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Track Reconstruction In The NAL 30-Inch Bubble Chamber-Wide Gap Spark Chamber Hybrid System*,**

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ABSTRACT

We describe the track reconstruction and bubble chamber/spark chamber hookup software used in the NAL hybrid spectrometer. Results for 15-200 GeV/c tracks are presented. Further details of the physical characteristics of the hybrid system and preliminary physics results are presented in accompanying papers.

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The software system for the Experiment 2B NAL Hybrid spectrometer has three basic components: (1) reconstruction in the bubble chamber; (2) reconstruction in the spark chambers, and (3) the track hookup between the two detectors. The physical characteristics of the hybrid system are described in an accompanying paper. Reconstruction in the bubble chamber is done with the standard program TVGP.

In Figure 1 we show a block diagram of the logic flow in the spark chamber reconstruction program. The film plane measurements are first transformed to the ideal film plane in much the same way that TVGP does for the bubble chamber. Then each direct view track is paired with the 90-degree mirror view tracks and each resulting view-pair reconstruction is rejected unless there is a corresponding 10-degree mirror view track image. This procedure is continued until all tracks have been reconstructed without ambiguities. Figures 2 and 3 show point scatter (FRMS) distributions in space for a sample of beam tracks. The direct views (Figure 2) measure the momentum determining coordinate (y) and the indirect views (Figure 3) measure the equivalent of the bubble chamber depth (z) coordinate. Since each dual gap spark chamber has a separate 90-degree mirror view, this process is repeated four times and the four resulting track segments are subjected to a least square fit to obtain a best determination of the physical quantities of interest for each track. These quantities are: (1) two angles corresponding to azimuth and dip in the usual bubble chamber terminology, and (2) two transverse beam-coordinates, all calculated at a fixed value of x, the coordinate along the beam direction.

Pursuant to the hookup with the bubble chamber, the track coordinates and angles are then transformed to the bubble chamber coordinate system. The matrix used to carry out this transformation is obtained from a sample of magnet off, straight-through tracks. Figure 4 shows, for example, the distribution of the difference between the y coordinate in the spark chamber system and the bubble chamber y coordinate extended to the spark chamber system for a sample of magnet off tracks. The width of this distribution is understood in terms of the straight forward propagation of bubble chamber errors to the spark chambers.

The track hookup program now combines the bubble chamber and spark chamber results. Figure 5 shows a block diagram of the logic flow of this program. Each bubble chamber track with angles and momentum approximately consistent with the spark chamber acceptance is propagated to the no field region using a Runge-Kutta stepping method, then drifted to the point x_0 at which the spark chamber coordinates and angles are known. At this point, one of two options is elected: (1) if there is no track candidate in the region of acceptability the track is completed with only the bubble chamber information for it; or (2) if there is a track candidate, then the program proceeds to iterate angles and momentum repeating the bend-drift until a best fit is obtained.

We have measured forward tracks with the spark chamber/bubble chamber hybrid system having momenta between 15 GeV/c and 200 GeV/c. The momentum distribution for a sample of 200 GeV/c beam tracks is shown in Figure 6. We note that the FWHM of the distribution is 25 GeV/c. considerably smaller than the ~90 GeV/c value obtained with the bubble chamber data alone in the same film.

In Figure 7 we show a $\pm\ \Delta p/p$ vs. p scatterplot for a sample of secondary tracks as measured in the bubble chamber alone and as measured in the combined hybrid system. The straight line indicates our early expectations for the system, with a form

$$\pm \frac{\Delta p}{p} (\%) = 0.07\ p\ (\mathrm{GeV}/c) \qquad (1)$$

Our results indicated a more realistic representation of the form

$$\pm \frac{\Delta p}{p} (\%) \approx 0.04\ p\ (\mathrm{GeV}/c) \qquad (2)$$

At all values of momentum the accuracy of the hybrid system is vastly superior to that of the bubble chamber alone.

Preliminary physics results at 200 GeV/c are presented in an accompanying paper.

FIGURE CAPTIONS

Figure 1 - Flow diagram used in spark chamber track reconstruction.

Figure 2 - Point scatter (FRMS) results on beam tracks in the direct view.

Figure 3 - Point scatter (FRMS) results on beam tracks in the 90-degree view.

Figure 4 - Distribution of transverse coordinate of bubble chamber track (extended to spark chambers) around same coordinate of spark chamber track for beam tracks with no magnetic field.

Figure 5 - Flow diagram used in bubble chamber-spark chamber hookup.

Figure 6 - Distribution of fitted beam momentum for known 200 GeV/c beam.

Figure 7 - Scatter plot of ± $\Delta p/p$ versus p for secondary tracks from 15 to 200 GeV/c based on (a) bubble chamber alone (open circles) and (b) hybrid system (closed circles).

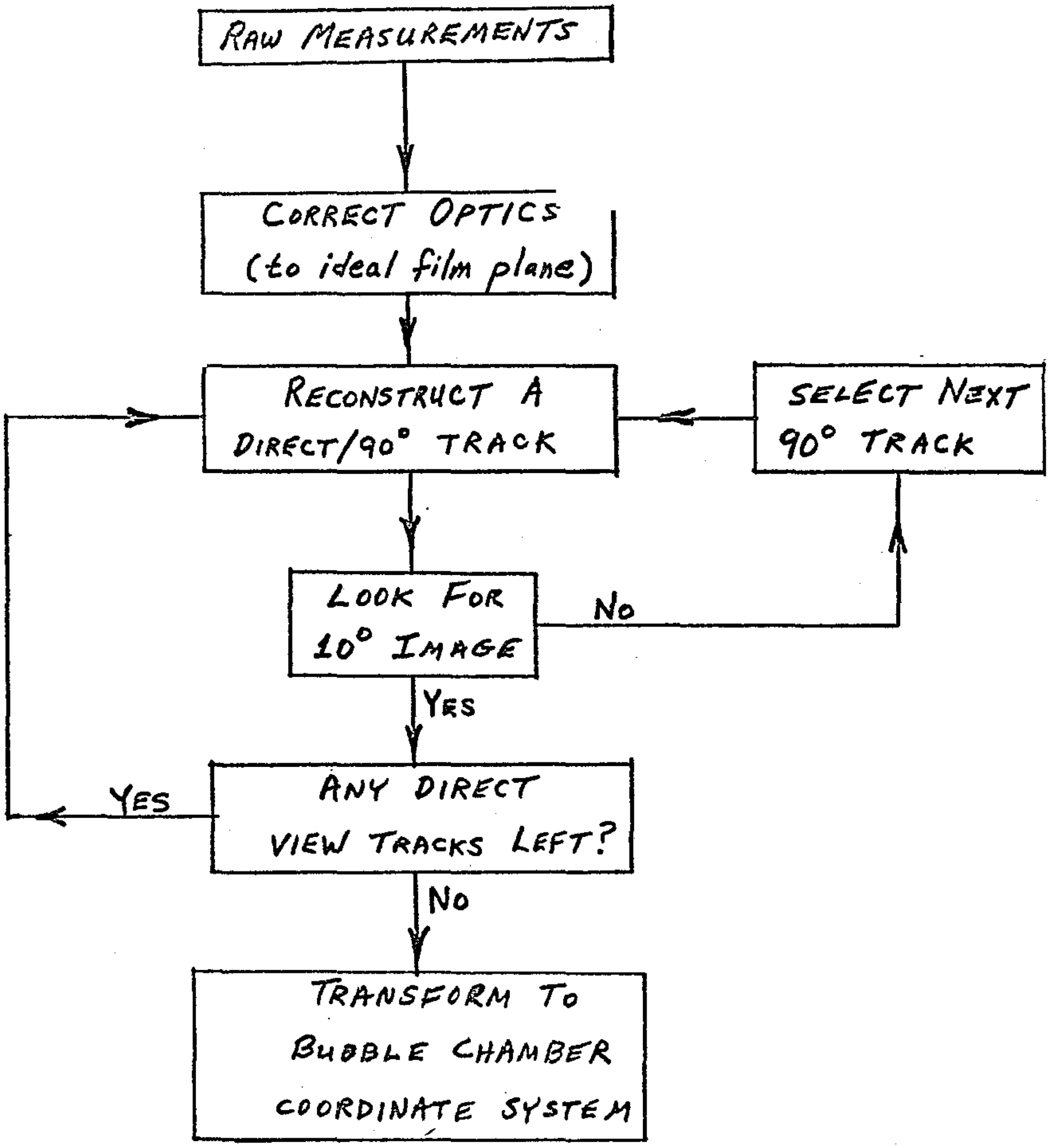

RAW MEASUREMENTS
CORRECT OPTICS (to ideal film plane)
RECONSTRUCT A DIRECT/90° TRACK
SELECT NEXT 90° TRACK
LOOK FOR 10° IMAGE
NO
YES
ANY DIRECT VIEW TRACKS LEFT?
YES
NO
TRANSFORM TO BUBBLE CHAMBER COORDINATE SYSTEM

FIGURE 1

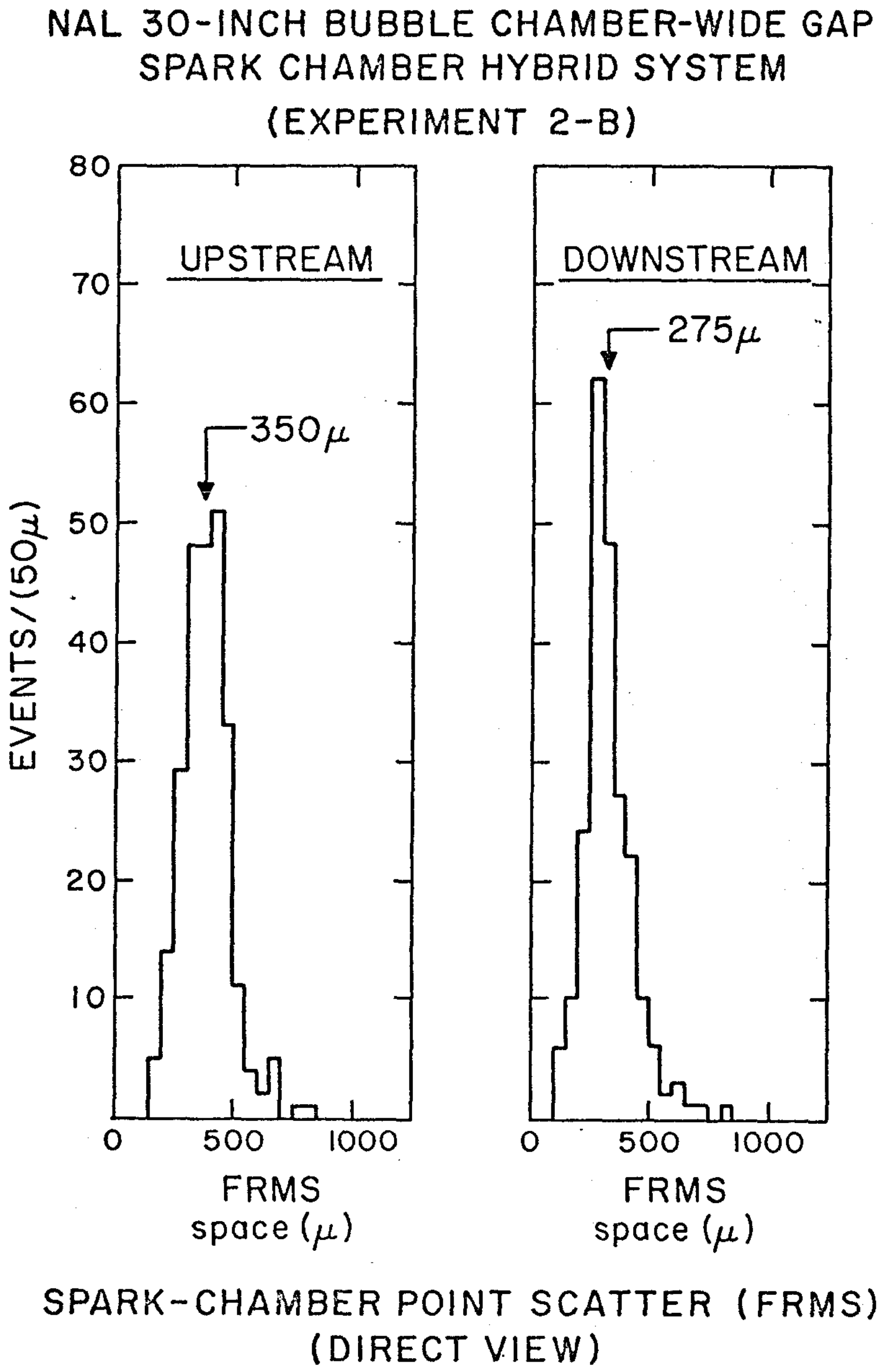
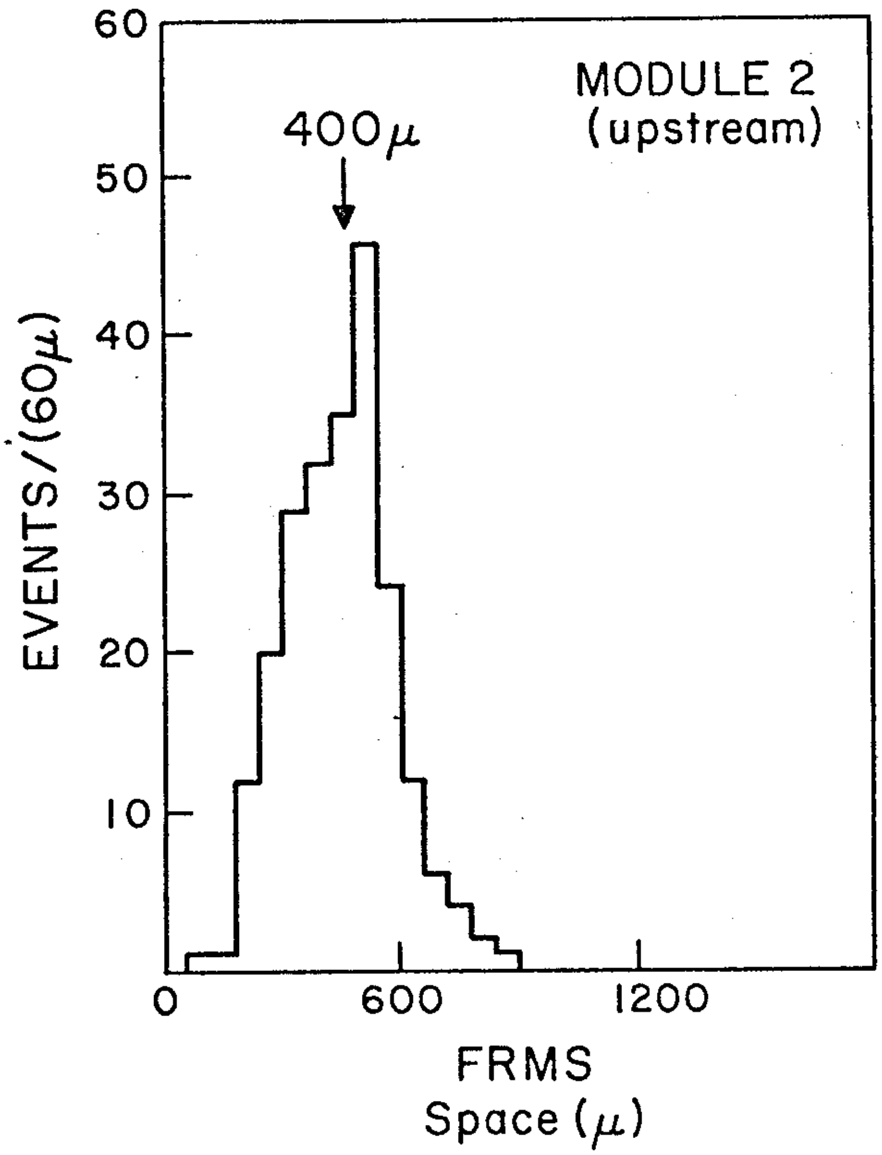

NAL 30-INCH BUBBLE CHAMBER-WIDE GAP
SPARK CHAMBER HYBRID SYSTEM
(EXPERIMENT 2-B)
UPSTREAM
DOWNSTREAM
350μ
275μ
EVENTS/(50μ)
80
70
60
50
40
30
20
10
0
500
1000
FRMS
space (μ)
SPARK-CHAMBER POINT SCATTER (FRMS)
(DIRECT VIEW)

Figure 2

NAL 30-INCH BUBBLE CHAMBER-WIDE GAP SPARK CHAMBER HYBRID SYSTEM

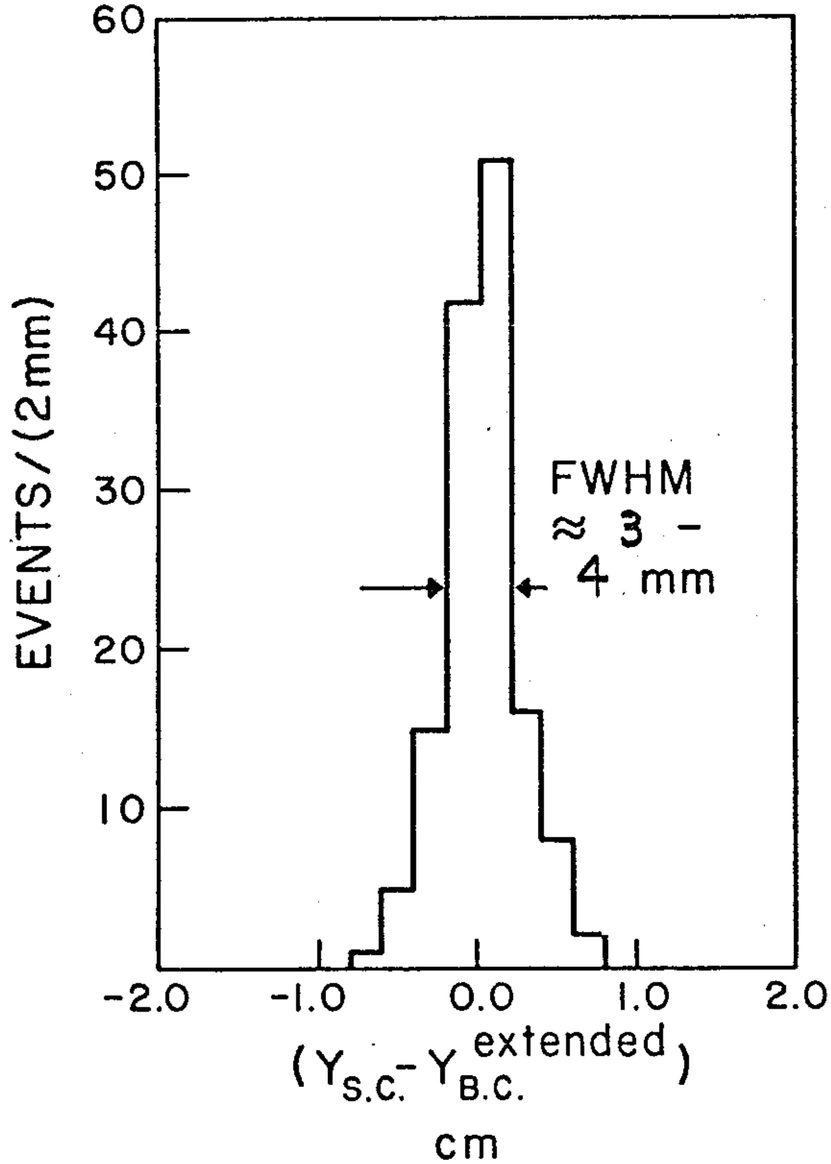
(EXPERIMENT 2-B)



SPARK-CHAMBER POINT SCATTER (FRMS)
(90-DEGREE VIEW)

Figure 3

NAL 30-INCH BUBBLE CHAMBER-WIDE GAP
SPARK CHAMBER HYBRID SYSTEM
(EXPERIMENT 2-B)



BUBBLE CHAMBER – SPARK CHAMBER
HOOK-UP MEASUREMENT

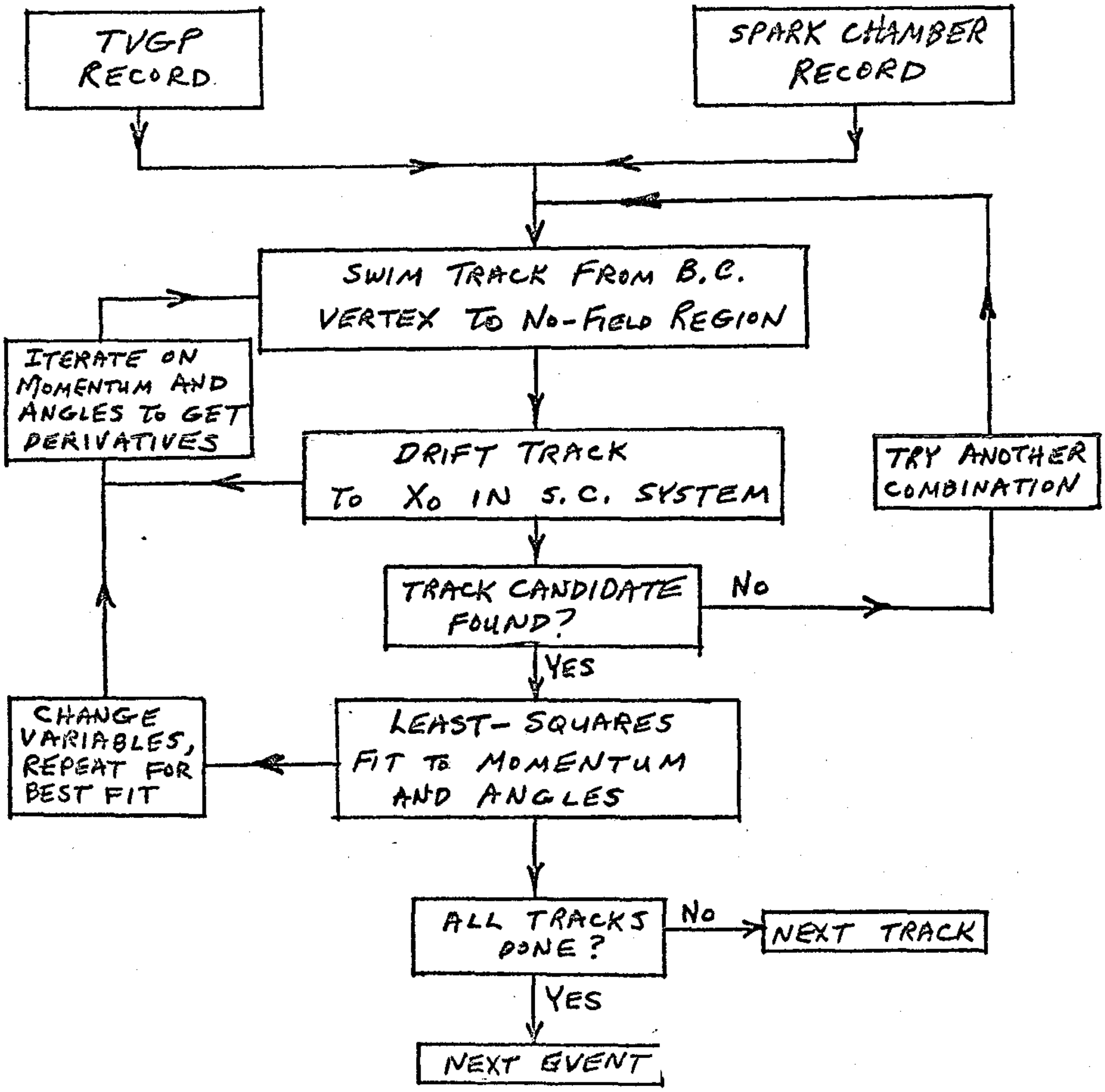
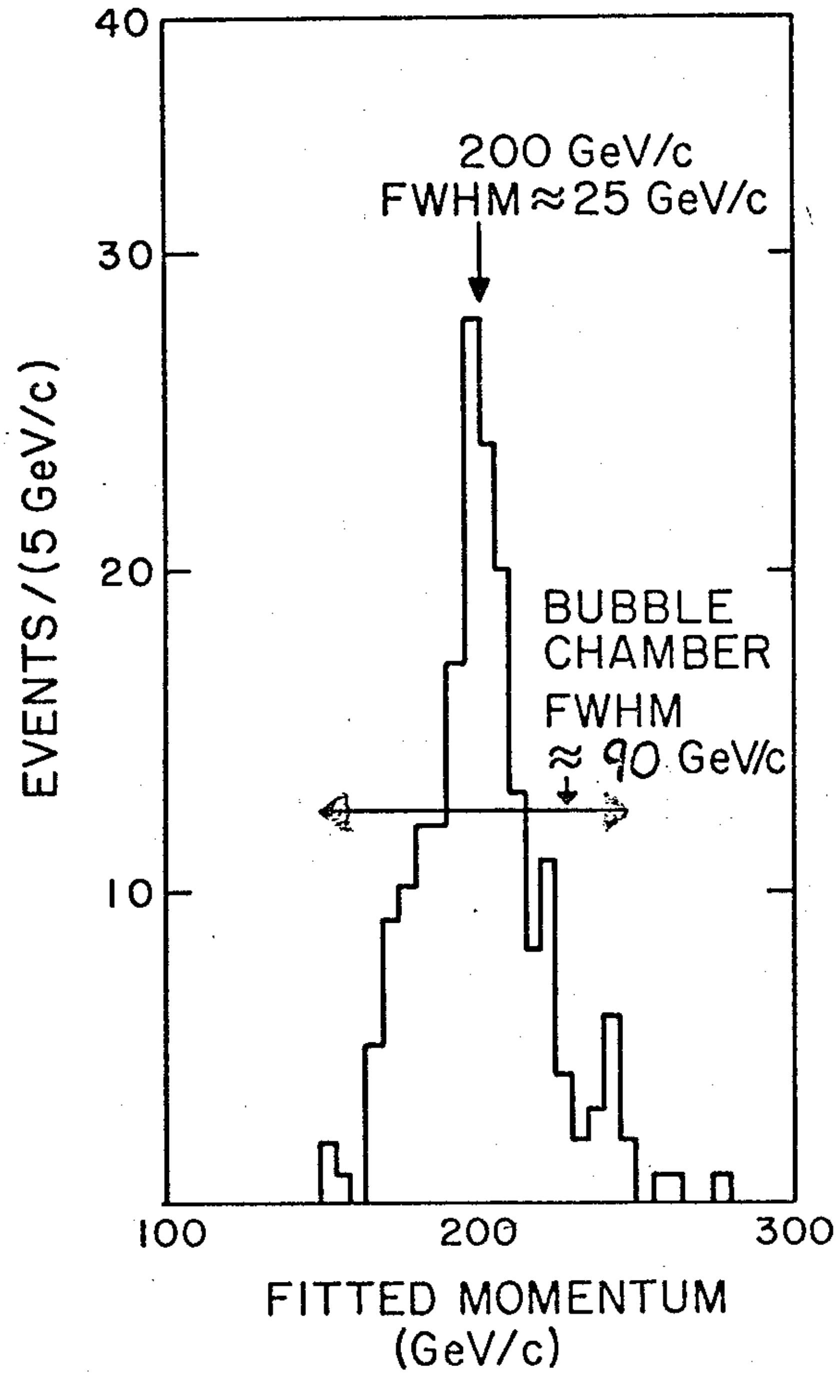

TVGP RECORD
SPARK CHAMBER RECORD
SWIM TRACK FROM B.C. VERTEX TO NO-FIELD REGION
ITERATE ON MOMENTUM AND ANGLES TO GET DERIVATIVES
DRIFT TRACK TO X_0 IN S.C. SYSTEM
TRACK CANDIDATE FOUND?
NO
TRY ANOTHER COMBINATION
YES
LEAST-SQUARES FIT TO MOMENTUM AND ANGLES
CHANGE VARIABLES, REPEAT FOR BEST FIT
ALL TRACKS DONE?
NO
NEXT TRACK
YES
NEXT EVENT

FIGURE 5

NAL 30-INCH BUBBLE CHAMBER-WIDE GAP SPARK CHAMBER HYBRID SYSTEM

(EXPERIMENT 2-B)



FITTED BEAM MOMENTUM USING BUBBLE CHAMBER—SPARK CHAMBER HOOK-UP DATA

Figure 6

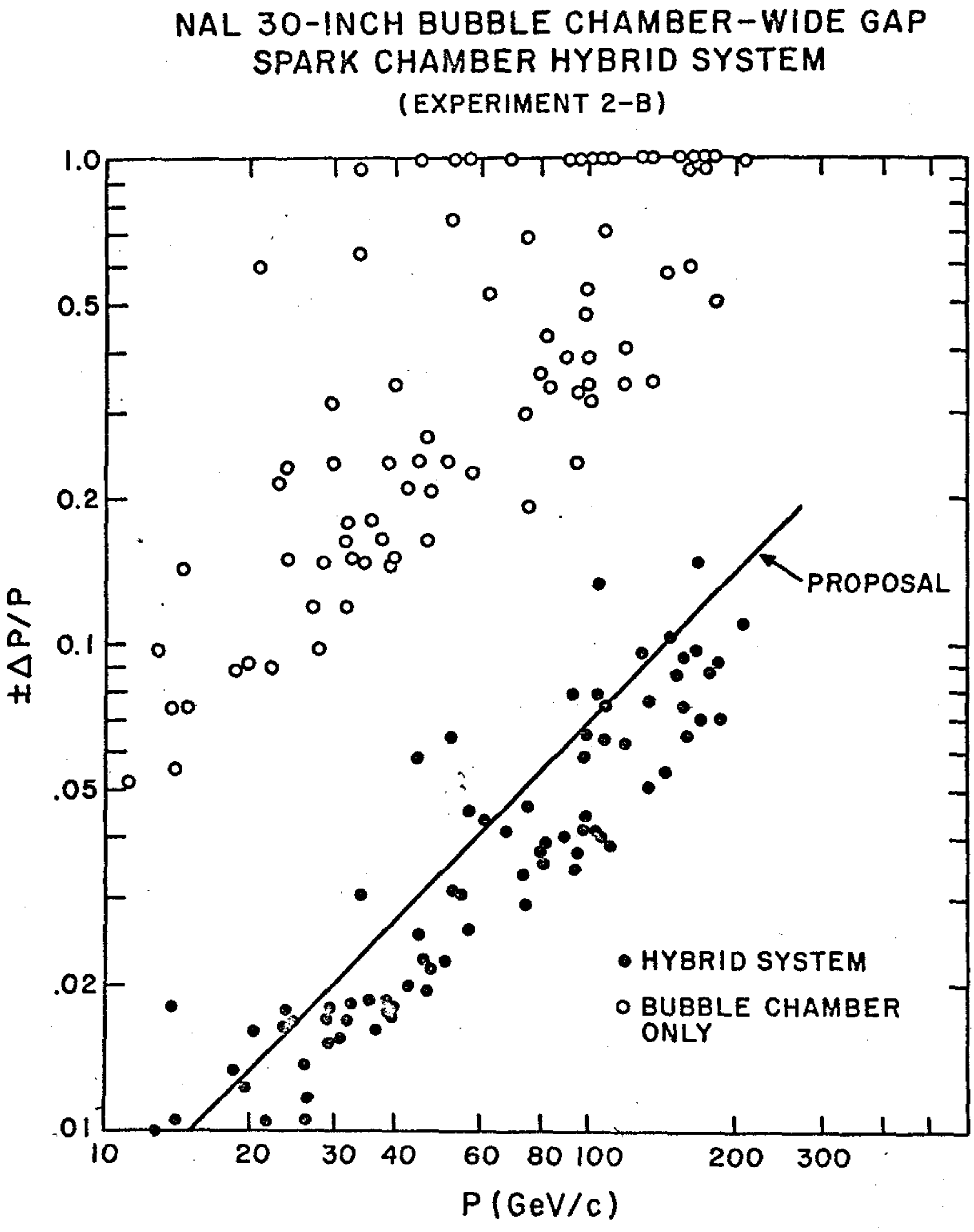

NAL 30-INCH BUBBLE CHAMBER-WIDE GAP
SPARK CHAMBER HYBRID SYSTEM
(EXPERIMENT 2-B)
1.0
0.5
0.2
0.1
.05
.02
.01
±ΔP/P
10
20
30
40
60
80
100
200
300
P (GeV/c)
PROPOSAL
HYBRID SYSTEM
BUBBLE CHAMBER ONLY

Figure 7