

# OPTIMIZATION PARAMETERS OF A PART OF ACCELERATING STRUCTURE WITH DRIFT TUBES PRESTRIPPING SECTION THE MILAC HEAVY ION LINEAR ACCELERATOR

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Investigations on optimization of parameters of a part of accelerating structure with drift tubes prestripping section PSS-20 for acceleration of heavy ions with the relation of their mass to charge  $A/q \leq 20$  are prolonged. On the second part of acceleration of ions from 150 keV/ nucl. up to 1 MeV/ nucl. the highest rate of acceleration is created interdigital-H (IH) accelerating structure with drift tubes. Radially-phase stability of the accelerated bunch of ions is provided with a combination of alternative phase focusing with updating of high-frequency focusing.

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## INTRODUCTION

The purpose of making new prestripping section PSS-20 for the heavy ion linear accelerator MILAC is the possibility of substantial increase of intensity accelerated heavy ions beam of a wide gamut masses. It is supposed to raise a current accelerated beam on two orders and to provide possibility of acceleration ions of any elements of periodic system. It can be reached at the expense of use in initial part PSS-20 of accelerating structure with Radio-Frequency Quadrupole focusing (RFQ) [1 - 3] which allows to almost capture an injected heavy ions beam and in the course of its acceleration in a gamut 6...150 keV/nucl. to carry out formation of parameters beam with high radially-phase characteristics. Working out of site RFQ and effects is executed are given in publications [4 - 7]. The heavy ions beam generated thus is accelerated from 150 to 975 keV/nucl. in interdigital-H (IH) accelerating structure with drift tubes on wave  $H_{110}$  [6, 7] which provides much higher rate of acceleration, maintaining its basic characteristics. Specificity viewed PSS-20 consists that both sites of accelerating structure are supposed to be combined in one resonator raised by high-frequency power on operational frequency, peculiar MILAC, 47.2 MHz. On site RFQ and on site with drift tubes it is necessary to provide demanded quantities of lapse rates of an accelerating field. Practically, working out of methods of adjustment of both sites on a uniform distribution of quantity of a potential difference between electrodes in structure RFQ 100 kV and an electric field between drift tubes 90 kV/cm, is required.

## ACCELERATING STRUCTURE OF SITE WITH DRIFT TUBES PRESTRIPPING SECTION PSS-20

On a site of accelerating structure with drift tubes is used the interdigital-H (IH) accelerating structure raised on wave  $H_{110}$ .

Feature of this accelerating structure is the essential magnification of a working wave length. It is especially important for acceleration of heavy ions with the high relation of mass to a charge  $A/q=20$ .

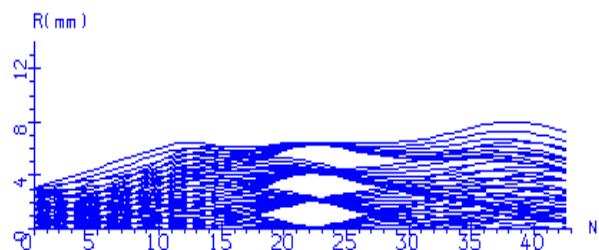
Thus, considering that acceleration is carried out on  $\pi$  – a wave, there is a possibility to raise rate of acceleration in 2 times in comparison with structure of type Alvarez. Calculation of accelerating structure with drift

tubes in a gamut of energies 150...975 keV/nucl. is executed. Effects are given in the table.

*Parameters of accelerating structure DTL for PSS-20*

Parameters	Value
Input energy, keV/nucl.	151
Output energy, keV/nucl.	975
Mass to charge ratio, A/q	20
Operating frequency, MHz	47.2
Synchronous phase, deg	-10
Number of drift tubes	42
Cavity length, cm	422.9
Tank diameter, cm	110
Acceleration rate, MeV/m	2,9
Input beam emittance, $\pi$ -mm-mrad	0.456
Output beam emittance, $\pi$ -mm-mrad	0.84
Longitudinal capture, %	90
Transmission, %	60
Pulsed current of accelerated ions, mA	4.5

Apparently, the full length of a site makes 423 cm, quantity of tubes of drift 42 which provides acceleration of ions with  $A/q=20$  in a gamut of energies 151...975 keV/nucl. Focusing of beam in the course of acceleration is carried out by means of corresponding selection of quantity of a synchronous phase which is constant on the first 15 cells and is equal  $0^\circ$ , and on all subsequent cells is equal  $-10^\circ$ , besides on an input of 17 drift tubes focalizing nets are erected.



*Fig. 1. Radial trajectories of a motion ions for DTL*

All it provides demanded radial and phase stability of beam in the course of acceleration. On Fig. 1 is given dynamics of radial oscillations of the ions beam injected within radius  $\pm 4$  mm and the phase extent within  $30^\circ$ .

Calculations show that such structure in a combination with site RFQ provides transmission of beam to 60%. The radial emittance of the beam at the input is  $0.456\pi$ -mm-mrad, and at the output the emittance is  $0.84\pi$ -mm-mrad.

### PROCEDURE AND DEVICES OF ADJUSTMENT OF ACCELERATING STRUCTURE

At coupling of two diverse structures, RFQ and DTL in one resonator it is necessary to maintain level of electrodynamic parameters on each of sites up-to-the-mark. For this purpose presence of the effective adjusting devices providing as local, so global adjustment of allocation of the accelerating field along each of sites is necessary. Now there are available such devices of adjustment which allow to carry out tasks in view. Initial process of adjustment is carried out by mathematical modelling of accelerating structure by means of 3 measured solutions. As local systems selection of quantities of diameter of drift tubes can be used, thus change capacitive characteristics of cells which involve changes of their natural frequencies and accordingly quantity of accelerating field strength. Other devices of adjustment having the inductive character of local action, represents so-called "contrivance" in a view rods located on the drift tube side, opposite to their holders [8]. These devices are used in practice in structure of accelerator PSS-4 [9], and also have shown high efficiency at adjustment of a site of accelerating structure RFQ for PSS-20.

As the device of global action on electrodynamic parameters of accelerating structure the ending resonance devices of adjustment located on the input and output accelerating structure [10] are used. On the ending devices of adjustment are located the mobile pistons which allow to regulate distribution of an accelerating field at respective alteration of their natural resonance frequency. In a Fig. 2 is given the general view of accelerating structure IH-DTL for PSS-20.

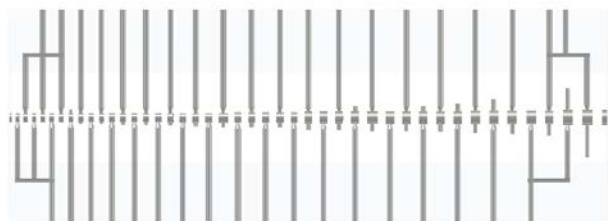


Fig. 2. The General view of accelerating structure IH-DTL for PSS-20

Apparently from a Fig. 2 the diameter drift tubes grows with magnification of length of cells from 50 mm on the input accelerating structure to 80 mm on an exit. Adjustment devices in a view "contrivance" are concentrated in the core to initial and ending sites of structure, considering that in interdigital-H (IH) accelerating structure distribution of an accelerating field in ideal equidistant variant has sinusoidal character.

In a viewed variant of a site with drift tubes takes place proliferation of an accelerating field on the two first cells and rapid slump on the ending sites of structure. Electric field distribution along the accelerating structure IH-DTL for PSS-20 is given in Fig. 3.

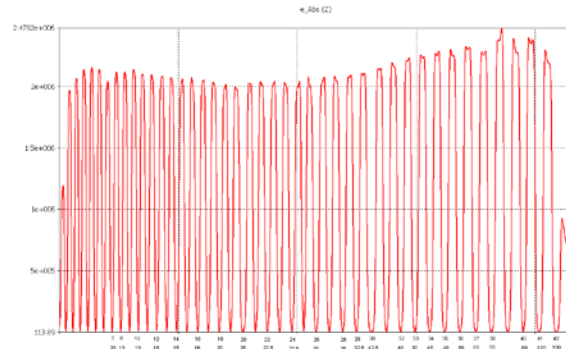


Fig. 3. Electric field distribution along the accelerating structure IH-DTL for PSS-20

In the coupling structure consisting of diverse sites with RFQ and DTL there is a necessity for global character of adjustment of electrodynamic parameters by change of natural frequency of all site of structure without changing of character of distribution accelerating field, its level is thus regulated only. As such devices of adjustment can be used volume devices which entered into resonator field where high level of a magnetic field takes place. This field is located on the periphery of the resonator which are at an angle  $90^\circ$  in relation to plane of accelerating structure. In Fig. 4 the variant of an arrangement of such devices of adjustment for site DTL in PSS-20 is given. Six adjusting devices allows to change natural frequency of the resonator in limits 0.25 MHz.

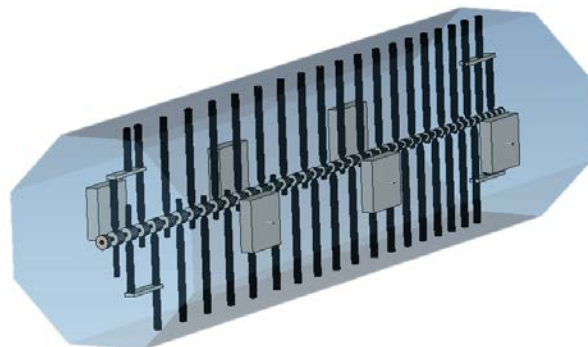


Fig. 4. The General view of accelerating structure IH-DTL for PSS-20 with devices of adjustment

### CONCLUSIONS

The procedure of formation of demanded electrodynamic parameters of a site accelerating structure with drift tubes for created new prestripping sections PSS-20 on initial part of the multicharging ions linac MILAC is developed. Calculation of accelerating structure in which bottom the variant of radially-phase stability of a beam in the course of acceleration of heavy ions with the relation of mass to charge  $A/q=20$  is executed. Generated on a site with Radio-Frequency Quadrupole focusing (RFQ) the heavy ions beam prolongs will be accelerated in structure with drift tubes, maintaining demanded radially-phase parameters and high intensity. New PSS-20 will allow more, than on two orders to

raise a current of the beam accelerated ions in comparison with existing PSS-15 and considerably to dilate a gamut of their masses. The problems arising at coupling of two diverse structures in one resonator are viewed. The procedure and devices adjustment of frequency is developed at maintenance of demanded distribution of accelerating fields along each sites of accelerating structure PSS-20.

## REFERENCES

1. I.M. Kapchinsky, V.A. Teplyakov // *PTE*. 1970, №2, p. 19.
2. I.M. Kapchinsky, V.A. Teplyakov // *PTE*. 1970, №4, p. 17.
3. R.H. Stokes et al. RF Quadrupole beam dynamic // *IEEE Trans.* 1979, NS-26, p. 3469.
4. V.O. Bomko, B.V. Zajtsev, E.V. Ivakhno, A.P. Kobets, K.V. Pavlii, Z.E. Ptukhina, S.S. Tishkin. Accelerating structure with radio-frequency quadrupole focusing RFQ for the heavy ions accelerating // *Problems of Atomic Science and Technology. Series "Nuclear Physics Investigations"*. 2010, №3(54), p. 26-30.
5. V.A. Bomko, B.V. Zajtsev, A.P. Kobets, et al. Heavy Ions Beams Formation In An Initial Part of Accelerating Structures Prestripping Section the MILAC Linear Accelerator // *Problems of Atomic Science and Technology. Series «Nuclear Physics Investigations»*. 2012, №4, p. 15-19.
6. V.O. Bomko, B.V. Zajtsev, A.P. Kobets, et al. Accelerating structures pre-stripping section the MILAC heavy ion linear accelerator MILAC // *Problems of Atomic Science and Technology. Series "Nuclear Physics Investigations"*. 2012, №4, p. 20-23.
7. V.O. Bomko, A.P. Kobets, V.V. Panov, et al. Modernization of an initial part the MILAC // *Proceeding of RUPAC 2012*. Sant-Petersburg. 2012, p. 466-468.
8. V.A. Bomko, E.V. Ivakhno // *Nucl. Instrum. and Meth. in Ph. Res, Section A* 582. 2007, p. 354-377.
9. V.O. Bomko, O.F. Dyachenko, A.P. Kobets, et al. Adjustment of a new pre-stripping section the multicharge ion linear accelerator (MILAC) // *Proc. International Conf. EPAC08*, Genoa, Italy, June 23-27, 2008, p. 3410-3412.
10. V.O. Bomko, O.F. Dyachenko, A.V. Pipa. Resonant systems for adjustment accelerating structure type H // *Problems of Atomic Science and Technology. Series "Technics of Physical Experiment"*. 1981, №3, p. 28.

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## ОПТИМИЗАЦИЯ ПАРАМЕТРОВ УЧАСТКА УСКОРЯЮЩЕЙ СТРУКТУРЫ С ТРУБКАМИ ДРЕЙФА ПРЕДОБДИРОЧНОЙ СЕКЦИИ ЛИНЕЙНОГО УСКОРИТЕЛЯ ЛУМЗИ

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Продолжены исследования по оптимизации параметров участка ускоряющей структуры с трубками дрейфа предобдирочной секции ПОС-20 для ускорения тяжёлых ионов с отношением их массы к заряду  $A/q \leq 20$ . На втором участке ускорения ионов от 150 кэВ/нукл. до 1 МэВ/нукл. наиболее высокий темп ускорения создаёт встречно-штыревая ускоряющая H-структура с трубками дрейфа. Радиально-фазовая устойчивость ускоренного пучка ионов обеспечивается комбинацией переменнo-фазовой фокусировки с модификацией высокочастотной фокусировки.

## ОПТИМІЗАЦІЯ ПАРАМЕТРІВ ДІЛЯНКИ ПРИСКОРЮЮЧОЇ СТРУКТУРИ З ТРУБКАМИ ДРЕЙФУ ПЕРЕДОБДИРКОВОЇ СЕКЦІЇ ЛІНІЙНОГО ПРИСКОРЮВАЧА ЛУМЗИ

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Продовжені дослідження з оптимізації параметрів ділянки прискорюючої структури із трубками дрейфу передобдиркової секції ПОС-20 для прискорення важких іонів з відношенням їх маси до заряду  $A/q \leq 20$ . На другій ділянці прискорення іонів від 150 кеВ/нукл. до 1 МеВ/нукл. найбільш високий темп прискорення створює зустрічно-штырева прискорююча H-структура із трубками дрейфу. Радіально-фазова стійкість прискореного пучка іонів забезпечується комбінацією перемінно-фазового фокусування з модифікацією високочастотного фокусування.