Characterization of 35v1 HVCMOS Detectors

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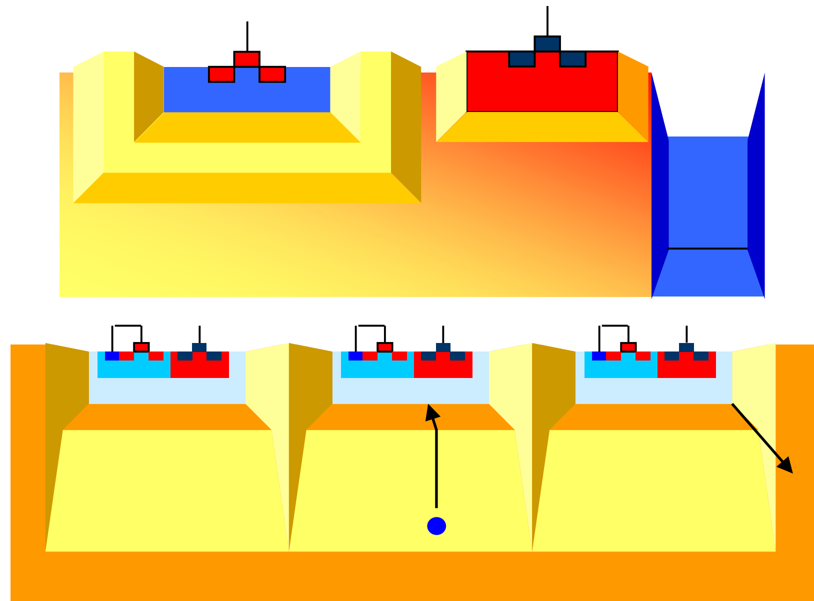
Experiment and Goals

- The CERN-RD50 collaboration “Radiation hard semiconductor devices for very high luminosity colliders” was formed to develop radiation harder detectors.
- Novel active sensors are being produced using HV-CMOS processes, which allow for amplification directly on sensor, and for the use of discriminators and logic elements allowing for improved resolution.
- One of the key aspects of CMOS-based sensors is the thickness of the charge collection layer, which will be measured using an edge-TCT setup.
- One of the most important effects to be measured is the growth of the depletion region in response to irradiation. It is expected that due to a change in the effective doping, the resistance will increase, resulting in the growth of the depletion region.

HVCMOS vs CMOS Technologies

- CMOS technologies are distinguished by their implementation of electronics in the silicon wafer itself.
- Naturally, the electronics are very sensitive.
- What are the ways around this?
- Shielding
- "Hiding"

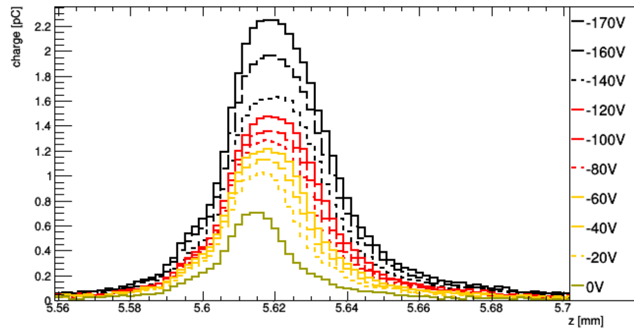


- Diagrams source: indico.cern.ch/event/403299/attachments/808021/1107372/CERNSeminar_IvanPericV1.pdf

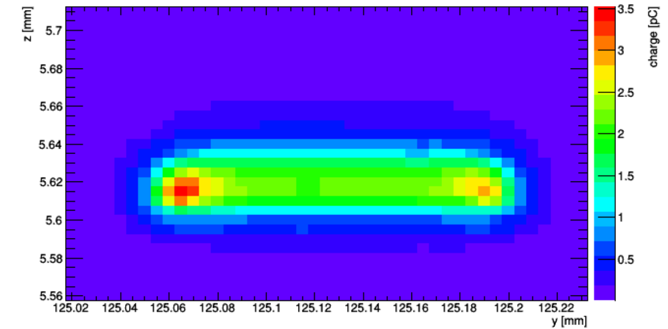
Bias Structure Study

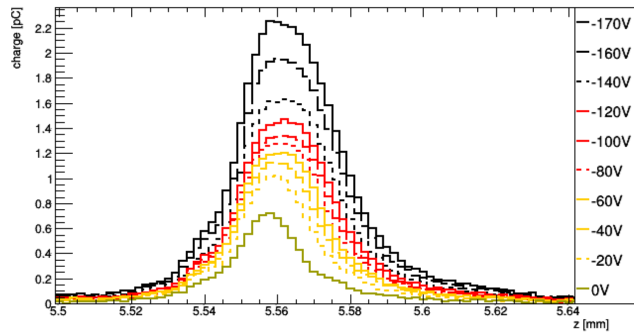
- For the unirradiated sample only, three different biasing structures were tested.
- Due to the high resistivity of the bulk material, no real difference was expected between the structures.
- SUB structure biases the diode from the bulk material.
- SUBGR biases the diode from the guard ring surrounding the sensor.
- SUB_SUBGR biases from both places simultaneously.

Unirradiated at 20C

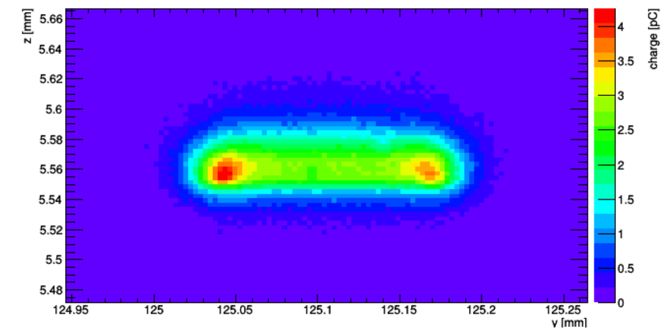


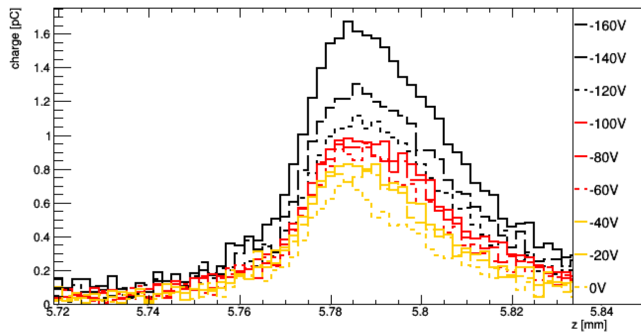
SUB





SUB_SUBGR





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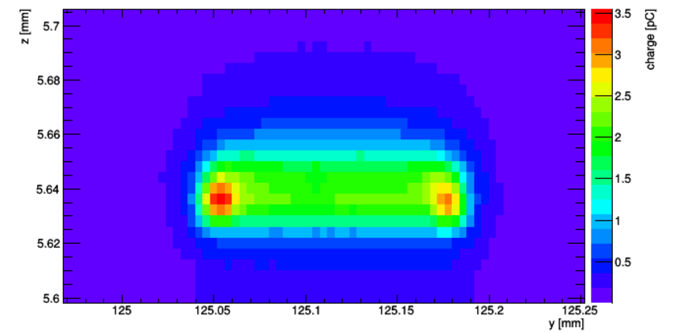
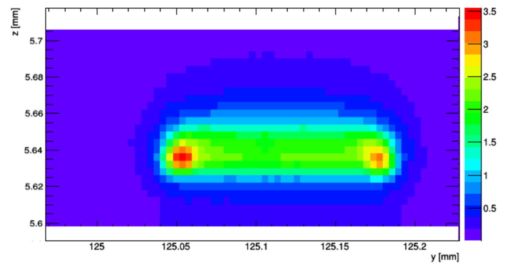
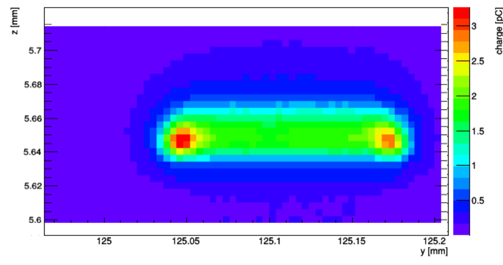
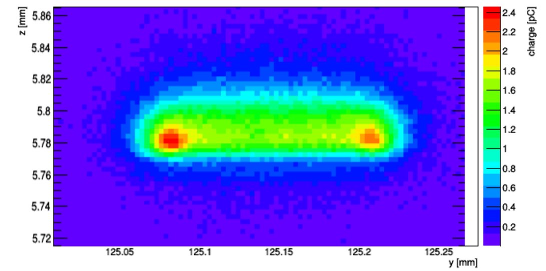
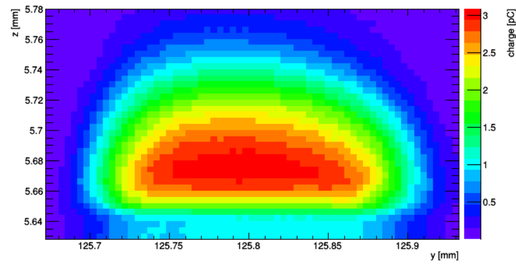
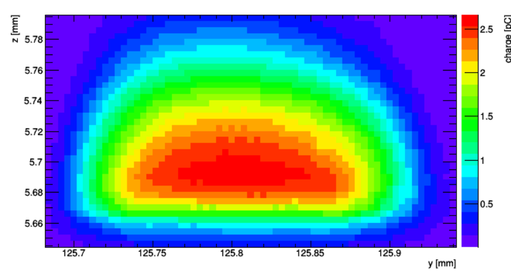
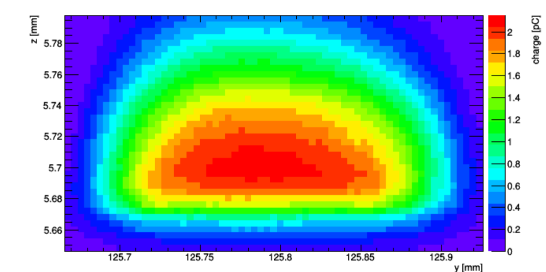
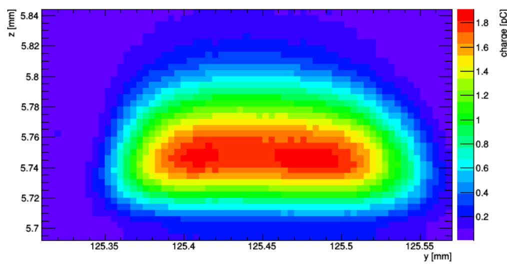
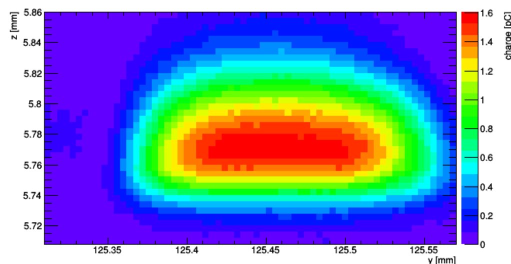
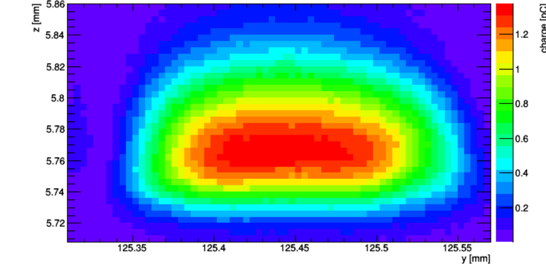
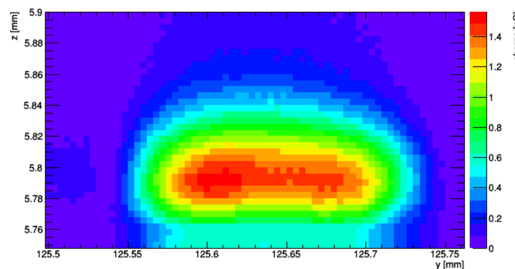
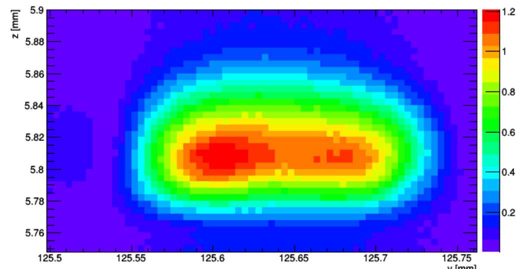
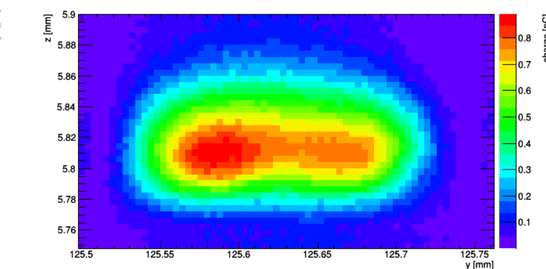


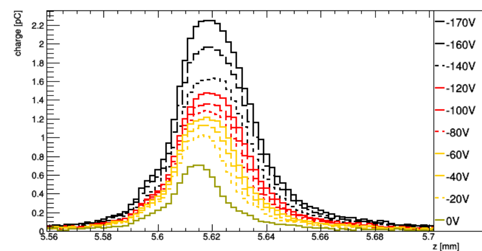
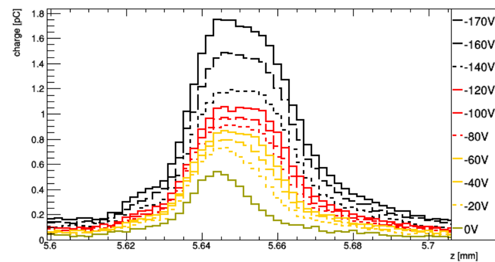
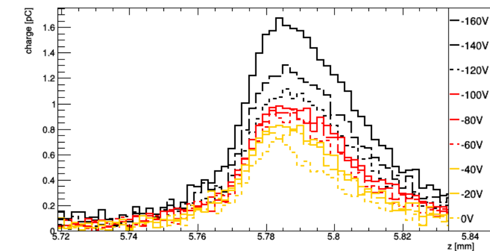
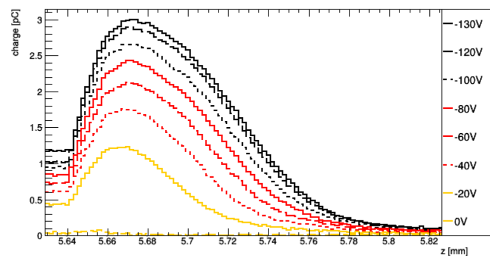
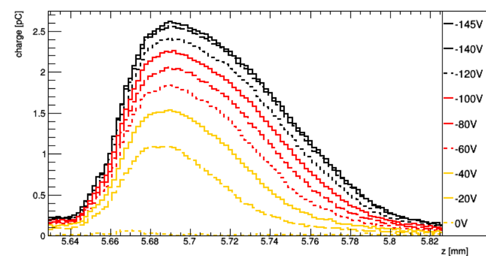
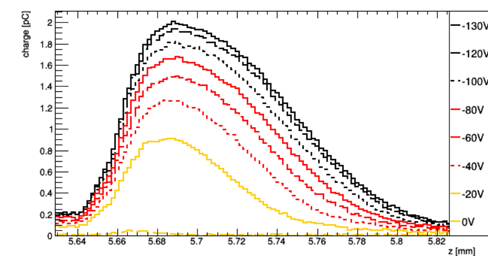
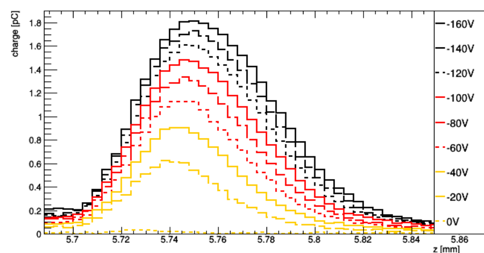
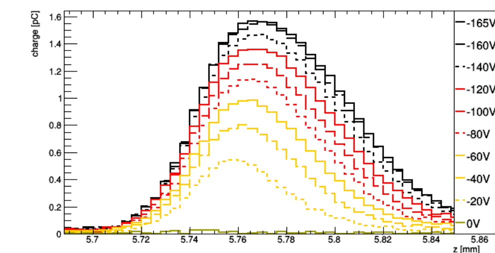
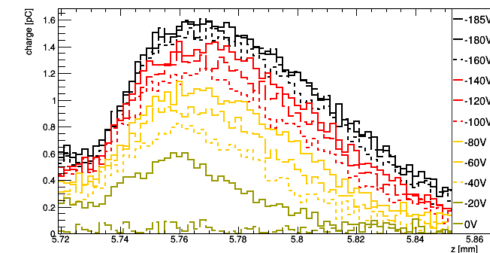
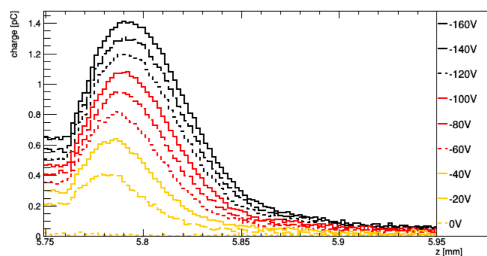
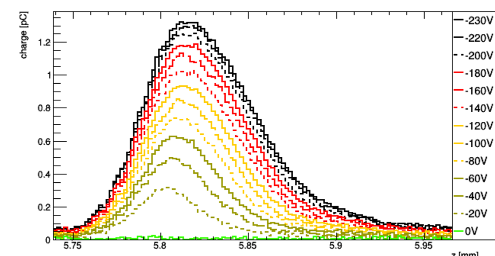
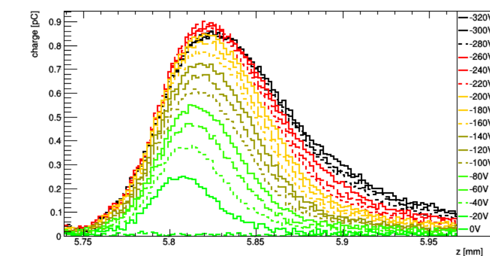
Irradiation Study

- Samples had fluences of 0, 2.30E15, 6.00E15, and 1.11E16 protons/cm^2.
- Irradiation was performed at the PS with 24GeV/c protons.
- Hardness factor is 0.62 1MeV neq/24GeV p+
- Samples tested at -20C, 0C, and 20C to observe any temperature dependence.
- In most cases, compliance was set to 100 microamps, although in some cases, increasing to ~500 microamps was necessary to obtain meaningful data.

Surface Scans

- Very interested in depletion depth as function of irradiation.
- Surface scans also help to understand electromagnetic field inside depletion region.
- Depletion region changes with voltage and fluence, so it is important to test many different configurations.
- Scans have same scale for to allow for comparison.

	20	0	-20
Unirrad			
2.3E15			
6.00E15			
1.11E16			

	20	0	-20
Unirrad			
2.3E15			
6.00E15			
1.11E16			

FWHM of Charge Collection Region

	20C	0C	-20C	Average
Unirrad	30um [-170V]	30um [-170V]	28um [-160V]	29.3um
2.30E15	82um [-130V]	90um [-145V]	96um [-130V]	89.3um
6.00E15	60um [-160V]	68um [-165V]	80um [-185V]	74.3um
1.11E16	64um [-160V]	71um [-160V]	87um [-160V]	74um
1.11E16 (peak)	66um [-160V]	61um [-160V]	62um [-160V]	63um

- Values are given in micrometers.
- Value is for highest bias voltage applied to sample during scan.
- The value in brackets is the voltage at which the FWHM was measured.
- Size peaks at or before 2.30E15.
- More testing at lower fluences would be needed to know exact maximum.
- Values taken from ROOT program.

Future Plans for Project

- Completed:
  - Temperature study of irradiated samples with SUB biasing structure.
  - Biasing structure study of unirradiated sample.
- Still needs to be done:
  - Biasing structure study of irradiated samples at all three temperatures.
  - Testing back biasing by removing both SUB and SUBGR wirebonds, once all other data has been taken.
  - Testing other samples at lower fluences.