

Post-swap Horizontal Drift PDS Schedule/MOU

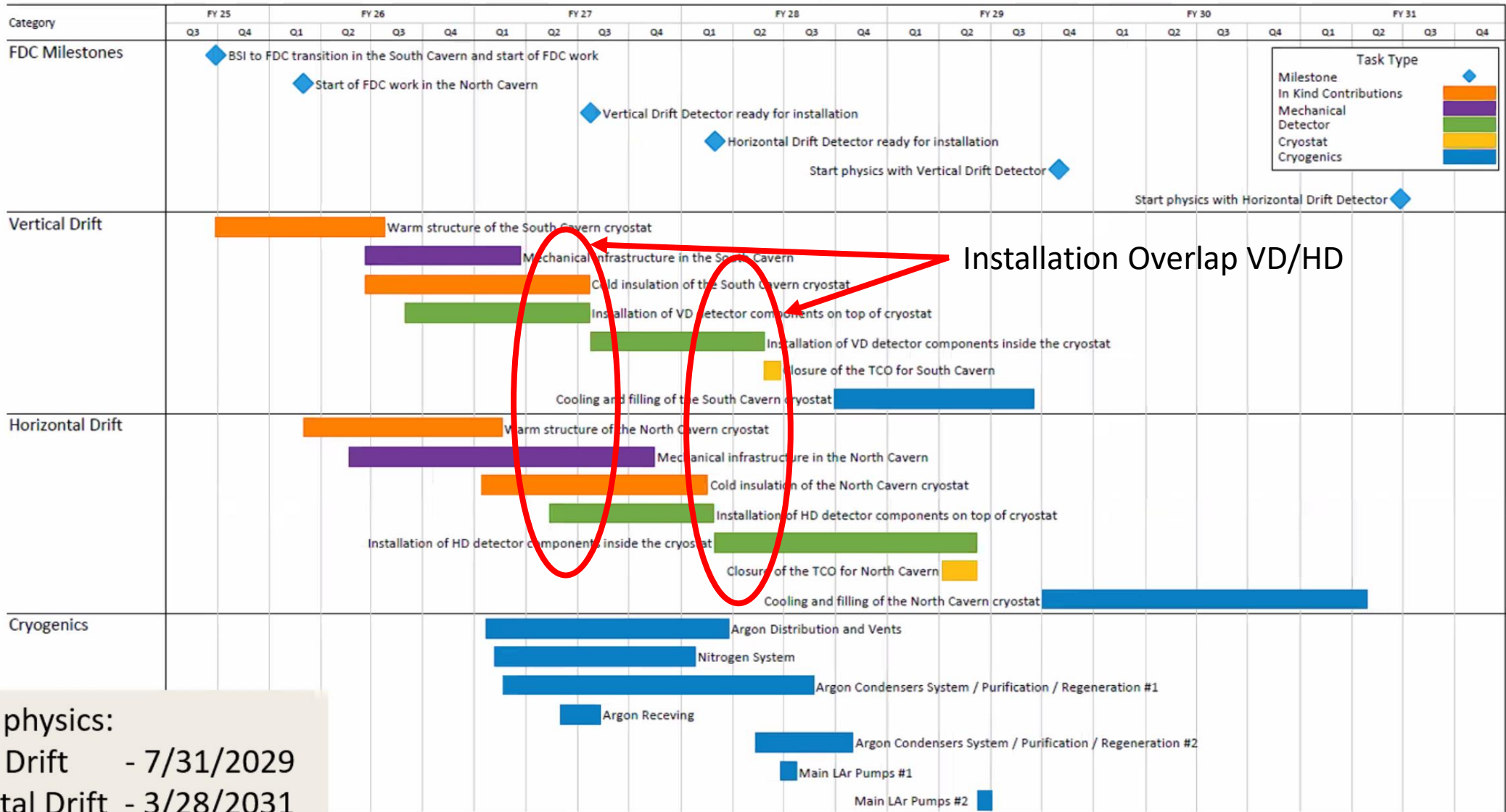
David Warner

Colorado State University

May 19, 2024

Updated Far Detector Schedule

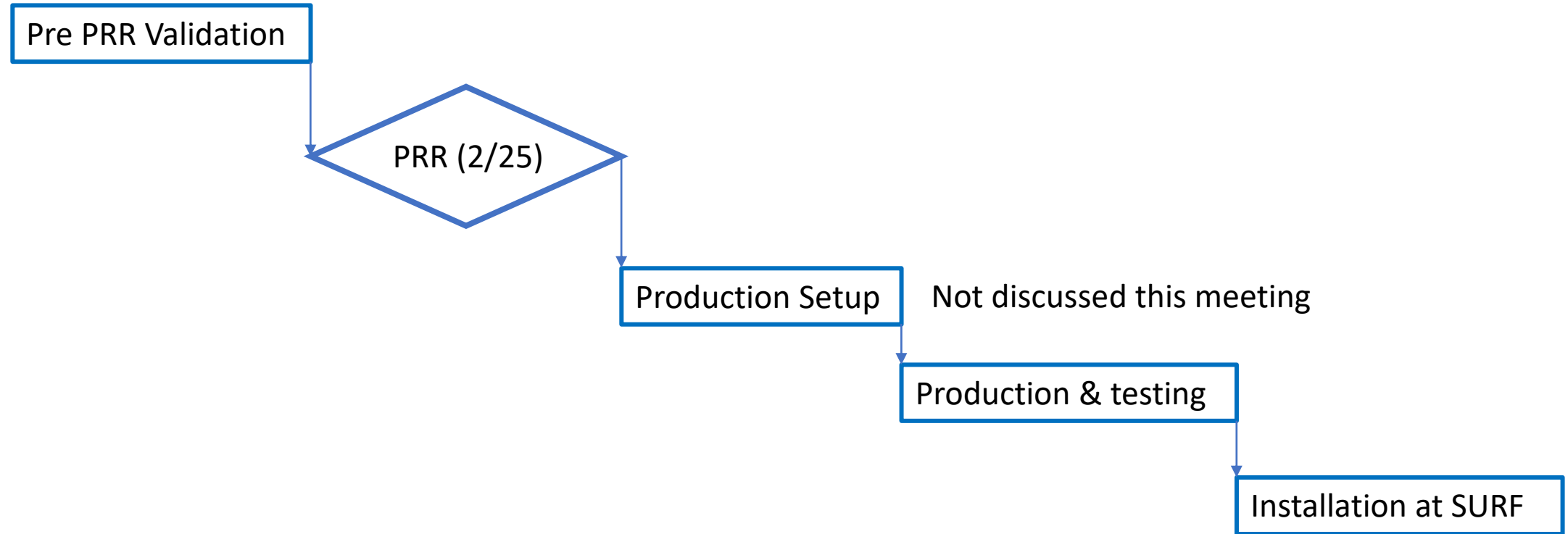
Far Detector Summary Schedule



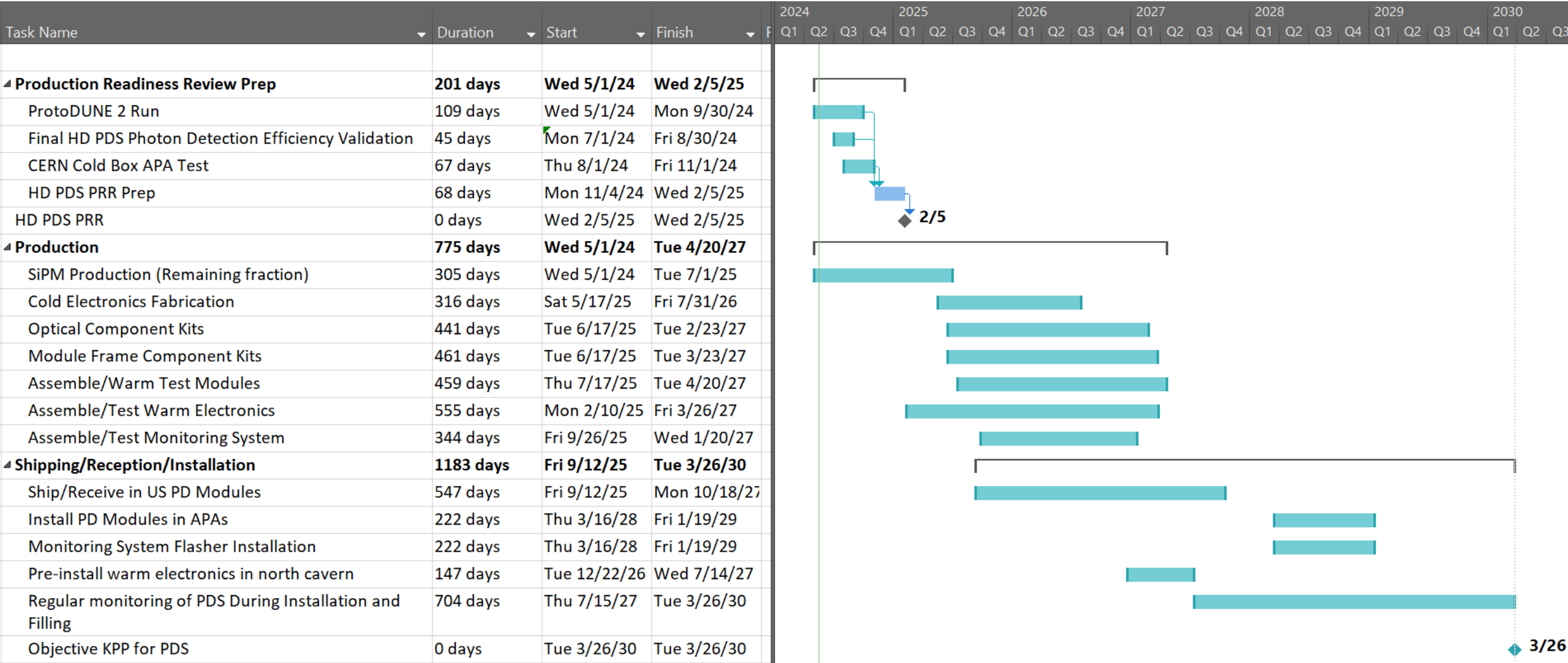
Installation Overlap VD/HD

Start of physics:
 Vertical Drift - 7/31/2029
 Horizontal Drift - 3/28/2031
 5/19/2024

General Workflow

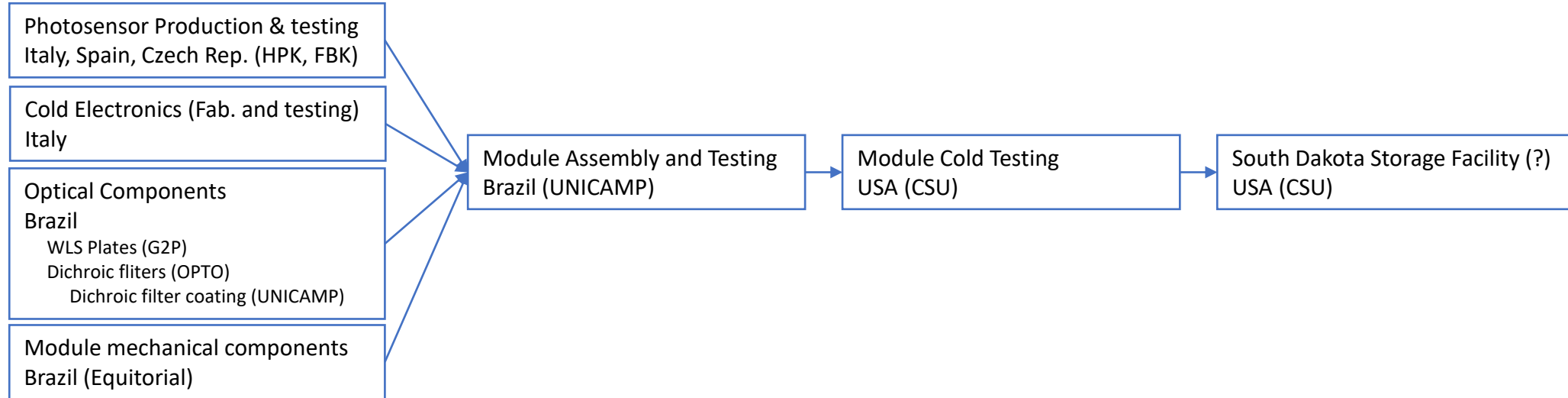


Updated High-Level HD PDS Schedule

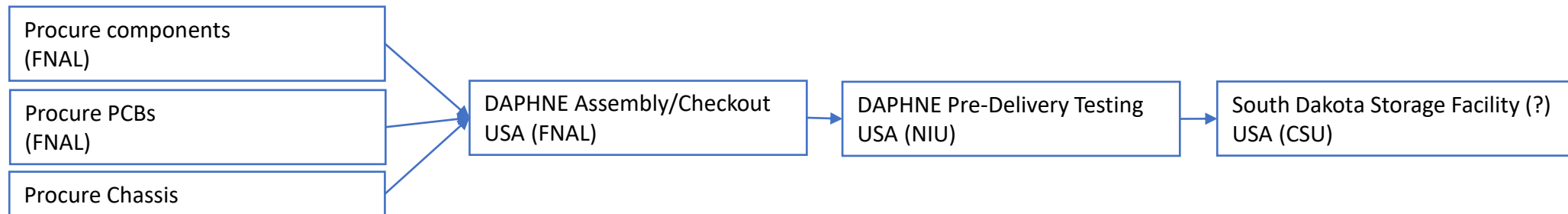


General HD PDS Workflow as reflected in P6 (1)

Optical Module Fabrication/Testing

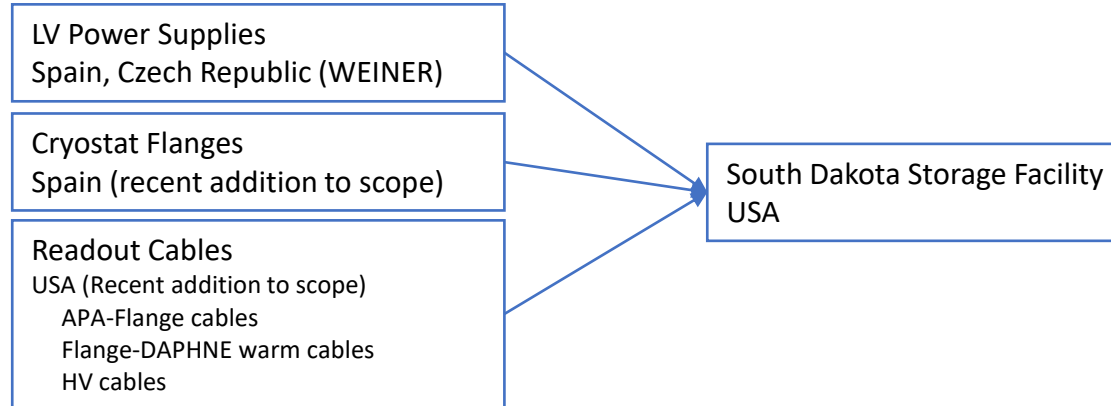


Warm Electronics (DAPHNE) Fabrication/Testing

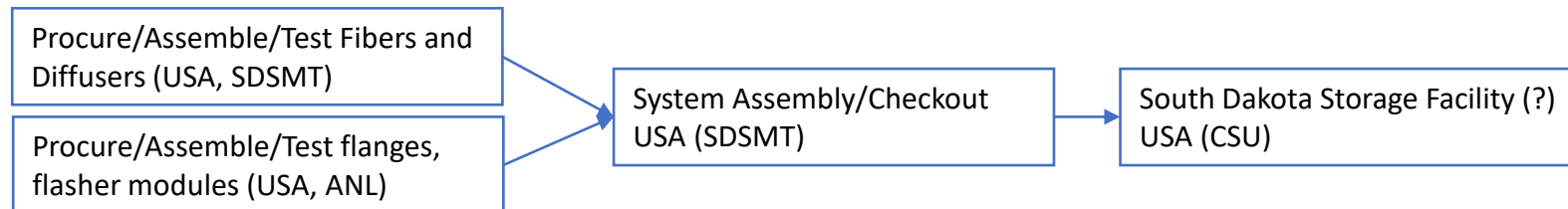


General HD PDS Workflow as reflected in P6, (2)

Readout Cables/Power Supplies/Flanges

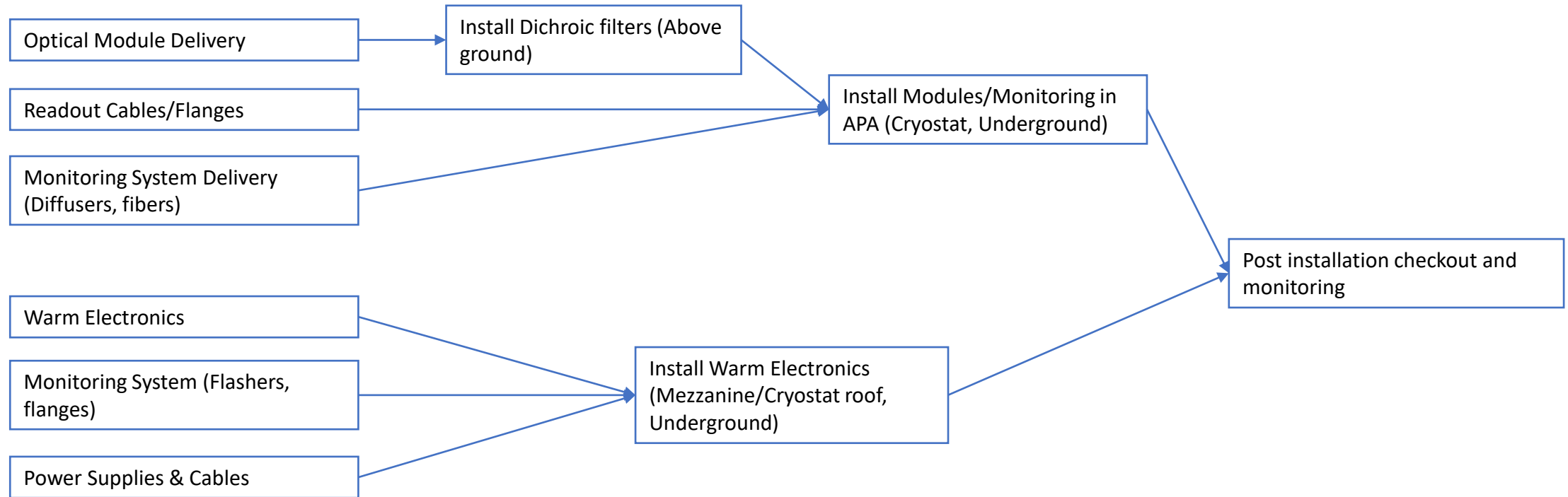


Monitoring System



General HD PDS Workflow as reflected in P6, (3)

Integration and Installation (I&I)

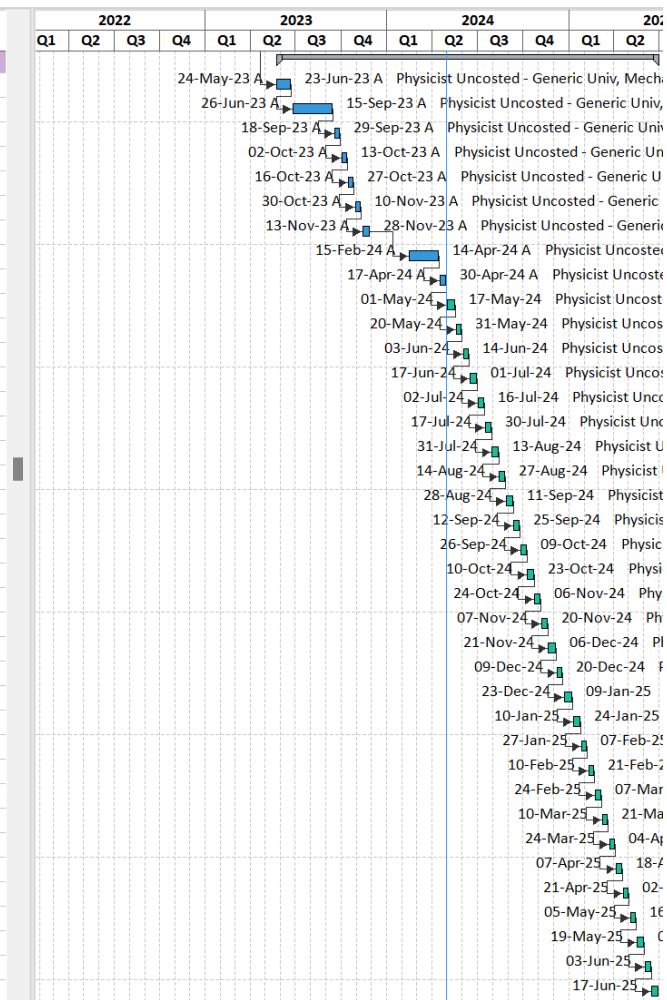


2 shifts of 4 PDS personnel, 4 days/week, Through duration

Photosensors (Spain, Italy, Czech Republic)

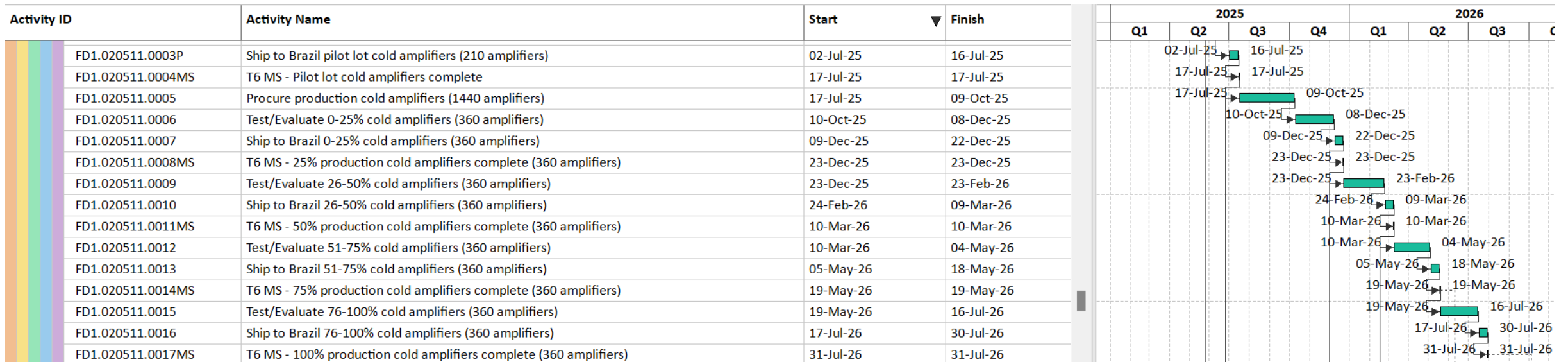
- A photosensor “Kit” is the number of boards needed for 1 module (32 boards) + 5% spares.
- Testing runs May 2023 – July 2025.
- Assumes ~ 2,500 boards per month.
- Currently reporting 360 (~25%) kits complete.
- Currently uses US calendar assumptions (holidays...).
- Separate contemporaneous lines (not shown) for Spanish and Czech contributions.

Activity ID	Activity Name	Start	Finish
Photosensors and Active Ganging			
13122.A12516	Assemble 40 PD Module Photosensor Kit #1 (40 total) - Italy	24-May-23	01-Jul-25
13122.A12518	Assemble 40 PD Module Photosensor Kit #1 (80 total) - Italy	24-May-23 A	23-Jun-23 A
13122.A12520	Assemble 40 PD Module Photosensor Kit #1 (120 total) - Italy	26-Jun-23 A	15-Sep-23 A
13122.A12522	Assemble 40 PD Module Photosensor Kit #1 (160 total) - Italy	18-Sep-23 A	29-Sep-23 A
13122.A12524	Assemble 40 PD Module Photosensor Kit #1 (200 total) - Italy	02-Oct-23 A	13-Oct-23 A
13122.A12526	Assemble 40 PD Module Photosensor Kit #1 (240 total) - Italy	16-Oct-23 A	27-Oct-23 A
13122.A12528	Assemble 40 PD Module Photosensor Kit #1 (280 total) - Italy	30-Oct-23 A	10-Nov-23 A
13122.A12530	Assemble 40 PD Module Photosensor Kit #1 (320 total) - Italy	13-Nov-23 A	28-Nov-23 A
13122.A12532	Assemble 40 PD Module Photosensor Kit #1 (360 total) - Italy	15-Feb-24 A	14-Apr-24 A
13122.A12534	Assemble 40 PD Module Photosensor Kit #1 (400 total) - Italy	17-Apr-24 A	30-Apr-24 A
13122.A12536	Assemble 40 PD Module Photosensor Kit #1 (440 total) - Italy	01-May-24	17-May-24
13122.A12538	Assemble 40 PD Module Photosensor Kit #1 (480 total) - Italy	20-May-24	31-May-24
13122.A12540	Assemble 40 PD Module Photosensor Kit #1 (520 total) - Italy	03-Jun-24	14-Jun-24
13122.A12542	Assemble 40 PD Module Photosensor Kit #1 (560 total) - Italy	17-Jun-24	01-Jul-24
13122.A12544	Assemble 40 PD Module Photosensor Kit #1 (600 total) - Italy	02-Jul-24	16-Jul-24
13122.A12546	Assemble 40 PD Module Photosensor Kit #1 (640 total) - Italy	17-Jul-24	30-Jul-24
13122.A12548	Assemble 40 PD Module Photosensor Kit #1 (680 total) - Italy	31-Jul-24	13-Aug-24
13122.A12550	Assemble 40 PD Module Photosensor Kit #1 (720 total) - Italy	14-Aug-24	27-Aug-24
13122.A12552	Assemble 40 PD Module Photosensor Kit #1 (760 total) - Italy	28-Aug-24	11-Sep-24
13122.A12554	Assemble 40 PD Module Photosensor Kit #1 (800 total) - Italy	12-Sep-24	25-Sep-24
13122.A12556	Assemble 40 PD Module Photosensor Kit #1 (840 total) - Italy	26-Sep-24	09-Oct-24
13122.A12558	Assemble 40 PD Module Photosensor Kit #1 (880 total) - Italy	10-Oct-24	23-Oct-24
13122.A12560	Assemble 40 PD Module Photosensor Kit #1 (920 total) - Italy	24-Oct-24	06-Nov-24
13122.A12562	Assemble 40 PD Module Photosensor Kit #1 (960 total) - Italy	07-Nov-24	20-Nov-24
13122.A12564	Assemble 40 PD Module Photosensor Kit #1 (1000 total) - Italy	21-Nov-24	06-Dec-24
13122.A12566	Assemble 40 PD Module Photosensor Kit #1 (1040 total) - Italy	09-Dec-24	20-Dec-24
13122.A12568	Assemble 40 PD Module Photosensor Kit #1 (1080 total) - Italy	23-Dec-24	09-Jan-25
13122.A12570	Assemble 40 PD Module Photosensor Kit #1 (1120 total) - Italy	10-Jan-25	24-Jan-25
13122.A12572	Assemble 40 PD Module Photosensor Kit #1 (1160 total) - Italy	27-Jan-25	07-Feb-25
13122.A12574	Assemble 40 PD Module Photosensor Kit #1 (1200 total) - Italy	10-Feb-25	21-Feb-25
13122.A12576	Assemble 40 PD Module Photosensor Kit #1 (1240 total) - Italy	24-Feb-25	07-Mar-25
13122.A12578	Assemble 40 PD Module Photosensor Kit #1 (1280 total) - Italy	10-Mar-25	21-Mar-25
13122.A12580	Assemble 40 PD Module Photosensor Kit #1 (1320 total) - Italy	24-Mar-25	04-Apr-25
13122.A12582	Assemble 40 PD Module Photosensor Kit #1 (1360 total) - Italy	07-Apr-25	18-Apr-25
13122.A12584	Assemble 40 PD Module Photosensor Kit #1 (1400 total) - Italy	21-Apr-25	02-May-25
13122.A12586	Assemble 40 PD Module Photosensor Kit #1 (1440 total) - Italy	05-May-25	16-May-25
13122.A12588	Assemble 40 PD Module Photosensor Kit #1 (1480 total) - Italy	19-May-25	02-Jun-25
13122.A12590	Assemble 20 PD Module Photosensor Kit #1 (1500 total) - Italy	03-Jun-25	16-Jun-25
		17-Jun-25	01-Jul-25



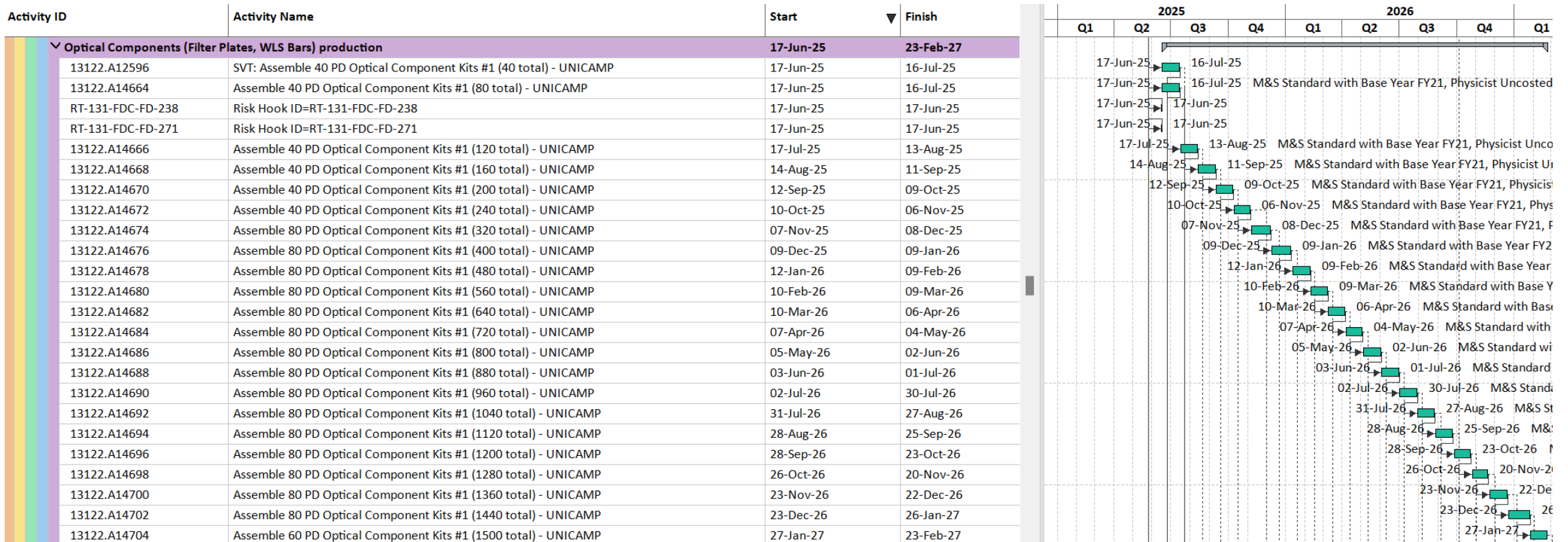
HD Cold Electronics (Italy)

- Cold electronics include 1,500 cold amplifiers and 6,000 signal Routing Boards boards (+10% spares).
- Production and testing currently starts July 2025, ends July 26.
 - It is understood that this will need to be moved earlier to meet the INFN funding profile (Procurement line must occur in 2024).
 - Will require additional PRR to accommodate this schedule.



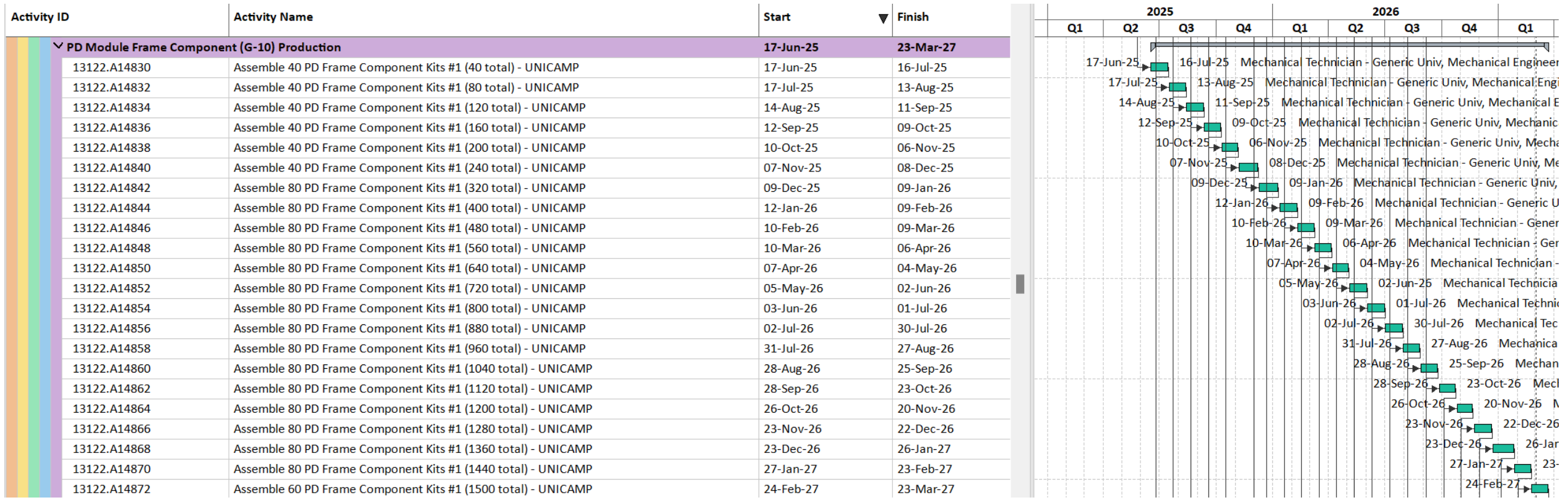
Optical Components (UNICAMP)

- An optical component “Kit” includes the WLS bars and coated dichroic filters for a single module
- Fabrication occurs June 2025 – February 2027
- Maximum required production rate of 4 kits/day



Module Frame Components (UNICAMP)

- A frame component “Kit” includes the mechanical components for a single module
- Fabrication occurs June 2025 – March 2027
- Maximum required production rate of 4 kits/day



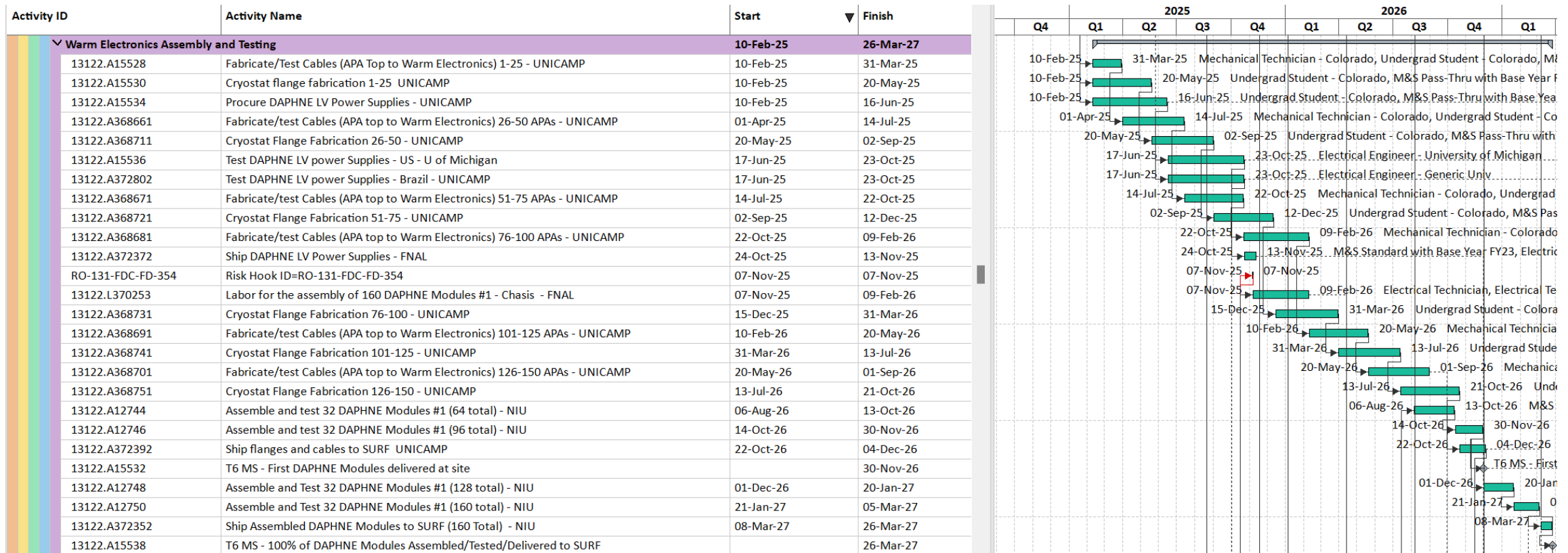
Module Assembly (UNICAMP)

- Modules assembled at UNICAMP
- 2 modules/day initially, 4 modules per day for second half of production
- Production occurs July 25 through April 27.

Activity ID	Activity Name	Start	Finish	2025				2026					
				Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
Module Assembly and Testing				17-Jul-25				20-Apr-27					
13122.A14744	Assemble 40 PD Modules #1 (40 total) - UNICAMP	17-Jul-25	13-Aug-25				17-Jul-25	13-Aug-25	Mechanical Technician - Generic Univ, Mechanical Engin				
13122.A14746	Assemble 40 PD Modules #1 (80 total) - UNICAMP	14-Aug-25	11-Sep-25				14-Aug-25	11-Sep-25	Mechanical Technician - Generic Univ, Mechanical En				
RT-131-FDC-FD-269	Risk Hook ID=RT-131-FDC-FD-269	14-Aug-25	14-Aug-25				14-Aug-25	14-Aug-25					
13122.A14748	Assemble 40 PD Modules #1 (120 total) - UNICAMP	12-Sep-25	09-Oct-25				12-Sep-25	09-Oct-25	Mechanical Technician - Generic Univ, Mechanical				
13122.A14750	Assemble 40 PD Modules #1 (160 total) - UNICAMP	10-Oct-25	06-Nov-25				10-Oct-25	06-Nov-25	Mechanical Technician - Generic Univ, Mechar				
13122.A14752	Assemble 40 PD Modules #1 (200 total) - UNICAMP	07-Nov-25	08-Dec-25				07-Nov-25	08-Dec-25	Mechanical Technician - Generic Univ, Mec				
13122.A14754	Assemble 40 PD Modules #1 (240 total) - UNICAMP	23-Dec-25	26-Jan-26				23-Dec-25	26-Jan-26	Mechanical Technician - Generic Univ,				
13122.A14756	Assemble 80 PD Modules #1 (320 total) - UNICAMP	12-Jan-26	09-Feb-26				12-Jan-26	09-Feb-26	Mechanical Technician - Generic Un				
13122.A14758	Assemble 80 PD Modules #1 (400 total) - UNICAMP	10-Feb-26	09-Mar-26				10-Feb-26	09-Mar-26	Mechanical Technician - Generic				
13122.A14760	Assemble 80 PD Modules #1 (480 total) - UNICAMP	10-Mar-26	06-Apr-26				10-Mar-26	06-Apr-26	Mechanical Technician - Gene				
13122.A14762	Assemble 80 PD Modules #1 (560 total) - UNICAMP	07-Apr-26	04-May-26				07-Apr-26	04-May-26	Mechanical Technician - C				
13122.A14764	Assemble 80 PD Modules #1 (640 total) - UNICAMP	05-May-26	02-Jun-26				05-May-26	02-Jun-26	Mechanical Technician				
13122.A14766	Assemble 80 PD Modules #1 (720 total) - UNICAMP	03-Jun-26	01-Jul-26				03-Jun-26	01-Jul-26	Mechanical Technici				
13122.A14768	Assemble 80 PD Modules #1 (800 total) - UNICAMP	02-Jul-26	30-Jul-26				02-Jul-26	30-Jul-26	Mechanical Technr				
13122.A14770	Assemble 80 PD Modules #1 (880 total) - UNICAMP	31-Jul-26	27-Aug-26				31-Jul-26	27-Aug-26	Mechanical T				
13122.A14772	Assemble 80 PD Modules #1 (960 total) - UNICAMP	28-Aug-26	25-Sep-26				28-Aug-26	25-Sep-26	Mechanic				
13122.A14774	Assemble 80 PD Modules #1 (1040 total) - UNICAMP	28-Sep-26	23-Oct-26				28-Sep-26	23-Oct-26	Mecha				
13122.A14776	Assemble 80 PD Modules #1 (1120 total) - UNICAMP	26-Oct-26	20-Nov-26				26-Oct-26	20-Nov-26	Me				
13122.A14778	Assemble 80 PD Modules #1 (1200 total) - UNICAMP	23-Nov-26	22-Dec-26				23-Nov-26	22-Dec-26					
13122.A14780	Assemble 80 PD Modules #1 (1280 total) - UNICAMP	23-Dec-26	26-Jan-27				23-Dec-26	26-Jan-27					
13122.A14782	Assemble 80 PD Modules #1 (1360 total) - UNICAMP	27-Jan-27	23-Feb-27				27-Jan-27	23-Feb-27					
13122.A14784	Assemble 80 PD Modules #1 (1440 total) - UNICAMP	24-Feb-27	23-Mar-27				24-Feb-27	23-Mar-27					
13122.A14786	Assemble 60 PD Modules #1 (1500 total) - UNICAMP	24-Mar-27	20-Apr-27				24-Mar-27	20-Apr-27					

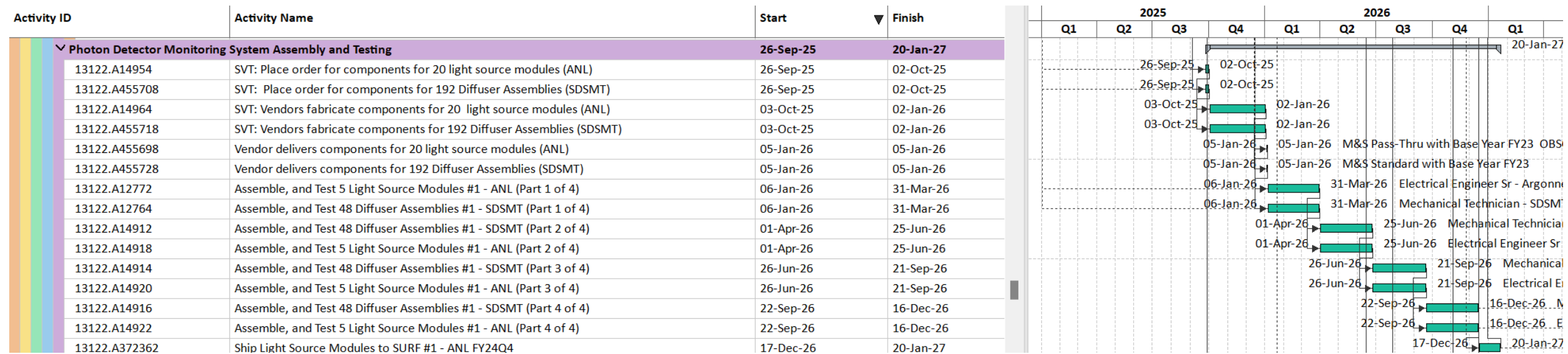
Warm Electronics (Spain, Czech Republic, Fermilab, NIU, U Michigan, CSU)

- Includes multiple activities associated with warm-side readout
 - Flanges, power supplies (Spain, Czech Republic)
 - Power Supply Testing (U of Michigan)
 - Warm cables (CSU)
 - DAPHNE Fabrication (FNAL)
 - DAPHNE testing (NIU)



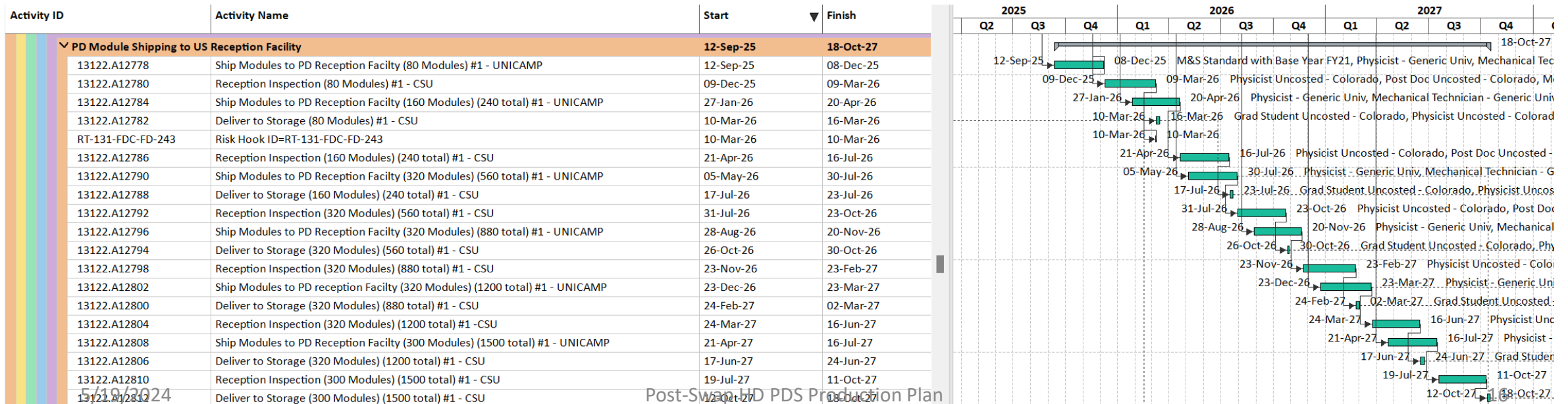
Monitoring System (ANL, SDSMT)

- Includes 192 diffuser/fiber assemblies (+20 spares, SDSMT) and 20 Light source modules (ANL)
- Production occurs September 2025 through January 2027.



Module Reception/Testing/Storage

- Following assembly and initial warm testing at UNICAMP, Modules are shipped to the US module reception facility at CSU for cold testing and repair, then storage
 - 60 day shipping UNICAMP – CSU
 - Modules tested at a rate of 10/day
 - 5 day shipping CSU – SURF
- Reception/Inspection starts 9/25, Ends 10/27

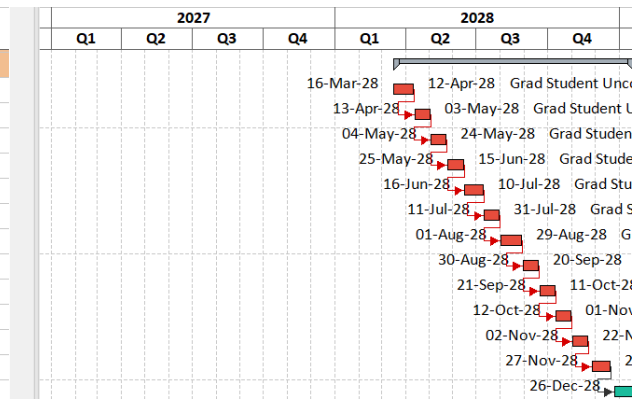


Installation and Integration

- I&I activities occur at SURF site in Lead SD
- Warm Electronics installation occurs Dec. 26 through July 27 (with availability of cryostat roof)
- Light detector and monitoring installation occurs March 28 – January 29
- 2 4-person crews for modules, 1 2-person crew for flashers/diffusers

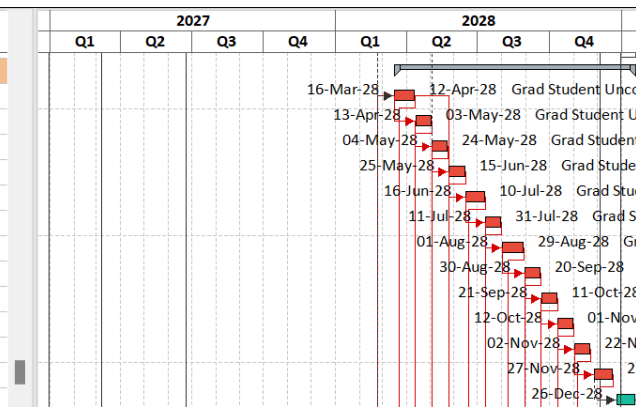
Light Detector

Activity ID	Activity Name	Start	Finish
PD Module Integration		16-Mar-28	19-Jan-29
13122.A14534	Install Modules in Detector Slices 1-2 (120 Modules total) #1 - Italy	16-Mar-28	12-Apr-28
13122.A14536	Install Modules in Detector Slices 3-4 (240 Modules total) #1 - Italy	13-Apr-28	03-May-28
13122.A14538	Install Modules in Detector Slices 5-6 (360 Modules total) #1 - Italy	04-May-28	24-May-28
13122.A14540	Install Modules in Detector Slices 7-8 (480 Modules total) #1 - Italy	25-May-28	15-Jun-28
13122.A14542	Install Modules in Detector Slices 9-10 (600 Modules total) #1 - Italy	16-Jun-28	10-Jul-28
13122.A14544	Install Modules in Detector Slices 11-12 (720 Modules total) #1 - Italy	11-Jul-28	31-Jul-28
13122.A14546	Install Modules in Detector Slices 13-14 (840 Modules total) #1 - Italy	01-Aug-28	29-Aug-28
13122.A14548	Install Modules in Detector Slices 15-16 (960 Modules total) #1 - Italy	30-Aug-28	20-Sep-28
13122.A14550	Install Modules in Detector Slices 17-18 (1080 Modules total) #1 - Italy	21-Sep-28	11-Oct-28
13122.A14552	Install Modules in Detector Slices 19-20 (1200 Modules total) #1 - Italy	12-Oct-28	01-Nov-28
13122.A14554	Install Modules in Detector Slices 21-22 (1320 Modules total) #1 - Italy	02-Nov-28	22-Nov-28
13122.A14556	Install Modules in Detector Slices 23-24 (1440 Modules total) #1 - Italy	27-Nov-28	21-Dec-28
13122.A14558	Install Modules in Detector Slice 25 (1500 Modules total) #1 - Italy	26-Dec-28	19-Jan-29



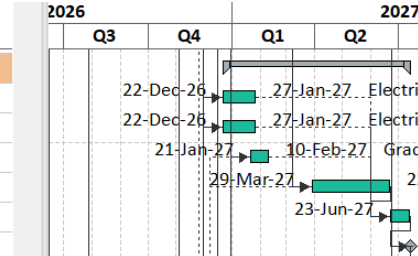
Monitoring

Activity ID	Activity Name	Start	Finish
PD Monitoring System Installation		16-Mar-28	19-Jan-29
13122.A12840	Install PD Monitoring in Detector #1 Slices 1-2 - SDSMT	16-Mar-28	12-Apr-28
13122.A12842	Install PD Monitoring in Detector #1 Slices 3-4 - SDSMT	13-Apr-28	03-May-28
13122.A12844	Install PD Monitoring in Detector #1 Slices 5-6 - SDSMT	04-May-28	24-May-28
13122.A12846	Install PD Monitoring in Detector #1 Slices 7-8 - SDSMT	25-May-28	15-Jun-28
13122.A12848	Install PD Monitoring in Detector #1 Slices 9-10 - SDSMT	16-Jun-28	10-Jul-28
13122.A12850	Install PD Monitoring in Detector #1 Slices 11-12 - SDSMT	11-Jul-28	31-Jul-28
13122.A12852	Install PD Monitoring in Detector #1 Slices 13-14 - SDSMT	01-Aug-28	29-Aug-28
13122.A12854	Install PD Monitoring in Detector #1 Slices 15-16 - SDSMT	30-Aug-28	20-Sep-28
13122.A12856	Install PD Monitoring in Detector #1 Slices 17-18 - SDSMT	21-Sep-28	11-Oct-28
13122.A12858	Install PD Monitoring in Detector #1 Slices 19-20 - SDSMT	12-Oct-28	01-Nov-28
13122.A12860	Install PD Monitoring in Detector #1 Slices 21-22 - SDSMT	02-Nov-28	22-Nov-28
13122.A12862	Install PD Monitoring in Detector #1 Slices 23-24 - SDSMT	27-Nov-28	21-Dec-28
13122.A12864	Install PD Monitoring in Detector #1 Slices 25 - SDSMT	26-Dec-28	19-Jan-29



Warm Electronics

Activity ID	Activity Name	Start	Finish
PD Warm Electronics/UV flasher Installation/Checkout		22-Dec-26	14-Jul-27
13122.A15540	Install LV Power Supplies (US) - MICH	22-Dec-26	27-Jan-27
13122.A15542	Install LV Power Supplies (UNICAMP)	22-Dec-26	27-Jan-27
13122.A372342	Install/Checkout Monitoring System Flashers - SDSMT - ANL	21-Jan-27	10-Feb-27
13122.A12866	Install/Checkout Warm Electronics Detector #1 - Colombia	29-Mar-27	22-Jun-27
13122.A15522	PD Warm Electronics System DAQ Interface Checkout - FNAL	23-Jun-27	14-Jul-27
13122.A372382	T6 MS - 100% of PD Warm Electronics System Installation Complete		14-Jul-27



Horizontal Drift Photon Detector System MOU

Subsystem	Description	Quantity (FD1)	Contributing Institutions	Funding Agencies
Light Collector Modules	X-Arapuca modules (10 per APA); frames, filters, and assembly	1,500	Unicamp, CTI, Unifal, UFABC, LNLS, Unifesp, ITA	FAPESP
Photosensors	6x6 mm ² SiPM, (192 for each of 1,500 modules); post-fabrication testing in both warm and cold	192,000	INFN Bologna, INFN Milano Bicocca, INFN <u>Laboratori Nazionali del Sud</u> , University of <u>Insubria</u> and INFN, INFN Ferrara, INFN Milano, INFN Naples	INFN-Italy
Photosensors	6x6 mm ² Silicon Photomultipliers (SiPM), (192 for each of 1,500 modules); post-fabrication testing in both warm and cold	96,000	CIEMAT, IFIC, UGR	MCIN
Photosensors	Post-fabrication testing in both warm and cold		CAS, CTU	MEYS

Subsystem	Description	Quantity (FD1)	Contributing Institutions	Funding Agencies
CE	Photosensor passive (X6) and active (X8) ganging circuit (1 board per module); post-fabrication testing in both warm and cold	1,500	INFN Milano Bicocca, INFN <u>Laboratori Nazionali del Sud</u> , INFN Milano	INFN-Italy
CE	Post-fabrication testing in both warm and cold		CIEMAT, IFIC	MCIN
Warm Electronics	DAPHNE warm readout boards (1 per APA); post-fabrication testing	150	Fermilab, University of Michigan	Fermilab LBNF/DUNE-US project (DOE)
Calibration and Monitoring system	Pulsed ultraviolet (UV) flashers with Cathode Plane Assembly (CPA) mounted diffusers	204 diffusers, 18 control modules	ANL, SDSMT	Fermilab LBNF/DUNE-US project (DOE)
Detector Infrastructure	Module support rails, electrical connectors, and readout cables (1 set per APA)	150	Colorado State University	Fermilab LBNF/DUNE-US project (DOE)

Items not currently explicitly covered in MOU

- LV Power supplies
- Flanges
- Readout cables
 - While the intention was that the warm cables and APA-flange cold cables would be made in Brazil, the existing MOU text can be read to include those cables so no edits are needed

Subsystem	Description	Quantity (HD PDS)	Contributing Nation	Funding Agency
LV Power Supplies	WEINER power supplies and crates for DAPHNE and monitoring flashers	150 channels + 10% spares	Spain, Cz. Republic	
Cryostat Flanges	Flanges for HD PDS signal/calibration cryostat penetration	75 flanges + 10% spares	Spain (Grenada)	

Other MOU/scope changes (resulting from this meeting)

Subsystem	Description	Quantity (HD PDS)	Contributing Nation	Funding Agency

Backup

HD/VD Overlap topics

- Resource utilization is not monitored carefully across HD/VD PDS boundaries.
- Shared human resources and facilities need to be carefully evaluated to ensure resource utilization duplication is avoided.
- Particular examples include:
 - SiPM fabrication/testing HD vs. VD. HD and VD fabrication and testing share any share CACTUS testing sites and operators, and definitely share vendors for fabrication.
 - Dichroic filters: While HD and VD use separate vendors for dichroic filters mitigating overlap, there may be competition for pTP coating facilities. P6 includes separate HD and VD sites, but the risk of overlapping resources needs to be monitored.
 - WLS plates: Both HD and VD PDS plan to use the same vendor (Glass to Power) for wavelength shifting plates. Care must be taken to overtax this vendor.
 - DAPHNE: While HD and VD DAPHNE production is conducted at separate sites in Europe and the US, intellectual leadership of the effort is provided by the same teams. This possibility exists for resource conflict at FNAL primarily, however care must be taken to manage intra-European responsibilities for the VD PDS .
 - ~3 months explicit I&I HD and VD overlap exists in P6, which will need to be managed.
- + resource overlaps with multiple different tasks at the same institution.
 - Several institutions are involved in hardware tasks for both HD and VD PDS.
 - Additionally, some are involved in HD fabrication during VD I&I.
- This potential interference may be mitigated by:
 - Involving more groups in some tasks.
 - Shifting the P6 schedule to better “Load level” resource utilization.