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Update of annealing measurements on heavily irradiated p-type Si sensors

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OUTLINE

- Accelerated annealing studies (@80^{o}C) have been completed in term of CCE of signal induced by mip-like electrons on p-type substrate miniature detectors after 1.1, 3.5 and 7.5 10^{15} pcm^{-2}.

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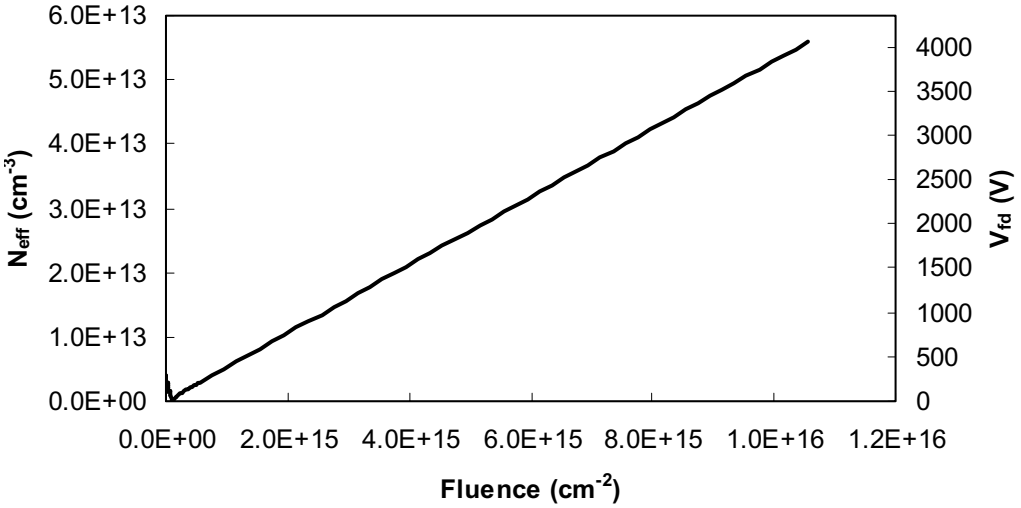
V_{FD} as a function of the proton fluence (at minimum after beneficial annealing)

The irradiated devices have been studied in term of CCE after the different irradiation doses and at the end of the beneficial annealing period. The results have been previously presented. They were extremely encouraging in term of the collected charge, especially compared with the expectation derived by the extrapolation of the V_{FD} at those extreme



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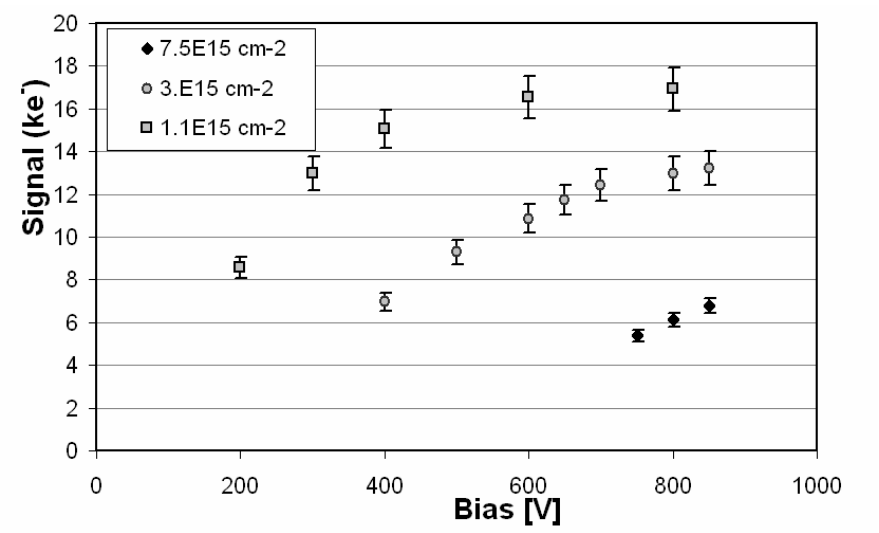
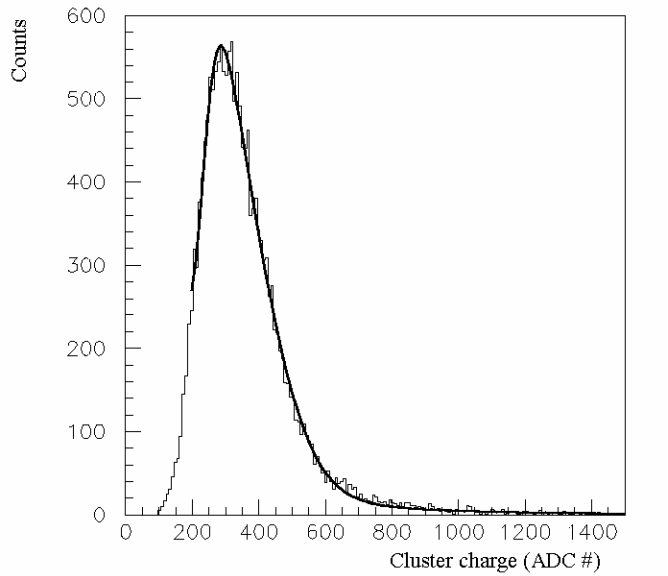
The V_{FD} after $7.5 10^{15}$ p cm^{-2} is expected at about 2800V for oxygen enriched n-type substrates. A bias voltage of 900V gives a depletion depth of about 160µm, that would yield a bit less than 12000 electrons in absence of trapping! The charge collected by the miniature p-type detectors is of ~7000 electrons, with a charge loss of 40%, which is remarkably good for that level of radiation.





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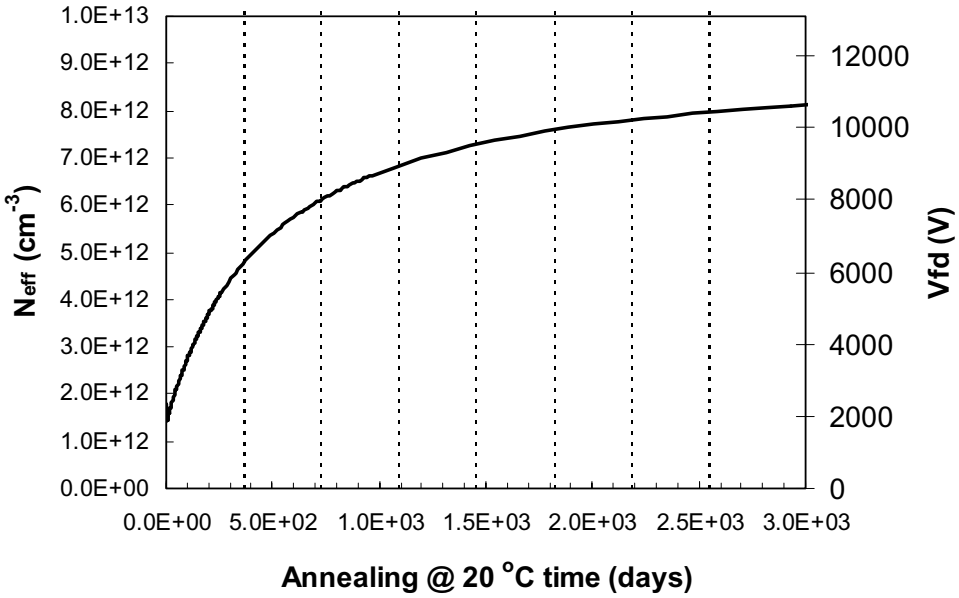

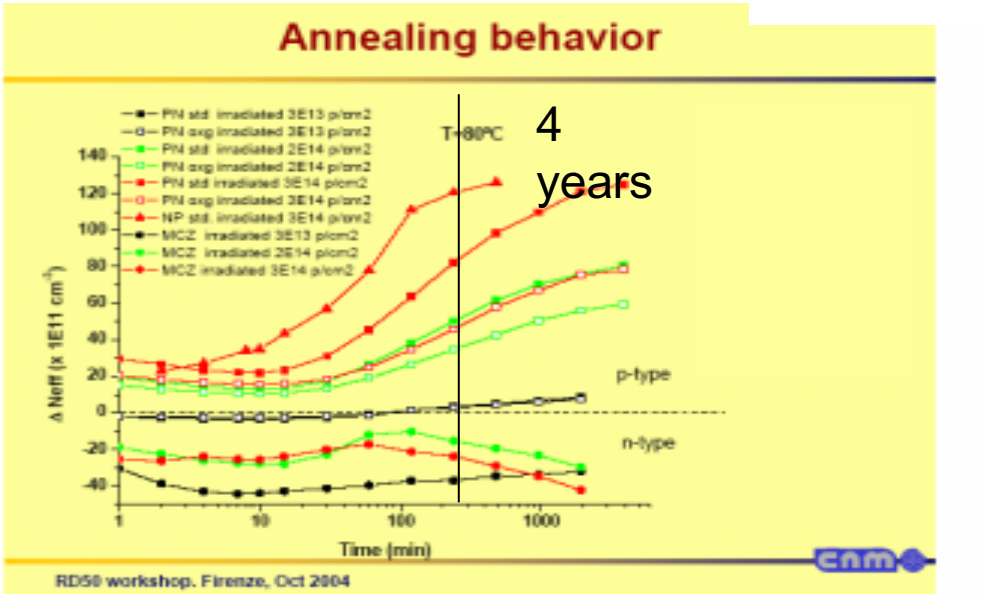

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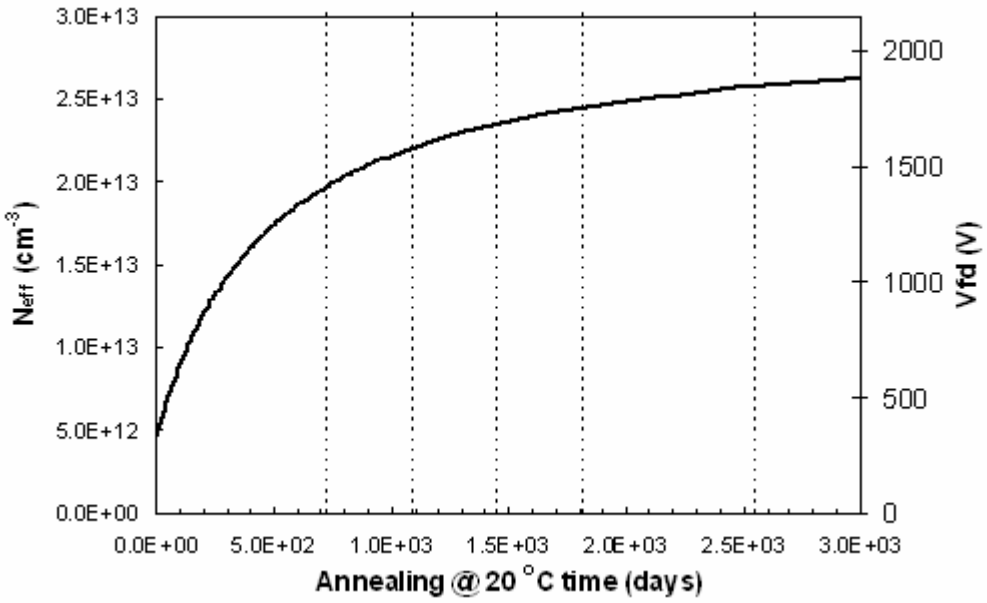
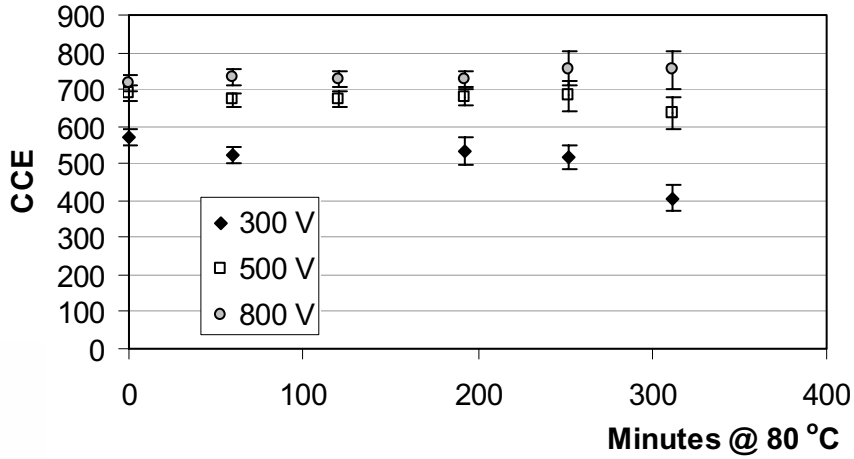
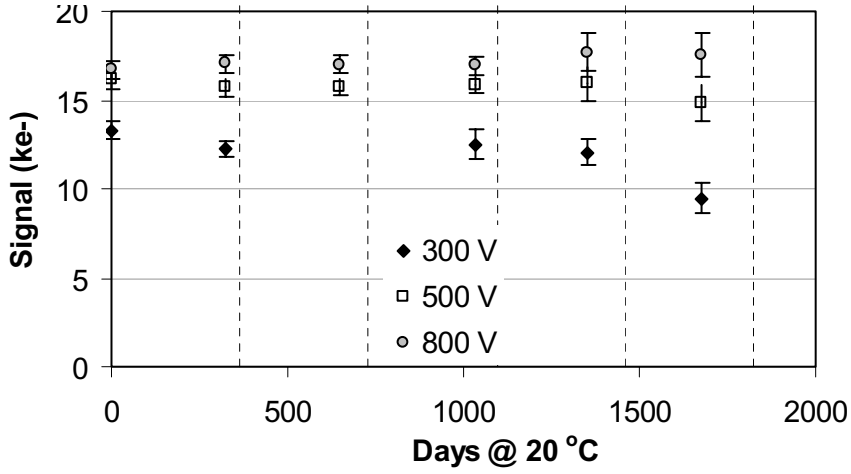
P-type detector irradiated to 1.1 10^{15} p cm^{-2}

Initial V_{FD} ~ 420V

Final V_{FD} ~ 1900V







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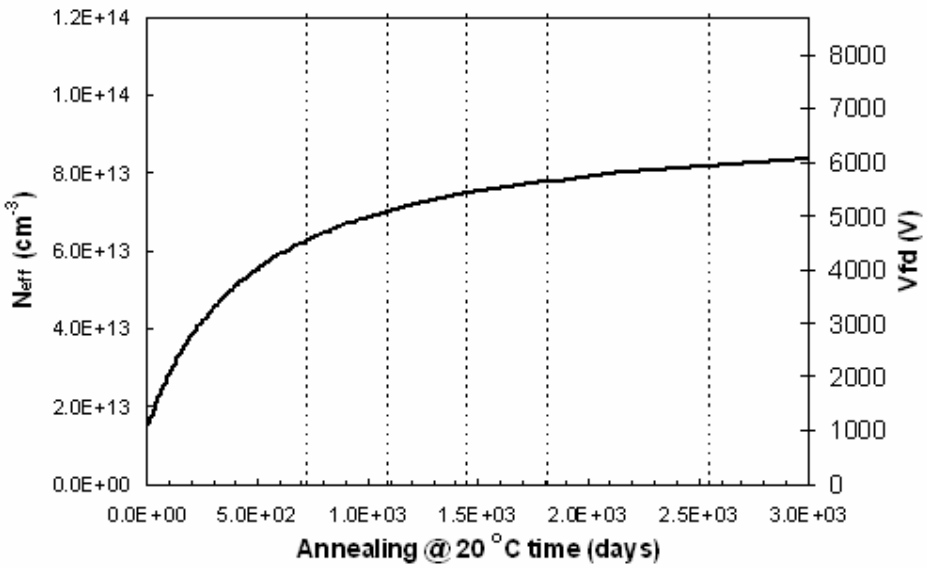
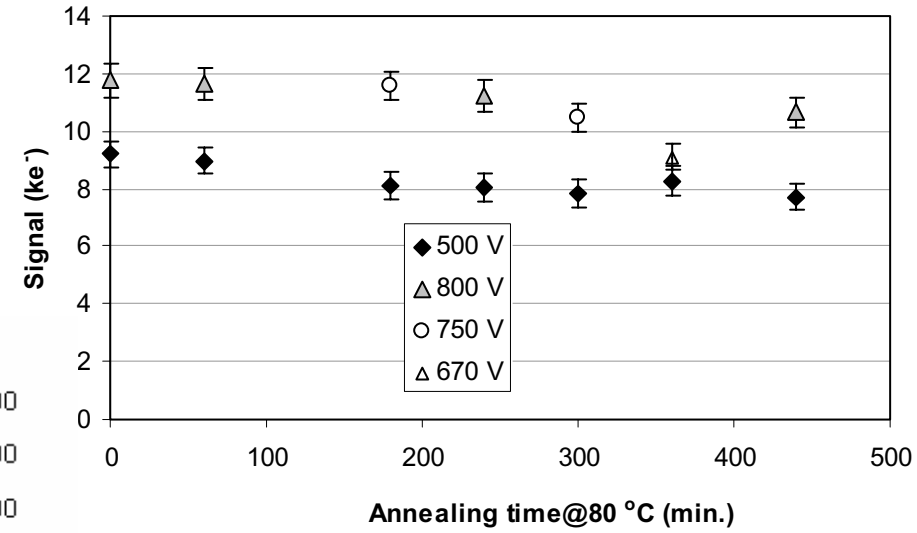
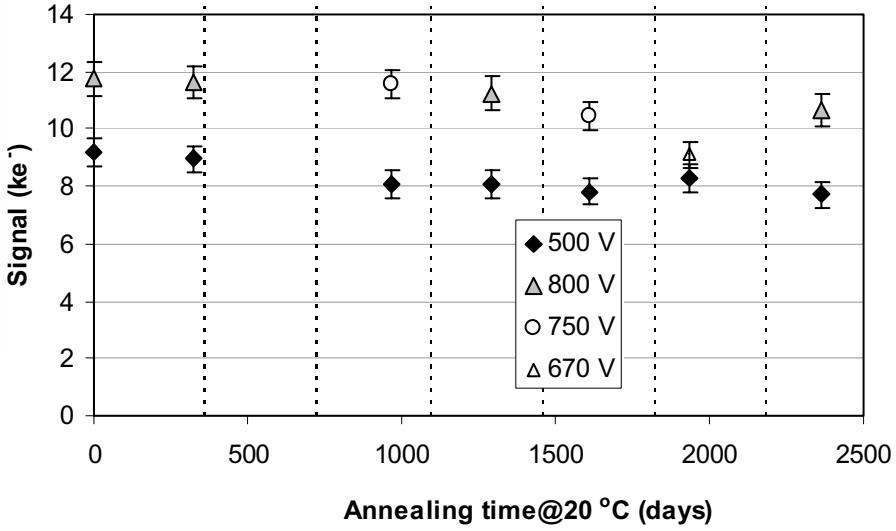
P-type detector irradiated to 3.5 10^{15} p cm^{-2}

Initial V_{FD} ~ 1300V

Final V_{FD} ~ 6000V







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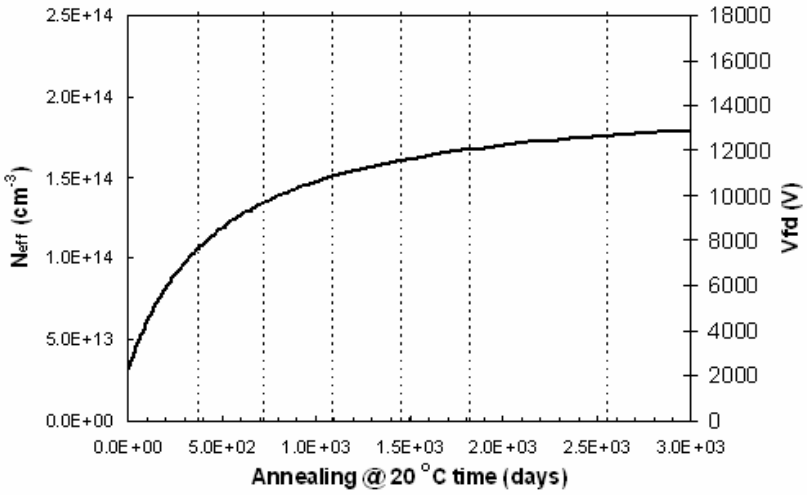
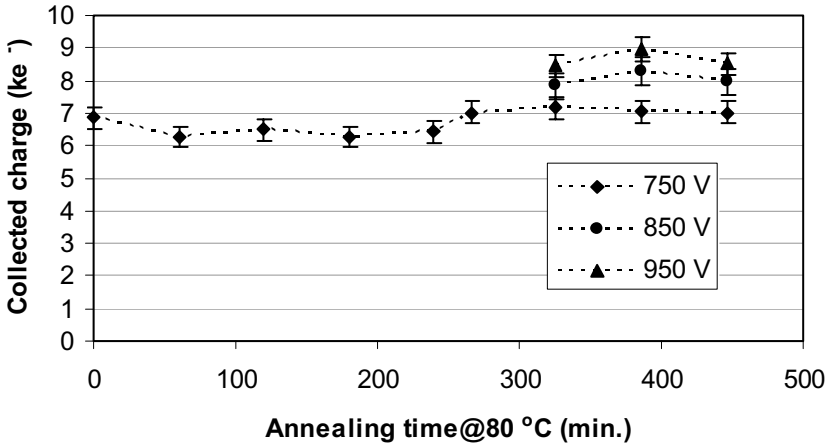
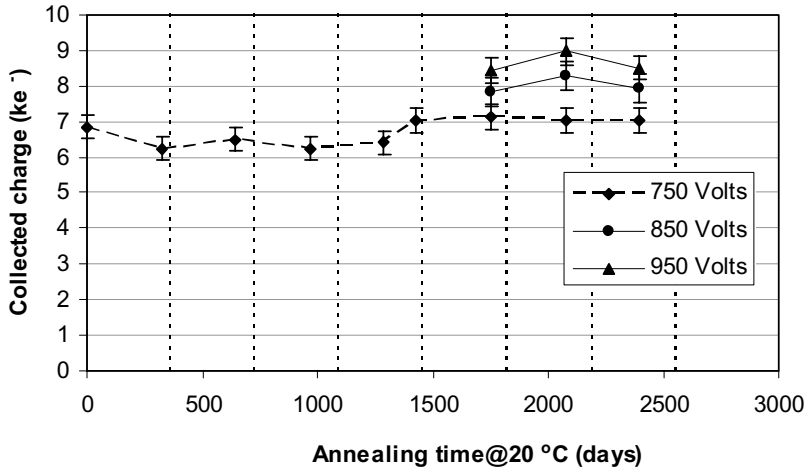
P-type detector irradiated to 7.5 10^{15} p cm^{-2}

Initial V_{FD} ~ 2800V







Predictions from RD48 parameters for Oxygen enriched devices (best scenario: after 7 RT annealing years the V_{fd} goes from ~2800V to ~12000 V!

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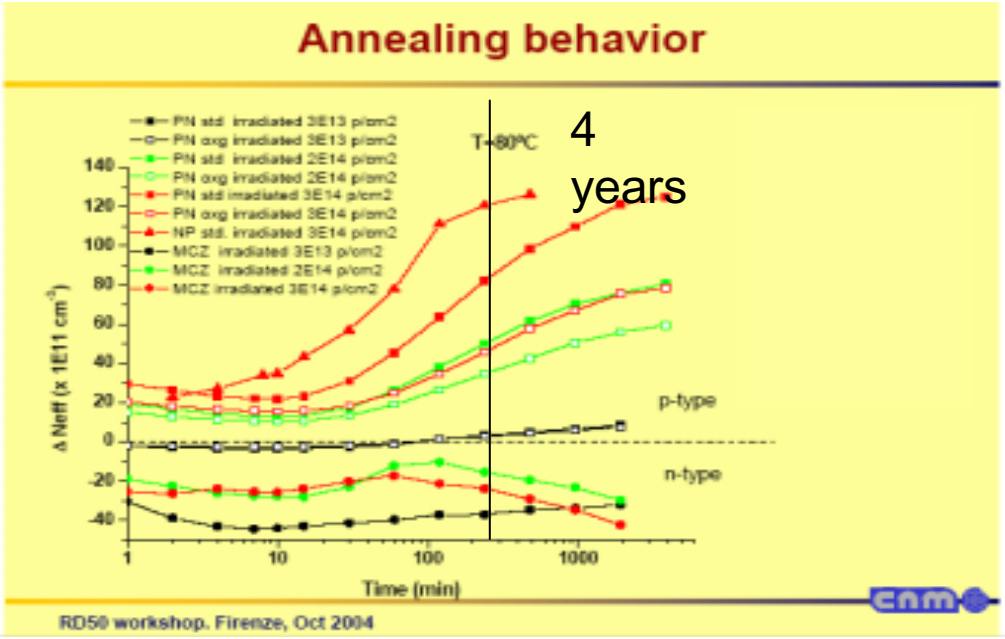
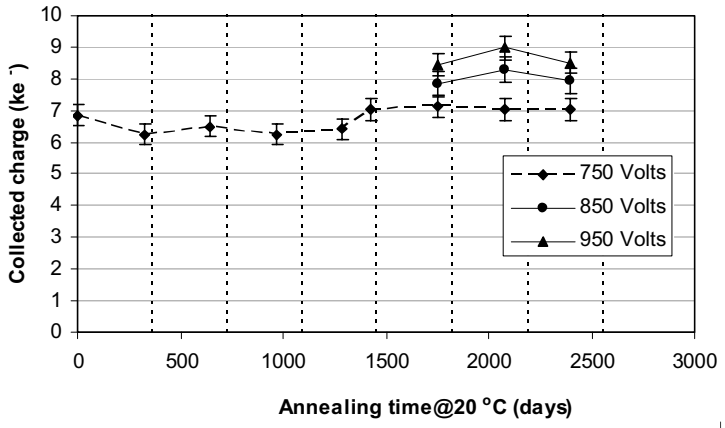


Pad diodes made of similar material, irradiated to 3 10^{14} p cm^{-2}, show a six times increase of V_{fd}, after 4 years of annealing time @ 20°C.



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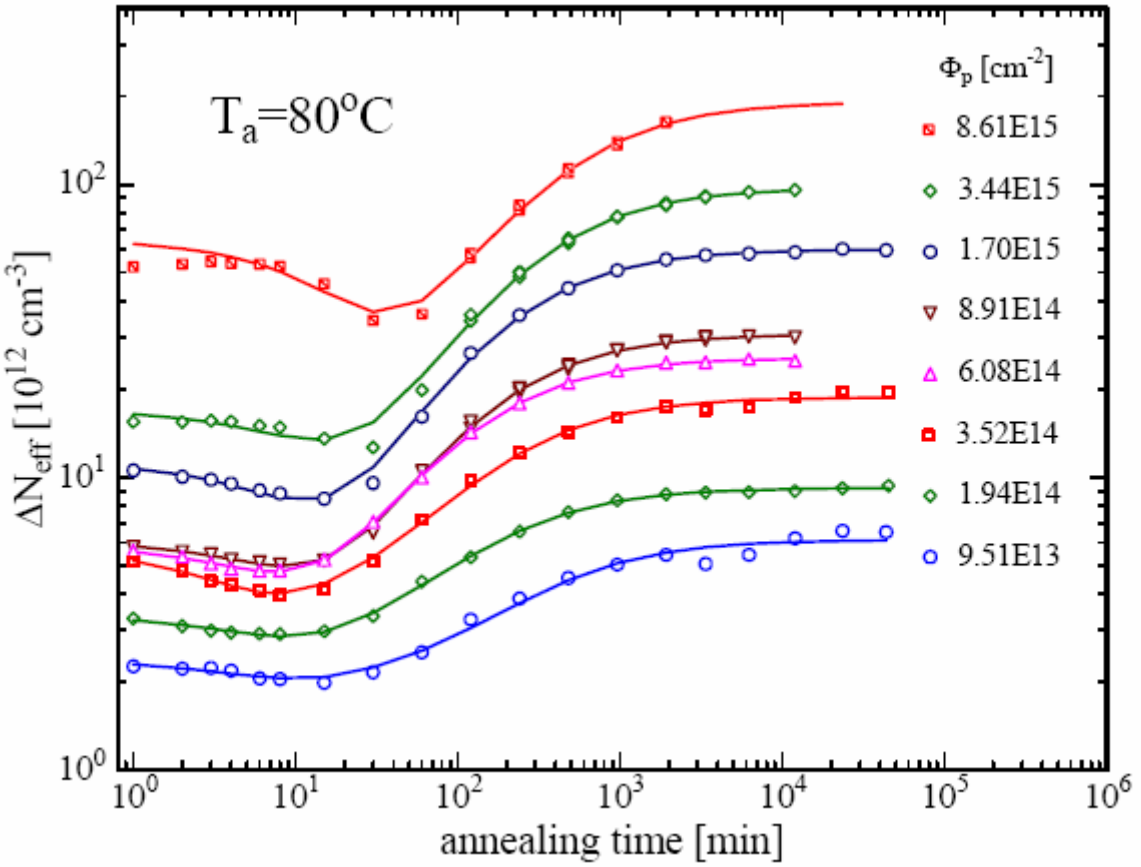
The only direct CV measurements available are on thin devices (50 μm thick). The corresponding VF_D value after 7 years equivalent annealing time at 20°C for a device irradiated to 8.6 10^{15} p cm^{-2} is >12000V (in agreement with the RD48 predictions).



Presented by E. Fretwurst at the 4th RD50 workshop, CERN 5th-7th May 2004.

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It is noticeable that for the three different fluences, and at all voltages (even at the lowest voltage measured, namely 300 V after 1.1 10^{15} cm^{-2}, and 500 V after 3.5 and 7.5 10^{15} cm^{-2}), the collected charge doesn't decrease sensitively up to an entire year at R.T. This allows an easy maintenance schedule throughout the all experimental lifetime of the detector in sLHC experiments. The decrease of the CCE is observed only for the lower voltages after a few years at R.T. Basically, given the necessity of providing high voltages for the operation of silicon microstrip detectors in a sLHC-like environment, the annealing effects could be neglected. It must be stressed that the detector cooling during operation is necessary (the detectors must be kept at temperature safely below the thermal run-away limit) to be able to apply the required high voltage.