Title
BEVATRON OPERATION AND DEVELOPMENT. X. May, June, July 1956.

Permalink
https://escholarship.org/uc/item/2rq3b2z8

Author
Hartsough, Walter.

Publication Date
1956-11-08

DISCLAIMER

UCRL-3519
Physics Distribution

UNIVERSITY OF CALIFORNIA
Radiation Laboratory
Berkeley, California
Contract No. W-7405-eng-48

BEVATRON OPERATION AND DEVELOPMENT. X.

May, June, July 1956

Walter Hartsough

November 8, 1956

Printed for the U. S. Atomic Energy Commission

BEVATRON OPERATION AND DEVELOPMENT. X.

Contents

Beam Monitoring

Bevatron Development

Beam Studies

BEVATRON OPERATION AND DEVELOPMENT. X.

May, June, July 1956

Walter Hartsough

Radiation Laboratory
University of California
Berkeley, California

November 8, 1956

ABSTRACT

The absorption of antiprotons in hydrogen was measured by use of counters and a liquid hydrogen target. An experiment was begun using a lead glass Cerenkov counter to observe the annihilation of antineutrons produced from antiprotons by charge exchange in a beryllium target. Emulsion was exposed to a focused and analyzed antiproton beam for seven groups.

The investigation of K-meson production, interaction, and decay was continued by four groups at this laboratory, using counters, emulsions, a 10-inch liquid hydrogen bubble chamber, and a propane bubble chamber. Nine emulsion exposures to focused and analyzed K-meson beams were made for seven groups outside this laboratory. The study continued of the π^0 modes of heavy-meson and hyperon decay. The angular distribution of θ^0 meson decay was measured.

Twenty-five target bombardments in the internal proton beam were made for the chemistry group.

The internal beam-deflection magnet and an energy-loss target were installed in the Bevatron. The number of quadrant-mounted targets for use by the experimental groups was increased from seven to eleven.

The new wide-band rf driver was tested. Although it was possible to accelerate a beam to full energy with this unit, modifications to both the new driver and the existing final-amplifier saturating supply will have to be made before satisfactory operation will be obtained.

BEVATRON OPERATION AND DEVELOPMENT. X.

May, June, July 1956

Walter Hartsough

Radiation Laboratory
University of California
Berkeley, California

November 8, 1956

EXPERIMENTAL FACILITIES

During the shutdown of June 11, 1956 the outside platform at the west experimental area was strengthened. The allowable platform load limit was increased from 1000 lb/ft^2 to 2000 lb/ft^2. Five additional quadrant-mounted flip-type targets were installed. Table I lists the quadrant-mounted targets that were available during the latter half of this period.

BEAM MONITORING

New Sum and Radial Discrimination Beam Induction Electrodes

Two new beam induction electrode assemblies were installed in the south straight section. These replaced the electrode described in the preceding quarterly report.[1] The new design allows installation of the electrodes in the confined transition sections between the tangent tank and the magnet so that the tangent tank itself can be free of obstruction for the installation of the internal-beam deflection magnet. The same design considerations, described for the previous electrode sets, were optimized empirically by model tests: The assembly should not present any obstruction to the beam; the electrodes should have a minimum capacity to ground; the assembly for radial beam-position information should yield maximum beam-position discrimination but should have a sum-signal output independent of the radial location of the beam; the electrodes should be shielded. Transistor cathode followers were installed on each electrode. Figure 1 pictures the sum-signal electrode; Fig. 2 shows the relative signal amplitude vs beam position for the radially split electrode model.

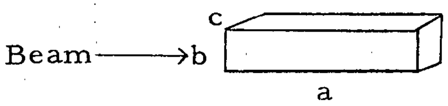
---

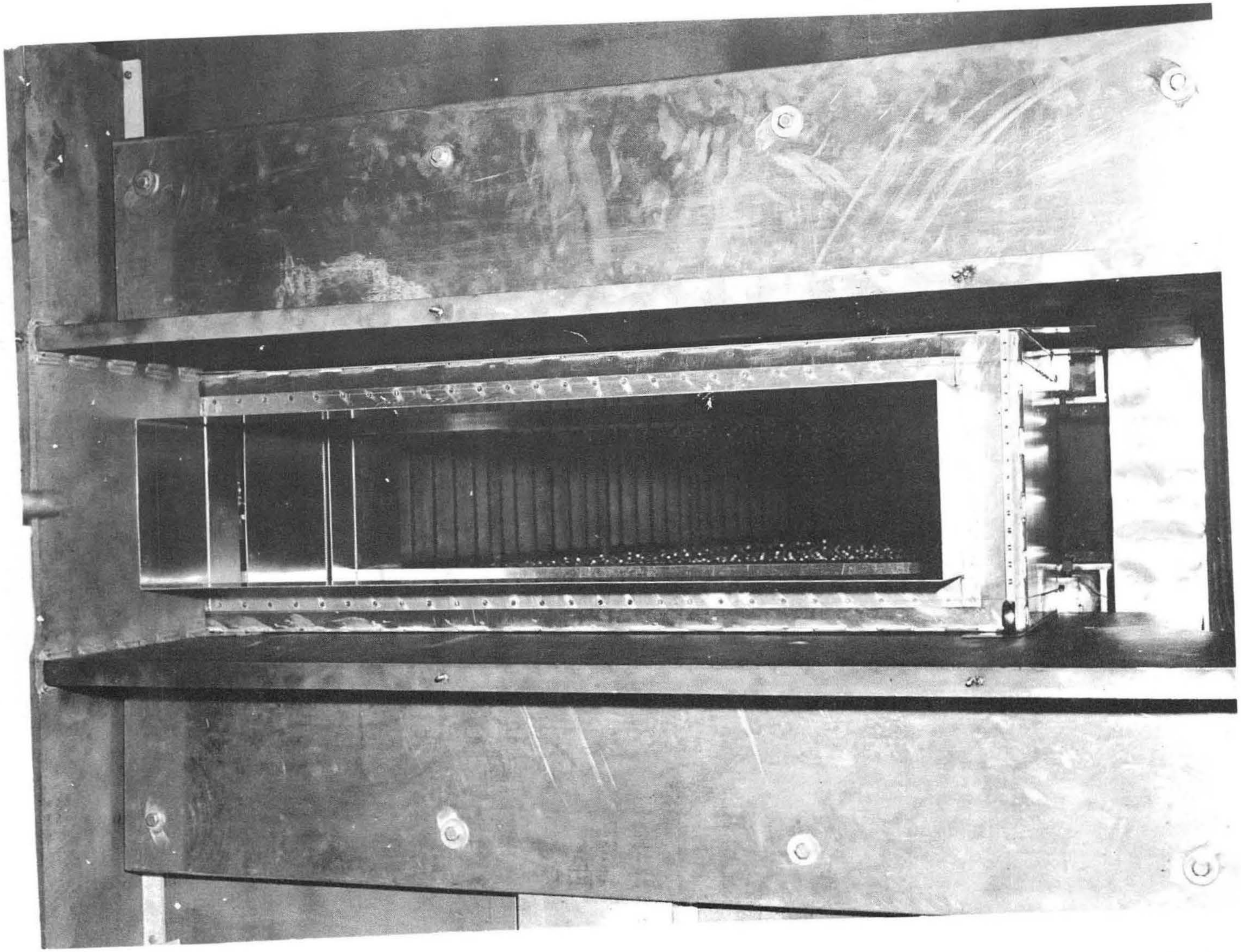
[1] Walter Hartsough, Bevatron Operation and Development. IX, UCRL-3444, June 6, 1956.

Table I. Quadrant-mounted targets

(June 11 to July 31, 1956)

Quad-rant	Azimuthal location (Ref: West straight section)	Radial location		Target material	Target size a x b x c (in.)
		Outer-radius edge of target (in.)	Outer-radius edge of lip (in.)		
II	$2^{\circ}24'$	598-13/16	599-3/8	Copper	1 x 1 x 1
II	$5^{\circ}01'$	600-9/16	601-1/16	Beryllium	6 x 1/2 x 1
II	$5^{\circ}35'$	599-3/8	599-9/16	Copper	1 x 1/2 x 1/2
II	$8^{\circ}04'$	601-15/16	602-3/16	Copper	6 x 1/2 x 1/2
II	$13^{\circ}02'$	601-5/8	601-13/16	Uranium	1 x 1/2 x 3/4
II	$13^{\circ}57'$	601-9/16 max. (adjustable)	601-3/4 max. (adjustable)	Beryllium	4 x 1 x 11/16
II	$16^{\circ}06'$	605 in. to inner radius edge (outer-radius target)	---	Copper	7/8 x 1 x 3/4
II	$19^{\circ}54'$	600-15/16	601-1/8	Polyethylene	1 x 1/2 x 1
III	$35^{\circ}20'$	596-13/16	597	Carbon	3 x 3/4 x 4
III	$73^{\circ}00'$	598-1/32	598-3/8	Copper	3-1/2 x 1/2 x 1
III	$73^{\circ}38'$	598-1/32	598-3/8	Aluminum	6 x 1/2 x 1





ZN-1624

Fig. 1. Sum-signal beam-induction electrode in the south transition section.

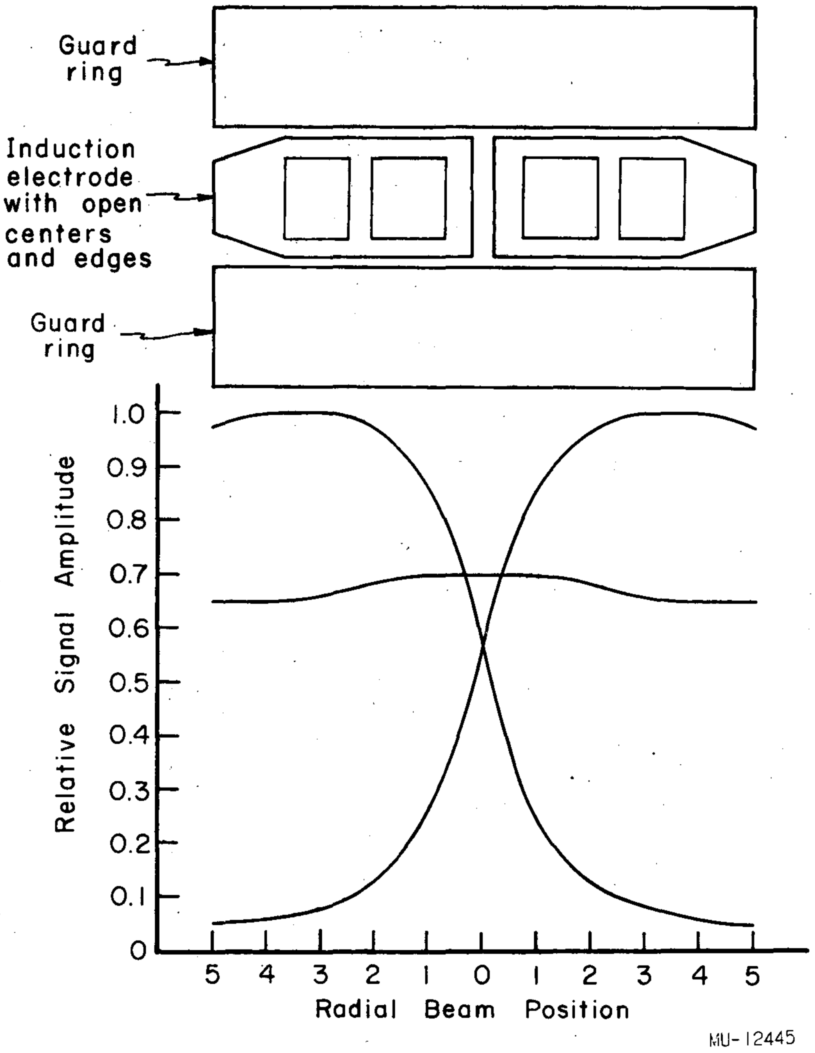


Fig. 2. New split induction electrode in the south transition section. Sum and radial discrimination curves. Curves obtained from model measurements.

OUTER-RADIUS ENERGY-LOSS FOIL TO PRODUCE AN EXTENDED SECONDARY-PARTICLE BEAM PULSE

In many experiments it is desirable to have long secondary beam pulses free of rf and synchrotron oscillation structure. Several methods of producing secondary-particle beams have been reported previously.[2] In each case the beams were produced by causing the primary proton beam to strike an inner-radius target.

A new method has been tried which utilizes an outer-radius energy-loss foil and the usual inner-radius target to produce the secondary-particle beam. The energy-loss target consists of a 0.001-in. thick aluminum foil, 6 in. square. (The foil material and thickness were chosen on the basis of maximum durability and minimum multiple scattering.) The circulating proton beam is tracked into this foil. As the energy loss of a particle traversing the foil is greater than the energy gain per turn, the particle falls out of synchronism and begins to spiral inward. The rf and synchrotron structure that characterizes the synchronous circulating beam are lost during the spiral in time. The secondary-particle beams, therefore, exhibit structure due only to magnet-current ripple. Beam pulses 500 msec in duration have been produced in this manner. The energy spread of the secondary-particle beams produced by this method is a function of the duration of the beam pulse.

BEVATRON DEVELOPMENT

Internal Beam-Deflection Magnet

The internal beam-deflection magnet (Fig. 3) was installed in the south straight section during the June shutdown.[3] The magnet was centered in the tangent tank on a radial track. It is positioned radially by manual operation of a sliding drive shaft. The drive shaft, which also carries the electric service and cooling water to the magnet, is brought out of the tangent tank through a vacuum seal. The design of the drive shaft, vacuum seal, water and electric service, and magnet carriage is such that, with the addition of a pneumatic drive mechanism, the magnet could be driven in and out of the beam aperture. For the present, however, the magnet will be positioned manually and will be retracted from the beam aperture when not in use.

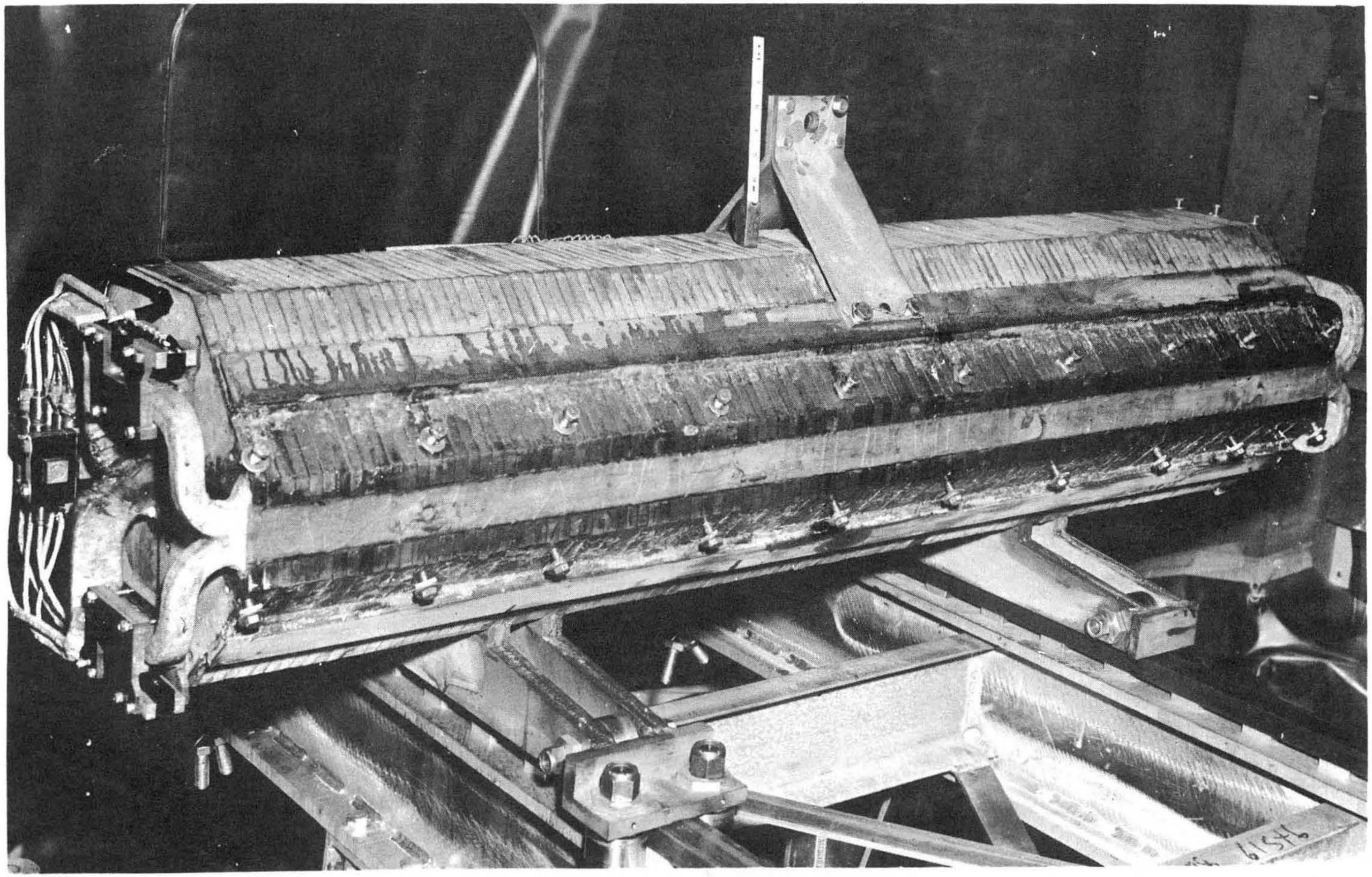
An energy-loss target was installed in Quadrant III, 35° 20' downstream from the west straight section. The target is carbon, 0.75 in. high, 3 in. in the beam direction, and 4 in. wide. The inner-radius edge of the target is positioned at 596-13/16 in. radius.

Beam-deflection experiments have been delayed because of a vacuum leak in the magnet-winding water-cooling circuit.

---

[2] Harry G. Heard, Slow and Fast Structure of Secondary-Particle Beams of the Bevatron, UCRL-3428, July 1956.

[3] Bruce Cork, Warren Chupp, and Edward Lofgren, Bevatron Operation and Development. IV, UCRL-2954, April 1955.



ZN-1623

Fig. 3. Internal beam-deflection magnet in the south straight section.

Full-energy beam-intensity measurements vs deflection-magnet radial position have been attempted. With the magnet located at 599-3/8 in. radius (the expected optimum location for deflecting the beam), the expected beam survival was 50% of the normal value with the deflection magnet retracted. The observed value of beam survival was 25%. The additional 25% loss was due to two causes: improper rf frequency tracking during the early part of the acceleration period, and perturbations of the equilibrium orbit induced by the presence of the deflection magnet.

The above figures are the results of a first attempt at measurements under conditions that vary considerably from normal operation and therefore represent a lower limit of magnitude of the circulating beam under deflection conditions.

New Wide-Band Rf Driver

The new wide-band rf driver and driver modulator were installed for tests in May. The new modulator did not have sufficient range to properly cut off the rf driver. Substitution of the original modulator made possible beam acceleration to full energy. The beam intensity, however, was down from the normal value by a factor of ten. The beam loss, which occurred during the first 100 msec of acceleration, was due a slow rise time of the accelerating-electrode rf and due to improper tracking of the final-amplifier reactor-saturating supply. Modifications to both the new driver and the 1000-ampere saturating supply will be necessary before satisfactory beam acceleration will be obtained.

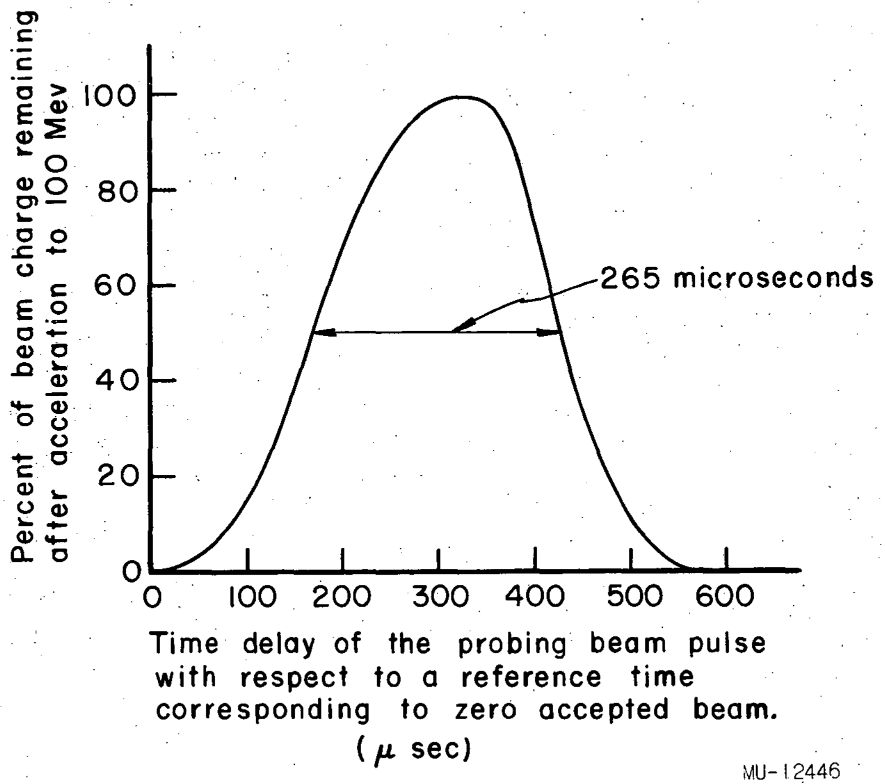
During the tests, primary beam-tracking information was obtained from both the magnet-current tracking system and the $\dot{B}$ tracking system. Each system yields substantially the same amount of beam pickup and survival. The maximum beam obtained at I 10 (88 msec after injection) was 1.5×10^{10} protons per pulse; at full energy, 3×10^{9} protons per pulse.

Modifications to the new driver, the modulator, and the 1000-ampere saturating supply are now in progress, and further tests are scheduled for September.

BEAM STUDIES

Bevatron Beam Acceptance Time

The Bevatron beam-acceptance time was measured for two values of magnet excitation voltage, by use of a 95-μsec injected beam pulse. The probing beam pulse was moved, in time, across the Bevatron acceptance time interval, and the accepted beam was measured after being accelerated to 100 Mev. The acceptance time of the Bevatron was found to be 265 μsec (full width at half maximum) for 16.05 kv magnet excitation. For 8.03 kv magnet excitation the acceptance time was 1100 μsec. The acceptance time curves for the above two cases are plotted in Figs. 4 and 5.



MU-12446

Fig. 4. Bevatron acceptance time for 16.05-kv magnet excitation (duration of probing pulse, 195 μsec.)

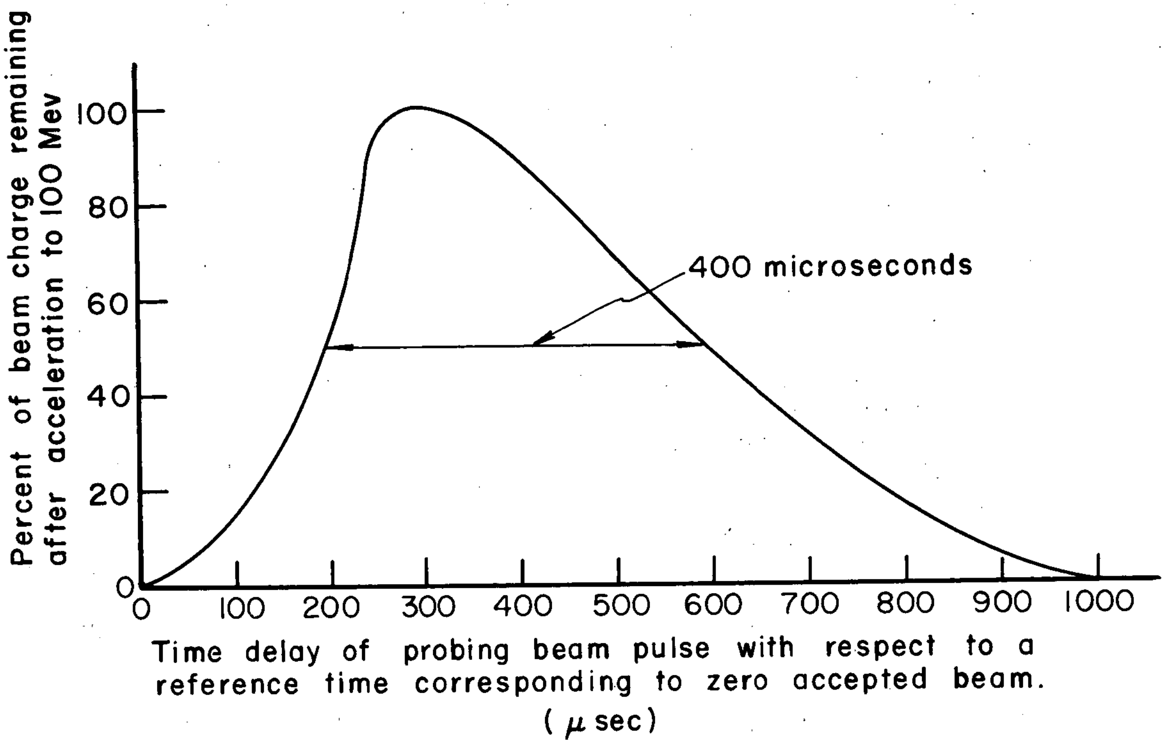


Fig. 5. Bevatron acceptance time for 8.03-kv magnet excitation (duration of probing pulse, 195 μsec.)

Magnet-Field Ripple Correction

A self-excited buck-out circuit was installed in the pole-face-winding circuit to reduce variations in magnet field due to magnet-current ripple.[4] Installation of this circuit resulted in a factor-of-3 reduction in magnetic field ripple. This reduction was sufficient to essentially remove the magnetic field ripple modulation on secondary-particle beams. The same effect was observed for both thick (100 Mev) and thin (500 ev) targets.

Out-of-Phase Beam

Recent measurements were made of secondary-particle beam structure during an rf cycle which indicate that, in addition to the phase-stable beam bunch, there exists a somewhat continuous distribution of primary-beam particles around the Bevatron orbit. These out-of-phase beam particles were detected by counting during a 50-mμsec gate interval delayed with respect to the phase of the rf accelerating voltage. The exact nature of the process by which these protons are lost from the phase-stable bunch is not known, but they probably are lost after having made multiple traversals through the target. The magnitude of this out-of-phase beam is about 1% of the amplitude of the beam in the phase-stable bunch.

MEASUREMENTS OF MAGNET CURRENT AND RIPPLE FOR MAXIMUM AND MINIMUM MAGNET VOLTAGE

Measurements were made of the magnet current and current ripple for maximum and minimum rates of rise of magnet current. Table II summarizes the results of these measurements.

MAGNET POWER SUPPLY

One ignitron failed owing to a cracked anode bushing during this quarter. The replacement tube was the first factory-rebuilt tube to be placed in service which had hydrogen-baked, vacuum-outgassed graphite parts. The high-voltage bake-in time (reduced voltage pulsing) was about one-half the time required previously for tubes that were not rebuilt with hydrogen-baked, vacuum-outgassed graphite.

Movement of wedges in the generator stator winding continues to be a problem. Westinghouse engineers are investigating the possibility of lashing the end wedges in place.

The magnet-pulsing record and fault-rate report appear in Table III.

---

[4] Harry G. Heard, A New Method For Controlling the Magnetic Field in the Aperture of Synchrotrons, UCRL-3427, May 1956.

Table II

Measurements of magnet current and current ripple for maximum and minimum magnet voltage

Magnet voltage (kv)	Rate of rise of current at injection (amp/sec)	Current ripple at injection (ma)	Ripple percent of current change during the acceptance period	Spiral in time (μsec)	Ripple percent of total current	Time to reach injection field (msec)
16.05	2795	350	25	500	0.35	30.8
1.70	297	1400	99	4700	1.4	270

BEVATRON SHUTDOWN

Four shutdowns occurred during this quarter. The first, on May 2, 1956, was for the purpose of changing the Quadrant III flip target from copper to beryllium. The second, on May 10, 1956, was for the removal of the Quadrant III load-measurement cell.[5] On June 1, 1956 the Quadrant III flip target was changed back from beryllium to copper. The fourth shutdown, from June 11 to June 16, 1956, was for installation of new equipment and for maintenance. The following jobs were accomplished during this shutdown.

Removal of the existing beam-induction electrodes in the south tangent tank and installation of new electrodes (one for sum signal and one for radial beam position discrimination) in the transition sections at each end of the south straight section.

Installation of the new beam-deflection magnet, its track, and radial position adjusting mechanism in the south tangent tank.

Installation of four new flip-target mechanisms in addition to checking and modification of existing units.

Inspection of the generator bearings and replacement of the generator stator winding wedges that had moved.

Strengthening of the west outside experimental area platform. (The load limit is now 2000 lb/ft^2).

---

[5] Walter Hartsough, Bevatron Operation and Development. VIII, UCRL-3332, March 1956.

Table III

Ignitron Fault Rate

	5 to 7 pulses per minute						7 to 10 pulses per minute						10 to 17 pulses per minute						Total			
	1500 to 6000 amp			6000 to 8000 amp			1500 to 6000 amp			6000 to 8000 amp			1500 to 6000 amp			6000 to 8000 amp						
Month	Pulses	Faults	P/F	Pulses	Faults	P/F	Pulses	Faults	P/F	Pulses	Faults	P/F	Pulses	Faults	P/F	Pulses	Faults	P/F	Month	No Pulses	No Faults	P/F
1954																			1954			
OCT	103	0	---	3,111	27	115	11,200	47	239	16,200	114	142	80,300	24	3,348	2,363	35	68	OCT	112,361	247	454
NOV	3,434	8	429	5,146	42	122	255	0	---	33,200	259	128	29,100	18	1,617	7,237	39	186	NOV	78,348	366	214
DEC	310	2	155	35,600	122	292	1,640	18	91	1,529	39	39	19,600	12	1,630	0	0	0	DEC	58,693	193	304
1955																			1955			
JAN	1,757	4	439	42,500	193	220	0	0	0	9,480	60	158	55,400	36	1,538	259	3	86	JAN	109,381	296	370
FEB	793	0	---	19,600	76	258	431	4	108	19,800	97	204	39,000	29	1,347	9,817	44	223	FEB	89,503	250	358
MAR	434	0	---	14,900	16	933	456	0	---	37,500	64	586	48,400	39	1,240	16,400	51	232	MAR	118,135	170	695
APR	948	0	---	19,600	39	503	425	1	425	16,700	38	440	102,500	8	12,800	9,587	18	533	APR	149,753	104	1,440
MAY	0	0	---	14,500	34	427	34	0	---	58,400	171	341	76,400	15	5,094	3,400	9	379	MAY	152,739	229	667
JUNE	0	0	---	8,500	2	4,249	0	0	---	9,700	9	1,075	132,800	4	33,194	12,500	14	896	JUNE	163,500	29	5,638
JULY	0	0	---	300	1	341	0	0	---	10,300	9	1,144	137,700	25	5,510	15,800	22	720	JULY	164,210	57	2,881
AUG	0	0	---	6,469	9	719	580	2	290	70,832	62	1,142	48,037	1	48,037	18,473	10	1,847	AUG	144,391	84	719
SEPT	86	0	---	0	0	---	0	0	---	33,269	44	756	44,798	10	4,480	341	0	---	SEPT	78,494	54	1,454
OCT	1,361	0	---	1,289	0	---	0	0	---	54,562	88	620	38,136	1	38,136	29,305	56	523	OCT	124,653	145	860
NOV	---	-	---	16	0	---	0	0	---	46,656	86	542	37,670	2	---	59,304	84	706	NOV	143,646	172	835
DEC	---	-	---	0	0	---	0	0	---	11,875	18	659	14,378	14	1,027	91,761	113	812	DEC	118,014	145	814
1956																			1956			
JAN	---	-	---	---	-	---	---	-	---	6,718	7	960	11,148	1	11,148	3,433	1	3,433	JAN	21,299	9	2,367
FEB	177	-	---	7,468	15	4,976	2,922	4	730	38,146	95	401	23,624	3	7,874	6,735	15	449	FEB	79,072	132	599
MAR	678	6	113	3,208	7	4,582	207	1	207	43,782	71	616	30,358	9	3,373	119,065	162	735	MAR	197,298	256	771
APR	13,193	1	13,193	26,778	43	622	35,831	3	11,943	31,209	57	547	16,297	6	2,716	16,024	17	942	APR	139,332	127	1,097
MAY	165	-	---	3,054	1	3,054	2,062	1	2,062	59,288	115	515	35,595	6	5,932	72,777	92	790	MAY	172,876	215	804
JUNE	120	-	---	285	---	---	3,198	0	---	123,197	187	657	17,759	16	1,109	3,070	3	1,023	JUNE	147,629	206	717
JULY	---	-	---	---	---	---	---	-	---	90,655	131	684	14,036	2	7,018	90,375	83	1,088	JULY	195,066	216	903
																			AUG	208,702	216	966

MU-12432

OPERATING AND RESEARCH PROGRAM

Figure 6 summarizes the Bevatron operation during this quarter. The scheduled operating time of 95-1/2 hours per week is reduced by magnet power-supply warm-up period of 1/2 hour per day. The vertical bars, therefore, represent the percentage of the effective operating hours that were available for physics research.

The peak and average values of beam-survival efficiency are shown in Fig. 7. The maximum recorded beam amplitude at full energy was 4.0×10^{10} protons per pulse.

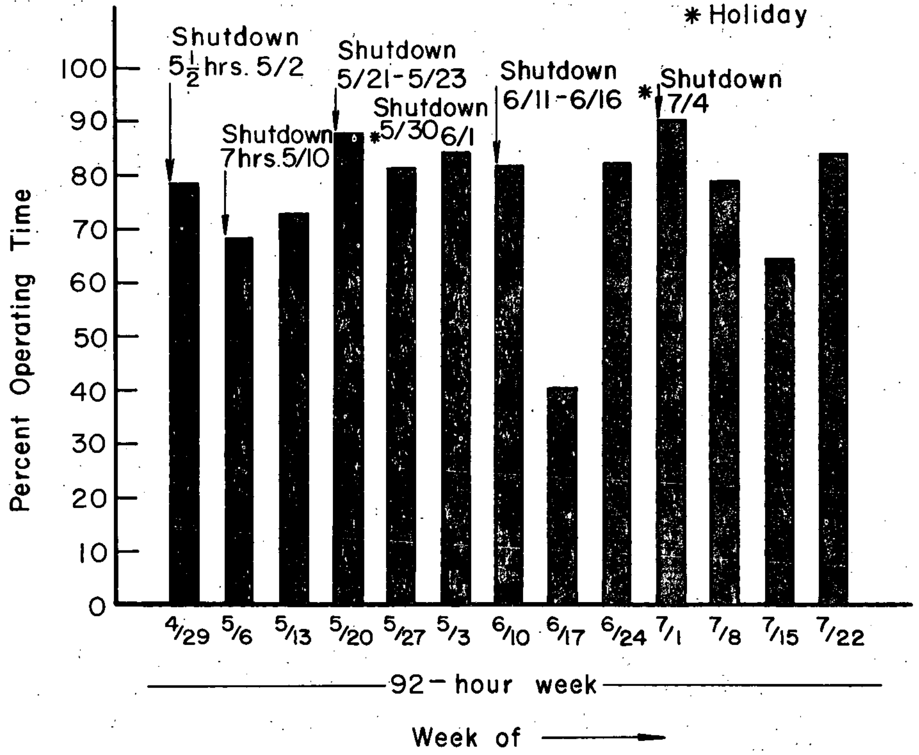
The investigation of K-meson production, interaction, and decay continued during this period. In total, 18 emulsion stacks were exposed to focused (and in many cases separated) K-meson beams. These exposures were made by three groups from this laboratory and by seven groups outside the laboratory. Emulsion exposures to the focused 700-Mev/c antiproton beam were made by three groups from this laboratory and by four outside groups. The Lofgren Physics Research Group (Cork, Lambertson, Piccioni, and Wenzel) measured the absorption of antiprotons in a liquid hydrogen target, using counters. The antiprotons were focused, momentum-analyzed (1.15 Bev/c and 1.43 Bev/c), and velocity-selected by a time-of-flight selection scheme. This group also began a search for antineutrons created from antiprotons by charge exchange in a Be target. A large lead-glass Cerenkov counter was used to observe antineutron annihilation events.

A summary of the total research activity during this quarter appears in Table IV.

ACKNOWLEDGEMENTS

The Bevatron Group leader is Edward J. Lofgren, and under him Harry Heard, with Walter Hartsough assisting, is in charge of operations. The Bevatron Operators are Robert Anderson, Wendell Olson, and Robert Richter as crew chiefs: William Boyd, C. Stanley Boyle, Baird Brandow, Gary Burg, Duward Cagle, Norris Cash, Frank Correll, Robert Gisser, William Kendall, Fred Lothrop, Ross Nemetz, Charles Neumann, Glenn White, and Emery Zajec and crew members. Harold Vogel was the engineer in charge of the motor generator sets. Special development projects were carried out by Bruce Cork, Harry Heard, and Nahmin Horwitz. The mechanical engineering group was headed by William Salsig; the electrical engineering group by Clarence Harris and Marion Jones. Jerome Russell directed the electronic development group. Lorenzo C. Eggertz was in charge of the electrical maintenance group.

This work was done under the auspices of the U. S. Atomic Energy Commission.



MU-12448

Fig. 6. Bevatron operating time - May through July 1956.

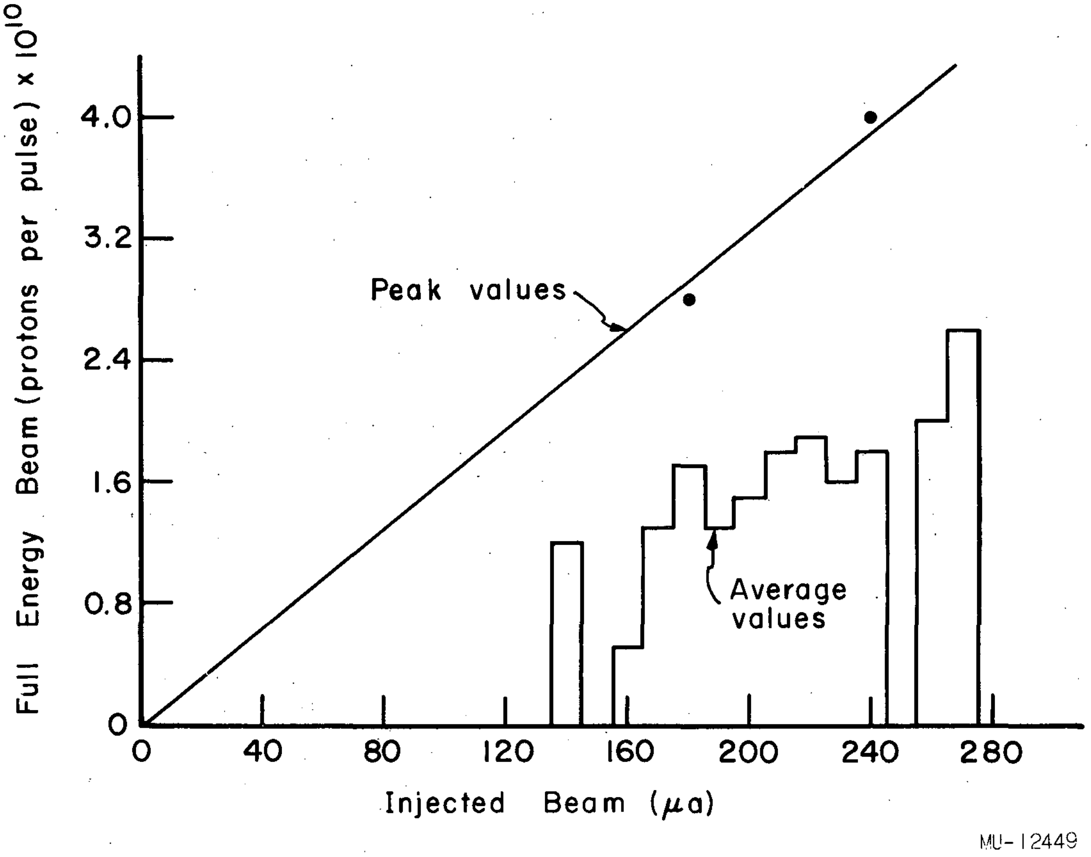


Fig. 7. Bevatron performance. Beam survival efficiency.

Table IV

Bevatron experimental research program
May, June, July 1956

INTERNAL GROUPS

Experimenters Group	Experiments
ALVAREZ	
Rosenfeld, Tripp	K^-/π^- ratio at 0° from a Be target (430 Mev/c)
Gow, Rosenfeld, Tripp	K^- absorption in hydrogen, using the 10-in. liquid hydrogen bubble chamber (430 Mev/c)
BARKAS	
Giles	Emulsion exposure in the focused and analyzed K^- meson beam (430 Mev/c)
Heckman	Emulsion exposure in the focused K^- meson beam (430 Mev/c)
Barkas	Emulsion in the focused and analyzed antiproton beam (700 Mev/c)
LOFGREN	
Cork, Wenzel	Effectiveness of the 4-in.-thick copper clipper at 6 Bev
Heard	Bevatron acceptance time measurements
	Investigation of the fine structure of secondary-particle beams
Horwitz, Murray	C^{12} (ppn) C^{11} cross section and excitation function (3.2 Bev, 4.5 Bev, and 6.2 Bev)
Chupp, S. Goldhaber	Emulsion exposure in the focused and analyzed K^--meson beam (430 Mev/c)
Chupp, S. Goldhaber, Lannutti	Emulsion exposure in the 60° separated K^+-meson beam (480 Mev/c)

Experimenters Group	Experiments
LOFGREN (Cont.)	
Cork, Lambertson, Piccioni, Wenzel	Antiproton absorption in hydrogen, using a time-of-flight selection spectrometer and a liquid hydrogen target (1.15 Bev/c and 1.43 Bev/c). Search for the antineutron
LOFGREN-SEGRÈ	
Chupp, G. Goldhaber, S. Goldhaber	Emulsion exposure in the focused and analyzed antiproton beam (700 Mev/c)
MOYER	
Brabant, Squires	Measurement of the fine structure of secondary-particle beams, using a counter telescope
Brabant, Smith, Squires	Determination of the location of the neutron beam from the Quadrant II 16° 15' target
Osher, Parker	π^0 modes of heavy-meson and hyperon decay; search for Σ^+ decay; angular distribution of θ^0 decay
POWELL	
E. Fowler, W. Fowler, Lander, Oswald	$K^{\pm}$ meson and hyperon production by neutrons, using a propane bubble chamber with magnetic field
Fowler, Maenchen, Wright	p-p interactions at 5.3 Bev using a 35-atmos hydrogen-filled diffusion cloud chamber in a magnetic field
Lander, Saphir	Ratio of neutral to charged mesons produced by 5.3-Bev protons in an expansion cloud chamber, with tungsten plates, in a magnetic field
	Total cross section for 5.3-Bev protons on Cu and Al, using above cloud chamber
BIRGE	
Kerth, Van Rossum	Investigation of the focused and analyzed 0° K^+-meson beam from the 2° 30' target using counters and emulsions (500 Mev/c)

Experimenters Group	Experiments
BIRGE (Cont.)	
Birge, Kerth, Van Rossum	Emulsion exposure to the focused and analyzed 30° K^+-meson beam (500 Mev/c)
Birge, Kerth, Stork, Van Rossum	Emulsion exposures to the focused and analyzed 60° K^+-meson beam (470 Mev/c)
	Emulsion exposure to the focused and analyzed 60° K^--meson beam (420 Mev/c)
Birge, Sandweiss	Emulsion exposure to the focused and analyzed antiproton beam (700 Mev/c)
CHEMISTRY (SEABORG)	
Barr	Cu foil bombardment (5.7, 6.2 Bev)
Benioff	Bombardments of niobium, teflon, sodium peroxide, Cu, mylar, polyethylene, and 5-aminotetrazole targets (5.7 Bev)
Caretto	Cu, U foil bombardment (2.0 Bev)
	U foil bombardment (3.2, 4.5, 5.7, 6.2 Bev)
	Cd foil bombardment (2.0 Bev)
Carnahan	U foil bombardment (5.7 Bev)
Grover	Ta, Al foil bombardment (5.7 Bev)
Grover, Turkevich	Ta, Al foil bombardment (6.2 Bev)
Nethaway	In foil bombardment (2.0, 4.1, 6.2 Bev)
Turkevich	Cu, Al foil bombardment (5.7 Bev)
Turkevich, Winsberg	Cu, Al foil bombardment (6.2 Bev)
Winsberg	Mn foil bombardment (1.0, 3.5, 6.2 Bev)

EXTERNAL GROUPS

Experimenters
Institutions

Experiments

Emulsion exposures to the focused and analyzed 700 Mev/c antiproton beam were made for the following groups:

AMALDI
University of Rome, Italy

EKSPONG
University of Uppsala, Sweden

FRYE
Los Alamos

HILL
University of Illinois

Emulsion exposures to the focused 430-Mev/c K^--meson beam were made for the following groups:

EKSPONG
University of Uppsala, Sweden

FRY, SCHNEPPS
University of Wisconsin

SCHEIN, SPRAGUE
University of Chicago

VON FRIESEN
Lund, Sweden

Emulsion exposure in the focused 60° K^+-meson beam (660 Mev/c) was made for:

PEVSNER
MIT

Emulsion exposures in the focused and separated 60° K-meson beam were made for the following groups (420 Mev/c):

FRY, SWAMI University of Wisconsin	K^+
GILBERT, WHITE Livermore Nuclear Emulsion Group	K^-
PEVSNER MIT	K^+

Experimenters Institutions	Experiments
PRICE, TICHO UCLA	K^+

Internal emulsion exposure to 6.2-Bev protons was made for:

HOANG
Rochester University