ELECTRON BUNCH LENGTH MEASURMENT FOR LCLS AT SLAC*

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Abstract

At Stanford Linear Accelerator Center (SLAC) a Bunch Length Measurement system has been developed to measure the length of the electron bunch for its new Linac Coherent Light Source (LCLS). This destructive measurement uses a transverse-mounted RF deflector (TCAV) to vertically streak the electron beam and an image taken with an insertable screen and a camera. The device control software was implemented with the Experimental Physics and Industrial Control System (EPICS) toolkit. The analysis software was implemented in Matlab™ using the EPICS/Channel Access Interface for Scilab™ and Matlab™ (labCA). This architecture allowed engineers and physicists to develop and integrate their control and analysis without duplication of effort.

MEASURING THE BUNCH LENGTH

In order to measure the bunch length for the given beam energy you need to determine 1.) the distance the beam is deflected per TCAV phase degree and 2.) the two TCAV phase settings known as the zero-crossings. An accurate bunch length can be calculated using these values, along with some interesting math [1]. This paper will describe how the measurements are taken from a control prospective.

Calibration

Calibration is the process of finding the distance the beam is deflected per TCAV phase degree. We are interested in vertical deflection because with the TCAV activated the vertical axis becomes the time axis. While doing this, it is useful to acquire the values of nearby Beam Position Monitors (BPMS) for reasons listed later in this paper. The SLAC LCLS Bunch Length Measurement Calibration Graphical User Interface (GUI) (Figure 1), Developed with Matlab's™ Graphical User Development Environment (GUIDE), allows the user to perform a calibration and shows the results of the last successful calibration.
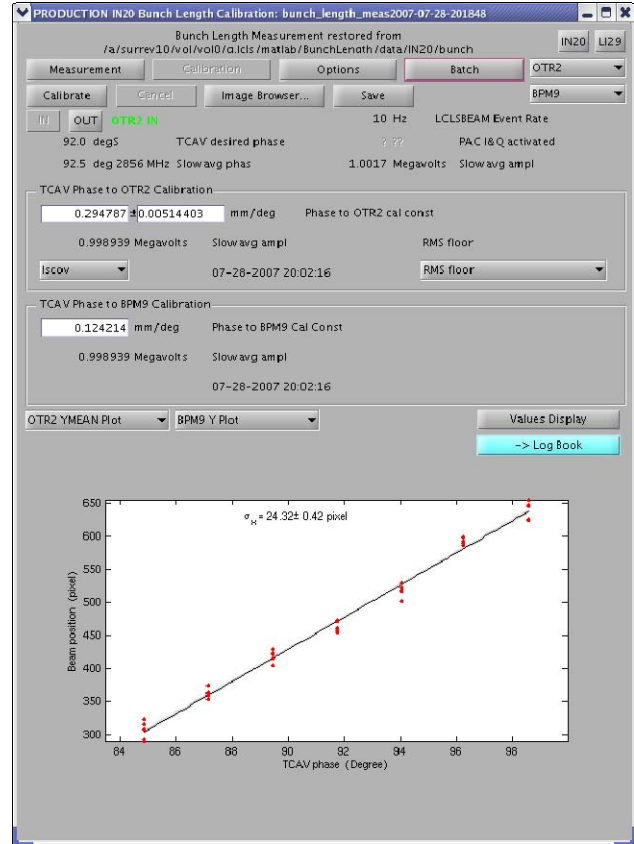

Figure 1: Bunch Length Calibration GUI

The TCAV phase to profile monitor calibration constant is the slope of the line created by the arithmetic mean of the *y* position of the beam on an Optical Transition Radiation (OTR) or Yttrium Aluminum Garnet (YAG) screen for the given TCAV phase as calculated by the Matlab™ *Polyfit* function (see Figure 2). The TCAV phase to BPMS calibration constant is calculated the same way (see Figure 3).
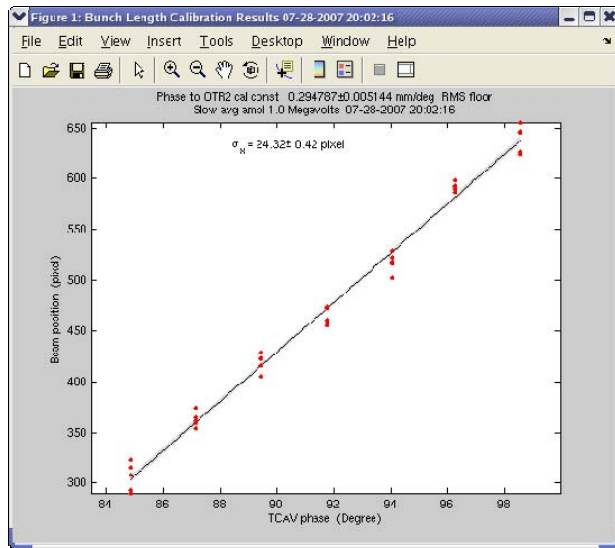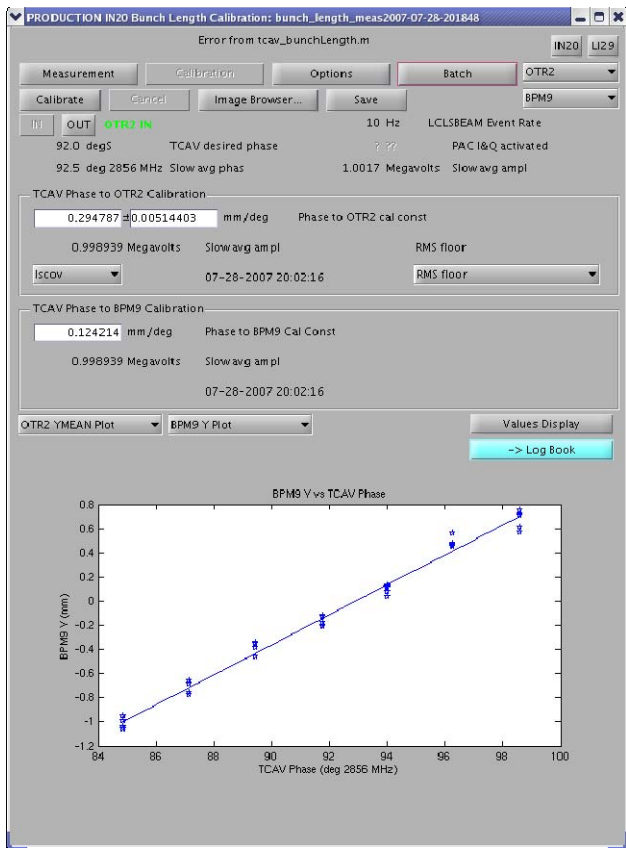
Figure 2: TCAV phase to screen calibration

Figure 3: TCAV phase to BPMS y-position calibration

Options

The Bunch Length Measurement Options GUI (Figure 4) provides a way for the user to select various options related to the TCAV, Toroids, Cameras, and BPMS. More importantly, however, it provides a way for the user to allow automatic detection of the two TCAV phase zero crossings. To calculate the two TCAV phase zero crossings the software starts with the initial provided guess then sends a few pulses down the LINAC while it adjusts the TCAV phase until the selected nearby BPMS

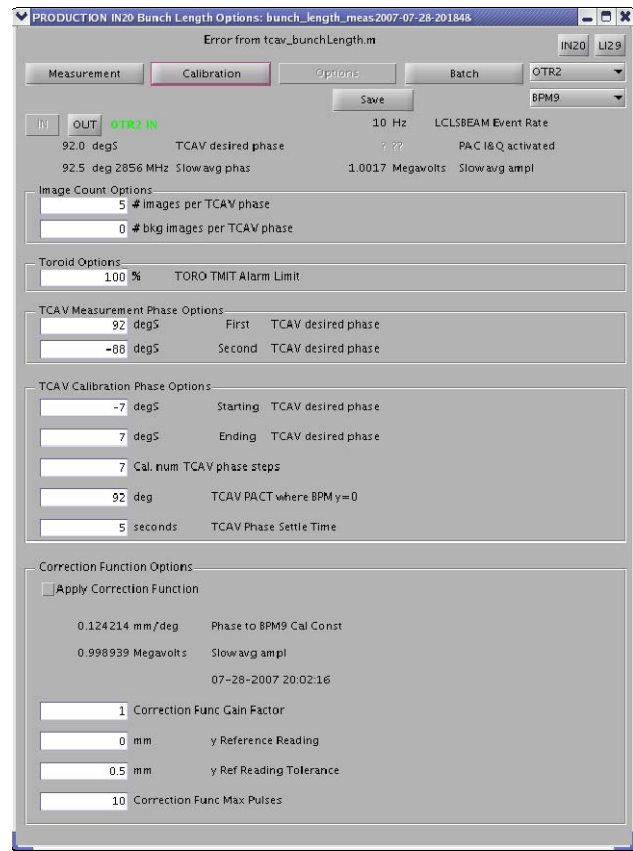y-position reads significantly close to zero as defined by the given options.

Figure 4: Bunch Length Options GUI

Measurement

The Bunch Length Measurement GUI (Figure 5) allows the user to request the measurement. It provides status of the various control devices involved as well as a running status of the current, last successful, or last loaded measurement. A measurement consists of a number of images taken with the TCAV powered off (Figure 6), and with the TCAV powered on (Figure 7) with its phase set to the two zero crossings. The application also provides a way to browse the collected images (Figure 8) in order to remove unneeded or unwanted images. The results (Figure 9) and then recorded in the electronic log. A temporal profile (Figure 10) can also be calculated to compare to the requested laser pulse length [2].

WHY USE MATLAB™?

The physicists at SLAC typically specify their algorithms by providing a Matlab™ script to the Controls Software Engineer. The algorithm is then integrated into the SLAC Control Program (SCP) GUI framework. To do this the engineer will implement the logic in another programming language, FORTRAN, C, or C++. Doing this provides a common look and feel to all of SLAC's physics applications as well as increased speed and efficiency over Matlab™. This framework, however, has aged to the point of needing replacement [3]. A new

physics application framework is being developed using Java and Eclipse technologies [4]. It, however, was not ready to deploy in time to meet schedule demands. The choice to develop several application prototypes in Matlab™, while controversial at times [5], proved effective.
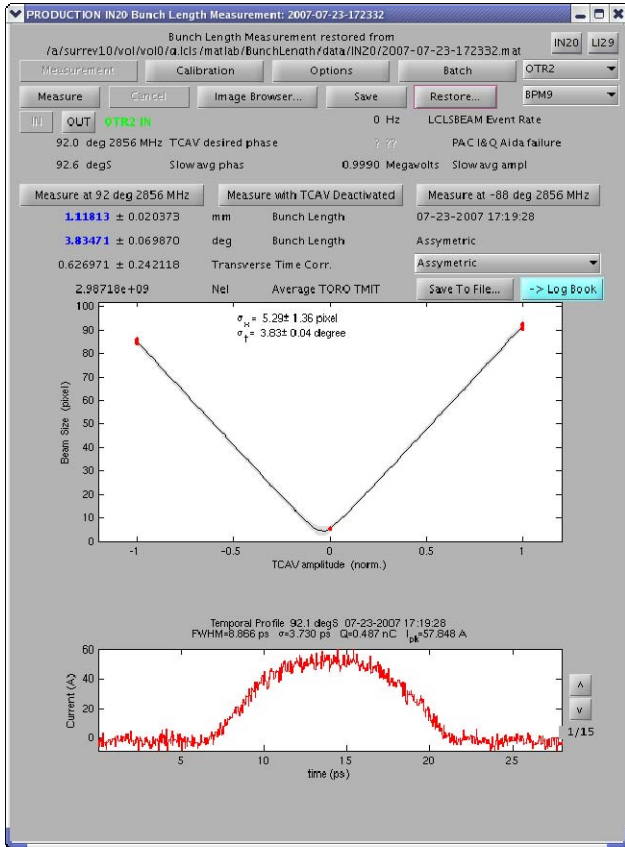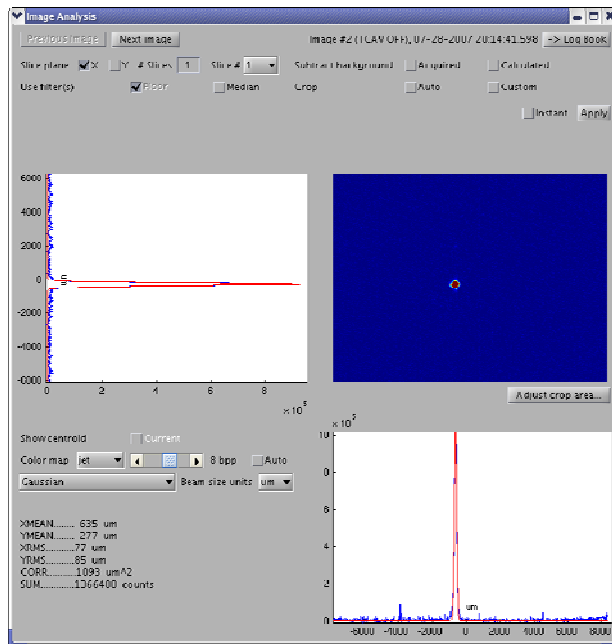

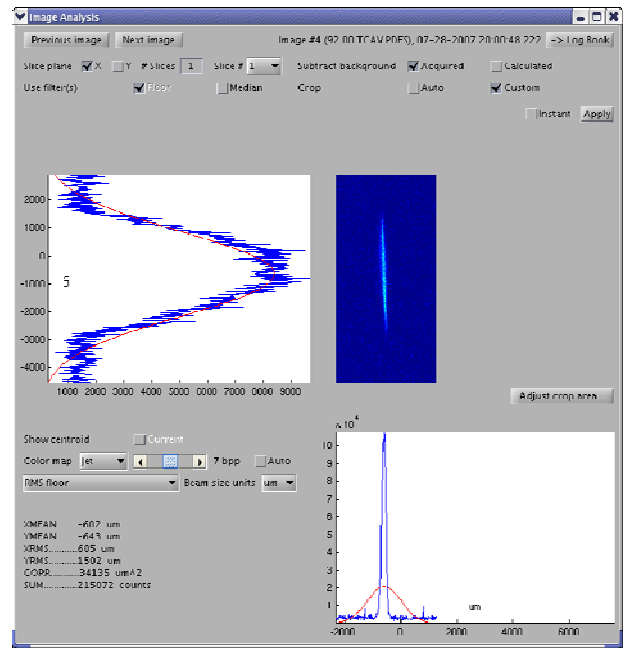Figure 5: Bunch Length Measurement GUI
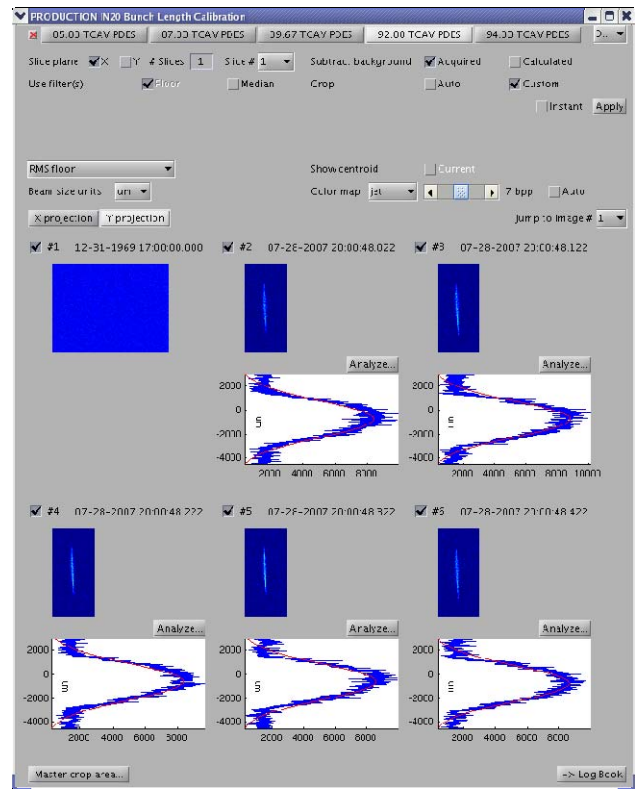

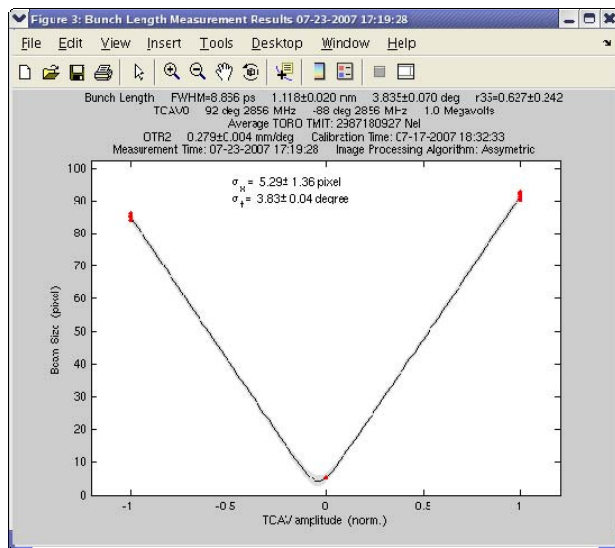Figure 6: TCAV off.

Figure 7: TCAV on.
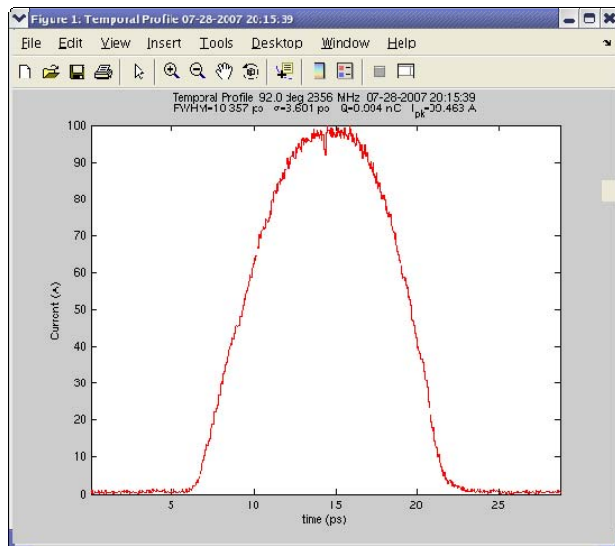

Figure 8: Image Browser

Figure 9: The Bunch Length

Figure 10: Temporal Profile.

REFERENCES

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