Swfit UV-OT

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The effect of power-off on a Swfit image intensifier

Document Number: Swift-UVOT/MSSL/TN/007.01 **30-January-01**

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30 January 2001
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1. Time profile

Voltages at impulsive phase of the sudden power off were measured at anode, MCP_out and MCP_in points with a low capacitance probe. Figs. 1a, b and c show the voltages relative to ground recorded by a digital oscilloscope, Tektronix TDS3054.

The bleeding resistor in the HV unit for the photocathode gap is small, 0.05 GΩ, while the probe 1 GΩ. Therefore, the fall time of the photocathode gap voltage was not affected by the probe. It was 260V in the first 80ms.

The bleeding resistor in the HV unit for the MCPs and the resistance of the MCPs itself are compatible with the probe resistance, i.e. 1.0 GΩ and 0.5 GΩ. The fall time of the MCPs voltage was fasten by the 1 GΩ probe by the factor of 1.33. The observed fall time was 500V in the first 80ms, therefore the true fall time is estimated to be 375V/80ms, ignoring the behavior of cathode gap voltage. Since the voltage fall is faster than that at photocathode gap, over voltage will not be applied to the MCPs during the impulsive phase.

The bleeding resistor in the HV unit for the anode gap and the resistance of the gap itself are higher than 1GΩ of the probe, i.e. 5.3 GΩ and 400GΩ. The fall time of the anode voltage was fasten by the probe by significant factor, ~6 times. The observed fall time was 400V in the first 80ms. The true fall time is estimated to be between 650V/80ms and 233V/80ms depending on the stray capacitance due to the fibre block. If the stray capacitance is far larger than the anode capacitor in the HV unit, the anode voltage can fall slower than that at MCP_out, hence over voltage can be applied to the anode gap during the impulsive phase. The time constant created by the anode capacitance, 250pF, and effective bleeding resistance in the measurement, 0.84GΩ, is 210ms, while observed 260ms. This indicates non-negligible current was fedback from the fibre block, which slowed down the falling time. It is essential to use a probe with low capacitance as well as high resistance in order to measure time profile more precisely.

2. Currents across MCPs and anode gap

To measure the small currents at high D.C voltages, a resister of 99.91kΩ was inserted at the anode or MCP_out cables, and the small voltage drop across the resister was measured with a precision multimeter, FLUKE 87 IV, in the minimum readout of 1uV. The FLUKE 87 IV was also used for the precise calibration of the resistor. The input impedance of Fluke 87IV is 10MΩ, therefore anode or MCP currents were multiplied by the factor of 1.01.

The MCP current vs. applied voltage was measured before starting the sudden power off test (Table 1). It was measured again after 5 times of the sudden power off, 100 times of the power off, and 200 times of the power off. The results are tabulated in Tables 2-4. The resistance of the MCPs at 1800V after 5 times of power off showed slightly smaller value than that after 100 times by 1% and 200 times by 1%. But, these small differences are marginal. The resistance of the MCPs at 1800V before starting the power off test showed noticeably smaller value than that after 5 times by 4%. Since the measurement before the power off test was carried out with a different HV unit and with a different voltage meter, the difference of 4% may be due to inaccuracy of the different voltage meter.

The resistance of MCP has negative voltage coefficient of -3.3%/kV (between 800-1800V) before the power off test, -7.8%/kV after 5 times power off, -9.0%/kV after 100 times and -6.8%/kV after 200 times. The voltage coefficient might be steepened by the sudden power-off, but again the small change is marginal.

The warm up effect was purposely investigated after 200 times power-off. There is very little increase of resistance by 1% after 40min warm up at photon counting voltages. The warm up effect was too small to be detected in other measurements (Tables 1-4).

As a short summary, there was not distinguished change in MCP current.

The anode current vs. applied voltage was measured before starting the sudden power off test (Table 6). It was measured again after 5 times of the sudden power off, after 100 times and after completing 200 times of the power off. The results are tabulated in Tables 7-12. Since there is significant warm up effect on the resistance, 30% per 50min (see Table 8), it is difficult to compare the difference without history of applied voltage. Resistance of the anode gap at photon counting voltage was 400 GΩ before the power off test and 494-366 GΩ depending on warm up level after 100 times of the power-off. The change of resistance by the power-off test is within the uncertainty.

The resistance of the anode gap has negative voltage coefficient of -11.5%/kV (between 1200-5000V) after 5 times of the power-off. For comparison without the warm up effect, anode voltage was applied with exactly same time sequence as that at the 5th power off, after completing 200 times power off. The intensifier was kept power-off over weekend, and then the anode voltage was applied 3 times until the intensifier reached the same warm up level as at the 5th power off. From the resistance at photon counting voltage, the intensifier seemed to be in the same warm up level between Tables 11 and 12. The voltage coefficient between the 2 tables was -19.6%/kV (1200-5000V), whose absolute value was bigger than that at the 5th power off.

The warm up effect was not purposely investigated before 100 times power-off. It was kept at the photon counting voltage only for 3 min at the 5th power off. There was not detectable change within 0.4% accuracy. While, Tables 11 and 12 at the 200th power off showed decrease of the resistance by 2.6% for the 3 min. This small difference may be

due to the effect of other factors, for instance humidity and temperature around fiber taper.

As a short summary, there are indications of minor change in characteristics of anode current.

3. F-F image in analog mode with low gain

F-F images were acquired in low gain analog mode throughout the 200 times power off test. Since the response of MCP is more linear in low gain than that in high gain, their F-Fs are more sensitive to minor change of MCPs. Another benefit is permission of intense illumination for the F-Fs, hence the higher S/N can be obtained in a short time period.

Raw F-F images in Fig. 2 show pinhole array pattern in the left boundary and in the near centre. These were caused by intense pinhole illumination 1 year ago. Figs. 3a and 3b show high contrast F-F images divided by the original F-F before starting the power-off test. It is clear that the pinhole array pattern came out gradually with the sequence of power-off. It reached maximum around 30-40th power off and stayed in the same level.

The brightness of acquired F-F was not stable, varied a little measurement-by-measurement. There is, however, no systematic change in the brightness throughout the 200 times power off. There was no correlation between the pinhole images and acquired F-F brightness. The change may not be due to MCP gain but simply to the light source.

There is stripe pattern in the right boundary. It was turned out to be interference pattern and not to be created by the power offs. The details will be discussed in the next section.

4. F-F image in photon counting gain

F-F images were acquired in analog mode with high gain throughout the 200 times power off test. Since the response of MCP is saturated, it is not easy to detect minor change of MCPs. But, this represents the real detector operation. Since the F-F illuminations had to be faint, 2000 frames were acquired to obtain reasonable S/N. Again, raw F-F images in Fig. 4 show pinhole array patterns in the left boundary and in the near centre. Fig. 5 shows high contrast F-F images divided by the F-F before starting the power-off test. The pinhole array pattern disappeared in this high gain F-F. This means the gain at pinhole positions did not change in this saturated operation. Fig. 6 shows a F-F acquired in photon counting mode after 100 times power off. There is no symptom by the power off test, as expected.

The stripe pattern was seen in the left boundary, as seen in the low gain F-Fs. The amplitude and position seen in a high gain F-F were exactly same as those in a low gain F-F, if the 2 F-Fs were acquired closely in time. The top left panel of Fig. 5 is the ratio

of a high gain F-F to a low gain F-F at the 30th power off. The stripe pattern was cancelled cleanly, though pinhole pattern was distinctly remain. This evidence implies that the stripe pattern was not originated in MCPs.

The CCD camera was rotated by 180 degrees and attached to the image intensifier with maximum carefulness to avoid the air gap between CCD and fibre block of the image intensifier, after completing 100 times power off. Fig. 7a shows the 2 F-F images before and after the adjustment, displayed in positive. Fig. 7b in negative. The images in the right panel were rotated by 180 degree inside computer for the comparison. There are 3 stripe patterns in the left panel, while no stripe in the right panel. This concludes that the black stripe pattern is caused by optical interference at the air gap.

5. Dark image in high gain

Fig. 8 shows dark images acquired in photon counting mode before starting the power off test and after the 50 times power off. The photocathode was off to emphasize SW-on channels within the MCPs. There is no difference. Fig. 9 shows dark image in analog mode with photon counting gain after the 100 times of power off. The bright points in the figure existed from the beginning. There is no other significant feature.

6. Summary

a) No change was detected in MCP current after 200 times sudden power off.
b) No change was distinguished in anode current after 200 times sudden power off. Warm up effect and voltage dependence might be amplified a little by the power offs.
c) Excessively used points changed their gains in the low gain operation by the power off test. The change reached maximum at the 30th power off.
d) No change was seen in photon counting gain during 100 times power-off
e) No change was seen in photon counting image during 100 times power-off
f) No SW-on channel was newly created by the 100 times power-off
g) MCP is protected from over voltage during impulsive phase of the sudden power off.

This report has proven the ruggedness of Swift intensifier against sudden power off. But, there are a few indications on very minor change of anode gap and MCP characteristics. Therefore, it is strongly recommended to ramp up and ramp down the intensifier voltages slowly at all the times.

Mr. R. Card and Mr. Garry Davison provided a H.V. unit, which was used throughout this experiment.
Mr. P. Thomas provided a CCD camera, which was used for establishing measurement procedure of this experiment.

Table 1. MCP current vs. voltage Power-OFF #000
14:33 - 14:47 1999/05/11

Voltage	Current	Resistance
0V	0.010μA	
200V	0.359	573 MΩ
400V	0.732	554
600V	1.100	550
800V	1.462	551
1000V	1.837	547
1200V	2.211	545
1400V	2.600	541
1600V	2.996	536
1800V	3.388	533

Table 2. MCP current vs. voltage Power-OFF #005
15:59 - 16:11 2000/12/19

Voltage	Current	Resistance	Time
0V	-0.002μA		
500V	0.786	636 MΩ	16:00
800V	1.330	602	
1000V	1.678	596	
1200V	2.069	580	
1400V	2.447	572	16:03
1600V	2.818	568	16:03
1800V	3.231	557	16:04
2000V	3.625	552	16:05
2250V	4.150	542	16:06
2000V	3.641	549	16:06
1800V	3.244	555	16:07
1600V	2.849	562	16:07
1400V	2.450	571	16:08
1200V	2.064	581	
1000V	1.677	596	
800V	1.322	605	
500V	.797	627	16:10
0V	-0.002(offset)		

Table 3. MCP current vs. voltage Power-OFF #100
16:34 - 16:48 2001/01/05

Voltage	Current	Resistance	Time
0V	-0.001μA		
500V	0.769	650 MΩ	16:35
800V	1.298	616	
1000V	1.663	601	
1200V	2.043	587	
1400V	2.417	579	16:38
1600V	2.812	569	16:39
1800V	3.196	563	16:39
2000V	3.595	556	16:41
2250V	4.120	546	16:42
2000V	3.610	554	16:43
1800V	3.216	560	16:43
1600V	2.826	566	16:44
1400V	2.438	574	16:45
1200V	2.059	583	
1000V	1.673	598	
800V	1.312	610	
500V	0.778	643	16:48
0V	-0.002(offset)		

Table 4. MCP current vs. voltage Power-OFF #200
10:10 - 10:22 2001/01/26

Voltage	Current	Resistance	Time
0V	-0.000μA		
500V	0.797	627 MΩ	10:11
800V	1.325	604	
1000V	1.674	597	
1200V	2.062	582	
1400V	2.430	576	10:14
1600V	2.800	571	10:14
1800V	3.194	564	10:15
2000V	3.583	558	10:16
2250V	4.097	549	10:17
2000V	3.594	556	10:17
1800V	3.210	560	10:18
1600V	2.819	568	10:18
1400V	2.436	575	10:19
1200V	2.059	583	
1000V	1.680	595	
800V	1.334	600	
500V	0.803	623 MΩ	10:22
0V	-0.002(offset)		

Table 5. MCP current vs. voltage, warm-up effect

Power-OFF #200 11:10 - 12:03 2001/01/26

Voltage	Current	Resistance	Time
0V	-0.002mA		
500V	0.798	627 MΩ	11:11
800V	1.325	604	
1000V	1.683	594	
1200V	2.044	587	
1400V	2.427	577	11:14
1600V	2.807	570	11:14
1800V	3.199	563	11:15
2000V	3.589	557	11:16
2250V	4.102	549	11:17
2250V	4.148	542	11:58
2000V	3.634	550	11:59
1800V	3.242	555	12:00
1600V	2.840	563	12:00
1400V	2.460	569	12:00
1200V	2.081	577	
1000V	1.695	590	
800V	1.335	599	
500V	0.808	619 MΩ	12:02
0V	-0.002(offset)		

Table 6. Anode current vs. voltage Power-OFF #000
2000/08/20

Voltage	Current	Resistance	Time
5370V	13.43 nA	400 GΩ	

Table 7. Anode current vs. voltage Power-OFF #005
14:36 - 15:47 2000/12/19

Voltage	Current	Resistance	Time
0V	-0.3 nA		
1220V	1.63	748 GΩ	14:37
2090V	2.73	766	
2640V	3.72	710	
3230V	4.96	651	
3810V	6.48	588	14:39
4400V	8.28	531	
5000V	10.40	481	14:40
5000V	10.39	481	14:41
5000V	10.55	474	14:42
5000V	10.44	479	14:43
5000V	10.35	483	14:43
4380V	8.27	530	14:43
3810V	6.19	616	14:44
3230V	5.05	640	
2660V	3.66	727	
2080V	2.60	800	
1240V	1.40	886	15:47
0V	-0.6 (offset)		

Table 8. Anode current vs. voltage Power-OFF #100
2001/01/08

Voltage	Current	Resistance	Time
0V	- 0.02 nA		
1220V	0.93	1312 GΩ	14:07
2090V	2.14	977	
2640V	3.26	810	
3230V	4.57	707	
3810V	6.09	626	
4400V	8.01	549	
5000V	10.13	494	14:11
5000V	10.13	494	14:12
5000V	10.53	475	14:13

5000V	10.84	461	14:15
5000V	11.44	437	14:20
5000V	13.67	366	15:00
5000V	13.67	366	
5010V	13.67	366	
4380V	10.63	412	
3810V	8.31	458	
3230V	6.19	522	
2660V	4.47	595	
2080V	2.95	705	
1240V	----	---	15:07
0V	- 0.20(offset)		

Table 9. Anode current vs. voltage Power-OFF #100
16:28 - 16:54 2001/01/08

Voltage	Current	Resistance	Time
0V	- 0.10 nA		
1220V	1.21	1008 GΩ	16:29
2060V	2.53	814	
2640V	3.74	706	
3230V	5.26	614	
3800V	7.08	537	
4380V	9.30	471	
4980V	11.83	420	16:34
4980V	12.03	414	16:35
4980V	12.23	407	16:36
4980V	13.45	370	16:46
4980V	13.45	370	16:47
4980V	13.55	368	16:48
4380V	10.72	409	
3790V	8.39	452	
3220V	6.27	514	
2650V	4.55	582	
2070V	2.93	706	
1230V	1.31	939	16:53
0V	- 0.51(offset)		

Table 10. Anode current vs. voltage Power-OFF #200
11:55 - 12:07 2001/01/22

Voltage	Current	Resistance	Time
0V	- 0.02 nA		
1220V	0.90	1356 GΩ	11:56
2090V	2.03	1030	
2640V	2.80	942	
3230V	3.98	812	
3810V	5.34	713	
4400V	6.85	642	
5000V	8.81	568	11:59
5000V	8.91	561	12:00
5000V	9.13	548	12:01
5000V	9.22	542	12:02
5000V	9.20	543	12:02
4380V	7.35	596	
3810V	5.70	668	
3230V	4.19	771	
2660V	2.99	890	
2080V	1.99	1045	
1240V	0.87	1425	12:06
0V	- 0.51(offset)		

Table 11. Anode current vs. voltage Power-OFF #200
12:15 - 12:28 2001/01/22

Voltage	Current	Resistance	Time
0V	- 0.02 nA		
1220V	1.07	1140 GΩ	12:16
2090V	2.24	933	
2640V	3.37	783	
3230V	4.54	711	
3810V	6.00	635	
4400V	7.77	566	
5000V	9.86	507	12:18
5000V	9.97	502	12:20
5000V	10.09	496	12:21
5000V	10.14	493	12:22
5000V	10.14	493	12:22
4380V	7.95	551	
3810V	6.15	620	
3230V	4.64	696	
2660V	3.39	785	
2080V	2.20	945	
1240V	0.48	----	12:26
0V	- 0.51(offset)		

Table 12. Anode current vs. voltage Power-OFF #200
12:30 - 12:42 2001/01/22

Voltage	Current	Resistance	Time
0V	- 0.05 nA		
1220V	1.22	1000 GΩ	12:31
2090V	2.52	829	
2640V	3.67	719	
3230V	4.94	654	
3810V	6.53	583	
5000V	9.86	507	12:18
4400V	8.35	527	
5000V	10.53	475	12:34
5000V	10.64	470	12:35
5000V	10.74	466	12:36
5000V	10.81	463	12:37
5000V	10.78	464	12:37
4380V	8.57	511	
3810V	6.76	564	
3230V	5.00	646	
2660V	3.51	758	
2080V	2.35	885	
1240V	1.00	---	12:41
0V	- 0.61(offset)		

Appendix. Measurement procedure with DEP_#8 intensifier

12 Dec 2000 - 26 Jan 2001

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---------------------------------------------------------------------------------------------------------
File Name        Current              Dark                   F-F                  Time(start)
---------------------------------------------------------------------------------------------------------
Before Damage for reference
      current MCPs                                                              1999/05/11
      current Anode                                                             2000/08/20
                                                                                2000/12/11
      current Anode (DEP_#2)                                                  19H 45M
                                                                                2000/12/12
      {Time profile, DEP_#2}                                                  21H 00M
                                                                                2000/12/15
HVu007                                low gain Quad-1 128FRs   21H 22M 58S
HVu008                                low gain Quad-3 128FRs   21H 27M 33S
HVu009                                low gain Quad-2 128FRs   21H 29M 40S
HVu010                                low gain Quad-4 128FRs   21H 34M 06S
HVu011             high gain centre  300S                      21H 39M 52S
                                                                2000/12/16
HVu012             high gain centre 3600S                      14H 49M 11S
HVu013                                low gain Quad-1 128FRs   17H 30M 56S
HVu014                                low gain Quad-3 128FRs   17H 39M 20S
HVu015                                low gain Quad-2 128FRs   17H 46M 08S
HVu016                                low gain Quad-4 128FRs   17H 49M 18S
                                                                2000/12/17
HVu017             high gain centre 3600S                      14H 05M 57S
HVu018             high gain centre 3600S                      15H 22M 08S
                                                                2000/12/18
HVu019                               high gain Quad1 2000FRs   12H 20M 10S
HVu020                               high gain Quad3 2000FRs   12H 39M 00S
HVu021                               high gain Quad2 2000FRs   13H 08M 29S
HVu022                               high gain Quad4 2000FRs   13H 25M 41S

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               Power-OFF #001          2000/12/18   14:48
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HVu023                                low gain Quad-1 128FRs   14H 58M 22S
HVu024                                low gain Quad-3 128FRs   15H 01M 09S
HVu025                                low gain Quad-2 128FRs   15H 03M 22S
HVu026                                low gain Quad-4 128FRs   15H 06M 32S

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               Power-OFF #002          2000/12/18   15:08
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HVu027                                low gain Quad-1 128FRs   16H 04M 30S
HVu028                                low gain Quad-3 128FRs   16H 06M 59S
HVu029                                low gain Quad-2 128FRs   16H 09M 10S
HVu030                                low gain Quad-4 128FRs   16H 11M 27S

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               Power-OFF #003          2000/12/18   16:13
\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/
HVu031                                low gain Quad-1 128FRs   16H 37M 42S
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File Name	Current	Dark	F-F	Time(start)
HVu032			low gain Quad-3 128FRs	16H 39M 50S
HVu033			low gain Quad-2 128FRs	16H 41M 54S
HVu034			low gain Quad-4 128FRs	16H 43M 52S
	Power-OFF #004		2000/12/18	16:52
HVu035			low gain Quad-1 128FRs	17H 36M 16S
HVu036			low gain Quad-3 128FRs	17H 38M 32S
HVu037			low gain Quad-2 128FRs	17H 40M 37S
HVu038			low gain Quad-4 128FRs	17H 42M 29S
	Power-OFF #005		2000/12/18	17:46
HVu039			low gain Quad-1 128FRs	17H 53M 06S
HVu040			low gain Quad-3 128FRs	17H 55M 22S
HVu041			low gain Quad-2 128FRs	17H 57M 21S
HVu042			low gain Quad-4 128FRs	17H 59M 15S
HVu043			high gain Quad1 2000FRs	18H 09M 14S
HVu044			high gain Quad3 2000FRs	18H 26M 58S
HVu045			high gain Quad2 2000FRs	18H 43M 48S
HVu046			high gain Quad4 2000FRs	19H 00M 33S
				2000/12/19
HVu047		high gain centre 3600S		10H 26M 14S
HVu048		high gain centre 3600S		13H 28M 00S
	current MCPs			15H 59M
	current Anode			14H 36M
HVu049			low gain Quad-1 128FRs	15H 35M 58S
HVu051			low gain Quad-2 128FRs	15H 40M 56S
HVu052			low gain Quad-4 128FRs	15H 45M 23S
HVu050			low gain Quad-3 128FRs	15H 48M 21S
	Power-OFF #006		2000/12/19	15:50
HVu053			low gain Quad-1 128FRs	16H 01M 25S
HVu054			low gain Quad-3 128FRs	16H 03M 08S
HVu055			low gain Quad-2 128FRs	16H 09M 43S
HVu056			low gain Quad-4 128FRs	16H 12M 02S
	Power-OFF #007		2000/12/19	16:14
	Power-OFF #008			16:56
	Power-OFF #009			17:00
	Power-OFF #010			17:05
HVu057			low gain Quad-1 128FRs	17H 12M 25S
HVu058			low gain Quad-3 128FRs	17H 14M 29S
HVu059			low gain Quad-2 128FRs	17H 16M 28S
HVu060			low gain Quad-4 128FRs	17H 18M 28S

File Name	Current	Dark	F-F	Time(start)
	Power-OFF #011		2000/12/19	17:23
	Power-OFF #012			17:27
	Power-OFF #013			17:30
	Power-OFF #014			17:34
	Power-OFF #015			17:38
	Power-OFF #016			17:43
	Power-OFF #017			17:46
	Power-OFF #018			17:50
	Power-OFF #019			17:53
	Power-OFF #020			17:57
HVu061		low gain	Quad-1 128FRs	18H 03M 34S
HVu062		low gain	Quad-3 128FRs	18H 05M 27S
HVu063		low gain	Quad-2 128FRs	18H 07M 26S
HVu064		low gain	Quad-4 128FRs	17H 09M 18S
	Power-OFF #021		2000/12/19	18:12
	Power-OFF #022			18:19
	Power-OFF #023			18:26
	Power-OFF #024			18:29
	Power-OFF #025			18:34
	Power-OFF #026			18:37
	Power-OFF #027			18:41
	Power-OFF #028			18:45
	Power-OFF #029			18:48
	Power-OFF #030			18:52
HVu065		low gain	Quad-1 128FRs	18H 58M 09S
HVu066		low gain	Quad-3 128FRs	19H 00M 06S
HVu067		low gain	Quad-2 128FRs	19H 02M 08S
HVu068		low gain	Quad-4 128FRs	19H 04M 23S
HVu069		high gain	Quad1 2000FRs	19H 10M 50S
HVu070		high gain	Quad3 2000FRs	19H 27M 43S
HVu071		high gain	Quad2 2000FRs	19H 44M 33S
HVu072		high gain	Quad4 2000FRs	20H 01M 26S
				2000/12/20
HVu073			Quad-3 3600S	10H 09M 36S
HVu074			Quad-1 3600S	11H 16M 21S
HVu075			Quad-2 3600S	12H 16M 43S
HVu076			Quad-4 3600S	13H 17M 05S
HVu077	high gain centre 3600S			15H 25M 20S
HVu078		low gain	Quad-1 128FRs	17H 08M 06S
HVu079		low gain	Quad-3 128FRs	17H 10M 39S
HVu080		low gain	Quad-2 128FRs	17H 13M 29S
HVu081		low gain	Quad-4 128FRs	17H 15M 24S

File Name	Current	Dark	F-F	Time(start)
	Power-OFF #031		2000/12/20	17:20
	Power-OFF #032			17:27
	Power-OFF #033			17:34
	Power-OFF #034			17:39
	Power-OFF #035			17:43
	Power-OFF #036			17:47
	Power-OFF #037			17:50
	Power-OFF #038			17:53
	Power-OFF #039			17:57
	Power-OFF #040			18:01
HVu082		low gain	Quad-1 128FRs	18H 08M 13S
HVu083		low gain	Quad-3 128FRs	18H 10M 48S
HVu084		low gain	Quad-2 128FRs	18H 12M 50S
HVu085		low gain	Quad-4 128FRs	18H 14M 54S
	Power-OFF #041		2000/12/20	18:24
	Power-OFF #042			18:27
	Power-OFF #043			18:30
	Power-OFF #044			18:33
	Power-OFF #045			18:36
	Power-OFF #046			18:39
	Power-OFF #047			18:42
	Power-OFF #048			18:46
	Power-OFF #049			18:49
	Power-OFF #050			18:52
HVu086		low gain	Quad-1 128FRs	18H 57M 14S
HVu087		low gain	Quad-3 128FRs	18H 59M 45S
HVu088		low gain	Quad-2 128FRs	19H 01M 50S
HVu089		low gain	Quad-4 128FRs	19H 03M 43S
HVu090			Quad-1 3600S	19H 20M 52S
HVu091			Quad-3 3600S	20H 21M 14S
HVu092			Quad-2 3600S	21H 21M 36S
HVu093			Quad-4 3600S	22H 21M 58S
HVu094			Quad-1 3600S	23H 52M 31S
				2000/12/21
HVu095			Quad-3 3600S	00H 52M 53S
HVu096			Quad-2 3600S	01H 53M 15S
HVu097			Quad-4 3600S	02H 53M 37S
Drk098	Quad-1 3600S			10H 39M 55S
Drk099	Quad-3 3600S			11H 49M 17S
Drk100	Quad-2 3600S			12H 49M 39S
Drk101	Quad-4 3600S			13H 50M 01S

File Name	Current	Dark	F-F	Time(start)
	Power-OFF #051		2000/12/21	15:34
	Power-OFF #052			15:39
	Power-OFF #053			17:06
	Power-OFF #054			17:08
	Power-OFF #055			17:13
	Power-OFF #056			17:15
	Power-OFF #057			17:18
	Power-OFF #058			17:21
	Power-OFF #059			17:23
	Power-OFF #060			17:26
HVu102			low gain Quad-1 128FRs	17H 33M 54S
HVu103			low gain Quad-3 128FRs	17H 37M 33S
HVu104			low gain Quad-2 128FRs	17H 39M 52S
HVu105			low gain Quad-4 128FRs	17H 41M 40S
HVu106			Quad-1 3600S	17H 53M 20S
HVu107			Quad-3 3600S	18H 53M 42S
HVu108			Quad-2 3600S	19H 54M 04S
HVu109			Quad-4 3600S	20H 53M 37S
Drk110	Quad-1	3600S		22H 24M 59S
Drk111	Quad-3	3600S		23H 25M 21S
				2000/12/22
Drk112	Quad-2	3600S		00H 25M 43S
Drk113	Quad-4	3600S		01H 26M 05S
HVu114			high gain Quad1 2000FRs	13H 07M 08S
HVu115			high gain Quad3 2000FRs	13H 42M 09S
HVu116			high gain Quad2 2000FRs	14H 17M 55S

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				2001/01/03
HVu117			high gain Quad1 2000FRs	16H 53M 06S
HVu118			high gain Quad3 2000FRs	17H 14M 25S
HVu119			high gain Quad2 2000FRs	17H 35M 43S
HVu120			high gain Quad4 2000FRs	17H 57M 02S
HVu121			Quad-1 3600S	18H 36M 54S
HVu122			Quad-3 3600S	19H 37M 16S
HVu123			Quad-2 3600S	20H 37M 38S
HVu124			Quad-4 3600S	21H 38M 01S
Drk125	Quad-1	3600S		23H 08M 34S
				2001/01/04
Drk126	Quad-3	3600S		00H 08M 56S
Drk127	Quad-2	3600S		01H 09M 18S
Drk128	Quad-4	3600S		01H 26M 05S
HVu129			low gain Quad-1 128FRs	11H 25M 48S
HVu130			low gain Quad-3 128FRs	11H 27M 11S
HVu131			low gain Quad-2 128FRs	11H 28M 35S
HVu132			low gain Quad-4 128FRs	11H 29M 58S

File Name	Current	Dark	F-F	Time(start)
	Power-OFF #061	2001/01/04	11:58	
	Power-OFF #062		12:01	
	Power-OFF #063		12:04	
	Power-OFF #064		12:08	
	Power-OFF #065		12:12	
	Power-OFF #066		12:15	
	Power-OFF #067		12:19	
	Power-OFF #068		12:23	
	Power-OFF #069		12:27	
	Power-OFF #070		12:31	
HVu133		low gain Quad-1 128FRs		12H 36M 28S
HVu134		low gain Quad-3 128FRs		12H 37M 52S
HVu135		low gain Quad-2 128FRs		12H 39M 15S
HVu136		low gain Quad-4 128FRs		12H 40M 38S
	Power-OFF #071	2001/01/04	12:37	
	Power-OFF #072		12:45	
	Power-OFF #073		12:48	
	Power-OFF #074		12:51	
	Power-OFF #075		12:54	
	Power-OFF #076		13:10	
	Power-OFF #077		13:13	
	Power-OFF #078		13:16	
	Power-OFF #079		13:19	
	Power-OFF #080		13:22	
HVu137		low gain Quad-1 128FRs		13H 29M 47S
HVu138		low gain Quad-3 128FRs		13H 31M 10S
HVu139		low gain Quad-2 128FRs		13H 32M 33S
HVu140		low gain Quad-4 128FRs		13H 33M 57S
HVu141		high gain Quad1 2000FRs		13H 42M 17S
HVu142		high gain Quad3 2000FRs		14H 03M 38S
HVu143		high gain Quad2 2000FRs		14H 24M 57S
HVu144		high gain Quad4 2000FRs		14H 46M 17S
	Power-OFF #081	2001/01/04	15:08	
	Power-OFF #082		15:13	
	Power-OFF #083		15:17	
	Power-OFF #084		15:19	
	Power-OFF #085		15:23	
	Power-OFF #086		15:26	
	Power-OFF #087		15:29	
	Power-OFF #088		15:32	
	Power-OFF #089		15:35	
	Power-OFF #090		15:38	
HVu145		low gain Quad-1 128FRs		15H 46M 49S
HVu146		low gain Quad-3 128FRs		15H 48M 13S
HVu147		low gain Quad-2 128FRs		15H 49M 36S
HVu148		low gain Quad-4 128FRs		15H 50M 59S

File Name	Current	Dark	F-F	Time(start)
	Power-OFF #091		2001/01/04	15:53
	Power-OFF #092			15:56
	Power-OFF #093			15:59
	Power-OFF #094			16:02
	Power-OFF #095			16:05
	Power-OFF #096			16:08
	Power-OFF #097			16:12
	Power-OFF #098			16:14
	Power-OFF #099			16:17
	Power-OFF #100			16:20
HVu149		low gain Quad-1	128FRs	16H 26M 57S
HVu150		low gain Quad-3	128FRs	16H 28M 20S
HVu151		low gain Quad-2	128FRs	16H 29M 44S
HVu152		low gain Quad-4	128FRs	16H 31M 07S
HVu153		Quad-1	3600S	17H 15M 05S
HVu154		Quad-3	3600S	18H 15M 27S
HVu155		Quad-2	3600S	19H 15M 49S
HVu156		Quad-4	3600S	20H 16M 11S
Drk157	Quad-1	3600S		21H 46M 44S
Drk158	Quad-3	3600S		22H 47M 06S
Drk159	Quad-2	3600S		23H 47M 28S
				2001/01/05
Drk160	Quad-4	3600S		00H 47M 50S
Drk161	high gain Quad-1	2000FRs		01H 48M 03S
Drk162	high gain Quad-3	2000FRs		02H 09M 26S
Drk163	high gain Quad-2	2000FRs		02H 30M 47S
Drk164	high gain Quad-4	2000FRs		02H 52M 09S
HVu165		high gain Quad1	2000FRs	11H 13M 33S
HVu166		high gain Quad3	2000FRs	11H 34M 54S
HVu167		high gain Quad2	2000FRs	11H 56M 13S
HVu168		high gain Quad4	2000FRs	12H 17M 34S
current MCPs				16H 34M
current Anode				17H 06M
				2001/01/08
current Anode				12H 25M
current Anode				14H 06M
current Anode				16H 29M
current Anode				16H 56M

End of 1st Round

2nd Round **Rotating CCD by 180 degrees**

File Name	Current	Dark	F-F	Time(start)
				2001/01/11
HVu169			low gain Quad-1 128FRs	17H 53M 34S
HVu170			low gain Quad-3 128FRs	17H 54M 58S
HVu171			low gain Quad-2 128FRs	17H 56M 22S
HVu172			low gain Quad-4 128FRs	17H 57M 45S
HVu173			low gain Quad-1 128FRs	18H 15M 07S
HVu174			low gain Quad-3 128FRs	18H 16M 30S
HVu175			low gain Quad-2 128FRs	18H 17M 53S
HVu176			low gain Quad-4 128FRs	18H 19M 17S
HVu177			high gain Qud1 10000FRs	18H 32M 03S
HVu178			high gain Qud3 10000FRs	20H 18M 37S
HVu179			high gain Qud2 10000FRs	22H 05M 08S
HVu180			high gain Qud4 10000FRs	23H 51M 42S
				2001/01/12
HVu181			low gain Quad1 2000FRs	12H 36M 49S
HVu182			low gain Quad3 2000FRs	12H 58M 16S
HVu183			low gain Quad2 2000FRs	13H 19M 42S
HVu184			low gain Quad4 2000FRs	13H 41M 09S

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Power-OFF #101	2001/01/12	14:11
Power-OFF #102		14:12
Power-OFF #103		14:14
Power-OFF #104		14:16
Power-OFF #105		14:18
Power-OFF #106		14:21
Power-OFF #107		14:23
Power-OFF #108		14:25
Power-OFF #109		14:27
Power-OFF #110		14:29
sudden power-UP	14:30	
Power-OFF #111		14:31
Power-OFF #112		14:33
Power-OFF #113		14:36
Power-OFF #114		14:38
Power-OFF #115		14:40
Power-OFF #116		14:42
Power-OFF #117		14:44
Power-OFF #118		14:46
Power-OFF #119		14:47
Power-OFF #120		14:49

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HVu185			low gain Quad-1 250FRs	14H 57M 06S
HVu186			low gain Quad-3 250FRs	14H 59M 49S
HVu187			low gain Quad-2 250FRs	15H 02M 31S
HVu188			low gain Quad-4 250FRs	15H 05M 14S

File Name	Current	Dark	F-F	Time(start)
	Power-OFF #121		2001/01/12	15:08
	Power-OFF #122			15:12
	Power-OFF #123			15:13
	Power-OFF #124			15:16
	Power-OFF #125			15:18
	Power-OFF #126			15:21
	Power-OFF #127			15:22
	Power-OFF #128			15:24
	Power-OFF #129			15:27
	Power-OFF #130			15:28
	Power-OFF #131			15:31
	Power-OFF #132			15:33
	Power-OFF #133			15:35
	Power-OFF #134			15:37
	Power-OFF #135			15:38
	Power-OFF #136			15:41
	Power-OFF #137			15:43
	Power-OFF #138			15:45
	Power-OFF #139			15:47
	Power-OFF #140			15:49
HVu189		low gain Quad-1 250FRs		15H 55M 24S
HVu190		low gain Quad-3 250FRs		15H 58M 07S
HVu191		low gain Quad-2 250FRs		16H 00M 49S
HVu192		low gain Quad-4 250FRs		16H 03M 32S
HVu193		high gain Qud1 10000FRs		16H 17M 37S
HVu194		high gain Qud3 10000FRs		18H 04M 48S
HVu195		high gain Qud2 10000FRs		19H 51M 55S
HVu196		high gain Qud4 10000FRs		21H 39M 05S
				2001/01/15
	Power-OFF #141		2001/01/15	10:52
	Power-OFF #142			11:16
HVu197		low gain Quad-1 250FRs		11H 28M 01S
HVu198		low gain Quad-3 250FRs		11H 30M 44S
HVu199		low gain Quad-2 250FRs		11H 33M 26S
HVu200		low gain Quad-4 250FRs		11H 36M 09S
	Power-OFF #143		2001/01/15	11:53
	Power-OFF #144			11:56
	Power-OFF #145			11:58
	Power-OFF #146			12:02
	Power-OFF #147			12:04
	Power-OFF #148			12:06
	Power-OFF #149			12:09
	Power-OFF #150			12:11
	Power-OFF #151			12:14
	Power-OFF #152			12:16
	sudden power-UP			
	Power-OFF #153			12:18
	Power-OFF #154			12:21
	Power-OFF #155			12:24

File Name	Current	Dark	F-F	Time(start)
	Power-OFF #156			12:27
	Power-OFF #157			12:28
	Power-OFF #158			12:31
	Power-OFF #159			12:33
	Power-OFF #160			12:35
HVu201		low gain Quad-1	250FRs	12H 42M 06S
HVu202		low gain Quad-3	250FRs	12H 44M 49S
HVu203		low gain Quad-2	250FRs	12H 47M 31S
HVu204		low gain Quad-4	250FRs	12H 50M 14S
	Power-OFF #161	2001/01/15		15:33
	Power-OFF #162			15:38
	Power-OFF #163			15:42
	Power-OFF #164			15:44
	Power-OFF #165			15:46
	Power-OFF #166			15:48
	Power-OFF #167			15:51
	Power-OFF #168			15:53
	Power-OFF #169			15:55
	Power-OFF #170			15:58
	Power-OFF #171			15:59
	Power-OFF #172			16:02
	Power-OFF #173			16:03
	Power-OFF #174			16:05
	Power-OFF #175			16:07
	Power-OFF #176			16:08
	Power-OFF #177			16:11
	Power-OFF #178			16:13
	Power-OFF #179			16:15
	Power-OFF #180			16:17
HVu205		low gain Quad-1	250FRs	16H 23M 50S
HVu206		low gain Quad-3	250FRs	16H 26M 32S
HVu207		low gain Quad-2	250FRs	16H 29M 15S
HVu208		low gain Quad-4	250FRs	16H 31M 57S
	Power-OFF #181	2001/01/15		16:50
	Power-OFF #182			16:52
	Power-OFF #183			16:54
	Power-OFF #184			16:56
	Power-OFF #185			16:58
	Power-OFF #186			17:01
	Power-OFF #187			17:03
	Power-OFF #188			17:05
	Power-OFF #189			17:07
	Power-OFF #190			17:08
	Power-OFF #191			17:10
	Power-OFF #192			17:12
	Power-OFF #193			17:14
	Power-OFF #194			17:16
	Power-OFF #195			17:18
	Power-OFF #196			17:21

File Name	Current	Dark	F-F	Time(start)
	Power-OFF #197			17:23
	Power-OFF #198			17:24
	Power-OFF #199			17:27
	Power-OFF #200			17:29

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HVu209			low gain Quad-1 250FRs	17H 34M 51S
HVu210			low gain Quad-3 250FRs	17H 37M 33S
HVu211			low gain Quad-2 250FRs	17H 40M 16S
HVu212			low gain Quad-4 250FRs	17H 42M 58S
HVu213			high gain Qud1 10000FRs	18H 03M 03S
HVu214			high gain Qud3 10000FRs	19H 50M 13S
HVu215			high gain Qud2 10000FRs	21H 37M 18S
HVu216			high gain Qud4 10000FRs	23H 24M 27S
				2001/01/16
Drk217		high gain Quad1 10000FRs		02H 05M 12S
Drk218		high gain Quad3 10000FRs		03H 52M 24S
Drk219		high gain Quad2 10000FRs		05H 39M 43S
Drk220		high gain Quad4 10000FRs		07H 26M 56S
HVu221			low gain Quad1 2000FRs	11H 33M 14S
HVu222			low gain Quad3 2000FRs	11H 54M 42S
HVu223			low gain Quad2 2000FRs	12H 16M 08S
HVu224			low gain Quad4 2000FRs	12H 37M 36S
HVu225			low gain Quad1 2000FRs	13H 25M 03S
HVu226			low gain Quad3 2000FRs	13H 46M 31S
HVu227			low gain Quad2 2000FRs	14H 07M 57S
HVu228			low gain Quad4 2000FRs	14H 29M 24S
				2001/01/22
	current Anode			11H 55M
	current Anode			12H 15M
	current Anode			12H 30M
				2001/01/26
	current MCPs			10H 10M
	current MCPs			10H 35M
	current MCPs			10H 50M
	current MCPs			11H 10M

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End of 2nd Round

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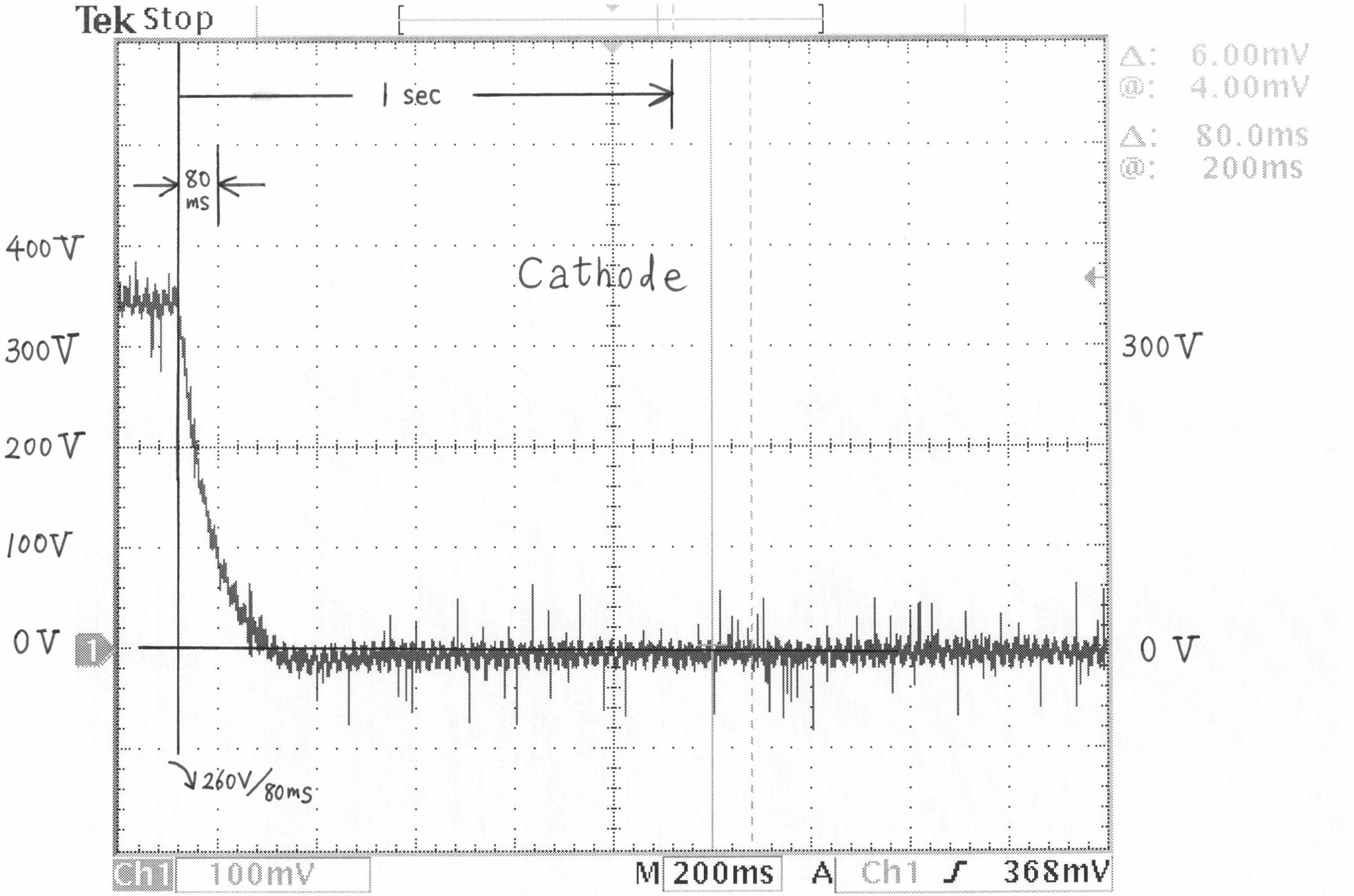


Fig. 1a Vcathode Power off time profile
[DEP_#2 tube]

13 Dec 2000
20:57:55

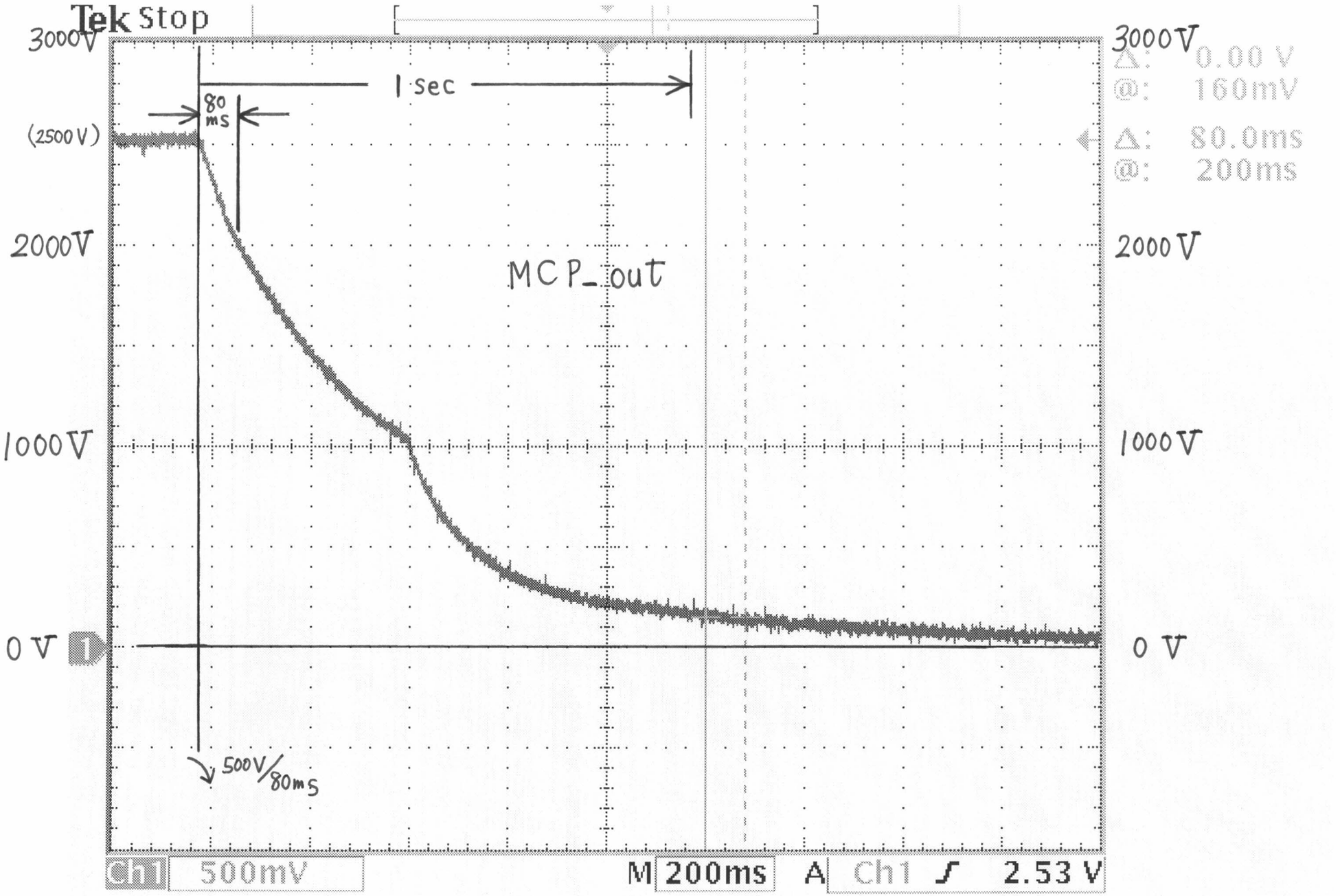


Fig.1b MCP_out

Power off time profile
[DEP_#2 tube]

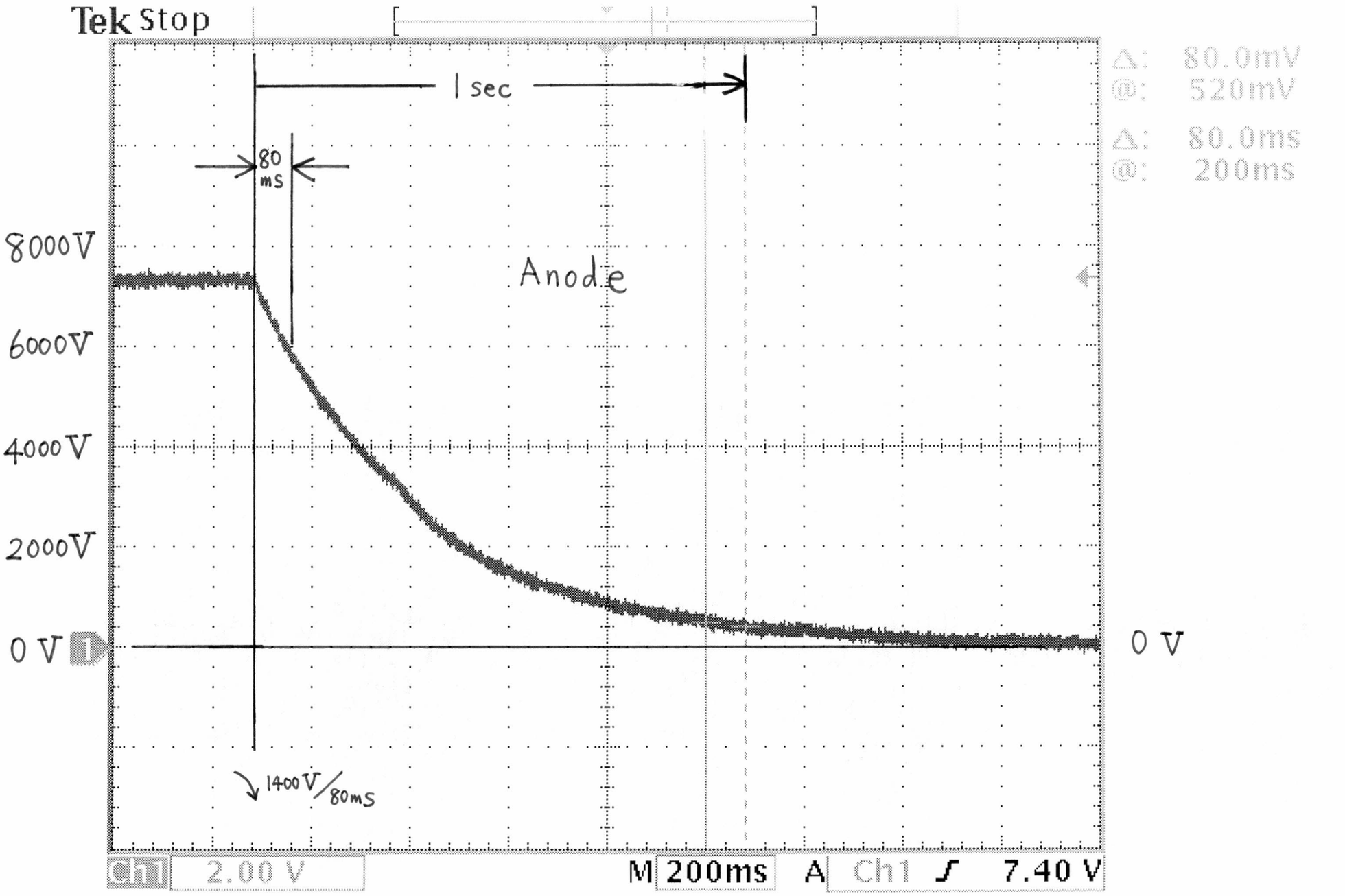


Fig. 1c Vanode Power off time profile
[DEP_#2 tube]

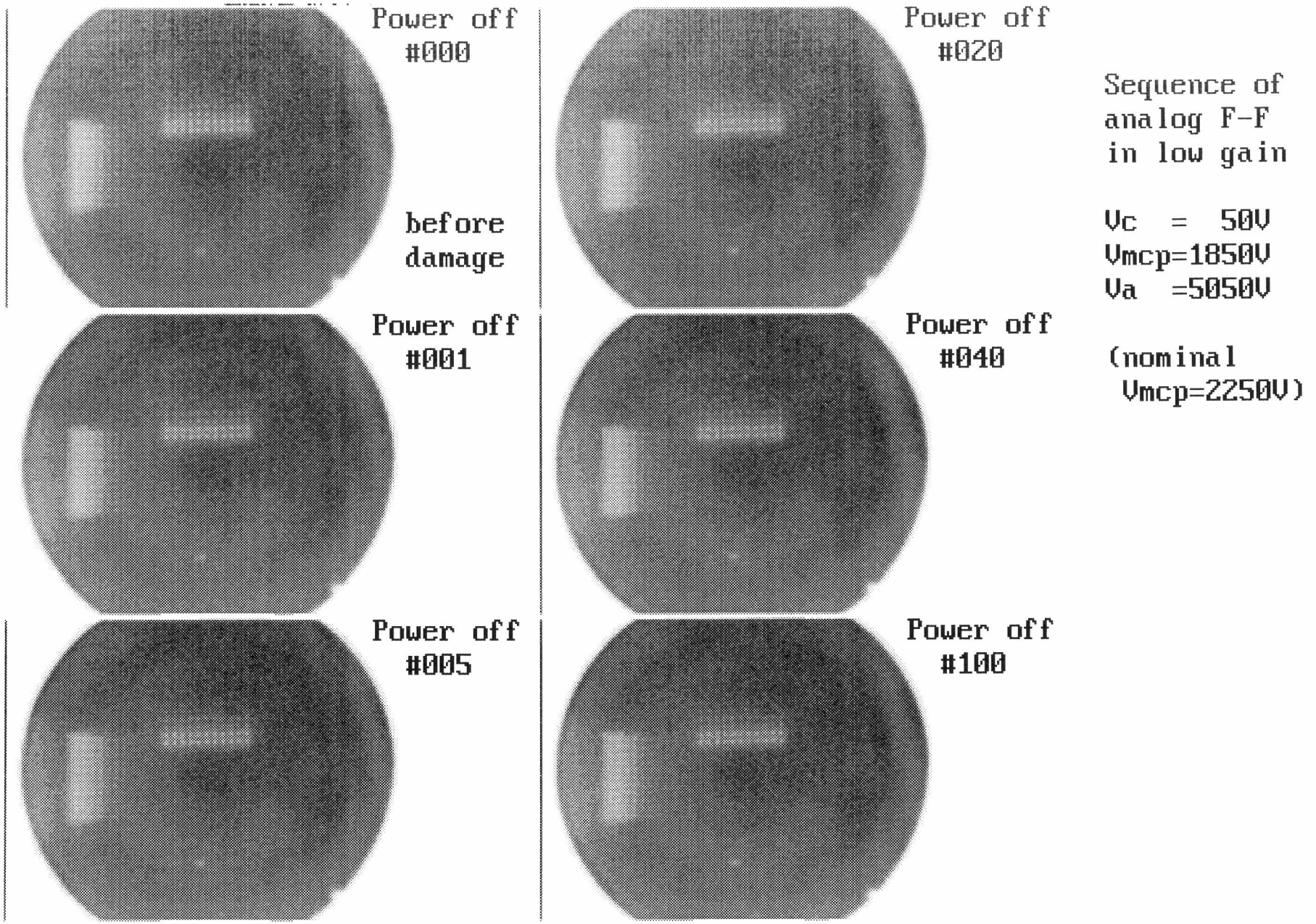


Fig. 2 **Raw image** Low gain Power-OFF #0, 1, 5, 20, 40 and 100

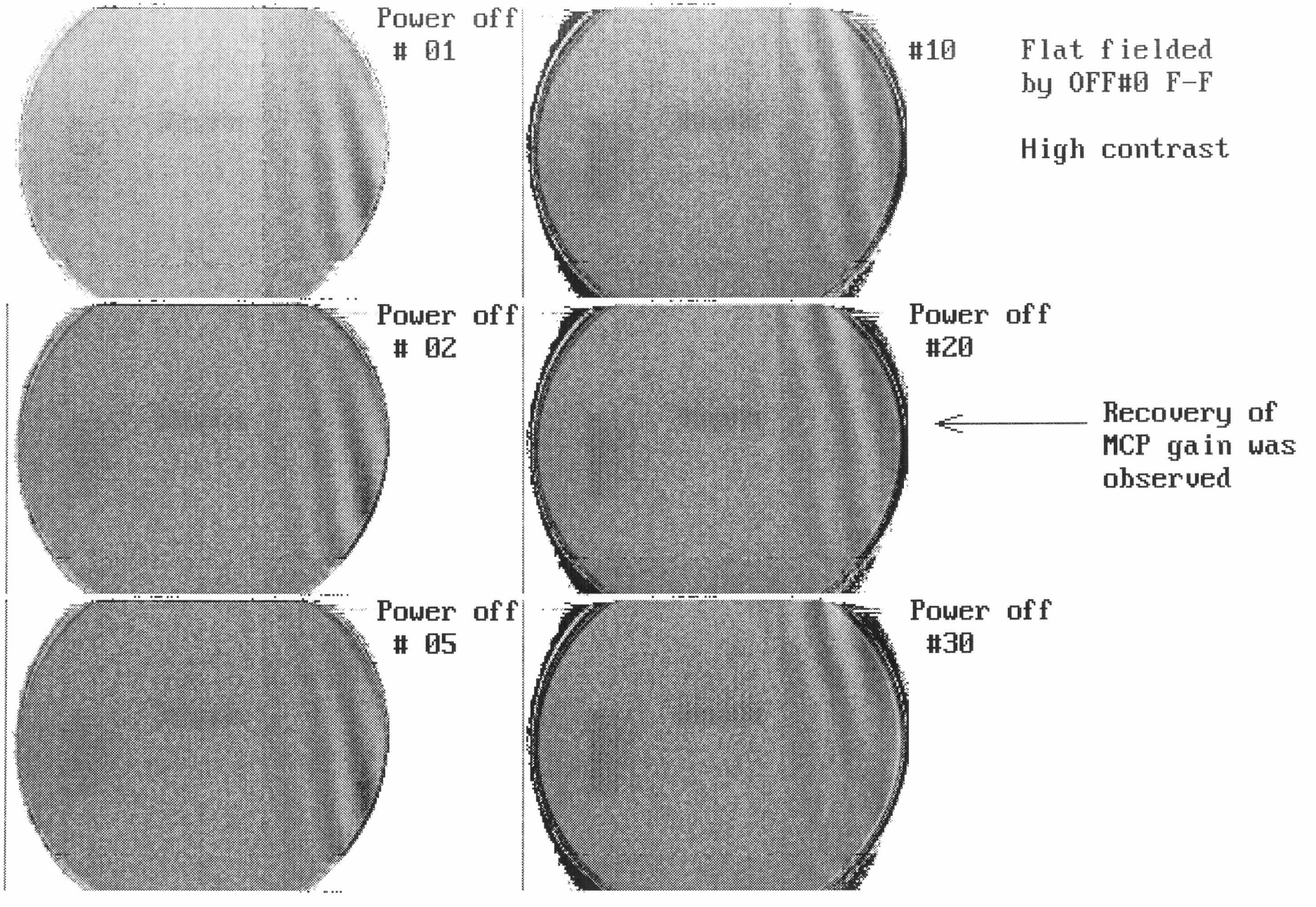
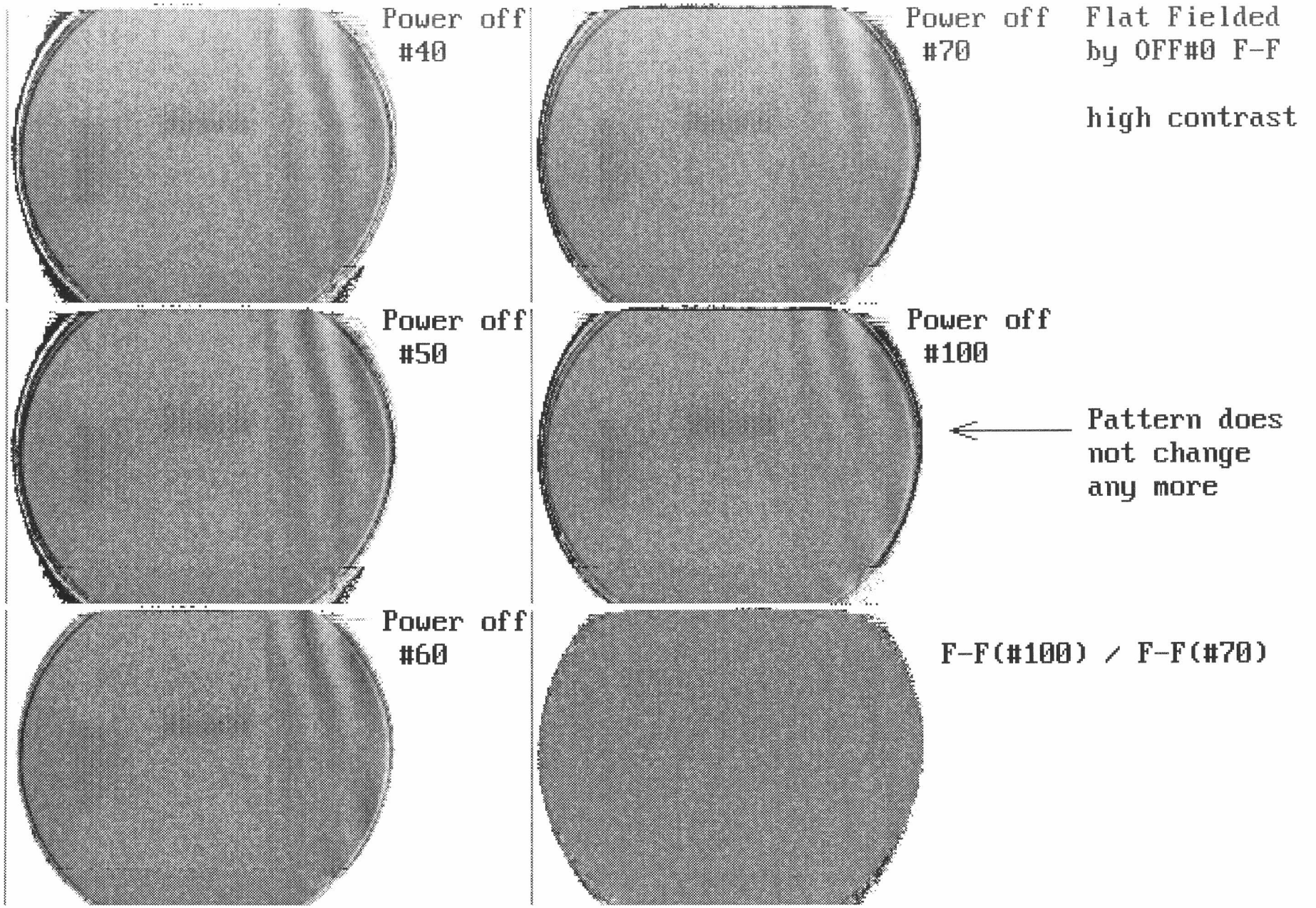
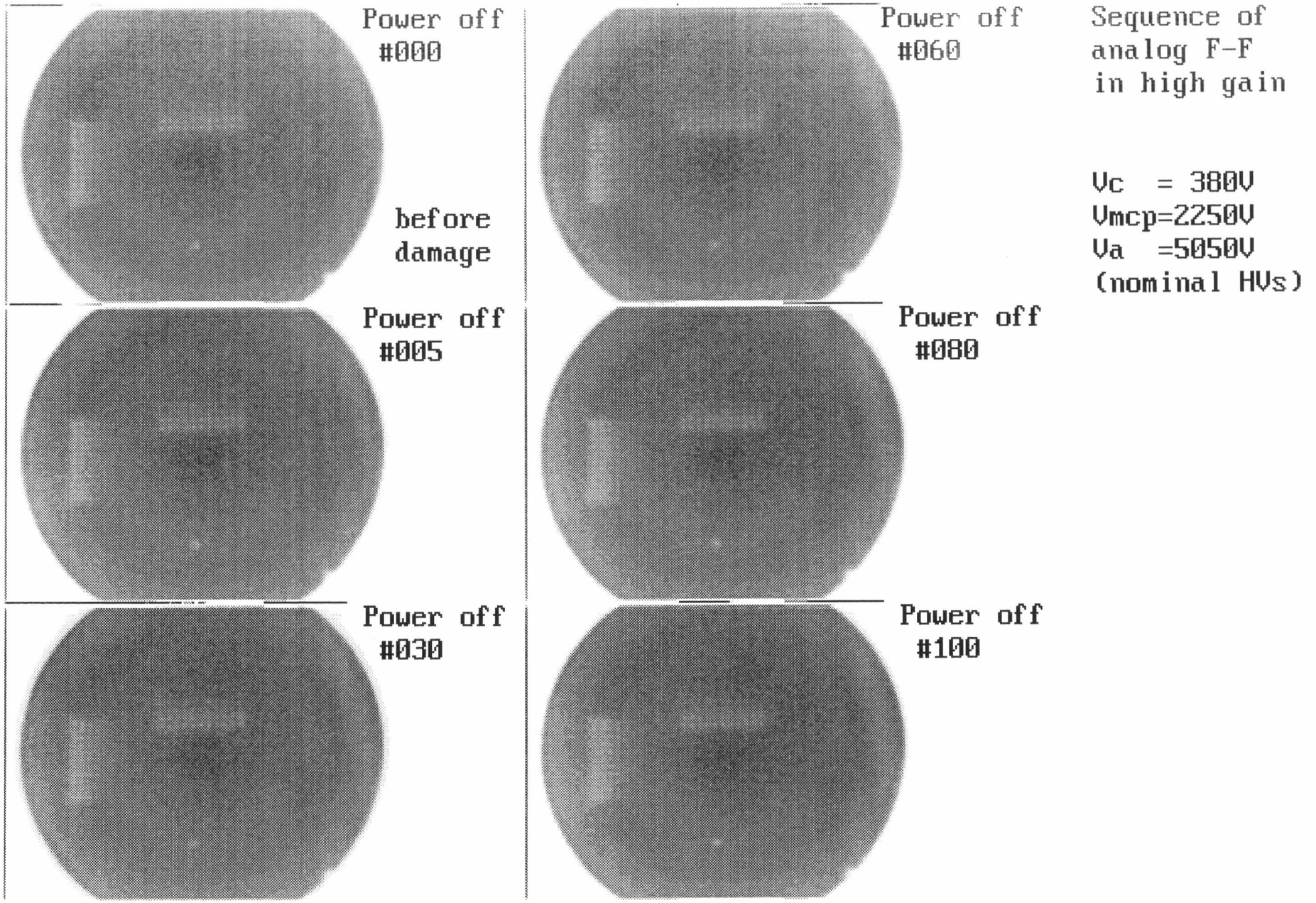


Fig. 3a F-Fed Low gain Power-OFF #1, 2, 5, 10, 20, 30



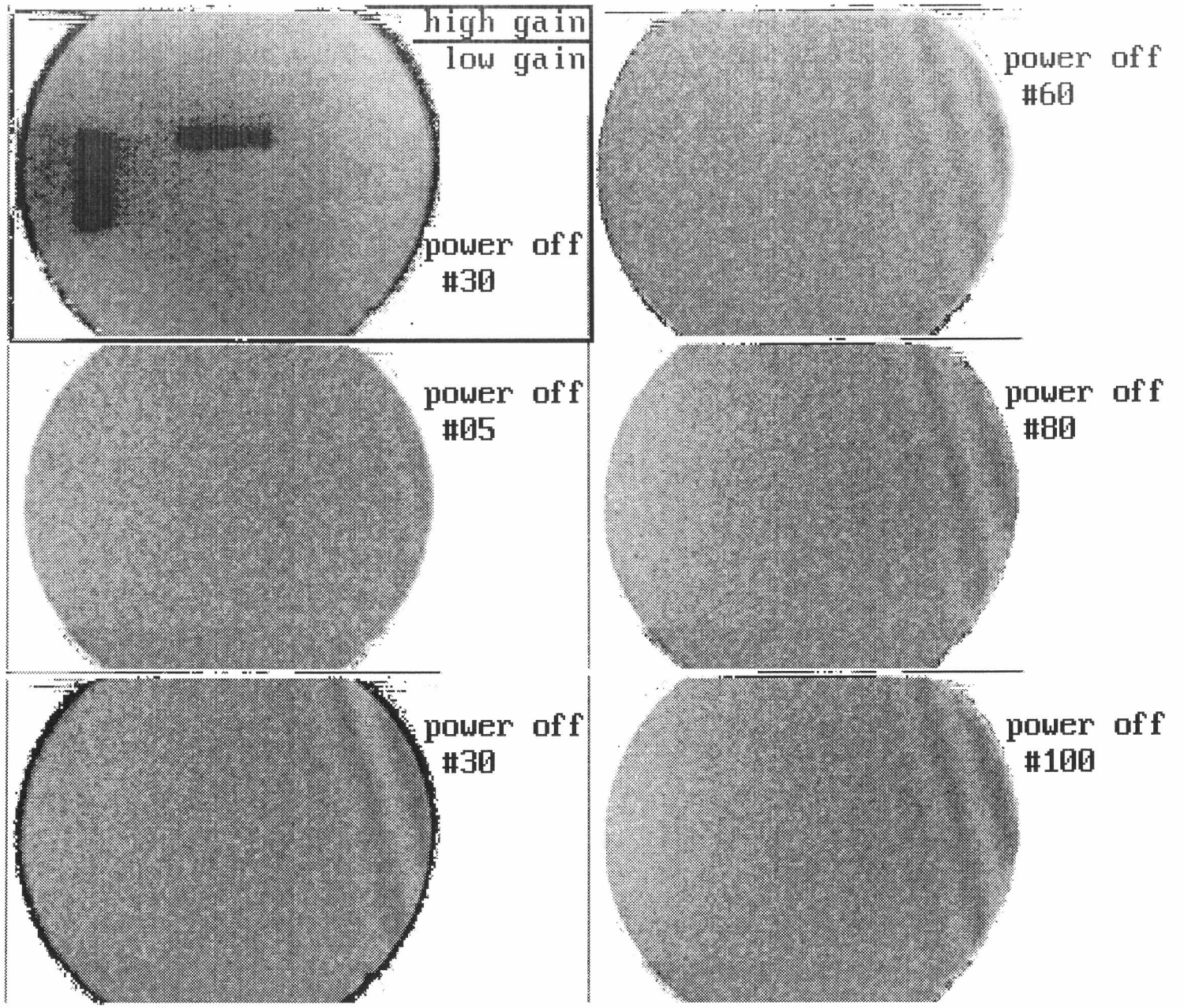
17H 15M S H M S 2000 01/10/

Fig. 3b F-Fed Low gain Power-OFF #40, 50, 60, 70, 100



14H 15M S H M S 2000 01/11/

Fig. 4 Raw image High gain Power-OFF #0, 5, 30, 60, 80 and 100



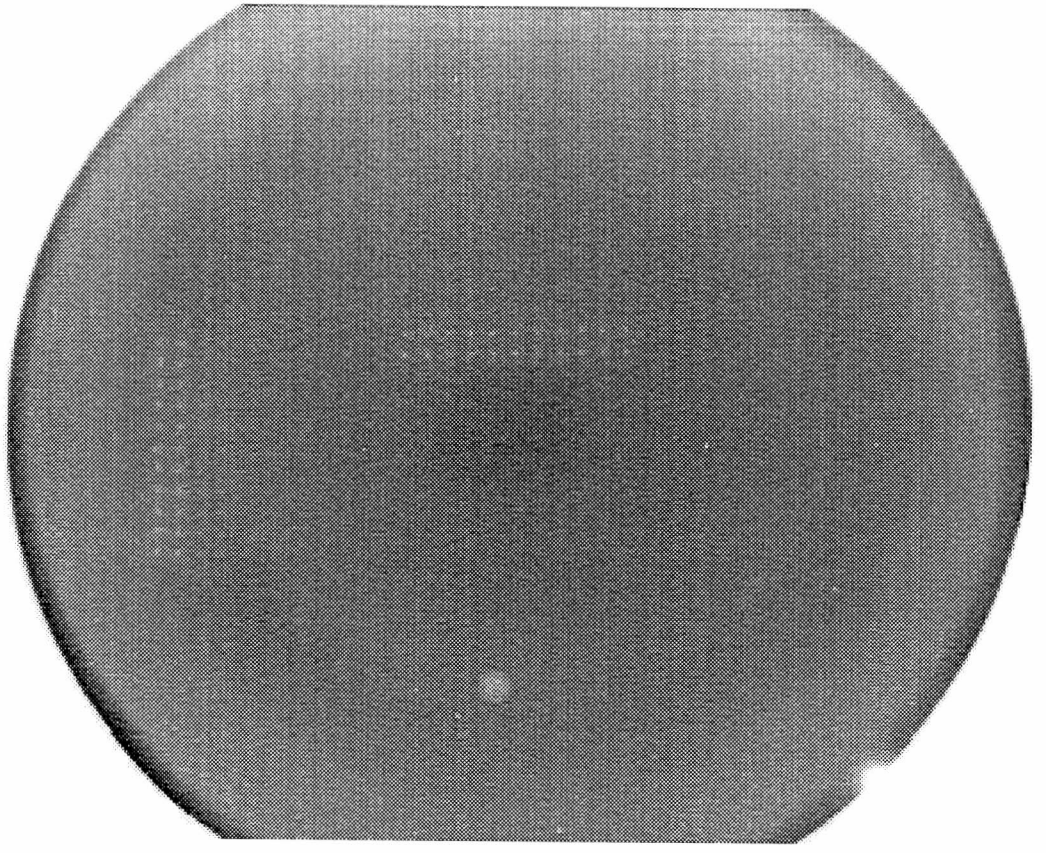
Flat fielded
by OFF#0 F-F

high contrast

recovery of
MCP gain at
pinhole
illumination
are was not
observed.

13H 51M S H M S 2000 01/12/

Fig. 5 F-Fed High gain Power-OFF #5, 30, 60, 80, 100



17H 15M 05S 21H 16M 11S 2001/01/04/

Fig. 6 Raw image in photon counting mode 3600sec 100th Power-off

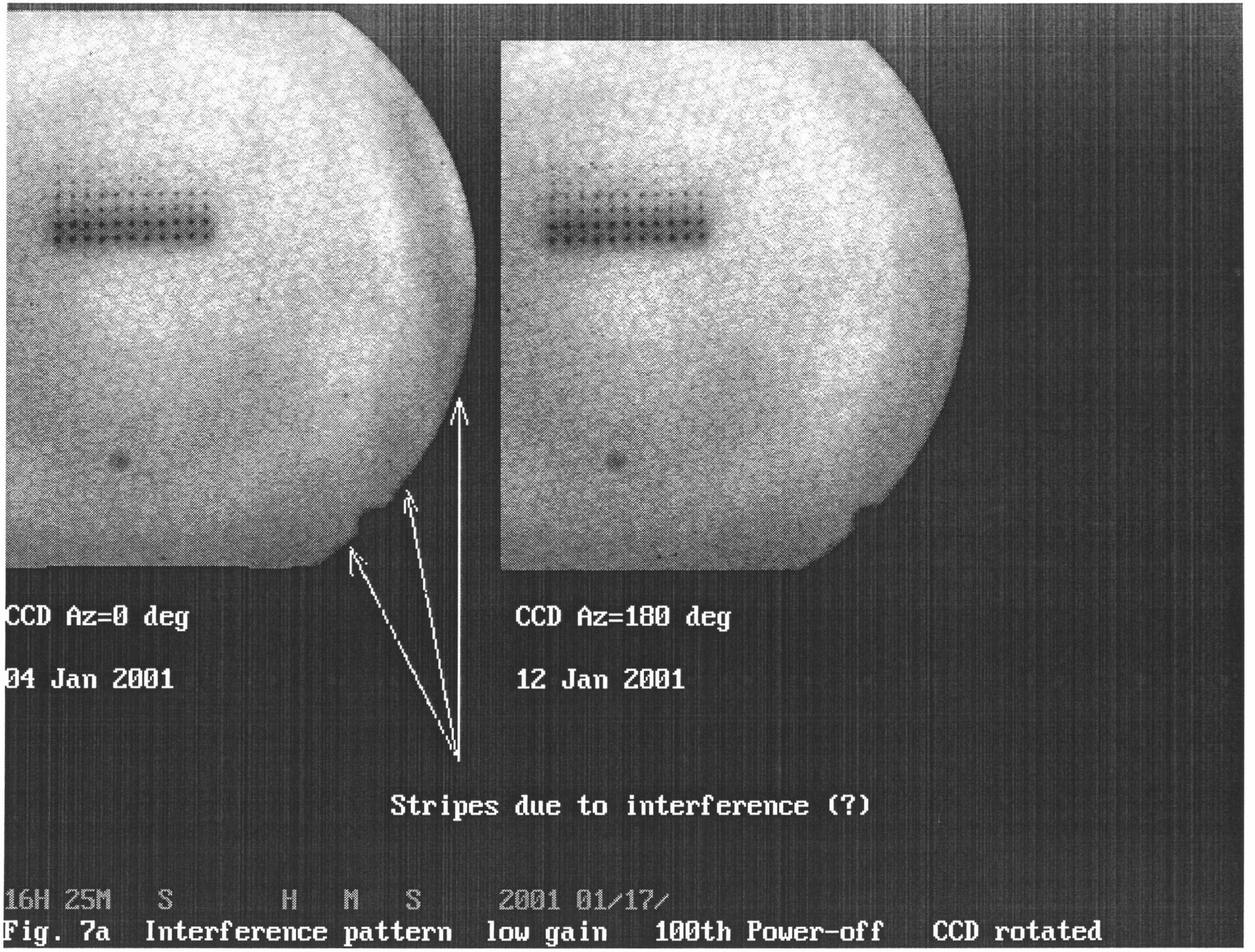
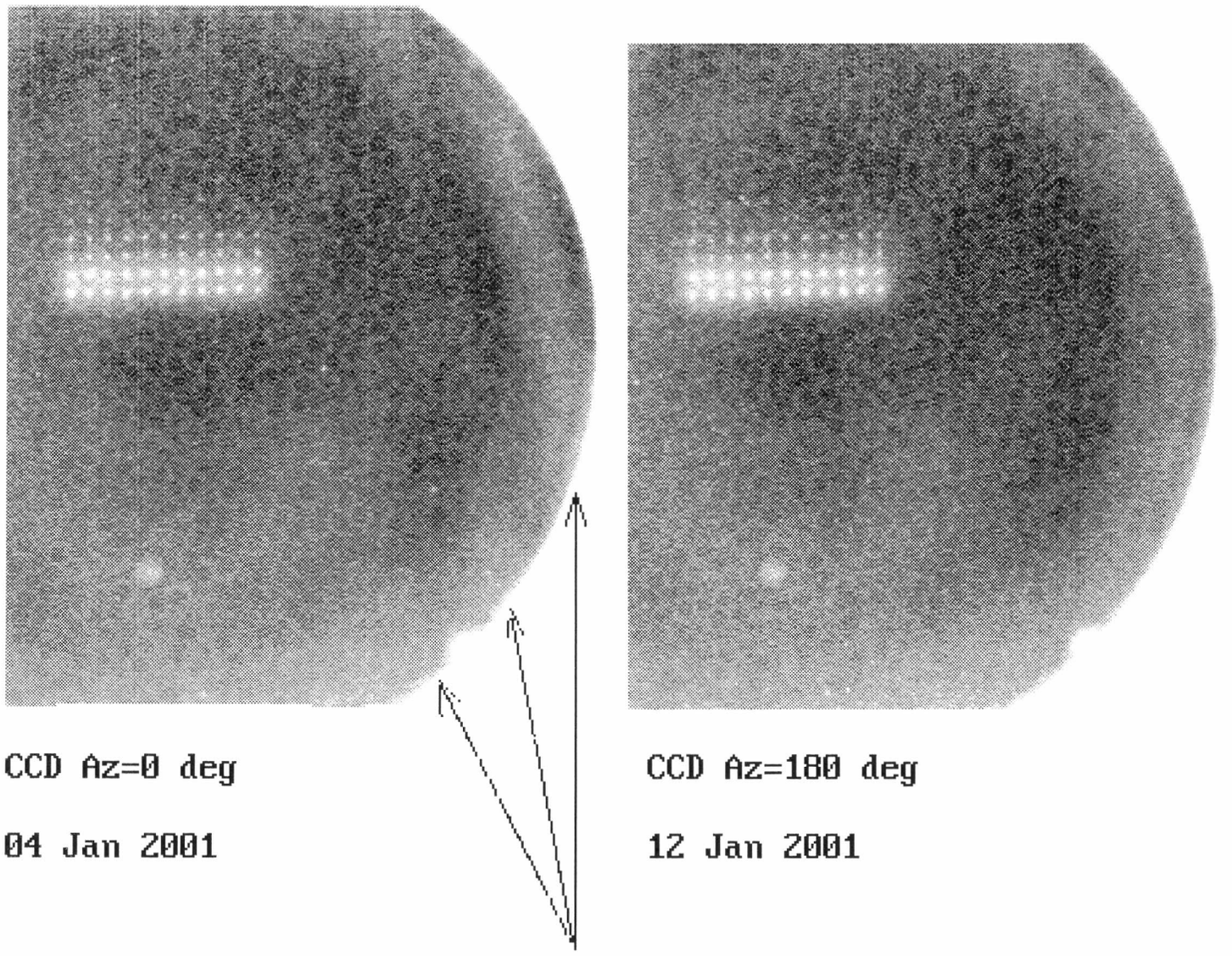


Fig. 7a Interference pattern low gain 100th Power-off CCD rotated



16H 25M S H M S 2001 01/17/

Fig. 7b Interference pattern low gain 100th Power-off CCD rotated

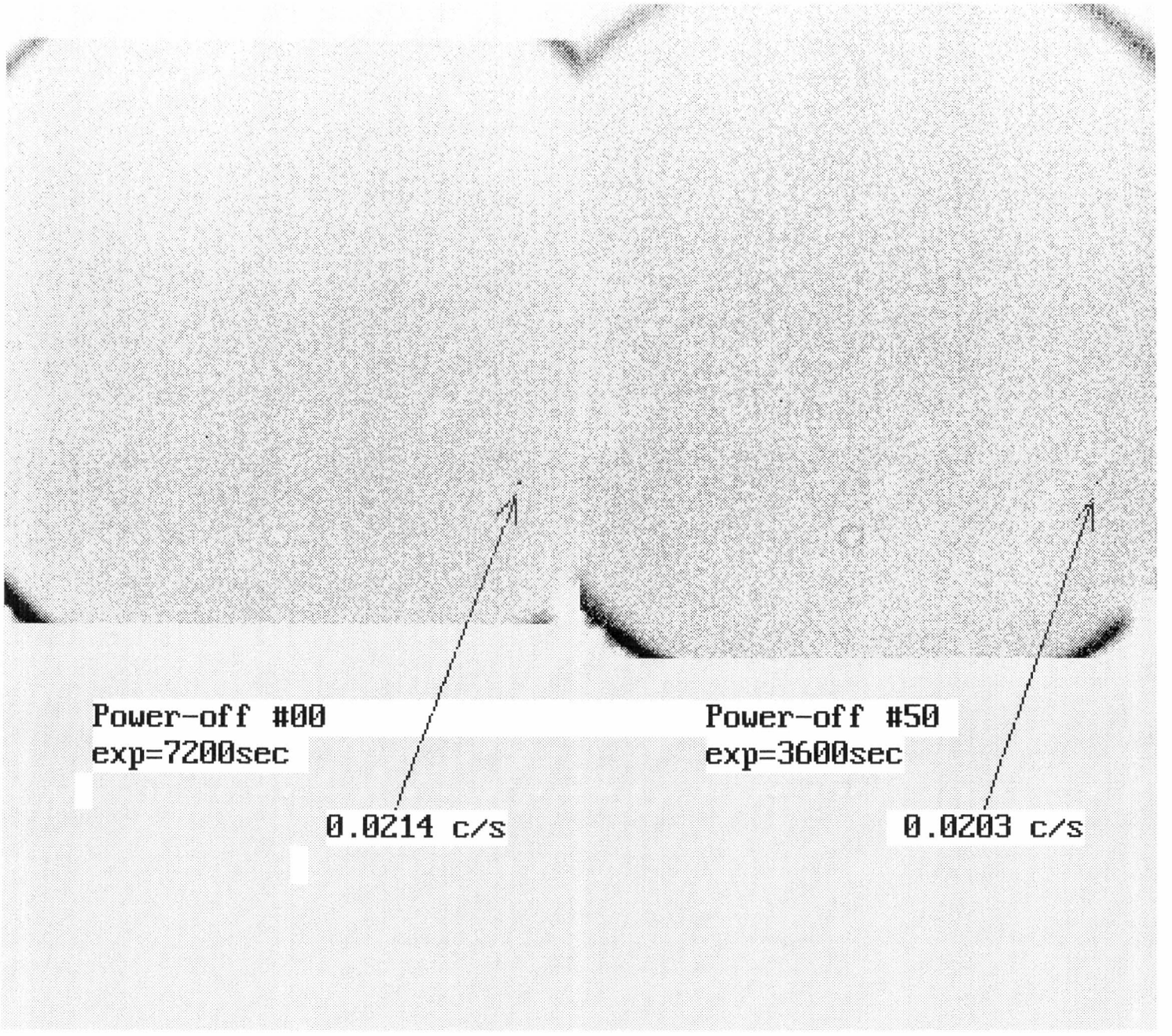
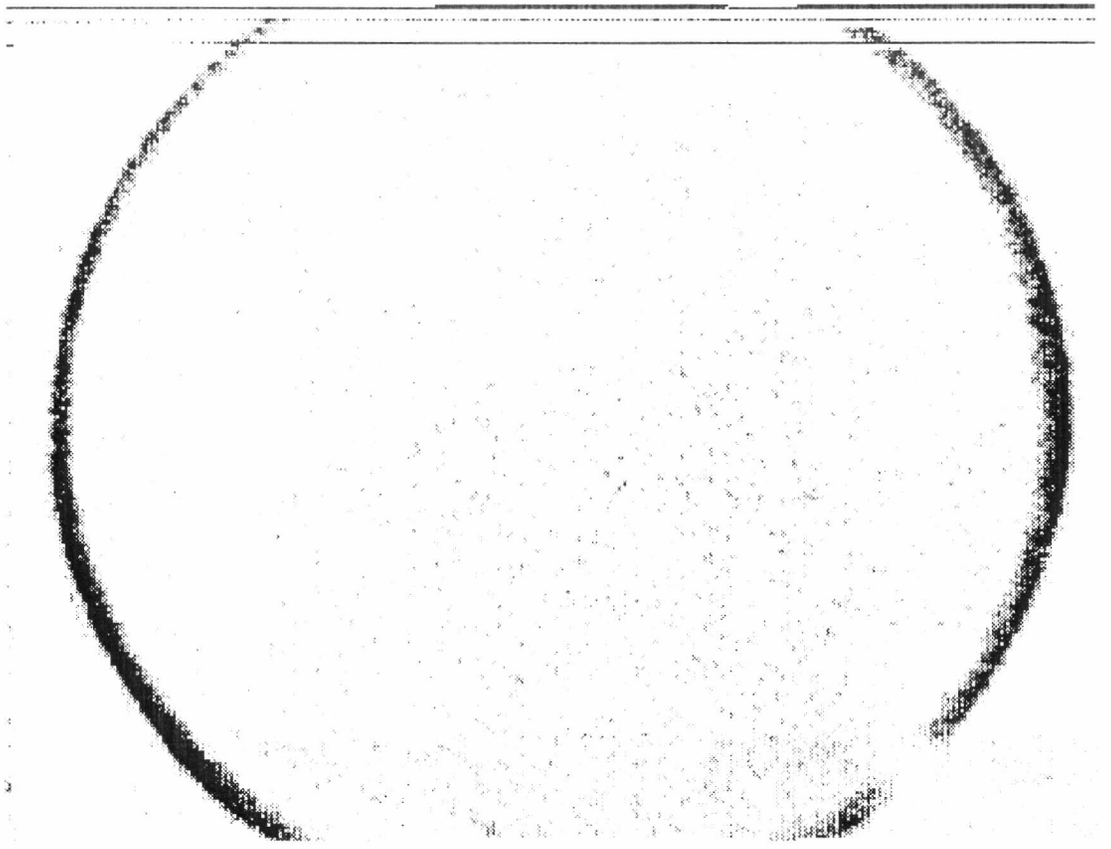


Fig. 8 Sw-on chanel in photon counting mode Photocathode = OFF



100th Power-off
2000 Frames

01H 48M 03S 03H 13M 29S 2001/01/05/

Fig. 9 Dark in analog mode with high gain Photocathode = ON