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Update on tests with passive strucutres on CHESS 2 chip

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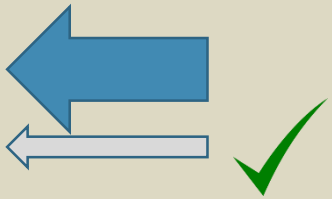
Samples

Chips from wafer 7: 50-100 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



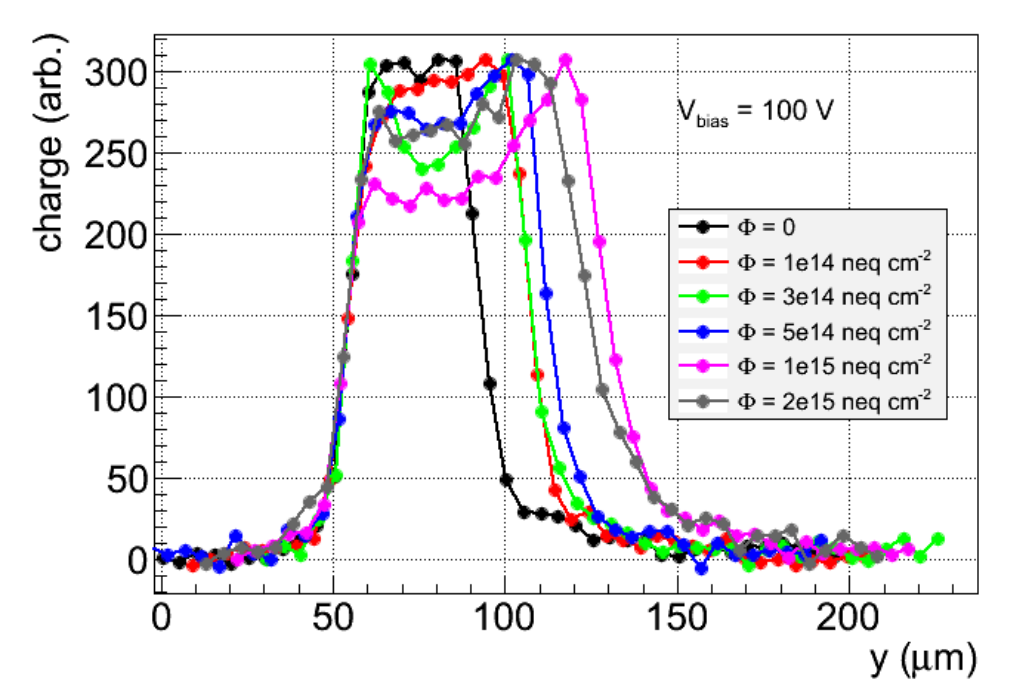
W13 already measured
(Igor‘s talk 8.11.)

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

Charge collection profiles

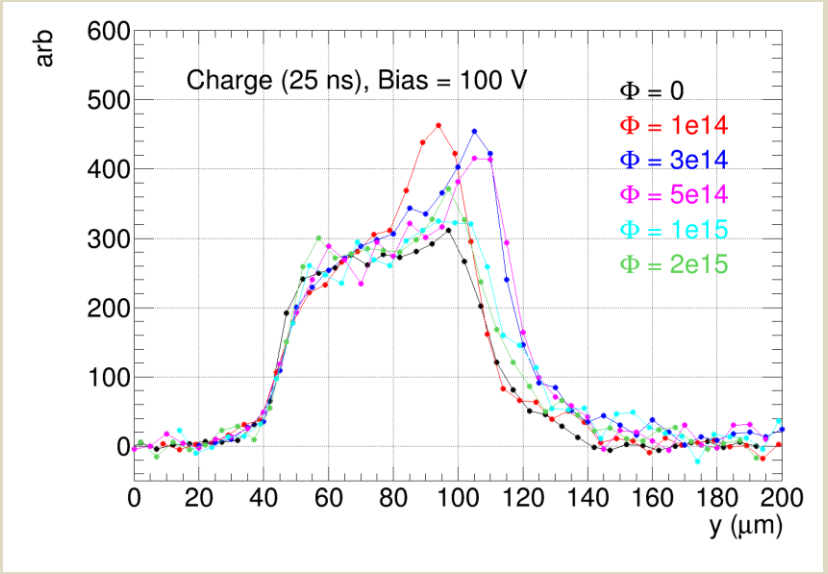
- Edge-TCT charge collection profile across central pixel

W7 (50 Ω·cm)



- increase of width with fluence up to 1e15

W13 (200 Ω·cm)

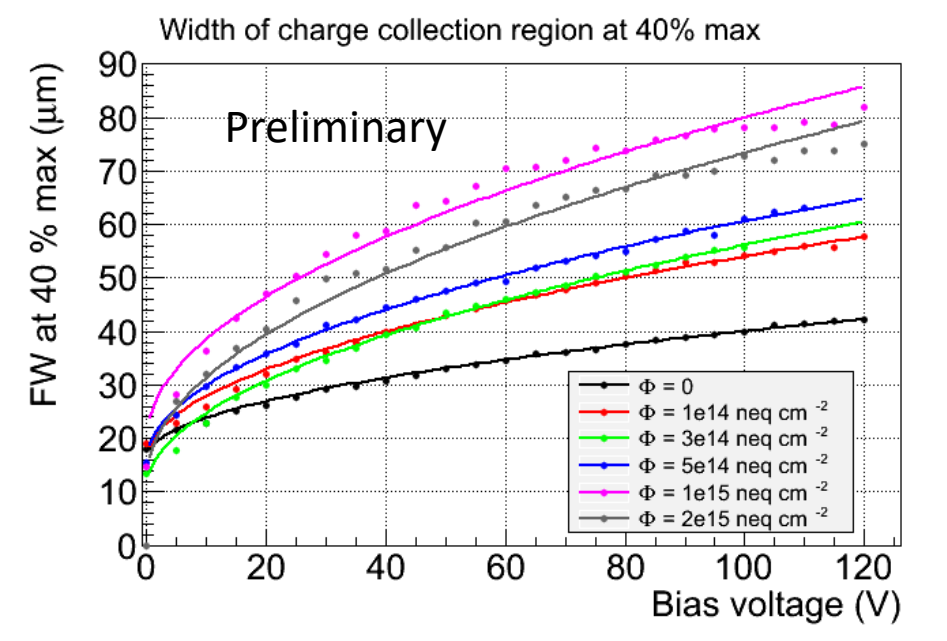


- not much change of profile width with fluence

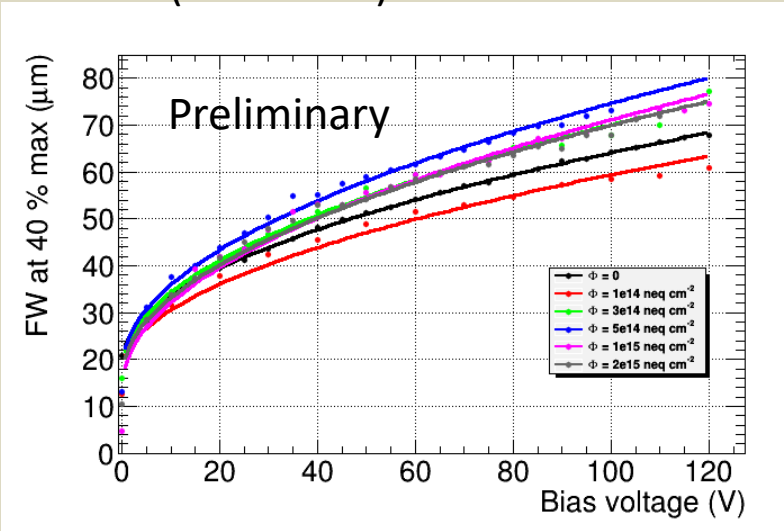
Depletion depth

- 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

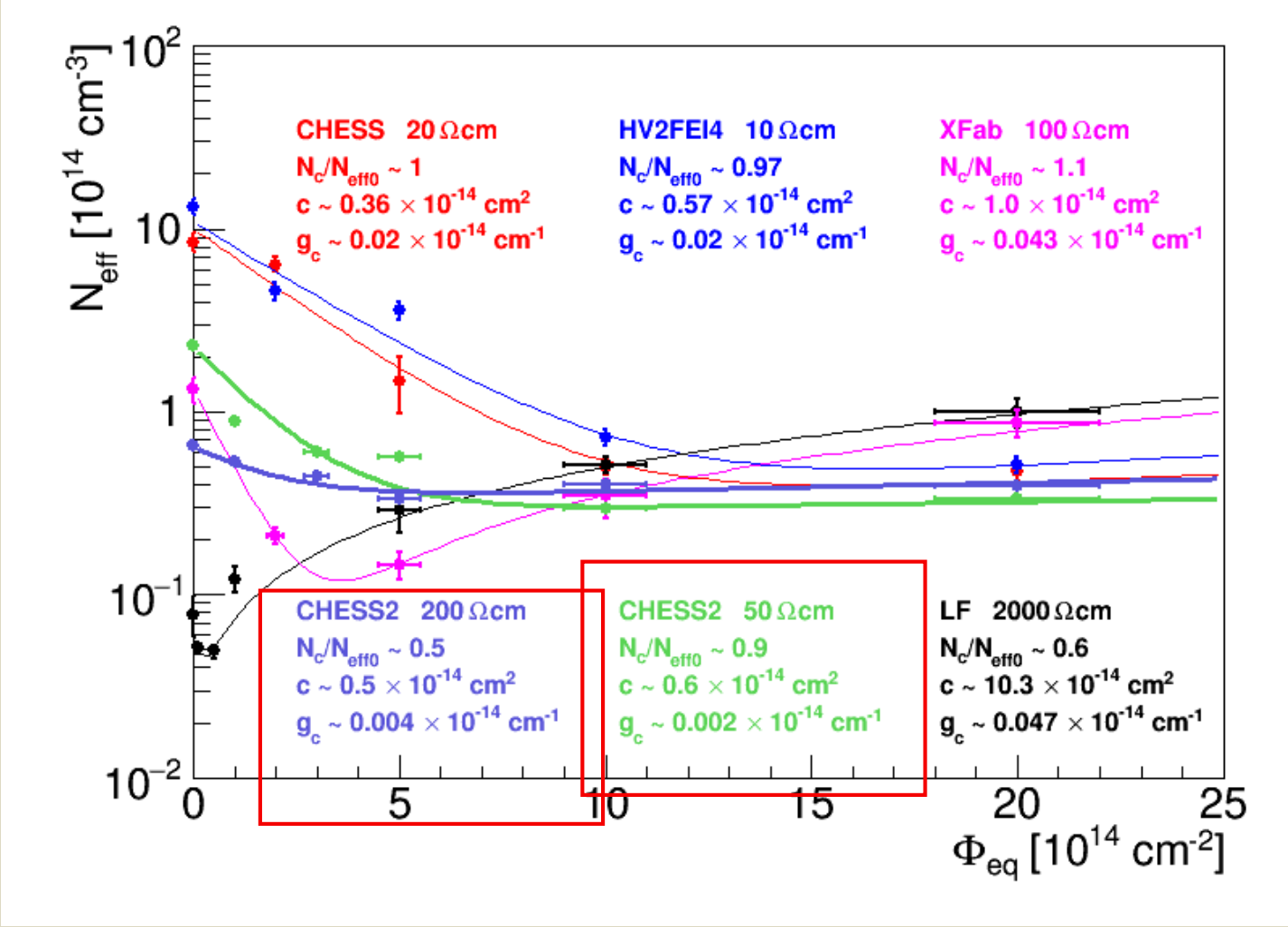
→ Good fit, good agreement with nominal resistivity

Neff vs. fluence

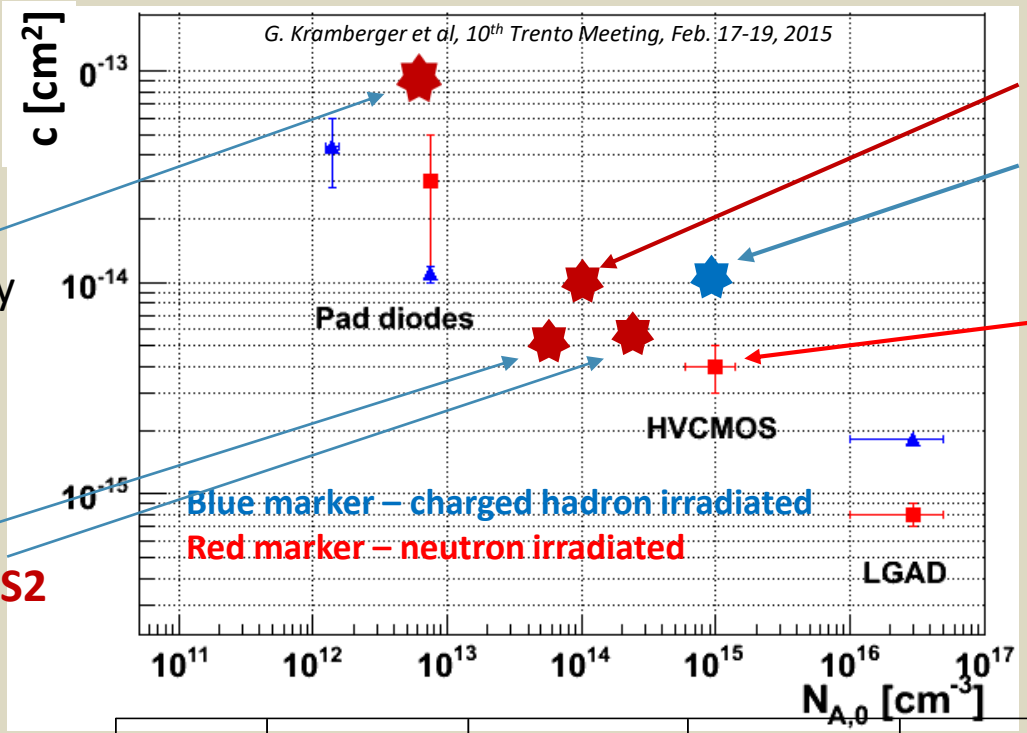
Fit: $$N_{eff} = N_{eff0} - N_c \cdot (1 - \exp(-c \cdot \Phi_{eq})) + g_c \cdot \Phi_{eq}$$

acceptor removal

Radiation introduced deep acceptors



Acceptor removal



LFoundry

AMS CHESS2

X-FAB, neutrons

AMS CHESS1, PS protons

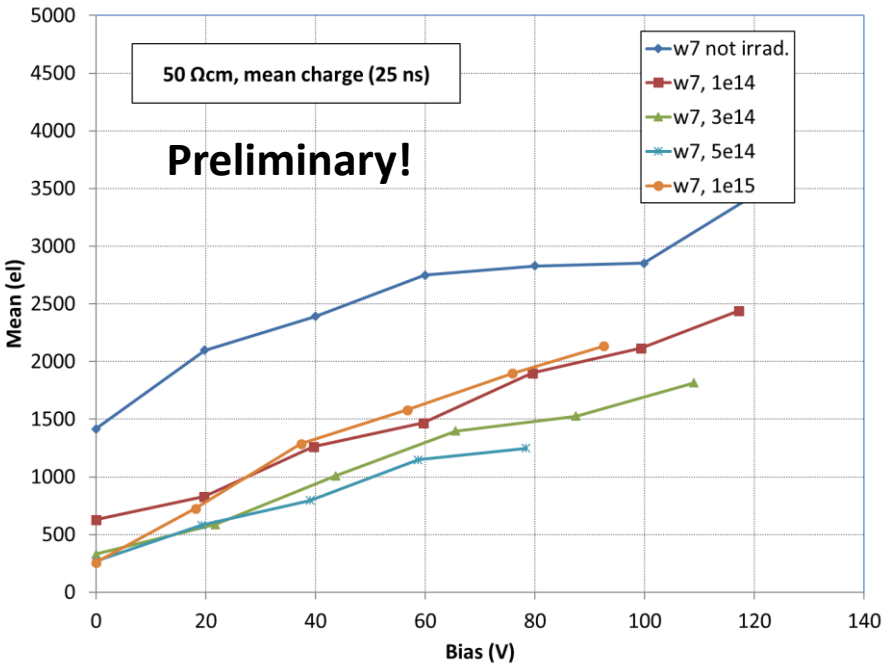
AMS CHESS1, neutrons

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	0.6	0.5	0.02 (fixed)
LF	2000	10	0.6	0.047

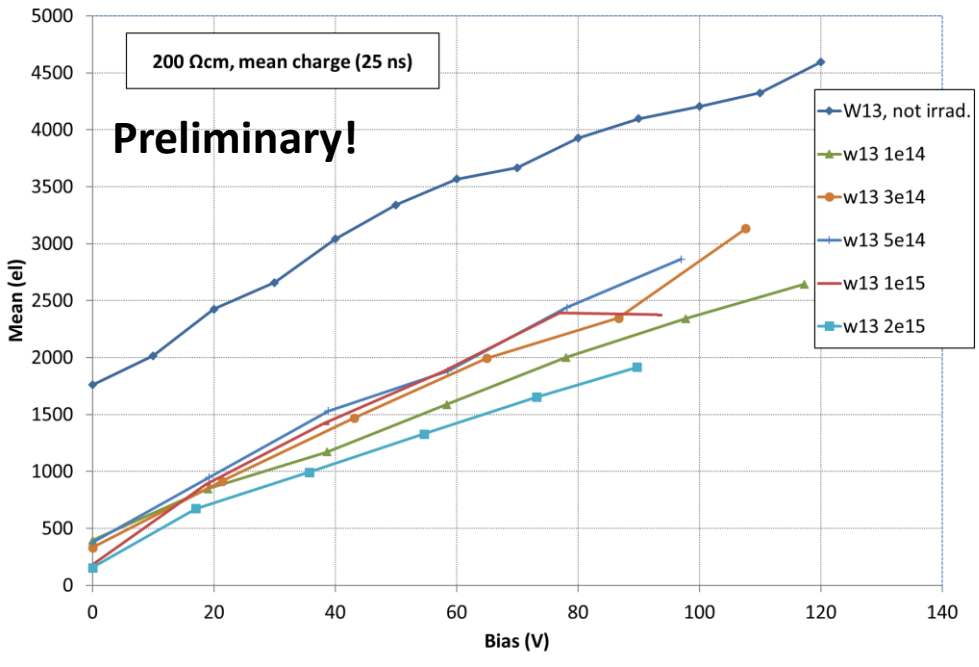
- acc. removal parameter ***c*** for CHESS2 similar as CHESS1 although higher initial resistivity
- g_c for **CHESS2** somewhat lower than usual for neutron irradiation!

Sr90

W7 (50 Ω·cm)

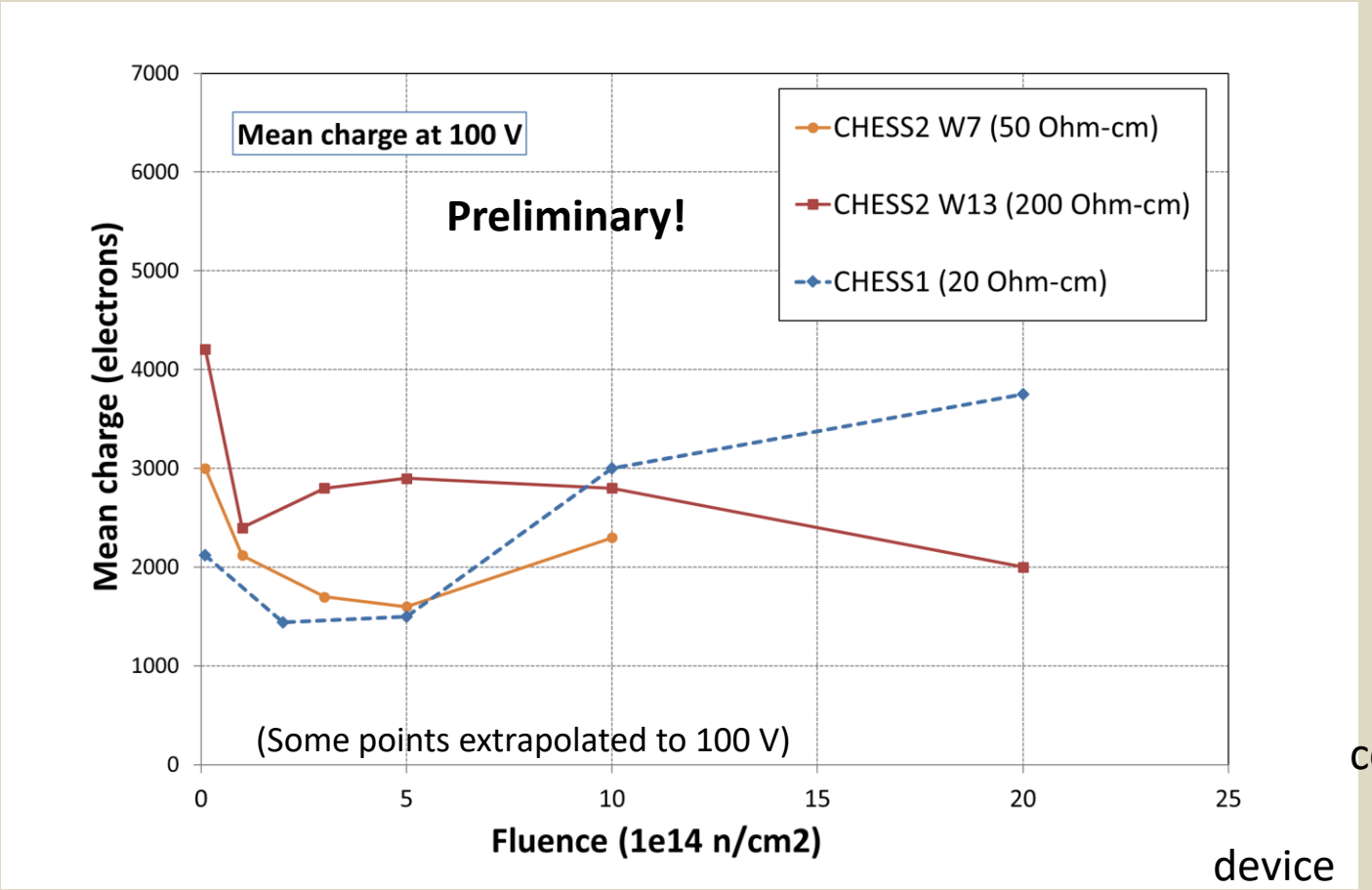


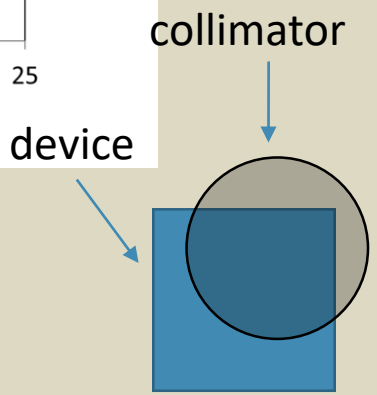
W13 (200 Ω·cm)



- 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.

Charge by Sr90





➔ Measured charge in CHESS2 might be underestimated!

→device: ≈ 1.mm x 1. mm, collimator r ≈ 1 mm

→ difficult to align correctly

Samples

Chips from wafer 19: > 600 Ohm-cm

Resistivity [Ω-cm]	Wafer numbers	Wafers cut	Number of cut chips
std	1-6	1, 2	94
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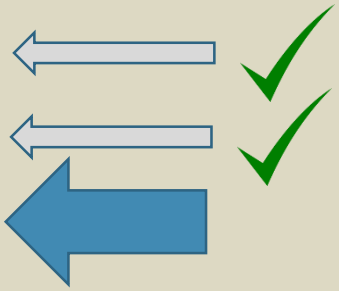
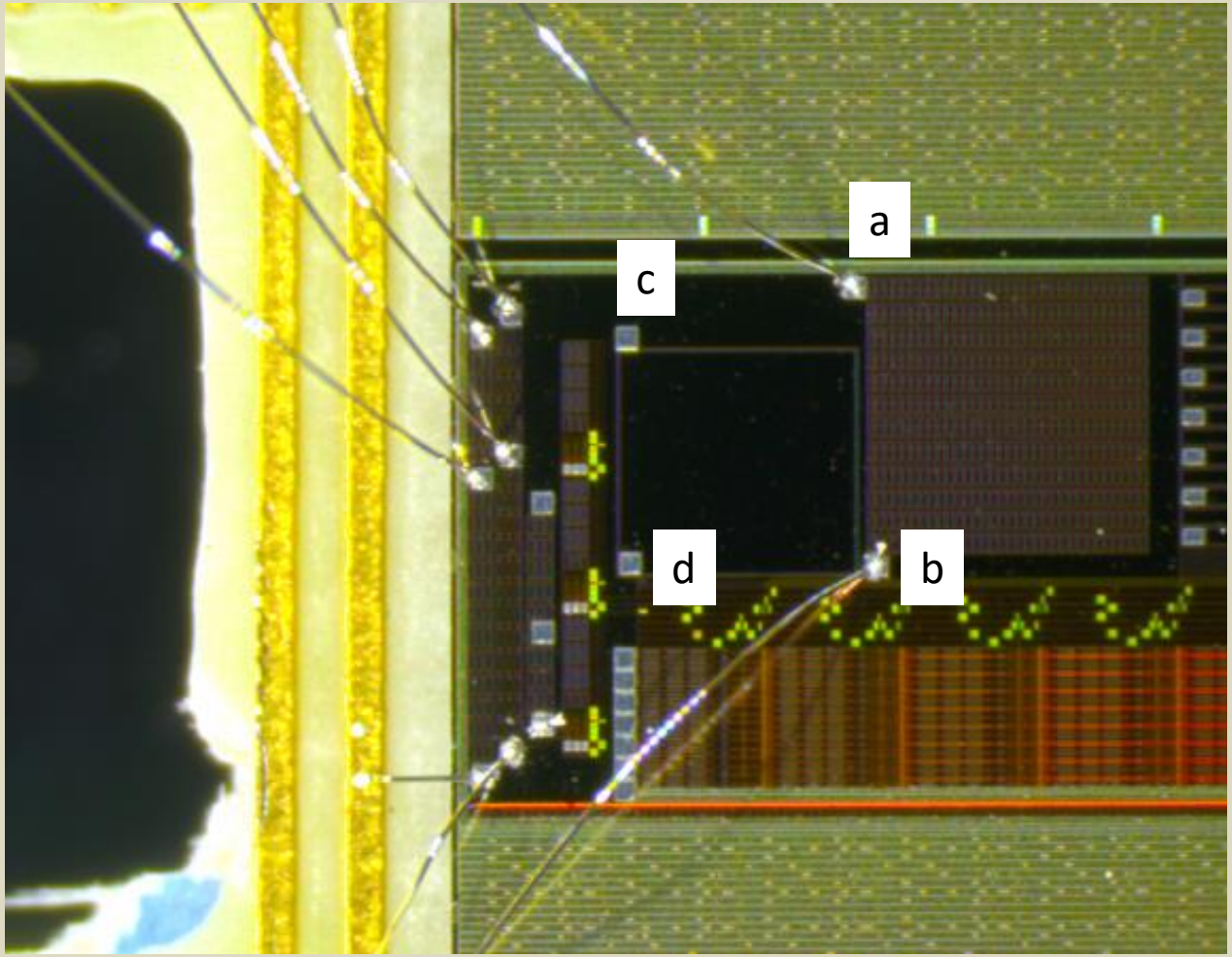


Neutron fluences 0e14, 1e14, 3e14, 5e14, 1e15, 2e15 neq/cm2

High Resistivity wafers

- So far tried to measure 2 chips (both unirradiated)
- Observed voltage breakdown at 15-20 V when connecting Large Passive Array (LPA)
  - (between <a> and <b> on the photo)

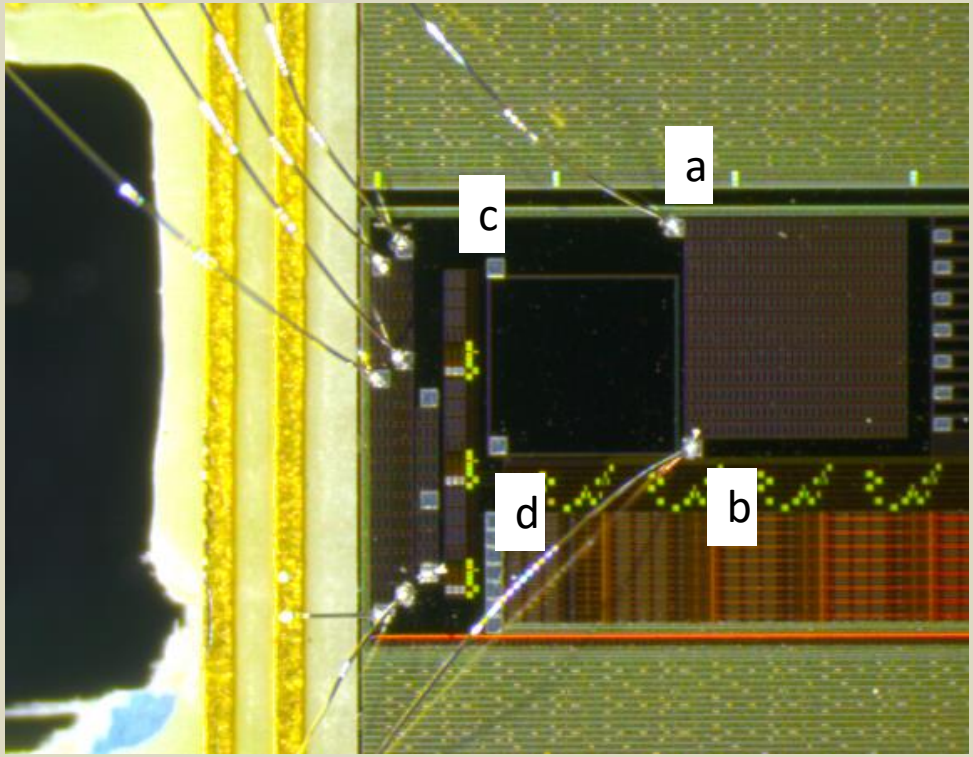


a – LPA nwells
b – LPA substrate
c – Large Pad nwells
d – Large Pad substrate

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



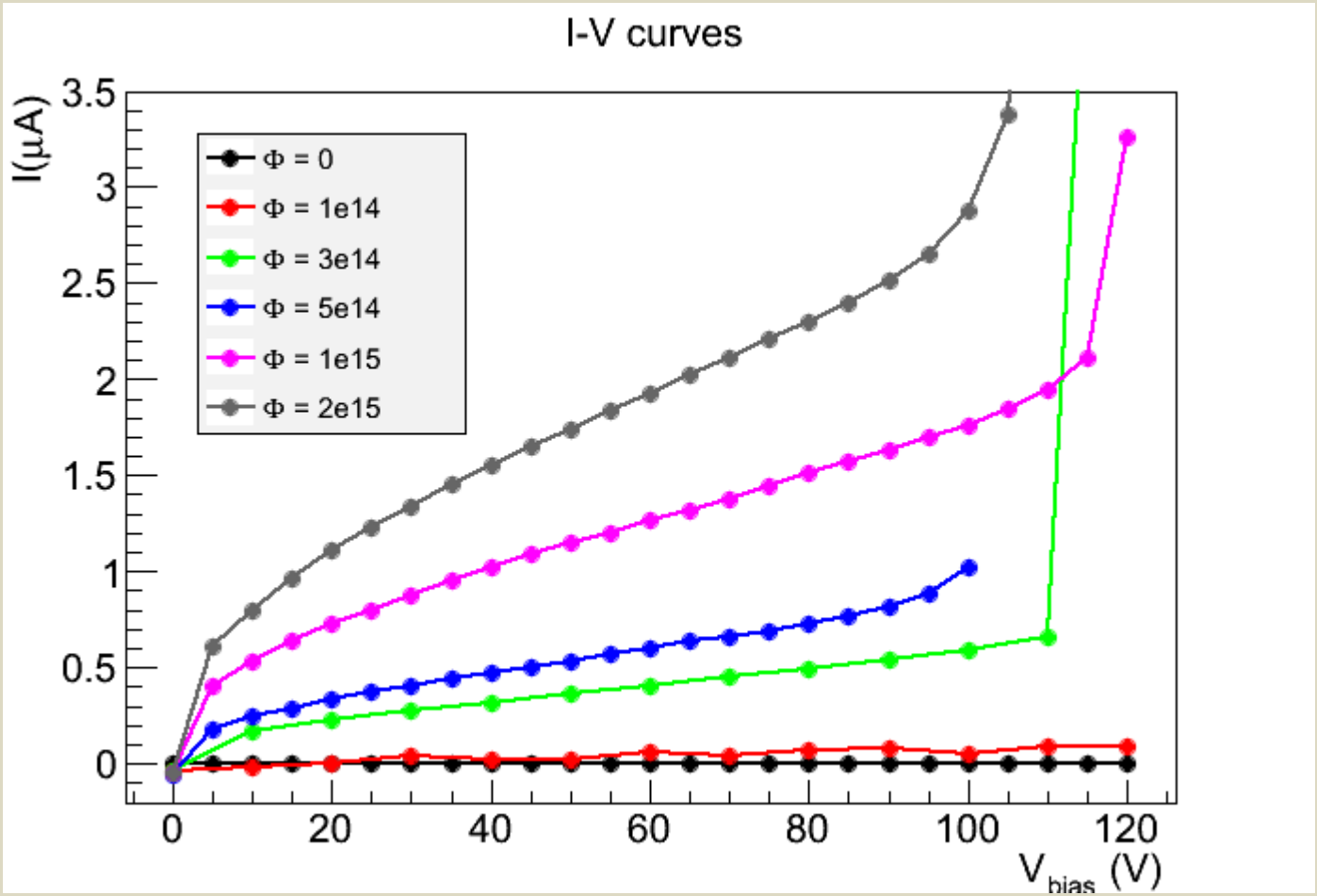
a – LPA nwells
b – LPA substrate
c – Large Pad nwells
d – Large Pad substrate

Summary

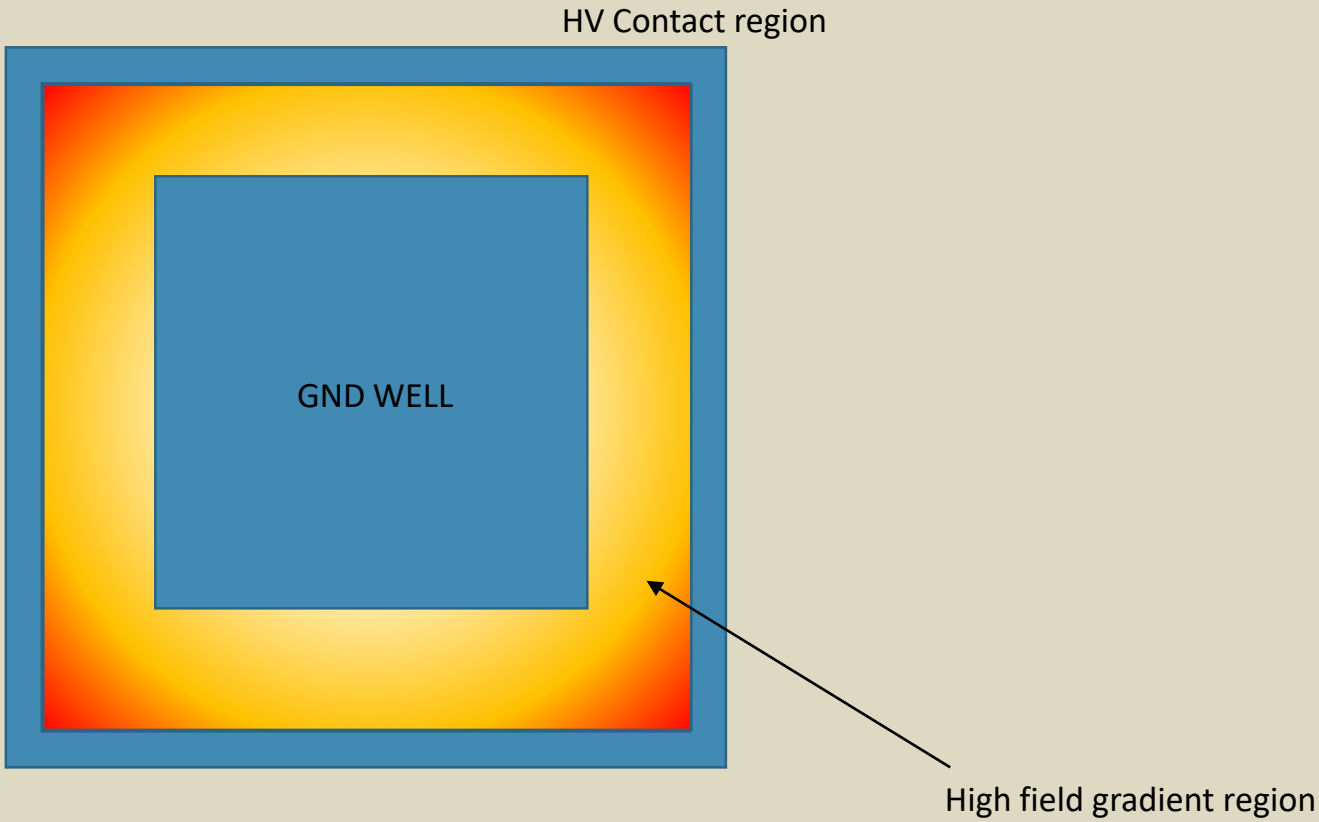
- Measured CHESS2 chips from wafers 7 (50 Ohm cm) and 13 (200 Ohm cm) up to 2e15 neutron irradiation
- E-TCT:
  - moderate acceptor removal
  - depleted depth > 40 µm on all chips and fluences
- Sr90
  - measure less charge than expected from E-TCT
  - might be due to the small test structure (empty events in spectrum)

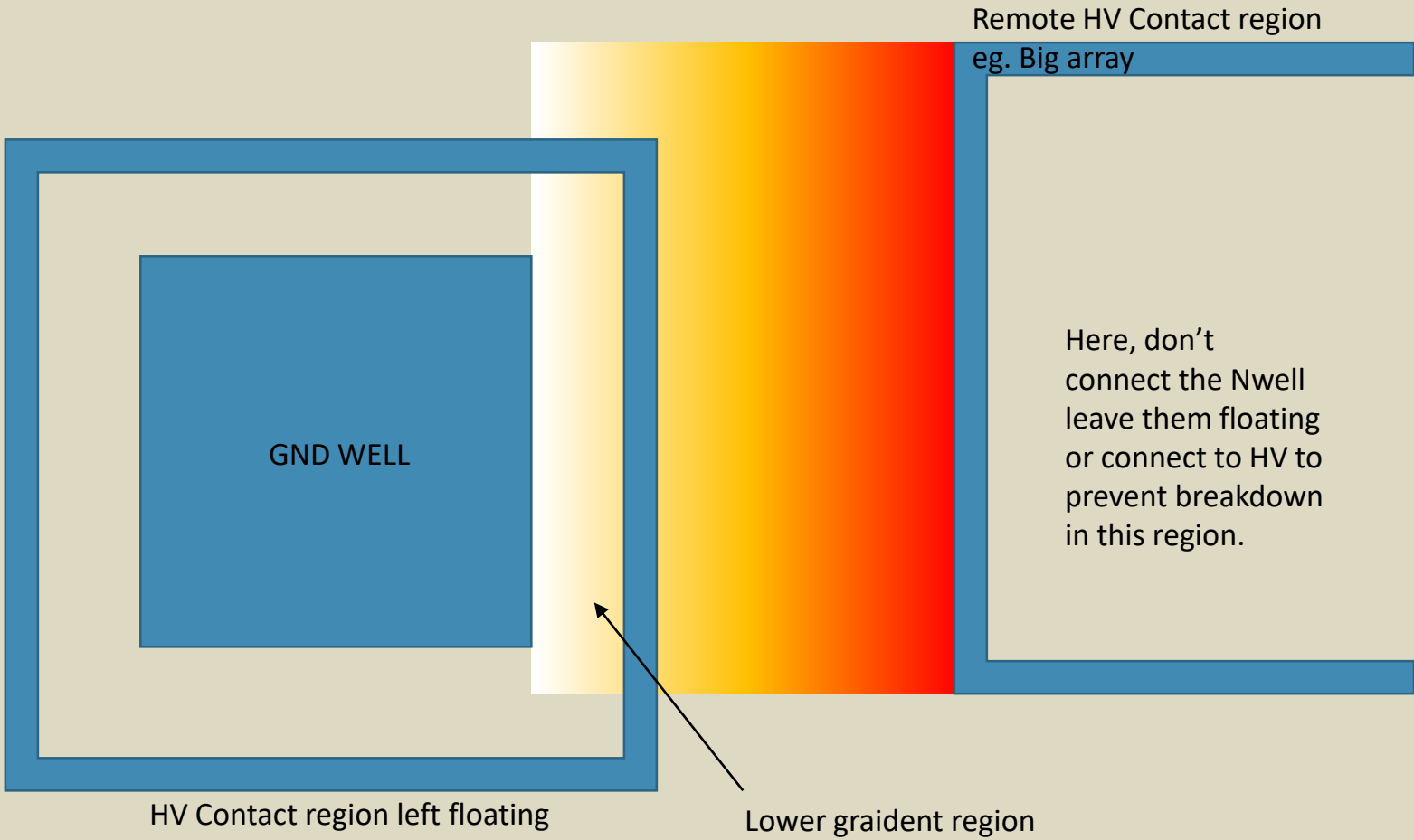
BACKUP

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