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## Beam Synchronized Acquisition and enhancements to associated services

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The Linac Coherent Light Source (LCLS) has developed a pulse-by-pulse data acquisition system, Beam-Synchronized Acquisition (BSA). BSA evolved from a 360 Hz software-based system to a 1 MHz firmware-based architecture tightly integrated with the LCLS timing system and beam rate.

Alongside this transition, the EPICS control platform evolved from Channel Access (CA) to PV Access (PVA), enabling BSA to meet modern acquisition requirements—particularly for high-rate, high-volume applications requiring timestamping, pulse ID tagging, and precise cross-system alignment across the facility.

BSA includes a fault buffer mechanism for each monitored variable, with four rotating buffers per variable, each capable of storing one million samples. One buffer collects data continuously at beam rate (1 MHz) in a ring configuration, while the others remain on standby. When the Machine Protection System (MPS) detects a fault, the active buffer is instantly frozen and a standby buffer takes over, preserving a one-second snapshot of data. This snapshot is synchronized across the facility and available for all BSA variables system-wide.

This paper presents the architecture, firmware and software components, and supporting services developed to meet the demanding requirements of SC operation, enabling machine learning and real-time feedback capabilities.

### Footnotes

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**Author:** KIM, Kukhee (SLAC National Accelerator Laboratory)

**Co-authors:** Mr WILLIAMS JR., Ernest L. (SLAC National Accelerator Laboratory); Dr DONADIO, Marcio P. (SLAC National Accelerator Laboratory); WEAVER, Matthew (SLAC National Accelerator Laboratory)

**Presenter:** KIM, Kukhee (SLAC National Accelerator Laboratory)

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