Installation of a pulse laser at the LEPS beamline

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1 Introduction

At the LEPS2 beamline, the lasers are injected into 8 GeV electrons of the SPring-8 Storage Ring. By transferring momentum from an 8-GeV electron to a laser photon via the Backward Compton scattering(BCS), the energy of the scattered photon becomes 2.9 GeV at the maximum. We reserch on hadron photonproduction reaction by injecting polarized photon beam into LH2, LD2 target. In order to carry out high statistic experiments for reaction with a small photoproduction cross section, increasing the intensity of the laser electron photon(LEP) beam is an urgent issue. The intensity is targeted at 5 MHz.

Until now, We have used CW lasers to generate LEP beam. Since the electron beam has a time structure(bunch structure), CW laser has a blank shot. By injecting a pulse laser at the timing when the electron beam enters the BCS region, the blank shot is reduced and the frequency of the BCS is increased. Since synchronization always collideswith the same bunch, multiplicity(the number of photons produced by the same bunch) must be low.

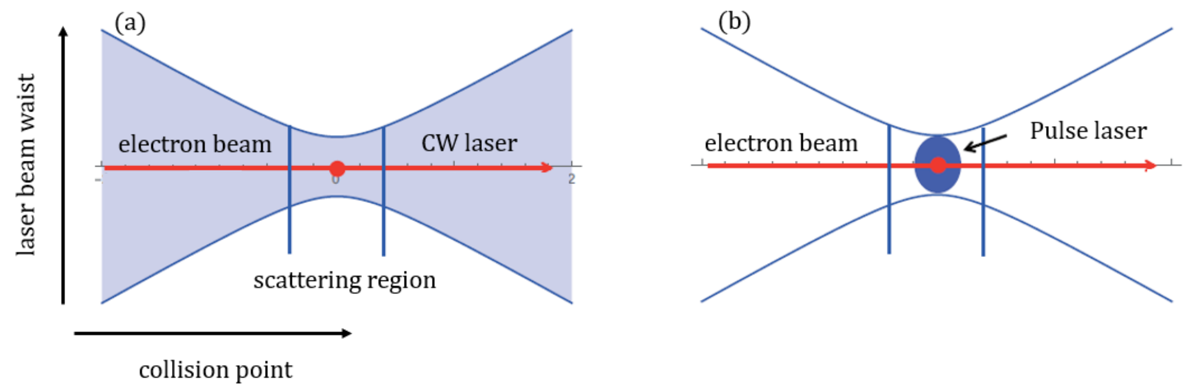

Figure 1: Collision of electron beam and laser. (a) In the case of a CW laser. (b) Synchronization of the eletron beam and a pulse laser.

2 Experiment

Fist, we constructed a circuit system to synchronize the electron beam and the pulse laser. We divide the RF fewquency of the Storage Ring once per cycle(4.789 µs), and use this signal as an external trigger of the function generator. The prepared waveform pattern is sent to the pulse laser from the function generator that received the external trigger. The irradiation of the pulse laser is controlled by this waveform pattern. The collision timing with the electron beam is adjusted by the delay of the function generator. This is the overview of the synchronous circuit system. There are three limitations to the waveform pattern.

- waveform time : < 4.439 µs
- input freq. : < 30 MHz
- pules interval : > 17 ns

Fig.2 shows the frequency characteristics of the power of the 355 nm pulse laser (LEP beam of up to 2.4 GeV) used in this experiment. The laser power decreases exponentially as the frequency increases from the frequency at which the power is maximum(3 MHz). Considering multiplicity, the frequency should be increased, but the maximum power will be smaller, so the beam intensity will not always increase.

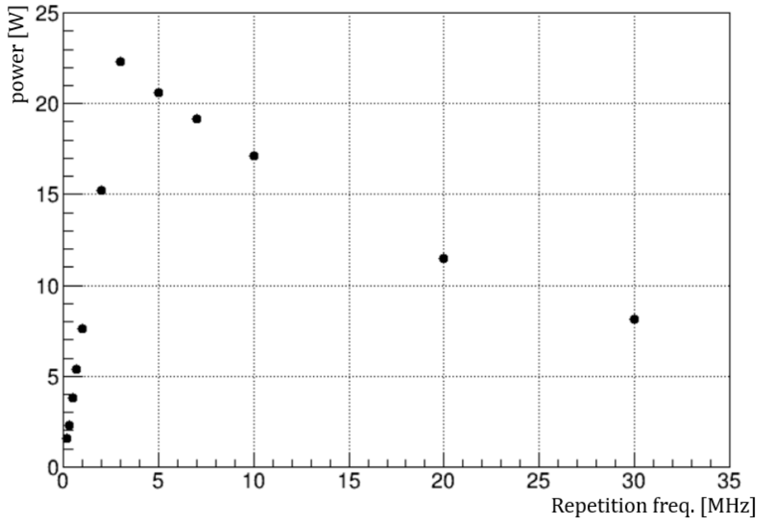

Figure 2: Frequency characteristics of the pulse laser.

3 Results

The test experiment was performed at the LEPS beamline. The incident position of the pulse laser can be changed by adjusting the delay of the function generator and two mirrors in the horizontal and vertical directions, respectively. Fig.3 shows the results of measurement in D-mode(1/7-filling + 5 bunches). At the beginning of the bunch mode, the bunch structure was scanned by irradiating the pulse laser once per cycle while changing the delay. This allowed us to figure out which bunches the pulse laser was colliding with. Using this scan data, the pulse laser irradiation was aimed only at the single bunch, avoiding filling region. By moving the mirrors one by one, we were able to measure the profile of the LEPS beam and determine the emittance. This can only be done with the pulse laser, which can keep the collision position constant.

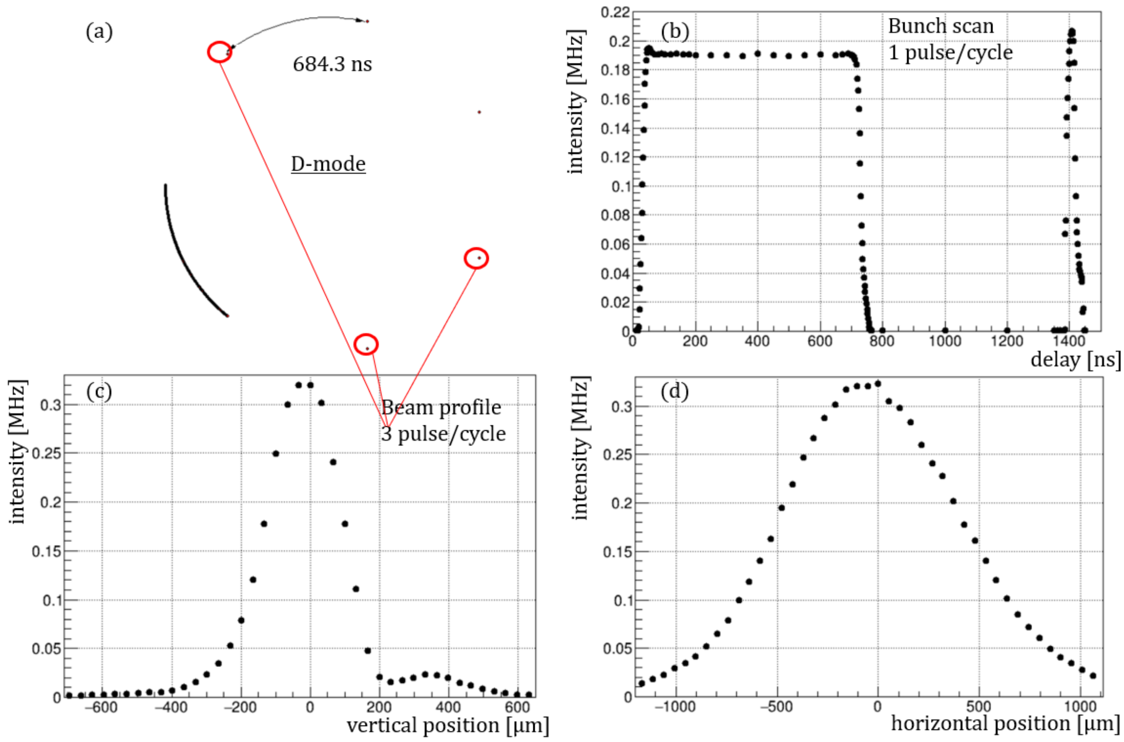

Figure 3: Results in D-mode. (a) Bunch structure. (b) Scanning bunch structure. (c) Measurement of vertica beam profile. (d) Measurement of horiontal beam profile.

Table.1 summarizes the maximum intensity and multiplicity obtained by adjusting the waveform pattern and laser power for each bunch mode.

Table 1: Results of optimization for each bunch mode

bunch mode	freq. [MHz]	power [W]	intensity [MHz]	multiplicity
A-mode	19.628	7	2.867	0.158
B-mode	16.287	9	4.308	0.307
C-mode	11.274	4	2.073	0.203
D-mode	9.187	6	1.852	0.139
E-mode	8.979	3	1.163	0.139
H-mode	21.507	8	3.045	0.153

4 Discussion

It is necessary to select bunch mode, but it can be introduced into actual experiments. With the current performance of the pulse laser and the function generator, the frequency will be operated at about 20 MHz. In order to operate the pulse laser at 20 MHz or higher, the frequency at which the maximum power of the pulse laser is maximized must be higher than 3 MHz.

Since this experiment was performed at the LEPS beamline, it is necessary to perform optimization at the LEPS2 beamline. We also plan to perform a similar experiment with a 266 nm pulse laser (LEP beam of up to 2.9 GeV).

References

[1] N. muramatsu et al., Nucl. Instr. and Meth. A. 737 (2013)

[2] Y. Kawashima and Y. Ohashi, SPring-8 Information Vol.13 No.1 Jan. (2008)

[3] http://www/spring8.or.jp/.