Test of PDPC radiation hardness

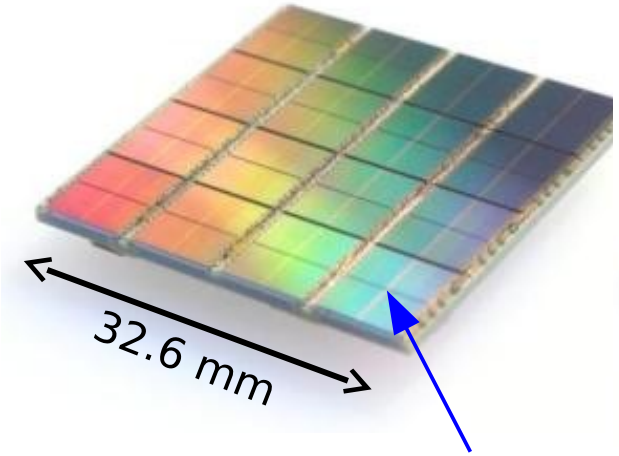
M.Yu.Barnyakov and al.
Budker Institute of Nuclear Physics

Outline

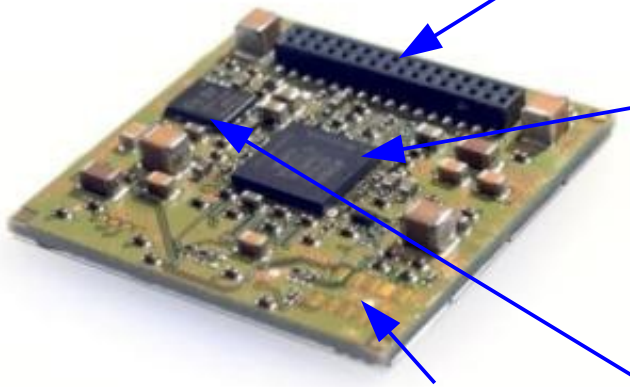
- PDPC
- Test setup
- Analysis and
  preliminary results

Philips Digital Photon Counter

DPC3200-22-44



4x4 dies

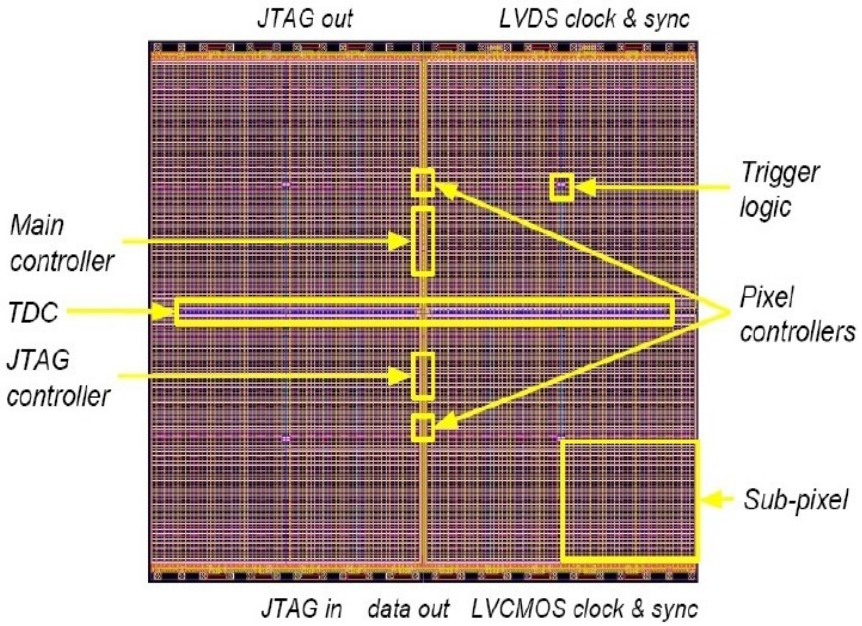


Connector

Temp. sensors

FPGA
- Clock distribution
- Data collection/concentration
- TDC linearization
- Saturation correction
- Skew correction

SPI Flash
- FPGA firmware
- Configuration
- Inhibit memory maps



Die
- 2x2 pixels
- TDC
- Logic

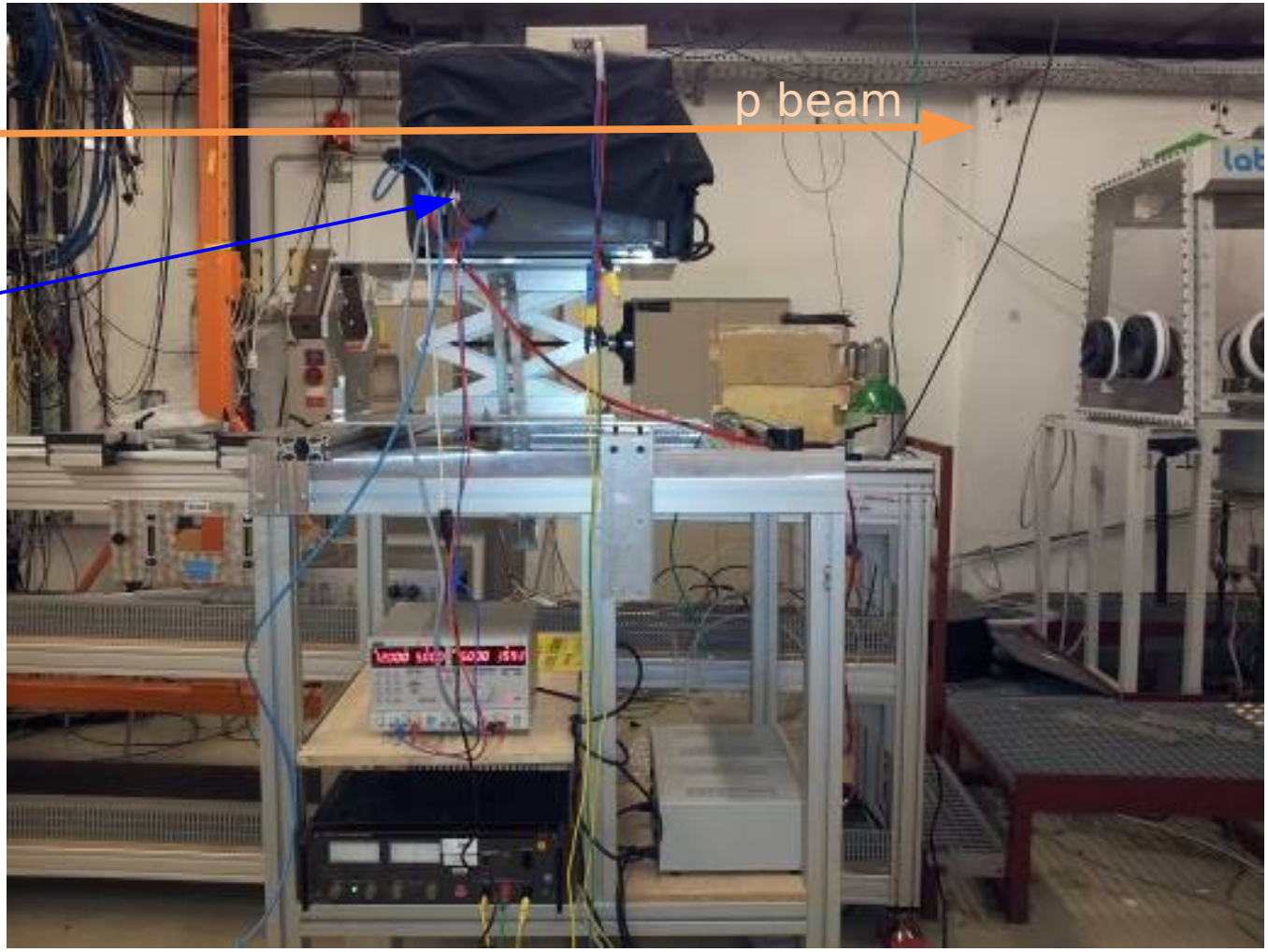
Pixel
- 3200 cells (photodiodes) divided in 2x2 subpixels
- Photon counter

Test setup

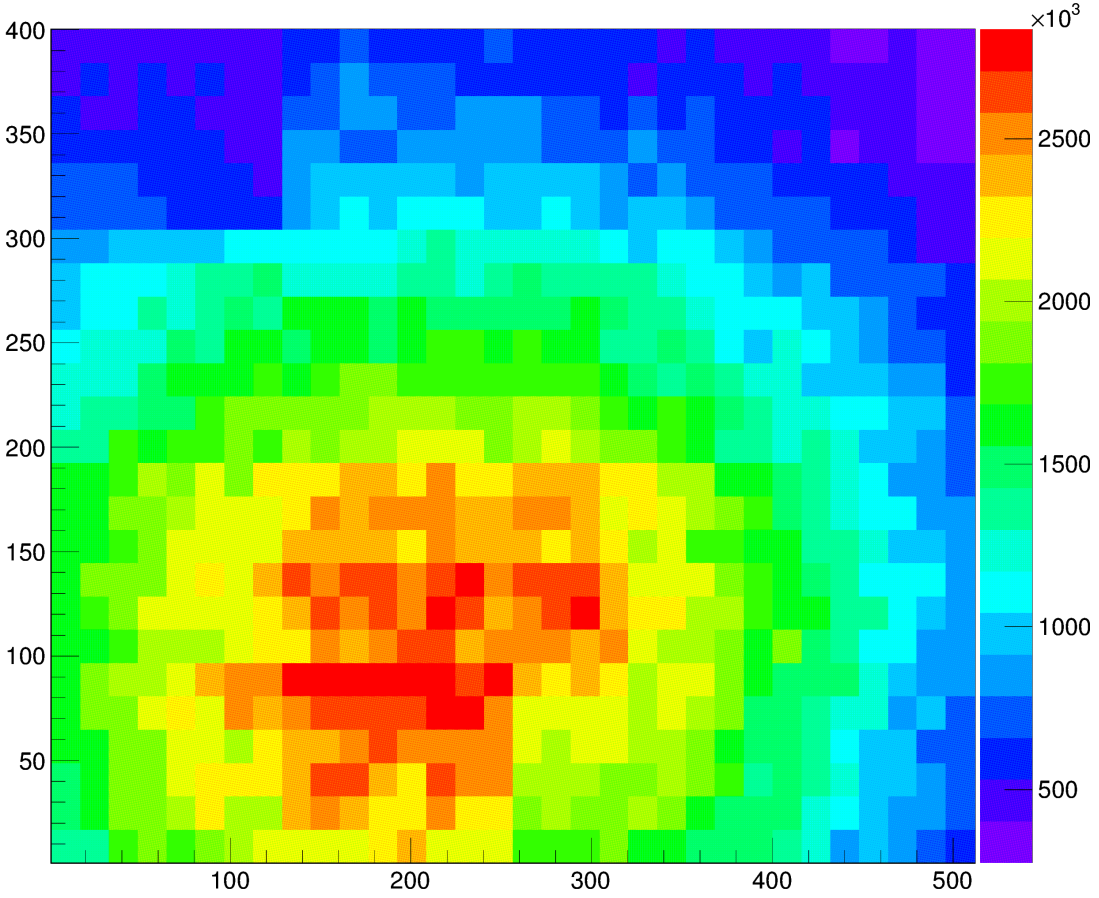
Proton beam from COSY
- P=800 MeV/c
- Beam size ~15 mm
- Intensity up to $2 \cdot 10^7$ s^{-1}

Test box
- Two PDPC tiles
- TEK for readout
- Tiles were cooled down to -15..20°C

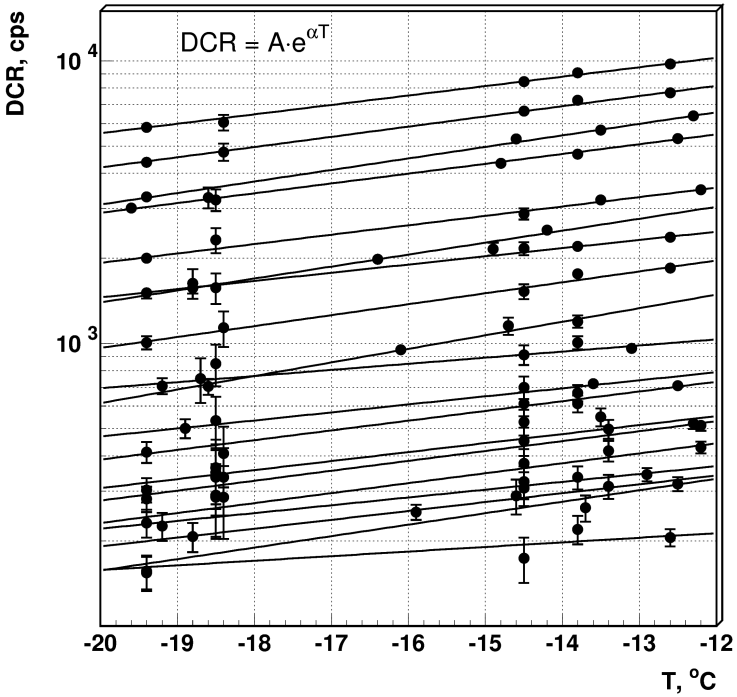
Beam diagnostics
- Ionization chamber (total dose per spill)
- Multi-wire proportional chambers (beam profile)



Dark Counting Rate scan



DCR vs. temperature



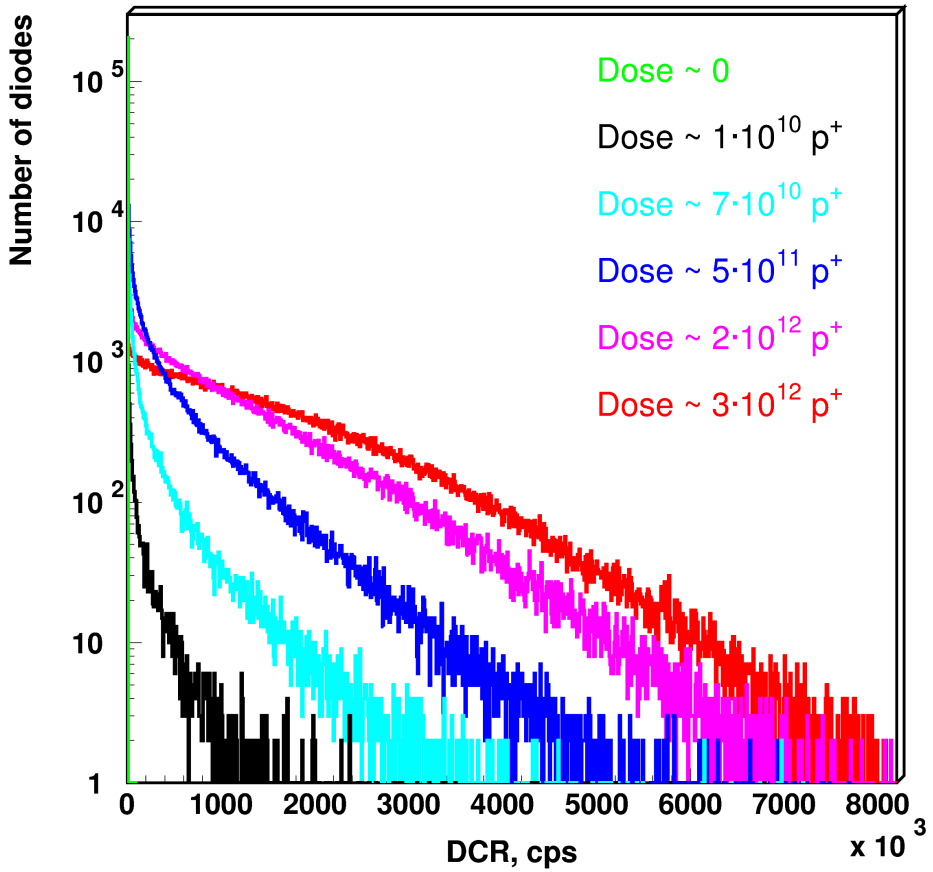
$\langle\alpha\rangle = 7.86 \cdot 10^{-2}\ ^\circ C^{-1}$

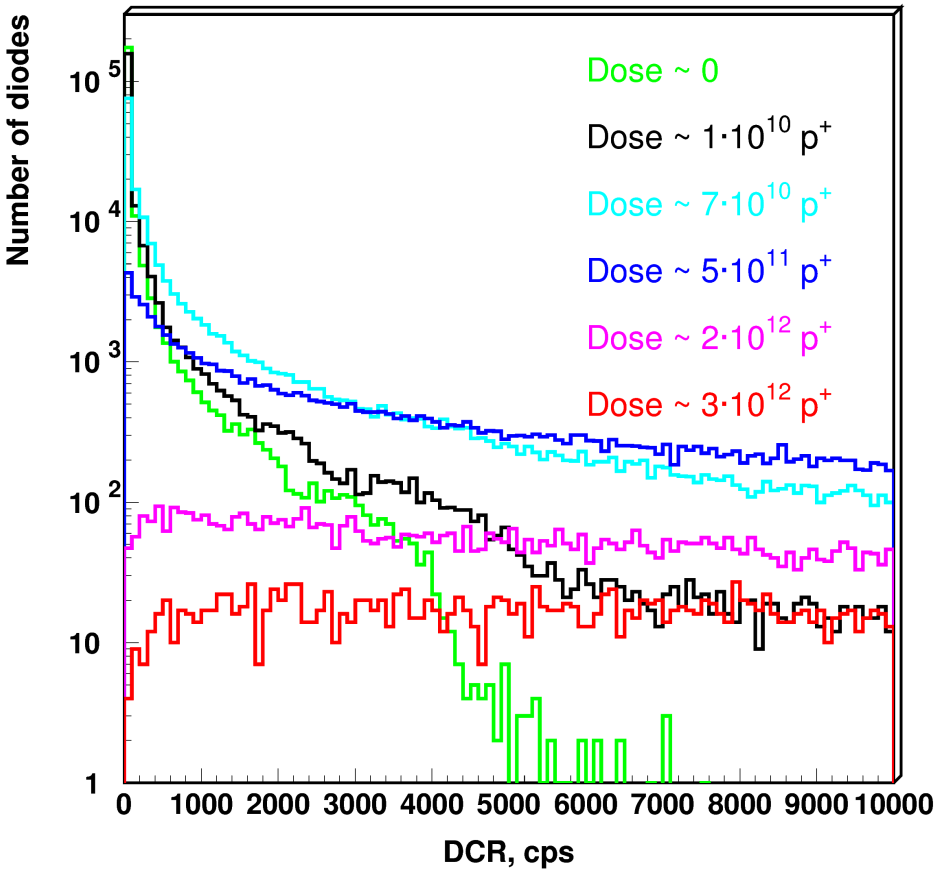
DCR changes in 2.2 times per 10°C

All measured rates are reduced to the same temperature (-19°C).

DCR is corrected for the cell dead time = 30..35 ns.

DCR spectra



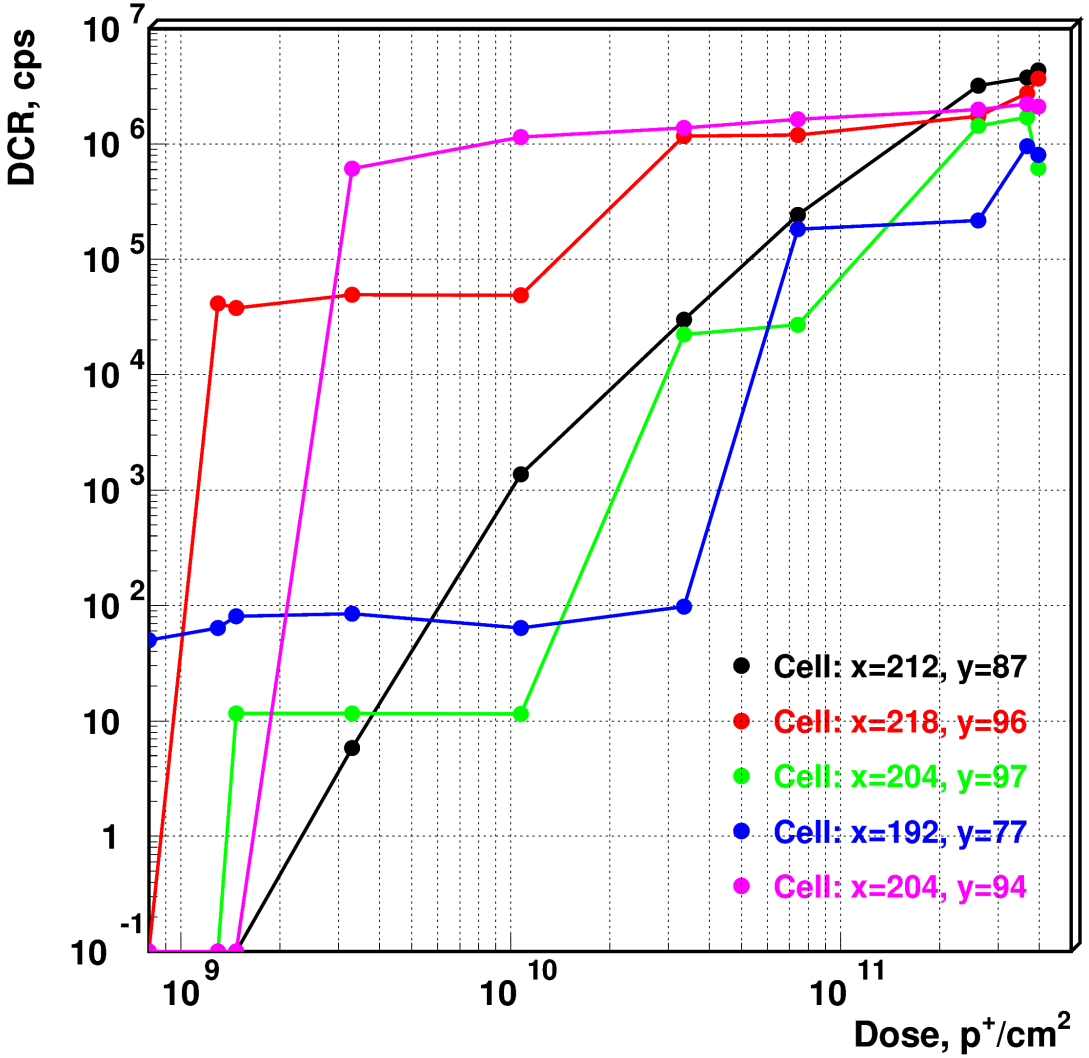


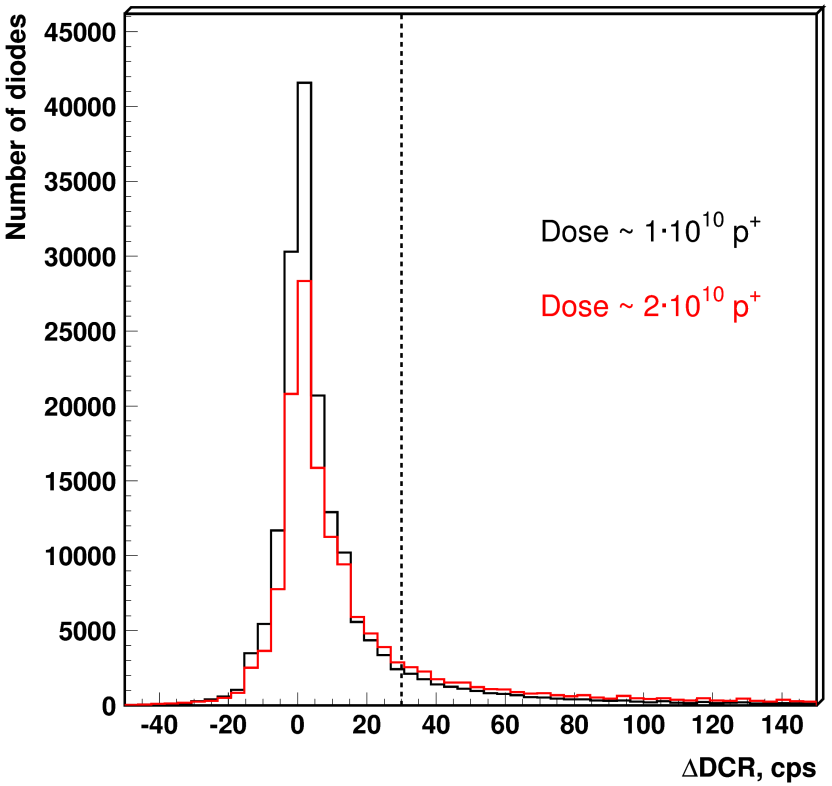
Number of noisy cells increases with total dose.

Single cell DCR

Step-like increase of DCR

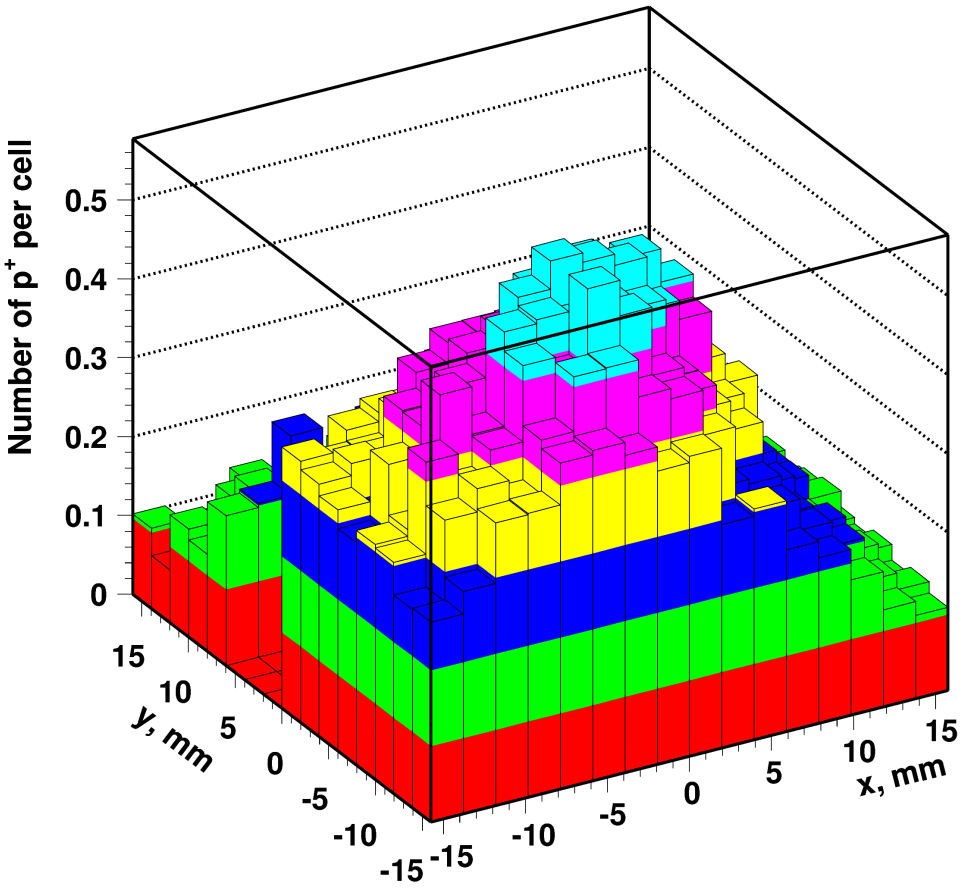
=> single interactions of protons with lattice?

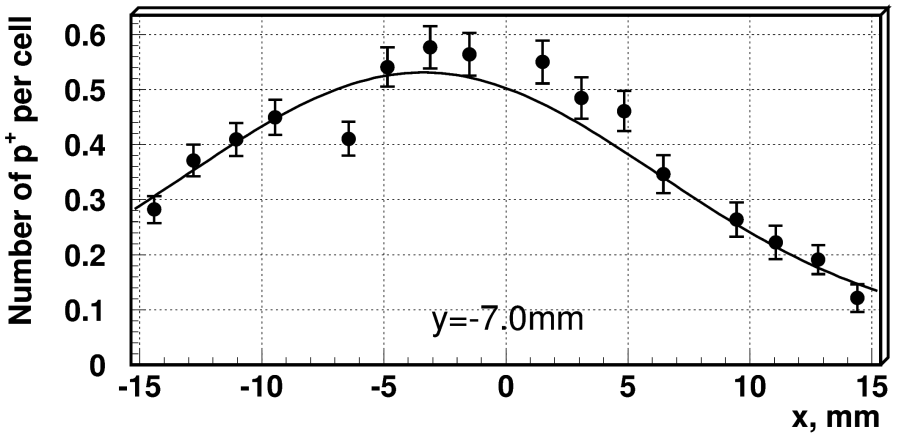


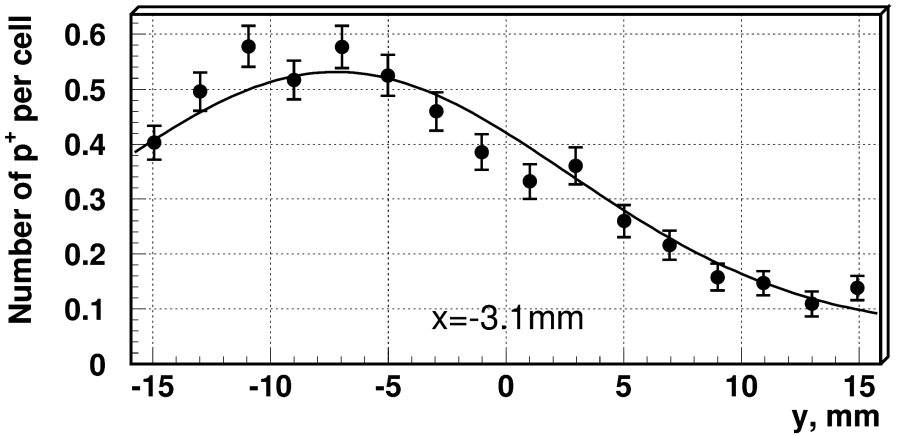


Number of “damaged” cells should be proportional to the proton fluence.

Beam profile estimation

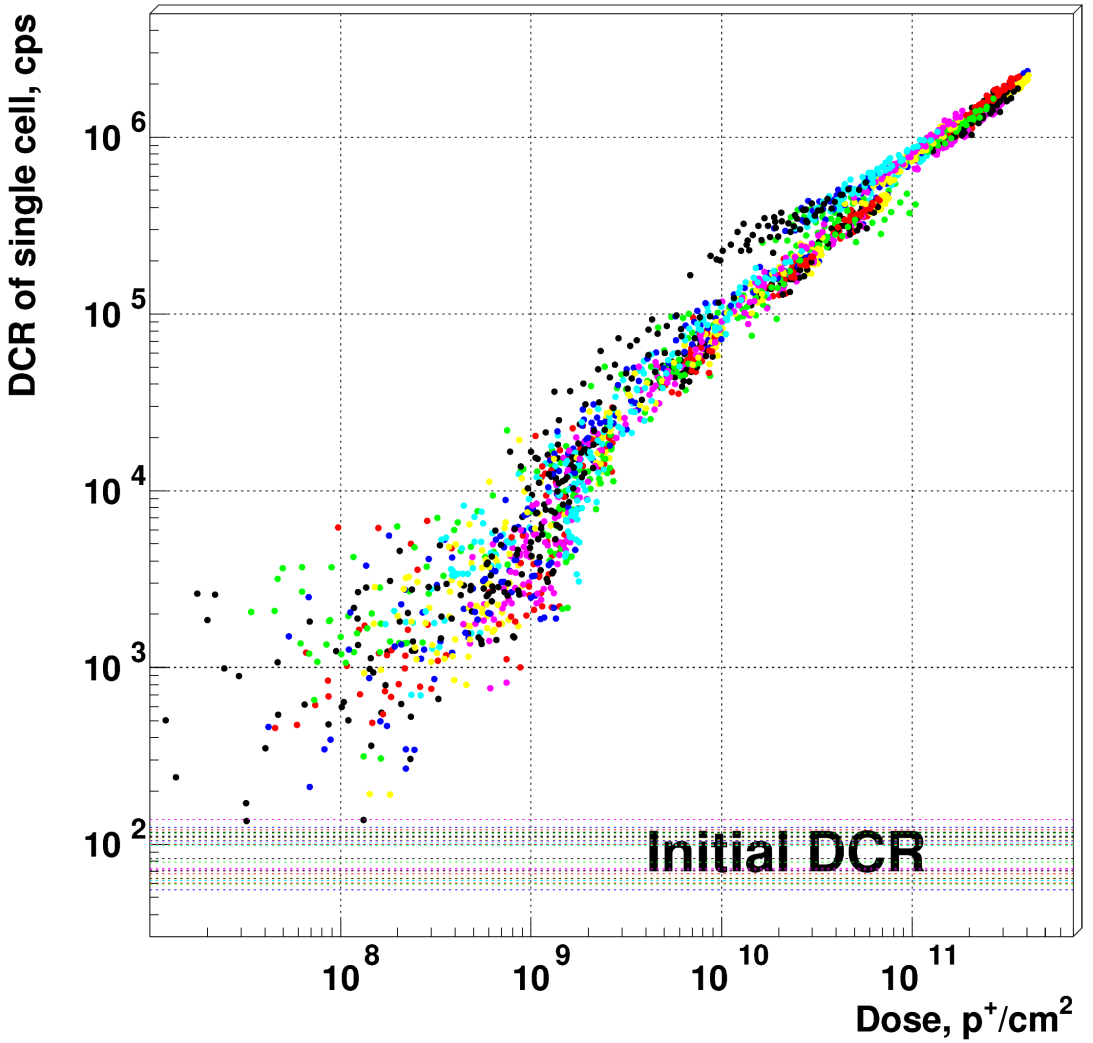






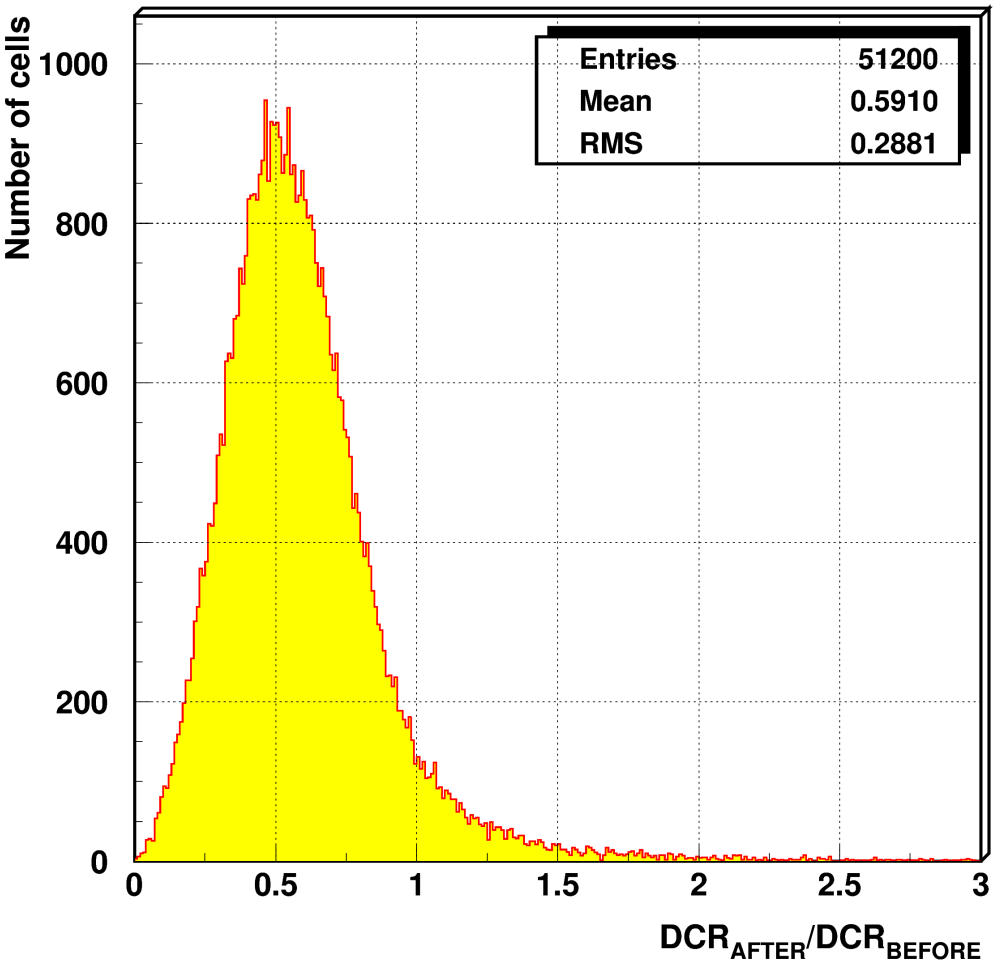
Well fitted by Gaussian + constant.
Origin of the constant is not clear.

DCR vs. proton fluence



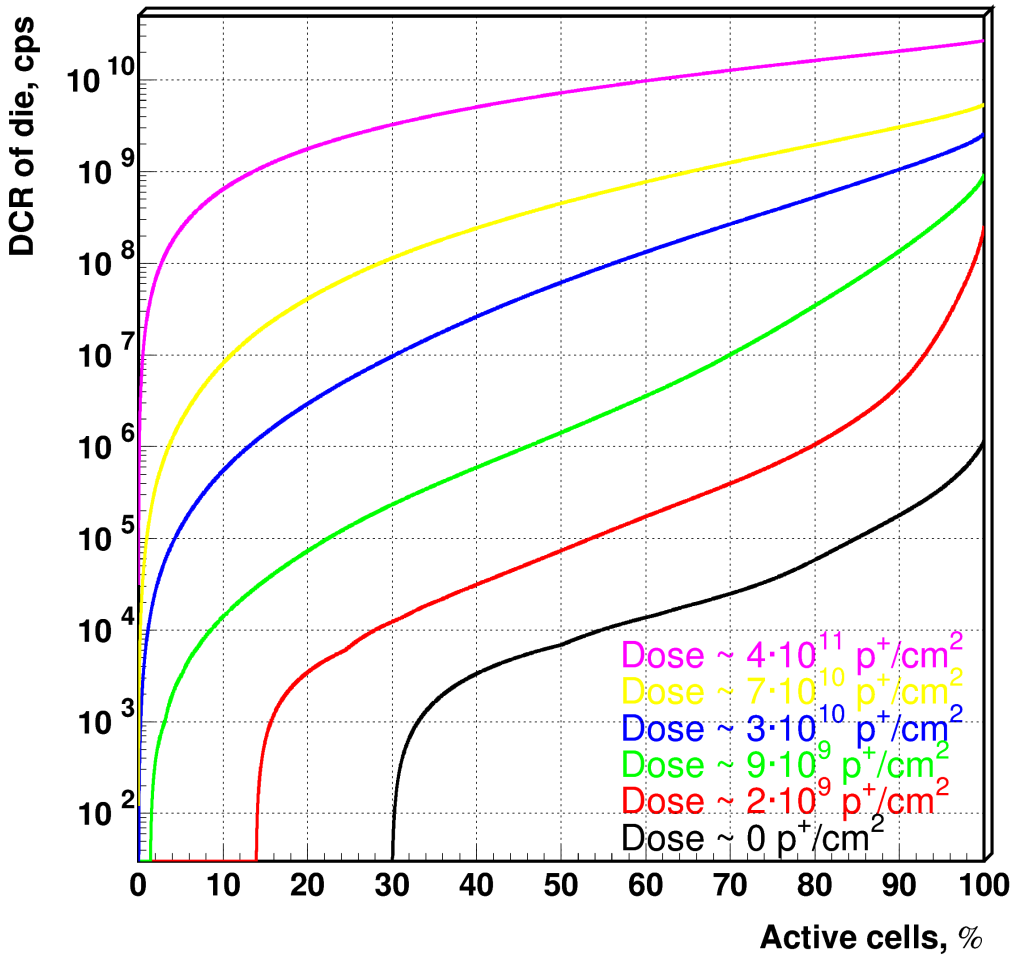
Every point is average DCR for one subpixel (32x25 cells).
Different colors for different dies.

Annealing

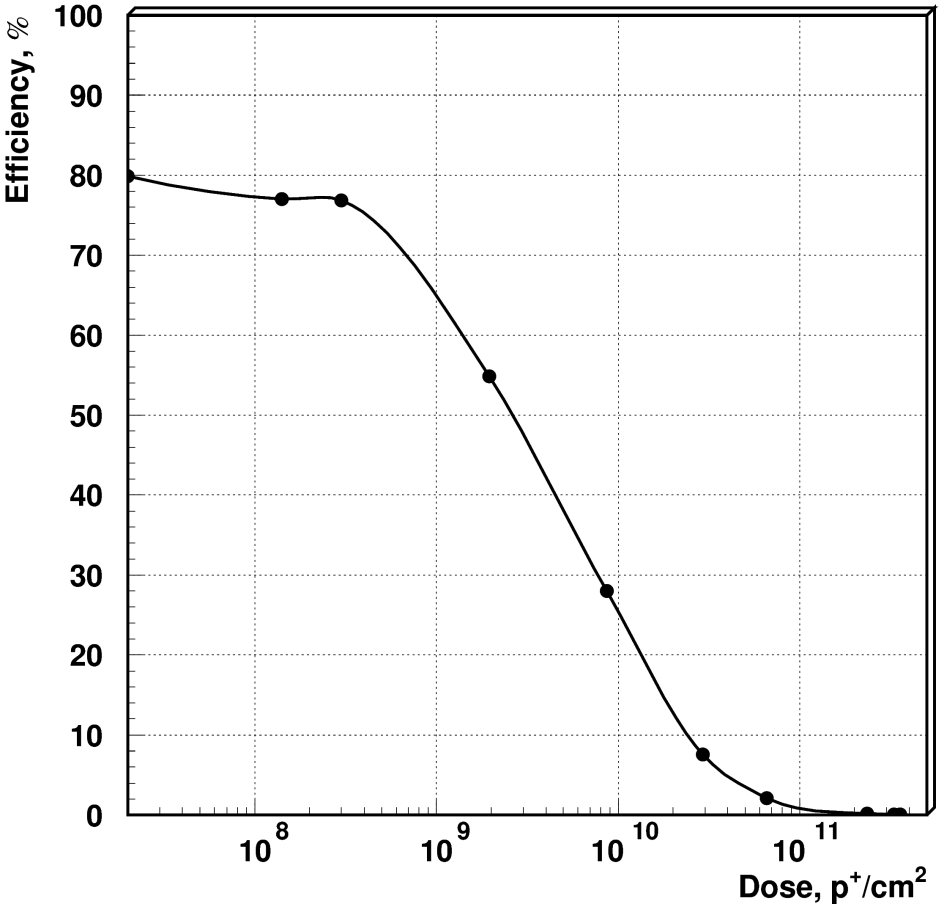


After 8 hours at T≈+40°C dark rate decreased by 40% on average.

Efficiency degradation



Minimum dead time for current die design is 720 ns.



Optimal efficiency is a tradeoff between number of active cells and dead time due to dark rate.