ADJUSTMENT OF A NEW PRE-STRIPPING SECTION THE MULTICHARGE ION LINEAR ACCELERATOR (MILAC)*

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Abstract

The adjustment results of new pre-stripping section (PSS-4 with A/q = 4) the multicharge ion linear accelerator (MILAC) designed for He^+ ion beam acceleration from 30 to 975 keV/u are presented. In this section irregular interdigital accelerating structure with beam focusing by radiofrequency field (alternating phase focusing with stepped changing the synchronous phase along the focusing period) are used. All needed systems for the new accelerating section were developed, designed and manufactured; assembling and adjustment.

INTRODUCTION

The existing pre-stripping section PSS-15 (see Fig. 1, p. 2) is designed for accelerating heavy ions with mass to-charge ration of A/q ≤ 15. It does not intend for acceleration of intense beams of heavy ions (protons, deuterons, helium). New initial part of the accelerator – PSS-4 (see Fig. 1, p. 5) is being constructed for accelerating only light ions and meant for significant increase of pulse beam current. In this section the maximum calculated accelerated current can be up to 12 mA with the injection current near 60 mA. After recharging (stripping) (see Fig. 1, p. 6) this beam will be output on the acceleration line of the MILAC main section (see Fig. 1, p. 3) and accelerated up to 8.5 MeV/u. New MILAC pre-stripping section will give a possibility to widen the range of scientific and applied investigations in the various areas, such as unique radionuclides production, nuclear reactor industry materials, and other nuclear physics problems solve.

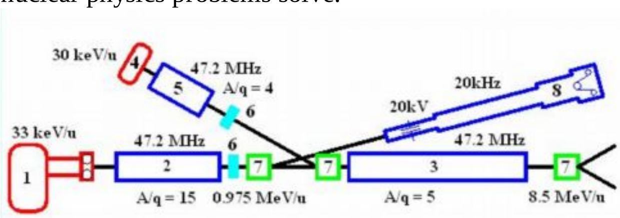

Figure 1: Scheme of the MILAC accelerator.

Created by results of numerical simulations in three-dimensional space section PSS-4 [1] some differed on the electrodynamic parameters (resonant frequency, accelerating field distribution along gaps of structure, Q-value) from set values according to the accelerated bunch dynamics. The reason for it were both calculations errors, and inaccuracy of manufacturing, assembly and alignment an accelerating structure elements. It has demanded carrying out of additional theoretical and experimental research works during stand adjustment. External view of the collected resonator with cooling system is presented on Fig. 2.

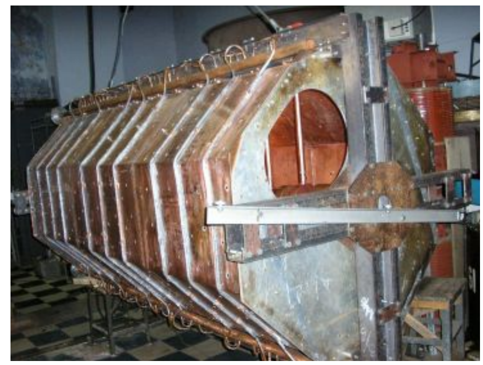

Figure 2: External view of the resonator after final technological assembly.

APPLICATION OF TRADITIONAL TUNING METHODS

As adjusting elements the developed earlier end resonant tuning elements (ERTE) [2], established on the entrance and exit ends of accelerating structure (see Fig. 3, 4) and two pairs additional current-carrying drift tubes stems, established only on its entrance end (see Fig. 4) were used. The physical reasoning this tuning method of the interdigital accelerating structure the MILAC basic section is described in work [3].

Figure 3: The end resonant tuning element on the exit end accelerating structure.

For creation this specified adjustment elements a some drift tubes stems were short-circuited by longitudinal conducting elements (pieces of waveguides were used): 1, 3 and 5 – for additional current-carrying stems fastening,

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even drift tube with 2 on 12 – for entrance ERTE formation and odd drift tube 27, 29 and 31 – for exit ERTE formation. Own resonant frequency ERTE changed by means of additional short-circuited stem which could move in some limits. For deviation angle change of an additional current-carrying stems their fastening (to the resonator and a longitudinal element) was carried out through flexible strip contacts.

Figure 4. The end resonant tuning element and additional stems on the entrance end accelerating structure.

As a result of the lead tuning operations an electric field distribution in gaps of accelerating structure close to set is received, but at higher resonant frequency value (almost on 1 MHz). Thus the second pair additional stems and short-circuited stem on entrance ERTE was necessary to remove. The first pair additional stems was under an angle 35º with respect to their zero position, and short-circuited stem on exit ERTE was near of the basic stem, that corresponded to the minimal resonant frequency.

NEW TUNING ARRANGEMENTS

The problem of local resonant frequency change at preservation of demanded an electric field distribution in H-structures always stood enough sharply because of tuning processes interconnectivity. Usually it was solved in a complex, and the created frequency adjustment elements operated only in a direction of its increase. The problem of creation an effective influence elements on structure characteristics with the purpose of decrease its resonant frequency has demanded new approaches, carrying out of numerical calculations and experimental researches [4].

As a result of it new tuning elements named «contrivances» are developed which were established on some drift tubes [5]. Their quantity, the sizes (length and diameter) and deviation angles from a plane which are passing through the basic stems of fastening drift tube, were preliminary defined by numerical simulations, and then checked experimentally at the stand. «Contrivances» have proved as the effective tuning element locally influencing an electric field value in the nearest gaps and lowering resonant frequency without noticeable worsening of resonant system electrodynamic characteristics. On Fig. 5 and 6 the constructive decision of fastening «contrivances» on drift tubes is shown, and in the table their sizes and deviation angle a from a plane which are passing through the basic stems are resulted.

Table: Constructive characteristics and disposition of the «contrivances» on drift tubes.

№	Number drift tube	Diameter, mm	Length, mm	Deviation angle, degree
1	16	10	30	0
2	18	15	35	30
3	21	15	33	0
4	23	20	27	0
5	25	10	40	0
6	26	26	30	0
7	28	26	45	45
8	30	26	45	45
9	31	26	70	45

Figure 5: «Contrivances» established on 16 and 18 drift tubes.

Figure 6: «Contrivances» established on 26, 28 and 30 drift tubes.

As a result of complex influence all tuning elements the set electric field distribution in structure on operating frequency 47,2 MHz is received. On the Fig. 7 character of change an electric field intensity (in relative units) on an axis of the resonator is traced (received at numerical simulations cross-section geometry of accelerating structure). Points are noted values which were set by calculation of dynamics of the accelerated bunch and asterisks are noted experimental measured values. Deviations of experimental an electric fields values in gaps from calculated values are in acceptable limits.

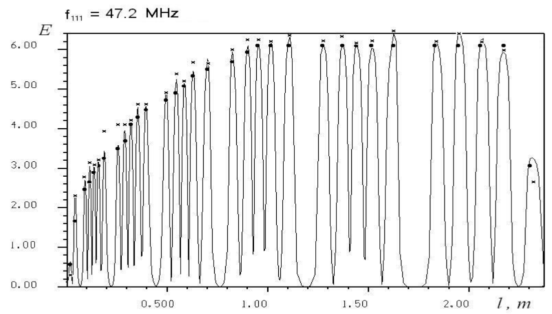

Figure 7: Electric field distribution in structure on operating frequency of 47,2 MHz (calculation field set by numerical simulations, • – set by bunch dynamics, ∗ – experimental).

ASSEMBLING OF ALL SYSTEMS PSS-4

As have shown experimental researches of electrodynamic characteristics an assembled accelerating structure, Q-value of the resonator has appeared considerably below calculated value. The reason for it were bad contacts in units of fastening the drift tube stems to a lateral resonator surface which had three areas of transitive contacts. Other contact devices are offered which were established on all current-carrying stems (see Fig. 6) and allowed to raise Q-value were at their insignificant influence on an accelerating structure frequency characteristics. As a result Q-value near by 12000 is received, that is within the norm limits.

On the Fig. 8 the schematic view of the PSS-4 accelerating structure after carrying out of final adjustment for the set frequency and electric field distribution is shown, and real accelerating structure is presented on the Fig. 9.

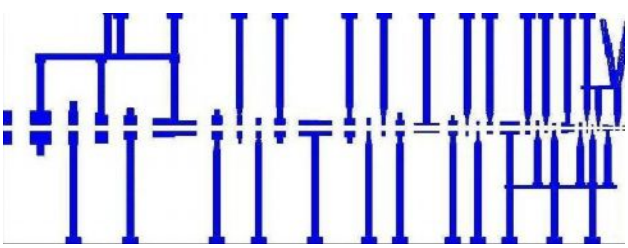

Figure 8: Schematic view of the PSS-4 accelerating structure.

Figure 9: Accelerating structure after final tuning (at the left above – RF-input).

After mounting of the resonator to a vacuum tank it is lead its preliminary alignment and radio-frequency (RF) input and three measuring loops are connected. Then the entrance and exit bottoms have been established, vacuum system elements are connected, process pumping and elimination of leaks has begun. Assembly works on RF-power supply system (the generator was in working order, the feeder path was mounted only) and cooling system were spent in parallel. Further the cooling system has been successfully tested and after achievement of necessary vacuum powering and training of accelerating structure pulse RF-power at an increasing frequency sending impulses has begun.

Now the accelerating structure is ready to passage of a bunch and adjustment works with ions source are intensively conducted. The general view new pre-stripping section PSS-4 with all its function ensuring systems in the MILAC main hall is shown on the Fig. 10.

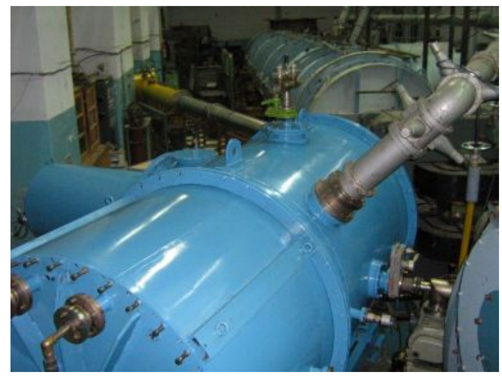

Figure 10: New pre-stripping section PSS-4 in the MILAC main hall.

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