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ACORN

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Modernizing Fermilab's Control Hardware

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In partnership with:

Idaho National Laboratory

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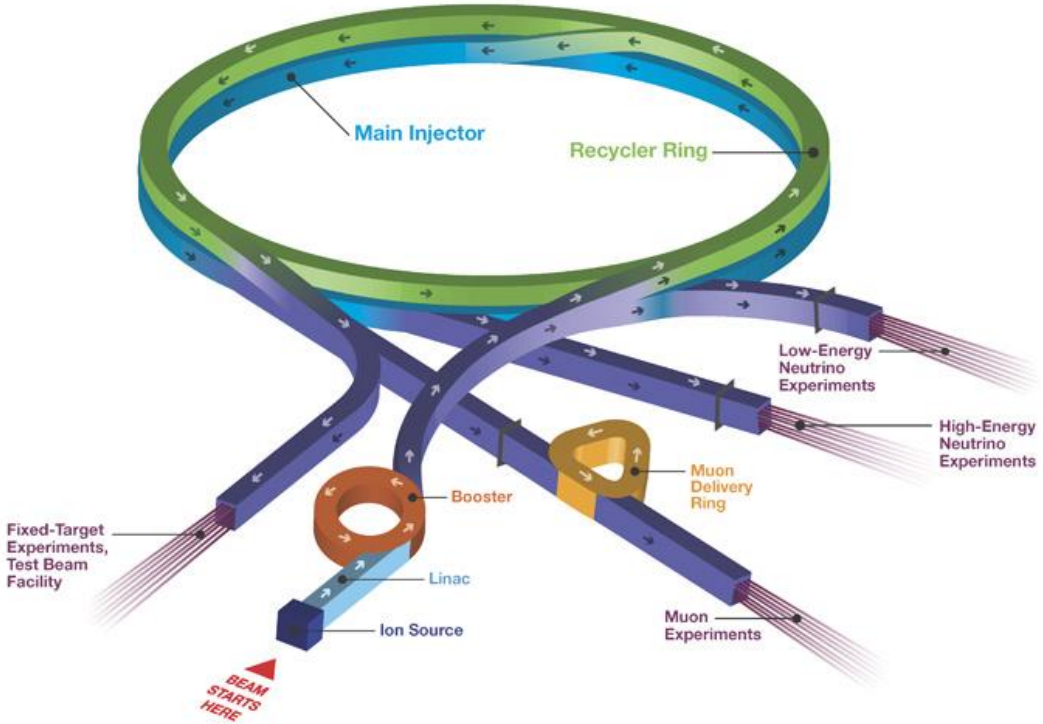
Overview

- Overview of Fermilab
- Overview of the ACORN Project
- History of Fermilab's Control System
- Summary of Fermilab's Control System CAMAC Subsystem
- Requirements for New Control Hardware
- Conceptual Design: µTCA Replacement Hardware

Goal: Provide an overview of the ACORN project's plan to modernize Fermilab's control system hardware.

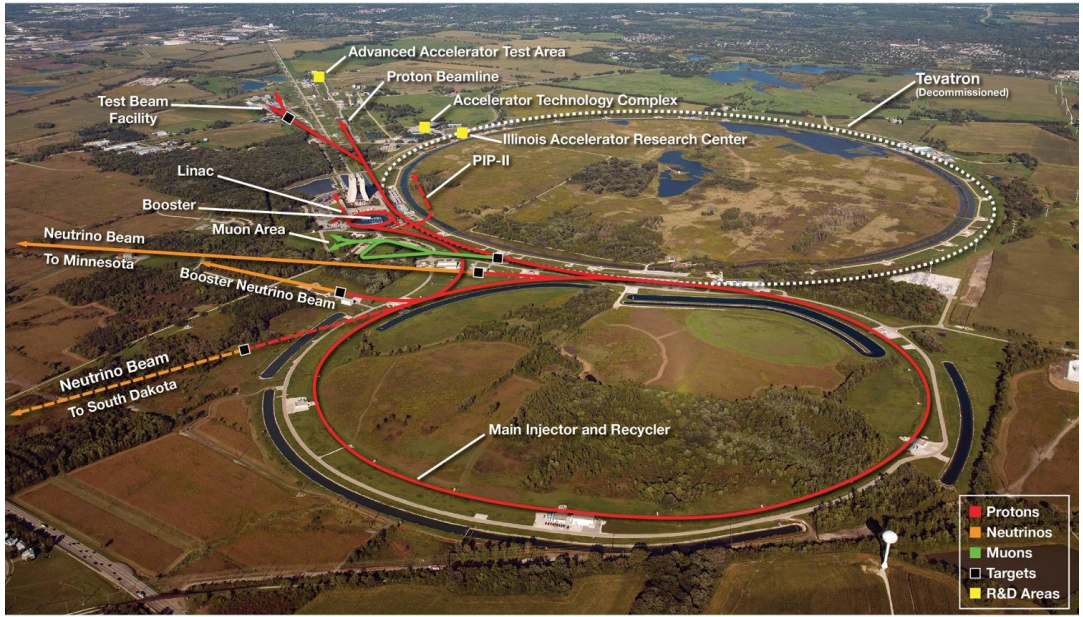
Overview of Fermilab



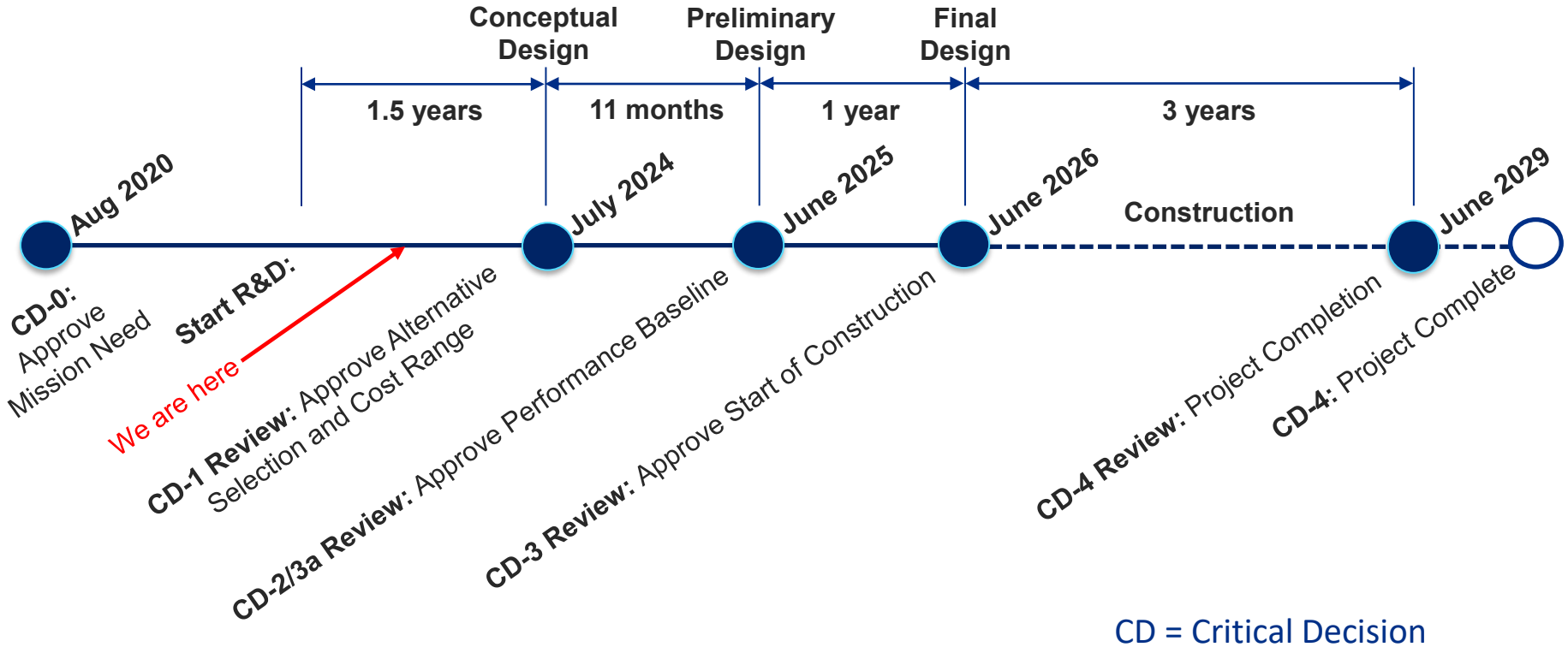
U.S. DEPARTMENT OF ENERGY

Accelerator Controls Operations Research Network (ACORN)

- The ACORN Project is a DOE O413 project that will modernize the laboratory's **accelerator control system** and replace end-of-life **accelerator power supplies**.
- Project start was approved August 28, 2020.
- Total Project Cost (TPC) range: 100 – 142M$
- Project Completion: 2028 – 2030



Project Timeline



CD = Critical Decision

History of Fermilab's Control System

- Utilized the CAMAC standard to build a significant portion of the control system
  - Ex: power supply controllers, digital I/O, analog readback controllers, etc.
- Also utilized custom-made hardware
  - Ex: Analog readbacks, vacuum control, edge computing, etc.
- Incorporates new hardware to meet project needs

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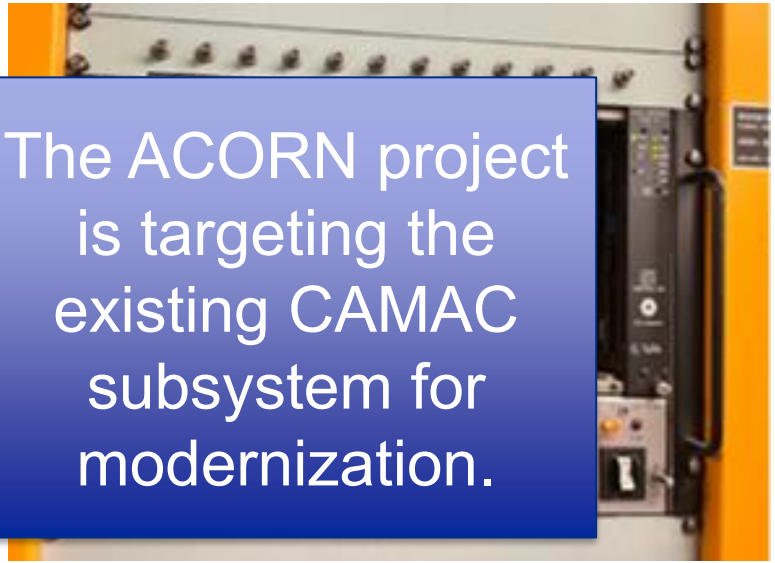
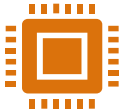


The ACORN project is targeting the existing CAMAC subsystem for modernization.

CAMAC Card Summary



2,184 CAMAC Cards

257 Crates

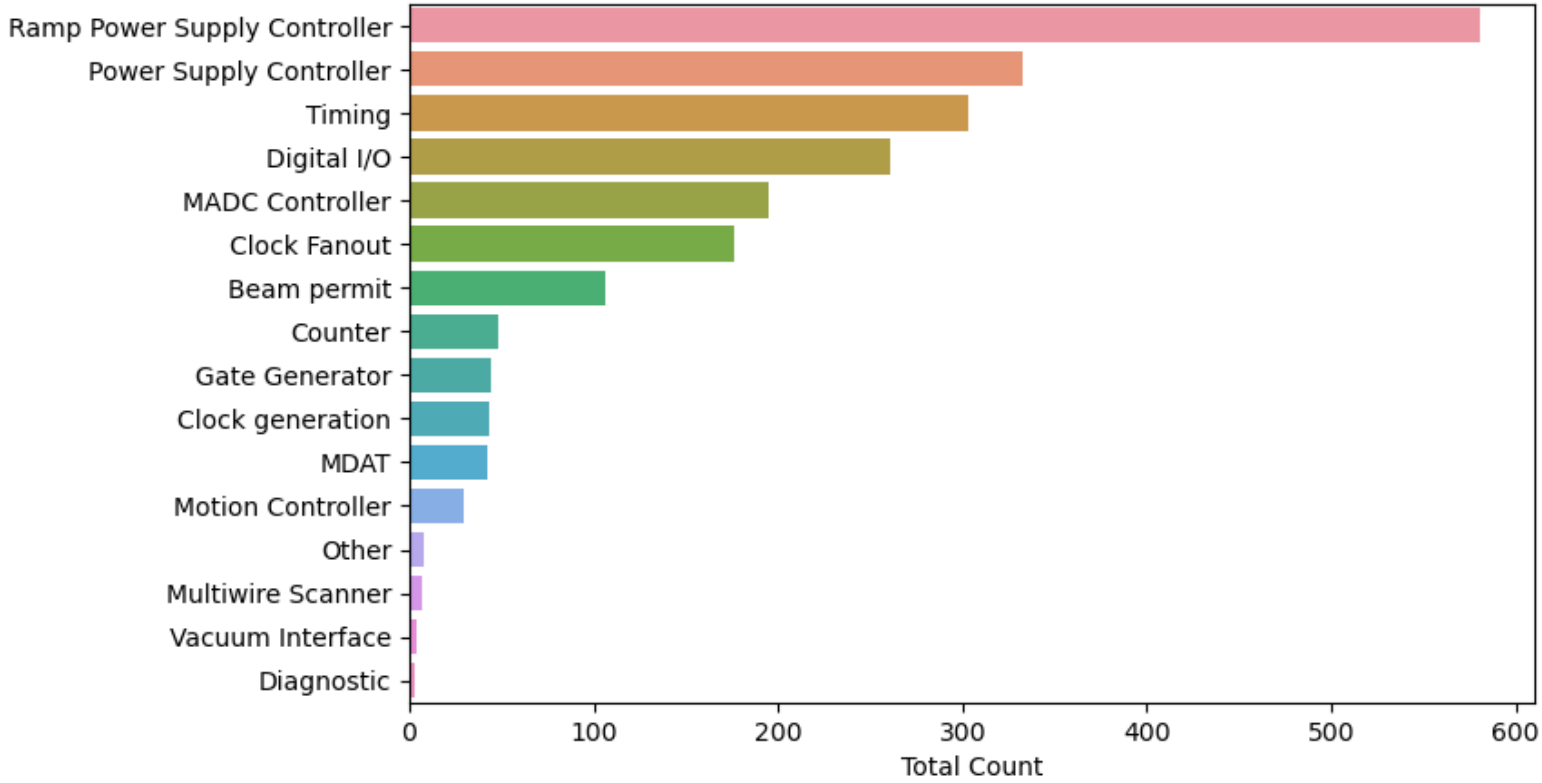
78 Modules

208 MADCs

Functions:

- Power Supply Controller
- Ramping Power Supply Controller
- Clock Generation
- Timing
- Beam Permits
- MDAT Link
- Digital I/O
- Analog Readback Controllers
- Analog Readback
- Gate Generator
- Counters
- Motion Controller
- Specialized Links (Abort or MDAT)
- Multiwire Controller
- Vacuum Interface
- Other

CAMAC Card Summary



Requirements for New Control Hardware

- Rear I/O to interface with existing edge connectors and cabling
- High-speed communications to industry-standard Ethernet
- Remote power and cooling monitoring and management
- Hot-swappable for online maintenance
- Practical ability to produce fully-custom hardware and software in-house for long-term supportability
- Flexible communications to enable low-latency, high-speed communications for online automation and AI control
- Multi-vendor commercial solutions for management and device hardware

ACORN Conceptual Design: µTCA

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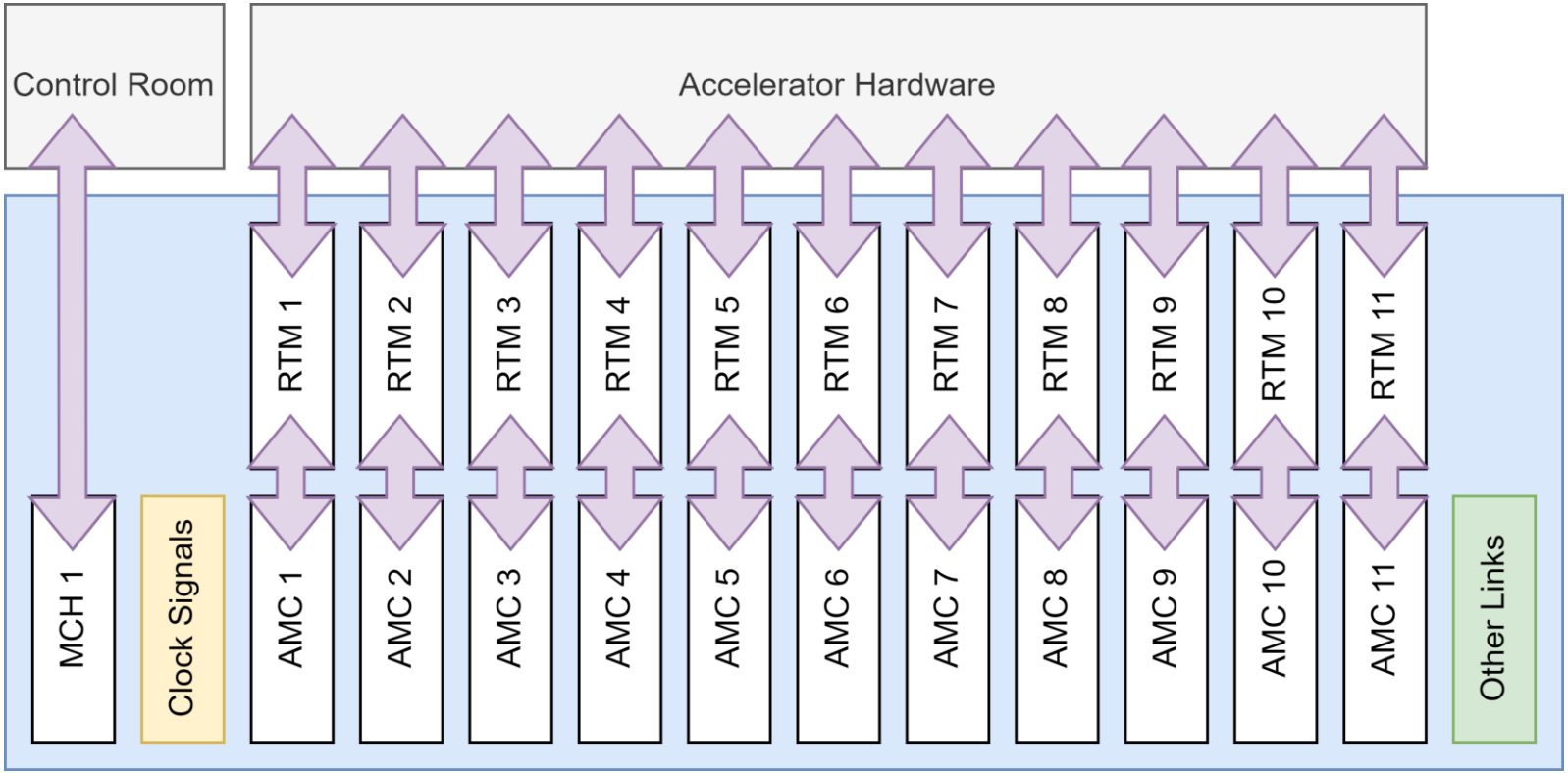
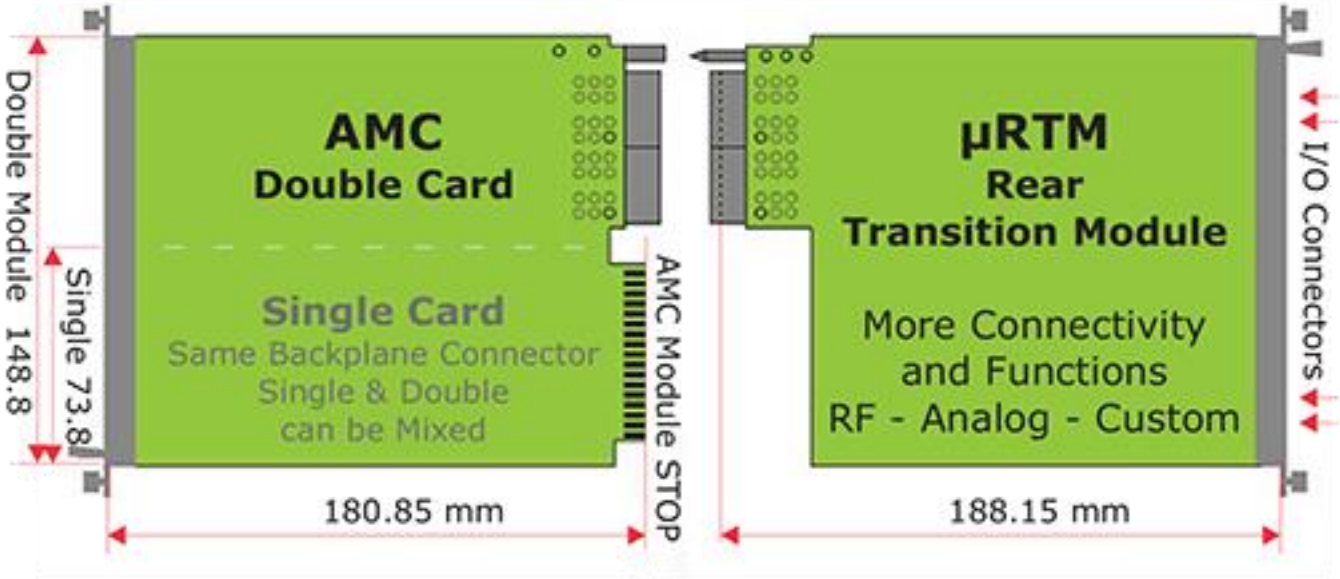
Solution: MTCA.4

Conceptual Design: ACORN's µTCA Crate



Conceptual Design: ACORN's µTCA Cards



- Commercial AMC card
- FPGA + microcontroller

- In-house µRTM
- Connector Daughter Board that allows flexibility to interface with different connectors

Conceptual Design: Card Types

850+

Ramping Power Supply Controller

Versions: 12V, 24V

CAMAC Functions replaced:

- Ramping Power Supply Controller
- Power Supply Controller

1000+

Analog Readback

Versions: Voltage, Current

CAMAC Functions replaced:

- Analog Readback
- Analog Readback Controllers

550+

Digital I/O

Versions: 5V Slow, 5V Fast, 24V

CAMAC Functions replaced:

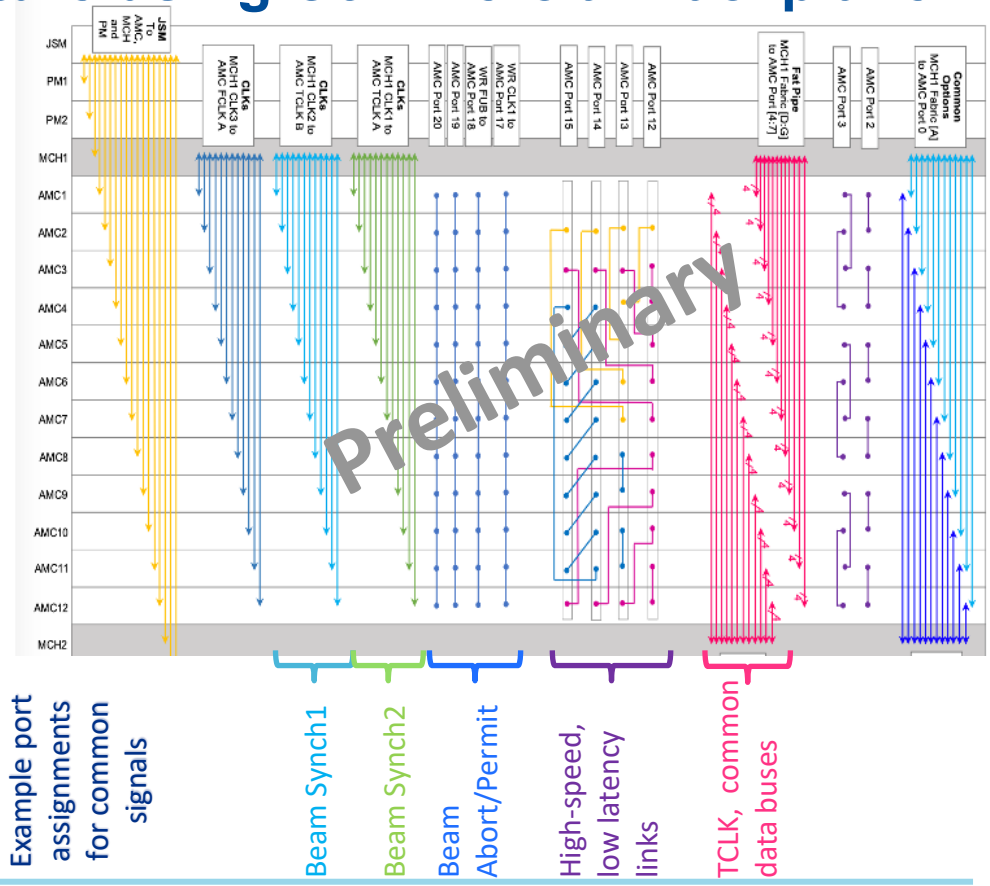
- Timing
- Digital I/O
- Gate Generator
- Counter

Remaining Functions:

- ~~Clock Generation~~
- Motion Controller
- ~~Beam Permit~~
- ~~MDAT Link~~
- Multiwire Controller
- Vacuum Interface
- ~~Other~~

Conceptual Design: Infrastructure using Commercial Backplane

- Provide common infrastructure to each AMC across backplane
  - Exploring the use of a custom secondary MCH to distribute common clocks and data buses on Fat Pipe ports
- Support high-speed ethernet for readout (40 GbE on Fat Pipe)
- Provide high-speed, low-latency links for AMC communication
  - to support advance automation and AI/ML applications
- Provide common debugging interface



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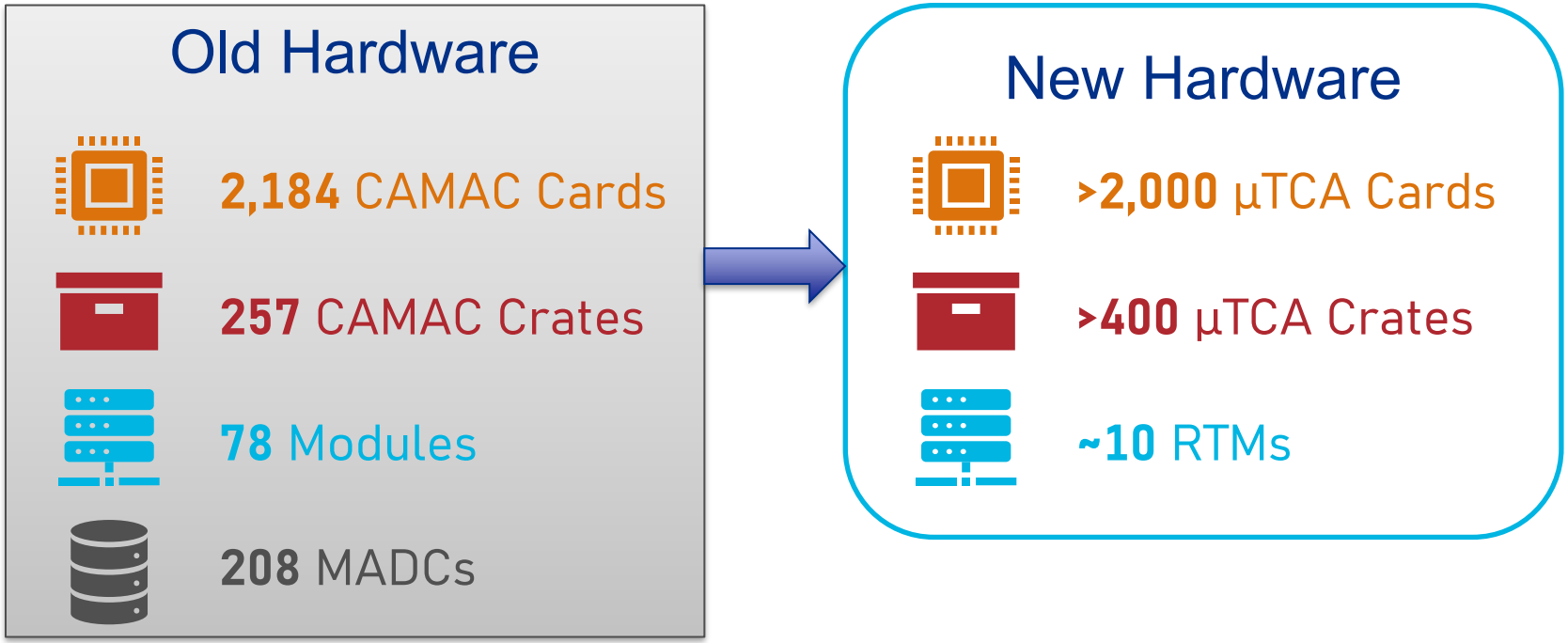
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