INTRODUCTION

The \( ^+ \)H linac of the INR meson facility is under tuning now. The results on the cavities tuning were reported in EPAC-88 [1]. Recently the initial operation of the first 20 MeV Alvarez tank have been started. The beam acceleration have been provided at 1 Hz repetition rate but the tank have been driven at 10 Hz.

The typical current measured beyond the copper foil of 0.46 mm thickness vs rf amplitude is shown in Fig.1.

For more precise determination of the \( E_0 \) the extrapolation of the experimental curve is used. The experimental curves in Fig.1 are corrected with the theoretical data in Fig.2. A new possibility for precise determination of the rf amplitude have been opened with BLM development and test [4,5]. This device is perfectly adequate for the rf amplitude determination due to very high sensitivity of the bunch shape vs accelerating field. The maximum value of the phase spectrum is achieved for the total phase advance of \( \Psi = 3.75 \pi \) at the exit of the tank which corresponds to accelerating field \( E^* = 0.995 E_0 \). Because the phase advance does not depend on the injection energy the nominal rf amplitude can be determined for any injection energy. In turn as soon as the rf amplitude is precisely determined the injection energy can be easily found by using the method described above.

To decrease the various errors influence on the accuracy of the phase spectrum the measurements have been conducted using automatic phase and amplitude control. The measurements have shown that for the injection current of 10 mA the rf amplitude and phase errors are not more than \( \pm 0.25\% \) and \( \pm 0.5\% \) respectively. The intrapulse ripple of the injection energy was equal to \( 0.25\% \) and have been caused by the pulse top oscillation of the \( 750 \) kV transformer. The injection energy instability from pulse to pulse was an order of magnitude better. The typical measured phase spectra are presented in Fig.5. The nominal accelerating field according to the maximum of the phase spectrum is achieved for the phase advance of 3.75 \( \pi \) at the exit of the tank which corresponds to the rf field of 0.995 \( E_0 \). Because the phase advance does not depend on the injection energy the nominal rf amplitude can be determined for any injection energy. In turn as soon as the rf amplitude is precisely determined the injection energy can be easily found by using the method described above.

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Fig. 3
Experimental signal proportional to phase difference of the excited field in the harmonic monitors vs the rf amplitude at the various injection energies.

Fig. 4
Experimental dependence of accelerated beam current on the rf amplitude at the various injection energies.

Fig. 5
Experimental phase spectra of the accelerated beam for the various rf amplitudes.

Fig. 6
Phase scan results for the buncher at the nominal rf amplitudes.

Fig. 7
Experimental acceleration efficiency vs rf amplitudes in bunching cavities.

Fig. 8
Real $x$, $y$ without (---) and with (----) buncher vs focusing gradient $G/G_0$.

Fig. 9
Phase spectra of the accelerated beam.

Fig. 10
Phase spectra sampling for various time delay.

Fig. 11
Phase spectra for the various BLM gain.
2. The two-cavity buncher amplitude and phase setting

There is two-cavity buncher at the entrance of the first tank. The setting of rf phase in the cavities is carried out by using of the phase scan while the first tank is excited to the nominal field level. Because the phase scan results depend on the beam intensity the phase setting runs are conducted at the relatively small current of $5 \pm 10$ mA.

The typical experimental curve of the phase scan is presented in Fig.6.

Next the dependence of the accelerated current from the rf amplitude in bunching cavities $E_1, E_2$ is taken. The values of $E_1$ and $E_2$ are set according to the maximum value of accelerating efficiency (Fig.7).

3. The beam parameter's measurement

The beam transverse parameters are studied using two profile monitors, mounted spaced in a distance of 0.6 m. After the installation of the second linac tank the intratank distance will be 19 cm which allows the only single profile monitor to be introduced. Therefore we investigate the possibility to obtain the maximum information from a single profile monitor. It is known, that by using the profile monitor one may find the coherent oscillation amplitude and determine the beam mismatch with the periodically focusing channel [5]. These data are used for the beam steering at the tank entrance. More detail study of these data allows to obtain rms values of the phase ellipse by measuring the beam size for the various strengths of the focusing channel (there are 44 focusing periods in INP tank 1). For this purpose the dependence of the rms beam sizes $x$ and $y$ as a function of focusing gradient $G/A$ in all quadrupole lenses have been taken. The typical behaviour of $x/y$ is shown in Fig.8. By using data of $x/\sigma, y/\sigma, f_0$ (Fig.8) rms emittance and rms parameters $\Delta x, \beta, \gamma$ are calculated.

By knowing rms parameters it is possible to match the beam at the tank entrance more carefully. For example $x, y$ behaviour is shown in Fig.8 for two mode of tank 1 operation: with and without buncher operation.

The measurement of longitudinal beam parameters was carried out by using BLM. To get the phase spectrum of the bunch the secondary emission current from BLM wire target vs the phase of the 594.6 MHz (3-rd harmonic of the accelerating frequency) deflecting field was measured. The signal was whether integrated along the beam macropulse (Fig.9) or sampled at a given 5 mks interval of that pulse (Fig.10).

The phase shift and decrement of the phase oscillations in the first tank are rather big. It makes the longitudinal phase portrait to be close to the canonical ellipse. In such a case the momentum spread $\Delta p/p$ and bunch length $\Phi$ are connected as

$$\frac{2}{\Phi} \cdot \frac{\Delta p}{p} = \Omega \ell^2 \omega$$

where $\omega$— accelerating frequency, $\Omega$— phase oscillation frequency. Having the full measured width of the bunch $20^\circ-30^\circ$ (100% of particles) we can derive momentum spread $\Delta p/p(=1.0-1.5\%)$.

At the exit of the tank 1 unaccelerated particles are presented. BLM measurements outside of the bunch length show that the fraction of unaccelerated particles at the exit of tank 1 is less than 1%. Making BLM sensitivity increased it turns to be possible to study longitudinal halo of the beam. The phase spectra measured with various amplification are presented in Fig.11. The flat top of the curves corresponds to the saturation. The adjustment of the amplification is carried out by changing of the photomultiplier voltage. The preliminary calibration of BLM was done using thermoelectrons [4].

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References


