

# Single Phase Photon Detector Integration and Installation

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# Production, Integration, Installation

- With respect to these consortia talks, four key elements are required:
- (1) Parts Breakdown Structure for your system. This should include the list of deliverables & all tooling. In addition, identify any items that require special handling (i.e., deliverables that exceed the cage dimensions identified in Section 2.d. Hoisting Parameters for Ross Shaft, Docdb#328 facility access specification);
- (2) Personnel requirements during installation & integration
- (3) QA & testing plans.
- (4) expectations about services provided by detector installation team and facility services team

# Parts Breakdown Structure

- Excel spreadsheet attached to Indico
- See the README tab for an explanation of the columns / color coding
- Coordinate PBS numbering with WBS to minimize confusion?

<b>Column A</b>
Blue lines indicate boxes or items that are transported through the shaft While lines are used to give more detail about the content of boxes
<b>Column B</b>
I have left space for a unique serial number (a range of serial numbers is suggested). There will be parts for which no serial number will be provided. Examples are screws/bolts/nuts/consumables.
<b>Column C</b>
For Blue lines-- total number of crates of that type for 1 detector module For white lines-- Contents of the crates
<b>Column D</b>
List of parts if there is more than one object, otherwise more explanation about the object. Could be replaced in the future by a list of identifiers.
<b>Column E/F</b>
Dimensions (in m) and weight (in kg). In most cases these are rough estimates
<b>Column G</b>
Origin (highlighted for the few cases where parts come from another consortium)

<b>Column H</b>
Earliest delivery date. This is usually way too early with respect to the needs and/or the availability of the SDWF / SURF
<b>Column I</b>
Phase where the components are required
<b>Column J</b>
Where should the parts be delivered ? Clean room or APAFrame factories
<b>Column K</b>
Slung load or cage load for packages delivered in shaft
<b>Column L</b>
Will the container be re-used (always no for PD, included for symmetry)
<b>Column M</b>
Notes

# PD Personnel Requirements (i)

- **Phase I: Warm Electronics Installation**

- Install warm front end electronics and readout cables (1 mini-rack per APA stack)
  - 2X DAPNNE modules (1U)
  - 1X Controller (1U)
  - 2 people (supervisor + tech)
  - 10 shifts total, prior to APA installation
- Install power supplies on detector mezzanine
  - Work happens on detector mezzanine
  - team of 2 people Supervisor + tech
  - 10 shifts total(?)
- Cable/fiber connections between mini-rack and detector mezzanine
  - Work happens on top of cryostat, ideally prior to APA Installation
  - team of 2 people Supervisor + tech
  - 10 shifts total(?)

# PD Personnel Requirements (ii)

- **Phase I: Warm Electronics Installation (Continued)**

- Install PD monitoring system electronics in mini-racks
  - 15 control modules (1U)
  - 15 LED flasher modules
  - Monitoring system cryostat flanges (30?)
  - Monitoring system patch fibers (180)
- 2 people, 8 shifts
- May occur at same time with warm electronics installation (efficient) or may be better to wait for more work to be complete
- Requires cable trays, flange locations TBD

- **Phase I: General**

- Not yet included in Bill's planning
- Require access to top of cryostat.
- Ideally occurs following installation of crossing tubes / spool pieces
- False flooring on top of the cryostat, carts for transporting parts (both on top of the cryostat / mezzanine), DAQ + slow controls available at the time of cabling / fiber connections

# PD Personnel Requirements (iii)

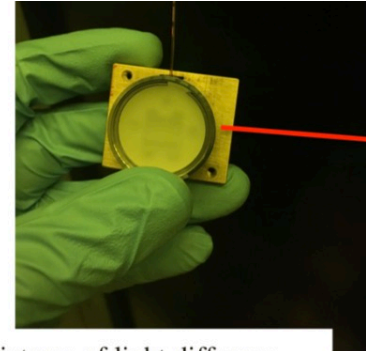
- Phase 2: PD module insertion into APA
  - Requires installation of PDs into 4 APA modules each week (40 PD modules)
  - Fully described in Bill's spreadsheet.
  - QC testing (module scanner, continuity checks) included in schedule
  - Two shifts per day. Each shift consists of:
    - 4 technicians, plus supervisor (5 total per shift)
  - Will require some facilities support for moving APA transport frame
  - Scanner results, continuity checks performed by PD Shift Scientist (1 post-doc level shift scientist per shift) following installation
  - There is some indication we may be able to reduce the required technician count

# PD Personnel Requirements (iv)

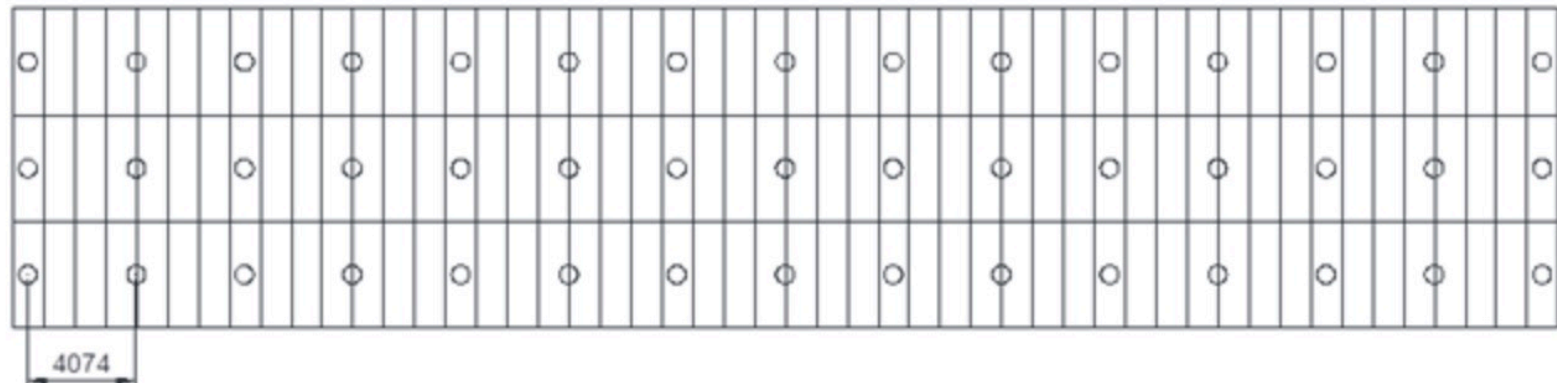
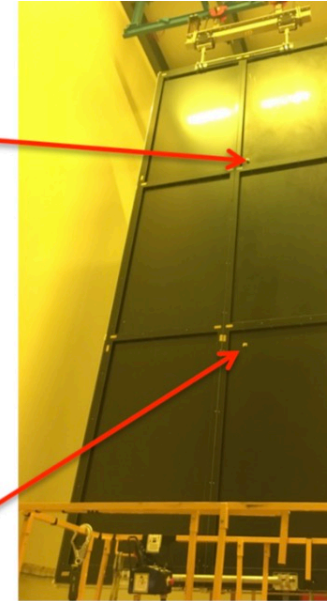
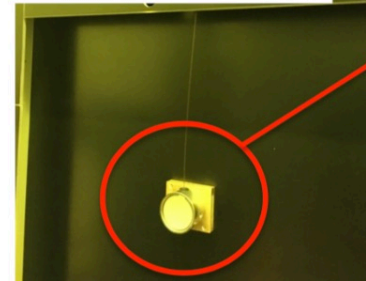
- Phase 3: PD cabling/cold box test/APA installation
  - Upper/lower APA PD cable junction
    - Occurs as part of APA junction
    - Performed by APA personnel
    - Continuity check by shift scientist following junction
    - Included in Bill's spreadsheet
  - Cold box test
    - Cabling by CE personnel
    - PD data check by PD shift scientist
  - Cabling in cryostat
    - Performed by CE personnel
    - Immediate connection to PD front-end electronics
    - Initial operational check by PD shift scientist

# PD Personnel Requirements (v)

- Phase 4: Monitoring system fiber installation
  - Install 180 PD monitoring system fibers inside cryostat
    - One fiber per PD flasher
      - Run from PD monitoring flange to patch panel atop each CPA position
    - Supported on CPA DSS beams
    - Installation performed by detector installation team
    - NOT included in Bill's spreadsheet
  - Diffuser installation
    - Performed by HV personnel as part of CPA panel assembly
    - PD data check by PD shift scientist
  - Fiber connection in cryostat
    - Performed by HV personnel
    - Occurs during CPA installation



Pictures of light diffusers and fibers integrated with one CPAs at CERN.





# Installation Personnel (Summary)

- The requirements of the PD consortium are reasonably modest due in part to support from other consortia
- Maximum personnel requirements occur during module installation
  - For a 40 h/week working maximum, we require 2 shifts per day, 5 technicians per shift
  - In addition, one PD shift scientist per shift
  - 6 total PD personnel per shift (Included in Bill's spreadsheet during PD installation)
- Some additional personnel will be required for PD FE electronics/monitoring system electronics installation
  - 2 personnel plus PD shift scientist
  - Not currently in Bill's schedule
  - Ideally prior to AP installation in cryostat

# Quality Control Prior to delivery

- Each PD module is checked at the PD reception Facility (in US) prior to being stored at SDSW
- Extensive test suite including
  - Re-check in PD scanner
  - Cryogenic test in full-length LN2 bath
- Monitoring system diffusers and fibers will be tested prior to shipping to SURF
- Warm electronics components will be tested immediately prior to shipping to SURF



# Quality Control at SURF (i)

- PD QC testing during APA insertion process
  - Each module scanned prior to insertion into APA frame
  - Continuity check performed to top of APA following insertion
- PD QC during APA stack assembly
  - Continuity check performed upon completion of upper-to-lower APA PD cable junction (prior to CE cable insertion)
  - Continuity check performed immediately following insertion into cold box test stand
- PD QC during APA insertion in cryostat
  - Continuity check immediately following cable connection to flange
  - Operational check (raise voltage just below breakdown) using PD FEB and stand-alone test station following cabling

# Quality Control at SURF(ii)

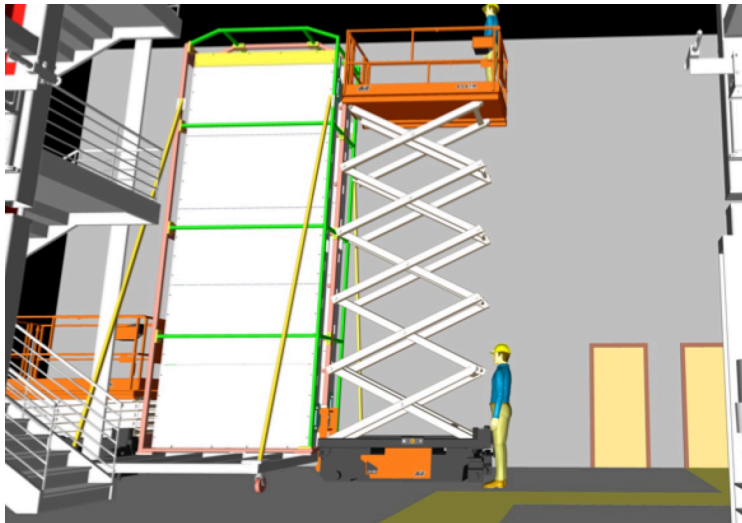
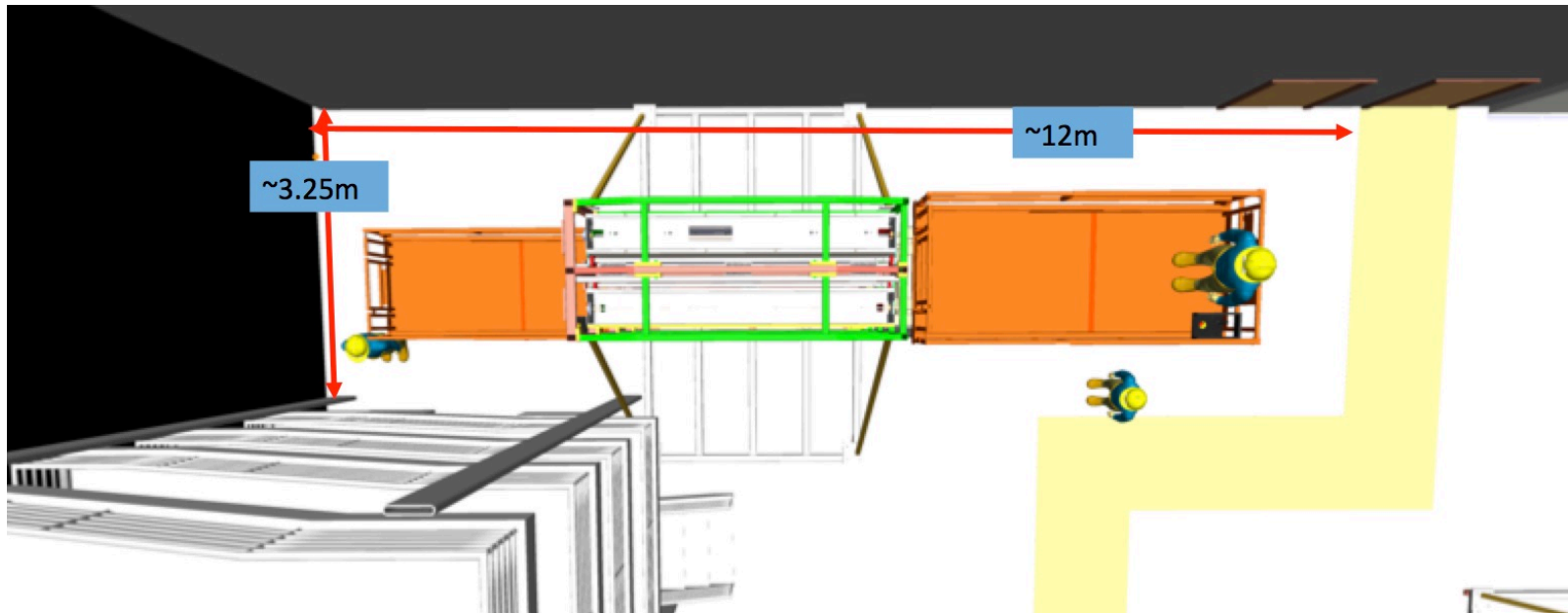
- Operational QC

- Each APA stack will be operated in the cold box prior to insertion into the cryostat
- Weekly operational test of installed APAs (?)
  - Requires functional darkening of cryostat
  - Photon detectors installed in the previous week operated warm to verify operation
    - Stand-alone DAQ (Or perhaps full DAQ connection)
    - Operate in conjunction with CE (cross-talk check?)
    - Operate PD monitoring system(?)
    - Included in Jim's planning
  - Occurs during Friday or weekend time outside normal shift schedule

# Services (i)-- Insertion floor space

- Space for PD insertion/QC testing
  - Minimal requirements include:
    - Space to position one APA shipping frame in vertical orientation
    - 2 person-lifts (6m lift, 2 person capability), one at each end of the APA shipping frame
    - 2m X 5m (minimum) floor space for scanner
    - Storage space for a minimum of 2 week supply of PD modules in the clean room (may be under scanner in part)
    - Space for desk for QC computer/PD shift scientist in PD insertion area
    - Space for cart to deliver modules from the scanner to person lifts
  - **NOTE: Most recent space allocated to PD insertion area does not appear sufficient at first blush...**

# Concerning Screen Shots!



# Services(ii)-- Shipping/Storage at SDWF

- Lighting
  - Photon detector modules will be shipped from PD reception facility (in US) in light-tight, near-hermetically-sealed plastic packaging.
  - Packages should NOT be opened in transit or at SDWF. Exposure to sunlight in particular is destructive to PD modules
- Humidity
  - Specifications document specifies less than 50% RH (at ambient temperature). Ideally this would be maintained during storage.
  - If 50% is unattainable, we need to investigate the impact of higher RH on pTP coatings, and consider modifying the specifications document accordingly
  - In any case, humidity in the SDWF should be controlled and monitored.
- Temperature
  - Ideally  $<35^{\circ}\text{C}$
  - If greater excursions are expected, we will need to investigate the impact on the modules
  - This may also arise as a concern during shipping.

# Services(iii)-- Environmental (SURF)

- Lighting
  - Governed by ALARA principle
  - Photon detectors can operate with “Blue” filtered light for short periods
    - Exposure limits will be re-investigated with new pTP coatings (TPB was used in
    - Work flow should be optimized to avoid long exposures to blue-filtered lights (can we install curtains in areas where access is not needed in assembly stands?)
  - “Orange” filtered lighting (as in ProtoDUNE) will be required for longer exposures (e.g. inside the cryostat
  - We should investigate double lighting, where light fixtures with each filter type can exist simultaneously in the clean room, allowing orange filtered light during non-sensitive operations.
- Humidity
  - Specifications document specifies less than 50% RH (at ambient temperature)
  - Current plans call for 70% RH (what temperature?)
  - If 50% is unattainable, we need to investigate the impact of 70% RH on pTP coatings, and consider modifying the specifications document accordingly
  - In any case, humidity in the clean room and cryostat will need to be controlled and monitored.
- Radiologicals: Clean room and cryostat should be maintained as a class 100,000 clean room. If this cannot be achieved, we will need to understand what (if any) mitigations can occur to prevent high PD data rates due to radiologicals from dust.



# Services(iv)-- Electrical

- Early access to top of cryostat / detector mezzanine
  - Includes early positioning of mini-racks for PD electronics
  - 110V power available on mezzanine for cabling/operational tests
- Availability of detector ground connections in the clean room near the PD insertion area outside the cryostat
- 110V power available in PD testing area
- Connection points for ESD safe mats during PD testing and installation
  - Responsibility for ESD safety equipment ?

# Other Comments (i)-- Safety

- PD personnel work at height--
  - Mostly on person lifts
    - PD Module insertion
    - Continuity checks
  - Occasionally on platforms
    - PD cable connection during APA stack connection, continuity testing
  - Need to understand training and equipment requirements
- ESD safety
  - Training of JPO personnel working on APAs ?

# Other Comments (ii)-- Consortia interfaces

- Much of the PD I&I work involves interactions with and tasks performed by other consortia personnel-- Work plan and training need to be arranged
  - APA Consortium
    - Module insertion tooling
    - Upper to lower cable connections
  - CE Consortium
    - Cold box testing
    - Cable connections in cryostat
    - Flange installation
  - HV Consortium
    - Diffuser installation
    - Optical fiber installation/connection
- QC Work on Fridays / weekends
  - Train some member of the TPC electronics consortium as SURF guides?
  - Need to coordinate with other consortia

# Conclusions

- Initial draft of PBS exists (in Indico)
  - Need to increase level of detail (guidance)
  - Coordination with WBS?
- Personnel requirements understood for PD module insertion
  - 5 technician plus one PD shift scientist, two shifts per day, four days per week
  - Need to include several low-level activities in Bill's spreadsheet
  - Need to understand weekend working requirements
- QC plans during I&I are identified, but may need further refinement
- Interfaces with installation team are defined, but scope and manpower requirements still need additional refinement
  - Particularly for monitoring system fiber installation

# BACKUP

Parts or box identifier	Parts or box serial number	Number of Items per far detector	List of parts included	Dimensions (W x L x H, all in m)	Weight (in kg)	Origin
String of characters, printed on a bar code	Integer number (64 bits ?) with unique correspondence to the identifier, used internally in database for searches because it's much faster to scan on integers than on string		For boxes, provide a list of parts included inside the box	These are estimates		
Detector Parts (Inside Cryostat)						
PD-APA-Doublet_Mount_Internal_Cable_Set-XXX		75+spares	PD Support rails, connectors, APA-mounted PD readout cables for one APA pair	1.0 W x 1.25 L x .3H	100 kg	US Assembly Facility
PD-APA-Upper-Frame Components			1 Set of Upper APA PD mount components			USA
PD_Rail_Assembly_Near	Not tracked individually. Part number for part type	10	PD near rail assemblies			USA
PD_Rail_Assembly_Far	Not tracked individually. Part number for part type	10	PD far rail assemblies			USA
PD_Upper_APA_Transit Cable	Not tracked individually. Part number for part type	10	PD_Upper_APA_Transit Cables			USA
PD_Upper_APA_Signal Cables	Not tracked individually. Part number for each length. 10 part types	10	PD_Upper_APA_Signal_ Cables			USA
PD_Upper_APA_Cable_Guide	Not tracked individually. Part number for part type	2	Sets cable guides			USA
PD-APA-Lower-Frame Components			1 Set of Lower APA PD mount components			USA
PD_Rail_Assembly_Near	Not tracked individually. Part number for part type	10	PD near rail assemblies			USA
PD_Rail_Assembly_Far	Not tracked individually. Part number for part type	10	PD far rail assemblies			USA
PD_Lower_APA_Signal Cables	Not tracked individually. Part number for each length. 10 part types	10	PD_Lowerer_APA_Signal_ Cables			USA
PD_Lower_APA_Cable_Junction_Blocks	Not tracked individually. Part number for part type	2	cable junction blocks (5 cables each)			USA
PD_Module_Set-XXX		150+spares	10 PD Modules (One APA)	1.0 W x 2.5 L x .3H	50 kg	US Reception-Test Facility
PD_Module_YYYY	Tracked individually. Part number YYYY	10	assembled PD module			Brazil
PD_Module_Frame-ZZZZ	Not tracked individually. Part number for part type		FR-4 G-10 Frame for one PD module			Brazil
PBS Detail level TBD						
PD_APA_Flange_Cable_Set-XXX		75+spares	PD APA Flange Cables for 1 APA stack	0.75 x 0.75 x 0.3	50 kg	Colombia/Peru
PD_APA_Flange_Cable	Not tracked individually. Part number per part type	20	PD cables running from APA top to PD flange for 1 APA pair			
PD_Monitoring_System_Difuser_Fiber_Assembly-XXX		4	PD APA Flange Cables for 1 APA stack	1.0 x 1.0 x 1.0		30 USA (SDAMT)
PD_Diffuser_Assembly (including Bracket)	Tracked individually	45	Optical Diffusers including mounts			
PD Diffuser Optical Fibers (Short)	Not tracked individually. Part number for part type	15	Short Diffuser Optical Fibers (length TBD)			
PD Diffuser Optical Fibers (Medium)	Not tracked individually. Part number for part type	15	Medium Diffuser Optical Fibers (length TBD)			
PD Diffuser Optical Fibers (Long)	Not tracked individually. Part number for part type	15	Long Diffuser Optical Fibers (length TBD)			
PD Monitoring System Fiber Junction Block	Not tracked individually. Part number for part type	8	Monitoring System Fiber Junction Block			
PD Monitoring System CPA-Flange Fiber	Not tracked individually. Part number for part type	45	Fibers between fiber junction block and flange			
PD Monitoring System Fiber Flange	Not tracked individually. Part number for part type	8	PD monitoring System Fiber Penetration Flange			

Detector Parts (Outside Cryostat)						
PD_Cryostat_Flange-FEB Cable Set-XXX		25	PD APA Flange Cables for 1 APA stack	0.75 x 0.75 x 0.3	50 kg	Colombia/Peru
PD_APA_Flange_Cable	Not tracked individually. Part number per part type	60	PD cables running from PD Cryostat flange to PD Front End			
PD_Front End Readout Electronics-XXX		25	Readout Electronics for 3 APA stacks	0.8 W x 0.8 L x 0.75H	30 kg	Colombia/Peru
Daphne Front End Modules	Tracked individually. Part number YYYY	6	1U 19" relay rack modules			
Controller boards	Tracked individually. Part number YYYY	3	1U 19" relay rack modules			
Daphne-Controller board cable set	Not tracked individually. Part number for part type	6	Connection cables			
PD_Monitoring System Electronics-XXX		3	Readout Electronics for 3 APA stacks	0.8 W x 0.8 L x 0.5H	30 kg	USA (ANL)
Monitoring System Drivers	Tracked individually. Part number YYYY	5	1U 19" relay rack modules			
LED Flasher Modules	Tracked individually. Part number YYYY	5	1U 19" relay rack modules			
Flasher Module-Monitoring System Flange Fibers	Not tracked individually. Part number for part type	45	Warm Fibers			
PD_DC Power Supplies-XXX		25	Readout Electronics for 3 APA stacks	0.8 W x 0.8 L x 0.5H	60 kg	Colombia/Peru
Low Voltage Power Supplies	Tracked individually. Part number YYYY	1	5U 19" relay rack module			
Power Supply Cables	Not tracked individually. Part number for part type	24	Power cables			
Tools used during the Detector Integration and Installation						
PD_Module Scanner-XXX		2	PD Scanners	1.0 W x 3.0 L x 1.5 H	100 kg	USA
PD_Module Test Scanner	Tracked individually. Part number YYYY	1	PD scanner			
PD_Module Scanner Readout	Tracked individually. Part number YYYY	1	Scanner electronics unit			
PD_Module Installation Tooling-XXX		2	PD Installation Tool Set	0.5 W x 3.0 L x 0.5 H	30 kg	USA
PD_Module Installation Rail	Tracked individually. Part number YYYY	1	PD scanner			
PD_Stand-Alone Electronics/Continuity Check		1	Misc. Electronics Test Equipment	1.0 W x 1.0 L x 1.0 H	50 kg	USA
Stand-alone test station	Tracked individually. Part number YYYY	1	PD scanner			
Continuity Check Station	Tracked individually. Part number YYYY	8	Cable Continuity Check Stations			
PD_Module Installation Tooling-XXX		1	PD Misc. tools	1.0 W x 1.0 L x 1.0 H	50kg	USA
PD_Module Misc. Tools	Not tracked individually.	1	Misc. PD Tooling			
Still needed						
PD handling cart						
?						