XMM Optical Monitor

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Report-C on the life time estimation of FM-intensifiers

<< Last report, Misc items >>

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2 May 2000
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18. Gain depletion of MCPs v.s. accumulated anode current

The plot of MCP gain depletion against accumulated photons showed split branches in high dose end according to the illumination intensities (Fig. 28 of Report-B on the life time estimation of DEP intensifier). This seemed to be due to pore paralysis of MCPs. The MCP gain depletion will be plotted against accumulated anode current in this section, instead of accumulated photons.

The 11x11 pinhole array image was projected at the left edge of the intensifier so that the brightest 2x11 pinholes only, whose intensities are same, are involved in generating MCP current (see Fig. 49). A 99.91k Ohm resister was inserted at the anode cable, whose voltage was 8000V, and the small voltage drop across the resister was measured with a precision multimeter, FLUKE 87 IV, in the readout accuracy of 1uV. The resistance value was also calibrated by the FLUKE 87 IV. Since voltage display of the FLUKE 87 IV was not stable in the last digit (1uV), the display was read 10 times and averaged for the lowest 2 illuminations (i.e. LED current levels=1 and 2). The input impedance of Fluke 87IV is 10M Ohm, therefore anode currents were corrected by the factor of 1.01. The results are tabulated in Table 28 in the illumination intensity range of 66 - 2E+6 counts/(sec pinhole).
Assuming pore paralysis is negligible at the count rate of 66 c/s,
1) Electric gain of the intensifier is ~5.5E+5 at low count rate.
2) Gain depletion is 1/12.9 at the count rate of 2E+6 c/s.

Gain of MCPs at pinhole positions should have changed during the heavy photon dose. The anode current was measured after completing the 100 hours photon dose by illuminating exactly same pinhole positions. This gauges the level of the change before and after the photon dose. As it was difficult to mask the medium-low brightness 9 columns without affecting the brightest 2 columns, all 11x11 pinholes were projected on the intensifier to measure anode currents. Unfortunately, the anode cable was connected with the current input terminal of the FLUKE 87 IV to measure the current directly. This way of measurement lost sensitivity by the factor of ~100 compared with the measurement described above. The contribution from the medium pinholes belonging to columns=6-9 are roughly estimated using Table 28. As the gain depletions at these pinholes are large(50-70%) at low input rate, their gains at high count rate should be lower than those listed in Table 28. Therefore, the estimation for these pinholes are upper limit. The total anode current was subtracted by the estimated current from column=6-9, and the anode current from the brightest pinholes were calculated. The gain for the brightest pinholes are tabulated in Table 29. These are lower limit. In spite of the large gain depletion measured at the low input rate, the gain in the saturated count rate does not change much, before and after the 100 hours dose.

MCP gain depletion was plotted against anode current in Fig.50, using Table 28 and

assuming constant electric gain throughout the photon dose. This assumption would be correct for pinholes at columns=10-11. It should be, however, noted that the assumption is not proven for columns=6-9. Their gains at high count rate were not derived after the 100 hours dose. The split branches seen in Fig. 28 (v.s. accumulated photons) merged together in this Fig. 50. This result implies that the gain depletion mainly occurs at the 2nd MCP.

James(1998) gives excellent review on the life time of MCPs for various position sensitive detectors. The life time was defined at half gain depletion point. Their ranges are 0.7 - 38 mC/cm^2. The half gain point of DEP_#8 intensifier is 4.5E-4 coulomb/spot from Fig 50. The pinhole image size at the input is D=70um, and electron cloud size at the 2nd MCP is D~100um. If the latter is taken, the life time is 5700 mC/cm^2, which is outstanding compared with other position sensitive detectors.

Table 28. Electric gain of XMM-OM tube in high count rate (at nominal voltage)

LED level	Intensity (c/s pinhole)	Measured anode current (pA)	Electric Gain	Relative Gain
L=1	65.7	126	5.43 E+5	1.00
L=2	251	409.5	4.63 E+5	0.85
L=3	769	1011	3.73 E+5	0.69
L=4	2438	2622	3.05 E+5	0.56
L=5	11800	7547	1.815E+5	0.33
L=6	34800	16415	1.338E+5	0.25
L=7	105000	34951	0.944E+5	0.17
L=8	427000	90942	0.604E+5	0.11
L=9	1025000	175658	0.486E+5	0.09
L=10	2070000	307777	0.422E+5	0.08

Table 29. Electric gain after 100 hours dose at the brightest pinholes

LED level	Intensity (c/s pinhole)	Measured anode current (pA)	Contribution column=6-9(pA)	Electric Gain
L=6	34800	10000		
L=7	105000	40000	< 9300	>0.83E+5(?)
L=8	427000	100000	<26900	>0.49E+5(?)
L=9	1025000	210000	<49600	>0.47E+5
L=10	2070000	390000	<79900	>0.42E+5

Ref-18
James A. "A fast plasma analyser for the study of solar wind interaction with Mars", PHD thesis for UCL (1998).

19. Photocathode sensitivity loss v.s. accumulated anode current

The plot of photocathode sensitivity loss against accumulated photons showed split branches in high dose end according to the illumination intensities (Fig. 35 of Report-B). Again, this seemed to be due to the pore paralysis of MCPs. Photocathode sensitivity loss was plotted against anode current in Fig.51, using Table 28 and assuming constant electric gain throughout the photon dose.
The split branches seen in Fig. 35 (v.s. accumulated photons) merged together in this Fig. 51. This result implies that ion feed back is proportional to the electron cloud at the 2nd MCP.

20. Spatial extent of MCPs gain depletion ---- II

The gain depletion at the pinhole position seen in the analog F-F was sallower than that derived from the pulse height distribution, as stated in section 16 of the previous document.
Pulse height distributions near the pinhole were measured using the pinhole illumination, which was displaced step by step using a precision linear stage, Unidex ATS100-150. This approach is free from image blurring due to event splash at the phosphor screen, hence gives better spatial resolution. Three pulse height distributions were derived by projecting the pinhole images at offset=0um (the original position), offset=70um and offset=117um as shown in Figs. 52 and 53. The results were plotted in Fig. 54. They showed deep(70%) and sharp(150um HWHM) drop. The plots seem to merge to the gain depletion profile derived from the analog F-F at the longer distance. Spatial extent from these results is about half of Edgar et. al.(1992).

Ref-20
Edgar M., Lapington J. and Smith A. "The spatial extent of gain depression for MCP-based photon detectors", Rev. Sci Instrum vol 63 p816 (1992).

Files used for this section
/depfm8/ZPHD539.dat, ZPHD897.dat, ZPHD900.dat, ZPHD902.dat
/depfm8/ZDEM866.dat

21. Recovery of MCPs gain and photocathode sensitivities

Pulse height distributions were monitored for 45 days after completing the 100 hours photon dose. Recovery was seen in the 1st 10 days for all illumination intensities as shown in Fig. 55. There was no noticeable recovery later than 10 days. Photocathode sensitivities were monitored for 42 days in the 3 colours after completing the 100 hours photon dose. No recovery was seen in blue (Fig. 56). Further degradations were rather seen in green and red (Figs. 57 and 58).

Ref-21
Edgar M., Lapington J. and Smith A. "The spatial extent of gain depression for MCP-based photon detectors", Rev. Sci Instrum vol 63 p816 (1992).

Files used for this section
/depfm8/ZPHD539.dat, ZPHD897.dat, ZPHD900.dat, ZPHD902.dat
/depfm8/ZDEM866.dat
/depfm8/ZDEP538.dat,
/depfm8/ZDEP793.dat, ZDEP796.dat, ZDEP810.dat, ZDEP840.dat, ZDEP866.dat, ZDEP873.dat, ZDEP891.dat,
/depfm8/ZDEP806.dat, ZDEP820.dat, ZDEP845.dat, ZDEP893.dat,
/depfm8/ZDEP802.dat, ZDEP816.dat, ZDEP850.dat, ZDEP854.dat, ZDEP879.dat, ZDEP887.dat,

22. Photocathode sensitivity loss at UV to visual wavelengths

Later than 50 days since completing the 100 hours photon dose, photocathode sensitivity loss was measured with collimated monochromatic light (band width < 50nm) using the UV vacuum monochrometer. Since a reference F-F image was not acquired before the photon dose, raw F-F images were analysed. Sensitivity losses at pinhole position centre were determined relative to the adjacent D=200um circular region but excluding D=100um. Fig. 59 shows photocathode sensitivity losses at various wavelengths. F-F images were acquired in photon counting mode with a low threshold level, 8ADU, to minimize the photon loss due to the gain depletion of MCPs. The effects of fluorescence and MCPs gain depletion were corrected. The photocathode loss was maximum at the longest wavelength, 580nm. The minimum loss occurred at 300nm, though almost same at wavelengths below 350nm.

Fig. 60 shows photon loss in a photon counting image with standard threshold level of 15ADU. F-F images for this diagram were acquired later than 120 days since completing the 100 hours photon dose. This diagram contains both of photocathode sensitivity losses and the effect of MCP gain depletion. The loss is still smaller at UV wavelengths, but the benefit is not large because MCPs gain depletion is a dominant factor for the photon loss.

There were noticeable photocathode sensitivity drops at wavelengths below 300nm between the 2 periods (i.e. for Fig 59 and 60). The intensifier was completely off between the 2 periods, the elapsed days of the 81st to the 123rd. It, however, should be tested further to conclude the change, as they were measured in different threshold levels.

Ref-22
/depfm8/ZDEP906.dat, ZDEP912.dat, ZDEP916.dat, ZDEP921.dat, ZDEP923.dat,
ZDEP927.dat, ZDEP929.dat, ZDEP935.dat, ZDEP941.dat, ZDEP945.dat,
ZDEP948.dat, ZDEP958.dat, ZDEP959.dat, ZDEP962.dat, ZDEP967.dat,
ZDEP969.dat, ZDEP972.dat, ZDEP975.dat

Appendix. Experiment procedure for DEP_#8 intensifier

24 October 1999 - 3 March 2000

File Name   Pinhole   PHD   Dark   F-F   Time(start)

Before damage for reference

```
1999/09/28
DEP538                                          54000S      21H 10M
14S

1999/09/29
PHD539                 60000FRs                             12H 45M
46S


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           30 hour             Day-9     06:00 - 12:00     1999/10/23
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End damage

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1999/10/24
Drk773                                    0300S              12H 01M
53S
Drk774                                    0300S              12H 07M
18S
Drk775                                    0300S              12H 12M
41S
Drk776                                    0300S              12H 18M
05S
Drk777                                    0300S              12H 23M
28S
PHD778                 70000FRs                              12H 38M
50S
Drk779    -----                           7200S              13H 33M
45S
Drk780      |                             7200S              15H 34M
09S
Drk781      |                             7200S              17H 34M
32S
Drk782      |                             7200S              19H 34M
56S
Drk783      |                             7200S              21H 35M
19S
Drk784      |                             7200S              23H 35M
43S
       Bit Broken
1999/10/25
Drk785      |                             7200S              01H 36M
07S
Drk786      |                             7200S              03H 36M
```

```
30S
Drk787      |                              7200S             05H 36M
54S
Drk788      |                              7200S             07H 37M
18S
Drk789    -----                            7200S             09H 37M
42S
PHD790                 70000FRs                              12H 09M
49S
Ana791                                  (256V) 20000FRs      13H 27M
38S
Drk792                                     7200S             17H 35M
01S
DEP793                                           54000S      19H 35M
26S

1999/10/26
Drk794                                     7200S             10H 35M
51S
Drk795                                     7200S             12H 36M
14S
DEP796                                           54000S      15H 36M
21S

1999/10/27
Drk797                                     7200S             06H 36M
42S
Drk798                                     7200S             08H 37M
00S
Drk799                                     7200S             10H 37M
18S
PHD800                 70000FRs                              13H 57M
59S
Drk801                                     7200S             16H 32M
46S
DEP802                                       Red 54000S      18H 35M
03S
```

File Name Pinhole PHD Dark F-F Time(start)

```
1999/10/28
Drk803                                     7200S             09H 35M
28S
PHD804                 70000FRs                              11H 59M
52S
Ana805                                  (256V)  1000FRs      13H 33M
39S
DEP806                                     Green 54000S      18H 25M
09S

1999/10/29
Bin807                                      4x4B  7200S      09H 25M
30S
```

Drk808 7200S 11H 35M
12S
PHD809 70000FRs 14H 18M
11S
DEP810 Blue 54000S 16H 14M
10S

1999/10/30
Drk811 7200S 07H 14M
42S
Drk812 7200S 09H 15M
09S
Drk813 7200S 11H 15M
35S
Drk814 7200S 13H 16M
01S
Drk815 7200S 15H 16M
27S
DEP816 Red 54000S 18H 35M
51S

1999/10/31
Drk817 7200S 09H 36M
21S
Drk818 7200S 11H 36M
47S
Drk819 7200S 13H 37M
13S
DEP820 Green 54000S 16H 30M
16S

1999/11/01
Drk821 7200S 07H 30M
52S
Drk822 7200S 09H 31M
25S
PHD823 70000FRs 11H 56M
29S
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Fuel Test 1min Day-9 13:28 - 13:29
1999/11/01
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Drk824 0300S 13H 30M
07S
Drk825 0300S 13H 35M
42S
Drk826 0300S 13H 41M
17S
Drk827 0300S 13H 46M
52S
Drk828 0300S 13H 52M
27S
Drk829 7200S 14H 26M
40S
Drk830 7200S 16H 27M
09S
Drk831 7200S 18H 27M
37S
Drk832 7200S 20H 28M

```
05S
Drk833                                  7200S             22H 28M
33S

1999/11/02
Drk834                                  7200S             00H 29M
01S
Drk835                                  7200S             02H 29M
29S
Drk836                                  7200S             04H 29M
58S
Drk837                                  7200S             06H 30M
26S
Drk838                                  7200S             08H 30M
54S
Drk839                                  7200S             10H 31M
22S
DEP840                          TH=8    Blue  54000S      18H 14M
26S

1999/11/03
Drk841                                  7200S             09H 15M
02S
Drk842                                  7200S             11H 15M
37S
Drk843                                  7200S             13H 16M
12S
PHD844                  70000FRs                          15H 19M
39S
DEP845                          TH=8    Green 54000S      16H 48M
22S
```

File Name	Pinhole	PHD	Dark	F-F	Time(start)

```
1999/11/04
Drk846                                  7200S             10H 06M
33S
Drk847                                  7200S             12H 07M
26S
Drk848                                  7200S             15H 01M
50S
PHD849                  70000FRs                          18H 02M
12S
DEP850                          TH=8    Red   54000S      19H 04M
05S

1999/11/05
Drk851                                  7200S             10H 04M
41S
Drk852                                  7200S             12H 55M
49S
Ana853                          (256V)  Red   20000FRs    16H 12M
21S
DEP854                          TH=8    Red   54000S      19H 35M
22S
```

1999/11/06
Drk855 7200S 10H 35M
52S
Drk856 7200S 12H 36M
18S
Drk857 7200S 14H 36M
44S
Drk858 7200S 16H 37M
10S
Drk859 7200S 18H 37M
36S
Drk860 7200S 20H 38M
02S
Drk861 7200S 22H 38M
28S

1999/11/07
Drk862 7200S 00H 38M
54S
Drk863 7200S 02H 39M
20S

1999/11/08
PHD864 70000FRs 11H 17M
17S
Ana865 (256V) Blue 30000FRs 12H 17M
42S

1999/11/09
DEP866 TH=8 Blue 54000S 10H 12M
37S

1999/11/10
Drk867 7200S 01H 13M
13S
Drk868 7200S 03H 13M
46S
Drk869 7200S 05H 14M
19S
Drk870 7200S 07H 14M
52S
Drk871 7200S 09H 15M
25S
PHD872 70000FRs 15H 00M
10S
DEP873 TH=8 Blue 54000S 17H 51M
10S

1999/11/11
Drk874 7200S 10H 54M
00S
Drk876 7200S 12H 54M
35S
Drk877 7200S 14H 55M
10S
Drk878 7200S 16H 55M
45S
DEP879 TH=8 Red 54000S 20H 00M
25S

1999/11/12
Drk880 7200S 11H 01M

```
01S
Ana881                          (256V) Red   30000FRs    13H 11M
26S
PHD882                70000FRs                           17H 42M
34S

////////////////////////////////////////////////////////////

1999/12/03
DEP887                          TH=8   Red   54000S      20H 02M
31S
                                                      1999/12/04
Drk888                                 7200S             11H 03M
07S
```

File Name	Pinhole	PHD	Dark	F-F	Time(start)
Drk889			7200S		13H 03M 40S
Drk890			7200S		15H 04M 13S
DEP891		TH=8	Blue 54000S		18H 58M 58S
Drk892			7200S		09H 59M 28S
1999/12/05					
DEP893		TH=8	Green 54000S		15H 11M 57S
1999/12/06					
Drk894			7200S		06H 12M 26S
Drk895			7200S		08H 12M 52S
PHD896		70000FRs			10H 37M 12S
1999/12/08					
PHD897		70000FRs			14H 37M 49S
Pin898	L=1 0300S		000um-OFF		15H 41M 51S
Pin899	L=1 0300S		060um-OFF		16H 06M 03S
PHD900		70000FRs	060um-OFF		16H 20M 41S
Pin901	L=1 0300S		120um-OFF		17H 38M 58S
PHD902		70000FRs	113um-OFF		17H 50M 34S
Pin903	L=1 0300S		Left-edge		19H 31M 00S
				1999/12/09	
Ana904		(256V)	Red 10FRs		12H 32M 57S

File Name	Pinhole	PHD	Dark	F-F	Time(start)

<< Monochrometer >>

					1999/12/16
DEP905		TH=8	0-th	1800S	17H 33M 56S
DEP906		TH=8	0-th	54000S	18H 43M 41S
					1999/12/17
Drk907			7200S		09H 44M 23S
Drk908			7200S		11H 45M 00S
Drk909			7200S		13H 45M 36S
Drk910			7200S		15H 46M 13S
Drk911			7200S		17H 46M 49S
DEP912		TH=8	5060A	54000S	20H 56M 21S
					1999/12/18
Drk913			7200S		11H 57M 07S
Drk914			7200S		13H 57M 44S

Drk915 7200S 15H 58M
21S
DEP916 TH=8 4060A 54000S 19H 12M
54S
1999/12/19
Drk917 7200S 10H 13M
36S
Drk918 7200S 12H 14M
14S
Drk919 7200S 14H 14M
54S
Drk920 7200S 16H 15M
31S
1999/12/20
DEP921 TH=8 3060A 54000S 21H 49M
54S
1999/12/21
Drk922 7200S 12H 50M
41S
DEP923 TH=8 2060A 54000S 15H 24M
25S
1999/12/22
Drk924 7200S 09H 09M
02S
Drk925 7200S 11H 09M
46S
Ana926 (256V)2060A 20000FRs 14H 20M
09S
DEP927 TH=8 2560A 54000S 18H 41M
50S
1999/12/23
Drk928 7200S 09H 42M
33S
2000/01/07
DEP929 TH=8 3560A 54000S 14H 47M
35S
2000/01/08
Drk930 7200S 05H 48M
20S
Drk931 7200S 07H 49M
01S
Drk932 7200S 09H 49M
41S
Drk933 7200S 11H 50M
21S
Drk934 7200S 13H 51M
01S
DEP935 TH=8 4560A 54000S 17H 15M
49S
2000/01/09
Drk936 7200S 08H 16M
34S
Drk937 7200S 10H 17M
14S
Drk938 7200S 12H 17M
54S
Drk939 7200S 14H 18M
35S
Drk940 7200S 16H 19M
15S
DEP941 TH=8 5560A 54000S 18H 25M

```
32S
                                                                2000/01/10
Drk942                                    7200S                   09H 26M
13S
Drk943                                    7200S                   11H 26M
49S
Drk944                                    7200S                   13H 27M
25S
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File Name       Pinhole         PHD             Dark    F-F
Time(start)
-------------------------------------------------------------------------------------------------
---
                                                                2000/01/11
DEP945                          TH=8  5560A  54000S              17H 09M
37S
                                                                2000/01/12
Drk946                                    7200S                   08H 10M
19S
Drk947                                    7200S                   10H 10M
54S
DEP948                          TH=15 5560A  54000S              16H 57M
50S
                                                                2000/01/13
Drk949                                    7200S                   07H 58M
36S
Drk950                                    7200S                   09H 59M
16S
Drk951                                    7200S                   11H 59M
56S
                                                                2000/02/25
DEP958                          TH=15 2060A  54000S              21H 34M
42S
                                                                2000/02/26
DEP959                          TH=15 3060A  54000S              17H 50M
58S
                                                                2000/02/27
Drk960                                    7200S                   08H 51M
43S
Drk961                                    7200S                   10H 52M
24S
DEP962                          TH=15 4060A  54000S              14H 21M
11S
                                                                2000/02/28
Drk963                                    7200S                   05H 21M
57S
Drk964                                    7200S                   07H 22M
37S
Drk965                                    7200S                   09H 23M
17S
Drk966                                    7200S                   11H 23M
57S
DEP967                          TH=15 5060A  54000S              14H 18M
45S
                                                                2000/02/29
Drk968                                    7200S                   05H 19M
31S
DEP969                          TH=15 5560A  54000S              17H 03M
54S
```

```
                                                                    2000/03/01
Drk970                                    7200S                     08H 04M
40S
Drk971                                    7200S                     10H 05M
20S
DEP972                                TH=15 4560A  54000S           13H 08M
08S
                                                                    2000/03/02
Drk973                                    7200S                     04H 08M
53S
Drk974                                    7200S                     06H 09M
33S
DEP975                                TH=15 2560A  54000S           18H 20M
31S
                                                                    2000/03/03
Drk976                                    7200S                     09H 21M
17S
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