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DESIGN AND TEST OF A S BAND TW BUNCHER FOR THE INJECTOR LINAC OF HEPS

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Abstract

The bunching system of injector Linac in High Energy Photon Source (HEPS) includes two sub-harmonic bunchers, a pre-buncher and a traveling wave S band buncher. The buncher is a 6-cell constant impedance traveling wave structure operating in 2π/3 mode at 2998.8 MHz. In this paper, the design and test of the traveling wave buncher are presented. First, the characteristic parameters are optimized in CST. Then the buncher is precisely tuned and cold tested with a vector network analyzer after fabrication. Finally, the high power test was finished before installation in Linac. The buncher can operate stably with input power of 10 MW after a week of conditioning. So far, the buncher has been applied successfully in Linac of HEPS.

INTRODUCTION

The High Energy Photon Source (HEPS) is a 4th generation synchrotron light source under construction in China, which includes a 500 MeV injector Linac, a 6 GeV booster and a storage ring [1]. The injector Linac includes a thermionic cathode electron gun, a bunching system and a main accelerating section. The layout of injector Linac is shown in Figure 1. To improve the transmission efficiency of single bunch with high charge, the bunching system consists of two sub-harmonic bunchers, a pre-buncher and a traveling wave buncher, which is used to compress the bunch length from 1.6 ns at exit of electron gun to 10 ps at entrance of the first accelerating structure [2]. In this paper, the de-tailed design and test results of the traveling wave bunch-er are presented. So far, the buncher has been applied successfully in Linac of HEPS.

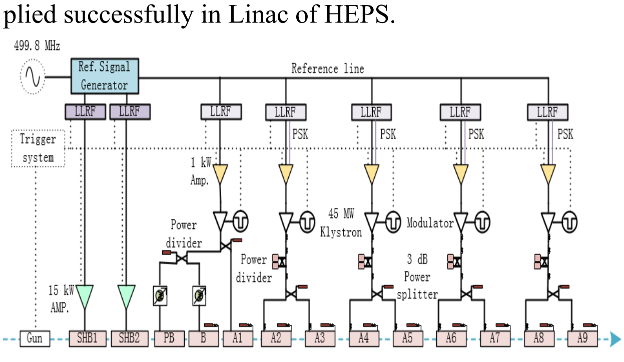

Figure 1: Layout of Linac injector.

RF DESIGN

The buncher is a 6-cell disk-loaded constant impedance traveling-wave structure operating in 2π/3 mode at 2998.8 MHz. The phase velocity is 0.75 times the velocity of light. The iris aperture is 24 mm and the total length is 235 mm. The buncher is simulated and optimized in CST [3]. The shunt impedance is 33.2 MV/m and the unloaded quality factor is 11083. The main parameters of traveling wave buncher are shown in Table 1. The maximum bunching voltage can achieve 1.2 MV with input power of 5.5 MW. The electromagnetic field distribution is shown in Figure 2. The maximum electric field on iris surface is 18.8 MV/m. The maximum magnetic field on cavity surface is 1.06E5 A/m. The normalized electric field and phase along axis is shown in Figure 3. The input and output cavities are matched using a quantitative method to determine the coupling coefficient and frequency deviation of a coupler cavity [4].

Table 1: Main Parameters of the Buncher

Parameters	Value
Frequency [MHz]	2998.8
Phase advance	2π/3
Cell number	6
Phase velocity	0.75
Group velocity	0.0193
Attenuation constant [Np/m]	0.147
Shunt impedance [MΩ/m]	33.2
Unloaded Q	11083
VSWR	<1.1
RF Structure type	TW/CI
Input power [MW]	5.5
Bunching voltage [MV]	1.2

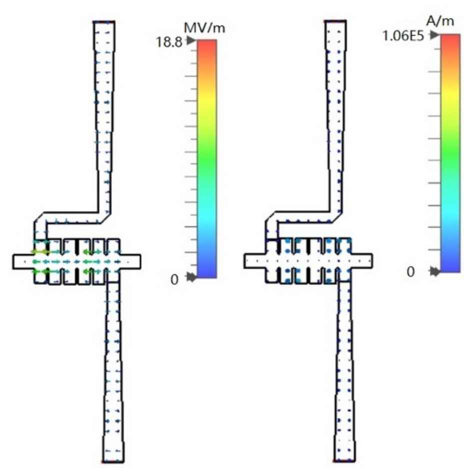

Figure 2: Electromagnetic field distribution.

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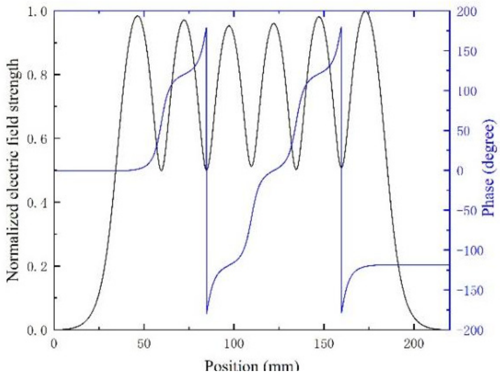

Figure 3: Normalized Electric field and phase along axis.

CAVITY TUNING AND COLD TEST

After fabrication and brazing, the cavity is tuned with a vector network analyzer (VNA). The VSWR from the input coupler at the working frequency is 1.01, as shown in Figure 4. The bandwidth of the VSWR below 1.2 is about 9 MHz. The filling time is about 31.5 ns, as shown in Figure 5. The test results are in good agreement with simulation results. The buncher is shown in Figure 6.

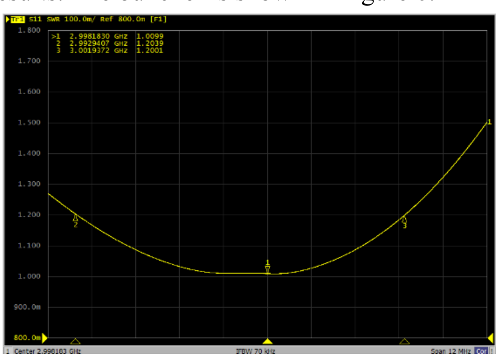
Figure 4: Cold test results of VSWR.

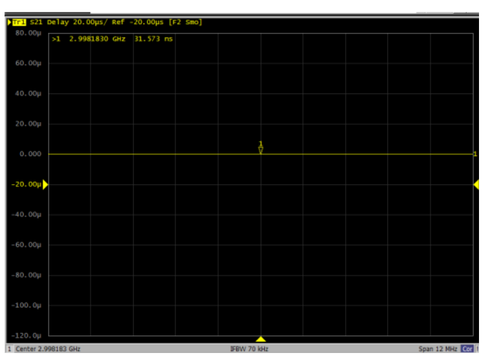
Figure 5: Cold test results of filling time.

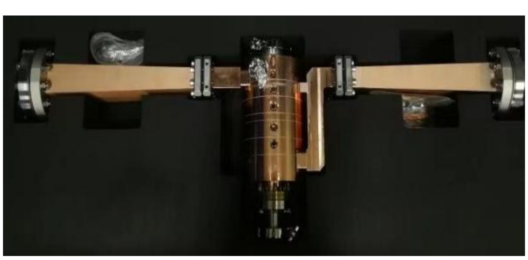
Figure 6: Traveling wave buncher.

HIGH POWER TEST

In order to ensure the stable and reliable operation online, the high power test of the buncher was finished before installation in Linac. A photograph of the high power test bench is shown in Figure 7. The RF power from the klystron is fed into the bunhcer through the waveguide system. A high power load is used to absorb RF power from the output coupler. The input and reflect-ed power is monitored using a directional coupler. An auto-conditioning program is applied for high power conditioning [5]. The interlock is determined by the vacuum level and reflected power. When the vacuum level exceeds 1E-5 Pa, the RF power was shut off and restarted until the vacuum was recovered. After a week of conditioning at a repetition rate of 50 Hz and pulse length of 2 us, the input power reaches 10 MW, which is almost twice of physical requirements.


Figure 7: High power test bench.

CONCLUSION

A S band constant impedance traveling wave buncher is designed and fabricated for injector Linac in HEPS. Since the buncher was put into operation in March 2022, it has operated stably.

ACKNOWLEDGEMENT

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