Update on dark-noise/gain measurements @ IFIC, Valencia

Julio Ureña, Carlos G. Benítez, Jose A. Soto
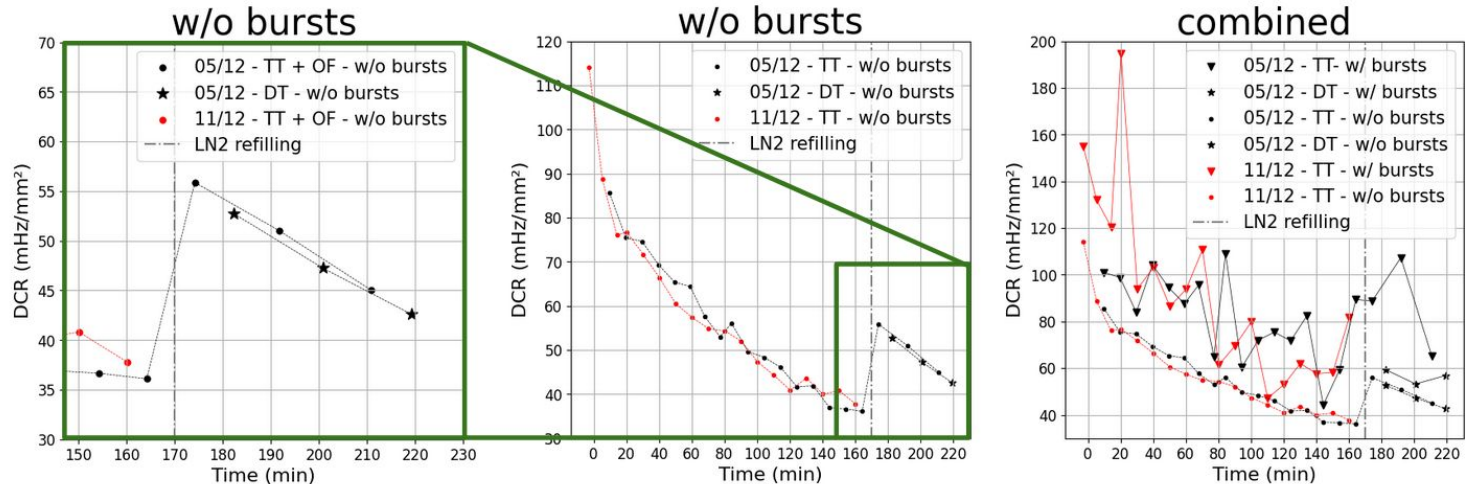
Photosensors WG - 13 February 2024

**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
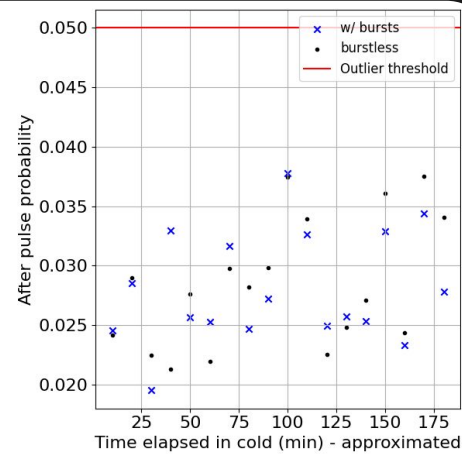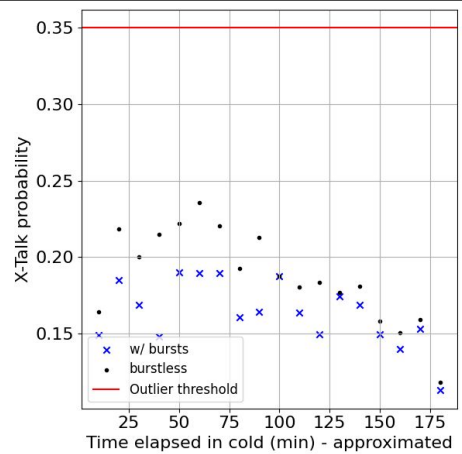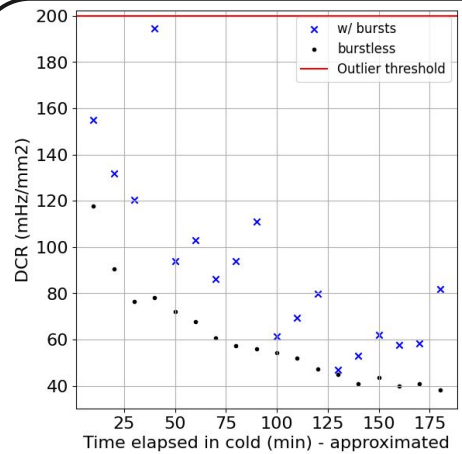

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10

2

Dark noise as a function of cryo. time (pre-production)

2023/12/05
First SiPM of
<u>first</u> pre-production
board, plugged to
the <u>first</u> massibo
socket
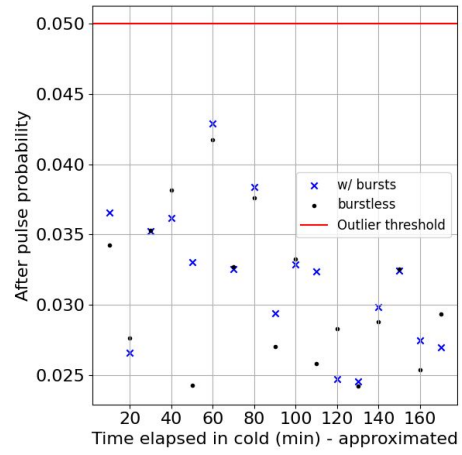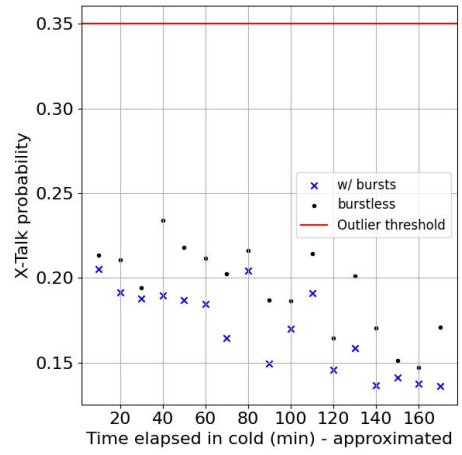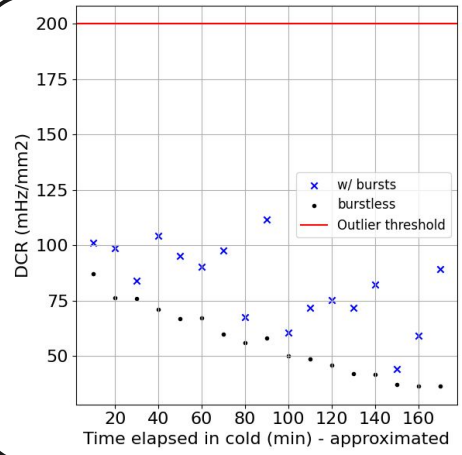
2023/12/11
First SiPM of
<u>second</u>
pre-production
board, plugged to
the <u>second</u> massibo
socket

Data-taking summary (production)

Test Number	Board ID	Test Date	Thermal C	VoP	Socket Number	MASSIBO Version	MASSIBO Board
1	1425	20_dic_2023	2	45	1	1	1
2	1426	20_dic_2023	2	45	2	1	1
3	1429	20_dic_2023	2	45	3	1	1
4	1431	09_jan_2024	1	45	1	1	1
5	1432	09_jan_2024	1	45	2	1	1
6	1435	09_jan_2024	1	45	3	1	1
7	1436	23_jan_2024	2	45	1	1	1
8	1437	23_jan_2024	2	45	2	1	1
9	1438	23_jan_2024	2	45	3	1	1
10	1441	12_jan_2024	1	45	1	1	1
11	1442	12_jan_2024	1	45	2	1	1
12	1443	12_jan_2024	1	45	3	1	1
13	1444	17_jan_2024	1	45	1	1	1
14	1445	17_jan_2024	1	45	2	1	1
15	1446	17_jan_2024	1	45	3	1	1
16	1447	18_jan_2024	1	45	1	1	1
17	1449	18_jan_2024	1	45	2	1	1
18	1451	18_jan_2024	1	45	3	1	1
19	1452	19_jan_2024	1	45	1	1	1
20	1456	19_jan_2024	1	45	2	1	1

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Dark noise

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Dark noise
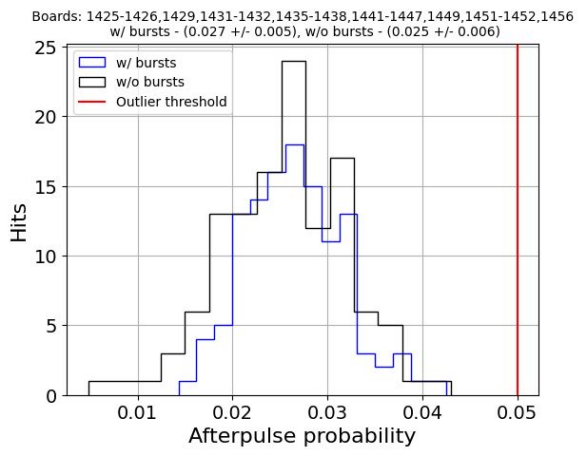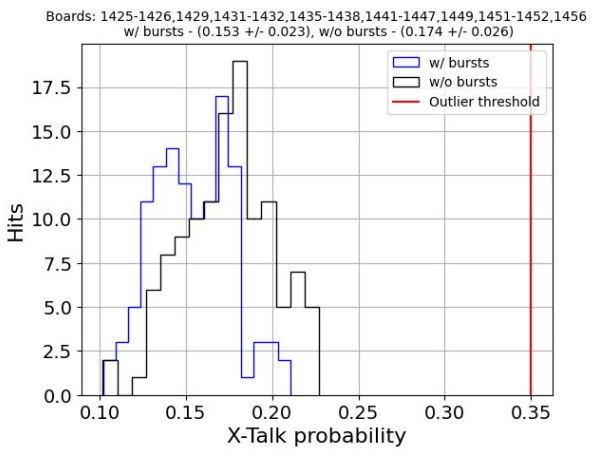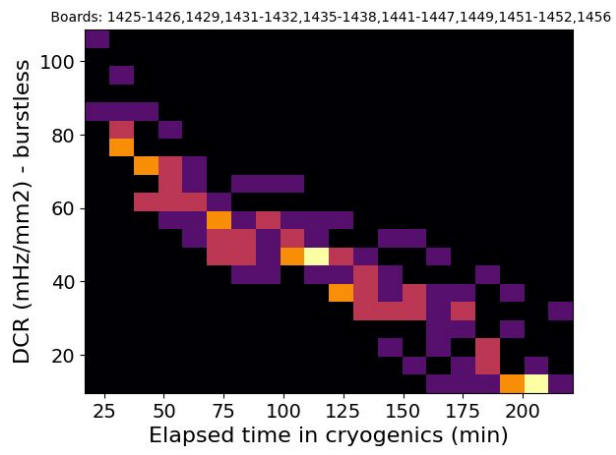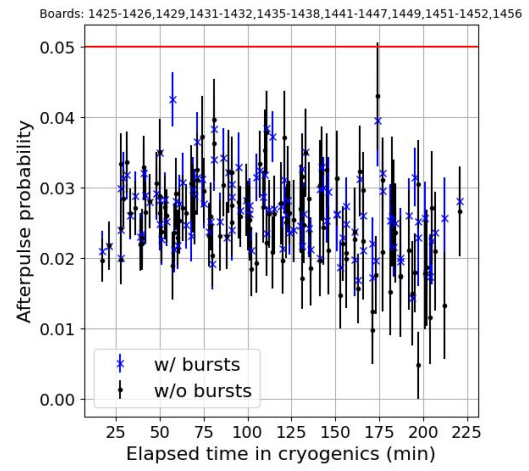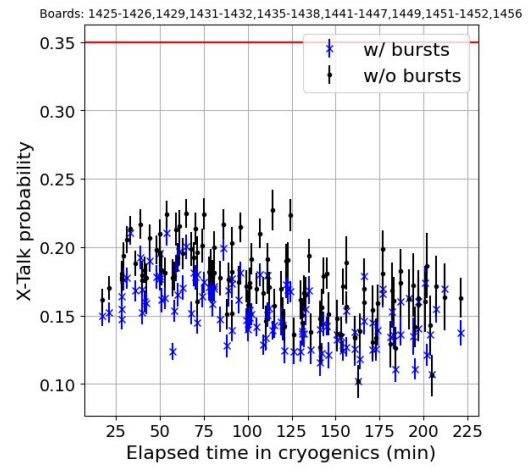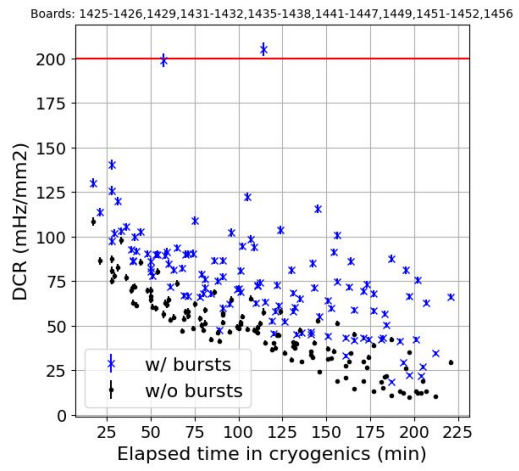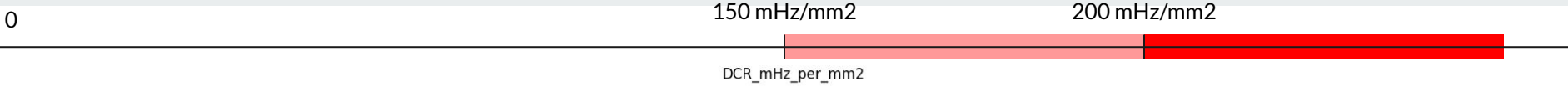
0   150 mHz/mm2   200 mHz/mm2

DCR_mHz_per_mm2

	1425	1426	1429	1431	1432	1435	1436	1437	1438	1441	1442	1443	1444	1445	1446	1447	1449	1451	1452	1456
1	42.3	90.3	58.2	66.2	86.6	115.6	97.4	62.0	74.9	140.5	60.1	59.8	105.6	70.8	33.1	125.7	77.5	91.4	130.1	66.2
2	113.6	76.2	46.4	103.1	102.2	100.7	91.8	122.2	42.0	86.7	80.9	71.6	90.5	62.6	43.3	92.7	94.7	86.3	102.0	75.0
3	119.8	86.6	44.3	102.7	98.5	58.8	89.8	63.4	58.4	80.4	72.5	73.1	89.6	45.8	43.0	86.2	74.1	42.2	86.3	70.5
4	99.8	68.8	43.1	90.0	205.2	68.0	81.3	52.5	18.5	91.6	72.9	56.7	66.9	68.3	41.1	84.9	61.2	50.3	82.1	93.9
5	77.8	73.0	69.5	93.7	103.7	87.7	90.5	45.8	22.3	90.1	60.1	29.3	79.1	45.2	75.8	66.5	45.0	81.1	198.9	52.5
6	72.0	58.1	42.3	108.8	65.2	66.4	68.0	55.3	62.9	67.8	84.9	21.6	47.6	63.9	34.4	71.4	71.4	26.9	82.3	81.1
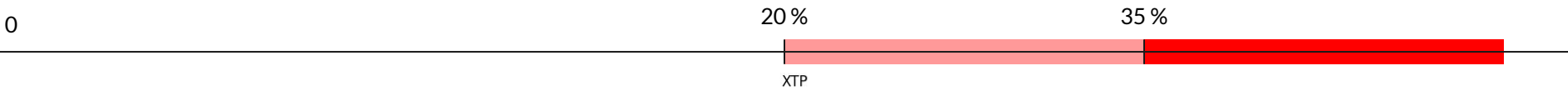
0   20 %   35 %

XTP

	1425	1426	1429	1431	1432	1435	1436	1437	1438	1441	1442	1443	1444	1445	1446	1447	1449	1451	1452	1456
1	0.17	0.14	0.14	0.14	0.2	0.14	0.16	0.16	0.15	0.15	0.17	0.13	0.17	0.14	0.13	0.15	0.18	0.12	0.15	0.17
2	0.15	0.17	0.12	0.21	0.18	0.13	0.16	0.14	0.18	0.17	0.15	0.1	0.18	0.13	0.14	0.19	0.15	0.12	0.18	0.13
3	0.18	0.14	0.14	0.19	0.18	0.15	0.16	0.14	0.17	0.2	0.18	0.13	0.15	0.14	0.15	0.18	0.16	0.14	0.15	0.15
4	0.16	0.15	0.14	0.21	0.14	0.17	0.17	0.12	0.16	0.18	0.17	0.14	0.18	0.14	0.16	0.17	0.17	0.11	0.18	0.13
5	0.16	0.15	0.12	0.2	0.17	0.14	0.16	0.13	0.16	0.18	0.14	0.14	0.17	0.14	0.12	0.18	0.15	0.11	0.12	0.15
6	0.2	0.12	0.13	0.17	0.17	0.14	0.15	0.12	0.15	0.16	0.12	0.14	0.17	0.13	0.17	0.17	0.14	0.11	0.15	0.12
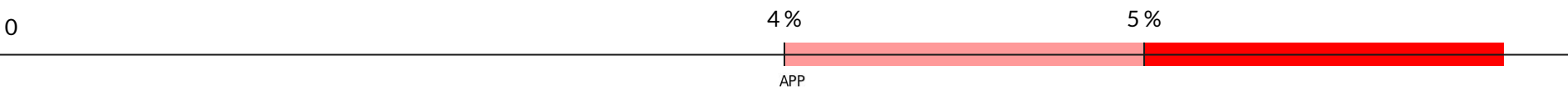
0   4 %   5 %

APP

	1425	1426	1429	1431	1432	1435	1436	1437	1438	1441	1442	1443	1444	1445	1446	1447	1449	1451	1452	1456
1	0.026	0.036	0.033	0.028	0.034	0.025	0.02	0.033	0.027	0.024	0.024	0.019	0.029	0.026	0.02	0.03	0.029	0.023	0.021	0.024
2	0.022	0.034	0.02	0.026	0.027	0.025	0.029	0.031	0.021	0.024	0.027	0.017	0.029	0.032	0.017	0.023	0.021	0.031	0.031	0.023
3	0.032	0.03	0.026	0.028	0.032	0.026	0.028	0.027	0.029	0.025	0.038	0.02	0.021	0.021	0.026	0.035	0.027	0.04	0.023	0.028
4	0.032	0.026	0.024	0.025	0.037	0.032	0.031	0.024	0.02	0.028	0.026	0.022	0.03	0.022	0.026	0.022	0.028	0.025	0.028	0.029
5	0.023	0.024	0.022	0.025	0.024	0.02	0.031	0.021	0.023	0.029	0.026	0.014	0.025	0.03	0.018	0.031	0.035	0.031	0.043	0.027
6	0.028	0.031	0.025	0.028	0.024	0.025	0.025	0.029	0.024	0.019	0.033	0.017	0.032	0.026	0.026	0.038	0.03	0.022	0.023	0.025

Gain

The baseline requirement for the SiPM gain G is 2e+6<G<8e+6, but the amplification factor of our system has not been calibrated yet
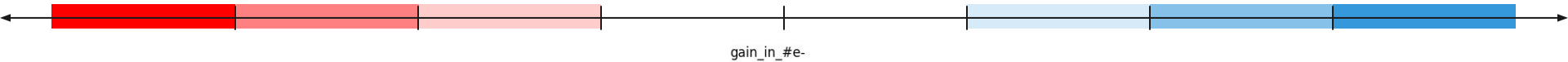
Boards: 1425-1426,1429,1431-1432,1435-1438,1441-1447,1449,1451-1452,1456

Boards: 1425-1426,1429,1431-1432,1435-1438,1441-1447,1449,1451-1452,1456
(35918.356 +/- 1639.405)

| -3*std | -2*std | -std | mean | +std | +2*std | +3*std |

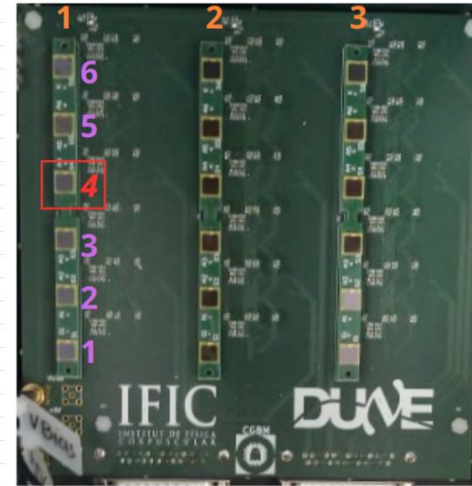gain_in_#e-

	1425	1426	1429	1431	1432	1435	1436	1437	1438	1441	1442	1443	1444	1445	1446	1447	1449	1451	1452	1456
1	3.6e+04	3.6e+04	3.7e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.6e+04	3.6e+04	3.7e+04	3.6e+04	3.5e+04
2	3.6e+04	3.7e+04	3.6e+04	3.4e+04	3.6e+04	3.5e+04	3.6e+04	3.7e+04	3.6e+04	3.5e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.7e+04	3.6e+04	3.7e+04
3	3.7e+04	3.7e+04	3.7e+04	3.6e+04	3.6e+04	3.7e+04	3.7e+04	3.7e+04	3.6e+04	3.7e+04	3.5e+04	3.5e+04	3.6e+04	3.7e+04	3.7e+04	3.8e+04	3.7e+04	3.7e+04	3.6e+04	3.7e+04
4	3.6e+04	3.7e+04	3.6e+04	3.2e+04	3.6e+04	3.6e+04	3.2e+04	3.7e+04	3.6e+04	2.5e+04	3.7e+04	3.5e+04	3.1e+04	3.7e+04	3.7e+04	3.6e+04	3.8e+04	3.6e+04	2.7e+04	3.7e+04
5	3.6e+04	3.7e+04	3.6e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.6e+04	3.8e+04	3.7e+04	3.7e+04	3.6e+04	3.7e+04
6	3.7e+04	3.8e+04	3.6e+04	3.6e+04	3.6e+04	3.6e+04	3.7e+04	3.6e+04	3.6e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.7e+04	3.7e+04	3.8e+04	3.6e+04	3.6e+04	3.7e+04

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Gain

Test Number	Board ID	Test Date	Thermal C	VoP	Socket Number	MASSIBO Version	MASSIBO Board
1	1425	20_dic_2023	2	45	1	1	1
2	1426	20_dic_2023	2	45	2	1	1
3	1429	20_dic_2023	2	45	3	1	1
4	1431	09_jan_2024	1	45	1	1	1
5	1432	09_jan_2024	1	45	2	1	1
6	1435	09_jan_2024	1	45	3	1	1
7	1436	23_jan_2024	2	45	1	1	1
8	1437	23_jan_2024	2	45	2	1	1
9	1438	23_jan_2024	2	45	3	1	1
10	1441	12_jan_2024	1	45	1	1	1
11	1442	12_jan_2024	1	45	2	1	1
12	1443	12_jan_2024	1	45	3	1	1
13	1444	17_jan_2024	1	45	1	1	1
14	1445	17_jan_2024	1	45	2	1	1
15	1446	17_jan_2024	1	45	3	1	1
16	1447	18_jan_2024	1	45	1	1	1
17	1449	18_jan_2024	1	45	2	1	1
18	1451	18_jan_2024	1	45	3	1	1
19	1452	19_jan_2024	1	45	1	1	1
20	1456	19_jan_2024	1	45	2	1	1

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-3*std   -2*std   -std   mean   +std   +2*std   +3*std

gain_in_#e-

	1425	1426	1429	1431	1432	1435	1436	1437	1438	1441	1442	1443	1444	1445	1446	1447	1449	1451	1452	1456
1	3.6e+04	3.6e+04	3.7e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.6e+04	3.6e+04	3.7e+04	3.6e+04	3.5e+04
2	3.6e+04	3.7e+04	3.6e+04	3.4e+04	3.5e+04	3.6e+04	3.6e+04	3.7e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.5e+04	3.6e+04	3.7e+04	3.6e+04	3.6e+04	3.7e+04
3	3.7e+04	3.7e+04	3.7e+04	3.6e+04	3.6e+04	3.7e+04	3.7e+04	3.7e+04	3.6e+04	3.7e+04	3.5e+04	3.5e+04	3.6e+04	3.7e+04	3.7e+04	3.8e+04	3.7e+04	3.7e+04	3.6e+04	3.7e+04
4	3.6e+04	3.7e+04	3.6e+04	3.2e+04	3.6e+04	3.6e+04	3.2e+04	3.7e+04	3.6e+04	2.5e+04	3.7e+04	3.5e+04	3.1e+04	3.7e+04	3.7e+04	3.6e+04	3.8e+04	3.6e+04	2.7e+04	3.7e+04
5	3.6e+04	3.6e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.6e+04	3.8e+04	3.7e+04	3.7e+04	3.6e+04	3.7e+04
6	3.7e+04	3.8e+04	3.6e+04	3.6e+04	3.6e+04	3.6e+04	3.7e+04	3.6e+04	3.6e+04	3.6e+04	3.6e+04	3.5e+04	3.6e+04	3.6e+04	3.7e+04	3.7e+04	3.8e+04	3.6e+04	3.6e+04	3.7e+04

Summary

- New results wrt pre-production SiPMs:
  - XTP seems to slightly follow a decreasing tendency with the time-in-cryo
  - APP seems ~stable

- The measurements performed for the first 20 production boards are in agreement with what was observed using pre-production boards: decreasing DCR, ~decreasing XTP, ~stable APP and stable gain.

- Outliers detection:
  - We detected only one DCR outlier (1432-4, 205 mHz/mm2) - **Shall we re-measure this one?**
  - No XTP or APP outliers were spotted
  - The measured gain for five SiPMs is smaller than gain_meas-2*gain_std, but the data suggests a setup-related issue

- Regarding our setup:
  - The calibration of the amplification factor of Massibo is pending
  - Tests must be done to check whether slot 4 of socket 1 is working properly

Reference

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