Fermilab

$\bar{p}$ NOTE #444

Debuncher Profile Monitor Evaluation

J. Krider

1/13/86

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Detector

The original microchannel plates have been damaged in the beam region. After an attempt to revive the plates by baking, the gain of the central 30mm is still reduced by approximately a factor of three. The plates appear to have been irreversibly damaged by being operated for an extended period of time at high gain with high debuncher beam currents. A new set of microchannel plates has been installed in the monitor.

Because of a production error, the gap between the microchannel plate output and the anode wire plane was set at 15mm instead of 3mm. The high voltage divider allowed a maximum of 170 volts to be applied across this gap. Under the conditions at which the Monitor was being operated, the distribution of collected electrons from a single micro channel was spread over a large area. A collimated UV light source which had a FWHM of 3mm produced a profile with a FWHM of 22mm with an amplifier threshold supply voltage of 1.0 V and FWHM of 9mm with a threshold voltage of 5.0V. See Figure 1. When new microchannel plates were installed, the anode gap was reduced to 9.5mm, and the gap voltage was increased to 760V, the results shown in Figure 2 were obtained. The width of the distribution depends strongly on the plate gain and discriminator threshold. Analog readout with a SWIC scanner eliminates the dependence of width on plate gain. Figure 3 shows two scanner profiles with plate gains differing by a factor of 64.

The anode wire plane allows a significant fraction of the charge to leak through into the low field region behind the plane and spread over several wires before being captured by the wires. This produces broad tails on the width distribution. Replacing the wire plane with strip electrodes etched on a printed circuit board eliminates this problem, as shown in Figure 4. Figure 5 shows scanner profiles with wire anodes and with P.C. strip anodes.

The intrinsic resolution of the detector appears to be less than one element width (2.2mm), so the P.C. anode will have 8 elements instead of the previous 32. This will provide more useful information in measuring $1/2\pi$ beams from the booster.

Local Readout

The pulse counting readout technique has two fundamental problems which cannot be eliminated. First, as discussed above, the difference between measured width and true width depends on plate gain/discriminator threshold, rather than being a simple constant. Second, it is not possible to reduce microchannel plate gain by 2 or 3 orders of magnitude to look at intense beam ($\geq 10^{10}$) without saturation or degradation of the plates.

Additional soluble problems include signal transmission and profile acquisition rate. The risetime of signals at the output of the cables from the detector to AP10 is degraded so that it barely crosses the scaler input threshold for the short pulse lengths out of the preamp/discriminator. The maximum profile acquisition rate of 25 Hz is marginal for observing the proposed rapid blowup of booster beam (100 ms).

Interface to Control System

The local hardware/software for the pulse counting readout will not be supported in its present form by the Controls Group. They proposed two options. For the short term they could read out raw scalar data independent of the local analysis system. An application program would have to be written to generate profiles, calculate fit parameters, and display the information. For the long term, ≥ 6 months, we could install hardware/software that would be compatible with and supported by the control System.

Alternative Readout with SWIC Scanner

I believe the SWIC scanner is a viable alternative. It would eliminate the preamp/ discriminators and the present rather complicated local system. It is better matched to the detector and provides solutions to the previously mentioned shortcomings of the pulse counting technique. It is already interfaced to the control system and would require minimal application programming to provide profile displays and time plots of profile mean, width and integral (beam intensity). If this system proves to be inadequate, an improved original system or some alternative may be implemented.

Two limitations of the SWIC scanner readout should be recognized. It will presently be limited to 10 profiles per cycle followed by a few seconds of deadtime. The 10 profiles can be recorded in as little as 95 ms. The cycle time may improve with control hardware which is now being developed. Second, this system may be some what more sensitive to microchannel plate gain degradation. However, that should be compensated for by being able to operate the plates at lower gain.

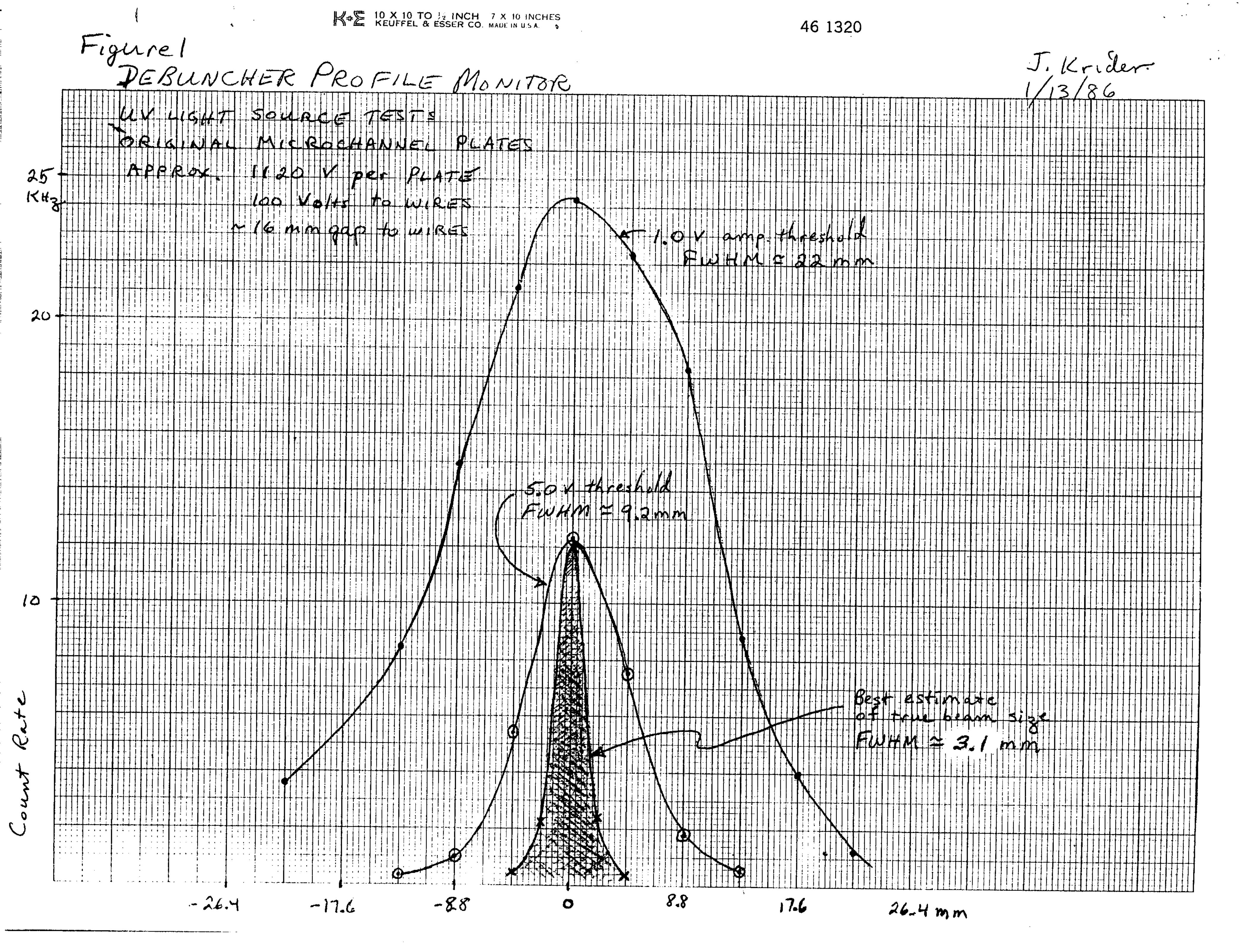
The cost of implementing SWIC scanner readout is approximately $1500 for hardware and cabling. We already have a scanner. The cost of short term upgrades required for the pulse counting system is ~ $6000. Long term upgrades for the pulse system have not been defined, but would add significantly to the cost.

Miscellanea

Figure 6 shows the relative gain of the microchannel plates (on one readout element) as a function of plate high voltage. Figure 7 shows the uniformity of gain across the microchannel plates at fixed high voltage. The beam of UV light was not wide enough to illuminate the entire detector at one time, so the left and right sides of the detector are shown on separate photographs. Figure 8 shows the pulse height spectrum on one readout element. This spectrum was measured by calculating the differential count rate as a function of plate high voltage using a preamp/discriminator in the pulse counting readout mode. These measurements are consistent with factory specifications

The high voltage divider which supplies the microchannel plates should have a standing current about 10 times the strip current which flows through the microchannel plates. Strip current for our several microchannel plates varies between 100 and 240 microamps at 1 KV per plate. A divider which uses 1 MΩ across each plate should be sufficient. Figure 9 shows the new divider. The original divider used 10 MΩ resistors.

Figure 1



K+E 10 X 10 TO ½ INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 1320
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UV LIGHT SOURCE TESTS
ORIGINAL MICROCHANNEL PLATES
APPROX. 1120 V per PLATE
100 Volts to WIRES
~16 mm gap to wires
1.0 V amp threshold
FWHM ≃ 22 mm
5.0 V threshold
FWHM ≃ 9.2 mm
Best estimate
of true beam size
FWHM ≃ 3.1 mm
25
KHz
20
10
Count Rate
-26.4
-17.6
-8.8
0
8.8
17.6
26.4 mm

Figure 2
DEBUNCHER PROFILE MONITOR

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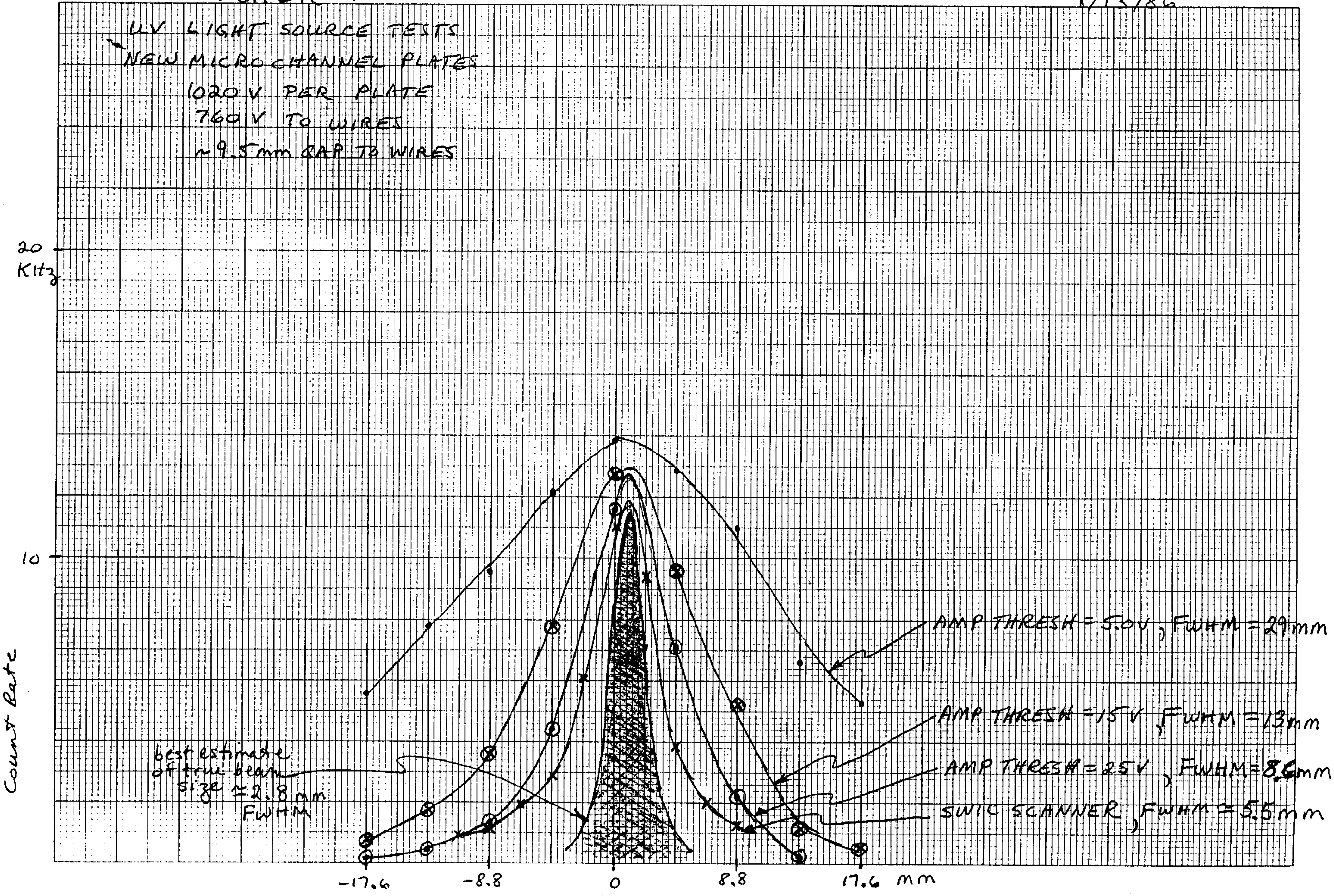
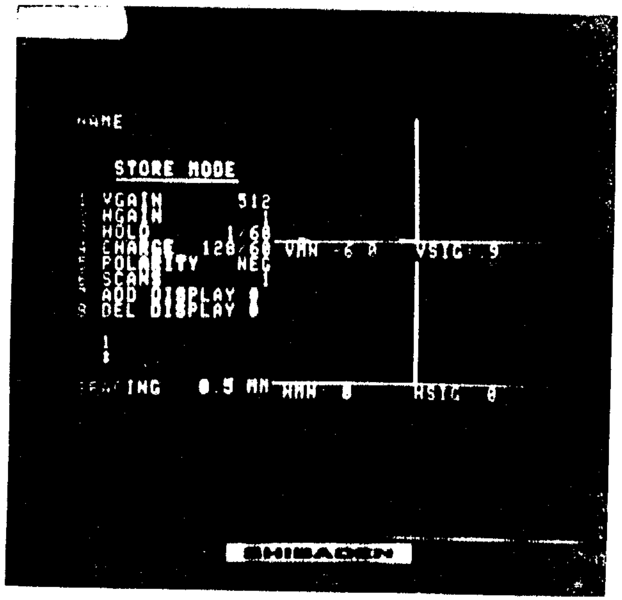


Figure 3 Profile width for two plate gains differing by 64

1532 V



2038 V

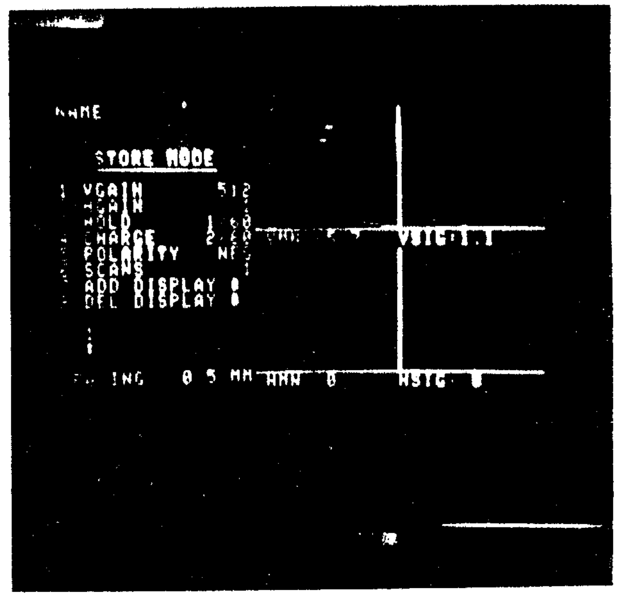


Figure 4
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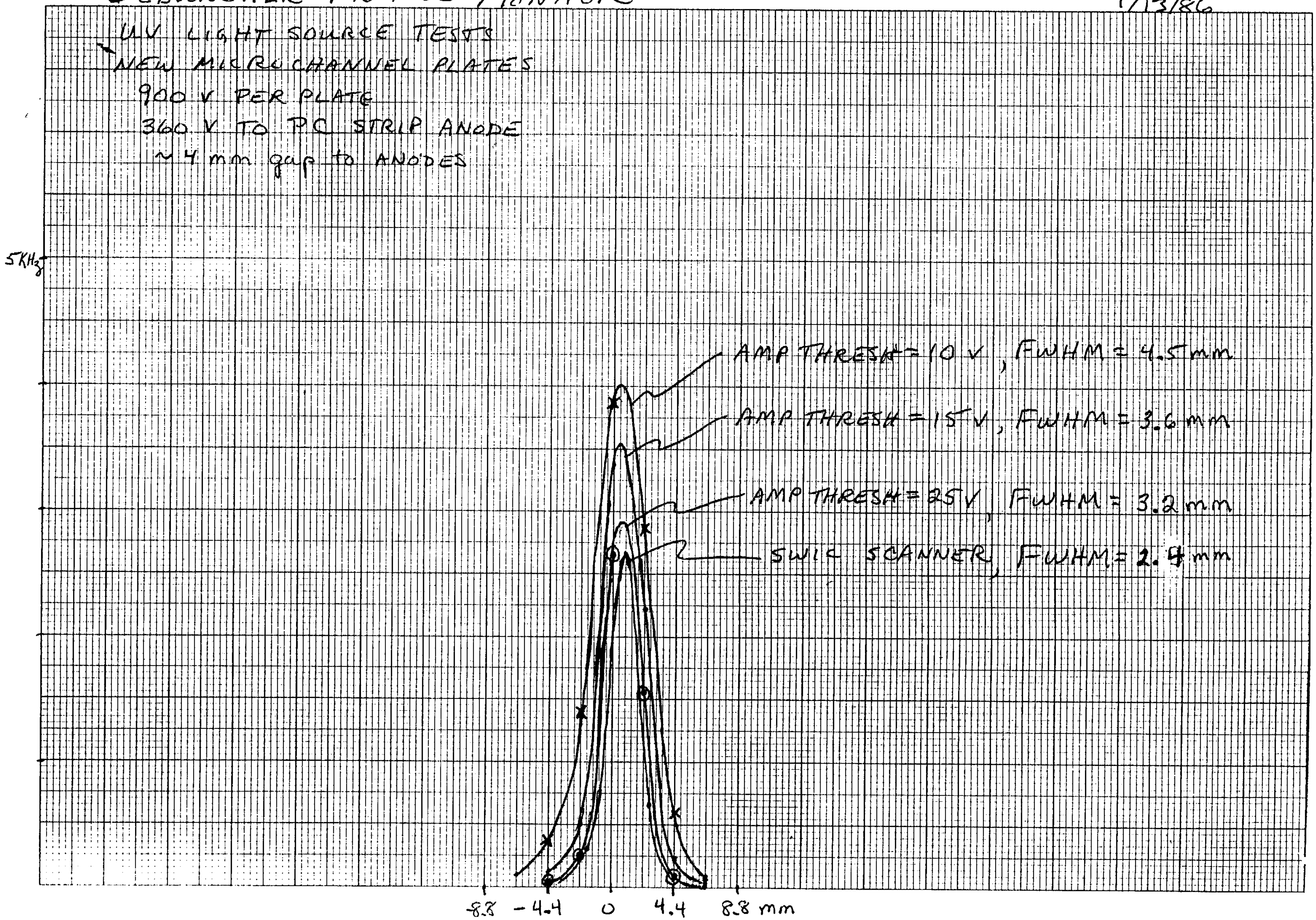
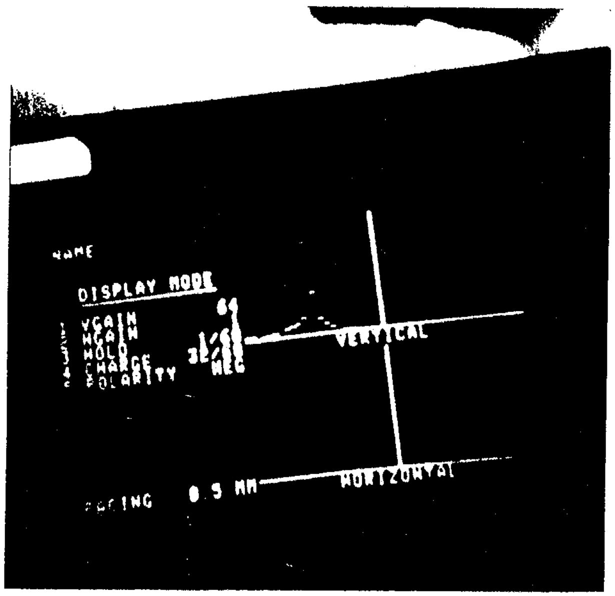
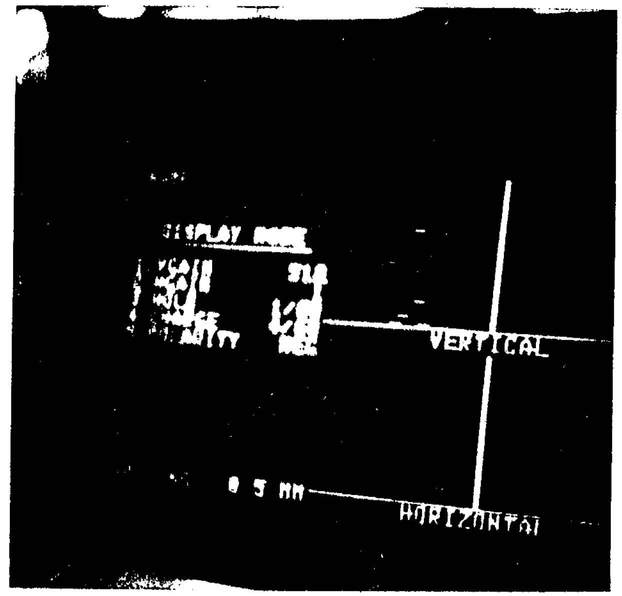


Figure 5 Anode wires vs. P.C. strips



wire anodes



P.C. strip anodes

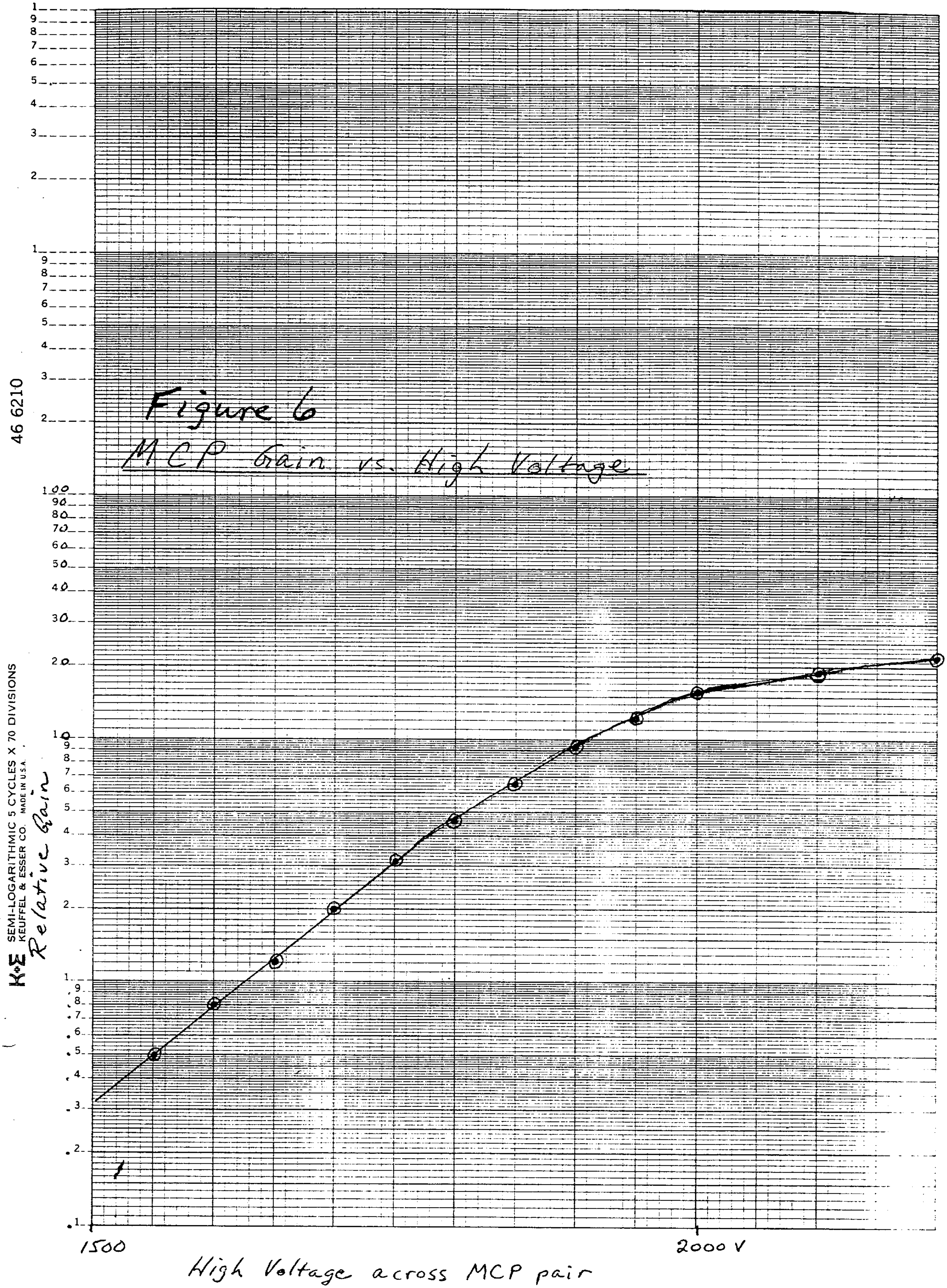
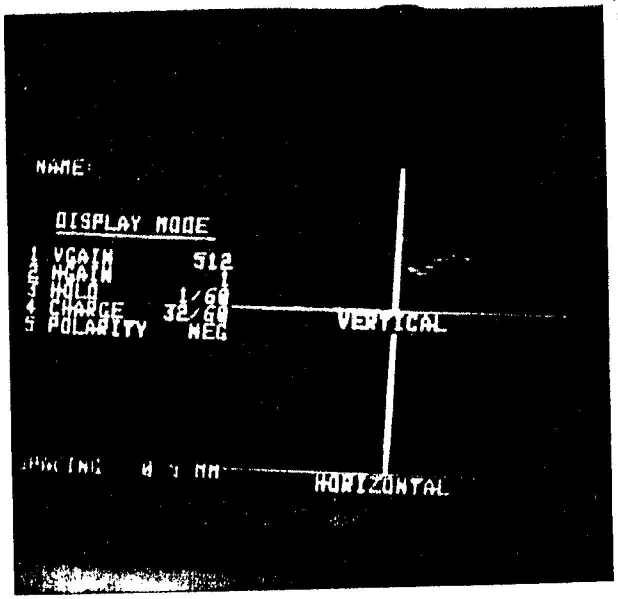


Figure 6

MCP Gain vs. High Voltage

Figure 7 - Uniformity of gain



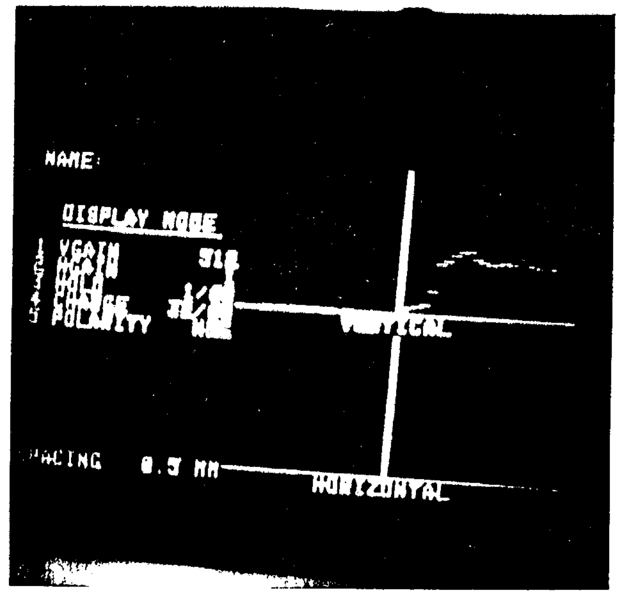


Figure 8
PULSE HEIGHT SPECTRUM

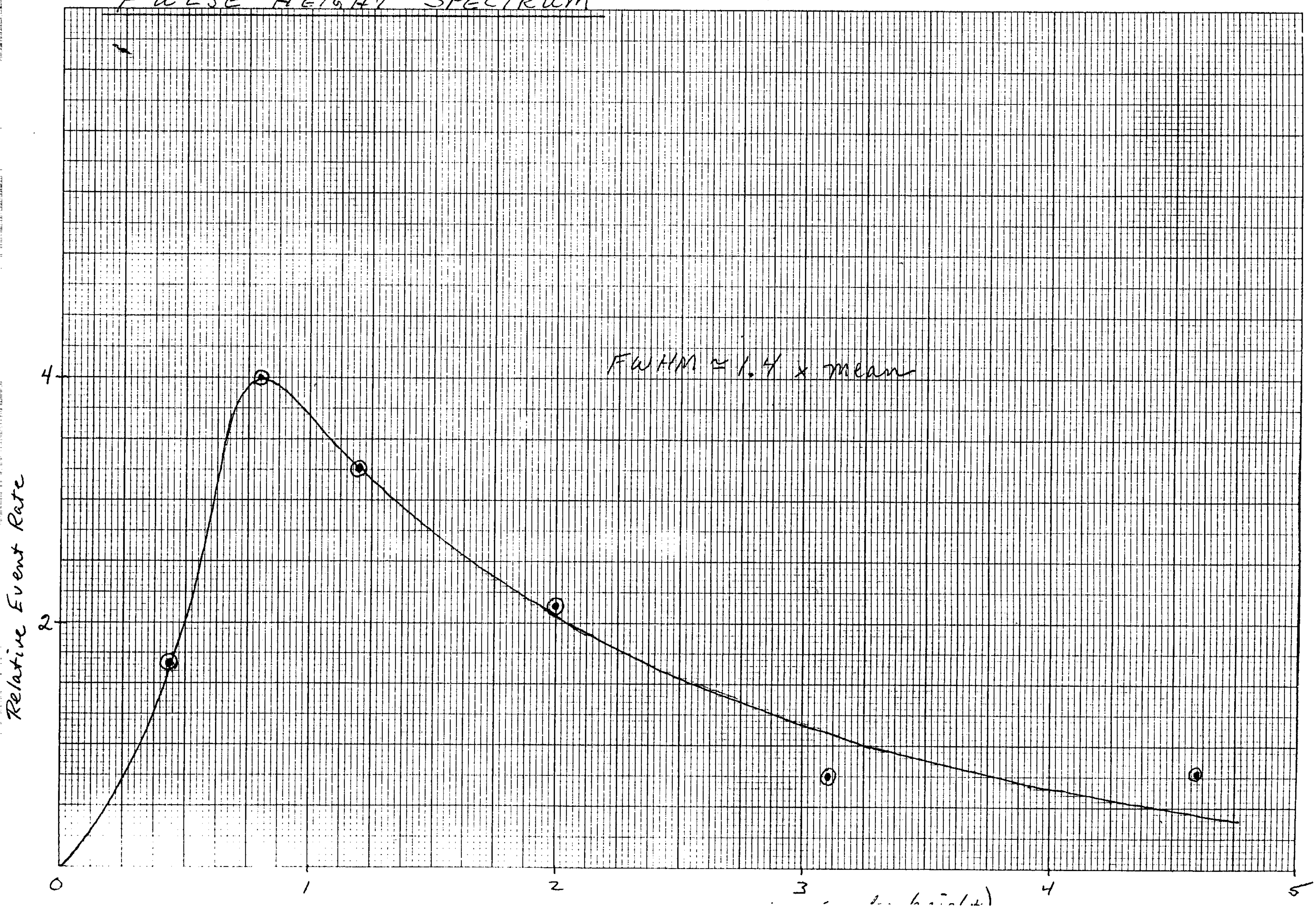


Figure 9 High Voltage Divider