Mykola Savitskyi

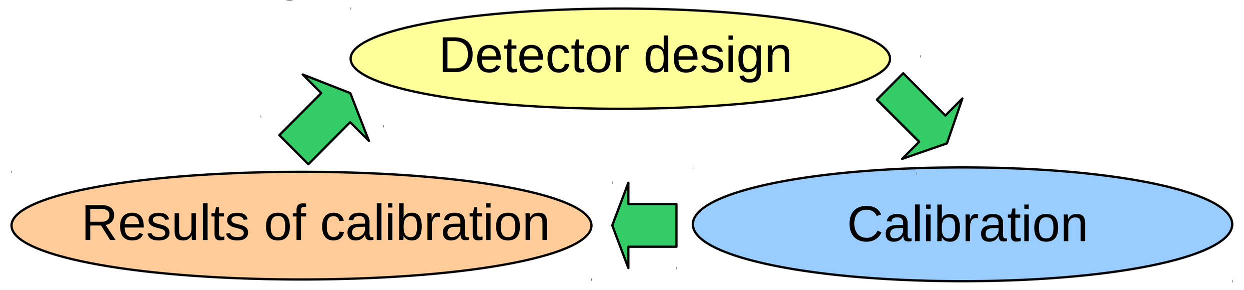
Taras Shevchenko National University of Kyiv

Intercalibration of CASTOR calorimeter at CMS using halo muons of collider LHC

1 Motivation

A detector must be calibrated to provide high-quality physics data. Every detector has unique design with it's own measuring principles, which makes it necessary to use different calibration methods.

First step towards a full calibration of calorimeter is intercalibration. It also provides better understanding of the detector performance, which can lead to improvement of the detector design.

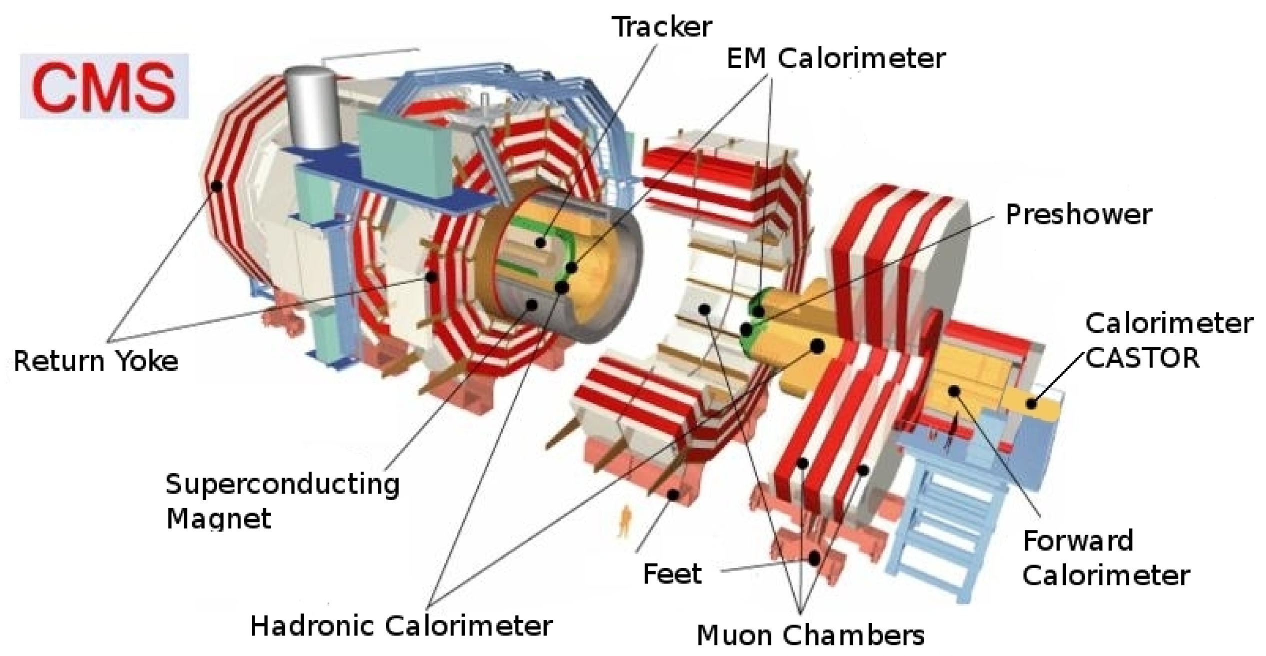


Here presented calibration of the relative response of every individual channel of the CASTOR calorimeter of the CMS detector that was performed by analyzing halo muons events collected during the LHC operation in 2011.

Main goal: calculation of intercalibration coefficients of calorimeter CASTOR.

2 The CASTOR calorimeter is a unique detector that covers a phase-space region that has never been explored before

CASTOR (**C**entauro **A**nd **ST**range **O**bject **R**esearch) - very forward Cherenkov sampling calorimeter of experiment CMS at collider LHC.



CASTOR has very rich physics program at proton-proton and heavy ion forward physics.

Pseudorapidity range: $-6.6 < \eta < -5.2$.

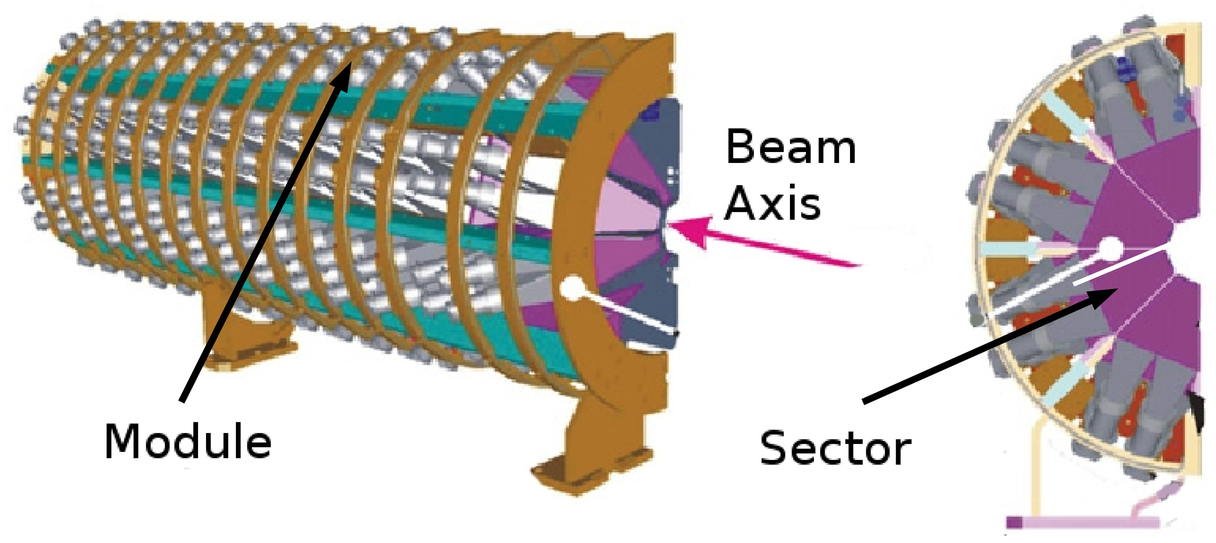
Due to its very forward location, CASTOR is influenced by a strong magnetic field, which affect response of some photo-multiplier tubes (PMTs) of CASTOR.

3 CASTOR has 224 readout channels

Energy range: 0.27 Gev – 1 TeV over one channel.

Each channel equipped with fine-mesh PMT, which are resistant to a magnetic field.

Only one half of the calorimeter is shown.

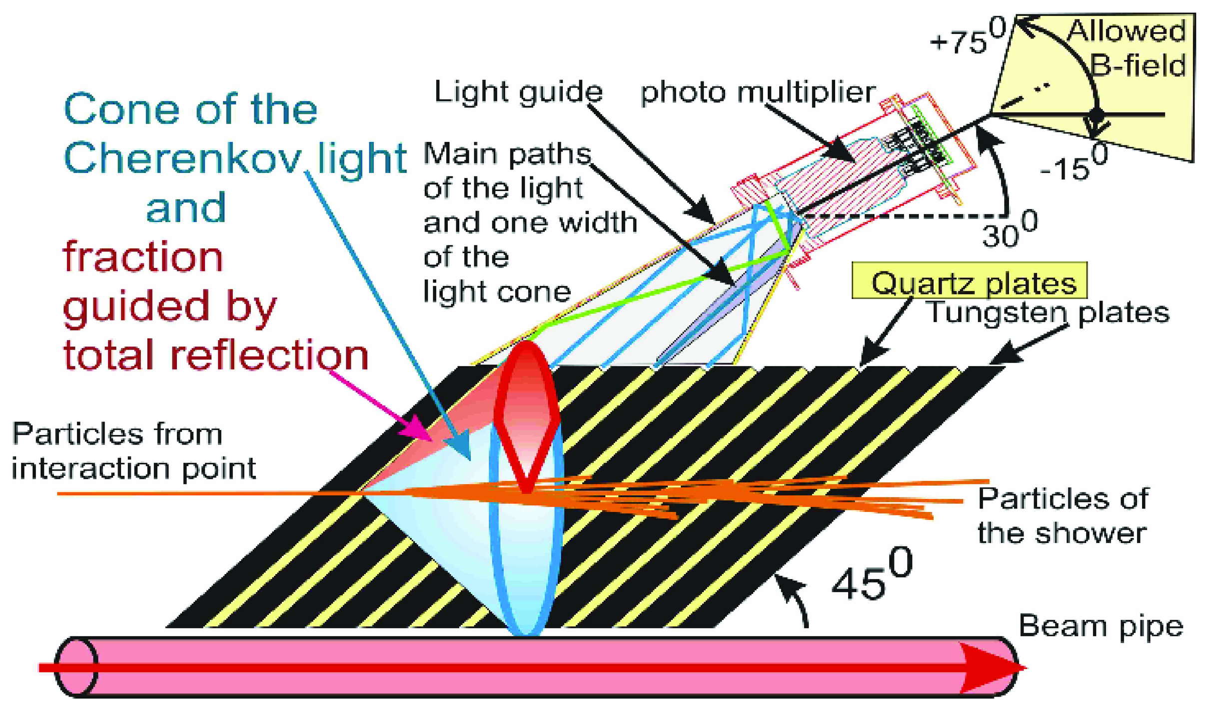


CASTOR consists of two stainless steel skeletons - one for each side of the beam pipe - contain **14 longitudinal sections** (modules), two of them are electromagnetic sections while the remaining 12 are hadronic sections.

In the r − φ plane the cylindrical geometry is approximated by an octagon divided into **16 individual semi-octant sectors**.

4 Photo-multiplier tubes produce signals proportional to the amount of collected light, which quantity depends on energy of a particle

CASTOR sampling structure consisting of tungsten and quartz plates.



Tungsten, as the absorber material, provides small transverse shower size.

Quartz glass, as the active material, is resistant to damage from radiation.

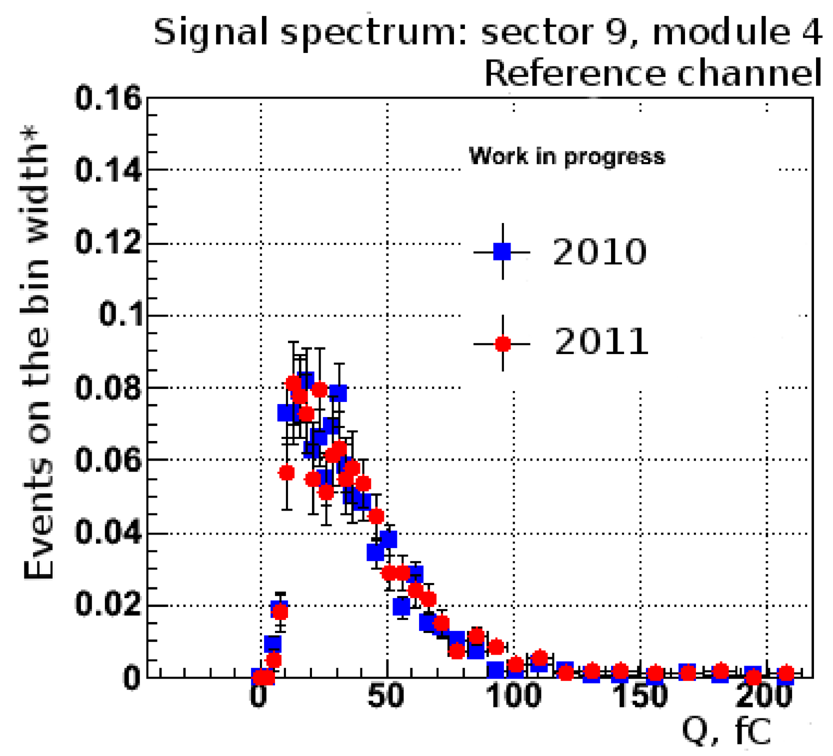
The Cherenkov light is collected by air-core light guides, whose inner surface is covered by a **wave-length selective mirroring foil**.

5 Intercalibration constants are used for correction of variations in the signals, that occur because of individual parameters of channels

The signal from a fine-mesh PMT reading out a CASTOR channel can be described by the following formula:

$$S[e^-] = N_\gamma(E) \cdot \varepsilon_{opt} \cdot QE^{PMT} \cdot G,$$

N_γ - the number of Cherenkov photons produced by particle,
ε_{opt} - the optical efficiency of the light guide,
QE^{PMT} - the quantum efficiency of the PMT,
G - the gain of the PMT ($10^4 < G < 10^5$).

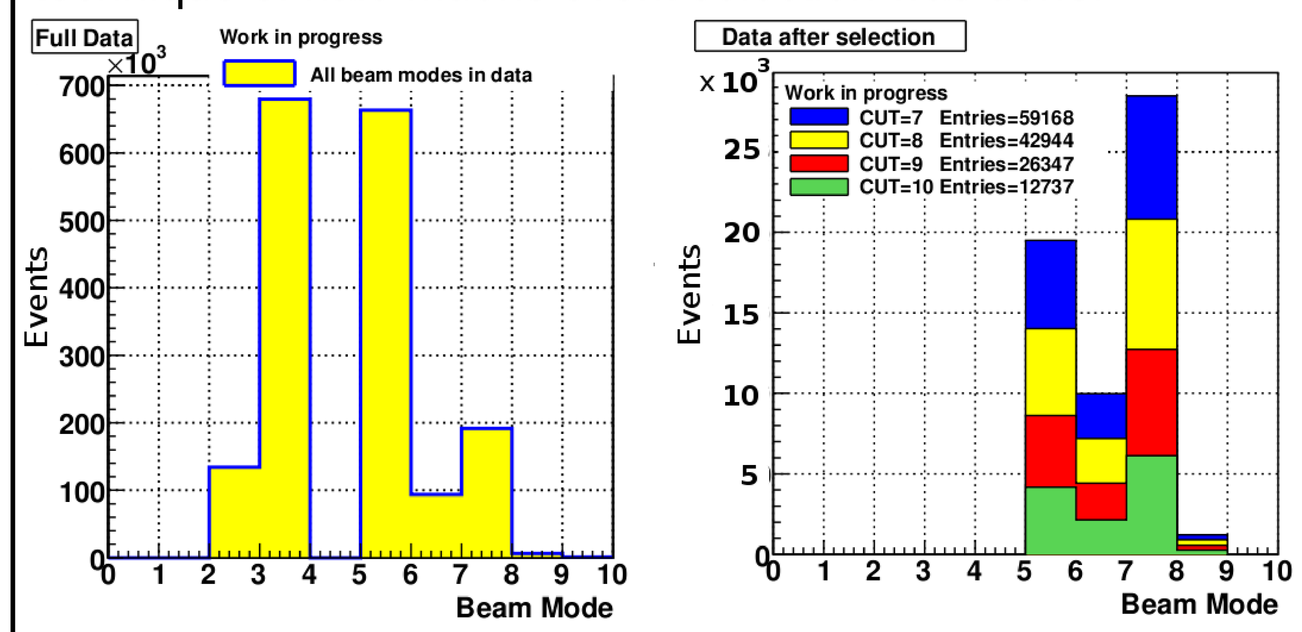


Typical spectrum in hadron channel normalized to the number of events.

6 To perform intercalibration events with halo muons of the collider LHC can be used

Main idea: events with equal energy deposition in each CASTOR channel must be used.

In a wide energy range muon energy loss is similar to the energy loss by a minimum ionizing particle, thus a special technique of halo muons event selection was done.



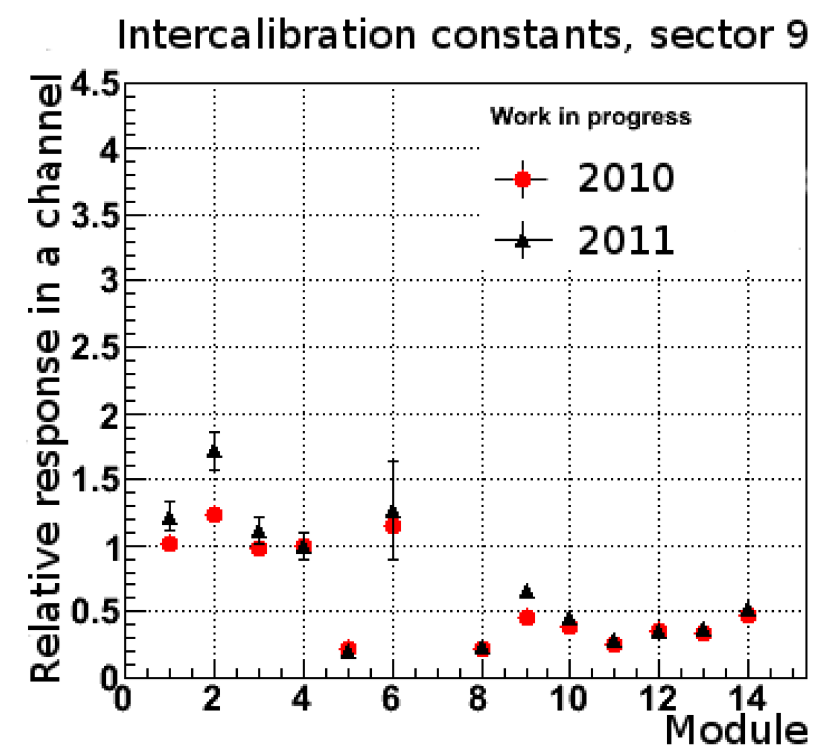
A sample of halo muon events was created by processing RAW DATA recorded during 2011 by CMS. The selection resulted in 400-2900 muons per sector.

Number of muon candidates does not scale in a simple way with the beam intensity, beam condition nor with the number of bunches per LHC orbit. Most halo muons in a sample were obtained during non-colliding beams.

7 During one year of operation CASTOR calorimeter has changed its position

Intercalibration constants are defined as: $I_i = S_{RC}/S_i$

Intercalibration constants obtained from 2011th period of data taking were compared to independent previous results from 2010.

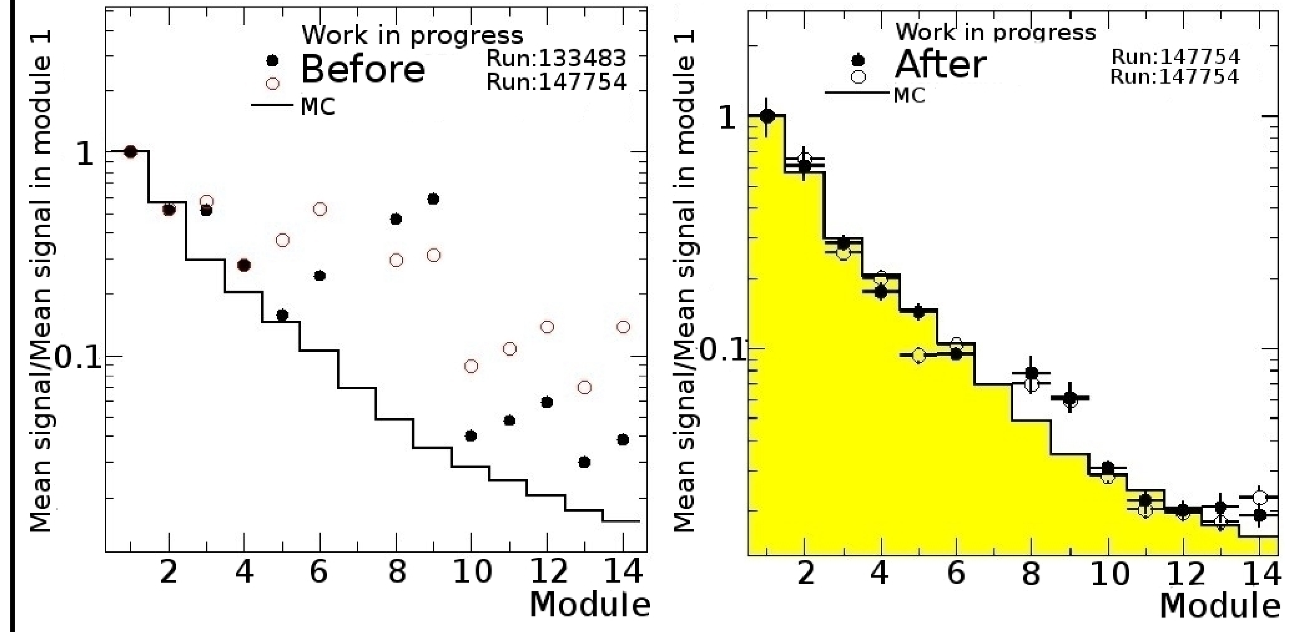


Significant change of constants in almost all electromagnetic modules was observed: position change, influence of a selection.

A change of constants in working hadronic channels was observed within the systematic uncertainties range.

8 Conclusions

Usage of intercalibration constants leads to significant enhancement of shapes of signal spectra.



Change of CASTOR calorimeter position and necessity of improvement of existing halo muons events selection procedure points to the importance of performance of new intercalibration.

Contact information:
E-mail: mykola.savitsky@gmail.com
Phone: +38 (096) 751-7575