04/6/2021

Installation

D. Autiero, T. Hasegawa

Important requirements/messages from VD Top Drift Electronics (TDE) Consortium

- "Chimenys" should be installed first
- It is needed to protect "Fragile materials" as the crates and the electronics. So their installation will be performed once all the work for the heavy material as the chimneys on the cryostat roof is finished
- "Blades" should be able to be kept lifted up in a safe position during CRP cabling/installation (Need check of interference with Mezzanin configuration)
- Installation work of TDE is essentially independent from CRP both in production tests and in installation (apart the fact that of course chimneys must be already installed before installing the CRPs, and need to check the interference on the roof with CRP work to secure the safe environment for "Fragile materials")

Overview

- First FD2 installation discussions took place recently with LBNF Integration and Installation team (I&I) lead by James Stewart
- A general installation schedule was presented at the LBNC installation review recently
- For the VD Top Drift Electronics (TDE) Consortium, first discussion was driven by what had been defined for the installation in the DP TDR (see set of slides in the backup)
- Given the different number/size of the chimneys, the installation procedure and tooling will have to be updated and refined in the next series of meetings with I&I with also the chimneys experts
- James Stewart summarized the outcome of the first discussion in a set of draft slides shown in the following

Slide prepared by James Stewart
Under discussion among I&I and TDE Consortium team

Top Electronics Schedule

- Start installation of the electronics modules -8
- End installation on the roof in week +3

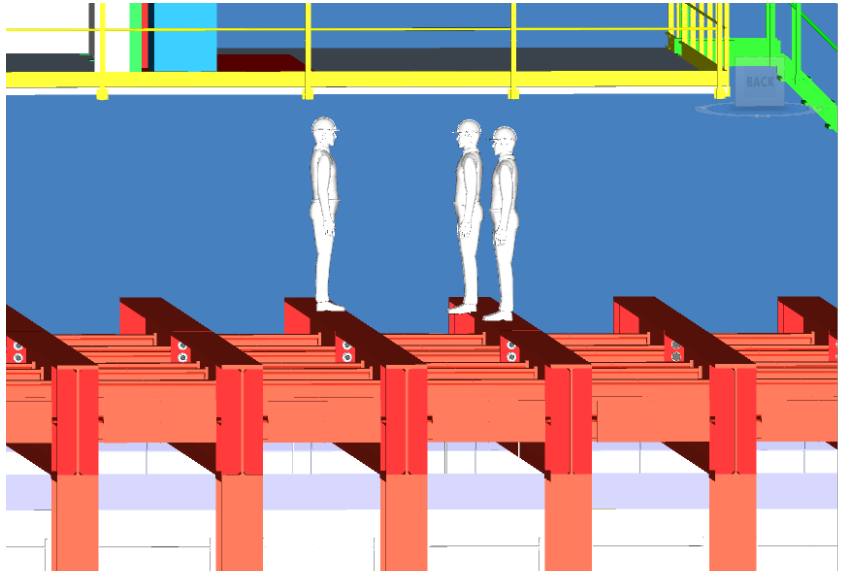
} 11 weeks

Note added by T.H:
See next to next slide for the assumption of ”week 0”

Working conditions

Assume 10hr shifts with 7/8hr of work per shift

- 6 days/week (some Sunday restrictions)
- 2 shifts/day



Big Picture Schedule

- Week# -8 Install rack mounted electronics
- Week#-7 to -2: Install Chimneys 1-109
- ……
- Week#-2 to +3: Install blades, uTCA crates, cable and test

Note added by T.H:
Typo, No. of Chimneys should be 105
Installation and tests of electronics + CRP pipelined with CRP installation

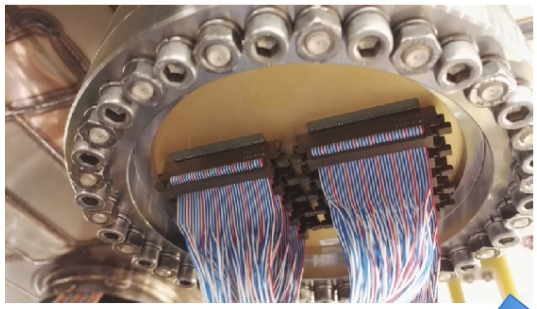
TDE – TOP Drift CRPs interface

- The configuration is similar to the dual-phase design

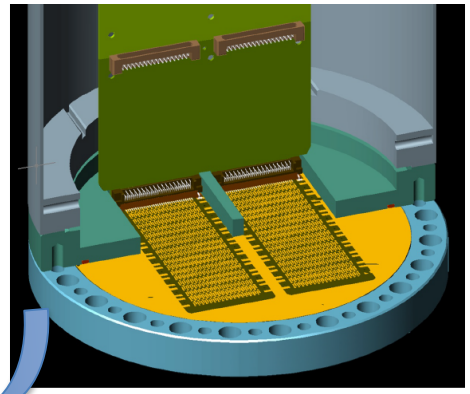
- Similarly as described in the dual-phase TDR the **interface between the electronics and the CRPs is defined at the level of the cold flanges**

TDE

CRP



Cold flange seen by the CRP



FE cards plugged on the cold flange at the bottom of the chimney

Implications (CRP consortium):

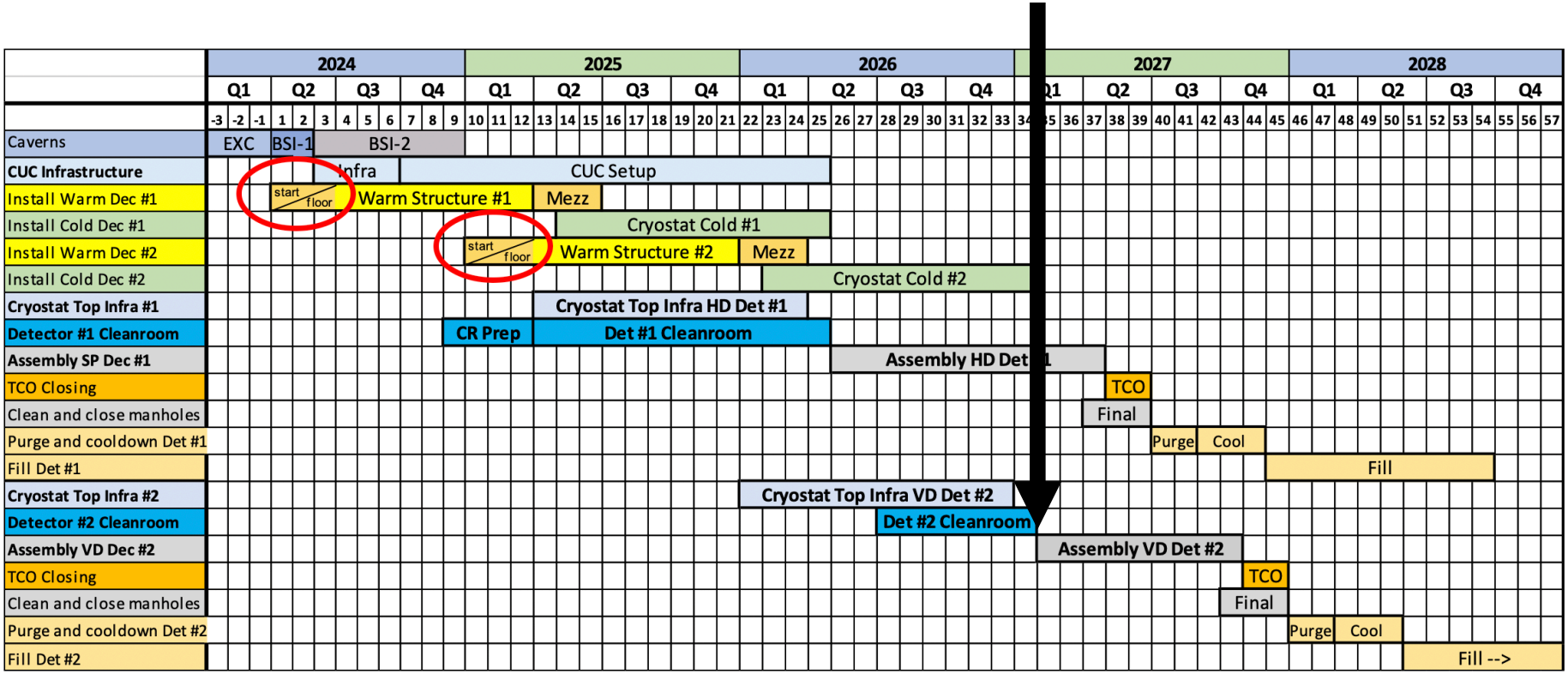
- **Cabling:** similar cabling with flat cables going from top drift CRP anodes to the cold flanges of the chimneys as for DP CRPs. This is integrated in the CRP installation activities which is also similar to DP (Dominique). It had an influence on the positioning of the KEL connectors at the CRP borders in order to guarantee accessibility to the chimneys and easiness of cabling (people involved Bo and Dominique)

- **Adaptor boards** (Bo). Adaptor boards are very simple hosting just the flat cable connectors and the anode biasing and decoupling components. They have to:

1) Host the KEL connectors guaranteeing the correct mapping of the anodes and accessibility to chimneys via cabling, modularity of 32, views not mixed on the same KEL connector
2) Host the anode biasing and decoupling components, biasing should happen locally with AC decoupling to the electronics (design in progress by Bo)

Slide shown by M.Nessi
at LBNC 11-May 2011

Note added by T.H:
Assumption of ”week 0”



- Filling of #2 concurrent with Filling of #1 is contingent upon:
  - Having 4th refrigeration unit available earlier than planned (basically with the rest of the scope). This is currently non-DOE scope.
  - Increasing size of water bath vaporizers above ground to 2 x 400 kW (currently 2 x 300 kW), otherwise we cannot send down enough GAr.
- Start of Filling of each cryostat assumes manholes (on each cryostat) are closed concurrently with TCO closing. The testing/safety activities can only be performed after closure of manholes and before starting the purge.

Note added by T.H:
Materials should be ready well before.
Current assumption is before July 2026

Slide prepared by James Stewart
Under discussion among I&I and TDE Consortium team

Predecessors:

General

- Cryostat roof finished (walking surface done)
- Detector mezzanines in place
- Cryostat penetrations welded and leak tested.
- Detector racks, power to racks, and safety system in place.
- Power and fibers for the µTCA crates in cable trays.
- DAQ ready to readout the µTCA crates. (not strictly necessary)

Top Electronics specific

Note: Chimneys installation must be completed first

- All Top Electronics parts are underground or in the SDWF
- The connection to the DAQ is fully tested
- All test equipment and software is available.

Note added by T.H:
"SDWF" is South Dakota Ware Facility

Slide prepared by James Stewart
Under discussion among I&I and TDE Consortium team

Manpower teams

Week# -8

- I&I technicians 5 people working day shift

- Top Electronics 8 people working day shift
  - Assumes 3 people installing modules and the rest setting up and testing software.

Week#-7 to -2

- I&I technicians 6+2 persons/week working on 2 shifts (5/shift)
- Top Electronics 12 persons /week working on 2 shift (6/shift)

Week#-2 to +3

- Top Electronics 12 persons /week working on 2 shift (6/shift)

Note added by T.H:
Numbers for chimneys installation (-7 to -2) to be refined in next meetings

- Crane drivers inside the S cavern 6 persons/week working on 2 shifts
- Surveyors 2 persons/week working 40h/week

Slide prepared by James Stewart
Under discussion among I&I and TDE Consortium team

Assembly steps related to a top electronics installation

Day 1 – 4: (Week: -8)

- Place all electronics modules in the electronics racks. Power and test.
  - LV PS and data concentrators for the white rabbit.

Day 5 – Day 32 (Week -7 to Week -2)

- Insert Chimney with welded cross.
- Tighten flange to cryostat and leak test.
- Position µTCA crate stands/mounts
  - 109 Chimneys total

Note added by T.H:
Typo, No. of Chimneys should be 105

One I&I crew of 5 people can support two teams of 3 T_Elect. experts. Four Chimneys can be installed in one day using both crews. (This is a rate of one Chimney per shift per crew)

Day 33 – 61 (Week -2 to Week +3)

- Install blades in chimneys
- Position µTCA crates
- Install cards in UTCA crates
- Cable µTCA crates to flanges
- Power and test

One team of 3 top electronics staff can install and setup one Chimney in one shift. Two crews working in parallel can install and setup 4 Chimney per day. (28 days)
I&I crew are not needed except for moving materials.

Slide prepared by James Stewart
Under discussion among I&I and TDE Consortium team

Activities happening in parallel

- Work on the cryostat roof is finishing
  - No work near the Chimneys during and after their installation.
- The cryostat membrane is being welded.
  - Blades are only connected during CRP installation so there is no hazard from the welding.
- The Gray room is being constructed along with the SAS and changing room.

- DAQ is being tested

Note added by T.H:
“Gray room” is clean room with no big cleanness requirement

Slide prepared by James Stewart
Under discussion among I&I and TDE Consortium team

M&S required from the I&I project for the Top Electronics

Note added by T.H:
"M &S" is Materials and Services

- Gray room and ventilation
- Racks on top of the cryostat, with AC power, safety and slow control
- Cable trays on the mezzanines and cryostat roof
- GAr purge for the feedthrough penetration outer volume
- Fibers and cables on the cryostat roof ?
- Standard rigging equipment
- Leak testing equipment and helium
- Surveyors + equipment
- 2 cabinets
- Supports for the µTCA crates on cryostat roof
- Cover box to protect the cables and fibers on the µTCA

Slide prepared by James Stewart
Under discussion among I&I and TDE Consortium team

M&S required from the Top Electronics consortia

- Required tools and any lifting/transport fixtures.
- Shipping boxes or pallets for all Top Electronics equipment.
- Top electronics Chimneys including seals and hardware.
- Insertion blades
- µTCA with all electronics modules
- Mounting structure for the µTCA crates
- All patch cables outside the cryostat (Chimney to µTCA crate)?
- All equipment for QC testing

- Needs Clarified: DC power supplies for the µTCA if the grounding committee recommends this. First the grounding committee needs to evaluate this. In NP02 220V was used and no significant issues were found.

Slide prepared by James Stewart
Under discussion among I&I and TDE Consortium team

Points to be clarified

Note added by T.H:
Weight of the Chimney is 340kg without the blade

1. Electronics rack layout
   - Input from Top Elect is available. Coordination with Terri is needed to define rack builds.
2. How is the Chimney lifted in position?
3. What is the weight of the Chimney? (initial estimate 550kg)
4. Cable fiber definition for the cryostat roof (µTCA crates to mezzanines and DAQ)
   - Information is available needs coordinated with Terri.
5. Are µTCA crates powered by 48V-DC or 110V-AC? (110V is assumed)
   - Should be verified with the grounding committee.
6. When can the installation start and can it be finished before the CRP installation starts?
7. Are there any light flashers on the CRP and would they interface to the electronics feedthrough?
8. The number of shipping boxes and other material handling information should be transmitted to Ladia.
9. Material handling
   - Chimney will fit in the cage. All other materials are smaller.
10. How are the short cables tested in the cryostat after installation?
11. How are fibers protected ?
12. Is the chimney weight an issue for the cryostat?
13. Check the head height under the mezzanine.
14. Coordination of the CRP hoisting and the final work on the top electronics is need. The fibers and cables are fragile.
15. When is a gray room needed and can this be on 4910?
16. Will there be any QC and testing in the warehouse?
17. Final QC
    - Integration checks concern the LV distribution system that the correct currents are distributed and the FE delivers data and grounding and noise are correct. A small dedicated DAQ system can be used to test individual crates if main DAQ is unavailable

Note added by T.H:
Logistic information sent to Ladia Jakubec (Far Side Logistics Manager) (see next slide)

Note added by T.H:
The IJCLAB people provided James Stewart a 3D model of the 50 cards chimneys so that their handling can be checked with respect to the clearance from other structures

Note added by T.H:
We are working at filling, as we did for the packaging, the tables of information for the electrical material and cabling for Terri Shaw

Information sent to Ladia Jakubec

Logistics:

Principal components for TD Eelectronics: this material can be brought directly underground for installation

Component	Total number	Shipping box dimensions LxWxH (m^3)	Shipping box weight (kg)	Number of units per box	Total number of boxes
SFT chimney	105	2.5 x 0.8 x 0.8	380	1	105
FE cards	4000	0.7 x 0.5 x 0.5	15	150	27
CRO AMCs	4000	0.7 x 0.5 x 0.5	20	120	34
WR-MCH	400	0.7 x 0.5 x 0.5	20	62	7
uTCA crate + MCH + PU	400	0.6 x 0.4 x 0.5	15	1 + 1 + 1	400
VHDCI	8000	0.7 x 0.5 x 0.5	18	100	80
WR switch	20	0.5 x 0.5 x 0.4	20	8	3
PS units	20	0.7 x 0.5 x 0.5	20	1	20
PS distribution	20	0.7 x 0.5 x 0.5	15	1	20

Total volume of boxed material is 250 m^3 of for 50 ton (chimneys: 160 m3, 40 ton)

Estimates are based on the experience with the deliveries of the the components for ProtoDUNE-DP

Apart from SFT chimneys, try to optimize the number of boxes such that each is ~20 kg and compact enough for manual handling during installation

Summary

- We made a first round discussion with I&I concerning the installation based on the previous DP information in the TDR

- We privileged the scenario where the heavy mechanical components such as the chimneys are installed first in order not to damage the fragile components (blades, crates, which will be installed in parallel to the CRPs to test the CRPs)

- The expected time for the chimneys installation is presently reduced from the DP TDR case of 3 months (240 chimneys) to 1 month for VD (105 chimneys). This has to be confirmed with developing more details.

- From the LBNC installation discussion we understand that I&I will take care of the manipulation of the heavy objects. If this applies to the chimneys the I&I work is supposed to be done with the supervision of some IJCLAB experts
  → details to be refined.

- We need now to go in more details and adapt the design of the installation tools to form the first DP design and define the work sharing among I&I and the TDE consortium team (IJCLAB team is attending the meetings with I&I to define the tooling to install the chimneys and the schedule/procedures)

Important requirements/messages from VD Top Drift Electronics (TDE) Consortium

- "Chimenys" should be installed first
- It is needed to protect "Fragile materials" as the crates and the electronics. So their installation will be performed once all the work for the heavy material as the chimneys on the cryostat roof is finished.
- "Blades" should be able to be kept lifted up in a safe position during CRP cabling/installation (Need check of interference with Mezzanin configuration)
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Backup slides summarizing the TDR information on the electronics installation

Technical details
Including past discussion from DP which are valid for VD TOP Electronics

Table 4.12: Milestones for the TPC electronics consortium.

Milestone	Date (Month YYYY)
Costing model for technical design report finalized	March 2019
Start of ProtoDUNE-SP-II installation	March 2021
Start of ProtoDUNE-DP-II installation	March 2022
South Dakota Logistics Warehouse available	April 2022
Beneficial occupancy of cavern 1 and CUC	October 2022
CUC counting room accessible	April 2023
Top of detector module #1 cryostat accessible	January 2024
Start of component production and procurement	January 2024
Completion of production of μTCA infrastructure components	July 2024
Completion of production and validation of WR system components	July 2024
Start of detector module #1 TPC installation	August 2024
End of detector module #1 TPC installation	May 2025
Top of detector module #2 accessible	January 2025
Completion of production and tests of SFT chimneys	January 2025
Completion of production and tests of cryogenic FE analog electronics	January 2025
Completion of production and tests of AMCs for CRO and LRO	January 2025
Start of detector module #2 TPC installation	August 2025
SFT chimneys installed	November 2025
Cryogenic FE electronics installed	December 2025
μTCA crates and WR network installed	December 2025
Installation of AMCs completed	January 2026
Commissioning of the DP TPC electronics system	January 2026
End of detector module #2 TPC installation	May 2026

DP-TDR

Sequential:

1) Chimneys (240)
→ 3 months
4 chimneys/day

2) FE cards + uTCA
1 month

3) AMC 1 month

Technical details
Including past discussion from DP which are valid for VD TOP Electronics

DP TDR

4.6 Installation, Integration, and Commissioning

Installing the TPC electronics systems requires several stages. The chimneys are installed before starting the CRP installation inside the cryostat. Once the CRPs are installed, the chimneys are cabled to them. Next the FE cards are mounted on the blades and inserted. The installation of the digital electronics and μTCA crates is postponed until all heavy work on top of the cryostat is done. This prevents damage to fragile components (like the optical fibers) from traffic and moving materials. Once the μTCA crates are installed and all the digital cards are inserted, the AMCs are cabled to the warm flanges of the SFTs for the charge readout, then connected to the PMT signal cables for the light readout. Finally, the 10 Gbit/s and 1 Gbit/s optical links to the DAQ and WR timing network are connected. At this point the full system is ready for commissioning.

4.6.1 SFT Chimneys

Installing the SFT chimneys requires a compact gantry crane with movable supports along the length of the cryostat. Enough overhead room to accommodate a chimney's 2.4 m length is required to allow the crane to freely move the chimney along the transverse direction. The crates containing the SFT chimneys are placed along the edges of the cryostat roof. An unpacked chimney is hoisted and transported to the appropriate penetration crossing pipe for installation. Once in place, the chimney is fastened to the flange on the crossing pipe.

In parallel with the SFT chimney installation, the FE cards are unpacked on top of the cryostat, mounted on the blades, and then, once the SFT chimneys are secured in the cryostat structure, the instrumented blades are inserted before sealing the chimney. The LAr and gas nitrogen delivery pipes will already be installed, making it possible to connect to the pipes. Pressure probes and temperature sensors are also connected to the slow control system at this stage.

Technical details
Including past discussion from DP which are valid for VD TOP Electronics

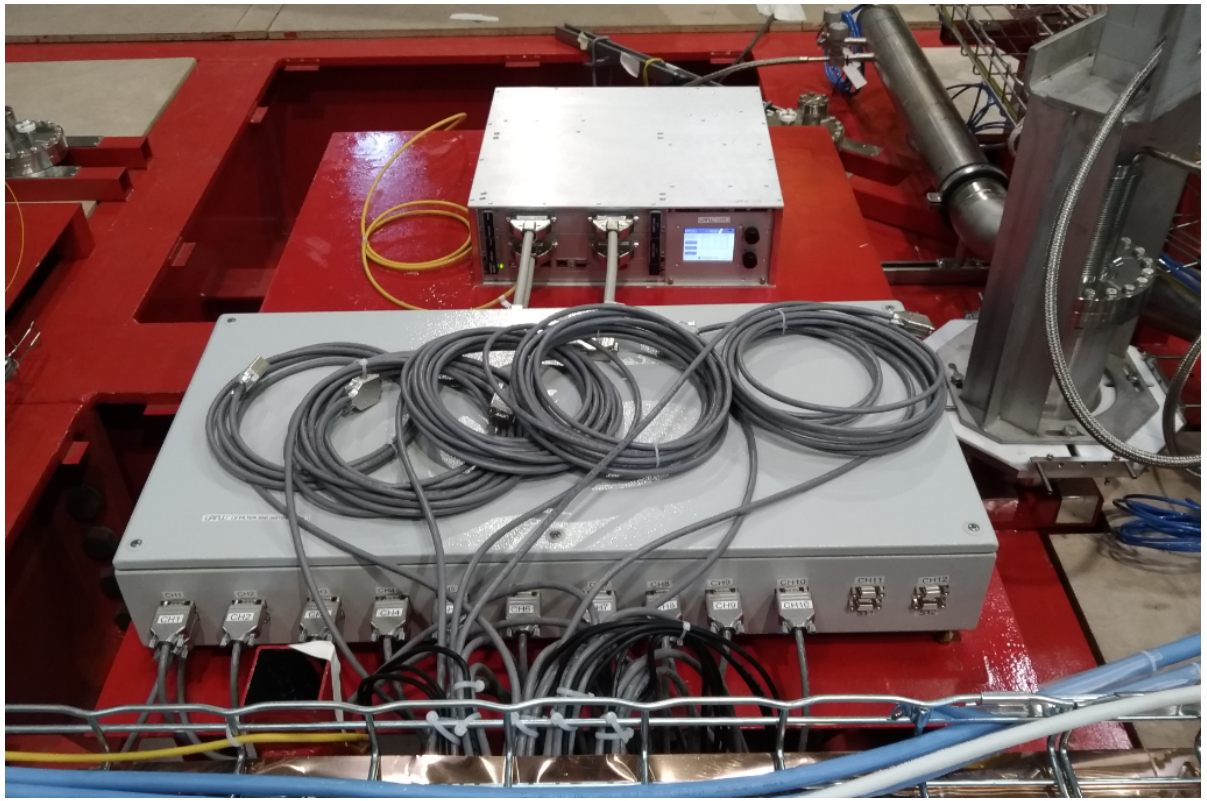
DP TDR

4.6.2 Digital μTCA Crates

Installing the μTCA crates with the digital electronics occurs in the final stage of the DP module installation to avoid damaging fragile equipment. The crates are placed in their designated positions on the cryostat and connected to the power distribution network. The AMC cards and WR-MCH modules are inserted into their slots. The VHDCI cables are then attached, connecting the CRO AMCs to the warm flange interface of the SFT chimneys. The fibers from the timing system are connected to the WR-MCH.

Technical details
Including past discussion from DP which are valid for VD TOP Electronics

Will stay in rack taking 3+6U

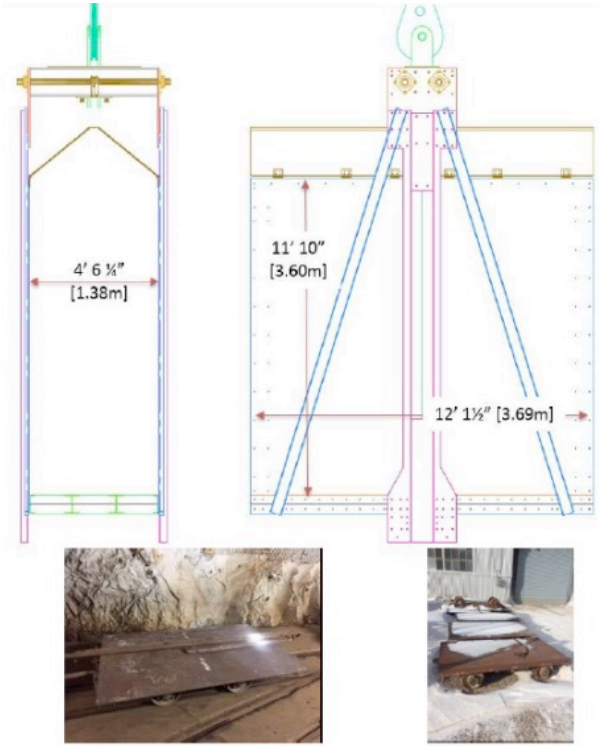


Technical details
Including past discussion from DP which are valid for VD TOP Electronics

Moving material underground

From Vic Guarino's presentation at the workshop

- Most equipment will be transported in the Ross Cage.
  ←AKA elevator for people not in mining industry
- Cage Parameters
  - Height – 3.6m
  - Depth – 3.7m
  - Width – 1.38m
  - Weight 13,000lbs
- Round trip travel time is 17 min (66 min) for a Cage (Slung load) trip. – Try to stay in the cage!
- The APA crate for example is to large to fit in cage and must be slung load.
  - Crates need to be able to be rotated 180 degrees and hung from ends – **challenge for crate design**
- Crates will be transported to cavern on carts 18" high.
- Wooden crates not allowed in cleanroom
- North drift needed to remove outer shell of crates?

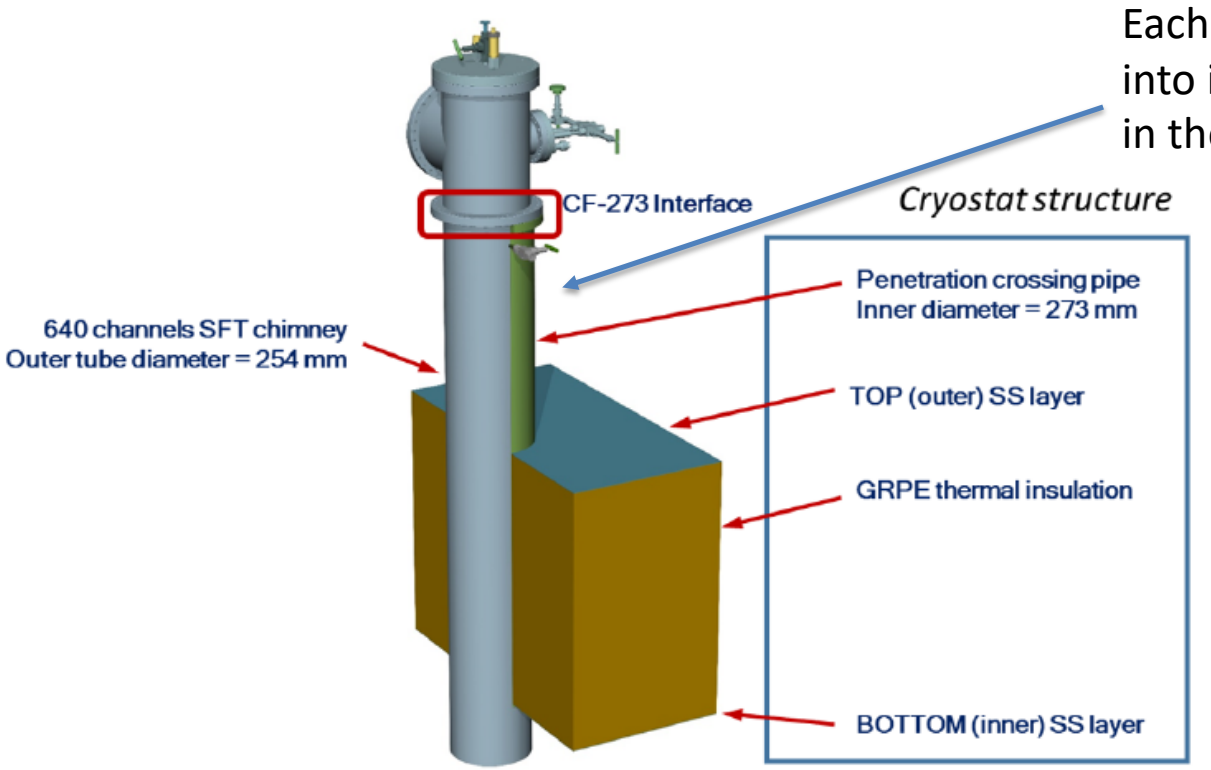


The cage is has enough depth to fit the SFT chimney crates

Technical details
Including past discussion from DP which are valid for VD TOP Electronics

SFT Chimney installation

- The is the largest component of the DP electronics sub-system to install
- An SFT chimney is 2.35 long and weights ~180 kg



Each chimney needs to inserted into its designated penetration in the cryostat insulation

Technical details
Including past discussion from DP which are valid for VD TOP Electronics

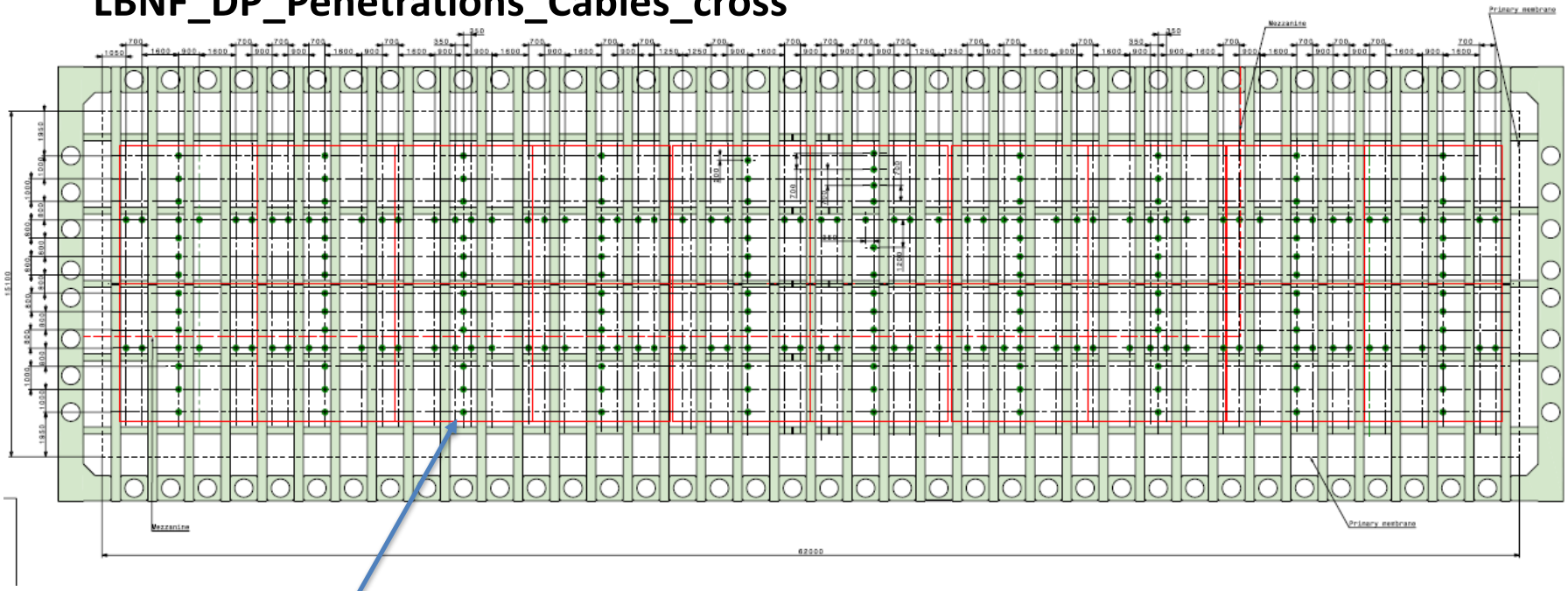
DUNE DP module: SFT penetrations

https://edms.cern.ch/document/1856961/1

Cable penetrations - 240 ps

“LBNF_DP_Penetrations_Cables_cross”

Top view of the cryostat warm structure



80 CRPs
240 SFT penetrations

SFT Chimney installation

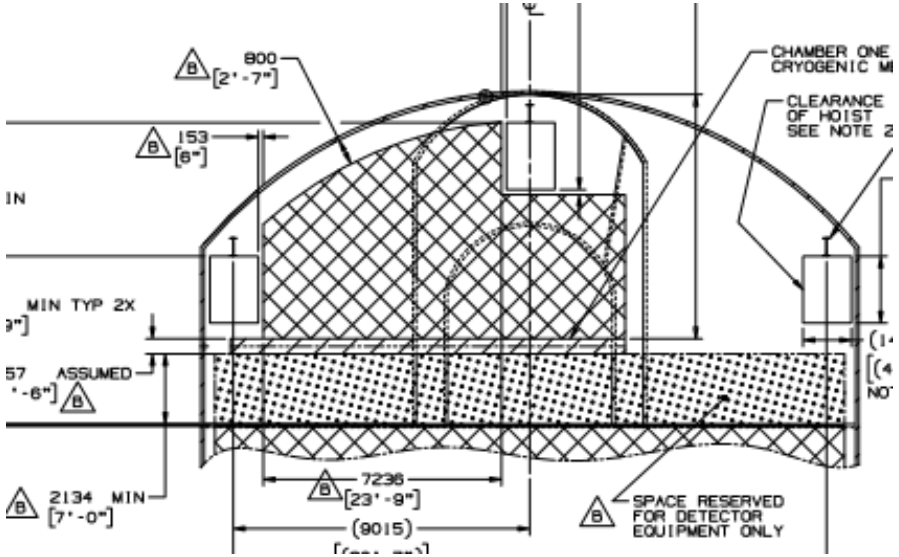
Small tool to lift the chimneys and lower them into the cryostat penetrations, such as a compact mobile gantry crane

Technical details
Including past discussion from DP which are valid for VD TOP Electronics

Working on the Cryostat Roof

From Vic Guarino's presentation at the workshop

- Only 2.1m is available under the Mezzanine
- Handling cable and structural feedthroughs requires gantry
- What is the height of the feedthrough flanges? (Limits height available and dictates the length of feedthrouhgs)
- Equipment installed on roof (SP and DP):
  - Racks
  - DSS feedthrough
  - DP chimney
  - Calibration & Slow Control



Technical details
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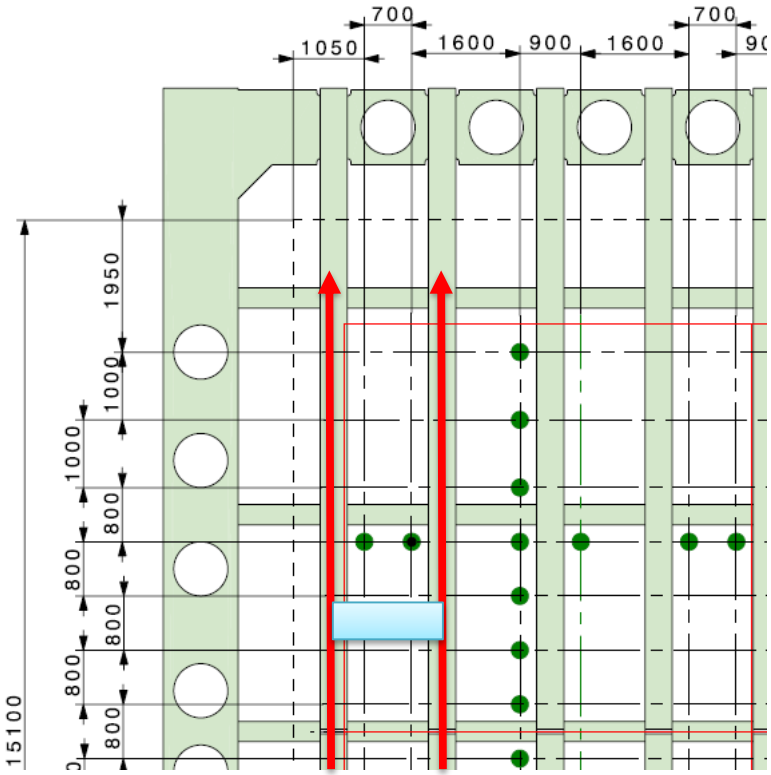
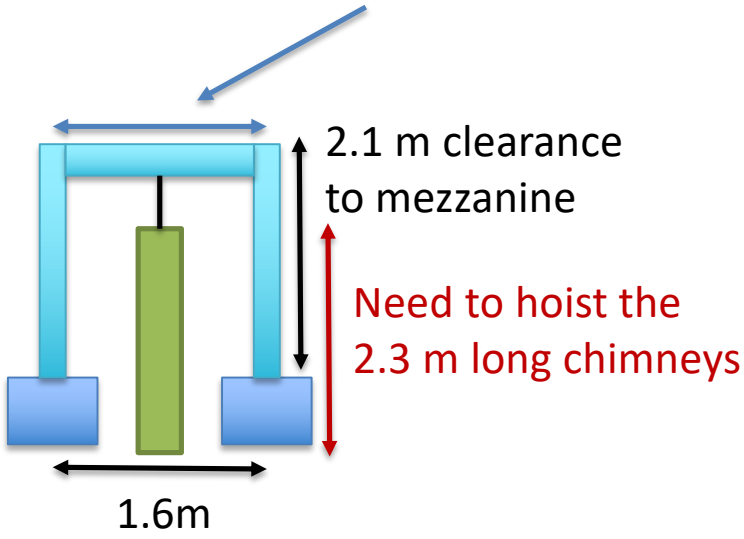
Constraints



The crane rolls on the rails along the two I-beams, the pitch is 1.6 m

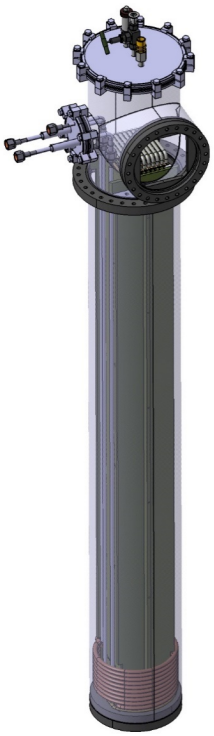
This movement does not need be motorized → can be chained-pulled



- 1.6 m width to match the pitch of the transversal I-beams
- 2.3 m chimney length (w/o top flange)

This crane total height needs to be optimized to go under mezzanine, where there is only 2.1 m clearance

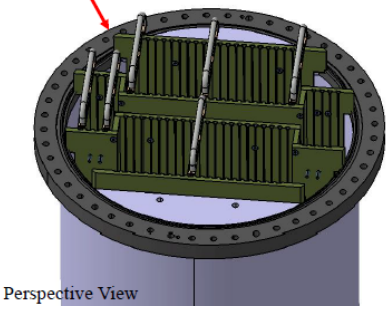
Technical details
Including past discussion from DP which are valid for VD TOP Electronics



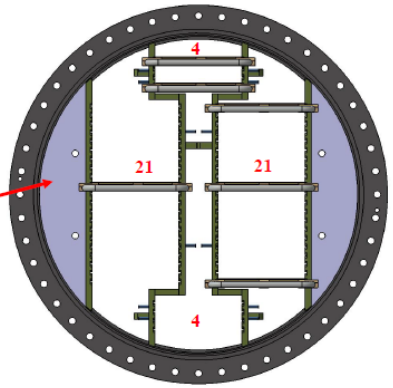
- **Good experience from Signal feed-through chimneys** implemented in NP02/ProtoDUNE dual-phase for 10 cards
- Within the activities of the DP Electronics consortium the Orsay IJCLAB group further developed that the design in order to optimize it for mass production and making it cheaper. Production ongoing of 5 mini-chimneys for the VD cold box tests
- VD design activities showed the opportunity for a further optimization (still based on the same basic design) by increasing the diameter of the penetration for the pipes and hosting more cards
- Design of the 50 cards chimneys in progress at IJCLAB, no foreseen technical issues, aiming at prototyping in 2022

Vertical Drift Chimneys

- Penetration diameter **from 250 to 480 mm**
- Able to house up to **50 FE boards** instead of 10
- **105 chimneys** to be produced
- Positioning of 50 connectors on Cold flange is possible with associated guiding system
- PCB design to be done



Perspective View



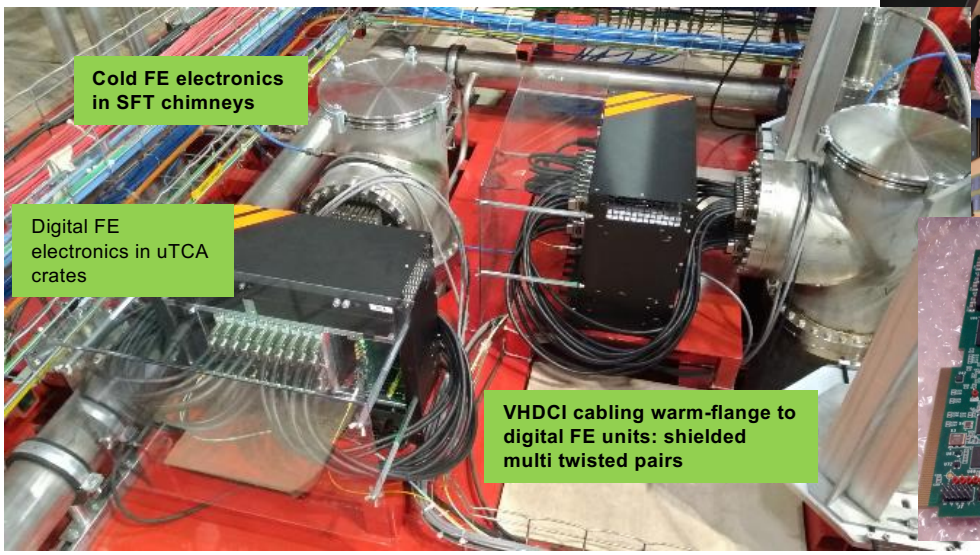
Top view

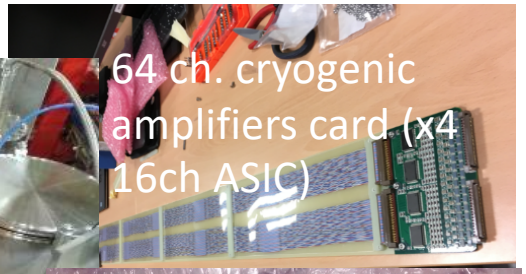
First design fitting 50 boards within defined diameter

F. Cavalier
TDE Consortium meeting
17/3/2021

Technical details
Including past discussion from DP which are valid for VD TOP Electronics

ProtoDUNE-DP FE electronics



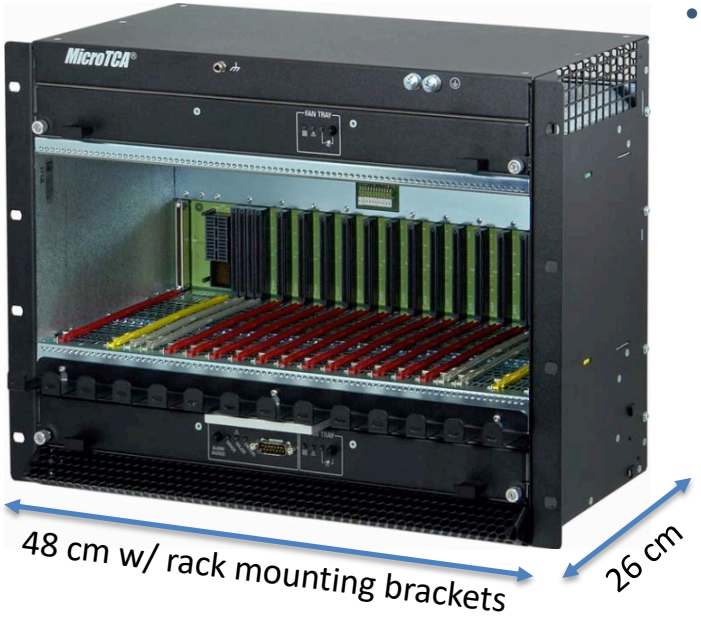


White-Rabbit timing slave node in each uTCA crate →

Technical details
Including past discussion from DP which are valid for VD TOP Electronics

Installation of uTCA crates with digital CRO and LRO electronics

- The uTCA crates for CRO should be placed at the level of the warm feedthrough of an SFT chimney on some suitable supports within a short distance <0.5m
- The crate footprint is 48 x 26 cm^2 (the width is standard for 19-inch rack-mounted equipment) and the height is 36 cm
- The weight is ~18 kg



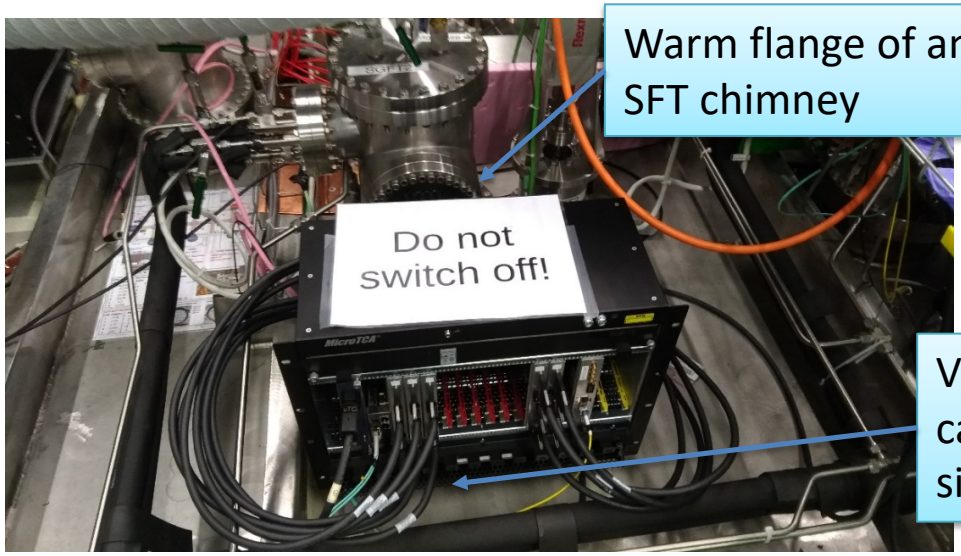
- There are 245 crates to install: 240 for CRO + 5 for LRO
- Crate installation & integration sequence:
  - Mount the MCH switch and PU
  - Mount the AMC cards (10 for CRO, 9 for LRO) and WR-MCH (time sync node)

  These operation are performed on top of the cryostat structure O(15min) per crate
  - Place the crate in its designated position and cable the AMCs to the warm flanges of SFT chimneys / LRO flanges

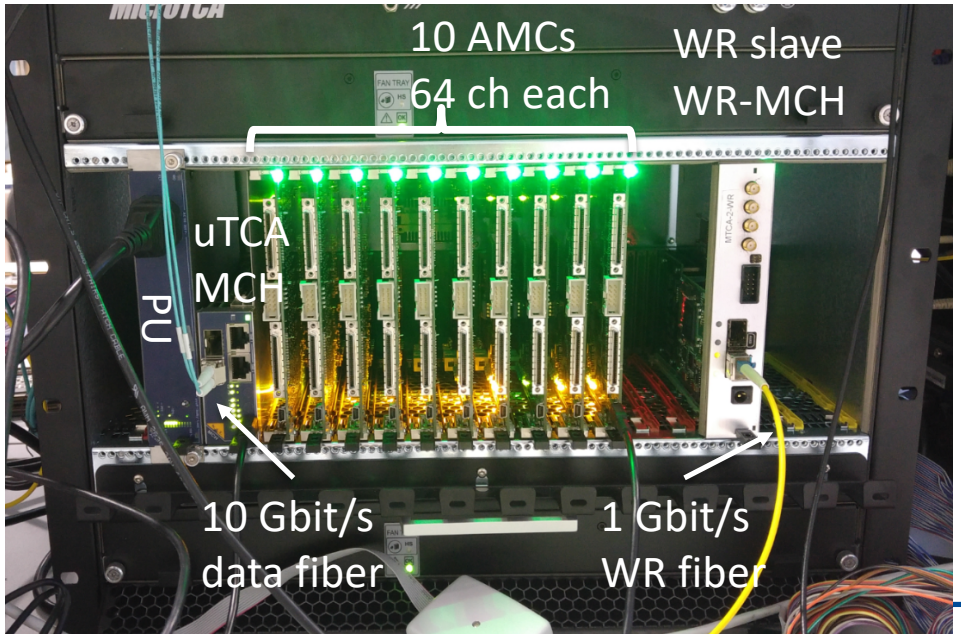
  Final step (after power cables/fibers have been pulled)
  - Connect mains AC power + two optical fibers to DAQ

Technical details
Including past discussion from DP which are valid for VD TOP Electronics

Installation of uTCA crates: some illustrations



Instrumented and cabled uTCA crate from 3x1x1 at CERN



A fully instrumented CRO uTCA crate with 10 AMCs (VHDCI cables are not connected)

During card tests at IPNL for ProtoDUNE-DP

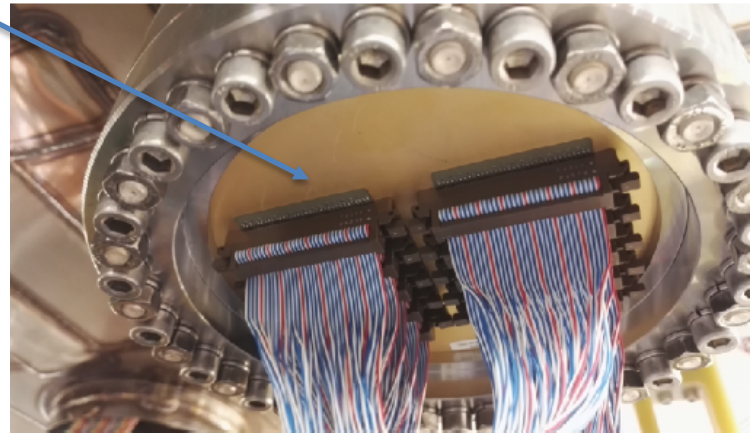
LBNF

Technical details
Including past discussion from DP which are valid for VD TOP Electronics

SFT Chimney installation

- The chimneys should be inserted first prior to the installation of the CRPs inside the cryostat to allow connecting the signal cables to the cold flanges
- 4 SFT chimney / day by a two-person crew
- Assume 3 months to complete this work
- Two crews can also work in parallel with two chimney gantry cranes
- During transport flanges are protected with plastic caps, these can be reused for protection if needed after installation (e.g., avoid dirt accumulation if piping work is still on-going)
- There are two (inlet/outlet) connection for LAr circulation in the cooling coil that need to be branched to the cryogenic system
- There is also an inlet for gas N2 that need to be connected
  - In the commissioning stage, after the FE electronics is installed, the chimneys are evacuated and filled with N2

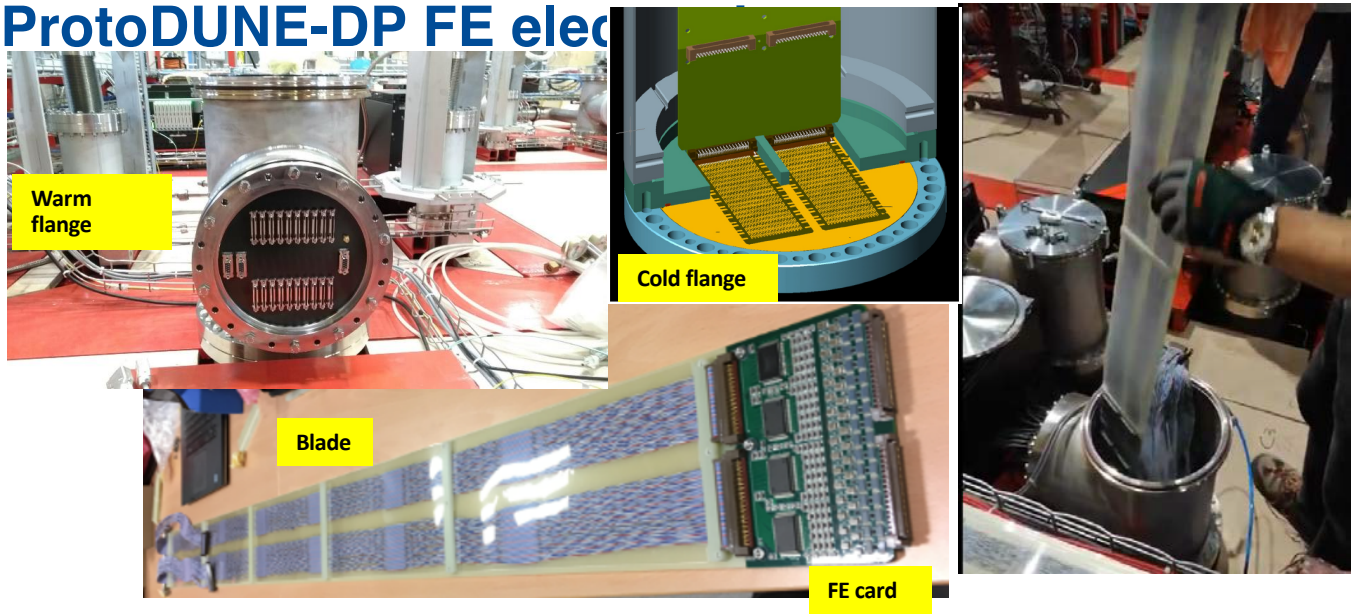
CRP signal cables connected to the cold flange interface of the SFT chimney inside the cryostat



Note: DP chimneys were 240

Technical details
Including past discussion from DP which are valid for VD TOP Electronics

ProtoDUNE-DP FE elec



- **Signal feed-through chimneys** containing the cryogenic amplifier cards mounted on the extraction blades

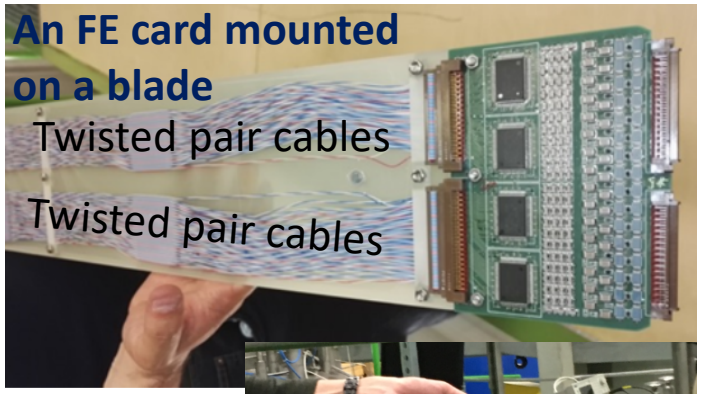
- **Cryogenic amplifiers in the signal feedthrough chimneys accessible at any time** without interfering with the functioning of the rest of the detector. Simple intervention, routinely exploited during NP02 operation

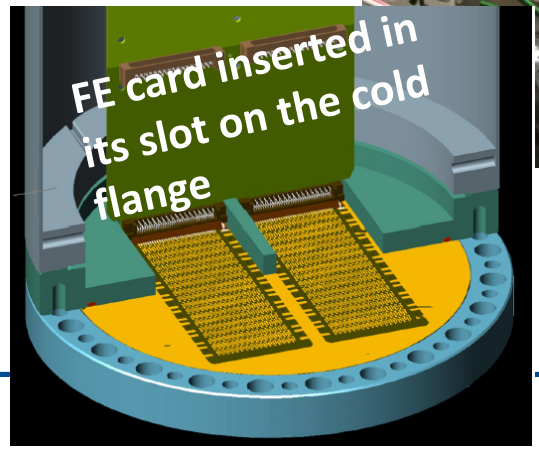
  (see also movie at: https://drive.google.com/file/d/16f2ADi4x-CpcNQltQHwR8ZUdAB4VtB1h/view)

Technical details
Including past discussion from DP which are valid for VD TOP Electronics

Cold FE electronics

- Each chimney hosts 10 cryogenic analog front-end amplifier cards
- The FE cards are mounted on 1.7 m long FR4 guides, “blades”, which allow for their insertion/extraction
- In principle, the SFT chimney installation should guarantee that there is already >1.7 m overhead clearance to allow for the blade insertion
- For the FE card installation on top of the cryostat warm structure:
  - Unbox the FE cards
  - Mount the cards on the blades (secured with 3 M4 screws to the blade)
  - Insert the blades into the SFT chimneys
  - Connect LV PS cables to warm SFT chimney flange after they have been lay out





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