Small Pitch Pixel Detector for the CMS Phase II

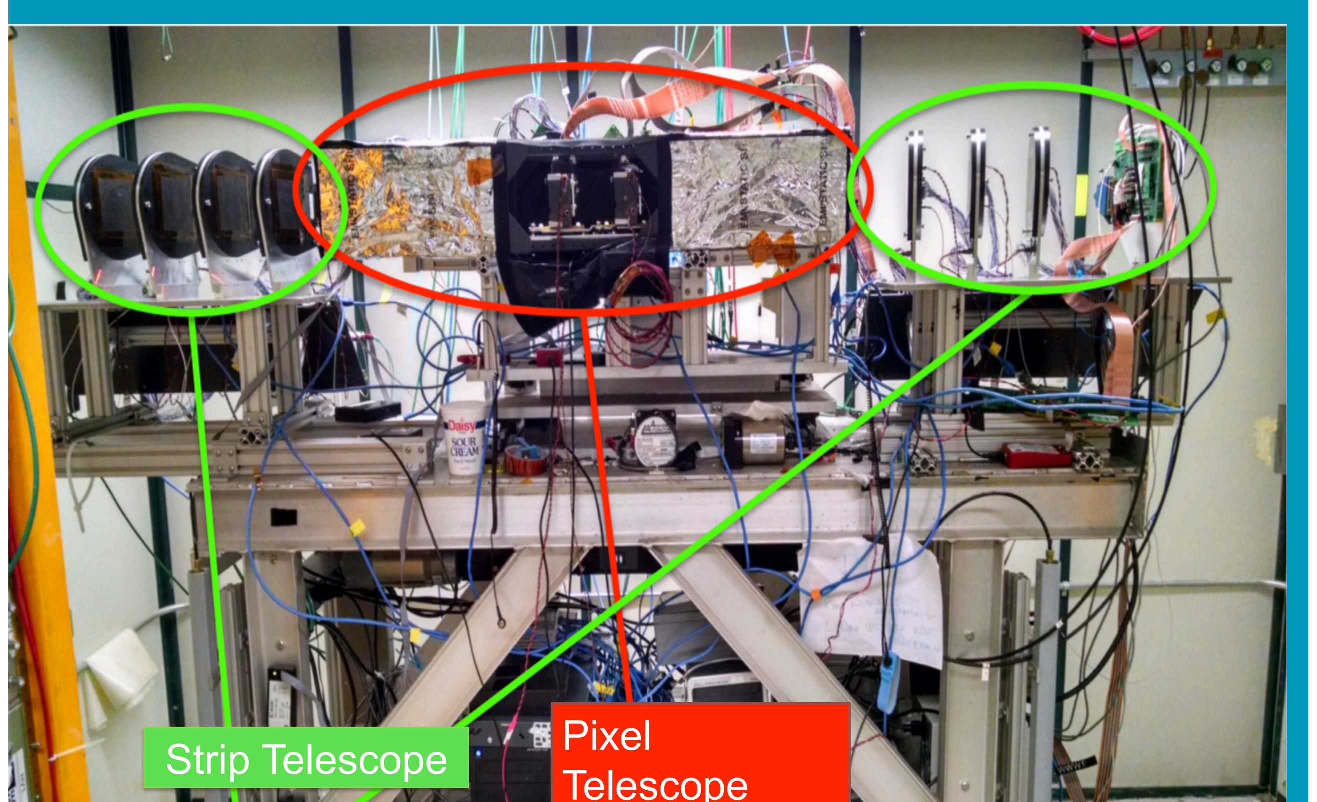
Ivette Jazmín Bermúdez Macias, IPM Program

In June 2015 we tested new pixel sensor prototypes for the CMS phase II tracker upgrade using the silicon pixel telescope installed at the Fermilab Test Beam Facility (FTBF). This poster shows the preliminary results of the analysis that I performed on one of the prototypes designed with a new Small Pitch (SP) pixel cell measuring 25x600 μm^2.

Strip and Pixel Telescope

Two telescopes are presently installed at the FTBF, one is made of pixels modules and another by strip modules. For this analysis only the pixel telescope has been used which is composed of 2 stations of 4 modules each, placed one upstream and one downstream of the the Detectors Under Test (DUTs).

The Pixel telescope is read out by the CAPTAN DAQ, a system developed and widely used at Fermilab.



The MTEST beamline provides 120 GeV protons for 4 seconds every minute. Since the accelerator radiofrequency is 54MHz the particles are spaced 18 ns. The detectors run at half that frequency, so data can be recorded every 36ns. When the pixel detectors receive a trigger from a coincidence between the scintillators along the beamline, the pixel modules send data to the DAQ corresponding to the correct clock cycle. Hits are grouped together according to the trigger number and then analyzed by an offline tracking program called Monicelli that reconstruct tracks and then by another analysis program called Chewie that allow a detailed studies using the extrapolated track impact point on the DUTs

Monicelli

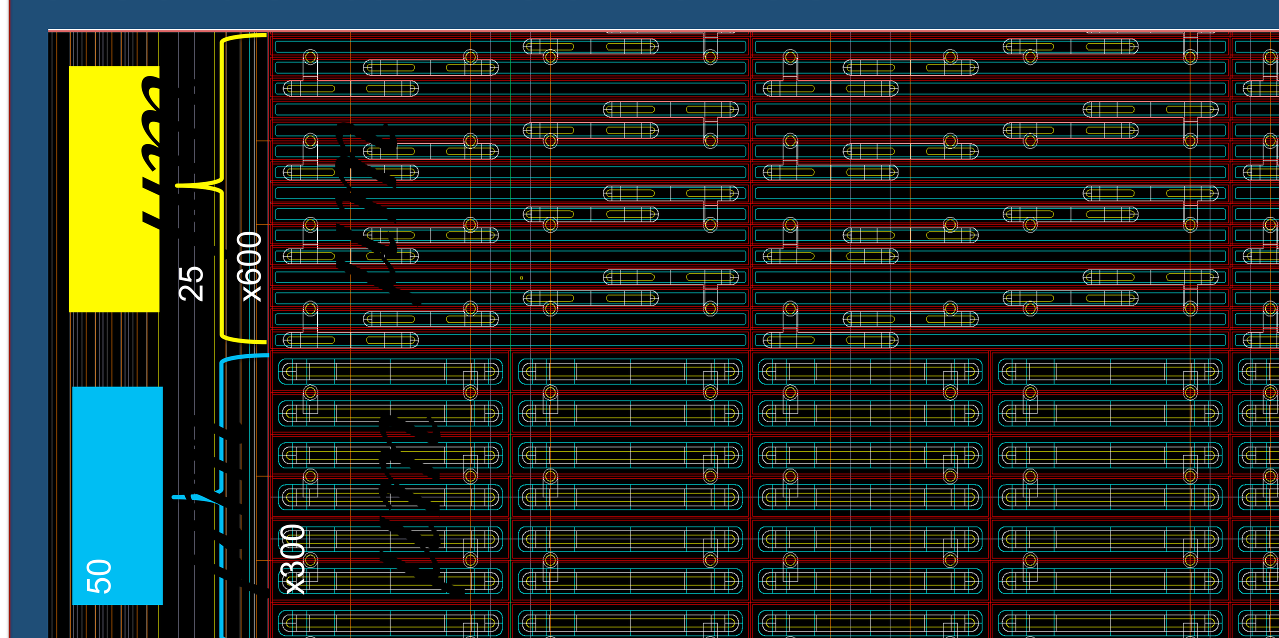
Monicelli is the alignment and track reconstruction program. Users will first read in raw data (merged from different readout chips, provided in a binary format) and reconstruct tracks. A geometry file is used to convert the detector data into points in space that are used to build tracks.

Due to the peculiar design of the SP DUT, with three zones each having a different pixel size, Monicelli had to be modified. I made it work selecting the "region" on the sensor with the small pitch pixels and fixing some parts of the code. In the end I was able to make it work even with this unusual sensor design.

Small Pitch (SP) Pixel Detector Design.

The CMS pixel detector is made of 52 columns and 80 rows of 100x150 μm^2 pixels. Each pixel is bump bonded to the read out electronics and read out by the Read Out Chip (ROC).

The new SP prototype has the first 20 rows (52 columns) of 100x150 μm^2 dimensions pixels (normal one). The next 60 rows and 26 columns are made of 50x300 μm^2 pixels and they are bump bonded to the 30 rows and 52 columns in the "middle "part of the ROC. The next 120 rows and 12 columns are made of 25x600 μm^2 pixels and are bonded to the last 30 rows and 52 columns of the ROC.

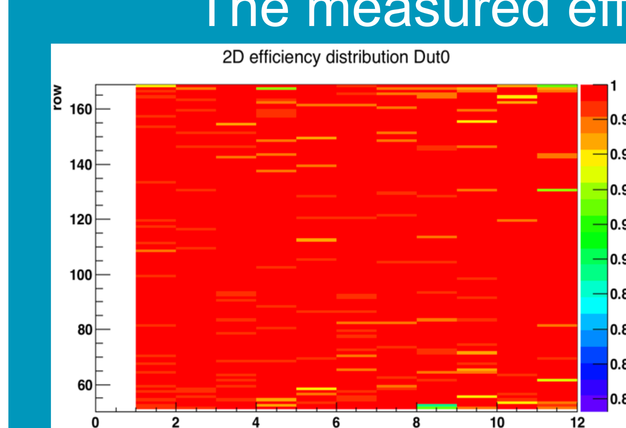


Chewie Analysis and Results

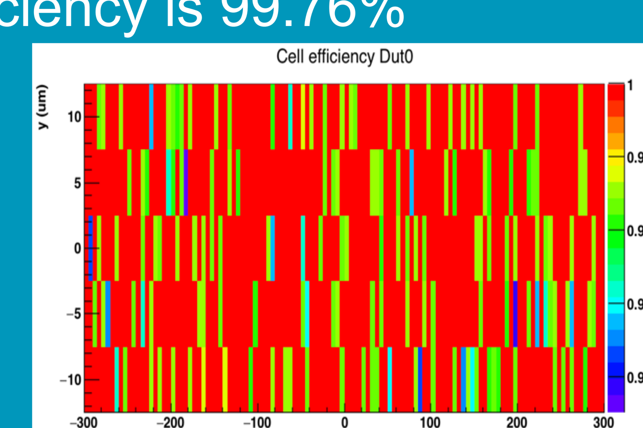
Chewie is the analysis program. Using tracks impact points on the Detectors Under Test (DUTs) Chewie can study efficiency, resolution and charge collection properties.

These preliminary results show the analysis of the "third part" of the SP DUT, which is made of 25x600 μm^2 pixels.

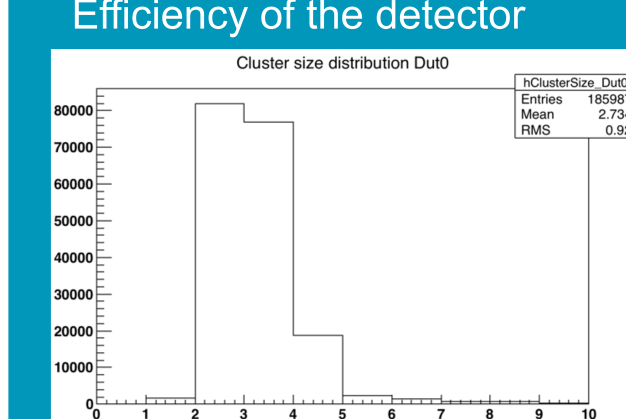
The measured efficiency is 99.76%



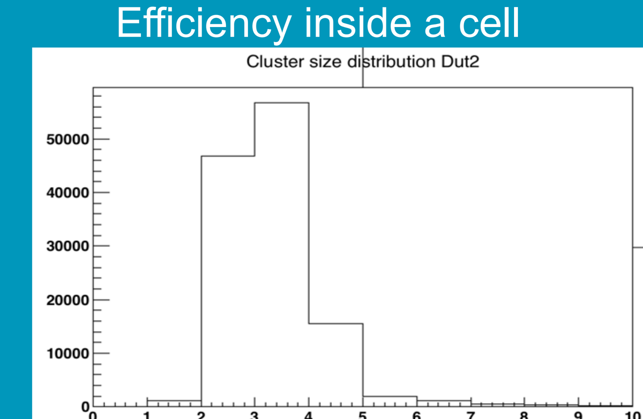
Efficiency of the detector



Efficiency inside a cell

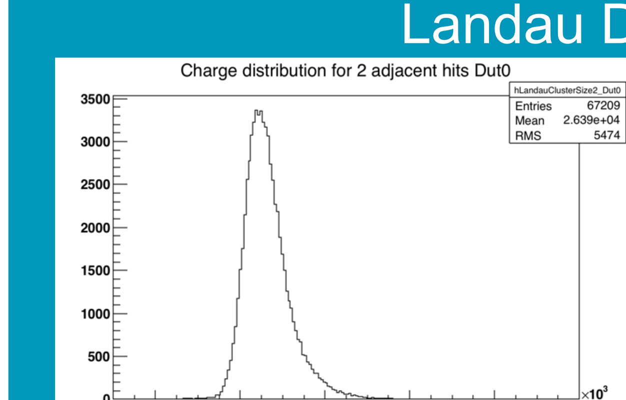


Cluster Size of DUT 0

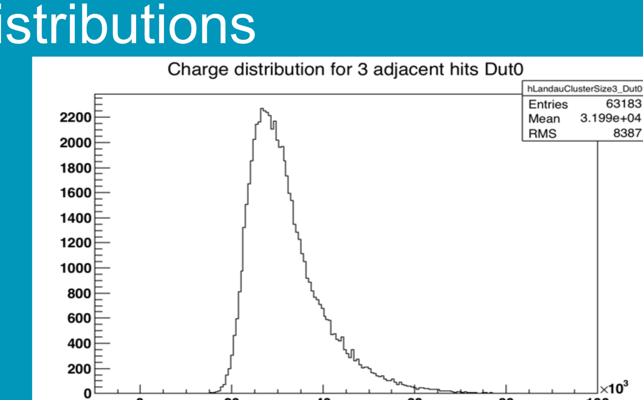


Cluster Size of DUT 2

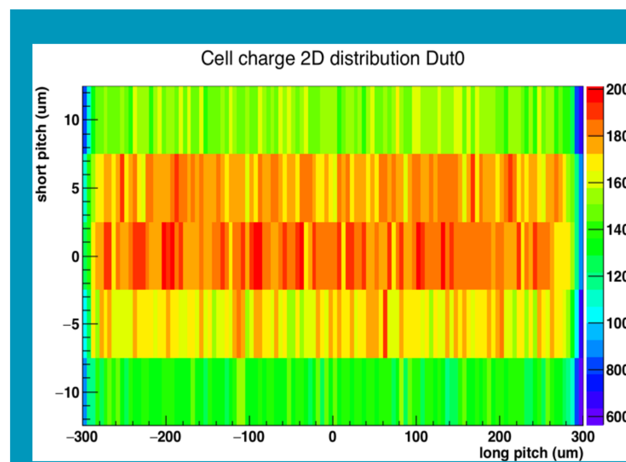
Landau Distributions



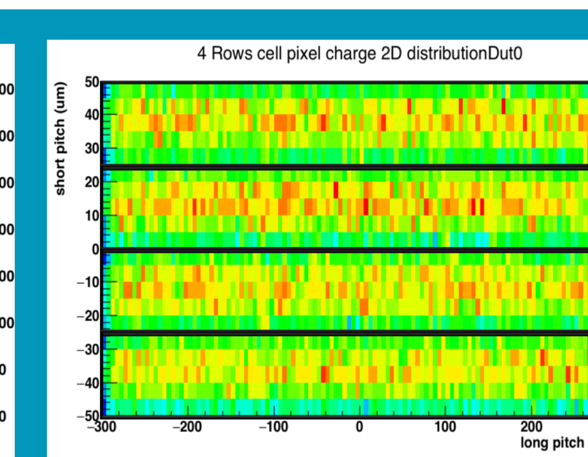
Landau for clusters of size 2
Mean Value: 26K e$^-$.



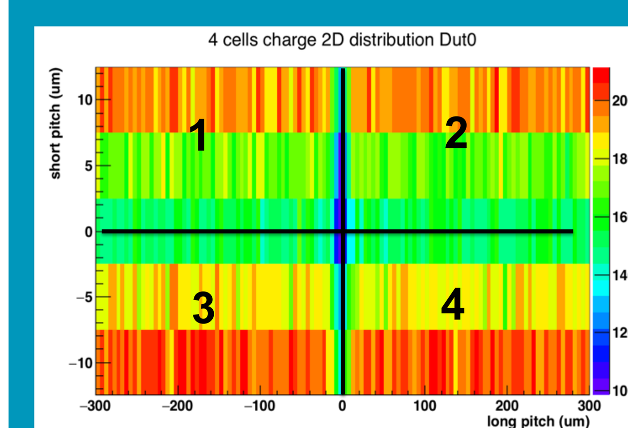
Landau for clusters of size 3
Mean Value: 31K e$^-$.



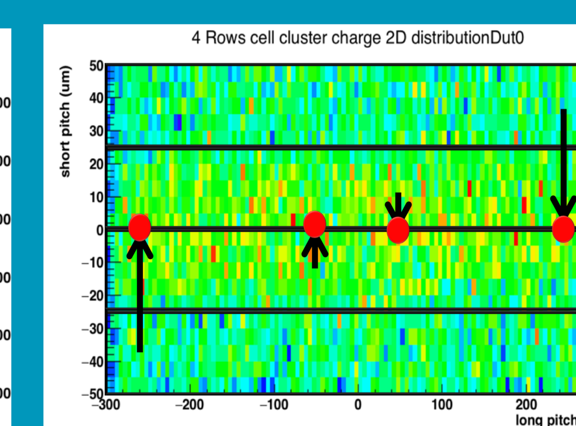
Mean charge of the pixel pointed by the track



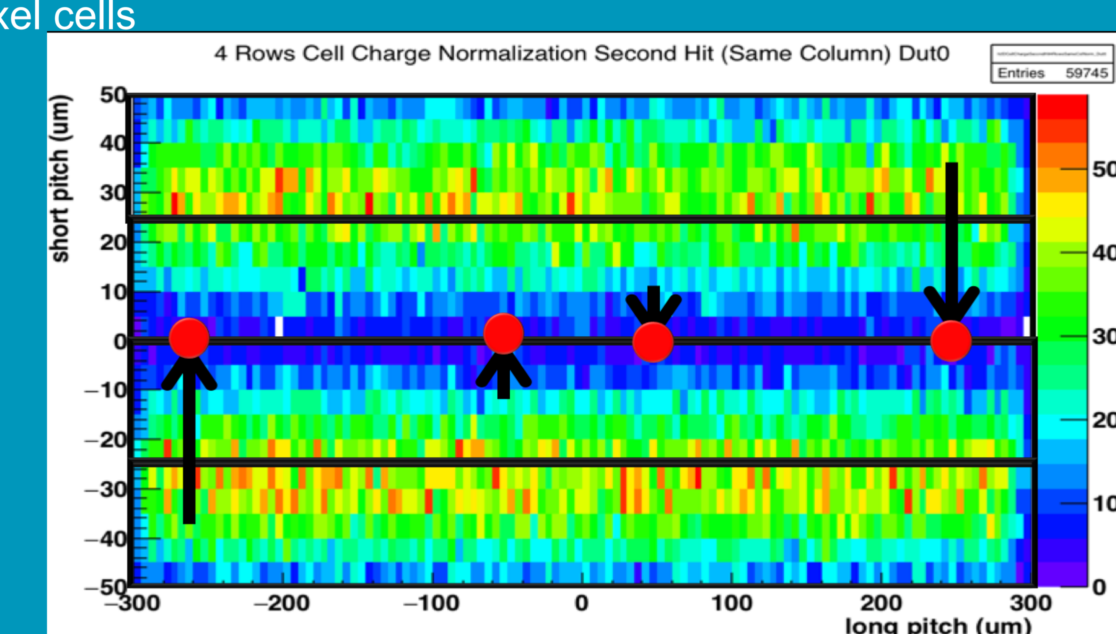
Charge of the pixel pointed by the track for a group of 4 pixel cells.



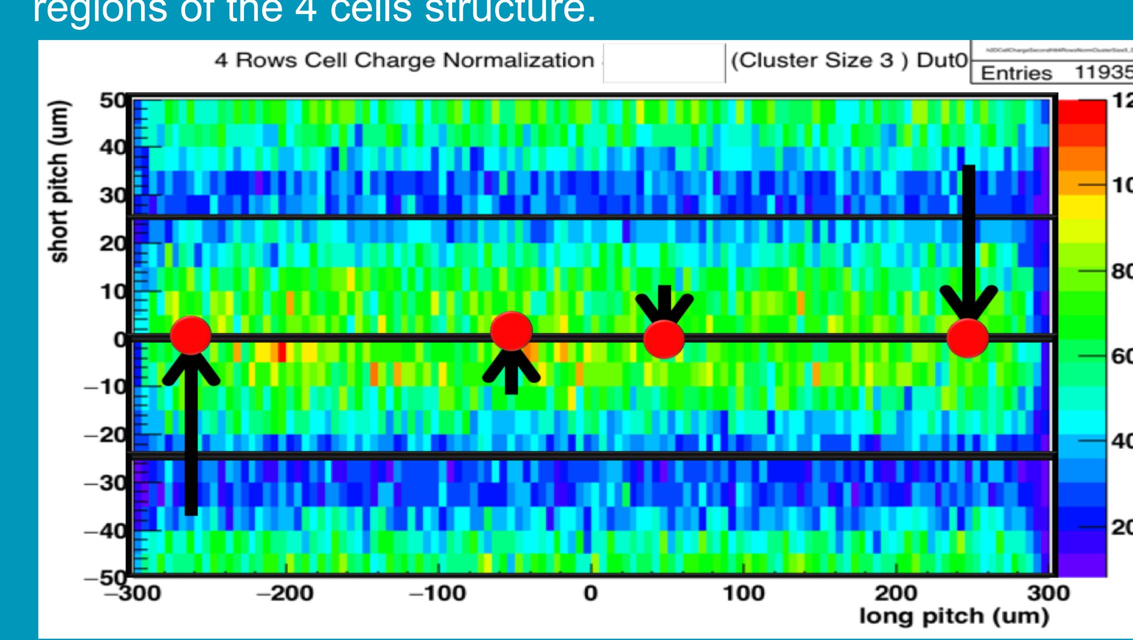
Charge of the pixel pointed by the track seen at the corner of 4 pixel cells



Cluster mean for a group of 4 pixel cells.



This figure shows that the majority of clusters of size 2 are generated when the track is pointing to the top and bottom regions of the 4 cells structure.



This figure shows that the majority of clusters of size 3 are generated when the track is pointing to the center of the region of the 4 cells structure.

Conclusions

I modified Monicelli and Chewie in order to analyze each part of the new small pitch sensor design and analyzed the 25x600 μm^2 pixels section.

I am going to do the same analysis for the other 2 parts of the SP detector, to compare the geometries and have a better understanding of each section.

Acknowledgements

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