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Comparison of Experimental Data with MC Simulated in PYTHIA and ISAJET

E. Kozlovsky

Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510

and

Institute for High Energy Physics
Protvino, Moscow Region 142284, Russia

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E. Kozlovsky

Fermi National Accelerator Laboratory

P. O. Box 500, Batavia, Illinois 60510, U. S. A.

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Abstract

The phenomenological extrapolative formula has been obtained for total jet cross sections from UA1 data. Experimental inclusive charged differential cross sections are compared with those MC in TeV energy range ($\sqrt{s} = 0.2 \div 1.8\, TeV$).

1 Introduction

In this paper I make an attempt to determine algorithm giving a Monte-Carlo (MC) sample from soft and jet events which describes the experimental data at TeV energies.

In the second section, phenomenological extrapolative formula was found for UA1 total jet cross section[1]. This formula is also used to estimate the jet cross section at D0 energy. In the third section, a set of experimental UA5[2],UA1[3] and CDF[4, 5] charged multiplicity data as a function of pseudorapidity (η) and transverse momenta (p_t) has been analysed. A comparison of these data with the predictions of a MC PYTHIA, version 5.6[6] and ISAJET[7, 8] was made. This analysis gives the fraction normalized constants of jet events from a MC sample.

2 Total inelastic and jet cross sections

Experimental inelastic cross section (σ_{inel}) is usually calculated according to

$$\sigma_{inel} = \sigma_{tot} - \sigma_{el} \ , \tag{1}$$

where $\sigma_{tot}, \sigma_{el}$ are total and elastic cross sections accordingly. The total and elastic cross sections for various energies of TeV range have been found empirically[9, 10, 12] or semiempirically[11]. As a rule in the cited experiments single-diffractive (SD) events are rejected. PYTHIA package was used to estimate SD cross sections. The obtained results are given in Table 1.

The total jet cross sections have been measured for various energies $\sqrt{s}$ in UA1 experiment[1]. The energy behaviour of these data may be parameterized by the following phenomenological formula:

$$\sigma_{jet} = A(\sqrt{s})^{\xi} \ , \tag{2}$$

where A,ξ are the fit parameters. The fit of experimental data with (2) shows that the slope ξ is equal to 0.98 ± 0.16, but A and ξ correlation is large. For the fixed $\xi = 1.0$ I have obtained the following values A=0.02 mb/GeV and $\frac{\Delta A}{A} = 6.5\%$ at $\frac{\chi^2}{NDF} = 0.03$, where NDF is *degrees of freedom.* The UA1 data and the fitted curve for $\xi = 1.0(fixed)$ are shown in Fig.1; the expected jet cross section is $\sigma_{jet} = 36.0 \pm 2.4$ mb at $\sqrt{s} = 1.8$ Tev (Tab.1). The corresponding cross sections for other energies are given in Table 1 too. The analysis of the tabulated values shows that jet events make up a considerable fraction of total inelastic cross section and this fraction increases with $\sqrt{s}$.

The theoretical jet cross sections at UA1 energies were calculated in [14] for example. These values can also be obtained with PYTHIA, ISAJET MC packages. However these characterististics depend on the choice of minimum and maximum values of $\hat{q}_t$, which is transverse momentum of outgoing partons which are produced in $2 \to 2$ scattering subprocesses. The minimum and maximum values of kinematical parameter $\hat{q}_t$ are the external characteristics of ISAJET and PYTHIA.

In this paper two different basic assumptions concerning $\hat{q}_t^{min}$ are made in order to obtain total cross sections of jet events and inclusive differential ones.

The first idea is the following: $\hat{q}_t^{min}$ is a function of $\sqrt{s}$. In reference[15] a set of $\hat{q}_t^{min}$ values for a wide energy range is proposed. I found that the relation between these variables is described by

$$\hat{q}_t^{min}[GeV] = 2.95 \ (\ \sqrt{s} \ [TeV] \ )^{0.23} \tag{3}$$

and the results for some energies are demonstrated in Table 2. The MC σ_{jet} corresponding to these $\hat{q}_t^{min}$ are included into Table 2 also.

The second idea is that: if for any $\hat{q}_t^{min}$ MC jet cross sections are approximately according to UA1 extrapolative one then this value of $\hat{q}_t^{min}$ is correctly. For this case the $\hat{q}_t^{min}$ has been estimated to be about 2.5 GeV and doesn't depend on $\sqrt{s}$. The calculated jet cross sections for this value of $\hat{q}_t^{min}$ parameter are shown in Table 4.

The $\hat{q}_t^{max}$ values are restricted only by the energy conservation and requirements of MC generators.

3 Charged multiplicity

In this section is devoted to comparison of experimental differential cross sections and MC simulated ones. It should be noted that MC generation utilized the information about a loss of events which fail to trigger and kinematical cuts for the corresponding experiments.

3.1 *Pseudorapidity distribution*

Differential cross sections are related to each other by the basic formula (Appendix A)

$$\left\{\frac{1}{\sigma_{\rm NSD}}\frac{{\rm d}\sigma^{\pm}}{{\rm d}\eta}\right\}_{\rm exp.data} = \alpha \left\{\frac{1}{\rm N_{jet}}\frac{\rm dN^{\pm}}{{\rm d}\eta}\right\}_{\rm jet} + (1-\alpha)\left\{\frac{1}{\rm N_{soft}}\frac{\rm dN^{\pm}}{{\rm d}\eta}\right\}_{\rm soft} \tag{4}$$

where $\alpha = \sigma_{jet}/\sigma_{inel}$ and $0. \leq \alpha \leq 1.$; and the jet and soft indexes correspond to jet and soft events accordingly. And σ_{NSD} is cross section of minibias events. If we consider

$$\sigma^{*}_{inel} = \sigma_{inel} - \sigma_{SD}$$

and compare σ^{*}_{inel} *and* σ_{NSD} (Tabl.1), it is clear that these cross sections lie within *one-two standard-deviations* one from the other.

This paper I demonstrate only comparisons of minibias experimental data and MC NSD events. Analogous comparison may be made for inelastic sample, but these experimental data are available for UA5 only. I've estimated the mentioned UA5 inelastic sample and drawn the conclusions similar to those for NSD events.

For this paper the differential inclusive cross sections $\left\{\frac{1.}{N_{jet,soft}} \frac{dN^{\pm}}{d\eta}\right\}_{jet,soft}$ are obtained by ISAJET and PYTHIA MC packages. The N_{jet} *or* N_{soft} are total evidence numbers of MC jet and soft events accordingly. These quantities depend on trigger conditions of real experiments (for example, see ref.[2]-[4]).

The MC differential distributions are presented as histograms. The comparison of histograms and experimental data is one of the tasks of statistical methods of mathematics[16]. Several methods are available for this purpose. Algorithm used in this paper is described in Appendix B.

3.1.1 ISAJET

First, in accordance with recommendations given in ref. [15] I have found from (3) a $\hat{q}_t^{min}$ value for the studied energies. The simulated TWOJET events for this $\hat{q}_t^{min}$ and

MINIBIAS[1] were smoothed with algorithm given in Appendix B.The obtained curves are used for fitting of experimental data with (4). The results of the fit are shown in Fig.2a and Table 2. It is clear that only the CDF data are described well where $\chi^2/NDF \sim 1.06$. However the fraction of jet events is about ten times less than that expected for UA1 extrapolation. If the major part of evidence events are supposed to be MINIBIAS then

$$\left\{\frac{1}{\sigma_{\rm NSD}}\frac{{\rm d}\sigma^{\pm}}{{\rm d}\eta}\right\}_{\rm exp.data} = {\rm k}\left\{\frac{1}{{\rm N_{MB}}}\frac{{\rm dN}^{\pm}}{{\rm d}\eta}\right\}_{\rm MB} \quad (5)$$

For this case the values of k and χ^2/NDF are given in Table 3. Fig.2b illustrates the fitted results. Satisfactory results are obtained at $\sqrt{s} = 0.2$ TeV ($\chi^2/NDF \sim 1.3$) only. For this case the renormalizing constant is k=0.93. Therefore the MINIBIAS multiplicity approximately 7% exceeds the real data[2].

Second, the set of data for TWOJET events was generated with $\hat{q}_t^{min} = 2.5$ GeV for all energies. The obtained jet cross sections are presented in Table 4. After smoothing of MC data and fitting of the experimental ones the satisfactory results were obtained for CDF only (Fig.2c). But this result isn't in accordance with UA1 extrapolated total jet cross sections. The obtained values of α with corresponding cross sections are given in Table 2.

3.1.2 PYTHIA

Studies of jet cross section similar to those presented in section 3.1.1 have been carried out with PYTHIA program. In Table 2 the corresponding $\hat{q}_t^{min}$, σ_{jet} and α parameters

[1] I suppose that soft events are reproduced by the MC MINIBIAS ISAJET generator.

[2] I should like to point out that here the CDF trigger conditions[4] were included.

are given for PYTHIA MC package. While generating soft events I have chosen the option which switches off the key of multiple parton interactions[3] and it results in strictly low-p_t events. This procedure enables the separation of (semi)hard and soft physical processes.

The fitted results are shown in Fig.3a. Satisfactory agreement between experimental and generated data is observed for $\sqrt{s}$=0.9 and 1.8 TeV. For data at $\sqrt{s}$=0.546 TeV χ^2 is about 4.7 (Tab. 2), however as it is seen from Fig.3a the smoothed curve characterizes the experimental cross sections fairly well. The data at $\sqrt{s}$=0.2 TeV are not described by MC PYTHIA. The corresponding values of α are also given in Table 2.

The results for the case of $\hat{q}_t^{min}$=2.5 GeV*(fixed)* are illustrated in Fig.3b and the numerical values are given in Table 4.

For both algorithms of $\hat{q}_t^{min}$ choice I obtained the jet cross sections about 50% and more for examined energies. This agrees with UA1 results (Tabl.1) at energies $\sqrt{s}$=0.9-1.8 TeV only.

3.2 *Transverse momentum distribution*

In this section I use the CDF invariant p_t cross sections[5] which are determined at $\sqrt{s}$ = 1.8 TeV for kinematical region:

- $|\eta| < 1.$ and
- $p_t > 0.4$ GeV

[3]MSTP(82)=0 (see page 107,[6])

and those measured in UA1[3] at $\sqrt{s} = 0.546$ TeV:

- $|\eta| < 2.5$ and
- $p_t > 0.3$ GeV.

In the original paper the following analytical function was applied for smoothing of the experimental data

$$E\frac{d^3\sigma^\pm}{d^3\mathbf{p}} = \frac{A}{(1 + p_t/p_0)^\gamma} \tag{6}$$

where A,γ are fit parameters, presented in Table 4. Using these curves I compare the MC data and the experimental results. This analysis is based on TWOJET events which are generated with $\hat{q}_t^{min} = 2.5$ GeV; samples for each type of MC class make up about 500K events equally in ISAJET and PYTHIA simulations.

3.2.1 ISAJET

The invariant differential cross sections for TWOJET and MB ISAJET events for $|\eta| < 1.$ at $\sqrt{s} = 1.8$ TeV are demonstrated in Fig.4a, which presents $\left\{\frac{E}{N_{jet,MB}}\frac{d^3n^\pm}{2d^3p}\right\}_{jet,MB}$ as a function of p_t. The CDF original data normalized to σ_{NSD} and the fitted ones are given too. It is evident, that the TWOJET events of the MC simulated ones are enough for satisfactory agreement with experimental data. Fig.4b where

$$R_{MC} = (E\frac{d^3\sigma}{d^3p})_{MC} \times \frac{(1 + \frac{p_t}{p_0})^\gamma}{B} \tag{7}$$

is plotted seems more demonstrative to me. Parameter $B = \frac{A}{\sigma_{NSD}}$ (Tabl.5) and A is taken from ref.[5]. Fig.4b shows that MC TWOJET data really describe the region

$p_t > 1$ GeV, if errors are taken into consideration (about 17% at $p_t \sim 5$ GeV and 35% at $p_t \sim 9$ GeV).The gray region shows the one standard deviations of ratio from unity, which are calculated for CDF experimental data. The curves result from smoothing procedure (Appendix B) for ratio of MC and experimental data. I must make a remark concerning these ratios. These are really equal to the ratios of inclusive cross sections of charged particles which are obtained from CDF experiments and MC ones. Therefore I can write the following equation which connects these distributions (analogous to Appendix A)

$$1. = \alpha R_{twojet} + (1. - \alpha) \times R_{soft} \tag{8}$$

where $R_{twojet,soft}$ are determined by (7) and shown in Fig.4b. After fitting (8) I have α parameter equal to 0.90 ± 0.18 with $\frac{\chi_2}{NDF} = 0.07$, therefore $\sigma_{jet} = 38.7mb$.

There is another way to estimate jet cross section. If one supposes[4] that differential p_t cross section for $p_t < 0.4$ GeV behaves like the one for $p_t > 0.4$ GeV , then total inclusive cross section for charged particles

$$\sigma^{\pm}_{incl} = 2. \times 2\pi \times \int_{0.}^{1.} d\eta \int_{0.}^{10.} (1 + p_t/p_0)^{-\gamma} p_t dp_t$$

constitutes about 207.0 mb. If average TWOJET charged multiplicity may be taken for rough estimate of these values at η =0.(Tab.6) then from $\sigma_{jet} = \frac{\sigma_{incl}}{<n^{\pm}>}$ one obtains the jet total cross section equal to about 29.0 mb. It is evident that this estimates showing the large fraction of jet demonstrate satisfactory agreement with the one obtained in section 3.1.2. for PYTHIA (Tab.2).

[4]note that it is rough description

Further, it is necessary to note that in the range $0.4 < p_t < 1.6$ GeV the MC TWOJET charged multiplicity exeeds experimental data. This region is about 42% of total inclusive cross section of charged particles. I have considered this region specially. First, interpolations of R_{MC} are made with linear dependence

$$R_{MC} = a - b \times p_t$$

where $a_{twojet} = 2.40$ and b_{twojet}=0.82 and $a_{MC} = 1.42$ and b_{MC}=0.89 for $0.4 < p_t < 1.5$ GeV. Therefore using (8) I may obtain

$$\alpha = \frac{0.89p_t - 0.42}{0.98 + 0.07p_t}$$

and values of jet fraction are 2.5% and 45% for p_t=0.5 GeV and p_t=1 GeV respectfully. Therefore it is possible that estimates of jet cross sections would change if all p_t interval is included into analyses.

The result of the UA1[3] data analysis is shown in Fig.5. Here also TWOJET events generated at $|\eta| < 2.5$ provide a better description; but TWOJET MC points lie systematically above the experimental ones.

The rough estimate of fraction of jet cross sections with (8) gives $\alpha = 0.56 \pm 0.09$.

3.2.2 PYTHIA

Analogous scenario (section 3.2.1) has been used for MC PYTHIA simulation. The results are given in Fig.5 and Fig.6. The analysis of these data demonstrates satisfactory agreement of experimental distributions and the MC TWOJET generated ones for the studied kinematical regions. Estimates of α with (8) are about 88% and 62% for CDF and UA1 experiments respectfully.

4 Conclusions

The basic conclusions have been already drawn in the text and in this section I should like to emphasize the results for $\sqrt{s} = 1.8$ TeV because of their special interest to me.

The obtained UA1 extrapolation of total jet cross section shows that the jet fraction is about 84% minibaias(Non Single Diffractive) events for $\sqrt{s} = 1.8$ TeV. This value is in satisfactory agreement with the PYTHIA estimate (64-88%) yielding from CDF experimental data fit with the sum of twojet and soft MC distributions, where normalized constants are fitting parameters.

The satisfactory agreement with the ISAJET results is achieved only in case when the jet event contribution is $6 - 8\%$ (for difference $\hat{q}_t^{min}$) for η-distributions. But it contradicts the estimates taken from p_t-distributions where this fraction is about 90%. It may be explained by the fact that ISAJET gives for small p_t larger multiplicity of charged particles then may be attained in practice.

Our results for PYTHIA point out the leading role of (mini)jet processes and are in accordance with analogous studies of other authors, see ref.[17]-[19] for example.

This study provides estimates for values of kinematical limits and fraction of jet events for MC minibias sample which may be used for statistical background separation in research of muon b,c decay, where inflight decay of charged pion and kaon contributes to background processes.

Acknowledgements.

I thank S.Wimpenny, E.Levin and D.Green for fruitful discussion.

Table 1. The total, (in)elastic, single diffractive and jet cross sections.

$\sqrt{s}$, (TeV)	σ_{tot}, (mb)	σ_{el}, (mb)	σ_{SD}, (mb)	σ_{inel}, (mb)	σ^{NSD}, (mb)	σ^{UA1}_{jet}, (mb)
0.2	52.4	9.86	11.29	42.54	31.25	
				41.8 ± 0.6 [11]	34.7 ± 1.7 [1]	4.1 ± 0.8 [1]
0.546	61.3	12.8	14.0	48.5	34.5	
	61.8 ± 1.5 [12]				39.3 ± 2.1 [1]	10.4 ± 2.0 [1]
0.9	66.62	14.64	15.37	51.98	36.61	
	$65.3 \pm 0.7 \pm 1.5$ [11]			$50.3 \pm 0.4 \pm 1.0$ [11]	43.5 ± 2.1 [1]	17.5 ± 3.6 [1]
1.8	74.8	17.6	17.25	57.2	40.	36.0 ± 2.4*
					43 ± 6 [5]	
	72.0 ± 3.6 [10]	16.5 ± 1.3 [10]				
	72.1 ± 3.3 [9]	16.6 ± 1.6 [9]	11.7 ± 2.3 [9]		43.8 ± 4.3	

* - The value is calculated in section 2.

Table 2. The "hard" parameter ($\hat{q}_t^{min}$), total jet cross sections (σ_{jet}) and α parameters.

$\sqrt{s}$, TeV	$\hat{q}_t^{min}$, GeV	σ_{jet}, mb		$\alpha(\%)$, χ^2/NDF		$\alpha\sigma_{NSD,exp}$, mb	
		ISAJET	PYTHIA	ISAJET	PYTHIA	ISAJET	PYTHIA
0.2	2.02	9.02	8.47	10^{-4} 7.25	51.0 ± 0.9 4.17	-	17.69 ± 0.88
0.546	2.56	12.11	11.	10^{-5} 54.89	51.6 ± 0.4 4.7	-	20.27 ± 1.01
0.9	2.87	14.19	12.8	10^{-5} 18.98	53.7 ± 0.5 1.48	-	23.36 ± 1.17
1.8	3.39	17.20	15.35	7.0 ± 1.2 1.06	$64. \pm 1.$ 0.88	3.1 ± 0.7	27.52 ± 2.75

Table 3. The normalized constants k for MC ISAJET MINIBIAS events.

$\sqrt{s}$,TeV	0.2	0.546	0.9	1.8
k	0.93 ± 0.01	0.908 ± 0.003	0.94 ± 0.01	1.06 ± 0.01
χ^2/NDF	1.3	13.3	10.3	0.58

Table 4. The total jet cross sections (σ_{jet}) and α parameters for fixed $\hat{q}_t^{min}$=2.5 GeV.

$\sqrt{s}$, TeV	σ_{jet}, mb		$\alpha(\%)$, χ^2/NDF		$\alpha\sigma_{NSD,exp}$, mb	
	ISAJET	PYTHIA	ISAJET	PYTHIA	ISAJET	PYTHIA
0.2	4.35	4.07	10^{-6} 7.26	$46. \pm 0.8$ 6.81	-	15.96 ± 0.83
0.546	12.96	11.81	10^{-6} 54.	52.1 ± 0.4 4.54	-	20.47 ± 1.11
0.9	20.36	18.13	10^{-6} 18.9	58.0 ± 0.6 1.58	-	25.23 ± 1.25
1.8	35.79	31.45	8.5 ± 1.0 0.7	72.9 ± 1.2 0.25	3.66 ± 0.67	31.33 ± 4.40

Table 5. The fitted parameters obtained for experimental invariant p_t distributions from UA1 and CDF.

$\sqrt{s}$,TeV	interval p_t, GeV	A,mb	B=$\frac{A}{\sigma_{NSD}}$	γ	p_0,GeV
0.546	0.3 - 10 $\|\eta\| < 2.5$	$470. \pm 10.$ [3]	10.9	9.14 ± 0.90 [3]	1.30 ± 0.20 [3]
1.8	0.4 - 10 $\|\eta\| < 1.$	$450. \pm 10.$ [5]	11.5	8.28 ± 0.02 [5]	$1.30(fixed)$ [5]

Table 6. The average multiplicity of MC events at η=0. (TWOJET $\hat{q}_t^{min}$ =2.5 GeV).

	$\sqrt{s}$,TeV	0.2	0.546	0.9	1.8
ISAJET	*TWOJET*	5.86	6.54	6.70	7.13
	MB	2.74	3.22	3.33	3.67
PYTHIA	*TWOJET*	4.20	4.49	4.64	4.75
	soft	1.37	1.49	1.46	1.54

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Appendix A

I should like to remind the fundamental formulas.

First, the relation between total inelastic cross sections is the following

$$\sigma_{inel} = \sigma_{inel}^{jet} + \sigma_{inel}^{soft} \tag{9}$$

Second, the corresponding formula for total inclusive cross sections is

$$\sigma_{incl} = \sigma_{incl}^{jet} + \sigma_{incl}^{soft}, \tag{10}$$

and for differential inclusive ones

$$\frac{\mathrm{d}\sigma}{\mathrm{d}\eta} = \left\{\frac{\mathrm{d}\sigma}{\mathrm{d}\eta}\right\}_{\mathrm{jet}} + \left\{\frac{\mathrm{d}\sigma}{\mathrm{d}\eta}\right\}_{\mathrm{soft}} \tag{11}$$

Using eq.(9-11) I can write

$$\left\{\frac{1}{\sigma_{\mathrm{inel}}}\frac{\mathrm{d}\sigma_{\mathrm{incl}}}{\mathrm{d}\eta}\right\} = \alpha \left\{\frac{1}{\sigma_{\mathrm{inel}}^{\mathrm{jet}}}\frac{\mathrm{d}\sigma_{\mathrm{incl}}}{\mathrm{d}\eta}\right\}_{\mathrm{jet}} + (1-\alpha)\left\{\frac{1}{\sigma_{\mathrm{inel}}^{\mathrm{soft}}}\frac{\mathrm{d}\sigma_{\mathrm{incl}}}{\mathrm{d}\eta}\right\}_{\mathrm{soft}}, \tag{12}$$

where $\alpha = \sigma_{inel}^{jet}/\sigma_{inel}$ and $0. \leq \alpha \leq 1.$. But $\left\{\frac{1}{\sigma_{inel}^{jet}}\frac{d\sigma}{d\eta}\right\}_{jet} = \left\{\frac{1}{N_{jet}}\frac{dn_{incl}}{d\eta}\right\}_{jet}$, where N_{jet} is a number of jet events, and n_{incl} is the overall number of jets or particles. Analogous ratio may be written for soft events. Therefore differential cross sections are related to each other by the basic formula

$$\left\{\frac{1}{\sigma_{\mathrm{inel}}}\frac{\mathrm{d}\sigma_{\mathrm{incl}}}{\mathrm{d}\eta}\right\}_{\mathrm{exp.data}} = \alpha \left\{\frac{1}{\mathrm{N_{jet}}}\frac{\mathrm{dn_{incl}}}{\mathrm{d}\eta}\right\}_{\mathrm{jet}} + (1-\alpha)\left\{\frac{1}{\mathrm{N_{soft}}}\frac{\mathrm{dn_{incl}}}{\mathrm{d}\eta}\right\}_{\mathrm{soft}} \tag{13}$$

Appendix B

The histograms for MC events are smoothed using the following polynomial form

$$\frac{\mathrm{d}\sigma_{\mathrm{incl}}}{\mathrm{d}\eta} = \sum_{\mathrm{i=0}}^{\mathrm{n}} \mathrm{a_i x^i} \tag{14}$$

where $3 \leq n \leq 10$ and a_i fitting parameters. I use the χ^2 method which enables determination of these parameters at each n.

I suppose that the best description is obtained when for any n_0 the following condition is satisfied

$$\frac{\chi^2_{\mathrm{n_0}}}{\chi^2_{\mathrm{n_0+1}}} \sim 1. \tag{15}$$

Figure captions

Figure 1. Jet cross section (UA1 data and fitted curve for $\xi = 1.0(fixed)$).

Figure 2. The UA5 and CDF average charged multiplicities vs η and the ISAJET fit with (4).

(a) MC TWOJET events are obtained with $\hat{q}_t^{min}$ which is calculated from formula (3);

(b) MC MINIBIAS events only;

(c) MC TWOJET events are obtained with $\hat{q}_t^{min}$=2.5 GeV (*fixed)*.

Figure 3. The UA5 and CDF mean charged multiplicities vs η and the PYTHIA fit with (4).

(a) MC TWOJET events are obtained with $\hat{q}_t^{min}$ which is calculated from formula (3);

(b) MC TWOJET events are obtained with $\hat{q}_t^{min}$=2.5 GeV (*fixed)*.

Figure 4.

(a) The CDF invariant p_t differential cross sections of charged particles vs p_t (is normalized to σ_{NSD}); the fitted curve from (6) and the MC TWOJET and MINIBIAS ISAJET results;

(b) the ratio of MC data to experimental ones; the curves are the result of smoothing according to formula of Appendix B. The "gray" region is the corridor of errors obtained from CDF data.

Figure 5.

(a) The fitted curve obtained with (6) for UA1 invariant p_t differential cross sections of charged particles vs p_t (is normalized to σ_{NSD}); and the MC TWOJET and MINIBIAS ISAJET results;

(b)the ratio of MC data to experimental ones; the curves are the result of smoothing according to formula of Appendix B.

Figure 6.

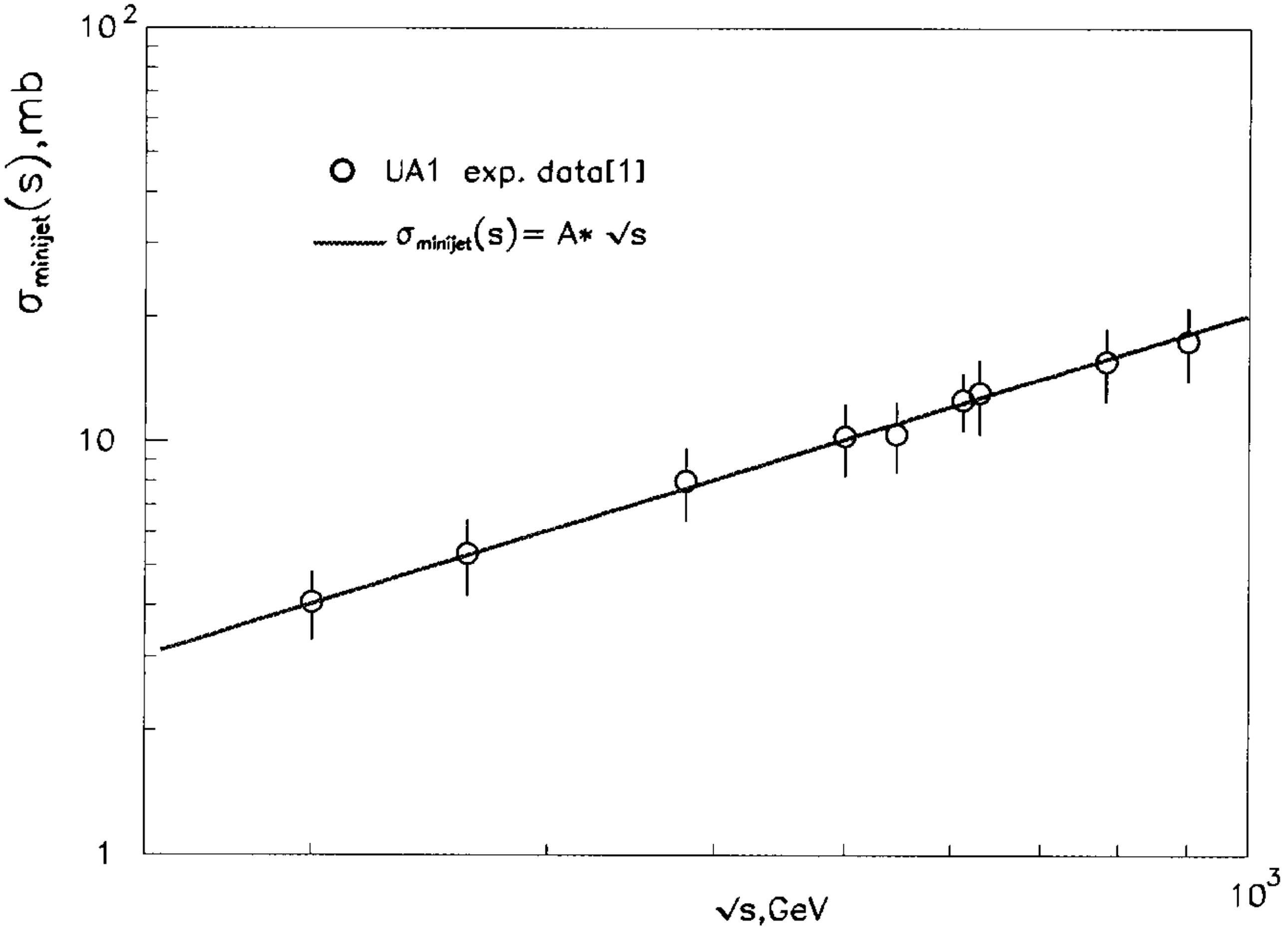
(a) The CDF invariant p_t differential cross sections of charged particles vs p_t (is normalized to σ_{NSD}); the fitted curve from (6) and the MC TWOJET and soft PYTHIA results;

(b) the ratio of MC data to experimental ones; the curves are the result of smoothing according to formula of Appendix B. The "gray" region is the corridor of errors obtained from CDF data.

Figure 7.

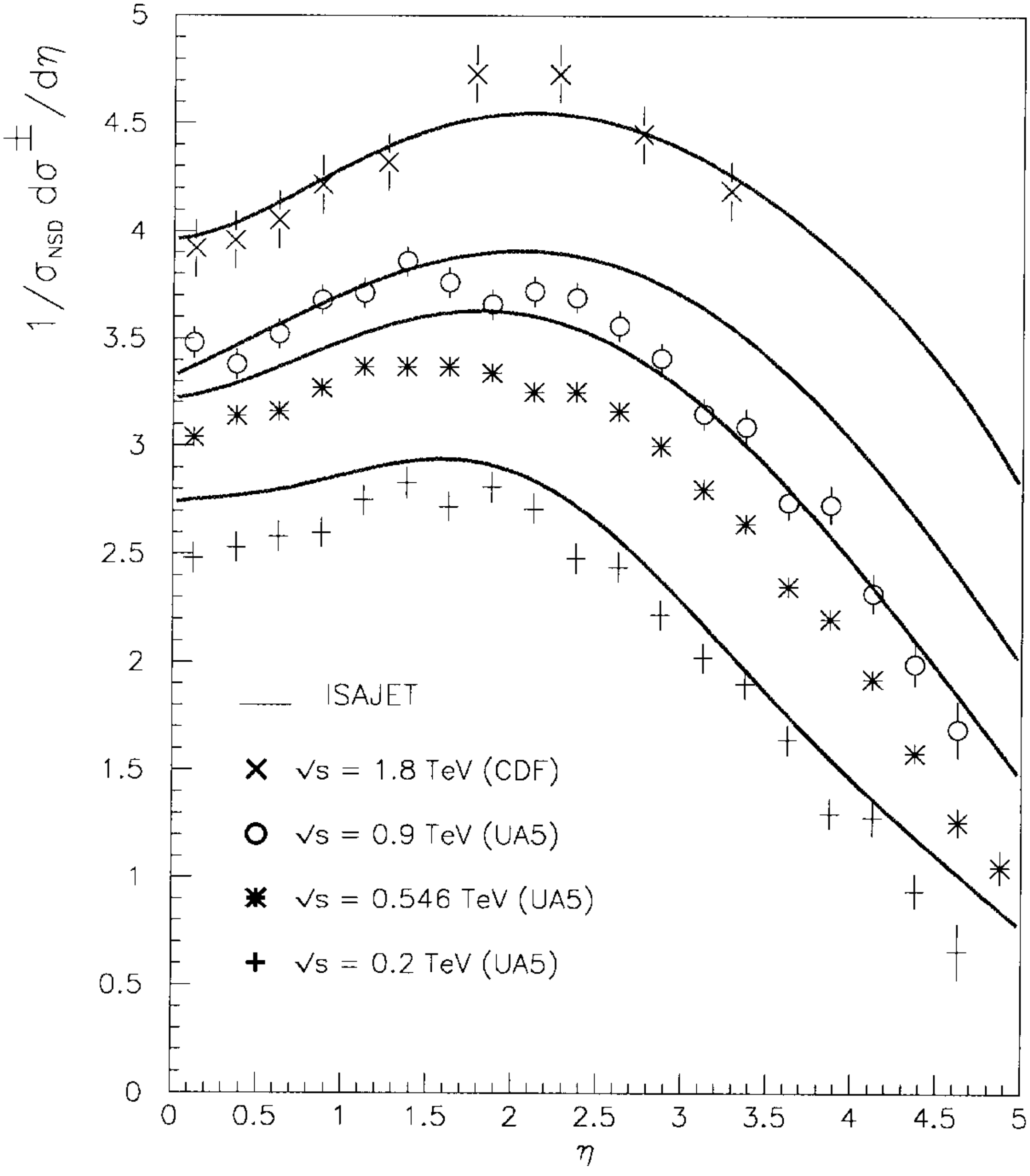
(a) The fitted curve from (6) for UA1 invariant p_t differential cross sections of charged particles vs p_t (is normalized on σ_{NSD}); and the MC TWOJET and soft PYTHIA results;

(b)the ratio of MC data to experimental ones; the curves are the result of smoothing according to formula of Appendix B.



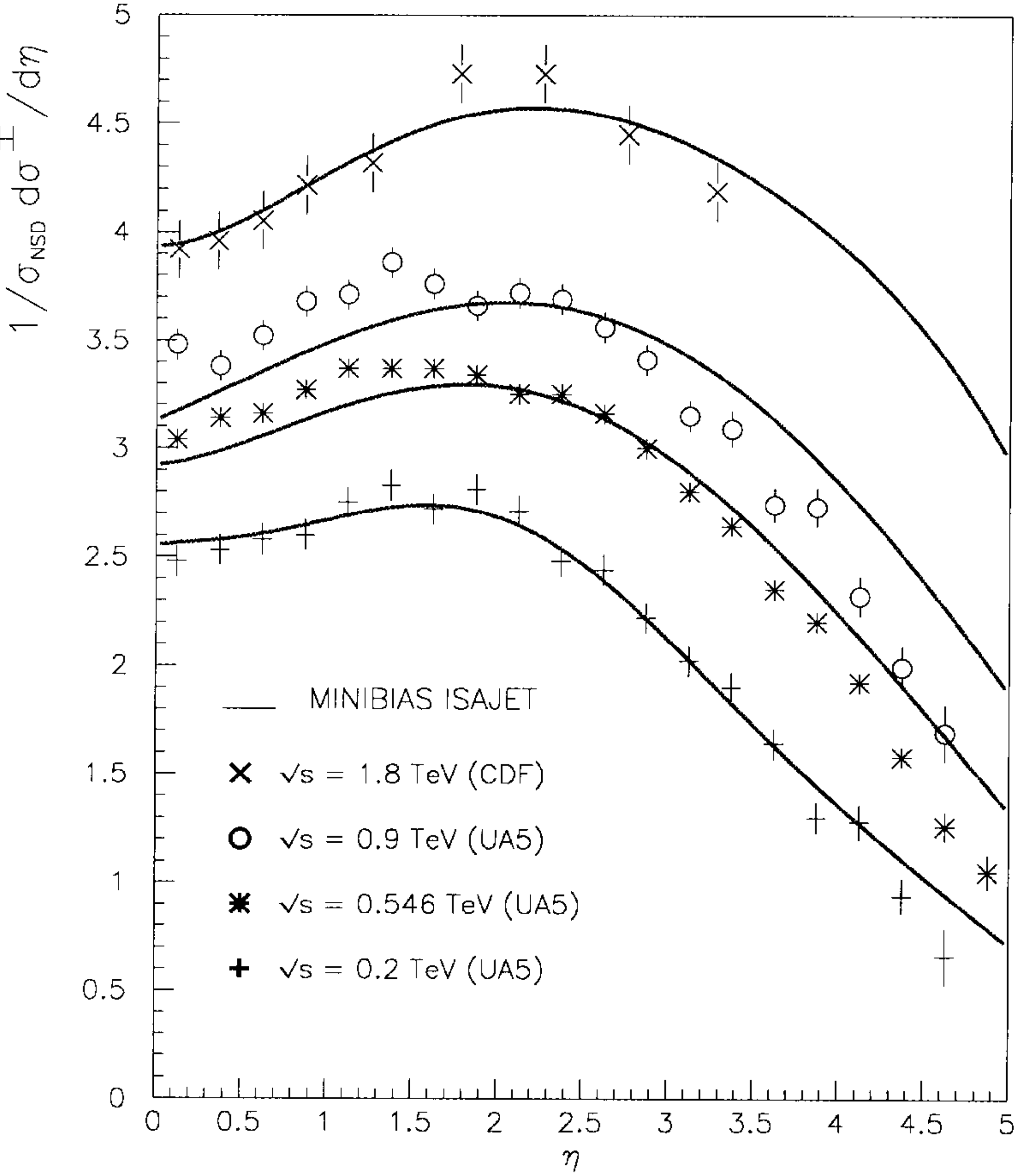
10^2
10
1
10^3
$\sigma_{minijet}(s)$,mb
UA1 exp. data[1]
$\sigma_{minijet}(s) = A * \sqrt{s}$
$\sqrt{s}$,GeV

Figure 1.



$1/\sigma_{NSD}\, d\sigma^{\pm}/d\eta$
η
ISAJET
$\sqrt{s}$ = 1.8 TeV (CDF)
$\sqrt{s}$ = 0.9 TeV (UA5)
$\sqrt{s}$ = 0.546 TeV (UA5)
$\sqrt{s}$ = 0.2 TeV (UA5)

Figure 2a.



$1/\sigma_{NSD}\, d\sigma^{\pm}/d\eta$
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
η
MINIBIAS ISAJET
$\sqrt{s}$ = 1.8 TeV (CDF)
$\sqrt{s}$ = 0.9 TeV (UA5)
$\sqrt{s}$ = 0.546 TeV (UA5)
$\sqrt{s}$ = 0.2 TeV (UA5)

Figure 2b.

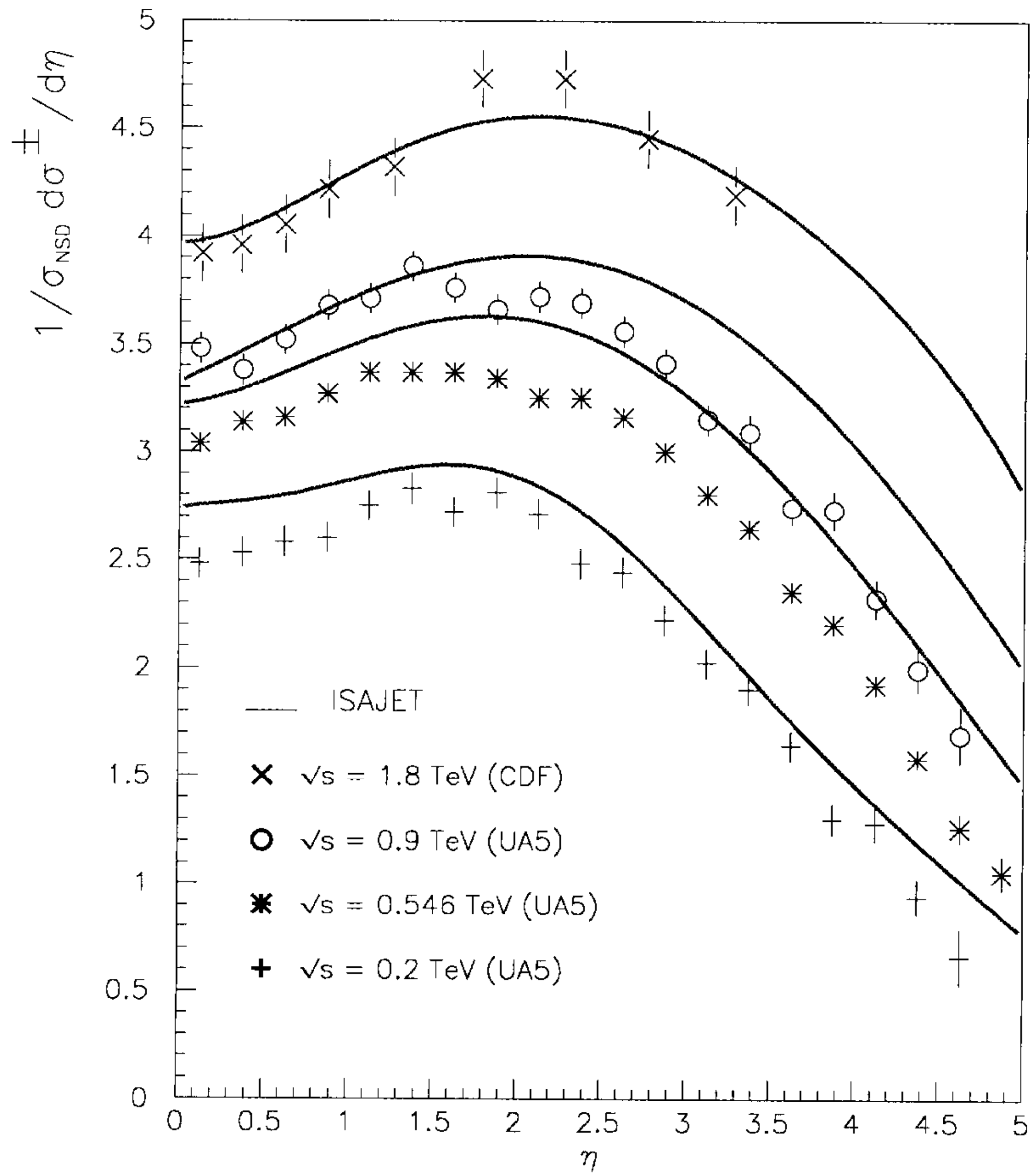
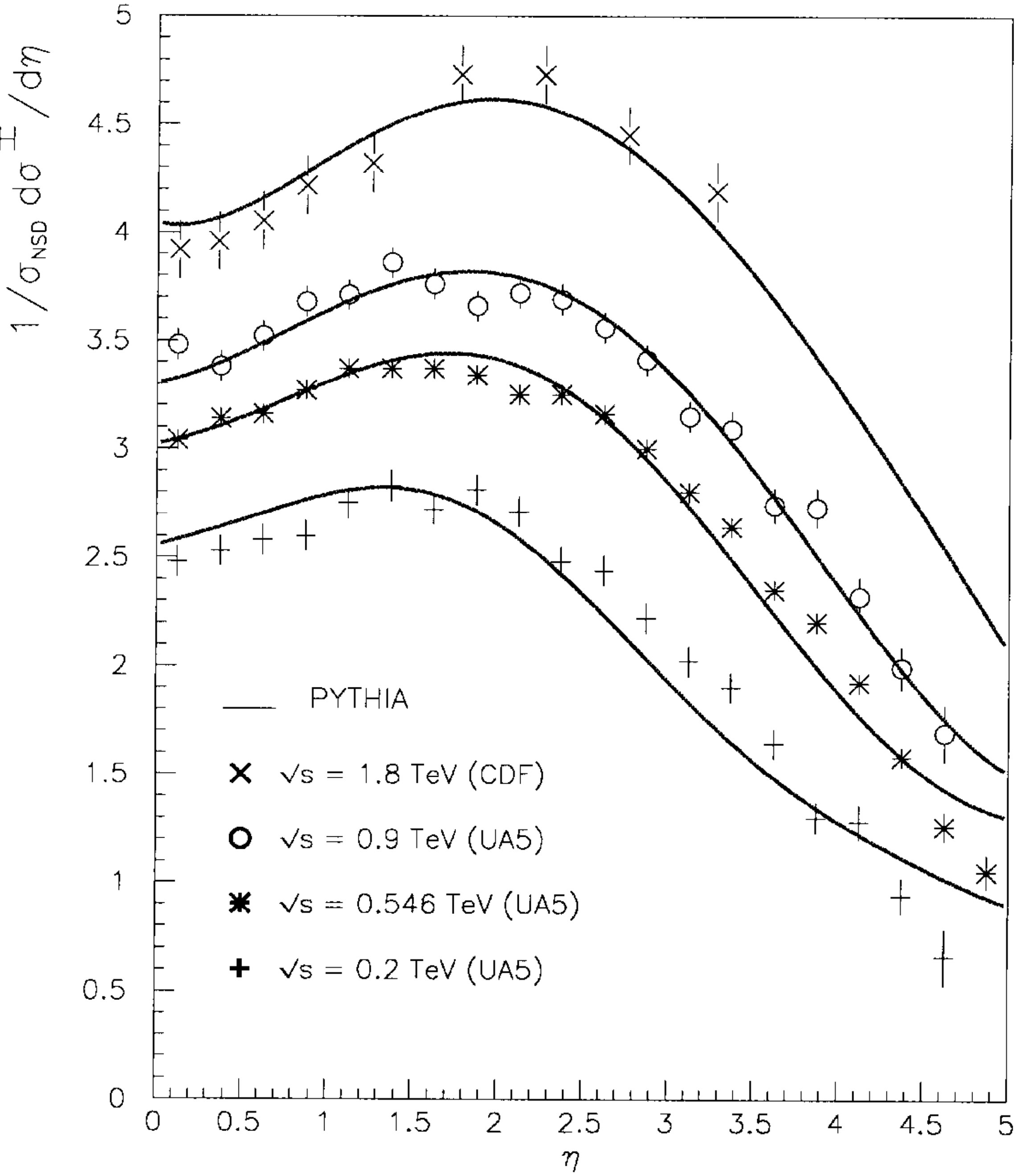
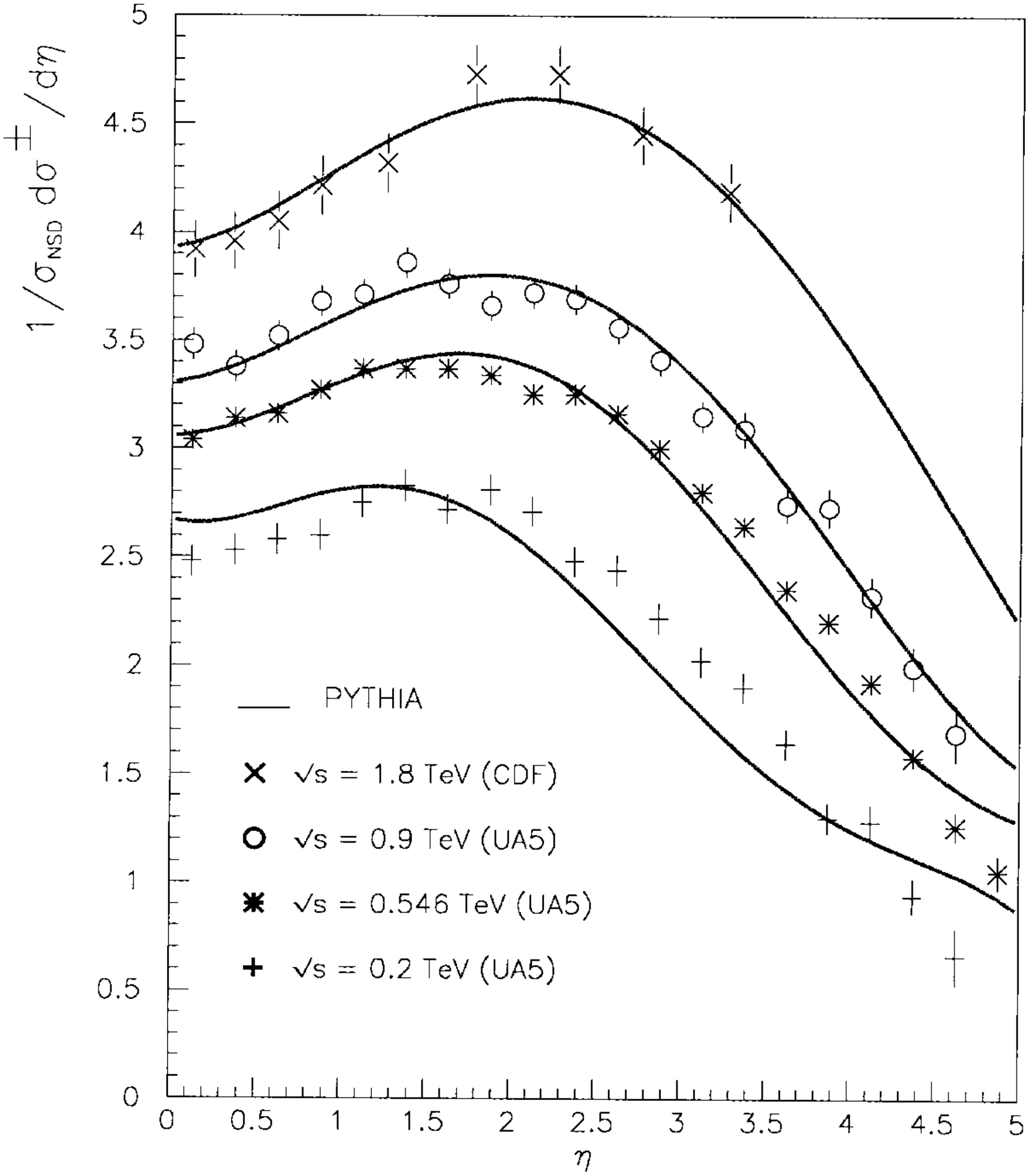

$1/\sigma_{NSD}\, d\sigma^{\pm}/d\eta$
η
ISAJET
$\sqrt{s}$ = 1.8 TeV (CDF)
$\sqrt{s}$ = 0.9 TeV (UA5)
$\sqrt{s}$ = 0.546 TeV (UA5)
$\sqrt{s}$ = 0.2 TeV (UA5)

Figure 2c.



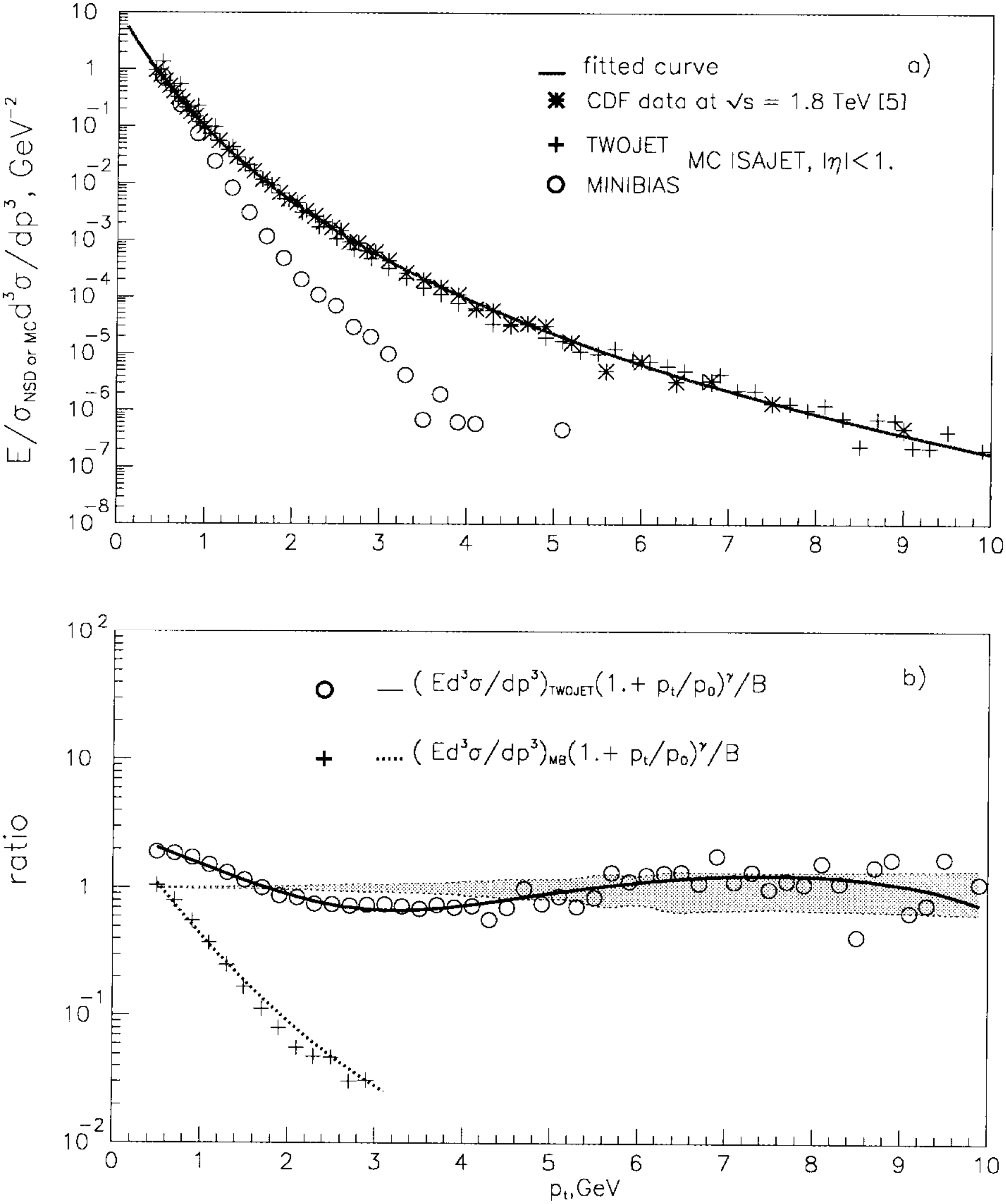
$1/\sigma_{NSD}\, d\sigma^{\pm}/d\eta$
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
η
PYTHIA
√s = 1.8 TeV (CDF)
√s = 0.9 TeV (UA5)
√s = 0.546 TeV (UA5)
√s = 0.2 TeV (UA5)

Figure 3a.



$1/\sigma_{NSD}\, d\sigma^{\pm}/d\eta$
η
PYTHIA
$\sqrt{s}$ = 1.8 TeV (CDF)
$\sqrt{s}$ = 0.9 TeV (UA5)
$\sqrt{s}$ = 0.546 TeV (UA5)
$\sqrt{s}$ = 0.2 TeV (UA5)

Figure 3b.



fitted curve
CDF data at √s = 1.8 TeV [5]
TWOJET
MINIBIAS
MC ISAJET, |η|<1.
a)
E/σ_NSD or MC d³σ/dp³, GeV⁻²
(Ed³σ/dp³)_TWOJET(1.+ p_t/p_0)^γ/B
(Ed³σ/dp³)_MB(1.+ p_t/p_0)^γ/B
b)
ratio
p_t,GeV

Figure 4.

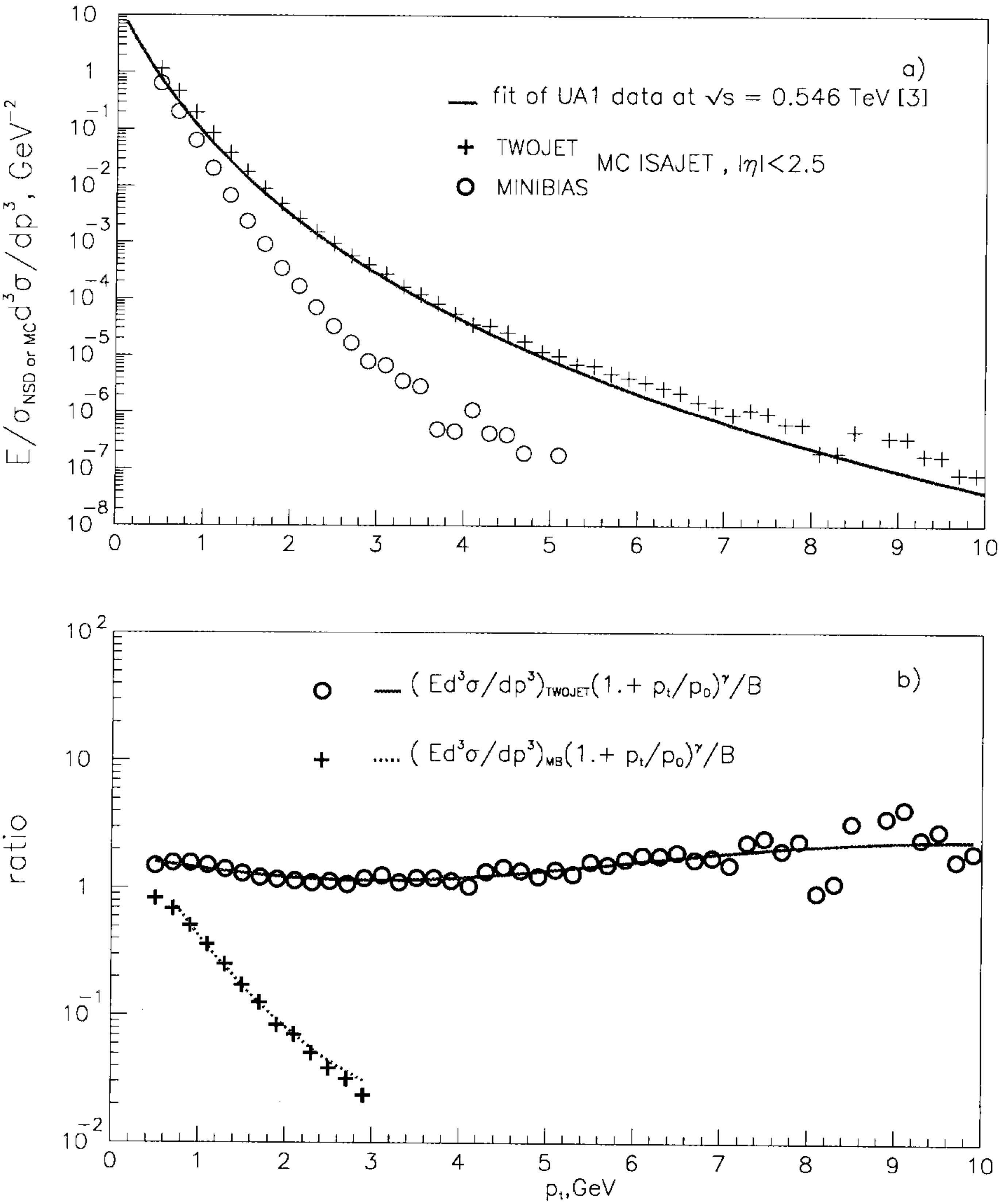

a)
fit of UA1 data at √s = 0.546 TeV [3]
TWOJET
MINIBIAS
MC ISAJET , |η|<2.5
E/σ_NSD or MC d³σ/dp³, GeV⁻²
b)
(Ed³σ/dp³)_TWOJET(1.+ p_t/p_0)^γ/B
(Ed³σ/dp³)_MB(1.+ p_t/p_0)^γ/B
ratio
p_t,GeV

Figure 5.

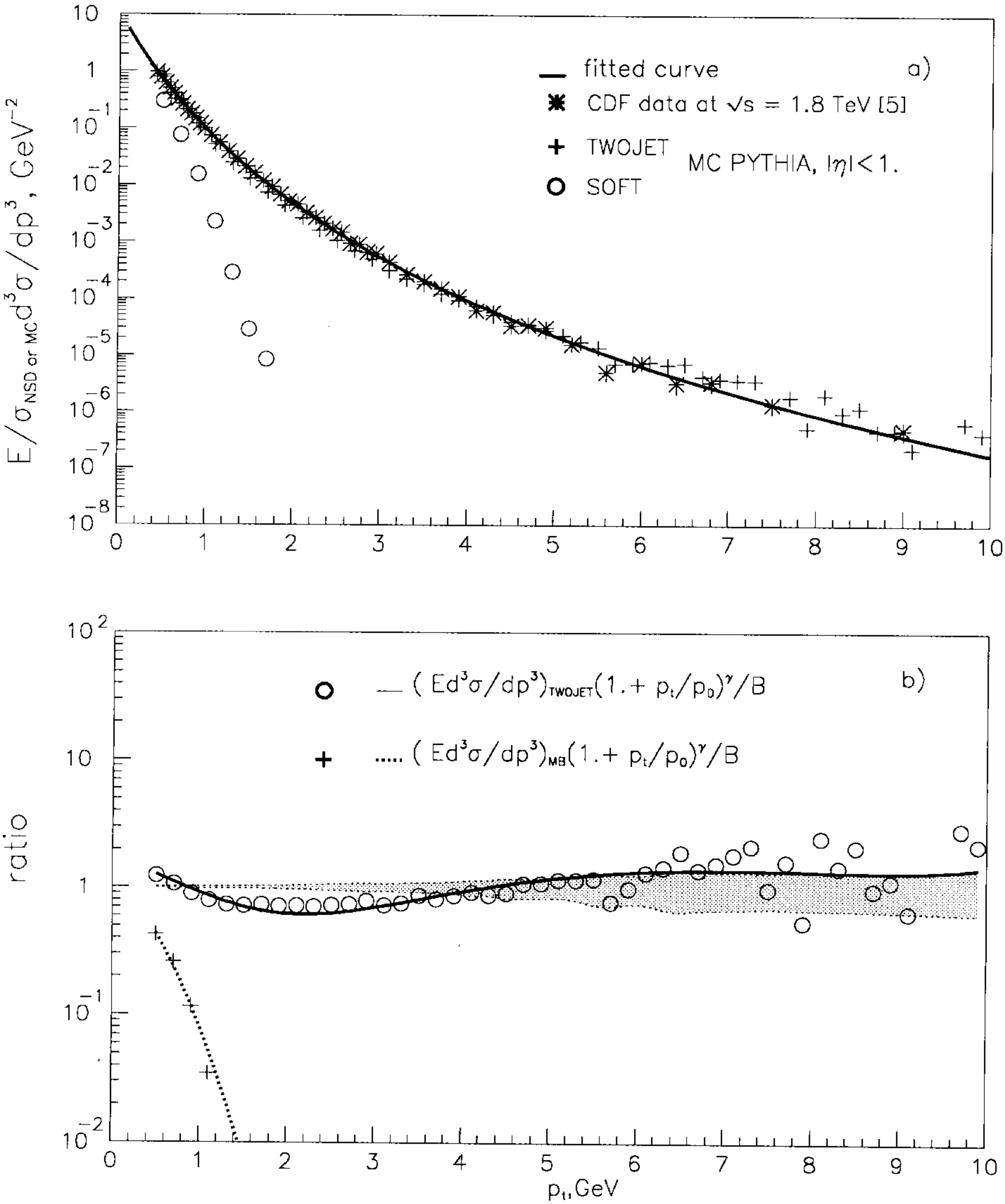

fitted curve
CDF data at √s = 1.8 TeV [5]
TWOJET
SOFT
MC PYTHIA, |η|<1.
a)
E/σ NSD or MC d³σ/dp³, GeV⁻²
(Ed³σ/dp³)TWOJET(1.+ pt/p0)^γ/B
(Ed³σ/dp³)MB(1.+ pt/p0)^γ/B
b)
ratio
pt,GeV

Figure 6.

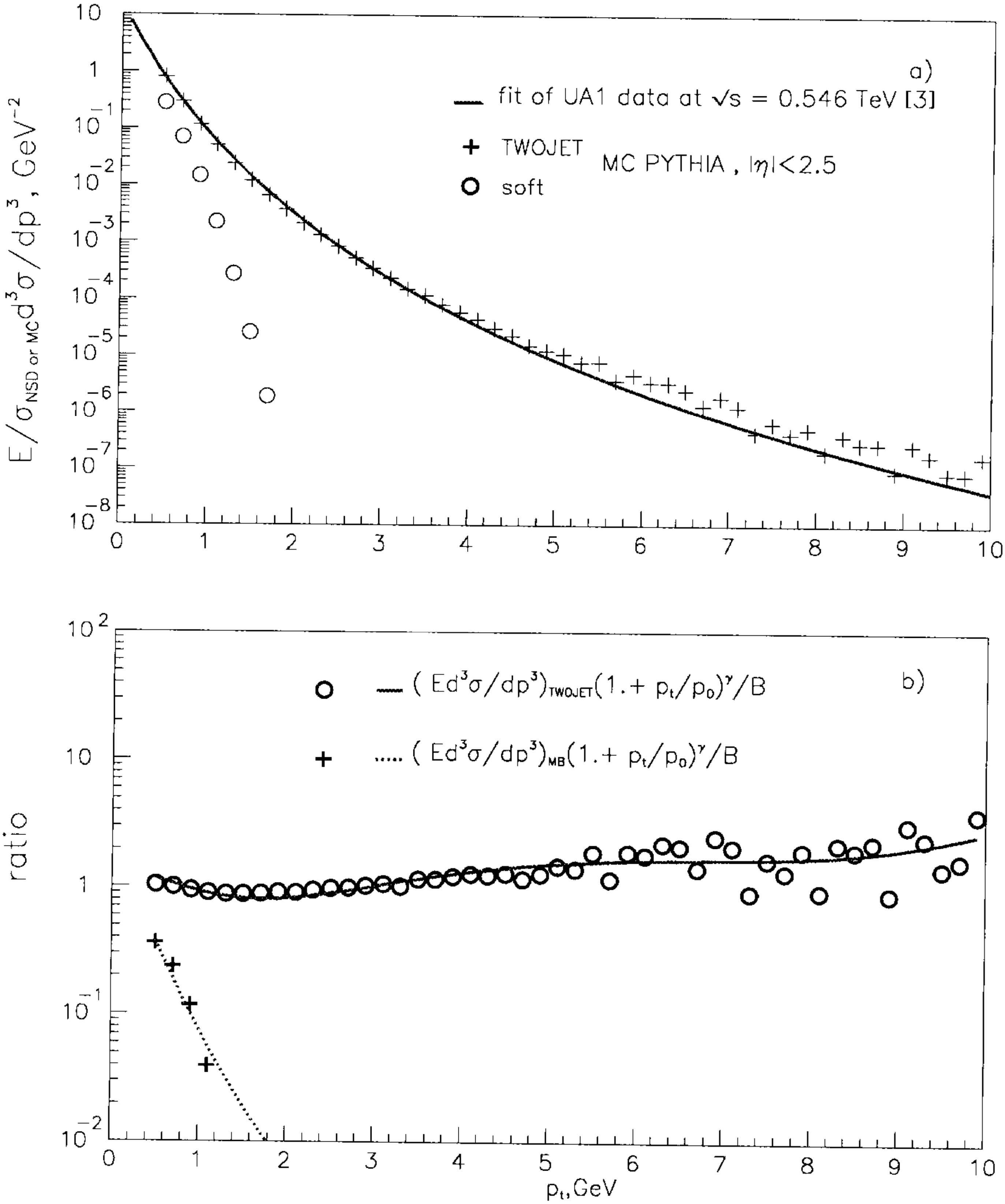

a)
fit of UA1 data at √s = 0.546 TeV [3]
TWOJET
soft
MC PYTHIA , |η|<2.5
E/σ NSD or MC d³σ/dp³, GeV⁻²
b)
(Ed³σ/dp³)TWOJET(1.+ pt/p0)γ/B
(Ed³σ/dp³)MB(1.+ pt/p0)γ/B
ratio
pt,GeV

Figure 7.