Calculation of CC vs. fluence for different resistivities

Assumptions:

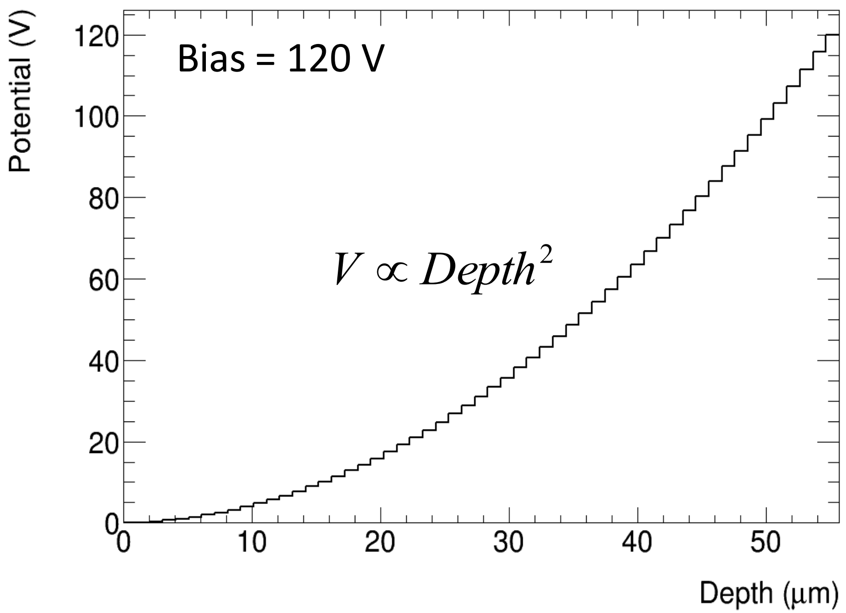
1) planar (pad)detector geometry ➔ depleted depth: $d = \sqrt{\frac{2\varepsilon\varepsilon_0}{e_0 N_{eff}} V_{bias}}$

2) detector thickness same as depleted depth ➔ no influence of weighting field in irradiated detector

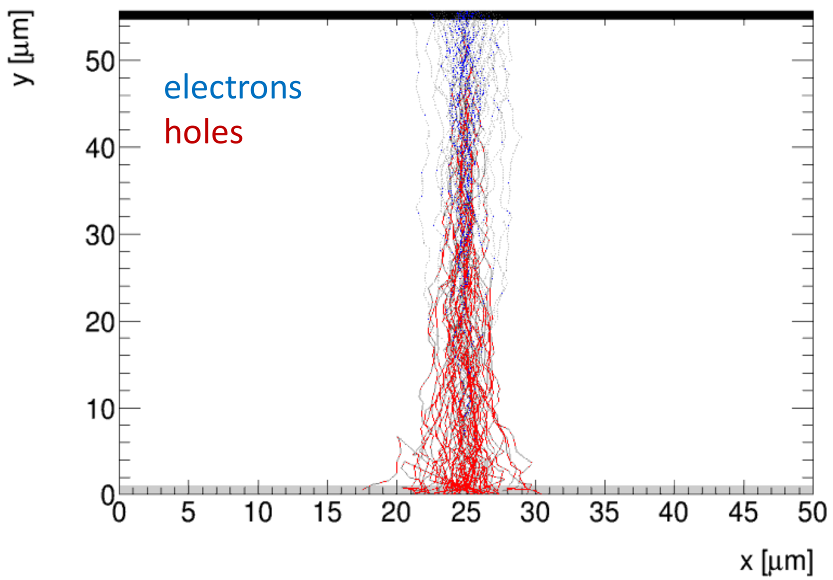
3) CC changes with fluence because of change of depleted depth (N_{eff}) and bacause of charge trapping

Use Gregor Kramberger's code: http://www-f9.ijs.si/~gregor/KDetSim/
to calculate induced signals from MIP and estimate trapping loss

Potential in pad detector (example):



Passage of a MIP



- buckets of charge treated as point charge
- calculate induced current of each bucket using Ramo's theorem

Trapping: $$\frac{1}{\tau_{eff}} = \beta \cdot \Phi_{eq}$$

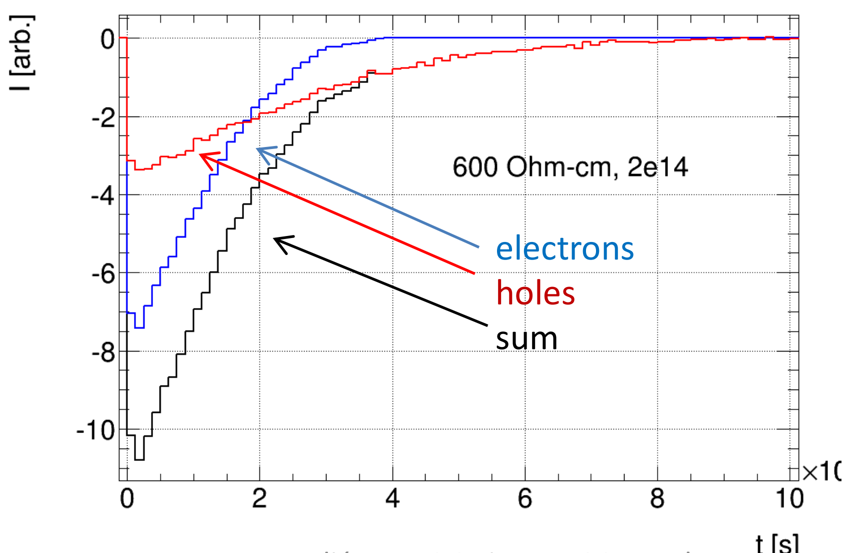
$$\beta = 4 \cdot 10^{-16}\mathrm{cm}^{-2}\mathrm{ns}^{-1}$$ (for p-type silicon, V. Cindro et al., NIMA 599 (2009)60)

Induced current multiplied by: $$I(t) = I_0(t) \cdot e^{-t/\tau_{eff}}$$

Charge: integral of induced current

→compare charge before and after trapping to estimate the trapping loss at given detector thickness (depletion depth) and fluence

Induced currents



Evolution of N_{eff} with fluence:

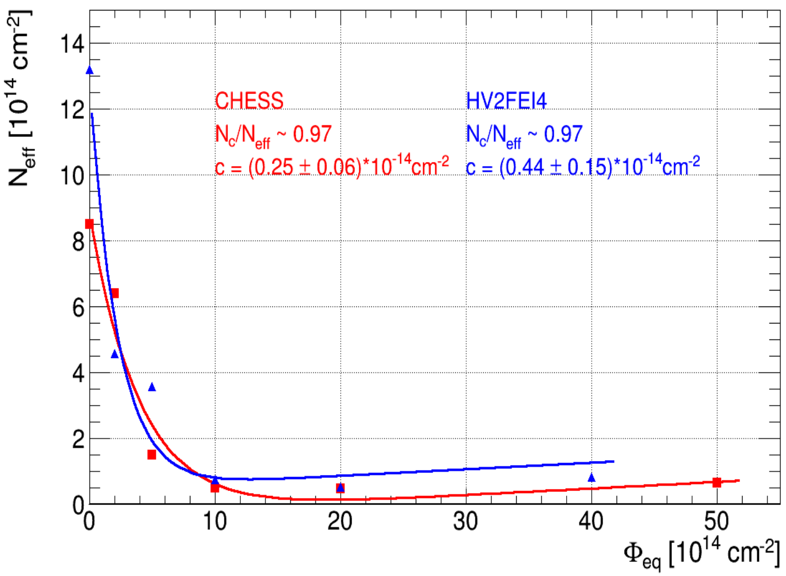
$$N_{eff} = N_{eff\,0} - N_c \cdot (1 - \exp(-c \cdot \Phi_{eq})) + g \cdot \Phi_{eq}$$

Initial concentration

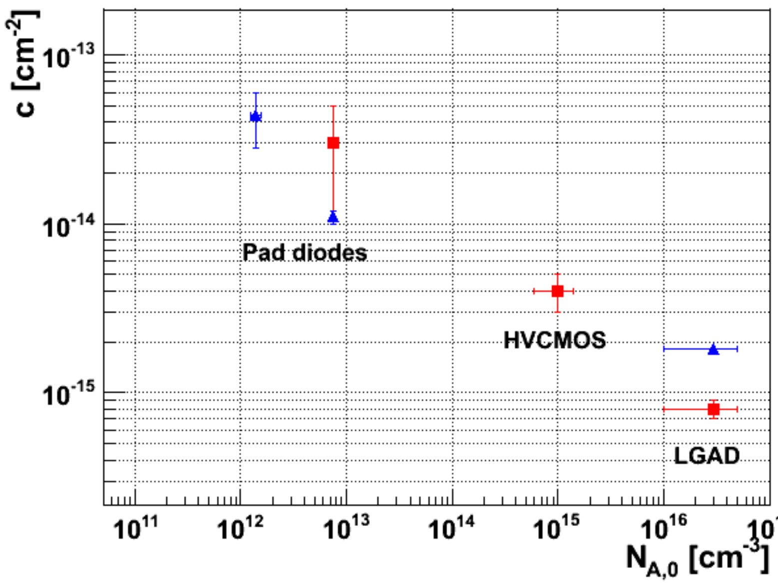
acceptor removal

Radiation introduced deep acceptors (stable damage): $g \sim 0.02\ cm^{-1}$

HVCMOS (E-TCT measurements)



Removal rate depends on initial space charge concentration



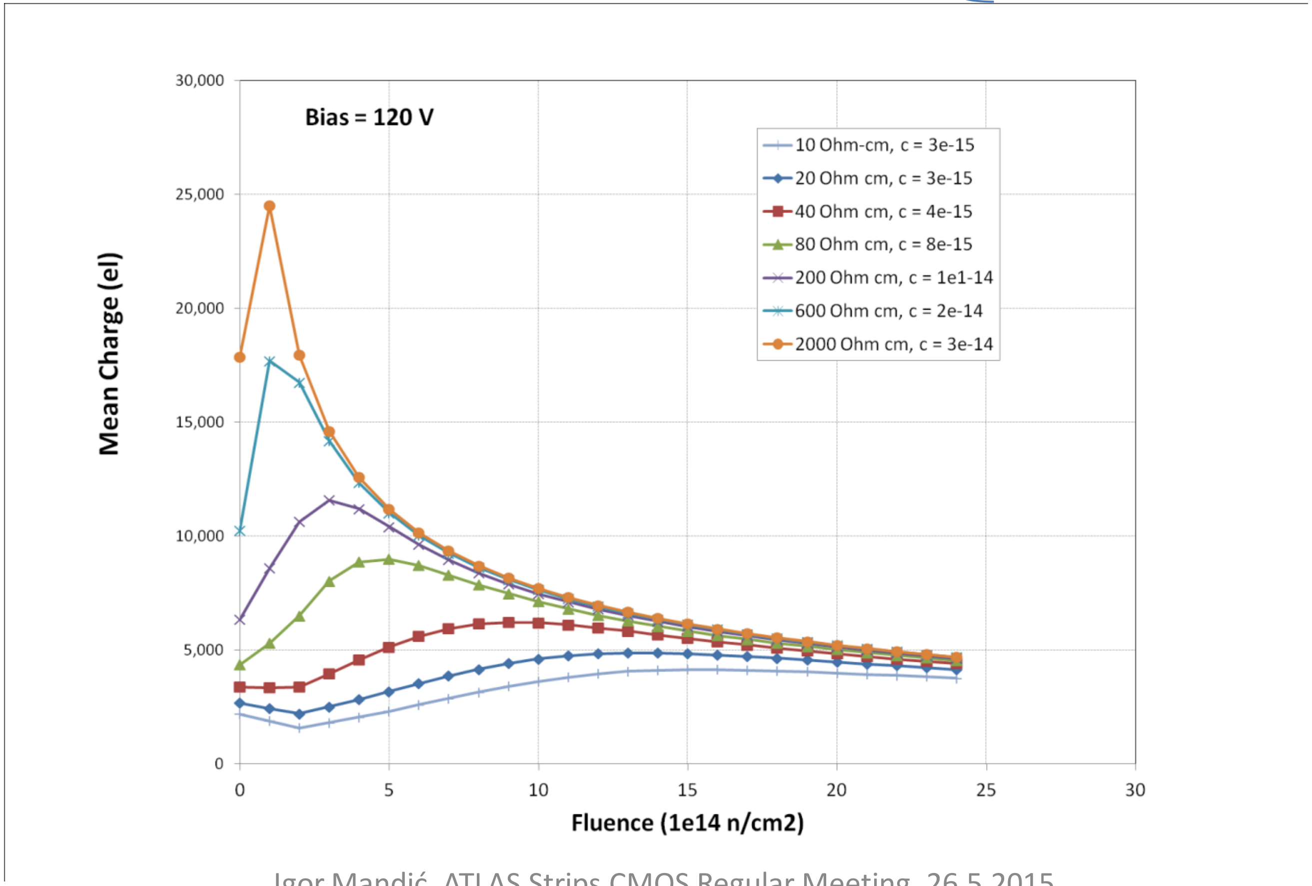
G. Kramberger, 10th Trento workshop

http://indico.cern.ch/event/351695/session/4/contribution/4/material/slides/0.pdf

Estimate CC for different resistivites:

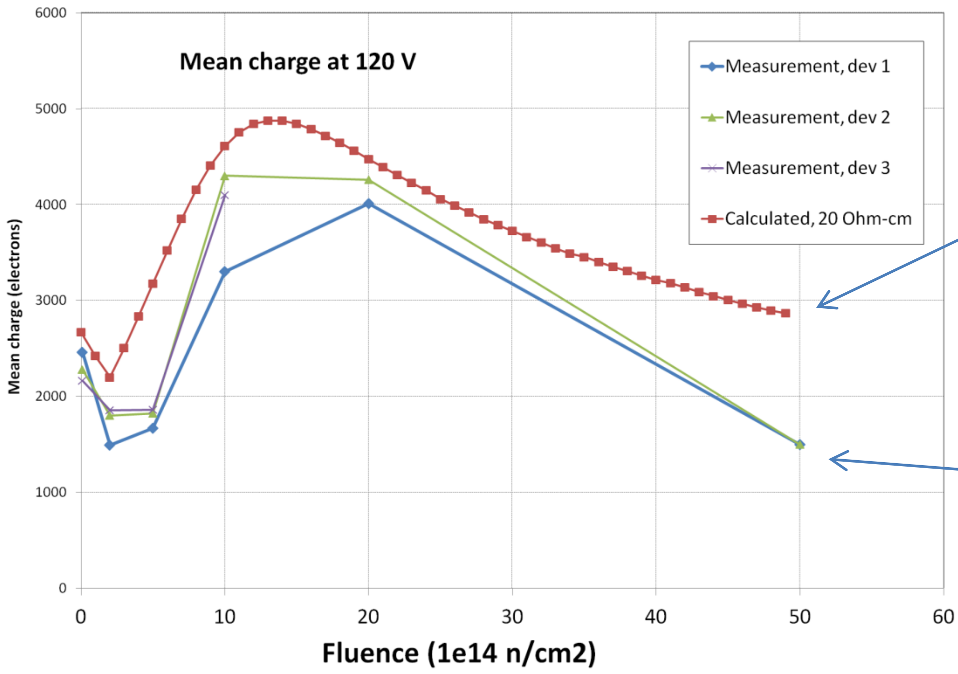
1. calculate depletion depth from $N_{eff}(\Phi)$, bias = 120 V
2. calculate trapping loss at given depth and Φ

➔ Mean Charge = depletion(µm)* 108 el/µm * trapping_loss + { 1000 el at $\Phi = 0$; 500 el at $\Phi = 1e14$; 0 el at $\Phi > 1e14$ } Diffusion (mostly gues)



Comparison with measurement

→ agreement reasonable for this rough calculation



Is the sensor back plane still at the border of the depleted region (how conductive is the material at this fluence)?

Extrapolation, measurements only up to ~ 100 V

Conclusions:

Collected charge vs. fluence estimated for different detector resistivities:

- larger resistivity → more charge
  → larger depletion → initially smaller capacitance/noise

- at high fluence not much difference between materials

- for ~ 80 Ohm-cm charge not below initial up to 2e15

➔ the selection of material resistivity depends on amplifier performance
→ how much charge is needed for good S/N