Design and Commissioning Results of MicroTCA Stripline BPM System

SLAC NATIONAL ACCELERATOR LABORATORY

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Abstract

The Linac Coherent Light Source (LCLS) is a free electron laser (FEL) facility operating at the SLAC National Accelerator Laboratory (SLAC). A stripline beam position monitor (BPM) system was developed at SLAC to meet the performance requirements necessary to provide high-quality stable beams for LCLS. This design has been modified to achieve improved position resolution in a more compact form factor. Prototype installations of this system have been operating in the LCLS LINAC and tested at the Pohang Accelerator Laboratory (PAL). Production systems are deployed at the new PAL XFEL facility and at the SPEAR storage ring at the Stanford Synchrotron Radiation Lightsource at SLAC. This poster presents the design and commissioning results of this system.

System Overview

•Stripline BPM system to measure transverse position of electron bunches
•MicroTCA crate architecture
•SLAC-built Analog Front End module to condition raw signals
•Struck SIS8300 ADC to digitize BPM signals
•Data transferred to CPU via PCIe backplane
•Real-time Linux operating system
•EPICS high-level software
•MicroResearch Finland PMC EVR to receive timing data and trigger data acquisition
•Online calibration system
•120 Hz beam rate
•Bunch charge from 10 pC to 1 nC
•Beam position resolution improved by factor of two from previous system

BPM system block diagram
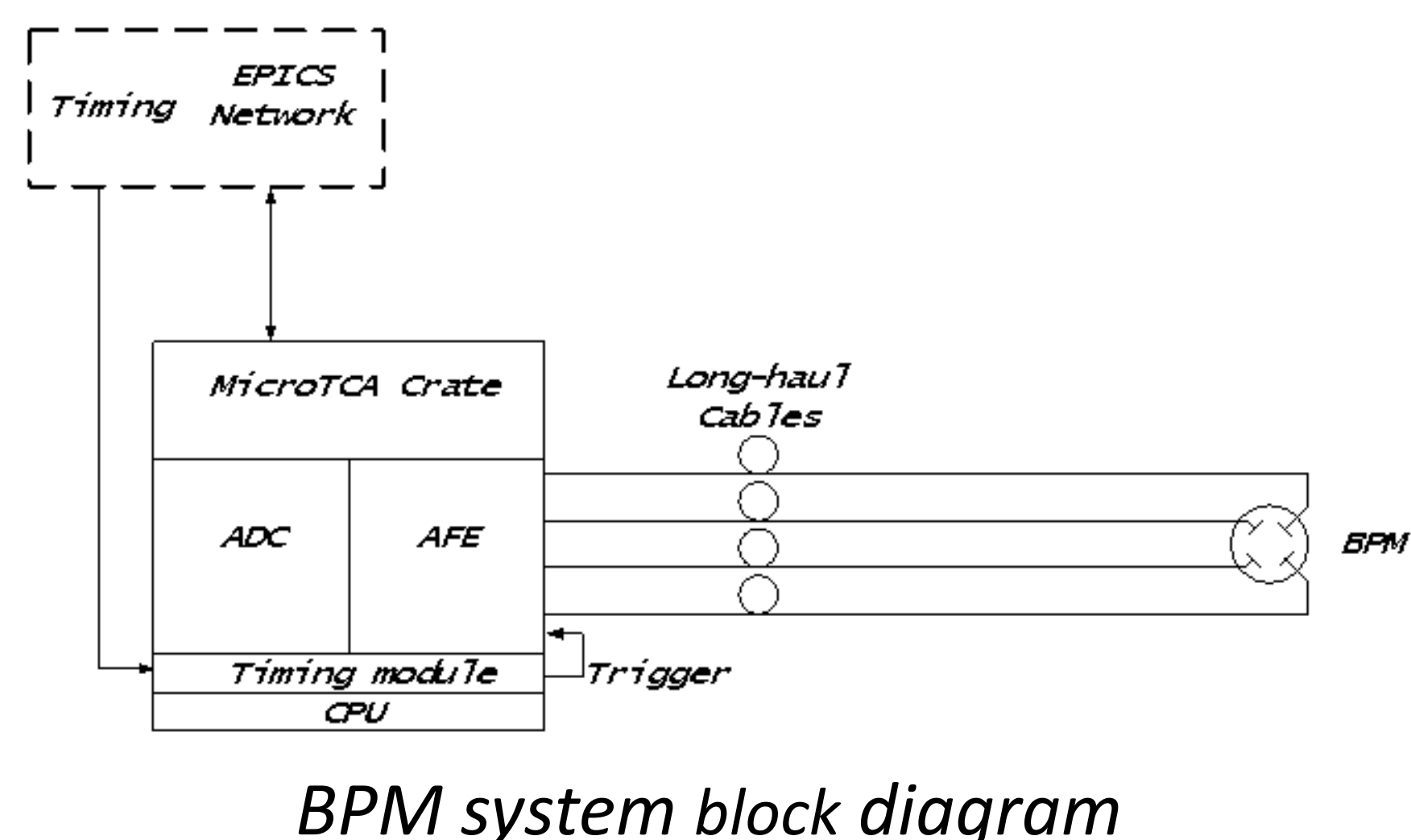
Example crate with four BPMs

System Design

Analog Front End

•Analog Front End reduces signal bandwidth and sets the signal level before digitization
•Low loss in cables and first AFE stage is important for good resolution at low bunch charge
•Two stages of amplification and attenuation
•Attenuators can be adjusted from control system to maintain reasonable signal level
•Bandpass filters select processing frequency of 300 MHz and bandwidth of 30 MHz
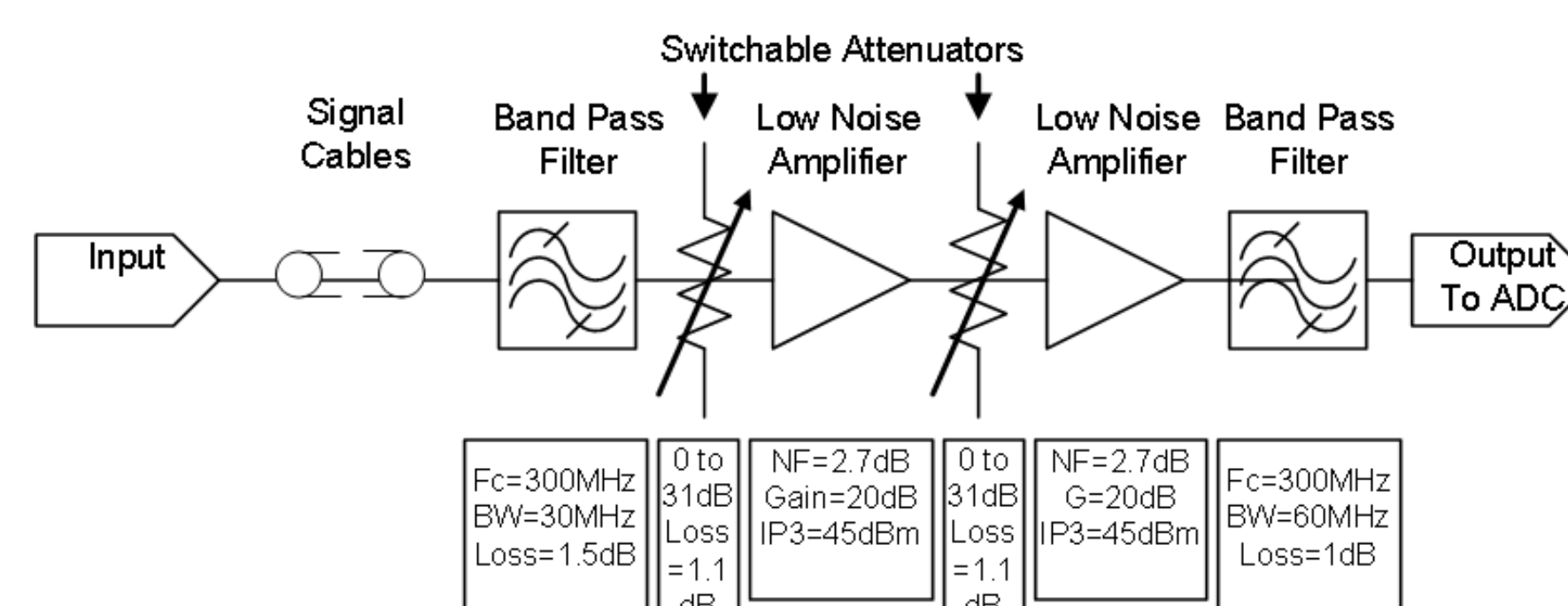

Analog Front End block diagram

Calibration

•On-line calibration scheme to compensate for thermal drift and gain variation among channels
•Calibration cycles performed between beam pulses
•300 MHz test tone injected into stripline; coupled response is measured from adjacent striplines
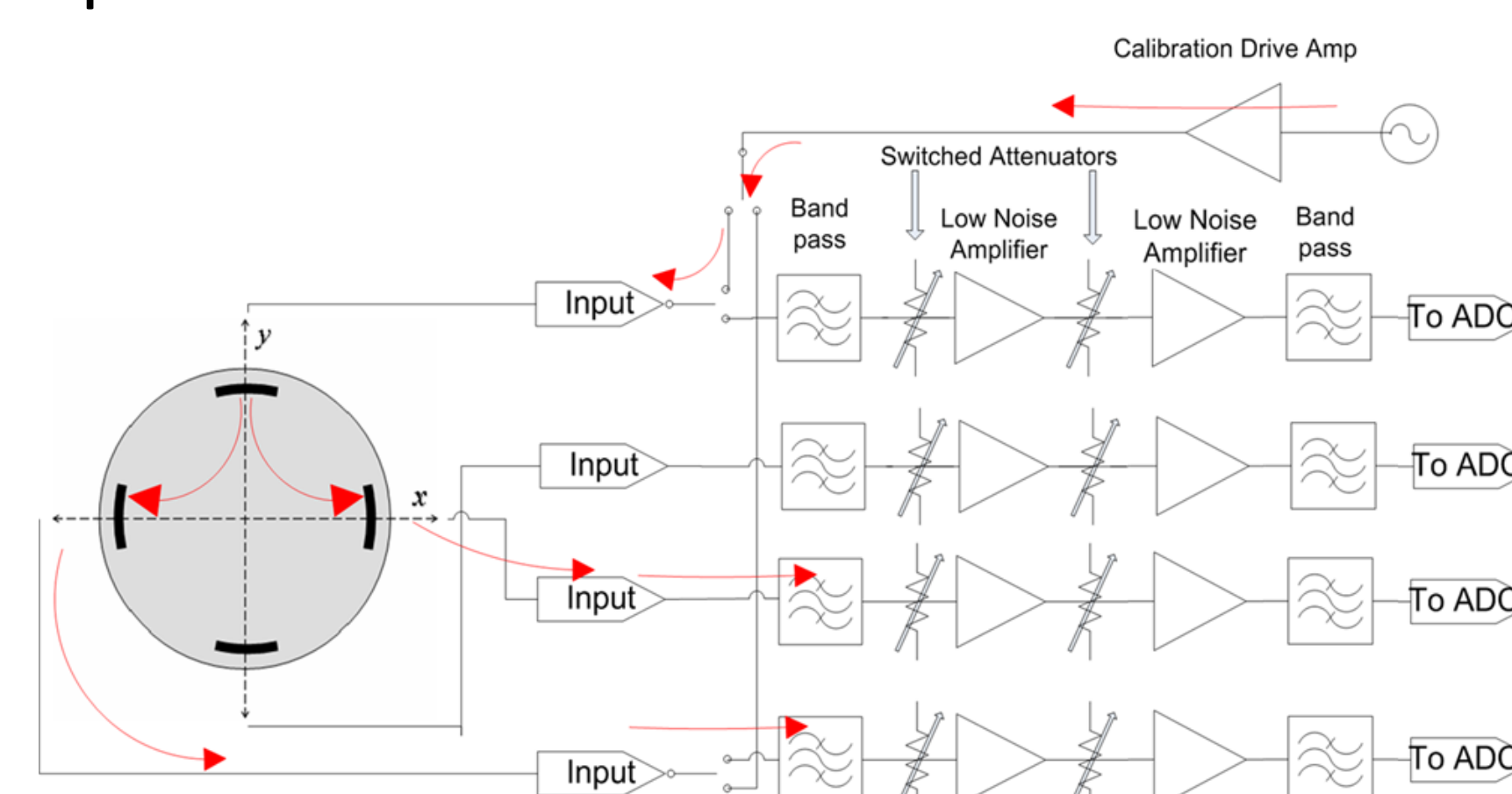

Calibration Scheme

Digitizer

•Digitizer must provide sufficient effective number of bits and signal-to-noise ratio
•Digitization rate is selected to center the signal in the Nyquist zone
•300 MHz BPM signal undersampled at 250 MSPS


Sampling frequency
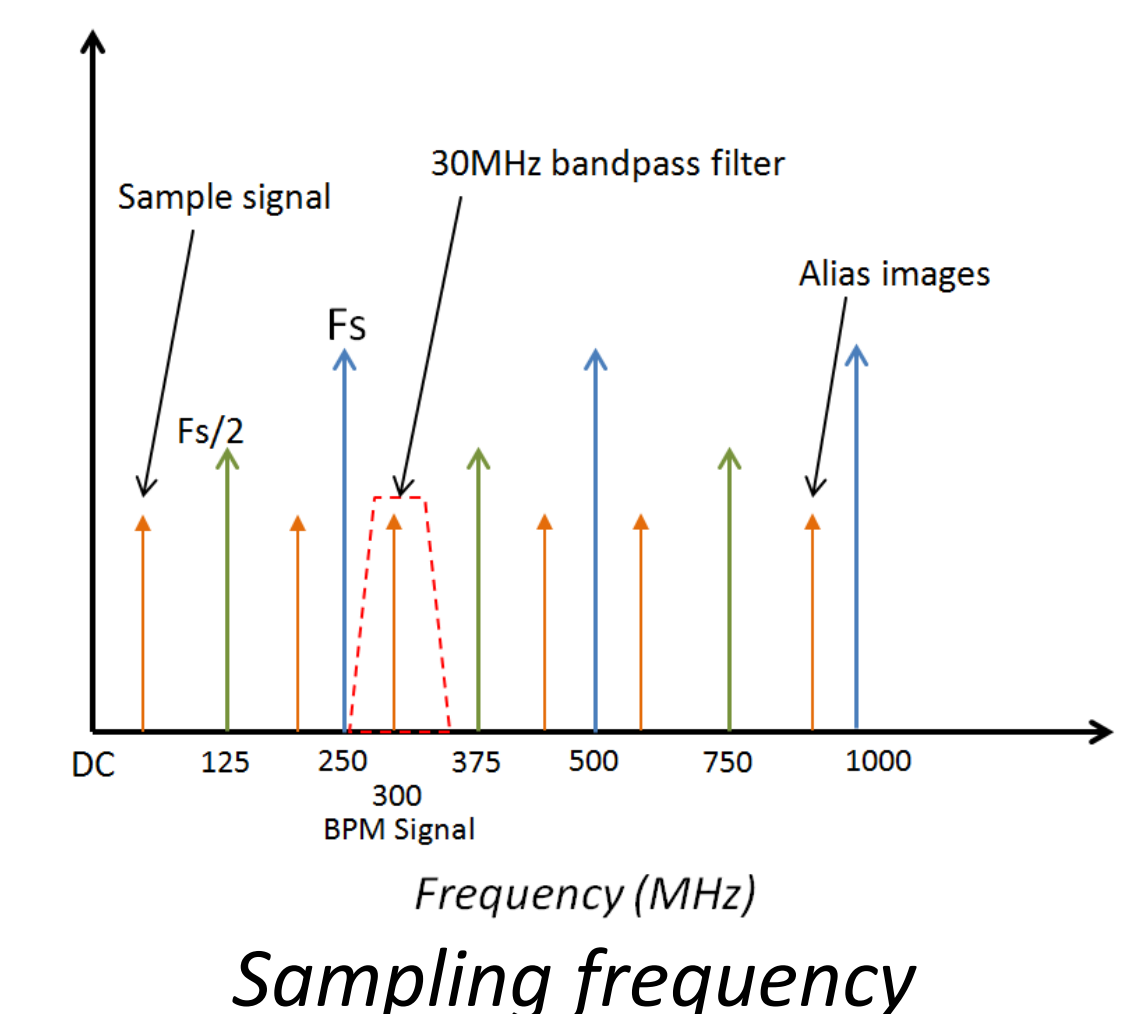
Data Acquisition and Processing

•Embedded Linux with real-time patch
•Integrated into existing BPM application
•Event-driven processing, external trigger initiates data acquisition
•DMA engine used to transfer data to CPU

BPM software architecture
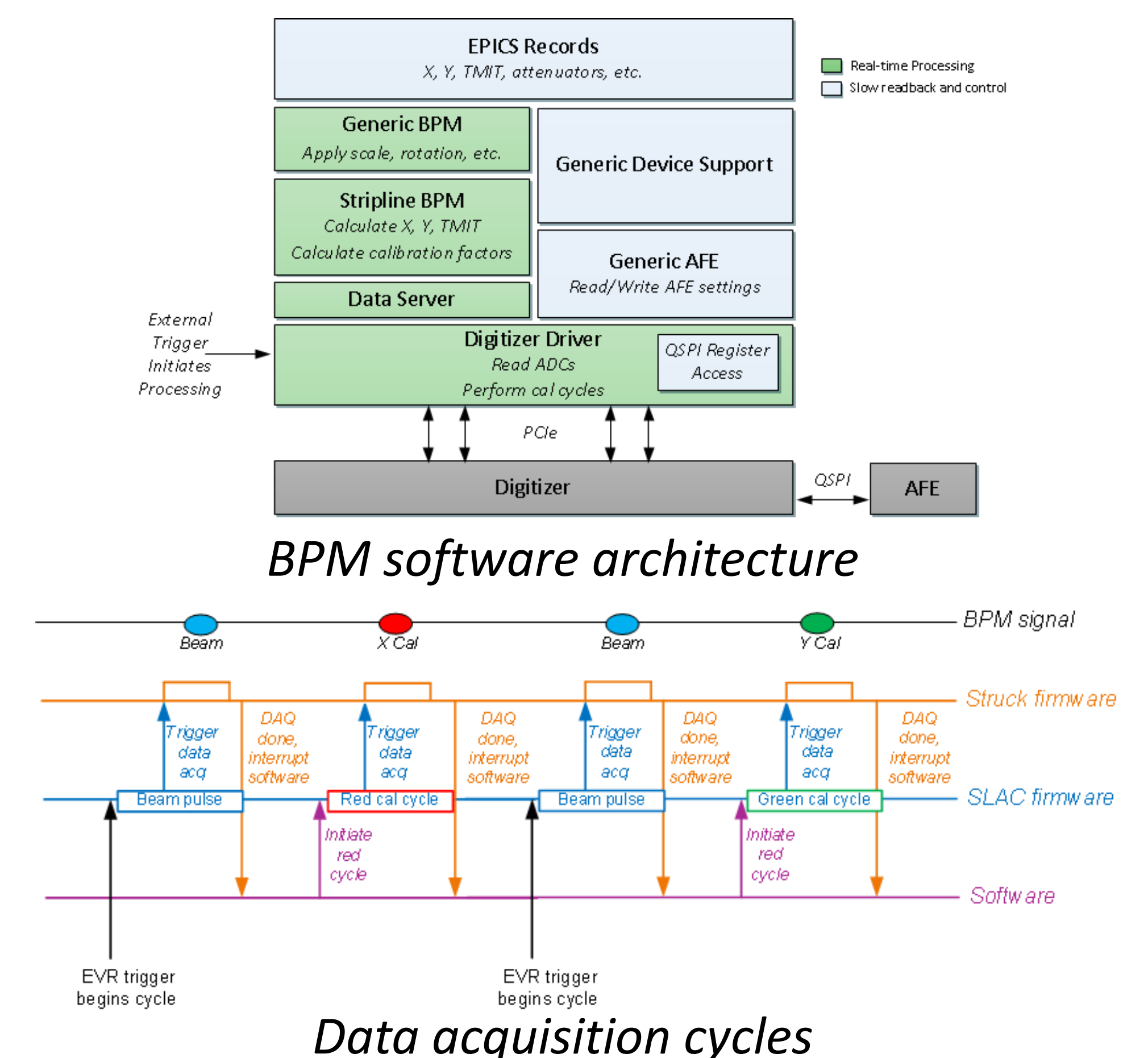
Data acquisition cycles

Initial Results and Future Use

•LCLS Linac BPMs: position resolution measurements; two red data points on right are prototypes

20 pC bunch charge

160 pC bunch charge
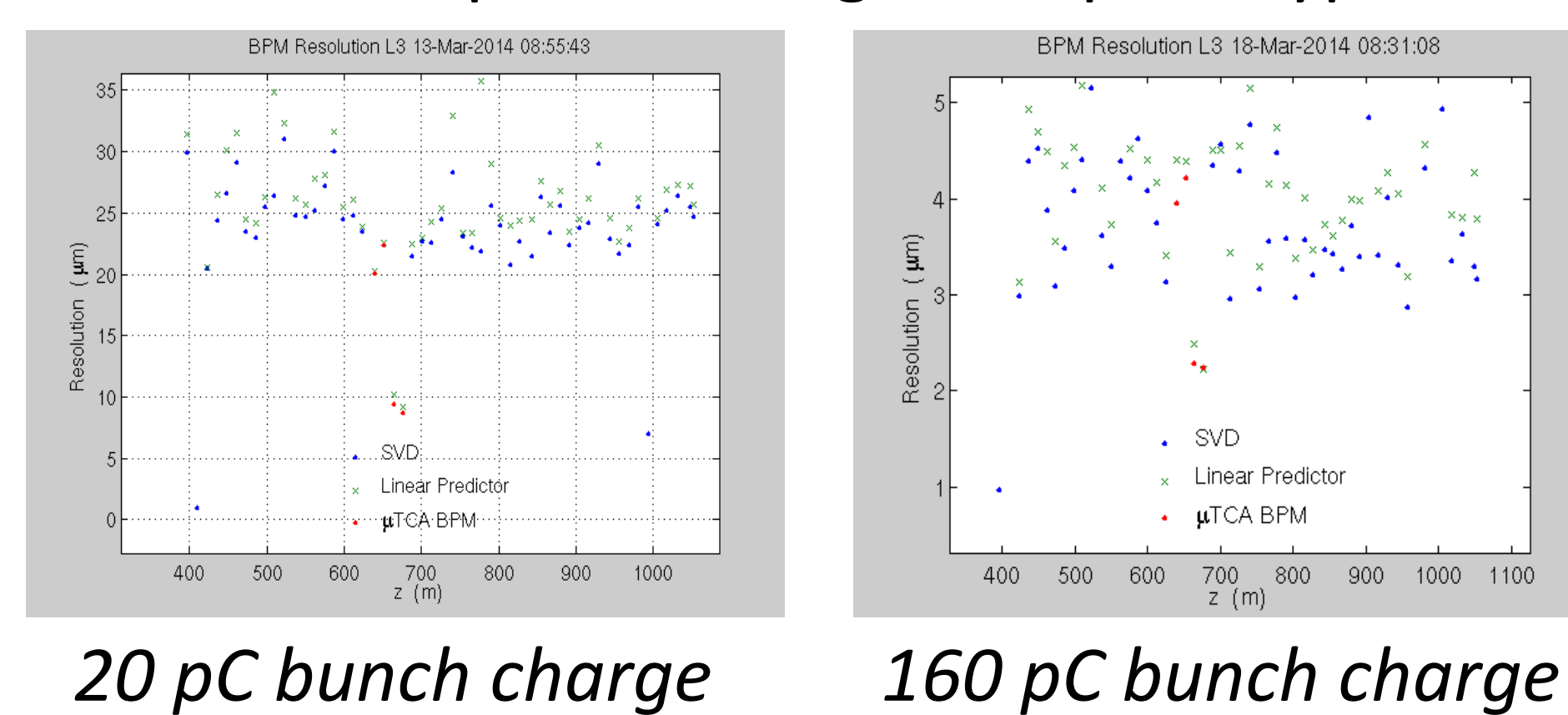
•PAL test facility BPMs: measured versus actual position (using movers); measured position should be linear within +/- 1 mm from BPM center in X and Y transverse planes
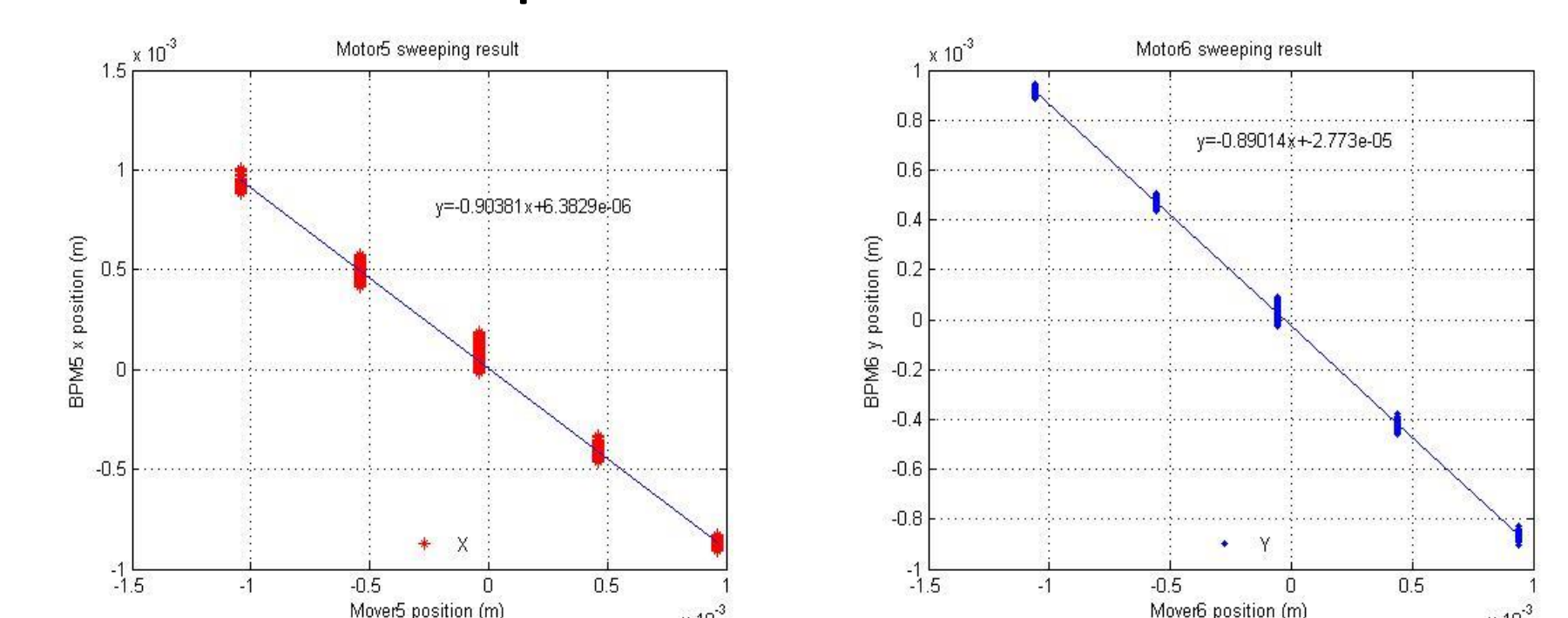
The PAL XFEL facility will use this system for its 144 Stripline BPMs. This system will be commissioned with beam in early 2016.
SPEAR is currently using two of these BPMs in its transport line and plans to install more in early 2016.