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Test Beam Results of Planar Pixel Sensor for the CMS Phase 2 Inner Tracker Upgrade

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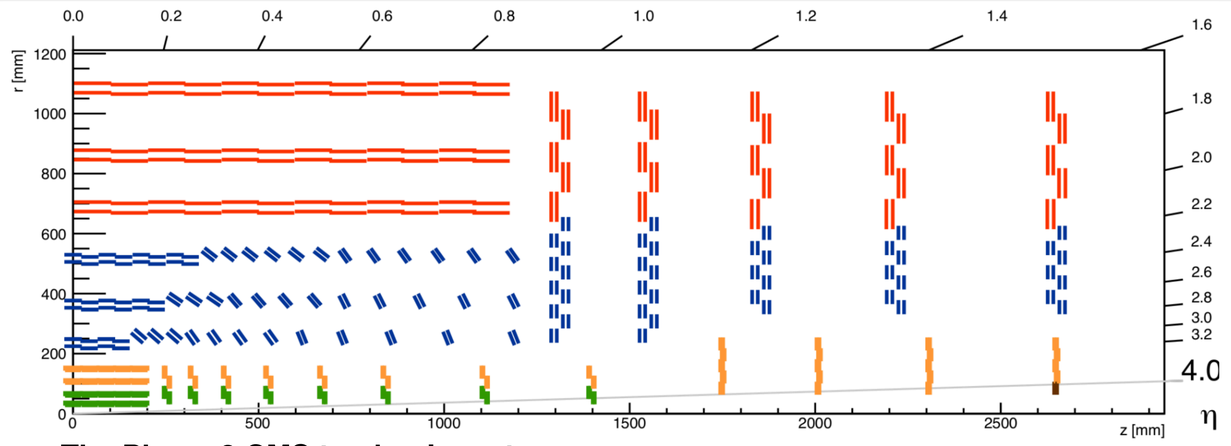
on behalf of CMS Tracker collaboration

Introduction

- Test beam measurements of CMS Readout Chip (CROC) were performed. These sensors will be used in the forward pixel disks of the Inner Tracker in the High Luminosity era of the Large Hadron Collider (HL-LHC).
  - HL-LHC peak instantaneous luminosity of 7.5×10^{34} cm^{-2} s^{-1} corresponds to an average of around 200 inelastic proton-proton collisions per beam-crossing every 25 ns.
  - The present CMS tracking detector will be completely replaced in order to efficiently reconstruct and track particles in these extreme and challenging conditions.
  - Effect of bias voltage and charge collection threshold on efficiency, cluster charge, and cluster size are presented in this poster.



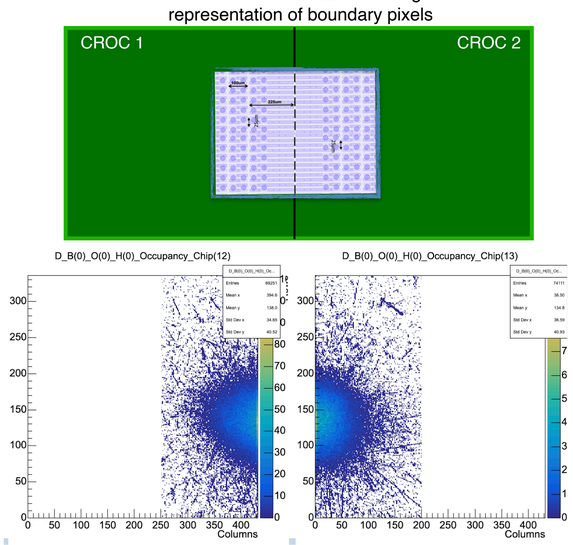
The Phase-2 CMS tracker layout

Pixel modules, in orange (quad-chip modules) and green (double-chip modules), form the Inner Tracker system. The Outer Tracker is composed of two different types of modules indicated with blue (PS modules) and red (2S modules) lines

The sensor

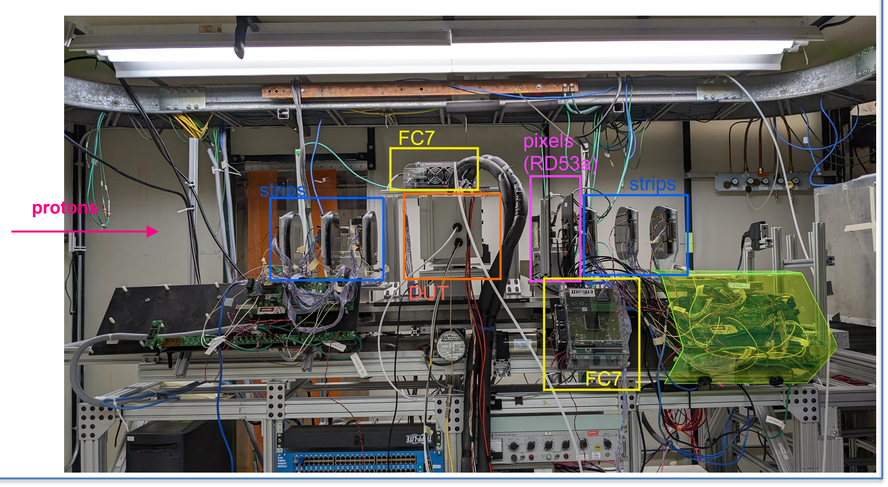
- CROC 1x2 planar module
- Dimensions:
  - 25 µm x 100 µm standard pixels
  - 25 µm x 225 µm boundary pixels
- Beam centered on the boundary between the ROCs
  - Bias scan 0-100V at charge collection threshold of 1200 electrons
  - Nominal-bias data taken at thresholds of 1000 electrons and 1200 electrons

A section of the module showing a representation of boundary pixels



Telescope at FNAL

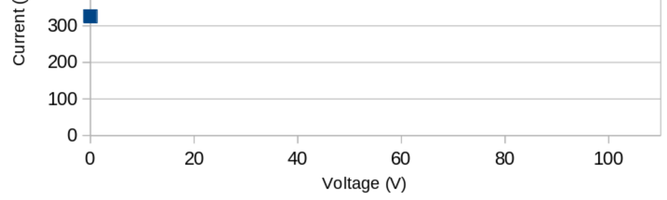
- 120 GeV proton beam with 1 spill per minute
- Each spill lasts 4s
- About 50k protons per spill.
- ~1 cm width
- ~5 µm resolution



Settings

- Environment:
  - Chiller temp: 20C
  - dew point: ~13C
- Power
  - HV bias: -100 V
- Normal incidence

I-V Curve



Credit: Corrinne Mills

Acknowledgements

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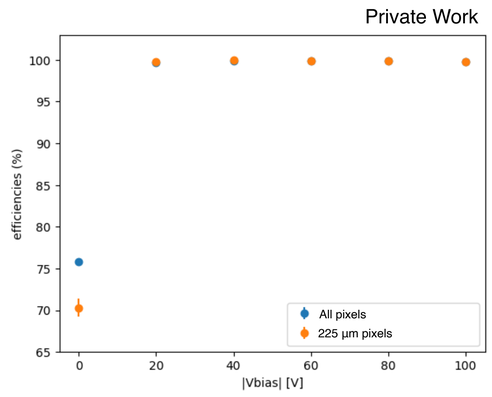
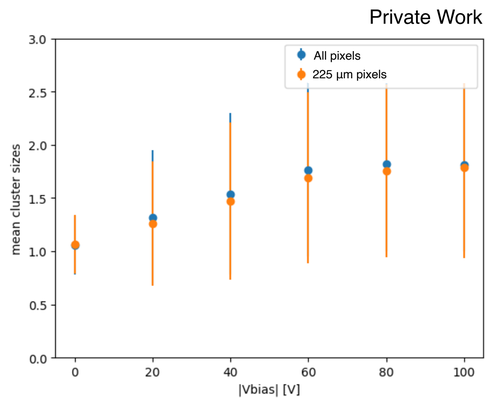
Results

Bias Scans

Efficiency



Cluster size

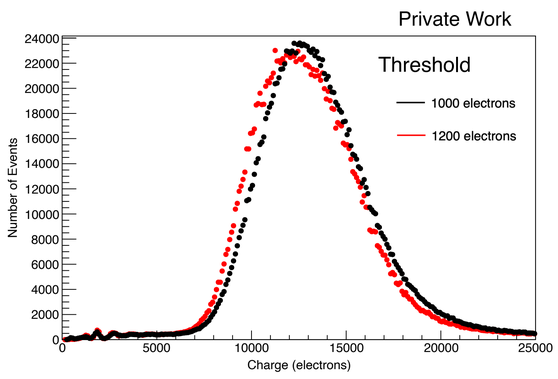


- Efficiency is 99.8 % at 100V.
- Cluster size increases slightly with bias voltage, with primarily 2 pixel clusters.
- Cluster charge increases with bias voltage.
- Consistent behavior for 100 µm and 225 µm pixels.

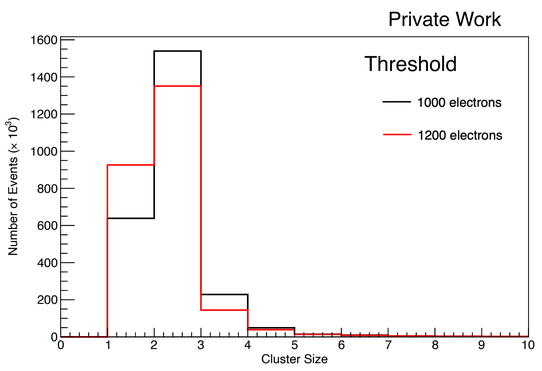
Credit: Hsin-Wei Hsia

Threshold comparisons

Cluster charge



Cluster size



- Efficiency is ~99.79 % at the threshold of 1000 electrons and ~ 99.72 % at the threshold of 1200 electrons.
- Slight increase in mean value of charge distributions with decrease in threshold.
- Slight increase in cluster size at lower threshold.

Future Work

- Understand the effect of cross talk on cluster size and resolution.
- Validating final modules for the upgrade.