PROJECT OF COMPLEX TANDEM - RF LINEAR POSTACCELERATOR

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Construction of tandem-RF linac facilities is a dynamically developing trend in acceleration technique [1]. There are several tandems in the USSR [2] which can be provided by the postaccelerators. This paper presents the first results of development of this type of accelerators. The main parameters of the combination are the following:

Output energy, W	10 MeV/n
Atomic mass, A	12-35
Tandem terminal potential, V	5-6 MV
Operation regime	continuous

Traditional scheme of the postacceleration is accepted (fig.1). It includes stripping target, multiharmonics buncher, many gaps acceleration resonators, focusing elements and operation system.

The acceleration channel parameters were chosen from the beam dynamics simulation using the results of the scaling model investigations. For acceleration of different particles the followings scaling laws are used:

$$\frac{\sqrt{P q}}{W_0} = \text{const}, \quad \beta = \text{const}, \qquad (1)$$

where P -power stored in resonator, W_0 - rest energy, q -charge, β - reduced velocity. Following these conditions the trajectories of different particles are identical, whichgives the possibility to optimize acceleration system.

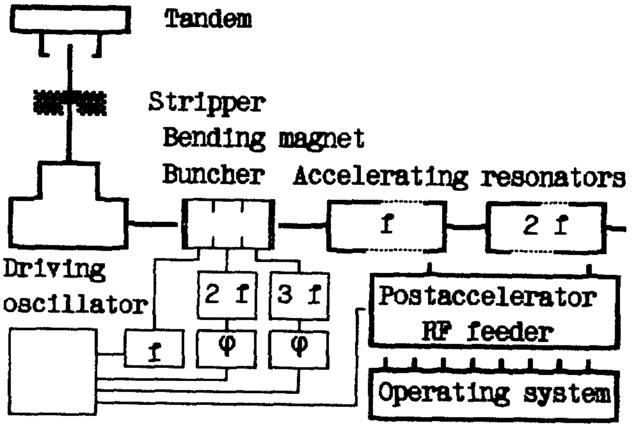

Fig.1. The scheme of the postaccelerator.

Initial velocity of the particles was obtained from the criterion of highest intensity of the beam under the highest charge condition. As a result the value β=0.04936 was chosen. Possible parameters of the accelerated particles are presented in table 1, where the coefficient of beam using k means the intensity of the beam with charge q_2. It was assumed that Cl ions are injected to the first resonator, S, Si ions - to the second and F, O ions -to the third resonator. The ratio A/q_2 is in the range of 2.3 - 2.9. The maximum effective RF voltage for $^{35}Cl^{12}$ is 26 MV.

Table 1. Parameter of particles under injection.

Elements	V, MV	q_1	q_2	W, MeV	k
^{35}Cl	5.0	7	12	40.0	0.1
^{32}S	5.94	7	12	47.5	0.12
^{28}Si	5.94	6	11	41.6	0.16
^{19}F	5.79	5	8	34.7	0.22
^{16}O	4.87	5	7	29.2	0.24

For chosen β the value of the RF frequency f = 152.5MHz was adjusted. Starting

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with $\beta=0.1$ it seems reasonable to increase the value of RF frequency by a factor of 2 to reduce the longitudinal size of the postaccelerator. The transverse stability of particles is provided by doublets of magnetic quadrupole lenses placed between resonators. The main parameters of the acceleration channel are presented in table 2.

Table 2. Postaccelerator parameters.

RF frequency 1 stage, MHz	152.5
RF frequency 2 stage, MHz	305.0
Number of resonators 1 stage	9
Number of resonators 2 stage	15
Resonator length, m	0.75-1.5
Total length, m	25
Synchronous phase, deg.	-20
Number of gaps in resonator	15
RF gap voltage, kV	90
Gap width, mm	15
Gap efficiency	0.82-0.94
Resonator effective voltage, kV	1.1-1.2
Drift tubes aperture, mm	15
Lens aperture, mm	20
Max gradient, Tl/m	32
Transversal acceptance, π mm mrad	1.3
Max RF power of oscillator, kW	6
Total RF power consumption, kW	100-120

RF system consists of 24 resonators. A voltage of 1.1-1.2 MV is applied to every resonator, which gives the possibility to change the output energy both sharply (switching off the power in resonator) and smoothly (changing the phase and amplitude of the field in the last resonator). Maximum total RF power consumption is 100-120 kW.

Two variants of RF structure are under consideration. The first is an interdigital H-resonator loaded by the rods (fig.2). It consists of the tank body (1) with the plates (2), where the rods with the drift tubes (3) are mounted, and the cooling system (4). The necessary distribution of electric field is achieved by the tuning elements (5). The second variant of RF structure (fig.3) is a toroidal resonator with the drift tubes mounted at the plates. Experimental parameters of both scale models are presented in table 3. The shunt impedance of the first structure at the frequency f=152.5 MHz is a bit higher than the second one, but the both variants should be optimized. The final choice will be made later.

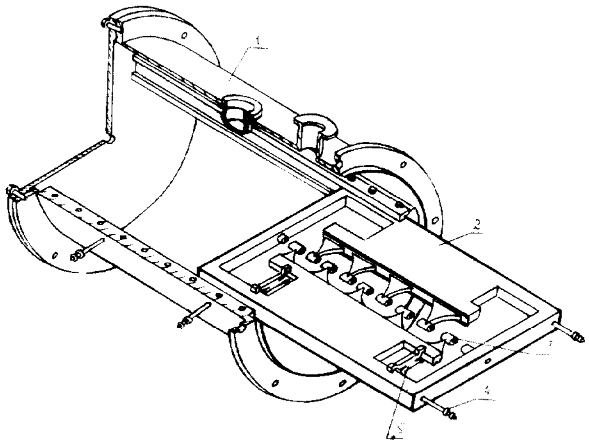

Fig.2. Sectional view of H-resonator.

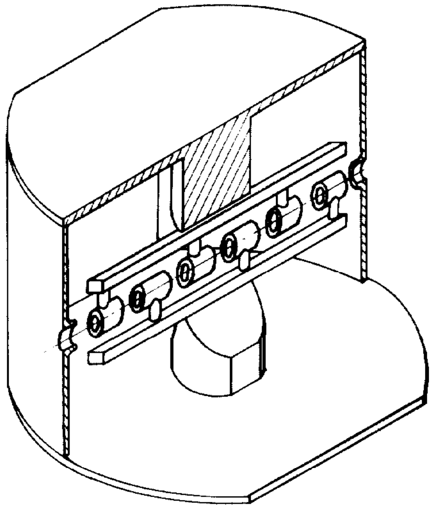

Fig.3. Sectional view of toroidal resonator.

For bunching of the particles the multiharmonics buncher scheme was accepted. The modulation voltage $g(t)=2U_m ft$ with the period T is approximated by the series:

$$u(t)=\sum_{i=1}^{\infty} b_i \sin(2\pi i f t), \qquad (2)$$

Table 3. Parameters of resonators.

Parameter	1 model	2 model
Diameter, mm	366	420
Length, mm	537	282
Operation frequency, MHz	187	171
Quality factor	10000	9500
Drift tube outside diameter, mm	20	16
Drift tube inner diameter, mm	14	12
Drift tube length, mm	20	20
Gap width, mm	20	12
Number of drift tubes	13	12
Shunt impedance, MΩ/m	203	240

where the frequency f is a frequency of the first stage of postaccelerator. The voltage amplitudes b_i are defined from the linear matrix system:

$$\frac{\partial}{\partial b_1}\left(\int_{-\tau/2}^{\tau/2}(g(t)-u(t))^2 dt\right)=0, \qquad (3)$$

where τ is the time interval of the linearized part of the function $g(t)$. The dependences $|b_i|(\tau/T)$ normalized on $(2U_m/\pi)$ are shown in fig.4. For obtaining the short bunches it is reasonable to exclude the sharp voltage peculiarities and choose $\tau/T=0.7-0.8$.

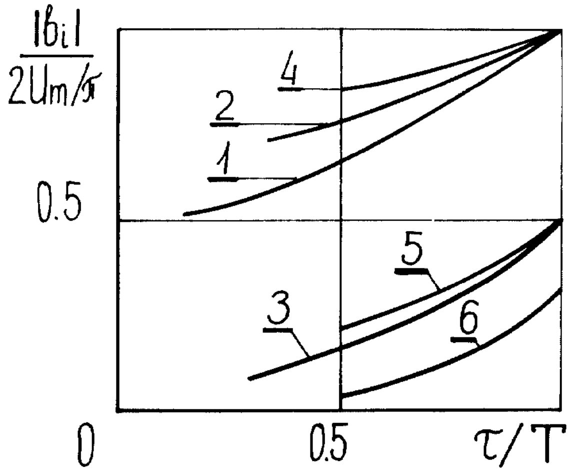

Fig.4. The normalized dependences $|b_i|(\tau/T)$:
1 - one harmonic buncher,
2-3 - two harmonics buncher,
4-6 - thre harmonics buncher.

The value U_m is connected with the distance L between buncher and postaccelerator by the expression:

$$\frac{U_m}{(W_0/q_2)} = \frac{\beta^3}{2(L/\lambda)-\beta} \qquad (4)$$

For considering project we have L = 5 m, $\tau/T=0.75$. For $^{35}Cl^{12}$ $U_m=65.4$kV, $b_1=37.6$kV, $b_2=13.7$kV, $b_3=4.9$kV. It is assumed to use three-gaps resonator with the voltage distribution among the gaps 0.5:1:0.5. The bunch duration at the entrance of postaccelerator is less than 0.2 ns.

At the moment the RF power system is under construction. The driving three-harmonics oscillator with transistor amplifiers for the power 5W, 40W, 20W and the frequencies f, 2f, 3f has been constructed. The 2kW amplifier with the tetrod feeding system which is the model for 5-6kW amplifier has been constructed also.

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