# Update on dark-noise/gain measurements @ IFIC, Valencia Results from tray 115

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Photosensors WG - 07 May 2024



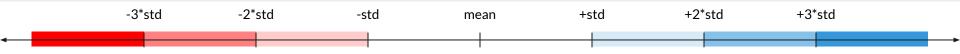
#### Introduction

- 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\_#emonth='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)

1	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 #emonth='04' [overvoitage\_V=3.1] Boards: 2210,2213-2214,2216,2218-2221,2223-2224,2229-2230,2234,2239-2240,2243,2251-2254 Mean +/- stci (45002.06 +/- 4435.59)

Г	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 #emonth='04' [overvoltage V=4.1] Boards: 2220-2221,2223-2224,2229-2230,2234,2239-2240,2243,2251-2254 Mean +/- std: (58121.39 +/- 7053.96)

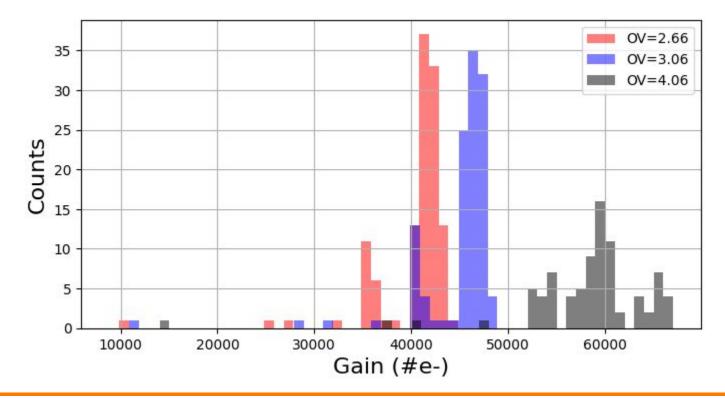
្រា	2220	2221	2223	2224	2229	2230	2234	2239	2240	2243	2251	2252	2253	2254
1	6.6e+04	6.5e+04	6.6e+04	5.6e+04	5.9e+04	5.8e+04	5.8e+04	5.8e+04	5.8e+04	5.8e+04	6.1e+04	5.4e+04	5.2e+04	5.5e+04
2	6.4e+04	6.6e+04	6.4e+04	5.9e+04	5.7e+04	6.0e+04	5.9e+04	5.9e+04	5.9e+04	6.2e+04	5.9e+04	5.3e+04	5.7e+04	5.3e+04
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

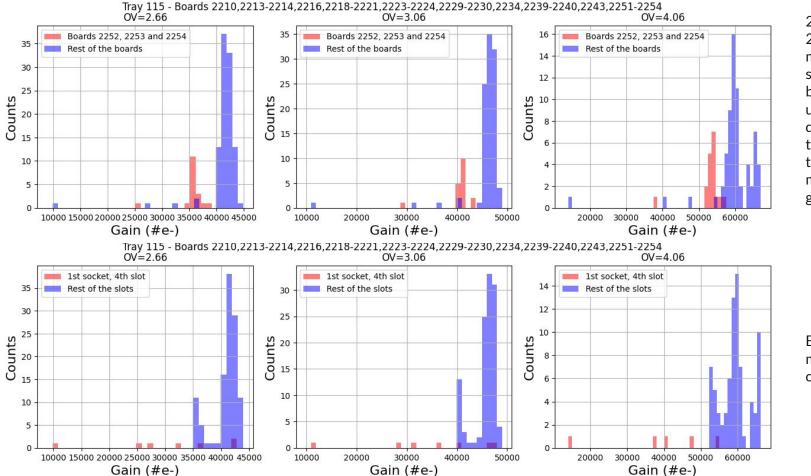
#### **Gain results**

Tray 115 - Boards 2210,2213-2214,2216,2218-2221,2223-2224,2229-2230,2234,2239-2240,2243,2251-2254





#### **Gain results**



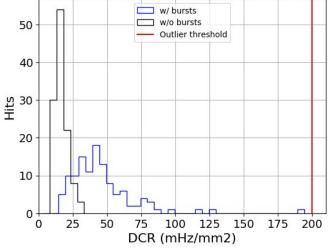
2252, 2253 and 2254 boards were measured in the same batch - We believe that an unexpected V\_op drop could have taken place posterior to the V\_op measurement. thus giving an smaller OV

Electronic malfunction of channel 4 of socket 1

# Dark noise results: DCR

0

- 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 sigms which were analyzed



w/ bursts - (45.6 +/- 24.1), w/o bursts - (16.4 +/- 4.4)

Boards: 2210,2213-2214,2216,2218-2221,2223-2224,2229-2230,2234,2239-2240,2243,2251-2254

150 mHz/mm2

200 mHz/mm2

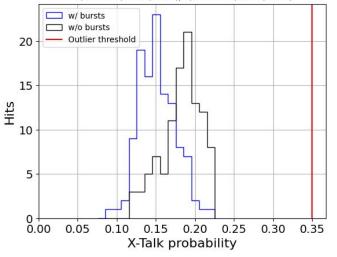
DCR mHz per mm2

221	0 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	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	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	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	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

0



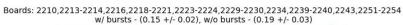
35 %

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

20%

XTP

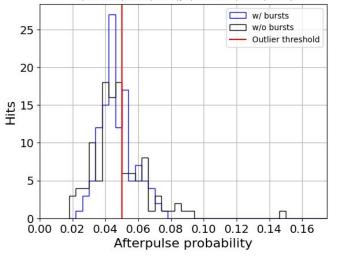
<u>2210</u> <u>2213</u> <u>2214</u> <u>2216</u> <u>2218</u> <u>2219</u> <u>2220</u> <u>2221</u> <u>2223</u> <u>2224</u> <u>2229</u> <u>2230</u> <u>22</u>	4 <u>2239</u> <u>2240</u> <u>2243</u> <u>2251</u> <u>2252</u> <u>2253</u> <u>2254</u>
1         0.15         0.13         0.18         0.14         0.13         0.15         0.14         0.14         0.16         0.19         0.16         0.1	5 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	7 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         0.15	
4         0.15         0.2         0.18         0.14         0.14         0.19         0.17         0.15         nan         nan         0.15         0.15	3 nan 0.15 0.13 0.15 0.09 0.13 0.12
5         0.17         0.16         0.17         0.13         0.19         0.14         0.15         0.15         0.18         0.18         0.15         0.15	
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         0.15         0.17	9 0.12 0.12 0.13 0.13 0.16 0.16 0.12



#### Dark noise results: APP

0

- 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.



Boards: 2210,2213-2214,2216,2218-2221,2223-2224,2229-2230,2234,2239-2240,2243,2251-2254 w/ bursts - (0.05 +/- 0.02), w/o bursts - (0.05 +/- 0.02)

5%

2210 2213 2214 2216 2218 2219 2220 2221 2223 2224 2229 2230 2234 2239 2240 2243 2251 2252 2253 2254 0.046 0.042 0.037 0.036 0.05 0.045 0.046 0.034 0.043 0.046 0.043 0.032 0.05 1 2 3 4 5 0.045 0.03 0.045 0.041 0.043 0.047 0.048 0.044 0.044 0.045 0.044 0.045 0.029 0.042 0.045 0.042 0.047 0.047 0.049 0.038 0.038 0.042 0.046 0.046 0.022 0.038 0.035 0.036 0.039 0.044 0.047 nan 0.037 0.036 nan 0.045 0.05 0.035 0.036 nan 0.035 0.033 0.044 0.045 0.042 0.04 0.047 0.043 0.043 0.042 0.041 6 0.044 0.042 0.044 0.05 0.039 0.027 0.037 0.047 0.042 0.041 0.041 0.038 0.03 0.045 0.049 0.033

APP

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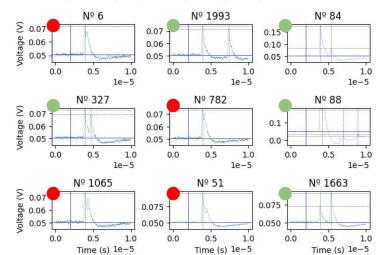
8

# The APP discrepancy

0																			5 %	
- , I										- <b></b>										、
$\begin{array}{c c} 1425\\ \hline 1 & 0.026\\ \hline 2 & 0.022\\ \hline 3 & 0.032\\ \hline 4 & 0.032\\ \hline 5 & 0.023\\ \hline 6 & 0.028\\ \end{array}$	1426 0.036 0.034 0.03 0.026 0.024 0.031	1429 0.033 0.02 0.026 0.024 0.022 0.025	1431 0.028 0.026 0.028 0.025 0.025 0.025 0.025	1432 0.034 0.027 0.032 0.037 0.024 0.024	1435 0.025 0.025 0.026 0.032 0.02 0.025	1436 0.02 0.029 0.028 0.031 0.031 0.025	1437 0.033 0.031 0.027 0.024 0.021 0.029	1438 0.027 0.021 0.029 0.02 0.022 0.023 0.024	1441 0.024 0.024 0.025 0.028 0.029 0.019	1442 0.024 0.027 0.038 0.026 0.026 0.033	1443 0.019 0.017 0.02 0.022 0.014 0.017	1444 0.029 0.029 0.021 0.03 0.025 0.032	1445 0.026 0.032 0.021 0.022 0.03 0.026	1446 0.02 0.017 0.026 0.026 0.018 0.026	1447 0.03 0.023 0.035 0.022 0.031 0.038	1449 0.029 0.021 0.027 0.028 0.035 0.03	1451 0.023 0.031 0.04 0.025 0.031 0.022	1452 0.021 0.031 0.023 0.028 0.043 0.023	1456 0.024 0.023 0.028 0.029 0.027 0.025	APP results presented on 27/02 for tray 68 in [2]
	APP																			
2210           1         0.046           2         0.045           3         0.044           4         0.038           5         0.047           6         0.063	2213 0.042 0.03 0.045 0.035 0.035 0.035 0.039	2214 0.037 0.045 0.029 0.036 0.033 0.027	2216 0.052 0.051 0.073 0.039 0.044 0.044	2218 0.036 0.057 0.042 0.062 0.043 0.053	2219 0.052 0.038 0.044 0.033 0.037	2220 0.05 0.041 0.067 0.068 0.052 0.047	2221 0.061 0.069 0.065 0.061 0.052 0.042	2223 0.045 0.043 0.045 0.047 0.045 0.045 0.042	2224 0.053 0.047 0.042 nan 0.043 0.041	2229 0.046 0.054 0.059 nan 0.051 0.041	2230 0.063 0.048 0.047 0.037 0.042 0.038	2234 0.034 0.044 0.047 0.036 0.053 0.053	2239 0.043 0.044 0.058 nan 0.056 0.03	2240 0.046 0.066 0.042 0.045 0.042 0.044	2243 0.061 0.062 0.049 0.05 0.054 0.045	2251 0.057 0.061 0.046 0.051 0.077 0.056	2252 0.043 0.071 0.046 0.207 0.067 0.049	2253 0.032 0.058 0.022 0.035 0.041 0.033	2254 0.05 0.045 0.038 0.036 0.04 0.04 0.05	APP results presented today for tray 115

Iterator 8, Socket 3, Strip ID 1429, SiPM 6, T.C. 2, 2023-12-28 13:28:04

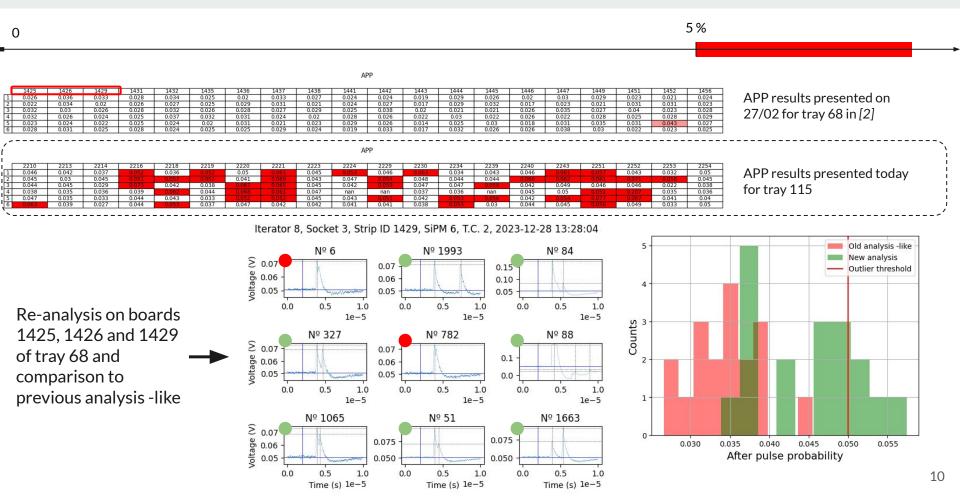
Re-analysis on boards 1425, 1426 and 1429 of tray 68 and comparison to previous analysis -like



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



#### Dark noise results (tables)

0								150 mHz	z/mm2	200 mHz/mm2									
								DCR_mHz	per_mm2										
		221.0		2210				2224	2000	2020	2024	2220	0010	2242	0051	2050	0050	2254	
2210 221 1 28.5 39	.5 49.6	2216 35.1	2218 47.1	2219 50.4	2220 41.5	2221 29.0	2223 22.9	2224 49.8	2229 34.5	2230 41.1	2234 47.7	2239 72.9	2240 34.6	2243 16.0	2251 16.2	2252 66.6	2253 77.8	2254 63.6	
2         28.2         45           3         50.2         41           4         26.9         39.           5         57.4         48           6         17.7         46		22.9 28.4	39.0 61.5	31.9 79.7	35.8 33.3	42.9 50.3	26.1 43.1	48.4 97.1	35.5 49.2	42.0 75.8	30.7 33.8	41.5 60.7	28.8 47.9	42.4 26.6	30.7 44.3	128.7 45.3	20.9 58.9	26.0 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	47.9	83.9	28.2	115.2	63.2	75.4	
5 57.4 48 6 17.7 46		51.3 51.5	59.3 29.7	35.6 58.5	48.7 81.0	61.2 58.7	31.4 22.3	48.3 59.6	39.4 36.3	43.6 30.6	20.4 18.2	42.4 44.3	86.2 44.1	32.3 33.0	20.0 35.1	191.0 22.9	31.7 22.8	79.2 20.3	
6 17.7 40	.4 39.7	51.5	29.7	28.2	81.0	58.7	22.3	59.0	30.3	30.6	18.2	44.5	44.1	33.0	35.1	22.9	22.8	20.3	
0								20 9	%				35 %						
0									-										
																		►	
								X	ГР										
2210 22 1 0.15 0.1		2216 0.14	2218 0.13	2219 0.13	2220 0.15	2221 0.14	2223 0.14	2224 0.16	2229 0.19	2230 0.16	2234 0.15	2239 0.15	2240 0.13	2243 0.18	2251 0.13	2252 0.12	2253 0.12	2254 0.11	
2 0.16 0.1	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 0.1 4 0.15 0.		0.19 0.14	0.15	0.13 0.14	0.16 0.19	0.18 0.17	0.14 0.15	0.15 nan	0.17 nan	0.14 0.15	0.16 0.13	0.16 nan	0.16 0.15	0.14 0.13	0.14 0.15	0.15 0.09	0.15 0.13	0.13 0.12	
5 0.17 0.1		0.14	0.13	0.14	0.13	0.17	0.15	0.18	0.18	0.15	0.13	0.16	0.13	0.15	0.15	0.03	0.13	0.12	
6 0.13 0.2	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	
													F 0/						
0													5%						
								AF	р										
2210 22		2216	2218	2219	2220	2221	2223	2224	2229	2230	2234	2239	2240	2243	2251	2252	2253	2254	
1 0.046 0.0 2 0.045 0.0		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	
3 0.044 0.0	45 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 0.0		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 0.0 6 0.063 0.0		0.044	0.043	0.033	0.052 0.047	0.052 0.042	0.045	0.043	0.051 0.041	0.042	0.053	0.056	0.042	0.054	0.077	0.067	0.041 0.033	0.04	
0.0	0.027			0.007	0.017	0.012	0.012	0.011		0.000		0.00	5.511	0.010		0.015	0.000	0.00	



#### **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



