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A MEASUREMENT OF THE DIHADRON MASS CONTINUUM IN PROTON-Be COLLISIONS AND A SEARCH FOR NARROW RESONANCES

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A Measurement of the Dihadron Mass Continuum in Proton-Be Collisions and a Search for Narrow Resonances[a]

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We have studied the high mass dihadron continuum in 400 GeV proton-Be collisions over the mass range 4-10 GeV. The experiment was performed at Fermilab using a double arm magnetic spectrometer including Čerenkov particle identification. Mass spectra for all combinations formed with an identified $\pi^{\pm}$, $K^{\pm}$ or $p\,(\bar{p})$ in each arm have been examined. No evidence for resonance production was observed. Results on mass and p_T dependence of the dihadron inclusive cross sections are presented.

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that this analog sum exceed a threshold low mass events were rejected, enabling us to take data at the high luminosities required to search for very massive states.

Data were collected in three overlapping mass ranges with corresponding changes in Čerenkov gas, analyzing magnet current, and beam intensity. For each mode the intensity was limited by the requirement that at the lowest masses for that mode the fraction of arm-to-arm accidentals be less than 50%. For all three modes this fraction decreased rapidly with increasing mass. Misidentification of π, K and p ($\bar{p}$) was always less than 5% (12% for $\bar{p}$), while the identification efficiency was better than 85% for all particles types over the momentum ranges accepted. Checks on particle identification and normalization were made with single arm data taken simultaneously. Our measured ratios of particle species agree to within 10% with those measured by the Chicago-Princeton group[2] at this energy using a Be target. Similarly our single particle inclusive cross sections agree with those of the same group to within our estimated normalization uncertainty of 20%.

Our sensitivity to narrow structures in the mass spectrum was monitored by the simultaneous observation of the J/ψ (3. 1).[3] Detection of the e^+e^- decay mode of this resonance provided experimental checks of both the mass scale and resolution of the apparatus. During this experiment our measured J/ψ mass was 3. 113 (GeV) with an estimated uncertainty of ±30 MeV. Its observed width σ = 0. 48% was consistent with that expected from Monte Carlo calculations. The resolution at terms of $B\frac{d\sigma}{dy}\Big|_{y=0}$. For comparison, the values for the $\mu^+\mu^-$ decay of $J/\psi(3.1)$[3,6] and the recently observed $\Upsilon(9.4)$[7] are also shown. The dihadron acceptance was calculated by a Monte Carlo integration assuming isotropic decay of the dihadron parent system and flat y dependence over our narrow range from -0.2 to +0.3 and using the measured distribution in parent p_T.

In Fig. 2 we plot $\frac{d^2\sigma}{dm\,dy}\Big|_{y=0}$ versus mass m for various particle combinations. The arm-to-arm accidental background, calculated from single arm data taken simultaneously with the pair data, has been subtracted. Corrections for trigger efficiency and π and K decays in flight were made.[8] We estimate the overall normalization uncertainty to be about $\pm 35\%$ and the relative normalization uncertainty between various particle combinations to be about $\pm 15\%$.

We find that these dihadron cross sections, over the mass range 4-10 GeV, cannot be described as a simple exponential $e^{-\alpha m}$. The exponential slopes vary from $\alpha \simeq 2.1$ near masses of 4 GeV to $\alpha \simeq 1.3$ near 10 GeV. Within a factor of 2 the ratios of pair production cross sections for various particle types are as expected from inclusive single particle cross section data.

Finally, results on the p_T dependence of the invariant cross section $E\frac{d^3\sigma}{dp^3}$ are presented in Fig. 3 for various mass regions. The cross sections are plotted for all hadron pairs since identified combinations were found to behave similarly. All spectra exhibit a steepening in slope as the

REFERENCES

[1] D. C. Hom et al., Phys. Rev. Lett. 36, 123 (1976).

[2] Private communication, M. Shochet. See also: J. W. Cronin et al., Phys. Rev. D 11, 3105 (1975).

[3] Results on J/ψ production have been reported previously. See H. D. Snyder et al., Phys. Rev. Lett. 36, 1415 (1976).

[4] Approximately 15% of our data taking time was devoted to searching for doubly charged states. The corresponding sensitivities are similar to those in Fig. 1.

[5] D. Bintinger et al., Phys. Rev. Lett. 37, 732 (1976). Note: The FMP data was obtained with a CH_2 target and presented as a ratio $S_c = \sigma_c B_{hh}/\sigma_{J/\psi} B_{\mu^+\mu^-}$. This ratio has been multiplied by our measured $B_{\mu^+\mu^-} \left.\frac{d\sigma}{dy}\right|_{y=0}$ for J/ψ production from Be.

[6] B. C. Brown et al., Fermilab-77/54-EXP 7100.288.

[7] S. W. Herb et al., Phys. Rev. Lett. 39, 252 (1977).

[8] The HM trigger efficiency was measured using unbiased data triggered by a simple arm-arm coincidence. The efficiency varied slightly for different particle types but was always greater than 50% at the lower edge of each mass range.

[9] J. J. Aubert et al., Phys. Rev. Lett. 35, 639 (1975).

FIGURE CAPTIONS

Fig. 1 The curves show our 4 standard deviation upper limit of $B\frac{d\sigma}{dy}\Big|_{y=0}$ for the production of a narrow dihadron state of mass m. B is the branching ratio for the decay into 2 hadrons. The 2 points give $B\frac{d\sigma}{dy}\Big|_{y=0}$ for $\psi(3.1)$ and $\Upsilon(9.4) \rightarrow \mu^+\mu^-$ for comparison.

Fig. 2 The dihadron production cross sections $\frac{d^2\sigma}{dm\,dy}\Big|_{y=0}$ for hadrons and identified pairs of opposite charge versus mass m.

Fig. 3 The invariant pair cross section as a function of the dihadron p_T for various mass ranges.

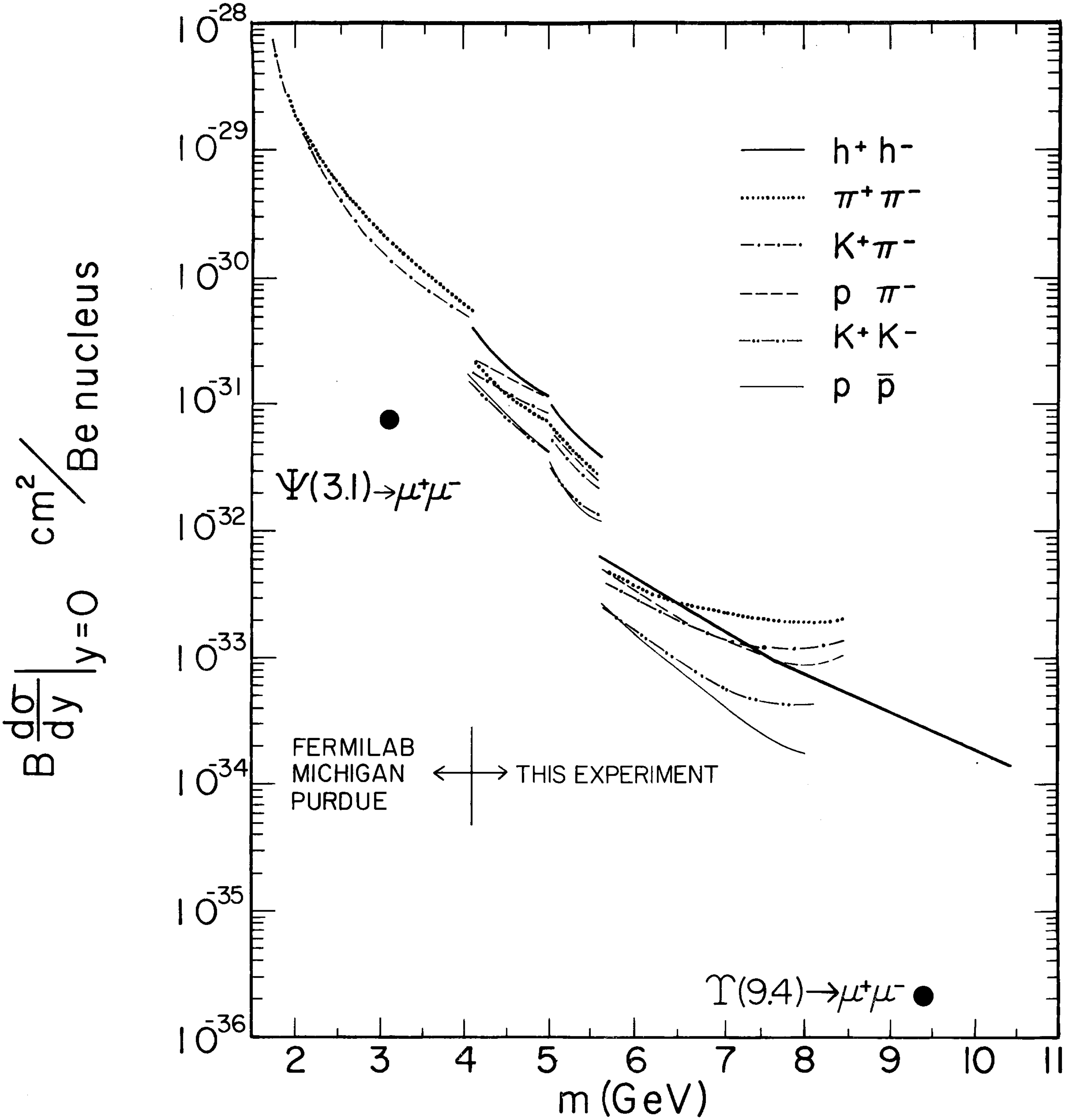
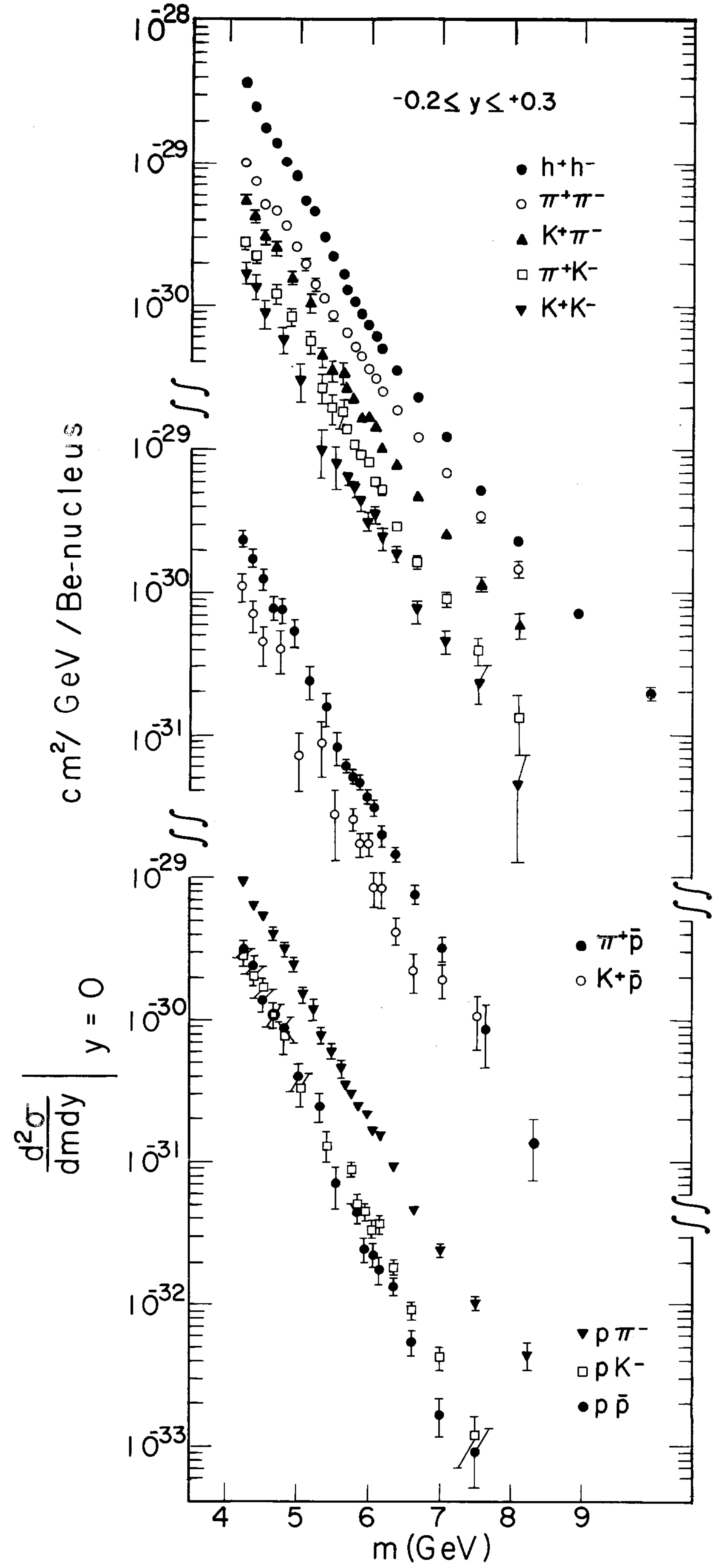

10^{-28}
10^{-29}
10^{-30}
10^{-31}
10^{-32}
10^{-33}
10^{-34}
10^{-35}
10^{-36}
$B\frac{d\sigma}{dy}\Big|_{y=0}$ cm²/Be nucleus
h⁺ h⁻
π⁺ π⁻
K⁺π⁻
p π⁻
K⁺ K⁻
p p̄
Ψ(3.1)→μ⁺μ⁻
FERMILAB
MICHIGAN
PURDUE
THIS EXPERIMENT
ϒ(9.4)→μ⁺μ⁻
2
3
4
5
6
7
8
9
10
11
m (GeV)

Fig. 1



-0.2 ≤ y ≤ +0.3
h+h-
π+π-
K+π-
π+K-
K+K-
π+p̄
K+p̄
pπ-
pK-
pp̄
cm²/ GeV / Be-nucleus
d²σ/dmdy | y = 0
m (GeV)

Fig. 2

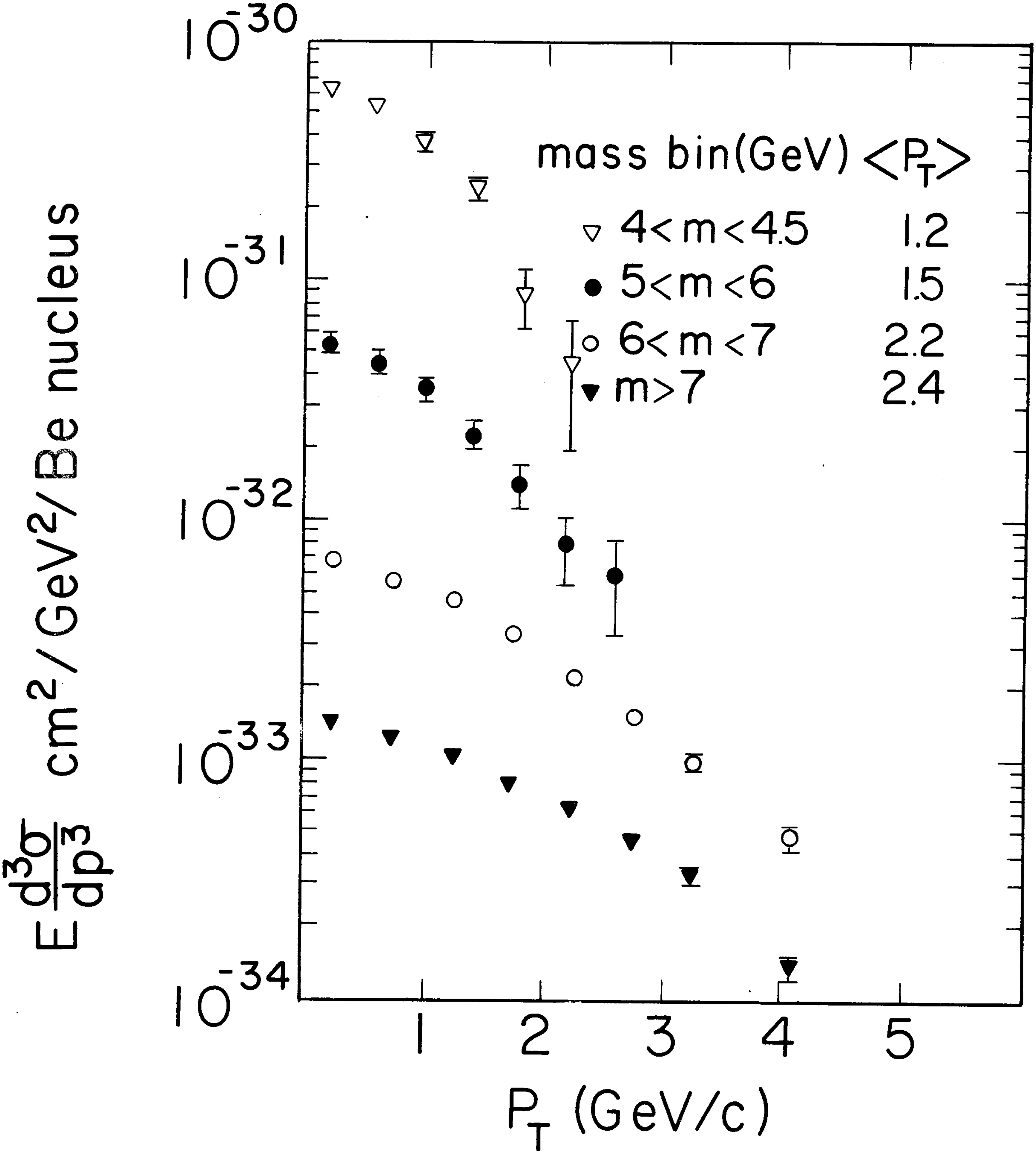

10^{-30}
10^{-31}
10^{-32}
10^{-33}
10^{-34}
$E\frac{d^3\sigma}{dp^3}$ cm^2/GeV^2/Be nucleus
mass bin(GeV) <P_T>
4<m<4.5 1.2
5<m<6 1.5
6<m<7 2.2
m>7 2.4
1
2
3
4
5
P_T (GeV/c)

Fig. 3