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

Results from tray 115

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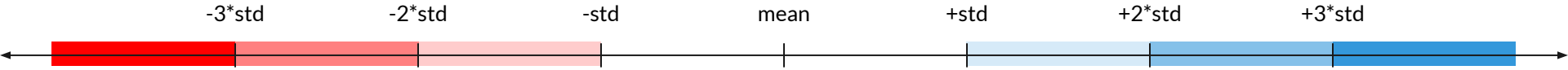
Photosensors WG - 07 May 2024

Introduction

- Carlos has measured tray 115 received from CIEMAT on 31st January
- This tray was previously measured in Granada's CACTUS
- This is the second tray we have received so far
- It contains boards with the following strip-IDs:
  2210, 2213-2214, 2216, 2218-2221, 2223-2224, 2229-2230, 2234, 2239-2240, 2243, 2251-2254
- The measurements by Carlos concluded on 24/04/2024
- Gain (at 3 different OVs), DCR, XTP and APP results are shown in the following slides

Gain results



gain_in_#e-
month='04' overvoltage_V=2.7
Boards: 2210,2213-2214,2216,2218-2221,2223-2224,2229-2230,2234,2239-2240,2243,2251-2254
Mean +/- std: (46666.72 +/- 8747.26)

	2210	2213	2214	2216	2218	2219	2220	2221	2223	2224	2229	2230	2234	2239	2240	2243	2251	2252	2253	2254
1	4.2e+04	3.6e+04	4.2e+04	4.3e+04	4.3e+04	4.3e+04	4.3e+04	4.2e+04	4.2e+04	4.3e+04	4.2e+04	4.0e+04	4.0e+04	4.1e+04	4.1e+04	4.1e+04	4.2e+04	3.5e+04	3.6e+04	3.6e+04
2	4.1e+04	4.3e+04	4.2e+04	4.2e+04	4.2e+04	4.2e+04	4.1e+04	4.2e+04	4.1e+04	4.1e+04	4.0e+04	4.2e+04	4.1e+04	4.1e+04	4.1e+04	4.4e+04	4.2e+04	3.6e+04	3.8e+04	3.5e+04
3	4.1e+04	4.2e+04	4.2e+04	4.2e+04	4.3e+04	4.3e+04	4.3e+04	4.2e+04	4.3e+04	4.3e+04	4.1e+04	4.1e+04	4.3e+04	4.2e+04	4.0e+04	4.2e+04	4.2e+04	3.6e+04	3.5e+04	3.6e+04
4	4.2e+04	4.3e+04	4.2e+04	4.3e+04	4.2e+04	4.3e+04	3.6e+04	4.3e+04	4.2e+04	2.8e+04	9.8e+03	4.1e+04	4.2e+04	3.3e+04	4.1e+04	4.3e+04	4.1e+04	2.5e+04	3.6e+04	3.6e+04
5	4.2e+04	4.2e+04	4.2e+04	4.3e+04	4.3e+04	4.2e+04	4.3e+04	4.3e+04	4.2e+04	4.2e+04	4.1e+04	4.1e+04	4.0e+04	4.1e+04	4.2e+04	4.3e+04	4.1e+04	3.7e+04	3.8e+04	3.6e+04
6	4.1e+04	4.2e+04	4.0e+04	4.3e+04	4.3e+04	4.2e+04	4.2e+04	4.3e+04	4.0e+04	4.2e+04	4.2e+04	4.3e+04	4.1e+04	4.0e+04	4.1e+04	4.2e+04	4.1e+04	3.6e+04	3.6e+04	3.5e+04

gain_in_#e-
month='04' overvoltage_V=3.1
Boards: 2210,2213-2214,2216,2218-2221,2223-2224,2229-2230,2234,2239-2240,2243,2251-2254
Mean +/- std: (45002.06 +/- 4435.59)

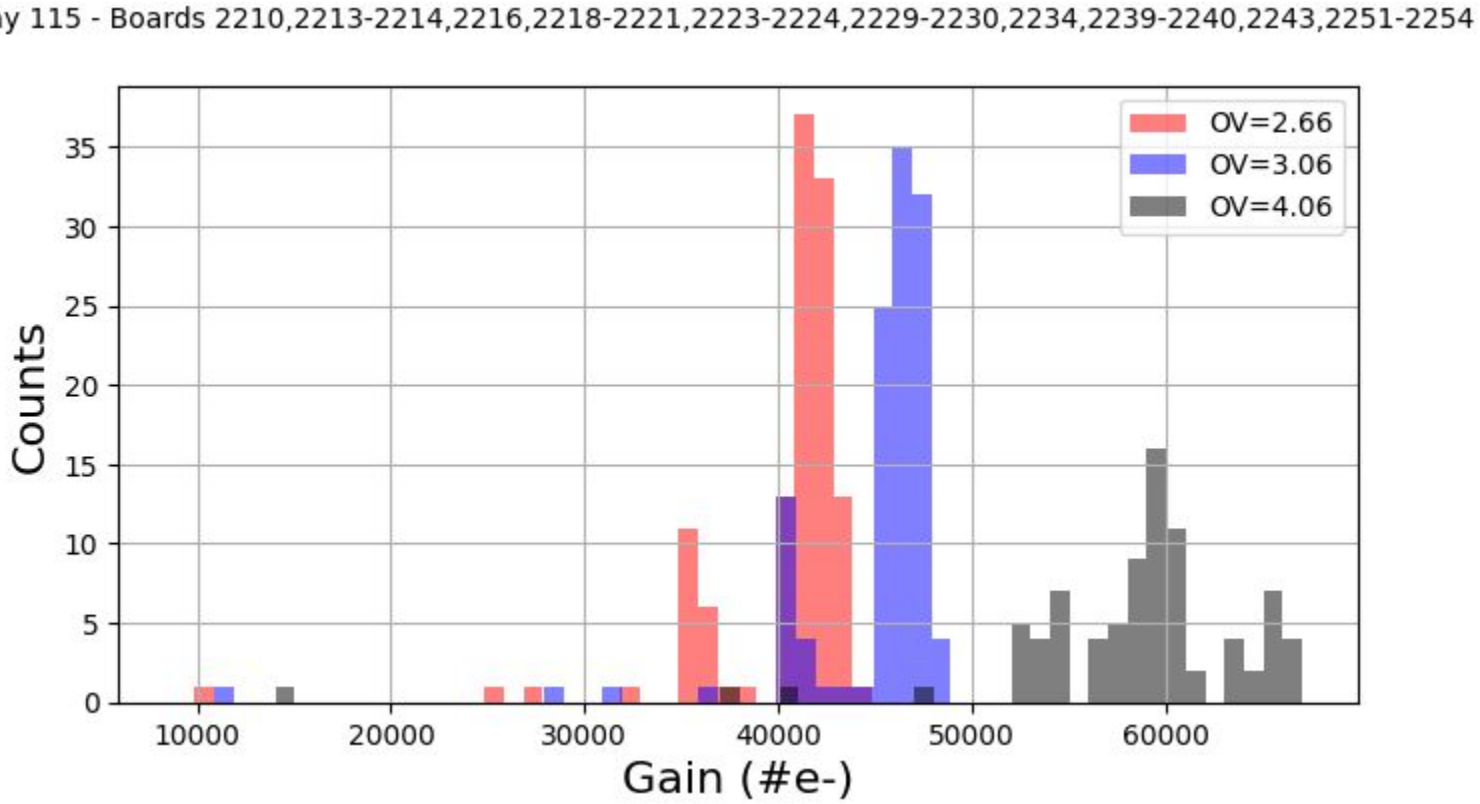
	2210	2213	2214	2216	2218	2219	2220	2221	2223	2224	2229	2230	2234	2239	2240	2243	2251	2252	2253	2254
1	4.6e+04	4.0e+04	4.6e+04	4.8e+04	4.7e+04	4.8e+04	4.8e+04	4.7e+04	4.7e+04	4.7e+04	4.5e+04	4.6e+04	4.5e+04	4.6e+04	4.6e+04	4.5e+04	4.7e+04	4.1e+04	4.0e+04	4.1e+04
2	4.5e+04	4.8e+04	4.7e+04	4.7e+04	4.7e+04	4.7e+04	4.6e+04	4.7e+04	4.6e+04	4.5e+04	4.5e+04	4.7e+04	4.5e+04	4.6e+04	4.6e+04	4.8e+04	4.6e+04	4.1e+04	4.3e+04	4.1e+04
3	4.6e+04	4.7e+04	4.7e+04	4.6e+04	4.7e+04	4.8e+04	4.7e+04	4.7e+04	4.8e+04	4.7e+04	4.6e+04	4.6e+04	4.8e+04	4.7e+04	4.5e+04	4.6e+04	4.7e+04	4.1e+04	4.0e+04	4.0e+04
4	4.7e+04	4.8e+04	4.6e+04	4.8e+04	4.7e+04	4.8e+04	4.0e+04	4.8e+04	4.6e+04	3.1e+04	1.1e+04	4.5e+04	4.7e+04	3.6e+04	4.6e+04	4.6e+04	4.6e+04	2.9e+04	4.1e+04	4.1e+04
5	4.6e+04	4.7e+04	4.7e+04	4.9e+04	4.7e+04	4.6e+04	4.8e+04	4.7e+04	4.6e+04	4.7e+04	4.6e+04	4.7e+04	4.5e+04	4.6e+04	4.6e+04	4.7e+04	4.6e+04	4.1e+04	4.3e+04	4.0e+04
6	4.6e+04	4.7e+04	4.6e+04	4.7e+04	4.7e+04	4.7e+04	4.7e+04	4.7e+04	4.5e+04	4.7e+04	4.7e+04	4.8e+04	4.6e+04	4.5e+04	4.6e+04	4.7e+04	4.5e+04	4.1e+04	4.2e+04	4.0e+04

gain_in_#e-
month='04' overvoltage_V=4.1
Boards: 2220-2221,2223-2224,2229-2230,2234,2239-2240,2243,2251-2254
Mean +/- std: (58121.39 +/- 7053.96)

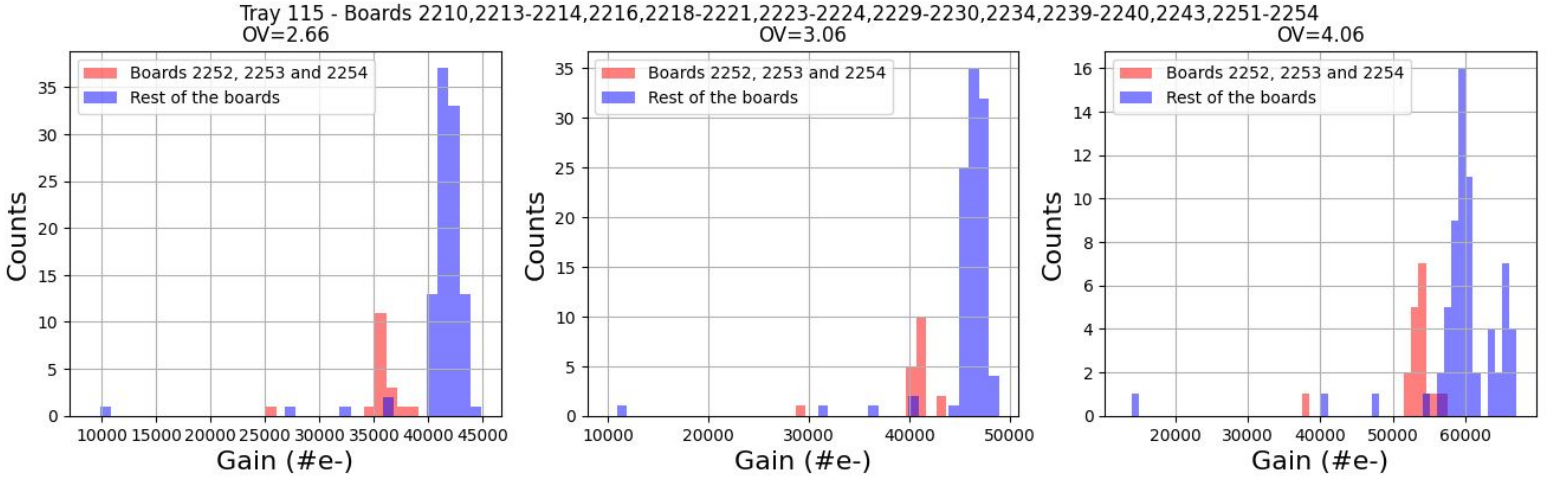
	2220	2221	2223	2224	2229	2230	2234	2239	2240	2243	2251	2252	2253	2254
1	6.6e+04	6.5e+04	6.6e+04	5.6e+04	5.9e+04	5.8e+04	5.8e+04	5.8e+04	5.8e+04	5.8e+04	6.1e+04	5.4e+04	5.2e+04	5.5e+04
2	6.4e+04	6.6e+04	6.4e+04	5.9e+04	5.7e+04	6.0e+04	5.9e+04	5.9e+04	5.9e+04	6.2e+04	5.9e+04	5.3e+04	5.7e+04	5.3e+04
3	6.6e+04	6.6e+04	6.5e+04	6.0e+04	5.9e+04	5.9e+04	6.1e+04	6.0e+04	5.8e+04	5.9e+04	6.0e+04	5.4e+04	5.3e+04	5.3e+04
4	5.4e+04	6.6e+04	6.6e+04	4.0e+04	1.4e+04	6.0e+04	6.0e+04	4.7e+04	6.0e+04	6.1e+04	5.9e+04	3.8e+04	5.4e+04	5.4e+04
5	6.5e+04	6.6e+04	6.3e+04	6.0e+04	5.9e+04	6.0e+04	5.8e+04	5.9e+04	5.9e+04	6.0e+04	5.9e+04	5.4e+04	5.6e+04	5.3e+04
6	6.5e+04	6.6e+04	6.4e+04	6.0e+04	6.0e+04	6.1e+04	5.8e+04	5.7e+04	5.9e+04	6.0e+04	5.9e+04	5.4e+04	5.5e+04	5.3e+04

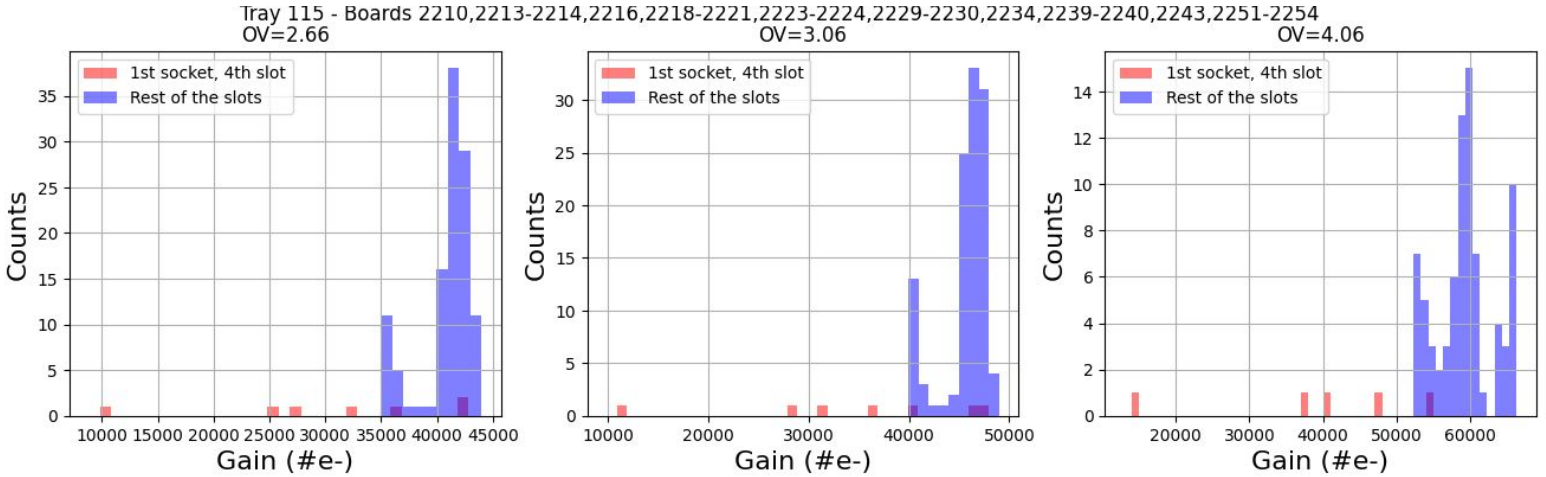
Measurements are taken in the following order:
1 - w/o LED DN data, 2 - w/ LED gain data, from smaller to bigger OV, for 3 different OVs
For the first measurements batches (2210-2219), the LN2 level reached the SiPMs level before the last-OV measurement, preventing us from taking such measurement

Gain results



Gain results



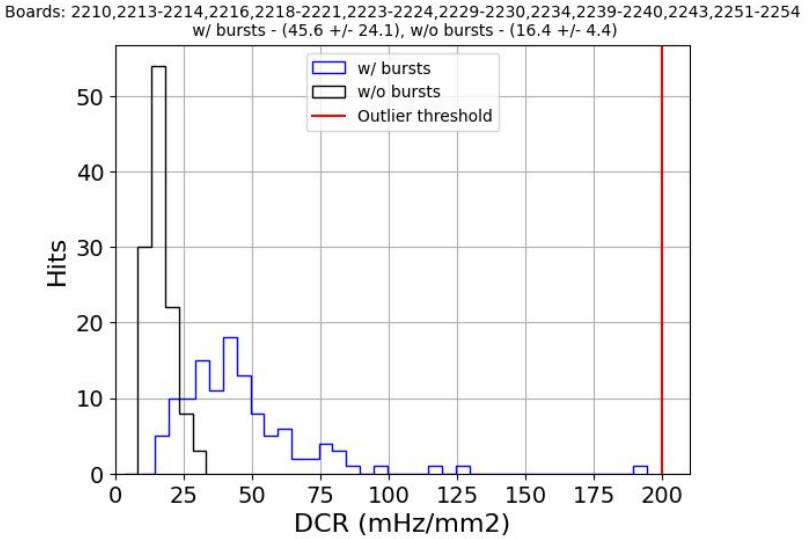


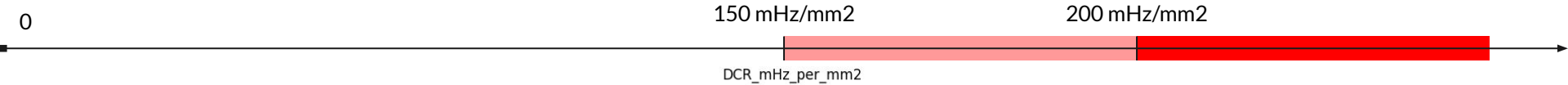
2252, 2253 and 2254 boards were measured in the same batch - We believe that an unexpected V_op drop could have taken place posterior to the V_op measurement. thus giving an smaller OV

Electronic malfunction of channel 4 of socket 1

Dark noise results: DCR

- The malfunction of slot 4 of socket 1 prevented us from taking DN data for 2224-4, 2229-4 and 2239-4
- The rest of the boards which were tested on the first socket also presented a very noisy dataset for the fourth slot, but were still analyzable (~40-80% noisy fast frames removed by the offline filter)
- We did not spot any DCR outliers in the sipms which were analyzed

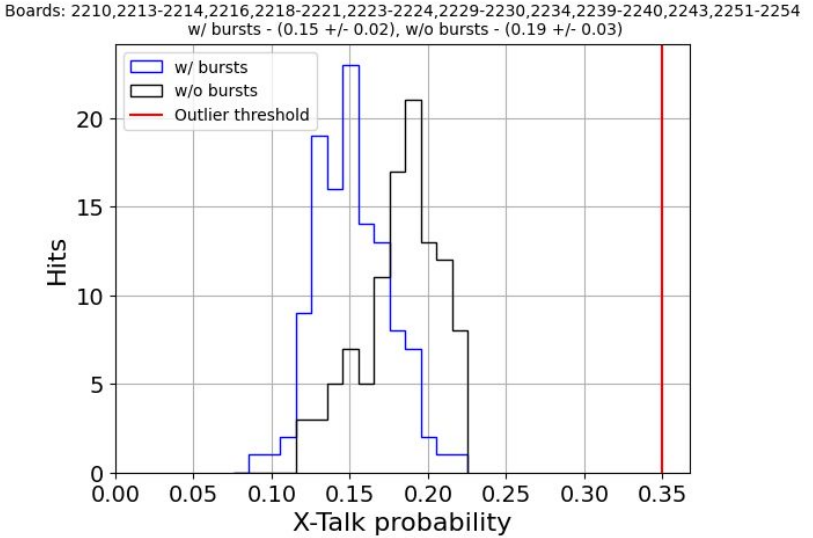


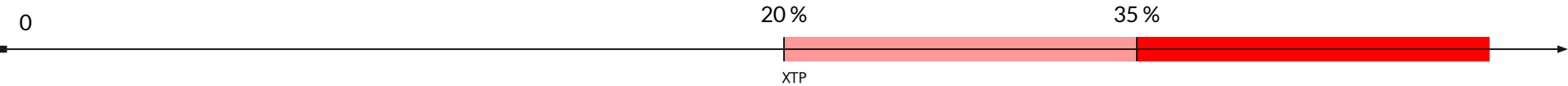


	2210	2213	2214	2216	2218	2219	2220	2221	2223	2224	2229	2230	2234	2239	2240	2243	2251	2252	2253	2254
1	28.5	39.5	49.6	35.1	47.1	50.4	41.5	29.0	22.9	49.8	34.5	41.1	47.7	72.9	34.6	16.0	16.2	66.6	77.8	63.6
2	28.2	45.2	14.4	22.9	39.0	31.9	35.8	42.9	26.1	48.4	35.5	42.0	30.7	41.5	28.8	42.4	30.7	128.7	20.9	26.0
3	50.2	41.8	54.3	28.4	61.5	79.7	33.3	50.3	43.1	97.1	49.2	75.8	33.8	60.7	47.9	26.6	44.3	45.3	58.9	32.9
4	26.9	39.3	40.8	67.9	30.1	39.6	20.3	33.4	31.8	nan	nan	70.4	35.8	nan	46.1	83.9	28.2	115.2	63.2	75.4
5	57.4	48.5	47.6	51.3	59.3	35.6	48.7	61.2	31.4	48.3	39.4	43.6	20.4	42.4	86.2	32.3	20.0	191.0	31.7	79.2
6	17.7	46.4	39.7	51.5	29.7	58.5	81.0	58.7	22.3	59.6	36.3	30.6	18.2	44.3	44.1	33.0	35.1	22.9	22.8	20.3

Dark noise results: XTP

- We did not spot any XTP outliers in the sipms which were analyzed

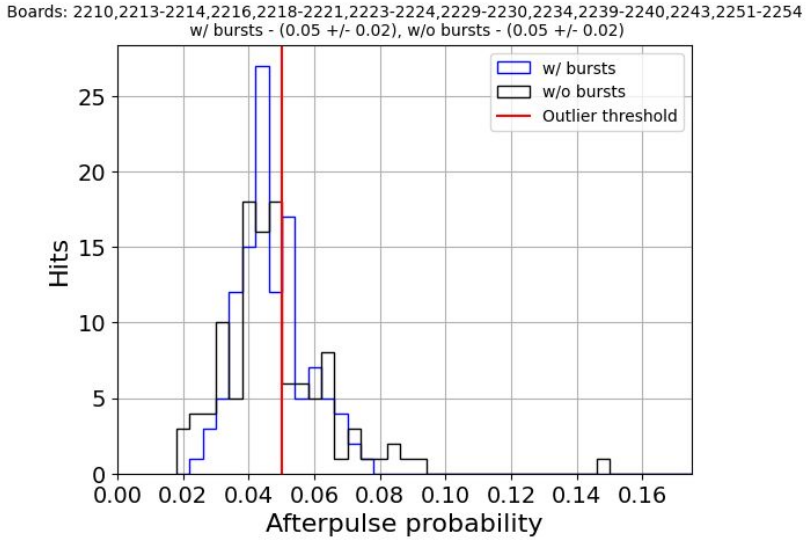




	2210	2213	2214	2216	2218	2219	2220	2221	2223	2224	2229	2230	2234	2239	2240	2243	2251	2252	2253	2254
1	0.15	0.13	0.18	0.14	0.13	0.13	0.15	0.14	0.14	0.16	0.19	0.16	0.15	0.15	0.13	0.18	0.13	0.12	0.12	0.11
2	0.16	0.15	0.18	0.19	0.16	0.11	0.16	0.15	0.15	0.17	0.19	0.17	0.17	0.14	0.16	0.2	0.14	0.12	0.17	0.1
3	0.15	0.17	0.22	0.19	0.15	0.13	0.16	0.18	0.14	0.15	0.17	0.14	0.16	0.16	0.16	0.14	0.14	0.15	0.15	0.13
4	0.15	0.2	0.18	0.14	0.18	0.14	0.19	0.17	0.15	nan	nan	0.15	0.13	nan	0.15	0.13	0.15	0.09	0.13	0.12
5	0.17	0.16	0.17	0.13	0.13	0.19	0.14	0.15	0.15	0.18	0.18	0.15	0.17	0.16	0.13	0.15	0.15	0.13	0.13	0.13
6	0.13	0.22	0.18	0.13	0.12	0.16	0.14	0.17	0.14	0.15	0.17	0.15	0.19	0.12	0.12	0.13	0.13	0.16	0.16	0.12

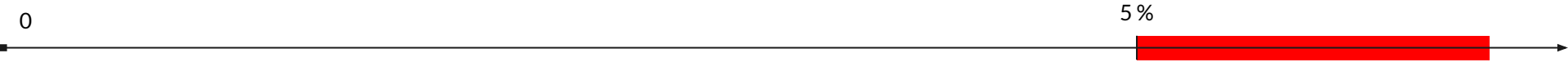
Dark noise results: APP

- We spotted a lot of APP outliers in the sipms which were analyzed.
- There is a discrepancy between the APP distribution of this tray (115) and the one we measured for the previous tray (68).
- **The discrepancy has to do with the tuning of the parameters of the peak-finding algorithm**. See next slides.



	2210	2213	2214	2216	2218	2219	2220	2221	2223	2224	2229	2230	2234	2239	2240	2243	2251	2252	2253	2254
1	0.046	0.042	0.037	0.052	0.036	0.052	0.05	0.061	0.045	0.053	0.046	0.063	0.034	0.043	0.046	0.061	0.057	0.043	0.032	0.05
2	0.045	0.03	0.045	0.051	0.057	0.052	0.041	0.069	0.043	0.047	0.054	0.048	0.044	0.044	0.066	0.062	0.061	0.071	0.058	0.045
3	0.044	0.045	0.029	0.073	0.042	0.038	0.067	0.065	0.045	0.042	0.059	0.047	0.047	0.058	0.042	0.049	0.046	0.046	0.022	0.038
4	0.038	0.035	0.036	0.039	0.062	0.044	0.068	0.061	0.047	nan	nan	0.037	0.036	nan	0.045	0.05	0.051	0.207	0.035	0.036
5	0.047	0.035	0.033	0.044	0.043	0.033	0.052	0.052	0.045	0.043	0.051	0.042	0.053	0.056	0.042	0.054	0.077	0.067	0.041	0.04
6	0.063	0.039	0.027	0.044	0.053	0.037	0.047	0.042	0.042	0.041	0.041	0.038	0.053	0.03	0.044	0.045	0.056	0.049	0.033	0.05

The APP discrepancy



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

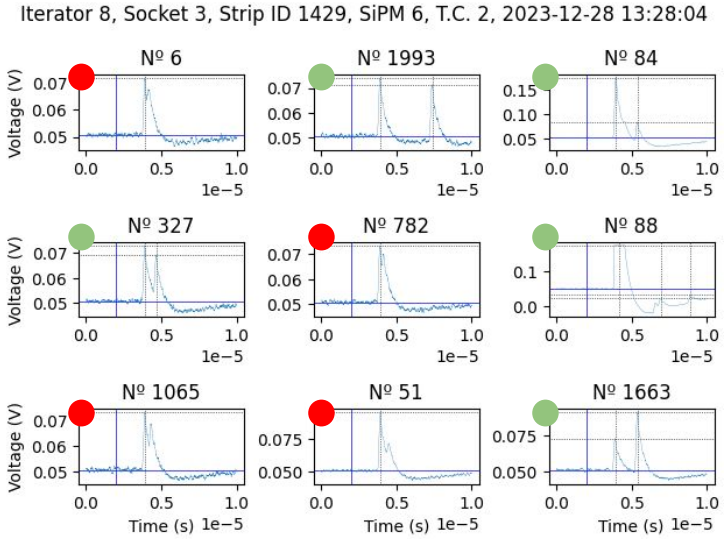
APP results presented on 27/02 for tray 68 in *[2]*

APP

	2210	2213	2214	2216	2218	2219	2220	2221	2223	2224	2229	2230	2234	2239	2240	2243	2251	2252	2253	2254
1	0.046	0.042	0.037	0.052	0.036	0.052	0.05	0.061	0.045	0.053	0.046	0.063	0.034	0.043	0.046	0.061	0.057	0.043	0.032	0.05
2	0.045	0.03	0.045	0.051	0.057	0.052	0.041	0.069	0.043	0.047	0.054	0.048	0.044	0.044	0.066	0.062	0.061	0.071	0.058	0.045
3	0.044	0.045	0.029	0.073	0.042	0.038	0.067	0.065	0.045	0.042	0.059	0.047	0.047	0.058	0.042	0.049	0.046	0.046	0.022	0.038
4	0.038	0.035	0.036	0.039	0.062	0.044	0.068	0.061	0.047	nan	nan	0.037	0.036	nan	0.045	0.05	0.051	0.207	0.035	0.036
5	0.047	0.035	0.033	0.044	0.043	0.033	0.052	0.052	0.045	0.043	0.051	0.042	0.053	0.056	0.042	0.054	0.077	0.067	0.041	0.04
6	0.063	0.039	0.027	0.044	0.053	0.037	0.047	0.042	0.042	0.041	0.041	0.038	0.053	0.03	0.044	0.045	0.056	0.049	0.033	0.05

APP results presented today for tray 115

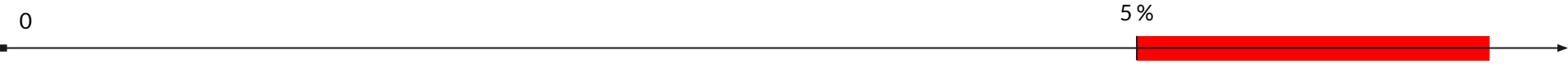
Re-analysis on boards 1425, 1426 and 1429 of tray 68 and comparison to previous analysis -like



Cuts on the parameters for the peak-finding algorithm such as the peak width and prominence are set so that accidental sinusoidal noises are not identified as PE-peaks.

During tray-115 analysis, the values given to those parameters were find to be so restrictive so as to overlook actual APs.

The APP discrepancy



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

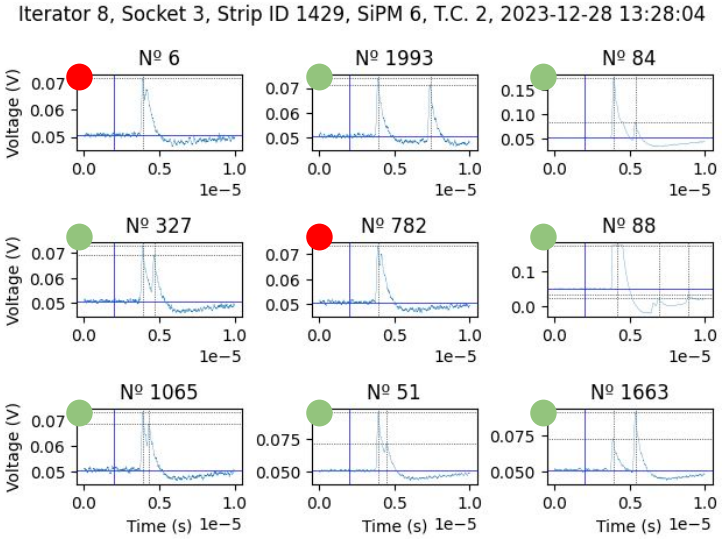
APP results presented on 27/02 for tray 68 in *[2]*

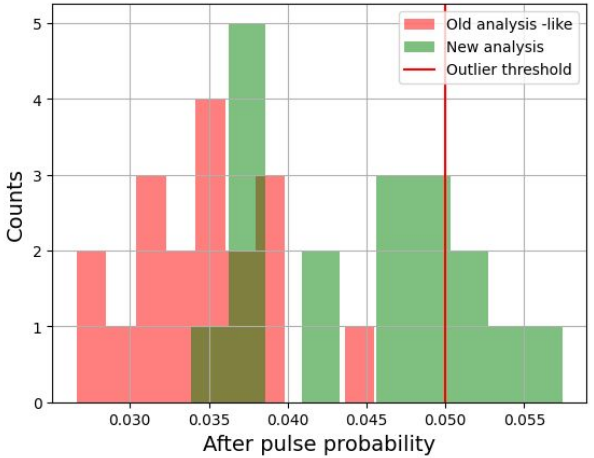
APP

	2210	2213	2214	2216	2218	2219	2220	2221	2223	2224	2229	2230	2234	2239	2240	2243	2251	2252	2253	2254
1	0.046	0.042	0.037	0.052	0.036	0.052	0.05	0.061	0.045	0.053	0.046	0.063	0.034	0.043	0.046	0.061	0.057	0.043	0.032	0.05
2	0.045	0.03	0.045	0.051	0.057	0.052	0.041	0.069	0.043	0.047	0.054	0.048	0.044	0.044	0.066	0.062	0.061	0.071	0.058	0.045
3	0.044	0.045	0.029	0.073	0.042	0.038	0.067	0.065	0.045	0.042	0.059	0.047	0.047	0.058	0.042	0.049	0.046	0.046	0.022	0.038
4	0.038	0.035	0.036	0.039	0.062	0.044	0.068	0.061	0.047	nan	nan	0.037	0.036	nan	0.045	0.05	0.051	0.207	0.035	0.036
5	0.047	0.035	0.033	0.044	0.043	0.033	0.052	0.052	0.045	0.043	0.051	0.042	0.053	0.056	0.042	0.054	0.077	0.067	0.041	0.04
6	0.063	0.039	0.027	0.044	0.053	0.037	0.047	0.042	0.042	0.041	0.041	0.038	0.053	0.03	0.044	0.045	0.056	0.049	0.033	0.05

APP results presented today for tray 115

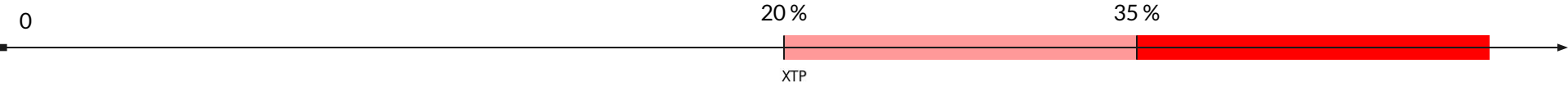
Re-analysis on boards 1425, 1426 and 1429 of tray 68 and comparison to previous analysis -like





Dark noise results (tables)

	2210	2213	2214	2216	2218	2219	2220	2221	2223	2224	2229	2230	2234	2239	2240	2243	2251	2252	2253	2254
1	28.5	39.5	49.6	35.1	47.1	50.4	41.5	29.0	22.9	49.8	34.5	41.1	47.7	72.9	34.6	16.0	16.2	66.6	77.8	63.6
2	28.2	45.2	14.4	22.9	39.0	31.9	35.8	42.9	26.1	48.4	35.5	42.0	30.7	41.5	28.8	42.4	30.7	128.7	20.9	26.0
3	50.2	41.8	54.3	28.4	61.5	79.7	33.3	50.3	43.1	97.1	49.2	75.8	33.8	60.7	47.9	26.6	44.3	45.3	58.9	32.9
4	26.9	39.3	40.8	67.9	30.1	39.6	20.3	33.4	31.8	nan	nan	70.4	35.8	nan	46.1	83.9	28.2	115.2	63.2	75.4
5	57.4	48.5	47.6	51.3	59.3	35.6	48.7	61.2	31.4	48.3	39.4	43.6	20.4	42.4	86.2	32.3	20.0	191.0	31.7	79.2
6	17.7	46.4	39.7	51.5	29.7	58.5	81.0	58.7	22.3	59.6	36.3	30.6	18.2	44.3	44.1	33.0	35.1	22.9	22.8	20.3



	2210	2213	2214	2216	2218	2219	2220	2221	2223	2224	2229	2230	2234	2239	2240	2243	2251	2252	2253	2254
1	0.15	0.13	0.18	0.14	0.13	0.13	0.15	0.14	0.14	0.16	0.19	0.16	0.15	0.15	0.13	0.18	0.13	0.12	0.12	0.11
2	0.16	0.15	0.18	0.19	0.16	0.11	0.16	0.15	0.15	0.17	0.19	0.17	0.17	0.14	0.16	0.2	0.14	0.12	0.17	0.1
3	0.15	0.17	0.22	0.19	0.15	0.13	0.16	0.18	0.14	0.15	0.17	0.14	0.16	0.16	0.16	0.14	0.14	0.15	0.15	0.13
4	0.15	0.2	0.18	0.14	0.18	0.14	0.19	0.17	0.15	nan	nan	0.15	0.13	nan	0.15	0.13	0.15	0.09	0.13	0.12
5	0.17	0.16	0.17	0.13	0.13	0.19	0.14	0.15	0.15	0.18	0.18	0.15	0.17	0.16	0.13	0.15	0.15	0.13	0.13	0.13
6	0.13	0.22	0.18	0.13	0.12	0.16	0.14	0.17	0.14	0.15	0.17	0.15	0.19	0.12	0.12	0.13	0.13	0.16	0.16	0.12

	2210	2213	2214	2216	2218	2219	2220	2221	2223	2224	2229	2230	2234	2239	2240	2243	2251	2252	2253	2254
1	0.046	0.042	0.037	0.052	0.036	0.052	0.05	0.061	0.045	0.053	0.046	0.063	0.034	0.043	0.046	0.061	0.057	0.043	0.032	0.05
2	0.045	0.03	0.045	0.051	0.057	0.052	0.041	0.069	0.043	0.047	0.054	0.048	0.044	0.044	0.066	0.062	0.061	0.071	0.058	0.045
3	0.044	0.045	0.029	0.073	0.042	0.038	0.067	0.065	0.045	0.042	0.059	0.047	0.047	0.058	0.042	0.049	0.046	0.046	0.022	0.038
4	0.038	0.035	0.036	0.039	0.062	0.044	0.068	0.061	0.047	nan	nan	0.037	0.036	nan	0.045	0.05	0.051	0.207	0.035	0.036
5	0.047	0.035	0.033	0.044	0.043	0.033	0.052	0.052	0.045	0.043	0.051	0.042	0.053	0.056	0.042	0.054	0.077	0.067	0.041	0.04
6	0.063	0.039	0.027	0.044	0.053	0.037	0.047	0.042	0.042	0.041	0.041	0.038	0.053	0.03	0.044	0.045	0.056	0.049	0.033	0.05

Conclusions and plans

- The calibration of the amplification factor of Massibo is still a pending task
- Slot 4 of socket 1 must be fixed
- Shall we re-test boards 2252, 2253 and 2254?
- Perfectly separating noise-induced peaks and APs may not be achievable. How sensitive do we need to be to APs? We can benefit from details on the analysis algorithm used for *[1]*
- We will not be able to re-test tray-115 outliers nor start the measurements of the third tray we received from CIEMAT until the construction works at our lab. finish

Reference list

[1] M. Andreotti et al (2024)
Cryogenic characterization of Hamamatsu HWB MPPCs for the DUNE photon detection system

[2] Julio Ureña's talk (13/02/2024)
Update on dark-noise/gain measurements @ IFIC, Valencia
https://indico.fnal.gov/event/63323/contributions/284677/attachments/175094/237500/slides.pdf