A NOVEL MONOSTRUCTURE BUNCHER FOR HIRFL

Gao Xiulin,Shi Aimin,Yin Zukang and Zhong Jie

Institute of Modern Physics,Academia Sinica
P.O.Box 31, Lanzhou, China

INTRODUCTION

The design of HIRFL buncher traveled a difficulty selection,due to the face of the higher injector extract beam energy; disperse of the harmonic number used; small space dimension to limit the profile dimension of the buncher and the price to construct the machine.

At last a factor of the fouth working frequency of the SSC was chosen,it reduce the construction price sharply and the profile dimension of the buncher is limited at one meter,but the cost for those is to bear the technique risk.

Considering the working frequency region (26-56MHz) leaps over the H.F and V.H.F band and the plate load of the R.F amplifier is the resonance cavity itself,a monostructure buncher was designed.

In the middle of 1988,the R.F.measurement for prototype buncher was done and the conditioning was also carried out successfully.

CHARACTERS

1. The power tube of the R.F amplifier is ridden on the top of the cavity directly. The gap between the anode of the power tube and drift tube of the cavity is composed as a capacitor to couple the cavity with the R.F amplifier. This capacitor can be adjusted under the vacuum condition for changing the parameters of the R.F amplifier.
2. The distance of the drift tube can be adjusted under the vacuum condition for the adopted harmonic numbers.
3. The D.C power supply of the power stage also can be adjusted to the required R_{oe} for matching purpose through the whole working band.
4. A new super-vapotron power tube was trial-produced with our existing water cooling system,the dimension of the anode is very small. The main parameters are listed in table 1.

Table 1: Main parameters

Working frequency range	26-56MHz
R.F voltage range	35-72KV(peak)
R.F power amplifier	10KW
Phase stability	±1°(R.F phase)
Frequency stability	$1x10^{-5}$
R.F amplitude stability	$1x10^{-2}$

PHYSICS PARAMETERS

1. Acceleration region: The constructure of one drift tube with two gaps is adopted. The effective voltage obtained when the beam passes through it is as follows:

$$V_{eff}=2V_dT_aT_gT_l$$

V_d is the voltage of the drift tube. T_a, T_g, T_l are the transit time factor of the drift tube diameter (2a),gap width (g), dynamic drift tube length (l) respectively. They are also the function of the harmonic numbers. To determine the whole parameters,a compromise proposal was coordinated and it is satisfactory for both of the amplifier and space dimention promised. The definitive values are given in table 2.

Table 2: The values of the transit time factor

	$T_a(a=25^{mm})$	$T_g(g=30^{mm})$	$T_l(L=29^{cm})$
h=2	1.02	0.99	0.48
h=4	1.08	0.98	0.84
h=6	1.18	0.96	0.99
h=8	1.32	0.94	0.9

2. Working voltage of the drift tube: Two bunchers are equiped in the beam line.Under the condition of the definite injection

energy (for example 6 MeV/A), and the energy spread (for example 2×10^{-2}), the working voltage of the drift tube V_d was calculated with different drift length and harmonics.

The V_d value with different frequency is shown in table 3. On the basis of the V_d^{max}, the R.F power amplifier was designed.

Table 3: V_d vs frequency L=29cm

V_D^{KV}peak	f(MHz)								
	26	30	34	38	42	46	50	54	56
h=2		36	44	53	64	71	61		
h=4				27	33	38	45	55	61
h=6	36		45	51					
h=8						21	29	35	37
V_D^{KV}(max)	36	36	45	53	64	71	61	55	61

CAVITY

The cavity is a quarter wavelength resonator with two gaps. The working frequency can be adjusted between 26-56 MHz by two movable capacitive panels mounted on the both side of the cavity (Fig.1).

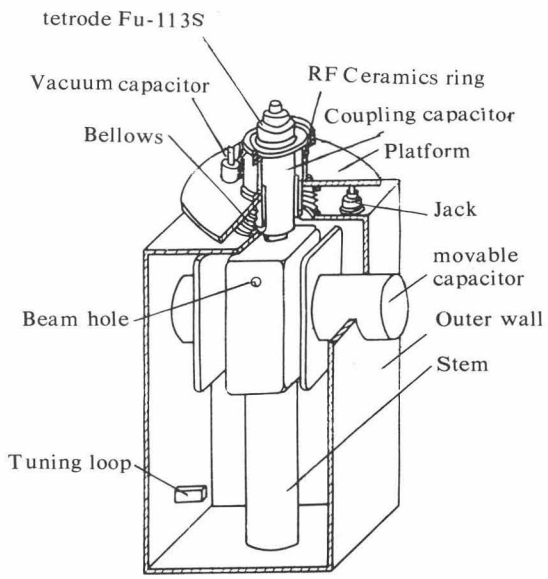

Fig.1: Scheme of the buncher monostructure.

A set of the power tube, in reality the main part of the amplifier, is installed on the top of the cavity. It can be drived mechanically under the vacuum condition.

The R.F power dissipation of the whole cavity is about 7 KW. The current density of the sliding contact fingers of the movable panle is about 19 A/cm. The power density was also calculated for water cooling system.
The outer wall of the cavity is made of copper-clad steel which has many cooling pipes welded on the surface.

A cyro-pump and a turbo-molecular pump are mounted on the outer wall through a tee.

The fine tuning adjustment is obtained by a movable panel (tuning loop) working in the short circuit of the cavity.

R.F AMPLIFIER

The 10 KW R.F amplifier is consist of two stage, the preamplifier and the power stage.

It is essential to arrive at a driving power of more than 200 W, so a broad-band solid amplifier is more comfortable. For power stage, a tetrode (FU-113S) which is used for grounded-cathode-setup, AB operation, is applied.

The most comfortable way to couple the cavity to the power amplifier is by means of a variable capacitive coupling consisting of the anode of the tetrode and drift tube directly. The anode working resistance R_{oe} can be changed easily by moving the coupling capacitor (the set of the power tube), it can be variated from 300Ω to 1300Ω .

An anode scheme that the cavity is used as a plate-tank-circuit was developed(Fig.2), due to the cavity is a resonator. The grid-scheme is a k-type low band-pass filter with 50Ω input resistance. A special LC network is used to reduce the effect of the capacity of the FU-113S for working band. The power out put and V_d valut with frequency are shown in Fig.3.

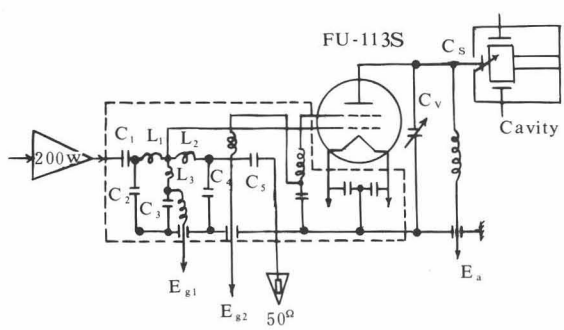

Fig.2: The scheme of the R.F amplifier.

The whole elements of the input circuit including neutral capacitors and by-pass capacitors are fixed in a silver-plating box. This box is installed directly to the tetrode's poles with sliding contect fingers.

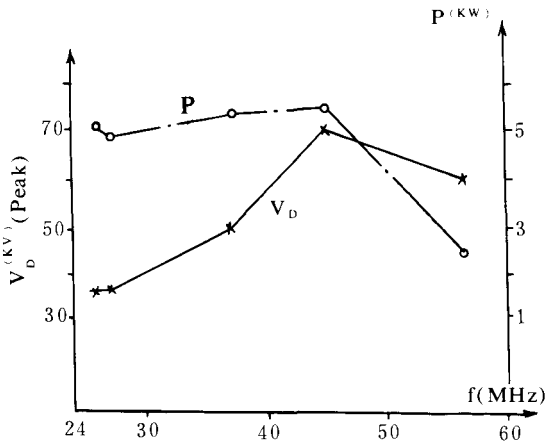

Fig.3: V_d value with frequency.

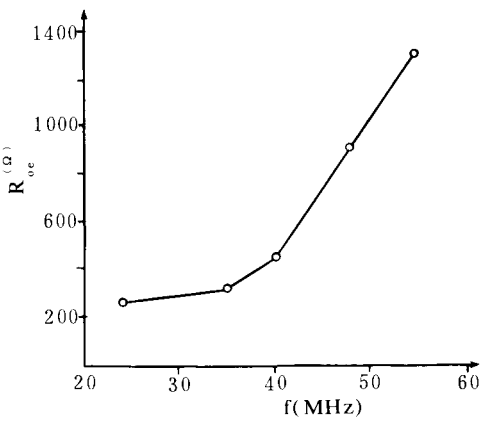

Fig.4: R_{oe} with frequency C_s=const

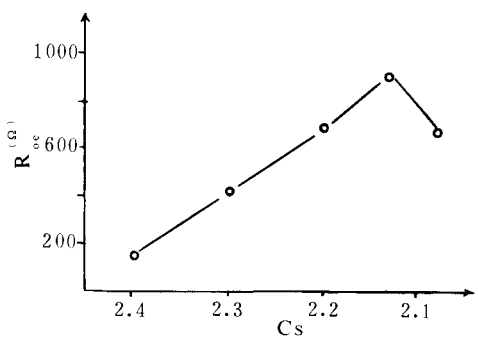

Fig.5: R_{oe} vs C_s(relative value) f=47.7 MHz.

TEST RESULTS

Working frequency range 24-54.8 MHz
(We can attain the design value by moving the short plant easily)
Working resistance R_{oe} 300Ω-1300Ω
(see Fig.4,5)
R.F voltage V_d(maiden obtained) 40 KV
(peak at 37.572 MHz)
Dynamic Q value 5500(at 37.572 MHz)
R.F amplifier stability (open loop) 2×10^{-2}
(at 37.572 MHz, 40 KV)

Two bunchers have been installed on sites in the beam line. One of them has been operated at 37.572MHz for beam adjustment.

The control system is operated at manual condition,microcomputer system is being perfected now

The servo tuning system,phase regulation system,R.F amplitude stability system are the same as SSC and they have been tested at open loop.