New CCE results with microstrip detectors made on various substrates

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OUTLINE:

The charge collection efficiency of µ-strip sensors made with the RD50 mask set with various silicon substrates (n and p FZ and MCz) have been compared to different high doses of neutron and protons, well in the range of the anticipated fluences in SLHC.
Detectors: 1x1 cm^{-2}, Readout: SCT128, Source: ^{90}Sr, Temperature: ~-20/25^{o}C.

- FZ n-in-p (10 and 30 kΩ cm^{-1})
- FZ p-in-n
- FZ n-in-n
- MCz p-in-n
- MCz n-in-n
- Epi p-in-n
- Epi n-in-n
- Various thicknesses FZ n-in-p and n-in-n

Irradiation

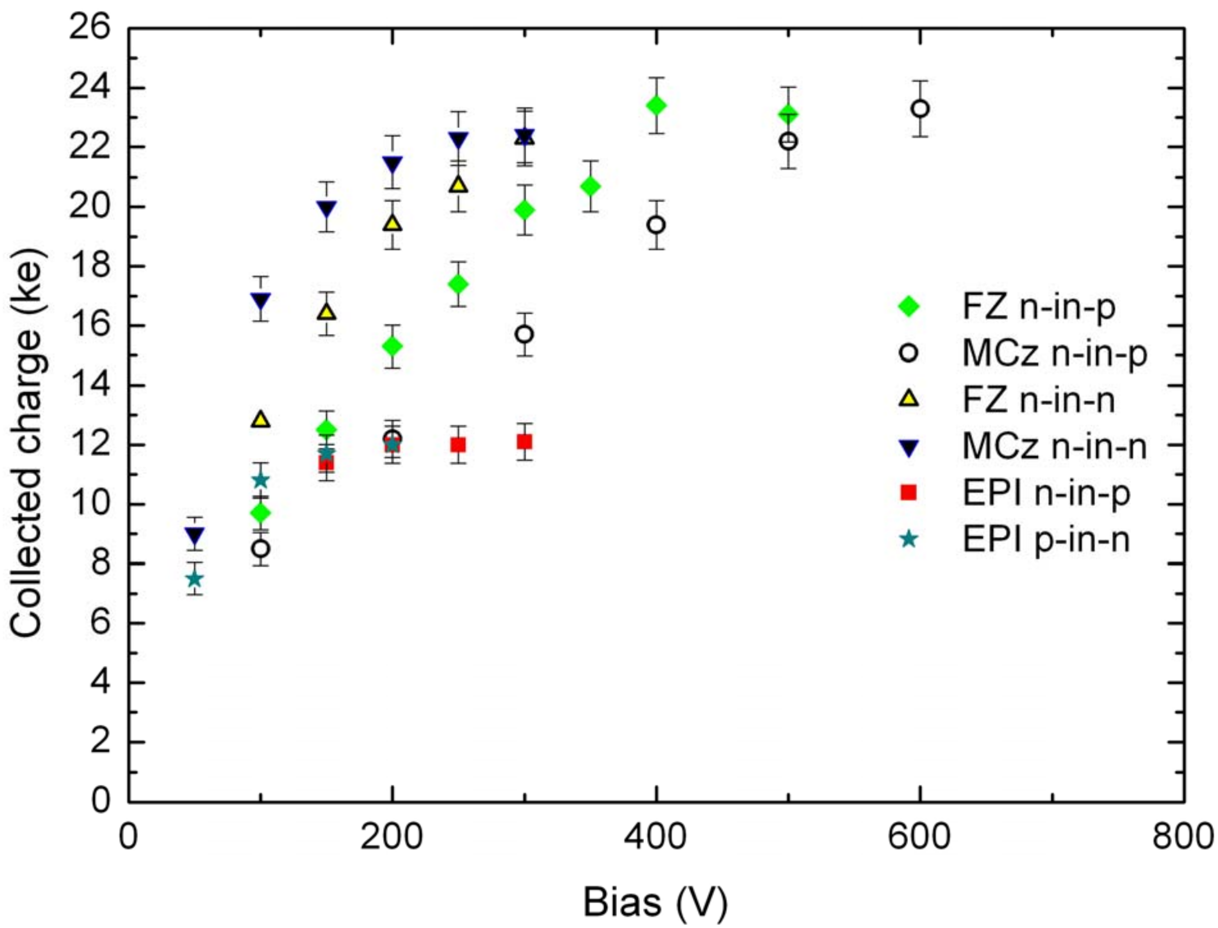
Many thanks to our RD50 collaborators:

Neutron irradiations, our gracious hosts: JSI of Ljubljana (V. Cindro et al.).

24GeV/c protons, CERN/PS: M. Glaser et al.

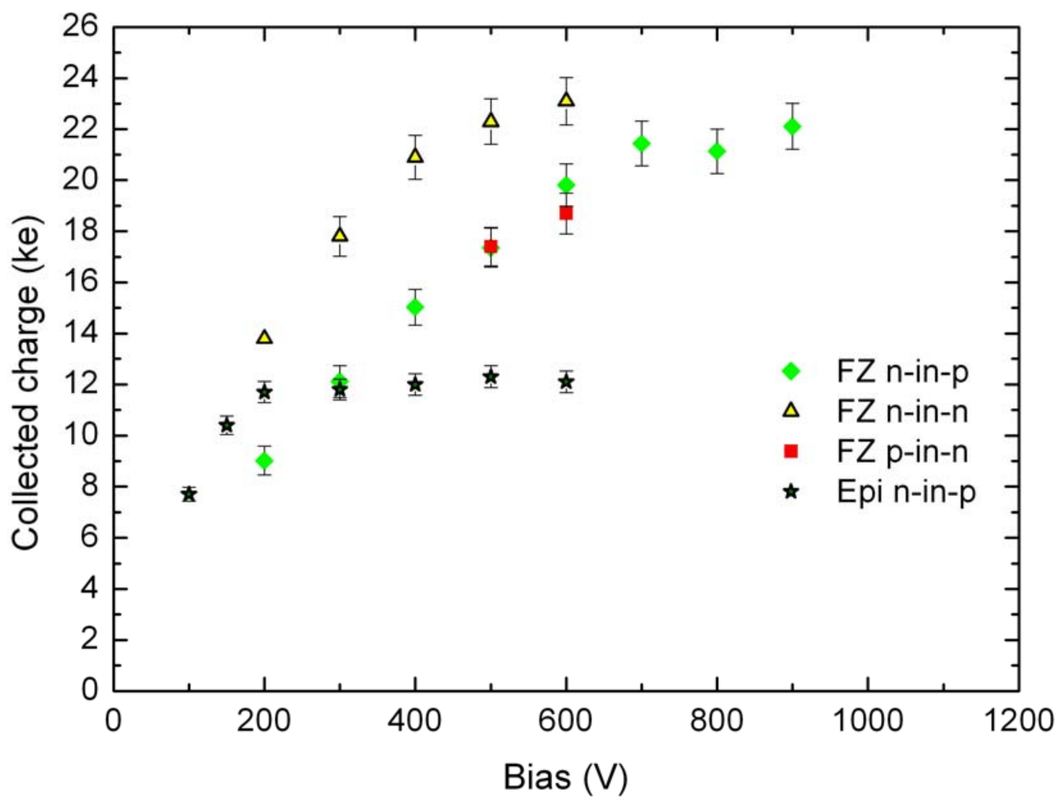
26 MeV protons Karlsruhe (W. de Boer et al).

Neutron irradiations: low doses ($1x10^{14}$ n cm^{-2})

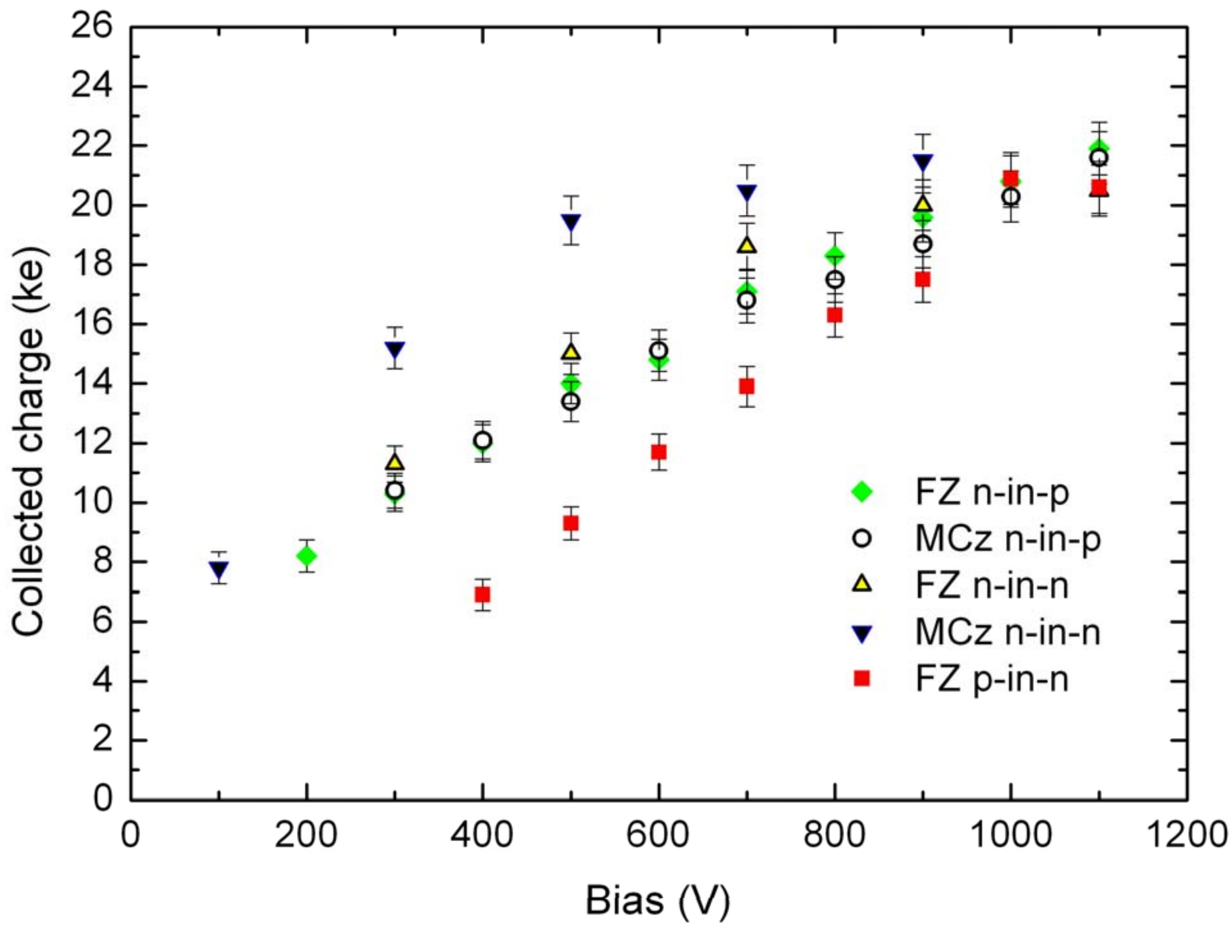


Neutron irradiations: still low doses ($2x10^{14}$ n cm^{-2})

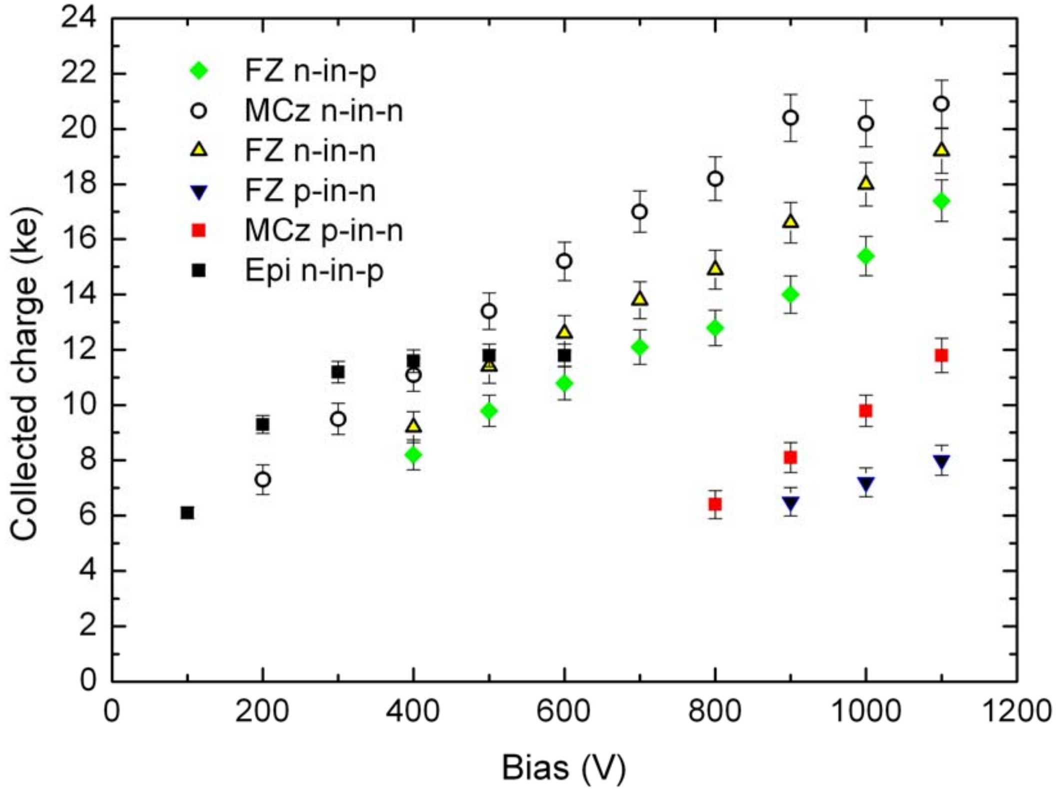
Epi detector irradiated to $3x10^{14}$ cm^{-2}).



Neutron irradiations: low/medium doses ($5x10^{14}$ n cm^{-2})

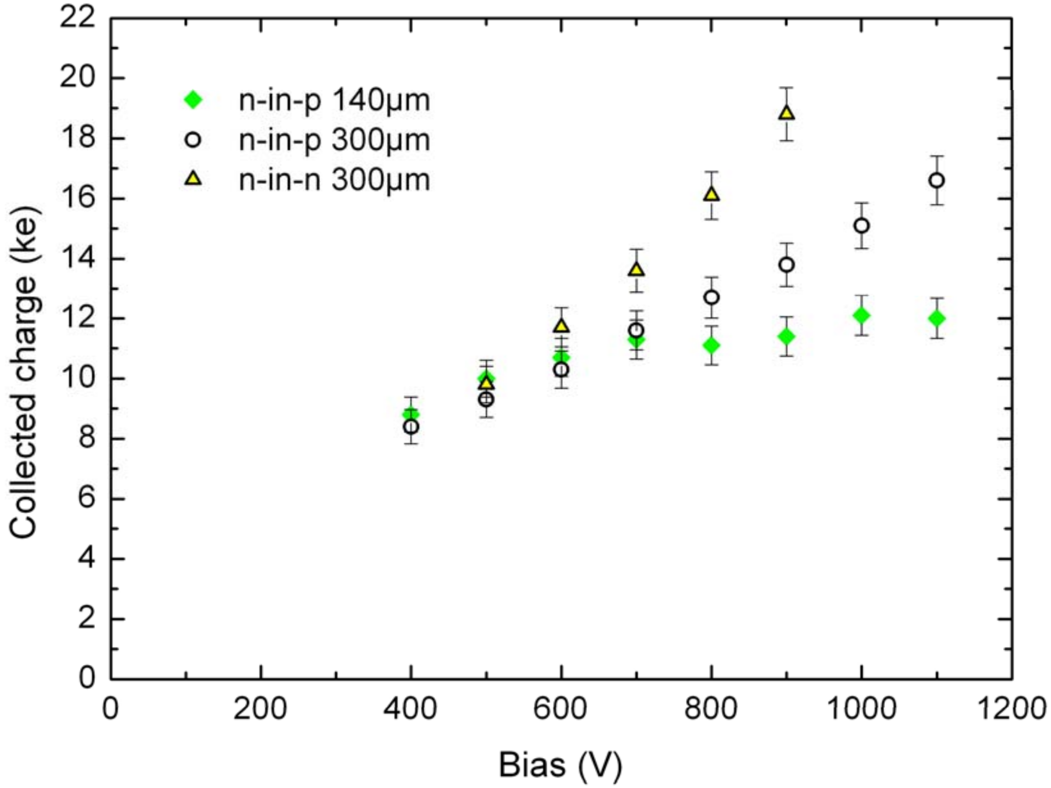


Neutron irradiations: medium doses ($1x10^{15}$ n cm^{-2})



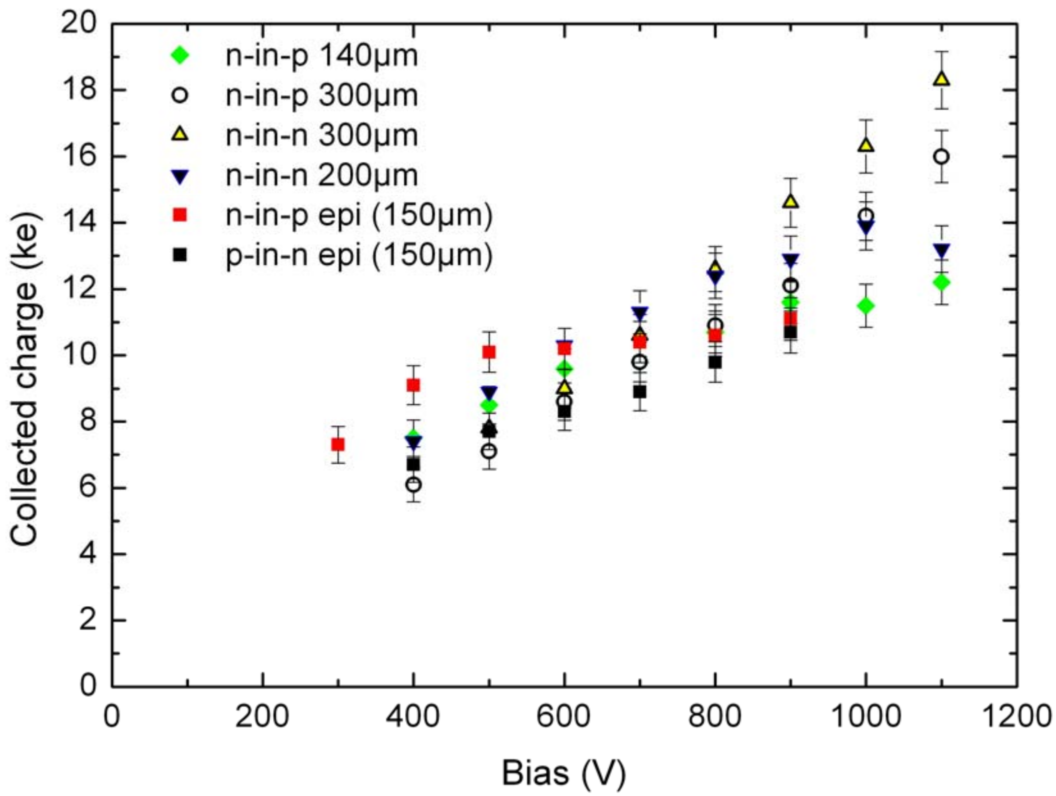
Neutron irradiations: medium/high doses ($1.6x10^{15}$ n cm^{-2})

Collected charge (ke)



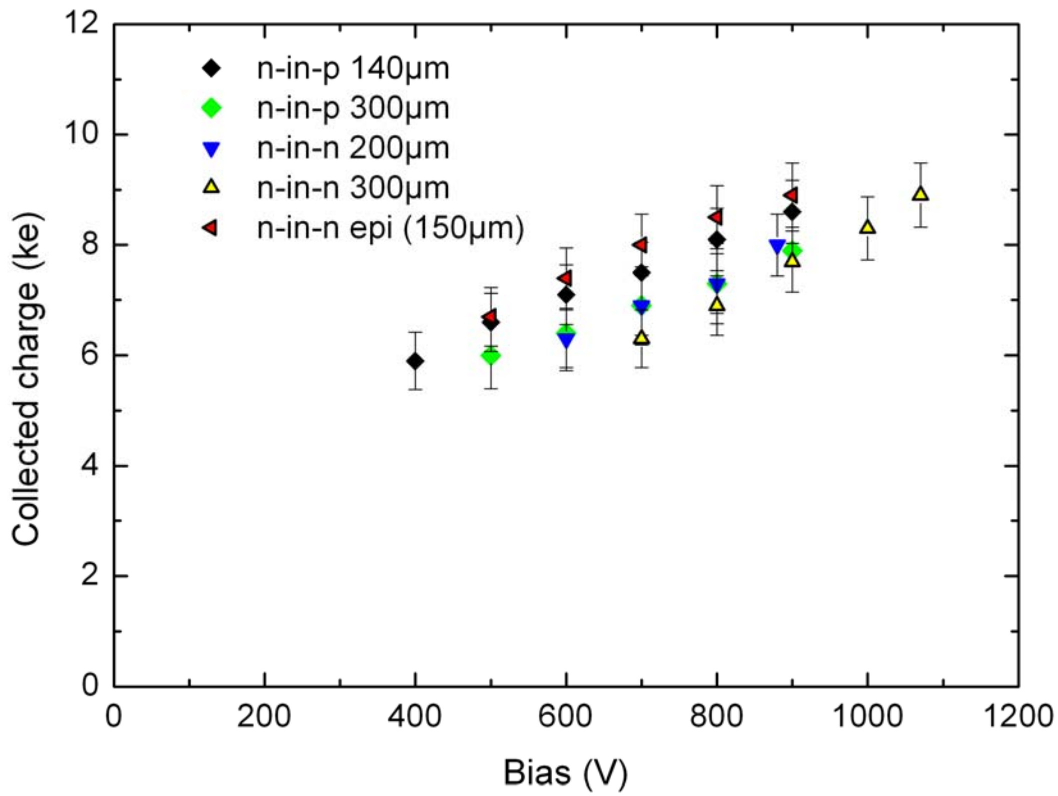
Bias (V)

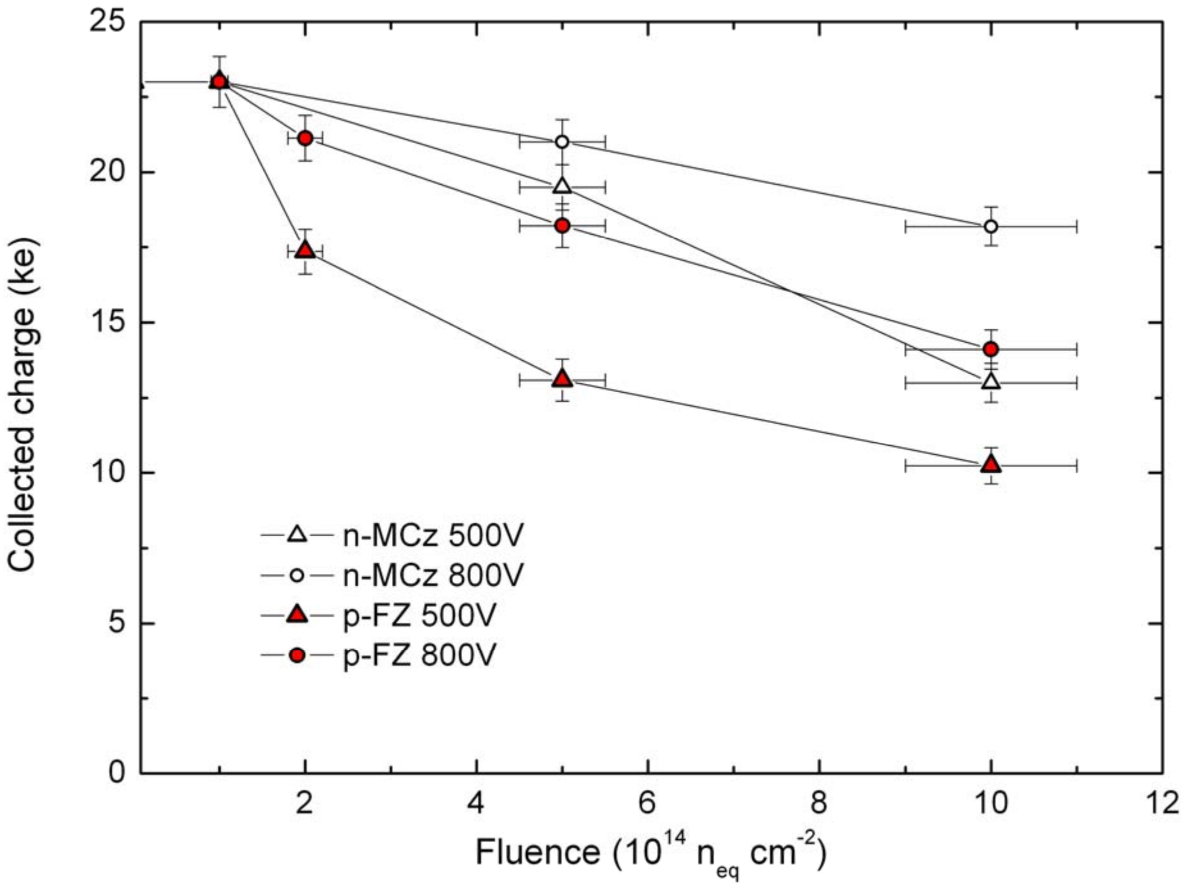
Neutron irradiations: high doses ($3x10^{15}$ n cm^{-2})



Neutron irradiations: very high doses ($1x10^{16}$ n cm^{-2})

Epi detector irradiated to $8x10^{15}$ cm^{-2}).





Collected charge (ke)
0
5
10
15
20
25
2
4
6
8
10
12
Fluence (10^14 n_eq cm^-2)
n-MCz 500V
n-MCz 800V
p-FZ 500V
p-FZ 800V

Summary neutron irradiation

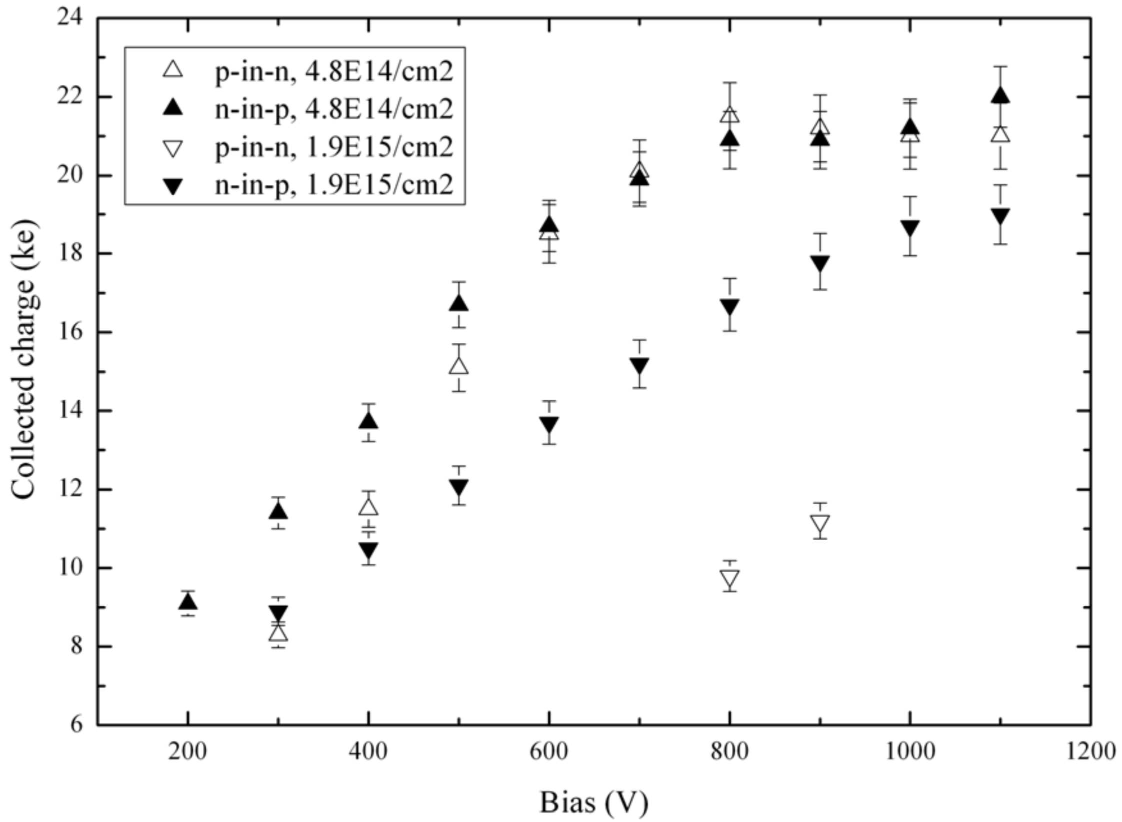
Thin vs thick: no sensitive difference even after 10^{16} cm^{-2}. Choice of thickness left to considerations other than radiation hardness.

Only significant improvement: n-MCz, which adds lower degradation of N_{eff} with Φ, to the advantage obtained by going through type inversion.

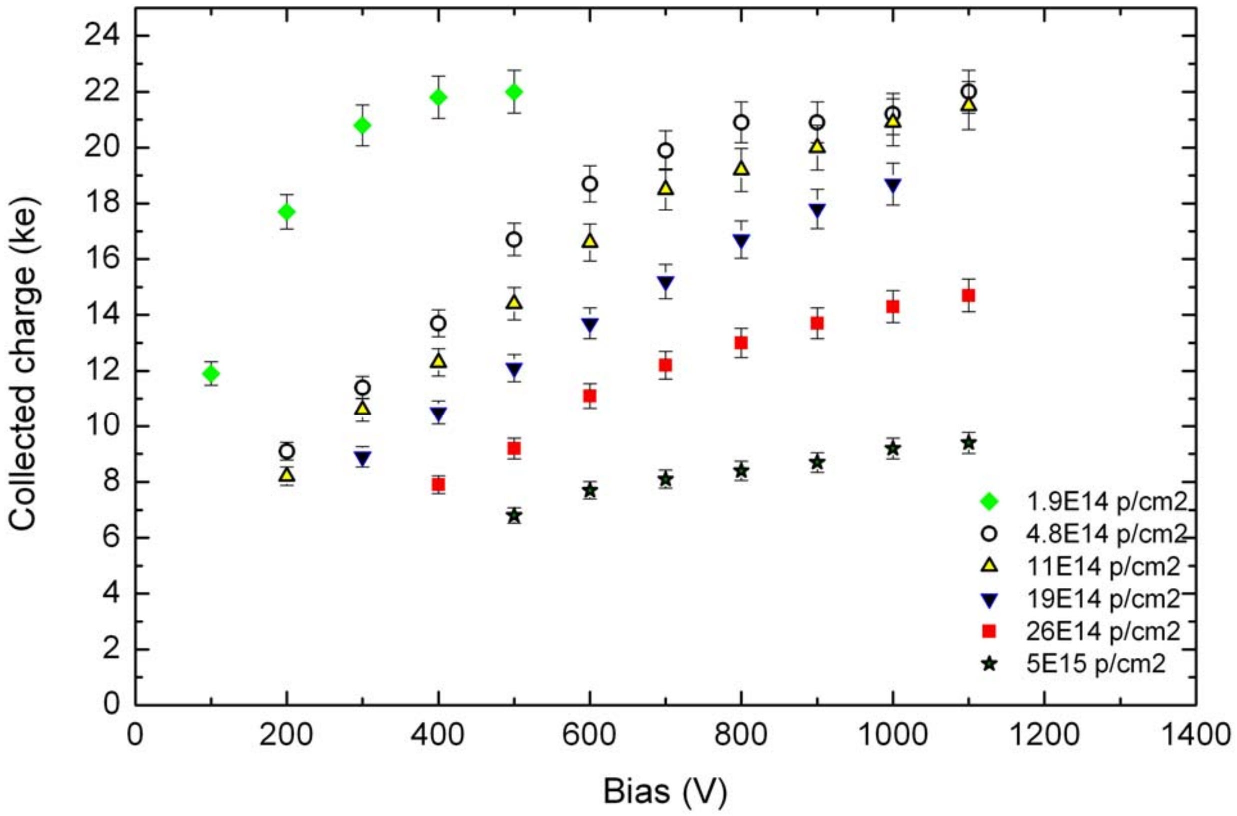
No significant advantage seen with epi n or p, although p-in-n epi shows a much bigger signal than other p-in-n sensors.

24GeV/c proton irradiations

N-side readout vs p-in-n

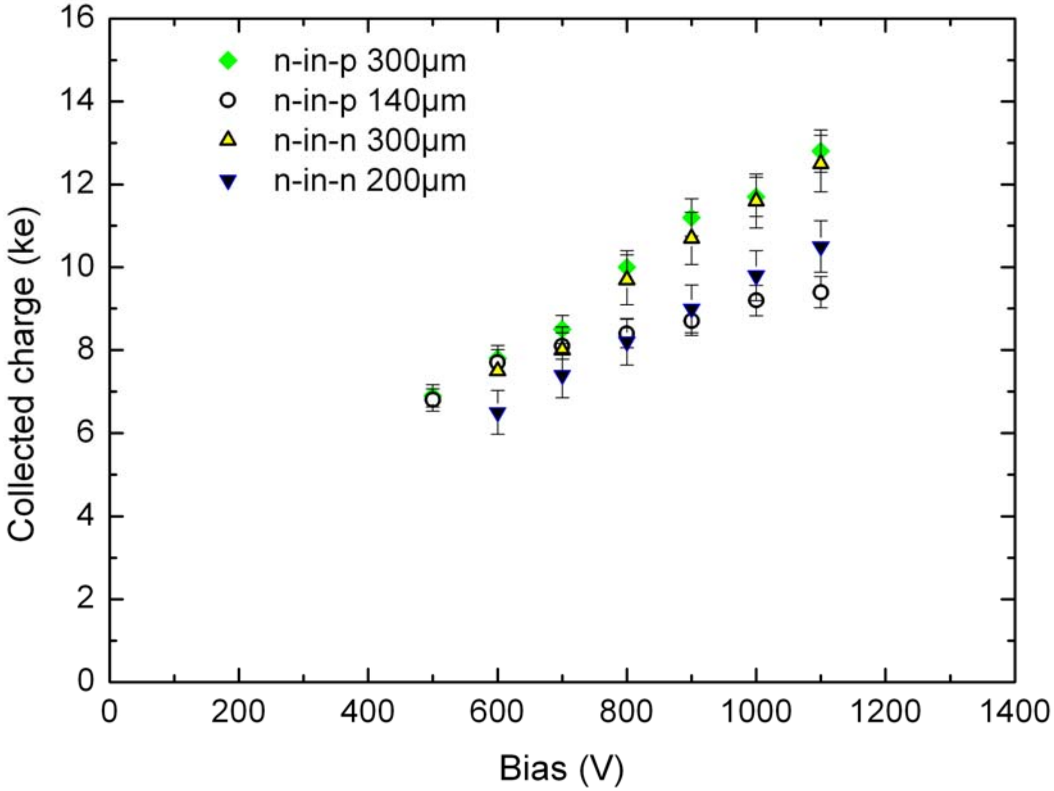


24GeV/c proton irradiations

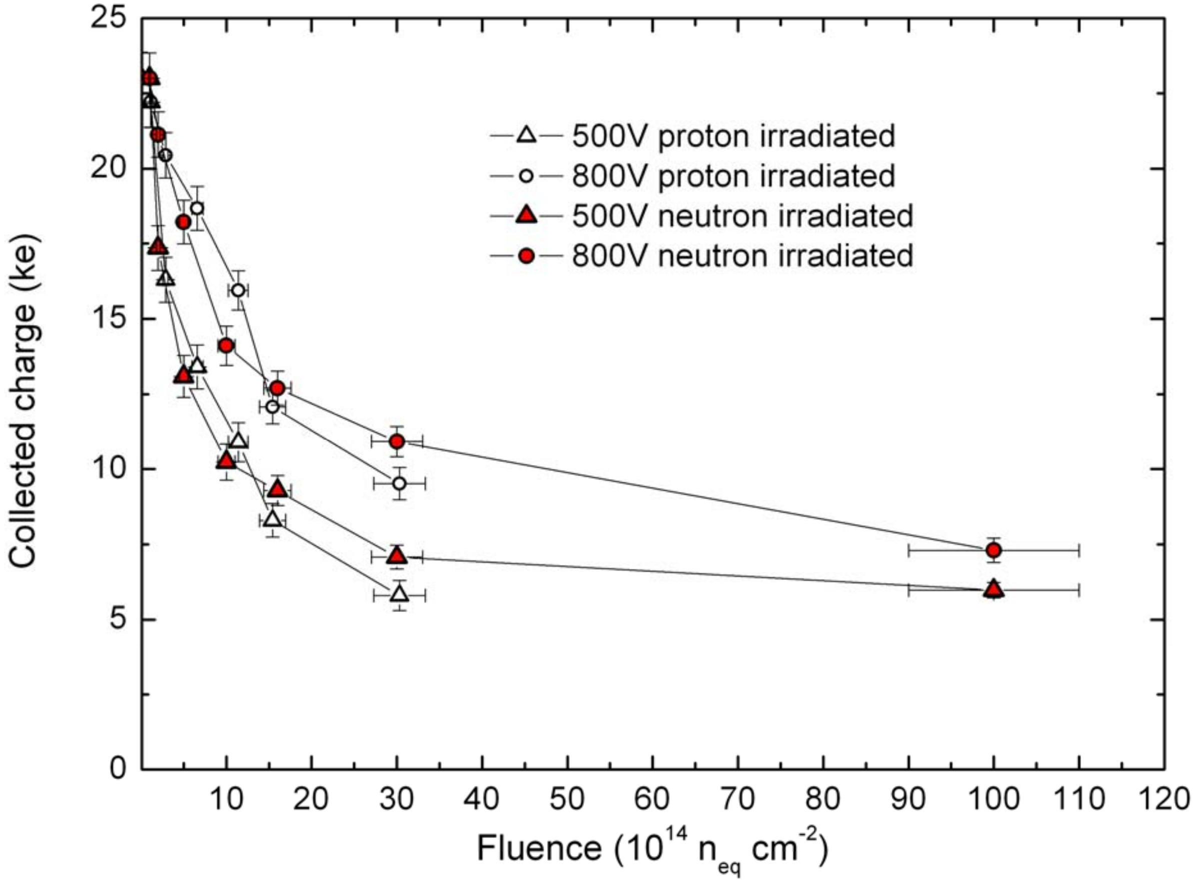


Thin vs thick, n vs p substrate, neutron and 24GeV/c proton irradiations

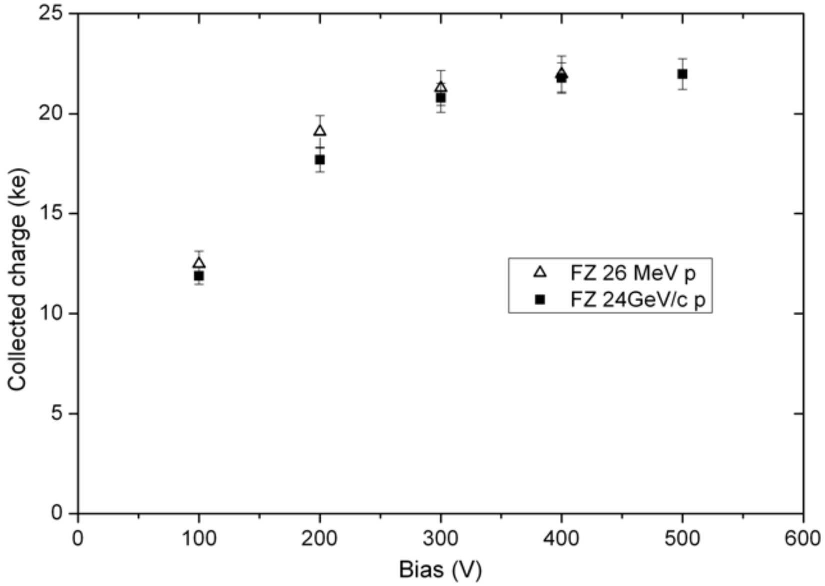
$5x10^{15}$ cm^{-2}



24GeV/c proton irradiations vs neutron

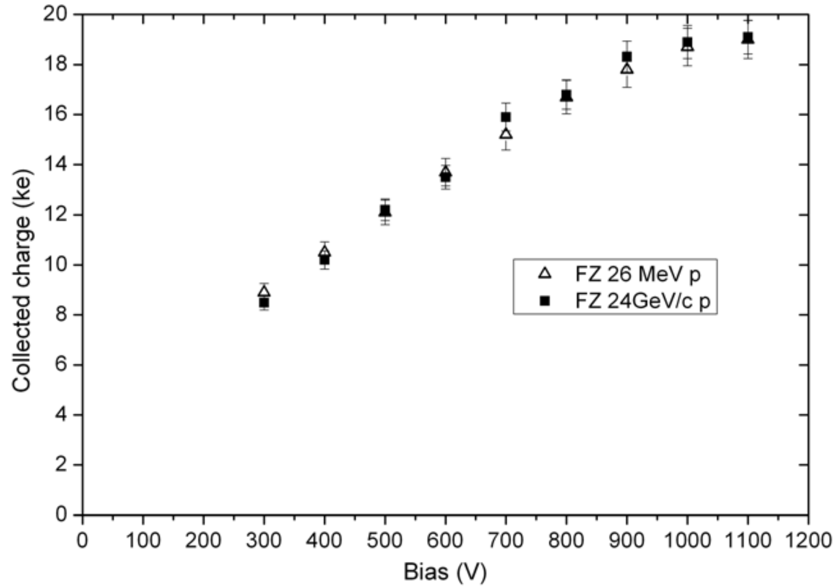


Low energy proton irradiations: comparison (with 24GeV/c p) of CCE for NIEL equivalent doses



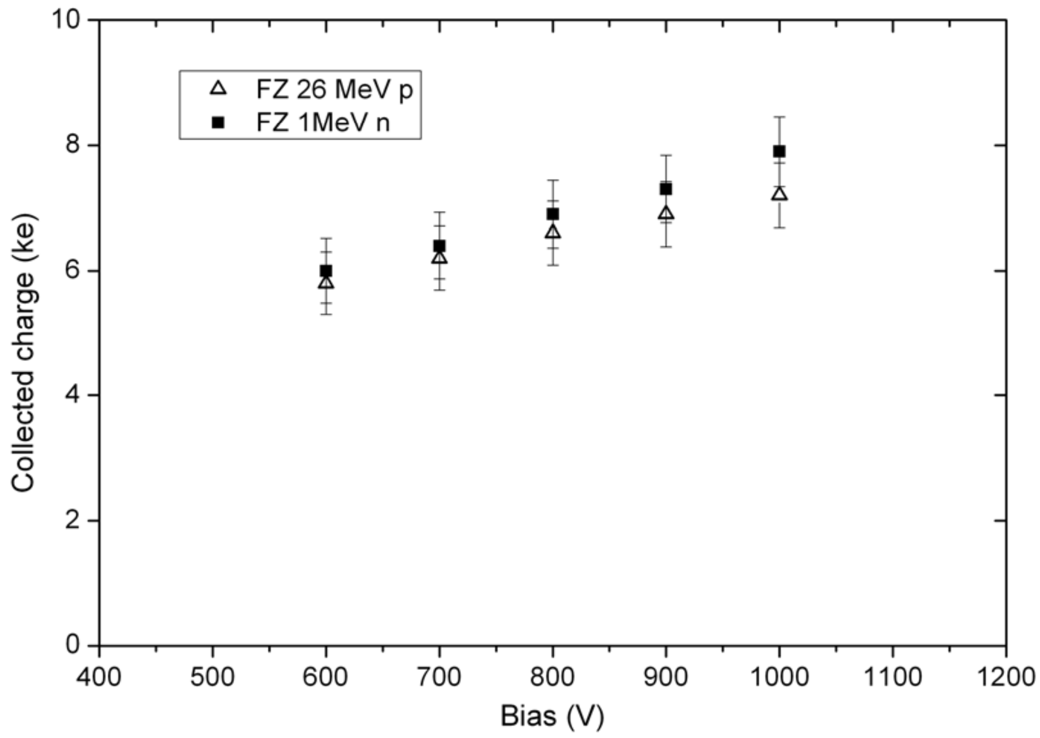
$1x10^{14}$ n_{eq} cm^{-2}

$1x10^{15}$ n_{eq} cm^{-2}

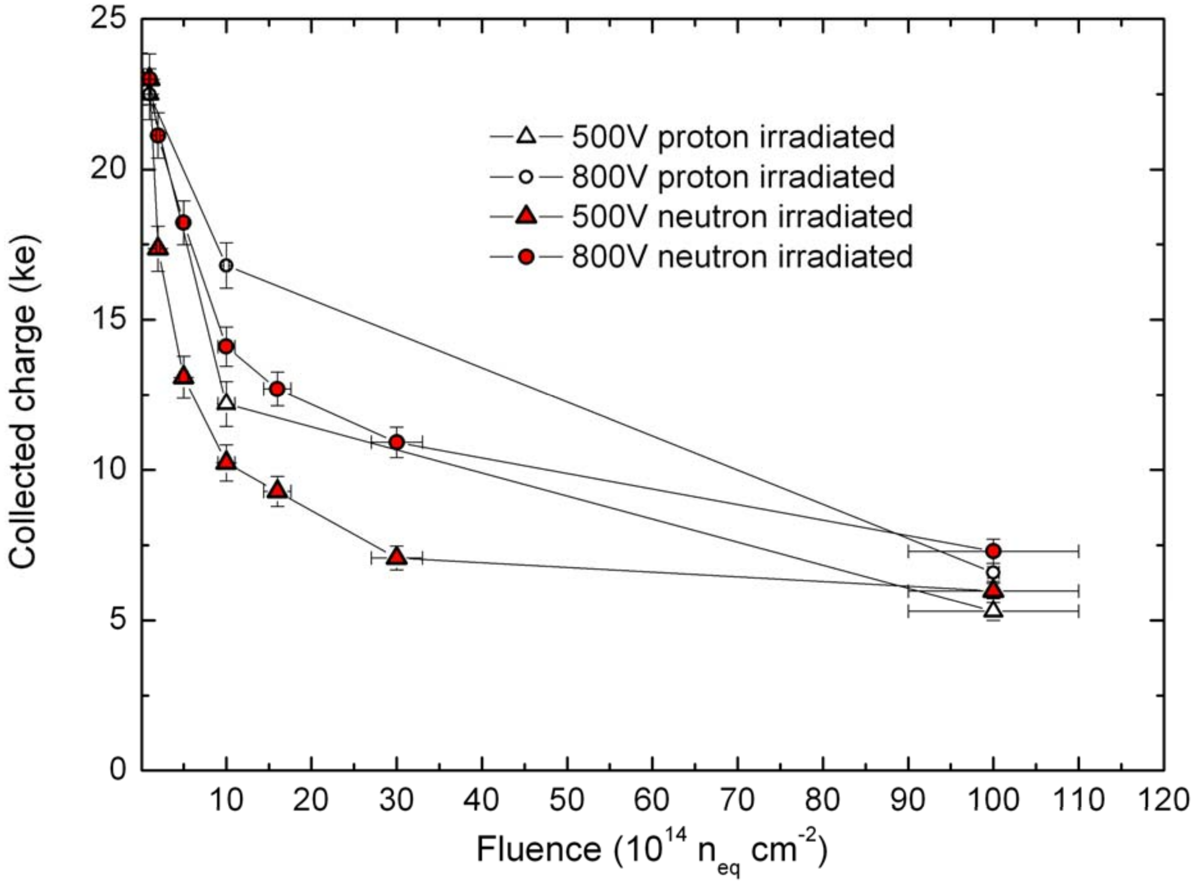


Low energy proton irradiations: comparison (with rector neutron) of CCE for NIEL equivalent doses

$1x10^{16}$ cm^{-2}!



Low energy proton irradiations vs neutron



Summary proton irradiation

New data with protons show that the effect of the CCE degradation is much closer to neutron than previously expected. Still, in front of a lower degradation of the V_{FD}, a higher charge trapping is introduced by protons. Irradiation with 26MeV protons, when NIEL corrected, are well representative of the 24GeV ones, being a very useful tool for achieving high doses in shorter times (more evidence of equivalence still wel welcome and needed).