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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	DEP	

2 May 2000
Hajime Kawakami

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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. Unfortunately, the anode cable was connected with the current input of the FLUKE 87 IV to measure the anode current directly. This way of measurement lost sensitivity by the factor of ~100 compared with the measurement through the resister. The contribution from the medium pinholes belonging to columns=6-9 was 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 are expected to be lower than those listed in Table 28. Therefore, the estimation for these pinholes are for the upper limit. The measured anode current was subtracted by the estimated current from column=6-9, and the anode current from the brightest pinholes was determined. The gains of the brightest pinholes are tabulated in Table 29. These are for the lower limit. In spite of the large

gain depletion 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 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 loss 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 as the area size, 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 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 described 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) depletion profile. The profile seems to merge to that 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 by ~10%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. 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. 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. The effects of fluorescence and MCPs gain depletion were corrected. Fig. 59 shows photocathode sensitivity losses at various wavelengths. The photocathode loss was maximum at the longest wavelength, 580nm. The minimum loss occurred at 300nm, though nearly same at wavelengths below 350nm.

Fig. 60 shows photon loss in a photon counting image with the 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 much because gain depletion of MCPs is a dominant factor for the photon loss.

There is noticeable photocathode sensitivity drop 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 - the 123rd. It, however, should be tested further to

conclude the drop, as they were measured with 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

Before damage for reference

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

File Name	Pinhole	PHD	Dark	F-F	Time(start)
					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
\/\						
Fuel Test	1min		Day-9	13:28 - 13:29		1999/11/01
\/\						
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

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		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

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

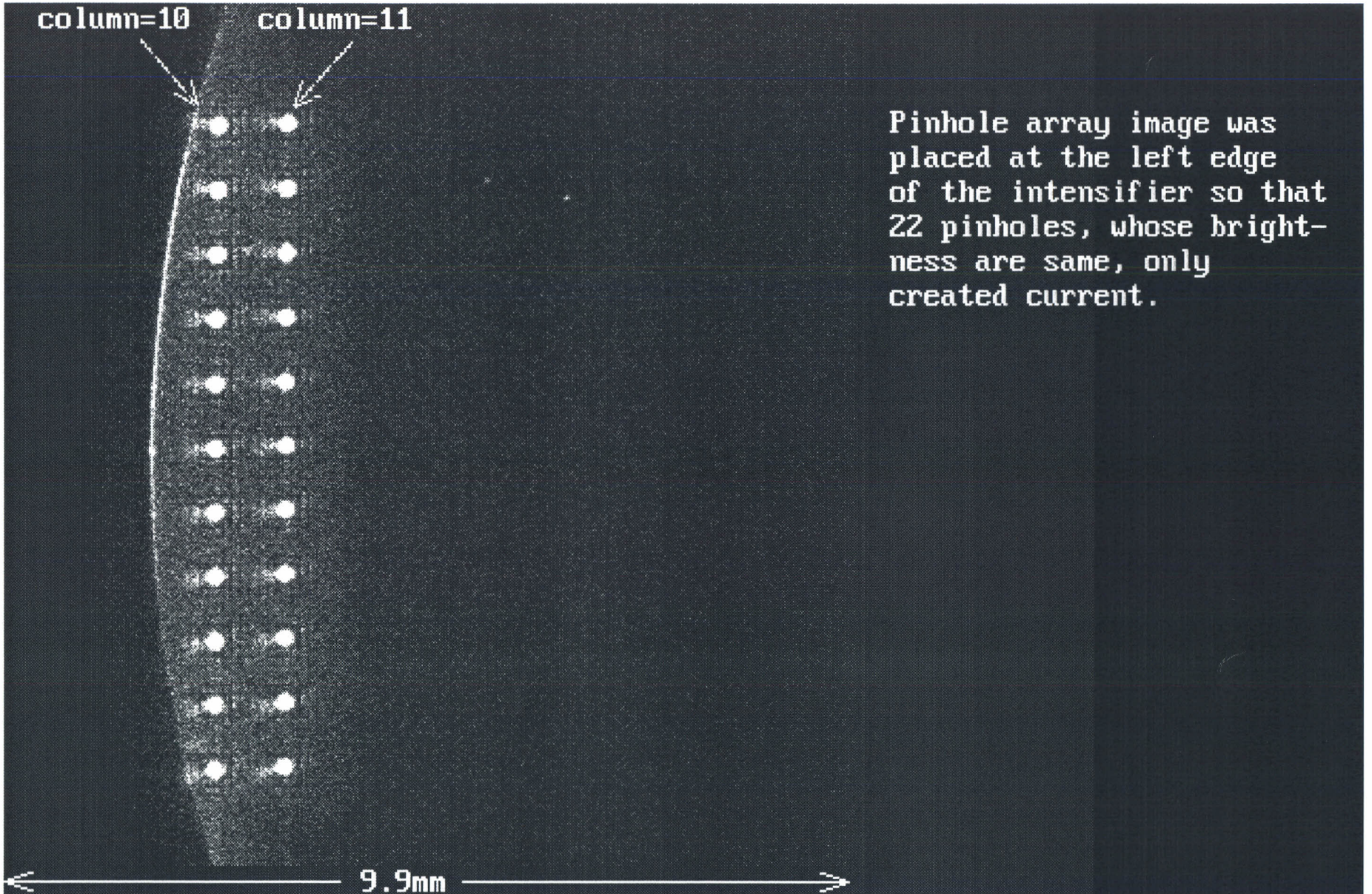

Fig. 49 Anode current measurement. Illuminated by brightest columns only.

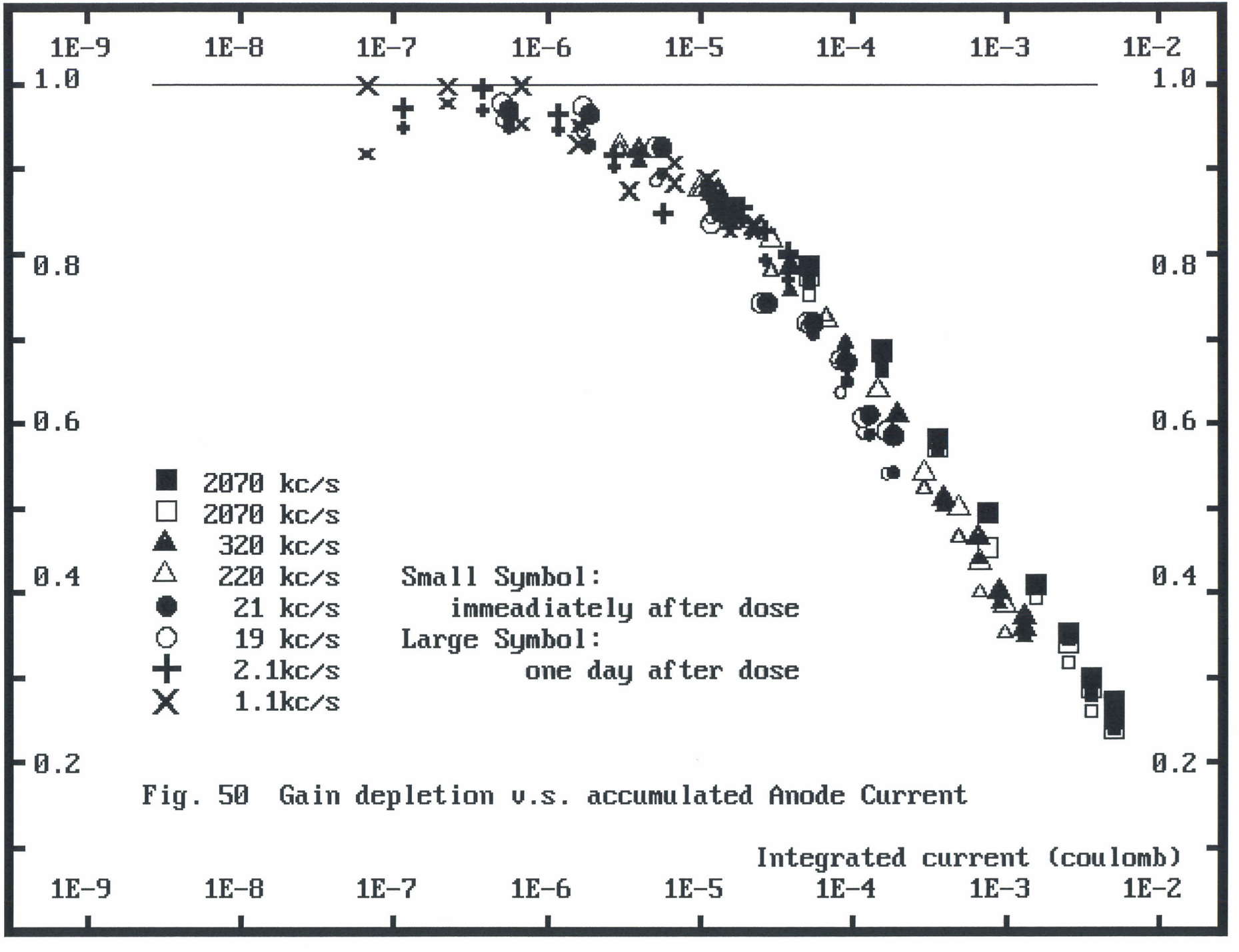

Fig. 50 Gain depletion v.s. accumulated Anode Current

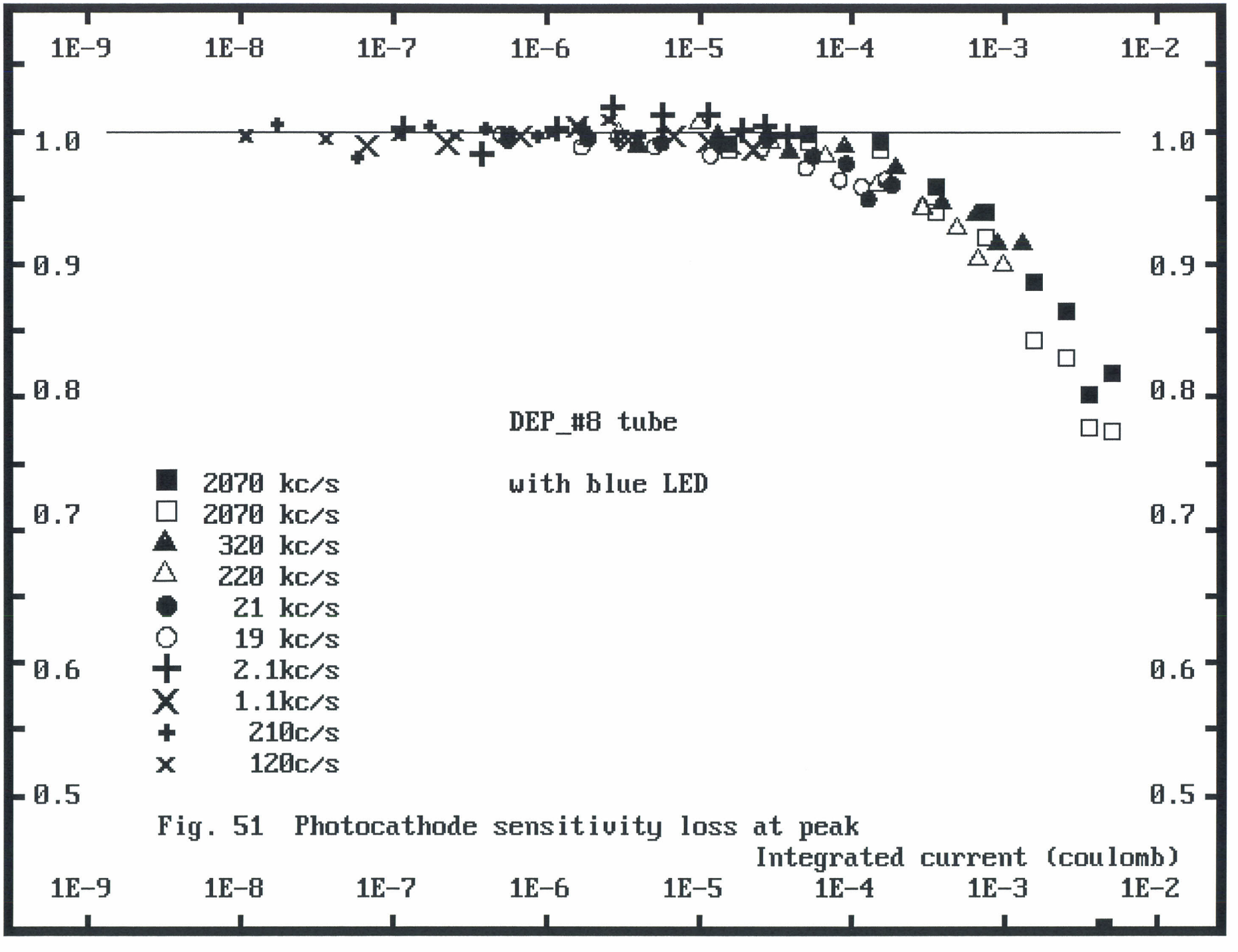

Fig. 51 Photocathode sensitivity loss at peak

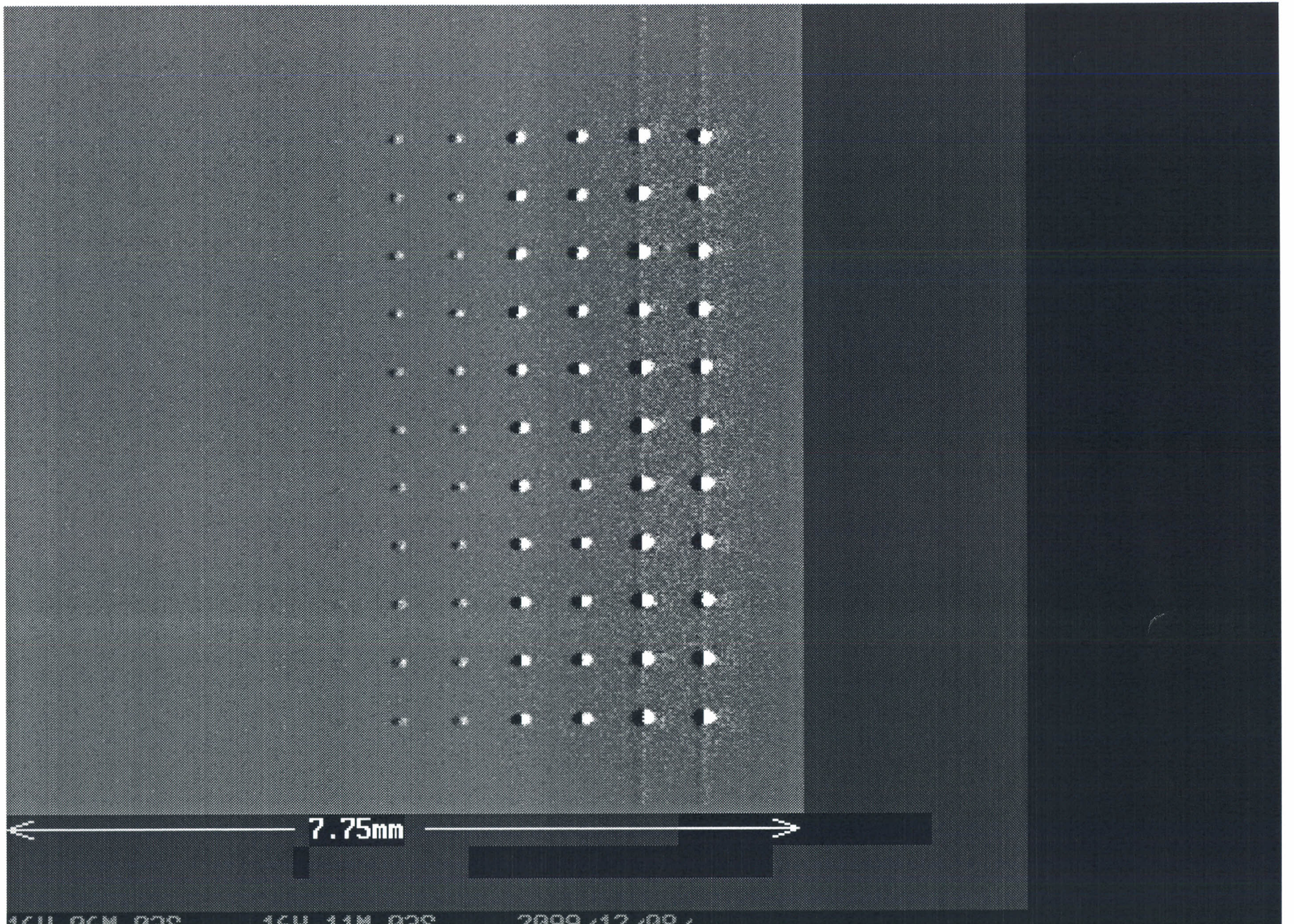

Fig. 52 Pinhole illumination with Offset=60um relative to original

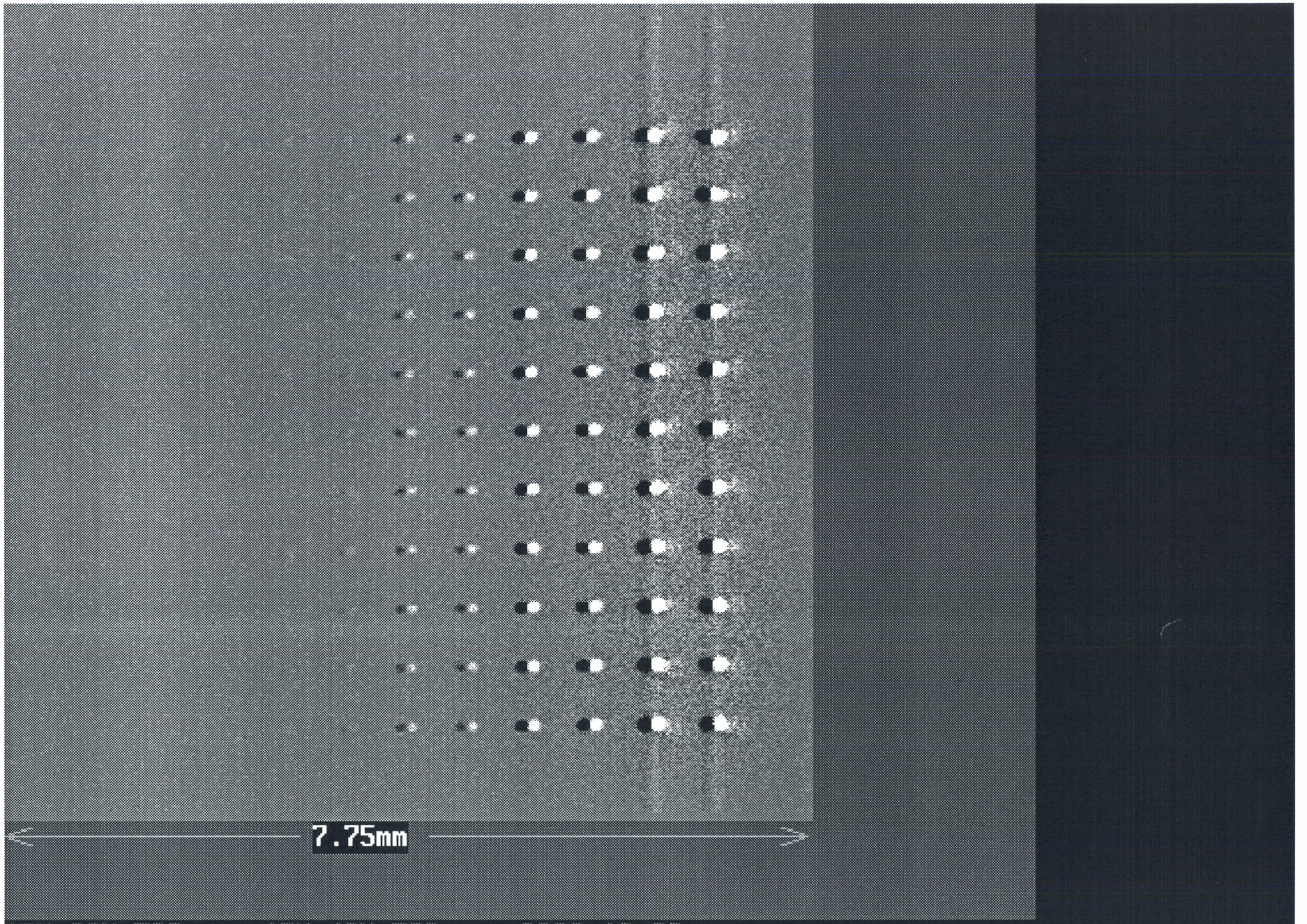

Fig. 53 Pinhole illumination with Offset=117um relative to original position

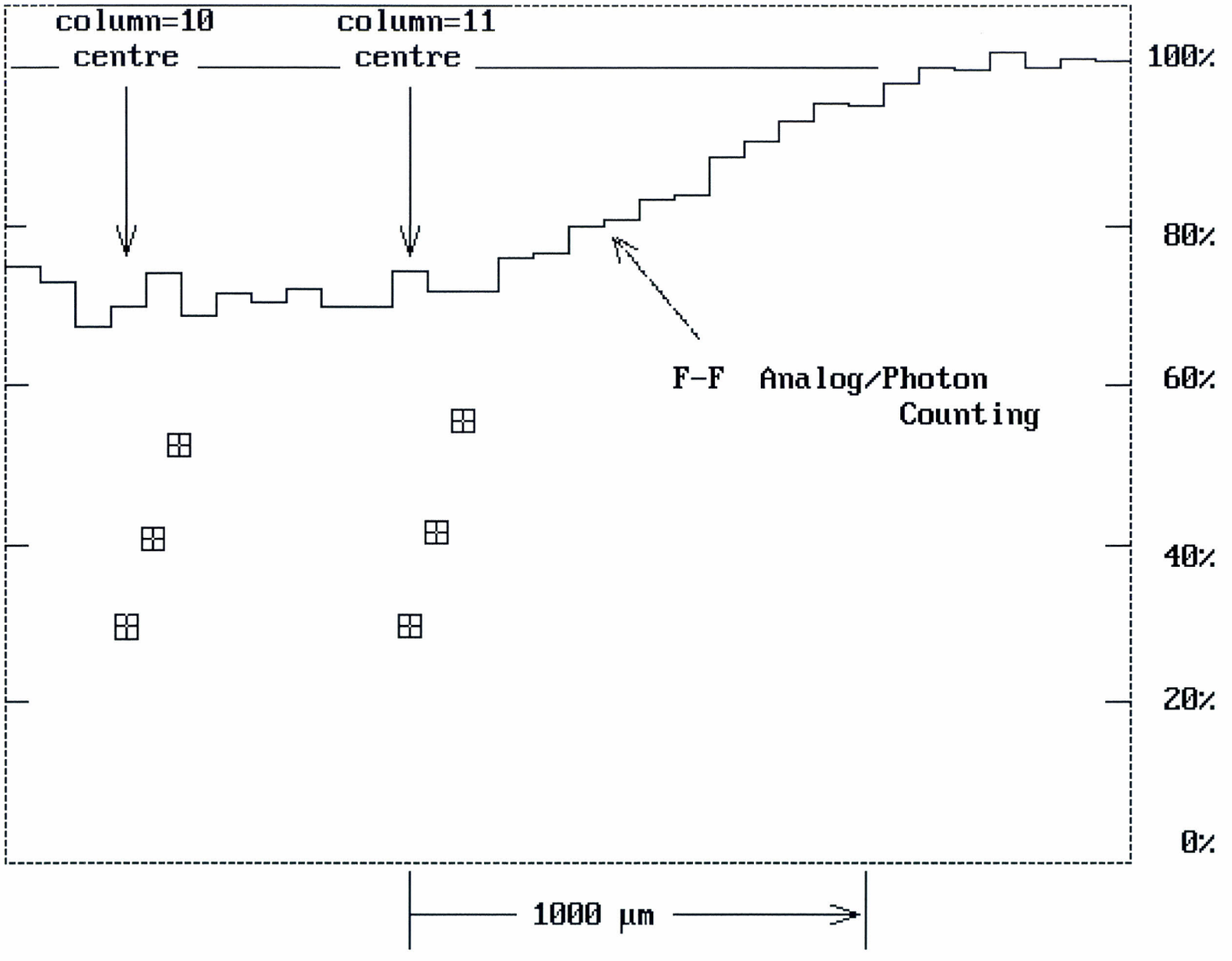

Fig. 54 Global extension of MCP gain depletion. Sliced along H-direction.

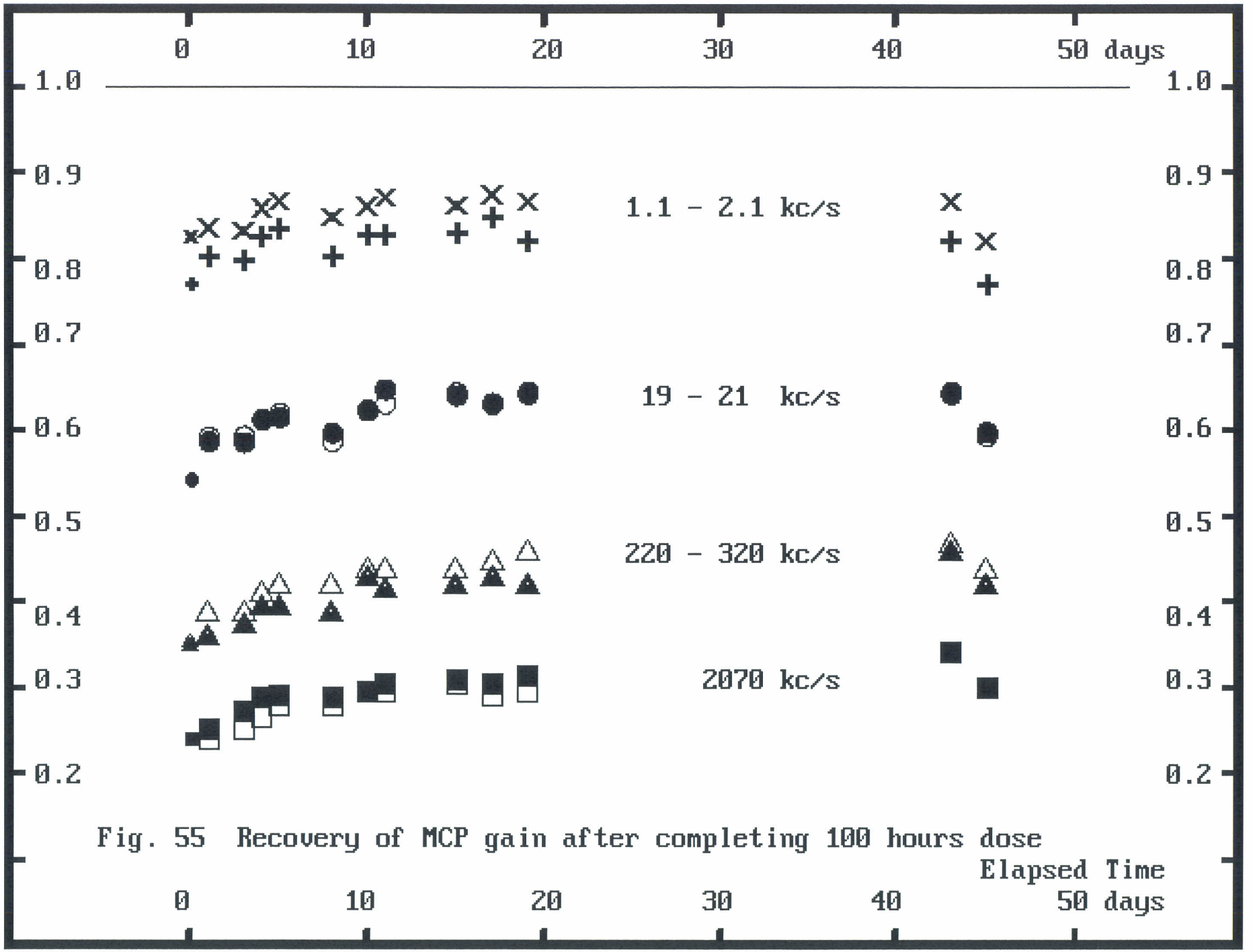

Fig. 55 Recovery of MCP gain after completing 100 hours dose

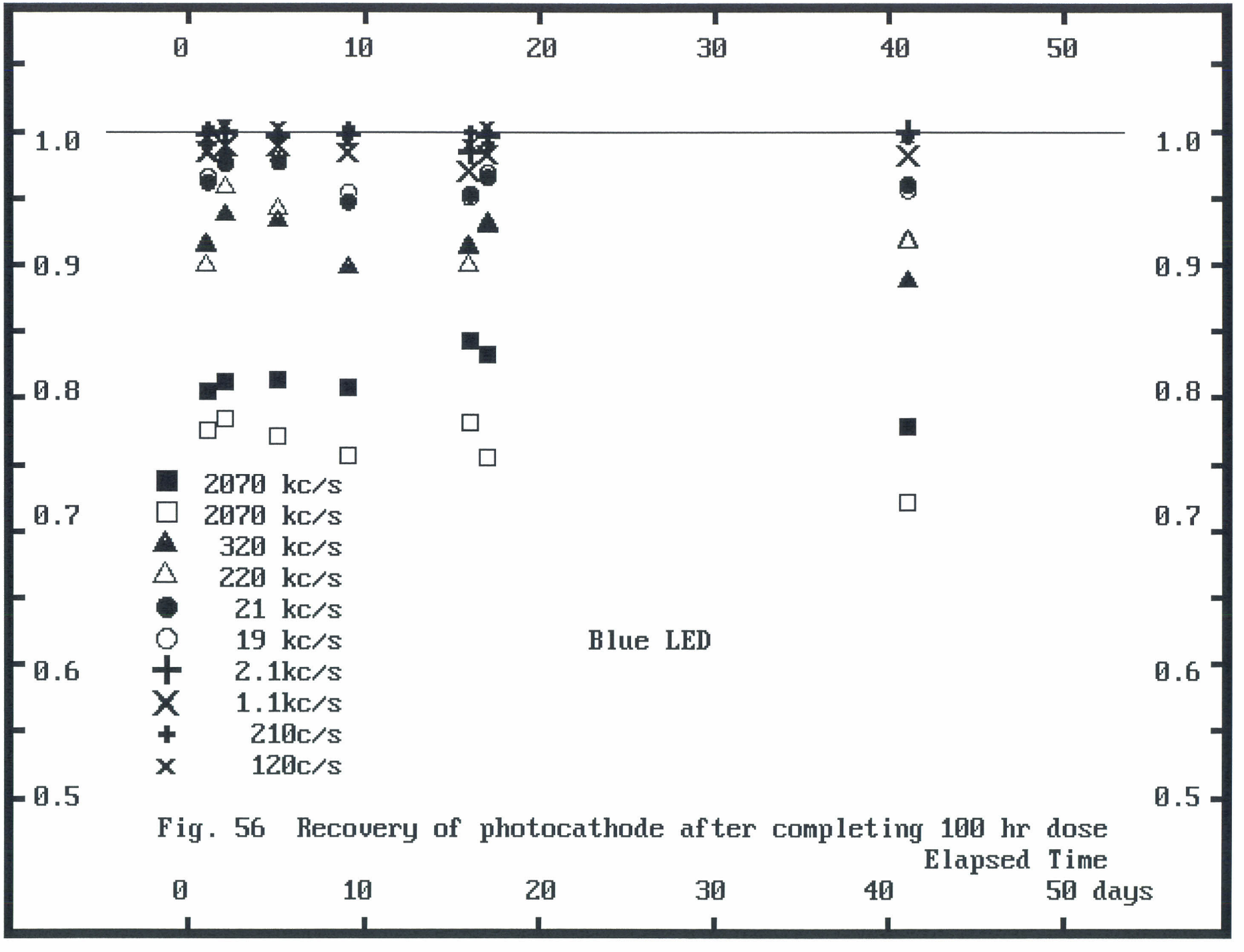

Fig. 56 Recovery of photocathode after completing 100 hr dose

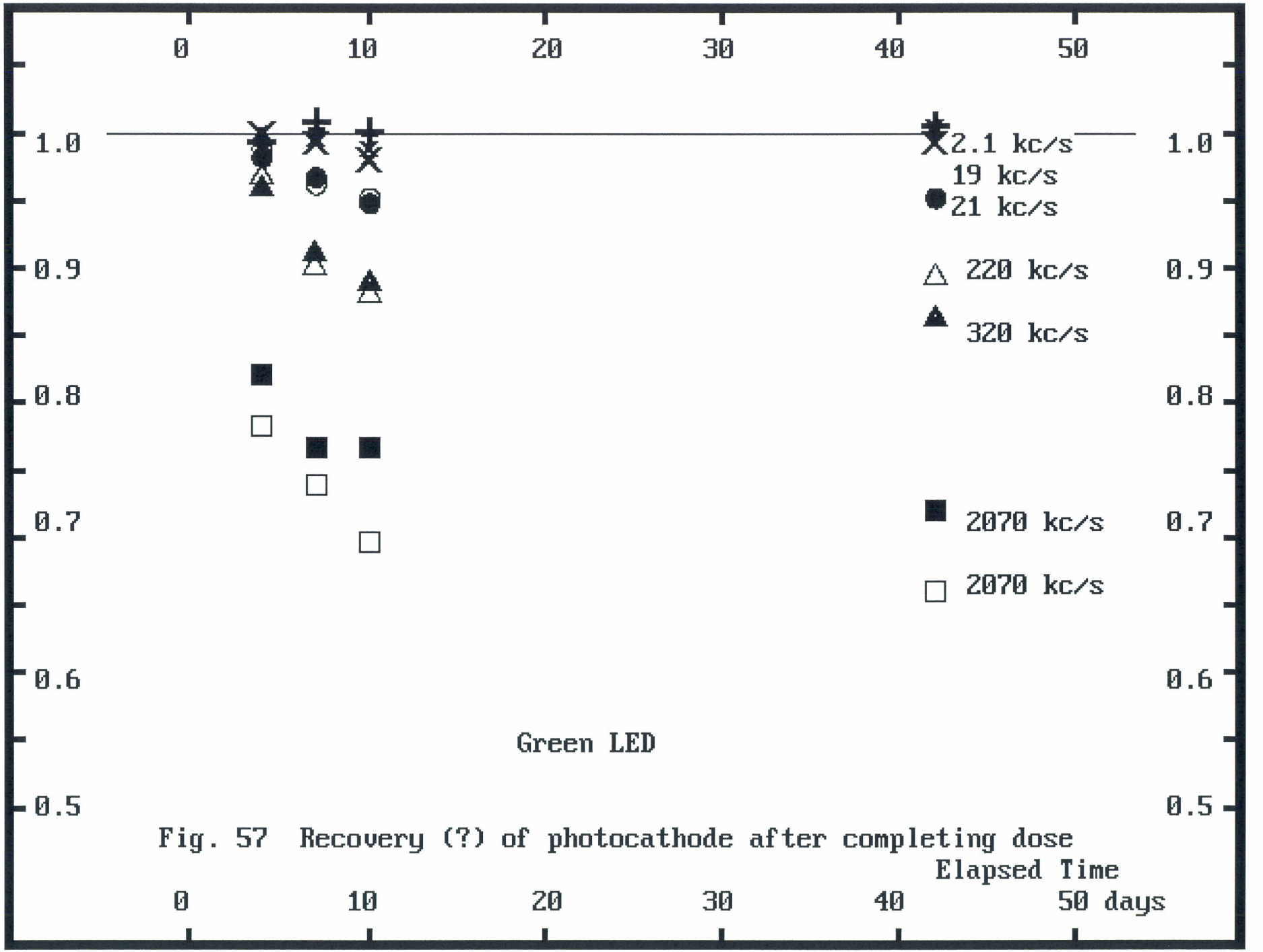

Fig. 57 Recovery (?) of photocathode after completing dose

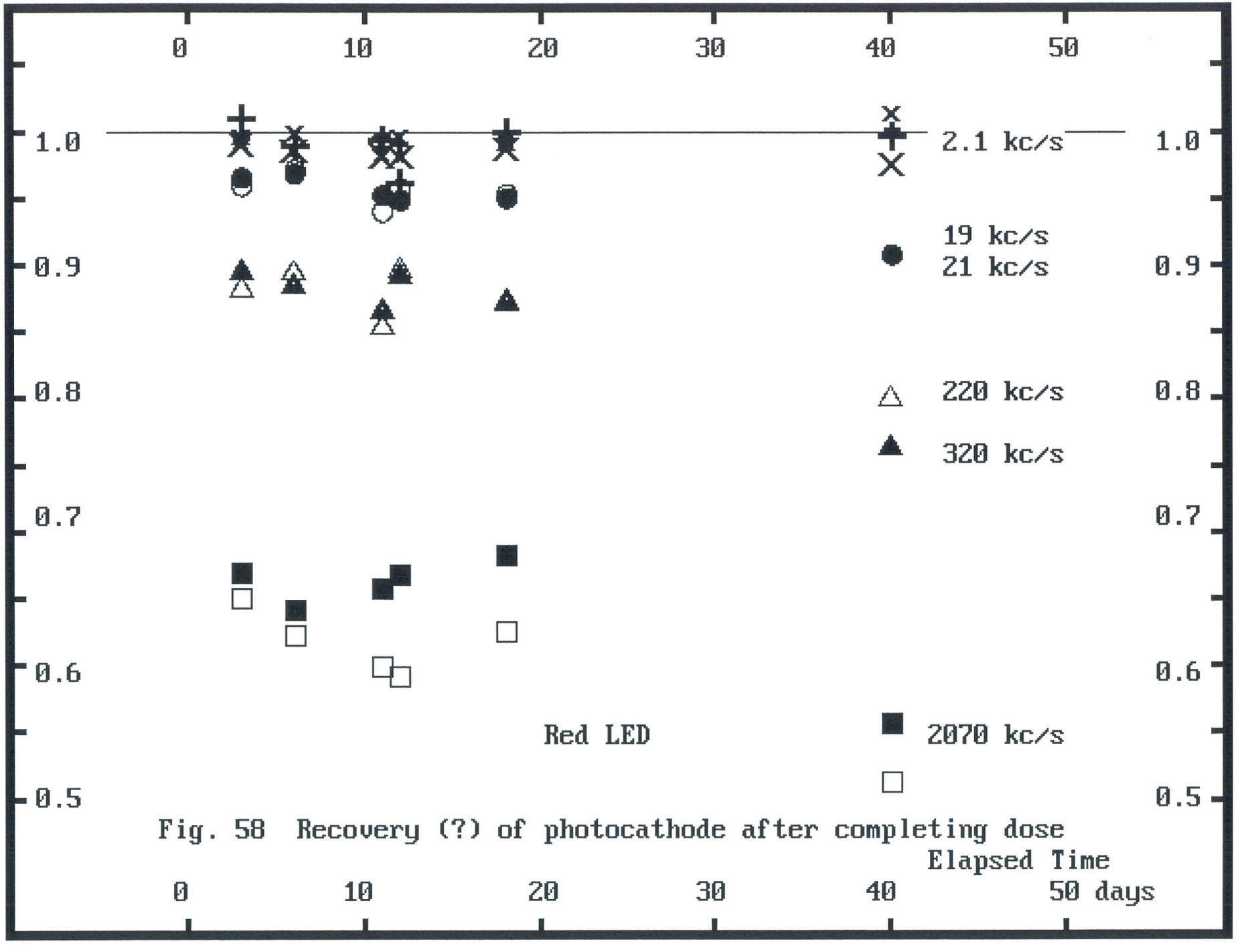

Fig. 58 Recovery (?) of photocathode after completing dose

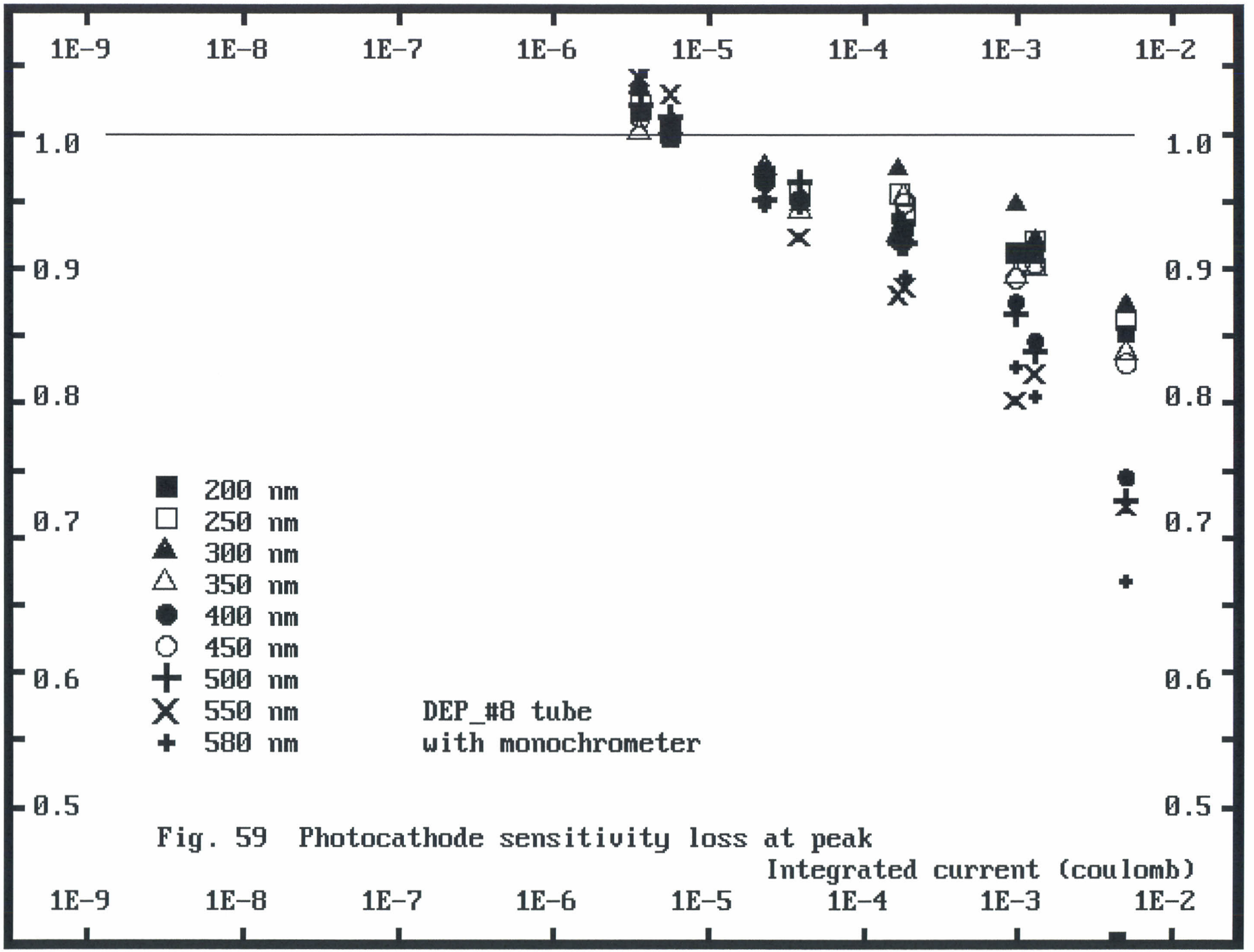

Fig. 59 Photocathode sensitivity loss at peak

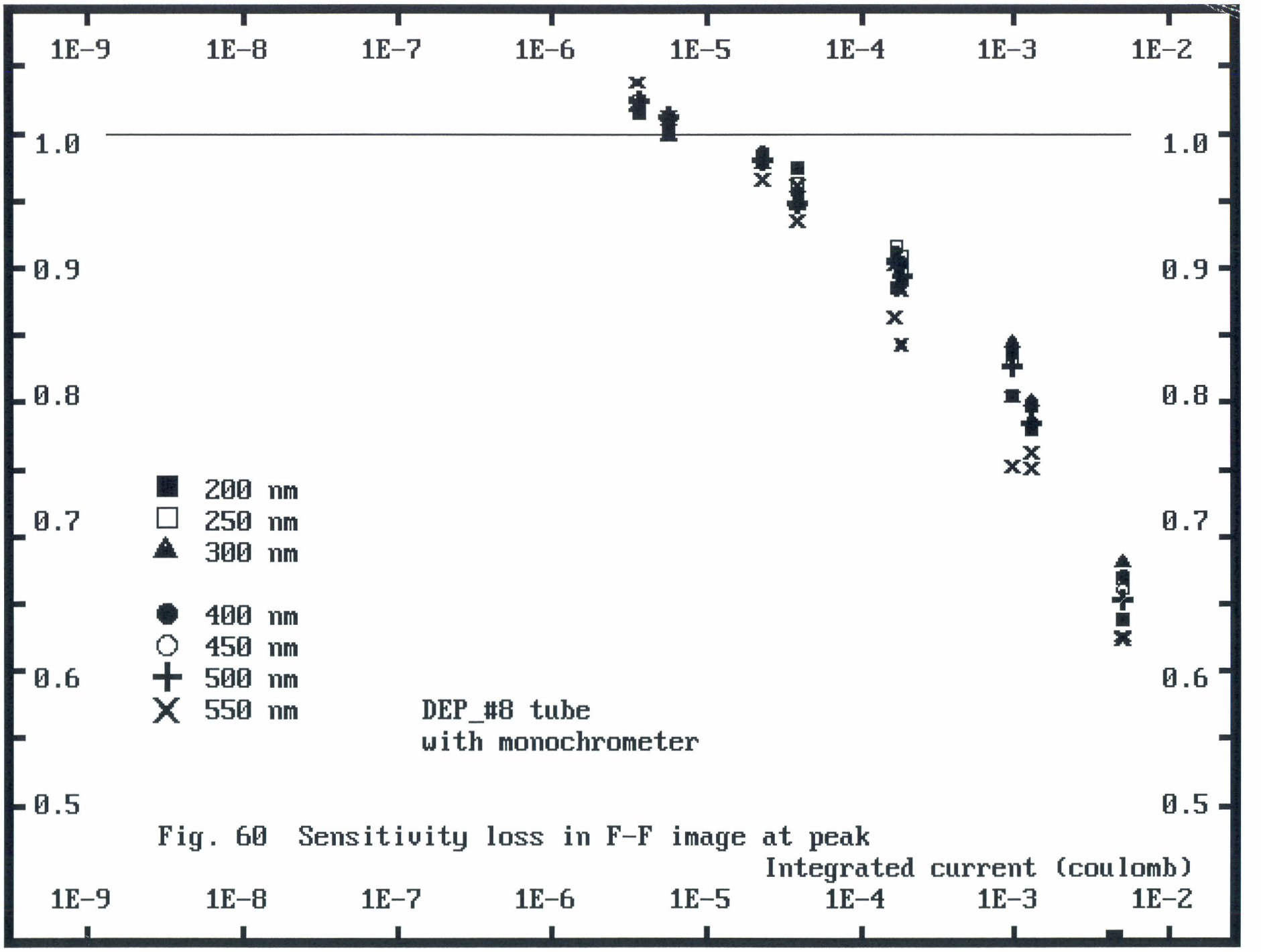

Fig. 60 Sensitivity loss in F-F image at peak