Radition hardness study of the Philips Digital Photon Counter with proton beam

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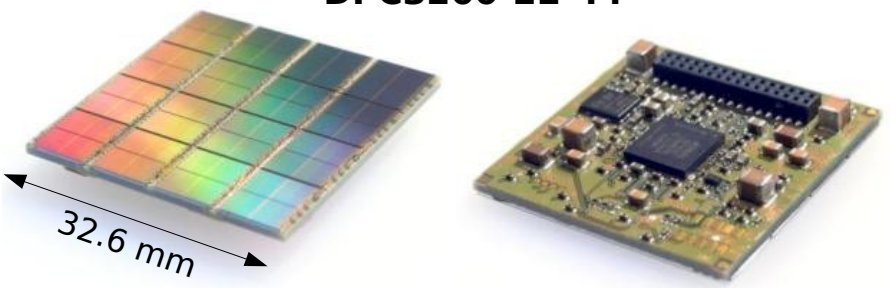
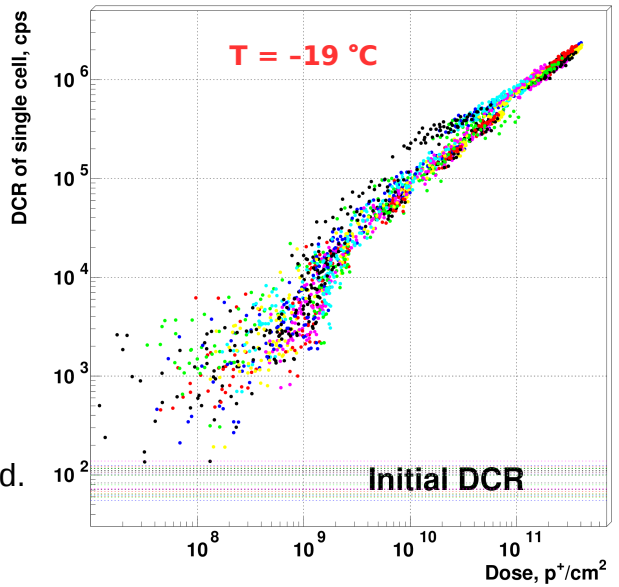
DPC3200-22-44



Array of 4x4 die.
Die = 128x100 cells (Geiger-mode APDs) +
+ TDC (LSB=20ps) + 4 photon counters.

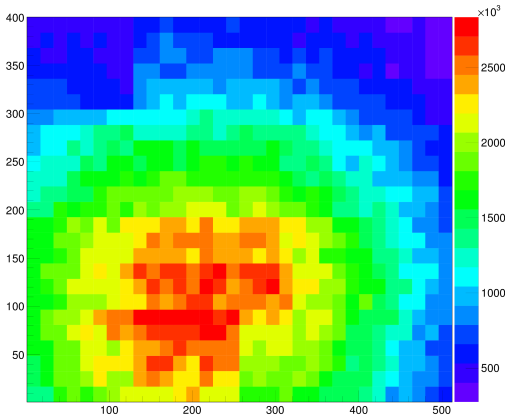
Active cell quenching.
Full digital data output.
Noisy cells can be disabled.



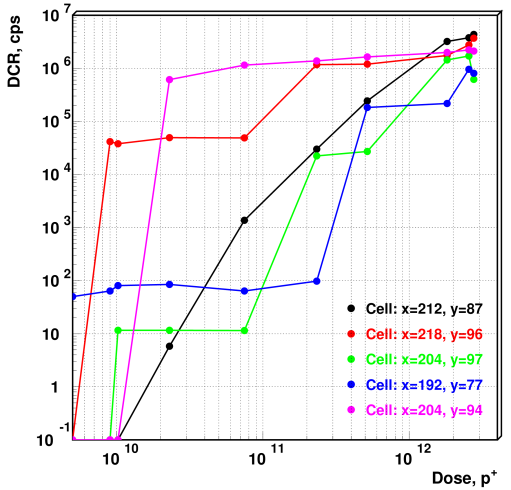
At maximum accumulated proton fluence of 4×10^{11} cm^{-2} DCR increased by ~4 orders of magnitude.

DCR of irradiated detector is less sensitive to the temperature variation => DCR reduction by cooling down becomes less efficient.

Irradiation by protons with P=800MeV/c (T=295MeV).
Beam size: $\sigma_x \approx \sigma_y \approx 1$ cm.

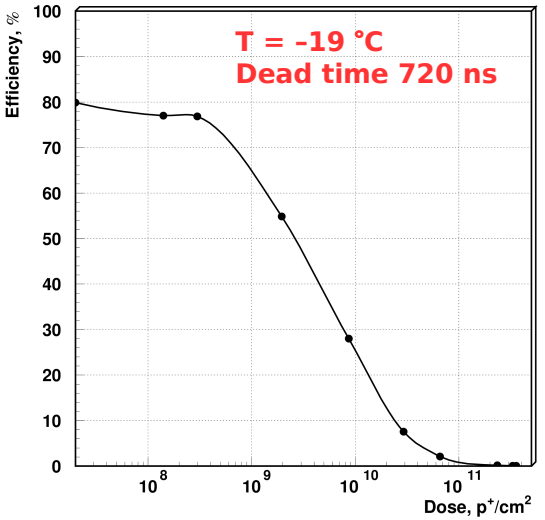


Dark counting rate (DCR) map after irradiation.



Step-like increase of cell DCR caused by single interactions of protons with Si lattice.

Average dose between FPGA failures is ~140 rad.
Functionality can be fully restored by initialization.



The DCR increase caused by irradiation results in loss of single photon detection efficiency due to the total dead time increase.

Optimal efficiency at each fluence is a tradeoff between fraction of active cells and total dead time.