Background in the CMS Drift Tubes: measurements with LHC collision data and implications for detector longevity at HL-LHC

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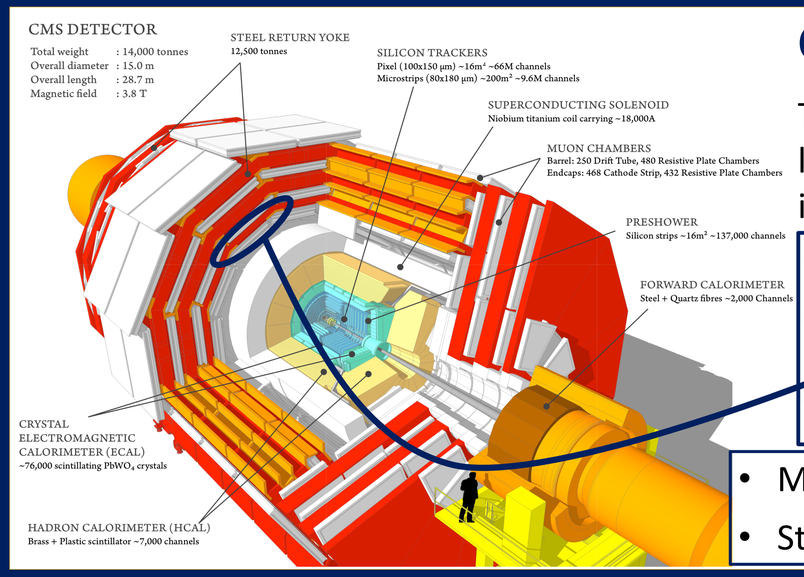
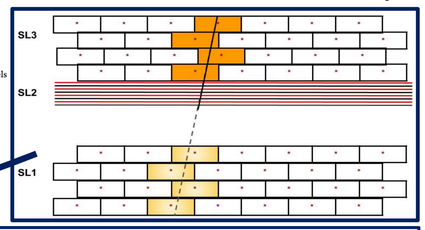
CMS Drift Tubes gaseous muon detector



The CMS Drift Tubes (DT) muon detector, built for standing up the LHC expected integrated and instantaneous luminosities, will be called to operate also in the High Luminosity LHC (HL-LHC) at a 5 times larger instantaneous luminosity: higher levels of radiation, about 10 times the expected LHC integrated luminosity



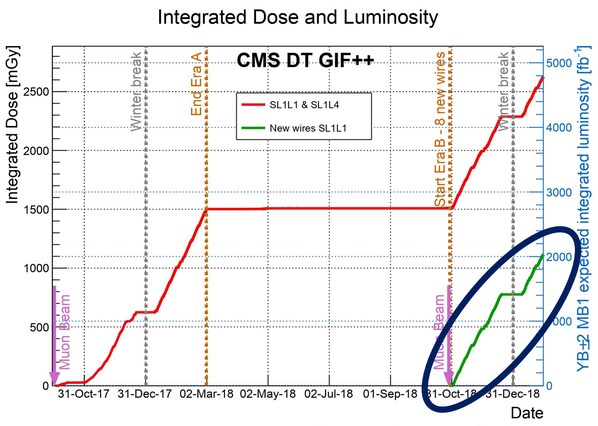
- Muon track reconstruction
- Standalone trigger

Background studies

- Longevity studies show ageing of the DT chambers, but given the redundancy of the DT system the ageing effects have a small impact on the muon reconstruction
- Measurements of background in the CMS DT system exploiting Run-2 data are crucial to keep the its levels under control and understand the impact at HL-LHC

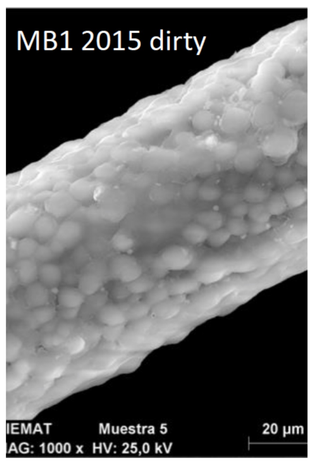
Accelerated ageing studies @ CERN Gamma Irradiation Facility (GIF++) [1]

Irradiation of a DT MB2 chamber started in October 2017 (2 layers with HV on, non-aged layers used as reference)



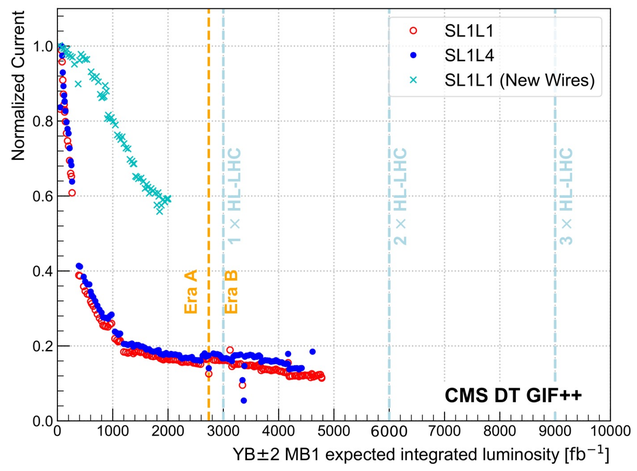
Integrated dose as a function of time

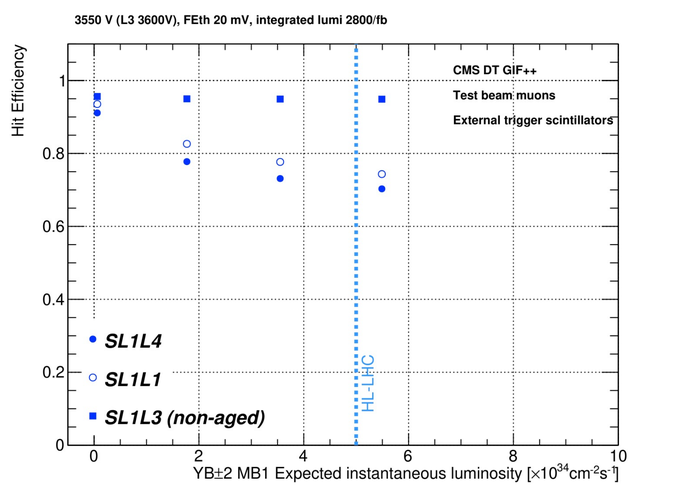
- few wires replaced in SL1 L1 to study extracted wires and monitor the ageing of the new ones



Electronic microscope scan of an extracted aged wire coated with pollutant

Normalized current of irradiated layers (and new wires) wrt reference layer



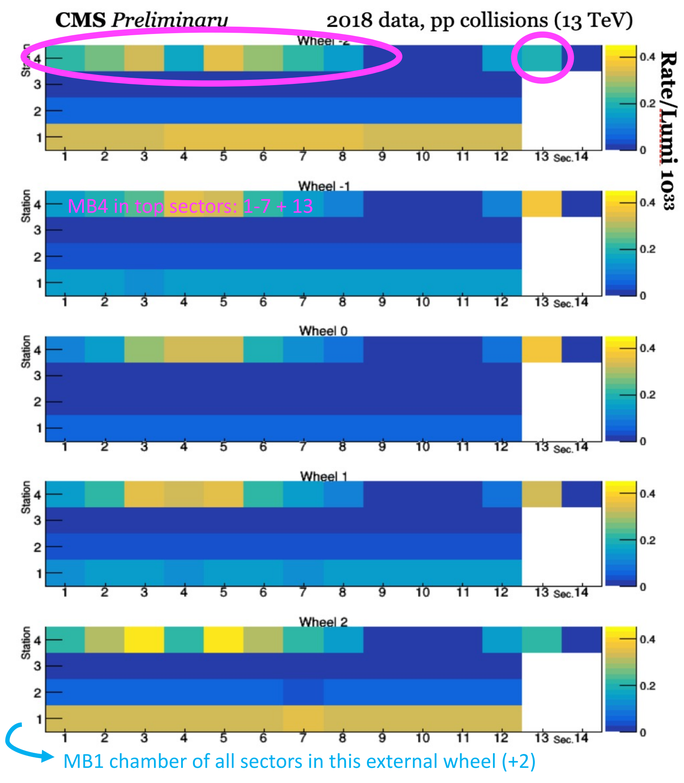


Hit efficiency as a function of instantaneous luminosity

Clear indication of lower efficiency in the aged layers

Background studies with Run-2 data [2] [3]

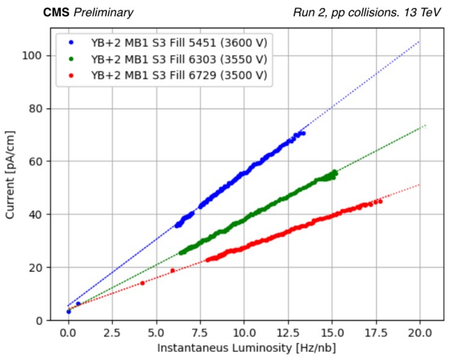
Hit rates



Measurement of the currents

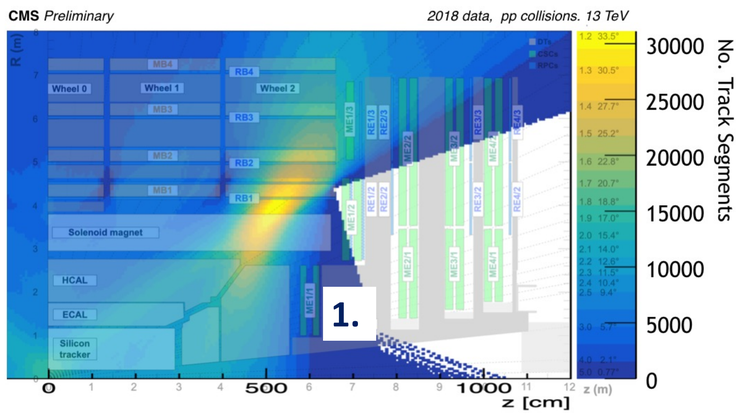
Currents show (as expected) a linear dependence on LHC Instantaneous Lumi

- Slopes depend on the chamber position and High Voltage (HV) settings
- Since the trends of currents vs LHC Luminosity are linear in all chambers, the slopes obtained by fitting these trends are used to characterize the background

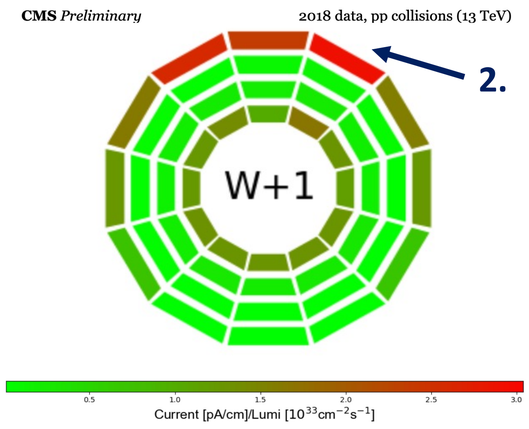


Highest background levels observed in:

1. **MB1** chambers of external wheels **coming directly from the interaction point**
2. **MB4** chambers of top sectors of all **coming from outside the detector, "neutron gas" setting up in the cavern**



Background segments reconstructed in the MB1 chambers propagated in the z-R plane: due to calorimeter gaps and originate from conversions in the solenoid or in the iron yoke

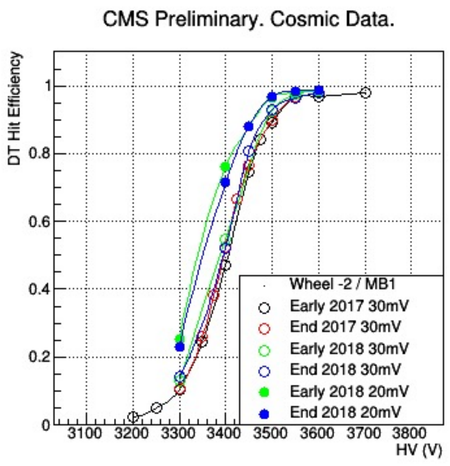


Slope of current vs LHC Luminosity

Actions to reduce background level and mitigate ageing effects [3] [4]

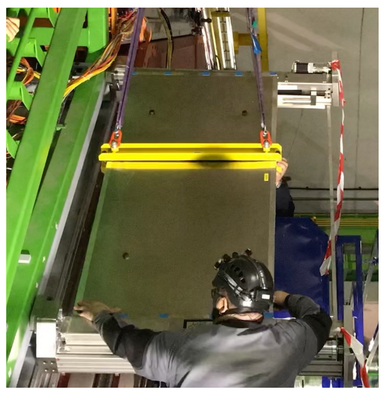
Lowering of High Voltage of some chambers

Anode HV in the most exposed chambers progressively reduced to these values (same for Run-3)

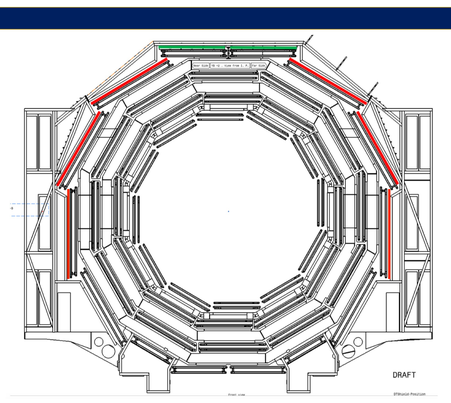


Lowering of the FE threshold to compensate for the small loss of efficiency in the MB1 chambers

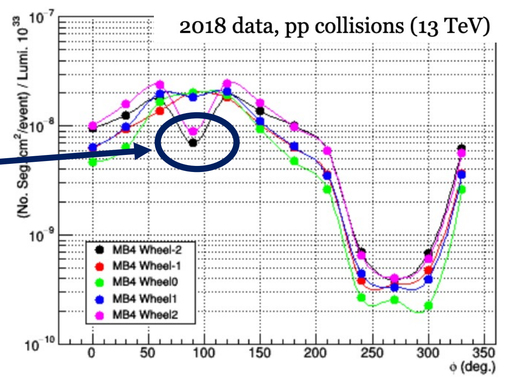
Installation of shields in all top sectors



Lead + borated polyethilene shielding cassettes installed in all top sectors



Different prototype shields already installed during Run-2 in Sect 4 of wheel +/- 2



Significant effect on the background segment density!

Waiting for Run-3 to confirm the reduction of the background levels in all top sectors

References from the CMS DT public results TWIKI: https://twiki.cern.ch/twiki/bin/view/CMSPublic/DtPublicResults

[1] CMS DT Longevity Studies - new HGCal geometry
[2] Background measurements in the CMS DT chambers during LHC Run 2
[3] Background studies in the CMS DT chambers during LHC Run 2
[4] DT hit efficiency measurements with reduced High Voltage