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The RunII tracking performances of the CMS detector

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Summary. — In order to perform physics analysis on collision data, it is essential that all relevant physical processes are well modelled by Monte Carlo (MC) simulations. These simulations include the detector response. The measurement of the hadronic tracking efficiency in the CMS detector with a center of mass energy of $\sqrt{s} = 13\,\text{TeV}$ collected by CMS at CERN in 2015 will be discussed.

1. – Introduction

The tracking efficiency for charged pions in the CMS silicon tracker is measured using the ratio of neutral charm-meson decays to final states of charged particles: the four-body final state $D^0 \to K3\pi$ and the two-body final state $D^0 \to K\pi$. The D^0 decays is reconstructed in the chain $D^* \to D^0\pi$. Assuming that the decay chains are well simulated by the Monte Carlo samples, one measures the signal yield in data and the total efficiency in Monte Carlo, obtaining the ratio $R = \frac{N_{k3\pi}\epsilon_{k\pi}}{N_{k\pi}\epsilon_{k3\pi}}$. Since we know from the PDG [1] $R(PDG) = 2.08 \pm 0.05$, we can measure the pion reconstruction relative efficiency as the ratio

$$\epsilon_{rel} = \left(\frac{\epsilon_{DATA}}{\epsilon_{MC}}\right)^2 = \sqrt{\frac{R}{R(PDG)}}.$$

2. – Event selection

We have analysed $2.69\,\text{fb}^{-1}$ data events collected at 13 TeV with a ZeroBias trigger (requiring only that a p-p collision has occurred) and Monte Carlo events. We look for $K\pi$ and $K3\pi$ candidates in a preselected set of tracks ($p_T > 500\,\text{MeV}/c$), by combining two or four tracks coming from the primary vertex which conserve the D^0 charge. Since the combinatorial background is predominant and completely hides the signal an invariant mass cut around the D^0 mass within 1.5 standard deviations is applied. We need to consider the D^0 generates a secondary displayed vertex that can be reconstructed from

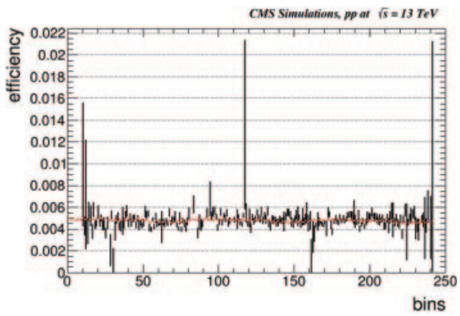

Fig. 1. – The linear function used well describes the efficiency as shown by the superimposition of the two variables (linear function and efficiency bin by bin).

the tracks in the final state because of the relatively long mean lifetime, $t = (4.101 \pm 0.015) \cdot 10^{-13}\,\mathrm{s}$; we cut on the significance of primary-secondary vertices distance ($\sigma_L > 3$). Then we combine all the D^0 selected candidates with an additional track coming from the primary vertex, the slow pion, to reconstruct the D^* meson. We select only events in which the D^* candidates momentum is greater than $5.5\,\mathrm{GeV}/c$ and the difference $\Delta M = m_{inv}^{D^*} - m_{inv}^{D^0}$ is less than $160\,\mathrm{MeV}/c^2$.

3. – Correction and efficiency determination

The $D^0 \to K3\pi$ decay shows a complex structure due to the interference of various intermediate states in two and three bodies that could affect the efficiency calculation [2]. Defining five invariant quantities, $s_i = (p_i+q_j)^2$, as the square of the two bodies invariant mass in the final state it is possible to define a function $F(x) = m_0 + m_1 s_1 + m_2 s_2 + m_3 s_3 + m_4 s_4 + m_5 s_5$ that well describes the Monte Carlo efficiency as shown in fig. 1. Finally we weight each event in the final state $K3\pi$ with the value $1/|F(x)|$ to get the correct fraction of events.

We determine signal yields in data and MC samples using an unbinned maximum-likelihood fit to the ΔM distributions for each decay mode as shown in fig. 2 [3].

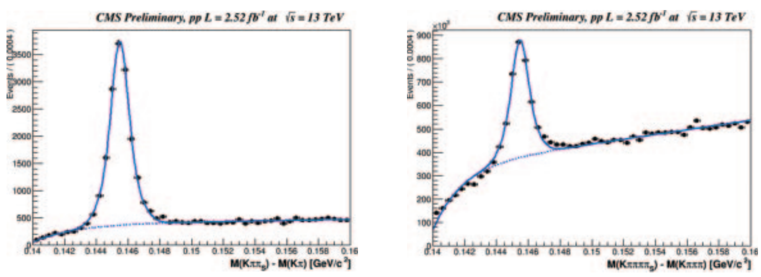

Fig. 2. – ΔM spectrum: the fit (blue line) well describe data (black dots) for both decay chains, two bodies on the left and four bodies on the right.

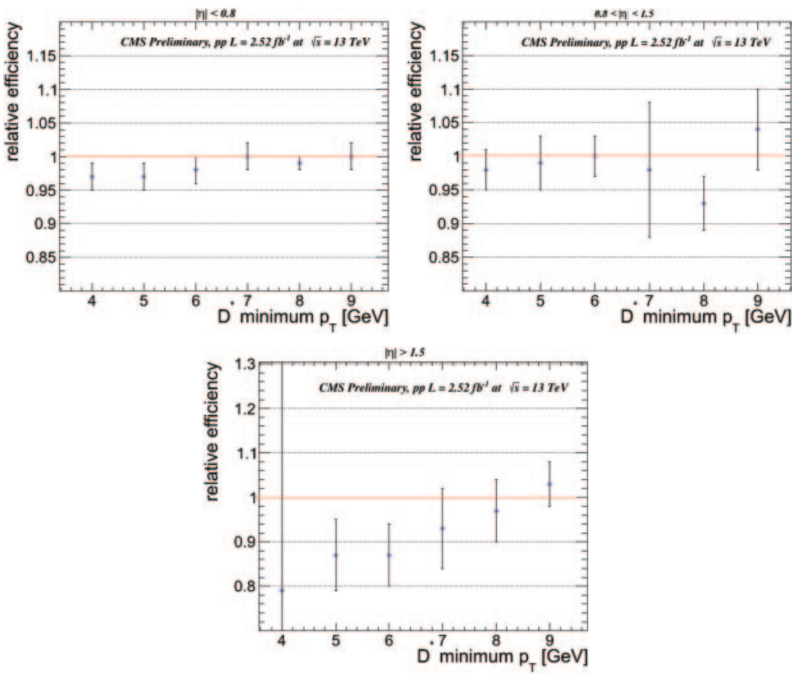

Fig. 3. – Relative efficiency for the charged-pion reconstruction.

4. – Conclusion

The relative tracking efficiency for charged pions is shown in fig. 3 in different pseudorapidity regions and for different pT_{D^*} thresholds. As expected the barrel region ($|\eta| < 0.8$) is the most performing; the relative efficiency is stable and close to one in the whole kinematics range.

REFERENCES

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