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Fermilab Dedicated Collider: Physics Issues*

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I. Introduction

The year 1983 has seen an important round of decisions on US high energy physics planning issues. A HEPAP Subpanel on Long Range Planning, chaired by Stanley Wojcicki, met during the spring and early summer to consider and make recommendations on various initiatives for future US high energy facilities. One of these proposals, the Fermilab Dedicated Collider (DC), is the topic here. At the time of the Lake Tahoe meeting, the jury was still out. The emergent verdict of the Wojcicki committee, endorsed by HEPAP, was to "not proceed at this time with the Dedicated Collider." Consequently the DC initiative is now totally inactive, which makes this written account something of a lame, if not dead, duck. Therefore we shall concentrate here on physics issues, as extensively documented in the proposal, in the hope they may provide some perspective on physics questions for both our near and far future.

For the record, the Wojcicki subpanel also recommended, by a split vote, against the Brookhaven CBA proposal, while strongly and unanimously endorsing an aggressive push toward a 20×20 TeV high luminosity pp Superconducting Super Collider (SSC). Unfortunately most of the estimates in the DC proposal do not reach to this extraordinary energy scale. This deficiency should be rectified in the near future.

As described in the proposal, the Dedicated Collider would be a proton-antiproton/electron-proton facility at Fermilab, to be built between 1985 and 1989. The center-of-mass energy of the $p\bar{p}$ collider would be more than 4 TeV and the (Stage I) ep facility would provide collisions of a 10 GeV electron beam on the 2-TeV proton beam ($s = 80000$ GeV^2). An increase of the electron energy to 40 GeV could be a natural second-stage project for a later date.

The DC was designed to have a total of six experimental areas, four major experimental areas for $p\bar{p}$ collisions and two for ep collisions. It would make use of the Tevatron as an injector for both protons and antiprotons, and also would make use of existing Fermilab superconducting-magnet and refrigeration-system technology to provide a rapid way to complete the facility. The Tevatron fixed-target program would no longer share the accelerator with the TeV I collider and could therefore operate at full efficiency. The $p\bar{p}$ luminosity is in excess of 10^{31}cm^{-2}sec^{-1} and the ep luminosity is 6×10^{31}cm^{-2}sec^{-1}.

The idea of a "site-filling" ring at Fermilab goes back very far, but this revival of the idea can be traced to the 1981 Subpanel on Long Range Planning, chaired by G. Trilling, which recommended "a start by the mid 1980's on a new high energy construction project...". Examples of such a new facility cited in that report are "an electron-proton collider or a less expensive high luminosity ($L \sim 10^{33}$cm^{-2}sec^{-1}) hadron-hadron collider built in the ISABELLE tunnel; a second proton collider ring at Fermilab dedicated to $p\bar{p}$, pp, and/or ep collisions, an e^+e^- collider using superconducting cavities (as proposed for CESR II), or a combination of smaller facilities, one of which might be a major non-accelerator facility." The DC proposal was prepared from August 1982 to May 1983, when it was submitted to the HEPAP Subpanel. The $p\bar{p}$ machine design is largely due to Tom Collins and Lee Teng, and the ep collider design was contributed by Steve Holmes and Wonyong Lee. The physics was contributed by Chris Quigg and Estia Eichten. Many others contributed to the proposal. Some copies of the proposal remain and may be obtained upon request to JDB.

A site layout is shown in Fig. 1, and a parameter list for the $p\bar{p}$ collider is shown in Table I. Briefly, 44 bunches of protons would collide against 44 $\bar{p}$ bunches, with electrostatic deflectors providing separation of the bunches except at the four interaction regions. Preparation of p and $\bar{p}$ beams would use the Saver and TeV 1 systems which exist or are soon to exist. Injection into the new ring would be at 1 TeV, followed by a 3 minute ramp to the operating energy of 2 TeV/beam.

Parameters for the 10 GeV×2 TeV ep option are given in Table II. There would be two collision regions in a long utility straight section, distinct from the four $p\bar{p}$ collision regions.

Costs ($FY83) are $360M for the $p\bar{p}$ option (ep assembly areas postponed) or $405M for the ep option ($p\bar{p}$ assembly areas postponed), with completion date estimated as 1989.

II. Physics Issues: $p\bar{p}$ and pp Collisions at the TeV Energy Scale

This section is extracted nearly verbatim from the DC proposal, with editorial changes designed to broaden the considerations somewhat in hopes that it may be of use in a context more general than the original proposal. The existing documentation of ep physics is quite extensive in the light of the HERA initiative. In the interest of brevity, the DC ep discussion has been omitted here.

A. Beyond the Bellwethers

The spectacular results from $S\bar{P}PS$ experiments UA1 and UA2 are important not only for their direct contributions to science, but also for what they portend for future facilities. They demonstrate that:

1. $\bar{p}p$ colliders work. Intense antiproton sources of good emittance can be built. The beam-beam interactions are (at worst) no more disruptive than anticipated.

2. Hard collisions occur in hadron-hadron interactions. The theoretical rate projections have been reasonably accurate, and extraction of signals from background has not been any more difficult than generally anticipated. Indeed, those who felt that a very high integrated luminosity would be required to extract the signal for the leptonic decay of the W were unprepared for the convincing evidence for the intermediate boson that emerged from only a few events.

Table I.
Dedicated Collider Parameters: $p\bar{p}$

Normal cell	90° separated function FODO
Half cell length	37.4 m
Ring circumference F	13.2 km
Number of dipoles	1168
Length of dipoles	7.75 m
Peak dipole field	4.6T
Length of cell quadrupole	2.5 m
Peak gradient of cell quadrupole	1.0 T/cm
Max/min normal β	127/22.5 m
Max/min normal η	2.2/1.07 m
Transition γ_t	37.2
Tune (horiz/vertical)	46.6/44.4
Natural chromaticity (horiz/vertical)	-92/-119
β^*	1 m
β_{max} (horiz/vertical)	725/1925 m
RF Harmonic number	2332
RF Frequency	53.1 Mhz
Peak voltage/turn	1 MV

	injection	peak momentum
Bucket area	14.8	21 ev-sec
Synchrotron frequency	11.8	8.3 Hz
Bunch length ($\pm 3\sigma$)	1.9 m	1.6 m
Bunch width $\delta p/p(\pm 3\sigma)$	$\pm 3\times 10^{-7}$	$\pm 1.8\times 10^{-7}$
Maximum Z_ℓ/n for stability	19.52	
Number of $p/\bar{p}$ per bunch	$10^{11}/10^{11}$	
Number per bunch	10^{11}	
Number of $p/\bar{p}$ bunches	44/44	
Normalized transverse emittance	24π mm-mrad	
Luminosity/crossing	4×10^{25} cm^{-2}	
Luminosity	4×10^{31} cm^{-2} sec^{-1}	
Beam-beam linear tuneshift/crossing	.003	
Luminosity lifetime	15 hrs.	

Table II
Electron-Ring Parameters

Energy	10.0	GeV
Injection Energy	5.0	GeV
Circumference	1659.7	m
Number of Bunches	98	
Bunch Separation	16.94	m
Bunch Frequency	17.7	MHz
Electrons/Bunch	8.5×10^{10}	
Emittance (horiz/vert, rms)	.035/.016	mm-mrad
Energy Spread	1.2×10^{-3}	
Tune (Horizontal/Vertical)	37.1/36.2	
Momentum Compaction	6.7×10^{-4}	
Polarization Time	14.8	min
Equilibrium Polarization	80.5	%
Energy Loss/Turn	13.2	MeV
Damping Time (Transverse)	8.4	msec
Bending Field	3.4	kG
Number of Interaction Regions	2	
Beam Size at Interaction Point (horiz/vert, rms)	0.13/0.09	mm

Luminosity

	Protons	Electrons
Energy	2000.	10. GeV
N/Bunch	6.9×10^{10}	8.5×10^{10}
Bunch Frequency	17.7 MHz	
Current	0.20	0.24 mA
Emittance (horiz/vert)	.01/.01	.035/.016 mm-mrad
β^*_H/β^*_V	8.5/8.5	.48/.53 m
Beam Size (horiz/vert, rms)	0.12/.012	0.13/0.09 mm
Crossing Angle	0. mrad	
Luminosity	6.2×10^{31} cm^{-2}sec^{-1}	
Tune Shift (horiz/vert)	.0029/.0040	.027/.030

RF System

	Peak	Injection
Energy	10.0	5.0 GeV
Energy Loss/Turn	13.2	0.8 MeV
RF Voltage	16.5	4.9 MV
Frequency	496.	496. MHz
Harmonic Number	2744	2744
Synchrotron Tune	0.017	.017
Bunch length	1.09	0.54 cm
Energy Acceptance	0.007	.016
Power into Beam	3.2	0.2 MW
Total Length	12.6	12.6 meters
Total RF Power	4.0	0.9 MW

3. Multijet events are manifestly analyzable. The striking LEGO plots of these events promise a rich future for fine-grained calorimetric techniques for identifying and measuring electromagnetic and hadronic jets. One can well imagine the measurement of inclusive spectra of jets and leptons becoming relatively pedestrian as techniques of multijet spectroscopy mature. We may already anticipate relatively strong statements from the next S$\bar{P}$PS running period on the existence of the top (or other) quark(s) in the mass range of 20-60 GeV/c^2, based on the measurement of two or more particles (or jets) per event. These multijet phenomena are likely to dominate experimental and theoretical attention within the next few years, and certainly in the time frame we consider here. The mastery of multijet spectroscopy will liberate us from reliance upon low-branching-ratio signatures for interesting new phenomena. One must also bear in mind that the c.m. energy of 4-5 TeV is more than seven times greater and the luminosity more than 200 times greater than what is now available at the S$\bar{P}$PS.

In what follows we survey physics opportunities by proceeding from the conventional features implied by the standard model to more speculative topics, and close the $p\bar{p}$ discussion with a very brief general discussion of the rates for hard collisions among partons, along with a discussion of the limitations of the calculations.

B. Electroweak Phenomena

The discovery of the intermediate boson establishes, as expected, the 100 GeV regime of c.m. energy as the natural scale of the electroweak interactions. The S$\bar{P}$PS and Tev I programs, and especially the LEP and SLC electron-positron colliders, should provide a rather thorough exploration of this energy regime. In addition, TeV I will make possible the first look beyond this energy scale. As already mentioned, the natural habitat of the DC is in the realm of hard-collision invariant masses between 0.5 and 1 TeV.

As an example, the number of standard model intermediate bosons to be expected in a standard run (integrated luminosity $\int \mathcal{L} dt = 10^{38}$ cm^{-2}) at the DC is of order 10^6, which should be large enough to permit many detailed studies. This represents a significant increase over the rates anticipated for the S$\bar{P}$PS and TeV I, and is also competitive with what might be achieved in a high-luminosity CBA. For the neutral gauge bosons Z° the e^+e^- colliders would seem to retain a decided advantage in event rate.

The situation is similar for the production of pairs of gauge bosons, a measurement which provides some of the motivation for LEP II. The cross section is sensitive to three-gauge-boson couplings, and has been advocated as a test of the non-Abelian nature of the interaction. Whether it will in fact be the most sensitive test remains to be seen. In any case, a DC produces these events in interesting numbers, of order 10^3. The cross section for the related $W\gamma$ final state, which is sensitive to the magnetic moment of the intermediate boson, is strongly dependent on the cut imposed upon the photon momentum. The anticipated event rate is typically greater than or equal to the pair production rates.

Within the standard model, the spontaneous symmetry breaking is accomplished by an elementary scalar Higgs boson. The mass of the Higgs boson is an arbitrary parameter of the theory as it is currently understood, subject only to the bounds

$$7.4 \text{ GeV}/c^2 < M_H \lesssim 1 \text{ TeV}/c^2.$$

It is plausible that the upper bound, which is based on the consistency of perturbation theory, can be improved to approximately 400 GeV/c^2. If $M_H \lesssim 40$ GeV/c^2, it should be possible to detect the Higgs boson in Z° decays at SLC or LEP. LEP II could perhaps extend the limit to about 100 GeV/c^2 in the process

$$e^+e^- \rightarrow H + Z^\circ.$$

The DC is sensitive to still higher masses. The production mechanism of $gg \rightarrow H$ via a fermion triangle is sensitive to the mass of the top quark, as shown in Fig. 2. The highest Higgs boson mass for which 100 events will be produced for the benchmark luminosity of 10^{38}cm^{-2} is ~220±120 GeV. For Higgs masses in excess of about $2M_W$, the dominant decay mode will be into pairs of gauge bosons. This would provide a characteristic signature for hadron-jet spectroscopy. The mass range $M_W < M_H \lesssim 2M_W$ is more problematic, and may require good luck--or an e^+e^- collider.

Should the top quark be very heavy, or should a fourth fermion generation exist, it is of interest to search for heavy quarks using the methods now being evolved at the $Sp\bar{p}S$. Pair production cross sections estimated from the gluon fusion mechanism are shown in Fig. 3.

A simple extension of the standard model would entail the existence of additional gauge bosons. In the case of a right-handed W-boson, which would restore left-right symmetry at high energies, an ep collider would be an important diagnostic tool. Couplings of additional gauge bosons to the light fermions are evidently model dependent, but reasonable cross section estimates for production in $p\bar{p}$ collisions may be had by assuming universality of the gauge couplings. The highest masses for which 100 events are produced at a DC energy and luminosity are well beyond 1 TeV/c^2.

C. Hadron Jets

Early running at the CERN $Sp\bar{p}S$ has confirmed the expectation that the cross sections for hard scattering of constituents are large. Moreover, LEGO displays have shown that for an important class of events the jets are well collimated, isolated, and straightforward to analyze. Already in limited running, hard collisions have been observed at c.m. energies in excess of those that may be attained in e^+e^- collisions for a decade or more.

Jet studies in hadron-hadron collisions have traditionally been viewed as less incisive than those carried out in electron-positron annihilations or in lepton-nucleon scattering because of the added complexity of events. The S$\bar{\mathrm{P}}$PS experience indicates that, as hoped, the hard scattering events take on a much simpler aspect at high energies, and there is no impediment to detailed analyses. We may therefore expect to take advantage of the higher energies attainable in hadron-hadron collisions and of the greater diversity of elementary interactions made possible by our unseparated broad-band parton beams.

To give an indication of the expected cross sections, we show in Fig. 4 the lowest-order QCD hard-scattering contributions to $d\sigma/dydp_T$ at 90° in the c.m. Our current understanding of QCD seems not to justify a more elaborate calculation. In any event, the prediction for $\sqrt{s} = 0.54$ TeV is in reasonable agreement with the preliminary data from the UA1 experiment.

The prospect of studying fully-developed jets is enhanced by the possibility of distinguishing between gluon jets and quark jets by kinematic selections. How this might be done is indicated first in Fig. 5, which shows separately the contributions to $d^2\sigma/dydp_T$ of the

$$gg \to (gg \text{ and } q\underline{\bar{q}})$$
$$gq \to gq \text{ and } g\bar{q} \to g\bar{q}$$
$$\begin{cases} \underline{qq} \to \underline{qq} \\ q\underline{q} \to q\underline{q} \\ qq \to qq \end{cases}$$

processes. Because the cross section for $gg \to q\bar{q}$ is negligible compared to that for $gg \to gg$, these three classes of processes correspond closely to two-gluon, (anti)quark-gluon, and two (anti)quark jets. At modest transverse momenta, of order 100 GeV/c or less, the two-gluon final state is dominant. The mix changes markedly at larger values of p_T, so that quark jets ultimately prevail.

Another method of separation is made possible by the different rapidity dependence of the components. Figures 6 (a)-(e) show the behavior of

$$\left.\frac{d\sigma}{dp_T\,dy_1\,dy_2}\right|_{y_2=-y_1}$$

as a function of y_1 for various fixed values of p_T. The gluon-gluon process prevails at small p_T and small rapidities, while the reactions involving valence quarks become dominant at large p_T and large rapidities. The possibilities for dramatic changes in the mix of jets are readily apparent.

Interesting as the study of two-jet events may now seem, it may well be rather straightforward and thus rapidly assume the traditional role of Bhabha scattering in e^+e^- colliders: prominent, quickly and accurately measurable, and thereafter neglected by all but the Feynman-diagram computer technologists. Multijet events and multijet spectroscopy would then become the focus of research interests for perturbative QCD in this regime. Again, it is the high energy, diversity of processes, and simplicity of jet spectroscopy which raise our hopes.

D. New Landmarks in 1-TeV Physics

In many ways, the scale of 1 TeV represents the frontier of our ignorance. It describes a regime in which we have, as yet, no direct experimental information and one in which our current understanding seems to compel the existence of new phenomena. The necessity of new physics is more convincing than the argument for any specific manifestation of the new scale, so it is important to explore this region with good sensitivity to many possibilities.

What are the physics landmarks in this regime? The clearest one is given by the fundamental parameter of electroweak spontaneous symmetry breaking, the vacuum expectation value $\langle\phi\rangle_0$ of the Higgs field, which is equal to about 174 GeV. The origin of this scale, which is considerably larger than that of the intermediate bosons, is dimly understood. This alone provides a solid stimulus to the exploration of this regime. Most lines of theoretical speculation have as a primary goal the improved understanding of the dynamics of the Higgs sector. Typical scenarios populate the region between 100 GeV and 10 TeV with a multitude of new particles. In each of the proposed scenarios:

Technicolor
Supersymmetry
Compositeness

there are clearly identifiable signals of this dynamics at energies at or below $G_F^{-1/2} \simeq 250$ GeV. Each of these alternatives has a light sector of bosons (and/or fermions) whose existence is associated in a fundamental way to the approximate chiral symmetries at the new interaction scale. This light sector comprises the set of least massive members of the family of new particles and is a general feature of any dynamics at this scale.

In technicolor the light sector is bosonic--the specific new particles have been called technipions--while in the supersymmetric models both bosons (squarks and sleptons) and fermions (gluino, photino,...) result. In composite models the role of the light sector of the theory is provided by some (or all) of the ordinary quarks and leptons. Here, therefore, the signal of the new dynamics will show up directly in the hard scattering of quarks and leptons. We will discuss each of these alternatives in turn.

1. Technicolor

In the standard electroweak theory, the spontaneous symmetry breaking is accomplished by the action of a complex doublet of elementary scalar fields. Subject to constraints imposed by neutral current phenomenology, there may in principle be any number of elementary scalars and the resulting Higgs bosons. How many there are, what are the masses of the surviving physical scalars, and what are their couplings to ordinary matter can only be settled experimentally. The standard theoretical framework offers no guidance, other than rather broad (and nonrigorous) bounds on the Higgs boson mass.

An alternative description goes by the name of dynamical symmetry breaking or, colloquially, technicolor. This program attempts to find a dynamical basis for the Higgs scale in terms of new strong (technicolor) interactions at a scale of about 1 TeV, and thus to explain the breakdown of $SU(2)_L \otimes U(1)_Y \rightarrow U(1)_{EM}$ and the generation of fermion masses. In this approach, spinless bound states of heavy fermion-antifermion pairs play the role of the elementary scalars of the standard model. The lightest of these, dubbed technipions, are the most immediately accessible to experiment.

No phenomenologically acceptable model of dynamical symmetry breaking has been developed, and so many details of the conjectured spectrum are unsettled. The general idea of dynamical symmetry breaking is however so natural and appealing, and the general arguments for structure in the few-hundred GeV regime so compelling, that a careful search is mandatory.

A number of the conjectured composite scalar mesons have appreciable couplings to gluons and hence can be produced copiously in hadron-hadron colliders. The so-called technieta (η_T or P_8) can be produced in two-gluon fusion with the cross sections shown in Fig. 7. Heavy pairs of colored technihadrons can also be produced, as indicated in Fig. 8 with (solid curves) and without (dashed curves) the expected technivector meson enhancements. The technihadrons should have distinctive decay signatures involving multiple jets and leptons.

2. Supersymmetric Partners of the Known Particles

A possible sign of the incompleteness of the standard model is the arbitrariness that remains even after a minimal unification of the strong, weak, and electromagnetic interactions. The gauge bosons may be said to be prescribed by the local gauge symmetry, but the elementary fermions are put in by hand, and the elementary scalar fields and their self-interactions are, for now, total invention. The possibility of relating vector, spinor, and scalar particles in a way that reduces or eliminates the unwanted freedom of the model has an obvious appeal. The fermion-boson symmetry known as supersymmetry raises the hope that such a simplification might be achieved.

However, it is now apparent that the observed particles cannot be supersymmetric partners of each other. Therefore, if supersymmetry is useful on the present energy scale, it implies a doubling of the spectrum with the following minimal complement of new objects:

	Established Particles		Supersymmetric Partners	
	gluons		gluinos $\tilde{g}$	
J=1	intermediate bosons	$W^{\pm}$	winos $\tilde{W}^{\pm}$	J=1/2
		Z:	zino $\tilde{Z}$	
	photon γ		photino $\tilde{\gamma}$	
	leptons ℓ		sleptons $\tilde{\ell}$	
J=1/2				J=0
	quarks q		squarks $\tilde{q}$	
J=0	Higgs boson H		higgsino $\tilde{h}$	J=1/2

These are plainly not degenerate with the established particles, so supersymmetry must be broken. No convincing model of broken supersymmetry which meets phenomenological requirements has yet been formulated. Consequently the pattern of masses and decay chains of the superparticles is open to speculation. In contrast, the elementary couplings involving superparticles should be related to known couplings by Clebsch-Gordan coefficients.

While worthwhile in its own right, a complete survey of possibilities would be out of proportion to the importance of superparticles to the justification of a high-energy hadron collider. The particles which seem to be of greatest interest are the colored squarks and gluinos. The cross section for pair production of squarks is shown in Fig. 9 as a function of squark mass.

The expected gluino production rates are still larger, because of the larger color charge of the gluino. These are shown in Fig. 10. In this case, the DC should provide sensitivity out to a mass of 400 GeV/c^2.

3. Compositeness

The standard model is based upon the notion that the quarks and leptons are elementary particles, and indeed there is direct experimental evidence that they are structureless on a scale of ~10^{-16}cm. However, both history and the proliferation of flavors encourage us to consider the possibility that quarks and leptons are themselves composite. The right such model might then predict the spectrum and reduce the arbitrariness inherent in the standard model.

If quarks and leptons are bound states, the force that binds the constituents will also mediate new interactions among the bound states. At energies far below the compositeness scale, these new interactions may be represented as effective contact terms of the form

$$\delta = \pm\frac{g^2}{\Lambda^2} (\bar{f}f)(\bar{f}'f') ,$$

where Λ is the compositeness scale. It is plausible (since the interactions must be strong) that $g^2/4\pi = 1$.

The effect of the contact term on jet production for various values of Λ and for both + and - signs in the coupling is shown in Fig. 11. Under the assumption that detection of a departure from QCD expectations would be noticeable if the deviation is (i) by a factor of two or more, (ii) gives at least 100 events/run variation from expectation, and (iii) gives a detectable non-scaling energy behavior, the sensitivity is 2-3 TeV.

If both the light quarks and muons are composite, then the effects of the contact interaction will modify the usual Drell-Yan cross section. The resulting cross sections are shown in Fig. 12. The maximum compositeness scale to which one may expect to be sensitive is of order 5 TeV, under similar assumptions to those made for the hadron jets.

Finally, there is the possibility in a composite model that excited colored objects may be pair-produced in hadronic collisions. These exotic fermions might be expected to appear with masses of a few hundred GeV/c^2.

E. Parton Luminosities; Summary of $p\bar{p}$ Opportunities

High-mass hard collisions are the principal avenue to high-energy parton-parton interactions. Cross sections for hard collisions are characterized by the limiting high-energy behavior

$$\sigma(\hat{s}) = c/\hat{s},$$

where $\hat{s}$ is the squared subenergy for the elementary process and c is a process-dependent number which typically lies between 10^{-3} and 1. The number of events N accumulated in a collider run with integrated luminosity $\int dt\mathcal{L}$ at machine c.m. energy $\sqrt{s}$ will be given by

$$N = (c/\hat{s})\ F(\hat{s},s) \int dt\mathcal{L} ,$$

where $F(s,\hat{s})$ is a convolution over parton distribution functions in the colliding beams. For various values of c and for an assumed integrated luminosity of $\int dt\mathcal{L} = 10^{38}\text{cm}^{-2}$ characteristic of a machine with peak luminosity of $10^{31}\text{cm}^{-2}\text{sec}^{-1}$, we show in Fig. 13 the value of the maximum subenergy $\sqrt{\hat{s}}$ for which a run at machine energy $\sqrt{s}$ will accumulate 100 events. We see again in a general way that the natural scale of subenergies to be explored at DC energies is typically of order 0.5 to 1.5 TeV.

F. Uncertainties in Rate Estimates

In spite of the great efforts devoted to the study of deeply inelastic scattering and the extraction of structure functions, important ambiguities remain in the parton distributions. These are especially significant for small values of x and at all Q^2, and at large values of x for large Q^2. They arise both from the original parameterizations at modest Q^2 and from the QCD evolution to larger Q^2.

The parton distributions of Owens, Reya, and Duke[1] that we have used for the illustrative calculations may be characterized as "gluon poor." For most purposes they may be regarded as providing conservative estimates of the cross sections. In the preliminary studies which led to this proposal, we have found it useful to consider in addition the Baier, et al.[2] distributions used in the Snowmass study,[3] which represent the opposite extreme of "gluon rich" distributions. [For the Snowmass calculations, Λ=0.1 GeV was used; we take Λ=0.4 GeV, the value obtained by Baier, et al. in their fits. This makes little difference in the results.] Although we believe that reality is likely to lie closer to the gluon poor distributions, the more important point is that a comparison of the two distributions provides a measure of the uncertainty of any such calculations in light of current knowledge. It should also be remembered that the calculations we present are all lowest-order estimates subject to their own theoretical uncertainties.

Luminosity contours for the Baier, et al. distributions are shown in Fig. 14. The relative importance of $u\bar{u}$ and gg collisions is different from what is displayed in Fig. 13, but the energy dependence (as reflected in the slopes of the contours) is quite compatible. Thus the the absolute scale probed by a given machine is distribution-dependent, but the relative comparison among machines is rather insensitive to the parton distributions.

Acknowledgment

The Dedicated Collider proposal was the combined effort of many people. We have already mentioned, but acknowledge again here, that the physics portion of this talk is basically the work of C. Quigg and E. Eichten. The accelerator design is to large extent the work of T. Collins and L. Teng ($p\bar{p}$), and of S. Holmes and W-Y. Lee (ep). Important contributions to the proposal were made, among others, by F. Beck, E. Berger, D. Carey, F. Cole, R. Diebold, J. Griffin, R. Huson, L. Lederman, P. Limon, P. Livdahl, R. Lundy, P. Mantsch, W. Nestander, A. L. Read, A. Ruggiero, R. Schwitters, D. Theriot, A. Tollestrup, and T. Toohig. Stalwart secretarial help was provided by S. Grommes and G. Rudd.

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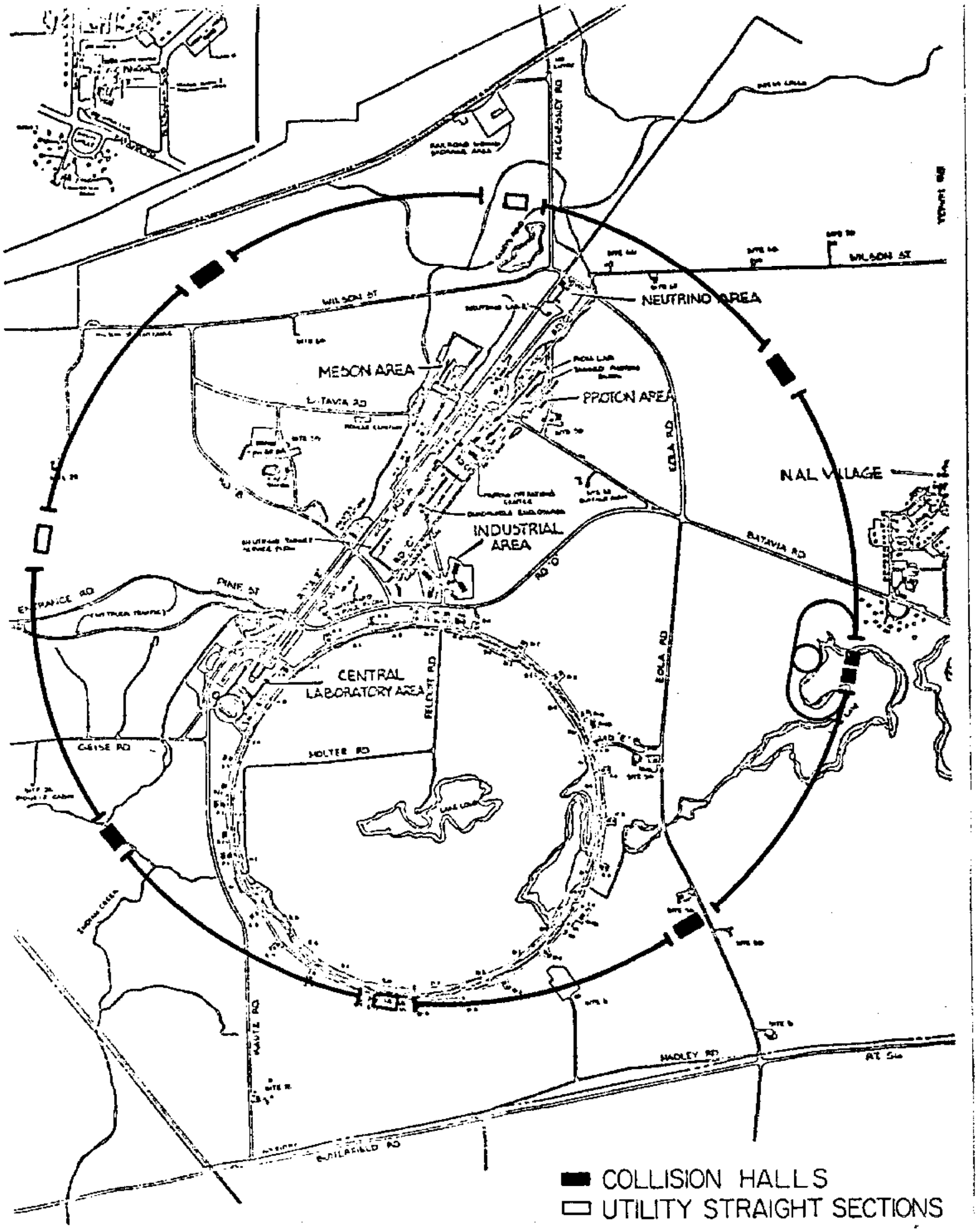

Fig. 1. Layout of the Dedicated Collider on the Fermilab Site.

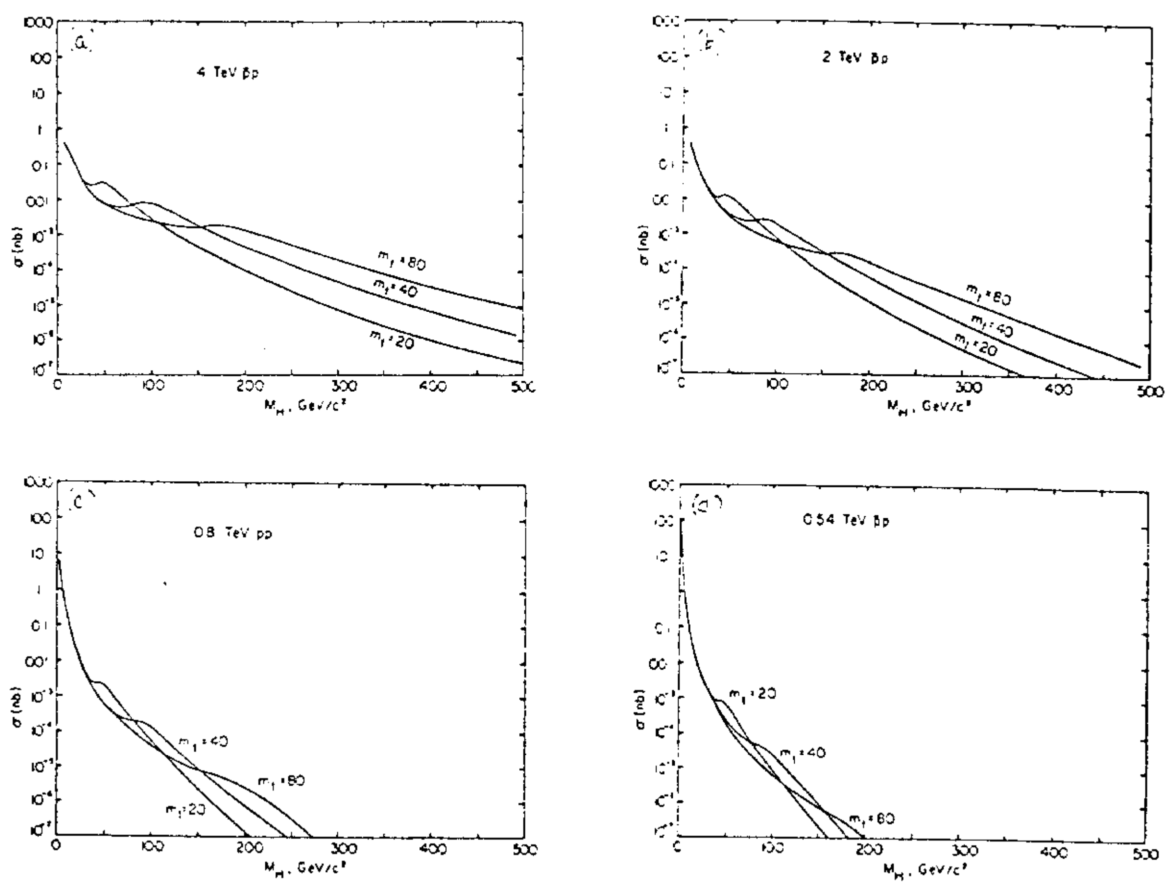

Fig. 2. Cross sections for production of Higgs bosons in hadron-hadron collisions. (a) 4 TeV $\bar{p}p$; (b) 2 TeV $\bar{p}p$; (c) 0.8 TeV pp; (d) 0.54 TeV $\bar{p}p$.

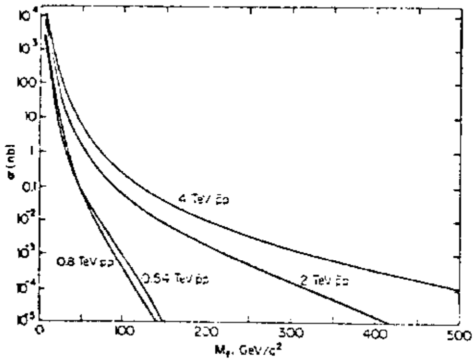

Fig. 3. Cross sections for production of heavy quark pairs in hadron-hadron collisions.

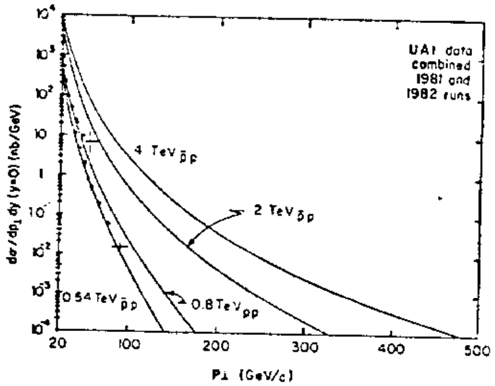

Fig. 4. Hard scattering contribution to the production of hadron jets at 90° in the c.m. The 1981-1982 UA1 data collected in 0.54 TeV p̄p collisions are shown for reference.

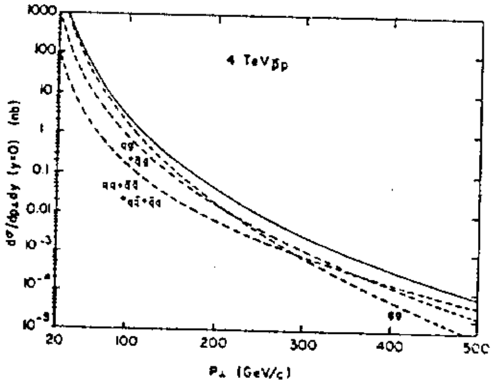

Fig. 5. Jet production by components in 4 TeV p̄p collisions.

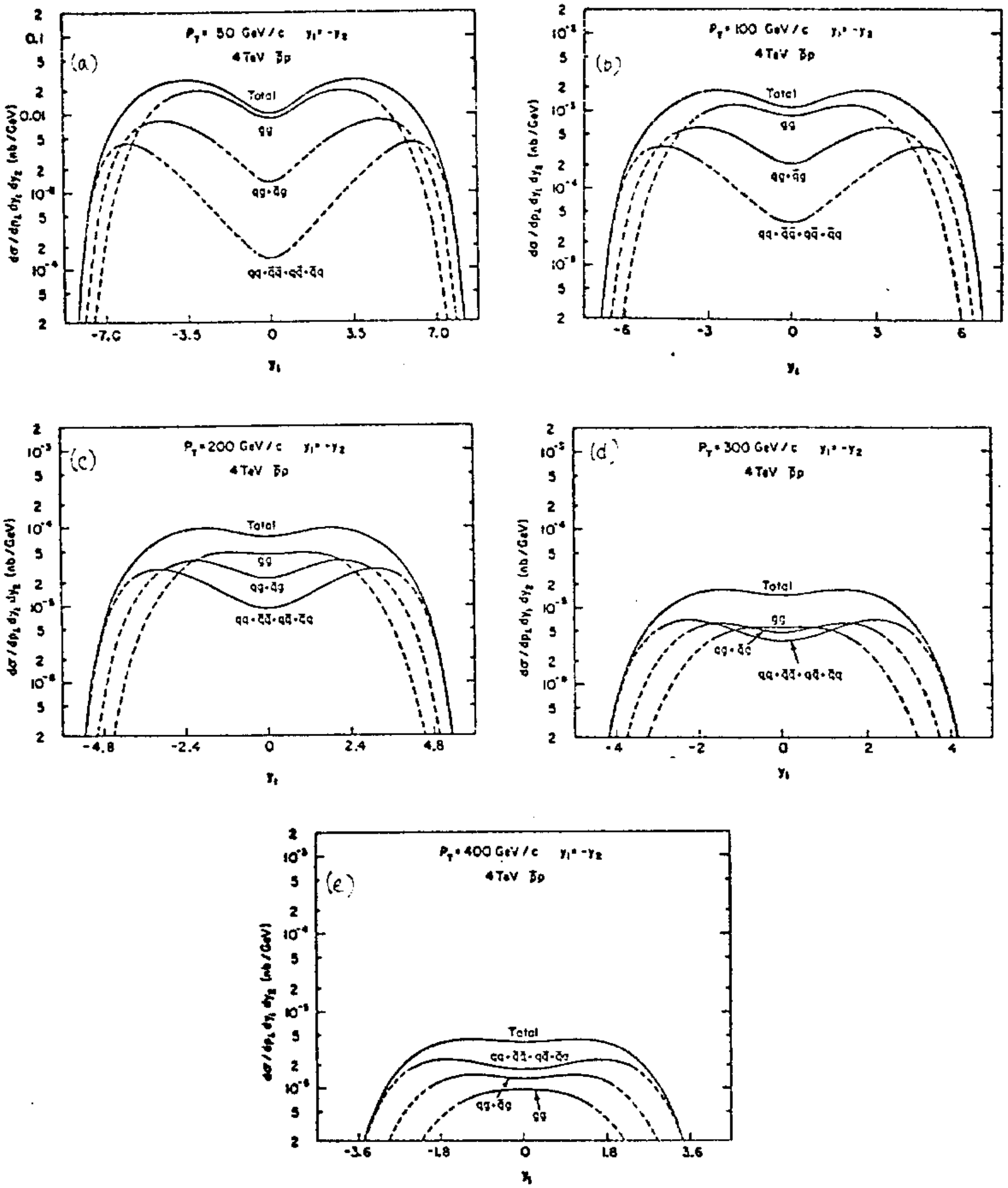

Fig. 6. Contributions of hard-scattering components to symmetric ($y_1+y_2 = 0$) jet production, for specified transverse momentum of each jet in 4 TeV $\bar{p}p$ collisions. (a) p_T = 50 GeV/c; (b) p_T = 100 GeV/c; (c) p_T = 200 GeV/c; (d) p_T = 300 GeV/c; (e) p_T = 400 GeV/c.

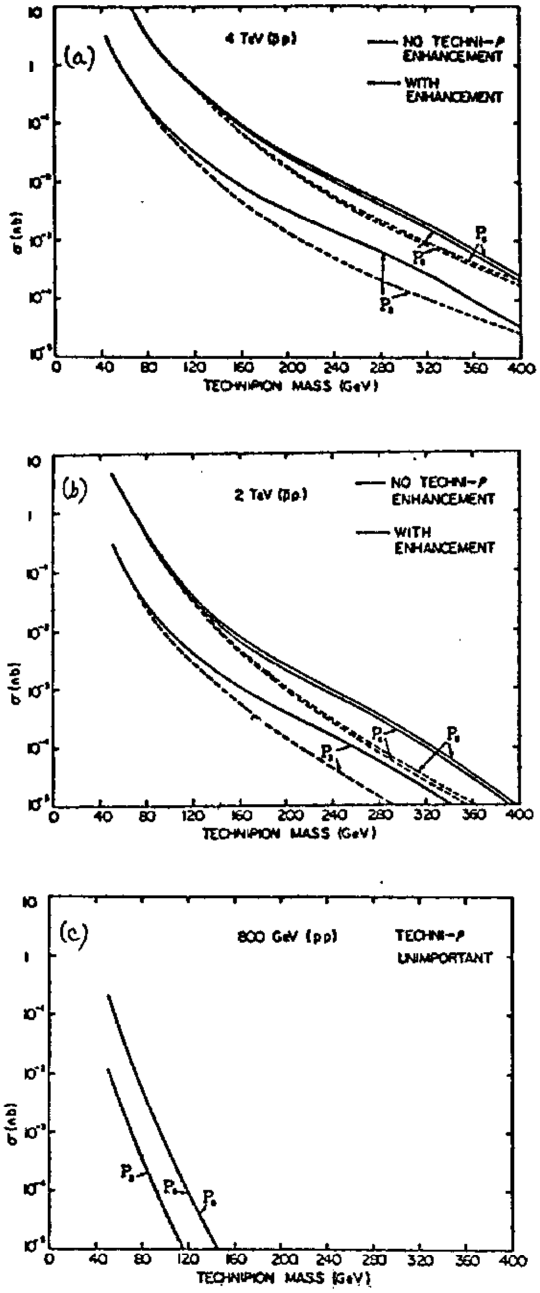

Fig. 7. Cross sections for pair production of technipions with (solid curves) and without (dashed curves) technirho enhancement. (a) 4 TeV $\bar{p}p$; (b) 2 TeV $\bar{p}p$; (c) 0.8 TeV pp.

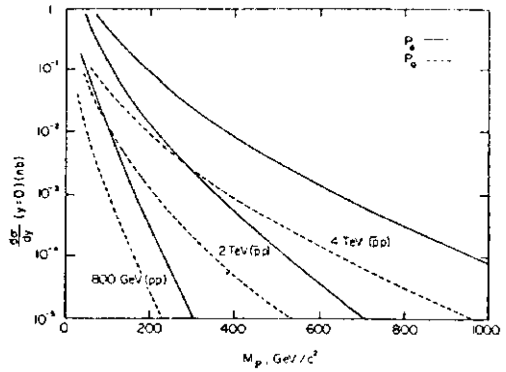

Fig. 8. Differential cross sections dσ/dy (y = 0) for production of Higgs-like scalars in hadron-hadron collisions.

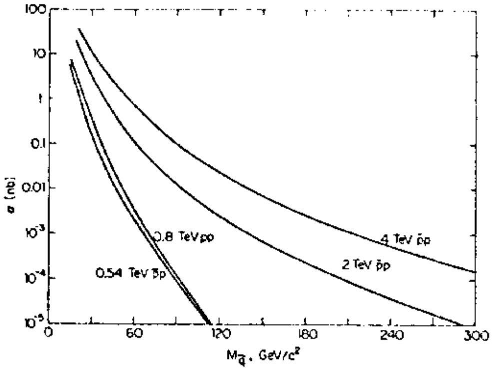

Fig. 9. Cross sections for pair production of squarks in hadron-hadron collisions.

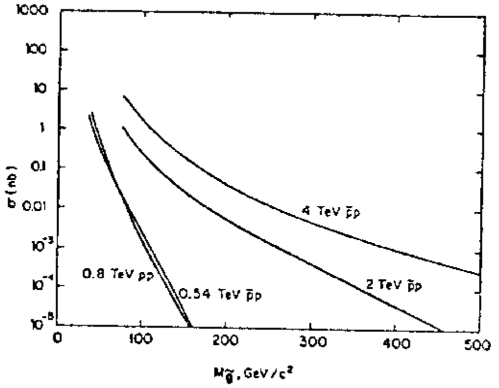

Fig. 10. Cross sections for pair production of gluinos in hadron-hadron collisions.

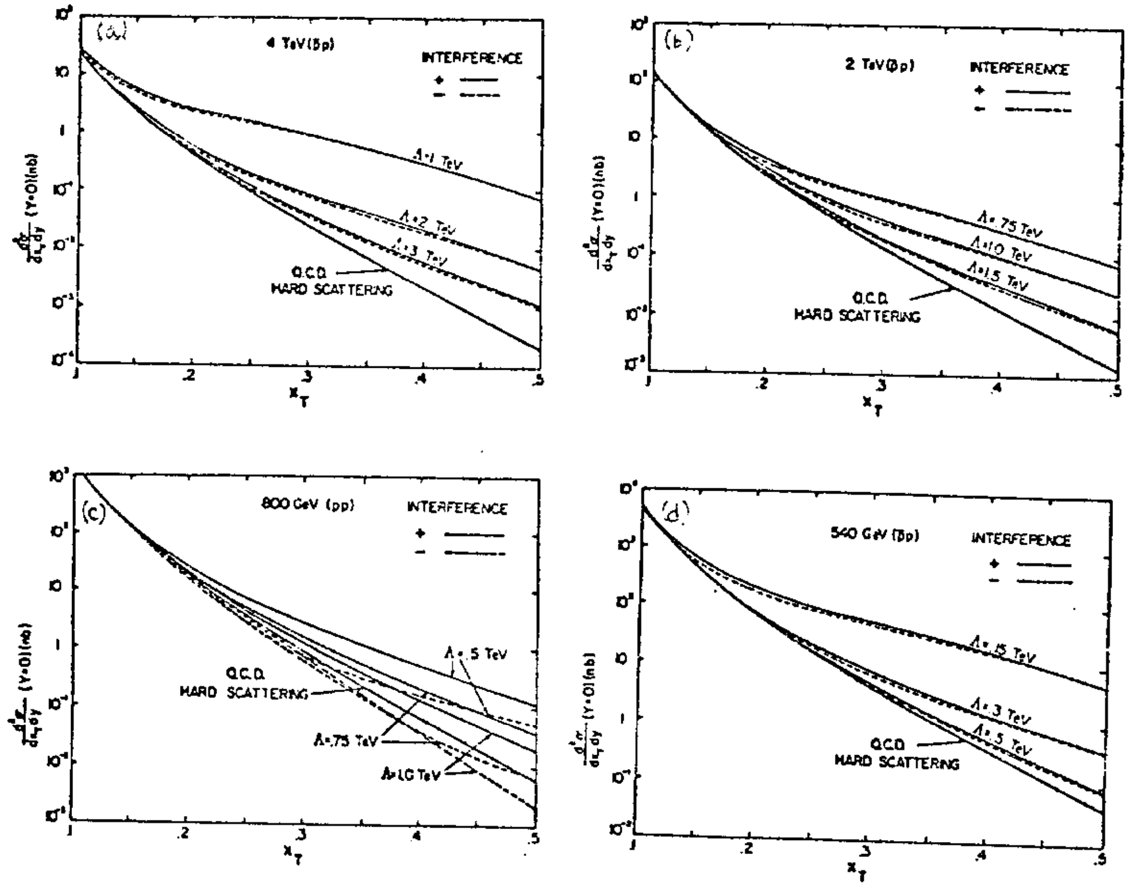

Fig. 11. Deviations from QCD yields for jet production induced by quark compositeness. (a) 4 TeV $\bar{p}p$; (b) 2 TeV $\bar{p}p$; (c) 0.8 TeV pp; (d) 0.54 TeV $\bar{p}p$.

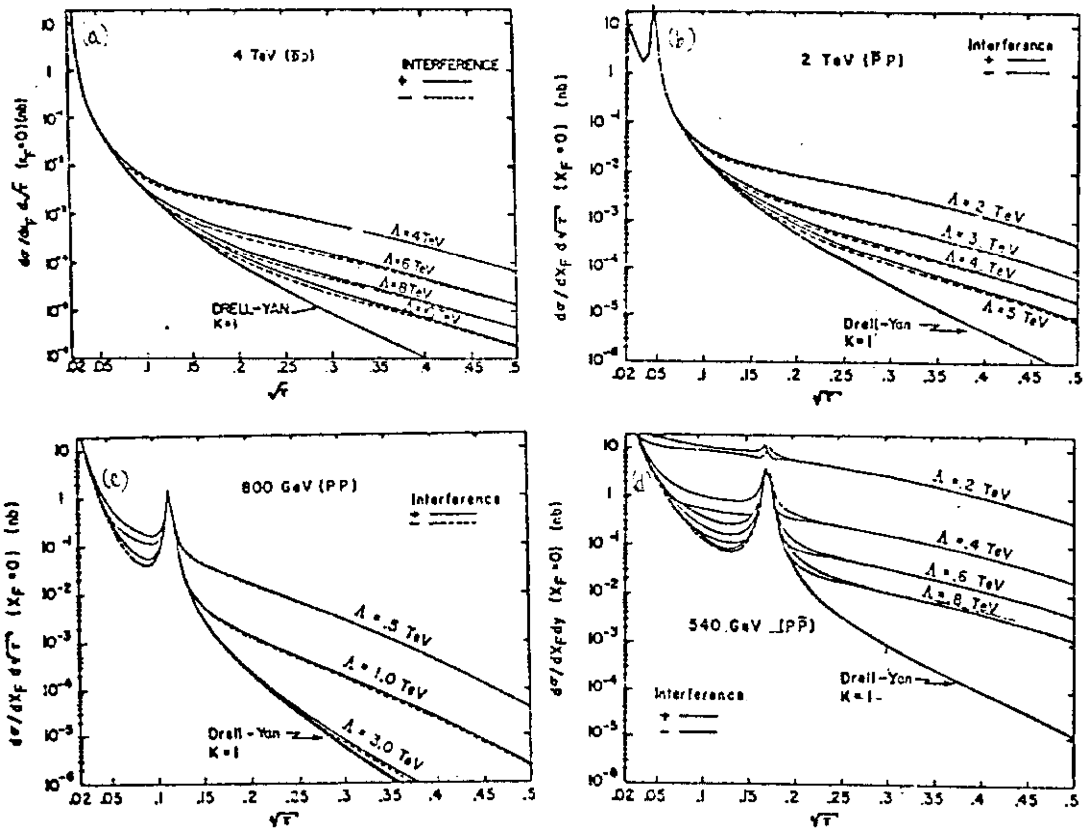

Fig. 12. Deviations from lowest-order Drell-Yan yields induced by quark and lepton compositeness. (a) 4 TeV $\bar{p}p$ (b) 2 TeV $\bar{p}p$; (c) 0.8 TeV pp; (d) 0.54 TeV $\bar{p}p$. Here $\tau = m^2/s$.

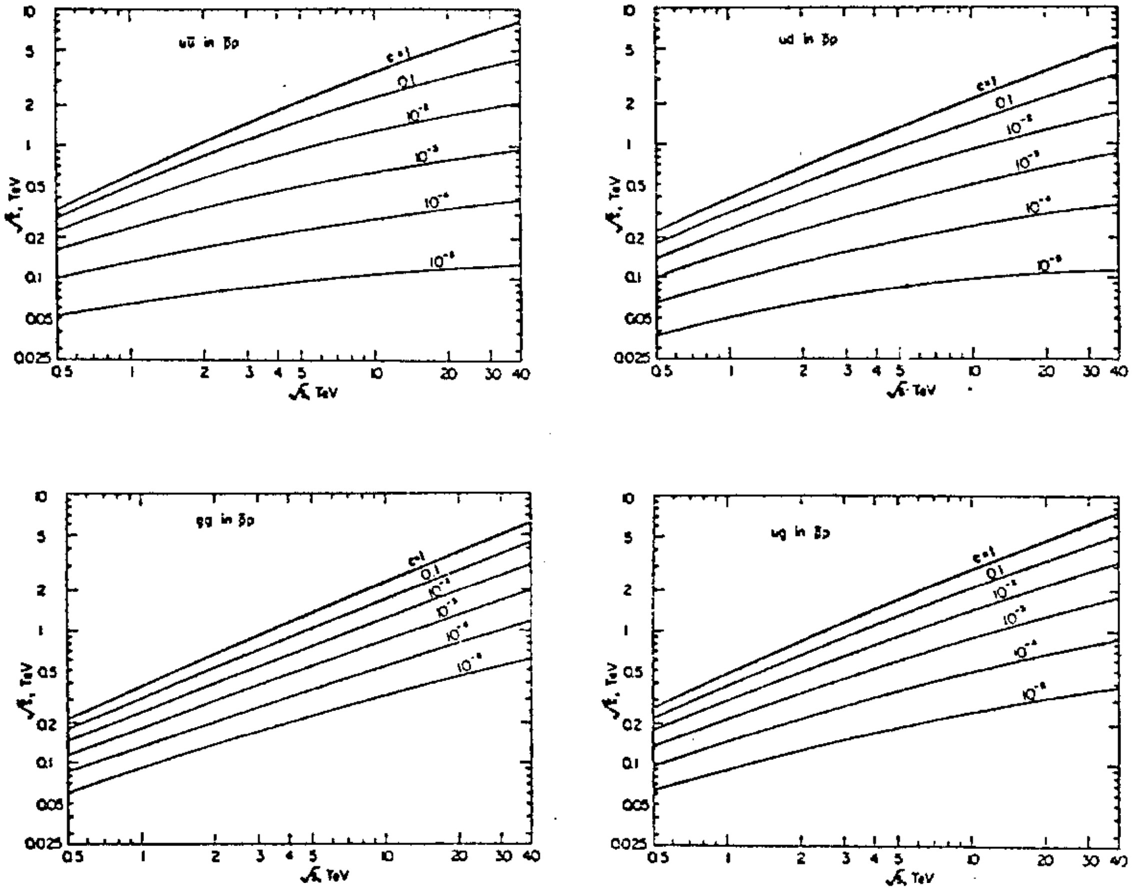

Fig. 13. Contours in invariant mass of a hard collision yielding 100 events in running with integrated luminosity $10^{38}cm^{-2}$, for hard-scattering cross sections $\sigma(\hat{s}) = c/\hat{s}$.

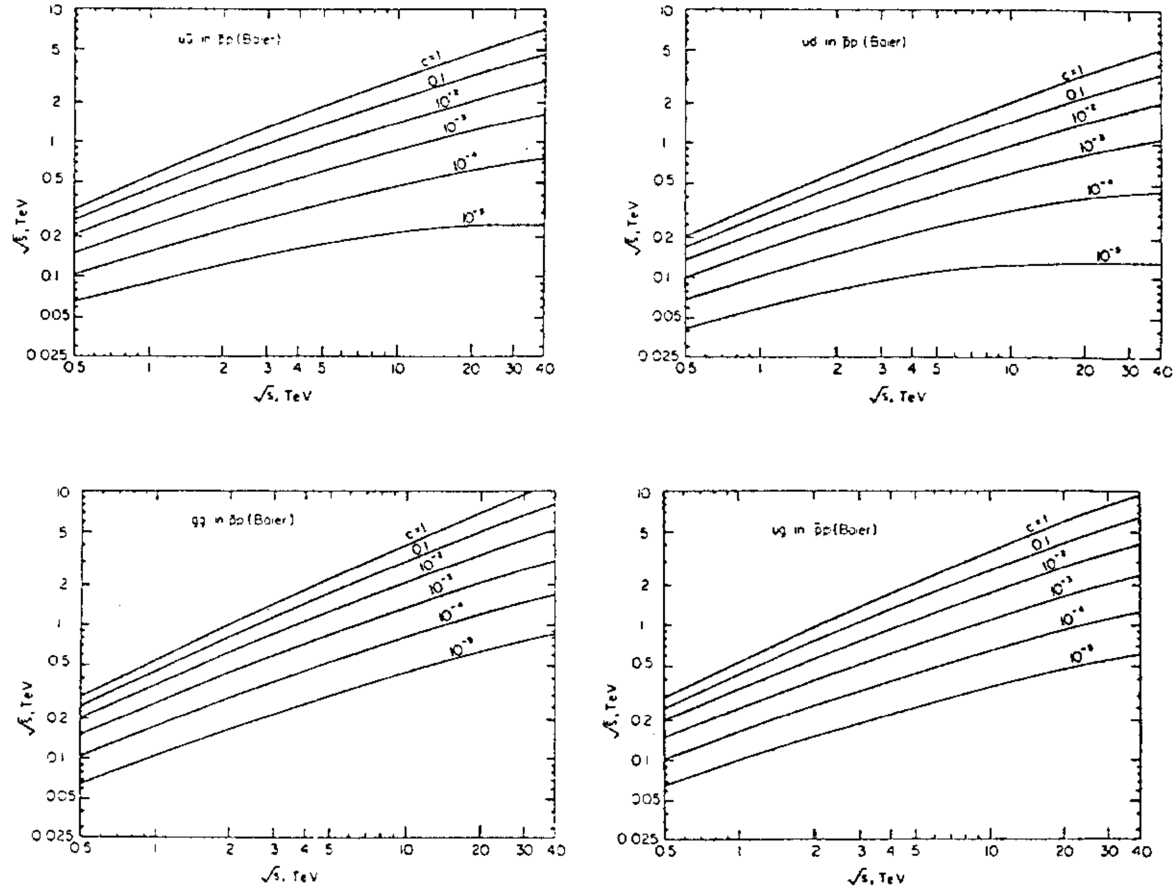

Fig. 14. Contours in invariant mass of a hard collision yielding 100 events in running with integrated luminosity 10^{36}cm^{-2}, for hard-scattering cross sections $\sigma(\hat{s}) = c/\hat{s}$ (Baier parton distribution).