Inclusive \( \gamma \) and \( \pi^0 \) Production in \( K^- p \) Interactions at 32 GeV/c

France - Soviet Union and CERN - Soviet Union Collaboration

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Abstract. The inclusive production of \( \gamma \)'s and \( \pi^0 \)'s in \( K^- p \)-interactions at 32 GeV/c is studied. About 30,000 \( \gamma \)'s coming from a Mirabelle bubble chamber experiment with a sensitivity of 6.5 ev/\( \mu \)b have been used for the analysis. Inclusive and topological cross sections of \( \gamma \)'s are measured. The \( \gamma \) invariant differential distributions and their scaling properties are investigated. The inclusive cross section of \( \pi^0 \)-production is determined and the \( \pi^0 \) invariant differential distributions are evaluated and compared to those of \( \pi^- \).

1. Introduction

The study of inclusive differential distributions of hadrons, charged and neutral, is an important means for disentangling the dynamics underlying multiparticle production in hadronic interactions [1]. Data for the inclusive production of neutral hadrons, however, are quite scarce. In particular the analysis of inclusive \( \pi^0 \) production requires a good detection efficiency for \( \gamma \)'s, a reasonably large acceptance and high statistics.

Experiments using bubble chambers filled with heavy liquids would be well suited in respect to \( \gamma \) detection capability because of their good \( \gamma \) conversion properties, but data analysis is complicated by nuclear effects and background problems. In spite of the lower \( \gamma \) detection efficiency of liquid hydrogen bubble chambers high statistics experiments such as the present one using a very large chamber of this type can provide very useful information on \( \pi^0 \) (as well as on \( \gamma \)) production mechanisms.

In this paper results are given for the inclusive reactions

\[
K^- p \rightarrow \gamma + X \tag{1}
\]
\[
K^- p \rightarrow \pi^0 + X \tag{2}
\]

at 32 GeV/c, obtained with the Mirabelle hydrogen bubble chamber. Preliminary results based on partial statistics have been presented in [2, 3].

This paper is organised as follows: in Sect. 2 we discuss the data and the experimental procedure: inclusive and semi-inclusive cross sections for \( \gamma \) and \( \pi^0 \), as well as an estimate of the inclusive \( \eta \) cross section, are given in Sect. 3; in Sect. 4 we present the inclusive \( x \) and \( p_T^2 \) distributions of \( \gamma \) and \( \pi^0 \) and compare them with the corresponding distributions for charged pions. The results are summarized in Sect. 5.

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2. Experimental Procedure

The data are obtained from an exposure of the 4.7 m Mirabelle hydrogen bubble chamber to an r.f. separated K⁻ beam of 32 GeV/c at the Serpukhov accelerator. The total statistics of our experiment is 132 K events of all topologies (on DST) corresponding to a sensitivity of 6.5 ev/µb. Events of all topologies have been scanned twice, measured (up to three times) and reconstructed by the H-GEOM program. In this experiment γ's were detected by scanning and measuring the e⁺e⁻-pairs resulting from γ conversion. 3c-fits were tried in order to identify the γ's and associate them to primary vertices. The details of the data handling system and of γ identification have been described in a previous publication [4]. The total number of γ's used in the present analysis is about 30,000. The raw numbers of events with associated γ's are summarized in Table 1.

Losses of γ's during scanning, measuring and kinematic analysis are taken into account by applying topology dependent passing rates. Corrections are also made for γ's materializing outside the fiducial volume or too close to the primary vertex as well as for the losses due to Compton scattering of γ's.

Special care is needed in order to find appropriate corrections for scanning and measuring losses of γ's converting into e⁺e⁻-pairs with a low energy e⁺ or e⁻. These losses are energy dependent and therefore lead to a distortion of the energy distribution of γ's. In order to tackle this problem we used different correction procedures for γ's with Eγ > mπ⁰/2 and for low energy γ's with Eγ < mπ⁰/2. All e⁺e⁻-pairs with at least one electron (e⁺ or e⁻) having energy less than 25 MeV have been excluded from the first sample (Eγ > mπ⁰/2). A correction has been made for this by using an additional weight calculated from QED formulae [5]. For the energy region Eγ > 0.5 GeV the influence of this procedure is negligible; the region Eγ < 0.5 GeV is shown in Fig. 1a and it is seen that this correction is most important for the low momentum part of the Eγ spectrum. The corrected \( \frac{dσ}{dEγ} \) distribution has a maximum at about Eγ = mπ⁰/2, as expected from the kinematics of a π⁰ decay. After applying all the corrections described above we have obtained the following value of the cross section for γ's from the first sample:

\[ \sigma_γ(Eγ > mπ⁰/2) = 70.1 \text{ mb}. \]

A different correction procedure has been applied for the region Eγ < mπ⁰/2. Both the cross section (\( \sigma_γ(Eγ < mπ⁰/2) = 4.0 \text{ mb} \)) and the laboratory energy distribution for this region of Eγ have been reconstructed from the Eγ distribution at Eγ > mπ⁰/2** by using the kinematical expression

\[ \frac{dσ}{dEγ}(Eγ) = \frac{dσ}{dEγ} \left( mπ⁰^2 / 4Eγ \right) \]  

(3)

which relates the two parts (below and above Eγ = mπ⁰/2) of the laboratory energy distribution of γ's from π⁰ decay. Since such a procedure cannot be applied to other kinematical distributions, one needs to use information from the measured γ's with Eγ < mπ⁰/2. Thus for γ's with Eγ < mπ⁰/2 we use an empirical energy dependent weight obtained by requiring that the experimental \( \frac{dσ}{dEγ} \) distribution thus weighted approximately reproduces the one obtained by reflection according to (3).*** The result is shown in Fig.1a by dots (the region Eγ < mπ⁰/2). Figure 1b shows the invariant x-distribution corrected

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Table 1. Raw numbers of events with numbers of γ's associated

<table>
<thead>
<tr>
<th>nγ</th>
<th>nγγ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20,309</td>
</tr>
<tr>
<td>2</td>
<td>3,298</td>
</tr>
<tr>
<td>3</td>
<td>439</td>
</tr>
<tr>
<td>4</td>
<td>56</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

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* All cross sections in this paper are obtained by normalization to the total cross section 20.5 mb [6].
** Here we assume that all γ's originate from π⁰ decay.
*** Even after correction with this empirical energy dependent weight the points in the region Eγ < mπ⁰/2 lie somewhat below the expectations using (3), but in light of the sizable errors this is not a severe effect.