The CMS RPC performance and simulation

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for the CMS collaboration

The CMS RPC performance and simulation

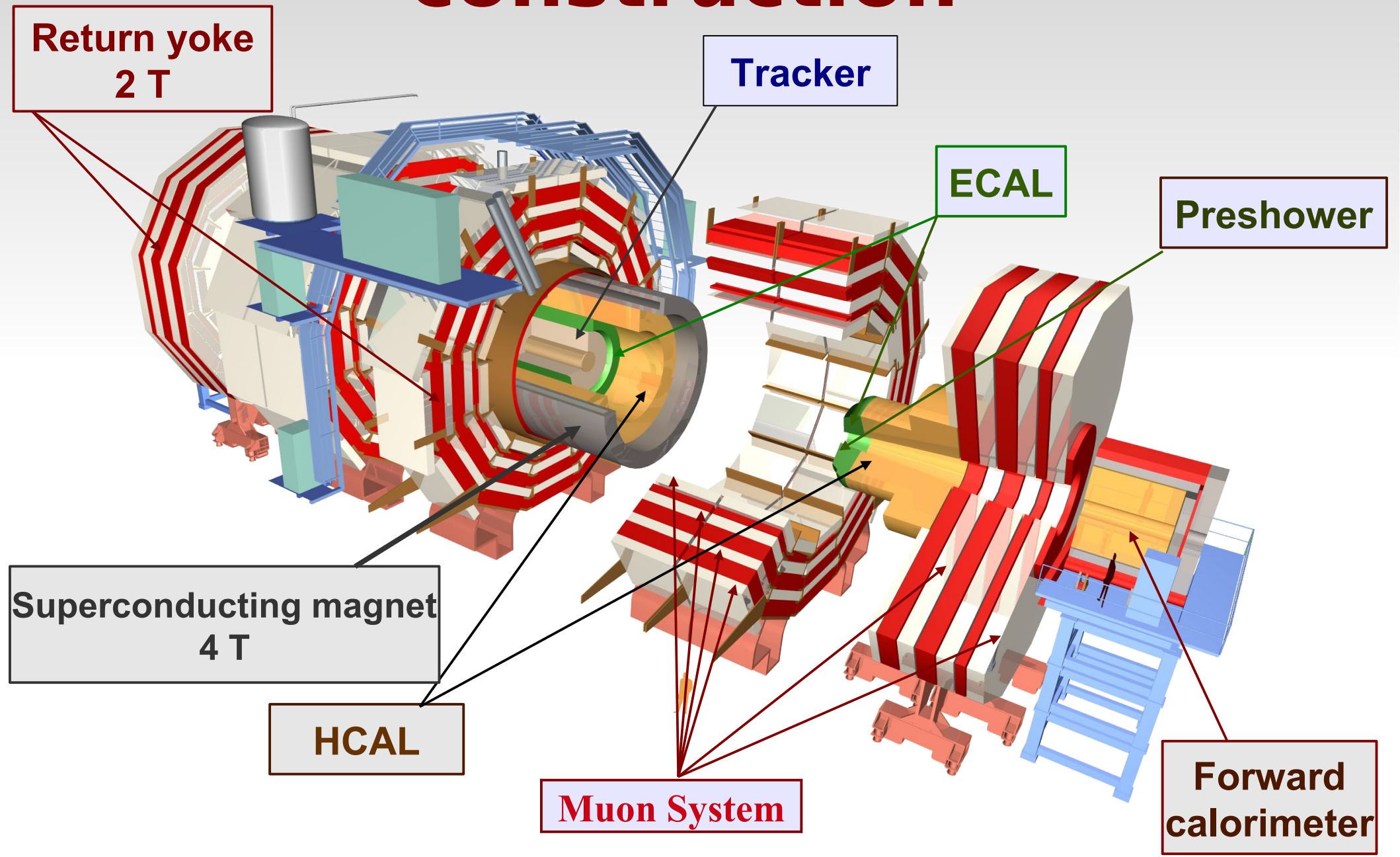
CMS design and construction and the muon system

CMS software full simulation chain

RPC response simulation

Validation procedures

CMS: design & construction



CMS Muon System

$\eta = -ln\ tg\ (\theta/2)$

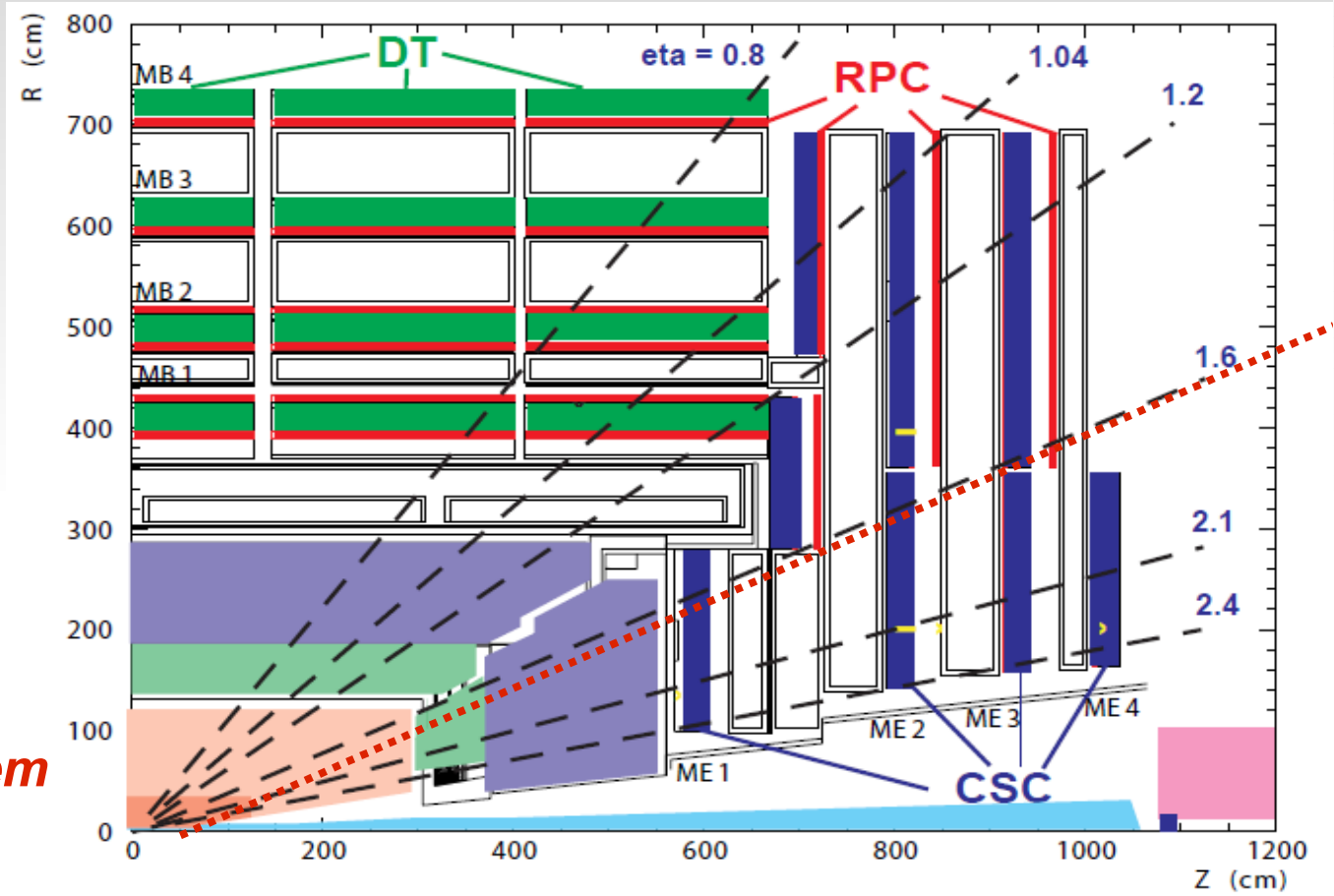
Barrel $|\eta| < 0.8$
DT & RPC

Overlap $0.8 < |\eta| < 1.2$
DT & CSC & RPC

EndCaps $1.2 < |\eta| < 2.4$
CSC & RPC ($|\eta| < 1.6$)

..... *Reduced RPC system*

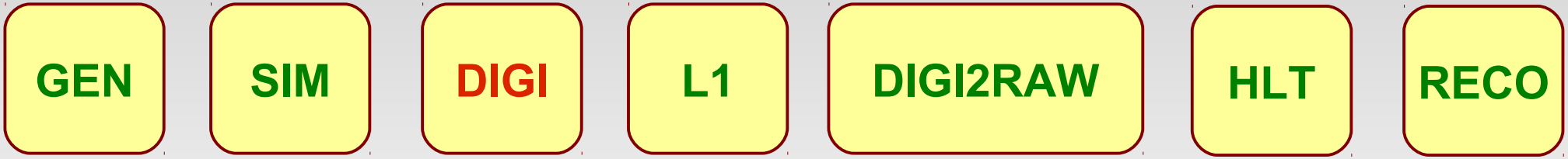
Barrel *1020 RPC Rolls*
EndCap *1296 RPC Rolls*



DT – Drift Tube Chambers;
CSC – Cathode Strip Chambers;
RPC – Resistive Plate Chambers

A roll represents a RPC double gap in the CMSSW (CMS software)

CMSSW chain



GEN Event generation: Pythia, Particle gun generator, etc

SIM *based on the GEANT4 to describe mechanical design and material budget; passage of particles* **through matter**

DIGI add RPC response

uses a set of parameters for modeling the detector response

- *RPC efficiency*
- *Noise*
- *Cluster size*
- *Timing*

L1 *emulate the Level 1 trigger (L1 muon trigger)*

DIGI2RAW *convert to RAW data*

HLT *pass the High Level Trigger (PC farm)*

RECO *event reconstruction*

Detector response simulation

During the data taking MC is updated regularly

RPC parameters determined from 2011 data after the automatic pressure correction of HV supply has been applied

Please, see the talk "Calibration of the RPC working voltage in the CMS experiment"; Silvia Costantini

- Data collected in the first part of 2011 have been used to simulate the efficiency in MC
- Intrinsic RPC noise is measured during cosmic runs and used to model the MC response.
- Cluster Size of RPC hits is simulated according to the data collected with cosmic rays and used to parametrize the MC

Private MC sample production with new parameters
Results validation
Submit the new RPC constants in the off-line data base (ORCOFF)
Ready for official MC production

Detector response simulation

Efficiency

- Find the channel (strip) where the RPC Sim Hit is produced

- All the strips of the chamber get the average efficiency assigned

- Simulate the probabilistic strip response based on comparison of the efficiency value with a value taken from uniform distribution

Efficiency constants	Estimated from	Used by
95%	default value	MC 2009
realistic	cosmic data collected during 2009	MC 2010
realistic	collision data collected during 2010	MC 2011
realistic	collision data collected during the first part of 2011	current

Detector response simulation

Noise

- *Two possible parametrization:*
  - *ideal - all the strips get the default noise of 0.05 Hz/cm² ; used before*
  - *realistic - all the strips get different noise, estimated from experimental data –used by MC from the second part of 2011*

-Calculate the noise rate for the strip: $\nu = N_j S_{str} t$

N_j *- strip noise in Hz/cm2;* S_{str} *- strip area cm ²;* $t = n_{bx} 25\text{ns}$ *;* n_{bx} *– number of BX*

- Simulate the stochastic strip noise around the Bunch Crossing based on Poisson distribution having mean ν

Cluster size

- number of consecutive strips fired in response of a single particle
- the number of the fired strips in the cluster is generated according to the hit position on the central fired strip, using experimentally measured cluster distributions

Timing

- the delay of signal along the cables for each chamber, the time of flight of the particle and the signal propagation speed on the strip are taken into account in order to estimate the total time for response

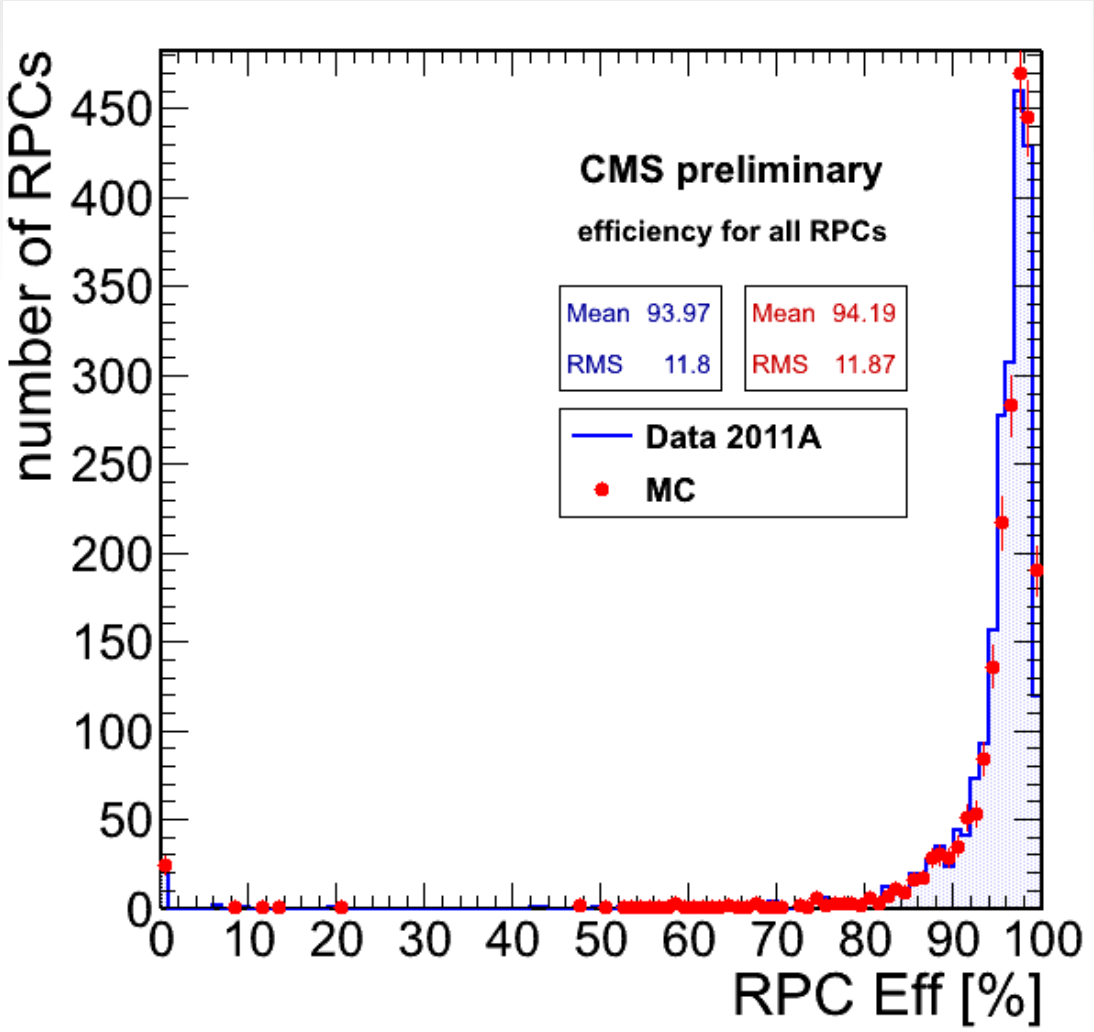
validation results

Validation

efficiency from experimental data vs simulated efficiency

We estimate the simulated efficiency as:

$$Eff_{digi} = \frac{Digi}{SimHit}$$



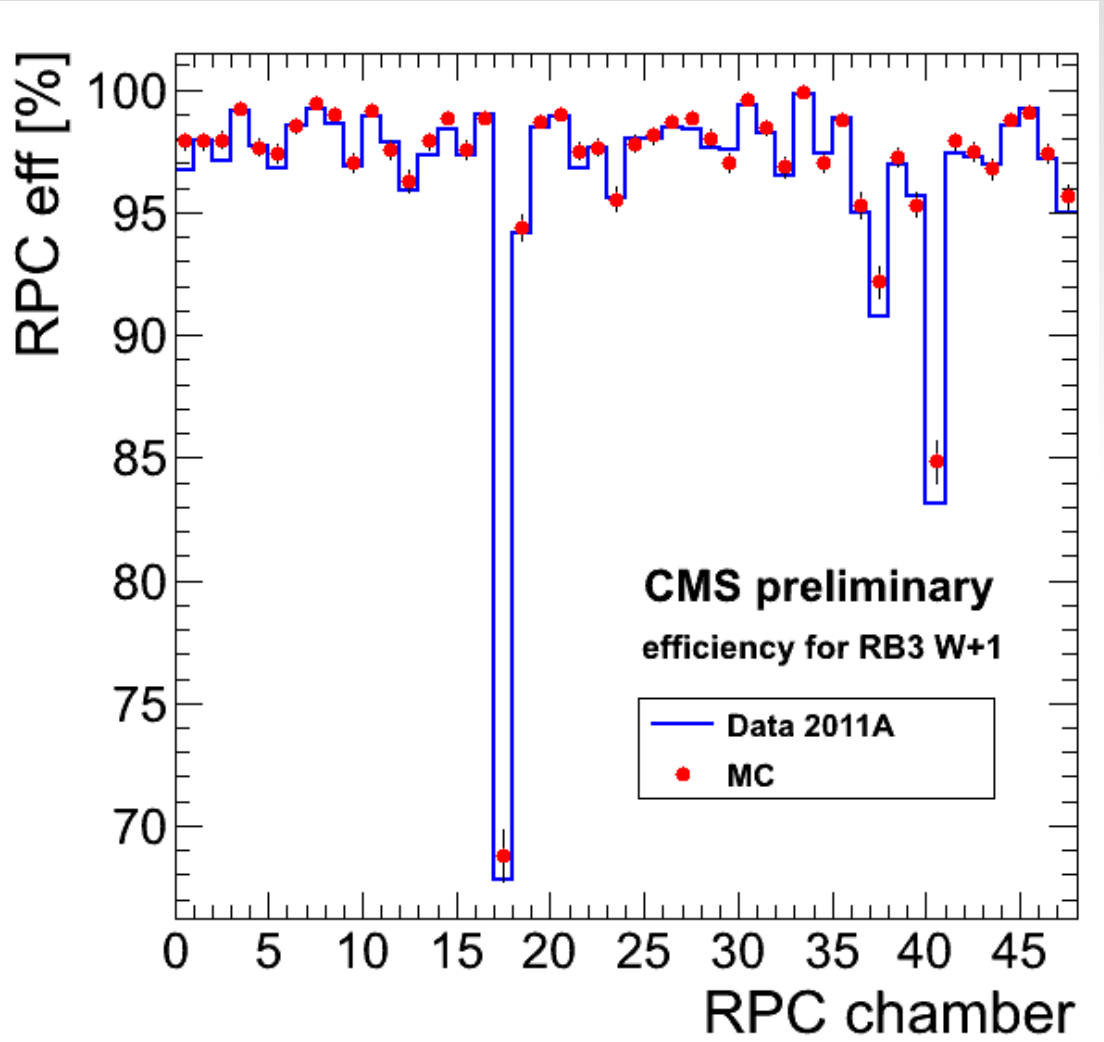
SimHit
number of simulated muons, crossed RPC (RPC hits)

Digi
number of events with at least one fired strip, corresponding to the simulated muon hit

Efficiency distribution for all the RPCs (data in blue, MC in red)

Validation

efficiency from experimental data vs simulated efficiency



example of the efficiency for all the RB3 chambers of the Barrel Wheel+1 (data in blue, MC in red)

Validation

noise from experimental data vs simulated noise

we estimate the simulated noise strip as a fired strip without a simulated hit

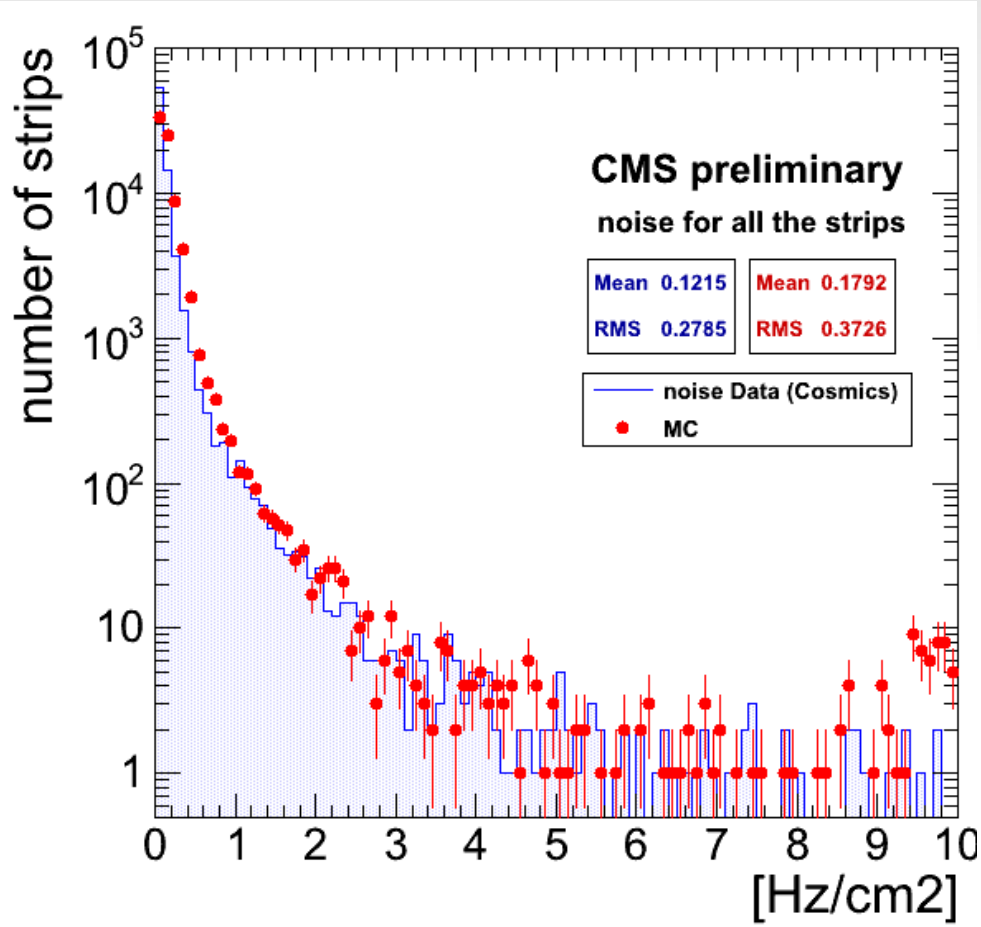
average simulated noise for the strip:

$$N_{str} = \frac{f_{noise}}{S_{str} T}$$

f_{noise} ***- total number of simulated noisy response for the strip***

S_{str} ***- strip area***

T ***- total time***



Intrinsic noise distribution for all the RPCs strips (data in blue, MC in red)

Validation

noise from experimental data vs simulated noise

average simulated noise for the chamber

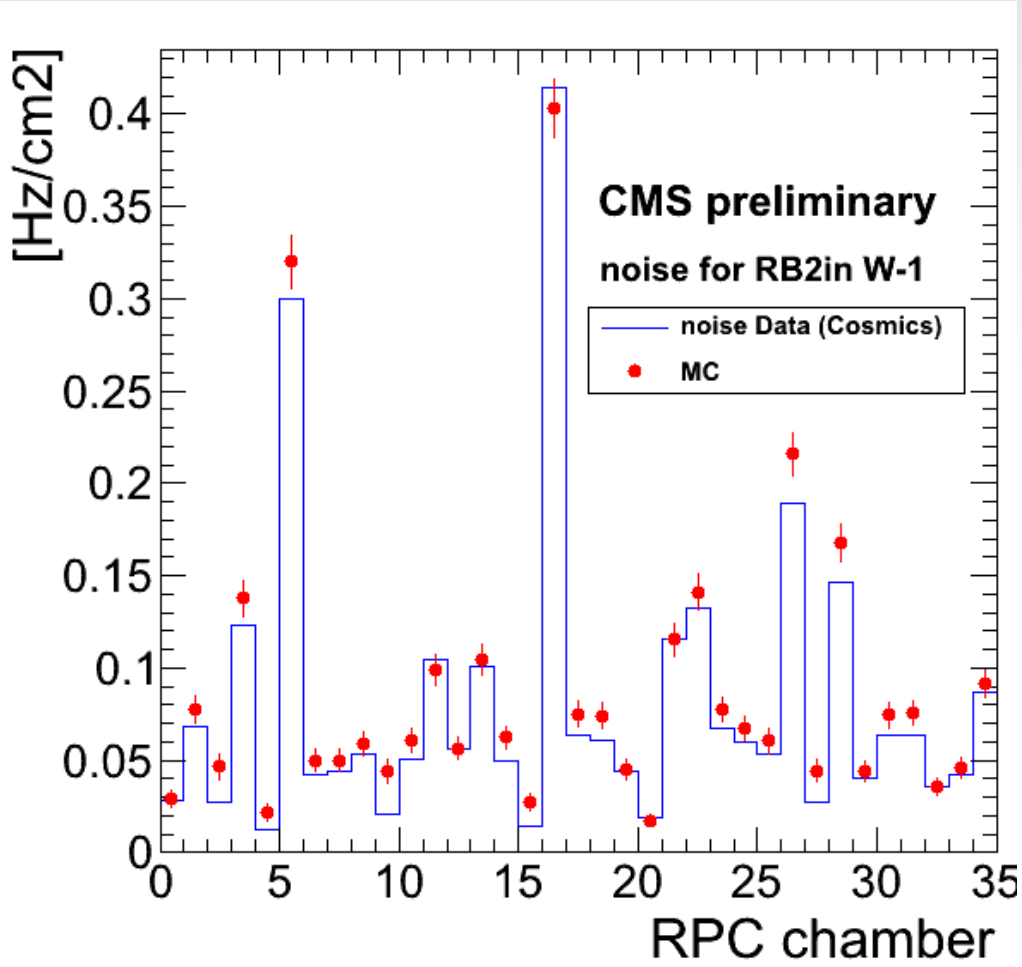
$$\bar{N}_{ch} = \frac{\sum_{n_{ev}} d_{noise}}{S_{ch} T}$$

d_{noise} ***- all noisy strips for the chamber in the event***

S_{ch} ***- chamber area***

T ***- total time***

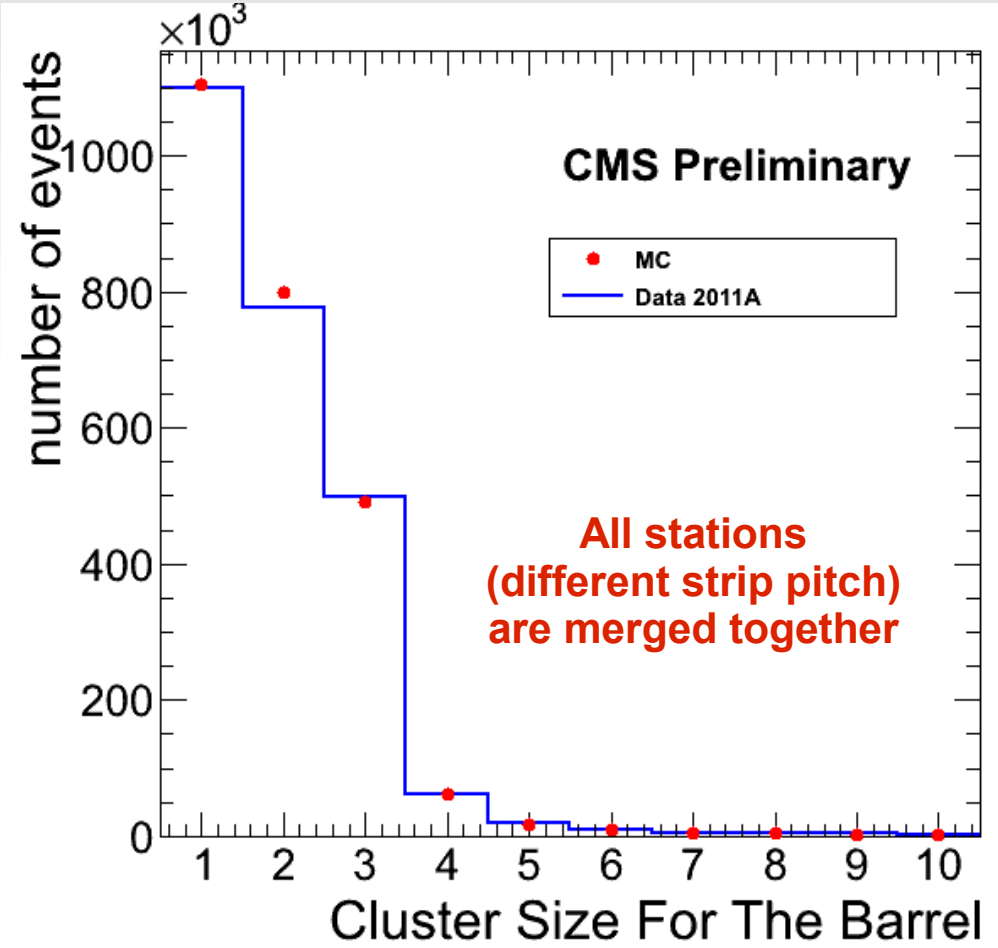
n_{ev} ***- number of simulated events***



example of correlation between simulated and measured noise for all the RB2in chambers of the Barrel Wheel-1 (data in blue, MC in red)

Validation
Cluster size

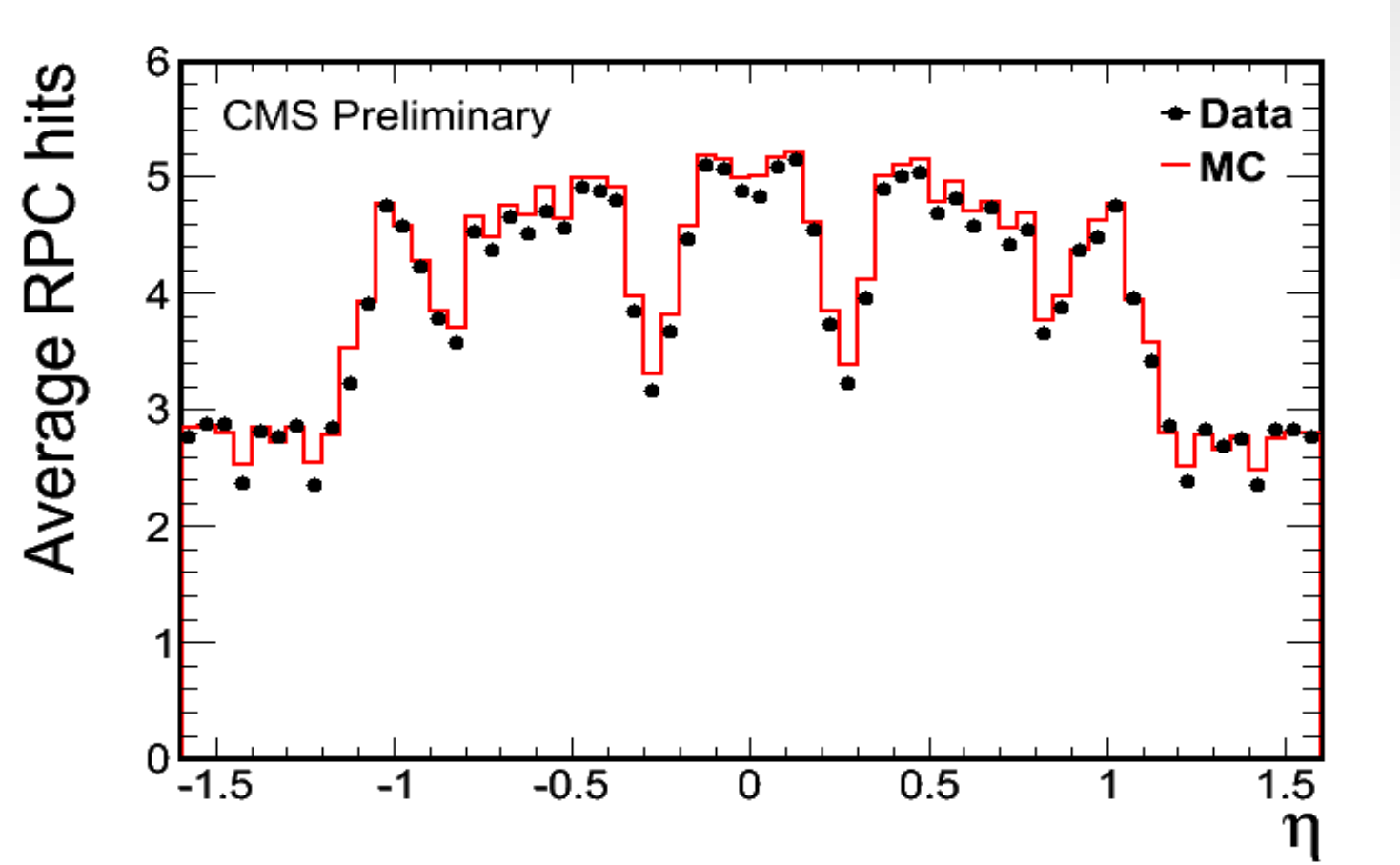
Cluster Size:
Number of consecutive strips fired on a Chamber for a given muon crossing



Overall Barrel cluster size for muons crossing RPCs (data in blue, MC in red)

Reconstruction step
MC vs real data

The average number of RPC hits associated to the muon as function of eta for Global Muons with Pt>20 GeV/c coming from Z decay (data in black, MC in red)

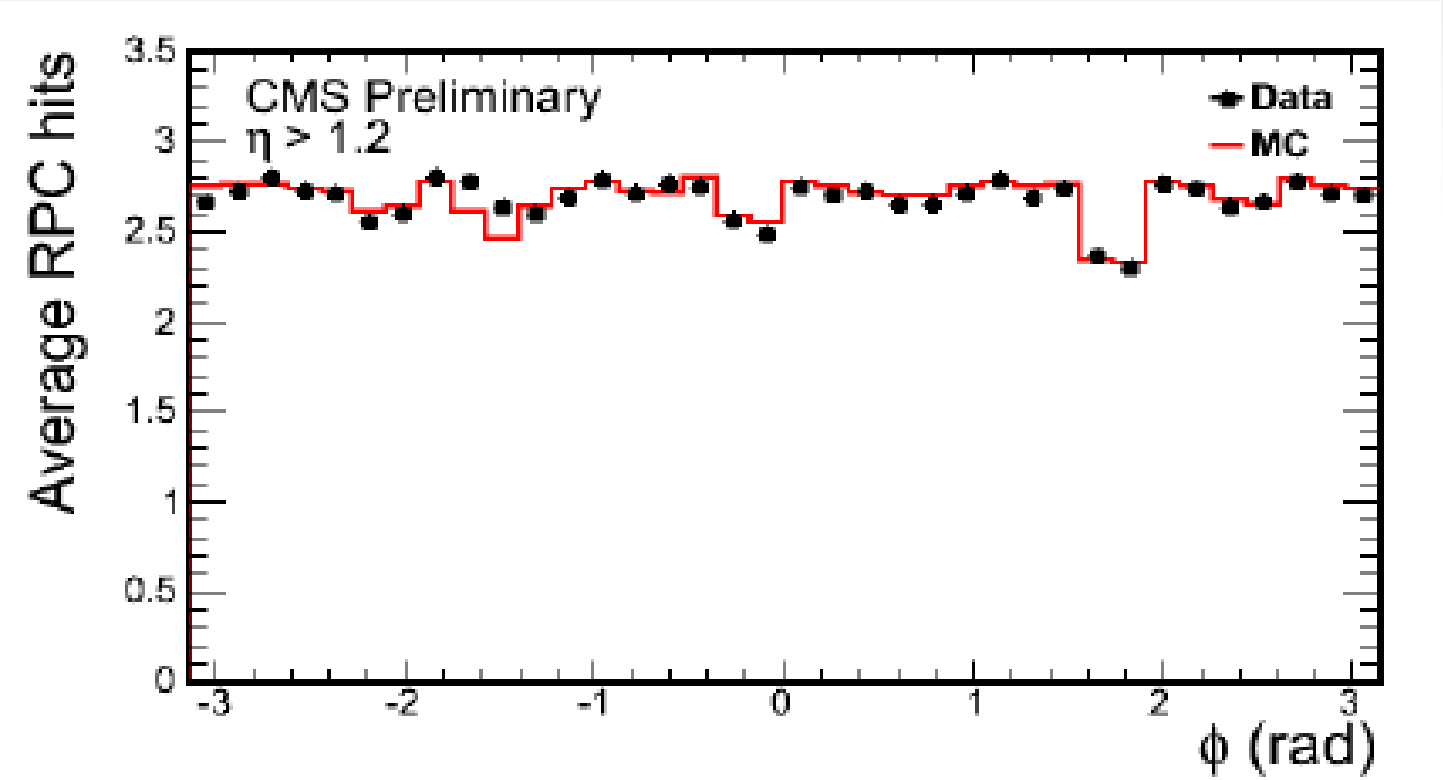


Please, see the poster "The RPC hits in the CMS muon reconstruction"; Min Suk Kim

Reconstruction step
MC vs real data

The average number of RPC hits associated to the muon as function of phi for Global Muons with Pt > 20 GeV/c coming from Z decay (data in black, MC in red).

Some region is affected by dead chambers well reproduced in the MC.



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SUMMARY

An algorithm for simulation of the RPC response is implemented in the CMSSW

The algorithm uses following parameters:

- **efficiency parameter for each readout strip;**
- **noise parameter for each readout strip;**
- **timing parameter for each chamber;**
- **cluster size distribution for each chamber;**

The parameters are regularly updated

A dedicated validation procedure is developed

The simulation is in a good agreement with the experimental data

Thank You!

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