PROGRESS IN CONSTRUCTION OF GUN TEST FACILITY FOR COMPACT ERL

T. Miyajima*, Y. Honda, M. Yamamoto, T. Uchiyama, K. Sato, S. Nozawa, M. Tobiyama, T. Mitsuhashi, T. Obina, R. Takai, T. Takahashi, T. Ozaki, A. Ueda, S. Nagahashi, M. Shimada, K. Haga, T. Honda, K. Harada, E. Nakamura, S. Sakanaka and Y. Kobayashi, KEK, Tsukuba, Ibaraki 305-0801, Japan
S. Matsuba, Hiroshima University, Higashihiroshima, Hiroshima 739-8530, Japan
T. Muto, Tohoku University, Sendai, Miyagi 982-0826, Japan

Abstract

In order to develop the photo cathode gun for the Compact ERL (cERL), which is a test accelerator to establish accelerator technologies for GeV-class synchrotron light source based on ERL (Energy Recovery Linac), Gun Test Facility is constructing in KEK, AR south experimental hall. The Gun Test Facility consists of a 500 kV gun construction area, a laser system area and a gun test beamline with beam diagnostic system. Design of the gun chamber, the insulators, and the preparation chambers for the 500 kV gun were finished. Vacuum test of the gun system started at April 2010. Development of 1.3 GHz fiber laser system for 1 mA beam commissioning is almost reach the target. To evaluate performance of the DC guns, the gun test beamline is developing in the beamline area. From April 2010, beam running in the gun test beamline started using NPES3 200 kV DC photo cathode gun.

INTRODUCTION

Compact ERL (cERL) is a test accelerator to establish accelerator technologies for GeV-class synchrotron light source based on ERL, and will be constructed in KEK [1]. It consists of an injector with photo cathode 500 kV DC gun, super conducting RF cavities for acceleration and energy recovery, return loops, and a beam dump. To operate and test the photo cathode gun before installing it in the cERL injector, Gun Test Facility is constructing in KEK, AR south experimental hall. The gun test facility has two photo cathode guns, 200 kV gun developed by Nagoya University [2] and new 500 kV gun which is being developed, laser system to be emitted electrons from photo cathode surface, beam transport lines, and a beam diagnostics system. The diagnostics system consists of a double slit emittance measurement system, beam position monitors, transverse profile monitors, and a deflecting cavity to measure the bunch length and the longitudinal profile. Figure 1 shows the layout the gun test facility in the AR south experimental hall. In this presentation, the progress in the construction of the gun test facility is shown.

PHOTO CATHODE 500 KV DC GUN

For the cERL, two 500 kV DC gun systems are developing in JAEA and KEK. The first reason, there is a lot

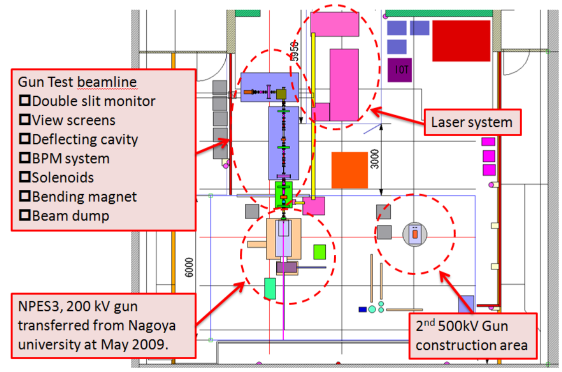


Figure 1: Layout of AR south experimental hall to develop and study gun system.

of development elements like the problem how to avoid insulator breaking, how to produce extreme high vacuum of 10^{-10} Pa or less, and how to suppress a dark current from electrodes in high electric field. Especially, in order to achieve 100 mA beam operation, the R&D machine is indispensable to break through many problems such as high power laser development, cathode heating problem and very serious cathode lifetime problem. The second reason is a backup when a serious damage is occurred in installed gun system while operation. In this paper as follows, the gun of JAEA is called the first gun and the gun of KEK is called the second gun.

Figure 2 shows the second gun system. The concept of the second gun is as follows. In order to achieve extreme high vacuum, we employed titanium for the gun chamber. The design of the second gun was done with considers about easy maintenance, extendibility and compatibility with the 1st gun. For pumping system, we employed specialized pump of a bakeable cryopump. For cathode preparation system, we are planning to develop multiple cathode preparation system for decrease cathode preparation duty.

Figure 3 shows a brief the 2nd gun system. The target of vacuum condition of each chamber is about 10^{-8} to 10^{-10} Pa or less. Several cathodes are fixed on a puck revolver and installed in the loading chamber. In the loading chamber, the cathodes are cleaned by atomic hydrogen and heating. Then the cathodes are transferred to the activation chamber, and create NEA surface by Cs and oxygen deposition. Then the revolver is transferred to the stock

* tsukasa@post.kek.jp

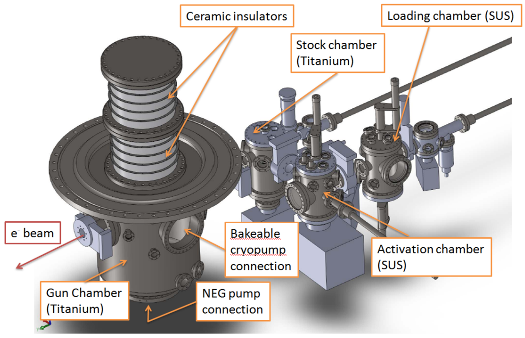


Figure 2: 2nd photo cathode 500 kV DC gun system.

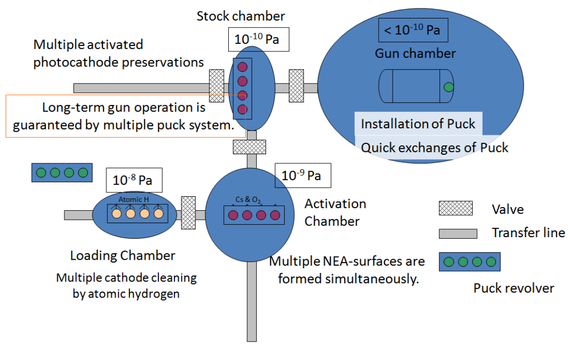


Figure 3: Brief of 2nd photo cathode 500 kV DC gun system.

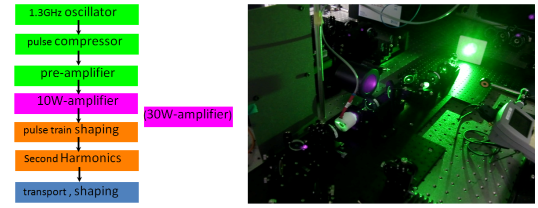
chamber. In the stock chamber, the cathodes are preserved in extreme high vacuum to maintain high cathode QE condition. Then, one cathode is transferred to the gun. If the cathode QE is decreased, we can exchange the extra fresh cathode quickly. This is our multi-puck system concept.

The fabricating processes of the gun chambers were finished at March 2010. Since April 2010, we are making an examination of the vacuum chambers, and constructing the gun system.

FIBER LASER SYSTEM

A 1.3 GHz fiber laser system are developed in AR-south area for the first aim of injector commissioning up to 1 mA. Figure 4 shows the laser system configuration. The drive laser for AR-south injector commissioning test area is started since 2009. The requirements for 10 mA operation of cERL are 1.3 GHz(repetition), 530 nm (wavelength), 20 ps (pulse duration), and 1.5 W (power). The system has been built based on commercial units (1.3 GHz oscillator, fiber amplifier, SHG, etc.). The second harmonic power of 100 mW has been achieved. This is enough for first commissioning of the injector up to 1mA. Development of high power amplifier is progressing for second harmonic power of over 1 W that can generate 10 mA beam.

Pulse train shaping (pulse train of 1000 bunches) has been introduced for burst operational mode. This is for commissioning phase of ERL operation. In order to test



(a) Outline of fiber laser system (b) Photo graph of laser

Figure 4: Configuration and photograph of fiber laser system.

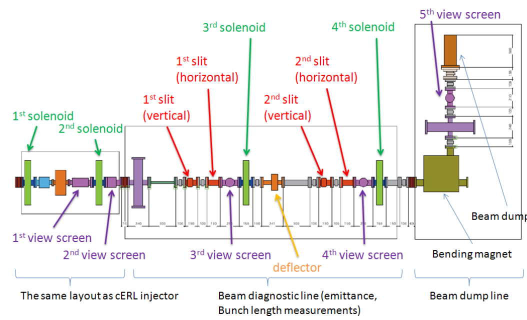


Figure 5: Layout of gun test beamline.

high bunch charge beam, lower rep.rate higher intensity Ti:sapphire laser system will be used. Laser transport line and input chamber are made.

GUN TEST BEAMLINE

Since 2009, we started construction of the gun test beamline. The purpose of the test beamline is to gain operation experience of the low energy beam, to evaluate performance of the DC guns by an additional diagnostic line to measure emittance and bunch length, to develop a new 500 kV gun and the injector line used at cERL. Now, a 200 kV gun developed by Nagoya university for ILC polarized electron source [2] is used in the beam operation. This gun was transferred from Nagoya university at May 2009. Until middle of 2011, we will use the 200 kV gun to test the beam diagnostic system. After construction of the 500 kV gun, we will switch the gun from 200 kV to 500 kV.

Figure 5 shows the layout of the gun test beamline. The beamline consists of three sections. The first section has the same layout as cERL injector. After this section, we connect a beam diagnostic line, which have a double slit emittance measurement system and a deflecting cavity to measure bunch length. The third section has a beam dump. We are constructing the gun test beamline with the 200 kV gun in AR south experimental hall, KEK.

DEFLECTING CAVITY

Some of photo cathodes have slower response time, which generate a longer beam tail compared with laser pulse width. The slower cathode response affects the beam parameter generated by the DC gun. For example, the emittance growth is caused by both the longer tail and space

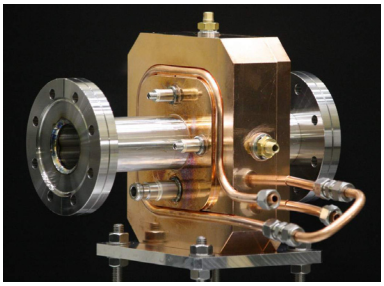


Figure 6: Photograph of deflecting cavity to measure bunch length.

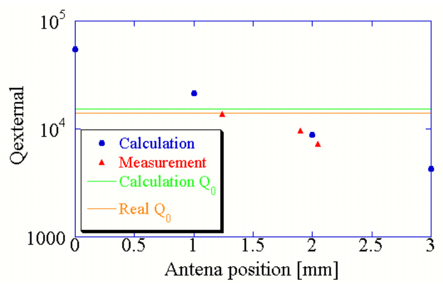


Figure 7: Q-external of deflecting cavity versus head of antenna position from cavity wall. Positive position is direction of intrusion into the cavity.

charge effect. For that reason, since the beam parameter depends on the property of the photo cathodes, the investigation of the cathode property is required to generate high quality beam. The cathode response can be measured by the measurement of the bunch length. In order to observe bunch length and longitudinal beam profile, we have designed a single-cell deflecting cavity with 2.6 GHz dipole mode [3].

The cavity was made by two main bodies, beam pipe, coupler, probes, tuners, pipes for water cooling, and flanges. Figure 6 shows the photograph of the cavity. The power input test and vacuum test of the cavity was finished. As an input coupler, a coaxial type antenna, which has an inner conductor of 3 mm diameter with outer conductor of 7 mm diameter, is used. Calculated and measured Q-externals of this coupler are shown in Fig. 7. The deflecting cavity will be installed in the gun test beamline.

BEAM OPERATION IN NPES3 200 KV GUN BEAMLINE

From April 2010, we are operating a beam using an original NPES3 200 kV beamline [2] until completion of the gun test beamline. Figure 8 shows the layout of the NPES3 200 kV beamline, which has a view screen to measure a transverse beam profile. After rough tuning of the magnet parameters, we have obtained preliminary results of the beam profiles, when the magnetic field of the third solenoid is varied. The dependence of the beam profile on the solenoid field was calculated using a particle tracking code,

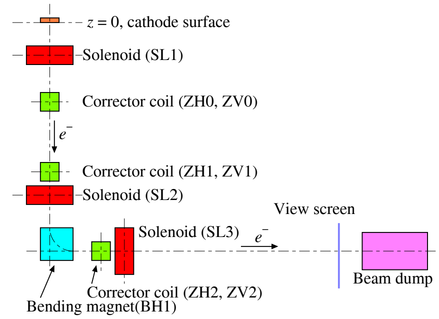


Figure 8: Layout of NPES3 200 kV gun beamline.

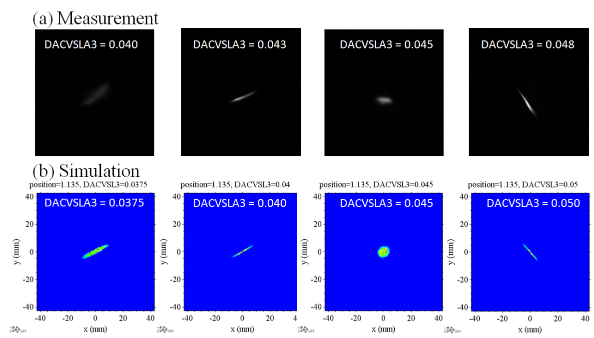


Figure 9: Preliminary results of measured and simulated beam profile on a view scree, when magnetic field of 3rd solenoid is varied.

GPT. The measured and simulated results of the beam profile on the view screen are shown in Fig. 9. Although the solenoid strengths are different between the simulation and measurement, the similar profiles are obtained as shown in Fig.9. To try to find the cause of the difference, we have continued the beam operation.

SUMMARY

Design and fabrication of the gun chamber, the insulators, and the preparation chambers for 500 kV gun were finished. Bakeable cryopump is employed for the gun. Vacuum test of the gun system started from April 2010. Design of the multiple cathode preparation system is progressed. Development of 1.3 GHz fiber laser system for 1 mA beam commissioning is almost reach the target. Development of higher power amplifier is on going. To evaluate performance of the DC guns, we are developing the gun test beamline in the PF-AR south experimental hall. From April 2010, we started beam running in the gun test beamline using NPES3 200kV DC photo cathode gun.

REFERENCES

[1] R. Hajima et al. (ed.), KEK Report 2007-7/JAEA-Research 2008-032 (2008) (in Japanese).

[2] T. Nakanishi, *Proceedings of LINAC2002*, Gyeongju, Korea, 202, pp. 811-815.

[3] S. Matsuba et al., in these proceedings, MOPE002.