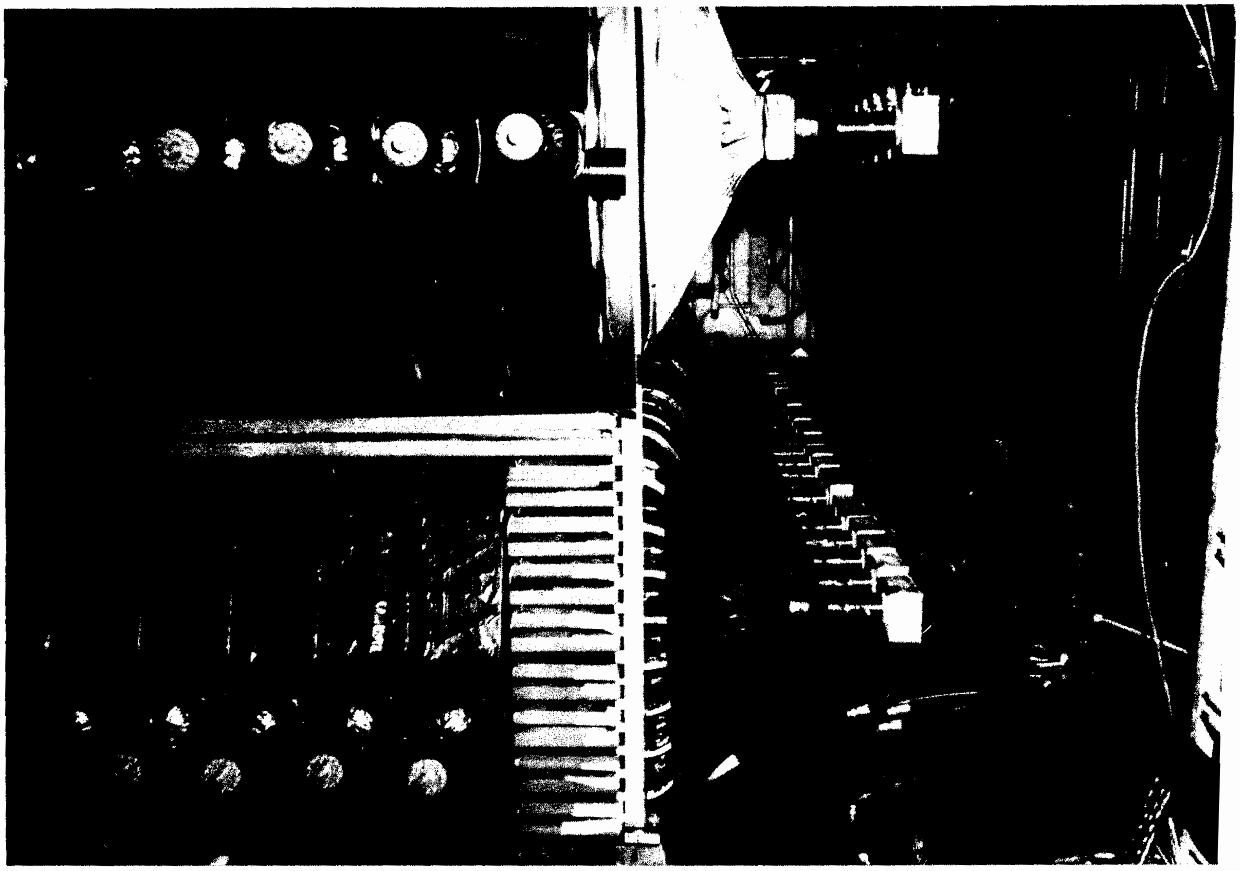
fermilab report

Fermi National Accelerator Laboratory Monthly Report

April 1980



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FERMILAB-80/4 Fermi National Accelerator Laboratory 0090.01

THE COVER: Segmented Hadron Calorimeter for Experiment #516.
(Photograph by Fermilab Photo Unit)

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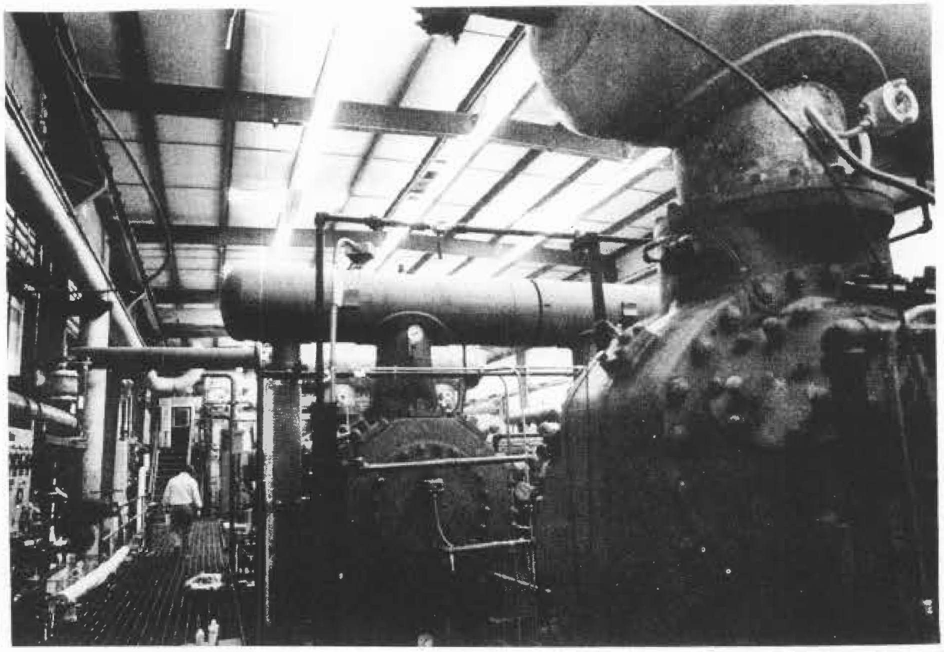
STOCHASTIC BEAM COOLING AT FERMILAB

Stochastic cooling of a proton beam has been demonstrated experimentally at Fermilab. The experiment was carried out by a collaboration of Lawrence Berkeley Laboratory and Fermilab. The cooling equipment was built at Berkeley and installed in the Fermilab Cooling Ring.

In experiments in February, the relative momentum spread of a 200-MeV proton beam was reduced from 1.7×10^{-3} to 6×10^{-4} (all full widths at half maximum) with a decay time of roughly 3 to 4 sec. At the end of March, with improvements in the equipment by the Berkeley group, the relative spread was reduced from 1.2×10^{-3} to 5×10^{-4}. A group from Argonne National Laboratory, also collaborating with us on cooling, has developed a special loss-compensating network for the frequency filter used in the momentum cooling system. Using this addition to the LBL equipment, a cooling of the momentum spread from 1.1×10^{-3} to 3×10^{-4} was achieved.

Stochastic cooling was invented by Simon van der Meer of CERN in 1968 and it had previously been demonstrated at CERN. In stochastic cooling, electronic pickup signals from statistical fluctuations in the beam are used to drive a kicker electrode acting to reduce the size of the beam. Stochastic cooling is an important part of the plan to produce an intense circulating antiproton beam in the Fermilab superconducting ring, to be used for proton-antiproton colliding beams at 2 TeV in the center of mass.

This work is part of the collaborative research and development effort on colliding beams at Fermilab. The Institute of Nuclear Physics, Novosibirsk, USSR, and the University of Wisconsin are also part of the collaboration.



The Central Helium Liquefier, now being tested.
(Photograph by Fermilab Photo Unit)

TEVATRON II - FIXED-TARGET FACILITIES AT 1 TEV

C. N. Brown

Introduction

There are many different aspects of the major construction programs now under way at Fermilab. The Energy Saver (**Fermilab Report**, April 1979 and January 1980), which is already approved, allows for the construction of magnets and refrigeration for a superconducting ring in the Main-Ring tunnel. Tevatron Phase I (**Fermilab Report**, November 1979), a line-item construction project which the Department of Energy has submitted to Congress for approval in FY 1981, includes raising the energy of the superconducting ring to 1 TeV and the construction of a proton-antiproton colliding-beam facility based on the 1-TeV ring.

The existence of a 1-TeV accelerator also opens the possibility of an exciting program of fixed-target physics in the three external laboratories. With the increased energy and intensity of secondary beams produced by 1-TeV protons on fixed targets, it will be possible to extend weak-interaction experiments and measurements of quark and gluon spectroscopy and dynamics into significant new ranges. Work is progressing on conceptual designs to provide the facilities for these experiments. The construction project needed to accomplish these goals is called Tevatron Phase II. Fermilab has submitted this to the Department of Energy for funding in FY 1982.

There are many advantages that arise from the fact that this is an expansion program and not a completely new experimental area or laboratory. First, there is the obvious one that there are large savings because so much of the existing facilities can be adapted to 1 TeV and need not be rebuilt. Second, there is considerable experience in using the facilities at lower energies that will necessarily influence the design at 1 TeV. There is even experience in upgrading the energy of an experimental area; the Meson Area was originally designed for 200 GeV and has already been expanded to 400. Finally, there is the advantage that with the areas in place and with other yearly improvement funds available, we can choose those improvements of the 400-GeV program that enable us to continue operating the external areas at 500 GeV during the Saver commissioning and that are compatible with our conceptual plans for Tevatron II. This report will discuss the improvements and upgrading contemplated in the Tevatron II proposal without going into the details of the funding.

Accelerator Improvements

The Tevatron I project will provide a superconducting synchrotron (and storage ring) capable of sustained operation at 1 TeV. Tevatron II will need to provide for beam extraction at 1

TeV and improvement of the Switchyard to transport 1-TeV beams to the targets. Conventional bump magnets, electrostatic septa, and Lambertson magnets will be built for the extraction channel from the 1-TeV accelerator. The extracted 1-TeV protons will intersect the existing 400-GeV extracted beam line near the end of the Transfer Hall. The large dipole strings in the Switchyard will be upgraded by replacing the existing EPB dipoles with Energy Saver superconducting magnets. A bending string of 3 Energy Saver magnets has already been run successfully for many months in the Meson Area M6 beam line.

In the three external areas, conceptual plans have been developed for a 1-TeV Fixed Target Physics Program through a series of summer studies, workshops, and informal meetings with users. None of the plans below are final nor have final priorities been decided. Forthcoming workshops and PAC meetings are expected to influence both our plans and priorities. We present our current thinking here to encourage users to continue to contribute their ideas.

Neutrino Area

In the Neutrino Area, the spectrum of secondary mesons and hence the decay neutrinos produced from the production target will be increased in both intensity and energy. Since additional decay flight path for the higher energy mesons produced at 1 TeV is needed, Nuhall will be extended 100 m upstream to provide this space, all the way to the present location of the G3 manhole. This will enable us to move the primary proton target upstream. In addition, the first 150 meters of the earth shield in the NO line will be replaced by steel to absorb the higher-energy muons produced by 1-TeV protons. Dichromatic neutrino beams will be possible up to an energy of 750 GeV.

Muon experiments at Fermilab have always been limited by the energy and intensity limitations of the present N1 beam. It is planned to build a totally new muon beam and Muon Experimental Building with an independent primary beam. It is estimated that the intensity will increase by two orders of magnitude, making it possible to probe the structure of nucleons down to 10^{-16} cm at an energy of 750 GeV.

A number of other smaller improvements are planned for the Neutrino Area, including a new Neutrino Experimental Hall and improvements of the hadron calibration beam lines.

Proton Area

An immediate gain in the intensity and energy of the secondary-particle beams is realized in the Proton Laboratory when the Switchyard and Enclosure H proton triple split are upgraded to 1-TeV capability. In both the P-West high-intensity secondary beam and the P-Center hyperon channel, the gain in intensity is immediate. The secondary-beam and the experimental-detector energy capabilities will be increased as the physics proposals received dictate.

Presently P-East houses both the Tagged-Photon Laboratory and the broad-band photon beam. A major shortcoming of the present design is the inability to operate both of these beams simultaneously. It is planned to introduce an additional split of the P-East primary proton beam in Enclosure H, creating two independent targeting stations in P-East. One of these two stations will produce the existing electron beam to the Tagged-Photon Laboratory. The 1-TeV incident proton energy will result in a factor of 500 increase in the electron yield at 270 GeV, the present limit of the secondary-beam energy delivered to the Tagged-Photon Laboratory.

The other P-East primary beam will be used to produce a broad-band charged or neutral beam feeding a completely new Broad-Band Laboratory. In this beam it will be possible to generate a high-energy, high-intensity electron beam of wide momentum acceptance up to an energy of 600 GeV. The beam can also be used as a high-intensity charged-pion beam or a neutral hadron or photon beam because its unique "double dog-leg" design returns the final beam to the incident primary beam centerline.

Meson Area

The new Meson two-way split and plans for its improvement to a 400 GeV three-way split were discussed in **Fermilab Report** in November 1979. By upgrading the triple split to 1 TeV, immediate intensity increases will be gained in all the Meson Area secondary-beam lines. It is currently planned to rebuild the target box, adding an overhead target service building to enable more flexibility in adding and handling active targeting magnets for the present primary proton targets. Magnets and magnetized shielding immediately downstream of the primary targets are expected to alleviate the background muon problem that will arise when 1-TeV proton beams are targeted.

The upgrading of the major bend points in the Meson Area secondary-beam lines by substituting Energy Saver dipoles for the existing Main-Ring dipoles has already begun. It is expected that the secondary beam line energy capabilities will keep pace with experimental proposals for physics with the Tevatron. It is planned to modify the experimental detector stations in the M6 line to optimize the handling of the higher energy and intensity secondary fluxes produced at 1 TeV. The modification includes building a detector enclosure downstream of the Meson Detector Building and rearranging the existing Wonder Building enclosures in the M6 area.

Other projects under discussion include modification of the present M2 beam line to include a Polarized-Proton Beam Facility, being constructed in collaboration with Argonne National Laboratory. Studies indicate that the 200-GeV M4 secondary beam line will become a very useful test beam at Tevatron energies, because its large production angle and both charged and neutral particle capabilities, give it a large range of secondary-particle possibilities but a limited intensity.

Conclusion

Although the detailed design of a 1-TeV fixed-target program for the external laboratory facilities will continue to evolve during the next three years, it is clear from the conceptual plans that many exciting technical projects and physics opportunities exist in these areas. The Research Division has announced a workshop to be held on May 1, 1980, to discuss the "Physics Opportunities at 1 TeV" to explore the physics questions and experimental techniques relevant to a 1-TeV fixed-target physics program.

The Fermilab experimental areas have developed to an advanced state of flexibility and utility at 400 GeV and have hosted some outstanding physics experiments. It is our aim to devlop the external areas and a physics program that will make the Tevatron era at least as productive as the first decade of fixed-target research at Fermilab.

Chuck Schmidt inspects a new ion source.
(Photograph by Fermilab Photo Unit)

HISTORY OF PARTICLE PHYSICS SYMPOSIUM

An International Symposium on the History of Particle Physics will be held at Fermilab on May 28-31. The focus will be on the beginnings of particle physics before the era of large accelerators. There will be discussions of cosmic-ray experiments and quantum field theory. Among the speakers will be P.A.M. Dirac, Carl Anderson, Gilberto Bernardini, Victor Weisskopf, Satio Hayakawa, Robert Serber, Bruno Rossi, Willis Lamb, Julian Schwinger, and Murray Gell-Mann. The symposium is supported by the Sloan Foundation, the Division of Particles and Fields of the American Physical Society, the Center for the History of Physics of the American Institute of Physics, and Fermilab. The Symposium secretary is Lillian Hoddeson, Fermilab.

Phil Livdahl, Leon Lederman, and Bob Wilson greet Chai Ze-Min (extreme left), the ambassador of the People's Republic of China.

(Photograph by Fermilab Photo Unit)

SUMMARY OF OPERATIONS - MARCH 1980

Program Planning Office

The accelerator has been undergoing maintenance and development for the past two months and began new operations at the end of March. The start-up was distributed over a number of separate periods in order to aid in the identification and solution of any problems which may have been incurred over the long shutdown. Also, during one of these periods, M4 beam tests were conducted in order to make that line operational for the first time since the Mesopause. The high-energy physics program resumed on March 21 with the accelerator running at 350 GeV.

During March all but one experiment was in a start-up or check-out mode. The only data-taking experiment was Particle Search #580 (M6). The failure of the M-West magnetic septa disrupted smooth operation in the M6 line. The temporary replacement, an EPB dipole, has allowed continued operation of that line, but Particle Search #580 has noted a reduction in rates. The M4 beam tests conducted during the start-up proved fruitful with Kaon Charge Exchange #585 reporting rates at pre-Mesopause levels.

FERMI NATIONAL ACCELERATOR LABORATORY
MONTHLY OPERATIONS HISTORY
MARCH 1980

Date		Accelerator	Internal Target Area	Proton Area	Neutrino Area	Meson Area
Sat.	3/1	M & D				
Sun.	3/2					
Mon.	3/3					
Tue.	3/4					
Wed.	3/5					
Thu.	3/6	Accelerator Startup				
Fri.	3/7					
Sat.	3/8					
Sun.	3/9					
Mon.	3/10	M & D				
Tue.	3/11					
Wed.	3/12	Accelerator Startup & Tuneup Meson (M4) Tests @200 GeV				
Thu.	3/13					
Fri.	3/14					
Sat.	3/15					
Sun.	3/16					
Mon.	3/17	M & D				
Tue.	3/18					
Wed.	3/19	Accelerator Startup				
Thu.	3/20					
Fri.	3/21	350 GeV 0.5 sec flattop		516 (PE) 326 (PW)	595 (N5) 610 (N1) 594 Test (NO)	580 (M6) 515 (M1) 585 (M4) OFF (M2,M3)
Sat.	3/22					
Sun.	3/23					
Mon.	3/24					
Tue.	3/25	Accelerator Research and Maintenance				
Wed.	3/26					
Thu.	3/27	Accelerator Startup				
Fri.	3/28	~7.0×10^{12}ppp @350 GeV 0.5 sec flattop 10 sec rep rate	591	516 (PE) 326 (PW)	595 (N5) 610 (N1) 594 Test (NO)	580 (M6) 515 (M1) 585 (M4) OFF (M2,M3)
Sat.	3/29					
Sun.	3/30					
Mon.	3/31	Reprs:Linac:Preacc.				

BEAM UTILIZATION BY

	Beam	Hours
PROTON AREA		
Dimuon #326	PW	130
Photoproduction #516	PE	160
NEUTRINO AREA		
Particle Search #610	N1	100
Particle Search #595	N5	110
MESON AREA		
Particle Search #515	M1	160
Kaon Charged Exchange #585	M4	160
Particle Search #580	M6	160
INTERNAL TARGET AREA		
Particle Search #591	CO	160
TOTAL HOURS FOR HIGH ENERGY PHYSICS		1140

EXPERIMENTAL ACTIVITY - MARCH 1980

Activities

start-up; beam line tune time in counters, and trigger studies

start-up; fixed tagging system and studied drift chambers

start-up; timing counters

start-up; beam line check-out and test data

start-up; beam line tune-up

start-up; set-up beam line and checked out chambers

start-up and data at 250 GeV

Initial check-out of equipment

FACILITY UTILIZATION SUMMARY - MARCH 1980

I. Summary of Accelerator Operations

		Hours	
A. Accelerator use for physics research			
High energy physics research		158.6	
Accelerator physics research		16.7	
	Subtotal		175.3
B. Other Activities			
Program interruption		306.1	
Accelerator setup and tuning to experimental areas		244.5	
	Subtotal		550.6
C. Unscheduled interruption			18.1
D. Unmanned time			-
Total			744.0

II. Summaries of High Energy Physics Research Use

	# of Expts.	Hours	Results
A. Counter experiments	8	1140	
B. Bubble chamber experiments	-	-	
C. Emulsion experiments	-	-	
D. Special target experiments	-	-	
E. Test experiments	1	10	
F. Engineering studies and tests	-	-	
G. Other Beam Use	-	-	
Totals	9	1150	

III. Number of Protons Accelerated and Delivered ($\times 10^{17}$) at 350 GeV

A. Beam accelerated in Main Ring	2.99
B. Beam delivered to experimental areas	2.92
Proton Area	0.28
Neutrino Area	
Slow Spill	0.31
Fast Spill	0.07
Meson Area	2.26

MANUSCRIPTS AND NOTES PREPARED FROM MARCH 11 TO APRIL 10, 1980

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 some articles listed are on the reference shelf in the Fermilab Library.

Experimental Physics

V. V. Ammosov et al. Experiment #180	Measurement of SU(3) Symmetry Violation in the Quark Jet (FERMILAB-Pub-80/31-EXP; submitted to Phys. Lett.)
A. S. Ito et al. Experiment #288	Measurement of the Continuum of Dimuons Produced in High-Energy Proton - Nucleus Collisions (FERMILAB-Pub-80/19-EXP; submitted to Phys. Rev. D)
D. R. Fortney and N. T. Porile Experiment #466	Angular Distributions of Sc Fragments from the Interaction of ^{238}U with 0.8-400 GeV Protons (Submitted to Phys. Rev. C)

Theoretical Physics

V. Visnjic-Triantafillou	Consequences of Flavor as a Dynamical Quantum Number (FERMILAB-Pub-80/15-THY; submited to Phys. Rev. Lett.)
D. B. Creamer et al.	Statistical Mechanics of an Exactly Integrable System (FERMILAB-Pub-80/25-THY; submitted to J. Math. Phys.)
C. T. Hill and G. G. Ross	Penguins in ΔS,1 Nonleptonic Weak Decays (FERMILAB-Pub-80/30-THY; submitted to Phys. Lett.)

PRESENT MEMBERSHIP - APRIL 1980
UNIVERSITIES RESEARCH ASSOCIATION, INC.
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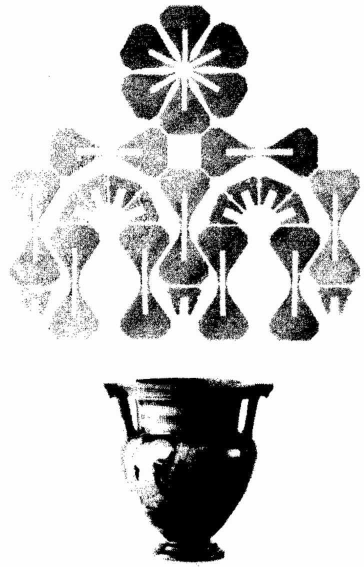
A recent photograph of the URA Board of Trustees (back row, left to right): Alfred Mann, Univ. of Pennsylvania; Jerome Friedman, MIT; Prabahan Kabir, University of Virginia; Robert Bless, Univ. of Wisconsin; Donald Osterbrock, UC, Santa Cruz; Rodney Cool, Rockefeller Univ.; Morris Davis, Univ. of North Carolina; James Matheson, Vice President of URA; Harold Ticho, UCLA; Robert Williams, Treasurer of URA; Oswald Schuette, Univ. of South Carolina; (front row left to right) Wolfgang Panofsky, SLAC; Ely Shrauner, Washington University; Leon Lederman, Fermilab Director; Norman Ramsey, President of URA; Harry Woolf, Institute for Advanced Study, Princeton; Herbert Gursky, Harvard/Smithsonian Center for Astrophysics; Robert Williams, Univ. of Washington; James Colvin, Univ. of Texas; Robert Ketter, SUNY, Buffalo; Joseph Wampler, Acting Director Space Telescope Science Institute.

(Photograph by Fermilab Photo Unit)



An Attic red-figure column-krater photographed against modern magnet laminations, both from the current Fermilab exhibit, "Greek Vases of the Fifth Century B. C." The vase painting is by an undetermined Earlier Mannerist, c. 460 B.C. The side shown depicts Salmoneus, son of Aeolus of Thessaly, who has been punished by Zeus for his arrogance.

(Photograph by Fermilab Photo Unit)

Louise Berge (left), Assistant Curator of the Art Institute of Chicago's Classical Department, and Saundra Cox of Fermilab help assemble the current exhibit of Greek vase painting on display in the gallery on the second floor lounge area.
(Photograph by Fermilab Photo Unit)

DATES TO REMEMBER

May 2, 1980	Annual Users Organization Meeting.
May 15-16, 1980	Proposal Presentation Meeting.
May 28-31, 1980	International Symposium on the History of Particle Physics (contact L. Hoddeson, Symposium Secretary, at Fermilab for further information).
June 21-27, 1980	Summer meeting of the Physics Advisory Committee (Aspen).
September 1980	Summer Study on Tevatron Physics (contact Program Planning Office).

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