STATUS OF 200 MeV ELECTRON LINAC AND ITS APPLICATION

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Abstract

200 MeV Electron LINAC is an injector of HLS. The LINAC has been running well for ten years since 1987. A typical operation parameters are energy of 200 MeV, Current of 50 mA and energy spread of 0.8%. Some improvements are described in this paper, such as developing an energy stabilized system, developing a two mode combined pulser for the electron gun to meet single-bunch and multi-bunch mode running in the storage ring. Some applications are briefly described here also.

Keywords LINAC Synchrotron Radiation Gun Single bunch Isotope production

1 INTRODUCTION

200 MeV Electron LINAC is an injector of HLS(Hefei Synchrotron Radiation Light Source) [1], which layout is shown in Fig.1. The LINAC has been running well for ten years since 1987. A typical operation parameters energy of 200 MeV, Current of 50 mA and energy spread of 0.8%. Since 1991 some improvements were done, such as developing an energy stabilized system, adding a post-transport line in order to guide the beam into a nuclear physics experimental hall, developing a two mode combined pulser for the electron gun to meet single-bunch and multi-bunch mode running in the storage ring. The LINAC is also an electron beam source for some application users, such as detector crystal calibration, isotopes products using photonuclear reaction, and so on.

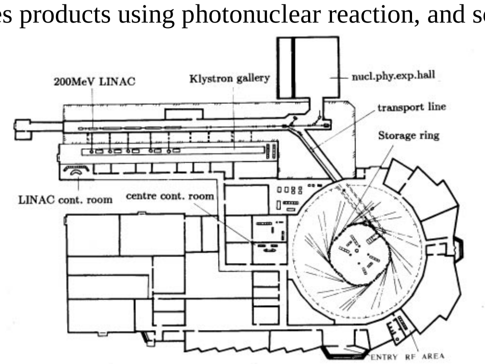


Figure 1. Plan of HLS

2 IMPROVEMENTS

2.1 Energy Stabilities

The 200 MeV LINAC has been run for 50,000 hours since 1987. The LINAC is running for both injecting the electron beam into HLS storage ring and providing the beam for producing some short lifetime isotopes, irradiation biology effects etc. The typical operation parameters are summarized in table 1.

Table 1. Operation Parameters of LINAC

Energy(MeV)	200.5
Current (mA)	70
Frequency (MHz)	2856.04
cavities' temperature ($^\circ$C)	42
output power of Klystron (MW)	
1# Klystron	9.7
2# Klystron	16.2
3# Klystron	15.7
4# Klystron	16.8
5# Klystron	9.3
beam pulse length(μs)	0.2~1.0
Energy spread (FWHM)	0.8%
Vacuum (mbar) (without beam)	$<1\times10^{-8}$
(with beam)	$<1\times10^{-7}$

In the beginning of the LINAC, its energy was not so stable that sometime it was difficult to inject the beam into the storage ring. After machine study, we adopted some measures. The energy stability has been improved. The main improvement was established an automatic energy stabilization system(AESS). Fig.2 showed a layout

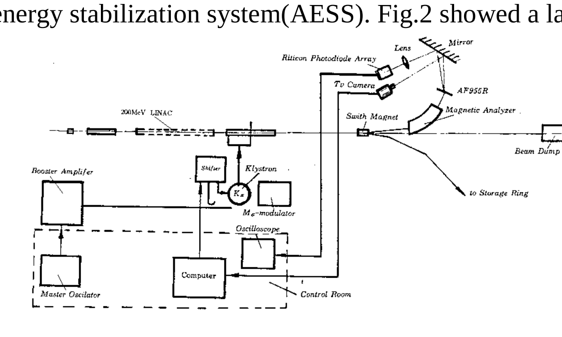


Figure 2. Layout of the automatic energy stabilizer

of the AESS. The energy stabilizing system was successful in stabilizing the energy. Typical running results are as following. When the AESS was not on, the central energy change rate $\Delta E_0/E_0$ was more than 0.8%. When the AESS was on, the $\Delta E_0/E_0$ was reduced down 0.4%. Now the LINAC has been running stably [2].

2.2 Combination pulser

The electron gun has been running for providing a pulse of μs beam for injection since 1989, so that there are multi-bunch running in the storage ring. Some users hope the ring running on a single bunch mode. This means that the beam pulse length from the LINAC must short than 4ns and the jitter time of the timing system is less than 0.5 ns. In order to meet the requirement, we need to improve the timing system, trigger system, beam diagnostic system and develop a ns pulser, and so on.

In order to produce a short pulse beam with width less than 3 ns, a grid pulser was developed and tested. The electronic circuit diagram is shown in Fig. 3. A key element of the circuit is employed a high frequency transistor 3DA87C with avalanche characteristics. The pulser can produce a short pulse of 2.5 ns (FWHM) and its amplitude is 120 volts. The waveform of the pulse is shown in Fig.4.

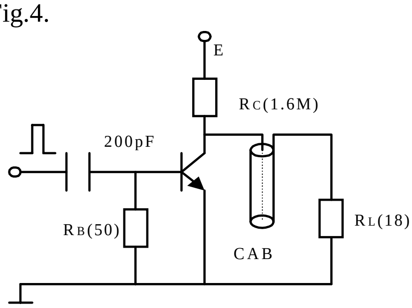


Figure 3. Circuit diagram of the ns pulser

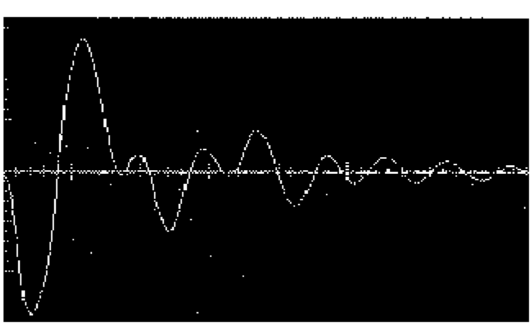


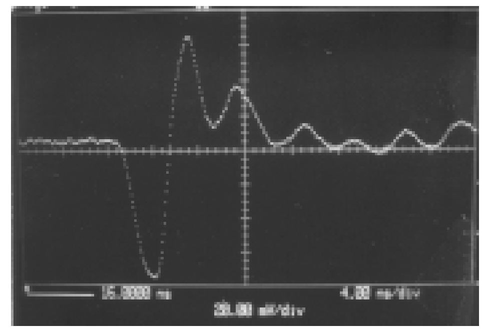
Figure 4. Waveform of the ns pulse

To transmit a trigger signal from the ground potential to a high potential, an optical fiber is most suited. The trigger signal transmission system consists of an electric-optical signal conversion circuit (E/O), and an optical- to -electric signal conversion (O/E). Time jitter including timing system, trigger system and pulser is less than 0.5 ns which is better enough for us.

Both grid pulser for long and short beam are assembled together in a circuit board, and employed a power splitter/combiners to transmit their signal respectively and isolate them each other. The trigger signals for the long and short beam are from a center control room and LINAC control room respectively.

Both long pulse and short pulse have been got and measured by means of Toroid monitors and wall current monitors which are installed in the LINAC and the transport line. The beam waveform are shown in Fig. 5(a),(b).

(a)



(b)

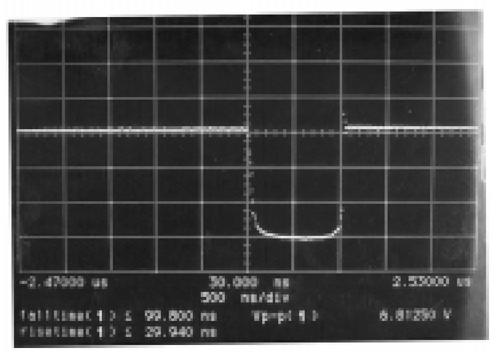


Figure 5. Waveform of output voltage of the combination pulser (a) ns waveform, (b) μs waveform

A single bunch mode running in the HLS storage ring has been successful using the combination pulser and a new timing system with jitter time less 100 ps (3σ) [3]. A waveform of the single bunch in the storage ring is shown in Fig. 6.

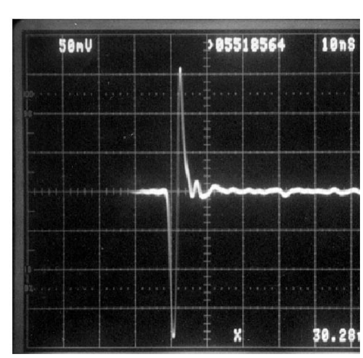


Figure 6. Waveform of a single bunch in the ring

3 APPLICATIONS

In the beginning the 200 MeV LINAC was designed for two purposes, one was as an injector of the HLS storage ring, another was to provide an electron beam of 200 MeV or less so that the machine can meet requirements from different scientific fields. Meanwhile the budget was shortage, a transport line for guiding the electron beam into a nuclear experimental hall and necessary experimental equipment were not constructed yet. last year a post-transport line for guiding the beam into the hall was added and an electron beam line was also established. The beam line will be used for studying the properties of single piece of P_bWO_4, such as light yield, decay time of the light and uniformity of the light output etc..

In order to utilize the electron beam from the LINAC fully, we established an equipment for photonuclear reaction at the end of the LINAC. As everyone knows, radioactive isotopes with short lifetime have been widely applied in medicine as tags or traces to study complex bodily processes and to diagnose some illness. Sequentially some new technologies , such as PET (positron emission tomography), SPECT (single photon emission computed tomograpgy), have developed. All of these have promoted a requirement of short-lived isotopes.

How do we get the radioactive short- lived isotopes? Neutron-capture reactions have long been used to induce them. By contrast, photon-induced nuclear reaction have been relatively neglected. But photonuclear reaction have great potential because they can results in medically important biological elements, such as carbon, nitrogen, oxygen and fluorine etc.

Since 1994, some researches on producing short-lived isotopes have been done in our LINAC. Some short lifetime isotopes, such as ^{18}F, ^{15}C, ^{11}C, ^{123}I, were got using the following photonuclear reaction ,

$$^{19}F(\gamma, n) \to {}^{18}F$$

$$^{16}O(\gamma, n) \to {}^{15}O$$

$$^{12}C(\gamma, n) \to {}^{11}C$$

$$^{124}X_e(\gamma, n) \to {}^{123}X_e \xrightarrow{\beta^+} {}^{123}I$$

Fig.7 showed a typical Gamma spectrum of the products of photonuclear reaction of natural Xenon which was irradiated by bremsstrahlung beam of 200 MeV, half hour generated via Tungsten convertor of 6 mm thick.

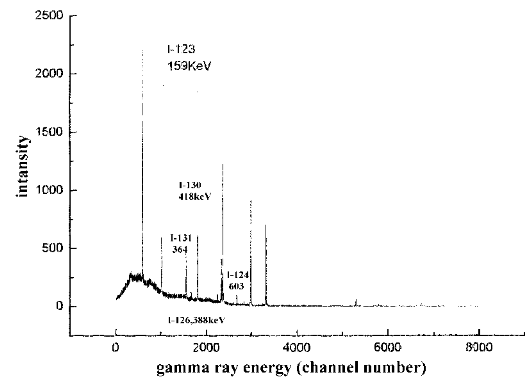


Figure 7. Gamma spectrum of products of photonuclear reaction of Xenon

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