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BEVATRON OPERATION AND DEVELOPMENT. XXXII

November 1961 through January 1962

Berkeley, California

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BEVATRON OPERATION AND DEVELOPMENT. XXXII

November 1961 through January 1962

Kenneth C. Crebbin, William W. Salsig,
William A. Wenzel, and Fred H. G. Lothrop

December 14, 1962

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ABSTRACT

Experimental work consisted of: two continuing runs in the 72-inch hydrogen bubble chamber; K^- interactions at 1.2 to 1.95 BeV/c, and $\pi^\pm$ differential scattering. A new experiment started–study of K^--p scattering by using spark chambers (0.33 to 1.4 BeV/c). An emulsion exposure was made in a 900-MeV/c π^- beam.

The flywheels and shaft assemblies for the main generators were changed during the October shutdown. A vacuum extension tank was provided for external secondary beams. New induction electrodes and rapid beam ejector coils were installed. A trial poleface winding, and magnetic field and gradient probe were installed.

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I. OPERATION

The Bevatron operation record is presented in Fig. 1 and Tables I and II.

The machine was shut down from October 9 to November 4 for maintenance and for installation of new components. The primary job during this shutdown was the replacement of the main MG-set flywheels. The Bevatron was shut down from December 24 to December 30 for maintenance. The vacuum shutdown lasted 17 hours.

For a trial period starting December 1, the Friday morning shutdown for weekly maintenance was stopped. The Tuesday morning shutdown would be extended into the afternoon when required by the work load.

II. SHUTDOWN

A. October and November

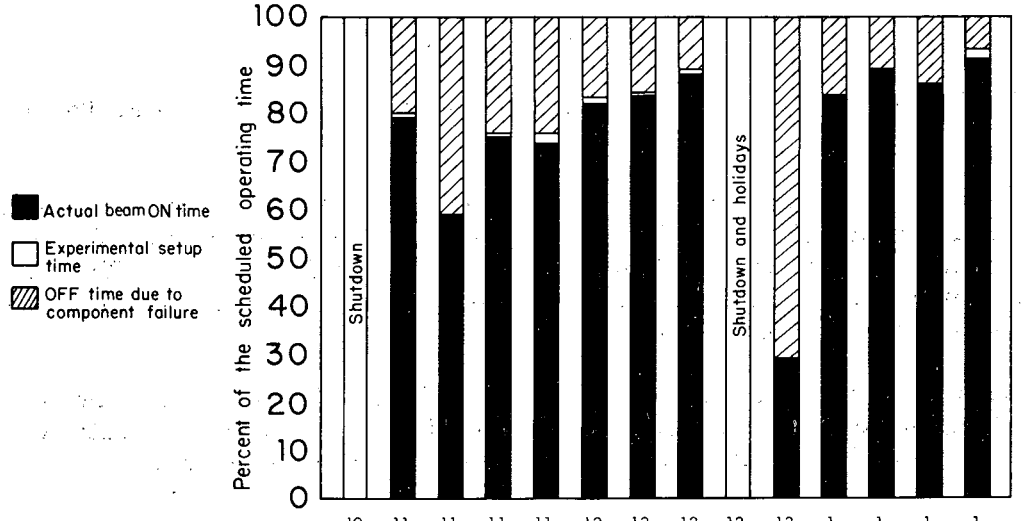
1. New Flywheel and Shaft Assemblies for Generators

W. W. Salsig

Between October 9 and November 7, 1961, new flywheel-and-shaft assemblies were installed on both generators. The existing units were replaced because the steel characteristic, combined with a sharp keyway notch, presented an ever-present possibility of sudden brittle rupture which could have been disastrous to personnel in the area, nearby equipment, and future Bevatron schedules. The new equipment was fabricated from vacuum-poured steel forgings, and achieved the best brittle-failure protection yet provided in very large components–Fracture Appearance Transition Temperature (FATT) of 0 to 10° F for both shafts and 36-in. -thick flywheel disks. The flywheel is mounted on the shaft by shrink fit only. No key is provided between shaft and flywheel.

Additional improvements were made when the flywheels were installed:

(1) All generator pedestals were electrically insulated and a single grounding-brush arrangement was provided on the motor coupling. In the future this should prevent large fault currents from going to ground through the journals, with consequent major arc damage to the journals.



Week of		10/29	11/5	11/12	11/19	11/26	12/3	12/10	12/17	12/24	12/31	1/7	1/14	1/21	1/28
Crew hours		168	168	168	120	168	168	168	168	48	120	168	168	168	168
Turn-on and maintenance time	(h)	0	0	9	5	5	5	5	9	0	5	9	5	5	9
Scheduled operating time	(h)	0	83	155	112	163	157	160	152	0	115	154	157	157	151
Scheduled Bevatron test time	(h)	0	0	4	3	0	6	3	7	0	0	5	6	6	8
Scheduled shutdown time	(h)	168	85	0	0	0	0	0	0	120	0	0	0	0	0
Holiday	(h)	0	0	0	48	0	0	0	0	48	48	0	0	0	0

MU-29140

Fig. 1. Bevatron operating schedule, November 1961 through January 1962.

Table I. Beam record.

Week of	Number of 8-hour shifts	Total integrated beam (10^{15} protons)
(1961)		
Oct. 29 - Nov. 4	----------Shutdown----------	
Nov. 5 - 11	10	0.6
Nov. 12. - 18	20	1.9
Nov. 19 - 25	14	2.7
Nov. 26 - Dec. 2	21	4.1
Dec. 3 - 9	21	6.0
Dec. 10 - 16	21	5.6
Dec. 17 - 23	19	7.2
Dec. 24 - 30	----------Shutdown----------	
Dec. 31 - Jan 6, 1962	6	0.7
(1962)		
Jan. 7 - 13	21	7.5
Jan. 14 - 20	21	10.2
Jan. 21 - 27	20	11.0
Jan. 28 - Feb. 3	21	6.9

Maximum beam amplitude at full energy = 2.2×10^{11} protons per pulse
Maximum injected beam = 600 μA
Average beam per 8-hour shift = 3×10^{14} protons

Table II. Analysis of the total lost beam time due to component failure (%).

Month	Injector	Magnet power supply	rf accelerating system	Other
Nov. 1961	46	10	20	24
Dec. 1961	52	16	11	21
Jan. 1962	27	25	15	33

(2) New coupling studs with low FATT were fitted.

(3) The shaft axis was again made horizontal. During 8 years of operation the foundations had tilted 1/8 in., which allowed the journal shoulders to bump bearing thrust lands and upset the vibration monitoring when the generators were running unexcited.

(4) Journals on the new flywheel shafts were made 0.040 in. oversize so that existing bearings could be rebored. Essentially, this provided new bearings on these shafts, and corrected a bearing oversize condition incurred years ago when the journals were "wiped" during a lubrication failure.

The shafts will be removed from the old flywheels and the flywheels used as backstop shielding for the new external proton beam. Flywheel geometry is optimum for this application.

2. Quadrant III 29-deg Area Vacuum Nozzle

The thin window in the Quadrant III 29-deg area was removed and replaced by a vacuum extension tank. This required modification of the leg slabs. A plan view of this is shown in Fig. 2.

By coupling vacuum piping to this extension tank, the secondary beam can now be kept in vacuum all the way to the experimental target area. In addition the vacuum tank through the leg slabs provides space for collimators and small magnets to give better control of secondary beam optics as the beam passes through the fringing field of the Bevatron.

3. Rapid Beam Ejector (RBE)

The RBE coils[1,2,3] had to be relocated to make room for the proposed external beam magnets. This was a reasonable time to incorporate some additional modifications. A smaller more rigid coil was built and potted in epoxy.[4] This was installed in the east tangent tank. Short beam pulses for two experimentors per Bevatron pulse are provided by double pulsing the RBE. Some programming of the rf is necessary to have some of the beam survive the first RBE pulse.

4. Induction Electrodes

F. H. G. Lothrop

Relocation of the RBE from the south tangent tank to the east tangent tank required the complete removal of the east sum induction electrode.[5] In anticipation of this move, an electrode was designed and fitted into the transition area at the exit of Quadrant II last summer. Calibrations were made against the east electrode. The east electrode was removed and the associated electronics moved to the outside south platform during the October shutdown.

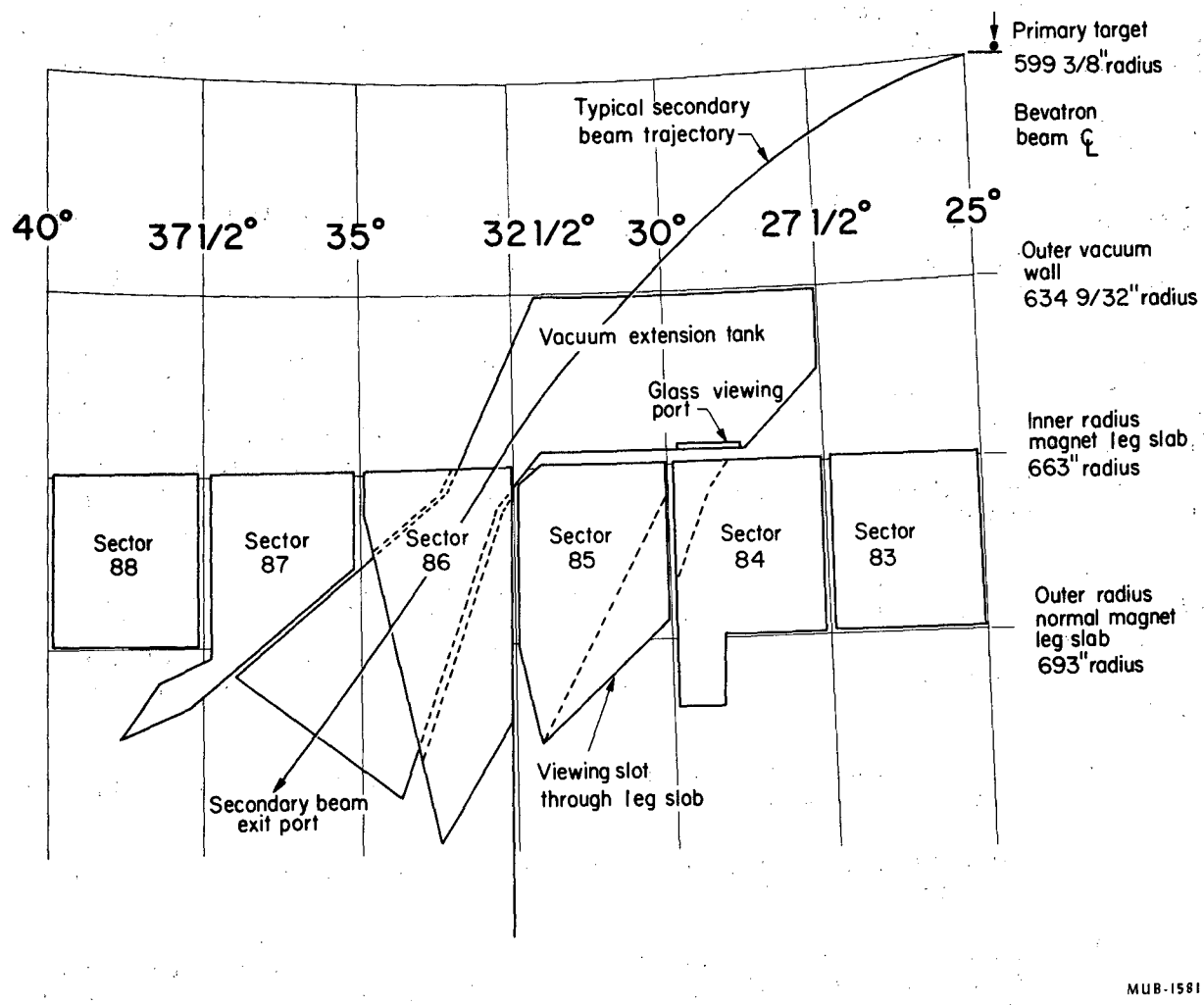


Fig. 2. Quadrant III 29-deg area, showing modified leg slabs (sectors 84, 85, 86, 87), vacuum extension tank, and typical secondary beam trajectory.

The new system[6,7] was modified to provide information of radial beam position over the central 2 ft of aperture. This is a change from about 2 in. either side of centerline covered by the old system. The output of the new electrodes can now serve as an input to the automatic radius-control system.

5. rf System

Plumbing, electrical, and platform changes were made in preparation for the new rf system to be installed during the long shutdown starting June 15, 1962.

6. Poleface Windings

The beam intensity in the Bevatron is expected to increase by a factor of from 25 to 50 when the Mark II linear-accelerator injector is installed. This will increase the residual radiation to where it creates a hazard to persons working in the gap.

The present poleface windings are copper tubing pulled through stainless steel tubes clamped to the pole tips. Insulation is provided by a melamine strip between the pole tips and the stainless steel tubing and clamps. The windings require periodic maintenance to remove minor shorts, usually caused by small metallic chips shorting from the pole face to the clamps or stainless steel tubing.

Completely sheathing the conductor in an insulator reduces the probability of shorts of this type. However, the insulator must be covered on the beam side with a conductive surface to prevent charging of the insulator—which can disturb the beam. The insulator must satisfy the following requirements:

(1) It must be able to withstand the physical, electric, magnetic, and thermal stresses that are applied.

(2) It must be able to withstand the above stresses after absorbing 10^8 rad of radiation.

(3) It must not outgas to the extent that it raises the pressure of the Bevatron. Polyethylene seems to be the best material available. This is to be covered and held in place by a stainless steel cap. A sheet of Nema-G-10-glass reinforced epoxy sheet insulates this assembly from the pole faces. The working voltage of the winding is raised from 1 to 5 kV with the new insulation.

Before changing the entire Bevatron, a test winding was installed in Quadrant II (lower poleface winding No. 19) to see if any unanticipated problems arose.

The initial physical characteristics of polyethylene can be improved for our use by using irradiated polyolefin.[8] The original samples of irradiated polyolefin and all the samples of chemically cross-linked polyethylene tested were unsatisfactory for use in vacuum. Only plain irradiated polyolefin without chemical additives has shown good vacuum properties.

7. Traveling Target

The track for the traveling target in Quadrant III was extended 2 deg, for a total of 30 deg. This permitted moving the target to a position where it could be observed through a port at the 29-deg vacuum-nozzle area.

8. Magnetic Field and Gradient Probe

A radially adjustable probe was installed in Quadrant II sector to measure field and gradient in the Bevatron. This probe can be operated from the main control room. The accuracy of field measurement is 0.1%, of gradient 3%. The remanent field of the Bevatron is measured with an rf magnetomotor. The dynamic field is measured by measuring the change in flux. The outputs of these coil sets are fed into a voltage-to-frequency converter. The frequency output is fed into a digital frequency counter that is calibrated to read the field and gradient directly in gauss and gauss per 2 inches.

A probe such as this provides essentially two basic services. It is a diagnostic tool for normal operating problems. It can be used to study the effect of poleface winding currents or other magnetic changes such as modified leg slabs.

As a diagnostic tool our probe has already provided some information. When the Bevatron's magnet pulse rate is changed, there is a certain amount of retuning necessary to accelerate maximum beam. The magnetic field, in particular the remanent field, has often been blamed for this effect. Probe measurements at 9.3 pulses per minute (p.p.m.), 10.9 p.p.m. (normal operating rate), and 12 p.p.m. showed no detectable change in either remanent or dynamic field in the sector being monitored.

B. December 26 - 28

The vacuum shutdown lasted for 17 hours, starting on the morning of December 26. The following jobs were carried out during this shutdown.

(1) A ground shield was placed on the RBE coil to prevent any charge-up on the epoxy-covered coils from disturbing the beam. Glass-fiber-reinforced epoxy printed circuit board was used because of its rigidity and thinness of the metal surface. Lines were etched in the copper to reduce eddy-current losses. The shielding was lashed to the coil form with monofilament nylon fishing line.

(2) A vacuum valve was installed at the Quadrant III 29-deg beam port. This permits use of the secondary beam without having to go through a thin window. It also permits use of a thinner window when isolation of the Bevatron and experimental vacuum systems is necessary.

(3) The protective doors for the old thin window at Quadrant III 29-deg port were removed. This solves the problem of their coming loose and swinging out to block the aperture, as happened after the last shutdown.

(4) A broken wire to the field and gradient probe was replaced. The signal cable from the probe to the driver control goes through a flexible metal spring which coils up on a drum. As the probe is

positioned this wire is twisted. This caused a break in one lead. A polyethylene sleeve was placed around the wires to provide a smoother surface for the wires to twist against.

(5) Vertical clippers were installed in the east straight section to check vertical position of the beam. This was to check beam position changes due to subsidence of the Bevatron, caused by tunneling operations under the inside foundation.

(6) A flip target was installed near the exit of Quadrant III for a future run.

(7) Routine servicing and maintenance was done on the Bevatron magnet and associated equipment.

III. IMPROVEMENT PROGRAM PROGRESS

A. Shielding Progress

W. W. Salsig

During November and the early part of December shielding design work was concentrated on completing drawings and obtaining bids on the new roof shielding, estimated to be the longest delivery item in the shielding block program. During the first part of January we let the contract for 7100 tons of concrete, in the form of 236 blocks of 11 different designs, each 43 ft long and 30 tons in weight.

The latter half of this report period was devoted to restudying wall-block and labyrinth requirements, including fabrication of aluminum blocks for the 1/48-size Bevatron model, to better visualize optimum block geometry.

B. External Beam

W. A. Wenzel

Work continues on the "two-magnet" system, which should bring the beam out with a considerably reduced dispersion, compared with the earlier "one-magnet" system. Installation of the internal magnets is scheduled for February.

Construction and testing of the four laminated internal magnets continued. Characteristics are as follows:

1. M_1, C-magnet aperture 3 in. radial by 2 in. vertical; length 13 in.; septum (including coil) 1 in.; maximum field 9.6 kG.

2. Q_1, current sheet (Panofsky type) quadrupole aperture 3 by 3 in.; length 24 in.; septum 1 in.; gradient 750 G/in. maximum.

3. M_2, C-magnet; aperture 4 by 6 in.; length 50 in.; maximum field 7.0 kG.

4. Q_2, current sheet (Panofsky type) quadrupole; aperture 6 by 6 in.; length 24 in.; gradient 500 G/in. maximum.

A life test was begun on a plunging mechanism for positioning the assemblies of the internal magnets. Reproducibility of the mechanism is excellent; positioning errors have been reduced to a few thousandths of an inch. A 6-in.-diameter differentially pumped chevron seal for the plunging mechanism has been successfully developed and tested.

Development of a regulator suitable for controlling the four power supplies is in progress. A combination of slow "mag-amp" and fast transistor regulation will be used to achieve the precision of ±0.1% required for the magnetic field of M_2.

Design has begun on the magnets to be used on the west outside platform. M_3 will be a laminated skewed H-magnet of aperture 2 by 5 in. and length 54 in. with a design operating field of 15 kG. Q_3 will be a laminated doublet quadrupole set with hyperbolic pole surfaces, following a Brookhaven design. The aperture will be 4.4 in. diameter and the length of each quadrupole section will be 29 in.. A maximum operating gradient of 6.2 kG/in. is required.

IV. RESEARCH

The experimental program from January 1961 through December 1961 is summarized in Table III. Table IV lists the experiments done during January 1962.

V. MAGNET POWER SUPPLY

The record of magnet pulsing appears in Table V.

Table III. Summary of Bevatron experimental research program, January through December 1961.

Group	Start of experiment	End of experiment	Experiment	Beam time (start of run through Dec. 1961) 12-hour periods	hours	Pulse schedule	Primary or secondary experiment
Internal Groups							
Alvarez	4-22-60	6-11-61	$\pi^{\pm}$ interactions in hydrogen and deuterium, by using the 72-inch hydrogen bubble chamber (0.9 to 1.6 BeV/c).	304 50	3096 548	1:1 1:2	P
Alvarez	8-9-60	1-24-61	K^- interactions in hydrogen and deuterium, by using the 15-inch hydrogen bubble chamber (740 MeV/c)	119 34	1279 330	1:1 1:2	P
Lofgren	12-7-60	1-31-61	K^+-p and K^+-n total cross sections and elastic scattering (1 to 3 BeV/c).	22 10	248 106	1:1 1:1	P S
Lofgren	1-27-61	1-31-61	π^+-p scattering, measurement of angular distribution (1.5, 2.0, and 2.5 BeV/c).	3	25	1:1	S
Segrè	2-5-61	5-28-61	π-π scattering (280-MeV/c to 2.25-BeV/c π^-).	83	769	1:1	P
Barkas	3-9-61	3-15-61	Emulsion exposure (740-MeV/c K^-).	10	87	1:1	P
Lofgren	3-16-61	4-23-61	Spark-chamber tests in a π-meson beam.	--	14	1:1	S
Lofgren	4-21-61	6-10-61	Study of Σ, Λ decay polarization, by using spark chambers (1-BeV/c π^+).	38 4	459	1:1	P S
Crowe	6-4-61	7-17-61	Ke_3, $K\mu_3$ decay spectra (700-MeV/c K^+).	38 --	426 129	1:1 1:1	P S
Powell	6-10-61	9-19-61	Study of $\Lambda^0, \Sigma^+, \Sigma^-$ leptonic decay, by using the 30-inch propane bubble chamber (700-MeV/c K^-).	42 19	455 290	1:1 1:1	P S

Table III. (continued)

Group	Start of experiment	End of experiment	Experiment	Beam time (start of run through Dec. 1961) 12-hour periods	Hours	Pulse schedule	Primary or secondary experiment
Internal Groups							
Alvarez	6-11-61	6-11-61	Study of RBE spill on targets. Preliminary studies for a future experiment.	--	9	1:1	P
Lofgren	7-10-61	7-13-61	Test of a hydrogen Cerenkov counter.	--	30	1:1	S
Segrè	7-21-61	9-7-61	π-π scattering (280-MeV/c to 2.25-BeV/c π^-).	41	448	1:1	P
Moyer	8-11-61	8-12-61	Test counters for a future experiment.	--	15	1:1	S
Alvarez	8-16-61	8-25-61	Test counters for a future experiment.	--	6	1:1	S
Alvarez	8-29-61	In progress	K^- interactions in hydrogen, by using the 72-inch hydrogen bubble chamber (1.2 to 1.95 BeV/c).	42	479	1:1	P
Moyer	8-28-61	12-22-61	$\pi^{\pm}$-p differential scattering. Measurement of angular distributions and polarization (0.5 to 1.5 BeV/c).	56 21	549 238	1:1 1:1	P S
Alvarez	9-1-61	In progress	Study the reactions $\pi^- - p \rightarrow \pi^+ + \pi^- + n$, by using the 72-inch hydrogen bubble chamber (700 MeV/c).		Time is included with the K-meson experiment.		S
Chamberlain, Glaser, Lofgren	12-8-61	12-21-61	Test and calibration of a liquid-hydrogen counter.	1	15	1:1	S
Perlman	Chemistry target bombardments (26) in the internal proton beam.						

Table III. (continued)

Group	Start of experiment	End of experiment	Experiment	Beam time (start of run through Dec. 1961) 12-hour periods	Hours	Pulse schedule	Primary or secondary experiment
External Groups							
Institution and experimenter							
Univ. Chicago Northwestern U. Livi-Setti	1-14-61	1-23-61	Emulsion exposure (800-MeV/c K^-). Study of production of hyperfragments.	9	106	1:1	P
Duke Univ. Block	1-27-61	4-10-61	K^- interactions in a helium bubble chamber (740-MeV/c).	65[a]	636[a]	1:1	P
U. Tennessee King	3-16-61	3-16-61	Emulsion exposure (740-MeV/c K^-).	--	$1\frac{1}{2}$	1:1	P
U. Stockholm Ekspong	4-12-61	4-13-61	Emulsion exposure (700-MeV/c K^-).	2	30	1:1	P
Univ. Miami Perlmutter	4-13-61	4-15-61	Emulsion exposure (700-MeV/c K^-).	1	14	1:1	P
Tufts Univ. Schneps	4-15-61	4-15-61	Emulsion exposure (700-MeV/c K^-).	2	18	1:1	P
Oxford Univ. Wilkinson	4-16-61	4-20-61	Emulsion exposure (700-MeV/c K^-).	9	88	1:1	P
Univ. Washington Masek	7-19-61	7-31-61	Test of a hydrogen Cerenkov counter.	5	50	1:1	S
U. Chicago	8-18-61	8-20-61	Emulsion exposure (700-MeV/c K^-).	3	41	1:1	P
U. Michigan Jones, Perl	9-10-61	9-24-61	Study of $\pi^{\pm}$-p elastic scattering (3 to 5 BeV/c).	16 2	213 20	1:1 1:1	P S
Washington U., St. Louis, Mo. Friedlander	12-12-61	12-12-61	Emulsion exposure (900-MeV/c π^-).	--	1	1:1	P

[a] This experiment was done on a 1:1 and 1:2 pulse basis. The beam-time record, however, represents the equivalent of 1:1 pulse operation.

Table IV. Summary of Bevatron experimental research program, January 1962.

Group	start of experiment	End of experiment	Experiment	Beam time (start of run through Jan. 1962) 12-hour periods	hours	Pulse schedule	Primary or secondary experiment
Internal Groups							
Alvarez	8-29-61	In progress	K^- interactions in hydrogen, by using the 72-inch hydrogen bubble chamber (1.2 to 1.95 BeV/c).	69 30	722 358	1:1 1:1	P S
Alvarez	9-1-61	In progress	$\pi^\pm$ differential scattering, by using the 72-inch bubble chamber.	(Included in above totals)			
Lofgren	1-7-62	In progress	K^--p scattering experiment, by using spark chambers (0.33 to 1.4 BeV/c).	20 23	248 225	1:1 1:1	P S

Table V. Bevatron motor-generator set monthly fault report.

	4 to 6 pulses per minute				7 to 9 pulses per minute				10 to 17 pulses per minute				Totals					
	1500 to 6900 A		7000 to 9000 A		1500 to 6900 A		7000 to 9000 A		1500 to 6900 A		7000 to 9000 A			Faults				
MONTH	Pulses	Faults	Pulses	Faults	Pulses	Faults	Pulses	Faults	Pulses	Faults	Pulses	Faults	Pulses (P)	Arc-backs	Arc-throughs	Total (F)	P/F	Ignitrons replaced
(1961)																		
Jan.	2001	--	1200	--	5099	--	--	--	6671	--	277091	59	292062	24	35	59	4951	--
Feb.	--	--	--	--	--	--	--	--	4431	--	345853	45	350284	9	36	45	7784	--
Mar.	--	--	--	--	--	--	--	--	3941	--	396827	51	400768	10	41	51	7857	--
April	--	--	--	--	--	--	--	--	4364	--	398449	55	402813	20	35	55	7323	--
May	--	--	--	--	--	--	--	--	2752	--	416350	61	419102	16	45	61	6870	--
June	--	--	--	--	--	--	--	--	9781	--	343112	38	352893	7	31	38	9287	--
July	--	--	--	--	--	--	--	--	3891	--	373182	41	377073	11	30	41	9197	--
Aug.	--	--	--	--	--	--	--	--	10235	--	322324	53	332559	15	38	53	6275	--
Sept.	--	--	--	--	--	--	--	--	5010	--	351237	44	356247	7	37	44	8097	--
Oct.	--	--	--	--	--	--	--	--	1308	--	110165	11	11473	11	--	11	1044	--
Nov.	1080	--	--	--	6684	--	--	--	11633	--	235942	45	255339	10	35	45	5675	Flywheel shutdown
Dec.	--	--	--	--	838	3	2905	2	2477	--	317347	48	323567	16	37	53	6105	
(1962)																		
Jan.	--	--	--	--	--	--	--	--	4911	--	383584	50	388495	23	27	50	7769	--

ACKNOWLEDGMENTS

Edward J. Lofgren is the Bevatron Group Leader; William A. Wenzel is the Alternate Group Leader. Walter D. Hartsough, with Glen R. Lambertson and Wendell Olson assisting, is in charge of Bevatron Operation. Members of the Operating Crew are: Robert W. Allsion, G. Stanley Boyle, Robert W. Brokloff, Ashton H. Brown, Duward Cagle, Norris D. Cash, Frank W. Correll, Ferdinand Dagenais, John R. Ellisen, Robert Gisser, William Kendall, William Lee, Wayne Logan, David Loucks, Kenneth Morgan, and Martin E. Scolnick. The following members of the Operating Group are carrying out support and development projects: Robert Anderson, Perry Arana, Trancuilo Canton, Warren Chupp, Bruce Cork, Kenneth Crebbin, Walter Hartsough, Rudin Johnson, Leroy Kerth, Glen Lambertson, Fred Lothrop, Ross Nemetz, Douglas Pounds, Robert Richter, Joseph Smith, William Wenzel, Glenn White, Emery Zajec, and Theodore Zipf. Engineering Groups were headed by Edward Hartwig, Electrical Engineering; Clarence Harris, Electrical Coordination; Harold Vogel and Gordon Harding, the Motor Generator Group; and William Salsig, Mechanical Engineering. Donald Milberger was in charge of the Electrical Maintenance Group.

REFERENCES

1. Charles G. Dols, The Electrical System of the Bevatron Rapid Beam Ejector, University of California Radiation Laboratory Report UCRL-8346, June 1958 (unpublished).

2. Walter D. Hartsough, Bevatron Operation and Development. XV, University of California Radiation Laboratory Report UCRL-8114, January 1958 (unpublished).

3. Walter D. Hartsough and Glen Lambertson, Bevatron Operation and Development. XVII, University of California Radiation Laboratory Report UCRL-8334, June 1958 (unpublished).

4. John R. Shively, Bevatron Rapid Beam Ejector III Coil Epoxy - Insulation Development, Lawrence Radiation Laboratory Engineering Note EN 7307-12-MI, April 1962 (unpublished).

5. Harry Heard, Bevatron Beam Induction Electrodes, University of California Radiation Laboratory Report UCRL-3609, February 1957 (unpublished).

6. Fred H. G. Lothrop, Beam Induction Electrode System, Lawrence Radiation Laboratory Report Bev-691, November 1961 (unpublished).

7. Fred H. G. Lothrop, Bevatron Induction Electrodes, Lawrence Radiation Laboratory Report UCRL-10132, July 1962 (unpublished).

8. Maurice Zaslawsky, The Effect of Radiation on Low Density Polyethylene, Lawrence Radiation Laboratory Report UCID-4443, ENS-117, March 1962 (unpublished).

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