

Status of the dark-noise and gain measurements in Valencia

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Photosensors WG - 16 January 2023

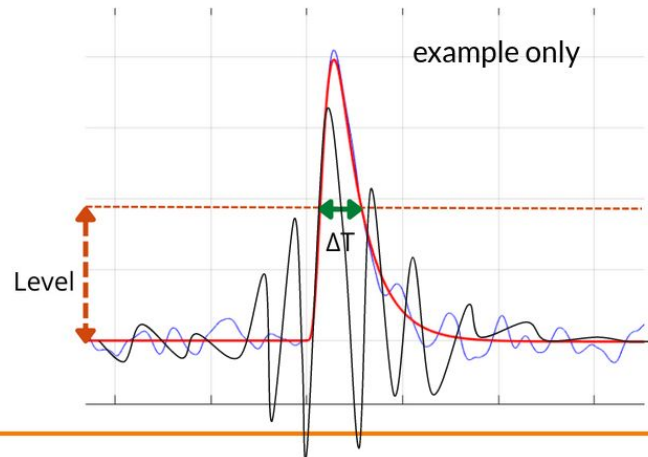
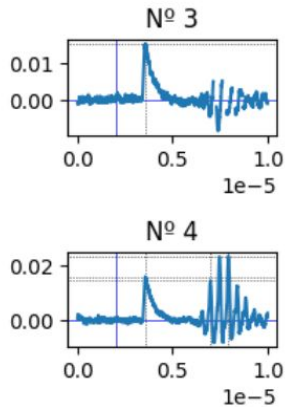


Trigger for the signal

- For the Gain Analysis signal capture, the trigger is the Sync Signal from the LED.

But...

We have a problem to capture the signal in “self-trigger” because the system have a burst sinusoidal noise. For this case we implemented a special trigger.



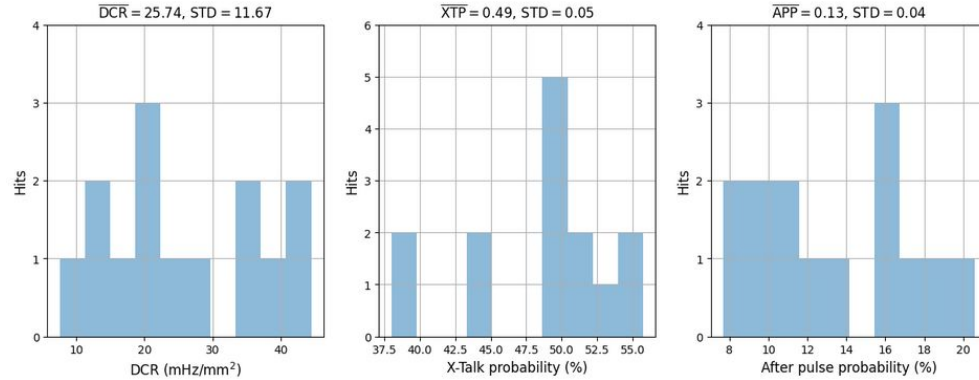
If the signal voltage > level
and
Pulse duration > ΔT
= Signal trigger

We are working to solve this problem, to eliminate the noise.

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Measurement 1 of Tray 68 (Strips 1425, 1426 & 1429) - Burstless

SiPMs (1,5), (2,1), (2,2) and (2,3) are excluded from the analysis



Results from [1]

SiPM		Gain		DCR+B (mHz/mm ²)		DCR-B (mHz/mm ²)		Xtalk (%)		Afterpulses (%)	
Model	PDE (%)	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
⋮											
75_HQR	40	3.93E+06	0.09E+06	58	11	28	10	6.6	0.7	0.9	0.2
	45	4.83E+06	0.09E+06	65	18	26	7	9.0	1.0	1.1	0.4
	50	5.70E+06	0.09E+06	55	17	30	9	11.0	1.0	1.3	0.3

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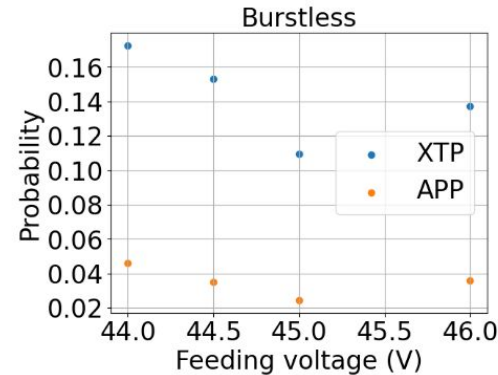
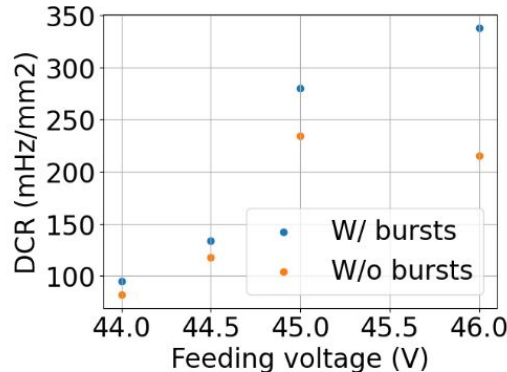
Further tests

Using just one amplifier, Carlos took new dark noise data for one SiPM (pre-production) at four different voltages, [44, 44.5, 45, 46] V (operation voltage is ~54.80 V at warm)

- After the peaks analysis, 300 (out of the 1000 acquired) fast frames of each one of the four datasets were visually inspected.
- Only 12 misidentified (noise-induced) peaks were spotted, out of the 1250 peaks which were detected in the $300 \times 4 = 1200$ inspected frames, i.e. a $12/1250 \sim 1\%$ error.

Measurements with the new card do not display as-ample noises, which let us lower the trigger threshold.

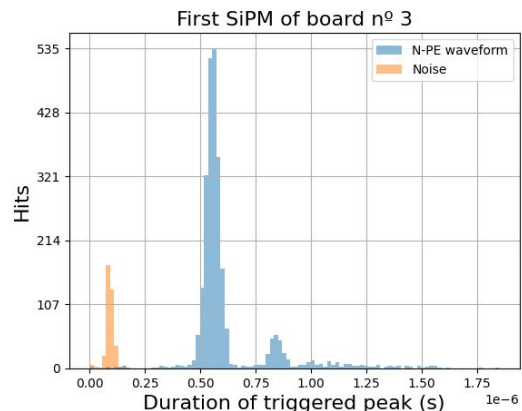
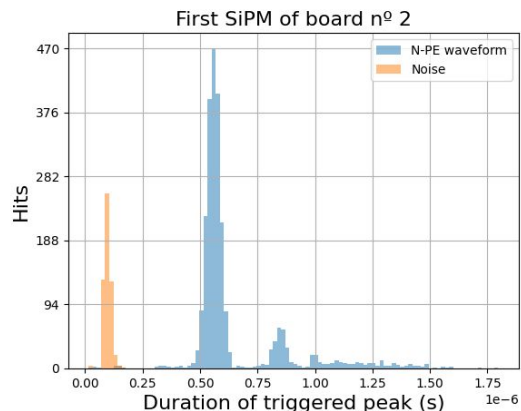
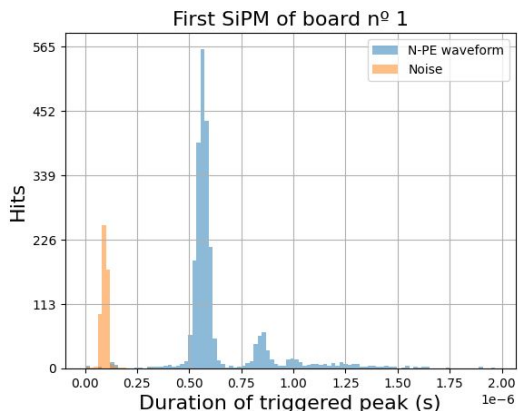
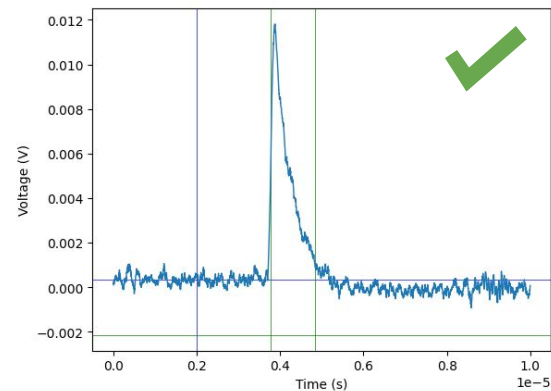
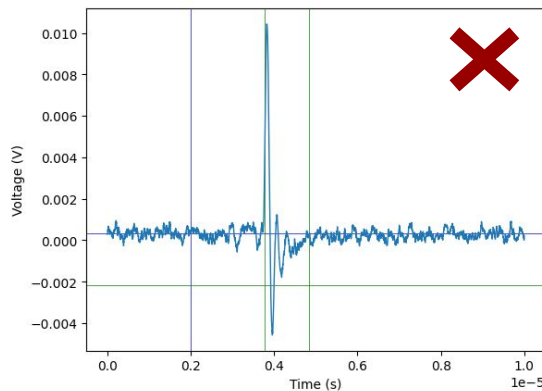
- The amplitude vs. time-delay histograms now resemble our reference to a larger extent than previous results (XTP and APP are smaller)
- However, DCR is not compatible with the reference anymore → Light might be leaking into our black box



- We improved the light-sealing of the box
- We fine-tuned our duration-trigger
 - To do so, we analyzed dark noise data which was taken using a simple threshold trigger
 - In such analysis, we use an offline filter

Offline filter and trigger set-up

- Given a frame, we consider a reduced time window and check whether the signal drops below a certain threshold in such window. If so, then this frame is considered to be a noisy one.
- We use this criterion to split our set of frames into two sets, one containing noisy frames and another one containing *common* waveforms.
- We then study the width of the first peak spotted in each frame, to fine-tune the duration trigger in our oscilloscope.



$$\Rightarrow \Delta T^{\text{opt}} \simeq 220 \text{ ns}$$

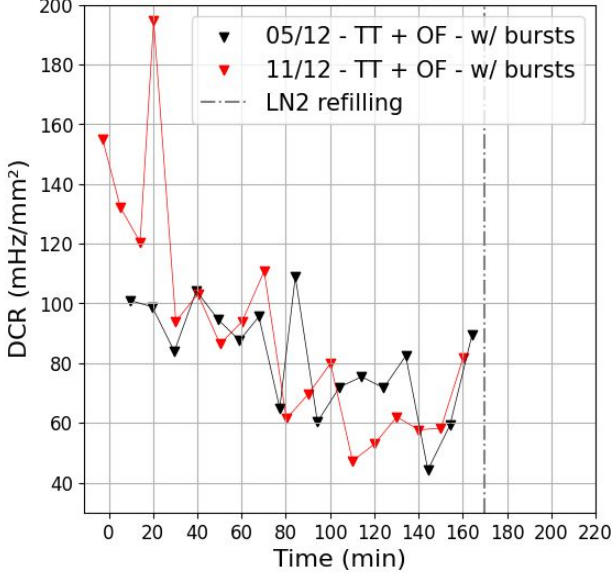
Trigger validation

- In order to validate our duration-trigger, we compare its results to those gotten when
 - using a (simple) threshold trigger and eliminating the noisy fast frames offline using the previous-slide filter
- The results did not match
- We thought that
 - the duration-trigger was working fine
 - the discrepancy came from a possible DCR thermalization and the time in between duration-trigger and threshold-trigger measurements
- To check this, on Dec 5th, Carlos performed a measurement which involved, in the following order:
 - 10 mins. dark noise data-taking with a fixed pre-production SiPM for 18 times in a row
 - LN2 refilling
 - 6 more data-takings alternating threshold- and duration-trigger (3 times each type of trigger)
- The results motivated another data-taking, which was performed on Dec 11th using a similar scheme - ***See results in the next slides***

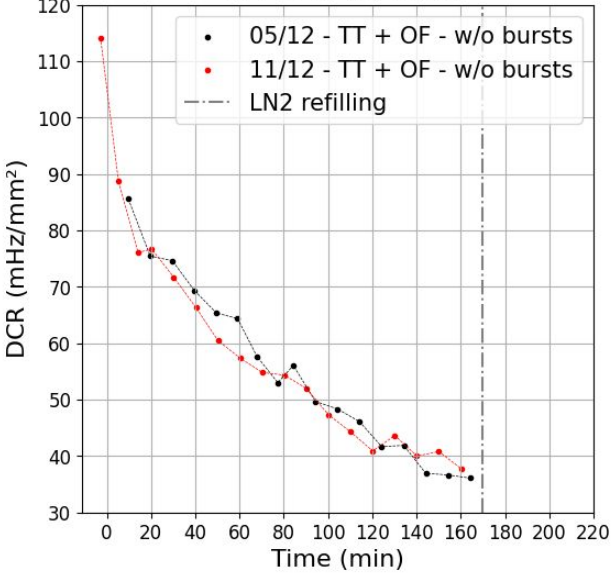
DCR vs. time in cold (TT - Threshold trigger, OF - Offline filter)

- Dec 5th meas. - first SiPM of the first pre-production board plugged to the first massibo socket
- Dec 11th meas. - first SiPM of the second pre-production board plugged to the second massibo socket

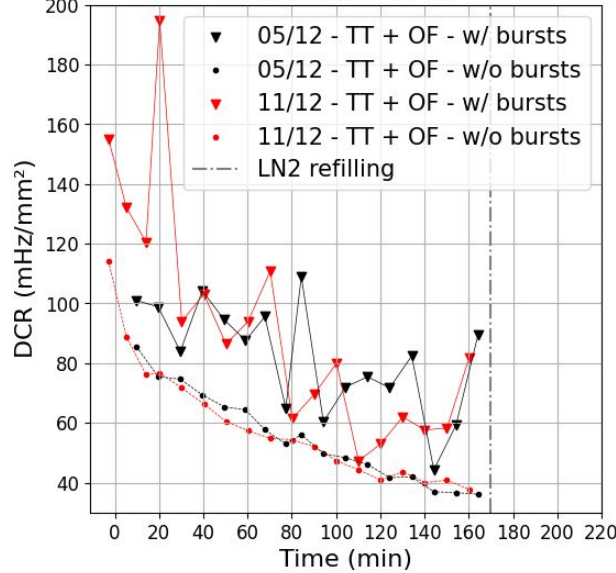
w/ bursts



w/o bursts

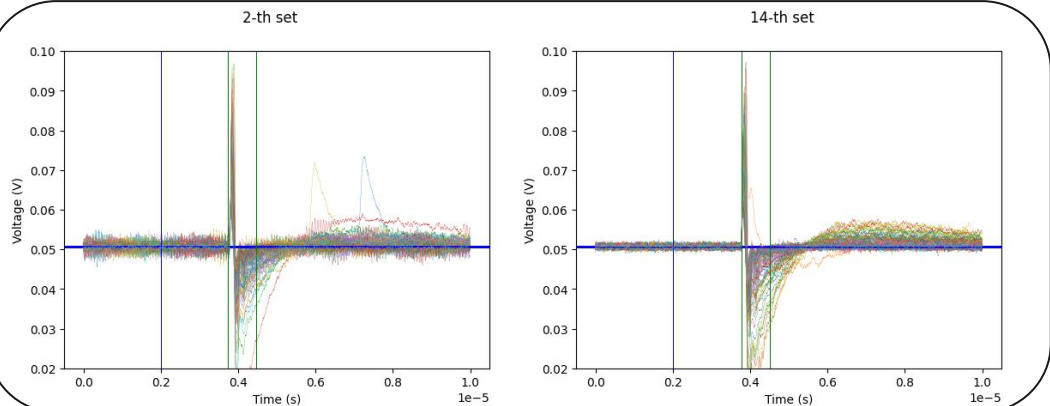


combined



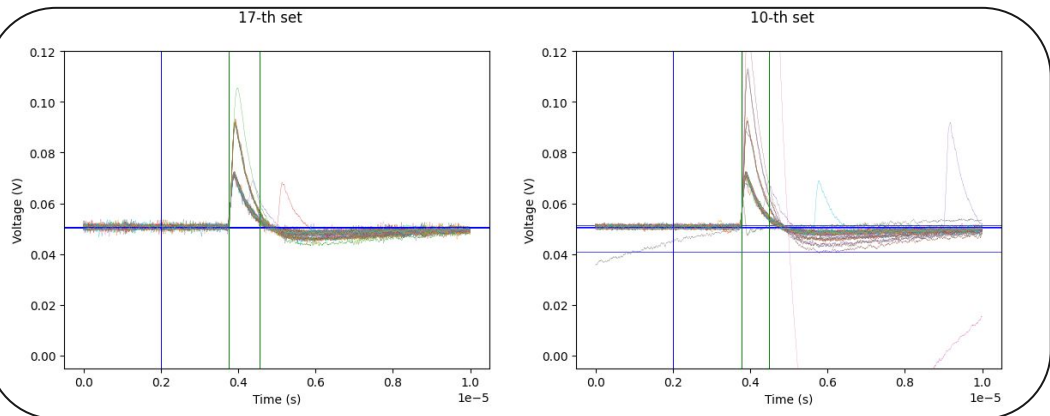
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Offline filter



Some examples of discarded frames

Some of the accepted ones

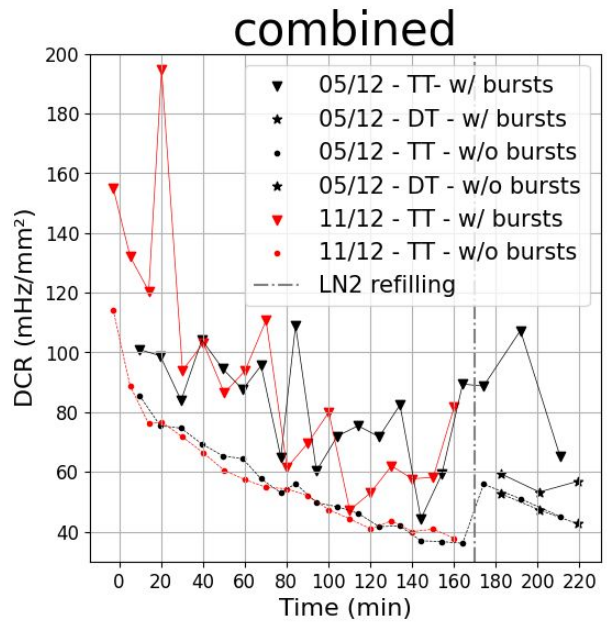
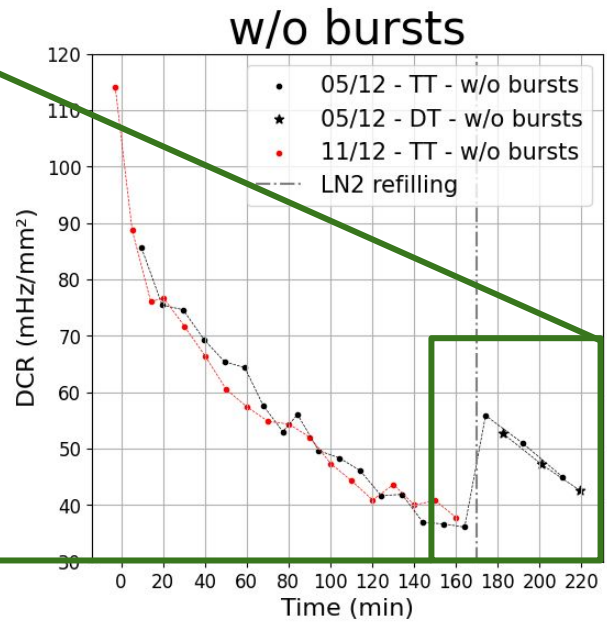
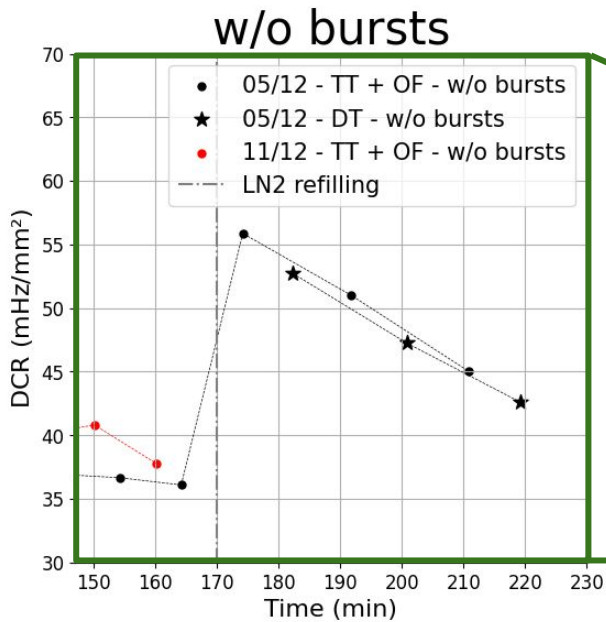


On average, 2404 frames per data-taking were recorded, from which **685** frames were filtered out, meaning that a **28%** of the frames are discarded.

The efficiency of the offline filter is $\sim 99\%$. It will be improved for future analysis.

Trigger validation results (DT - Duration trigger, TT - Threshold trigger, OF - Offline filter)

- Dec 5th meas. - first SiPM of the first pre-production board plugged to the first massibo socket
- Dec 11th meas. - first SiPM of the second pre-production board plugged to the second massibo socket

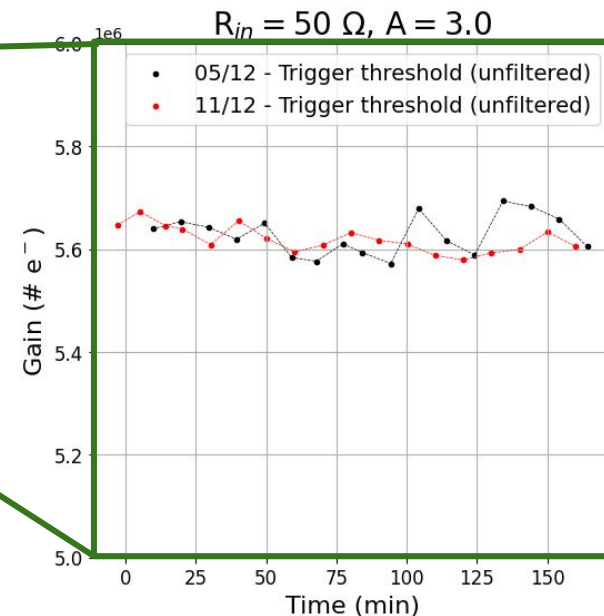
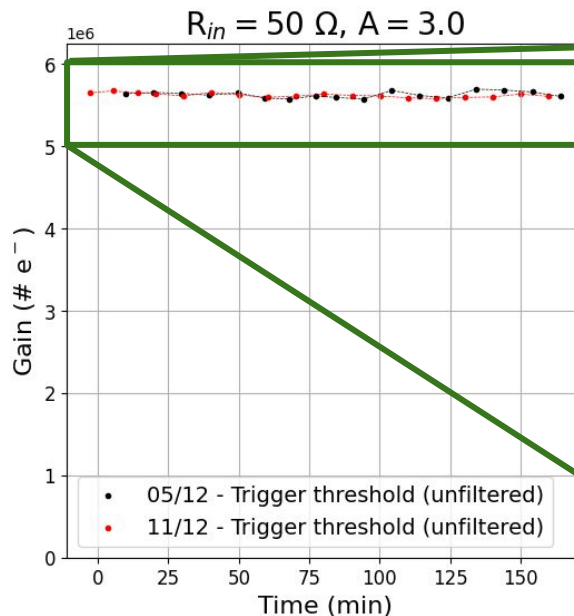
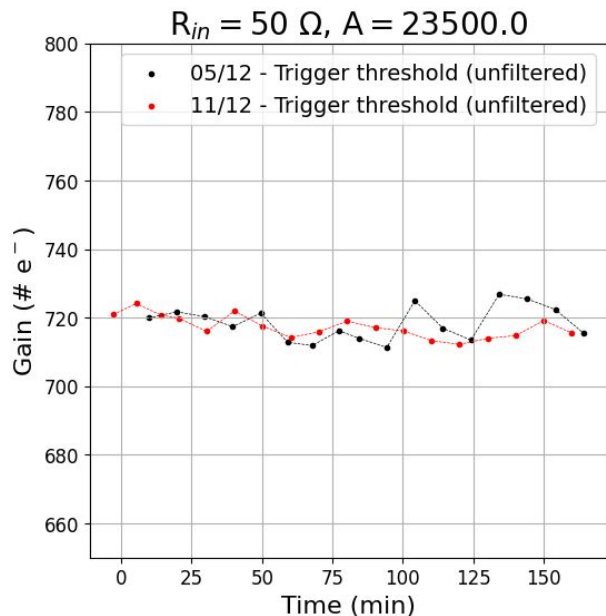


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Gain vs. time in cold

Dec 5th meas. - first SiPM of the first pre-production board plugged to the first massibo socket

Dec 11th meas. - first SiPM of the second pre-production board plugged to the second massibo socket



- [1] Cryogenic Characterization of Hamamatsu HWB MPPCs for the DUNE Photon Detection System
M. Andreotti et al