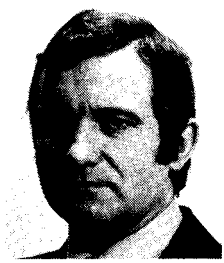
CONTINUUM DIMUON PRODUCTION BY 39.5 GEV/C $\pi^{\pm}$, $K^{\pm}$, p AND $\bar{p}$ INCIDENT ON A TUNGSTEN TARGET

Birmingham - CERN - Ecole Polytechnique
J.D. Dowell
Physics Department, University of Birmingham



Inclusive dimuon production by 39.5 GeV/c $\pi^{\pm}$, $K^{\pm}$, p and $\bar{p}$ has been studied for masses greater than 2.0 GeV/c^2. The π^-,π^+ and (π^--π^+) cross sections exceed the naive Drell-Yan predictions by a factor ∿2.4 and the scaling cross section $M^3/d\sigma/dM$ scales with higher energy data within the systematic errors. The ratios of the cross sections for the different incident particles to π^- agree with Drell-Yan predictions. The pion valence structure function is consistent with that found at 200 GeV/c. Some x_F dependence of the angular distribution is observed with large errors. A comparison of $<P_t^2>$ at fixed τ to higher energy data shows an increase with increasing s at four values of τ.

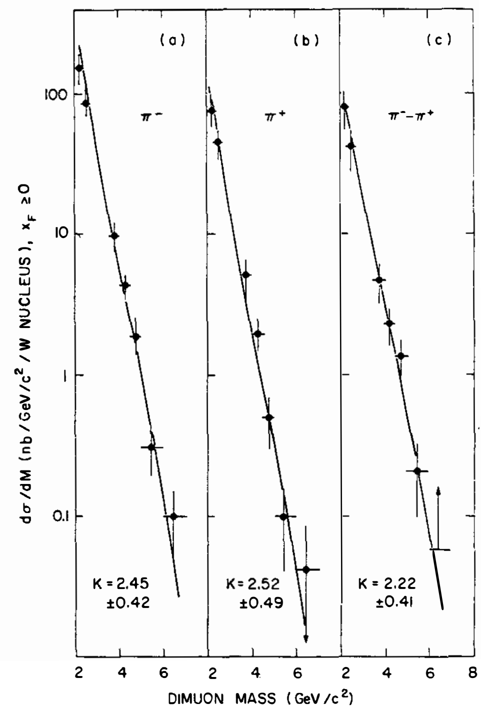


Fig. 1 $d\sigma/dM$ ($nb/GeV/c^2/W$ nucleus) for $x_F>0$ versus mass. The curves are Drell-Yan predictions multiplied by a factor K.

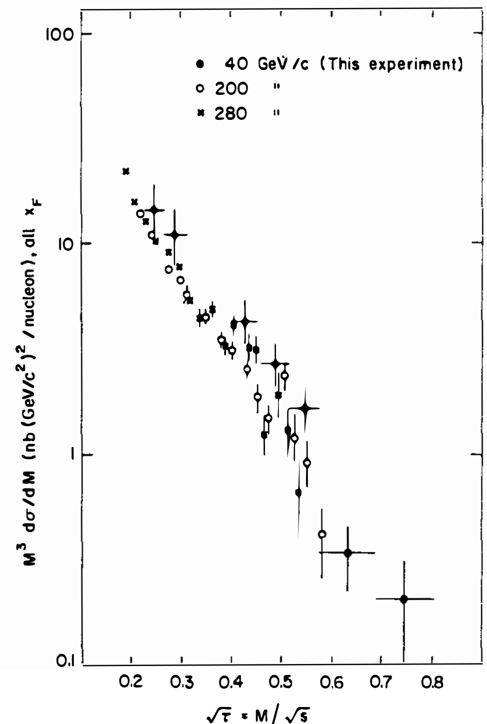


Fig. 2 $M^3 d\sigma/dM$ for all x_F as a function of $\sqrt{\tau}= M/\sqrt{s}$ for incident π^- in this experiment and ref {10}. Overall systematic errors are shown for the 40 GeV data.

The experiment was carried out in the CERN Omega Spectrometer which has a large acceptance ($-0.5<x_F<1.0$) for the produced dimuons. Details of the experimental method may be found in reference {1} and further information about the results discussed here in reference {2}. Data were obtained for dimuon masses from 2.0 to 7.0 GeV/c^2 or $0.23<\sqrt{\tau}<0.80$. Figure 1 shows the differential cross sections ($x_F>0$) as a function of dimuon mass for π^-, π^+ and ($\pi^- - \pi^+$). The data are corrected for acceptance but not for Fermi-motion and the errors include all systematic effects. The curves are calculated assuming a linear A-dependence and the simple Drell-Yan formula, using the structure functions of NA3 {3} for the pion and CDHS {4} for the nucleon, but multiplied by a factor K to fit the data. The difference cross section ($\pi^- - \pi^+$) is expected to be free from hadronic backgrounds and requires $K=2.22\pm0.41$ similar to the value observed in higher energy experiments {5,6,7}. The fact that the K-values obtained for π^+ and π^- separately are only about 10% higher and the good agreement with the curves indicate that dimuon production is dominated by the Drell-Yan mechanism even at the lowest masses.

Figure 2 is a plot of the scaling cross section $M^3 d\sigma/dM$ versus $\sqrt{\tau}$ at all x_F for our data and those of NA3 {10} at 200 and 280 GeV. A linear A-dependence has been used to obtain the cross section per nucleon but this is not critical as the targets (W and P_t) have similar A-values. No Fermi-motion corrections have been applied in either experiment. Our data lie about 20% higher on average but we are compatible with scaling within our errors which include all systematic effects. A small deviation in the direction observed would be expected on the basis of the scaling violations observed in deep inelastic scattering.

Figure 3 shows the cross sections for different incident particles relative to π^- as a function of mass and include our J/ψ results ($2.7<M<3.5$ GeV/c^2). The π^+/π^- ratio is close to unity for J/ψ production while for the continuum it decreases with increasing dimuon mass towards the value of ¼, the ratio of the squares of the annihilating valence quark charges. For the other particles the ratios fall with mass without a discontinuity at the J/ψ. This is consistent with quark model expectations. The small ratios for K^+ and p are consequences of the absence of valence $\bar{u}$ or $\bar{d}$ in these particles. The solid curves are computed from the

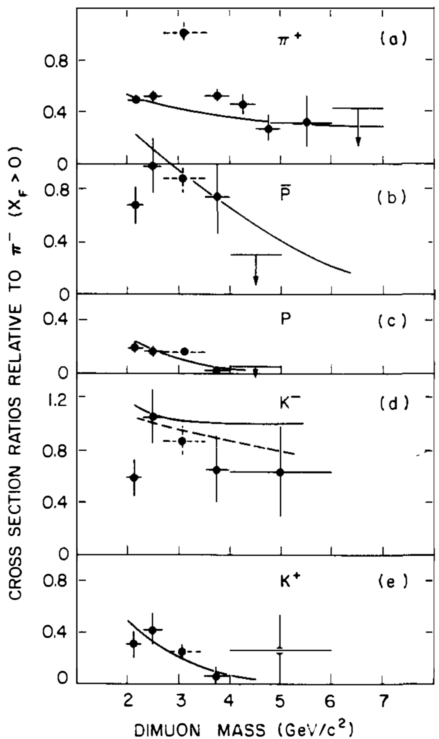


Fig. 3 Ratios for different incident particle cross sections to those for π^-. The curves are Drell-Yan predictions (see text).

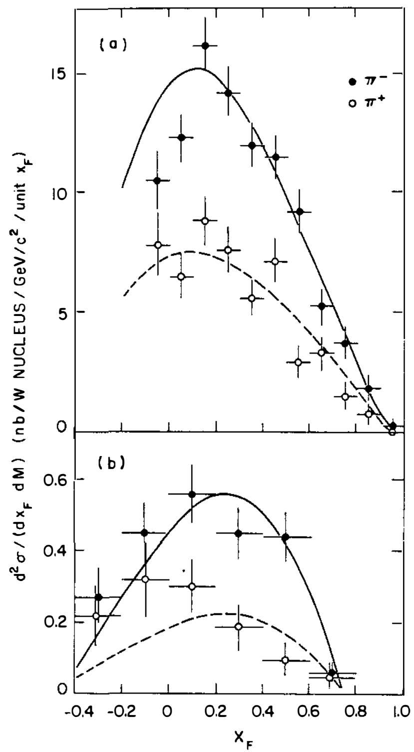


Fig. 4 $d^2\sigma/dMdx_F$ for incident π^- and π^+, a) $2.3<M<2.7$ GeV/c^2, b) $4.0<M<5.0$ GeV/c^2. The curves are Drell-Yan predictions.

Drell-Yan model using the structure functions of references {3,4}. The agreement is generally good. The solid curve for K^-/π^- is where the $\bar{u}$ distribution for the K^- is taken to be the same as for the π^- while the dashed curve uses the results of ref. {9}. for the K^- structure function. The latter agrees better with the data providing further evidence that the $\bar{u}$ distribution in a K^- falls more steeply with x than in a π^-. The variation we observe for the K^-/π^- ratio as a function of x_F is also consistent with this result.

Figure 4a and 4b show the x_F distributions for muon pairs in the mass ranges 2.3-2.7 and 4.0-5.0 GeV/c^2 for incident π^- and π^+. The superimposed curves (normalised to the data for x_F>0) are calculated using the structure functions mentioned earlier and reproduce the data reasonably well. At higher masses the predicted x_F distributions are broader and peak further away from zero because of the difference in the valence quark distributions between pions and nucleons and the fact that large quark x-values are required to produce high masses. In order to determine the pion structure function we have fitted the data for π^+ and π^- simultaneously in the mass interval 2.0-2.7 GeV/c^2 for x_F between -0.1 and 0.8 with the pion valence structure function parameterized as $Ax^{\alpha}(1-x)^{\beta}$. The pion sea is fixed as $B(1-x)^{\gamma}$ where γ=5 and B is such that 6% of the pion momentum is carried by each sea quark flavour while for the nucleon the CDHS parameters have been used {4}. The fitted results give α=0.44±0.12 and β=0.98±0.15 and a K factor of 2.6±0.5 to be compared with α=0.40±0.06 and β=0.90±0.06 in ref. {3}. There is no evidence within experimental error of any scaling violation from the shape of the pion structure function between 40 GeV/c and 200 GeV/c; the prescription of Buras and Gaemers {8} applied to the pion predicts that the parameter β would be smaller by $\sim$0.2 at the lower momentum.

The cos θ angular distribution has been studied in the Gottfried-Jackson system for $|\cos\theta|<0.8$ assuming that the azimuthal distribution ϕ is isotropic. The results are critically dependent on the acceptance for which a systematic error has been included. Allowance has also been made for the smearing effect of multiple scattering. The combined π^+ and π^- distributions have been fitted with $1+\alpha\cos^2\theta$. The large $|\cos\theta|$ values have the largest influence on α but are the most poorly determined because the corrections are

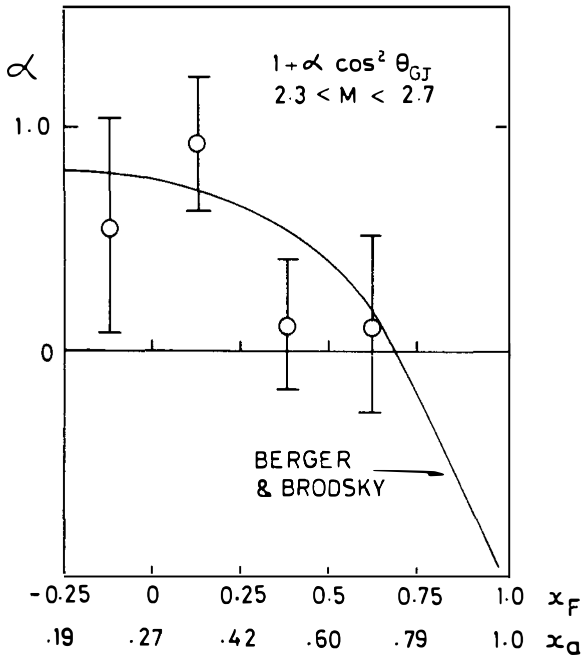


Fig. 5 The angular parameter α versus x_F for $2.3<M<2.7$ GeV/c^2 for π^+ and π^- data. The curve is the prediction of reference 11. The lower scale gives the x of the pion quark.

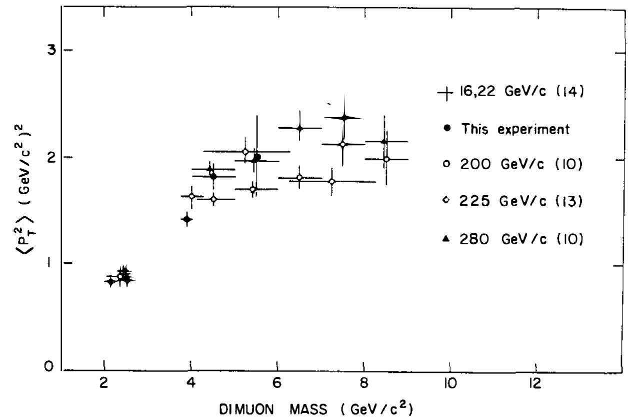


Fig. 6 $<P_t^2>$ versus mass for incident π^- for these and other data.

large and the statistics low. Consequently one should be cautious in interpreting the results. The values of α obtained for $x>-0.25$ are $\alpha=0.44\pm0.17$ (0.44 ± 0.48) for the mass regions 2.3-2.7 GeV/c^2 (4.0-5.0 GeV/c^2). Figure 5 is a plot of α versus x_F for the lower mass range, with the lower scale showing the x-value of the quark in the pion. The curve is the prediction of Berger and Brodsky {11} and the data show the predicted decrease in α with increasing x_F as first observed at 225 GeV/c {12}. However the large errors and systematic uncertainties make it difficult to draw a conclusion.

The P_t^2 distributions for the π^- and π^+ induced dimuons are well fitted by an exponential form for $P_t^2 < 2.0(\text{GeV/c})^2$. At higher P_t^2 the data fall more slowly than the exponential as observed in reference {10}. The $<P_t^2>$ values are similar for all beam particles and show a dependence on mass and x_F. Corrections have been applied to $<P_t^2>$ to allow for the smearing effect of multiple scattering. Figure 6 shows $<P_t^2>$ versus mass compared to other data. Our data have a similar mass dependence to the higher energy data but correspond to much higher values of $\sqrt{\tau}$. Figure 7 shows $<P_t^2>$ versus s at four values of $\sqrt{\tau}$. There appear to be some inconsistencies but the data show that $<P_t^2>$ increases with s at fixed τ. The straight lines are not fits but are to guide the eye and have slopes ranging from .0023 to .0035 with no clear systematic trend. There is not a common intercept on the $<P_t^2>$ axis implying that the primordial $<P_t^2>$ is a function of τ. Our data show a smooth decrease of $<P_t^2>$ with increasing x_F (figure 8) which is particularly striking at high mass where it must at least partly reflect the approach to the kinematic boundary. The acceptance is a slowly varying function of both x_F and P_t and could not, due to error, account for the behaviour.

In conclusion we observe at 40 GeV/c only a small change in the scaled continuum cross section $M^3 d\sigma/dM$ from the values measured at 200 and 280 GeV/c. The cross sections exceed the naive Drell-Yan predictions by a factor $\sim$2.4. The pion valence structure function is consistent with that found at 200 GeV/c. Some evidence of a dependence of the angular distribution parameter α on x_F is observed but the errors are large. Comparing to higher energy data $<P_t^2>$ rises with increasing s at fixed τ but decreases with x_F at our energy.

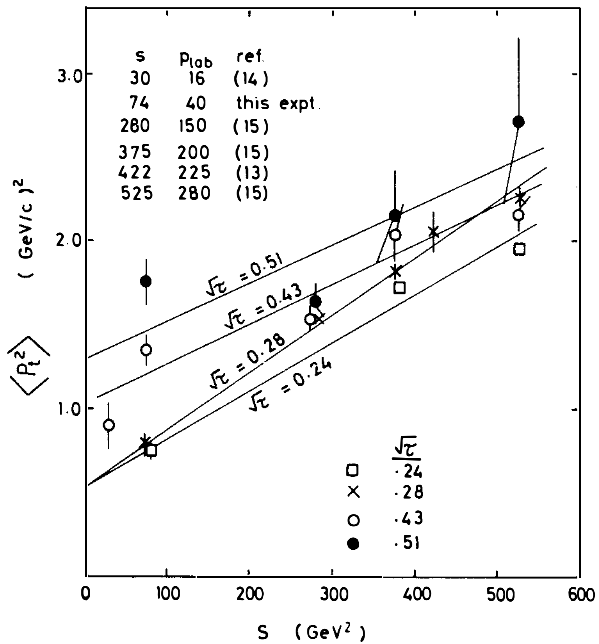


Fig. 7 $<P_t^2>$ versus s for incident π^- at four values of $\sqrt{\tau}$ for these and other data. The lines are to guide the eye.

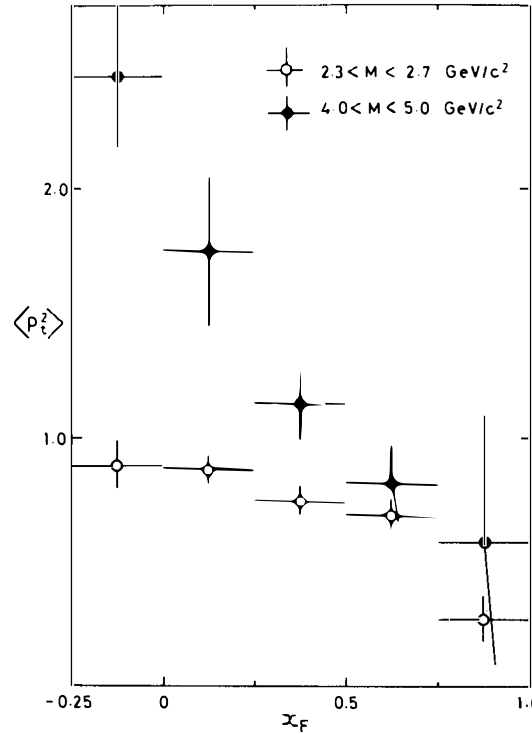


Fig. 8 $<P_t^2>$ versus x_F for incident π^- and two mass intervals.

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M.J. Corden, J.D. Dowell, J. Garvey, R.J. Homer, M. Jobes, I.R. Kenyon, T.J. McMahon, R.C. Owen, K.C.T.O. Sumorok, R.J. Vallance, P.M. Watkins and J.A. Wilson.
University of Birmingham, UK.

P. Sonderegger.
CERN, European Organisation for Nuclear Research, Geneva Switzerland.

B. Chaurand, A. Romana and R. Salmeron.
Ecole Polytechnique, Palaiseau, France.