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BEVATRON EXTERNAL PROTON BEAM FACILITIES*

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Abstract

A septum magnet beam-splitting system has been successfully operated at the Bevatron. This system has made possible a more flexible placement of secondary particle beams and the simultaneous sharing of the external proton beam between two end stations. A second beam-splitting system is under construction, and simultaneous beam sharing among three end stations will soon be possible. Other developments which will greatly increase the total flux of the external proton beam are also discussed.

External Proton Beam (EPB) System

As the demand for secondary particle beams increased at the Bevatron, an external proton beam system was installed.² The initial system set up in 1963 was a single channel system which was superseded by a dual channel system in 1967. An energy loss system was used to extract protons from the Bevatron, and series targeting of the proton beam permitted the sharing of protons among several secondary particle beams. Furthermore, fast pulsed magnets were used to switch the proton beam along alternate beam channels during different portions of the spill.

This system proved to have some drawbacks, however. For instance, there was no capability for providing simultaneous, long beam spills in two EPB channels for counter experiments. Also, it was possible to build large solid angle, zero production angle beams only at the final focus of a beam channel. Then too, series targeting at subsequent foci of a single channel required complex and precise beam tuning, although by 1969 computer control³ eased the operators' task considerably.

For these reasons, a septum magnet beam-splitting system was installed at the Bevatron in early 1970. A set of three septum magnets⁴ was installed in EPB Channel I to split the proton beam between Channel I and a new beam channel, the "Septum Channel (SI)." The proportion of beam which went into each channel could be varied easily by deflecting the beam toward either side of the magnetic septum. Beam losses at this septum (.125 in. wide) were on the order of 10%.

The beam-splitting system was successfully operated when it was first turned on in early 1970. A portion of the proton beam was deflected into the Septum Channel as desired, and simultaneous beam sharing was achieved. However, the positional stability of the Septum Channel beam at its final focus was not satisfactory. This instability was found to be due to pulse-to-pulse variation of the Bevatron energy. These variations were as large as $\pm .1\%$ in early 1970, and this energy instability was manifested by $\pm .3$ in. excursions of the beam at the Septum Channel. Since then, improvements in the stability of the machine energy and of the EPB magnets power supplies have largely eliminated the problem. Further improvements to the Bevatron were made during a shut-down this winter; in early 1971 the machine energy will be stable to $\pm .003\%$. Among these improvements will be a new filter system for suppressing Bevatron magnet ripple. Also, a new "closed loop" computer control system will ensure long term stability in the targeting of the Septum Channel beam.

Aside from this initial problem of instability, the septum magnet beam-splitting system has worked very well. Six secondary particle beams located at the ends of Channel I and the Septum Channel could be run simultaneously. Not all experiments could take data simultaneously, because of conflicting requirements on the currents in the backstop magnets which were used to disperse the secondary beams. However, a very high level of compatibility was achieved, particularly when some experiments were in the tuning-up stage. The reduced crowding of secondary beams and their independence from the EPB and between one another permitted great flexibility in the design and operation of these beams. It was possible to change the sharing of beam to switch the beam between channels with very little re-tuning of the EPB system.

Beam sharing with Channel II was still accomplished with beam switching; therefore, such sharing still had to be sequential, not simultaneous. This restriction led to the present EPB improvements.

EPB Improvements

A second triplet of septum-type bending magnets⁵ has been installed at the F1 focus, where the EPB splits into Channels I and II. See Figure I. These magnets are similar to the magnets which split the EPB between Channel I and the Septum Channel, except that the new magnets have thinner steel laminations to permit faster switching in order to track the beam. Magnet current will be 5160 A for 6.6° deflection. The operation of this new beam splitter is somewhat different, however.⁶ The narrow aperture of the beam channel coming from the Bevatron places such tight restrictions upon the beam position that it is not possible to deflect the incident beam to either side of the septum. Instead, the protons are focused to a 3" wide, parallel beam at the center of the channel, and the three septum magnets with their single common vacuum tank are moved laterally across the beam to vary the sharing of the beam. A sliding seal preserves the vacuum integrity of the EPB. The three septum magnets are electrically in series. The critical first septum consists of a single turn, brazed copper, water-cooled .125" x .75" conductor. Data for the two different installations are listed for a proton beam of 6.2 GeV kinetic energy (7.1 GeV/c momentum):

	Angle	Amps	Amps/in ²	GPM @ 60 psid	Septum $\Delta T, ^\circ C$
F1	6.6	5110	81,800	1.8	40.5
F2	5.25	4060	65,000	1.4	33

The improved EPB system will permit simultaneous, long-spill beam sharing among three end stations. See Figure II. Also, there exists the capability to re-distribute the beam during different portions of the spill. For example, a low-energy beam may be switched to Channel II during "mezzanine", and a high-energy beam may be shared among all three EPB channels during "flat-top". A further advantage of the EPB system, one that is becoming increasingly important, is the fact that the production targets are located outside of the Bevatron. As the Bevatron proton flux is increased, radiation damage to the accelerator becomes a serious problem which can be alleviated only by using an EPB system with a high extraction efficiency. For this

reason, the use of internal targets at the Bevatron will be discouraged in the future.

Future Plans

Present experimental scheduling call for the use of EPB Channel II as a proton beam for most of 1971. Later, this beam channel will be extended approximately 100 feet into the northern part of the experimental hall, which has all necessary power, water, and crane facilities and which is well separated from the other secondary beams.

Design studies are being made for a high-intensity stopping K beam and this beam will likely be built at this new backstop area.

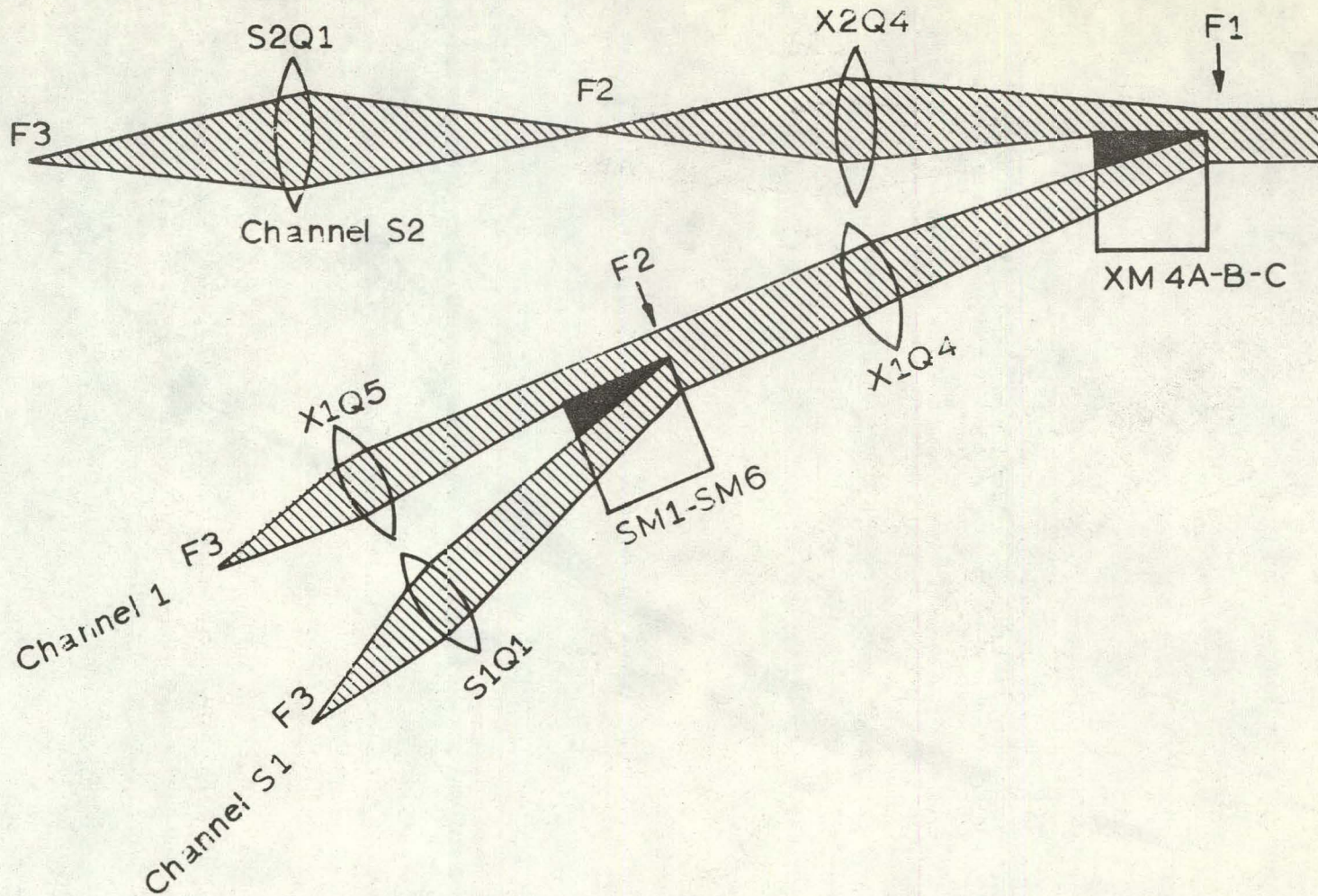
The proton flux in the EPB will be greatly increased in 1971 when the resonant extraction system is introduced. The new extraction efficiency is expected to be about 70% initially, as compared with about 55% for the energy loss system. This efficiency is expected to increase to 85% in mid 1971, when a transport magnet with a limiting aperture will be replaced.

Several other Bevatron improvements are being studied, in the effort to increase the internal proton beam. Among these possible improvements is a cryogenic vacuum pumping system which will improve the vacuum by an order of magnitude.⁷ Also under consideration is the conversion of the BNL 50 MeV linac to replace the present Bevatron 19 MeV linac in the injection system.

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Schematic of EPB System

Fig. II

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