Title
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Publication Date
1969-02-20

UCRL-18598

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Presented at the National Particle Accelerator
Conference, Washington, D. C., March 1969

UCRL-18598
Preprint

UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
Berkeley, California

AEC Contract No. W-7405-eng-48

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Introduction. The external proton beam (EPB) system at the Bevatron has undergone intensive improvement since its commissioning in 1963.[1,2] The system that has evolved in the past five years is unmatched in flexibility of experimental operations and has completely overshadowed the use and functions of internal beams target stations. The number of simultaneous secondary beam setups has been more than doubled. At present, four EPB target stations in two proton-channels from one extraction point typically serve eight simultaneous experiments. Of even greater importance is the substantial increase in compatible operation of experiments. The EPB has provided a large degree of operational independence in that experiments may be set up, tuned, operated or removed with very little mutual interference. Also of significance is the fact that Bevatron operations are largely decoupled from experimental area operations. The machine, for example, is rarely shutdown because of experimental area activities. In addition, external targetting results in decreased radiation damage and activation of the accelerator components.

External Proton Beam System. The achromatic extraction system [2,3] for the Bevatron employs an energy loss target and two internal deflection magnets and has an extraction efficiency of ~ 40%. In 1963 the initial EPB facility consisted of a[4] single magnetic channel with three successive foci (or target stations). The operational success resulted in heavy reliance upon the facility by the experimental program. This warranted further development to increase the number and the independence of target stations.

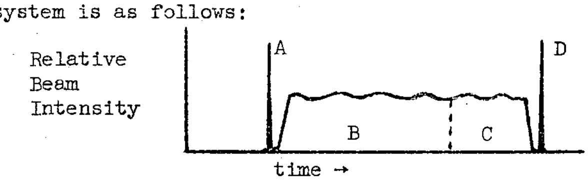
In order to provide a more tractable arrangement of target stations an improved dual channel system was constructed in 1967. This system provides two external proton beam channels from a single extraction point. Target stations are located at each second and third focus as shown in Fig. 1. Each channel can operate independently such that setup changes or maintenance procedures in one channel do not effect operation of the other. Other improvements include smaller beam images at the various foci and shielding [5] which now allows intensities of ~ 10^{12} protons/pulse at any target station. Heavy duty foundations were constructed to sustain the increased shielding load and to minimize alignment problems. Additional experimental floor area together with a new overhead crane and an improved utility distribution system were also installed.[6]

The target station (F3) at the end of each channel can be used advantageously for multiple secondary beams from the same target. While these secondary beams are not always completely compatible for simultaneous data-taking operations, it is found that a high degree of compatibility exists in the preliminary tune-up procedures which now occupy the largest fraction of the calendar time for experiments. As seen in Fig. 1, two to three experiments utilize each end-station.

EPB System Operation. The dual-channel system described here has operated extremely well for the past year. EPB Channels I and II operate on the same Bevatron pulse by beam switching between channels. This is accomplished by magnet (XMK) in ~ 7 ms. In this manner a long beam spill can be efficiently divided between channels. Also the beam may be directed to each channel on alternate pulses by programming other transport magnets.

In Channel II another pulsed magnet (RBK) can direct the beam out of Channel II onto the F2 target which is used for bubble chamber Beam #9. The on-time for this magnet is ~ 3 ms, which is ample for the normal chamber beam spill length of 1/4 ms duration. Magnet BD is used to remove the beam from the F2 target (in ~ 5 μs) after the required number of particles have entered the bubble chamber.

A typical operating mode for the two channel system is as follows:



B + C is a slow spill (one to two seconds duration) than can be shared simultaneously between internal targets and the EPB. In the EPB, B can be shared simultaneously in Channel I on targets at F2 and F3. Beam spill C may be deflected to Channel II users at F3, while A and D are fast bubble chamber spills directed to Channel II – F2. B and C can be divided into any desired ratio. With this system eleven experiments have operated simultaneously seven of them being in the EPB system.

The pulsed transport magnets of the EPB system are now computer controlled.[7] Aside from the operational advantages of continuous monitoring, efficient tune-up procedures, and instantaneous changes to previous or predetermined conditions, the computer also provides flexible magnet controls for beam spills on mezzanine, flattop, and back-porch during the same pulse.

Planned Improvements. Figure 1 shows the existing system with a planned modification indicated by the dashed area. This modification would allow the beam to be split at Channel I – F2 by steering the beam across a series of septum magnets. Thus part of the beam would remain in Channel I and part would be deflected into the "septum channel". Approximately 3% of the beam will be lost on the septum. The new septum channel is designed to enhance the overall operational efficiency of the external beam complex. At present only one secondary beam of low momentum and with either large production angle or small solid angle can be utilized at F2 Channel I. Beam sharing between the second and third focus regions is complex as series targetting is required, and correction of beam steering and beam optical properties is necessary. This new improvement, in effect, will decouple the second and third focus regions, greatly enhancing the independence of these areas, and will provide a new target area (SF3) with flexibility equal to that of the other end-stations. The first secondary beams planned for the SF3 area will be arranged somewhat differently than the other end-stations where a deflecting magnet is used to disperse the secondary beams. At this station the first secondary beam transport elements will be new design narrow quadrupoles which will view the target directly and thereby provide large solid angle and independent momentum control for each secondary beam.

Other improvements scheduled for this year include the installation of a thinner septum deflecting magnet and quadrupole for the first extraction magnets within the Bevatron. Preliminary tests indicate that the extraction efficiency for the energy loss system may increase to ~ 55%.(8) These new magnets are designed also to implement a resonant extraction system. In recent tests of a proto-type resonant extraction system ~ 60% extraction efficiency has been achieved.(9) The new septum magnets should increase this efficiency to ~ 80%.

The increasing complexity of today's experiments has resulted in longer tune-up and operating periods at the accelerator, hence better sharing techniques as well as more versatile facilities are required. The developments described here are aimed at maintaining the capability to meet these requirements.

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*Work done under the auspices of the U. S. Atomic Energy Commission.

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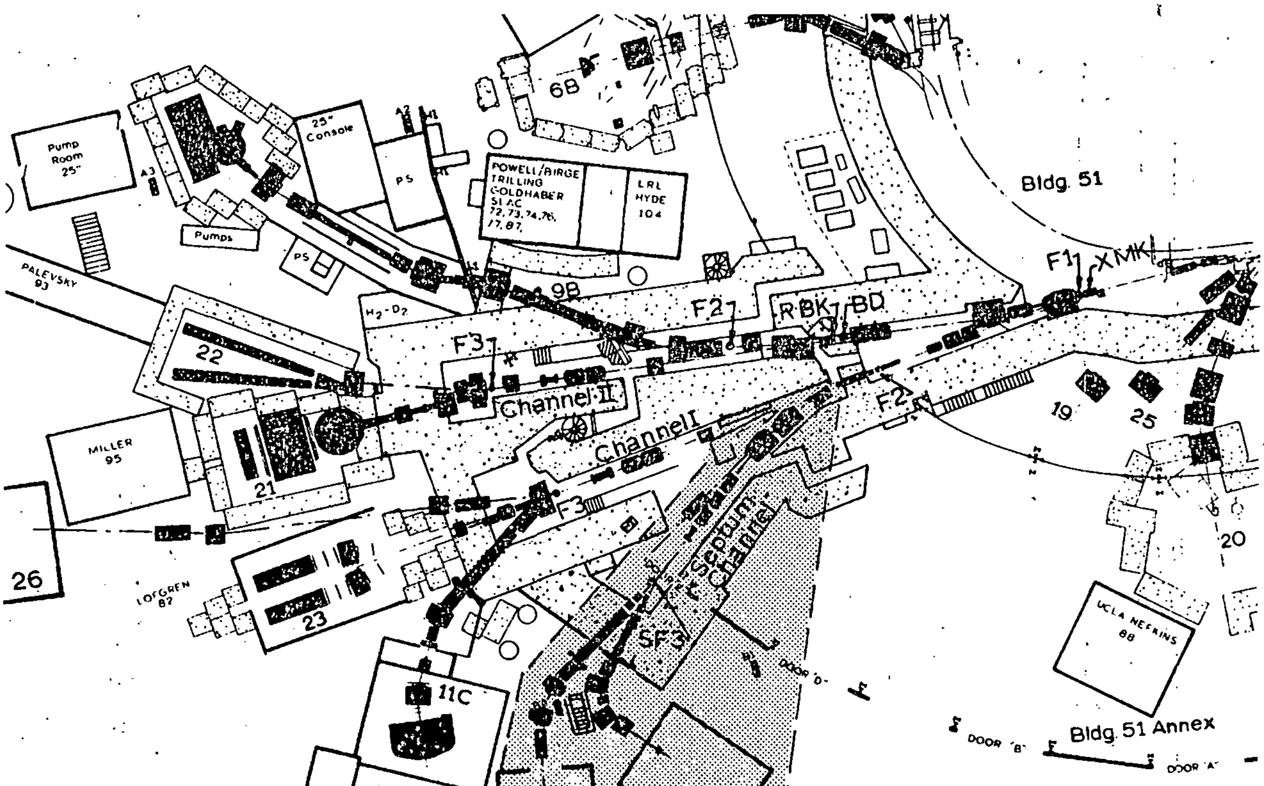

Fig. 1

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