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A PORTABLE BEAM DIAGNOSTIC SYSTEM FOR SECONDARY BEAM LINES

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INTRODUCTION

It was recognized at an early date that a simple system of proportional wire chambers would be exceedingly useful in the initial tuning of some of the NAL beam lines. Such a device would display the beam phase space on a pulse by pulse basis. Hence a portable data acquisition and display system was built for the detector development effort and secondary beam line diagnostics at NAL.[1] Here we will concentrate on the beam line diagnostic aspect of this device. The results obtained from this system in the M6 beam line have proven its usefulness.

The Research Services Section has provided beam profile and position monitoring systems with standard proportional wire chambers for the secondary beam lines.[2] In these systems the pulses obtained from every wire are scaled and displayed on the cable T.V. system via the area MAC-16 computer. This type of operation does not allow us to follow and study the individual charged particle trajectories. As we will ses, the beam diagnostic system (BDS) provided phase space distributions of charged particle beams by detecting individual charged particle trajectories. This is accomplished by two orthogonal pairs of multiwire proportional chambers which are timed to provide pulses in coincidence from two separate locations. Experimenters may choose to provide a gate to select certain particle tracks (e.g., Cerenkov signals).

The beam diagnostic system consists of multiwire proportional chambers, readout electronics and a minimally equipped PDP-11 computer.

THE PROPORTIONAL WIRE CHAMBERS

The Chambers are of a standard NAL design.[2]

Wire Spacing	1 mm
Number of wires per chamber	48
Active Area	10 cm in diameter (4.8 cm is used)
Gap	3 mm on either side of the signal plane
Wire	0.0005" Au-plated W
Chamber Gas Mixture	80% Ar - 20% CO_2
Coincidence Gate	40 nsec

Figure 1 shows some construction details. The chambers reach a narrow plateau (about 20 - 50 volt wide) with efficiencies above 99% at an average of 2400 volts. An Ar - CO_2 gas mixture has proved satisfactory.

Wider plateaus may be obtained using hydrocarbon gas mixtures. However, these gases leave insulating deposits on the wires and the cathode planes.[3]

Each chamber contains a miniature high voltage supply (manufactured by Venus Scientific). These power supplies derive their input power from the amplifier power supply. There is a screwdriver adjustment to set the high voltage.

READOUT ELECTRONICS

The basic amplifier circuits use MC 1035 (Motorola ECL I.C.) which were originally designed by W. Sippach of NEVIS Laboratories. (See Figure 2). The cards are eight channels wide and have an eight fold OR output with a standard ECL level. The OR outputs from six amplifier cards of each chamber are OR summed (NIM output) on a separate card inside each chamber. The discriminators are set to accept pulses above 0.5 mV across an input resistance of 2kΩ at the input of the amplifiers. An overall block diagram of the readout system is shown in Figure 3.

The amplifiers drive a flat cable which is received differentially to minimize noise pickup on the lines. The ORs from the pustream pair of chambers are placed in coincidence then delayed to provide a gate for the latch bin timed to the arrival of the direct outputs of the amplifiers. The amplifiers are slightly temperature sensitive but are stable enough within a reasonable operating temperature range. Gate width is adjustable at the LeCroy 365 logic gate. (Adjusted to 40 nsec.) Gate delays for each pair of chambers are independently adjustable to allow for beam transit time between chamber pairs.

The data transfer is initiated by a trigger applied to the latch-CAMAC interface. This trigger is derived by delaying the gate pulse. The trigger sets a LAM which provides an interrupt to the computer (a PDP-11/20). The interrupt starts a routine which transfers the 16 bit words to core memory. The CAMAC to PDP-11 interface is a Kinetic Systems KS0011 CAMAC branch driver.

The PDP-11 system includes the KS0011, BISON Gate & Interrupt, 16k memory, DEC tape, Tektronix 611 storage display, Teletype ASR-33, and optional remote display and teletype.

The program may display a histogram for each chamber, an X-Y plot of each pair of chambers (horizontal, vertical, intensity), write on DEC tape each event in proper sequence and location, or print out data.

The software of the BDS is described by MB-03.2 programming note which is available from the computer group.

RESULTS

The BDS was first used at the west branch of the M6 beam line for diagnosing the 3.5 miliradian high resolution beam with instantaneous intensities reaching 10^6 charged particles per second. Figure 4 shows histograms of the vertical and horizontal profiles at two locations 80 feet apart. The horizontal-vertical scattergram distributions (x_1,y_1) and (x_2,y_2) and the phase space distributions (x_1-x_2,x_1) and (y_1-y_2,y_1) are shown in Figure 5. SCATTR = 1 shows a blown-up cross-section of the beam (x_1,y_1) at the first set of chambers. SCATTR 2 shows the cross-section of the beam (x_2,y_2) at the focus which is 80 feet downstream. SCATTR 3 and 4 show the phase space distributions about the horizontal and vertical axes. Here x_1-x_2 and y_1-y_2 are effectively the particle angles. From these distributions, we can also determine an approximate position of a focal point of the beam. These distributions can be displayed and DEC-tape logged for every beam pulse.

The BDS may be requested by the laboratories for tuning beam and determining beam parameters.

ACKNOWLEDGMENT

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2. M. Atac, I.E.E.E. Transactions on Nuclear Science, Vol. NS-19, No. 3, (1972), 144.
3. M. Atac, NAL Internal Report, TM-461, (1973).
4. H. Cunitz, W. Sippach, and J. Dieperink, Nucl. Instr. and Meth. 91(1971)211-220.

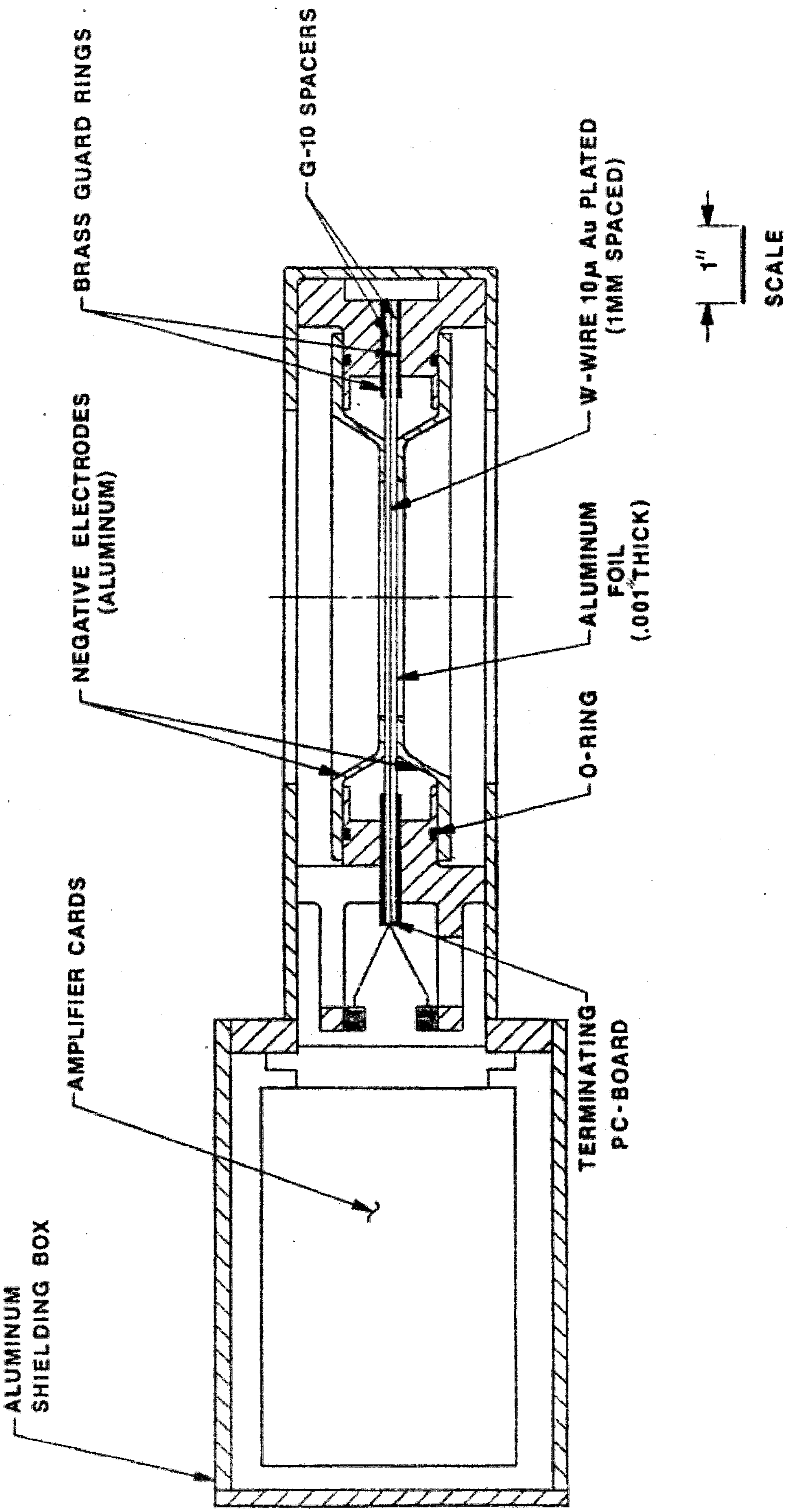
BRASS GUARD RINGS
G-10 SPACERS
W-WIRE 10μ Au PLATED
(1MM SPACED)
1"
SCALE
NEGATIVE ELECTRODES
(ALUMINUM)
ALUMINUM
FOIL
(.001" THICK)
O-RING
AMPLIFIER CARDS
TERMINATING
PC-BOARD
ALUMINUM
SHIELDING BOX

FIG 1

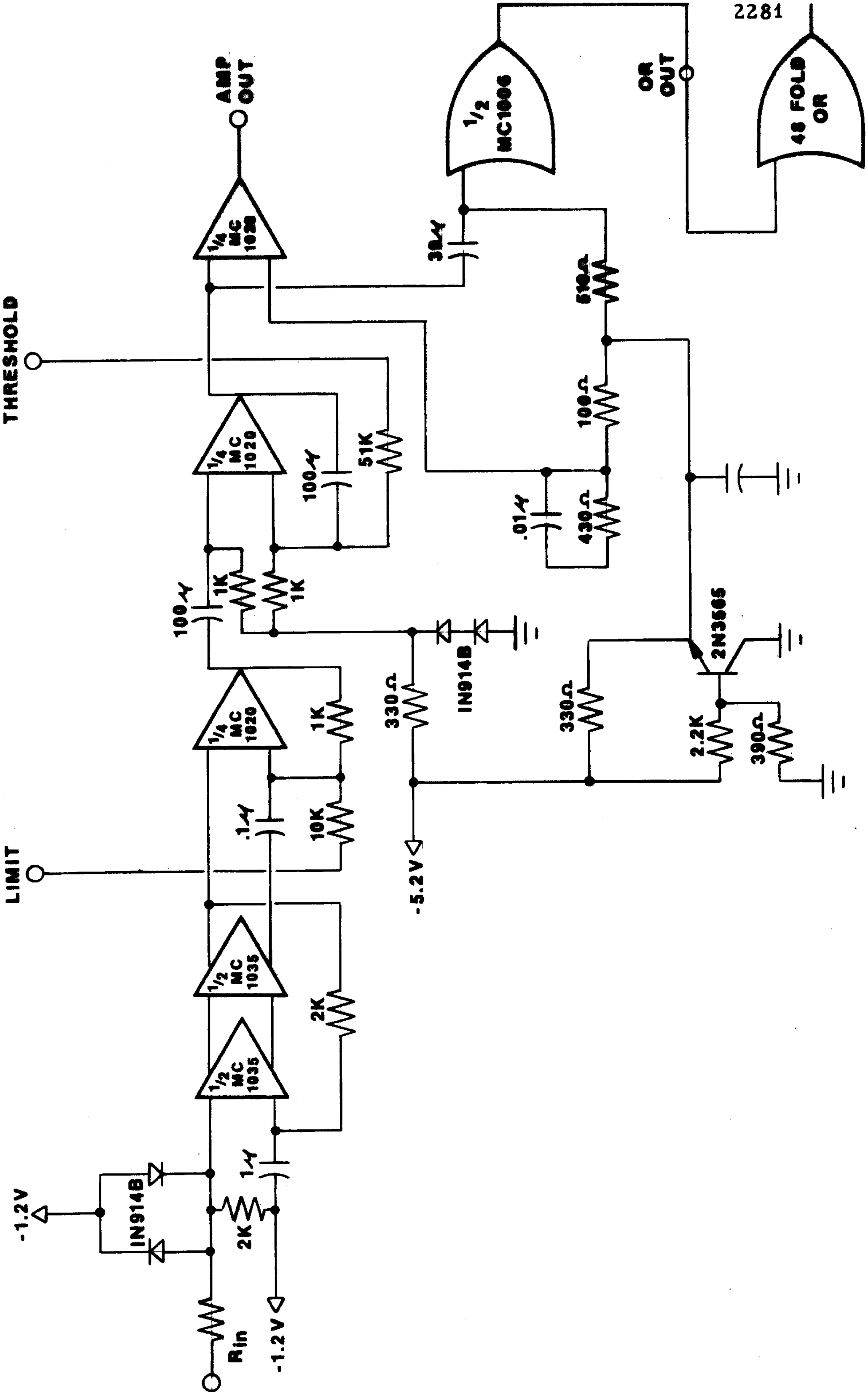
AMP OUT
THRESHOLD
LIMIT
1/2 MC1006
OR OUT
48 FOLD OR
1/4 MC 1020
1/4 MC 1020
1/4 MC 1020
1/2 MC 1035
1/2 MC 1035
39
510Ω
100Ω
430Ω
.01
100
51K
100
1K
1K
IN914B
330Ω
330Ω
2N3565
2.2K
390Ω
1K
10K
.1
2K
-5.2V
1
2K
IN914B
-1.2V
-1.2V
Rin

FIG 2

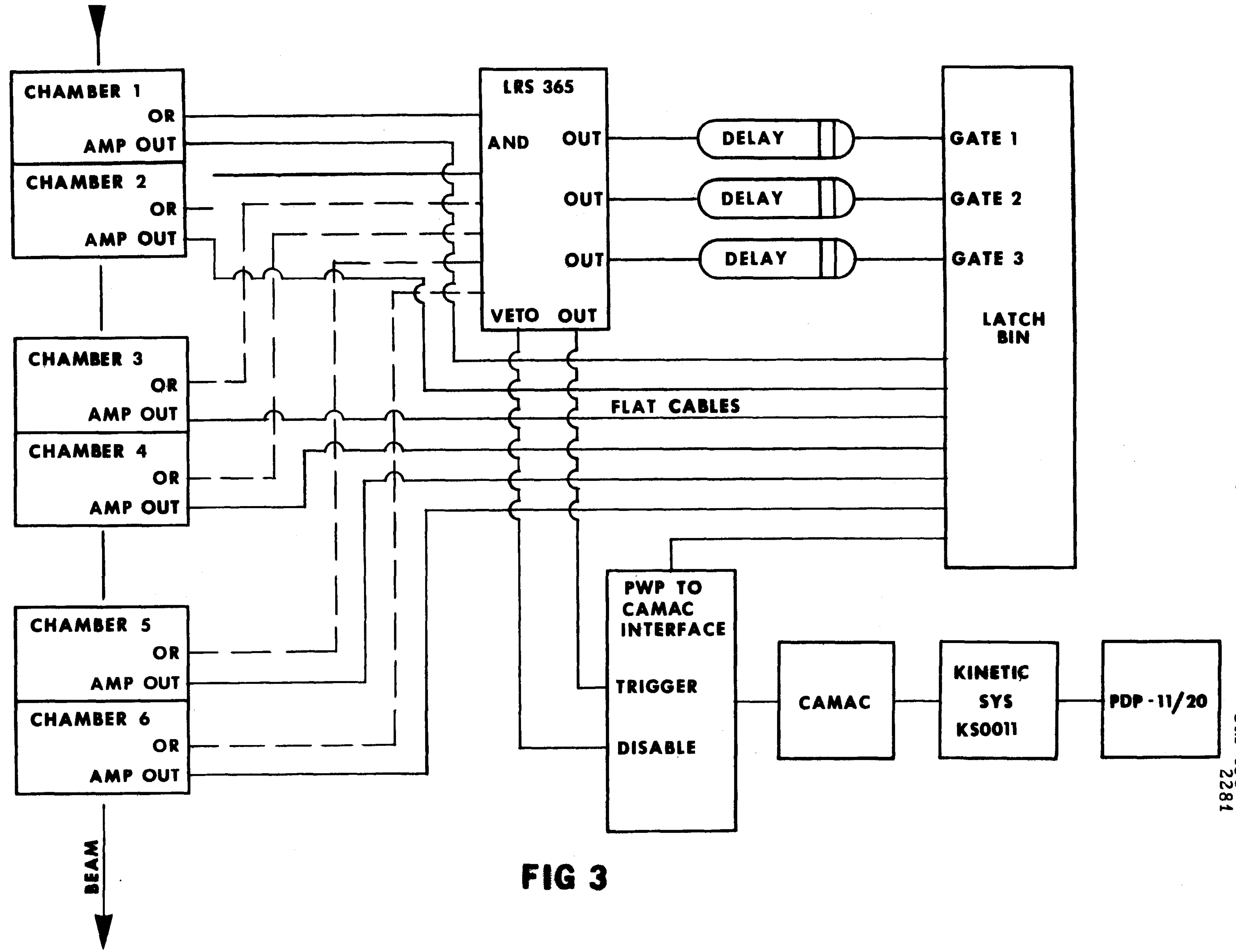

FIG 3

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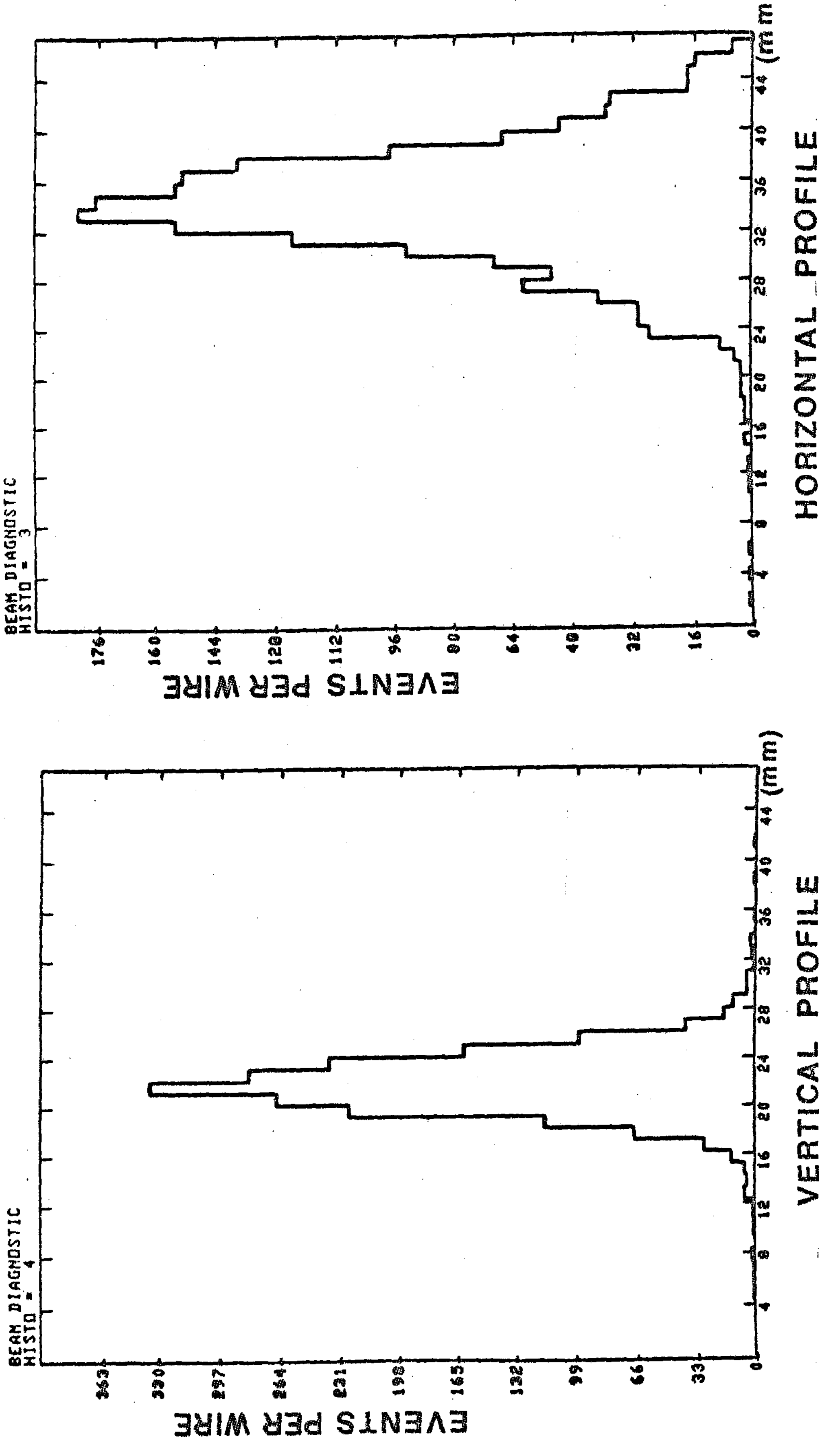
BEAM DIAGNOSTIC
HISTO = 3
EVENTS PER WIRE
176 160 144 128 112 96 80 64 48 32 16 0
0 4 8 12 16 20 24 28 32 36 40 44 (mm)
HORIZONTAL PROFILE
BEAM DIAGNOSTIC
HISTO = 4
EVENTS PER WIRE
363 330 297 264 231 198 165 132 99 66 33 0
0 4 8 12 16 20 24 28 32 36 40 44 (mm)
VERTICAL PROFILE

FIG 4

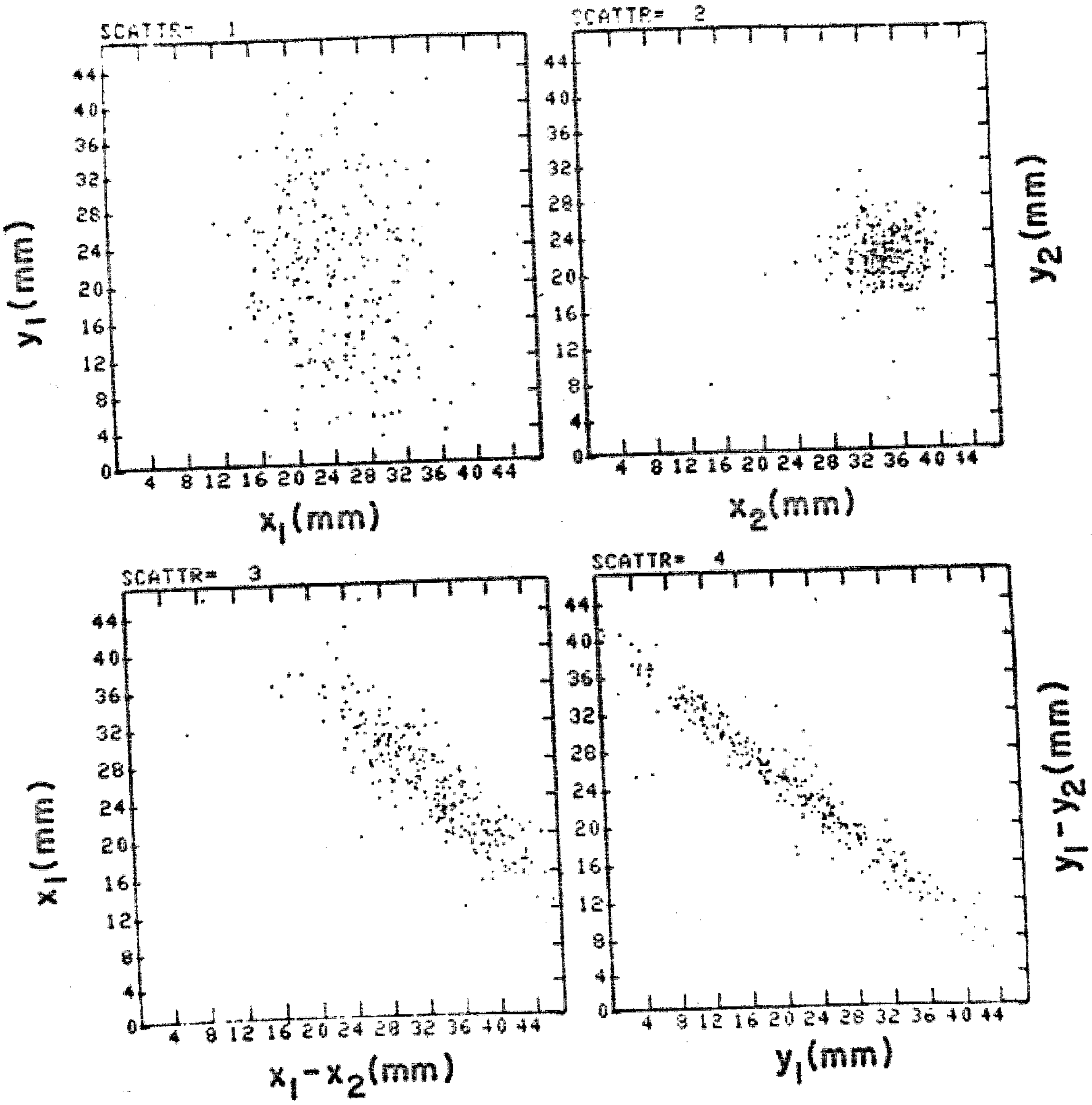
SCATTR= 1
y1(mm)
x1(mm)
SCATTR= 2
y2(mm)
x2(mm)
SCATTR= 3
x1(mm)
x1-x2(mm)
SCATTR= 4
y1-y2(mm)
y1(mm)
0 4 8 12 16 20 24 28 32 36 40 44

FIG 5