

# Background measurements and simulations for CODEX-b

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LHCb summer student presentation

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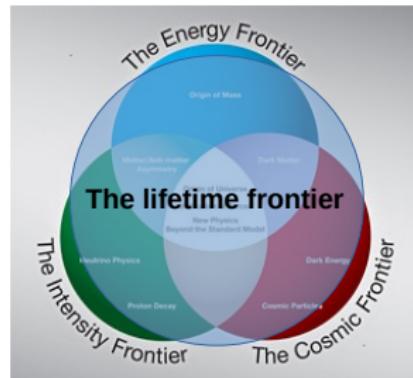
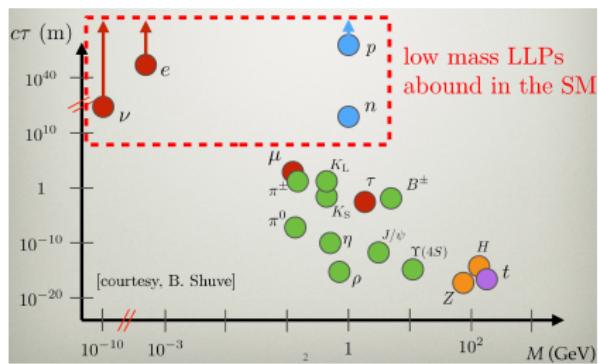
# About Me



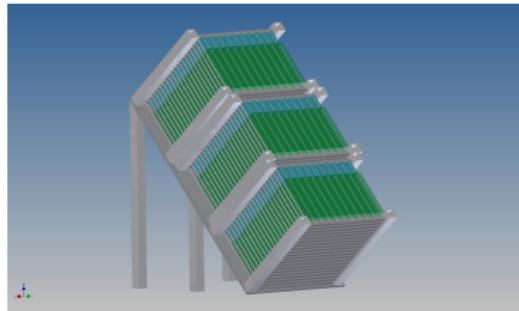
- From South Korea (9,200 km)
- Kyungpook National University, Daegu
- First year master course student in experimental high energy physics

# Long-lived particles (LLPs) at HL-LHC

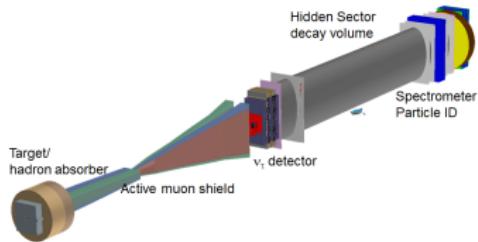
- No clear observation of new physics (NP) at the LHC as yet
- NP portal: weakly coupled sector with long lifetime
- Long lifetimes very generic in any theory with multiple mass scales, broken symmetries... SM is a good example



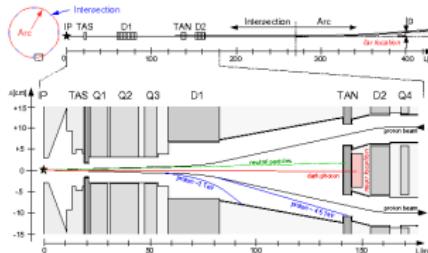
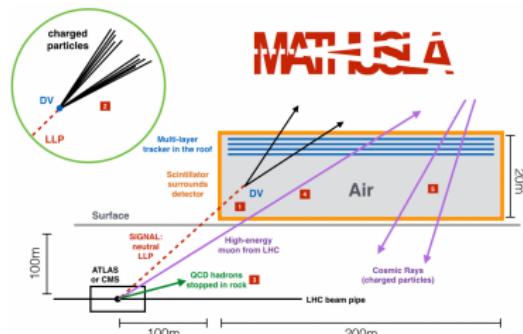
# Other LLP detector proposals at the LHC



MilliQan: 1607.04669



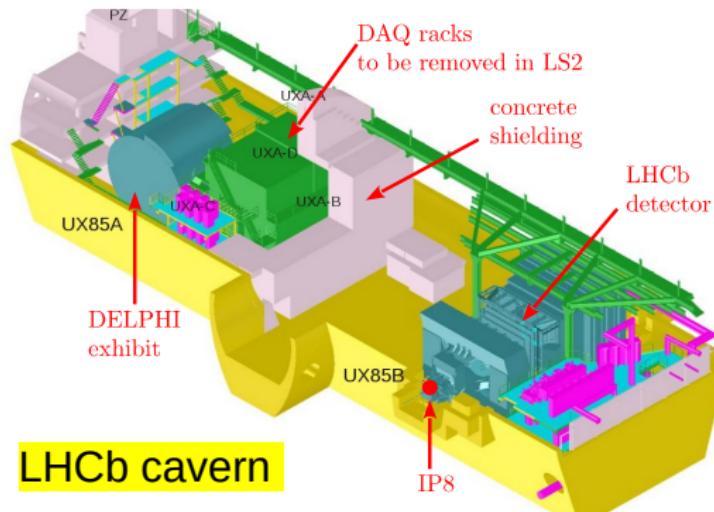
SHiP: 1504.04855



FASER: 1708.09389

# Introduction - CODEX-b

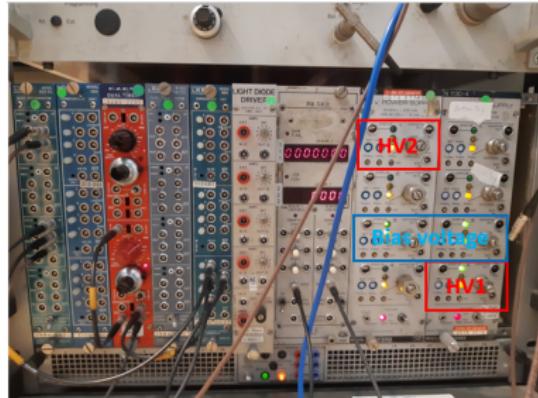
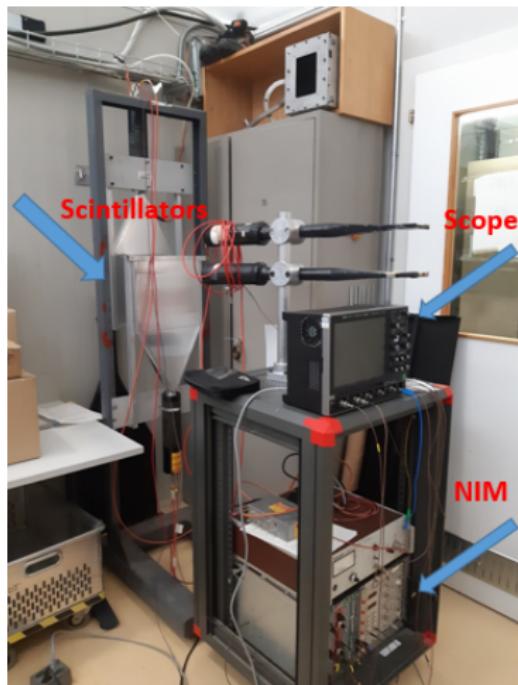
- COmpact Detector for EXotics at LHCb ([1708.09395](#))



- Move DAQ racks to surface for Run 3, instrument with tracking layers
- Measure background in UXA with beam on, for physics reach studies

# Measurements equipment setup

- About test-bench



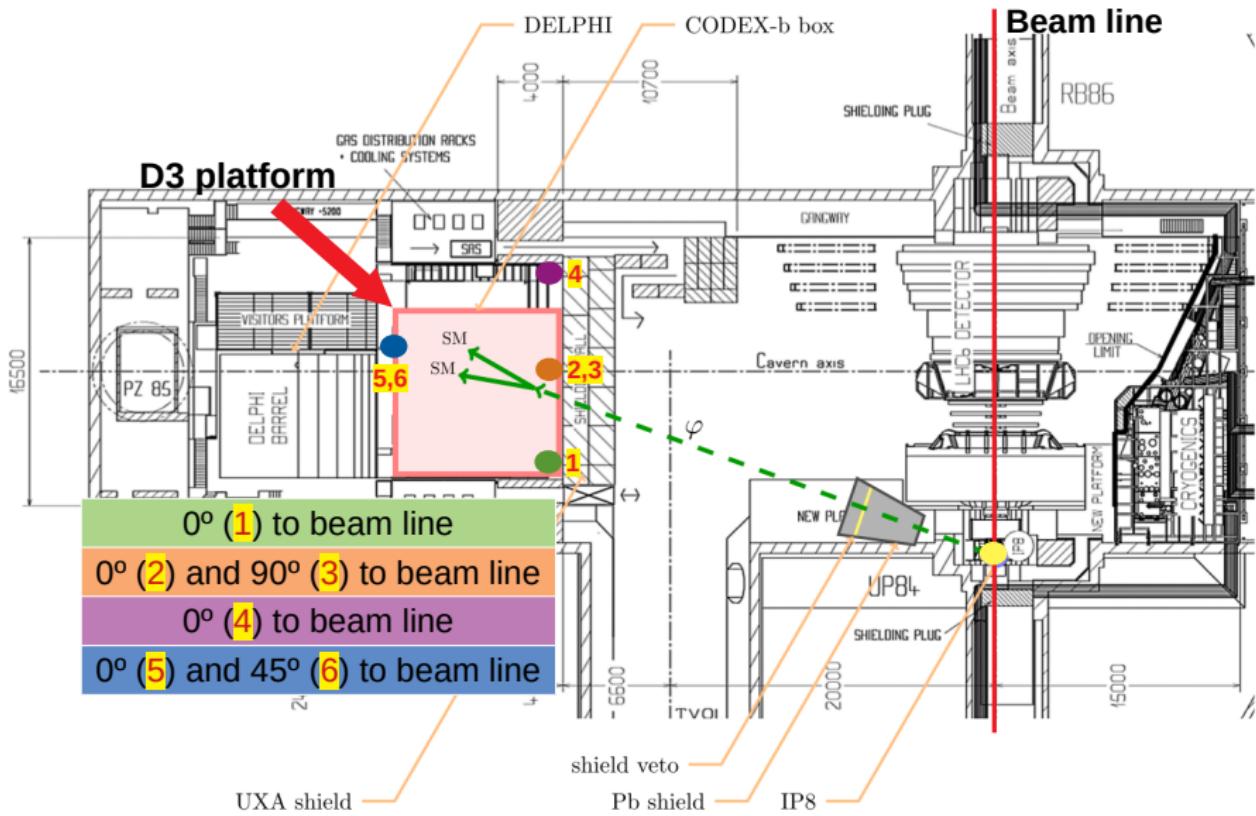
- Used equipments from Herschel detector
- Scintillators, PMTs, NIM, scope

# Scope trigger setup



- Yellow - 1st scintillator (B), pink - 2nd scintillator (A)
- Trigger threshold: -30 mV (falling edge)
- Coincidence trigger when event A and B occur within 5 ns

# Four measurement positions on D3 platform



# Measurements positions - photos



- D3 back passerelle right corner
- Parallel to beam line

- D3 back passerelle central
- Perpendicular to beam line

# Measurements positions - photos



- D3 back passerelle left corner
- Parallel to beam line



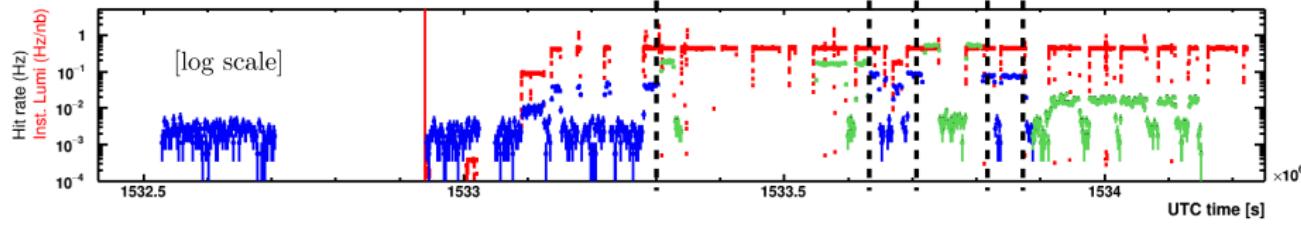
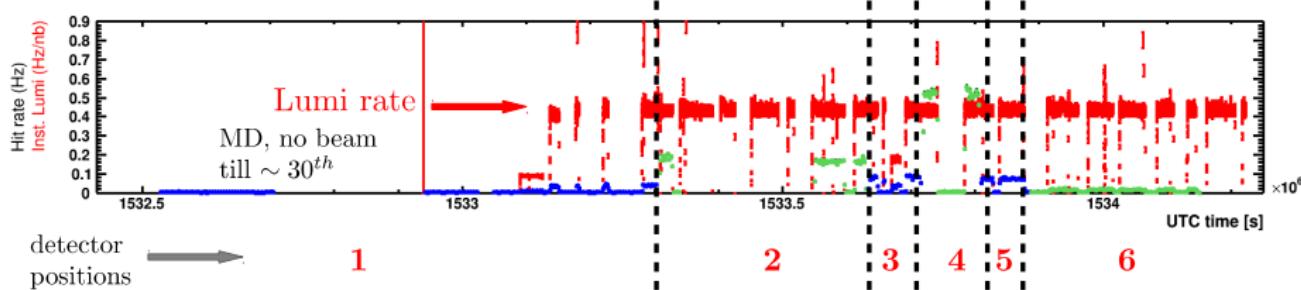
- D3 front central
- $45^\circ$  angle to beam line

## Global snapshot of the data

- Measurement campaign spanning **17 days** in July-Aug. **52036** triggers.
  - **6 positions/configurations** on D3 marked in blue and green, alternatingly:

25<sup>th</sup> July

10<sup>th</sup> Aug



## Detailed features – background rate w/o beam

- Reminder: rate of  $pp$  collisions + interactions is 25 MHz (PU=1).
- Ambient background hit rate between fills or in MD, without beam.

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

- Pretty consistent,  $\sim 2$  mHz, across all positions and essentially negligible

## Specific features – rate during stable beam

- Background hit rate during **stable beam**.

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

- Maximal rate at P4,  $\sim 0.5$  Hz during beam. Calibrate simulation.
- The D3 racks definitely add some shielding as well (hard to simulate).

## DD4hep

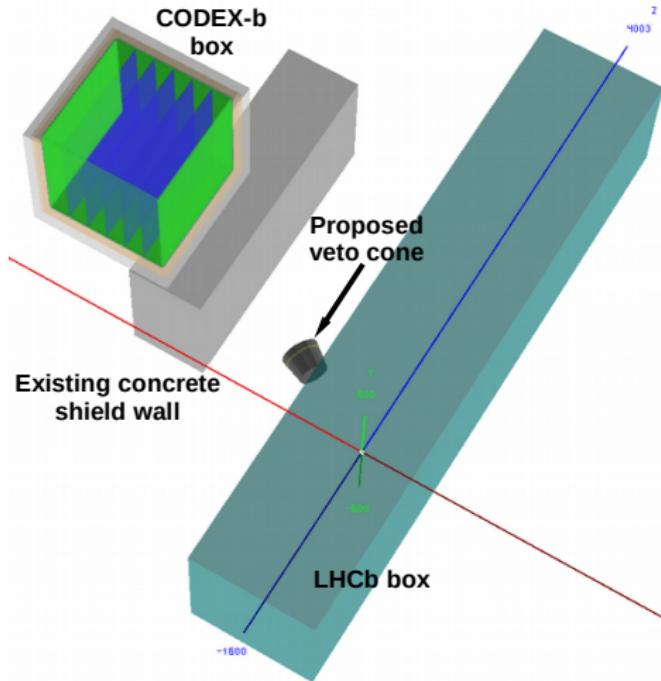
Detector Description Toolkit for High Energy Physics

<https://dd4hep.web.cern.ch/dd4hep/>

- DD4hep is a software framework for HL-LHC upgrade
- Since CODEX-b is a new detector for HL-LHC, we chose to use it

- Built CODEX-b geometry in DD4hep
  - Made **hierarchy system** (envelope → super station → station → layer)
  - Tested with a  $\mu$  particle gun
  - Checked **energy deposits and positions** of CODEX-b hits
- Tested with **MinBias** (standalone Gauss) → HepMC format → DDG4
- Hits read out using DD4hep plugin, checked that they look reasonable

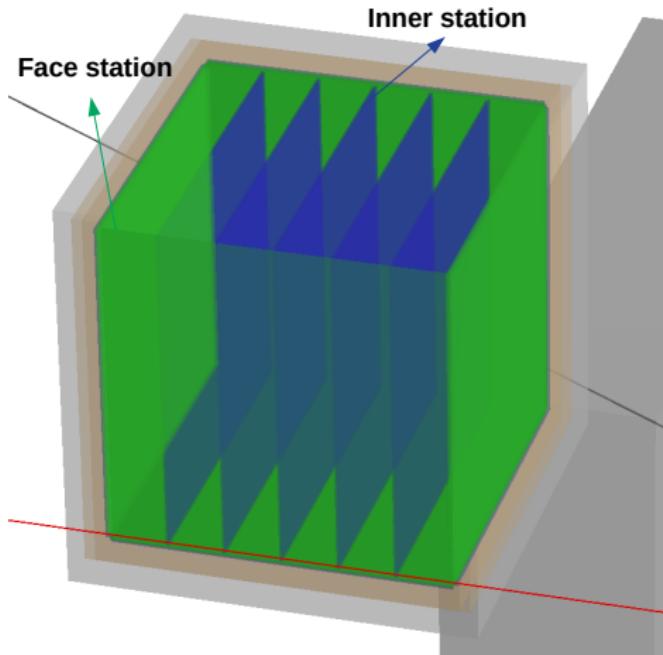
# Detector geometry in DD4hep



- Veto cone
  - Two Pb absorbers
  - One active Si shield layer
- Concrete shield wall
  - 3.2 m thickness
  - Block most particles from  $p\bar{p}$  collisions
- CODEX-b box
  - Consists of two types of stations

# Detector geometry in DD4hep - Zoom

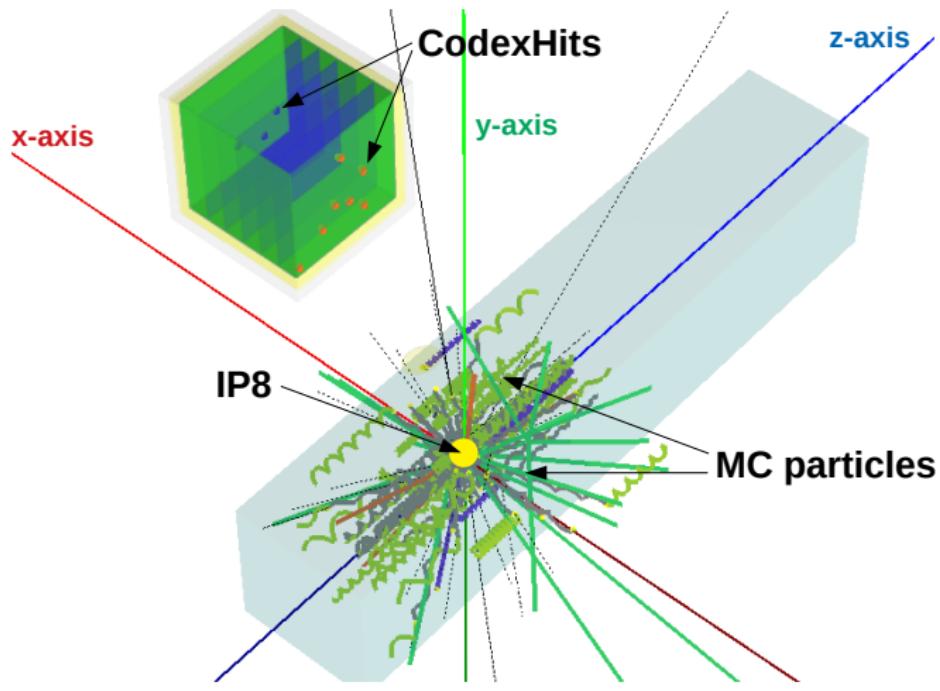
- Geometry was taken from 1708.09395 (not final!)



- Inner station (x5)
  - Silicon tracker
  - 3 layers of  $10 \times 10 \text{ m}^2$  size and 2 cm thickness
  - Distance between layers is 4 cm
- Face station (x6)
  - Silicon tracker
  - 6 layers of  $10 \times 10 \text{ m}^2$  size and 2 cm thickness
  - Distance between layers is 4 cm

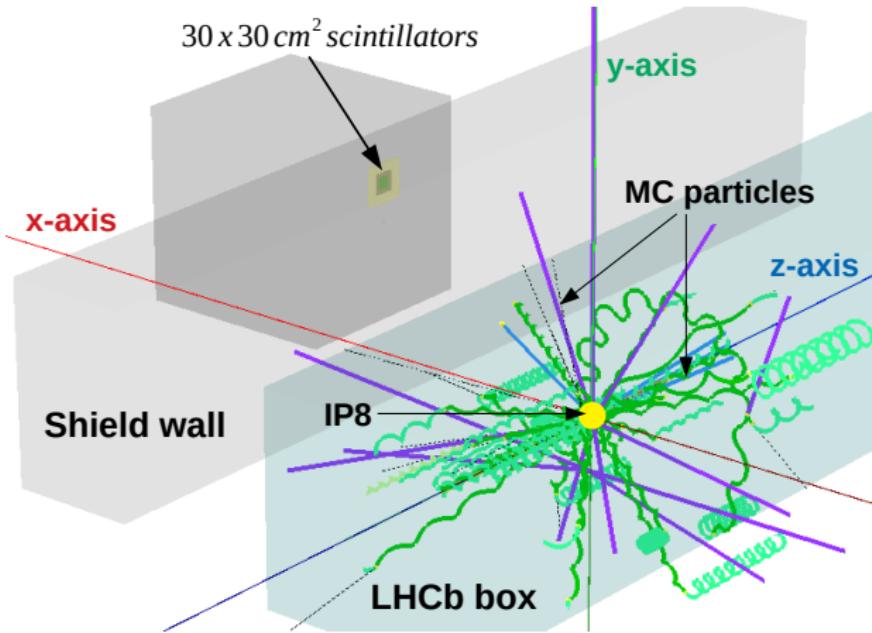
# DD4hep simulation with minbias events - CODEX-b

- 13 TeV minbias events with **existing shield removed**



# DD4hep simulation with minbias events - scintillators

- 32k events, generated in  $4\pi$ , using minbias.dec, no hits!



- New dec file with generator cuts is work in progress

## Summary and future plan

- Very successful background measurement campaign at D3
- Background rate just behind shield wall around 0.5 Hz over 900cm<sup>2</sup>
- DD4hep-based simulation fully tested both measurement and CODEX-b configurations
- Working on more efficient MC generation in Gauss w/ generator cuts
- Presented at Run meeting on 10/08
- Once simulation is ready, finalize the internal note

# Acknowledgements

- My summer student supervisors: Biplab Dey, Victor Coco
- DD4hep developer: Markus Frank
- Equipments from Herschel detector: Heinrich Schindler, Raphael Dumps
- Theoretical parts: Vladimir Gligorov
- At the pit: Tengiz Kvaratskheliya

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Thanks to LHCb for a wonderful experience !

# Thank you