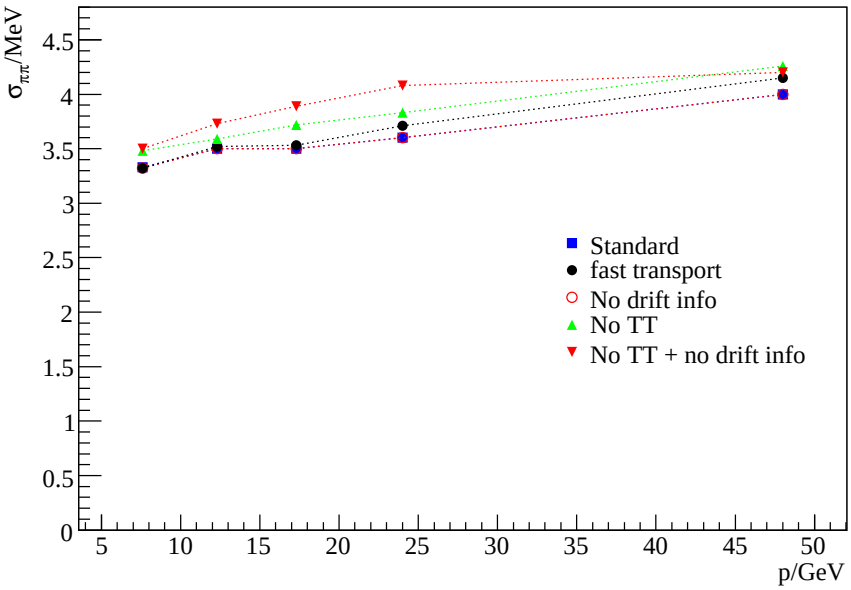

Figure 2: Mass resolution for selected K_s candidates versus p/GeV for the scenarios discussed in the text. The mean momentum of the selected candidates is 17 GeV.

[6] M. Needham. Studies of momentum scale calibration using $J/\psi \to \mu^+\mu^-$. LHCb-note 2008-036.

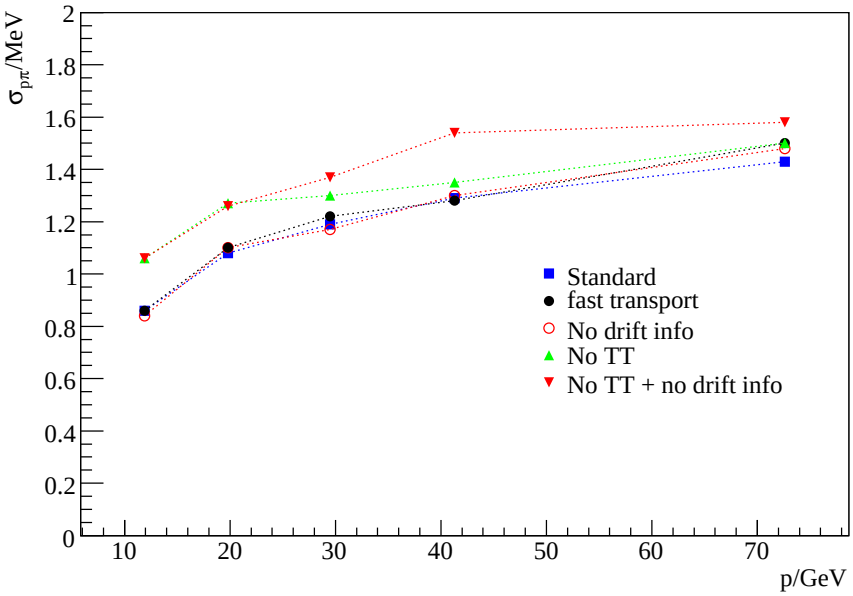

Figure 3: Mass resolution for selected Λ candidates versus p/GeV for the scenarios discussed in the text. The mean momentum of the selected candidates is 29 GeV.