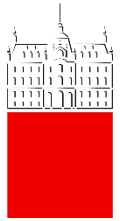
Institut "Jožef Stefan" Ljubljana, Slovenija

Univerza v Ljubljani
Fakulteta za matematiko in fiziko



Update on tests with passive strucutres on CHESS 2 chip

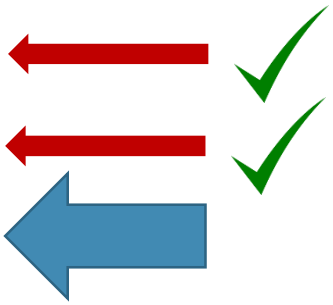
ATLAS Strip CMOS meeting, 06.12.2016

Bojan Hiti, Igor Mandić et al.
Jožef Stefan Institute, Experimental Particle Physics Department (F9)
Ljubljana, Slovenia

Samples

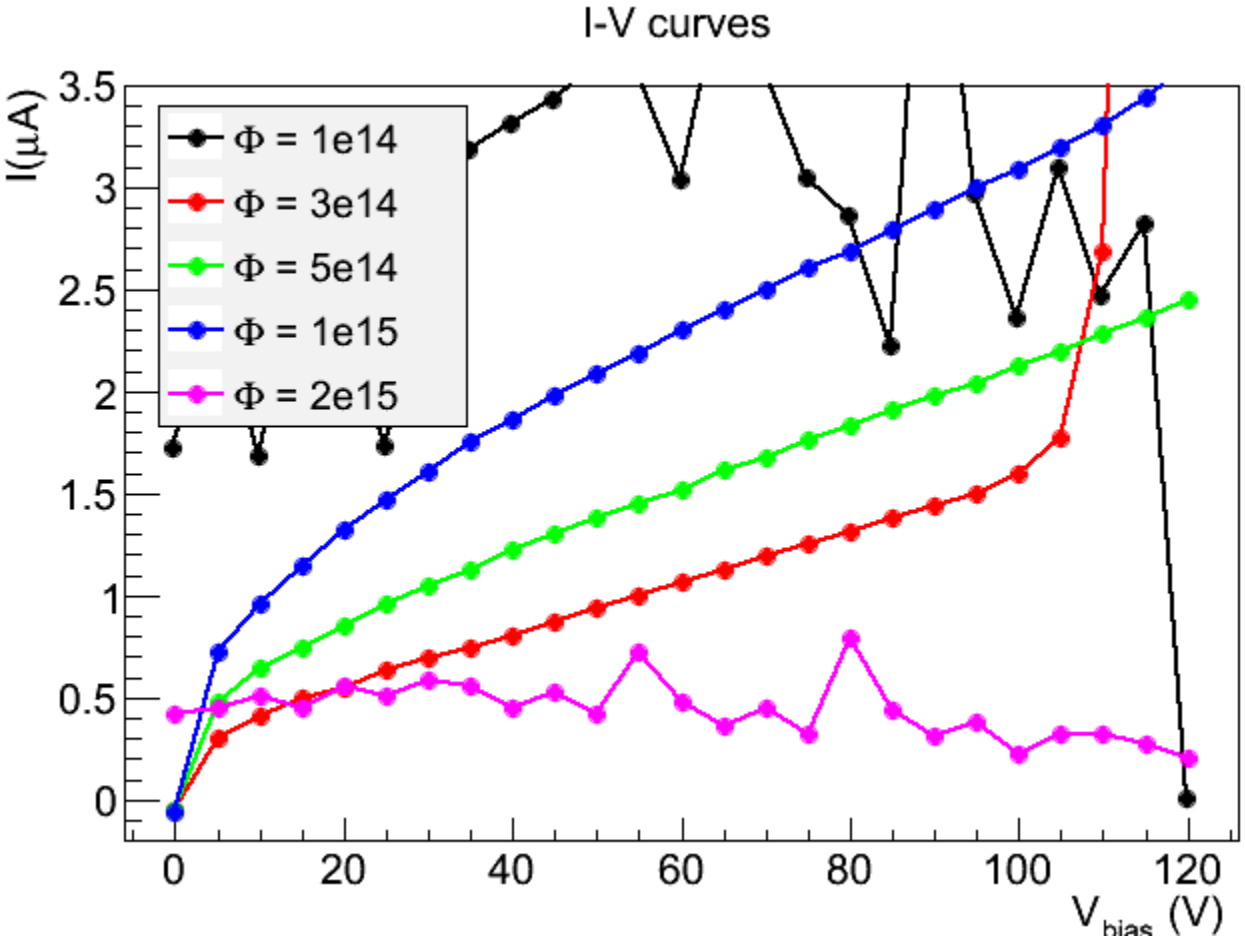
Chips from wafer 19: 600-2000 Ohm-cm

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

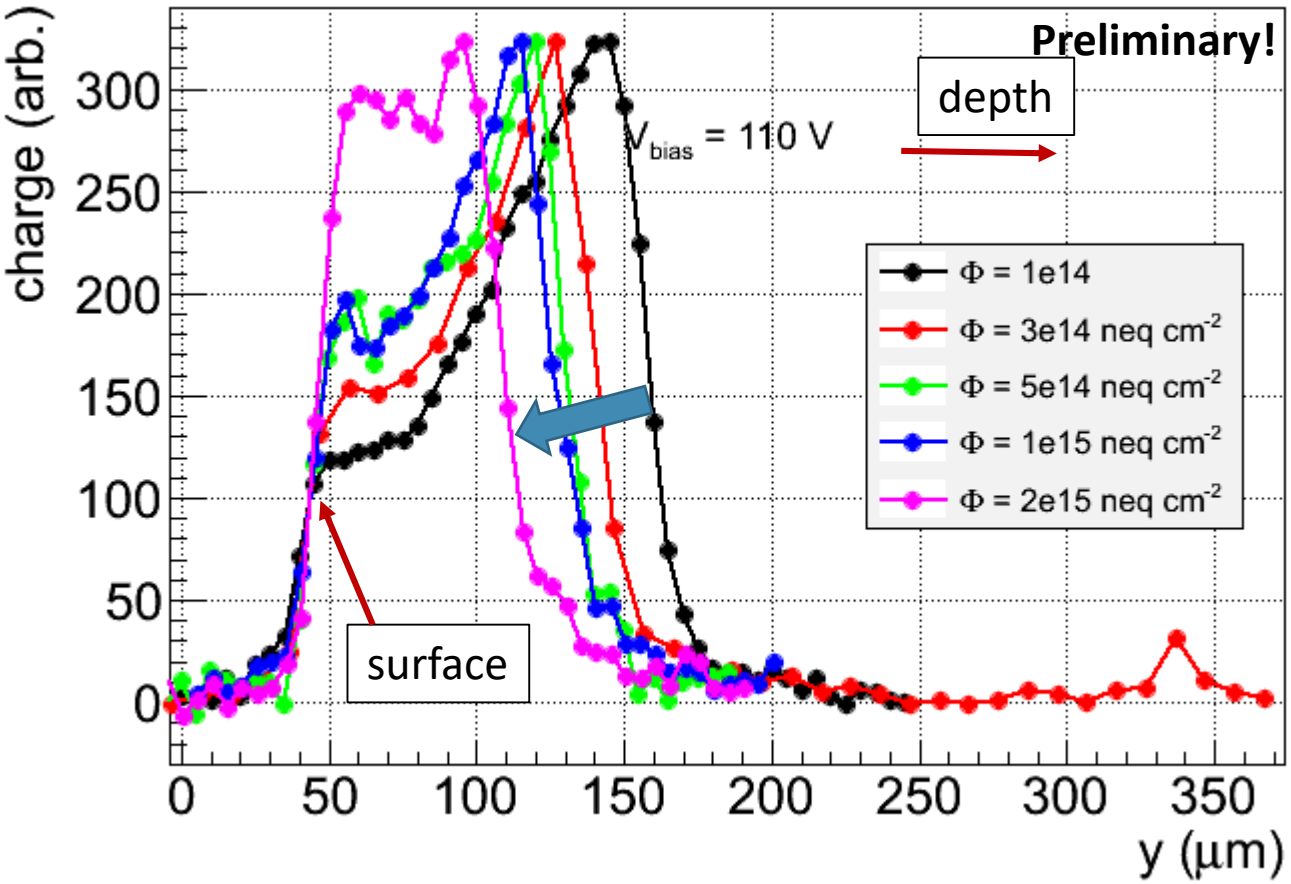


Neutron fluences 0e14, 1e14, 3e14, 5e14, 1e15, 2e15 neq/cm2

W19 I-V curves

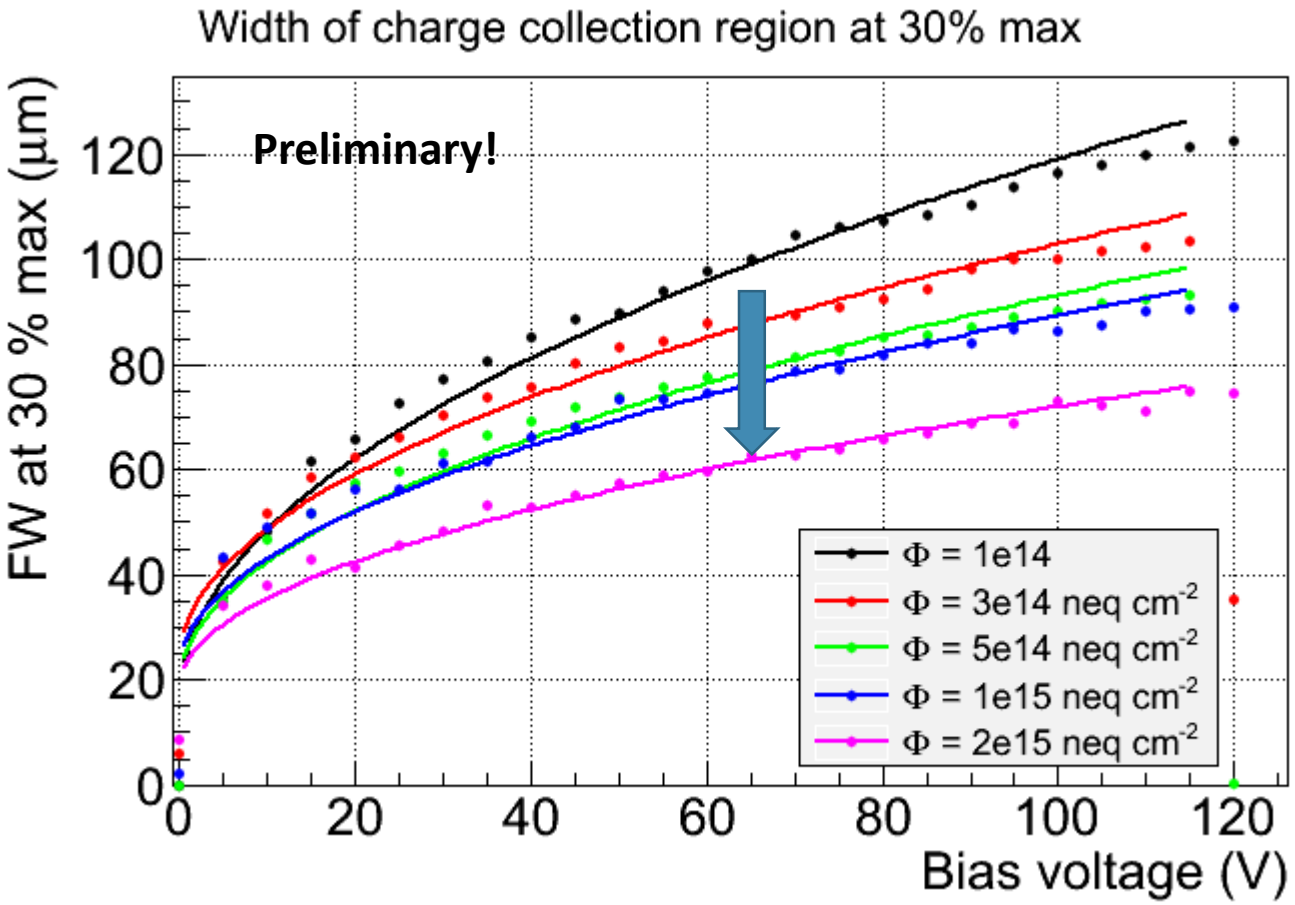


E-TCT Charge collection profiles W19



- Large charge collection width (up to 120 µm)
- High resistivity material → Charge collection width falling monotonously with irradiation (acceptor removal fast)
- Unirradiated sample cannot be biased (breakdown at 18 V – 2 samples)

Depletion depth W19

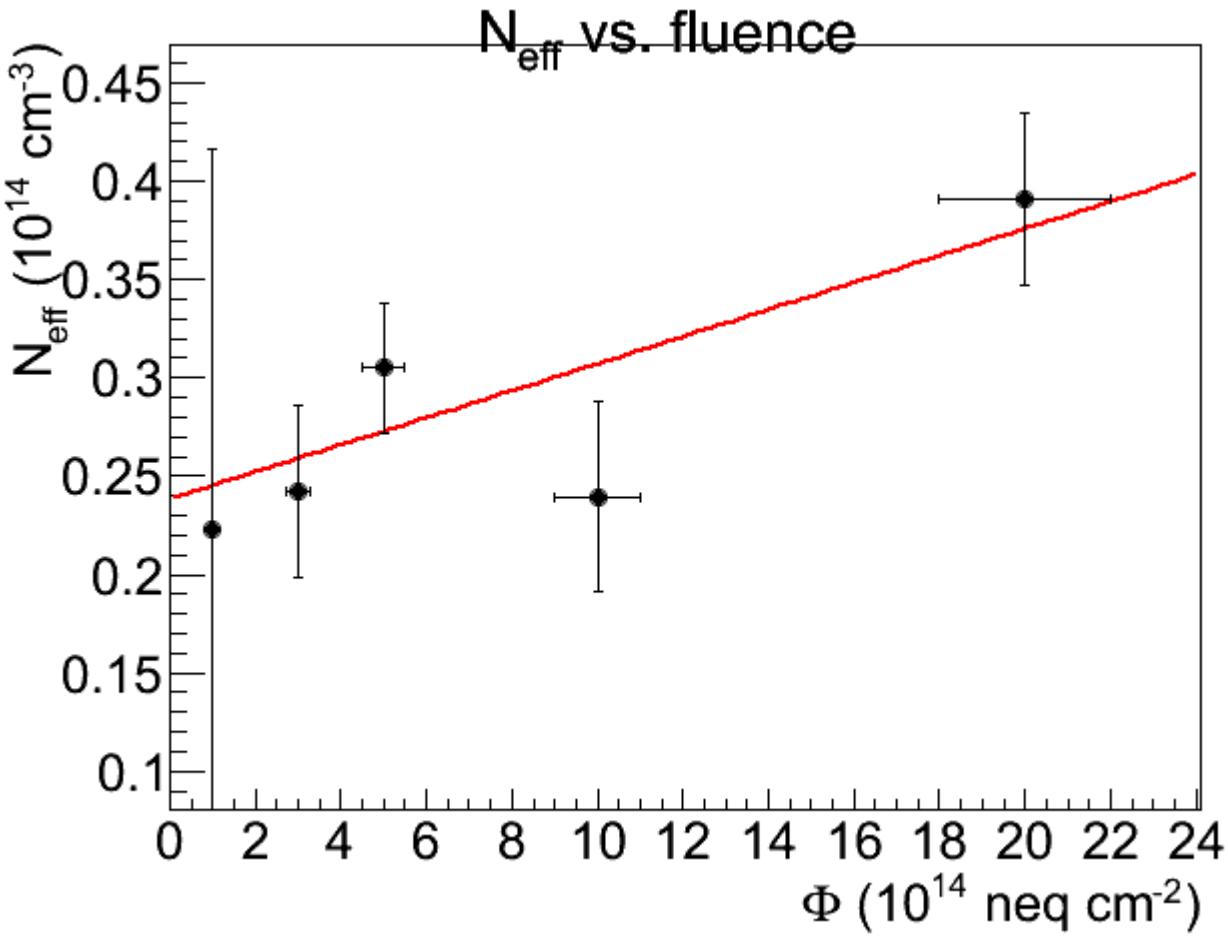


$$Width(V_{\text{bias}}) = w_0 + \sqrt{\frac{2\varepsilon\varepsilon_0}{e_0 N_{\text{eff}}} V_{\text{bias}}}$$

- Sqrt functions falling monotonously with fluence

Neff vs. fluence

- Points still need verification, very preliminary, not correct!

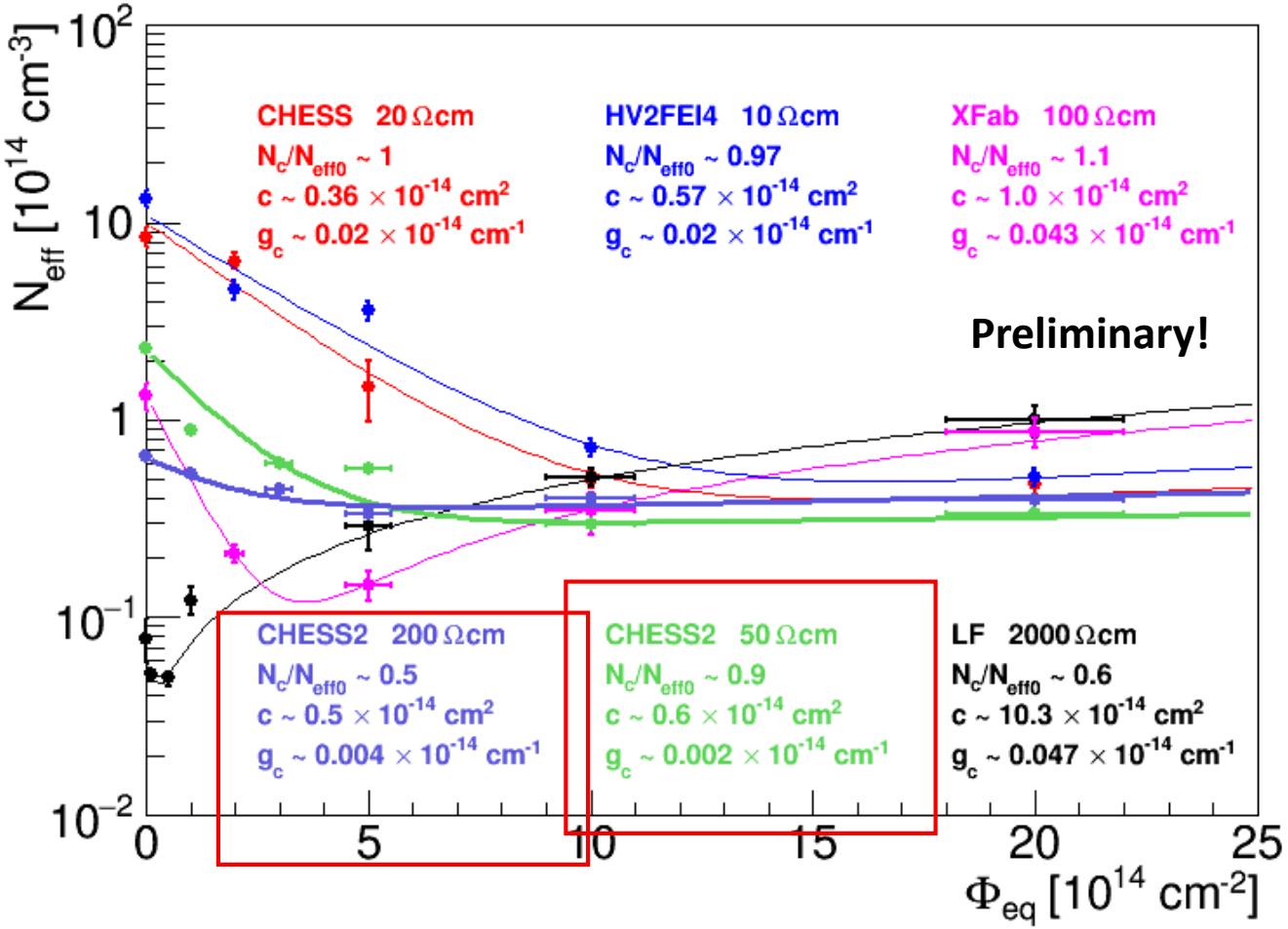


Neff vs. fluence

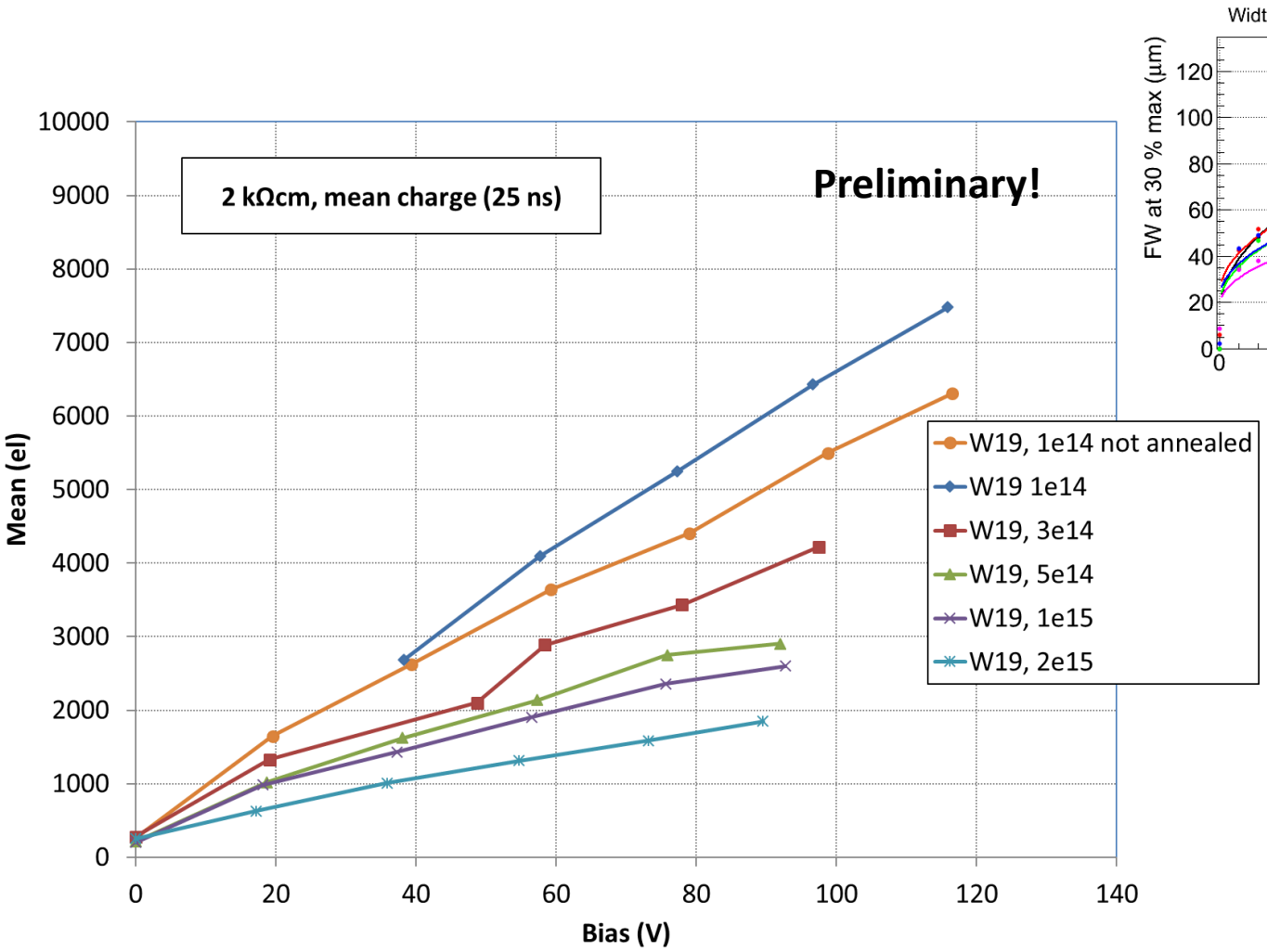
Fit: $$N_{eff} = N_{eff0} - N_c \cdot (1 - \exp(-c \cdot \Phi_{eq})) + g_c \cdot \Phi_{eq}$$

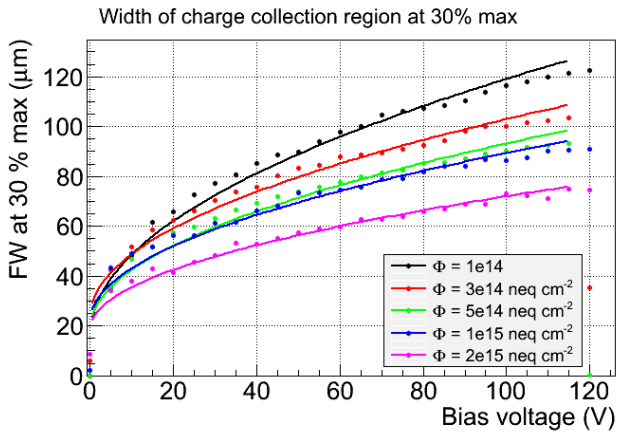
acceptor removal

Radiation introduced deep acceptors



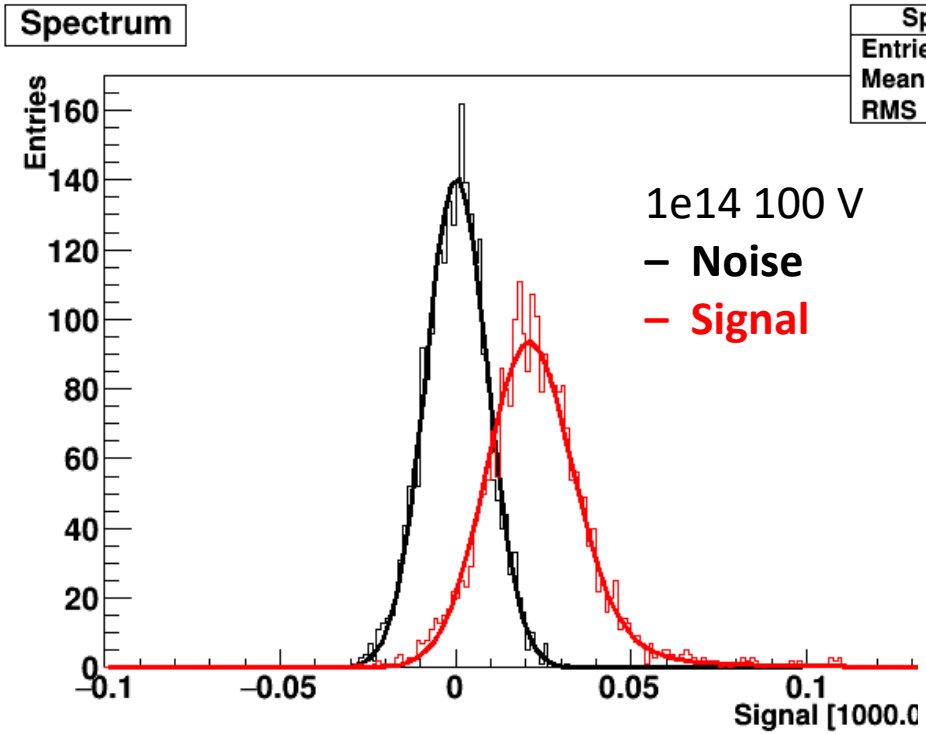
Sr90 charge

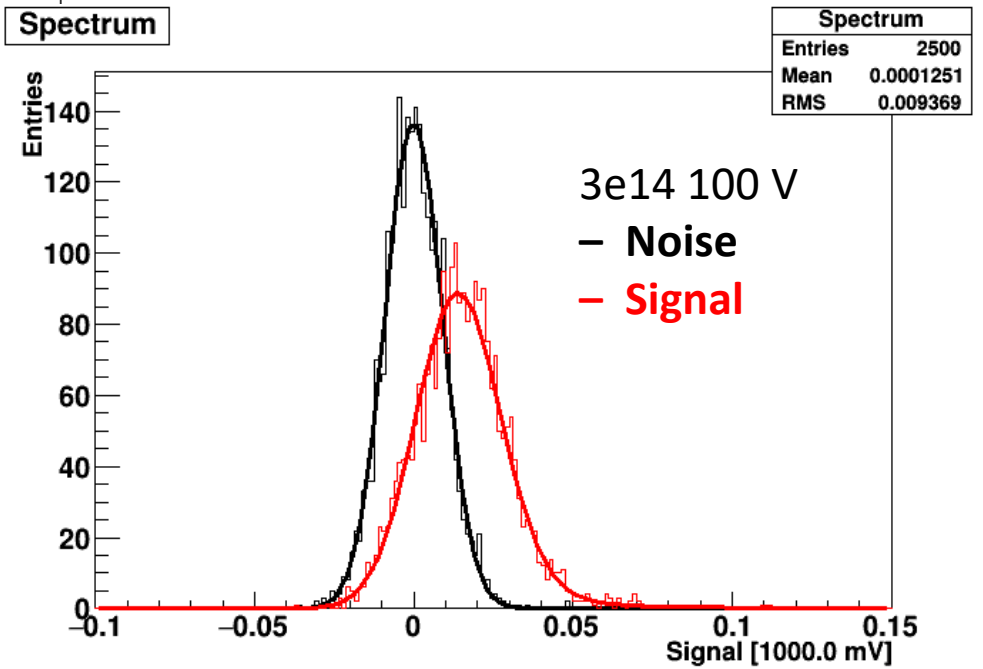




- TCT 1e14: depletion zone 120 um at 100 V
- We still collect less charge than expected (f.e. meas. 7000 e vs. 12000 e expected)
- Investigate with top TCT ?

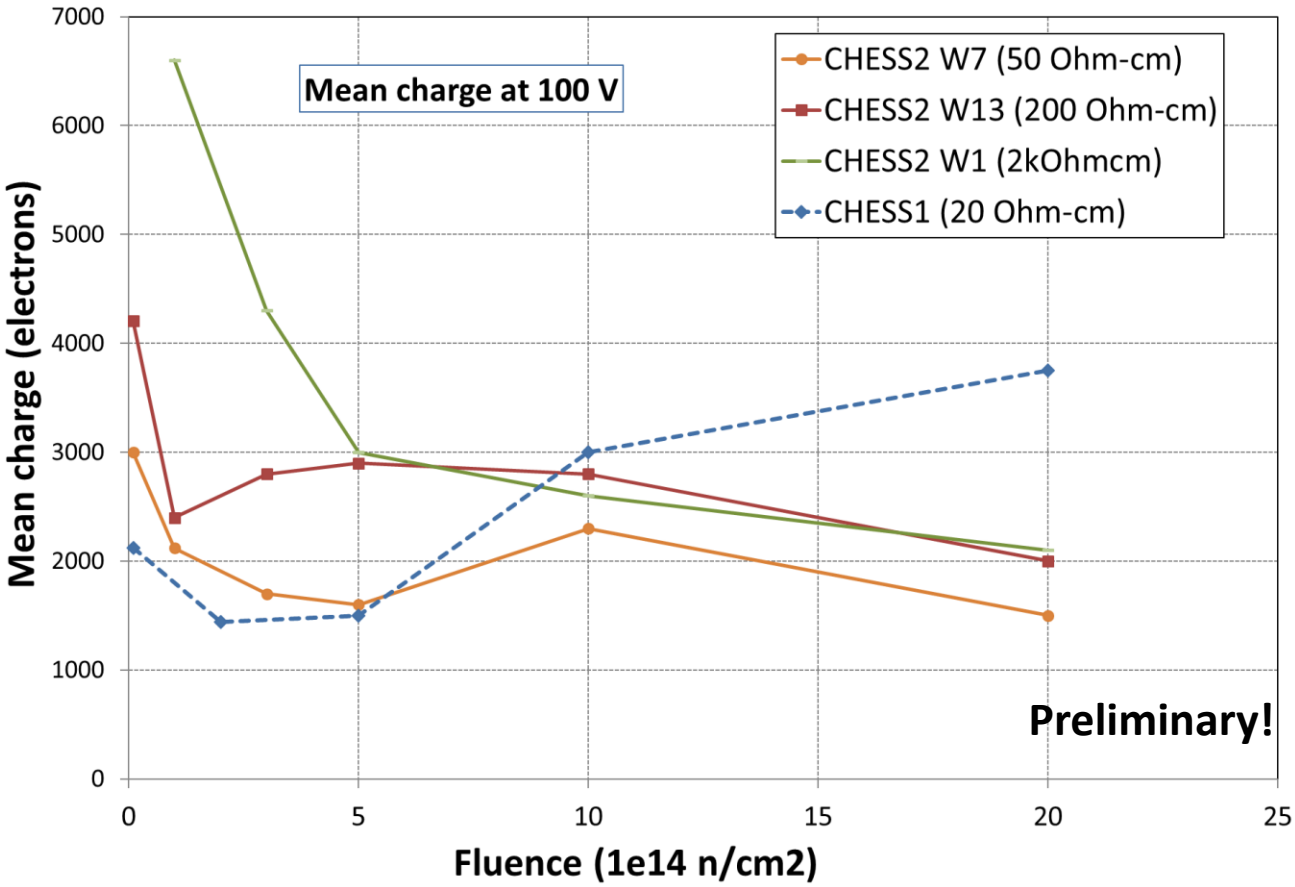
Sr90 spectra W19





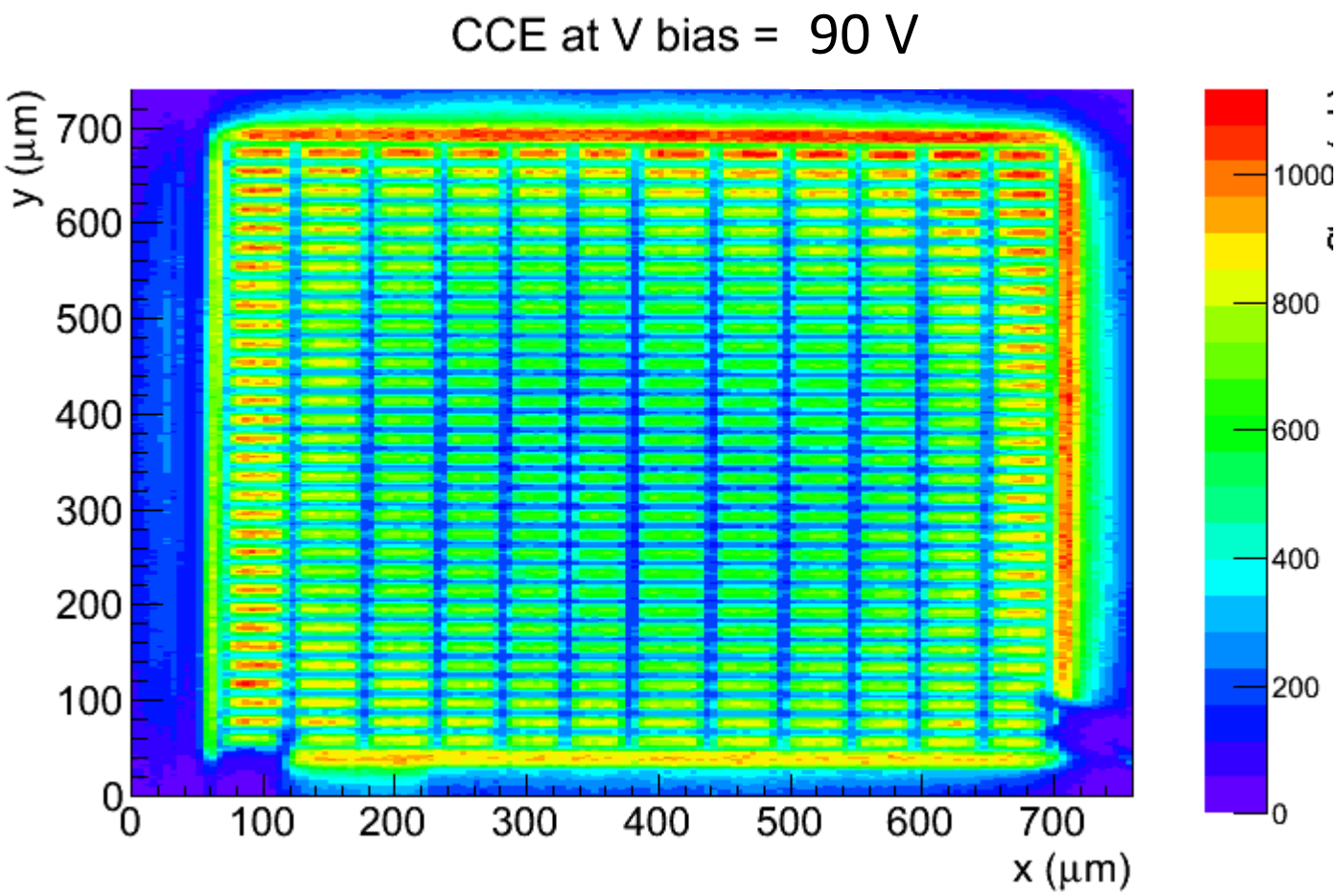
- Relatively good separation between signal and noise
- No peak around 0 in signal spectrum → misalignment does not seem to be the main factor for smaller charge

Sr90 Comparison for different substrates



Top TCT

- Charge from Sr90 measurements systematically only 60 % of that expected for the depletion depth measured by E-TCT
- Top TCT with IR light (abs. depth 1 mm) gives a similar picture as Sr90 measurements

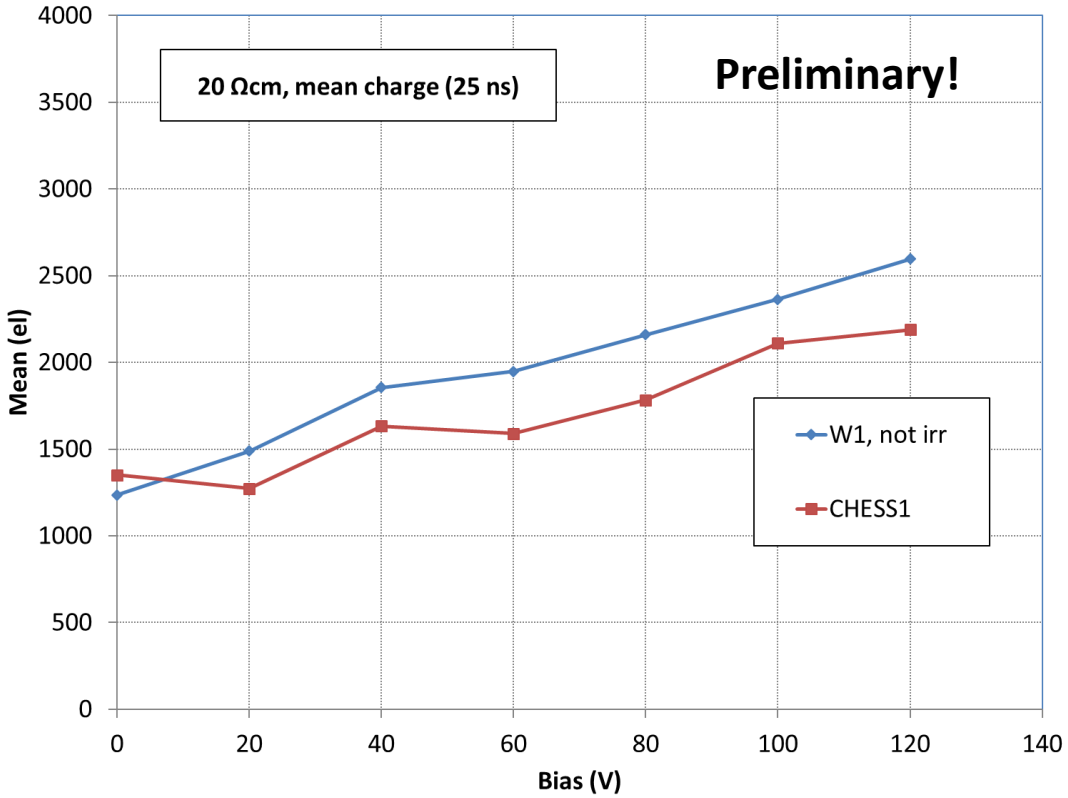


W19 5e14
Big array for Sr90

Less charge collected between pixels

Can this be the reason for lower charge we see with Sr90?

W1 (20 Ohm cm) - flash



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Summary

- Additional series of CHESS2 chips measured with E-TCT and Sr90: 50, 200, 2000 Ohm cm
- No data for unirradiated chips (cannot bias above 18 V)

- E-TCT:
  - Depletion depth reduces with irradiation (as expected)

- Sr90
  - Charge is lower than expected from E-TCT
  - Consistency between 3 different substrate resistivities
  - Top TCT indicates some non-uniformity in the charge collection across the array, might be the source of lower charge

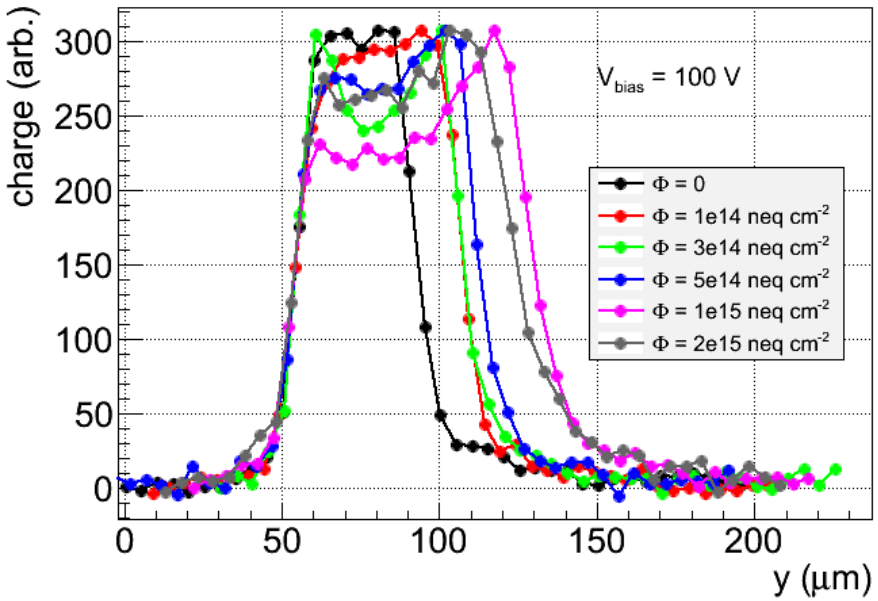
- One more wafer (standard resistivity) to measure in this study

BACKUP

Charge profiles W7, W13

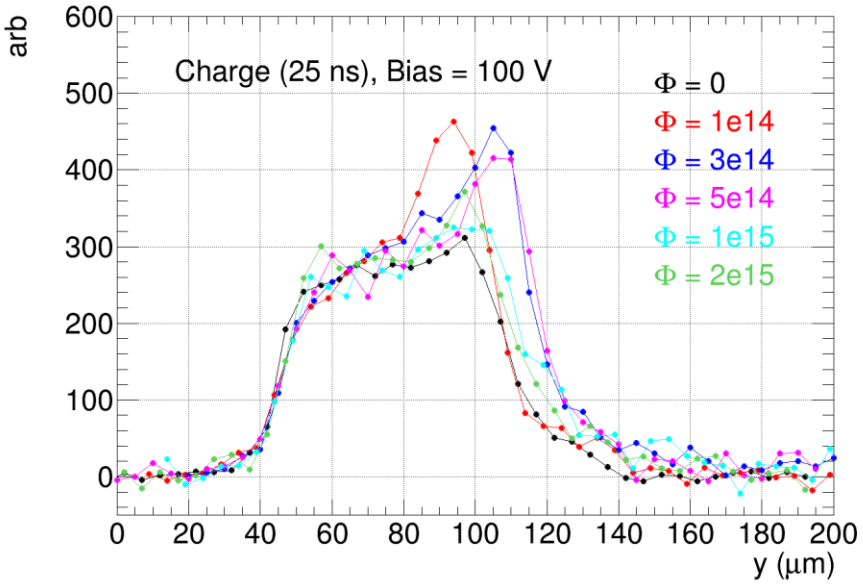
- Edge-TCT charge collection profile across central pixel

W7 (50 Ω·cm)



- increase of width with fluence up to 1e15

W13 (200 Ω·cm)

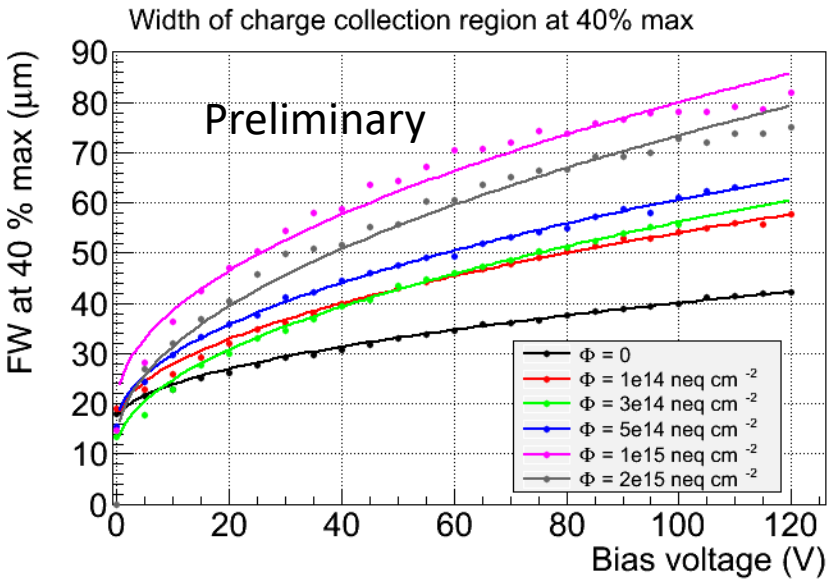


- not much change of profile width with fluence

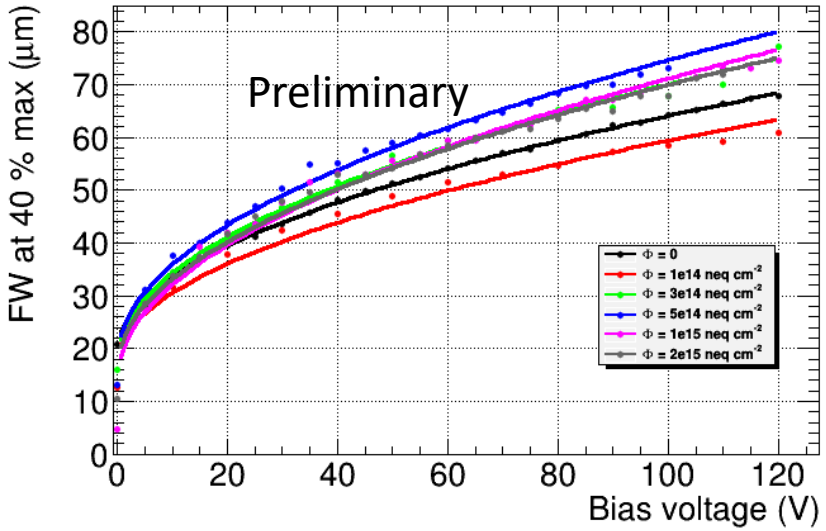
REMINDER Depletion depth W7, W13

- width of charge collection profile vs. bias

W7 (50 Ω·cm)



W13 (200 Ω·cm)



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

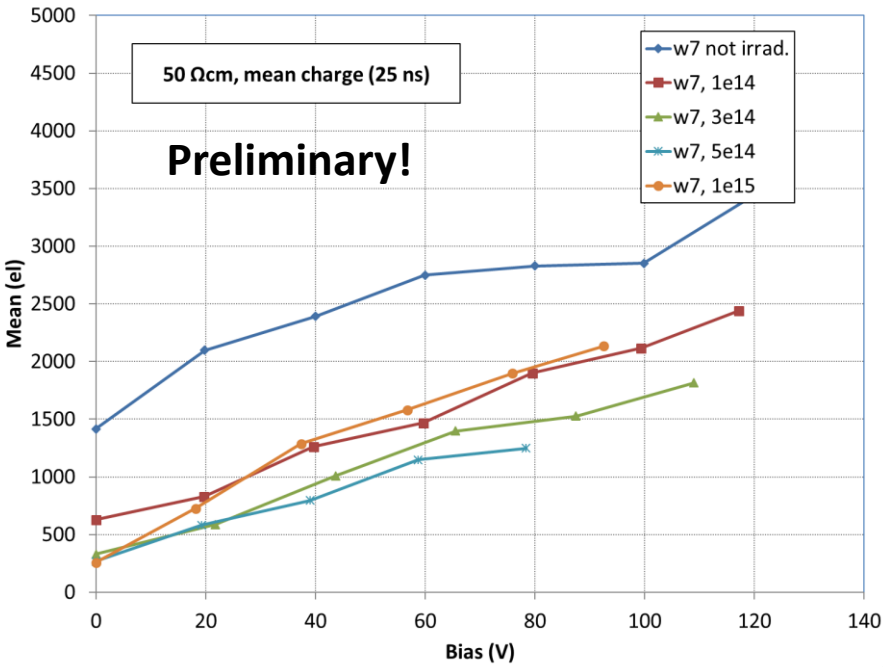
At Φ = 0

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

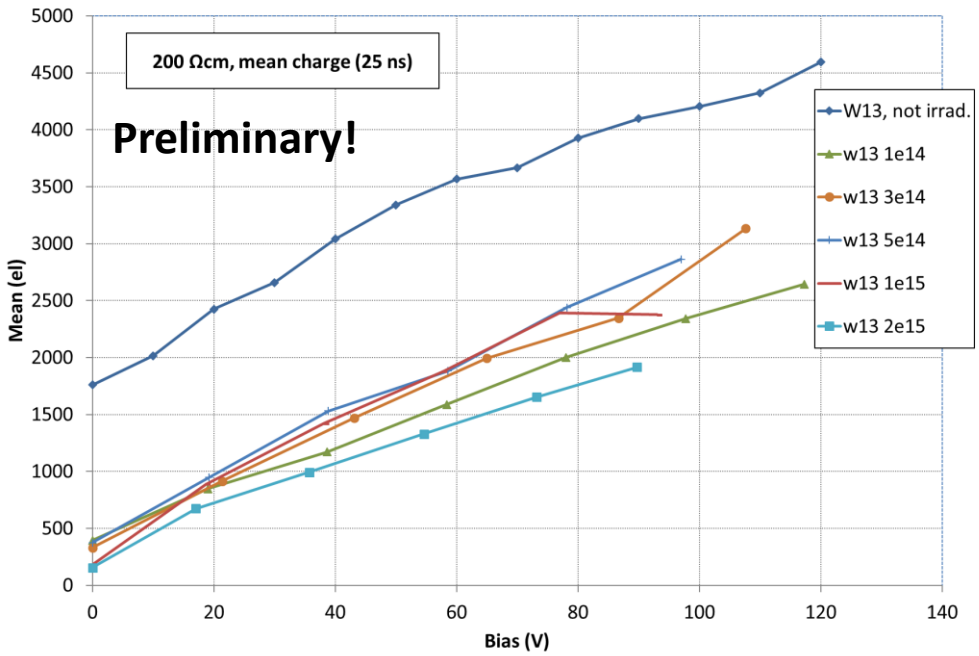
➔ Good fit, good agreement with nominal resistivity

REMINDER Sr90 W7, W13

W7 (50 Ω·cm)

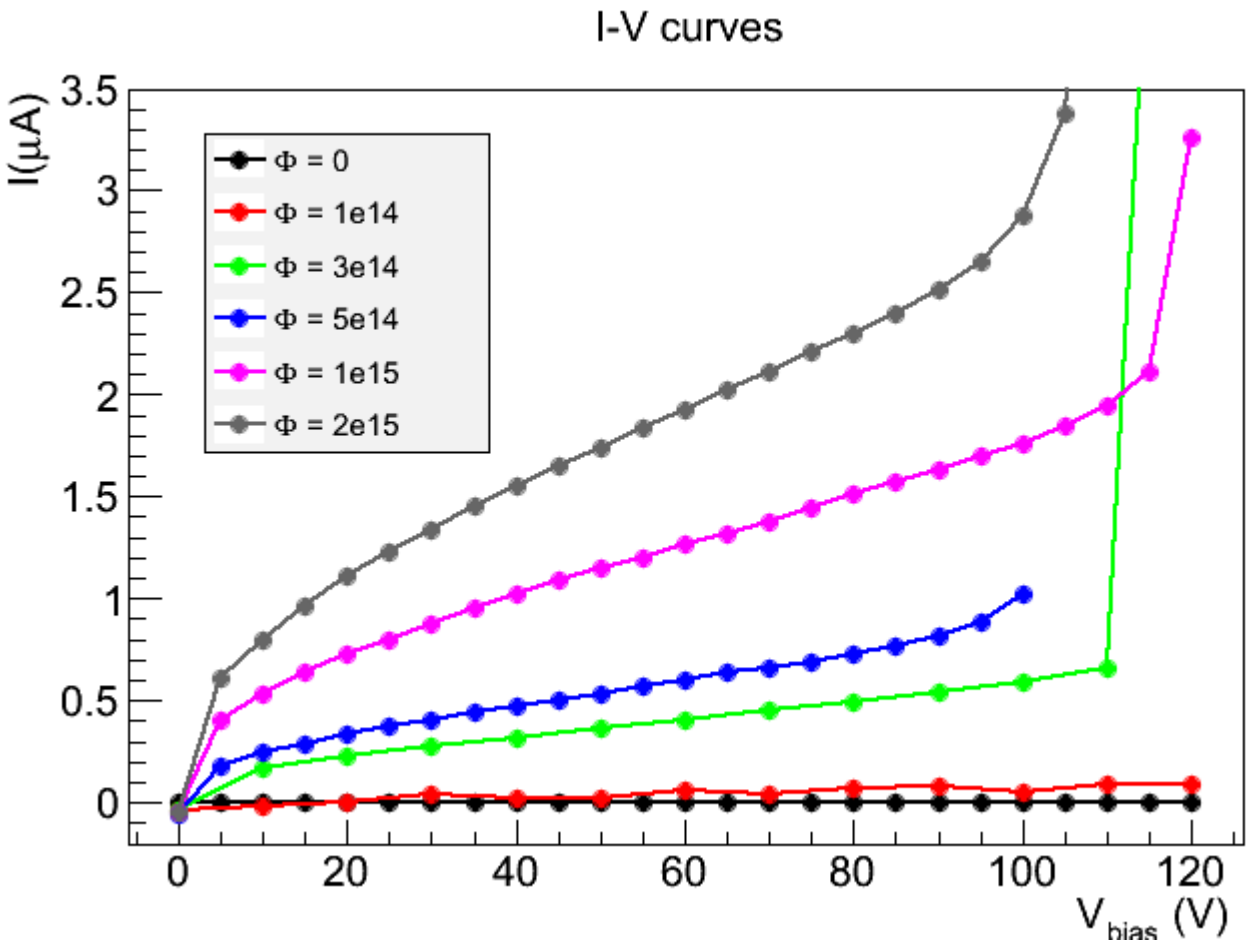


W13 (200 Ω·cm)

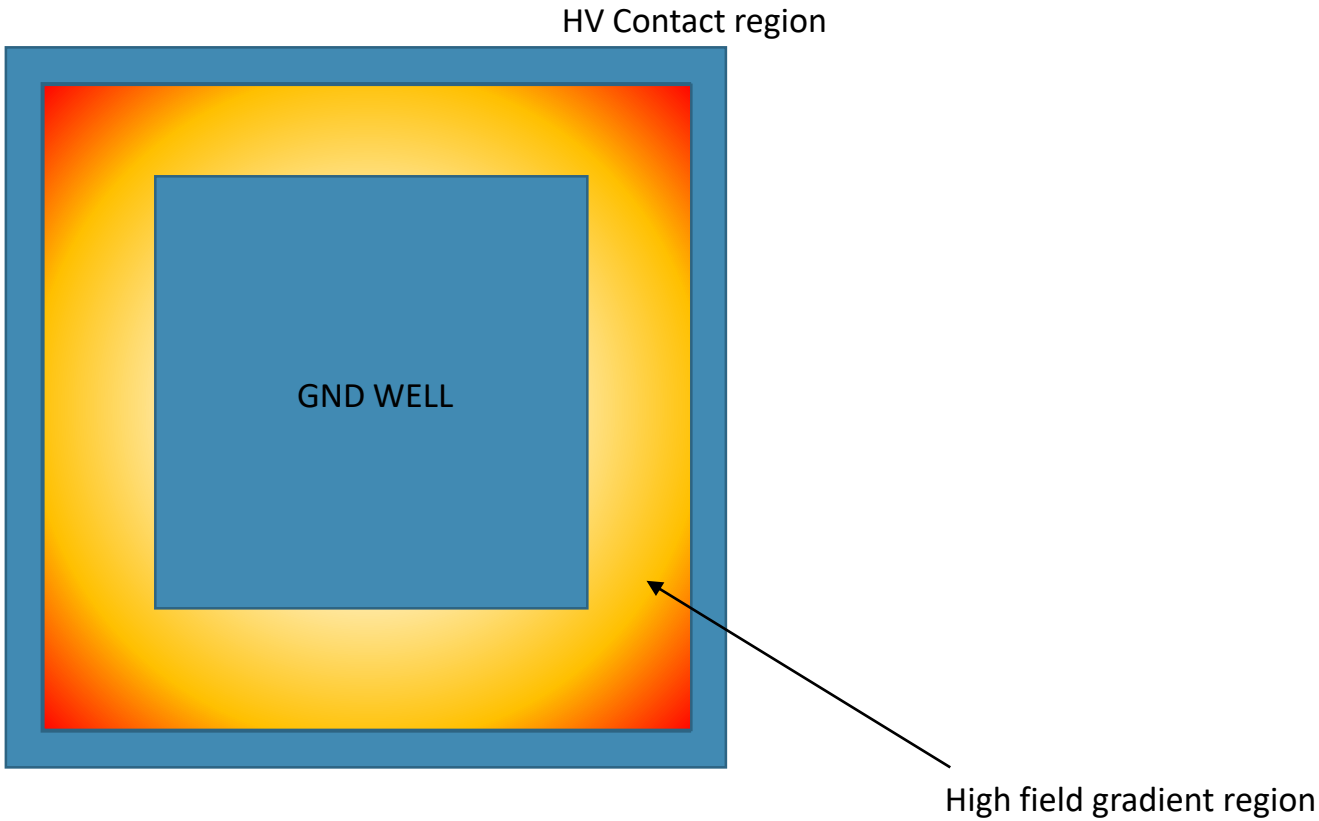


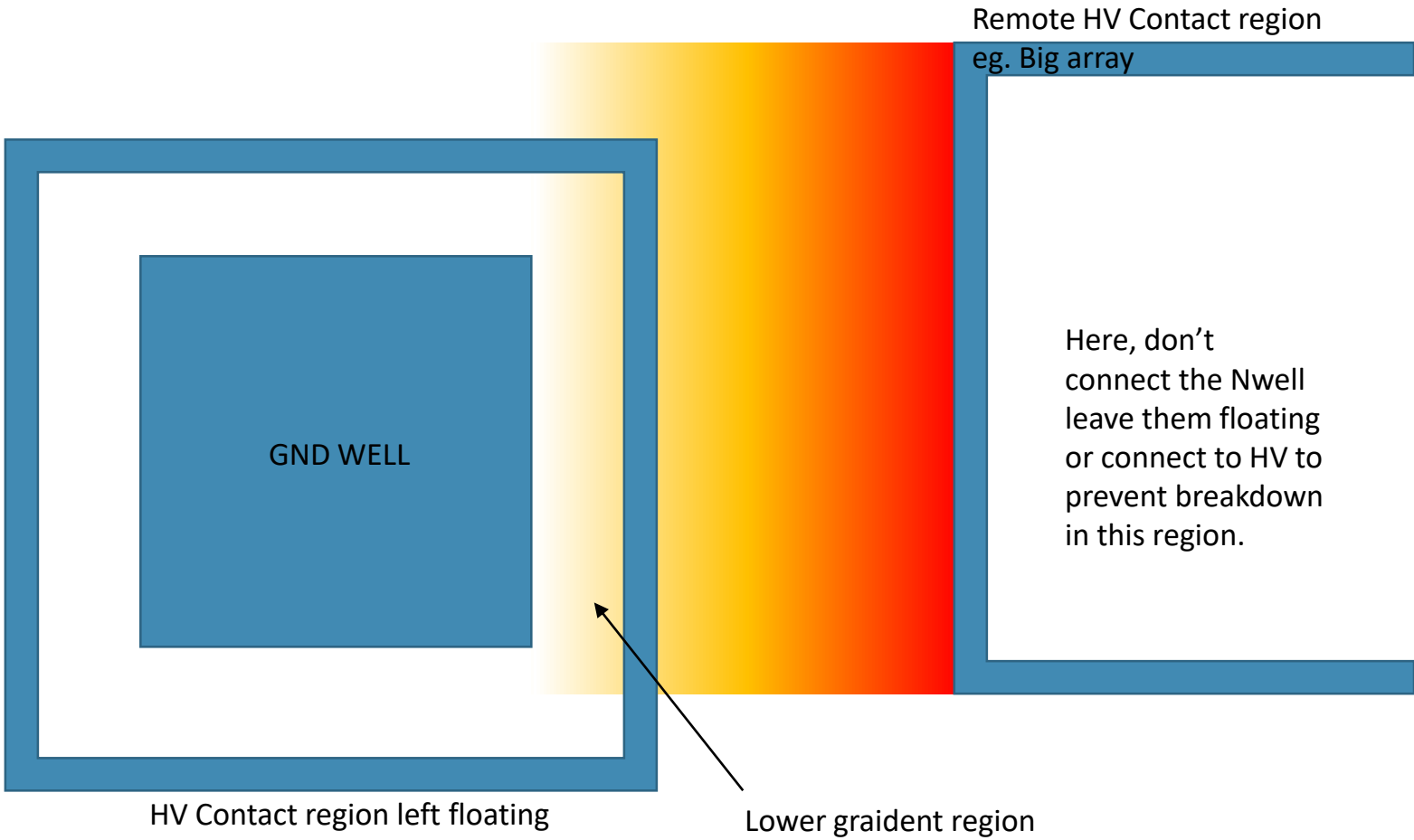
- large drop of collected charge (delta ≈ 1300 el) after first irradiation step to 1e14 n/cm2
  ➔ reduced contribution from diffusion
- TCT measurements indicate depleted region > 50 µm
  - Expect > 5000 el. from drift
  - Measure 2000 el.

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

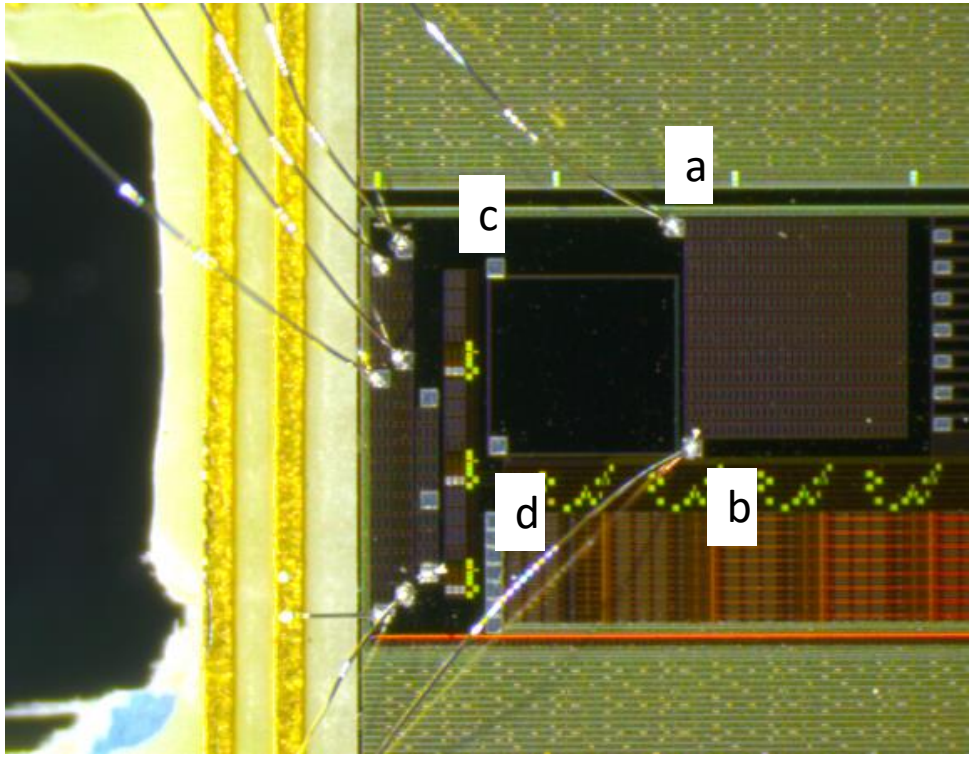

HV Contact region
GND WELL
High field gradient region


Remote HV Contact region
eg. Big array
GND WELL
Here, don't
connect the Nwell
leave them floating
or connect to HV to
prevent breakdown
in this region.
HV Contact region left floating
Lower graident region

High resistivity wafers

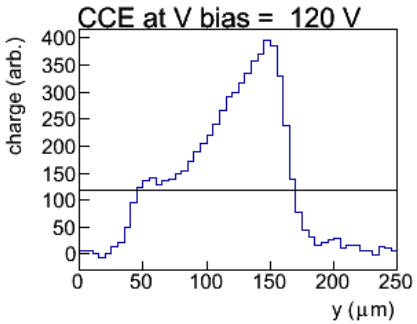
- After suggestion from Santa Cruz tried biasing the substrate from other pads:
  - a & d → breakdown at 18 V
  - a & b → breakdown at 18 V
  - c & d → breakdown at 1 V
  - c & b → breakdown at 1 V

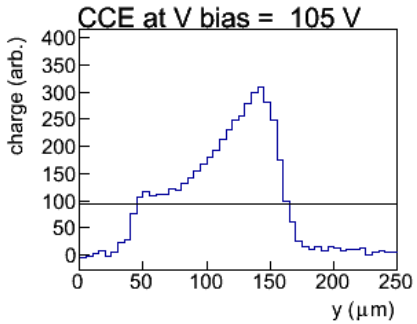
Planning also to measure IV of irradiated devices on probe station to see if there is improvement after irradiation

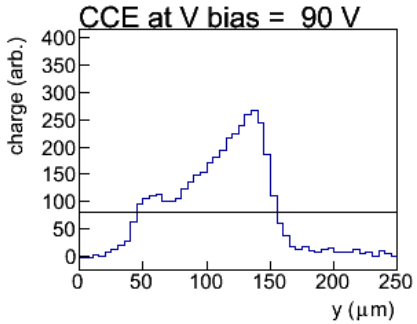


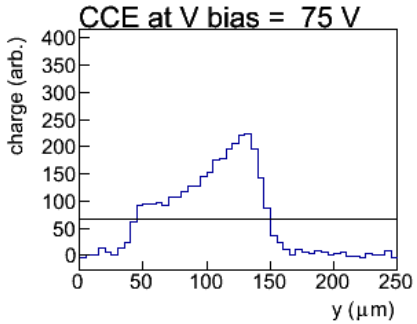
a – LPA nwells
b – LPA substrate
c – Large Pad nwells
d – Large Pad substrate

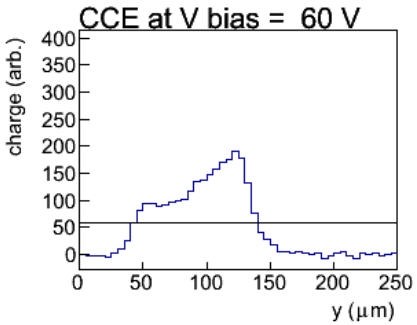
Profiles W19 1e14

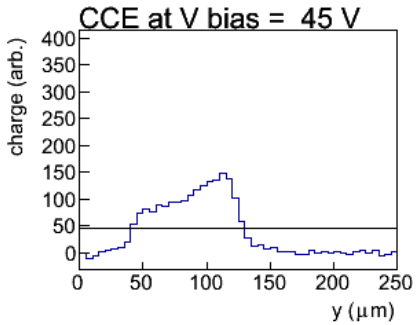


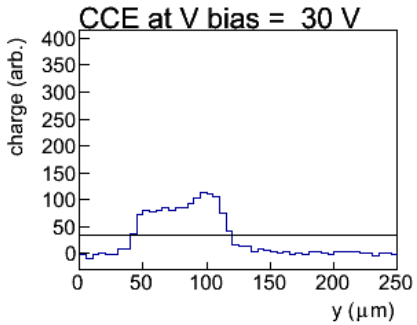


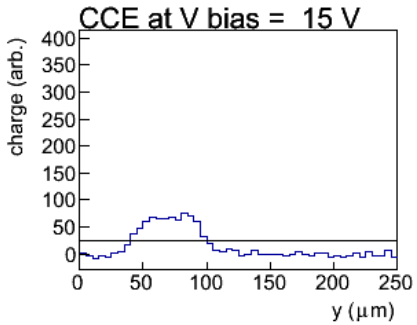


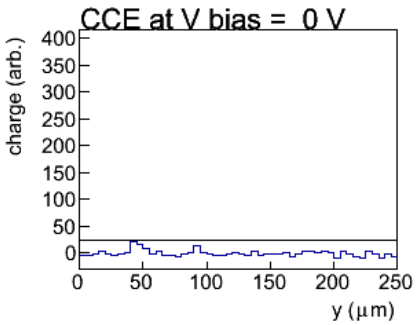




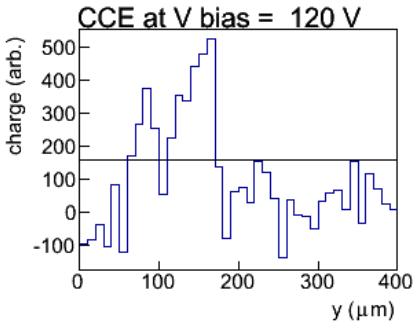


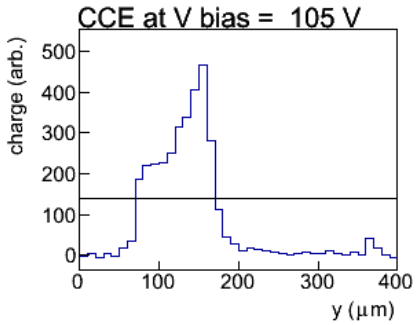


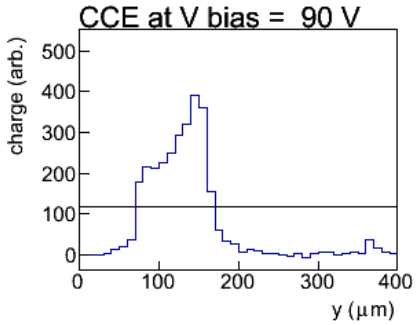


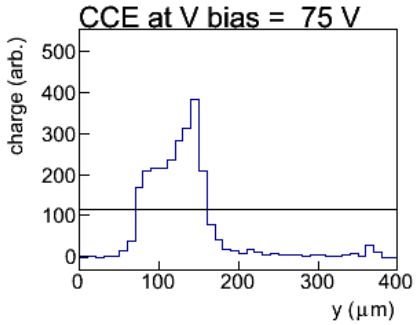


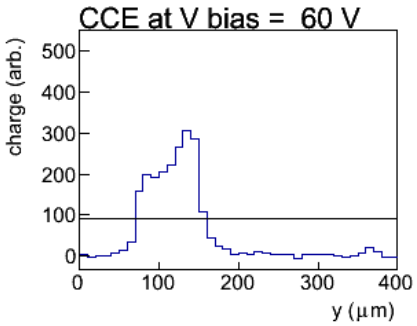
Profiles W19 3e14

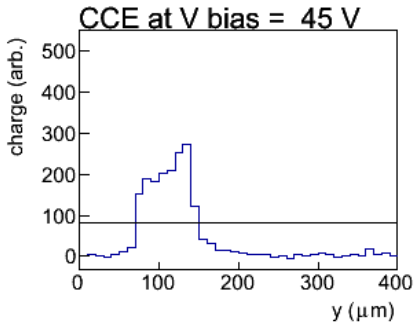


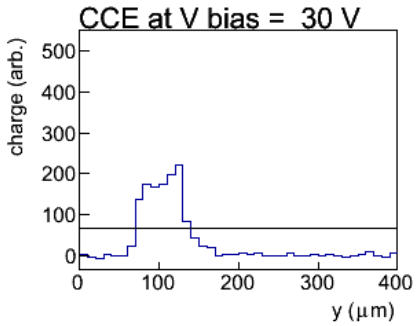


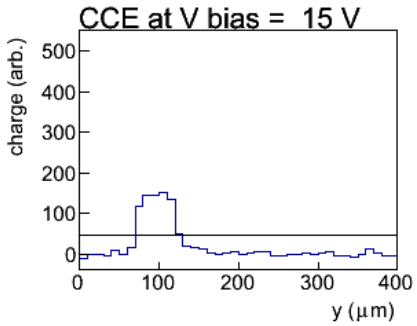


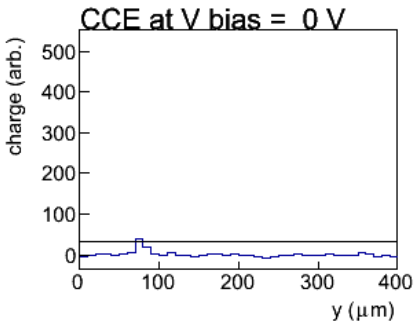




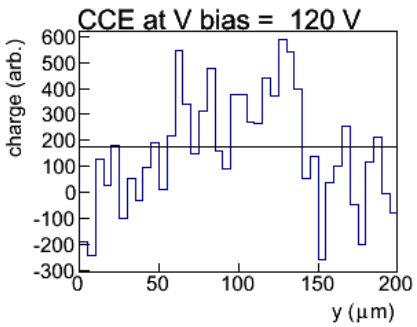


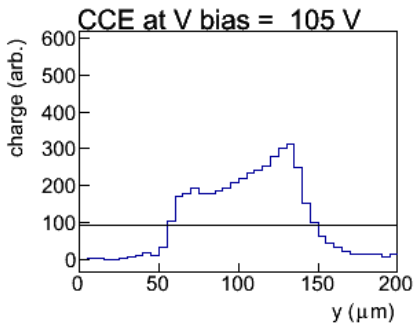


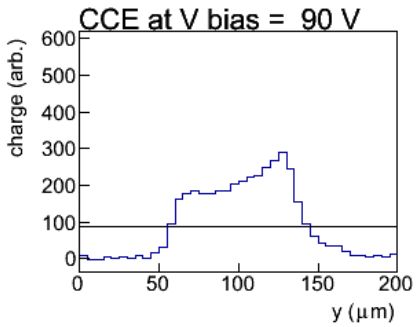


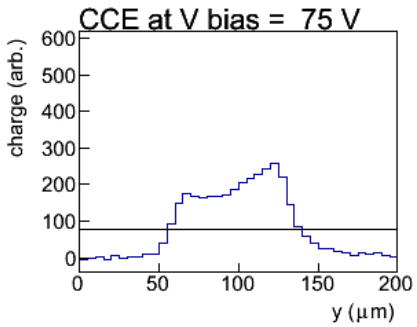


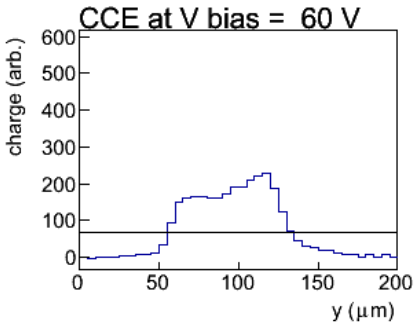
Profiles W19 5e14

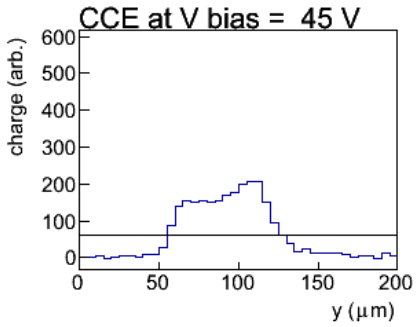


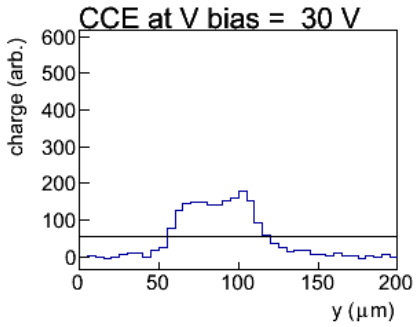


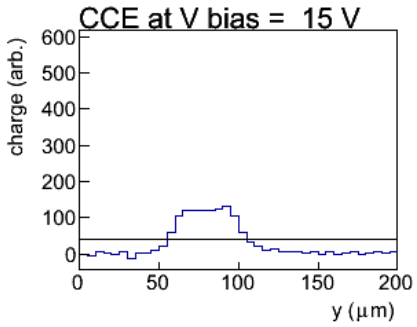


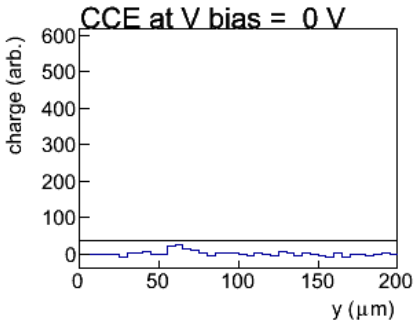




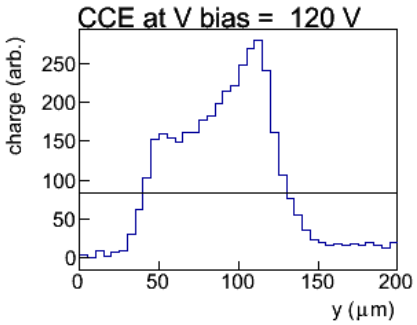


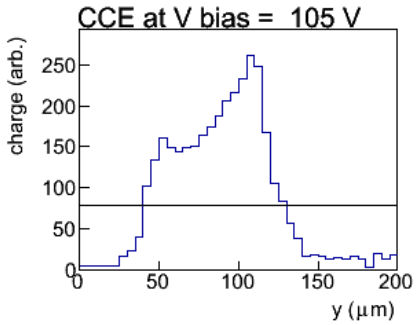


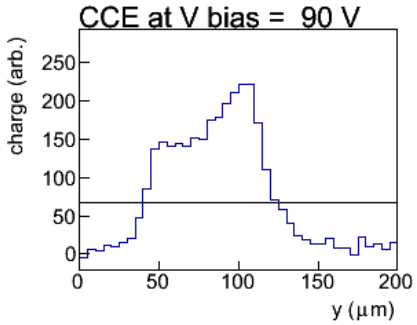


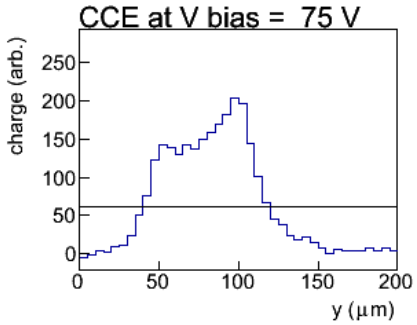


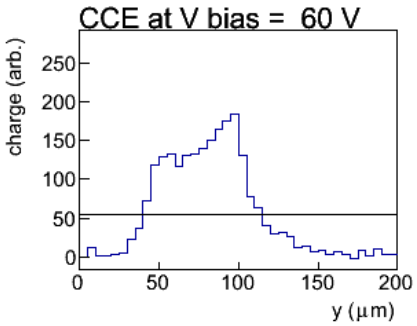
Profiles W19 1e15

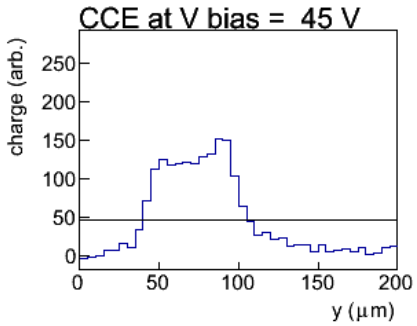


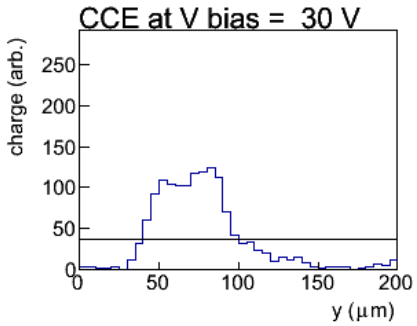


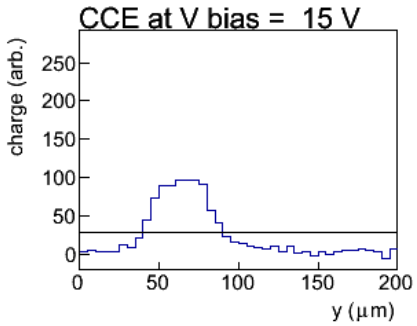


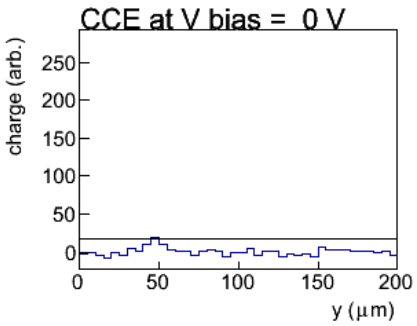












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