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LARGE TRANSVERSE MOMENTUM PRODUCTION OF GAMMA RAYS AT NAL

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ABSTRACT

We have measured the single photon inclusive cross section, $d\sigma_\gamma/dk\,d\Omega$, for the reaction $p + \begin{pmatrix} p \\ n \end{pmatrix} \rightarrow \gamma$ + anything, which can be related to the inclusive π^0 cross section. The results indicate that the invariant π^0 cross section falls exponentially for transverse momenta p_T less than about 1 GeV/c. At larger transverse momenta the cross section falls more slowly. Preliminary results on the energy dependence at fixed transverse momentum are given.

APPARATUS AND DATA ACQUISITION

The experiment was performed using an internal target in the C0 straight section of the National Accelerator Laboratory main ring where data may be taken over the complete range of proton momentum available during the acceleration cycle.

The target was either a hydrogen gas jet or a rotating carbon fiber target. The data being presented here were obtained for the carbon target at a fixed laboratory angle for the detected gamma ray of 100 mrad. A lead collimator restricted the apparatus to detecting only one of the photons from the π^0 decay for all π^0's with less than 60 GeV energy (transverse momentum less than 6 GeV/c). The data presented here are below this two photon detection limit.

The relevant dimension of the counters and other apparatus following the collimators are shown in Fig. 1. The distance to the target was 648 inches and the solid angle acceptance was 9.5 μsr. The lead converter was 1.1 radiation lengths thick while the glass total absorbtion Cerenkov counter was 28 radiation lengths thick.

An energy calibration of the lead glass Cerenkov counter C4 was made using 1.8 to 5 GeV electrons and muons at Argonne National Laboratory. The photomultiplier and base were tested and found to be linear up to a response equivalent to 280 GeV photon energy. The response of the counter to muons (defined by an S1-S2-S3-S5-S6 trigger) was monitored during the data taking. The pulse-height distribution from C4 for this trigger showed a clean peak with a 30% FWHM. The muon peak provided a stability check during the runs. The calibration was found by this means to be stable to ± 4%.

The photon data were taken using an $\overline{S1}$-S2 - S3 - C4 trigger. When a trigger occurred, the pulse heights in all counters, the main ring magnetic field (which gave the proton incident momentum), and all other scaler information were written onto magnetic tape for later analysis. The number of muons per run was used as a measure of the luminosity.

PRELIMINARY ANALYSIS

Converter in and converter out data were divided into 20 GeV/c wide bins in the incident proton momentum. A cut on the pulse height in trigger counter S2 was applied to required that the events have doubly ionizing or greater pulse heights in that counter.

The energy spectra for the lead glass Cerenkov counter for both the converter in and converter out data were then normalized to the number of muons appropriate to that data and the converter out subtraction made, resulting in a distribution proportional to

$d\sigma_\gamma/dk\,d\Omega$. The ratio of events with converter out, to that with converter in, was usually a few percent and always less than 20%.

A number of checks were made on the data. In particular, an aluminum converter of the same radiation length but different interaction length was substituted for the lead converter. The yield of photon events per muon was then compared for the two situations. It was found that the difference was less than (3.8 ± 2.3)% for transverse momentum values of the photon between 3.0 and 5.5 GeV/c and less at lower transverse momentum. This check proved that neutral hadrons did not contaminate our photon events to a significant extent.

PRELIMINARY RESULTS

We present $d\sigma_\gamma/dk\,d\Omega$ as a function of transverse momentum p_T for 170 to 190 GeV/c incident proton momentum in Fig. 2. In discussing the p_T dependence at fixed incident momentum, we make the usual assumption that the main source of photons is π^0 decay. The π^0 invariant cross section is proportional to the derivative of $d\sigma_\gamma/dk\,d\Omega$ with respect to the photon energy k.[1] At low photon energy our data for $d\sigma_\gamma/dk\,d\Omega$ fit a single exponential so that $d\sigma_\gamma/dk\,d\Omega$ is directly proportional to the π^0 invariant cross section. Hence the invariant π^0 cross section falls exponentially [approximately $\exp(-6\,p_T)$] for $p_T \leqslant 1$ GeV/c. For $p_T \geqslant 1$ GeV/c the photon cross section and therefore the π^0 cross section falls less rapidly with increasing p_T.

We now briefly discuss the center of mass energy dependence $\sqrt{s}$ of the photon cross section for fixed p_T. For this purpose, we have normalized $d\sigma_\gamma/dk\,d\Omega$ for each bin in $\sqrt{s}$ to the same value at a p_T of 0.2 GeV/c. At this low p_T the π^0 cross section is known to scale to within 20%.[2] The result is shown in Fig. 3. It can be seen that the main qualitative feature is that for large fixed p_T the cross section increases with increasing center of mass energy.

It may be remarked that for given incident proton energy and fixed laboratory detection angle there is a correlation between p_T and x (where $x = p_{11}^*/p_{max}^*$). Further measurements will be made at different laboratory angles to separate the x and p_T dependence of the cross section.

In conclusion, we confirm the results from the ISR[3,4] that the single particle inclusive distribution deviates markedly from an exponential behavior at transverse momenta greater than about 1 GeV/c. In addition, we have obtained preliminary results that show that for large fixed transverse momentum (2 to 4 GeV/c) the single particle cross section rises with increasing center of mass energy.

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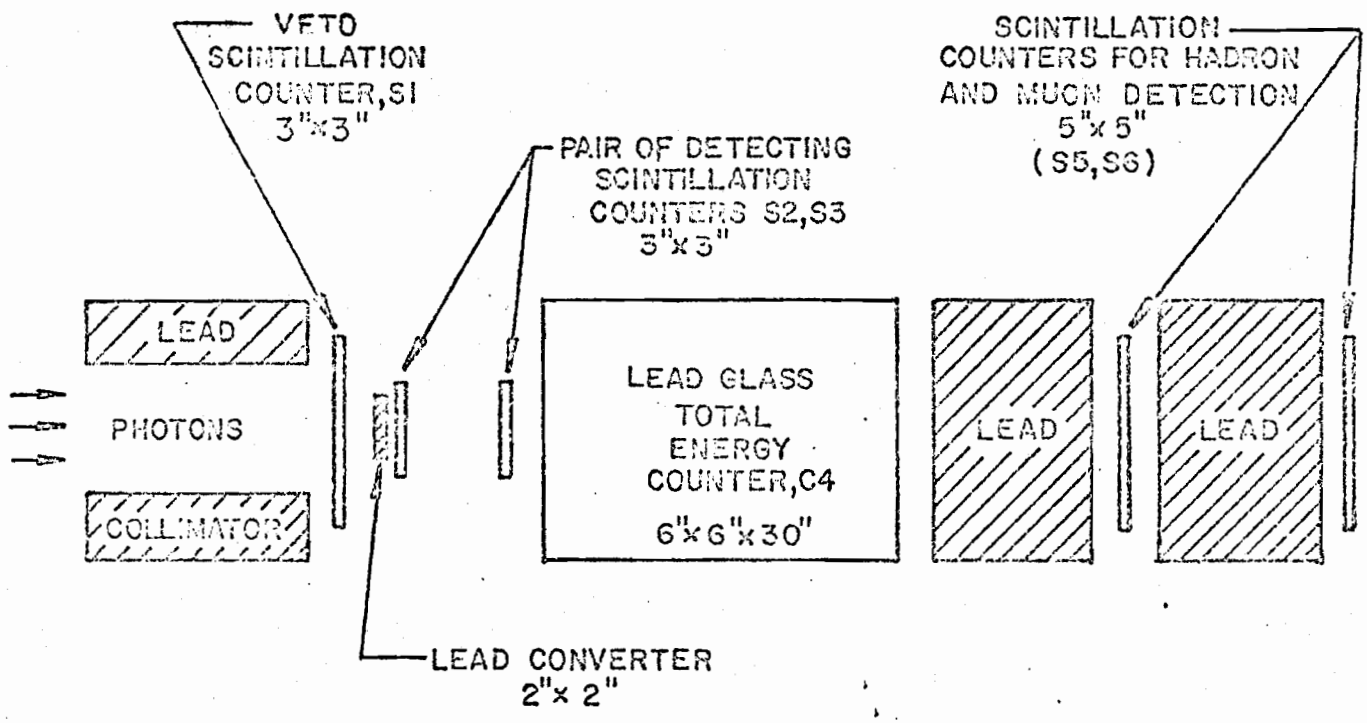

PHOTON DETECTION SYSTEM

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Figure 1

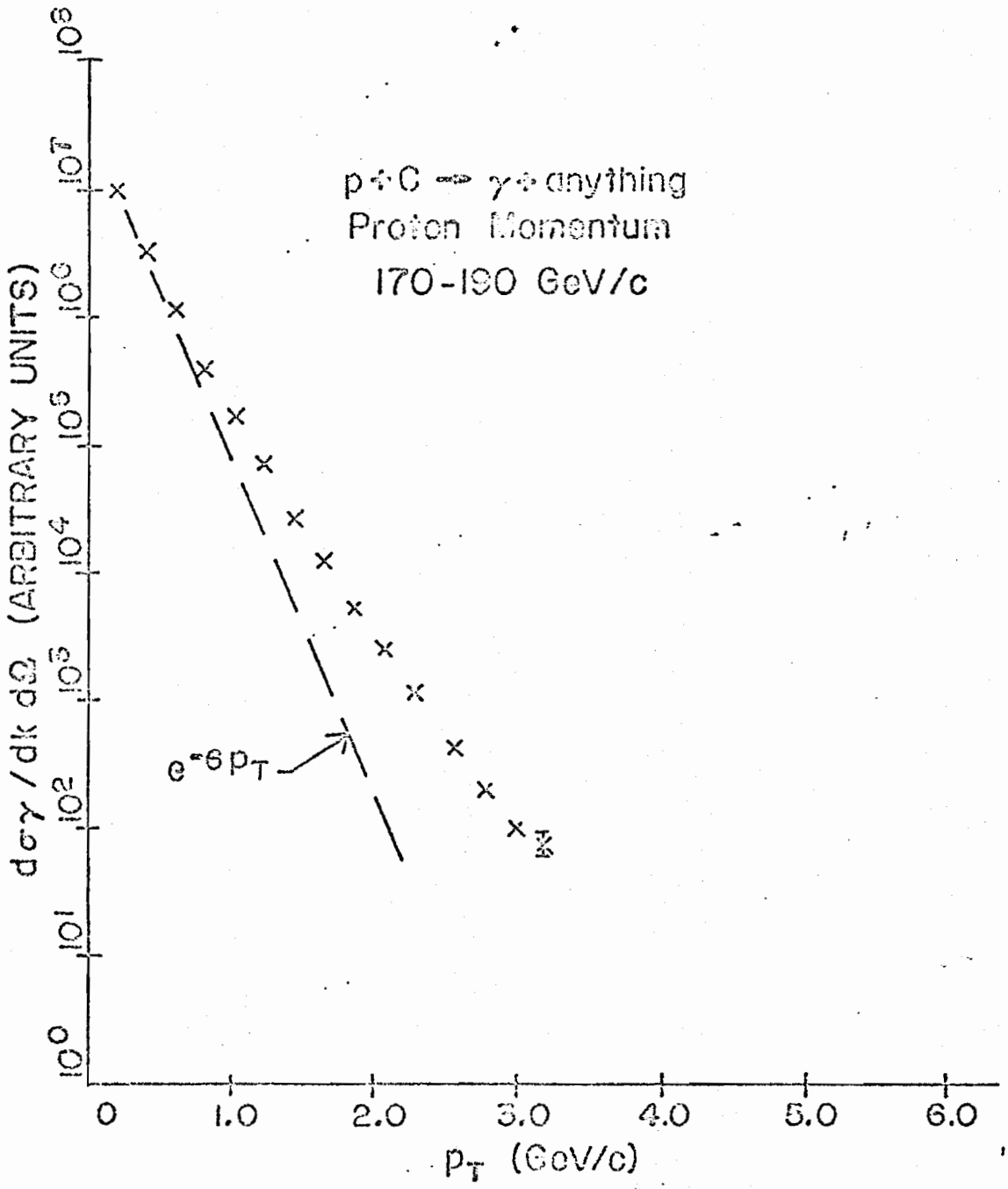

Figure 2

$d\sigma_\gamma/dk\,d\Omega$ versus p_T for 170-190 GeV/c incident proton momentum

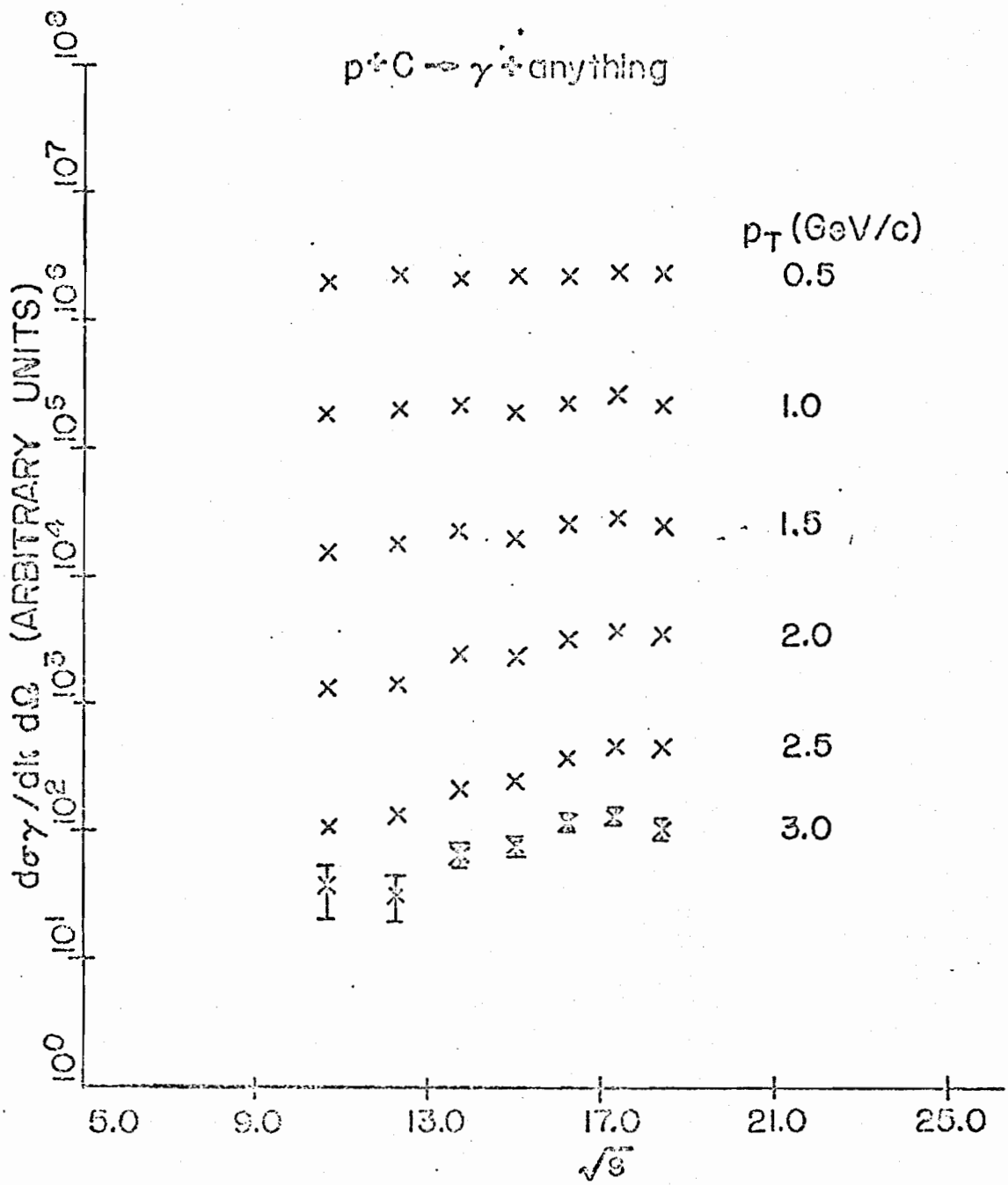

Figure 3

$d\sigma_\gamma/dk\,d\Omega$ versus $\sqrt{s}$ at fixed p_T