# IMPROVEMENT ON THE SINGLE BUNCH OPERATION OF THE TLS INJECTOR

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*Abstract*

The improvement on single bunch operation of the TLS (Taiwan Light Source) injector is presented in this study. Limited by the existing design of the TLS injector, the single bunch operation was not optimized in terms of bunch purity for specific users of TLS. A high voltage pulser was implemented to improve the situation. This pulser has been integrated into the high-voltage-deck (HV-deck) electronics of electron gun for single bunch generation. Both high-voltage pulses and the associated electron bunches are monitored with a wideband digital oscilloscope. The result shows that the bunch purity can be greatly improved by using the newly installed pulser. It also greatly eliminates the beam losses while injected into the booster ring.

## INTRODUCTION

The SB (single bunch) mode operation in TLS has been requested for user program and machine study purposes [1]. However, the electron populated in the neighboring bunches are always bothersome to the experimental observation. The source of causing the impurity in the neighboring bunches is the SB pulser signal. It is a triangle pulse with 2ns basewidth delivered from SRD (step-recovery-diode) located next to the cathode [2]. Usually, one would expect the SB electrons to fill into one rf bucket in the booster ring, equipping with 500MHz rf cavity, without polluting the neighboring bunches. However, the estimated 400ps jitter of the timing and pulser system degrades the expected performance. The observed population in the neighboring bunches can be as high as 50% of the major bunch. This bunch impurity can be effectively reduced by increasing the bias-voltage of the cathode in the routine operation and reducing the impurity population to 5% of the major bunch. During this operation, the signal of the major bunch reduced, which prolongs the beam accumulation time and is not practical when high SB beam current is required.

In order to improve the SB bunch purity situation, a recently available high voltage pulser is installed to replace the original SRD unit for SB test-run. The new pulser provides HV-PFN (pulse forming network) signal of 800ps width. It generates electron beam pulse with corresponding bunch length. The measured test-run results are presented in this report.

## INSTRUMENT ARRANGEMENT

A high voltage pulser of Kentech-CPS1 [3] is used to replace the original SRD unit for SB electron beam generation. The functional block diagram of the newly installed SB pulser is depicted in figure-1.

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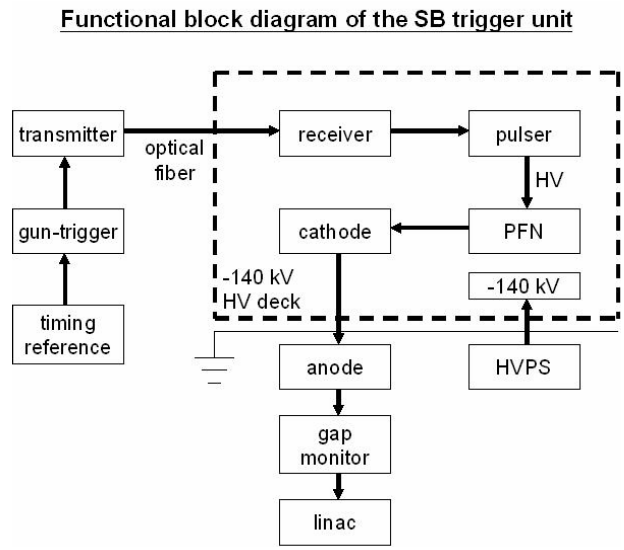


Figure 1: Functional block diagram of the newly installed SB trigger unit.

The electron gun trigger signal initiated from the timing system is converted into optical signal so as to transmit onto the HV-deck of -140kV where the timing signals is restored and fed into the CPS1. This CPS1 provides HV of -2.5kV, as shown in figure-2, applying to a subsequent connected PFN module which delivers a square pulse of 500ps (FWHM) to the cathode, as shown in figure-3, for electron pulse generation.

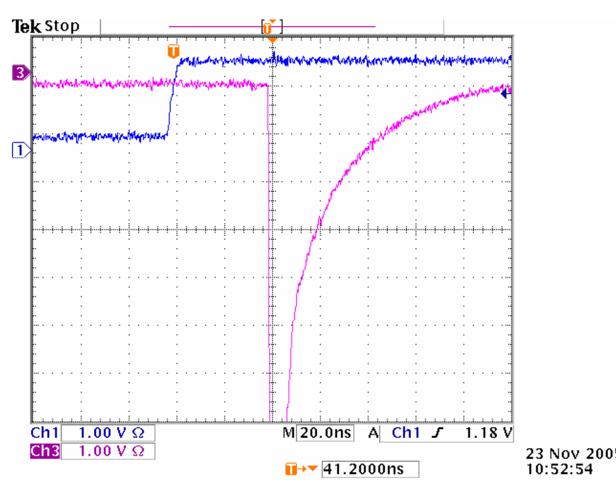


Figure 2: The performance of Kentech-CPS1. 1. gun trigger signal; 2. the -2.5kV signal.

The short pulse of 140keV electron beam emitted from the gun cathode is longitudinally compressed before entering the linac in which it is accelerated to 50MeV and then injected into the booster ring. Gap monitors are used to monitor the short electron bunch. The locations of available gap monitor are depicted in figure-4. The transition radiation monitors indicated in the figure for beam property measurement are currently under development.

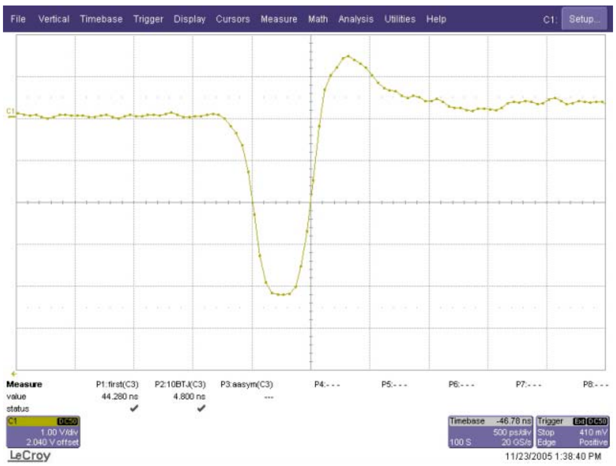


Figure 3: The performance of Kentech - PFN module. The 500ps square pulse (FWHM) signal is displayed by a wideband digital oscilloscope, SDA-6000A.

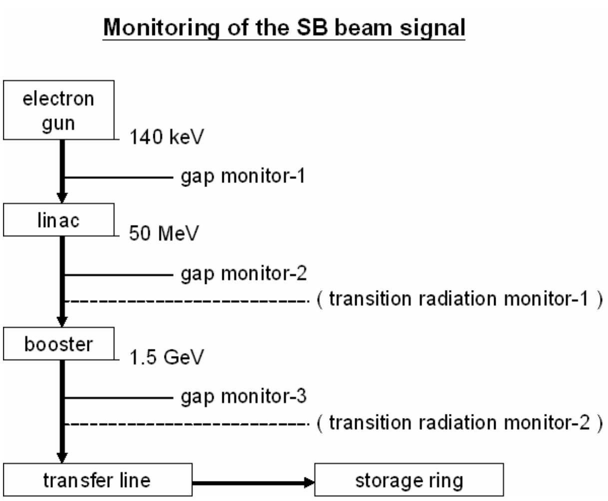


Figure 4: SB beam monitoring tools at various locations.

A 3GHz electron pulse chopping tools has been installed between electron gun and linac [5]. The calculated results show that about one-fifth of the electrons would be injected into the linac under the required specifications. Observation of the routine operation indicates that over 95% of the electrons transmit through the linac.

## RESULTS AND DISCUSSION

The original SB beam generation using Hermosa trigger unit is shown in figure-5. The signals given in upper and lower traces are observed at fast gap monitor G1 and G2, respectively. The 2ns pulse length at G1 reveals the character of the SRD and the associated trigger circuit. The G2 signal gives corresponding bunch length property (2ns) which indicates that the electrons pulse signal observed at G2 consists of six 3GHz bunches. The one-sixth amplitude ratio of G2 to G1 indicates an optimized transmission of SB from electron gun to the exit of linac in routine operation as well as for MB (multi-bunch) operation [4].

Unfortunately, there is no 500MHz sub-harmonic buncher equipped in the beam chopping section of the preinjector so that half of the 50MeV electrons are lost while injected into the booster ring. By properly manipulating the strength of SB trigger pulse and the bias-voltage to the cathode, it is possible to reduce the SB electron pulse length to 1ns. However, the electron pulse height decreases to about one-forth of the original height. This adjustment prolongs the beam accumulation duration in the storage ring to an unacceptable level and is not usually applicable except for particular machine study need. The situation of lacking sub-harmonic buncher is not likely to change in the foreseeable future due to practical considerations. Alternatively, the newly installed CPS1-pulser may help to improve the situation.

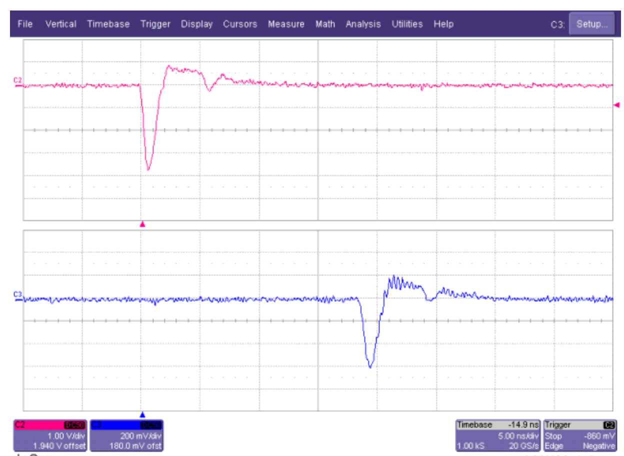


Figure 5: The electron pulse signal observed with SDA-6000A. upper: G1; lower: G2.

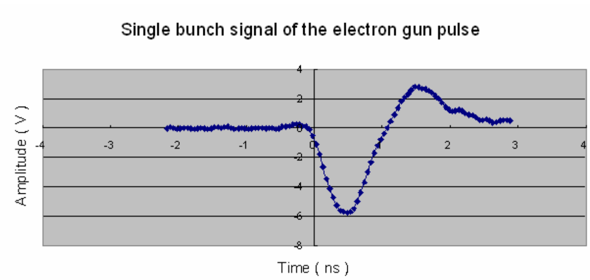


Figure 6: The electron pulse signal observed at G1 with SDA-11000.

Figure-6 illustrates the electron pulse signal observed at G1 using CPS1-pulser. The pulse length reduces to 1ns base-width and the intensity increases to about twice of the previous case shown in the upper trace of figure-5. Notice that the cathode operation condition for both cases is the same. The increased intensity indicates that it is possible to further enhance the amount of SB electrons by manipulating the pulse height and bias setting of the cathode.

Examination indicates that this shortened electron pulse, with 1ns basewidth at the gun exit, does not increase the amount of electrons injected into the linac due to the chopping mechanism designed particularly for this application. Consequently, the amount of 50MeV electron stays the same. However, it removes those 50MeV electrons who would sit on the deceleration phase of the 500MHz cavity in the booster if the pulse length is 2ns. Those removed electrons are being put into the acceleration phase of 500MHz cavity. It is interesting to examine whether the electron beam injected into the booster becomes double due to this operation. Further exploration on the performance of SB operation of the injector is needed.

## REFERENCES

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