INCLUSIVE HIGH- p_T ω^0 AND η' PRODUCTION AT THE ISR

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ABSTRACT

The inclusive production cross-section of ω^0 and η' were measured at transverse momenta of 3 to 7 GeV/c at 90° in the centre of mass. The ω^0/π^0 and η'/π^0 production ratios were found to be 0.87 ± 0.17 and 0.9 ± 0.25 , respectively, at 3.5 GeV and constant up to 7 GeV/c. The large meson/ π^0 production ratio supports the hypothesis that high- p_T mesons are the leading fragments of the basic constituent jet. The η'/η ratio exemplifies the SU(3) singlet nature of the η' .

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The study of inclusive production of particles at very high transverse momenta (p_T) is motivated by the suggestion that they are produced as a result of the basic interactions of the hadron constituents, quarks and gluons. The very high p_T particles are the leading fragments of the jet produced as a result of the fragmentation of the scattered constituents, and thus single-particle inclusive cross-sections at high p_T are directly related to the basic constituent interactions. Studies of the production ratios of particles at high p_T have already revealed important properties of constituent scattering [1,2]. A general feature of all these measurements is that different mesons tend to be produced with roughly the same cross-section at sufficiently high p_T .

The measurements of vector mesons at high p_T are also important since they are a source of prompt leptons. The measurements of inclusive vector-meson cross-sections at lower p_T , utilizing the e^+e^- decay mode [3,4], have so far not been able to separate the ρ and ω contributions. The small leptonic branching ratio of the vector meson limits the p_T range which can be covered using this method. The measurements of inclusive ρ^0 cross-sections using the $\pi^+\pi^-$ decay mode suffer from large non-resonant background, and additional assumptions are required in order to extract the signal [5,6]. Some of these problems can be overcome by measuring the ω^0 cross-section, using its electromagnetic decay mode $\omega^0 \rightarrow \pi^0(\rightarrow \gamma\gamma) + \gamma$. A recent measurement by Donaldson et al. [7] using this decay mode has measured an ω^0/π^0 ratio of 0.44 ± 0.08 at $p_T \geq 2.2$ GeV/c and $\sqrt{s} = 20$ GeV.

The inclusive production ratios of η and η' are of special interest because of their quark composition and SU(3) assignment. The η production cross-section up to 11 GeV/c in p_T has been measured [8] by this experiment. Up to now no η' signal has been observed at high p_T . An upper limit for η'/π^0 of 1.4 for $p_T \geq 2.2$ GeV has been reported by Donaldson et al. [7].

In this letter we report on new measurements of the inclusive high- p_T ω^0 and η' cross-sections at $X = 0$ produced in pp collisions at the CERN Intersecting Storage Rings (ISR). The mesons were measured via their electromagnetic decay mode $\omega^0 \rightarrow \pi^0(\rightarrow \gamma\gamma) + \gamma$ and $\eta' \rightarrow \gamma\gamma$. Since no other mesons nearby in mass have similar decay modes, background problems could be more easily controlled.

The energies and the position of the electromagnetic showers were measured using lead/liquid-argon calorimeter modules with resolutions of $\sigma(E) = 10\%/\sqrt{E}$ and $\sigma_x = 5$ mm, respectively [9]. Two different configurations of the modules were used in the ISR (see fig. 1). In the so-called normal geometry configuration (fig. 1a), each calorimeter module covered an azimuthal interval of 45° and a polar angular region of 45° to 135° . The trigger requirement for this configuration was either a large energy deposit in one calorimeter ($E \geq 5.5$ GeV) called "Super-High", or a "High-High" trigger, which required an energy $E \geq 1.2$ GeV, in each of the two adjacent modules. At very high p_T , when the opening angle of the decay meson is small, all showers are detected in a single module. At lower p_T , the opening angles tend to be large and the mesons are detected with one electromagnetic shower in one module and the others in the adjacent module. The retracted configuration (fig. 1b) had a trigger threshold of 3 GeV in either calorimeter module. The primary physics motivation in this configuration was the measurement of direct single-photon production [10], but the data taken have also been analysed for this study. The p_T range covered by this configuration overlaps with the "normal geometry" and is used to confirm those results.

In figs. 2a and 2b the invariant mass plots for $(\pi^0\gamma)$ and $(\gamma\gamma)$ events with a "High-High" trigger are shown. In this trigger configuration, one γ is detected in one calorimeter and the second π^0 or γ in the adjacent one. A clear ω^0 signal can be observed in fig. 2a. The background under the ω^0 signal is due mostly to two uncorrelated π^0 's, where one π^0 had both photons reconstructed in the calorimeter and the second π^0 only one. The background slope was fitted with a polynomial curve. After correcting for branching ratios [11] ($8.8 \pm 0.5\%$), geometrical acceptance, and reconstruction efficiency, one obtains an ω^0/π^0 cross-section ratio of 0.87 ± 0.17 for $p_T \geq 3$ GeV/c (see Table 1).

From fig. 2b an η'/π^0 cross-section ratio of 0.9 ± 0.25 was calculated using the $\eta' \rightarrow \gamma\gamma$ branching ratio of $2.0 \pm 0.3\%$ [11]. The main background in the $\gamma\gamma$ invariant mass plot in the region between the η and η' is due to ω^0 , where the π^0 has been reconstructed as a single shower. The mass region above the η' may have a background contribution from f^0 decaying into $\pi^0\pi^0$ when both π^0 's have only one shower reconstructed.

In figs. 3a and 3b we show the corresponding invariant mass plot for the Super-High trigger. A p_T cut at 6 GeV/c was imposed by the trigger requirement. An ω^0 signal is clearly seen in the $(\pi^0\gamma)$ invariant mass plot; the shape of the background is different from that in fig. 2a owing to the different geometrical constraints. The relative ω^0/π^0 production cross-section ratio was calculated to be 0.90 ± 0.18 for $p_T \geq 6$ GeV/c. The $(\gamma\gamma)$ invariant mass plot for $p_T \geq 6$ GeV/c shows the η and η' signals. The relative acceptance of η and η' favours the η over η' in this configuration, because of its lower Q value, while the adjacent module configurations favour η' acceptance. The η'/π^0 cross-section ratio is calculated to be 0.70 ± 0.30 for $p_T \geq 6$ GeV/c.

In figs. 4a and 4b we show the $(\pi^0\gamma)$ and $(\gamma\gamma)$ invariant mass distributions obtained from the retracted octant configuration (fig. 1b). The $(\pi^0\gamma)$ events were selected with $p_T \geq 3.6$ GeV/c and the $(\gamma\gamma)$ with a cut at $p_T \geq 5$ GeV/c. The higher p_T requirement for η' was due to the poor acceptance at lower p_T for the mass region of interest. From the ω^0 and η' signal observed, one can calculate the ω^0/π^0 to be 0.89 ± 0.22 for $p_T \geq 3.6$ GeV/c, and η'/π^0 to be 0.95 ± 0.38 for $p_T \geq 5$ GeV/c. These results are in good agreement with those obtained from the normal geometry runs. The two sets of measurements utilize different trigger requirements and have different geometrical acceptance.

The substantial production of high- p_T ω^0 and η' is consistent with the previous observations that meson/ π^0 cross-section ratios tend to be of the order of unity at high p_T . The ω^0/π^0 ratio observed here is consistent with earlier measurements of vector meson/ π^0 , and the expectation that ω^0 and ρ cross-sections are comparable. We have measured the η/π^0 ratio with the same apparatus [8], with the result that $\eta/\pi^0 = 0.55$ over a large range of p_T . We conclude that $\eta'/\eta \cong 1.7$. In the current naive quark scattering picture, the high- p_T mesons are the leading fragments of the scattered u and d valence quarks. This leads to the expectation of a ratio of 2 for η'/η , assuming no SU(3) mixing. The addition of gluons to the picture does not alter the expectation of an η'/η production cross-section ratio greater than one, since gluons are presumed to favour coupling to SU(3) singlets and thus prefer η' to η .

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Table 1

The ω^0/π^0 and η'/π^0 ratios obtained using
the different experimental configurations

Configuration	p_T	ω^0/π^0	p_T	η'/π^0
Normal:				
High-High	≥ 3	0.87 ± 0.17	≥ 3	0.90 ± 0.25
Super-High	≥ 6	0.90 ± 0.18	≥ 6	0.70 ± 0.3
Retracted	≥ 3.6	0.89 ± 0.22	≥ 5	0.95 ± 0.38

Figure captions

- Fig. 1 : The experimental configuration of the liquid-argon calorimeter modules in the ISR:
- a) normal geometry arrangement;
 - b) retracted geometry.
- Fig. 2 : Invariant mass plot for events in normal configuration and a "High-High" trigger:
- a) $(\pi^0\gamma)$ invariant mass, $p_T \geq 3 \text{ GeV/c}$;
 - b) $(\gamma\gamma)$ invariant mass, $p_T \geq 3 \text{ GeV/c}$.
- Fig. 3 : Invariant mass plot for events in normal geometry configuration using the Super-High trigger:
- a) $(\pi^0\gamma)$ invariant mass, $p_T \geq 6 \text{ GeV/c}$;
 - b) $(\gamma\gamma)$ invariant mass, $p_T \geq 6 \text{ GeV/c}$.
- Fig. 4 : Invariant mass plot for events in retracted geometry:
- a) $(\pi^0\gamma)$ invariant mass, $p_T \geq 3.6 \text{ GeV/c}$;
 - b) $(\gamma\gamma)$ invariant mass, $p_T \geq 5 \text{ GeV/c}$.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

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