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BEVATRON OPERATION AND DEVELOPMENT. 62 APRIL - JUNE 1969

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Publication Date
1969-08-27
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Kenneth C. Crebbin

August 27, 1969
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April through June 1969

Kenneth C. Crebbin

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AEC Contract No. W-7405-eng-48
BEVATRON OPERATION AND DEVELOPMENT. 62

April through June 1969

Kenneth C. Crebbin

Lawrence Radiation Laboratory
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Berkeley, California

August 27, 1969

ABSTRACT

During the period covered by this report, the Bevatron provided beam for 86.8% of the scheduled operating time. During this period, \(2.8 \times 10^{18}\) protons were accelerated. We achieved a maximum beam intensity of \(5.2 \times 10^{12}\) protons per pulse. Three primary experiments were completed and three new primary experiments were set up.

The piston rod of a hydraulic cylinder used in plunging the extraction magnets for the EPB system failed.

Vertical beam blowup that occurs on flattop when the rf voltage is turned off was correlated to a space-charge phenomenon.

I. MACHINE OPERATION AND EXPERIMENTAL PROGRAM

The Bevatron operation record is shown in Fig. 1. The beam was "on" for 86.8% of the scheduled operating time. It was "off" 10.7% of the scheduled operating time because of equipment failure and 2.5% of the time for experimental setup, tuning, and routine checks. During this quarter the Bevatron accelerated \(2.8 \times 10^{18}\) protons. The maximum intensity beam accelerated this quarter was \(5.2 \times 10^{12}\) protons per pulse.

The Bevatron provided beam to fourteen primary and three secondary experiments during the period covered by this report. The Bevatron operated for 124 12-hour periods for high energy physics, and integrated 407 12-hour periods of data-taking and 124 12-hour periods of experimental tuneup for a total of 528 periods for primary experiments. An additional 42 12-hour periods of operation were integrated by the three secondary experiments for a total of 570 12-hour periods for high energy physics.

During this quarter three primary exper-
ments were completed. Experiment #93, done by the Palevsky group from Brookhaven National Laboratory, was completed on June 9, 1969. This experiment, a study of p-d scattering, was done at the third focus of Channel II in the external proton beam (EPB) facility. Experiment #94, by the Jones group from the University of Michigan, was completed on June 26, 1969. It was a study of neutron cross sections, carried out in a neutral beam from an internal target near the north straight section. Experimental #106, by the University of Arizona (Jenkins group), was completed on June 2, 1969. This study of K-nucleon cross sections was done at the second focus of EPB Channel I.

Three new experiments were set up this quarter, and in one of them (Experiment #107) data taking was started by the end of June. The other two, Experiments #82 and #95, are partially set up, and preliminary beam-channel tuning and equipment checks have been done.

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

As reported in the preceding quarterly report, the Brookhaven National Laboratory group, Experiment #93, needed an rf-off spill and lower-energy beam than the rest of the experiments. We had therefore set them up on our new "back-porch" pulsing mode. When we originally started back-porch operation, a number of pieces of equipment had to be modified for back porch tracking. All the EPB transport magnets had to be reprogrammed to track down with the decreasing magnetic field of the Bevatron. Several of the magnet power supplies had to be modified to drive the magnet currents down so that tracking could be maintained. During this quarter, the Brookhaven group required a primary proton beam energy of 1 GeV. When we tried to go down to this energy level on the back porch, the rf final amplifier circuit for the Bevatron failed to track. We could track down to about 2.5 to 2.0 GeV, but then lost beam control.

The Brookhaven group needed only a few periods at this energy level so it was decided to operate only for them on a low-energy flattop. Later in the quarter they needed some additional low-energy periods. This time we operated them on a mezzanine. In this mode of operation, we turned the Bevatron rf voltage back on after the Brookhaven beam spill and recaptured and bunched part of the remaining beam. This resulted in a beam loss of about 50%, so we were unable to provide beam to any other counter experiments. We operated with Brookhaven on the mezzanine at variable energies from 1 to 3 GeV, and accelerated some beam to 5 GeV and provided two beam spills to the hydrogen bubble chamber on a 300-msec flattop.

In the last few years, the operating complexity of the Bevatron has increased considerably. Operating simultaneously for a num-
The number of experimenters has placed great demands upon the operations crew at the Bevatron. The new multiple-energy pulsing mode we have been trying the last few months has placed even greater demands on their skill. In particular, the tracking program for the current in the EPB transport magnets has caused some difficulties for operation at two different energies on the same Bevatron pulse. The tracking program for the EPB magnets controls the rate of change of current in each of seven zones (Fig. 2). As a result, any tracking adjustments in an early zone affects the tracking for that magnet in all subsequent zones. This obviously causes problems for experimenters operating on a later zone as well as for the operations crew. A new method of selecting references to eliminate this "series" effect has been chosen. Converting this new procedure to a working computer program is, however, not simple. It is under study and we hope the solution will be available within the next year.

The first two magnets in the EPB extraction system are plunged 28 inches in about 0.75 second. The first magnet in the system, M1, weighs 2600 pounds. This magnet has an additional 2-in. plunge to provide energy tracking in the Bevatron. This additional 2-in. stroke is provided by a 5-in. diameter hydraulic cylinder mounted between the main plunge hydraulic actuator and the magnet-positioning jack screw. On April 3, 1969, the piston rod of the 5-in. hydraulic cylinder broke in fatigue, after experiencing about $4 \times 10^7$ reversing tension and compression cycles over a span of more than 5 years (Fig. 3). The magnet plunge was stopped by emergency crash pads, and no other damage occurred. About 6 hours of down time were necessary to make emergency repairs to the system. The 5-in.-diam hydraulic cylinder was removed and a spacer spool was installed. The 2-in. stroke has never been used in an energy-tracking mode, but has occasionally been used to provide an additional 2-in. radial position adjustment during extraction studies.

II. SHUTDOWN

The Bevatron was shut down from April 7 to April 14, 1969, as an economy move in the present tight fiscal budget. During this period, routine quarterly maintenance was done on the main motor-generator sets. There was a short vacuum shutdown on the Bevatron to replace scintillators on the M1 and M2 magnets and to check the M1 magnet system inside the vacuum tank after the failure in the plunging system reported above. Routine maintenance was carried out on the rest of the Bevatron and associated equipment.

Channel I of the EPB system remained shut down an additional week because of setup work in the backstop region.
III. BEVATRON DEVELOPMENT AND STUDIES

Bevatron studies continued this quarter in four general categories.

1. Resonant extraction studies continued, with some effort being devoted to changes in the closed orbit in the Bevatron. These shifts were accomplished by shunting part of the current in the third quadrant of the Bevatron magnet. Shifts of "tune" in the region of the resonance and better control of the resonance were achieved by pulsing currents up to several hundred amperes through some of the pole-face windings in the Bevatron. These currents cause changes in the field index $n$ of the Bevatron and resultant changes in the $\nu$ value of the betatron oscillations.

One observed phenomenon that gives trouble in resonant extraction as well as in normal energy-loss extraction is the vertical blowup of the beam when the rf is turned off and the beam allowed to coast on flattop. This effect was studied in detail this quarter. The blowup is a space-charge effect. The mechanism is still under investigation.

The remaining areas of Bevatron study this quarter were:

2. High beam studies and injection phenomena.
3. Main motor-generator flattop control.

IV. BEVATRON MOTOR GENERATOR

The magnet pulsing record is shown in Table II.

References

1. Kenneth C. Crebbin, Don M. Evans, and Robert Frias, Bevatron Operation and Development. 61, UCRL-19232, August 1969.
STAFF

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- Alternate Group Leader
- In charge of Bevatron operations

- Operation Supervisors

- Radiation Control

- Operating Crew Supervisors

- Bevatron Operators

- Development and Support

- In charge of Electrical Engineering Group

- In charge of Electrical Coordination Group

- In charge of Mechanical Engineering

- In charge of Motor Generator Group

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Emery Zajec
Table I. Summary of Bevatron Experimental Research Program April through June 1969.

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<thead>
<tr>
<th>Groups</th>
<th>Experiment locations</th>
<th>Dates</th>
<th>Start</th>
<th>End</th>
<th>Experiment</th>
<th>Beam Time</th>
<th>This quarter 12-Hour periods</th>
<th>Start of run through June 1569</th>
<th>Pulse Schedule</th>
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<td>12-Hour periods Hours</td>
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<td>p^+p Interactions</td>
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<td>250</td>
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<td>K^p and K^d reactions</td>
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<td>268</td>
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<td>169</td>
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<td>88</td>
<td>255</td>
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<td>$\pi^+\pi^-\gamma$ Differential cross sections</td>
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<td>6/9/69</td>
<td>p^+ Elastic and inelastic scattering</td>
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<td>7/13/68</td>
<td>6/16/69</td>
<td>Neutron cross sections for p, d, and various metal targets</td>
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UCRL-19299
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Figure 1. Bevatron operating schedule.
Figure 2. General magnet pulsing mode showing seven control zones.
Figure 3. Fatigue failure of piston rod from EPB plunged magnet M1. Piston provided 2-in. energy tracking stroke.
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