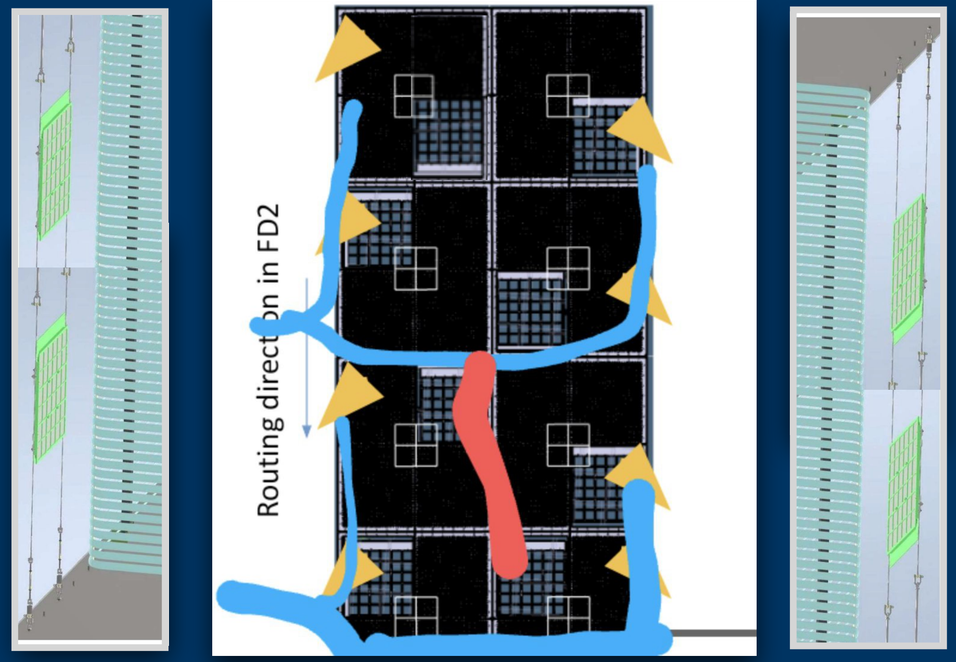
FD2 protoDUNE-VD PDS Installation Plan



(initial tentative, preliminary Plan)

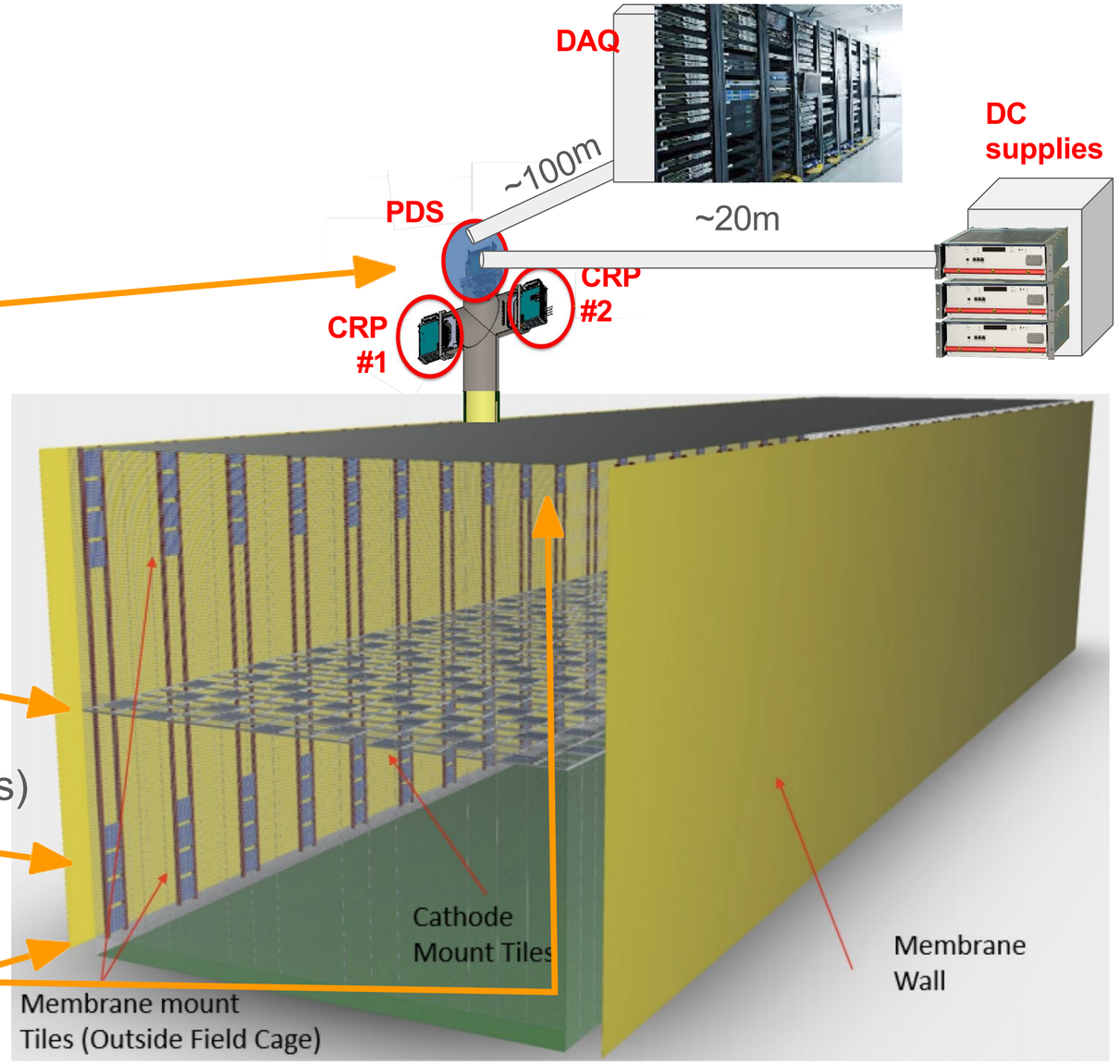
~~24 August 2022~~
Ryan Rivera -- DUNE FD2 PDS Level 2 Manager

Sept.7 2022 (protoDUNE-VD Integration mtg)
Flavio (slides prepared by Ryan + some updates)

Sept.9 2022
Flavio (slides revisited)

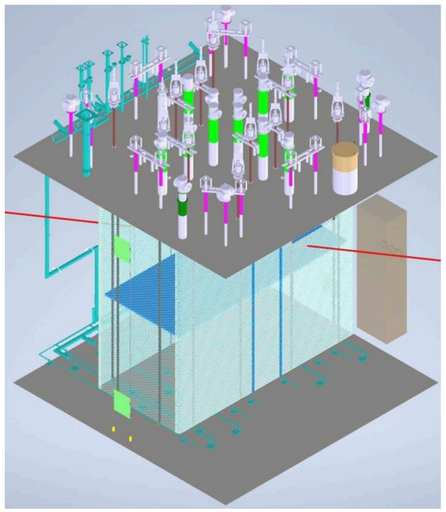
FD2 PDS Topology

- Warm electronics
  - 1280 digitizer channels (640 opto-electrical)
  - Cathode fiber power supplies
  - DC copper power supplies
  - Calibration source modules
- 320 Cathode modules
  - Each module has (up to) 8 fibers:
    - 2 signal-over-fiber channels out
    - 6 power, calibration, control, redundancy
- 320 + 32 Membrane modules (Long and Short sides)
  - Each module has 6 conductors:
    - 2 differential signal pairs
    - 1 low-voltage/return pair
- Response & Stability Monitoring light diffusers
  - 160 LED flasher fibers + diffusers
- 40 Penetrations
  - Each services 8 cathode modules + 8 membrane modules

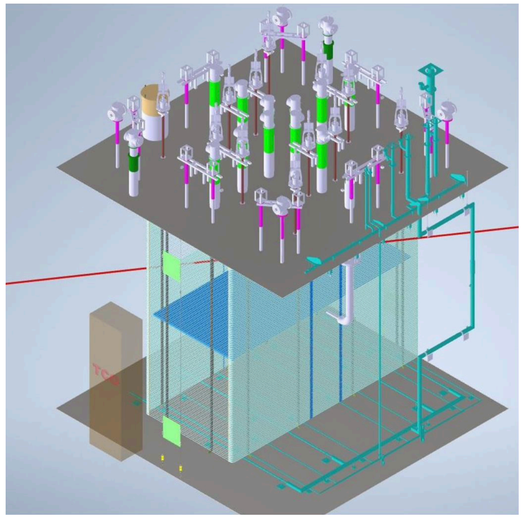


FD2 ProtoDUNE-VD PDS Topology

- 8 Cathode-mount XA modules
- *(up to)* 8 Membrane-mount XA modules
  - 2 columns, 4 XA per column (2 upper volume and 2 lower volume wrt Cathode).

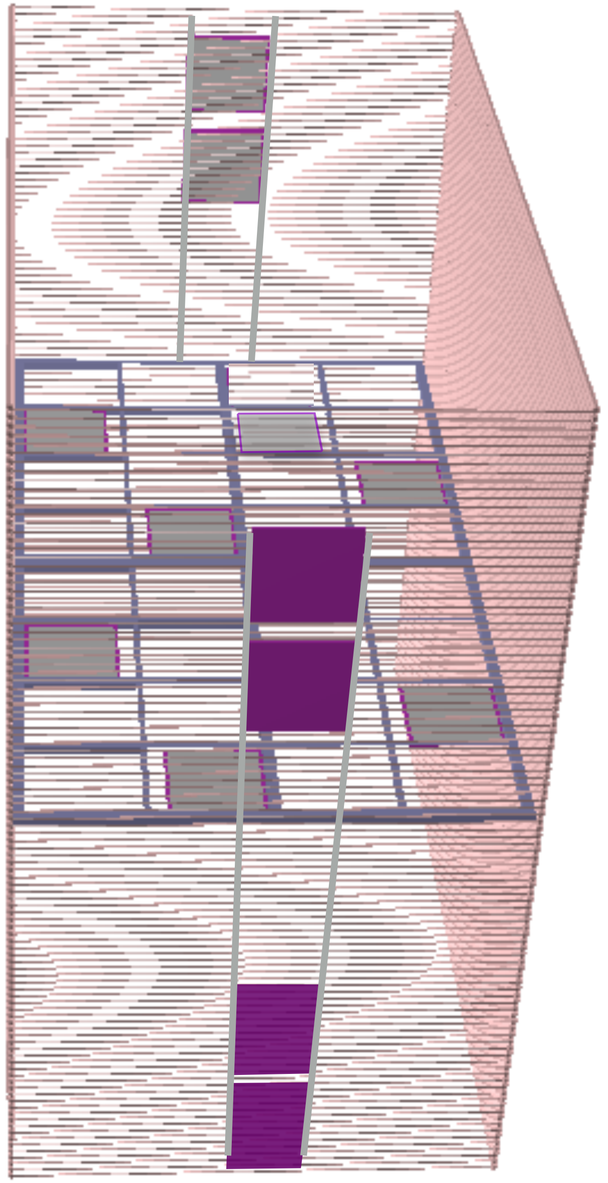


Far-side Membrane-mount installation



TCO-side Membrane-mount installation

Beam direction



Working Assumptions:

TCO closing by End of March 2023

LAr filling at the end of pDUNE-HD Module-0 run (fall 2023 ?)

FD2 protoDUNE-VD PDS Installation Steps

initial tentative, preliminary

start 1st of December

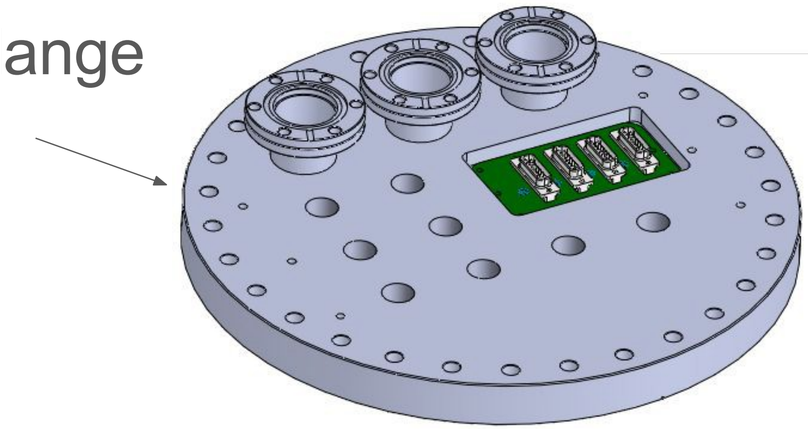
1. Initial (temporary) Warm electronics
2. Flange, feedthroughs, cables, fibers (prior to detector installation)
3. Far-side Membrane X-ARAPUCA column
4. Response & Monitoring System fibers/diffusers
5. Cathode X-ARAPUCA into cathode modules
6. Splice cathode fibers **AND** pull fibers up
7. TCO-side Membrane X-ARAPUCA column (to be confirmed)
8. Optimized Warm electronics

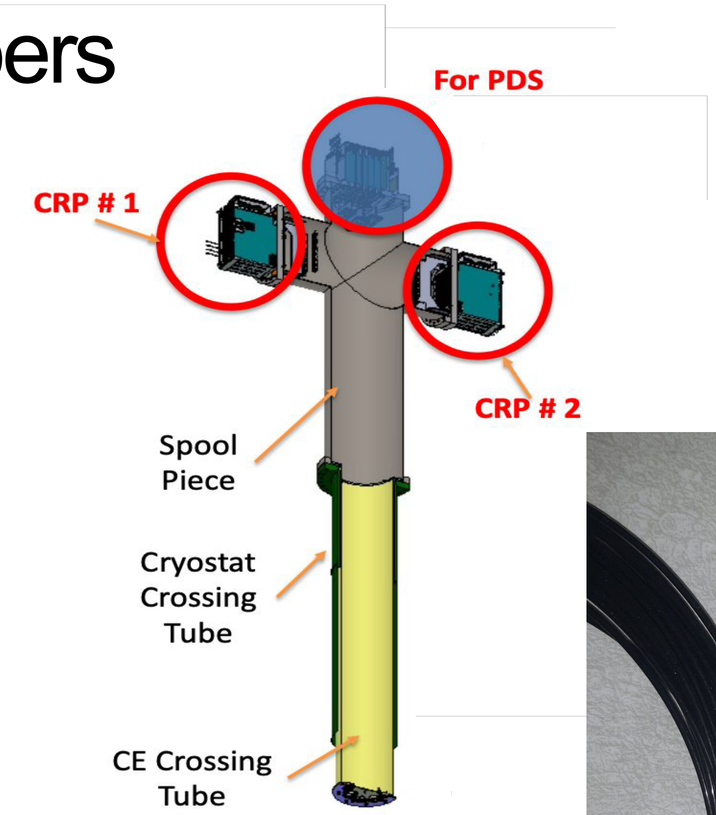
1. Initial Warm Electronics at protoDUNE-VD

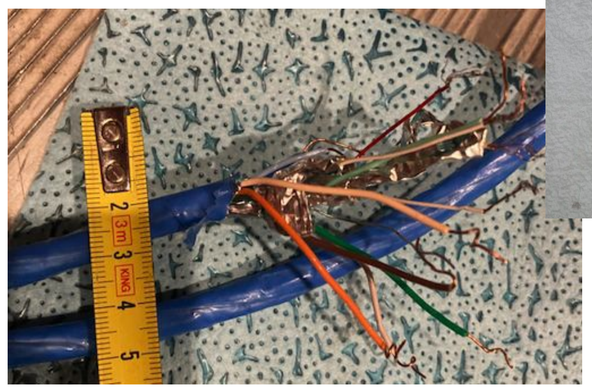
- Initial warm electronics installation is to support warm verification testing of X-ARAPUCA and Response & Monitoring installation
- Temporary PoF transmitter units
- Temporary digitizers/oscilloscope
- Minimal/limited DAQ integration
- Space:
  - Need (at least) 1 full-height (36U) rack near penetration

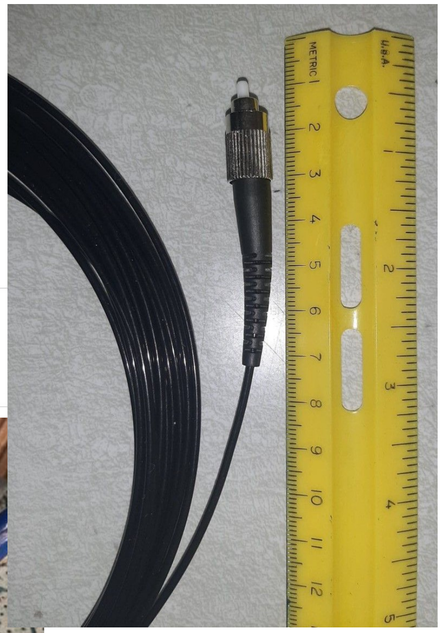
2. Flange, feedthroughs, cables, fibers

- Copper cables, ½ cathode fibers, and Response & Monitoring fibers can be dressed to cryostat (cable tray solution unknown, potentially use field-cage support structure)
- Declare other ½ cathode fiber space with septum
- Secure primary flange





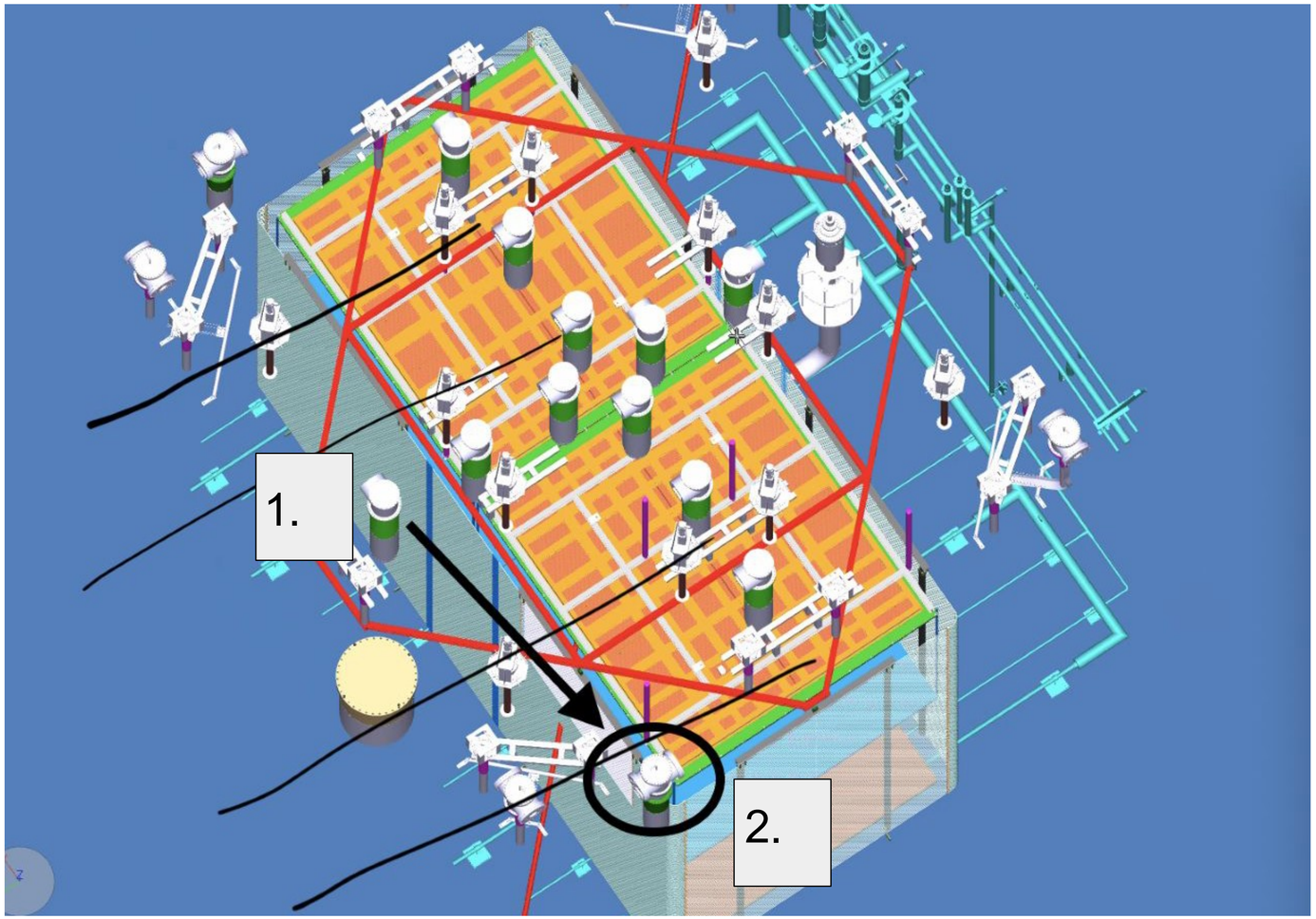




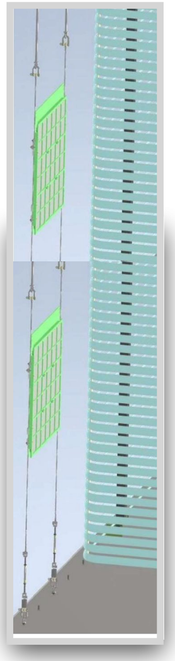
Which penetration?

1. Initial BDE-PDS penetration

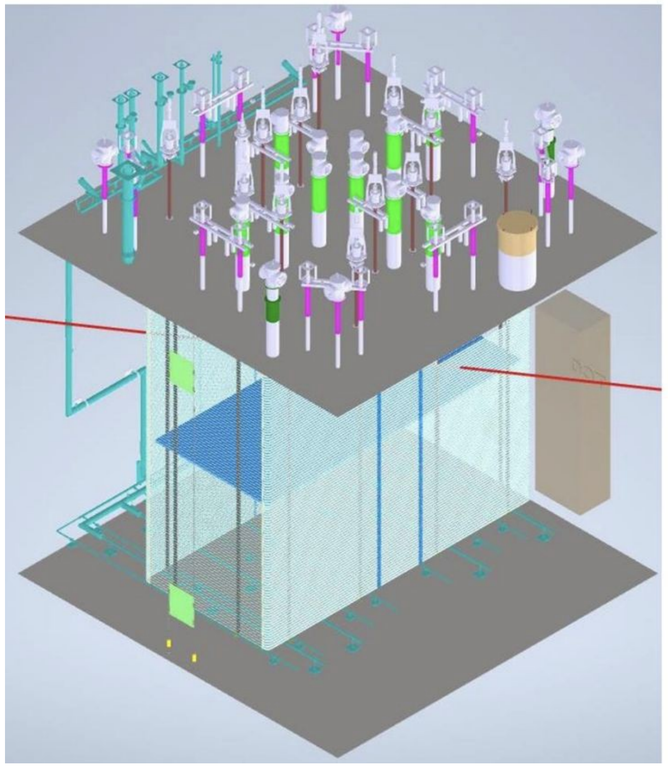
2. More similar to FD2 cable route (especially for BDE and TCO-membrane XA)?

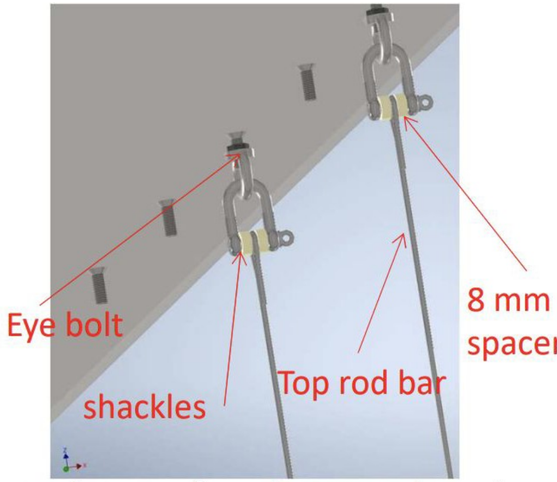


3. Far-side Membrane-mount X-ARAPUCA Column (“back”)

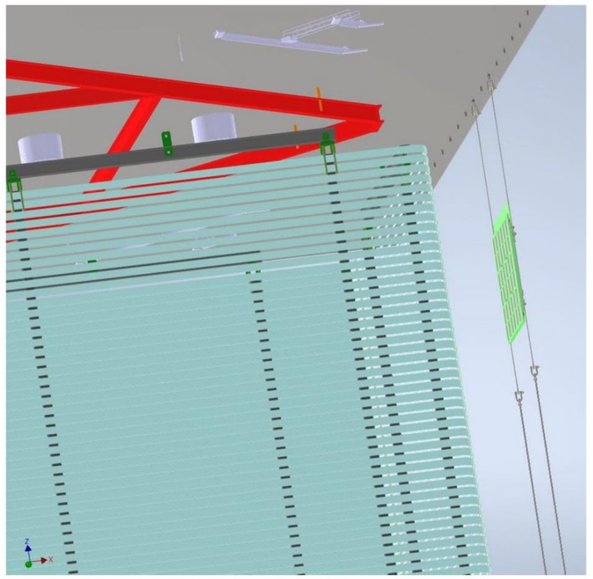


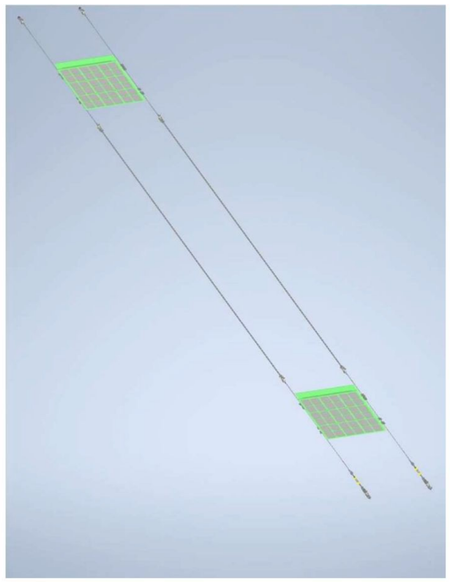
- Minimum column has 2 XA modules
- Ideally 4 XA in column from Spare or Cold Box prototypes (2 XA at top and 2 XA at bottom to represent FD2 one-cable-per-2XA topology)

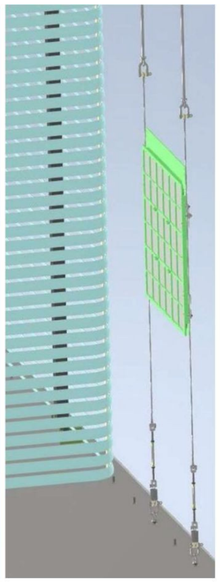




The tools to perform it are ready and tested. Several prototypes has beem produced.

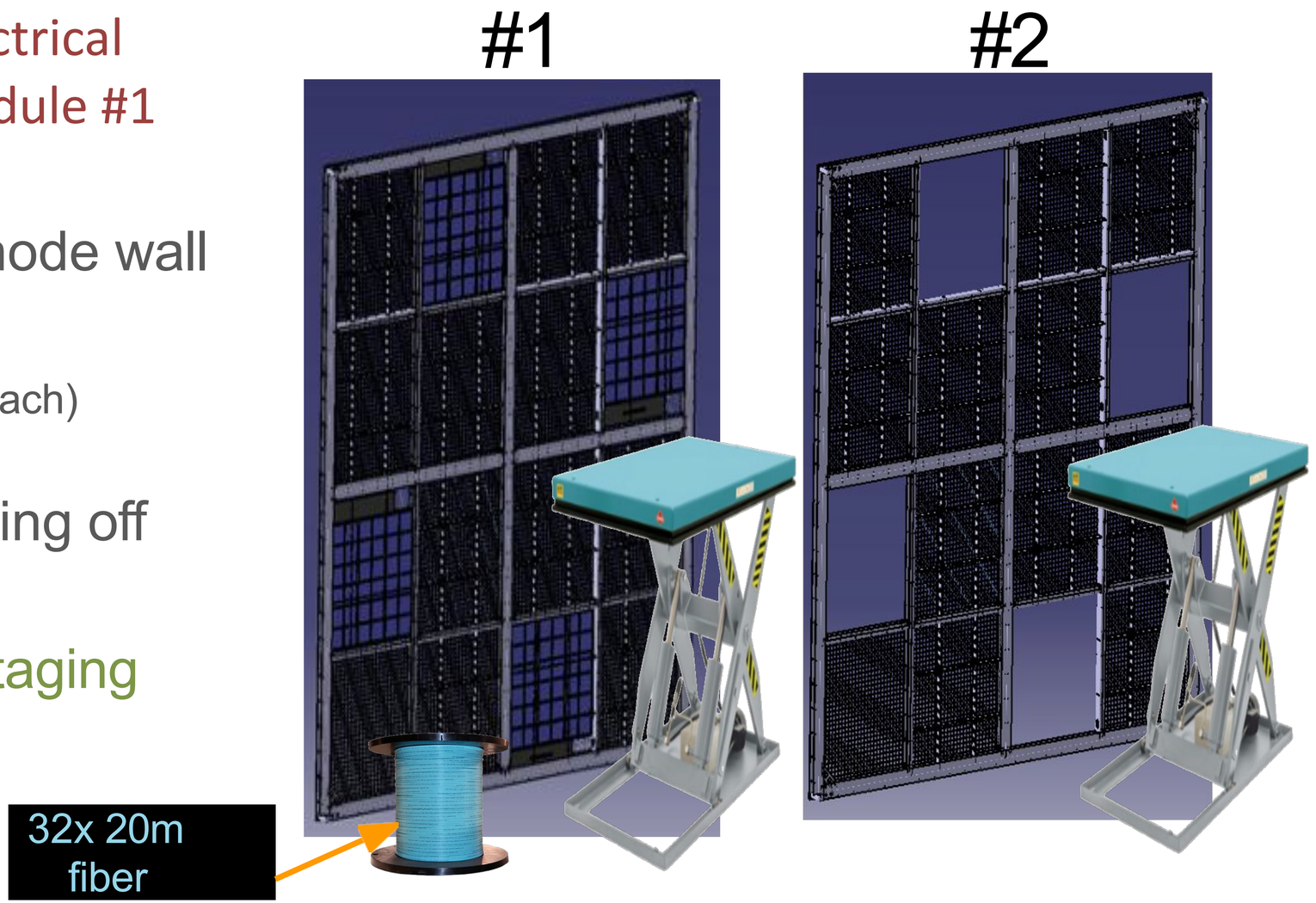






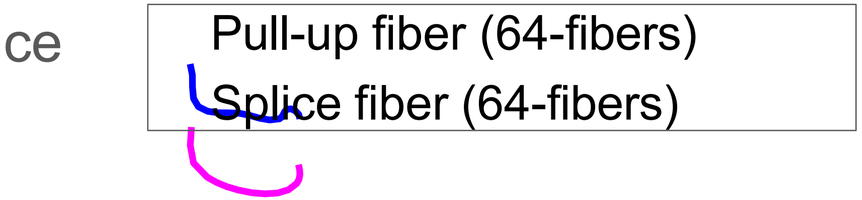
5. Cathode-mount X-ARAPUCAs into Cathode module #1 and #2

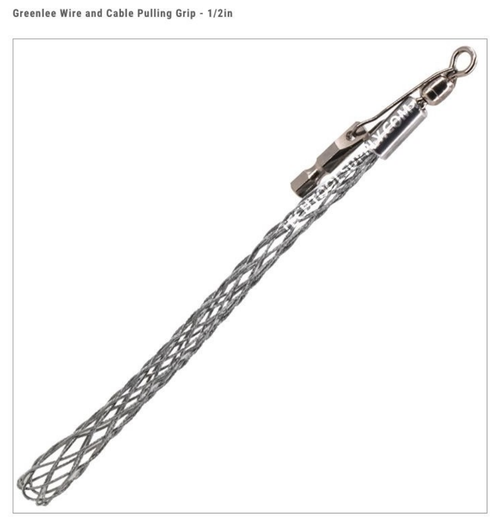
- xA layout, fiber routing and electrical connections are different in Module #1 and #2
- Assemble modules into cathode wall in staging area
  - 8 XA into two cathode modules (4 each)
- 32 x 20m fibers will be hanging off cathode module
- Warm class-4 laser test in staging area!

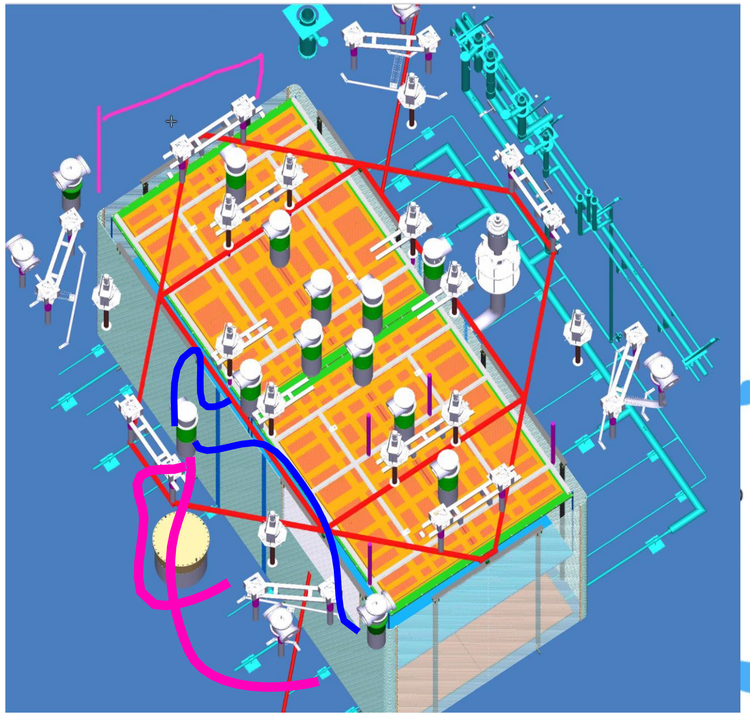


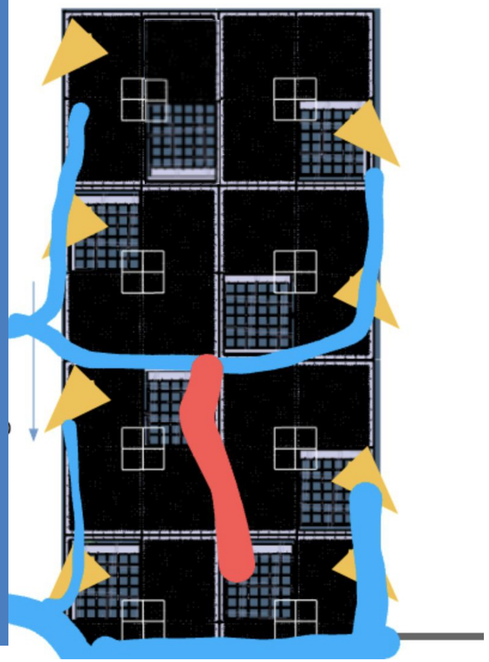
6. Splice cathode fibers AND pull fibers up

- Install double fiber plant to experience splice **AND** pull
- Splice spare fibers first
- If confident
  - Splice primary fibers
  - Pull-up cut off fiber ends for experience
- If not confident
  - Do not splice primary fibers
  - Pull-up primary fiber ends
- Final warm class-4 laser test in cryostat after fiber installation complete!



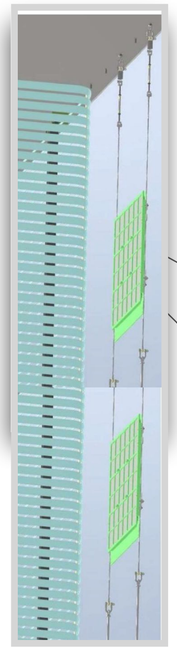


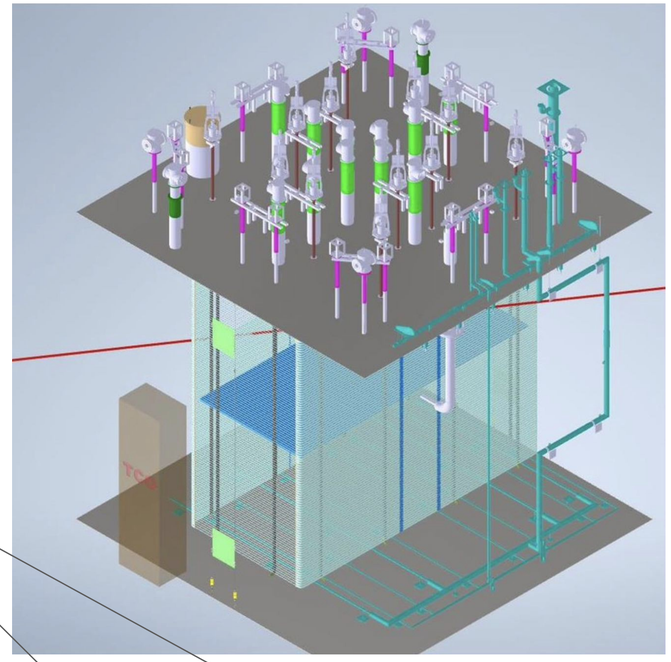


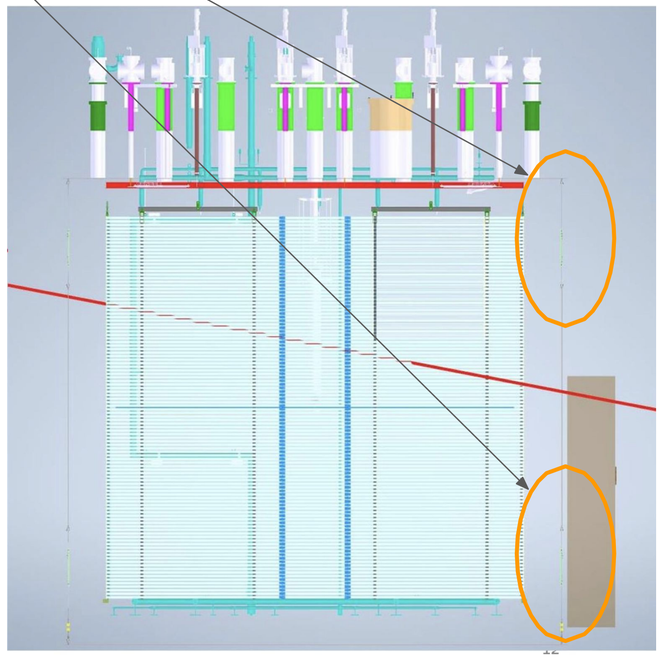


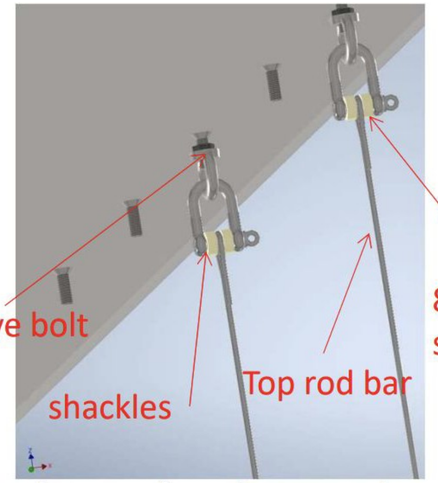
Electrical Connection in Cathode Module#2

7. TCO-side Membrane-mount X-ARAPUCA column “front)









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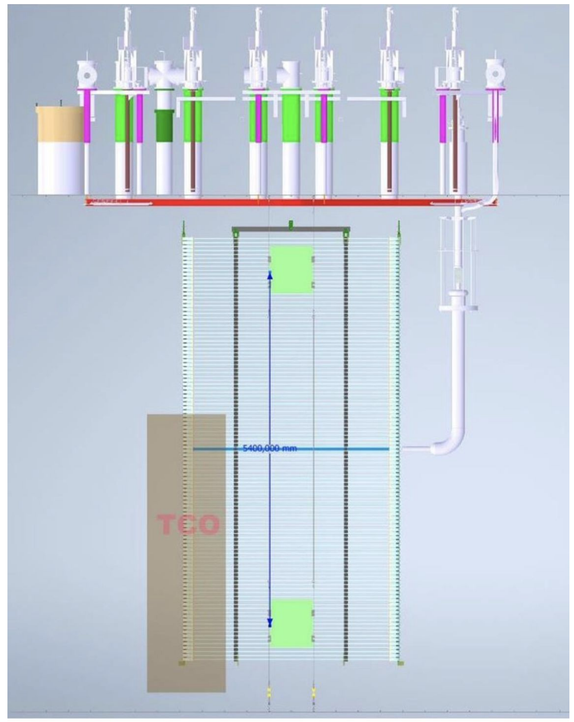
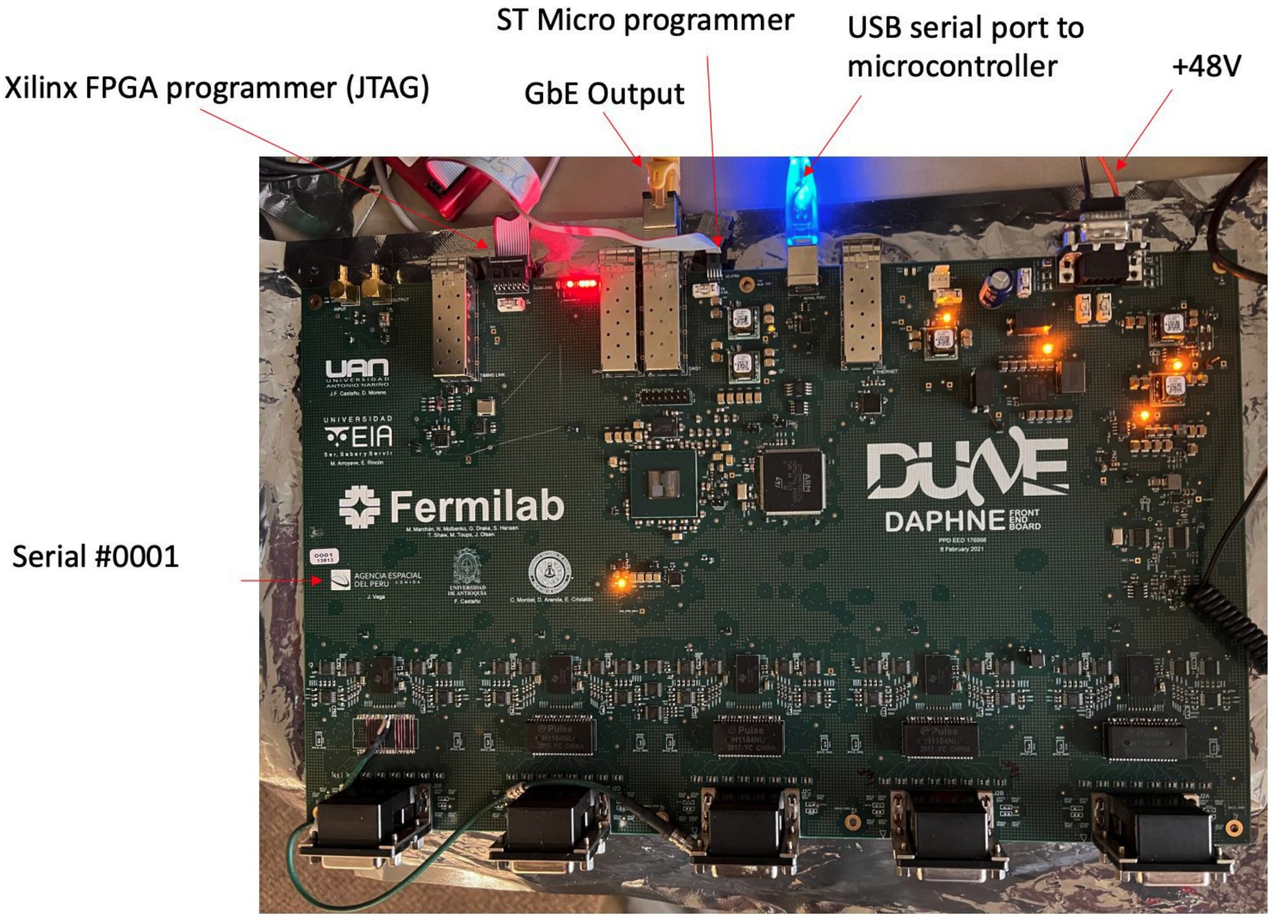


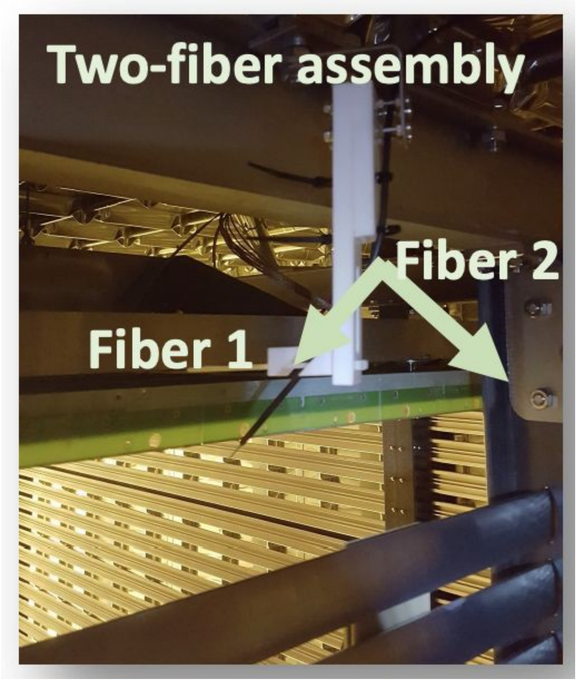
- Minimum column has 2 XA
- Ideally/Goal 4 XA in column from Spare or Cold Box prototypes (2 XA at top and 2 XA at bottom to represent FD2 one-cable-per-2XA topology)

8. Optimized Warm Electronics at module-0

- Optimized warm electronics installation allows for full DAQ integration
- Advanced PoF transmitter units
- DAPHNE digitizer

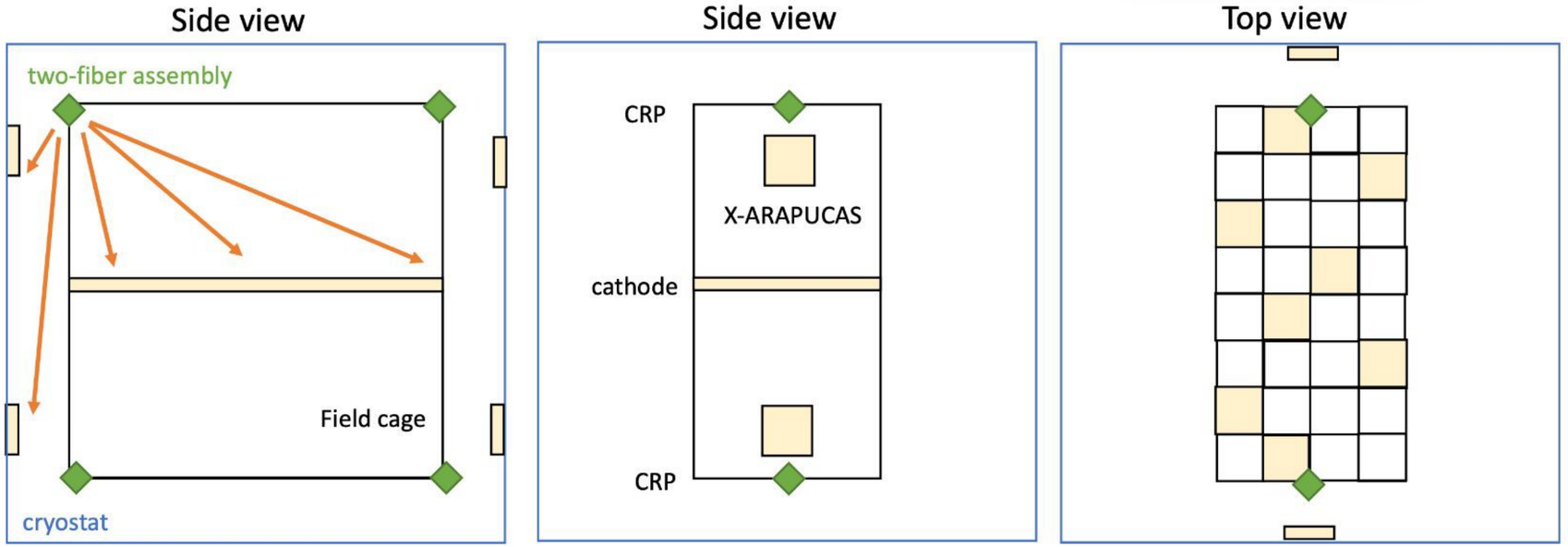


4. Response & Monitoring System fibers/diffusers



- 3 feedthroughs allow for 15 fibers; 3 flavors of fibers. Fibers mount to CRP superstructure.
- Goal is to compare approaches and characterize.

It's a redundant system, only 4 fibers should illuminate the whole system probing the extrapolation to DUNE FD2-VD.



tentative PDS Installation timeline

- **Cable trays**
  installed **November 2022**

- 4 **Membrane-mount XA**
  installed December 2022
  - One column on short-wall is being pushed from a mechanical perspective
    - This could have a significant interference with the instrumentation cabling or CALCI.
  - PD consortium would like to plan for two columns, one on each short-wall

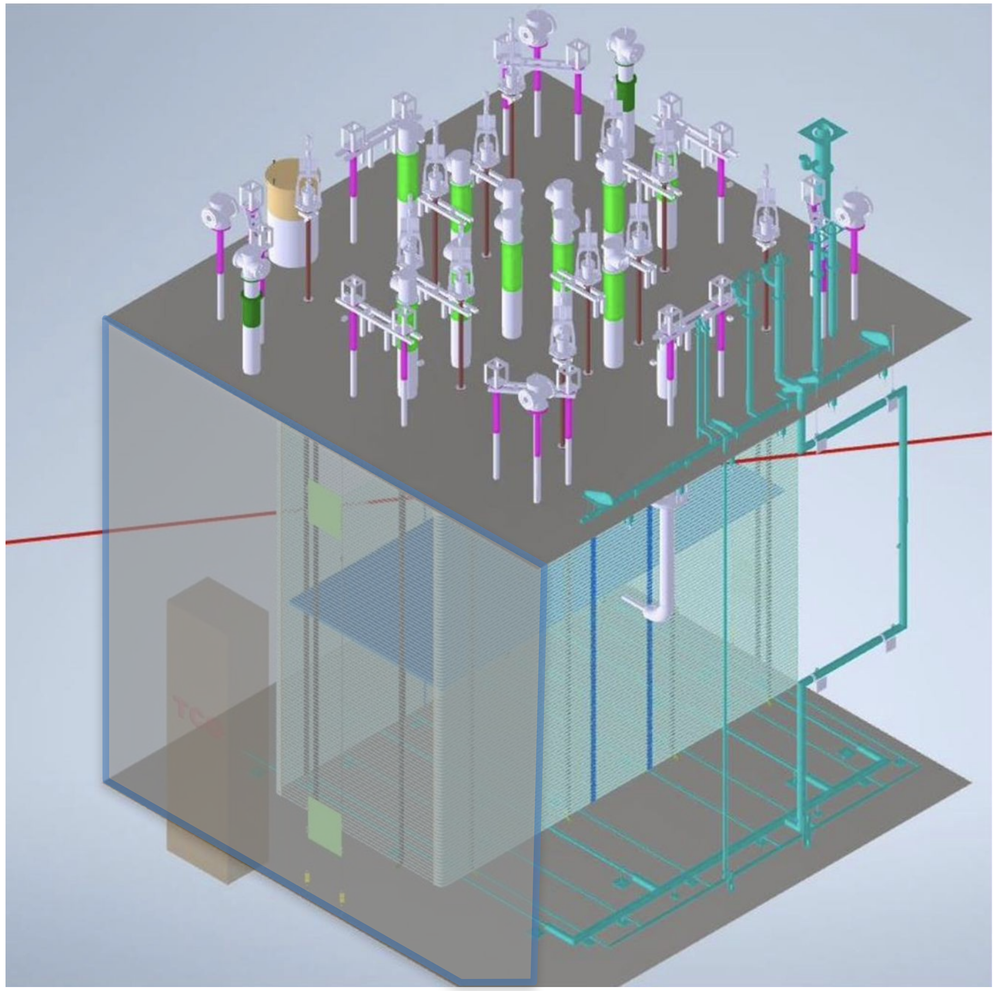
- 8 **Cathode-mount XA** installed **January** 2023

- **Response & Monitoring** installed **December** 2022 and **January** 2023
  - Attached to top CRP
  - Direct to XA

- 4 **Membrane-mount XA**
  installed February 2023
  - The 2nd column on TCO side

if possible

backward in time form Working Assumptions of TCO closing by End of March 2023



Side comments (my comments):

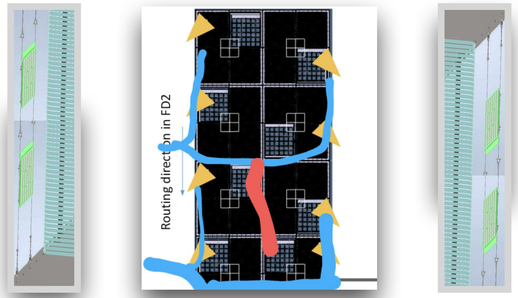
- procurement of some of the relevant detector components (SiPM, dichroic filters, WLS plates) and electronics components (PoF, SoF, CE parts, fibers) are on the critical path
- fabrication of the built in-house parts (xARAPUCA frames, printed circuits, WLS film deposition,..) is launched but can find delays in delivery (lack of available resources)
- assembly (where, who, ..) and test procedures (where, who, how) before installation have still to be defined, agreed and organized.
- installation in pDUNE-VD cryostat may hide still unknown mechanical constraints, interference with other system, yet unspecified time limitations or labor intense demands *[the overall installation plan by Neutrino Platform is at early stage]*
- schedule & plans for cryostat sealing after TCO closing, GAr purging, LAr filling, detector activation and run are largely undefined
- beam time, data taking program (and beam plug !) at placeholder stage.

All (or most of) this is the (expected) fall-out from moving pDUNE-VD at earlier times by 9 months within an already critical time schedule. Nonetheless, once agreed, we have to cope with this and turn it into success.

We have to build our own credible and affordable plan for procurement, fabrication, assembly of the PDS and negotiate with NP and other Consortia for installation in pDUNE-VD

We are transitioning from “ColdBox Mode” into “protoDUNE Mode”,
deliverables change from xARAPUCA modules (v.1, v.2, …) into

- *Cathode Module #1*
- *Cathode Module #2*
- *Membrane Column #Back*
- *Membrane Column #Front*



in tighter collaboration with our partners: Cathode Group - IJC Lab-Paris and Cryostat Group - CERN-NP

We need a step-up in internal organization:
Opportunities for PDS Consortium groups to take new responsibilities and/or strengthen their role.