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TM-688
2562.000

SOME TEST RESULTS FROM AN INTERNAL PICKET FENCE CHAMBER FOR THE FERMILAB 15' BUBBLE CHAMBER

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September 24, 1976

TM-688
2562.000

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As a part of the External Muon Identifier (EMI) improvement program (see the Appendix), a prototype drift chamber (called internal picket fence [IPF] chamber) has been built at Fermilab and tested at the Chicago-Cyclotron Magnet in a field of 13.5kG with generally satisfactory performance. The IPF chamber had three 25μm anode wires which are kept at +2kV and two 76μm field wires at ground potential all inside a 2 cm thick, 6 cm wide, 1m long rectangular aluminum tube. The tube served as the cathode at ground potential. Twenty percent CO_2-Ar mixture was used for the gas. The chamber was bracketed by two Type A proportional chambers of 1 mm spacing. Thirty-two wires from each chamber were used to define the beam. Pulses from each wire were amplified and shaped and then OR'ed to provide a single trigger pulse. Pulses obtained from every signal wire of the IPF were amplified and shaped by an amplifier-one shot circuit provided by T. Droege. Figure 1 shows the cross-sectional view of the chambers and the experimental arrangement. As seen in the figure, the electron drift spacing in the gas was 1 cm. Figure 2 shows a high voltage plateau obtained for the IPF chamber. The chamber was positioned vertically so that the magnetic field lines would be along the signal wires.

The efficiency of the IPF chamber was determined by taking triples (PWC1 • IPF • PWC2) ÷ doubles (PWC1 • PWC2). The accidentals were very small since the chambers were kept in the minor halo (3 - 5 x 10^3muons per pulse in each chamber). The efficiency values as a function of the magnetic field are given in Table 1. The drift time distribution was measured using a time-to-amplitude converter (TAC) with the doubles for a start signal and the IPF for a stop. The time jitter of the PWC1 and PWC2 was measured to be ~30nsec. This is expected from the 1 mm wire spacing. Figures 3, 4, and 5 show the drift time distributions obtained from the IPF chamber at fields of 0, 7.5, and 13.5 kG respectively. As we see from these figures, there is a substantial increase in the drift time of electrons produced by the muons in the gas. This is expected due to the external magnetic field effecting the electrons in the least favorable direction. For most gas mixtures (velocity saturating) maximum drift time per cm is around 200 nsec. Because of safety reasons, we have chosen Ar-CO_2 gas mixture in which the drift time is substantially longer.

Time resolution of 100-200nsec is desirable for the effectiveness of the IPF to improve the present background problems of the EMI, thus we should reduce the electron drift time at least a factor to two. For this, we hope to build a chamber with drift spacings of 4 mm. This would not increase the cost of electronics since we plan to use one amplifier per chamber by connecting the signal wires together. Further improvement in the drift time can be made by more complicated chamber design. For simplicity and cost reasons, we have not elected this choice.

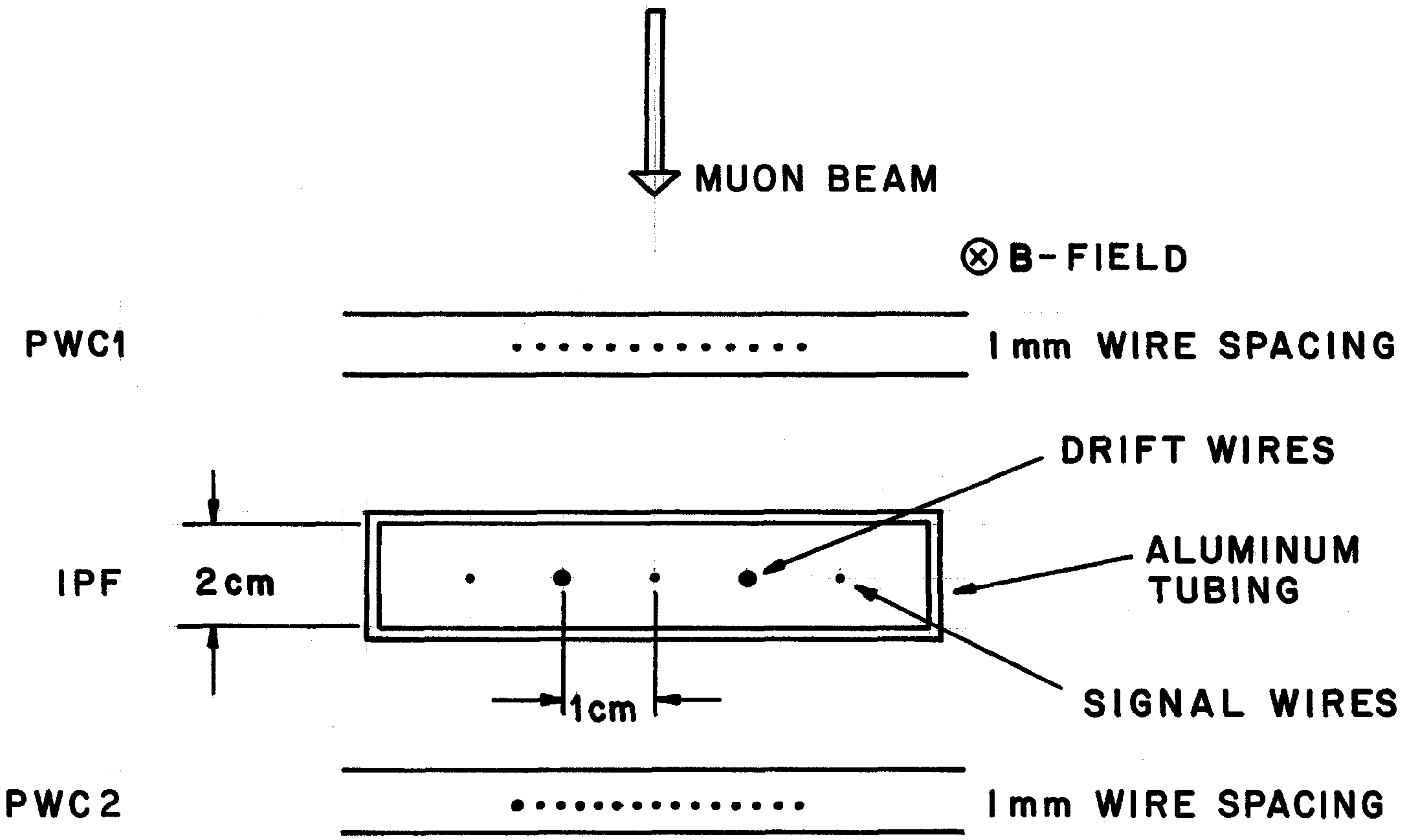
We plan to build the 4 mm drift spacing chamber and test it in the Energy Doubler sample testing, superconducting magnet, which is capable of 70 kiloGauss.

The authors would like to express their appreciation to Q. Kerns and H. Kautzky for useful suggestions and to M. Hrycyk and J. Urish in constructing the detectors.

Table 1

Efficiency = $\frac{T}{D}$

B(kG)	T	D	% Efficiency
0	1753	1757	99.8
3.6	1471	1541	97.2
7.5	43717	44418	98.4
13.5	30632	31795	96.3



EXPERIMENTAL ARRANGMENT
OF TEST CHAMBER

FIG. 1

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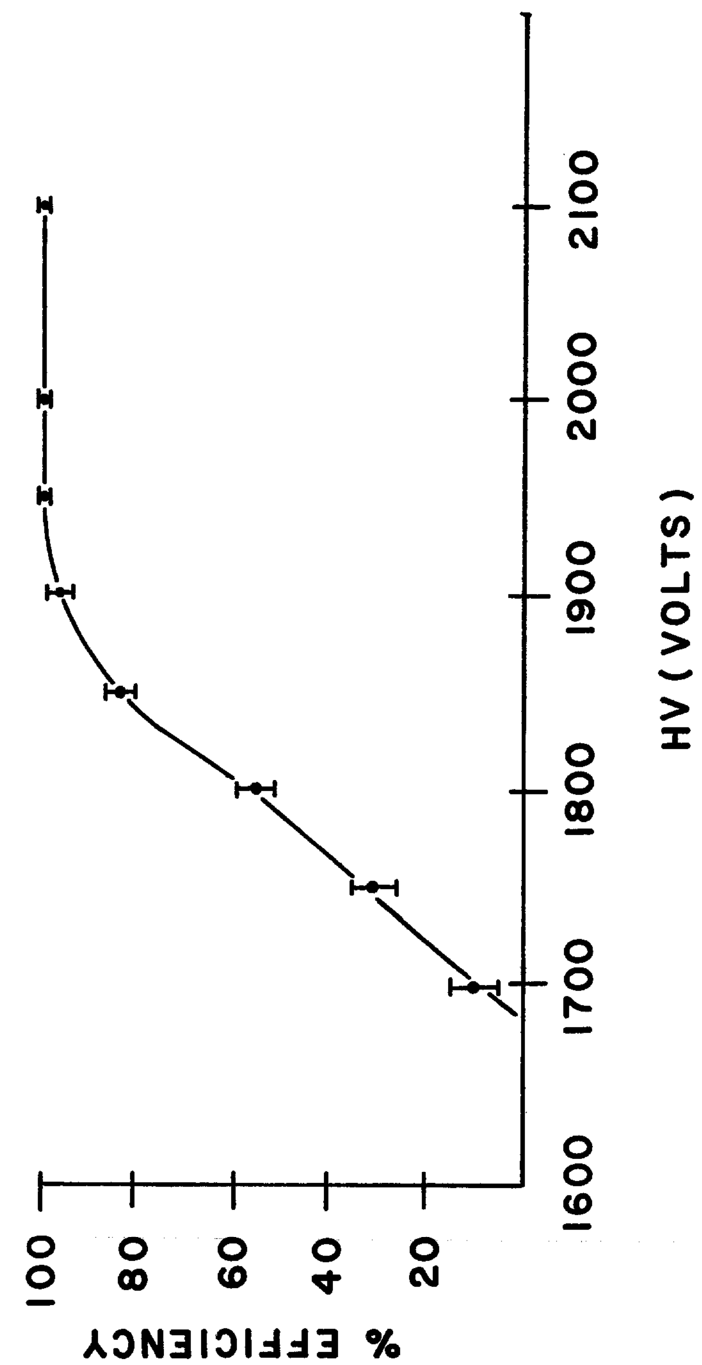
% EFFICIENCY
100
80
60
40
20
1600
1700
1800
1900
2000
2100
HV (VOLTS)

FIG. 2

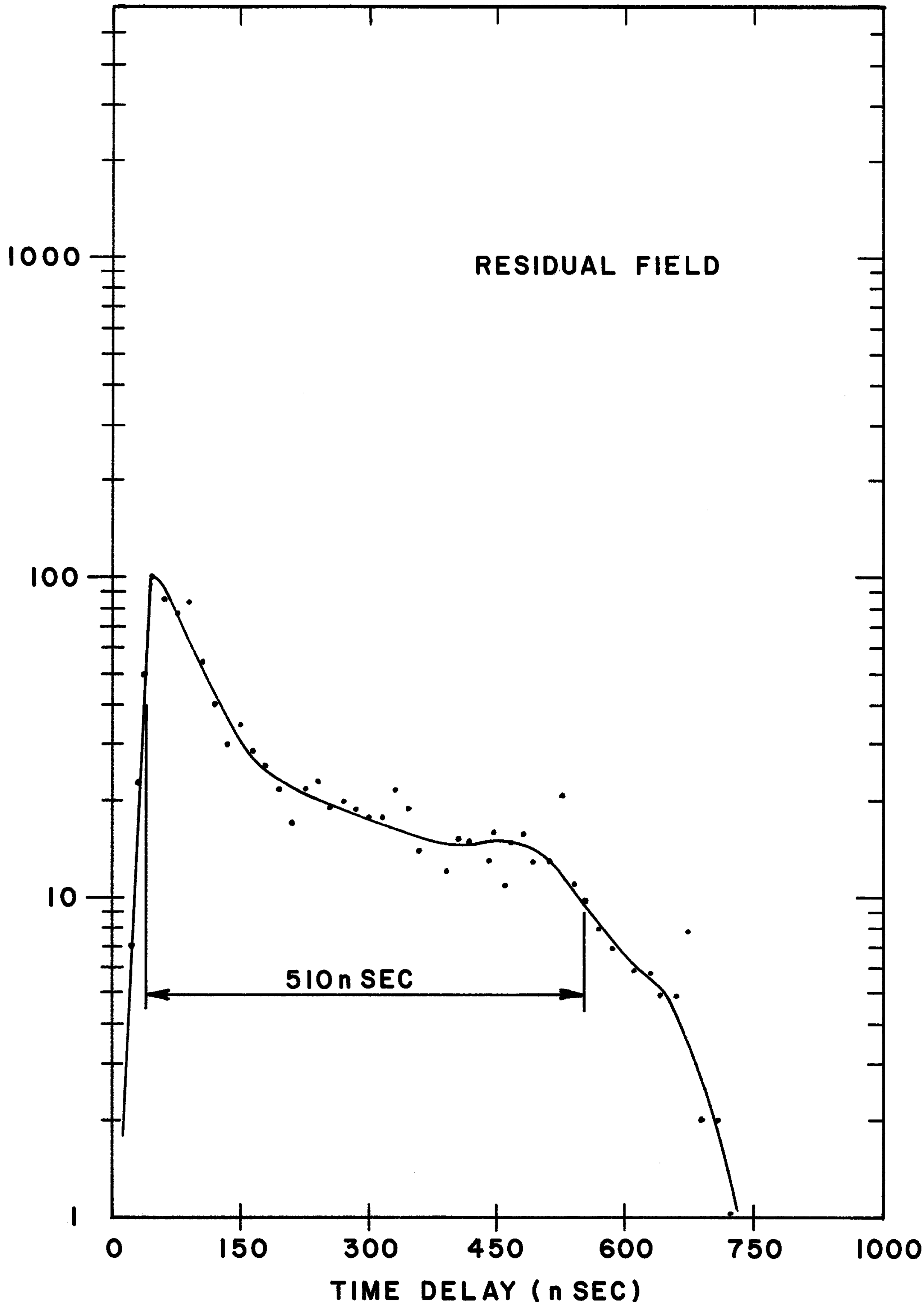
RESIDUAL FIELD
1000
100
10
1
510 n SEC
0
150
300
450
600
750
1000
TIME DELAY (n SEC)

FIG. 3

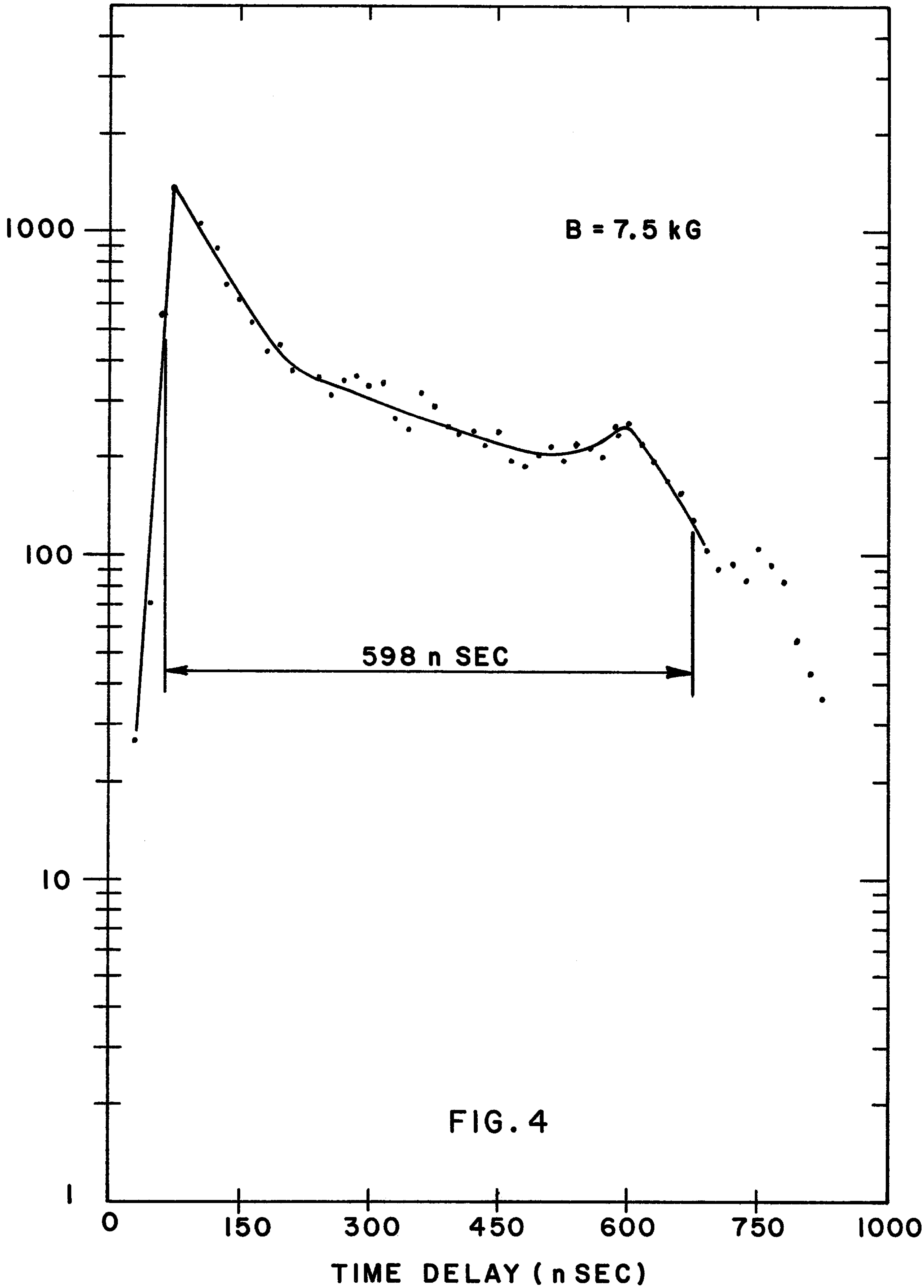
1000
100
10
1
B = 7.5 kG
598 n SEC
0
150
300
450
600
750
1000
TIME DELAY (n SEC)

FIG. 4

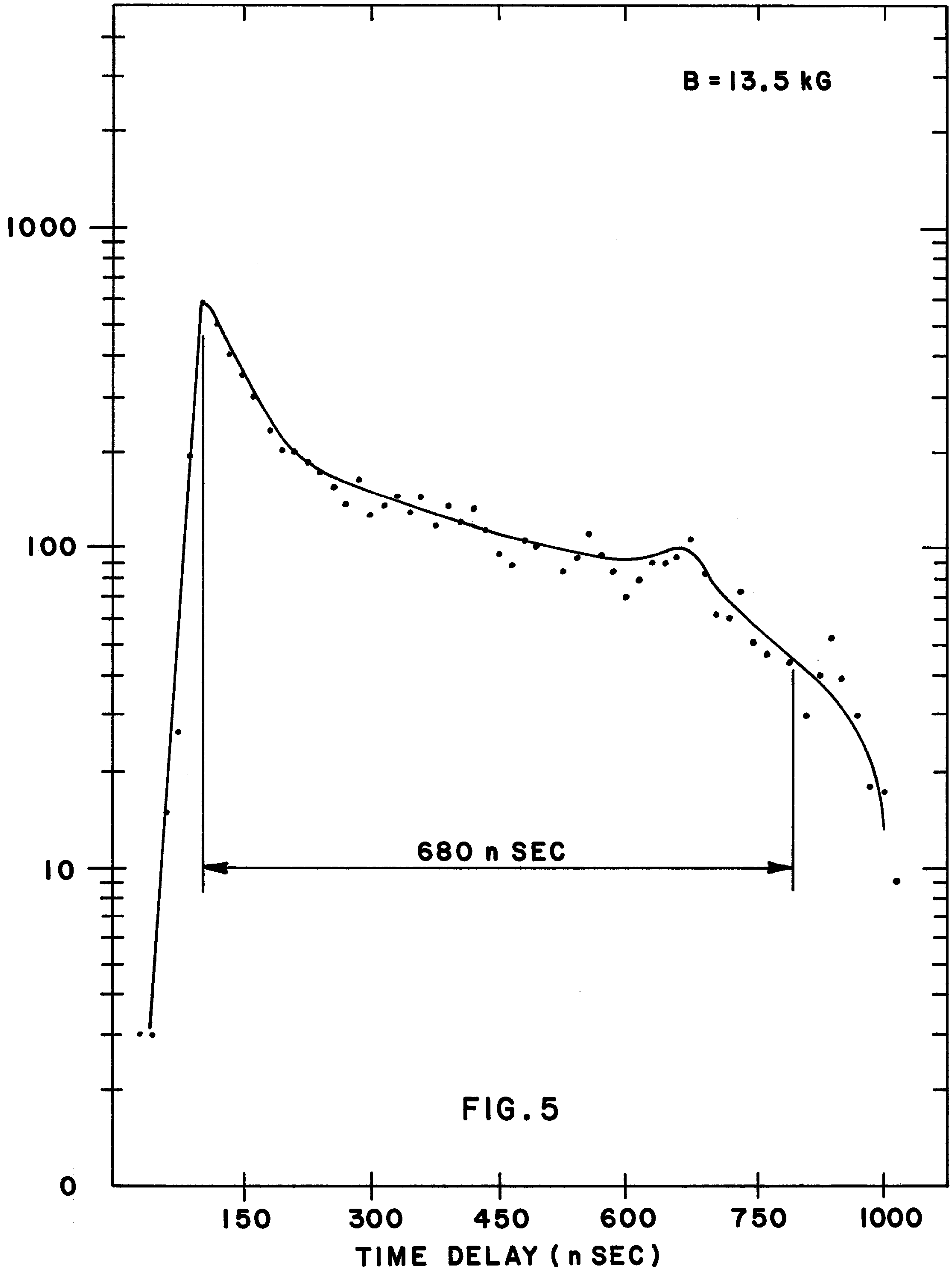
B = 13.5 kG
1000
100
10
0
680 n SEC
150
300
450
600
750
1000
TIME DELAY (n SEC)

FIG. 5

APPENDIX

U.H. Internal Report 26-76
July 23, 1976

STATUS OF THE INTERNAL PICKET FENCE
FOR THE
FERMILAB 15' BUBBLE CHAMBER

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INTRODUCTION: THE INTERNAL PICKET FENCE

One aspect of the External Muon Identifier (EMI) improvement proposal[1] is the installation of a device to determine the time of a neutrino interaction inside the 15' Bubble Chamber. This device, called the Internal Picket Fence (IPF),[2] would consist of a large number of detectors located inside the vacuum tank between the bubble chamber and the superconducting magnet, as shown in Fig. 1.,to measure the times of all tracks emerging from the bubble chamber, before they interact in the magnet coils or zinc absorber. The time of the neutrino interaction is obtained by interrogating those modules predicted to be hit by analysis of the bubble chamber film. Coincidences between modules struck by tracks from the event may be used to eliminate times associated with other tracks in the bubble chamber and accidentals.

Knowing the time of the neutrino interaction greatly improves the separation of pions and muons at low momentum. Presently all hits in the EMI (integrated over the entire beam spill) in the vacinity of the extrapolated bubble chamber track must be considered as potential muon matches. Most of these hits (85% to 90%) arise from neutrino interactions in the absorber and other material surrounding the bubble chamber and are out of time with the neutrino interaction of interest. Since the multiple Coulomb scattering deviation scales as 1/momentum $\left(r \simeq \frac{10\,(\mathrm{cm})}{P\,(\mathrm{GeV}/c)}\right)$,the probability of an accidental match becomes very large for low momentum tracks. This limits the usefulness of the EMI presently for neutral current physics and for deeply-inelastic charged current physics, where it is necessary to identify low momentum muons and hadrons.

For example, during the Fall 1975 Neutrino Run of Experiment #45, a typical hit rate in the EMI was 5 hits/m^2. For fast spill this leads to approximately 20 solutions per square meter out of the EMI reconstruction program, CID[3]. The probability of an accidental association with one of these solutions in the EMI (in a multiple Coulomb scattering region around the extrapolated track large enough to contain 96% of true muons) is given approximately by Prob. $\simeq \frac{2.5}{P^2}$, where P is in GeV/c. For a 2 GeV/c hadron track, there is a 60% chance of an accidental association with random background leading to an interpretation that the track is a muon.

IPF COUNTERS

A possible detector for the IPF is the multiwire proportional chamber (MWPC), although other possibilities are also being considered. A potential design is to epoxy fiberglass caps (G-10) into the ends of rectangular aluminum tubing and to string the wires through holes in the fiberglass. The wires are held in place by epoxy and are soldered together to minimize the cost of the readout since only coarse spatial resolution is necessary. The aluminum tubing not only provides sufficient strength to withstand the pressure difference in the vacuum tank but also provides a reasonable temperature for the proportional chamber gas, being thermally coupled to the outside of the vacuum tank.

The proportion chambers would be located directly in front of the superconducting magnet. Local fields in this region can be as high as 50 kilogauss. It is therefore essential to test the operation of the proportional chamber (efficiency and time resolution) in extreme high magnetic fields of this type before proceeding further on the IPF.

A prototype chamber has been constructed for this purpose. It consists of aluminum tubing 6cm x 2cm in cross section with one meter long wires. The wires are positioned as shown in Fig. 2. The signal wires are 1 mil in diameter, while the field shaping wires are 3 mils in diameter.

The efficiency and time resolution of this chamber have already been measured under no field conditions using a cosmic ray telescope of 3 scintillation counters, Running at 2100 volts with 80% Ar - 20% CO_2 and a 1μsec. wide coincidence gate, an efficiency of $(99.94 \pm .03)\%$ was obtained. The time resolution is shown in Fig. 3. Most pulses are within 0.5μsec. of the start pulse (scintillator coincidence), but there is a small tail (2%) which extends out to nearly 1μsec. The final MWPC might have closer wire spacing to improve the time resolution. A time resolution of 1μsec. would reduce the accidental background by a factor of 20 for fast spill.

Magnetic field tests are to be carried out in two steps. The first is a test in the Chicago-Cyclotron magnet at a moderate field (10-15 kilogauss). Two high resolution MWPC's with 1 mm wire spacing will be used in coincidence with the test chamber. A few hours of beam should be sufficient. Hopefully, this test will be done parasitically in August with E-398 running.

The second and most important test will be conducted in the Energy Doubler, sample testing, superconducting magnet, which is capable of 70 kilogauss. The efficiency and time resolution would be obtained using cosmic rays defined by two (2" x 8") scintillation counters. The apparatus for this test, sketched in Fig. 4., is presently being assembled. The warm bore is complete and the scintillation counters are being assembled and tested. This test test will be completed in September.

FH:dla

REFERENCES

[1] "EMI - II: A Phase-Two External Muon Identifier for the 15-Foot Bubble Chamber at Fermilab"; Hawaii-LBL EMI Group; Nov. 7, 1975.

[2] "The Internal Picket Fence: A Device That Could Reduce the Background in the Phase I EMI"; by M.L.Stevenson; LBL Physics Note 809; October 1975.

[3] "Background Problems Associated with Neutrino Experiments in the 15' Bubble Chamber"; by Gerry Lynch; LBL Note 814; Jan. 6, 1976.

LBL Physics Note 809

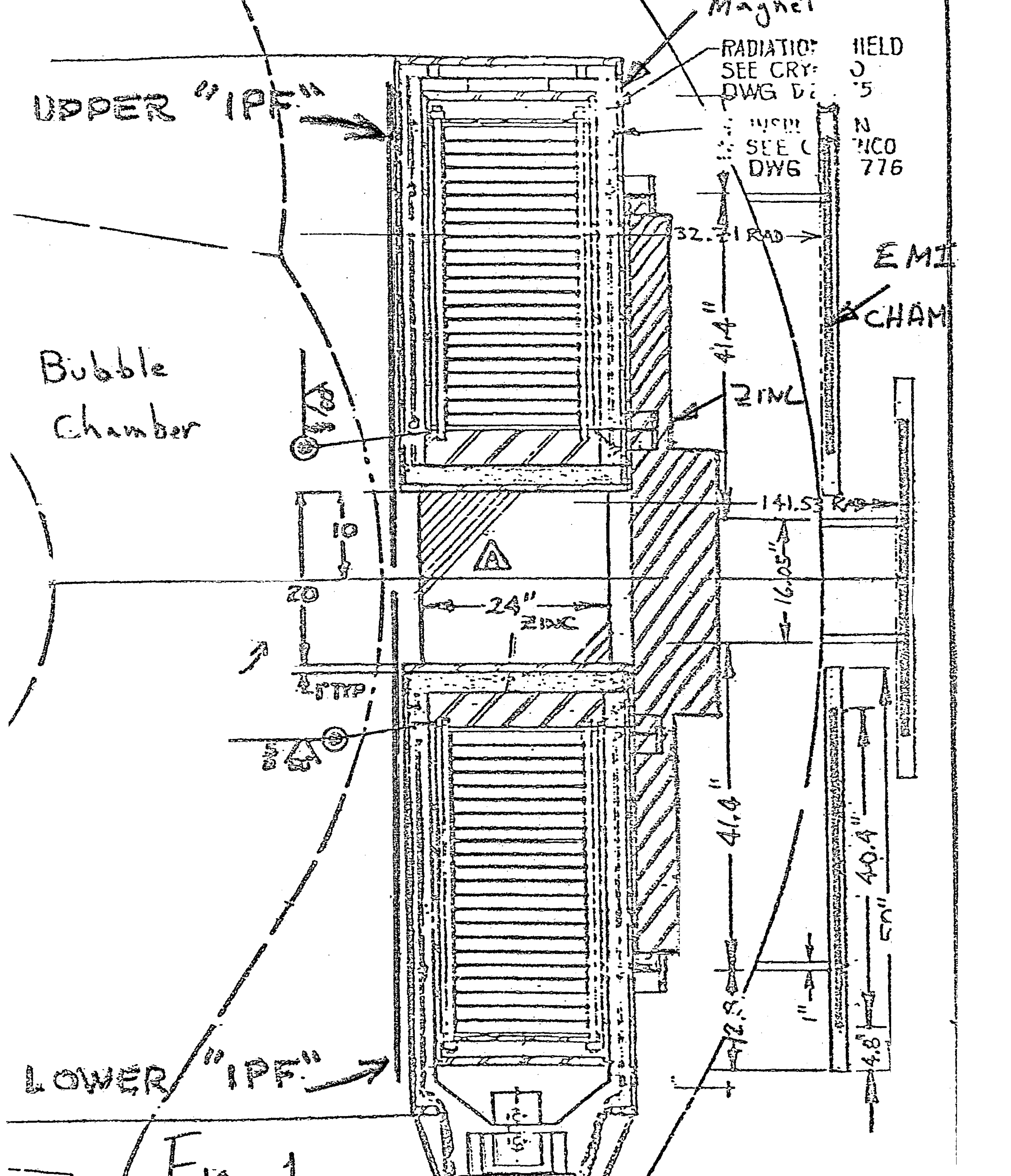
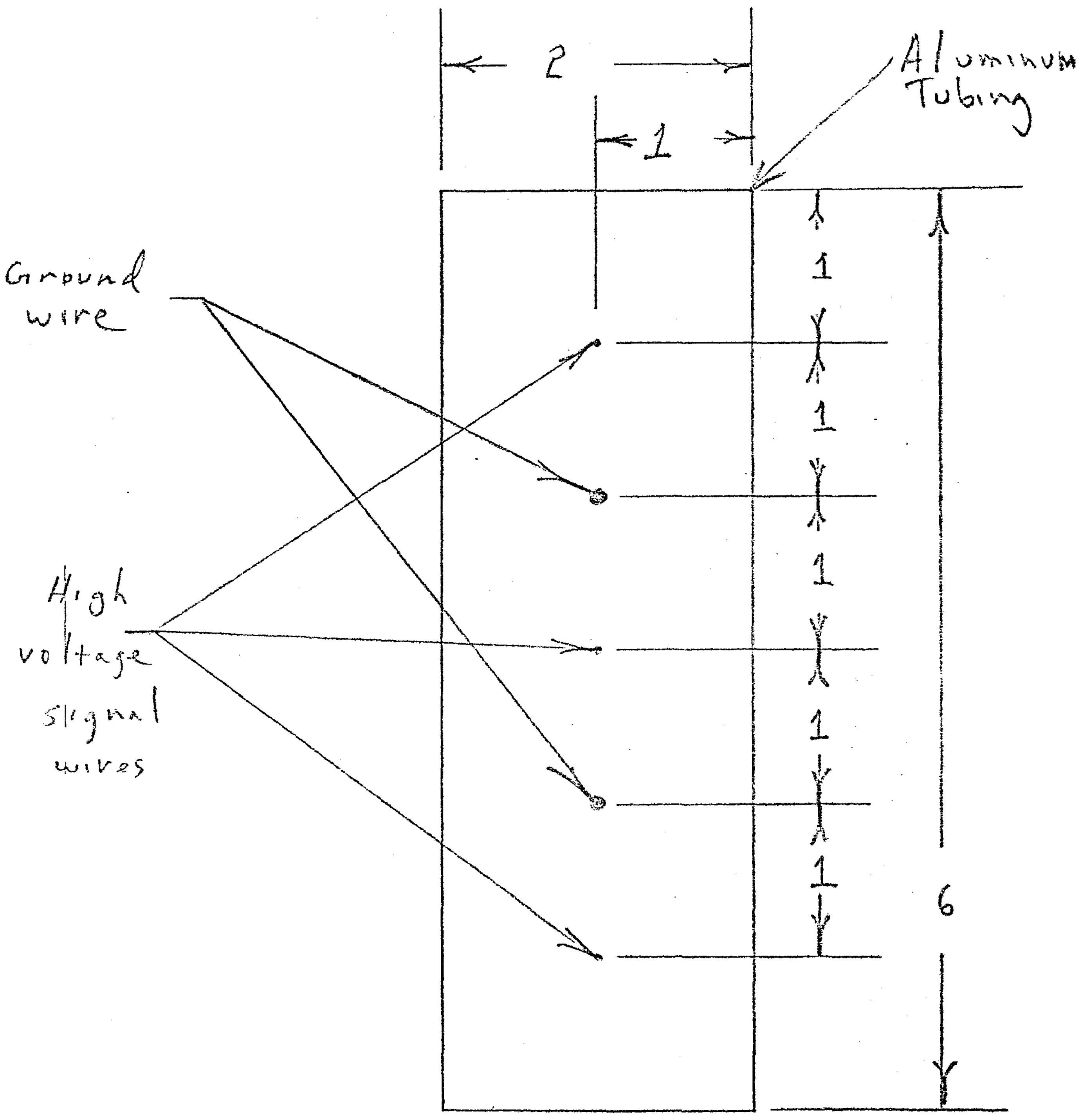


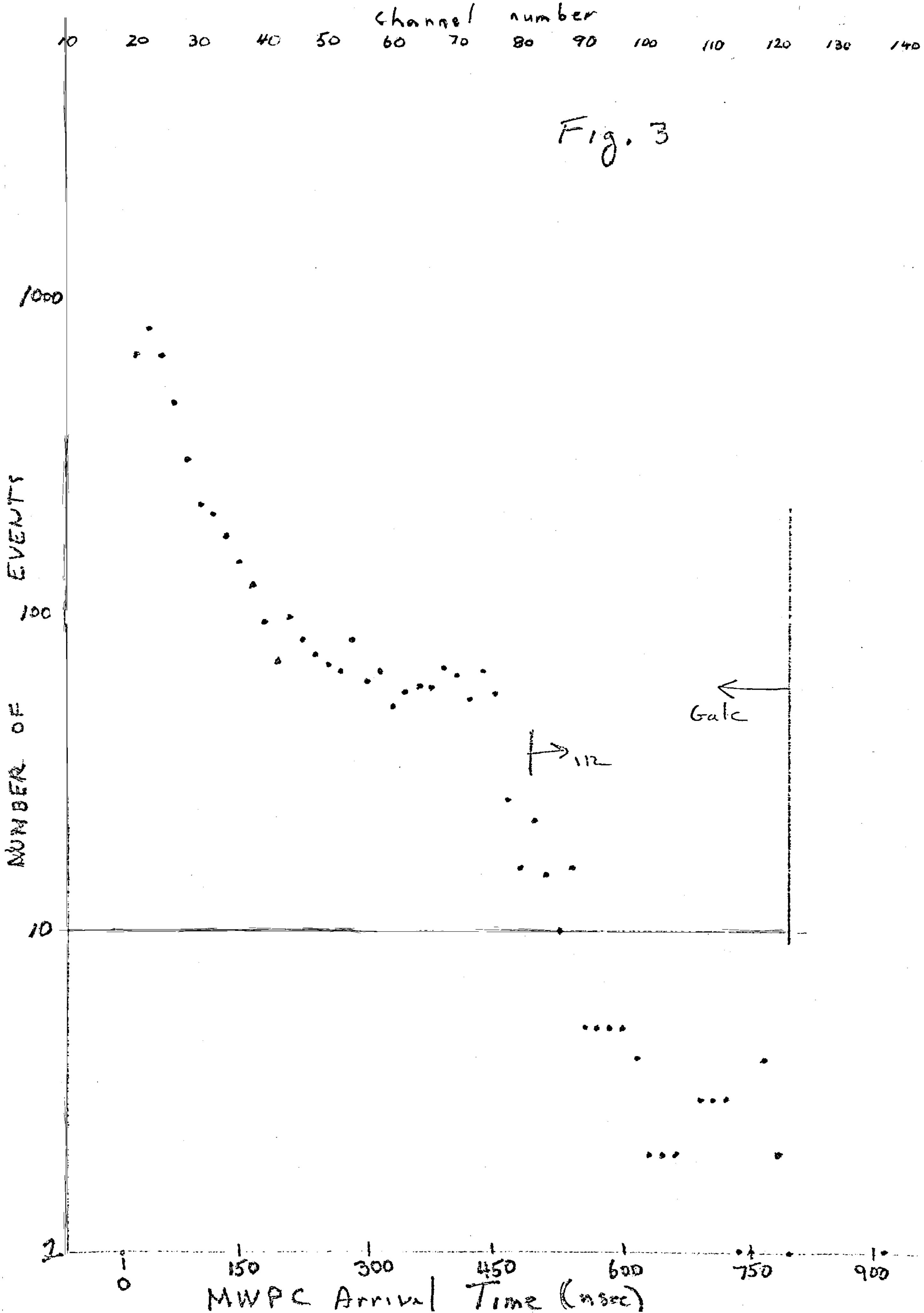
Fig 1

FIG. 2.



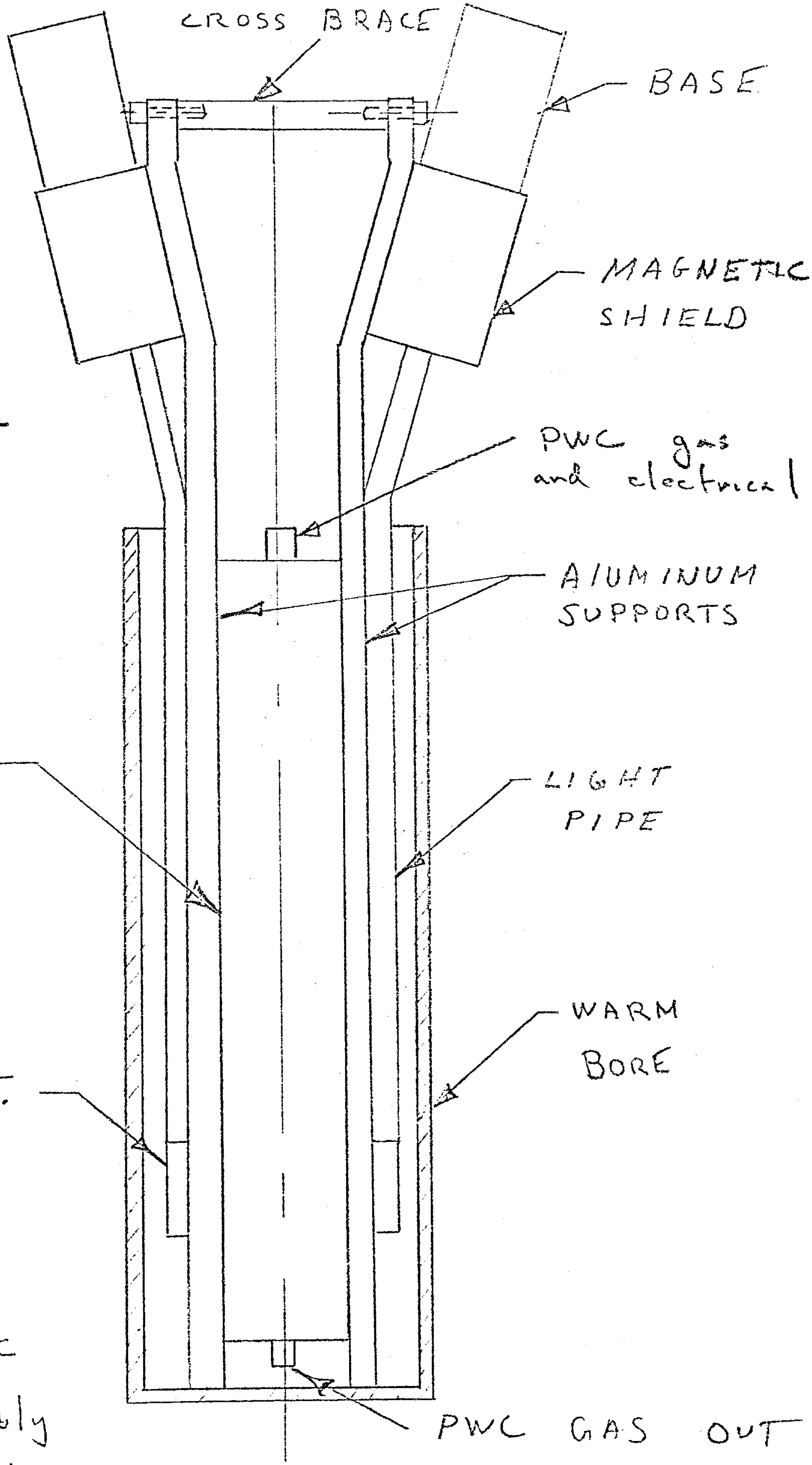
PWC TEST CHAMBER
CROSS SECTION

All dimensions in cm.



channel number
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Fig. 3
1000
100
10
2
NUMBER OF EVENTS
Gate
IR
0
150
300
450
600
750
900
MWPC Arrival Time (nsec)

Figure 4



Warm Bore PC Test Assembly
F Harris
July 23, 1976