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CSC Calibration Constants and Validation Using 2022 Calibration run results

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Abstract

The reconstruction of data from the CSC requires calibration data including electronic constants, such as gains and pedestals, timing constants used in triggering, and electronic channels and full chamber validity information. These calibration conditions, also called conditions data, are produced in dedicated calibration runs or dedicated studies taken between periods of data taking. This poster discusses the procedure to measure these constants, their validation and storage. This poster also discusses about the procedure of creation a bad chamber file and its storage.

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PROCEEDINGS OF SCIENCE

CMS Cathode Strip Chamber Calibration Constants and Validation Using the 2022 Calibration Run data

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The reconstruction of data from the CSC(Cathode Strip Chamber) requires calibration data including electronic constants, such as gains and pedestals, timing constants used in triggering, and electronic channels and full chamber validity information. These calibration conditions, also called conditions data, are produced in dedicated calibration runs or dedicated studies taken between periods of data taking. This note discusses the procedure to measure these constants, their validation and storage. This note also discusses about the procedure of creation a bad chamber file and its storage.

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1. Introduction

There are 540 Cathode Strip Chambers (CSCs) installed in the endcap region of the CMS experiment. The CSC is a cylindrical detector around the beamline, meaning the coordinates are typically described in cylindrical coordinates. The wires run radially (along the r-direction) and are used to measure the ϕ-coordinate, while the strips are perpendicular to the wires and give the z-position. Using both the z-position from the strips and the ϕ-position from the wires, a full 3D hit position can be reconstructed. Fig. 1 shows the geometry of strip and wire planes in a CSC chamber and illustrates how we detect muons using the CSCs. Conditions data for the CSCs contain parameters needed to reconstruct muon hits for use in the High Level Trigger (HLT), offline data reconstruction, and monte carlo (MC) simulations. Conditions data are sets of run- or time-dependent information stored in a central database system. Table 1 presents the various types of condition data, detailing their purpose, usage scenarios, and update intervals.

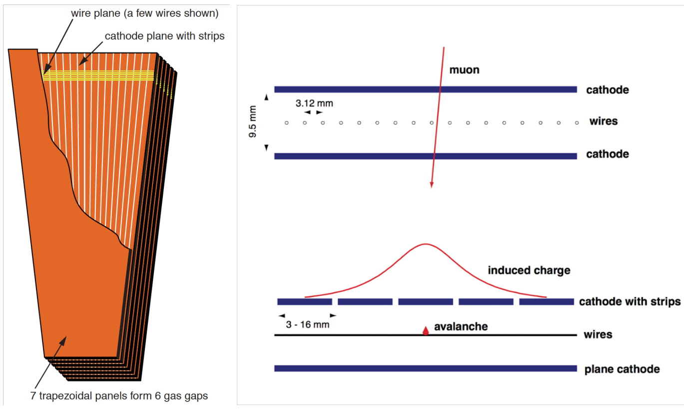

Figure 1: (Left) CSC chamber showing wire plane and cathode strips and (Right) Muon detection in CSCs

2. Calibration

The calibration constants of the CSC electronics are determined from dedicated pulser runs, in non-beam conditions,. Each of the 270k strips in the CSC system is labeled with a linear integer index, allowing optimal storage in the database and rapid and efficient retrieval of associated values from the database. For example, pedestal values are determined with the pulser amplitude set to zero. In Fig. 2 a point is plotted for each of the 270k strips in the system, where the ordinate is the strip channel index, and the abscissa is the relative change in the pedestal value, defined as the difference between the new and old values divided by the old value. The large differences in pedestal values correspond to chambers with newly-installed upgraded electronics.

3. Validation

A muon passing through one of the CMS muon detectors gives rise to hits, which can then be used to reconstruct the muon kinematics. The calibration constants must be applied to the CSC raw

Conditions data	**What are they?**	**Where are they used?**	**When are they updated?**
CSCBadChambers CSCBadStrips CSCBadWires	Flags for chambers/channels not providing data	Simulation: for best match with an existing real dataset	When best simulation of existing data is required
CSCChambersTimeCorrections CSCDBChipSpeedCorrections	Offline adjustments to center rechit times on t=0 for IP muons	Real data and Simulation: for best offline rechit times	When online timing is changed (rarely)
CSCDBCrosstalk CSCDBGains CSCDBNoiseMatrix CSCDBPedestals	Electronics parameters of strip channels	Real data: precise values of minor importance Simulation: need values to convert hits to signal	When CSC Operations provides calibration data from dedicated CSC local runs
CSCCrateMap CSCChamberMap CSCDDUMap	Electronics cable mappings	Real data: hardware labels to geometric values	'Never' change
CSCRecoGeometry	C++ CSC strip and wire geometry in db format	Simulation: Digitization Real data: Local reco	'Never' change
CSCRecoDigiParameters	Chamber parameters associated with strip and wire geometry	Simulation: Digitization Real data: Local reco	'Never' change
CSCDBGasGainCorrections	Precise corrections to system gas gain derived from detailed Run I analysis	Precision CSC studies in run 1 only	No plans to update
CSCDBL1TPParameters	Basic pieces of information used by the trigger system obtained from CSC detector	To make decisions about whether to retain or discard collision events (Muon selection)	'Never' change

Table 1: Conditions Data Summary Table.

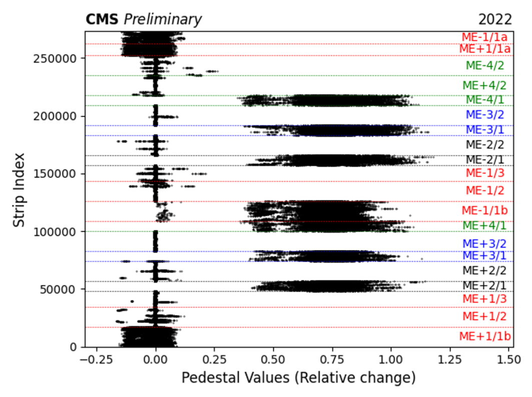

Figure 2: The relative change in pedestal values taken in 2016 and 2022 for each CSC strip channel. The labels on the right indicate the different rings of chambers in the CSC system. For example, ME+1/1 refers to station 1, ring 1 on the plus endcap side.

data in order to obtain the most precise values for the properties of the reconstructed hits (rechits). We then generate plots of the rechit residual distribution for each chamber. The width of the rechit position residual distribution reflects the precision with which the position of a hit in the CSC detector can be determined. The residual is defined as the difference between the position of a rechit on layer 3 of a CSC and the expected position, which is derived from a segment fit to hits on all 6 layers of a CSC. The residuals are measured in units of the width of the strips. Validation plots such as Fig. 3 are examined for each chamber to observe the effect of the new constants and compare them with that of the old constants. This plot is based on crosstalk, gain, pedestal and noise matrix values. There is typically little difference between old and new rechit position residuals because of the robustness of rechit builder algorithm but we need to ensure that the new constants maintain the good resolution. These constants play an important role in data taking and simulation to convert hits into spatial positions, times, and charge amplitudes.

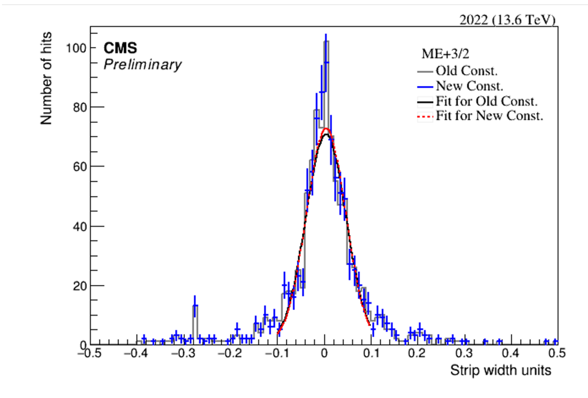

Figure 3: Rechit residual distribution for ME+3/2 chamber.

4. Bad Chambers

During CSC operation, some of the chambers can stop functioning until there is an opportunity to repair them in shorter technical stops held every 10 weeks or during the longer year-end technical stops. There are typically two or three bad chambers per running period. There are many reasons why a chamber might not provide rechits, e.g., failed HV, LV, electronics boards, etc. For the time interval where they are not working, we designate these as "bad chambers". We update the list of bad chambers in the central database to avoid digitization of such chambers in MC production in order to have the best match to the real dataset. Fig. 4 shows an example of how a bad chamber appears in data quality monitoring (DQM) plots.

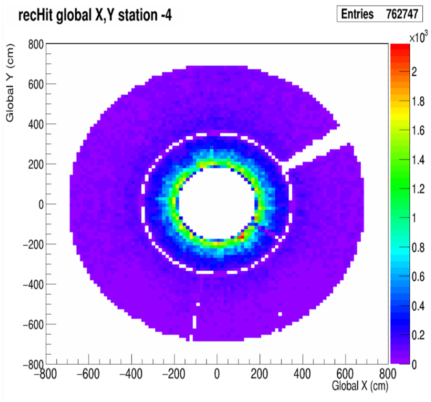

Figure 4: DQM plot showing a bad chamber in 2023.

5. Conclusion

Conditions data values for the CSC chambers are derived from dedicated electronics calibration runs. After following systematic procedures for validation, the constants are uploaded to the conditions database, where they are used in data reconstruction and in Monte Carlo simulation. In addition, chambers that are bad during each major data period are flagged in the database so that the simulation accurately reproduces the effect of the dead chambers.

References

[1] CMS Collaboration, “Development of the CMS detector for the CERN LHC Run 3”,arXiv:2309.05466.

[2] O. Boeriu, “Endcap Muon Chamber Calibration and Monitoring Procedures in CMS”, technical report, Northeastern Univ., Boston, MA USA, Jun, 2009, CMS-CR-2009-157