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STATUS REPORT ON EXPERIMENT R-108

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I. Summary of Operations - Calendar Year 1978

In calendar year 1978, the ISR was scheduled for $\sim 29\frac{1}{2}$ weeks of running, almost exclusively at 31 GeV. During this period the operation of R-108 was as follows : data taking $16\frac{1}{2}$ weeks; special runs and tests $2\frac{1}{2}$ weeks; refrigerator failure- solenoid off 8 weeks; lower quality data (mainly due to drift chamber broken wires) $2\frac{1}{2}$ weeks. Also, during the July ISR shut-down all 336 lead glass blocks were removed from the ISR, calibrated at the PS, and reinstalled at the ISR.

II. Results 1978

a) e^+e^- Pairs.

The $13\frac{1}{2}$ weeks of good data obtained before the solenoid failure on 19 October 1978, correspond to an integrated luminosity of $7.2 \times 10^{37} \text{ cm}^{-2}$. These data have been fully analyzed for e^+e^- pairs (Fig. 1). A continuum is observed for e^+e^- masses from 6.0 to $14.25 \text{ GeV}/c^2$; and a peak containing 35 events is observed in the T region (8.75 to $10.75 \text{ GeV}/c^2$). Preliminary results (integrated luminosity $3.5 \times 10^{37} \text{ cm}^{-2}$) have also been reported at the Tokyo Conference (Appendix I).

b) High $p_T \pi^0$.

An important feature of this experiment is the ability to measure high $p_T \pi^0$ production simultaneously with the data taken for e^+e^- pairs. Two separate triggers are used.

The inclusive cross section for high $p_T \pi^0$ production has been measured at three $\sqrt{s}$ values, 30.7, 53.1 and 62.4 GeV, using data taken at various times between August 1977 and March 1978. (Fig. 2). At lower p_T , in agreement with previous experiments¹⁾, the invariant cross section can be fit by the simple scaling law

$$E \frac{d^3\sigma}{dp^3} = p_T^{-n} F(2p_T/\sqrt{s}) \quad (1)$$

with the power $n \cong 8$, as shown by the broken lines in Fig. 2. At higher p_T , the results are well above the extrapolation of this fit and are inconsistent with scaling of the form given by equation (1) even if n is

allowed to depend on $x_T = 2p_T/\sqrt{s}$ (Fig. 3). However, in the range $7.5 < p_T < 14.0$ GeV/c, for the $\sqrt{s}$ values 53.1 and 62.4 GeV, n is consistent with having the constant value $n = 5.1 \pm 0.4$. This is significant in terms of constituent scattering models ²⁾, and QCD ³⁾, since the power n is characteristic of the force law between the constituents. These results have been presented at Tokyo and are being published in Physics Letters B (Appendix II).

c) Associated Particles.

The cylindrical drift chambers inside the superconducting solenoid allow the detection over the full azimuth of the charged particles produced in association with any trigger. For π^0 triggers with transverse momenta $p_{Tt} > 7.0$ GeV/c, the azimuthal distributions of associated charged particles as a function of their transverse momentum p_T are shown in Fig. 4. Strong peaks on top of flat backgrounds are observed around both the trigger azimuth ($\phi = 0$), and the azimuth opposite the trigger ($\phi = \pi$), for all bands of associated particle p_T . This striking effect corresponds to the naive picture of jets. The width of these peaks is proportional to the rms transverse momentum, $\langle |p_{out}| \rangle$, perpendicular to the trigger plane. In constituent scattering models ⁴⁾, $\langle |p_{out}| \rangle$ is a measure of the rms transverse momentum $\langle k_T \rangle$ of the quarks inside each of the colliding protons. A value of $\langle k_T \rangle = 0.85$ GeV/c has been used ³⁾ in order to explain the p_T imbalance in high mass lepton pair production at Fermilab ⁴⁾. The results shown in Fig. 5 suggest an even larger value of $\langle k_T \rangle$ and also a dependence of $\langle k_T \rangle$ on the trigger p_{Tt} .

These results have been presented at the Copenhagen Jet Conference and at Tokyo, (Appendix III).

III. Apparatus Improvements 1978

During the past year, we have built cathode read-out proportional chambers which give pulse-height measurement on 1 cm spaced strips. These strip chambers will cover the faces of both arrays of lead-glass shower counters. They give coordinate measurement of tracks and showers, thus assisting in the study of particle correlations, in eliminating background in high p_T π^0 events, and in discriminating electrons and pions.

A first chamber, of sensitive area $1.86 \times 1.54\text{m}$, is now operational, complete with read-out on 128 strips, in front of one of the lead glass arrays (Fig. 6). The second chamber and the complete read-out will be installed during January. We expect that some debugging of the system will be necessary in March when the ISR starts up, so that the system will be fully operational in April.

IV. Request for Running in 1979

In general we would like to run at the highest value of $\sqrt{s} = 62.4 \text{ GeV}$, with the highest luminosity possible, since all the reactions under investigation have cross sections that increase with increasing $\sqrt{s}$. However, in order to study in detail the onset of the new power law in high $p_T \pi^0$ production (Figs. 2 and 3) we propose to take data also at the 3 values of $\sqrt{s}$, 30.7, 44 and 53.1 GeV. These data will also allow the study of associated particles for all values of $\sqrt{s}$.

A proper measurement of the $\sqrt{s}$ dependence of high $p_T \pi^0$ production can only be made by reducing systematic errors to a minimum. In order to achieve this goal, we have two basic requirements. The first is to collect all of the data over a period of time as short as possible; the second is to run with the solenoid at its usual magnetic field $B = 1.4 \text{ T}$ and with the low β turned on for all values of $\sqrt{s}$. In fact, during the first machine development run by the ISR at $\sqrt{s} = 30.7 \text{ GeV}$ with the solenoid and low β turned on, excellent conditions for physics were achieved.

The detailed running request is given in Table 1. The estimates of ISR running time assume average luminosities as given in the Table and a running efficiency of 70%. Using an ISR running time of ~ 100 hours per scheduled week, the special request amounts to $10\frac{1}{2}$ weeks out of $26\frac{1}{2}$ weeks scheduled in the preliminary 1979 plan. We request that the other 16 weeks be run at $\sqrt{s} = 62.4 \text{ GeV}$ at the highest possible luminosity ⁵⁾.

Finally we have the intention of recalibrating all of the lead glass counters at the PS during the ISR shut-down at present foreseen during the month of July 1979. It is imperative, therefore, that the amounts of ISR running time listed in Table 1 be scheduled during the first three ISR periods in 1979.

Table 1

$\sqrt{s}$ (GeV)	Integrated luminosity (cm^{-2})	Average luminosity ($\text{cm}^{-2} \text{s}^{-1}$)	ISR running time (hours)
30.7	3×10^{36}	5×10^{30}	240
44	10^{37}	10^{31}	400
53.1	2×10^{37}	2×10^{31}	400

REFERENCES AND FOOTNOTES

- 1) F.W. Büsser, et al., Nuclear Physics B106 (1976) 1, and references quoted therein.
- 2) S.M. Berman, et al., Phys. Rev. D4 (1971) 3388.
R. Blankenbecler, et al., Phys. Rev. D12 (1975) 3649.
- 3) R.P. Feynman, et al., CALT-68-651 (1978).
- 4) S.W. Herb, et al., Phys. Rev. Letters 39 (1977) 252.
W.R. Innes, et al., Phys. Rev. Letters 39 (1977) 1240.
- 5) The optimum ratio of $\sqrt{s} = 62.4$ running to $\sqrt{s} = 53$ running can be estimated for 2 reactions e^+e^- and π^0 . For the e^+e^- no scaling test is contemplated, so all the running should be at the $\sqrt{s}$ value with the highest cross section $\times$ luminosity. For π^0 with scaling as $p_T^{-n} F(x_T)$, the ratio of integrated luminosities to give optimum errors on n is $L(53)/L(62) = (53/62)^{n-1}$, which equals $\frac{1}{2}$ for $n = 5.1$.

Figure captions

- Fig. 1 : Invariant mass spectrum of same charge and opposite charge electron pairs.
- Fig. 2 : Invariant cross-sections (cm^2/GeV^2) for the reaction $p + p \rightarrow \pi^0 + \text{anything}$ versus p_T . Also shown are the data points from ref. 1 with their best fit using Eq. (1) (dashed lines). The cross-section scale corresponds to the data at $\sqrt{s} = 62.4$ GeV. For $\sqrt{s} = 53.1$, the data have been divided by a factor of 10; for $\sqrt{s} = 30.6$, by a factor of 100.
- Fig. 3 : The exponent n of Eq. (1) plotted as a function of x_T using the two lowest and two highest $\sqrt{s}$ values.
- Fig. 4 : Charged particle correlations for π^0 trigger with $p_{Tt} > 7.0$ GeV/c.
a) Same side azimuthal correlation of charged particles relative to the triggering neutral.
b) Away-side azimuthal correlation of charged particles relative to the triggering neutral.
Five plots corresponding to 1 GeV/c intervals in p_T of the charged particle are shown. The pseudorapidity of the charged particles is restricted to $|\eta| < 0.7$.
- Fig. 5 : a) and b) $\langle |p_{\text{out}}| \rangle$ of away-side charged particles relative to the trigger for three sets of trigger p_{Tt} .
- Fig. 6 : Five individual events recorded by the strip chamber installed in I-1. The distributions represent the pulse height in 128 strips of 1 cm. The first 64 channels are vertical strips, and the second 64 channels are horizontal strips. The black lines labelled "1092" and "B18" show the location of the triggering lead glass block in each projection.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6. Strip Chamber Hits
On Line.

A summary is presented of the status of experiment R-108 at the ISR. Electron pairs and neutral pion transverse momentum are noted. 6 references (JFP)