Institut "Jožef Stefan" Ljubljana, Slovenija

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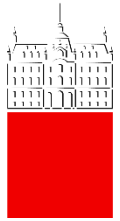
Fakulteta za matematiko in fiziko



Update on tests with passive strucutres on CHESS 2 chip

ATLAS Strip CMOS meeting, 20.12.2016

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Ljubljana, Slovenia

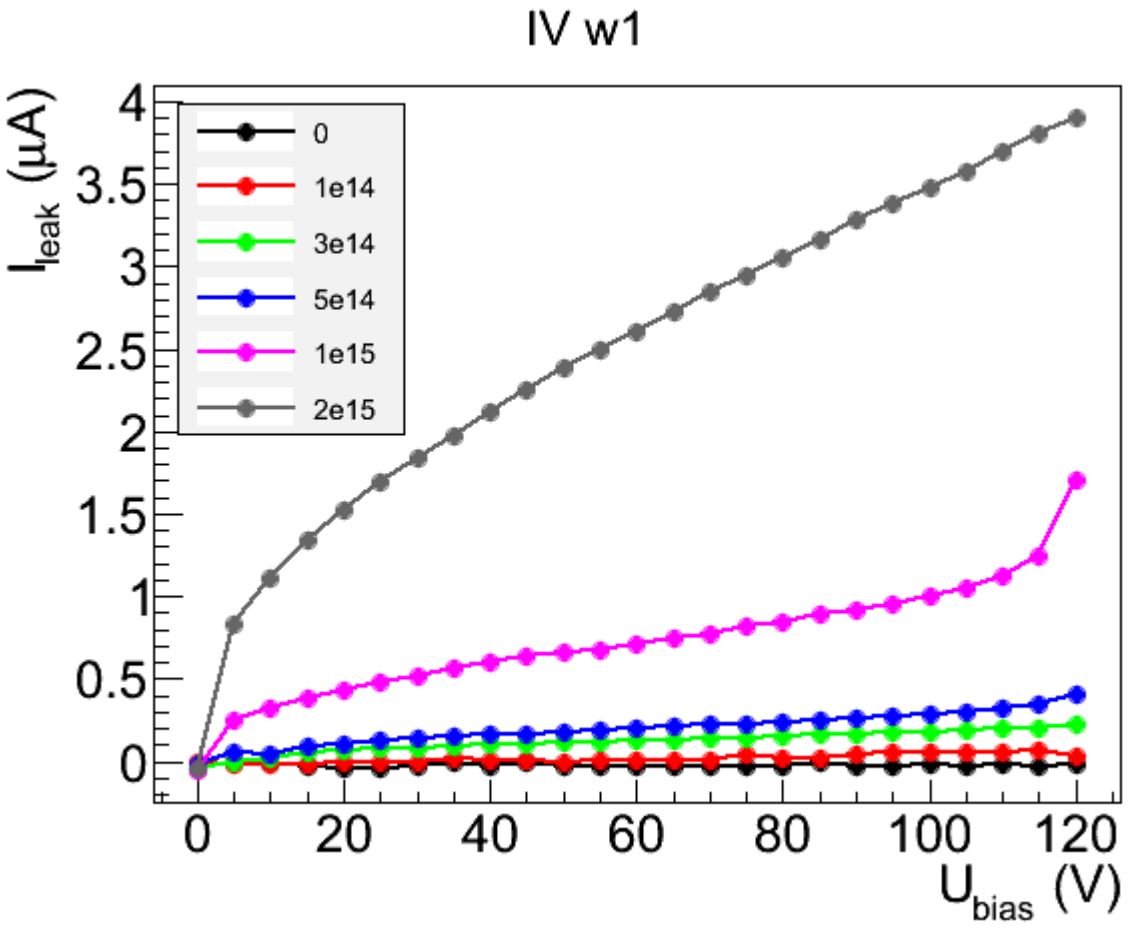
Samples

Chips from wafer 1: standard AMS resistivity (20 Ohm-cm)

Resistivity [Ω-cm]	Wafer numbers	Wafers cut	Number of cut chips
std	1-6	1, 2	94
50-100	7-12	7, 8	97
200-300	13-18	13, 14	94
600-2000	19-24	19, 20	95

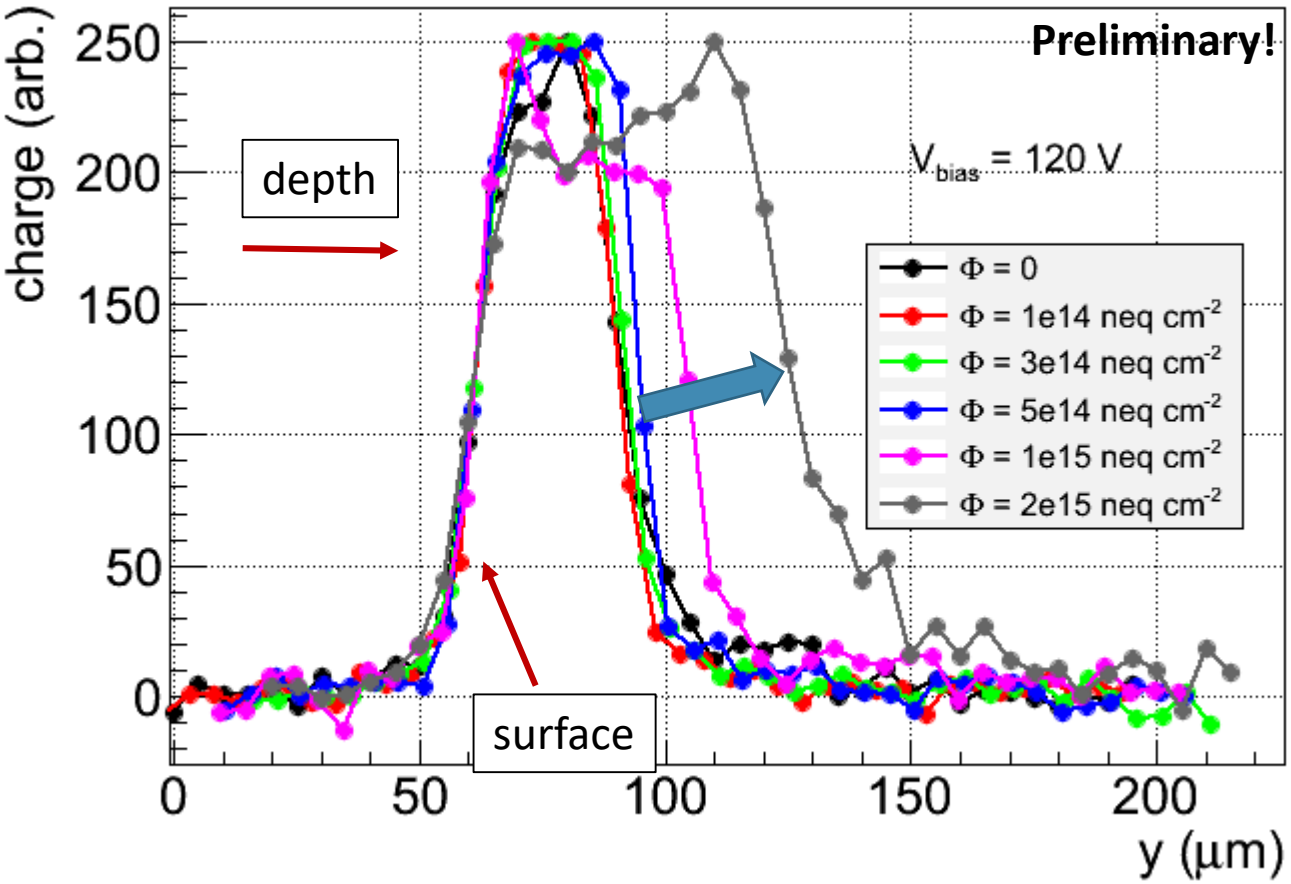
Neutron fluences 0e14, 1e14, 3e14, 5e14, 1e15, 2e15 neq/cm2

I-V characteristic



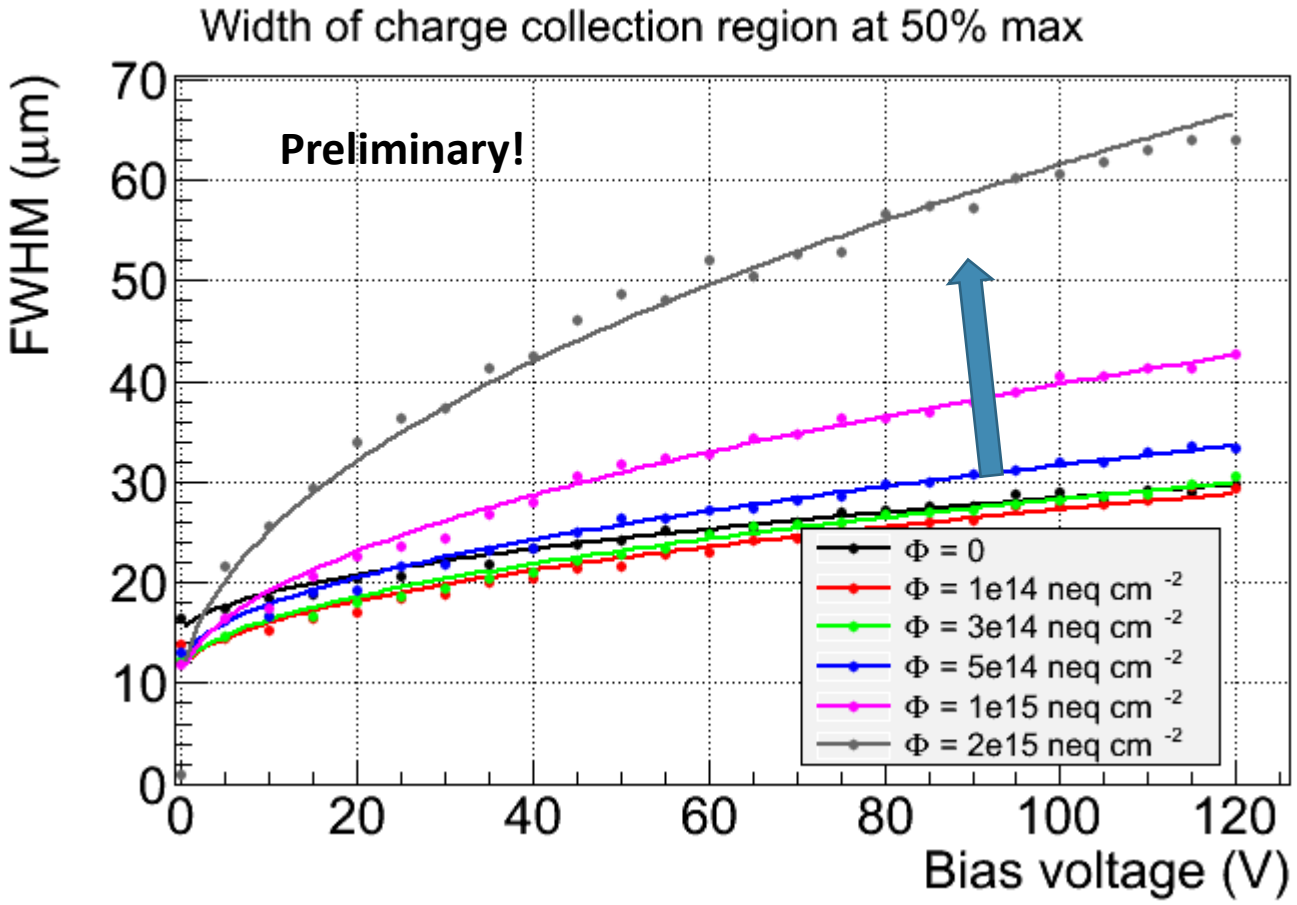
I-V measured on a TCT array
(3 x 3 pixels, pixel size 630 x 40 µm^2)

E-TCT Charge collection profiles W1



- Moderate charge collection width, but increases with irradiation
- Low resistivity → late acceptor removal

Neff vs. fluence



$$Width(V_{bias}) = w_0 + \sqrt{\frac{2\varepsilon\varepsilon_0}{e_0 N_{eff}} V_{bias}}$$

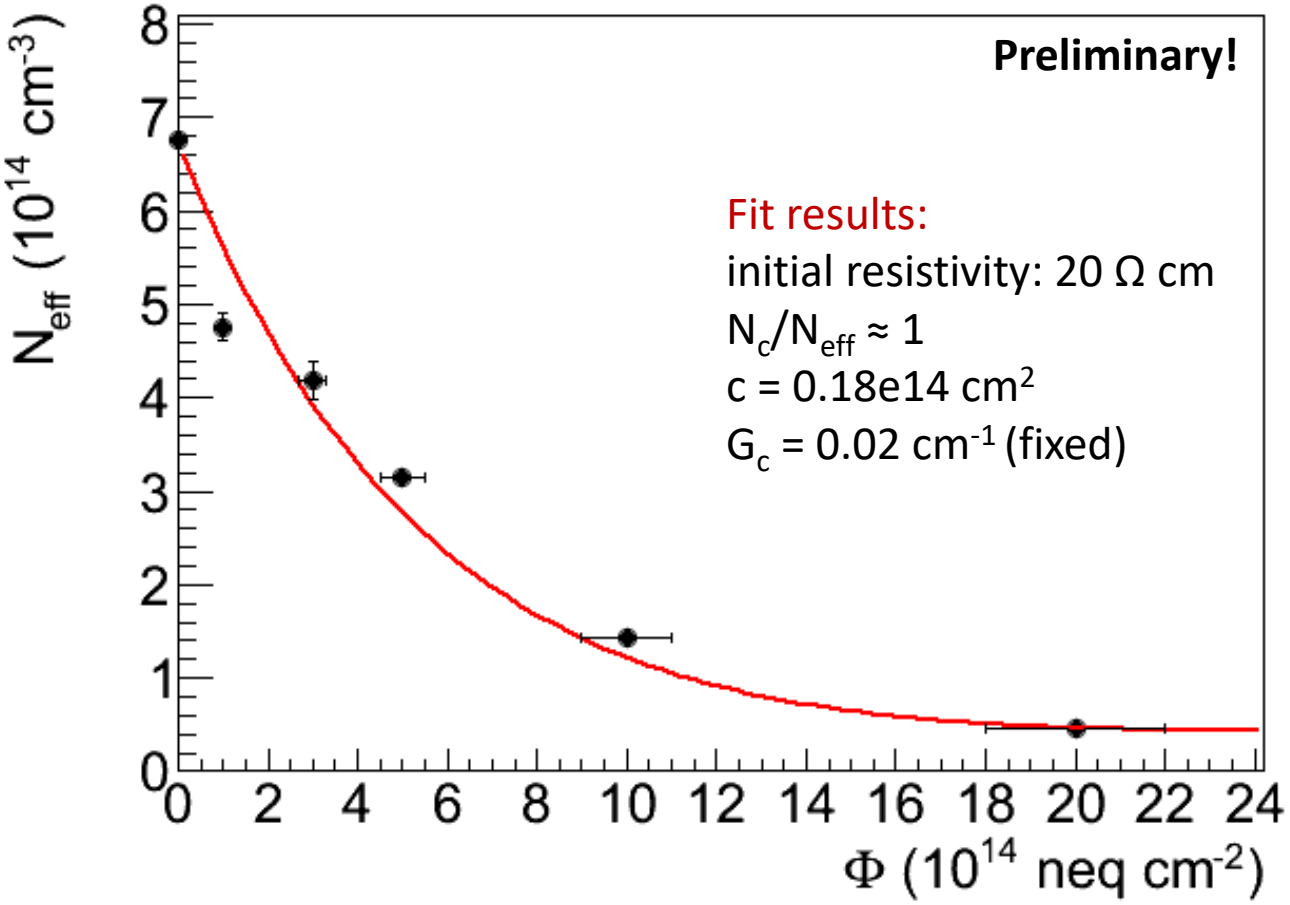
Extract value from fit

N_{eff} vs. fluence

Fit: $$N_{eff} = N_{eff0} - N_c \cdot (1 - \exp(-c \cdot \Phi_{eq})) + g_c \cdot \Phi_{eq}$$

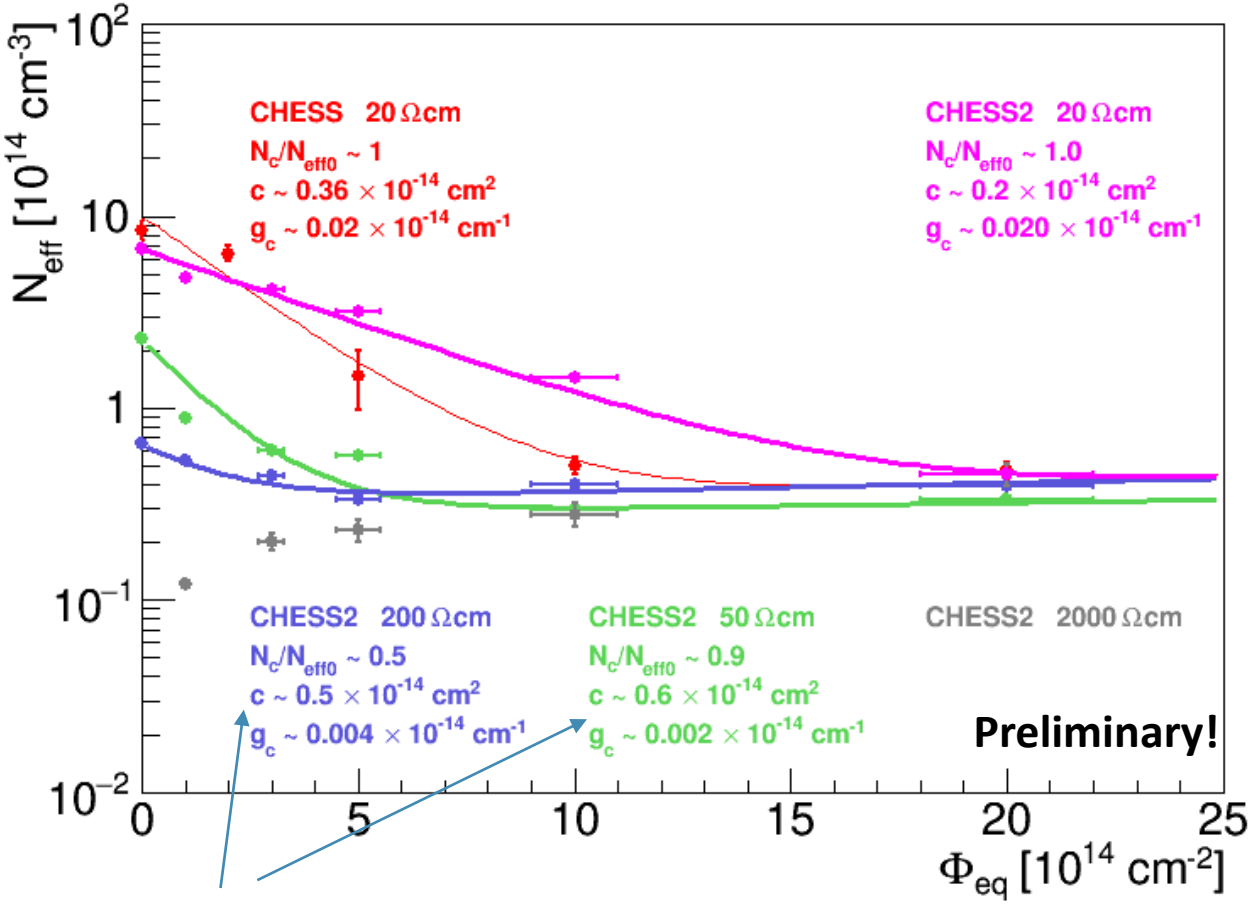
acceptor removal

Radiation introduced deep acceptors



Neff vs. fluence

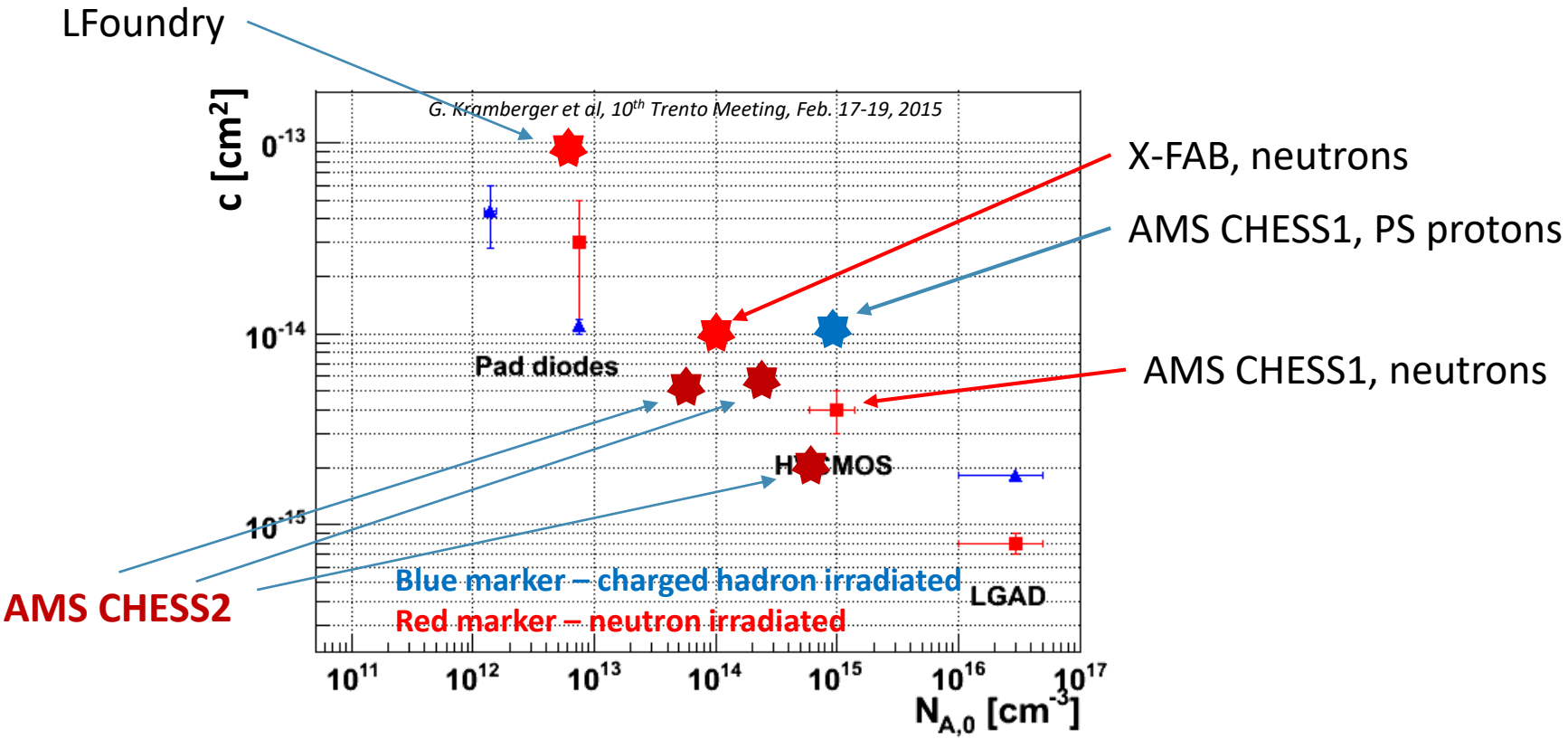
$$N_{\text{eff}} = N_{\text{eff0}} - N_{\text{c}} \cdot (1 - \exp(-c \cdot \Phi_{\text{eq}})) + g_c \cdot \Phi_{\text{eq}}$$



should verify again

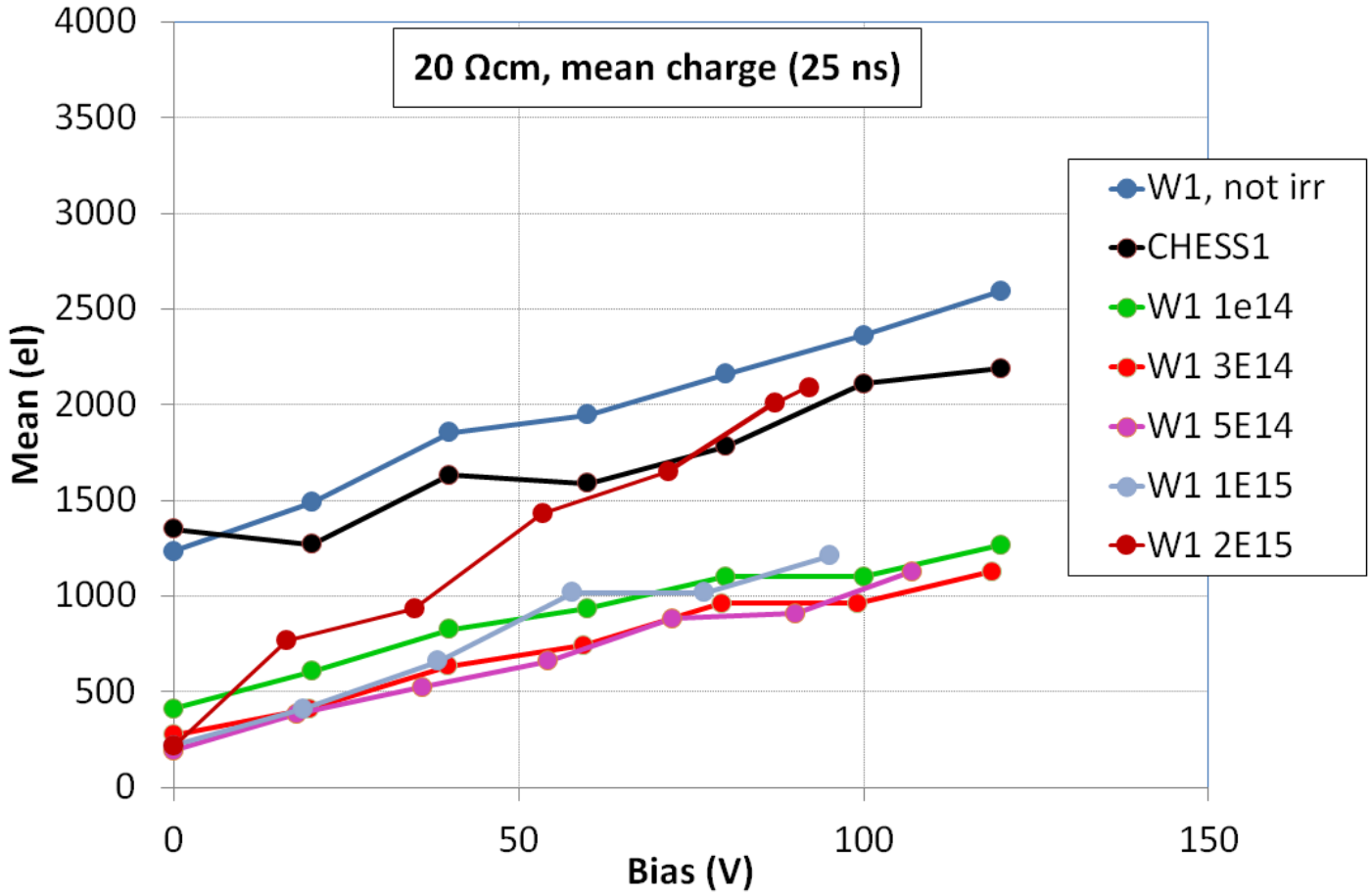
Removal at the highest resistivity substrate is completed below 1e14 neq/cm2 and was not observed in this study

Acceptor removal constant vs. doping



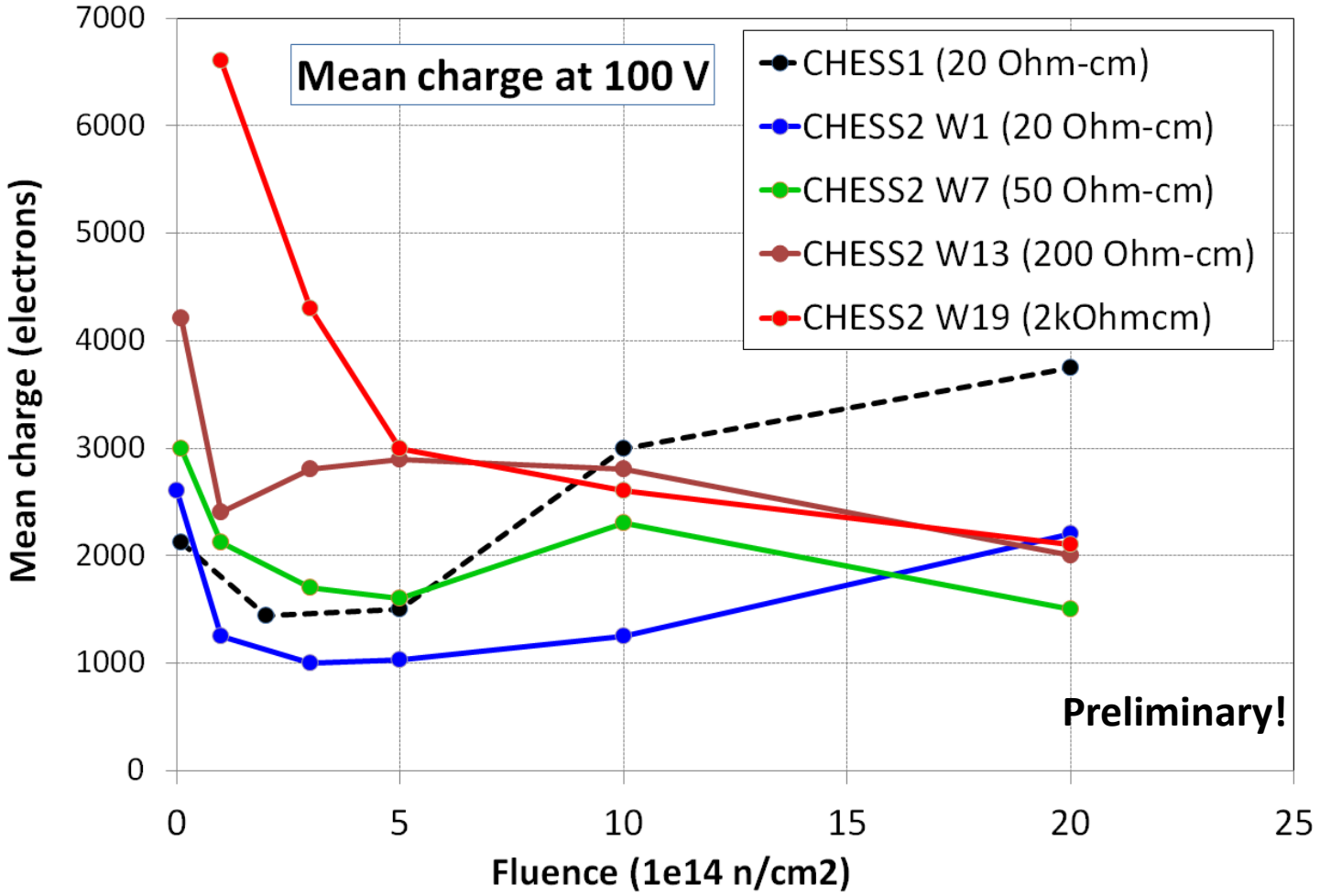
Chip	ρ (Ohmcm)	c (1e-14 cm-2)	Neff/Neff_0	g_c (cm-1)
HV2FEI4	10	0.6	1	0.02 (fixed)
CHESS1	20	0.4	1	0.01
CHESS2	50	0.5	1	0.02 (fixed)
Xfab	100	1	1	0.043
CHESS2	200	0.3	0.8	0.02 (fixed)
LF	2000	10	0.6	0.047

Sr90 measurements



Collected charge is less than expected from E-TCT measurements

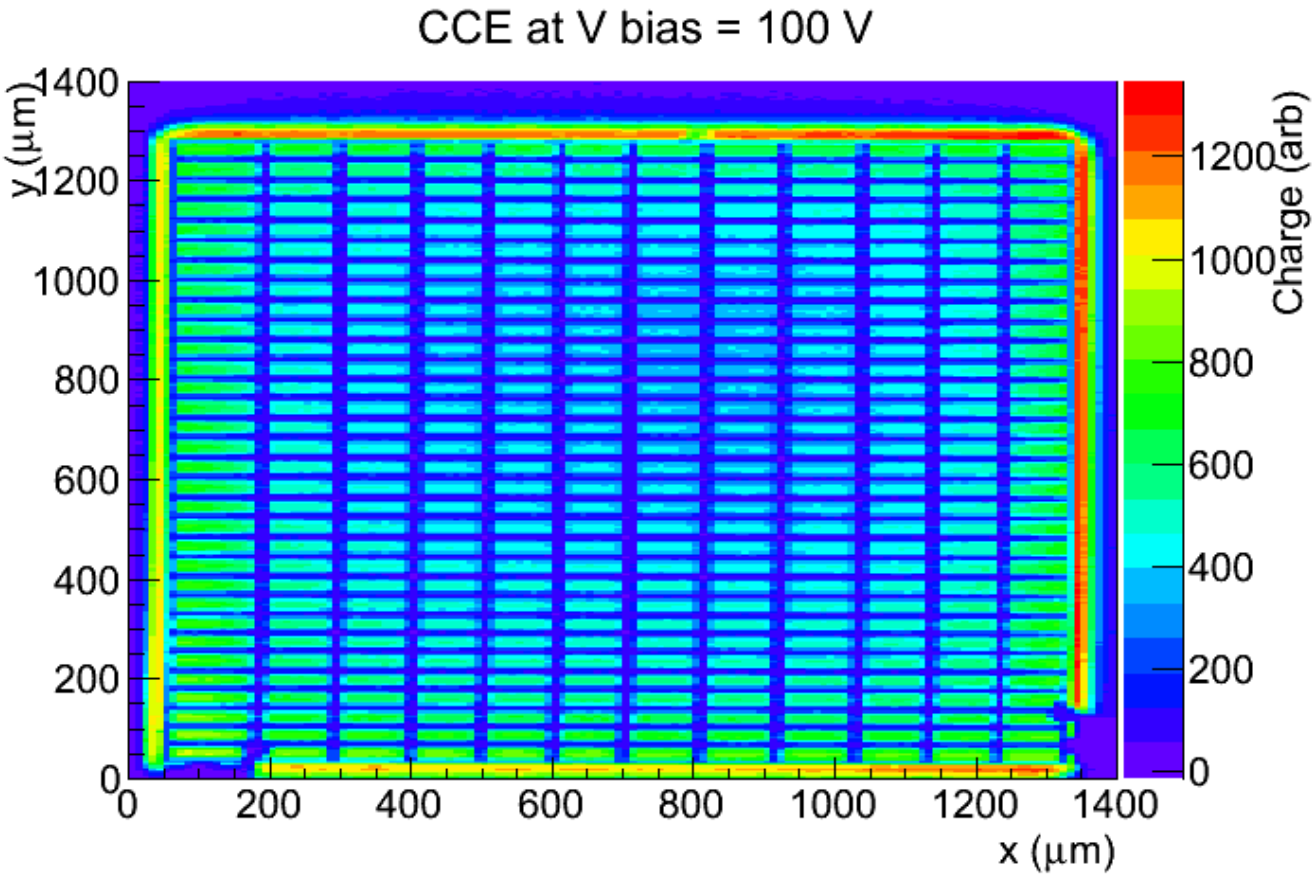
Sr90 Comparison for different substrates



CHESS1 vs. CHESS2: trend is similar, but numbers differ

Top TCT

- Charge from Sr90 measurements systematically only 60 % of that expected for the depletion depth measured by E-TCT
- Investigate with top TCT
  - IR light – 980 nm, abs. depth 100 µm → no reflections from back plane



W19 5e14
Big array for Sr90
(1.2 mm x 1.2 mm)

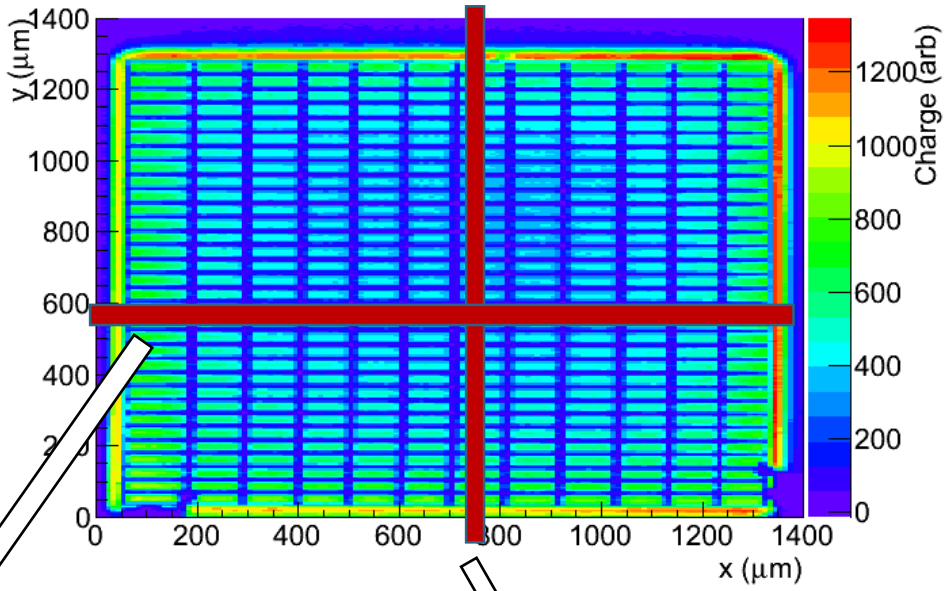
Gaps between pixels due to metalization on top of the chip

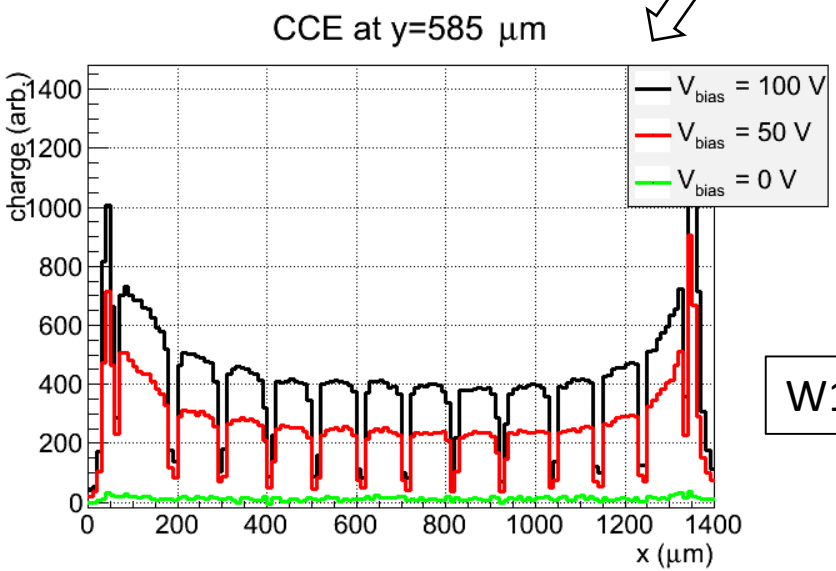
But on the large scale **intensity in central pixels less than on edges !**

Top TCT 2

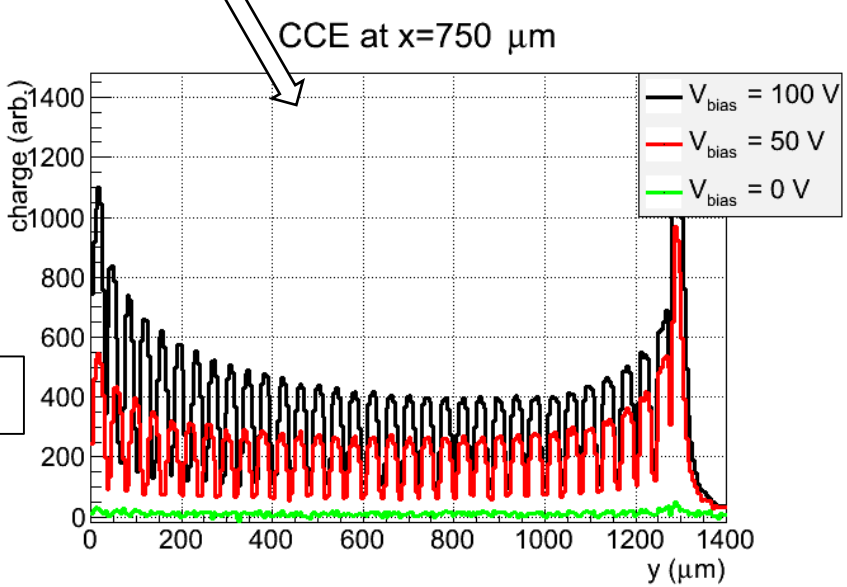
Difference in the collected charge indicates a larger depletion depth on the edges of the Sr 90 array.

Edge-like pixels also measured in Edge-TCT. This may be a reason for discrepancy between the measurements.



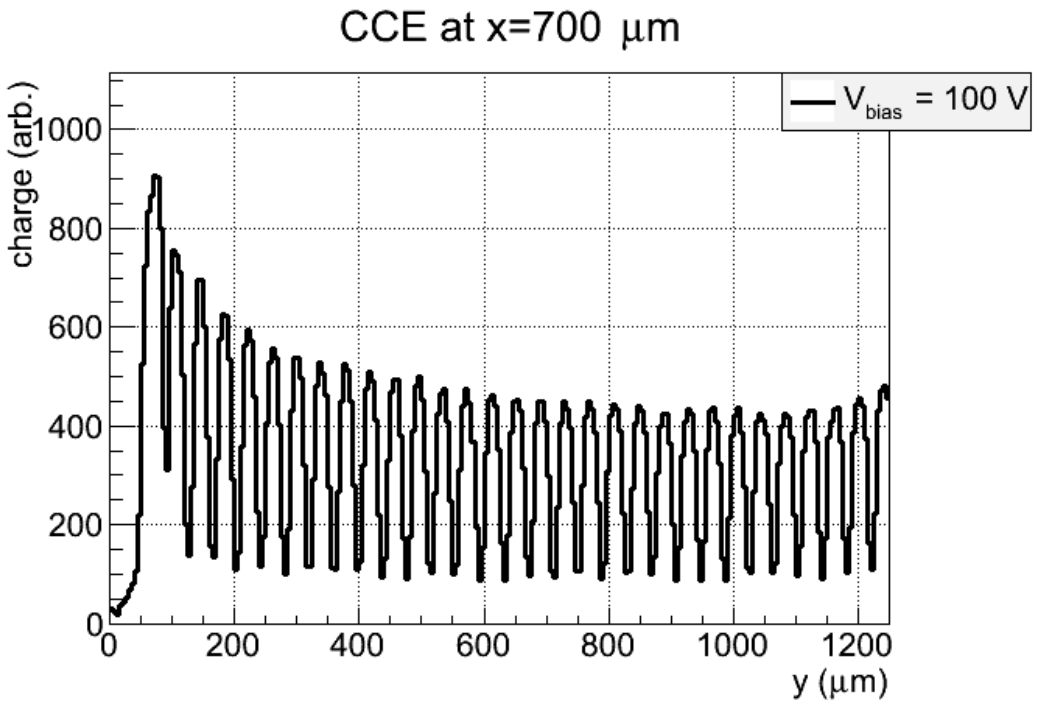


W19 5e14



Top TCT 3

Similar behavior observed also on the sample W19 3e14



W19 3e14

Summary

- Completed measurements of charge collection on passive structures on CHESS 2
  - 4 wafer resistivities 20 – 2000 Ohm-cm, each wafer 6 neutron fluences up to 2e15 n/cm2
  - E-TCT and Sr90

- E-TCT:
  - Behavior of different wafers as expected from previous studies with different substrates
  - Acceptor removal plays a role in depleted depth after irradiation – effects depending on initial resistivity

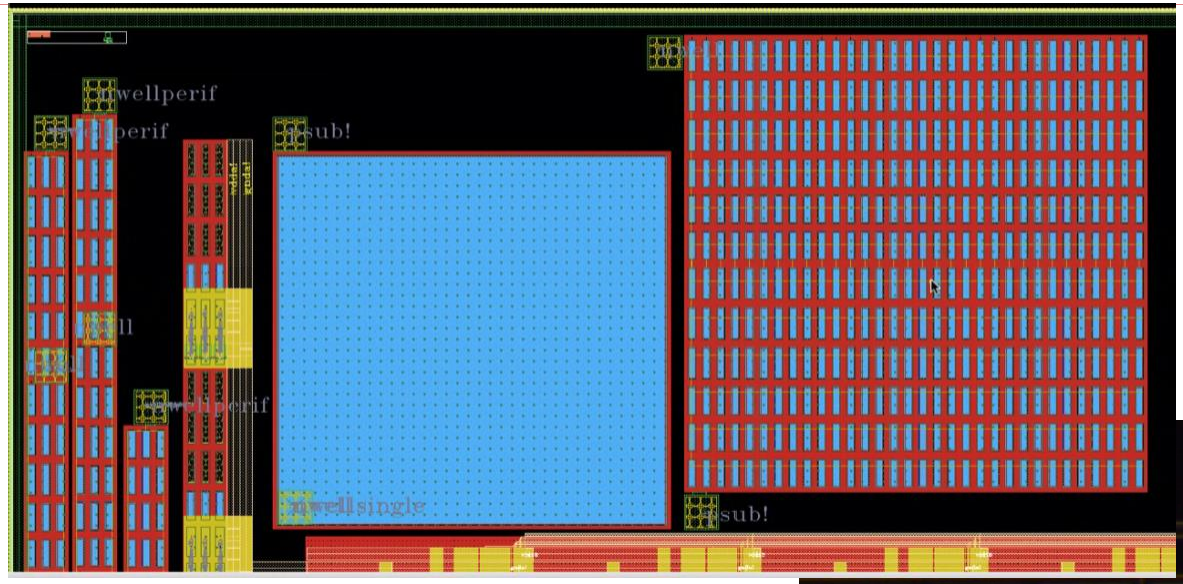
- Sr90
  - Collected charge greater at least 1000 electrons for any substrate and fluence

- Systematic discrepancy between E-TCT and Sr90 in collected vs. expected charge charge (40 %)
  - Indications that pixels in a large array collect less charge than pixels with only few neighbors

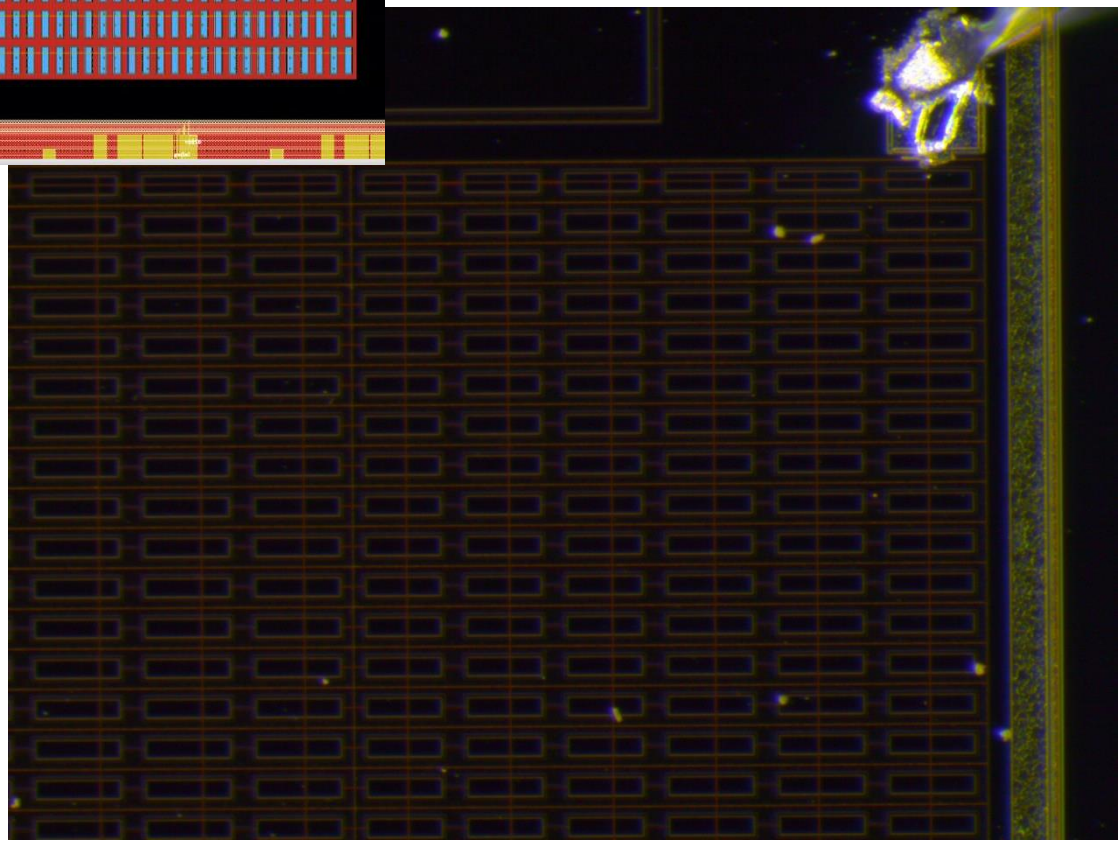
- Outlook: Tests with active analog structures

BACKUP

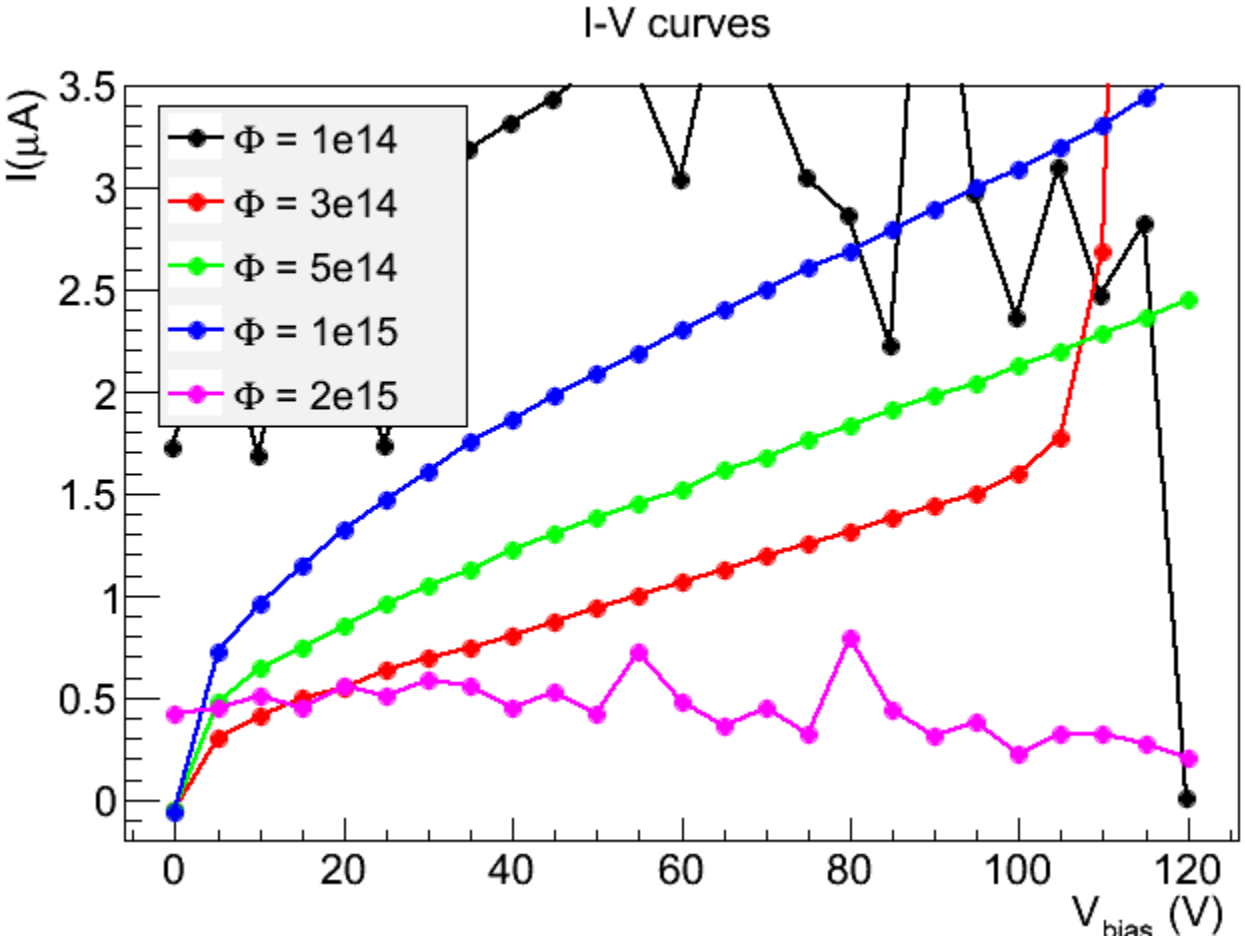
Passive structures on CHESS2



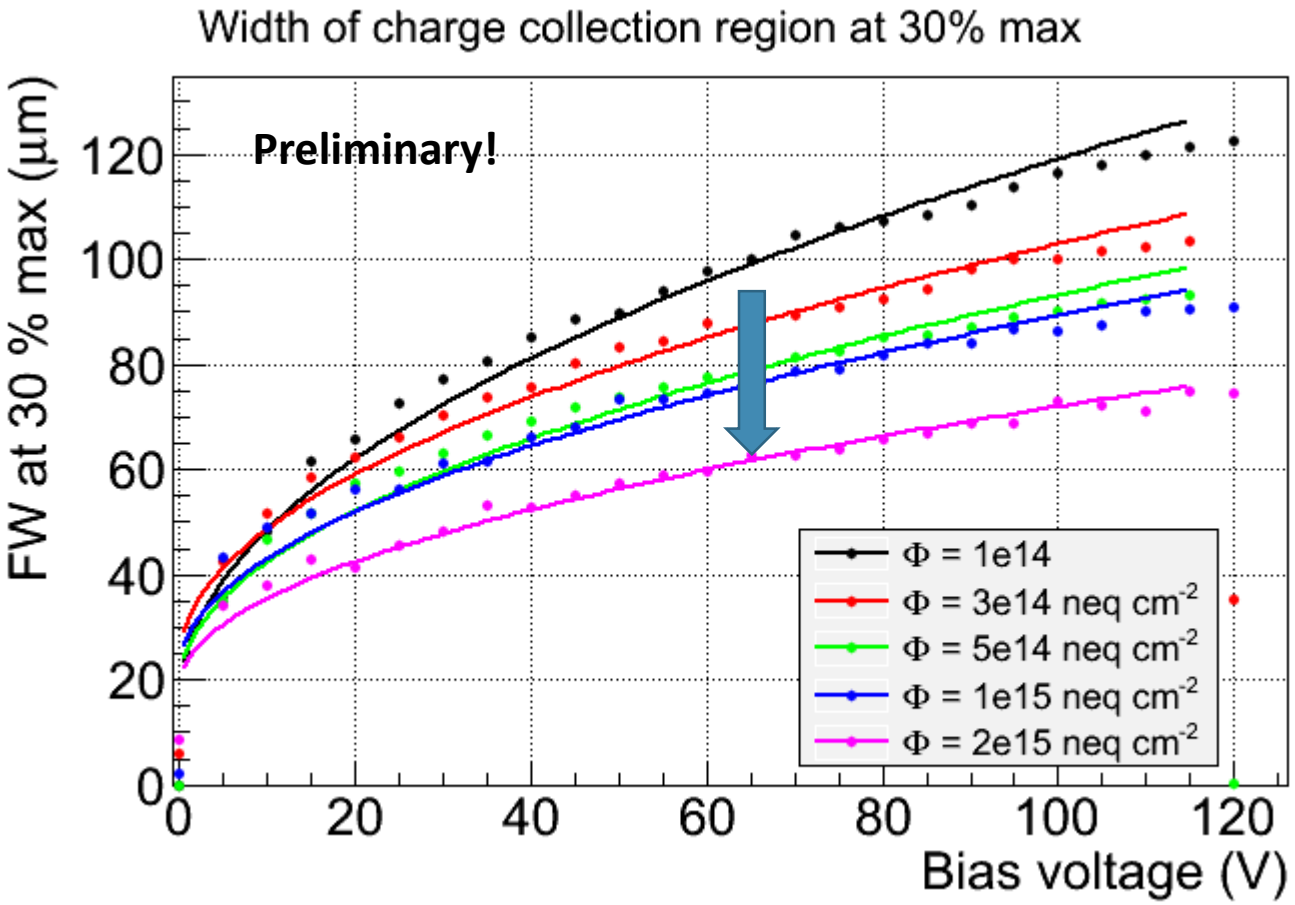
Red traces - metalization



W19 I-V curves



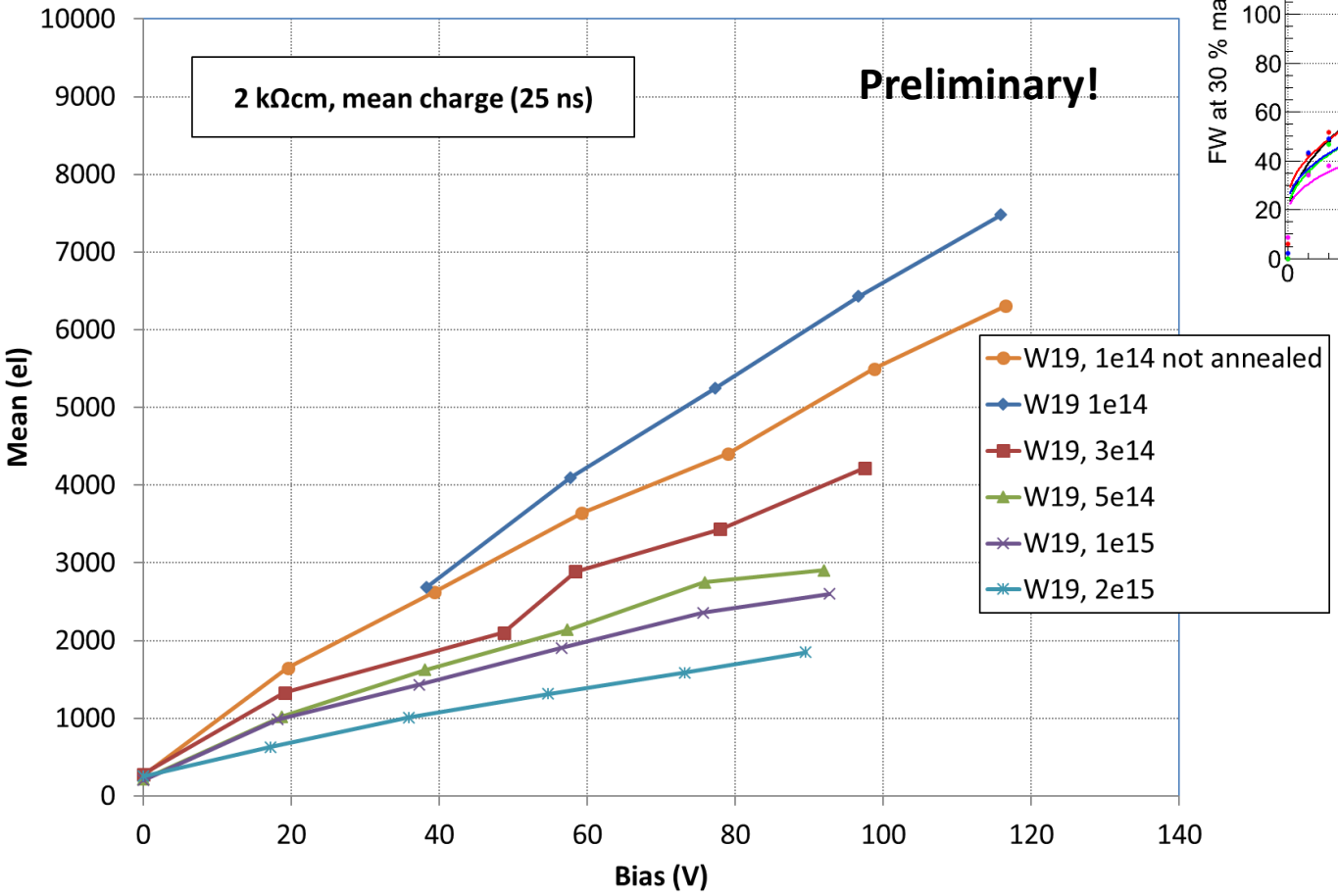
Depletion depth W19

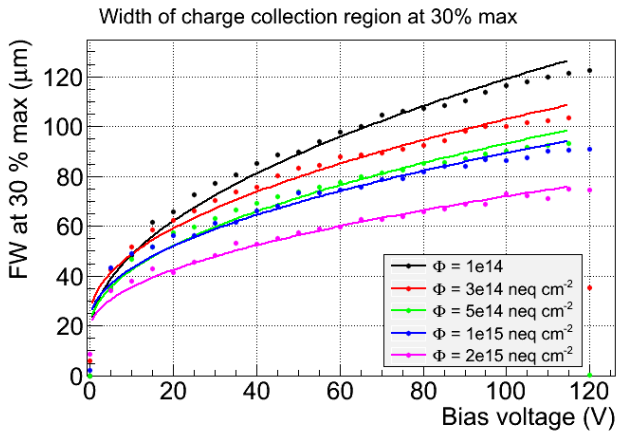


$$Width(V_{\text{bias}}) = w_0 + \sqrt{\frac{2\varepsilon\varepsilon_0}{e_0 N_{\text{eff}}} V_{\text{bias}}}$$

- Sqrt functions falling monotonously with fluence

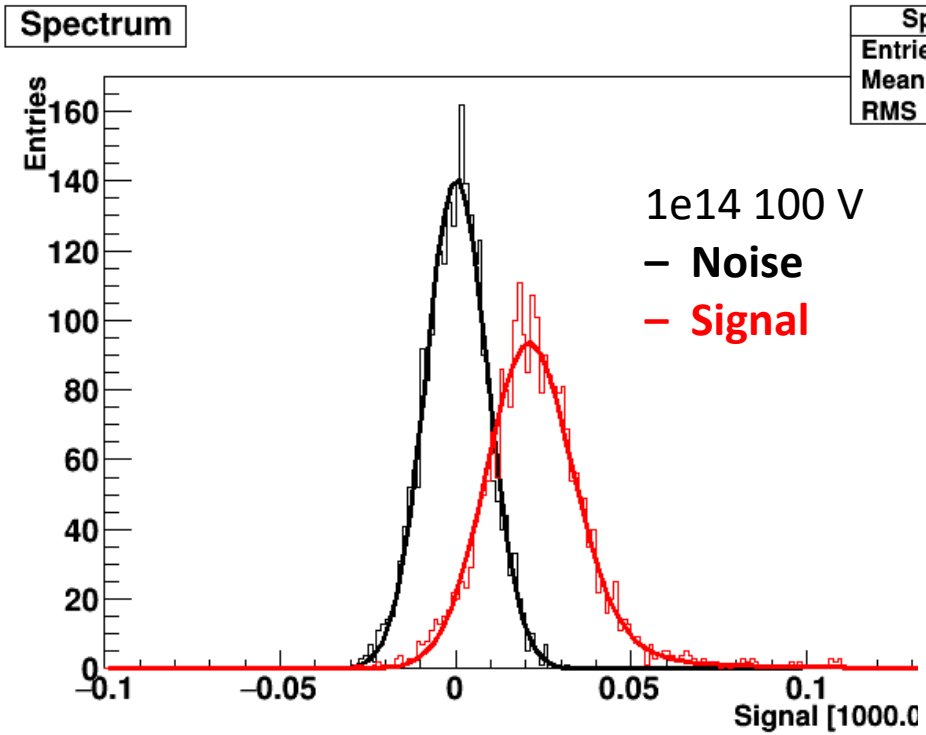
Sr90 charge

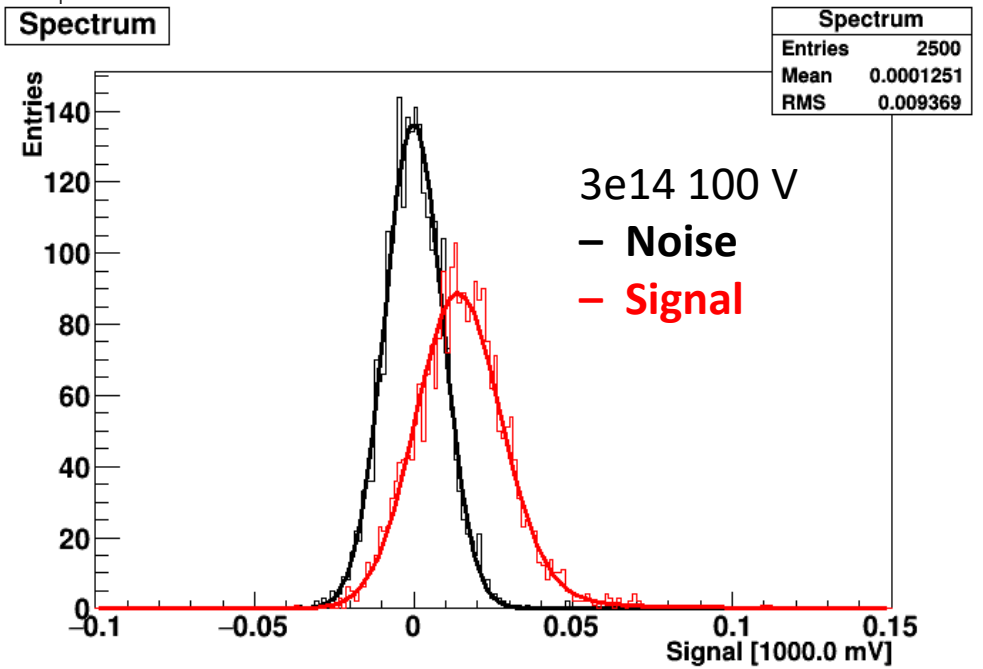




- TCT 1e14: depletion zone 120 um at 100 V
- We still collect less charge than expected (f.e. meas. 7000 e vs. 12000 e expected)
- Investigate with top TCT ?

Sr90 spectra W19



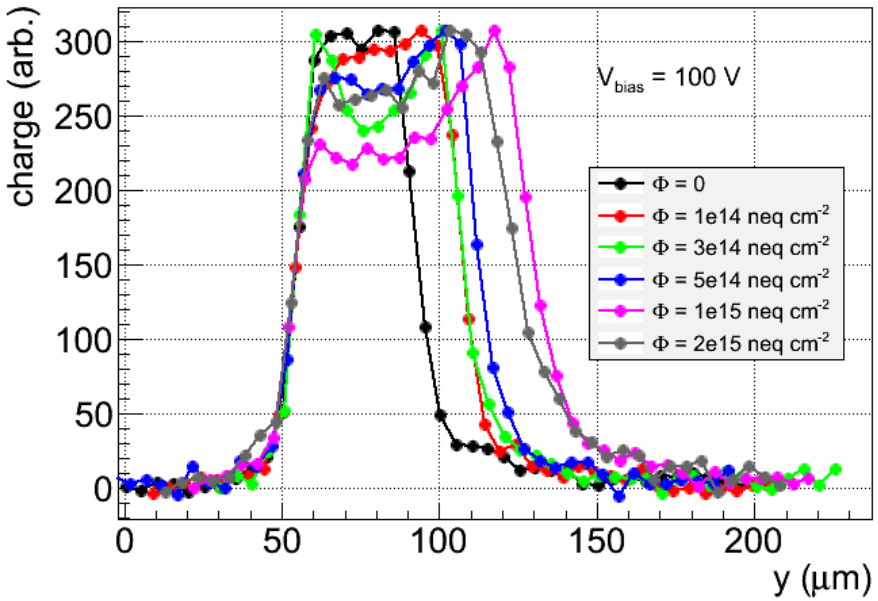


- Relatively good separation between signal and noise
- No peak around 0 in signal spectrum → misalignment does not seem to be the main factor for smaller charge

Charge profiles W7, W13

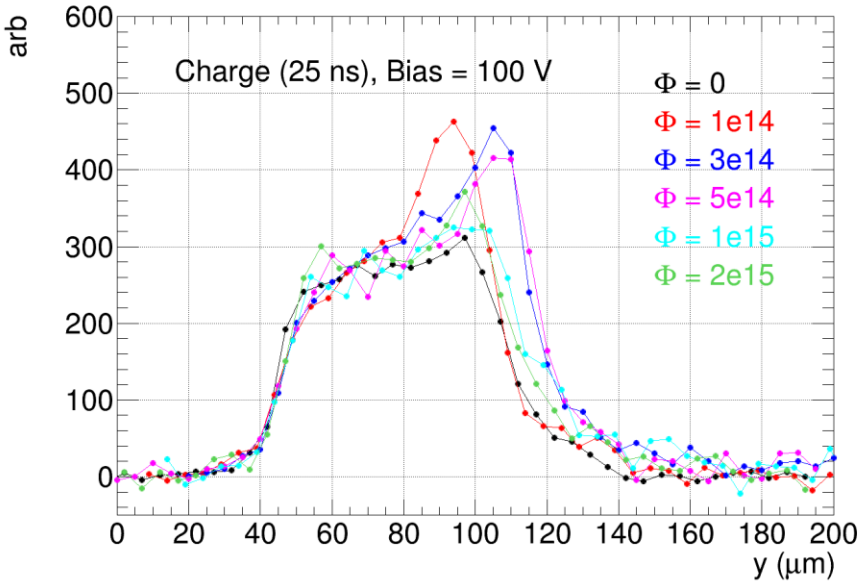
- Edge-TCT charge collection profile across central pixel

W7 (50 Ω·cm)



- increase of width with fluence up to 1e15

W13 (200 Ω·cm)

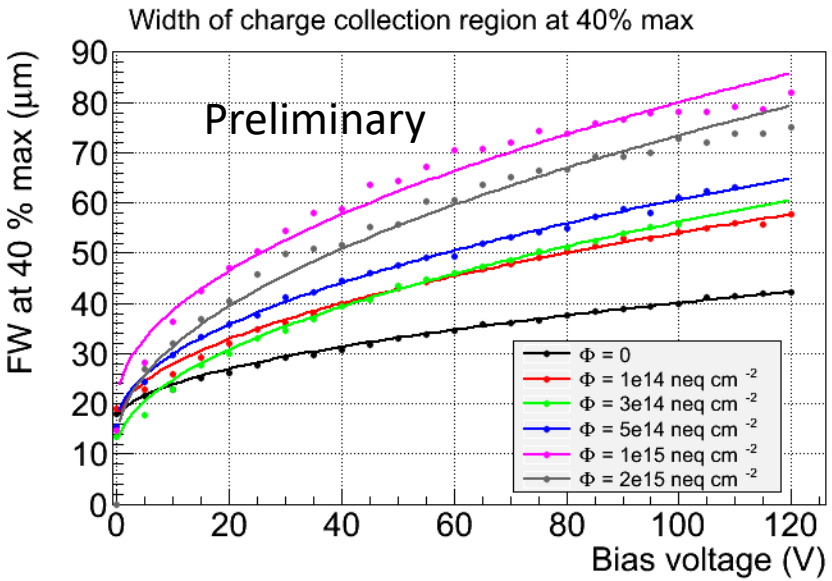


- not much change of profile width with fluence

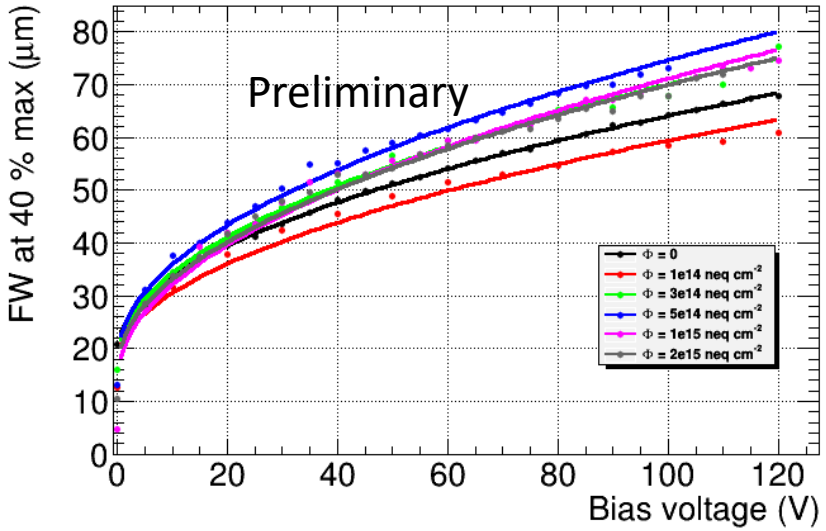
REMINDER Depletion depth W7, W13

- width of charge collection profile vs. bias

W7 (50 Ω·cm)



W13 (200 Ω·cm)



Fit: $$Width(V_{\text{bias}}) = w_0 + \sqrt{\frac{2\varepsilon\varepsilon_0}{e_0 N_{\text{eff}}} V_{\text{bias}}}$$

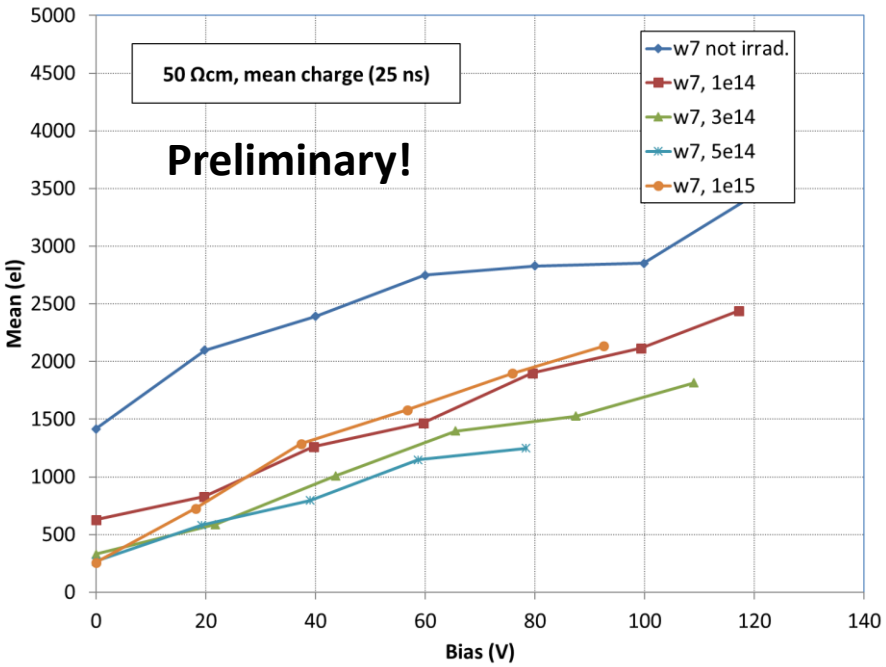
At Φ = 0

- W7: N_{eff} = 2.3e14 cm^{-3} ➔ 56 Ω·cm
- W13: N_{eff} = 6.6e13 cm^{-3} ➔ 200 Ω·cm

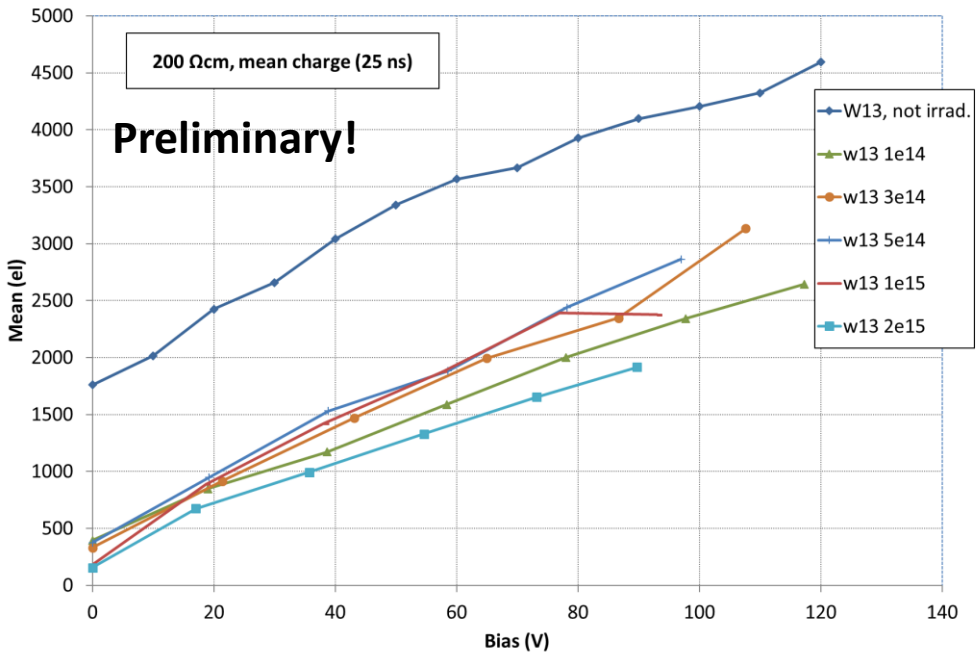
➔ Good fit, good agreement with nominal resistivity

REMINDER Sr90 W7, W13

W7 (50 Ω·cm)

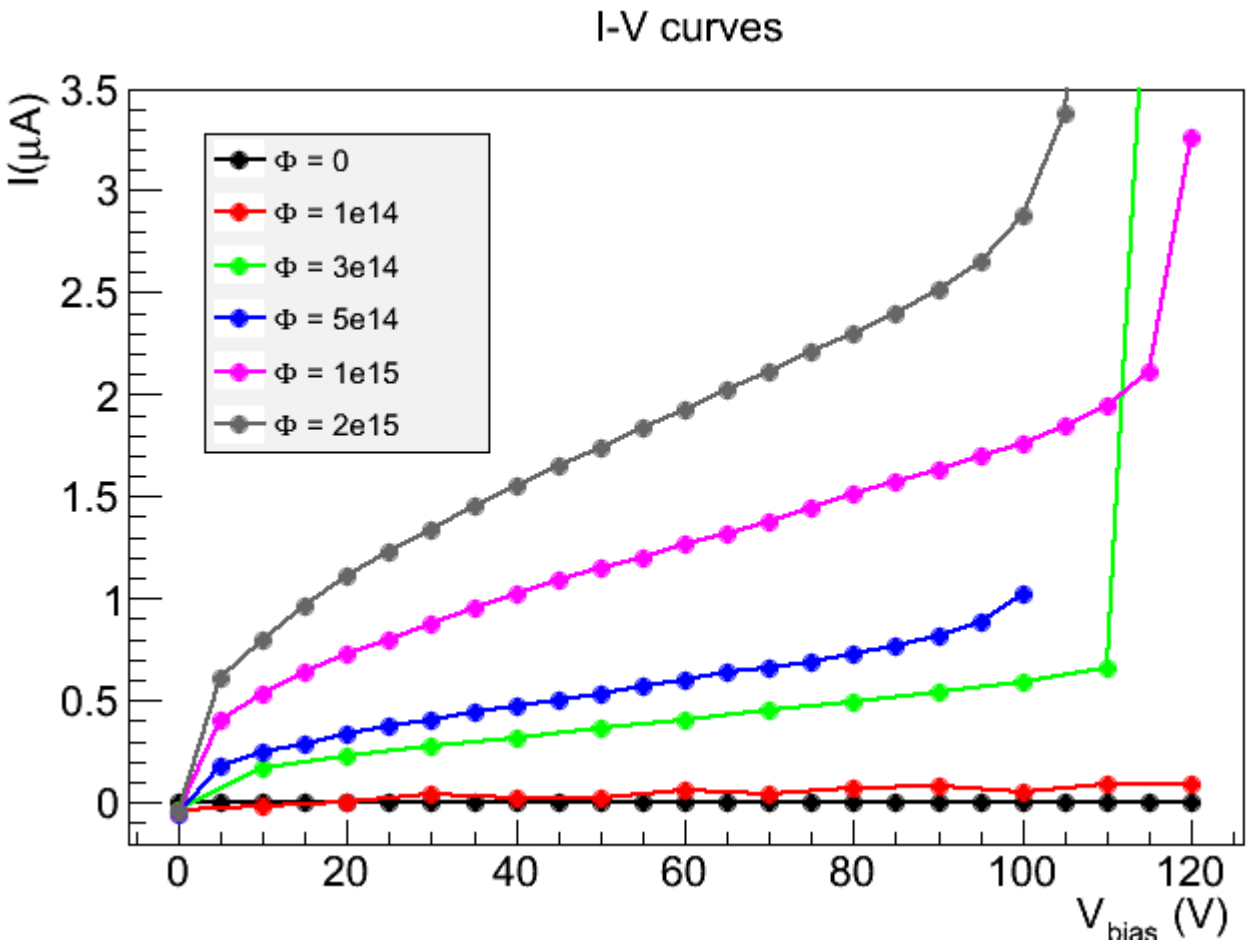


W13 (200 Ω·cm)



- large drop of collected charge (delta ≈ 1300 el) after first irradiation step to 1e14 n/cm2
  ➔ reduced contribution from diffusion
- TCT measurements indicate depleted region > 50 µm
  - Expect > 5000 el. from drift
  - Measure 2000 el.

IV-curves wafer 13

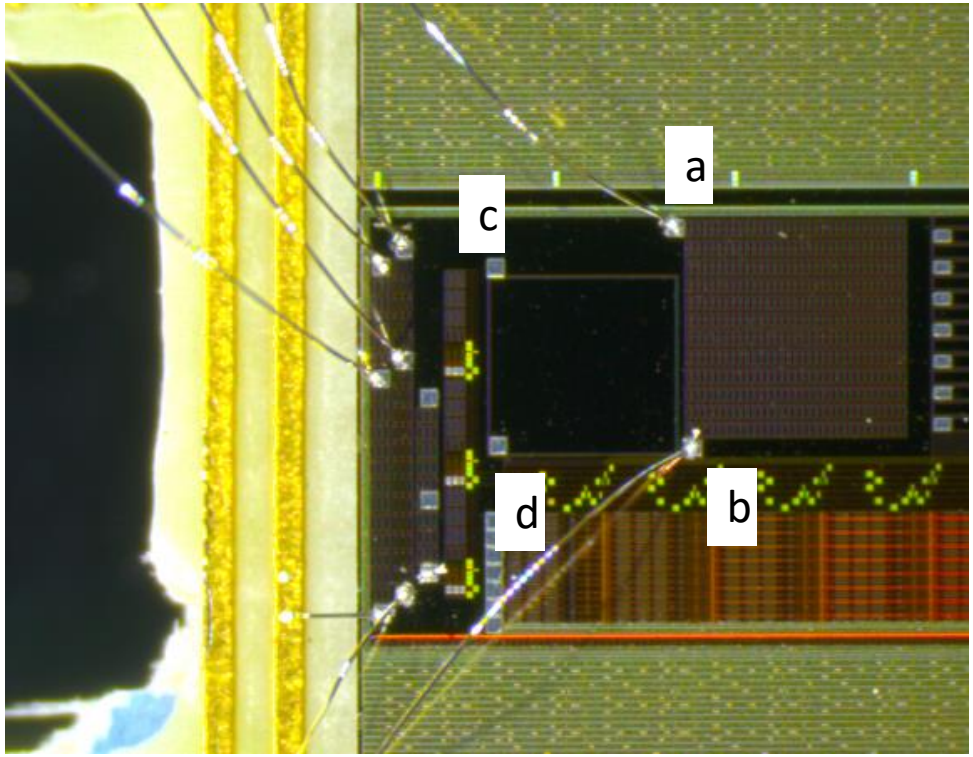


No IV curves for wafer 7 due to a bug, but 0e14, 1e14, 1e15, 2e15 OK up to 120 V
5e14 up to 110 V, 3e14 at least up to 90 V

High resistivity wafers

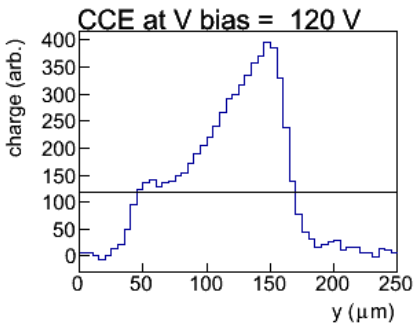
- After suggestion from Santa Cruz tried biasing the substrate from other pads:
  - a & d → breakdown at 18 V
  - a & b → breakdown at 18 V
  - c & d → breakdown at 1 V
  - c & b → breakdown at 1 V

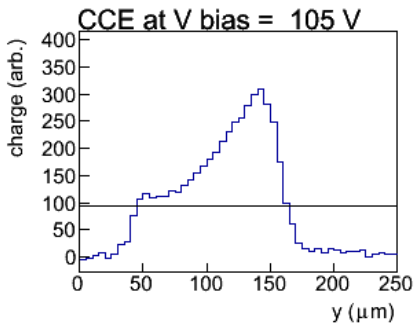
Planning also to measure IV of irradiated devices on probe station to see if there is improvement after irradiation

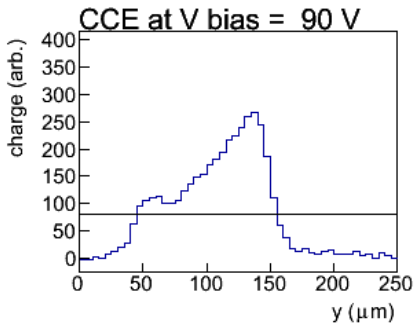


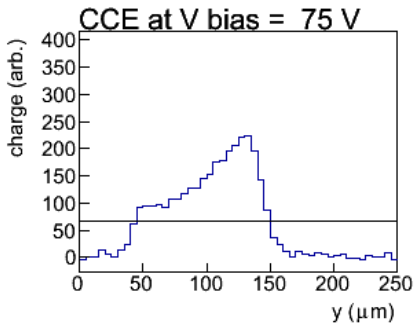
a – LPA nwells
b – LPA substrate
c – Large Pad nwells
d – Large Pad substrate

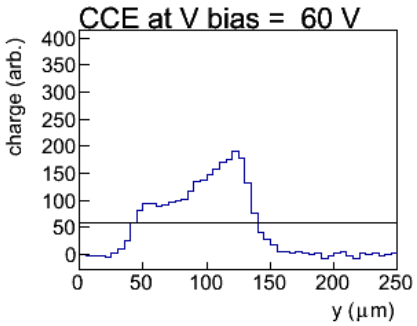
Profiles W19 1e14

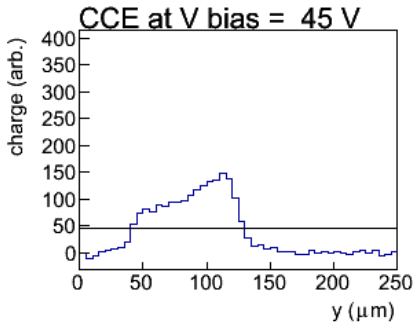


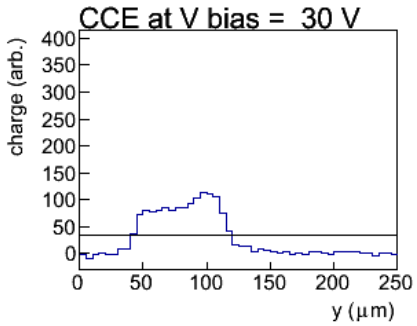


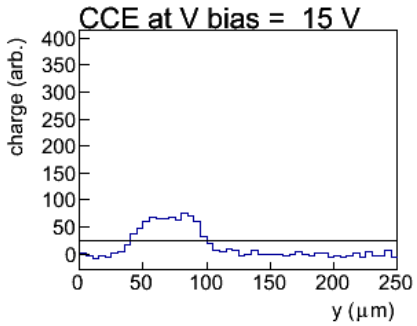


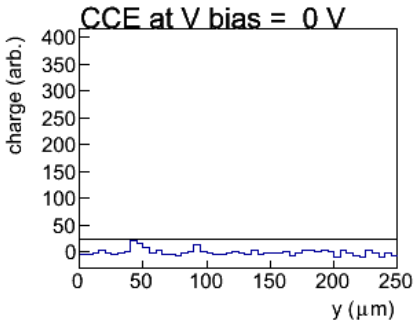




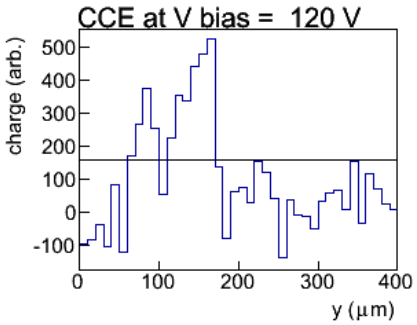


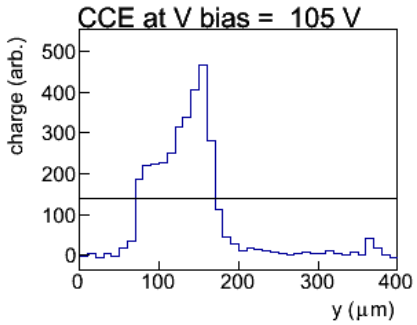


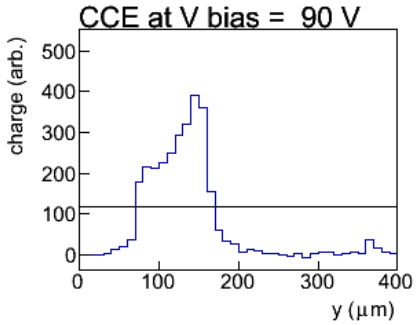


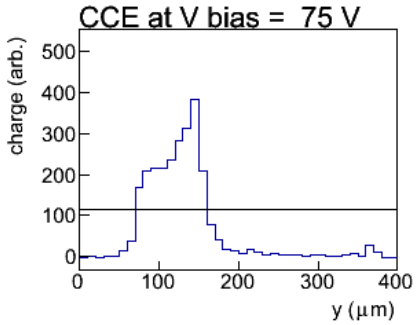


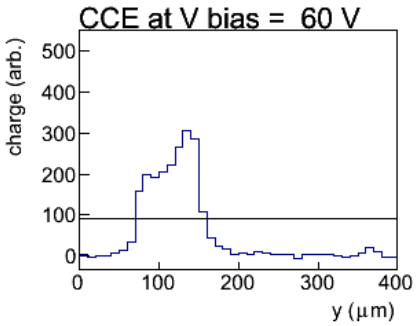
Profiles W19 3e14

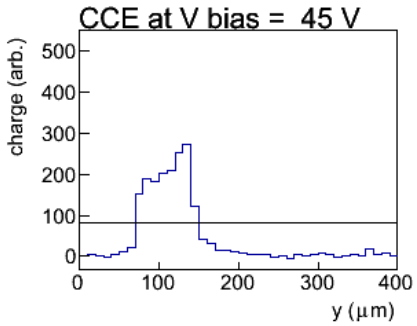


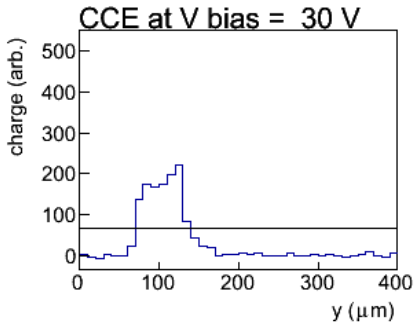


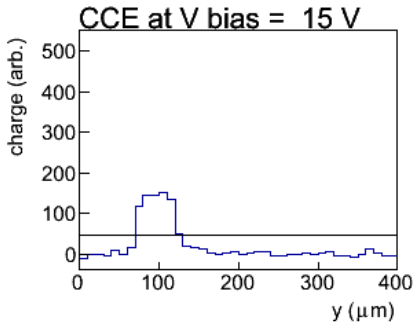


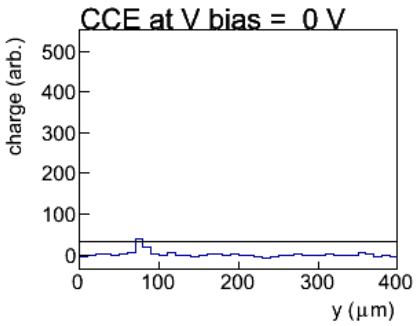




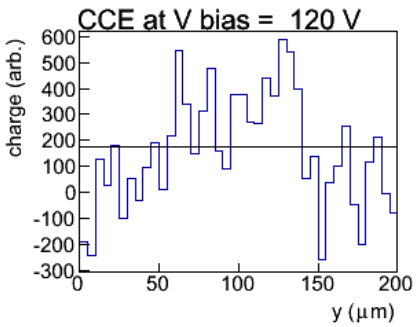


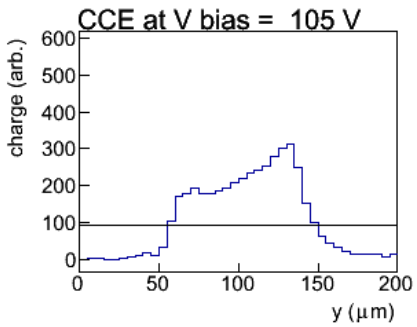


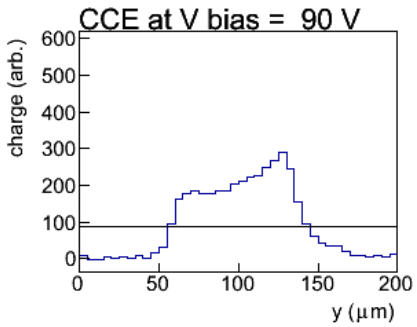


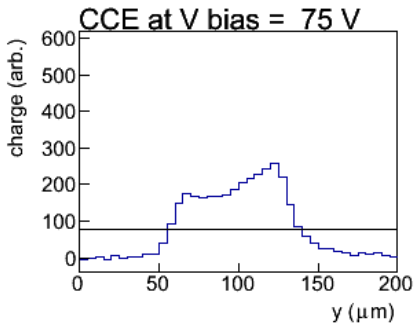


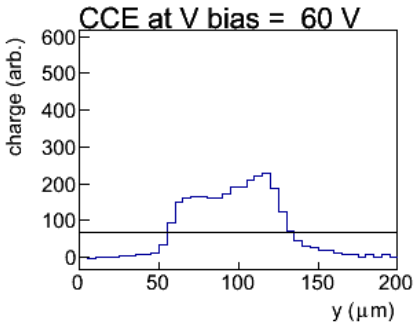
Profiles W19 5e14

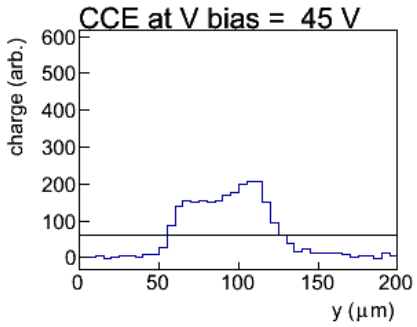


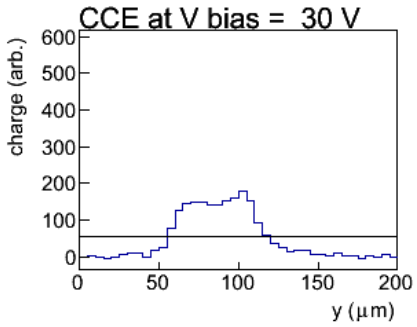


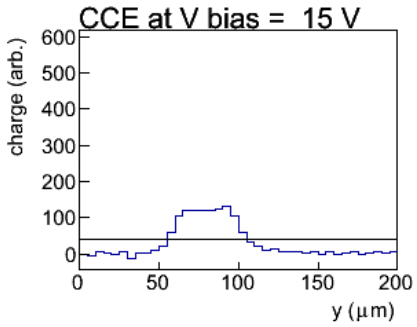


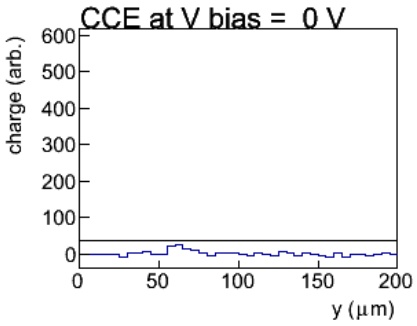












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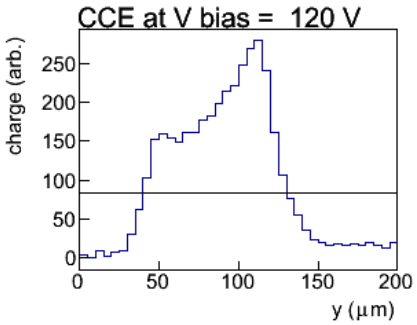

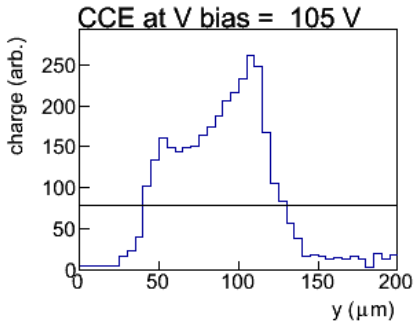

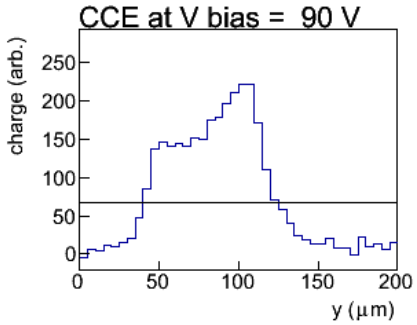

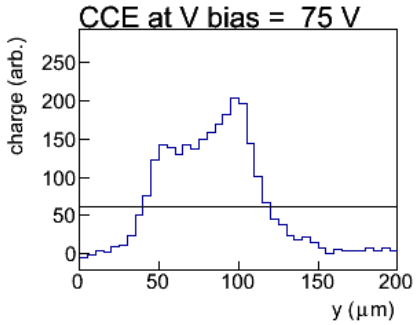

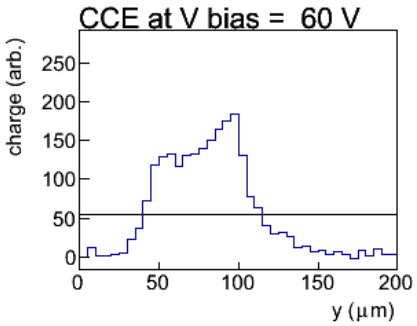

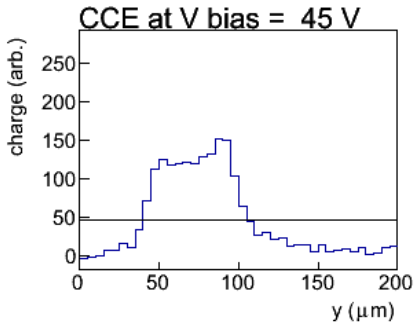

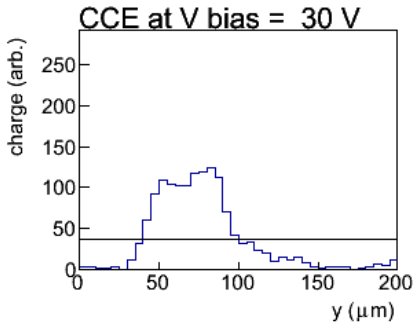

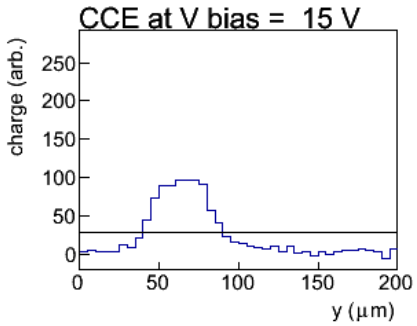

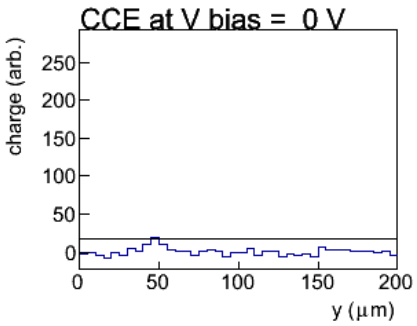

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