



# ACORN Project

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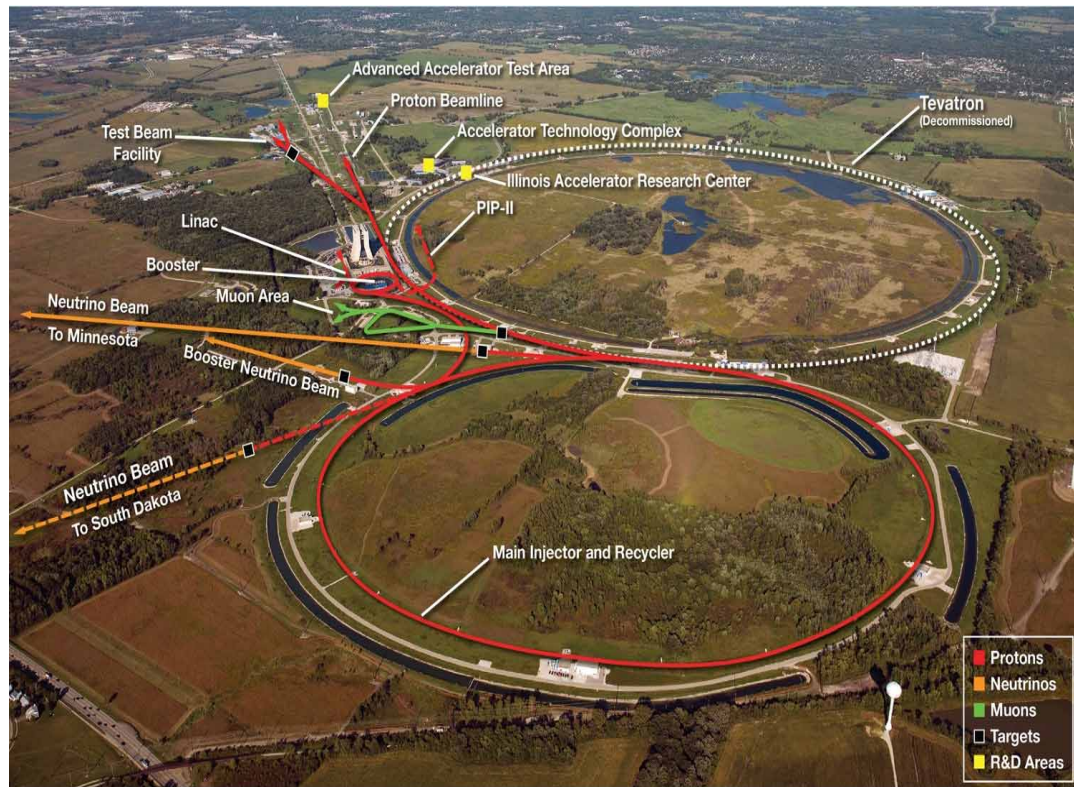
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# Accelerator Controls Operations Research Network (ACORN)

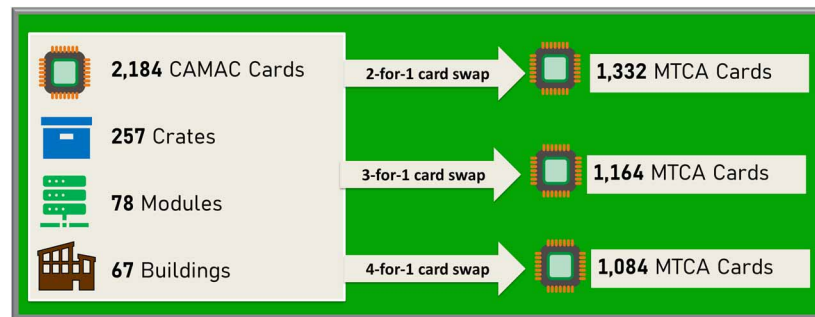
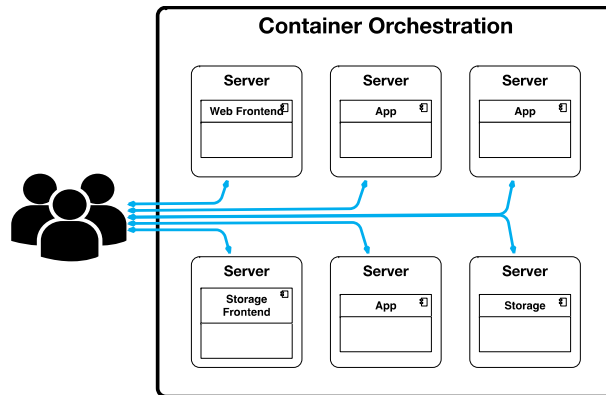
The ACORN Project is a Department of Energy (DOE) project that will modernize the laboratory's **accelerator control system** and replace end-of-life **accelerator power supplies**.

- 40-year-old control system
- 200,000 devices
- Several million lines of code
- Operating over 10 miles of accelerator and beam transfer lines.
- Project stage requires evaluating alternatives and estimating costs.
- Total Project Cost range: 100 – 142M\$



# Research and Development

- Rapid prototyping platform for R&D
  - Implementing Kubernetes
    - Consolidation of computing resources
    - Automatic scaling based on load
- Data Acquisition and Control R&D
  - CAMAC control system hardware replacement
    - Over 250 CAMAC crates
    - Over 2,100 CAMAC cards
    - Over 70 card types
    - Over 60 buildings
  - Assessing  $\mu$ TCA hardware
    - Evaluating card replacement strategies
    - Looking into MTCA.4 extension which adds rear I/O





# Collaboration

- Collaborating with other projects at Fermilab
  - Proton Improvement Plan II (PIP-II) minimally viable core application
    - Developing user acceptance plan
    - Fast feedback on design and process concepts for ACORN cost estimates
    - Define interfaces
  - AI research projects – requirements for the future
    - READS: Edge deployment on FPGAs to determine source of beam loss monitor signals in a shared beam enclosure
    - L-CAPE: Use anomaly detection to predict beam downtime in Linac
- Collaborating with other labs
  - Idaho National Laboratory Human Factors Team – Style guide
  - (Proposed) Argonne National Laboratory – Project and engineering support
  - (Proposed) Oak Ridge National Laboratory – Power supplies

## ACORN

Accelerator Controls Operations Research Network

Collaboration and R&D

October 2023

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### ACORN Overview

ACORN aims to modernize the Fermilab accelerator control system by replacing obsolete components. The project will integrate new capabilities into the existing accelerator control to enable the most intense high-energy beam of neutrons for the Deep Underground Neutrino Experiment at the Long Baseline Neutrino Facility (LBNF).

At the early stage in the project, the ACORN team is focused on control system R&D and on collaboration with other projects.

### Collaboration with PIP-II

In collaboration with the Proton Improvement Plan II (PIP-II) Project, the ACORN team is working with the PIP-II team to deliver a minimally viable core application (Proton Stage) to PIP-II stakeholders. The two teams are developing a user acceptance plan to validate that applications meet user requirements. For members of the ACORN team, this R&D enables fast feedback on design and process concepts that ACORN will use in developing one or more future project reviews. The collaboration also helps define interfaces for integrating PIP-II applications with future applications that will be developed by the ACORN team.

The experience from developing this application will give the ACORN team a basis of evidence for converting core applications from the legacy control system to the modernized control system. Approximately 800 legacy applications requiring several million lines of code are under consideration for conversion. The complexity of the conversion process requires accurate labor estimates to determine the amount of effort needed to modernize applications.

### Rapid Prototyping Platform for R&D

**Goal:** Create a reusable platform where concepts and tasks can be rapidly prototyped, tested, and evolved.

**Implementation:** Kubernetes, Ceph/Minio

- 6 nodes (large master) and 10 nodes (worker) cluster - v1.26.0
- Each node has:
  - 3x AMD EPYC 7763 3.0 GHz CPU
  - 240GB memory
  - 4x 100GbE network interfaces
  - 3x 7TB parallel file

**Core usage:**

- 10 TB NFS users
- 51 namespaces
- 20 LocalStorage (LVS)
- 17 CPU nodes on traffic
- 160 running pods


**Future:**

ACORN is proposing the use of Kubernetes for the production computing facility, allowing the consolidation of computing resources as well as providing automatic scaling based on load and other metrics.

### Data Acquisition and Control R&D

Fermilab's existing CAMAC control system hardware needs to be replaced. An R&D effort by the ACORN team is assessing the replacement of CAMAC hardware with uTCA hardware from the Integrated Experimental Physics and Accelerator Control System (IEXACS) capabilities into the modernized control system.

Fermilab's CAMAC hardware consists of over 250 CAMAC crates with over 5,000 CAMAC cards and over 70 card types and VME front-end crates. The CAMAC crates communicate with VME front-end crates through three CAMAC links.




The R&D is evaluating card replacement strategies and is looking into the uTCA ecosystem to the uTCA standard. uTCA 4 adapts the uTCA specification for several configurations by adding new IO, IO card re-cabling and a secondary crate. The ACORN team is planning a crate-for-crate replacement maintaining the current connectors to the CAMAC cards. However, to maintain the current crate density, a single uTCA card will be replacing multiple CAMAC cards.

### Collaboration with AI Projects

AI research projects at Fermilab push the limits of the existing control system and determine requirements for ACORN for the future control system.

- **READS:** Edge deployment on FPGAs to determine source of beam loss monitor signals in a shared beam enclosure.
- **L-CAPE:** Use anomaly detection techniques to predict beam downtime in the linear accelerator (Linac).

To ensure sustainable operations of AI control algorithms, the following ML Ops infrastructure will be supported by ACORN.



Supporting existing control system users that interact with modernized system changes by supporting the development of new control system components. We are also supporting the development of new control system components.

Fermilab National Accelerator Laboratory

Source: [Accelerator Controls Operations Research Network](#), October 2023