APD Screening and Matching

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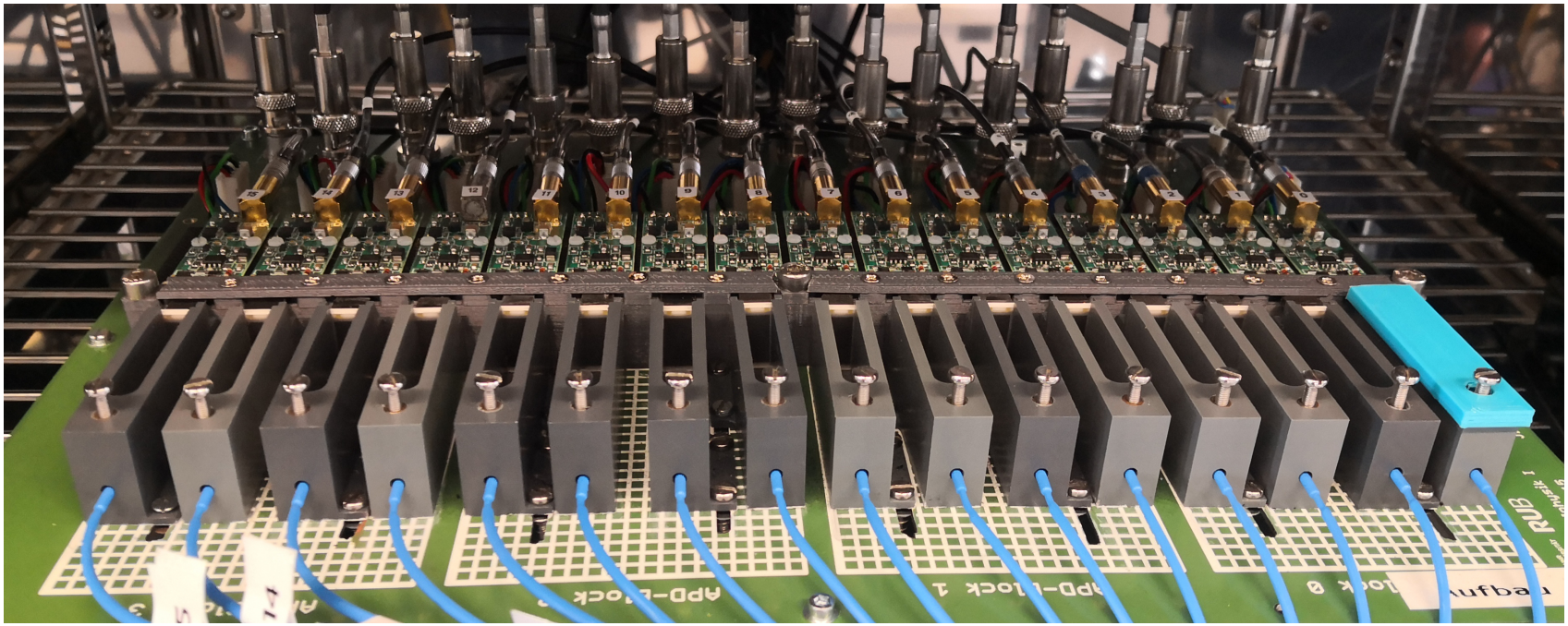
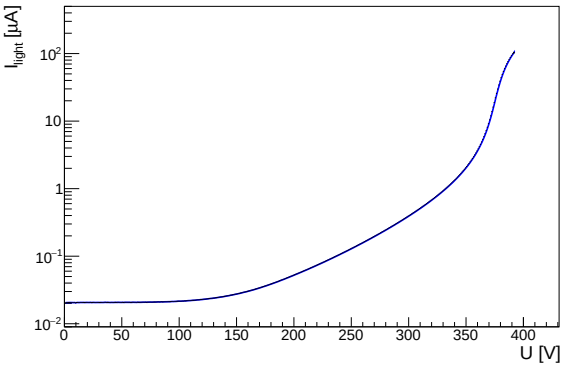
Setup

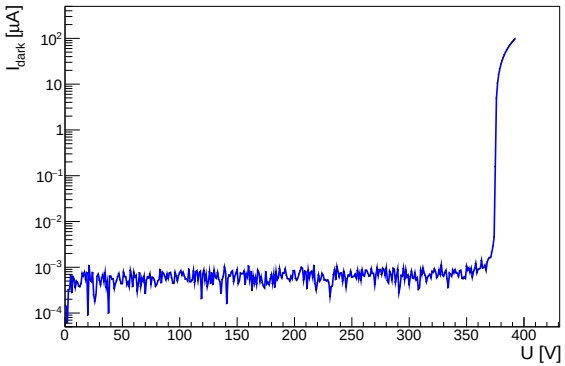
- Two climate chambers
- Each climate chamber contains two PCBs
- PCBs have 16 slots (1 reference)
- 60 APDs per screening

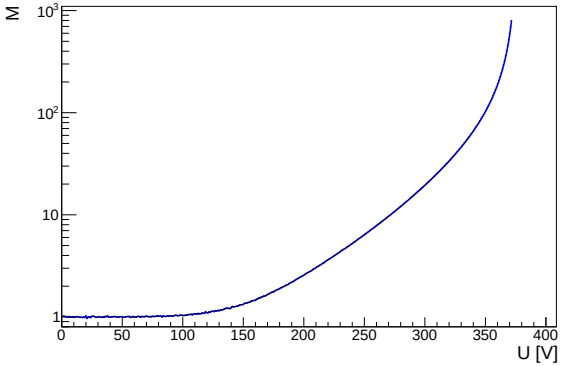
- Milled APD brackets that also hold light fibers
- APDs illuminated with blue LED light (guided by light fibers)
- APDs connected to submodule preamp SP883 ($R_{\mathrm{HVF}} = 150\,\mathrm{k\Omega}$)



Gain Calculation and Matching







Gain calculation

- $l =$ light, $d =$ dark and $i =$ measure step
- Correct APD voltage
  $U_{\mathrm{apd}}(i) = U(i) - I(i)\, R_{\mathrm{HVF}}$
- Calculate photo current
  $I_{\mathrm{photo}}(i) = I_{\mathrm{l}}(i) - I_{\mathrm{d}}(U_{\mathrm{apd,l}}(i))$
- Consider LED fluctuations
  $I'(i) = \frac{I_{\mathrm{photo}}(i)}{I_{\mathrm{l,ref1}}(i) + I_{\mathrm{l,ref2}}(i) - \bar{I}_{\mathrm{d,ref12}}}$
- Calculate current for gain one
  $I'_{M=1} = \frac{1}{35-11} \sum_{i=11}^{35} I'(i)$
- Calculate gain curve
  $M(U_{\mathrm{apd}}) = \frac{I'(U_{\mathrm{apd}})}{I'_{M=1}}$

Matching

- Spread:
  $\frac{1}{n-1} \sum_{i}^{n-1} [(U(200)_i - U(200)_{i+1})^2 + (U(300)_i - U(300)_{i+1})^2]$
- Recursively create pairs of 2/4/8/16/32
- Sort list by spread
- This algorithm just creates best local matches

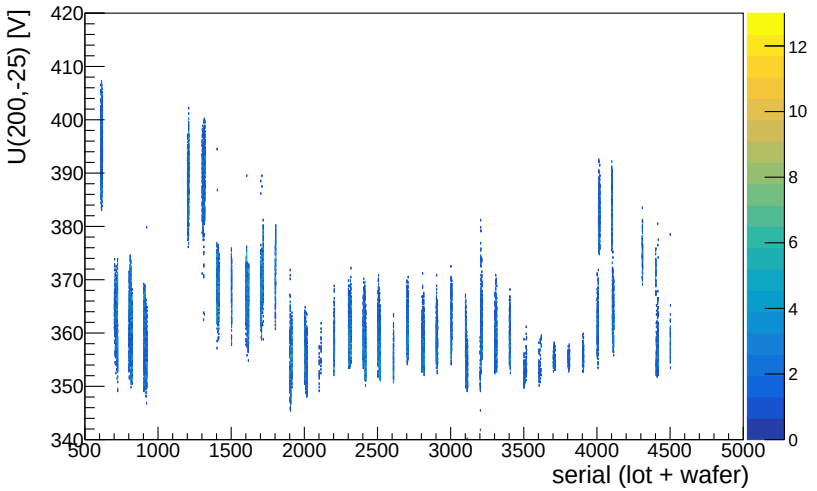
→ Spread gets higher with less available APDs

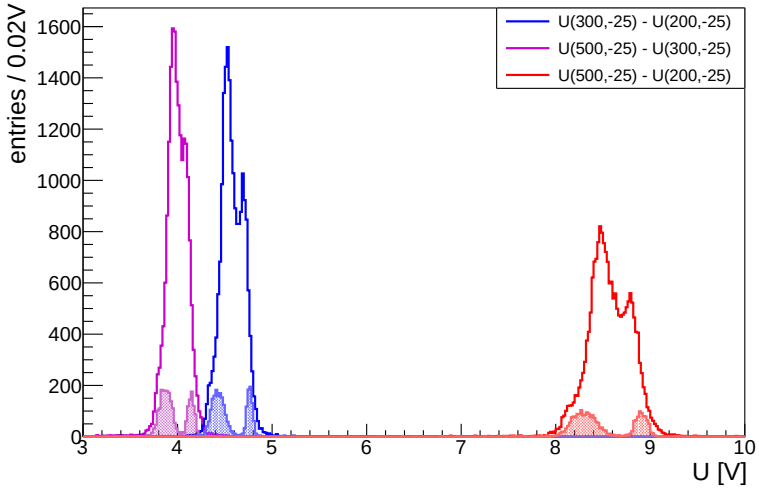
Data Overview: $T = -25\,^{\circ}\mathrm{C}$

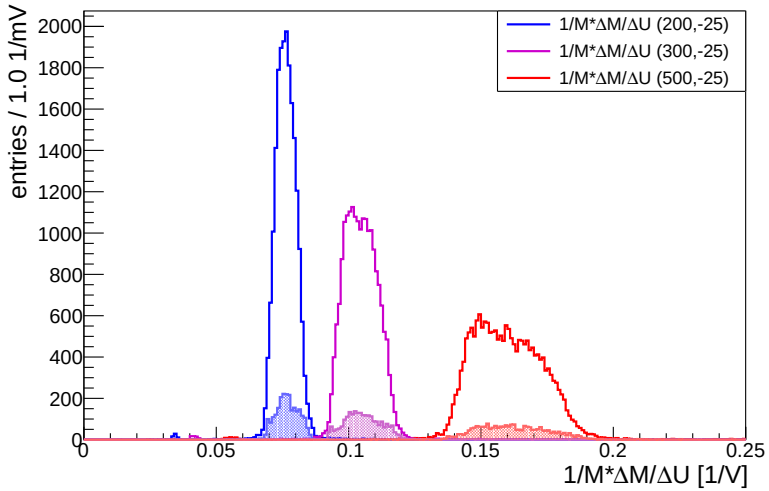
- 22436 datasets for irradiated
- 10576 datasets for pre-irradiated
- 8311 of the pre-irradiated measured are also measured after irradiation
- 4500 delivered APDs in 2021 (SN $\geq$ 3810038805)

→ 2100 left for first screening after irradiation

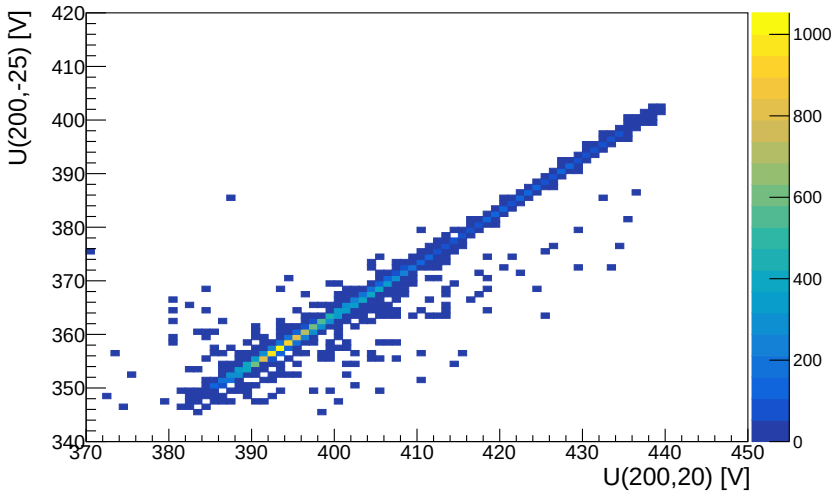
! Filled plots SN $\geq$ 3810038805

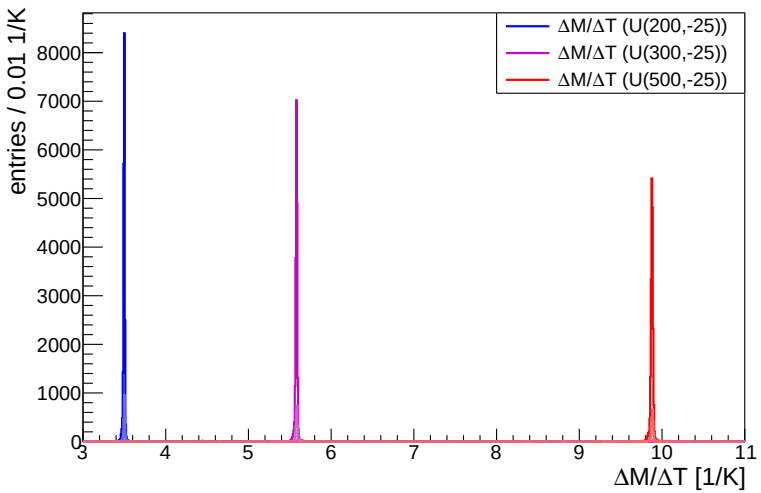


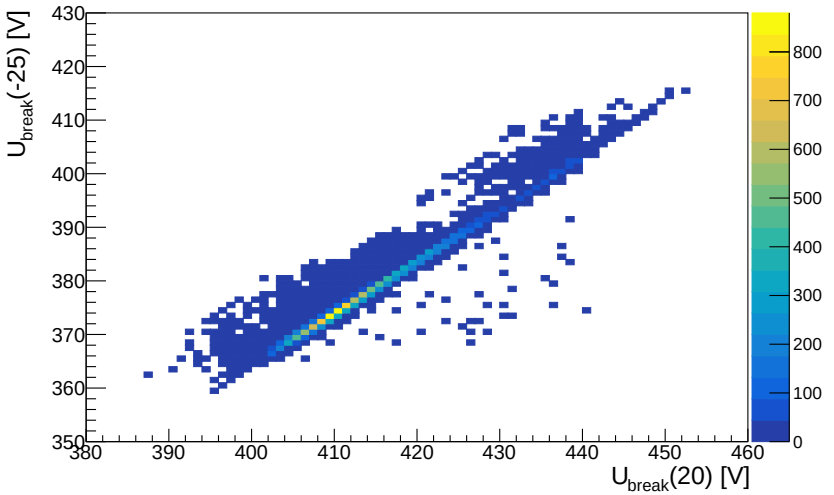


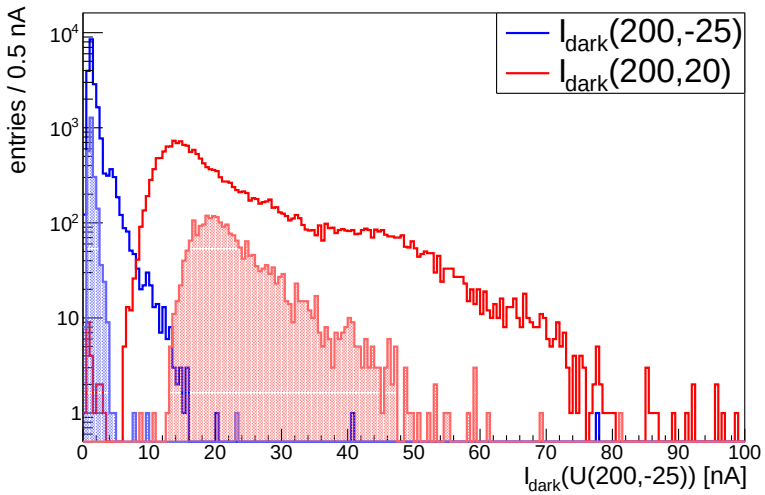


Data Overview: $T = -25\,^{\circ}\mathrm{C}$ vs. $T = 20\,^{\circ}\mathrm{C}$

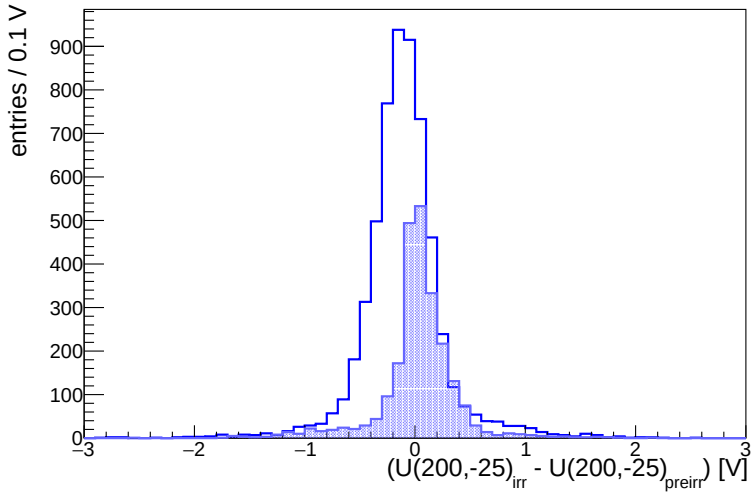


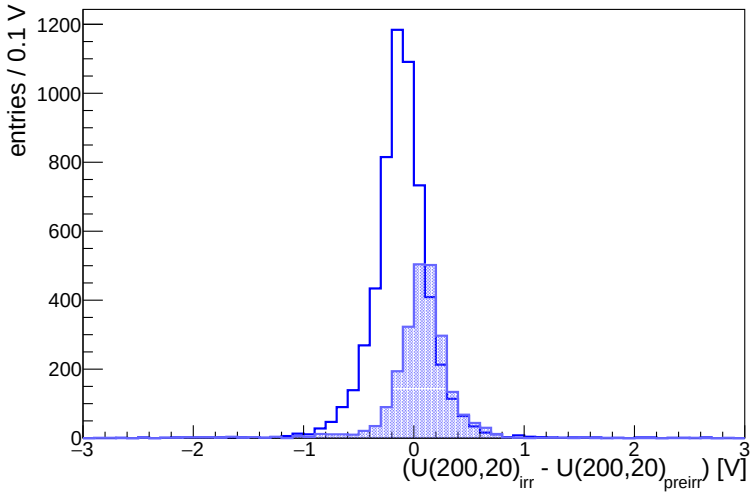


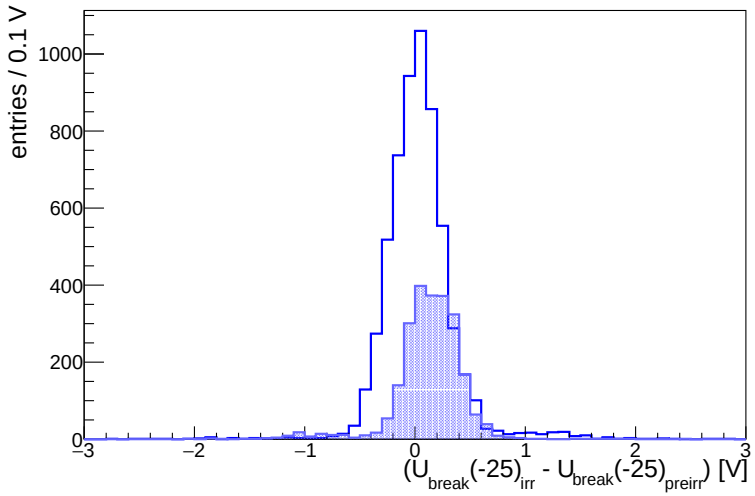


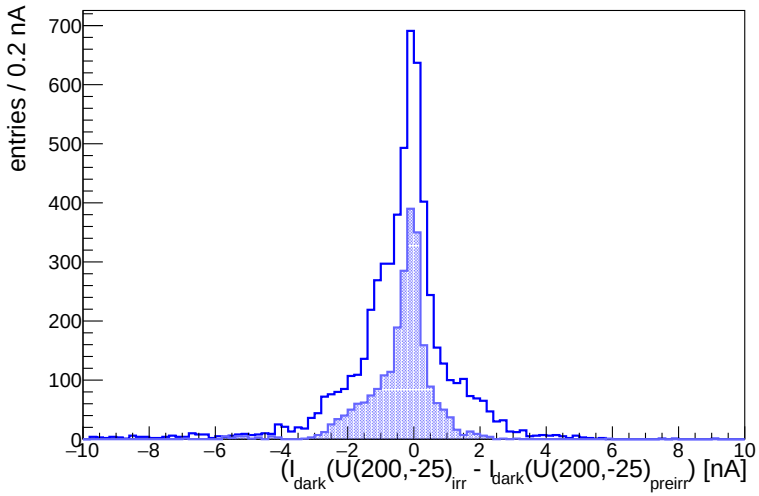


Data Overview: Irradiated (30 Gy) vs. Pre-Irradiated



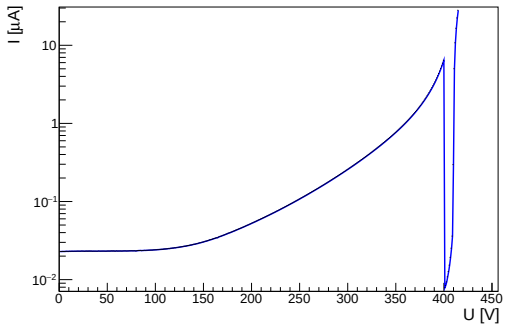


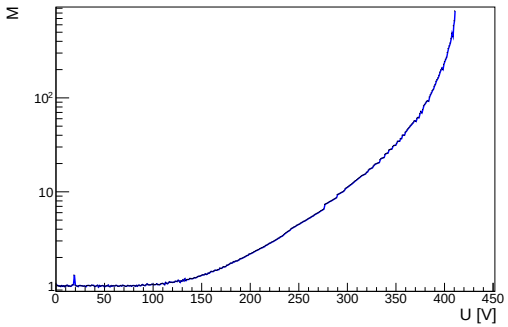


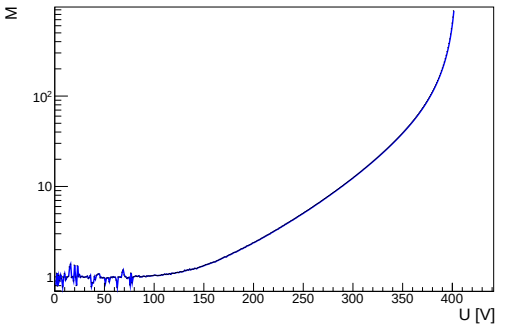


Corrupted Data

- Some data corrupted due to false setup configuration or other reasons





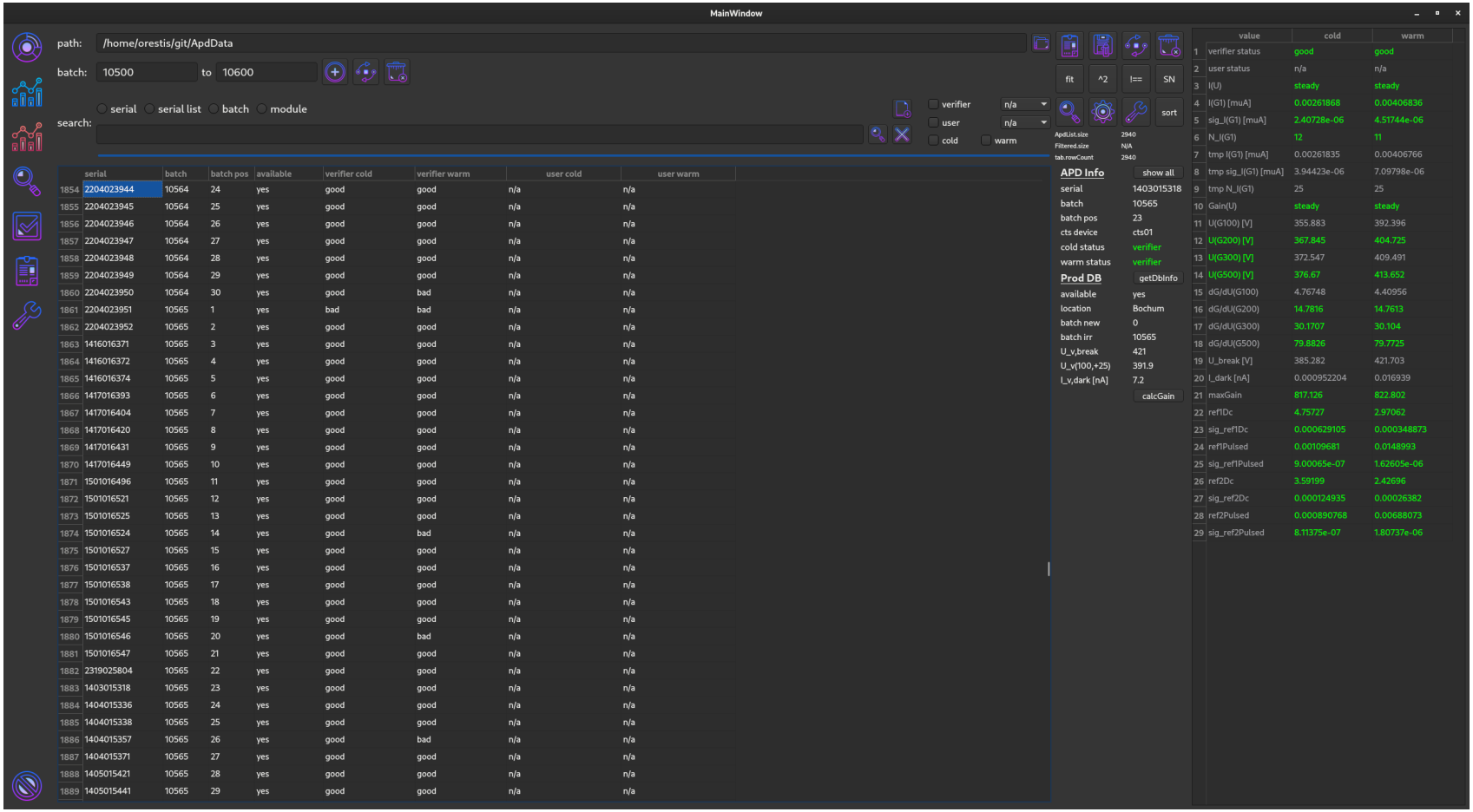


- Corrupted data must be found and affected APDs need to be remeasured (if possible)

→ Algorithm to test screening data for expected values and behaviour, e.g.:
  - Difference between warm and cold gain voltage e.g. $U(200, -25) - U(200, 20)$
  - Variance of current for gain one
  - Steadily increasing light current above $0.1\,\mu\mathrm{A}$

- Supposedly corrupted data has to be checked manually
- Framework and algorithm for this task is in development

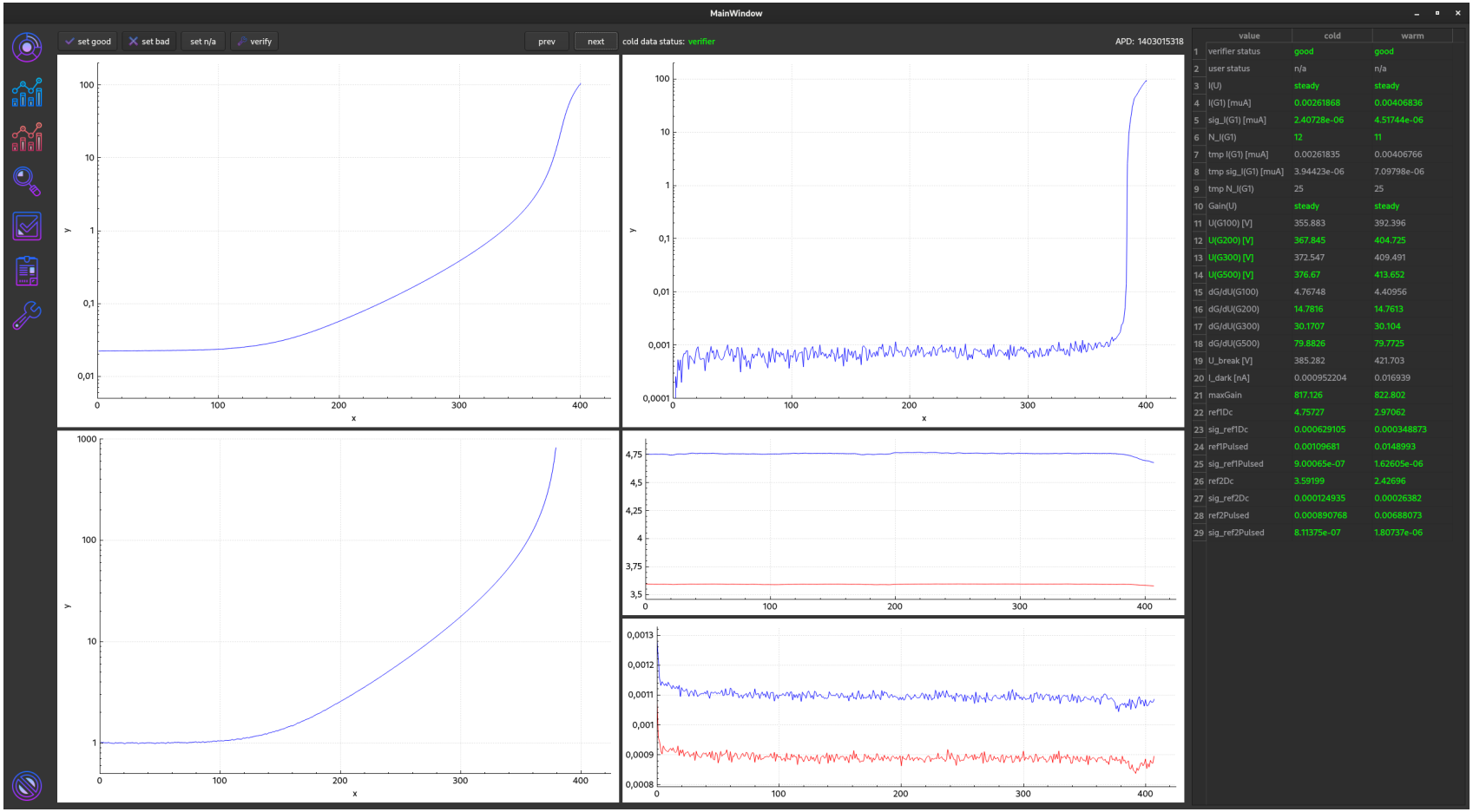
Corrupted Data



	serial	batch	batch pos	available	verifier cold	verifier warm	user cold	user warm
1854	2204023944	10564	24	yes	good	good	n/a	n/a
1855	2204023945	10564	25	yes	good	good	n/a	n/a
1856	2204023946	10564	26	yes	good	good	n/a	n/a
1857	2204023947	10564	27	yes	good	good	n/a	n/a
1858	2204023948	10564	28	yes	good	good	n/a	n/a
1859	2204023949	10564	29	yes	good	good	n/a	n/a
1860	2204023950	10564	30	yes	good	bad	n/a	n/a
1861	2204023951	10565	1	yes	bad	bad	n/a	n/a
1862	2204023952	10565	2	yes	good	good	n/a	n/a
1863	1416016371	10565	3	yes	good	good	n/a	n/a
1864	1416016372	10565	4	yes	good	good	n/a	n/a
1865	1416016374	10565	5	yes	good	good	n/a	n/a
1866	1417016393	10565	6	yes	good	good	n/a	n/a
1867	1417016404	10565	7	yes	good	good	n/a	n/a
1868	1417016420	10565	8	yes	good	good	n/a	n/a
1869	1417016431	10565	9	yes	good	good	n/a	n/a
1870	1417016449	10565	10	yes	good	good	n/a	n/a
1871	1501016496	10565	11	yes	good	good	n/a	n/a
1872	1501016521	10565	12	yes	good	good	n/a	n/a
1873	1501016525	10565	13	yes	good	good	n/a	n/a
1874	1501016524	10565	14	yes	good	bad	n/a	n/a
1875	1501016527	10565	15	yes	good	good	n/a	n/a
1876	1501016537	10565	16	yes	good	good	n/a	n/a
1877	1501016538	10565	17	yes	good	good	n/a	n/a
1878	1501016543	10565	18	yes	good	good	n/a	n/a
1879	1501016545	10565	19	yes	good	good	n/a	n/a
1880	1501016546	10565	20	yes	good	bad	n/a	n/a
1881	1501016547	10565	21	yes	good	good	n/a	n/a
1882	2319025804	10565	22	yes	good	good	n/a	n/a
1883	1403015318	10565	23	yes	good	good	n/a	n/a
1884	1404015336	10565	24	yes	good	good	n/a	n/a
1885	1404015338	10565	25	yes	good	good	n/a	n/a
1886	1404015357	10565	26	yes	good	bad	n/a	n/a
1887	1404015371	10565	27	yes	good	good	n/a	n/a
1888	1405015421	10565	28	yes	good	good	n/a	n/a
1889	1405015441	10565	29	yes	good	good	n/a	n/a

	value	cold	warm
1	verifier status	good	good
2	user status	n/a	n/a
3	I(U)	steady	steady
4	I(G1) [muA]	0.00261868	0.00406836
5	sig_I(G1) [muA]	2.40728e-06	4.51744e-06
6	N_I(G1)	12	11
7	tmp I(G1) [muA]	0.00261835	0.00406766
8	tmp sig_I(G1) [muA]	3.94423e-06	7.09798e-06
9	tmp N_I(G1)	25	25
10	Gain(U)	steady	steady
11	U(G100) [V]	355.883	392.396
12	U(G200) [V]	367.845	404.725
13	U(G300) [V]	372.547	409.491
14	U(G500) [V]	376.67	413.652
15	dG/dU(G100)	4.76748	4.40956
16	dG/dU(G200)	14.7816	14.7613
17	dG/dU(G300)	30.1707	30.104
18	dG/dU(G500)	79.8826	79.7725
19	U_break [V]	385.282	421.703
20	I_dark [nA]	0.000952204	0.016939
21	maxGain	817.126	822.802
22	ref1Dc	4.75727	2.97062
23	sig_ref1Dc	0.000629105	0.000348873
24	ref1Pulsed	0.00109681	0.0148993
25	sig_ref1Pulsed	9.00065e-07	1.62605e-06
26	ref2Dc	3.59199	2.42696
27	sig_ref2Dc	0.000124935	0.00026382
28	ref2Pulsed	0.000890768	0.00688073
29	sig_ref2Pulsed	8.11375e-07	1.80737e-06

Corrupted Data



Thanks for your attention