RD39 Status Report 2009

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http://rd39.web.cern.ch/RD39/

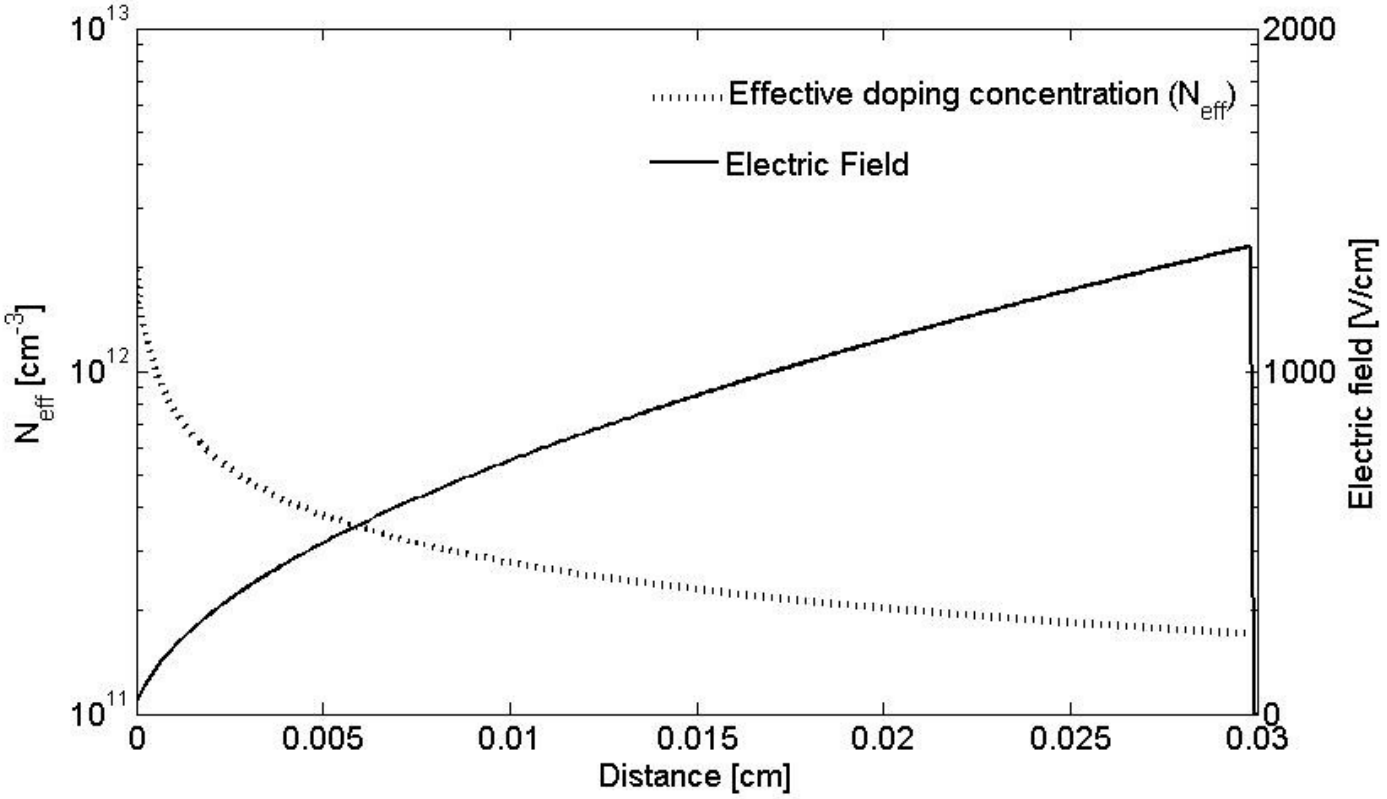
Outline

- Principle of Charge Injected Detector (CID)
- IV characteristics of CID
- Test beam 2009 on full size CID strip detectors
  - n and p-type MCz-Si sensors
  - Collected charge
  - Noise
- Comparison of CID vs same detector reverse biased
- New concept for 3D detectors -E field manipulation
- Summary

Charge Injected Detector (CID) –Operational Principle

The electric field is controlled by charge injection, i.e. charge is trapped but not detrapped at “low” temperature

$$\tau_{trapping} = \frac{1}{\sigma_{e,h} v_{th} N_t} \qquad \tau_{detrapping} = \frac{1}{\sigma_{e,h} v_{th} e^{\frac{-E_t}{kT}}}$$



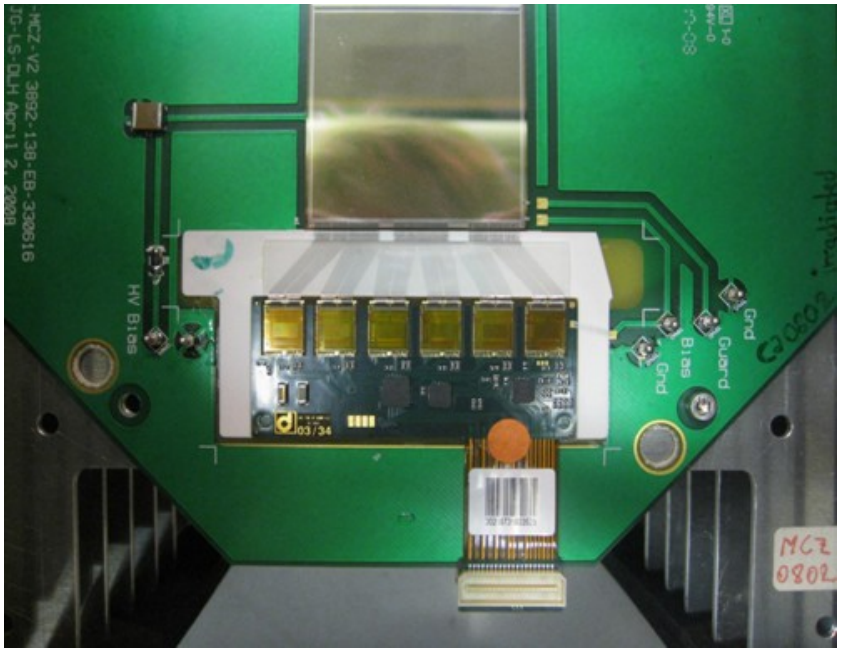
Electric field is extended through entire bulk regardless of irradiation fluence.

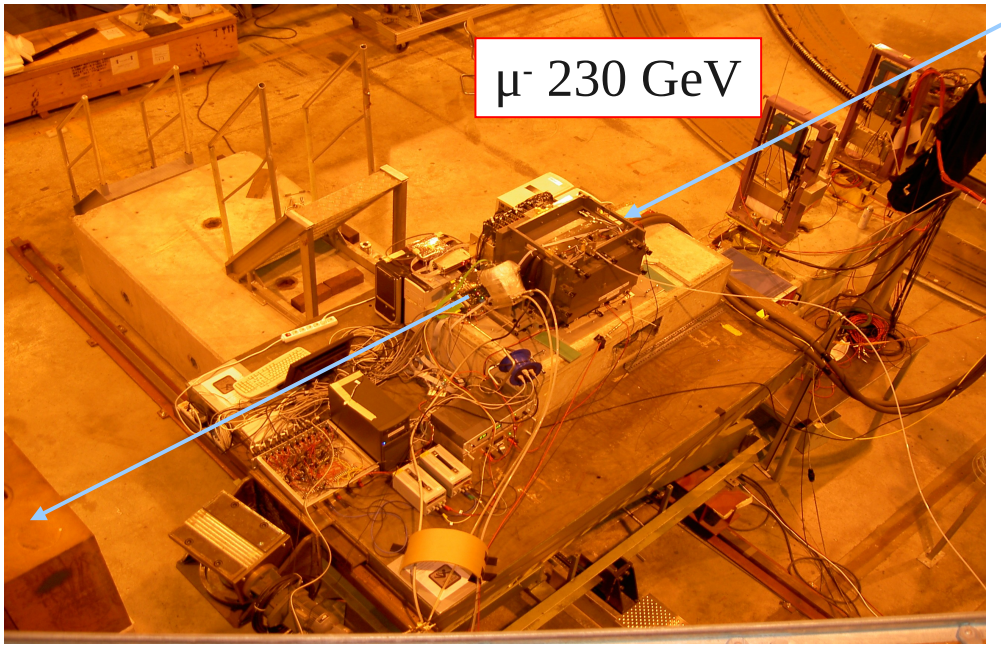
Electric field is proportional to square of distance
$E(x) \sim \sqrt{x}$

Detector is “fully depleted” at any bias or irradiation fluence

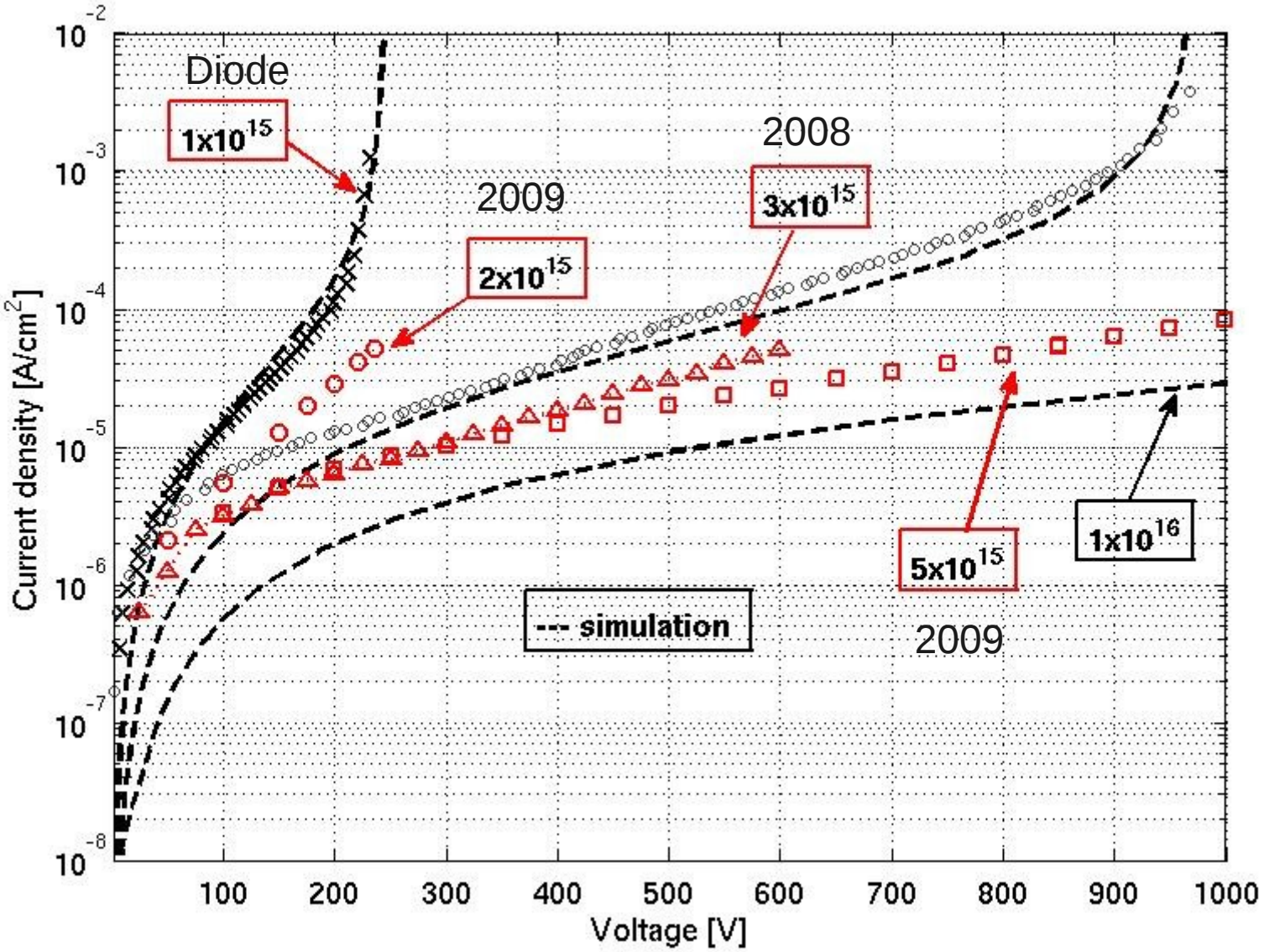
Test Beam experiment on CID detectors 2009

- Sensors investigated
  - 2×10^{15} n_{eq} /cm^2 $n^+/p^-/p^+$ MCz-Si
  - 5×10^{15} n_{eq} /cm^2 $p^+/n^-/n^+$ MCz-Si (in 2008 3×10^{15} n_{eq}/cm^2 $p^+/n^-/n^+$ MCz-Si)

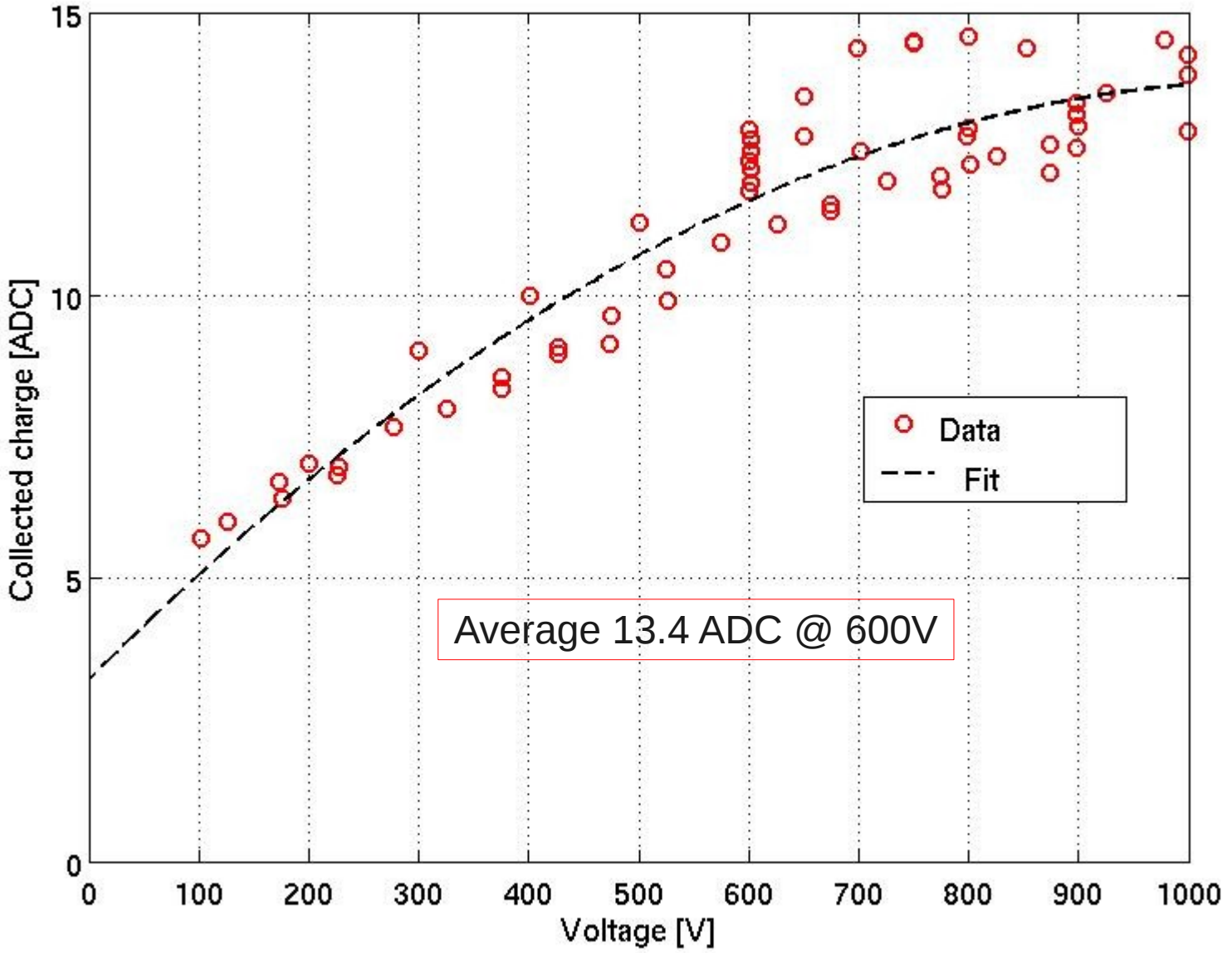




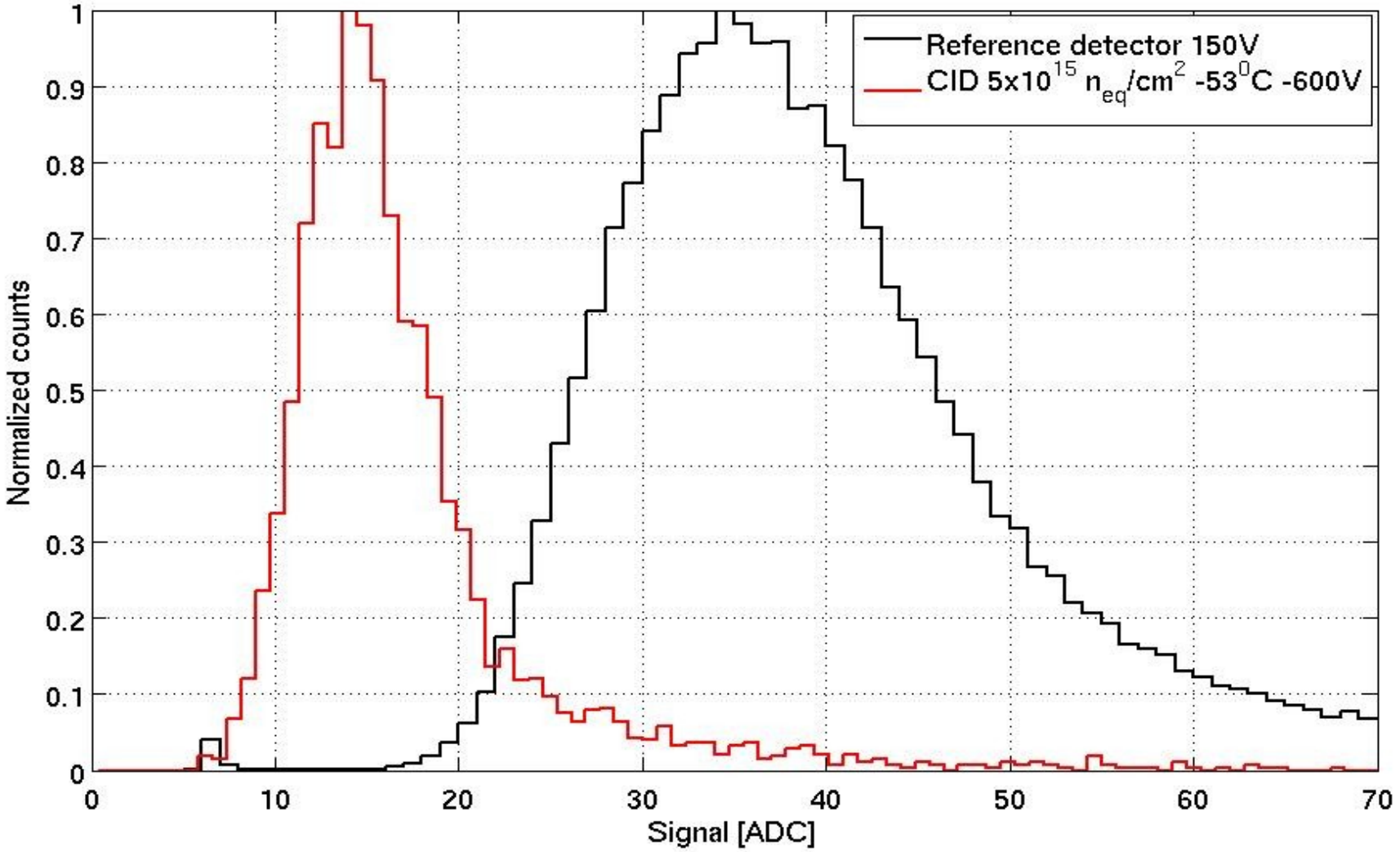
IV characteristics



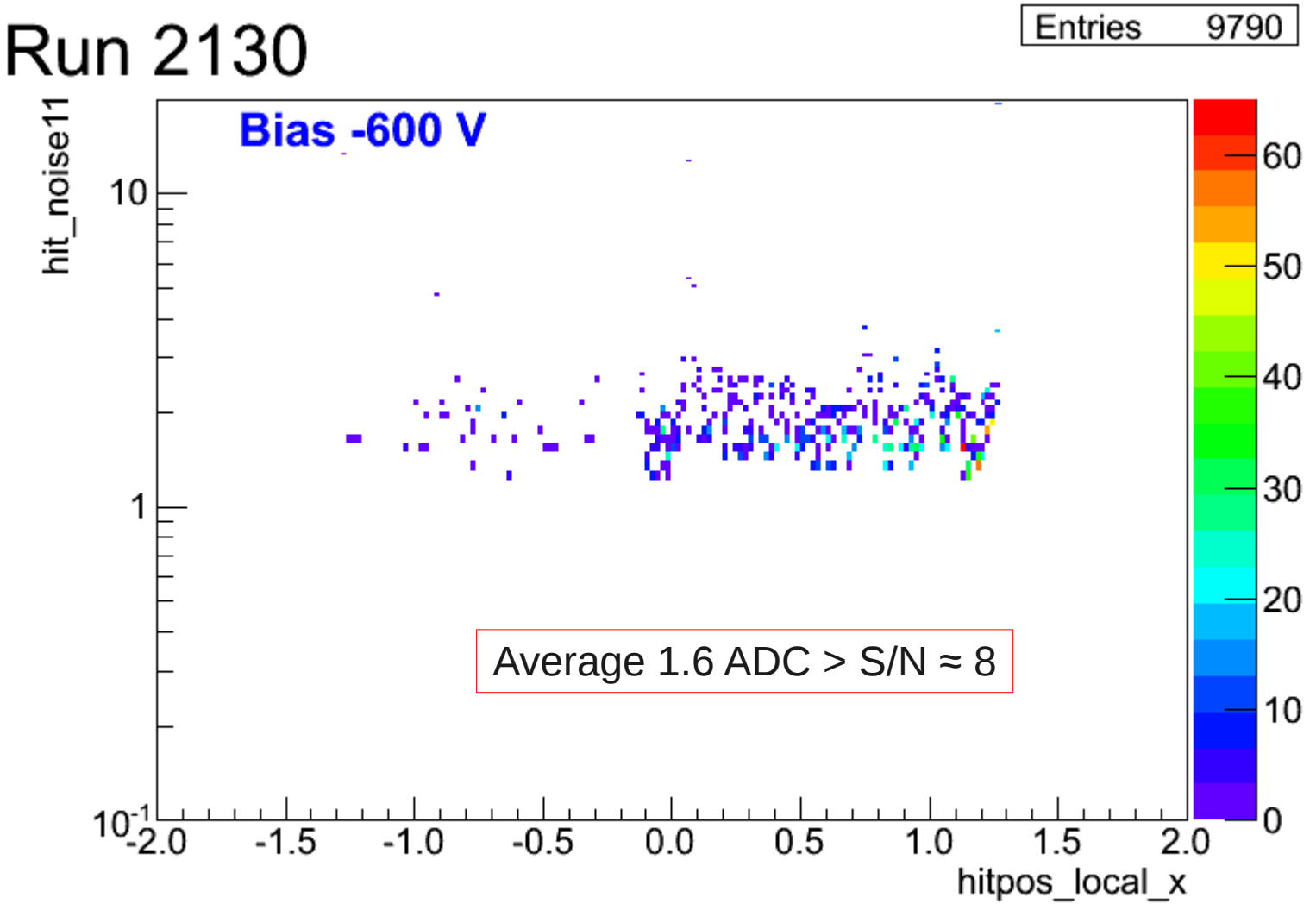
5×10^{15} n_{eq}/cm^2 results -Collected charge vs V



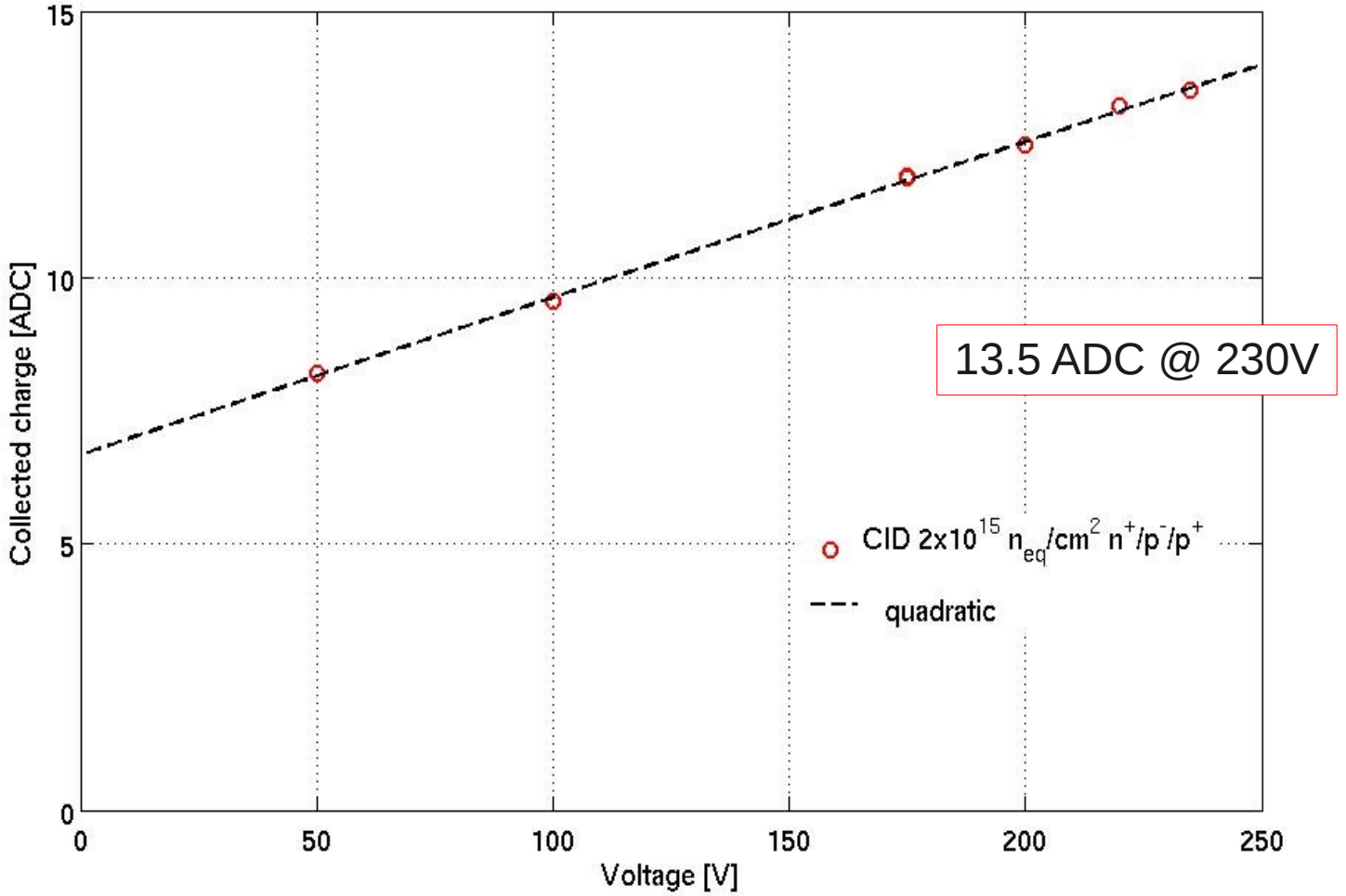
5×10^{15} n_{eq}/cm^2 results -Collected charge vs non-irrad



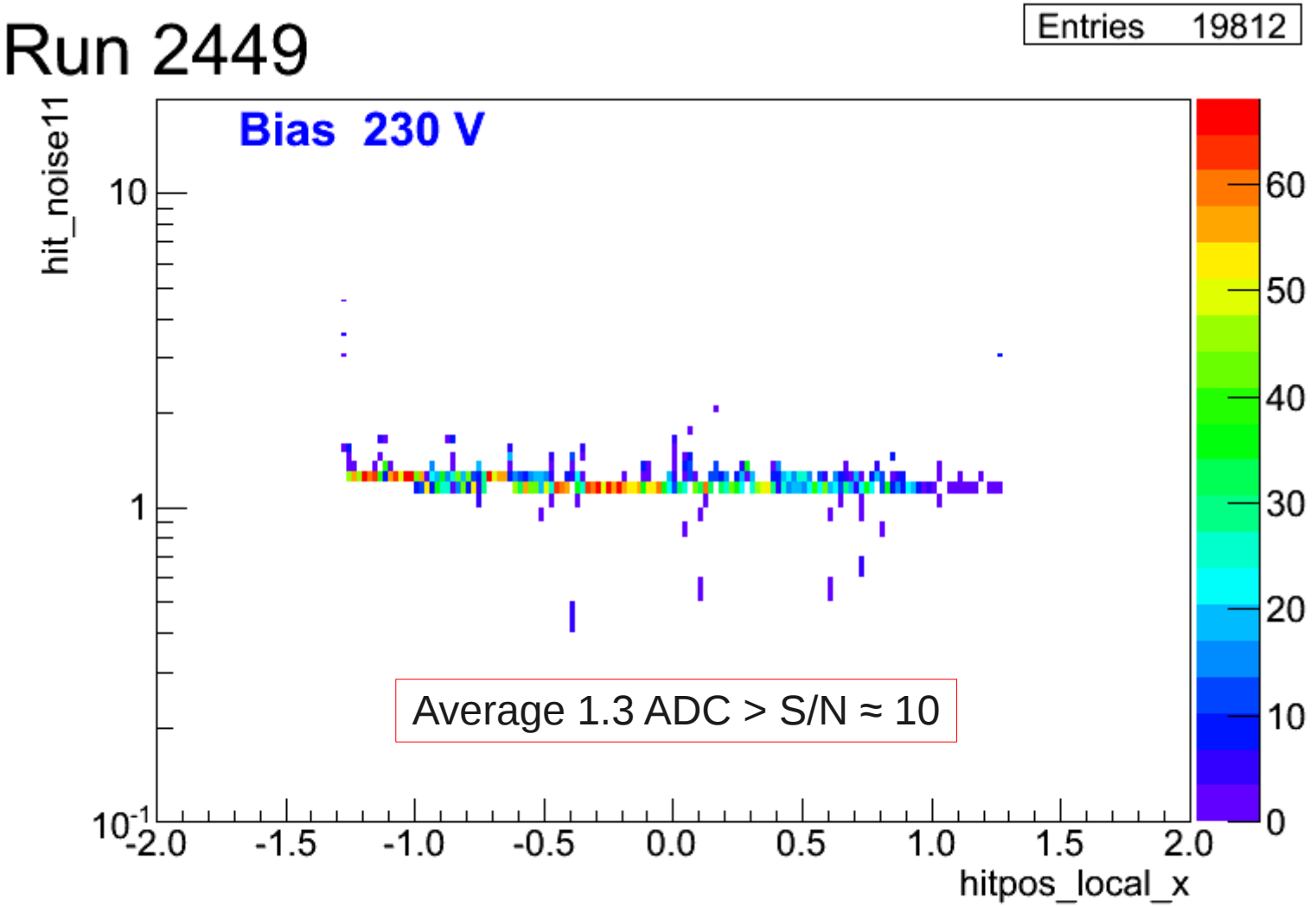
5×10^{15} n_{eq} /cm^2 results -Noise



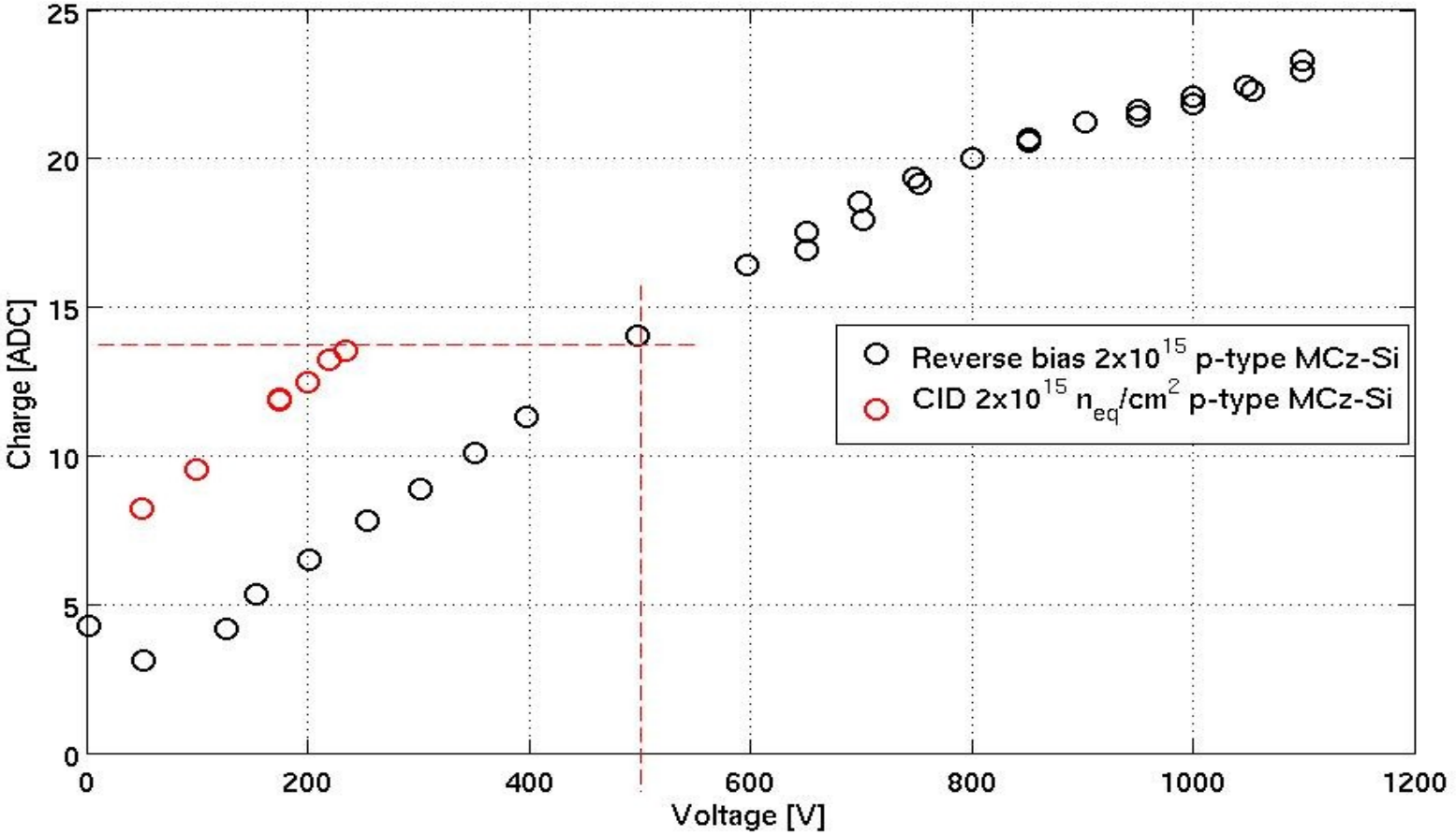
2×10^{15} n_{eq} /cm^2 results -Collected Charge



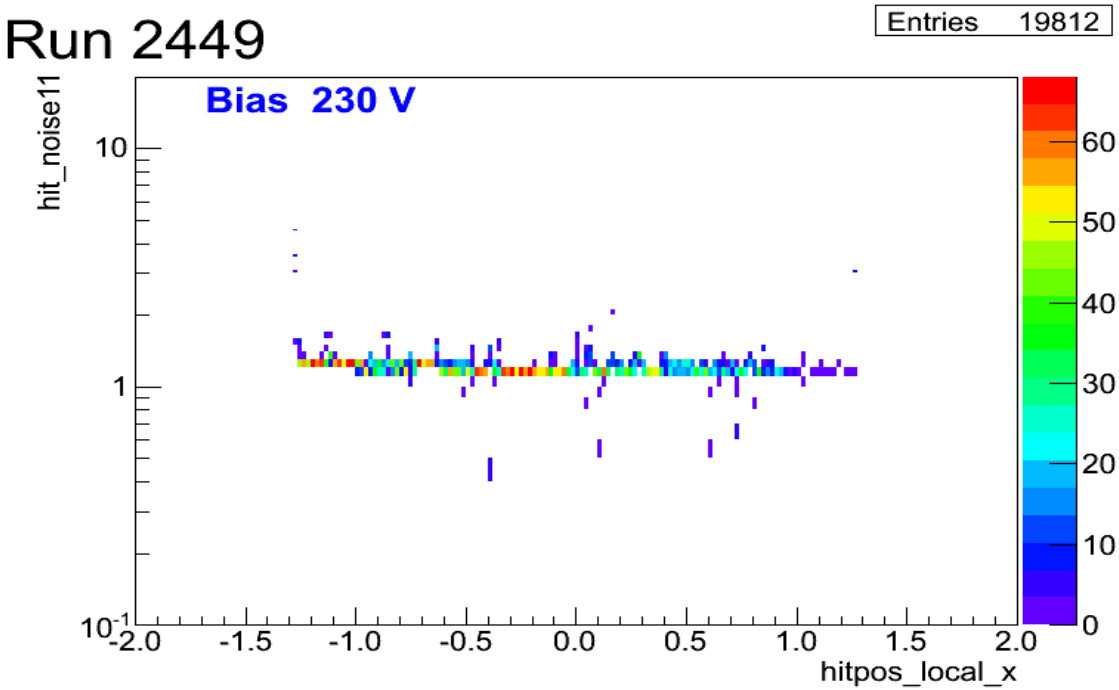
2×10^{15} n_{eq} /cm^2 results -Noise

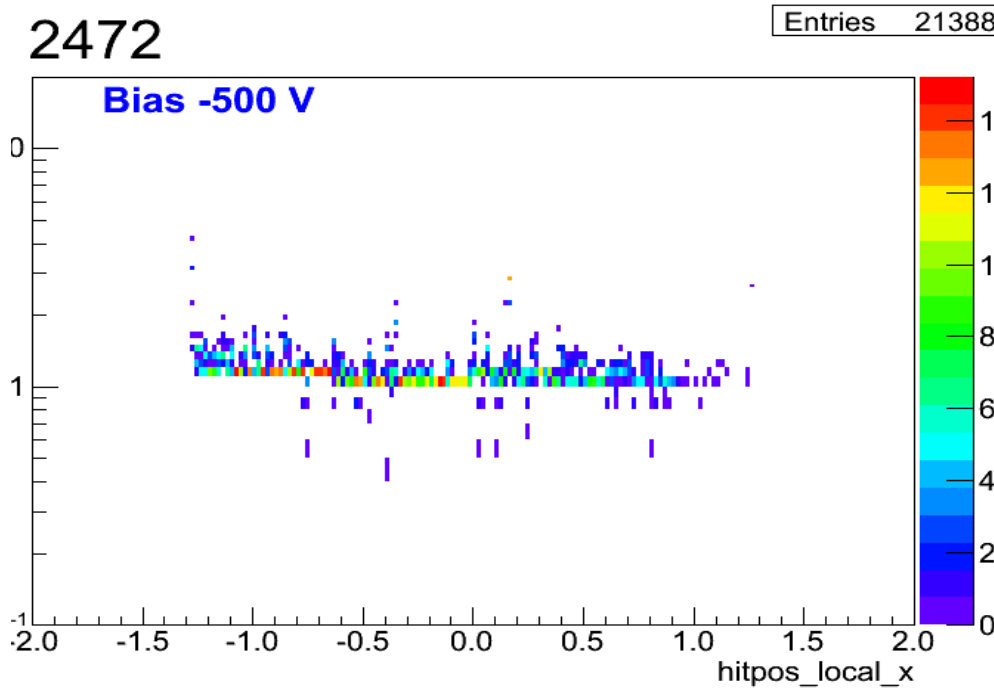


Comparison of CID vs reverse bias -Collected charge



Comparison of CID vs reverse bias -Noise

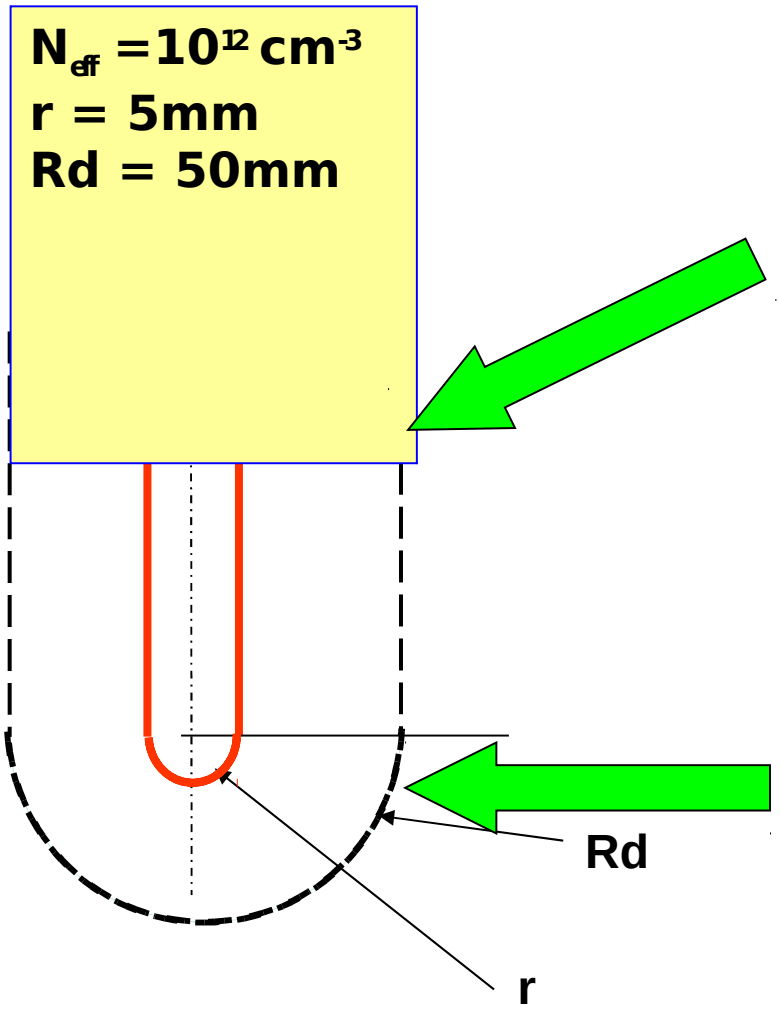


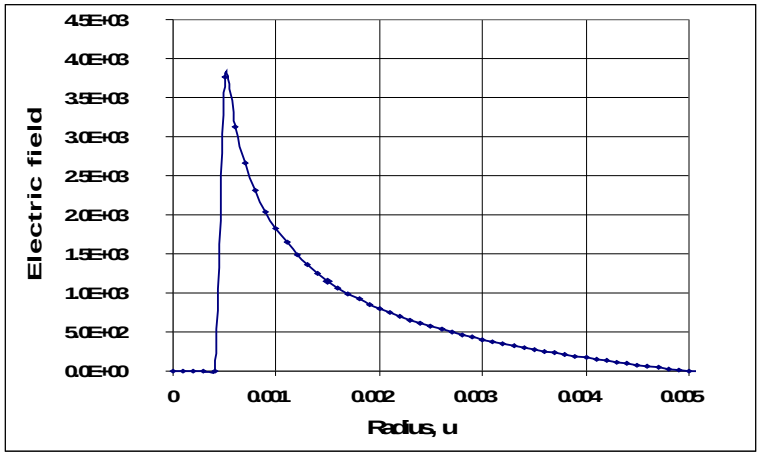


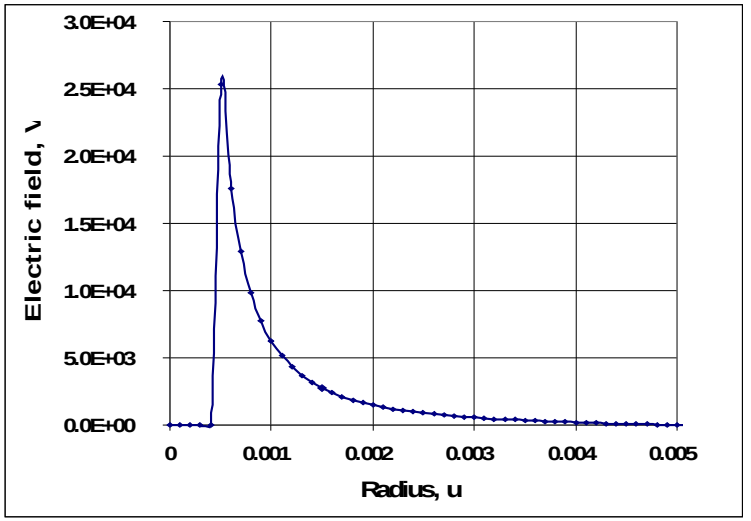
Average 1.3 ADC > S/N ≈ 10

Average 1.1 ADC > S/N ≈ 12

The electric field distribution around the junction column in 3D detector

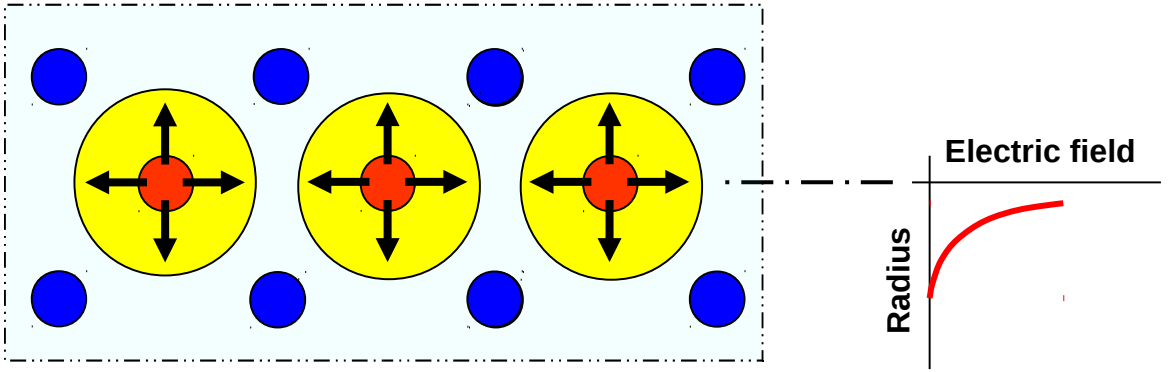




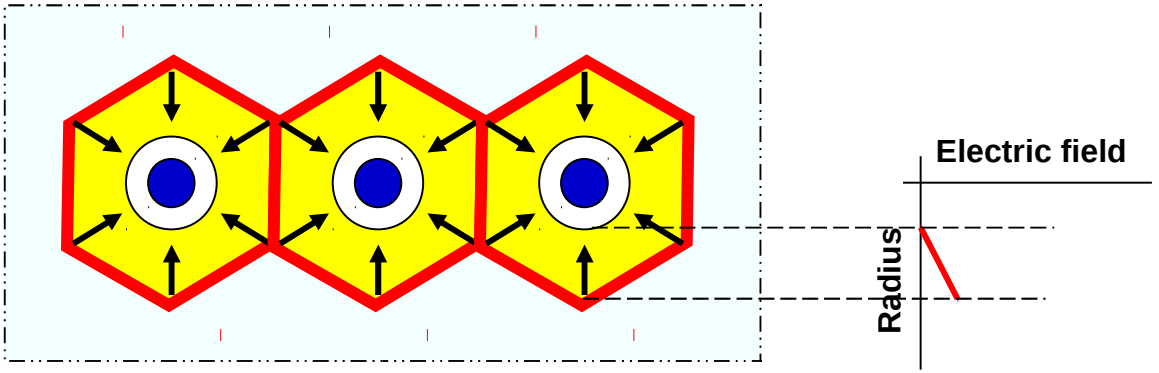


Electric field manipulation in 3D detectors

Column
p^+-n junction

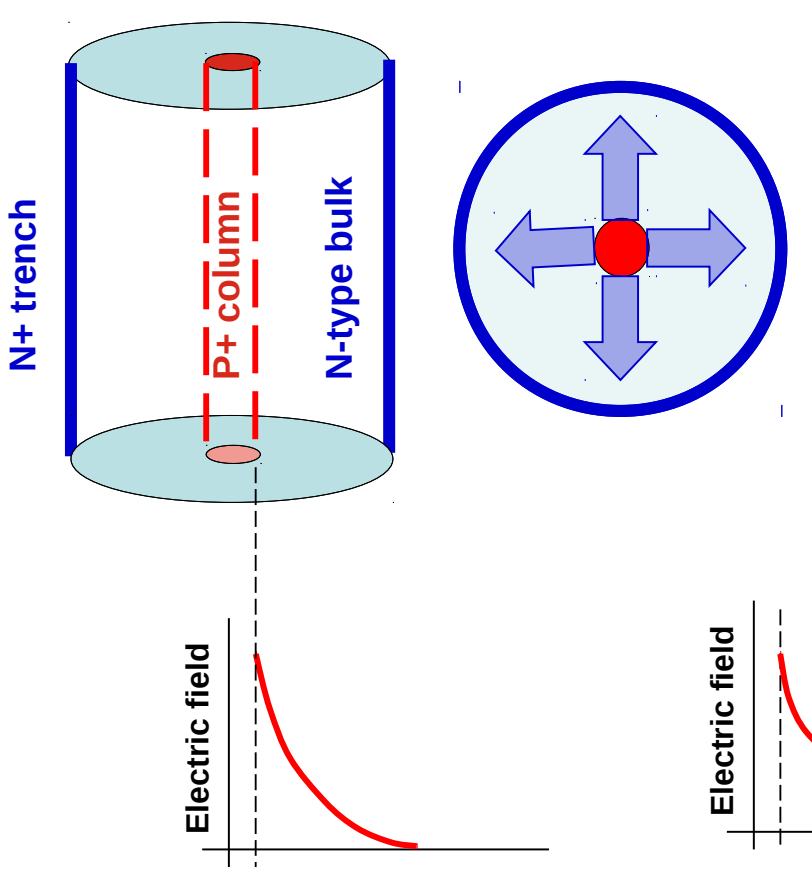


Trench
p^+-n
junction

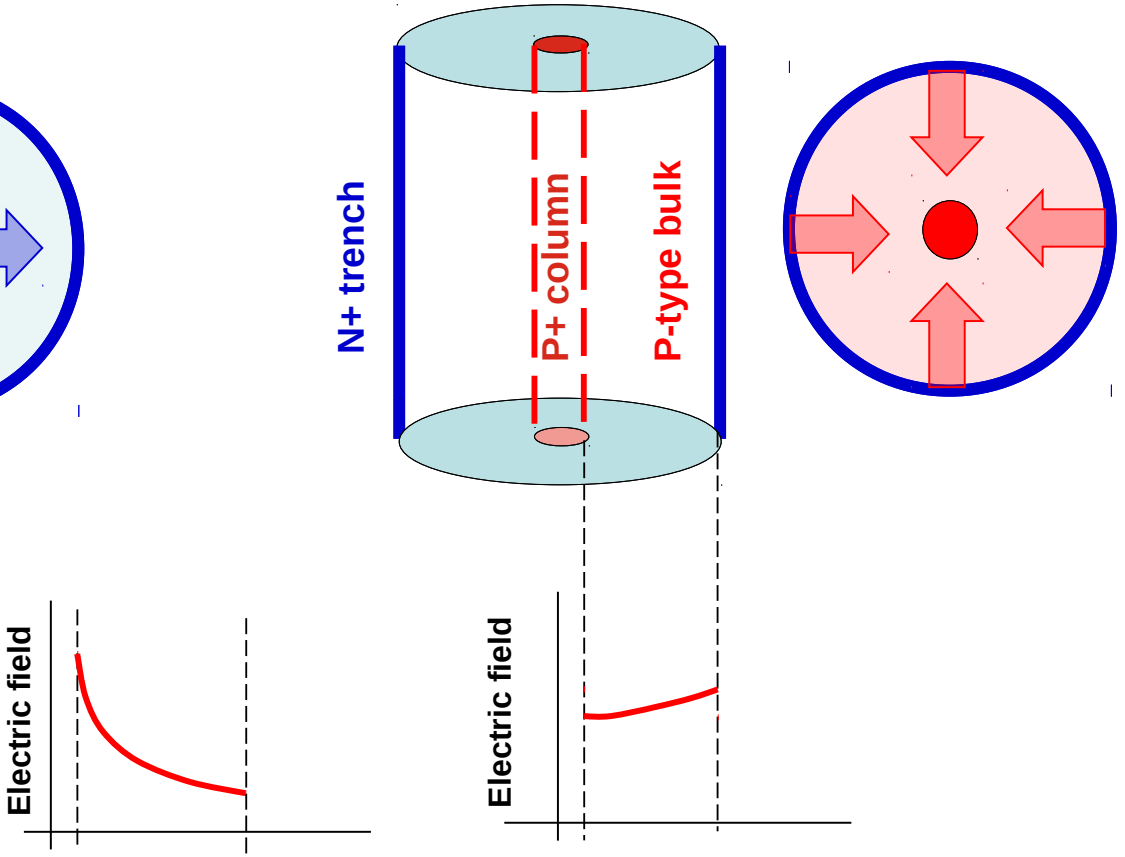


Electric field evolution in 3D junction-trench detector cell under irradiation

Before irradiation



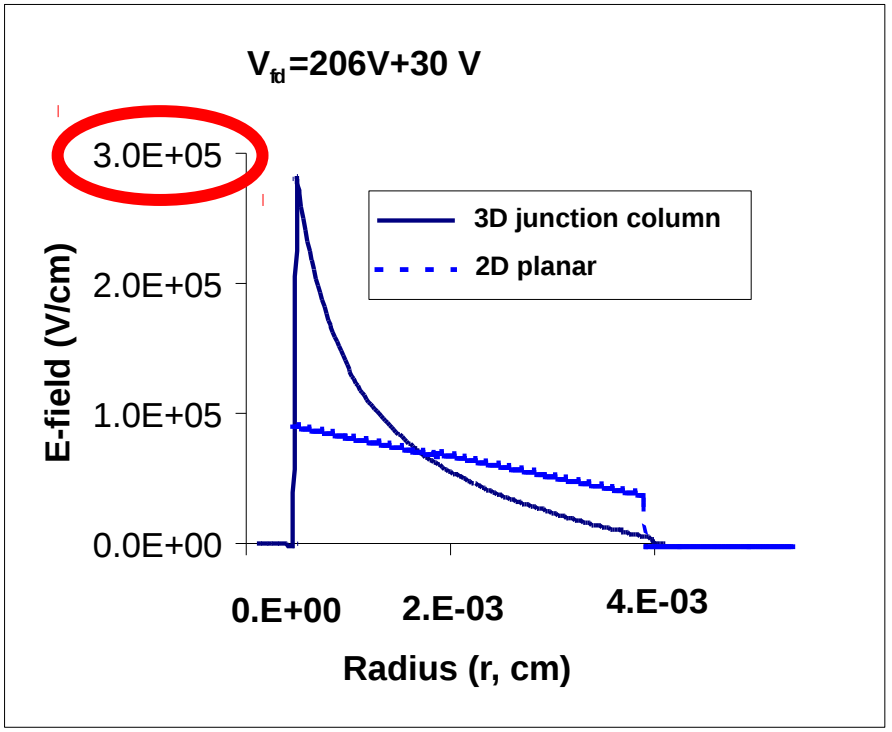
After irradiation and SCSI



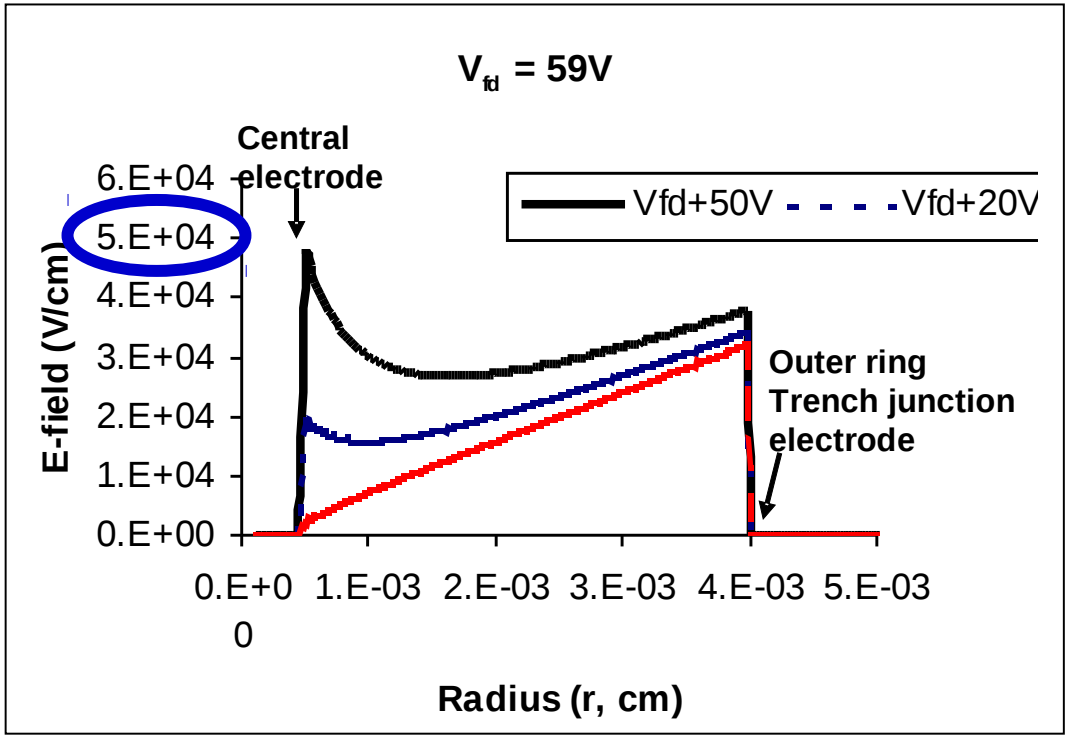
Analytical prediction for electric field distribution in 3D trenched detectors

$F=10^{16}$ neq/cm², r = 10 mm, R_{tr} = 40 mm

Junction column



Junction trench



Summary

- n and p-type full size CID detectors were beam tested in 2009.
- 2×10^{15} n_{eq}/cm^2 and 5×10^{15} n_{eq}/cm^2 irradiated CID detectors show > 30% charge collection efficiency.
- S/N were 8 and 10.
- Measurements were done at -50^0C.
- One needs 2× reverse bias in n on p sensor to gain same CCE.