

Background measurements and simulation for CODEX-b

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Abstract

Include abstract here.

1 List of changes between versions

- 2 ● version 1
3 – Start version.
4 ● version 1.01
5 – Add figures in each section and rewrite.

6 1 Introduction and motivation

⁷ This is the reference [1]

⁸ “The results shown are unofficial and have not been formally approved by the
⁹ LHCb collaboration”

10 1.1 Motivations

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

¹⁶ 1.2 Compact Detector for Exotics at LHCb

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

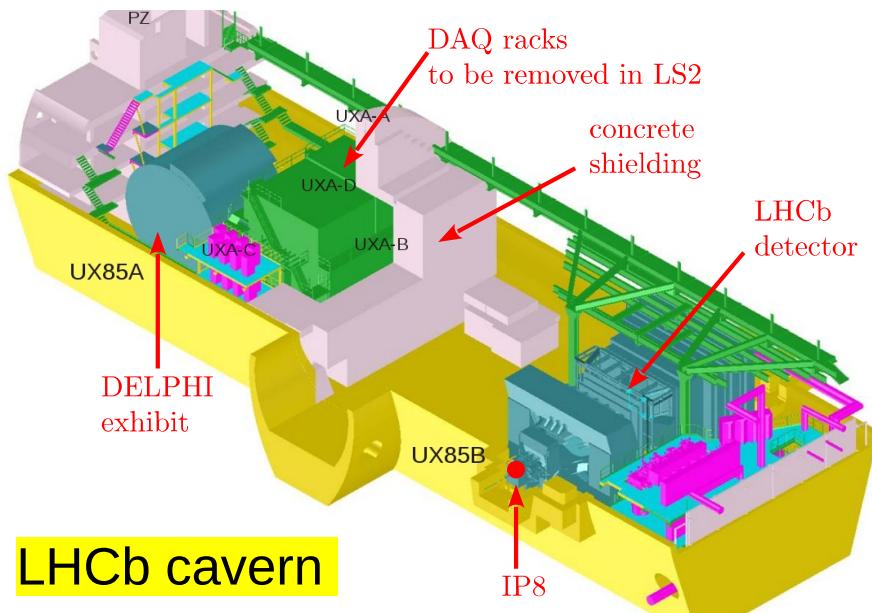


Figure 1: Schematic plot of LHCb cavern

24 2 Measurement

25 2.1 Background measurement

26 2.2 Test-bench

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



Figure 2: Test-bench photo

33 2.3 Trigger

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

39 2.4 Detail Configuration

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



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

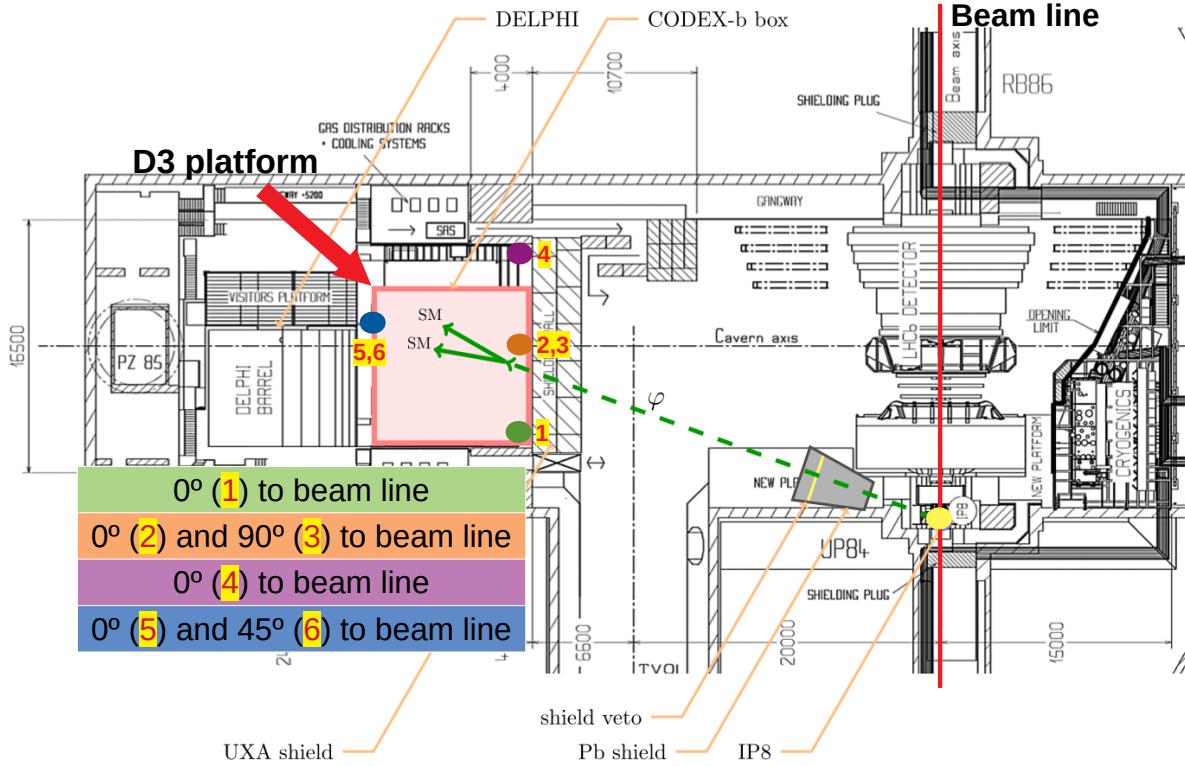


Figure 4: Four measurement positions at the LHCb cavern

45 2.5 Results

- 46 The measurement campaign spanning 17 days in July-Aug 2018. The scope performed
 47 52036 triggers during the runi. The LHCb lumi rate was stable during the measurement.

⁴⁸ There was no beam until July 30th because of machine develop and power cut happened
⁴⁹ during measurement.

⁵⁰ Below tables are shown hit rate based on measurement position and configuration.
⁵¹ The rate of pp collisions is 25 MHz. First table is about ambient background hit rate
⁵² 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

⁵³ The average hit rate of each position and configuration is 2 mHz. It is indicated that
⁵⁴ background can be negligible. However, during stable beam, hit rate increases a large.
⁵⁵

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

⁵⁶ By moving position from P1 to P2, from P2 to P4, we found that hit rate depends on
⁵⁷ η
⁵⁸

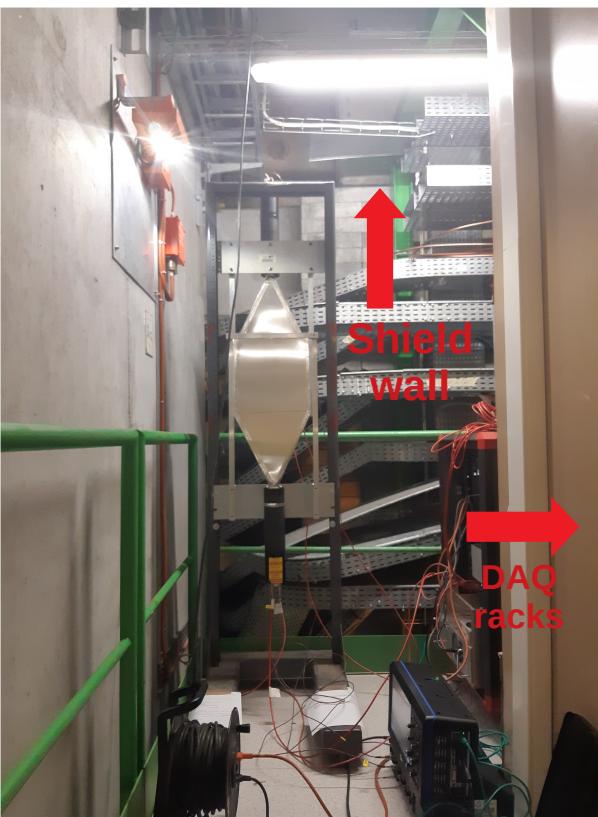


Figure 5: Photos from each position

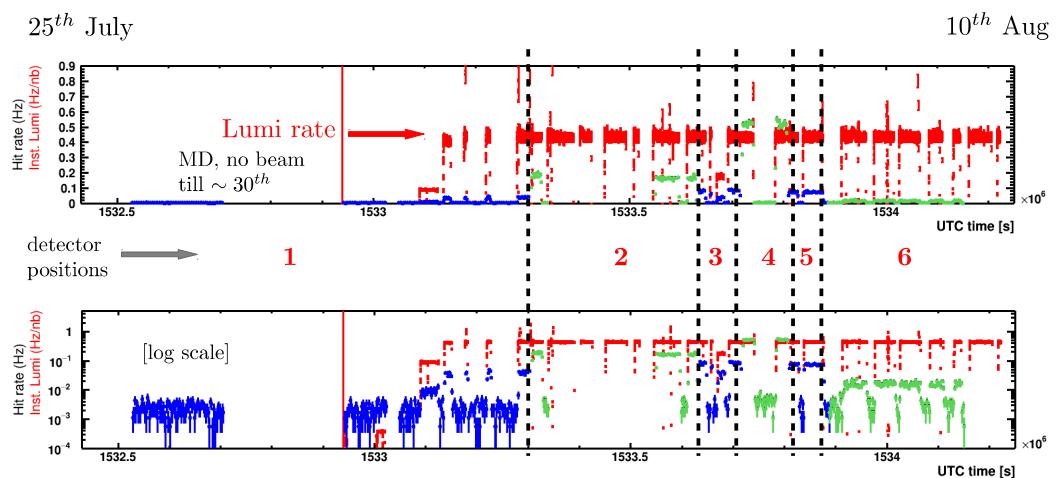


Figure 6: Hit rate plots during the run based on 6 positions/configurations linear and log scale. Red dots mean the lumi rate of LHCb, blue and green dots mean hit rates.

59 3 Simulation

60 3.1 Detector Description for High Energy Physics

61 I used Detector Description for High Energy Physics (DD4hep) standalone version. DD4hep
62 is a simulation program I learn how to make geometry: layer, station, super station, envelope
63 (hierarchy). I define materials for our detector and CODEX-b geometry such as concrete,
64 Herschel detector. Layer consists of silicon, station consists of aluminum. There is a
65 veto cone with two lead and one silicon. Also just in front of CODEX-b, concrete wall
66 exists to veto muons. First of all, using muon particle gun with high energy, test our
67 geometry. And then using HepMC to generate pp collisions and do the same process as
68 muon particle gun. I made hierarchy system to build CODEX-b (envelope, super station,
69 station, layer). I could check energy deposits and positions of CODEX-b hits.

70 3.2 Simulation geometry

71 To make coincidence setup with test-bench, I made two Herschel plates with the same
72 positions where all equipment have set. Two plates with $30 \times 30 \text{ cm}^2$ size, 2 cm thickness.
73 There is a concrete wall in front of scintillators. 3 m thickness to suppress particles from
74 pp collisions. Roughly in 1000 events, it has hits on scintillators 4 - 9 events. There is a
75 proposed veto cone. It consists of two lead absorbers and one silicon tracker. There is
76 also concrete wall which blocks radiations (or particles) to reach CODEX-b box. It has
77 3.2 m thickness.

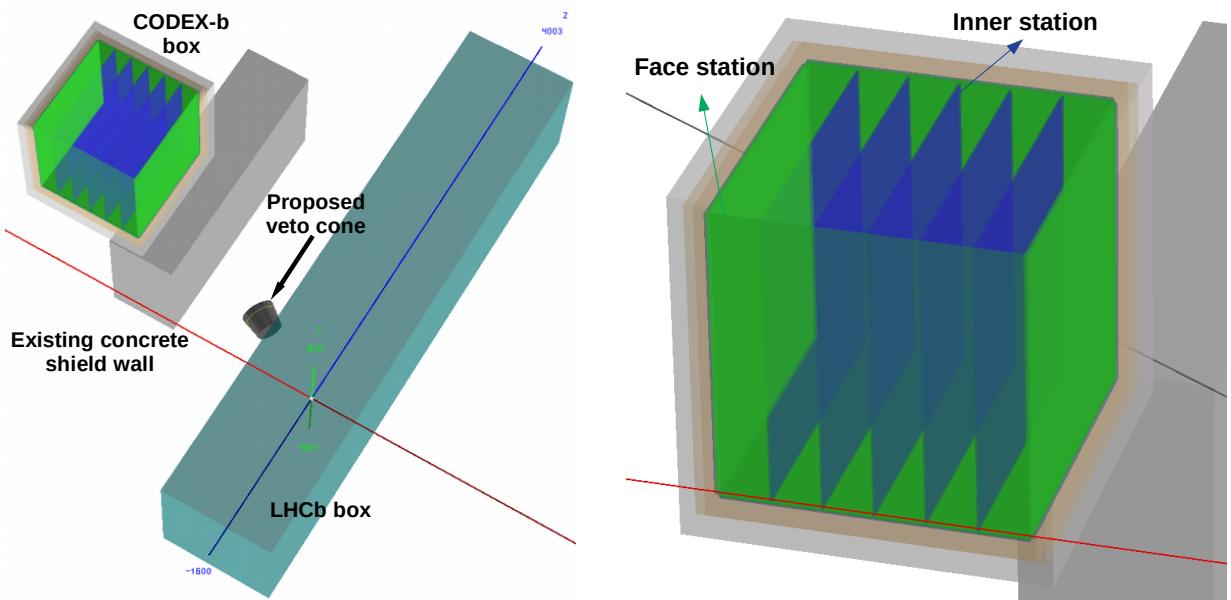


Figure 7: Wide view of CODEX-b simulation geometry

78 3.3 Simulation status

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

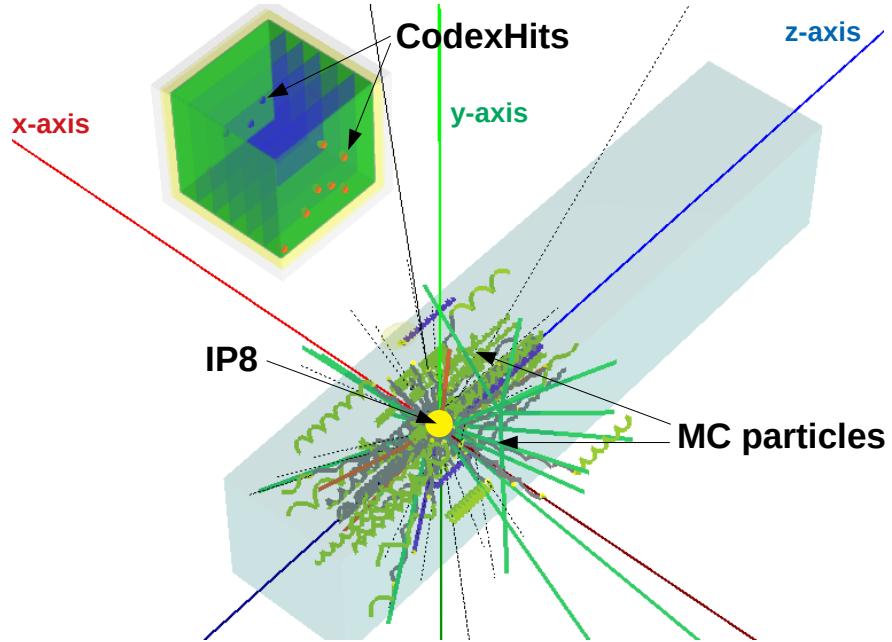


Figure 8: Validation of the CODEX-b simulation by removing the concrete shield wall with minimum bias events

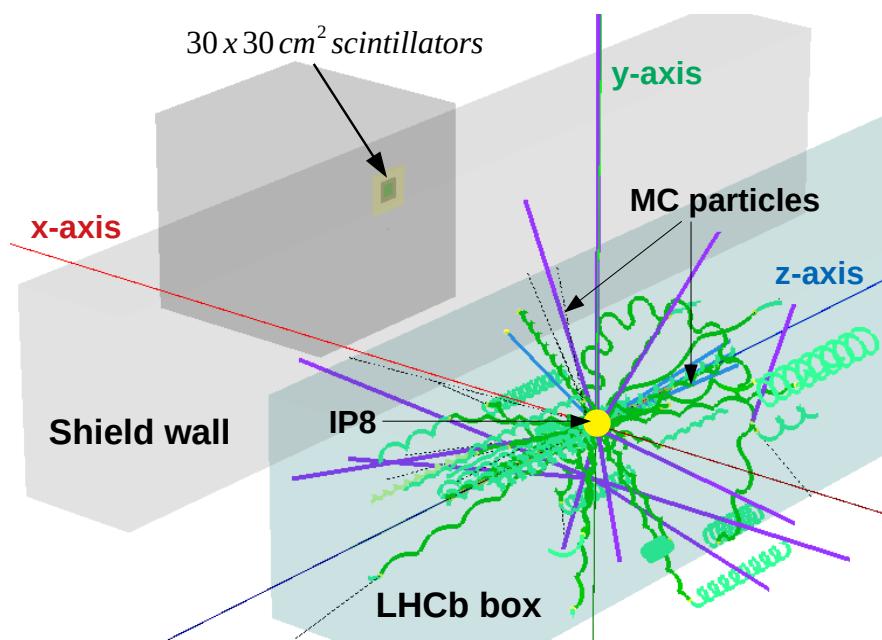


Figure 9: Test of the scintillitor configuration with minimum bias events

82 4 Summary

⁸³ **References**

- ⁸⁴ [1] V. V. Gligorov, S. Knapen, M. Papucci, and D. J. Robinson, *Searching for Long-lived*
⁸⁵ *Particles: A Compact Detector for Exotics at LHCb*, Phys. Rev. **D97** (2018) 015023,
⁸⁶ arXiv:1708.09395.