

First look at irradiated SiPM at low temperatures

Experimental setup
Measurements
Discussion

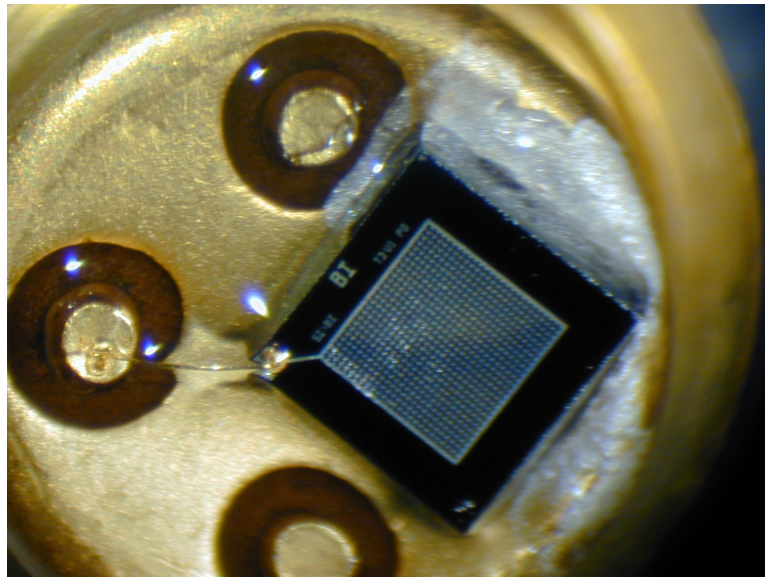
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Motivation

- Detection of low light (single photons) with SiPM => high dark rate can be a problem
 - Can be reduced by lowering the temperature
- High radiation environment
- In damaged SiPM:
 - Dark rate as a function of the temperature has the same behavior before and after irradiation?
 - Charge traps created by radiation damage affects after-pulse probability?

Experimental setup: SiPM

- Consider FBK SiPM, 40 μm pixel size, 1mm²
 - Non irradiated
 - Irradiated with $2.1 \cdot 10^{10}$ 1 MeV n / cm²
 - From the same batch



Experimental setup: dry ice (-78.5C)

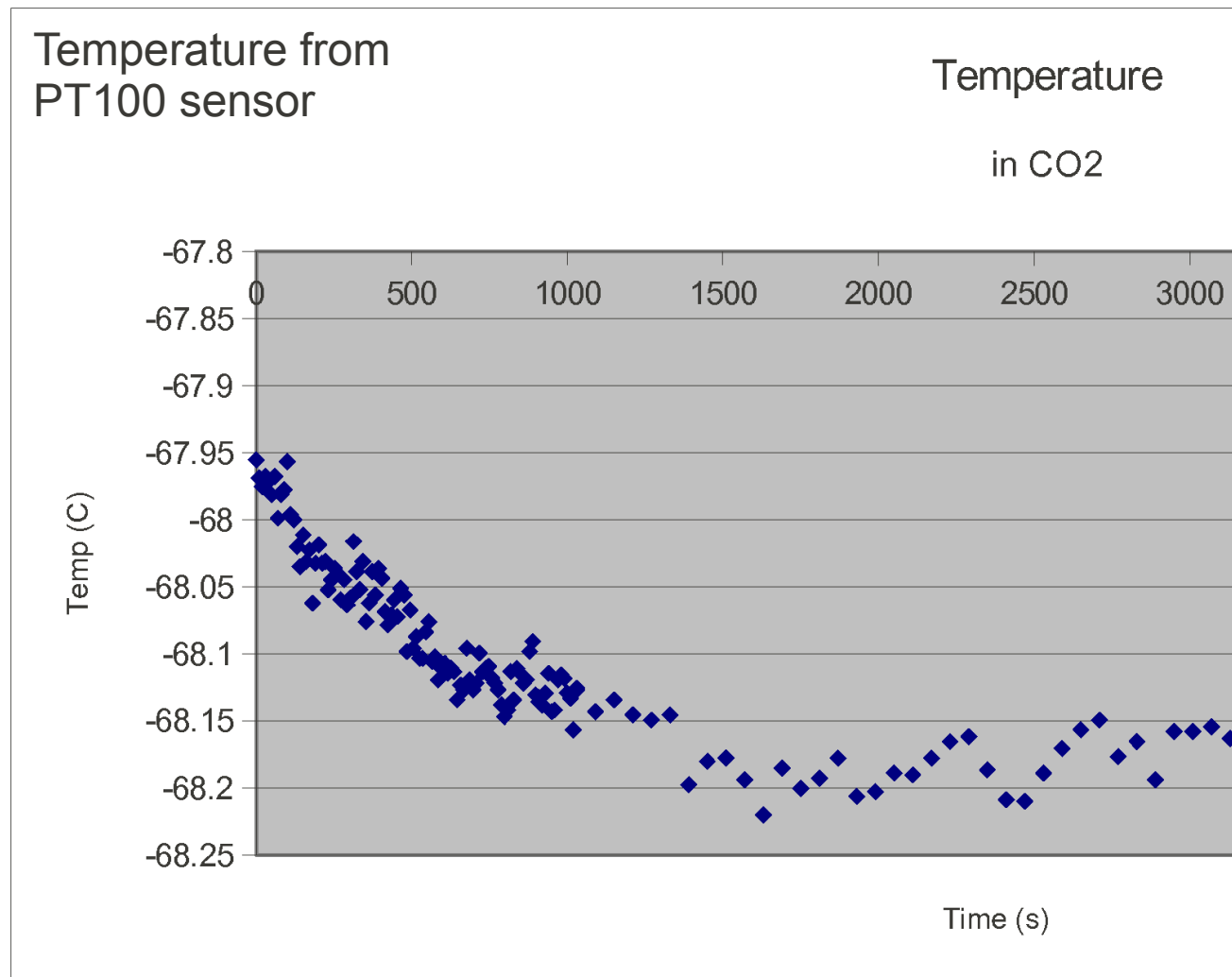


pt100

VBias

Signal

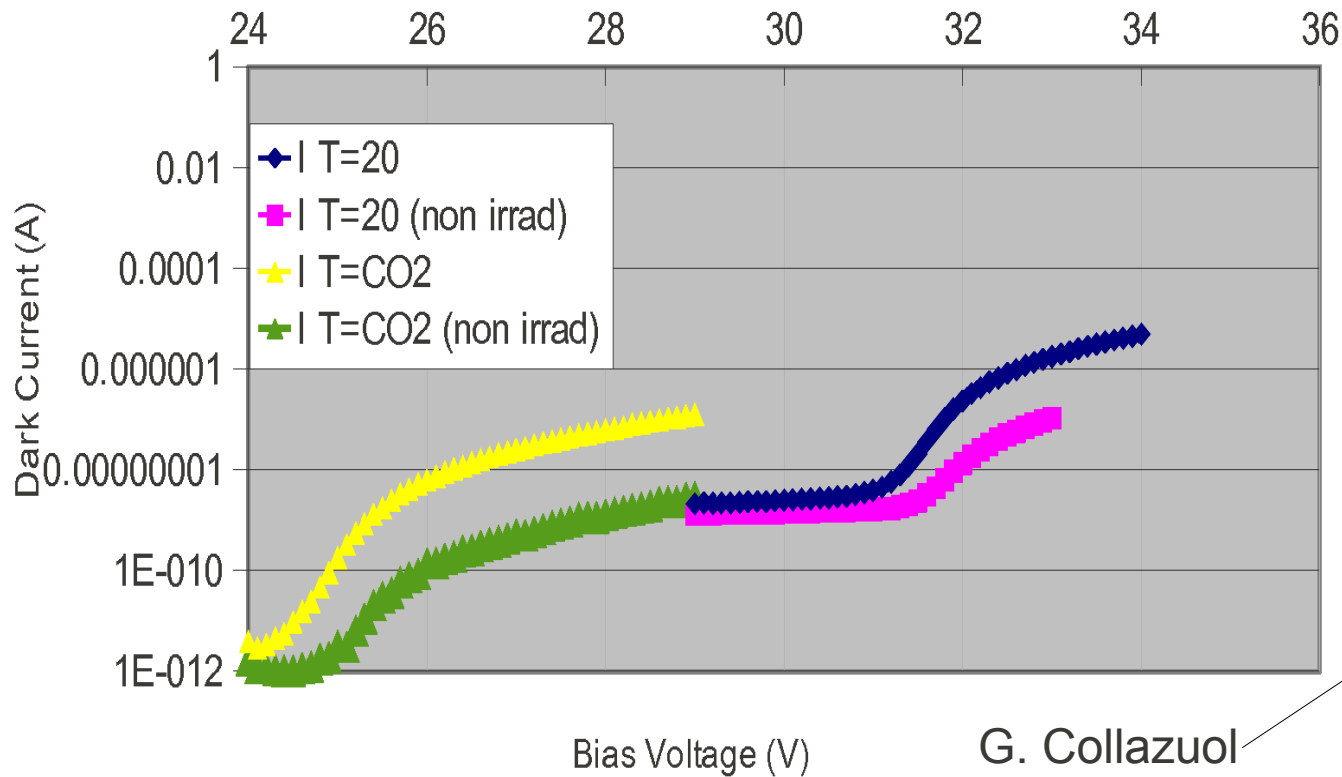
Temperature stabilization



IV and breakdown voltage

FBK 40-I(irrad) and 40-II(non irradi)

IV characteristic



V_{bd} (Volts) from linear fit of dI/dV

T	non irr.	irr
20C	31.5V	31.6V
CO ₂	27.3V	26.2V

$$dV_{bd}/dT/V_{bd} \sim 0.15\%/C$$

Measured on other FBK SiPM=0.25%/C
 → expect $V_{bd} \sim 24V$

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Dark Rate

- Dark rate at $\frac{1}{2}$ photon threshold
 - Fit spectrum to determine $\frac{1}{2}$ photon level

	T=20	T=CO ₂	ratio
Non Irradiated	8.5MHz	350KHz	2 ^{4.6}
Irradiated	1.4MHz	55KHz	2 ^{4.7}
Ratio	6.1	6	

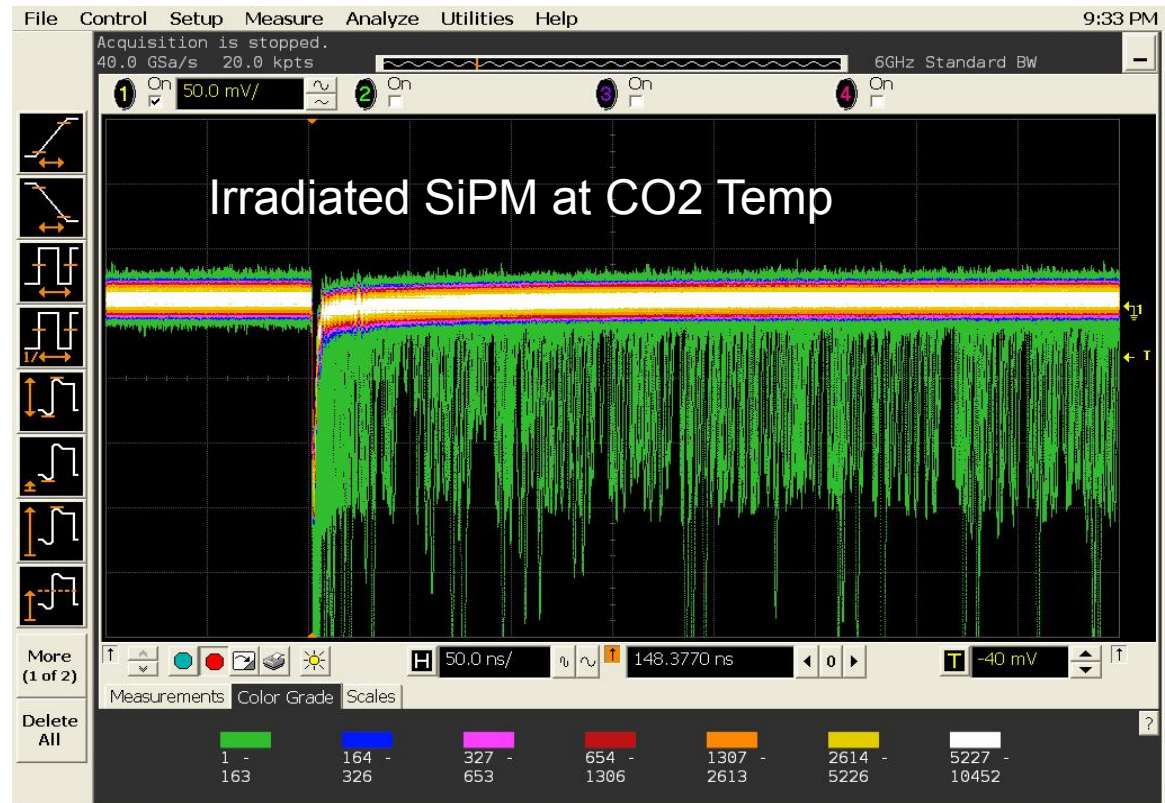
- Rad damage : dark rate increase x6
 - Independent of temperature
- Temperature: dark rate decrease x25

Thermal contact

- Opened detector box
 - Found bad thermal contact between SiPM and metal box
 - ==> SiPM probably at higher temperature than the temperature sensor
 - This could explain
 - Reduction of V_{bd} smaller than expected
 - Reduction of dark rate smaller than expected
 - → test to be repeated with better thermal contact

After pulse

- Pulses generated by charge trapped in defects
- Number of defects increases with rad damage
- At low temperatures the release time increases → might affect dark rate
- To be estimated quantitatively



Conclusions

- First look at dark rate at CO₂ temperatures
- Breakdown voltage and dark rate are reduced at low temperature
- Possible bad thermal contact makes difficult to quantify the reduction of the dark rate → need to repeat the exercise
- However irradiated detector has same reduction as non-irradiated one
- After-pulses become more important → make a quantitative estimate