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HADRONIC MUON PRODUCTION AS A SIGNATURE OF BEAUTY PRODUCTION

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Presented by Ph. Charpentier

ABSTRACT

We have used our data on like sign dimuons and trimuons in order to put an upper limit on the production cross-section of B meson. Both methods give limits between 25 and 100 nb/nucleon, depending on the branching ratio assumed.

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1. INTRODUCTION

Since the discovery of the Υ in 1977[1], everybody believes that this meson is composed of a $b\bar{b}$ pair where b is a charge -1/3 quark. It is thus very interesting to look for mesons having this new quantum number (beauty..) as a naked quantum number, i.e. formed of a b-quark and an "ordinary" antiquark. These are called in the litterature the B mesons.

This search has been emphasised since the claim at the 1979 EPS Conference in Geneva[2] of a resonance at 5.3 GeV/c^2 in both the channels $\psi K^0\pi$ and $\psi K^-\pi^+$, which can be interpreted as the charged and neutral B mesons. However, including the theoretically expected branching ratio, one gets rather large cross-sections, of the order of 100 nb/nucleon.

An other way of looking for these states is to observe their semi-leptonic decay mode and the fact that they decay very likely into charmed mesons.

In the NA3 Experiment[3] where we search for high mass dimuons[4], we have also collected a sample of multimuon events and of like sign dimuons, which could be induced by such decays.

2. LIKE SIGN DIMUONS

Semi-leptonic decays of B mesons can be responsible for production of like sign dimuons, according to the reaction :

$$\pi^- N \to B\ \bar{B} + X$$
$$\bar{B} \to D + Y, \quad D \to \mu\nu + Z$$
$$B \to \mu\nu + Z'$$

The cross section for such a process is :

$$\sigma(\mu^\pm\mu^\pm) = 2\cdot\sigma(B\bar{B})\cdot B(B \to \mu\nu\ldots)\cdot B(B \to D\ldots)\cdot B(D \to \mu\nu\ldots)$$

where the B's are the branching ratios of the different decay modes and $\sigma(B\bar{B})$ the production cross section for naked beauty(*). The acceptance

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*) It should be noticed that only the meson production is studied here but the "beautiful" baryon production would give a similar signature, only the kinematics would be different.

for such events has been estimated by a Monte-Carlo program making the following assumptions for the dynamics of the reaction :

a) The $B\bar{B}$ pair is generated with the same rapidity distribution as the Υ, and the B is generated with a rapidity difference of 0.1 rapidity units (the acceptance is quite insensitive to this value).

b) The traverse distribution is generated as a gaussian with a σ of 1.0 GeV/c to 2.0 GeV/c, the result being insensitive to this value.

c) The decay of the B meson into μ follows the same kinematics as the decay of the K into μ[5].

d) The distribution of the D meson coming from the B meson is taken similarly to that of the π in the decay $K \to \pi\mu\nu$.

e) The semi-leptonic decay of the D meson is taken out of the results from SPEAR[6], correcting for the μ-e mass difference.

All these distributions are corrected for the different masses of the involved particles.

The following cuts have been made on the data (and in the Monte-Carlo) in order to reduce the background from π- and K- decays and halo contributions :

a) A cut on the longitudinal momentum of the muons at 60 GeV/c.

b) A cut on the transverse momentum of each muon : one must have more than 0.4 GeV/c and the other more than 1 GeV/c of p_t. After this cut, 32% of the events remain, as the muon coming from the B meson must have a large transverse momentum.

Table 1 shows the number of events actually observed and obtained by Monte-Carlo for different mass ranges. One can notice that the background increases in the data as the mass decreases, and thus we have made a third cut on the dimuon mass :

c) $M\mu^{\pm}\mu^{\pm} > 2.0$ GeV/c^2

TABLE 1

Number of events observed and generated

Mass range	$\mu^+\mu^+ + \mu^-\mu^-$	Monte-Carlo
4 → 5	18	5
3 → 4	143	33
2.4 → 3	433	63
2 → 2.4	811	81
1.6 → 2	1272	58

The overall acceptance of the spectrometer for those events is then 2.4%.

One can extract that the cross-section for like sign dimuons coming from B mesons is less than 1 nb/nucleon.

A somewhat model-dependent calculation can then be made to extract the beauty cross section :

$$B(B \to \mu\ldots) \simeq 10\% \text{ and } B(B \to D\ldots) \simeq 50\% \text{ gives } \sigma(B\bar{B}) < 100 \text{ nb/nucleon}$$

$$B(B \to \mu\ldots) \simeq 15\% \text{ and } B(B \to D\ldots) \simeq 65\% \text{ gives } \sigma(B\bar{B}) < 50 \text{ nb/nucleon}$$

The different background which can contribute together with beauty to like sign dimuons are :

a) Muons from the beam halo : this contribution is negligible, as one can see from fig. 1 that the number of $\mu^+\mu^+$ events is roughly the same as the number of $\mu^-\mu^-$ events.

b) Muons from π- and K- decays : this contribution is also low, because the vertex distribution of the $\mu^+\mu^+$ events (fig. 2) shows the same ratio between the dump and the platinum target as for $\mu^+\mu^-$ events.

c) $\psi\mu$ events where one of the muons from the ψ is out of the acceptance of the experiment. This contribution should be not negligible since in our data :

$$\psi\mu/\psi \simeq 1.6\ 10^{-3} \text{ and } \mu^\pm\mu^\pm/\psi \simeq 10^{-3}$$

If we could eliminate these events, we should certainly decrease the above limit on the cross-sections.

3. TRIMUON EVENTS

A possible contribution of the trimuon events is the pattern :

$$\pi^- N \rightarrow B\,\bar{B} + X$$
$$\bar{B} \rightarrow \mu^+ \nu + Y$$
$$B \rightarrow \mu^- \nu + Y'$$
$$\qquad\qquad Y' \ni D \rightarrow \mu^+ \nu + Z$$

This pattern leads to the topology $\mu^+\mu^-\mu^\pm$ and we have the following cuts :

a) Two of the μ's must have more than 1 GeV/c transverse momentum (μ_1 and μ_2) and the third more than 0.4 GeV/c transverse momentum. In addition μ_1 and μ_2 must form a $\mu^+\mu^-$ pair (these are supposed to come from the B meson).

b) A cut at 60 GeV/c on the longitudinal momentum of each muon.

The mass spectrum of the $\mu_1\mu_2$ pair is shown in fig. 3 and is dominated by the ψ signal ($\psi\mu$ events). Excluding the region between 2.8 and 3.4 GeV/c^2, one gets above 2 GeV/c^2 55 events for an overall acceptance of 1.2%.

This gives a limit on trimuon cross-section of 0.08 nb/nucleon. With the same assumption as before for the branching ratios, one gets limits for $B\bar{B}$ production between 25 and 80 nb/nucleon.

However, this limit could be decreased, as we still have in our sample contributions of the tail of the ψ.

4. CONCLUSIONS

Using like sign dimuons and trimuons, we have put limits on the naked beauty cross-section for 280 GeV/c pions between 25 and 100 nb/nucleon. This limit should be decreased by a more precise analysis of the data. It is in agreement with limits obtained by the same mechanism for 400 GeV/c protons[(7)] and by $\psi\mu$ events by the CIP collaboration[(8)].

We are now analysing a much higher statistics at 280 GeV/c in order to improve these limits.

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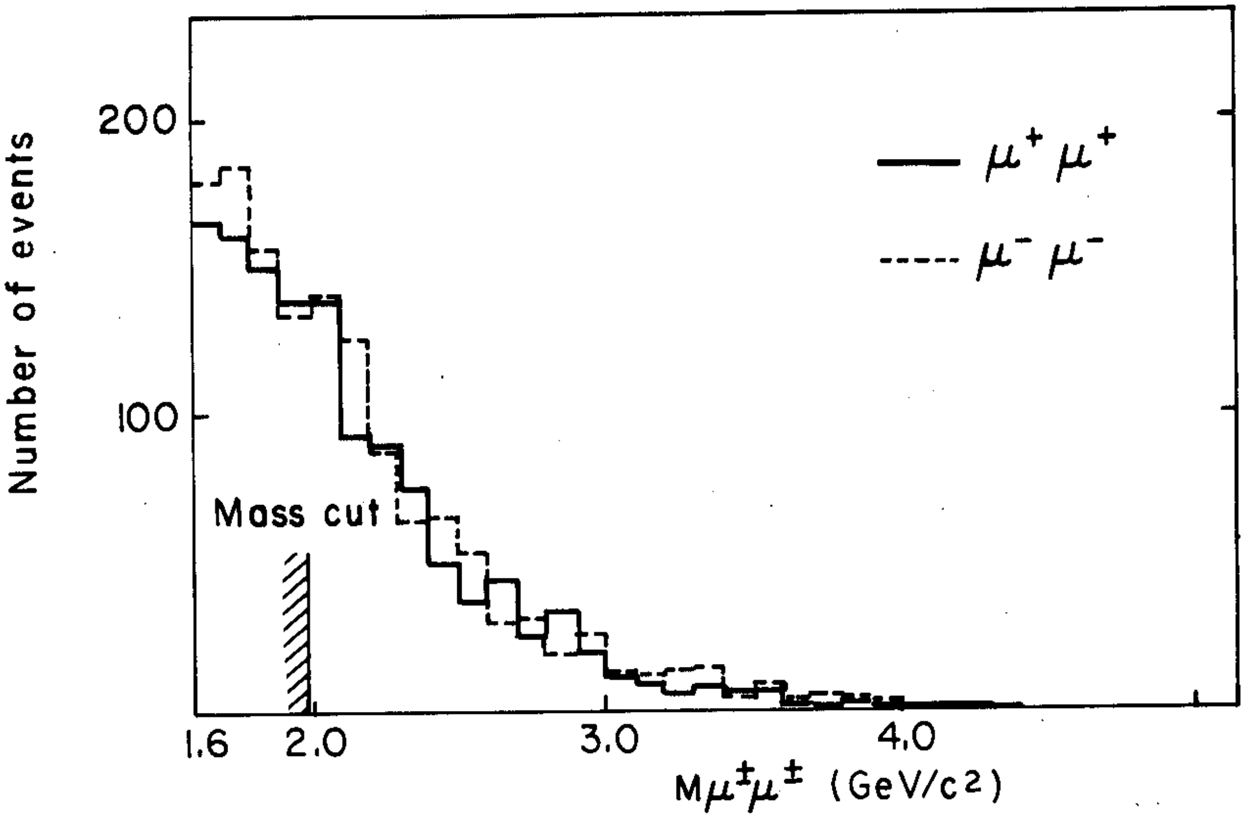


Fig. 1 : Mass spectrum of like sign dimuons.

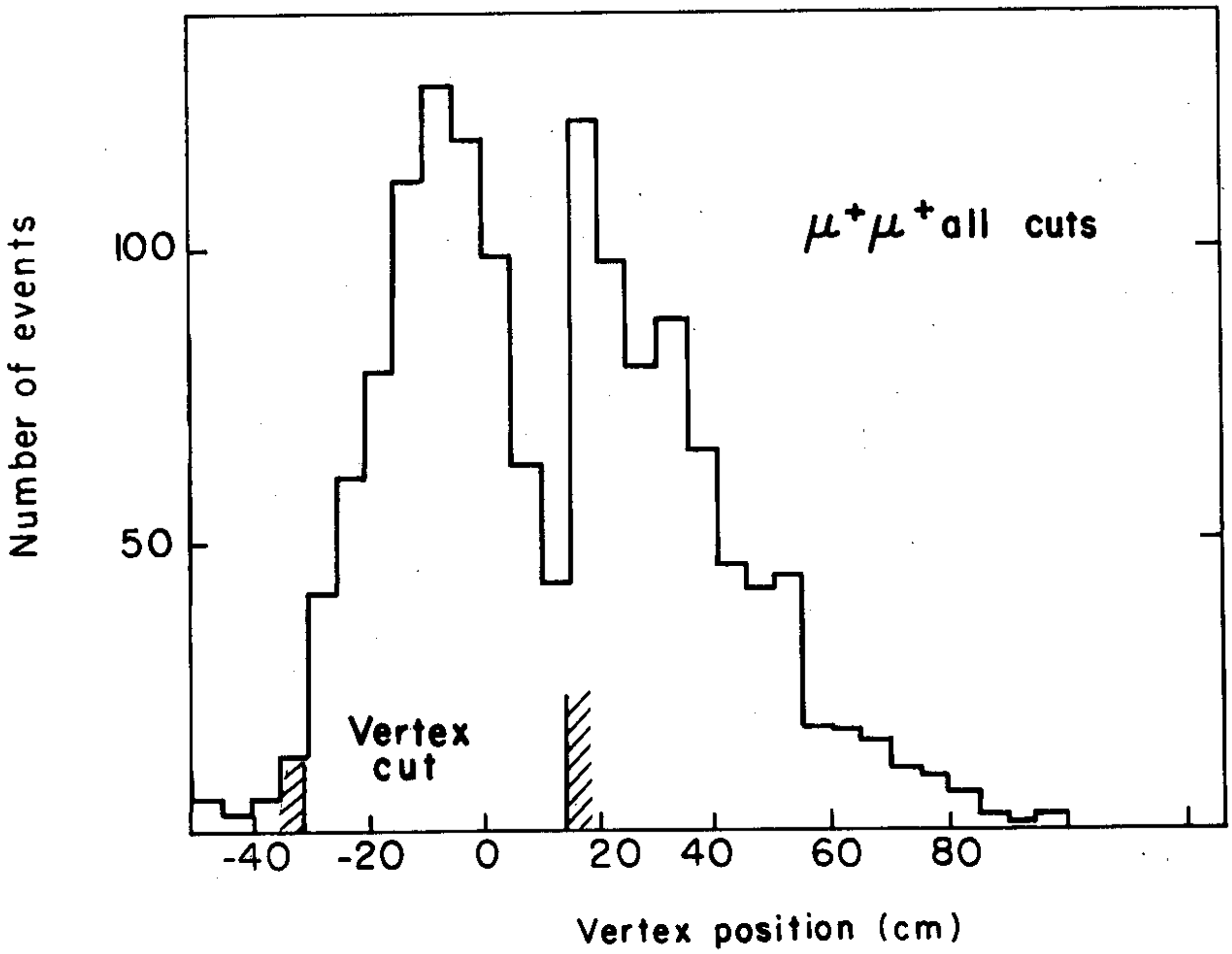
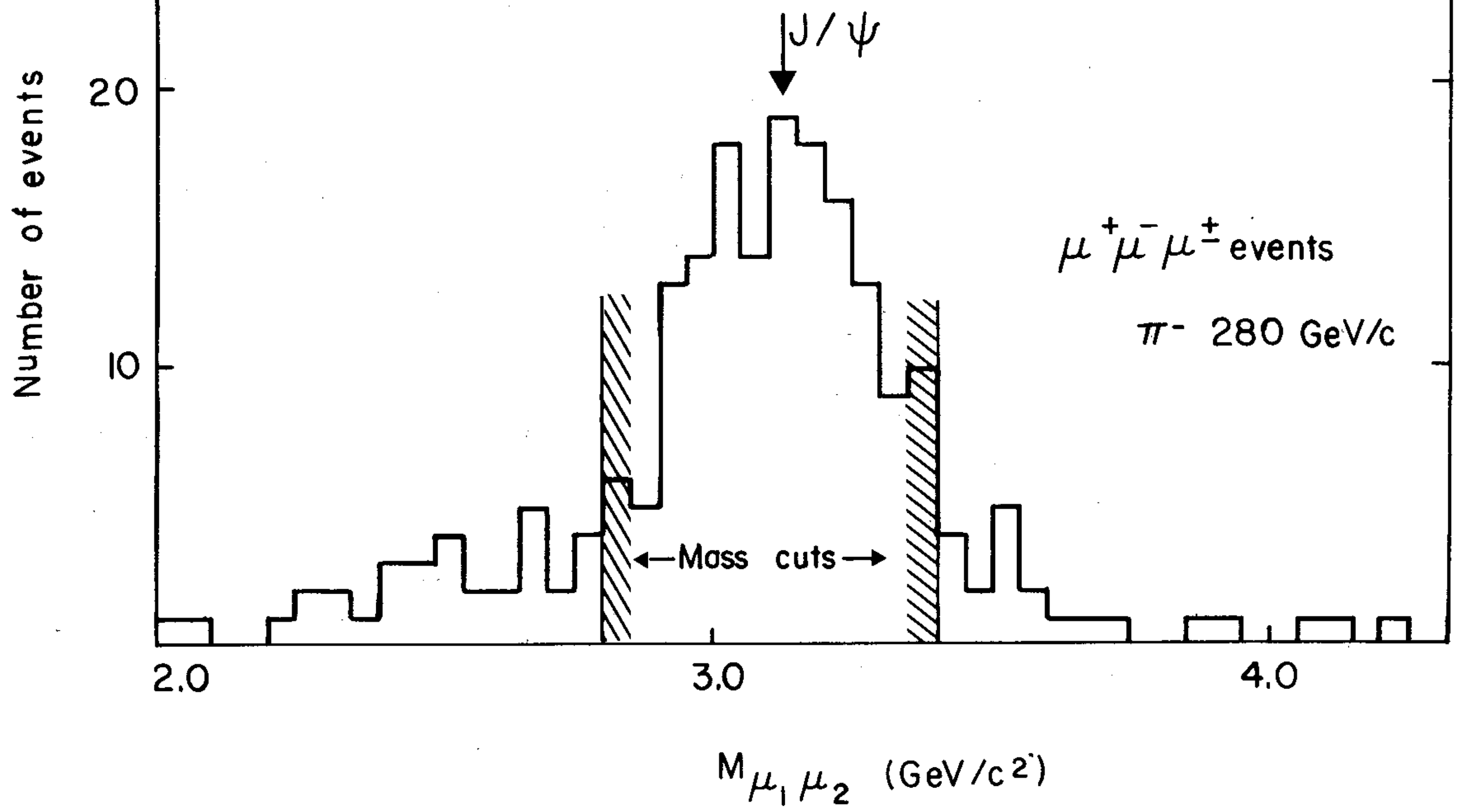


Fig. 2 : Vertex distribution for $\mu^+\mu^+$ events (the platinum target is centered at −9 cm, the dump begins at +38 cm.



<u>Fig. 3</u> : Mass spectrum for the $\mu^+\mu^-$ pair of highest p_t in the trimuon events.

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