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26th RD50 Workshop (Santander)

Tests of 50µm thick silicon micro-strip sensors after extreme fluences up to $3x10^{16}$ n_{eq}/cm^2

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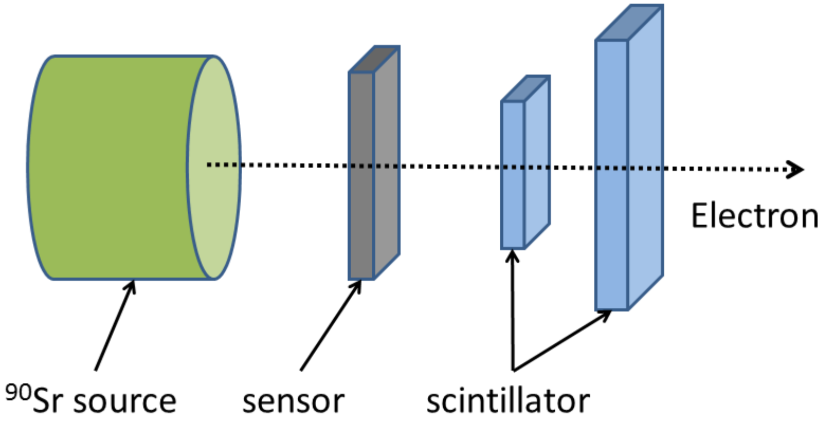
Sensors

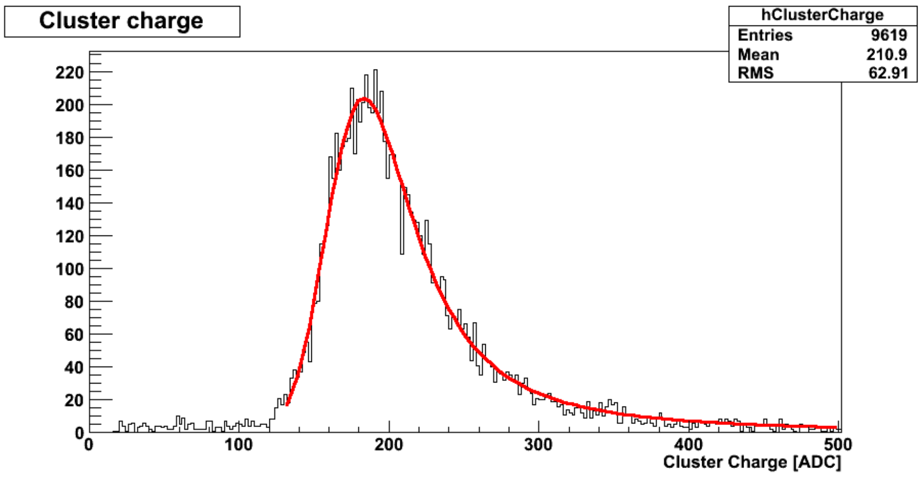
- Sensors used for the shown measurements were produced by Micron Semiconductor Ltd. with standard RD50 design
  - 131 strips: 80µm pitch, 10.470mm long
- Sensor 2922-1: irradiated with protons at CERN to 3.2×10^{16}p/cm^2 (1.66×10^{16}n$_{eq}$/cm^2) fluence
- 3107: irradiated with neutrons at Ljubljana
  - Fluences: 1×10^{15}, 2×10^{15}, 5×10^{15}, 1×10^{16} and 2×10^{16} n$_{eq}$/cm^2

Collected Charge

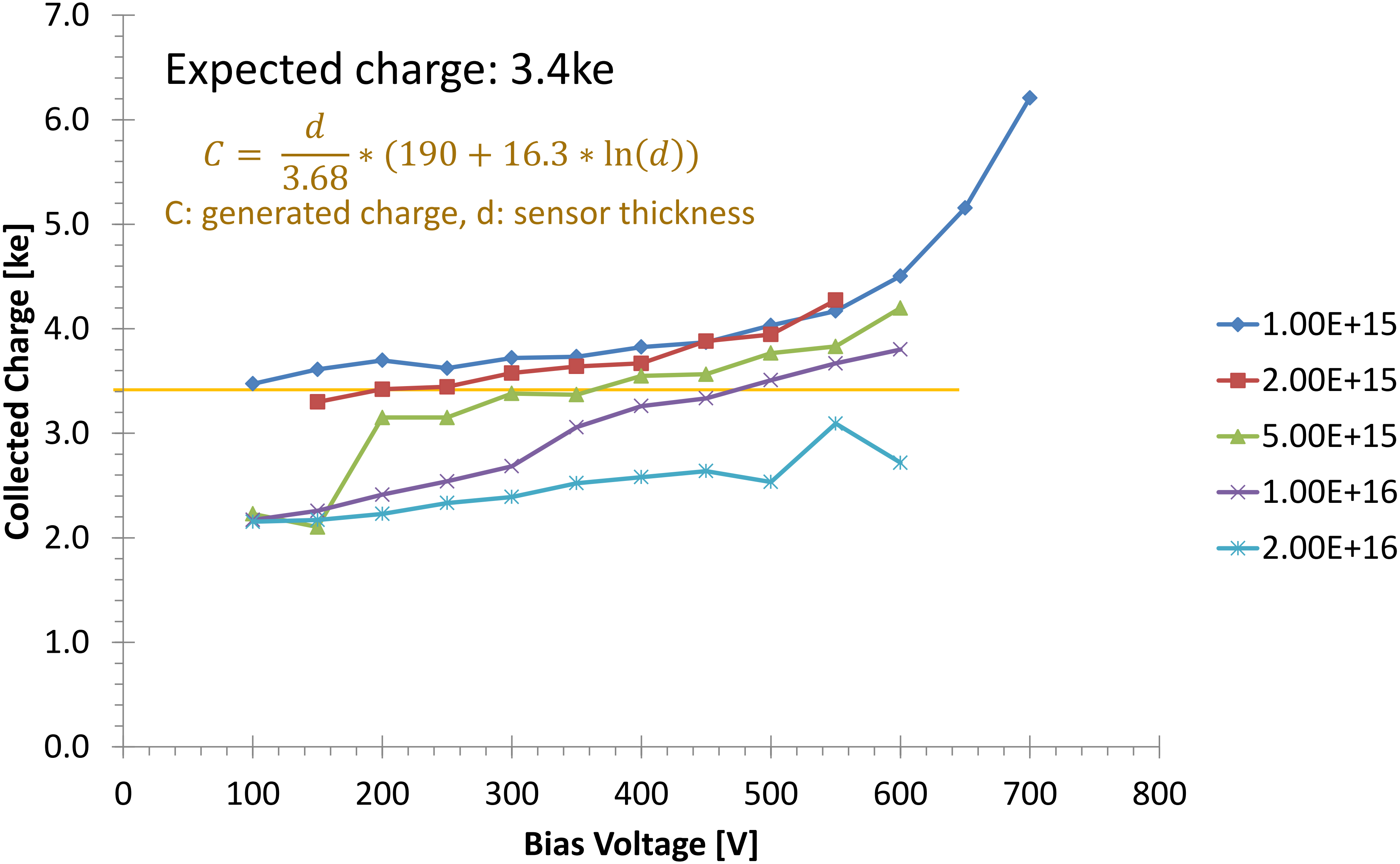
Beta Source Measurements

- MIP's from ^{90}Sr source to perform charge collection measurements
- Scintillators for triggering
- Resulting spectrum is fitted with a convolution of a Gaussian and Landau distribution to determine MPV
- With calibration value of daughterboard the collected charge is calculated from the MPV
- Irradiated sensors measured at temperatures between -20°C and -30°C in a freezer





Collected Charge



- One issue in analysis: for some data it is not clearly possible to distinguish between signal and background/noise peak
  - This issue occurred only for thin sensors:
    - Thin sensor mean less material for charge generation
  - Analysis tool needs improvement

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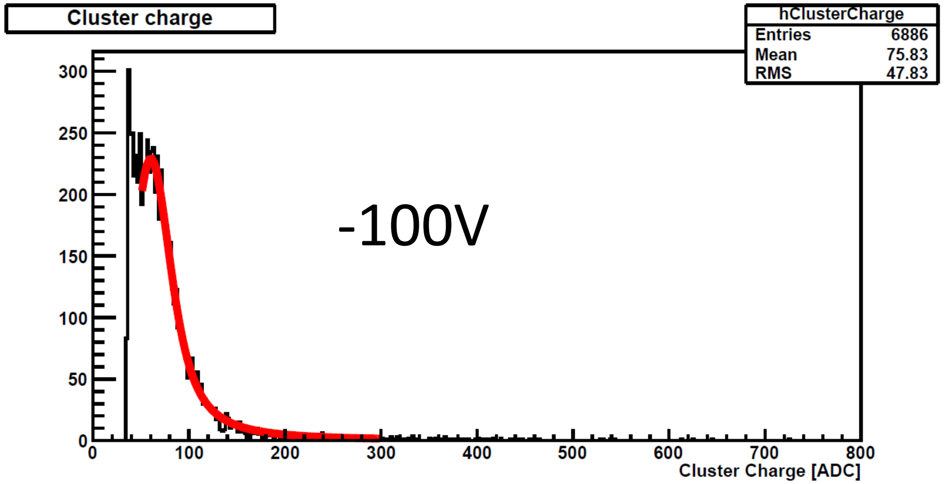
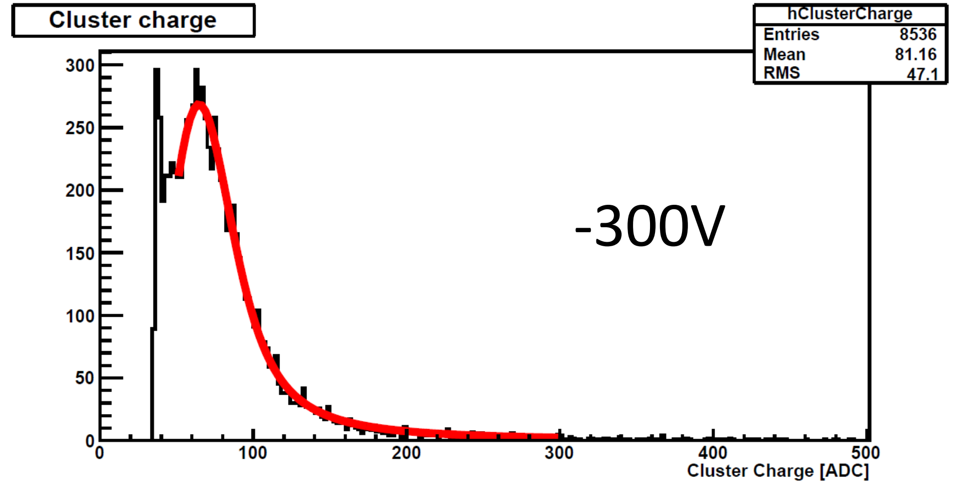
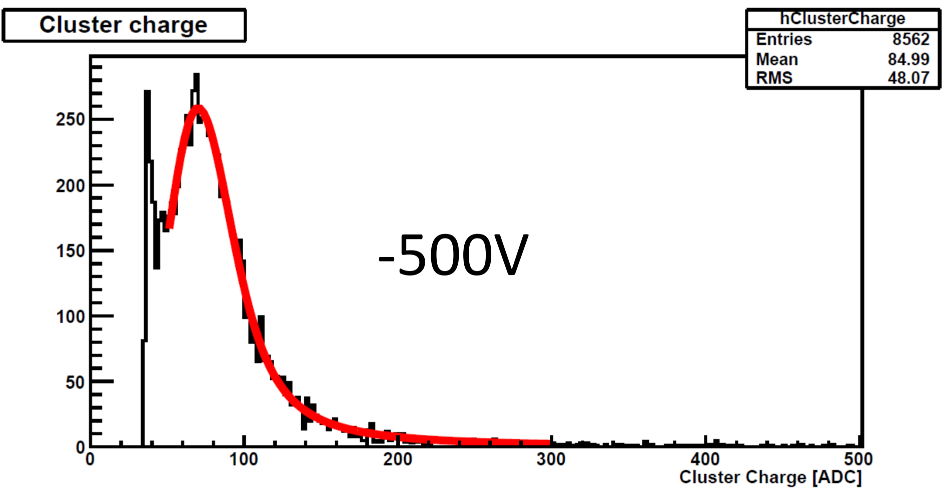
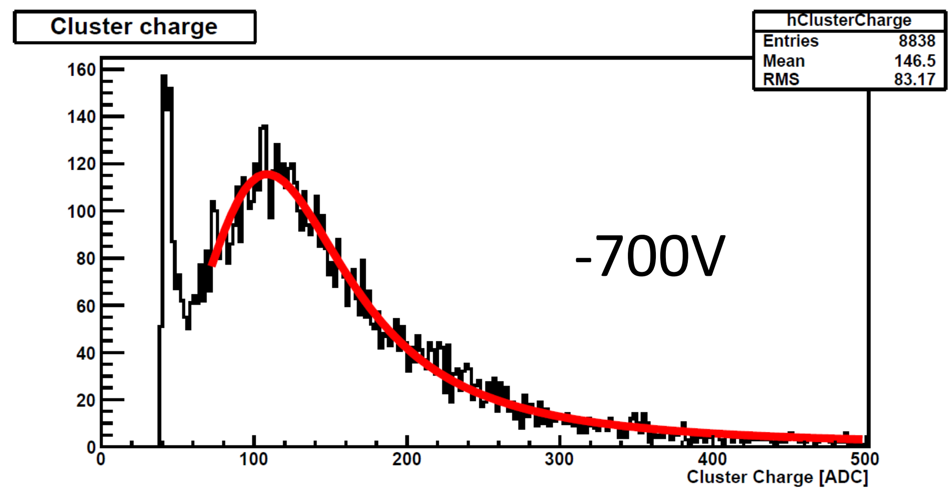
$1\times10^{15} n_{eq}/cm^2$; good fit



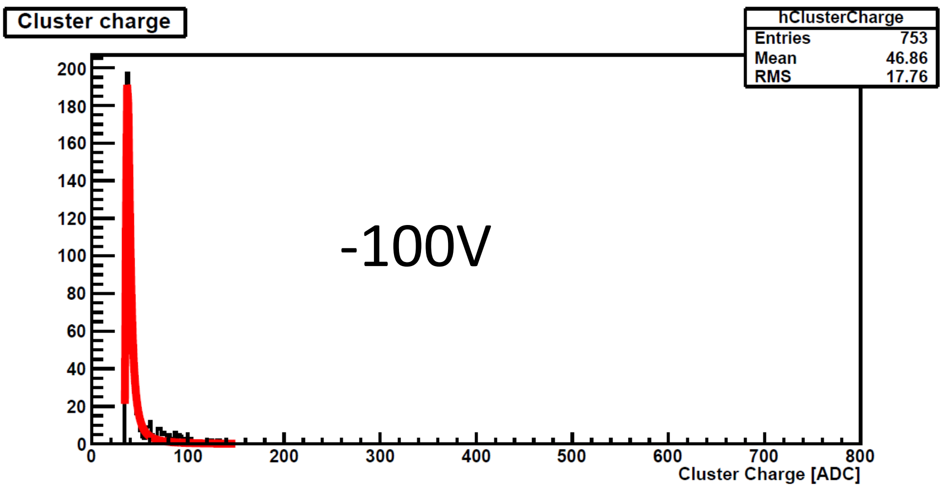


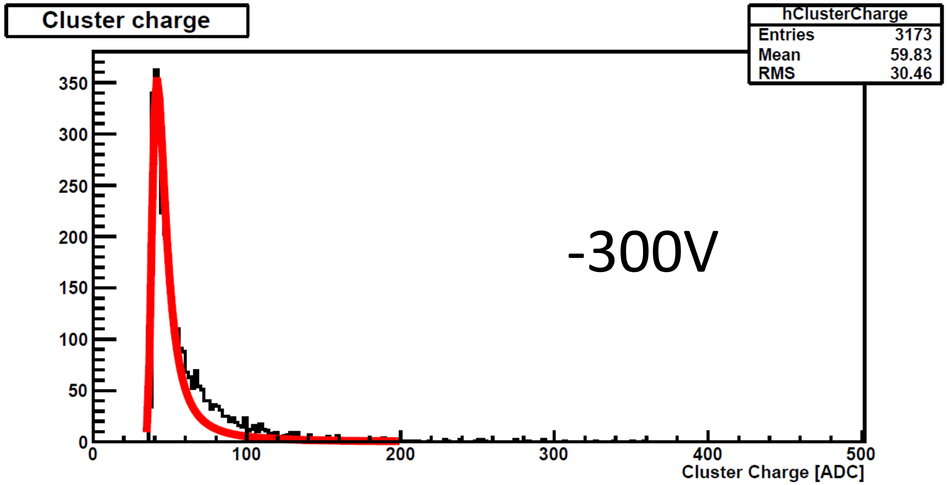
Signal peak clearly separable from noise peak for all voltages



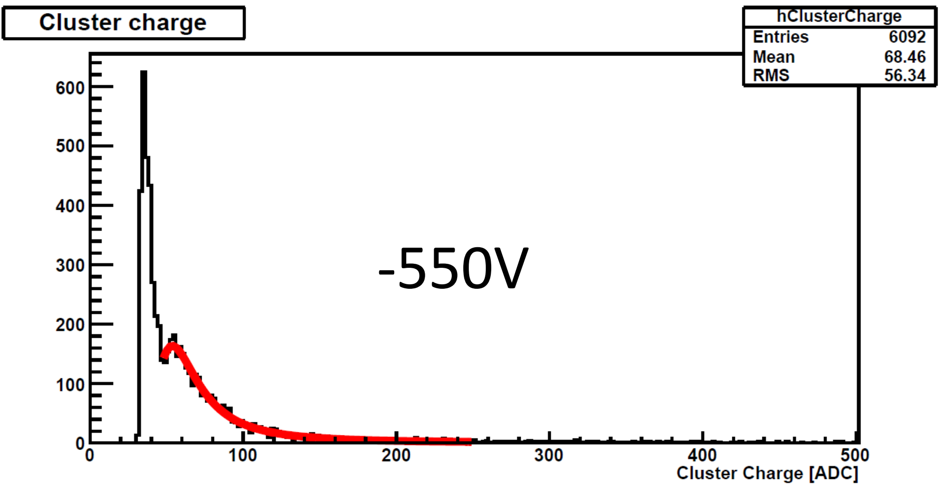


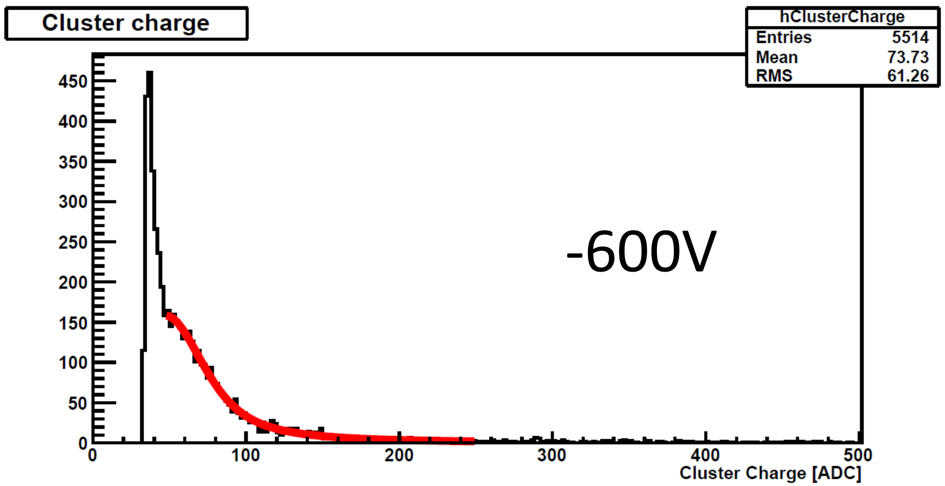
$2\times10^{16} n_{eq}/cm^2$; bad fit



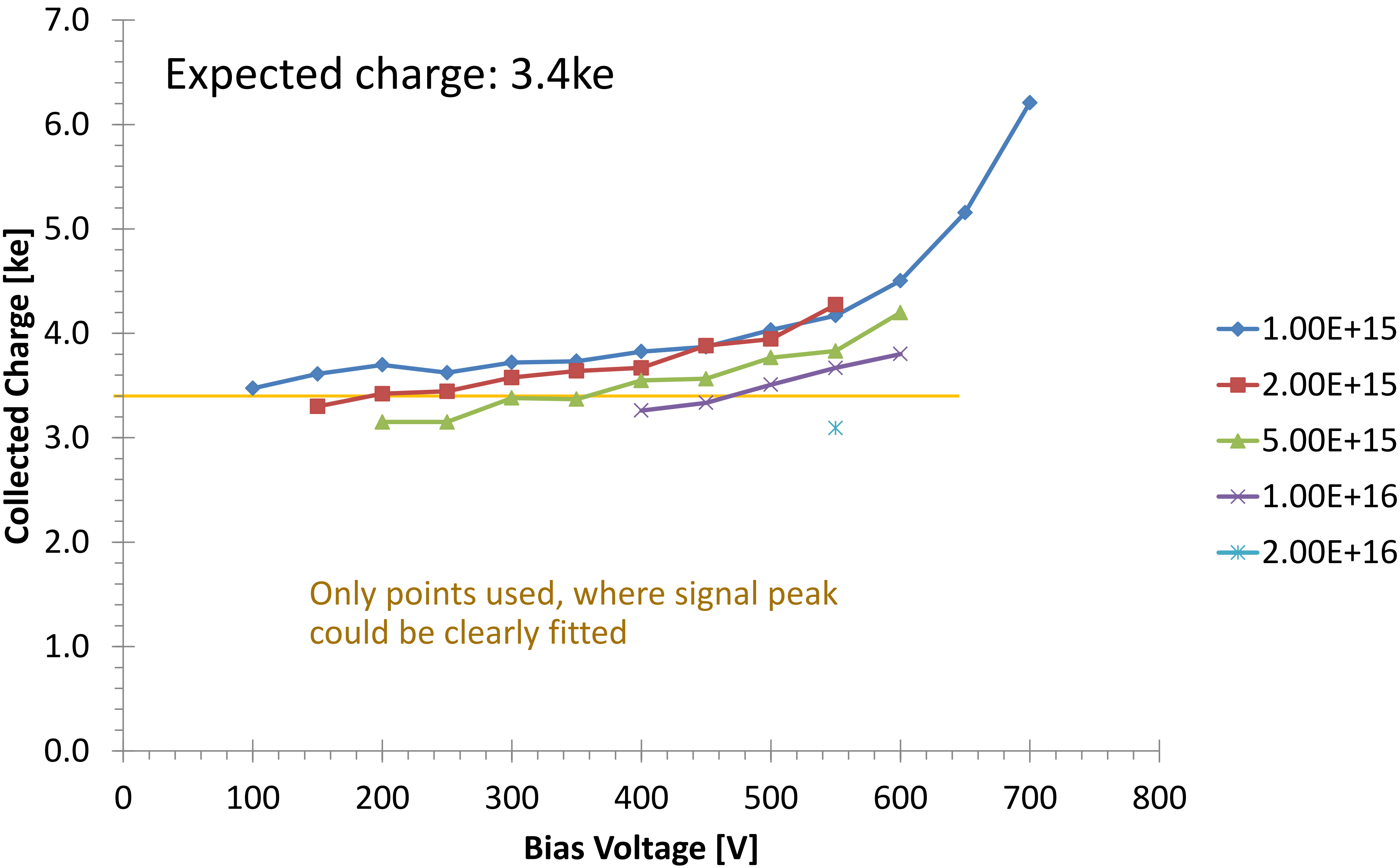


Signal not clearly separable from noise, even for high voltages
Need better analysis tool for this samples

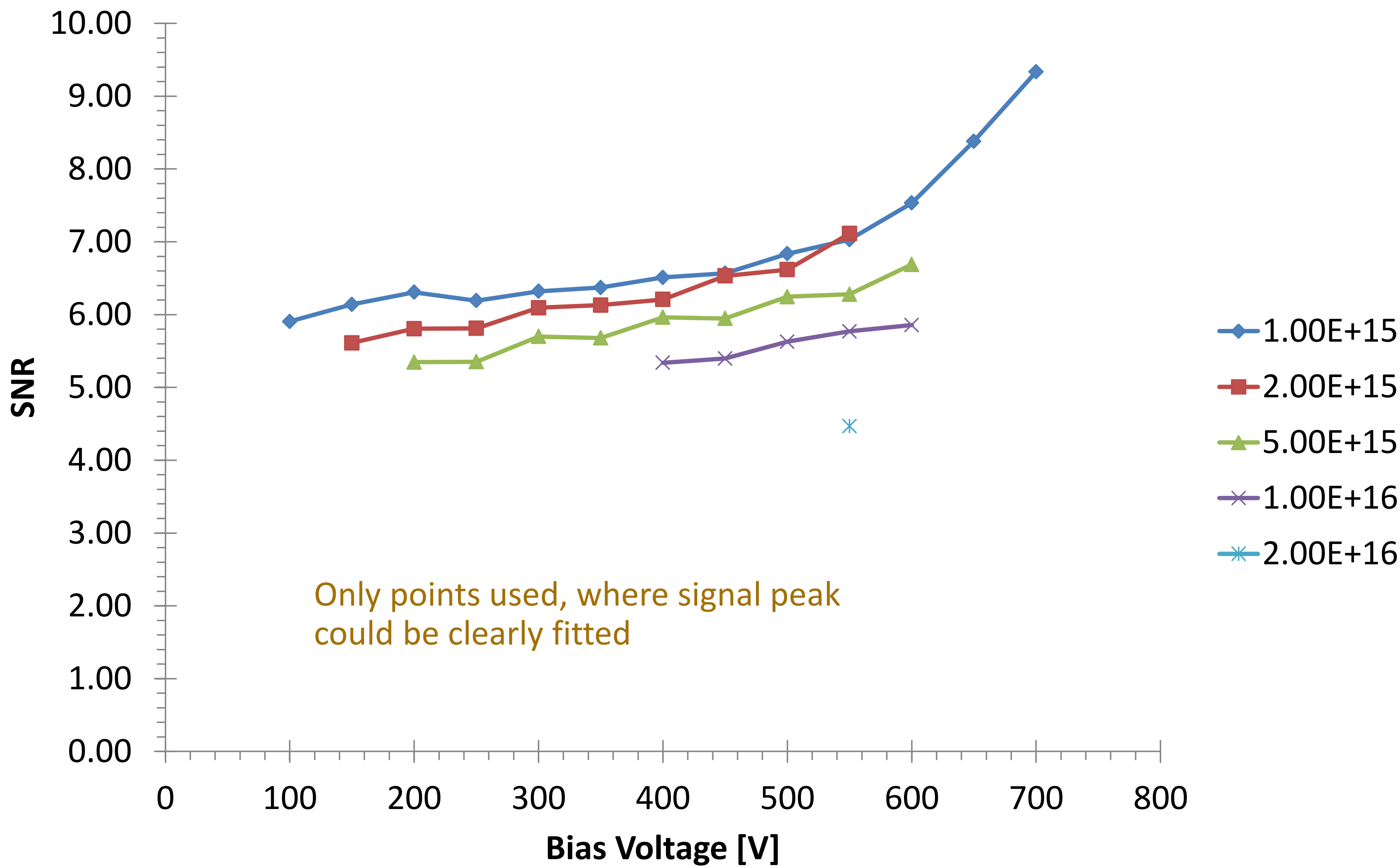




Collected Charge



Signal to Noise Ratio

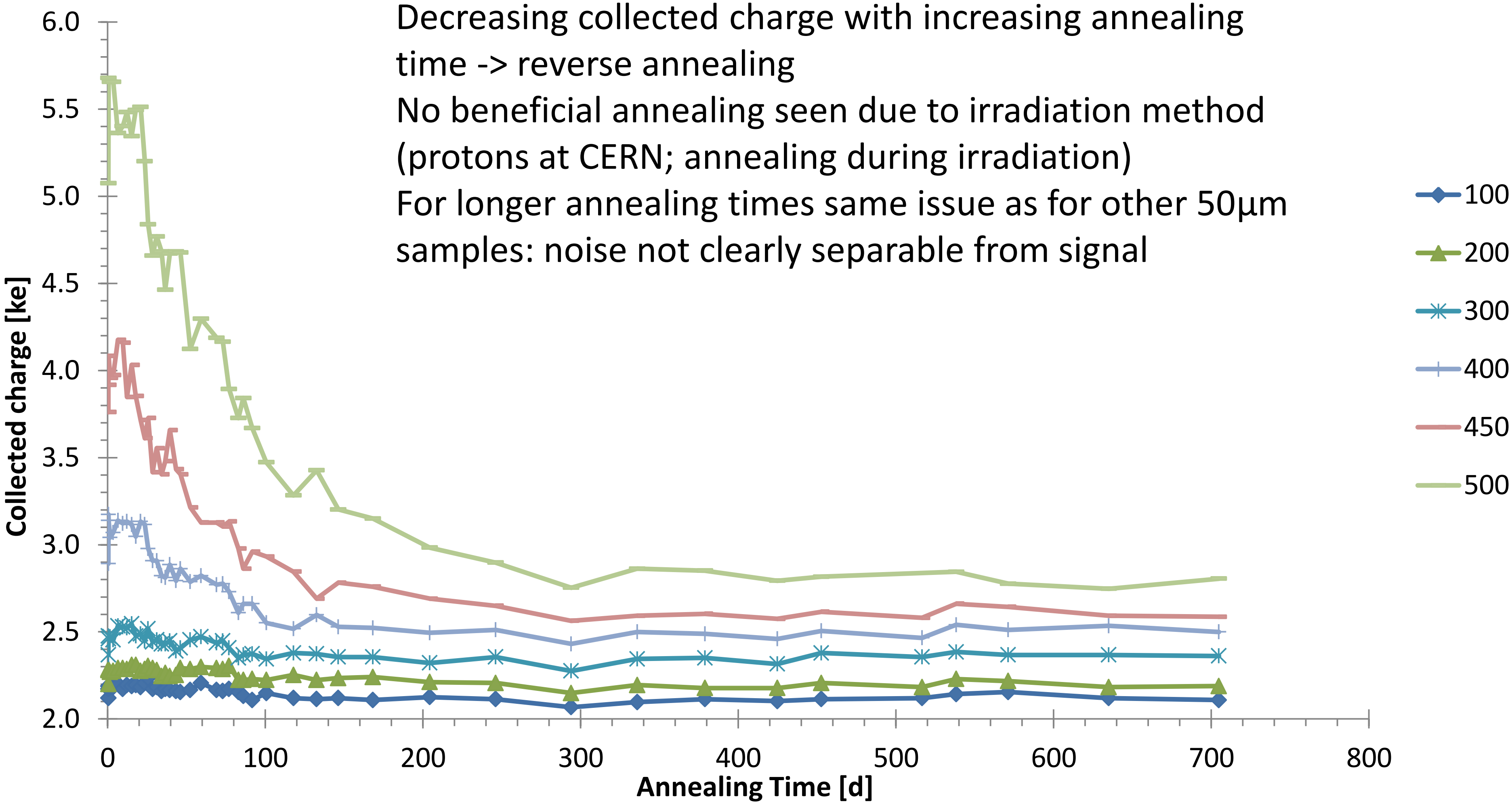


$1.66{\times}10^{16}n_{eq}/cm^2$; room temperature annealing

Decreasing collected charge with increasing annealing time -> reverse annealing

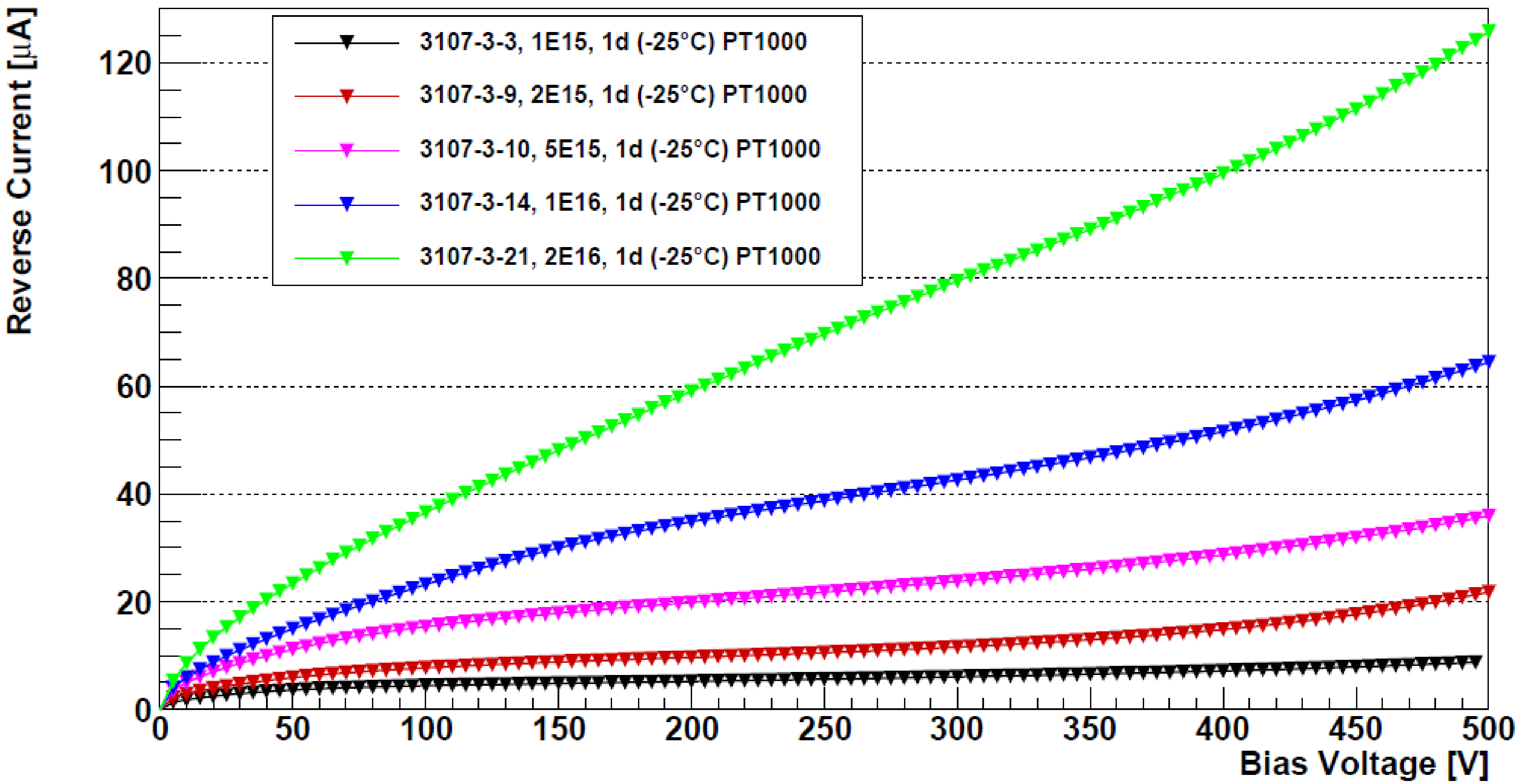
No beneficial annealing seen due to irradiation method (protons at CERN; annealing during irradiation)

For longer annealing times same issue as for other 50µm samples: noise not clearly separable from signal



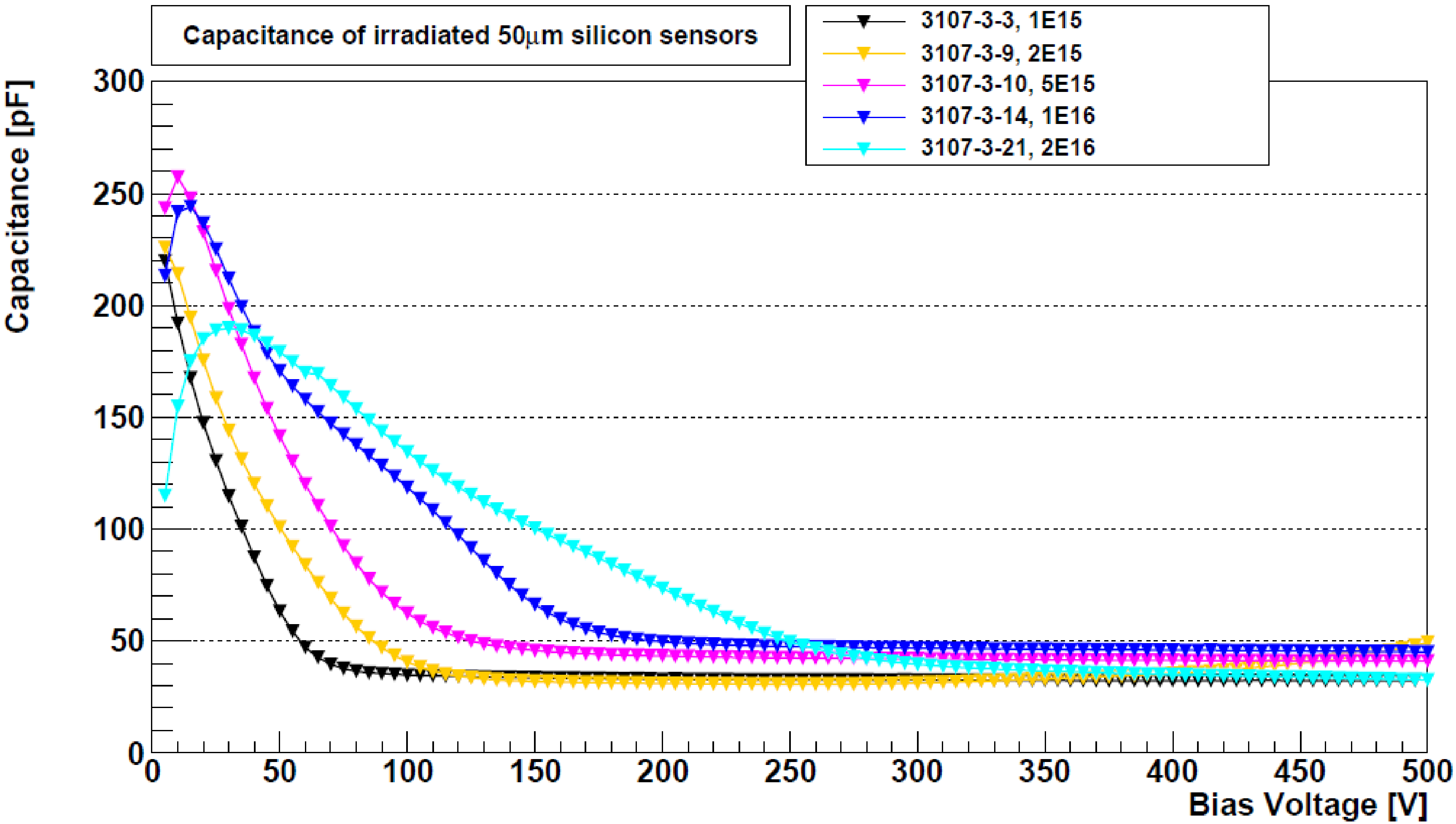
IV/CV results

IV measurement results



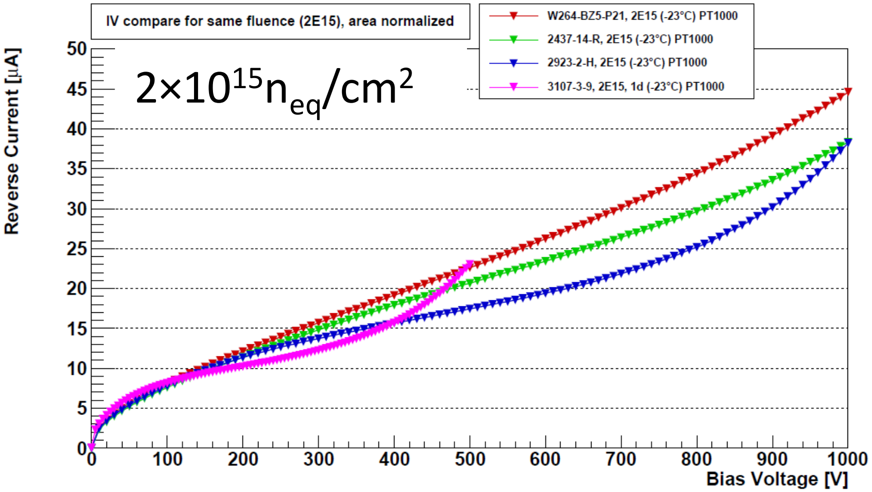
Expected hierarchy: higher fluence leads to higher current
Temperature measurement with PT1000 glued on silicon sensor; measurement in freezer at ≈-22°C; scaled to -25°C using E_{eff}=1.214eV

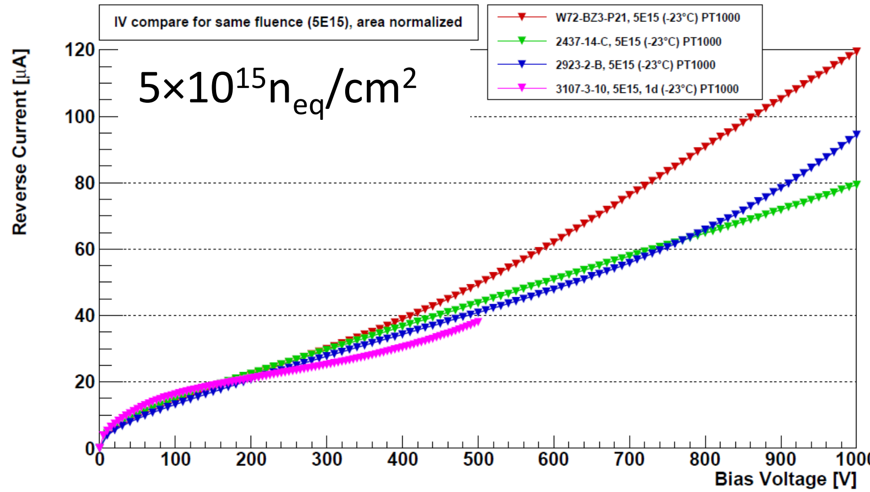
CV Results



CV measurements: 1kHz, 500mV amplitude

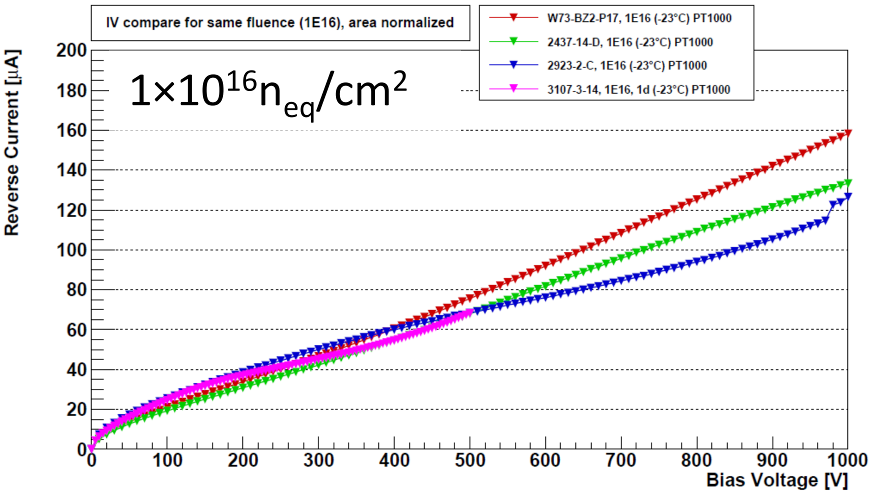
IV comparison

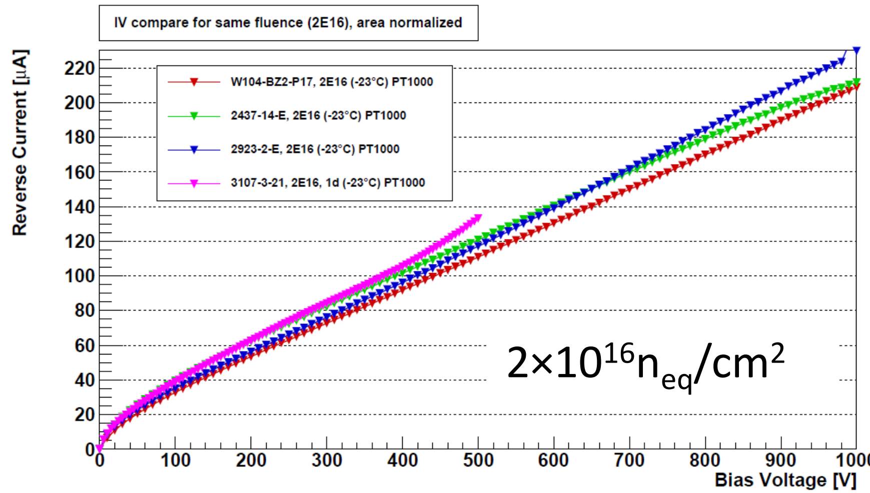




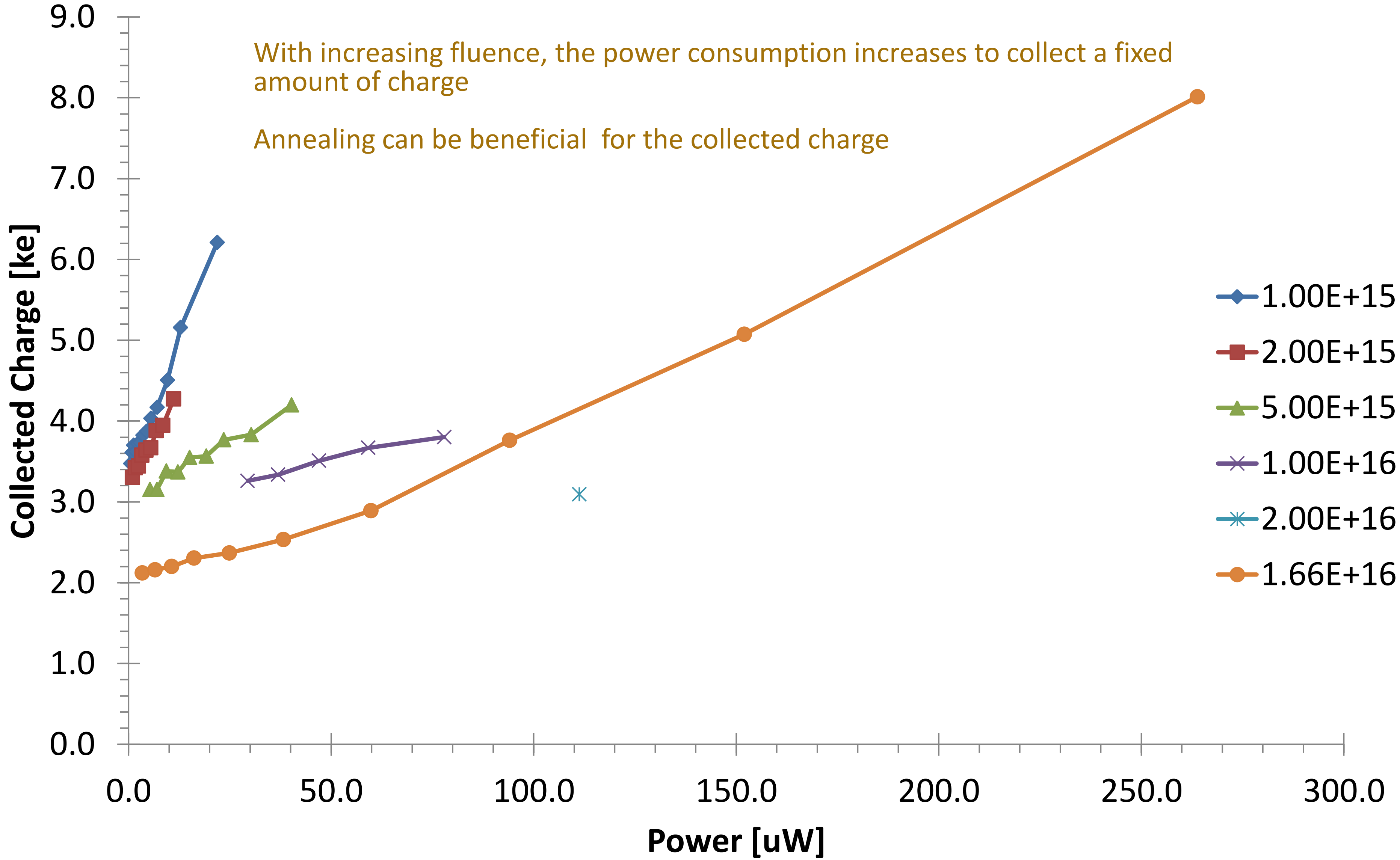
With increasing irradiation fluence the deviation of the reverse bias current for sensors with different thicknesses (50, 108, 149, 298 µm) decrease
In particular up to 500V the deviation is small

All currents scaled to -23C and normalized using the active area

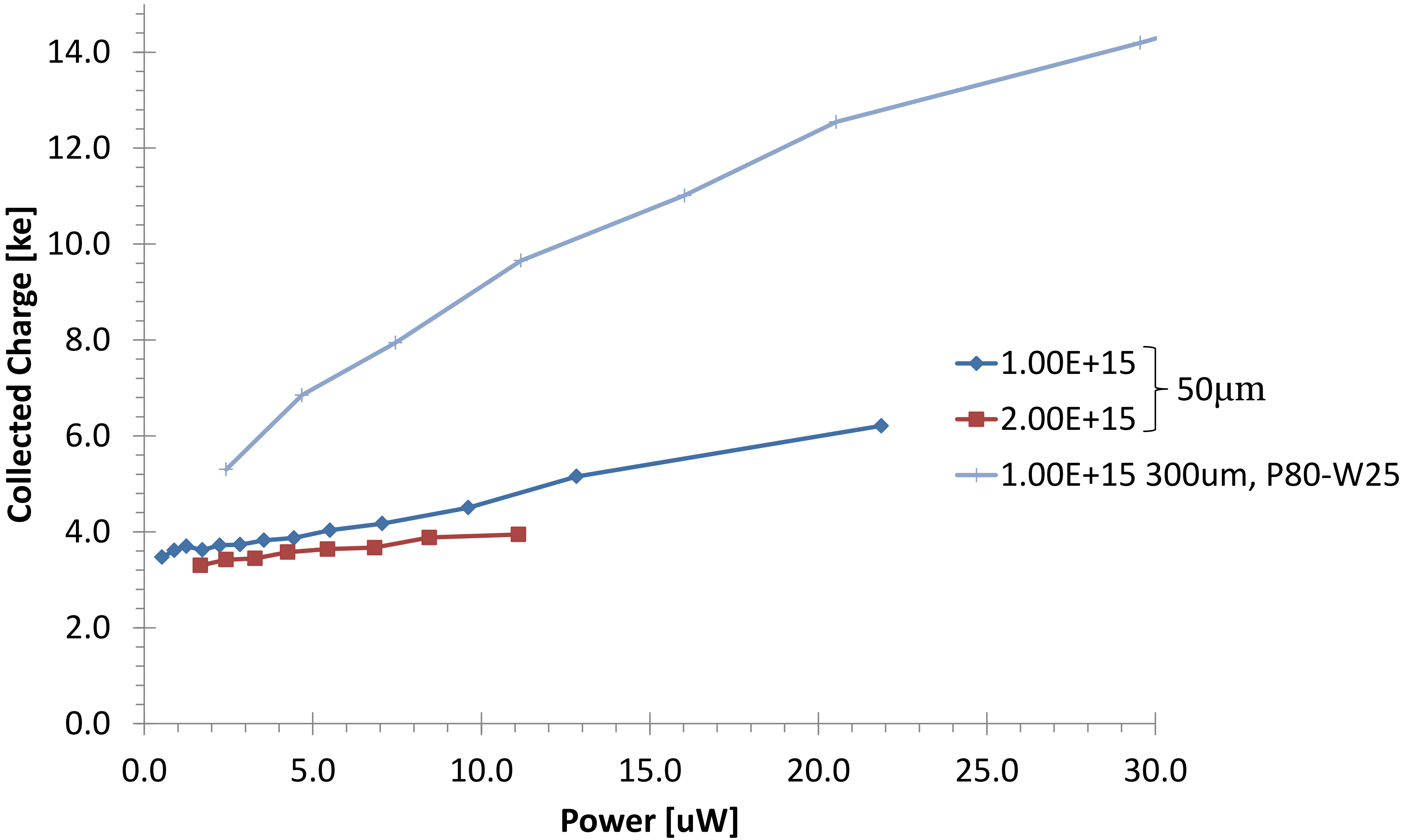




Charge vs. Power (50µm)



Comparison 50μm and 300μm



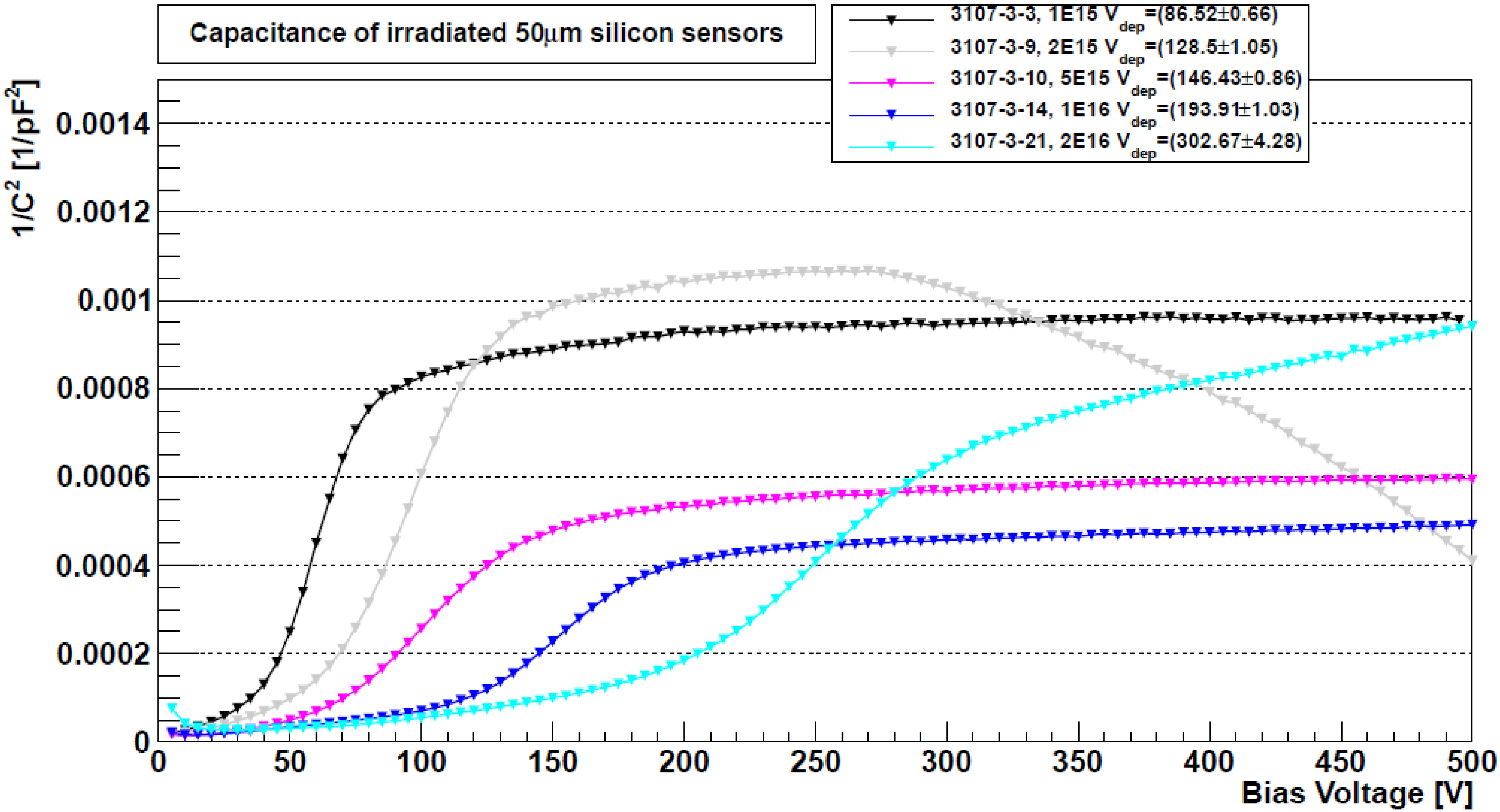
Summary

- With increasing irradiation fluence the collected charge decrease
  - An issue occurred while fitting the ALiBaVa results: for high fluences the signal is not always separable from the noise peak
- Long-term room temperature annealing of a 50μm sensor, irradiated at CERN to 1.66×10^{16} n_{eq}/cm^2 shows only reverse annealing
  - Irradiation at room temperature for several days

- IV measurements of the 50μm sensors have shown the expected increase in current with increasing fluence
- Comparing the current of sensors with different thicknesses but irradiated to the same fluence shows that the current becomes mostly independent of the sensor thickness for high fluences
- From the investigation of collected charge vs. power it was shown that for higher fluences more power is needed to collect a significant amount of charge
  - Comparing 50 und 300 μm sensors at 1×10^{15} n_{eq}/cm^2 the thicker device collects more charge with the same amount of power

Backup

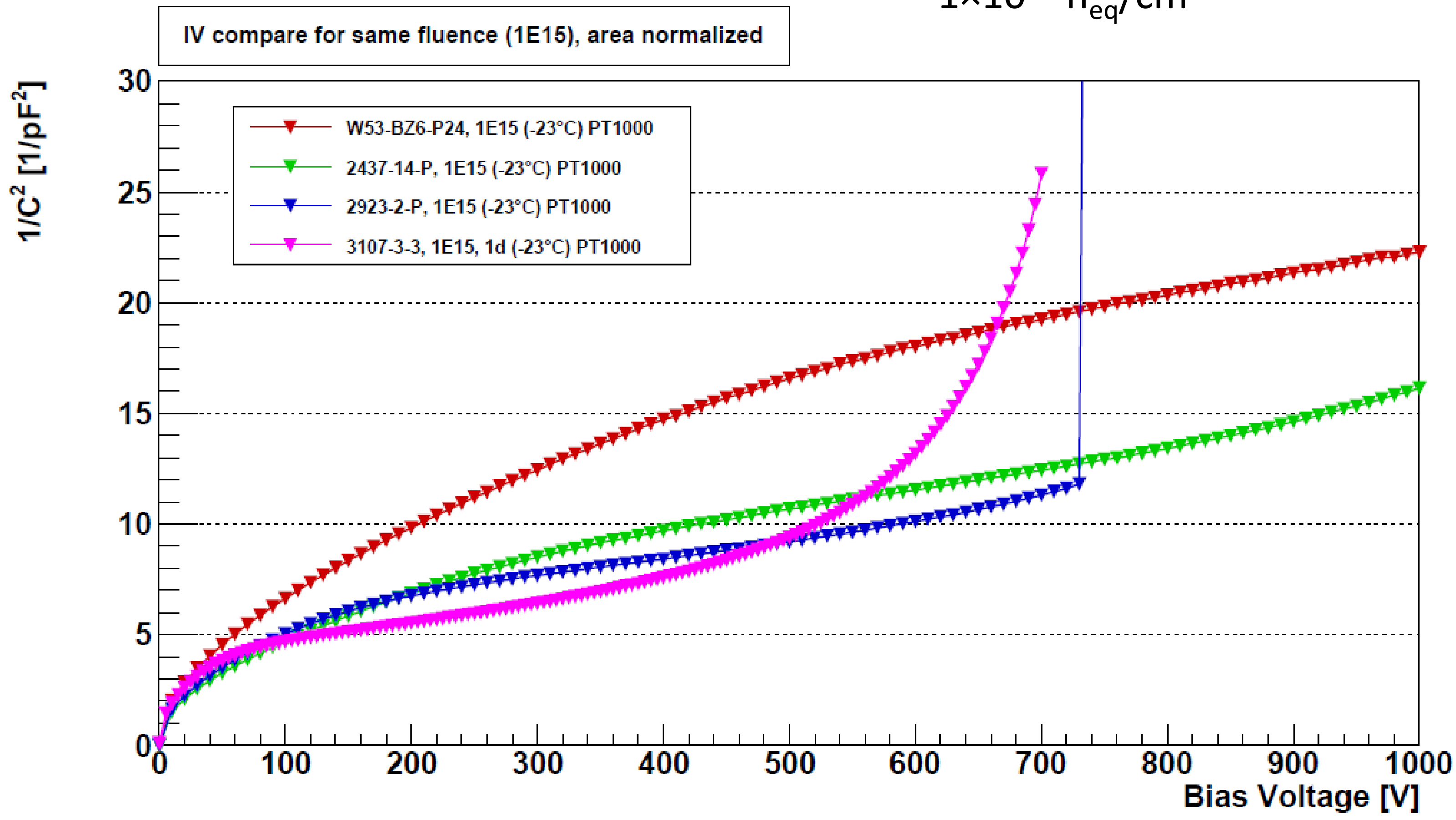
1/C²



Capacitance of irradiated 50µm silicon sensors
3107-3-3, 1E15 V_dep=(86.52±0.66)
3107-3-9, 2E15 V_dep=(128.5±1.05)
3107-3-10, 5E15 V_dep=(146.43±0.86)
3107-3-14, 1E16 V_dep=(193.91±1.03)
3107-3-21, 2E16 V_dep=(302.67±4.28)
1/C² [1/pF²]
0.0014
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
0
50
100
150
200
250
300
350
400
450
500
Bias Voltage [V]

Current comparison

1×10^{15} n_{eq}/cm^2



$1.66{\times}10^{16} n_{eq}/cm^2$; room temperature annealing