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

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October through December 1968

Kenneth C. Crebbin
May 16, 1969
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UNIVERSITY OF CALIFORNIA
Lawrence Radiation Laboratory
Berkeley, California
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BEVATRON OPERATION AND DEVELOPMENT. 60
October through December 1968

Kenneth C. Crebbin

May 16, 1969
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 $2.4 \times 10^{18}$ 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 Segré-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 $K_{e4}$ 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 $\pi^+$ 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
Fig. 1. Bevatron operating schedule.
is set up in a secondary $\pi^-$ 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 1. Summary of Bevatron experimental research program, October through December 1968.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Experiment Location</th>
<th>Dates</th>
<th>Experiment</th>
<th>12-Hour periods</th>
<th>12-Hour periods</th>
<th>Pulse Schedule</th>
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<td>Internal Groups</td>
<td></td>
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<td></td>
<td>This quarter</td>
<td>Start of run</td>
<td>Primary or</td>
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<td>October - December</td>
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<td>secondary</td>
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<td></td>
<td></td>
<td></td>
<td>December 1968</td>
<td></td>
<td>experiment</td>
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<td>Powell-Hingle (Kalas)</td>
<td>EPB</td>
<td>72 3/19/68</td>
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<td>0</td>
<td>0 1</td>
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<td>95</td>
<td>1027</td>
<td>11</td>
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<td>(Kalous)</td>
<td>25 in. BC</td>
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<tr>
<td>Powell-Hingle (Ely-Kalous)</td>
<td>EPB</td>
<td>73 4/8/68</td>
<td>in progress</td>
<td>10</td>
<td>104</td>
<td>10 11</td>
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<tr>
<td></td>
<td>25 in. BC</td>
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<tr>
<td>Trilling-Goldhaber</td>
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<td>76 10/30/68</td>
<td>in progress</td>
<td>10</td>
<td>104</td>
<td>10 11</td>
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<td>(Kodyn)</td>
<td>25 in. BC</td>
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<tr>
<td>Segri-Chambelain (Wigand)</td>
<td>EPB</td>
<td>84 7/17/68</td>
<td>K-neutrino analysis</td>
<td>70</td>
<td>737</td>
<td>107 113</td>
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<td>XI F3</td>
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<td>Group A</td>
<td>EPB</td>
<td>85 6/14/68</td>
<td>pp + d *</td>
<td>2</td>
<td>28</td>
<td>70 773</td>
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<td>(Abolins-Smith)</td>
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<td>Moyer-Haldorff (Kneese)</td>
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<td>Group A</td>
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<td>Powell-Hingle (Gild)</td>
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<td>87 13/24/68</td>
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<td>32</td>
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<td>32 345</td>
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<td>(Gild)</td>
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<td>Segri-Chambelain (Chambelain)</td>
<td>EPB</td>
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<td>Polarization in pp + p charge exchange scattering, 1-6 GeV.</td>
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<td>485</td>
<td>56 635</td>
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<tr>
<td>Nuclear Chemistry</td>
<td>EPB</td>
<td>104 9/23/68</td>
<td>Production of light fragments from p-p collisions</td>
<td>83</td>
<td>888</td>
<td>101 220</td>
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<td>(Hyde-Puckensteiner)</td>
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<td>Miller</td>
<td>EPB</td>
<td>105 9/23/68</td>
<td>K*0 charge asymmetry tests for future</td>
<td>46</td>
<td>62</td>
<td>9 134</td>
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<td>Lefgren</td>
<td>EPB</td>
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<td>(Woud)</td>
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<td>Fusion-track foil exposure</td>
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<td>21</td>
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<td>(Wellesher)</td>
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<td>U.C. — Santa Barbara (Caldwell)</td>
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<td>108 11/14/68</td>
<td>Counterc efficiency checks for future</td>
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<td>experiment #105</td>
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<td>1% 11</td>
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<td>(Fiori)</td>
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<td>Scintillation counter tests for future</td>
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<td>experiment of S-AC</td>
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<td>109 8/23/68</td>
<td>in progress</td>
<td>17</td>
<td>218</td>
<td>23 288</td>
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<td>Moyer-Haldorff (Perez-Mendoza)</td>
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<td>110 11/8/68</td>
<td>Counter and spark chamber tests for</td>
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<td>experiment #86 to be set up at EPB XI F3</td>
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<tr>
<td>U. Washington (Williams)</td>
<td>EPB</td>
<td>111 12/20/68</td>
<td>Magnetic moment</td>
<td>106</td>
<td>1103</td>
<td>177 1843</td>
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<tr>
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<td>U. C. San Diego (Paton)</td>
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<td>K regeneration amplitudes 1-5 GeV/c</td>
<td>60</td>
<td>623</td>
<td>134 1424</td>
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<td>U. C. San Diego (Musko)</td>
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<td>K*0 charge asymmetry</td>
<td>87</td>
<td>905</td>
<td>169 1836</td>
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<td>U. C. — Los Angeles (Neffens)</td>
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<td>114 11/15/68</td>
<td>Counterc efficiency checks for future</td>
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<td>LRL (George)</td>
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<td>experiment #105</td>
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<td></td>
<td>88 12/5/68</td>
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<td>1%</td>
<td>7</td>
<td>1% 7</td>
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<td>XI F3</td>
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<td>Scintillation counter tests for future</td>
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<td>experiment of S-AC</td>
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<tr>
<td>U. Michigan (Jones)</td>
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<td>116 7/21/68</td>
<td>Neutron cross section for p-d and various</td>
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<td>705</td>
<td>113 1249</td>
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<td>94 7/22/68</td>
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<td>6%</td>
<td>74</td>
<td>6% 74</td>
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<td>U. of Arizona (Jenkins)</td>
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<tr>
<td></td>
<td>P.30</td>
<td>10/12/68</td>
<td>Preliminary equipment tests for experiment</td>
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<td>58</td>
<td>5</td>
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<td></td>
<td></td>
<td></td>
<td>#88</td>
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</tbody>
</table>

**Legend:**
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

Table II. Bevatron motor generator set monthly fault report.

<table>
<thead>
<tr>
<th></th>
<th>4 to 6 pulses/min</th>
<th>7 to 8.7 pulses/min</th>
<th>9.3 to 17 pulses/min</th>
<th>Total</th>
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<tr>
<td></td>
<td>1.5 to 6.9 kA</td>
<td>7.0 to 9 kA</td>
<td>1.5 to 6.9 kA</td>
<td>7.0 to 9 kA</td>
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<td></td>
<td>Poles</td>
<td>Faults</td>
<td>P/F</td>
<td>Poles</td>
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<td>200</td>
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<td>200</td>
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<tr>
<td>Feb.</td>
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<tr>
<td>Mar.</td>
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<td>May</td>
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<td>June</td>
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<td>436</td>
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<td>Aug.</td>
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<td>Oct.</td>
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Poles, Faults, P/F, and Arc-backs through P/F are recorded monthly for each motor generator set.
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Alternate Group Leader
In charge of Bevatron operations
Operation Supervisors
Radiation Control
Operating Crew Supervisors
Bevatron Operators

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In charge of Electrical Coordination Group
In charge of Mechanical Engineering
In charge of Motor Generator Group
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