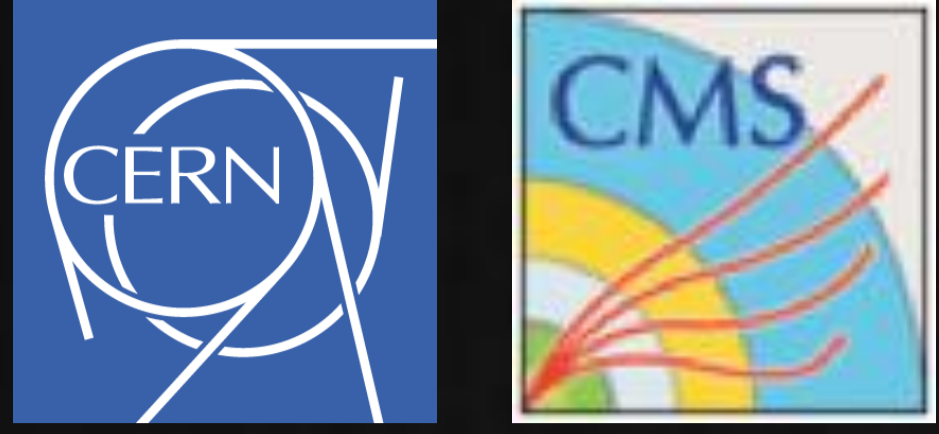# Study of the CMS Phase 1 Pixel Pilot Blade Reconstruction

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INTRODUCTION

▸ The CMS Pixel Detector will be replaced in 2017 with a newly constructed detector (called Phase 1 upgrade)

▸ Pilot Blades (PB), four Phase 1 type module prototypes, were placed on a third disk next to the present disks of the CMS Forward Pixel Detector (FPix) in 2014

▸ DAQ commissioning of the PB is ongoing, reconstruction methods are developed using Monte Carlo simulations

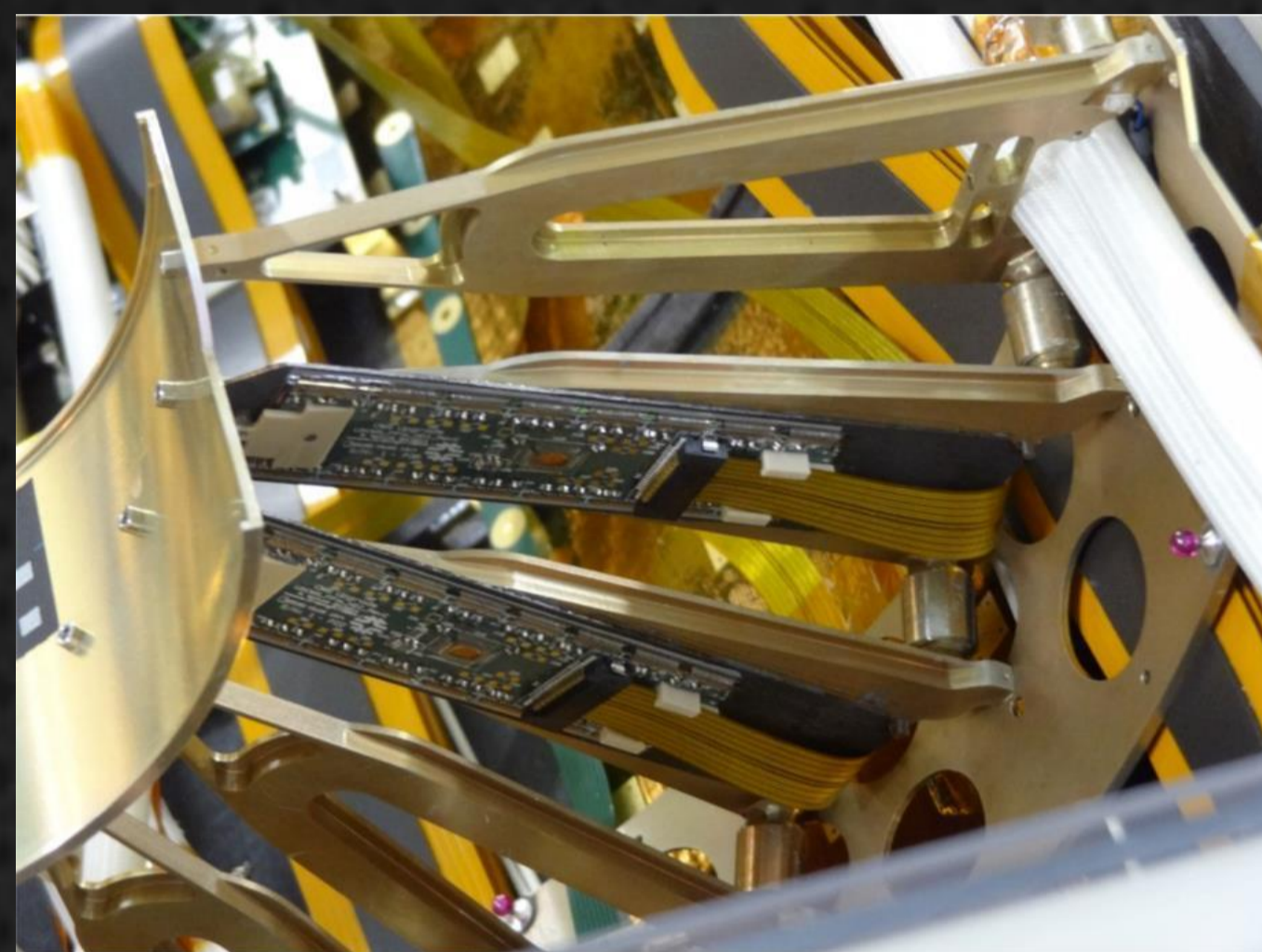▸ Preparation for offline studies of the PB detector is presented

Fig. 1. Pilot Blades in front of the FPix

OBJECTIVES AND METHODS

Objectives

▸ Develop analysis method to study the properties of the new Phase 1 sensors

▸ PB studies will help Phase 1 detector simulation to be prepared in 2016

▸ Changes in the new sensor modules to be characterised

• Simplified geometry in the forward region

• Digital read-out

• Mitigated efficiency loss at high particle rate
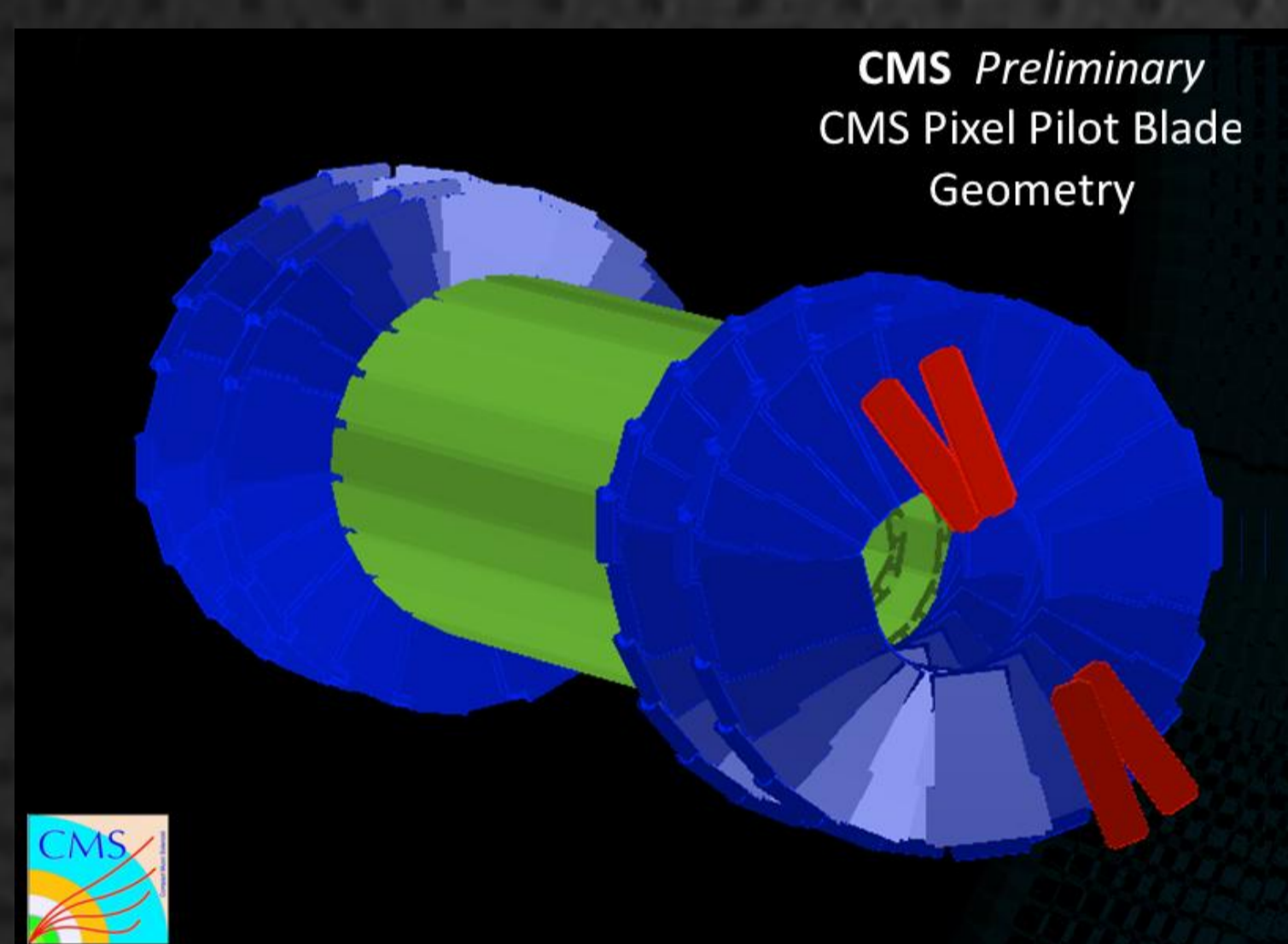
CMS *Preliminary*
CMS Pixel Pilot Blade Geometry

Fig. 2. Simulated pixel geometry with PB in red

Procedure

▸ The CMS detector is fully simulated with the Pilot Blade sensors and support structures included

▸ PB hits are clusterised, cluster positions measured, but exlcuded from tracking

▸ Real data is reconstructed with code identical to simulation

Condition database for reconstruction

▸ Lorentz Angle

• Simulates Lorentz force induced charge sharing

• Also used in cluster position measurement

• Same values used as the FPix modules, to be measured

▸ Gain calibration – same as present sensors, to be updated from online calibrations

Simulated results

Cluster occupancy on FPIX -Z side (R-Z plane)
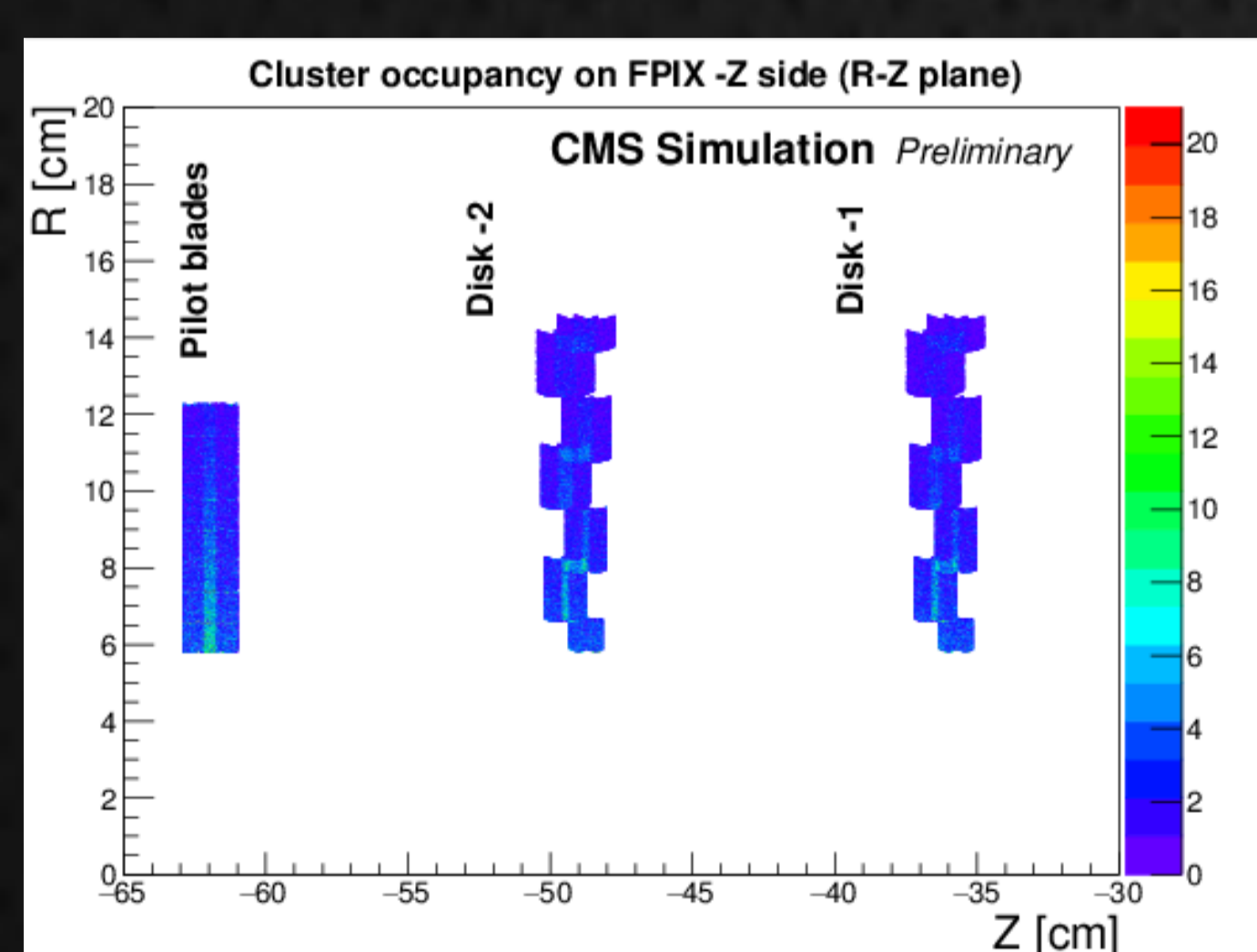CMS Simulation *Preliminary*

Fig. 3. Cluster occupancy on the -Z side of the FPix and the PB in the R-Z plane in minimum bias events

In Fig. 3. only those blades of the FPix are visible which are in the phi-region occupied by the PB (in all R-Z plot)

▸ A Pilot Blade is a double-sided rectangle with 2x8 ROCs on each side. FPix blades are double-sided with 3 and 4 modules of various sizes on each side

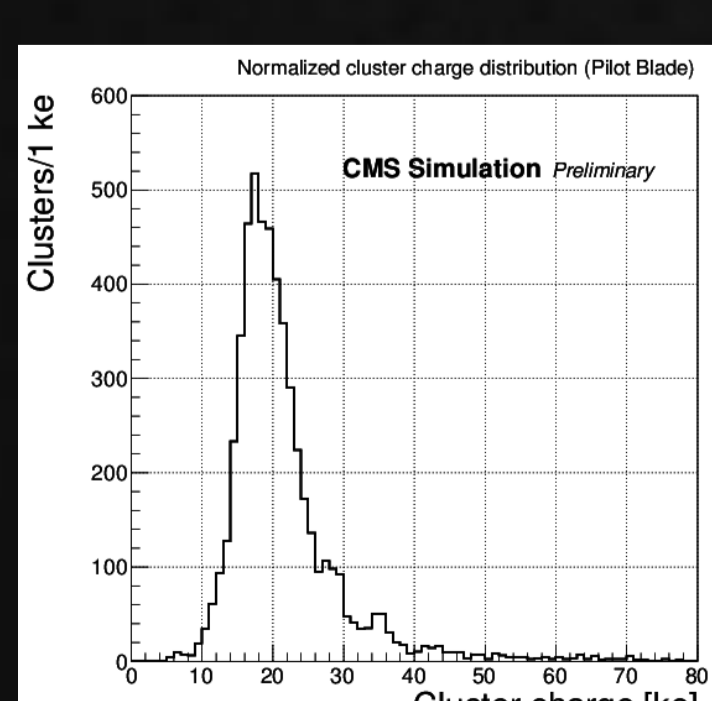▸ Adjacent blades have an offset in this projection, one can see that the overlapping areas have higher number of hits

Normalized cluster charge distribution (Pilot Blade)
CMS Simulation *Preliminary*

Fig. 4. Pilot Blade cluster charge distribution

▸ The Pilot Blade cluster charge distribution is normalized to track length

▸ The sensor thickness is 285 μm
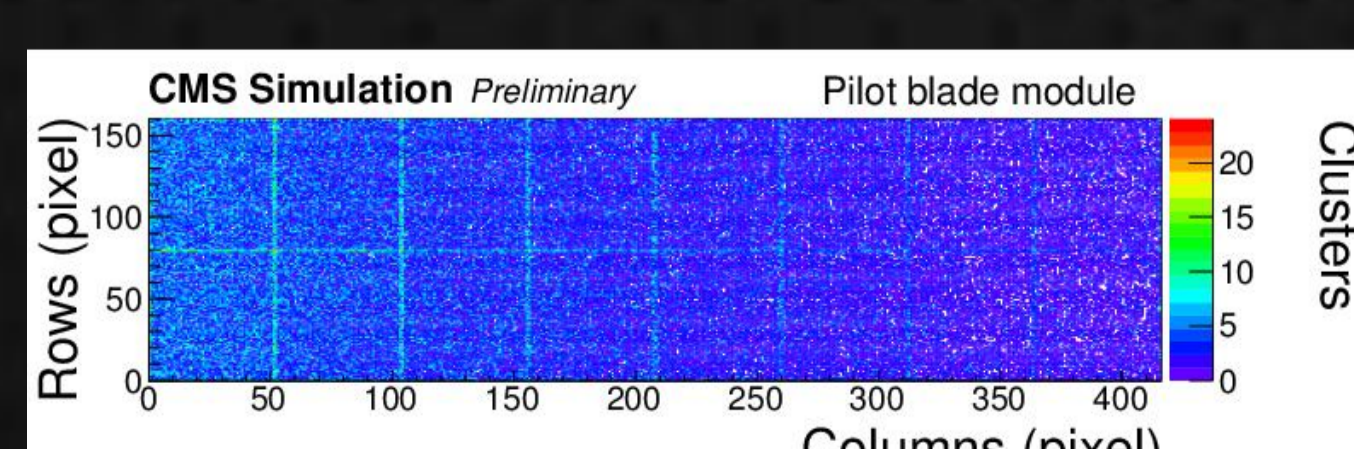
CMS Simulation *Preliminary* — Pilot blade module

Fig. 5. Cluster occupancy of a Pilot Blade

▸ Column 0 is the closest one to the beam resulting higher occupancy on the left

HIT RECONSTRUCTION

Fig. 6. shows the instrumented sensor volumes

▸ FPix Disk 1 and Disk 2 are in blue

▸ Pilot Blades in red

▸ The Pilot Blades are behind the disks in this view

Cluster positions on FPIX -Z side (transverse plane) — CMS Simulation *Preliminary*
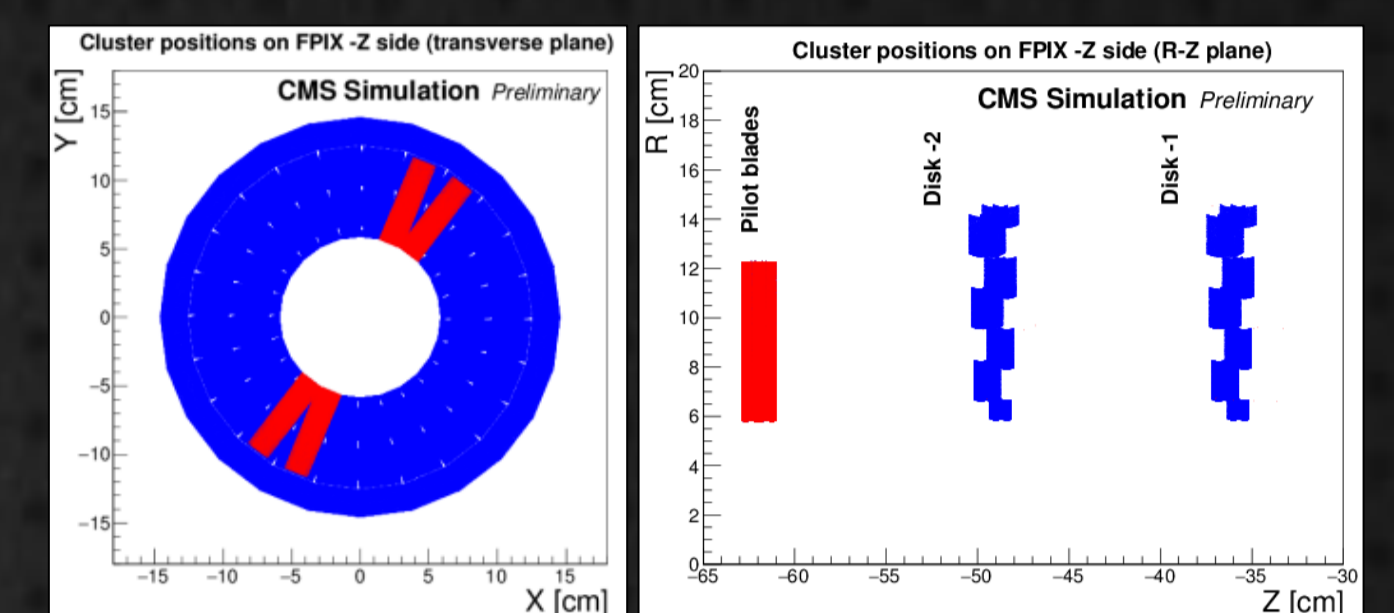Cluster positions on FPIX -Z side (R-Z plane) — CMS Simulation *Preliminary*

Fig. 6. Cluster positions in the transverse plane and in R-Z plane, respectively

▸ In Fig. 7. hit occupancy shows the areas of the sensors that are probed by reconstructed particle tracks in the present setup

▸ The Pilot Blade is only spectator in tracking

▸ High purity tracks are used

Tracking hits on the FPIX -Z side (transverse plane) — CMS Simulation *Preliminary*
Tracking hits on the FPIX -Z side (R-Z plane) — CMS Simulation *Preliminary*
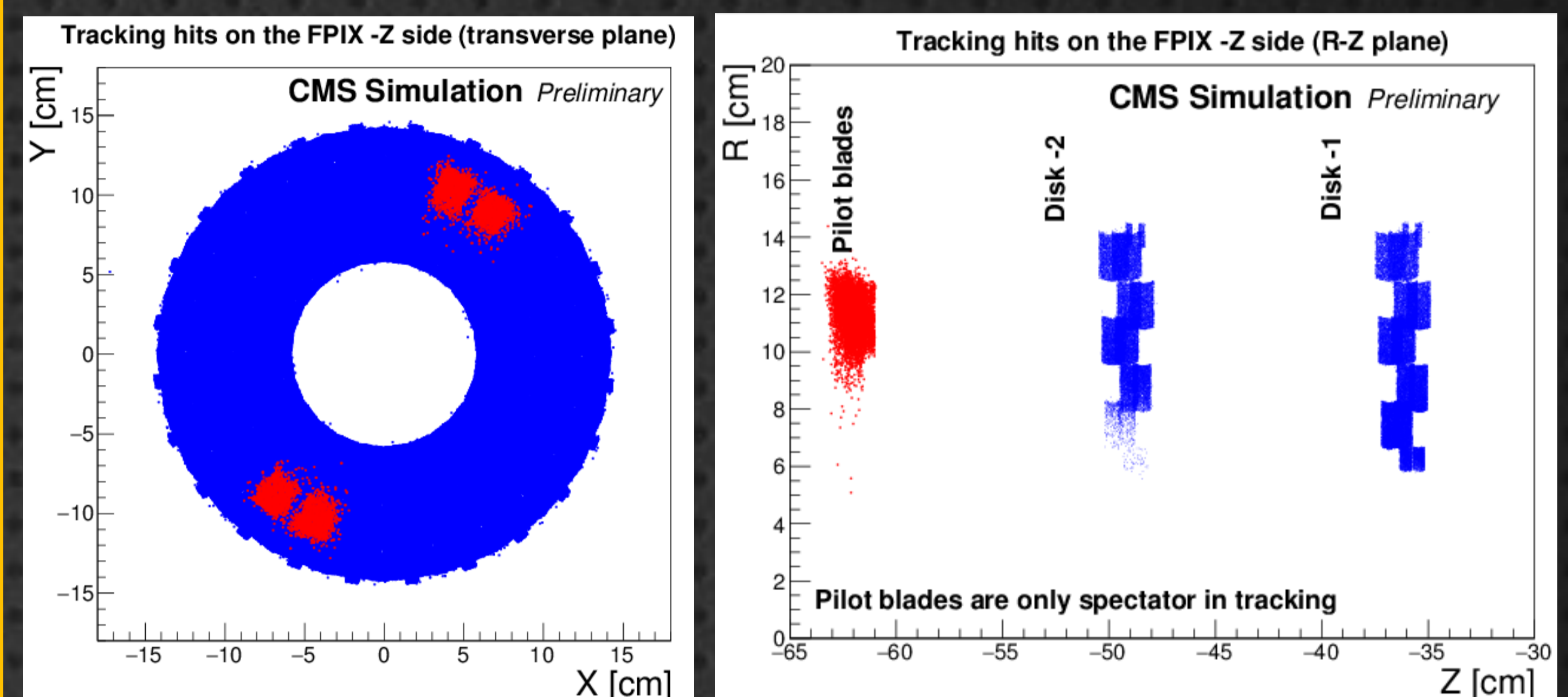
Pilot blades are only spectator in tracking

Fig. 7. The tracking hits on the -Z side of the Forward Pixel and the Pilot Blade detectors in the transverse plane and in the R-Z plan, respectively

RESIDUAL AND HIT PROPERTIES

▸ Finding the closest cluster to good quality tracks projected on the PB sensors

▸ Residual plots in Fig.8. show the distance between the cluster and the projected PB hit

▸ Clusters are associated to tracks with precision at the pixel level

▸ Associated cluster properties will be monitored, such as cluster charge profile and hit finding efficiency

Track hit residual on pixel blade (azimuthal direction) — CMS Simulation *Preliminary* — RMS = 0.01038
Track hit residual on pixel blade (radial direction) — CMS Simulation *Preliminary* — RMS = 0.01729

$\sqrt{s}$ = 8 TeV — CMS preliminary 2012

Layer 1
Layer 2
Layer 3
Disk 1
Disk 2

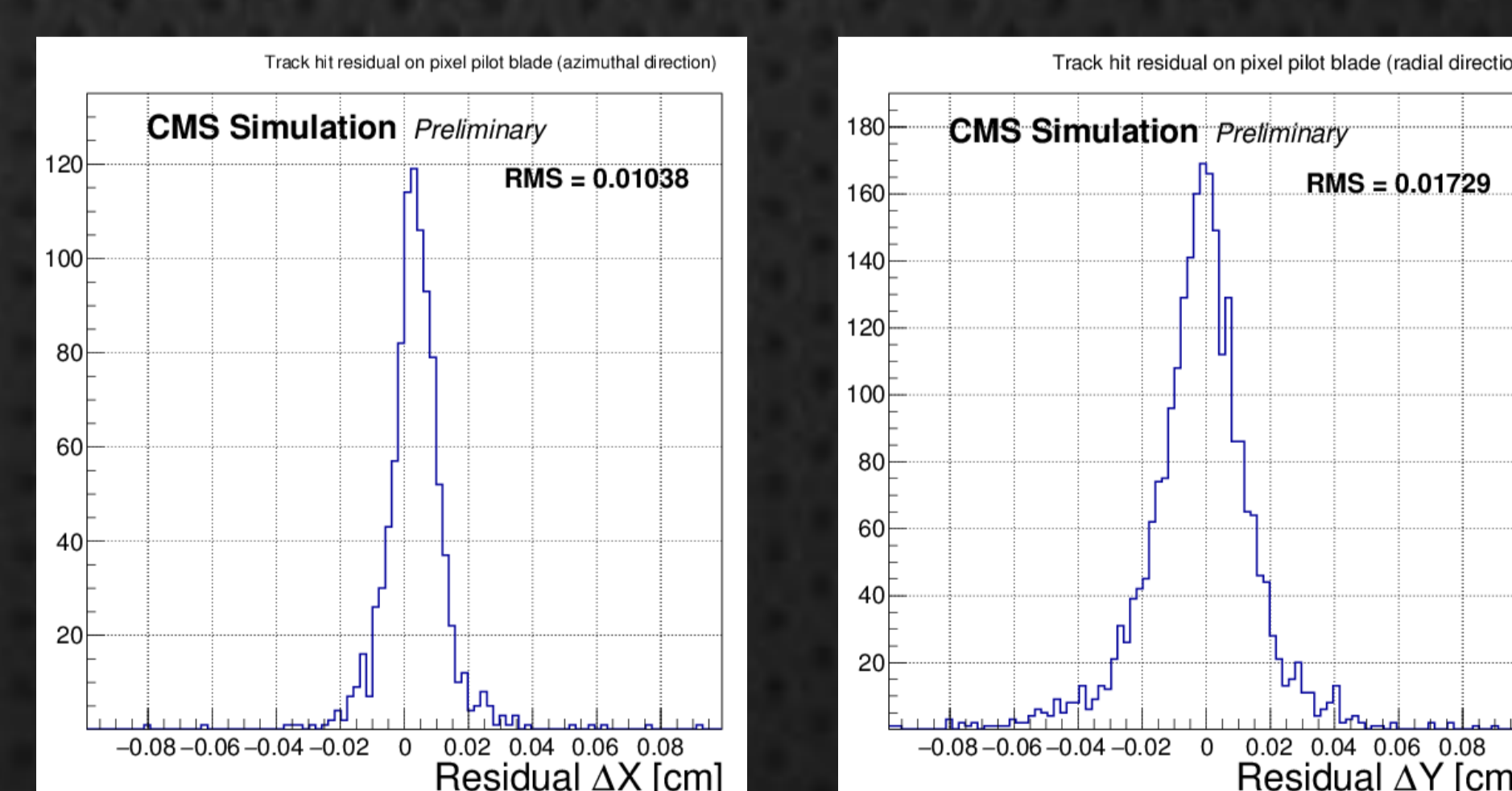Fig. 9. Hit finding efficiency for the present pixel detector as function of instantaneous luminosity

Fig. 8. Track hit residual in the azimuthial and radial direction, respectively. RMS is compatible with the size of a pixel in both directions (X: 100 μm, Y: 150 μm)

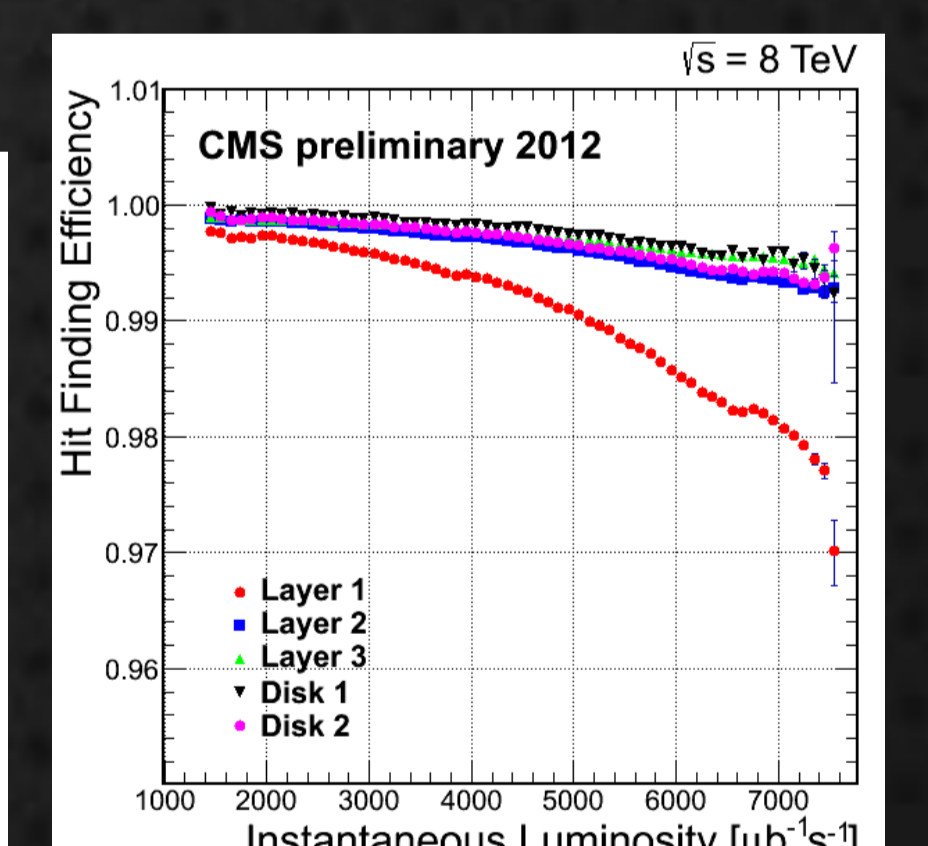▸ Fig. 9. shows the efficiency of the present detector at various particle rates. The Phase 1 sensors will operate at instantaneous luminosity of 20 $nb^{-1}s^{-1}$

▸ Measuring the efficiency of the upgraded detector and adjust its simulation

CONCLUSION

▸ **Reconstruction code has been developed with Monte Carlo Simulation**

▸ **Ready to analyze collision data being taken in the Fall**

▸ **After alignment, residual in data expected to be small enough to perform measurements of cluster properties and hit efficiency**