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IPA

Documentation

Low Pulse Heights in CMS Pixel Chips

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Abstract

During the test of new 3D diamond detectors in PSI beam tests using 260 MeV positive pions we measured pulse heights far below the trimmed threshold of the ROCs. Both a diamond 3D detector connected via indium bump bonds as well a standard silicon sensor were measured using the psi46digv21respin ROC and showed the same behaviour. The observed behaviour could could not be reproduced using test signals of the ROC electronics.

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Contents

1 Test Site

The measurements were taken at the Paul Scherrer Institut (PSI) beam line PIM1 with the following parameters:

- particle type: positive pions
- particle momentum: 260 MeV
- particle fluxes: $10 \sim 20\,000\,\mathrm{kHz/cm^2}$

2 Detectors

2.1 Si352

Standard silicon pixel detector built at PSI using the psi46digv21respin readout chip (ROC). The detector is almost nonirradiated and has just seen radiation during beam tests.

2.2 3D Diamond Detector - II6-B6

The detector is made out of poly-crystalline Chemical Vapour Deposition (pCVD) diamond, has a thickness of ∼500 µm and has 50×50 µm 3D pixel cells. In order to match the pixel pitch of the CMS pixel chip (150×100 µm) 3×2 cells were ganged together and connected to the same bump bond.

A picture of the final detector is shown in Figure 1. Since the diamond detector has only a size of $\sim 4 \times 4$ mm it is only connected to a part of the bigger ROC.

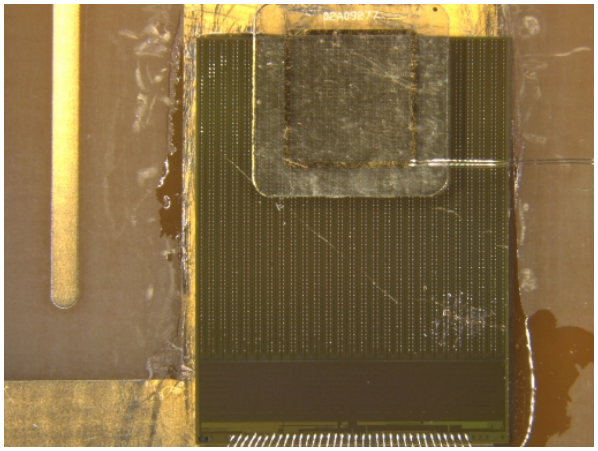


Figure 1: 3D diamond detector on a CMS pixel chip

3 Measurements

3.1 Setup & Readout

A demo setup of a ETH Telescope module is shown in Figure 2. The detectors are glued and wirebonded to a standard carrier-board and then connected to a custom Adaptor-plane via

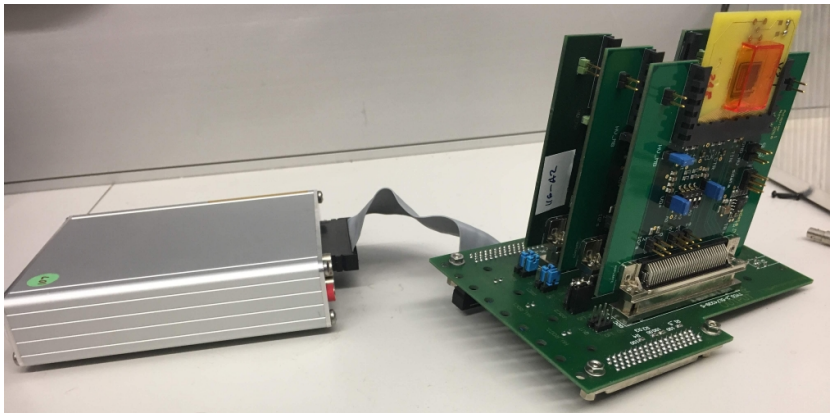


Figure 2: ETH Telescope setup with one motherboard and three planes

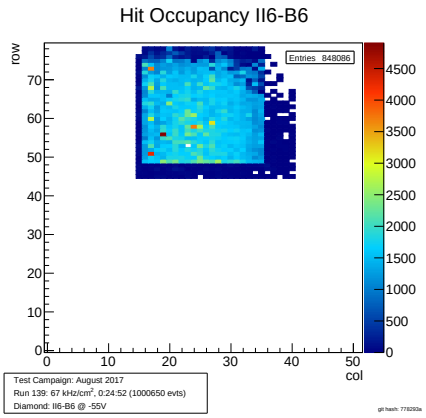
the SAMTEC connector. These Adaptor planes are then plugged into a motherboard which directly connects to the digital test board (DTB).

The test boards are operated with the pixel-dtb-firmware dtb_v4.2 using the pXar-core libraries.

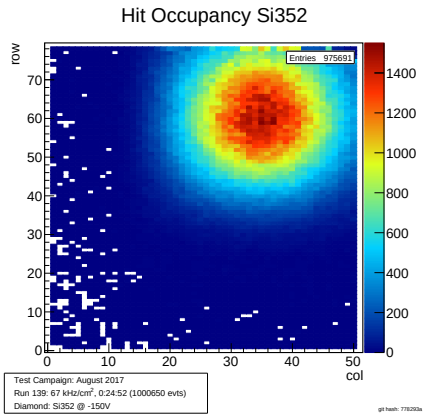
3.2 Preparation

Both ROCs of the diamond detector was trimmed to a threshold of 30 vcal and the one of the silicon to 32 vcal using the standard trimming algorithm of the pXar GUI in the beam area at ambient temperature without cooling. The pulse-height digital to analogue converters (DACs) phoffset and phscal were then adjusted to achieve linear response of the adc vs vcal in the desired range. The according dacParameter.dat files are shown in section 3.5 (Appendix).

3.3 Hit Maps



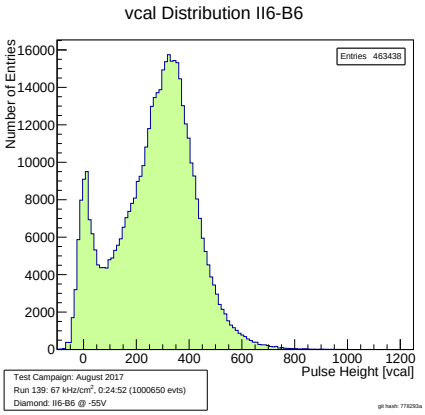
(a) Hit map of the diamond detector. Dark blue area corresponds to area where the detector has no readout columns and is only connected to the bump bond. The white area is masked by the chip.



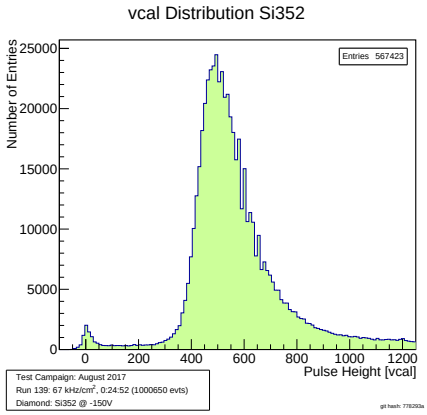
(b) Hit map of the silicon detector. The profile corresponds to the shape of the trigger area.

3.4 VCAL Distributions

Using the phCalibration.dat files yields the following vcal distributions. Even though more



(a) Diamond

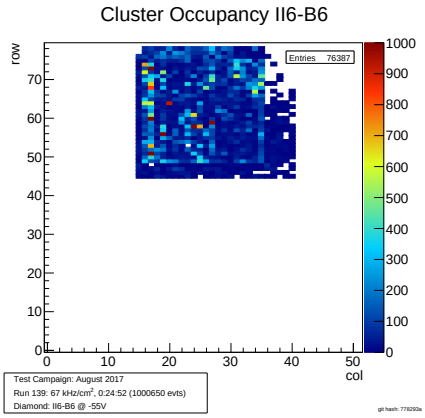


(b) Silicon

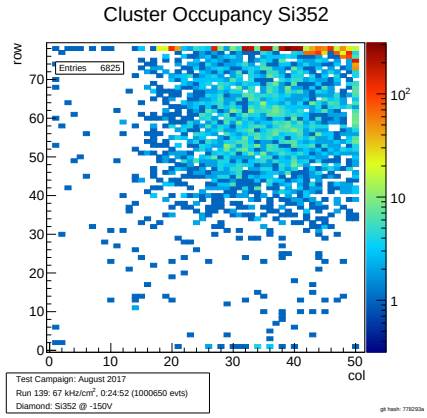
dominant in the diamond device both chips show parts of the distribution that are below a the tuned threshold. It even appears as if there is an additional Gaussian contribution around exactly zero vcal. The Most Probable Values (MPVs) are exactly in the expected positions considering the deposited energies in the detectors.

3.5 Low Pulse Height Hit Maps

The position of the hits with a pulse height below the tuned threshold seems more dominant certain pixels but is distributed over the full chip.



(a) Diamond



(b) Silicon

Appendix

Nr.	Name	Value
1	vdig	6
2	vana	74
3	vsh	30
4	vcomp	12
7	vwllpr	150
9	vwllsh	150
10	vhlddel	250
11	vtrim	130
12	vthrcomp	108
13	vcolorbias	30
17	phoffset	185
19	vcomp_adc	50
20	phscale	65
22	vicolor	100
25	vcal	200
26	caldel	152
253	ctrlreg	0
254	wbc	100
255	readback	0

Table 1: dacParameters.dat for II6-B6

Nr.	Name	Value
1	vdig	6
2	vana	90
3	vsh	30
4	vcomp	12
7	vwllpr	150
9	vwllsh	150
10	vhlddel	250
11	vtrim	145
12	vthrcomp	106
13	vcolorbias	30
17	phoffset	220
19	vcomp_adc	50
20	phscale	100
22	vicolor	100
25	vcal	200
26	caldel	101
253	ctrlreg	0
254	wbc	100
255	readback	0

Table 2: dacParameters.dat for Si352

List of Acronyms

ROC readout chip

DAC digital to analogue converter

DTB digital test board

PSI Paul Scherrer Institut

pCVD poly-crystalline Chemical Vapour Deposition

MPV Most Probable Value