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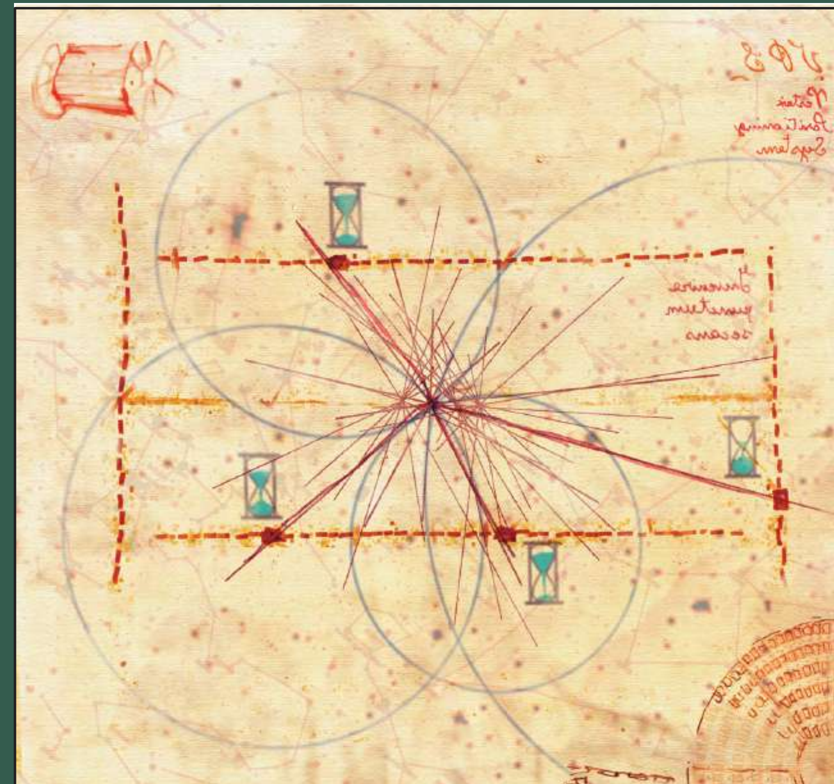
CERN-LHCC-2019-003
CMS-TDR-020
29 March 2019

CMS



A MIP Timing Detector
for the CMS Phase-2 Upgrade
Technical Design Report

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TECHNICAL DESIGN REPORT

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ISBN: 978-92-9083-523-3

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Acknowledgements

This document would not exist without the devoted efforts of many colleagues, too many to be named explicitly, who contributed text and figures to this TDR. We would like to thank the technical staffs from the various MTD institutions for their excellent work during the design and R&D phase of this upgrade, without which this TDR and the MTD itself would not be possible.

The very useful input from the MTD collaboration, the CMS internal reviewers (Wolfgang Adam, Johan Borg, Tulika Bose, Didier Contardo, Karl Gill, Frank Hartmann, Jan Kieseler, Katja Klein, Frans Meijers, Michael Moll, Paolo Rumerio, Alexander Savin, Jeff Spalding, Roberto Tenchini, Wolfram Zeuner), and the chair of the Phase-2 TDRs editorial board (C. Lourenço) helped to improve the quality of this document and is greatly appreciated. We also thank the individual and institutional reviewers who participated in the Collaboration-Wide Review of the TDR.

We would like to acknowledge the support of the CMS Management, the Upgrade Project Coordination team as well as the many contributions from CMS Technical Coordination. We thank the Offline, Computing, Physics Performance and Datasets, Upgrade Physics Strategy Group, and all the Physics groups for their help in developing and executing the physics and performance studies. The CMS Tracker and Endcap Calorimeter Upgrade projects provided crucial support and advice on various inter-detector coordination issues.

Chapter 5

Reconstruction, performance and physics impact

5.1 Introduction

Studies have been performed on the impact of the MTD on the physics deliverables of CMS. The CMS event reconstruction relies on a Particle Flow algorithm [10] that provides the most global description of an event. With the addition of track-time information from the MTD, the event reconstruction is significantly improved. The time information from charged tracks is exploited in a space-time reconstruction of tracks and vertices (Section 5.2). Final state particles and observables are defined using vertices and track collections that are cleaned from spurious (pileup) tracks using space and time compatibility requirements (Section 5.3). The cumulative effect of the benefits on individual final state observables is quantified on a selected set of analyses of key physics processes of the HL-LHC program, such as precision measurements of the Higgs boson, the search for di-Higgs boson production, and the search for new signatures, including long-lived particles (Section 5.4). Particle identification from time-of-flight measurements with the MTD also provides unique opportunities in Heavy Ion physics.

Acceptance and efficiency studies, as well as the study of the track association with the time measurements in the MTD and the study of physics observables rely on a complete simulation of the MTD in the CMS Phase-2 detector using the GEANT package [113], with a detailed description of the MTD geometry (Section 5.2). The digitization process, with a complete simulation of the signal pulses, the leading edge discrimination and amplitude reconstruction, is based on the current design of the readout electronics and tuned using input from test beam data. The time information from the MTD, matched to the charged tracks and extrapolated to the vertex (Sections 5.2.5 and 5.2.6), is incorporated in the track information and used in a "time-aware" 4D-extension of the deterministic annealing technique of the CMS vertex reconstruction. Current results demonstrate that the back-propagation of the time information to the production vertex makes a negligible contribution to the time resolution and validate the reliability of the results from the fast-simulation approach adopted in the MTD Technical Proposal [8].

In this document, studies of the MTD impact on final state observables and on the analyses of specific physics processes rely either on full simulation or on the parametric fast-simulation model of Ref. [8], in which the time information is added to the CMS simulation and reconstruction workflow with an appropriate smearing of the simulated track time at the production vertex. The efficiency for track-time measurements is also included in the fast simulation. For some studies, the DELPHES simulation package [114] is used.

Where relevant – for example for final state observables such as particle isolation – the studies

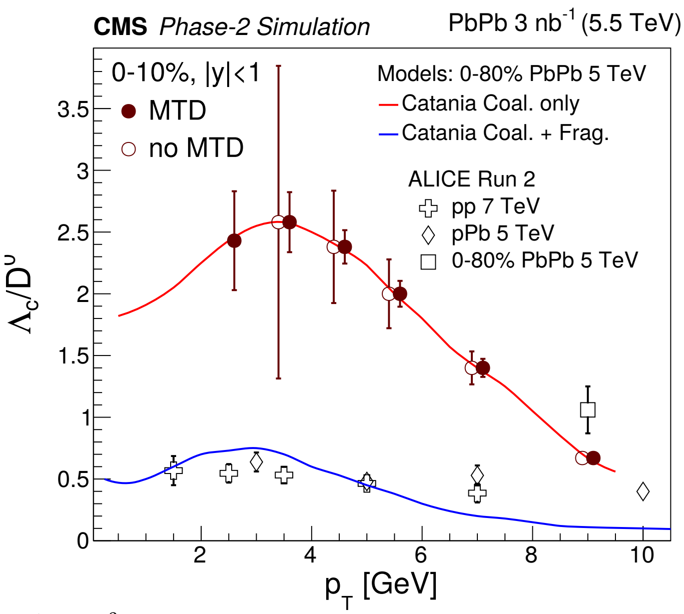

Figure 5.36: The Λ_c^+ to D^0 yield ratio as a function of p_T projected for 0–10% most central PbPb collisions at 5.5 TeV without (open circles) and with (filled circles) MTD, for rapidity range $|y| < 1$, corresponding to an integrated luminosity of 3 nb^{-1}. Only points with significance greater than 2 are shown. Curves represent theoretical calculations at midrapidity assuming scenarios of coalescence only and coalescence plus fragmentations [128]. Measurements in pp, pPb and 0–80% centrality PbPb at midrapidity by the ALICE collaboration [129, 130] are also shown.

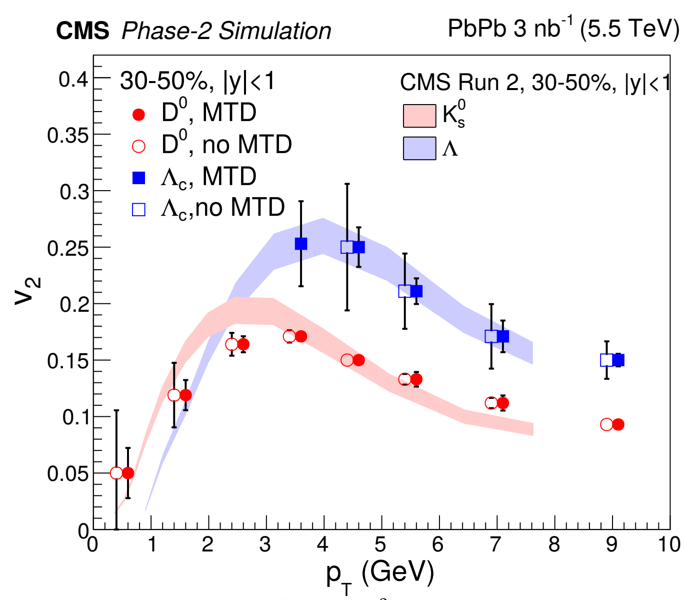

Figure 5.37: The elliptic flow (v_2) of Λ_c^+ and D^0 as a function of p_T projected for 30–50% centrality PbPb collisions at 5.5 TeV without (open markers) and with (filled makers) MTD, for rapidity range $|y| < 1$, corresponding to an integrated luminosity of 3 nb^{-1}. Only points with significance greater than 2 are shown. Measurements of strange meson and baryon v_2 for 30–50% centrality PbPb collisions from the CMS Run-2 are also shown (shaded bands) [131].