Test beam results of Current Injected Detectors (CID) irradiated up to 5×10^{15} n_{eq}/cm^2)

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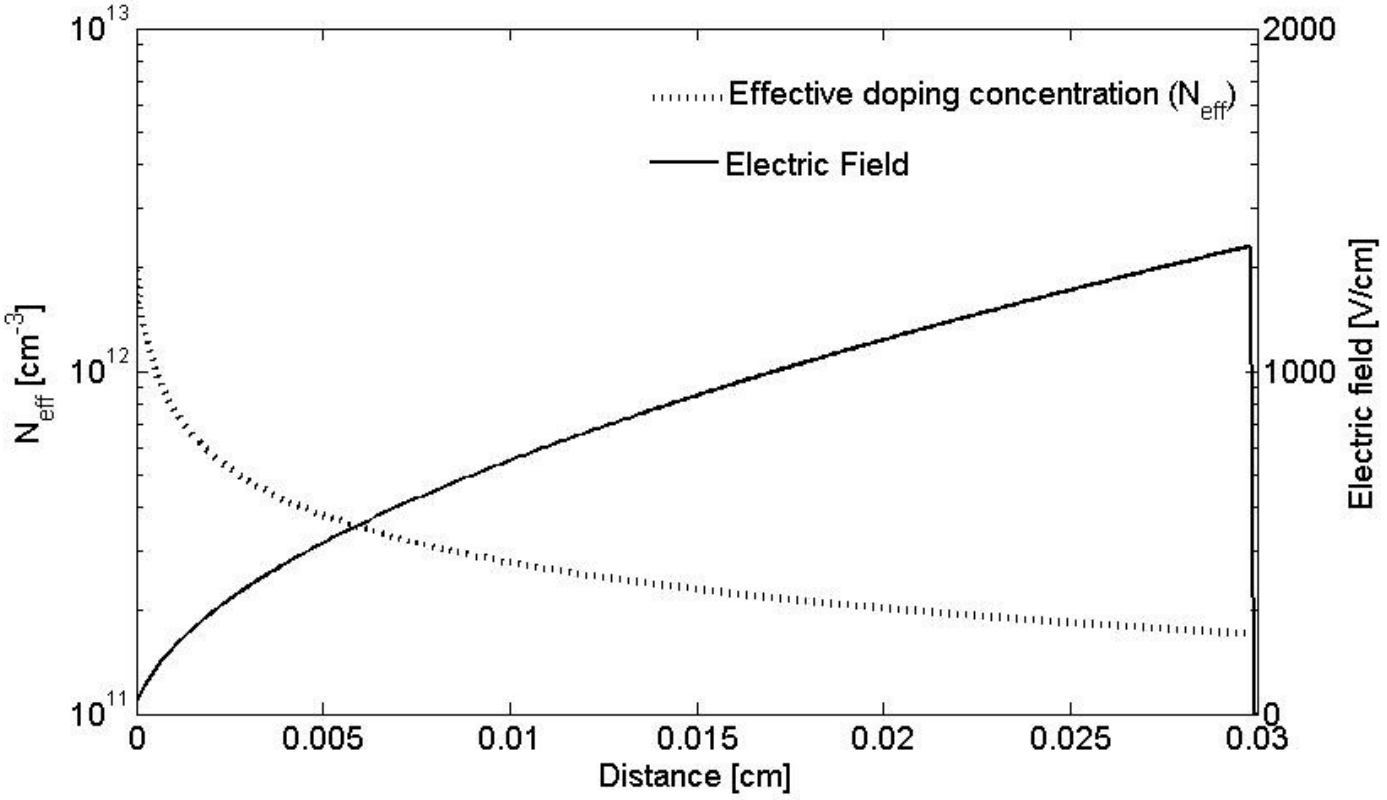
- Short introduction on operation principle of Charge Injected Detector (CID)
- Samples and test beam setup
- Test beam results

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

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



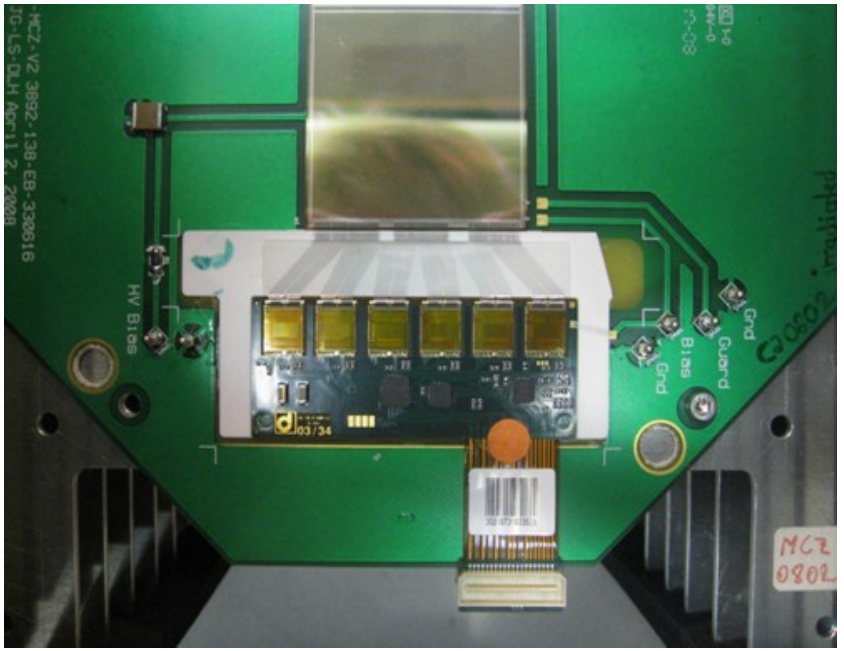
Electric field is extended through entire bulk regardless of irradiation fluence.

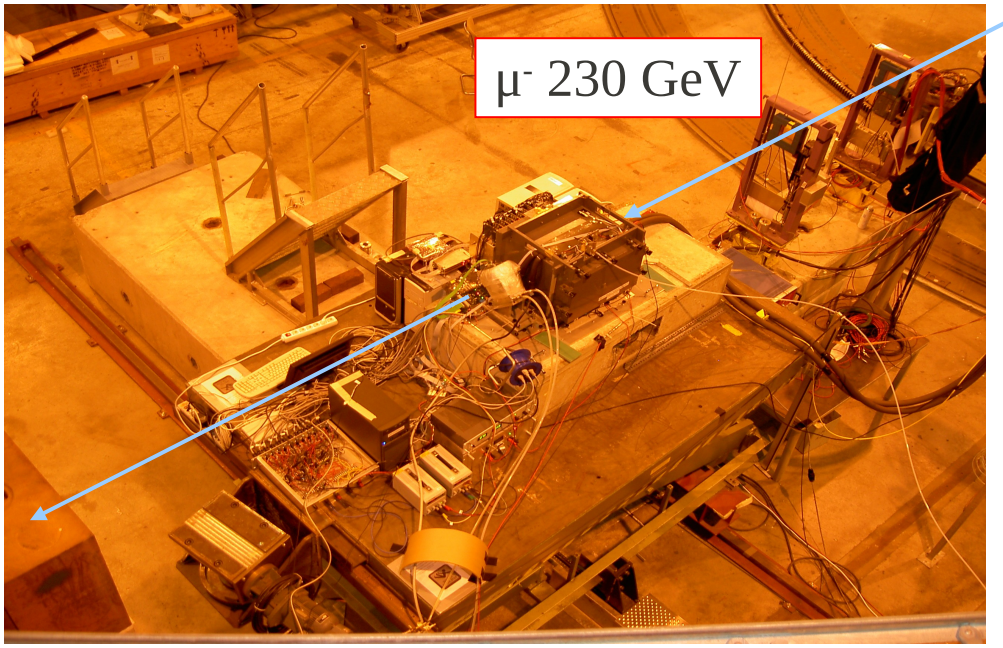
Electric field is proportional to square of distance
$E(x) \sim \sqrt{x}$

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

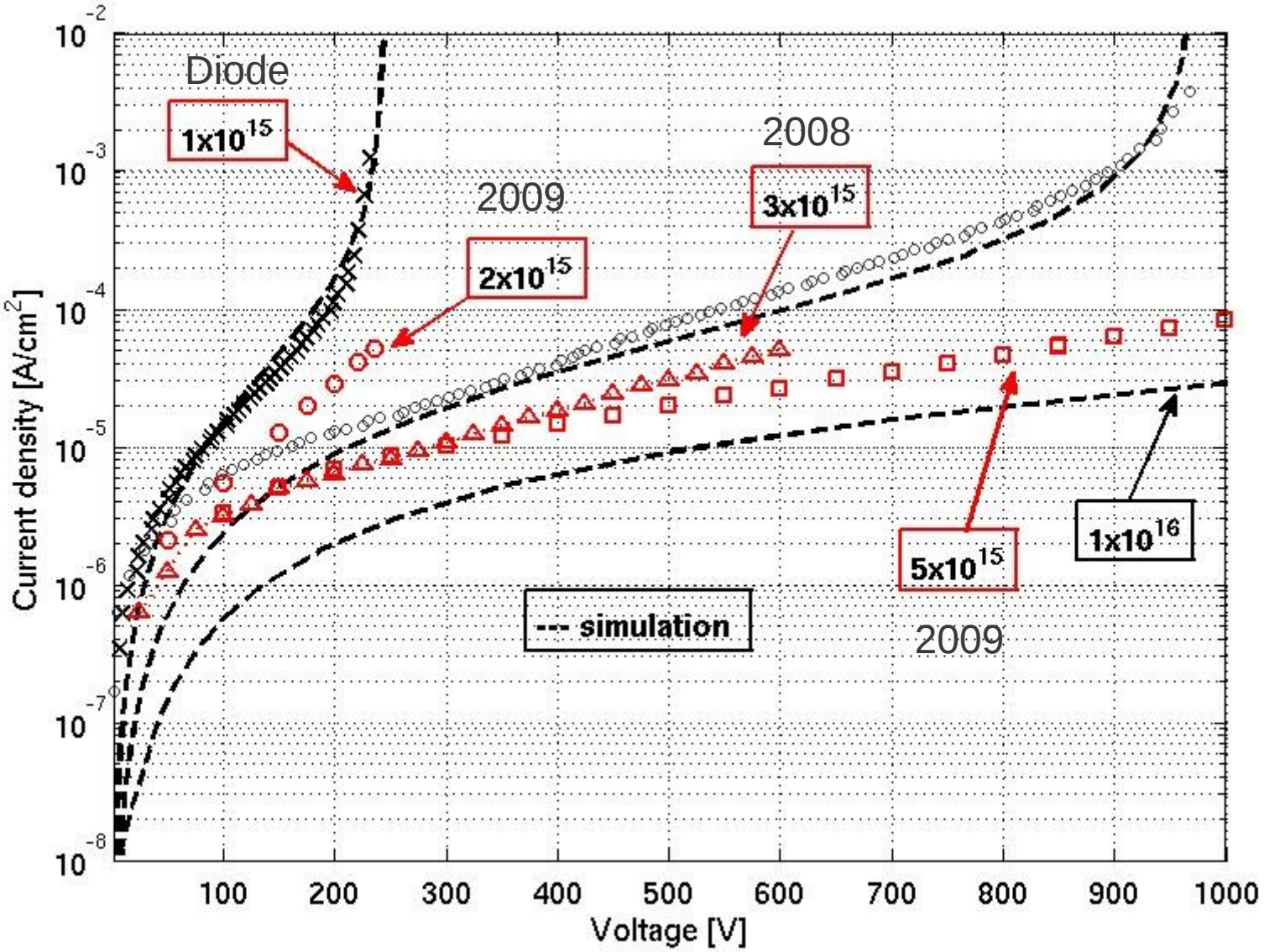
Test Beam experiment on CID detectors 2009

- 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)

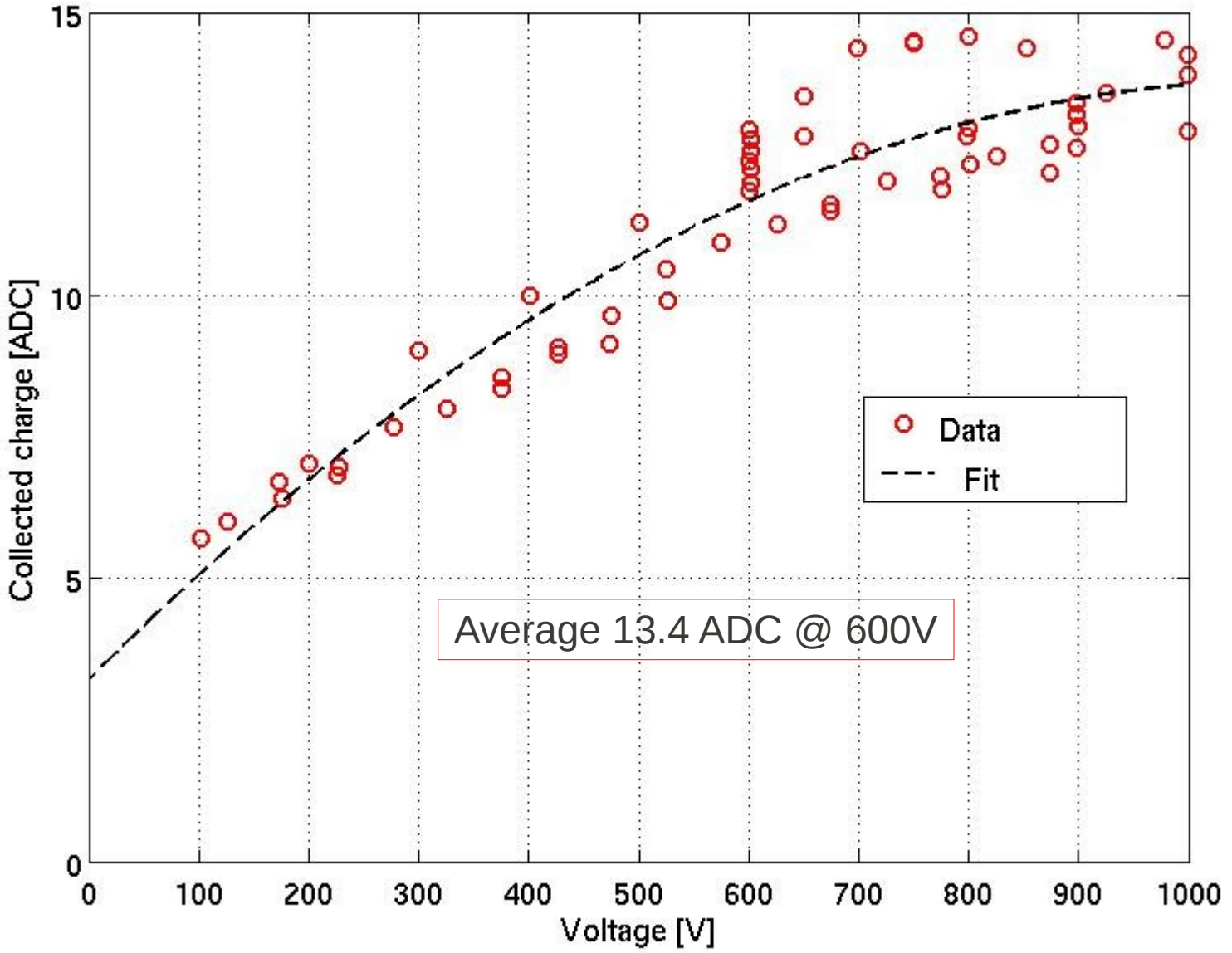




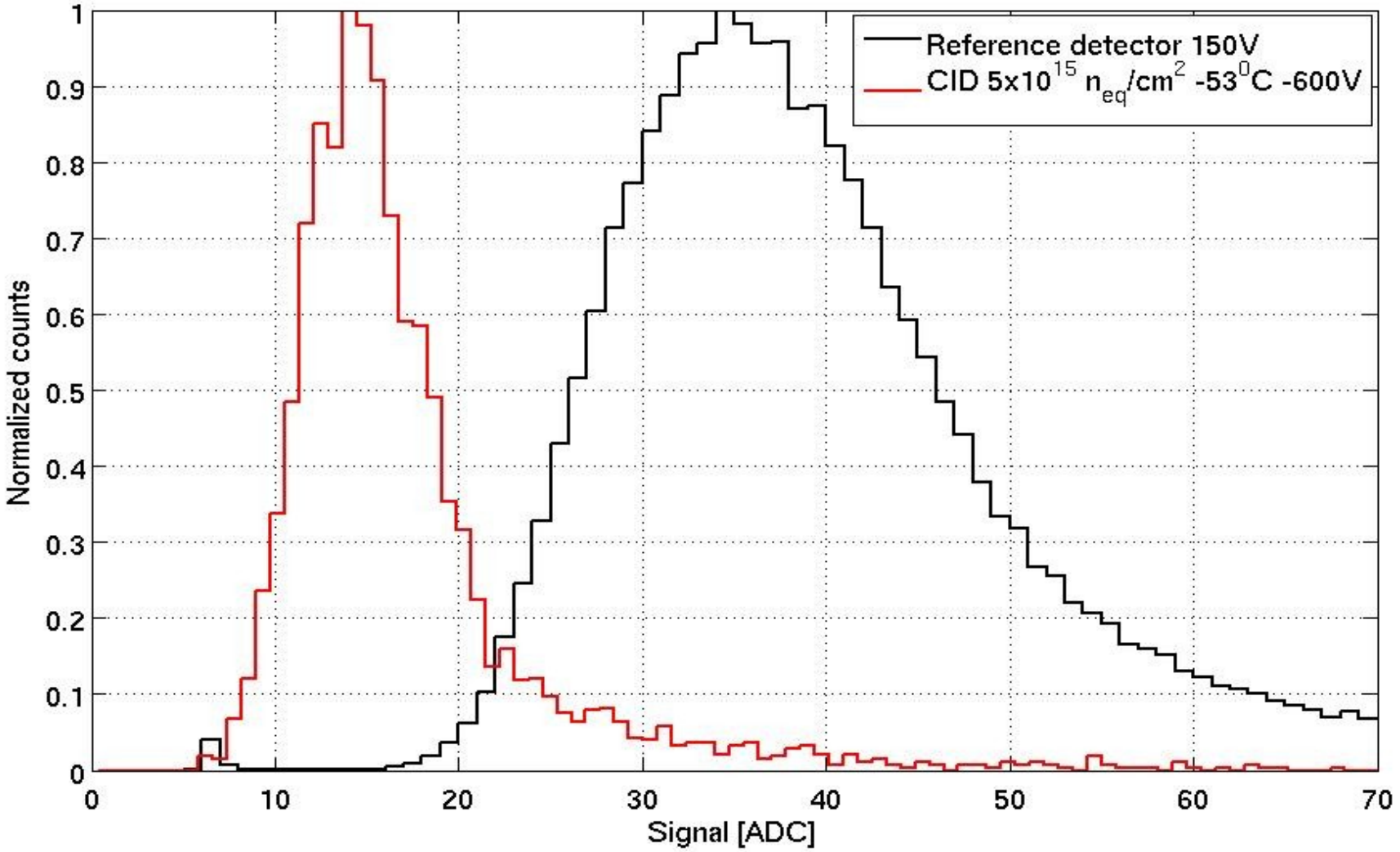
IV characteristics



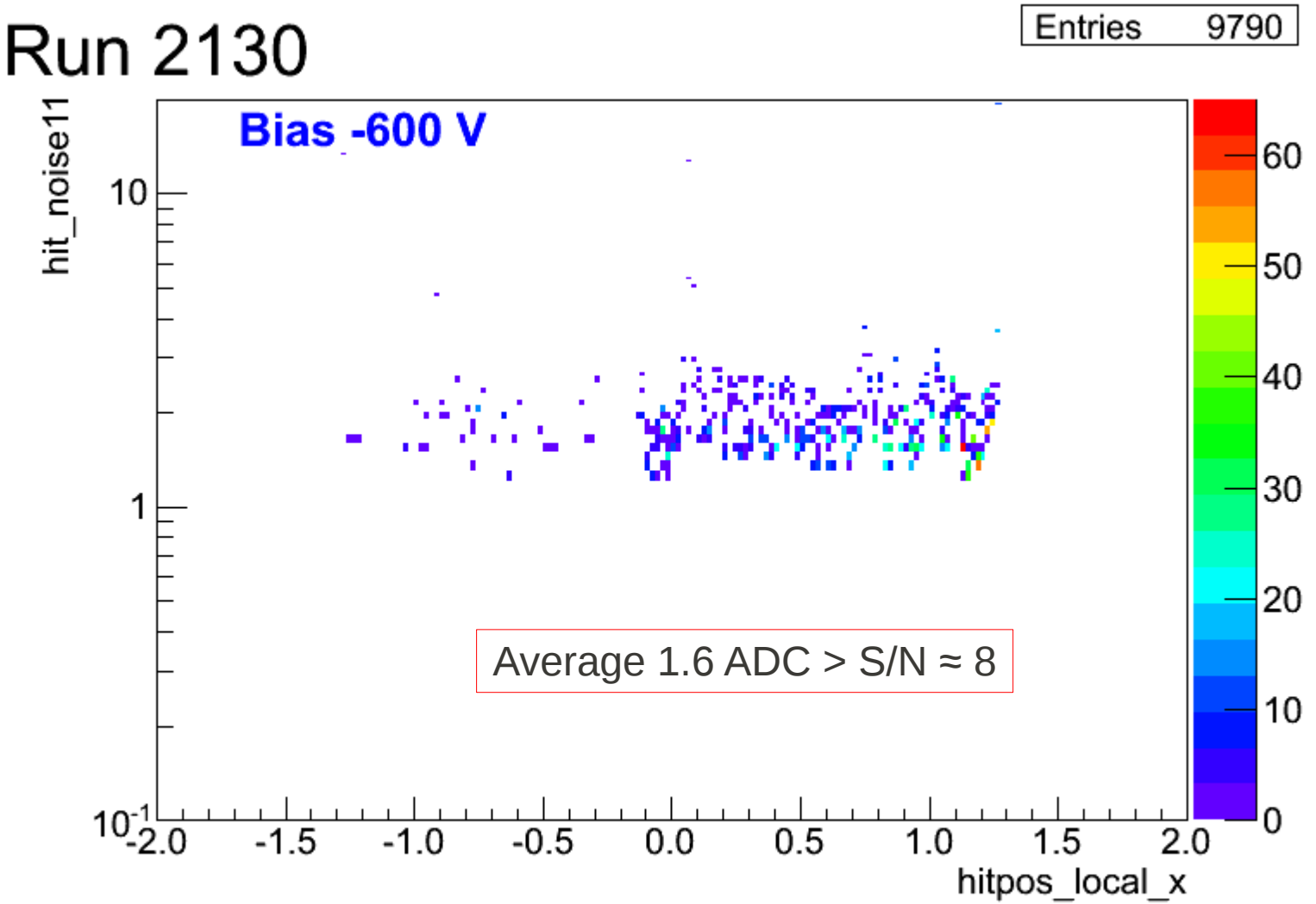
5×10^{15} n_{eq}/cm^2 results -Collected charge vs V CID mode



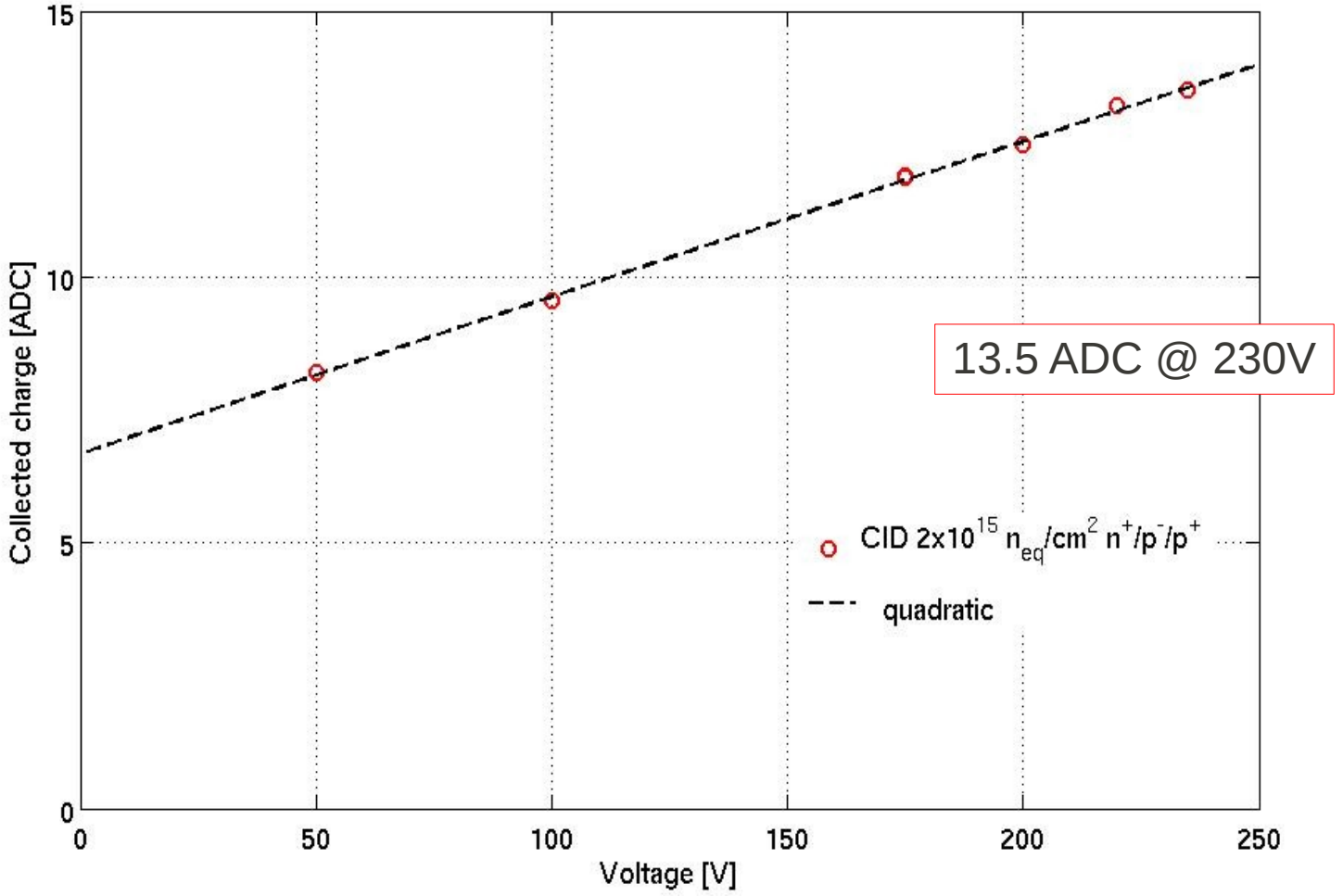
5×10^{15} n_{eq}/cm^2 results -Collected charge vs non-irrad



5×10^{15} n_{eq}/cm^2 results -Noise

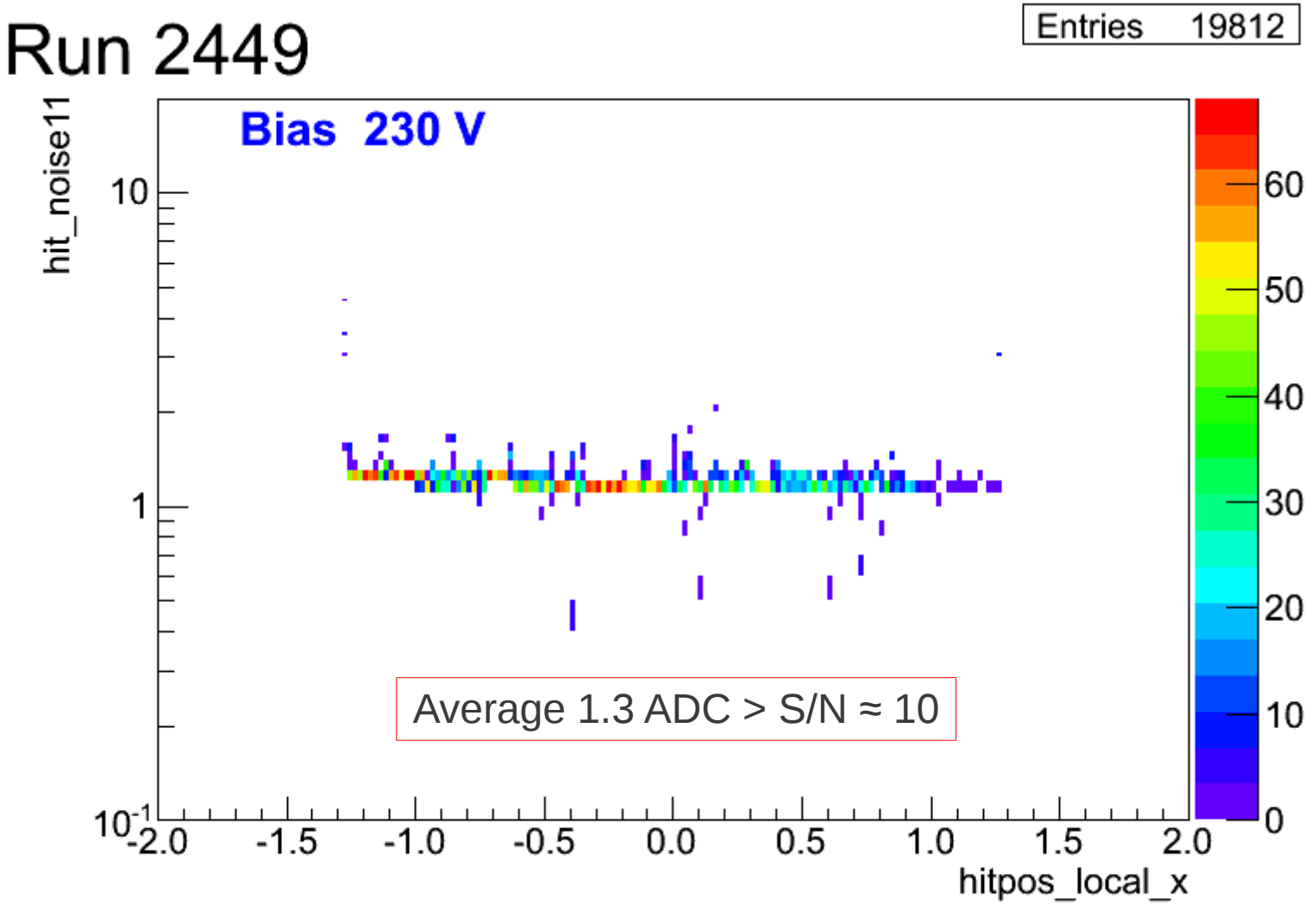


2×10^{15} n_{eq}/cm^2 results -Collected Charge CID mode

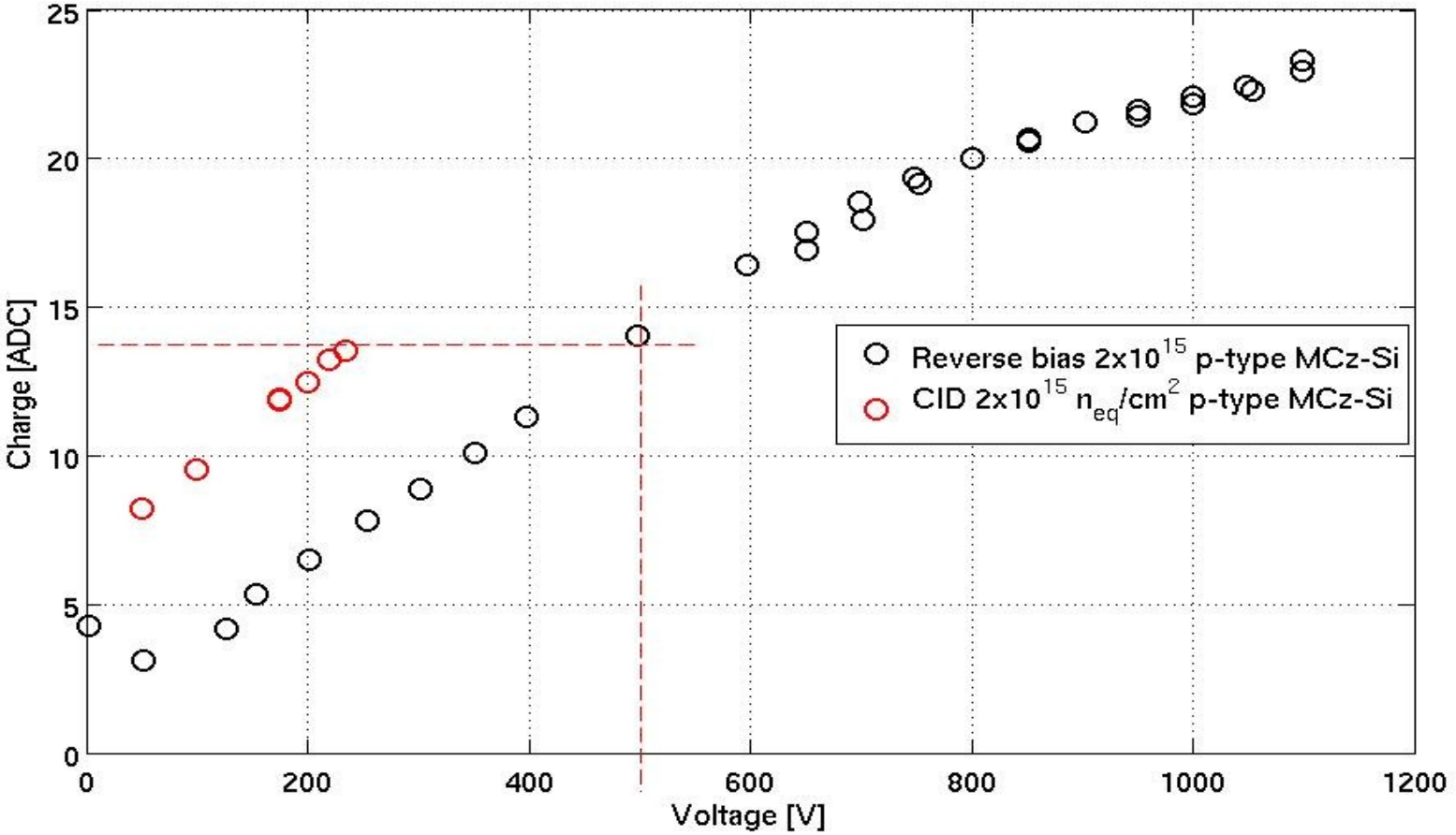


13.5 ADC @ 230V

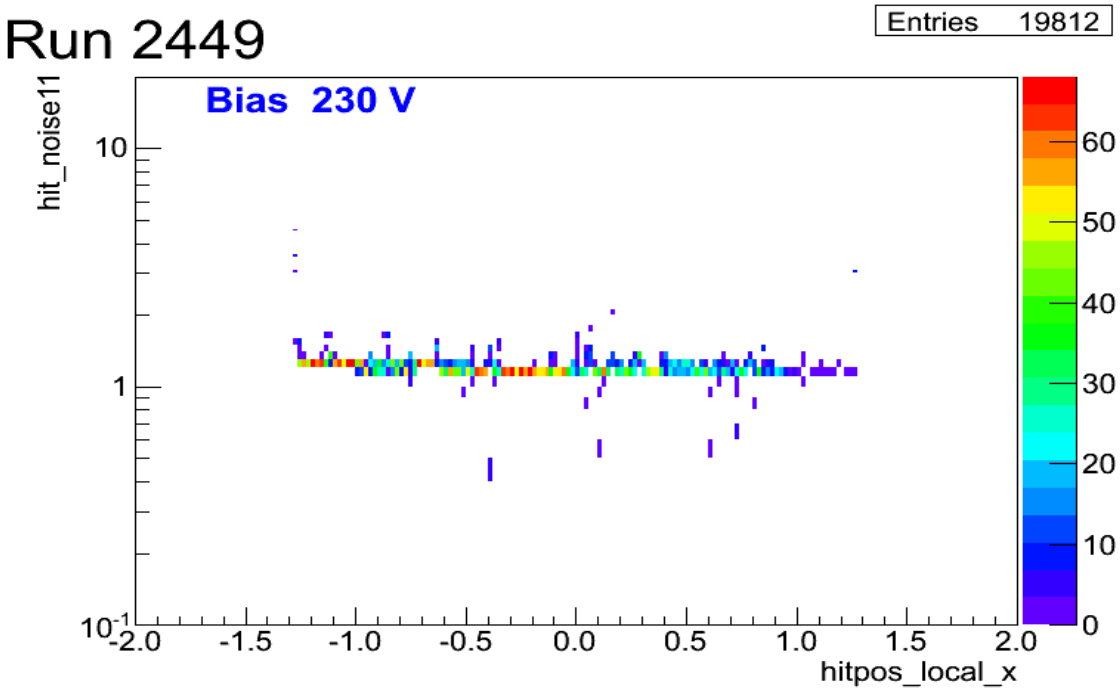
2×10^{15} n_{eq}/cm^2 results -Noise

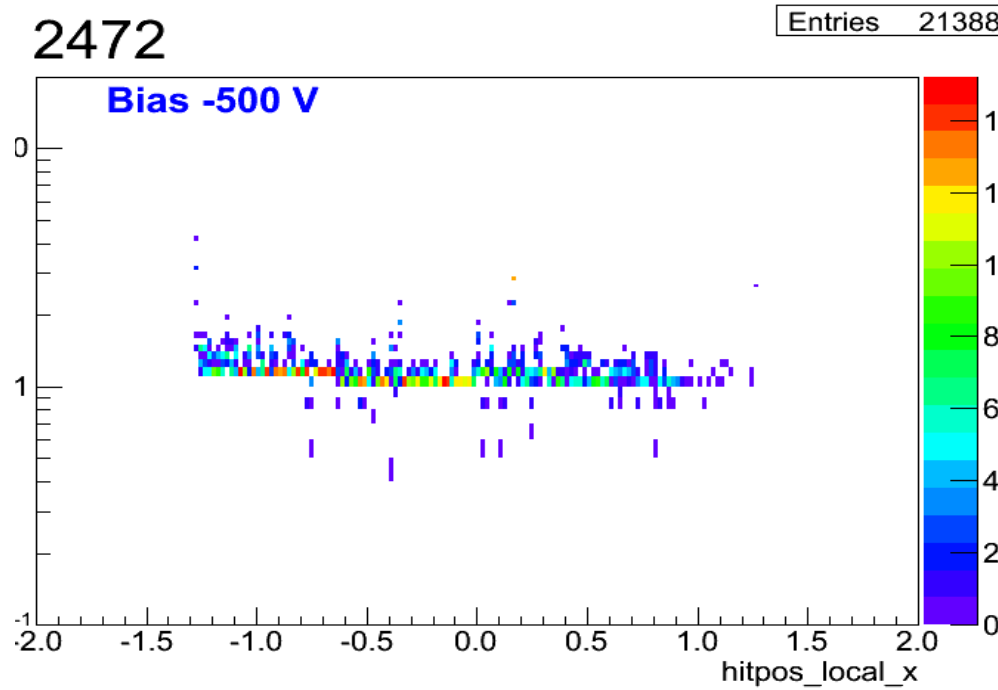


Comparison of CID vs reverse bias -Collected charge



Comparison of CID vs reverse bias -Noise

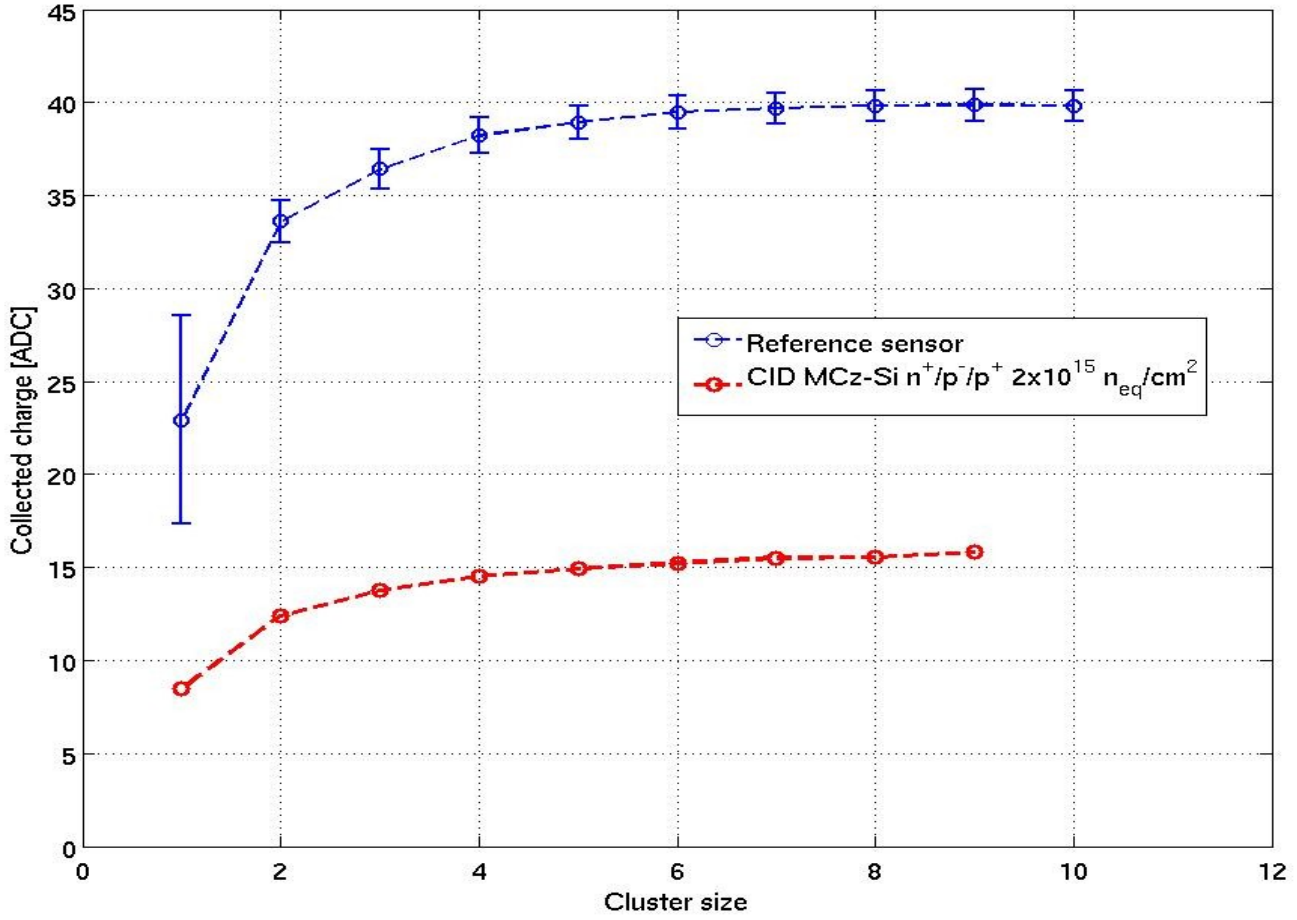




Average 1.3 ADC > S/N ≈ 10

Average 1.1 ADC > S/N ≈ 12

Cluster size



HPK reference sensor
average of 8 planes
bias 150V

CID bias 230V
2×10^{15} n_{eq}/cm^2

Summary

- CID detectors are operational at -50^{0}C. That's feasible with CO_2 cooling
- 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^{0}C.
- One needs 2× reverse bias in n on p sensor to gain same CCE.
- Average noise (1.6ADC) of a 5×10^{15} n_{eq}/cm^2 irradiated CID is about 960e^- at -50^{0}C/600V. Injected forward current is about 20µA for 4cm × 4cm sensor at this operating point.