Study of the effects of radiation on the CMS Drift Tubes Muon Detector for the HL-LHC

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The DT CMS detector at the HL-LHC

During the High Luminosity LHC (HL-LHC) the CMS Drift Tubes (DT) chambers will receive 10 times the radiation they were designed for. The extreme conditions of the HL-LHC may have an impact on the detector performance.

The continuous operation of the DT chambers under a high radiation environment is known to produce the deposition of outgassing material on the anode wires (aging), changing their resistivity, and thus, reducing the amplification and the efficiency of detecting the signal caused by the passing muons.

The effect of the aging is being investigated. Several strategies of mitigating the aging by removing the depositions or reducing the efficiency drop by changing the HV values are being developed.

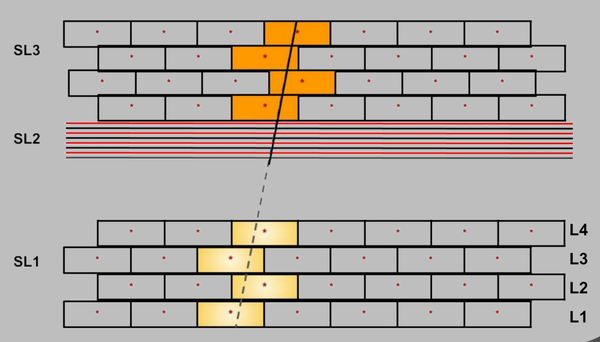
MB2 chamber irradiation at GIF++

A MB2 DT spare chamber was introduced in the bunker of the CERN Gamma Irradiation Facility (GIF++) in September 2017. Two layers, 1 and 4, of superlayer 1 (SL1L1, SL1L4), were irradiated while operated at 3550 V. The rest of the chamber was kept on standby. The exercise was mostly performed at a source rate equivalent to 10 times the expected background rate for the MB1 chambers on the external wheels ($YB_{\pm}2$) during the HL-LHC.

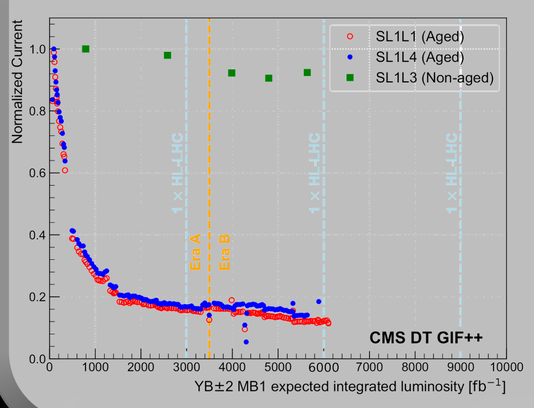
Hit efficiency definition and trigger

The efficiency to detect a hit in a cell of a layer is defined as the ratio between the number of detected and expected hits. The position of expected hits is determined using sets of well reconstructed track segments with 4 associated hits in SL3 and at least 1 hit in SL1.

Internal DT auto trigger is used to measure cosmic muons. External scintillators were used to trigger events during muon beam runs.



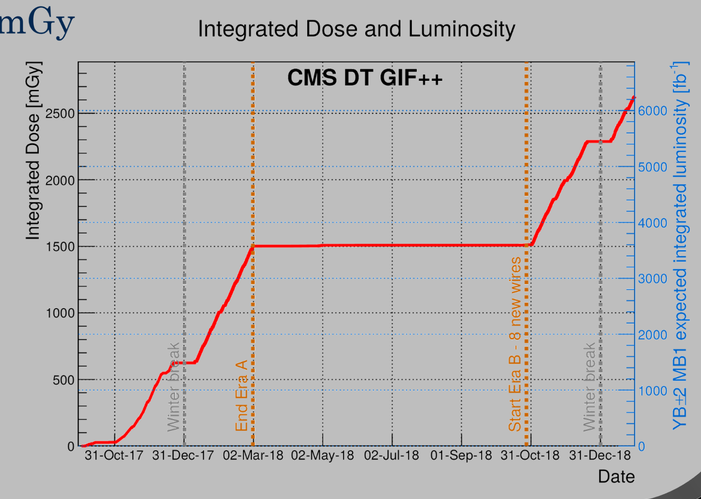
Evolution of currents with the integrated luminosity



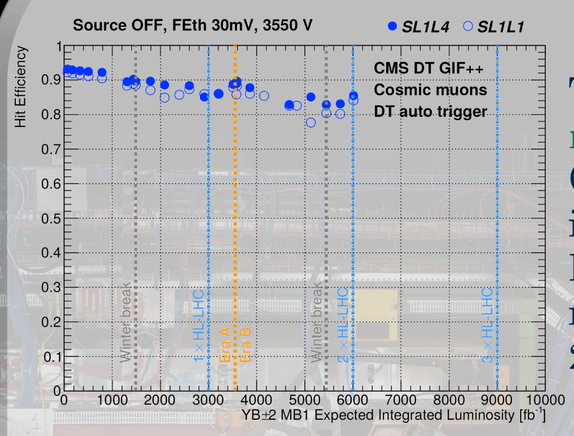
The currents in the aged layers (SL1L1, SL1L4) were monitored during the irradiation period. The currents on the non-aged layer SL1L3 are used as a reference. Most of the drop of currents is observed during the first 1000 fb^{-1} of accumulated luminosity.

Dose rate and extrapolation to HL-LHC conditions

At GIF++, the dose rate is measured with a REMUS dosimeter situated inside the GIF++ bunker and it is extrapolated to the dose rate at the surface of the MB2 chamber using a portable dosimeter. The dose is converted into expected instantaneous and integrated luminosity for the MB1 chambers on the external wheels (YB±2) during the HL-LHC. A conversion factor of 1 fb^{-1} = 0.304 (0.42) mGy for the HL-LHC (x10) instantaneous luminosity have been calculated. By Feb. 2019, the chamber accumulated a dose equivalent to 2 times the one expected at the HL-LHC.



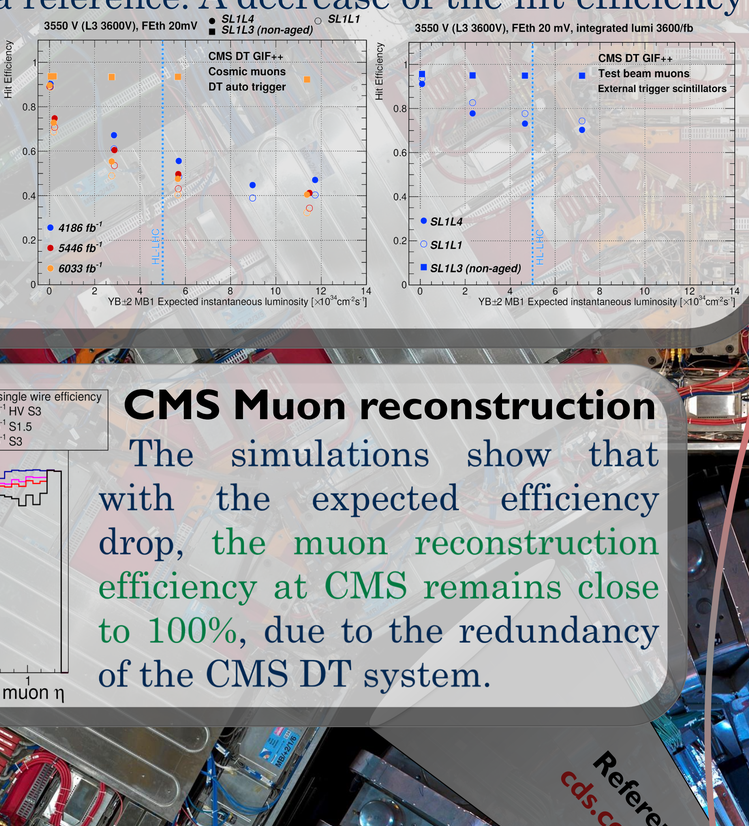
Evolution of the hit efficiency with the integrated luminosity



The hit efficiency was weekly measured with no background (source off) during the irradiation of the chamber. For a HV of 3550 V, the hit efficiency is reduced <10% after integrating 2xHL-LHC expected luminosity.

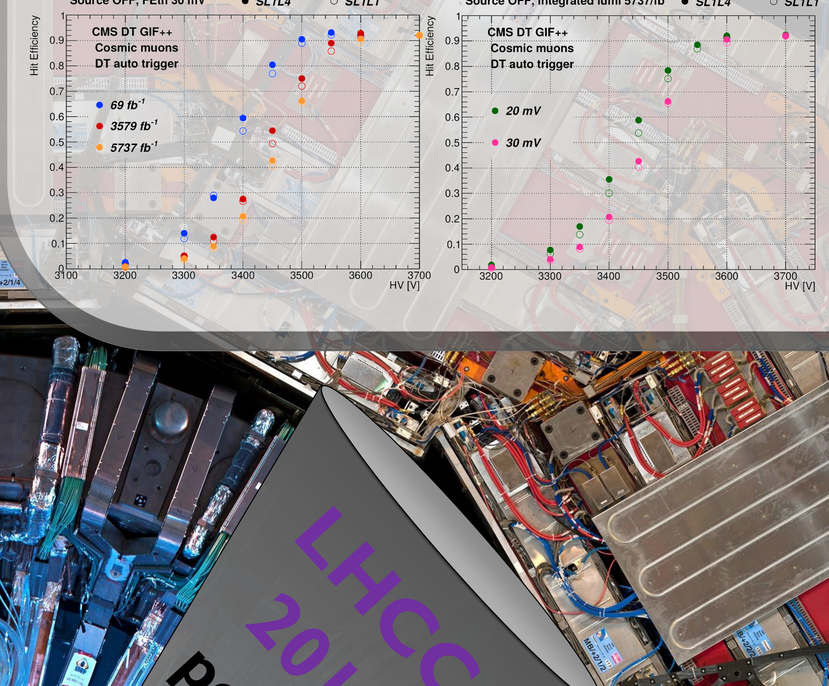
Hit efficiency as a function of the instantaneous luminosity

The hit efficiency is also measured as a function of the background rate, at 3550 V, for the aged layers. The plots show results for cosmic muons and muon beam. Non-aged SL1L3 is shown as a reference. A decrease of the hit efficiency of about 30% is observed at the HL-LHC rate, after accumulating 2xHL-LHC luminosity.



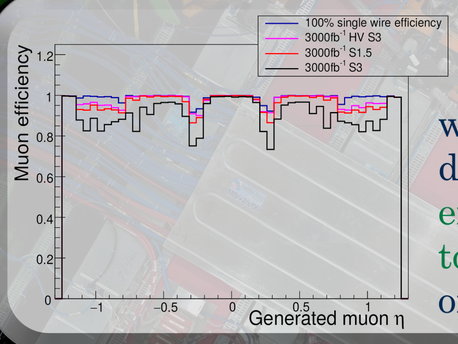
Hit efficiency as a function of the high voltage

At high HV, a plateau is reached and the change of the efficiency with the integrated luminosity is small.



The drop of efficiency for a front-end threshold (FEth) value of 20 mV and high HV values is of the order of a few %.

CMS Muon reconstruction



The simulations show that with the expected efficiency drop, the muon reconstruction efficiency at CMS remains close to 100%, due to the redundancy of the CMS DT system.

References:
cds.cern.ch/record/2283189

LHCC 2019 poster sesion