PD Integration/Installation

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Outline

- Pre-ITF integration and testing
- ITF Requirements
- Installation Requirements
- Summary

PD cabling pre-positioned inside APA frames

- PD cables inside the APA frame will be pre-installed prior to wrapping the APA frames.
- Cable installation will occur at APA construction sites
- Cables will arrive at APA fabrication sites pre-tested.
- Any post-APA installation testing (pre wire-wrapping) must use robust testing equipment, and plans for testing result data migration must be carefully thought out.
- Costing for cable installation needs to be coordinated with APA group

PD Module Cryogenic Testing

- Cold box testing of integrated APA/CE/PD units has now been moved underground immediately prior to installation into the cryostat.
  - CE cables and conduit will have been installed prior to this testing
  - This will occlude removal of PD modules found to fail testing
- To mitigate the implied risk, PD modules will be cryogenically tested (in LN2, in a large test dewar such as the one in the CDDF at CSU) prior to shipping to the ITF
- This will constitute the final checkout of the PD modules following assembly.

PD Integration at Integration Site

- Following assembly and QC testing, PD modules will be shipped to the Integration/Test Facility (ITF) site in South Dakota for insertion into the APA frames.
- Photon detectors will be integrated into APA frames and initial testing (warm) will occur at ITF
- Following integration, modules will be stored at ITF until ready for installation into the cryostat (Up to two years storage possible)

PD pre-installation testing at integration site

- PD modules will arrive at integration site in shipping crates (sub-crates of 10 modules each, sub-crates gathered into larger storage crates of 5-10 sub-crates for shipping efficiency)
- Immediately prior to installation into APA frames, the modules will be scanned to ensure satisfactory operation
  - Two modules at a time will be scanned
  - Approximately two hour per scan. Scanning is a two-person operation (two technicians)
  - ½ Grad student/Postdoc level person required for data evaluation
  - One scanner + one backup (two total scanners, backup scanner in storage against need)
  - Approximately 1.5 days will be required to scan modules for one APA

Module installation

- APAs will be oriented horizontally for PD module integration
  - Cable connection will occur automatically with module integration (no cable running during integration)
- 2 persons will be required for installation (perhaps occasional need for a third person for assistance with handling
  - Approximately 45 minutes per module, 1 day per APA including testing and alignment tool handling
- Immediately upon module integration, a continuity/diode check will be performed to ensure satisfactory connection
- Supervision provided by grad student/postdoc?
- PD installation and handling equipment required to minimize handling difficulty (single person module moving desirable!)

Environmental requirements at ITF

- PD modules will be shipped to ITF in light-tight sealed plastic bags to facilitate storage prior to integration
- Whenever PD modules are exposed (during integration and handling) the lights must be UV-filtered and the humidity minimized
- Dust contamination of PD modules is a significant concern. PD integration and storage should occur in a class 100,000 cleanroom or better. Modules should be covered in light-tight static-resistant materials whenever possible.

Integration Summary

- Integration will occur at a minimum rate of ~ 20 PD modules per week
  - Could be accelerated significantly by parallelizing incoming scanning and module integration into APAs
- Integration testing will consist of
  - Pre-installation scan
  - Continuity check during integration
- 1 “Supervisor” (Postdoc or Grad student) plus 2 techs will be needed continuously
- Additional labor will be needed occasionally for special handling, incoming material receipt, etc.
- Operations need to be carefully coordinated with integration site coordinators

PD Installation at Sanford Lab

- Sanford Lab operations are split into two classes: cabling and testing.
- It is expected that approximately 6 APAs will be installed per week.
- It is a general philosophy that minimal personnel should go underground.
  - All testing should be automated to the extent possible to minimize PD-specific people
  - Some PD experts may be required for specialized testing
- In general, PD cabling operations are tied closely with CE cabling, and we should attempt to schedule operations so that the same trained technicians can do both at the same time.

PD Cabling

- PD cabling operation at Sanford Lab will consist of making the following connections:
  - Connecting the upper to lower APA in a stack
  - Cabling from the APA top to the cryostat flange
  - Cabling from the flange to the FE electronics
  - Cabling from the FE electronics to the DAQ
- Minimal PD-specific personnel will be needed for these operations
  - PD cables from the cryostat flange to the final APA position may be pre-installed, greatly facilitating PD connecting. Needs to be determined if this will interfere with CE cabling…
  - Cabling outside the cryostat should probably occur on an ASAP basis, to minimize installation delays/interferences.

Testing upon Unpacking

- Ideally the APAs would be packaged in nearly-light-tight plastic wrapping following integration, which would allow us to do a final checkout prior to unpacking from the crate
- Perhaps with an LED in the package?
- All APAs would have an operational test prior to unpackaging.
  - Estimated time: 15 to 30 minutes per APA pair
- Remediation: TBD. Cable checks? Possible replacement of damaged PD (depends on available space, and conduit installation)

Tests upon Hanging Outside Cryostat

- Immediately following assembly of upper APA to lower APA, a continuity check will be performed for all 20 cables at the top of the APA stack
- All assembled APA stacks would have a continuity check throughout installation
- Estimated time: 10 to 15 minutes?
- Remediation: Re-check cable connections. Possibly separate APA stack to access middle connectors if necessary?

Cold Box Testing

- Following assembly of APA stack assembly and CE cable installation, the complete APA stack will be tested in a cold box.
- During the cold test, PD modules will be operated
  - Dark count measurement
  - LED illumination
- Mitigation: As noted previously, the presence of the CE cables and conduit in the APA side tubes makes access to and replacement of defective modules difficult.
  - Access to PD connectors at the head of the APA should be easy.
  - Need to understand if we could reach the connectors between upper and lower APAs (If TDR measurements suggested it might be useful?)

Initial Testing upon Positioning Inside Cryostat

- Immediately following the APA arriving in position inside the cryostat, but prior to connecting the APA-Flange feedthrough cable, a continuity check will be performed
- This checkout is envisioned early in the installation process, and may be eliminated later.
- The goal of this checkout is to catch cabling issues caused by the rail installation system early enough to allow us to gain access for remediation
- Estimated time: 20 minutes (?) depending on ease of access
- Remediation: Move APA stack enough to allow access to cables for repair. Possible other remediation as agreed to.

Full Cable Run Checkout

- Following installation of APA-Flange feedthrough cable, a continuity check will be performed
- This check will occur for all PDs as early as possible after installation.
- Estimated time: 15 minutes
- Remediation: Check cable connections. Note issues in database.

Post-installation Operational Test

- As soon as possible following installation and cable checkout, it would be ideal if the cryostat lights could be turned off and an operational (dark) check performed.
- Ideally, this would happen on an stack-by-stack basis in the initial installation phase, then perhaps on a weekly basis as our understanding evolves?
- Estimated time: 1 hour per stack (during off-installation-shift time)
- Test possible involves LED illumination?
- Remediation: Note module status in logbook, try to improve handling procedures to eliminate sources of failures.

Tooling

- A continuity check tool will need to be developed to allow for rapid testing.
  - Multi-cable simultaneous connection?
  - No twist lock operation?
  - Automatic test result evaluation?
  - Automatic data storage?
- A portable operational testing station should be developed
  - 4 channel readout?
  - Automatic test result evaluation?
  - Automatic data storage?
- Aim for operation by technicians, not scientists.

Data Storage/Evaluation

- Ideally, the data from all installation QC checks would be downloaded to the database automatically, no later than at the end of the shift where they were taken.
- Data flagged as outside operational norms (TBD) would be automatically flagged for expert intervention
- Weekly (?) expert examination of QC data from recently installed modules
- Performance trend lines maintained (automatically?) to look for long-term changes to the system.

Installation Summary:

- While underground remediation is difficult, QC testing during installation is important to improve procedures and make possible repairs.
- PD QC must be planned with the understanding that no module repair will be possible following the integrated cold box test.
- Tooling must be developed to allow testing to de made by non-PD experts
- Data must be automatically stored, and easily retrievable, to be most useful.