fermilab report

March/April
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89/3 **Fermi National Accelerator Laboratory**

On the cover: *A transition moment. Fermilab Director Designate John Peoples (left) and Fermilab Director Leon M. Lederman at the former's press conference on April 21, one day after Universities Research Association, Inc., announced Peoples' selection as Fermilab's third Director.* *See page 1.*

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John Peoples Appointed Fermilab Director Designate

Universities Research Association, Inc., (URA) announced on April 20, 1989, the appointment of Fermilab Deputy Director John Peoples, Jr. as Fermilab's Director Designate. URA, as contractor to the Department of Energy (DOE) for management and operation of Fermilab, selects a Laboratory director subject to final approval of the DOE. DOE approval of John Peoples' appointment to a five-year term was forwarded to URA on April 19.

Peoples' appointment as Fermilab's third Director in the Lab's 22-year history will become effective on July 1, 1989, when Leon M. Lederman retires at the expiration of his second five-year term as Director. Fermilab's founding Director, Robert R. Wilson, served from 1967-1978.

''John Peoples has won the unanimous endorsement of every governing body of the URA,'' said URA President Edward A. Knapp. ''His record of achievement at Fermilab, in both experimental particle and accelerator physics, and in the Superconducting Super Collider magnet program, has drawn the attention and respect of the worldwide high-energy physics community. We make this appointment with great confidence in his ability to lead the Laboratory into yet another new and dynamic era of physics, as his predecessors have done. It is clear that much of Fermilab's successful recent past is due to John Peoples' tremendous commitment and energy, and we are glad to put the future in his hands.''

Leon Lederman, who appointed Peoples Deputy Director in September 1988, said of the announcement: ''John will provide the Laboratory with continuity and the drive to continue the evolution of the TEVATRON, now the most powerful accelerator in the world. John is also one of the best recruiters the Lab has ever had; in each of his many Laboratory assignments, he has left behind a group of able young scientists and engineers who could replace him. He is a gifted and dedicated experimental physicist, skilled in accelerator science, and a superb manager, one who has earned the respect of the Department of Energy and of his colleagues around the world.

''The Laboratory is now in a critical stage as it seeks to exploit the TEVATRON facility during the next decade, when the Superconducting Super Collider [SSC] is being constructed in Texas, assuming Congress proceeds with the SSC proposal. The goal will be to maintain the leadership at the energy frontier and to prepare for a scientific phase beyond SSC which will explore complementary particle-physics issues. I can't think of anyone more suitable than John Peoples to carry out this difficult and challenging program. He must, of course, also maintain the artistic, educational, and ecological concerns which have made Fermilab unique among federal installations or else suffer the pain of being haunted by both his predecessors.''

Robert O. Hunter, Jr., Director of the DOE Office of Energy Research, stated that, ''I believe Dr. Peoples is an outstanding choice. He will provide the scientific and technical leadership as this pre-eminent facility moves into the 21st century. We're looking forward to the new world of high-energy physics as it unfolds at Fermilab.''

Wilmot N. Hess, Associate Director, DOE Office of High Energy and Nuclear Physics, said the Department was very pleased with the selection of Peoples. ''He is well known to us in DOE and well known to the scientists who work at Fermilab. He is an excellent choice to guide the premier high-energy physics laboratory. We will work closely with Dr. Peoples to fully exploit the highest energy particle detector in the world, and to ensure that Fermilab maintains its leadership for a very long time.''

The road leading to the announcement was marked by an extensive, painstaking selection process undertaken by the URA Search Committee for Director of Fermilab. This process included a worldwide mailing of over 300 letters of solicitation for recommendations, and the placing of advertisements in leading scientific periodicals, including the *CERN Courier*, *Physics Today*, and *Science* magazine. Once a list of candidates had been compiled, the Search Committee (Harold K. Ticho, Vice Chancellor for Academic Affairs, University of California [Chairman]; Kenneth Heller, School of Physics and Astronomy, University of Minnesota; Albert Silverman, Newman Laboratory, Department of Nuclear Studies; and Robert R. Wilson, Professor Emeritus, Cornell University; with Raymond L. Brock, Department of Physics and Astronomy, Michigan State University, representing the Fermilab Users' Executive Committee, and *ex-officio* members Edward A. Knapp and Harry Woolf, Institute for Advanced Study and Chairman, URA Board of Overseers) met in formal session three times, twice at Fermilab in late January and early February 1989, and once in California in mid-February 1989.

Having made their selection, the Committee presented their recommendation to the URA Fermilab Board of Overseers, which endorsed the decision to the URA Board of Trustees. URA President Knapp then conveyed the Board's nomination to DOE.

At a meeting with the press on April 21, the Director Designate stated: ''I'm delighted that the URA has selected me to succeed Leon Lederman. Leon was one of my first teachers in graduate school at Columbia in 1959. I recall walking into his office with my class card, trying to persuade him that I could actually do physics.

"I'm also happy to be chosen to direct Fermilab at this very exciting time. As Leon has said, the TEVATRON is the highest energy accelerator in the world. It is a magnificent instrument, largely to Leon's credit, since it was built during his tenure as Director. Credit also goes to people like Helen Edwards, Rich Orr, and Dick Lundy, and countless others who contributed immensely to the TEVATRON's successes. And we cannot forget the vision of Bob Wilson. I'm lucky; I get to see all of the magnificent physics the TEVATRON will do.

"We have very good plans for this machine during the next five years. We have reviewed those plans with the Department of Energy. They praised the Lab, they praised Leon, and they stated that this was the pre-eminent high-energy physics lab in the world. That is something we have believed ourselves, but it is always nice to hear somebody else say it.

"After five years, we will see what the physics teaches us, but the TEVATRON will continue as the highest energy accelerator into the wee hours of the 21st century. Between then and now, we will think up some things that will help us to maintain our position as the top laboratory. We've shown imagination before, and I'm sure we'll show it again. We'll be a great laboratory 10 and 15 years from now."

* * * * *

John Peoples thesis research in 1962, under the guidance of Alan Sachs at the Nevis Synchrocyclotron, resulted in the most precise measurement to date of the positron energy spectrum of muon decay. The analysis of the experimental data formed the basis of his doctoral thesis, which was accepted by the Graduate Faculty of Columbia in December 1965. Peoples' academic career includes an appointment to the faculty of Columbia University as an instructor in Physics in 1964, with promotion to Assistant Professor of Physics in 1966, and Assistant Professor of Physics at Cornell University in 1969.

His research activities include: A search at the Brookhaven National Laboratory (BNL) Alternate Gradient Synchrotron (AGS) for the breakdown on charge conjugation symmetry in the decays of the η meson, a forerunner of modern multiparticle spectrometers as it detected and measured three and four particle final states. In 1968, he continued to work on physics related to C and CP violations by joining a group measuring the charge asymmetry between the electron and positron decay of the long-lived neutral K meson, again using the AGS. The experiment's data analysis provided the most accurate measurement of that asymmetry parameter when the results were published in 1969. While at Cornell, he and others proposed a measurement of large momentum transfer elastic scattering of hadrons. In collaboration with physicists from BNL and Northeastern, they performed this measurement at the AGS during 1970-71, extending the large angle pion scattering to 23 GeV, the highest energy measurement at the time.

Together with collaborators from Columbia, the University of Illinois, and the University of Hawaii, Peoples proposed in 1970 to search for heavy leptons and massive vector bosons in high-energy photon nucleus collisions at Fermilab. This experiment, E-87, was approved in the summer of 1971. In the fall of 1971, he took a leave of absence from Cornell to work full time on E-87, which went on to run successfully from 1974 until 1984, when it became the first secondary hadron beam to take advantage of 800-GeV protons from the newly-commissioned TEVATRON.

Between 1976 and 1978, Peoples formed a small group of Fermilab physicists which, in collaboration with Columbia and Illinois, made the first observation of the photoproduction of the D^0 and D^{**} charmed mesons and the Λ_c^+ charmed baryon. Between 1978 and 1979, the group made the first measurement of ψ and ψ' photoproduction of hydrogen and deuterium. For a time, these measurements provided the most accurate measurement of the ψ-nucleon cross section.

In October 1972, Peoples accepted a continuing appointment at the Lab as Associate Section Head of the Proton Lab. Concurrent with turning the construction of the Proton Lab around to a successful course, he worked with Helen Edwards on the commissioning of the Main Ring slow extraction system, sparking his interest in accelerator physics.

At the beginning of 1973, Peoples was asked to serve as Section Head of the Proton Lab. After resigning from Cornell, he accepted the position on February 14. He developed and implemented plans for the installation of the first experiments in the Proton Area, and by May of 1973, E-100, a collaboration of the University of Chicago and Princeton University, became the first experiment taking data in Proton, publishing preliminary results on particle spectra at large transverse momenta that same year. Shortly thereafter, E-70, a Columbia University experiment led by Leon Lederman, published preliminary results on direct lepton production.

The design, fabrication, and installation (begun during his tenure as Proton Department Head and completed in early 1975) in the Proton Area of an electrostatic beam splitter made it possible to operate all three Proton target areas simultaneously, a development of particular importance to E-288, a dimuon mass spectra measurement being done by Lederman's group, and to the Columbia-Illinois-Fermilab E-87 photoproduction experiment. In 1977, the data from E-288 led to the discovery of the upsilon family, and the data from E-87 provided the first observation of the ψ at Fermilab.

In 1975, following a return to experimental physics at the Lab, Peoples accepted the position of Head of the Research Division, where he guided the completion of the Proton Area and the rebuilding of the Meson and Neutrino areas. A plan for building a 750-GeV muon beam and upgrading the neutrino beams in the Neutrino Area formed basis for the the conceptual design for the TEVATRON II project.

After again returning to experimental physics, Peoples served, from 1980 to 1981, as liaison between the Collider Detector at Fermilab (CDF) experimenters and the civil engineering groups on the design of the B0 experimental hall, and participated in the conceptual design of an antiproton source based on electron cooling, which, as it developed, required a major upgrade in the operating voltage of the electron beam to a factor of four greater than what Fermilab had achieved up to that time. At Lederman's request, Peoples led a team which produced, in 1982, a conceptual design for the Antiproton (Pbar) Source based on stochastic cooling. In May of '82, the revised design and cost estimate were accepted by DOE and funding for the Pbar Source was approved. As Pbar Source Project Manager, Peoples directed both the R&D and construction programs. While he was responsible for the accelerator system improvements to the Main Ring and TEVATRON that created the TEVATRON Collider, the technical direction was carried out by Fermilab's Accelerator Division under Helen Edwards and J. Richie Orr.

In 1984, Peoples and others proposed to measure the mass and widths of the bound chamonium states which can be formed in antiproton-proton collisions. The collaboration includes physicists from the University of California, Irvine; Northwestern; Penn State; Ferrara; Genova; Torino; and Fermilab. The experiment, approved in 1985, uses the Fermilab Accumulator Ring (an element of the Pbar Source) in conjunction with a gas jet target.

Commissioning of the Pbar Source and the accelerator improvements was begun in April of 1985. Six months later, the first collisions of 800-GeV protons on 800-GeV antiprotons were observed by the partially completed CDF detector. The TEVATRON I project became operational in January of 1987, and the Pbar Source reached a peak accumulation rate of 1.2 x 10^{10} pbars/hour in April of that year, making it the most intense antiproton source in operation at that time. It subsequently reached an accumulation rate of 2 x 10^{10} p^{-1}p/hour in 1988.

Peoples served as Deputy Head of the Accelerator Division beginning in January of 1987, with responsibility for the Linac, Booster, and Pbar Source and their upgrade proposals. In October of 1987, he took a 1-year leave from Fermilab to manage the magnet R&D program for the SSC, which was ongoing under the direction of the SSC Central Design Group, with work being carried out at Lawrence Berkeley Laboratory, BNL, and Fermilab. As Head of the Magnet Division, Peoples was responsible for the design, fabrication, and testing of the magnets, which had been unable to reach their design field without excessive quenches. Subsequently, a number of substantial design changes were made to the magnet design, improving the mechanical restraint of the collared coils. All magnets using this design have reached design current with two or fewer quenches. Of greater importance is the fact that Peoples organized the work of the Division and began a modest expansion of its efforts so that it could provide the needed leadership.

In September of 1988, Peoples was appointed Deputy Director of Fermilab by Leon Lederman.

Peoples' appointments have included a 2-year term on the BNL High Energy Advisory Committee from 1972-74; election to the Fermilab Users' Executive Committee in 1974; membership in the DOE High Energy Physics Advisory Panel from 1976 to 1979 and again from 1984 to 1986; membership in the Fermilab Physics Advisory committee in 1982 and 1983; election to Vice-Chairman of the Division of Particles and Fields of the American Physical Society (APS) in 1983, and to Chairman in 1984, when he was also elected a Fellow of the APS. He was a member of the Cornell Physics Advisory Committee from 1986 until 1989, and Chairman of that committee in 1987.

URA President Edward A. Knapp Resigns to Resume His Research at LANL

On April 18, 1989, Universities Research Association, Inc., which manages Fermilab for the U. S. Department of Energy, announced that Edward A. Knapp will resign as President in order to return to Los Alamos National Laboratory, where he will resume his research activities. Knapp, who has served as URA's President since 1985, has been on temporary leave of absence from Los Alamos.

''Now that the Superconducting Super Collider (SSC) contract is in place and a new Fermilab Director has been designated, it is time for a new president to lead URA through the next stage of development,'' Knapp said. ''Fermilab is the premier high-energy physics facility in the United States, and the SSC holds tremendous promise for a new era of discoveries. Having commissioned the Fermilab TEVATRON Collider, accomplished the conceptual design and coordinated long-lead R&D for the SSC, and now been awarded the management and operating contract for the Supercollider's first nine years, URA is ready to enter a new management phase. It's been an honor to be associated with these key achievements, which have been and will continue to be integral to the advancement of particle physics.''

A formal search for the new president will be initiated by the URA Board of Trustees. The Board, composed of university presidents and corporate executives from across the U.S., is chaired by John Marburger, President of the State University of New York at Stony Brook. A search committee will be formed in accordance with URA precedent and will recommend a successor, to be approved by the Board. Knapp has agreed to remain with URA until a new president is in place, anticipating a transition no later than December 31, 1989.

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Micro-Review of Structure Functions and Parton Distribution Functions*

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January 1989

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Micro-Review of Structure Functions
and
Parton Distribution Functions

Jorge G. Morfín
Fermilab

There has recently been a great deal of discussion concerning the surprising differences in the measurements of the nucleon structure function $F_2(x,Q^2)$, off of a hydrogen target, by the high statistics muoproduction experiments EMC [1] and BCDMS [2]. In this short review I will attempt to summarize the status of the experimental measurements of the structure functions and highlight any significant disagreements. At the conclusion I will comment on the status of the extraction of the parton distribution functions from these measurements.

As can be seen from Tables I and II, there are high statistics measurements of the structure function $F_2(x,Q^2)$, which reflects the sum of $q + \bar{q}$ [3], obtained by scattering both muon and neutrino beams from a wide range of targets. In addition the neutrino experiments provide a direct, although statistically less significant, measurement of $xF_3(x,Q^2)$ which reflects the contribution of the valence quarks q_v.

Table I

MUON EXPERIMENTS			
	BCDMS	BFP	EMC
Target	C and H_2	Fe	H_2 D_2 Fe
Energy	100 - 280	93, 215	120 - 280
x-range	.06 - .80	.08 - .65	.03 - .65
Q^2-range	25 - 280	5 - 220	3 - 200
* events	C: 680K	690K	Fe: 1080K
$R(x,Q^2)$	Expt.	0.0	0.0

Table II

NEUTRINO EXPERIMENTS				
	BEBC	CCFRR	CDHSW	CHARM
Target	Ne H	Fe	Fe	Marble
Energy	10 - 200	30 - 250	30 - 300	10 - 200
x-range	.025 - .80	.02 - .65	.02 - .65	.02 - .55
Q^2-range	2 - 70	1 - 200	0.2 - 200	0.2 - 100
$R(x, Q^2)$	R(QCD)	R(QCD)	R(QCD)	0.1
# Events	25K	170K	940K	160K
SU(3) symmetry	$\bar{s} = 0.25\,(\bar{u} + \bar{d})$ $c = \bar{c} = 0$		$\bar{s} = 0.2\,(\bar{u} + \bar{d})$ $c = \bar{c} = 0$	
Charm	slow rescale: m = 1.5		No correction	

Before comparing these measurements it should be noted that differences, outside of the statistical errors, are **expected** due to experimental systematic effects and to the different kinematical regions covered by experiments. The impact of this last point is shown in Fig. 1. Note that at the same value of x the average value of Q^2 can differ by as much as an order of magnitude between various experiments. Care must be taken to remove this "natural" difference before comparing measurements.

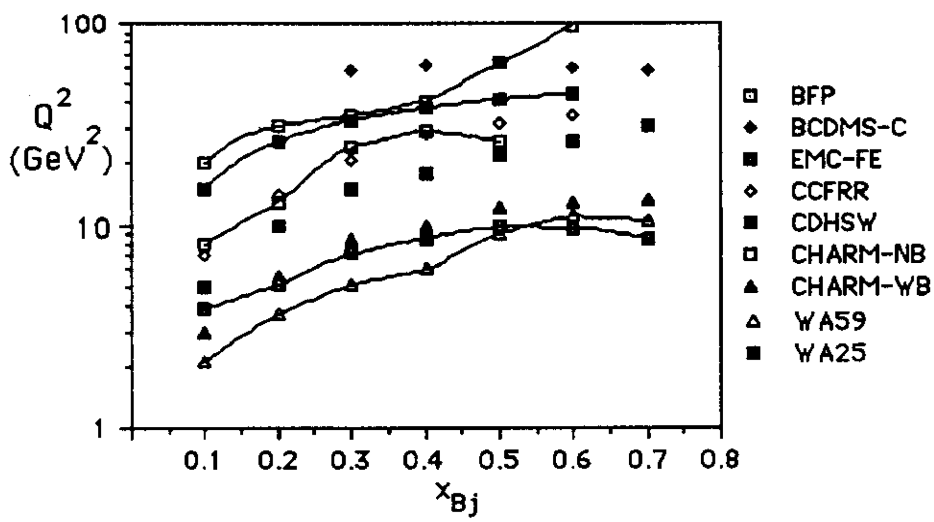


Fig. 1 The dependence of Q^2 on x_{Bj} for various experiments

$F_2(x,Q^2)$: Heavy Targets Experiments

Because of the relatively small neutrino cross section most of the high statistics neutrino experiments have used heavy target (i.e Fe) detectors. Muon experiments, on the other hand, can get sufficient statistics even with H_2 or D_2 targets. We will discuss the relation between heavy and light target results - the "EMC Effect" - shortly, but for now let's examine the ratio of the structure function $F_2(x,Q^2)$ as measured by the heavy target experiments. The black points on Fig. 2 indicate the ratio of $F_2(x,Q^2)$ as measured by two high statistics muon experiments, EMC on iron [4] and BCDMS on carbon [5].

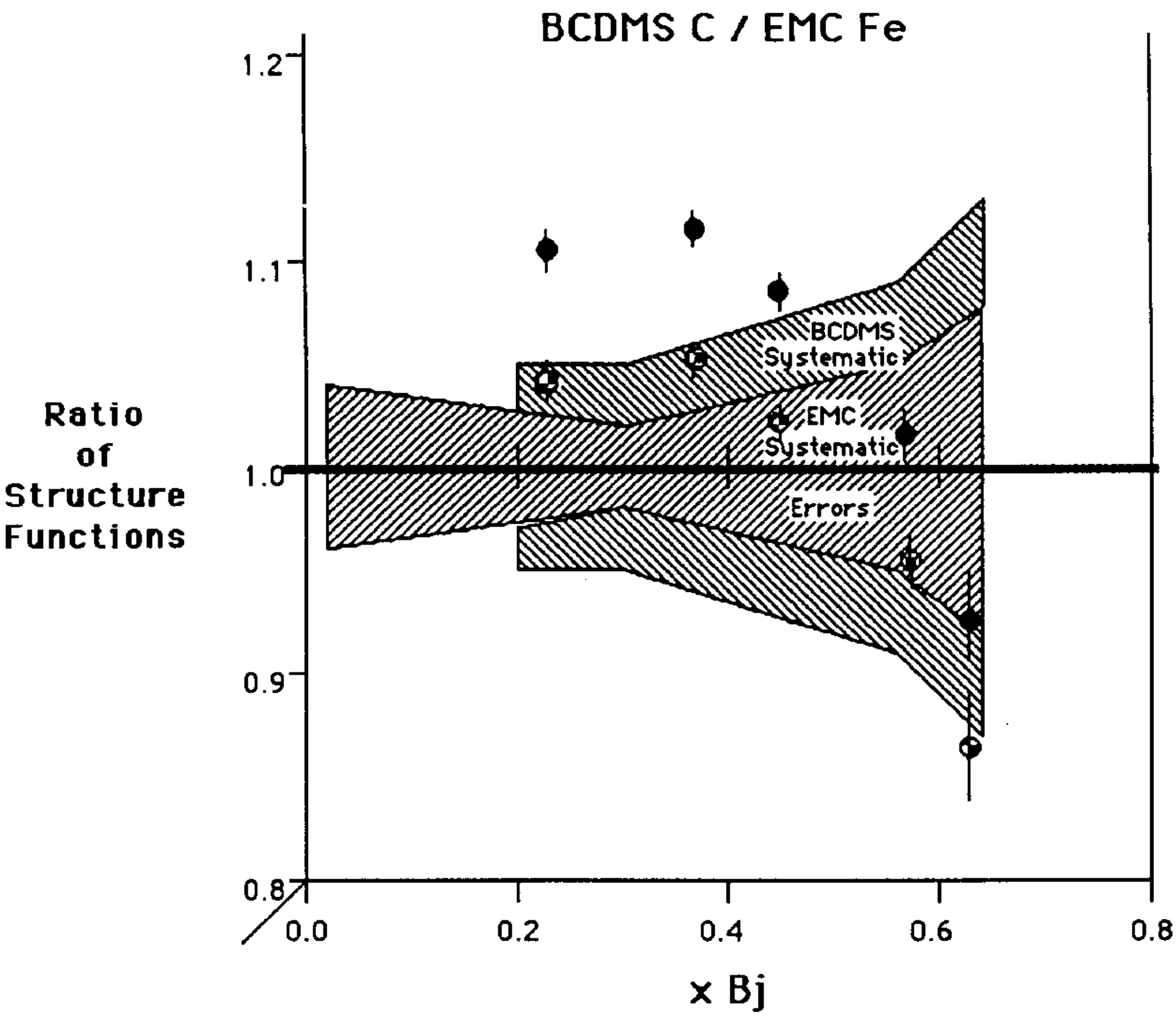
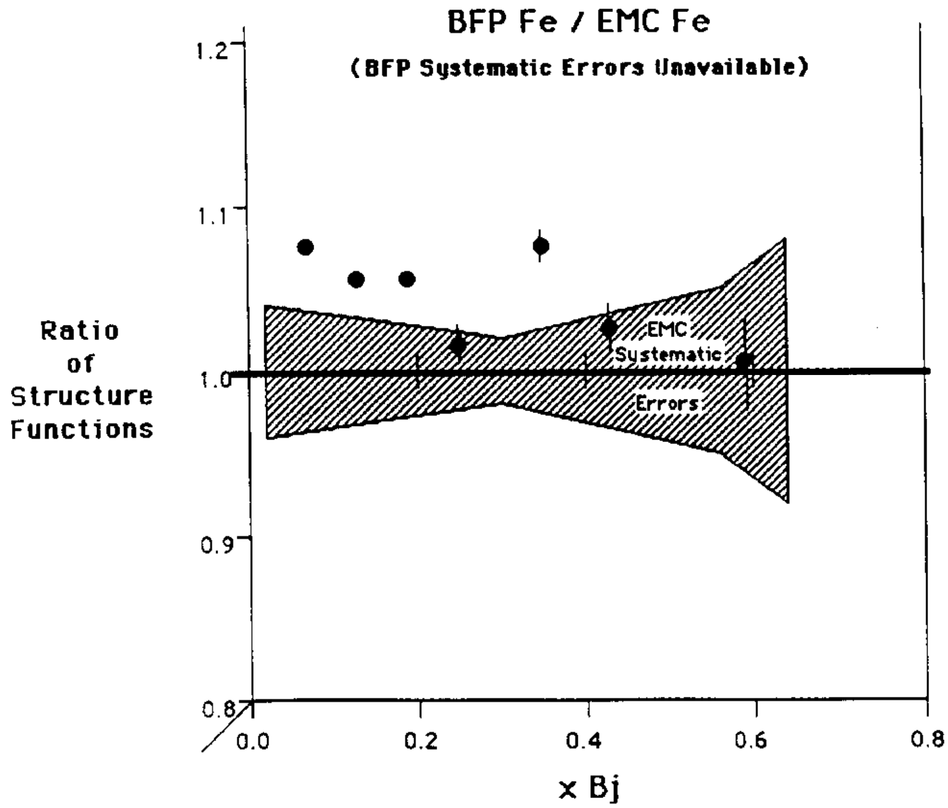
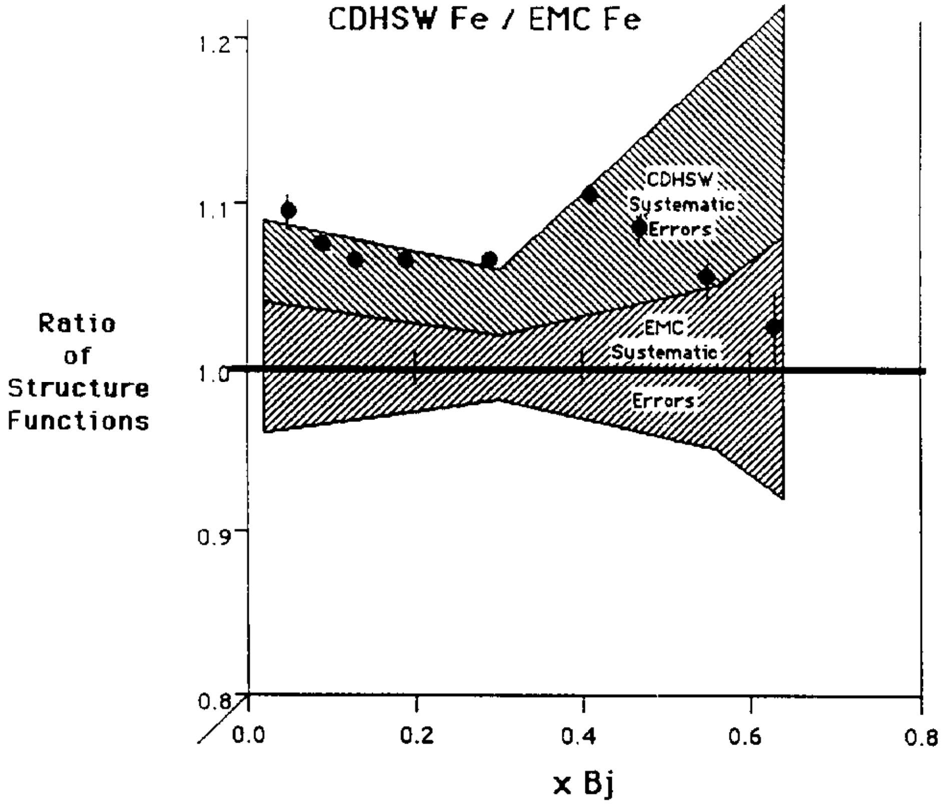


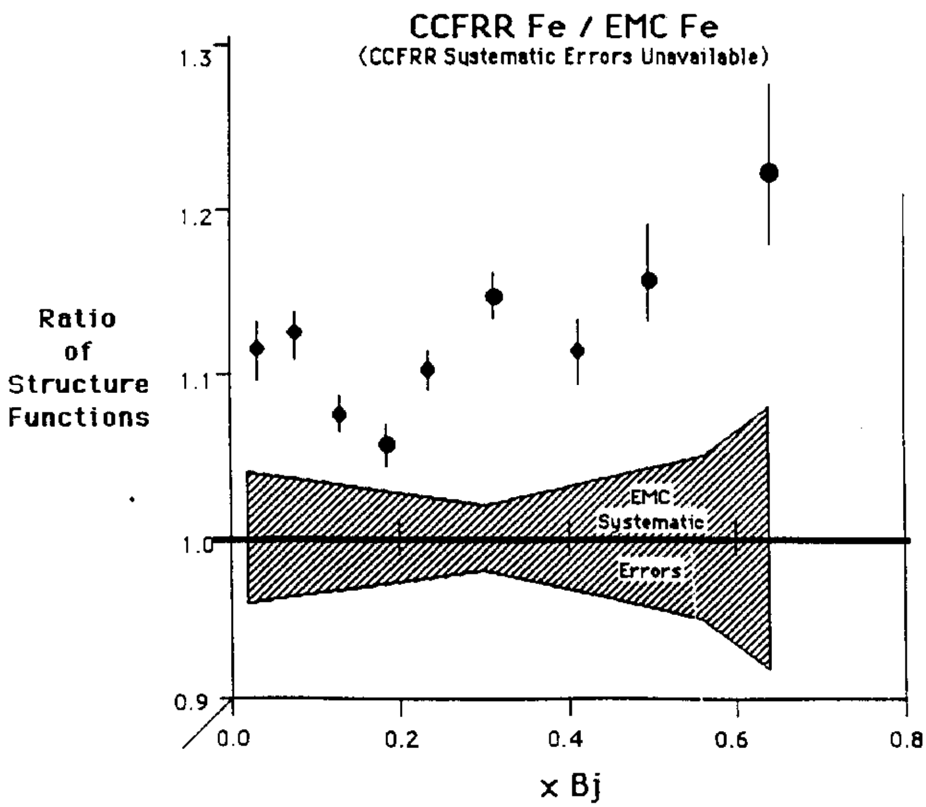
Fig. 2 The ratio of $F_2(x,Q^2)$ measured by the BCDMS carbon experiment to that measured by the EMC Fe experiment (black points). The black / white points show the effect of a 5% change in relative normalization.

The error bars on the individual points are statistical and the systematic error from each experiment is shown in the cross hatched area. There are no low x points since the high minimum Q^2 of the BCDMS carbon experiment translates to a minimum x of about 0.2. The first thing one notices is the x-dependent trend of the ratio. However, as the black/white points indicate, the significance of this trend is lost when a 5% change in the relative normalization between the two sets of data is introduced. Even though both experiments sit in the same beam at CERN, each measures the flux independently so a relative offset is certainly possible.

The following set of figures shows the ratio of $F_2(x,Q^2)$ measured by the other considered heavy target experiments BFP [6], CCFRR [7], and CDHSW [8] always with respect to EMC. When comparing neutrino to muon results, a constant 5/18 has been applied neglecting the small x contribution from sea quarks to this factor. The systematic errors for the CCFRR and BFP points are not available but are thought to be larger than the EMC systematic errors which are shown. In all cases, a shift in scale of a few percent statistically eliminates any discrepancy.




CDHSW Fe / EMC Fe
1.2
1.1
1.0
0.9
0.8
Ratio
of
Structure
Functions
CDHSW
Systematic
Errors
EMC
Systematic
Errors
0.0
0.2
0.4
0.6
0.8
x Bj


CCFRR Fe / EMC Fe
(CCFRR Systematic Errors Unavailable)
1.3
1.2
1.1
1.0
0.9
Ratio
of
Structure
Functions
EMC
Systematic
Errors
0.0
0.2
0.4
0.6
0.8
x Bj

Before leaving the heavy target experiments there is one very new result from the Fermilab-MIT-MSU neutrino collaboration (E594) which tests whether the quark distributions as seen by the neutral current and the charged current are the same. The following figure shows the valence quark distribution (Fig. 4a) as determined from the FMM neutral current data [9] as compared to the distribution determined by the CCFRR, CDHSW and CHARM [10] charged current data. Fig. 4b shows a similar comparison for the sea quark distribution. There is excellent agreement in both cases.

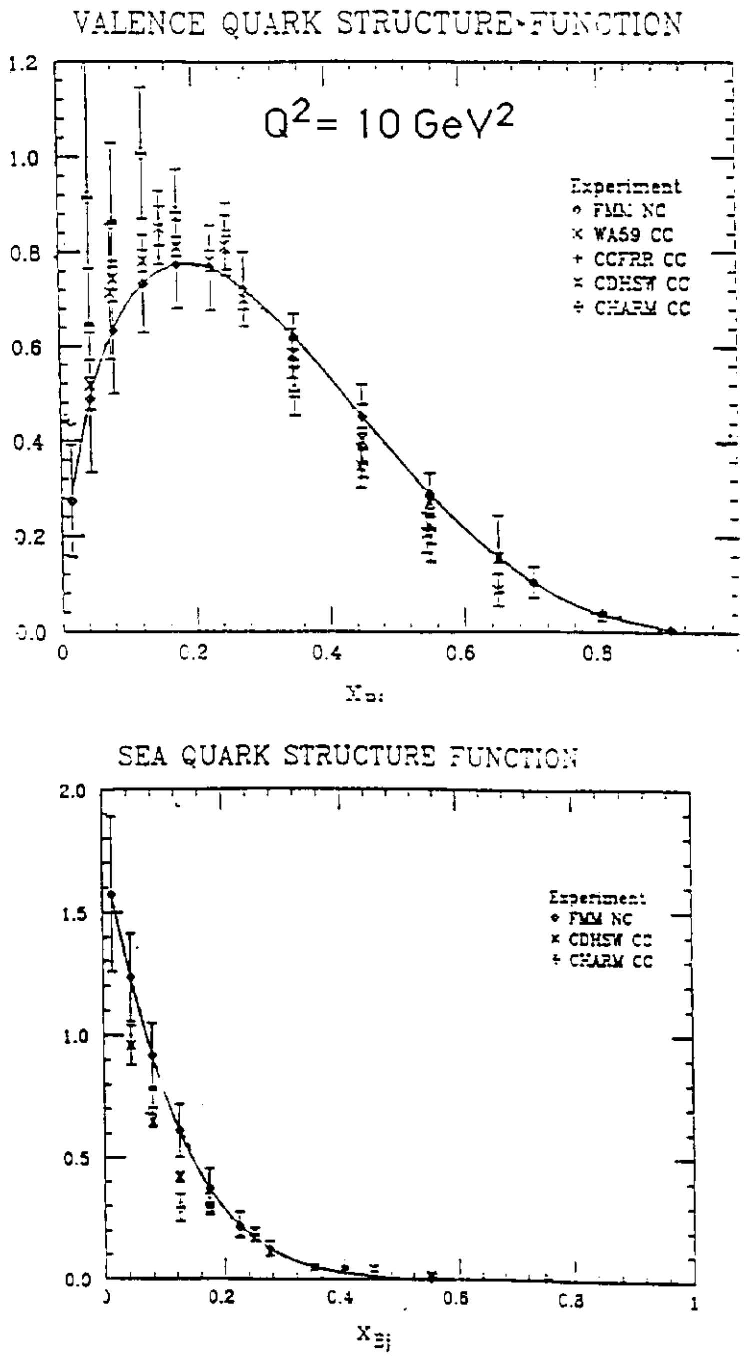


Fig. 4 Comparison of NC to CC valence and sea quark distributions

$F_2(x,Q^2)$: Hydrogen Data

Fig. 5 shows the ratio of $F_2(x,Q^2)$ as measured by the two muon experiments BCDMS and EMC using a hydrogen target in both cases. There is an x-dependent trend similar to the BCDMS-EMC heavy target comparison shown earlier. However, in this case, no shift in relative normalization can eliminate the differences. There is a statistically significant difference between these results of the two muon experiments. The curve drawn is an

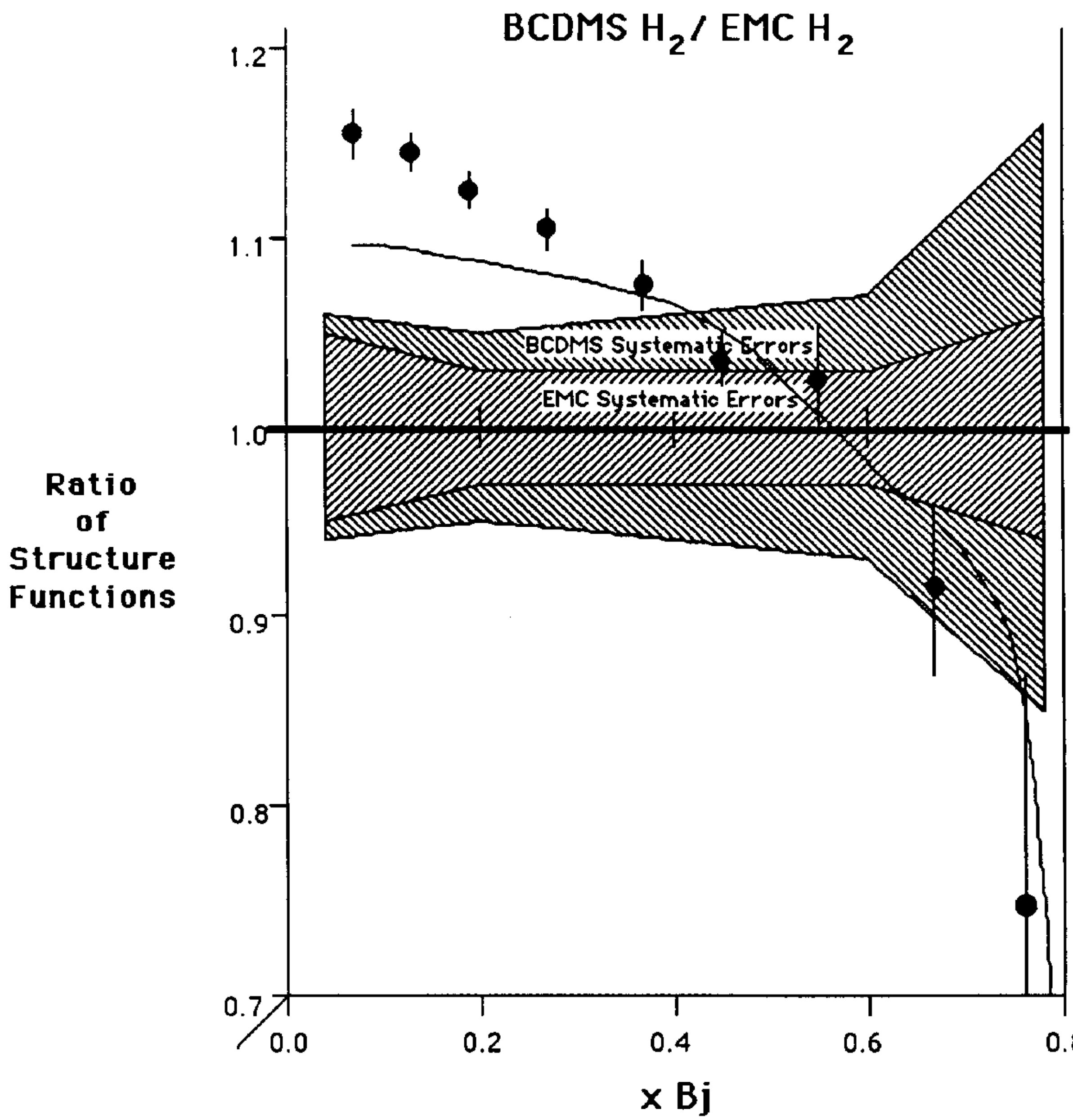


Fig. 5 The ratio of the BCDMS and EMC hydrogen exposures. Refer to the text for an explanation of the curve.

attempt by R. Mount [11] to simulate the ratio by assuming a 10% relative normalization error **and** that the BCDMS scattered muon energy was wrong by 0.5 GeV + 0.6% E_μ. Even these extreme assumptions cannot force an agreement between these two high statistics experiments.

Status of the "EMC Effect"

The most recent results, supporting the observation of an x-dependent discrepancy between $F_2(x,Q^2)$ when measured on iron as compared to deuterium, come from SLAC E140 [12] and EMC' [13]. These new results are plotted together with earlier results in Fig. 6. They confirm the important characteristics that the ratio is below 1 at very low x rises above 1 around x ≈ 0.15 and then steadily decreases until x ≈ 0.7.

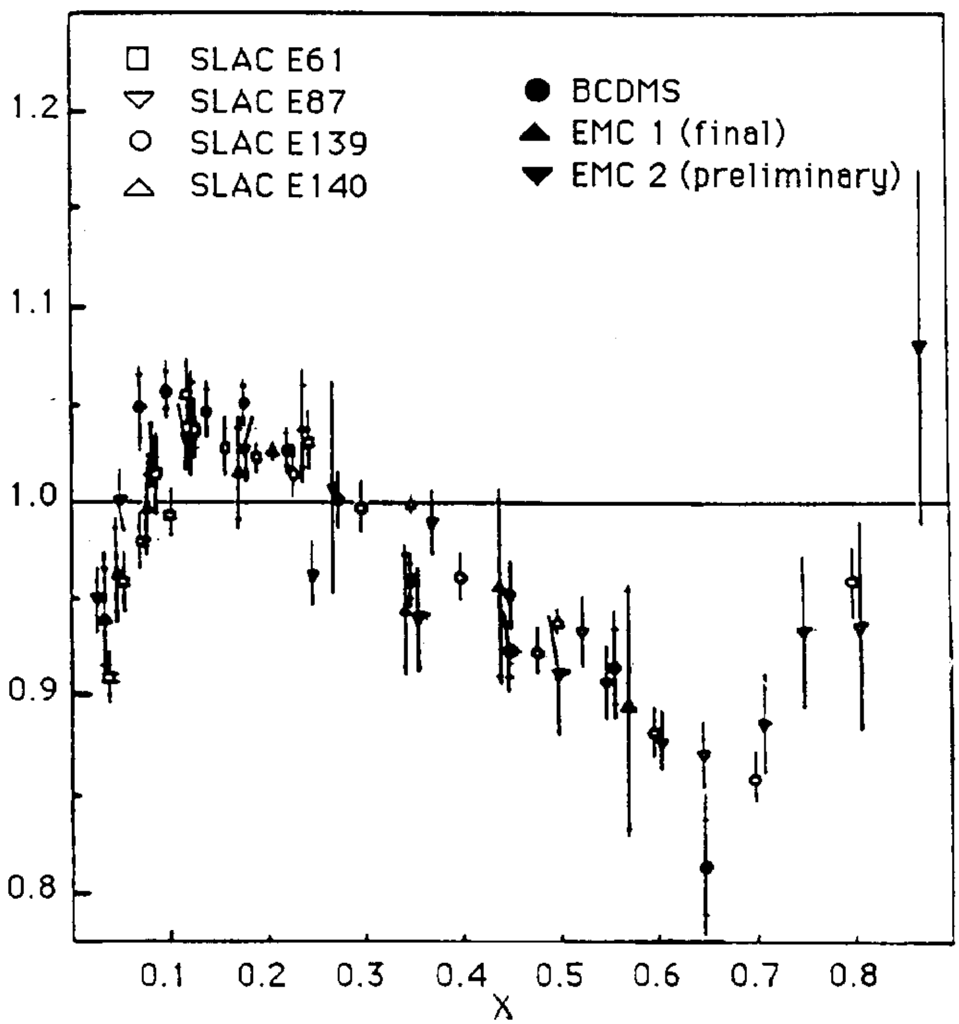


Fig. 6 A summary of recent measurements of the ratio of $F_2(x,Q^2)$ as measured with Fe or C compared to deuterium measurements.

There have been many attempts to explain this effect. One recent model by Berger and Qiu [14] has model predictions, shown in Fig. 7, for x > 0.1 and the assumption of shadowing to describe x < 0.1. A recent quark cluster model by Lassila [15] claims to be able to predict the entire x range without additional input. Reference to other models can be found in [14] and [15].

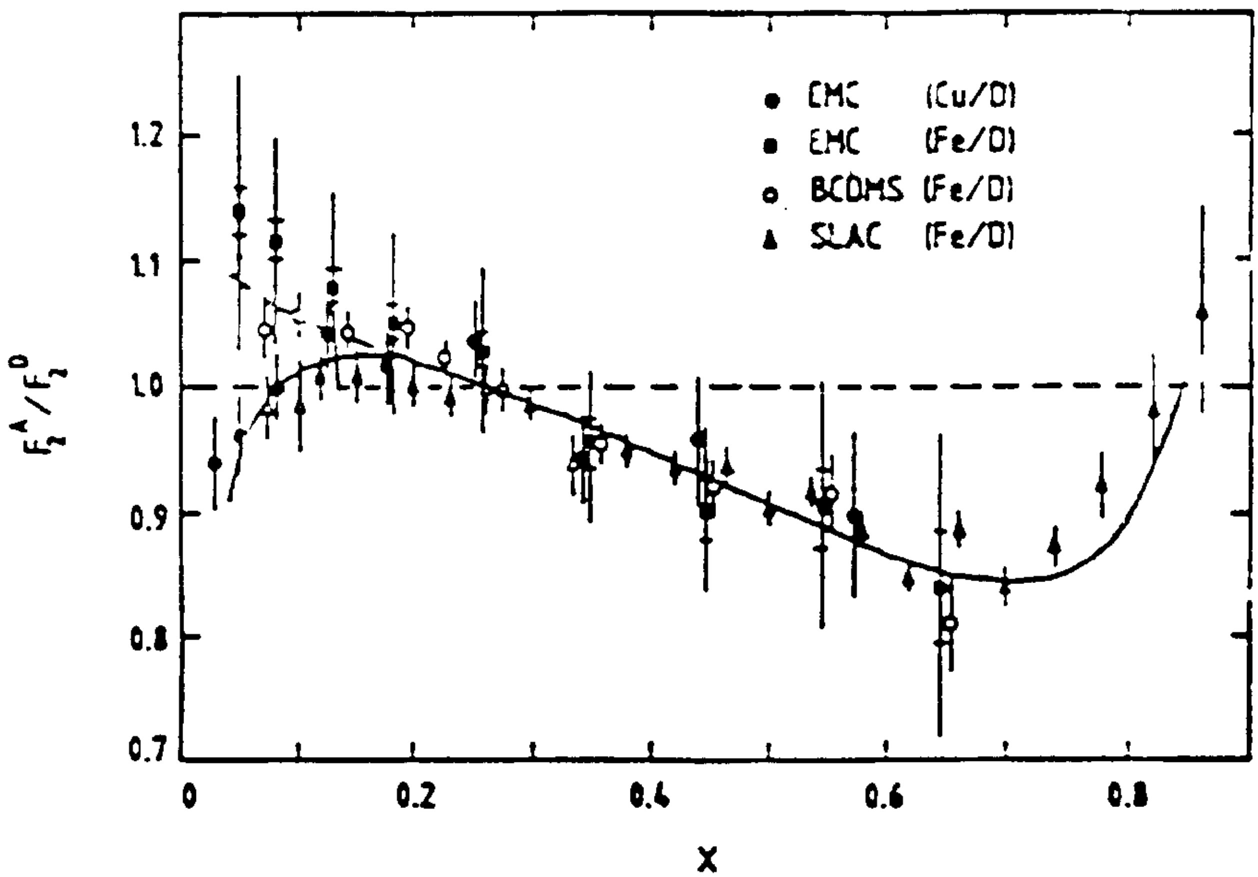


Fig. 7 The prediction of the model of Berger and Qiu compared to the most recent measurements of the EMC Effect.

The experimental evidence for a possible new attribute of the EMC effect was recently summarized by F. Taylor [16] who fit current data to the hypothesis that the EMC effect has a Q^2 dependence given by

$$\frac{d\,(F_2^{Fe} / F_2^{D_2})}{d\,(\ln Q^2)} = (0.077 \pm 0.023 \pm .047) - (0.25 \pm 0.09 \pm 0.14)\, x_{Bj}$$

($\pm$ statistical $\pm$ systematic). The data and fit are shown in Fig. 8.

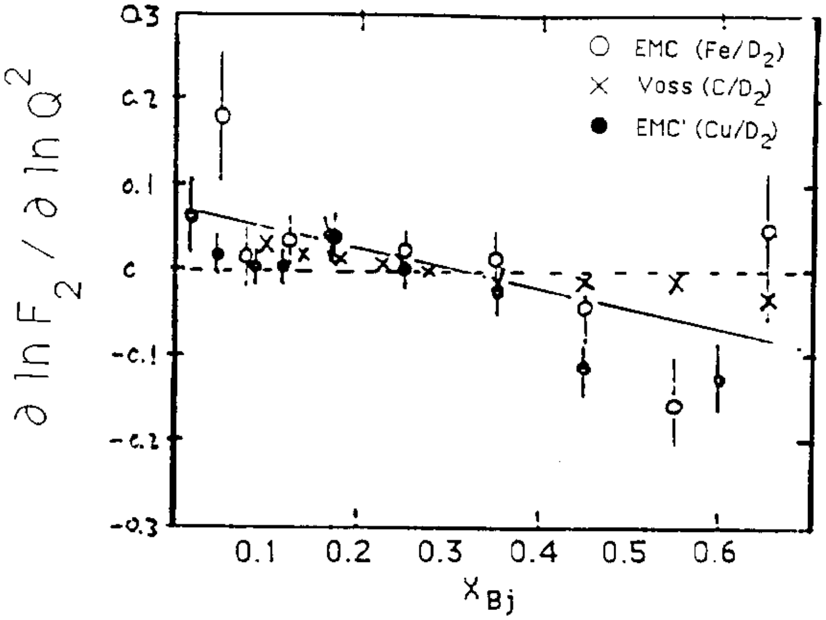


Fig. 8 The Q^2 dependence of the EMC effect using the data from SLAC experiment E139, EMC, and BCDMS experiments.

The Longitudinal Structure Function

There have been numerous experiments attempting to measure the ratio - $R(x,Q^2)$ - of the longitudinal to transverse structure functions. An indication of the accuracy of the current measurements is shown in Fig. 9.

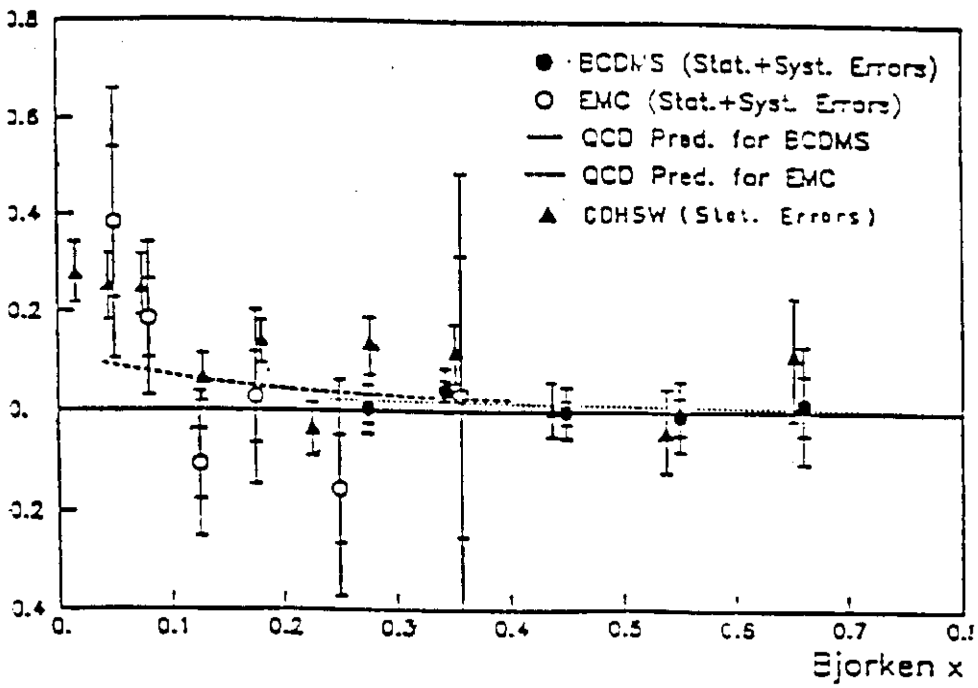


Fig. 9 R(x) as measured by CDHSW, EMC, and BCDMS

The most recent effort by SLAC experiment E140 has demonstrated the importance of (kinematical) higher twist contributions to the interpretation of this ratio. As shown in Fig. 10, the bare Twist 2 QCD prediction lies significantly below the E140 data points. With the addition of target mass corrections, the prediction is consistent with the data.

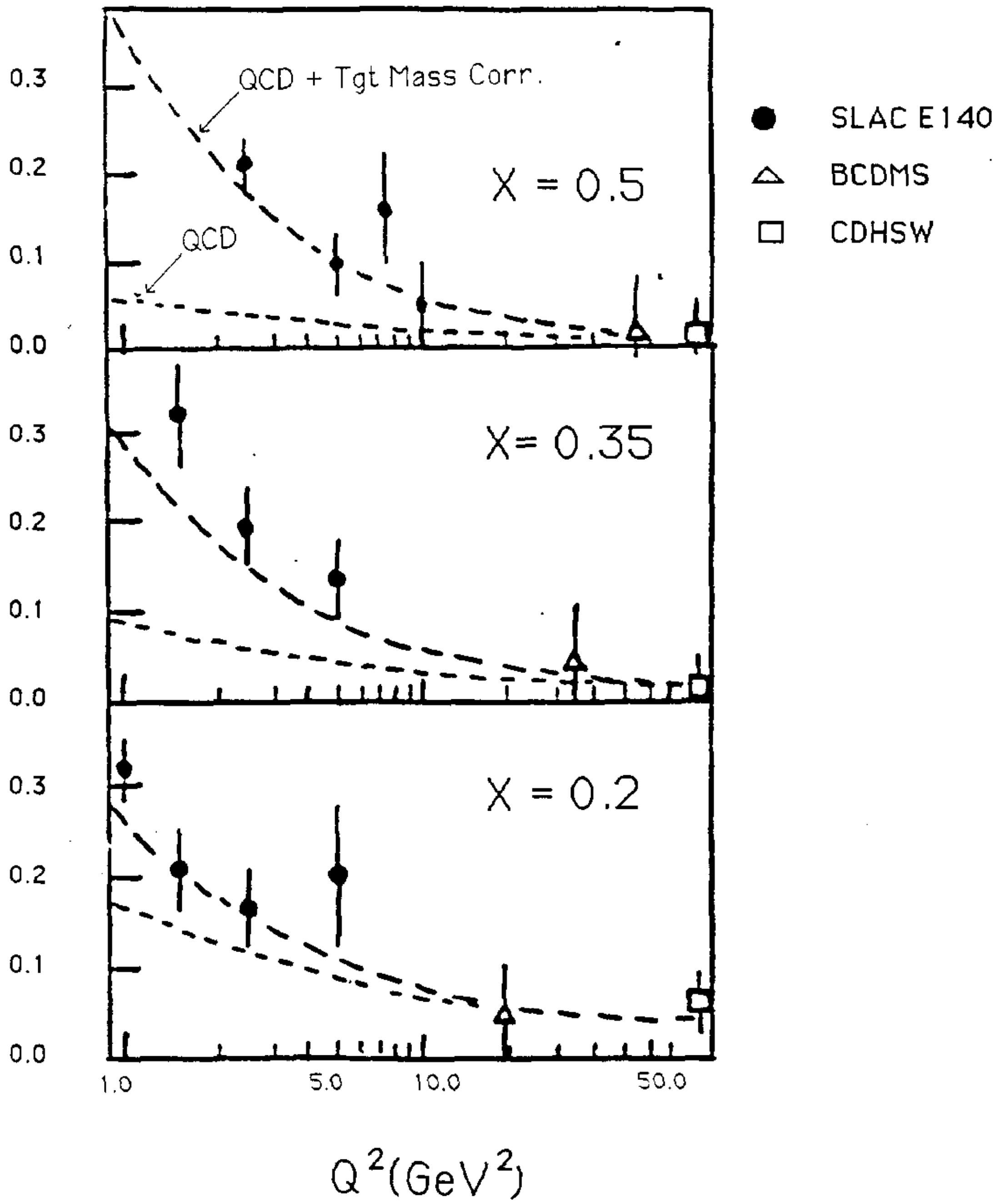


Fig. 10 The measured values of R from E140, CDHSW and BCDMS as compared to the QCD predictions with and without target mass correction.

QCD Interpretation of the Structure Function Data

That there is an x and Q^2 dependence to F_2 is clearly demonstrated in Fig. 11 which compares all high statistics results.

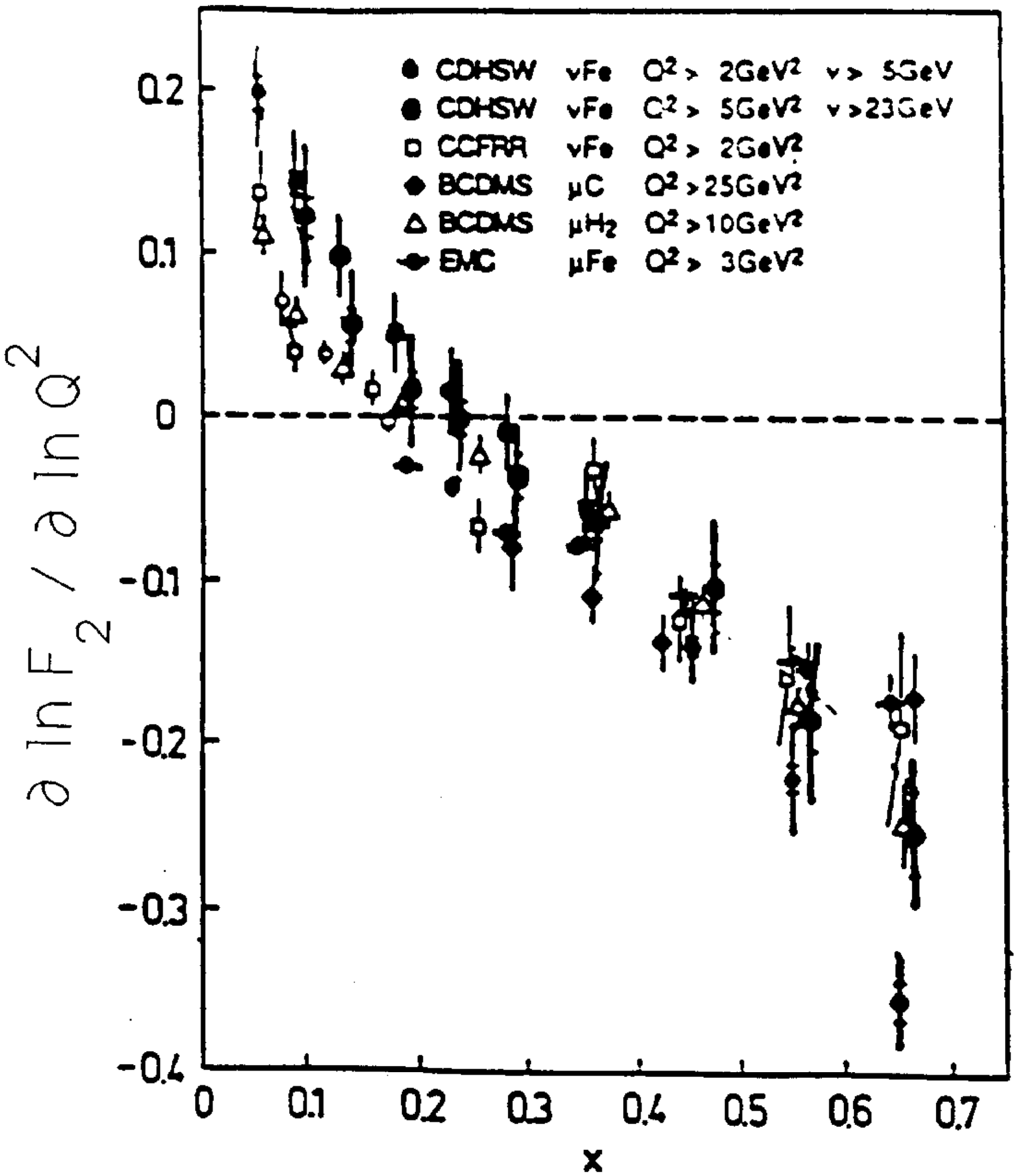


Fig. 11 d (ln F_2) / d (ln Q^2) as a function of x for the major high statistics experiments.

However, the quantitative interpretation of this x - Q^2 dependence in terms of QCD is not as straightforward. For example, Fig. 12 shows the measured slopes of F_2 by EMC and CDHSW and the **best** fit from next-to-leading order QCD. The fit is obviously atrocious! It has been pointed out [17] that as the minimum Q^2 of the data is raised, the quality and the stability of the fit improve dramatically.

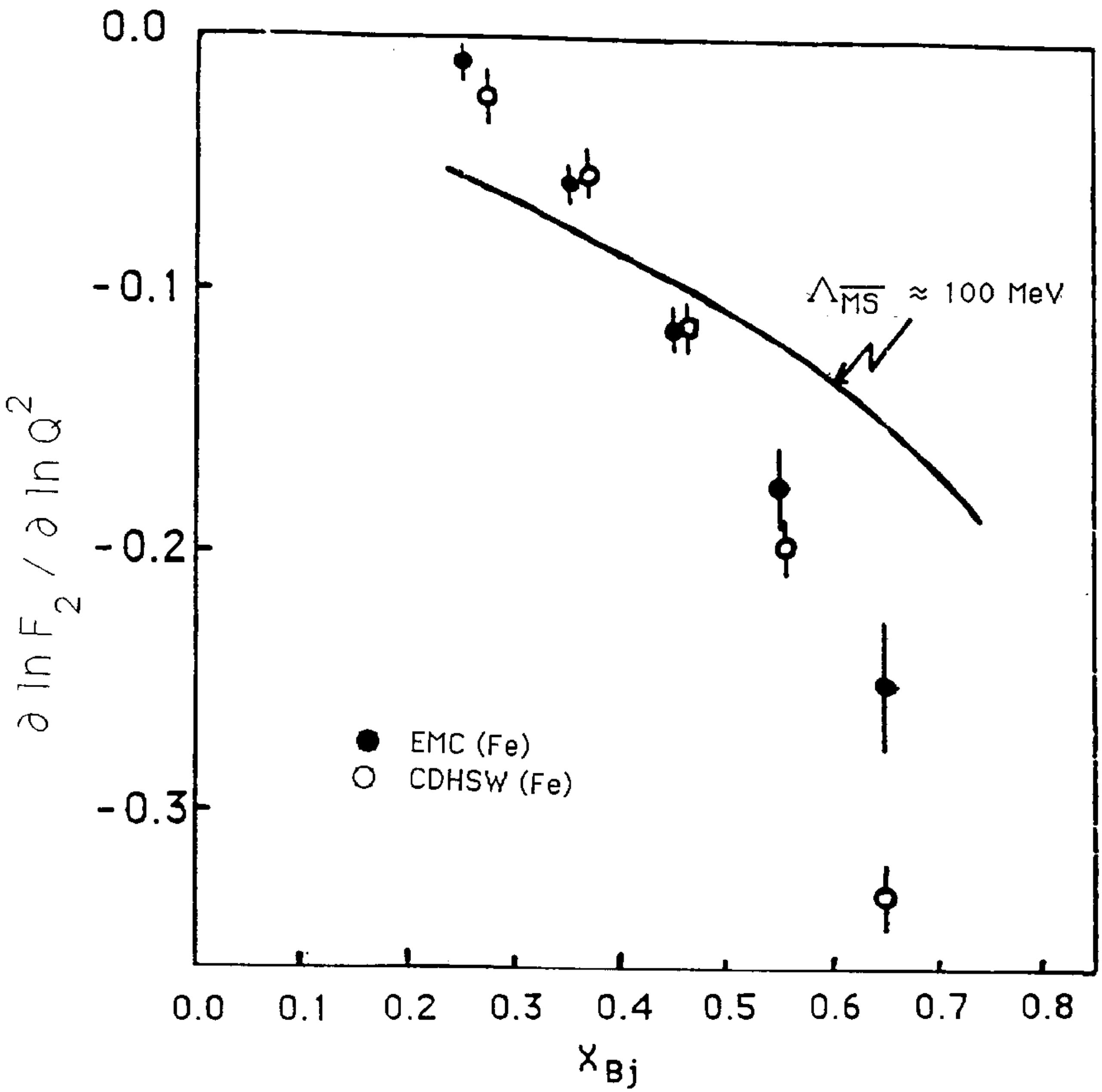


Fig. 12 F_2 measured on Iron targets by EMC and CDHSW compared to the best QCD fit.

It was only with the recently published BCDMS carbon data (Q^2 > 20 GeV^2) that a full agreement with QCD predictions was attained. The QCD analysis of the BCDMS carbon and hydrogen results are shown in Fig. 13. They yield a consistent value of slightly over 200 MeV for $\Lambda_{\overline{MS}}$. This value was obtained by two different methods; one taking only the high x (>0.25) data and performing a non-singlet fit, while the other fit used the data from the entire x range and simultaneously fit to the Gluon distribution with the following result,

$$x\,G(x, Q_0^2) = A\,(\eta + 1)\,(1 - x)^{\eta}\ ,\quad Q_0^2 = 5\ \mathrm{GeV}^2,\ \eta = 10 \pm 3$$

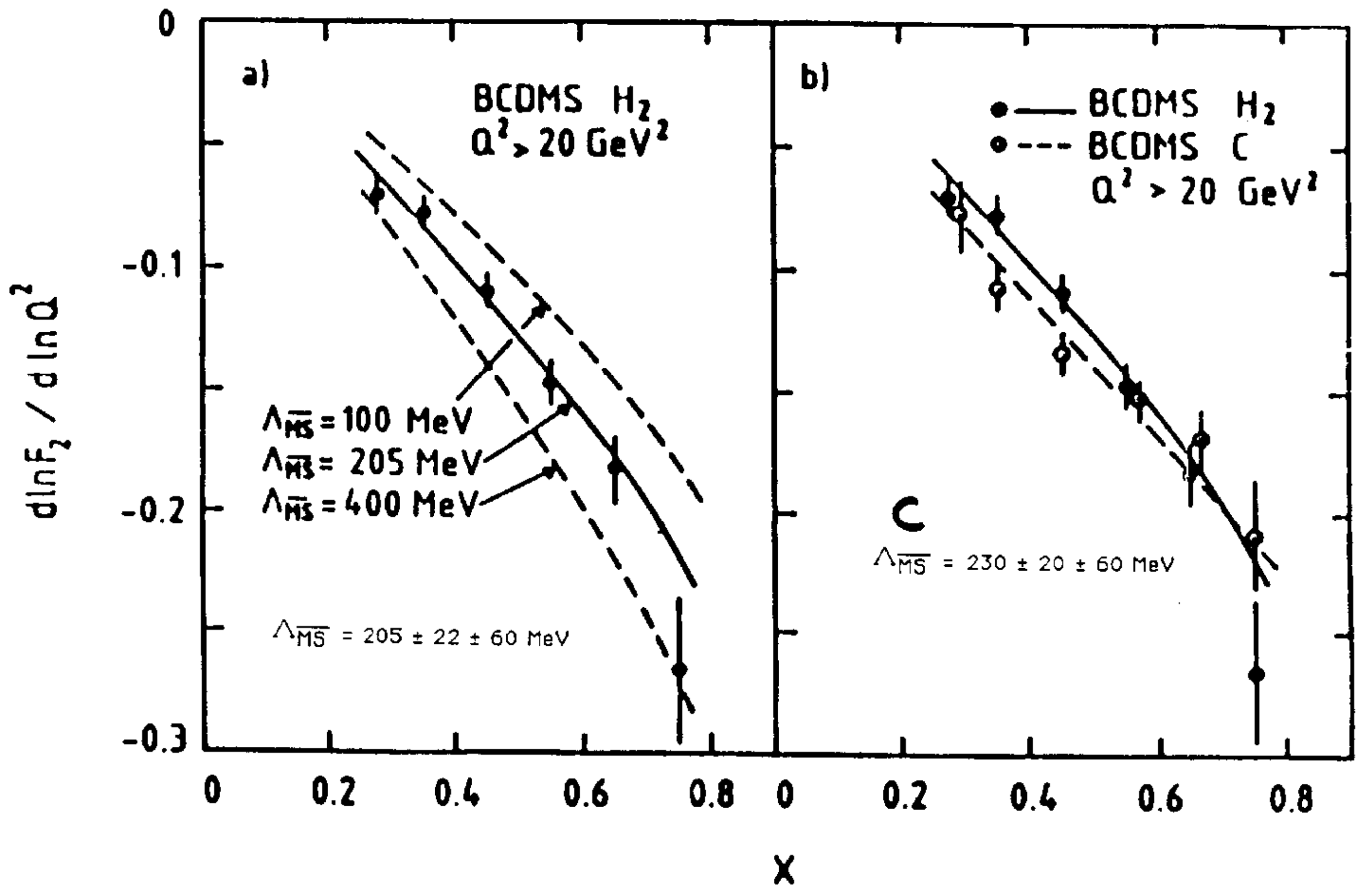


Fig. 13 The QCD analysis of BCDMS Hydrogen and Carbon Data

As mentioned, the agreement between measurement and QCD predictions can be improved by raising the minimum Q^2 of the data considered for the analysis. Another way of reconciling the data and predictions, according to F. Taylor, is to apply the Q^2 dependence of the EMC effect as formulated in an earlier section. Using the relation,

$$\frac{\partial \ln F_2^{Fe}}{\partial \ln Q^2} = \frac{\partial \ln F_2^{D_2}}{\partial \ln Q^2} + \frac{\partial \ln R^{Fe/D_2}}{\partial \ln Q^2}$$

the QCD fit to the EMC data is improved as shown in Fig. 14. A similar improvement was found for the BFP fit.

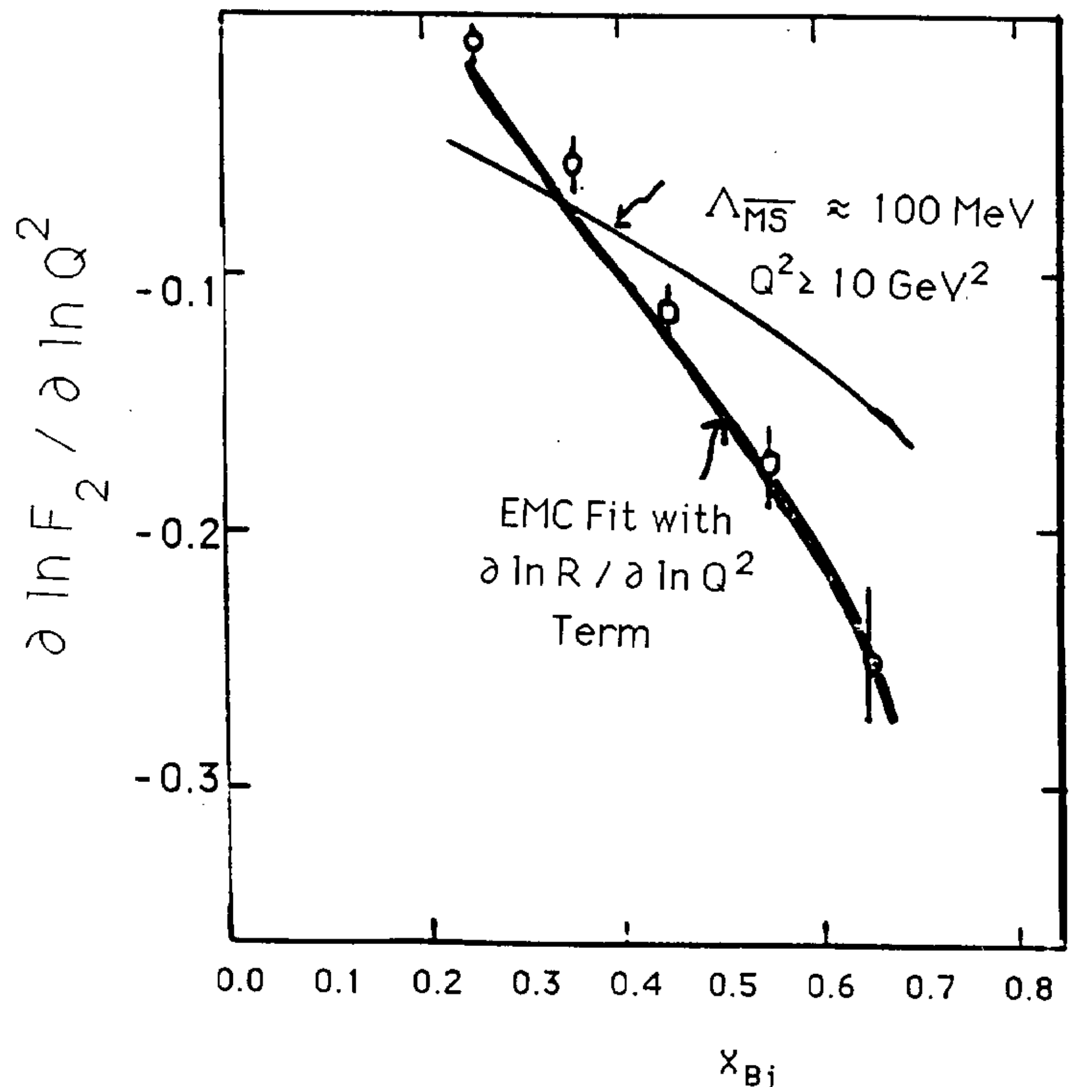


Fig. 14 QCD fits to the EMC Fe data with and without the Q^2 dependent EMC effect term - $\partial \ln R / \partial \ln Q^2$.

Determining the Parton Distribution Functions

One of the main goals of measuring the structure functions is the determination of the parton x distributions $q_i(x, Q^2)$. This is accomplished by assuming a form for the parton x dependence at a given Q^2 and using a QCD evolution program based on the Altarelli-Parisi equation to evolve the function to a Q^2 where there is a measured data point. The form of the distribution is changed until the best fit to all the measured points is obtained. The commonly used sets of parton distribution functions (PDF's) can be divided into two groups; leading order distributions such as those of references [18], [19] and [20] which were published prior to 1985, and PDF's determined using the next-to-leading expansion such as those of references [21] and [22]. Unfortunately, ALL of the above attempts to determine the PDF's ignored one or more of the following important features; EMC effect, experimental systematic errors, correlated errors, error migration, large statistics experiments. A new systematic effort is now underway which will attempt to include most of the above missing considerations as indicated in the following schematic representation of the fits.

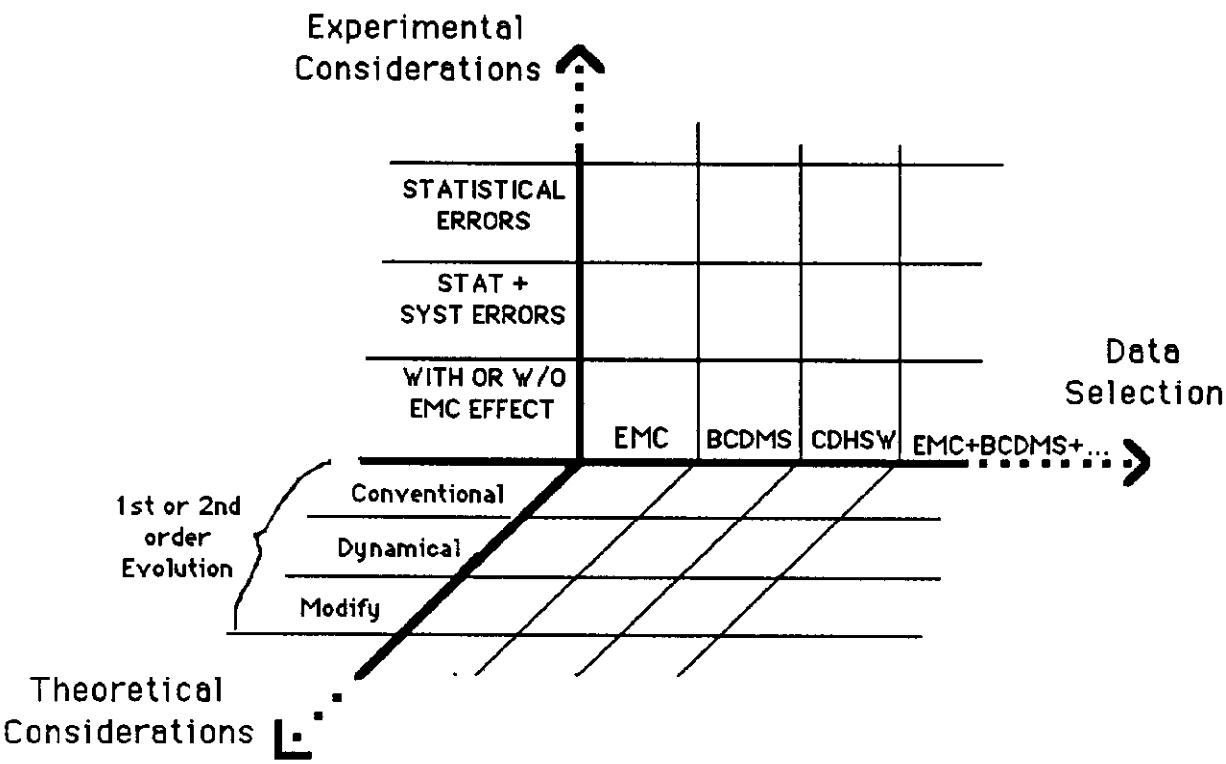


Fig. 15 An indication of the various fit combinations being attempted by the authors of reference [24].

It uses the Tung [23] QCD evolution program and is based on the H_2 data of EMC and BCDMS as well as the heavy target data of EMC, BCDMS and CDHSW. All of the data sets mentioned include systematic errors. The first results of this ongoing work is now available as a Snowmass '88 contribution [24]. A sample fit to all the data sets mentioned above is shown below. It yields a χ^2/d.o.f. of 1.06 and uses all data with Q^2 > 20 GeV^2 (428 data points) with both statistical and systematic errors (added in quadrature) included in the fit.

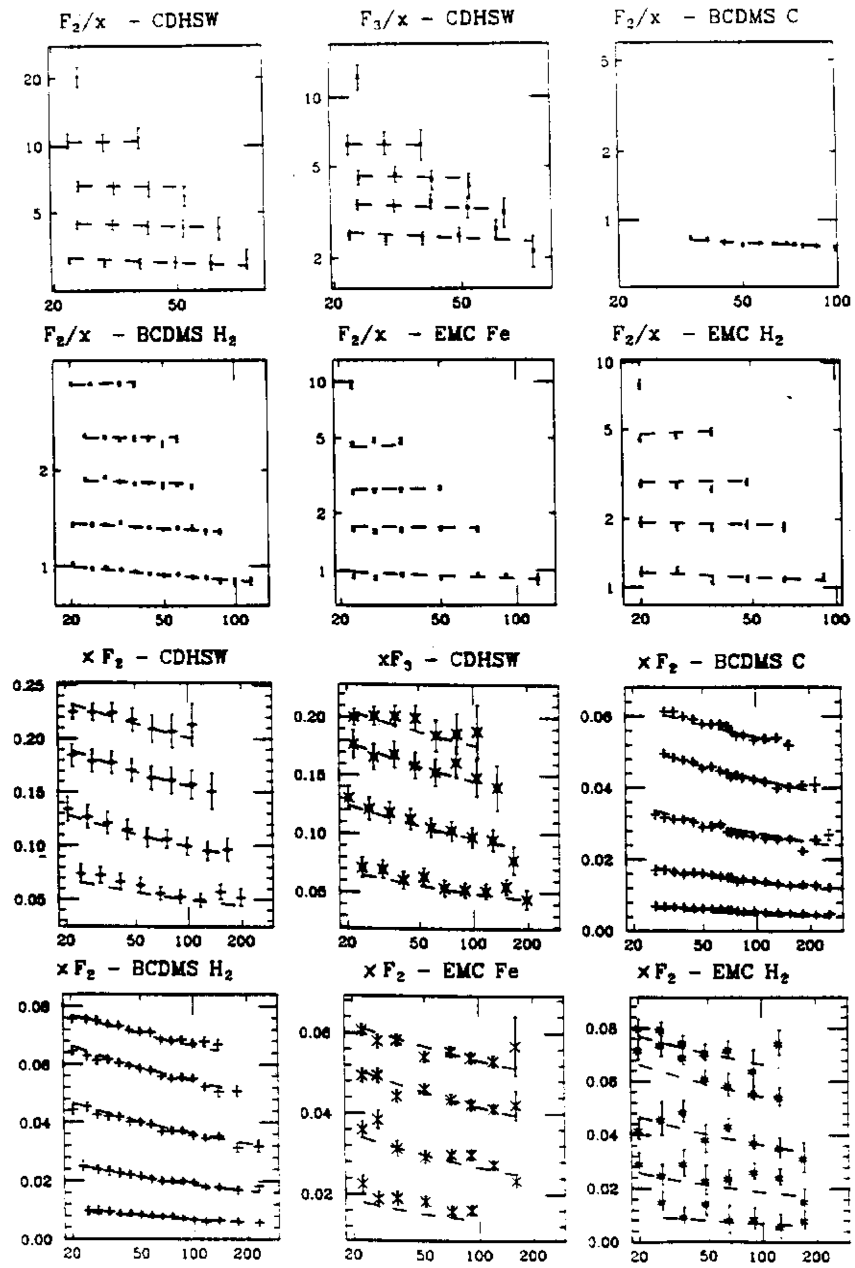


Fig. 16 A typical fit from reference [24] for data with Q^2 > 20 GeV^2. The fit yields a χ^2/d.o.f. of 1.06 and a value of $\Lambda_{\overline{MS}}$ ≈ 350 MeV

SUMMARY

1. Measurements of $F_2(x,Q^2)$ using iron targets with muons and neutrinos are consistent.

2. There is a discrepancy between the published $F_2(x,Q^2)$ results as measured with iron as compared to those measured off carbon.

3. There is also an apparent discrepancy between the hydrogen results of EMC and BCDMS.

Are the discrepancies reported in 2. and 3. still significant if:
a) the same Q^2 cut is applied to all data
b) the same value of R is used for all analysis
c) systematic errors are included in the comparison.

4. Nucleon structure is independent of the nature of the intermediate vector boson probe. In particular, the neutral current sees the same valence and sea quark distribution as the charged current.

5. Both shadowing and anti-shadowing are now established features of the EMC effect.

6. Most models can still not explain the behavior of the ratio of $F_2(x,Q^2)$ over the entire x range.

7. Does the ratio $R(F_2^A / F_2^D)$ itself exhibit a Q^2 dependence?

8. There is still an extreme need for an accurate measurement of the longitudinal structure function.

9. The iron data do **not** agree with QCD; however, beware of Q^2 cut.

10. Carbon data non-singlet analysis agrees with QCD.

11. The hydrogen data from both EMC and BCDMS agrees with QCD

12. The world average of $\Lambda_{\overline{MS}}$ is (215 ± 15 ± 50) MeV
±stat. ± syst.

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Fermilab Joins a Network of DOE National Environmental Research Parks

by Kevin A. Brown

"We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect." - Aldo Leopold

At home within and around Fermilab's accelerator is the biota (flora and fauna) of prairie, oak-savanna, forest, and wetland communities once common throughout the Midwest. Because many of these ecological communities - in some cases entire ecosystems - have all but disappeared in this region of the country, ecologists and environmental scientists cannot thoroughly study them to predict the outcomes of human stresses on those habitats that do remain. Fortunately, Fermilab, recently designated by the U.S. Department of Energy (DOE) as part of a network of National Environmental Research Parks, offers researchers exceptional opportunities to study protected habitats on-site. With these opportunities, natural scientists and other interested persons can address some of the ecological questions that could benefit both the environment and mankind.

According to John Paulk *(Res.Div./Adv. Compt.)*, Research Park Coordinator at Fermilab, an Environmental Research Park is "a protected public land where qualified researchers can conduct various types of ecological research." The Department of Energy's Office of Health and Environmental Research established a network of Environmental Research Parks, or ParkNets, at various sites across the country in response to the National Environmental Policy Act (NEPA) of 1969. NEPA defined the nation's goals of restoring, protecting, and enhancing environmental quality. The Parks uphold the policy's goals by supporting an assortment of ecological research projects and protecting priceless habitats within a given Park's boundaries.

The Road to Research Park Designation at Fermilab

Although Robert Betz, Professor of Biology, Northeastern Illinois University; Ray Schulenberg, former Curator of the Morton Arboretum; and Rudy Dorner *(Bus. Sect./Emer. Ser.)* did not realize it, the road to Research Park designation began in 1973 with their efforts to restore tall-grass prairie inside the Main Ring. The prairie restoration project currently includes approximately

700 acres of prairie, in various stages of restoration, inside and outside the Main Ring. It has a long history of internal and external support. Internally, Fermilab Director Emeritus Robert R. Wilson supported the project at its inception, and that support has been carried forward by the Lab's current Director, Leon M. Lederman. Fermilab's Roads and Grounds Department has also contributed time and effort to the project. Externally, professional consultant Betz has applied scientific and practical expertise to nurture the project, and countless seed-harvesting volunteers have advanced the restoration effort. In May 1974, a Prairie Committee, comprised of Fermilab employees and Betz, was in place to establish goals for the project and monitor its development. Finley Markley *(Tech. Suppt./Eng.)* currently chairs the Prairie Committee.

The Research Park idea originated from discussions at a Prairie Committee meeting several years ago. The Committee then worked closely with Leon Lederman to investigate the advantages and disadvantages of Research Park designation. Argonne National Laboratory (ANL) fueled additional interest in Research Park designation at Fermilab when, in 1984, ANL Director Alan Schriesheim requested that a group of Argonne terrestrial ecologists be permitted to conduct ecological research in the prairie restoration project. This accelerated the chain of events that culminated in the proposal that Fermilab become a DOE Research Park.

This proposal was endorsed, signed, and submitted by Lederman in September 1985. Official approval came in a letter to Lederman dated April 5, 1989, from Andrew E. Mravca, Area Manager, Batavia Area Office, Department of Energy. That letter was in response to a memo to Hilary J. Rauch, Manager, DOE Chicago Operations Office, from Robert O. Hunter, Jr., Director of the Department of Energy's Office of Energy Research, authorizing the designation. Essentially, the Prairie Committee's unequivocally successful prairie restoration project, which demonstrated the ecological value of the Fermilab site, justified Research Park designation at Fermilab.

The National Environmental Research Park Network

Fermilab is the DOE's sixth National Environmental Research Park. Each Park in the national network has ecosystems unique to a geographical region (Fig. 1, page 20). ''In the past,'' said Walt Conley, Director, National Environmental Research Program, ''the National Environmental Research Park network was viewed as a patchwork quilt that didn't constitute a program, and people didn't see where the Research Park program was going. The emphasis now is to pull the Parks together to represent a spectrum of ecological areas.''

The overall goals of the Park program are to (1) develop methods to quantitatively and continuously assess and monitor the environmental impact of human

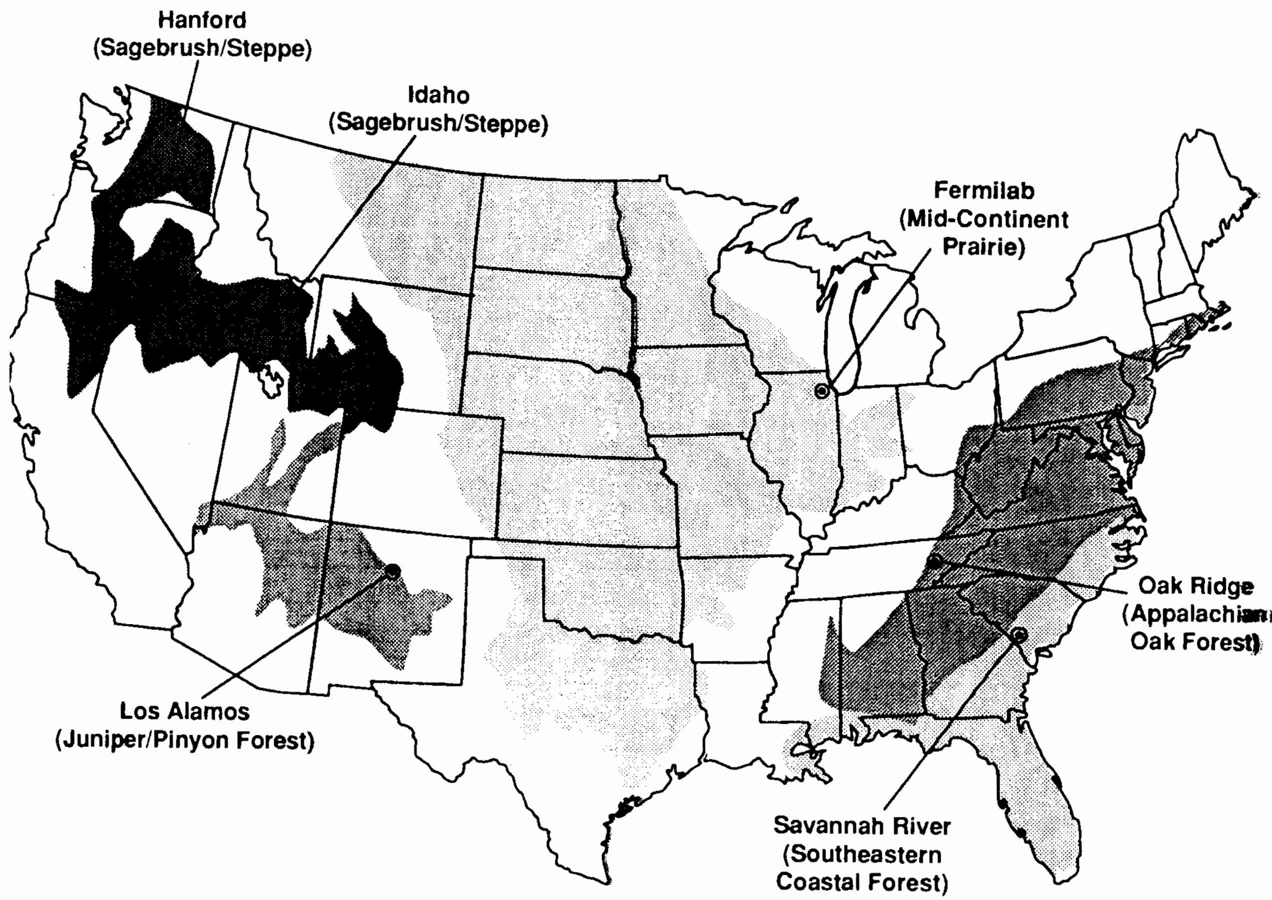


Fig. 1 Sites of the DOE National Environmental Research Parks and associated ecological regions.

activities; (2) develop methods to establish or predict the environmental response to proposed and ongoing activities; and (3) demonstrate the impact of various activities on the environment and evaluate methods to minimize adverse impacts.

There are two Parks in the east. The first, Savannah River National Environmental Research Park at the Savannah River Plant in South Carolina, encompasses 192,000 acres of hardwood forests, swamp forests, and wetlands. It was designated in 1972. The second, Oak Ridge National Environmental Research Park on the Oak Ridge Reservation in Tennessee, encompasses 13,590 acres of oak-hickory and hardwood forests, old fields, grasslands, loblolly pine plantations, eastern red-cedar barrens, streams, and rivers. It was designated in 1980.

Two of the three Parks in the west were established in 1975: the 570,000-acre Idaho National Environmental Research Park at the Idaho National Engineering Laboratory in southeastern Idaho, and the 570-square-mile Hanford National Environmental Research Park near Richland, Washington. The Idaho Research Park supports the biota characteristic of an arid sagebrush ecosystem as well as aquatic systems; the Hanford Research Park encompasses a Shrub-steppe biome (a complex biotic community characterized by the distinctive life-forms of important climax species covering a large geographic area). Unique to the Hanford Park is a 120-square-mile Arid Lands Ecology Reserve for long-term, extensive ecological study. The third Park, Los Alamos National Environmental Research Park at Los Alamos National Laboratory, New Mexico, was established in 1977. It encompasses 27,000 acres of Pinyon-juniper woodlands and grasslands.

Fermilab's Research Park exemplifies distinctive and threatened grassland and oak-savanna ecosystems in the Midwest. Said Paulk, "Adding Fermilab to this network fills a void in a vital and probably most vulnerable part of the country by providing a site for monitoring important environmental trends in these ecosystems." Fermilab is fortunate to have many other kinds of natural and human communities, including agricultural fields, woodlands, fence rows, wetlands, and the Fermilab Village. These habitats are suitable for a wide range of research opportunities, especially in agroecosystem and landscape ecology. Furthermore, 26 archaeological camp and village sites have been identified on-site: one of these sites, inside the Main Ring, could be eligible for the National Register of Historic Places.

The Research Park designation for Fermilab applies to the entire 6800-acre site, but certain areas will be off-limits due to accelerator operations or other activities. Even with these limitations, researchers have access to approximately

3700 acres encompassing a variety of ecological systems.

Environmental Research at Fermilab

Several specific areas of research have been proposed for the Fermilab Park. One area of research is to characterize the developing prairie and other systems on-site. Researchers would collect information to build a data base on site meteorological conditions, hydrology, soil properties, vegetation communities, animal populations, and aquatic biota. Another area of research is to establish long-term studies to follow successional changes in the developing prairie and other areas, such as old fields and woodlands. Of special interest to ecosystem ecologists would be combined long-term and short-term studies of these habitats to understand the mechanisms of community developments and changes. Moreover, the prairie restoration project is illustrative of accelerating vegetational succession (where a climax plant community has evolved within decades from human enrichment rather than over millennia from natural forces); studies of this process at Fermilab would also contribute to an understanding of succession.

Although Fermilab lacked official Park designation during the past three years, natural scientists have conducted a number of formal and informal ecological studies on-site. Current research projects include bird surveys by Vicki Byre, an ornithologist from the Chicago Academy of Sciences; insect surveys by Ron Panzer, an entomologist from Northeastern Illinois University; reptile and amphibian surveys by Kenneth S. Mierzwa of the Chicago Herpetological Society; and soil studies by Julie Jastrow from ANL. Researchers typically receive funding from their sponsoring organizations or other resources - the National Science Foundation, for example.

Unique to the Fermilab Park is a six-member Environmental Advisory Committee organized by Lederman. This committee reviews research proposals in a selection process that parallels that of the high-energy physics research program. Committee members, who are specialists in botany, biology, and zoology from across the country, include Paul G. Risser, University of New Mexico; Roger C. Anderson, Illinois State University; Timothy R. Seastedt, Kansas State University; John A. Wiens, Colorado State University; Samuel J. McNaughton, Syracuse University; and Betz. Prospective projects are evaluated in terms of scientific merit, availability of a suitable research site, compatibility with other activities, and potential contribution to the objectives of the Research Park program. The committee then makes its recommendations to Fermilab's Director.

The Benefits of Research Park Designation

Research Park designation will benefit Fermilab, the Park network, natural scientists, and the public in a number of ways. First, Research Park designation demonstrates Fermilab's dedication to protecting vanishing habitats, which will attract support from a broader public who may have been unaware of Fermilab's concern for the environment. Second, Fermilab, as a Research Park, advances the DOE's ambition to establish a continental gradient of Research Parks representing a broad spectrum of ecosystems in the United States. Third, natural scientists will benefit by being a part of the national network of parks. Fermilab's Research Park will attract attention from other researchers, especially those interested in the processes of ecological systems. Commented Byre, "The network will improve the effectiveness of large-scale research because it will help scientists create larger, more comprehensive data bases."

To illustrate, scientists at the Hanford Park in southeastern Washington state are studying Great Blue Heron eggs. The purpose of their research is to monitor the heron eggs nationwide for toxic chemicals. To aid their research, the scientists on the project are corresponding with other Parks home to Great Blue Herons, including Fermilab. The comprehensive, nationwide results of such research could further protect these and other species of birds from hazardous chemicals. "Professional and amateur ornithologists are very aware of the value of the Fermilab site," said Byre.

Fourth, approximately 50,000 people visit Fermilab each year; moreover, Fermilab's site is more open and accessible to the public than most other Parks in the network. This affords Fermilab an excellent opportunity to share with the public the importance of environmental issues in our society. Scientists' research projects could be used to illustrate the efforts to address those issues. Remarked Betz, "Fermilab could significantly contribute to a growing effort in the Chicago area to restore vanishing prairie-savanna communities." Fermilab's Prairie Committee is establishing a restored prairie outside the Main Ring for the general public. This prairie will have an interpretive trail, accessible to the handicapped, so that people can see, smell, and feel what a prairie is - probably for the first time. Research Park status will support this and other Lab efforts to heighten public awareness of ecosystem restoration, protection, and preservation.

The Future of the Environmental Research Park Network

Under Conley's direction, the Park network has ambitious but attainable intra- and interpark goals for the future, ranging from gathering baseline data to characterize the natural history of an area - Byre's bird surveys, for example - to developing ecological models that accurately predict the global outcomes of human pressures on the environment. "I think the possibilities are endless," Conley said.

Fermilab has tremendous potential to help attain program goals. At the intrapark level, Fermilab's Environmental Advisory and Prairie committees have already won Conley's praise for their effectiveness and vision in administering research projects and restoring prairie. To illustrate, the Prairie Committee's updated 10-year plan recommends that specific tracts of restored prairie outside the Main Ring be set aside for manipulative research, including studies of the responses of prairie communities, in various stages of development, to mechanical disturbance, fire, changes in water-table elevation, introduction of toxic materials, selective removal of system components through the use of pesticides, and artificial changes in available nutrients or moisture. This research will expand the ParkNet data base to include information about prairie responses to perturbations.

In addition to manipulative research, Fermilab will begin to enrich older prairie plots inside the Main Ring with plants characteristic of pre-settlement prairie. Plans also call for the reintroduction, where appropriate, of threatened and endangered plants and animals. Examples under consideration for reintroduction include the Spotted Turtle (*Clemmys guttata*), the Barn Owl (*Tyto alba*), the Greater Prairie Chicken (*Tympanuchus cupido*), the Buffalo Clover (*Trifolium reflexum*), the Showy Lady's Slipper (*Cypripedium reginae*), and the Spotted Coral-Root Orchid (*Corallorhiza maculata*). Prior to Research Park designation, the Prairie Committee set a precedent for enrichment and reintroduction efforts by supporting studies that began to characterize the ecological communities on site.

One objective at the interpark level is to conduct workshops at Research Parks and universities for cross-site synthesis. Between July 1989 and November 1989, five topical workshops are scheduled that focus on transects, meteorology, standards, or data-structures; a broad spectrum of topics that Conley refers to as boiler plate; and succession. These workshops, organized by Conley through the Office of Health and Environmental Research, will enable scientists to discuss their research and address world-wide environmental problems, including global warming, acid rain, and endangered species. Conley felt that Fermilab could make an especially significant contribution to the succession workshop because the Lab's prairie restoration project is a chronology of developing plots. This chronosequence reveals the evolution of prairie soils, plants, and soil/plant interactions.

NERPs have demonstrated their value through an inestimable number of published and unpublished papers, species lists, and ongoing and proposed projects.

Fermilab and the other Parks collectively possess impressive resources, many of which remain untapped because of weak links that have afflicted the network in the past. Mindful of that, the DOE is strengthening the Park network and preparing each Park to play a more significant role in ecological research. Said Conley, ''All the DOE labs have extraordinary opportunities for ecological research. They also have world-class technology and incredible expertise available; we want to hook them together and extract this expertise. ParkNet is going to grow.''

A Report on Fermilab's Full-Scale Horizontal Cable-Tray Fire Tests

by William M. Riches

Preface

Fire is the lurking nemesis of any high-energy physics program. A costly, complex array of equipment that requires years of assembly, and that is situated in enclosed spaces, can be decimated in an instant by a fire. The time required to recover from such an incident could be devastating to a laboratory's mission.

At the urging of Fermilab Director Leon M. Lederman, and already in possession of a recommendation that all of the Lab's accelerator, beamline, and experimental enclosures be equipped with fire-suppression sprinkler systems, the Fermilab Safety Section conducted extensive tests of the most likely source of fire in an accelerator complex: the unassuming horizontal cable tray, where possible combustion raised the specter of a fire racing the length of an accelerator or an experimental hall.

What follows is a synopsis of the introduction to a lengthy analysis of Fermilab's cable-tray fire tests. This information has already been made available to the Department of Energy and other interested parties. Detailed descriptions of each fire test, including sketches of cable-tray configuration and contents, instrumentation, ventilation rates, Fermilab Fire Department observations, photographs, and graphs of thermocouple temperatures are available in a complete test report from the Fermilab Safety Section. - Larry Coulson
Head, Fermilab Safety Section

Introduction

In recent years, there has been much discussion throughout industry and various governmental and fire protection agencies relative to the flammability and fire propagation characteristics of electrical cables in open cable trays. It has been acknowledged that under actual fire conditions, in the presence of other combustibles, electrical cable insulation can contribute to combustible fire loading and toxicity of smoke generation. Considerable research has been conducted on vertical cable-tray fire propagation†, mostly under small-scale laboratory conditions, but little was known about horizontal cable trays.

The author, who at the time of this writing was with the Fermilab Safety Section, is now with the Business Services Section Facility Engineering Department.

Between July 1987 and June 1988, Fermilab initiated a program of full-scale, horizontal cable-tray fire tests, in the absence of other building combustible loading, to determine the flammability and rate of horizontal fire propagation in cable tray configurations and cable mixes typical of those existing in underground tunnel enclosures and support buildings at the Laboratory. The series of tests addressed the effects of ventilation rates and cable tray fill, fire-fighting techniques, and effectiveness and value of automatic sprinklers, smoke detection, and cable-coating fire barriers in detecting, controlling, or extinguishing a cable-tray fire.

Environment

The many miles of accelerator and beamline underground concrete tunnel enclosures contain beam pipe, electromagnets, water-cooled electrical bus, cooling-water piping, and electrical power, signal, and control cables installed in horizontal single and multiple stacked cable trays. Power supplies and electronic control equipment are located in adjacent above-ground support buildings and are connected to the tunnel equipment through sealed vertical pipe penetrations. Large, high-bay experiment halls located at the ends of the various beamlines, a mile or more downstream from the Switchyard, house large particle detector equipment and are connected by sealed horizontal pipe penetrations to adjacent electronic counting houses. In addition to the accelerator and beamline enclosures, the Antiproton Ring and Transport Line represents another two-thirds of a mile of underground enclosures containing equipment similar to that in the accelerator enclosures.

Fire Protection

Above-ground experimental halls, support buildings, and counting houses are protected with a combination of automatic sprinklers, Halon 1301 suppression systems, smoke detection, heat detection, portable fire extinguishers, hose cabinets, and exterior fire hydrants as appropriate. However, because of the non-combustible construction and mainly non-combustible contents in the underground enclosures, together with their enormous lengths, fire suppression systems are not provided in the underground enclosures. Due to radiation levels experienced in some portions of the enclosures, ionization or photoelectric smoke detectors are not practical or functional. The 24-hour/day on-site Fermilab Fire Department provides a four-minute response time to all accelerator and beamline locations upon fire alarm notification via a site-wide supervisory alarm system, FIRUS-88.

The Cable-Tray Fire-Test Program

The Laboratory conducted a physical survey of accelerator and beamline enclosures to establish typical cable-tray configurations and cable contents, including quantities and types of cables and their insulation. This survey resulted in a plan to conduct a total of five burn tests, complete with thermocouple instrumentation, videotape, and photography documentation, fire-fighter observations, and qualitative smoke analysis. Because of information gathered in the first five tests, the program was expanded to a total of 14 burn tests.

The simulations of cable-tray configurations included those found in the Main Ring, the Booster Tunnel, the NMO enclosure, the New Muon Lab NMS, and the Collider Detector at Fermilab's movable cableway.

Since the main purpose of this series of cable-tray fire tests was to determine the flammability of cable insulation, rate of horizontal flame propagation, and possible benefit of automatic fire suppression systems in typical Fermilab underground enclosures, no effort was made to measure the probability or ease of ignition of the cables. With no other combustibles present, it was assumed that ignition could occur due to an overheated magnet or an electrical short circuit in the cable tray. To this end, every effort was made to ignite the cable insulation, including increasing the propane burner intensity from 20 kW to 40 kW and extending the burner ignition time to more than 60 minutes during some tests. These tests, therefore, represented "worst case" conditions. In actual field conditions, it is highly unlikely that any probable ignition source would be sustained for the duration of time utilized in the tests. For the same reasons, smoke generation during the tests represented "worst case" conditions.

The Cable-Tray Fire-Test Facility

A fire-test facility was constructed utilizing 10-ft-long by 12-ft-diameter precast concrete Main Ring enclosure sections set on a concrete slab to form a 65-ft-long tunnel, exactly duplicating the Main Ring. Each end was enclosed with a plywood wall and door. Variable-volume fans were installed in a wall opening at the upstream end with inside horizontal plywood directional baffles to provide laminar air flow through the tunnel; adjustable louvers discharging into a smoke chimney were installed in the downstream wall. Floor-standing fans were also used to assist in controlling air velocity and laminar air flow. Since several of the early tests were conducted during winter weather, electric and propane heaters were used to maintain tunnel temperatures.

Single-, double-, or multiple-stacked 24-ft-long cable trays with various cable quantities and mixes were supported on unistrut along one wall near the center of the tunnel. An adjustable volume, 20-40 kW, 12-in.-diameter propane burner with a gravel diffuser was placed 6 inches below the cable tray to be burned. A total of 30 thermocouples were surface mounted and embedded in the cable bundles and connected to a data logger located in a van outside the tunnel. Thermocouple temperatures were recorded every 60 seconds during the course of the burn tests.

Pre-burn and post-burn photographs and a videotape camera inside the tunnel during each burn provided documentation for each test. Fermilab Fire Department observers with air packs and radio communication were located inside the tunnel during each test. Qualitative smoke monitoring equipment was installed at the exhaust louvers and chimney at the downstream end of the test enclosure.

An open-burning permit was obtained from the State of Illinois Environmental Protection Agency prior to the start of the test series. Burn residue was sampled, tested, and disposed of as hazardous waste where required. All tests were observed by representatives of the Department of Energy.

Fire-Test Results

The salient finding was that high-intensity fires with fast flame propagation in horizontal cable installations in Fermilab underground enclosures is highly improbable, if not impossible, in the presence of adequate sealing of penetrations to above-ground support facilities.

Specifically, ignition of the larger-sized power cables could not be achieved during any of the tests. PVC-insulated cables self-extinguished with a minimum of flame propagation. Twist'n'flat planar cables would not support combustion.

Only the polyethylene-insulated Hardline coaxial cables and the polyethylene-insulated flat-ribbon cable supported horizontal flame propagation with accompanying dripping of flaming insulation, but at an extremely slow propagation rate. In the case of the Hardline cable, this rate was a very slow 1.7 inches/minute, which could go undetected for a considerable period of time. In such cases, a very-early-warning smoke detection system might be appropriate. An alternative was presented by an intumescent-paint cable coating applied at selected intervals to the total cable bundle after the cables were placed in the tray. This proved to be a very effective fire barrier for both horizontal and vertical Hardline cable runs.

After 2.5-3 minutes of burner ignition to the Hardline cables, the out-gassing pressure build-ups inside the cable ruptured the aluminum casing causing a minor explosion, fireball, and heavy smoke generation. The subsequent horizontal flame propagation along the outer polyethylene jacket was of low intensity with only light smoke generation.

Although cables were placed in the trays in a rather random fashion with loose compaction as would be found in the field, it became apparent during the fire-test series that resistance to ignition and flame propagation increased with greater cable densities and compaction.

Thermocouple temperatures, both surface mounted and embedded in the cable bundles, were recorded during the fire tests. As indicated by the graphs included with the individual test reports, due to the low heat release rate and very slow flame propagation rate, automatic sprinklers, if installed in the enclosures, would be very slow to operate, if indeed they operated at all. The very slow temperature rise of the embedded thermocouples indicated that linear heat detectors installed in the cable trays might not be dependable or practical since there is every probability that they would become buried as additional cables were added to the trays.

In the Main Ring, Booster, and New Muon Lab NMS fire tests, the cable-tray fire self-extinguished almost immediately or within a few minutes after removal of the propane burner ignition source. Because of machine safety interlocks and time required for access into the enclosures, it is probable that a fire would have self-extinguished before the arrival of fire fighters. Therefore, it is somewhat questionable whether automatic smoke detection systems would be justified in such areas.

Automatic sprinkler spray nozzles mounted along each side of the Collider Detector at Fermilab's movable cableway would not be thermally activated in the event of a cable fire even if equipped with heat reflectors. They would be ineffective against a deep-seated cable fire. The existing VESDA smoke detection system provides very early warning to the on-site Fire Department. Flame propagation would be extremely slow and with a very low heat release rate. Portable Halon extinguishment was proven to be most effective.

Automatic sprinkler systems in Fermilab underground enclosures would be of little benefit and would not be cost-effective due to the low heat-release rate and very slow flame propagation, if any, in horizontal cable trays. Automatic sprinkler systems would also be ineffective in minimizing potential smoke damage. The presence of an automatic sprinkler or fire detection system would not prevent a cable-tray fire, but rather would only limit the time for possible slow flame propagation before extinguishment. Property loss value would not be a major factor. Accelerator or experimental beam time would be lost in any case, with an estimated one person-week recovery time. During an operating period, such an outage could undoubtedly also be used to accomplish desired elective maintenance and development work.

Observations by Fermilab Fire Department personnel located in the fire test tunnel during each test indicated no problem in heat build up, no appreciable increase in flame propagation as a result of increased ventilation rates, and no serious visibility problems. Any flame propagation was very slow and easily contained by portable fire extinguishers. The greatest surprise was the violence of the short-lived Hardline cable explosions, but once finished, there was no problem in fire containment or extinguishment. The deep-seated fire and re-ignition in the CDF moveable cableway test was also a surprise to the Fire Department but represented no problem in containment or extinguishment due to its very slow propagation. Early detection was proven to be of much greater importance than the presence of automatic suppression systems.

† **Note:** It is important to emphasize that the results of these tests are not indicative of the fire-propagation characteristics of *vertical* cable trays, particularly where ducts are present. Please consult the pertinent literature for results of vertical cable-tray tests.

Lab Notes

New Pbar Record Set. . .

On 27 April, 1989, Fermilab's Antiproton Source Accumulator Ring set a new record for antimatter accumulation by attaining a stack of 97.2×10^{10} antiprotons. The previous world record of 86.5×10^{10} pbars, also held by the Fermilab machine, was exceeded the previous day. The new record is just short of the Antiproton Source Department's short-term goal of accumulating 1×10^{12} antiprotons. Along the way, Fermilab "pulled away" from CERN in the antimatter race. CERN's Antiproton Accumulator recently achieved its own peak stack record of 85.7×10^{10} antiprotons.

What is the significance of this achievement? It has been theorized, but not yet proven, that at some intensity there looms a point at which the stacking rate decreases to nearly zero. This limit has now been pushed to above the new stack record.

Despite the fact that the stacking rate decreases as a function of stack size, the stacking rate was a respectable 7.5×10^9 pbars/hour when the new record was attained. TEVATRON Collider upgrade plans call for stack sizes of up to 2×10^{12} antiprotons. The Accumulator has now proven its ability to approach half of this intensity.

This milestone came as the result of diligent efforts by personnel in the Antiproton Source Department led by John Marriner, the Accelerator Operations Group led by Bob Mau, and by a TEVATRON Collider studies period along with a fair amount of good luck. - *Elvin Harms*

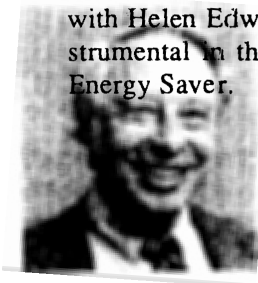
Appointments: J. Richie Orr and Dennis Theriot Named Associate Directors. . .

Fermilab Director Leon M. Lederman has announced two appointments to the Directorate.

Effective May 1, 1989, J. Richie Orr, currently Associate Director at Large, will become Associate Director for Administration, and Dennis Theriot will become Associate Director for Technology.

Both individuals bring to their new positions a great range of experience with and knowledge of Fermilab's workings, as well as impressive records of accomplishment in various areas of the Lab's programs.

J. Richie Orr was Head of the Meson Lab in 1971 and one of the Main Ring Managers in the early days of the then National Accelerator Laboratory (NAL). He then became head of the Neutrino Lab from 1972 to 1974, Deputy Head of the Research Division from 1974 to 1975, Fermilab's Business Manager from 1976 to 1977, Head of the Energy Saver Project from 1978 until its completion in 1984, and Head of the Accelerator Division from 1981 to 1986. Orr, together with Helen Edwards, who succeeded him as Accelerator Division Head, was instrumental in the successful construction, commissioning, and operation of the Energy Saver.



J. Richie Orr *Dennis Theriot*

Dennis Theriot began at NAL with the Radiation Physics Section under Miguel Awschalom in the Village in 1969, then, in 1972, became Head of the Remote Handling Group in the Neutrino Area. He and his group were responsible for the construction of the Neutrino Target trains and the servicing of their components. These devices were a major advance in target systems over what had existed at Brookhaven National Lab and CERN. He next became Head of the Neutrino Mechanical Group, then Deputy Head of Neutrino Area. In 1977 he was named Head of the Neutrino Department. In 1979, Theriot returned to experimental physics while, at the same time, overseeing the upgrade of the beams in the Neutrino Area. In the fall of 1980, Theriot joined the Collider Detector at Fermilab (CDF) as Deputy Project Manager of the CDF detector and Deputy Head of the CDF Department, where he was the effective project manager of CDF construction.

''I am confident,'' the Director said, ''that Dennis and Rich will help to keep Fermilab a strong Laboratory.''

Manuscripts and Notes

received between March 21, 1989, and May 5, 1989. Copies of Fermilab TM's, FN's, and preprints (exclusive of Theoretical Physics and Theoretical Astrophysics preprints) can be obtained from the Fermilab Publications Office, WH6NW, or by sending your request to (DECnet) FNAL::TECHPUBS or (BITnet) TECHPUBS@FNAL. For Theoretical Physics or Theoretical Astrophysics preprints, contact those departments directly. For papers with no Fermilab catalogue number, contact the author directly.

Experimental Physics Results

Experiment #605/772
D. M. Kaplan et al., "Study of the Nuclear Antiquark Sea via $p + N \rightarrow$ Dimuons," (presented by D. M. Kaplan at "DPF '88": the 1988 Meeting of the DPF of the APS, Storrs, Connecticut, August 15-18, 1988)

Experiment #623
J. K. Woosley, "Observation of a Resonance at 2.36 GeV/c^2 in 400 GeV/c pN Interactions," (Ph.D. Thesis, Vanderbilt University, Nashville, Tennessee, August 1987)

Experiment #691
J. C. Anjos et al., "A Study of $D_s^{\pm}$ and $D^{\pm}$ Decays into Four-Body Final States, Including $\eta\pi^{\pm}$ and $\omega\pi^{\pm}$," (FERMILAB-Pub-89/23-E; submitted to Phys. Lett.)

Experiment #705
S. W. Delchamps et al., "Precision Charge Amplification and Digitization System for a Scintillating and Lead Glass Array," (FERMILAB-Conf-89/25-E; to be published in the proceedings of the 1988 IEEE Nuclear Science Symposium on Transactions in Nuclear Science, Orlando, Florida, November 8-13, 1988)

Experiment #711
K. Streets et al., "Atomic Weight Dependence of the Production of Hadron Pairs from 800 GeV/c Protons on Nuclear Targets," (FERMILAB-Pub-89/42-E; submitted to Phys. Rev. Lett.)

Experiment #741/CDF
F. Abe et al., "Dijet Angular Distributions from $\bar{p}p$ Collisions at $\sqrt{s}$ = 1.8 TeV," (FERMILAB-Pub-89/62-E; submitted to Phys. Rev. Lett.)

Experiment #743
M. F. Senko, "Charmed Meson Production in 800 GeV p-p Interactions," (Ph.D. Thesis, Vanderbilt University, Nashville, Tennessee, May 1989)

Experiment #772
J. C. Peng et al., "Lepton-Pair Production in Hadron-Nucleus Collisions," (invited paper presented by J. C. Peng at the LAMPF Workshop on Nuclear and Particle Physics on the Light Cone, Los Alamos, New Mexico, July 18-22, 1988)

General Particle Physics

C. N. Brown, "20 Years of Drell-Yan Dileptons," (presented at the 16th SLAC Summer Institute on Elementary Particle Physics, SLAC, Stanford, California, July 18-29, 1988)

L. Spiegel et al., "Performance of a Lead Radiator, Gas Tube Calorimeter," (TM-1573; presented by L. Spiegel at the 1988 IEEE Nuclear Science Symposium on Transactions in Nuclear Science, Orlando, Florida, November 8-13, 1988)

Accelerator Physics

S. A. Bogacz, "Coherent Instability Limits - Supplement," (FN-507)

R. C. Bossert et al., "Analytical Solutions to SSC Coil End Design," (FERMILAB-Conf-89/54 [SSC-209]; presented by R. C. Bossert at the International Industrial Symposium on the Super Collider [IISSC], New Orleans, Louisiana, February 8-10, 1989)

R. C. Bossert et al., "SSC Magnet Mechanical Interconnections," (TM-1582 [SSC-N-601]; presented by R. C. Bossert at the International Industrial Symposium on the Super Collider [IISSC], New Orleans, Louisiana, February 8-10, 1989)

J. A. Carson et al., "SSC Dipole Coil Production Tooling," (FERMILAB-Conf-89/53 [SSC-208]; submitted to the International Industrial Symposium on the Super Collider [IISSC], New Orleans, Louisiana, February 8-10, 1989)

C. E. Dickey, "Coil Measurement Data Acquisition and Curing Press Control System for SSC Dipole Magnet Coils," (FERMILAB-Conf-89/55 [SSC-210]; presented at the International Industrial Symposium on the Super Collider [IISSC], New Orleans, Louisiana, February 8-10, 1989)

J. Dinkel and J. Biggs, "A Magnetically Switched Kicker for Proton Extraction," (FERMILAB-Conf-89/72; presented by J. Dinkel at the IEEE Particle Accelerator Conference, Chicago, Illinois, March 20-23, 1989)

R. W. Fast et al., "A Very Large Superconducting Solenoid," (invited talk presented by R. Kephart at the International Industrial Symposium on the Super Collider [IISSC], New Orleans, Louisiana, February 8-10, 1989)

D. A. Finley, "Calculation of Integrated Luminosity for Beams Stored in the TEVATRON Collider," (presented at the IEEE Particle Accelerator Conference, Chicago, Illinois, March 20-23, 1989)

J. Gannon et al., "Flying Wires at Fermilab," (FERMILAB-Conf-89/64; presented by J. Gannon at the IEEE Particle Accelerator Conference, Chicago, Illinois, March 20-23, 1989)

J. D. Gonczy et al., "Multilayer Insulation (MLI) in the Superconducting Super Collider - a Practical Engineering Approach to Physical Parameters Governing MLI Thermal Performance," (TM-1583 [SSC-N-602]; presented by J. D.

Gonczy at the International Industrial Symposium on the Super Collider [IISSC], New Orleans, Louisiana, February 8-10, 1989)

S. D. Holmes et al., "The Fermilab Upgrade," (presented at the IEEE Particle Accelerator Conference, Chicago, Illinois, March 20-23, 1989)

E. T. Larson et al., "Status of Suspension Connection for SSC Coil Assembly," (TM-1580 [SSC-N-599]; presented by E. T. Larson at the International Industrial Symposium on the Super Collider [IISSC], New Orleans, Louisiana, February 8-10, 1989)

N. Merminga, "A Study of Nonlinear Dynamics in the Fermilab TEVATRON," (FN-508; Ph.D. Thesis, University of Michigan, Ann Arbor, Michigan, January 1989)

N. Merminga and K.-Y. Ng, "Analytic Expressions for the Smear Due to Nonlinear Multipoles," (FN-505 [SSC-N-594])

N. V. Mokhov, "The MARS10 Code System: Inclusive Simulation of Hadronic and Electromagnetic Cascades and Muon Transport," (FN-509)

C. D. Moore, "The Vertical Alignment of the D0 Overpass in the Fermilab Main Ring," (TM-1578; presented at the IEEE Particle Accelerator Conference, Chicago, Illinois, March 20-23, 1989)

T. H. Nicol et al., "Design and Analysis of the SSC Dipole Magnet Suspension System," (TM-1579 [SSC-N-598]; presented by T. H. Nicol at the International Industrial Symposium on the Super Collider [IISSC], New Orleans, Louisiana, February 8-10, 1989)

R. C. Niemann, "Model SSC Dipole Magnet Cryostat Assembly at Fermilab," (TM-1581 [SSC-N-600]; presented at the International Industrial Symposium on the Super Collider [IISSC], New Orleans, Louisiana, February 8-10, 1989)

B. L. Norris and J. C. Theilacker, "TEVATRON Operational Experiences," (FERMILAB-Conf-89/39; submitted to the International Industrial Symposium on the Super Collider [IISSC], New Orleans, Louisiana, February 8-10, 1989)

T. J. Peterson and P. O. Mazur, "A Cryogenic Test Stand for Full Length SSC Magnets with Superfluid Capability," (TM-1562 [SSC-N-592]; to be published in the proceedings of the International Industrial Symposium on the Super Collider [IISSC], New Orleans, Louisiana, February 8-10, 1989)

S. M. Pruss, "Operational Experience with Using Collimators to Remove Halo in the TEVATRON Collider," (presented at the IEEE Particle Accelerator Conference, Chicago, Illinois, March 20-23, 1989)

J. Strait et al., "Fermilab R&D Test Facility for SSC Magnets," (TM-1563 [SSC-N-591]; presented at the International Industrial Symposium on the Super Collider [IISSC], New Orleans, Louisiana, February 8-10, 1989)

Theoretical Physics

T. Altherr and P. Aurenche, "About Fermion Self-Energy Corrections in Perturbative Theory at Finite Temperature," (FERMILAB-Pub-89/107-T; submitted to Phys. Rev.)

P. B. Arnold and M. H. Reno, "ERRATA: The Complete Computation of High-p_T W and Z Production in 2nd-Order QCD," (FERMILAB-Pub-89/59-T; to be published in Nucl. Phys. B)

P. Arnold et al., "High-p_T W and Z Production at the TEVATRON," (FERMILAB-Pub-89/60-T; submitted to Phys. Rev. D)

D. Chang and W.-Y. Keung, "Constraints on Muonium-Antimuonium Conversion," (FERMILAB-Pub-89/61-T; submitted to Phys. Rev. Lett.)

I. M. Dremin, "Multifractality of Inelastic Events," (FERMILAB-Pub-89/71-T; submitted to Phys. Rev.)

P. B. Mackenzie, "An Improved Hybrid Monte Carlo Method," (FERMILAB-Pub-89/100-T; submitted to Phys. Lett. B)

Theoretical Astrophysics

A. Albrecht and N. Turok, "Evolution of Cosmic String Networks," (FERMILAB-Pub-89/42-A; submitted to Phys. Rev. Lett.)

D. S. P. Dearborn et al., "The Shocking Development of Lithium (and Boron) in Supernovae," (FERMILAB-Conf-89/50-A; submitted to Astro. Phys. J.)

E. E. DeLuca et al., "On the Effects of Cosmions upon the Structure and Evolution of Very Low Mass Stars," (FERMILAB-Pub-89/49-A; submitted to Astro. Phys. J.)

Z. Frei and A. Patkós, "Surface Energy from Order Parameter Profile at the QCD Phase Transition," (FERMILAB-Pub-89/47-A; submitted to Phys. Lett. B)

J. A. Frieman and B. W. Lynn, "A New Class of Non-Topological Solitons," (FERMILAB-Pub-89/31-A; submitted to Phys. Rev. D)

K. Griest and B. Sadoulet, "Model Independence of Constraints on Particle Dark Matter," (FERMILAB-Conf-89/57-A; presented at the International School of Particle Astrophysics, 2nd Course: "Dark Matter in the Universe," Erice, Italy, May 4-14, 1988)

D. N. Schramm, "SUPERNOVA 1987A: 18 Months Later," (FERMILAB-Conf-89/27-A; presented at "DPF '88": the 1988 Meeting of the DPF of the APS, Storrs, Connecticut, August 15-18, 1988)

M. S. Turner and F. Wilczek, "Positron Line Radiation from Halo Wimp Annihilations as a Dark Matter Signature," (FERMILAB-Pub-89/44-A; submitted to Phys. Rev. Lett.)

T. York, "Fragmentation of Cosmic-String Loops,' (FERMILAB-Pub-89/32-A; submitted to Phys. Rev. D)

Computing

I. Gaines, "Microprocessors and Other Processors for Triggering and Filtering at the SSC," (FERMILAB-Conf-89/52 [SSC-207]; presented at the Workshop on Triggering and Data Acquisition for Experiments at the Superconducting Super Collider, Toronto, Canada, January 16-19, 1989)

I. Gaines, "Summary Talk: Data Acquisition, Event Building, and On-Line Processing," (FERMILAB-Conf-89/51 [SSC-206]; presented at the Workshop on Triggering and Data Acquisition for Experiments at the Superconducting Super Collider, Toronto, Canada, January 16-19, 1989)

T. Nash et al., "A Site Oriented Supercomputer for Theoretical Physics: The Fermilab Advanced Computer Program Multi-Array Processor System (ACMAPS)," (FERMILAB-Conf-89/58; presented by T. Nash at the 4th Hypercubes Concurrent Computers and Applications Conference, Monterey, California, March 6-8, 1989)

Other

A. W. Kolb, "A Chronology: VBA (ICFA) → SSC (US-DOE)," (FN-415-Rev.)

Colloquia, Lectures, and Seminars

by Fermilab staff, at Fermilab, March-April 1989, unless otherwise noted.

February 2
E. Kolb, "The Big Bang," at Chicago State University

February 23
R. Gregory, "Cosmic Strings and Skyrmion Decay," at Lake Louise Winter Institute

February 27
E. Kolb, "Cosmology of Non-Topological Solitons," at Indiana University

March 2
G. Jackson, "Bunched Beam Cooling in the TEVATRON"

March 6
H. Montgomery, "Parton Distributions from Deep Inelastic Scattering"

March 7
H. Montgomery, "Parton Distributions from Deep Inelastic Scattering"
E. Kolb, "Cosmology of Non-Topological Solitons," at the University of Minnesota

March 8
A. Albrecht, "Scaling Networks of Cosmic Strings," at Elmhurst College

March 9
R. Flora, M. MacPherson, and O. Calvo, "The New TECAR"
T. Peterson, "Status: Large-Scale Sub-Atmospheric Cryogenics Systems"

March 10
H. Montgomery, "Parton Distributions from Deep Inelastic Scattering"

March 13
H. Montgomery, "Parton Distributions from Deep Inelastic Scattering"

March 15
C. Brown, "The Study of Dileptons"

March 16
S. Pruss, "Beam Halo and Experimental Backgrounds"

March 17
C. Brown, "The Study of Dileptons"
W. Merritt, "Online Event Analysis"
M. Turner, "Dark Matter in the Universe," at Iowa State University

March 18
A. Lennox, "The Role of Physics in Cancer Treatment," at Glenbrook North High School, Glenbrook, Illinois

March 23
D. Anderson, "A Report on the Vienna Wire Chamber Conference"

A. Kronfeld, "Progress in Lattice QCD," at Cornell University
M. Turner, "Dark Matter in the Universe," at LosAlamos National Laboratory

March 29
H. Johnstad, "PAW at Fermilab"

March 30
D. Kosower, "Recursion Relations for QCD Amplitudes"

March 31
D. Eartly, "Performance of the D0 Toroids"

H. Jöstlein, "Fringe Fields from the Toroids"
A. Lennox, "Neutrons Against Cancer," at Northern Illinois University

April 5
M. Lindner, "Hierarchical Chiral Symmetry Breaking and Quark Masses," at the University of Virginia

April 6
N. Gelfand and S. Hsueh, "An Absolute Determination of the Collider Luminosity"

M. Turner, "Astrophysical and Cosmological Constraints," at Brookhaven National Laboratory

April 7
L. Michelotti, "Geometry of Instability," at Northern Illinois University

April 12
M. Gormley, D. McGinnis, and E. Harms, "Recent Antiproton Source Improvements and Performance"

A. Lennox, "The Role of Physics in Cancer Treatment," at Argonne National Laboratory

April 18
R. Rubinstein, S. Holmes, and S. Stahl, "The Fermilab Accelerator Physics Ph.D. Program"

April 20
S. Holmes and R. Gerig, "Main Injector Aperture Estimates"

April 25
D. Petravick, "High-Level Software for Linking Computers of Various Types"

April 26
A. Albrecht, "Evolution of String Networks," at the Harvard Smithsonian Center for Astrophysics

L. Sagalovsky (University of Illinois/Fermilab), "Dipole Fringe Fields in TRANSPORT"

April 27
A. Albrecht, (i) "Overview of Cosmic Strings," (ii) "Cosmic String Simulations," at the Canadian Institute for Theoretical Astrophysics

C. Ankenbrandt, R. Johnson, "Improvements to the Accelerator Upgrade"

April 28
T. Murphy, "D0 Survey and Alignment"

Dates to Remember

May 19-20, 1989

Fermilab Users Annual Meeting. Fermilab, Batavia, Illinois. For information, contact Phyllis Hale, Fermilab Users Office, (312) 840-3111 or BITnet USERSOFFICE@FNAL.

June 17-23, 1989

Physics Advisory Committee Meeting.

June 19-30, 1989

1989 US Particle Accelerator School (graduate-level courses), University of California, Berkeley, California. For information or application, contact the Accelerator School Office, Fermilab, P.O. Box 500, MS 125, Batavia, IL 60510, (312) 840-3896 or BITnet [USPAS].

July 24-August 4, 1989

1989 US Particle Accelerator School (intensive lecture courses), Brookhaven National Laboratory, Upton, New York. For information or application, contact the Accelerator School Office, Fermilab, P.O. Box 500, MS 125, Batavia, IL 60510, (312) 840-3896 or BITnet [USPAS].

August 15-24, 1989

Physics at Fermilab in the 1990's. For information, contact Cynthia Sazama, Fermilab, P.O. Box 500, MS 322, Batavia, IL 60510, (312) 840-3082 or BITnet UPGRADE@FNAL.

August 22-26, 1989

XIV International Conference on High Energy Accelerators. KEK, Nova Hall, Tsukuba, Japan. For information contact S. Ozaki, HEACC 89 Conference Secretariat, KEK, 1-1 Oho, Tsukuba, Ibaraki, 305 Japan, or BITnet HEACC89@JPNKEKVM.

October 23, 24, 28, 1989

1989 IEEE Short Course Program, San Francisco, California. For information, contact Kevin Blackwell, Lawrence Livermore National Laboratory, P.O. Box 5504, L-130, Livermore, CA 94550, (415) 422-8067.

October 25-27, 1989

1989 IEEE Science Symposium (including Nuclear Power Systems sessions), San Francisco, California. For information, contact Guy Armantrout, Lawrence Livermore National Laboratory, P.O. Box 5504, L-440, Livermore, CA 94550, (415) 422-1594.