Analysis of noise in production VPTs at 1.8T

II. VPTs with bar-codes 1501-5000

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1. Introduction

While most of the VPTs supplied by RIE perform satisfactorily in the RAL 1.8T test rig, a minority (approximately 6%) display discharges at 1.8T, making them unsuitable for use in the CMS experiment. This note summarises the VPTs with bar-codes in the range 1501-5000 which are observed to behave in this way, and supersedes a previous note [1] covering the bar-code range 3501-5000. A complete report on discharges observed in the remaining tubes delivered so far will be compiled as soon as possible.

2. Rapid changes in VPT response

Some VPTs display rapid changes in response during the course of acceptance testing. This is common at low magnetic fields, but most of the VPTs become stable at fields above 1T. However, a small proportion continue to display this behaviour at 1.8T.

2.1 Response of stable VPTs

Figure 1 shows the expected response of a VPT to a sequence of light pulses. The tube was operated under the standard conditions, in a 1.8T magnetic field with the cathode earthed and the dynode and anode at 800V and 1000V respectively. The upper plot shows the VPT response to a set of 5000 light pulses at a frequency of approximately 80Hz, while the lower plot is a histogram of the response. The plot covers a period of approximately 1 minute.

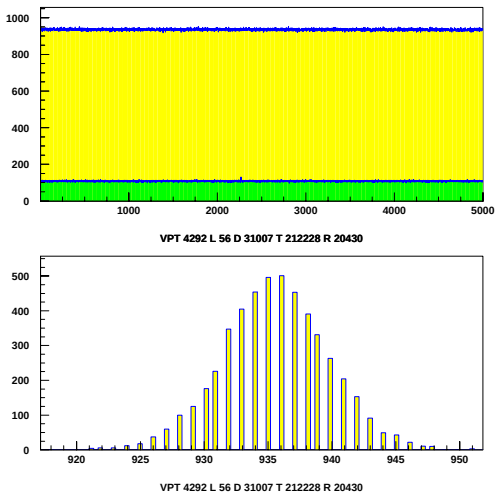

Figure 1. VPT 4292 - constant response to a series of uniform light pulses.

A stable VPT such as this generates a characteristic pattern of response as a function of angle to the magnetic field. Figure 2 shows the complete angle and magnetic-field scans obtained from VPT 4292. The response (shown by solid circles) varies in a periodic manner with angle in a 1.8T magnetic field, and is stable at fields above 1T (with the VPT held at an angle of 15° to they magnetic field). The response at each scan point is Gaussian, as shown in Figure 1, with a Gaussian width of approximately 3 ADC counts (shown by the open symbols, which refer to the scale on the right of the figure).

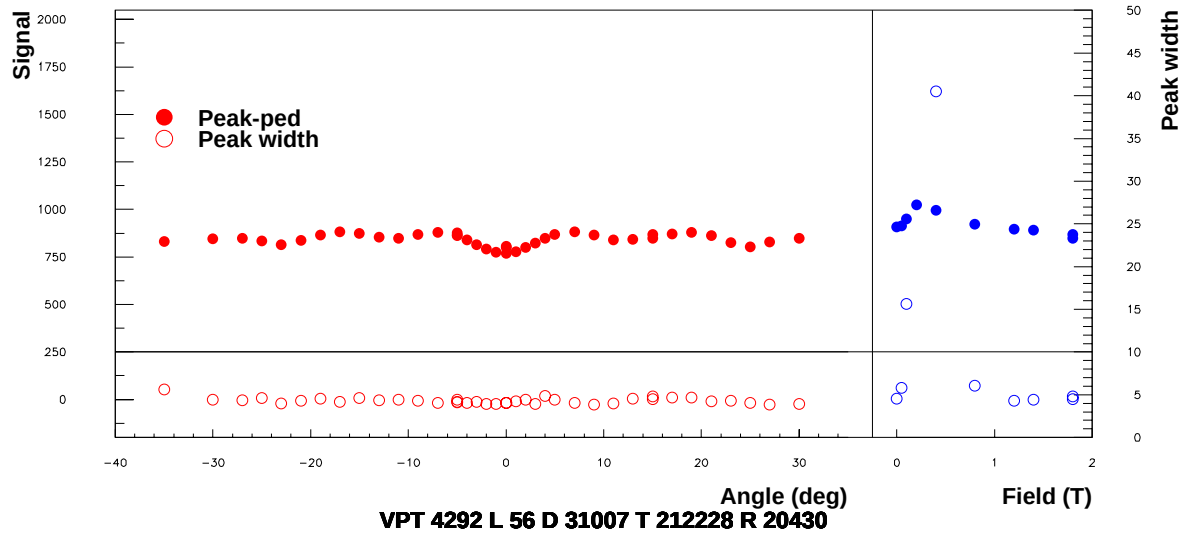

Figure 2. Angle and field scans on VPT 4292.

Some VPTs however display sharp spikes in the measured output, which are attributed to discharges occurring inside the VPT. An example of this behaviour is shown in Figure 3, taken from VPT 4756 at an angle of 17° to the 1.8T magnetic field. These spikes are reproducible over a period of many months, and can be made less severe by reducing the operating voltage of the VPTs, as described in [2].

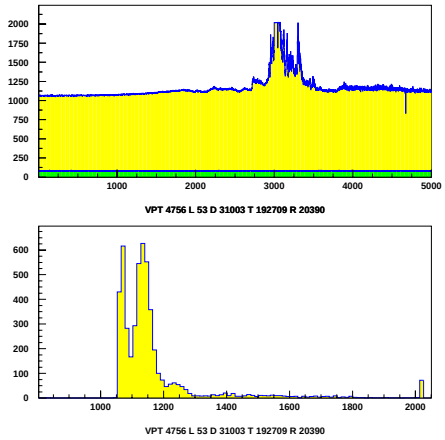

Figure 3. Discharge at an angle of 17° to the magnetic field.

3. VPTs displaying discharges

A complete list of VPTs showing spikes of the kind illustrated in Figure 3 is given in Table 1. This list covers all tubes with bar-codes in the range 1501-5000. Table 2 lists the same devices in order of their RIE production number.

Bar-code range	Noisy	Bar-codes of noisy VPTs
1501-1600	8	1503 1508 1529 1546 1550 1553 1559 1571
1601-1700	8	1613 1615 1616 1619 1638 1639 1641 1672
1701-1800	8	1700 1708 1742 1745 1752 1758 1765 1794
1801-1900	8	1808 1829 1837 1846 1852 1853 1855 1875
1901-2000	6	1905 1937 1944 1950 1996 1999
2001-2100	10	2020 2036 2042 2058 2062 2064 2085 2089 2090 2096
2101-2200	4	2134 2156 2174 2179
2201-2300	6	2212 2220 2228 2256 2283 2299
2301-2400	4	2310 2319 2382 2395
2401-2500	5	2400 2413 2448 2456 2461
2501-2600	2	2564 2579
2601-2700	6	2635 2647 2669 2697 2698 2699
2701-2800	2	2712 2719
2801-2900	3	2804 2830 2896
2901-3000	2	2902 2947
3001-3100	3	3065 3070 3086
3101-3200	2	3117 3174
3201-3300	3	3215 3227 3249
3301-3400	4	3322 3339 3368 3373
3401-3500	1	3422
3501-3600	3	3511 3592 3594
3601-3700	3	3610 3647 3663
3701-3800	10	3704 3705 3714 3744 3756 3760 3762 3782 3786 3798
3801-3900	4	3822 3826 3833 3836
3901-4000	12	3903 3904 3907 3909 3911 3928 3930 3932 3946 3951 3956 3985
4001-4100	8	4000 4010 4013 4017 4046 4059 4082 4090
4101-4200	5	4107 4124 4150 4151 4157
4201-4300	5	4205 4210 4212 4221 4281
4301-4400	11	4303 4314 4326 4328 4336 4353 4374 4377 4385 4393 4399
4401-4500	3	4409 4465 4490
4501-4600	8	4508 4509 4517 4519 4550 4563 4565 4568
4601-4700	7	4623 4626 4642 4644 4649 4650 4661
4701-4800	12	4701 4705 4710 4718 4731 4754 4756 4758 4765 4775 4784 4786
4801-4900	5	4833 4844 4848 4867 4899
4901-5000	5	4900 4908 4945 4980 4983
1501-5000	**196**	

Table 1. Bar codes of VPTs displaying discharges in a 1.8T magnetic field

PN range	VPTs in range	Noisy	PNs of noisy VPTs
<2501	21	0	
2501-2600	5	0	
2601-2700	4	0	
2701-2800	4	2	2770 2791
2801-2900	7	1	2884
2901-3000	10	1	2982
3001-3100	36	1	3042
3101-3200	62	6	3109 3121 3130 3132 3144 3176
3201-3300	58	7	3215 3221 3222 3269 3270 3272 3292
3301-3400	58	3	3313 3388 3397
3401-3500	57	4	3406 3468 3473 3492
3501-3600	56	5	3536 3555 3567 3571 3598
3601-3700	50	3	3621 3676 3697
3701-3800	57	3	3708 3719 3752
3801-3900	49	3	3819 3835 3842
3901-4000	63	5	3914 3924 3950 3979 3985
4001-4100	60	5	4013 4019 4066 4074 4087
4101-4200	56	3	4132 4133 4186
4201-4300	66	6	4235 4245 4247 4254 4284 4294
4301-4400	43	3	4320 4375 4395
4401-4500	45	2	4443 4453
4501-4600	44	2	4562 4568
4601-4700	53	0	
4701-4800	37	2	4733 4799
4801-4900	48	1	4808
4901-5000	46	4	4918 4922 4927 4967
5001-5100	55	1	5086
5101-5200	51	1	5143
5201-5300	55	3	5207 5251 5288
5301-5400	53	4	5307 5310 5315 5335
5401-5500	50	1	5467
5501-5600	48	1	5570
5601-5700	57	1	5671
5701-5800	40	3	5704 5747 5794
5801-5900	54	0	
5901-6000	43	0	
6001-6100	41	3	6046 6056 6093
6101-6200	52	1	6161
6201-6300	48	3	6259 6287 6293
6301-6400	62	1	6312
6401-6500	54	2	6413 6451
6501-6600	74	1	6511
6601-6700	65	3	6636 6684 6691
6701-6800	69	1	6739
6801-6900	46	3	6815 6834 6887
6901-7000	65	2	6923 6993
7001-7100	67	7	7005 7012 7019 7053 7075 7087 7099
7101-7200	68	1	7134
7201-7300	72	9	7241 7252 7262 7274 7279 7281 7292 7295 7298

PN range	VPTs in range	Noisy	PNs of noisy VPTs
7301-7400	61	4	7329 7332 7360 7371
7401-7500	63	1	7468
7501-7600	46	5	7539 7556 7561 7576 7590
7601-7700	57	5	7619 7627 7632 7648 7673
7701-7800	61	1	7739
7801-7900	48	4	7802 7843 7853 7854
7901-8000	55	3	7940 7983 7989
8001-8100	69	1	8021
8101-8200	63	5	8106 8160 8165 8194 8196
8201-8300	66	4	8215 8220 8247 8248
8301-8400	70	9	8301 8311 8319 8325 8331 8353 8376 8381 8396
8401-8500	65	6	8426 8438 8443 8453 8454 8483
8501-8600	76	2	8514 8581
8601-8700	65	1	8623
8701-8800	51	7	8707 8744 8746 8773 8784 8785 8798
8801-8900	53	5	8820 8850 8855 8871 8891
8901-9000	51	5	8901 8904 8928 8931 8945
9001-9100	20	0	
9101-9200	0	0	
9201-9300	47	2	9248 9259
9301-9400	29	2	9303 9364
2701-9400		**196**	

Table 2. Production numbers of VPTs displaying discharges in a 1.8T magnetic field

The distributions of the noisy VPTs as a function of bar-code number and production number show very distinct peaks and troughs; this structure may help in understanding the cause of the observed discharges. For example, of the 1082 VPTs with production numbers in the range 5001-7000, 35 (3.2%) show discharges, while of the 1226 tubes with production numbers in the range 7001-9000, 85 (6.9%) show discharges.

Table 3 gives more detailed information on these VPTs, including the angle at which the discharges were first observed. In this table the VPTs are again ordered by the RIE production number rather than the bar code. The angle can be positive or negative, according to the alignment of the VPT in the 1.8T test rig.

RIE Production number	Bar code	Angle to 1.8T field (deg)
2770	1905	13
2791	1550	-35
2884	3956	11
2982	1508	-35
3042	1503	11
3109	1529	13
3121	1559	15
3130	1553	17
3132	1546	-35
3144	1571	-35
3176	1619	-35
3215	1613	-35
3221	1615	-35

RIE Production number	Bar code	Angle to 1.8T field (deg)
3222	1616	-35
3269	1638	11
3270	1639	15
3272	1641	-35
3292	2179	-10
3313	1672	-35
3388	1700	-25
3397	1708	-35
3406	4157	-27
3468	1742	13
3473	1745	15
3492	1765	25
3536	1758	-35
3555	1752	13
3567	1808	17
3571	1794	19
3598	1837	-35
3621	1846	13
3676	1829	-19
3697	1852	11
3708	1853	15
3719	1855	-27
3752	1875	-35
3819	1944	19
3835	1950	19
3842	1937	15
3914	1996	27
3924	1999	17
3950	2042	23
3979	2020	19
3985	2036	9
4013	2058	-35
4019	2085	11
4066	2062	11
4074	2064	23
4087	2096	27
4132	2089	19
4133	2090	13
4186	2134	-19
4235	2156	13
4245	2174	17
4247	3117	-35
4254	3798	-30
4284	2212	20
4294	2228	13
4320	2220	-35
4375	2256	15
4395	2283	17
4443	2299	17
4453	2319	-30
4562	2310	25

RIE Production number	Bar code	Angle to 1.8T field (deg)
4568	2395	-35
4733	2413	17
4799	2461	-35
4808	2456	11
4918	2382	-35
4922	2400	-35
4927	2448	-23
4967	2564	-35
5086	2579	-35
5143	2635	-35
5207	2647	-35
5251	2669	-35
5288	2697	-19
5307	2698	-35
5310	2699	11
5315	2719	-35
5335	2712	-35
5467	2896	21
5570	2804	-35
5671	2830	17
5704	2902	11
5747	2947	23
5794	3907	-35
6046	3086	13
6056	3065	11
6093	3070	15
6161	3174	19
6259	3322	-35
6287	4303	17
6293	3786	-35
6312	3249	-35
6413	3215	21
6451	3227	-30
6511	3368	-35
6636	3714	25
6684	3782	-35
6691	3339	-35
6739	3373	-35
6815	3511	-35
6834	3422	-35
6887	3909	13
6923	3911	-35
6993	3592	-35
7005	3594	-35
7012	3610	-35
7019	3663	-35
7053	4833	-35
7075	3647	-35
7087	3903	-35
7099	3985	21
7134	3705	-30

RIE Production number	Bar code	Angle to 1.8T field (deg)
7241	3833	21
7252	3704	-35
7262	4046	-35
7274	3762	-25
7279	3760	23
7281	4212	-15
7292	3822	21
7295	3756	13
7298	3744	30
7329	3826	-35
7332	4124	-27
7360	3836	-25
7371	3904	11
7468	4059	-35
7539	3928	-1
7556	3930	-35
7561	3932	-35
7576	3946	21
7590	3951	11
7619	4000	-35
7627	4010	-35
7632	4013	-35
7648	4017	-35
7673	4082	-35
7739	4090	5
7802	4107	-23
7843	4150	13
7853	4899	-30
7854	4151	17
7940	4900	23
7983	4210	15
7989	4393	-35
8021	4221	-35
8106	4205	-30
8160	4385	-35
8165	4281	-35
8194	4326	-35
8196	4314	-35
8215	4328	19
8220	4353	-30
8247	4336	-35
8248	4399	27
8301	4374	-21
8311	4409	-35
8319	4377	17
8325	4983	19
8331	4508	23
8353	4908	19
8376	4465	-35
8381	4509	-25
8396	4490	-30

RIE Production number	Bar code	Angle to 1.8T field (deg)
8426	4517	-27
8438	4519	-35
8443	4550	-30
8453	4786	-35
8454	4642	-35
8483	4563	17
8514	4565	-35
8581	4710	-35
8623	4718	-30
8707	4568	27
8744	4644	13
8746	4623	15
8773	4626	-35
8784	4649	-35
8785	4650	-30
8798	4661	-27
8820	4701	-35
8850	4775	17
8855	4754	13
8871	4705	-35
8891	4731	-35
8901	4756	21
8904	4758	23
8928	4765	-35
8931	4848	-27
8945	4784	-35
9248	4844	9
9259	4867	23
9303	4945	19
9364	4980	-35

Table 3. Details of VPTs displaying discharges, ordered by RIE production number.

4. Summary and conclusions

This note has presented data on the bar-codes and production numbers of all VPTs with bar-codes in the range 1501-5000 which have displayed discharges when measured in the RAL 1.8T test rig. The distribution of these devices in bar-code number is not uniform, and this may help to understand the cause of the discharge behaviour.

5. References

[1] 'Analysis of noise in production VPTs at 1.8T: I. VPTs with bar-codes 3501-5000', B W Kennedy, 14 October 2003
[2] 'Observation of noise in production VPTs at 1.8T', B W Kennedy, 10 February 2003