IL NUOVO CIMENTO **39 C** (2016) 223
DOI 10.1393/ncc/i2016-16223-0

Colloquia: IFAE 2015

LHCb upgraded Muon System performance studies

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received 7 January 2016

Summary. — After the second Long Shutdown of the LHC scheduled for 2018–2020, LHCb will operate at an istantaneous luminosity of $2 \cdot 10^{33}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ and at a centre-of-mass energy of 14 TeV. An overview of the LHCb Muon System Monte Carlo-based performance studies in upgrade conditions is presented.

1. – Introduction

The LHCb experiment is optimised to study b- and c-hadrons decays in order to perform CPV measurement and to possibly reveal New Physics. In this regard, the study of decay channels with muons in the final state is crucial, therefore the present muon system has been designed to ensure high momentum resolution and high efficiency at the present data-taking conditions.

At the upgrade conditions, the elevated particle fluxes could degrade the muon identification performances and lead to inefficiencies due to the dead time. In particular, particle misidentification has deleterious consequences on analyses requiring high signal purity.

2. – The LHCb Muon System upgrade

The current muon system consists of five stations: M1, located in front of the calorimeters, not used in the upgrade; M2 to M5, placed behind the calorimeters and interleaved with iron walls. Each station is divided into four regions, R1 to R4. They are equipped with MultiWire Proportional Chambers (MWPCs), except for M1R1 which hosts Gas Electron Multiplier (GEM) detectors.

The data from pp collisions collected at $\sqrt{s} = 7\,\mathrm{TeV}$ during the 2010 run allowed to study the performance of the muon detector [1] laying the groundwork for the extrapolations of the behaviour at high luminosity and for the possible interventions [2]. However, a detailed understanding of the possible solutions is still under study.

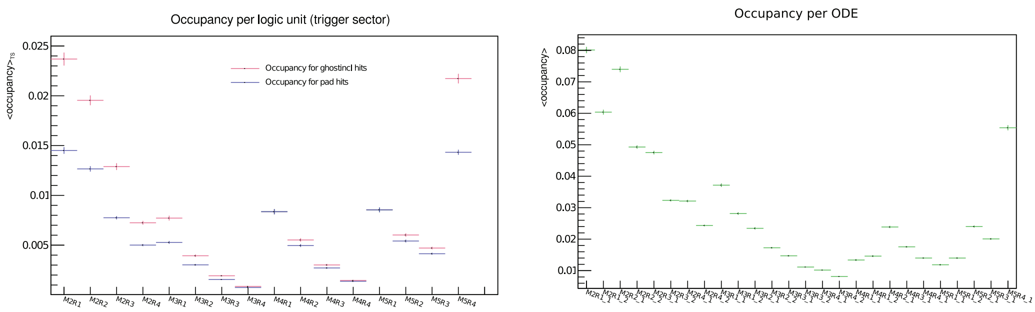

Fig. 1. – Left: mean occupancy for the current (ghostincl hits) and the pad (pad hits) readout scheme for all the regions. Right: average ODE channels occupancy for each ODE.

3. – Results on Monte Carlo studies

The official simulations for the upgrade do not reproduce correctly the low-energy background component and the cavern description, hence a tuned high luminosity Monte Carlo has been produced. A flexible tool that mimics the digitisation process and that allows to change the readout configuration with ease, has been developed.

The physical channels in the muon chambers are OR-ed to create readout strips read by the ODEs (Off Detector Electronics). The information on the logical pad is then reconstructed by crossing the strips. The crossing process generates fake hits that increase almost quadratically the measured rate and the occupancy consequently (as shown in fig. 1 left). Performance studies (see fig. 1 right) show that the occupancy of the most illuminated ODE channels is so high that could lead to a loss of information. A possible solution of this problem is the use of a pad readout in the most illuminated regions.

The muons are identified by extrapolating the tracks in acceptance with $p > 3\,\mathrm{GeV}/c$ and evaluating the number of hits inside a FOI (Field Of Interest) for each station. To evaluate the muon identification and misidentification performances at high luminosity, a muonID algorithm has been implemented. The studies do not show further advantages in the use of a pad readout. However, other solutions are under scrutiny.

4. – Conclusions

New readout configurations for the upgraded LHCb Muon System are under study. A pad readout is a promising solution for the most illuminated regions; together with the other foreseen interventions, this will improve the detector performances. The developed tool is crucial to understand the performances of the system and to define the interventions to be realised.

REFERENCES

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