Analysis and design of HW/SW electronic systems for Mu2e data acquisition

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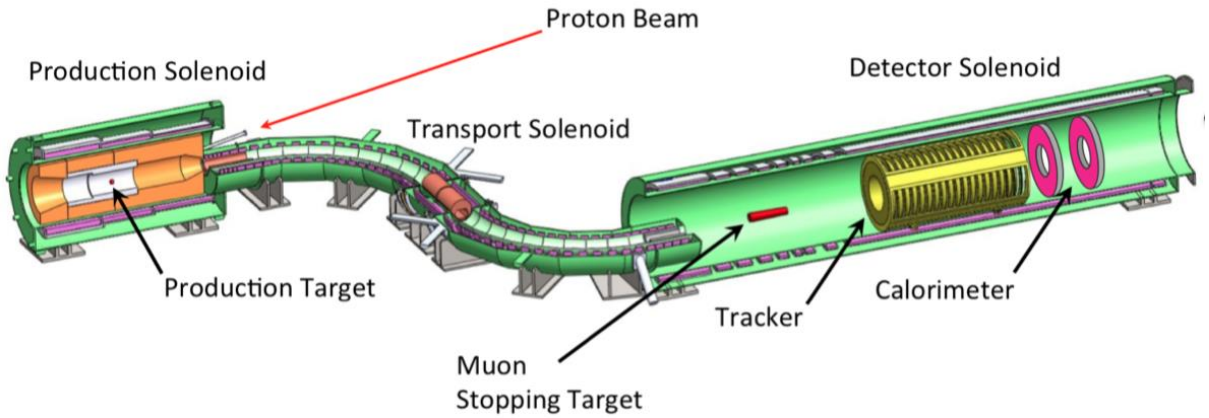
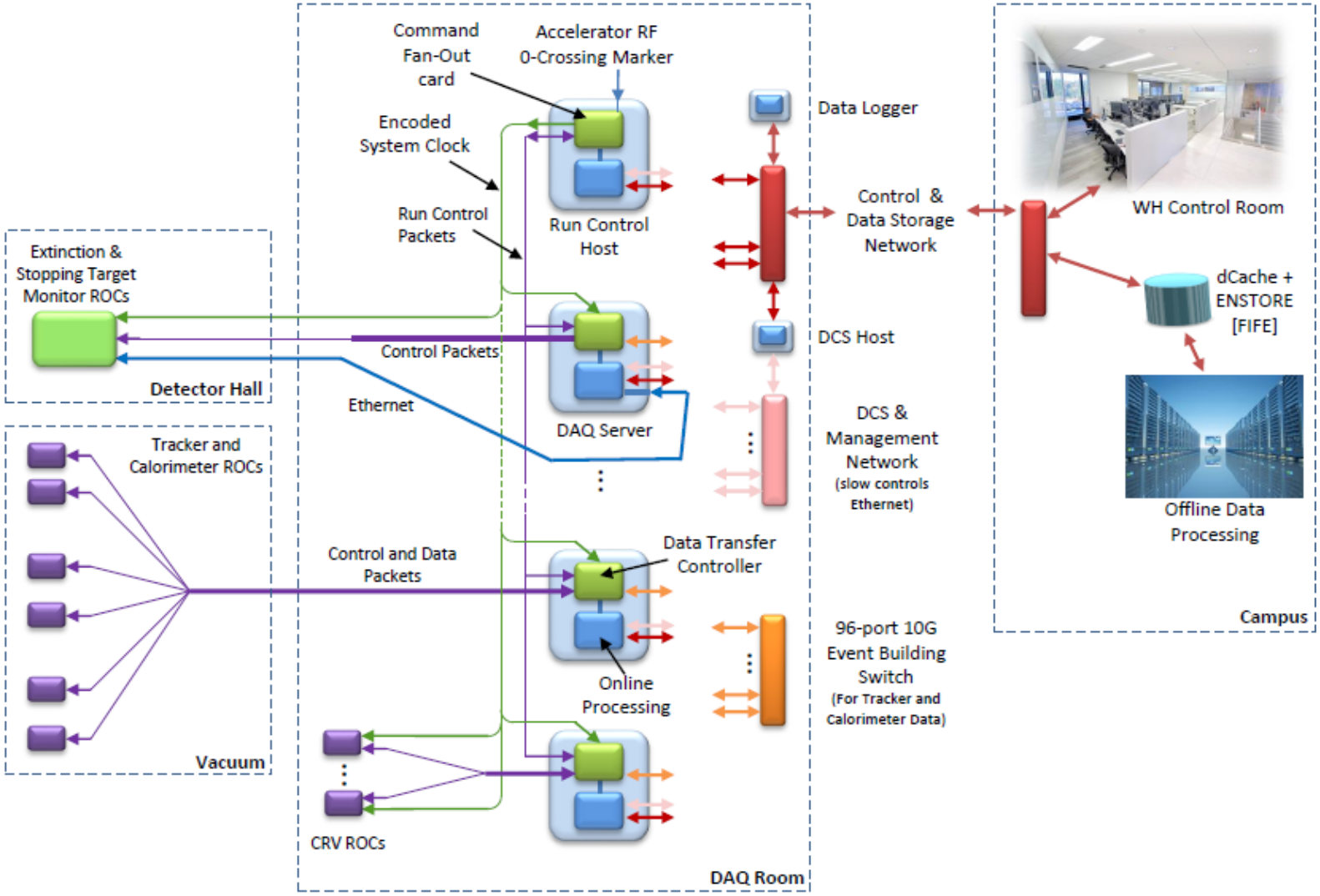
Mu2e – explained by an engineer



Mu2e has been designed and is currently being constructed at Fermilab to search for the neutrino-less muon conversion to an electron in the field of an aluminum nucleus

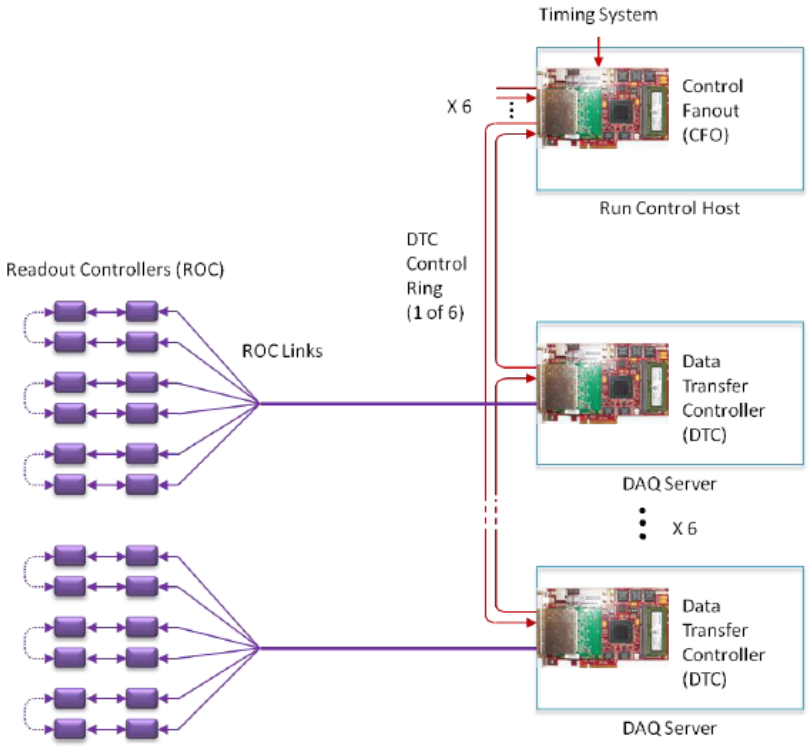
TDAQ – Trigger and Data Acquisition



Fermilab

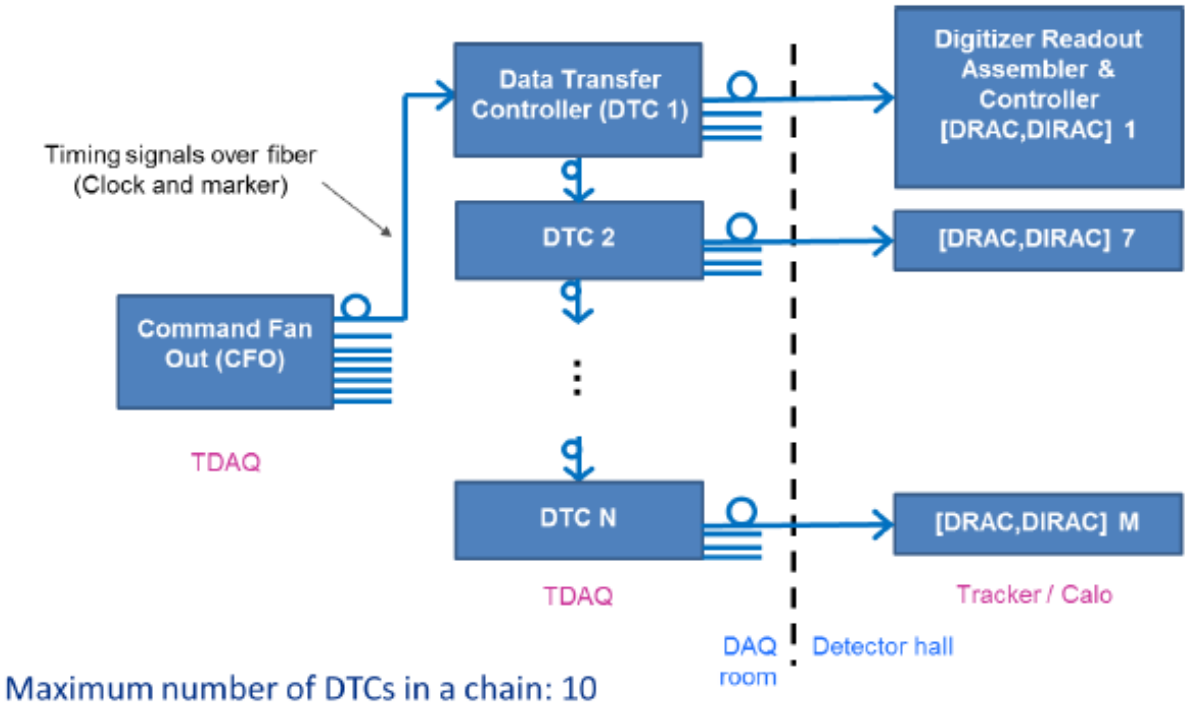
TDAQ – DTCs

- The Data Transfer Controller (DTC) collects data from multiple detector Readout Controllers.
- The DTC is implemented using a commercial PCIe card located in the DAQ Server.
- There are a total of 36 DAQ servers, occupying four racks in the electronics room.



TDAQ – Clock distribution

- The Command Fan Out (CFO) is the 40 MHz single clock source and fans out clock to N Data Transfer Control (DTC) units
- Transmission to the front-end ROCs will be done using optical fiber employing clock-encoded data at 4.0 Gbps
- ROCs will extract a 200MHz clock from the clock-encoded data bitstream, which will be used by the ROCs as Reference Clock for timestaping data



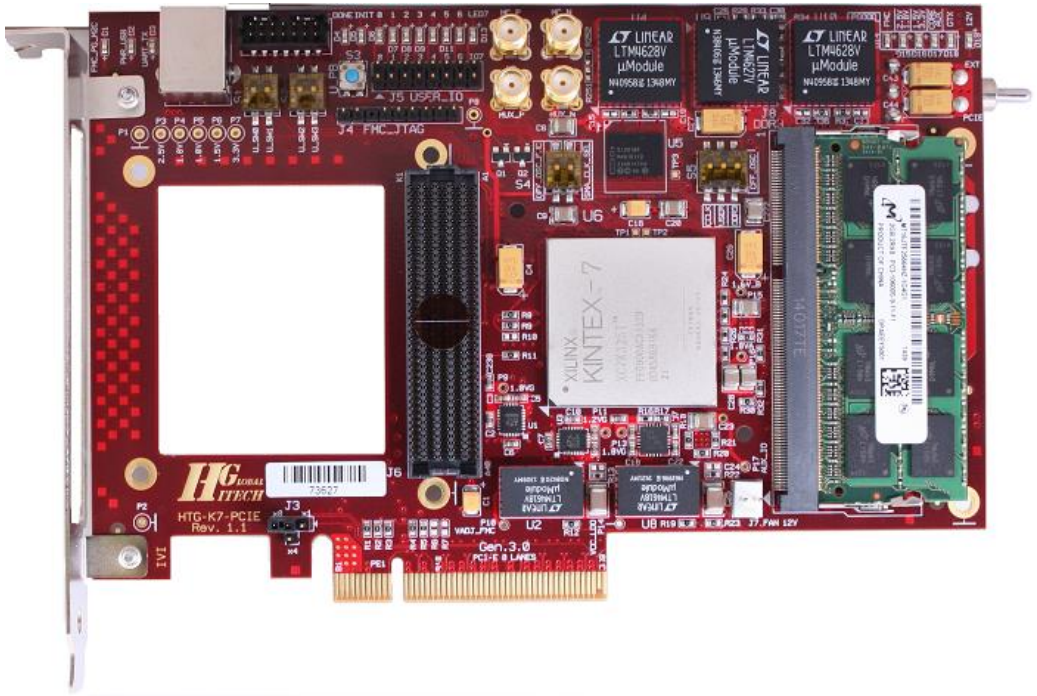
DTC loss of lock

There are troubles in the synchronization of the calorimeter DTCs chain:

- Along the distribution loop the DTCs were accumulating too much jitter so the signal back to the CFO was not in phase
  - An RTF has been added to have parallel distribution of the clock to the DTCs
- The DTCs can’t lock on the clock signal
  - Updating the firmware of the RTF and DTCs to improve the clock signal quality.

We reached a semi-stable configuration that managed to keep the DTCs locked for five days

DTC loss of lock – Measuring Jitter

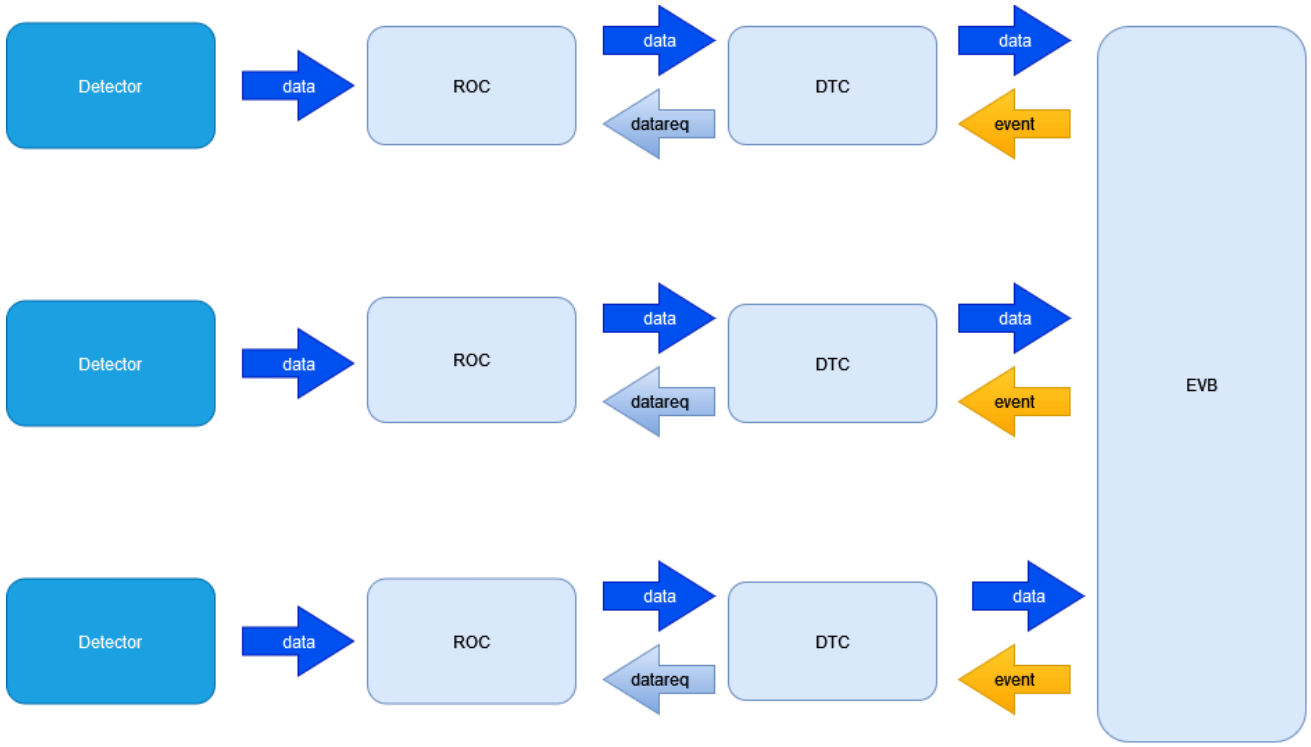


The next step is to measure the jitter on the clock for the 10 DTCs chain, using an oscilloscope:

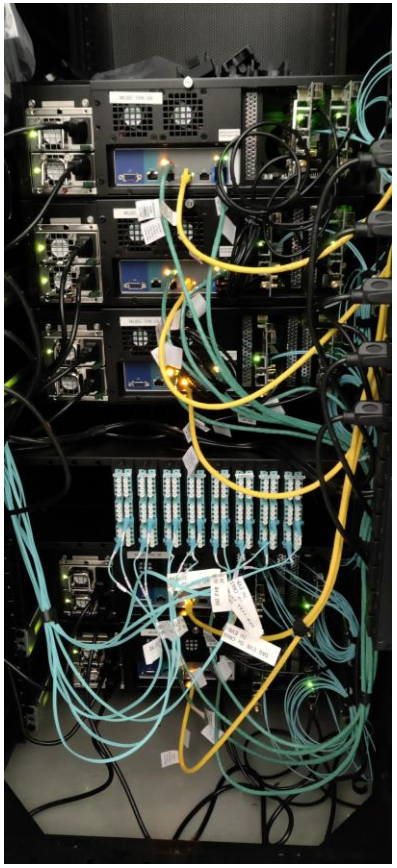
- A 40Mhz clock is fed to one of the USER IO pins on the CFO
- A clock cable pull out the signal from the server and it is hookup to a scope.

EVB – Event Builder

- The Event Builder (EVB) collects data from all the DTCs
- Defines the Event
- Send back the event to all the DTCs one at a time
- The DTCs send the events to the TDAQ servers



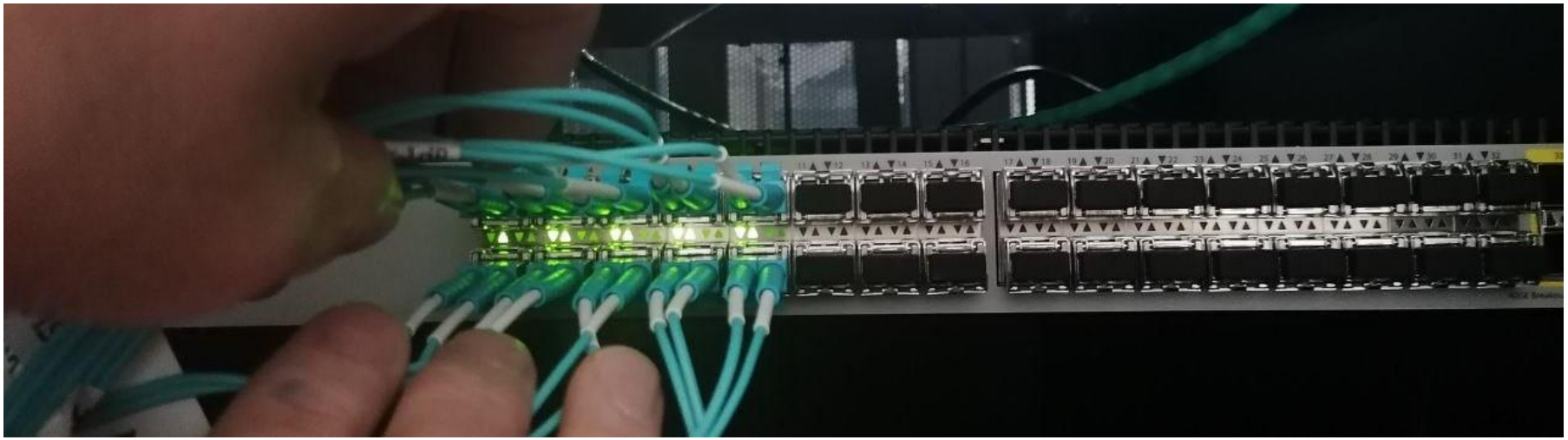
EVB – Connections



- The fibers used are 10 duplex fiber optic cables(Rx-Tx) of 2mm of diameter

- The labels are designed to be as general as possible. For each fibers there are 2 labels in which the position of each end is indicated: Rack, Chassie, Cassette, Pin

EVB – Connections

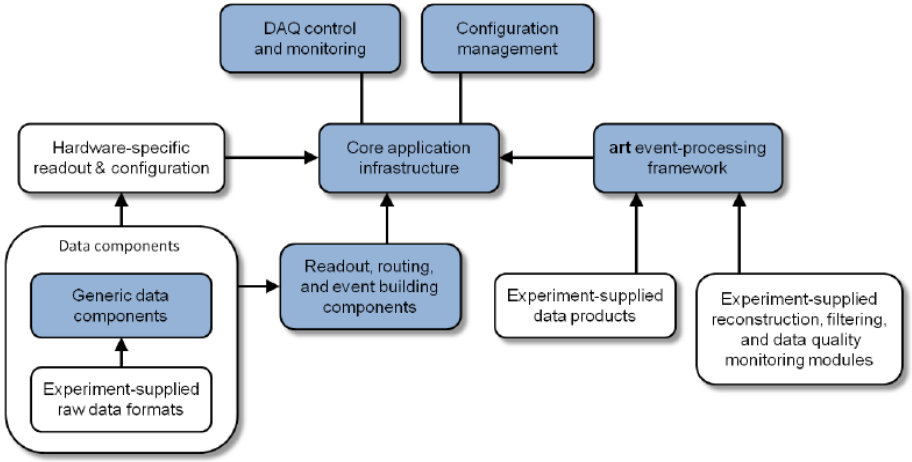


- The LED off shows a connection that does not work
- We switched the fiber with one of a working connection, but the problem remains
- Probably the DTC involved is dead

Artdaq

Artdaq is a toolkit of C++ 2011 libraries and programs for use in the constructions of TDAQ systems.

Basically, it provides scalable, low-cost data acquisition architecture as a service.



It provides functionality that includes the following:

- Configuration of the TDAQ HW
- DAQ control and monitoring
- Event analysis and filtering using the art event-processing framework.
- Encapsulation of the data and support for experiment-specific raw data formats to provide type-safe data access

Otsdaq – Off-The-Shelf data acquisition

Otsdaq is the online DAQ software framework that Mu2e has chosen.

Otsdaq uses the artdaq framework providing a web interface to configure, control and monitor the online DAQ software entities.

Otsdaq – Optimizing otsdaq configure()

Configuring the electronics via OTSdaq took 5-10 minutes

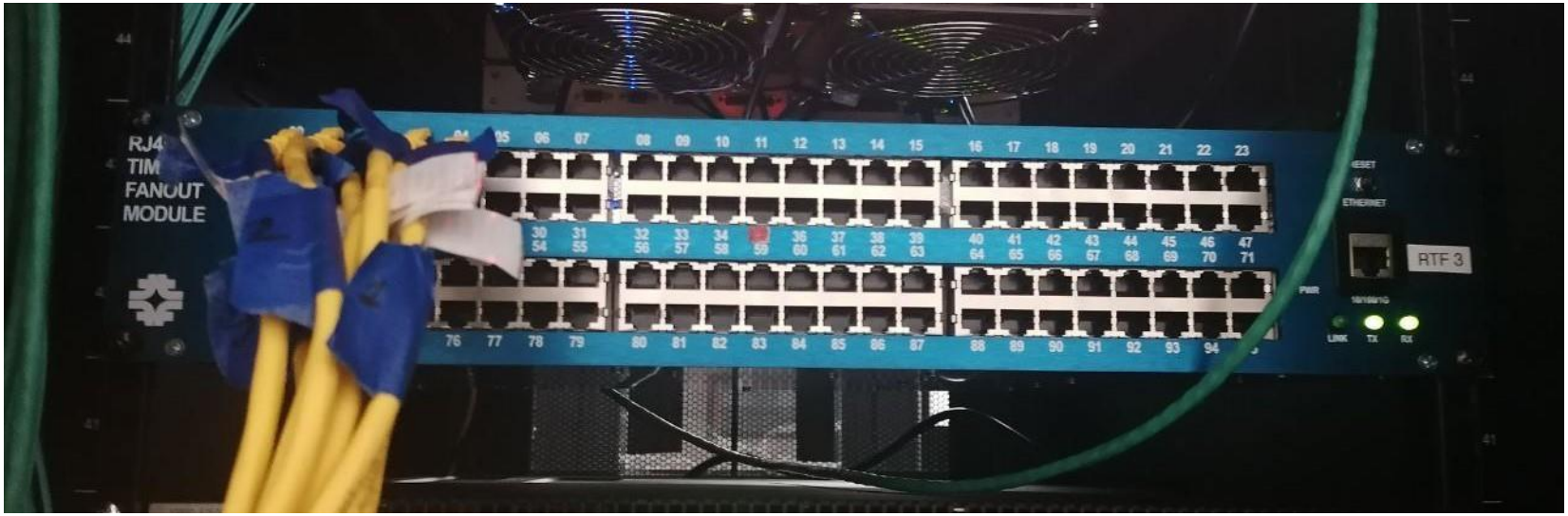
1. Studying the configuration process by printing out the writing access to the registers of the DTCs

2. Compared the printouts with a script used to configure the electronics manually

3. Parallelized the configuration process via otsdaq adding more threads to the configuration process

Now the configuration process takes more or less 30 seconds

RTF firmware



Currently there is only one chain of 10 DTCs connected to the CFO. At the end there will be 36 DAQ servers with 2 DTCs each.

- The RTF firmware has been updated so it fans out the clock to 96 DTCs.
- All the RTF outputs have to be tested, by moving the 10 DTCs through all ports and seeing if they hold the lock