NEW STREAK-CAMERA SYSTEM FOR THE KEKB LINAC

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Abstract

A new streak-camera system optimized for beam diagnostics of a linac has been developed. It is an all-in-one system such as oscilloscopes, involving not only the streak camera itself, but also a delay unit synchronized to a linac beam trigger and an rf, and a control system for input optical systems. Two such systems have been installed for the KEKB linac as bunch-length monitors utilizing optical transition radiation (OTR) at the end of the bunching section as well as at the exit of the J-arc section. The first beam test was successfully completed; the operation as well as the set-up of the system becomes quite simple, which enables the linac beam diagnostics to be much easier than before.

1 INTRODUCTION

Prompt beam diagnosis plays an essential role for stable operation of accelerators, like the KEKB linac[1], in which frequent injection into the ring is absolutely necessary; whenever the beam is down, it must be recovered as soon as possible while diagnosing the beam state. Various kinds of beam instrumentation[2, 3] have been employed at the KEKB linac for this purpose; wall-current monitors, position monitors, screen monitors and wire-scanner monitors have been installed. Although it has been recognized that bunch monitors[4] are also indispensable for precise beam tuning and diagnosis, they have been used not as easy tools that anybody could use, but as special ones that only experts could handle.

One of the reasons is that the pulse width of the beam is very short (10 ps) in the case of an S-band linac, such as the KEKB linac. Therefore, streak-cameras[5] had usually been used to see a bunch structure by observing a light pulse (e.g. OTR) emitted through the interaction between charged particles and matter inserted into the beam line. The system, however, was neither easy to cope with nor optimized for beam diagnosis of linacs; control of the optical beam transport from the beam line to the streak camera, which is usually quite long, and a streak triggering is one example of the main difficulties of easy handling. In this connection, a new streak-camera system optimized for the KEKB linac has been developed and tested at two positions of the linac: the end of the bunching section and the exit of the J-arc section. The system configuration and functions are described together with the first results of a beam test.

2 SYSTEM SPECIFICATIONS

2.1 System Configuration

The hardware of the new streak-camera system comprises three parts: an input-optical system, a streak camera with a trigger-delay unit synchronized to the rf of the linac and a data-analyzing computer. The key feature of the design was an integration of controls; it is an all-in-one system, such as oscilloscopes.

Cabling to the system is also quite simplified; only two inputs (a beam trigger and an rf signal) and two outputs (a steak video signal and its trigger) are required apart from connections of GP/IB controls. Figure 1 shows the system configuration.

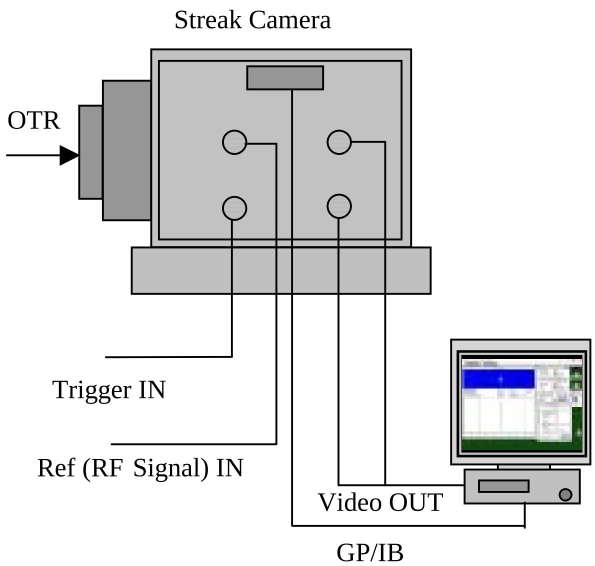

Figure 1: System configuration of the new streak camera.

2.2 Input Optical System

The input optical system is divided into two parts: the tunnel optics for extracting and transporting OTR from the beam line to the klystron gallery, and the gallery optics for the input of the streak camera (Fig. 2). It was usually controlled with another software separated from the main streak-camera control, which made the set-up of the optical system quite tiresome. The new integrated software allows the set-up to be very easy.

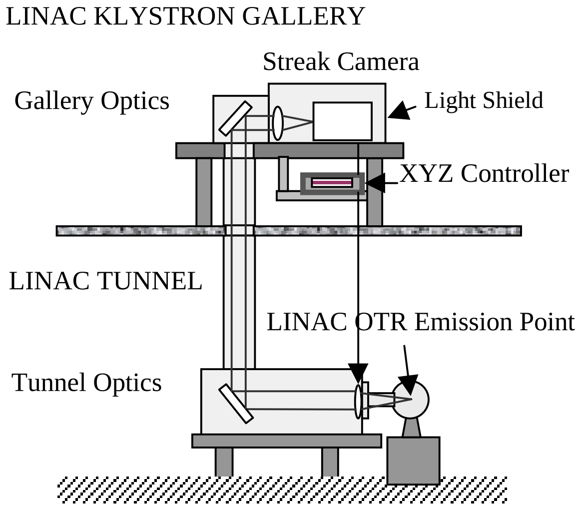

Figure 2: Input optical system controlled by integrated software.

2.3 Streak Camera with a Delay Unit Synchronized to RF

The streak tube is made by Hamamatsu Photonics K. K., and has a time resolution of better than 2 ps in the range of wavelength from 200 to 850 nm. The driver circuits and a trigger-delay unit synchronized to the rf signal as well as the streak tube with a fiber-coupled CCD camera are configured in the streak camera.

When a long delay is required for adjusting the timing between the input light and the streak trigger in operating the streak sweep, it may give rise to a timing jitter in the fast-sweep range. In the electron linac using an rf for acceleration, the beam timing is in principle perfectly synchronized to the rf. Therefore, the trigger-delay timing for the streak sweep is resynchronized to the rf in the delay unit of the streak-camera system.

2.4 Software

The image signal from the CCD camera is taken into a video frame grabber and processed by the software on a Power Macintosh, which also controls the streak-camera via GP/IB networks. The new features of the software are the following:

(1) Easy set-up of the input optical system
(2) Automatic peak search in the streak mode
(3) Real-time gravity integration of a single shot pulse

(1) Easy set-up of the input optical system
In the former system, the control system for input optics was not included in the main streak-camera software, as mentioned in section 2.2. The present software integrates all functions for controlling the streak-camera system into single software and makes the adjustment of the input optics quite easy.

(2) Automatic peak search in the streak mode
The streak sweep timing (trigger) used to be adjusted to that of the input light by comparing a beam trigger with a wall-current monitor signal near to the bunch monitor using an oscilloscope. This procedure took a long time and was one of the main difficulties to use a streak-camera system. The function of an automatic peak search, in which a signal is searched automatically by changing the trigger delay, is thus introduced; it turns out that it worked quite well, provided that the input light had a certain amplitude level.

(3) Real-time gravity integration of a single shot
For observations with a time resolution of the streak camera (better than 2 ps), a single-shot measurement must be performed. The single-shot signal, however, is usually not so large as to accomplish this resolution. Moreover, the timing jitter of triggers dose not allow an average process (integration) for an improvement of the S/N ratio; as a result, off-line gravity integration must be performed. The new system automates this function as a real-time process, which enables a measurement with a good S/N ratio, as long as the input signal has no fast time variations.

3 EXAMPLES OF LINAC BEAM DIAGNOSIS

Using the new streak-camera system as a tool for beam diagnosis, tuning of the bunching section and checking isochronicity along the J-arc section were performed.

3.1 Observation at the End of the Bunching Section

Figure 3 shows an example of the tuning process in the bunching section for a beam with a charge of 2 nC, using the streak-camera system installed at the end of the bunching section. Two subharmonic bunchers (SHB1: 114 MHz, SHB2: 571 MHz) as well as a prebuncher and a buncher (2856 MHz) are used for realizing a single bunch; a beam with a pulse width of several nanoseconds is compressed into a single bunch with a width of about 10 ps.

3.2 Observation at the Exit of the J-Arc Section

The J-arc section is designed as an achromatic and isochronous system. In order to verify the isochronicity, the relative time delay of the beam in the J-arc section was measured as a function of the input energy into the J-arc section using the streak-camera system installed at the exit of the J-arc section. Figure 4 shows an example of observations for the dependence of the beam time delay upon the input energy, indicating non-isochronicity. After the observation, an isochronicity correction was tried and an isochronous system was realized.

4 CONCLUSIONS

A new streak-camera system optimized for the KEKB linac has been developed and used as a powerful tool (a bunch monitor) for beam diagnosis. The system has several useful features related to an integration of controls

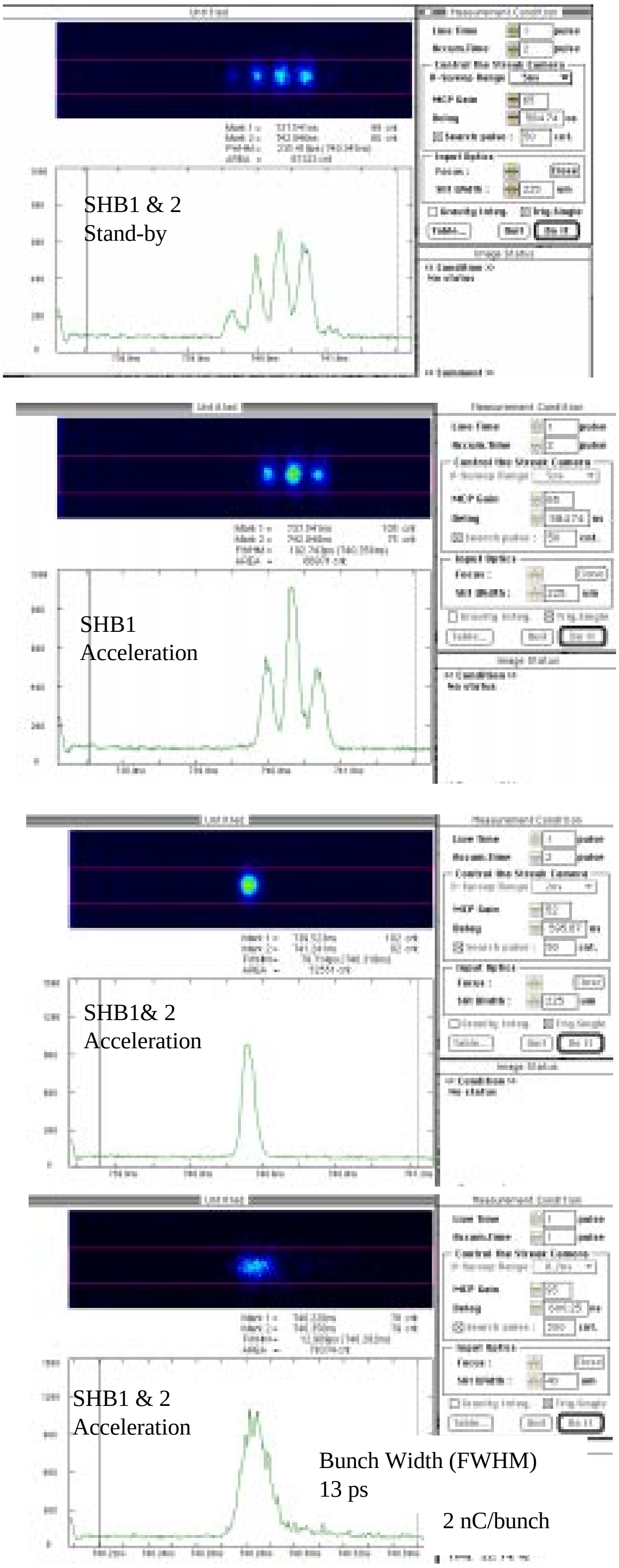

Figure 3: Tuning process of the bunching section.

allowing easy operation of the streak-camera system. The bunch structure at the end of the bunching section as well as the isochronicity in the J-arc section have been measured using the system for verifying the features. The

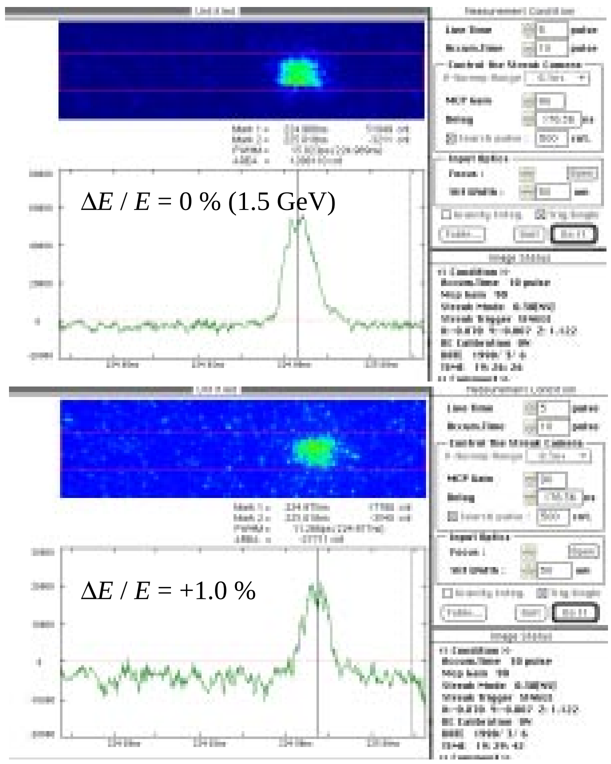

Figure 4: Examples of isochronicity measurement.

results are quite satisfactory and another two systems (one near to the positron production target and the other at the end of the linac) are being prepared for the full-beam commissioning of the KEKB project scheduled in autumn.

5 ACKNOWLEDGMENTS

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