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BEVATRON OPERATION AND DEVELOPMENT. 52

September through December 1966

Kenneth C. Crebbin and Robert Frias

May 23, 1967

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Contents

Abstract v

I. Machine Operation and Experimental Program 1

II. Shutdown 5

III. Bevatron Development and Studies 5

IV. Magnet Power Supply 6

Staff. 10

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Kenneth C. Crebbin and Robert Frias

Lawrence Radiation Laboratory
University of California
Berkeley, California

May 23, 1967

ABSTRACT

The Bevatron provided beam 87.1% of the scheduled operating time this quarter and accelerated a total of 1.7×10^{18} protons. There were basically three modes of magnet pulsing this quarter, using both flattop and mezzanine type of operation. Beam height measurements were made in the south straight section and showed the beam to be 0.75 in. above the gap center line.

A fracture was discovered in one of the rotor pole pieces of the main motor generators. As a result of this failure a shutdown was started which was expected to last until some time in May 1967.

I. MACHINE OPERATION AND EXPERIMENTAL PROGRAM

The Bevatron operation record is shown in Fig. 1. The beam was off 7.3% of the scheduled operating time because of equipment failure and 5.6% of the time for experimental setup, tuning, and routine checks. The beam was on 87.1% of the scheduled operating time. During this quarter, the Bevatron accelerated 1.7×10^{18} protons.

On December 9, 1967, experiment #68, using the 72-inch hydrogen bubble chamber, was completed. The 72-inch bubble chamber was shut down at this time for conversion to an 82-inch bubble chamber. When the conversion is complete the bubble chamber will be moved to the Stanford Linear Accelerator Center.

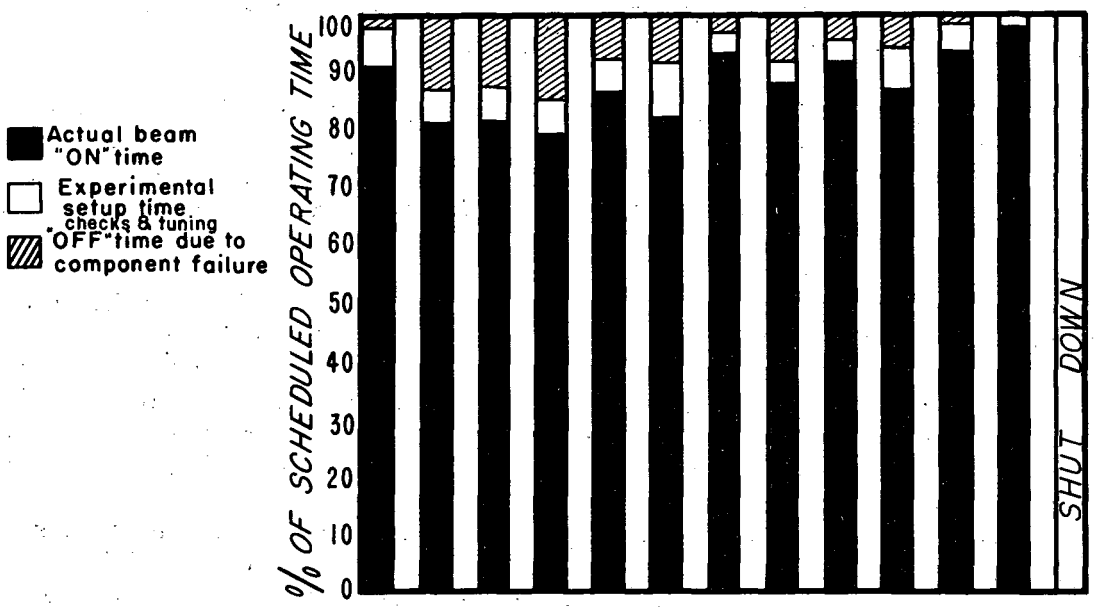
The new External Proton Beam Area craneway and building columns were installed last quarter. Roof construction started this December. During part of this period of roof construction it was necessary for reasons of safety to shut down operations in the area using liquid hydrogen. The 25-inch bubble chamber was therefore shut down. Experiment #48 at the third focus in the external proton beam was completed during this time.

There were basically three modes of magnet pulsing used this quarter. The first, and major, mode was a 900-msec flattop at 5.3 BeV. The 72-inch hydrogen bubble chamber took a 300-μsec spill at the start of flattop. This short beam spill was placed on a target at F1 in the external proton beam channel. The secondary beam from this target went to the 72-inch bubble chamber. The remaining beam was spilled during a 700 to 800 msec period for counter experiments (Fig. 2a). The long beam spill was shared simultaneously with internal-beam experiment 47A, and one of the external beam third-focus experiments, 43A or 48.

The second mode of magnet pulsing was a 600-msec mezzanine at 5.3 BeV followed by a 300-msec flattop at 6.1 BeV (Fig. 2b). In this mode of operation the spills on the mezzanine at 5.3 BeV were the same as on the flattop at 5.3 BeV in the first mode as described above. A 300-μsec beam spill was put on an internal target during the flattop at 6.1 BeV. This beam spill was for the 25-inch hydrogen bubble chamber.

The third mode of magnet pulsing was a 300-msec flattop at 6.1 BeV. The 72-inch bubble chamber took a 300-μsec beam spill on the rising field at 5.3 BeV on every pulse. This was the only external proton beam in this mode of operation. The two internal beam experiments ran on an alternate-pulse basis. On one pulse the 25-inch bubble chamber took two 300-μsec spills, the first spill at the start of flattop and the second spill just before the end of flattop. On the alternate pulse the University of Washington group, experiment #50, took a 200-msec beam spill. This mode is shown in Fig. 2c.

A summary of the experimental program for this quarter is shown in Table I.



Week of	10/2	10/9	10/16	10/23	10/30	11/6	11/13	11/20	11/27	12/4	12/11	12/18	12/25
Crew hours	168	168	168	168	169	168	168	120	168	168	168	96	48
Turnon & maintenance time (h)	16	11	10	11	13	17	0	15	9	9	10	0	0
Scheduled operating time (h)	146	148	146	148	152	142	168	105	152	152	152	32	0
Scheduled Bevatron test time (h)	6	9	12	9	4	9	0	0	7	7	6	0	0
Scheduled shutdown time (h)	0	0	0	0	0	0	0	0	0	0	0	64	48
Holiday (h)	0	0	0	0	0	0	0	48	0	0	0	16	32

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Fig. 1. Bevatron operating schedule.

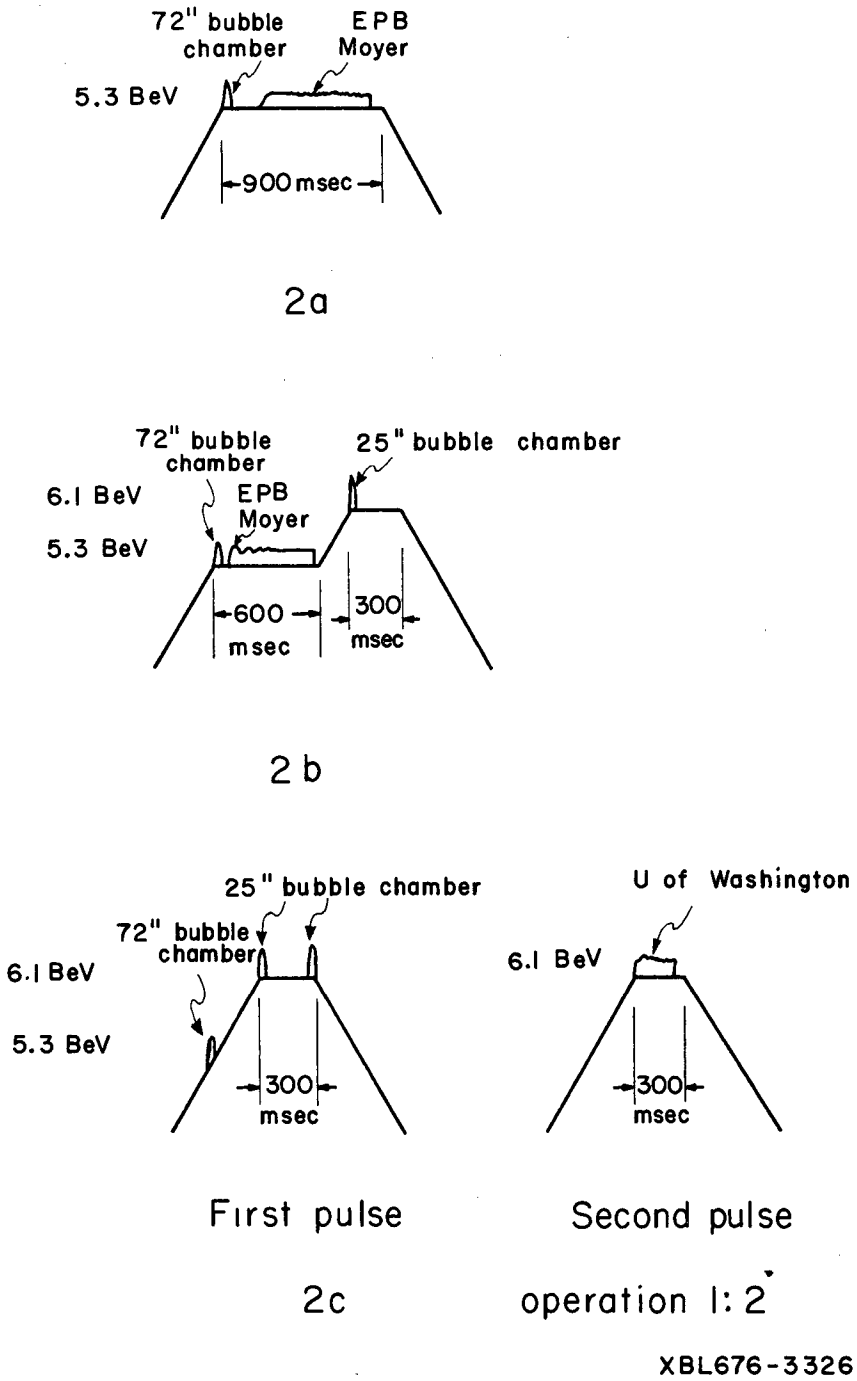


Fig. 2. Bevatron magnet pulsing modes.

Table I. Summary of Bevatron experimental research program, October through December 1966.

Groups	Run	Dates: Start	Dates: End	Experiment	BEAM TIME: This Quarter (Oct. - Dec.): 12-Hour periods	BEAM TIME: This Quarter (Oct. - Dec.): Hours	BEAM TIME: From start of run through December 1966: 12-Hour periods	BEAM TIME: From start of run through December 1966: Hours	Pulse Schedule	Primary or secondary experiment
Internal Groups										
Alvarez (Murray)	39	8/5/65	In progress	K°-K_2° Interference using 25-in. bubble chamber	13	124	217	2305	1:1	P
Moyer-Helmholz (Parker)	47A	5/19/66	In progress	Investigation of neutral particles	31 0	252 8	63 66	683 828	1:1 1:1	P S
Lofgren - (Cork) - (Wenzel)	48	5/26/66 9/16/65	12/9/66 10/21/66	Diboson mass spectra	59 6	698 62	97 47	1113 773	1:1 1:1	P S
Segrè-Chamberlain (Chinowsky) U. C. -Irvine - (Schultz)	64	9/27/66	10/21/66	Multi- and strange-particle production	27	302	28	323	1:1	P
Trilling-Goldhaber	68	10/25/66	12/9/66	Study of π-p interactions in 72-in. bubble chamber, 3.65-BeV/c separated π^+ beam	43	485	43	485	1:1	P
Segrè-Chamberlain (Wiegand)	69	8/16/66	11/5/66	Study of solid-state detectors	13	138	25	254	1:1	P
Powell-Birge	72	11/12/66	11/28/66	Study of π^+-p interactions in 25-in. bubble chamber 1.3- to 1.8-BeV/c separated π^+	25	272	25	272	1:1	P
Chemistry - Hyde	P-13	9/21/66	In progress	Light-fragment production from interactions of heavy nuclei with protons	67	655	80	803	1:1	P
External Groups										
U. of Washington - (Masek)	50	3/18/66 5/20/66 9/10/66	In progress 8/29/66 In progress	Magnetic moment of Ξ^- Cascade	3 24 34	85 225 368	98 29 39	1148 309 428	1:1 1:1 1:2	S P P
U. of Wisconsin - (Camerini)	59	8/19/66	11/18/66	K-d Interaction in 25-in. bubble chamber	17	314	37	423	1:1	P
U. of Washington - (Davis)	P-12	7/21/66		Spark chamber tests for Run # 54	33	367	38	426	1:2	S

II. SHUTDOWN

The 72-inch hydrogen bubble chamber conversion program and schedule and the construction schedule on the new external proton beam experimental hall created a rather firm turnoff date for the 72-inch bubble chamber. Time was very tight for completion of the scheduled experiments in the 72-inch bubble chamber. To provide some additional time for the experimental physics program, the normal weekly 8-hour maintenance period and the Bevatron development period were skipped on November 14. We were shut down for 48 hours from 8 a.m. November 24 to 8 a.m. November 26, over the Thanksgiving holidays. However, the experiments with the 72-inch bubble chamber were completed on schedule.

On Monday, December 19, during the routine maintenance check of the main motor generators, a failure was discovered. One of the rotor poles had started to break away from the rotor and had moved toward the field coils. This is discussed in detail in Section IV of this report. As a result of this failure Bevatron operation was suspended until new rotor poles could be obtained and installed. Resumption of operation is expected in May 1967.

III. BEVATRON DEVELOPMENT AND STUDIES

Some of the development periods this quarter were devoted to beam tracking and multiple experiment compatibility. Studies of improved methods of beam monitoring continued. Some time was devoted to the continuing problems of injection and extraction efficiency. Vertical beam position measurements were made at the energy-loss target in the south straight section and at the entrance to the first extraction magnet M1 in the east straight section. The beam was found to be on aperture center in the east straight section but was 0.75 in. high at the energy-loss target. Plans were made to measure the vertical position of the beam in the other two straight sections. This measurement was not made because of the failure of the main motor generators. A closed-orbit calculation was made, using the magnet survey data. This calculation showed the orbit about 0.9 in. low in the north target area. The two measured points in the south and east straight sections were fairly close to the calculated closed orbit. Plans were being made to realign the Bevatron magnet during the shutdown. This will be discussed in detail in the next quarterly report.

IV. MAGNET POWER SUPPLY

A. Fatigue Failure of Bevatron Generator Pole Piece Laminations

Discovery of Failure

Fatigue cracks were discovered in pole laminations of the Bevatron's two 46 000-kVA generators, during a routine periodic mechanical inspection. The prompt discovery of the cracks, by electronics technician Willie Thompson, averted what could otherwise have led to very costly and extensive damage had a rotor pole scraped stator windings. The pole with the largest cracks had broken its damper windings and moved into the air gap to within 0.25 in. of the stator (see Figs. 3 and 4).

The cracks are located in the "dovetail sections" of the pole laminations of both machines. More than 50% of the total of 16 poles showed visible cracks.

Machine History

The fatigued pole assemblies are original equipment on the Bevatron generators. During the 15 years since their installation the generators have pulsed the Bevatron magnet more than 37 million times.

Generator Repair

Because of the large number of cracks found in a majority of the poles it was decided to completely replace all 16 poles, 8 per generator. New poles will be delivered on or about March 1, 1967. The poles are being constructed by Westinghouse Electric Corporation at the East Pittsburgh Plant. Westinghouse was the original manufacturer of the generators.

In conjunction with the pole replacement the shutdown time will be used to completely overhaul and refurbish the motor generator sets. Included in this overhaul will be bearing inspection and clean-up, generator rewedging, motor generator cleaning and painting, and a complete machine alignment.

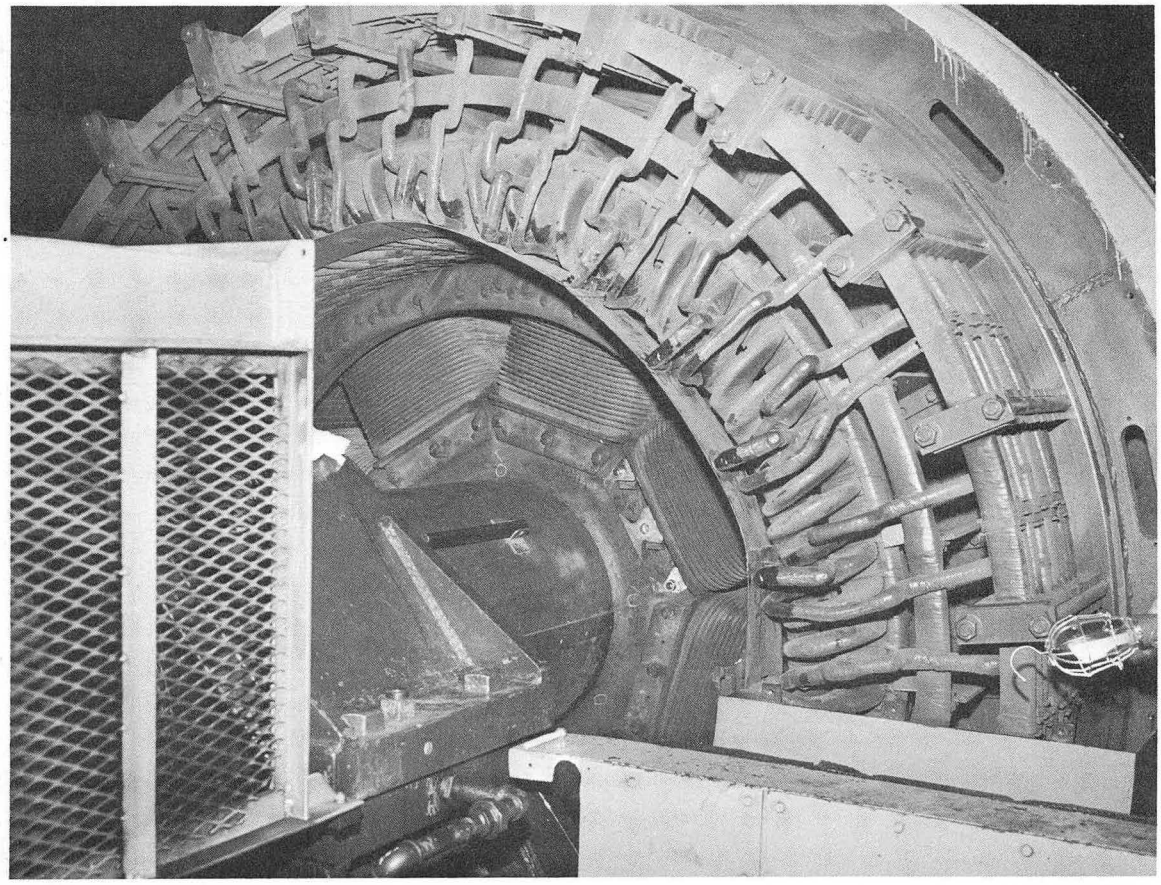
Scheduling and Costs

Present scheduling calls for the completion of all work and tests by the middle of May 1967.

The cost of the poles and associated special parts is $132 000. The machine teardown, installation of new poles, and refurbishing will cost approximately $175 000; total cost will be more than $300 000.

B. Magnet Pulsing Record

This record is shown in Table II.



BEV 4138

Fig. 3. Fatigue failure of Bevatron generator pole-piece laminations. Rotor and stator, showing pole pieces.

BEV 4136

Fig. 4. Fatigue failure of Bevatron generator pole-piece laminations. Close-up of pole piece and dovetail joint, showing fracture in laminations.

Table II. Bevatron motor generator set monthly fault report.

1966	4 to 6 pulses/min									7 to 9 pulses/min									10 to 17 pulses/min									Total				
	1.5 to 6.9 kA				7.0 to 9 kA					1.5 to 6.9 kA				7.0 to 9 kA					1.5 to 6.9 kA				7.0 to 9 kA									
	Pulses	Faults 14	Faults 26	P/F	Pulses	Faults 14	Faults 26	P/F		Pulses	Faults 14	Faults 26	P/F	Pulses	Faults 14	Faults 26	P/F		Pulses	Faults 14	Faults 26	P/F	Pulses	Faults 14	Faults 26	P/F		Total	Arc backs	Arc through	P/F	Ignitrons replaced
Jan.	4,576		1							440				122,184	4	13			996				209,883	13	2			338,079	17	16 33	10,245	2A1-Ign. Chg. 1/11/66
Feb.										2,744				144,584	5	5			177,870	2	1		9,519					334,717	7	6 13	25,747	
Mar.	53									61				44,316	6	6			178,891	4	10		145,699	7	6			369,020	17	22 39	9,462	
April	242													75,037	10	3			9,356				283,873	20	20			368,508	30	23 53	6,952	
May	2,543				185					2,728				67,902	27	14			177,616	8	12		151,184	15	20			402,158	50	46 96	4,189	
June										47,550				15,200	1	1			208,250	4	6		108,128	4	7			379,128	9	14 23	16,483	
July										16,419		1		106,261	4	10			177,184	3	1		46,771	2	7			346,635	9	19 28	12,379	
Aug.										877				20,980	1	1			281,843	7	9		89,830	5	9			393,530	13	19 32	12,298	
Sept.										28,572		5							260,769	11	12		57,417	5	11			346,758	16	28 44	7,881	
Oct.										35,736	17	10		55,296	31	23			211,351	9	14		58,571	1	6			360,954	58	53 111	3,252	
Nov.										15,334		3		89,349	1	11			230,425	9	9		5,078		1			340,186	10	24 34	10,005	
Dec.										47,040	5			15,609	5	3			107,072	3	4		74,480	3	4			244,201	16	11 27	9,044	

STAFF

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William Everette	Radiation control
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