
# Field and Charge Collection studies on pion irradiated p-type Float Zone detectors

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# Outline

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2. Detectors and irradiations
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4. Fluence calculation and dosimetry comparison
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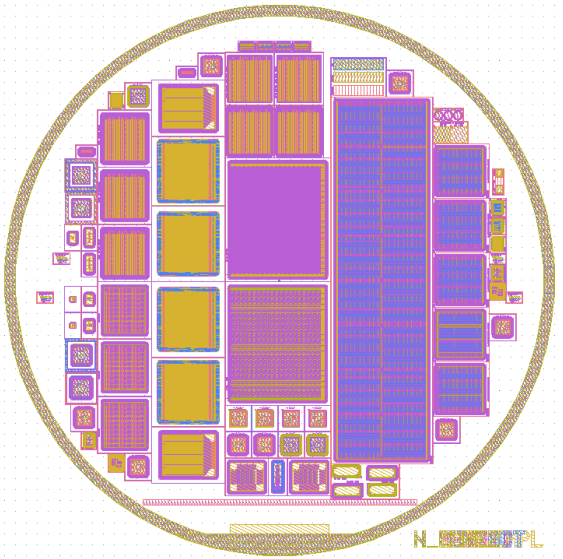
# Motivations

•Studying field profile characteristics of FZ-p type silicon irradiated with pions

•Correlation of the charge collection efficiency of the device with field profile development

•Correlation study of CV depletion voltage (often used as “fast” mean to extract depletion voltages from detectors) with actual depletion voltage given by CCE studies with different techniques

# Producer: CIS pixel/strips production 2009



## Material:

FZ n-on-p
Thickness 285 um
Initial resistivity > 10 kOhm
Initial V_dep 35-40 V

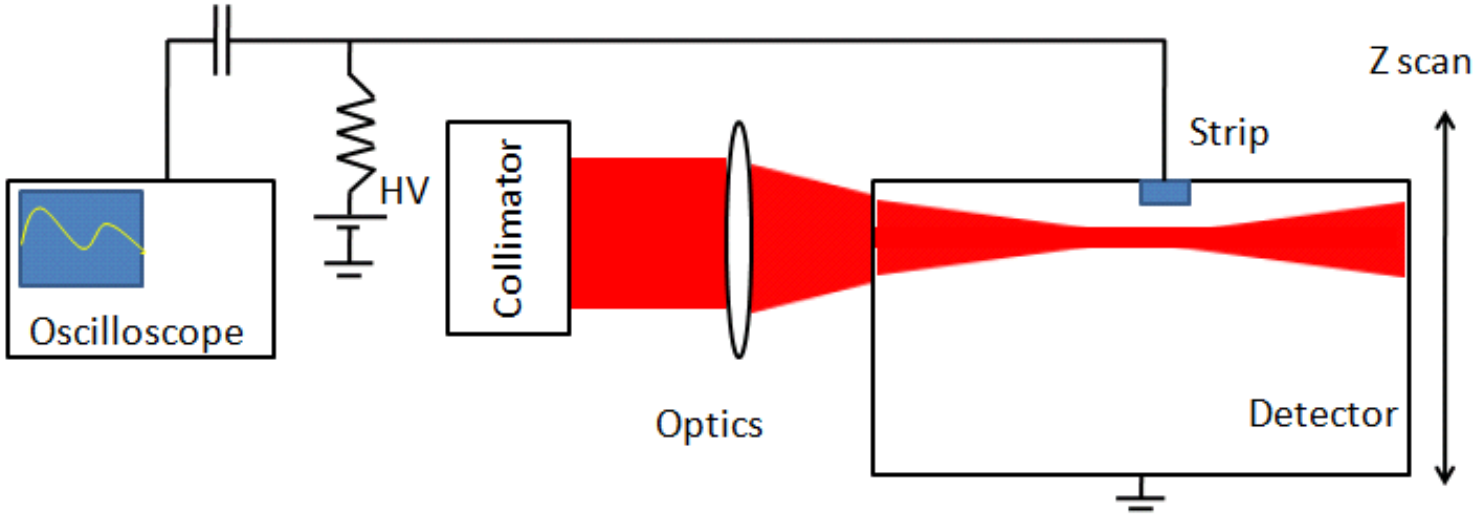
## Structures:

Ministrip detectors (10x10 mm^2)
128 strips, 80 um pitch, 20 um strip width
DC Coupling of the strips (Thanks to J. Haerkoenen for providing AC-Coupled pitch adaptors for Alibava measurements)

## Irradiation:

200 MeV pion irradiation in Villingen (PSI), summer 2010
Maximum fluence: 1.0x15 pions/cm$^2$

# CERN Edge-TCT setup




- 1060 nm, 80 ps FWHM laser pulse
- 16 μm FWHM focusing underneath the strip.
- 1.8 GHz Phillips amplifier (50 dB)
- Decoupling Bias-Tee (750kHz-12GHz)

Edge TCT allows detector probing by means of localized charge generation at given depths inside the detector. Drift velocity, charge collection efficiencies profiles can thus been generated.

Prompt current method was used to extrapolate drift velocities profile.
(ref. G. Kramberger et al. doi:10.1109/TNS.2010.2051957)

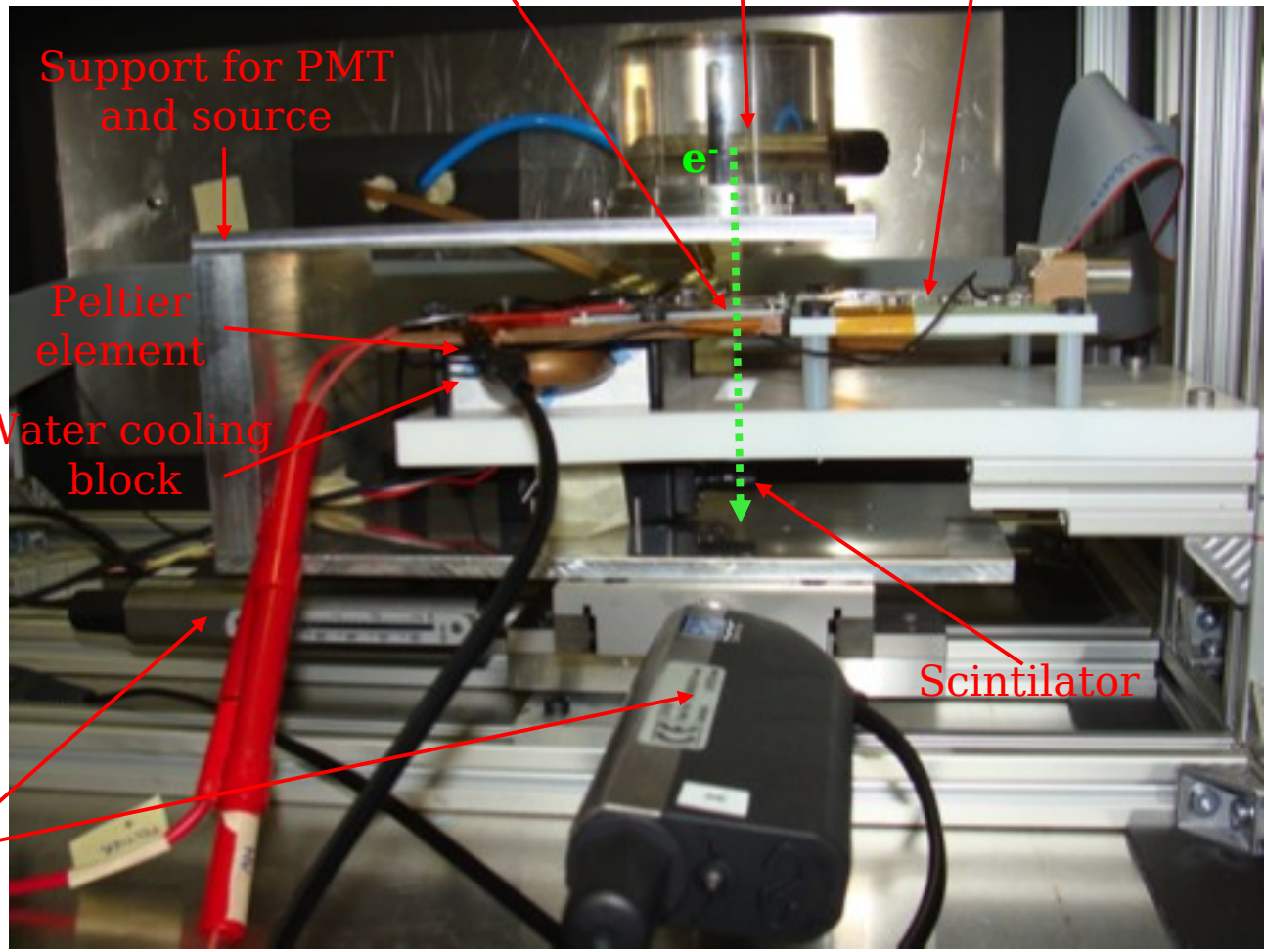
# CERN Alibava β CCE Setup

Alibava based setup
Setup enclosed in Al box, flushed with dry air.

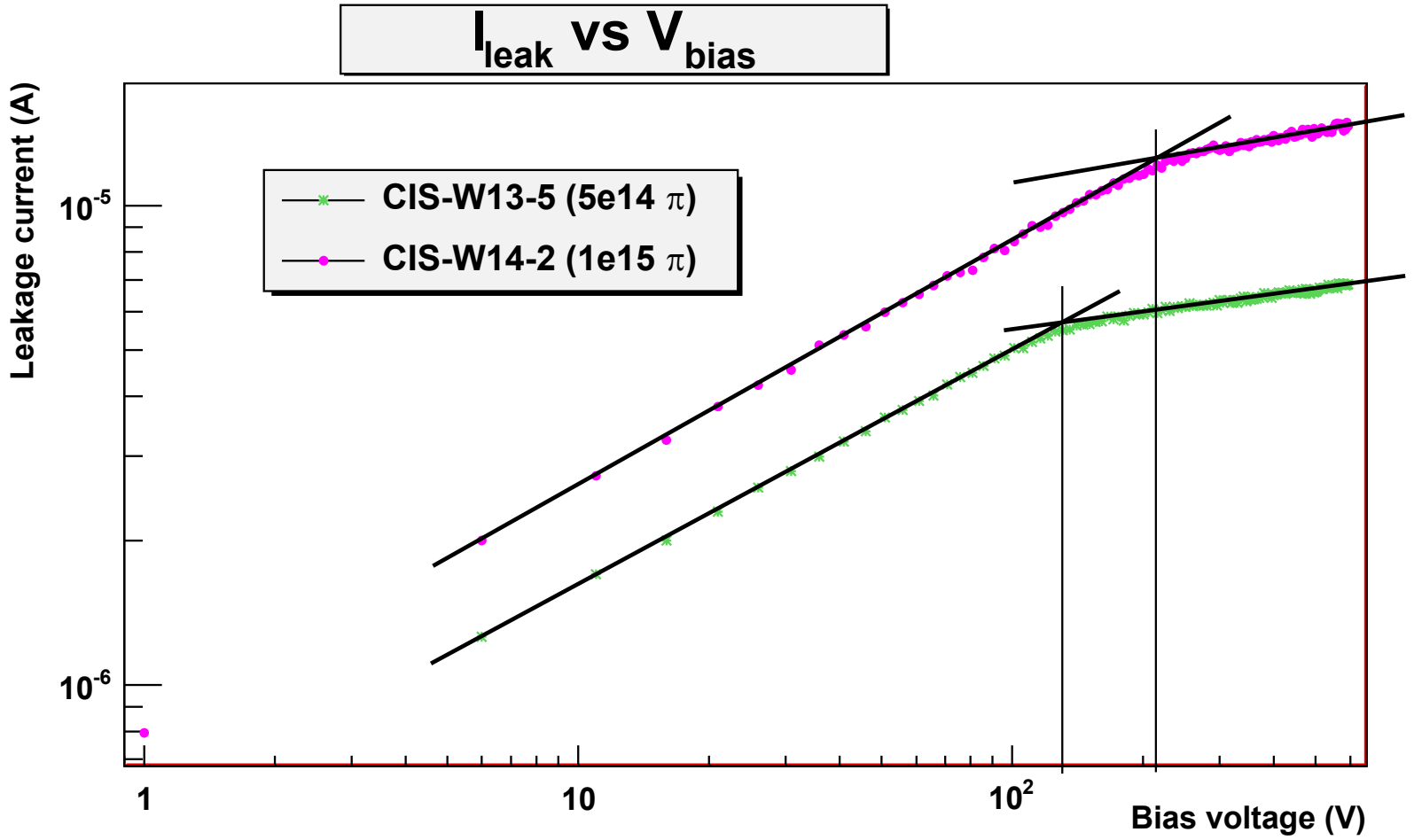
Cooling of detector
Water cooled peltier
Temperatures down to -25°C

Source
3.7MBq $^{90}$Sr electron source,
placed ~2cm above the detector
PCB itself acts as a moderator to stop slow electrons

Trigger signal
Provided by scintillator with PMT,
Collimation by ~1mm hole in the $^{90}$Sr holder plate



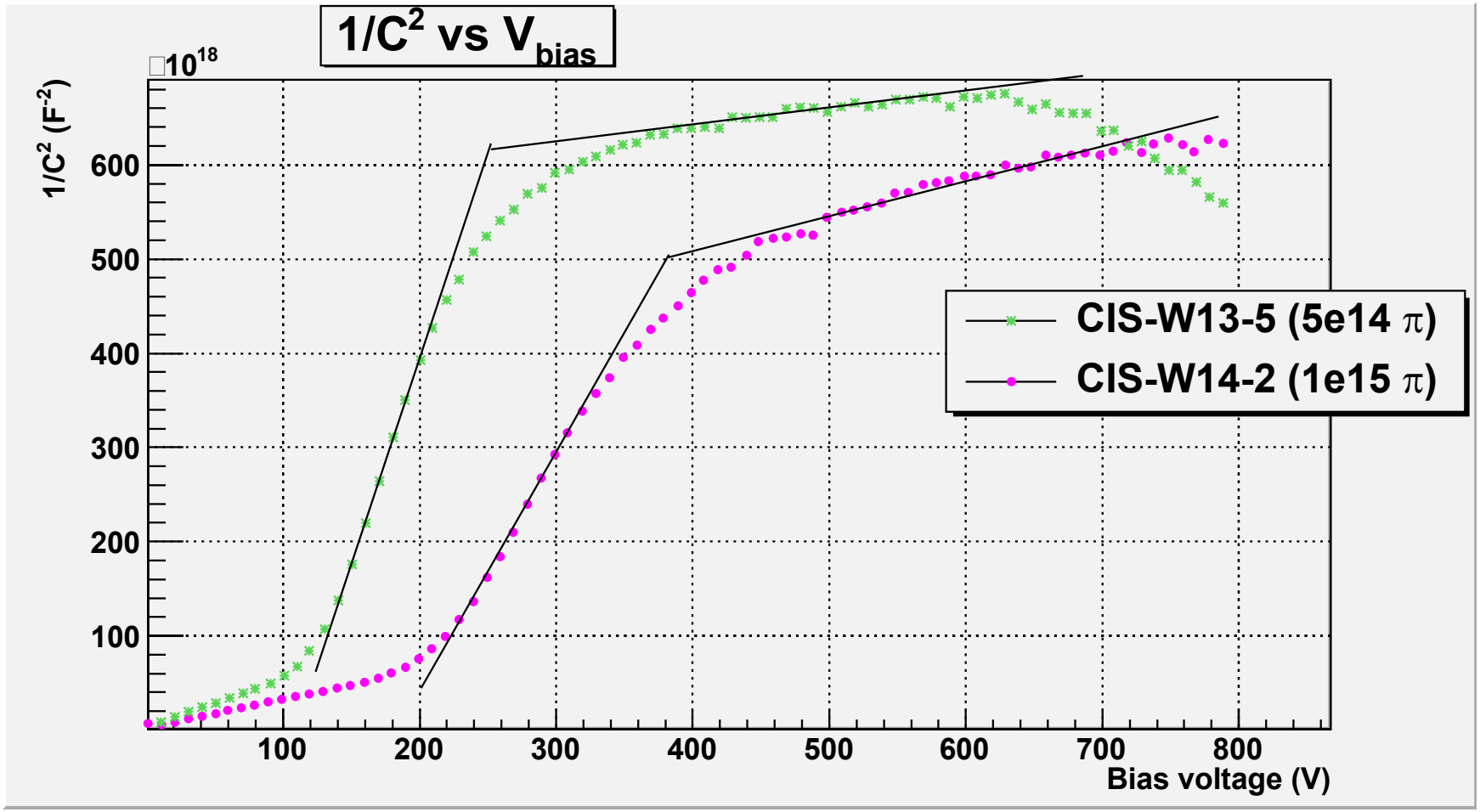
# Fluence check (IV measurements)




# Fluence from IV (α=3.99e-17, k=1.14)

W13-5 - dosimetry: 4.11e14 π (4.68e14 neq) - IV: 3.81e14 neq
W14-2 - dosimetry: 8.39e14 π (9.70e14 neq) - IV: 8.51e14 neq

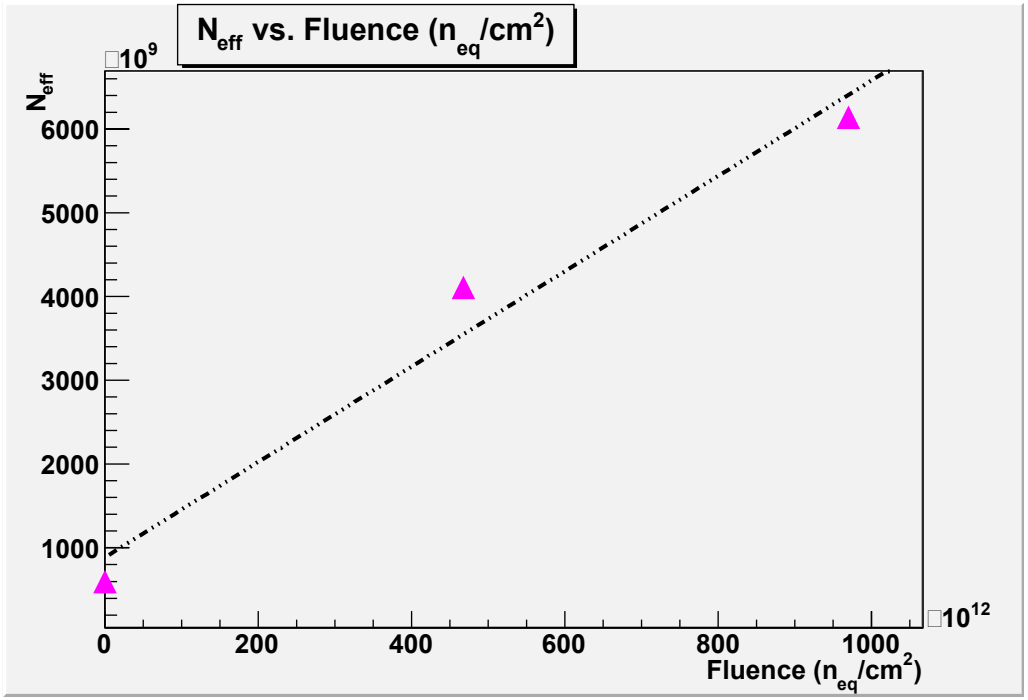
# Depletion voltages from IV and CV




# Depletion voltages from CV(-25C, 55 Hz) and IV:

W13-5 Vd(CV) = 254 V, Vd(IV)=128 V
W14-2 Vd(CV) = 379 V, Vd(IV)=241 V

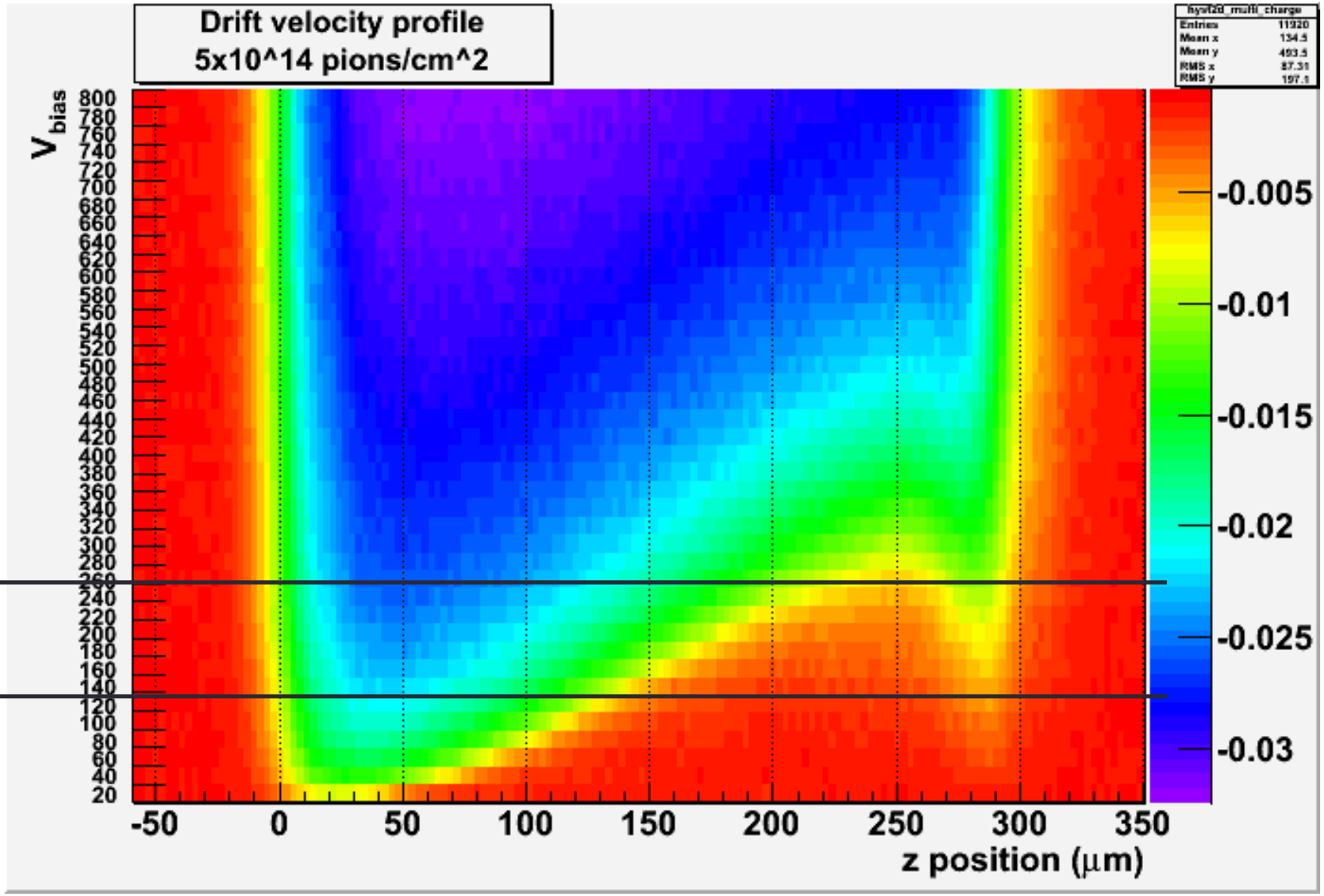
# Defects introduction rate:




Our data: $\underline{5.7 \pm 1}$ x $10^{-3}$ $cm^{-1}$

Reference: $\underline{13.4 \pm 1.6}$ x $10^{-3}$ $cm^{-1}$ *(G. Kramberger et al doi:10.1016/j.nima.2009.10.139)*

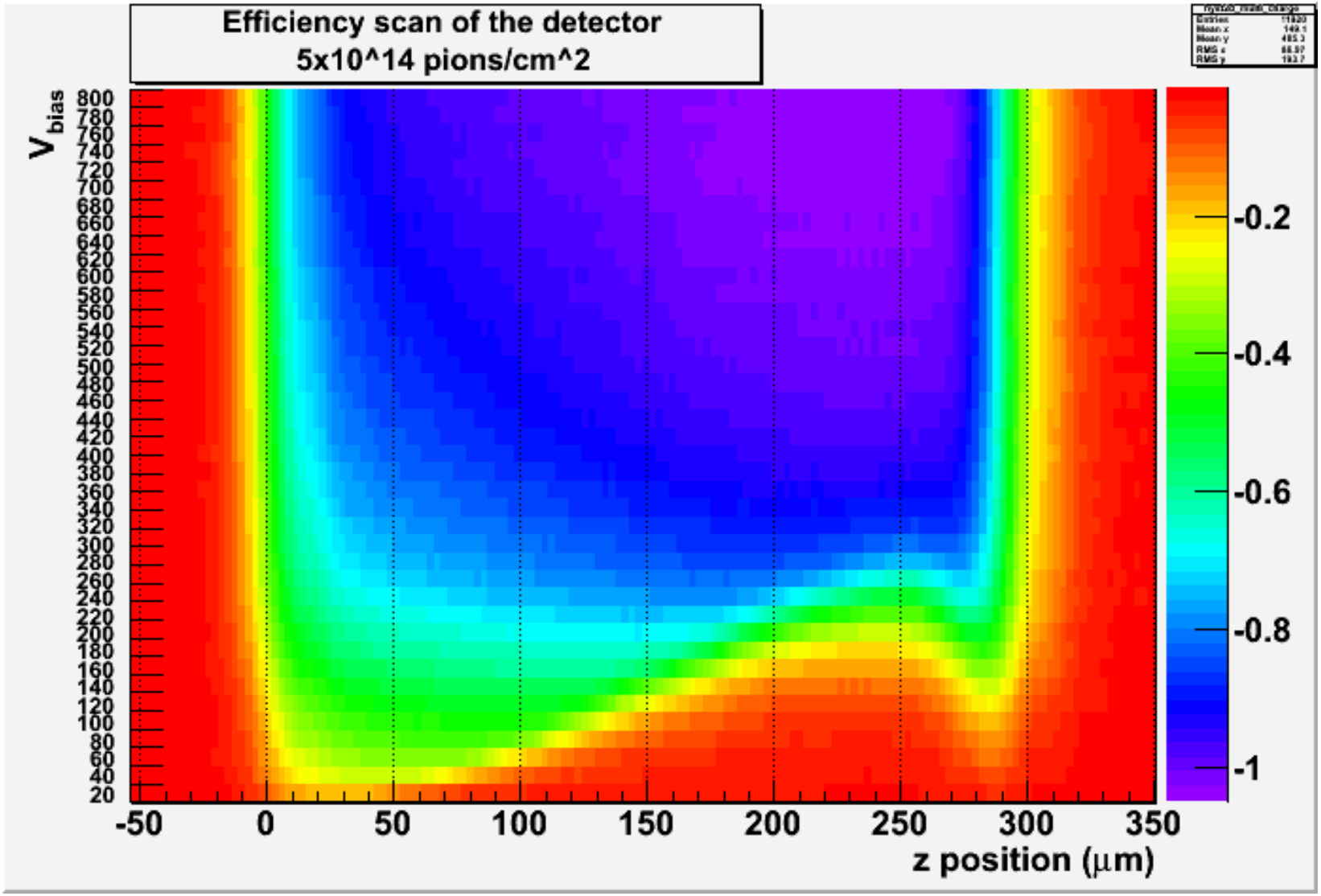
# Drift velocity profile: $5x10^{14}$ π/cm$^2$ irradiated detector




$V_{dep}$(C)

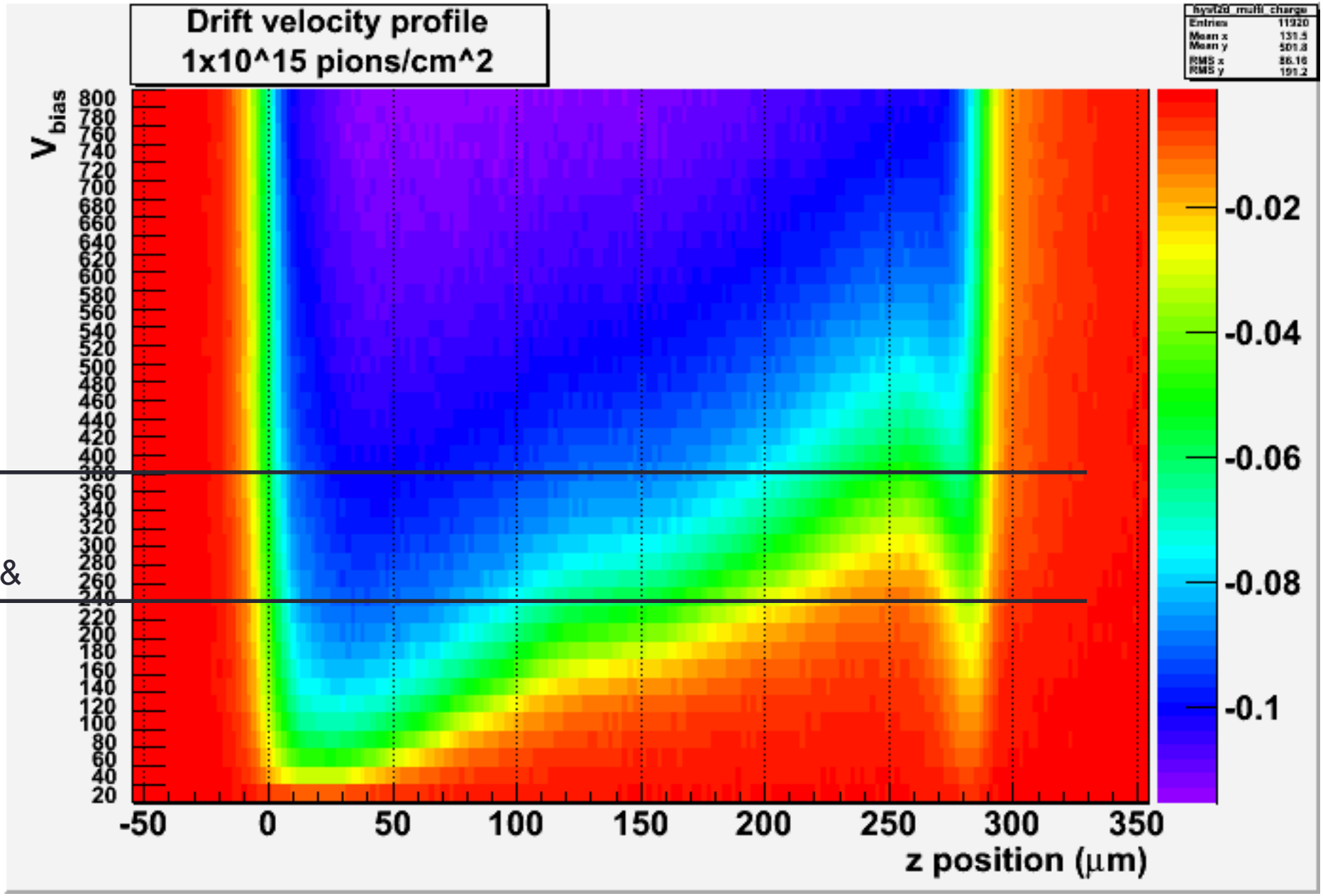
$V_{dep}(I_{leak})$ & CV first kink

# Efficiency scan: 5x10$^{14}$ π/cm$^2$ irradiated detector




Back of the detector becomes more efficient than front region at high voltages

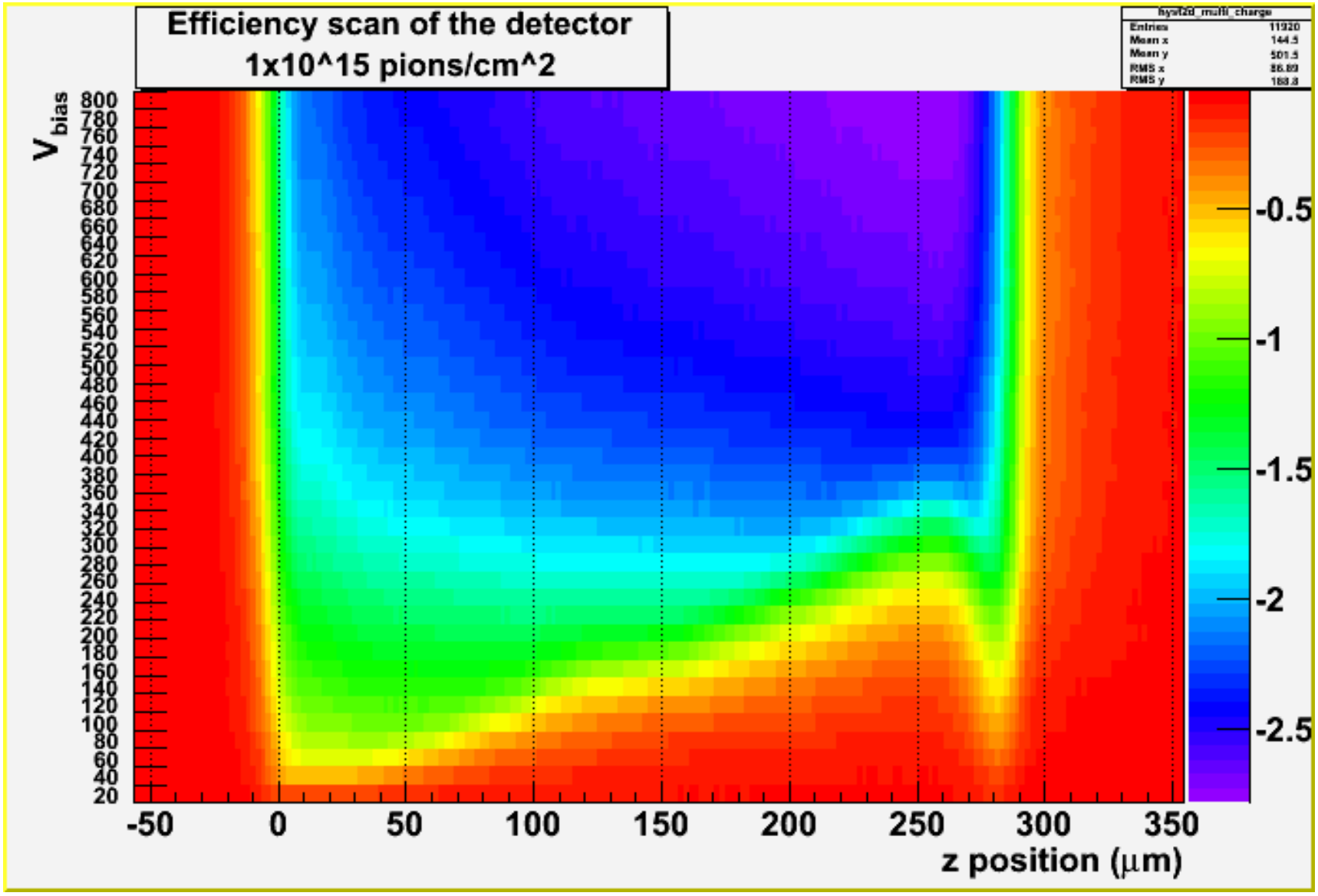
# Drift velocity profile: 1x10$^{15}$ π/cm$^2$ irradiated detector




$V_{dep}$(C)

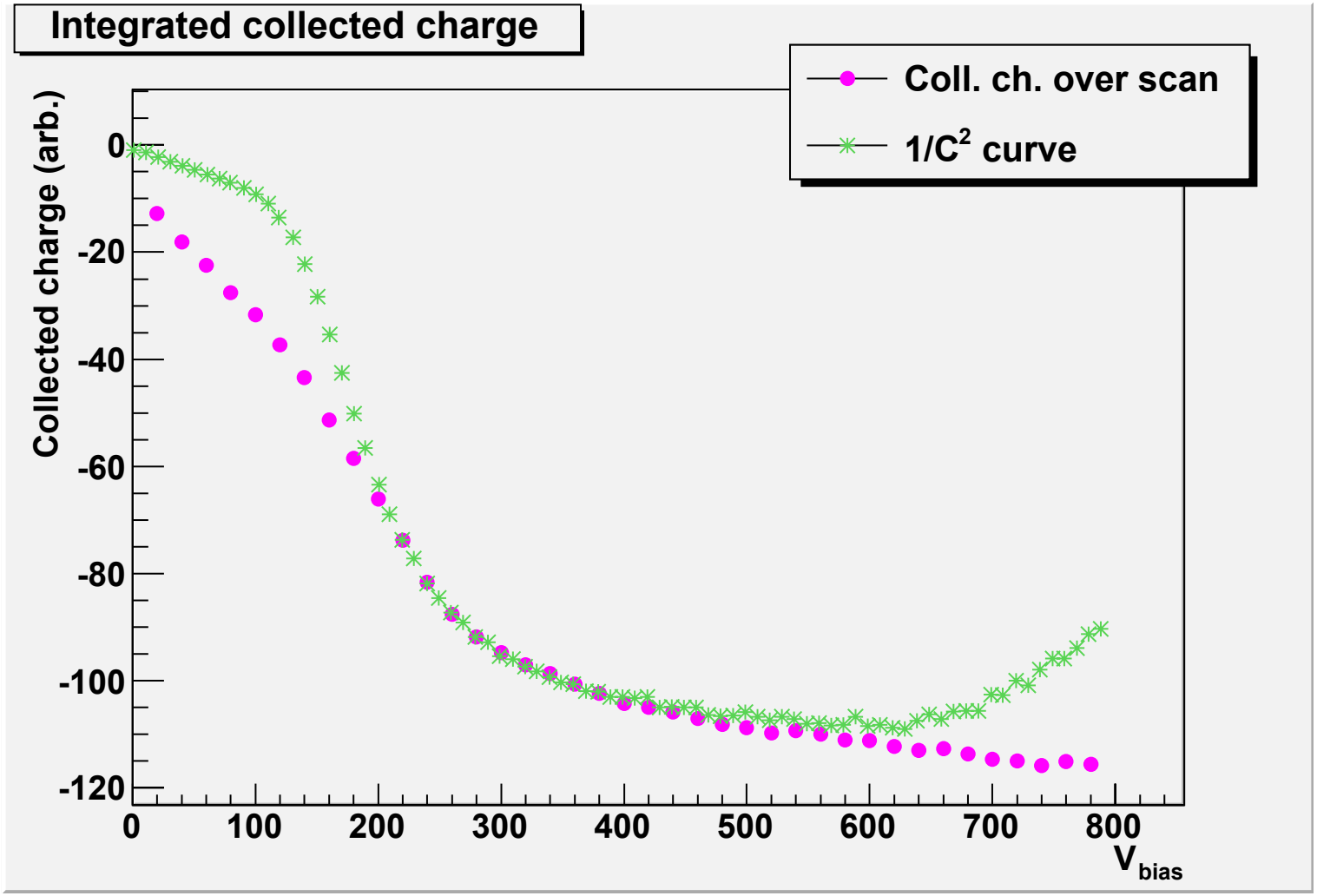
$V_{dep}$($I_{leak}$) & CV first kink

# Efficiency scan: 1x10$^{15}$ π/cm$^2$ irradiated detector

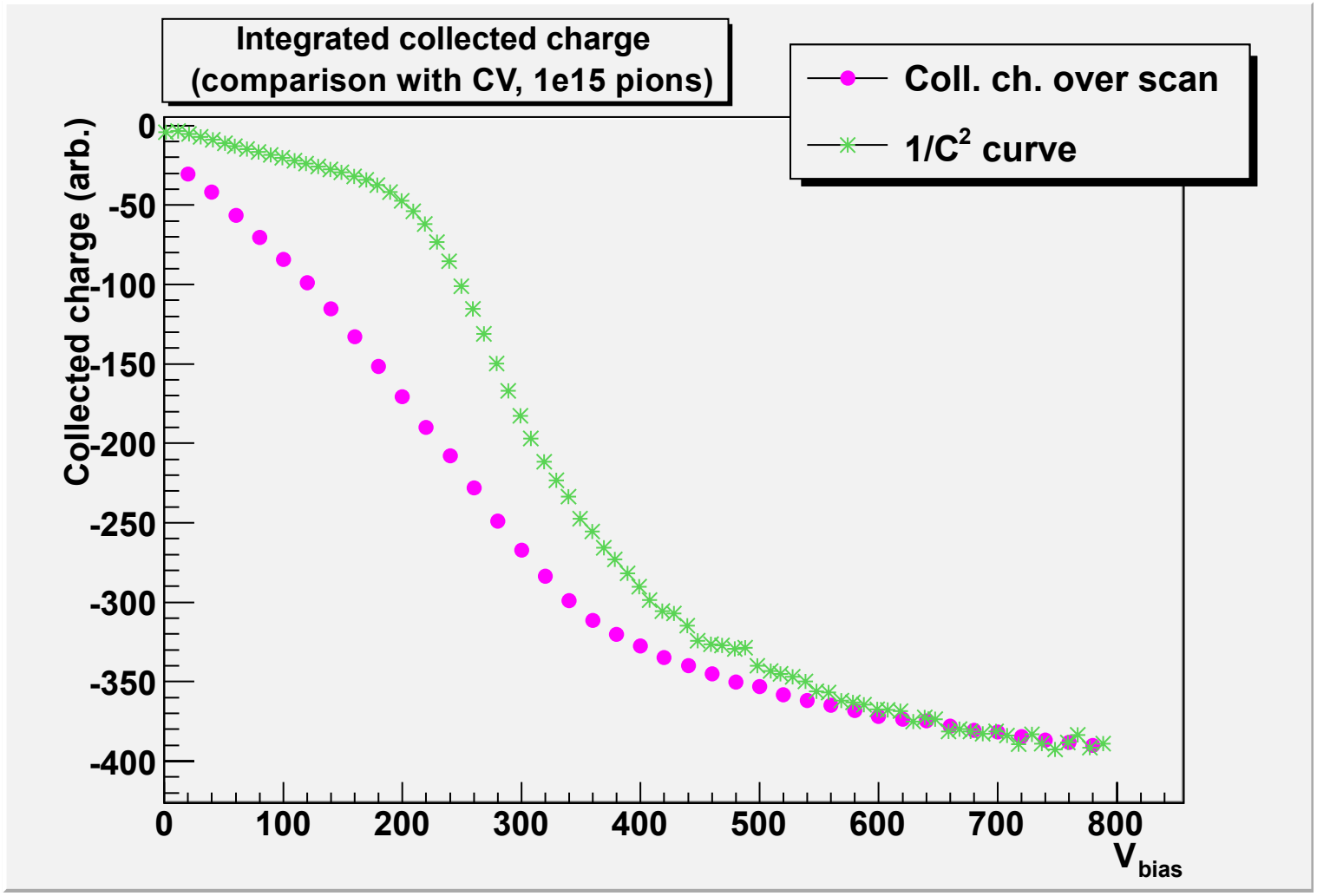



Again, more efficiency in the back region at high voltages. Trapping is influencing less carriers generated in this region (might be due to higher drift velocity of electons that have anyway lifetimes comparable to holes)

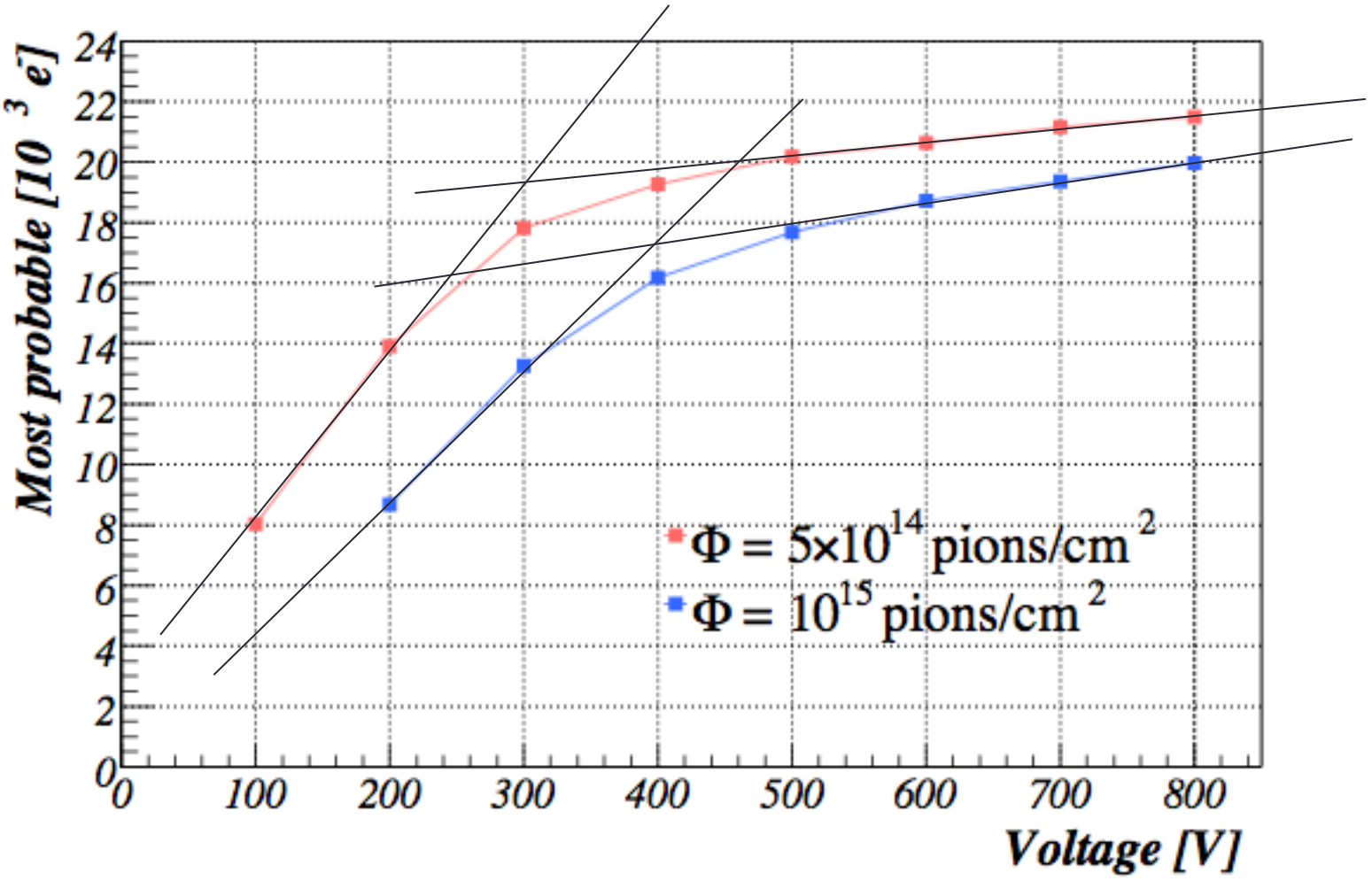
# Comparison between CV curves and total collected charge $5x10^{14}$ π/cm$^2$



# Comparison between CV curves and total collected charge $1x10^{15}$ π/cm$^2$



# Collected charge (Alibava β⁻ CCE)




Excellent agreement with Edge-TCT(CCE) and CV measurements

# Conclusions

•Fluence check agreed well from the point of view of current increase, in reasonable agreement with dosimetry expected values (within 20%)

•Even after high pion fluences, there is no major change in the field shape within the detector

•Total collected charge even at 1e15 π/cm$^2$ fluence is at its maximum already at 350 V

•Depletion voltage is too low. Measured values are about three times lower than what would be expected (previous results from K. Kaska, 15$^{th}$ RD50 Workshop, G. Kramberger doi:10.1016/j.nima.2009.10.139).

•Fluence value was correct (IV curves), and other particles that could have "contaminated" the beam (protons? neutrons? gammas?) have introduction rates which are comparable to each other. It's not even possible to have an annealing effect ($V_{dep}$ would go up opposite to leakeage current going down)