national accelerator laboratory

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TOTAL ABSORPTION CALORIMETER TEST

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A prototype of total absorption calorimeters for NAL Experiment #260 has been built and studied using an unseparated positive hadron beam at SLAC. Measurements were made at beam momenta of 7, 10 and 14 GeV/c. The primary goal of this study was to establish optimum parameters for the hadron shower calorimeters, i.e., economical, practical and still usable in the energy range from 15 GeV to 200 GeV. We are particularly interested in finding the minimum number of scintillation counters for shower sampling and the total iron thickness needed in the energy region near 15 GeV. A large number of measured data[1-4] of shower absorption calorimeters have recently become available. At the higher energies ($\gtrsim$ 30 GeV) the existing data seem to provide sufficient information for our calorimeter design.

Figure 1 shows a schematic diagram of the experimental set-up. Forty-eight iron shower plates, 1 in. thick by 12 in. by 12 in., were welded on a solid iron beam, spaced by ½ in. for installation of scintillation counters of ¼ in. by 7¼ in. by 13 in. The counters were mounted from the top of the iron shower plates on a separate frame in order to allow independent motions. The iron shower plates were lowered out of the beam line without disturbing the scintillation counters when minimum ionizing signals were measured.

Firstly, 24 counters were mounted after every second iron plate, to give an iron thickness between two counters (iron spacing) of 2 in. This arrangement provided a series of measurements with iron spacings of 2 in., 4 in., 6 in., and 8 in. and with the total iron thickness up to 48 in. Secondly, 18 counters were mounted after every third iron plate to make measurements with iron spacings of 3 in. and 6 in. and with the total iron thickness up to 48 in. Ten-stage RCA 6655 tubes of 2 in. diameter were used for individual counters.

High voltages were adjusted using a Ru^{106} source to give average signals of 5 mV across 50 ohms for electrons which went through the counters and were detected by a trigger counter placed behind the counters. The typical high voltage was about 900V. Figure 2 shows the electronics arrangement.

Figure 3 shows shower pulse height distributions for 14 GeV/c, iron spacings of 2 in. and 4 in., and a total iron thickness of 48 in. A small peak corresponding to minimum ionizing signals is mainly due to muons. No attempt was made to identify beam particles. They consist mostly of positive pions and a few protons and muons.

Figure 4 summarizes measured energy resolutions (FWHM, %) as a function of the iron spacing for beam momenta of 7, 10 and 14 GeV/c. The indicated error bars are typical for all our data. Results obtained by a CERN-Karlsruhe group[1] and a BNL-Penn-Wisconsin group[3] for iron spacings of 0.5 in., 0.8 in., and 1 in. are also shown. (Some points are interpolated from the nearest measured points.) Resolutions as a function of the total iron thickness are shown in Figure 5. Curves in Figures 4 and 5 are drawn to guide the eye, and typical error is indicated.

A crude energy dependence of resolutions for some of existing data is shown in Figure 6. Straight lines, corresponding to $1/\sqrt{p}$ are drawn through our data for 2 in. and 4 in. iron spacing. Although geometrical arrangements, particularly iron spacings, are quite different, the resolutions are roughly inversely proportional to the square root of energy.

References

1. J. Engler, et al, Nuc. Instr. and Meth. 106 (1973) 189.
2. B. C. Barish, et al, preprint, September 1973.
3. F. Turkot, et al, University of Pennsylvania Internal Report, October 15, 1973.
4. L. W. Jones, et al, University of Michigan Internal Report U.M.H.E. 73-24.

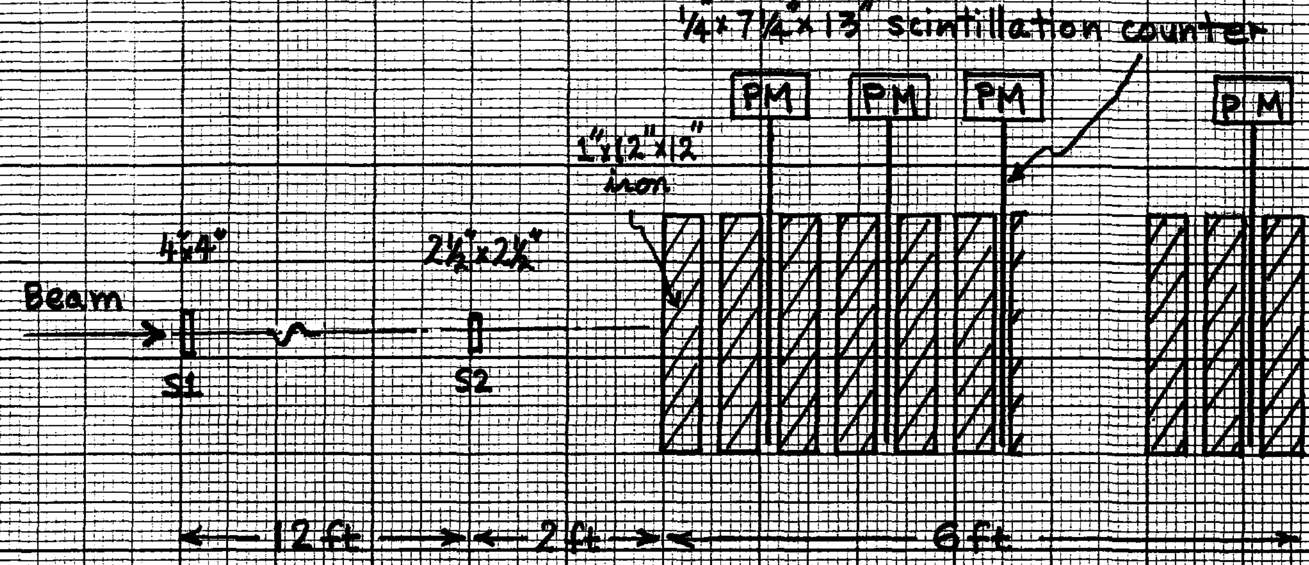


Figure 1. Schematic Diagram.

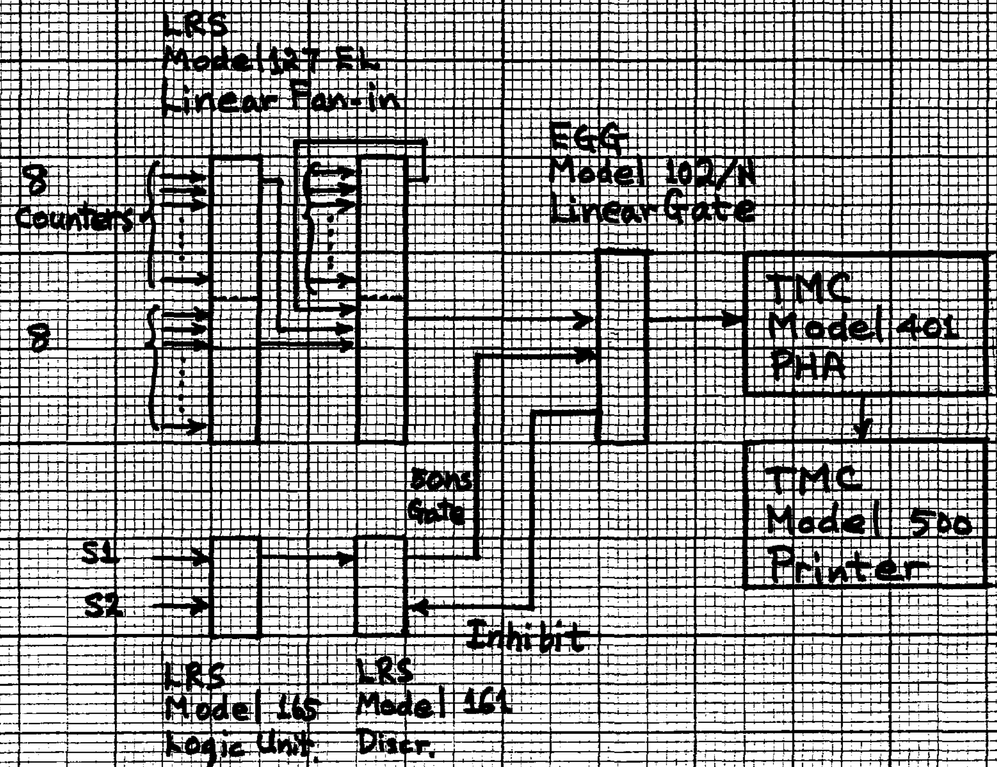


Figure 2. Electronics Arrangement.

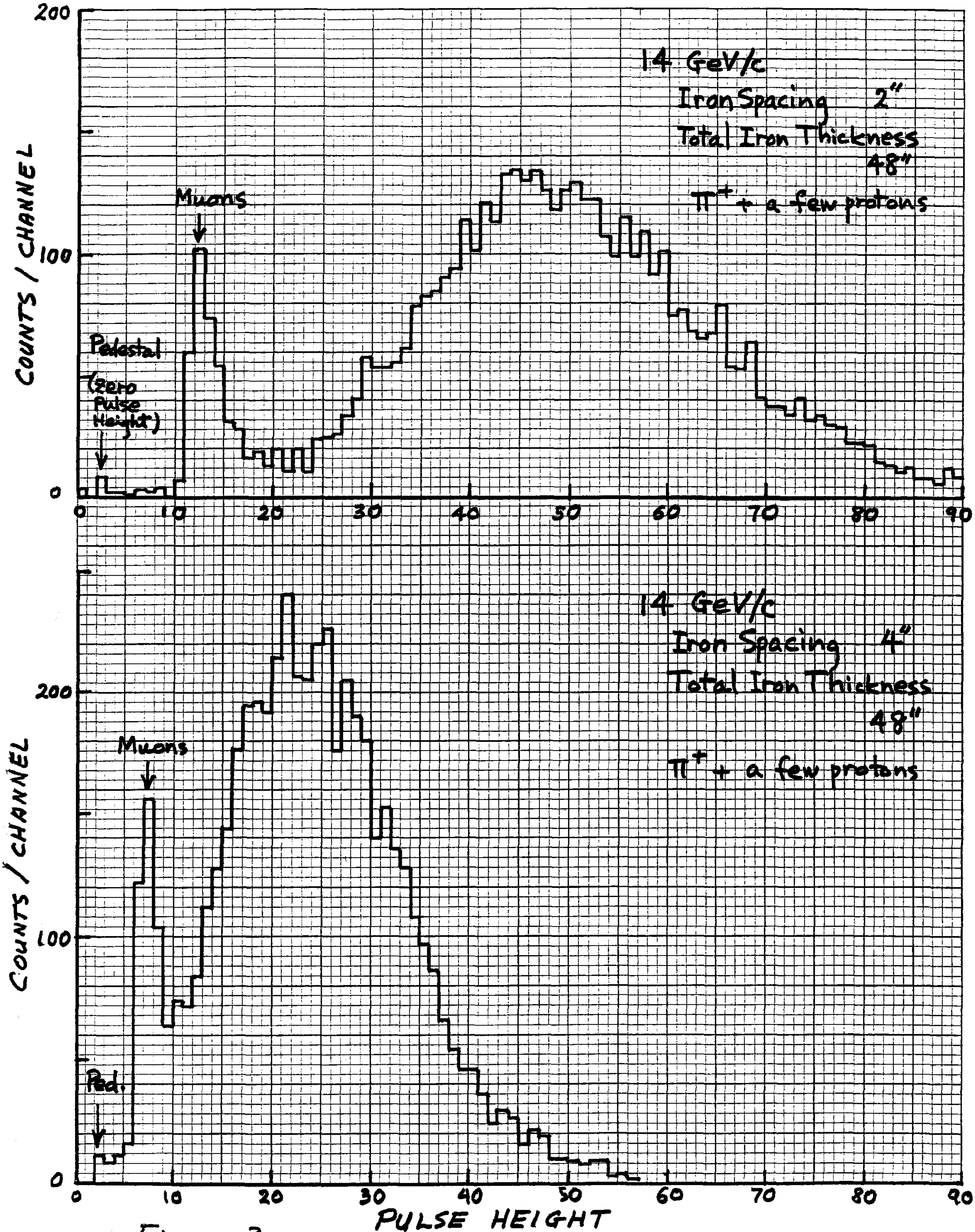

14 GeV/c
Iron Spacing 2"
Total Iron Thickness 48"
π+ + a few protons
Muons
Pedestal (zero Pulse Height)
COUNTS / CHANNEL
14 GeV/c
Iron Spacing 4"
Total Iron Thickness 48"
π+ + a few protons
Muons
Ped.
COUNTS / CHANNEL
PULSE HEIGHT

Figure 3.

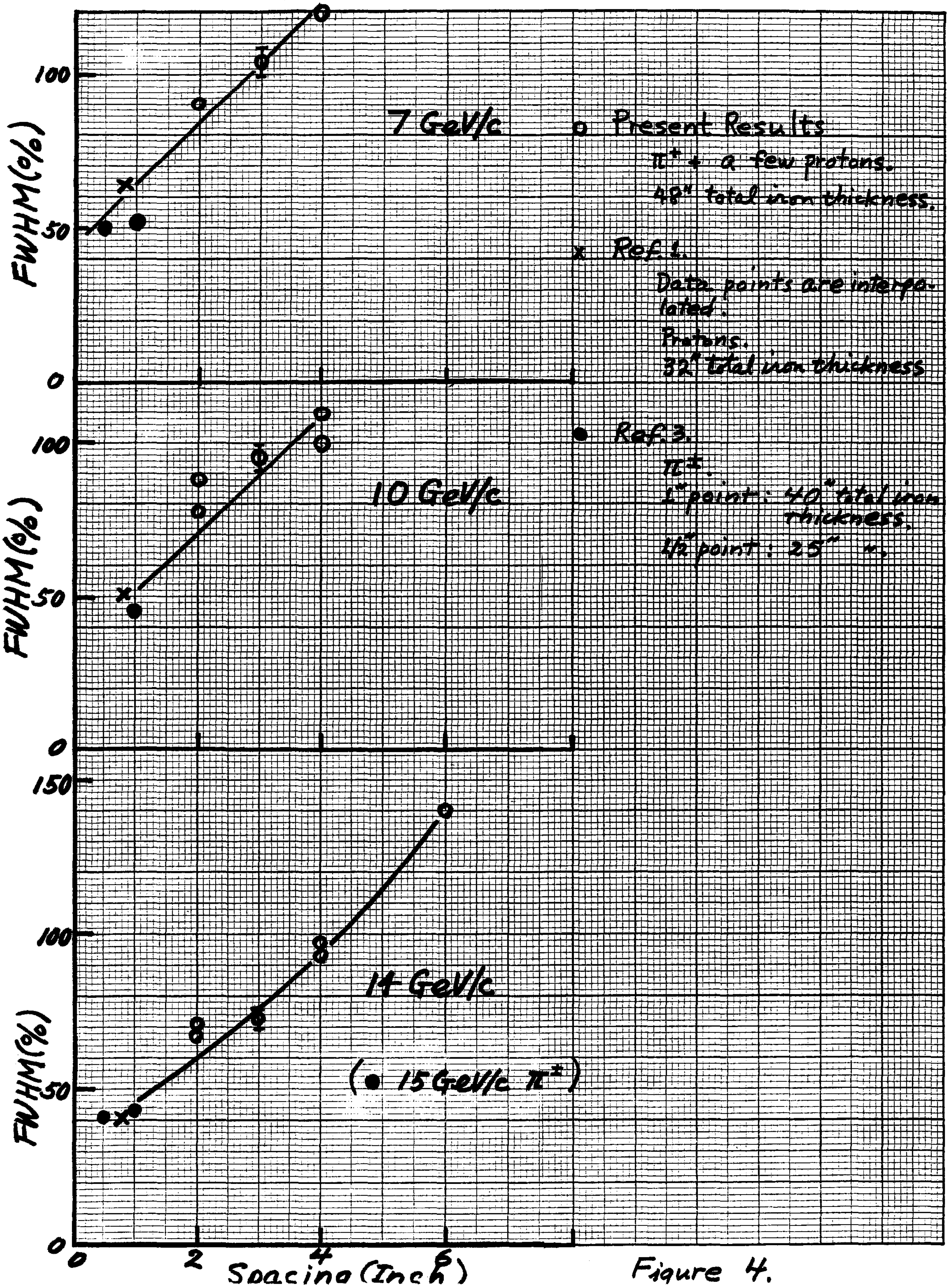
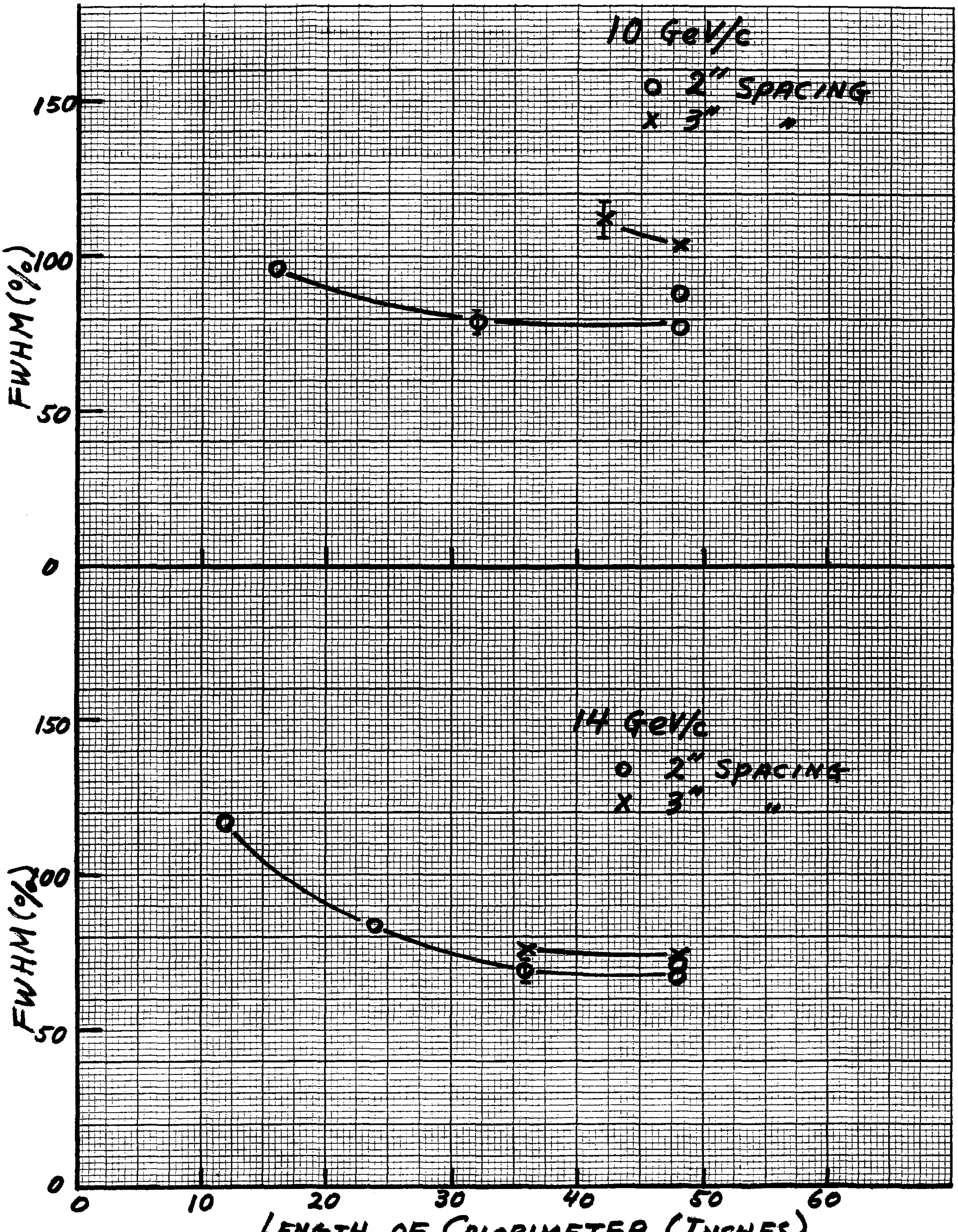

FWHM(%)
100
50
0
7 GeV/c
o Present Results
π+ + a few protons.
48" total iron thickness.
x Ref. 1.
Data points are interpolated.
Protons.
32" total iron thickness
• Ref. 3.
π±.
1" point: 40" total iron thickness.
1/2" point: 25" "
10 GeV/c
150
14 GeV/c
(• 15 GeV/c π±)
0
2
4
6
Spacing (Inch)

Figure 4.



10 GeV/c
o 2" SPACING
x 3" "
14 GeV/c
o 2" SPACING
x 3" "
FWHM (%)
150
100
50
0
0
10
20
30
40
50
60
LENGTH OF CALORIMETER (INCHES)

Figure 5.

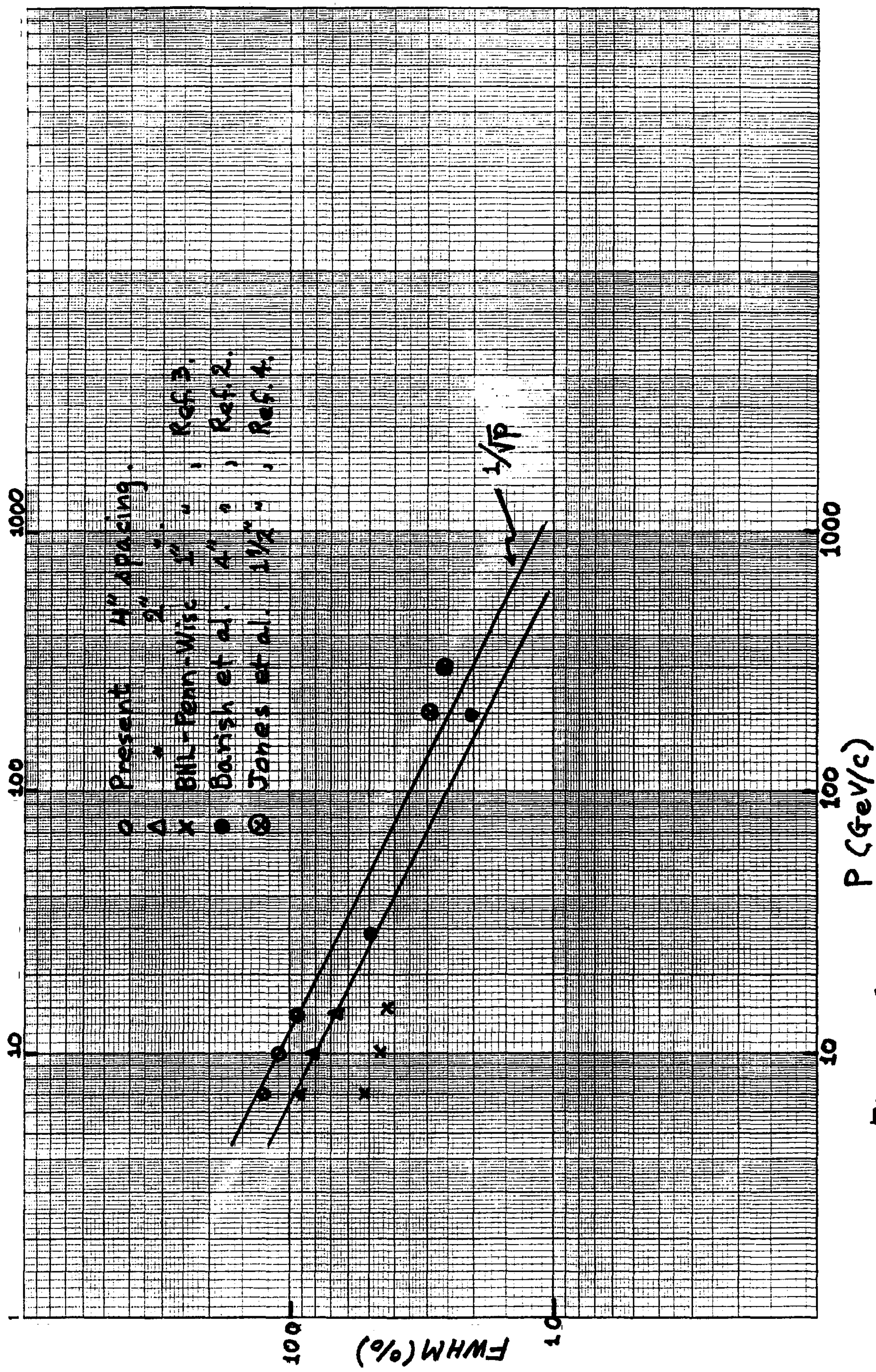

o Present 4" spacing.
Δ " 2" "
x BNL-Penn-Wisc 1" " , Ref. 3.
● Barish et al. 4" " , Ref. 2.
⊗ Jones et al. 1½" " , Ref. 4.
1/√P
10
100
1000
P (GeV/c)
100
10
FWHM (%)

Figure 6.