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October through December 1965

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ABSTRACT

The beam was on for experimenters 87% of the scheduled operating time. Machine operation for five simultaneous experiments is discussed. A rubber gasket located near the external beam port was replaced; the gasket had been damaged by radiation.

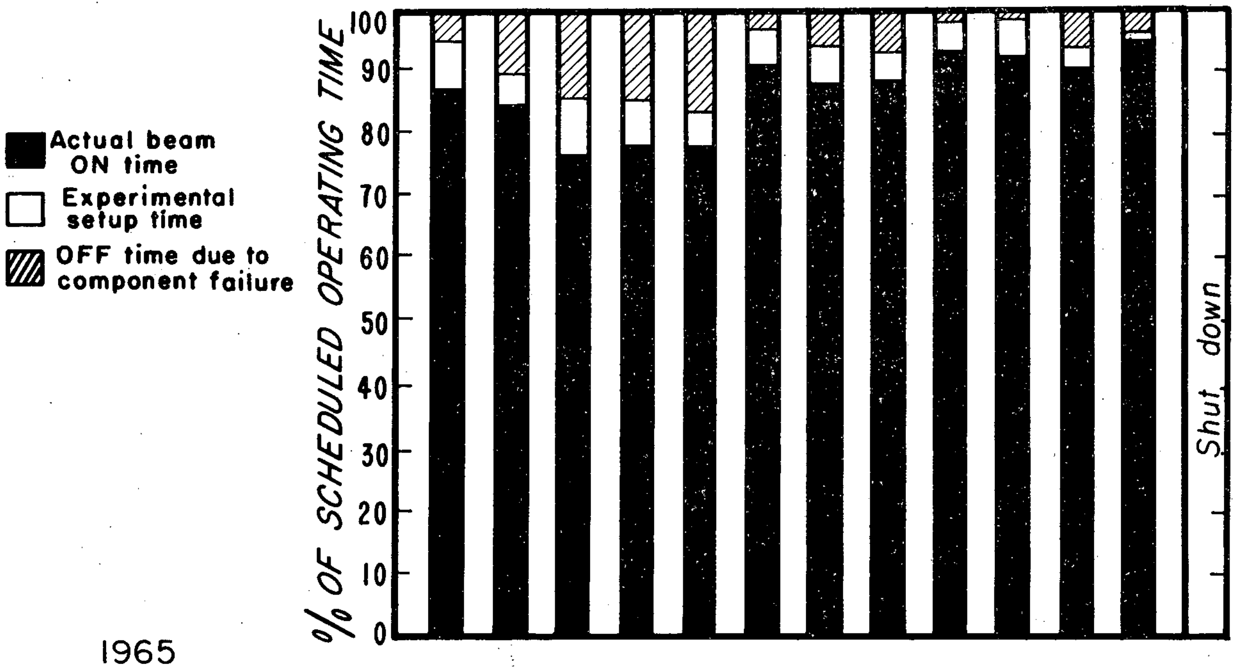
I. MACHINE OPERATION AND EXPERIMENTAL PROGRAM

The Bevatron operations record is shown in Fig. 1. The beam was on 87% of the scheduled operating time. The beam was off 7.6% of the time because of equipment failure and 5.4% of the time for experimental setup, tuning, and routine checks. The experiments were of two basic types: (a) bubble chamber experiments wanting short beam spills (200 μsec), and (b) counter experiments wanting long beam spills (800 msec). The long beam spills at the Bevatron are usually provided during a magnet flat-top. This is a mode of operation in which the magnet current is held constant for an interval of time.[1] The length of time that we can flat-top is a function of peak magnet current--the lower the magnet current the longer the flat-top length. This lowering of the current level reduces the energy of the beam during the spill. As a result, the operating mode of the Bevatron must be a compromise between the energy of the beam and the length of the beam spill. The Alvarez-Murray experiment (run No. 39) done in the 25-inch bubble chamber required a short beam spill (200 μsec) at an energy of 6.1 BeV or higher. At this energy we can run a flat-top of 300 msec. The 72-inch hydrogen bubble chamber had several experiments scheduled. Part of these experiments required 6.1-BeV primary protons, part could be run at lower energy. All of the counter experiments wanted a longer beam spill (800 msec) and were able to run at a reduced energy of 5.3 BeV for the primary protons. The 200-msec beam spill is provided by a pair of deflection coils called the "rapid beam ejector" (RBE).[2] The long spills are provided by controlling the rf amplitude with an "electronic beam spiller" (EBS).[3]

To satisfy these different operating requirements we established two primary modes of beam sharing during time quarter. The 6.1-BeV operation was with a 300-msec flat-top. The 25-inch bubble chamber took a short spill (200 μsec) about 30 msec before the start of flat-top. We gave a 200-msec spill to the counter groups and a final 200-μsec spill to the 72-inch bubble chamber just before the end of flat-top. This is shown in Fig. 2. The bubble chambers were controlling experiments in this mode of operation, so the number of protons available for the long spill was determined by the bubble chamber needs. This usually left insufficient beam for most of the counter experiments to take data. However, they could often use this beam very profitably for tune-up and counter checks.

The 5.3-BeV operation was with a 900-msec flat-top. The 72-inch bubble chamber took a 200-μsec beam spill just after the start of flat-top. We then gave a 600-msec spill to the counter experiments. See Fig. 3. The 25-inch bubble chamber did not run in this mode. The counter experiments were controlling experiments in this mode of operation, so the beam intensity available to the 72-inch bubble chamber was occasionally limited.

The above two modes of Bevatron operation are rather broad and general. We now consider the actual details of targetry and beam sharing for each of these operating modes. The Alvarez-Murray Group (experiment No. 39) used secondary beams from targets inside the Bevatron. The 72-inch bubble chamber experiments used a secondary beam from a target at the first focus (F1) in the external proton beam. The Segrè-Chamberlain-Stiening experiment (No. 40) used a secondary beam from a target at the second focus (F2) of the external proton beam. The Piccioni experiment (No. 51) and the Segrè-Chamberlain-Steiner experiment (No. 37) used



1965 Week of	10/5	10/10	10/17	10/24	10/31	11/7	11/14	11/21	11/28	12/5	12/12	12/19	12/26
Crew hours	168	168	168	168	168	168	168	120	168	168	168	120	0
Turnon & maintenance time (h)	10	10	42	9	14	10	11	14	12	10	10	62	0
Scheduled operating time (h)	143	143	102	141	137	142	139	100	149	152	150	55	0
Scheduled Bevatron test time (h)	15	16	24	18	17	16	18	6	7	6	8	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	48	0	0	0	48	0

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Fig. 1. Bevatron operating schedule.

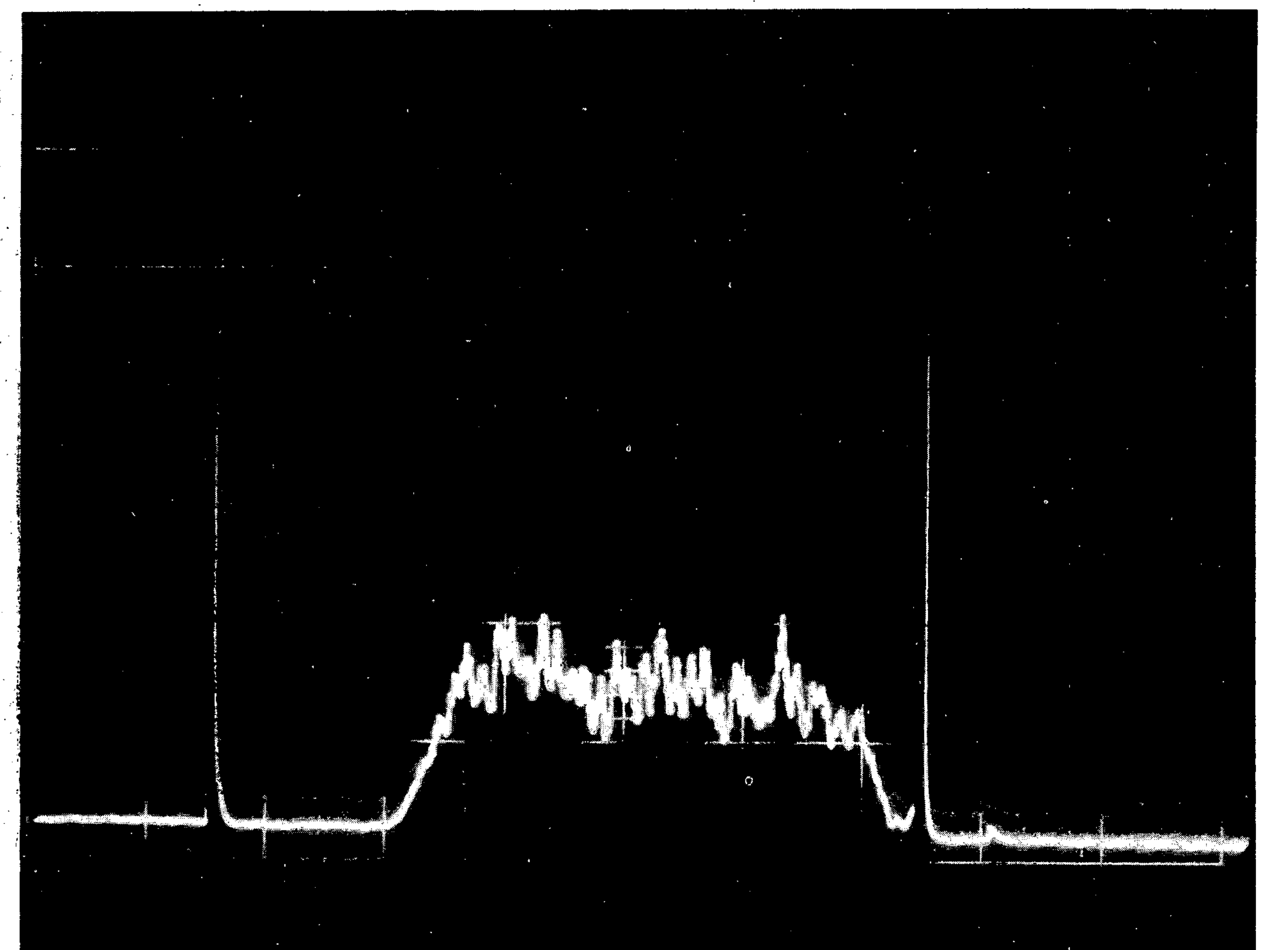

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Fig. 2. Oscilloscope trace of 6.1-BeV beam spill. Sweep speed 50 msec/cm.

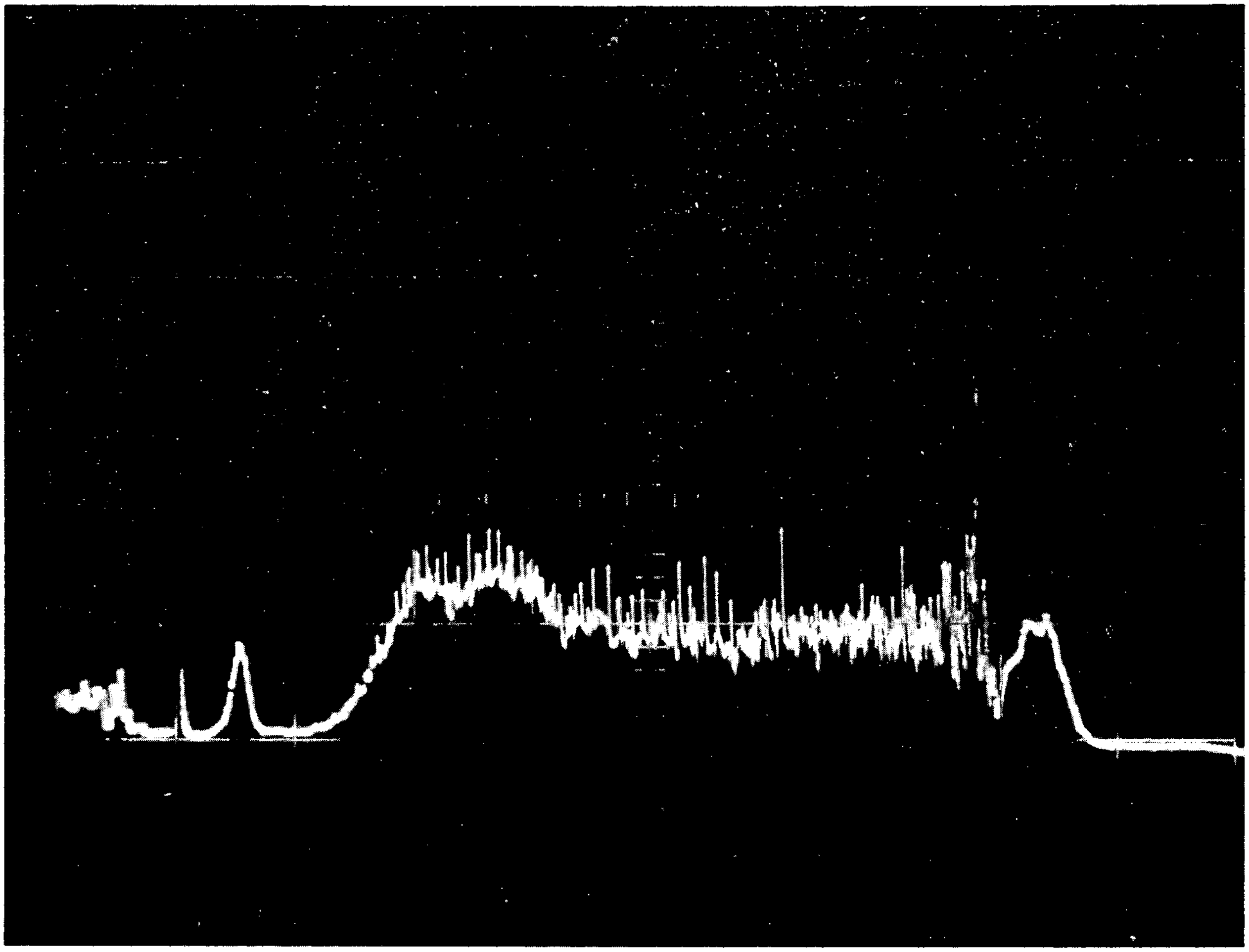

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Fig. 3. Oscilloscope trace of 5.3-BeV beam spill. Sweep speed 100 msec/cm.

separate targets, 6.5 feet apart, in the third focus area of the external proton beam.[4]

For 6.1-BeV operation, the internal gap-mounted Alvarez-Murray target was flipped up and a 200-μsec beam spill of about 1.5×10^{12} protons per pulse was spilled on the target. At the end of the spill this target was started down and the internal energy-loss target for external proton-beam extraction was started up. Under some conditions of tuning the energy-loss target can interfere with beam spill on the Alvarez target and care must be exercised in their position and timing. About 30 msec after the first spill we go into magnet flat-top. About 40 msec after starting of flat-top we start a long beam spill, using the electronic beam spiller (EBS), onto the energy-loss target. This long-spill (200 msec) beam goes down the EPB channel and is shared by one to three experiments at the F2 and F3 focus. In the 6.1-BeV mode of operation there was usually insufficient beam to run all three groups. This long spill was also shared by the Arizona group on an internal target 180 deg around the Bevatron from the energy-loss target. Their beam intensity requirements were fairly low, so they were able to run satisfactorily by intercepting the edges of the beam being extracted in the EPB system. Figure 4 shows the beam distribution in the east straight section just ahead of the first extraction magnet (M1). In the north section the picture would be similar but compacted radially outward. The Arizona target was run in the "valley" region shown between 597 to 598 inches radius in the dotted curve. Because of scattering on the target this part of the beam is outside the acceptance of the EPB system, so in general there was no loss of intensity in the EPB. Just before the end of flat-top, the slow spill was turned off and the remainder of the circulating beam was spilled in 200 msec for the 72-inch bubble chamber with the RBE onto the energy-loss target, and thus into the EPB. Near F1 this short beam pulse was deflected by a small magnet pulsed at the same time as the RBE coil. This magnet deflects the beam about 3/4 in. at the downstream target in the F1 area. There is a target at this location to provide a secondary beam to the 72-inch bubble chamber experiments. In this manner the short beam pulse for the bubble chamber spill is deflected onto the F1 target, the long spill goes through the F1 area without striking the F1 target.

During the 5.3-BeV 900-msec flat-top mode of operation the Alvarez-Murray group did not run. All the beam spill was from the energy-loss target. The RBE spill for the 72-inch bubble chamber F1 target came just after the start of flat-top. This beam went through the fast pulse magnet in the EPB line and was deflected 3/4 in. to strike the bubble chamber target. The long beam spill followed and was about 600 msec long. This was shared simultaneously by the four different experiments, as described above. They were now the controlling experiments and their intensity requirements were met first and the remaining beam, if sufficient, was given to the 72-inch bubble chamber experiment.

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

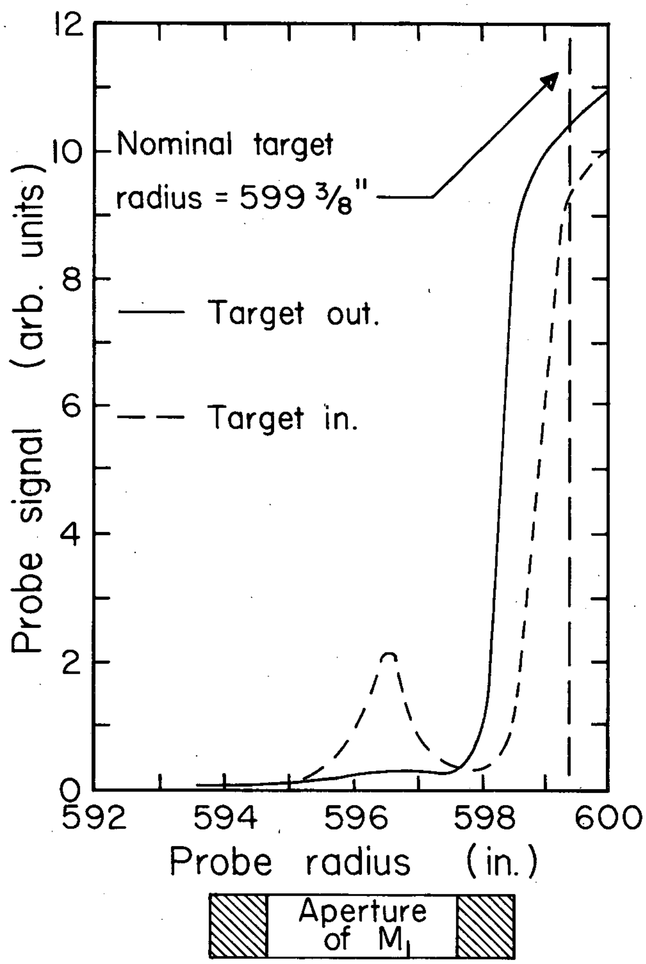

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Fig. 4. Beam distribution in east straight section just ahead of first extraction magnet.

Table I. Summary of Bevatron experimental research program, October through December 1965

Group	Start of experiment	End of experiment	Experiment	Beam time: This quarter (Oct. - Dec.) 12-Hour periods	Beam time: This quarter (Oct. - Dec.) Hours	Beam time: Start of run through Dec. 1965 12-Hour periods	Beam time: Start of run through Dec. 1965 Hours	Pulse Schedule	Primary or secondary experiment
Internal Groups									
Segrè-Chamberlain- Stiening (No. 40)	10-13-65 9-2-65	In progress In progress	Study of polarization in K_3 decays with spark chambers	5 11	65 155	5 11	65 155	1:1 1:1	P S
Alvarez-Ticho Purdue, Ill. (No. 45)	8-13-65 5-7-65	In progress In progress	Study of p-p interactions in 72-inch bubble chamber	47 0	473 0	104 21	1072 233	1:1 1:1	P S
Alvarez-Murray (No. 39)	8-5-65 2-11-65	In progress In progress	Septum separator K beam 25-inch H_2 bubble chamber	18 0	218 0	75 11	821 143	1:1 1:1	P S
Segrè-Chamberlain (SLAC) (No. 41)	4-27-65 4-21-65	12-18-65 12-18-65	Study of inelastic p-p interactions in 72-inch H_2 bubble chamber	59 0	636 0	103 7	1112 67	1:1 1:1	P S
Powell-Birge (No. 44)	12-19-65	12-21-65	Test for future experiment	2	26	2	26	1:2	P
Segrè-Chamberlain- Steiner (No. 37)	10-5-65 8-21-65	In progress In progress	Study of elastic scattering of pions and K^+ from H_2 target	85 5	846 53	85 43	846 436	1:1 1:1	P S
Lofgren (No. 48)	9-16-65	12-21-65	Diboson mass spectra	1	19	2	31	1:1	S
External Groups									
Piccioni (No. 51) U. of San Diego	7-28-65 7-10-65	12-21-65 12-21-65	Determination of sign and magnitude of K_1-K_2	86 0	889 0	133 55	1341 575	1:1 1:1	P S
Bowen (No. 42) U. of Arizona	7-28-65 7-19-65	12-21-65 12-21-65	Study of Λ-K reactions using spark chamber	123 0	1314 0	127 34	1341 396	1:1 1:1	P S

II. SHUTDOWN

There was a 42-hour shutdown on October 18 and 19 to "Magnaflux" the main motor generator shafts and bearings. This is a routine check that occurs about every 3 months after 1.3×10^6 magnet pulses. There was a short vacuum shutdown to repair the east-outside-south Faraday cup. Any time we are at air pressure, a routine inspection is made of the bearing and support mechanism of the EPB plunging magnets. The bearings on the east system showed signs of wear and were replaced.

During the fall of 1962 a secondary beam port was installed at the 89-deg area of Quadrant II.[5] This year we learned that the rubber used for the vacuum gasket between the Bevatron vacuum wall and the extension tank had a rather annoying feature. After a radiation exposure of between 10^7 and 10^8 rad, the rubber turns to a liquid. Weekly inspection of the air side of the gasket was started. Whenever there was a vacuum shutdown the vacuum side of the gasket was examined. In August the first signs of damage appeared on the outside face of the gasket. A small drop of rubber appeared. This area was in the plane of the center line of the magnet gap, very near the point where the external proton beam leaves the Bevatron. There was an exit collimator[6] in the EPB at this point. Two years of operation had made the collimator fairly radioactive. This collimator was removed during the October shutdown to decrease the environmental radiation level at the gasket. This level dropped from 8 r/h to 450 mr/h at the gasket surface with the removal of the collimator. Inspection of the inside surface of the gasket showed no apparent damage. The spare gasket we had was of the same material as was in the Bevatron. Therefore we decided to leave the gasket in place and attempt to get a replacement of a more radiation-resistant rubber. Weekly inspection of the air side of the gasket continued. Figure 5 shows a photograph taken on November 29.

There was a 48-hour shutdown November 25 and 26, for the Thanksgiving holiday. No work was scheduled during this period.

The Bevatron was shut down from December 21, 1965 through January 3, 1966 for the Christmas and New Year holidays. Starting the shutdown on December 21 gave us a week of nonoperation prior to the vacuum shutdown. This allowed the residual radiation level inside the Bevatron to decrease by a factor of from 8 to 10 before we started work in the machine.

The gasket at the 89-deg Quadrant II exit part was replaced at this time. The spare gasket, of the same type of rubber, was installed because of the inability of the fabricator to supply us with an acceptable new gasket in time for this shutdown.

The Piccioni experiment in the external proton beam and the Arizona experiment at the north tangent tank were removed. Setup was started at the EPB third focus for an experiment by Longo-Helland, and installation of a new experiment using the internal beam was started at the north tangent tank for the Moyer Group.

A new scintillator was installed in the west tangent tank, 180 deg around the Bevatron from the injection point. It covers full vertical aperture

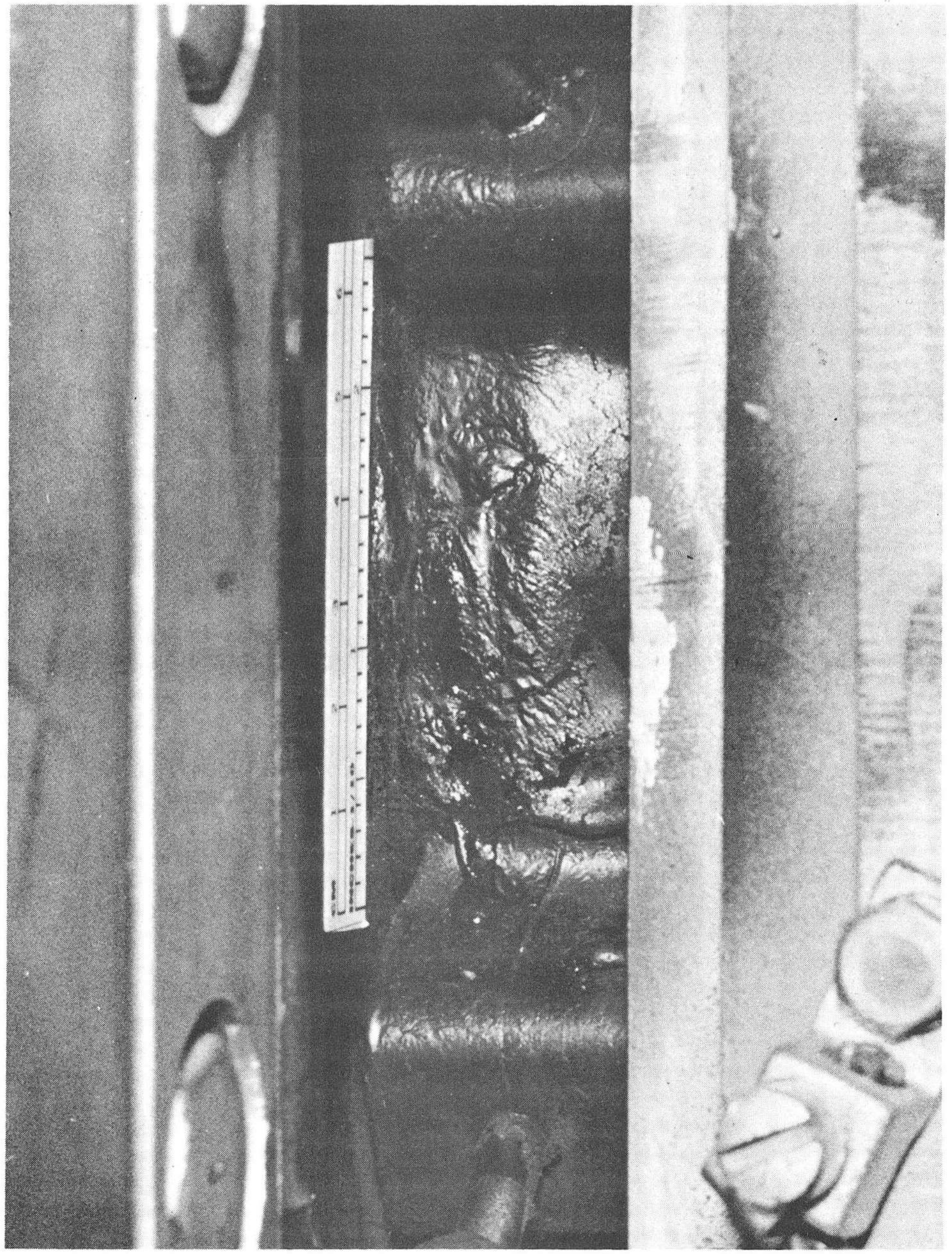

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Fig. 5. Radiation damage to the gasket in the 89-deg area of Exit Quadrant II.

and about one-half the radial aperture. This scintillator is to be used for injection studies at half turn around the Bevatron. It is monitored with a closed-circuit television system.

The remainder of the shutdown work was devoted to routine maintenance and installation work.

III. BEVATRON DEVELOPMENT AND STUDIES

Parts of the periods were devoted to compatibility and beam-sharing problems between the various experimenters. Some time was spent in trying to increase the extraction efficiency of the external proton beam from the operating level of 30% to the previous level of 40%. The target height and thickness were varied with no appreciable change in percent of extracted beam. Removing the collimator at the exit of Quadrant II made no difference, either. The reason for this apparent loss in extraction efficiency is still unknown and is under investigation.

IV. MAGNET POWER SUPPLY

The magnet pulsing record is shown in Table II.

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

1965	4-6 PPM								7-9 PPM								10-17 PPM								TOTAL					
	1.5-6.9 KA				7.0-9 KA				1.5-6.9 KA				7.0-9 KA				1.5-6.9 KA				7.9-9 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 thru	P/F	Ignitrons replaced
Jan	1,566				1,732								2,397	2			26,909				246,571	19	42		279,175	21	63	42	4431	
Feb	4,501				1,358								10,422				89,963	4	4		168,801	14	31		275,045	18	53	35	5189	2A6-3A3-4A4
Mar									454								246,308	10	10		145,517	22	30		392,279	32	72	40	5448	
April									245				49,942	2	2		160,776	12	28		11,422		2		222,385	14	46	32	4834	
May	2,539								4,039				2,071	1			310,039	16	35		34,413	4	6		353,155	21	62	41	5696	2A5-2A6
June	10,095				272				945				1,496				68,818	2	5		3,317				84,943	2	7	5	12,135	
July																	291,894	7	27		94,788	10	21		386,682	17	65	48	5,949	
Aug	2,388				1,162				54,768	2	9		125,834	4	17		109,644	3	11		69,563	2	10		363,359	11	58	47	6,264	4A4-2A6
Sept	2,052				1,035								233,635	9	26		43,616	4	5		44,094	4	6		324,432	17	54	37	6,008	3B4
Oct									1,222	0	0		281,461	17	16		10,773	0	1		106,640	4	5		400,096	21	43	22	9,305	3B4
Nov									53,441	0	1		12,188	1	2		220,430	6	12		68,496	2	7		354,555	9	31	22	11,437	
Dec									23,190	0	0						239,794	9	10		1,633	0	1		264,617	9	20	11	13,231	

STAFF

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Harold Vogel	In charge of Motor Generator group
Donald Milberger	In charge of Electrical Maintenance group
Kenow Lou Cedric Larson Abraham Glicksman	In charge of Mechanical Engineering group

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