



# CMS Tracking performances in 2016 and for the Phase-1 Upgrade of the pixel detector



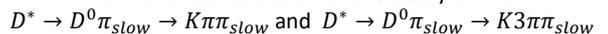
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In 2016 LHC worked at a very high luminosity and CMS collected about  $40 \text{ fb}^{-1}$  with a center of mass energy  $\sqrt{s} = 13 \text{ TeV}$ . With this large amount of data it is important to evaluate the detector performances regularly during the data taking in order to point out the quality of the reconstructed physics objects.

## Tracking efficiency measurement for charged pions

### Method

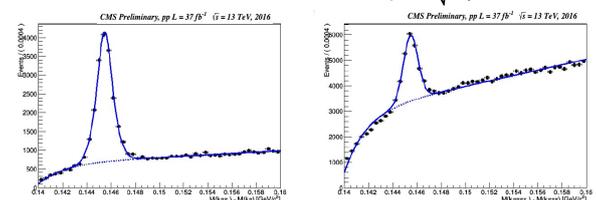
From the reconstruction of two decay chains



in data and Monte Carlo one can calculate the ratio  $R = \frac{N_{K^* \pi \pi_{slow}}}{N_{K \pi \pi_{slow}}}$ .

From the PDG we know  $R(PDG) = 2.08 \pm 0.05$ , so we can compute the

$$\text{relative efficiency as } \epsilon_{rel} = \left( \frac{\epsilon_{DATA}}{\epsilon_{MC}} \right)^2 = \sqrt{\frac{R}{R(PDG)}}$$

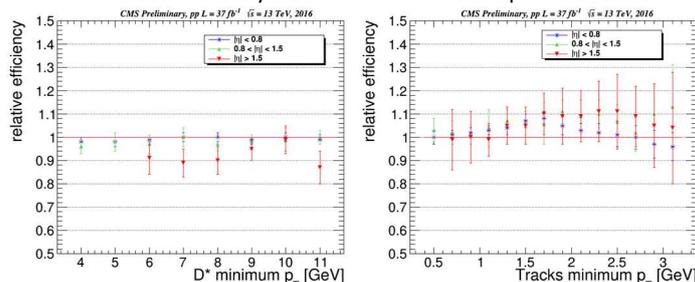


$\Delta M = M_{D^*} - M_{D^0}$  for 2-body decay (left) and 4-body decay (right)

### Results

$$\epsilon_{rel} = 0.991 \pm 0.019 (stat) \pm .003 (sys) \cdot .012 (PDG)$$

The total uncertainty on this measurement is quoted as 2.3%



The stability of the tracking efficiency is studied as a function of the minimum pT threshold of the D\* meson (left) and the minimum pT threshold of the selected tracks (right) in three eta regions.

## Muon tracking efficiency using tag and probe method

### Method

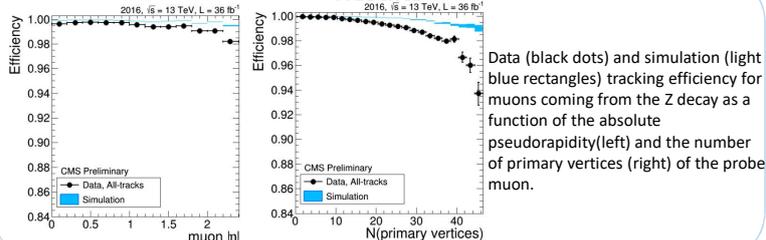
The tag and probe method has been used at the Z mass peak.

- **Tag:** a muon with  $p_T \geq 15 \text{ GeV}$ , associated to one leg of the resonance and with a single muon trigger.
  - **Probe:** any stand-alone muon with  $\geq 1$  valid hit.
- **Passing probe:** any probe muon matched to at least one track.

For the matching the size of the cone in the space drawn around the stand-alone muon is used. The (tag + passing/failing probe) invariant mass spectrum is fitted.

The efficiency is the fraction of (tag + passing probe) pairs.

### Results



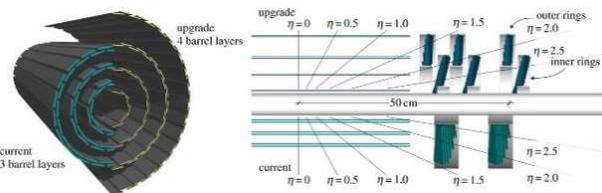
The CMS tracking system showed good performances during the 2016 data-taking in the charged hadron reconstruction. The data/MC discrepancy is ascribed to detector dynamic inefficiencies that are not fully simulated

In 2017 the CMS pixel detector is being completely replaced because of the radiation damage and scheduled LHC luminosity. The new pixel detector has a different geometry and it was designed to work in extreme condition of high luminosity.

## Tracking for the Phase-1 Upgrade of the pixel detector

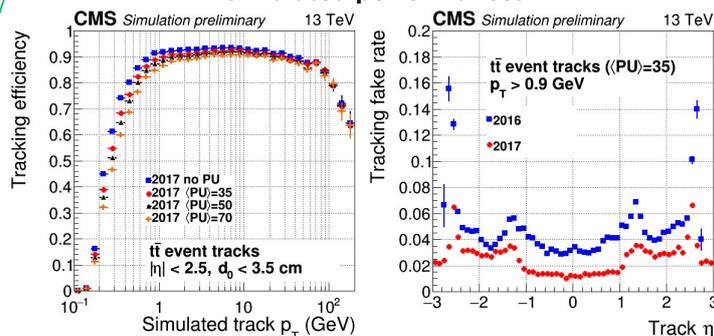
### New detector features

With the new structure, 4 layers in the barrel region and 3 layers in each endcap, the upgraded pixel detector will provide an excellent four-hit coverage in the pseudorapidity region  $|\eta| < 2.5$ .



This will allow the creation of four-hit track seed (w.r.t. the three-hit seed of the previous one) with an intrinsically lower fake rate and a consequent improvement of the tracking performances.

### Simulated performances



The tracking reconstruction efficiency as a function of the simulated track pT for the Phase-1 tracker at different PU scenarios.

The tracking fake rate as a function of the track eta comparing 2016 and 2017 simulations. The fake rate of the upgraded detector is lower in the whole spectrum

The new CMS pixel detector improves the tracking performances in terms of efficiency and fake rate.