MOSCOW MESON FACTORY LINAC - OPERATION AND IMPROVEMENTS*

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1 INTRODUCTION

Moscow Meson Factory Linac (MMFL) [1] has provided in 1997-1998, 4400 beam hours for physics, isotope production and machine development. The lack of adequate funding for machine operation (electricity etc.) has put severe limitation on the beam production time. Beam energy was limited by 305 MeV and in some production shifts even by 209 MeV. A significant part of the beam time has been devoted to isotope production for medical use at an energy of 160 MeV. The maximum average proton current during regular operation is 65 μA with a pulse duration of 85 μs and repetition rate of 50 Hz. In 1998 a proton beam has been delivered for the first time to the Pulsed Neutron Source. A number of improvements have been implemented, with a strong impact on the operation efficiency. One of the most important measures is the creation of a new control network (based on PCs) for the beam diagnostics data acquisition. The injection beam transport channel and RF power supply system are presently undergoing reconstruction. The aim of this reconstruction is to increase the beam pulse up to 140 μs and repetition rate up to 100 Hz which will result to the growth of average beam current to 200 μA.

2 LINAC OPERATION

The total scheduled time of the linac operation includes the beam delivery to users, the tuning of the linac and unexpected down time. On average for the last two years the beam delivery time to users was ~60%. About 30% of the time was spent for tuning and accelerator experiments and developments, the rest was down time. Essential development has been done on the linac RF system with the main aim of increasing the reliability and linac operation efficiency, as well as to prepare the RF system for operation at 100 Hz and a 140 μs beam pulse. Obtaining of 100 Hz repetition rate is simpler task than providing of the beam pulse length more than 100 μs, because of operation at 100 Hz is the design specification of all linac equipment. The design beam pulse duration of the linac is 100 μs. Therefore the modulators and preamplifiers have been revised. The automatic temperature control system of the accelerating cavities has been tuned in order to provide 100 Hz repetition rate of rf amplifiers.

Although the linac control system is based on old computer equipment, it is adequate for the linac operation. This system is mainly used for the support of RF and other technical equipment. Major profit from the control system has been obtained by development of software in order to support the RF system operation. In many cases the restoration of the RF system immediately after the malfunction has increased operational time. This is an important issue for the system with large electrical power consumption which is the case of the MMF linac. However the original control system has very restricted ability for the data processing and presentation. The existing beam monitors already produce large amount of information which is not fully available from the original control system. In addition, many beam diagnostic devices have been developed and installed on the linac, including:

- A new type of detector allowing the measurement of the transverse density distribution was installed in the 750 keV transport line.
- A new Bunch Length and Velocity Detector (BLVD) is installed in the 160 MeV transition line.
- Several beam profile harps.
- Non-interceptive beam position monitors.

Therefore the new control system was developed based on PCs which are connected to the local area network. The analogue and digital hardware is housed in CAMAC crates (up to 4 crates per sector). The system is based on MOON-Lab (Multi-tasking Object-Oriented Network Lab System) - a software run-time system and an application programming technology developed at INR [2].

The new control system serves different types of beam diagnostic monitors: beam current transformers, wire scanners, profile harps, BLVD, beam loss monitors, a monitor for the measurement of transverse beam density and neutron detectors. Fig. 1, 2 and 3, represent examples of graphical information obtained by new control system.

The beam delivery system to the isotope production area includes 27° bending magnet and ~12 m long transport channel [3]. The control of beam losses in the vicinity of the bending magnet is a problem of great importance due to high level of the average beam

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current. Discrepancy between the beam energy and the magnet current as well as the violation of the correcting element parameters can lead to instantaneous melting of the vacuum pipe during an extremely short time. To prevent such accidents, a number of protections measures have been undertaken.

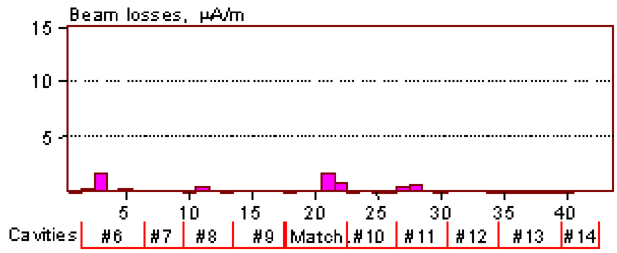

Figure 1: Scintillating beam loss counters (#1-40) along the 3rd sector of the MMFL. (Tanks #6-14)

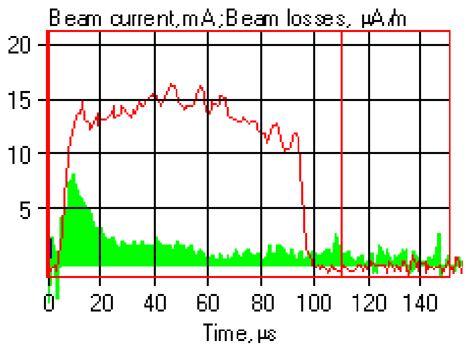

Figure 2: Beam current and particle losses along the macropulse. 3rd sector. Beam loss monitor # 21

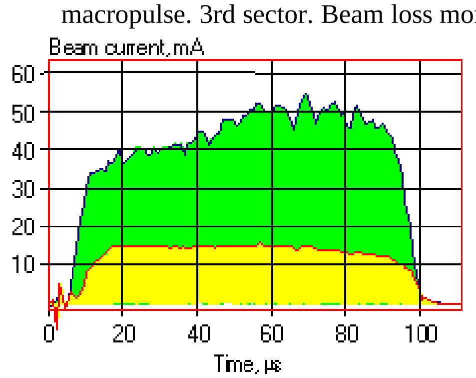

Figure 3: Capture coefficient control. Comparison of current transformer signals: at the input of the Tanks # 1 and at the output of the Tanks # 8.

The bending magnet in the 750 keV injection line is switched off and the 750 keV beam is deflected by a chopper, as well as the injector trigger being shifted with respect to the RF pulse if one of the following cases occurs: 1) Difference of the pulse charge in a given cycle registered with current transformers upstream and downstream of the bending magnet is in excess of the tolerance limit; 2) Beam loss monitor signal is in excess of the tolerance; 3) Phase and amplitude parameters of any RF system is out of tolerance; 4) Beam profile on the isotope production target moves too close to the edge of the target. Fig. 4 shows 2 signals from current transformers. The difference between the signals is well inside the tolerance. For initial accelerator tuning at the repetition rate of 1 Hz the protection is not used. At a repetition rate of 2 Hz and higher, the loss threshold may be reduced from 10% to 1%. As a result of careful tuning the total beam loss in the course of an isotope production shift does not exceed 0.5% and is usually kept near 0.1%.

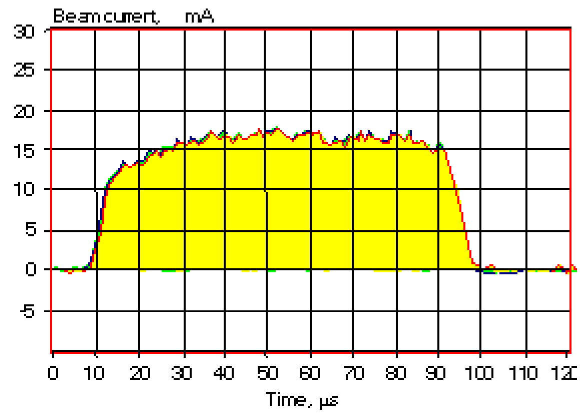

Figure 4: Two overlapped beam pulses: upstream of the bending magnet (almost invisible) and downstream of the bending magnet.

The MMFL contains two transition regions at 100 MeV and 160 MeV. It is important to verify the longitudinal bunch length in these regions. The bunch length measurement (BSM) system is well established at INR, and the most recently modified device, the Bunch Length and Velocity Detector (BLVD) has been installed in the 160 MeV area. The high resolution of the detectors, which is 14 ps, allows monitoring of the quality of the Linac beam during operation. The devices use a 100 µm wire which allows the measurements to be performed at up to 50 Hz repetition rate. After many years experience with the BSM and BLVD systems, we are able to detect the source of any deviation of the longitudinal profiles form the nominal state. Fig. 5 shows the bunch shape evolution along the macropulse at the energy of 160 MeV.

3 INJECTION CHANNEL UPGRADE

The essential reconstruction of the injection channel is under way. Fig. 6 a) shows the existing layout of the channel (equipment of 1st and 2nd parts of channel is not shown for simplicity). The channel is designed to inject 750 keV H_{+} and H_{-} beam simultaneously into the Alvarez tank. However, the electrical strength of the 750 kV pulsed transformer is not sufficient for operation at 100 Hz repetition rate, hence the linac operates at 50 Hz with half the average beam current of the maximum possible.

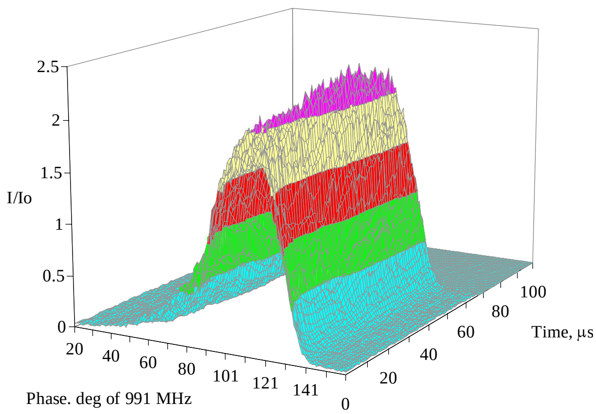

Figure 5: Bunch shape evolution along the macropulse at 160 MeV.

A decision was taken to insert the RFQ booster section into the 3rd part of the injection channel (Fig. 6 b)). The RFQ has been designed to accelerate hydrogen ions from 400 keV to 750 keV. The high voltage equipment of the injector works with good reliability up to the level of 400 kV. Moreover, the pulse length can be increased up to 140 µs without pulsed transformer saturation. It will allow the average beam current to beam increased up to 200 µA. The limited space does not permit to the realisation of adiabatic capture in the RFQ. To provide the longitudinal capture efficiency up to 80% at the peak current of 70 mA, the 400 keV prebuncher is placed upstream of the RFQ. A 750 keV buncher and four quadrupoles provide 3D beam matching between the RFQ and DTL tank. Fig. 7 shows the RFQ booster section which is now under high power test.

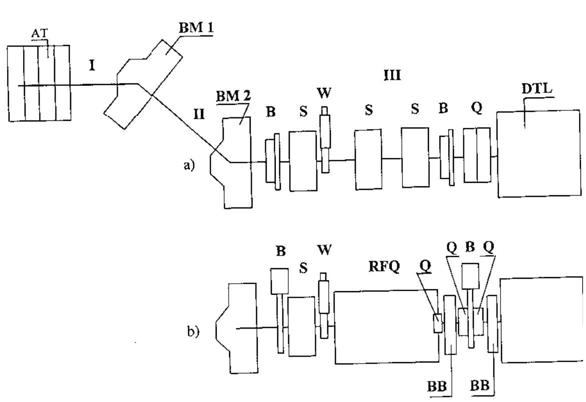

Figure 6: Injection channel layout.

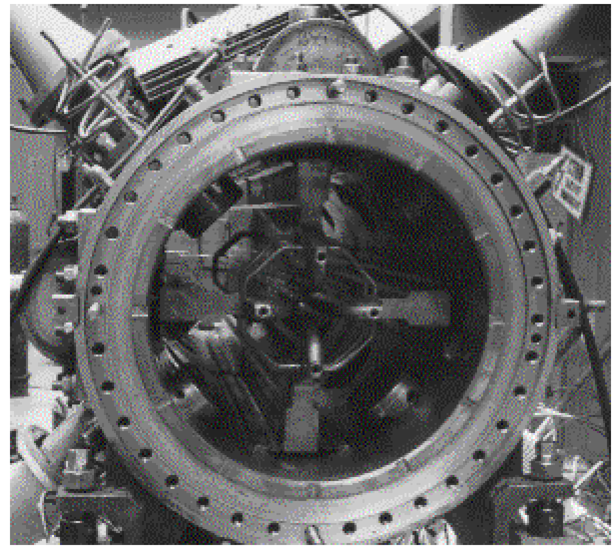

Figure 7: RFQ booster section.

High power modulators in the RF power supply permit to introduce moderate modification which will guarantee operation with longer rf pulses in order to accelerate 140 µs beam pulse.

Thus we hope increase the average beam current by up to a factor three over that presently attained.

4 ACKNOWLEDGEMENTS

In conclusion authors express their deep gratitude to the whole staff of the MMFL, who made the machine operational in recent times, which are not easy for scientific activity.

5 REFERENCES

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