THE STRUCTURE OF EVENTS WITH A HIGH P_T π^o OR SINGLE PHOTON

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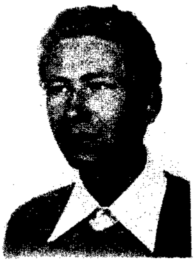

ABSTRACT

Differences in the structure of events associated with a high P_T π^o or a single photon were observed at the CERN Intersecting Storage Rings. On the trigger side, the average associated charged multiplicity is significantly lower for single photon events than that for π^o events, and the rapidity and azimuthal correlations between the trigger particle and an additional particle depend on the nature of the trigger particle for small Δy and $\Delta\phi$. On the away side, only small differences are seen. This is consistent with the hypothesis that the π^o's form a part of a trigger jet while the single photons are produced directly in constituent scattering processes.

RESUME

Nous avons observé aux anneaux de stockage du CERN des différences dans la structure des événements associés à la production d'un π^o ou d'un photon de grand P_T. Dans l'hémisphère du "trigger", la multiplicité moyenne des particules chargées est sensiblement inférieure pour les événements à un photon que les événements π^o. La rapidité et les corrélations azimutales entre particules "trigger" et particules additionnelles dépendent de la nature de la particule "trigger" pour de petits Δy et $\Delta\phi$. Dans l'autre hémisphère, on ne voit que de petites différences. Ceci est compatible avec l'hypothèse que le π^o est une particule d'un jet alors que le photon est produit directement par les processus de diffusion des constituants.

I. INTRODUCTION

The production of large p_T single photons in hadronic reactions has recently gained considerable interest in the understanding of the constituent structure of hadrons. In the framework of QCD, large p_T single photons are expected predominantly to be produced directly in hard scattering processes between quarks and gluons. The "Compton" scattering $gq \rightarrow \gamma q$ (Fig. 1a) is thought to dominate in proton-proton interactions at small x_F, with contributions also from photons emitted in bremsstrahlung processes like $qq \rightarrow qq\gamma$ (Fig. 1b). The signature of the first diagram will be a large p_T photon

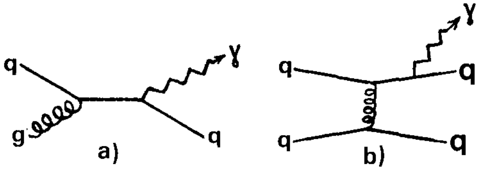

Fig. 1: Examples of lowest order QCD diagrams producing single photons directly (a) or as "bremsstrahlung" (b).

unaccompanied by other particles, recoiling against a jet of hadrons, originating from the fragmentation of a quark. Large p_T mesons, on the other hand, are believed to be produced in the fragmentation process of a large p_T quark or gluon, originating from the hard scattering of proton constituents. Thus, a high p_T meson is expected to be the leading particle in a jet of hadrons, recoiling against another hadron jet. The different production mechanisms for large p_T mesons and single photons will thus likely be reflected in differences in the structure of the associated events. The present experiment aims at revealing some of these differences between events with a high P_T π^o or single γ.

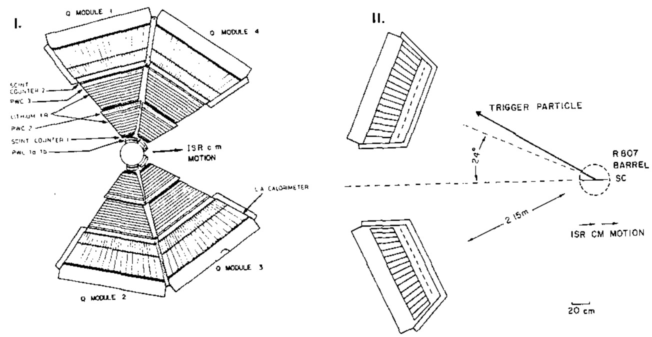

Fig. 2: Two phases of the apparatus of the A^2BC collaboration, the close (I) and the retracted (II) geometry.

2. APPARATUS AND EVENT SELECTION

The experiment was done at the CERN ISR with two rather different setups (Fig. 2) [1]. Photons were detected as electromagnetic showers in lead/liquid-argon calorimeters positioned at $\theta = 90^o$. The trigger requirement was a large energy deposition in any one of the calorimeter modules (E > 6 GeV). The segmentation allows separation of showers with a distance of 6 cm, corresponding to 3 GeV/c (10 GeV/c) π^o's in the close (retracted) geometry. A single γ trigger is defined as a single shower in the calorimeter module while a π^o is taken as two showers reconstructing the π^o mass. In addition, we impose on the single γ sample, a fiducial volume cut, we require showers to have a radius less than 13.5 mm and demand that all energy (within 50 MeV) in the calorimeter module be assigned to the trigger particle. The last cut introduces a physics bias by rejecting events with any particle close to the trigger. Exactly the same cuts were imposed on the π^o sample. In this way, the background of false events in the single γ sample in the close geometry (Fig. 2a) is believed to be 30-40% at 7 GeV/c trigger momentum.

Charged hadrons were detected by multiwire proportional chambers and scintillation counters in the close configuration, and by a scintillation counter array surrounding the intersection region in the retracted configuration. No momentum or charge information was available.

3. RESULTS

The observed ratio γ/π^o is shown in Fig. 3 [2] as a function of p_T together with the curve for the expected ratio from known sources of photons, such as electromagnetic decay of π^o and η. At p_T = 7 GeV/c the directly produced single photons form around 70% of the total photon signal.

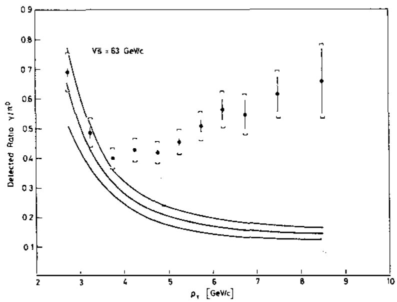

Fig. 3: Observed ratio γ/π^o at $\sqrt{s}$ = 63 GeV. The outer error bars include statistical errors. The curve shows the expected ratio assuming no direct photon production.

The data was separated into samples containing a π^o or a single γ candidate. Fig. 4a [3] shows for the retracted geometry the average multiplicity of hits in the scintillator array associated with π^o's or single γ triggers. In this geometry, no rapidity or momentum information was available for secondary particles. At large trigger-p_T we observe a lower associated multiplicity for single γ events than for the π^o events. The p_T dependence mainly reflects the changing purity of the photon sample, and the result is consistent with a nearly constant multiplicity for the directly produced photons. Figs. 4b and 4c show the same quantity, restricted to the trigger side ($|\Delta\phi| < 24^o$) and the away side ($|\Delta\phi| > 156^o$), respectively. On both sides, the single γ multiplicity is consistently lower than for π^o's, but the effect is most pronounced on the trigger side, where the single γ multiplicity after background subtraction is consistent with being constant.

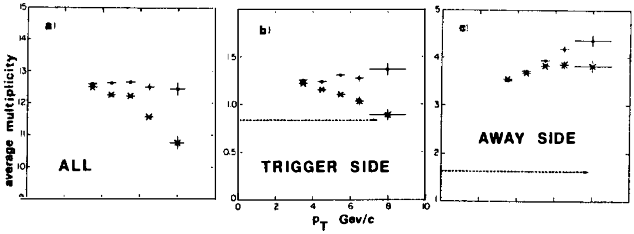

Fig. 4: The average number of scintillator hits for π^o (dots) and single γ candidates (crosses)

We now turn to the results [4] from the close geometry where the modules not containing the trigger particle allow a determination of pseudo-rapidity of secondary charged particles and of four-momentum of secondary π^o's. The trigger particle is required to have p_T>6.5 GeV/c. The acceptance limits the azimuthal difference $\Delta\phi$ between the trigger and a secondary particle to the ranges $20^o < \Delta\phi < 70^o$ and $110^o < \Delta\phi < 180^o$.

The normalized distributions of the difference Δy in rapidity between the trigger and a secondary particle on the same side ($20^o < \Delta\phi < 70^o$) are shown in Fig. 5 . Figs. 5a and 5b show the distributions for charged secondaries in π^o and single γ events, respectively. The line represents the expected Δy distribution, when normalized to the same number of events with $\Delta y > 0.6$. A clear excess is observed at small Δy for π^o triggers in qualitative agreement with similar distributions for charged triggers [5], while the single photon candidate sample shows a much weaker effect. In fact, a subtraction of 35% background in the γ sample due to the merged π^o's

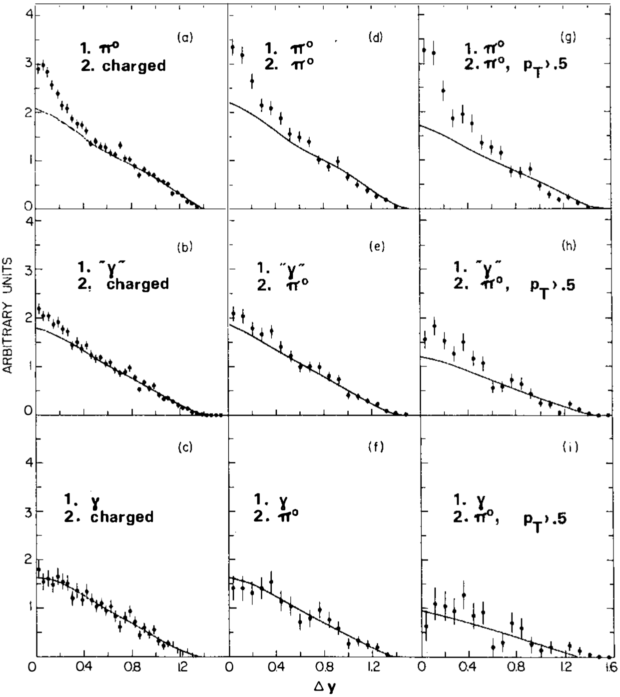

Fig. 5: Rapidity difference between 1. trigger particle and 2. secondary particle for different identity of particles. Pure γ is defined as a statistical subtraction of 35% of the π^o sample from the γ-candidate sample.

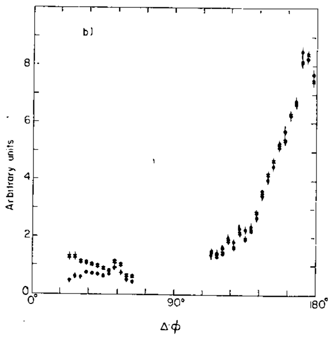

Fig. 6: Azimuthal difference between a π^o (dots) or γ-candidate trigger and a secondary π^o with p_T > 0.5 GeV/c.

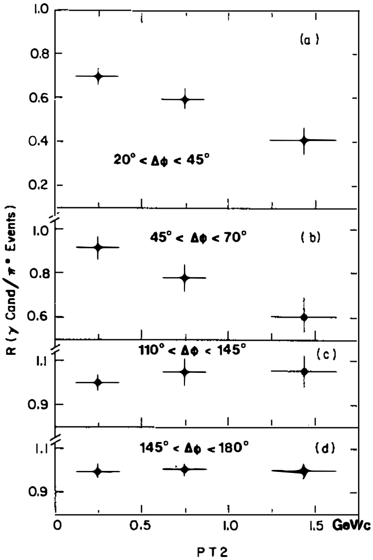

Fig. 7: The relative probability for the γ candidate sample and the π^o sample to find a second particle of p_{T2} in the Δϕ regions indicated.

gives the result in Fig. 5c. No excess over the uncorrelated background is seen for these "pure" single photons. The general features are the same for secondary π^o's (Figs. 5d-f). An even stronger correlation effect is found for secondary π^o's with $p_T > 0.5$ GeV/c (Figs. 5g-i), but also here no correlation is seen for single γ events.

In Fig. 6 we show azimuthal differences between the trigger particle and a secondary π^o with $p_T > 0.5$ GeV/c, analogous to Figs. 5 g-h. One observes a significantly lower density on the trigger side for single photons compared with π^o triggers, while no big differences are found on the away side.

Finally, Fig. 7 shows the dependence of the effect on the p_T of the secondary π^o (p_{T2}). The ratio R is defined as the probability of finding a second π^o at a given p_T and given $\Delta\phi$ in a single γ event, divided by the same probability in a π^o event. On the trigger side, the ratio R decreases with increasing p_{T2}, i.e. single γ's have a low probability to be accompanied by high p_T π^o's in comparison with π^o triggers. On the away side, no significant difference is observed.

4. CONCLUSION

Differences are observed in the structure of events containing a high p_T single photon or a high p_T π^o. Close to the trigger particle, the associated charged density is significantly lower in single photon events compared to π^o events, and the effect increases with increasing P_T of both trigger particle and secondary particle. On the away side, a slightly lower charged multiplicity is observed when including a large rapidity gap (± 2 units), while otherwise no significant differences are seen.

The results are consistent with the "Compton" diagram (Fig. 1a) whereby a direct photon is unaccompanied by other particles on the trigger side while the away side quark jet is similar to the jet opposite a π^o trigger.

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