SINGLE MUON DISTRIBUTIONS FROM BEAUTY IN 800 GeV/c *pp* INTERACTIONS

David E. Wagoner
Prairie View A&M University
Prairie View, Texas 77446-0355

December, 1987

Abstract

PYTHIA is used to study some of the kinematic distributions for muons from semi-muonic B decays and various backgrounds in 800 GeV/c *pp* fixed target interactions. The backgrounds examined include $B \rightarrow D \rightarrow \mu$ decays, direct $D \rightarrow \mu$ decays, and $\pi/K \rightarrow \mu$ decays.

Discussion

The PYTHIA Monte Carlo program[1] is used to study single muon distributions for beauty production and backgrounds in 800 GeV/c *pp* fixed target interactions. Four sources for single muons are examined:

i) The semi-muonic decay of B mesons.

ii) The decay of $B \rightarrow D\,X$ with the D decaying semi-muonically.

iii) The semi-muonic decay of directly produced D mesons.

iv) The semi-muonic decay and punchthrough[2] of $\pi^{\pm}$ and $K^{\pm}$ mesons from total cross section (*i.e.*, minimum bias) events.

The geometric acceptance used for muons is that of experiment E771[3] which has an outer rectangular aperture of ± 145 mrad $\times$ ± 83 mrad and an inner square beam hole of ± 10 mrad. The lower momentum cutoff used for the muon shield is 6 GeV/c. The decay region used for π and K decay is 13.5 m.

For this analysis, case i) had 4320 $B \rightarrow \mu$ decays thrown, case ii) had 5069 $B \rightarrow D \rightarrow \mu$ decays thrown, case iii) had 39,879 direct $D \rightarrow \mu$ decays thrown, and case iv) was based on 10,000 minimum bias events. In cases i), ii), and iii) all decays are forced to the mode specified and the following figures and table show the number of accepted muons from the total number of forced decays thrown. In case iv) the probability for a $\pi^{\pm}$ or $K^{\pm}$ to decay within the decay region or for it to punchthrough the 6 GeV/c muon shield is calculated for each $\pi^{\pm}$ or $K^{\pm}$ in an interaction and then these individual track decay probabilities are summed for that event to give the overall probability for π/K decay in that interaction. The figures and table showing case iv) are normalized in units of this overall probability/interaction. For case iv) the decay probabilities dominate over the punchthrough probabilities.

Figures 1a)–1d) show the momentum spectrum of muons within the E771 acceptance for cases i)–iv) respectively. Figures 2a)–2d) show the p_T spectrum of muons within the E771 acceptance and with the 6 GeV/c muon shield cutoff. Note that Figures 1d) and 2d) have a logarithmic vertical scale. Figures 3a)–3d) are scatter plots of the angle (θ) of the muon versus its momentum without any cuts imposed. Table 1 shows the accepted fraction of muons per event for the four cases with various kinematic cuts. The mean $\pm$ RMS momentum for the four plots of Fig. 1 are 1a) 36.6 ± 30.5 GeV/c, 1b) 17.6 ± 17.9 GeV/c, 1c) 15.9 ± 15.7 GeV/c, and 1d) 4.0 ± 4.6 GeV/c. The mean $\pm$ RMS tranverse momentum for the four plots of Fig. 2 are 2a) 1.3 ± 0.6 GeV/c, 2b) 0.7 ± 0.4 GeV/c, 2c) 0.6 ± 0.3 GeV/c, and 2d) 0.3 ± 0.2 GeV/c. Finally, the mean $\pm$ RMS angle (θ) for muons having a momentum greater than 6 GeV/c for the four cases is i) 50 ± 40 mrad, ii) 38 ± 32 mrad, iii) 35 ± 29 mrad, and iv) 25 ± 21 mrad.

Conclusions

As expected, muons from semi-muonic B decay are stiffer, have a larger p_T, and come out at a larger angle on average than those muons from other sources. However, these differences between muons from B decay and those from the backgrounds are not as large as one might wish in order to efficiently select or

Table 1: Probability for finding a muon produced from beauty and various muon backgrounds as a function of different kinematic cuts.

	Fraction of Muons in E771 acceptance and			
Decay	No p cut	p > 6 GeV/c	p > 9 GeV/c	p > 21 GeV/c
$B \to \mu$	0.691 / B	0.664 / B	0.623 / B	0.428 / B
$B \to D \to \mu$	0.703 / B	0.549 / B	0.429 / B	0.195 / B
$D \to \mu$	0.674 / D	0.508 / D	0.390 / D	0.164 / D
$\pi/K \to \mu$	0.211 / Int	0.043 / Int	0.020 / Int	0.003 / Int
	Fraction of Muons in E771 acceptance and p > 6 GeV/c and			
Decay	No p_T cut	p_T > 0.5 GeV/c	p_T > 1.0 GeV/c	p_T > 1.5 GeV/c
$B \to \mu$	0.664 / B	0.615 / B	0.426 / B	0.203 / B
$B \to D \to \mu$	0.549 / B	0.323 / B	0.092 / B	0.032 / B
$D \to \mu$	0.508 / D	0.278 / D	0.059 / D	0.009 / D
$\pi/K \to \mu$	0.043 / Int	0.006 / Int	0.0002 / Int	0.00002 / Int
	Fraction of Muons with p > 6 GeV/c and			
Decay	No θ cut	θ > 10 mrad	θ > 80 mrad	θ > 150 mrad
$B \to \mu$	0.838 / B	0.759 / B	0.182 / B	0.036 / B
$B \to D \to \mu$	0.659 / B	0.576 / B	0.071 / B	0.009 / B
$D \to \mu$	0.625 / D	0.530 / D	0.053 / D	0.005 / D
$\pi/K \to \mu$	0.058 / Int	0.044 / Int	0.0015 / Int	0.00007 / Int

trigger on muons from B decay only. The chief muon background in terms of the total number of muons is that from π/K decay and punchthrough. In order to retain as many muons from semi-muonic B decay as possible and reject as many muons from π/K decay as possible one would like large angular acceptance out to 100–150 mrad and a moderately thick muon shield of 6–9 GeV/c stopping power. In addition a cut on p_T of 1 GeV/c is quite efficient at eliminating nearly all the muons from π/K decay, while only rejecting approximately half the muons from semi-muonic B decay. This p_T cut also rejects to a lesser degree muons from semi-muonic D's produced either directly or from a B cascade decay. It is clear that in any scheme to trigger on semi-muonic B decays, the ability to trigger on the p_T of the muon in the 0.5–1.0 GeV/c region will be a very useful tool in addition to the other triggers that one may use to trigger on B mesons in general (such as displaced vertex or multiplicity jump triggers).

References

1. PYTHIA 5.1 and JETSET 6.3 versions were used.
   H. U. Bengtssen and G. Ingelman, Computer Phys. Comm. **34** (1985) 251; T. Sjöstrand, Computer Phys. Comm. **39** (1986) 347.

2. A. Bodek, University of Rochester preprint UR 911 (1985).

3. Fermilab Proposal E771 (1986).

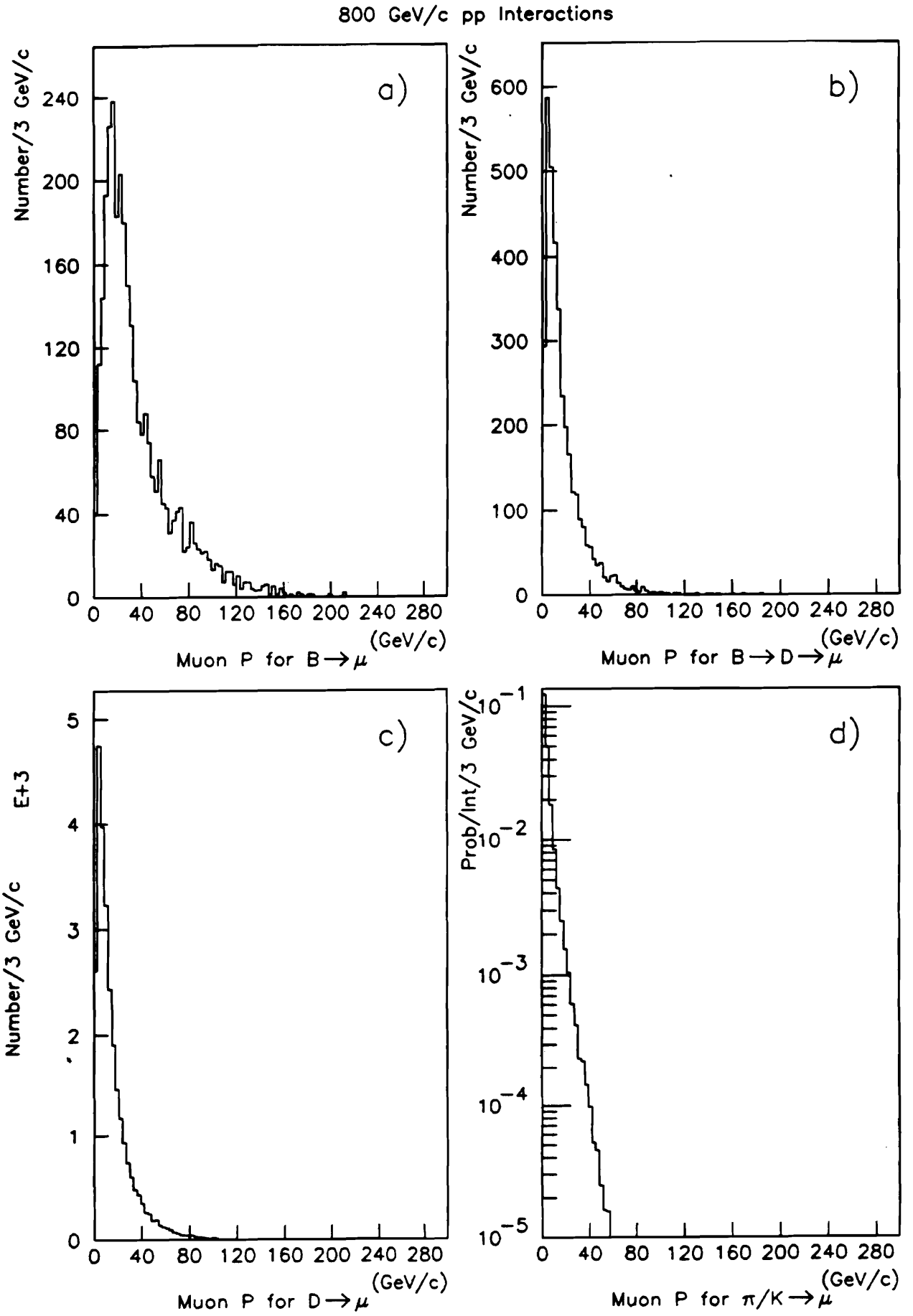

Fig. 1 Momentum of muons into E771 aperture for a) semi-muonic B decay, b) $B \to D \to \mu$ decay, c) semi-muonic decay of directly produced D mesons, and d) muons from π/K decay and punchthrough. Note that the ordinate of d) is logarithmic.

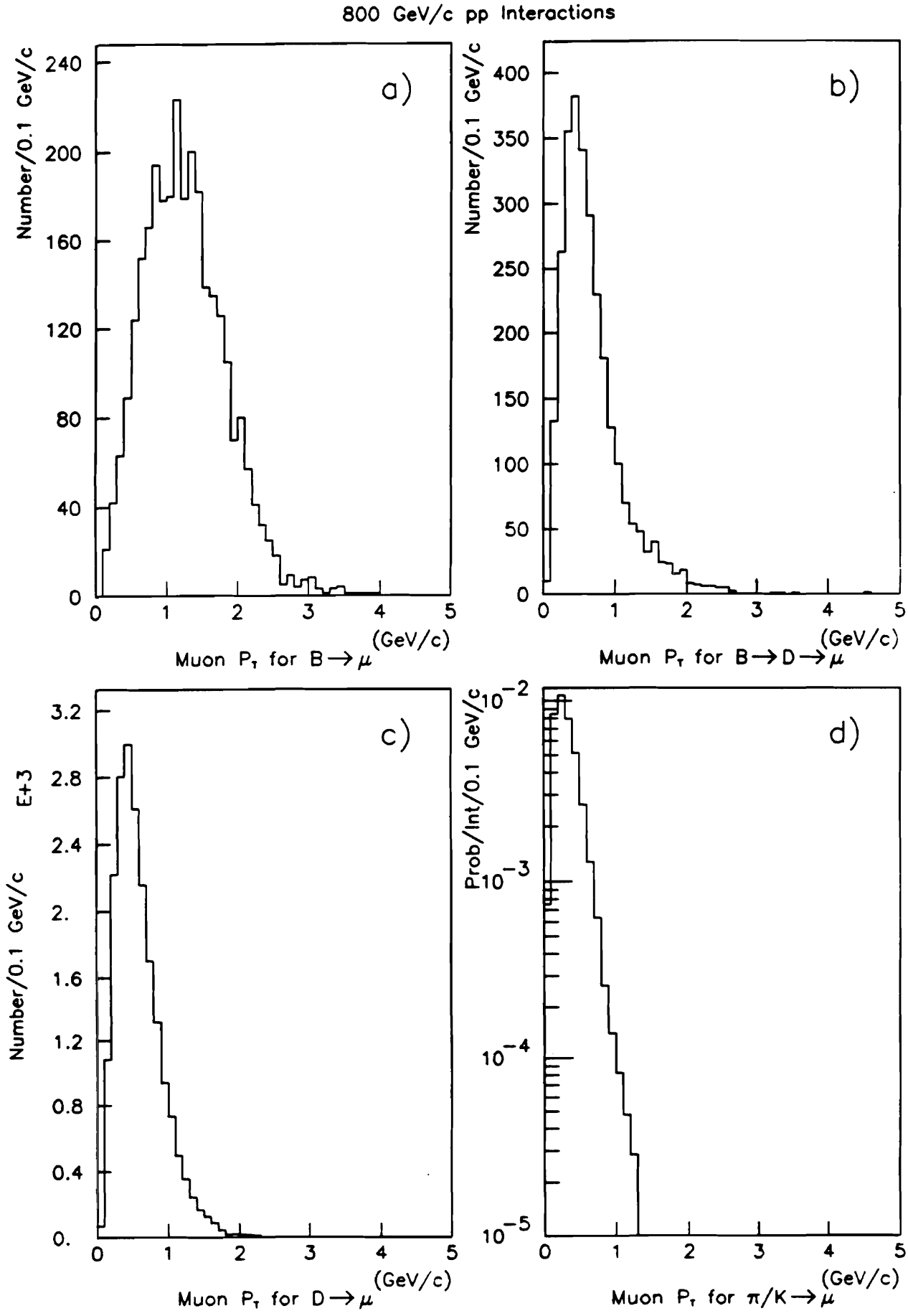

Fig. 2 Tranverse momentum of muons into E771 aperture and with momentum greater than 6 GeV/c for a) semi-muonic B decay, b) $B \rightarrow D \rightarrow \mu$ decay, c) semi-muonic decay of directly produced D mesons, and d) muons from π/K decay and punchthrough. Note that the ordinate of d) is logarithmic.

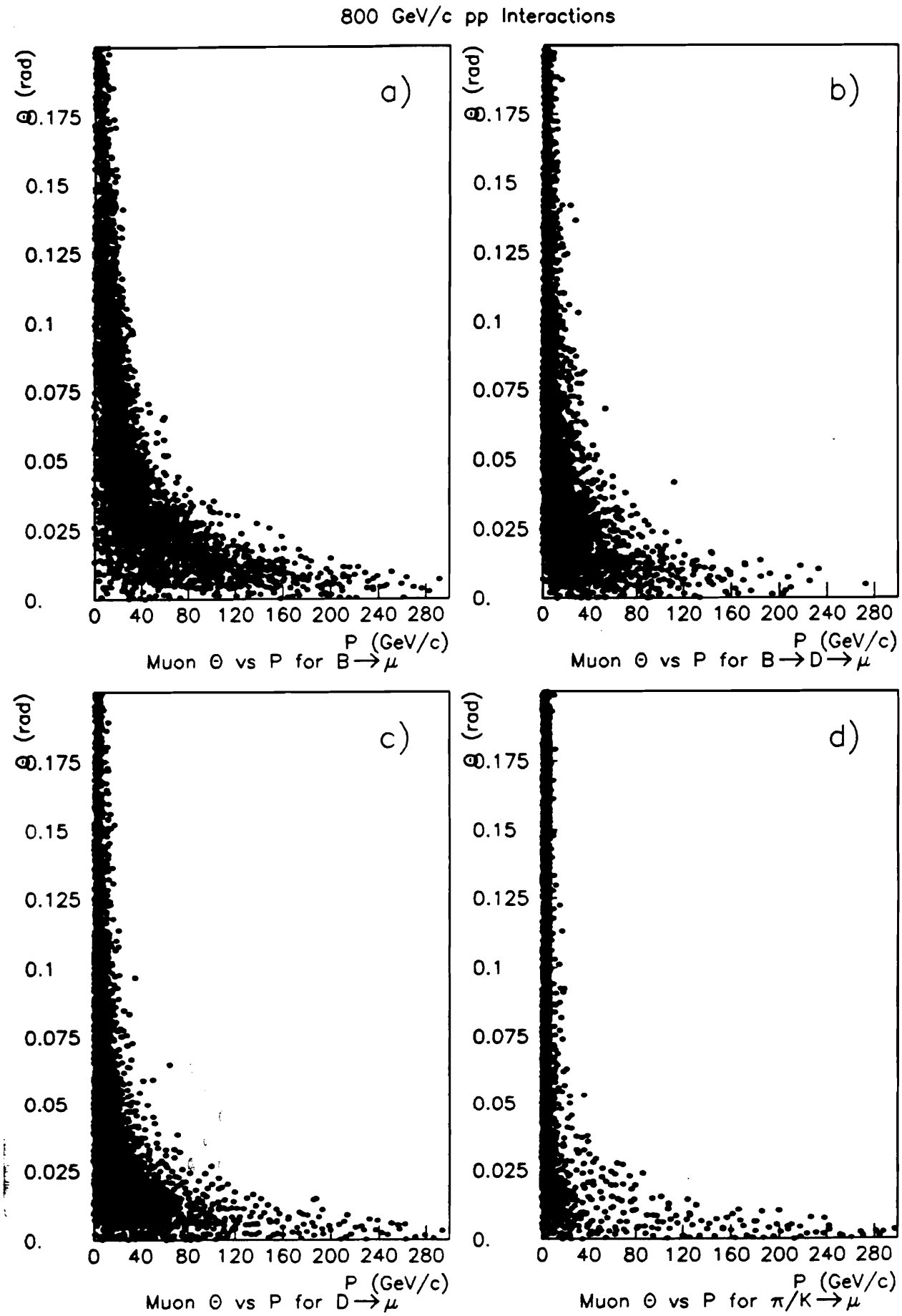

Fig. 3 Scatter plot of θ of the muon versus its momentum for a) semi-muonic B decay, b) $B \to D \to \mu$ decay, c) semi-muonic decay of directly produced D mesons, and d) muons from π/K decay and punchthrough. No aperture or momentum cuts are imposed.