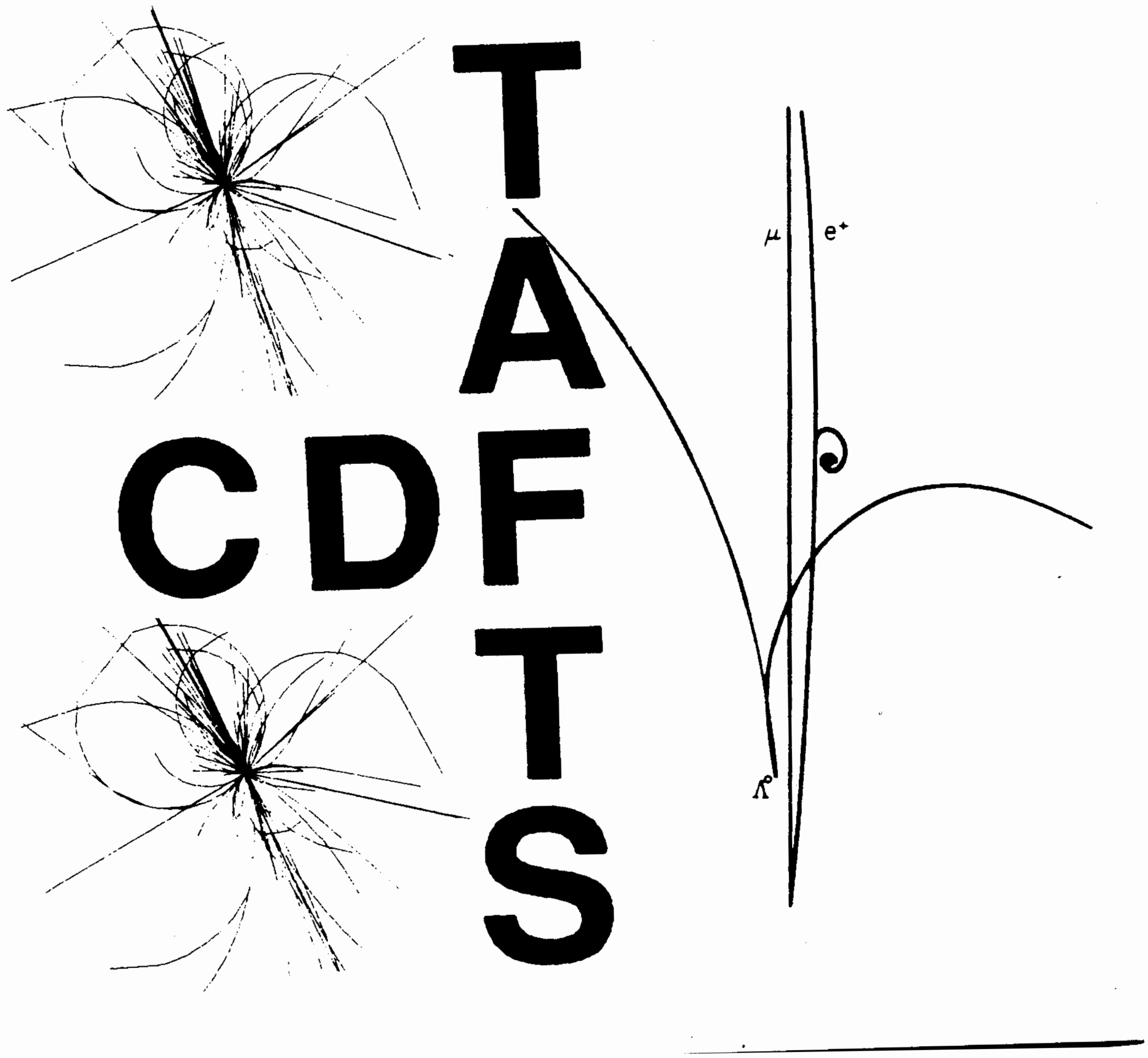
fermilab report

Fermi National Accelerator Laboratory Monthly Report

May/June
1987



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On the cover: At 0730 hours on May 11, the TEVATRON was shut down, ending the engineering run of the Collider Detector Facility (CDF). The CDF detector was rolled out of the B0 collision hall, the extraction septa were inserted into the Saver, and the run for fixed-target physics began at 0800 hours on June 1; by Friday, June 5, 800-GeV beam was on its way to the fixed-target users. The changeover is noted by the cover design, which intersects the initials for the Collider with those of The Association of Fixed-Target Spokespersons, and by three articles: "The 1987 TEVATRON Collider Run in Retrospect," beginning on page 4, "Status Report on CDF" beginning on page 15, and "Approved Experiments in the Fermilab Fixed-Target Program by Category" beginning on page 22.

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Physics Advisory Committee Meeting
June 13-19, 1987

General Remarks and Recommendations

Fermilab recently completed a very successful first physics run of the $\bar{p}p$ collider at 1.8 TeV. During the course of that run the Accelerator Division increased the $\bar{p}p$ luminosity to levels competitive with the CERN S$\bar{p}p$S. In particular the initial physics output from the CDF detector looks most promising. A long fixed-target run with emphasis on stable running is now in progress. The Committee endorses the Laboratory's plan for maximum utilization of its facilities within available resources. Cycles of colliding beams followed by fixed-target runs are planned for the next few years with downtime only for change-over and minimal repairs. The first priority of the Collider program remains the improvement of the luminosity so that the exciting possibilities for new physics can be definitively probed in future runs.

Among the many recent successes we particularly note the following:

- The successful $\bar{p}p$ collider run at 900 GeV on 900 GeV which achieved peak luminosities in excess of 10^{29} cm^{-2} sec^{-1} at B0 and which promises further steady improvement.

- A first look at physics at 1.8 TeV by the CDF group and encouraging preliminary data from E-710 and E-735.

- Recent results from the '85 fixed-target run which include:
  - Charm lifetimes and branching ratios from E-691 which in many cases are the most accurate to date.

  - Significantly improved measurement of ϵ'/ϵ by E-731.

  - Improved understanding of same-sign dileptons from the E-744 collaboration.

- High statistics study of large x_T physics from E-605.

- Definitive measurement of the energy dependence of charm particle production by E-743.

- Successful SSC aperture studies performed in the TEVATRON at the end of the Collider run.

We also note with dismay the inadequate budget within which the Laboratory must operate. In particular, the schedule for the high-priority D0 detector is in jeopardy due to insufficient equipment funds. It appears to be impractical to transfer these funds from the already starved fixed-target program.

CDF

The Committee expressed its great satisfaction with the initial physics run of CDF. They now have 33 nb^{-1} on tape and have demonstrated the capability of the detector. We concur with the priorities they have stated in preparation for the next Collider run. This run should provide interesting Standard Model physics and could produce initial signs of new physics.

D0

The D0 group is now actively engaged in the construction of all components of the detector and is making good progress toward the completion of the detector. The collaboration is growing in size and the outlook for new physics with the D0 detector is bright. It now appears that substantial components of the detector will be ready for an engineering run in the first quarter of 1989. The components ready for this run should be the large-angle parts of the Central Detector, the Central Calorimeter, and a major fraction of the muon system. They will need a low-beta insertion for at least part of the engineering run. For the timely completion of the whole detector they need $4 million in fiscal '88 in addition to the $14 million now designated for them in that year. This additional funding cannot be provided by re-allotment of the equipment funds presently programmed for Fermilab. The timely completion of this detector is essential for the future program of the Laboratory.

The Luminosity Upgrade

The Fermilab TEVATRON Collider has the world's highest energy collisions. In the next few years experimenters at Fermilab will be able to search for massive quarks up to 120 GeV and to explore the mass range up to 350 GeV for new weak vector bosons. The full exploitation of the discovery potential of the TEVATRON, however, demands an upgrade by a factor of 50 from the present design luminosity of 10^{30} cm^{-2} sec^{-1}. This will effectively double both the mass reach of the Collider and the intensity of fixed-target beams. It is essential that work begin now to implement this upgrade by 1992. The upgrade will ensure a vigorous and unchallenged frontier program at Fermilab through the mid-nineties. Experience with the upgraded TEVATRON Collider will also be an important step in the development of detectors for the high luminosity environment of the SSC.

Computing and the Advanced Computer Program (ACP)

The Committee heard with interest a review of the status and future of computing resources at Fermilab. The aggressive response by the Laboratory to the computing demands from the physics program deserves strong encouragement. In particular, we recognize the Advanced Computer Program as an inventive response to the overwhelming demand for number crunching and data acquisition capability.

B-Physics

In response to the Committee's request, the Laboratory is organizing a B-Physics Workshop for November which will study the potential for doing high-sensitivity B studies at Fermilab. The Committee believes that the study of B-physics is very important and that the Laboratory may have great potential in this area. The experiments are difficult and will require innovative techniques in both fixed-target and collider modes.

Low-Energy Antiproton Facility (AMPLE)

The PAC was informed that the Laboratory has established a committee to study the physics opportunities and the cost of a low-energy $\bar{p}$ facility. We consider this to be a wise response to the interest in such a facility expressed by some members of the community, and request that an interim report of the Fermilab AMPLE Committee be presented at the fall 1987 PAC meeting.

The 1987 TEVATRON Collider Run in Retrospect *

John L. Crawford and David A. Finley

Operation of the First 1.8-TeV Collider Run

Overview

This first TEVATRON Collider run at 1.8 TeV had exceeded, or very nearly met, all of its goals by the end of April 1987. This is shown in Table I which summarizes the history and goals of the TeV I project. The progress made since the very first use of the Collider in October 1985 is reflected in the increase in the peak luminosity by about four orders of magnitude, and it is now within an order of magnitude of the design report.

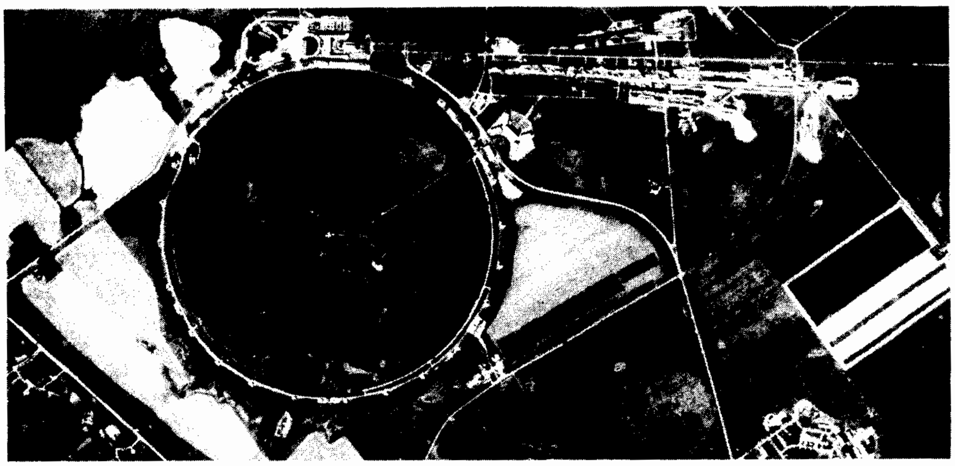

Table II shows these accomplishments sorted into three categories: TEVATRON, Antiproton Source, and antiproton production. This table also demonstrates the progress that has been made in all areas since the initial shakedown of the Collider in November 1986 after the civil construction period.

Table III (page 6) sorts these accomplishments according to antiproton transmission, proton transmission, and factors which can degrade the luminosity. At this time, the worst offender in expected antiproton transmission (64% instead of 100%) occurs in the TEVATRON. More will be said about this later.

*Excerpted from Fermilab TM-1454, "1987 DOE Review - First Collider Run Operation," S. Childress et al. (May 1987).

	Design	Oct 85	Apr 87	Goals Winter 86-87
p/bunch	6E10	2E10	5E10	4E10
$\bar{p}$/bunch	6E10	Few E6	0.91	1E10
number bunches	3x3	1x1	3x3	3x3
$\bar{p}$ extracted/bunch		Few E8	2.6E10	2.7E10
MR transmission		0.25	0.85	3/4
coalescing efficiency (proton)		0.2-0.4	0.70	1/2
transverse emittance 95%	24	15-50	20-25 (p)	24
Normalized (πx10^{-6}m)			30-40 ($\bar{p}$)	
bunch length luminosity reduction		0.8	0.85	0.9
luminosity	10^{30}	Few 10^{24}	10^{29}	10^{29}
average minimum storage time required from $\bar{p}$ production rate	2 hr		7 hr	5-6 hr
$\bar{p}$ accumulation rate	11xE10/hr	10^{9}/hr	1.2x10^{10}/hr	1.5xE10/hr

TABLE I. TEV I Collider history and goals.

TEVATRON	Design (TeV I)	Oct 85	Nov 86	Apr 87	Goal 87
energy	0.8-1.0 TeV	0.8 TeV	0.9 TeV	0.9 TeV	0.9 TeV
number of bunches	3x3	1x1	1x1	3x3	3x3
luminosity	10^{30}cm^{-2}sec^{-1}	Few 10^{24}	~10^{26}	10^{29}	10^{29}
factor from design		Few x 10^{5}	~10^{4}	10	~10
$\bar{p}$ source (8 GeV)					
$\bar{p}$/10^{12} protons	3x10^{7}	10^{6}	0.38x10^{7}	0.68x10^{7}	0.8x10^{7}
$\bar{p}$/hr	10^{11}	10^{9}	0.3x10^{10}	1.2x10^{10}	1.5x10^{10}
$\bar{p}$ total stack	5x10^{11}	10^{10}	0.9x10^{11}	3.8x10^{11}	10^{11}
factor from design ($\bar{p}$/hr)		150	33	8.3	7
MR (target production)					
proton intensity	2x10^{12}	1x10^{12}	0.8x10^{12}	1.3x10^{12}	1.5x10^{12}
target cycles/hr	1800	720	990	1400	1200
factor from design		5	3.3	2.0	2

TABLE II. TEVATRON Collider $\bar{p}$-p.

	Design	Apr 87	Missing Factor	Goals Winter 86-87	Goal Factor 87
$\bar{p}$ extracted from accumulator/bunch		2.6E10		2.7E10	
$\bar{p}$ MR transmission		0.77		3/4	
$\bar{p}$ coalescing efficiency		0.70		1/2	
$\bar{p}$ transmission from MR to TeV low-β		0.64		1	
$\bar{p}$ overall transmission		0.35		.37	
$\bar{p}$ stored/bunch	6E10	0.91	6.6	1E10	6
p extracted from booster		1.5E11			
p MR transmission		0.75		3/4	
p coalescing efficiency		0.62		1/2	
p transmission from MR to TeV low-β		0.8		1	
p overall transmission		0.37		.37	
p stored/bunch	6E10	5.6E10	1.07	4E10	1.5
number of bunches	3x3	3x3		3x3	1
transverse emittance 95% normalized	24	20-25 (p)		24	1
(πx10^{-6}m)		30-40 ($\bar{p}$)			
bunch length luminosity reduction		0.85	1.2	0.9	1.1
luminosity	E30	10^{29}	10	E29	10
$\bar{p}$ accumulation rate	11xE10/hr	1.2E10	9.2	1.5xE10/hr	7
average minimum storage time required from pbar production rate	2 hr	6.5 hr		5-6 hr	

TABLE III. TeV Collider missing factors and goals.

Antiproton Transfer

Each step of the antiproton transfer process has the potential for completely obliterating the antiprotons before a store begins. Most steps have failed at least once and Fig. 1 summarizes the failures of antiproton transfers since February 2. The months of December and January were spent getting the mere mechanics of the transfer under control, and that was no small task. It is worth noting that once a failure was identified and corrected, it tended to stay corrected. Week nine stands out with a rash of failures since it followed (the last) three-day maintenance period.

The transmission of the antiprotons is summarized in a little more detail as follows: Accumulator to Main Ring injection, 87%; Main Ring injection to 150

GeV, 88%; coalescing, 70%; transfer from Main Ring to TEVATRON, 72%; TEVATRON acceleration, 99%; low-beta squeeze, 90%; overall efficiency from Accumulator to low beta, 34%. This represents the average of stores 910 to 920. Coalescing includes bunch monitor calibration of 0.80. The overall transmission from the Accumulator to a single bunch at low beta averaged about 34% by the end of April. (It started out in the few per cent range at the beginning of the run.) The biggest losses are associated with coalescing and the transfer into the TEVATRON; together they account for a loss of about a factor of two. Most of the loss in the TEVATRON occurs within the first second.

WEEK #	6	7	8	9	10	11	12	13	14	15	16	17	18	19	TOTAL
165 CARD SCRAMBLED INJECTION			1												1
CONSOLE DIED			1												1
DIDN'T COALESCE				1											1
DIED AT .7 SEC IN MR				1											1
PBAR DAMPERS				2	1										3
E48 KICKER				1			1								2
CO ABORT KICKER				1										1	2
SEQUENCER				1							1				2
VACUUM VALVE STARTING TO CLOSE				1											1
UNKNOWN LOSS IN MR				1				1							2
PBAR ARF2-3 PROBLEMS						1									1
E17 PBAR KICKER							1								1
TUNES ADJUSTED WRONG							1								1
KICKER TRIGGER PROBLEMS								1							1
53 MHZ BUNCHING TRIGGER WRONG											1		1		2
TEV FAST BYPASS												1			1
FORGOT TO DISABLE BLM ABORTS												1			1
TRANSFERS THAT FAILED			2	9	1	1	3	2			2	2	1	1	24

FIG. 1. Reasons for antiproton transfer failures.

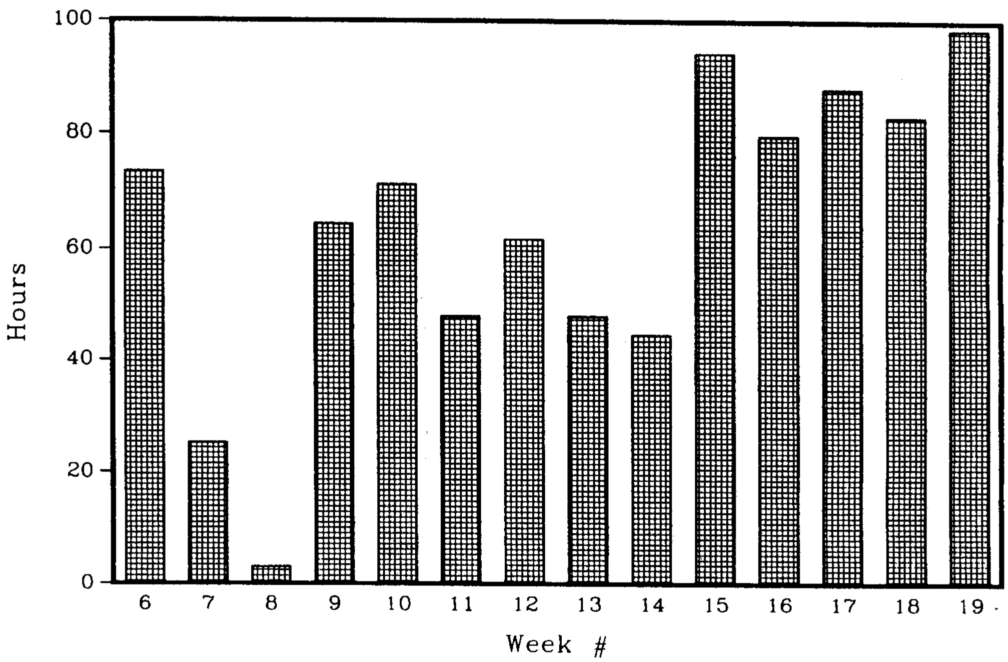

FIG. 2. Integrated store hours/week since February 2.

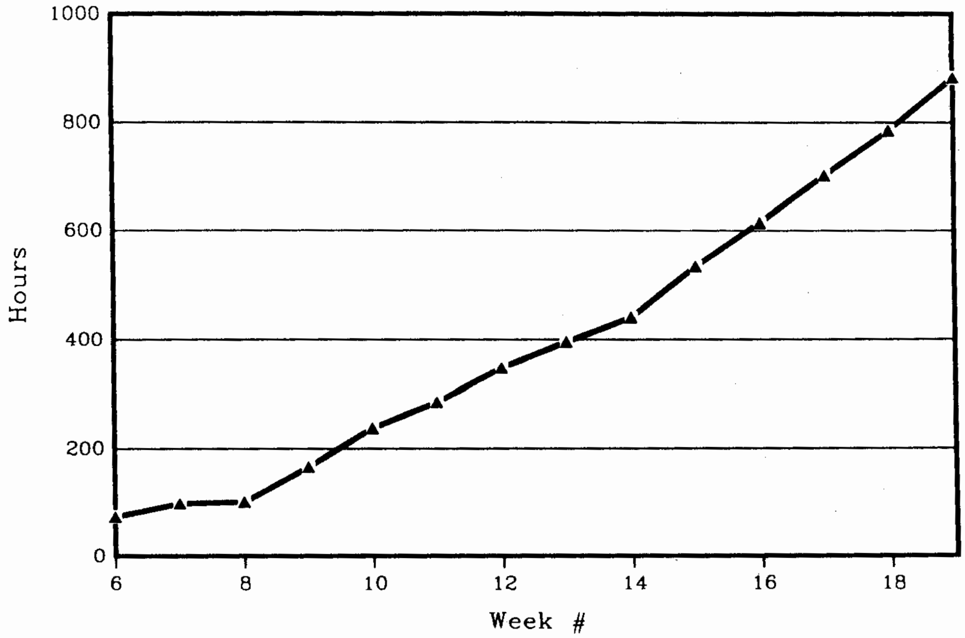

FIG. 3. Integrated store hours since February 2.

Once the transfer process is completed and a store has begun, the burden shifts to the TEVATRON which must maintain the store. Figures 2 and 3 summarize the time that the TEVATRON was acutally storing colliding beams. The peak week had 94.3 hours which represents 56% of clock time.

Figure 4 shows the reasons stores ended. About half the stores were deliberately ended, and less than 10% of the stores were ended due to the fact that the TEVATRON uses superconducting magnets.

WEEK #	6	7	8	9	10	11	12	13	14	15	16	17	18	19	TOTAL
SHOT MASTER ENDS	3	1		7	5	1	1	1	3	6	5	4	4	4	45
CORRECTION ELEMENTS	1	1			1	1	1	2							7
B0 QUADS	1												1		2
BLM/BPM	1														1
POWER SUPPLIES	2			1						1		1		3	8
QPM	1														1
VACUUM		1					1	1							3
RF		1					1					1			3
STUDIES					2							1			3
CRYO						1	2	1							4
KICKERS						2		1		1					4
POWER GLITCH						1									1
MR BEAM INDUCED QUENCH										1	1		1		3
FEEDER FAULT									1						1
TYPE 0 ABORT								1							1
PREDET ARC DOWN												1			1
MR WATER PUMP TRIPPED													1		1
CONTROLS														2	2
AIR CONDITIONER TRIPPED														1	1
STORES TOTAL	9	4	0	8	8	6	6	7	4	9	6	8	7	10	92

FIG. 4. Reasons for end of stores.

Reliability

There were neither regularly scheduled Accelerator maintenance periods nor accesses to the detectors during this Collider run. This apparently revolutionary approach did not take long to reap benefits because the reliability of the accelerator complex was the best it has ever been in recent memory.

This can be seen from Figures 5 and 6 which summarize reliability from two viewpoints - stacking and storing - during 13 weeks of the run. The figures indicate that, of the total calendar time, there were collisions taking place 35% of the time and antiproton production was taking place 48% of the time. TEVATRON downtime by itself prevented collisions 9% of the time, and antiproton production was prevented 22% of the time due to failures in the Linac, Booster, Main Ring, Debuncher, or Accumulator.

STACKING RELIABILITY SINCE FEBRUARY 2

WEEK #	STACK TIME	STACKING FAILURE	SETUP/ QUIET TIME	M&D	TOTAL
6	78.32	41.92	47.6		168
7	45.54	21.95	34.51	66.0	168
8	23.10	23.42	32.48	89	168
9	95.12	26.42	45.46		168
10	105.2	17.62	45.18		168
11	104.88	39.8	23.32		168
12	86.48	62.01	19.51		168
13	116.46	16.16	35.38		168
14	63.33	60.98	42.69		167
15	96.14	28.11	43.75		168
16	83.74	68.46	15.8		168
17	74.06	44.39	49.55		168
18	106.56	22.38	39.06		168
19	106.56	18.89	42.55		168

FIG. 5. Stacking reliability since February 2.

STORING RELIABILITY SINCE FEBRUARY 2

WEEK #	STORE TIME	TEV DOWNTIME	STACK W/O STORE	SETUP/ STUDY	M&D	TOTAL
6	73.42	28.13	43.31	23.14		168
7	25.25	12.97	28.52	35.26	66	168
8	3	14.18	23.1	38.72	89	168
9	64.48	12.0	54.38	37.14		168
10	71.30	6.43	41.94	48.33		168
11	47.85	29.07	68.39	22.69		168
12	61.8	17.25	38.34	50.61		168
13	47.9	12.1	82.16	25.84		168
14	44.59	17.82	32.66	71.93		167
15	94.3	8.75	16.79	48.16		168
16	79.81	7.47	46.9	33.82		168
17	88.05	20.92	16.5	42.53		168
18	83.15	31.9	36.48	16.47		168
19	98.6	14.53	32.4	22.47		168

FIG. 6. Storing reliability since February 2.

Figure 7 (page 10) shows the individual downtime for each of the accelerator systems. Since these are individual system downtimes, they do not necessarily add up to the total downtime. For example, controls downtime includes maintenance on computer consoles which does not necessarily prevent stacking or storing.

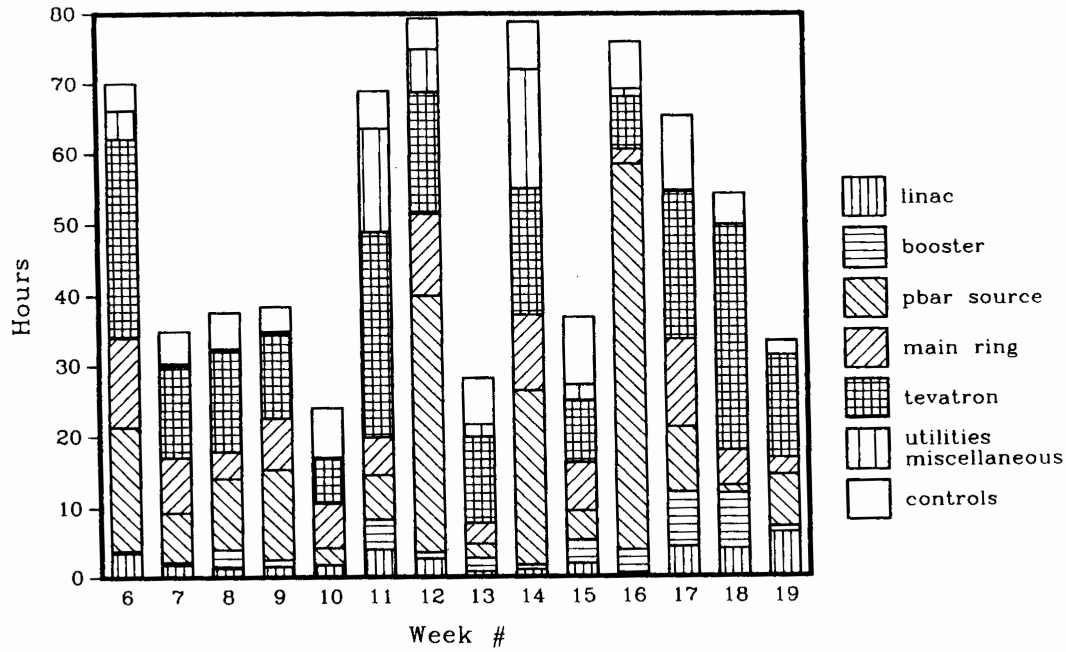

FIG. 7. Systems downtime by week since February 2.

Luminosity

The luminosity given in this report is based on original estimates of the response of the Accelerator detectors used to measure the beam intensities. These estimates are being re-evaluated and now it appears that the luminosity was actually higher than reported here by a factor of about 1.5.

Figure 8 shows the progression of the peak luminosity throughout the run. It grew exponentially for the first seven weeks as a whole host of carefully controlled adjustments were made in *all* parts of the accelerator complex. It then reached a plateau below 1×10^{29} for about a month, and then went back up.

Figures 9 and 10 show the "bottom line" for a collider: the integrated luminosity. The integrated luminosity per week increased significantly every week since the beginning of February with one exception. Week 17 had sequential failures in the Linac, Booster, Debuncher, and Accumulator which limited the antiproton production rate, and eventually an access to the Debuncher required dumping the stack and starting over. In spite of all this, by the beginning of May the integrated luminosity surpassed 10 nb^{-1} per week and approached 35 nb^{-1} for the run.

The Collider Detector Facility (CDF) luminosity lifetime averaged about 10 hours, which is about half of the TeV I design value. Early in a store, the lifetime is about 7-8 hours, and increases as the store progresses to about 15-20 hours for stores over 15 hours. The lifetime is dominated by a growth of the transverse beam size at a rate of a few microns per hour at the collision point. The primary source of this growth has not yet been identified, but if it can be found and corrected it could be worth a factor of two in the integrated luminosity.

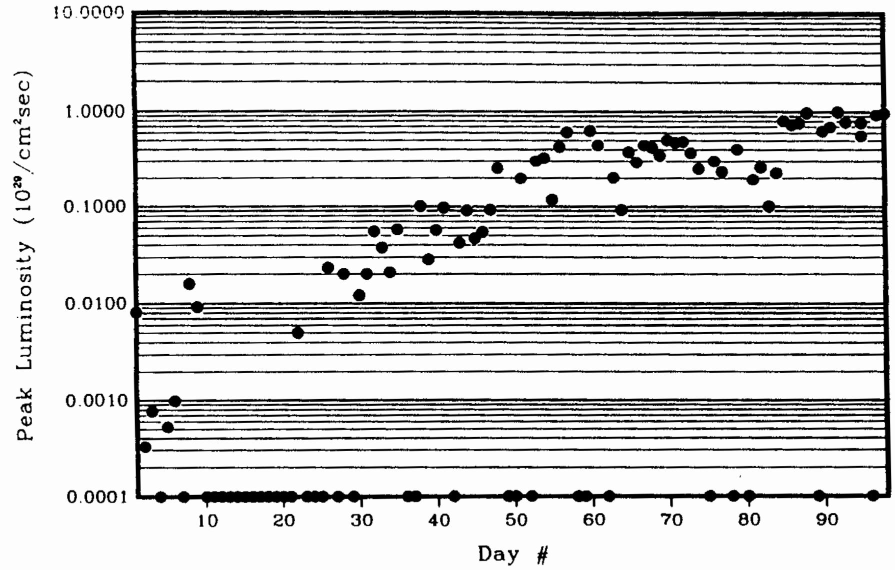

FIG. 8. Peak luminosity/day since February 2.

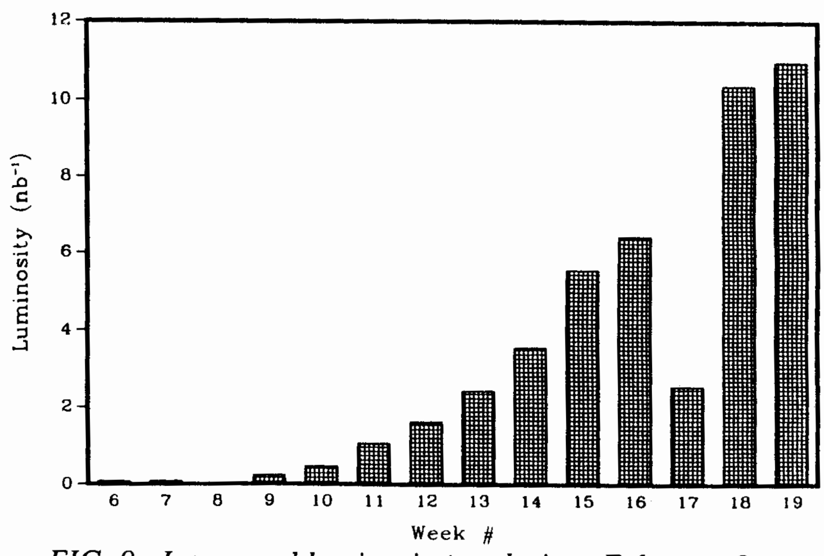

FIG. 9. Integrated luminosity/week since February 2.

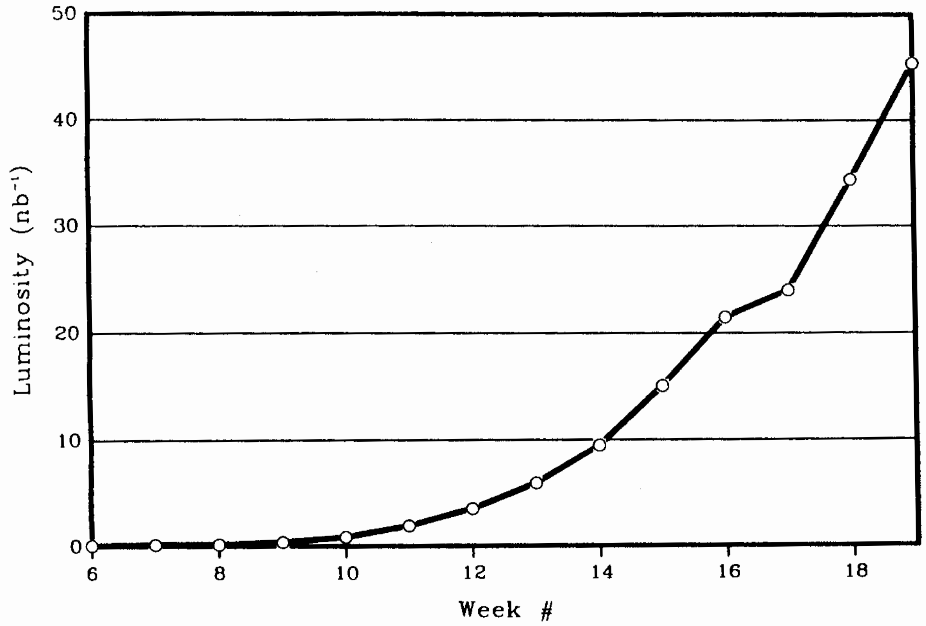

FIG. 10. Integrated luminosity since February 2.

In April a new low beta was implemented which increased the peak luminosity at CDF by a factor of 1.4. This yielded a net gain in the integrated luminosity even though the luminosity lifetime was a little worse. This so-called mini-beta was accomplished by changing the currents in the B0 low-beta quads.

Unusual Quenches

The only real problem associated with 900 GeV is the sensitivity of the superconducting magnets to otherwise insignificant beam loss. They can withstand much less loss than at 800 GeV because they have been pushed much closer to their quench currents. When antiprotons are in the TEVATRON, all the beam-loss-monitor aborts are deliberately disabled. This would not be a problem at all if everything always performed perfectly.

The first quench of a TEVATRON magnet with antiprotons occurred on January 17, 1987, when there were about $9x10^8$ antiprotons in a single bunch. The quench was caused by a malfunction of the antiproton abort kicker at C17 which did not properly deflect the antiprotons into their abort dump at C0. When this happens, the antiprotons continue going until they pass through the proton abort kicker at B48 which in turn deflects them into the dipoles at B4.

The Main Ring accelerates over $1.3x10^{11}$ protons 1400 times per hour for antiproton production at the same time (and in the same tunnel, of course) that the

Collider is running at 900 GeV. Extraction of the proton beam from the Main Ring at F17 can malfunction in a perverse manner and cause sufficient beam spray in the tunnel to induce a quench in the TEVATRON at F17. Three stores ended in this manner.

Another potential quench situation occurs when the TEVATRON rf misbehaves during a store and the beam debunches. This uncaptured beam would normally spiral inward as it slowly loses energy due to synchrotron radiation and eventually leave the TEVATRON after 2-3 hours. If the abort kickers fire for some reason, and there is enough debunched beam in the TEVATRON, then it can cause a quench in one or more locations. The worst of these happened on the last day of April and caused quenches in four places around the ring.

Improvements for the Next Collider Run

It should not surprise anyone that the Main Ring aperture has shrunk after it ceased being the last accelerator in the chain. This is primarily due to several aperture-restricting magnets which have been added for TEVATRON injection, and antiproton production and injection. In addition, the vertical overpasses around B0 and D0 not only restrict the horizontal aperture locally, but also introduce vertical dispersion which compromises the vertical aperture in the rest of the ring. Progress is continually being made by identifying the offending restrictions and either moving them or installing larger aperture devices. This will necessarily continue during the fixed-target run because fixed-target experiments always need more beam than is available.

The TEVATRON has come up with one big surprise that has been avoided operationally at a cost in setup time. The design report supposed that the TEVATRON could come out of a flattop store and then be reliably set at 150 GeV for the few minutes required for injection of protons and antiprotons. This has not been feasible due to a continually drifting chromaticity. The amount of the drift is as much as 20 units in the first few minutes after it has come out of a flattop store and been put at 150 GeV. The drift becomes slower, and after about an hour it can be adequately corrected manually. A more automatic method of chromaticity correction will cut down on the setup time and provide more time for stores.

Another improvement that will be attempted for the next run is to control the transverse emittances of the antiprotons. When they enter the Main Ring, the emittances are about 8π mm-mrad. This increases to about 25π mm-mrad by the time they are first observed in the TEVATRON. This increase may be due to injection steering mis-matches into the Main Ring and then into the TEVATRON, but they may also be due to emittance blowup during coalescing. This will be investigated before the next run using an updated flying-wire system in the Main Ring. The emittance blows up to about 35π mm-mrad during TEVATRON acceleration and the low-beta squeeze. This last increase is very likely due to the antiprotons being driven onto tune resonances because of the beam-beam interaction. During the present run, new tune-measuring devices were installed and have just begun to be used to their full potential. By the next run, they should be able to sort out just what is happening with the antiproton emittances. If the emittances can be controlled completely, it is worth a factor of three in the peak luminosity.

The success of this first run is due to those people who worked to prevent repeated equipment failures and kept up the struggle to improve each step of the transfer process. Their efforts have paid off.

Status Report on CDF*

The CDF Collaboration

CDF Collaboration - June, 1987

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This was the first major run for the complete Collider Detector Facility (CDF) Detector. The object was to test and debug the data-acquisition system and to understand the characteristics of the tracking chambers and the calorimetry sufficiently well to do some preliminary physics measurements. In December of 1986 the CDF Detector was rolled into the collision hall, and the period between December 1986 and March 1, 1987, was spent in the testing and commissioning of the complete system. The major data-taking part of the run took place between March 1 and May 10.

The detector as installed, Fig. 1, was virtually complete in all of its systems with calorimetry and tracking covering the range from 2° to 178°. The central calorimetry system, both hadron and electromagnetic, is formed from scintillation plastic using shifter and phototubes for readout. The calorimetry forward

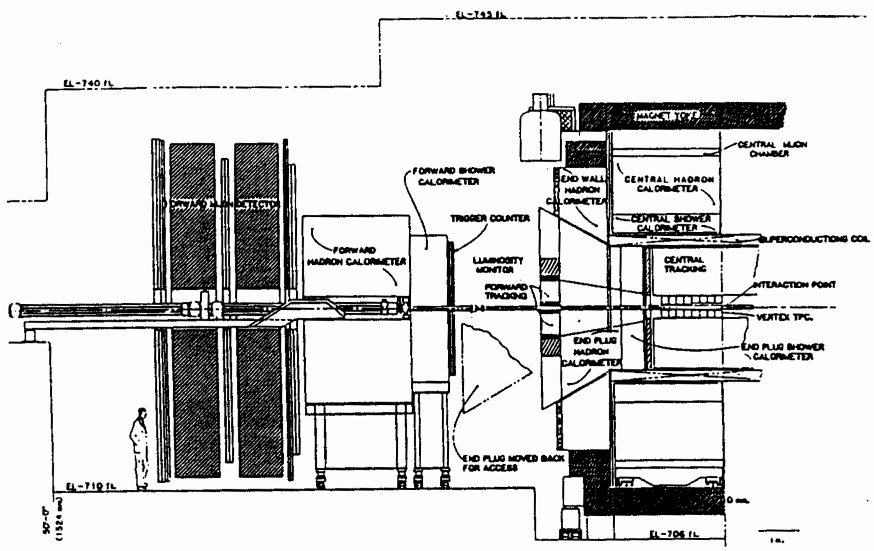

FIG. 1. Side view of the CDF Detector.

of 30° is based upon proportional chambers with resistive plastic walls and strip readout. In all cases the calorimetry is divided into towers in η and ϕ. The ϕ divisions are 15° in the central region and 5° forward of 30°. The division in η are .1 units over the whole range from -4.2 to +4.2. See Table I.

*Excerpted from an invited talk presented by A.V. Tollestrup at Rencontres de Physique de La Vallee d'Aoste on "Results and Perspectives in Particle Physics," La Thuile, Aosta Valley, Italy, March 1-7, 1987.

	Central		Endwall	Endplug		Forward	
	EM	Hadron	Hadron	EM	Hadron	EM	Hadron
$\lvert\eta\rvert$ - coverage	0-1.1	0-0.9	0.7-1.3	1.1.-2.4	1.3-2.4	2.2-4.2	2.3-4.2
Tower size, $\Delta\eta x\Delta\phi$	~.1x0.26	~.1x0.26	~.1x0.26	0.09x0.09	0.09x0.09	0.1x0.09	0.1x0.09
Longitudinal samples in tower	1*	1		1 3	1	2	1
Active medium	Polystyrene scintillator	acrylic scintillator	acrylic scintillator	Proportional tube chambers with cathode readout pads			
Scintillator thickness or proportional tube size	0.5cm	1.0cm	1.0cm	0.7x0.7cm^2	1.4x0.8cm^2	1.0x0.7cm^2	1.5x1.0cm^2
Number of layers	31	32	15	34	20	30	27
Absorber	Pb	Fe	Fe	Pb	Fe	94%Pb, 6%Sb	Fe
Absorber thickness	0.32cm	2.5cm	5.1cm	0.27cm	5.1cm	0.48cm	5.1cm
Typical phototube or wire high voltage	-1100V	-1500V	-1100V	+1700V	+2120V	+1900V	+2200V
Typical phototube or wire gain	1.2x10^5	6x10^5	10^6	2x10^3	2x10^4	5x10^3	10^4
Typical tower signal	-4pC/GeV	-4pC/GeV	-4pC/GeV	+1.25pC/GeV	1.3pC/GeV	+2pC/GeV	+0.7pC/GeV
Energy resolution $\left(\frac{\sigma}{E}\right)$ at 50 GeV	2%	11%	14%	3%	20%	4.5%	23%
Typical position resolution at 50 GeV	0.2x0.2cm^2*	10x5cm^2	10x5cm^2	0.2x0.2cm^2	2x2cm^2	0.2x0.2cm^2	3x3cm^2
Characteristic total width of azimuthal boundary region	3.5cm	4.1cm	3.8,8.9cm alternating	0.9cm	0.8cm	0.7cm;3.2cm**	1.3cm;3.2cm**

*An imbedded proportional tube chamber at shower maximum gives some additional information. The quoted position resolu tion is measured with this chamber.

**The first number is for the vertical boundary, the second for the horizontal.

Table I.

The tracking chamber, installed just before the detector rolled into the collision hall, performed beautifully. In addition to the central tracking chamber, which covers an angular region of about 30° to 150°, there is the vertex time projection chamber located close to the beamline, whose primary function is to identify the vertex and give an RZ view of the event tracks. There is also a forward tracking chamber located outside of the 10° hole in the forward end plug which provides track information between 2° and 10°. These various tracking chambers are all identified in Fig. 1.

In addition to testing the complete data-acquisition system and commissioning the tracking, it was hoped that enough luminosity from the run would be available to explore new regions in high-energy collider physics. Initially, it was determined that an integrated $\mathcal{L}$ of 100 inverse nanobarns would not only open up new areas in jet physics that had not yet been explored at CERN, but would also give a good sample of W's and Z's. The predicted counting rate in the central plus end plug region of the detector for W's is a little bit more than 1 per inverse nanobar, and the acceptance for $Z^o \rightarrow e^+ e^-$ is only about 8% of this number. Finally, sufficient time to do a preliminary study of low p_T physics with good statistical accuracy was included in the run plan.

The detector was rolled into the collision hall during the week of December 12-15. The period from January 1 to March 1 was spent in commissioning both the machine and the detector. Operation required a crew of seven people who were scheduled in eight-hour shifts, and during this period we not only studied the various components of the detector, but we also did extensive training of physicists in the operation of all the systems.

After March 1 it was deemed that the detector and the machine were working well enough so that one should start on the data collection phase of the experiment. During this period we collected over 30 inverse nanobarns of data on tape. The trigger was varied during the run to accommodate the slowly increasing luminosity that the Accelerator was able to deliver. The simplest trigger was one in which all channels of the detector were read out in every beam crossing. This gave an unbiased data set for estimating luminosity and for studying any biases imposed when the beam-beam counters were included in the trigger. A number of runs triggered by simple coincidences between the arrays of beam-beam counters on the two sides of the experiment were taken for studying minimum bias events. About 40,000 such events were accumulated. Figure 2 shows the uncorrected single particle p_T spectrum from some of these runs.

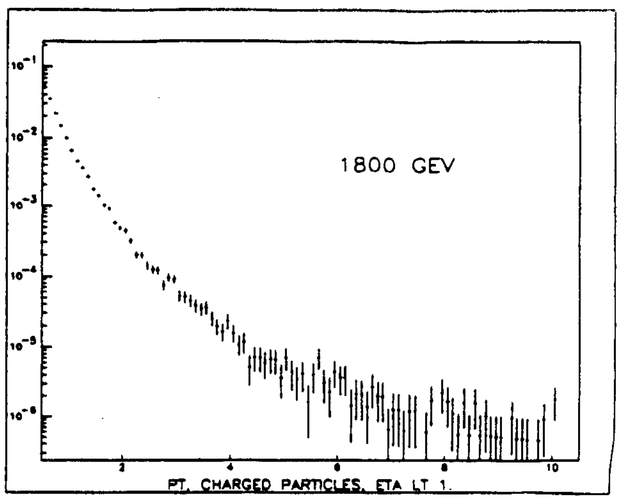

FIG. 2. Uncorrected single particle p_T spectrum obtained from a sample of minimum bias data.

Each calorimetry channel in the detector is equipped with a fast analogue readout; these are assembled into a trigger tower array for use in the level-1 and level-2 triggers. Most of the run was taken by simply setting a threshold level for E_t in a tower and a threshold on the sum of the E_t for those towers over threshold. These thresholds could be individually set for both electromagnetic and hadron calorimetry towers. Near the end of the run we started to commission the level-2 trigger which will enable one to trigger on clusters of energy rather than simply total E_t. This trigger, although installed, was not actually used during the data taking.

Complementing the calorimeter-based trigger was a fast track processor used for identifying high p_T particles and operated by defining roads through the central tracking chamber by means of prompt hits. These stiff tracks, once identified, could be placed in coincidence with the appropriate individual cell of the muon system located around the outside of the central calorimeter. This trigger was debugged and worked satisfactorily at the luminosities achieved in the present run. The forward muon system was also studied extensively, but its trigger rate was still too high during the run to include it in the trigger without prescaling.

It was observed that the gas calorimetry occasionally recorded a very large energy loss in a single tower. Further study indicated that the signal was being deposited in only a single layer of the calorimeter and was not associated with the high-energy track or a hadron shower. These large pulses were observed in all four of the forward gas calorimeters: the end plug electromagnetic and hadron, and the forward electromagnetic and hadron calorimeters. The electronic gains and the sensitivity of these chambers were all different, and the severity of the problem correlated with the individual characteristics of the system. The source of these pulses will be studied in the test beam this coming summer, and an attempt will be made to clarify the exact cause of the phenomena observed. It is postulated that the effect arises from the low-energy np collisions for which the cross section is approximately $4.4/\sqrt{E}$ barns. The energy loss of a proton in a typical gas calorimeter proportional tube can be 1 MeV compared to 1 or 2 kilovolts from a minimum ionizing particle crossing the tube. Thus, a proton can mimic several hundred track crossings and erroneously indicate a rather large shower energy. Since such effects occur only in a single layer of the calorimeter, it is not hard to identify such processes and eliminate them from the data, provided the calorimetry is subdivided in depth by connecting alternate layers to different digitizers.

The offline data-analysis programs exist and systematic analysis of the data is underway. Samplings of the data taken during the run have turned up a number of candidates for W and Z meson decays. In addition, a large number of QCD jet events were observed, some with E_t's of greater than 150 GeV.

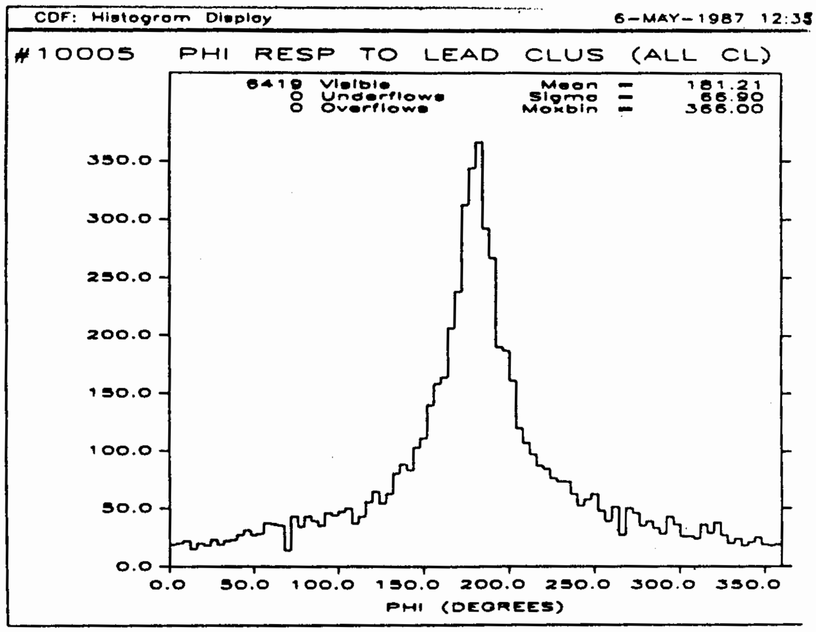

FIG. 3. ϕ distribution for all non-leading clusters relative to the leading cluster shown in Fig. 4.

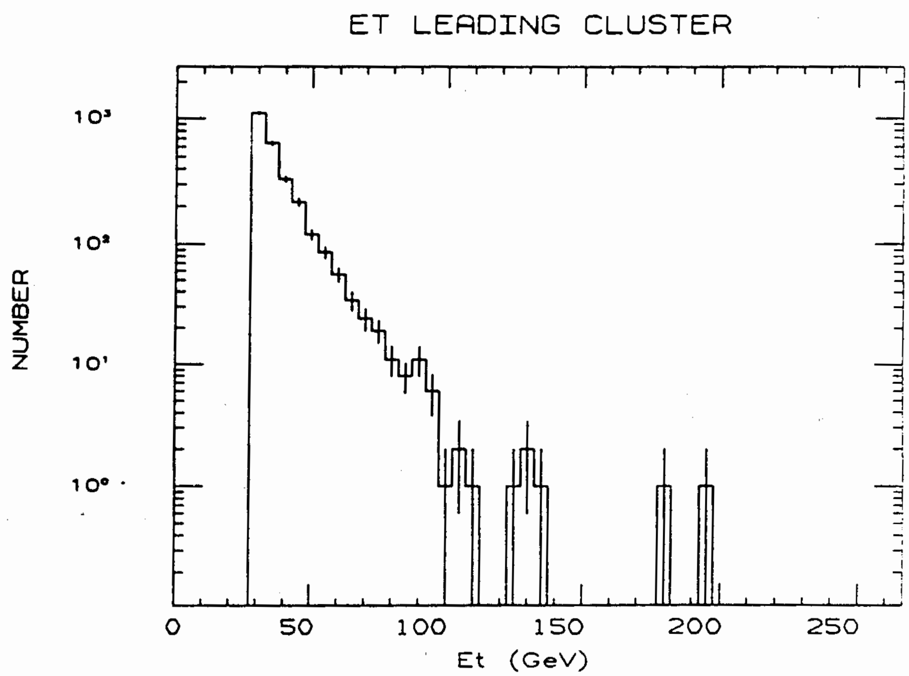

FIG. 4. Distribution of the observed E_t for the leading cluster in data about 1.5 nb^{-1}.

In Fig. 3 we show the azimuthal spectrum of all non-leading clusters relative to the leading one. The peaking in azimuth at 180° is clearly seen. Figure 4 shows the E_t spectrum of the leading cluster in a small sample of the data. The clusters are defined in a jet algorithm whose parameters are still being investigated. The spectrum is not corrected for acceptance, but it does give an indication of the quality and range of data that will eventually be available from this run.

The next run for colliding beams will start near the end of 1987 after the fixed-target running is finished. The improvements will involve installing the remaining chambers in the forward/backward hadron calorimeters and implementing the level-2 trigger. Additional work on shielding the detector from radiation from the Main Ring is necessary in order to completely commission the muon system.

The run was very successful, and this is perhaps an appropriate place to thank our colleagues in the Accelerator Division who helped make it possible.

Approved Fermilab Fixed-Target Experiments by Category

As compiled by the Fermilab Program Planning Office

Exp. #	Physics Objectives	Status
(Electroweak)		
E-632 (Morrison/Peters)	15-ft. Bubble Chamber exposure to wide-band neutrino beam.	Took 154K conventional pix and 111K holograms in 1985 run. Will run again in 1987 with improved holography.
E-665 (Kirk)	Target fragmentation in deep-inelastic muon scattering with proton and nuclear targets.	Beam and parts of detector were tested in 1985. Initial data run set to begin in 1987.
E-733 (Brock)	Weak neutral currents and same-sign dimuons in neutrino interactions in a fine-grained detector.	Took approx. one-half data in last run. Ready to continue in 1987.
E-745 (Kitagaki)	1-meter bubble-chamber exposure to wide-band neutrino beam.	Took 190K conventional pix last run and 60K holograms. Are installing new, larger B.C. for 1987 run.
E-770 (Smith)	High statistics study of nucleon structure functions and same-sign dimuons in neutrino interactions.	Had a data run in 1985 as E-744 and will continue in 1987.
(Decays and CP)		
E-731 (Winstein)	A precision measurement of the CP violating parameter ε'/ε in the neutral kaon system.	Ready for primary data run. Had initial tests and data in last run. Accumulated 15K events.

Exp. #	Physics Objectives	Status
E-756 (Luk)	Measurement of the magnetic moment of the Ω^- hyperon.	Installing experiment at present time. Should complete data run in 1987 run.
E-761 (Vorobyov)	Study of rare hyperon radiative decays.	To be set up in the P-Center hyperon beam on completion of E-756
E-773 (Gollin)	Measurement of the phase difference between η_{00} and η_{+-}.	Tentatively scheduled for 1989.
E-774 (Crisler)	Search for short-lived particles in an electron beam dump.	Tentatively scheduled for 1988.
(Heavy Quarks)		
E-653 (Reay)	Study of charm & beauty production in a hybrid emulsion spectrometer.	Took 5.2M triggers in the 1985 run. Ready to resume data-taking in 1987.
E-687 (Butler)	Photoproduction of charm and beauty in wide-band photon beam.	Beam was tested in 1985 run as well as some parts of the detector. Data-taking to start in 1987.
E-690 (Knapp)	High-rate study of charm and bottom production using pipeline trigger processor.	Recently moved from BNL to FNAL. Installation to begin in 1987.
E-769 (Appel)	Hadronic production of charm by kaons and pions in nuclear targets.	Modifying E-691 apparatus for data run in 1987.
E-771 (Cox)	Beauty production associated with dimuons.	First run scheduled for 1988.

Exp. #	**Physics Objectives**	**Status**
(Hard Collisions)		
E-672 (Zieminski)	Study of hadronic final states in association with high-mass dimuons.	Setting up with E-706 for first run in 1987.
E-704 (Yokosawa)	Polarized proton beam experiments to measure $\Delta\sigma_L$ among other things.	Ready for detector calibration and test at end of 1987 run.
E-705 (Cox)	A study of charmonium and direct photon production in antiproton, proton, and pion interactions.	Shakedown run in 1985. Set for data run in 1987.
E-706 (Slattery)	Direct photon production by hadrons yielding gluon structure functions of protons.	Setting up for initial run in 1987.
E-711 (Levinthal)	Constituent scattering in P+N collisions.	Initial shakedown run occurred in 1985. Primary data run to be in 1987.
E-760 (Cester)	Production of charmonium states in antiproton accumulator.	To begin testing in 1987. First data in 1988 fixed-target run.
E-772 (Moss)	Study of nuclear anti-quark sea in P+N collisions $\rightarrow$ dimuons.	Uses E-605 detector. Ready for initial run in 1987.

Lab Notes

Appointment . . .

The Director's Office has announced the appointment of William A. Bardeen as Head of the Theoretical Physics Department, succeeding Chris Quigg who has joined the SSC Central Design Group as Deputy Director.

QUANTUM COSMOLOGY WORKSHOP AT FERMILAB May 1-3, 1987

Rocky Kolb et al.

Physicists, astrophysicists, and cosmologists from throughout the world came to Fermiland on the weekend of May 1-3 for a workshop on quantum cosmology. The workshop was an informal affair in which there was a free-wheeling exchange of ideas and views. The workshop was attended by about 55 physicists from the U.S., Europe, the Soviet Union, and Japan, in addition to the Fermilab participants. The principle organizer of the workshop was Chris Hill of the Fermilab Theory Department; co-organizers were Rocky Kolb and Mike Turner from the Fermilab Theoretical Astrophysics Group.

The success of any workshop or conference depends to some extent upon the planning and thought that goes into organization, but success mostly depends upon the quality of the people in attendance. The Quantum Cosmology Workshop was fortunate to attract a large number of talented people. After all, the purpose of the workshop was to try to find out why and how the Universe was created. It was not a workshop for the faint of heart.

Among the most notable people in attendance were Murray Gell-Mann, Stephen Hawking, and Yakov Zel'dovich. Many Fermilab locals enjoyed interactions with them (and others). Herein we present the personal experiences of three Fermilab staff physicists:

Chris Hill on Murray Gell-Mann:

Part of the success of the Quantum Cosmology Workshop was the participation and contribution of Murray Gell-Mann. Few physicists have made such significant contributions to our culture, as well as to physics itself, as has Gell-

Mann. To him we owe the word "quark" in its modern-day incarnation, as well as the conceptual framework from which our understanding of real physical quarks derive. Gell-Mann received the 1969 Nobel Prize in physics for this and other contributions to the theory of elementary particles.

Recently, with Jim Hartle of the University of California, Santa Barbara, Gell-Mann has been attacking deep issues at the foundation of quantum mechanics which must be addressed in the context of cosmology. He opened his talk with the observation that crackpots do double damage to the fields they populate by spreading misinformation about these fields, and also by preventing serious people from doing honest research in such fields.

Though the foundation of quantum mechanics has experienced its share of crackpots, it contains subtleties which are amplified as one delves into the questions concerning the very earliest instants of the big bang. In ordinary textbook quantum mechanics, the state of a system is influenced by the observer; in the early Universe, who plays the role of observer?

Gell-Mann and Hartle propose that this dichotomy between observer and system arises only when one restricts attention to a few of the infinite degrees of freedom of the world; indeed, it is more than a practical necessity that one do so. Thus, in any analysis of the early Universe as a quantum mechanical system in which one tracks a subset of the full infinite degrees of freedom, there will be effective observers, termed IGUS's (Information Gathering and Utilization Systems) by Gell-Mann, which act to disturb the effective state of the system, but which arise self-consistently within the larger framework of the infinite number of physical degrees of freedom.

It is not immediately clear what impact these ideas will have on the field. I can only recount the personal experience of showing up at Caltech in 1972 as a graduate student and hearing Gell-Mann for the first time saying he considered the weight of evidence in support of the octet vector gluon picture to be so compelling that he considered it essentially established (this was before that minus sign was noticed in the Gell-Mann-Low ψ function). It took the rest of us a long time to come around to belief in QCD.

Drasko Jovanovic on Yakov Zel'dovich:

During the first days of May, and in connection with the Workshop on Quantum Cosmology, Fermilab was host to an extraordinary Soviet scientist: Yakov Zel'dovich. To grasp how versatile this short, energetic, charming 71-year-old man is, one only has to look up his publication list.

In 1939, he published papers on "The Chain Disintegration of Uranium under Slow Neutron Bombardment;" in 1940, "The Theory of Combustion and Detonations"; in 1956, "Development of the Antiparticle Theory"; in 1960, "Quasi-Stable States with a Strong Isotopic Spin in Light Nuclei"; in 1965, "Falling Stars in the Form of Twin Stars"; in 1966, "The Problem of the Century. Is Communication Possible with Extraterrestrial Civilizations?" A few years ago, he was a co-author of the *Scientific American* article "Neutrino Mass and the Galaxy Formation."

Some of my physicist colleagues must be impressed by such a diverse spectrum of subjects. Having read many of his astrophysics papers, I was delighted to serve as his tour guide at Fermilab. His English was perfect; he learned it by reading all six volumes of *The Forsyte Saga* by Galsworthy. He has two daughters and a son; the daughters are both physicists!

Our tour was of short duration. Jet lag, intense sessions, and late dancing in downtown Warrenville took their toll. After the "Leggo" display at CDF at 4:00 p.m., he was ready to retire.

"We shall see each other again?" he asked, shaking my hand.

"Nad'euss!" I replied. "I should hope so!"

Rocky Kolb on Stephen Hawking:

One of the most original minds in physics belongs to Stephen Hawking of the University of Cambridge. It was a rare treat to have hours of "quality time" with Stephen. Because of his handicap, Stephen cannot speak, but must depend upon a voice synthesizer to speak for him. Hawking's brain works much faster than his synthesizer; often he answers not only the question you asked, but tells you the question you should have asked, answers that one, too, and answers the follow-up question you would ask if you had a day or two to think of one.

Hawking is probably best known for the theory of the evaporation of black holes. He said that he came up with the idea of black hole evaporation in 1973 after a talk with Zel'dovich. Since he was able to have many conversations with Zel'dovich at the workshop, perhaps he will be influenced by his weekend at Fermilab. When great minds get together, expect the unexpected.

This was Hawking's second visit to Fermilab. We hope it is but one in a long series of visits. In addition to an enormous scientific stimulation, all who met him were influenced by his dedication to physics.

(Lab Notes cont'd.)

Highlights of the 7th Fermilab Industrial Affiliates Meeting May 21-22, 1987

Dick Carrigan

The seventh annual meeting of the Fermilab Industrial Affiliates (FIA) was held at the Laboratory on May 21-22, 1987. The meeting, with an outstanding array of speakers, attracted the largest attendance ever, including one congressman, Dennis Hastert, from the Illinois district that includes Fermilab. Indeed, there were as many non-Fermilab registrants for the meeting as there were for the annual Users Meeting held here several weeks earlier.

The FIA organization consists of about 35 companies interested in the work under way at Fermilab. Affiliate companies range in size from industrial giants to vigorous young start-up firms. Some of the Affiliates are interested in the electronics and computing work at the Laboratory, some in superconductivity and cryogenics, and others in accelerator technology. The annual meeting is held every year in May, and is attended by Affiliates, potential Affiliates, and other private and public-sector organizations interested in Fermilab technology transfer activities.

Attendance at this year's meeting was stimulated by two developments: the administration's approval of the Superconducting Super Collider (SSC) with the resultant heightened interest in the project, and the very intense interest in superconductivity generated by the new high-temperature superconductors. Because of Fermilab's track record in both accelerators (currently the most powerful in the world) and in applied superconductivity (by far the largest-scale application of superconductivity in the world), industry sees Fermilab as an important source of relevant information.

The meeting included significant presentations in both areas. Peter Limon, of the SSC Central Design Group, reviewed the status of that project. David Larbalestier of the University of Wisconsin, and Ted Geballe, of Stanford University, covered the new developments in the field of high-temperature superconductivity.

The central theme of the meeting was the 21st century. This theme was reflected in the talk given by Chris Quigg, then Head of the Fermilab Theoretical Physics Department, which dealt with physics at the SSC, and a review by Bernard Sadoulet of the importance of the interrelationship between particle physics and cosmology.

A tradition of the Affiliates Meeting is a Roundtable on the theme topic. This year, the Roundtable's charge was "Research Technology in the 21st Century." Dick Lundy, Fermilab Associate Director for Technology, moderated. The keynote speaker was Lloyd Thorndyke, President of ETA Systems, Inc., a new supercomputer company in Minneapolis Other participants included Prof. Theodore Geballe of Stanford University, Dr. Wilmot Hess of the Department of Energy, Dr. Thomas Nash, Head of the Fermilab Advanced Computer Program, and Dr. Andrew Sessler, Lawrence Berkeley Laboratory.

Geballe covered materials science and high-temperature superconductivity. He emphasized that the new superconductivity could have enormous and unexpected impacts on our future. Hess reviewed how the science-government relation could change in the future. Nash discussed detector systems for particle physics, and stressed that complexity was a growing problem. Sessler looked back 50 years and asked if we could have anticipated such developments as computers, space exploration, the A-bomb, and genetic engineering. He went on to anticipate a large increase in the practical application of accelerators.

The question and answer portion of Affiliates Roundtables is always stimulating. It offers industry and the other attendees a chance to ask some difficult questions. This year the questions ranged from speculation on the possibility of a national department of science, to barriers against foreign technology transfer. (A complete transcription of the Roundtable and many of the talks at this year's Affiliates Meeting will be available in a volume to be published in the very near future by the Fermilab Industrial Affiliates Office.)

Alvin Trivelpiece, Executive Director of the American Association for the Advancement of Science, continued the theme with his banquet speech, "The Marketing of Science in the 21st Century." His central point was that scientists needed to become better marketers of science.

Frank Cole, of Fermilab, presented an interesting review of the joint Loma Linda-Fermilab project to build a proton synchrotron for medicine. The industrial partner for that project, SAIC, is an Affiliate.

The Annual Affiliates Meeting continues to be an effective forum for Fermilab technology as well as an excellent place for Fermilab and industry to exchange views on a number of mutually interesting subjects.

Manuscripts, Notes, Colloquia, Lectures, and Seminars

prepared or presented from April 27, 1987, to July 1, 1987. Copies of technical publications with Fermilab publication numbers can be obtained from the Fermilab Technical Publications Office, Theoretical Physics Department, or Theoretical Astrophysics Group, 3rd floor, Wilson Hall. Copies of some articles listed are on the reference shelf in the Fermilab Library, 3rd-floor crossover, Wilson Hall.

Manuscripts and Notes

Experimental Physics Results

T.S. Mattison Experiment # 594	Comparison of Charged and Neutral Current Structure Functions (Ph.D. thesis, Massachusetts Institute of Technology, Cambridge, MA, December 15, 1987)
R.A. Carrigan, Jr. Experiment # 660	Phenomenological Summary of Dechanneling in Aligned Single Crystals (FN-454)
J.R. Raab Experiment # 691	Lifetime Measurements of the Three Charmed Pseudoscalar D-Mesons (Ph.D. thesis, University of California, Santa Barbara, Santa Barbara, CA, April 1987)
S. DePanfilis et al. Experiment # 805/BNL	Limits on the Abundance and Coupling of Cosmic Axions (FERMILAB-Conf-87/65-E; presented at Telemark IV - Neutrino Mass and Neutrino Astrophysics, Ashland, WI, March 16-18, 1987)
S. DePanfilis et al. Experiment # 805/BNL	Limits on the Abundance and Coupling of Cosmic Axions at $4.5 \langle m_a < 5.0\ \mu eV$ (Submitted to Phys. Rev. Lett.)

General Particle Physics

G. Alverson et al. — Experimental Search for W/Z Pairs and Higgs Bosons at Very High Energy Hadron-Hadron Colliders (FERMILAB-Conf-87/51; to be published in the *Proceedings of the 1986 Snowmass Summer Study on the Physics of the SSC*, Snowmass, CO, June 23-July 11, 1986)

G. Alverson et al. — Detecting W/Z Pairs and Higgs at High Energy pp Colliders: Main Experimental Issues (FERMILAB-Conf-87/54; to be published in the *Proceedings of the 1986 Snowmass Summer Study on the Physics of the SSC*, Snowmass, CO, June 23-July 11, 1986)

D.F. Anderson et al. — High Rate Operation of a Warm-Liquid Ionization Chamber (FERMILAB-Pub-87/80; submitted to Nucl. Instrum. Methods A)

D.F. Anderson et al. — Liquid Ionization Chambers with Electron Extraction and Multiplication in the Gaseous Phase (FERMILAB-Pub-87/81; submitted to Nucl. Instrum. Methods A)

J.D. Bjorken — Rare B-Decays: Experimental Prospects and Problems (FERMILAB-Conf-87/83; talk presented at the International Symposium for the Fourth Family of Quarks and Leptons, University of California, Los Angeles, CA, February 26-28, 1987)

J.D. Bjorken and I. Dunietz — Rephasing-Invariant Parametrizations of Generalized Kobayashi-Maskawa Matrices (FERMILAB-Pub-87/75; submitted to Phys. Rev. D)

CDF Collaboration — Status Report on CDF (Invited talk presented by A.V. Tollestrup at Recontres de Physique de La Vallee d'Aoste: "Results and Perspectives in Particle Physics," La Thuile, Aoste Vaslley, Italy, March 1-7, 1987)

G. Charpak et al.

Electrostatic Imaging of Charges Liberated in Dielectric Liquids by Ionizing Radiation (FERMILAB-Pub-87/79; submitted to Nucl. Instrum. Methods A)

G. Jackson

Design of the Transverse Current Emittance Monitor (XIEM) Detector (FN-453)

H.B. Jensen

CDF Calorimetry (FERMILAB-Conf-87/62; invited talk presented at the International Conference on Advances in Experimental Methods for Colliding Beam Physics, SLAC, Stanford, CA, March 9-13, 1987)

T. Nash

Study of Charm Production Mechanisms at the Fermilab Tagged Photon Spectrometer: $\gamma Be \rightarrow D\overline{D}\,x$ and $\gamma A \rightarrow \psi x$ (FERMILAB-Conf-87/71; invited talk at the XXII Rencontre de Moriond: "Hadrons, Quarks, and Gluons," Conference, Les Arcs, Savoie, France, March 15-21, 1987)

K.-Y. Ng

Fields, Impedances and Structures (FN-443; [SSC-N-276]; to be published as a section in *Principles of the High Energy Hadron Colliders, Part I: The SSC*, edited by A.W. Chao and M. Month)

M.V. Purohit

Experimental Results on Heavy Flavour Hadro- and Photo-Production (FERMILAB-Conf-87/82; invited talk presented at Les Rencontres de Physique de La Vallee D'Aoste: "Results and Perspectives in Particle Physics," La Thuile, Italy, March 1-7 1987)

J.D. Cossairt	Skyshine from the SSC Interaction Regions (TM-1459; [SSC-N-348]; presented at the Workshop on Radiological Aspects of SSc Operation, Berkeley, CA, May 4-6, 1987)
J.D. Cossairt	Review of the Abort Dump Shown in the SSC Conceptual Design Report (TM-1460; [SSC-N-349]; presented at the Workshop on Radiological Aspects of SSC Operation, Berkeley, CA, May 4-6, 1987)
J.D. Cossairt	Checking the Numbers for the Labyrinths Shown in the SSC Conceptual Design (TM-1461; [SSC-N-350]; presented at the Workshop on Radiological Aspects of SSC Operation, Berkeley, CA, May 4-6, 1987)
J.D. Cossairt	Unorthodox Method of Calculating the Activation of Groundwater by Routine SSC Operations (TM-1462; [SSC-N-351]; presented at the Workshop on Radiological Aspects of SSC Operation, Berkeley, CA, May 4-6, 1987)
R. Johnson	Initial Operation of the TEVATRON Collider (TM-1449; presented at the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
J.A. MacLachlan	Particle Tracking in E-ϕ Space as a Design Tool for Cyclic Accelerators (FN-457; submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
C.D. Moore and T. Topolski	Polar Coordinate Alignment of the Magnet Stands in the B0 Overpass Region of the Fermilab Main Ring (Abstract submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)

K.-Y. Ng — Damping of Coupled-Bunch Growth by Self-Excited Cavity (FN-456)

J. Strait et al. — Full Length Prototype SSC Dipole Test Results (TM-1450; [SSC-N-320]; presented at the 1986 Applied Superconductivity Conference, Baltimore, MD, September 28 - October 3, 1987)

J. Strait et al. — Tests of Prototype SSC Magnets (TM-1451; [SSC-N-321]; presented at the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)

M.J. Syphers — An Improved 8 GeV Beam Transport System for the Fermi National Accelerator Laboratory (TM-1456; Ph.D. thesis, University of Illinois at Chicago, Chicago, IL, April 23, 1987)

Theoretical Physics

A.A. Anselm — SUSY GUT with Automatic Hierarchy and Low Energy Physics (FERMILAB-Pub-87/44-T; submitted to Phys. Rev. Lett.)

A.A. Anselm — Experimental Test for Arion ⇆ Photon Oscillations in a Homogeneous Constant Magnetic Field (FERMILAB-Pub-87/45-T; submitted to Phys. Rev. Lett.)

P. Arnold and L. McLerran — Sphalerons, Small Fluctuations, and Baryon Number Violation in Electroweak Theory (FERMILAB-Pub-87/34-T; submitted to Phys. Rev. D)

C.-H. Chang and S.-C. Lee — Heavy Quark Contributions to W Pair Production at Hadron Colliders (FERMILAB-Pub-87/64-T; submitted to Phys. Lett. B)

C.-H. Chang and S.-C. Lee — Testing Couplings of the Three Vector Bosons through Hadron Collision at

	TEVATRON Energy (FERMILAB-Pub-87/68-T; submitted to Phys. Rev. D)
N.-P. Chang et al.	STr M^2 Sum Rule for Superstring Motivated Kähler Potentials (FERMI-LAB-Pub-87/47-T; [CUNY-HEP-87/4; IEM-HE-87/2] submitted to Phys. Rev. Lett.)
C.T. Hill	Theoretical Expectations for Mass Scales of the Fourth Generation and Higgs Bosons (FERMILAB-Conf-87/53-T; invited talk given at the Fourth Generation Workshop, Santa Monica, CA, February 1987)
S.-C. Lee	Polarization Density Matrix for Heavy $Q\overline{Q}$ Production in Hadron Colliders (FERMILAB-Pub-87/31-T; submitted to Phys. Lett. B)
R.D. Pisarski	Critical Point for Smooth Strings in a Large Number of Dimensions (FERMILAB-Pub-87/23-T; submitted to Phys. Rev. Lett.)

Theoretical Astrophysics

M. Gleiser et al.	First Order Formalism for Quantum Gravity (FERMILAB-Pub-87/73-A; submitted to Nucl. Phys.)
C.T. Hill et al.	Variational Study of Ordinary and Superconducting Cosmic Strings (FERMI-LAB-Pub-87/92-A; submitted to Phys. Rev. Lett.)
E.W. Kolb et al.	How Reliable Are Neutrino Mass Limits Derived from SN 1987A? (FERMI-LAB-Pub-87/74-A; submitted to Phys. Rev. D)

T. Pacher et al.

Can Bulk Viscosity Drive Inflation? (FERMILAB-Pub-87/69-A; submitted to Phys. Rev.)

D.N. Schramm

Neutrino Counting with the Supernova and the Big Bang (FERMILAB-Conf-87/70-A; prepared for the proceedings of the XXIInd Rencontres de Moriond: "Starbursts and Galaxy Evolution," Moriond, France, March 8-15, 1987)

A. Stebbins

Cosmic Strings and Galaxy Formation: Current Status (FERMILAB-Conf-87/61-A; to appear in the proceedings of the XIII Texas Symposium on Relativistic Astrophysics, Chicago, IL, December 14-19, 1986)

A. Stebbins et al.

Cosmic String Wakes (FERMILAB-Pub-87/60-A; submitted to Astrophys. J.)

J.A. Stein-Schabes and A.B. Burd

Cosmic Strings in an Expanding Spacetime (FERMILAB-Pub-87/77-A; submitted to Phys. Rev.)

M.S. Turner

Inflation in the Universe (FERMILAB-Conf-87/86-A; to be published in the *Proceedings of the International Workshop on Superstrings Composite Structures, and Cosmology*, edited by S.J. Gates and R. Mohapatra, College Park, MD, March 11-189, 1987)

Computing

T. Dorries et al.

VMS Software for the Jorway-411 Interface (TM-1457; presented at the Fifith IEEE Conference on Real-Time Computer Applications in Nuclear, Particle, and Plasma Physics, San Francisco, CA, May 12-14, 1987)

T. Dorries et al.	List Processing Software for the LeCroy 1821 Segment Manager Interface (TM-1458; presented at the Fifth IEEE Conference on Real-Time Computer Applications in Nuclear, Particle, and Plasma Physics, San Francisco, CA, May 12-14, 1987)
R. Hance et al.	The ACP Branch Bus and Real-Time Applications of the ACP Multiprocessor System (FERMILAB-Conf-87/76; invited talk at the Fifth IEEE Conference on Real-Time Computer Applications in Nuclear, Particle, and Plasma Physics, San Francisco, CA, May 12-14, 1987)
P. Heinicke et al.	Organizing, Maintaining, and Distributing Software Products (FN-442; submitted to the proceedings of the Digital Equipment Users Society, San Francisco, CA, October 6-10, 1986)
P. Heinicke et al.	A Multiple Node Software Development Environment (TM-1463; presented at the Fifth IEEE Conference on Real-Time Computer Applications in Nuclear, Particle, and Plasma Physics, San Francisco, CA, May 12-14, 1987)
L. Roberts	Evaluation of the FPS-164 Computer for High Energy Physics Pattern Recognition Problems (FERMILAB-Pub-87/72; submitted to *Computer Physics Communications*)
V. White et al.	The VAXONLINE Software System at Fermilab (FERMILAB-Conf-87/93; presented at the Fifth IEEE Conference on Real-Time Computer Applications in Nuclear, Particle, and Plasma Physics, San Francisco, CA, May 12-14, 1987)

Cryogenics

Q.S. Shu et al.	Theory and Technique for Reducing the Effect of Cracks in Multilayer Insulation from Room Temperature to 77K (Presented at the 1987 Cryogenic Engineering Conference/International Cryogenic Materials Conference [CEC/ICMC], St. Charles, IL, June 14-18, 1987; and submitted to Adv. Cryo. Eng.)

Other

S.I. Baker	Site Environmental Report for Calendar Year 1986 (FERMILAB 87/58; UC-41)

Colloquia, Lectures, and Seminars

(All at Fermilab in 1987 unless otherwise noted)

N. Neto	"First Order Formalism for Quantum Gravity" (April 27)
D. Ritchie	"Getting the Most Out of the VAX - Using the NULLJOB Product to Process Long-Running Batch Jobs" (April 28)
L. Teng	"Accelerator Projects Worldwide" (April 28)
M. Petter	"365 Specification and Performance of the 365 Module" (April 30)
G. Jackson	"The Use of the 365 Module for rf Curves" (April 30)
M. Syphers	"Transverse Phase Space Dilution Due to Injection Mismatches" (May 5)
K. Sliwa	"Decays of Charmed Particles" (May 6)
S. Hsueh and D. Peterson	"Deceleration in the Accumulator for E-760" (May 7)

A. Lennox	"The Role of Physics in Cancer Treatment," Waubonsee Community College, Sugar Grove, Illinois (May 9)
H. Edwards et al.	"Accelerator Division News and Collider Performance" (May 12)
A. Thomas and F. Nagy	"EPICURE" (May 12)
C. Moore	"Estimate of the TEVATRON Luminosity Based on Accelerator Measurements" (May 14)
J. Elias	"Estimate of the TEVATRON Luminosity Based on Measurements of CDF Counting Rates" (May 14)
A. Van Ginneken	"SSC Site Selection: Radiation Safety Criteria" (May 19)
D. Bogert	"1. Split of DEC - T. 2. Longer Range Controls R&D Study Topics." (May 21)
J. Wiss	"Recent Results from E-400" (May 22)
T. Collins	"Two Low-Beta Insertions for the TEVATRON Collider" (May 26)
M. Leininger	"Introduction to VAX Interactive Debugger for FORTRAN Programmers" (May 26)
AD Staff Members	"Accelerator Improvements" (June 2)
R. Flora	"Measurements of Emittance with the Flying Wire System" (June 4)
S. Baker and J. Grimson	"Crane Safety" (June 8)
T. Carroll	"Expert System for FASTBUS Network Diagnostics" (June 9)
J. Elias	"Design and Operation of CDF Gas System" (June 9)
D. Wildman	"Bunch Coalescing in the Main Ring" (June 9)

G. Dugan and R. Webber	"Comments on the Instrumentation Needed to Diagnose Losses of $\bar{p}$'s in the $\bar{p}$ Source and the Main Ring" (June 11)
J. MacLachlan	"ESME Unveiled: Principles and Practice of RF Simulation" (June 16)
S. Parke	"Duality and Multi-Gluon Scattering" (June 18)
J.D. Bjorken	"B Physics" (June 26)
L. Michelotti	"Problem-Solving with Interactive Graphics: A Personal View" (June 23)
R. Johnson	"Some Lessons from the Recent '87 Collider Run" (June 30)
D. Green	"Wire Chambers" (June 30)

Dates to Remember

October 8-10, 1987	"Collider Physics: Current Status and Future Prospects," Eighth Vanderbilt High Energy Physics Conference. Vanderbilt University, Nashville, Tennessee. For information: Vanderbilt High Energy Physics Conference, Department of Physics and Astronomy, P.O. Box 1807 Station B, Vanderbilt University, Nashville, TN 37235; phone: (615) 322-6550, ext. 2828; BITNET: VU87 @ VANDVMS1.
October 19-23, 1987	3rd Symposium on Pan-American Collaboration in Experimental Physics. CBPF - Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, RJ, Brazil. For information: A. Santoro, Centro Brasileiro de Pesquisas Físicas/CNPq, Rua Dr. Xavier Sigaud 150, Urca, CEP 22290, Rio de Janeiro, RJ, Brazil, or L. Lederman, Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, IL 60510, U.S.A.
November 9, 1987	Deadline for receipt of material to be considered at December 1987 Physics Advisory Committee Meeting
December 10-11, 1987	Physics Advisory Committee Meeting
May 11, 1988	Deadline for receipt of material to be considered at June 1988 Physics Advisory Committee meeting
June 18-24, 1988	Physics Advisory Committee Meeting