

Data Acquisition for E1039

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On behalf of the MIT SpinQuest/DarkQuest Group

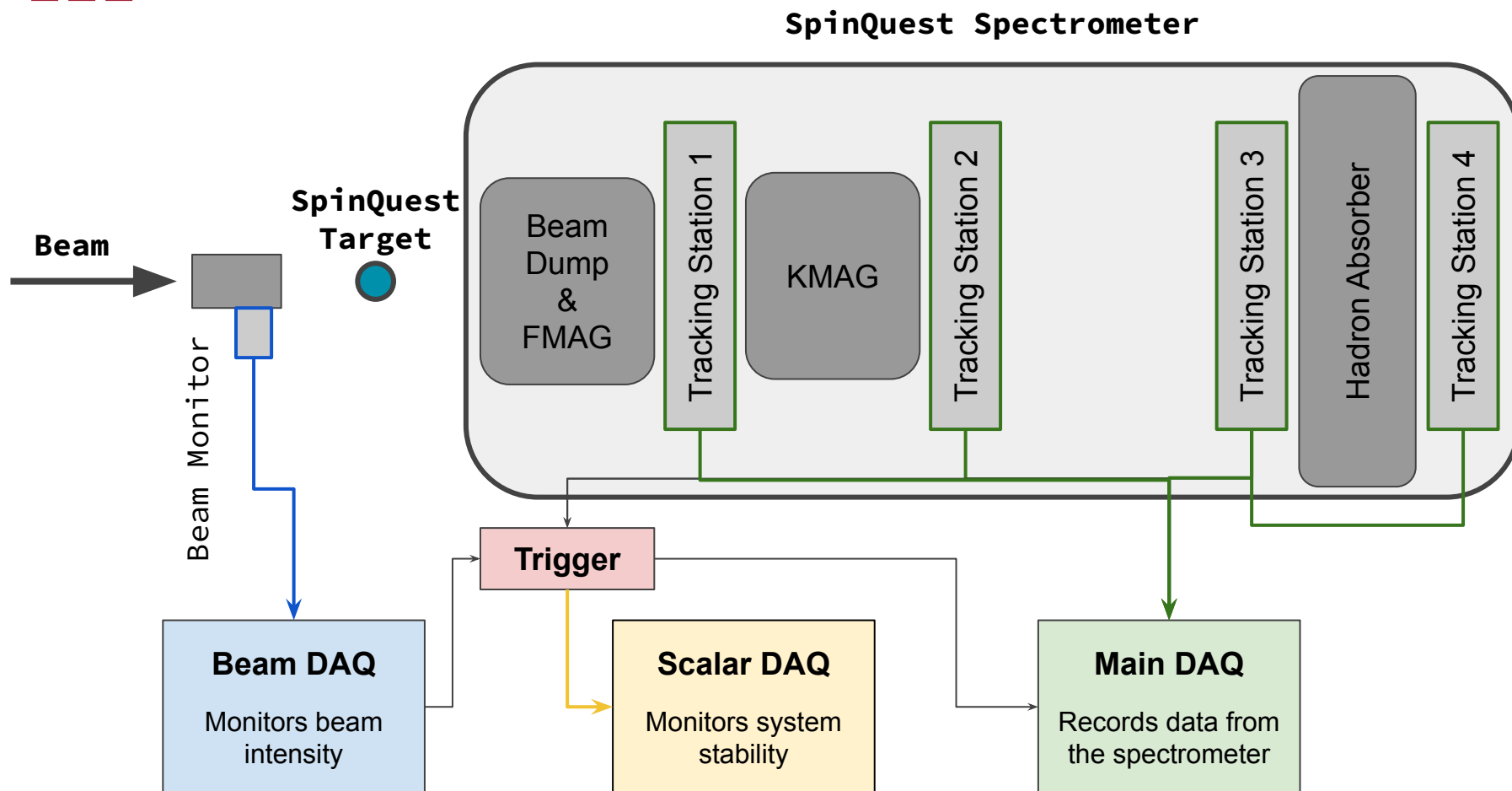
DarkQuest Collaboration Meeting - October 20th, 2023



Overview

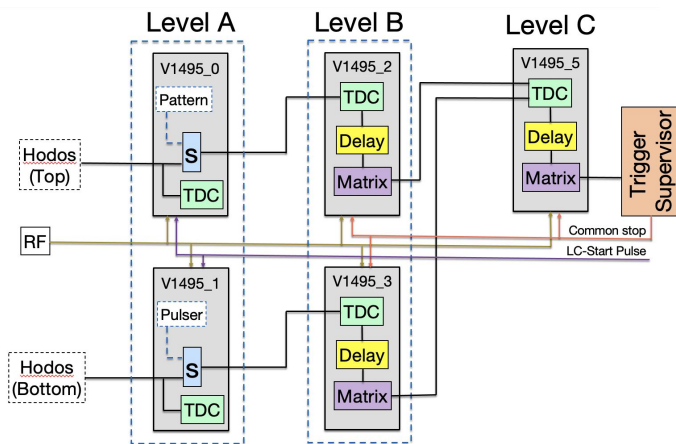
- Review of the three current DAQ systems
 - Beam DAQ
 - Scaler DAQ
 - Main DAQ
- Upgrade Plans
 - DAQ Server
 - Integration of Electromagnetic Calorimeter
 - Readout Crate Replacement
- Cost Summary

DAQ Structure



Trigger Overview

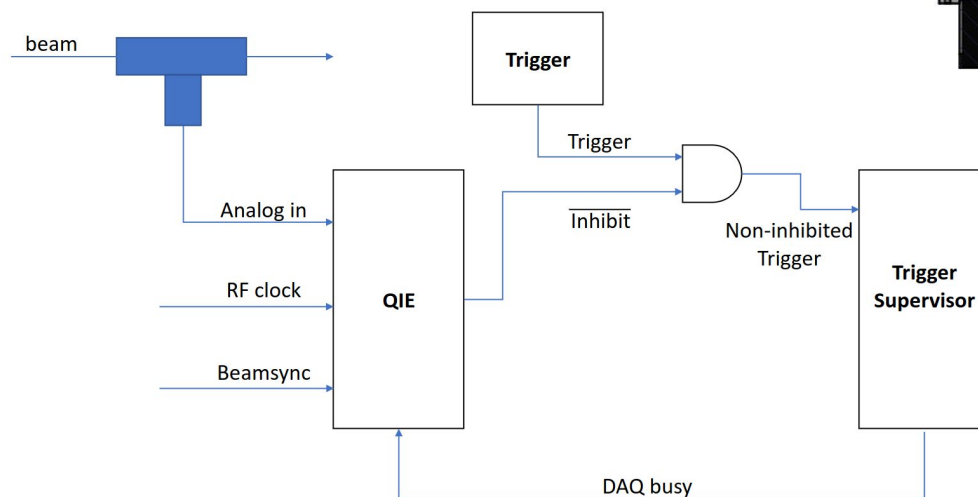
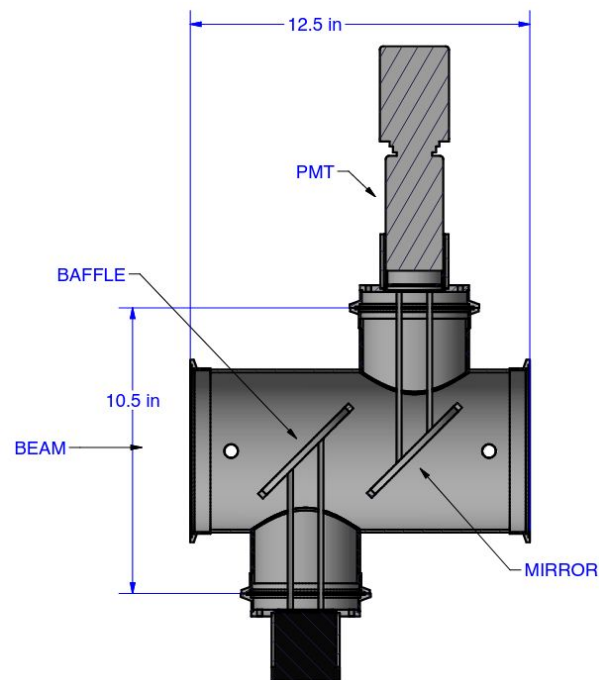
- FPGA cosmic trigger setup is currently active
- FPGA RS103 (J/Psi) trigger setup is Fully operational
- Stand-alone test setup to debug/update FPGA trigger system



Trigger Name	Trigger Condition Description
FPGA1	Opposite halves && Opposite charges (Primary)
FPGA2	Same half && Opposite charges
FPGA3	Opposite half && Same charges
FPGA4	Single Track && Any change
FPGA5	-- / / --
NIM1	$(H1X H1Y) \&\& (H2X H2Y) \&\& (H3X H4Y1) \&\& (H4X H4Y2)$
NIM2	$(H1X H1Y) \&\& (H2X H2Y)$
NIM3	Random
NIM4	$(H2X H2Y) \&\& (H4X H4Y2)$

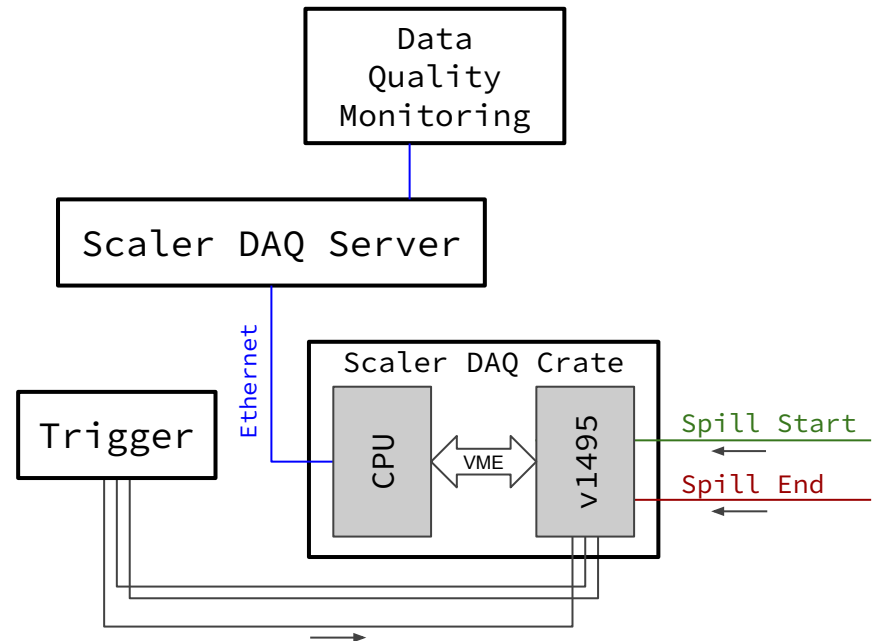
Beam DAQ Setup

- Beam quality assessed by Cherenkov detector in beam path upstream of target
 - Measures beam intensity per RF bucket
- Uses simple, custom software over the network

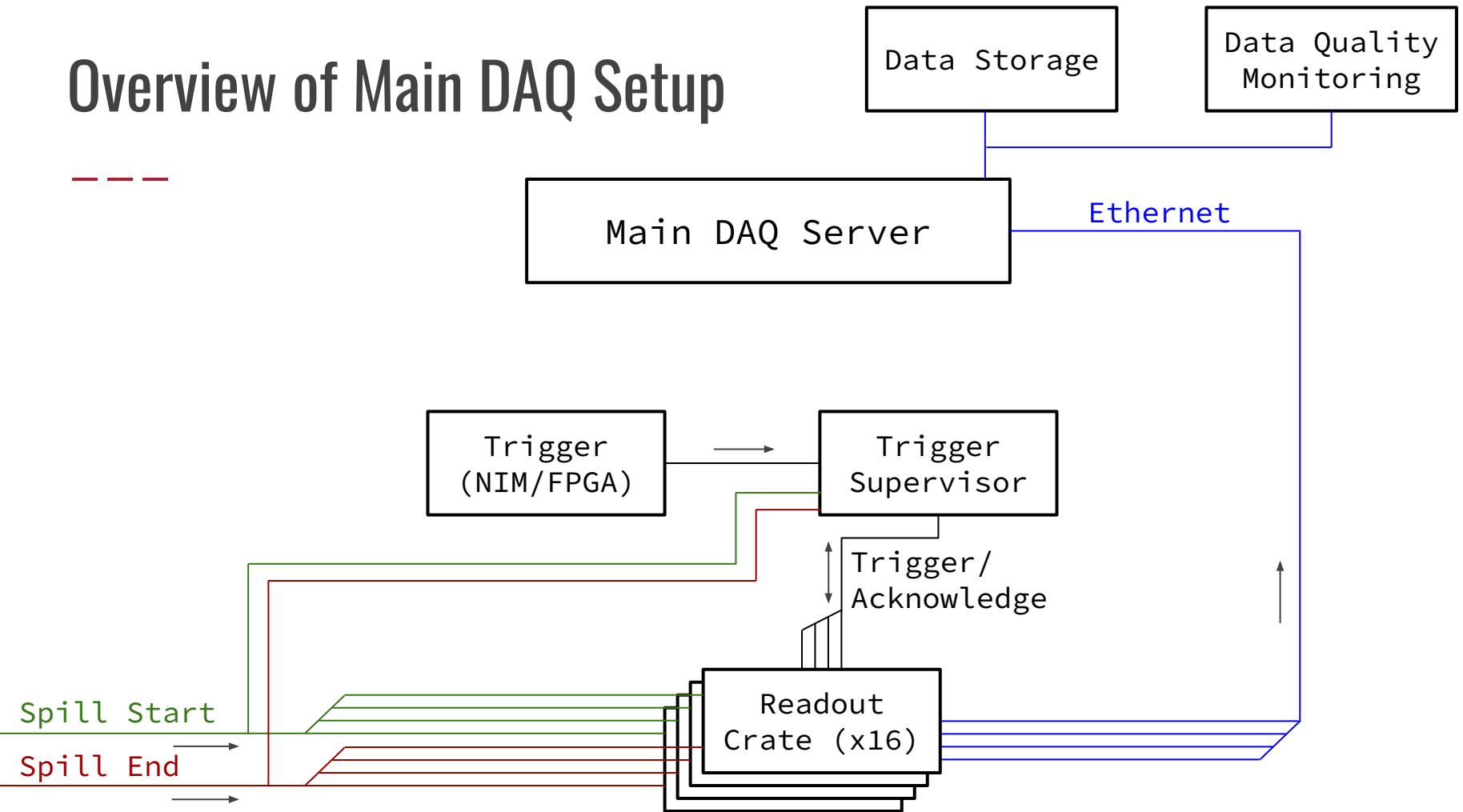


Scaler DAQ Setup

- Based on the CODA data acquisition system model developed by Jefferson Lab
- Tracks the counts per spill for each of the triggers present
- Counts read out via VME controller using single CAEN v1495 FPGA card
 - Takes each trigger and spill start/end signals as inputs
- Primarily assists in monitoring trigger performance and beam quality



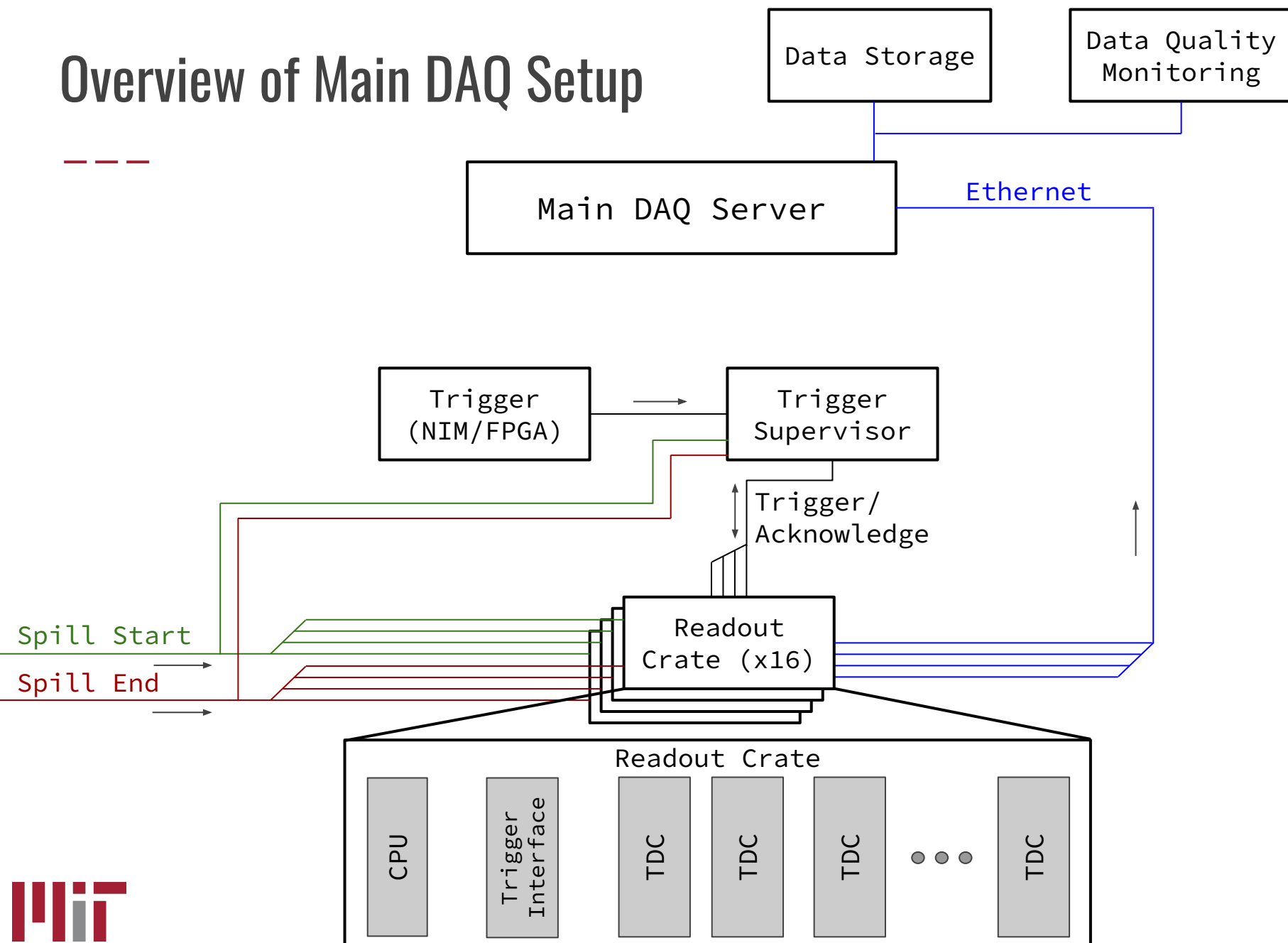
Overview of Main DAQ Setup



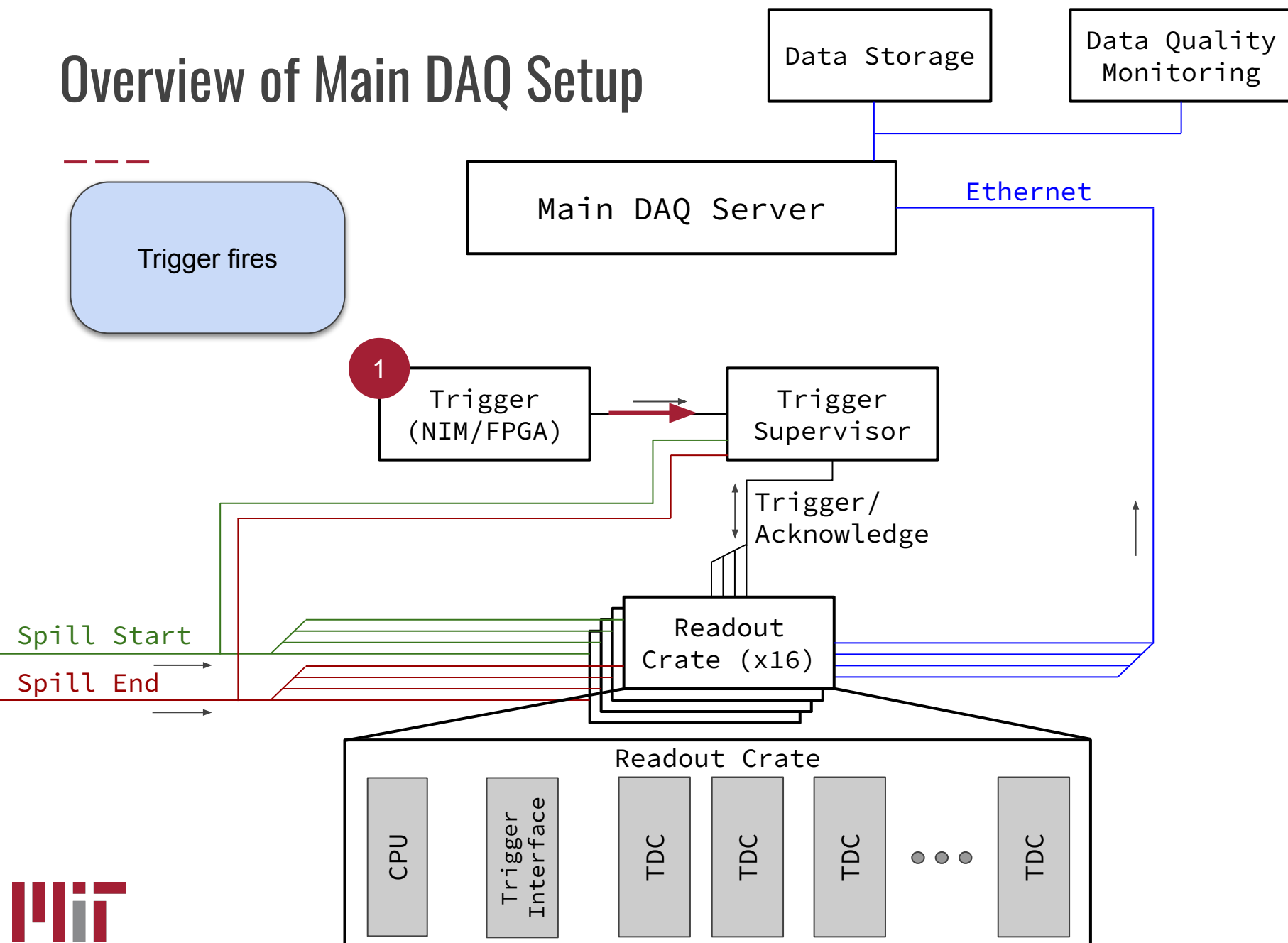
Main DAQ Setup

- Based on the CODA data acquisition system model developed by Jefferson Lab
- System divided into a trigger, trigger supervisor (TS), and a set of read out crates (ROCs) with TDCs linked via network being controlled by *1039daq1*
 - Stop trigger signal is sent to TS, put in a lock state and distributed to ROCs, which record the event in a local cache
 - Transfer of event data over the network happens after end of spill
- Maximum trigger rate up to about 5–8kHz
 - Limiting factor is cache size on TDCs
- Data rate of 1 GB/hr of raw data
 - Stored on *1039daq1*

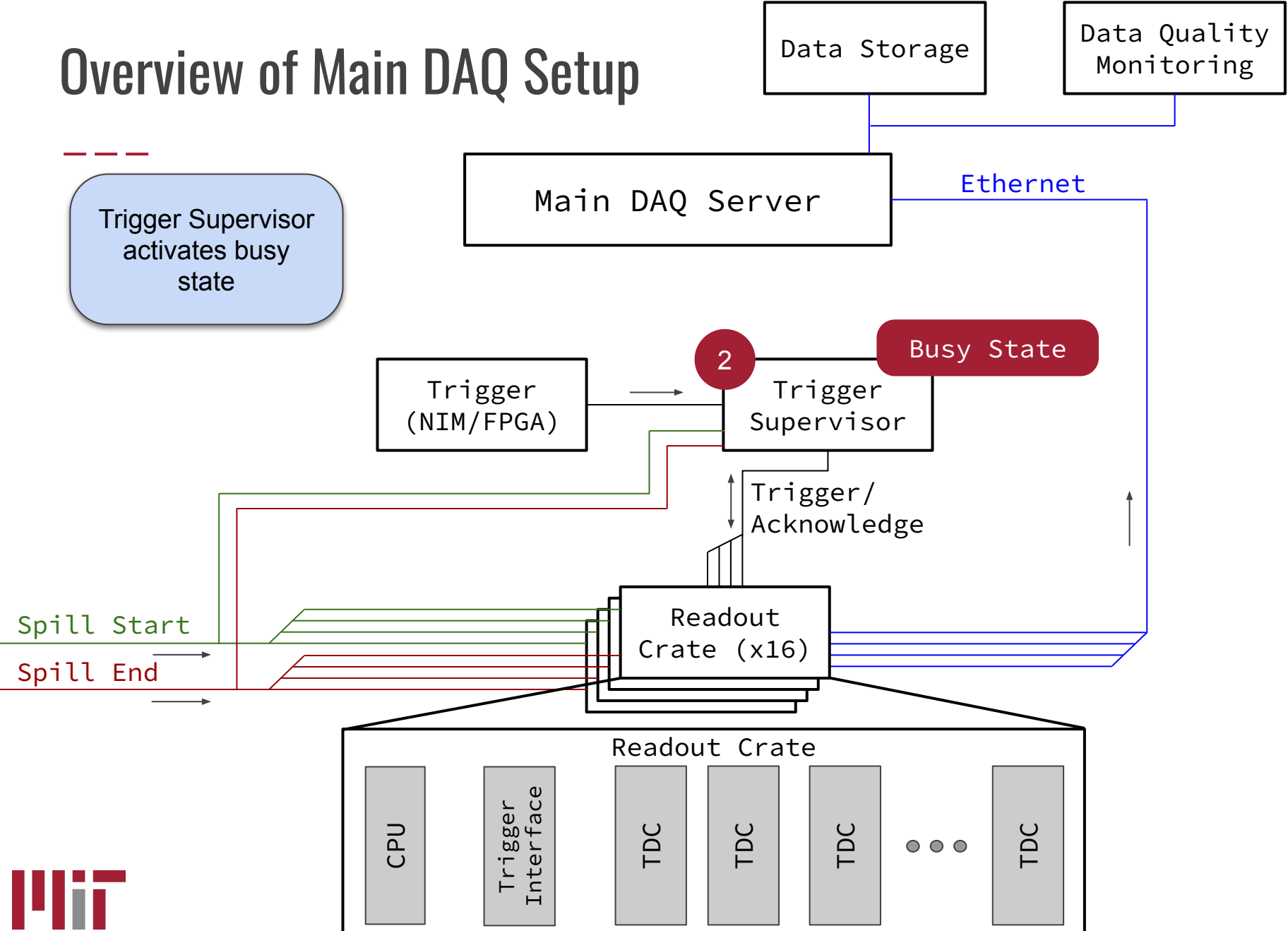
Overview of Main DAQ Setup



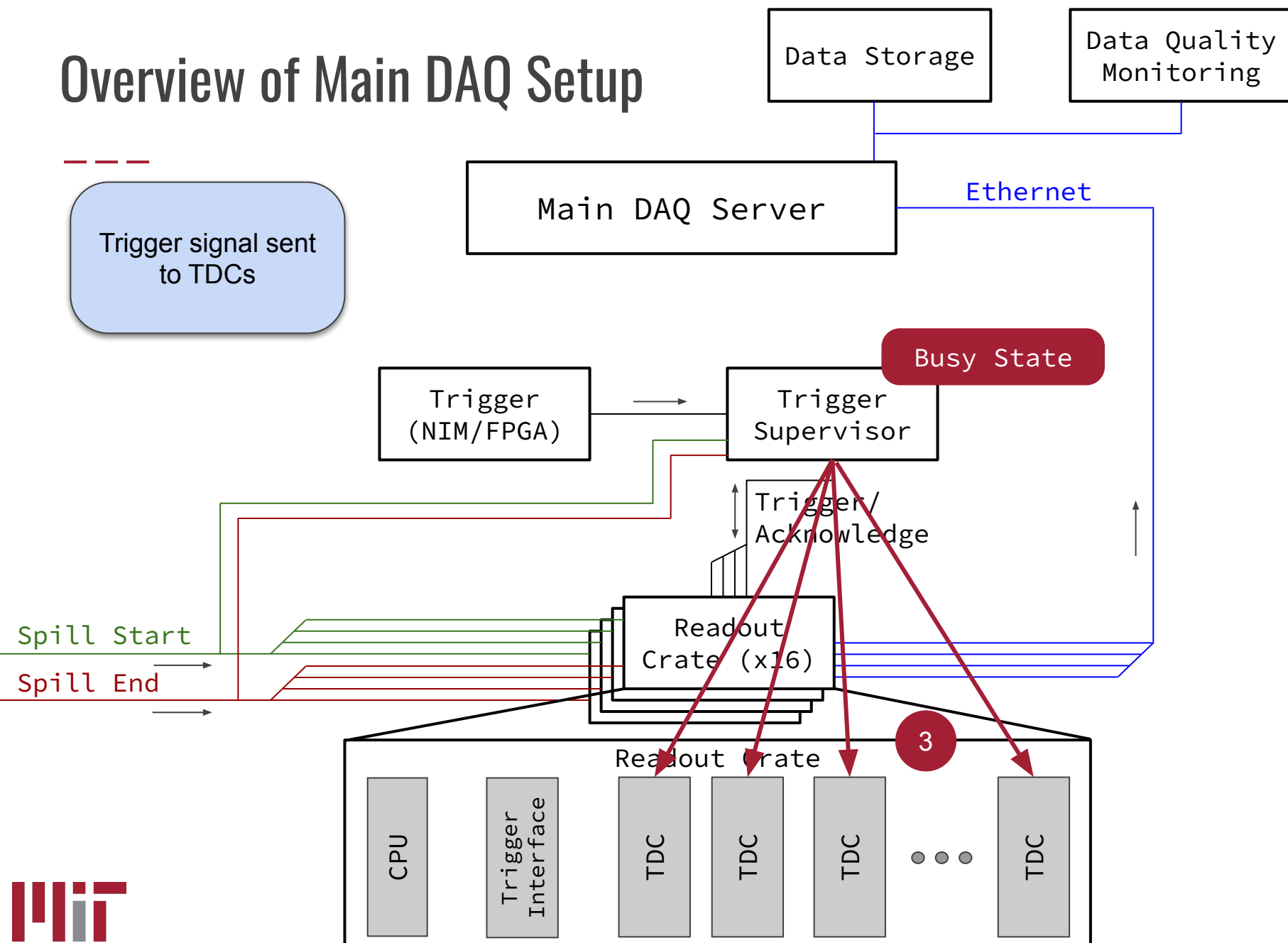
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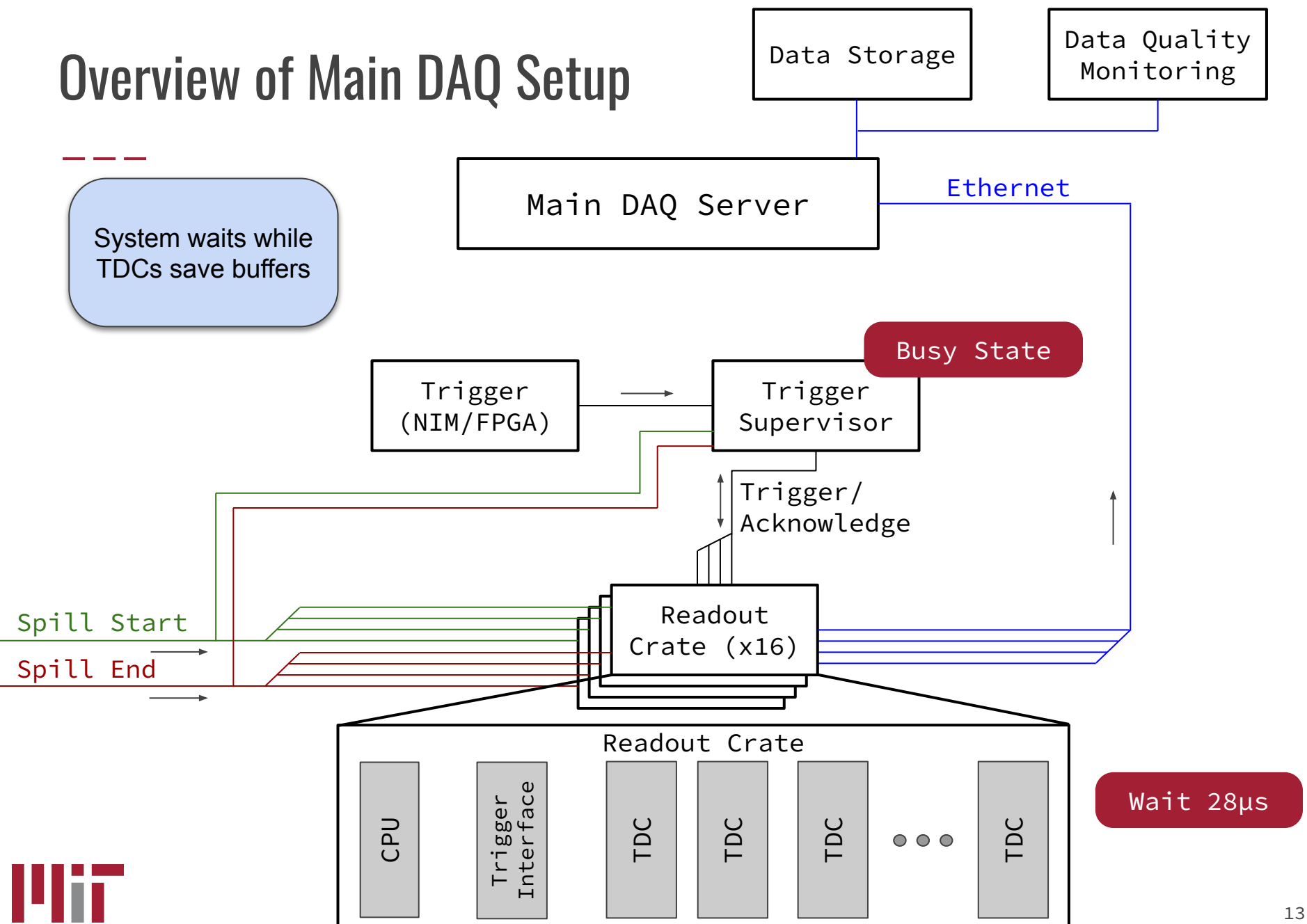
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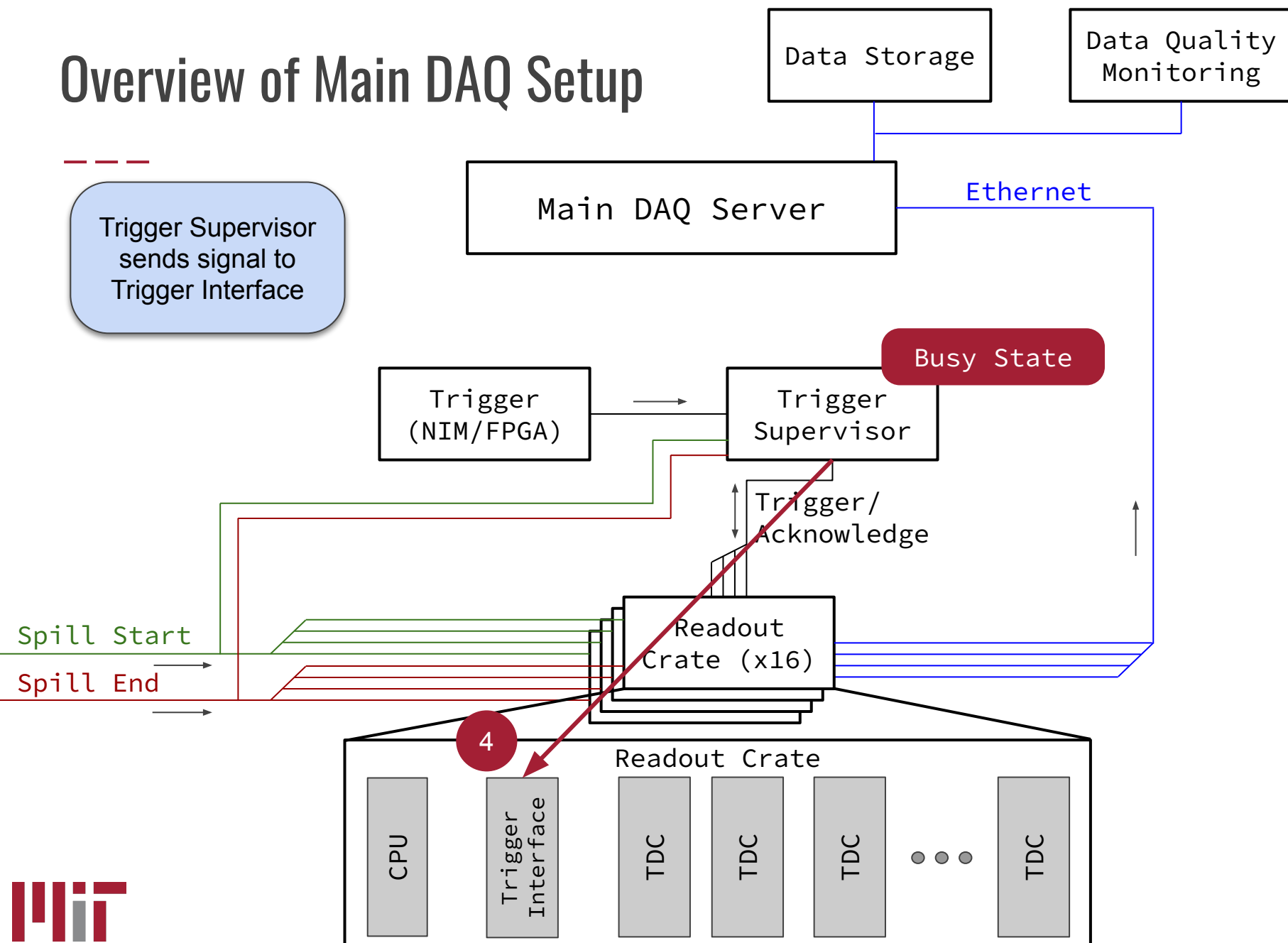
Overview of Main DAQ Setup



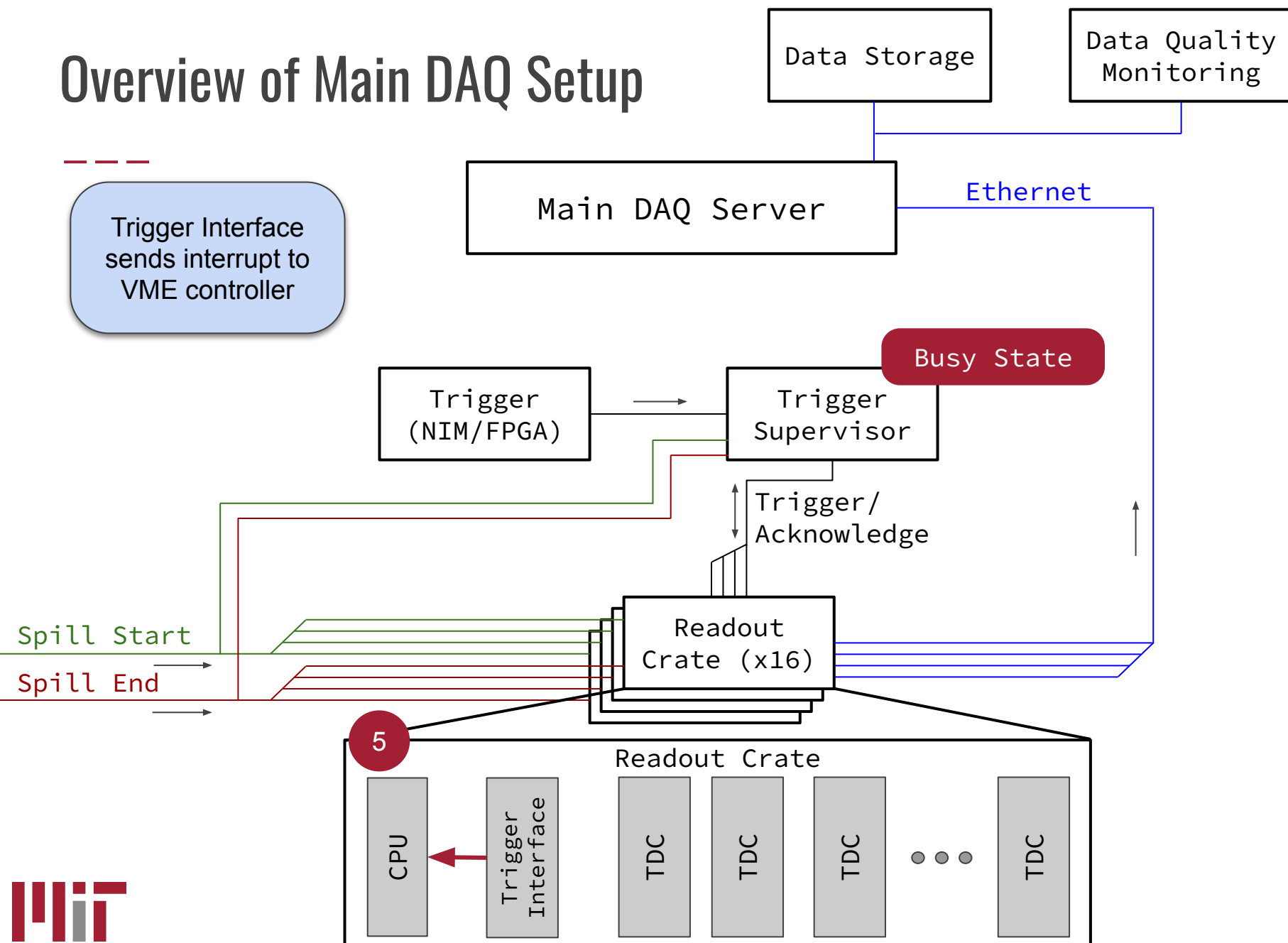
Overview of Main DAQ Setup



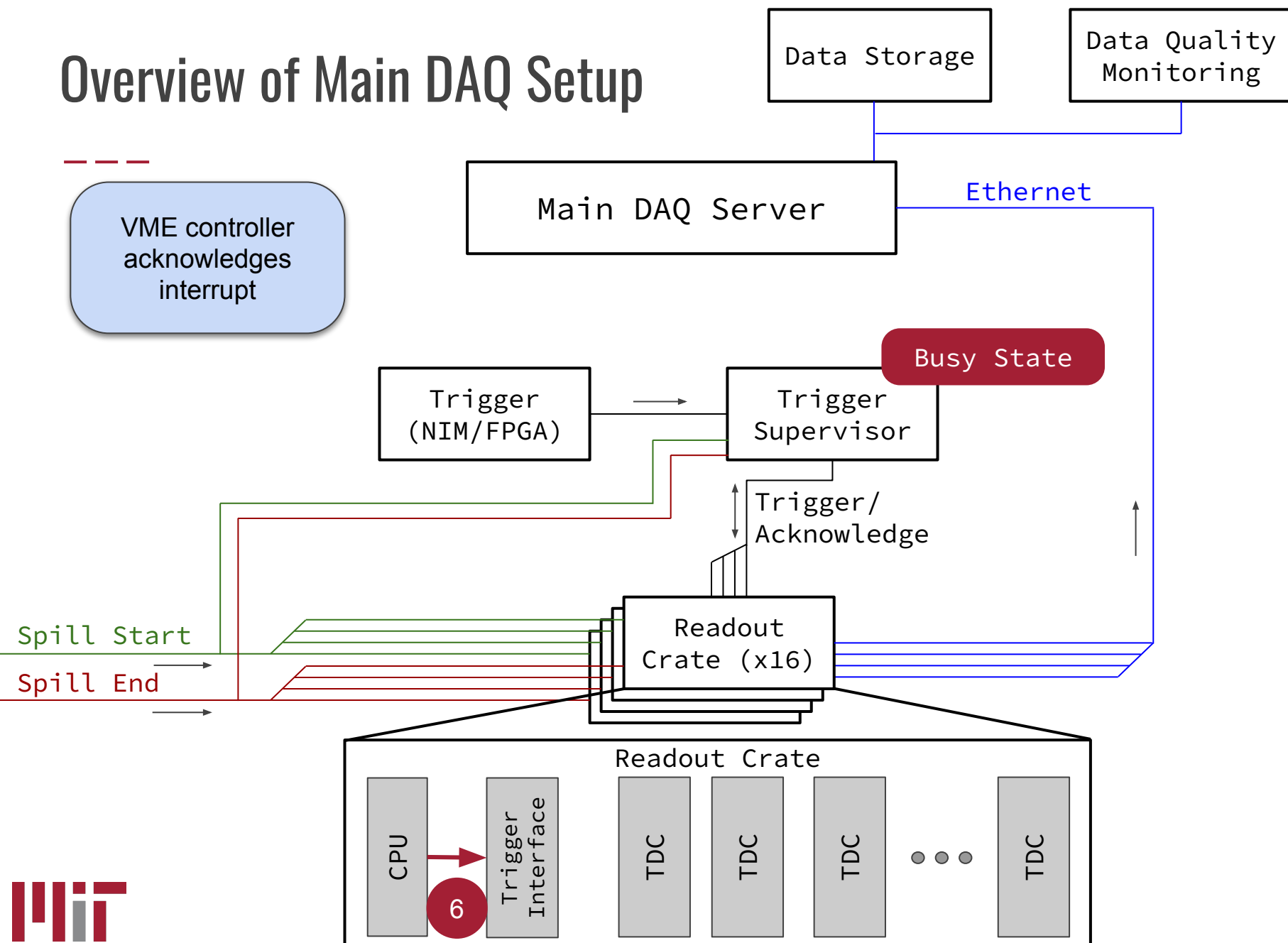
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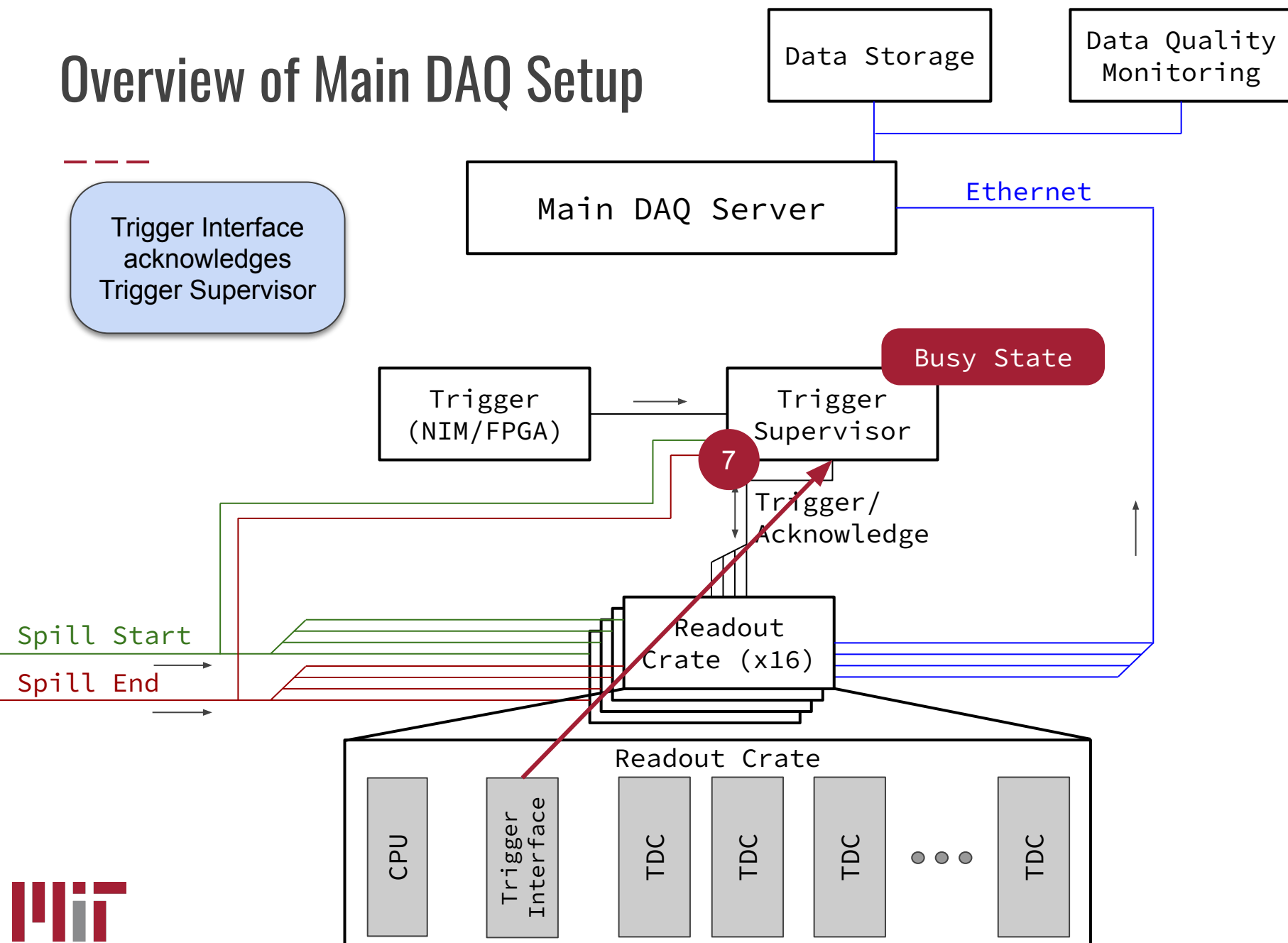
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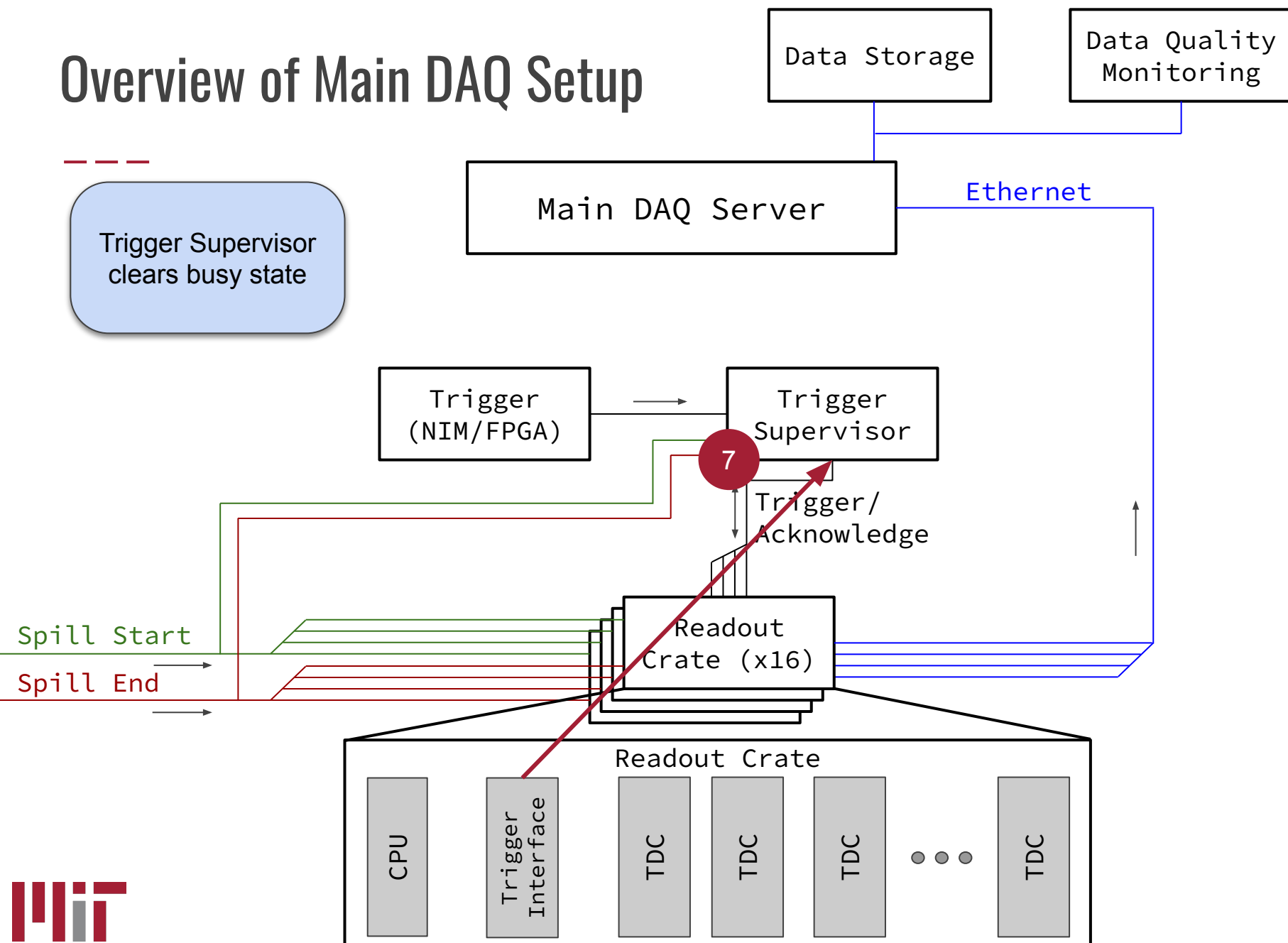
Overview of Main DAQ Setup



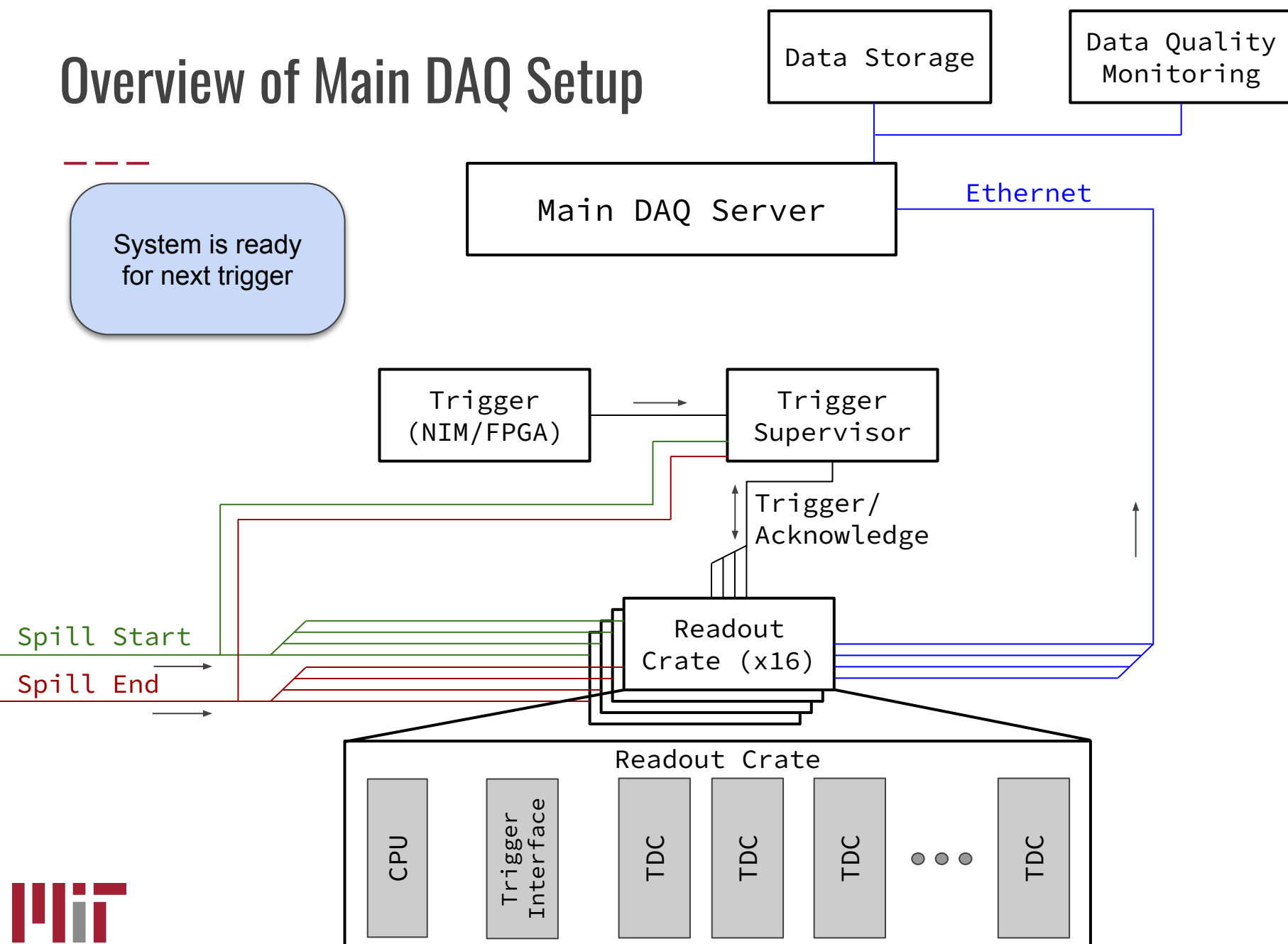
Overview of Main DAQ Setup



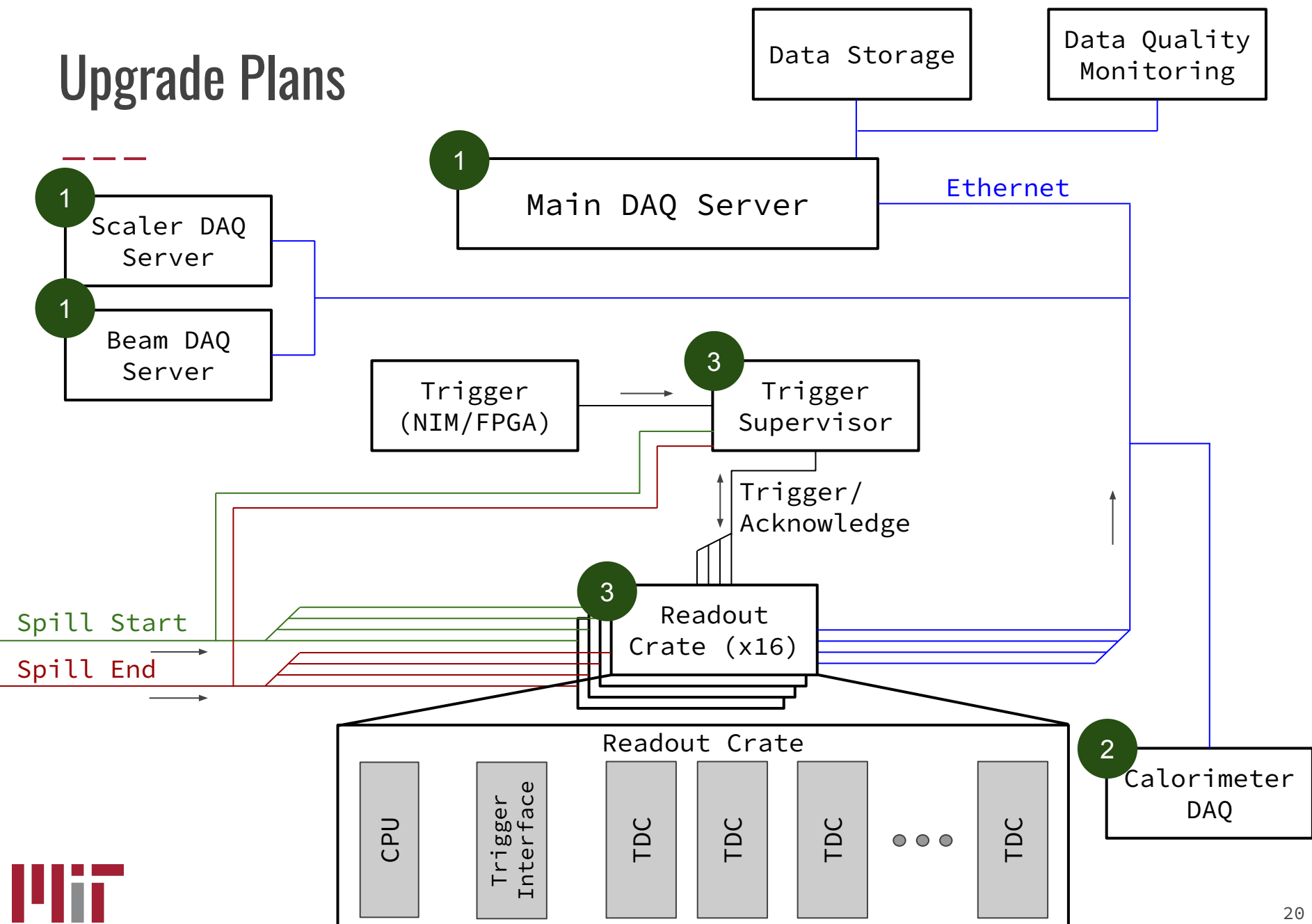
Overview of Main DAQ Setup



Overview of Main DAQ Setup



Upgrade Plans



Upgrade Plans - Main DAQ Server

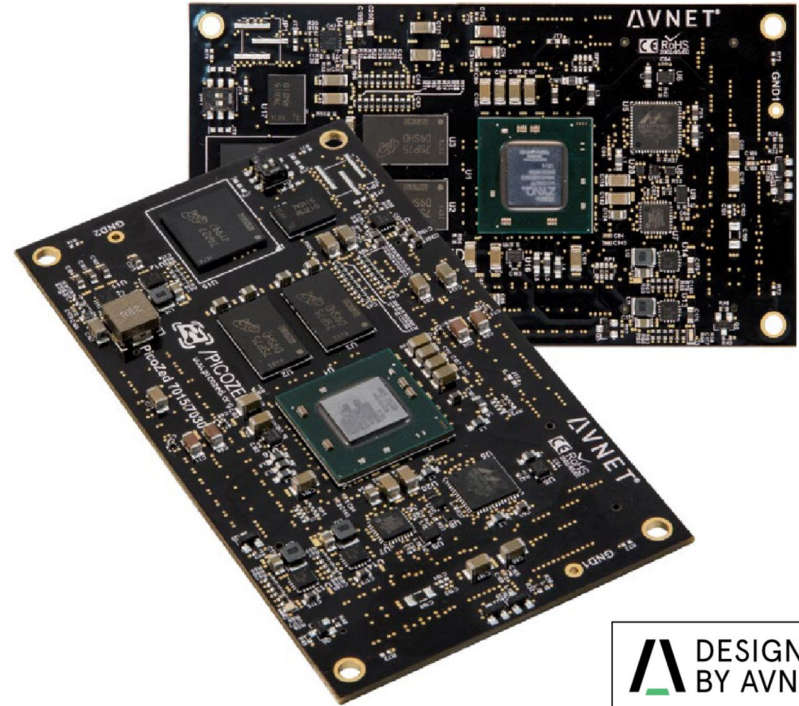
- Move the primary system to a Docker Compose setup and co-locate all three DAQ servers on the same hardware
 - Increased uptime due to ability to auto-restart after crash and reduced setup time in event of system failure
 - Currently have Docker setup running as a backup on a surplus server from Fermilab
- Purchasing a new DAQ server with additional storage space and computing power would allow us to move the current surplus machine to serve as a hot spare onsite
- Additionally, purchasing a new SpinQuest network gateway machine can improve remote access and management capabilities
 - Currently running on old office PC
 - Would be nice to have server-grade reliability, additional space for analysis, and faster network access
- Ideal timeframe for both upgrades before start of data-taking for SpinQuest

Upgrade Plans - Calorimeter DAQ Integration

- Current (minimally invasive) plan is to run a separate data acquisition server for the calorimeter software and synchronize offline
 - Use 10G ethernet link from hall to control room
 - Can operate the software as an additional container in Docker Compose setup to avoid the need for another machine
- Requires purchase of upgraded main DAQ server and 10G network switches

Upgrade Proposal - Readout Crate Replacement

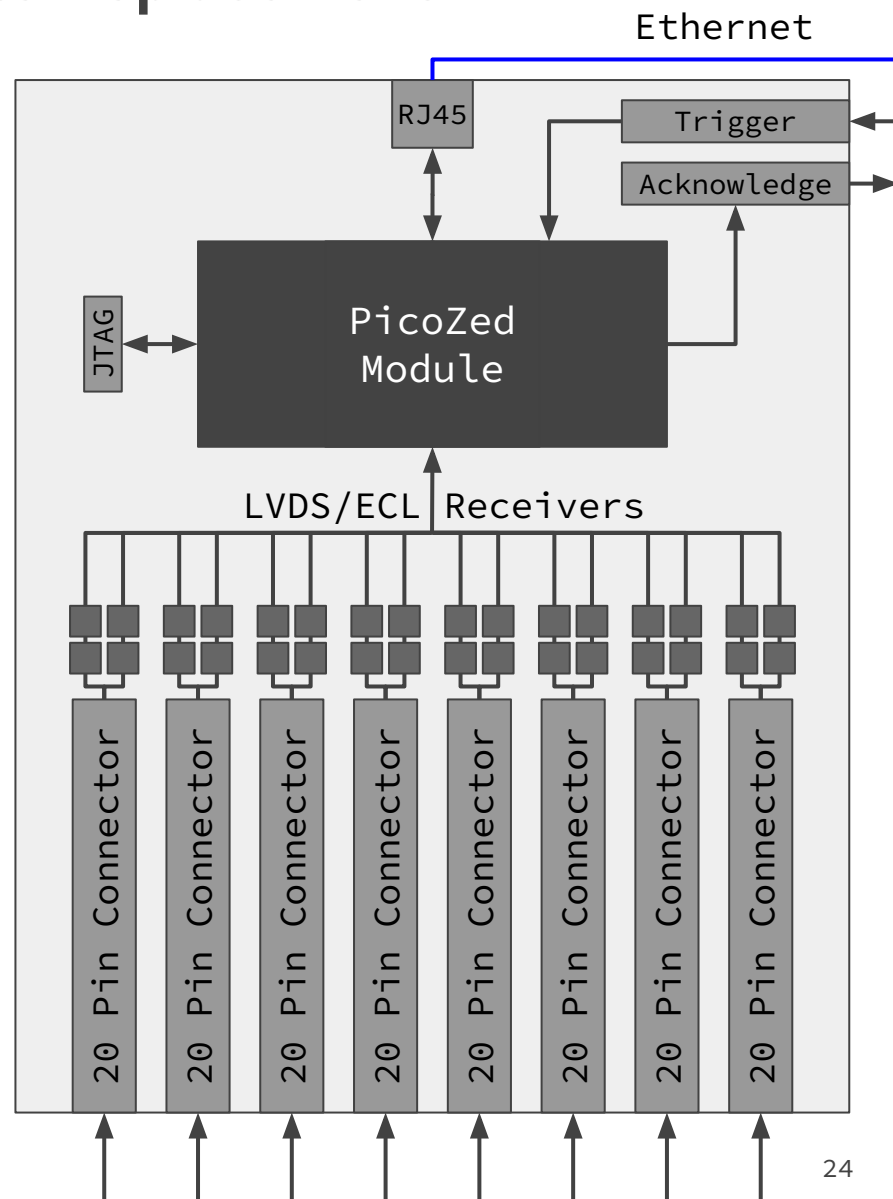
- Current readout crates have two bottlenecks
 - Each TDC VME card has limited buffer space (requires lower trigger rates)
 - Data must be read out to the event builder and be saved via the VME controller instead of directly through
- Solution would be to move to a Zynq-based system using PicoZed system-on-modules



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Upgrade Proposal - Readout Crate Replacement

- Implement carrier boards for PicoZed Modules (Zynq 7015) that will each replace two TDC cards (128 channels)
 - Carrier boards are based on current TDC board design and use same LVDS/ECL conversion ICs
 - Split carrier board/module construction allows for faster repair of failed boards and easier replacement due to use of commercial Zynq modules



Upgrade Proposal - Readout Crate Replacement

- Requires production of these (simple) carrier boards as well as purchase of PicoZeds and 10G network switches
 - Conservative cost estimate ~\$39,400 (including redundancy factor ≥ 2 for all components) + engineering review costs
 - 90 PicoZed Zynq 7015 System-on-Modules \$28,620
 - 100 Carrier Boards ~\$9,000
 - 5 24-Port Managed Network Switches with 10G Uplink \$1,750
 - Requires ~6 months development for new software/firmware

Upgrade Cost Summary

Item	Price	Quantity	Subtotal
DAQ Server - SuperMicro 32c, 128GB RAM, 64TB storage	\$7,444	1	\$7,444
Gateway Server - SuperMicro 32c, 128GB RAM, 64TB storage	\$7,124	1	\$7,124
DAQ Testbench Workstation - SuperMicro 16c, 64GB RAM, 2TB Storage	\$2,497	1	\$2,497
Control Room Network Switch - TP-Link TL-SX3008F	\$253	1	\$253
Networking Accessories (Fiber optic cables, transceivers, etc)	-	-	~\$3,000
Hall Network Switches - TP-Link TL-SG3428X 24-port + 4 uplink	\$350	5	\$1,750
PicoZed System-on-Module with Zynq 7015	\$318	90	\$28,620
Carrier Board (Estimated)	~\$90	100	~\$9,000

TOTAL: \$59,688