Investigations of the irradiated ALPIDE at cryogenic temperatures

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ITS upgrade characterisation
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Outline

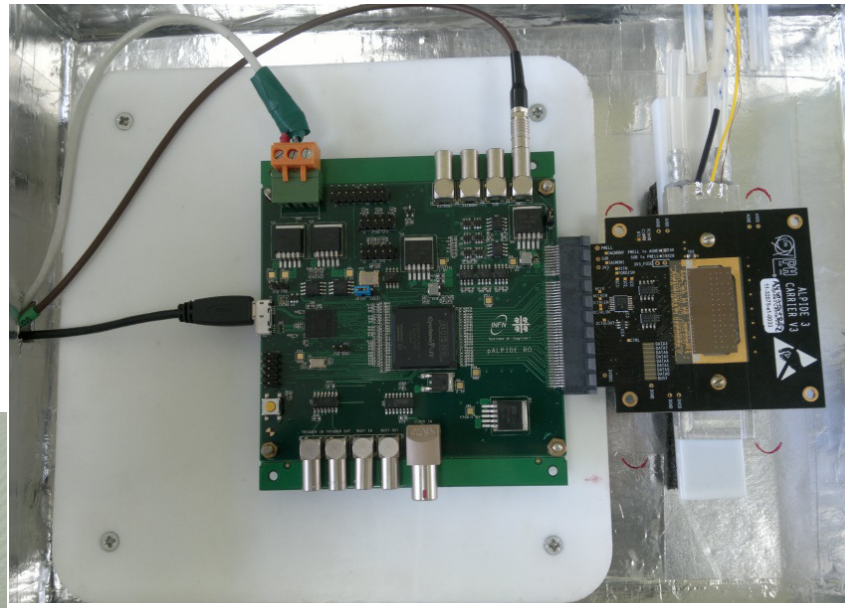
New set-up with cryogenic module

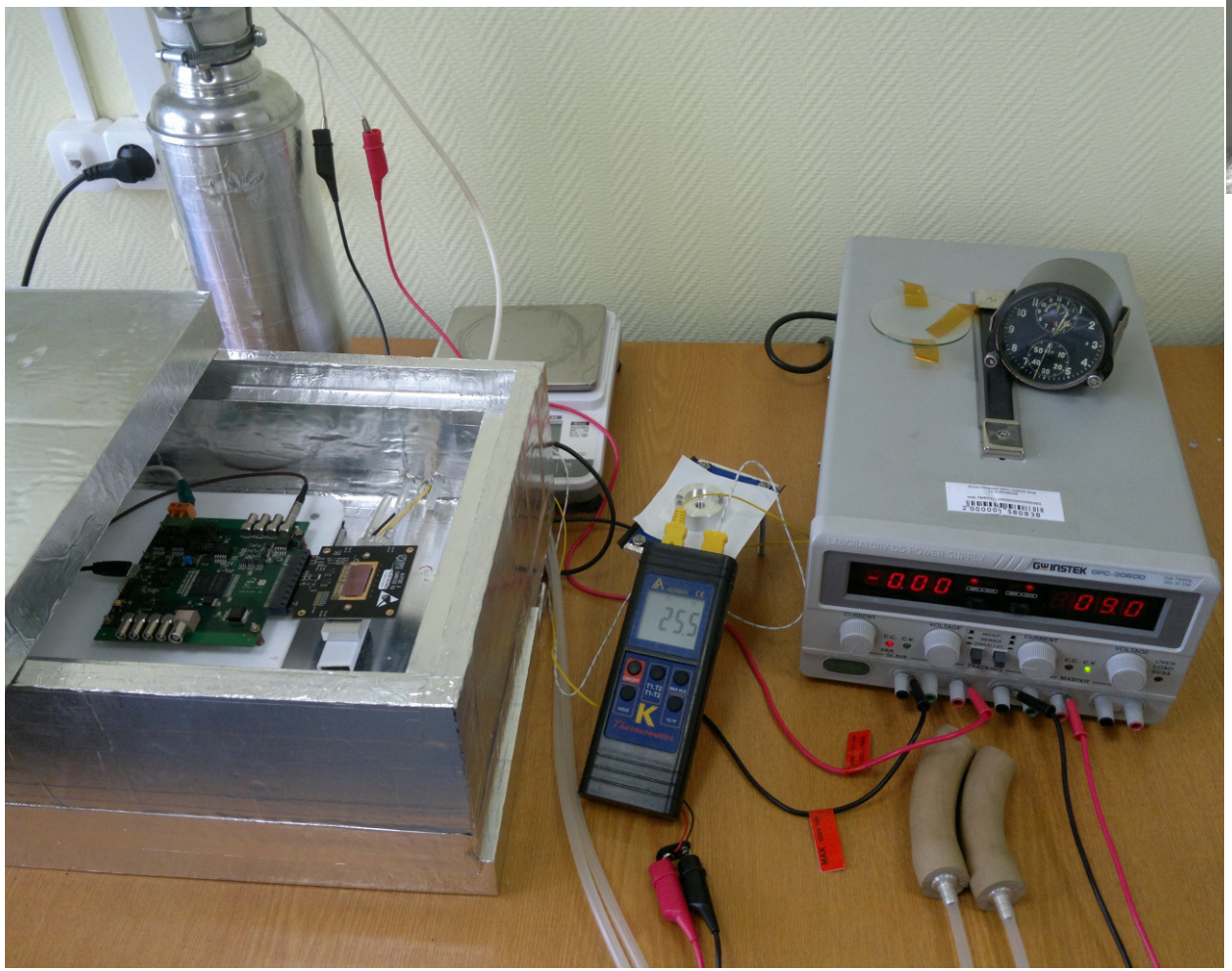
Chip tests for different temperatures

Source test + Cluster analysis

New test set-up with cryogenic module

1. Cryo-box.
2. Irradiated ALPIDE chip + DAQ board.
3. Chip was mounted on cooled platform.
4. Three thermocouples (1 copper-constantan, 2 chromel-alumel) mounted on cooled platform. Each thermocouple has own controller and DAQ





5. Dewar vessel with heater system.
6. Source holder.
7. Analytical balance

New test set-up with cryogenic module

Two different mode of the cooling process:

1. **Cooling by the chiller (alcohol-containing mixture) – only up to -20 ºC.**
   To prevent a chip from the frost the nitrogen was supplied into a cryo-box.

2. Cooling by cold nitrogen which evaporates from its liquid phase.
The liquid nitrogen was heated by nichrome heater putted into the Dewar vessel.
Then cold gas flowed through platform (inside platform).
We can regulate the nitrogen flow, powered nichrome heater (different currents up to 6 A).
Also we can control the volume of the liquid nitrogen weighing Dewar vessel.
Temperature control:
a) 3 thermocouples
b) on-chip temperature sensor. This sensor works only up to -80 ºC.

The temperature -115 ºC has been reached

Chip tests for different temperatures

Chip W8R22 – 60 krad (low dose)

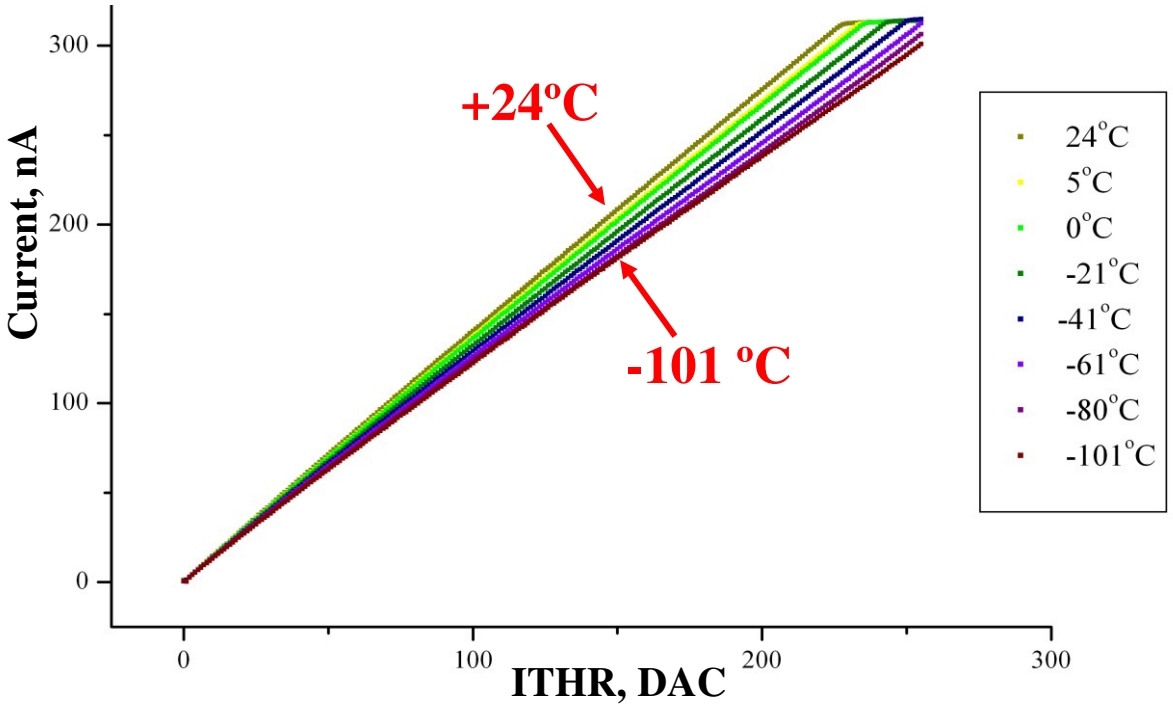
Chip W7R12 – 300 krad (high dose)

Before irradiation Chip W7R12 was measured at lab.
see my presentations *ALPIDE Qualification Task Force in october 2016*

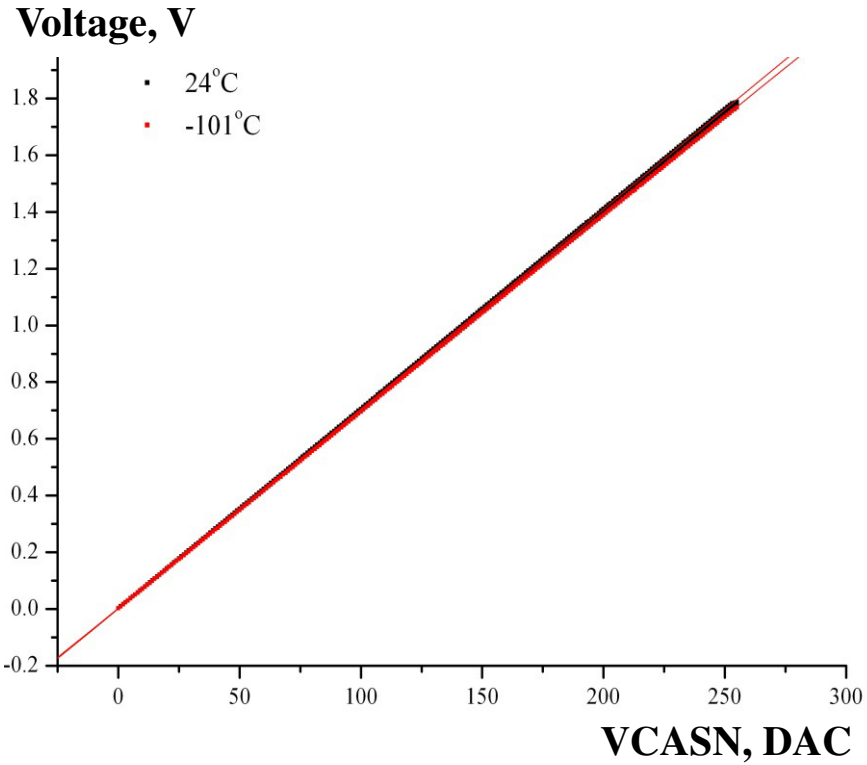
~ 5 month after irradiation

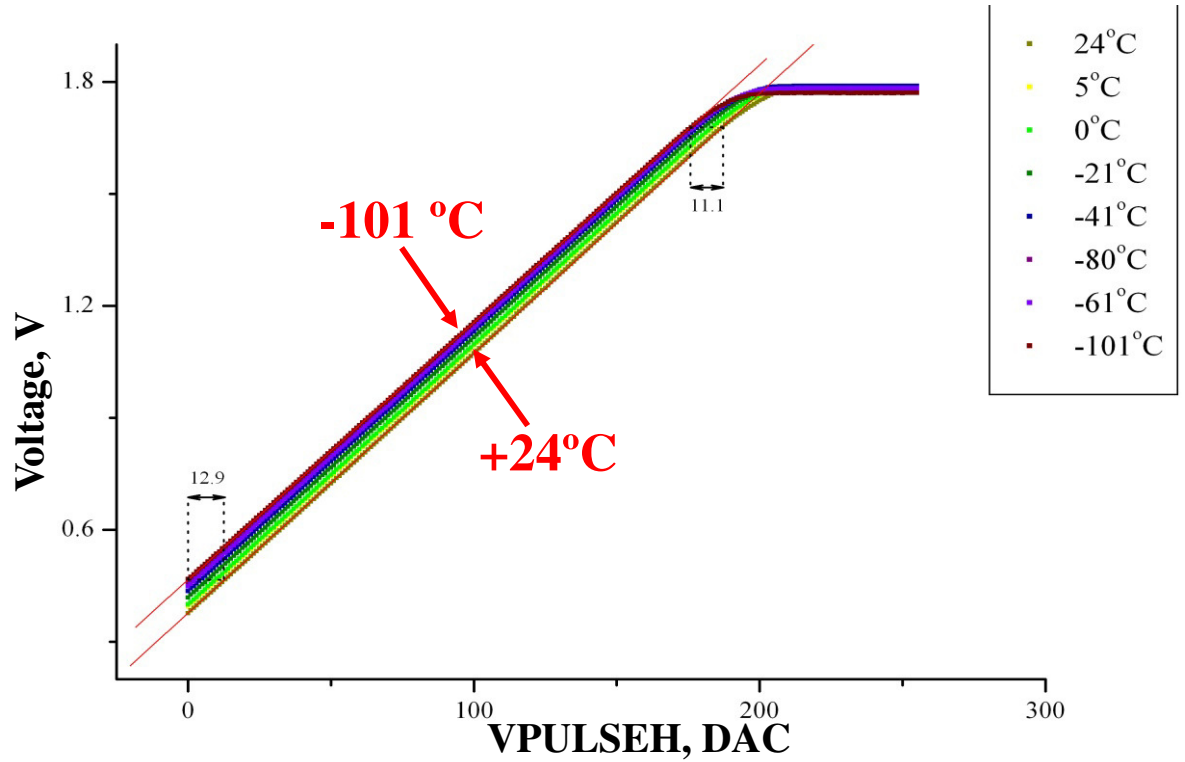
All measurements were done at Vbb = -3V

Chip tests for different temperatures

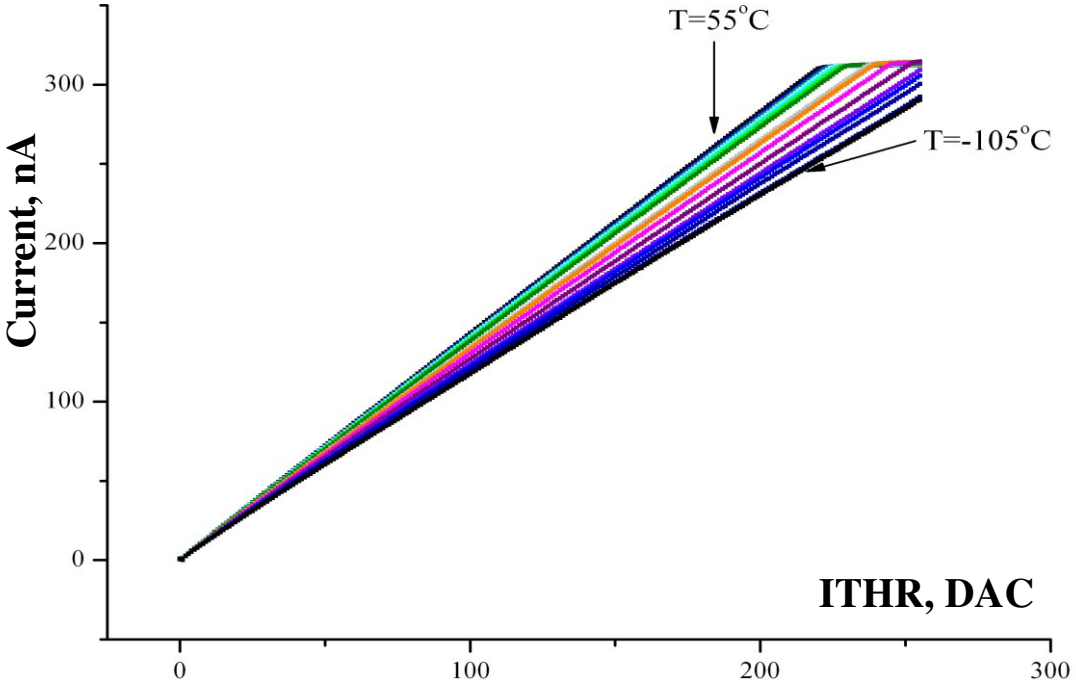


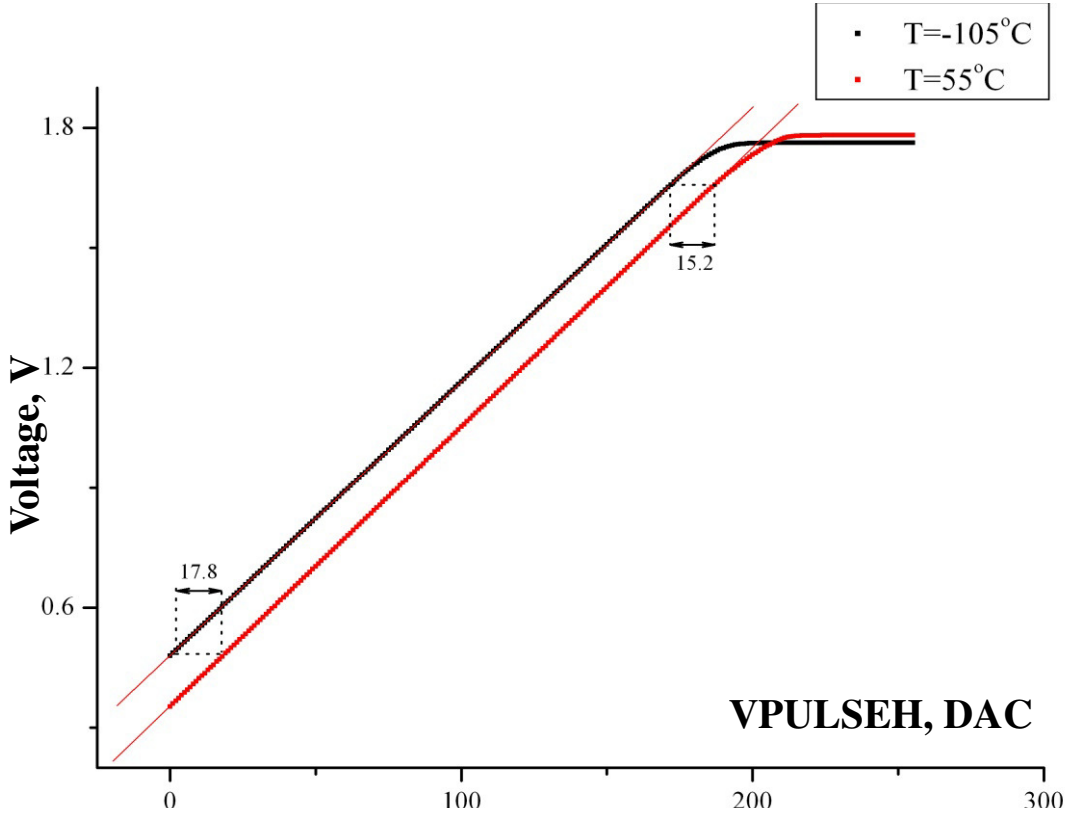
DAC Scan Chip W8R22



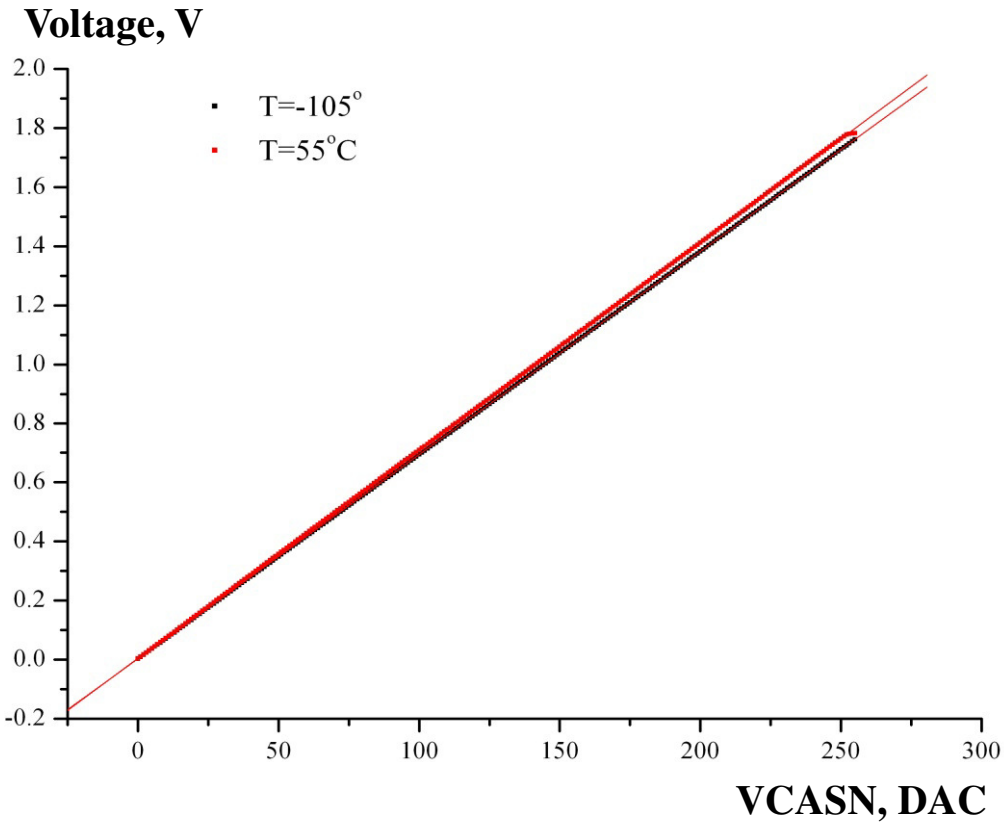


Chip tests for different temperatures





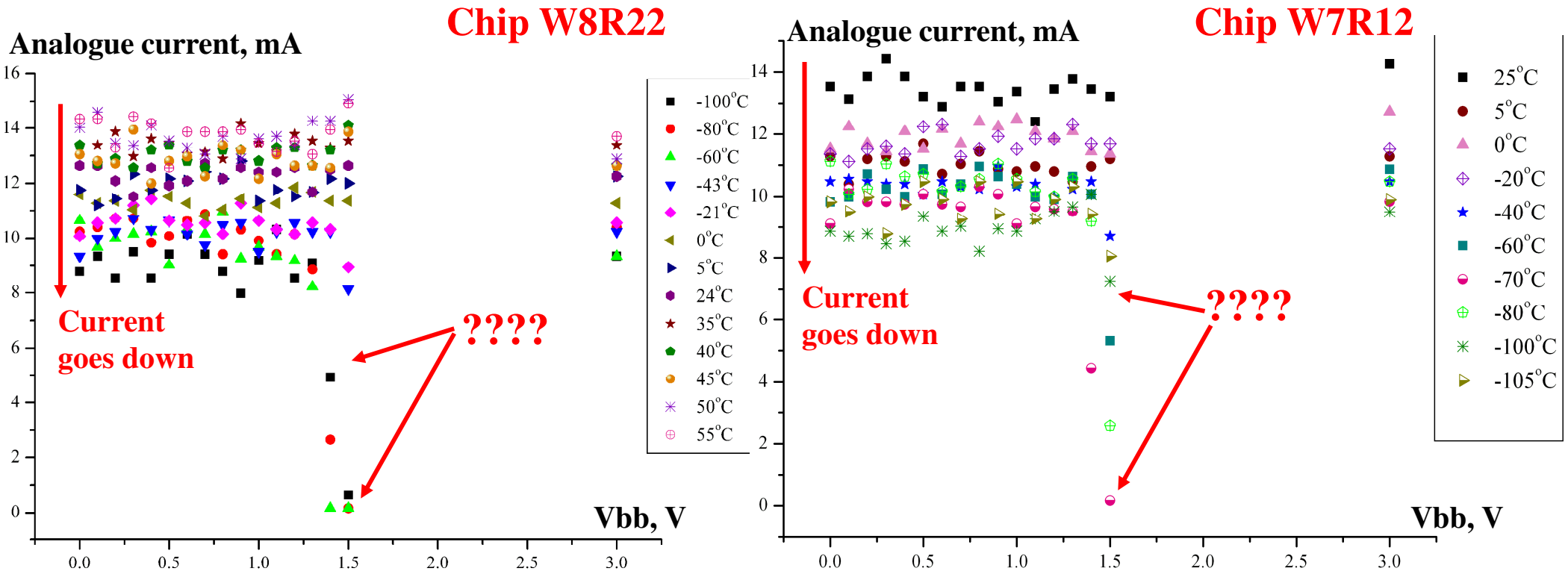
DAC Scan Chip W7R12



This chip was also heated to 55 ^{0}C (for annealing investigations)

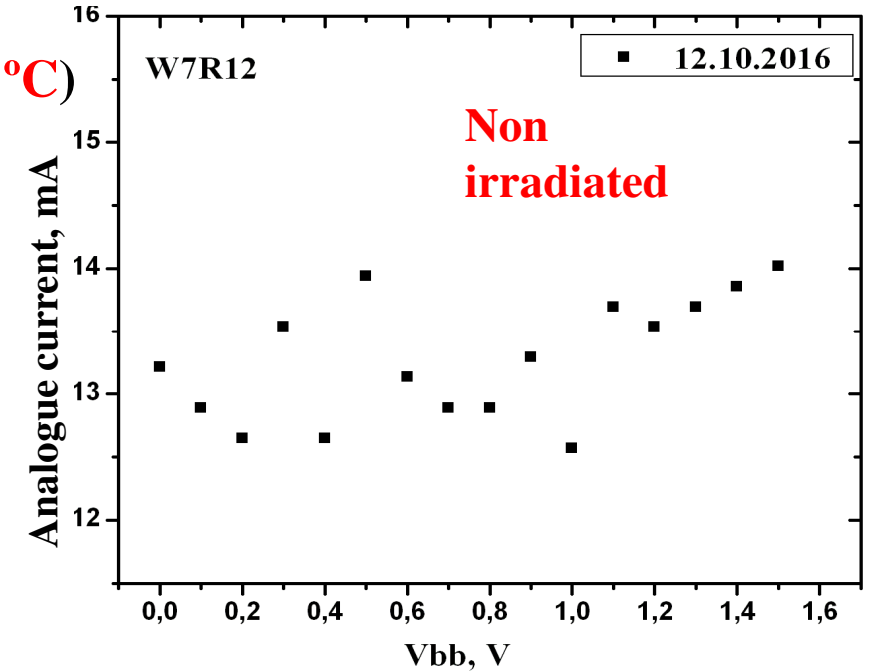
Chip tests for different temperatures

Analogue Currents



1. With lowering temperature (from +24 °C to -105 °C) for both Chips analogue current goes down from 14 to 9 mA;

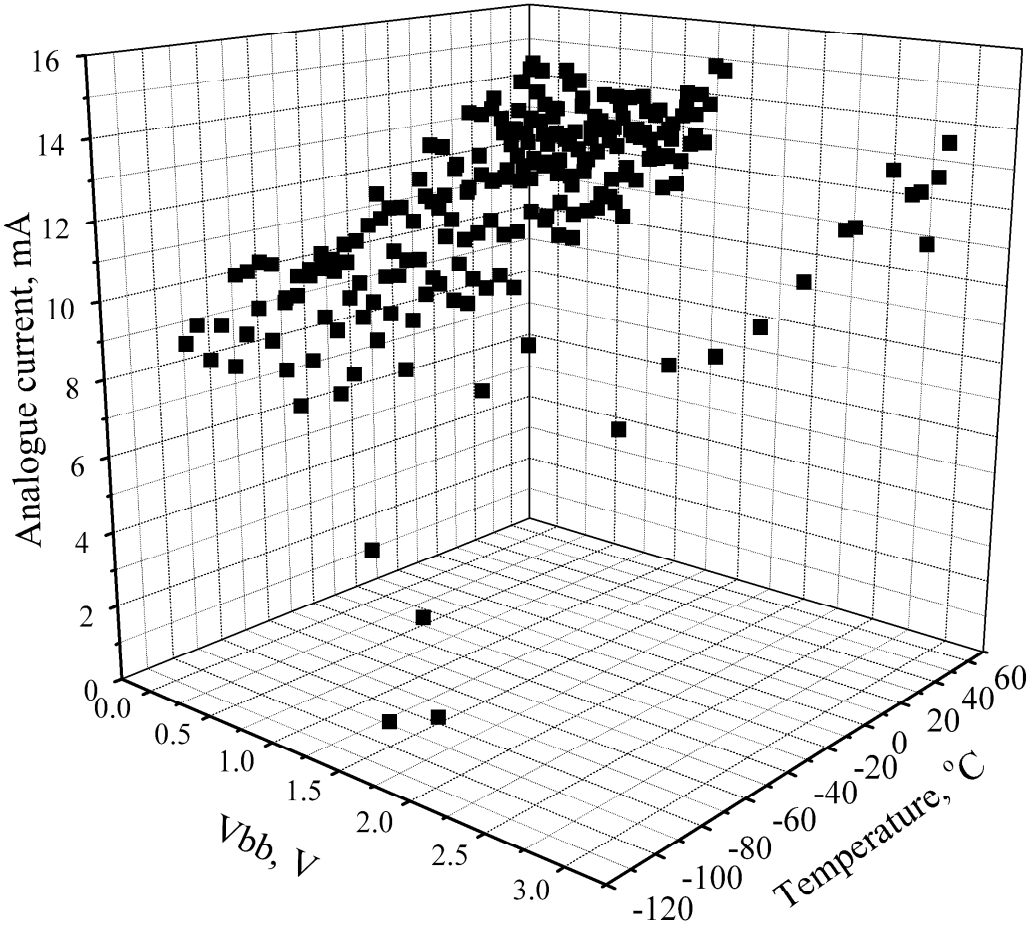
2. Strange current behavior for Vbb = 1.4-1.5 V has been observed for temperature range: -60 °C → -100 °C



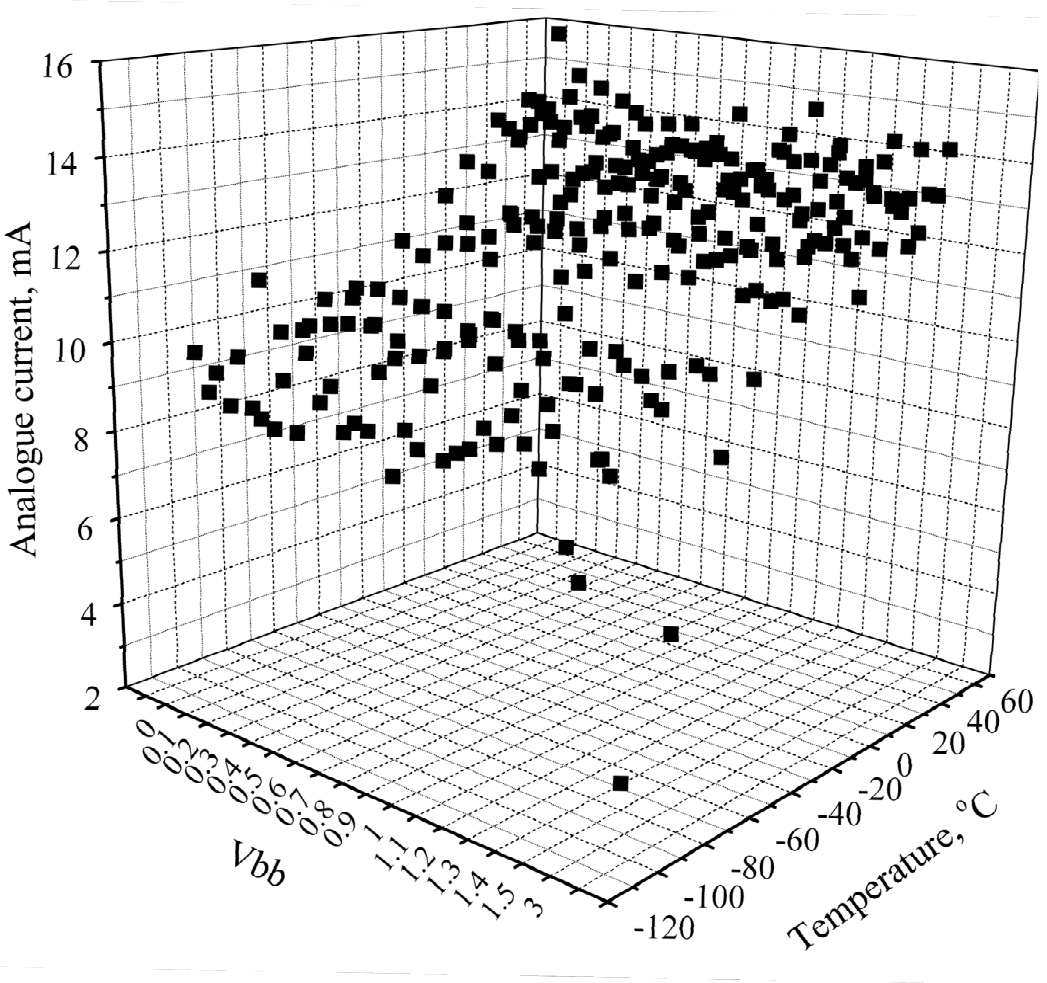
Chip tests for different temperatures

Analogue Currents

Chip W8R22

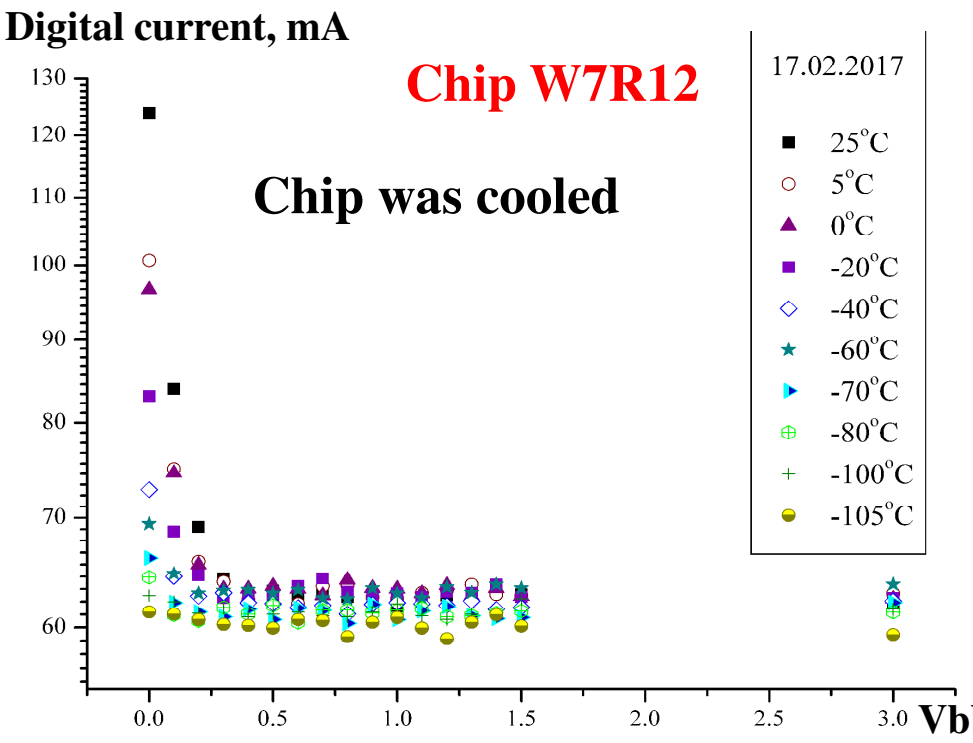


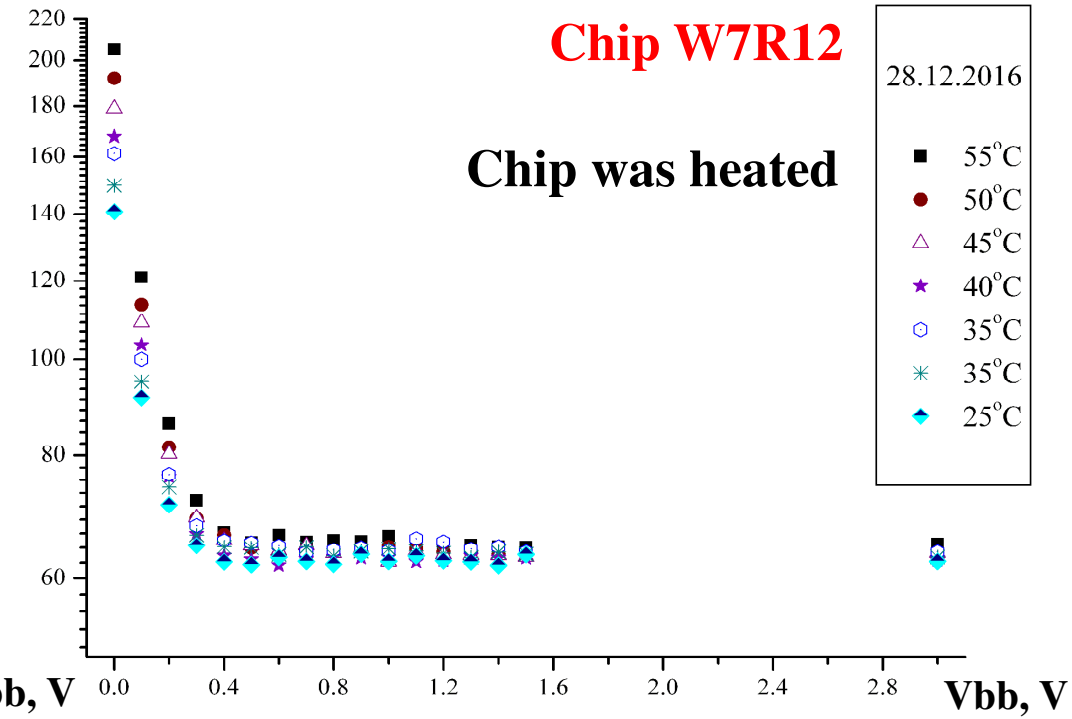
Chip W7R12

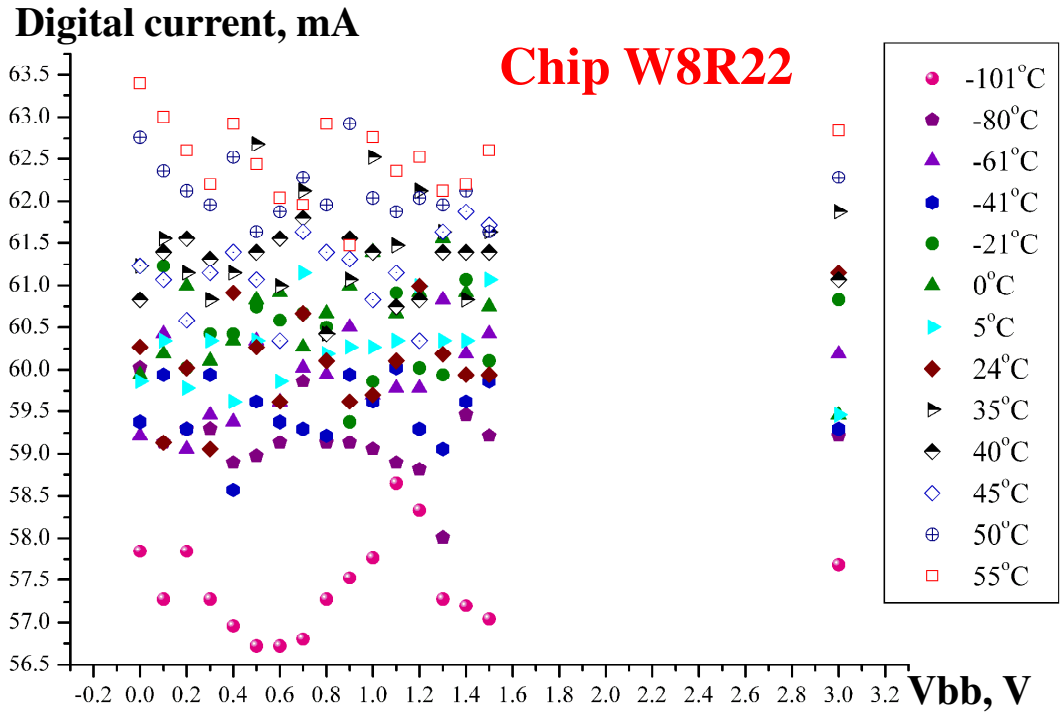


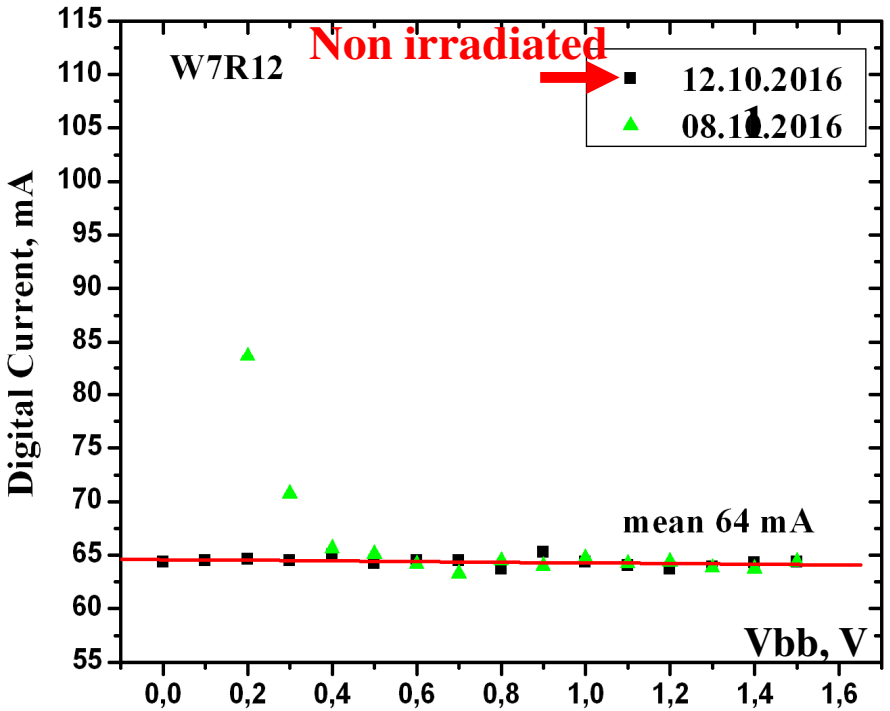
Chip tests for different temperatures

Digital Currents





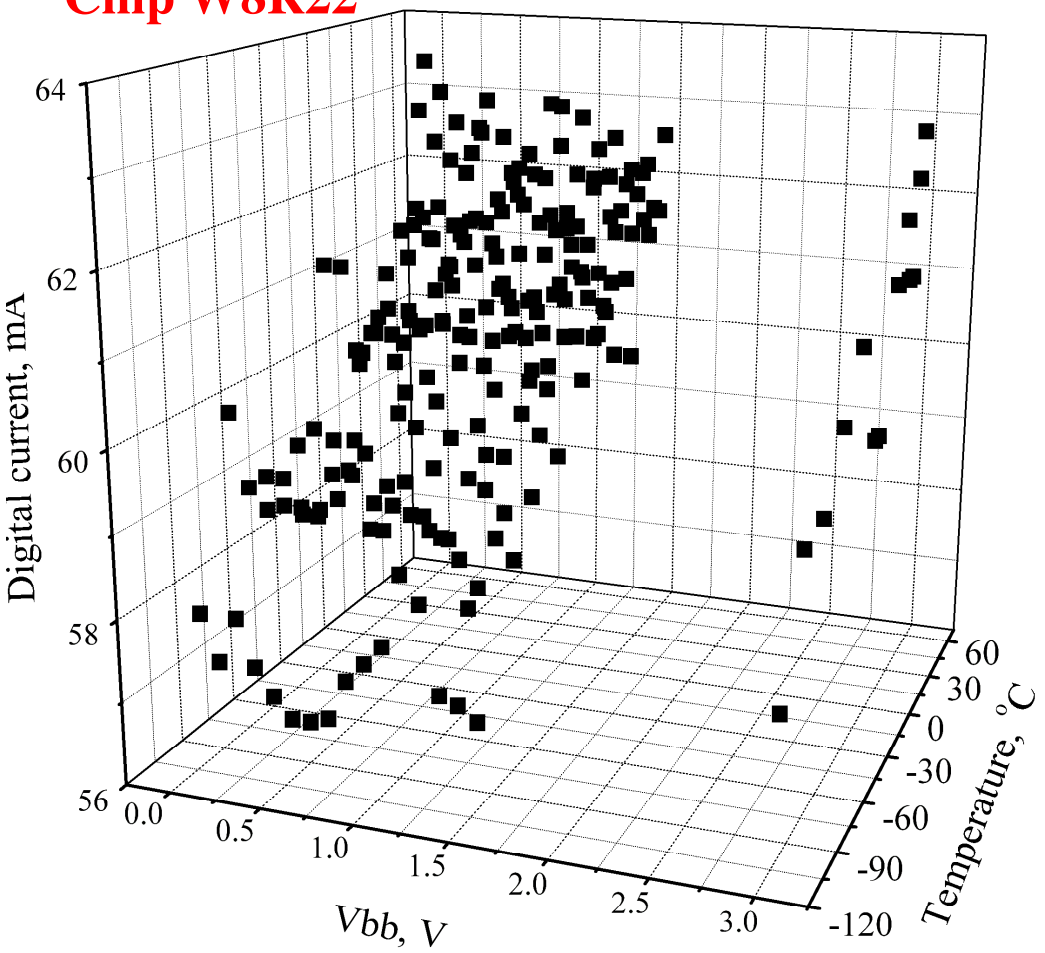




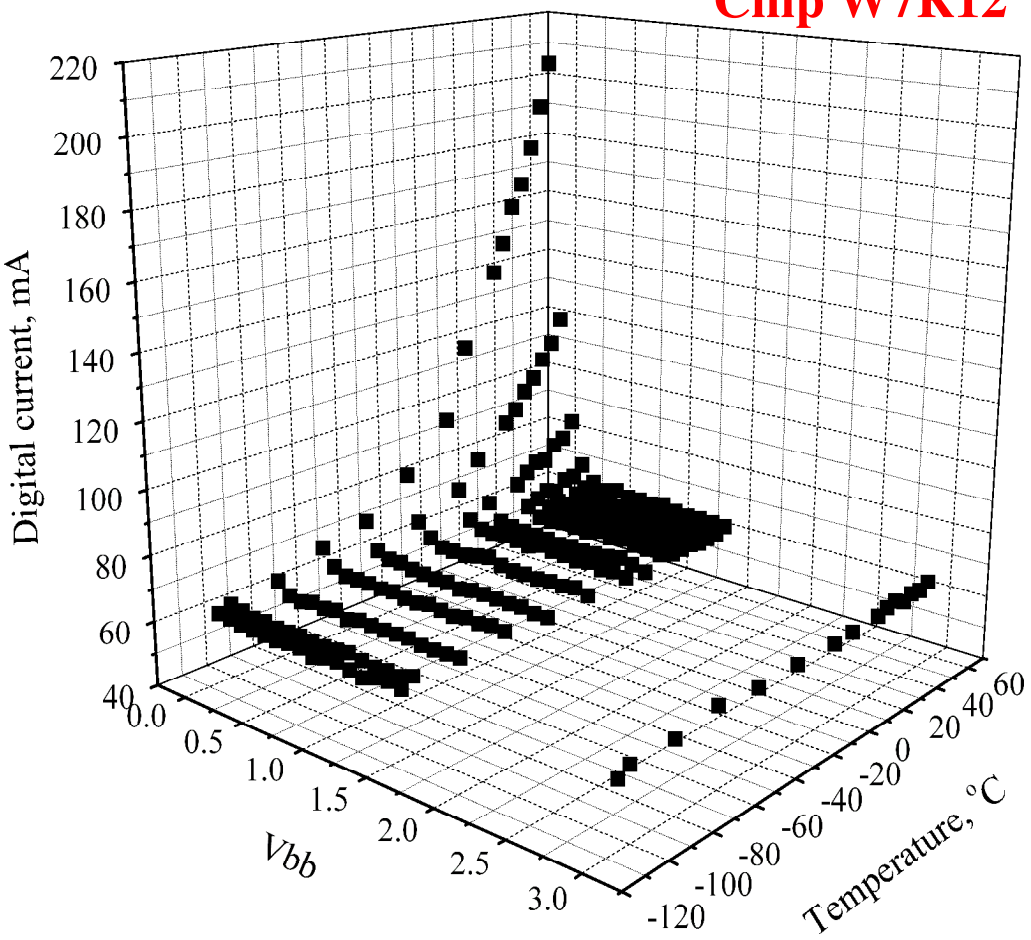
Chip tests for different temperatures

Digital Currents

Chip W8R22



Chip W7R12



1. **Starting from temperature -60 °C, for irradiated (big dose) chip the digital current at Vbb = 0 V has the same values as before irradiation.**

2. **With lowering temperature (from +24 °C to -105 °C) for both Chips digital current goes slowly down;**

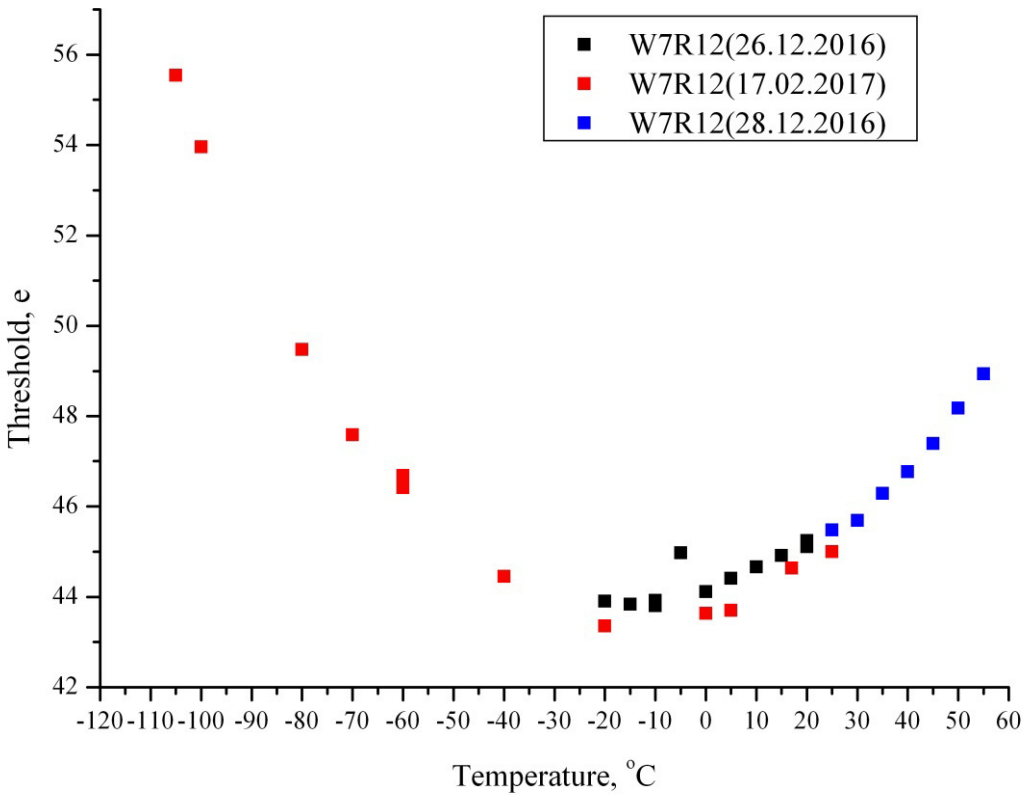
3. **For irradiated (big dose) chip after heating the digital current at Vbb = 0 went up again.**

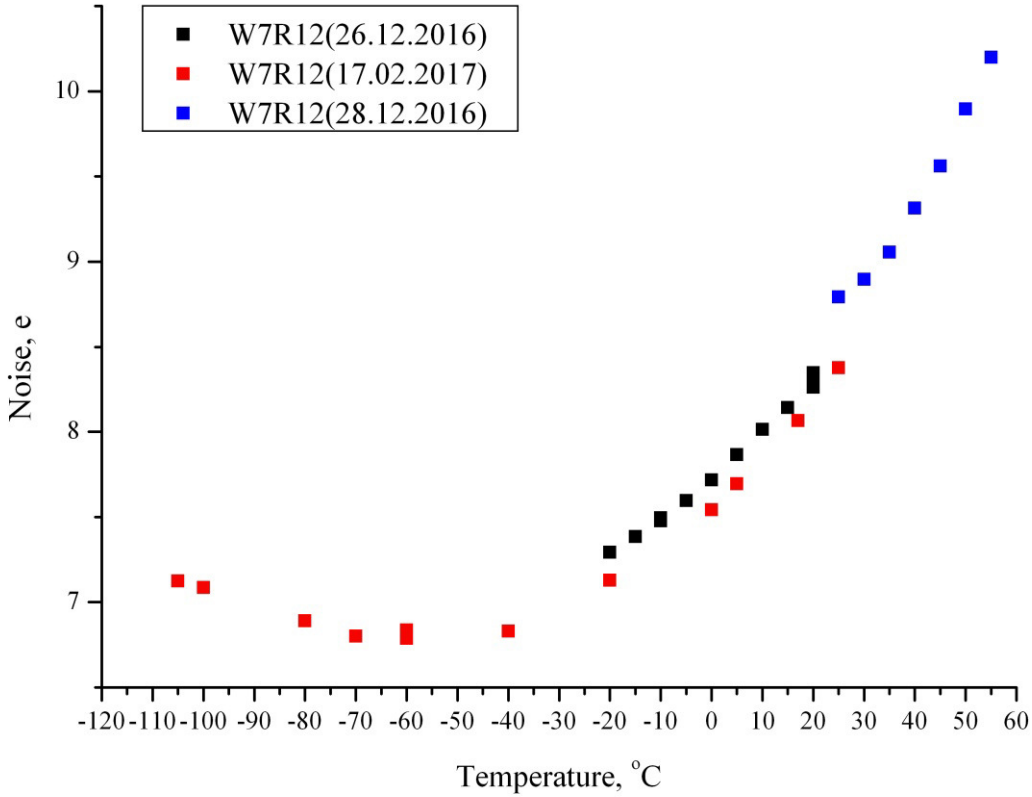
Chip tests for different temperatures

Threshold Scan

Results for high dose irradiated chip

Chip W7R12





Before irradiation the threshold was ~ 85 e,
after irradiation (300 krad)
the threshold became ~ 45-50 e

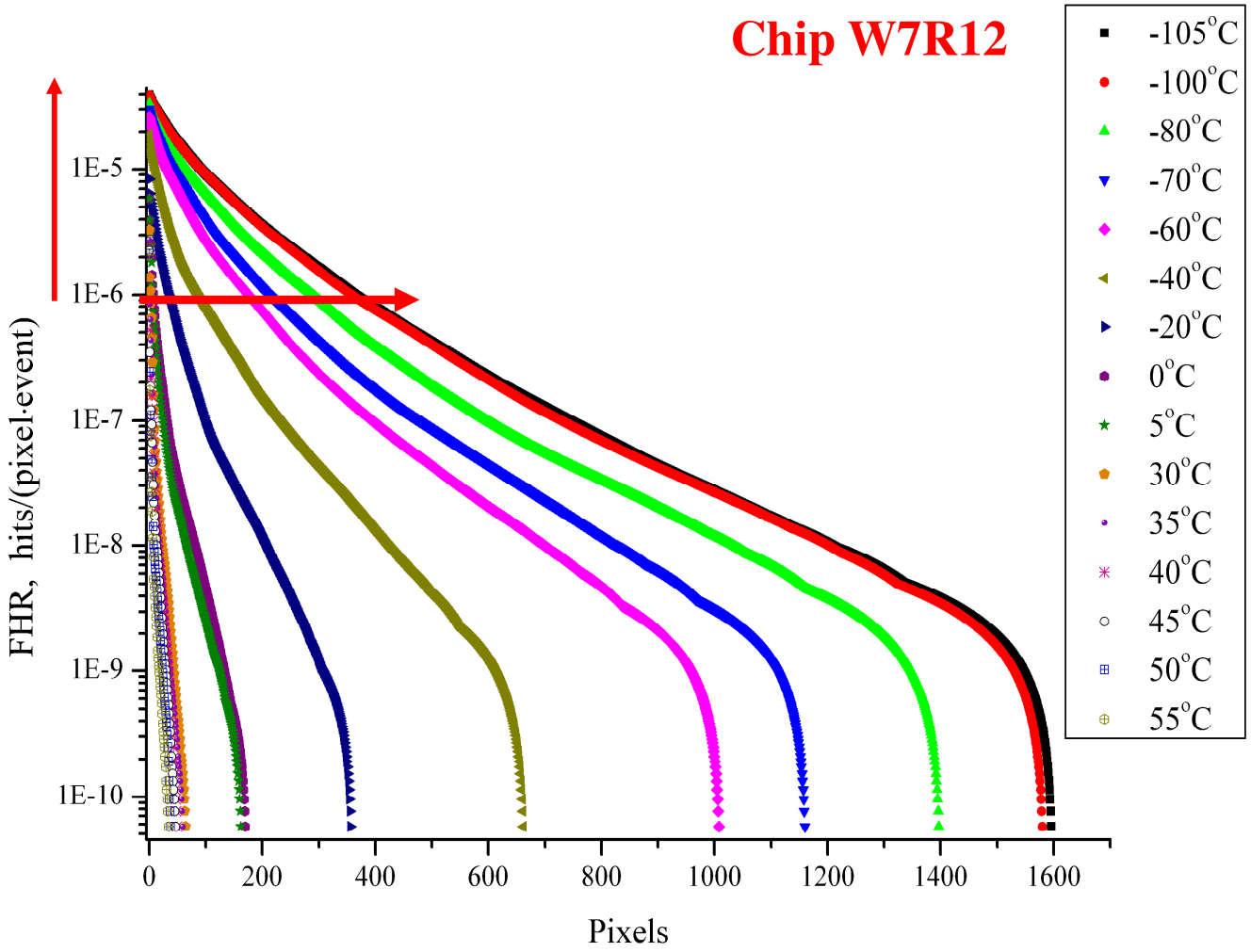
Before irradiation the noise was ~ 6 e,
after irradiation (300 krad)
the noise became ~ 14 e
After some time again ~ 8.5 e

The threshold goes up both with increasing temperature and with lowering temperature, but initial value (before irradiation) of the threshold is not reached.

Chip tests for different temperatures

Noise Occupancy Scan

Results for high dose irradiated chip



1. The number of noisy pixels increases with the lowering of temperature.

2. FHR also increases with temperature decreasing

3. The same results for low dose irradiated chip

Source test + Cluster analysis

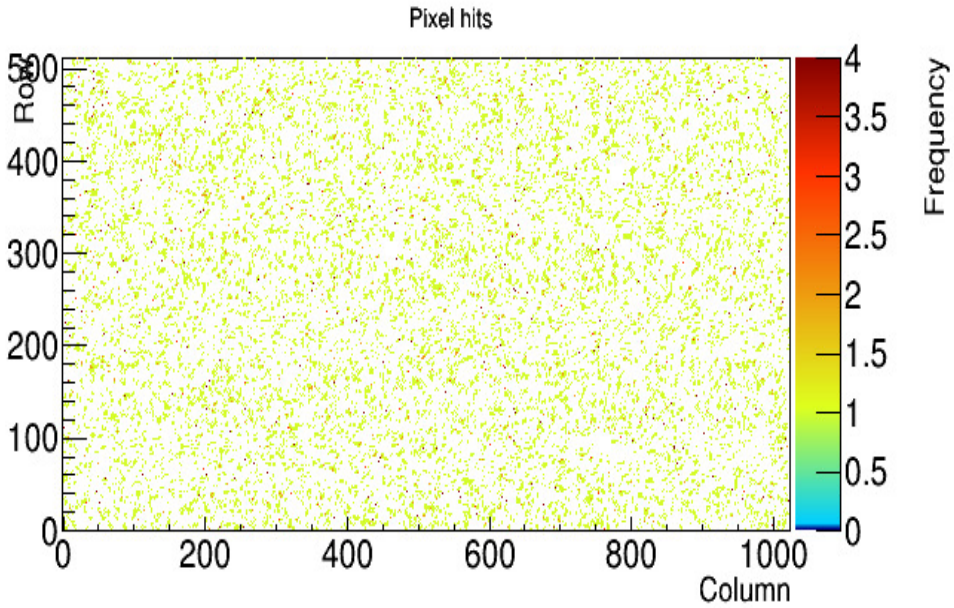
Triggers: 2000000
Vbb = -3V

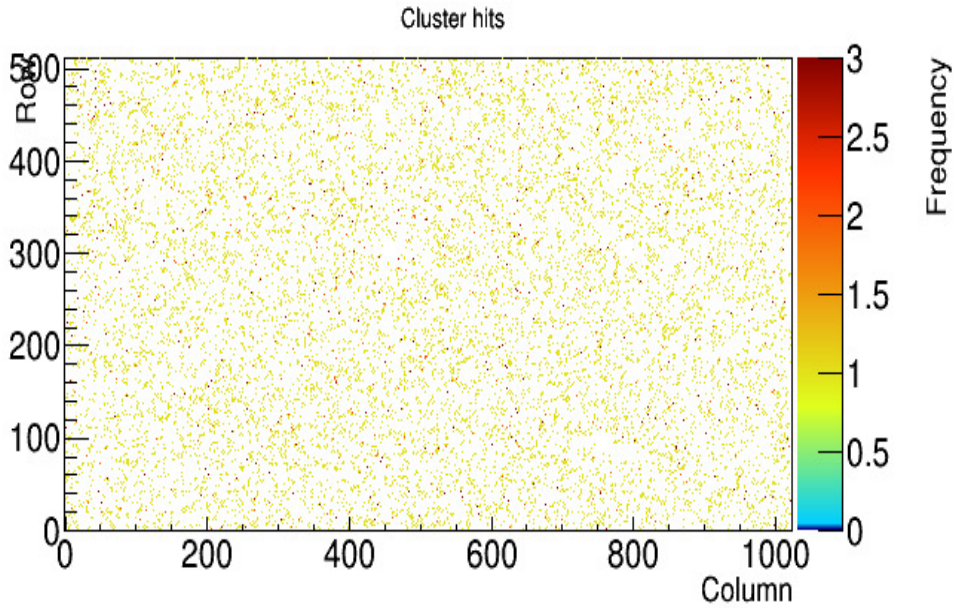
Results for high dose irradiated chip

Chip W7R12

Masked

Source 133Ba: energy γ - 4.29 keV





chip temperature -115 °C

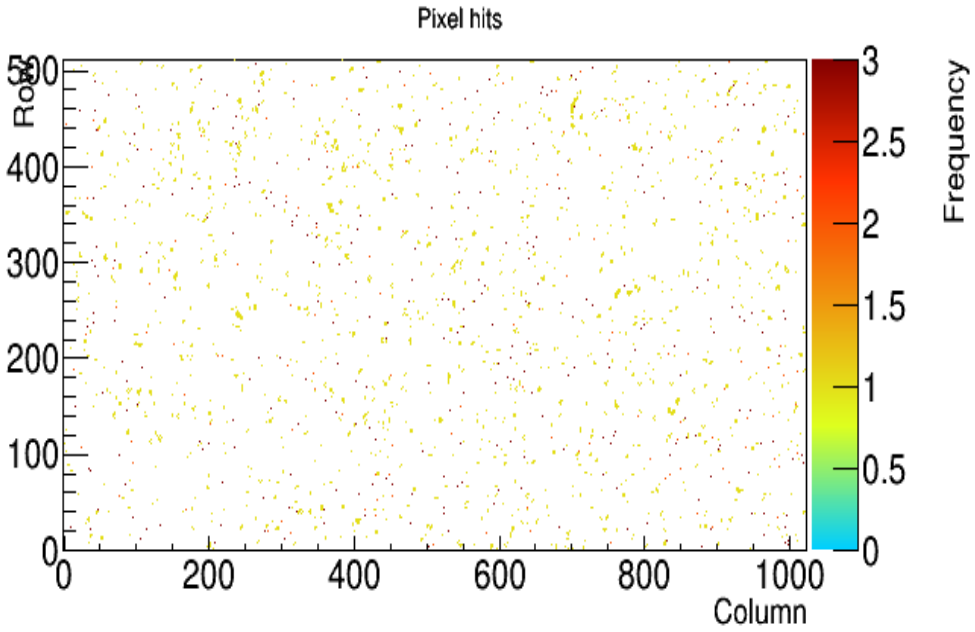
Source test + Cluster analysis

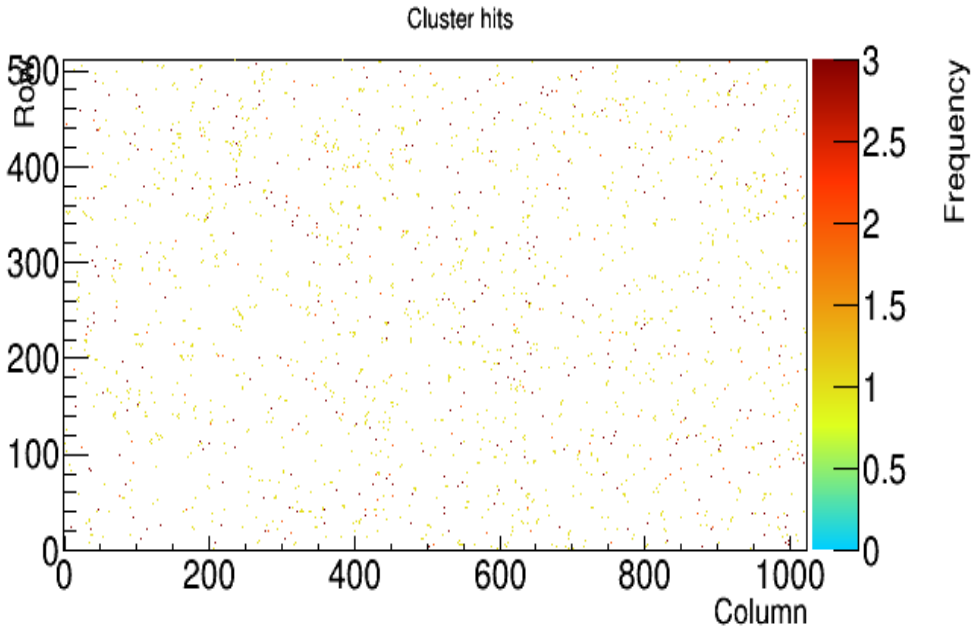
Results for high dose irradiated chip **Chip W7R12**

Triggers – 2000000
Vbb = -3V

Masked

Source: Sr-Y, chip temperature -100 °C





Source test + Cluster analysis

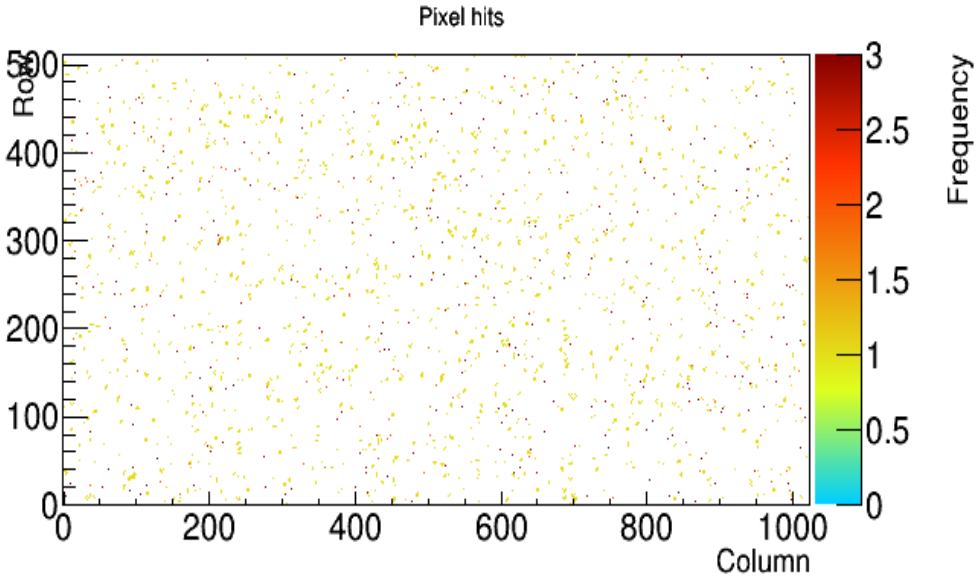
Results for high dose irradiated chip

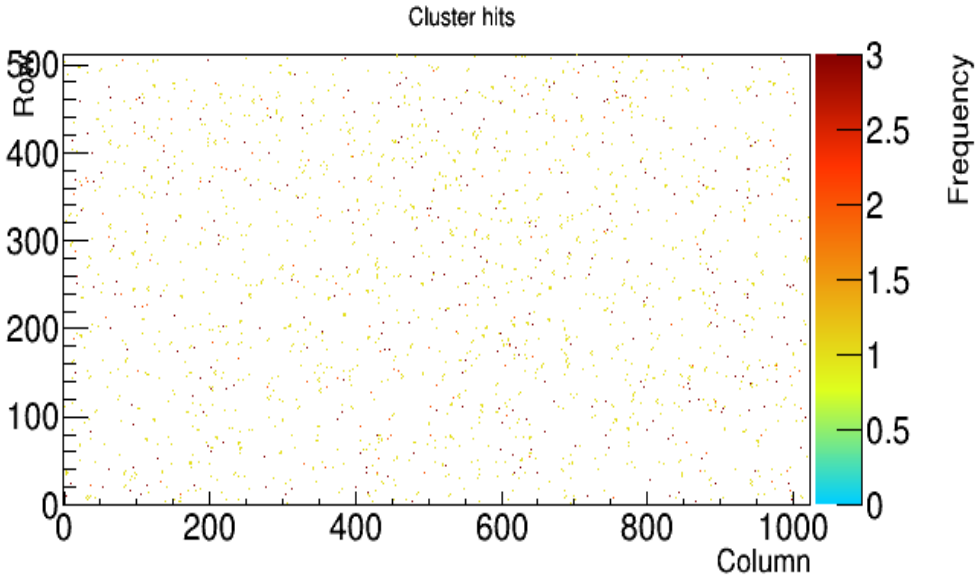
Chip W7R12

Triggers – 2000000
Vbb = -3V

Masked

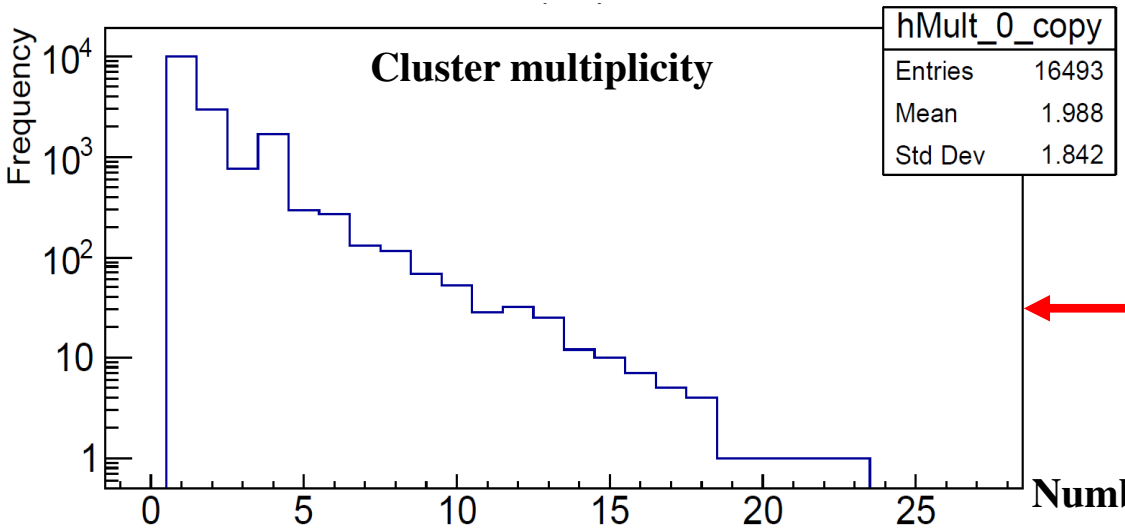
Source: 14C, chip temperature -100 °C



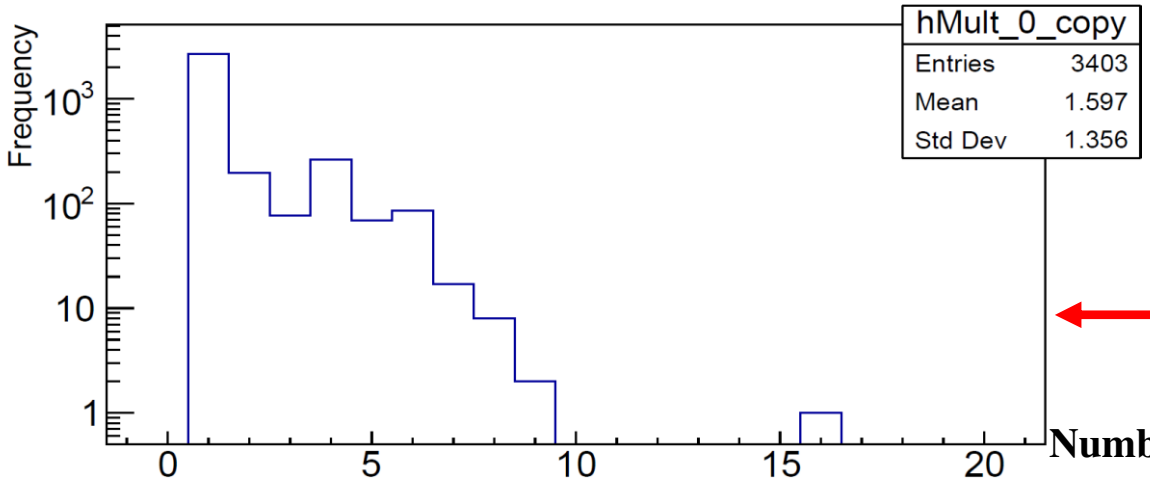


Source test + Cluster analysis

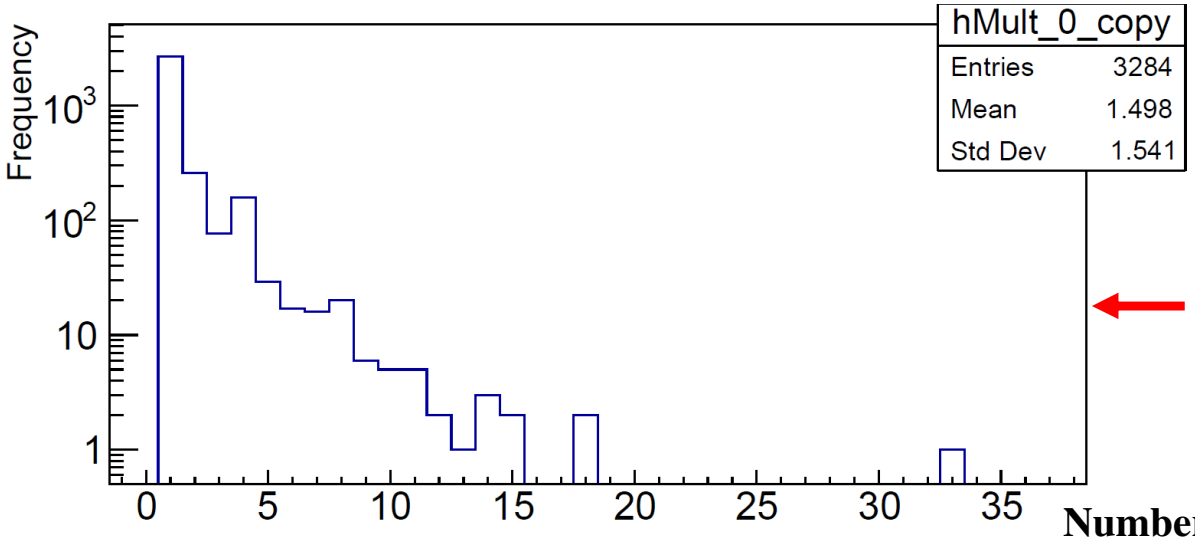
Chip W7R12



133Ba, chip temperature -115 °C

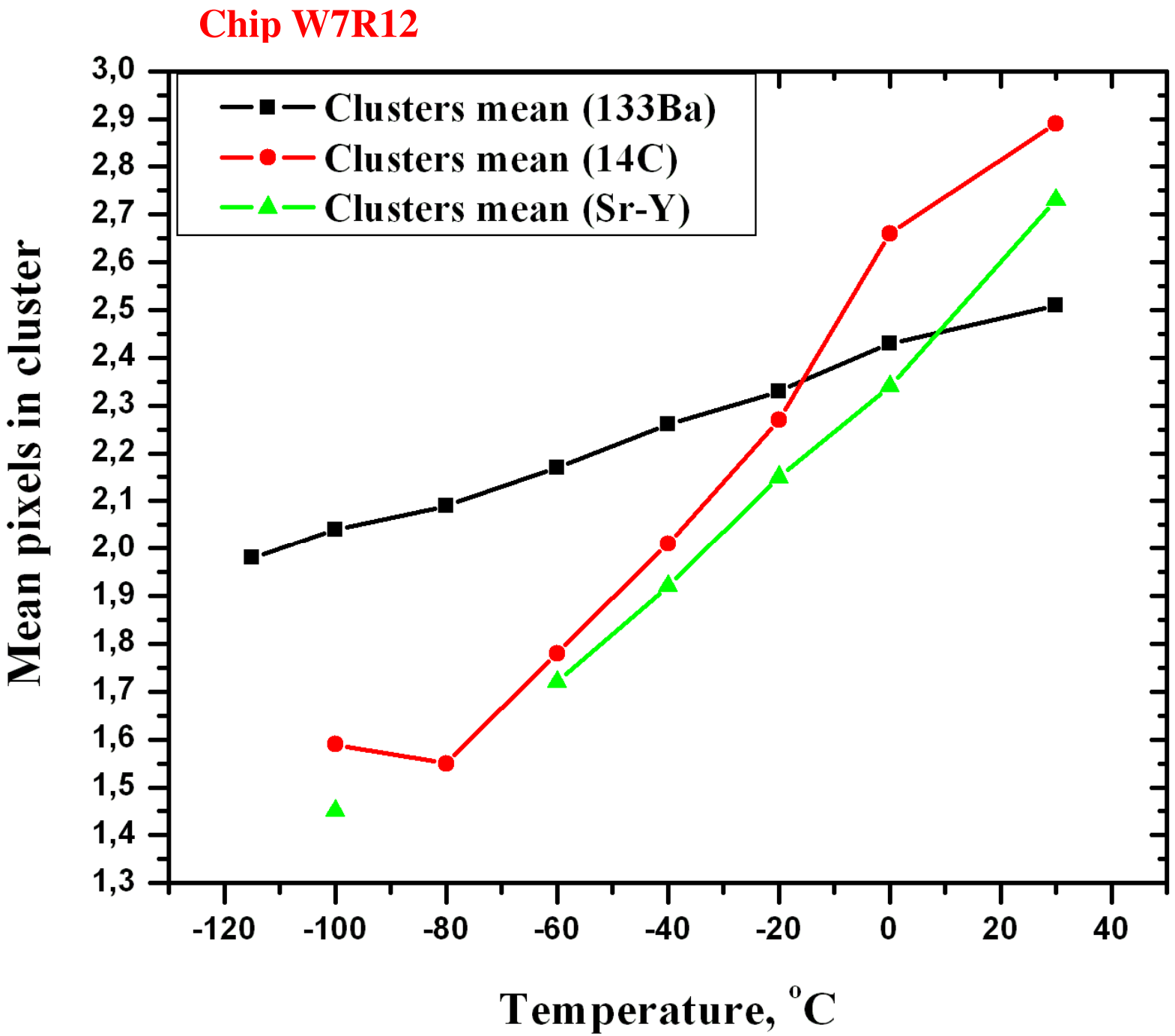


14C, chip temperature -100 °C



Sr-Y, chip temperature -100 °C

Source test + Cluster analysis



Conclusion

1. At temperature -115 ºC chip works. On-chip temperature sensor operates only up to -80 ºC.

2. For irradiated (big dose) chip digital current goes to nominal value at Vbb = 0 V (as before irradiation) and reach it at -60 ºC.

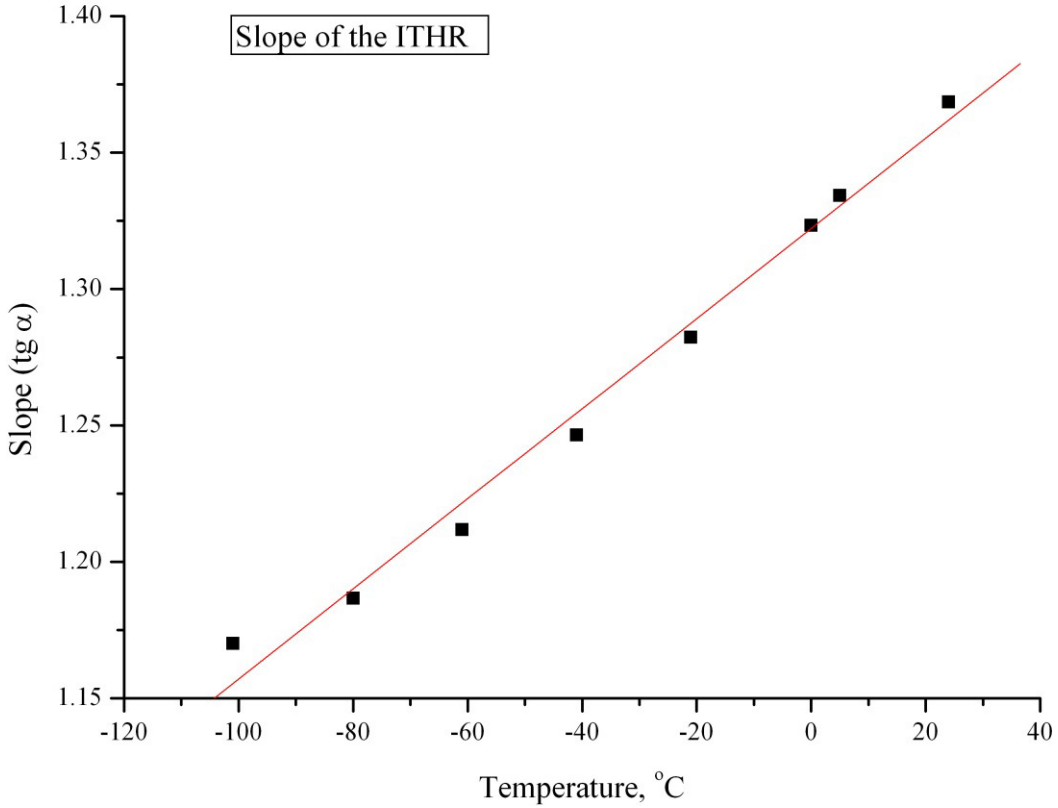
3. The number of noisy pixels and FHR increases with temperature decreasing

4. Mean pixels in cluster drop down with temperature decreasing

Back up

Chip tests for different temperatures

DAC Scan Chip W8R22



DAC Scan Chip W7R12