Annealing of Charge Collection Efficiency in highly irradiated low-resistivity MCz-p-on-n strip detectors.

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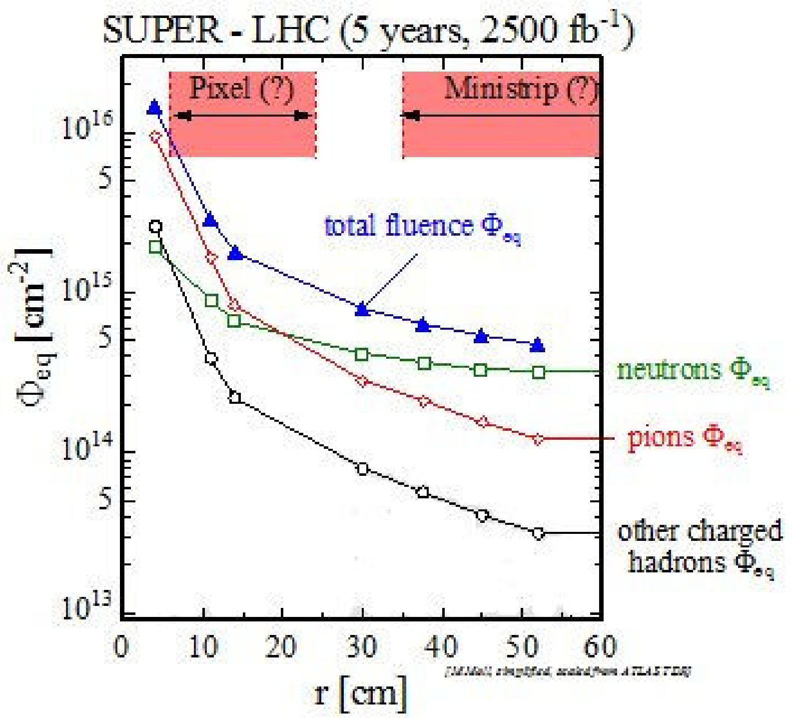
Motivations

The most probable candidates technologies for the s-LHC upgrade are:

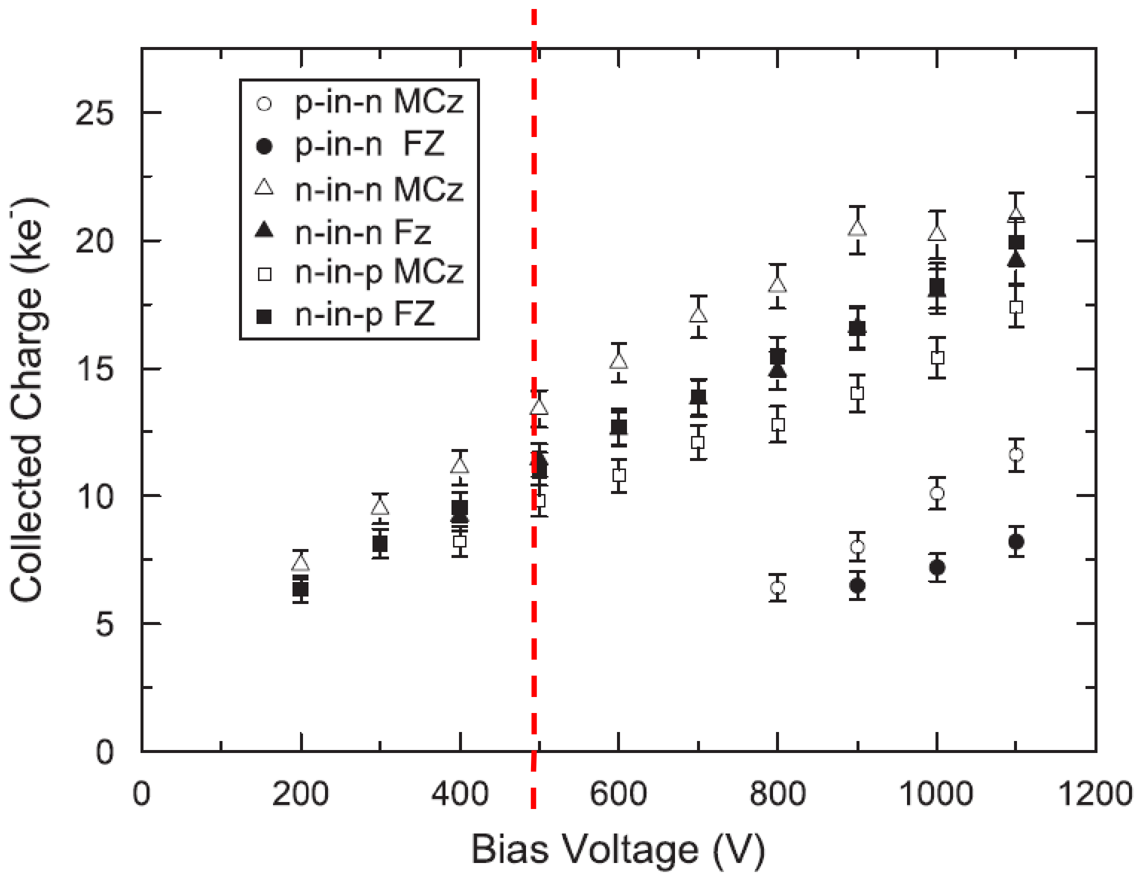
•n-in-p FZ silicon
•n-in-p MCz silicon
•n-in-n MCz silicon
•p-in-n MCz silicon

•p-bulk detector are the best performing choice, but at the present time engineering problems (strip insultation) are still present.
•Is it possible tu use p-readout n-type MCz-silicon?



•Annealing – The current generation of detectors needs to be kept cold even during mantainance cycles. MCz-n-on-p has proven to keep a constant CCE even during annealing. Is the same true for MCz-p-on-n?)

Previous studies on MCz-n: neutron study (Affolder)



A. Affolder et al. – NIMA 604 p. 250

Neutron irradiation – 10^{15} neutrons/cm^2

n-in-n MCz: 12.000e @ 500 V

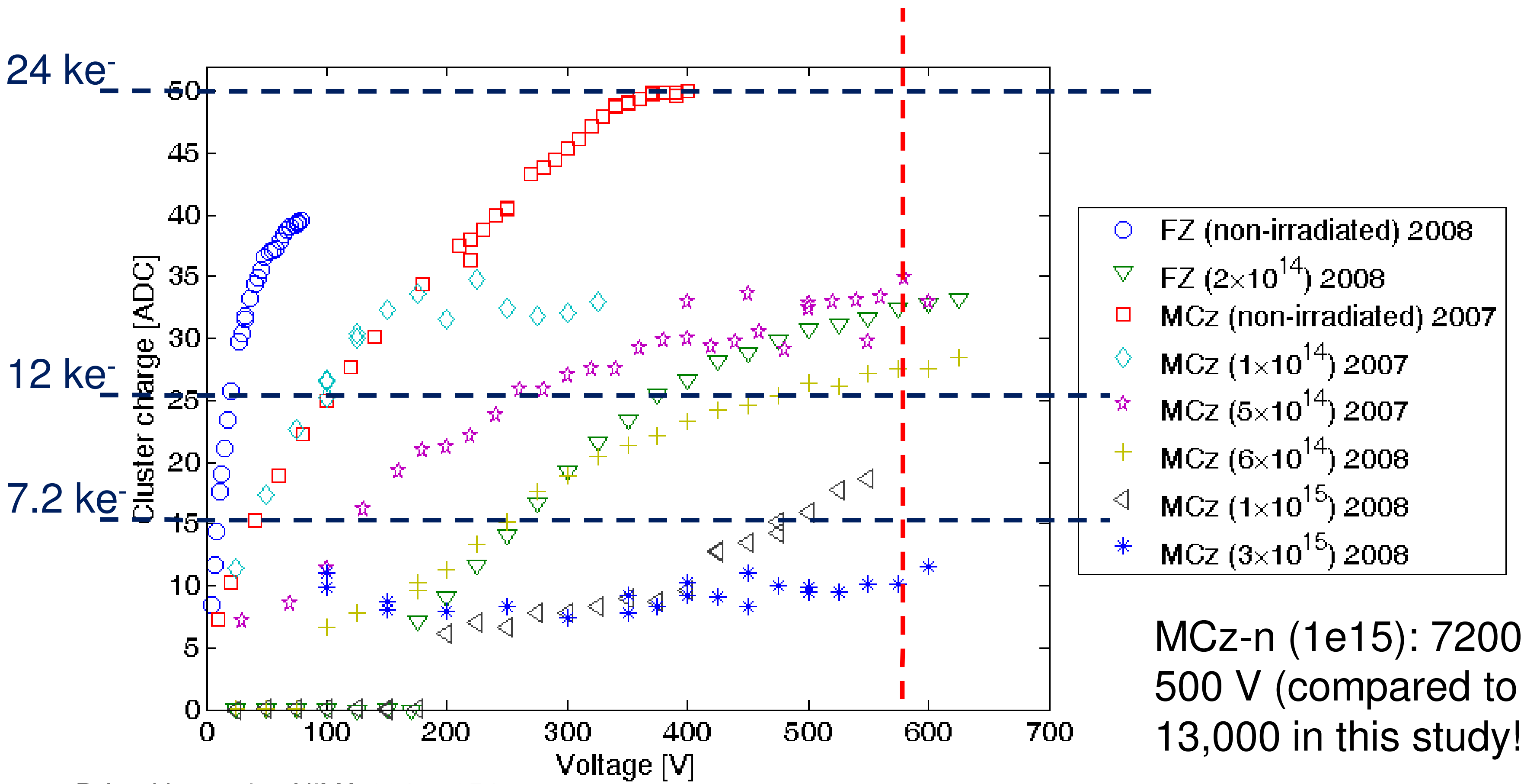
n-in-p MCz: 9.000e @ 500 V

p-in-n MCz: no sig. @ 500 V

(In our study 15.000 e-, with depletion reached @ 800 V)

1.5 kOhm for ptype, 2 kOhm for ntype

Previous studies on MCz-n: CCE on test beam (Luukka et al.)



P. Luukka et al. – NIMA 604 p. 254

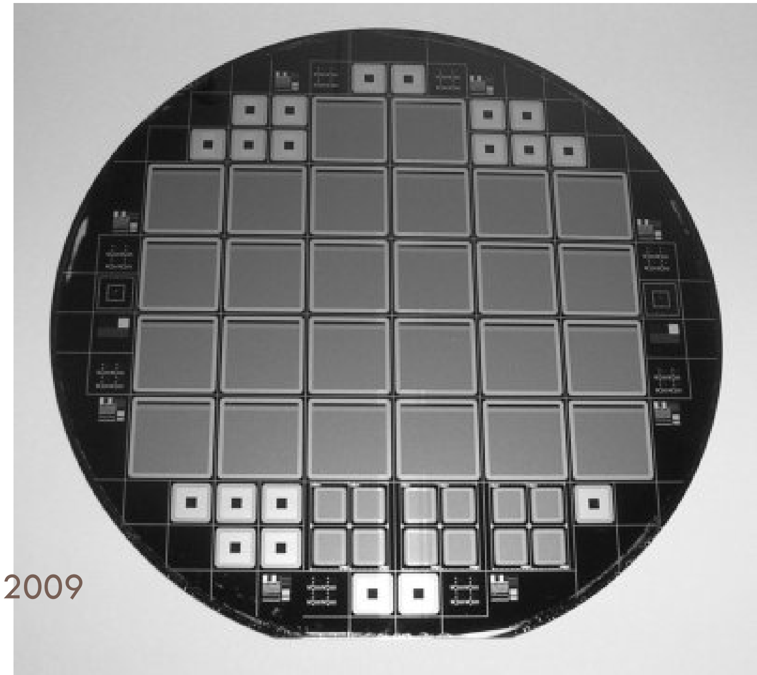
MCz-n (1e15): 7200 e- @ 500 V (compared to 13,000 in this study!)

26 MeV proton irradiation – MCz-p-on-n

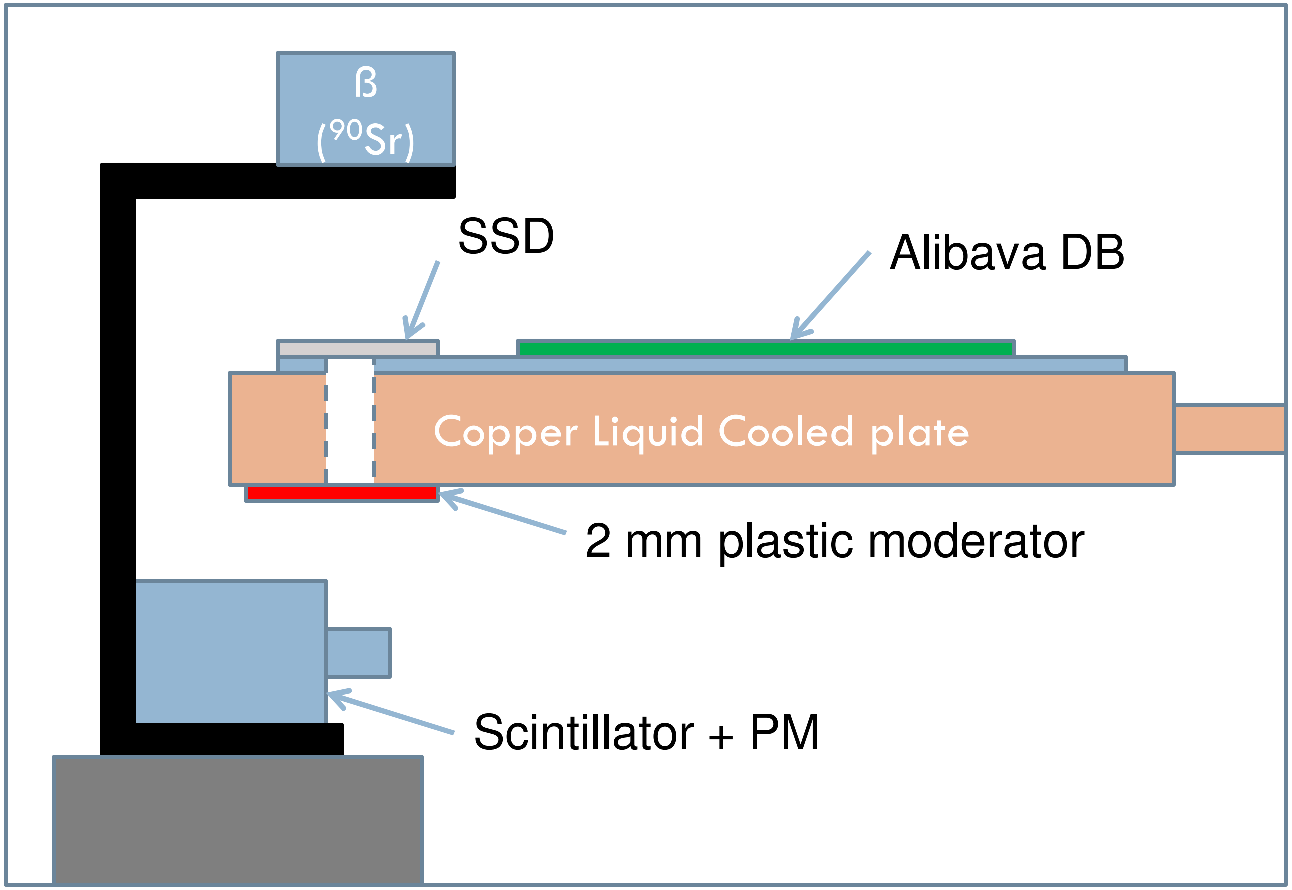
MCz-n irradiation

- RD50 production batch, 300 µm thickness, 80 µm strip pitch – expected resistivity 500 Ω·cm, actual resistivity ~ 200 Ω·cm (V_{dep}>1000 V).
- Diodes from the same wafers irradiated at the same fluences.

Samples irradiated in Ljubljana in February - March 2007
at fluences up to 8e15 n/cm^2



CCE Setup



Setup is enclosed into a box with nitrogen flushing.

Detector is biased indipendently through an external bias filter (Alibava RC filter burned @ 1100 volts)

Beetle chip was operated at stable -20 ± 0.5 °C

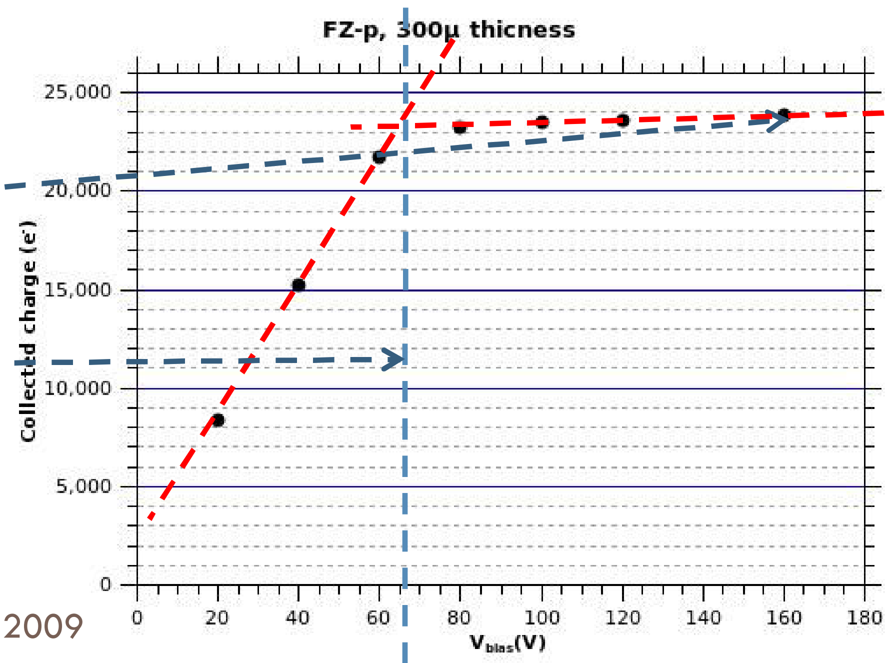
Refer to Eduardo del Castillo presentation in Alibava session…

Setup Calibration

- The calibration of the setup was performed in the 0-51200 e^- range.
- The calibration was done with unbonded beetle chips, at -20°C
- The calibration was cross-checked by measuring the CCE on an unirradiated FZ-p detector with 300μm thickness and V_{fd} (CV)=70V

Collected charge: 23,860 h^+

Depletion voltage from strip CCE in agreement with CV measurements

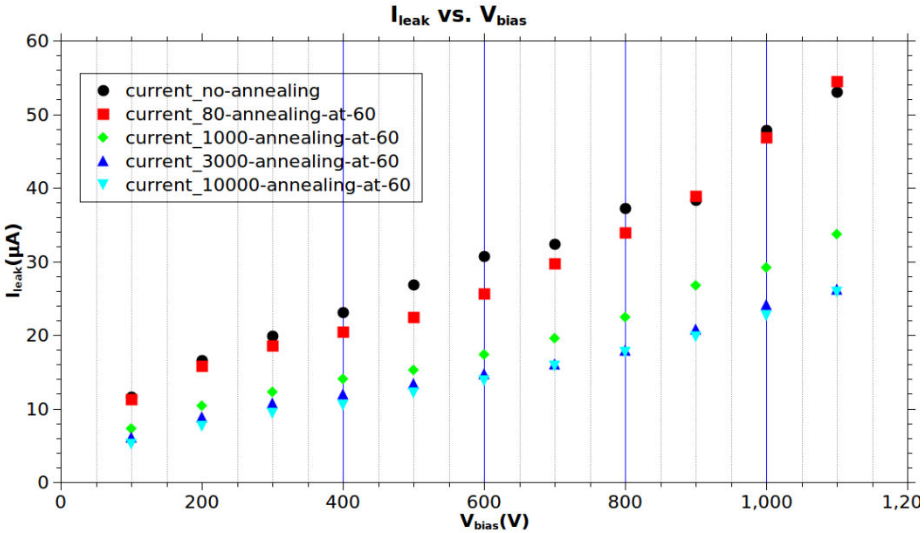


Annealing

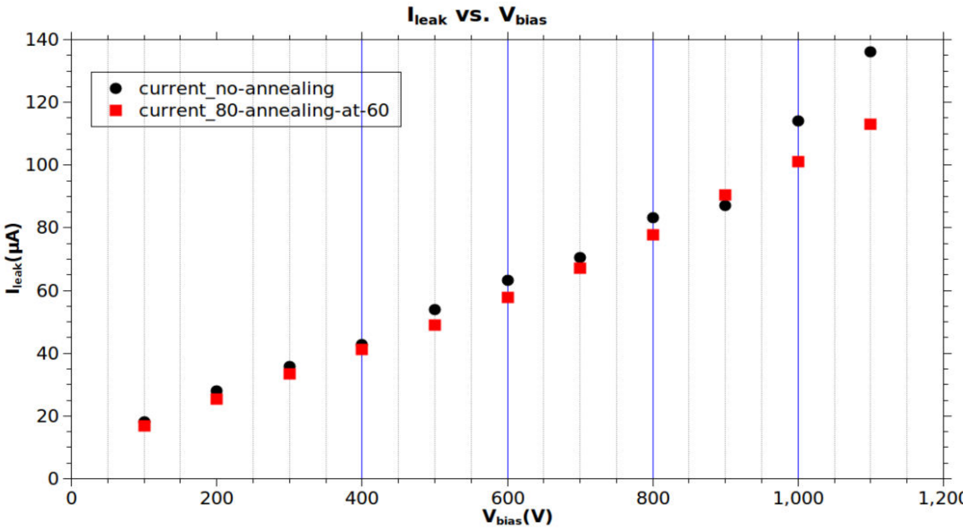
Detectors were annealed at 60°C at 5 different steps: 0, 80, 1,000, 3,000, 10,000, without unbonding them from the Alibava daughterboard. The “low” annealing temperature was chosen to preserve the daughterboard from eventual damage.

(Current curves at different annaling steps. Current measured at -20°C with RH<50%, bias+guard current)

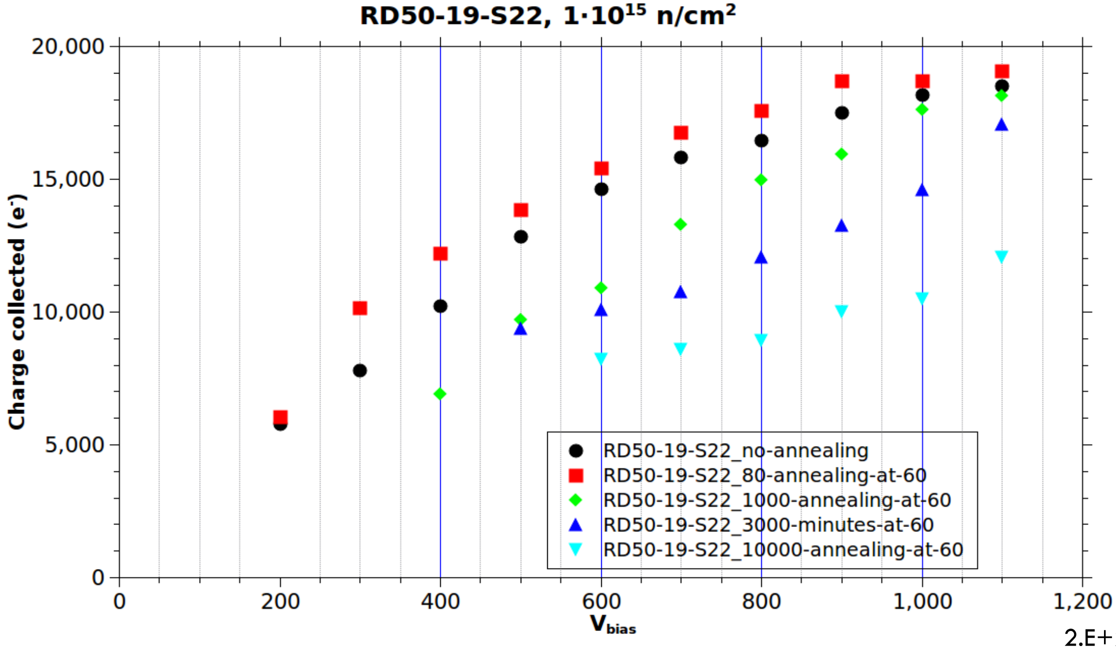
1e15 n/cm^2



3e15 n/cm^2

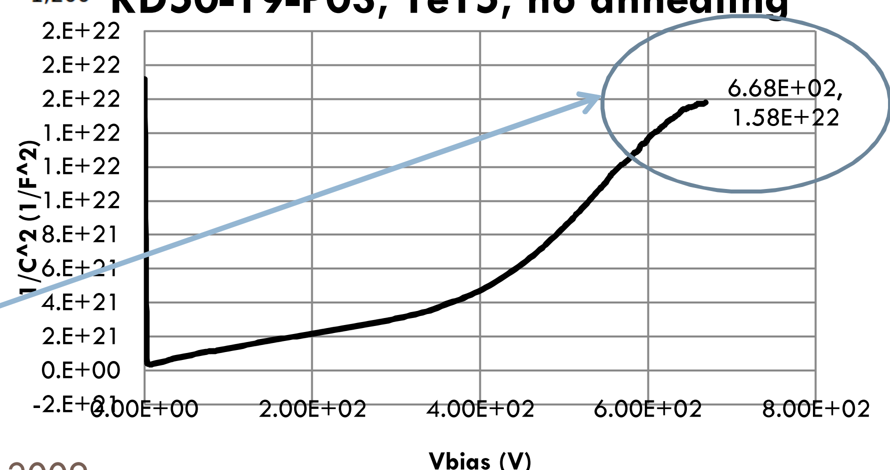


CCE Results: 1e15 n/cm^2



Collected charge goes down, but is appreciable even after long term annealing

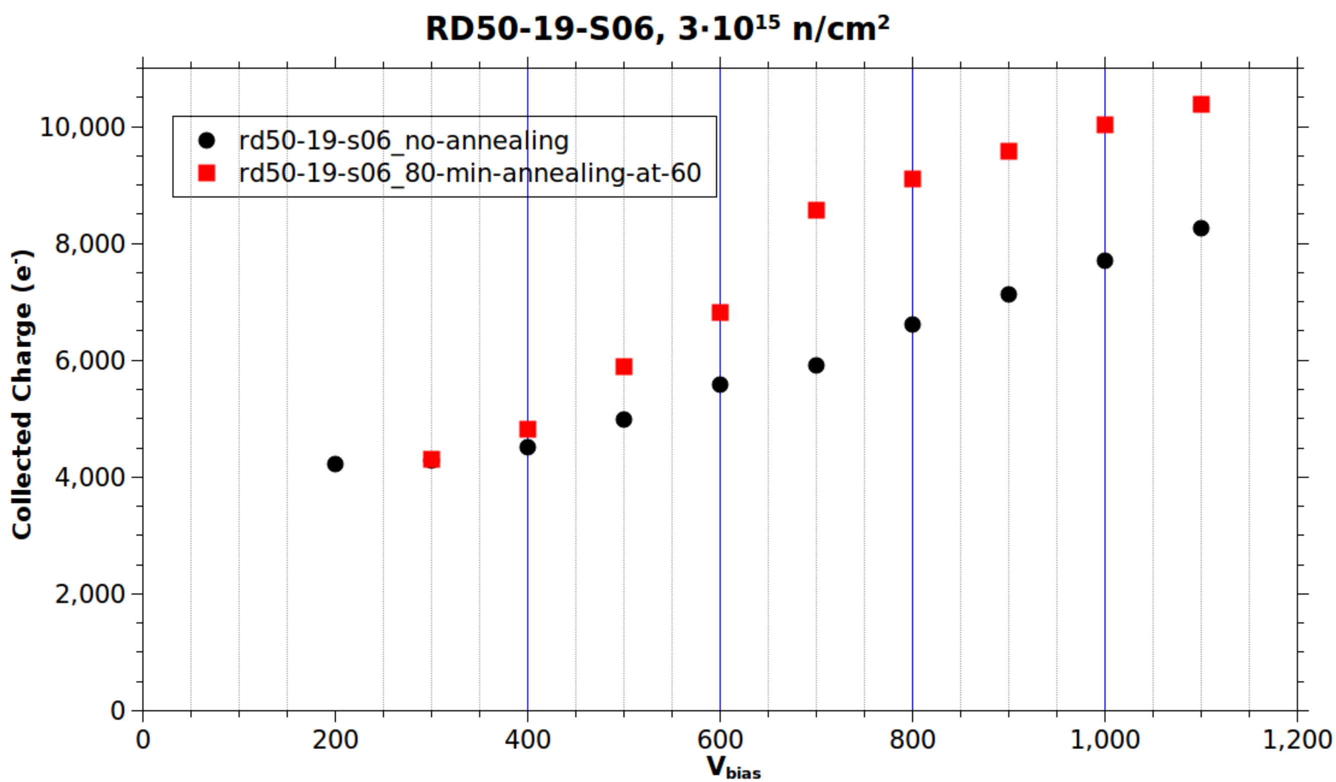
At the first step of annealing, *<u>depletion voltage from CCE is compatible with CV on diode (about 700-800 V)</u>*



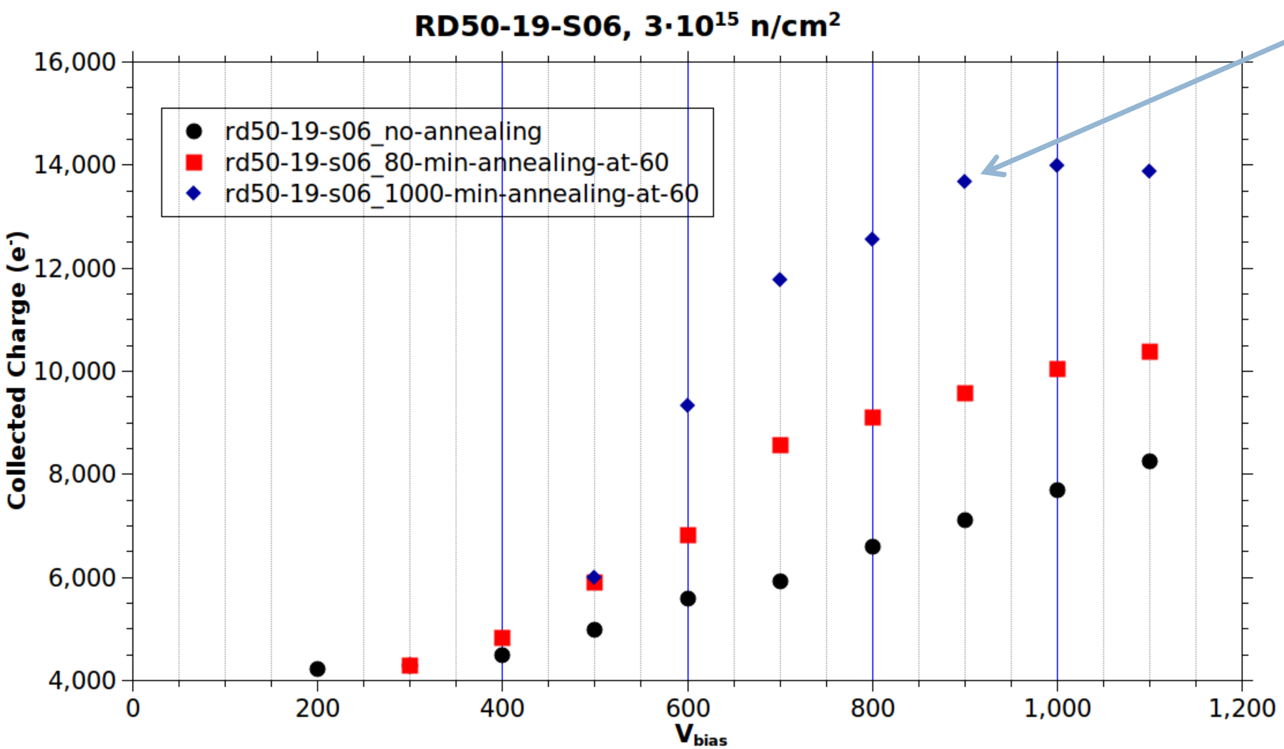
Depletion at @ ~ 700 V with no annealing

CCE Results: 3e15 n/cm^2

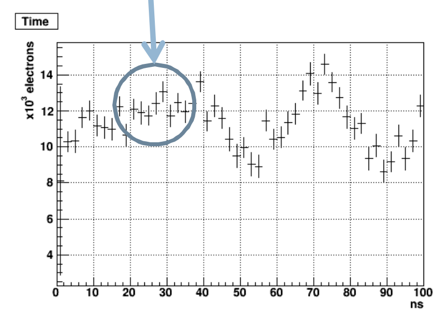
- Only 80 minutes annealing – after 3000 minutes the signal was not readable (baseline shift over the signal height, see next slide…)



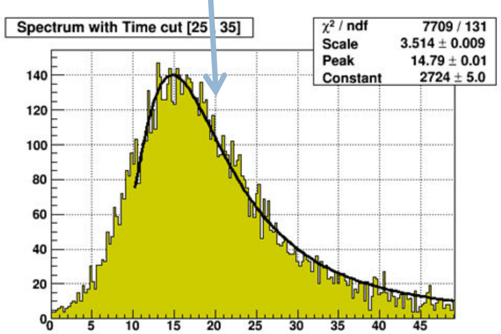
CCE Results: 3e15 n/cm^2



This curve is not correct!!!: No semigaussian peak visible, just baseline shift!

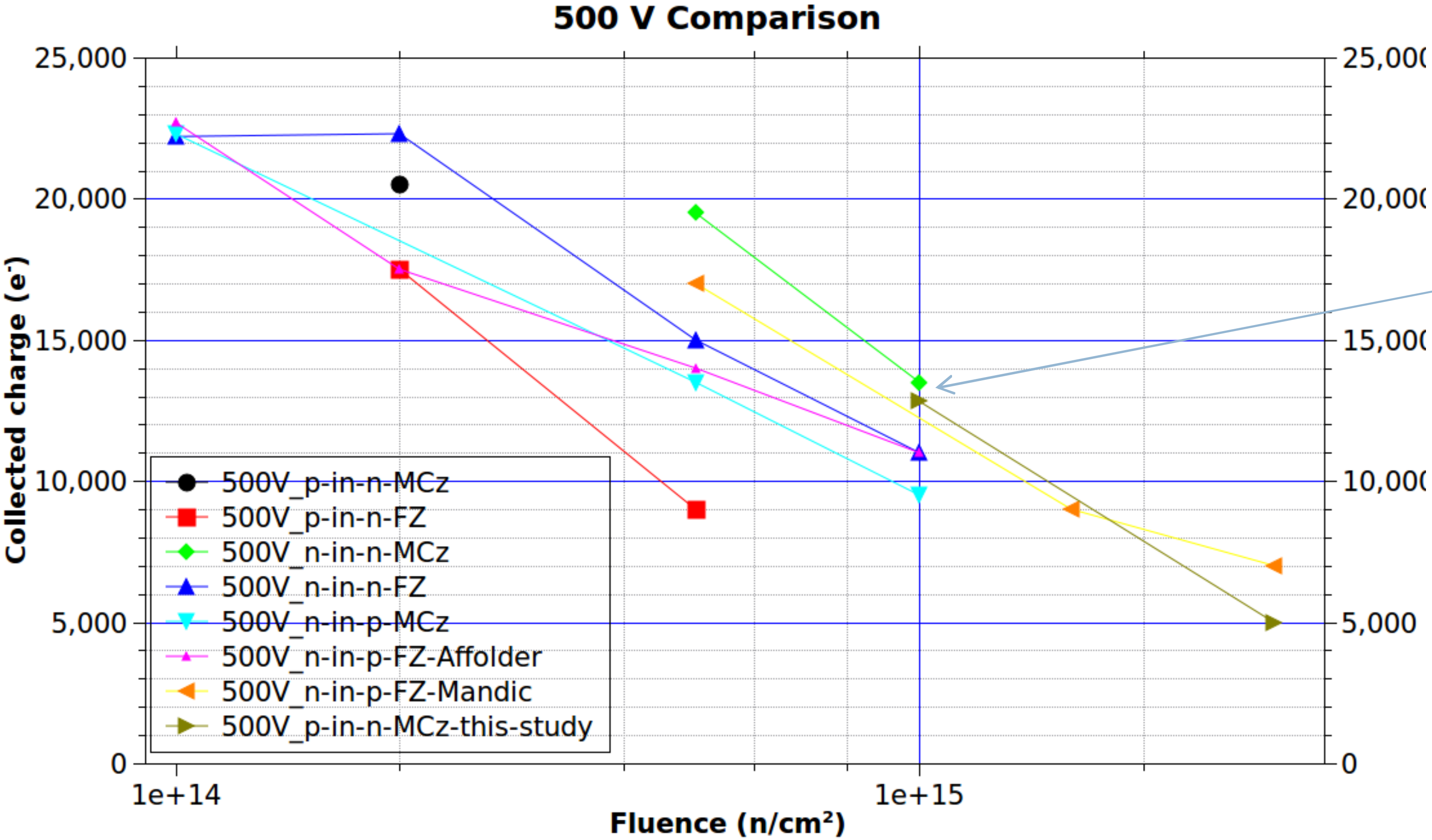


Produces a very nice Landau, though...



Efficicency omparison with existing results (500 V)

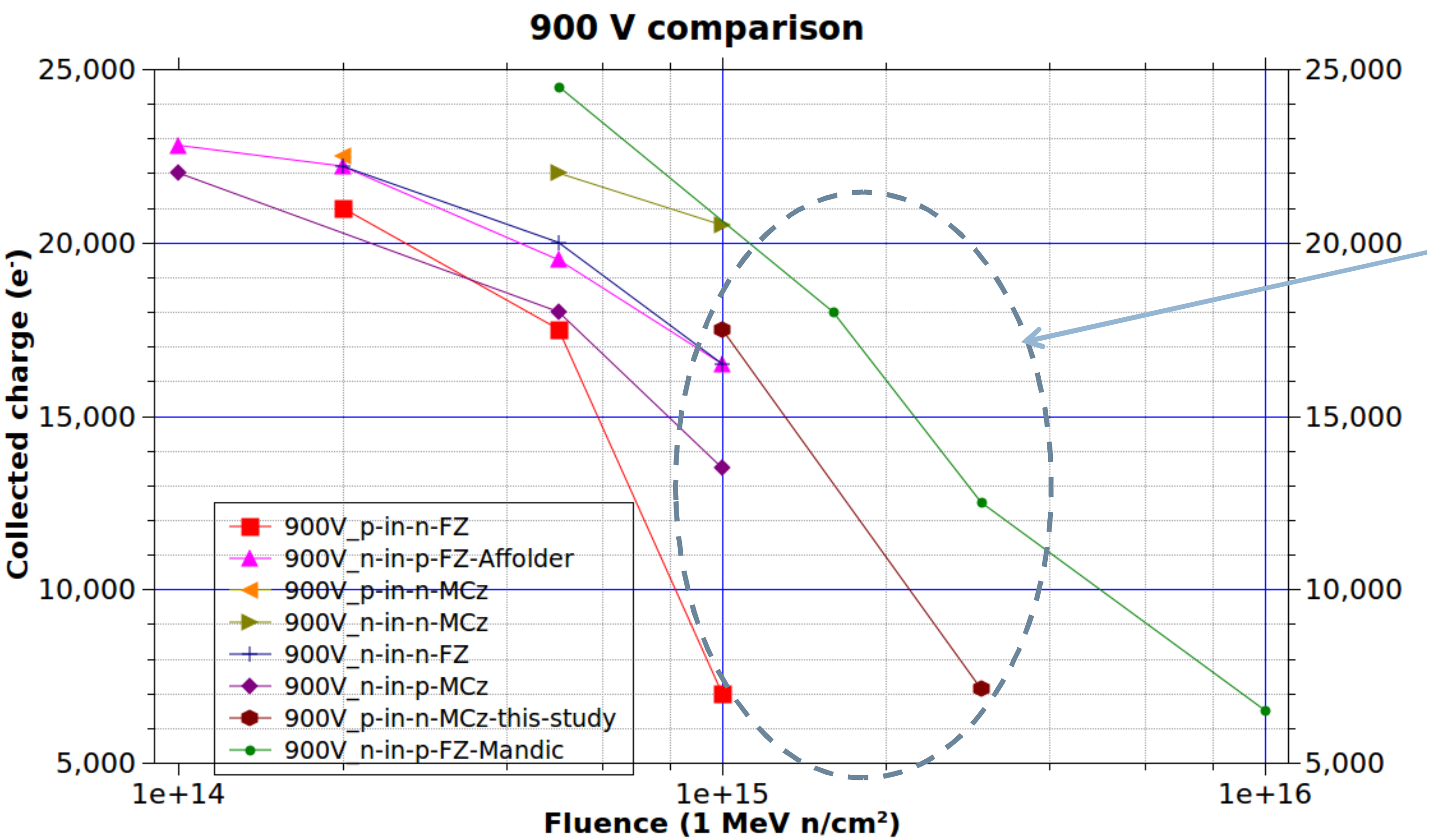
Data compared with equivalent study made on various type of detectors and published by A. Affolder on NIMA 604 and by Mandic on NIMA 603.



Similar performance to MCz n-on-n and FZ n-on-p

Efficiency comparison with existing results (900 V)

Data compared with equivalent study made on various type of detectors and published by A. Affolder on NIMA 604 by Mandic on NIMA 603.



At higher fluence performance degrades slightly compared to MCz n-in-n and FZ n-in-p

Conclusions

- Low resistivity MCz-n shows good CCE after neutron irradiation. A proton study is ongoing, as well as a CCE study on lower fluences.
- Differences are evident in terms of better charge collection efficiency as compared to standard “high resistivity” MCz p-on-n detectors. This is probably due to the shifting of SCSI to higher fluences.
- Reverse annealing decreases the performance of the detector, but for fluences up to 1e15 the collected charge is reasonable even after 10.000 mins at 60°C
- The real limiting factor in operating the detector irradiated at 8e15 was the too high current. A more powerful cooling is required.

Further notes

- 8e15 irradiated samples was not measurable – No signal up to 500 V. For higher voltages -20C cooling was not sufficient to keep current below 1 mA.
- Position-sensitive strip TCT will be performed on a twin set of samples, from the same wafer, to assess the effect of irradiation on electric fields

- Thank you!

Discussion session

- RC bias filter cannot withstand more than 1000 V (no tollerance at all!)
- Gaussian + Landaul fit: is the gaussian convolution just for taking care of the noise? A few objections:
  - The noise subtraction should take away all the noise, tails included
  - We're talking about a convolution, not a SUM(!!!) – Manuel pointed out that in CMS the gaussian convolution is used to account for the jitter in the signal sampling – In this case we should check whether with Alibava we need it or not
- Here at CERN a Daughterboard suddenly died after 3 annealing steps showing quite a weird behaviour in the baseline of the signal… any clue?
- If the sampling of the Alibava happens at 25 ns steps, where is generated the nice 2 ns – resoluted plot shown in the main output of the root macros? Is there a 500 MHz ADC somewhere?
- By using more times the pitch adapters, the bond wires will get longer, thus changing the capacitance seen by the beetle. Is there any parameter to adjust to compensate for this?