Cold Electronics Installation Plan

Contribution to the Integration/Installation workshop

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DUNE Integration and Installation Workshop

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Content

- Reminder: deliverables from the CE consortium
- Preparations inside the cryostat
- Preparations outside the cryostat
- Insertion of the APAs and initial tests

- I am not claiming that we know the entire sequence, this is how we understand it, and most important it contains our requirements in terms of time for testing / services from other consortia and technical coordination

Cold Electronics Deliverables

- Inside the cryostat
  - FEMBs will have already been installed on the APAs
  - Cables are connected to the APAs / SHV boards, tested, ready for routing through the cryostat penetrations
  - Cable trays
- At the boundary between cold and warm
  - Cryostat penetrations with strain reliefs
  - Cold flanges
- Outside the cryostat
  - Chimneys, warm interface crates
  - Electronic racks
  - Warm cables

Preparations inside the cryostat

- We assume that cable trays hanging from the cryostat ceiling are installed prior to the insertion of a given row of APAs
  - These are designed / procured by the Cold Electronics consortium
  - We assume that their installation is a joint responsibility of Technical Coordination and of the Cold Electronics consortium
- We assume that the rails inside the cryostat have already been installed by Technical Coordination
- Assuming that the cables are routed inside the APA frames there is nothing else to be done inside the cryostat prior to the insertion of the APAs
- Otherwise, we may want to route the cables from the top to the bottom of the cryostat prior to the arrival of one row of APAs

Preparations outside the cryostat (i)

- For protoDUNE the connections of the APAs to the warm interface crates were done long after the installation of the APAs inside the cryostat
- We cannot afford this in DUNE
  - As soon as an APA pair is installed inside the cryostat, we need to make the relevant connections and perform initial tests such that we can be confident that this APA pair will not require to be removed from the cryostat / repaired
  - Assume that we are not going to install the corresponding APA pair in the following row of the cryostat until this initial check has been performed
  - This requires that all the connections at the cryostat penetrations are performed as quickly as possible

Preparations outside the cryostat (ii)

- To achieve this
  - Electronics racks on top of the cryostat (shared by CE, PD, CISC, some DAQ) should be installed 2 weeks in advance of installation of a row of APAs (3 racks)
  - Cables and fibres from electronics racks to the cryostat penetrations should be put in place next
  - Fibre connections between the cryostat penetrations and the DAQ backend in the CUC should also be in place
  - Some DAQ partitions should already be available in the CUC for testing (ideally the DAQ backend in the CUC is installed in parallel to the APAs such that we don't have to move the connections on the CUC side)
  - The relevant CISC infrastructure (software for detector control) and the detector safety system should also be available
  - All needs to be completed before we insert a row of APAs in the cryostat

Preparations outside the cryostat (iii)

- Most important
  - Photon Detector and Cold Electronics should follow the same approach
  - All the PD electronics and readout should be available and installed in the same way as the CE electronics (we share the racks)

Our view of the installation sequence (i)

- Assume two or three 10 hours shifts per day (only 8 hour available for work), based on Vic's presentation of May 2
- Try to install one row per week
- 7 shifts required per APA pair
- Shift 1
  - Box with APA pair arrives in the cavern, is unpacked, crate moves into the clean room, APAs are lifted and the mechanical connection between the APAs is made
- Shift 2
  - Cable routing for APA pair #1
- Shift 3
  - Test: connect set of 5 cables to additional readout / powering system, perform connectivity tests, repeat for total of 40 cables

Our view of the installation sequence (ii)

- Shift 4
  - APA pair is moved into the cryostat
  - Work can begin on another APA pair
- Shifts 5 and 6
  - Routing cables for APA through the cryostat penetration and connections at the flange, installation and connection of the warm interface crate (estimate of work is 2 shifts)
- Shift 7
  - Test of APA with DAQ, if successful, green light for installation of APA pair in the same position for the next row

One row per week ?

- It does not mean that one APA row is completed in 1 week
- It means that work on the 2nd row of APAs can start on the first day of the 2nd week
- This works, without requiring TC personnel in the mine on the 5th working day of a week
- Only testing activities (CE personnel plus safety personnel) on one shift of the 5th working day (outside the cryostat)
- One APA row is completed in 7 working days
- See diagram on the next slide
- Did not allocate time for brief “HV” tests inside the cryostat nor for final adjustment of APA position

One row per week ?

	Week 1										Week 2									
	Shift 1A	Shift 1B	Shift 2A	Shift 2B	Shift 3A	Shift 3B	Shift 4A	Shift 4B	Shift 5A	Shift 5B	Shift 1A	Shift 1B	Shift 2A	Shift 2B	Shift 3A	Shift 3B	Shift 4A	Shift 4B	Shift 5A	Shift 5B
Pair 1	U	C	T	M	R	R	D													
Pair 2				U	C	T	M	R			R	D								
Pair 3							U	C	T		M	R	R	D						
Pair 4											U	C	T	M	R	R	D			
Pair 5														U	C	T	M	R		
Pair 6																	U	C	T	

U	Transport the crate with the APA pair into the cavern and unpack it
C	Connect the two APAs and route the cable from the bottom APA to the top
T	Test of the CE connections with a local system in the toaster area
M	Move the APA pair into the cryostat
R	Route the CE and PD cables through the cryostat penetrations and perform the connections of the warm interface crates (2 shifts)
D	Tests with the DAQ system

- CE personnel – 3 people teams
  - At most 2 teams plus 1 contact / control person for U and M activities
  - Include PD personnel in the same teams (4-5 people total)
- Additional CE personnel (1 team) working in parallel on the top of the cryostat on rack installation / cabling, another team may be required if installation of cable trays also happening inside the cryostat
- Final HV test of APA and position adjustments would happen in shifts 4B, 2A, and 3A (need fencing around APA being tested for short period of time)

Work on the top of the cryostat

- Racks are fully installed and cable prior to the installation of the corresponding row of APAs
- To reduce the number of transports in the shaft we should consider populating the racks at the integration facility, and not transporting racks, crates and modules within crates separately to the mine, all with their packaging
- Terri Shaw has studied (docDB 4499) various ways of arranging the racks for CE, PD, CISC, (some DAQ) balancing the power requirements
- Manhong Zhao has performed studies of how to cool the racks and there are two possible solutions (see next 8 slides), other meeting on this planned for this week
- Installation of cooling could also be done after first initial tests of CE/PD

Rack Cooling Concepts for DUNE Far Detector

Cooling requirement:

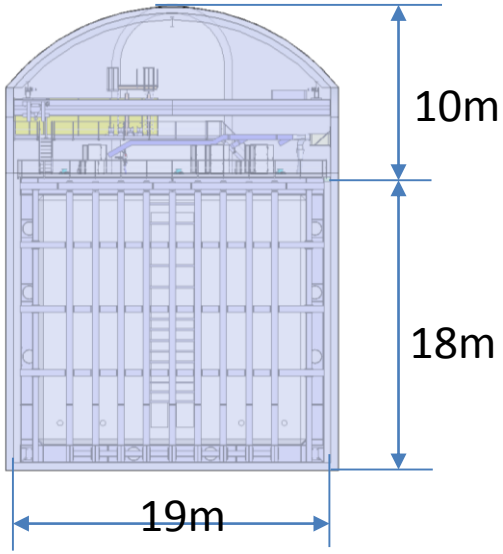
There are about 110 racks, 3.3 kW per rack.

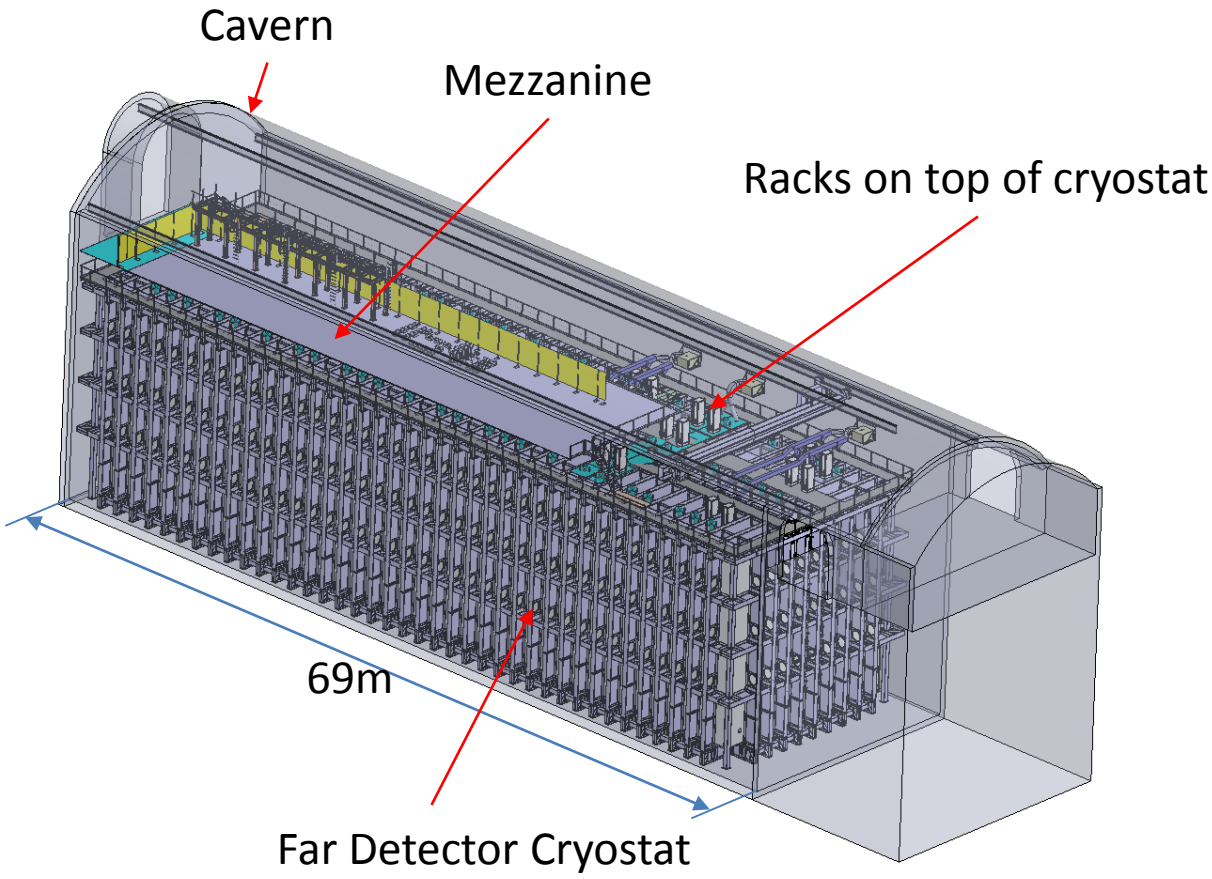
Requirements of temperature and humidity are

" FSCF shall maintain the Far Detector chambers at a temperature between 67 to 85 degrees F, a relative humidity level between 15 and 85 percent, and a maximum dew point of 48 F“

The cooler the better, but a maximum of 85 F for the rack should be a goal.

DUNE Far Detector in Cavern

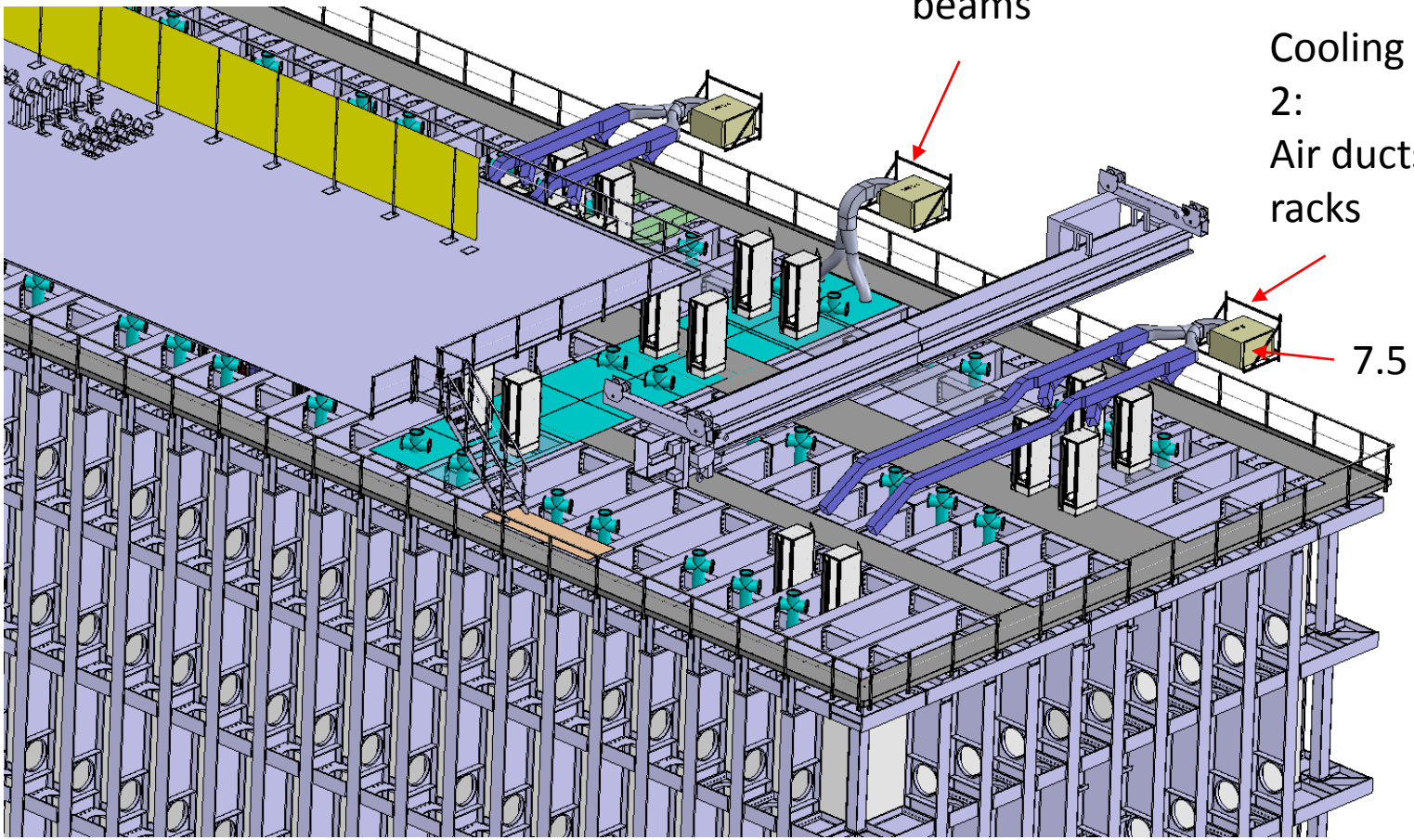


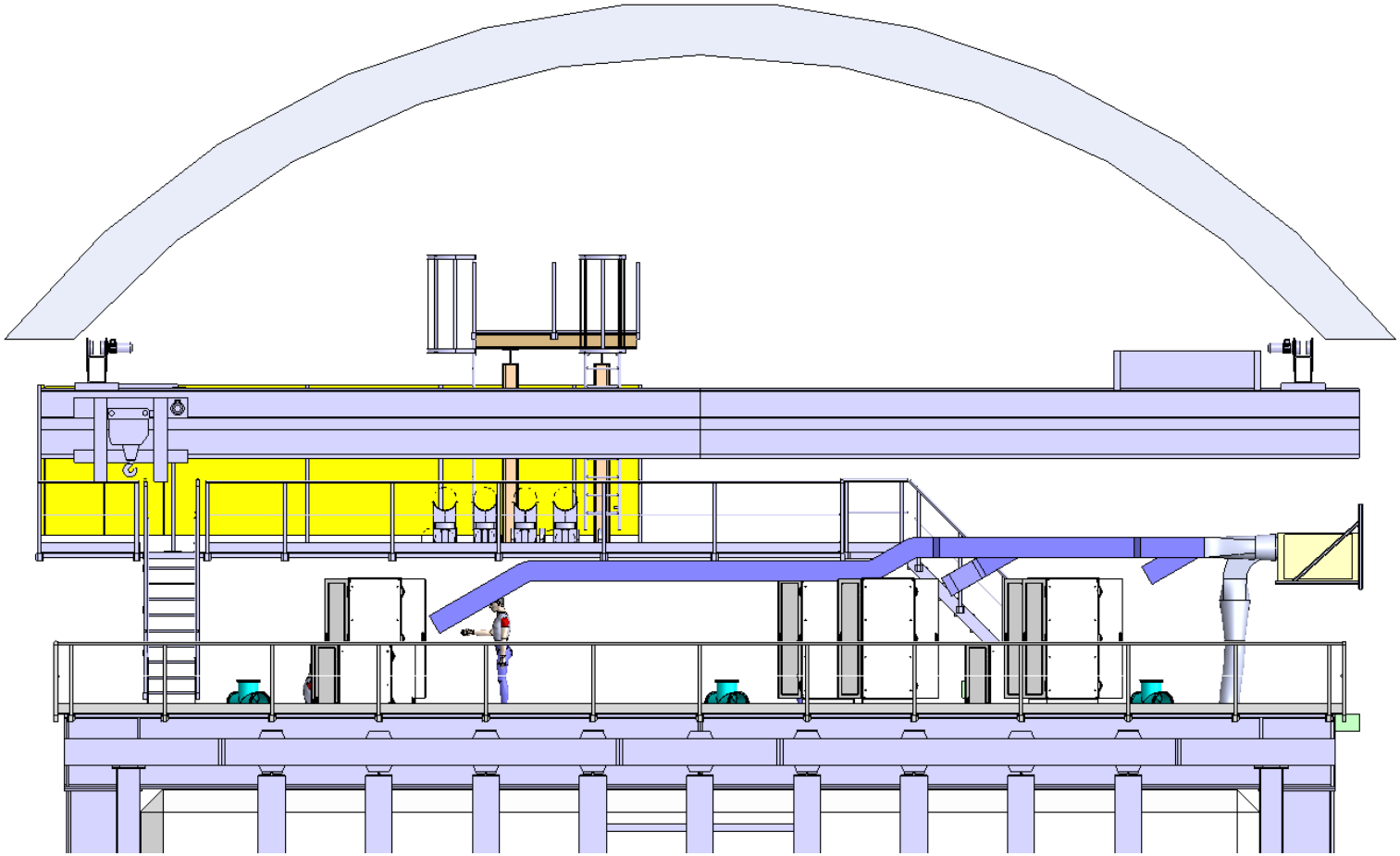


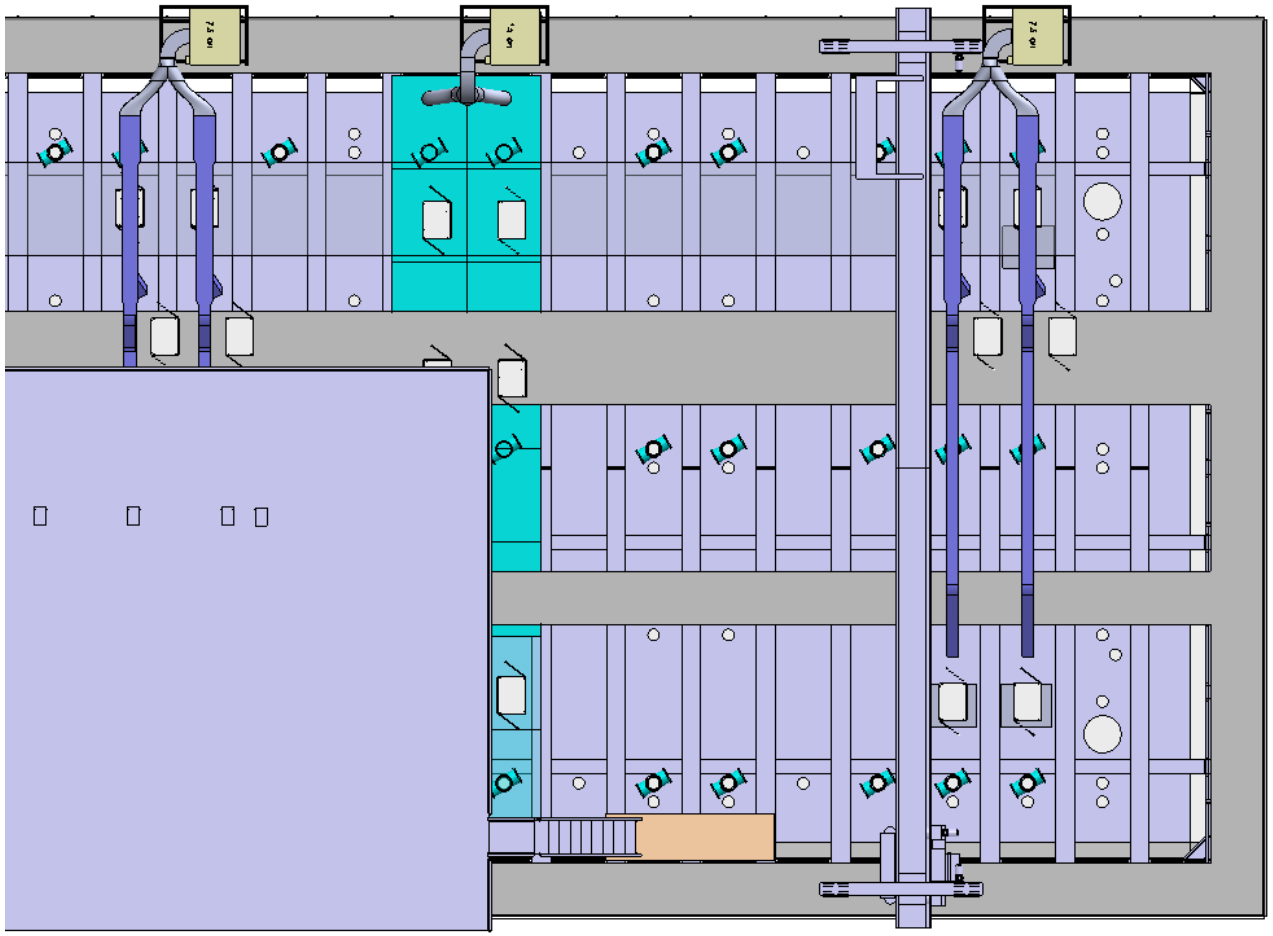
Cooling scheme 1: Air channel between I-beams

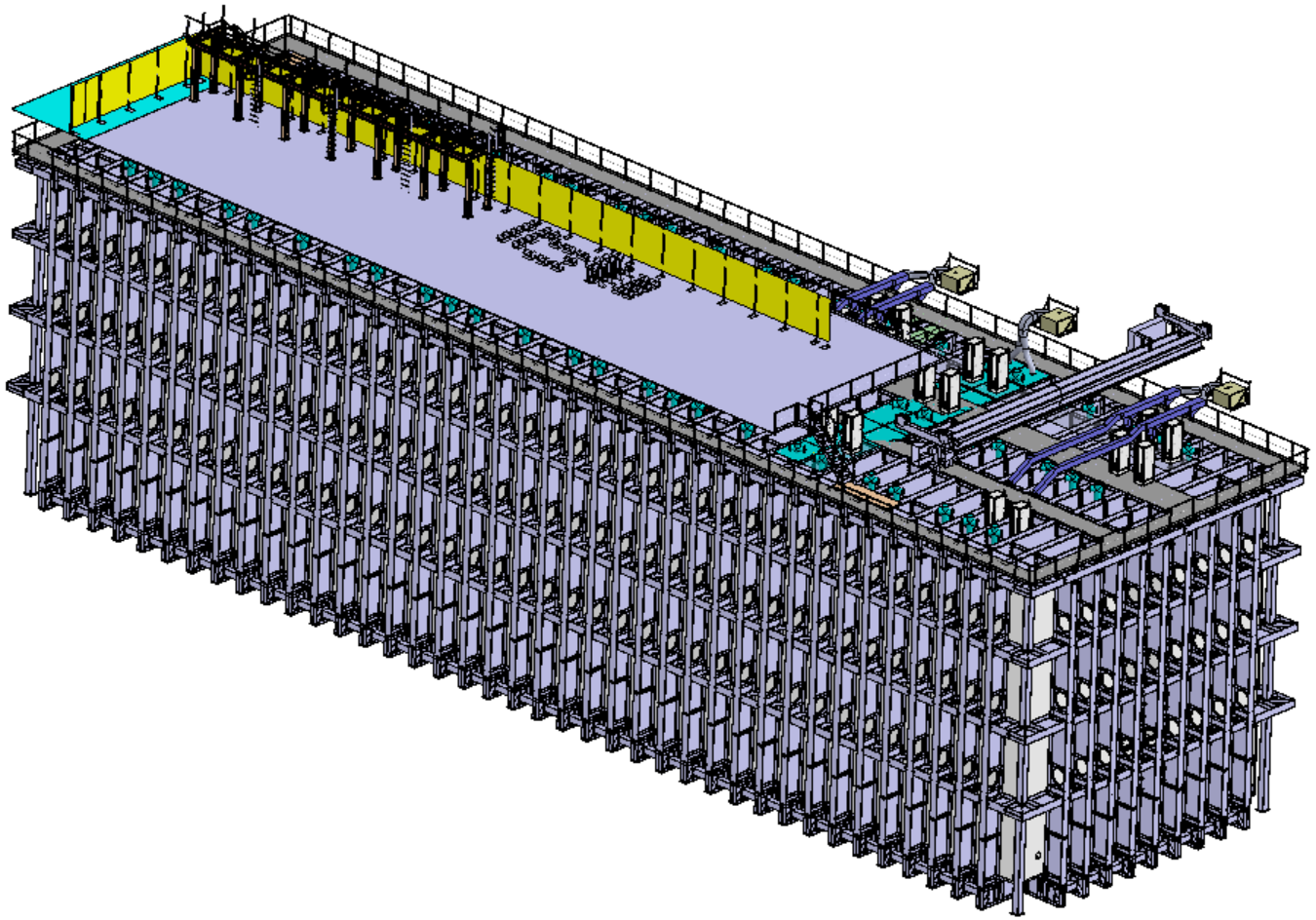
Cooling scheme 2: Air ducts over racks

7.5 ton AHU

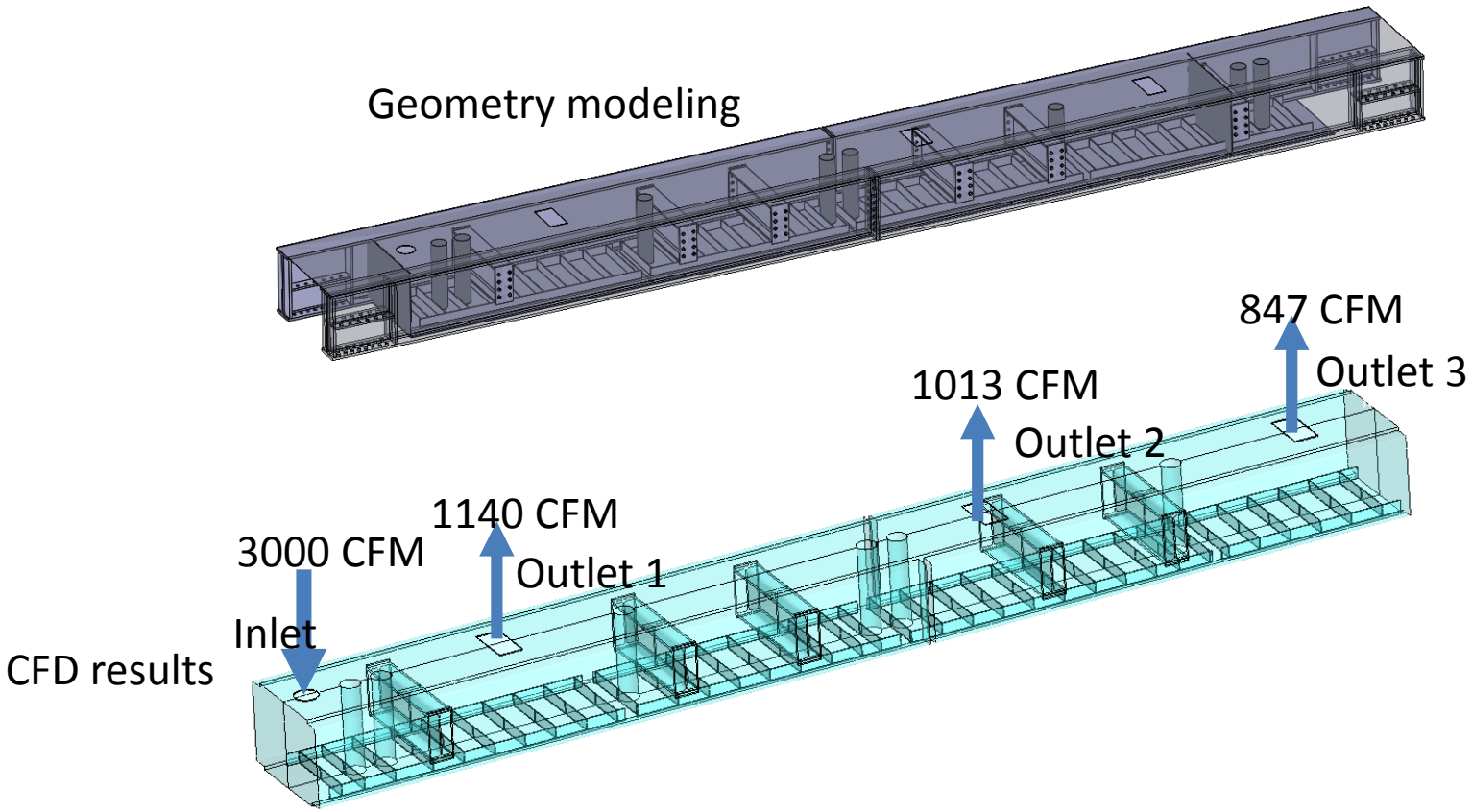




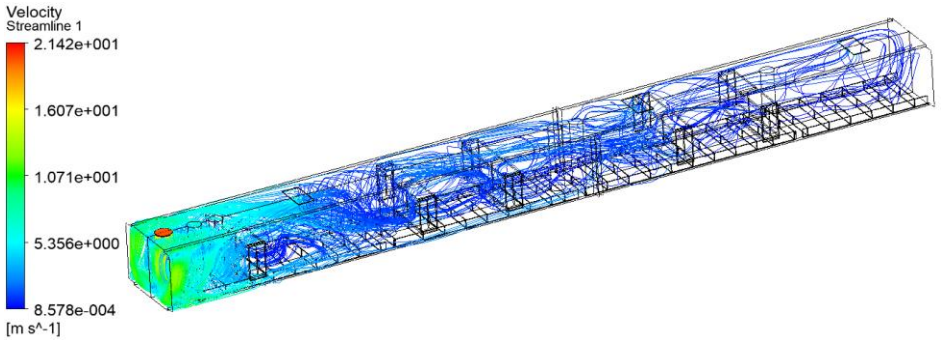




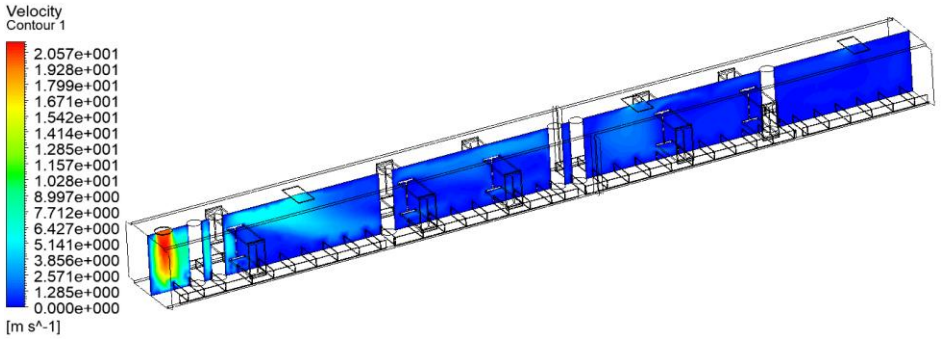
Air flow simulation of air channel between I-beams



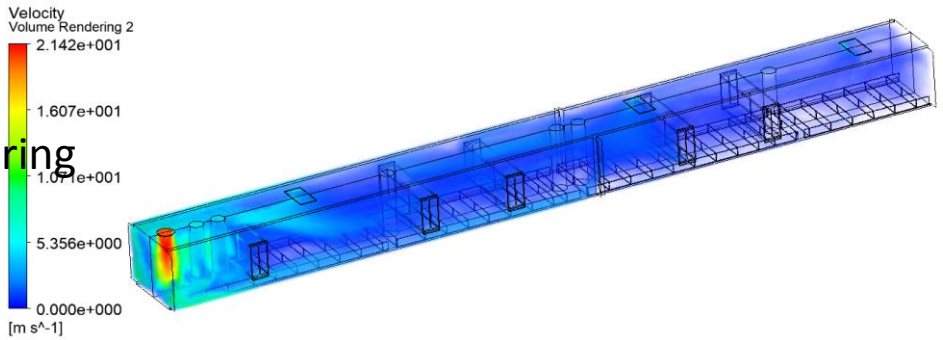
Velocity streamline



Velocity contour at center plane



Velocity volume rendering



Work on the top of the cryostat

- The solution that uses the channels of the cryostat as duct for the cooling seems feasible, we can balance the load among the racks
- Allows for false flooring on top of the cryostat, facilitate moving racks around and allows for extra cable ducts (connections between racks and cryostat penetrations for one row of APAs, connections between cryostat penetrations and DAQ backend)

Questions / requirements from CE consortium

- Who is responsible for the installation of the cable trays inside the cryostat ? When is this done ?
- CE, PD, CISC, and DAQ consortia need to start installing racks and electronics on top of the cryostat 2 weeks prior to the arrival of the 1st row of APAs in the cavern
  - This also includes routing readout fibres to the CUC
  - CE would like to investigate integration of racks prior to transport to SURF
- CE and PD consortia need DAQ backend and working detector controls and safety systems 1-2 weeks prior to the installation of the 1st row of APAs in the cavern
- CE consortium needs 1 shift of testing for APA pair in the toaster area, 2 shifts for each APA pair to do all the connections at the cryostat penetration plus 1 shift of testing
- CE consortium needs at least 1 shift of work (testing in the toaster area) on the 5th day of each week

Work on cryostat penetrations

- Assume chimney is already in place
- Route cables from the bottom to the three openings on the chimney (1 for PD, 2 for CE), cables are supported from outside
- Put in place the strain relief at the bottom of the cryostat penetration
- Connect the cables to the three end flanges and put in place the 2nd strain relief for the cables close to the end flanges
- Perform first quick connectivity tests
- Move the end flanges to their final position on the chimney (requires ~1 ft of slack for the cables, to be accommodated inside the chimney)
- Mount the warm interface crates and perform all electrical and optical connections between the WICs and the racks on top of the cryostat and the readout fibre plant to the CUC
- Specialized tooling / hoist to be developed for some of these tasks