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Inclusive Spectra of Secondaries From 200 GeV/c Proton-Proton Interactions Detected in the NAL 30-Inch Bubble Chamber-Wide Gap Spark Chamber Hybrid System*, **

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Abstract

Preliminary data are presented on π^- production in inclusive pp interactions at 200 GeV/c using the NAL 30-inch bubble chamber and downstream wide-gap spark chambers. Correlations between π^-'s are studied. No strong short-range correlation effect is seen in contrast to ISR results. Further details of the physical characteristics of the hybrid system and track reconstruction are described in accompanying papers.

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In this paper we present preliminary results on correlations between π^-'s in 200 GeV/c pp interactions obtained from the NAL 30-inch bubble chamber-wide gap spark chamber hybrid system. The physical characteristics of the hybrid system and track reconstruction are described in accompanying papers. The data came from a film sample of 5,000 pictures. By selecting frames with no upstream bubble chamber wall interactions and with the number of beam tracks less than 15, we have obtained 596 events (1604 negative tracks) from all topologies in the first measurement pass. By detecting high momentum secondaries in the spark chambers, we have obtained a complete momentum spectra in the entire range of kinematic variables.

Single particle spectra have been studied up to ISR energies[1] and scaling has been established as a general property of particle production. Until recently, however, correlations among secondaries have been studied only below 30 GeV/c[2]. Latest results from ISR[3,4] have shown the presence of short range clustering effects, which appear very significant.

In the following we limit ourselves to one particular type of correlation, namely rapidity correlations among π^-'s, averaging over transverse momentum distributions. Other types of correlations are under study and will soon become available. In Figure 1, we show $d\sigma/dy$ for π^-'s. A cross section normalization was obtained by referring to the topological cross sections determined by Charlton et al[5]. A central plateau of the order of $\Delta y = 2$ is seen. The value of $d\sigma/dy$ at $y = 0$,

26 mb, appears to be in agreement ($\pm$ 20%) with the ANL-NAL and ISR results[*,1]. A comparison with 28.5 GeV/c data (15 mb) and other data from ISR (which show an increase of 50% from $S = 450$ to $S = 2800$ GeV^2) indicates the rapid rise of $d\sigma/dy$ near $y = 0$ with energy.

Two particle rapidity distributions $d\sigma/dy_1\, dy_2$ are shown in Figure 2. In obtaining these data, the symmetry of pp interactions has been used, thus all the combinations of y_1 and y_2 have been plotted. It is seen that the shapes of $d\sigma/dy_1 dy_2$ at different fixed y_2 values remain very much the same and are peaked near $y_1 = 0$. A gradual tendency to find the second π- near the first one may be detected. This, however, is statistically not significant. Such short range effects observed at ISR energies, namely plots in $d\sigma/dy_1 dy_2$ reach their respective maximum when $y_1 = y_2$[3,4], are not readily detected in our data.

Alternate ways of displaying correlations would be to study associated rapidity and rapidity density. Associated rapidity corresponds to the multiplicity of remaining π-'s as a function of y, when the first one is already found in the same or different hemisphere of the C.M.

* These authors have used, instead of y, the variable $\eta = 1/2 \log (P+P_L/P-P_L)$, which involves production angles. The value of $d\sigma/d\eta$ at $\eta = 0$ should be typically 20% below the value of $d\sigma/dy$ at $y = 0$.

Namely,

$$\langle n(y_1<0)-1\rangle_{LL} = \int_{-\infty}^{0} \frac{d\sigma}{dy_1 dy_2}\, dy_2 \Big/ \frac{d\sigma}{dy_1} \quad (y_1<0) \quad (1)$$

$$\langle n(y_1>0)-1\rangle_{RL} = \int_{-\infty}^{0} \frac{d\sigma}{dy_1 dy_2}\, dy_2 \Big/ \frac{d\sigma}{dy_1} \quad (y_1>0). \quad (2)$$

Figure 3 shows these quantities. In Eqs. (1) and (2), we use $d\sigma/dy_1$ for $n(\pi-)\geq 2$ since the numerator integrand $d\sigma/dy_1 dy_2$ is contributed to by $n(\pi-)\geq 2$. The right-left associated rapidity distribution is essentially flat. However, the left-left associated rapidity distribution rises above the right-left level for $-2<y<0$ and falls rapidly beyond -3 (due most likely to phase space limits). However, statistics do not warrant definite conclusions at this time. If the left-left rapidity stays high with good statistics, it would be a manifestation of the clustering effects.

Finally in Figure 4, we show rapidity density, defined as

$$R(y_1,y_2) = \sigma_{INEL} \frac{d\sigma}{dy_1 dy_2} \left(\frac{d\sigma}{dy_1}\frac{d\sigma}{dy_2}\right)^{-1} - 1 \quad (3)$$

We use for σ_{inel} and $d\sigma/dy_1$ the values for $n(\pi-)\geq 2$. The results are similar to those of $d\sigma/dy_1 dy_2$ (Fig. 2), and less conclusive due to larger errors.

From our preliminary study of correlations we note that:

1. ISR data correspond to charged-charged or charged-neutral correlations in the central region (both y_1 and y_2 are inside of the central plateau). The observed short-range correlations have a range of the order of 1 in y, beyond which a long-range effect is dominant.

2. For the 200 GeV/c data, a relatively narrower central plateau (± 1), in conjunction with an expected range of ~1, demands higher statistics in order to study correlations. Furthermore both π-π- and π-π^+ (or $\pi^+\pi^\circ$) correlations should be studied.

3. The peaking of $d\sigma/dy_1 dy_2$ near $y_1 = 0$ (for y_2 values which are not far from the central plateau) has been noted earlier at lower energies. The data were favorably compared to the diffractive model[6].

4. It seems likely, based on our preliminary data, that at 200 GeV/c, both short-range clustering effects and long-range effects are present, although the separation of the two effects may be difficult due to kinematics and limited statistics (at least for this preliminary study).

References

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FIGURE CAPTIONS

Figure 1. Inclusive single particle rapidity distributions from $pp \to \pi^- X$ at 200 GeV/c.

Figure 2. Two particle rapidity distributions, $d\sigma/dy_1 dy_2$, from $pp \to \pi^- \pi^- X$ at 200 GeV/c for y_2 = (0, 0.8), (0.8, 1.6) and (1.6, 2.4).

Figure 3. Associated rapidity distributions (see text). Left-left and right-left associated rapidities are shown.

Figure 4. Rapidity density distributions (see text).

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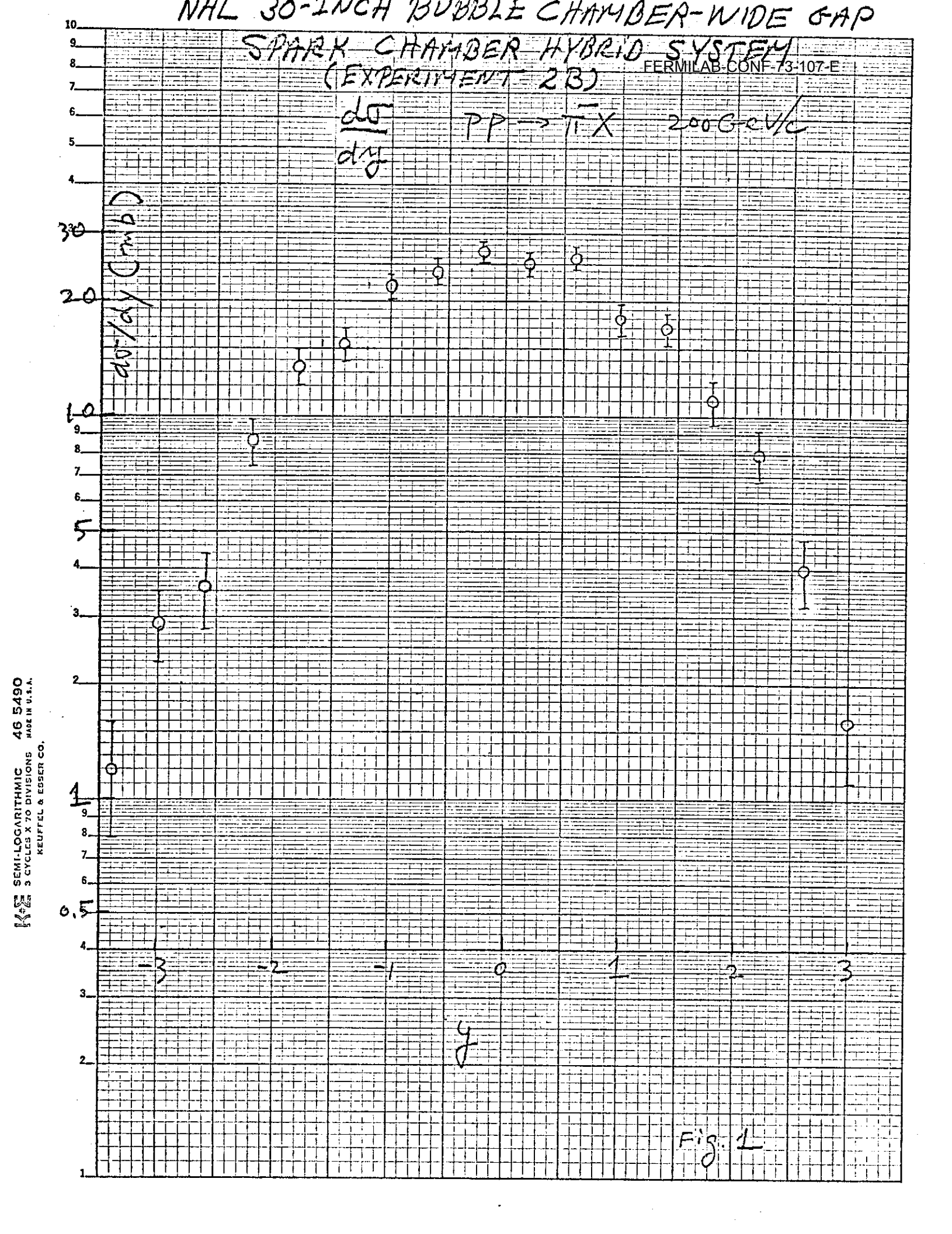

Fig. 1

NAL 30-INCH BUBBLE CHAMBER-WIDE GAP SPARK CHAMBER HYBRID SYSTEM (EXPERIMENT 28)

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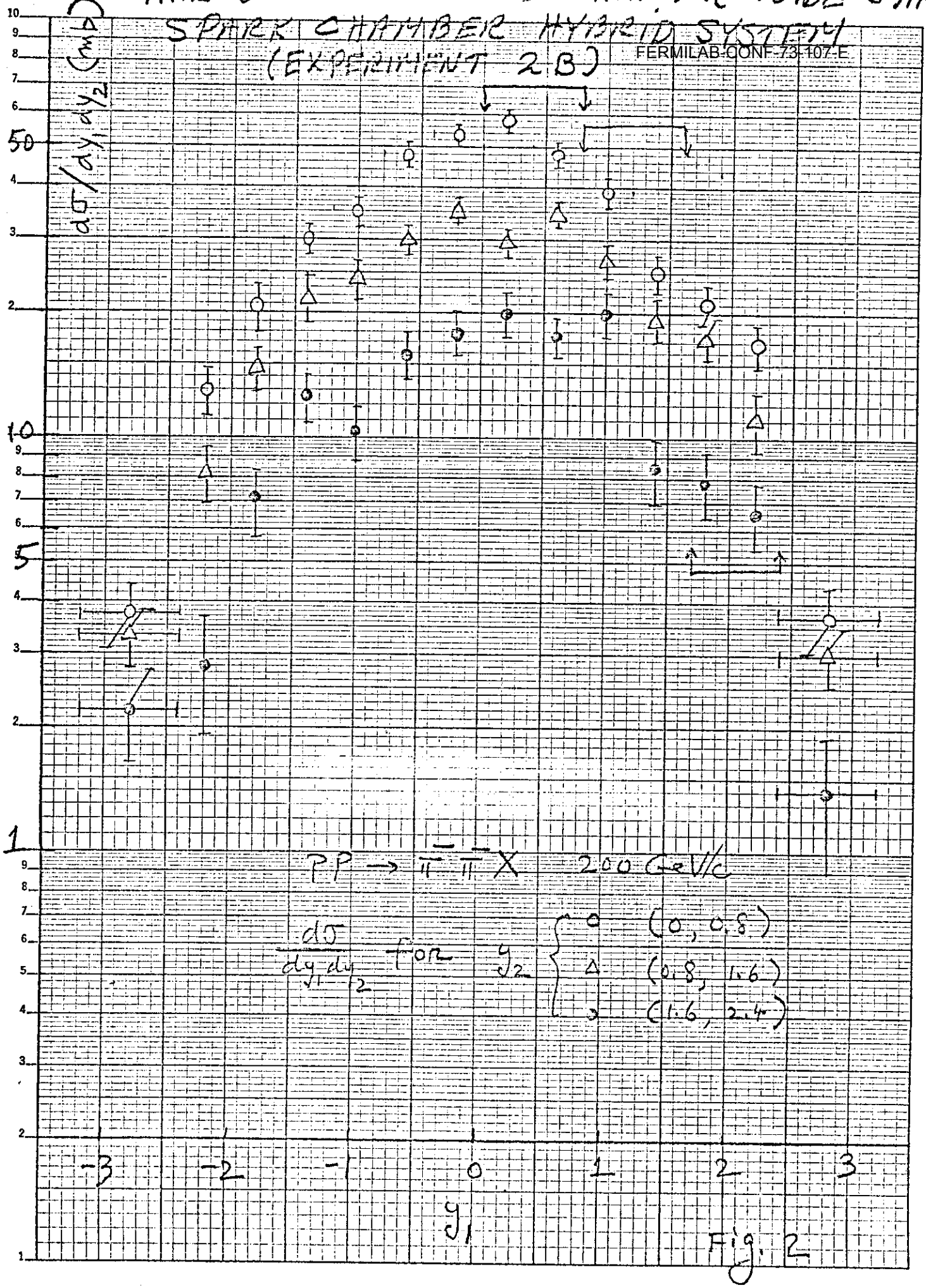

Fig. 2

NAL 30-INCH BUBBLE CHAMBER-WIDE GAP SPARK CHAMBER HYBRID SYSTEM (EXPERIMENT 23) $pp \to \pi^- \pi^- X$ 200 GeV/c

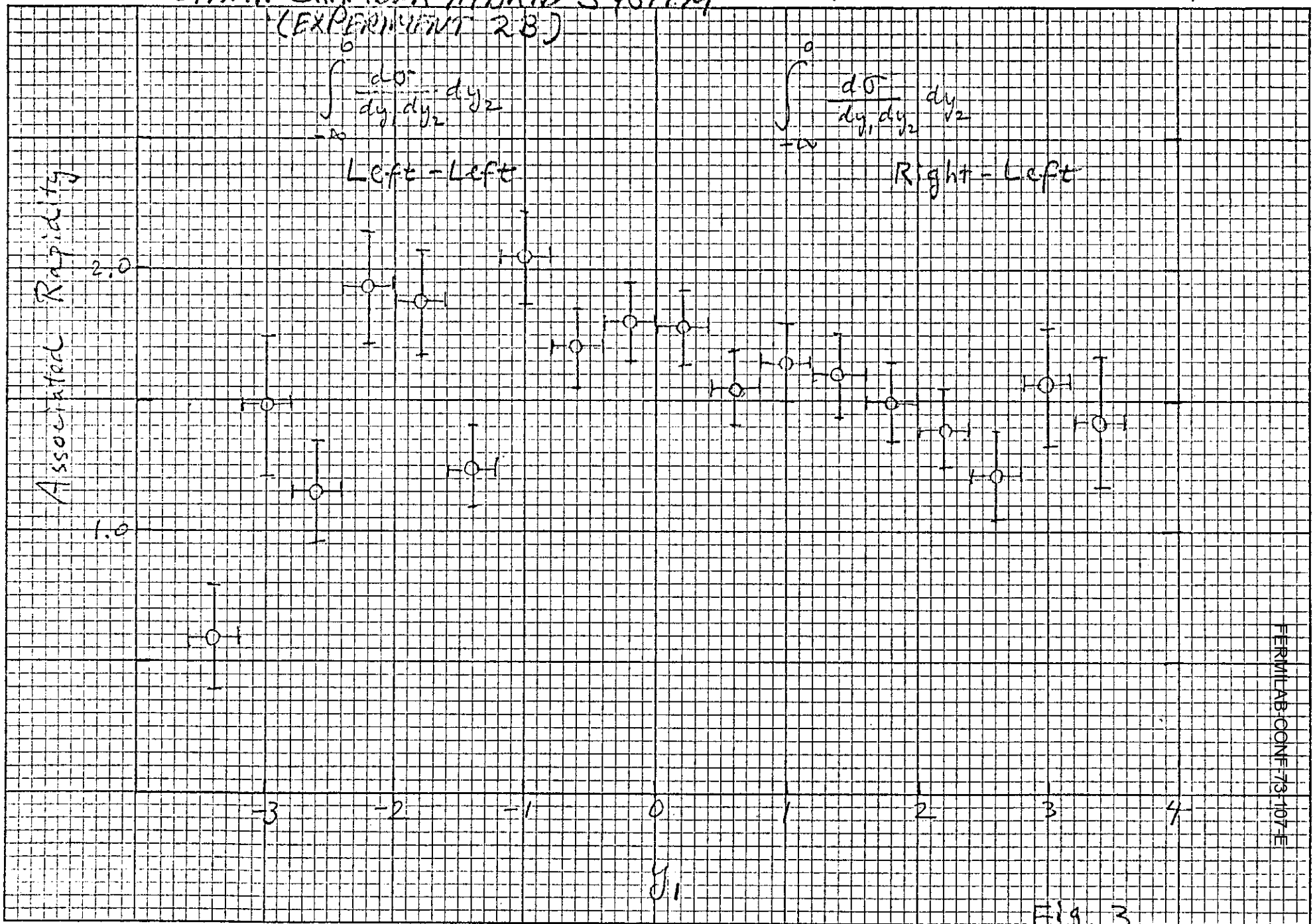

Fig 3

NAL 30-INCH DOUBLE CHAMBER-
WIDE GAP SPARK CHAMBER
17 X 13 INCH SYSTEM
(EXPERIMENT 28)

$PP \rightarrow \pi^- \pi^- X$

200 GeV/c

$0 < y_2 < 0.8$

$0.8 < y_2 < 1.6$

$1.6 < y_2 < 2.4$

R_1 Rapidity Density

y_1

Fig. 4