Fermi National Accelerator Laboratory

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Modifications and Tests of MWPC Mu0 *

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Introduction

E711 MWPC DC5 is on long term loan to E672 from the FNAL physics department. It was received at Indiana University (Bloomington) in May 1988. This paper is a summary of the testing and modifications that were done on this chamber. The chamber is now referred to as mu0.

Mu0 Construction

Mu0 is a multi-wire proportional chamber built by FNAL and Florida State University HEP (Contact Kurtis Johnson). The shell of the chamber is aluminum, and contains 11 planes: 4 anodes, 5 cathodes, and 2 ground planes. Detailed information about these planes is in appendix A.

The external dimensions of Mu0 are 102" X 102" X 15.375". Mu0 weighs approximately 1600 lbs.

Amplification

Anode signals were amplified using Nanometric N-277c amplifier cards plugged directly into Mu0. N-277c specifications are included in appendix D. The preamps previously used on this chamber were eliminated. Once internal breakdown problems in the chamber were solved, 700 V wide efficiency plateaus were achieved using the N-277c amplifiers without preamplifiers.

Initial Tests

Cosmic Ray Trigger

The trigger for the efficiency test was a cosmic ray telescope made from three scintillator counters, shown in fig. 1. Two counters were placed above the active area of the chamber, and the third below it. A coincidence of signals from three counters constituted a "trigger". A block diagram of the trigger electronics is presented in fig 2.

The amplified signals were latched by LeCroy PCOS III latches. The data were then displayed on an LSI-11 computer running the program MULTI.

Efficiency Plateaus

The efficiency vs. H.V. data taken with the unmodified MWPC are shown in fig. 3. Data were taken for amplifier thresholds of 0.5 mV, 1.0 mV, and 1.65 mV. For all of these thresholds, breakdown occurred in the chamber at a H.V. of about -4.1 kV, before an acceptable efficiency plateau was achieved. Lower thresholds resulted in high singles rates and amplifier oscillation.

Calculations (see appendix C) showed that unsupported anode wires should be unstable at H.V. = 4.2 kV. However, for two of the planes the wires were supported and they also broke down at H.V. = -4.1 kV. This suggested to us that the breakdown was not in the active area of the chamber.

Careful listening revealed that at H.V. = -4.1 kV a sizzling sound like an electrical discharge seemed to be coming from the edges of the chamber. The chamber was then opened.

Several potential problems were noticed:

1. an excessive amount of copper had been left on the cathode circuit board (see fig. 4), and it was as close as 3/16 inch from the Al cores of adjacent planes. This was only half of the anode-cathode gap.

2. the leads to the resistors limiting current to the cathode wires were uninsulated and within 3/8 inch of the planes' aluminum core.

3. some cathode H.V. traces came within 3/16 inch of holes exposing the cathodes' aluminum core. (fig. 4)

The following modifications were made to cathodes 4 and 5 only (these cathodes surround the U anode, which has a support wire):

1. the leads of the current limiting resistors were insulated with RTV sealant.

2. all excess copper was stripped from circuit boards.

3. copper traces too close to ground were removed and replaced by wire jumpers from traces further away. (fig. 5)

4. 5 mil kapton sheets were inserted between the cathode circuit boards and the adjacent planes. (fig. 5)

In addition, one inch of grounded copper along the active area of the U and V anodes was stripped away to reduce the chance of discharge.

The remaining planes of the chamber were left unmodified for comparison.

Tests of the Modified Planes

After the above modifications were completed, the chamber was reassembled, closed, and purged for eight days (resulting in 4 complete gas volume changes- see appendix B). The newly modified planes held H.V. = -5.2 kV without break- down. The unmodified planes continued to break down at H.V. = -4.1 kV. This showed that the modifications were successful.

Further Modifications

The calculations presented in appendix C show that electrostatic repulsion becomes a problem for unsupported anode wires at H.V. = (approx.) 4.2 kV. A support line installed half-way along the length of the anode increases the voltage limit to H.V. = 8.3 kV.

Nylon support lines were installed in the X and Y anodes. The lines are DuPont 'Stren' fishing line. A strand passes on either side of the wires, supporting them from both sides. The support lines are glued to each other at 6-inch intervals, and anchored in holes at the anode edge.

Beam Deadeners were attached to the center of each anode plane. The beam deadeners are two-inch diameter circles cut from three-mil Kapton sheet. One such disk was woven into the wires at the center of each anode. The disk was then glued to several wires with 5-minute epoxy.

Final Results

Efficiency data for each of the four Mu0 anodes are shown in fig. 7. Singles rates scaled by number of wires in the anode plane are shown in fig. 8.

Singles rate vs. amplifier threshold for the U and V anodes are plotted in fig. 9. The 50% efficiency voltage vs. amplifier threshold is shown in fig. 10.

Figures 11 and 12 display spatial and timing distribution data for the four anodes.

Mu -1

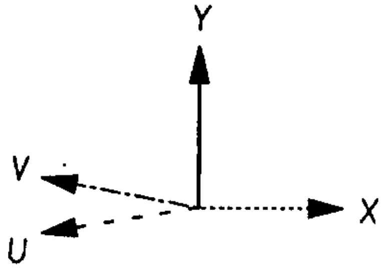
A duplicate chamber, Mu -1, which is now being assembled at Indiana University, incorporates the modifications described above. The program for machining the anode and cathode circuit boards using a computer-controlled mill has been modified by Jim Schellpfeffer at FNAL, and is now in his files.

APPENDIX A

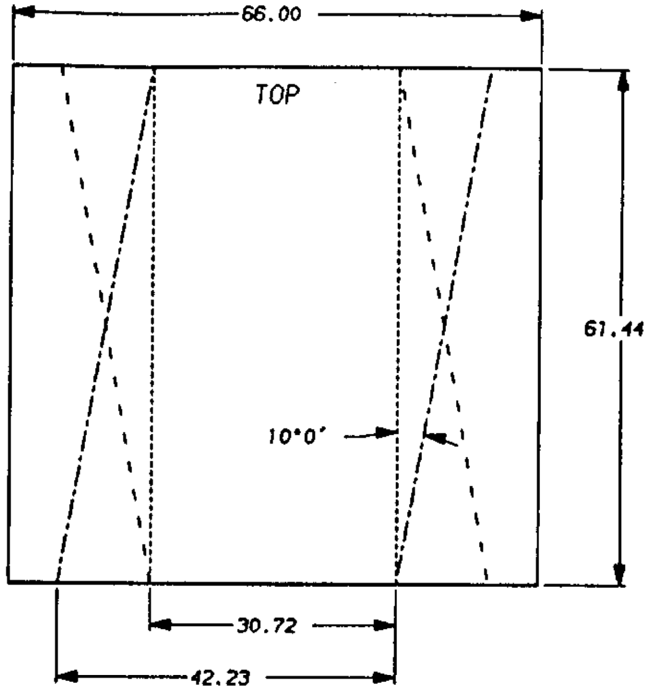
Mu0 Plane Wiring

	CATHODES(5)	ANODES(4)	GROUNDS(2)
Wire Diam.	0.0035"	0.001"	0.0035"
Pitch	0.040"	0.120"	0.040"
Length	66.0"	X - 66.0" Y - 66.0" U - 67.0" V - 67.0"	65"
Number	1650	X - 256 Y - 560 U - 352 V - 352	1725
Tension	350gm	90gm	350gm
Orientation	horizontal	X - horizontal Y - vertical U - vertical+10 degrees V - vertical-10 degrees	vertical
Composition	CuBe	AuW	CuBe
Source	Little Falls	Sylvania-GTE	Little Falls

Appendix A (cont.)



Looking Downstream



Plane Order

Upstream

Plane & #wires
Ground (1725)
Cathode #1 (1650)
Y - anode (512)
Cathode #2 (1650)
X - anode (256)
Cathode #3 (1650)
V - anode (352)
Cathode #4 (1650)
U - anode (352)
Cathode #5 (1650)
Ground (1725)

1/2-gap = 0.365"
Anode pitch = 0.12"
Cathode/GND pitch = 0.04"

Anode wire: 1 mil AuW
Cathode/GND wire:
3.5 mil Cu/Be

APPENDIX B

Gas

The gas mixture for our tests on Mu0 was as follows:

COMPONENT	% OF TOTAL
Argon	76
Isobutane	15
Methylal	8.9
Freon	0.1

The flow rate of this mixture was 0.5 L/M.

Total Gas Volume Exchange time

The gas volume of Mu0 is approximately 1600 liters. At a flow rate of 0.5 L/M, the gas in the chamber is completely exchanged in:

1600 L / 0.5 L/M = 3200 Minutes

= 53.3 Hours

= 2.2 Days

Appendix C

Wire Instability in Mu0

A calculation was done to estimate the voltage limit due to electrostatic repulsion between adjacent wires in anodes and cathodes. For anodes, the limiting voltage was calculated for unsupported wires and for wires supported half-way along their length.The following formula was taken from the Particle Properties Data Booklet (Particle Data Group, April 1986, page 70).

Where:

V = voltage limit

T = wire tension in grams

t = chamber half-gap

l = length of the wires

s = wire pitch

d = wire diameter

ANODE DATA:

For all Mu0 anodes,

T = 90 grams

t = 0.93 cm

l(unsupported) = 170.2 cm

l(supported) = 85.1 cm

s = 0.30 cm

d = 0.0025 cm

CATHODE DATA:

For all Mu0 cathodes,

T = 350 grams

t = 0.927 cm

l = 167.64 cm

s = 0.102 cm

d = 0.0089 cm

Using these data, the voltage limit for unsupported anode wires is:

V(uns) = 4.20 kV

The voltage limit for supported anode wires is:

V(sup) = 8.33 kV

The voltage limit for cathode wires is:

V(cat) = 6.36 kV

Appendix D

Nanometrics N-277c Amplifiers

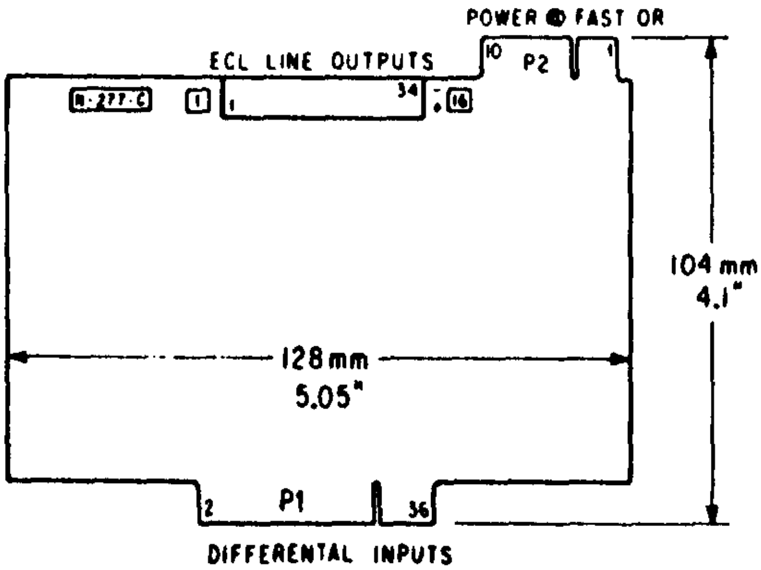
The N-277C is a general purpose proportional chamber system front end amplifier/discriminator with input sensitivity to ½ micro amp. Sixteen channels of amplifiers and discriminators are provided on a card 128 mm (5.05'') by 104 mm (4.1'') in size.

Differential inputs allow use with either positive or negative signals without jumpers or modifications, and all inputs are diode protected. The amplifier's input impedance is normally 330 ohms; however, other values can be supplied.

Differential ECL outputs are provided. These output signals are time over threshold; however, very long inputs are restricted to 45 n sec. wide outputs by a simple differentiator. A fast "OR" is also provided; this is useful in fast trigger systems or testing. The fast "OR" output is a current source which allows summing the signals from a number of adjacent cards on a single wire.

The model N-277D is very similar to the N-277C with the addition of a pulse shaping baseline restorer network consisting of a transfer function with one pole. The standard time constant of this pulse shaping network is 35 n sec.; however, other values may be special ordered. This type of signal processing filter is useful in high counting rate proportional counters.

The model N-311 is a four channel amplifier/discriminator designed for Drift Chamber use. Its size is 89 mm (3.5 inches) by 64 mm (2.5 inches). It uses a 26 position PIN connector.



N-277C SPECIFICATIONS

THRESHOLD	500 nano amps. ± 150 nano amps. Input impedance 330 ohms.
THRESHOLD ADJUSTMENT	Set by an external voltage. 1 volt = 1 micro amp. Range is 0 to 20 micro amps.
SIGNAL POLARITY	Handles both positive and negative inputs. No jumpers required!
NOISE	1000 Hz total for all 16 channels. 400 Hz maximum for individual channels. Test conditions: Threshold voltage 0.5 volts. Pos. input grounded. Neg. input shunted by 50 ohms or less.
TIME WALK	8.5 nano sec. maximum. 6.5 nano sec. typical average. Test conditions: Threshold voltage 0.5 volts. Test pulses: 1.3 to 6.5 micro amps.
CROSSTALK	Adjacent channels, greater than 30 db. Non adjacent channels, greater than 40 db.
FAST "OR" OUTPUT	Delivers -0.6 ma from a current source. i.e. -30 m volts into 50 ohms.
SIGNAL OUTPUTS	Drives 16 differential ECL lines.
POWER	350 m watts per channel. Total power for a 16 channel card: +5.0 volts at 0.4 amps. -5.2 volts at 0.68 amps.

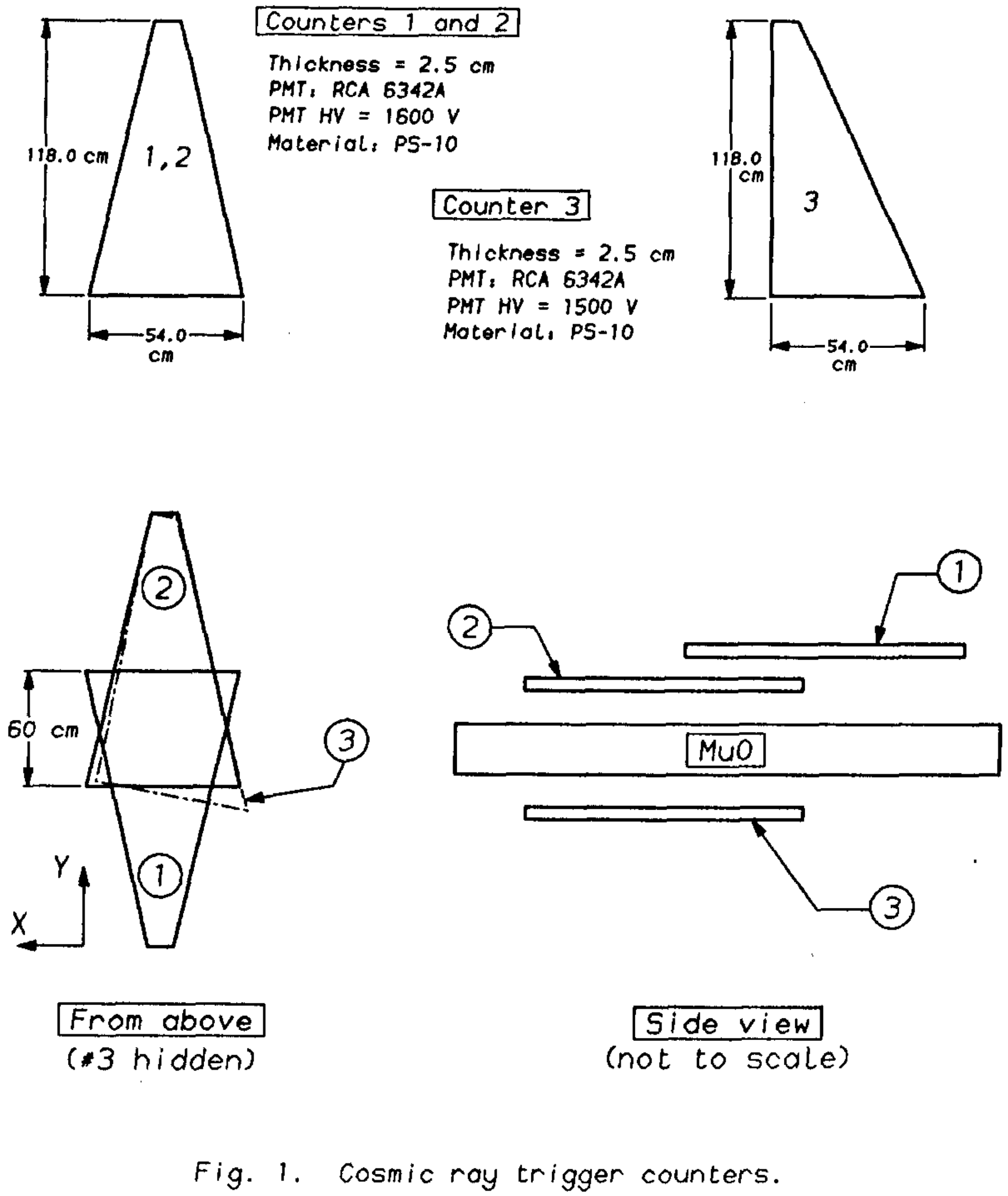


Fig. 1. Cosmic ray trigger counters.

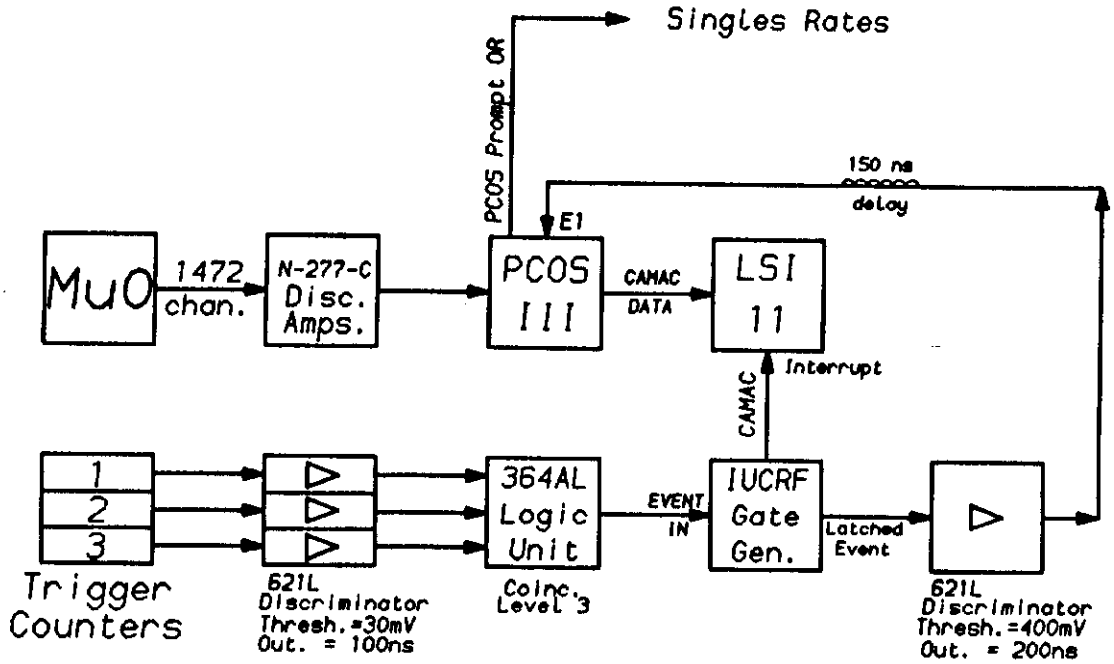


Fig. 2. MuO cosmic ray test trigger

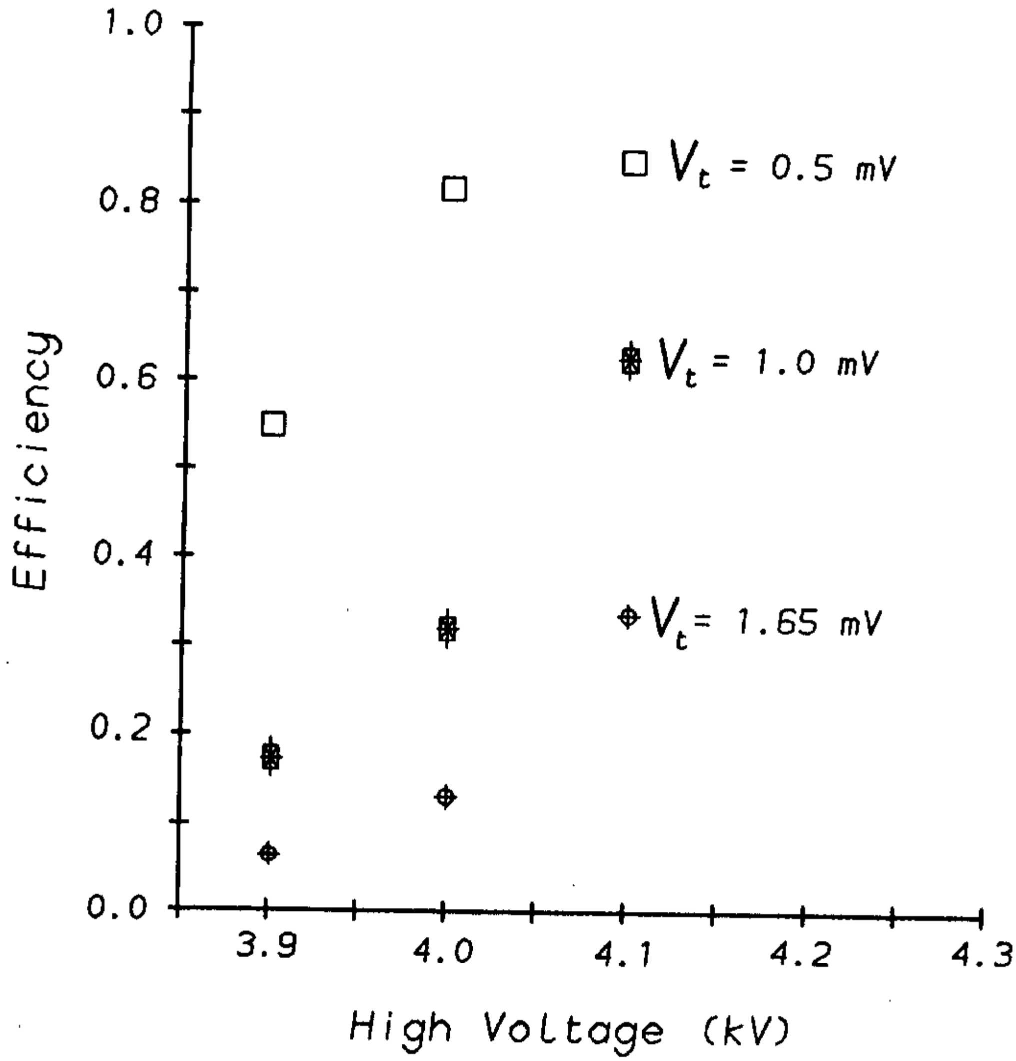


Fig. 3. Unmodified U anode efficiency vs. H.V. for various amplifier thresh-old voltages V_t

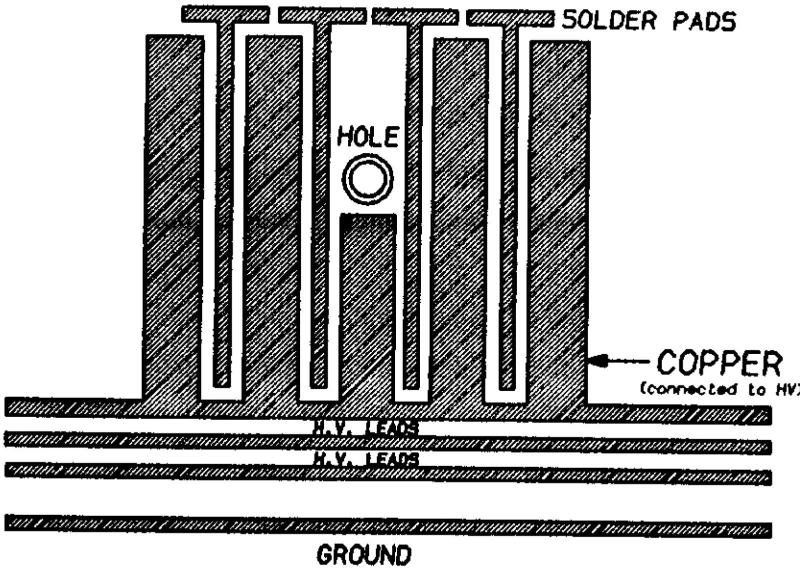


Fig. 4. Segment of unmodified MuO cathode traces

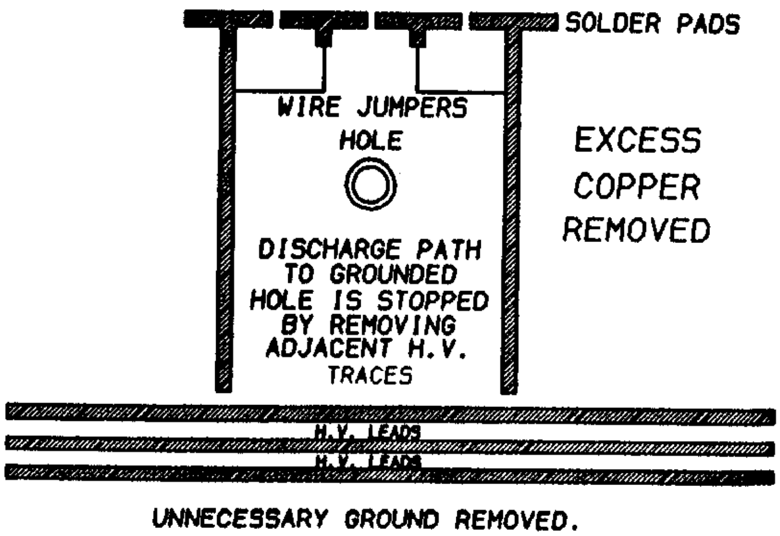


Fig. 5. Segment of modified MuO cathode traces

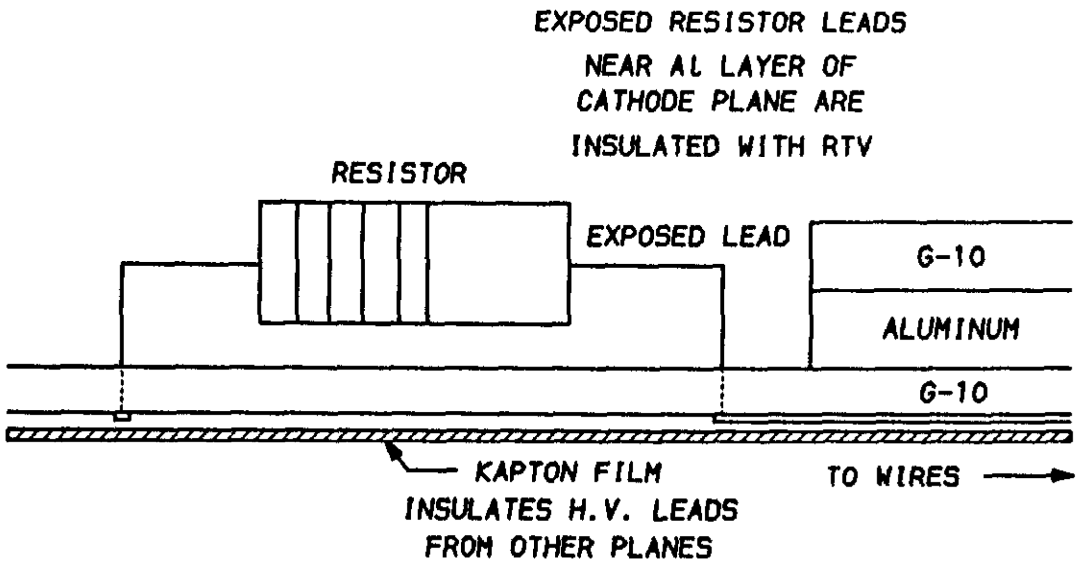


Fig. 6. Section of modified MuO cathode near limiting resistor

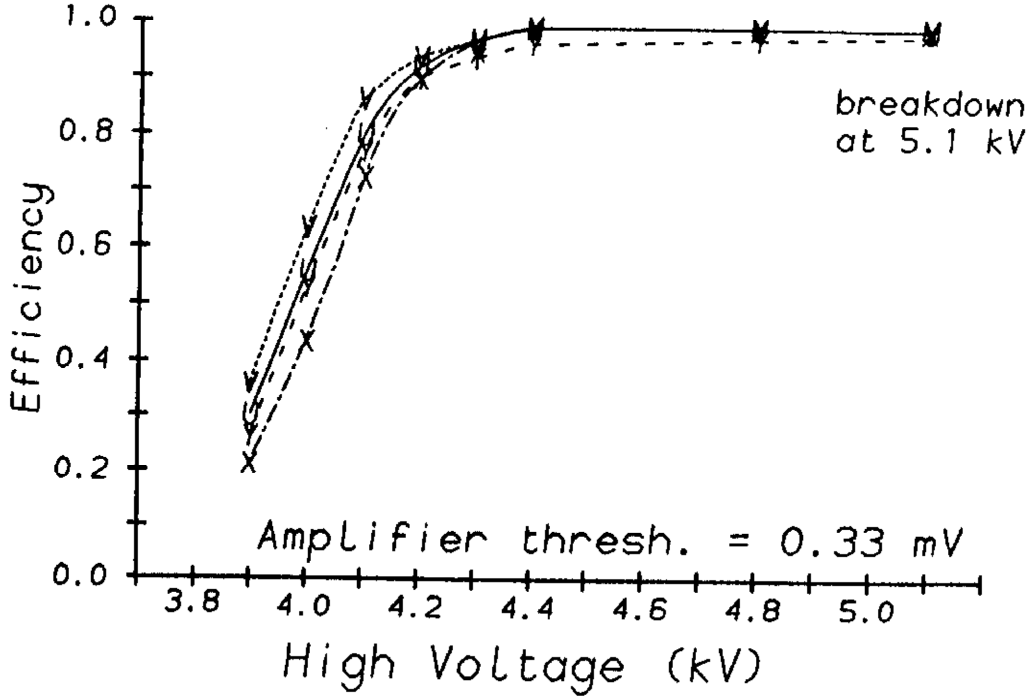


Fig. 7. Efficiency vs. HV for modified MuO anodes

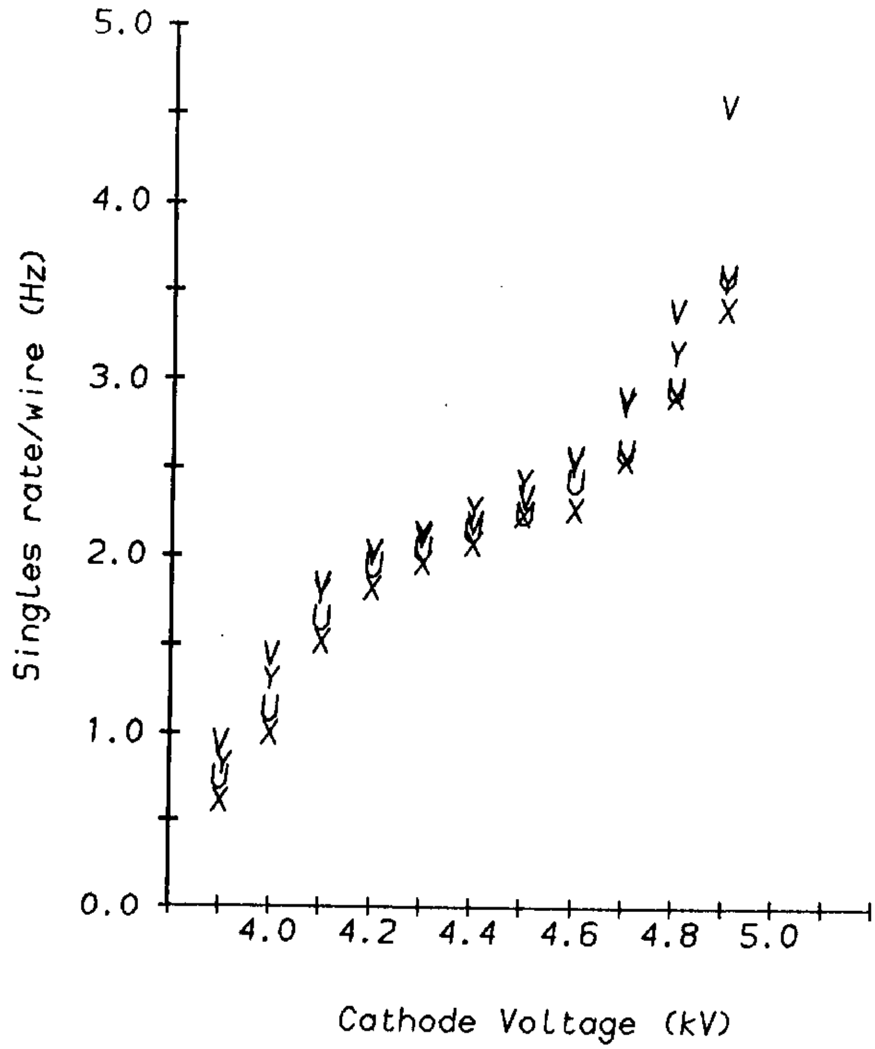


Fig. 8. Singles rate/wire for modified MuO anodes

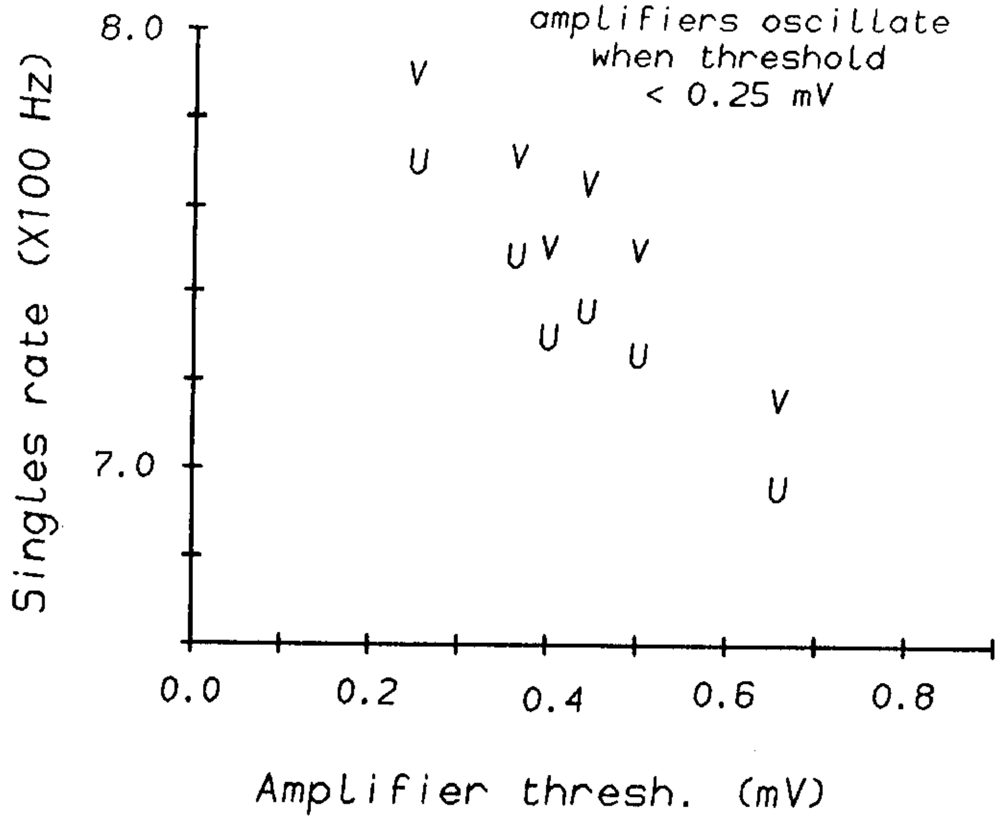


Fig. 9. Singles rate vs. amp. thresh.
for MuO U and V anodes (H.V. = -4.4 kV)

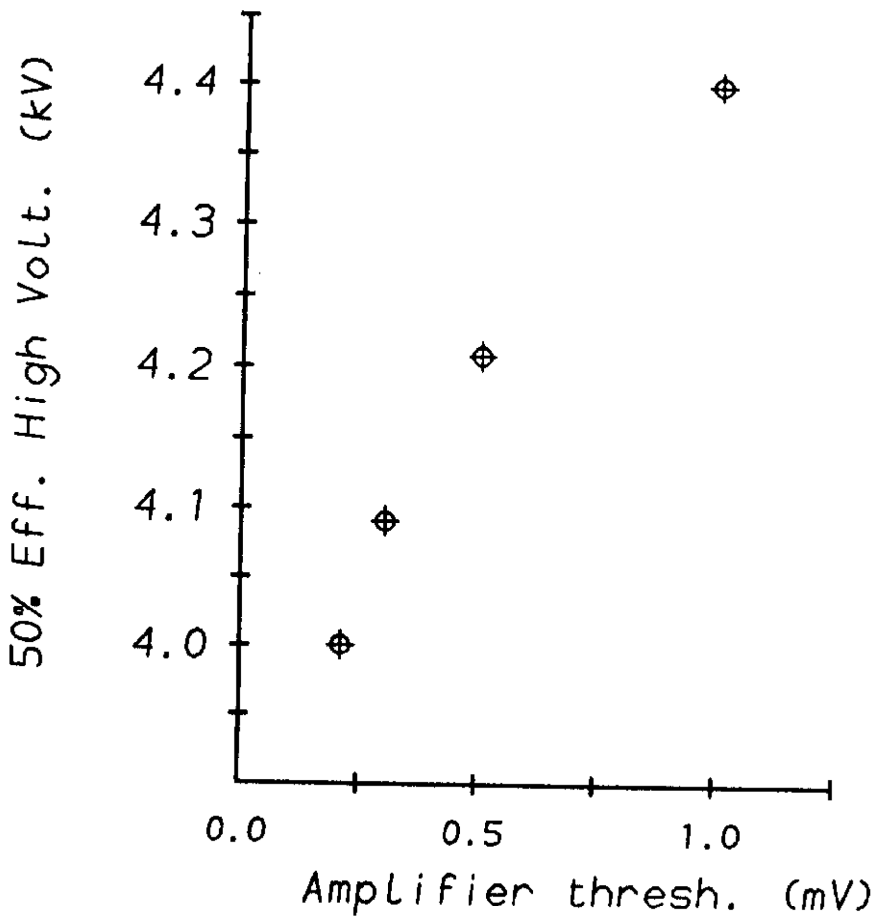


Fig. 10. 50% eff. HV vs. amp. thresh. for modified MuO U anode

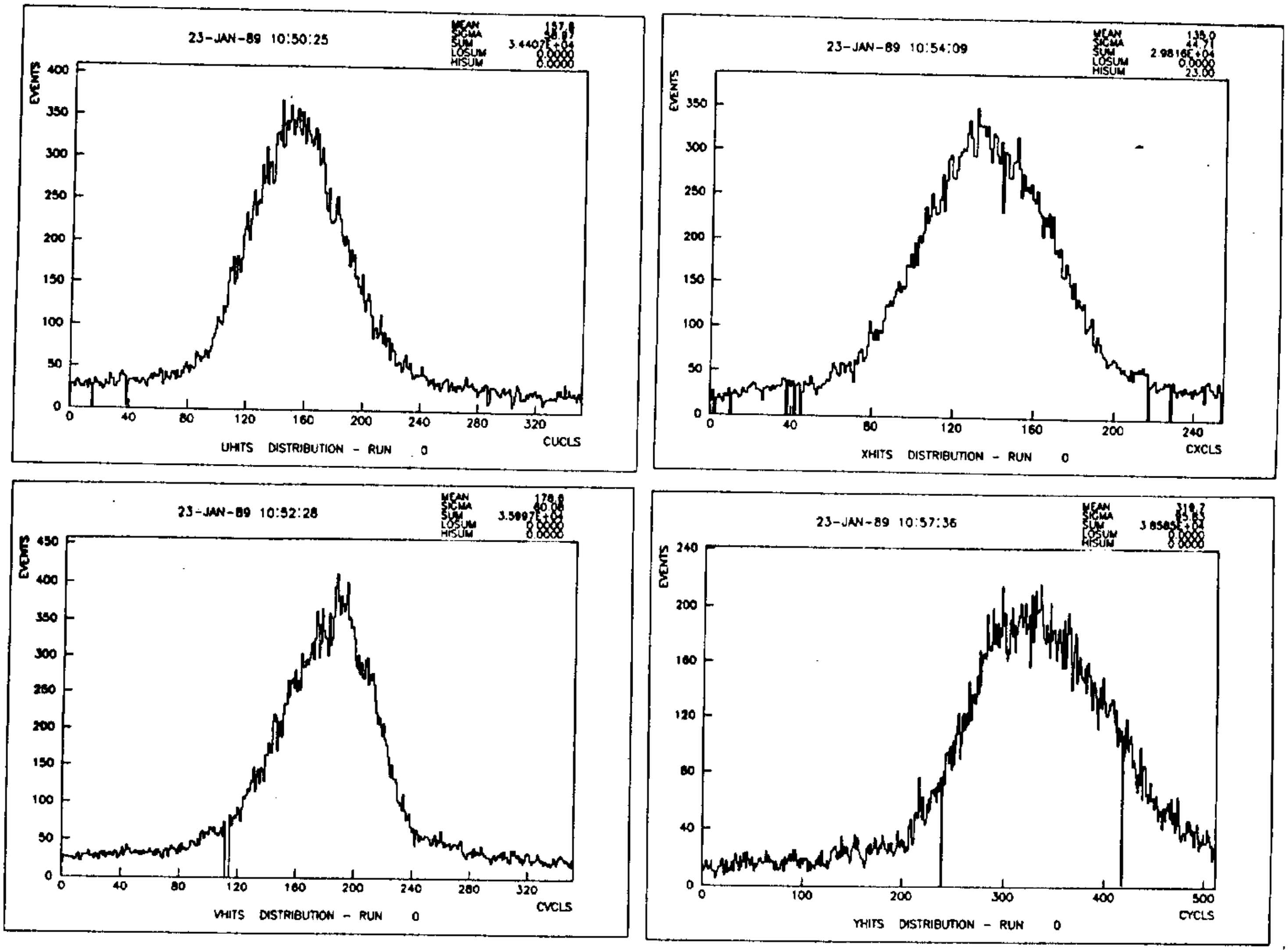


Fig. 11. MuO anode wire hit distributions

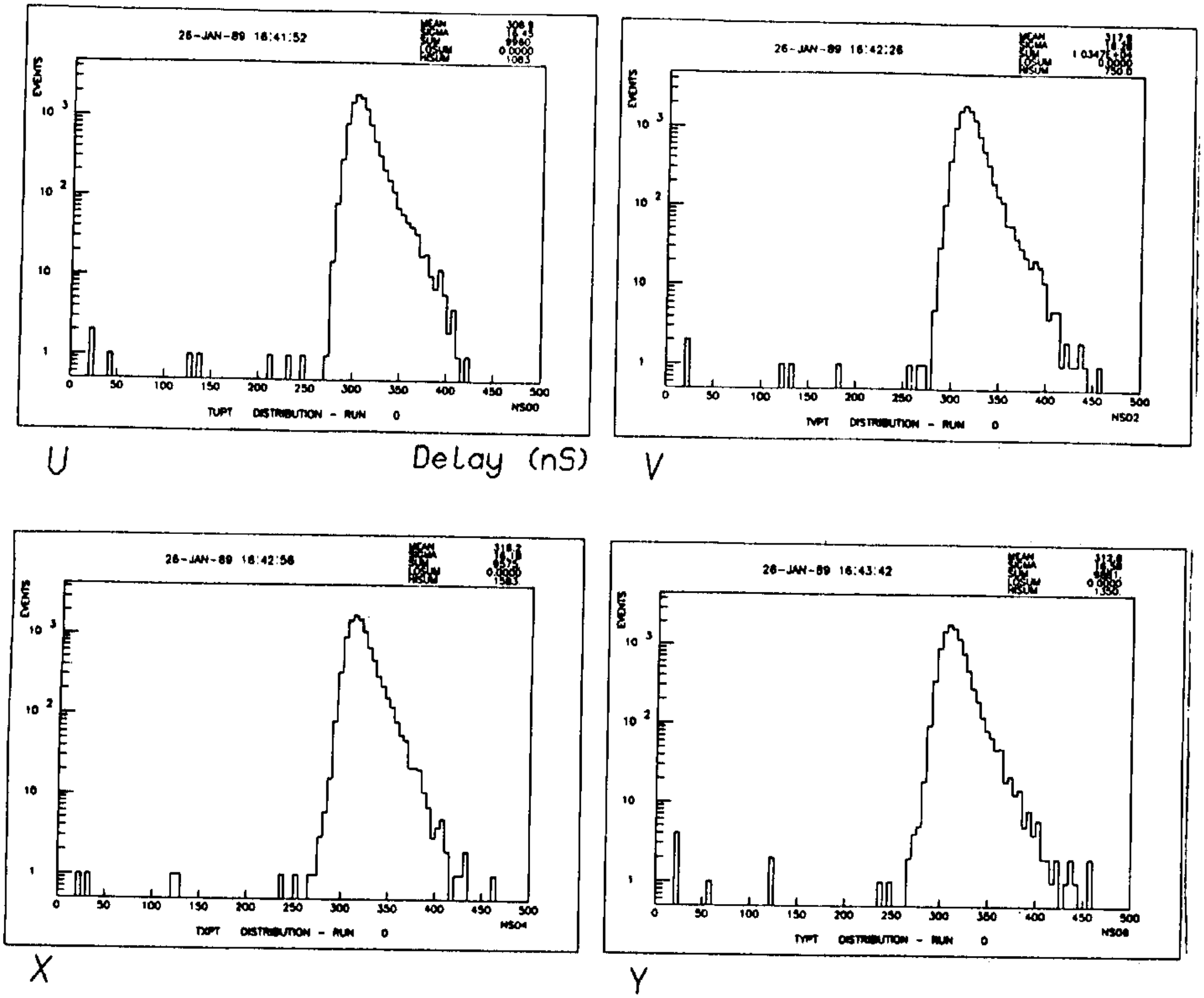


Fig. 12. MuO anode timing distributions