Phase I Electrical Infrastructure Assessment (Part 1)

- Existing Carriage Electrical Distribution
  - Building 1006 – ePIC
- 1006 Experimental Hall (off-carriage)
- 1006 AH (off-carriage)
- Rack Room
- Control Room
- Cooling Equipment
- Magnet Power Supply

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STAR/ePIC Carriage Infrastructure Assessment

Existing Electrical Infrastructure Review

Objective

- Document the existing carriage/platform electrical infrastructure.
- Capture historical knowledge from personnel familiar with the facility.
- Identify risks associated with reusing existing equipment.
- Establish a technical baseline before engineering and design begins.

Information Sources

- Existing drawings
- Field walkdowns
- Historical documentation
- Electrical Safety Subject Matter Experts
- Senior Electrical Engineers
- Previous detector personnel

Discussion Topics

Information Requested

Grounding

- NIS Isolated Ground System
- Ground Detection System
- Building 1006 Ground Grid
- Original grounding philosophy

Electrical Distribution

- Main carriage distribution
- Transformer documentation
- Magnet power supply drawings
- Existing one-line diagrams

Mechanical

- Platform modifications
- Detector clearance
- Cryogenic equipment

Codes / Standards

- Code of Record
- Future maintenance philosophy
- Equipment replacement strategy

Not Included

❌ Future detector loads
❌ Arc Flash Study
❌ Short Circuit Study
❌ Protective Coordination
❌ Voltage Drop Analysis
❌ Load Flow Analysis
❌ Controls

❌ Controls
❌ Load Flow Analysis

Grounding / NIS Isolation Ground System

- Looking for any documentation, drawings, or information on the NIS isolated grounding system and the ground detection system.
- Action: If anyone has drawings, reports, or background information on the NIS isolated ground or ground detection system, please send them my way so I can start getting up to speed.

Building 1006 Main Grounding System

- We discussed trying to locate drawings showing the Building 1006 grounding system.
- **Action:** Continue searching for original grounding and plant electrical drawings for Building 1006

Main Magnet Power Supplies

- We also discussed finding documentation and drawings for the **main magnet power supplies**.
- If anyone has access to Windchill or knows where these drawings are archived, it would be helpful to locate them.

Detector Platform

- Need to reach out to the mechanical group regarding possible modifications to the detector platform.
- Since the new detector diameter is expected to be larger, we'll need to understand whether portions of the platform will need to be cut back or modified.

Codes, Standards & Long-Term Design Philosophy

- What electrical code and standards should become the project's Code of Record.

EIC Requirements, Specifications, and Interfaces
Code of Record
September 4, 2025

NFPA 70 (1)	2023	National Electric Code (design/purchase)
NFPA 70E	2021	Electrical Safety in the Workplace

Note (1): In May of CY2022, BHSO approved BSA's request to use NFPA-70 (2020) and later editions solely for the design of new facilities and equipment and the purchase of new electrical equipment.

- Use the latest available code editions when detailed design starts, unless there is a good project reason to stay with the existing Code of Record.
- Once detailed design begins, lock in those code editions as the project's Code of Record.
- Keep an eye on future code updates during design and construction.
- Only bring in newer code requirements if they provide a clear safety or technical improvement and the impact to cost and schedule makes sense.

Question: Should the project reevaluate the electrical Code of Record before detailed design to determine whether later editions of NEC and NFPA 70E should be adopted, given the long design and operational timeline?

NEC Future Updates …

For example: Enclosure Doors & Minimum Egress Width

Clearance requirement remains 24" wide by 6½' high.

NEC 2023

"Right Now"

Evaluates room clearance based strictly on doors that are **physically open at the moment of inspection**.

The Loophole: Keeping doors closed passed inspection—even if swinging them open during future work would trap an electrician.

NEC 2026

"Worst-Case" Test

Evaluates clearance based on doors that **can be opened 90 degrees** during future servicing.

The Fix (Added 10 Words): *"...when such doors are or can be opened 90 degrees."* Guarantees a safe exit during actual maintenance.

The message = We must always maintain at least 24 inches of clear walkway width, assuming panel doors are fully swung open to 90°.

Designing to the latest standards is better

If the Preliminary Design Review (PDR) is in **2027 or later** and the facility will not be commissioned until **2032**, designing to the latest editions can provide benefits:

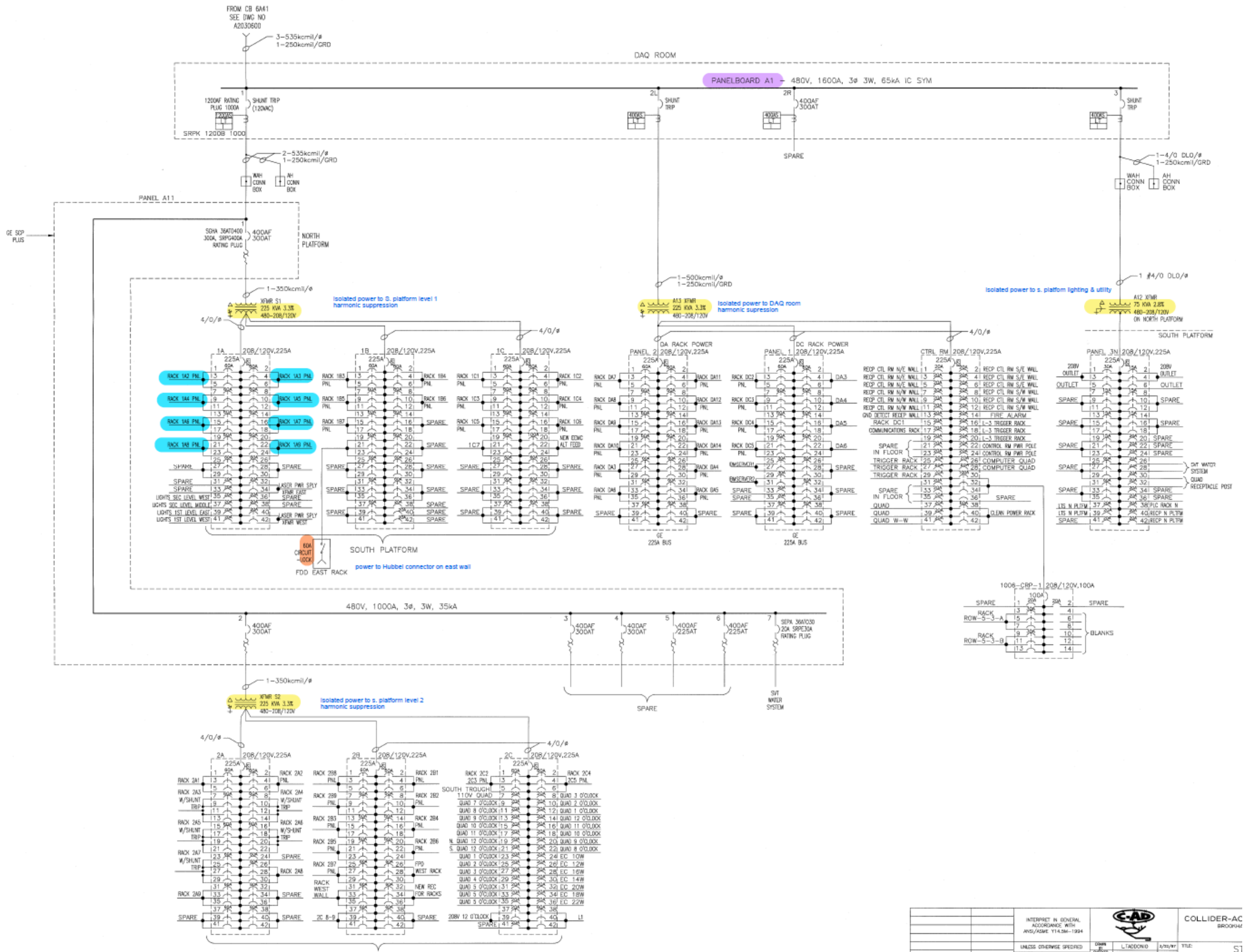
- **Improved safety.** New editions of the NEC and NFPA 70E often incorporate lessons learned from incidents, new technologies, and improved safety practices.
- **Reduced redesign later.** If codes change significantly during final design or construction, designing to an older edition may require engineering changes, drawing revisions, procurement changes, and rework.
- **Better compatibility with modern equipment.** Manufacturers increasingly design equipment around newer code requirements.
- **Simpler acceptance by AHJs and DOE reviewers.** Reviewers frequently ask why an older code edition was used when newer requirements were available.
- **Long-term maintainability.** Maintenance personnel will likely be working under the latest safety standards by 2035, even if the equipment was designed to an older code.

Existing Electrical Infrastructure

Questions being evaluated

✓ What exists today?
✓ How old is the equipment?
✓ Is it still supported?
✓ Was maintenance performed?
✓ Can replacement parts still be obtained?
✓ Has the equipment been exposed to radiation?
✓ Is the equipment reliable enough for another detector lifecycle?

Existing Carriage Power Distribution



Panel A1

↓

WAH Connection Box

↓

AH Connection Box

↓

Panel A11

↓

Transformers

↓

208V Distribution Panels

Panel 3N (Dirty Power XFMR)

225 kVA Transformer Assessment

Primary

480 V

Calculated Full Load

271 A

Installed Breaker

300 A

Three-phase transformer current:

$$I_p = \frac{kVA \times 1000}{\sqrt{3} \times V_p}$$

Substitute:

$$I_p = \frac{225{,}000}{1.732 \times 480}$$

$$\boxed{I_p = 271A}$$

Primary Conductor Ampacity Assessment

Existing Primary Conductors:

Size: **350 kcmil**

Quantity: **Verify field condition**

Material: Assume copper

Temperature rating: Assume 75°C terminals

NEC ampacity:

350 kcmil Copper:

(NEC 2020 Table 310.16)

Temperature Rating	Ampacity
75°C	~310 A
90°C	~350 A

✓ **310A > 271A**

Transformer Primary Overcurrent Protection

Per NEC Article 450.3(B), transformer primary overcurrent protection can generally be sized up to:

FLA = KVA / 1.73X V = 225000/(1.732×480) = 271 A

271A×1.25=339A

...next standard overcurrent device size above 339A would be **350A (installed breaker = 300A)**

Note 1 to Table 450.3(B) in the National Electrical Code (NEC) grants special permission to "round up" to the next standard size of fuse or circuit breaker

Feeder Impedance

Conductor impedance values for 4/0 AWG Copper, 75°C

R=0.066Ω/1000ft

For 50 ft => $R = 0.00330\Omega$

Reactance

40 ft PVC =>$X_1 = 0.083\Omega/1000ft \times 40 = 0.00332\Omega$

10 ft Cable Tray => $X_2 = 0.095\Omega/1000ft \times 10 = 0.00095\Omega$

Total => X=0.00427Ω

Magnitude => $Z_F = \sqrt{R^2 + X^2} = \sqrt{0.00330^2 + 0.00427^2}$
$Z_F = 0.00540\Omega$

The feeder impedance is added to the transformer impedance.
$Z_{TOTAL} = Z_T + Z_F$
$= 0.00635 + 0.00540 = 0.01175\Omega$

Available Fault Current

At the panel:

I_{SC} = 208 / $\sqrt{3}$ X 0.01175 =10220 A

Location	Available Fault Current
Transformer Secondary	**18.9 kA**
Panel Main Breaker	**10.2 kA**

- Installed breaker interrupting rating 10K AIC
- Calculated available fault current 10.2 K A
- Since10.2K A >10 K A the available fault current slightly exceeds the breaker's interrupting rating.

Unknown Maintenance Condition

Without documented records, it is difficult to verify whether equipment has received recommended activities such as:

- Infrared inspections
- Insulation resistance testing
- Breaker exercising
- Protective device maintenance
- Torque verification
- Cleaning
- Functional testing

Parts (replacements?)

Expected Life Cycle 20- 30 years

Equipment Reliability / Radiation
Expected Life Cycle 20- 40 years

Long-term concerns:

- The availability of spare and replacement parts.
- Whether existing equipment can still be validated, tested, refurbished, or recertified in the future.
- The risk of continuing to rely on electrical infrastructure that was manufactured in the 1990s, has operated for roughly 25 years, and has been exposed to a low-dose radiation environment.
- The possibility that a failure of a transformer, panel, breaker, or other major distribution component could lead to a much larger and more expensive outage than simply replacing the equipment today.
- The reality that if a major component fails years from now, replacement parts may no longer exist, forcing us to replace entire sections of the electrical distribution system and potentially causing significant downtime for detector operations.

More…

- Which equipment is still supported by the manufacturer, and what is already becoming obsolete?
- What should our replacement philosophy be for equipment that may no longer be manufactured in the future?
- Should we incorporate NFPA 70B recommendations into our long-term maintenance strategy?
- How do we maintain and support electrical equipment that could remain in service for the next 20–30 years?

Equipment Reliability / Radiation

NEC Considerations Existing Installation

The existing infrastructure was designed and installed under codes applicable at that time.

Engineering questions:

- Should equipment remain under the original Code of Record?
- What modifications require compliance with the current NEC?
- Are replacement parts still listed?
- Are existing assemblies still supported by manufacturers?

Future Obsolescence Risk

Equipment Availability

Potential concerns:

- Obsolete circuit breakers
- Obsolete trip units
- Discontinued shunt trip coils
- Unsupported transformer accessories
- No manufacturer spare parts
- Long replacement lead times

Example

A breaker failure in an obsolete switchboard may require:

- Custom retrofit
- Field engineering
- Replacement of an entire lineup rather than replacing a single breaker.

NFPA 70B
Maintenance Standard

NFPA 70B - Standard for Electrical Equipment Maintenance

Recommends:

- Preventive maintenance program
- Inspection intervals
- Testing intervals
- Condition-based maintenance
- Documentation of maintenance history
- Without maintenance records:
- Remaining equipment life becomes uncertain.
- Reliability predictions become difficult.
- Unexpected failures become more likely.

Testing vs Replacement Engineering Decision

Option 1 / Test and reuse

Advantages

- Lower initial cost

Risks

- Unknown remaining life
- Potential hidden degradation
- Future failures
- Obsolete replacement parts
- Higher lifecycle cost

Option 2 / Install new infrastructure

Advantages

- Higher reliability
- Manufacturer support
- Available spare parts
- Current technology
- Lower maintenance risk
- Better long-term support

Higher initial capital cost /Lower lifecycle risk

Risk Assessment

Risk	Impact
Equipment aging	High
Unknown maintenance history	High
Radiation exposure	Medium
Obsolete parts	High
Breaker failure	High
Long repair outage	High
Future detector downtime	High
Increased maintenance costs	High

Supporting Standards

- **NFPA 70 (NEC):** Provides requirements for the safe installation of electrical systems. Existing installations may remain under their original Code of Record, but new work and modifications generally need to comply with the applicable adopted edition.
- **NFPA 70B:** Recommends preventive maintenance, testing, documentation, and condition-based maintenance practices to improve equipment reliability and reduce failures.
- **NFPA 70E:** Requires employers to establish electrically safe work practices, maintain equipment in a condition that supports safe operation, and assess hazards before work is performed. While 70E is primarily a worker safety standard, poor equipment condition can increase electrical safety risks during operation and maintenance.

Phase II Roadmap:
Carriage Power Distribution Development - More Information Required…

Phase 2 Work Activities

1. Gather Detector and Load Information - Information Required from Detector Teams
   - Goal - Preliminary carriage electrical load schedule.
2. Develop the Carriage/Platform Power Distribution
3. Existing Infrastructure Verification (Can Proceed in Parallel)
4. Engineering Verification
   - Electrical engineering assessment and design recommendations (In-progress)

5. Develop the Final Carriage Distribution Design