

# USER-FRIENDLY INTERFACE FOR OPERATOR IN THE CONTROLS OF UNK BEAM-TRANSFER LINE

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The beam-transfer line (BTL) was commissioned in March 1994 [1]. BTL has to inject proton beam from the existing 70 GeV accelerator (U-70) into the 600 GeV one (UNK-I [2]) under construction. An operator user-friendly interface for UNK BTL controls is described. Interface is equipped with sufficient means allowing to operator by customary terms to interact with technological process. Working in real-time regime program gives the possibilities: to control the BTL power supplies currents; to see the beam trajectory and profile along BTL; to compare real and computed through the measured emittance beam dimensions; to store archive data, etc. Working with statistical data of power supply current instabilities and beam trajectory displacements, program allows to do an estimation of partial contributions of every element in the beam position instabilities.

## I. MAGNETIC STRUCTURE AND EQUIPMENT OF BTL

The injection channel of UNK [3] consists of three main parts: beam extraction system from U-70, beam-transfer line to UNK-I, and beam injection system into UNK-I. The extraction system consists of two full-aperture kicker-magnets KM-14 and KM-16, two septum-magnets SM-62 and SM-64, one quadrupole lens Q-66 for preliminary focusing, and two correction magnets in horizontal and vertical planes.

The line-of-route correction in every plane is made by eight correction stations disposed regularly along the line 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, 88 quads and 56 various correctors.

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.

## II. BTL CONTROL SYSTEM

The BTL control system [4] is divided into four functional subsystems:

- magnet power supplies control;
- beam diagnostics;
- synchronization and dynamic interlock;
- vacuum control.

Each of these subsystems has its own console computer IBM PC 386 at the user's working place. The console computers are linked through serial communication lines to subsystem multiplexers situated in three BTL technological buildings. Each multiplexer combines subsystem controllers, which serve the corresponding technological equipment.

The control system has three software levels:

- software of controllers and multiplexers providing real-time procedures of the equipment;
- resident programs of the console computers;
- high-level applications which represent the control system shell and consist of programs set with convenient graphic interface.

The third-level software is installed on one computer IBM PC 386, linked to the console computers by LAN "Ethernet".

## III. BTL CONTROL USER INTERFACE

The control system software was developed specially for the injection channel and was supposed to make the equipment on-line operation maximally convenient for the operator. The high-level user interface of the BTL control system allows the operator:

- to observe the physical structure of the whole transfer line with current data of the beam position and profile, magnetics elements parameters;
- to scroll the last measurement data from the power supply (PS) controllers and to change references of these supplies. These data are presented as physical values;
- to make a quick simulation of the beam trajectory and to correct the trace and focusing of the beam, using the measurement data;
- to accumulate and process statistical data from the beam diagnostic devices and the PS. Statistics can be viewed in form of tables and graphics.

The interface programs are written in "C" language using "Graphics Windows" package. It is presented in the form of graphic windows set like that of "Windows" system. Each window shows definite information by graphic or by table. In open windows the information is automatically renewed after each beam transfer cycle. In the windows there are horizontal and vertical menus and buttons. In order to change the menu, to switch between windows or to change the information in a window one should only press the standard set of function keys or use the mouse. If it is necessary, the operator can call the "Help window" with the description of commands.

Fig.1 shows the window with BTL fragment. The graphic images as icons of all magnets and beam diagnostic devices are given in this scheme. Near the beam position monitors there are indications to show the measurement data in form of adjustable resistors. "Invisible" buttons are hidden under the profile monitors and magnets images. By pressing those buttons with mouse one can open windows either with the beam profile or with the parameters of these magnets.

Magnets parameters table is given on fig.2. It contains the calculated fields and gradients and corresponding PS currents references, really measured PS currents and corresponding calculated magnets fields. Just after initialization the program calculates the fields and gradients of the magnets for a chosen energy, changes them into currents and sends as a data package

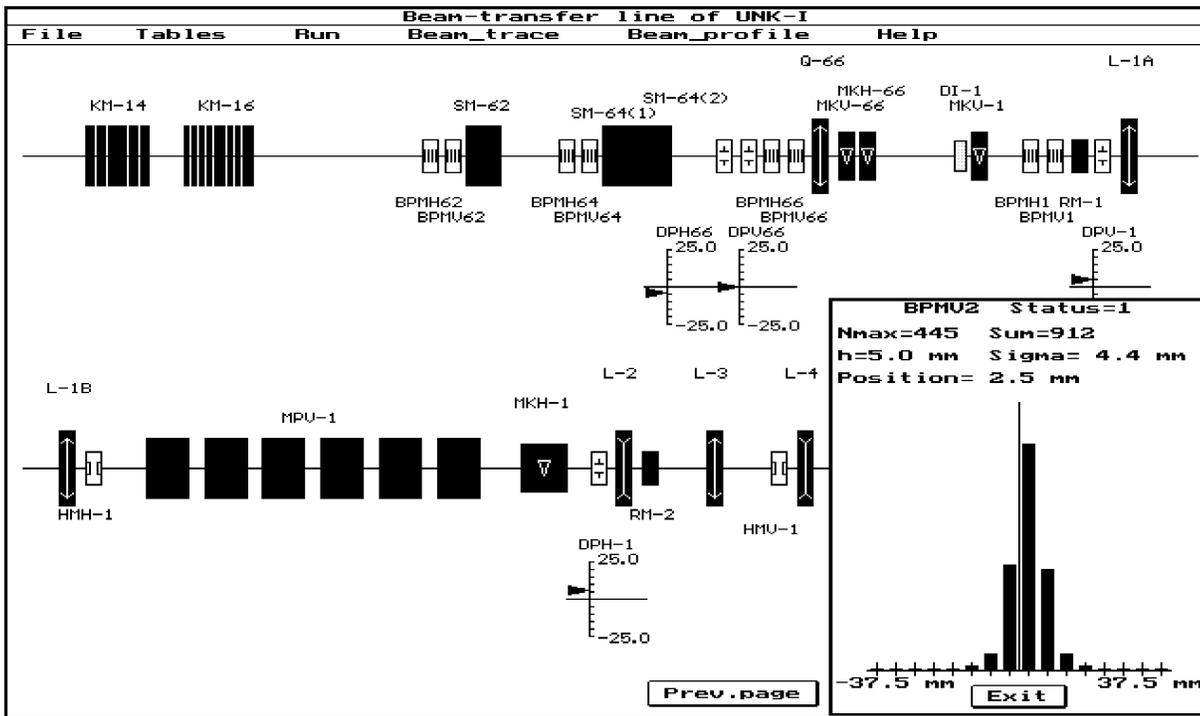


Figure 1: Window with the fragment of BTL.

to the console computer connected with the PS control. There they are processed and written in the PS controllers. The magnetic fields-into-PS-currents conversion is carried out by using the magnetic measurement results from the object-oriented BTL data base. The table also represents relative deviations of the real field in the magnets from calculated values.

The operator can change manually the magnetic fields or corresponding PS current sets by typing their new values on the keyboard. In this case the program watches for correctness of the user's action in order to keep the current deviations within the tolerances.

The program permanently receives (apart from the operator's action) data from the beam diagnostics and power supplies, processes them and accumulates the statistics, calculates correlation coefficients between PS and beam position instabilities. The PS currents changes from cycle to cycle are displayed in the form of graphic in window "Power supplies statistics". The statistics of the chosen PS is given.

The window "Beam trace" presents the beam trajectory along the whole channel in horizontal and vertical planes. The trace is drawn according to the measured data of the beam position, profile and halo monitors.

The beam trace is corrected only by operator's command in the window "Trace correction". Fig.3 shows this window. The table contains all correction dipoles, their status, corresponding monitors and correlation coefficient between the corrector current and beam position. Each corrector can be switched off (status "OFF"), switched on automatic mode (status "AUTO") or switched on manual control (status "HAND"). According to the operator's command the program calculates magnetic fields of

the correctors switched on automatic control mode. If it is necessary the operator switches some of the correctors on manual control and sets the corrector magnetic field by hand in the window "Parameters of magnet". By simulation the operator can view a expected trace after correction and write new current references in the PS controllers.

During calculations the program watches for the variation range of currents and polarity of the correction dipoles. If it is necessary to change the polarity the program informs the operator about it.

The convenience and visuality of the interface have made the user work more efficient. This fact allowed one to launch successfully the UNK beam transfer line in 1994.

#### IV. REFERENCES

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- [2] *IHEP 3000 GeV Accelerating-Storage Complex (UNK)*. IHEP Preprint 93-27, Protvino, 1993 (in Russian).
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- [4] 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).

Parameters of magnets						
Magnets	Theory	Work		Real		
	Field/grad	Field/grad	Current (A)	Field/grad	Current (A)	dB/B(%)
SM-62	2.553571	2.55357	1762.0	2.55137	1760.4	-0.086
SM-64(1)	-8.060000	-8.06000	-5561.4	-8.05002	-5554.5	-0.124
SM-64(2)	-8.060000	-8.06000	-5561.4	-8.06582	-5565.4	0.072
Q-66	4.249596	4.24960	294.0	4.24247	293.7	-0.168
MKV-66	0.0	0.93110	50.0	0.93417	50.2	9.342
MKH-66	0.0	0.00000	0.0	0.00000	0.0	0.000
MKV-1	0.0	0.00000	0.0	0.00000	0.0	0.000
L-1A	0.686271	0.68627	824.0	0.68618	824.4	-0.014
L-1B	0.686271	0.68627	824.0	0.68695	824.4	0.098
MPU-1(1)	-5.231856	-5.23186	-1236.8	-5.21772	-1233.4	-0.270
MPU-1(2)	-5.231856	-5.23186	-1237.0	-5.21081	-1231.9	-0.402
MPU-1(3)	-5.231856	-5.23186	-1236.0	-5.23670	-1237.2	0.092
MPU-1(4)	-5.231856	-5.23186	-1235.9	-5.23859	-1237.5	0.129
MPU-1(5)	-5.231856	-5.23186	-1234.3	-5.23226	-1234.4	0.008
MPU-1(6)	-5.231856	-5.23186	-1235.0	-5.23527	-1235.8	0.065
MKH-1	0.0	0.17078	40.0	0.17020	39.9	2.885
L-2	0.699207	0.69921	829.4	0.69899	829.1	-0.031
L-3	0.574665	0.57467	681.3	0.57563	682.5	0.168
L-4	0.768870	0.76887	925.6	0.76936	926.2	0.064
L-5	0.984593	0.98459	1170.8	0.98225	1168.0	-0.238

Energy: 65.00 GeV                       

Figure 2: Window with the fragment of table "Parameters of magnets".

Trace correction									
Correc.dipoles		Monitors		Correc.dipoles		Monitors			
Name	Status	Name	r	n12(mm/A)	Name	Status	z	n12(mm/A)	
MKH-66	AUTO	BPMH1	0.0	-0.166	MKV-66	AUTO	BPMU1	0.1	0.062
MKH-1	AUTO	BPMH2	0.3	0.140	MKV-1	AUTO	BPMU2	0.5	-1.715
MKH-2	HAND	BPMH3	0.9	4.420	MKV-2	OFF	BPMU3	0.5	-1.468
MKH		Parameters of magnet: MKH-2			U-3	AUTO	BPMU3	0.5	3.698
MKH		Theory field(kGs):	0.000000		U-4	OFF	BPMU4	-0.2	-0.046
MKH		Work field(kGs):	<input type="text" value="0.104988"/>		U-5	OFF	BPMU4	-0.2	-3.146
MKH		Work current(A):	<input type="text" value="0.650"/>		U-6	AUTO	BPMU4	-0.2	-3.147
MKH		Polarity:	<input type="text" value="1"/> <input type="button" value="Stat.OFF"/>		U-7	OFF	BPMU4	-0.2	0.059
MKH		r: 6.05 mm	z: -0.38 mm		U-8	OFF	BPMU5	1.1	-3.152
MKH		rd(BPMH3): 0.91 mm			U-9	OFF	BPMU5	1.1	0.058
MKH		n12: 4.4198 mm/A			U-10	OFF	BPMU5	1.1	0.067
MKH			<input type="button" value="Reset"/>		U-11	OFF	BPMU5	1.1	3.147
MKH-12	AUTO	BPMH5	0.6	-3.157	MKV-12	AUTO	BPMU5	1.1	3.151
MKH-13	AUTO	BPMH6	-0.7	3.772	MKV-13	AUTO	BPMU6	-0.9	-3.633
MKH-14	AUTO	BPMH8	0.9	-6.366	MKV-14	AUTO	BPMU7	0.8	6.041
MKH-15	OFF	BPMH9	0.6	-3.309	MKV-15	AUTO	BPMU8	1.4	6.045
MKH-16	AUTO	BPMH9	0.6	-6.033	MKV-16	AUTO	BPMU9	1.3	6.024
MKH-17	AUTO	BPMH10	-0.4	-5.293	MKV-17	AUTO	BPMU10	0.9	5.457
MKH-18	AUTO	BPMH12	-0.4	-5.474	MKV-18	AUTO	BPMU13	0.5	3.420
MKH-19	AUTO	BPMH13	0.4	-3.621					

Figure 3: Window "Trace correction".