Quality Assurance, Control, and Tracking

Norm Buchanan
Norm.Buchanan@ColoState.edu

Photon Detector Review
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Outline

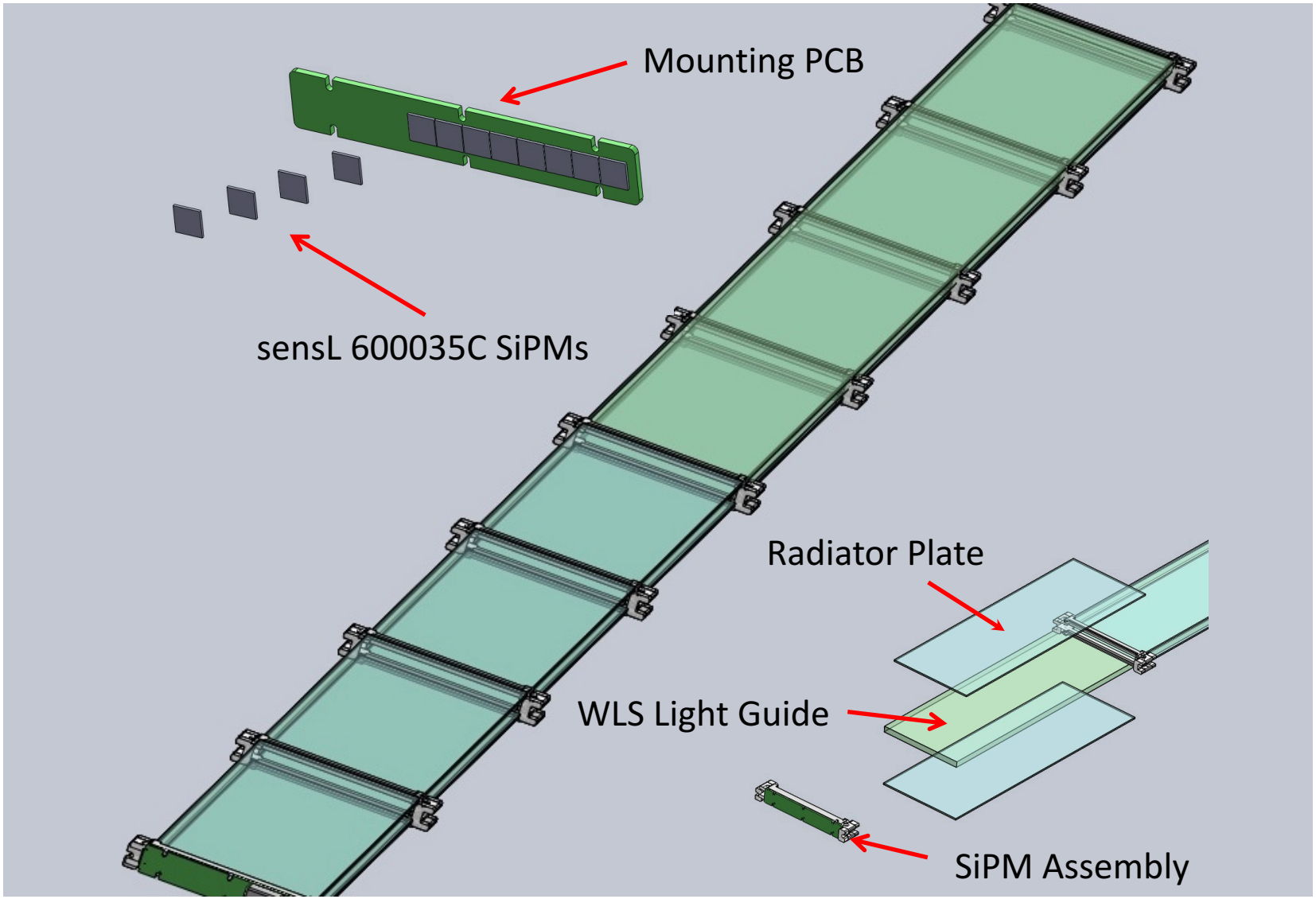
- Overview
- Quality Control
- Travelers
- Hardware Database
- Summary

QC Overview

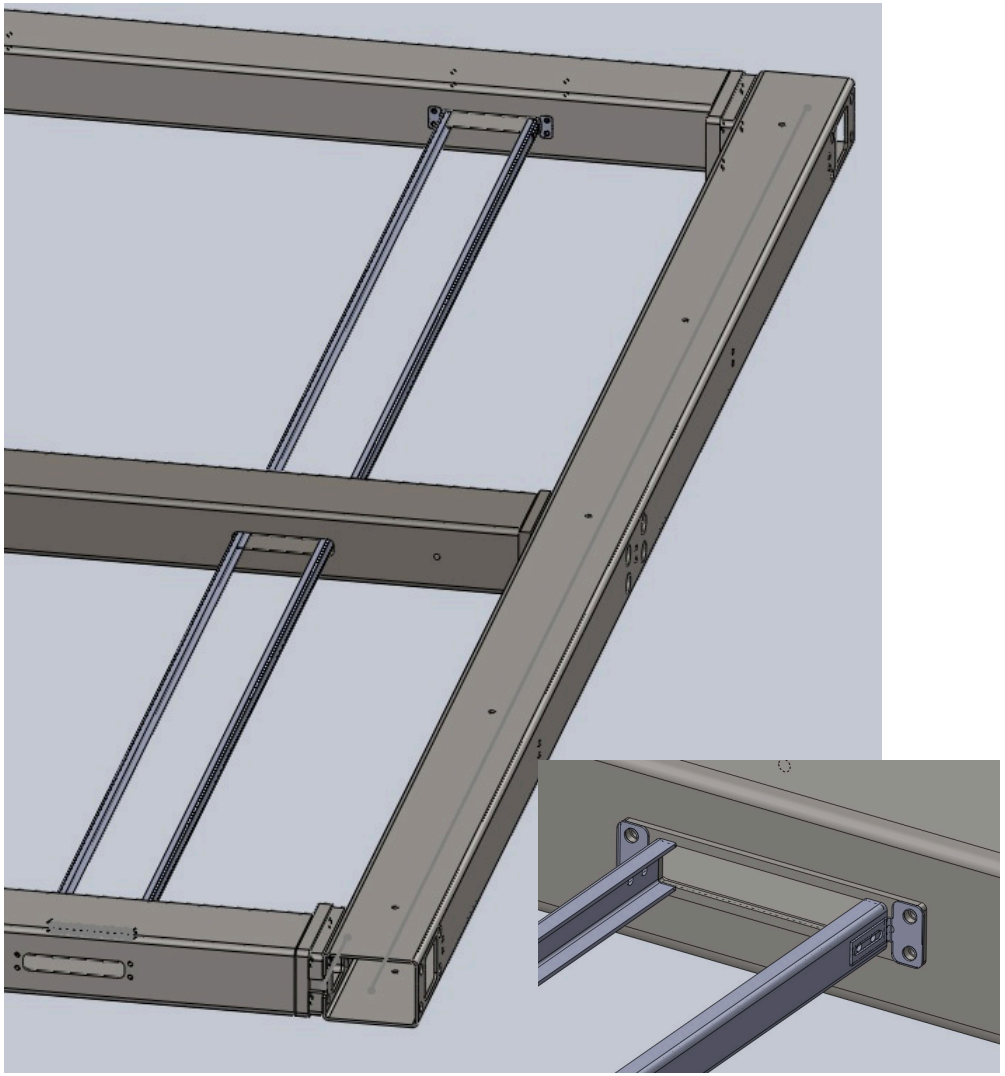
- Many individual components fabricated/acquired at multiple institutions
- Component quality control will be handled at institution of component origin
  - SiPMs (NIU)
  - SiPM mounting board assemblies* (NIU)
  - Bars (uncoated – IU), (coated – FNAL)
  - Radiators (IU)
  - SSPs and SSP calibration modules (ANL)
  - Cables (ANL)
  - Calibration components (ANL)

*CSU will be fabricating the boards which will be tested at NIU

PD Module (IU version) Design



Photon Detector (Module) Quality Control



Photon Detector (Module) Quality Control

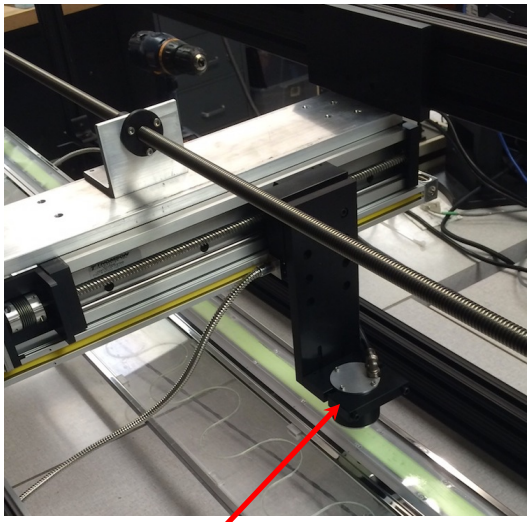
Upon receipt of PD components at CSU they will be unpacked and visually inspected

- Appropriate environmental conditions will be be maintained (eg. UV filters)
- Tracking and careful logging will be maintained – component travelers will be collected and added to tracking documents for the corresponding PD module
- Any components exhibiting visible damage or abnormalities will be set aside and investigated with responsible institution to ensure procedural problems corrected.

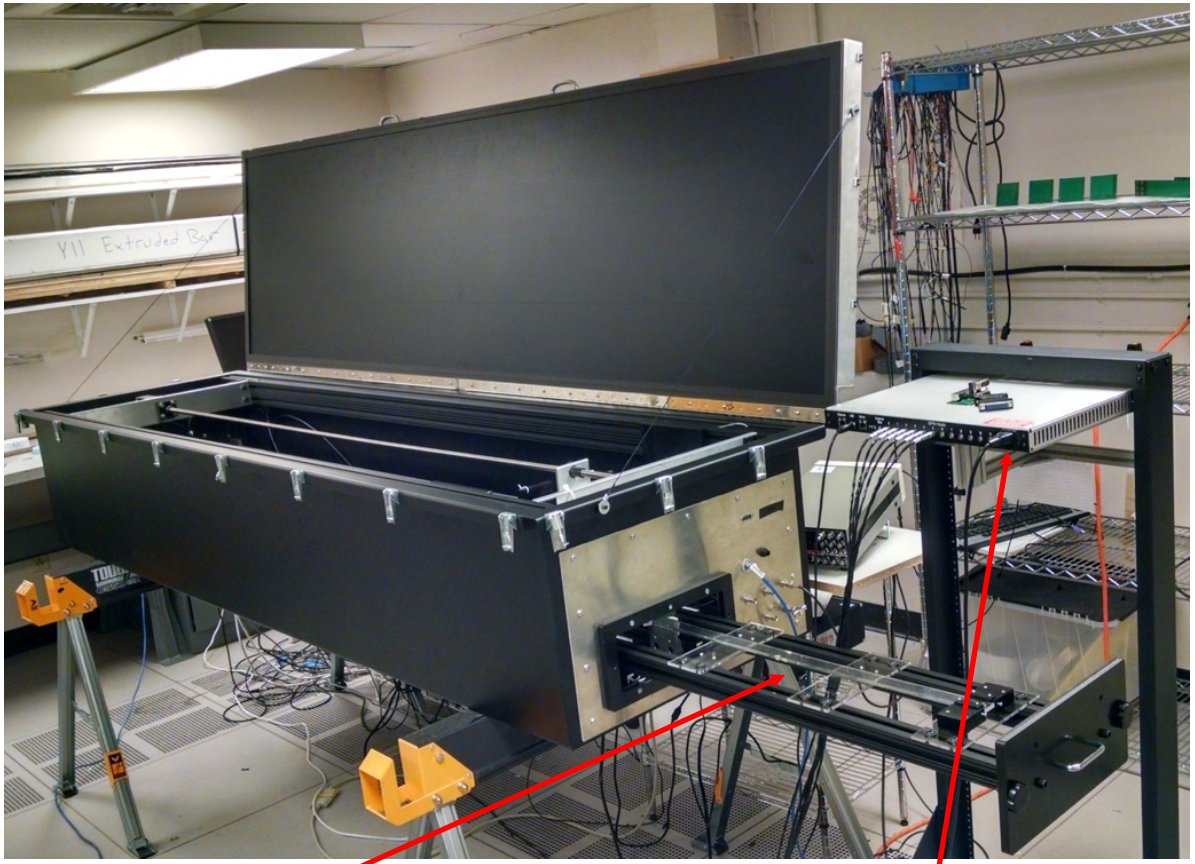
Once components have been received and inspected the PD module(s) will be assembled (see Warner talk)

- Tests of mechanical tolerances will be performed at this time (PDs will be inserted into testing frame for this)

CSU Module Scanner (Warm)



128 nm source



PD insertion drawer
– holds 2 PDs

SSP for readout

Photon Detector (Module) Quality Control

Assembled PD module will then be inserted into “warm” GAr tester (at CSU) for basic operation testing

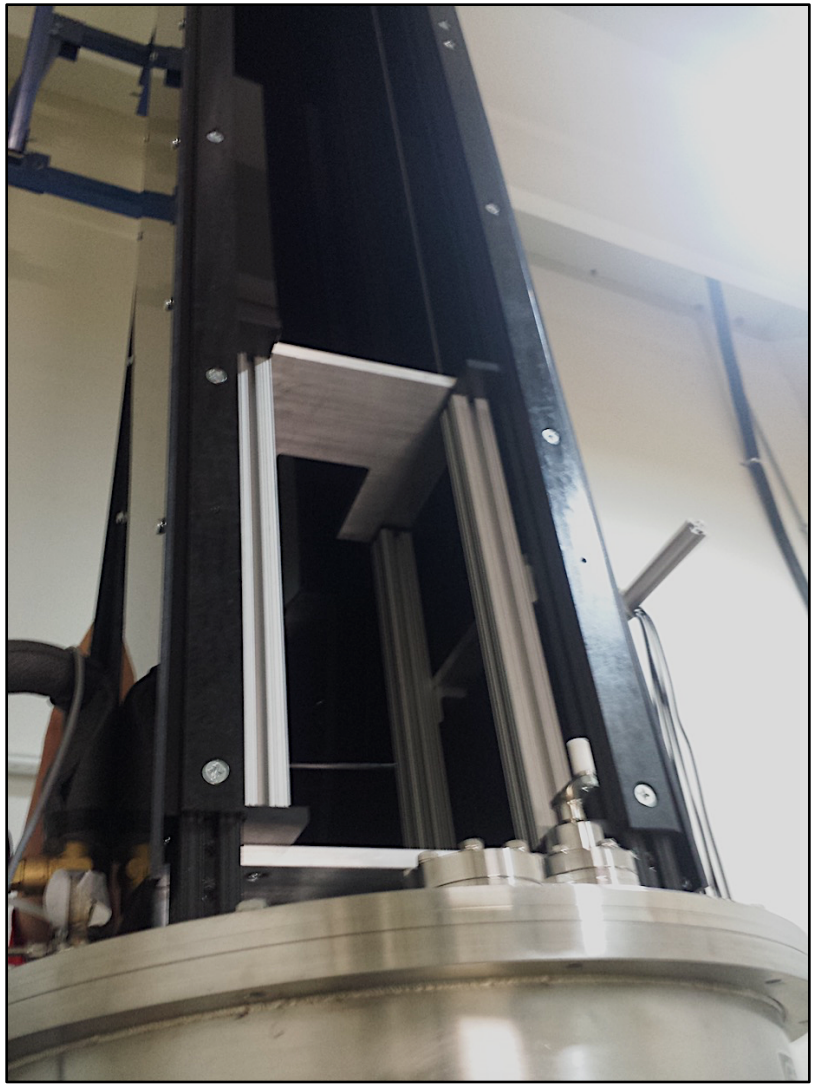
- PDs will be scanned (in x,y) with 128 nm source
- Tests will verify SiPM operation and channel connectivity

Following the warm scanner tests the assembled modules will be immersed in LN2

- Performed vertically in the CSU 500 l test dewar
- Test to ensure all mechanical and electrical connections for the PD maintain integrity through thermal cycle
- Only full PD cryo test prior to installation in protoDUNE (or far detector)
- PDs will be read out for basic operation during this test

PD Tests in 500 l (2.5 m) Dewar

Mechanical test apparatus for mechanical tests of up to 4 PDs in LN2 bath



Photon Detector (Module) Quality Control

Following cold test PDs again tested for operation in warm scanner prior to shipping to CERN.

PDs unpacked and visually inspected upon arrival at CERN

PDs tested for operation in warm scanner prior to installation in APAs

- Duplicate version of warm scanner will be used at CERN

Once PDs are installed in APAs basic electrical checks will be made

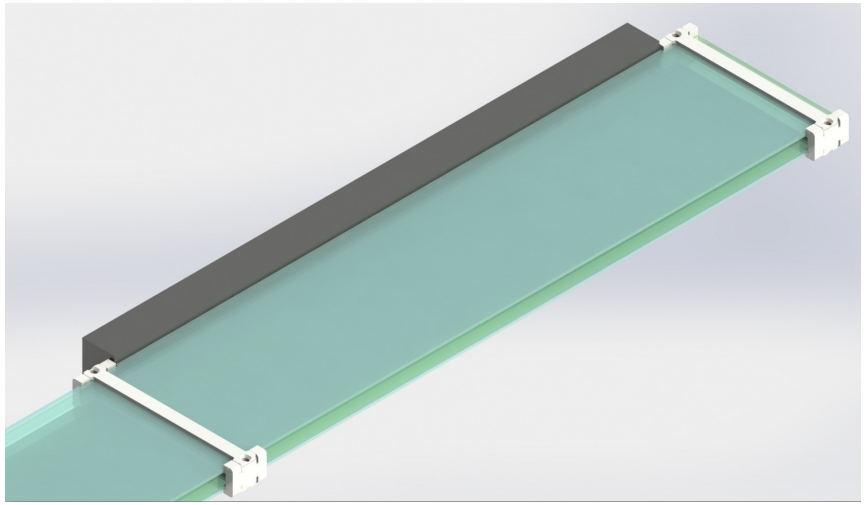
Mechanical Tolerance Quality Control

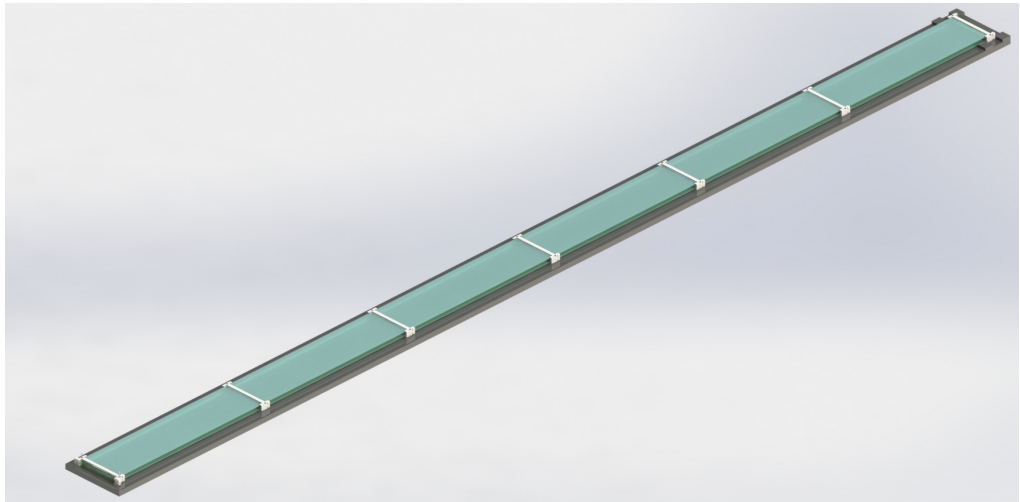
Tolerances based on experience with assembling photon detectors and installation into test version of APA frame.

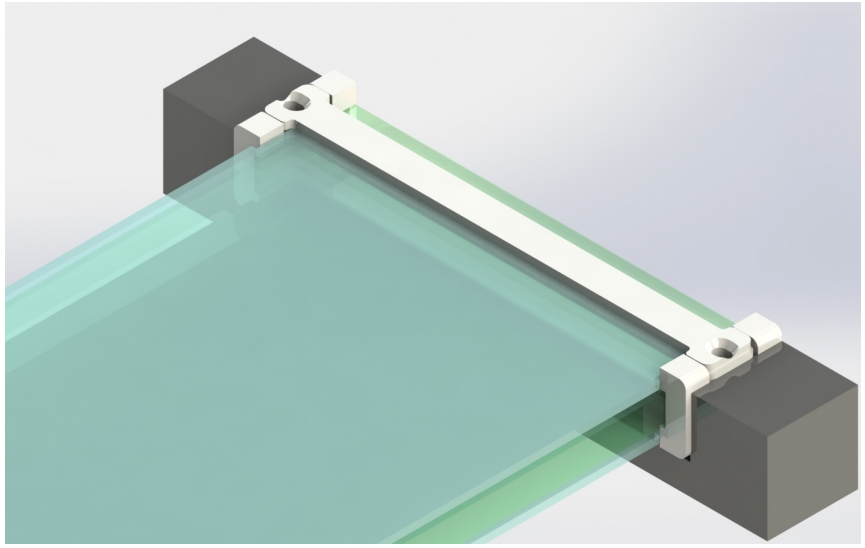
PD mechanical tolerance QC plan (upon receipt of components)

- will check that the tolerance on the width and thickness of the PD is correct at each of the 5 (MIT) or 7 (IU) design mounting points
- will check that the gap between the mounting points is within tolerance at each point
- will check (with an optical tool) that the gap between the SiPMs and the light guide is correct
- will check the overall length of the PD module to make sure it is within tolerance
- will check that the spacing of the PD mount rails is OK by sliding in a blank plate with the maximum tolerance of the PD into the slot after the rails are installed

Mechanical Tolerance Quality Control







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:			

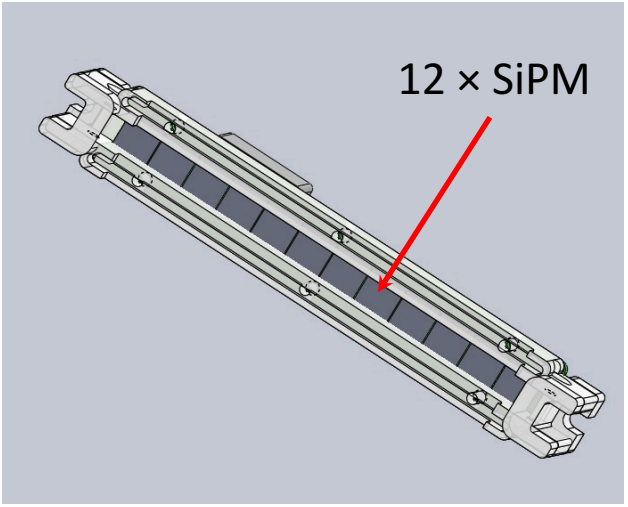
Go No-Go gauges (Solidworks models)

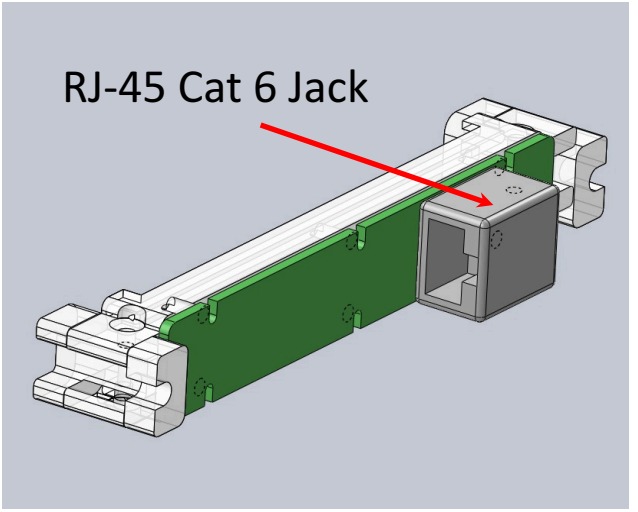
QA of SiPM Mounting Board Assembly

Example: qualification of SiPM mounted on readout board (under thermal cycle)

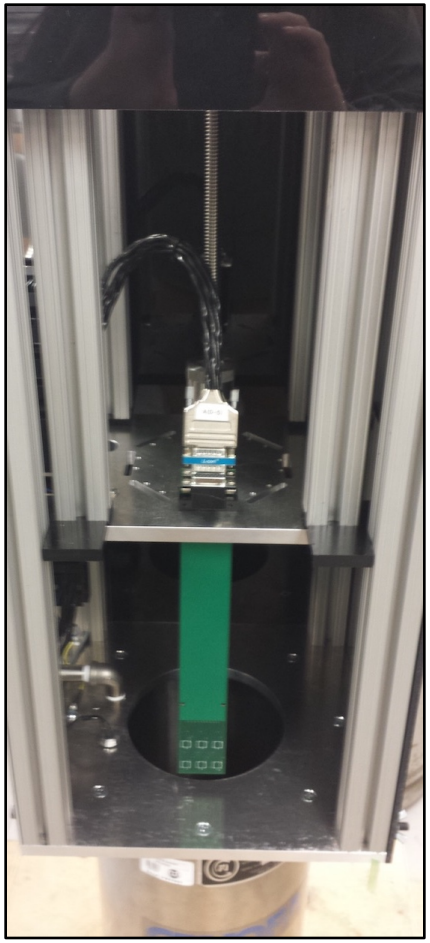
Sensl SiPM (C-series) soldered onto mounting board assemblies are being tested for operation through several thermal cycles at CSU.

- Crygoenic test stand has been built for the purpose of these tests (LED and LN2 utilized)
- Capable of testing up to 96 SiPMs (8 boards) at a time
- SiPM characteristics (gain, cross-talk, dark rate, and after-pulsing) measured using SSP for readout
- Devices put through 5 thermal cycles (more than twice what they will be expected to be cycled through





Cryogenic SiPM / Mounting Board Test Stand



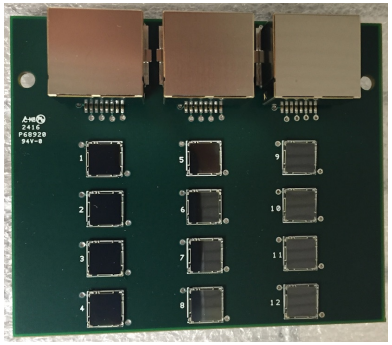
Test stand uses LED in LN2 for tests.

- Computer controlled stepper motor moves the boards into and out of the LN2
- LN2 depth is monitored using depth sensor like that developed for our 500 l vessel
- Light-tight cover put over system during testing
- Dry gaseous nitrogen above the test vessel to prevent condensation and icing on the boards during cold-warm cycle.
- Five cycles take about 2 days.

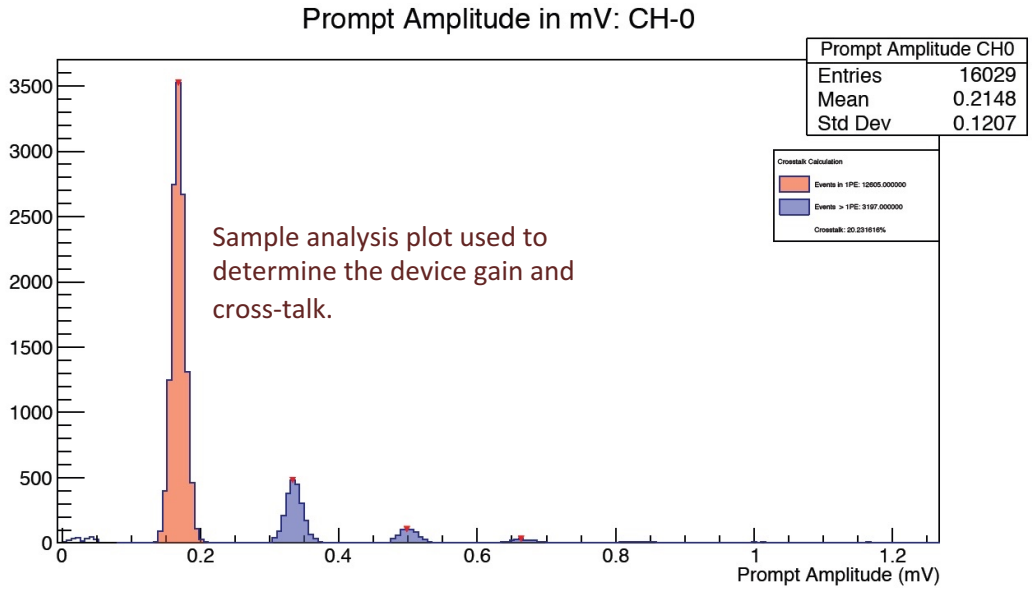
Mounting Board Assembly QA Results

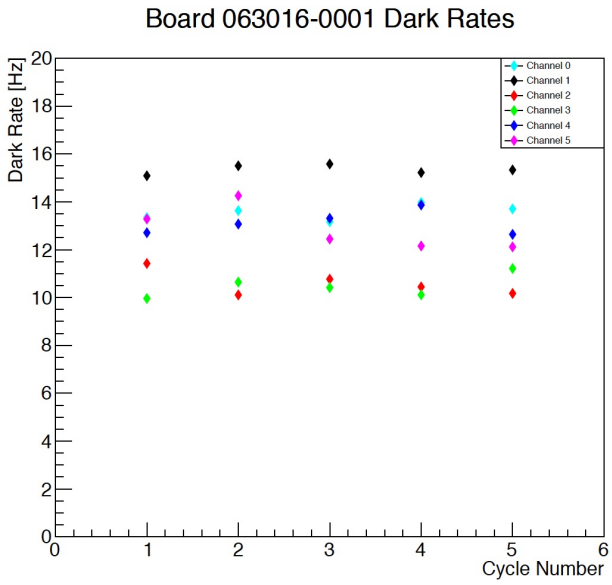
We will test a sample of about 40 SiPM assembly boards (SABs) – each with 12 soldered C-series – through thermal cycles

Currently finalizing test procedure and determining QC parameters



SiPM test assembly board





Tracking and Documenting

QC Record keeping for protoDUNE will be based on experience with 35 t

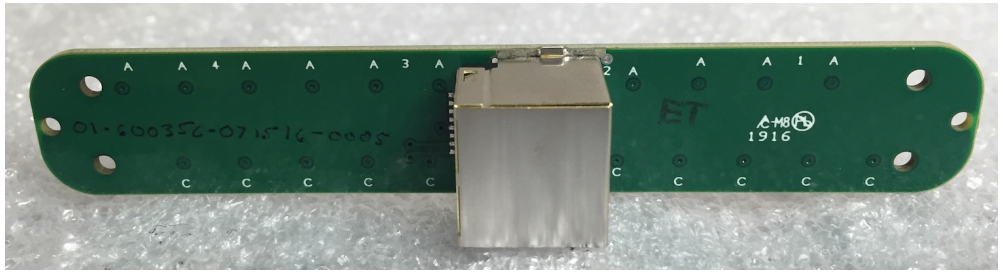
- Inspection forms of incoming materials will be created and filled out for all PD components supplied by external vendors and institutions.
- QC record forms (such as the model from the 35T detector on the next slide) will be filled out for each step of assembly.
- All component/module travelers/inspection forms will have paper copies which travel with the appropriate components, as well as a digital version (including scan of paper version) to be kept online.

SiPM Incoming Materials Inspection Record

Date Received _____
Receiving Individual _____
Manufacturer _____
Model Number _____
Manufacturer's Lot Number _____
LBNE Batch Number PD SiPM _____
Number received _____
Number Back-Ordered _____
Ordering Institution _____
Ordering Institution PO Number _____

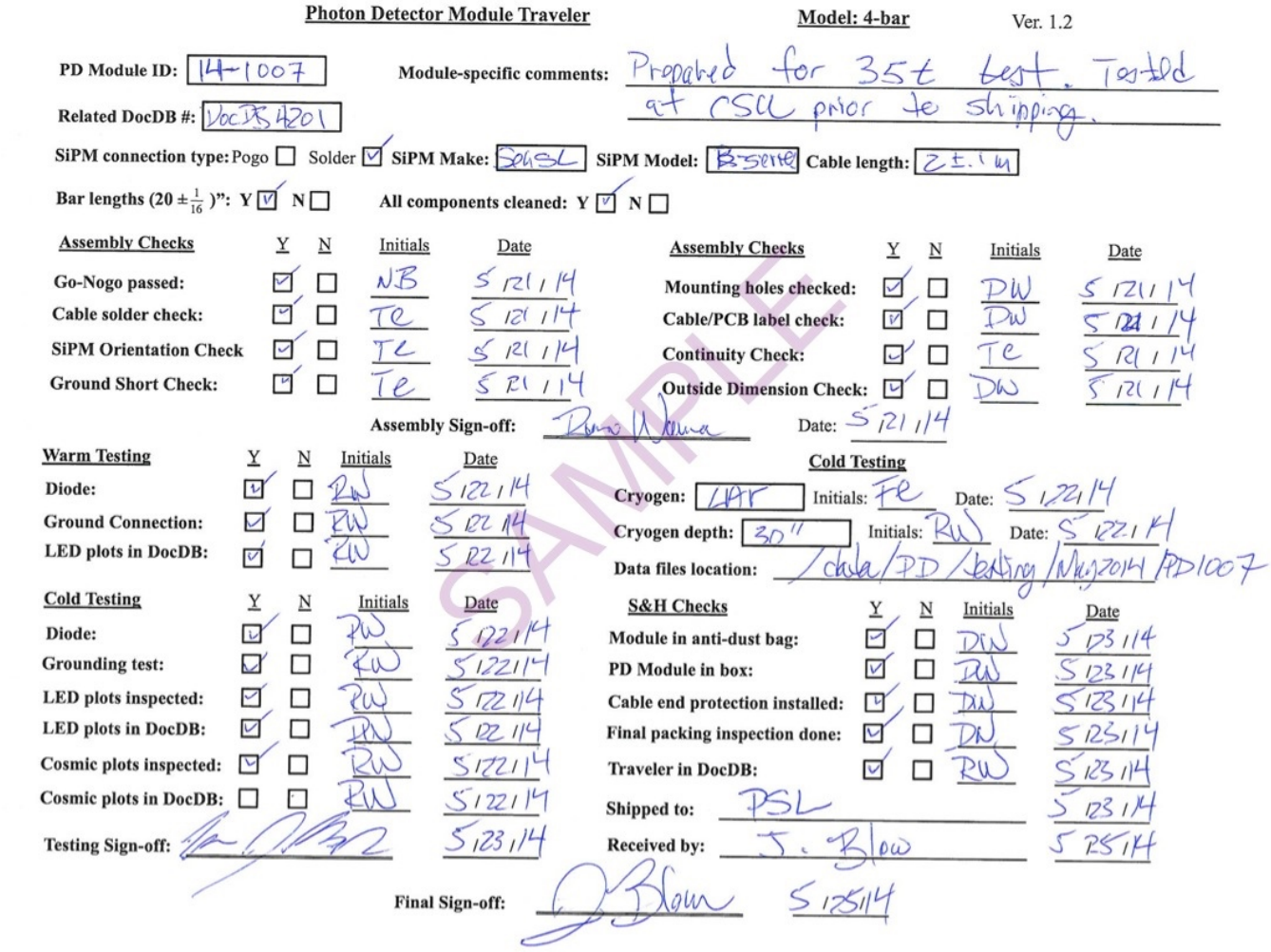
Visual Inspection P__ F__ Comments _____
Electrical Inspection (Diode Check) P____F____ Comments _____
No. Samples Tested _____
Cryogenic Single PE Plot (Representative QA sample)
Data File Location _____
Single PE Gain _____ at standard bias _____V
Cryogenic Dark Rate at 50% of 1PE _____
Test Operator _____Date_____

Incoming Shipment Approved by _____Date_____



Final version of SiPM mounting boards will have SN silk-screened on. We are using sharpie for now

35T PD “Traveler”--QC record sheet for modules



Photon Detector Module Traveler — **Model: 4-bar** — Ver. 1.2

PD Module ID: 14-1007 — Module-specific comments: Prepared for 35t test. Tested at CSU prior to shipping.

Related DocDB #: Doc 14201

SiPM connection type: Pogo ☐ Solder ☑ — SiPM Make: SensL — SiPM Model: B-series — Cable length: 2 ± .1 m

Bar lengths ($20 \pm \frac{1}{16}$)": Y ☑ N ☐ — All components cleaned: Y ☑ N ☐

Assembly Checks	Y	N	Initials	Date
Go-Nogo passed:	☑	☐	NB	5/21/14
Cable solder check:	☑	☐	TE	5/21/14
SiPM Orientation Check	☑	☐	TE	5/21/14
Ground Short Check:	☑	☐	TE	5/21/14

Assembly Checks	Y	N	Initials	Date
Mounting holes checked:	☑	☐	DW	5/21/14
Cable/PCB label check:	☑	☐	DW	5/21/14
Continuity Check:	☑	☐	TE	5/21/14
Outside Dimension Check:	☑	☐	DW	5/21/14

Assembly Sign-off: [signature] Date: 5/21/14

Warm Testing	Y	N	Initials	Date
Diode:	☑	☐	RW	5/22/14
Ground Connection:	☑	☐	RW	5/22/14
LED plots in DocDB:	☑	☐	RW	5/22/14

Cold Testing

Cryogen: LAr Initials: FE Date: 5/22/14

Cryogen depth: 30" Initials: RW Date: 5/22/14

Data files location: /data/PD/testing/May2014/PD1007

Cold Testing	Y	N	Initials	Date
Diode:	☑	☐	RW	5/22/14
Grounding test:	☑	☐	RW	5/22/14
LED plots inspected:	☑	☐	RW	5/22/14
LED plots in DocDB:	☑	☐	RW	5/22/14
Cosmic plots inspected:	☑	☐	RW	5/22/14
Cosmic plots in DocDB:	☐	☐	RW	5/22/14
Testing Sign-off: [signature]				5/23/14

S&H Checks	Y	N	Initials	Date
Module in anti-dust bag:	☑	☐	DW	5/23/14
PD Module in box:	☑	☐	DW	5/23/14
Cable end protection installed:	☑	☐	DW	5/23/14
Final packing inspection done:	☑	☐	DW	5/23/14
Traveler in DocDB:	☑	☐	RW	5/23/14
Shipped to: PSL				5/23/14
Received by: J. Blow				5/25/14

Final Sign-off: [signature] 5/25/14

SAMPLE

Online Component Database

- Photon detector modules will be tracked in an online database that can be used to link hardware components with performance
- The PD SN will be stored along with its location in the detector
  - Talking with DUNE computing leadership (T. Junk et al) about this
- QC values entered into spreadsheet – transferred into component database

	B	C	D	E	F	G	H
2	SiPM Board SN	063016-001	Date Tested	Tester (initials)	Gain (E6)	Dark Rate (Hz)	Cross-talk (%)
3	SiPM (Channel)		19-Jul-16	AC			
4	1				1.03	13.3	20.1
5	2				1.06	15.1	20.2
6	3				1.01	11.4	20.8
7	4				1.08	10	20.6
8	5				1.05	12.7	20.6
9	6				1.09	13.3	20.6
10	7				1.06	11.6	19.9
11	8				1.06	10.8	19.6
12	9				1.06	14	20.7
13	10				1.04	14.5	20
14	11				1.07	17.9	20.2
15	12				1.04	14.1	19.7

Cycle 1 | Cycle 2 | Cycle 3 | Cycle 4 | Cycle 5 | DB Summary | +

QA/QC Documentation

Documentation has been created, and will continue to be created, for the QA/QC testing.

Quality Assurance (Thermal Cycle) Procedure

A. Christensen

July 5, 2016

Contents

1 Introduction

This document explains how to operate and use the SiPM Cold Tester and the equipment related to it. All the current issues are documented here, so the date at the beginning of this document is important.

Because we are testing the failure rate of SiPMs in a controlled setting, it's very important that you follow these instructions carefully. These SiPMs will eventually be used in the Deep Underground Neutrino Experiment (DUNE), where many thousands of SiPMs will readout data while being submerged in Liquid Argon. Once the SiPMs in the liquid argon time-projection chamber (LArTPC) far detector are submerged, they will not be taken out or individually analyzed again. Because of this, we need to know the failure rates of the SiPMs so the analysis can be adjusted accordingly.

DUNE, in totality, is an international collaboration from physicists to analyze neutrino characteristics, such as its oscillation and symmetries, and proton decay. The detector can also be used to read and analyze supernova neutrinos as well as various other natural phenomena related to particle physics.

To study these parameters, DUNE will use the world's highest-intensity neutrino beam, which is located at Fermi National Accelerator Laboratory (Fermilab) in Illinois, a near detector located at Fermilab, and the LArTPC far detector located at the Sanford Underground Research Facility in South Dakota.

Conclusions

- A plan for quality control of the PD modules has been developed
- PDs will be tested following assembly at CSU and again at CERN prior to installation into APAs
- Quality Assurance of SiPM/Mounting Assemblies is ongoing
- Tracking plan based on experience with 35 t
- Plan for tracking PDs in hardware/online database is being developed
- Procedures are documented as they are implemented