Title
BEVATRON OPERATION AND DEVELOPMENT. 60, OCTOBER THROUGH DECEMBER 1968.

Author
Crebbin, Kenneth C.

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LAWRENCE RADIATION LABORATORY
UNIVERSITY of CALIFORNIA BERKELEY

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I. MACHINE OPERATION AND EXPERIMENTAL PROGRAM

The Bevatron Operation record is shown in Fig. 1. The beam was on for 89.8% of the scheduled operating time. It was off 8.7% of the scheduled operating time because of equipment failure and 1.5% of the time for experimental setup, tuning, and routine checks. The Bevatron accelerated 2.4×10^{18} protons this quarter.

During this quarter the Bevatron provided beam to fifteen primary experiments and eight secondary experiments, for a total of twenty-three. During October, we operated eleven experiments simultaneously; thirteen were set up and could have been run simultaneously. Ten of these thirteen experiments were major efforts. The Bevatron operated 123 12-hour periods for high energy physics and integrated a total of 720 12-hour periods of experimental high energy physics.

Four primary experiments were completed this quarter. Experiment #70, an effort by the University of Washington Group (Williams, Cook), was completed on December 20, 1968. This experiment was set up at the third focus of the external proton beam Channel II. Experiment #71A, an effort by the University of California—San Diego Group (Piccioni), was completed on November 11, 1968. This experiment was set up at the third focus of the external proton beam Channel I. Experiment #81, an effort by the Lawrence Radiation Laboratory Segrè-Chamberlain Group (Wiegand), was completed on November 18, 1968. This experiment was done at the second focus of Channel I of the external proton beam facility. Experiment #83, a collaborative effort by LRL Group A (Abolins-Smith) and the University of California—Davis Group (Pellet), was completed on October 22, 1968. This experiment was set up at the third focus of Channel II in the external proton beam facility.

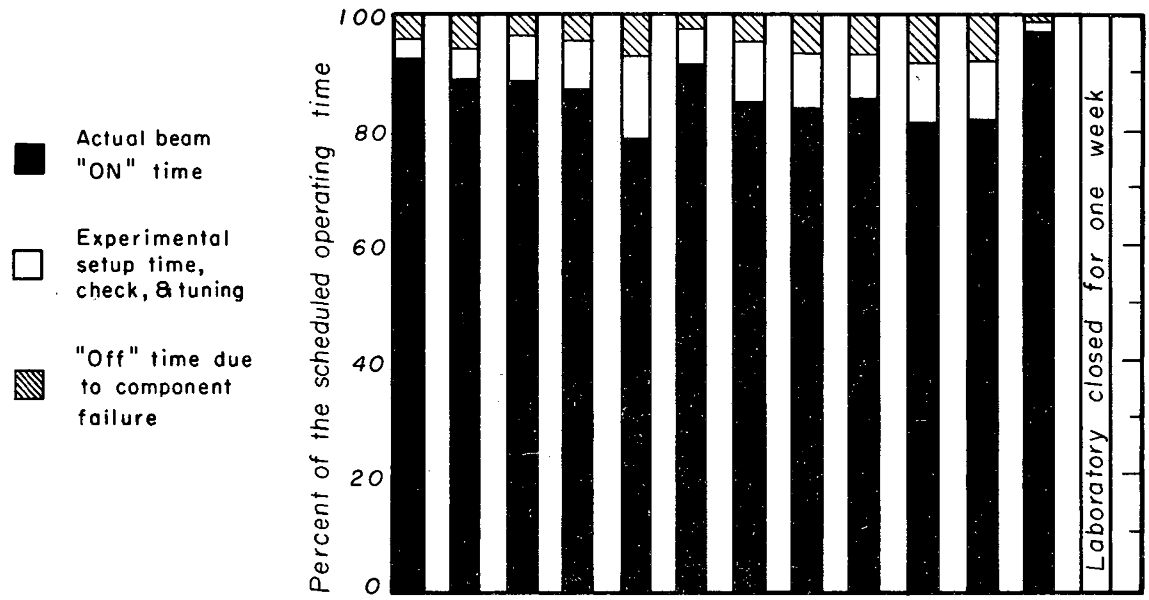
Setup was started on five new primary experiments.

(i) Experiment #87, by the Lawrence Radiation Laboratory Powell-Birge Group, is being done in the 25-inch hydrogen bubble chamber. This experiment is a study of $\pi + p$ interactions.

(ii) Experiment #60, a collaborative effort of the University of Hawaii (Cence) and the Lawrence Radiation Laboratory Moyer-Helmholz Group (Perez-Mendez), is being set up at the third focus of Channel I of the external proton beam facility. Experiment #60 is a study of Ke_4 decays using a separated 1.5-GeV/c K^+ beam and wire spark chambers.

(iii) Experiment #88 was set up in the west experimental area in a π^- beam from a target near the exit of Quadrant II of the Bevatron. This experiment, a study of $\pi^- p\ n\gamma$ differential cross section, is a collaborative effort of the University of California—Los Angeles Nefkens Group and the Lawrence Radiation Laboratory Crowe Group.

(iv) Experiment #97 is a collaborative effort of two Lawrence Radiation Laboratory groups: Group A (Pripstein) and the Moyer-Helmholz (Kenney) groups. The experiment



Week of		9/29	10/6	10/13	10/20	10/27	11/3	11/10	11/17	11/24	12/1	12/8	12/15	12/22
Crew hours		168	168	168	168	169	168	168	168	118	168	168	136	0
Turn on & maintenance time	(h)	10	10	10	10	10	10	10	10	14	12	12	4	0
Scheduled operating time	(h)	158	158	158	158	159	158	158	158	104	156	156	132	0
Scheduled Bevatron test time	(h)	6	14	8	10	14	6	10	14	18	18	12	0	0
Scheduled shutdown time	(h)	0	0	0	0	0	0	0	0	0	0	0	0	0
Holiday	(h)	0	0	0	0	0	0	0	0	50	0	0	0	72

XBL696-3118

Fig. 1. Bevatron operating schedule.

is set up in a secondary π^- beam from a target near the north straight section of the Bevatron. This experiment is essentially the same beam and setup as was used for Experiment #86, which this group just completed. Only minor modifications were made in the experimental setup.

(v) Experiment #106, by the University of Arizona (Jenkins) Group, is a study of K^+-nucleon cross sections using a 0- to 0.72-GeV/c separated K beam. This experiment was set up at the second focus of Channel I of the external proton beam facility.

The experimental program for this quarter is summarized in Table I.

At the Bevatron, long beam spills (200 to 2000 msec) are produced by an electronic device called the electronic beam spiller[1] (EBS). The technique used is to reduce the rf voltage until beam is lost from the phase-stable region. Then, if the magnetic field is increasing, the beam spirals radially inward until it strikes a target. This device uses a feedback circuit that works on the signal from the beam induction electrode system (BIE) that monitors the circulating proton beam. The fundamental shape of the beam spill is determined by the spill length and rate controls in the EBS circuit, the radius of the beam with respect to the target when the proton is lost from phase stability, and the rate of rise (or slope) of the magnetic field of the Bevatron. There are three major sources of fine structure in the beam spill:

(i) The rf structure, (ii) magnet ripple structure, and (iii) a structure characteristic of the beam spiller itself. There is essentially nothing we can do about the rf structure with this type of spill. The magnet ripple is substantially reduced by a magnet-ripple feedback circuit. The remaining source of fine structure--and the most troublesome to the experimenter--is the characteristic structure produced by the beam spiller.

When the reference signal in the EBS calls for beam spill, the servosystem lowers the rf voltage. Because of the time constants the rf is turned all the way off. When sufficient beam has disappeared from the BIE monitor the rf voltage is turned back on. Detailed comparison of the rf envelope and a Cerenkov monitor of the beam spill showed that beam was also kicked into the target when the rf voltage came back on. This caused large-intensity peaks of beam spill, which was undesirable for counter experiments.

Beam spill structure-control circuits were built to reduce this problem. Two different methods were used. First a simple time-constant circuit, to control the rise time of the rf voltage, was built. Second a "window" for the rf voltage was built to limit the maximum and minimum values of rf voltage during the time of beam spill.

Both these circuits provide considerable improvement in reducing the fine structure on the beam spills. The counting efficiency for one of the experiments was increased by a factor of about 2.5 when the structure-control circuits were used.

Experiment #70 uses a high-field pulsed magnet. The experimenters therefore can use only beam spills of from 100 to 200 msec duration that match the top of the magnet pulse. During this time they do not want any rf structure on the beam spill. We provide an "rf off" type of spill for this group. In this case, the slope on the magnetic is set up in a secondary π^- beam from a target near the north straight section of the Bevatron. This experiment is essentially the same beam and setup as was used for Experiment #86, which this group just completed. Only minor modifications were made in the experimental setup.

(v) Experiment #106, by the University of Arizona (Jenkins) Group, is a study of K^+-nucleon cross sections using a 0- to 0.72-GeV/c separated K beam. This experiment was set up at the second focus of Channel I of the external proton beam facility.

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Table I. Summary of Bevatron experimental research program, October through December 1968.

		Dates				Beam Time: This quarter October - December		Beam Time: Start of run through December 1968			
Groups	Experiment location	Run	Start	End	Experiment	12-Hour periods	Hours	12-Hour periods	Hours	Pulse Schedule	Primary or secondary experiment
Internal Groups											
Powell-Birge (Kalmus)	EPB 25-in. BC	72	2/21/68	In progress	π^+p interactions	0	0	95	1027	1:1	P
Powell-Birge (Ely-Kalmus)	EPB 25-in. BC	73	6/8/68	In progress	K^-p and K^-d reactions	65	664	87	899	1:1	P
Trilling-Goldhaber (Kadyk)	EPB 25-in. BC	76	10/30/68	In progress	Λp scattering	10	104	10	104	1:1	P
Segrè-Chamberlain (Wiegand)	EPB XI F2	81	7/17/68	11/18/68	K-mesic x-rays	70	737	107	1137	1:1	P
Group A (Abolins-Smith) U. C.–Davis (Pellet)	EPB XII F3	83	6/14/68	10/22/68	$pp \rightarrow d + x$	2	24	70	773	1:1	P
Moyer-Helmholz (Kenney) Group A (Pripstein)	Internal north area straight section	86	8/14/67	In progress	Branching ratios for the neutral and charged decay modes of the η	2	37	103	1130	1:1	P
Powell-Birge (Gidal)	EPB 25-in. BC	87	11/26/68	In progress	π^+p interactions	32	345	32	345	1:1	P
Segrè-Chamberlain (Chamberlain) U. Michigan (Longo)	EPB XI F3	91	7/20/68	In progress	Polarization in $np \rightarrow pn$ charge-exchange scattering, 1-6 GeV.	43	485	56	635	1:1	P
Moyer-Helmholz (Kenney) Group A (Pripstein)	Internal north area straight section	97	11/1/68	In progress	$\pi^-p \rightarrow \eta n$ differential cross sections	24	271	24	271	1:1	P
Nuclear Chemistry (Hyde-Poskanzer)	EPB XI F2	104	9/21/66	In progress	Production of light fragments from p-nucleon collisions	83	883	191	2206	1:1	P
Miller (Miller)	Internal west area straight section	P-32 (95)	5/31/68	In progress	$K^0\mu 3$ charge-asymmetry tests for future Exp. #95	4½	62	9	134	1:1	S
Lofgren (Wenzel)	Internal west area straight section	P-33	10/11/68	In progress	Preliminary counter checks for future experiment # 82	1¾	23	1¾	23	1:1	S
LRL–Health Physics (Wollenberg)	EPB XI F3	P-35	11/8/68	11/10/68	Fission-track foil exposure	2	21	2	21	1:1	S
Moyer-Helmholz (Kenney) U. C.–Santa Barbara (Caldwell)	Internal north area straight section	P-36	11/14/68	11/14/68	Counter efficiency checks for future experiment #105	1	12	1	12	1:1	S
Group A (Flatté)	Internal north area straight section	P-37	11/27/68	In progress	Scintillation counter tests for future experiment of SLAC	1¼	11	1¼	11	1:1	S
External Groups											
U. Hawaii (Cence) Moyer-Helmholz (Perez-Mendez)	Internal west area straight section	P-31 (60)	8/27/68	In progress	Counter and spark chamber tests for Exp. #60 to be set up at EPB XI F3	17	218	23	288	1:1	S
U. Washington (Williams)	EPB XII F3	70	5/3/68	12/20/68	Σ^+ magnetic moment	106	1103	177	1843	1:1	P
U. C. San Diego (Piccioni)	EPB XI F3	71A	3/15/68	11/11/68	K regeneration amplitudes 1–1.5-GeV/c separated $K^\pm$ beam	60	623	134	1424	1:1	P
U. C. San Diego (Masek)	EPB XI F3	79	3/27/68	In progress	$K^0{}_2(e_3)$ charge asymmetry	87	903	169	1834	1:1	P
U. C.–Los Angeles (Nefkens) LRL (Crowe)	Internal west area straight section	88	12/5/68	In progress	$\pi^-p \rightarrow n\gamma$ differential cross sections	½	7	½	7	1:1	P
U. Michigan (Jones)	Internal north area straight section	94	7/23/68	In progress	Neutron cross-section for p,d, and various metal targets	63	705	113	1249	1:1	P
Space Science Laboratory (Smith)	Internal west area straight section	P-30	10/1/68	In progress	Counter tests for balloon experiment	6½	74	6½	74	1:1	S
U. of Arizona (Jenkins)	Internal west area straight section	P-34	10/8/68	11/7/68	Preliminary equipment tests for experiment #88	5	58	5	58	1:1	S

field of the Bevatron determines the length of time of the spill. The motor generator room group was able to provide a separate slope control for the last 100 to 200 msec of flattop. This gave a control of slope for the "rf spill" that was different from the slope set on the earlier part of flattop for the EBS beam spill. This additional slope control gave increased flexibility in beam distribution to the experimenters. This type of flexibility is essential if we are to successfully operate simultaneously from 10 to 12 experiments.

II. SHUTDOWN

The Bevatron was shut down for 48 hours from 8:00 a.m. Thursday November 28 until 8:00 a.m. Saturday November 30 for the Thanksgiving holidays.

On December 20 the Laboratory was closed for the Christmas Holidays and for a two-day period of enforced vacation. Laboratory operations resumed on December 30, but the Bevatron remained shut down. The Bevatron was scheduled to resume operation about the middle of January. During the Bevatron shutdown, routine inspection and maintenance were done on the main motor generator, the main magnet, and associated equipment.

III. BEVATRON DEVELOPMENT AND STUDIES

The Bevatron development periods this quarter were devoted to a number of areas of machine improvements. Resonant-extraction studies continued for the external proton beam system. Some testing was done of a computer control system for the external proton beam magnets. The remaining effort was devoted to studies of: (i) high-beam effects, (ii) orbit dynamics, (iii) beam spill technique, (iv) ripple control tests, (v) main magnet pulsing modes--flattop, "mezzanine," and "back-porch"--and (vi) tests of new final rf amplifier tube for the Bevatron acceleration electrode.

IV. BEVATRON MOTOR GENERATOR

The magnet pulsing record is shown in Table II.

REFERENCES

1. Fred H. G. Lothrop, Bevatron Beam Spill by Amplitude Modulation, Rev. Sci. Instr. 37 [3], 358-361 (1966).

Table II. Bevatron motor generator set monthly fault report.

1968	4 to 6 pulses/min								7 to 8.7 pulses/min							
	1.5 to 6.9 kA				7.0 to 9 kA				1.5 to 6.9 kA				7.0 to 9 kA			
	Pulses	Faults AB	Faults AT	P/F	Pulses	Faults AB	Faults AT	P/F	Pulses	Faults AB	Faults AT	P/F	Pulses	Faults AB	Faults AT	P/F
Jan.	–	–	–	–	200	–	–	–	4 956	–	–	–	9 182	1	1	4 591
Feb.	–	–	–	–	1 625	–	–	–	–	–	–	–	25 816	2	8	2 582
March	1 834	0	–	–	–	–	–	–	687	–	–	–	15 065	1	7	1 883
April	1 689	–	–	∞	180	–	–	∞	203	–	–	∞	960	1	1	480
May	1 594	–	–	∞	308	–	–	∞	–	–	–	–	976	–	–	–
June	873	1	1	436	173	–	–	∞	410	–	–	∞	–	–	–	–
July																
Aug.									10 819	1	7	1 352	2 515	1	3	628
Sept.	1 711	–	–	∞	207	–	–	∞	42 050	1	0	42 050	434	–	–	∞
Oct.									33 288	1	1	16 644	3 345	0	1	3 345
Nov.													15 768	0	2	7 884
Dec.	–	–	–	–	–	–	–	–	–	–	–	–	8 370	1	3	2 092

1968	9.3 to 17 pulses/min								Total				
	1.5 to 6.9 kA				7.0 to 9 kA				Pulses	Arc-backs (AB)	Arc-through (AT)	P/F	Ignitrons replaced
	Pulses	Faults AB	Faults AT	P/F	Pulses	Faults AB	Faults AT	P/F					
Jan.	414 210	9	27	11 506	4 289	1	2	1 430	432 837	11	30	10 557	0
Feb.	195 627	6	9	13 042	55 162	2	10	4 596	278 230	10	27	7 520	1
March	293 760	46	7	5 543	88 108	14	13	3 263	399 454	61	27	4 539	2
April	198 047	9	11	9 902	183 230	10	36	3 983	384 309	20	48	5 652	2
May	95 108	3	6	10 568	106 720	13	27	2 668	204 706	16	33	4 178	1
June	303 899	16	29	6 753	114 209	10	27	3 087	419 566	27	57	4 995	1
July	425 825	20	50	6 083	3 474				429 299	20	50	6 133	0
Aug.	409 847	27	34	6 718					423 181	29	44	5 797	0
Sept.	284 739	5	7	23 728	1 386	–	–	∞	330 527	6	7	25 425	1
Oct.	333 528	5	26	10 758					400 266	6	28	11 772	0
Nov.	338 412	2	11	26 031	2 524	–	–	∞	356 704	2	13	23 780	0
Dec.	261 836	4	1	52 367	1 684	–	2	842	271 890	5	6	24 717	4

STAFF

Edward J. Lofgren	Bevatron Group Leader
W. A. Wenzel	Alternate Group Leader
Walter D. Hartsough	In charge of Bevatron operations
Kenneth C. Crebbin Fred H. G. Lothrop Wendell Olson	Operation Supervisors
William Everette	Radiation Control
G. Stanley Boyle Frank W. Correll Robert G. Gisser Ashton H. Brown Joseph F. Smith	Operating Crew Supervisors
Richard L. Anderson Robert W. Brokloff Gary M. Byer Donald N. Cowles Charles H. Hitchen Robert M. Miller Harvey K. Syversrud John E. Tommaney Stanley T. Watts	Bevatron Operators
Robert V. Aita Robert W. Allison, Jr. Robert A. Belshe James P. Brannigan Duward S. Cagle Kenneth C. Crebbin Warren W. Chupp Tom Elioff Hugh M. Ellison Don M. Evans Robert Force James B. Greer James R. Guggemos Fred H. G. Lothrop Donald Milberger Robert Richter Edward W. Stuart Marsh M. Tekawa W. A. Wenzel Glenn White Emery Zajec	Development and Support
Edward Hartwig Robert Force	In charge of Electrical Engineering Group
Marion Jones	In charge of Electrical Coordination Group
William Salsig Abe Glicksman Cedric Larson	In charge of Mechanical Engineering
Harold Vogel Robert Frias	In charge of Motor Generator Group