X ray study of the NDL Sensor

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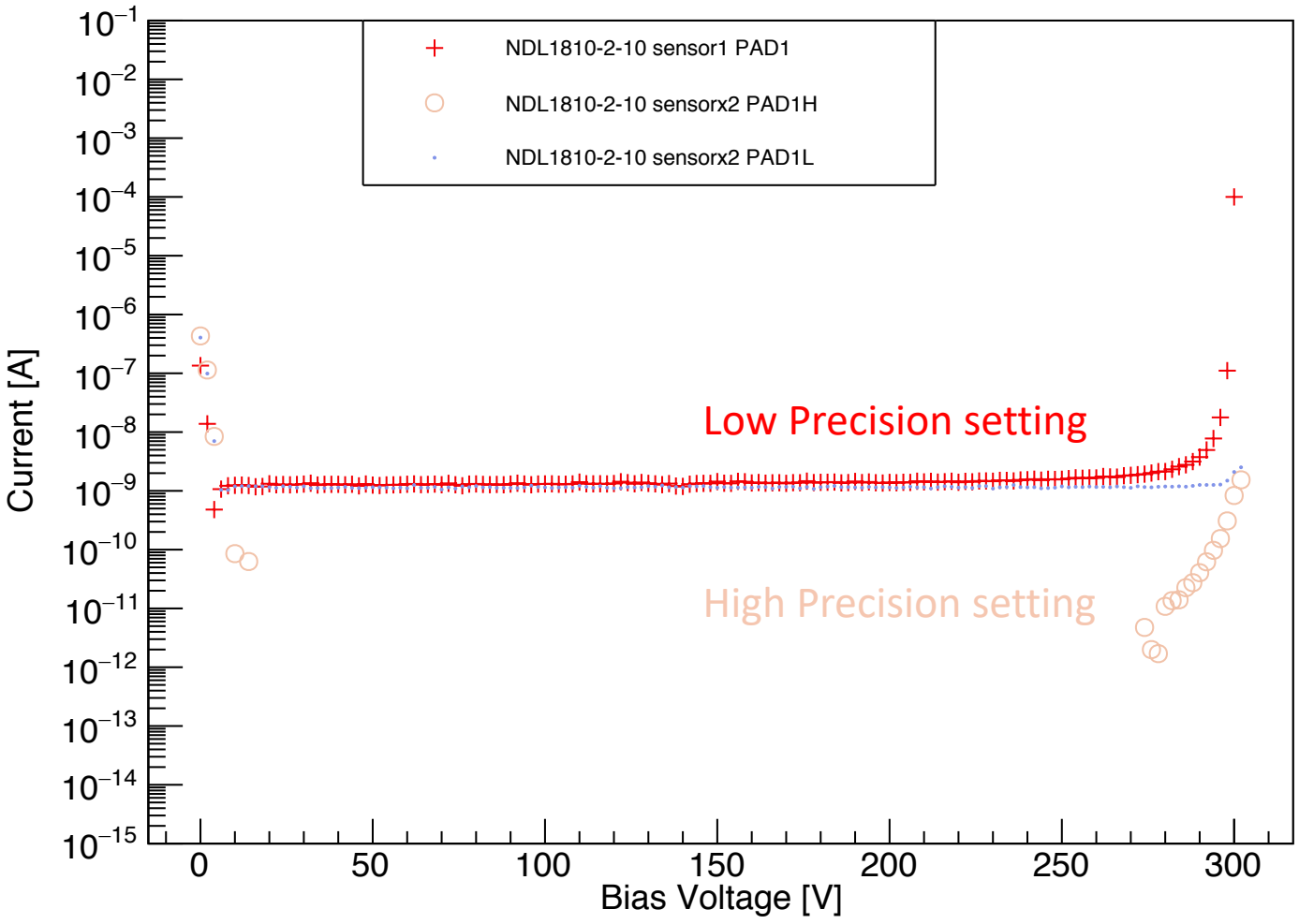
Outline

I. Precision of the Keithley 2410 -- NDL1810-2-10
II. 100kGy CV measurement
III. Plan

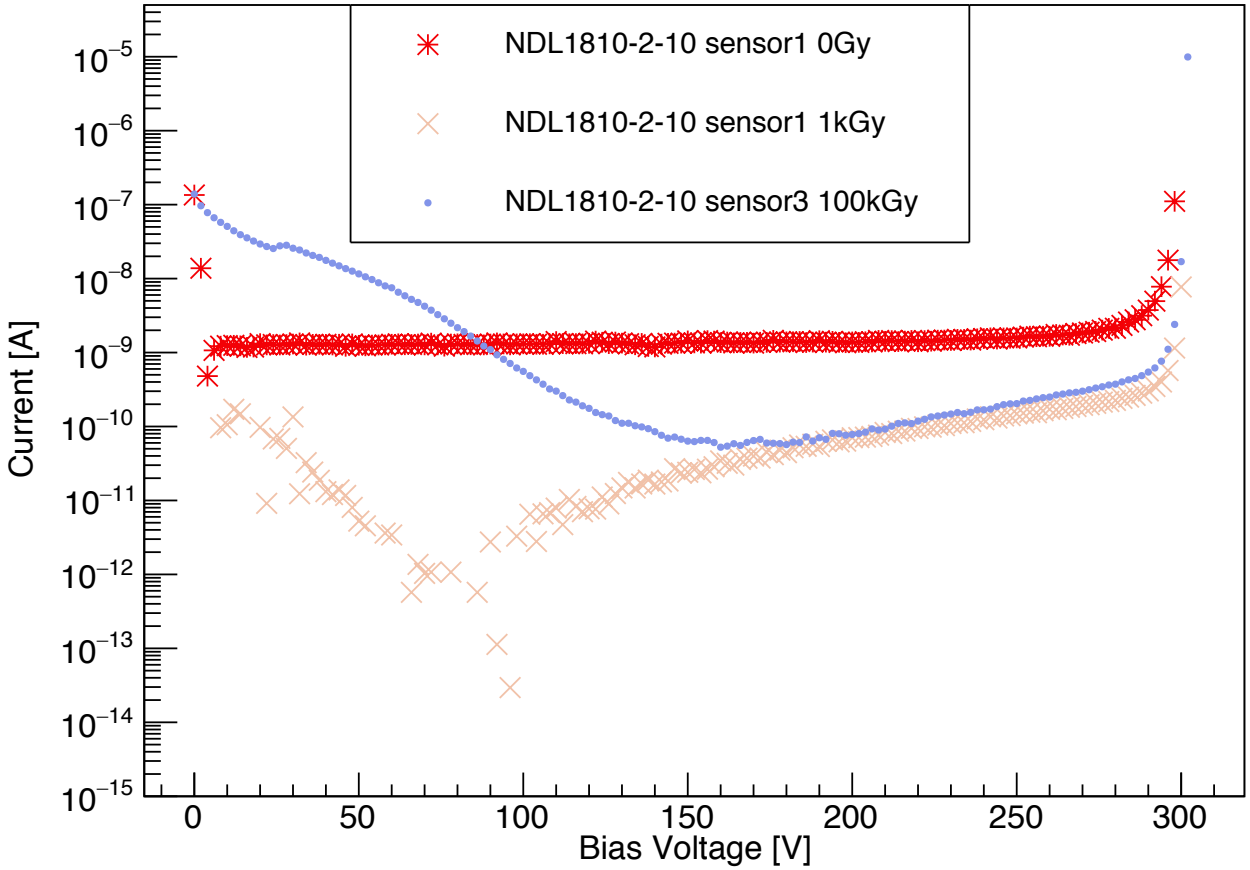
Precision of the Keithley 2410



- Low Precision setting：
  #self.kei2400c.write(":sense:current:range "+self.cmpl)
- High precision setting： auto range
  self.kei2400c.write(":sense:current:range:auto on")

Conclusion：
The leakage current changes with the precision setup of the Keithley 2410。

Leakage current of NDL1810-2-10



The leakage decreases. (need to check the precision of the Keithley 2410)

In fact
The leakage current increases with the TID dose.

- 100kGy CV measurement

Debugging the measurement system

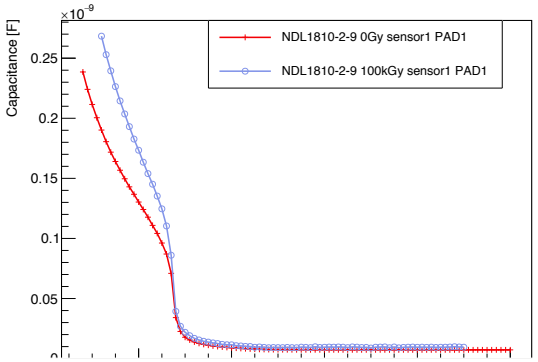
The IV/CV test system didn’t work.

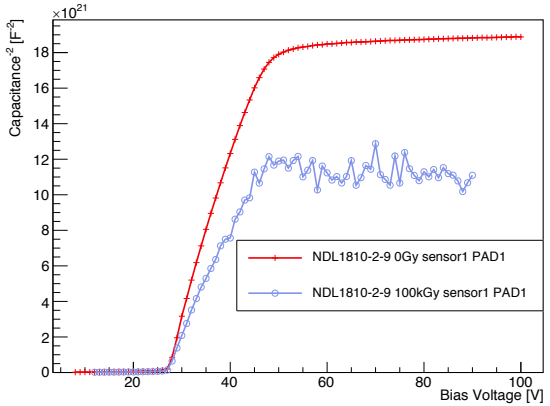
After debugging, the USB - RS232 cable failed.

Change the cable

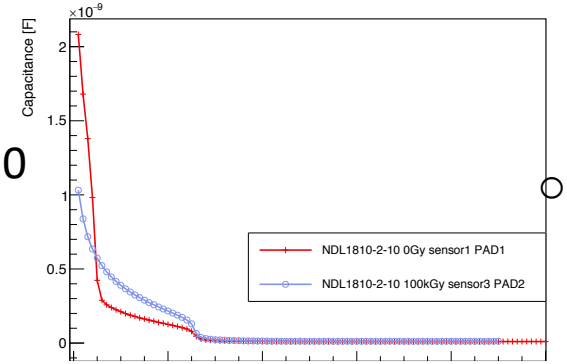
CV for 0 Gy and 100kGy

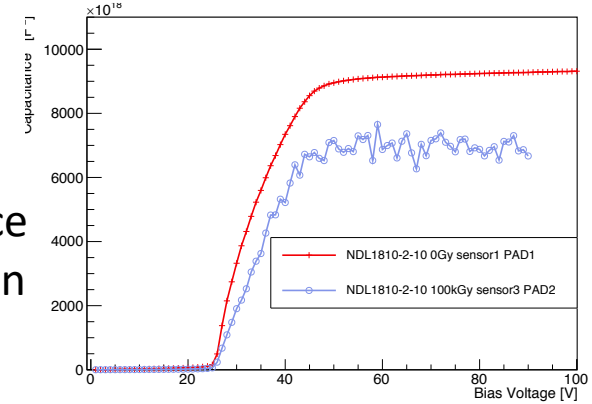
NDL1810-2-9



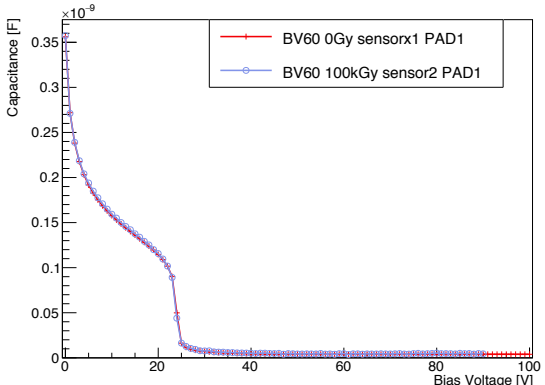


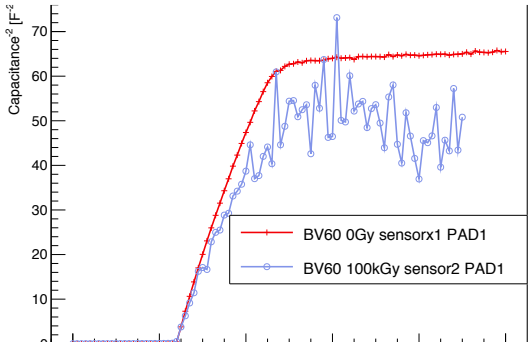
NDL1810-2-10





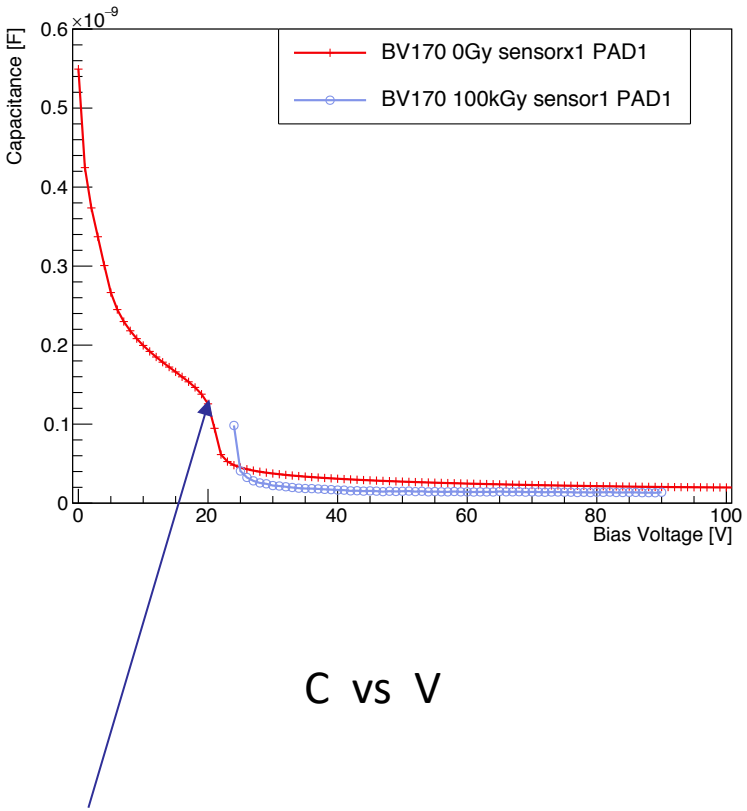
BV60



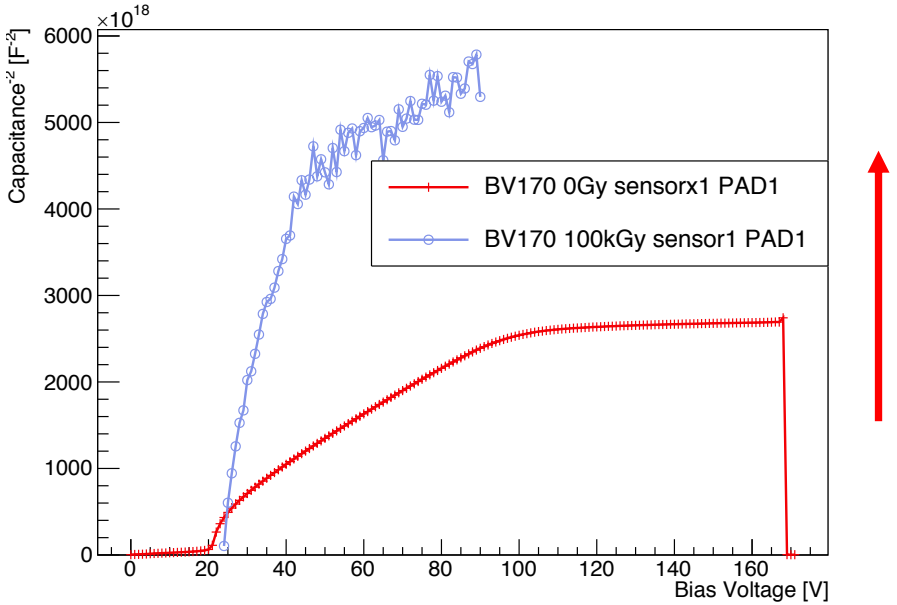


The capacitance increases in the same voltage.

BV170



?



C vs V

$1/C^2$ vs V

No data in the low bias voltage region. **Overload problem**– LCR machine

The BV170 is different from the other NDL sensors.

Plan

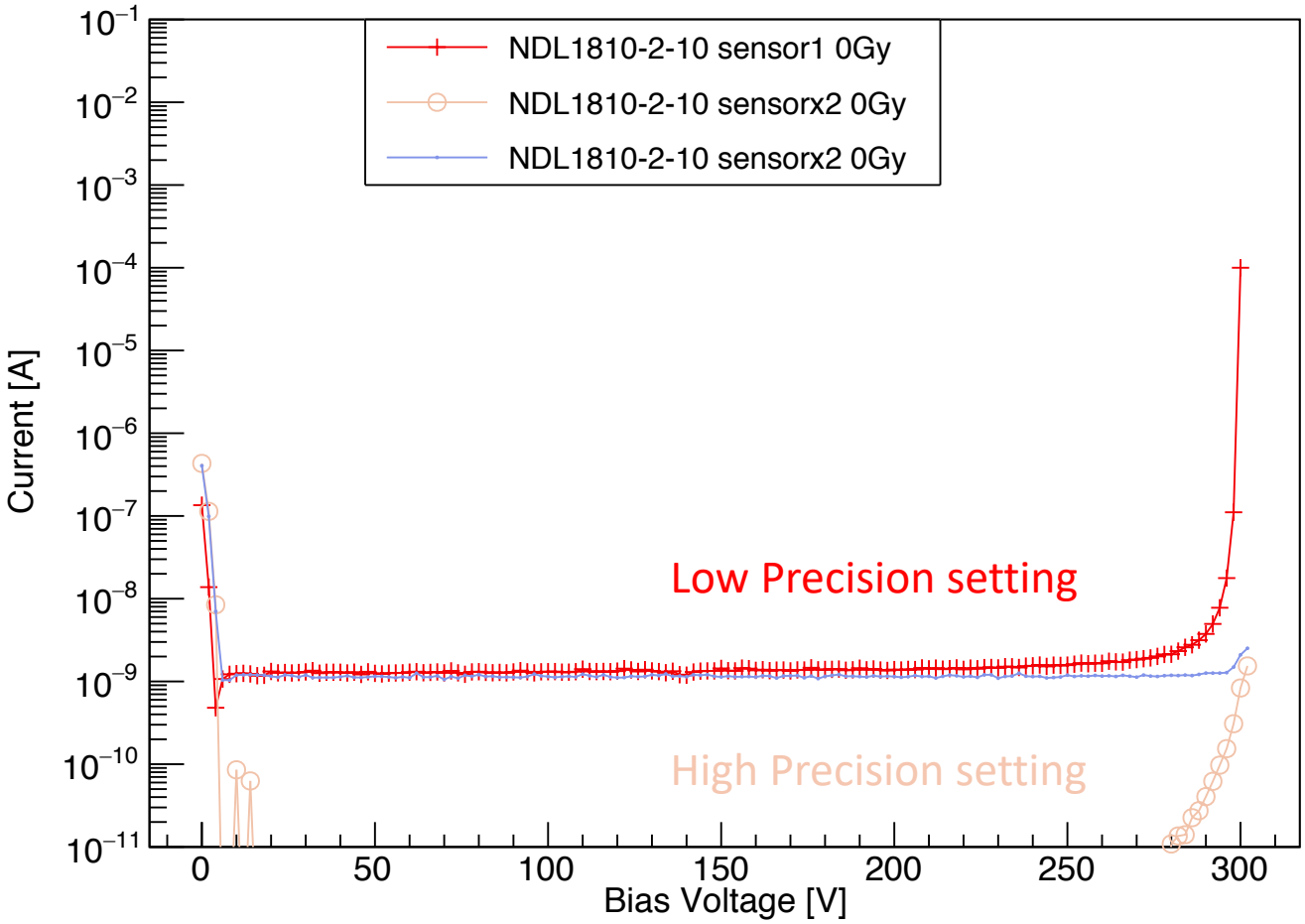
- Questions:
  - Why is the BV170 different ?
  - Why is the performance of the NDL sensors much worse than the HPK sensors?

- Problems:
  - CV – overload question
  - Calculation of the doping profile – some problems for the program/calculation methods

- Thank you !

- Back up

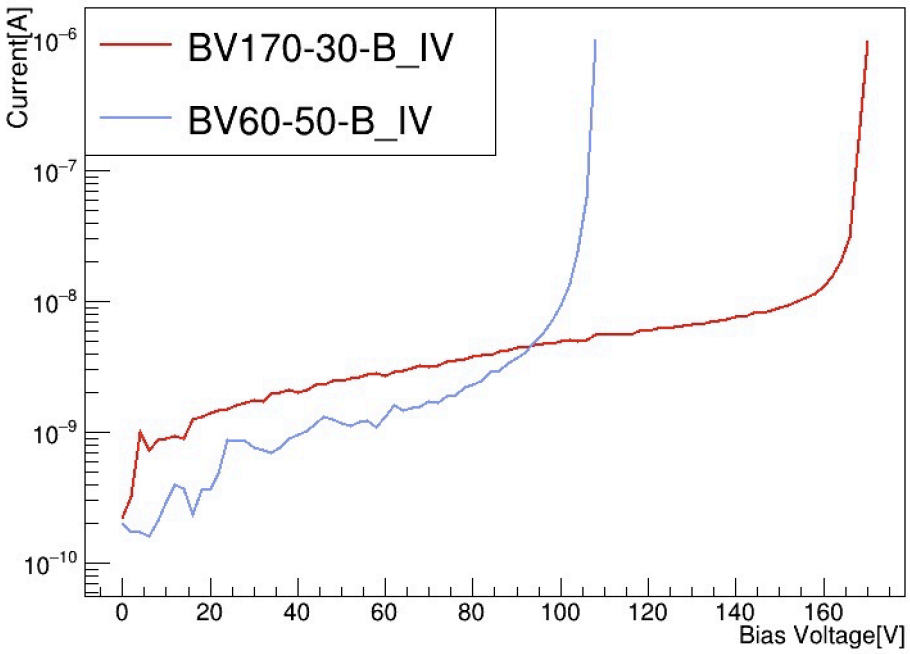
Precision of the Keithley 2410



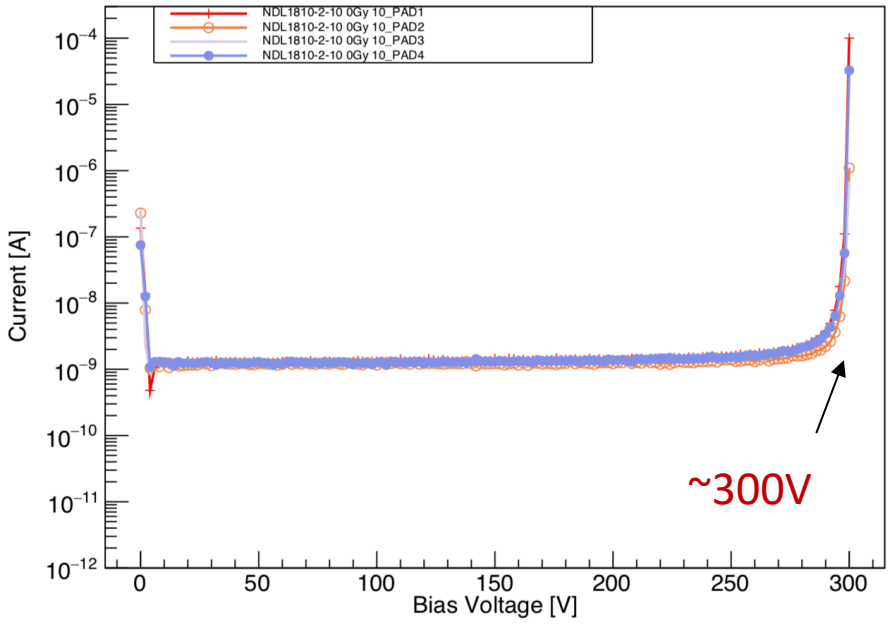
IHEP-NDL sensor : I-V measurement

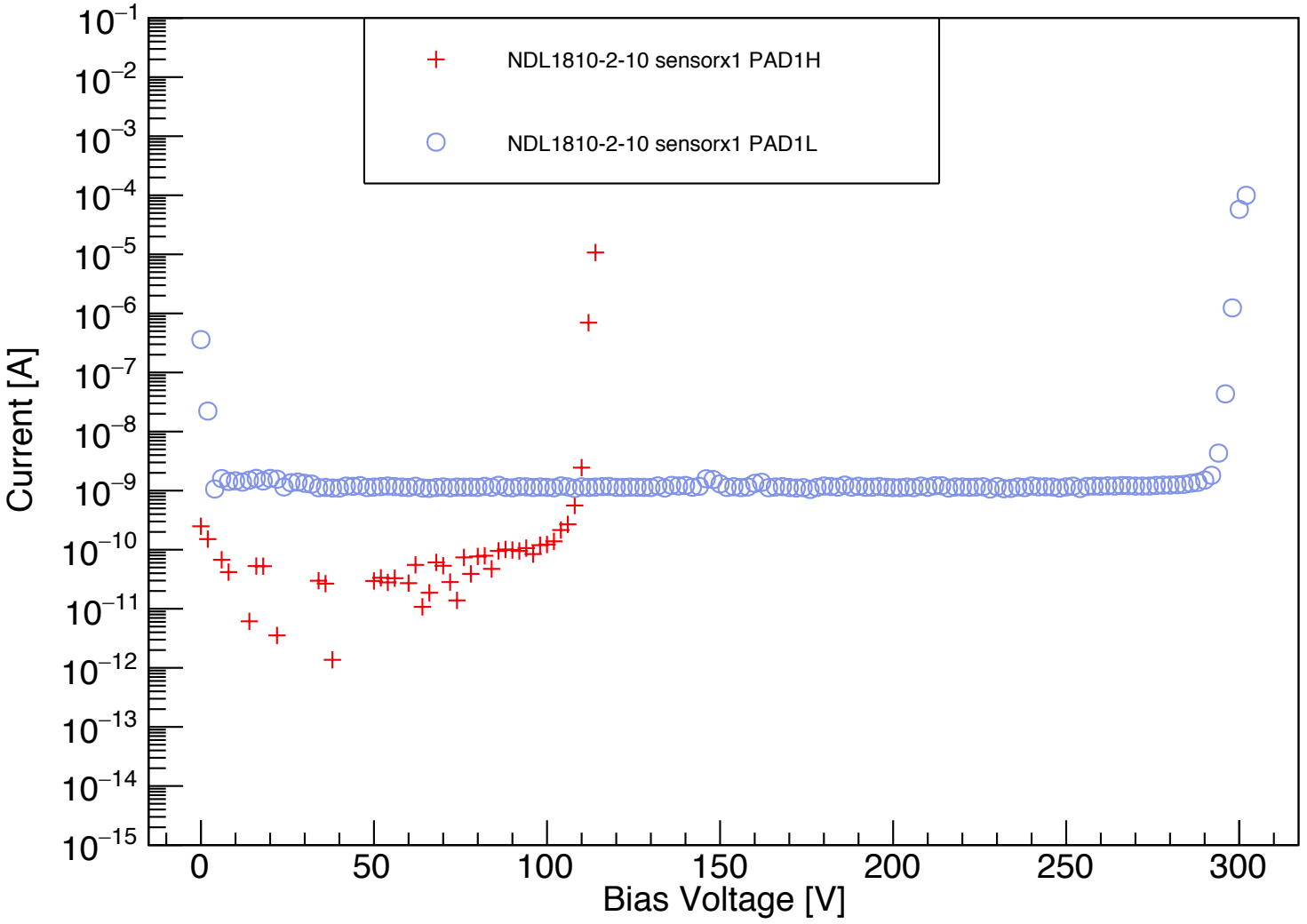
	VBD	V_Depleted	Layout	Wafer	Gain
Type 13# (BV170)	~165V	~100V	6GR	100Ω.cm	40
Type 12#(BV60)	~95V	~40V	6GR	300Ω.cm	40
Type 10#	~300V	~40V	2GR	300Ω.cm	40
Type 9#	~250V	~40V	2GR	300Ω.cm	80

6 Guard ring design :BV60,BV170



2 Guard ring （Type 10#， new!）

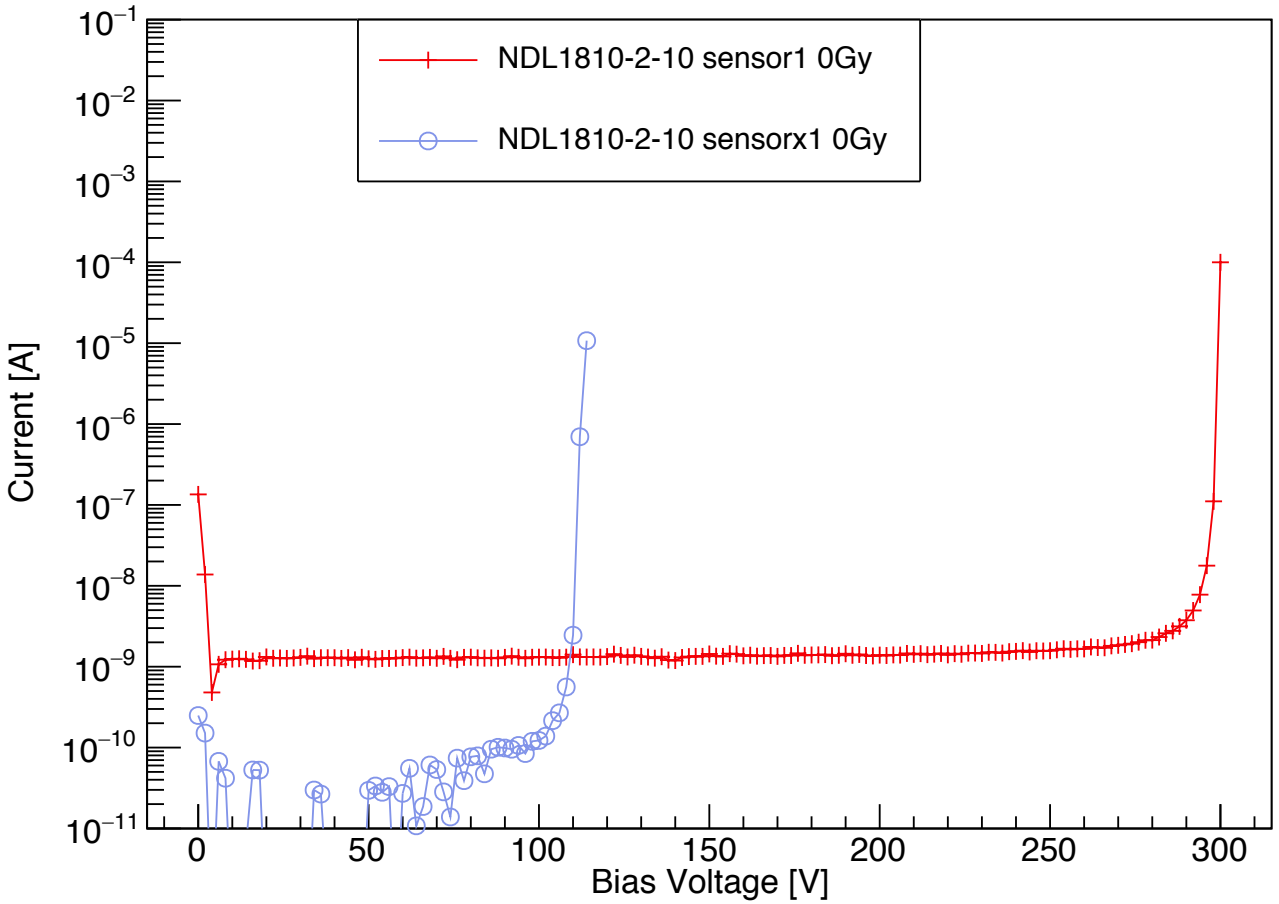



NDL1810-2-10 sensorx1 PAD1H
NDL1810-2-10 sensorx1 PAD1L
Current [A]
Bias Voltage [V]
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-15}
0
50
100
150
200
250
300

- for(int i=0; i<nvol-1; ++i){ // calculate derivatives and doping profile
- invcap2_dv[i] = (invcap2[i+1]-invcap2[i])/step; // forward difference
- doppf[i] = 2.0/q/esi/e0/A/A/invcap2_dv[i]; // [cm^{-3}]
- depth[i] = A*esi*e0*(1.0/cap[i])*1E+4; // [cm] to [um]
- if(depth[i]<0) depth[i]=depth[i-1];
- //cout<<vol[i]<<"V "<<cap[i]<<"F "<<invcap2[i]<<"F^{-2} "<<depth[i]<<"um "<<doppf[i]<<"cm^{-3} "<<endl; // for debugging
- }

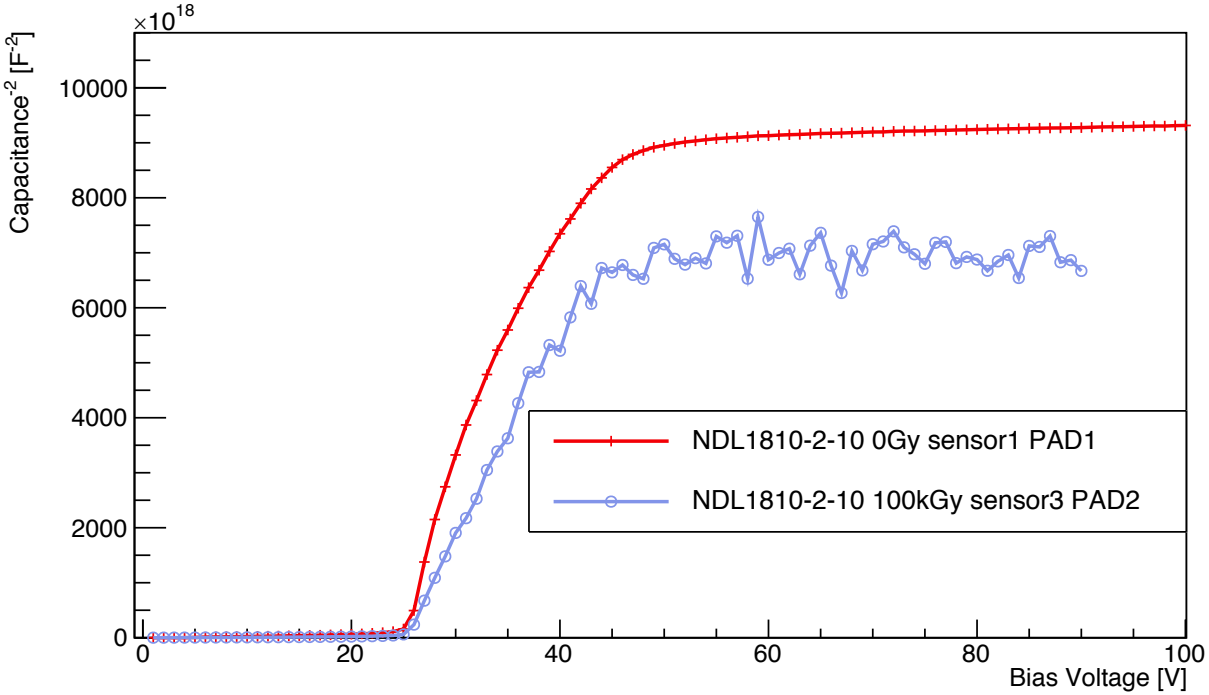
- **Data**
- /publicfs/atlas/atlasnew/hgtd/sensors/NDL/CV/BV170-30-B

Precision --

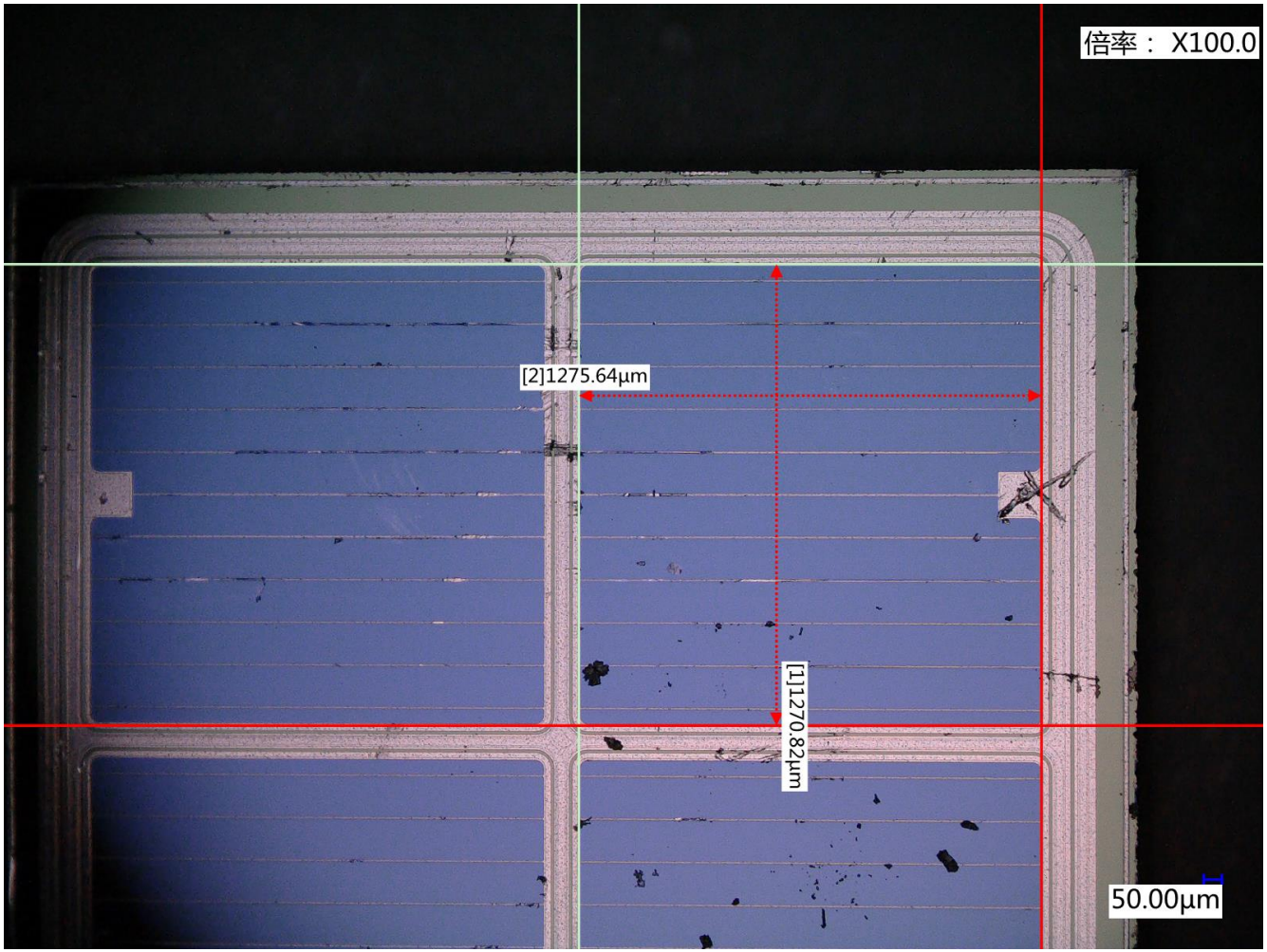


Breakdown Voltage for 10# is ~100V ?

Found the VBD of two sensors is ~100


×10^18
Capacitance^-2 [F^-2]
10000
8000
6000
4000
2000
0
0
20
40
60
80
100
Bias Voltage [V]
NDL1810-2-10 0Gy sensor1 PAD1
NDL1810-2-10 100kGy sensor3 PAD2

The area of the NDL1810-2-10 sensor



1275.64 x 1270.82 μm^2

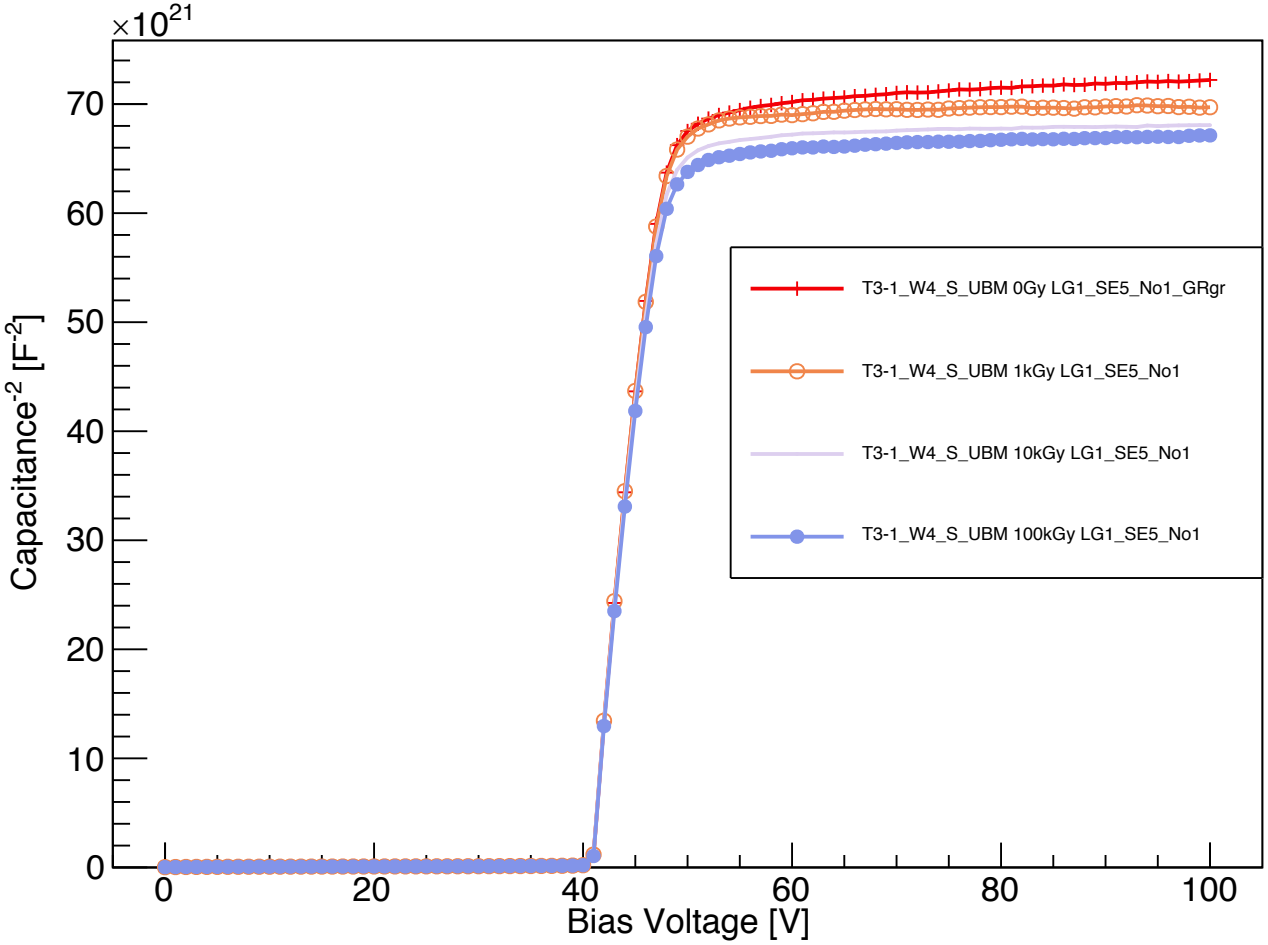
Thanks
Dengfeng

C-V after X ray irradiation

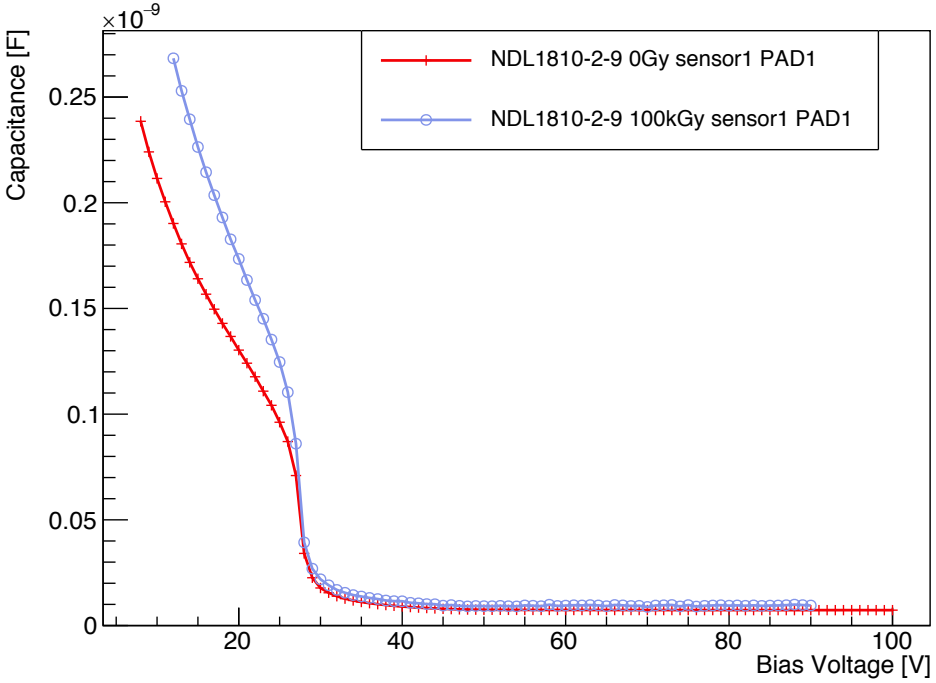
- $1/C^2$ decreased after X ray irradiation
  - Surface active area (A) may increased after X ray irradiation (to be study)

Diode junction capacitance $C_j = \varepsilon A/w$

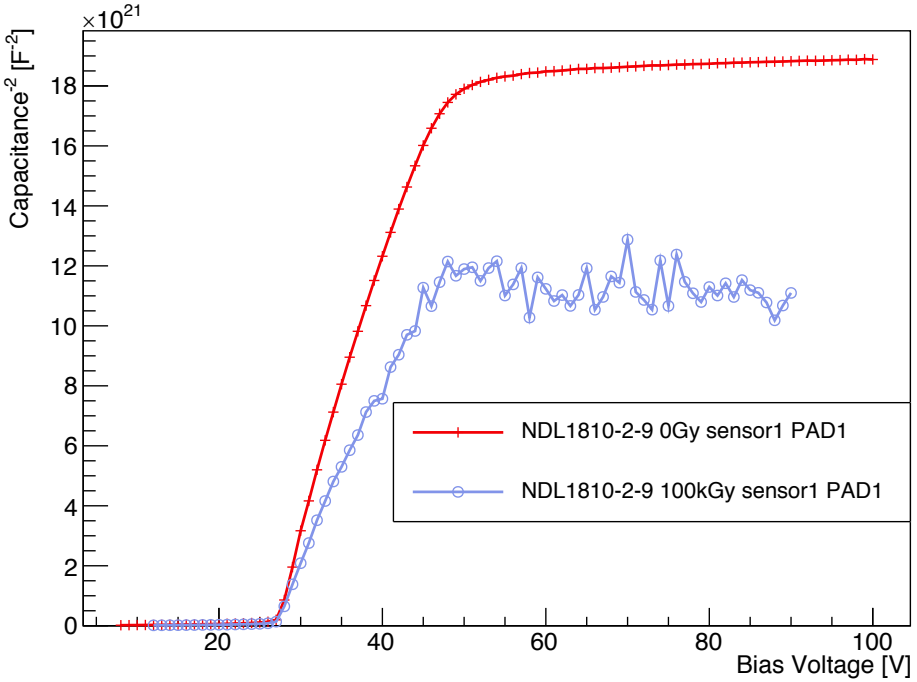
Depletion depth $$w \approx \left[\frac{2\epsilon_r \epsilon_0}{q} \left(\frac{N_A + N_D}{N_A N_D} \right) (V_{bi} - V) \right]^{\frac{1}{2}}$$


×10^21
70
60
50
40
30
20
10
0
Capacitance^-2 [F^-2]
0
20
40
60
80
100
Bias Voltage [V]
T3-1_W4_S_UBM 0Gy LG1_SE5_No1_GRgr
T3-1_W4_S_UBM 1kGy LG1_SE5_No1
T3-1_W4_S_UBM 10kGy LG1_SE5_No1
T3-1_W4_S_UBM 100kGy LG1_SE5_No1

CV for NDL1810-2-9

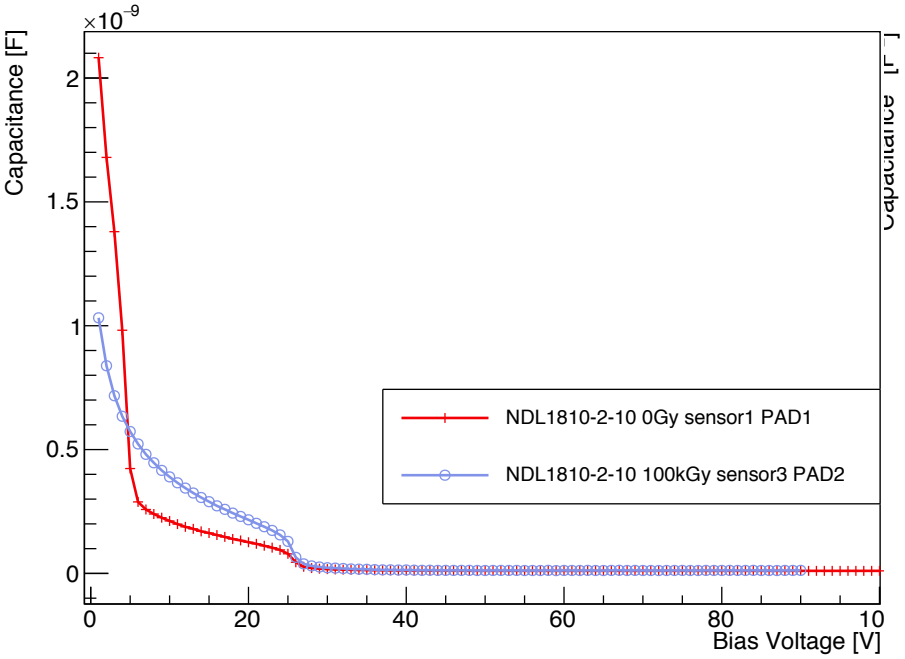


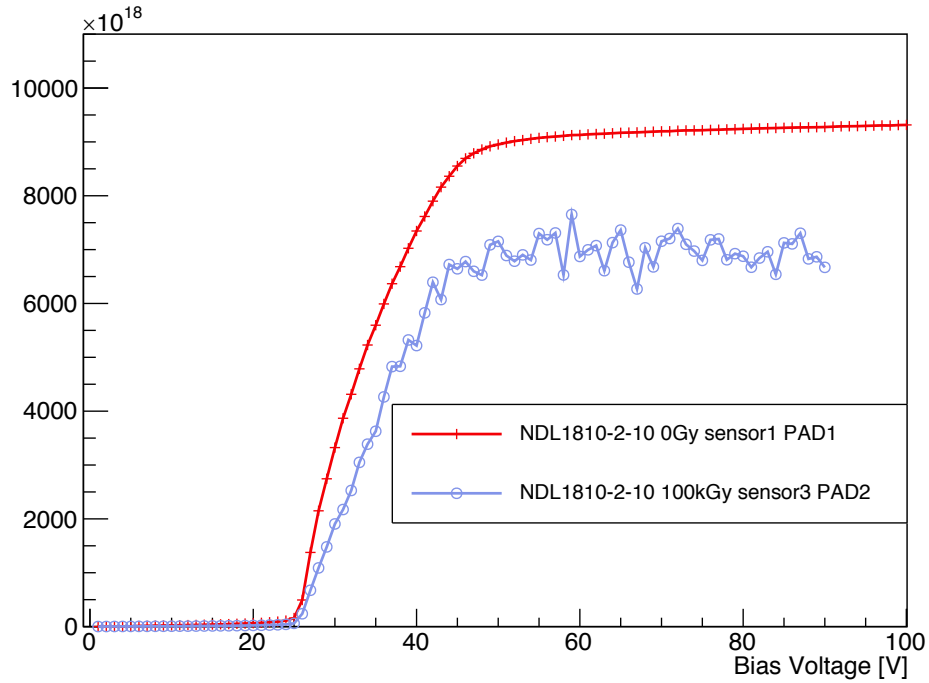
C vs V



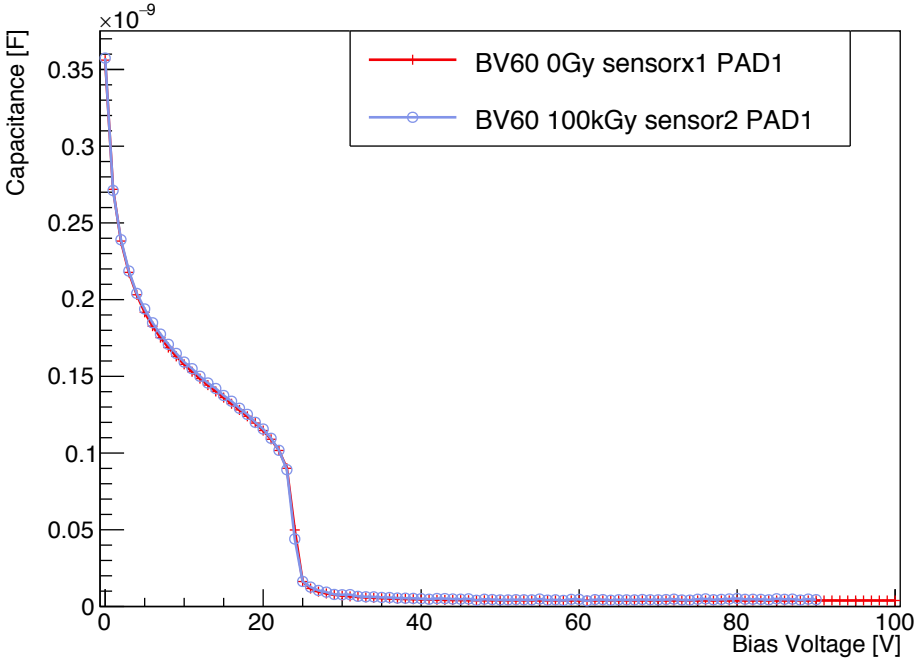
$1/C^2$ vs V

CV for NDL1810-2-10

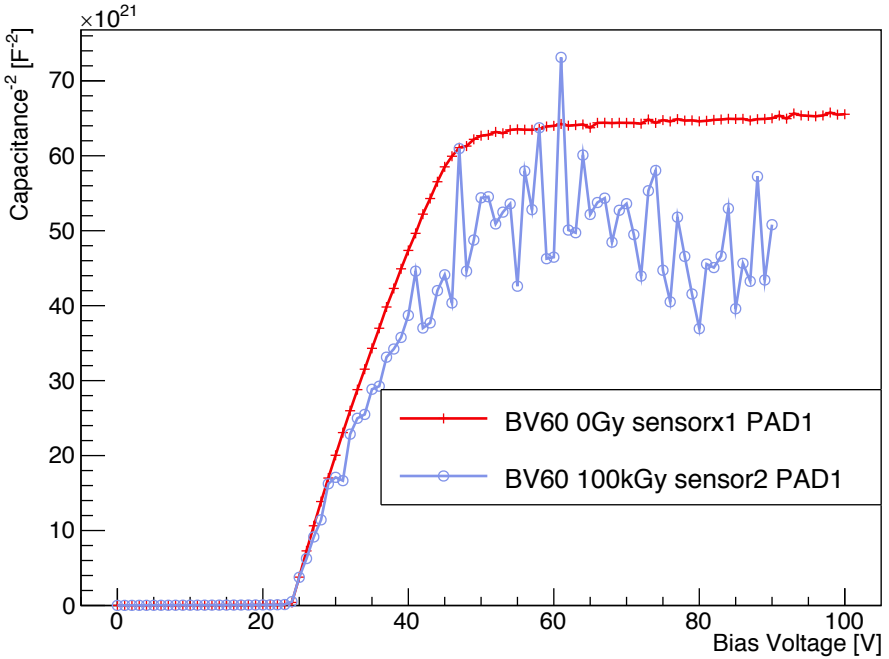




BV60



C vs V



$1/C^2$ vs V