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Background measurements and simulation for CODEX-b

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Abstract

Include abstract here.

List of changes between versions

- version 1
  - Start version.
- version 1.01
  - Add figures in each section and rewrite.
- version 1.02
  - Add contents at each section.

1 Introduction and motivation

This is the reference [1]
"The results shown are unofficial and have not been formally approved by the LHCb collaboration"

1.1 Motivations

There is no clear observation of new physics (NP) at the LHC as yet. The NP portal is considered in weakly coupled sector with long lifetime. The long lifetimes are very generic in any theory with multiple mass scales, broken symmetries and so on. Standard Model (SM) is a good example since it contains low mass particles with long lifetime such as electron, neutrino, proton and neutron.

1.2 Compact Detector for Exotics at LHCb

The Compact Detector for Exotics at LHCb (CODEX-b) was proposed to observe weakly coupled **LLP**s in LHCb cavern. Since ATLAS and CMS focused on high p_{T} and large QCD backgrounds and restricted lifetime of LHCb, current detectors can miss signals from weakly coupled **LLP**s. By following the fig. 1, the DAQ racks will be moved to the surface before run 3 and the CODEX-b will be placed at the site with 10 X 10 X 10 m size. The CODEX-b aparts 25 m from the impact point 8. If the DELPHI is removed, the size can be expanded to 20 X 10 X 10 m.

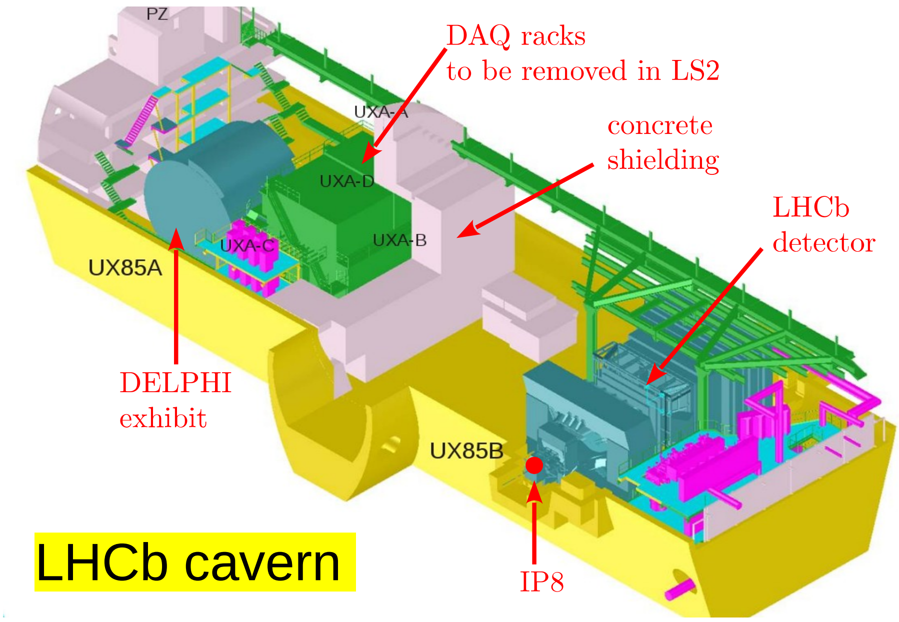

Figure 1: Schematic plot of LHCb cavern

2 Measurement

2.1 Background measurement

2.2 Test-bench

We used Herschel detector. For PMT, model: R1828-01 Because, it has high anode current upper limit, wide range of gain variation, fast time response to fit in 25 ns, large entry window to increase light yield, good single electron separation. The test-bench includes cosmic stand, scope with extended functions (auto save waveforms, coincidence logic), high voltage power supplies (1.5 kV, bias 350 V), current-voltage meter, laptop to remote connect to scope.

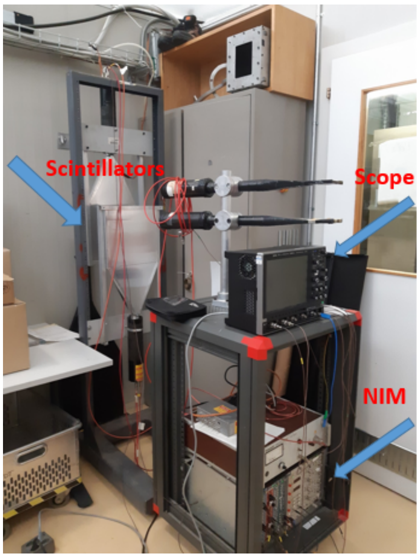

Figure 2: Test-bench photo

2.3 Trigger

We used simple 2x fold coincidence and a distance between two scintillators 2 cm. For this measurment, a discrimination (scope) threshold set as 30 mV. When first scintillator receive a signal and the other scintillator also receives a signal in 5 ns, scope counts. The scope automatically saved two waveforms from each scintillator and the number of mininum ionizing particles (mip) counted during the run.

2.4 Detail Configuration

The background measurement was taken at the LHCb cavern on D3 platform. The equipment had been set at 3 positions between DAQ racks and the concrete shield wall and the position between the DELPHI and DAQ racks. We basically placed the scintillator stand parallel to the beam line but also rotated 45° and perpendicular to the beam line. Fig 4. shows positions and configurations of measurement.

Figure 3: Trigger setup using coincidence occurence of two signals in 5 ns.

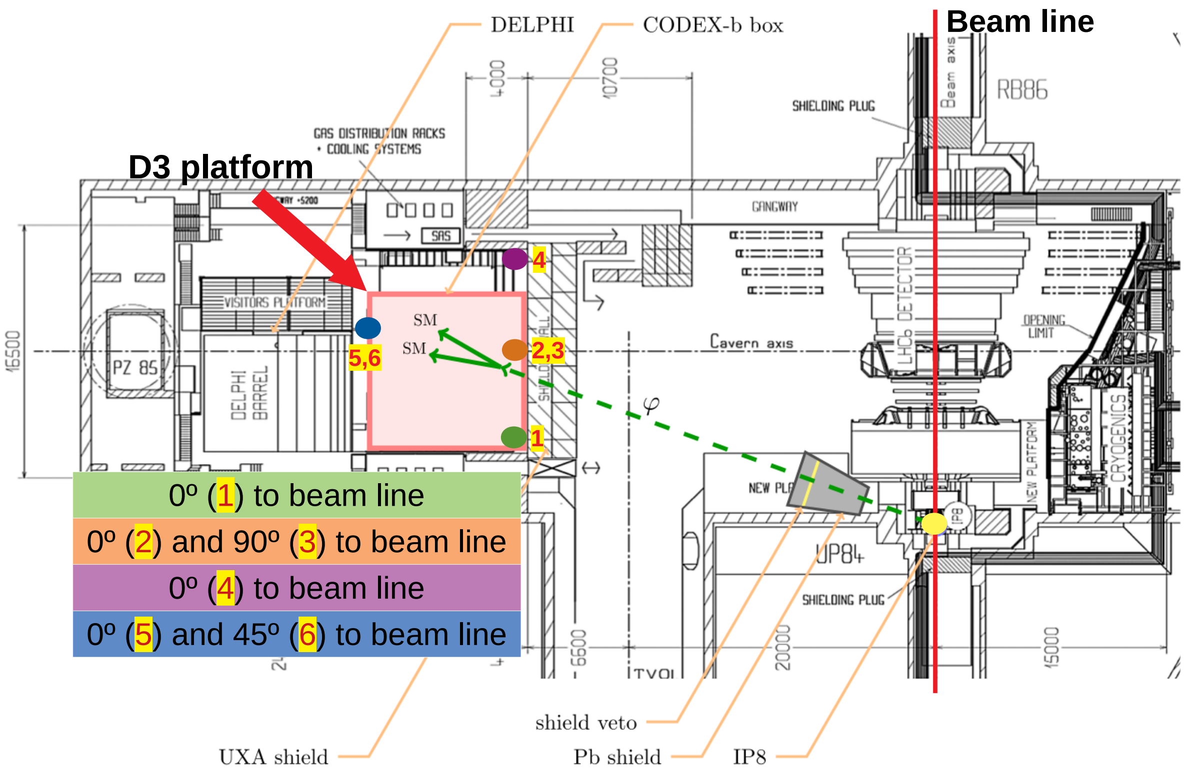

Figure 4: Four measurement positions at the LHCb cavern

2.5 Results

The measurement campagin spanning 17 days in July-Aug 2018. The scope performed 52036 triggers during the runi. The LHCb lumi rate was stable during the measurement.

There was no beam until July 30th because of machine develop and power cut happened during measurement.

Below tables are shown hit rate based on measurement position and configuration. The rate of pp collisions is 25 MHz. First table is about ambient background hit rate between fills and in MD without beam.

Position	Description	Hit rate [mHz]
P1	shield, right corner, $\parallel$ to beam	1.99 ± 0.07
P2	shield, center, $\parallel$ to beam	2.76 ± 0.03
P3	shield, center, $\perp$ to beam	2.26 ± 0.03
P4	shield, left corner, $\parallel$ to beam	3.11 ± 0.03
P5	shield + D3 racks, center, $\parallel$ to beam	1.95 ± 0.03
P6	shield + D3 racks, center, 45° to beam	2.22 ± 0.02

The average hit rate of each position and configuration is 2 mHz. It is indicated that background can be negligible. However, during stable beam, hit rate increases a large.

Position	Description	Hit rate [mHz]
P1	shield, right corner, $\parallel$ to beam	38.99 ± 0.99
P2	shield, center, $\parallel$ to beam	167.10 ± 1.43
P3	shield, center, $\perp$ to beam	82.81 ± 1.55
P4	shield, left corner, $\parallel$ to beam	517.45 ± 3.52
P5	shield + D3 racks, center, $\parallel$ to beam	73.58 ± 1.18
P6	shield + D3 racks, center, 45° to beam	15.71 ± 0.33

By moving position from P1 to P2, from P2 to P4, we found that hit rate depends on η

Figure 5: Photos from each position at D3 platform

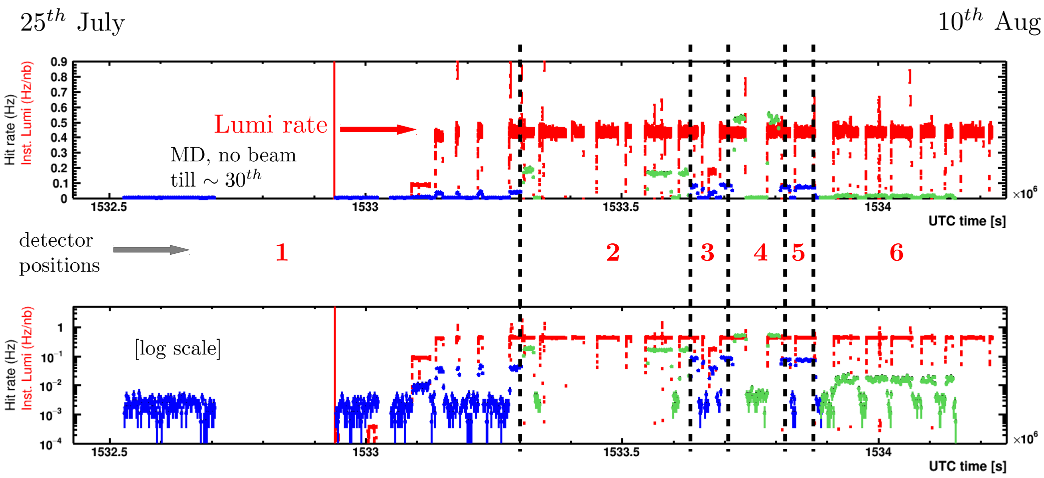

Figure 6: Hit rate plots during the run based on 6 positions/configurations linear and log scale. Red dots mean the lumi rate of LHCb, blue and green dots mean hit rates.

3 Simulation

3.1 Detector Description for High Energy Physics

I used Detector Description for High Energy Physics (DD4hep) standalone version. DD4hep is a software framework to provide overall detector description for experiments. It offers a consistent description through a single source of detector information for simulation, reconstruction, analysis, etc. I learn how to make geometry: layer, station, super staion, envelope (hierachy). I define materials for our detector and CODEX-b geometry such as concrete, Herschel detector. Layer consists of silicon, station consists of aluminum. There is a veto cone with two lead and one silicon. Also just in front of CODEX-b, concrete wall exists to veto muons. First of all, using muon particle gun with high energy, test our geometry. And then using HepMC to generate pp collisions and do the same process as muon particle gun. I made hierachy system to build CODEX-b (envelop, super station, station, layer). I could check energy deposits and positions of CODEX-b hits.

3.2 Simulation geometry

To make coincidence setup with test-bench, I made two Herschel plates with the same positions where all equipment have set. Two plates with 30 x 30 cm^2 size, 2 cm thickness. There is a concrete wall in front of scintillators. 3 m thickness to suppress particles from pp collisions. Roughly in 1000 events, it has hits on scinitillators 4 - 9 events. There is a proposed veto cone. It consists of two lead absorbers and one silicon tracker. There is also concrete wall which blocks radiations (or particles) to reach CODEX-b box. It has 3.2 m thickness.

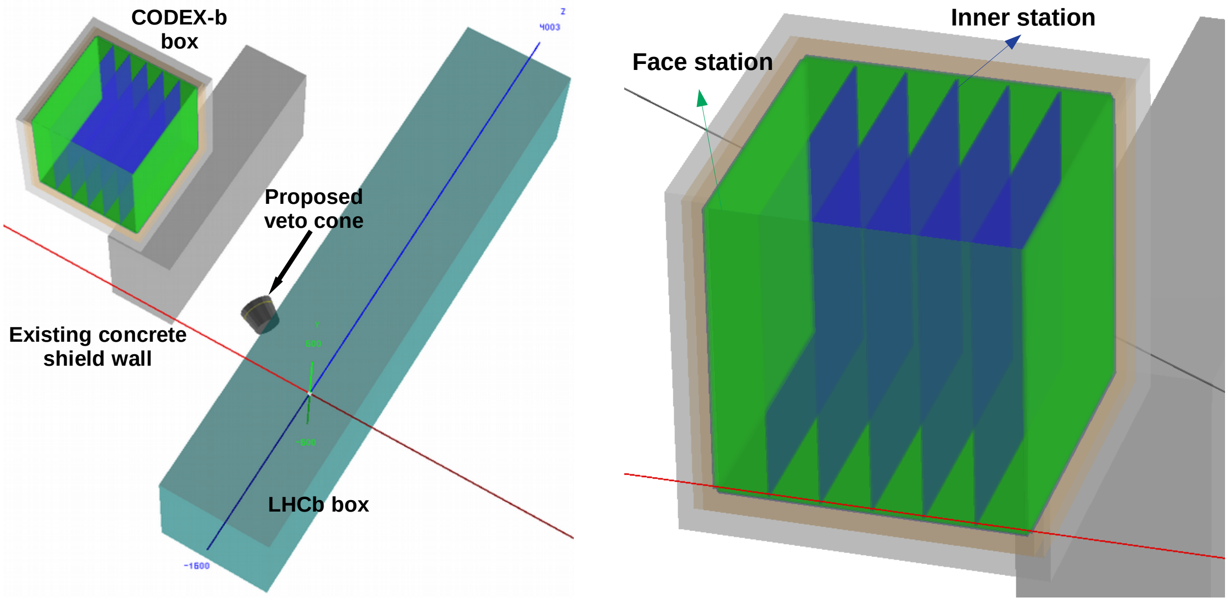

Figure 7: Wide view of CODEX-b simulation geometry

3.3 Simulation status

We designed two different detectors based on similar geometry, one is the CODEX-b and the other is scintillator. Both were tested with μ particle gun with 1 TeV and the minimum bias events generated from the standalone Gauss.

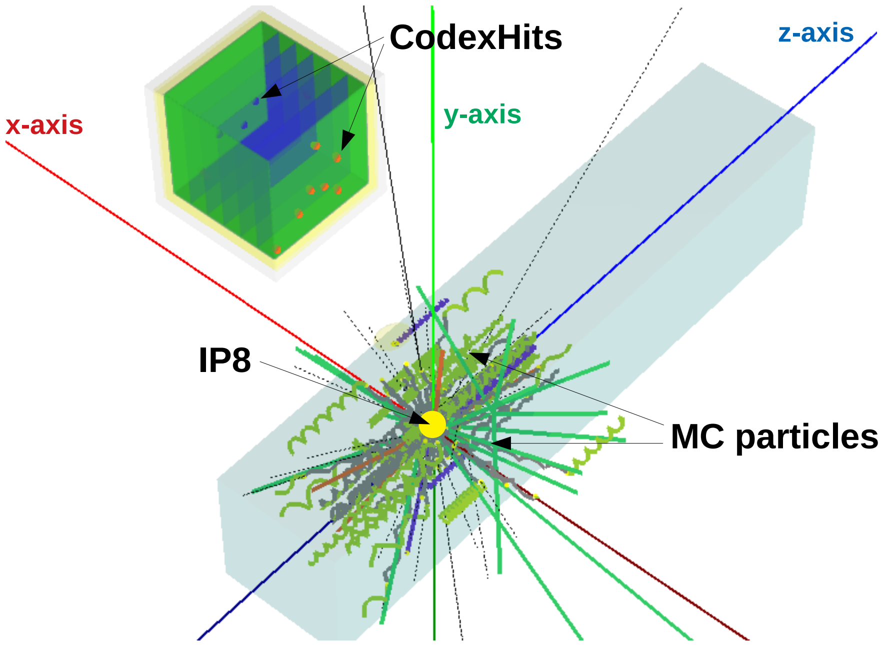

Figure 8: Validation of the CODEX-b simulation by removing the concrete shield wall with minimum bias events

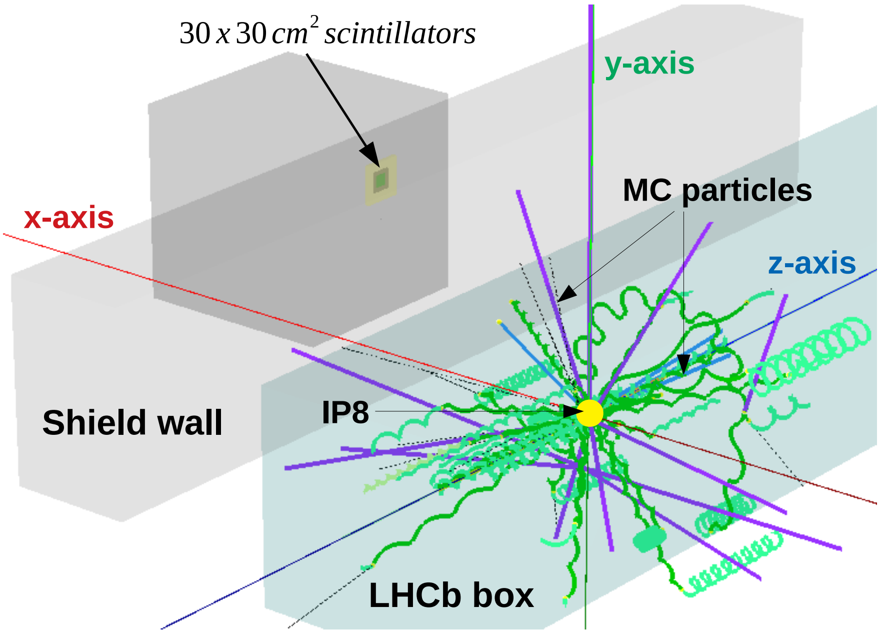

Figure 9: Test of the scintialltor configuration with minimum bias events

4 Summary

References

[1] V. V. Gligorov, S. Knapen, M. Papucci, and D. J. Robinson, *Searching for Long-lived Particles: A Compact Detector for Exotics at LHCb*, Phys. Rev. **D97** (2018) 015023, arXiv:1708.09395.