

## ELECTRON BUNCH LENGTH MEASUREMENT FOR LCLS AT SLAC\*

M. Zelazny<sup>#</sup>, S. Allison<sup>†</sup>, Sergei Chevtsov<sup>‡</sup>, P. Emma<sup>□</sup>, K. D. Kotturi<sup>°</sup>, H. Loos<sup>△</sup>, S. Peng<sup>×</sup>,  
D. Rogind<sup>⊛</sup>, T. Straumann<sup>◇</sup>, SLAC, Menlo Park, California 94025, U.S.A.

### 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<sup>™</sup> using the EPICS/Channel Access Interface for Scilab<sup>™</sup> and Matlab<sup>™</sup> (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 with respect to 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 perspective.

### 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<sup>™</sup> Graphical User Development Environment (GUIDE), allows the user to perform a calibration and shows the results of the last

\* Work supported by the U.S. Department of Energy under contract number DE-AC02-76SF00515.

<sup>#</sup> zelazny@slac.stanford.edu

<sup>†</sup> saa@slac.stanford.edu

<sup>‡</sup> chevtsov@slac.stanford.edu

<sup>□</sup> emma@slac.stanford.edu

<sup>°</sup> dayle@slac.stanford.edu

<sup>△</sup> loos@slac.stanford.edu

<sup>×</sup> pengs@slac.stanford.edu

<sup>⊛</sup> drogind@slac.stanford.edu

<sup>◇</sup> strauman@slac.stanford.edu

successful calibration.

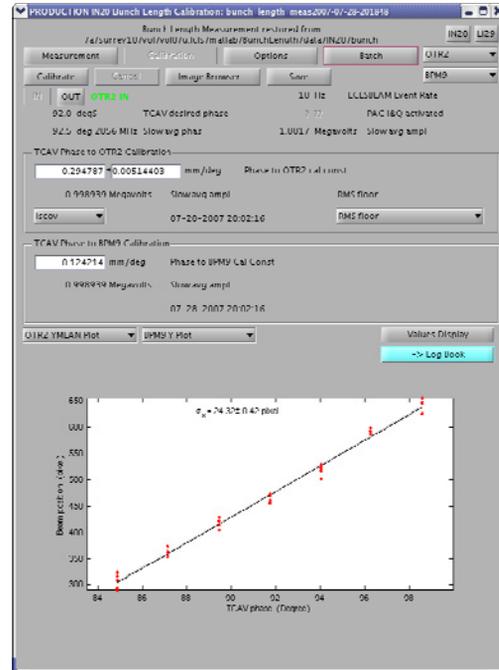


Figure 1: Bunch Length Calibration GUI

The TCAV phase to beam profile monitor calibration constant is the slope of the linear fit of the arithmetic mean of the y offset position of the beam on an Optical Transition Radiation (OTR) or Yttrium Aluminum Garnet (YAG) screen for various TCAV phases as calculated by the Matlab<sup>™</sup> *Polyfit* function (see Figure 2). The TCAV phase to BPMS calibration constant is calculated the same way (see Figure 3).

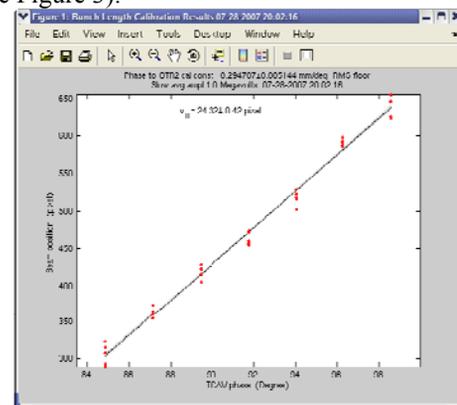


Figure 2: TCAV phase to screen calibration

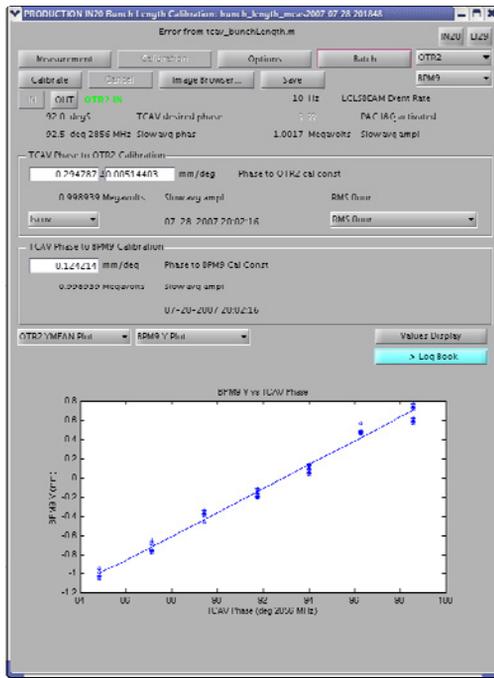


Figure 3: TCAV phase to BPMS y-position calibration

**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 an 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.

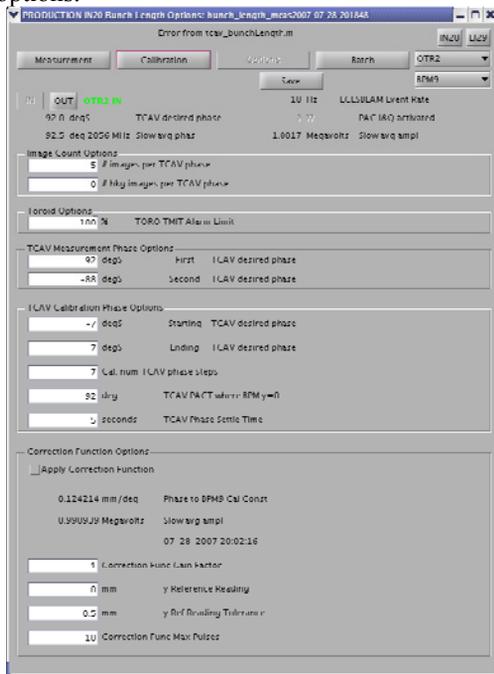


Figure 4: Bunch Length Options GUI

**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 profile images taken with the TCAV powered off (Figure 6), and with the TCAV powered on (Figure 7) with its phase set to the two beam 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) are 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™?**

At times the physicists at SLAC 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, by design, 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.

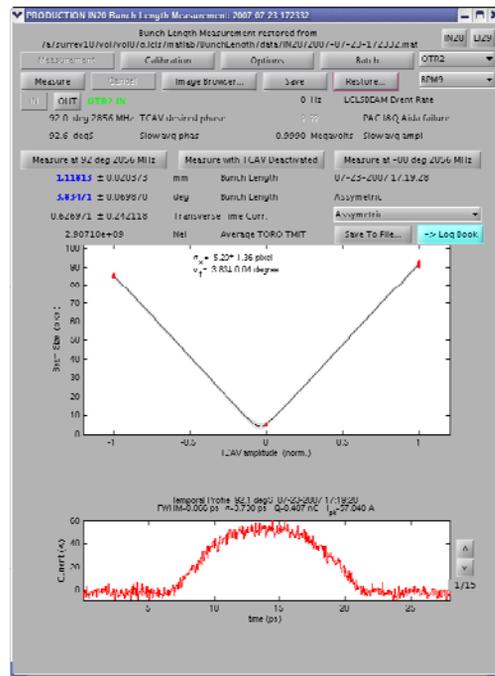


Figure 5: Bunch Length Measurement GUI

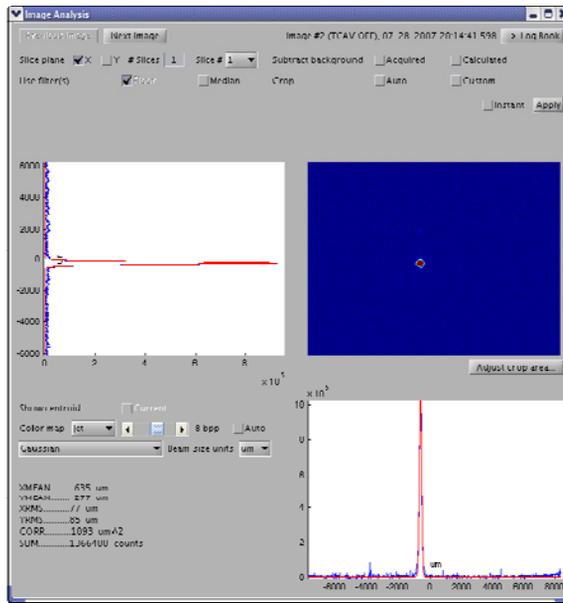


Figure 6: TCAV off.

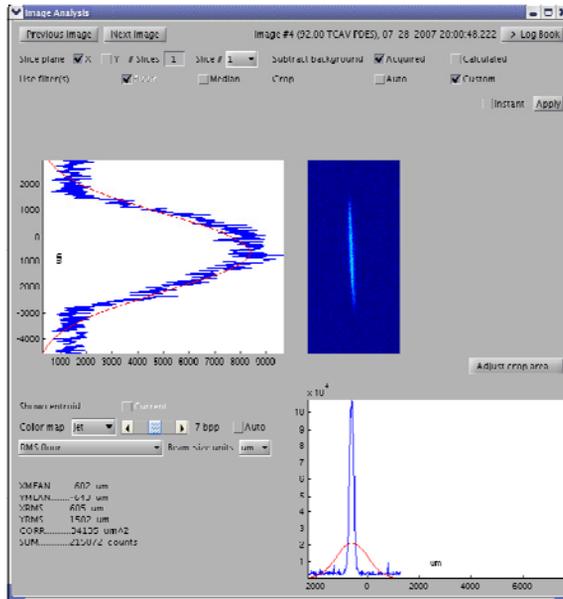


Figure 7: TCAV on.

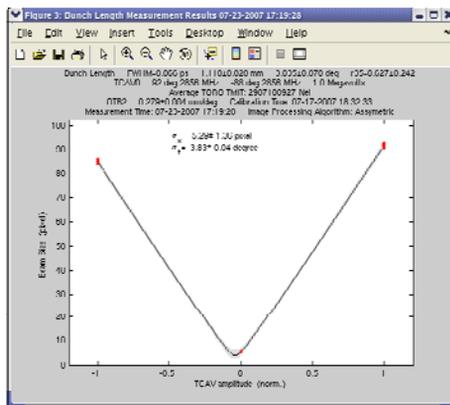


Figure 9: The Bunch Length

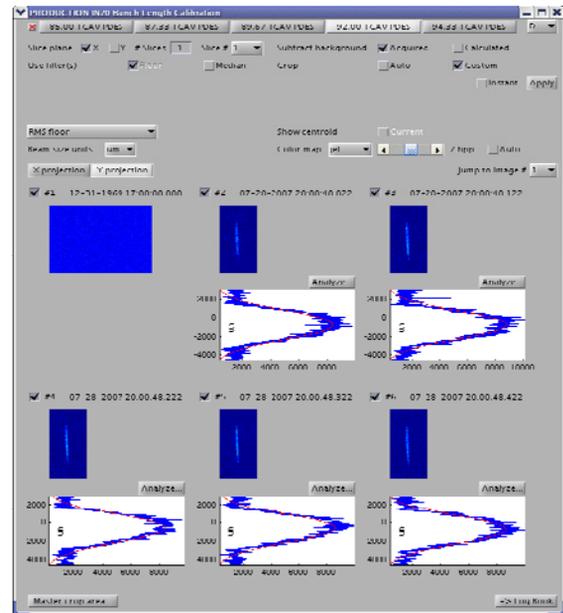


Figure 8: Image Browser

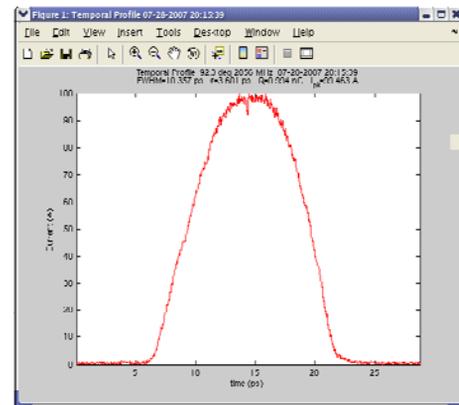


Figure 10: Temporal Profile.

## REFERENCES

- [1] P. Emma *et al*, "Bunch Length Measurements Using Transverse RF Deflecting Structure in the SLAC LINAC," EPAC'02, Paris France, June 2002, p. 1882, <http://accelconf.web.cern.ch/AccelConf/e02/PAPERS/THPRI097.pdf>.
- [2] P. Emma *et al*, "Initial Commissioning Experience With The LCLS Injector," PAC '07, Albuquerque, New Mexico, USA, June 2007, p. 1302, <http://pac07.org/proceedings/PAPERS/TUPMS049.PDF>.
- [3] G. White *et al*, "Operational Tools at the Stanford Linear Accelerator Center," ICALEPCS '07, Knoxville, Tennessee, USA, October 2007.
- [4] Chungming Paul Chu *et al*, "High-level Application Framework for LCLS," ICALEPCS '07, Knoxville, Tennessee, USA, October 2007.
- [5] S. Chevtsov *et al*, "Scripting vs Programming: An Application Developer's Perspective," ICALEPCS '07, Knoxville, Tennessee, USA, October 2007.