Commissioning of the Beam Transfer Line to UNK

A. Ageev, Yu. Fedotov, G. Gurov, Yu. Karshev, V. Komarov,
O. Kurnaev, K. Myznikov, A. Sytin, V. Tatarenko, A. Vasilevskiy
Institute for High Energy Physics, Protvino, Moscow region, 142 284, Russia

Abstract

Beam transfer line is the first system of UNK amongst the others which are under construction at IHEP now [1]. It has about 3 km length and a complicated lattice. The beam transfer line is to inject the beam from U–70 into a 600 GeV conventional-magnet accelerator. Description of the BTL lattice and the first results of its commissioning are presented. The brief description of the control system is given.

1 MAGNETIC STRUCTURE AND EQUIPMENT

The injection channel of UNK [2] consists of three main parts: beam extraction system from the 70 GeV accelerator, beam transfer line to the first stage of UNK (UNK–I, in short), and beam injection system into UNK–I. The channel's scheme in horizontal and vertical planes with the layout of magnetic optic elements is shown in Fig.1.

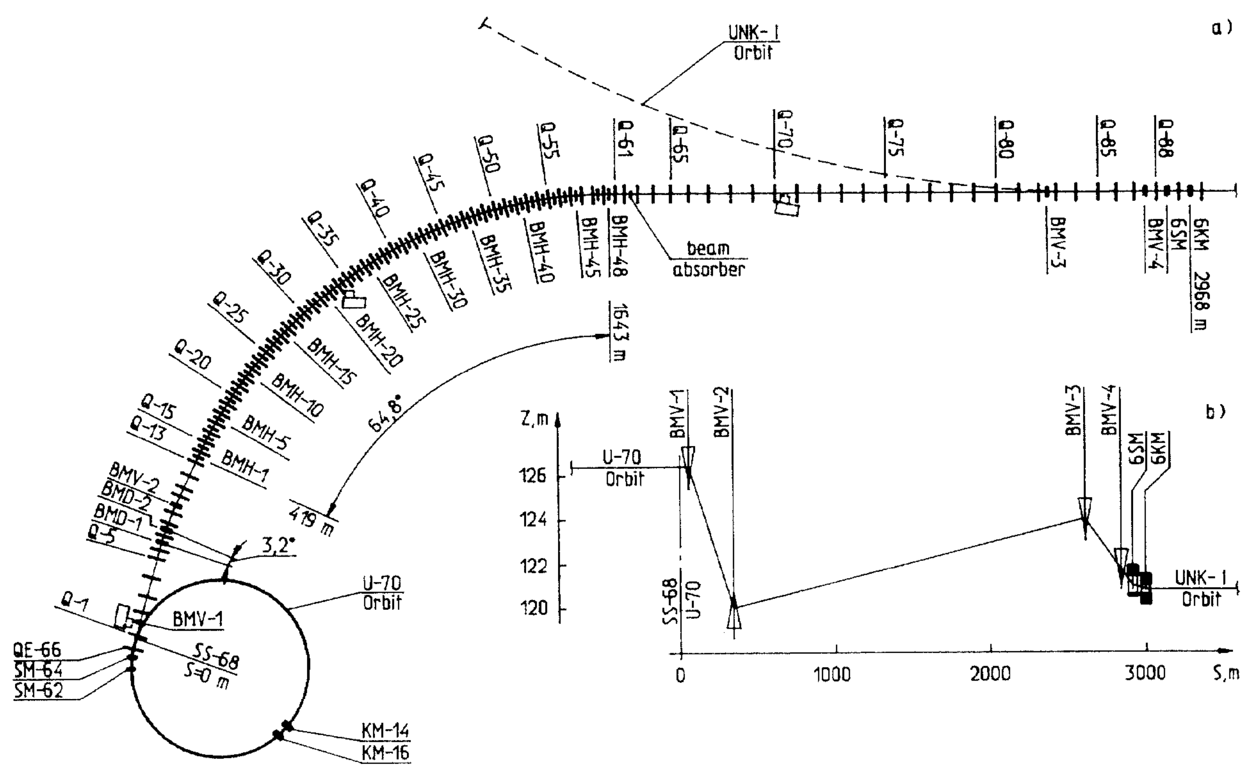

Figure 1: The BTL scheme in horizontal (a) and vertical (b) planes.

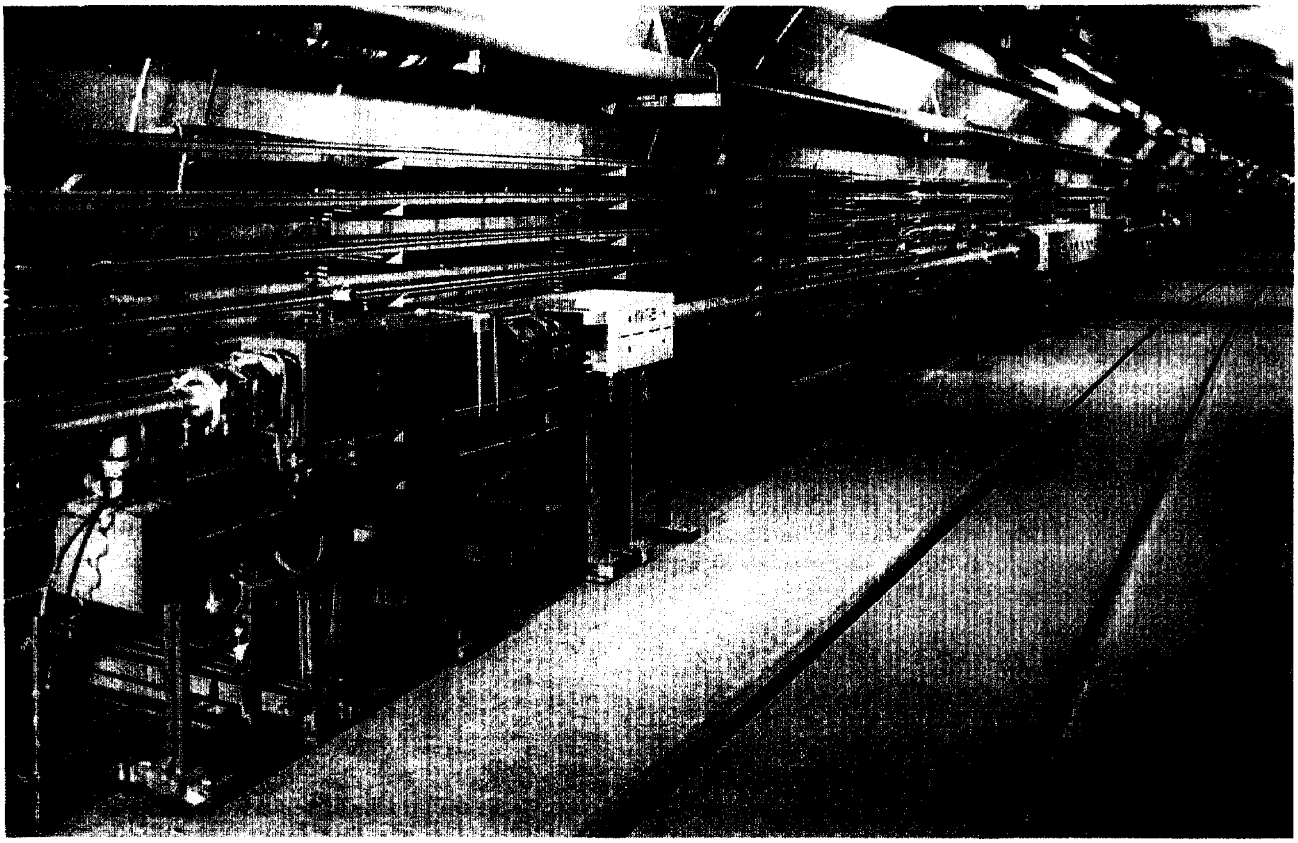

Figure 2: BTL tunnel with the beam-line equipment.

The extraction system consists of two full-aperture kicker-magnets KM-14 and KM-16 (with the numerals denoting the position number of straight section in the 70 GeV accelerator's lattice in which the equipment unit is installed), two septum-magnets SM-62 and SM-64, one quadrupole lens QE-66 for preliminary focusing, and two correction magnets in horizontal and vertical planes. The immovable septum-magnets are installed outside the working aperture of U–70 vacuum chamber. Preliminary beam displacement to the septa is carried out by means of the local closed-orbit distortion.

The beam transfer line starts in straight section N68. Its magnetic structure is the strong-focusing periodic one, of FODO type. In the straight part of the channel a period has the length of 102 m, while in the bending part the period is 52 m long. Phase advance per period is 90^0. At the beginning of the channel the dispersion function is suppressed to zero by magnets BMD-1 and BMD-2. At the entrance of the bending part the dispersion function is matched by means of four special magnets, the length of which being a half-length of the normal magnet. The dispersion function is matched in the same manner at the end of bending part of the BTL as well.

The vertical route of the channel is stipulated by the difference between the orbit plane depths of U–70 and UNK–I, and by complicated geological conditions, especially at the beginning. Arrangement and strengths of the vertical bending magnets are chosen so as to provide zero values of the vertical dispersion function throughout the main part of the channel. The horizontal acceptance is $\gtrsim$9 mm·mrad, and the vertical one is $\gtrsim$11 mm·mrad.

Beam injection into UNK–I is performed in the vertical plane. The injection system consists of a bending septum-magnet 6SM and a full-aperture kicker-magnet 6KM.

The line-of-route correction in every plane is made by eight correction stations disposed regularly along the channel length. Each of the stations consists of two pick-ups and two correctors, the distance between them being a one-cell period.

In total, the injection channel embeds 52 bending dipoles of 5.8 m length with the field strength of 1 T, 88 quads of 1 m length with the field gradient of 13 T/m and 56 various correctors.

The vacuum chamber of the channel is the stainless-steel pipe with the diameter of 100 mm, except for the bending dipoles where the elliptical pipe has the dimensions of 64×100 mm^2. Rough vacuum pumping is provided by 30 special mechanical and turbo stations, and high vacuum is achieved with 64 sputter-ion pumps.

The beam diagnostic system comprises 3 current monitors, 46 pick-ups, 26 beam profile monitors as well as beam loss and halo monitors and 3 TV-screens.

The BTL process equipment is controlled from the three surface utility buildings placed regularly above the channel. The BTL Control System consists of four autonomous subsystems: a power supply control, a beam diagnostic control, a vacuum control and a dynamic interlock control [3].

The Control System architecture is a three-level one. On the lower level, a microprocessor-based electronics control each equipment set (a power supply of the magnetic optics, a vacuum control rack etc.). All the microprocessor controllers to serve one type of equipment in each building are linked through a multiplexer to a dedicated local IBM PC/AT-386. The general control of the injection complex as of a coherent unit was accomplished by means of four console PCs integrating local PCs of all the subsystems in the three BTL buildings.

2 RESULTS OF INJECTION CHANNEL COMMISSIONING

The equipment of the injection channel was assembled till the quad Q82. Fig.2 shows the UNK's transfer-line tunnel with the beam-line equipment. The beam was steered down to a beam stopper placed near quad Q62 at the end of bending part of the channel. The average vacuum in the beam pipe was about $2{\cdot}10^{-6}$ Torr. In order to minimize the equipment irradiation, only 5 of 30 proton bunches available were accelerated at 6 MHz to 65 GeV in the synchrotron U–70. At this energy the beam was recaptured to 200 MHz, as is required for UNK [4]. On being recaptured, the beam was accelerated at 200 MHz to 65.47 GeV in 0.1 sec, while the particles falling beyond 200 MHz separatrices were dumped into the inner beam absorber. Then, the beam was displaced by the local orbit distortion to septa SM-62, SM-64 and, by means of KM-14 and KM-16, was thus ejected into the transfer line.

The observation of beam and its path control during commissioning was performed with the beam profile monitors and TV-screens. The beam emittance in U–70 synchrotron before extraction was about 1.6 mm·mrad (95%). The beam size observed in the channel was found to be in a good agreement with this value. The beam profiles at the first septum-magnet SM-62, at the entrance of bending part and near the beam stopper inside the channel are shown in Fig.3.

Sorting of bending dipoles for BTL was accomplished according magnetic measurements so as to bound the beam path excursions to less than ± 1 mm. The alignment of quads of the BTL in the transverse planes was carried out with the r.m.s. accuracy of 0.25 mm. The net beam path distortion at the end of the bending section, as found by numerical stimulations, must not exceed 7 mm (without correction). The value measured is in a good agreement with this prediction.

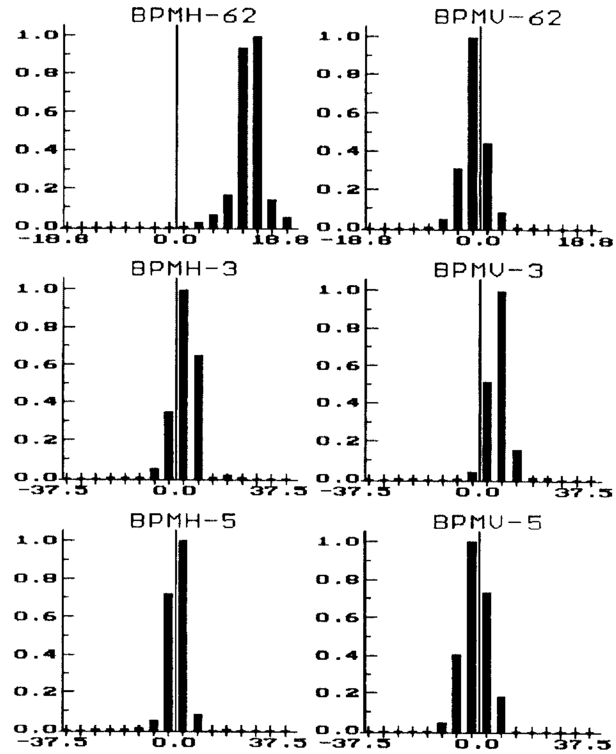

Figure 3: Beam profiles at septum-magnet SM-62, at entrance of bending part and near beam stopper.

The power supply current tolerances were established so as to guarantee the injection errors of $\lesssim$3 mm in horizontal, and $\lesssim$2 mm in vertical planes. The excursions of the beam position observed, on being reduced to the main-ring lattice, do not exceed the above values.

UNK injection channel commissioning confirmed the validity of both, the physical decisions chosen and of their technical realizations. Beam position stability and focusing properties achieved do meet the beam injection requirements in UNK–I.

The authors would like to thank the UNK Division team and other personnel at IHEP for their collaboration during the UNK BTL commissioning.

3 REFERENCES

[1] *IHEP 3000 GeV Accelerating – Storage Complex (UNK).* Preprint IHEP 93–27, Protvino, 1993 (in Russian).

[2] V.T. Baranov et al. *Beam-Transfer Line of UNK.* Preprint IHEP 92-118, Protvino, 1992 (in Russian).

[3] A.I. Ageev et al. *Present Status of the UNK Control System at IHEP.* In Proceed. of ICALEPCS'93, Berlin, Germany, October 1993 (to be published).

[4] V.A. Vasiljev et al. *Beam Recapturing Station to 200 MHz of 70 GeV Proton Synchrotron.* In Proceed. of 9th All-Union Conf. on High Energy Accel., Dubna, 1985, vol.2, p.384 (in Russian).