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EPICS IOC Control of Timepix3 Detector System: Emulator, Serval, Detector Driver, and systemd Integration

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Abstract
In this presentation, we will describe the design, implementation, and integration of a modular EPICS-based control architecture for the Timepix3 detector ecosystem deployed at ORNL neutron and X-ray facilities. Our control framework leverages multiple interlinked components:
1. ADTimePix3 Detector Driver: Built upon the EPICS areaDetector framework, the ADTimePix3 driver offers production-ready capabilities including real-time data acquisition, health monitoring, threshold tuning, preview imaging, and multi-stream support via socket and .tpx3 file outputs GitHubAreaDetectorOak Ridge National Laboratory. It enables the sparse, triggerless readout of the 65k-pixel Timepix3 chip, achieving up to 40 MHits/s/cm² with simultaneous ToA and ToT recording Oak Ridge National Laboratory.
2. Serval and Emulator IOCs: Control of the Timepix3 detector is centralized through the Serval HTTP/JSON-based server, which interfaces with the detector hardware. An emulator (emulator IOC) replicates Serval functionality for offline testing, development, and IOC validation. This allows seamless simulation of device behavior without physical hardware.
3. EPICS IOC Control of systemd Processes: To enhance robustness and integration, EPICS IOCs manage essential background services (e.g. Serval, emulator) using systemd via a custom IOC layer (systemdIOC). This enables EPICS to monitor, start, stop, and supervise service lifecycles such as D-Bus, ensuring reliable orchestration of system components.
4. Integrated Workflow and Use Cases: During IOC startup, Serval is launched via systemd and then configured by the ADTimePix3 IOC (with IP tunneling, .tpx3 output paths, thresholds, calibration uploads). The emulator IOC mimics Serval behavior for testing. Users interact with the system through CSS-Boy or Phoebus GUIs, adjusting chip thresholds, loading calibration files, viewing preview images, and monitoring detector metrics JACoWAreaDetector.
5. Benefits & Outcomes:
◦ Enables continuous detector operation with real-time previews and high-throughput data capture.
◦ Improves testability and IOC development by decoupling hardware access through the emulator.
◦ Enhances system reliability and maintainability by managing background services from EPICS, improving startup resilience and operational diagnostics.
In summary, this layered EPICS IOC architecture—encompassing hardware abstraction via emulator, detector acquisition via ADTimePix3, and service control via systemd—supports flexible deployment, testing, and stable operations of Timepix3-based experiments. We believe this modular approach can serve as a blueprint for integrating complex detector systems into EPICS control environments.

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