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Full-size Czochralski silicon detectors irradiated with 10 MeV protons

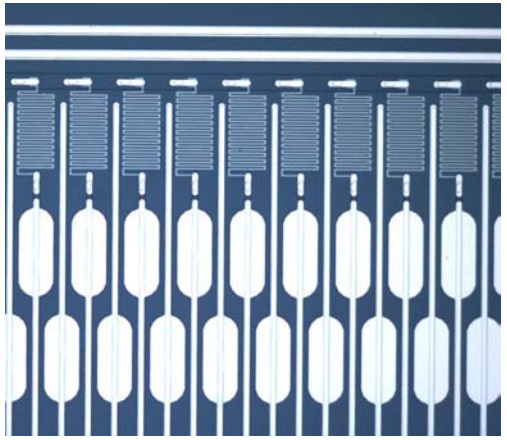
P. Luukka, S. Czellar, A. Heikkinen, J. Härkönen, V. Karimäki, T. Lampen, J. Nysten, E. Tuominen, J. Tuominiemi, E. Tuovinen and L. Wendland
Helsinki Institute of Physics, CERN/EP, Switzerland

F. Hartmann and A. Furgeri
University of Karlsruhe, Germany

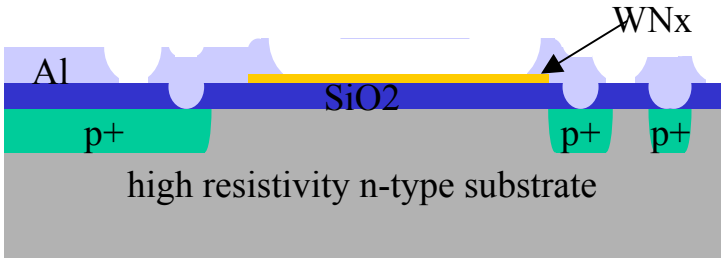
P. Laitinen, I. Riihimäki and A. Virtanen
Accelerator Laboratory, University of Jyväskylä, Finland

Device processing

The devices were processed at Helsinki University of Technology Microelectronics Center



- with simple 4 level mask process:
  - 4 lithographies
  - 2 ion implantations
  - 2 thermal dry oxidations
  - 3 sputter metal depositions
- on substrate grown by magnetic Czochralski
  - nominal resistivity 900 Ωcm,
  - thickness 380 um,
  - orientation <100>,
  - oxygen concentration <10 ppma



Irradiations and IV- and CV-measurements

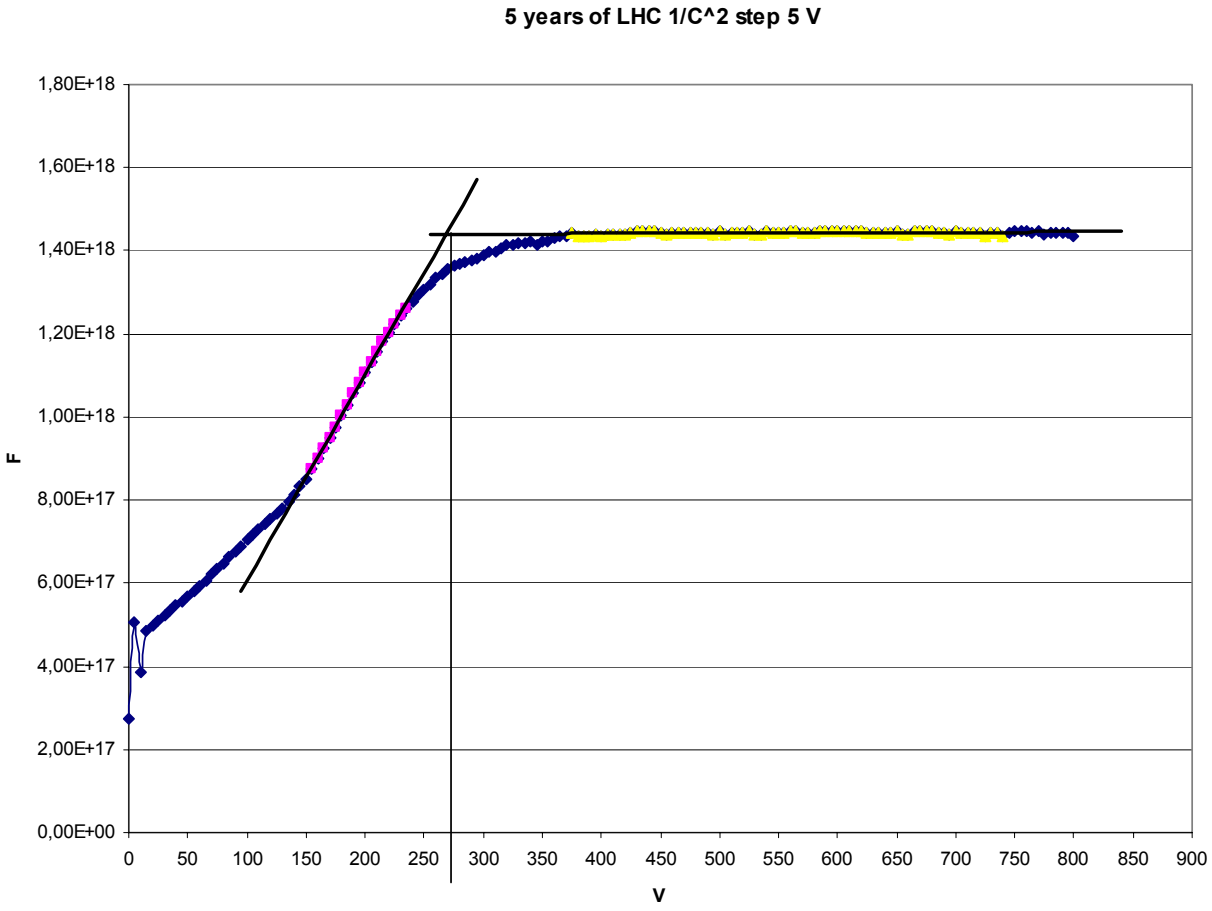
Irradiations were made at Jyväskylä University Accelerator Laboratory

- with 10 MeV protons

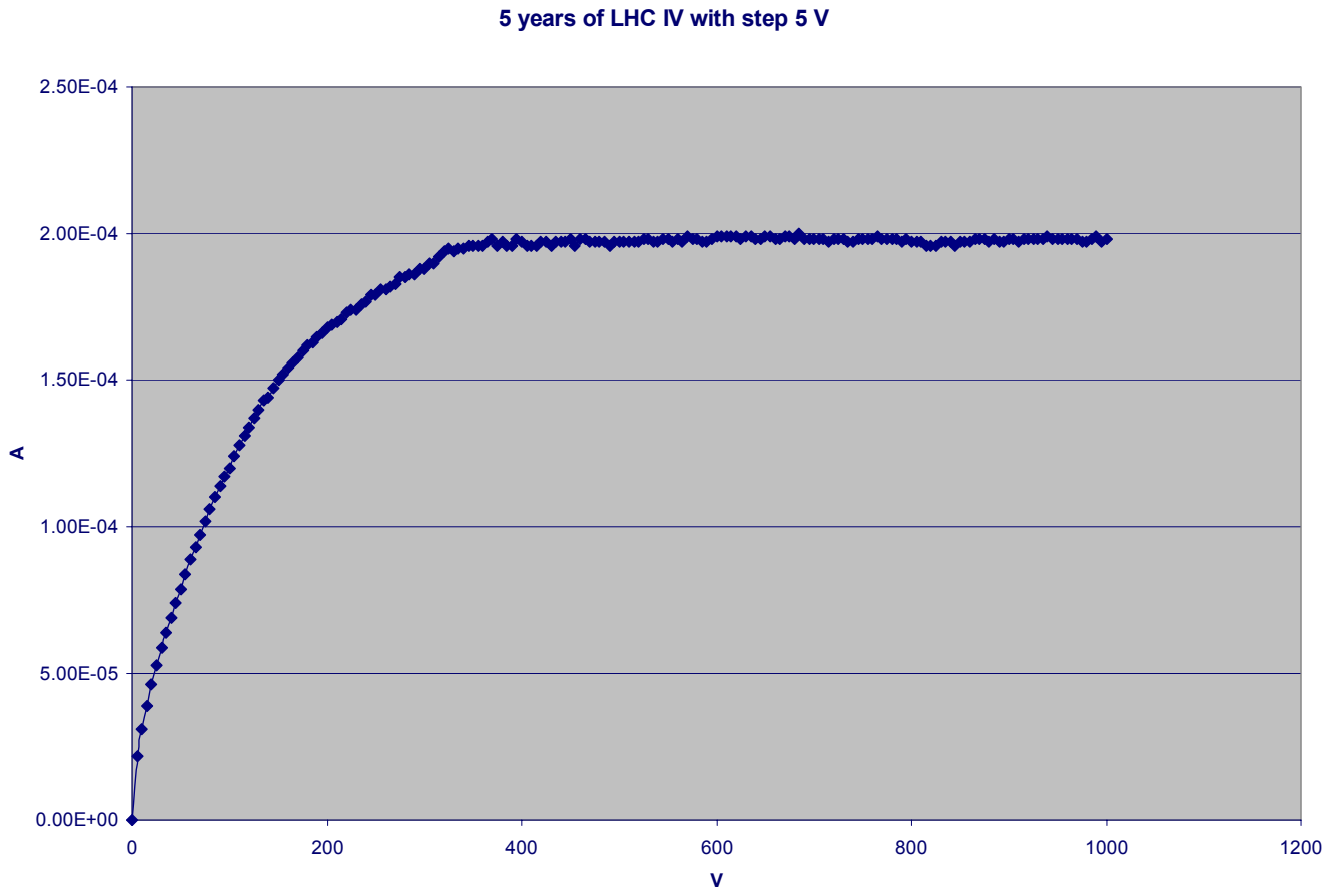
IV- and CV-measurements were made at University of Karlsruhe after irradiation

- with probestation
- @ -10°C
- guard grounded

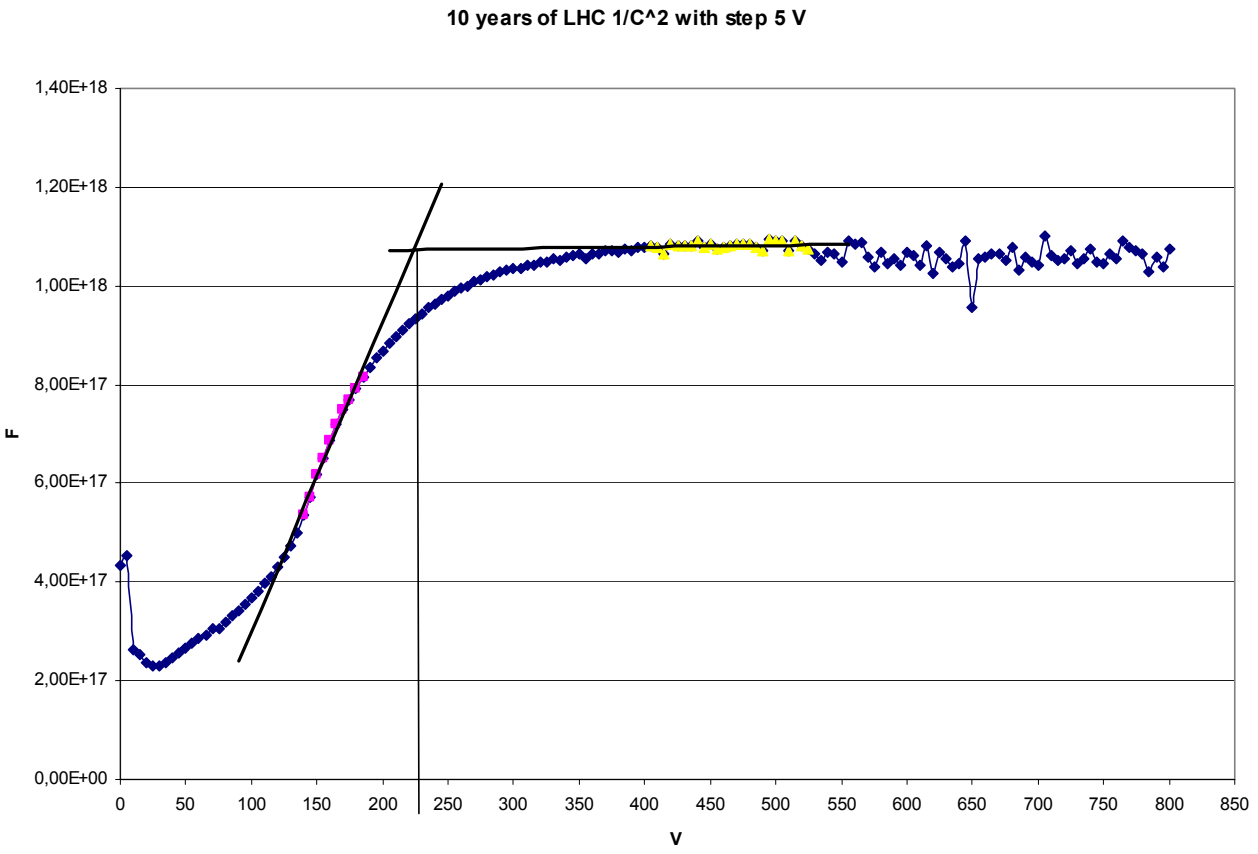
5 years of LHC 1/C^2 curve (depl. @ 270 V)



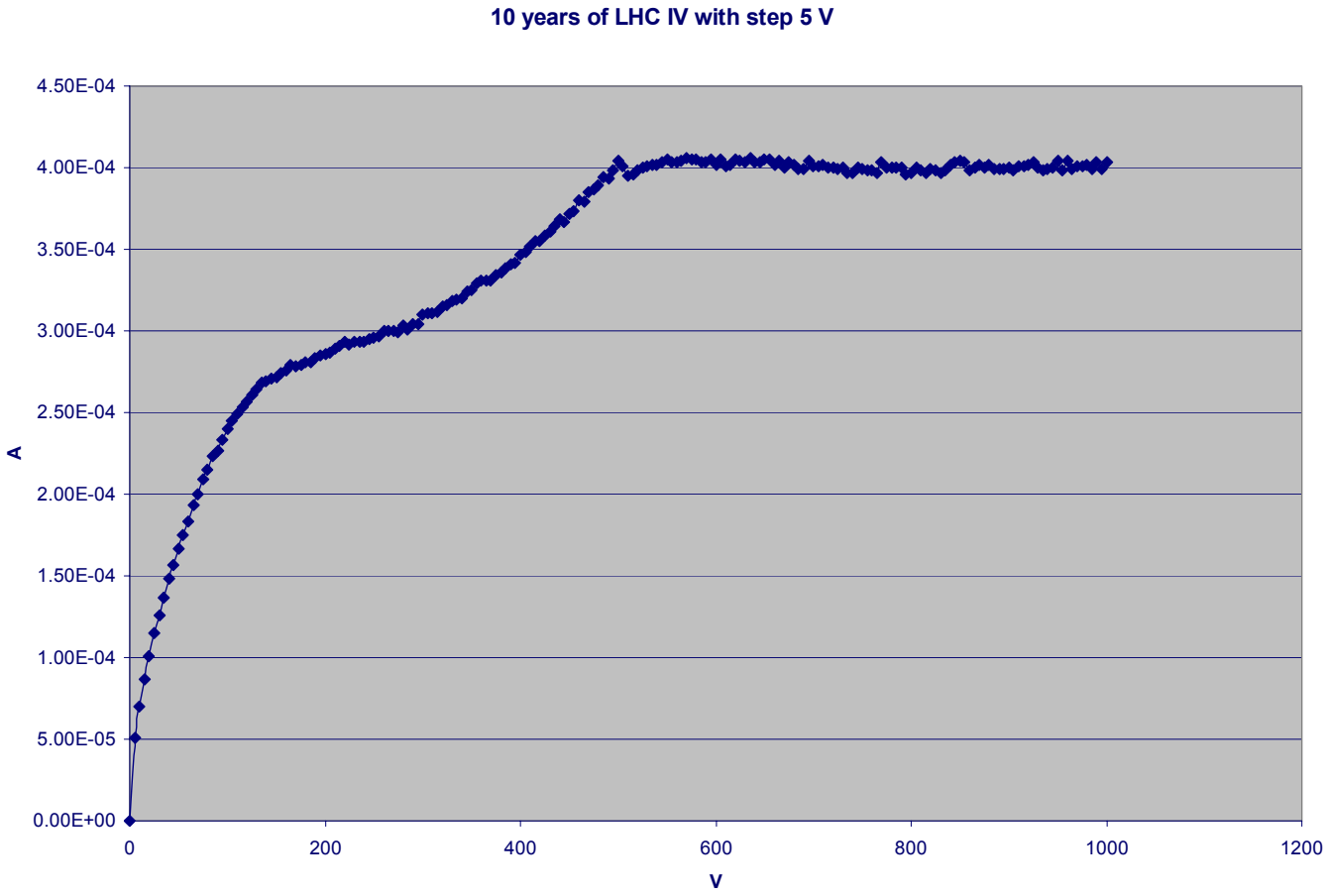
5 years of LHC leakage current



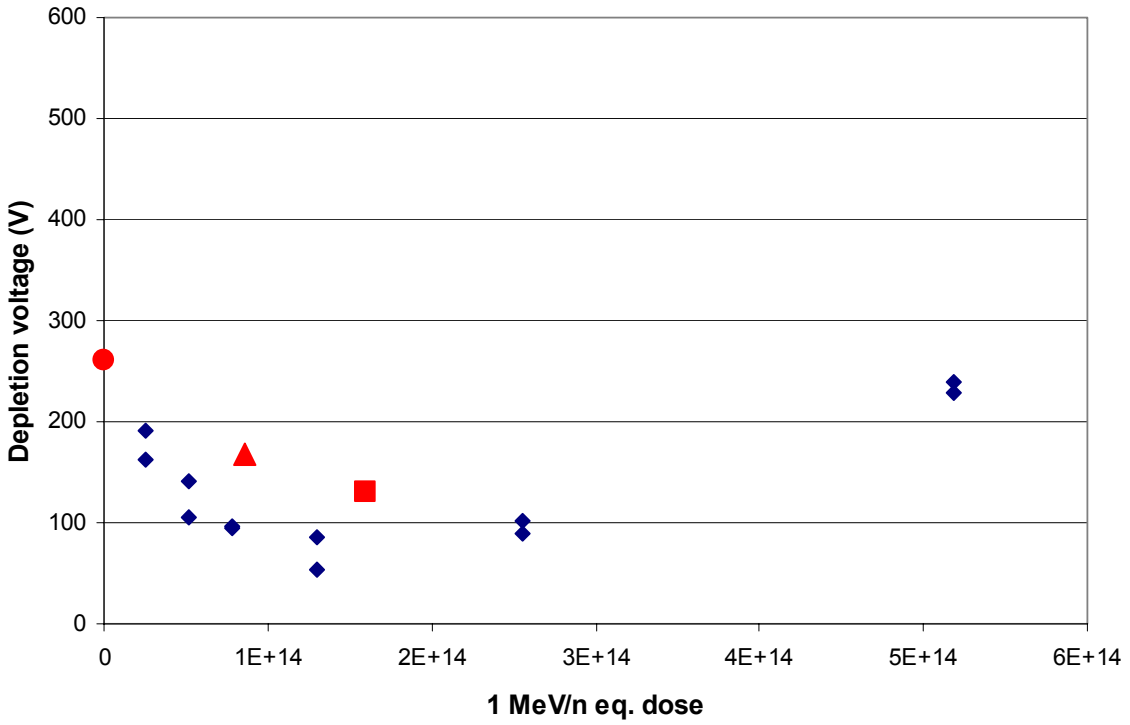
10 years LHC 1/C^2 curve (depl. @ 225 V)



10 years of LHC leakage current



Radiation hardness of Cz-Si



Detector leakage current vs Diode Ileak

Detectors @ -9,2^{0}C
1,9*10^{13} p/cm^2 Ileak≈ 183 μA
3,8*10^{13} p/cm^2 Ileak≈ 261 μA

Detectors scaled to 22^{0}C
1,9*10^{13} p/cm^2 Ileak≈ 3,17 mA
3,8*10^{13} p/cm^2 Ileak≈ 4,53 mA

Diodes @ 22^{0}C
1,9*10^{13} p/cm^2 Ileak≈ 43 μA
3,8*10^{13} p/cm^2 Ileak≈ 66 μA

$$\frac{A_{detector}}{A_{diode}} \approx 32cm^2/0{,}49cm^2 \approx 66$$

Temperature scaling

$$I(T) = I(T_m)\left(\frac{T}{T_m}\right)^2 e^{-\frac{E_g}{k_B}\left(\frac{1}{T}-\frac{1}{T_m}\right)}$$

,where T=22^{0}C (in Kelvin's)
T_m=-9,2^{0}C (in Kelvin's)

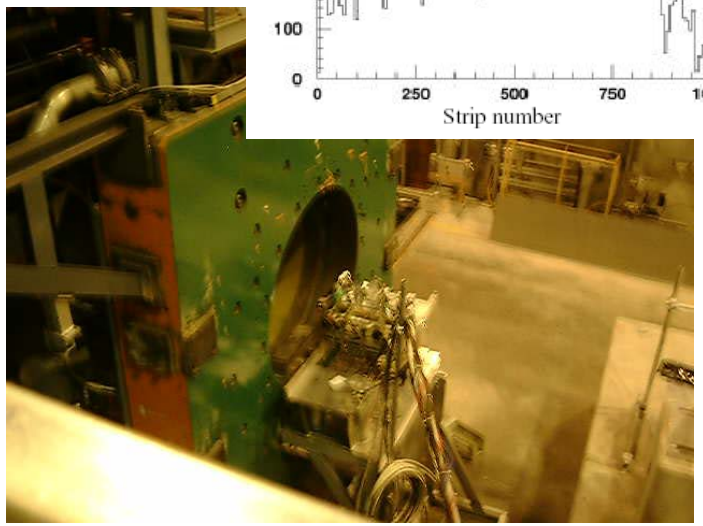
Ileak(detector)/Ileak(diode)

1,9*10^{13} p/cm^2 ≈ 3170/43 ≈ 74

3,8*10^{13} p/cm^2 ≈ 4530/66 ≈ 69

Future measurements with Helsinki Silicon Beam Telescope at CERN H2 test beam area

SiBT:



- Eight silicon strip detectors
- Front-end electronics with VA1 chips
- PC based DAQ with commercial ADC boards
  - online monitoring and analysis
  - offline analysis after the tests