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A 9 Proton-Proton Collisions with a High-/?$_r$ Charged Hadron Trigger at the CERN ISR

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Some main results

The experiment is concerned with an investigation of pp collisions (y^7 *s* ^52.6 GeV) with an identified large-;?$_r$ charged hadron (trigger) at 90° to the beams. It was carried out using the Split Field Magnet (SFM) and its detector (SFMD) in conjunction with the British-Scandinavian Wide Angle Spectrometer (WAS) (Fig. 1).

Many results are presented in terms of the ratio between the observed track densities observed in association with a high-/?$_r$ trigger and the track densities observed in Minimum Bias events :

$$\frac{\text{track density in high-/v events}}{\text{track density in Minimum Bias events}} \quad \textbf{a)}$$

where the acceptance of SFMD cancels. *R* is the usual two-particle correlation function representing the correlation between the trigger particle and the associated particles.

The true (acceptance corrected) particle densities *p* can be obtained from *R+l* and the known inclusive single particle density p_{Q9}

$$\rho = (R+1)\rho_0 \qquad (2)$$

The overall structure of the *high-p_T* triggered events is illustrated in Fig. 2 in terms of JR + 1, azimuthal angle *cp* around the beam direction and rapidity, *y*.

The distribution of associated charged particles is enhanced in a narrow *(y_9 cp)* region around the trigger particle and in the broad *y* range |*y*\ <3 on the Away Side. In particular for the high-/?$_r$ associated particles these enhancements are concentrated around the beam-trigger-plane with azimuthal half widths of 30°-45°. The enhancement around the trigger particle, which together with it constitutes the Trigger Side jet, consists mainly of particles with charge opposite to the trigger particle, while the Away Side enhancement is only weakly correlated to the trigger charge. For |j|>3, *R* becomes negative, but not in a <*p* symmetric way. The fast forward particles recoil away from the trigger particle with average recoil momentum *(p_x}=0.l*— 0.3GeV/*c* depending on the Feynman *x* of the particle.

The broad Away Side enhancement has an event by event structure in the distribution in the difference *Ay* in rapidity between two

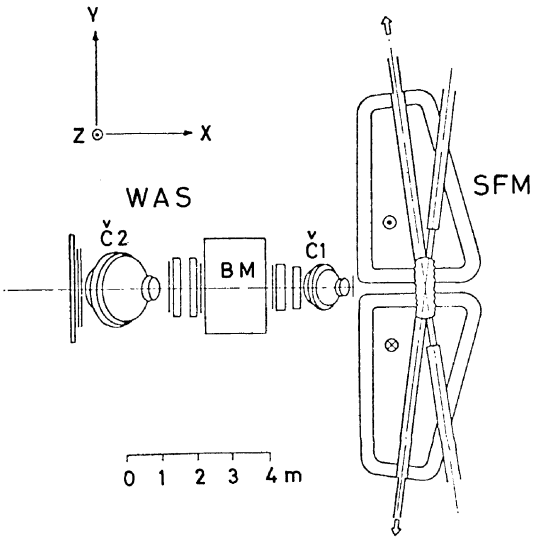

Fig. 1.

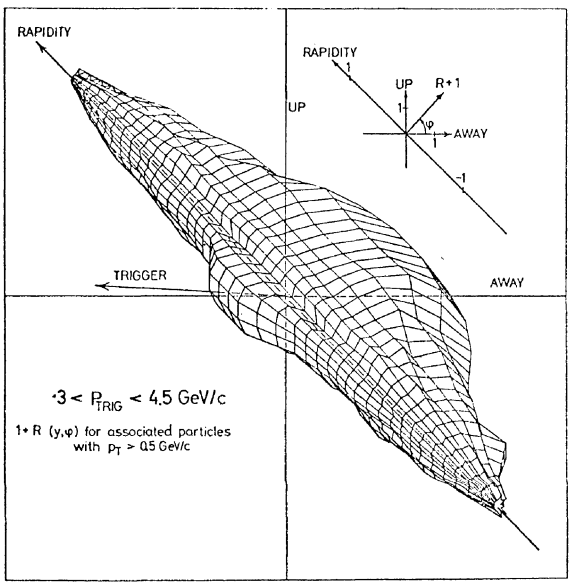

Fig. 2.

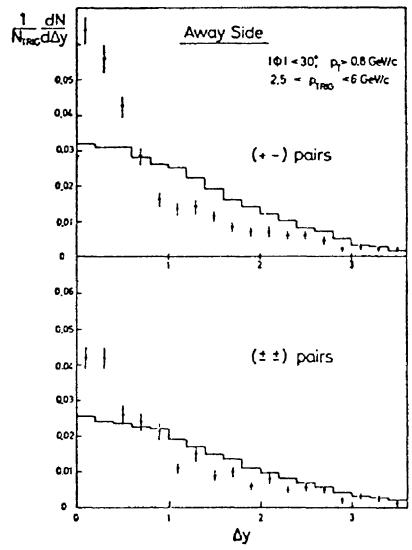

Fig. 3a.

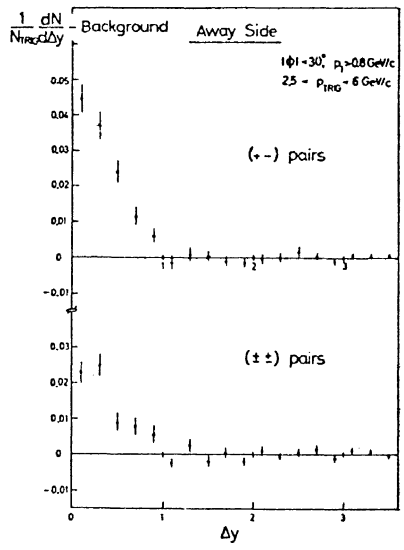

Fig. 3b.

high-$\wedge_r$ Away Side particles as shown in Fig. 3a and b. The "background" distribution in these figures is constructed from combinations of a particle from one event with a particle from another event. The real distribution and the background have the same shape for $Ay>\backslash$ and in Fig. 3b the background has been normalized to have the same area as the real distribution for $Ay>\backslash$ and subtracted. The correlation peak seen at small Ay is the primary evidence for an Away Side jet in this experiment. The peak is about two times as large for pairs of particles with opposite charges as for pairs with the same charge. Investigations indicate that the correlated pairs contain p mesons at a 10% level.

In pairs of high-/?$_r$ particles in the two jets the distribution of the momentum component q perpendicular to a jet axis defined as the vector momentum sum of the pair is found to be consistent with the exponential form $(l/q)(dtt/dq)$ oce$^{\sim 6q}$ in the limited range $0.1 < q < 0.8$ GeV/c, for which an unbiassed distribution could be obtained for pairs with rather large longitudinal momenta (>1 *GeV/c)* along the jet axis. For such pairs the found exponential distributions (after subtraction of a background constructed from mixed events) correspond to the average values of q:

Trigger Side jet: $\langle q \rangle = 0.52 \pm 0.05$ GeV/c

Away Side jet: $\langle q \rangle = 0.80 \pm 0.25$ GeV/c

Distribution of associated particles *inp$_x$*.

By use of the relation (2) the acceptance corrected densities of particles associated with n^* triggers have been determined for two intervals of p_{TR1G}, and the increase $Ap(p_x)$ corresponding to the increase Ap_{TRIG} obtained by subtraction. The result is shown in Fig. 4. For $|y|< 1$ a positive $Ap(p_x)$ is observed in two separate regions. A weak increase belonging to the Trigger Side jet for $p_x<0$ and a much

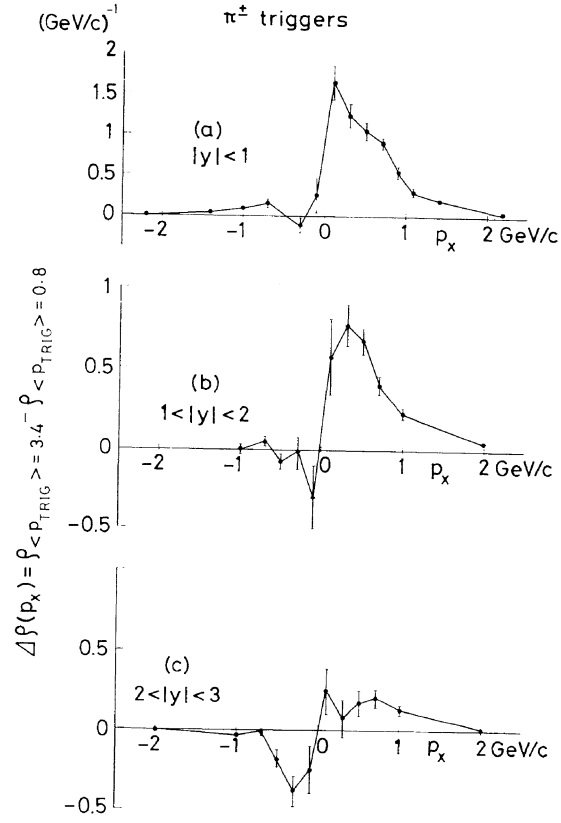

Fig. 4.

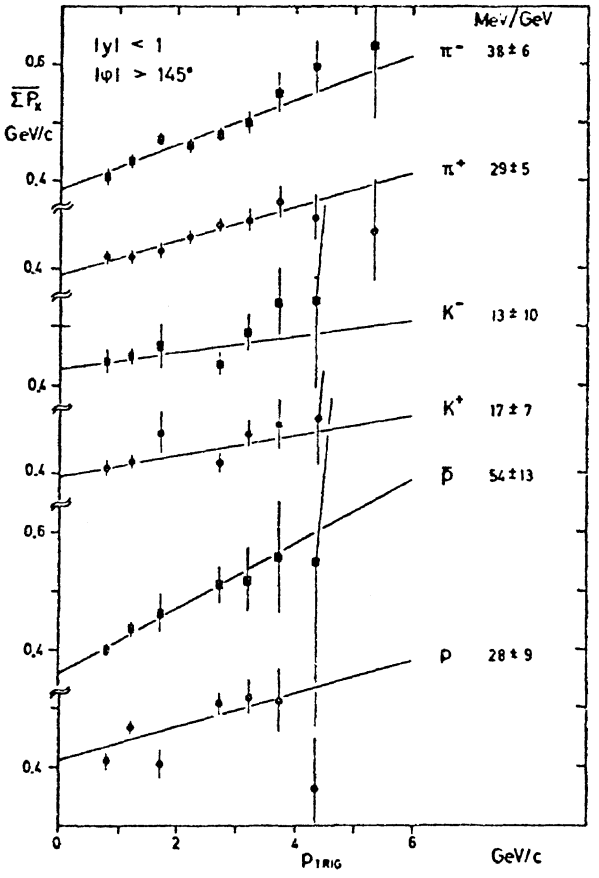

Fig. 5.

stronger increase, dominated by low p_x particles for $p_x>0$. The simplest interpretation of this increase on the Away Side is that it comes from those particles in the Away Side jet, which go into the considered rapidity interval. The integrated increases in the two groups and per GeV/c increase *of* p_{Tnm} are:

Trigger Side, |J>|<1:

0.022±0.007 particles and 31 ±4 MeV/c

Away Side, b|<l:

0.51 ±0.03 particles and 287±34 MeV/c

For the whole interval |j>|<3 we find for the corresponding increases:

Trigger Side, |j'|<3:

-0.08±0.02 particles and 3±7 MeV/c

Away Side, |j>|<3:

0.84±0.04 particles and 503±37 MeV/c

From these numbers we estimate that a 3 GeV/c trigger particle is on the average accompanied by 0.07±0.02 correlated charged particles and by about 90 MeV/c of correlated momentum in the Trigger Side jet, while the recoiling Away Side jet contains on the average about 2.5 charged particles and about 1.5 GeV/*c* of charged momentum.

The very low increase of particle density and momentum flow along the trigger particle is further illustrated in Fig. 5, which shows for each type of trigger particle as a function of *PTRIG* the average value of the sum $\langle p_x \rangle$ of the momentum component p_x carried by charged particles on the Trigger Side within $|y|<1$ and |ç9|>145°. For all trigger types the increase with p_{TRIG} is small and consistent with being a linear function of $J9_{TRIG}$. The slope $a=d(\langle p_x \rangle)/dp_{TRIG}$ is typically about 30 MeV/c/GeV/c.

In the directly observed mass spectra of combinations of the trigger particle and another charged particle (assumed to be a pion) on the Trigger Side resonance peaks are seen corresponding to about 5 % of the trigger particles. Ongoing investigations indicate that after corrections for acceptance (including lack of neutral particles) this means that 20-40 % of the trigger particles are part of a two-body resonance; but even this high resonance content does not seem to account for more than about half of the associated momentum in the Trigger Side jet.

If the Away Side jet *hasp{*^{et}~p_{TmG}, and if it is formed by fragmentation of a scattered parton with a scaling fragmentation function, the Away Side distribution in p_x is expected to scale with $p_{TRîG}$, *i.* e., the distribution in the parameter $x_E=p_x/p_{TRIG}$ should be independent of/?$_T$RiG- Results of the relevant observations are shown in Fig. 6. For x^>0.3 and p_{TRIG}> 3 GeV/c the observations are consistent with scaling. In Fig. 7 an attempt has been made to take into account that p^{TTi}^^ ^^ ^ = (1 + (3/2)a)/?$_{TRIG}$ where *a* is itself an experimentally determined function of x_E. The distribution in the corrected parameter $x'_{IIJ}=x_E/l^J\wedge(3/2)a$ is well fitted by the exponential e~^{90a}^'. It is very similar to the corresponding distribution found in other pp experiments, and similar to, although somewhat steeper than, the fragmentation function found in e^+e^- annihilations.

Correlations to the quantum numbers of the trigger particle

The charge of the particles in the Trigger Side jet is strongly correlated to the charge of the trigger particle. Outside this region a rather global charge compensating correla-

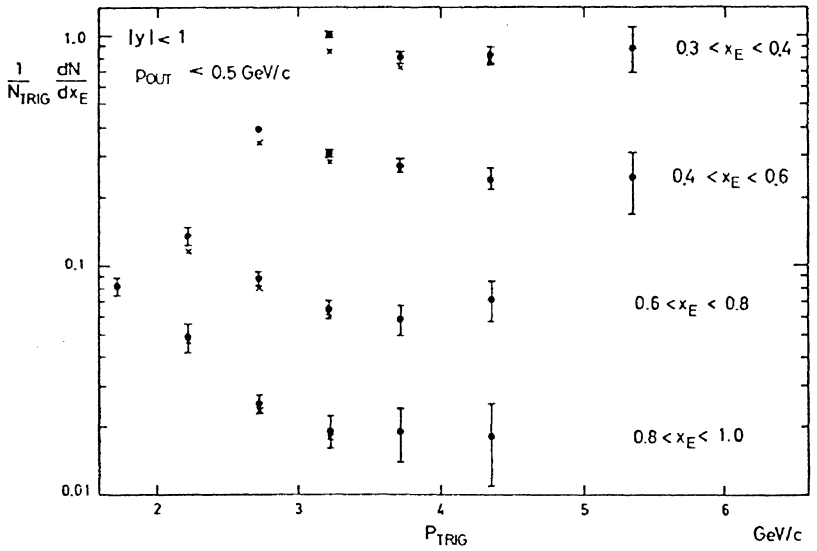

Fig. 6.

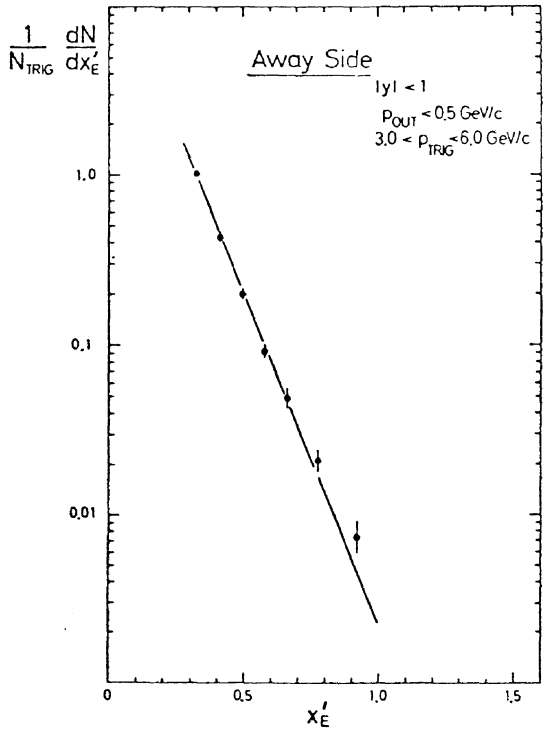

Fig. 7.

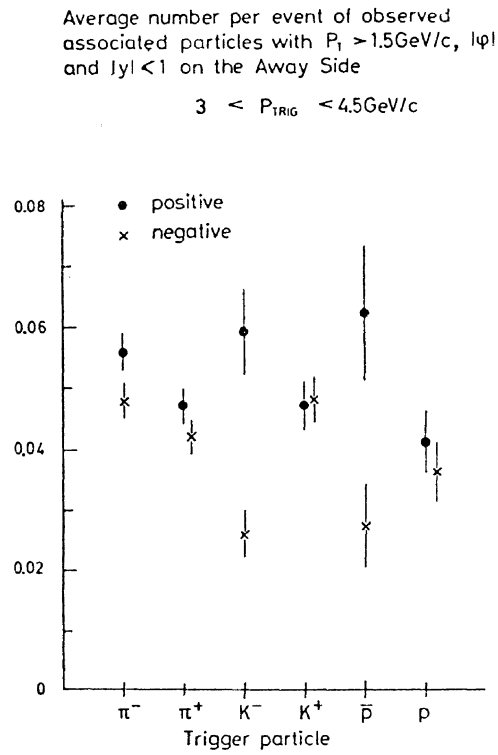

Fig. 8.

tion to the trigger is observed at a 10-15% level.

Apart from this charge correlation the distribution of associated particles is not strongly affected by changes in the quantum numbers of the trigger particle. Two exceptions to this general rule are observed:

i) p and p triggers have about 10% more associated particles with p_T<0.5 GeV/c on the Trigger Side than other types of trigger particles.

ii) K" and p triggered events with$^{\wedge}{}_{TRIG}$> 3 GeV/c have a low content on the Away Side of negative particles with p_T~>l.5 GeV/c as compared with *rc~* triggered events. This effect is not seen for/?$_{TRia}$<3 *GèV/c.*

The results of the observations concerning ii) are shown in Fig. 8. The observed positive/negative ratio for the particles associated to trigger particles with 3</>$_{TRIG}$<4.5 GeV/c in the considered region of phase space, [v|< 1, |p[<30°, p_T>l.5 GeV/c is close to one for $n^{\pm}$, K^+ and p triggers and close to two for K" and p triggers.

It is of interest to note in this connection that among the six trigger types, *K*~ and p are the only ones, which have no valence quarks in common with the incoming protons. It is also of interest to note that a picture of the basic hard scattering as a simple elastic scattering between quarks or other constituents of- the protons with no quantum number exchange has no room for a correlation between the quantum numbers of high-/?$_r$ particles on opposite sides.

References

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1. On forward particles in *high-p_T* reactions, Nucl. Phys. 6135(1978)461.
2. On the distribution of charged particles in the central region, CERN preprint, July 78, submitted to Nucl. Phys. B.
3. Jet-like structures, in preparation.

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A 9 Results from the Athens-BNL-CERN~Syracuse-Yale Collaboration —High Transverse Momentum *n°* and *rj* Production at the ISR—

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The production of high transverse momentum 7I° and *rj* in proton-proton collisions has been studied at the CERN ISR for CM energies between V *s* =31 and 63 GeV. Photons from *7z°* and *rj* decays were detected by means of liquid argon-Pb plate calorimeters[1] (17.7 radiation lengths of total thickness) with fine lateral and longitudinal subdivisions. The properties of these calorimeters are well suited for separating the desired signal due to electromagnetic showers from various backgrounds which are potentially severe at large values *oîp$_T$*.

y/n^0 ratio

In order to separately detect each of the two photons from *iz^-^ly* decay for *p_T(x°)* up to ~6 GeV/c, two of the four calorimeters were retracted to 160 cm from the ISR intersection from their normal distance of 85 cm. The angular resolution for separating two showers was about 1.5°. Figure 1 shows the diphoton mass spectrum at V *s* =63 GeV for the p_T interval between 3 GeV/c (determined by trigger thresholds) and 6 GeV/c. After subtraction of background and corrections for various efficiencies, *y/n^0* production ratio is found consistent with 0.56±0.02 over the V *s* range 31-63 GeV and p_T range 3-6 GeV/c.

Invariant cross section for 7r° production

Figure 2 shows the invariant cross section for TI° production at *V s* =63 GeV. *Forp$_T$<* 6 GeV/c, the cross sections were deduced from resolved *7z^0-*2j* decays measured with the retracted calorimeter geometry. For *p_T>6* GeV/c, the data were obtained from unresolved 7r°->2f decays measured with the normal calorimeter geometry, corresponding to an integrated luminosity of 1.32x 10^{37} cm^{-2}. The data were also taken at V *s* =53 GeV up to *p_T~l0GeV/c* with much less integrated luminosity. Up to about 10 GeV/c, the data are reasonably fitted by the scaling expression

$$E\frac{d^3\sigma}{dp^3} = 5.5\times 10^{-27} p_T^{-8}(1-x_T)^{9.5}$$

However, at the highest values of p_T, the observed cross sections are substantially larger than can be fitted with a $p^{\wedge s}$ behavior.