Electronics and DAQ Production and Deployment and APD Plans

Leon Mualem

FEB/TECC Status

- **FEBs Under assembly**
- >2000 FEBs have been received in by 4/30
  - Jumper problem slowed delivery – assembler reworking
  - ramping to 1000/wk
- Testing of first 100 boards documented in nova-doc-6979
- Testing of new production ramping up
  - Quality looks to be good, ~95% passing
  - Should begin production testing in May
- **TECC also in production and testing**
- Received 2000
- Receiving ~750/week
- 1080 tested so far, >97% passed
- Both of these tasks sprinting toward the finish line
- Should arrive at finish line in July 2012!

Power Distribution

- Operational readiness manual completed and posted on docdb.
  - 194 pages of documentation
- Operational Readiness Clearance for Power Distribution System
- Relay racks:
  - Rack protection system 90% done.
- Low Voltage test document completed
- Front-End cables: 1 diblock completed
- Distribution cables: 1 diblock completed
- High Voltage cables: 1 diblock completed
- LVPS-DCM cables: Done.
- Cable trays: At Ash River.
- Cable tray/PDB supports:
  All parts received.
  - They are being assembled at fab shop.
- 60/90 PDB-DCM tables
- 550/720 cable tray supports

Power Distribution (Part II)

- Power Distribution Box testing resumed in April.
- Parts counts: (at least this many)
- Power Distribution Box mainframes:
  - 30/ 74/ 198 tested/fabricated/total needed
- Front-End Board cards:
  - 480/1850/3168 tested/fabricated/total needed
- Data Concentrator Module cards:
  - 38/ 204/ 204 tested/fabricated/total needed
- Indicator cards:
  - 30/ 204/ 204 tested/fabricated/total needed
- Backplanes:
  - 30/ 100/ 200 tested/fabricated/total needed
- **Shipping:**
  - All LV power supplies shipped and installed
  - Ash River High Voltage mainframes and supplies shipped

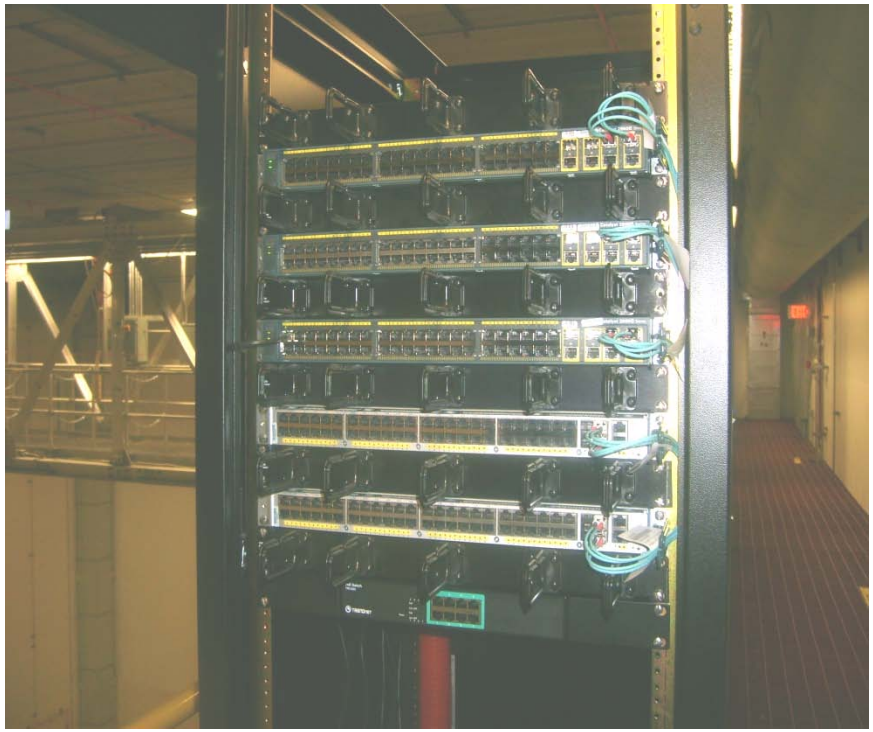
NOvA Computing Center (NCC)

- March 2012 we deployed the first 1/3 of the computing resources at Ash River.
  - 72 DAQ/trigger nodes (1152 cores, 75 TB buffer disk)
  - 3 SATA raid arrays (75 TB)
  - Network switches
  - Racks, term servers, KVMs etc…
- All of the hardware was initially tested, assembled and configured at FNAL (LCC)
  - Transplanted to Ash River
  - Network was remapped
  - Systems were brought up
  - UPS list is NOvA doc #7167

Detector Hall Network Racks

- Two network racks
  - Network rack one feeds LV racks 1- 8
  - Network rack two feeds LV racks 9 – 15

- 2 DAQ switches per rack
- 3 DCS/general switches per rack



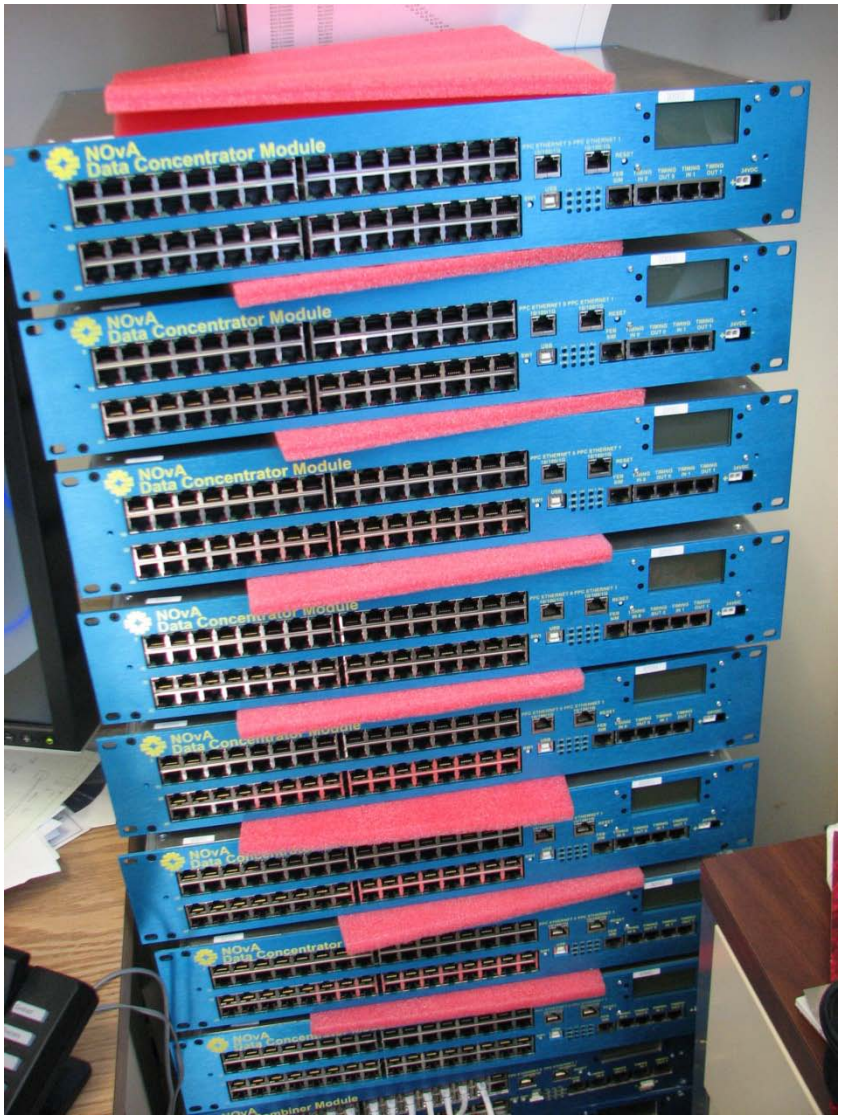
NCC Network Rack

- Two Nexus routers feeding all DAQ/DCS switches with dual uplinks
- DocDB # 6642-v7 shows rack layouts
- Current power and UPS connections are documented in NOvA docDB 6642-v7 “Detailed Switch Information”
- Uplogix terminal server stores all switch and router configurations and operating systems.

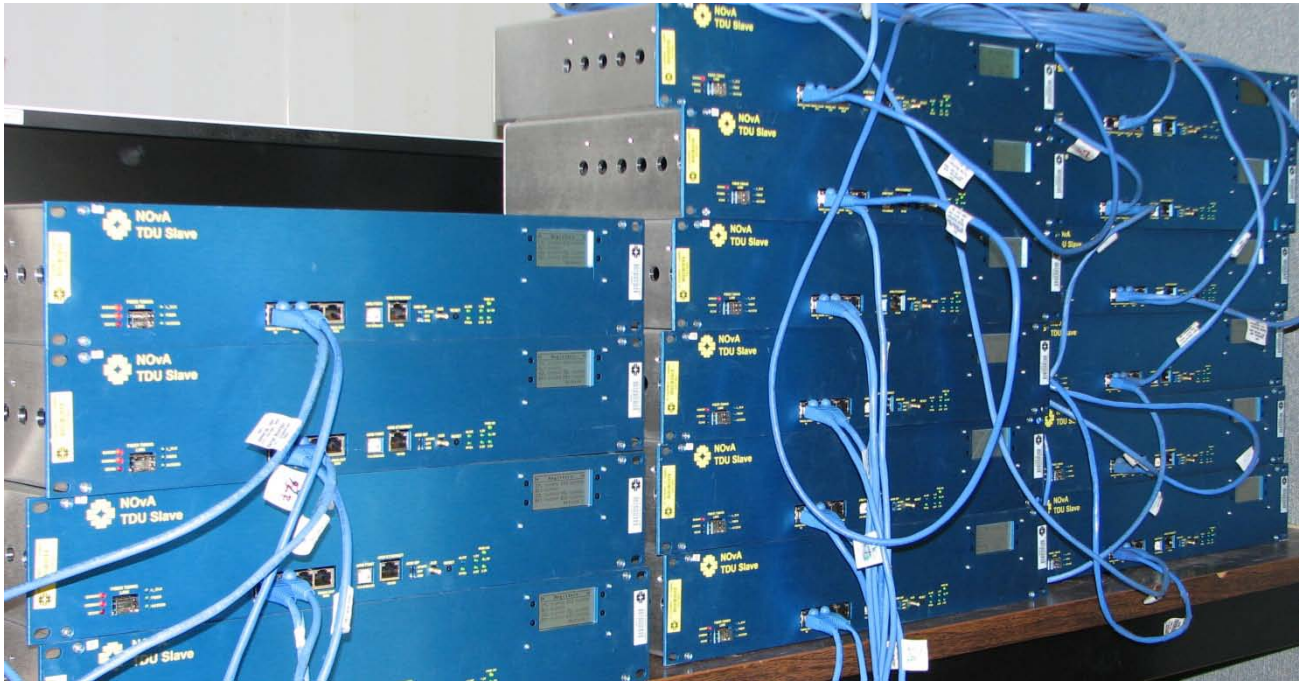
Data Concentrator Modules Production Status

Production DCMs have begun to arrive.

- 10 DCMs arrived on Monday.
- 35 more expected by April 30
- Build Quality is Excellent.
- All pass bench tests.
- Only a few minor issues.
- As of April 24 have 15 production and 5 pre-production DCMs.



Timing Distribution Units Production Status



Production TDUs at FCC Undergoing Testing

TDU Status

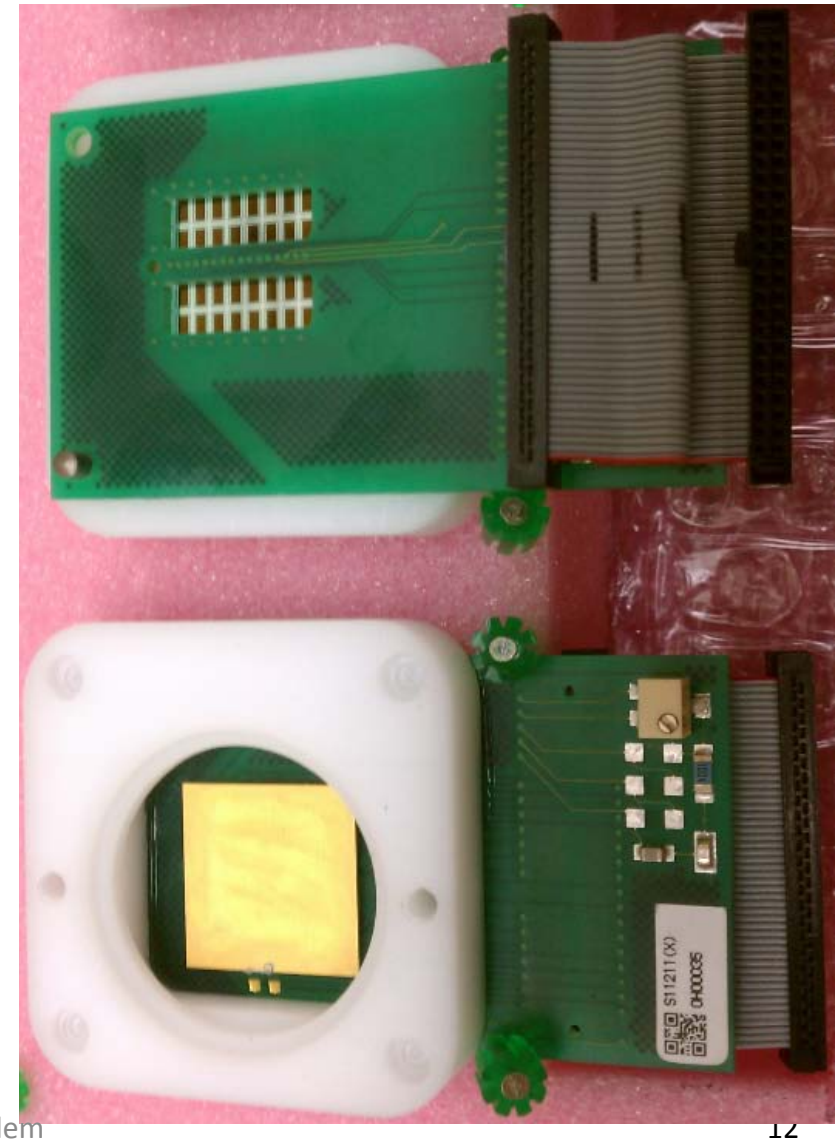
- 5 *Production* TDUs currently in use.
  - Two MTDUs are installed at Ash River.
    - Connected and logging GPS data
  - One MTDU and one STDU are installed at NDOS.
  - One MTDU is in use at the teststand.
- Taking 19 STDUs to Ash River 4/23 for installation on the catwalk.
  - This will provide the FULL timing chain/backbone for the 15kt far detector
  - Includes 4 hot spares for the far site/teststand

TDU Status

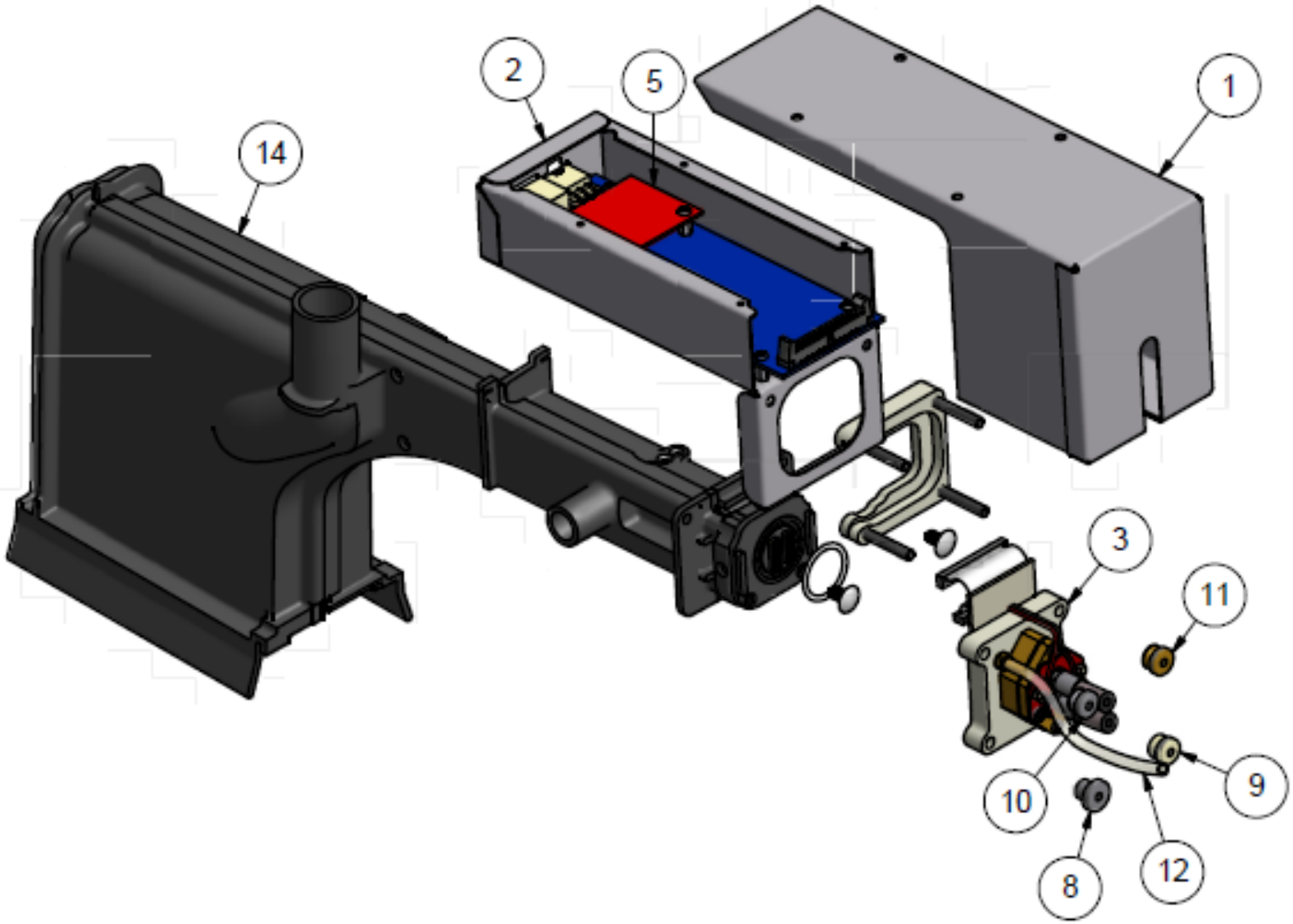
- Production run of 46 STDUs and 14 MTDUs is complete.
  - **All production TDUs are in hand.**
  - Bench testing completed – no problems.
  - Expect to complete FCC teststand testing and "LONG TDU Chain" testing/calibration in the next few weeks.
  - Testing begins on TDUs in the wild next week

APD Array from Hamamatsu

- Si Avalanche Photodiode Array
  - Custom design to match to fiber aspect ratio
  - Bare die mounted to PCB via gold bump
  - Optical surface oriented face-down on board.
  - Spacer frame mounted to board for installation



APD Assembly



APD installation tests

- Attempted to install ~20 sealed APDs/heat sinks in Dec.
- Using new mounting scheme:
  - 6 Parylene, 10 new silicone coated
- Using old mounting scheme:
  - 5 uncoated/recovered APDs to test new seals
- New Mounting parts worked well ergonomically
- Parts indicated small sealed failures
  - Some problems due to inadequate o-ring compression (new parts design corrects this)
  - Some heat sinks had small leaks
  - Small leaks found in other locations as well

APD volume Continuous Purge

- Several iterations were made over Oct-Jan
- Each found problems and improved greatly
- Still found problems after these iterations
  - Time was too short to continue AND be ready to install at Ash River
- Dry purge is needed to compensate for remaining known and any unknown seal problems
- Purging was always an option
- All initial prototypes included a purge of some type
- Desiccant option had been chosen to avoid a plumbing system and had been shown to have lifetime of >40 years for *sealed* modules

Further installations

- Planned to receive coated and uncoated APDs from Hamamatsu beginning at the end of January
- Actual delivery, end of March
- Substrate (carrier board) problems from Hamamatsu supplier caused the delay
- Delivered 185 in 2 weeks
  - production is getting faster, less worry about delivering 1000/month
- Uncoated received parylene coating in Rancho Cucamonga
- Meanwhile Stuart Mufson and Indiana University. started manufacture of 500 new boxes (needed for installation with new clamping hardware)
  - The start of this was delayed until impact of gas purge on box was known
  - Tooling took about 1.5 weeks, production < 1 week+1 week for plating
  - Good news for production, another sprint to the finish.
- Install/Test in May
- Will know much more in June.

Further installations

- Install FEBs in boxes when boxes arrived
- Remove boxes/FEBs from block 0
- Swap FEBs into new boxes and place on block 5 (almost empty)
- Work forward toward instrumented portion
- Week of 4/30
  - Begin Installing Coated arrays
  - ~160 silicone ~90 Parylene
  - Install gas purge on new strings
- APDs that are in the way of install, and on muon catcher can be removed and shipped to Caltech for parylene coating, testing and prep for reinstall

Task Force and Expert Reviews

- Convened internal task force to identify and mitigate causes of difficulties
- Convened expert review panel to guide future steps
- Task Force Recommendations
  - ✓ APD (Mualem,Oliver,Tesarek)
    - Proceed with Silicone (more uniform) coating on APD surface
    - Meet with Hamamatsu Factory to establish communication and finalize specifications
  - ✓ Determine cause of failures under cooling
    - Test seal with low compression (Mualem/Trevor/Caltech)
    - Test heat sink seal after gasket trimming procedure (Mualem/Trevor/Caltech)
    - Carefully collect evidence from parts that failed to determine cause (Muether/FNAL)
  - ✓ Mounting (Fox/IUSEEM)
    - Redesign mounting clip to ease installation
    - Use current specifications of parts/procedures to optimize seal compression
  - ✓ Electronics Boxes(Fox/IUSEEM)
    - Modify overlap design to ease installation
    - Provide positive ground connection of the two pieces
- Expert Review Recommendations
  - ✓ Devise test plans that separately address:
    - The long-term reliability and susceptibilities of the APD array itself
    - The long-term reliability and susceptibilities of the packaged device from Hamamatsu
    - The long-term reliability and susceptibilities of the assemblies mounted on the detector.
  - ✓ Develop a production qualification plan
  - – Fully qualify the installation procedure
  - ✓ Appoint a member of the collaboration with appropriate semiconductor detector experience to oversee the APD qualification and testing.
  - – Perform a Production Readiness Review, before launching the production of the APDs.
  - – Perform an Electronics Systems Readiness Review before installation of the APD assembles on the far detector.
  - ✓ Revise the installation schedule to accommodate the delays that will occur if these recommendations are followed.

APD Expert Recommendations & Responses

Expert Recommendation	NOvA Response
Devise test plans that separately address: **1 a)** The long-term reliability and susceptibilities of the APD array itself. This could consist of testing bare die from Hamamatsu, mounted and wire-bonded onto a suitable test board.	While these APDs required new masks, they are modifications to the structure of existing devices, S8550s, used extensively in medical imaging, and the whole class of single channel devices, such as those in use on CMS. The changes were considered low risk by Hamamatsu and others. As such, these types of tests were not planned. They can be performed as a test that might be useful if there are further problems at some point down the line, and we will investigate involvement of other groups that might perform these tests. Bare APD parts delivered in April Jaroslav Zalesak (Prague) in order to perform desired test and monitoring.

APD Expert Recommendations & Responses

Expert Recommendation	NOvA Response
Devise test plans that separately address: **1 b)** The long-term reliability and susceptibilities of the packaged device from Hamamatsu (i.e. APDs which have been bump-bonded on to a carrier)	Leon Mualem (L2) will do this test on the new parts coming from Hamamatsu. An environmental chamber exists at Caltech for such "aging studies" with cycling between low and high temperatures.
Devise test plans that separately address: **1 c)** The long-term reliability and susceptibilities of the assemblies mounted on the detector.	This was and still is the object of the prototype Near Detector. We intend to run the new Hamamatsu parts (and likely Parylene coated existing parts) on the prototype before giving the go-ahead to Hamamatsu for production of 12,000.

APD Expert Recommendations & Responses

Expert Recommendation	NOvA Response
1 d) These (above) tests should be performed with a statistically significant number of devices (~ 20 or more) so that reliable predictive data may be obtained. The test should follow industry standards for qualification of sensitive electronics, including heat cycling, and for the assembled modules humidity testing. The environmental tests should continue after the detector installation is complete and operation has begun, in order to detect any early signs of failure.	Test #1 (bare silicon), started with 5 at Prague due scarcity of parts. Test #2 (long term reliability in the lab) Batch testing of newly arrived parts will continue in order to monitor quality Test #3 (long term reliability on detector) Began installation and operation on the detector with samples of each type of coating. By July: For tests on the Near Detector we will have ~200 Hamamatsu silicone-coated parts and would aim for ~ 200 Parylene-coated parts.
1 e) Document, with milestone dates, which tests must be passed by which date in order to demonstrate that the APD array, its packaging, and the installation process have demonstrated sufficient reliability for production.	As indicated above, we inserted a 2 month test into the NOvA schedule of Hamamatsu silicone coated (in parallel with Parylene coated) on the prototype Near Detector. We need to demonstrate a success rate of ~ 95% to have a viable plan for Ash River. Need to set “passing mark” for the rapid aging tests at Caltech

APD Expert Recommendations & Responses

Expert Recommendation	NOvA Response
2) Develop a production qualification plan. As the APDs are delivered lot samples should be tested to ensure continuity of production quality. Equally, lot samples of the space frame need to be tested to assure the continued quality of their production.	The NOvA test plan already called for every APD to be tested on the APD test stand at room temperature and cooled to operating temperature of -15C. This is in addition to Hamamatsu factory qualification tests. In addition, the components will all be tested for seal quality before being shipped, and before installation. The tests and procedures developed in response to the rapid aging test at Caltech will also be used to sample test new lots of production of all components. Monitoring would use the same procedures developed for those tests.

APD Expert Recommendations & Responses

Expert Recommendation	NOvA Response
3) Fully qualify the installation procedure, with the steps minimized and simplified and, if necessary, any special tooling produced; this could include a further optimization of the mechanics for ease of installation.	An updated installation procedure exists based on the new mounting scheme. The procedure was updated prior to the installation of the coated devices based on installation of the test devices. In addition we intend to train the Ash River workforce in installation by having them here at Fermilab for the coated array installation work.
4) Appoint a member of the collaboration with appropriate semiconductor detector experience to oversee the APD qualification and testing.	Leon Mualem (L2) is it.
5) Perform a Production Readiness Review, before launching the production of the APDs.	We will hold such a review near the end of the 2 month test on the prototype Near Detector in Mid August, 2012.

QA Audits

- UVA Power distribution system
  - NOvA-doc-6820
- Harvard Front-End Electronics
  - NOvA-doc-7190
- IU Heat Sink and TECC production
  - NOvA-doc-NYAV

Production Readiness Reviews

- DCM
- TDU
- Harvard Front-End Electronics
- IU TECC production

Operational Readiness Clearance Reviews for ES&H

7106-v1	Far Detector Rack Protection pORC Signature Sheet (Approved - 22 Feb 2012)	RackProtection...pdf	Rick J Tesarek	FD Rack Protection Signed pORC/ORCs	08 Mar 2012
5334-v1	Rack Protection pORC Signature Sheet	RackProtection...pdf	Rick J Tesarek	Near Detector Rack Protection Signed pORC/ORCs	28 Feb 2012
5266-v1	Near Detector Block Structural pORC Signature sheet	Signature Sheet (pdf) 9/23/10	Rick J Tesarek	Near Detector Structure Signed pORC/ORCs	28 Feb 2012
5335-v1	Time Distribution Unit pORC Signature sheet	TDU Signature Sheet	Rick J Tesarek	TDU Signed pORC/ORCs	28 Feb 2012
5336-v1	Power Distribution System pORC Signature Sheet	PDB pORC Signature Sheet (10/7/10)	Rick J Tesarek	PDB Signed pORC/ORCs	28 Feb 2012
5337-v1	Data Concentrator Module pORC Signature Sheet	DCM pORC Signature Sheet (10/7/10)	Rick J Tesarek	DCM Signed pORC/ORCs	28 Feb 2012
5338-v1	Racks 1 and 2 pORC Signature Sheet	Racks pORC Signature Sheet (10/7/10)	Rick J Tesarek	Electronics Signed pORC/ORCs	28 Feb 2012
5364-v1	FEB pORC Signature Sheet	FEB pORC Signature Sheet	Rick J Tesarek	FEB Signed pORC/ORCs	28 Feb 2012
7300-v1	Power Distribution System pORC Signature Sheet (Approved - 19 Apr 2012)	PowerDistribut...pdf	Rick J Tesarek	FD PDB Signed pORC/ORCs	19 Apr 2012
7161-v1	NOvA DCM pORC Signature Sheet (Approved - 03 Mar 2012)	Signature Sheet (pdf)	Rick J Tesarek	FD DCM Signed pORC/ORCs	03 Mar 2012
7162-v1	NOvA TDU pORC Signature Sheet (Approved - 03 Mar 2012)	FD-TDUSignatur...pdf	Rick J Tesarek	FD TDU Signed pORC/ORCs	03 Mar 2012

Critical Path considerations

- Production rates and projection shows electronics and photodetectors to be off the critical path until the end.
- Start of production and testing of electronics showing quick progress, as planned
- Photodetector delivery risk still active due to prototype detector experience
  - Addressing problems in multiple ways to mitigate risk
  - Two types of coatings to prevent surface contamination
  - Improved sealing and testing all parts before installation
  - Active purge system to mitigate any remaining small leaks and natural vapor transmission

Summary

- Under Production and showing quick progress and good success rates
  - Data Concentrator Modules
  - Timing Distribution Units
  - Front End Boards
  - Thermo-Electric Cooler Controller
  - Power Distribution Boxes
  - HV and LV power supplies – DONE
- Qualifying final production of photodetector system