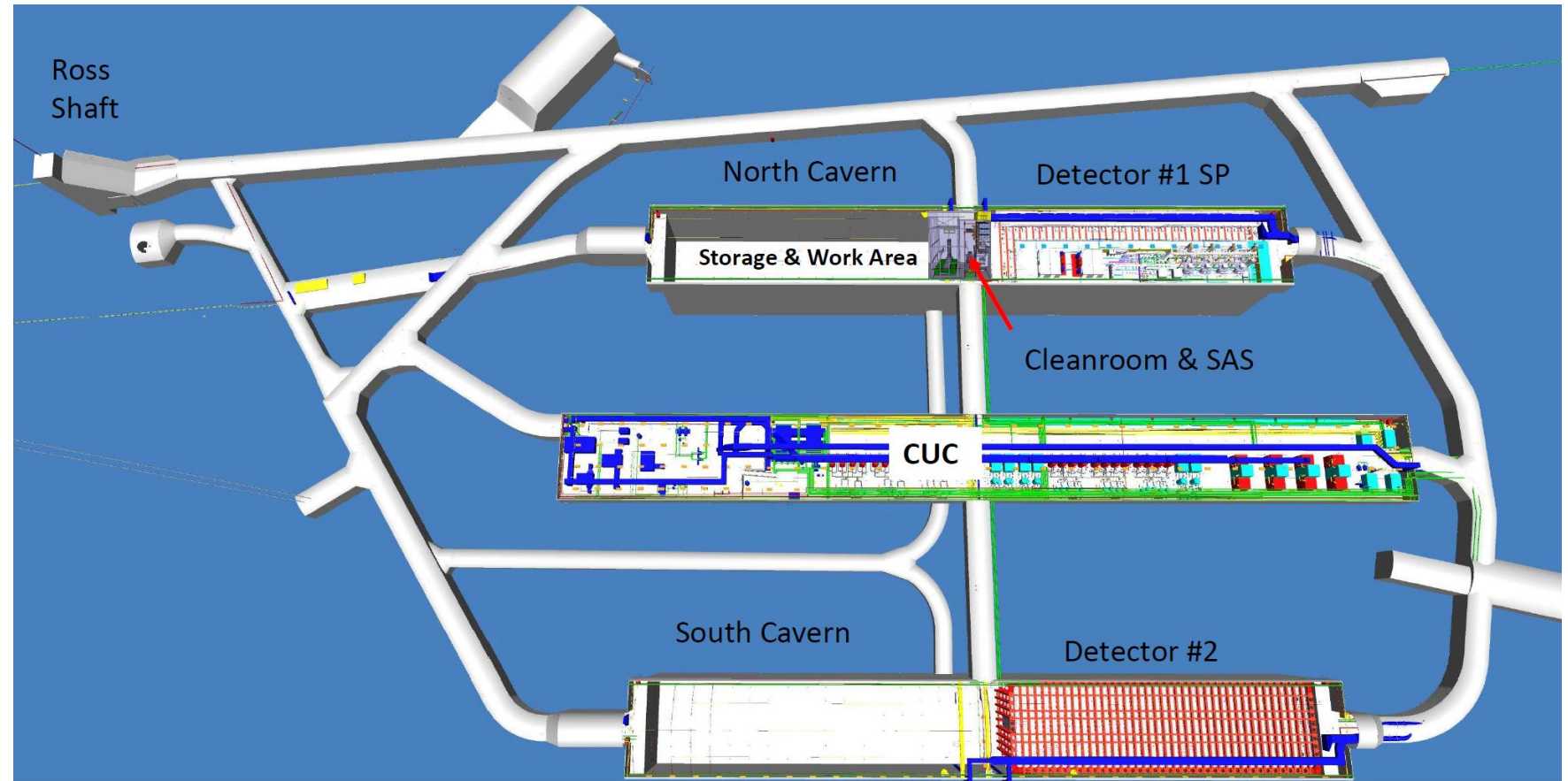


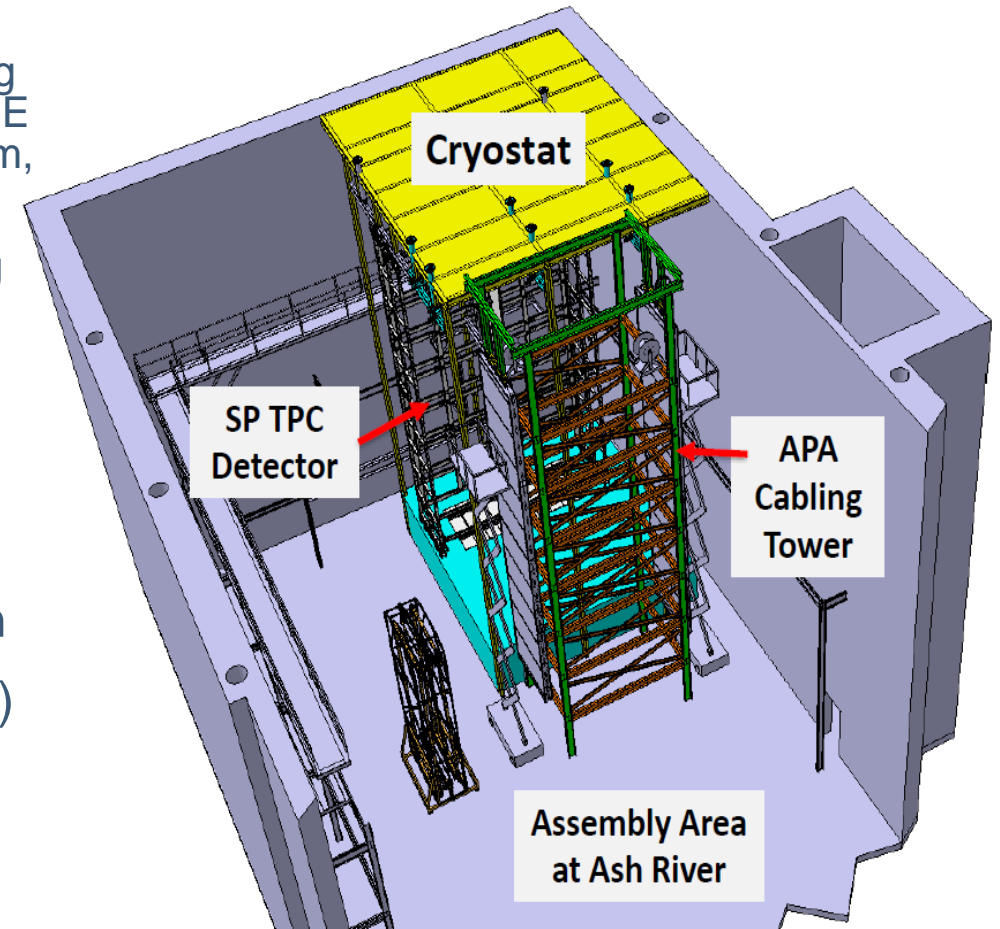
Baseline SP Detector #1 Installation plan



William Miller
January 25, 2019v1

Trial Assembly at Ash River FY19-21

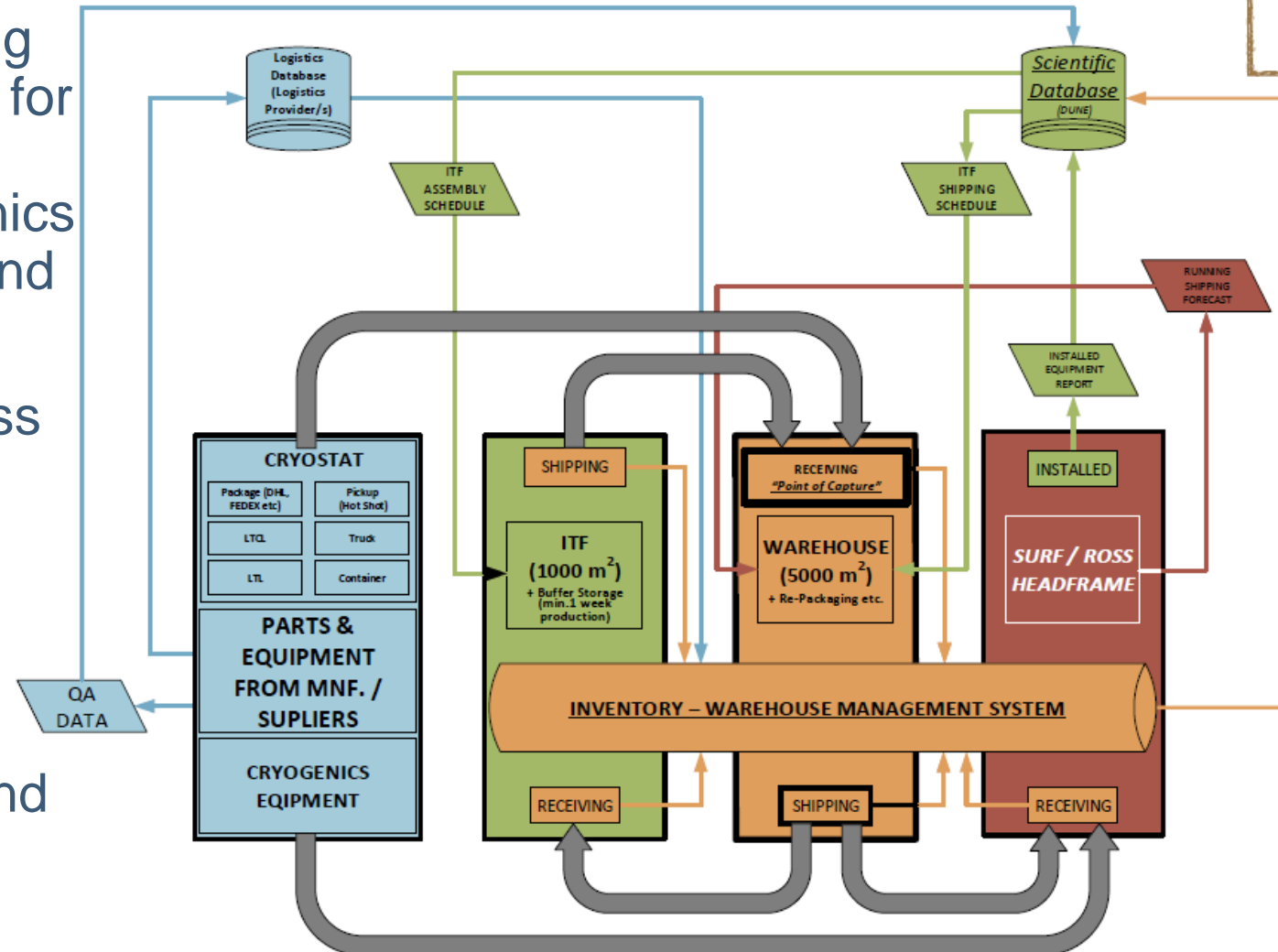
- Test all full scale TPC (Time Projection Chamber) components during assembly stages and inside the cryostat including
 - APA Assembly including manipulation of APA shipping frames, joining an APA pair together, testing of PD (Photon Detector) components, CE (Cold Electronics) cabling, APA protection, movement on shuttle beam, cryostat cabling and final deployment in cryostat.
 - DSS (Detector Support Structure) and shuttle beam system including final detector configuration
 - Assembly of HV system including construction of an End Wall, CPA pairs, movement on shuttle beam and final deployment in cryostat
 - Future Assembly of Dual Phase detector components
- Write full set of Hazard analyses and assembly procedure documents including gathering all component documentation
- Test access equipment (scaffold, scissor lifts, work platforms) and lifting fixtures
- Assembly time and motion studies including labor estimates



Logistic Center

- The Logistics Center is the long term storage and staging area for all the LBNF and DUNE equipment- Cryostats, cryogenics systems, SP & DP detectors and all the infrastructure
- There is no place near the Ross Shaft headframe to stage equipment for the trip underground so the Logistics Center is needed
- This is where the inventory for everything shipped underground originates

Logistics Flow from point of manufacture to SURF / Dataflow Schematic

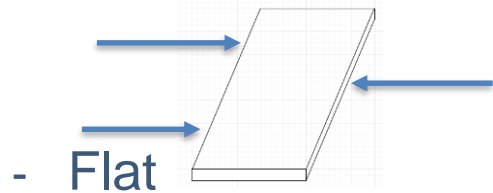


Drawn by
Ladia

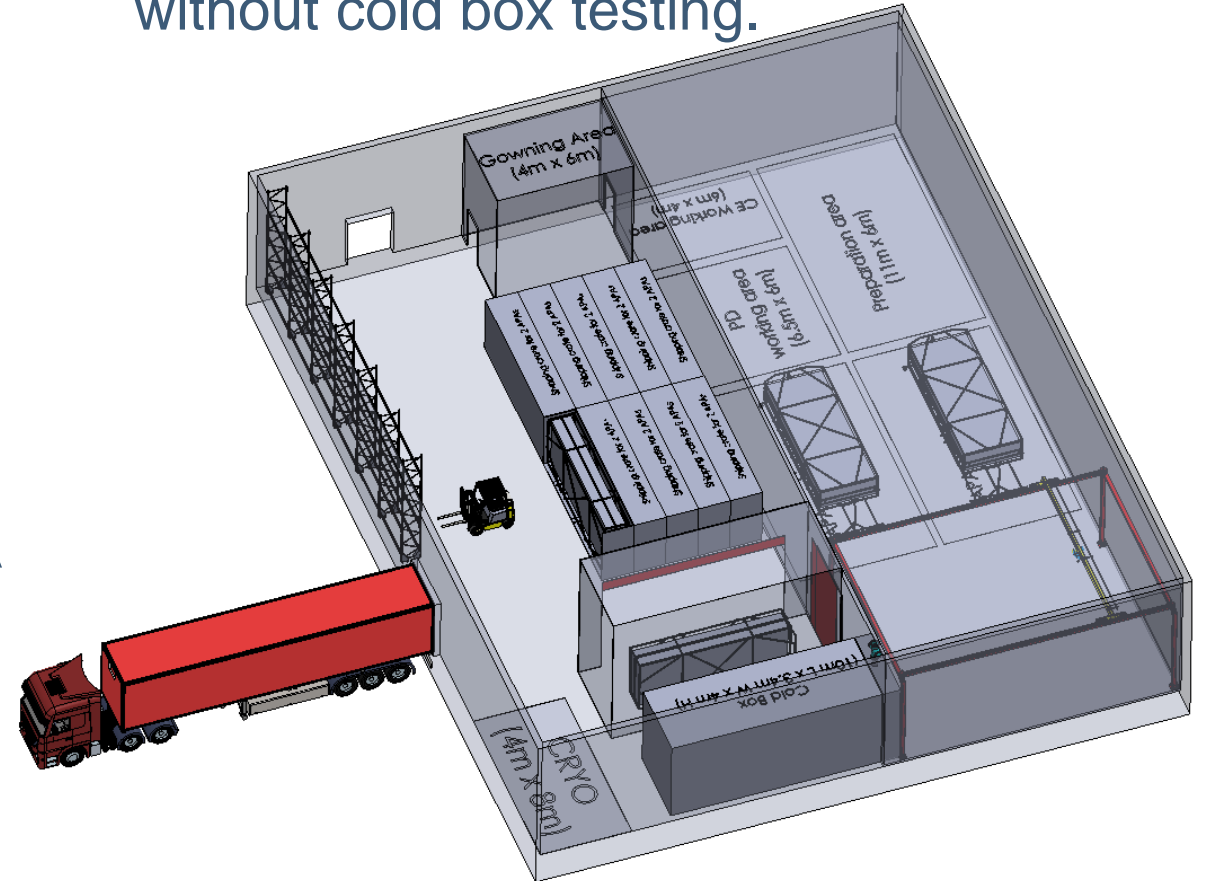
Integration and Test Facility

Assumptions

- APAs are integrated and tested with all PDs and CEs but no permanent cables in ITF
- APAs will be moved from the shipping boxes to process carts and later moved to the final transport frame
- Installation of the photon detector bars in the APA slots will happen with the APA in the “flat” position.



- Schedule Total: ~11 FTE shifts required for processing one APA pair at the ITF without cold box testing.



Integration Office-Labor Support

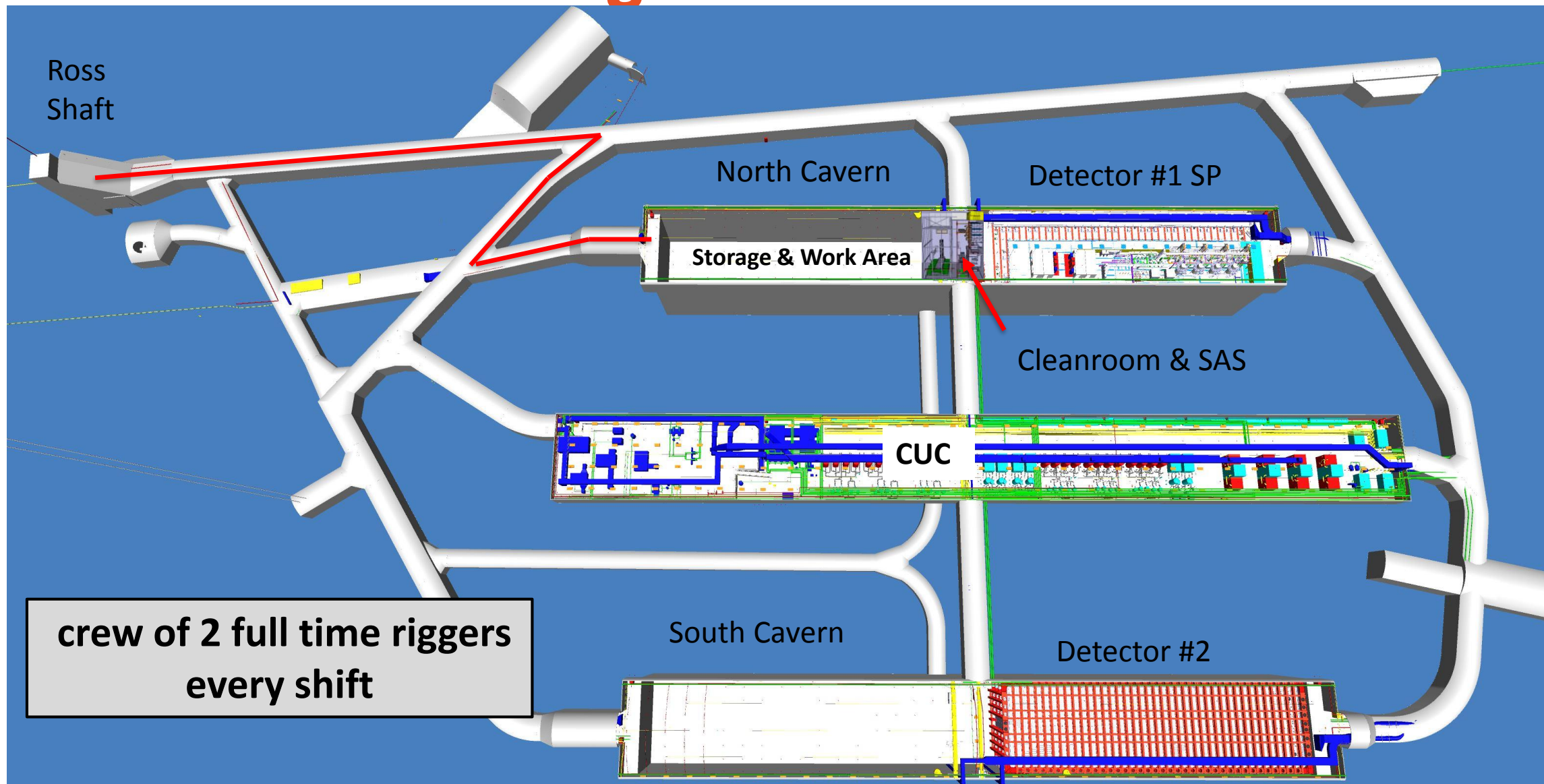
ITF and Logistics Facility	#FTE
Management	
ITF Scientific Lead	1.0
ITF Manager	0.5
ITF Supervisor	1.0
ITF Safety Officer	0.5
ITF Administrative Support	0.5
Labor Force	
Lead Worker	2
Riggers	4
Total	9.5

The Integration Office supplies the base labor for the ITF and Logistics Facility

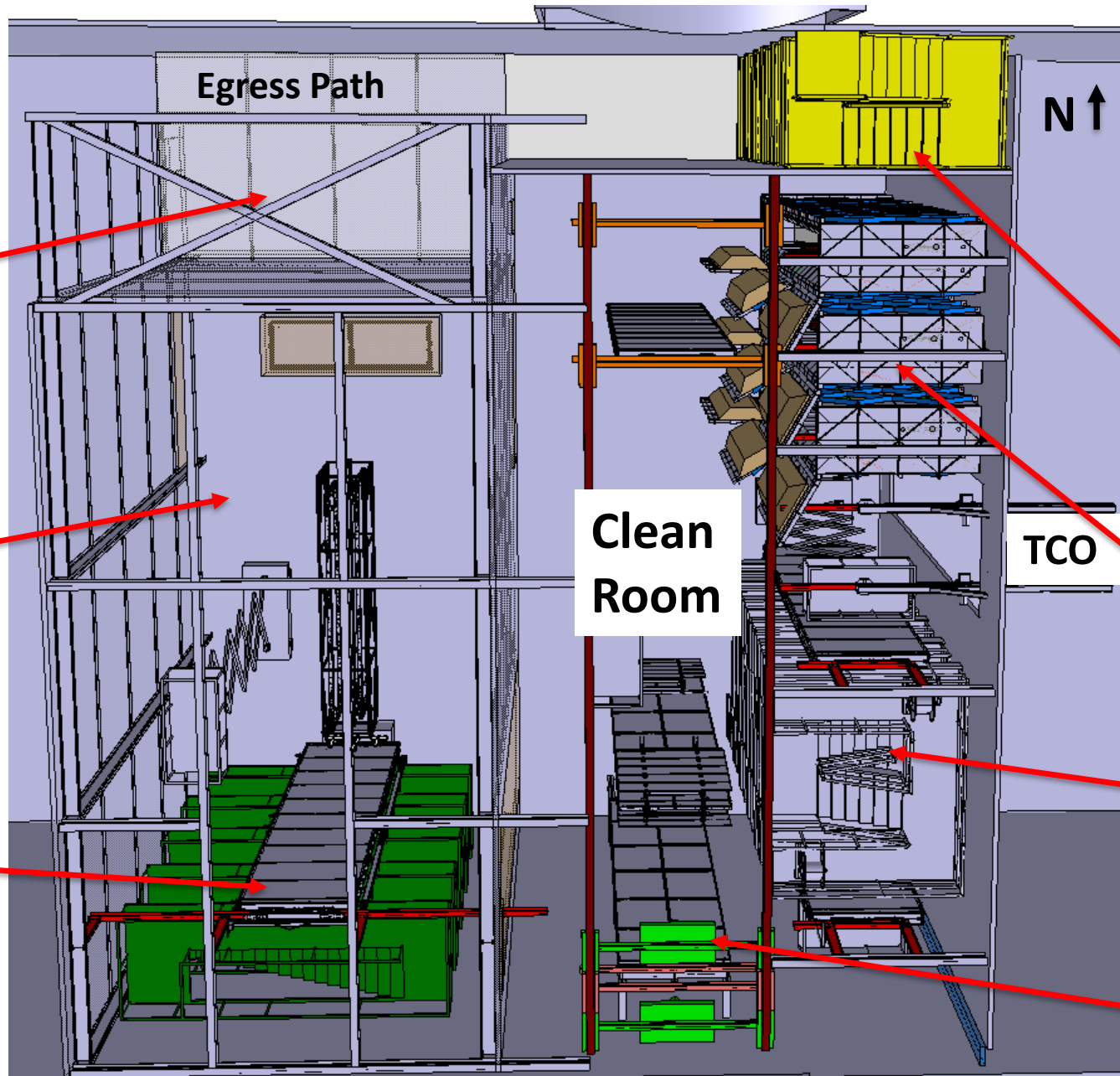
- Management-Scientific Lead, manager (50% ITF/50%Logistic Facility)
 - Schedule, Labor Management, works directly with SDSD/STSDA for shaft access, inventory control,
- Safety-Safety Officer (50%ITF/50%LF)
- Admin Support (50%ITF/50%LF)
- Lead worker and Riggers would supply labor for packing/repacking and moving material as needed, would be available to help as needed at all times.

Materials Handling Flow

Add number of cage loads



Layout of Cleanroom and SASs



Permanent Stairs

3 Cold Boxes

2 APA cabling stations

CPA Assembly Station

Personnel SAS

Materials SAS

APA Assembly Tower

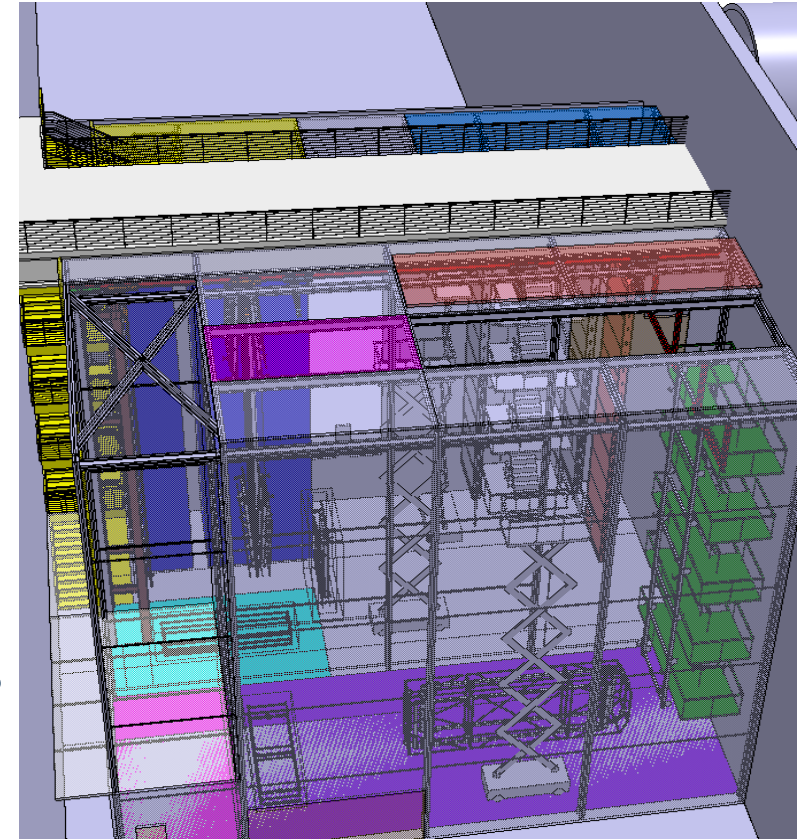
Clean Room

TCO

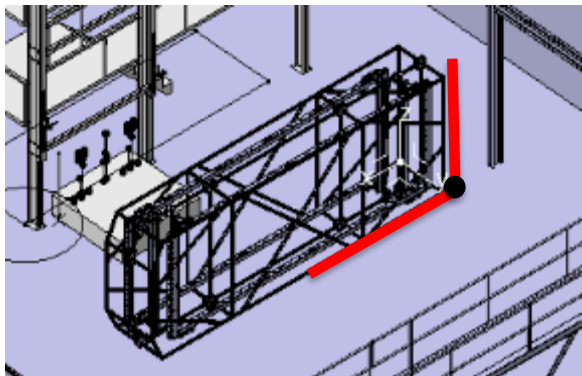
N ↑

APA pair schedule in SAS

- The APA shipping frame has it's outside box panels removed (not clear if it is in or out of SAS-APA in plastic)
- If possible the APA Frame is rotated using the Cavern Bridge Crane-If not design rotating fixture
- In both cases the roof remains open as shown on the next slide until the two APAs are mounted to the Assembly frame and have passed all PD and electrical isolation tests



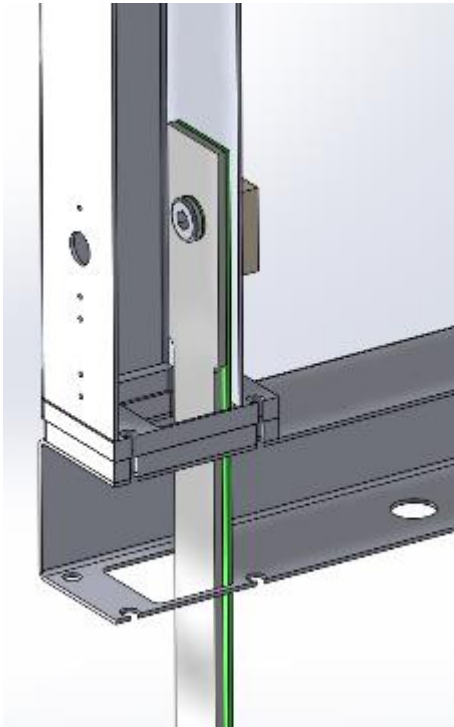
~4 hours with crew of 3 riggers and 3 techs



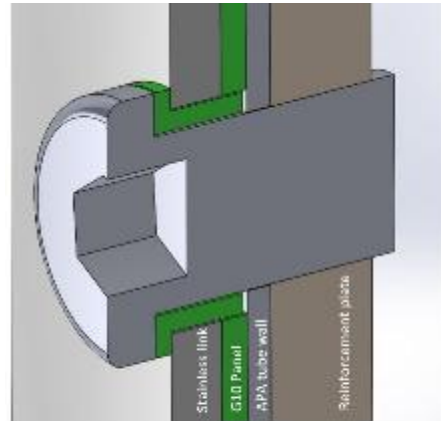
APA Task	APA # FTE	CE # FTE	PD # FTE	HV # FTE	Riggers # FTE	Location	Day 1				Day 2	
							Shift 1		Shift 2		Shift 1	
							6:00	11:00	16:00	21:00	6:00	11:00
APA Pair #1												
1 Move APA Pair into SAS	3				3	SAS	6					
2 Install Bot APA PD/Test	3				3	SAS		6	6			
3 Install Bot APA PD/Test	3				3	SAS				6	6	
4 Move APA to Work Station	3				3	SAS						6

APA Assembly Materials SAS

- The two APAs are attached and tested for electrical isolation
- Once the APA pairs are attached the hydraulic jacks are lowered and the quick release pins are released
- The APA is now ready to roll into the cleanroom and onto the shuttle beam
- It can now be moved to the open APA work station



Lower APA attaches in same way to bottom end of link.

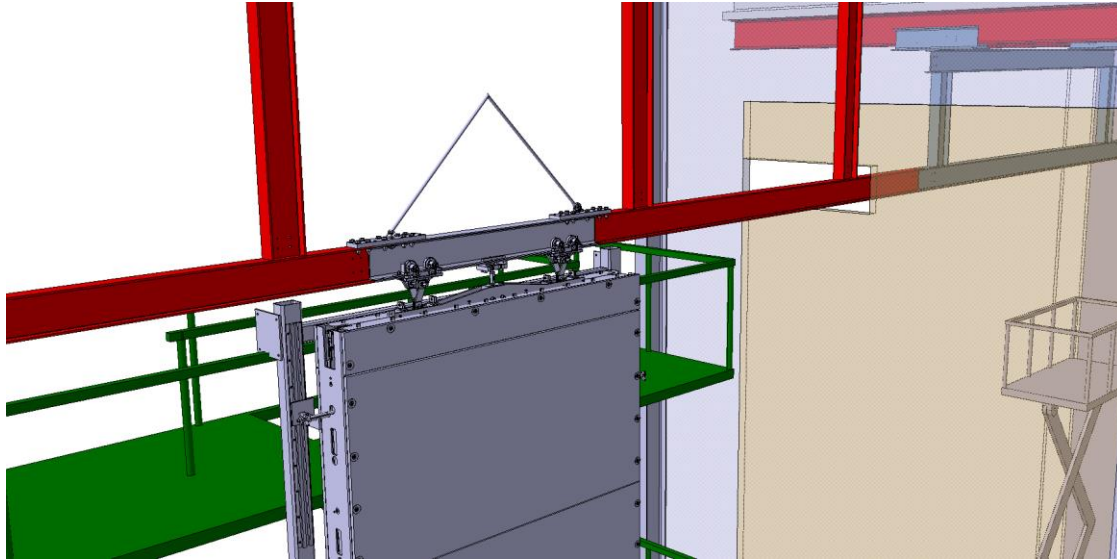


X-section of screw and insulating liner

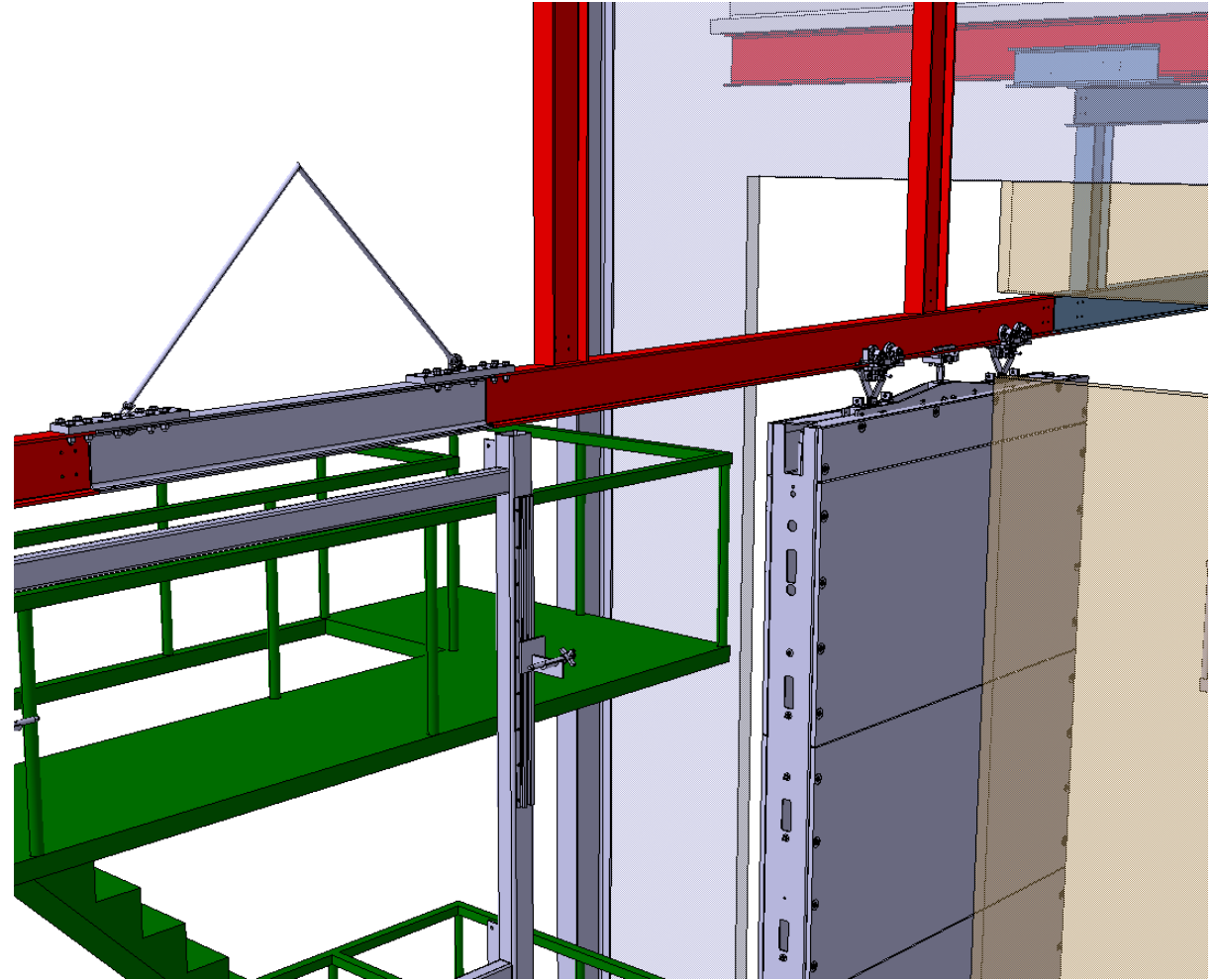
~4 hours using 3 riggers and 3 techs to attach and move to cleanroom

**Total time to get APA pair to the work stations
~4 shifts using 3 riggers and 3 techs**

Moving the APA into the cleanroom

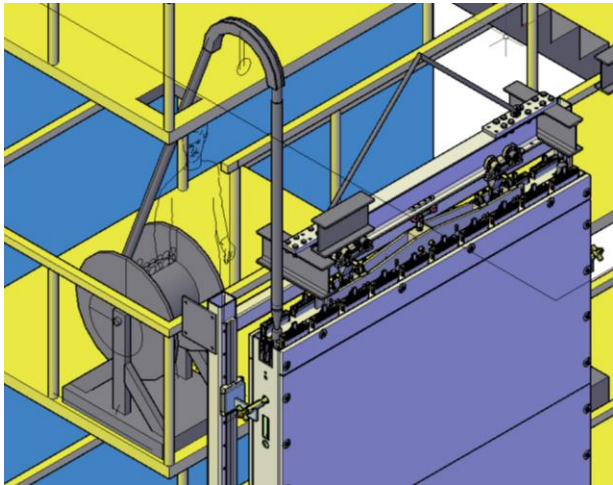


- The APA is already located on the rail system that is the same elevation as the TCO and DSS rails
- The “barn door” is rolled open and the trolley puller rolls it onto the cleanroom rail system

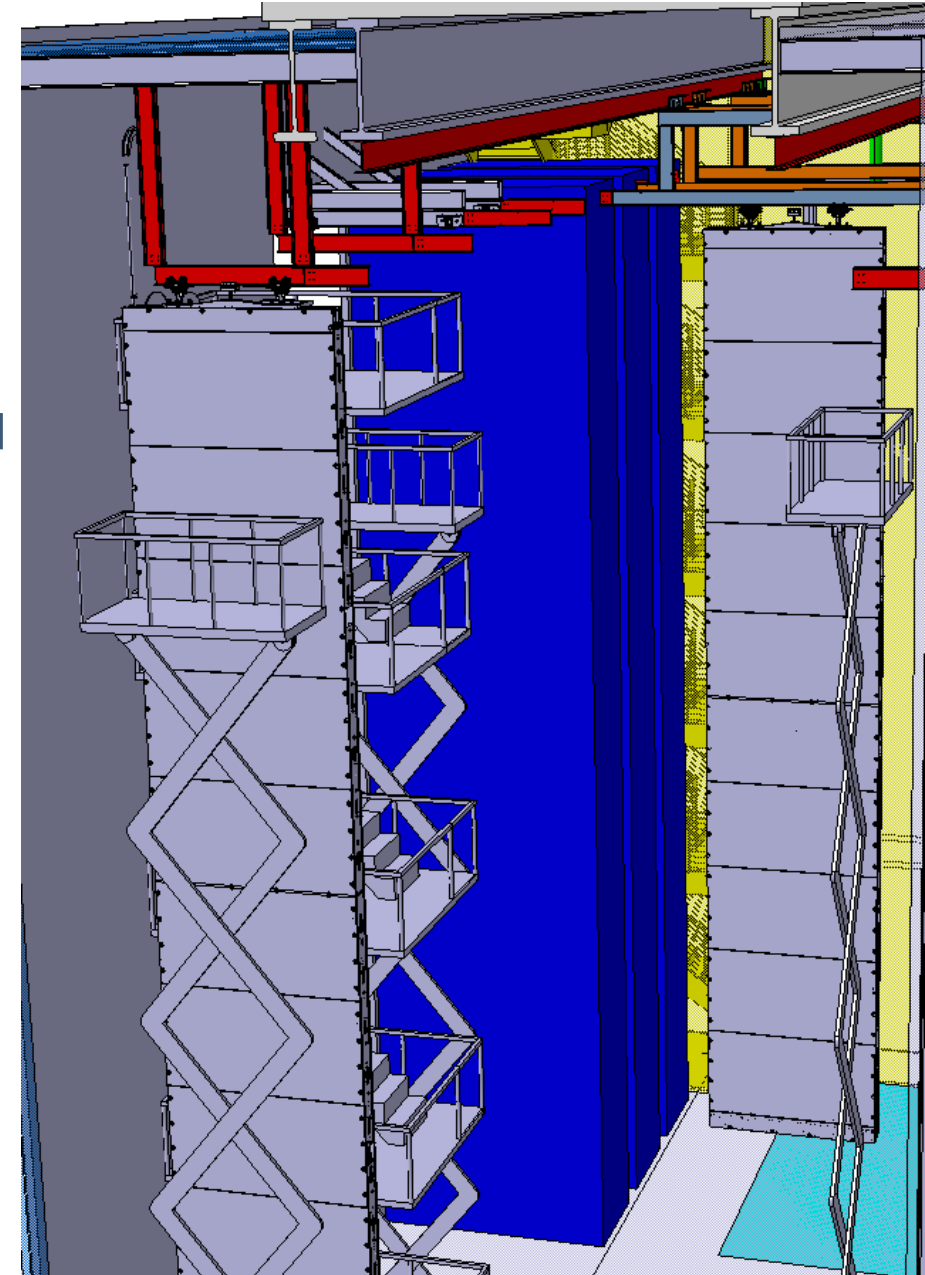
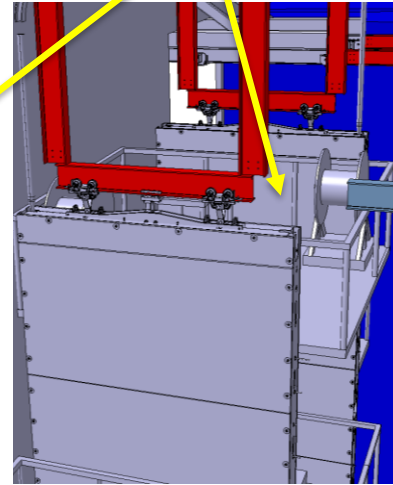
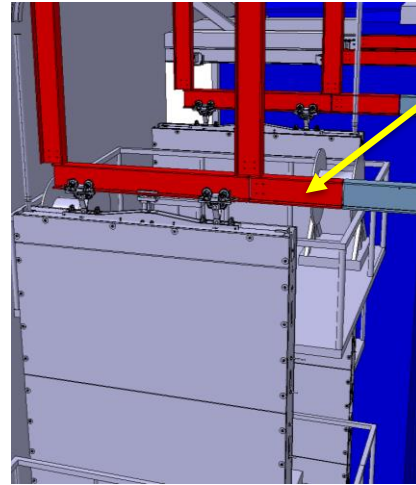


Two APA Work Stations

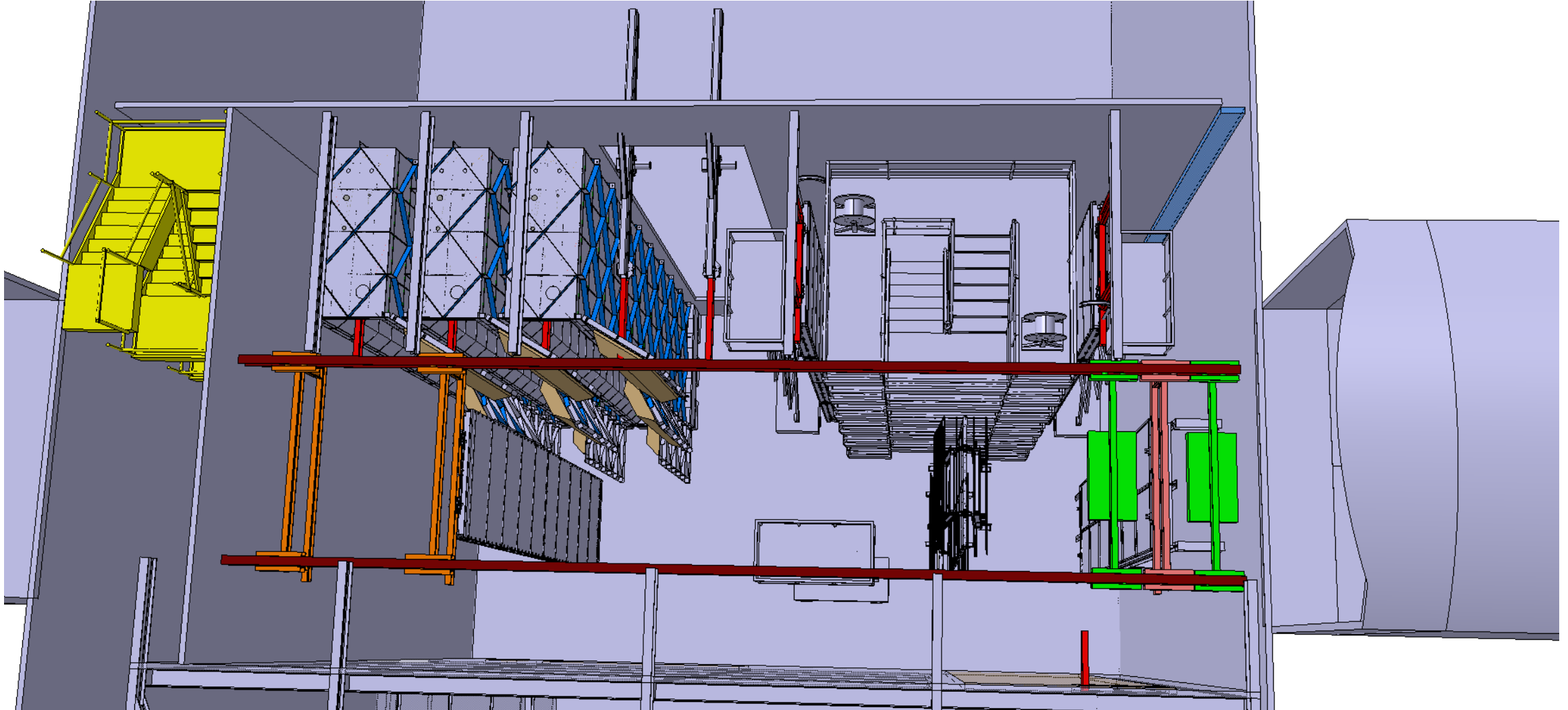
- Prepare APA pair in work station by locking the top APA and stabilizing the bottom using the same connection point as the hydraulic jack
- Access to both APA work station via stair scaffolding supported by a steel frame and on the other side via scissor lift
- Install APA cable trays
- Move cable spool into position. Remove section of beam to allow access to conduit.



Cable Spool System



Cleanroom Layout



Two APA Work Stations

- All the same steps in the original installation procedures happen at the work station
 - CE Cables are installed and hooked up to the CE boxes.
 - Each box and cable is tested and bundles are organized in cable tray with a main bundle prepared for installation to the feed-thru in the cold box
- Once all tests are completed and cable management is completed the APA pair the Protective panels are removed and there are two shifts to do photogrammetry/survey before it is moved to the cold box

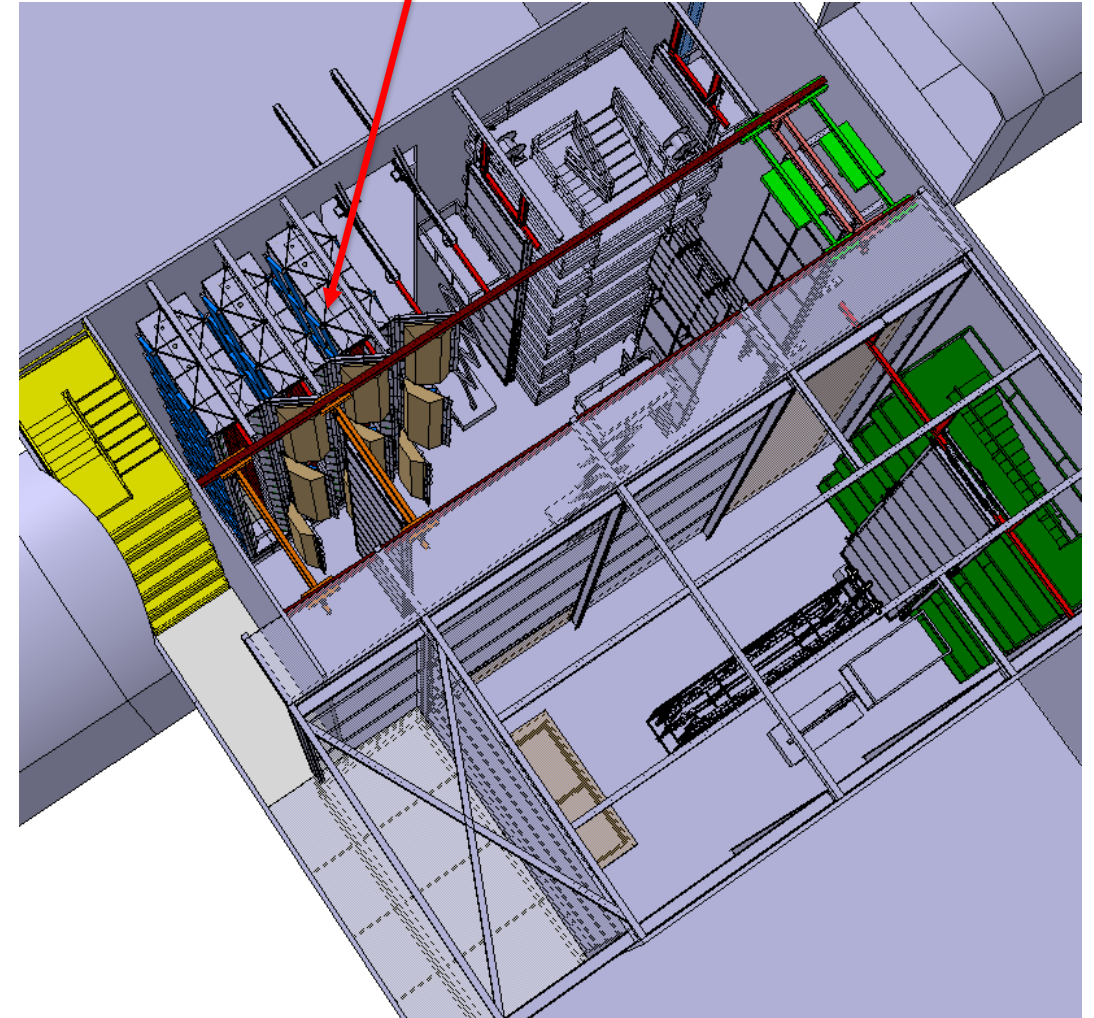
								V									
								Day 2		Day 3				Day 4			
								Shift 2		Shift 1		Shift 2		Shift 1		Shift 2	
APA		APA	CE	Shift	HV	Riggers	Location	16:00	21:00	6:00	11:00	16:00	21:00	6:00	11:00	16:00	21:00
Task		APA	CE	Shift	HV	Riggers	Location	16:00	21:00	6:00	11:00	16:00	21:00	6:00	11:00	16:00	21:00
5	Cable work/Test		4				WS-1	4	4	4	4	CE					
6	Cable management/CB Cable		4				WS-1					4	2A-2R				
7	Remove Protective panels	2				2	WS-1						4	2-Surveyor			
8	Photogrammetry/survey	2					WS-1							2	2	APA,CE,2Rig	
9	Close up Cold Box/Warm test	1	1			2	CB-1	Shifters								4	4

Three Cold Boxes

- They have hinged doors so a crane is not needed to open/close door
- We have one shift to move into position, cable to the junction box and close box with a crew of 2 riggers, 1 APA and one CE
- 1 full day to cool down, 1 shift to take data and one full day to warm up
- We then have one shift to move into position, cable to the junction box and close box with a crew of 2 riggers, 1 APA and one CE

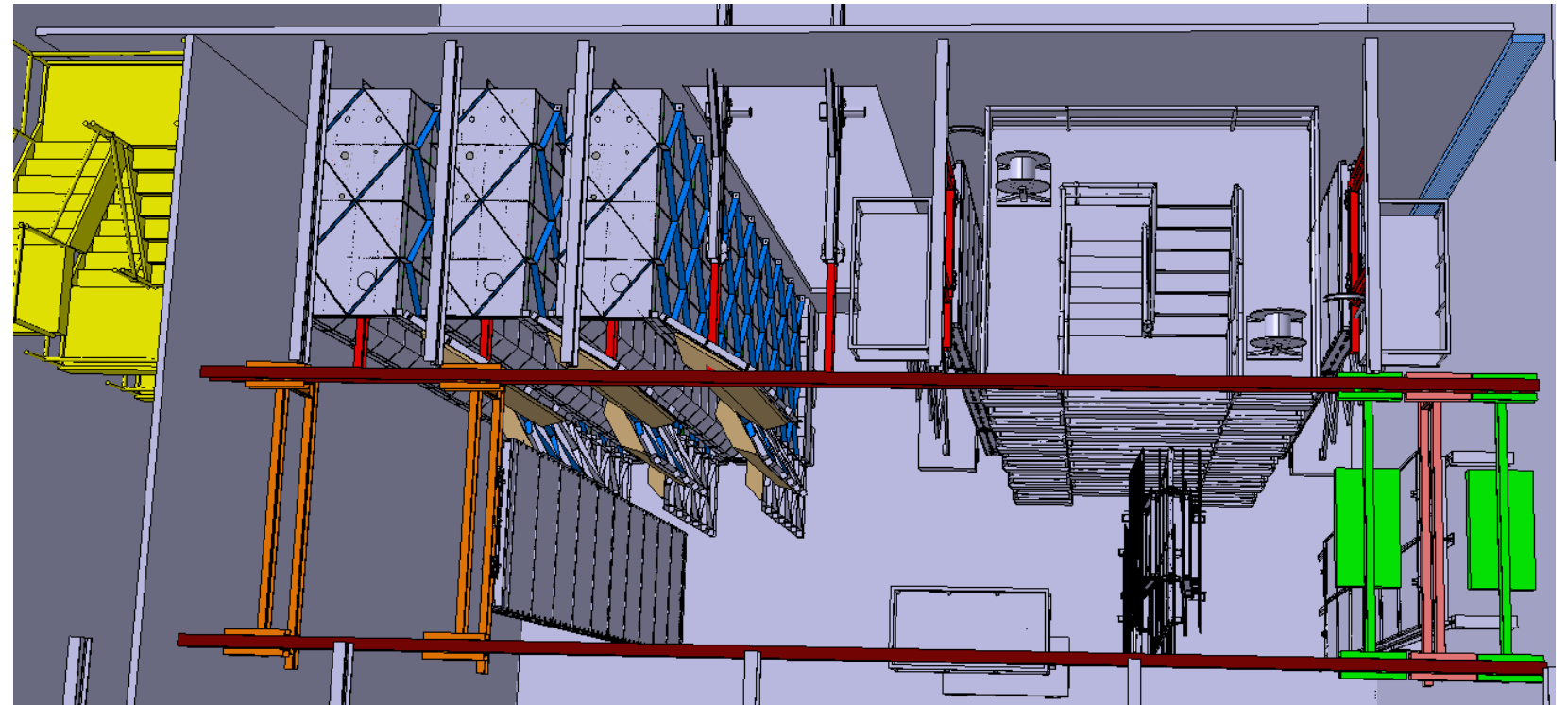
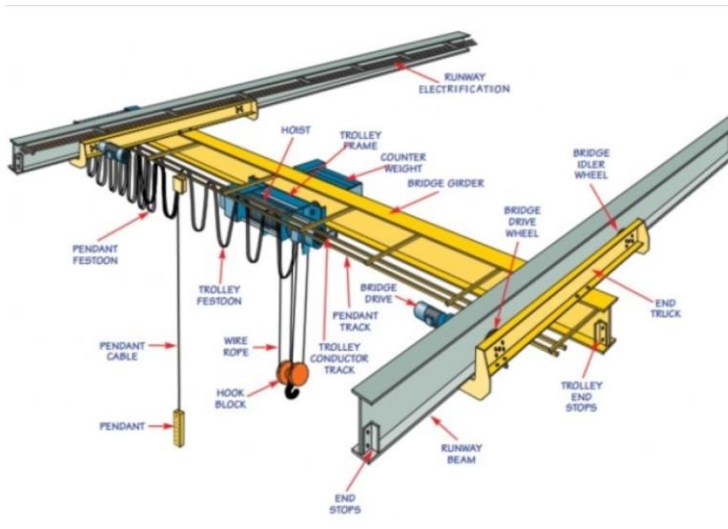
~ 7 full shifts dedicated to cabling & un-cabling APA, opening/closing the cold box doors and cold test

Three Cold Boxes



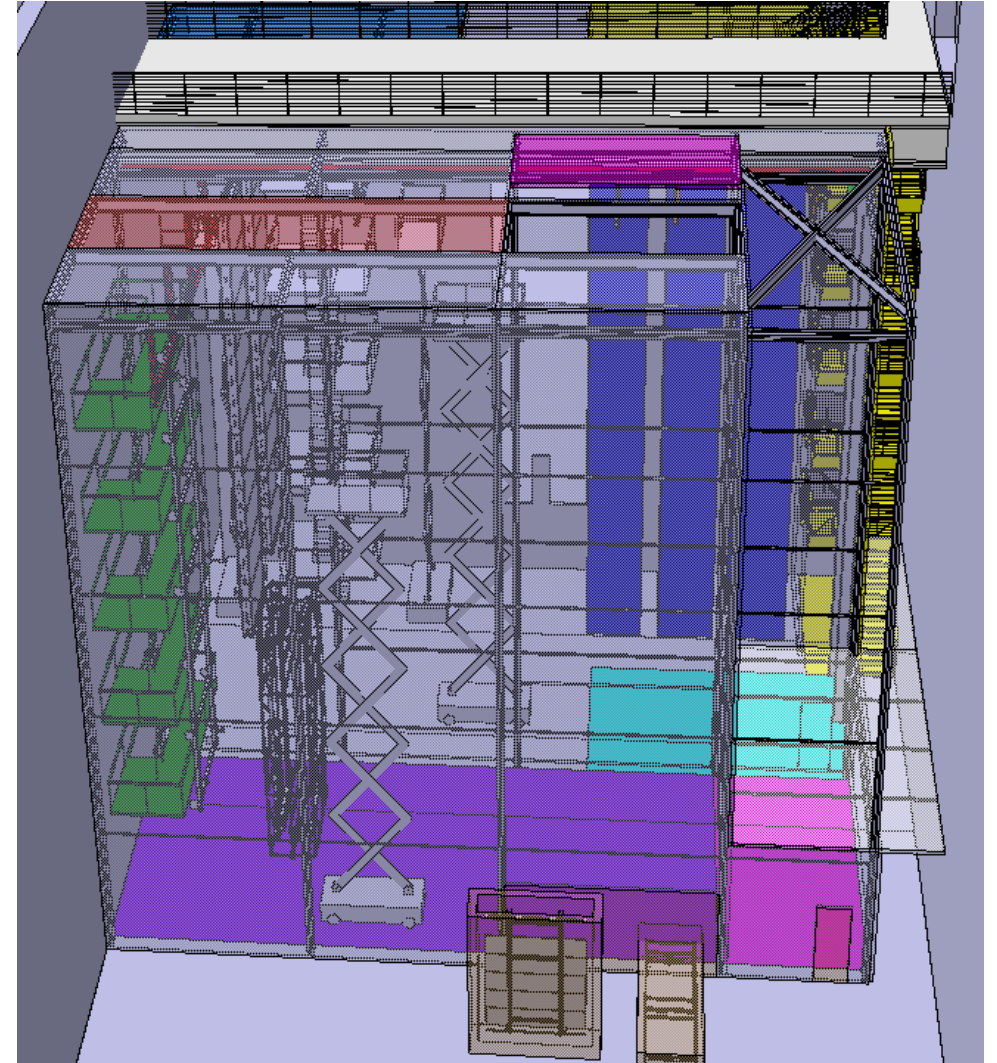
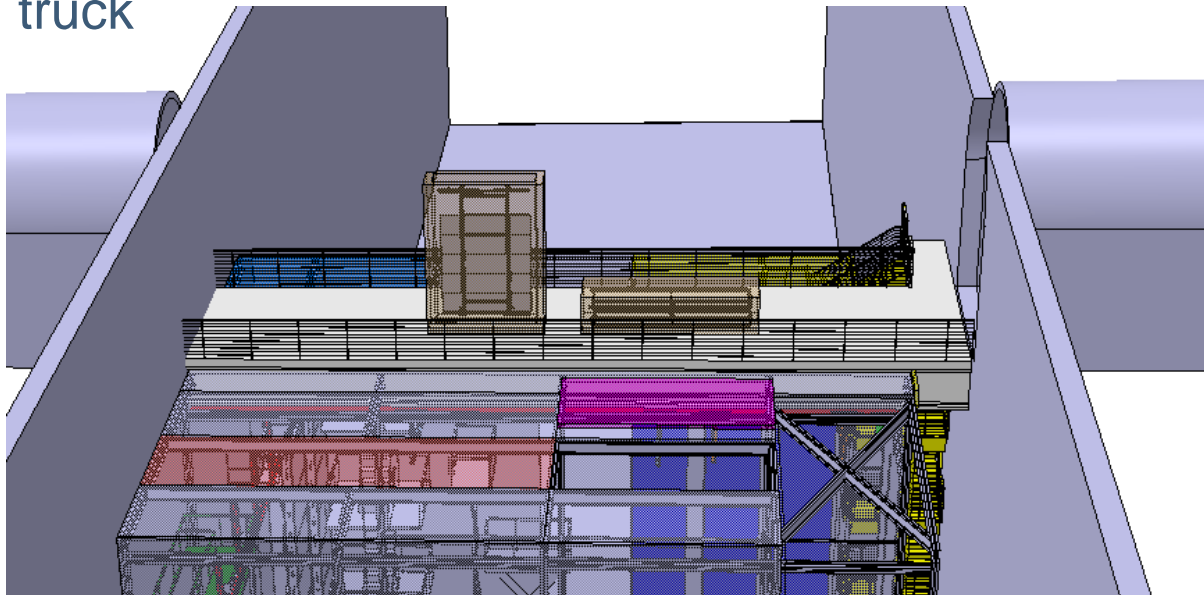
Cleanroom Shuttle Beam/Crane

- The cleanroom rail system is based on a standard bridge crane with two hoists and ~3 shuttle beams at the same elevation as the DSS beams
- It allows transport of trolleyed equipment
- Capacity of crane not defined yet



HV Component Assembly

- The first thing installed in the cryostat is the end wall. These are assembled just like we did in ProtoDUNE where the 8 sections are joined one at a time in place in the cryostat using an electric hoist. Some sort of cart must be designed to move the sections in place
- CPA and Field Cages are lowered from the bridge or moved from the cavern floor via fork truck



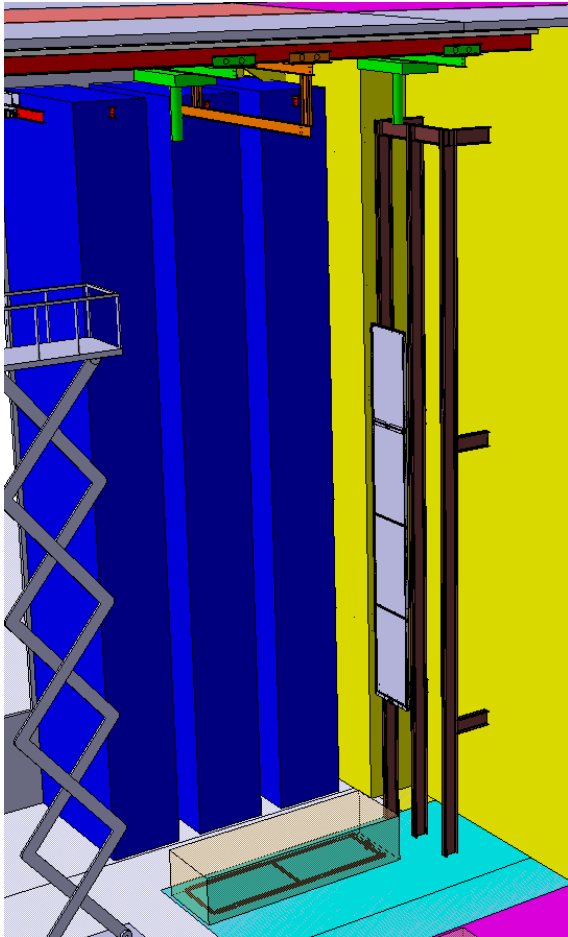
CPA Assembly

- This has not changed from the original concept. It uses a frame mounted on the wall along the stair egress walkway- ~1 day spare to adjust schedule
- CPA and Field Cage boxes are lowered down in the materials SAS and moved using forklift to place in CPA area.

								Week 1-														
								Day 1				Day 2				Day 3				Day		
APA								Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		Shift 2		Shift 1		
Task								6:00	11:00	16:00	21:00	6:00	11:00	16:00	21:00	6:00	11:00	16:00	21:00	6:00	11:00	
CPA Pair #1																						
1	Bring CPA & FC boxes in					2	Mat Han	2														
2	Lift CPA1A and bolt to frame			4			CPA 1	4	4													
3	Lift CPA1b and bolt to frame			4			CPA 1			4	4											
4	Add Field Shaping at profiles			4			CPA 1					4										
5	Add disfuser and Top FC			4			CPA 1				4		Riggers									
6	Move completed CPA to Cryo					4	Cryo					4	4									
CPA Pair #2																						
1	Bring CPA & FC boxes in					2	Mat Han					2										
2	Lift CPA2A and bolt to frame			4			CPA 2					4	4									
3	Lift CPA2b and bolt to frame			4			CPA 2							4	4							
4	Add Field Shaping at profiles			4			CPA 2									4						
5	Add disfuser and Top FC			4			CPA 2										4		Riggers			
6	Move completed CPA to Cryo					4	Cryo											4	4			

CPA Assembly

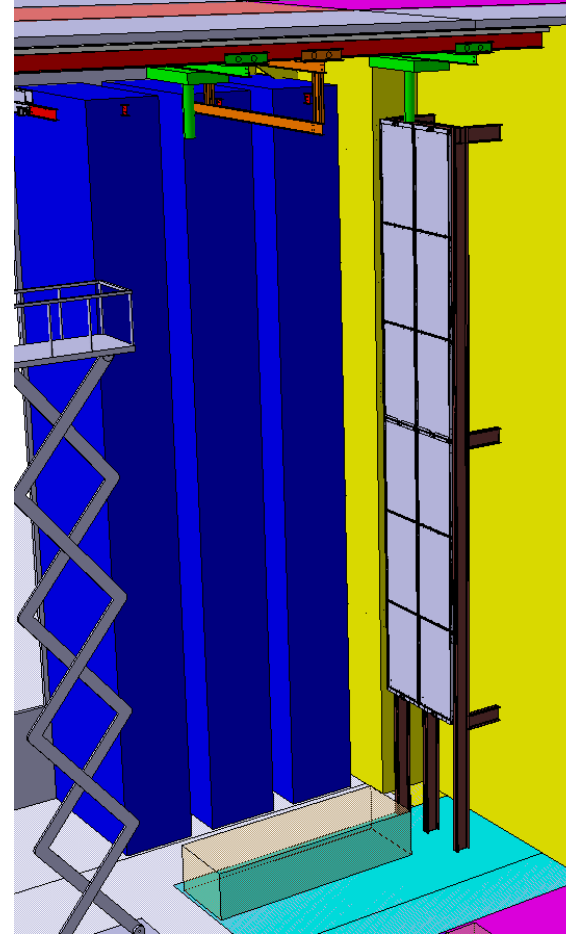
Old snap shots CPA station, cold boxes have been moved for minimize access issues



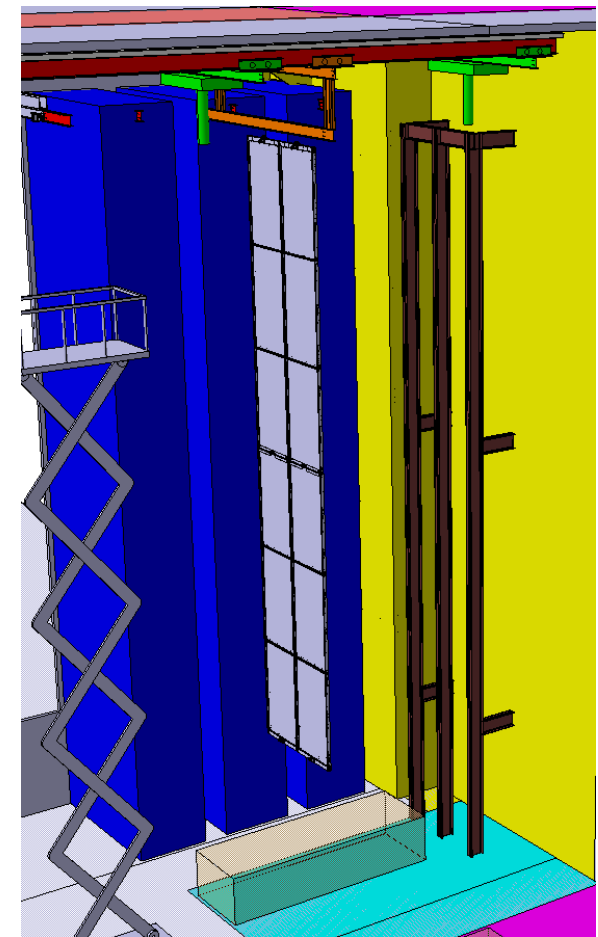
Second 4m CPA panel



First 12m CPA section



Second 12m CPA section
field shaping strips
installed and tested



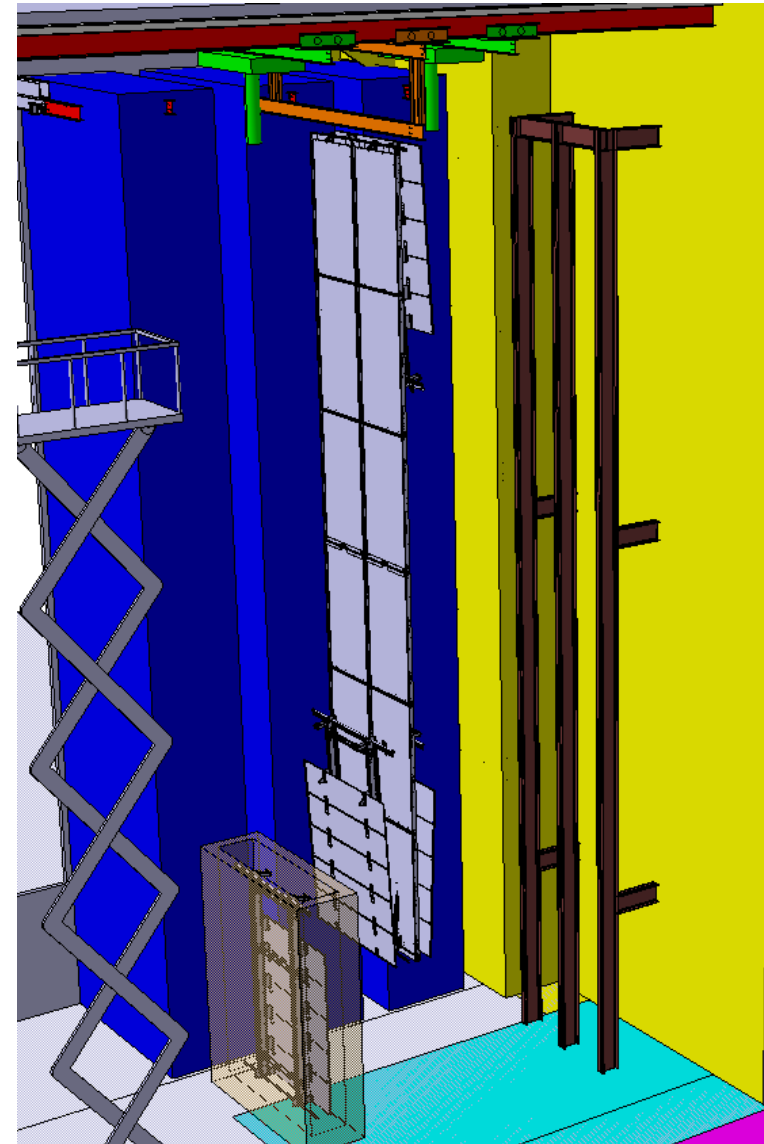
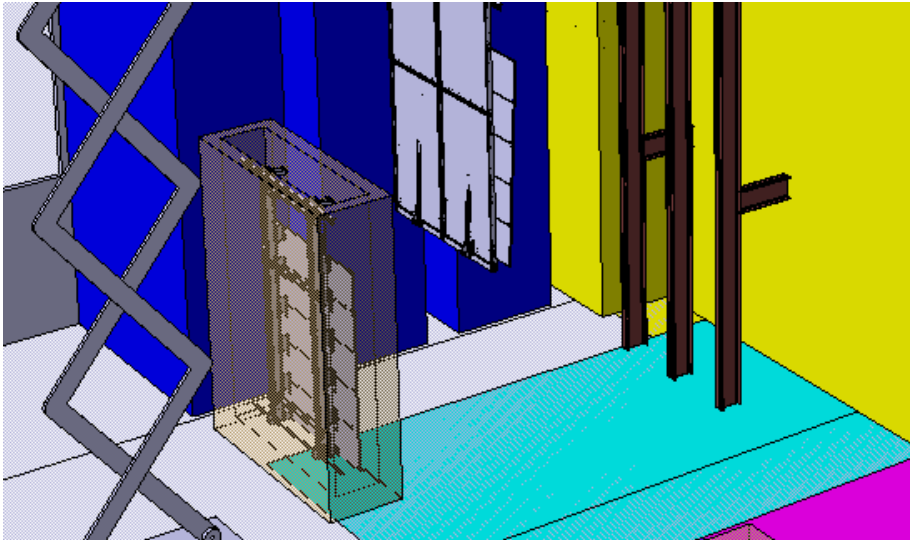
CPA Pair is completed

Field Cage Installation

Before Field cages are installed

- Back side of CPA Pair needs field shaping strips installed and all electrical connections tested
- Light defuser must be added. Access is required on both sides

Bottom FC might be installed in cryostat



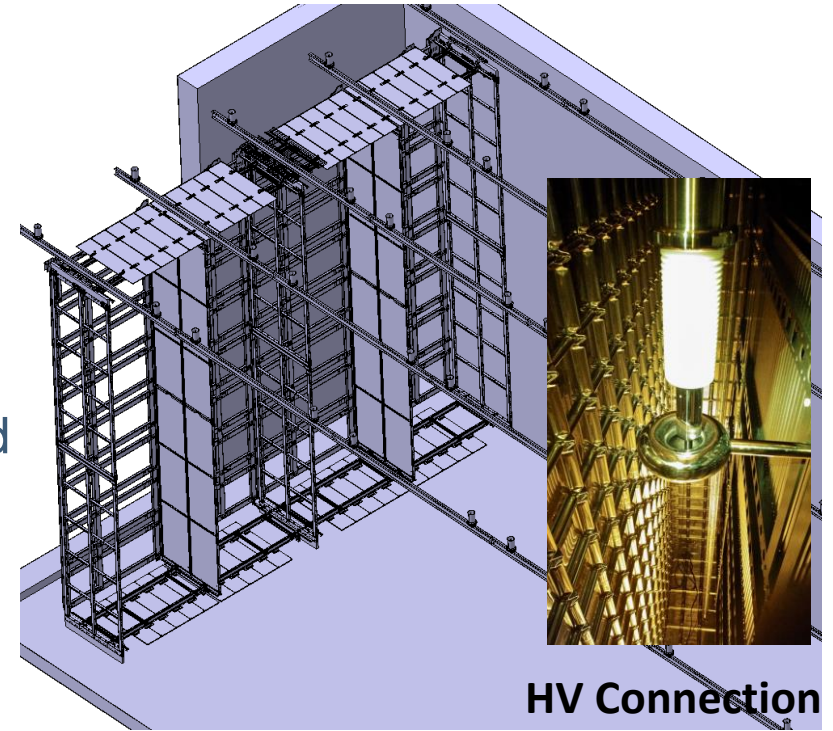
Crane hoist is used to lift FC into position

Inside the Cryostat

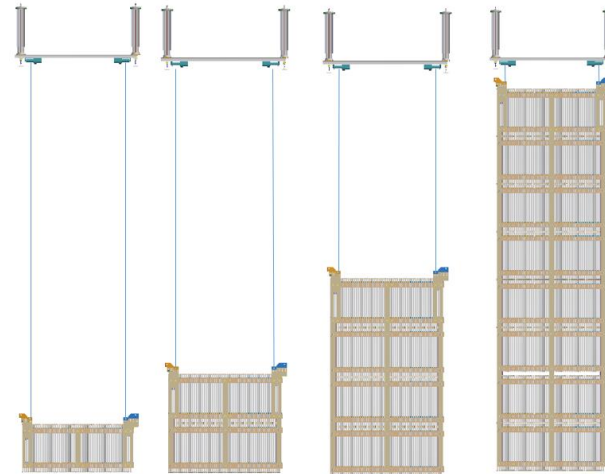
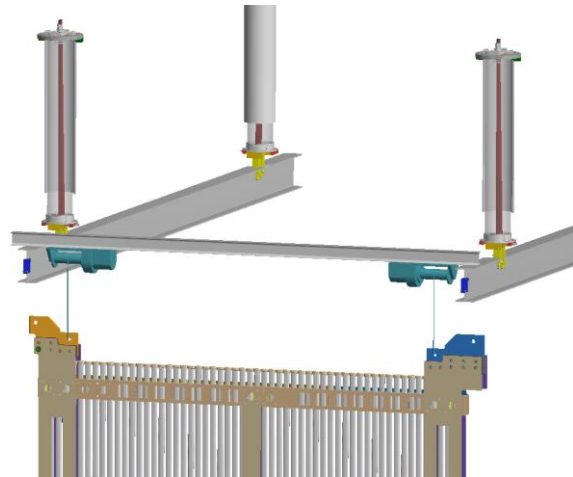
- Once the DSS has been installed and the subfloor is in place we are ready to start

No access equipment can reach once End Walls are in place

- First the any instrumentation (purity monitors, temperature sensors, cameras) that are installed at the end of the cryostat must be installed first
- HV connection is made to CPA
- Then the 4 end wall sections are build just like in protoDUNE with the pieces connected at floor level and raised up



HV Connection



Purity Monitor



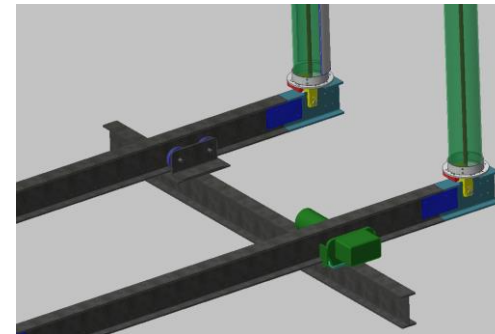
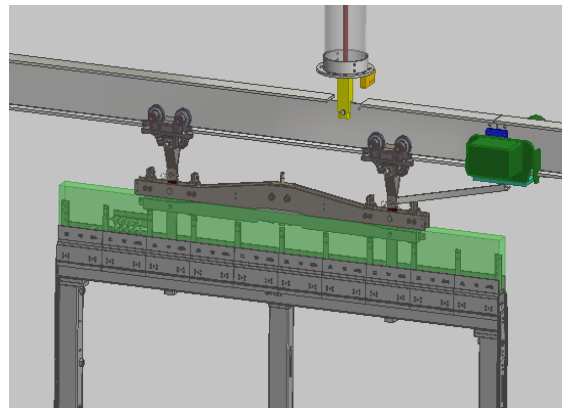
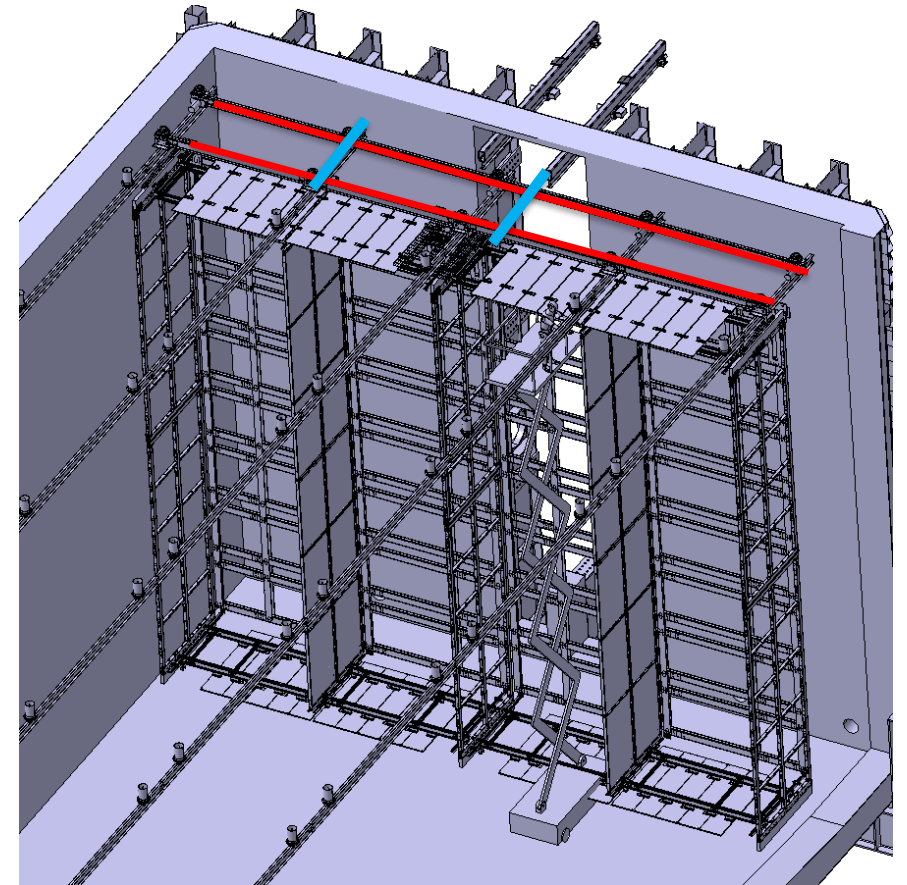
Temp Sensors



Gradient T Sen

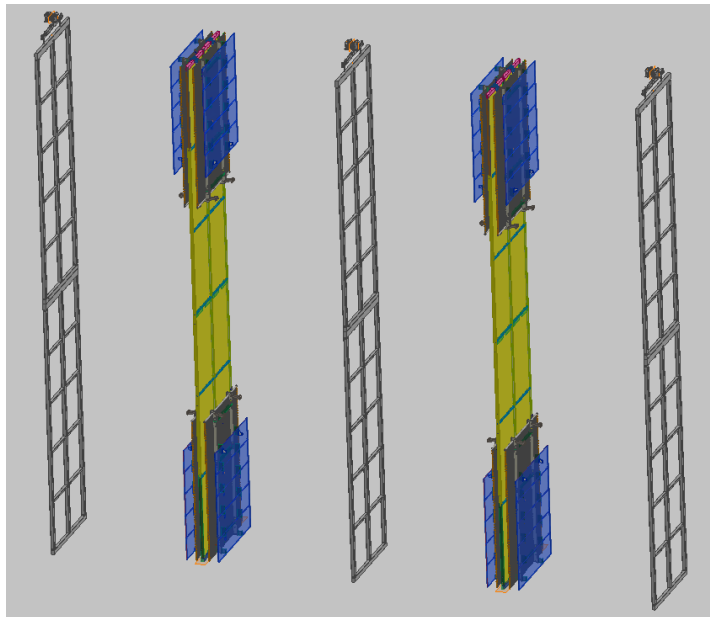
Inside the Cryostat

- The shuttle beam inside the cryostat allows you to move a completed APA or CPA pair from the TCO beam to the appropriate runway beam in the DSS
- Shuttle beams will be manually bolted to the TCO or runway beams as at ProtoDUNE so access is required
- It is transported trolley crawler or some similar device so that it is not done by hand. Several will be tried at Ash River, there is no power on the DSS so it will have to come from ground level

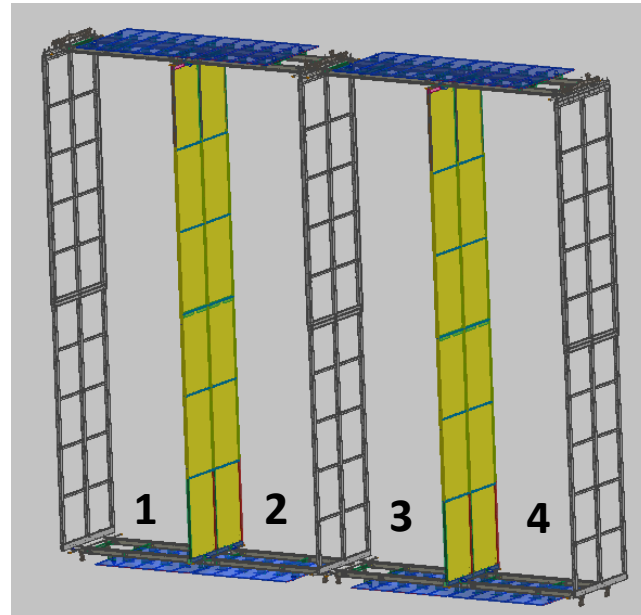


Inside the Cryostat

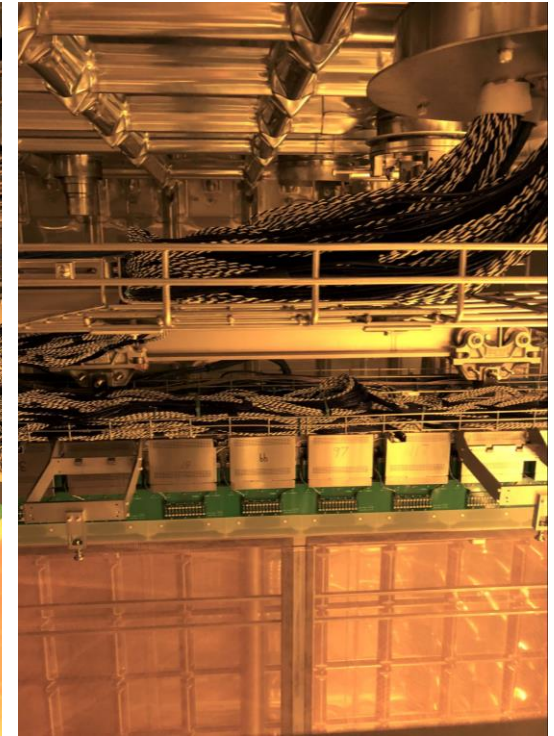
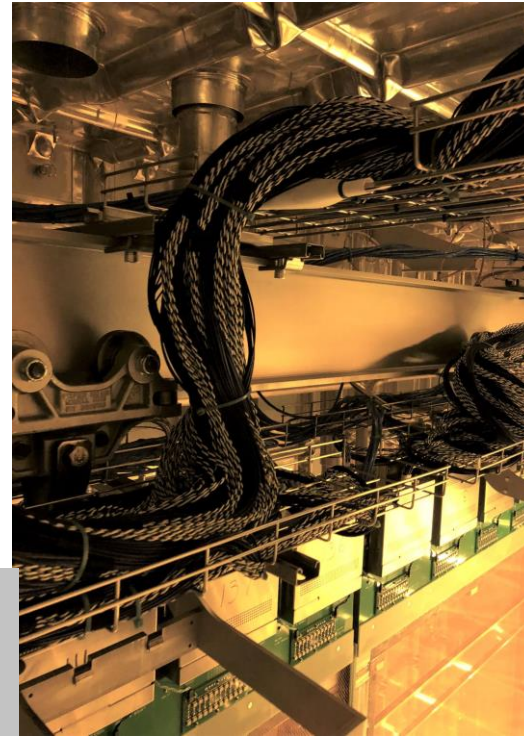
- APA and CPA pairs are moved in position to complete a row of 4 drift volumes
- APA Cables are installed and tested before Field Cages are deployed



APA CPA APA CPA APA



TPC Drift Volumes

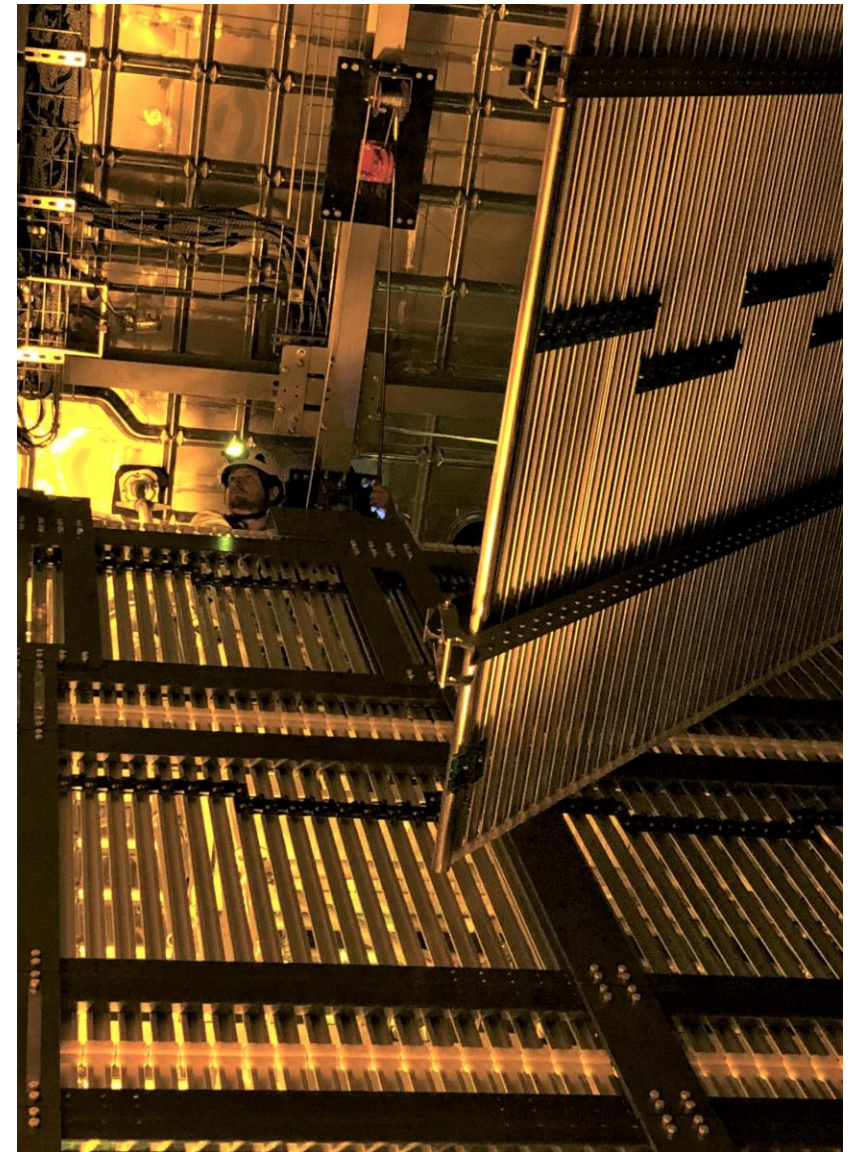


Inside the Cryostat

- Before the Field cages are deployed the floor sections must be removed, floor cleaned and all temperature sensors installed

There is less space beneath the FCs and the bottom of the cryostat. It appears we would not be able to sneak back under here and work like we did in ProtoDUNE

- Because DUNE does not have a bridge beam like we did in ProtoDUNE we have to come up with a new way to deploy the top field cages
- The bottom field cage we plan on moving into position with some sort of simple jib crane from the still in position floor



Deploying a top Field Cage at ProtoDUNE

Best estimate for an over all schedule for SP Detector #1

		Months	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	
Infrastructure Det #1	DUNE																																							
Cavern #1 Bridge/Shuttle	DUNE	3	Bridge/Shut																																					
Cold Boxes/N System	DUNE	6	Cold Boxes/N System																																					
Work shop/storage Area	DUNE	1	Sho																																					
Cleanroom/SAS Structure	DUNE	5		Cleanroom/SAS																																				
Cleanroom Infrastructure	DUNE	3			Clean Infra																																			
Assembly SP Dec #1	DUNE	13	Assembly SP Deceptor #1 15 months																																					
CE Feed-thru/Cross/Racks	DUNE	4				CE Feed/Racks																																		
DSS Feed-Thru Tubes	DUNE	2				DSS FT																																		
DSS Beam installation	DUNE	2					Beams																																	
Crostat Internal Plumbing	LBNF	1							Plu																															
Cryostat Floor	DUNE	1							Flo																															
West End Wall	DUNE	1								End																														
Start-up APA-CPA-FC 1-2	DUNE	1.5										1	2																											
Install APA-CPA-FC 3-24	DUNE	5.5										Install APA/HV 3-24																												
Install APA-/HV 25	DUNE	1																25																						
TCO Closing	CERN	2																																						
Final Assembly Completion	DUNE	2																																						
Purge Dec #1	LBNF	8																																						
Fill Dec #1	LBNF	8																																						