DUNE PD QA/QC, Tracking, and Databases

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DUNE Photon Detector Review
November 12, 2018

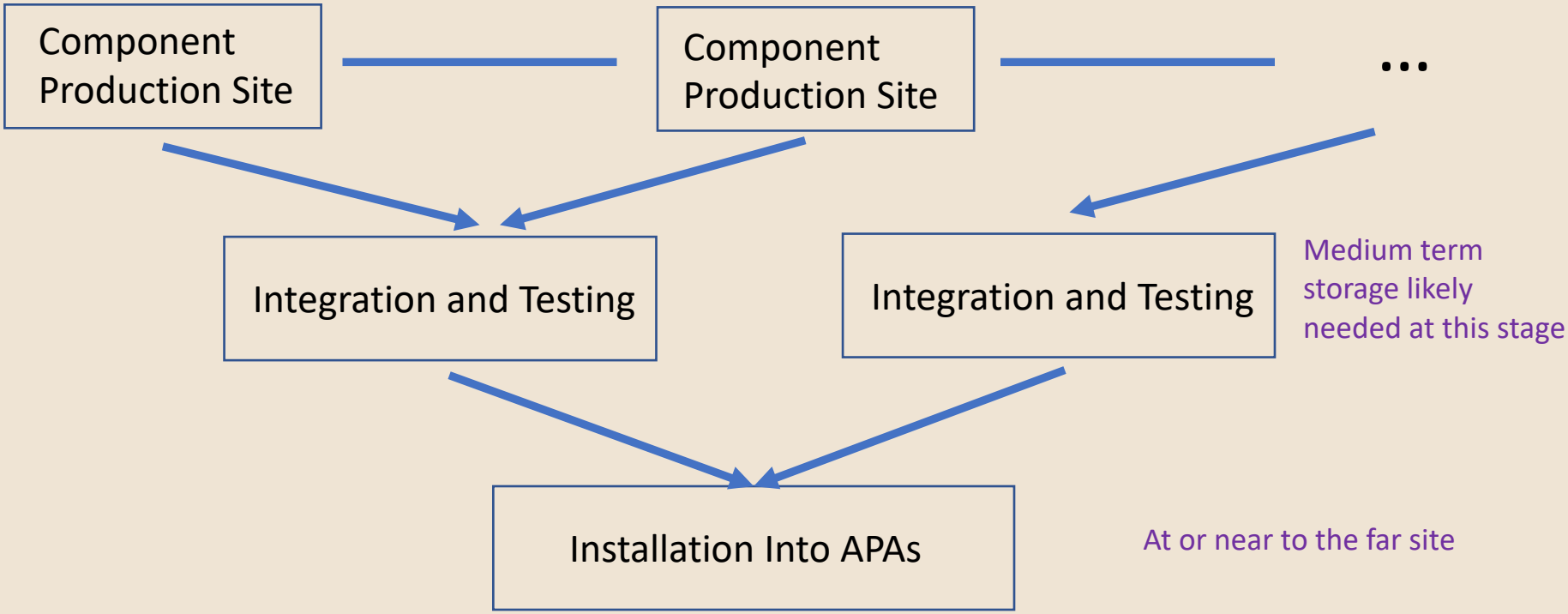
Overview

The DUNE Photon Detectors will be built from components produced or procured at a number of institutions – international and in the US

- Quality assurance (QA) will be undertaken for each component, as well as the full PD modules, resulting in the quality control procedures that will be employed for both.
- All component history must be carefully tracked and documented through installation
- Our experience with protoDUNE will guide the approach taken.
- The DUNE PD integration working group will oversee the QA/QC process

PD Fabrication and Installation

For DUNE the situation will be more complicated – although similar in design, with some additional challenges.



Component Production

Each of the production (or procurement) sites will be responsible for QA and QC as well as tracking and documentation

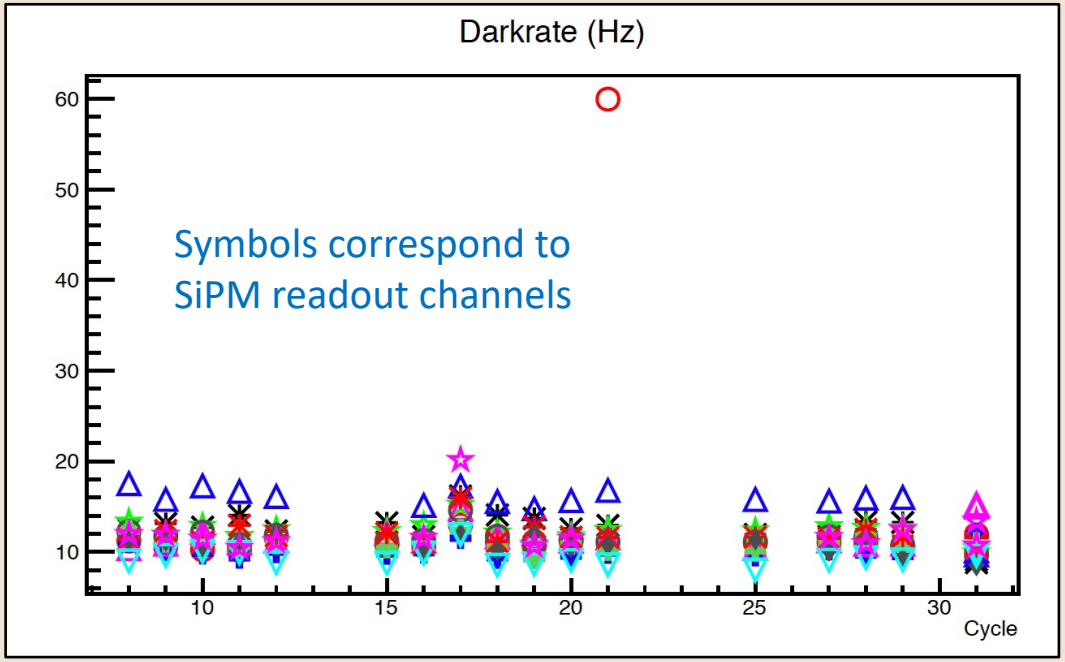
Components (X-Arapuca)

- Filter plates
- WLS plates
- X-Arapuca “boxes”
- MPPCs
- MPPC Mounting boards
- Active ganging boards
- Readout electronics
- Calibration components
- Cables/Connectors

A QA program will be developed for each component based on the mechanical and performance requirements for the system.

Component QA Example (SiPM Thermal Cycling)

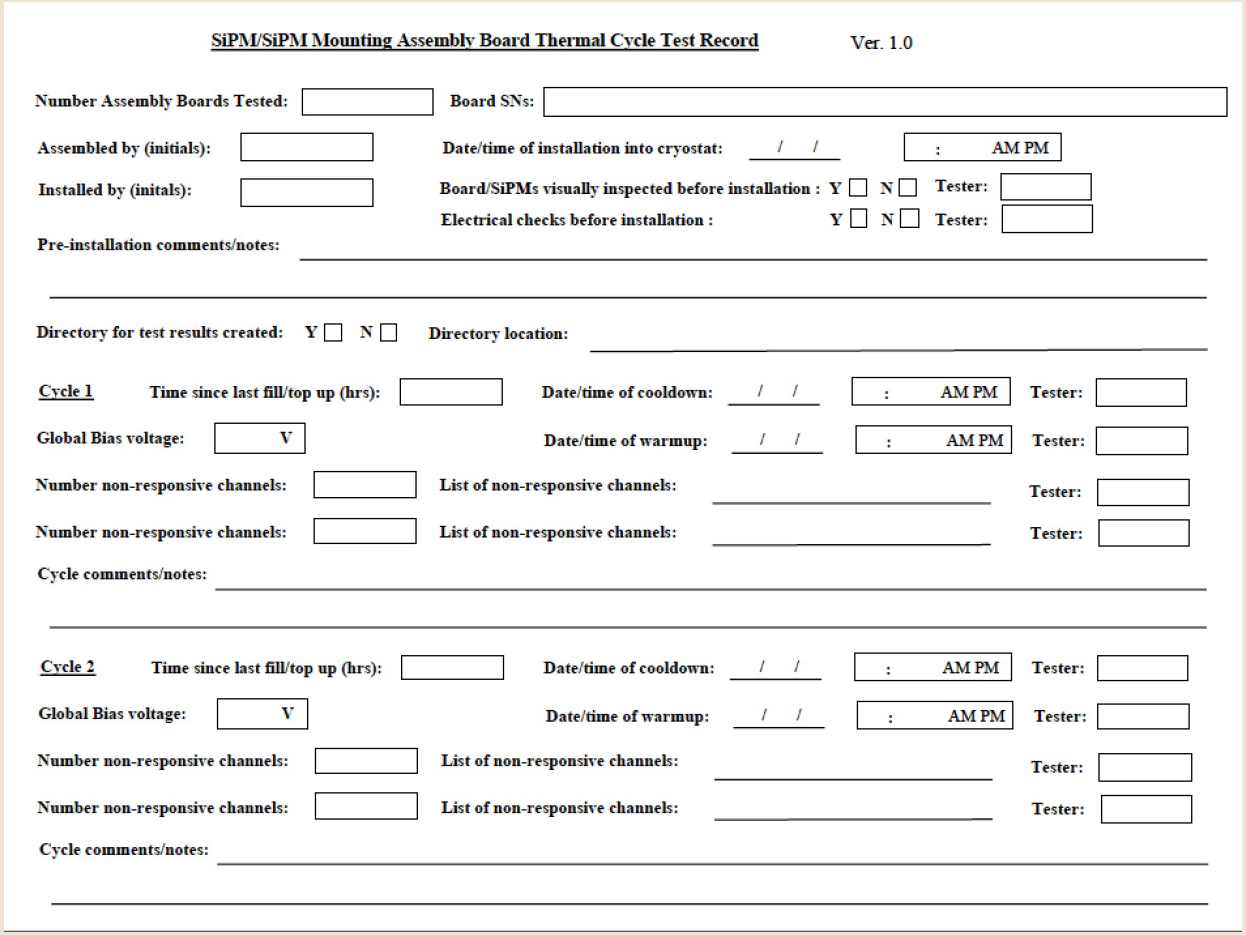
As part of the quality assurance program, for the protoDUNE SiPMs and mounting boards large numbers of thermal cycles were performed on a large number of devices - O(100s)



Determined SiPM operating parameters were not sensitive to 20+ thermal cycles.

Led to discovery of component failure at LN temperature resulting from change in vendor packaging process.

Component QA Example (SiPM Thermal Cycling)



SiPM/SiPM Mounting Assembly Board Thermal Cycle Test Record Ver. 1.0

Number Assembly Boards Tested: ☐ Board SNs: ☐

Assembled by (initials): ☐ Date/time of installation into cryostat: / / ☐ : ☐ AM PM

Installed by (initals): ☐ Board/SiPMs visually inspected before installation : Y ☐ N ☐ Tester: ☐

Electrical checks before installation : Y ☐ N ☐ Tester: ☐

Pre-installation comments/notes: ☐

Directory for test results created: Y ☐ N ☐ Directory location: ☐

Cycle 1 Time since last fill/top up (hrs): ☐ Date/time of cooldown: / / ☐ : ☐ AM PM Tester: ☐

Global Bias voltage: ☐ V Date/time of warmup: / / ☐ : ☐ AM PM Tester: ☐

Number non-responsive channels: ☐ List of non-responsive channels: ☐ Tester: ☐

Number non-responsive channels: ☐ List of non-responsive channels: ☐ Tester: ☐

Cycle comments/notes: ☐

Cycle 2 Time since last fill/top up (hrs): ☐ Date/time of cooldown: / / ☐ : ☐ AM PM Tester: ☐

Global Bias voltage: ☐ V Date/time of warmup: / / ☐ : ☐ AM PM Tester: ☐

Number non-responsive channels: ☐ List of non-responsive channels: ☐ Tester: ☐

Number non-responsive channels: ☐ List of non-responsive channels: ☐ Tester: ☐

Cycle comments/notes: ☐

Documentation/Traveler used for SiPM and mounting board testing.

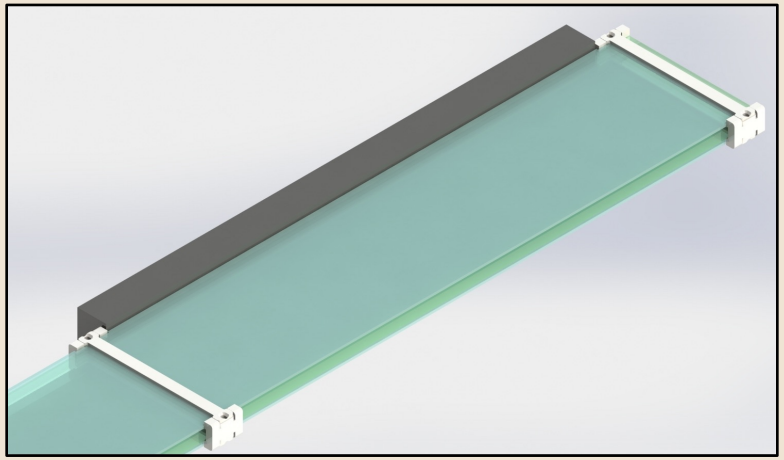
Each testing form was scanned into electronic format and the paper forms stored as well. Additionally the SiPMs were all photographed before and after testing.

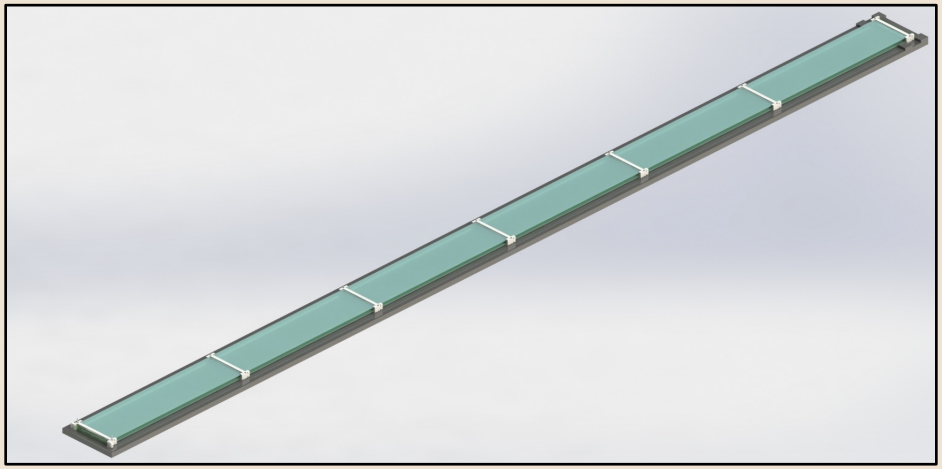
Component Quality Control

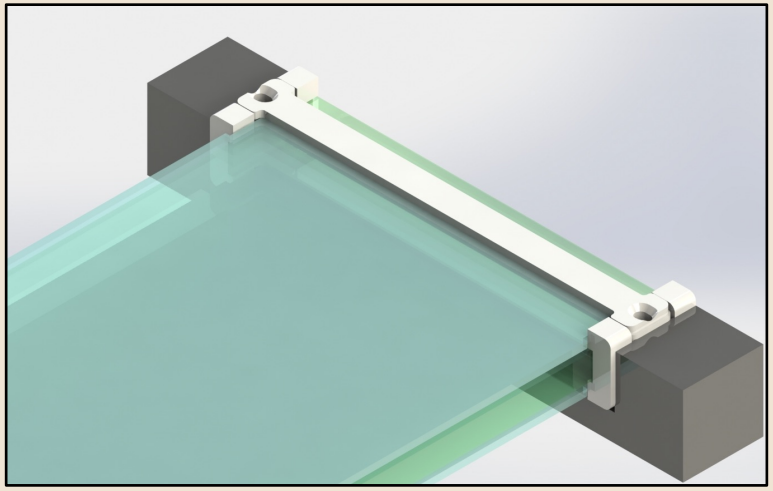
Once each component has been fabricated or procured it will undergo QC testing prior to being shipped off for PD assembly.

- QC testing based on requirements
  - Mechanical tolerances
  - Performance requirements
- Test results from QC procedures must be stored and traceable to the component
- Hardware database will contain the QC test results along with other information specific to the component (batch, SN, date of procurement, etc…)

Component Quality Control Example







Go No-Go gauges (Solidworks models)

Board ID:	WLS Bar ID:	Tester:	Test Date:
Radiator Plate ID:		Height:	
1:		Go	
2:		No Go	
3:		Width:	
4:		Go	
5:		No Go	
6:		Spacing:	
7:		Go	
8:		No Go	
9:		Overall Length:	
10:		Go	
11:		No Go	
12:			

QC testing results part of traveler.

Component Handling/Tracking Procedures

Each component will be tracked from procurement or during fabrication and forward.

- Paper travelers will remain with the component through to installation
- Each step will be documented, including dates/times, serial number(s) and personnel involved, along with description of what was done or test results
- Once travelers are completed, or prior to shipping to the assembly facility, they will be scanned so that an electronic version exists. These will be stored in the hardware DB.
- All QC test results will be entered into the hardware and QC testing DB.
- A final sign-off approval will be required at each component site prior to the components being shipped to the PD assembly site.
- A visual inspection of the components will be made at the assembly site prior to assembly into PD modules.

Photon Detector Module Handling and QC

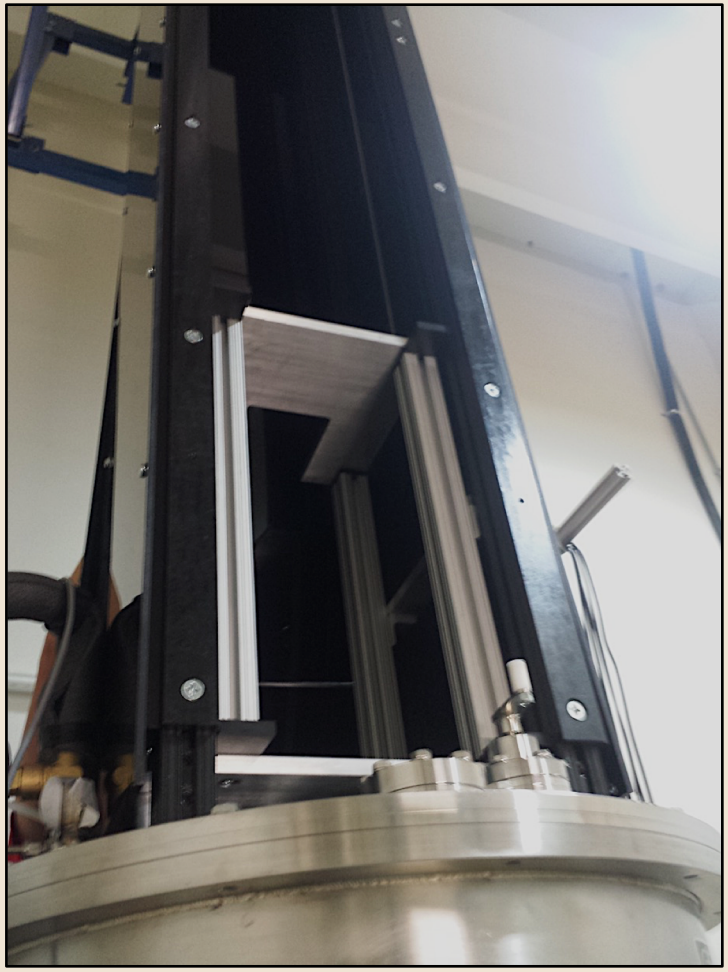
As each PD module is assembled the travelers for all components are collected and kept with that module through to installation into an APA. The scanned documents will also be combined into a single file for that module.

- Tracking and documentation of modules will be identical to that of the components.

Quality control testing will be performed on each module prior to the module being packaged for storage and shipping to the integration and test facility.

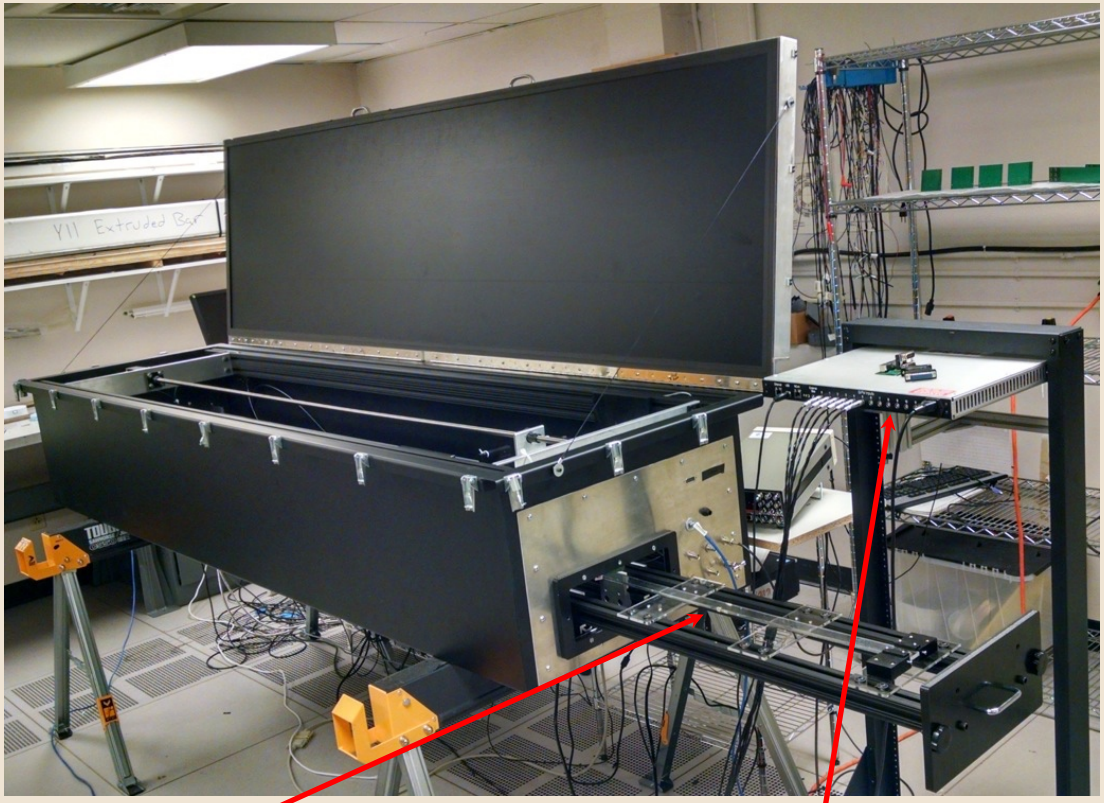
- A test of basic operation of the module through a cold cycle will be performed to ensure all mechanical and electrical connections are maintained.
- An optical scan of the module in a warm (room temperature) dark box will be performed.
  - This test will be performed at the installation and test facility prior to installation into an APA.
  - Results will be compared with those from the assembly site to ensure that no significant changes have taken place.

Full PD Thermal Cycle QC Testing



Mechanical test apparatus for mechanical tests of up to 4 PDs in LN2 (500 l dewar at CSU)

Full PD QC Scanning with LEDs

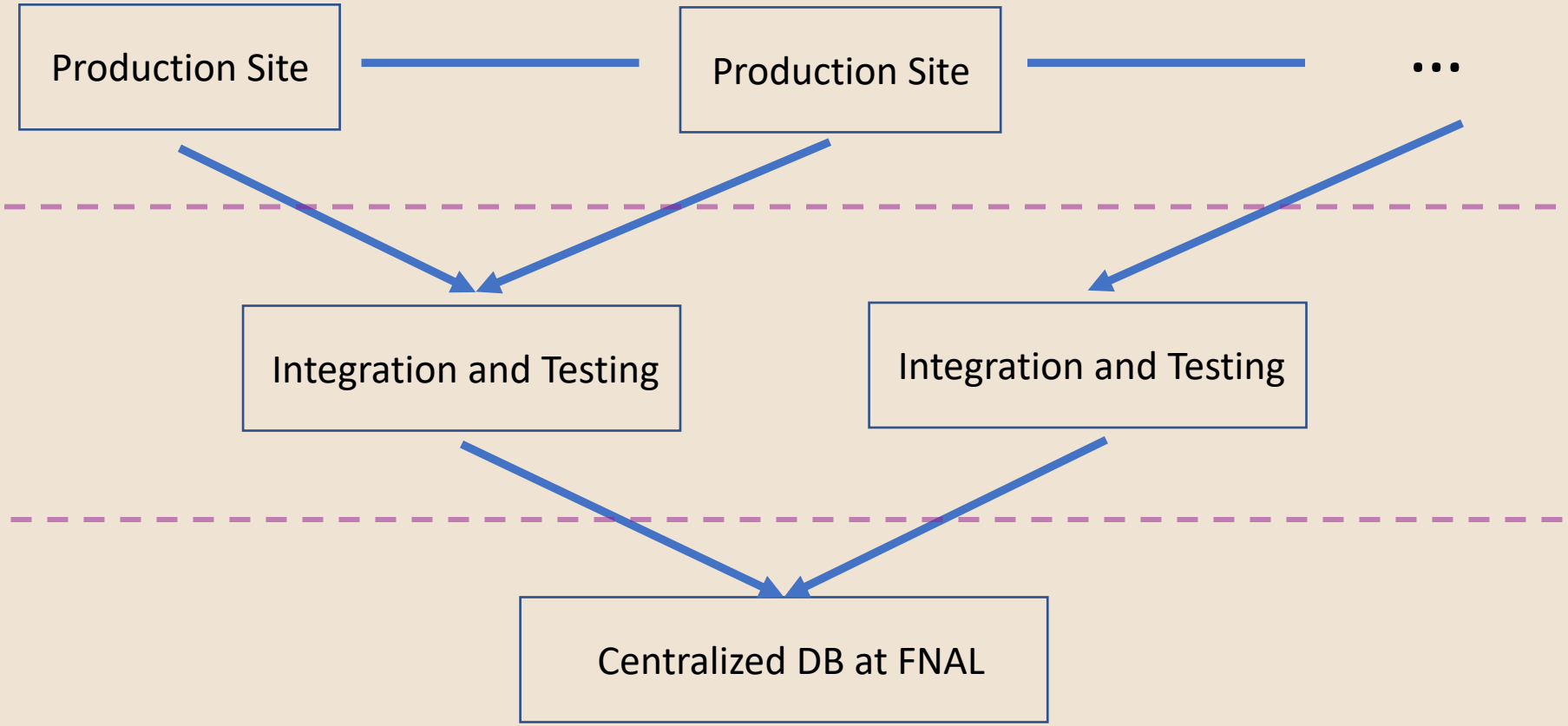


Scanner used for QC scans of PDs for protoDUNE.

Additional scanner(s) will be located at integration and test facility.

Hardware Database General Structure

For DUNE the situation will be more complicated – although similar in design, with some additional challenges.



Hardware/QC Database

While the centralized Hardware/Installation DB will reside at Fermilab, there needs to be planning for what happens at the Production and Integration and Testing sites.

It is conceivable that there may be 3rd party database and inventory solutions used at the production sites.

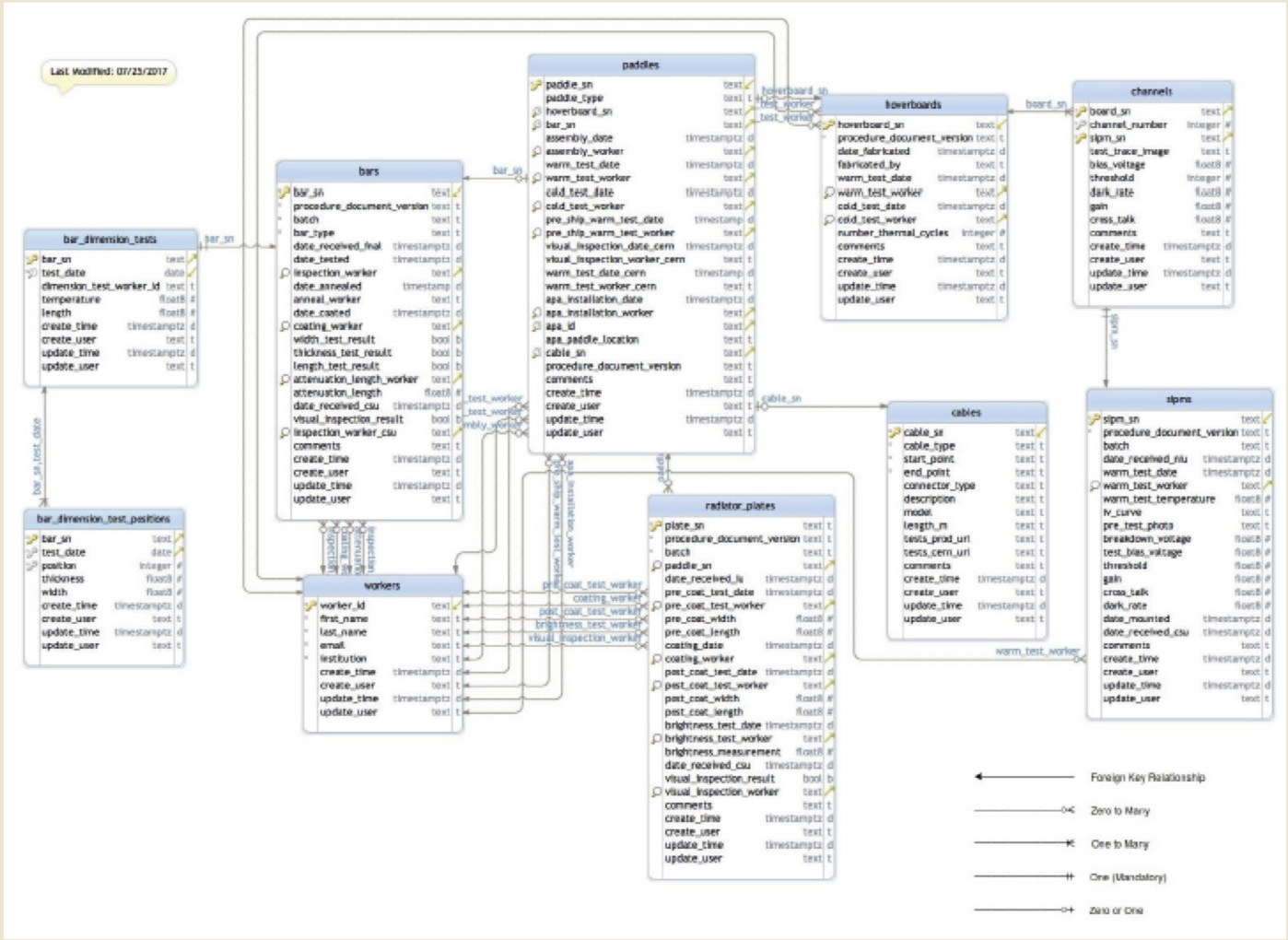
It will be critical to have involvement of the integration groups for the relevant consortia take a role in organization here.

We need to develop a set of requirements for how the various databases operate at the different tiers of the experiment.

One valuable lesson learned from the protoDUNE experience is that a plan for getting information from the production sites into the must be planned for well in advance to ensure success.

Hardware QC Database

Example Schema – photon detector for SP protoDUNE (relatively complicated)



Hardware QC Database

Due to the complex nature of the schema a lot of though was invested in providing the best infrastructure for the PD group

A tool was developed for transferring the component-level data into the appropriate tables.

- Takes csv files in subcomponent directories as input
- Checks for record key before pushing (will update existing records)
- Checks performed to ensure all relationships are correct (required entries are present across subcomponents).
- A web interface is also available for updating the tables if needed.
- It is expected that a similar approach will be used for DUNE

Summary

- Based on experience from protoDUNE a plan for QA/QC at both the component and full PD module level.
- Tracking of components will be handled in both paper (traveler) and electronic form.
- All QC results will be stored in a hardware/QC database with all metadata related to the PD module, including corresponding component-level information. Will utilize the same approach was was used for protoDUNE.
- The photon detector integration working group will oversee all QA/QC , tracking, and PD hardware-related databases.