Trigger Study for RPC Upscope Project of CMS

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Outline

1. Introduction
2. Problem
3. Simulation
4. Results
5. Conclusions and Outlook

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1 Introduction

2 Problem

3 Simulation

4 Results

5 Conclusions and Outlook

Muon Detectors

Different types for different purposes

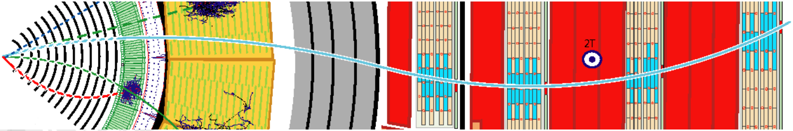
Overview

CMS will use three types of gaseous particle detectors:

- Drift Tubes (DT) in central barrel;
- Cathode Strip Chambers (CSC) in endcaps;
- Resistive plate Chambers (RPC) in barrel and endcaps;

to measure precisely:

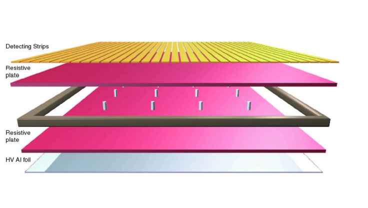
- the position (and thus the momentum) (DT & CSC);
- the time (for triggering purposes) (RPC).

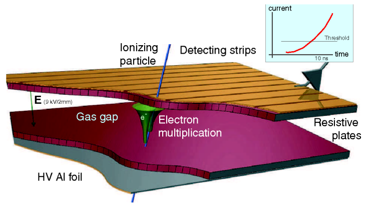


Resistive Plate Chambers

Working Principle of a very fast detector . . .

Resistive Plate Chambers

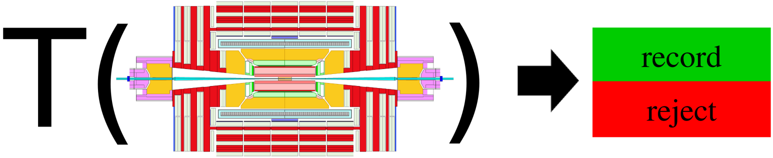




- Thin gas layer (2 mm) inbetween 2 resistive elektrodes with electrical field of 5 kV mm^{-1}
- Very fast $\mathcal{O}(1\,\text{ns})$ & good spatial resolution $\mathcal{O}(1\,\text{cm})$
- Assigns the correct bunch crossing to an event

Trigger

Picking out the right events . . .



- 40×10^6 events per second of which only 100 events per second can be recorded
- Not all detector information is promptly available
- Level 1: 40MHz to 75 kHz, only Muon and Calorimeters, Custom electronics
- Level 2 & 3 = High Level Trigger: 75 kHz to 100 Hz, also Tracker (L3), farm of commercial processors

▸ TriggerLevels

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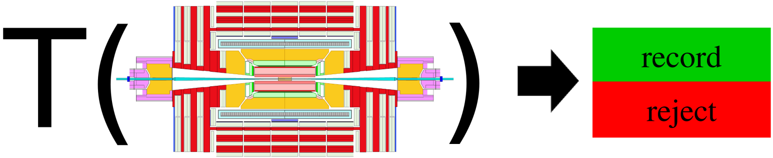

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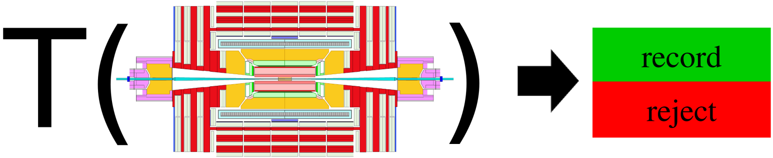

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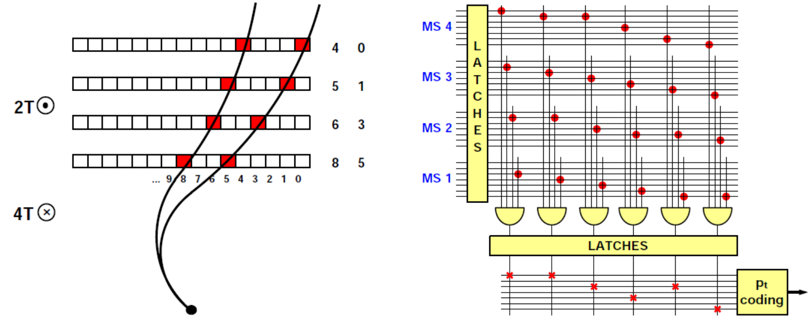
TriggerLevels

RPC Trigger Principle

A fast detecor need fast electronics . . .

PAttern Comparator (PAC)

Needs for Pattern Recognition:
memory to store patterns in catalog and **fast logic** for matching



- Pattern of hit strips is compared to predefined patterns corresponding to various p_T
- Gives up to 4 Muon Candidates of Barrel and up to 4 Muon Candidates from Endcap to Global Muon Trigger

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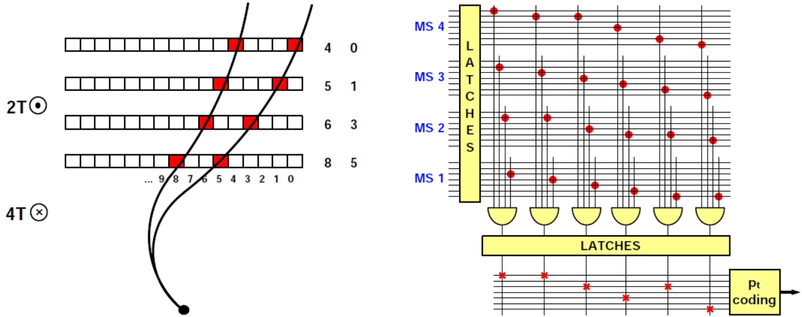
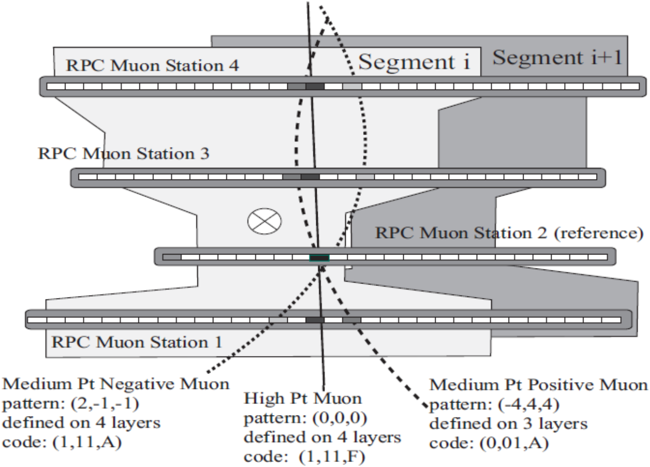


- Fast Detector and Fast Trigger electronics allows for unambiguous bunch crossing identification
- Trigger Algorithms: 4/6 in Barrel and 3/4 in Endcaps

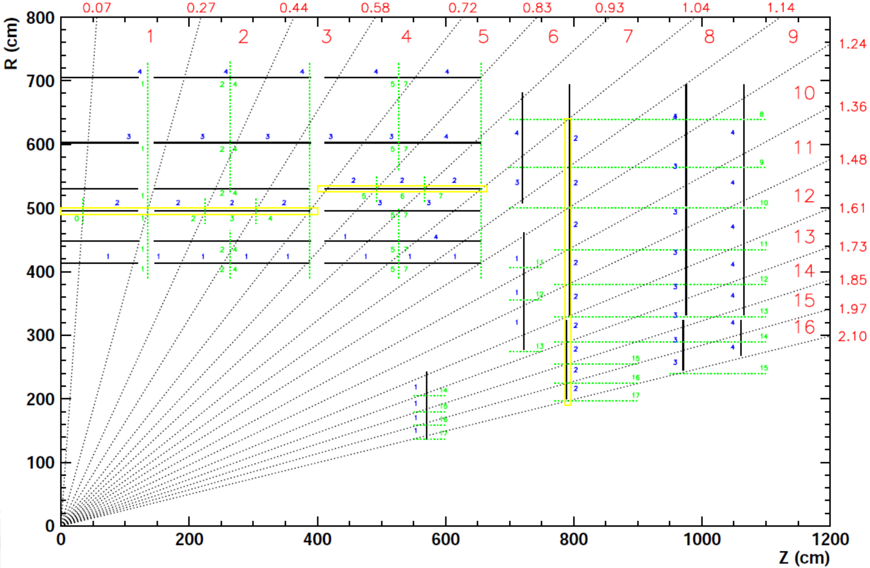
RPC Trigger Implementation

RPC Trigger Segment



- Two neighbouring Trigger Segments (TS) in $r\phi$.
- TS is uniquely defined in reference station 2.

RPC Trigger Geometry



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Completion of the RPC system

En attendent Godot . . .

- Only three layers per endcap are build with a limited pseudorapidity coverage up to $\eta < 1.6$
- Coverage is sufficient for the start-up, but not enough for the design luminosity
- A trigger algorithm study showed that a 4/5 algorithm would be better than 3/4

The completion of the Endcap RPC system is split up:

- Phase 1: completion of the low η part: ($\eta < 1.6$)
- Phase 2: completion of the high η part: $(1.6 < \eta < 2.1)$

- A double layer for the Trigger Reference Station was proposed: RE2bis
- Due to hardware problems final decision on the restoration was delayed
- A new study was requested . . .

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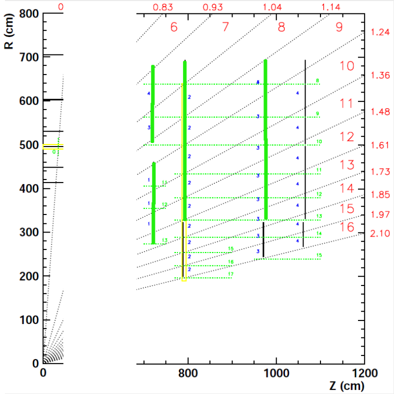
Hardware Solutions

What it is now and what it should have been . . .

Current and TDR System for $\eta < 1.6$



- Current Lay-out
- TDR Lay-out

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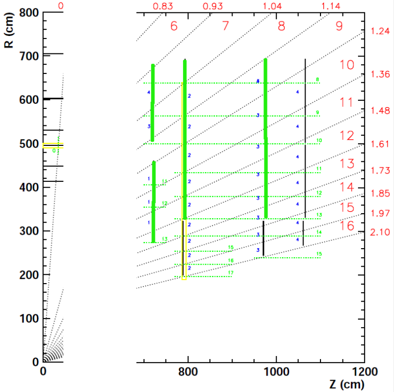

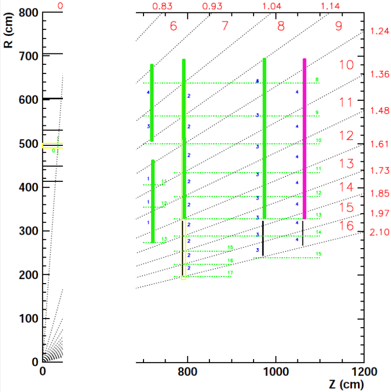

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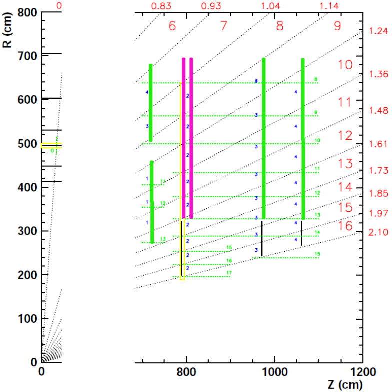
Hardware Solutions

What other options do we have?

RE2bis and RE4bis System for $\eta < 1.6$



- RE4bis Lay-out
- RE2bis Lay-out

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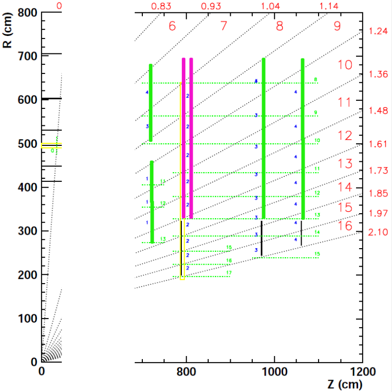

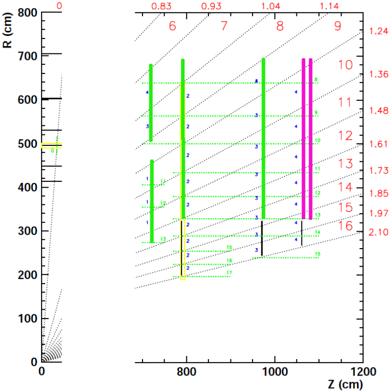

- RE2bis Lay-out
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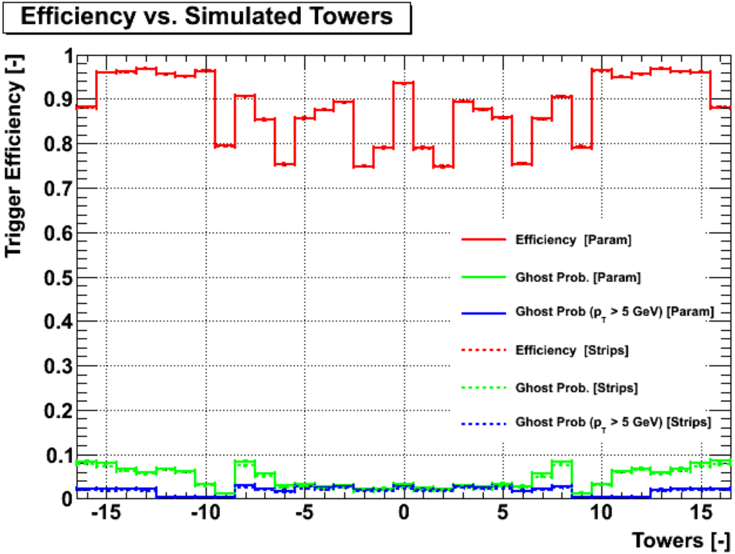
Trigger Efficiency

Efficiency vs. η



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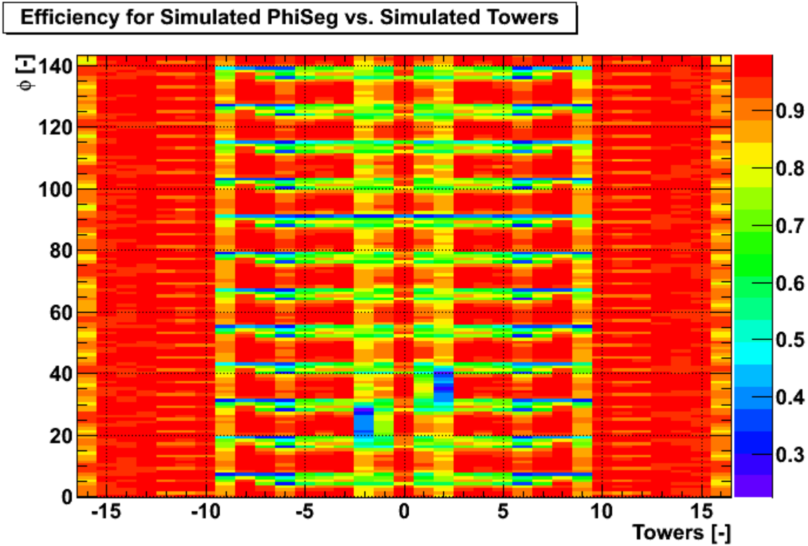
Efficiency vs. φ and η



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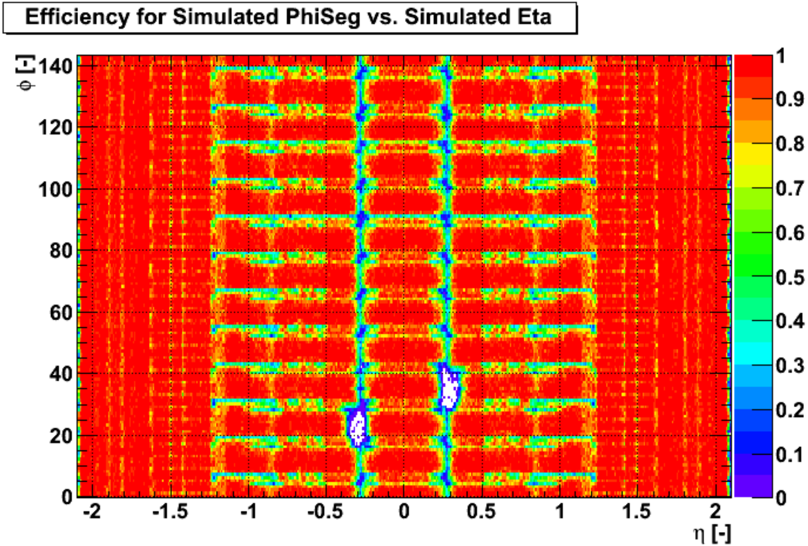

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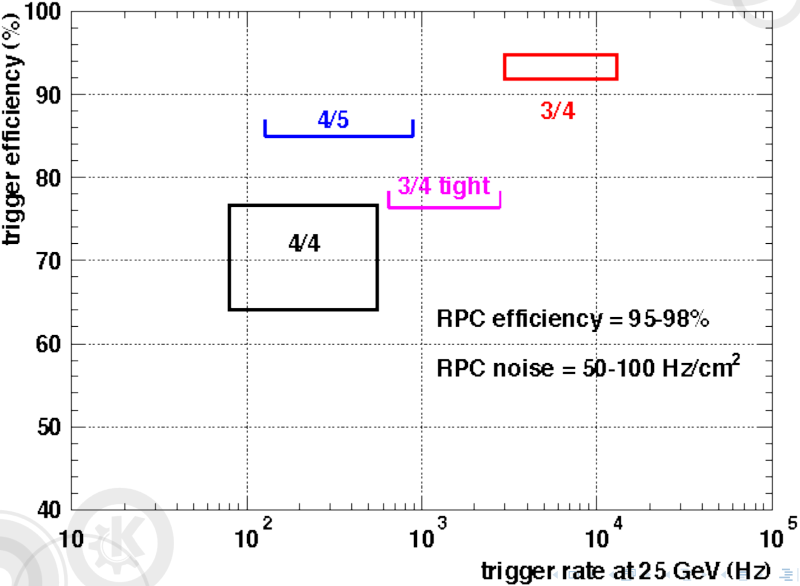
Algorithm Study



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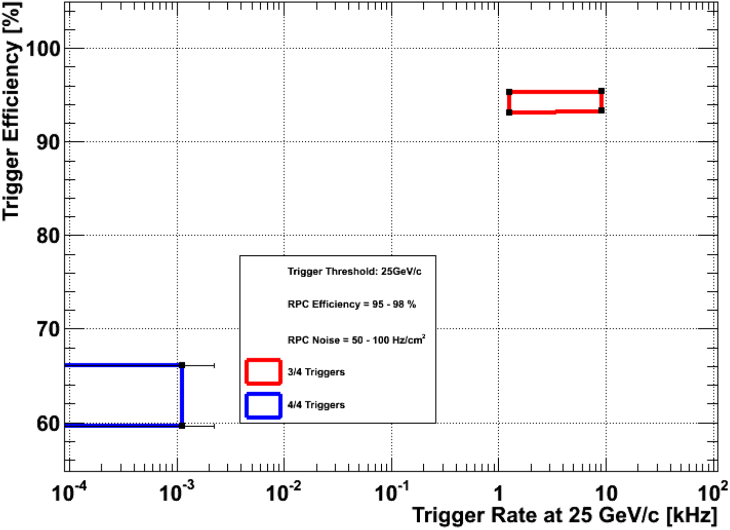
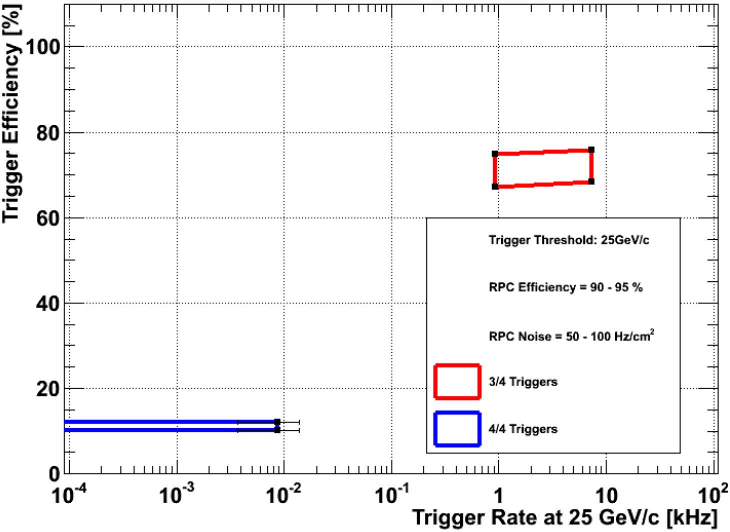
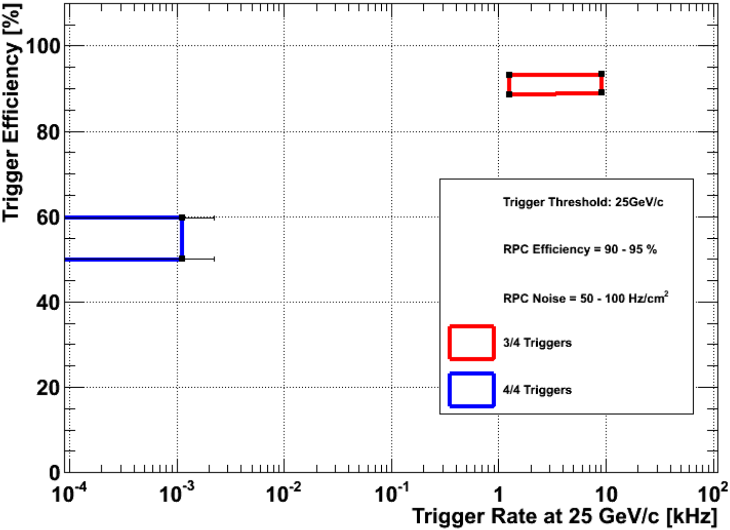


Current system



TDR system


Trigger Efficiency [%]
100
80
60
40
20
0
10^-4
10^-3
10^-2
10^-1
1
10
10^2
Trigger Rate at 25 GeV/c [kHz]
Trigger Threshold: 25GeV/c
RPC Efficiency = 90 - 95 %
RPC Noise = 50 - 100 Hz/cm^2
3/4 Triggers
4/4 Triggers

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Conclusions and Outlook

- Nothing
- Work is in progress
- I like detector performance
- Need to investigate in order to reproduce earlier results
- Rough assumptions are not satisfying
- Use Signal samples and Minimum Bias

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Questions ?

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Back Up Slides

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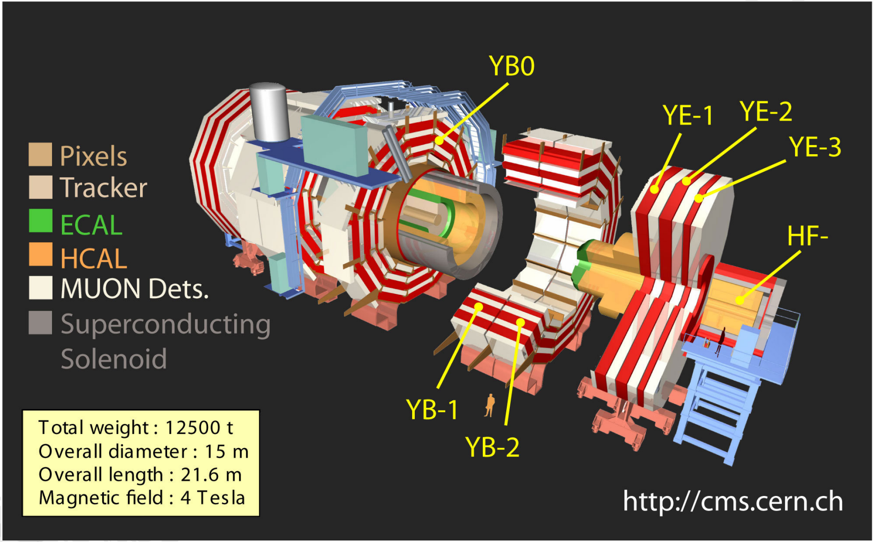
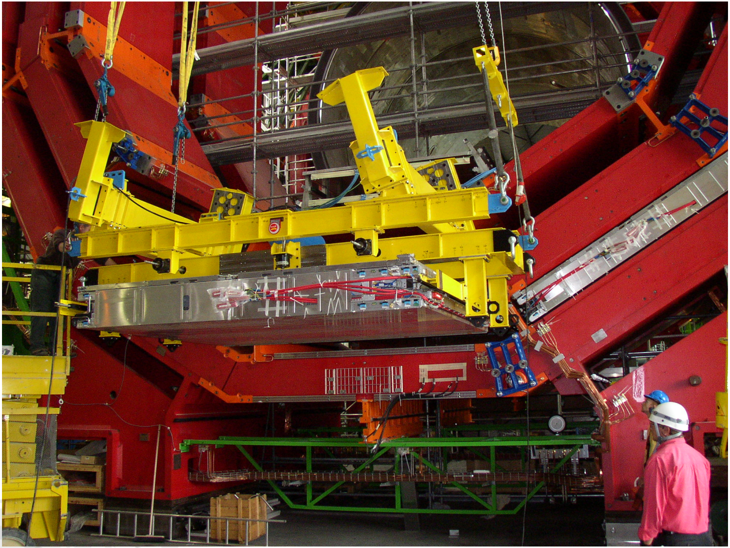
The CMS detector

The Compact Muon Solenoid



Drift Tubes

One picture says more than 1000 words



Cathode Strip Chambers

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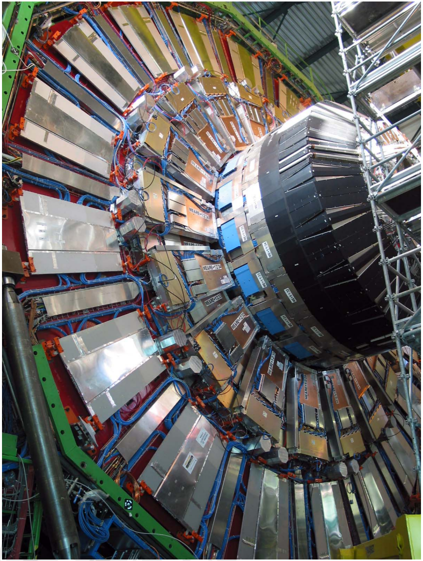

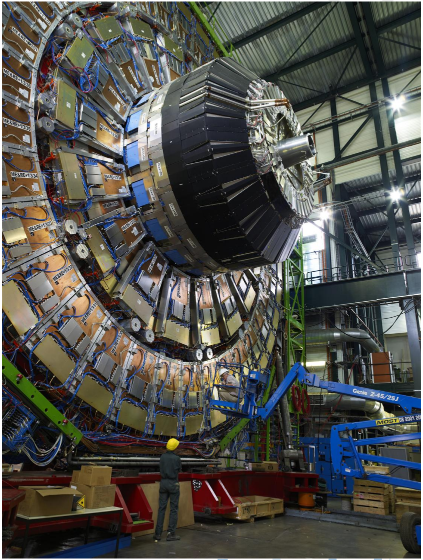

Resistive Plate Chambers

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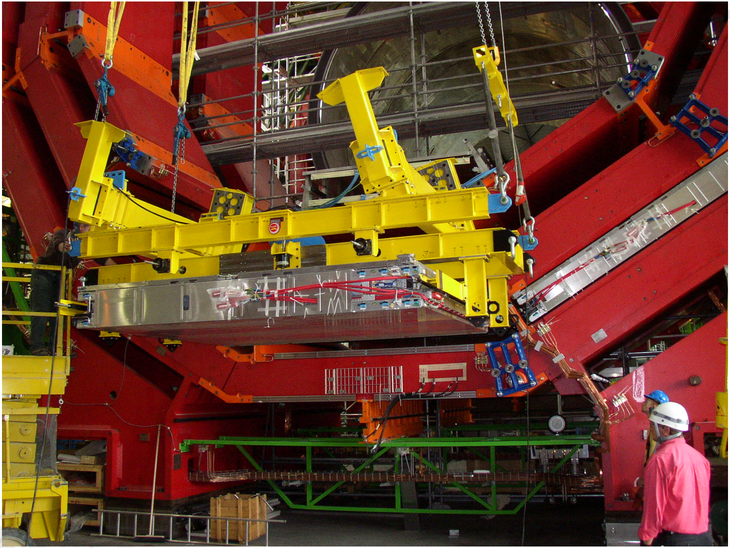

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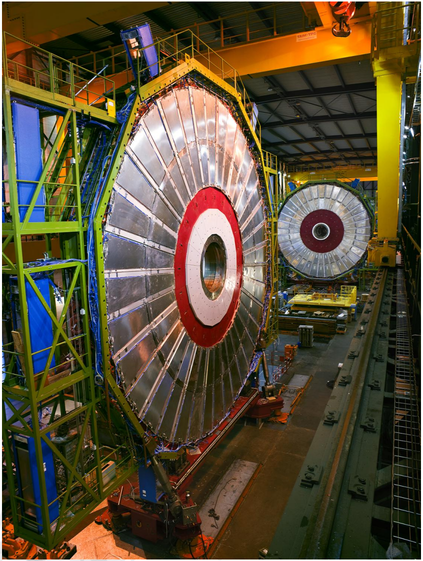
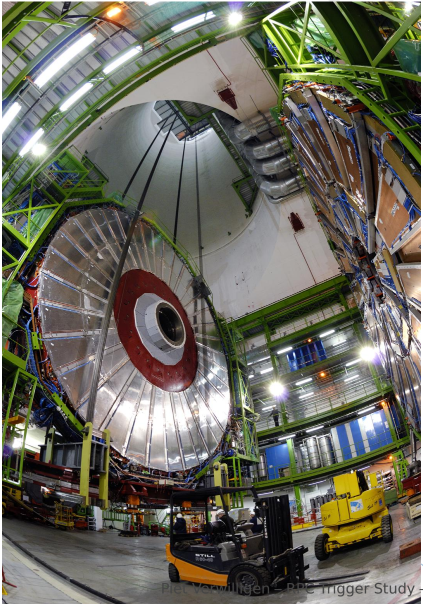
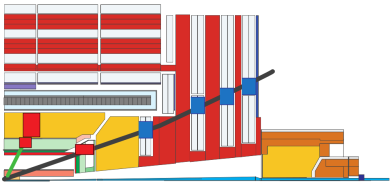




Trigger Levels

Level-1 and High Level Triggers

L1: 40 MHz $\longrightarrow$ 100 kHz



- Specialized processors (25 ns pipelined, latency < 1 μs
- Local pattern recognition on prompt macro-granular info from calorimeter and muon detectors

HLT: 100 kHz $\longrightarrow$ 100 Hz

- Large network of processor farms
- Mass, Track and Event reconstruction and analysis
- Finer granularity precise measurement

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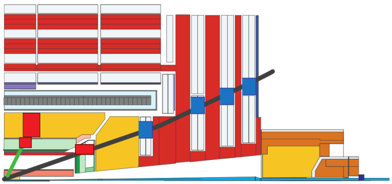

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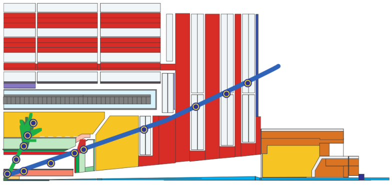

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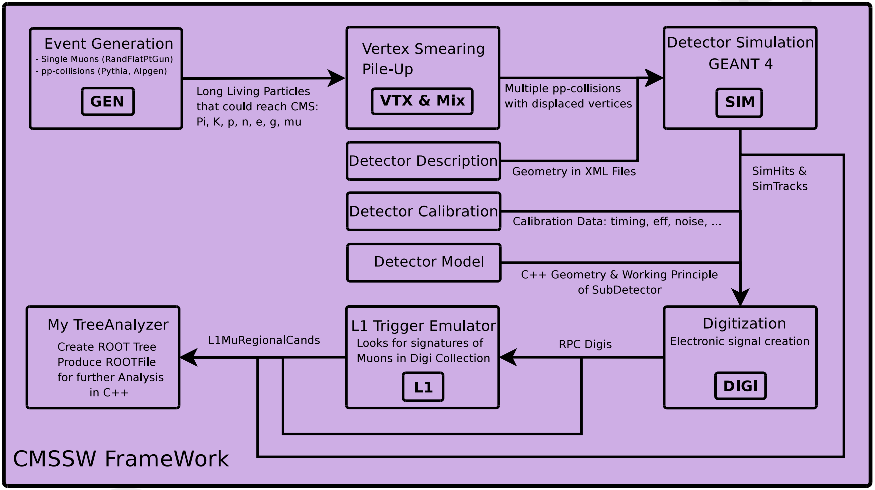
Trigger Simulation

- Reanimate RPC simulation developped mid. 2006
- Parameters: Efficiency , Noise and ClusterSize
- Different Models: Parameteric, Strip by Strip, ...
- Single Muons: $10 < p_{\mathrm{T}} < 200\,\mathrm{GeV\,c^{-1}}$ and $-2.1 < \eta < 2.1$
- Noise: 0.05 10 50 $100\,\mathrm{Hz\,cm^{-2}}$

Simulation Chain

Simulation Chain



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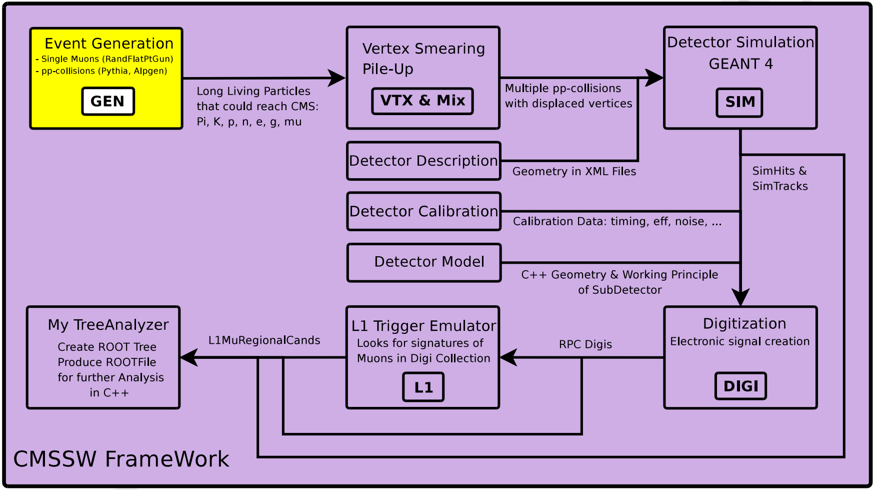

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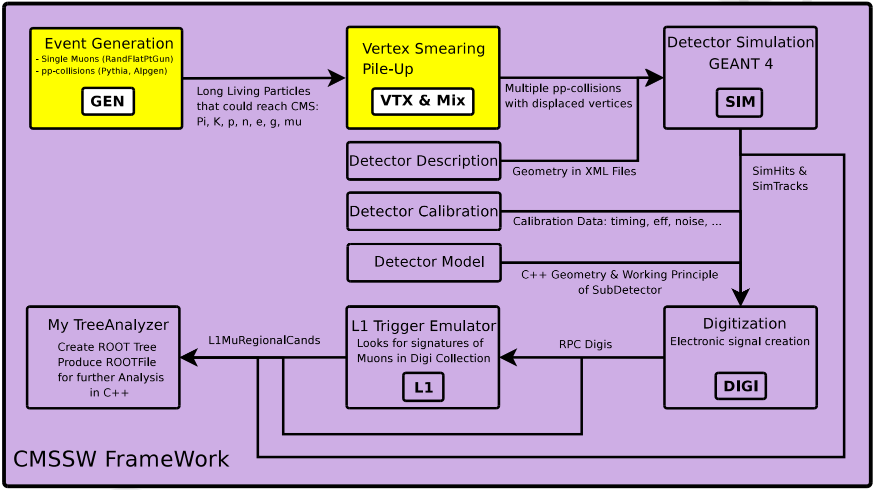

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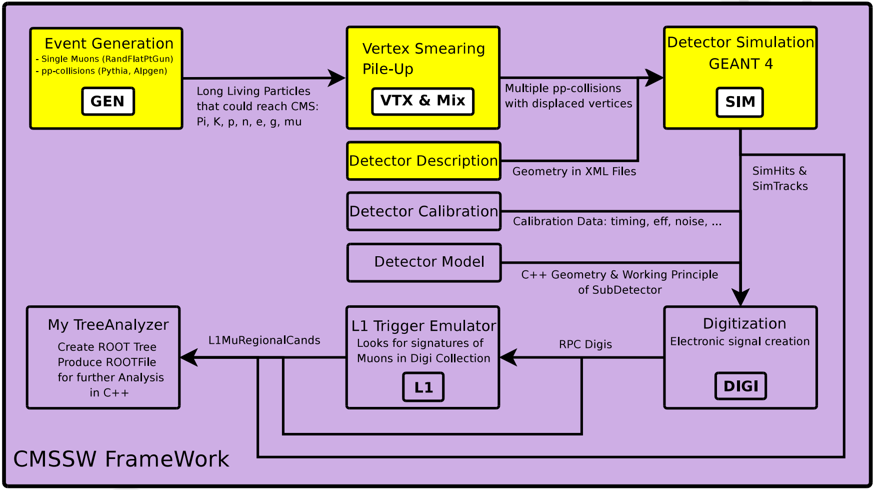

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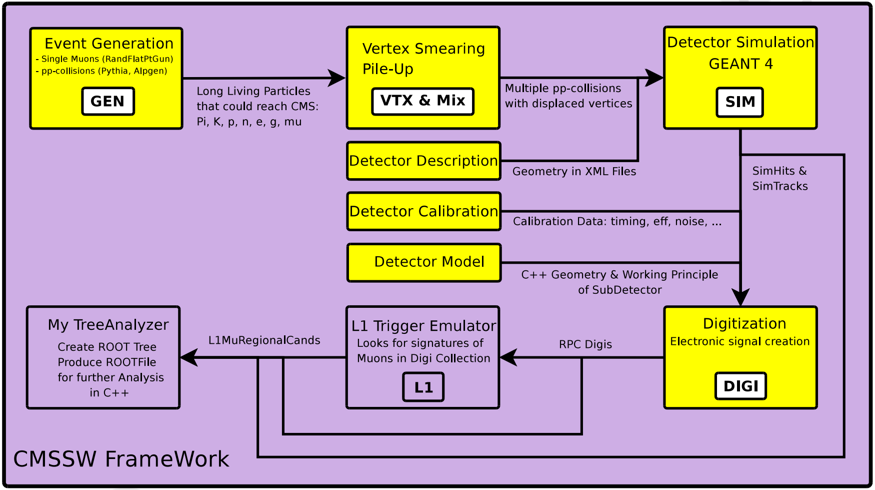

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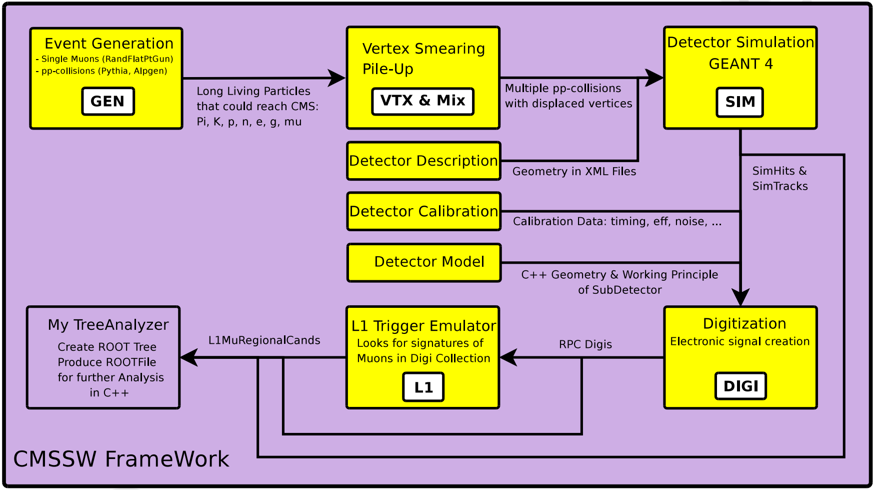

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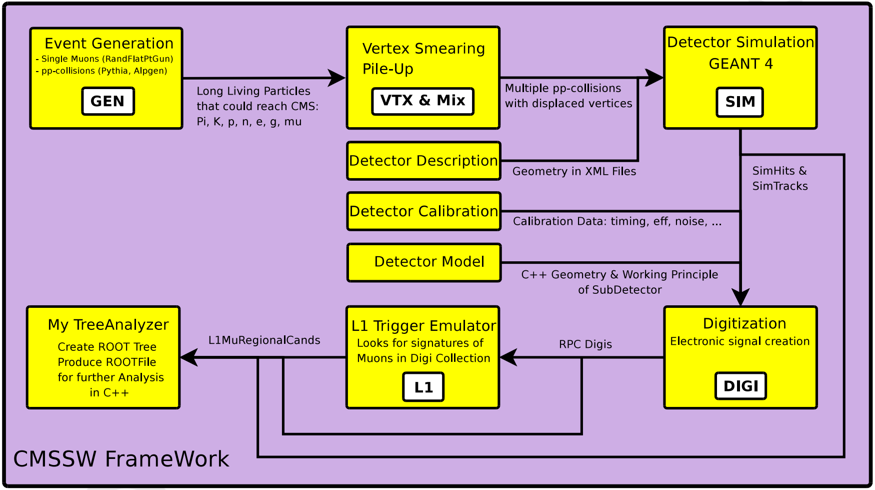

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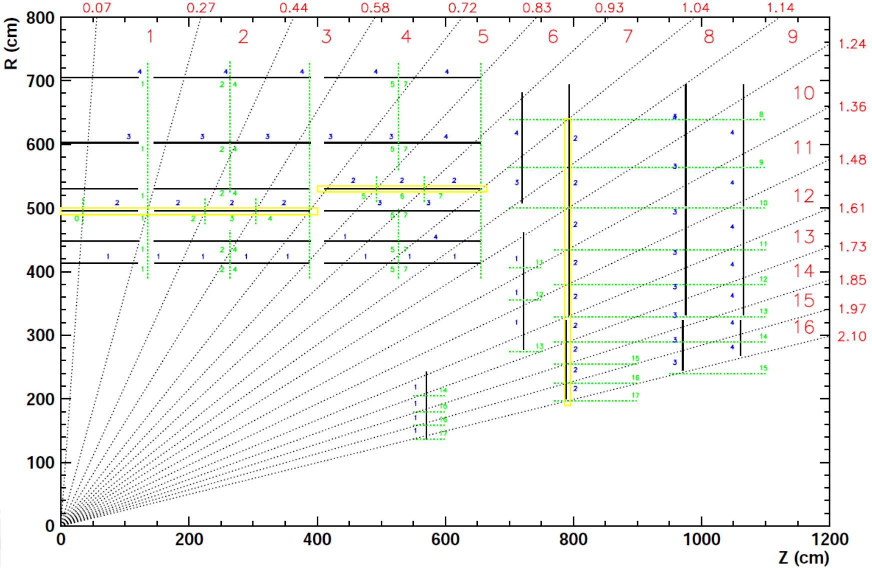
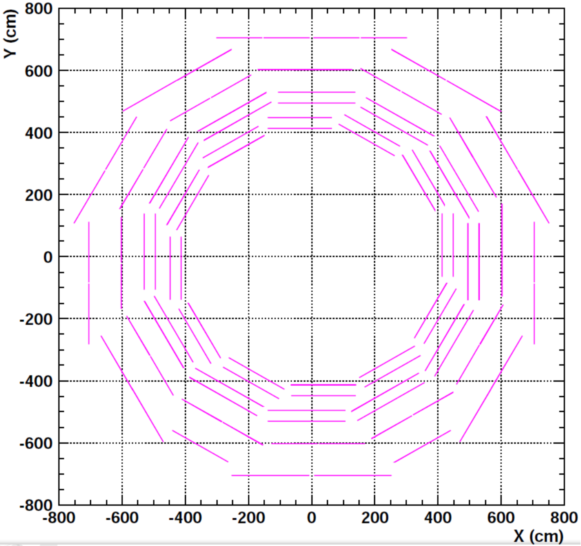
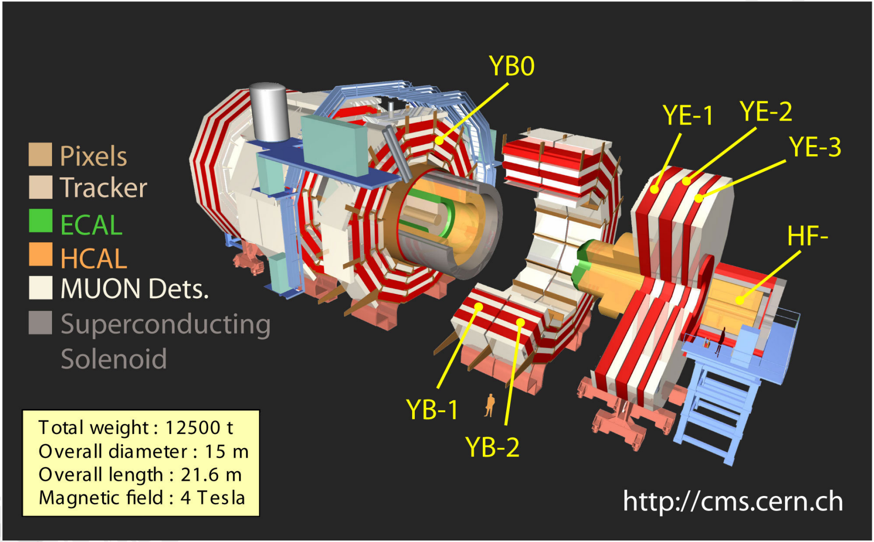
RPC Geometry in η



RPC Geometry in ϕ



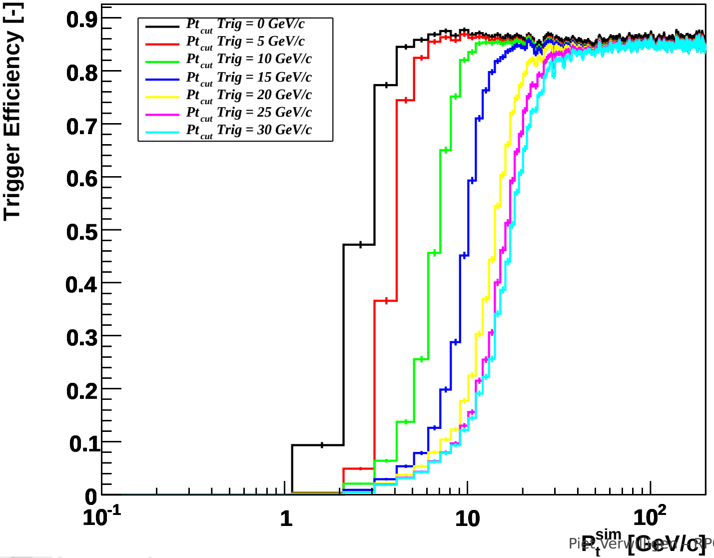
The CMS detector
The Compact Muon Solenoid



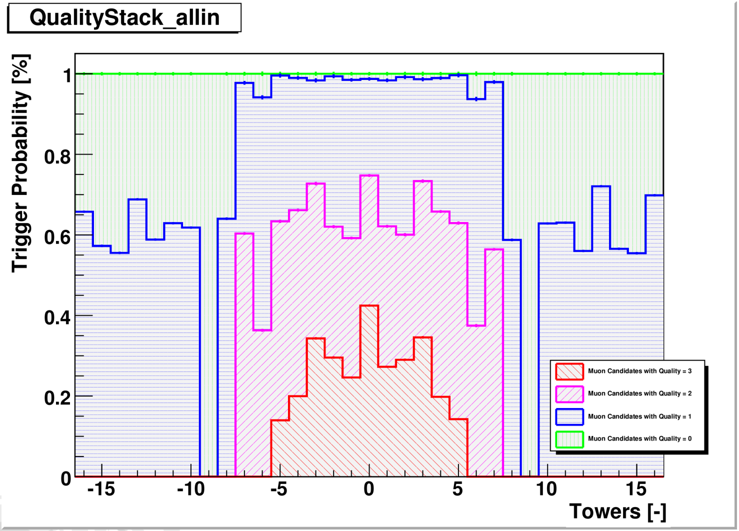
Trigger Efficiency

Efficiency vs. p_T

Efficiency vs. Simulated Pt



Trigger Quality



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