Muon efficiency for Z boson with the tag and probe method using CMS open data

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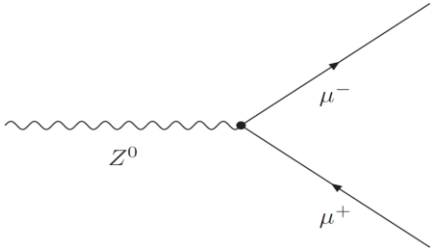
Outline

- Motivation;
- A brief overview of the project;
- CMS Open Data;
- Tag & Probe workflow;
- Muon identification;
- Evaluating efficiencies;
- Signal extraction;
- fitting results;
- Summary and Next steps.

Motivation

- Study of the efficiency of muon identification algorithm with Tag and Probe method using CMS Open Data. The Tag&Probe (TP) method is an experimental procedure used commonly in particle physics that allows to measure process efficiencies directly from data, not having therefore to rely on simulation (and on its accuracy describing the data).
- The method relies upon Z → di-lepton decays to provide an unbiased, high-purity, electron or muon sample with which to measure the rate of a particular selection or trigger. In this method, a single lepton trigger sample is used, from which a subset of di-lepton events is selected.

A brief overview of the project



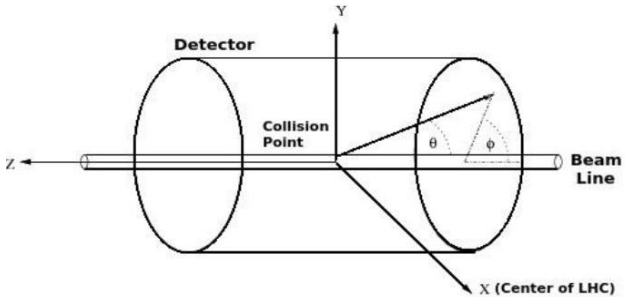
CMS Open Data

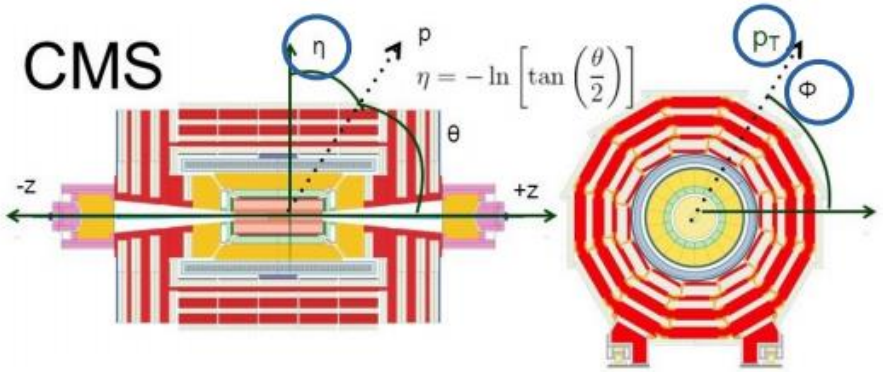
- Legacy Data (2012)
- Simulated Data

Tag & Probe → efficiency (ε)

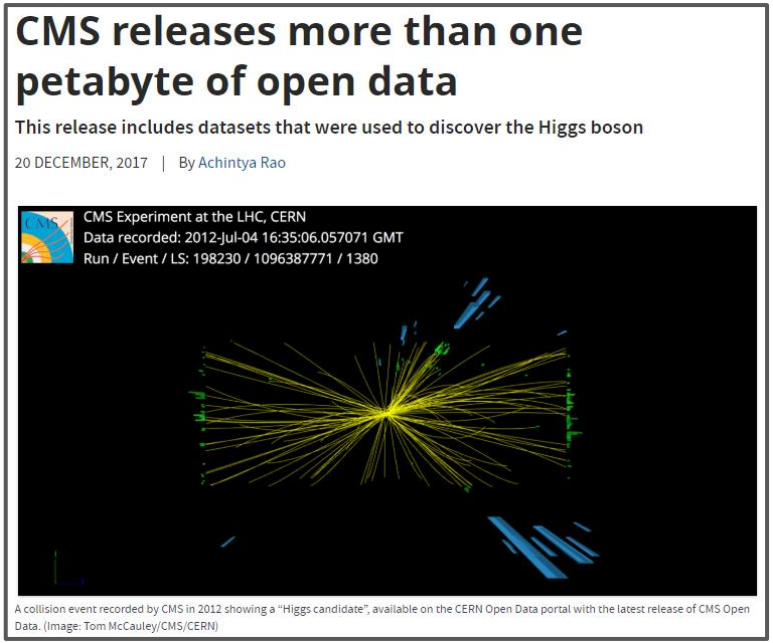
As function of:

- Pseudorapidity (η)
- Azimuthal angle (ϕ)





CMS Open Data



CMS releases more than one petabyte of open data

This release includes datasets that were used to discover the Higgs boson

20 DECEMBER, 2017 | By Achintya Rao

A collision event recorded by CMS in 2012 showing a "Higgs candidate", available on the CERN Open Data portal with the latest release of CMS Open Data. (Image: Tom McCauley/CMS/CERN)

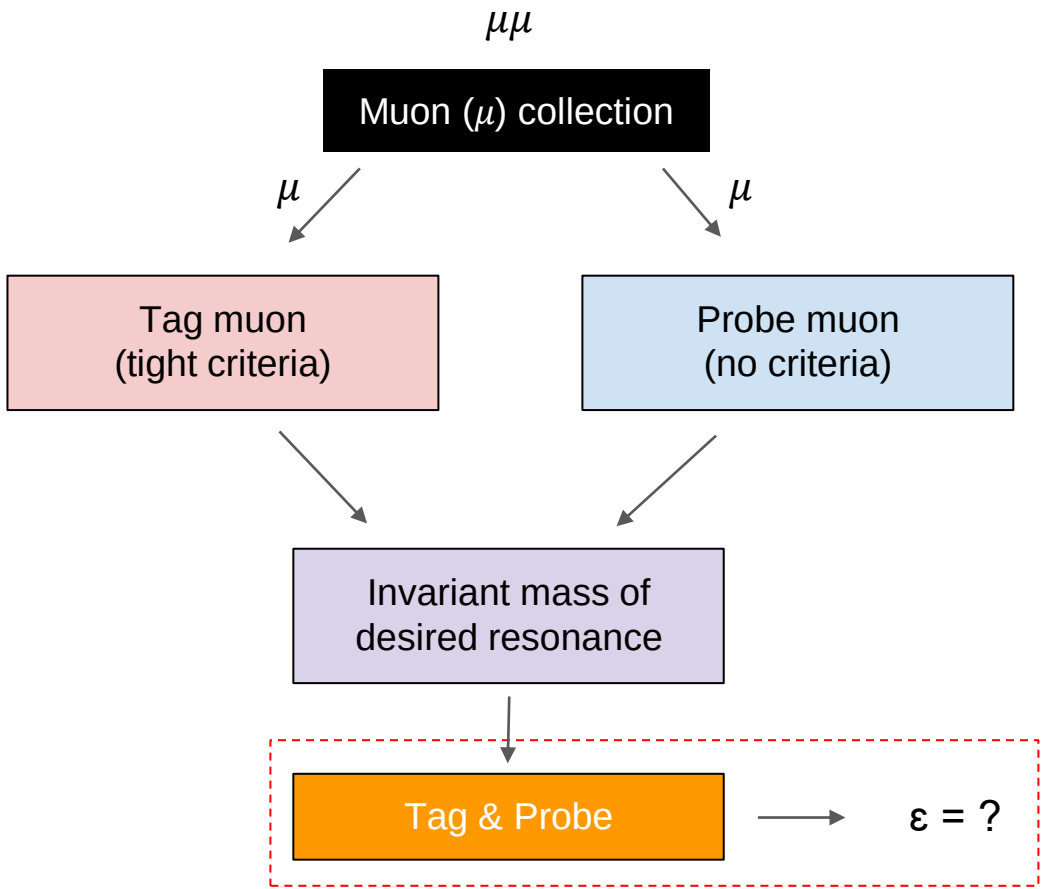
The CMS Open Data is an initiative that makes scientific data from the CMS experiment available to the public.
With data transparency It tries to make science more inclusive and open.

https://home.cern/news/news/experiments/cms-releases-more-one-petabyte-open-data

Tag & Probe workflow

Desired resonance:

Z → μ+ , μ-



Tag & Probe method efficiency (ε)

The Tag & Probe method consists in calculating the efficiency of a detector using gathered data without the dependency on the simulations.
This method uses known resonances (e.g J/ψ,ϒ,Z)

Tag muon = well identified, triggered muon (tight selection criteria)

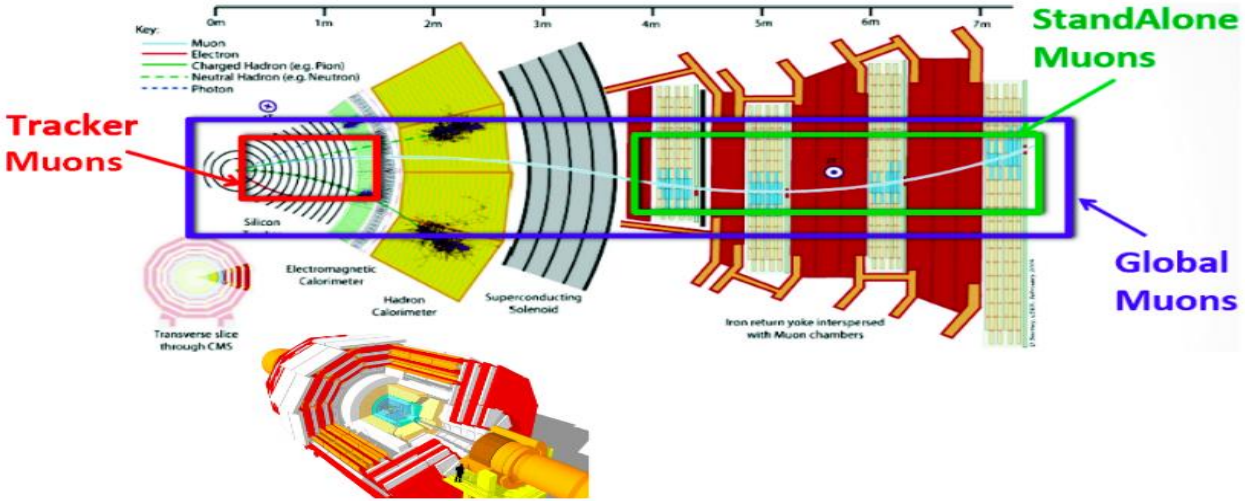
Probe muon = unbiased set of the desired particle type with a very loose selection criteria

$$\varepsilon = \frac{Passing\ probe\ muon\ criteria}{All\ probe\ muon} \longrightarrow \text{Muon id}$$

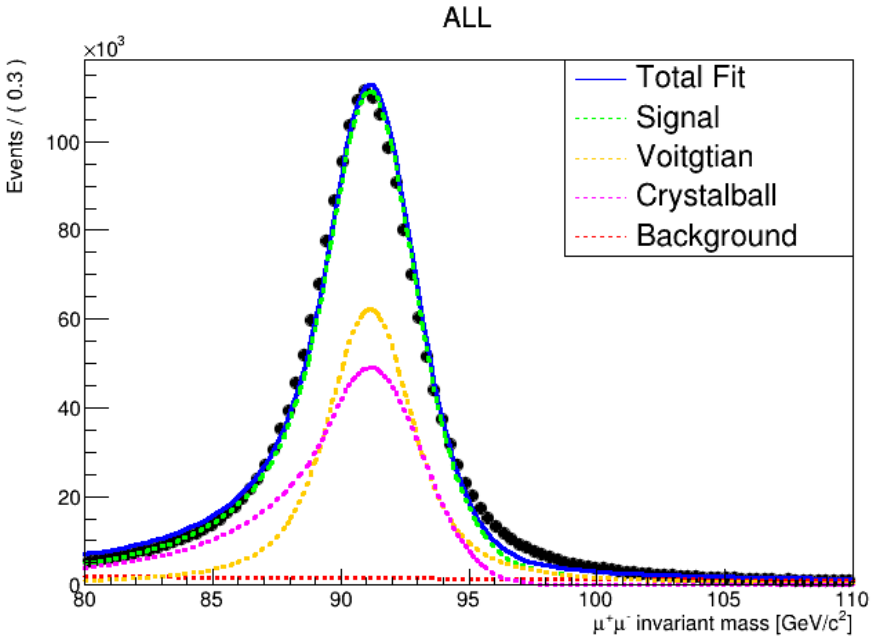
Muon identification

- Depending on where the muon is detected we can identify it as a global, standAlone or tracker muon

- The CMS detects muon from many sources, even not desired ones such as from cosmic rays, so it is very important that we identify the muons so we can be sure that they are coming from the desired sources.



Evaluating efficiencies



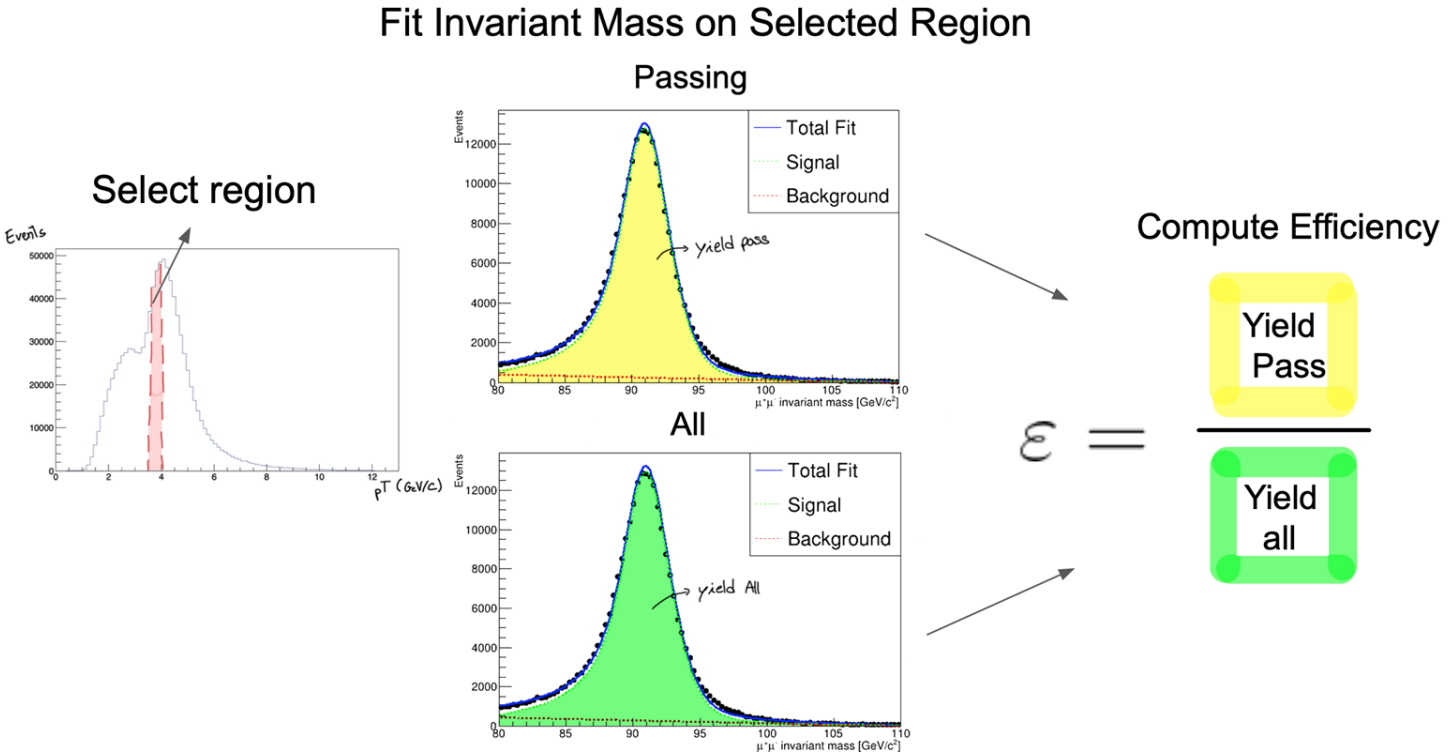
The efficiency is calculated using only **signal**
For example using Z invariant mass distribution we have:

Signal = Voitgtian + Crystal Ball

Background = polynomial

How can we extract signal quantities probe muon (η, ϕ)?

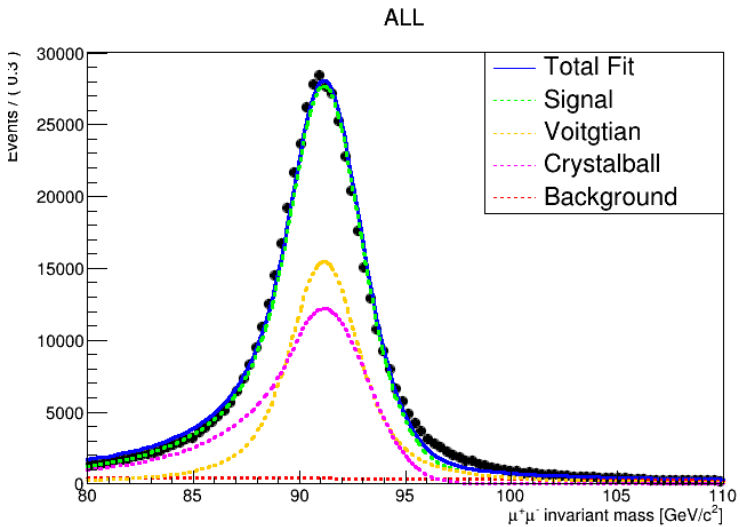
Extracting signal: Fitting method

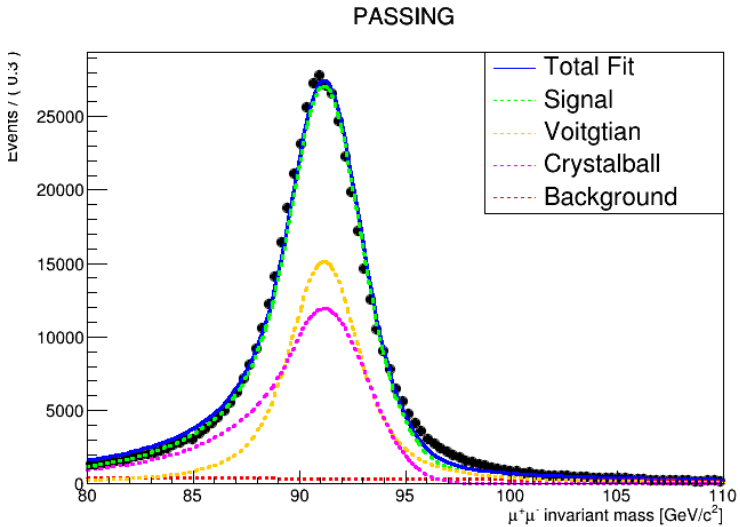


Evaluating efficiencies

- Plots for the Z boson invariant mass using Monte Carlo simulation.

- plots made by using Global muons between [0.8 , 1.0] in eta

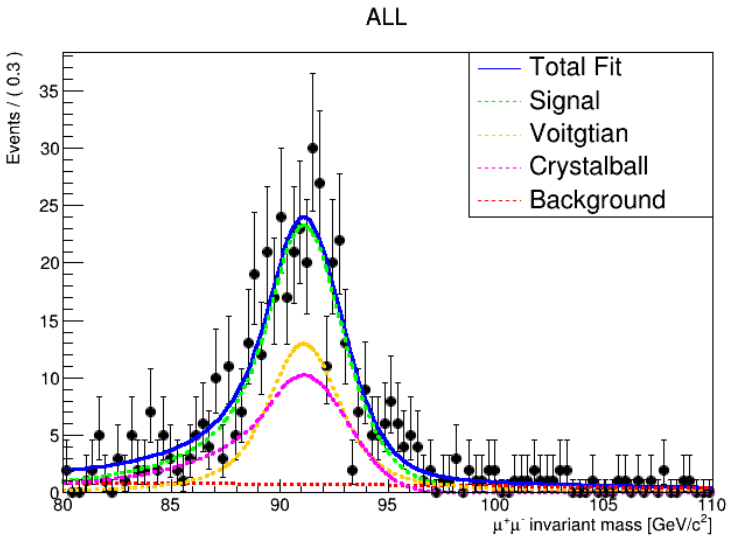


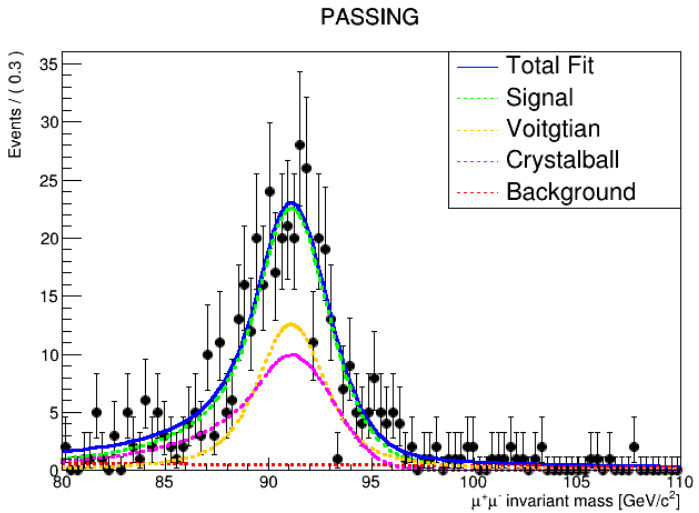


Evaluating efficiencies

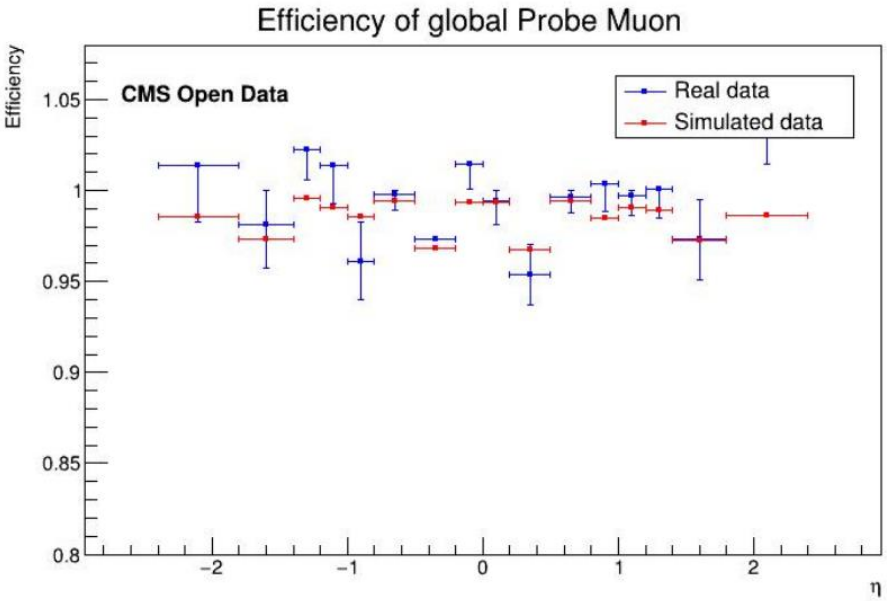
- Plots for the Z boson invariant mass using real data.

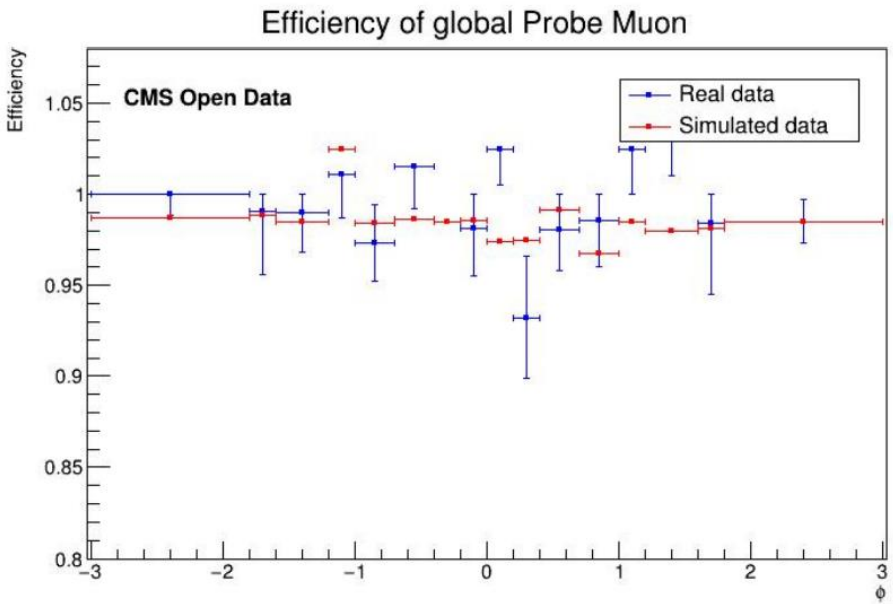
- Plots made by using Global muons between [0.8 , 1.0] in eta





Results: efficiencies for Z using fitting method





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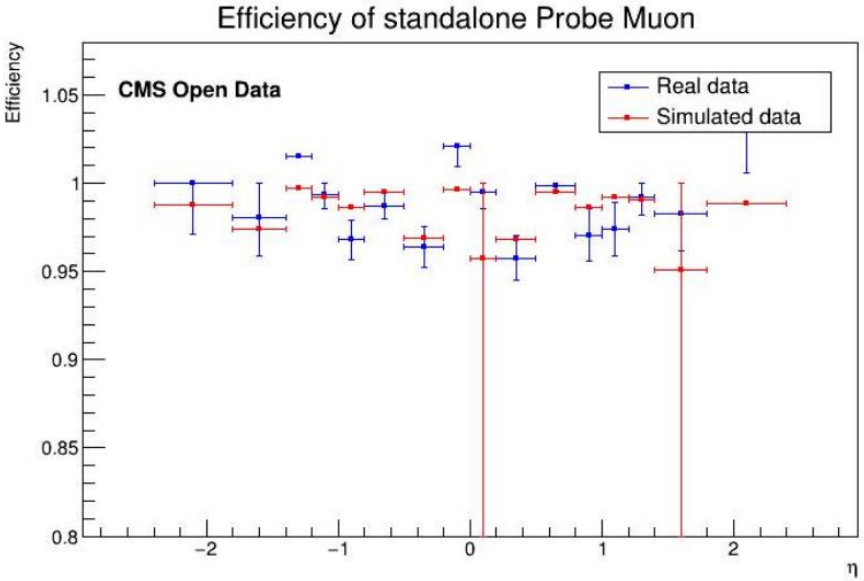

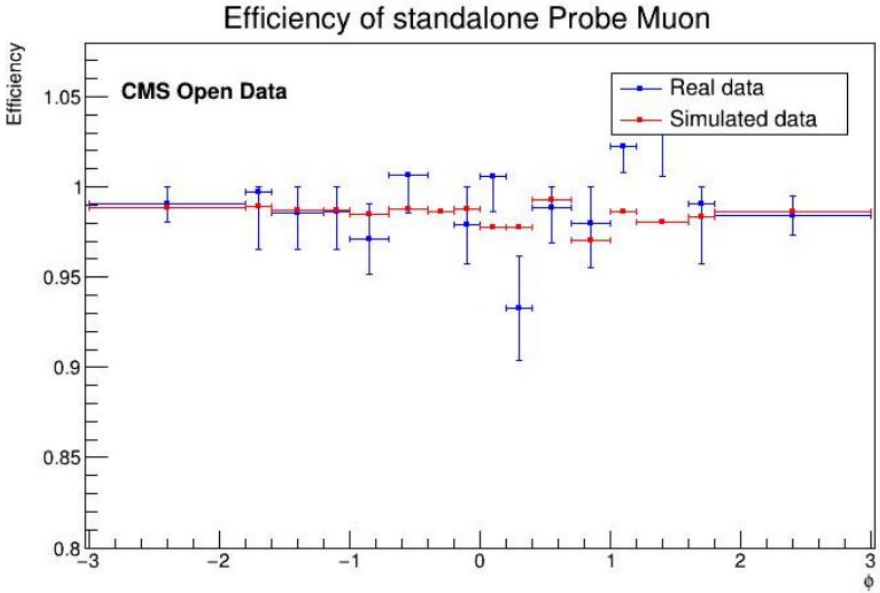

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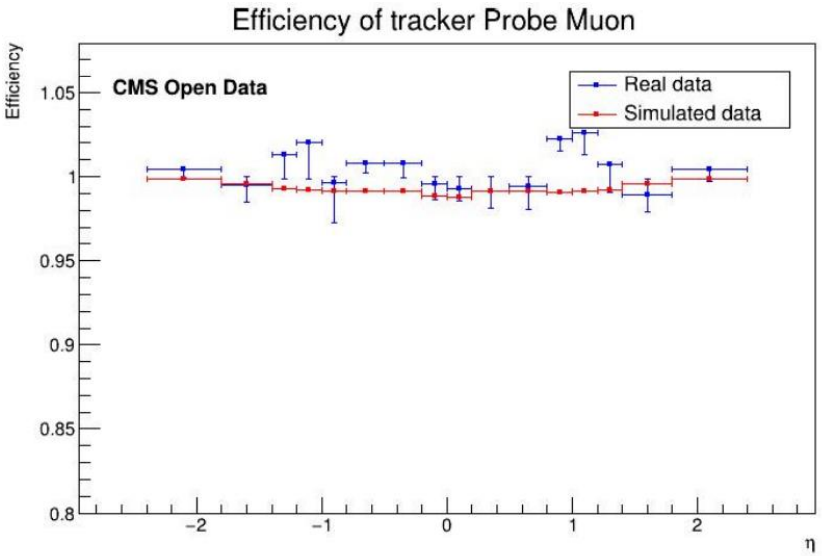
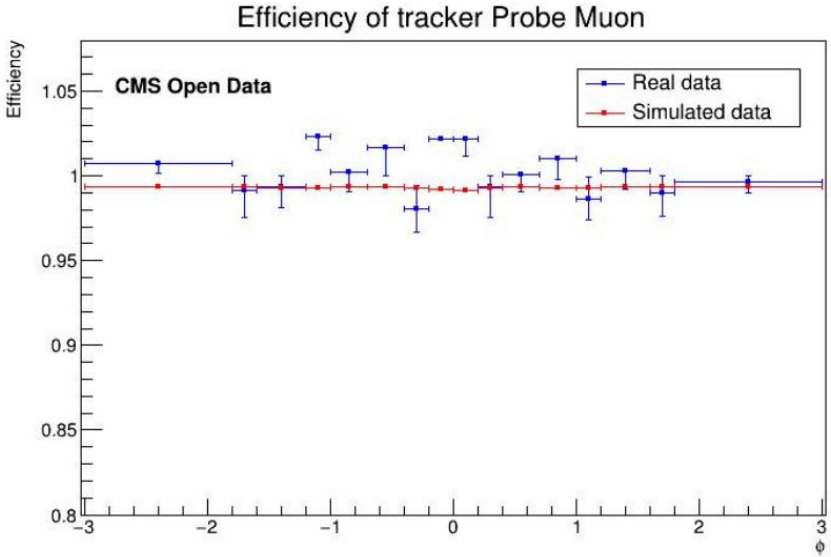




Summary

- We developed a tool to evaluate tag & probe method using CMS Open Data for Z decaying in dimuons;
- We measured efficiency for all muon ID making a comparison between data and MC;

Next steps

- Optimize the code for CMS Open Data users;
- Fine tunning of the PDF’s fits;

References

- HLT Trigger Path: HLT_Mu24_v*
- Z boson invariant Mass window :80.0 – 110.0 GeV.
- CMS open Dataset: /SingleMu/Run2012B-22Jan2013-v1/AOD: http://opendata.cern.ch/record/6021
- Monte Carlo Dataset: DYToMuMu_M-20_CT10_8TeV-powheg-pythia6 in AODSIM 2012 Data (http://opendata.cern.ch/record/7741)

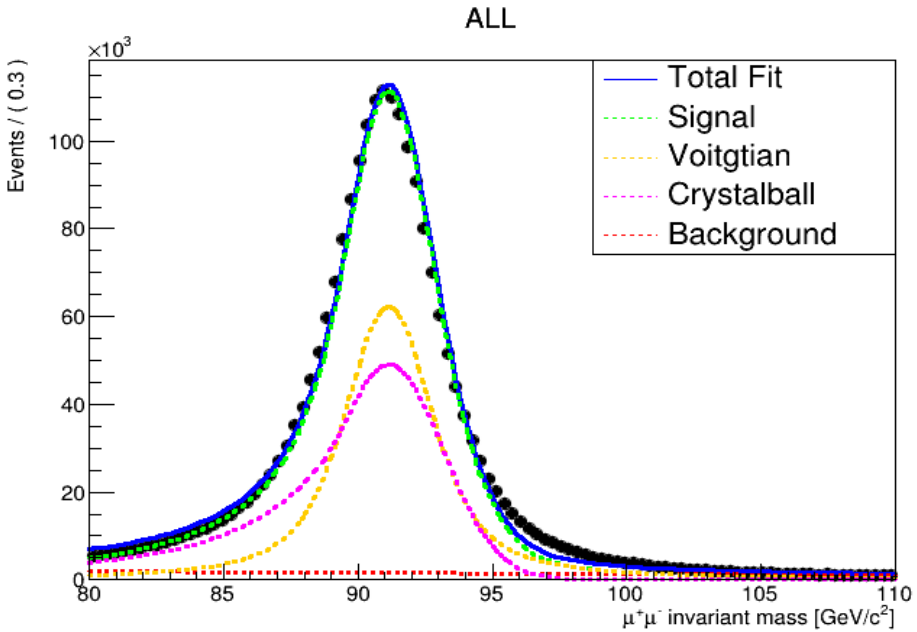
END

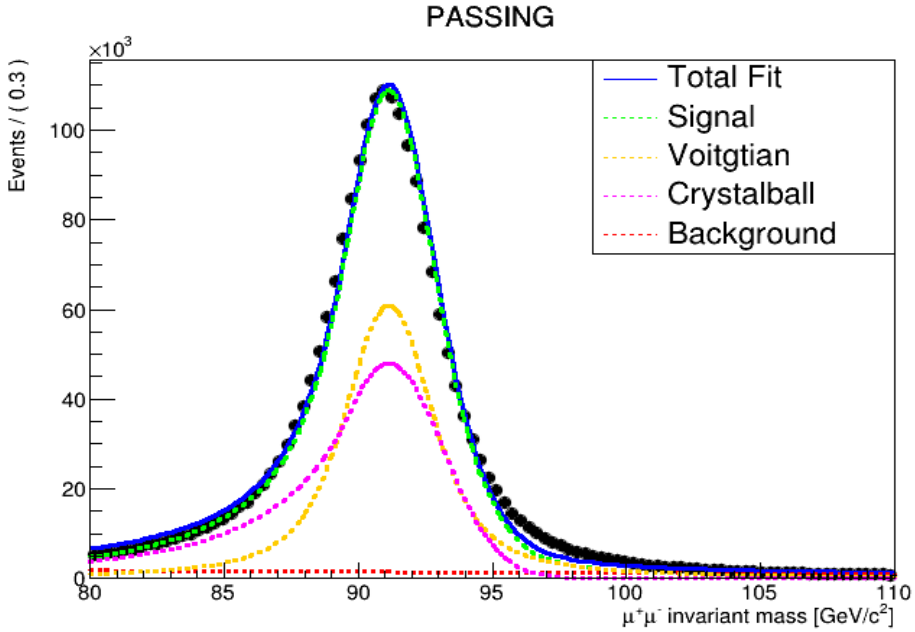
Backup

Evaluating efficiencies

- Plots for the Z boson invariant mass using Monte Carlo simulation.

- plots made by using Global muons between [1.8 , 3.0]rad in phi



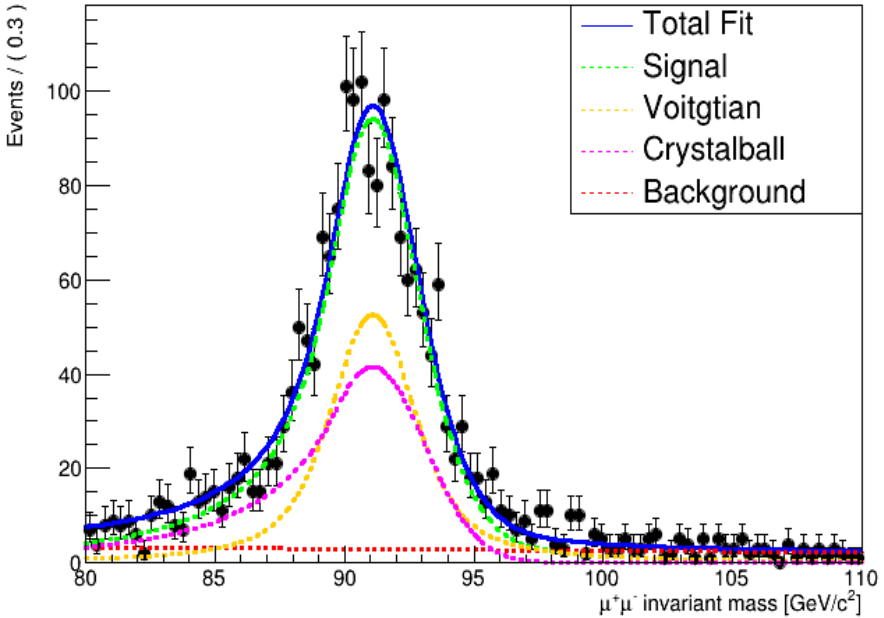


Evaluating efficiencies

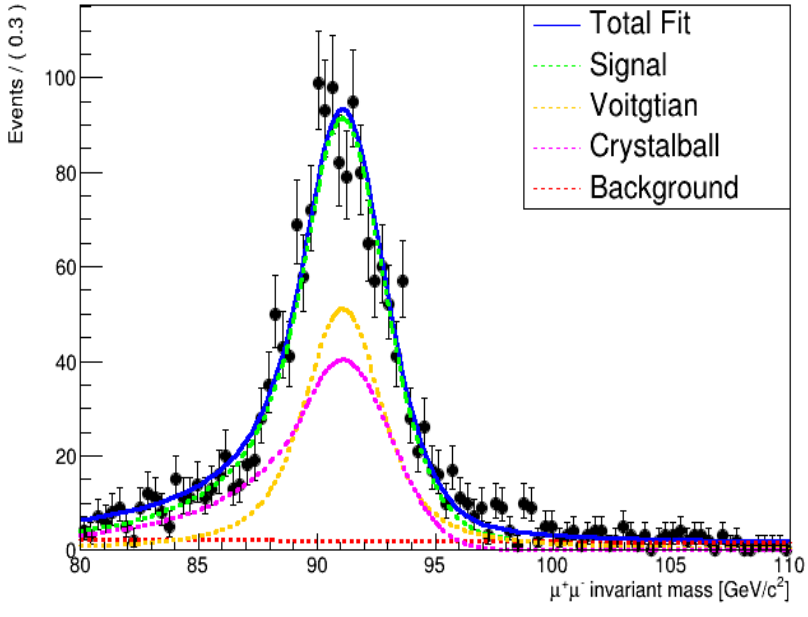
- Plots for the Z boson invariant mass using real data.

- plots made by using Global muons between [1.8 , 3.0]rad in phi

ALL

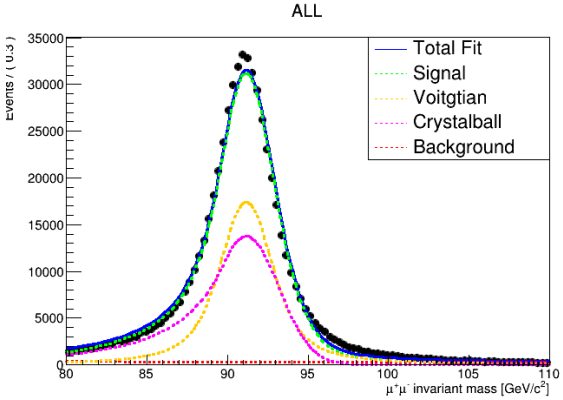


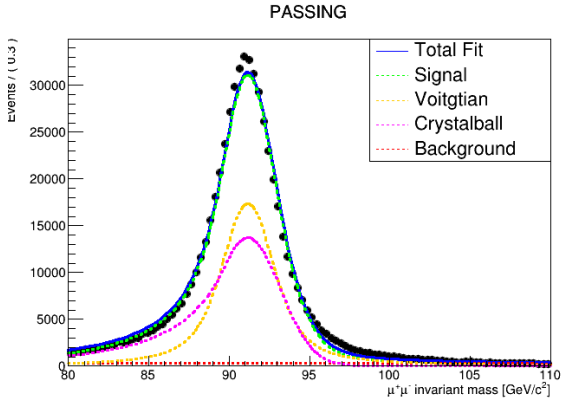
PASSING



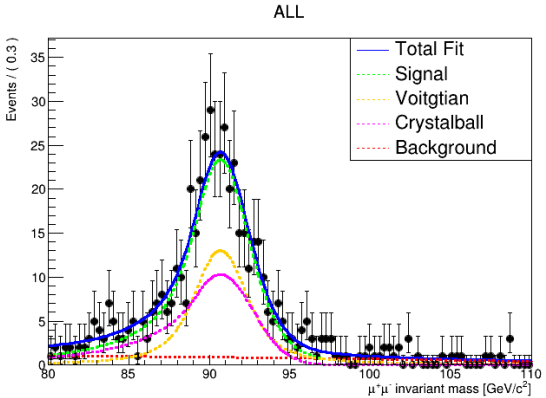
Evaluating efficiencies

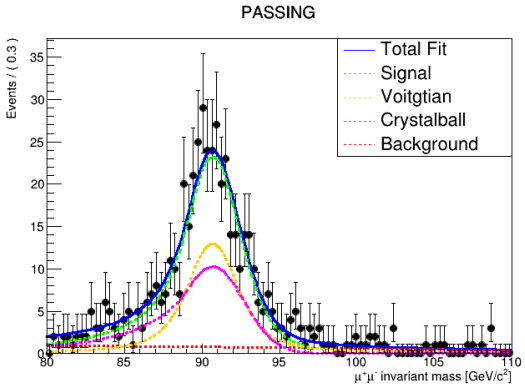
- Plots for the Z boson invariant mass using Monte Carlo in (-0.2 && 0.0).



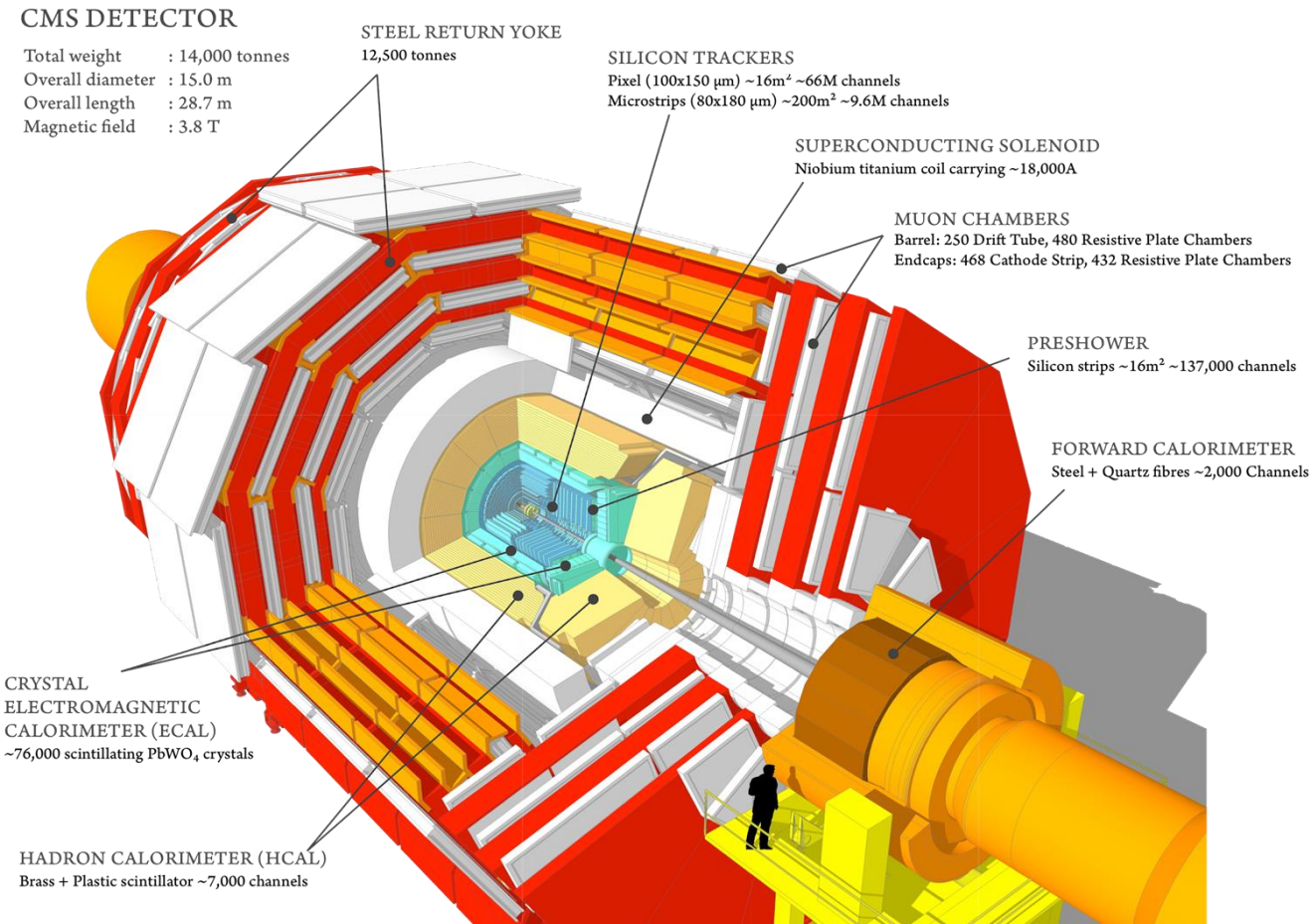


- Plots for the Z boson invariant mass using real data in (-0.2 && 0.0).

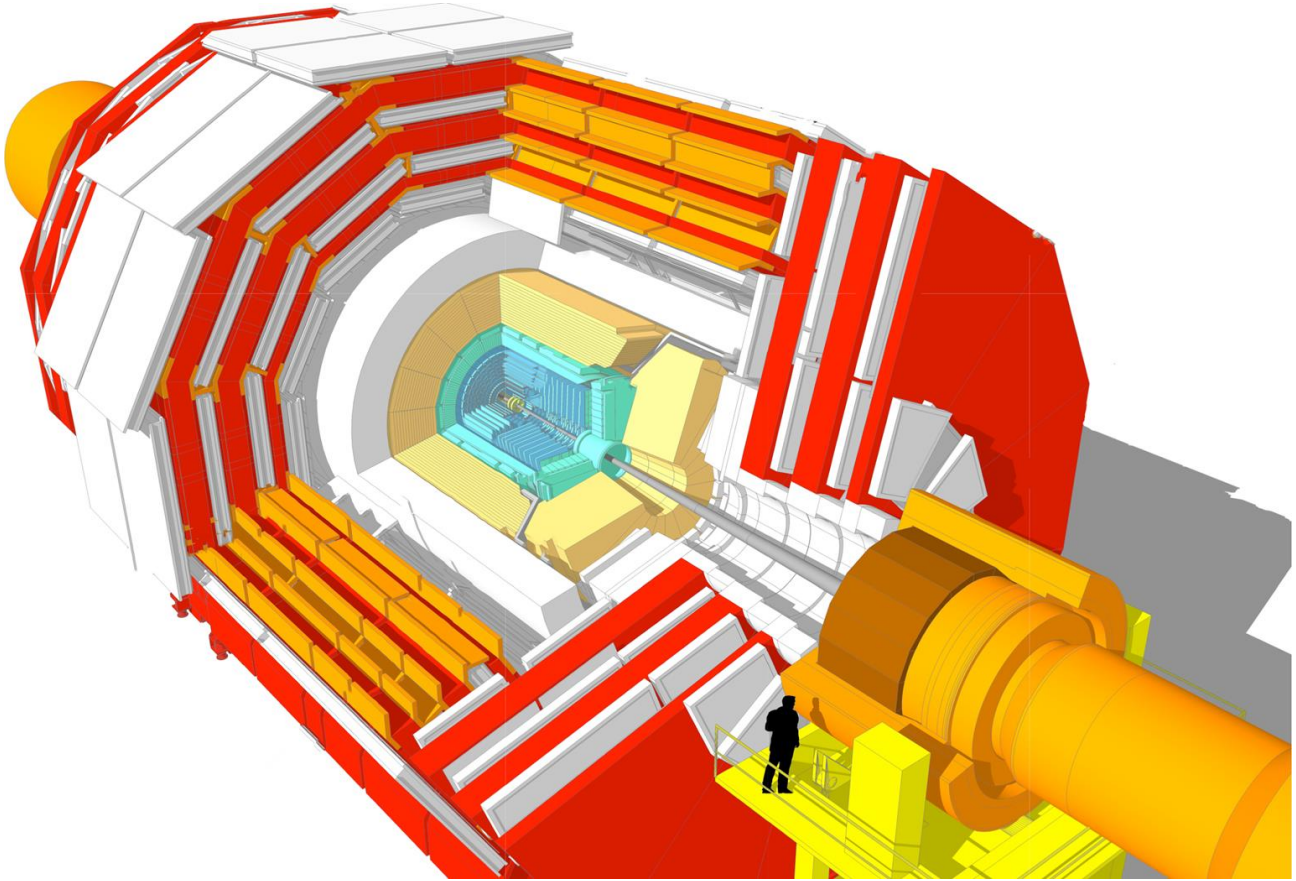




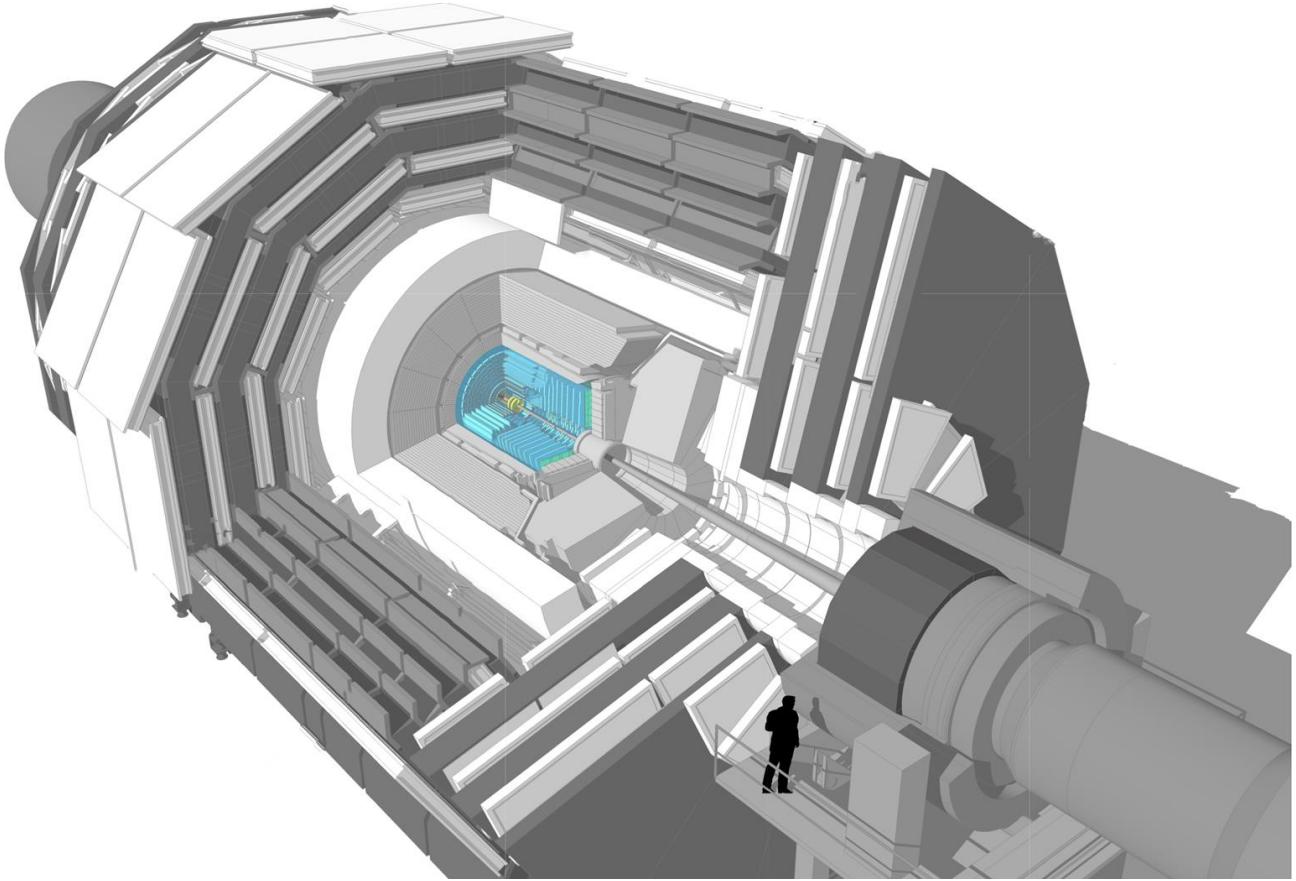
CMS Detector



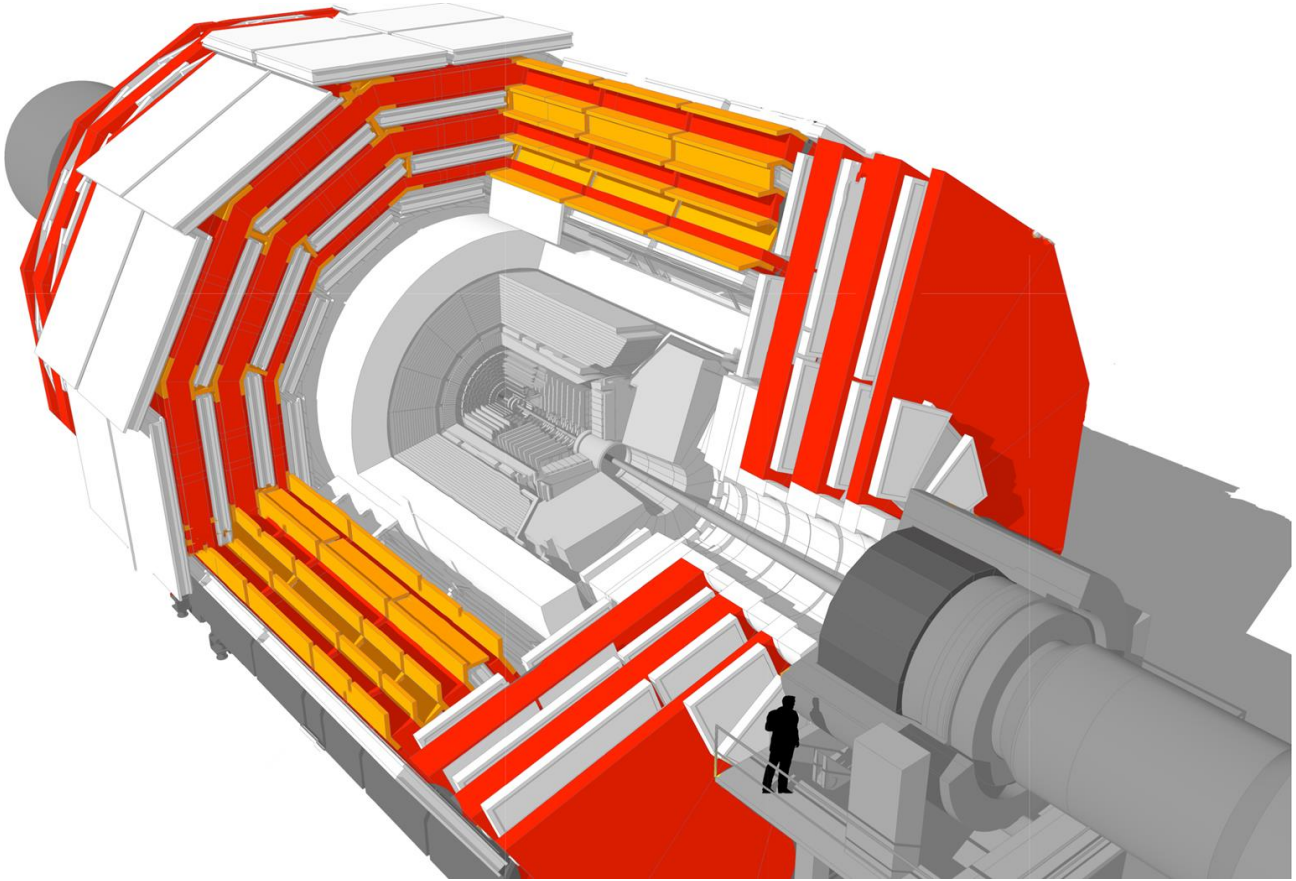
CMS Detector



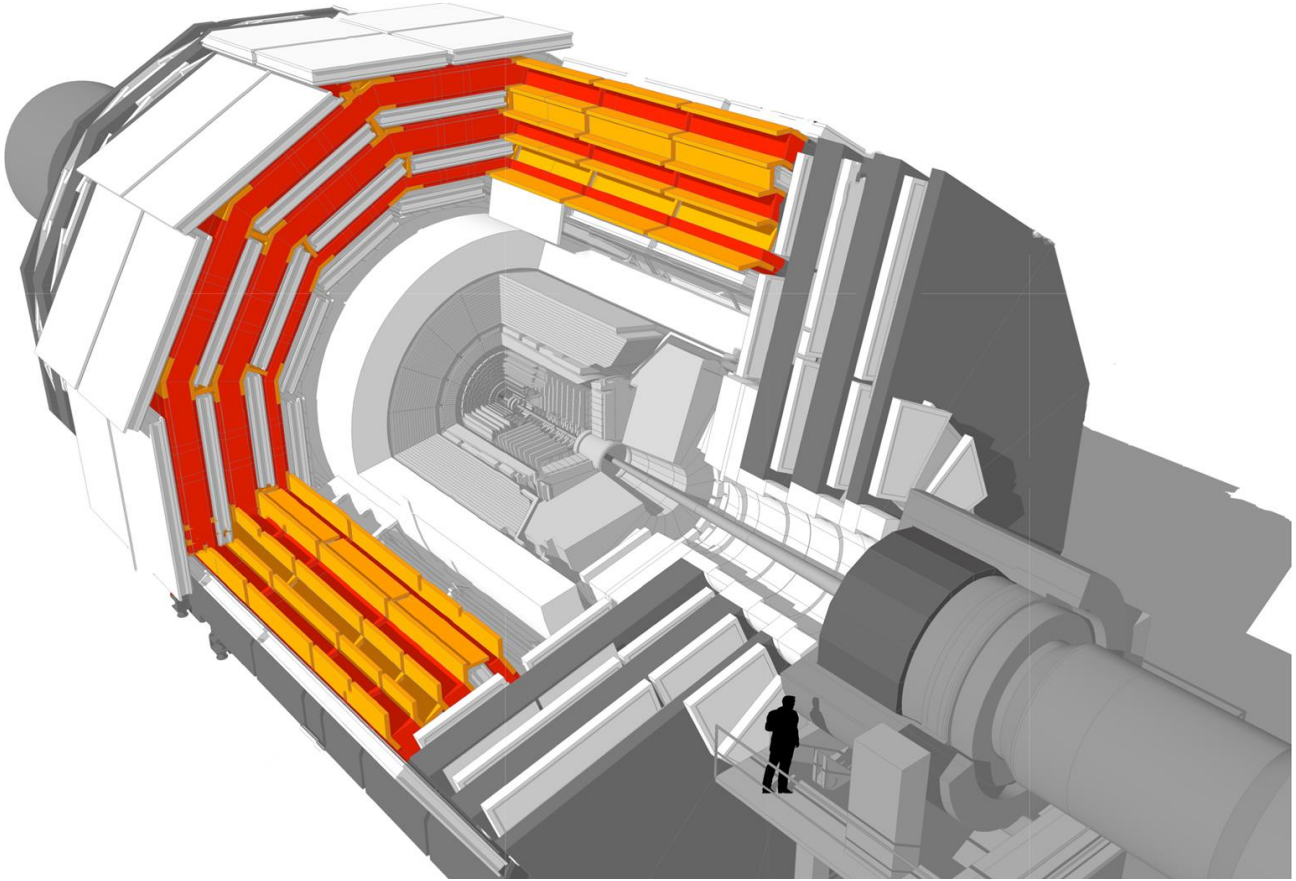
Inner Tracker



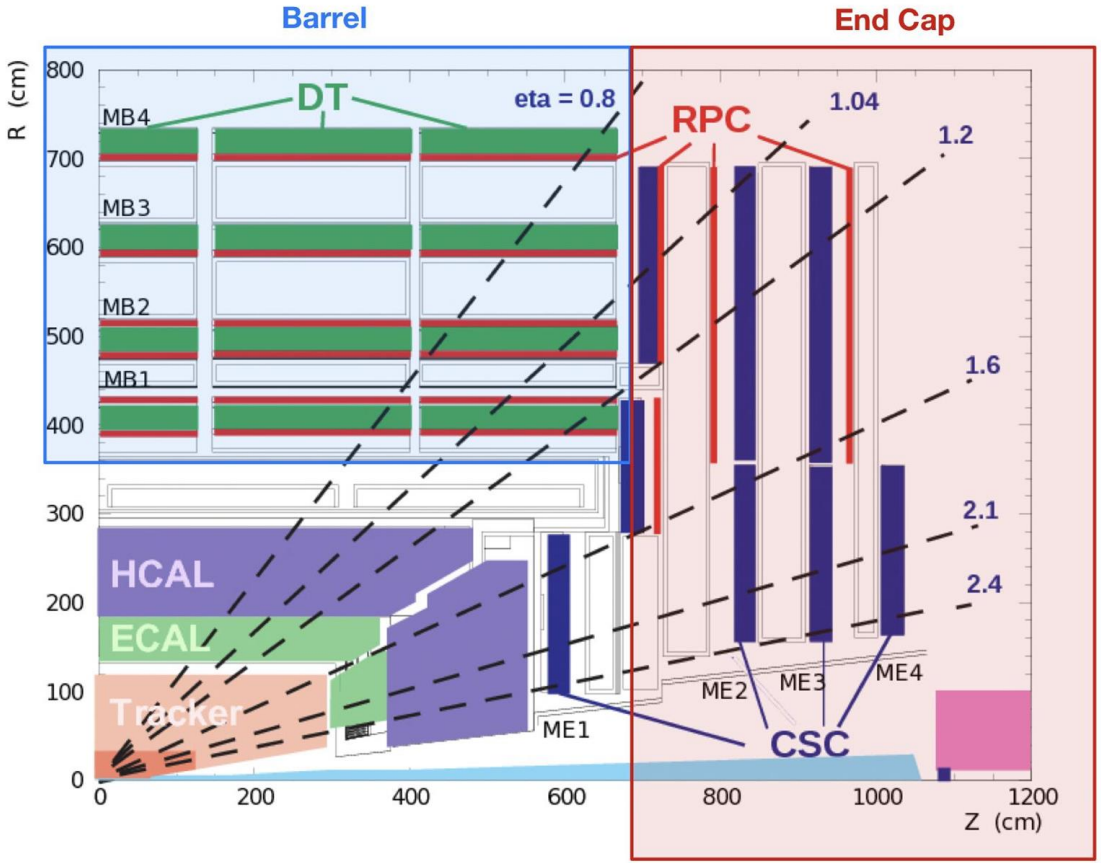
Muon Chamber



Barrel



Barrel


Barrel
End Cap
R (cm)
800
700
600
500
400
300
200
100
0
DT
MB4
MB3
MB2
MB1
eta = 0.8
RPC
1.04
1.2
1.6
2.1
2.4
HCAL
ECAL
Tracker
ME1
ME2
ME3
ME4
CSC
0
200
400
600
800
1000
1200
Z (cm)

Tag and Probe Efficiency Method

- Select the object that would fire the trigger in a way independente of the trigger itself
- Count how many time it fires the trigger
- Under the resonance peak (e.g Z, Jpsi, Upsilon) basically only the resonance (for example Z bóson) production is expected
- The result has to be corrected for combinatorial background under the Z peak (or the counting done by fitting the shapes)
- With suficiente statistics the efficiency can be evaluated in bins of pT, η and ϕ