PDS Consortium: Integration WG

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DUNE DUNE Conceptual Design Review

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Introduction

This talk represents the integration working group, and I will cover:

- -Integration/ITF
- -Installation work underground
- -Interface control

Integration: overview

- Interfaces with other systems:
  - Main:
    - APA
    - Electronics
    - DAQ
  - Secondary:
    - CPA
    - Cryostat

- QA/QC:
  - QA/QC for each component
    - Provided by the Institution/Group responsible for the specific delivery
  - Oversight plan
  - Database Design and Implementation

- Requirements towards the PDS commissioning at SURF
  - Integration Strategy
  - Integration Facility
    - Size requirements
    - Operational requirements
    - Environmental requirements:
      - Cleanliness
      - Light
      - Temperature
      - Humidity

Integration and Test Facility ITF

- Proto-DUNE experience constitutes the base line for the DUNE Integration Plan.
- Surveyed Proto-DUNE groups about their experience and how to improve during the integration at ITF.
- ITF will have a new scenario
- Flat assembly APA + PDS
- Cold test APA + PDS (a fraction of the PD modules will be cold tested before this joint tests)

Schedule/Planning/Costing

- Integration/Installation WG will coordinate closely with CE and APA groups to plan PD installation and testing underground
  - How much PD specific labor?
  - When/how often will PD personnel need to go underground?
  - Who will provide the general labor for cable installation?
  - How/where will the work be costed?
- While working in the underground lab is difficult, QC testing during installation is important to improve procedures and make possible repairs.
- Tooling must be developed to allow testing to de made by non-PD experts
- Data must be automatically stored.

DocDB 6721-DUNE Interface Document: SP PDS (Calibration Component)/HVS

This document describes the interface between the DUNE SP Far Detector Photon-Detection System (SP-PDS) and SP High Voltage System (HVS). In particular we concentrate on PDS Calibration/Monitoring system that is planned to have components installed with the HVS Cathode, and through Field Cage strips and File Cage ground plane. This document describes the necessary interfaces for both SP-PDS and HVS to complete the design, fabrication and installation of their subsystems. An additional document describes implementation of proposed PDS reflective foils with HVS Cathode.

DocDB 6730 -DUNE Interface Document: CISC/SP-PDS

This document describes the interface between the DUNE FD Joint Cryogenics Instrumentation and Slow Controls (CISC) consortium, and the Single Phase Photo Detector (SP-PDS) consortium. This includes the necessary interfaces for both CISC and SP-PDS to complete the design, fabrication and installation of their subsystems, and describes the elements of the scope of each subsystem at the interface between them.

Recent Integration development at the S.Dakota meeting

Option 1: PDs integrated above ground.

-As there is some degree of storage available for integrated PD/APAs, we could integrate PDs into APAs at the rate of ~3/week

-PDs would arrive at aboveground cleanroom on boxes of 10 PDs

-PDs would be scanned (12 hours per week, 1 technician and 1 scientist)

-PDs would be installed in APAs and tested for continuity. Installation would occur with the APA horizontal, one APA at a time (24 hours/week, 1 technician and 1 scientist)

TOTAL labor (with 10% inefficiency) 1 FTE scientist, 1 FTE technician

Option 2: PDs integrated below ground.

Since there is little storage available, 6 APAs/week must be tested and integrated.

Details of Option 1: PDs integrated above ground.

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

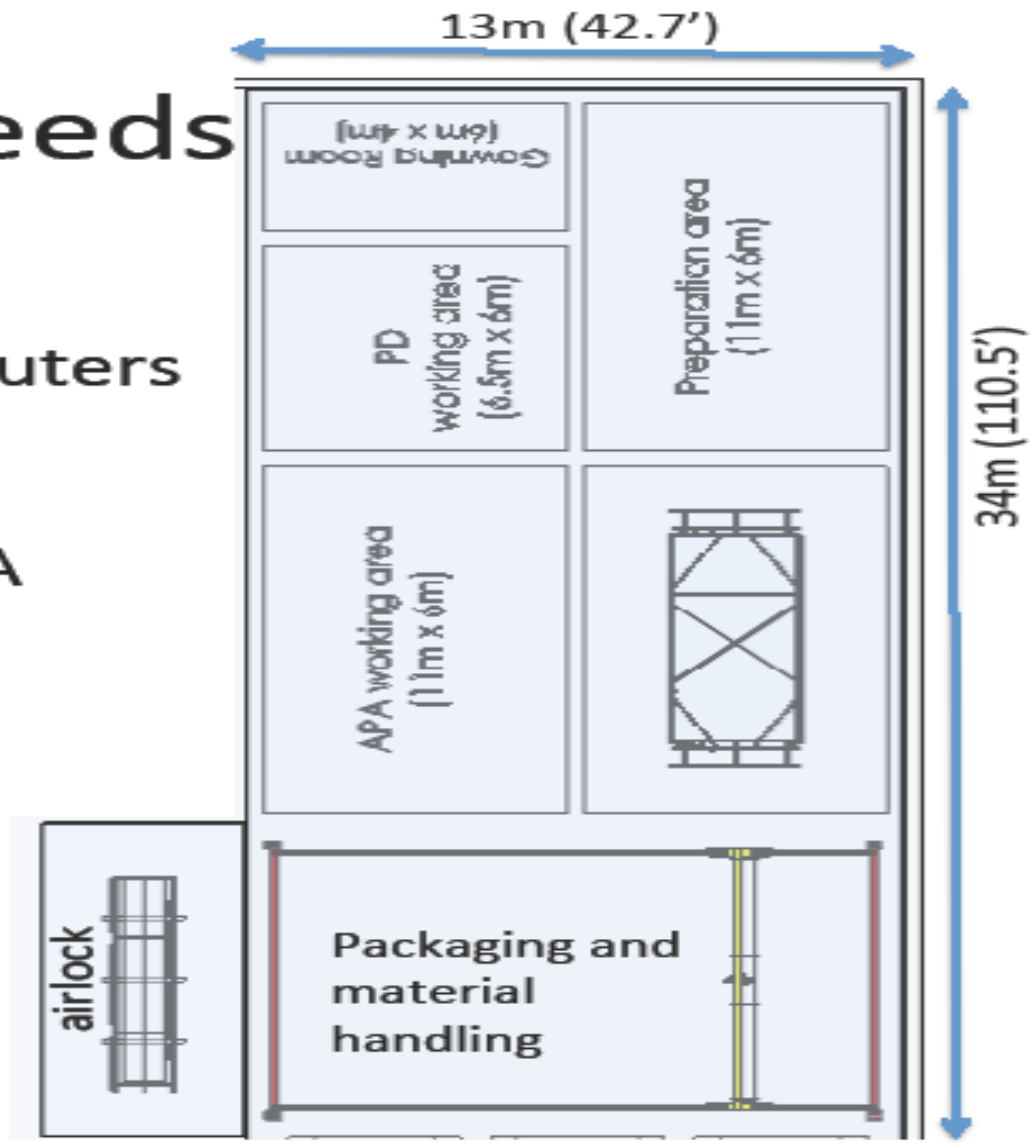
Integration Space Needs- J.Stewart

Integration Space Needs

- ISO8 cleanroom
  - Material airlock & changing room
- PD work area - 2 scanners, computers and storage 6.5m x 6m
- General work area 11m x 6m
- Two 11mx6m area for CE-PD-APA integration
- Material handling 12m by 13m
  - Transfer APA to process cart
  - Pack for underground transport
- Total area 500 m2 or 5,400 sqft

Assumes no cryogenics at the integration site.

Does not take into account storage of APAs. A buffer sufficient to keep the installation going is needed.



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 IOS 8) 100,000 cleanroom or better. Modules should be covered in light-tight static-resistant materials whenever possible.

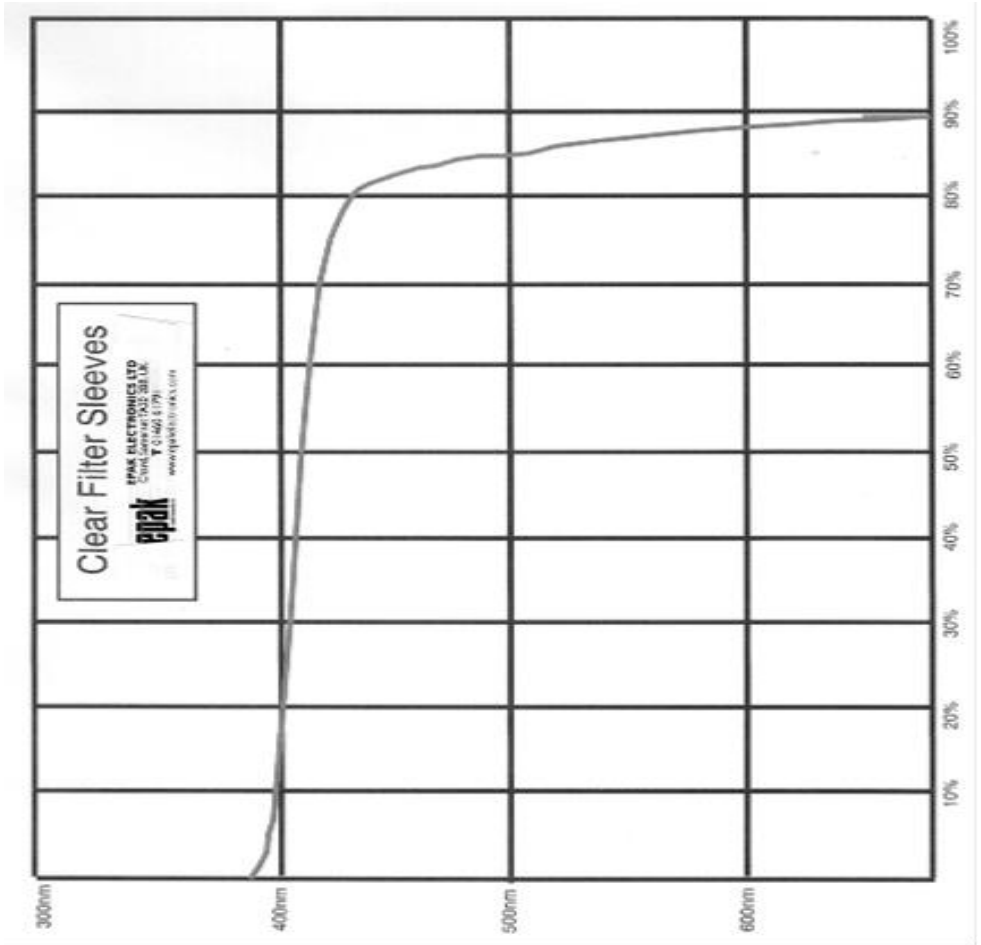
Specification for the Cavern Humidity control.

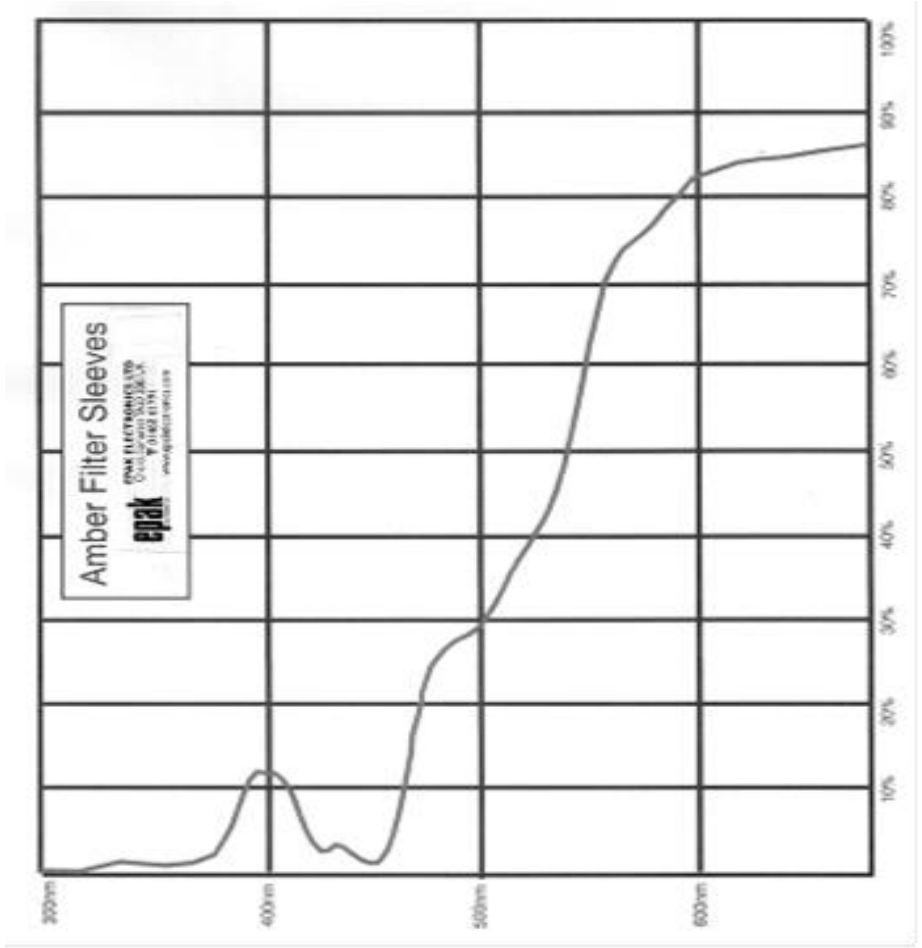
The current requirement that we have for the cavern HVAC is as follows:

"FSCF shall maintain the Far Detector chambers at a temperature between 67 to 85 degrees F (19.5 to 29.5 C) a relative humidity level between 15 and 85 percent, and a maximum dewpoint of 48 F (9 C) "

This is for the caverns and not inside the cryostat.

The transmission spectrum from Proto-DUNE- (Working light filters)





The amber (long exposure) filters

The short-exposure light filters

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.

Overall Summary

- The integration group is working closely with the CE and APA groups to develop a plan for integrating the PDs into the TPC system.
- Integration planning, including QC/QA planning and manpower requirements is underway
- Installing PD cabling into the APA frames is a particular challenge, as it involves installing the cables prior to wire installation
- Cabling and testing of the PD system underground poses particular problems, particularly due to limits on the number of personnel allowed underground.
  - Close coordination with the CE cabling effort will be required

Back-up

Additional Interface Documents

- DUNE-doc-6718: DUNE FD Interface Document: SP Photon Detector to SP TPC Electronics
  (Unapproved - No approved version)
- DUNE-doc-6721: DUNE FD Interface Document: SP Photon Detector to joint High Voltage
- DUNE-doc-7051: DUNE FD Interface Document: Calibration to SP Photon Detector
- DUNE-doc-6727: DUNE FD Interface Document: SP Photon Detector to Joint DAQ
- DUNE-doc-7123: DUNE FD Interface Document: Software and Computing to Joint DAQ

Mockup architecture for transport, handling, integration and installation

- We would like to construct a mockup station to study the dynamics, failure mechanisms, transportation, handling and safety regulations, integration and installation procedures, and overall, to study the critical features for the entire time the PD structures will spend outside their final location in the cryostat. The mockup station will include a structure at the realistic size and design of an APA with feasible material selection, and several PD structures, both with mimicking materials and actual PD modules.
- The APA mockup will be modular, therefore, any deviations from the baseline design as a result of the ProtoDUNE-SP results will be easily implemented in the mockup as well.
- The dimensional tests of the PD modules will be performed with test mockup structures. The material will be similar in rigidity/flexibility. The actual mechanical tests will be performed with the actual PD modules. The PD modules will be subjected to force, shear and bending. Therefore, the structures will not be intended to be used in the DUNE installation. Our project can in fact use a PD module which does not fully qualify to be a DUNE SPPD module/prototype due to lower quality e.g. damaged coating, scratched surface, etc. Also, the photodetectors are not necessary for this study. But the electronics boards should be assembled. **This proposal was not funded**

Integration and ITF

- PDS modules are planned to be shipped to ITF well in advance of their final integration
  - Storage space
    - Coordinated shipping
- Storage Environment (surface and underground)
  - Humidity (85% relative humidity Max in experimental cavity.
  - Light (WLS are sensitive to light exposure)
  - Cleanliness
  - How long the modules can be stored in adverse conditions

Integration and ITF

- Transportation issues
  - Cables will be pre-installed prior to integration with APA
    - Prevent cabling damage during wrapping
    - Prevent cabling damage during transportation from assembly area to underground
      - Robustness of connections
      - Risks of cable cutting
- Transportation + Storage issue
  - PDS modules need to have a "protective coating"
    - Easy to remove, no unwanted leftovers

Meeting with the APA group

- New concept of 2 APAs sitting on a single cart / frame all the way from the factory to SURF.
- APA group have tried to make a plan for activities at the ITF to understand the time needed, personnel and technical resources (cold boxes / work areas).
- Validates PD system plans for 2 to 6 APA frames per week in a horizontal position
- Results in 1.5 year installation period for one 10kt detector