

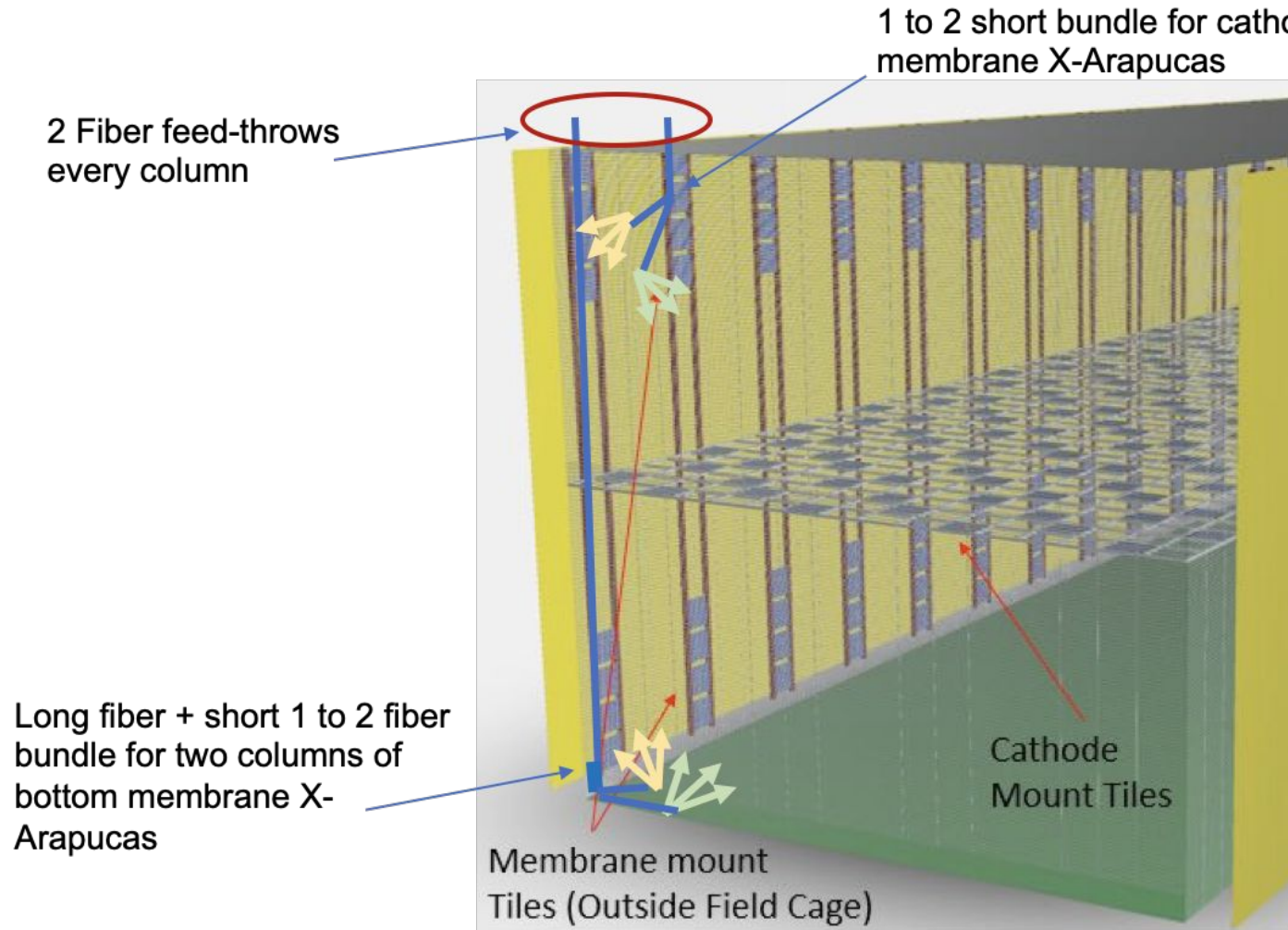
# ProtoDUNE-VD Light Response System

ProtoDUNE-VD PDS meeting

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# FD2-VD Design



- For every X-ARAPUCA membrane row (~every 3 m)
- Top fiber with a 1-to-2 fiber bundle pointing one fiber inside the cathode and the other one pointing towards the membrane X-ARAPUCAs.
  - One long fiber up to the bottom connected to a 1-to-2 fiber bundle with the same configuration for the top.

# FD2-VD required fiber and feedthroughs

## Assumptions:

- Top to bottom fiber: 16m (24m for end caps)
- 1 to 2 bottom fiber bundle: 2m
- 1 to 2 top fiber bundle: 7m

## Proposed configuration:

- **Length for bottom membrane X-Arapucas:** 40 single fiber (16m) + 44 bundles (2m) + 4 single fiber (24m) = 640m + 88 + 96 = 824m
- **Length for top membrane and cathode X-Arapucas:** 44 x 1 to 2 bundles (7m) : 44 x 2 x 7m = 616m
- **Total fiber length required:** **1440 m (aprox)**
- **Total Required feedthroughs:** **88** (2/flange, 3/flange near end-caps)

## Single fiber to each point:

- **Length for bottom membrane X-Arapucas:** 88 single fiber (18m) = 1584m
- **Length for top membrane X-Arapucas and cathode X-Arapucas :** 88 single fiber (7m) = 616m
- **Total fiber length required:** **2200m (aprox)**
- **Total Required feedthroughs:** **176** (4/flange, 6/flange near end-caps)

# FD2-VD cold fiber down-selection

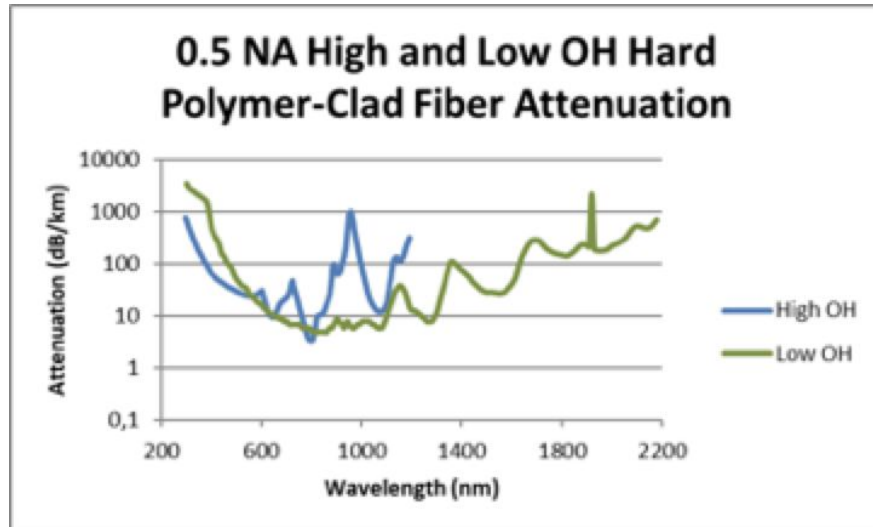
## 1) From ProtoDUNE-DP:

- 4 x 22.5m – FT800UMT – Stainless steel cover
- 2 x 7 to 1 bundles FT200UMT – Black plastic cover

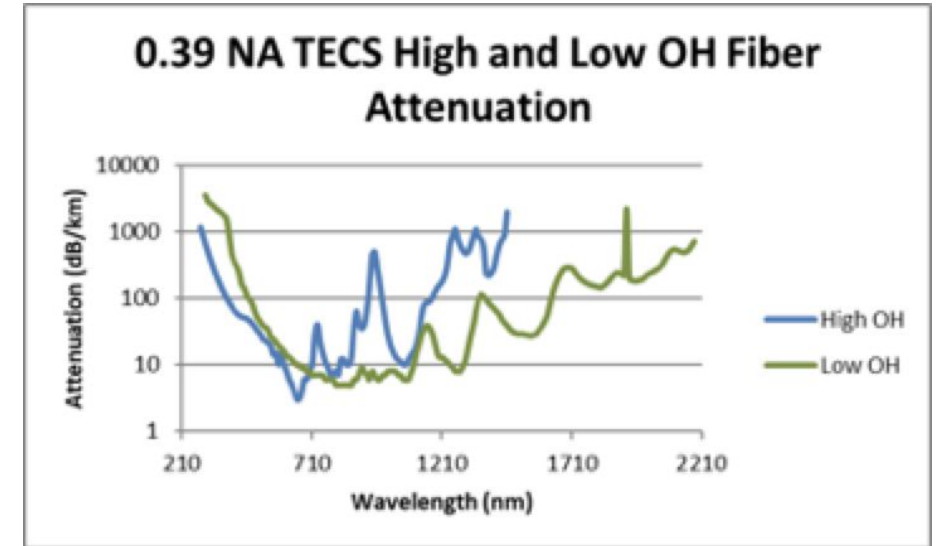
**Discarded**

Attenuation: 1174 dB/km @ 280 nm and 635 dB/km @ 300 nm

In addition, we measured an increase of 36 dB/km @ 465 nm in LN<sub>2</sub>, at 275 nm?



**FPxxxURT**



**FTxxxUMT**

- 2) The FTxxxUMT are similar to the FP600URT proposed by Zelimir:  
Attenuation: 766 dB/km @ 298 nm (lowest value provided by Thorlabs)  
Price: 8€/m, also similar to FT600UMT (7.7€/m).

**Discarded**

# FD2-VD cold fiber down-selection

## 3) Fiber currently used on ProtoDUNE-SP: FVP600660710

- Attenuation: Transmission below 300 nm, att @ 275 nm  $\approx$  200dB/km
- Tested both FDP, FVP in the past. Continued to use FDP for feedthrough, electronics module fibers.
- No observed degradation at 275 nm. Will repeat the test.

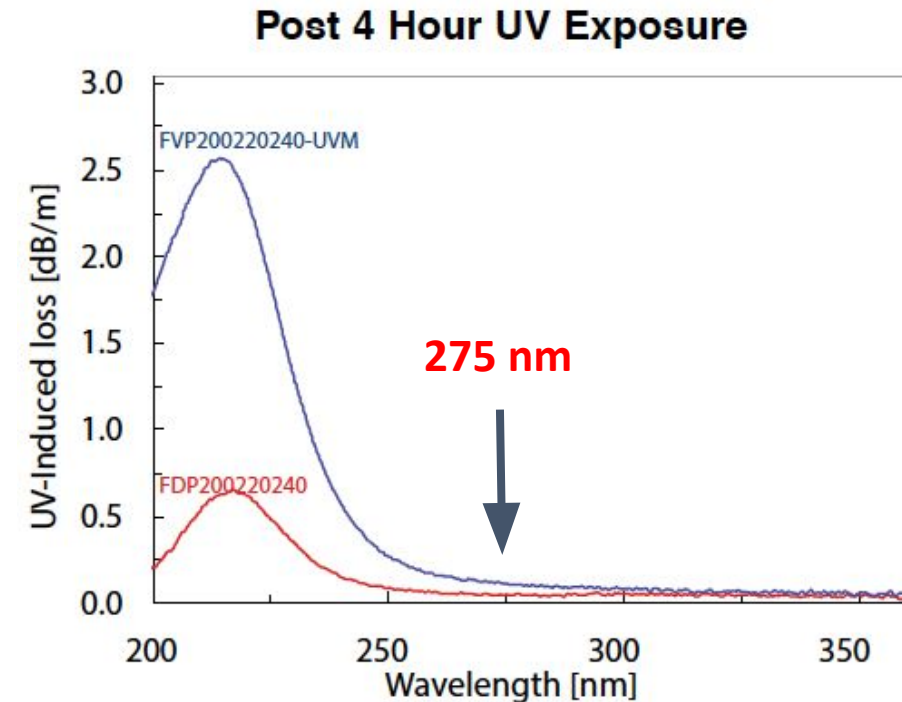
**FVP less favored for 20-year operation, will also test FDP (assuming sample in hand on time).**

In general FVPXXX susceptible to solarization damage over long exposures for a short wavelength, FDPXXX more solarization resistant.

### Specifications

Fiber Type	Wavelength Range	Characteristics	Cost
FVP	240-850nm	<ul style="list-style-type: none"> <li>• Economical</li> <li>• High solarization</li> <li>• Damage below 240nm</li> <li>• Minimal solarization recovery</li> <li>• All sizes available</li> <li>• Alternate coatings available</li> </ul>	Very Low
FVP-UVM	230 +/- 10 $\mu$ m	<ul style="list-style-type: none"> <li>• Moderate solarization damage</li> <li>• Minimal solarization recovery</li> <li>• All sizes available</li> <li>• Alternate coatings available</li> </ul>	Low
FVP-UVMI	500 +/- 30 $\mu$ m	<ul style="list-style-type: none"> <li>• Very small solarization damage diameter and temperature dependent</li> <li>• Degradation with time</li> <li>• Only larger diameters recommended (&gt;400<math>\mu</math>m)</li> <li>• Refrigeration recommended when not in use</li> <li>• Reverts to fvp-uvm over time</li> <li>• Available with polyimide coating only</li> </ul>	Moderate
FDP	$\leq$ 5 $\mu$ m	<ul style="list-style-type: none"> <li>• Small solarization damage</li> <li>• Minimal solarization recovery</li> <li>• No shelf life issues</li> <li>• Diameters 100<math>\mu</math>m to 600<math>\mu</math>m available</li> <li>• Available with polyimide coating only</li> </ul>	Moderate

\*The end manufacturer is responsible for bio-compatibility and sterilization testing and validation studies.



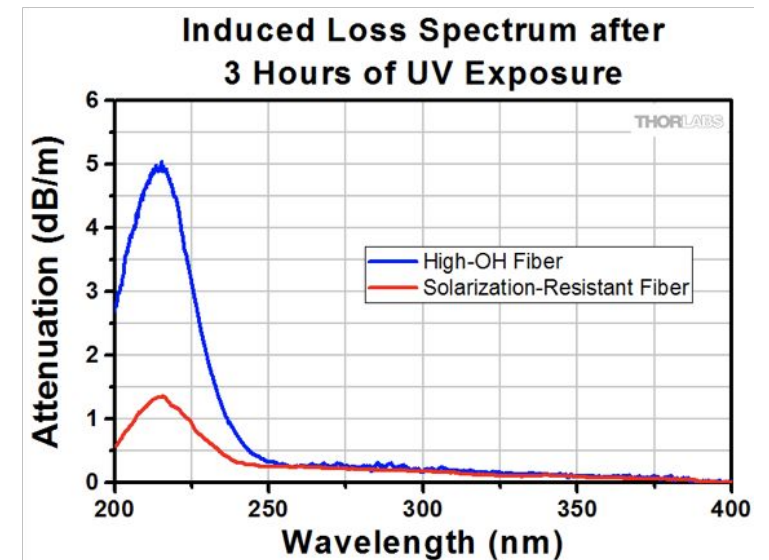
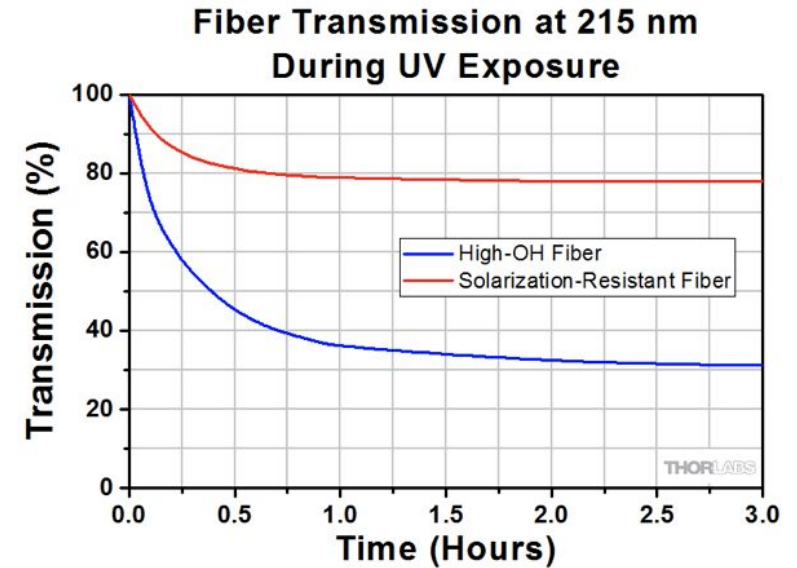
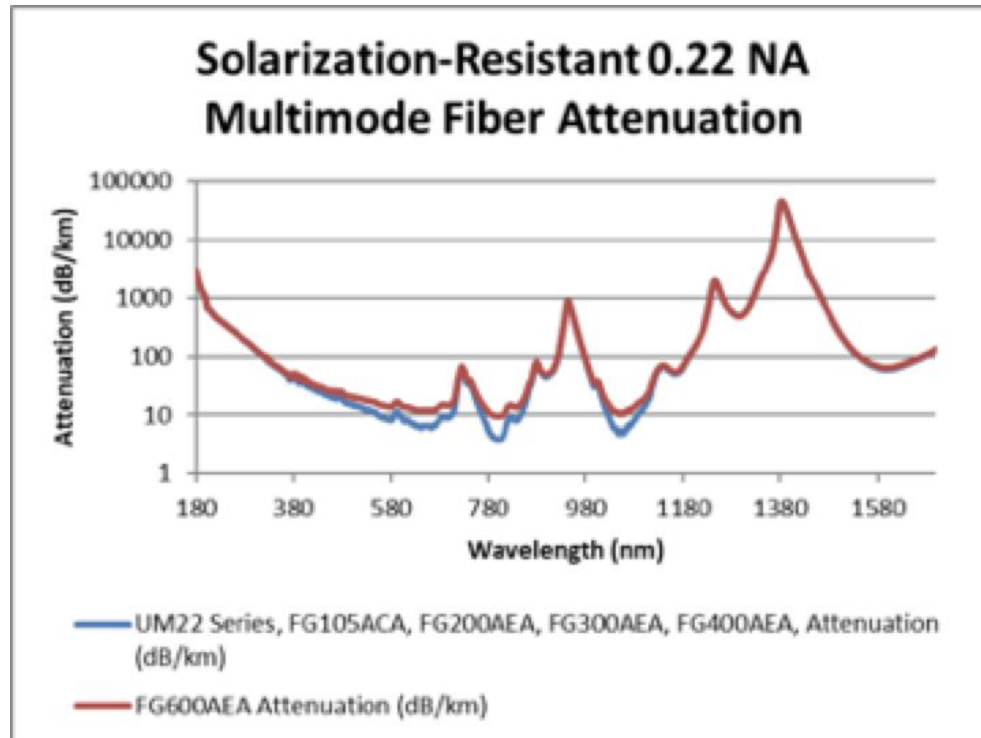
# FD2-VD cold fiber down-selection

## 4) Better fibers at 275 nm: FGxxxAEA

Selected

- Transmission from 180nm and solarization resistant.
- Solarization Resistance is required to monitor the aging of the X-Arapuca
- FG600AEA already tested in LN2 at CIEMAT and no additional attenuation was observed
- Att = 202 dB/Km @ 275nm  $\approx$  6 times lower than the other fibers

UM22 Series,  
FG105ACA,  
FGxxxAEA

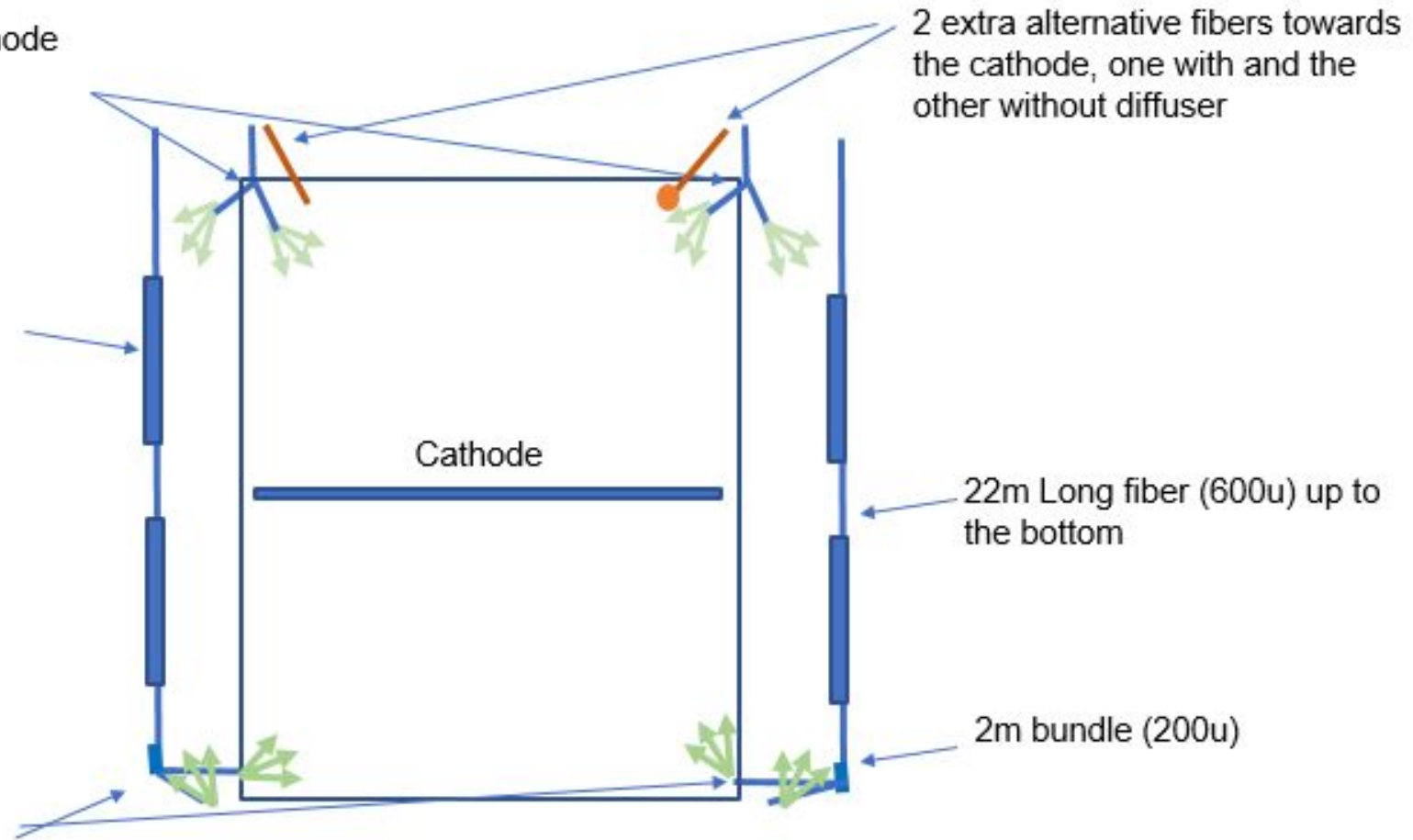


# ProtoDUNE-VD

1 to 2 (200u) fiber bundle for cathode and top membrane X-Arapucas

Membrane X-Arapucas

Long fiber (400u) + 1 to 2 fiber bundle (200u), both solarization resistant fibers.



# Flange feedthroughs

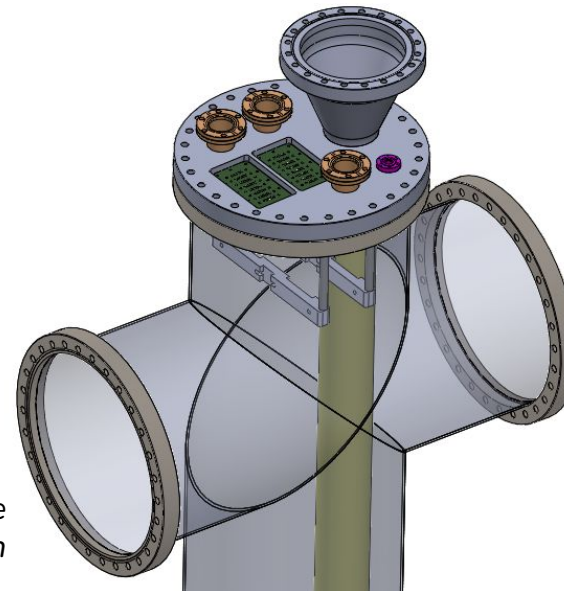
- Flange feedthroughs at new penetration:
  - o 1x CF-40 with 3 SMA feedthroughs vacuum compatible, available at CERN from ProtoDUNE-DP.
    - 1 top bundle
    - 1 bottom fiber
  - o 1x CF-75 5 SMA feedthrough UH vacuum compatible + 2 matting sleeves, FDP compatible
    - 1 top bundle
    - 1 bottom fiber
    - 1 alternative w/o diffuser
    - 1 alternative w diffuser



ProtoDUNE-DP flange feedthroughs



CF-40



ProtoDUNE-VD Optical flange and feedthrough

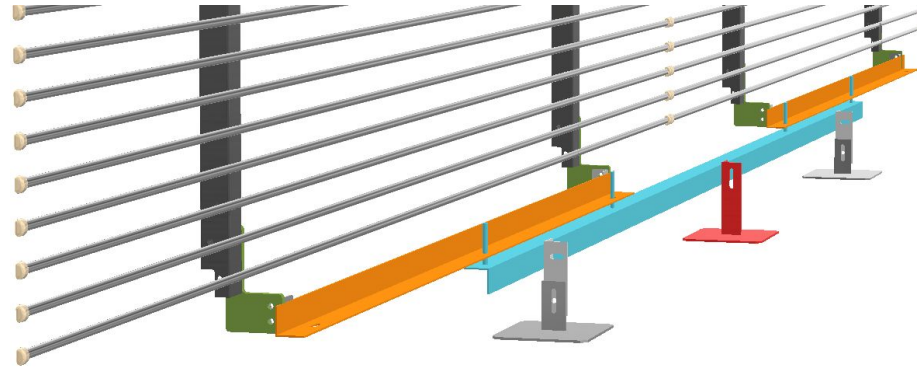
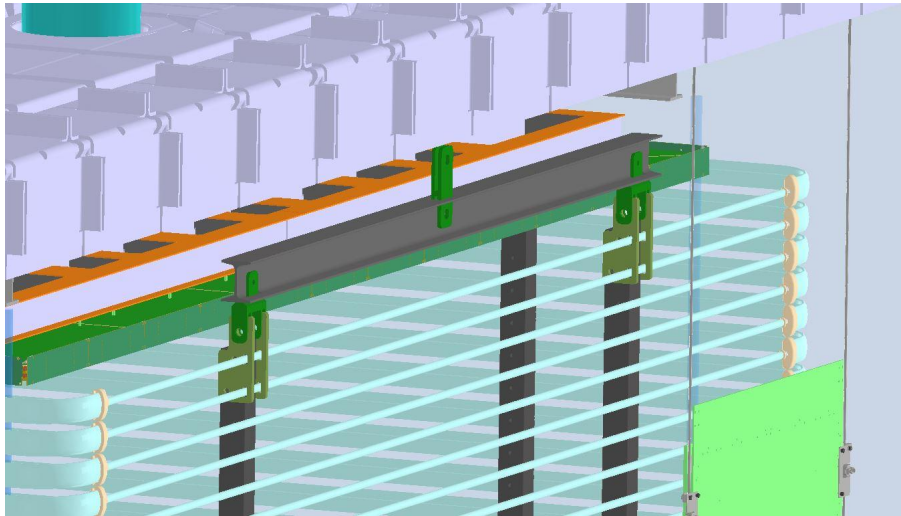


CF-75



# Holders

- Top: at top FC support beams that are metal, and grounded.
- Bottom: at the metallic stabilizer system at the bottom of the field cage. Need 3D design for ProtoDUNE-VD.



# Cold fibers

- Need them ready for installation in Nov. 28th - Dec. 9th
- Possibility to install later other light points, but not access to the top field-cage center.
- Need to reproduce FD installation procedure.

X-ARAPUCAS illuminated	Flange feedtru	Amount	Fiber specifications	Fiber length	Mechanical holder	Diffusers
<b>Top</b>	1x CF-40 1x CF-75	2 bundles 1-to-2	FG200AEA black cover	16 m	Top beam	1 w + 3 w/o
<b>Bottom</b>	1x CF-40 1x CF-75	2 fibers + 2 bundles 1-to-2	FG400AEA FG200AEA bundle black cover	22 m fiber + 2m bundle	Bottom beam	4 w/o
<b>Top (alternative)</b>	2x CF-75	2 fibers	FDP black cover	16 m	Top beam	1 w + 1 w/o

Back-up

# Responsibilities

Item	Optimization /Down-selection	M&S	Design Modification Labor	Acceptance Testing and Quality Control	Install NP02 Labor	Install SURF Labor
Warm Tx Box	Joint	ANL/SDSMT	ANL/SDSMT	ANL/SDSMT	ANL/SDSMT	ANL/SDSMT
Warm Fibers/Conduit	Joint	ANL/SDSMT	ANL/SDSMT	ANL/SDSMT	ANL/SDSMT	ANL/SDSMT
Flange/Feedthrough	Joint	ANL/SDSMT	ANL/SDSMT	ANL/SDSMT	ANL/CIEMAT/SDSMT	ANL/CIEMAT/SDSMT
Cold Fibers/Diffusers	Joint	CIEMAT	CIEMAT	CIEMAT	CIEMAT	CIEMAT
Cold Mechanical Infrastructure	Joint	CIEMAT	CIEMAT	CIEMAT	CIEMAT	CIEMAT