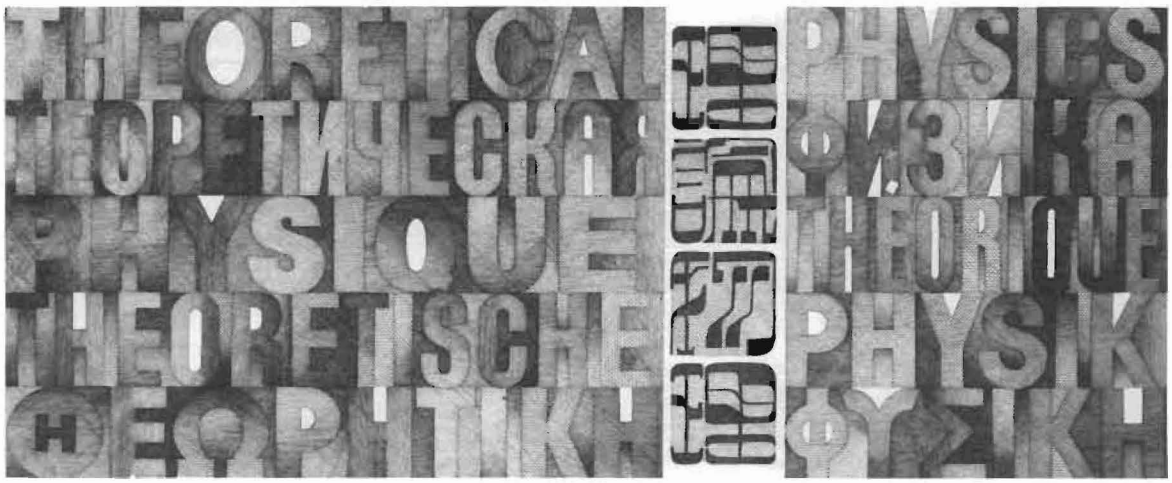
NALREP



Monthly Report of the Fermi National Accelerator Laboratory

March 1975

Fermi National Accelerator Laboratory

NALREP is published monthly by the Fermi National Accelerator Laboratory, P. O. Box 500, Batavia, Illinois 60510.

J. R. Sanford, Editor
N. Stiening, Assistant Editor

Contributions and comments should be addressed to the Program Planning Office. Requests for copies should be addressed to the Publications Office.

FERMILAB-75-3 0090.01

THE COVER: Illustration was drawn by A. Gonzales for the Theoretical Physics Department.

Operated by Universities Research Association Inc. under contract with the Energy Research and Development Administration

CONTENTS MARCH 1975

THEORETICAL PHYSICS AT FERMILAB

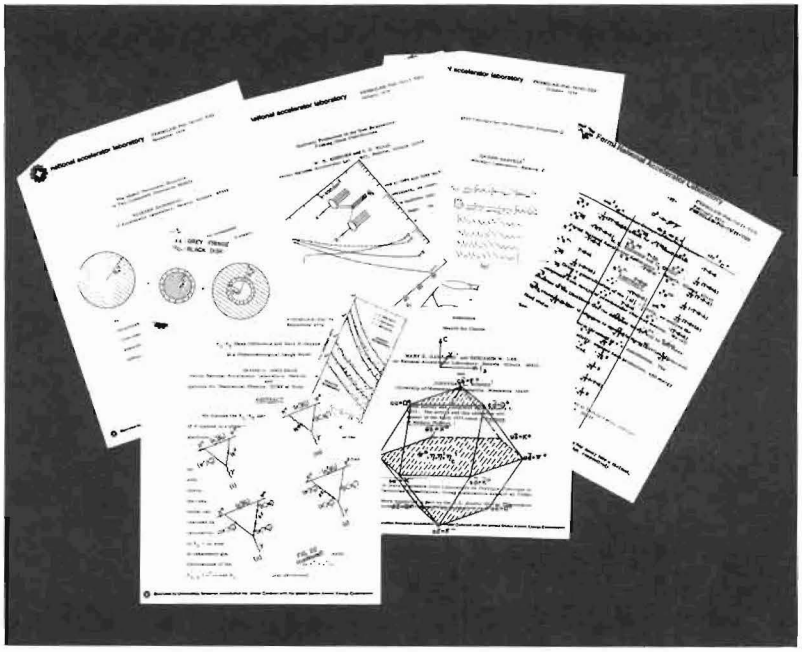
I. INTRODUCTION

Symbiosis between the experimental and theoretical branches of high energy particle physics is characteristic of a highly developed and organized scientific endeavor. Sophistication in mathematical reasoning and technology that has accompanied progress in particle physics no longer allows an ordinary mortal to pursue the science both in an experimental laboratory and in the quiet of a study, as in the good old days of Faraday, Cavendish and Rayleigh, or even in the more recent time of Enrico Fermi. Nonetheless, experimentalists and theorists share a common aspiration--pursuit of the laws of physical nature, and a common ability--intuition and logical reasoning. They share the needs for communicating with each other for inspiration and guidance. Without this vital link, theoretical physics would be an idle philosophizing, experimental physics an excercise in wizardry.

To cite recent history, speculations about the nature of weak interactions stimulated the discoveries, here and elsewhere, of the so-called neutral current effects in neutrino interactions. The discoveries in turn delimit the range of theoretical models worth pursuing. Experimental information on the absence of strangeness-changing neutral current prompted the theoretical hypothesis of the existence of a new degree of freedom in the internal structure of hadrons. Recent discoveries of narrow resonances may or may not have to do with this hypothesis, but the hypothesis suggests several avenues of experimental developments in studying the properties of these and related particles.

Fermi National Accelerator Laboratory strives to be a significant center of high energy physics research. As an important aspect of the implementation of this goal, the need for a strong theory group in residence at the Laboratory was recognized by the Directorate. This led to the establishment of a Theoretical Physics Department which became part of the Research Division early in 1974. It was understood from the outset that the theory group at the Laboratory should not merely be a service department. Rather, it was expected that the group would become a center of theoretical physics where new ideas were generated and developed, and theories were brought in confrontation with experiment. Recruitment of the theoretical physics staff has been proceeding under this general guideline, and the very best of available young theoretical physicists have been asked to come to the Laboratory. The Theoretical Physics Department at the same time welcomes the opportunity to promote communication between the experimental and theoretical high energy communities, and to make itself available for consultation to the Laboratory Directorate, scientific staff and users at both formal and informal levels. Members of the Theoretical Physics Department are appreciative of the unique opportunities Fermilab provides for their research and contact with experimentalists. They pride themselves in being a focal point of the intellectual life of the Laboratory.

This article describes the organization and activities of the Theoretical Physics Department.



II. ORGANIZATION

The Theoretical Physics Department is a unit in the Research Division, in parallel with the Physics Department and departments representing experimental areas and research support facilities.

Currently, the Theoretical Physics Department consists of three continuing appointees (H. D. I. Abarbanel, B. W. Lee, and C. Quigg), one term appointee (M. B. Einhorn), and several research associates. Research associates are usually appointed for a two-year period. This year, S. Jackson and R. Savit are at CERN on leaves of absence; they will return for their second year at Fermilab next year. Jochen Bartels, J. Carazzone, and E. Rabinovici were appointed research associates this year. Stephen Ellis returned from CERN to complete his last year at Fermilab.

In addition, the Fermilab Theoretical Physics Department plays host to a large number of theorists from various institutions here and abroad. They are here to share their research results and expertise with their theoretical and experimental colleagues at the Laboratory, and sometimes, to participate in research projects carried out in the department. There are two classes of visitors; some come for a few weeks to a month, and others for six months to a year. During the year 1974/75, W. Bardeen of Stanford University and S. J. Chang of the University of Illinois are spending a semester each at Fermilab. Short-term visitors are so numerous that it is not practical to list them here. NALCAL, the calendar of the Laboratory, lists the names of scheduled theory visitors each week. During the summer months when academic institutions are in recess, there is a large influx of theory visitors. Last summer, for example, S. Adler and R. Dashen of the Institute for Advanced Study; M. A. B. Beg and A. Pais of the Rockefeller University; S. B. Treiman and F. Wilczek of Princeton University, H. Lipkin of the Weizmann Institute, T. T. Wu of Harvard University, and many others were in residence for a month or longer. This summer, we are expecting the visits of an equally large number of theorists. The Theoretical Physics Department also accommodates a small number of graduate students when they accompany their research supervisors to Fermilab. This year, S. Joglekar (Stony Brook), and C. K. Lee (Stanford) have been in residence.

The Director of the Laboratory commissioned a Theoretical Physics Advisory Committee to oversee the management of the department, to report

its findings to the Director, and to be available to the head of the department for consultation on matters of management and recruitment. The committee has been chaired by J. D. Jackson of the University of California, Berkeley.

Victoria Caffey is the Administrative Assistant of the department. She assists in the administration of the department, and in particular, is charged with logistic support of the visitors program. She oversees the activities of the theory secretarial staff consisting of E. Moore and S. Rittierodt.

III. ACTIVITIES

The Theory Group was very vigorous in research under the two visiting heads, S. B. Treiman (1971-1972) and J. D. Jackson (1972-1973), and the Theoretical Physics Department continues the tradition as a part of the overall Fermilab research activities.

A brief review of some of the recent theoretical physics research projects is appropriate at this juncture. Henry Abarbanel has been the center of a concerted effort to develop a theory of high energy scattering based on the field theoretic formulation of Reggeon interactions originally due to Gribov. He has had a number of collaborators in residence at Fermilab: J. B. Bronzan (Rutgers), R. L. Sugar (University of California, Santa Barbara), R. Savit (Fermilab), J. Bartels (Fermilab), A. R. White (LBL), and others. Bartels and Savit have given a dynamical explanation for the disappearance of the negative parity members of a fermion parity doublet trajectory in Reggeon field theories.

Martin B. Einhorn has been active in studying various implications of the quark parton model. He and R. Savit gave rigorous upper bounds on

cross sections of inclusive dilepton production processes in hadron-hadron collisions. In collaboration with F. S. Henyey (University of Michigan), Einhorn has shown that there are no rescattering corrections to inclusive production estimates in a parton model. In a separate study, S. Ellis also showed the absence of absorptive effects in the Drell-Yan process and related hadronic inclusive processes. Ellis has been studying the question of correlations induced by transverse momentum conservation in large transverse momentum events.

Chris Quigg established the limited mobility of charge in multiple production and has been successful in pinning down direct evidence for the independent production of clusters in the distribution of rapidity gaps between charged particles produced at Fermilab energies. Some of this work was done in collaboration with P. Pirila and G. H. Thomas of Argonne National Laboratory, and was done with the active cooperation of experimenters using the 30-in. bubble chamber.

Stephen Ellis has been involved in a study of quark confinement with particular attention to chiral symmetry. William A. Bardeen and B. W. Lee have participated in this study. Mary K. Gaillard (now at CERN), S. Joglekar (Stony Brook/Fermilab), and B. W. Lee have worked on various implications of unified gauge theory of particle interactions on weak interactions. They include estimates of the mass scale of charmed particles, the origin of the octet enhancement in nonleptonic weak interactions, and production mechanisms of charmed particles. Mary K. Gaillard, B. W. Lee, and J. L. Rosner (University of Minnesota) conducted a comprehensive

survey of charmed particle phenomenology--spectroscopy, decay systematics, and production mechanisms--prior to the recent discoveries of narrow resonances.

Since the discoveries, an enormous amount of attention and time of the theorists at Fermilab have been devoted to studies of the properties of these new particles and of their hypothesized relatives. There are daily discussions in which all members of the department participate in the assessment of current knowledge and predictions. In addition, a number of specific investigations have been undertaken. Martin B. Einhorn and S. Ellis have estimated production cross sections of new particles in gluon processes. Martin B. Einhorn and C. Quigg are involved in the systematics of production and subsequent decays of charmed particles in electron-positron annihilation. Ben W. Lee and C. Quigg made estimates of photoproduction cross sections for pseudoscalar counterparts of the new particles. R. Field (CalTech) and C. Quigg computed cross sections for associated production of charmed particles.

All members of the group engage in exchanges of ideas and knowledge with users, and experimentalists on the staff of Fermilab. These meetings of minds take place more formally in seminars which will be described below and, more frequently, informally in offices on the third floor of the Central Laboratory and at the Cafeteria, Lounge and airports. Staff members of the Theoretical Physics Department are encouraged to be of assistance to the Directorate, in appraising proposals and by participation in workshops and, at the invitation of the Directorate, in PAC meetings.

There is a regularly scheduled Theoretical Physics Seminar every week, dealing with more theoretical subjects. Currently these seminars are organized by C. Quigg. The Joint Experimental-Theoretical Seminar which takes place every Friday is an innovative approach to communication among theorists and experimentalists at Fermilab. This seminar is preceded by wine and cheese in the Lounge and is usually punctuated with lively discussions. These seminars are organized by M. B. Einhorn.

Another tradition established at Fermilab is a series of topical mini-conferences. In the past few years, these conferences were held under the auspices of the Theoretical Physics Department, with H. D. I. Abarbanel and others of the department as organizers. They have been well attended by physicists from all over the country, as well as by members of Fermilab. The last one dealt with nuclei as targets in high energy scattering experiments, and featured K. Gottfried of Cornell University and L. Voyvodic of Fermilab as main speakers. These conferences usually take place on a Friday afternoon and the following Saturday morning; the review talks are followed by panel discussions.

Staff members of the department will have given lectures by the end of April in the Fermilab Academic Lecture Series, specifically addressed to graduate students and research associates in residence at the Laboratory. The series is currently coordinated by J. Walker. Henry Abarbanel spoke on hadron dynamics last summer, B. W. Lee on weak interactions and neutrino physics this winter. Martin B. Einhorn is giving a course on symmetry of hadrons and the charm model. It will be followed by C. Quigg's lectures on high-energy collisions.

This is just a sampling of what is going on in the Theoretical Physics Department. For more information go to the department members on the third floor.

Prepared by B. W. Lee

NOTES AND ANNOUNCEMENTS

NEW USERS EXECUTIVE COMMITTEE CHAIRMAN ELECTED. . .

At the January meeting of the Users Executive Committee, Uriel Nauenberg was elected Chairman of the Committee to fill the vacancy created by the untimely death of Darrell Drickey. Dr. Nauenberg is a member of the staff of the Physics Department at the University of Colorado, and has been a member of the Committee for the past year and a half. He will serve as Chairman until a new Committee is elected by the Users Organization membership this spring.

NEW CAFETERIA HOURS. . .

New serving hours have been established in the Fermilab Cafeteria and are as follows:

Monday - Friday

Breakfast	7:30 a.m. - 9:00 a.m.
Lunch	11:30 a.m. - 1:30 p.m.
Dinner	5:30 p.m. - 7:30 p.m.

Saturday and Sunday

Breakfast	8:00 a.m. - 10:30 a.m.
Lunch	11:30 a.m. - 1:30 p.m.
Dinner	5:00 p.m. - 8:00 p.m.

During the week, a cold breakfast in the form of sweet rolls, fruit juice, cereal, milk, and coffee, is also available from 9:00 a.m. to 11:00 a.m. Char-broiled hamburgers and steak sandwiches can also be purchased from 5:00 p.m. to 8:00 p.m., Monday through Friday.

REVISION IN STOCKROOM HOURS. . .

Due to recent budget constraints, it has become necessary to reduce the staffing of the Stockrooms and, therefore, revise the Stockroom hours. The new hours are as follows:

Industrial Building 3	Central Laboratory
Monday - Friday	Monday - Friday
8:30 a.m. - 5:00 p.m.	8:30 a.m. - 5:00 p.m.

PLEASE NOTE THAT BOTH STOCKROOMS ARE CLOSED ON SATURDAY AND SUNDAY.

Emergency withdrawals from the Central Laboratory Stockroom during other hours will be handled through the Site Patrol desk in the Central Laboratory. If withdrawals must be made from the Industrial Building 3 Stockroom during these hours, it will be necessary to contact a roving guard through the Site Patrol desk or Operations Desk in the Central Laboratory. The guard will then accompany the requisitioner to the Stockroom.

FERMILAB SAFETY HANDBOOK NOW AVAILABLE. . .

The first edition of the Fermilab Safety Handbook has been published and distributed to all employees and experimental groups. Additional copies may be obtained upon request by contacting the Safety Office or Users Office.

ANNUAL USERS MEETING PLANNED. . .

The annual Fermilab Users Meeting will be held on Friday and Saturday, May 2 and 3. The meeting will include reports from the Director of the Laboratory, the President of URA, as well as talks on experimental results and theoretical physics. A cocktail party, hosted by the Universities Research Association, will be held in the Users Center on Friday evening beginning at 5:30 p.m. Details of the meeting program have been sent to all members of the Users Organization.

BUBBLE CHAMBER NEUTRINO SUBCOMMITTEE TO MEET. . .

A two-day meeting of a Bubble Chamber Subcommittee of the Program Advisory Committee is planned for May 29-30, 1975. The meeting will be devoted to a review of the neutrino program for the 15-ft bubble chamber in preparation for the extended summer meeting of the PAC at Aspen. The subcommittee will discuss the progress to date of the currently approved neutrino experiments and will consider new and deferred proposals. Some special emphasis will be given to neutrino-deuterium proposals in preparation for determining the initial experimental program for deuterium operation of the 15-ft chamber. Discussion of the 15-ft chamber hadron program is not planned for this meeting and will be deferred until the extended summer meeting in June. The deadline for the submission of materials to be considered at the May meeting is April 29, 1975.

FACILITY UTILIZATION SUMMARY--FEBRUARY 1975

The experimental research program in high energy physics during February was carried out in two distinct time segments. The accelerator was operated at 300 GeV for the first half of the month, with slow-spilled beam being used in all four experimental areas. Within this period, both the Neutrino and Proton Areas experienced significant down-times of several days each, due to water leaks on the target train and in the target box respectively. On February 17, the main ring was retuned for 380-GeV operation and the research program continued in the Neutrino, Proton, and Internal Target Areas for the rest of the month. During this latter period, about 20% of the higher energy beam was slow-spilled and directed into the Proton Area, with the remaining 80% extracted in a one-millisecond spike for the Neutrino Area. The startup at 380 GeV proceeded very smoothly in comparison to previous 400-GeV runs. A major contributing factor to the successful transition was the new main ring magnet power supply program that was brought into operation. Improvements made in the power supplies, magnets, and other main-ring components over the past six months have also obviously aided the situation.

The efficiency of operation for the high energy physics research program was 74% during the 300-GeV portion of February's running time and 70% during the scheduled period at 380 GeV. The latter is a vast improvement over our previous experience during 400 GeV operating periods.

The Photoproduction #87A experiment in the Proton-East Area has continued to receive the strongest emphasis in the February research program.

This experiment, the only one running in the Proton Area, has continued to collect data on the production of electrons, muons, and hadrons in a beryllium target, using the deuterium filter to produce an enhanced incident photon beam.

The Neutrino Area was off for four days in early February to repair a ruptured electrical lead to a quadrupole on the target trainload. During the remainder of the 300 GeV running time, Muon #98 used a large fraction of the slow-spill for their muon scattering measurements, while four "pinged" pulses per machine cycle were sent to the 30-in. chamber for picture taking by Hybrid #299, π^--p @ 150 GeV. Tests by Detector Development #327 (particle identification by ionization loss system) were completed by running the experiment in the N-3 bubble chamber beam in an essentially parasitic mode. After accelerator operation at 380 GeV was established, the first two shifts of running with the fast-spilled beam were devoted to the exposure of a tungsten target for Super-Heavy Elements #285. This was accomplished while the Neutrino #370 group was repairing and restoring to operation their experimental apparatus which was heavily water-damaged as the result of a flooding in their experimental area. Since then the experiment has been using high intensity fast spill on the triplet target trainload to collect data on high energy neutrino and antineutrino induced events in the detectors.

Work on the Meson Area research program was necessarily limited to the period of 300-GeV operation, since that is the maximum capability of the beam transport system to the Meson Area at the present time. Within the available time Elastic Scattering #96, a long-term experiment using the

single-arm spectrometer, Di-Muon #337 and the Particle Search #365 groups all finished data-taking activities. In addition, data was also collected by the K^{O} Regeneration #82, Beam Dump #108, Photon Inclusive #268, Neutron Dissociation #305 and Particle Search #366 groups. Three other experiments made use of some beam time during the month for secondary beam set-up and equipment checking activities, namely Pion Dissociation #86A, Form Factor #216, and Particle Search #330. In addition, Hadron Jets #246 used a few hours of beam for preliminary tests on prototype detector modules.

Particle Search #363 used most of the available beam time in the Internal Target Area, running except during the daytime shift on weekdays, to take data with their single spectrometer arm, using the upstream rotating filament target. Proton-nucleon Inelastic #317 used the beam for four days in mid-month to test further their detectors and electronics logic circuitry, with the rotating target as the particle source. During the weekday periods, construction work on the new experimental area outside the Main Ring at C-0 continued.

A summary of the accelerator and beam utilization for the month of February follows:

I. Summary of Accelerator Operations

	Hours	
A. Accelerator use for physics research		
Accelerator physics research	77	
High energy physics research	383	
Research during other use	(31)	
Subtotal		460
B. Other activities		
Accelerator setup and tuning to experimental areas	19	
Scheduled interruption	49	
Unscheduled interruption	143	
Subtotal		211
C. Unmanned time		
Total		671*

II. Summaries of High Energy Physics Research Use

	# of Expts.	Hours	Results
A. Counter experiments	16	1823	
B. Bubble chamber experiments	1	112	158,024 pix
C. Emulsion experiments	0	-	
D. Special target experiments	3	6	6 targets
E. Test experiments	1	18	
F. Engineering studies and tests	0	-	
G. Other beam use	-	29	Beam tuning
	21	1988	

III. Number of Protons Accelerated and Delivered ($\times 10^{18}$)

	@300 GeV	@380 GeV	Totals
A. Beam accelerated in main ring	1.077	0.301	1.378
B. Beam delivered to experimental areas			
Meson Area	0.525	OFF	0.525
Neutrino Area			
Main beam	0.425	0.264	0.689
Bubble chamber beam (estimated)	0.006	0.001	0.007
Proton Area	0.031	0.029	0.060
Totals	0.987	0.294	1.281

*Change to Central Daylight Time, 0200, 2/23

IV. Beam Utilization by Experiment

	Hours	
A. Meson Area		
Nuclear Chemistry # 81A	-	4 Targets
K^O Regeneration # 82	102.9	
Pion Dissociation # 86A	32.7	
Elastic Scattering # 96	195.1	
Beam Dump # 108	1.0	1 Target
Form Factor # 216	182.7	
Hadron Jets # 246	39.0	Tests
Photon Inclusive # 268	71.4	
Neutron Dissociation # 305	122.9	
Particle Search # 330	35.7	
Di-Muon # 337	0.3	
Particle Search # 365	98.6	
Particle Search # 366	191.6	
B. Neutrino Area		
Muon # 98	131.6	
Super Heavy Elements # 285	5.1	1 Target ($\sim 10^{16}$ protons)
30-In. Hybrid # 299	112.3	158,024 pix
Detector Development # 327	18.0	
Neutrino # 370	116.1	$\sim 2.4 \times 10^{17}$ protons
C. Proton Area		
Photoproduction # 87A	277.6	
D. Internal Target Area		
Proton-Nucleon Inelastic # 317	66.8	
Particle Search # 363	157.7	
Total	1959.1	

MANUSCRIPTS AND NOTES PREPARED DURING JANUARY AND FEBRUARY 1975

Copies of preprints with Fermilab publication numbers can be obtained from the Publications Office or Theoretical Physics Department, 3rd floor east, Central Laboratory. Copies of all articles listed are on the reference shelf in the Fermilab Library.

Experimental Physics

F. A. Nezrick and R. A. Carrigan, Jr. Experiment #76	Search for Neutrino-Produced Magnetic Monopoles in a Bubble Chamber Exposure (FERMILAB-Pub-74/111-EXP; submitted to Nuclear Physics)
J. W. Cronin et al. Experiment #100	Production of Hadrons at Large Transverse Momentum at 200, 300, and 400 GeV (Submitted to Phys. Rev. D)
J. R. Elliott et al. Experiment #163	Multiple Pion Production in π-Ne Collisions at 10.5 and 200 GeV (Submitted to Phys. Rev. Letters)
L. R. Fortney et al. Experiment #163	Direct Electron-Positron Pair Production by 200 GeV Negative Pions (Submitted to Phys. Rev. Letters)

Theoretical Physics

B. M. McCoy and T. T. Wu	Mandelstam Diagrams Are Not Enough (FERMILAB-Pub-74/88-THY; submitted to Phys. Rev.)
B. M. McCoy and T. T. Wu	Three-Particle Regge Pole in ϕ^3 Theory (FERMILAB-Pub-74/89-THY; submitted to Phys. Rev.)
J. Bartels	A Reggeon Calculus for the Production Amplitude I (FERMILAB-Pub-74/94-THY; submitted to Phys. Rev. D)
J. Bartels	A Reggeon Calculus for the Production Amplitude II (FERMILAB-Pub-74/95-THY; submitted to Phys. Rev. D)
S. Joglekar	K_L-K_S Mass Difference and Rare K-Decays in a Phenomenological Gauge Model (FERMILAB-Pub-74/96-THY; submitted to Phys. Rev. D)

M. B. Einhorn and F. S. Henyey	Are There Rescattering Corrections to Inclusive Reactions? (FERMILAB-Pub-74/99-THY; submitted to Nuclear Physics B)
C. Quigg	Local Quantum Number Compensation in Multiple Production (FERMILAB-Pub-74/104-THY; submitted to Phys. Rev. D)
E. Rabinovici	The Impact Parameter Structure of Two Component Absorptive Models (FERMILAB-Pub-74/107-THY; submitted to Phys. Rev. D)

Physics Notes

A. G. Ruggiero FN-271	The Luminosity from the Collisions of Two Unequal and Not-Round Beams

DATES TO REMEMBER

March 30, 1975	Requests for summer accommodations, including dormitory space and family residences, should be received in the Housing Office.
April 18, 1975	Fermilab Auditorium Arts Series: The Atlantis Theatre Company. Tickets available in Guest Office.
April 29, 1975	Deadline for receipt of materials to be considered at the May 29-30 meeting of the PAC Bubble Chamber Subcommittee on Neutrino Experiments.
May 2-3, 1975	Annual meeting of the Fermilab Users Organization.
May 9-10, 1975	Fermilab Workshop on Ionization Calorimeters. Contact M. Atac, Research Services Department (Ext. 3960) for more information.
May 21, 1975	Deadline for receipt of materials to be considered at the summer meeting of the Fermilab Program Advisory Committee.
May 29-30, 1975	Meeting of the PAC Bubble Chamber Subcommittee on Neutrino Experiments.
June 21-27, 1975	Summer meeting of the Fermilab Program Advisory Committee.