SLAC-PUB-801
September 1970
(EXPI)

WIRE SPARK CHAMBER SPECTROMETER AT SLAC*

G. T. Armstrong, F. Bulos, R. K. Carnegie, G. E. Fischer,
A. Kilert, E. E. Kluge, D. W. G. S. Leith, H. L. Lynch,
B. Ratcliff, B. Richter, H. H. Williams, and S. H. Williams
Stanford Linear Accelerator Center
Stanford University, Stanford, California
M. J. Beniston
IBM Scientific Center
Palo Alto, California

We describe the characteristics and performance of a wire spark chamber system using a secondary pion beam at SLAC for the study of reactions of the form $\pi^- p \rightarrow$ 2 or more charged particles. Topics discussed include the pion beam transport system; wire spark chambers, their associated H.V. pulsing system, and magnetostrictive readout; a large multi-cell Čerenkov counter; and computer facilities used in online and offline analysis of data. The properties of this system with respect to its acceptance and resolution, in mass, missing mass, and momentum transfer, are analyzed and examples presented.

---

*Work supported by the U. S. Atomic Energy Commission

(To be presented at the International Conference on Instrumentation for High Energy Physics, Sept. 8-12, 1970, Dubna, USSR)

DESCRIPTION OF SYSTEM

The pion beam shown in Fig. 1 partially shared the existing RF separated π-K beam for the 82" bubble chamber. The system consisted of two beam lines, each achromatic and each containing a momentum-defining crossover, one following the other. The beam for this experiment branched from the bubble chamber beam at the second focus (see Fig. 1); this diversion was accomplished by a pulsed magnet capable of a repetition rate of up to 180/sec. Thus, for example, it was possible to transmit kaons to the bubble chamber and pions of the same momentum to this experiment on a pulse-to-pulse basis. A somewhat unusual feature of this beam design was the use of sextupoles to cancel second-order effects in order to improve the beam spot size at the target. The beam had an angular pass band of ±2.5 mr horizontally and ±3.5 mr vertically it had a momentum pass band of ±2.5%. Counter hodoscopes were used to label particles within each of these three bands; vertically and horizontally these hodoscopes resolved to ±0.5 mr and the momentum hodoscope resolved better than ±0.5%. The beam intensity was typically 10 pions per 1.4 μsec machine pulse at 150 pulses per second for beam momenta between 4.5 and 15 GeV/c. The beam at the target was focused such that 96% of the pions were within a 2.5 cm square. Electron contamination was ~0.2% and muon contamination was ~3.1% at 15 GeV/c.

Figure 2 shows the arrangement of the seven spark chambers, target, analyzing magnet, and Čerenkov counter. Each spark chamber consisted of two gaps (four wire planes), each of which was read by magnetostrictive techniques. The wire planes were constructed with an aluminum-polyester cloth having a wire spacing of 1.05 wires/mm. Two of the planes were conventional x-y planes and the other two were inclined at angles of ±30° with respect to the vertical. Because the main beam passed through the chamber, a polyurethane plug was installed in each gap to prevent extra tracks due to beam particles. There were no spurious sparks near the plug or the edge of the chamber, but in order to operate the chamber at high rates a pulsed clearing field was used to prevent restriking of old sparks. The clearing field had a 50 VDC component upon which was superposed a 250V pulse 3 ms long after each beam pulse. Each chamber received its H.V. by means of a set of eight 50-ohm cables which in turn was driven by a hydrogen thyratron and a matching set of charging cables. Typically the chambers operated with a 6-kV rectangular pulse 225 ns long. The H.V. pulsing systems were designed for use with the chambers at rates up to 180/sec, and the system was used at rates up to 100/sec.[1] Under normal data-taking conditions the chambers had a gap efficiency greater than 98% for up to 5 sparks (see Fig. 3).

The Čerenkov counter[2] had an aperture 100 × 250 cm and was filled with Freon 12 at pressures up to 3 atmospheres. Optically it consisted of eight separate mirror, light horn, and phototube (58 UVP) units; the radiating path length was 175 cm. The set of eight mirrors covered a total area of 125 cm × 250 cm at the back of the counter. The design permitted use of the counter either as a hodoscope of eight separate Cerenkov cells or, by mixing the phototube outputs, as a large counter having uniform efficiency. Operating at a Freon 12 pressure of 1.46 atm, the efficiency for detecting 8 GeV/c pions was about 99.8%. The threshold for 8 GeV/c kaons is 1.8 atm.

Data logging was done by means of an IBM model 1800 computer, which received the magnetostrictive scaler readout, content of strobed buffers, and analog-to-digital converters by means of multiplexors built at SLAC.

This information was then written on magnetic tape (about 400 tapes for the experiment). For online analysis, tracks were reconstructed and selected kinematic histograms were generated for display either on a line printer or a CRT. The computer also performed checks of chamber efficiency, spark frequency, counter rates, and magnet currents. More detailed checking was available by means of a data link from the experimental area to the main SLAC computer, and IBM 360/91. This link had the capability of a real time link between the two computers; however, it was used mostly in an offline mode where tapes were analyzed by the 360/91 under control of the remote terminal.[3]

PERFORMANCE OF SYSTEM

As a system the performance was quite satisfactory. The resolution was limited by the single plane coordinate precision (±0.5 mm) of the spark chamber, and by multiple scattering in the target and hodoscopes. Observation of the decay $K_s \rightarrow \pi^+\pi^-$ yielded a mass resolution of ±4 MeV/c^2 (see Fig. 4), and we calculate a resolution of ±6 MeV/c^2 in the region of the ρ. The missing mass resolution was about ±80 MeV/c^2 near the neutron (see Fig. 5). We calculate a resolution in t which is $\sim 4 \times 10^{-3}$ $(\text{GeV/c})^2$ for $|t| = 0.06$ and proportional to $\sqrt{|t|}$.

ACKNOWLEDGMENTS

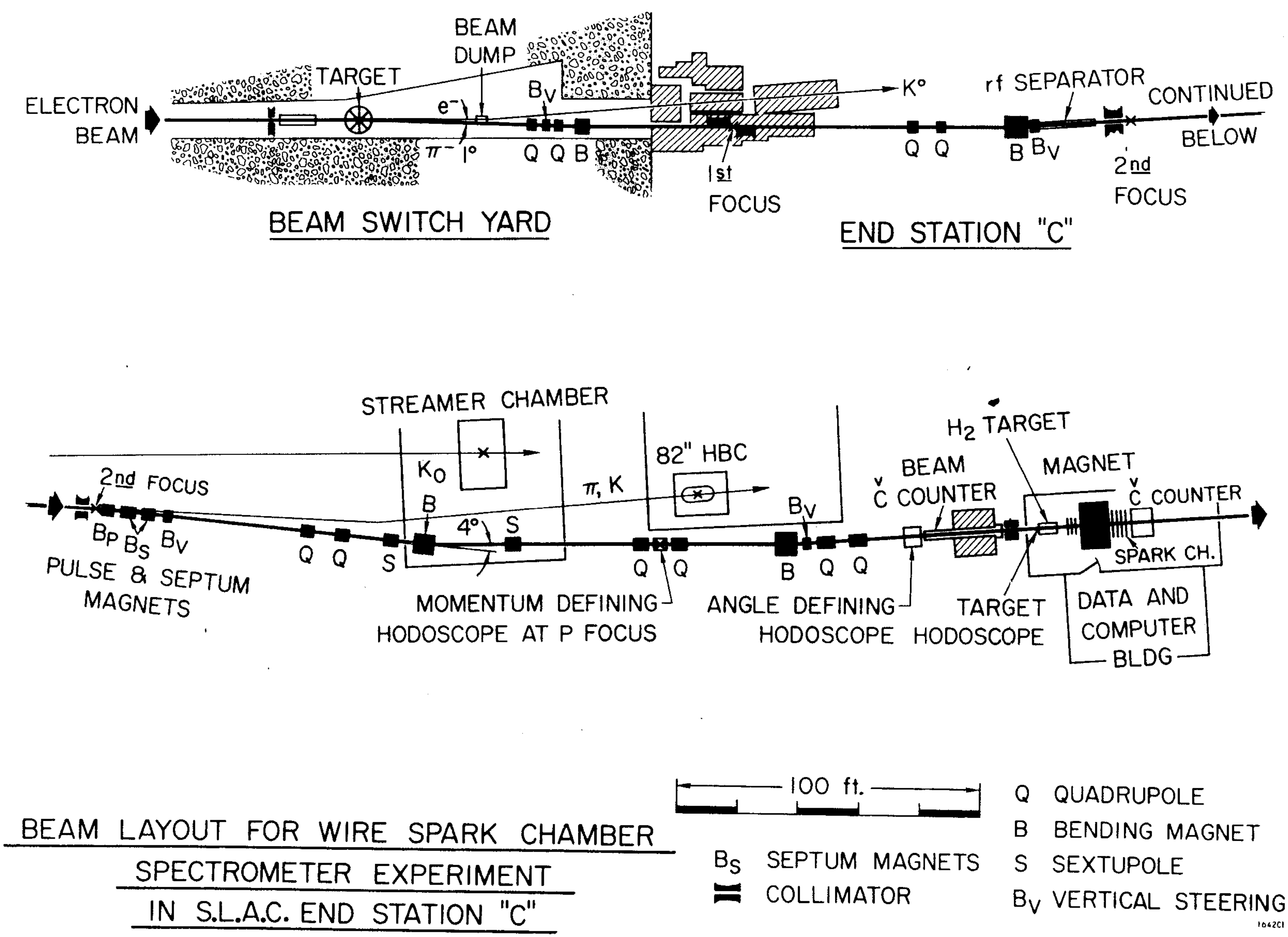
Many people were instrumental in putting together this experiment. We should like to extend our thanks for engineering help to U. Cummings, L. Karvonen, and E. Roskowski; for mechanical construction to H. Bowden, M. Lateur, R. Pickup, R. Ricks, and W. Walsh; for computer programming to R. Brody, D. Budenaers, D. Feick, J. Good, R. Good, M. Gravina, J. Schnecke, and K. Turcotte; and for electronics, M. Fishman, R. Friday, M. Gan, M. Hargain D. McShurley, and F. Rosche; and also to Dr. J. Murray for his help with the beam.

REFERENCES

1. F. Bulos and H.L. Lynch discuss details of the spark chamber system (to be published).
2. A. Kilert, D.W.G.S. Leith, and H.H. Williams, "A Large, Wide-Aperture Čerenkov Hodoscope," proceedings of this conference.
3. M.J. Beniston, D. Budenaers, R. Carnegie, E. Kluge, and H.L. Lynch, "Track Analysis for SLAC Wire Spark Chamber Spectrometer," proceedings of this conference.

FIGURE CAPTIONS

1. Beam Layout for Wire Spark Chamber Experiment.
2. Plan View of Wire Spark Chamber Spectrometer.
3. Single-Gap Efficiency of Spark Chambers.
4. Invariant Mass Resolution for $K_S^o \rightarrow \pi^+\pi^-$.
5. Missing Mass Resolution for the Reaction $\pi^- p \rightarrow \rho^o x$ and $\pi^- p \rightarrow \pi^-\pi^+\pi^- x^+$.



BEAM LAYOUT FOR WIRE SPARK CHAMBER SPECTROMETER EXPERIMENT IN S.L.A.C. END STATION "C"

Fig. 1

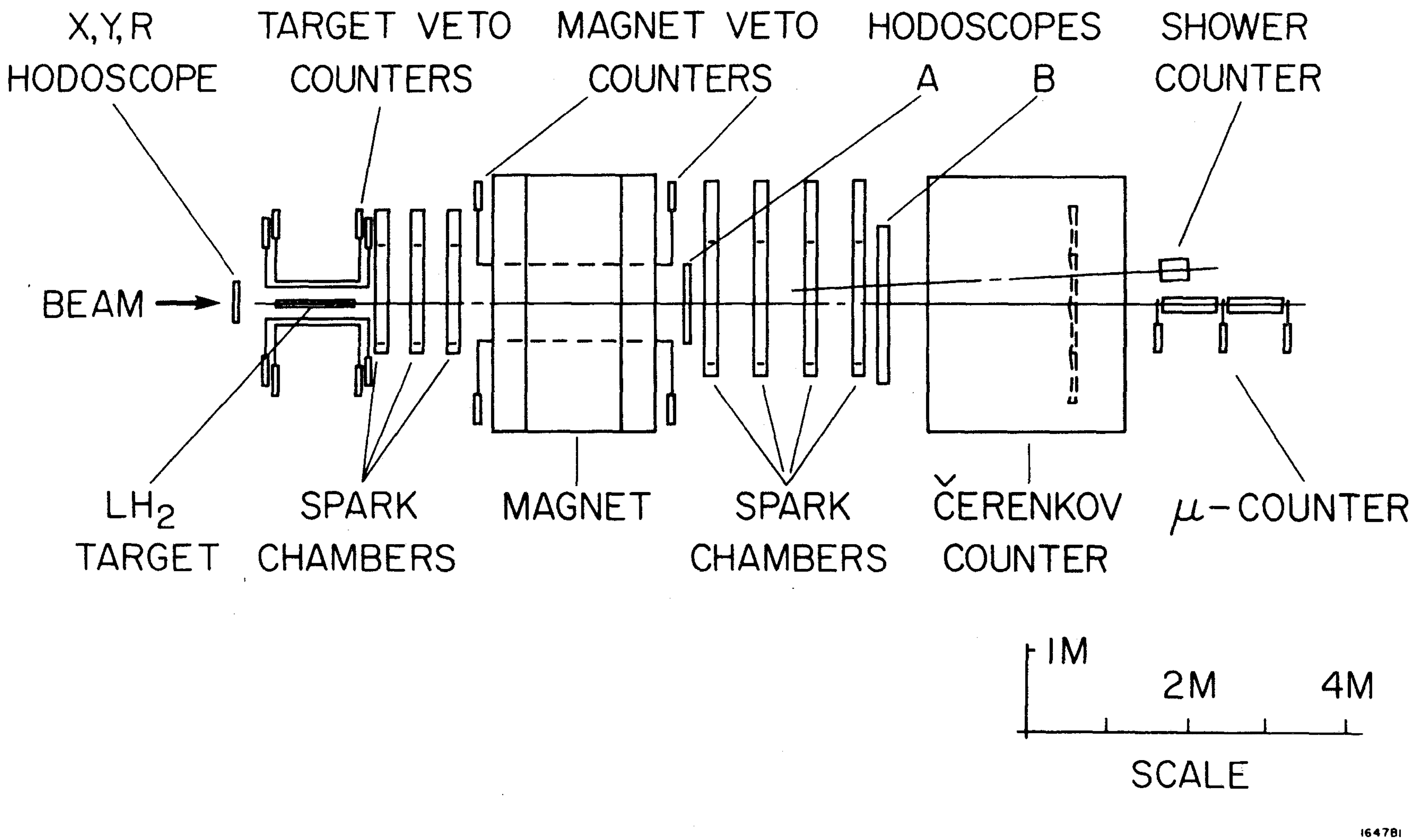

X,Y,R
HODOSCOPE
TARGET VETO
COUNTERS
MAGNET VETO
COUNTERS
HODOSCOPES
A
B
SHOWER
COUNTER
BEAM
LH2
TARGET
SPARK
CHAMBERS
MAGNET
SPARK
CHAMBERS
ČERENKOV
COUNTER
μ-COUNTER
1M
2M
4M
SCALE
164781

Fig. 2

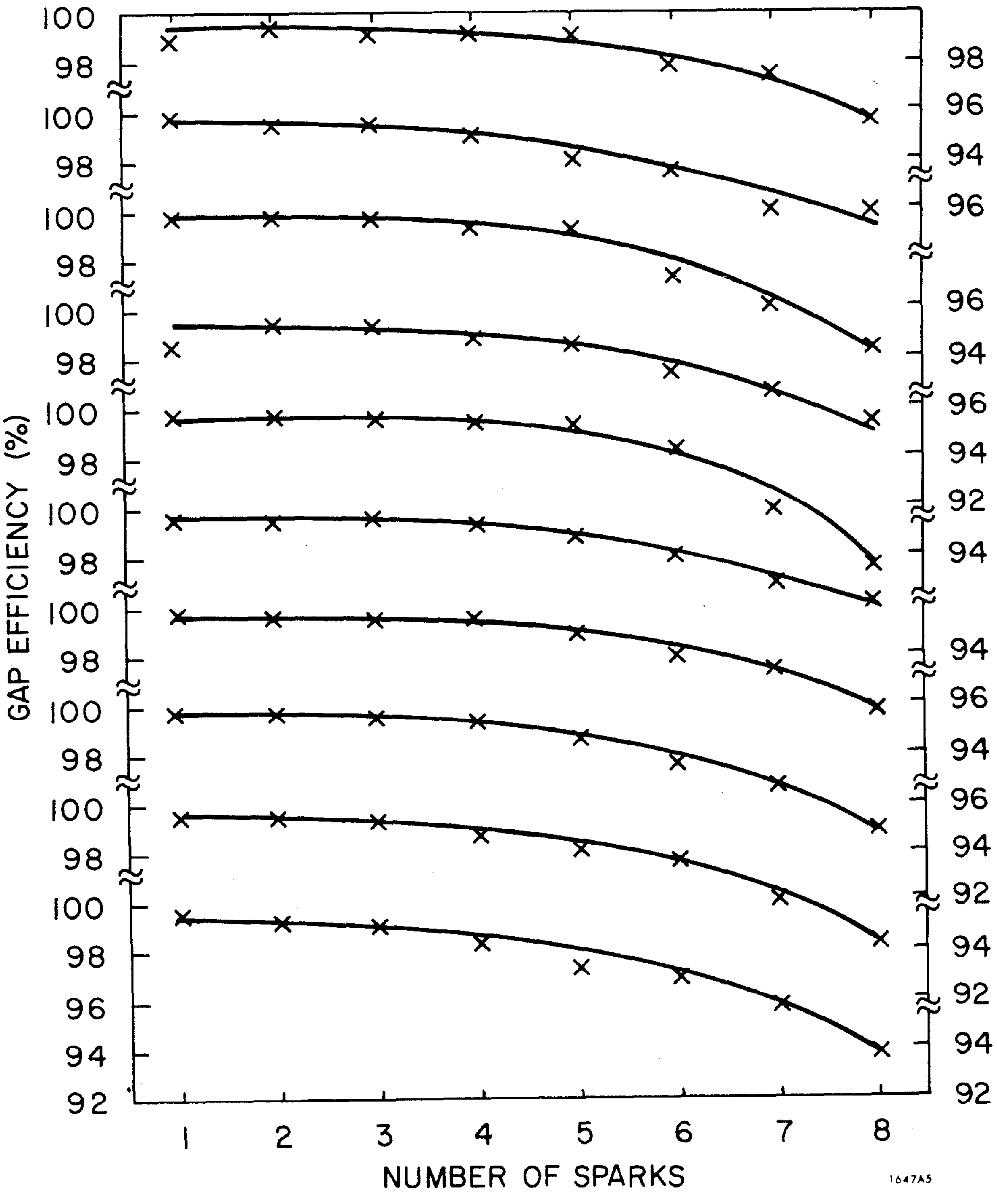


Fig. 3

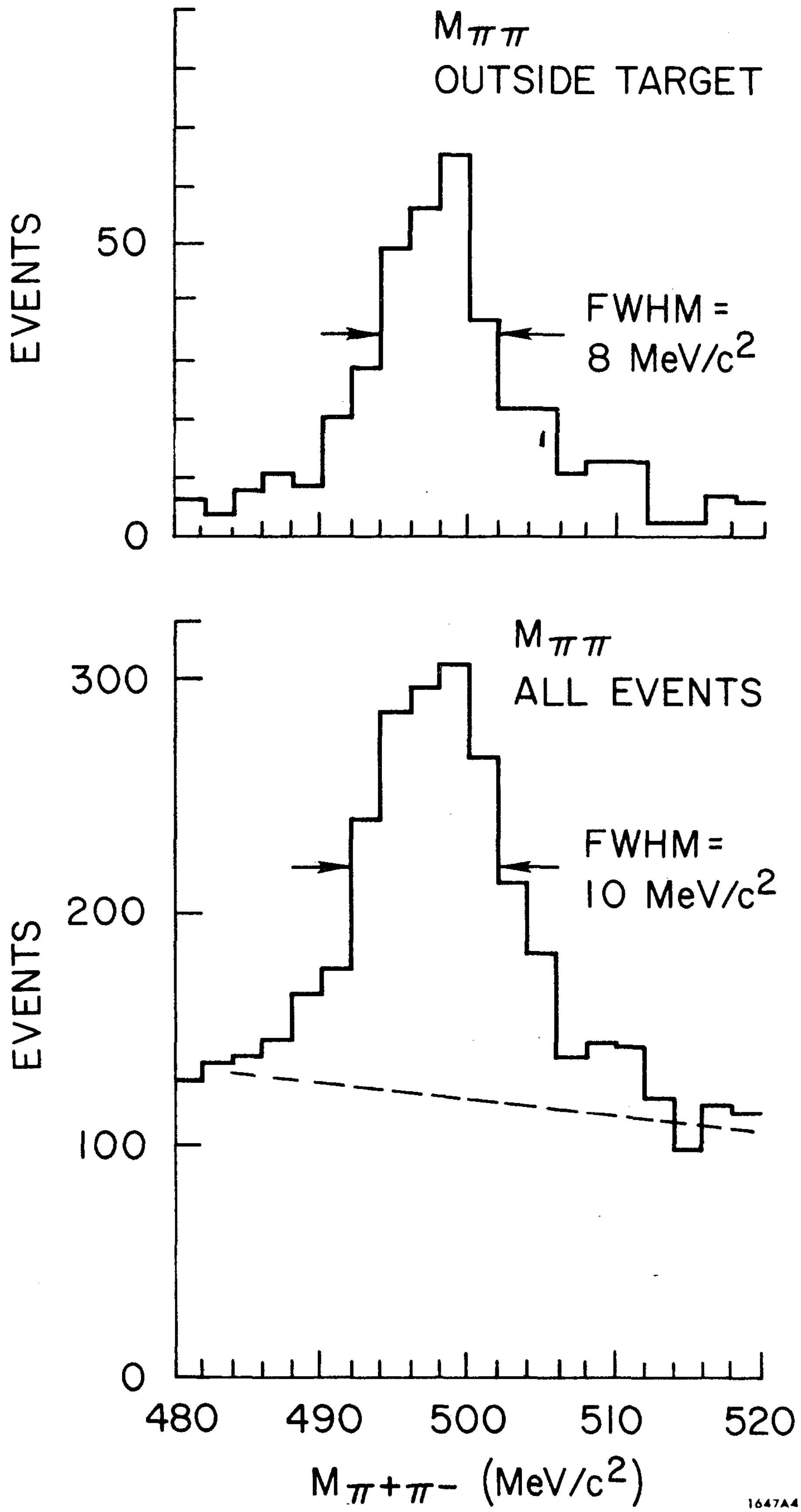

Mππ
OUTSIDE TARGET
EVENTS
50
0
FWHM =
8 MeV/c2
Mππ
ALL EVENTS
300
200
100
0
EVENTS
FWHM =
10 MeV/c2
480
490
500
510
520
Mπ+π- (MeV/c2)
1647A4

Fig. 4

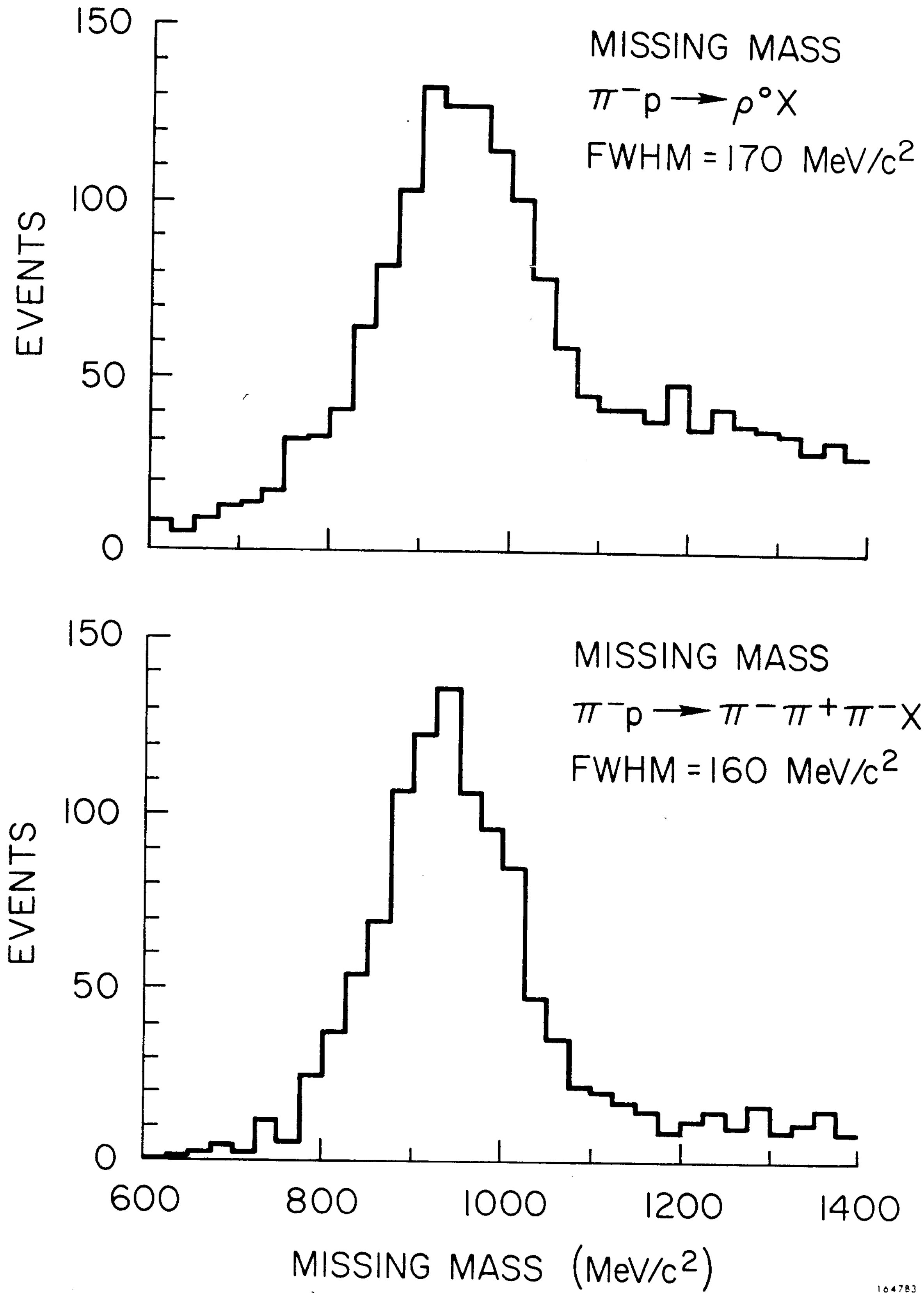

MISSING MASS
$\pi^- p \rightarrow \rho^\circ X$
FWHM = 170 MeV/c^2
MISSING MASS
$\pi^- p \rightarrow \pi^- \pi^+ \pi^- X$
FWHM = 160 MeV/c^2
EVENTS
0
50
100
150
600
800
1000
1200
1400
MISSING MASS (MeV/c^2)
164783

Fig. 5