# UPGRADE FROM ADCS WITH CENTRALLY SCHEDULED TRIGGERS TO CONTINUALLY TRIGGERED WAVEFORM DIGITIZERS

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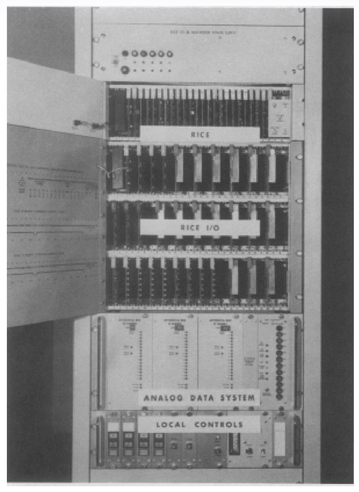
The Los Alamos Neutron Science Center (LANSCE) control system includes many data channels that are timed and flavored, i.e., users can specify the species of beam and time within the beam pulse at which data are reported. The legacy LANSCE control system accomplished this task by queuing up application software-initiated requests and scheduling Analog to Digital Converter (ADC) readout with custom programmable time-delay gated and multiplexed Remote Information and Control Equipment (RICE). This year we upgraded this system to a new Experimental Physics and Industrial Control System (EPICS) system that includes signal dedicated waveform digitizer. An appropriate subset of the data is then returned as specified by each client. This is made possible by improvements to EPICS software, a Commercial Off-The-Shelf (COTS) Field Programmable Gate Array (FPGA) Mezzanine Card (FMC) based ADC and a COTS VPX FPGA card with EPICS embedded on a soft-core processor. This year we upgraded over 1200 waveform channels from RICE to the new TDAQ (Timed/flavored Data Acquisition) system.

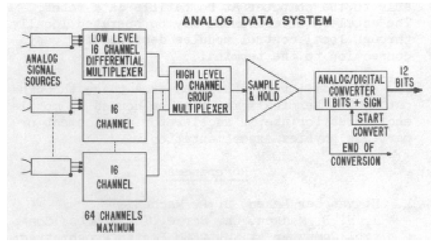



RICE module

Legacy RICE

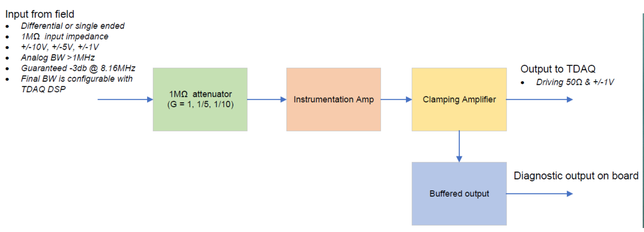
Software-initiated reads

Remote data acquisition with multiplexers connected to a central microVax computer

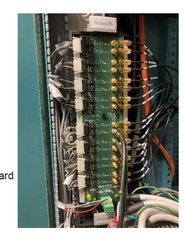



RICE Analog data acquisition

## Analog Signal Conditioning




TAFI (signal conditioning board) functions

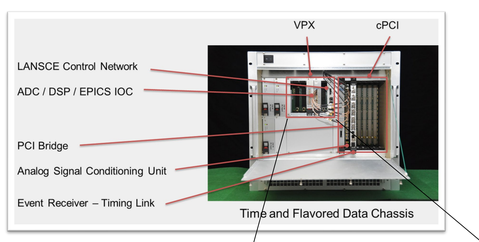


TAFI

Hardware collects waveforms from every input on every beam cycle

125 MHz 14-bit 16-channel FMC ADC connected to a BittWare VPX card with a Stratix IV FPGA produces 976 kHz data rate. Stratix III FPGA provides independent reset.

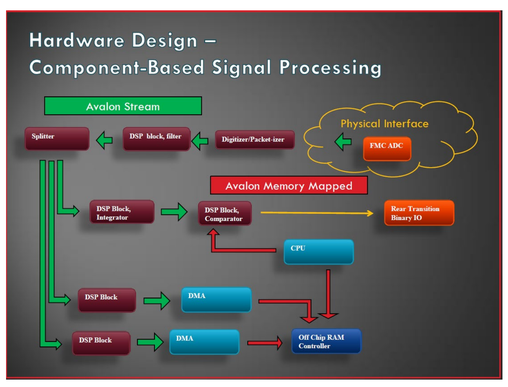
## Independent data acquisition in VPX/cPCI crates




Hybrid VPX/cPCI crate

VPX with 3 TDAQs

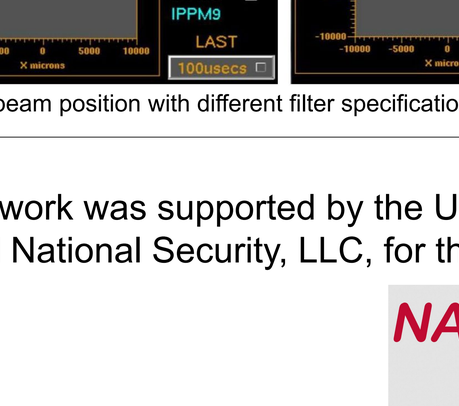
VPX allows multiple Input Output controller cards in a single crate with high-speed data acquisition cards.
cPCI allows Event Receivers with many gate outputs, and inexpensive signal conditioning cards.



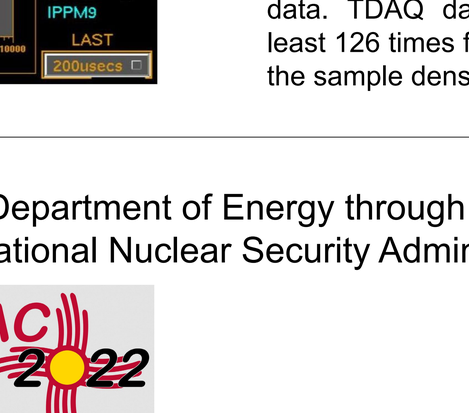

TDAQ functions

The same architecture is used for both TDAQ and Beam Position and Phase Monitor (BPPM) cards.

EPICS IOC running on NIOS-II soft-core processor



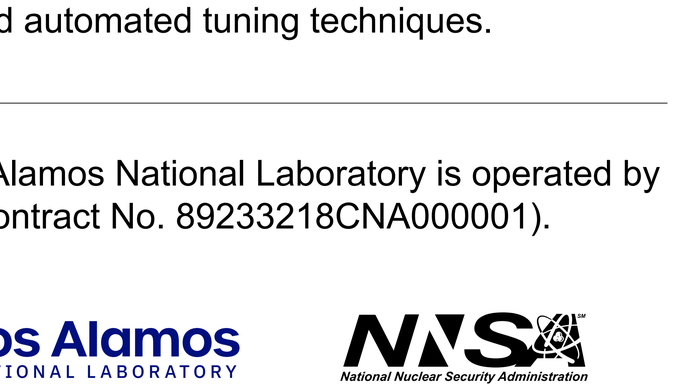

TDAQ system diagram




VPX Crate functions

Timing information and triggers are received from a cPCI Micro Research Finland Event Receiver. The root-port TDAQ card distributes timing information to all PCIe cards via the PCIe bus. The EPICS event-queues hold C++ smart pointers to containers with both data and timing information.

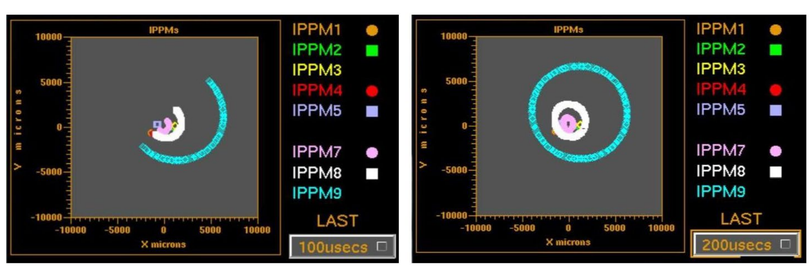
## Design – EPICS Enhancements Server Event Queue - Upgrade




Improved EPICS event queue

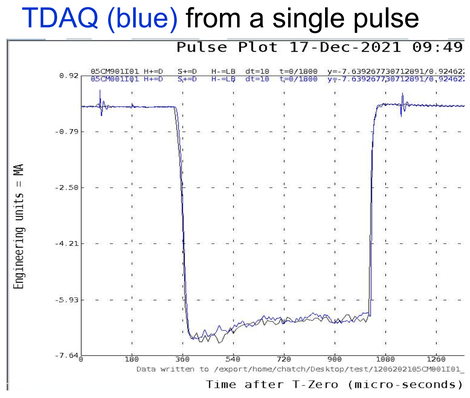
## Timed/Flavored Data

New EPICS filtering feature allows clients to specify time range and flavor of beam that is of interest. EPICS WaveformX records support containers that include both the data and timing information. Timing information is obtained via a timing-system-synchronized fiber link at 120 Hz. Each system runs the same decimation algorithm, so that data from independent systems can be correlated by client software.




Rastered beam position with different filter specifications

RICE (black) from multiple pulses
TDAQ (blue) from a single pulse




RICE and TDAQ data comparison

Data from RICE sampled every 10 microseconds (with data collection separated by at least 8.3 ms) compares well with 976 kHz TDAQ data. TDAQ data is collected at least 126 times faster with 10 times the sample density.

The RICE timed/flavored data features were successfully upgraded to an EPICS based system. The new system is more flexible with improved multi-element capture, precision and bandwidth, as well as the ability to implement arbitrary Lua language expression subscription update filters as desired when clients connect. Vector data is significantly more flexible as the RICE system required vector channels to use the same physical input on all modules. The new system can correlate a set of signals, and all inputs are sampled simultaneously. Additionally, waveform data can be requested allowing for measurements of beam from the start of the pulse to the end of the pulse from a signal cycle, in contrast to the legacy RICE pseudo waveforms assembled using time samples from different beam pulses. The more consistent and rapid data collection latency may improve the feasibility of algorithm-based optimization and automated tuning techniques.

This work was supported by the U.S. Department of Energy through the Los Alamos National Laboratory. Los Alamos National Laboratory is operated by Triad National Security, LLC, for the National Nuclear Security Administration of U.S. Department of Energy (Contract No. 89233218CNA000001).

LA-UR-22-28186