Radation 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.

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

**Dark counting rate (DCR) map after irradiation.**

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

**At maximum accumulated proton fluence of $4\times10^{11}\text{ cm}^{-2}$ 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.**

**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.**