University of Liverpool

Preliminary Results with Miniature Microstrip p-type Detectors after Neutron Irradiation to SLHC Doses

G. Casse, University of Liverpool

University of Liverpool

OUTLINE

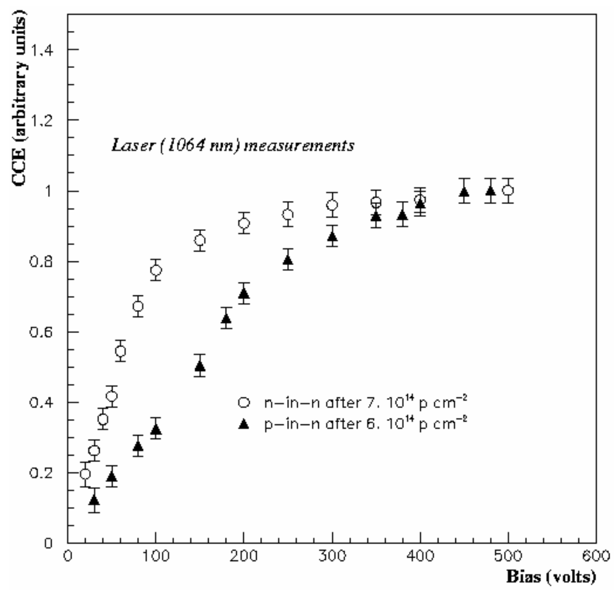
- Summary of previous results with 24GeV/c protons
- New preliminary results with neutron irradiated devices

University of Liverpool

Accepted facts about Si segmented devices for increased radiation hardness:

N-side read-out on n-type substrates gives the main advantage (ATLAS and CMS pixels, LHCb-VELO microstrips).

Comparison n to p-side read out



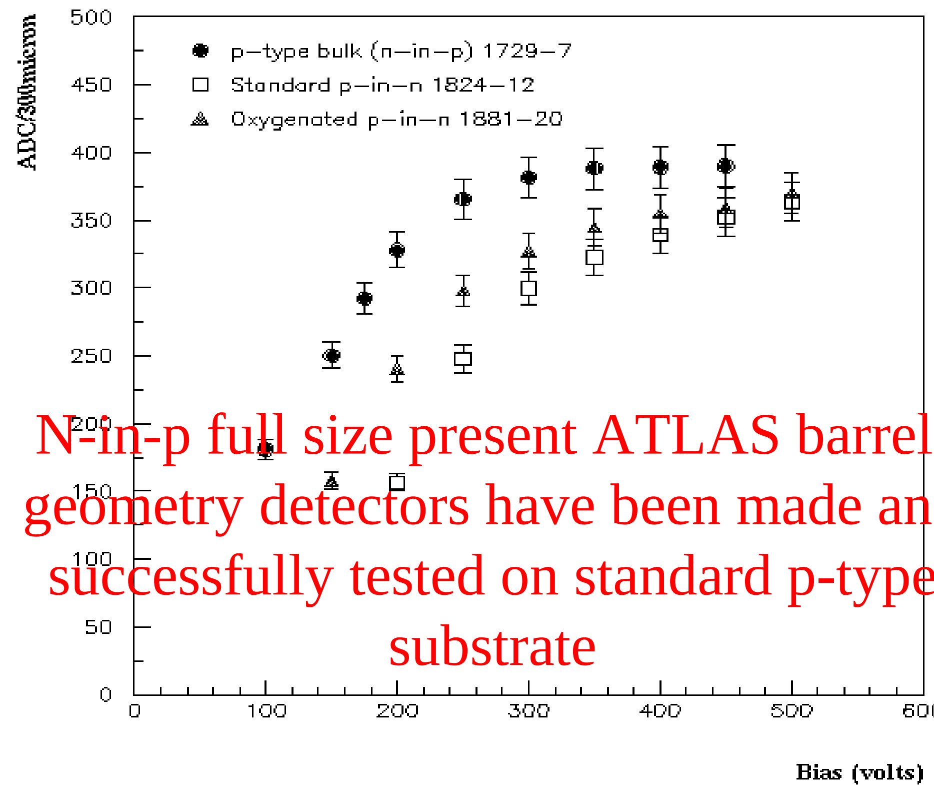
University of Liverpool

Implementing n-side read-out on p-type silicon

The n-side read-out can be equally well implemented on a p-type substrate and keep the same advantages for CCE after irradiation and exhibiting two additional advantages compared to the n-type bulk.

• The p-type bulk doesn't invert, so the junction side will always be on the same side before and after irradiation

•The p-type substrate devices don't required backplane processing, which turns out being cheaper (40-50%) than the n-type. This argument can be very important for large area coverage.



N-in-p full size present ATLAS barrell geometry detectors have been made and successfully tested on standard p-type substrate

Improvements of CCE(V) confirmed

University of Liverpool

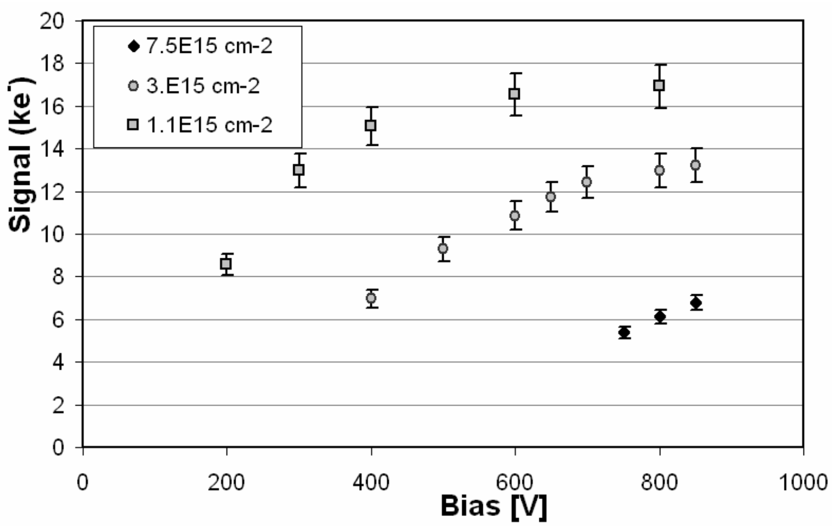
Facts about Si segmented devices for increased radiation hardness: n strip read-out on p-type silicon

24 GeV/c proton irradiation in CERN/PS (thanks to M. Glaser)

After 7.5$10^{15}$ p cm^{-2} 7000e are collected at 900V.

The charge collected at these doses is determined predominantly by trapping.

At low temperature the noise can be controlled.



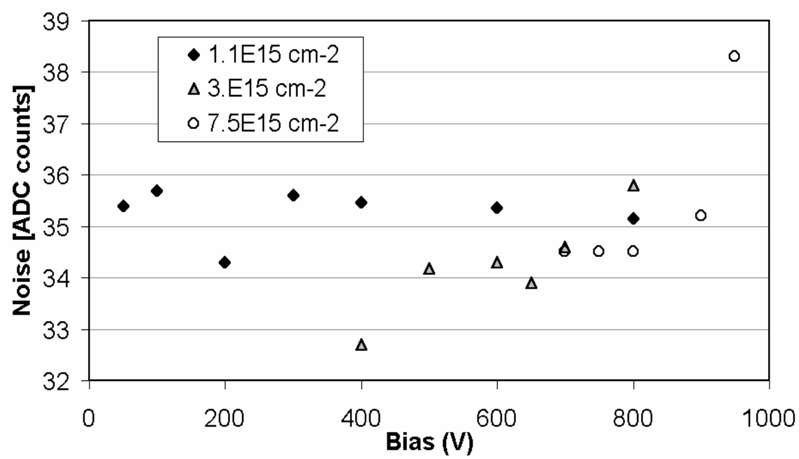
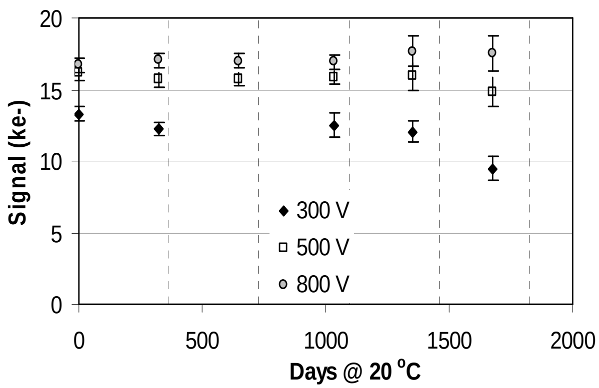


Fig. 1 Noise as a function of the applied voltage for the three different irradiation doses. The pre-irradiation value is about 35 ADC counts, similar to the value found after irradiation.

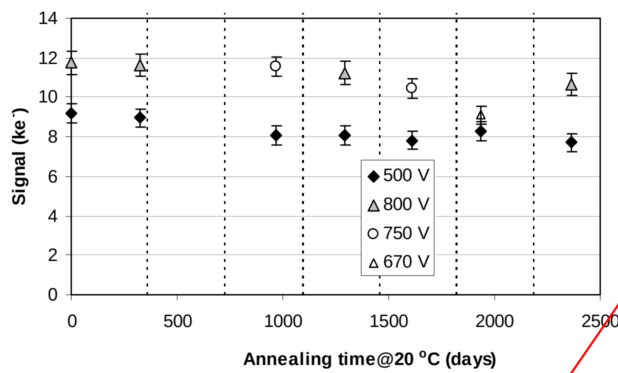
University of Liverpool

Annealing after proton irradiation

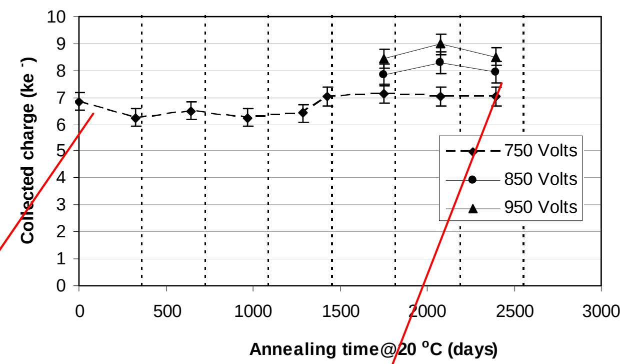
The signal doesn't degrade significantly with annealing time up to 7y equivalent at room temperature (while V_{FD} is expected to rise from 2.8kV to 12kV)!



1.1 10^{15} p cm^{-2}

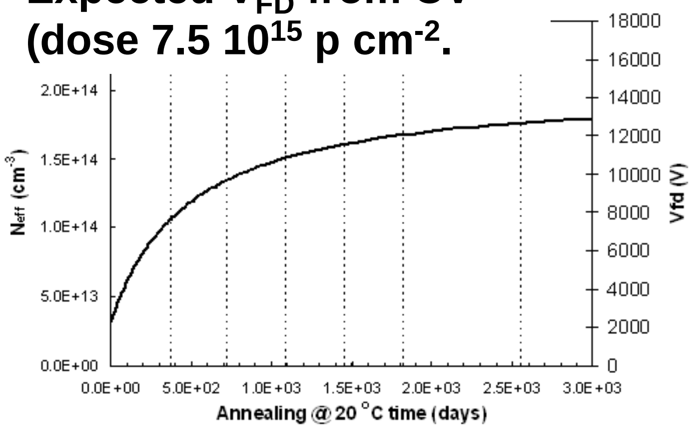


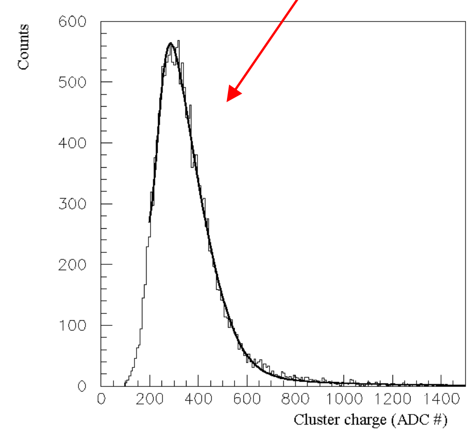
3.5 10^{15} p cm^{-2}

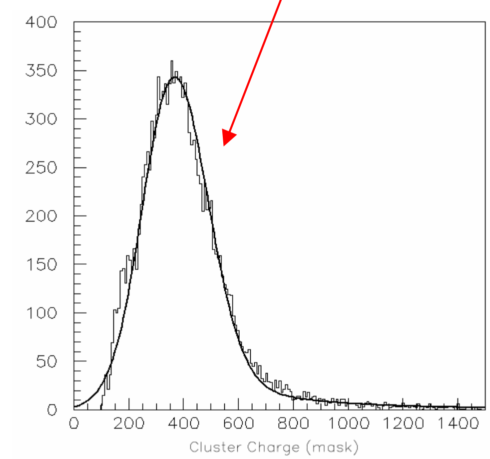


7.5 10^{15} p cm^{-2}

Expected V_{FD} from CV (dose 7.5 10^{15} p cm^{-2}.



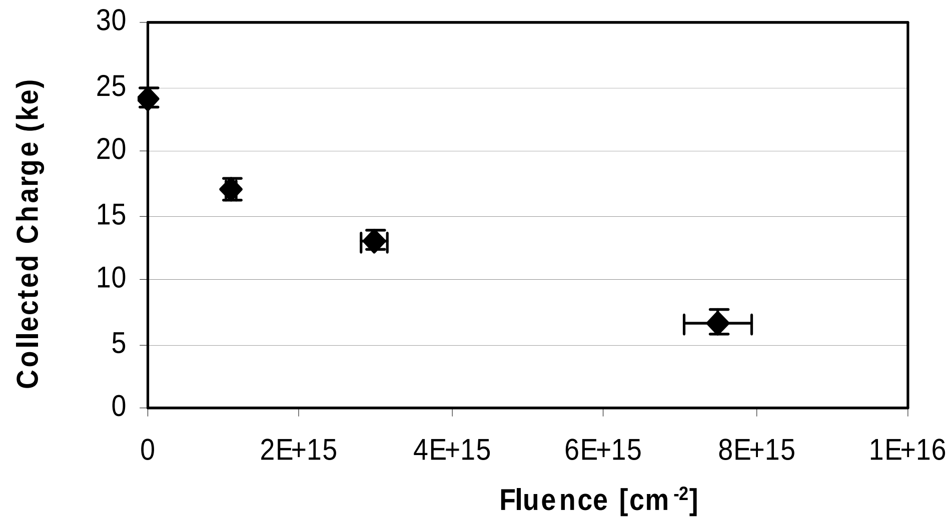




Summary of degradation after proton irradiation

University of Liverpool

Below is the figure for the charge collection degradation after proton irradiation of miniature µ-strip detectors read-out with 40MHz analogue electronics. According to what observed above, this figure is not significantly changing with time at 20°C after irradiation.



University of Liverpool

Need for neutron irradiation tests

The radiation damage in SLHC will be due to particles emerging from the interactions and to backscattered neutrons. The radius at which the two contributions are about equal is between 20-25 cm. For further radii the neutron contribution becomes dominating. The µ-strip detectors therefore will be operated in an area where the neutron contributes to the radiation damage for more than 50%.

It is therefore necessary to prove the radiation resistance of the µ-strip devices with neutron irradiation as well as with charged particles.

University of Liverpool

Neutron irradiations

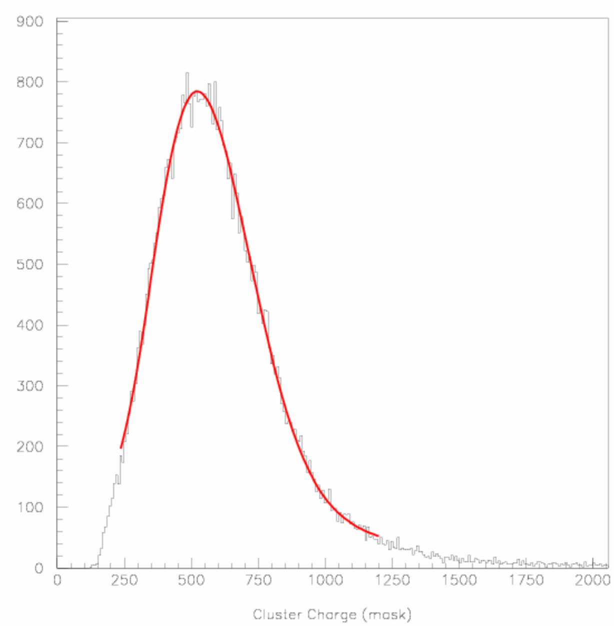
A few µ-strip detectors (1X1 cm^2) made by Micron on 140 and 300µm thick high resistivity (>10kW cm) p-type wafers and irradiated in the Ljubljana research reactor to 0.5, 1.6 and 3 10^{15} n cm^{-2} (thanks V. Cindro, M. Mikuz ……).

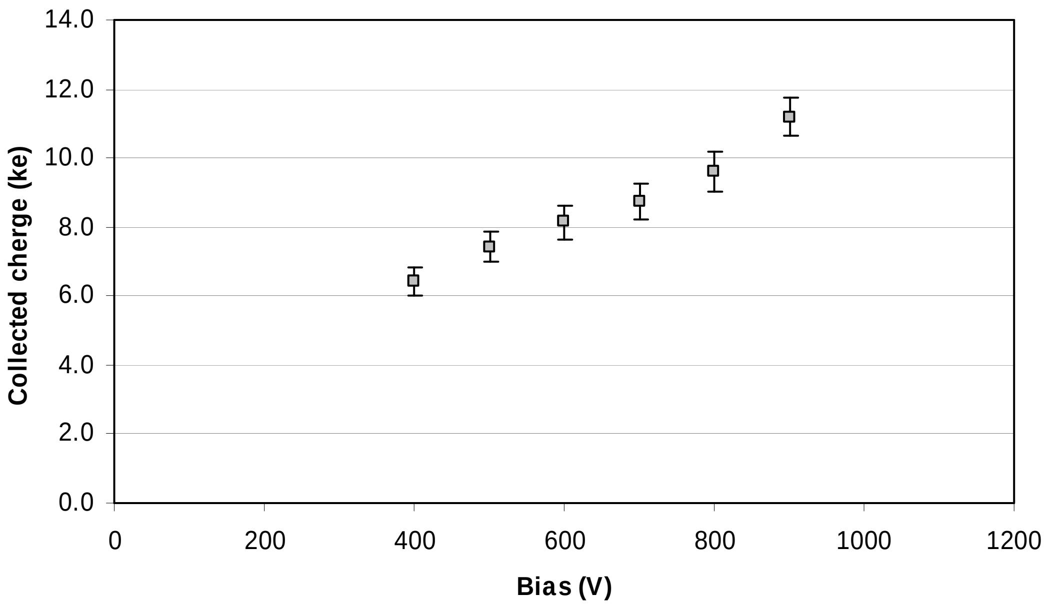
Two detectors irradiated to 1.6 and 3 10^{15} n cm^{-2} have been measured with LHC speed analogue electronics (SCT128A). The higher dose detector has also been measured after accelerated annealing to almost 3 years room temperature equivalent (two steps at 60ºC and two at 80ºC).

Neutron irradiations: $1.6 \cdot 10^{15}$ n cm^{-2}

University of Liverpool

PRELIMINARY

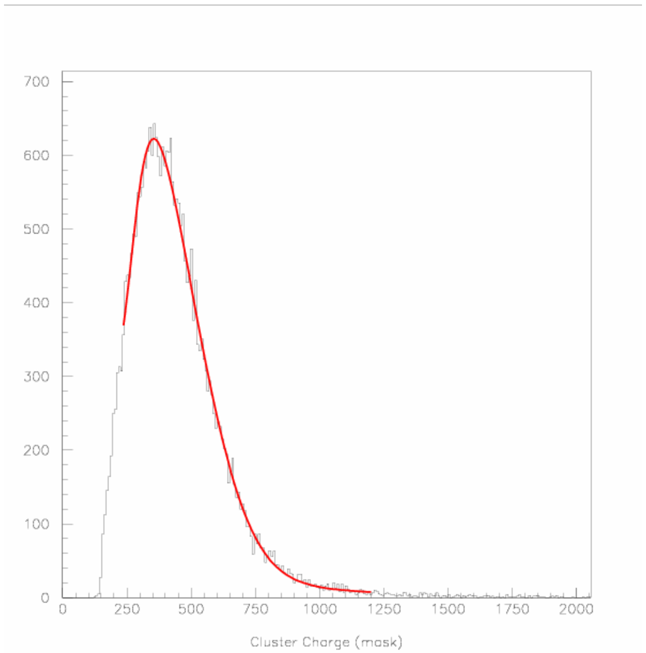


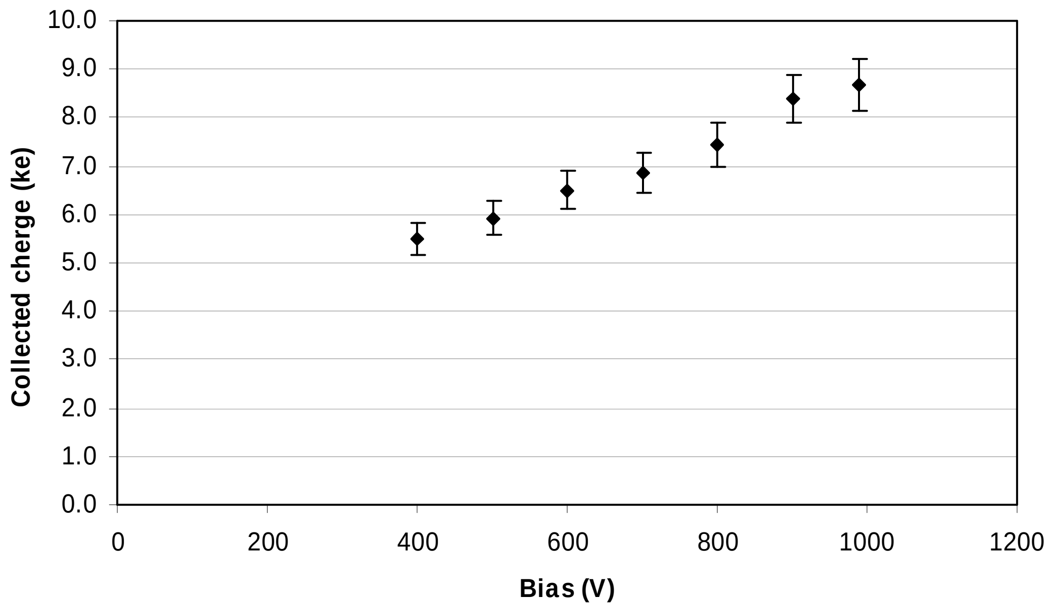


University of Liverpool

Neutron irradiations: $3 \cdot 10^{15}$ n cm^{-2}

PRELIMINARY



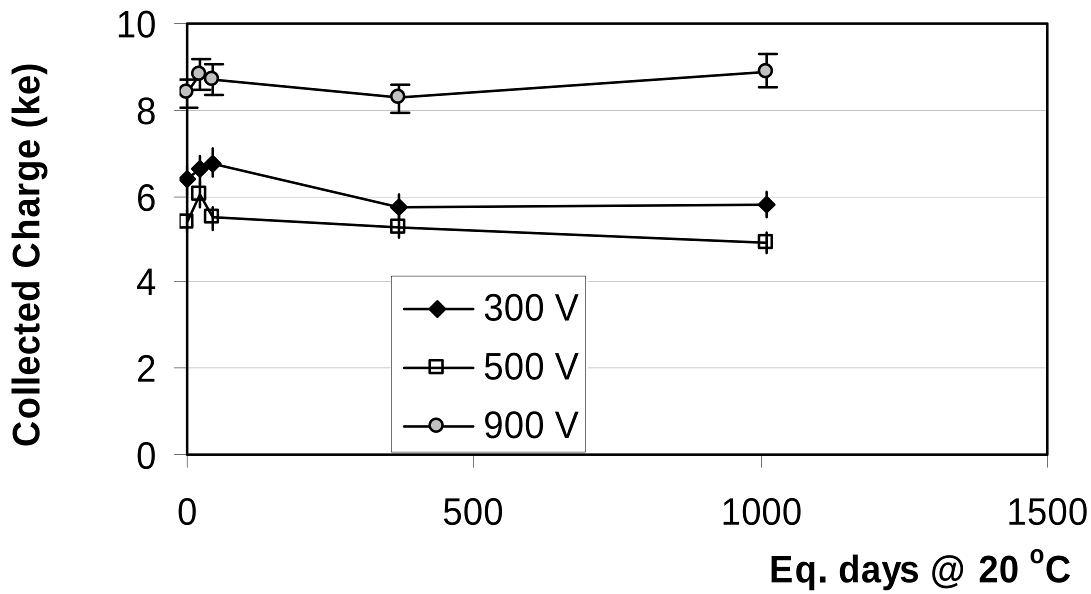


University of Liverpool

Neutron irradiations: $3 \cdot 10^{15}$ n cm^{-2}

Annealing

PRELIMINARY

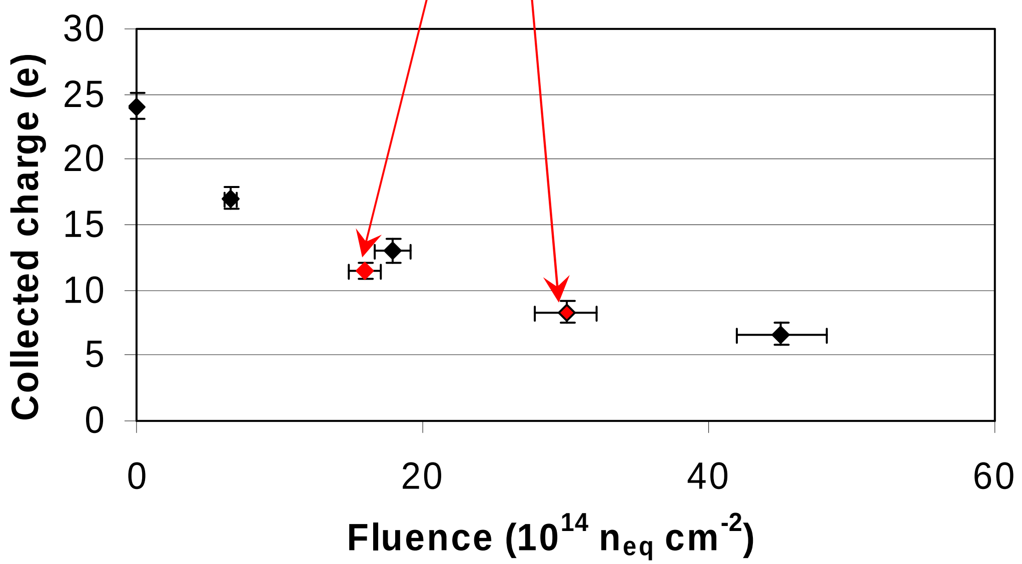


University of Liverpool

Neutron and proton irradiations summary

Neutrons

PRELIMINARY



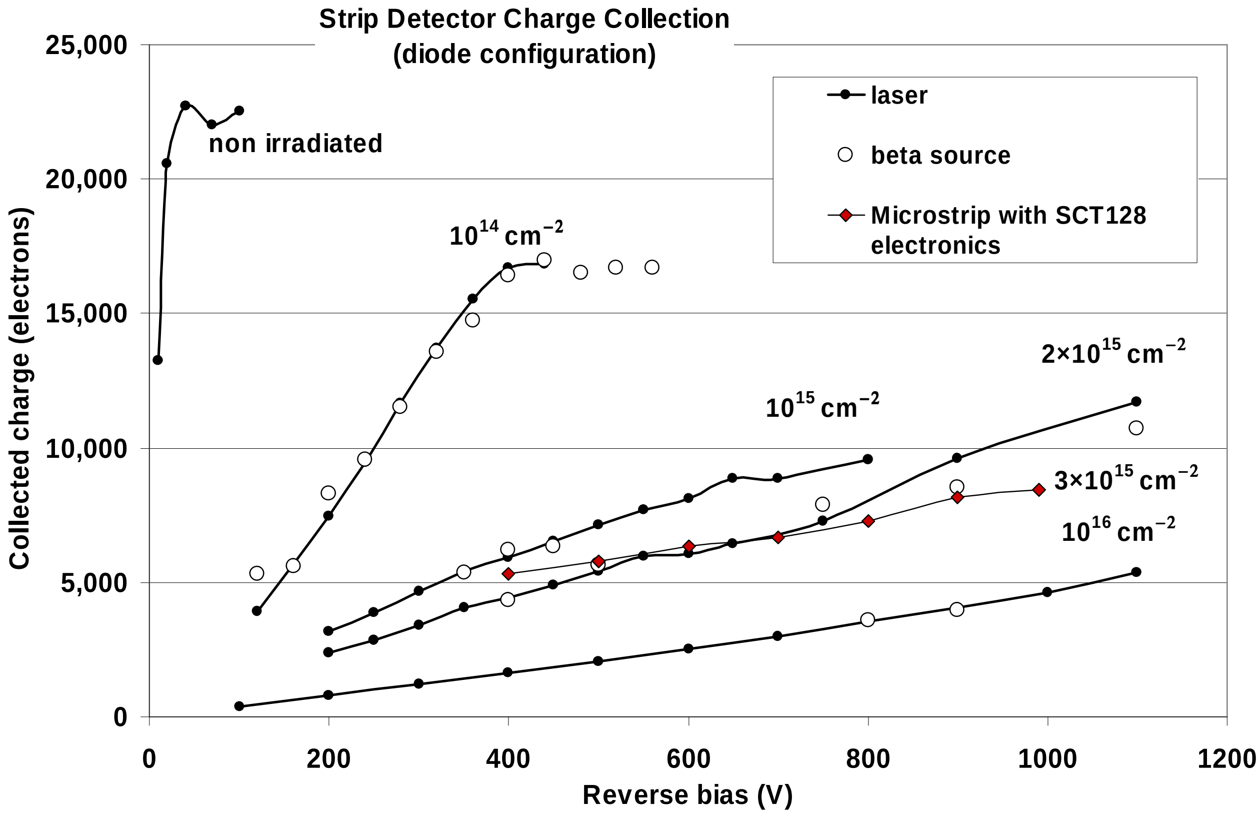
University of Liverpool

Neutron irradiations

More μ-strip detectors (1X1 cm^2) made by CNM Barcelona on 300μm thick high resistivity p-type wafers were irradiated in Ljubljana to various fluences. They have been measured in Valencia and Barcelona with a different method from the measurements just shown: the strips were connected to a common metal rail (*diode* configuration) and read-out with a high-bandwidth current amplifier.

University of Liverpool

Neutron irradiations: comparison “diode” vs µ-strips



University of Liverpool

Conclusions

- New (and preliminary) results with µ-strip detectors irradiated with neutrons to SLHC fluences and read-out with LHC-speed electronics are here shown. The collected charge seems to scale with the NIEL function. Need fresh system calibration to confirm/correct the numbers here presented. Long term annealing doesn't effect substantially the measured signal, at least within a practical time for operations.
- The differences found with other measurements can be due to the difference in the read-out scheme (individual strips or diode configuration)