SDC-92-217

SDC
SOLENOIDAL DETECTOR NOTES

SIMULATING MINIMUM-BIAS EVENTS AT SSC ENERGY

March 1992

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March, 1992 SDC-92-00217

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Abstract

Two versions of the multiple interaction model for inelastic non-diffractive events provided in the Lund Monte Carlo are adjusted to agree with existing data at $\sqrt{s} = 0.20 - 1.8$ TeV. The predictions of the two versions of the model are compared at $\sqrt{s} = 40$ TeV.

1. Introduction

Detailed computer simulation is an essential step in the design of a physics detector for the SSC. The simulation of minimum-bias events at $\sqrt{s} = 40$ TeV is a necessary part of this simulation effort. A bunch spacing of 16 ns, luminosity of $10^{33}\text{cm}^2\text{s}^{-1}$, and an inelastic non-diffractive cross section of 100 mb imply a mean event rate of 1.6 per crossing at SSC design luminosity. Thus, pileup of inelastic events needs to be considered at the outset and would be a subject for serious study at increased luminosity. The accurate modeling of minimum-bias events is not so important for calorimetry but is crucial for the design of a tracking system where soft particles contribute to the occupancy. Occupancy is therefore directly related to the mean event rate per crossing and the multiplicity of charged particles per event.

Minimum-bias events are those events which satisfy a trigger with maximum acceptance, or minimum bias. A minimum-bias trigger at a pp or $\overline{p}p$ colliding beam experiment would typically consist of scintillator covering several units of pseudo-rapidity, $\eta = -\ln[\tan(\theta/2)]$, at small angles to the beam. The trigger condition would be a 'simultaneous' hit in both directions. Such a trigger captures almost all of the inelastic non-diffractive events and some of the single diffractive and double diffractive events. Hence, minimum-bias events are essentially synonymous with inelastic non-diffractive events. A sample of several thousand such events needed for a simulation study would also contain some hard QCD processes. For example, a sample of 10^4 minimum-bias events at Tevatron energy would contain jets with E_T up to about 25 GeV [1].

It is not currently possible to predict from theory what the characteristics of minimum-bias events at $\sqrt{s} = 40$ TeV might be. The problem involves nonperturbative QCD and possible multiple parton interactions, neither of which is well understood. However, minimum-bias events have been modeled at varying levels of sophistication in several Monte Carlo programs. The thrust of this study is to find an existing model, see that it is in reasonable agreement with existing data from the SPS and the Tevatron, and to see that its predictions at $\sqrt{s} = 40$ TeV are a reasonable extrapolation of the data. The principal benefit of such a study will be for SDC to adopt a "standard" minimum-bias event sample or event generator, so that the term "minimum-bias background" will have the same meaning in different simulations of the competing technologies for the components of SDC. A standard minimum-bias generator is provided by the SDC Shell simulation package. The characteristics of the events generated by that package are shown in Figures 8 and 10 – 13 and in Appendix 3.

2. The Models

The Lund Monte Carlo provides a relatively complex model [2,3,4] to reproduce the features of inelastic non-diffractive events in pp and $\overline{p}p$ collisions. (Note: the Lund

Monte Carlo consists of two programs, Pythia and Jetset, which carry separate version numbers and revision dates, but which are executed concurrently and controlled by a single set of parameters. This Monte Carlo is subsequently referred to as Pythia, as is the common usage.) Models for elastic, single diffractive, and double diffractive events are also provided in Pythia.

The essential feature of the Pythia model for inelastic non-diffractive events is that it extends the perturbative QCD description of parton-parton interactions into the low Q^2 regimen. Divergence as $p_T \rightarrow 0$ is avoided by employing an abrupt p_T cutoff, $p_{T_{min}}$, or a "regularization" scale, p_{T_0}. Since in the former case a provision is made to model the low end of the p_T spectrum, the effect of the two parameters is the same: the lower the value of $p_{T_{min}}$ or p_{T_0}, the larger the parton-parton cross section, $\hat{\sigma}$. For sufficiently low $p_{T_{min}}$ or p_{T_0}, $\hat{\sigma}$ exceeds the inelastic non-diffractive cross section, $\sigma_{\rm ND}$. This creates no discrepancy since the model allows for multiple pair-wise independent parton-parton interactions in each event. The mean probability of parton-parton interactions per event is just $\hat{\sigma}/\sigma_{\rm ND}$. Since the multiplicity in an event is proportional to the number of parton-parton interactions, $p_{T_{min}}$ or p_{T_0} becomes a free parameter that may be used to achieve a desired multiplicity at a given energy.

Two variations of this model, available in Pythia, are extensively compared to SPS data in Ref. [2] and are the two we have chosen to study. (Note: we subsequently refer to each of these variations as separate models, although they have more similarities than differences.) The models differ in, among other things, how the probability of multiple interactions is distributed among events. In one model, the probability of multiple interactions is constant in each event. This corresponds classically to having a fixed impact parameter in each event and results in a Poisson distribution of the parton-parton interactions. This model employs an abrupt cutoff, $p_{T_{min}}$, to avoid divergence and to regulate the parton-parton cross section.

The second model employs a varying impact parameter and a double Gaussian matter distribution. This distribution models an object with 1/2 of its matter concentrated in a small region and the remaining matter in a volume 125 times greater. Thus, for a limited range of the impact parameter, there is a high probability for a parton-parton interaction. This has the effect of broadening the multiplicity distribution. A p_T normalization scale, p_{T_0}, rather than an abrupt p_T cutoff, is employed: $p_T^2 \rightarrow p_T^2 + p_{T_0}^2$ in the matrix element, thus allowing $p_T \rightarrow 0$ without divergence. In the expression for $\alpha_s(Q^2)$, Q^2 is chosen to be p_T^2 and $p_T^2 \rightarrow .075(p_T^2 + p_{T_0}^2)$. This removes the divergence as $p_T \rightarrow \Lambda$ ($\Lambda = .2$ GeV). The factor .075 acts like a k factor, enhancing the strength of α_s, but having a reduced effect at high p_T. Additionally, the fragmentation scheme is somewhat more complicated in this model. The first model is subsequently referred to as the *fixed impact parameter* model and the second as the *double Gaussian* model.

3.Tuning the models

In a study conducted for the LHC, the double Gaussian model was compared to Tevatron data and further tuned [5]. The Pythia parameters used to specify the double Gaussian model in our study (see Appendix 1) are the same as in the LHC study with the exception that the latter study used Pythia 5.3 with p_{T_0} set at 1.9 GeV [6] whereas we used Pythia 5.4 with $p_{T_0} = 1.3$ GeV. The treatment of α_s is changed in Pythia 5.4 so that α_s is smaller at low p_T than it was in version 5.3. Therefore, p_{T_0} must have a lower value to achieve the same multiplicity as in version 5.3. The Pythia parameters PARP(85) and PARP(86)(see Appendix 1) were tuned in the LHC study to produce the correct mean p_T versus multiplicity distribution.

In matching the two Pythia models to UA1 and CDF data, we first generated all QCD processes, including elastic and diffractive events. We then simulated the appropriate minimum-bias trigger for that experiment (see Appendix 2). No trigger simulation was used for explicit comparisons to UA5 data. Instead, we generated inelastic non-single diffractive events since UA5 corrected its data for trigger inefficiencies by using Monte Carlo simulation [7]. (The difference between simulating the UA5 trigger and generating inelastic non-single-diffractive events at $\sqrt{s} = 546$ GeV amounts to a 1% difference in multiplicity.)

In comparing Pythia results to UA1, UA5, and CDF multiplicity distributions, we observed a secondary peak at low multiplicity not present in the data [8,9,10]. We determined that the multiplicity distribution of the single and double diffractive events accepted by the simulated triggers did not combine smoothly with the inelastic non-diffractive events. Pythia offers two options for modeling diffractive events. In one (Pythia parameter MSTP(101) = 1), the interaction consists of a forward moving diquark and interacting quark. In the second (MSTP(101) = 2), the interaction consists of a forward moving diquark and quark joined by an interacting gluon. The latter choice increases the multiplicity in diffractive events [6]. The difference in the resulting multiplicity distributions is shown in Fig. 1. Using the second option gave good agreement with the data at low multiplicities and this option was used in both models in our test.

In order to compare the fixed impact parameter and double Gaussian models, we first tuned the two models to agree at a single data point. The point chosen was $dN_{ch}/d\eta(\eta = 0)$ at $\sqrt{s} = 500$ GeV, measured by UA1 and UA5 to be 3.0. The multiplicity in the fixed impact parameter model was initially too low and we looked at two methods of increasing it. One was lowering $p_{T_{min}}$, the cutoff for parton-parton interactions, default value = 1.45 GeV. The other was increasing the k factor, a constant factor applied to α_s. We found that we could not lower $p_{T_{min}}$ and still get agreement with the data for mean p_T, so we used the k factor to tune the multiplicity. An increase in the k factor in minimum-bias events increases the ratio of hard jet production at the expense of soft jet and no jet events, thus maintaining a constant cross section [6]. A k

factor of 1.2 compared to the default value of 1 produced the desired result. To tune the double Gaussian model, we lowered p_{T_0}, the p_T normalization scale, from the default value, 1.7 GeV, to 1.3 GeV. Mean p_T was not sensitive to this variable. This gave the desired $dN_{ch}/d\eta(\eta = 0)$.

In both models, the predicted multiplicity at the SSC depends on the inelastic non-diffractive cross section, $\sigma_{\rm ND}$, at SSC energy. Recall from section 2 that the multiplicity in both models is proportional to the ratio $\hat{\sigma}/\sigma_{\rm ND}$. The most recent data on $\sigma_{\rm ND}$ comes from CDF's measurement of the ratio of the minimum-bias trigger cross sections at $\sqrt{s} = 1800$ GeV and $\sqrt{s} = 546$ GeV[11,12]:

$$\frac{\sigma_{\rm trig,\,1800\,GeV}}{\sigma_{\rm trig,\,546\,GeV}} = \frac{46.8 \pm 3.2 \text{ mb}}{36.0 \pm 1.8 \text{ mb}} = 1.30 \pm .06.$$

Pythia uses:

$$\frac{\sigma_{\rm ND,\,1800\,GeV}}{\sigma_{\rm ND,\,546\,GeV}} = \frac{49.8 \text{ mb}}{36.8 \text{ mb}} = 1.35.$$

We estimate that $\sigma_{\rm ND} = 0.97 \times \sigma_{\rm trig}$ at both energies. Thus, Pythia's values for $\sigma_{\rm ND}$ are in general agreement with the CDF result and the lower value agrees very well with the UA4 measurement of the inelastic non-single diffractive cross section, 39.2 mb at $\sqrt{s} = 546$ GeV [13].

The value that Pythia uses for $\sigma_{\rm ND}$ at $\sqrt{s} = 40$ TeV, 96 mb, is close to the cross section of 100 mb assumed at the SSC. However, this value of $\sigma_{\rm ND}$ is based on fits of $\sigma_{\rm tot}$ to the data, made before recent measurements at $\sqrt{s} = 1800$ GeV were available. CDF measures $\sigma_{\rm tot} = 72.0 \pm 3.6$ mb[12] and FNAL E710 measures $\sigma_{\rm tot} = 72.8 \pm 3.1$ mb [14]. A recent paper [15], subsequent to the new data, predicts $\sigma_{\rm tot} = 121 \pm 5$ mb at the SSC. We infer $\sigma_{\rm inelastic} = 85$ mb from this result, which gives $\sigma_{\rm ND} \approx 70$ mb. A lower value for $\sigma_{\rm ND}$ would cause both models to predict a higher multiplicity per event, although, of course, the mean interaction rate at a given luminosity would decrease. With this caveat, let us proceed.

4. Comparing the models

We compared the two models to existing data at $\sqrt{s} = 0.20 - 1.8$ TeV and then evaluated the differences between the models at $\sqrt{s} = 40$ TeV. In generating events with Pythia at 40 TeV, we generated inelastic non-diffractive events and double diffractive events. These are essentially the same physics processes that are accepted by the UA1, UA5, and CDF triggers. Fig. 2 shows the value of $dN_{ch}/d\eta(\eta = 0)$ predicted by the two models, compared to the relevant data as well as two CDF fits to the data [16]. At $\sqrt{s} = 40$ TeV, the fixed impact parameter model predicts $dN_{ch}/d\eta(\eta = 0) = 6.5$, the double Gaussian model, 5.1. The prediction of the fixed impact parameter model lies between the two CDF fits while the double Gaussian model falls below both.

Both models are in good agreement with the integrated multiplicity in $|\eta| < 2.5$. With both models tuned to $dN_{ch}/d\eta(\eta = 0) = 3.05$ at $\sqrt{s} = 546$ GeV, the fixed impact parameter model gives $N_{ch,|\eta|<2.5} = 16.9$ and the double Gaussian model, 17.4, compared to 16.3 measured by UA5 [7]. At $\sqrt{s} = 1800$ GeV, $N_{ch,|\eta|<2.5} = 22.2$ in the fixed impact parameter model and 20.9 in the double Gaussian model compared to 22.0 reported by CDF.

The mean p_T in $|\eta| < 2.5$ is shown as a function of $\sqrt{s}$ in Fig. 3. Both models produce very similar results and are in good agreement with the data except perhaps at $\sqrt{s} = 1800$ GeV. An extrapolation of the data, linear in $\ln\sqrt{s}$, suggests $\langle p_T \rangle = .6$ GeV/c at $\sqrt{s} = 40$ TeV. The two models predict $\langle p_T \rangle \simeq 0.54$ GeV/c at this energy. UA1 infers an increase in $\langle p_T \rangle$ faster than linear in $\ln\sqrt{s}$ from their plot of this data [9].

The invariant inclusive cross sections in the two models at $\sqrt{s} = 1800$ GeV are compared to the CDF fit function [17] in Fig. 4. The Pythia events are normalized to the cross section of 43 mb for events accepted by the trigger used by CDF. Comparisons with the UA1 inclusive cross sections at $\sqrt{s} = 200$, 500, and 900 GeV and the CDF results at 630 GeV are very similar. The two models also produce very similar inclusive cross sections at $\sqrt{s} = 40$ TeV.

In Fig. 5, mean p_T versus multiplicity in both models is compared with FNAL E735 data at $\sqrt{s} = 1800$ GeV [18] and is in good agreement. Both models were also in reasonable agreement with UA1 data at $\sqrt{s} = 900$ GeV and were similar to each other at $\sqrt{s} = 40$ TeV.

Multiplicity distributions are compared to UA1 data at $\sqrt{s} = 900$ GeV [9] in Fig. 6. Below $N_{ch} = 50$, the double Gaussian model follows the UA1 data more closely. However, the fixed impact parameter model is clearly a closer match to the data at multiplicities above $N_{ch} = 50$. For large $N_{ch}(> 70)$, the two models disagree by more than an order of magnitude. Both models are compared to the UA5 multiplicity distribution in Ref. [2]. That comparison favors the double Gaussian model. Fig. 7 shows the multiplicity distributions at $\sqrt{s} = 1800$ GeV compared to CDF data (unpublished) [10]. Here, the double Gaussian model is a better match at all multiplicities. The multiplicity distributions for both models for inelastic non-diffractive events at $\sqrt{s} = 40$ TeV are shown in Fig. 8. The results are similar to those shown in Ref. [2].

Finally, we compared the soft jet production in both models to CDF data [1] (see Fig. 9). We generated 10^5 events for each model and used the Pythia jet finding algorithm. The segmentation of the CDF calorimeter is modeled correctly but the Pythia algorithm uses the hottest segment as the jet center whereas CDF finds an E_T weighted center. We do not think this difference should matter much in this study. The errors shown for CDF are primarily systematic; those shown for Monte Carlo results are, of course, statistical. Both Monte Carlo models are in close agreement with the data. A comparison of the two models at $\sqrt{s} = 40$ TeV shows no substantial differences in the soft

jet spectra (see Fig. 10). However, the jet multiplicity distributions differ substantially as shown in Fig. 11. Following the charged particle multiplicity distributions, the jet multiplicity distribution in the double Gaussian model is broader and extends to higher multiplicities.

5. Characteristics of simulated minimum-bias events at $\sqrt{s} = 40$ TeV

Figures 8 and 10 – 13 and Appendix 3 give the characteristics of the minimum-bias events generated by the Pythia minimum-bias model provided in the SDC Shell program. The fixed impact parameter model is used with a k factor of 1.2. Only inelastic non-diffractive events are generated. Double diffractive events which were included earlier for purposes of comparison with existing data are not included since they have no significance for detector design and, in any event, have almost no effect. The events were generated using Pythia 5.5 which has been installed in the SSC library since June 26, 1991. There are 10^5 events in this sample. The events were generated on the PDSF Sun cluster, but parallel tests on the PDSF Silicon Graphics system and on an IBM R-6000 proved indistinguishable.

Version 5.5 of Pythia was released midway in this study. There are only minor differences between version 5.5 and 5.4. We have, however, re-checked certain results and find close agreement between the two versions. All simulations at $\sqrt{s} = 40$ TeV that are explicitly compared to data or simulation at lower energies were generated with Pythia 5.4. Figures 8 and 10 – 13 were generated using version 5.5 since that version is currently being used in simulation studies.

6. Summary

The fixed impact parameter model seems like the better choice for simulating minimum-bias events at SSC energy, principally because it produces a higher multiplicity than the double Gaussian model, more in line with what might reasonably be extrapolated from the data (see Fig. 2). In most other respects, both models were in good agreement with existing data although both were slightly deficient in the p_T spectrum at higher p_T (see Fig. 4). However, the models differ markedly, by design, in the multiplicity distributions (see Fig. 8). Here, existing experiments do not agree (compare Figs. 6, 7 and Refs. [8,9]), so it remains for future experiments to decide.

We thank Torbjörn Sjöstrand for helpful advice. This work was supported in part by U.S. Department of Energy Contract DE–AS05–76ERO5096.

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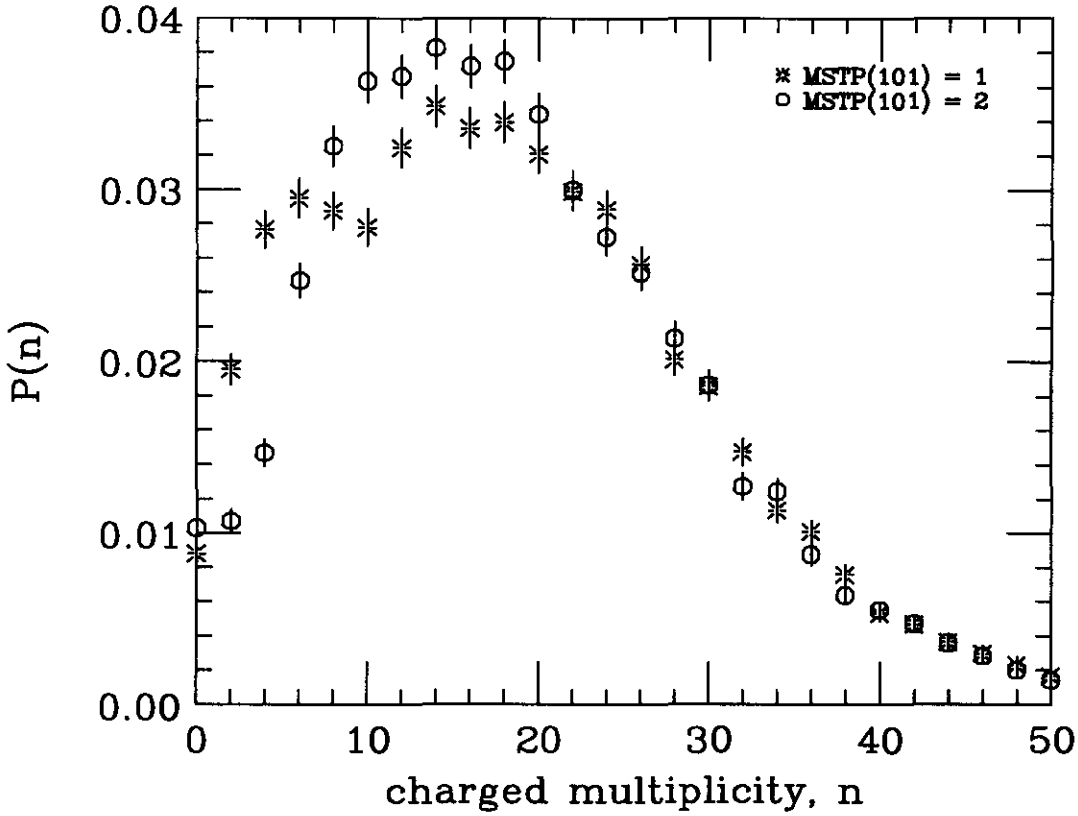

FIG. 1. The probability of n, P(n), versus n, the number of charged particles in $|\eta| < 2.5$, at $\sqrt{s}$ = 900 GeV, using a simulated UA1 minimum-bias trigger. Two versions of the Pythia model for diffractive events are compared. The fixed impact parameter model is used.

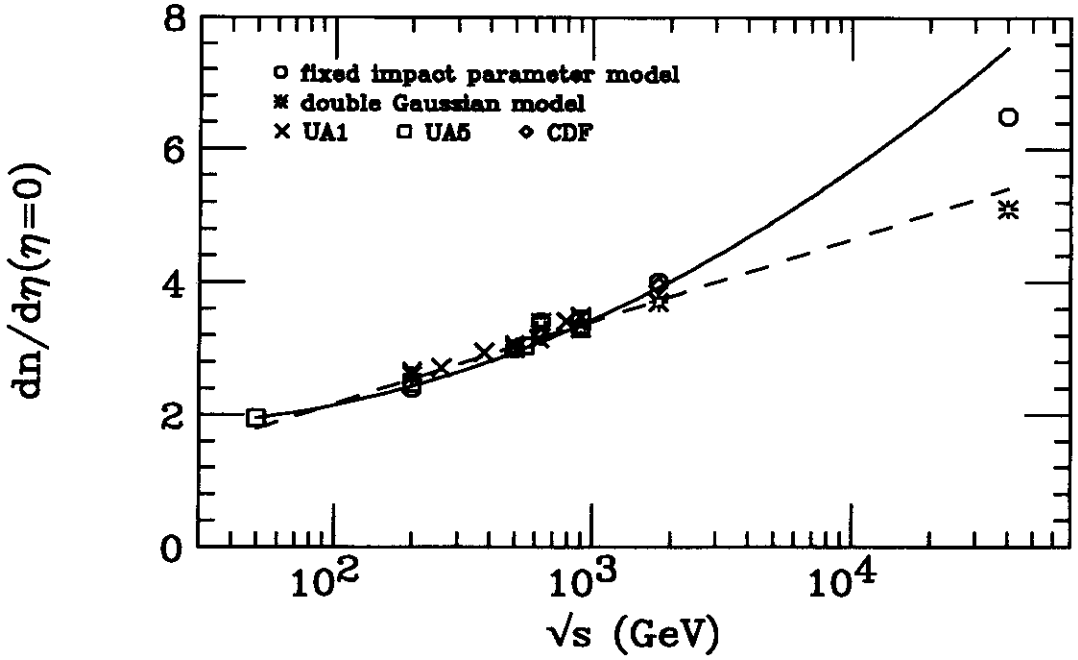

FIG. 2. The number of charged particles per unit of η, at $\eta = 0$, versus $\sqrt{s}$ for relevant experimental data and two Pythia models. The fits are to CDF and UA5 data, by CDF.

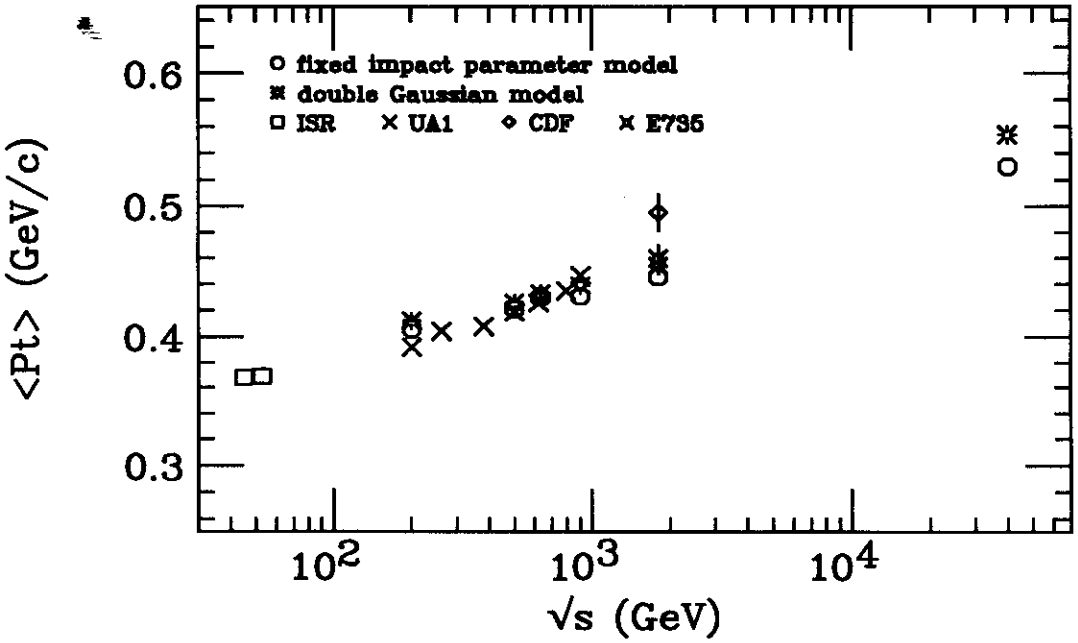

FIG 3. Mean Pt of charged particles in $|\eta| < 2.5$ versus $\sqrt{s}$ for relevant data and two Pythia models. Errors for the data and Monte Carlo are small and are omitted for clarity except for data at $\sqrt{s} = 1800$ GeV where there is disagreement.

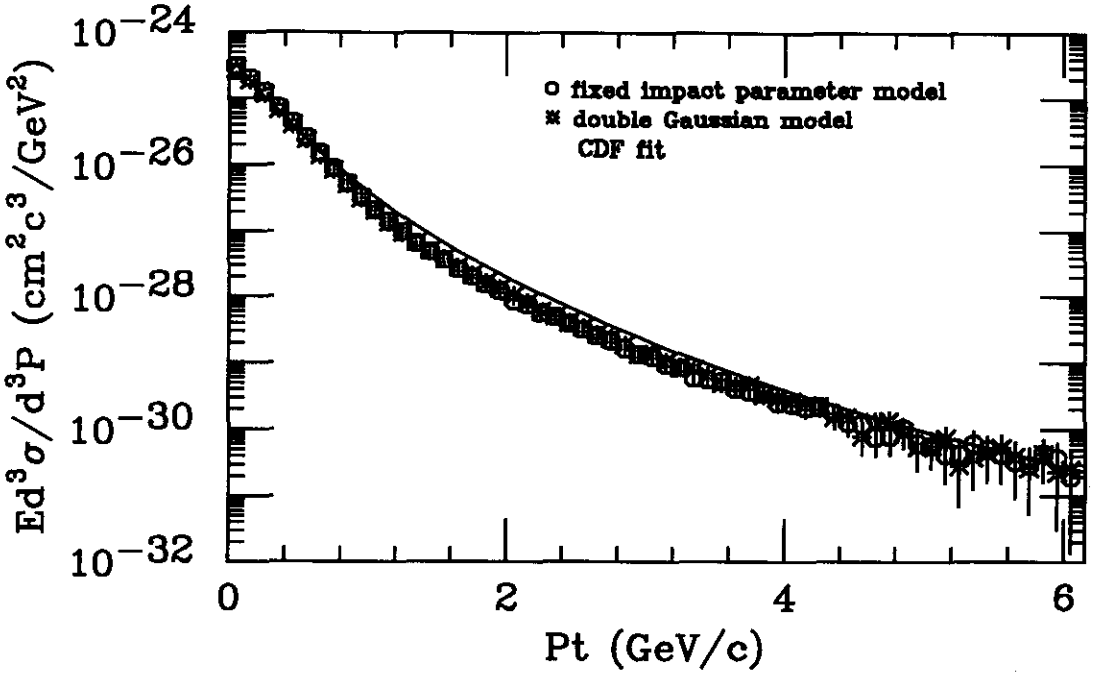

FIG. 4. The invariant inclusive cross section at $\sqrt{s}$ = 1800 GeV for the two models and the CDF fit to CDF data. There are 10^5 events in the Monte Carlo samples.

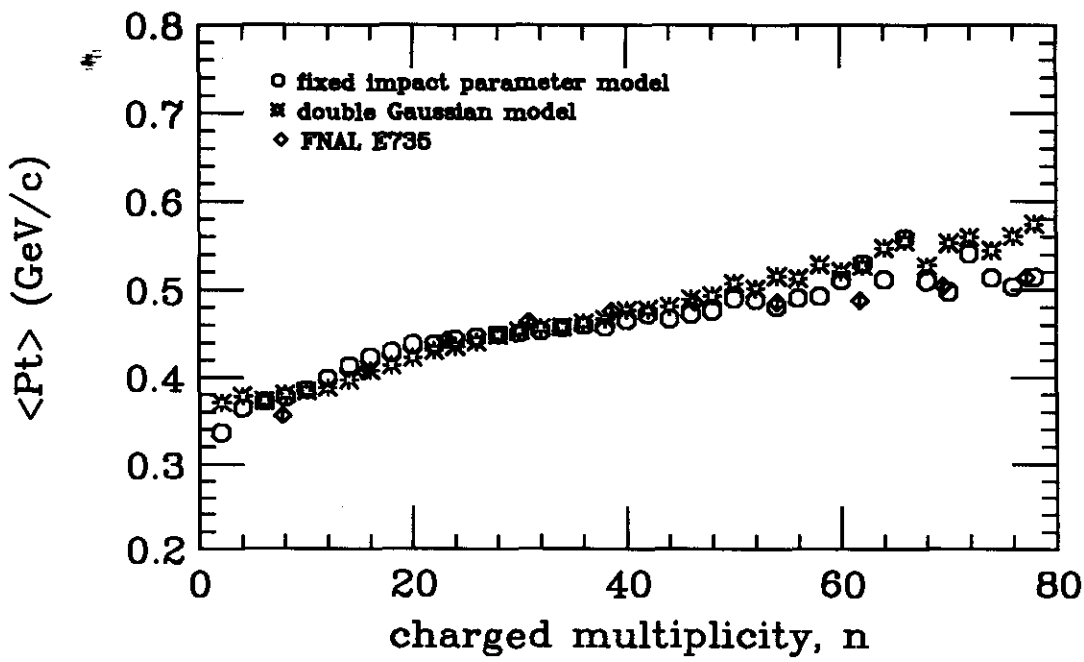

FIG 5. Mean Pt versus n, the number of charged particles in $|\eta| < 2.5$, for the two Pythia models and FNAL E735 data at $\sqrt{s}$ = 1800 GeV. There are 10^5 events in the Monte Carlo samples, 5×10^6 events in the E735 data.

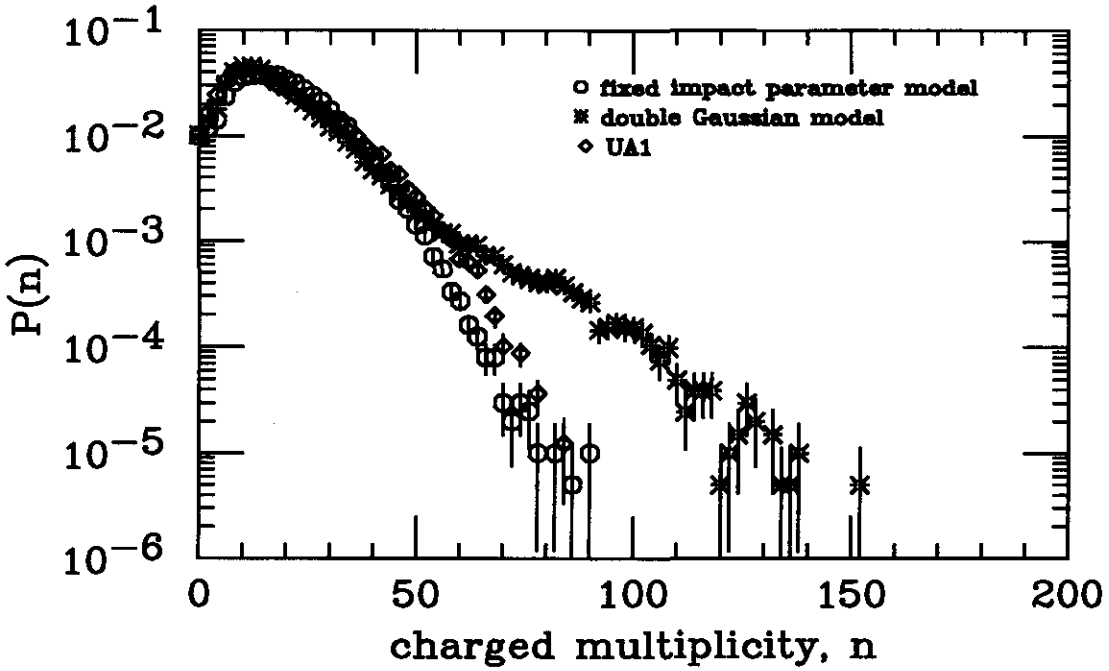

FIG. 6. The probability of n, P(n), versus n, the number of charged particles in $|\eta| < 2.5$, for the two Pythia models and UA1 data at $\sqrt{s} = 900$ GeV. There are 6.4×10^4 events in the data and Monte Carlo samples.

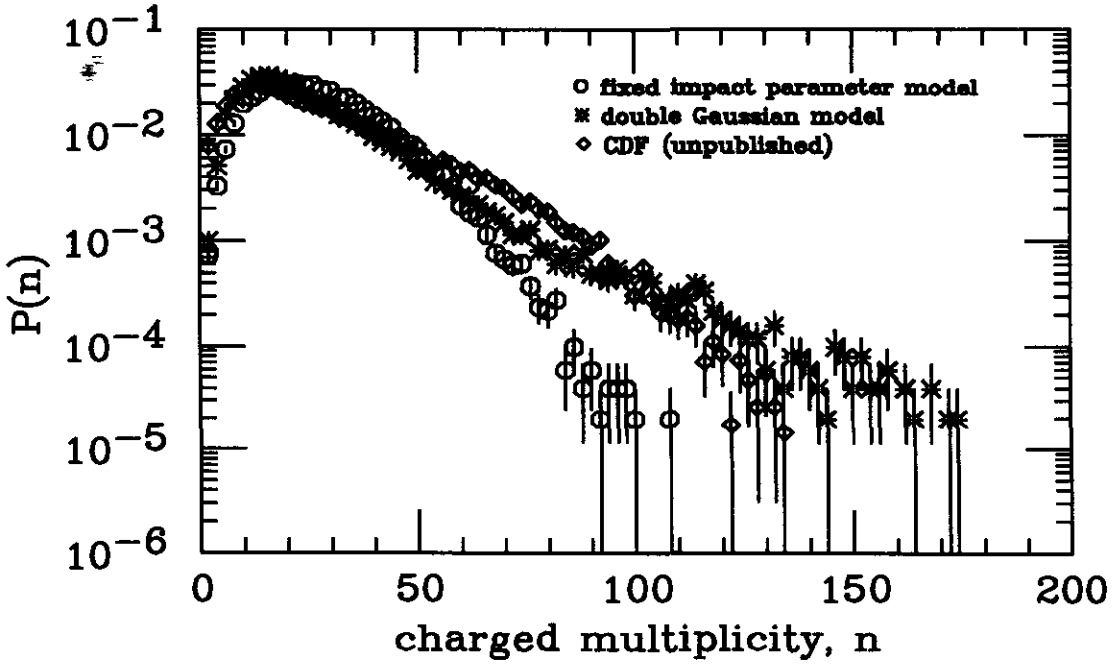

FIG 7. The same distribution as in Fig. 6, but at $\sqrt{s} = 1800$ GeV with CDF data. There are 2.5×10^4 events in the data and Monte Carlo samples.

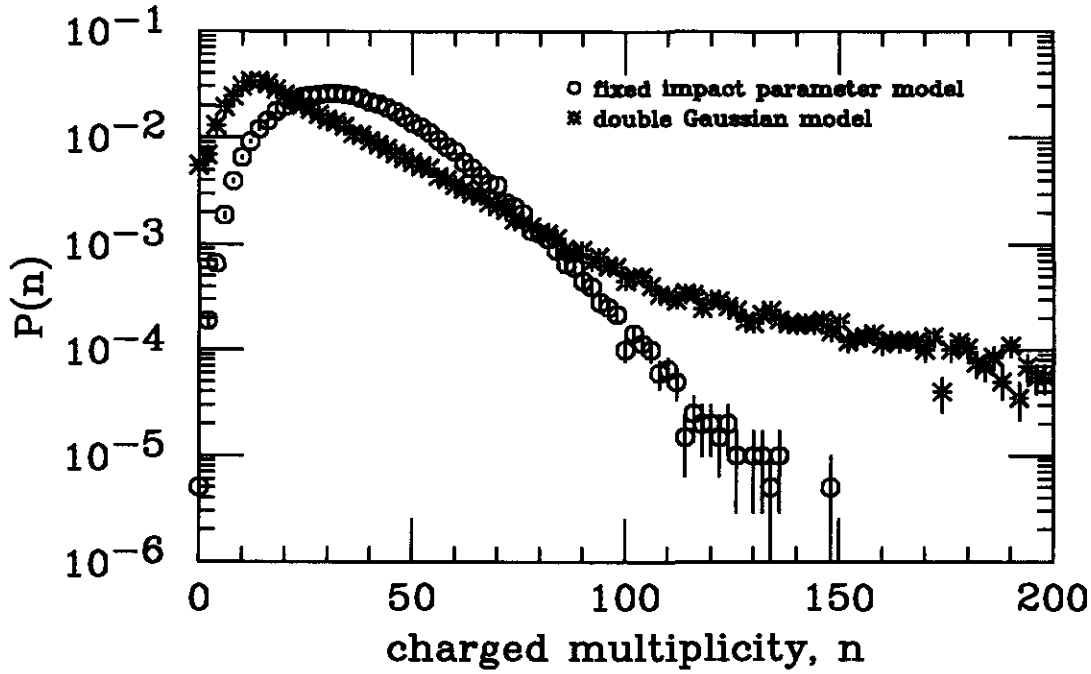

FIG. 8. The same distribution as in Fig. 6, but at $\sqrt{s}$ = 40 TeV for the two Pythia models. There are 10^5 events in the samples.

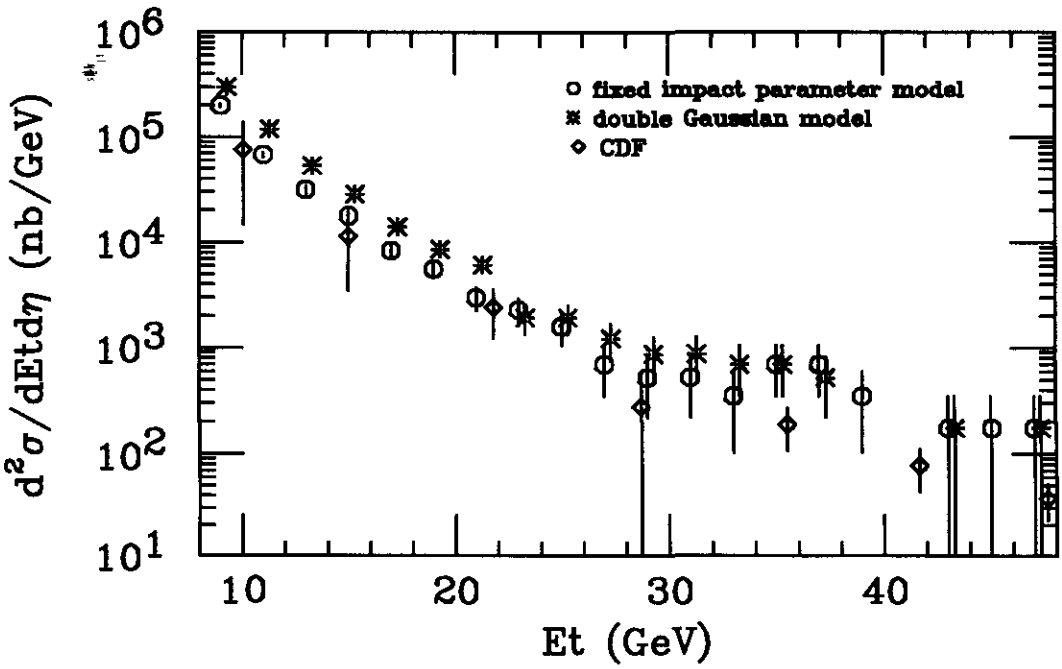

FIG 9. The inclusive jet cross section at $\sqrt{s}$ = 1800 GeV for the two Pythia models and CDF data for jets with Et > 8 GeV, centered in $.1 < |\eta| < .7$. The errors in the CDF data are largely systematic. There are 10^5 events in the Monte Carlo samples. The definition of a jet may be found in Appendix 1.

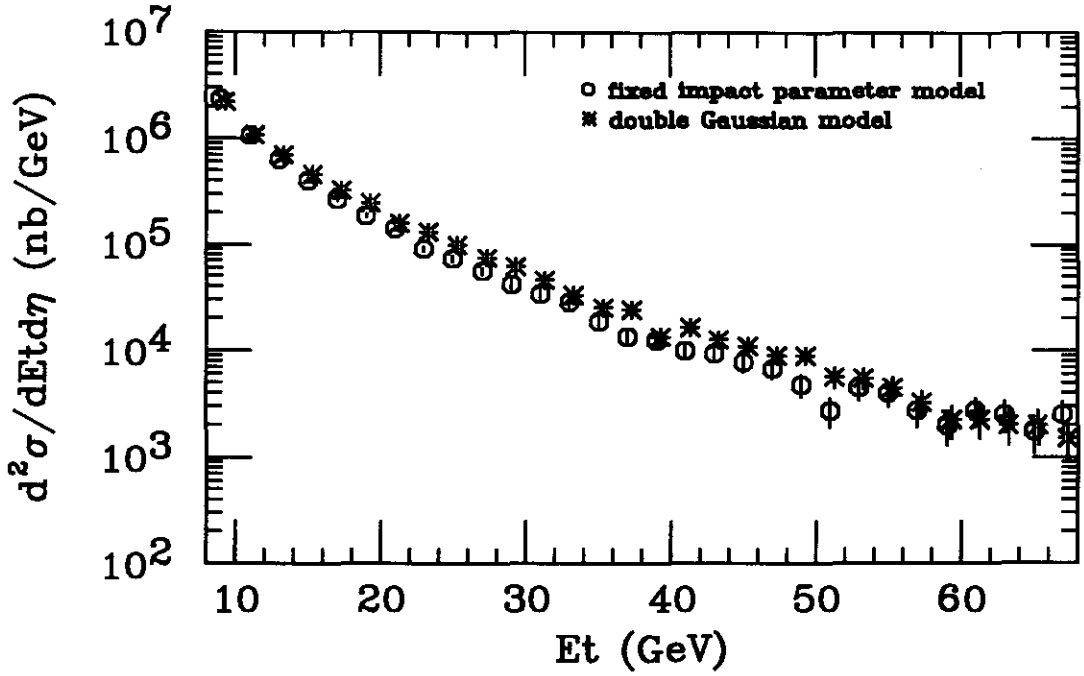

FIG. 10. The same as Fig. 9, but at $\sqrt{s}$ = 40 TeV for the two Pythia models with jets centered in $|\eta| < 1$.

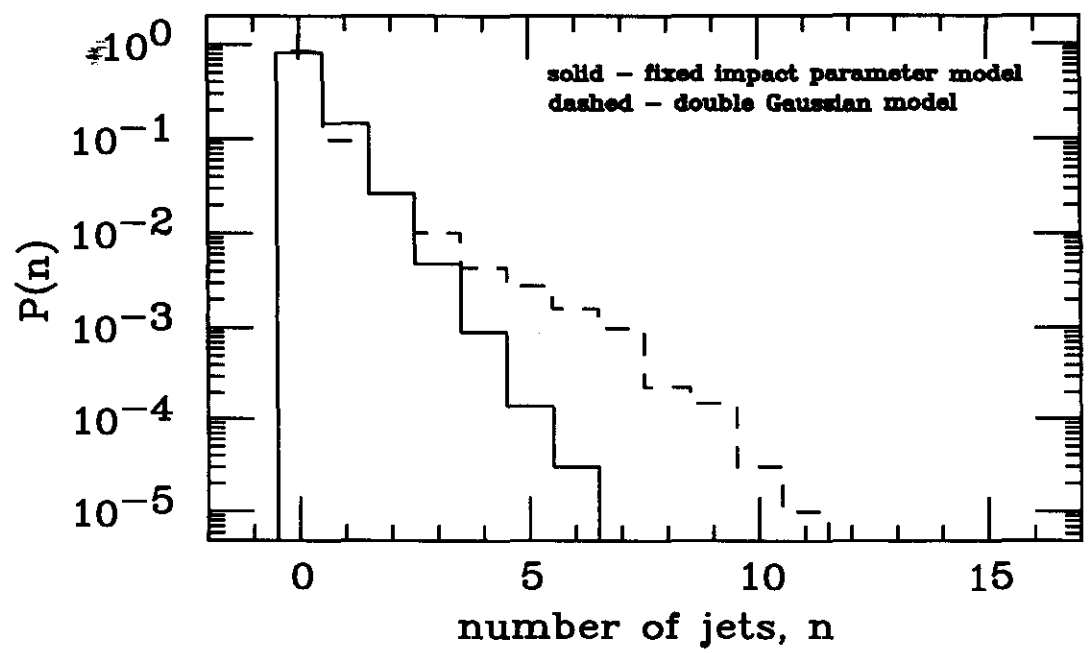

FIG 11. Probability of n, P(n), versus n, the number of jets per event with Et > 8 GeV, centered in $|\eta| < 1$, at $\sqrt{s}$ = 40 TeV for the two Pythia models. The definition of a jet may be found in Appendix 1.

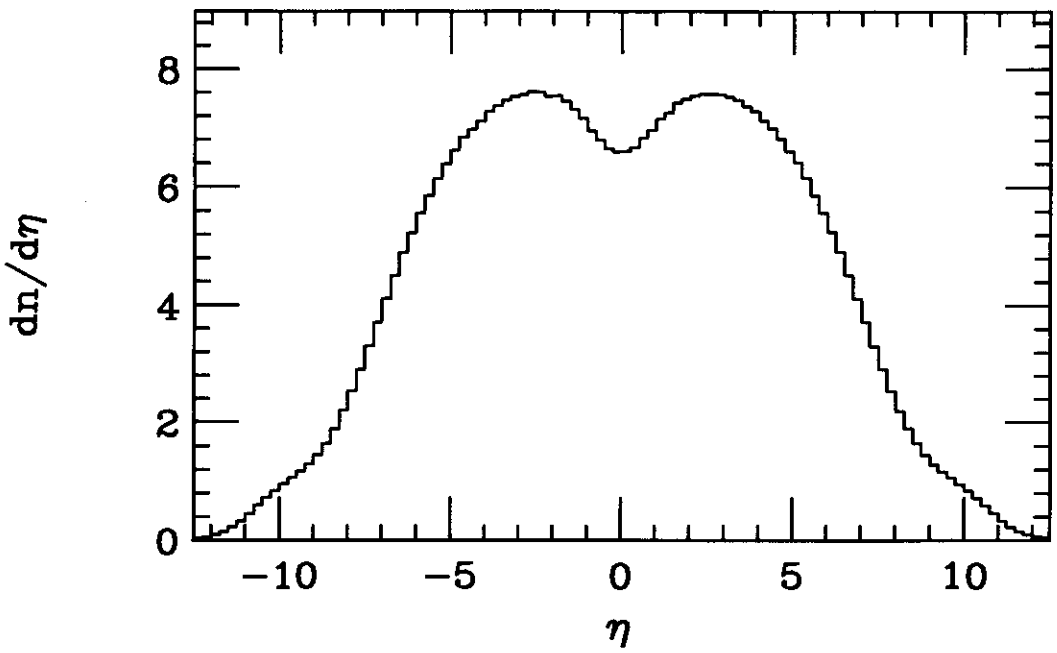

FIG. 12. The number of charged particles, n, per unit of pseudo−rapidity, η, at $\sqrt{s}$ = 40 TeV for the fixed impact parameter model. There are 10^5 events in the sample.

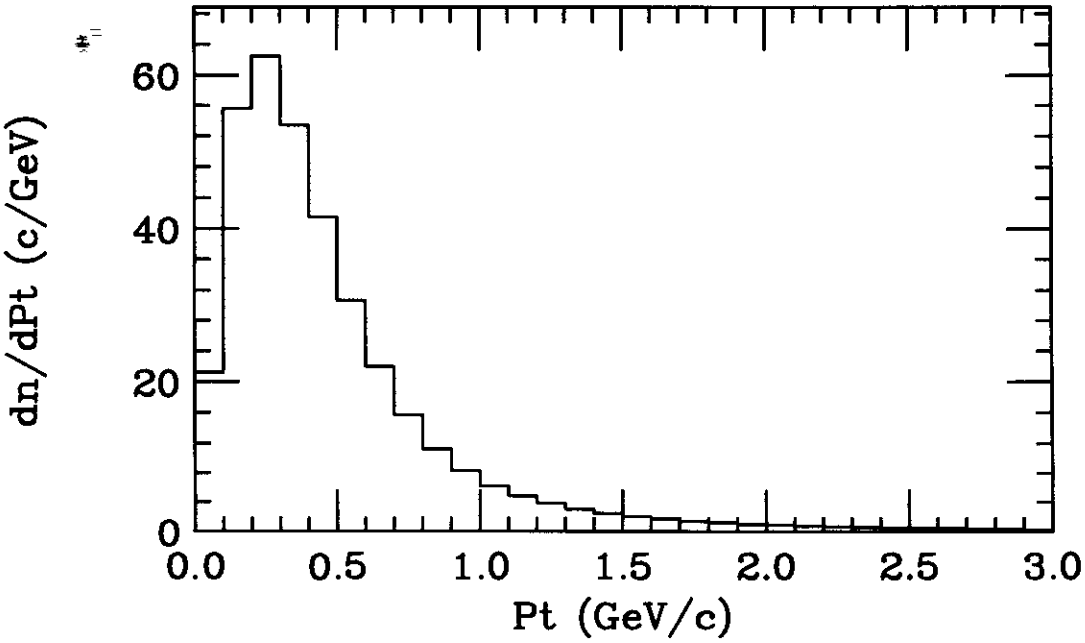

FIG 13. The number of charged particles in $|\eta| < 2.5$, n, per unit of transverse momentum, Pt, at $\sqrt{s}$ = 40 TeV for the fixed impact parameter model. There are 10^5 events in the sample.

Appendix 1

To generate Figures 1–7, 9:

Pythia 5.4, revised October 10, 1990 — Jetset 7.3, revised October 15, 1990

To generate Figures 8, 10–13:

Pythia 5.5, revised June 14, 1991* — Jetset 7.3, revised June 21, 1991*
* This version has been installed in the SSC library since June 26, 1991.

Parameters Set in Pythia (differing from the default values)

Fixed impact parameter model:

MSTP(33)=1	specifies that a constant k factor is to be applied to α_s
PARP(31)=1.2	specifies a k factor = 1.2

Double Gaussian model:

MSTP(82)=4	specifies double Gaussian matter distribution
MSTP(2)=2	use $\alpha_s(Q^2)$, Λ = .2 GeV
MSTP(33)=3	$Q^2 \rightarrow .075(p_T^2 + p_{T_0}^2)$
PARP(82)=1.3	p_{T_0}, the p_T normalization scale
PARP(85)=.81	gives the probability that an additional interaction gives two gluons with color connections to nearest neighbors.
PARP(86)=.9	the sum of the probability in PARP(85) plus the probability that an additional interaction gives a closed gluon loop. The remaining probability is assigned to quark-antiquark pairs.

When generating diffractive events:

MSTP(101)=2	the diffractive interaction consists of a forward moving diquark and a quark joined by an interacting gluon.

At all times:

MDCY(C310,1)=0	make K stable
MDCY(C3112,1)=0	make Σ^- stable
MDCY(C3122,1)=0	make Λ^0 stable
MDCY(C3222,1)=0	make Σ^+ stable
MDCY(C3312,1)=0	make Ξ^- stable
MDCY(C3322,1)=0	make Ξ^0 stable
MDCY(C3334,1)=0	make Ω^- stable
PMAS(6,1)=150.	set top quark mass to 150 GeV

To find jets for comparison to CDF:

PARU(51)=1.4	$\|\eta\|$ maximum
MSTU(51)=28	number of segments in η
MSTU(52)=24	number of segments in ϕ
PARU(52)=1.	minimum E_T (GeV) for initiator cell
PARU(54)=.7	$R = \sqrt{(\Delta\eta^2 + \Delta\phi^2)}$
PARU(53)=8.	minimum E_T for jet

(the program selects only jets centered in $.1 < |\eta| < .7$)

Appendix 1, continued

To find jets at $\sqrt{s} = 40$ TeV:

PARU(51)=1.7	$\|\eta\|$ maximum
MSTU(51)=34	number of segments in η
MSTU(52)=63	number of segments in ϕ
PARU(52)=1.	minimum E_T (GeV) for initiator cell
PARU(54)=.7	$R = \sqrt{(\Delta\eta^2 + \Delta\phi^2)}$
PARU(53)=8.	minimum E_T for jet

(the program selects only jets centered in $|\eta| < 1.0$)

To generate inelastic non- single diffractive events:

MSEL=0	use MSUB switches
MSUB(93)=1	generate double diffractive events
MSUB(95)=1	generate inelastic non-diffractive events

To generate inelastic non-diffractive events:

MSEL=0 and MSUB(95)=1
or MSEL=1
these two options generate the identical events

To generate all QCD processes:

MSEL=2

Appendix 2

Minimum-bias Triggers

UA1:

at least one charged particle in $-5.5 < \eta < -1.5$
and at least one in $+1.5 < \eta < +5.5$

UA5 (not used since UA5 data is corrected for trigger inefficiencies by Monte Carlo simulation):

at least one charged particle in $-5.6 < \eta < -2.0$
and at least one in $+2.0 < \eta < +5.6$

CDF (including selection criteria):

at least one charged particle in $-5.89 < \eta < -3.24$
and at least one in $+3.24 < \eta < +5.89$

-and-

(1) at least one charged particle in $-3 < \eta < 0$
and at least one in $0 < \eta < 3$
and at least 4 in $-3 < \eta < 3$

-or-

(2) at least 3 charged particles in $-5.89 < \eta < -3.24$
and at least 3 in $+3.24 < \eta < +5.89$
and at least 2 in $-3.00 < \eta < +3.00$

Appendix 3

Characteristics of inelastic non-diffractive events
at $\sqrt{s} = 40$ TeV, using Pythia 5.5,
fixed impact parameter model for multiple interactions, k factor = 1.2.

$$\langle p_T \rangle \text{ (in } |\eta| < 2.5) = .52 \text{ GeV}/c$$

$$\text{charged multiplicity (in } |\eta| < 2.5) = 35.8$$

Charged particles per event:

π	87.6
k	10.4
p	6.9
Σ, Ξ, Ω	1.0
e	1.3
μ	.02
total	107.2

Neutral particles per event:

n	6.5
k	10.1
Λ	2.0
Ξ	.15
γ	107.8
ν	.05
total	126.6

Charged particles in $|\eta| < 2.5$ with p_T greater than:

p_T (GeV/c)	N_{ch}
0	35.8
2	.84
4	.14
6	.043
8	.017
10	.0085
12	.0047
14	.0027
16	.0017
18	.0010
20	.0007