



Ciemat Centro de Investigaciones
Energéticas, Medioambientales
y Tecnológicas



Membrane PD Modules:

Ciemat proposal

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on behalf of the Ciemat Neutrino group.

2022 May 24

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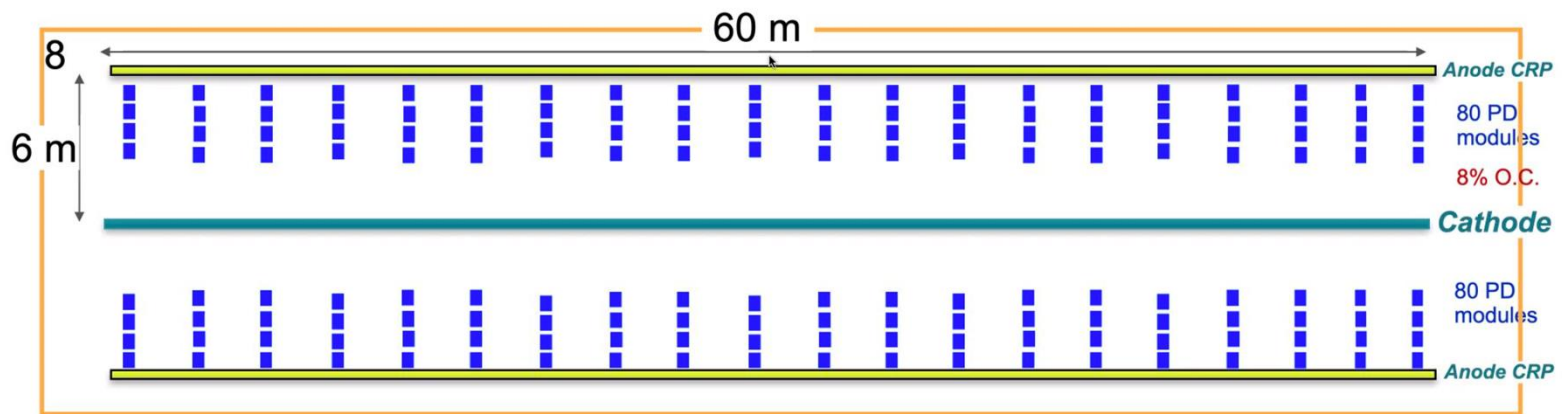
- 1.- Possible configurations of the PD modules on the membrane.
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1.- Possible configuration of the PD modules on the membrane:

Final configuration of the PD modules on the membrane is still being studied by the PDS sim./reco. group, in order to maximize the light yield and uniformity of the response within the volume. But the most likely options are:

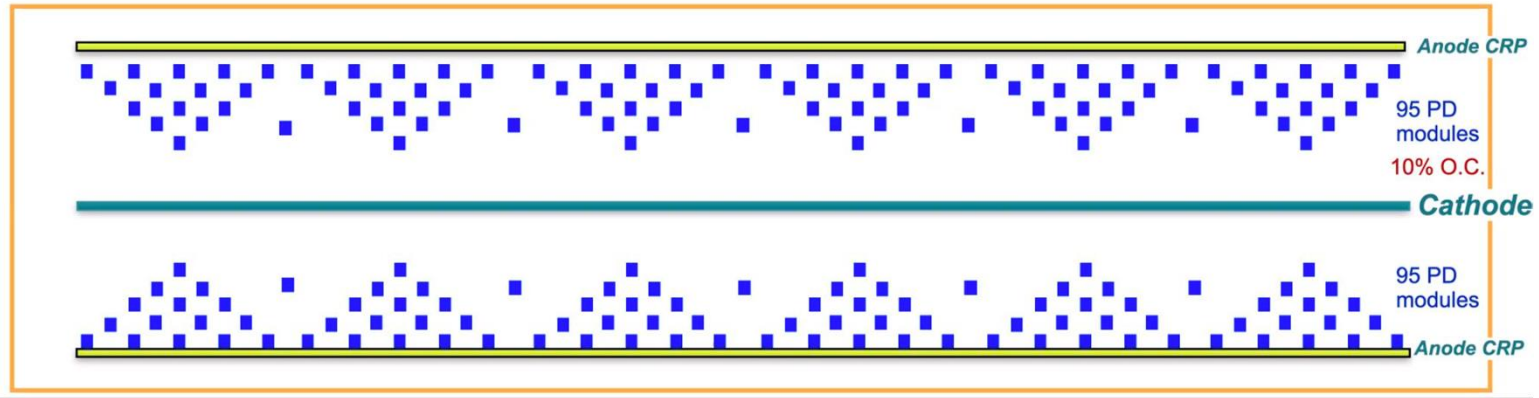
A option:

20 column of 8 PD modules by side:
320 PD modules on the membranes.



B option:


59 column of (2, 4 or 6) PD modules by side:
380 PD modules on the membranes.

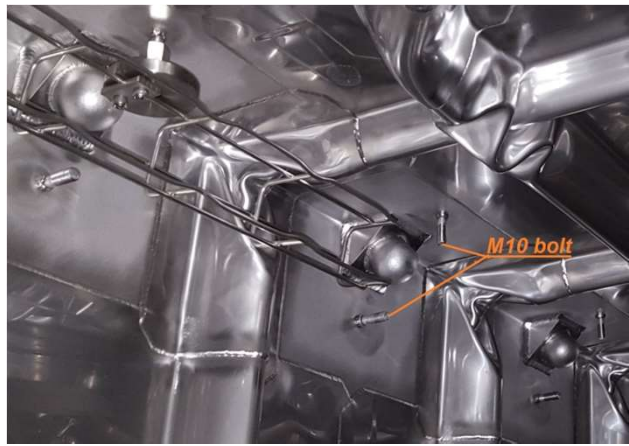
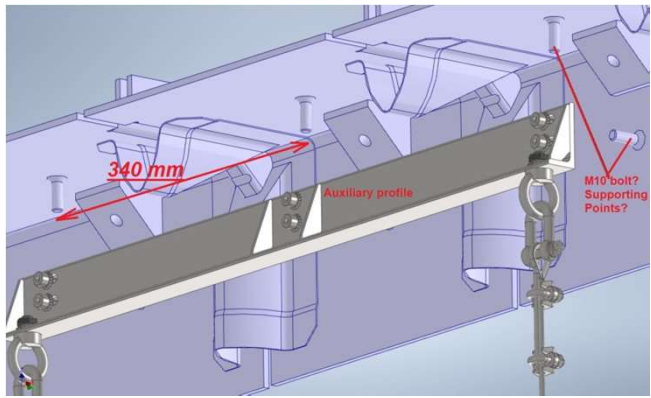


2.- Fixation system of the PD modules on the membrane:

Modular system fixed on the top and bottom sides of the membranes, on the *M10 bolt of the corners*.

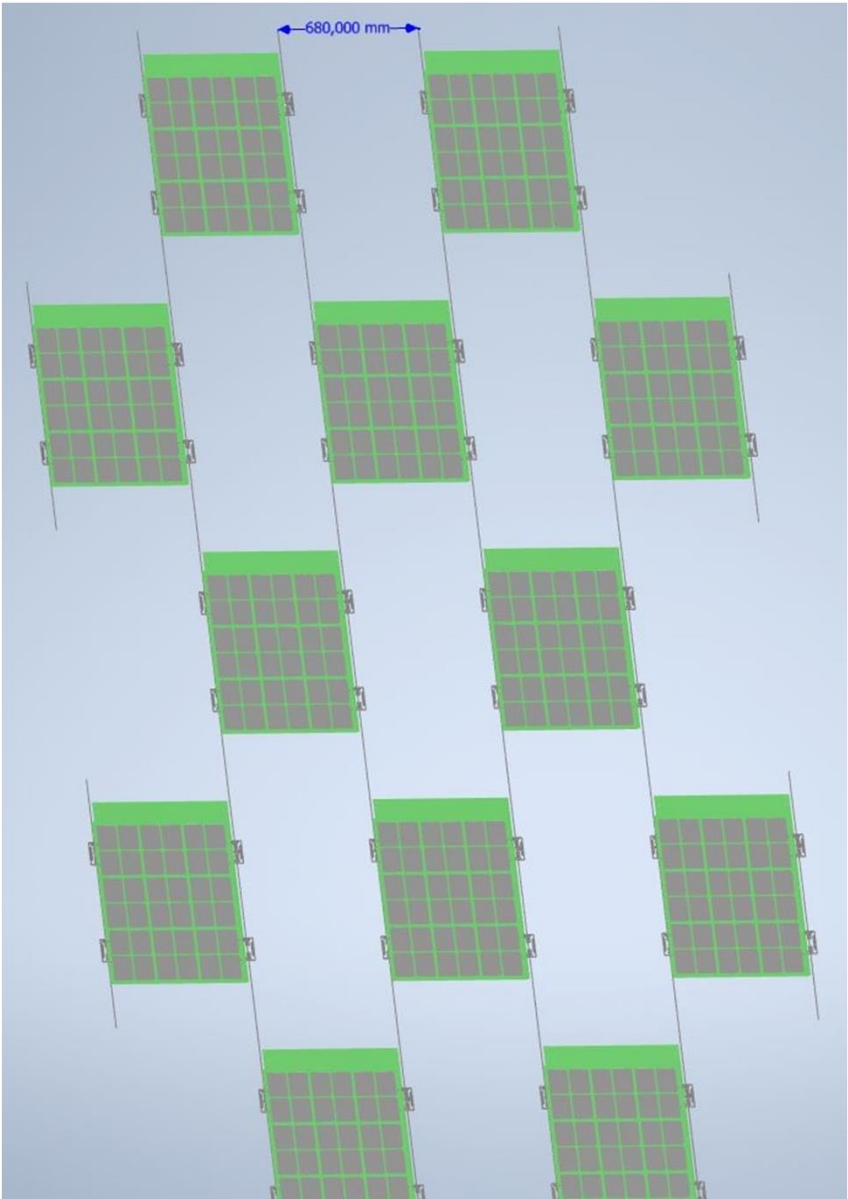
Main parameter supposed:

- Pieces and cables are Stainless steel (AISI 304 or AISI 304L or AISI 316)
- Minimum step between bolt are 340 mm (Option showed: columns separated 680, 1020, 1360)
- Install two vertical stainless steel cables of 5 mm diameter (7x7+0, configuration)  to support each PD module column.
- Pre-tensioned cables (15-20 kg)
- PD modules can be installed at the desired positions along the cables, placing *Wire Rope Grip*.
- Both top and bottom corner are free, but if there are elements along the corner (for ex. Big cables trays), and if will be not possible fix the cables directly to the M10 bolt of the corner, am '*auxiliary profile*' could be used and am '*intermediate piece*' should be defined between M10 bolt and auxiliary profiles.



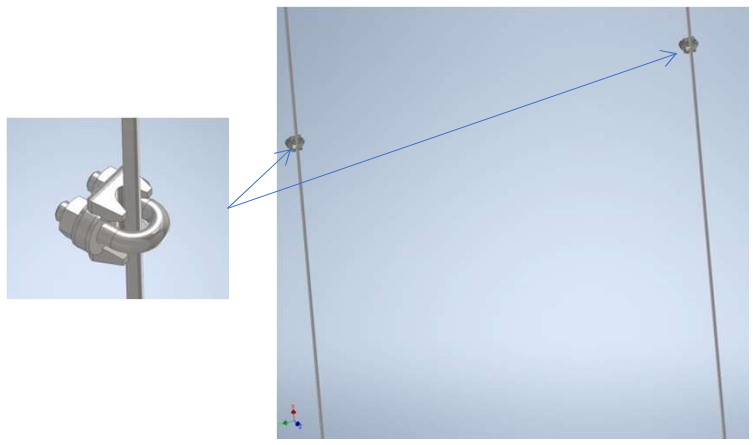
2.1.- PD modules fixation along the cables.

Minimum possible distance between lines: 680 mm

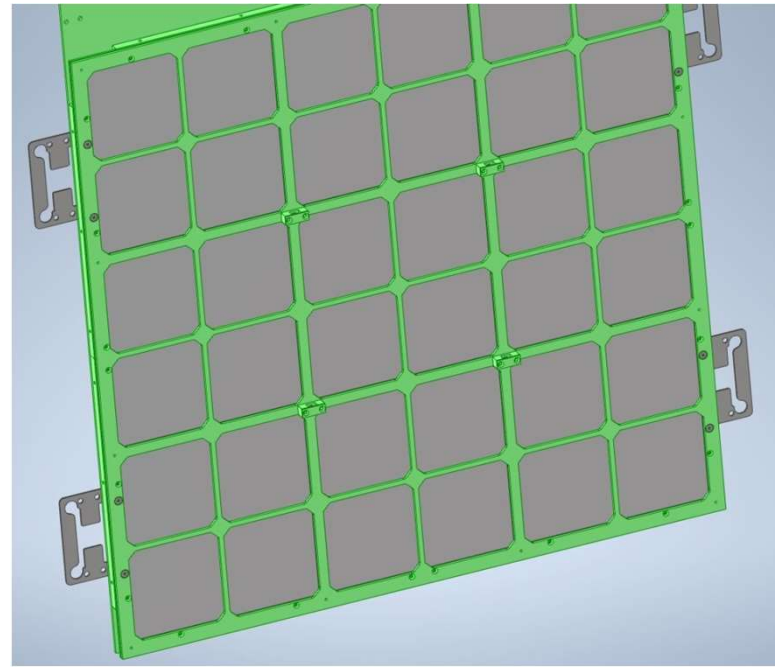
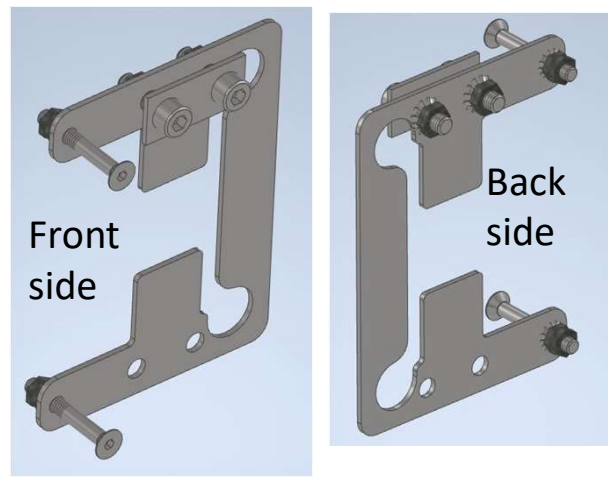


2.1.- PD modules fixation along the cables.

Each *PD module column* have two '*Wire Rope Grip*' pre-positioned along the 5 mm diameter cables to support each PD module:

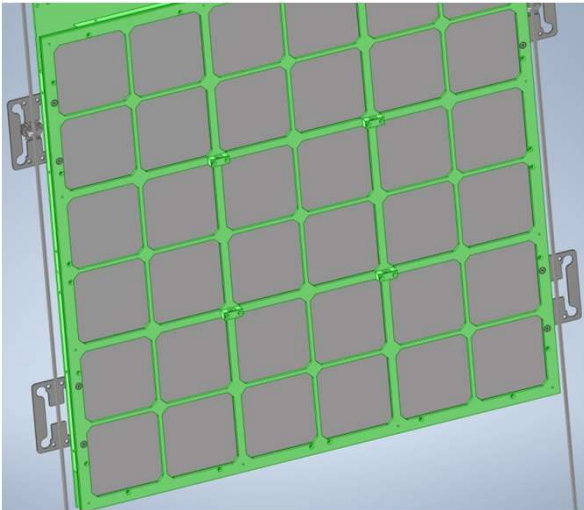
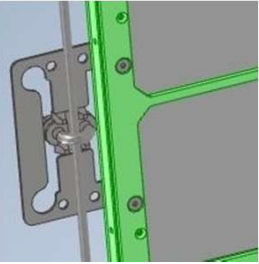


Each *PD module* have four '*fixation points*':
The two top fixation points will be inserted to the two '*Wire Rope Grip*' pre-positioned along the cables.
The fixation point are fixed to the PD module by M4 bolt.

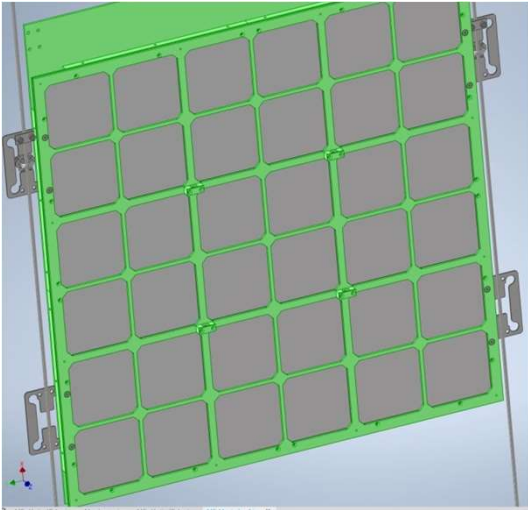
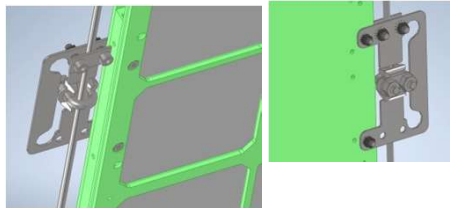


2.1.- PD modules fixation along the cables. The installation sequence :

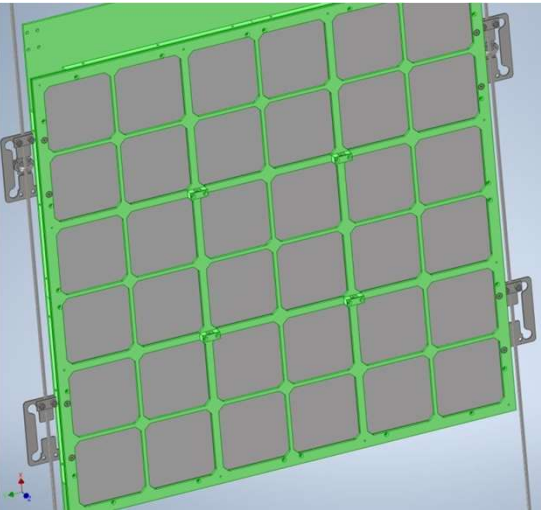
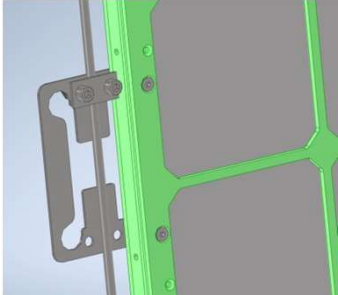
Step 1: Insert the PD module in the two 'Wire Rope Grip' pre-positioned along the column cables.



Step 2: Attach the two top fixation point of the PD module by two M5 bolts.



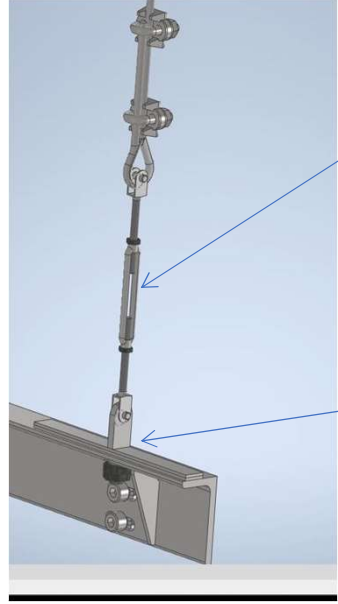
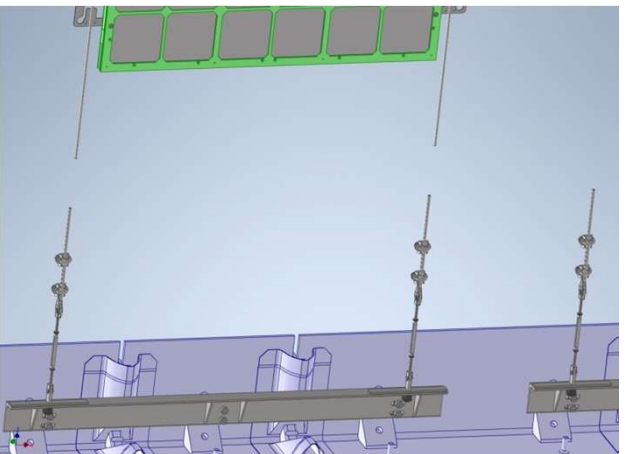
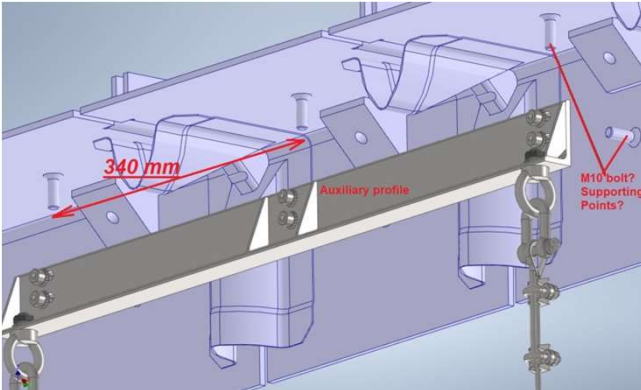
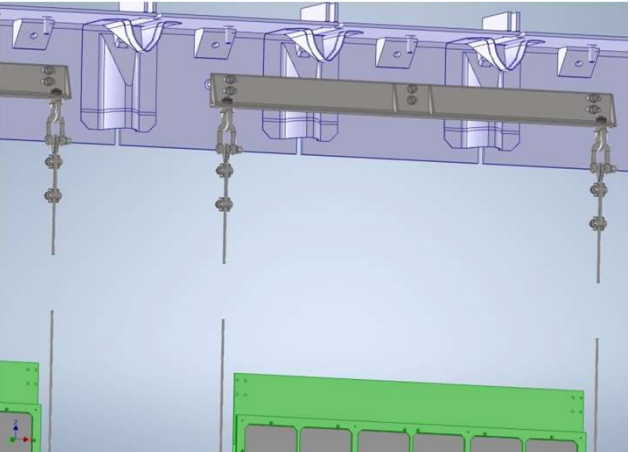
Step 3: Attach the two bottom fixation point of the PD module by two M5 bolts.



Estimative weight of the PD module, electronics and its fixations elements are about 12 kg.

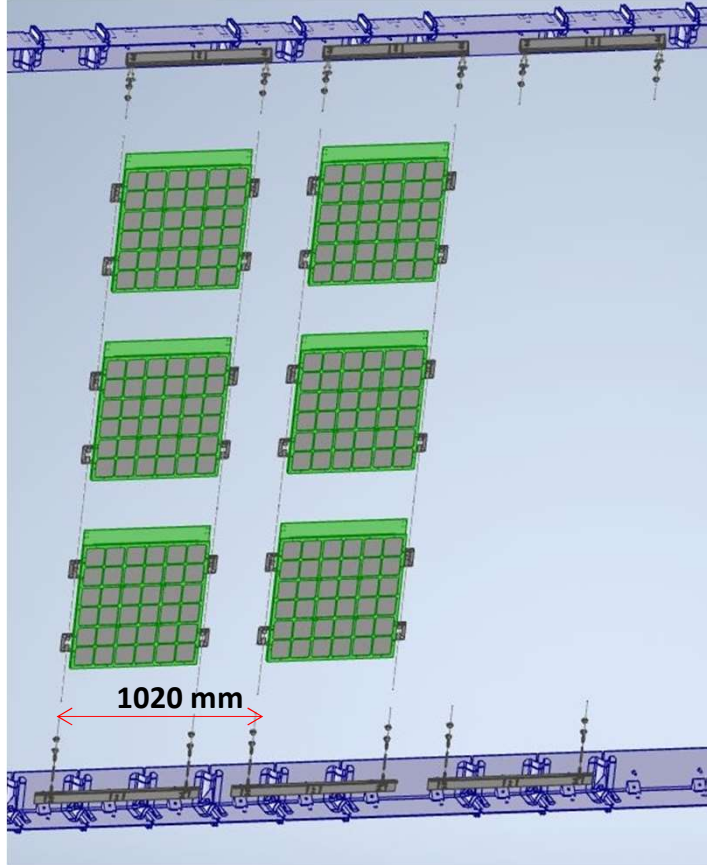
2.2.- Fixation system of the PD modules on the membrane: *Version 1*.

If there are elements along the corner (cables trays), and if will be not possible fix the cables directly to the M10 bolt of the corner, am 'auxiliary profile' could be used and am 'intermediate piece' should be defined between M10 bolt and auxiliary profiles.



Straining Screw, Jaw to Jaw (adjustment range 75 mm)

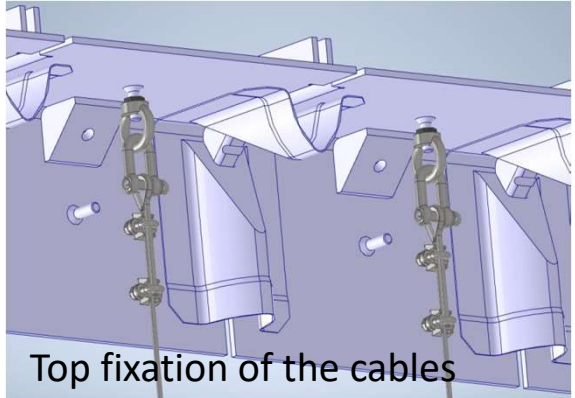
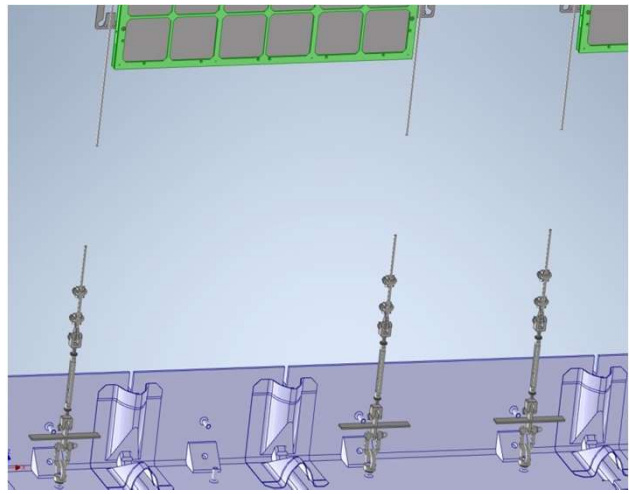
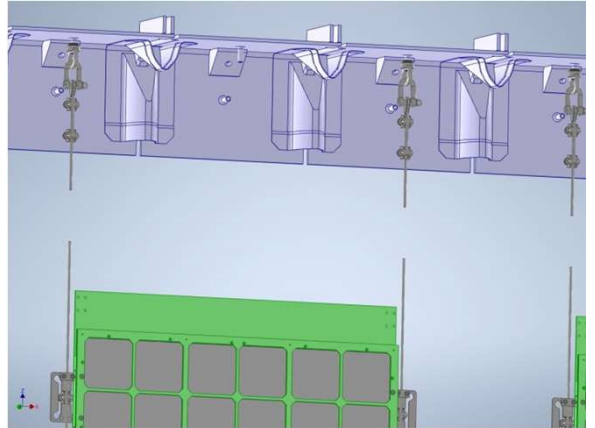
Custom deformable piece to absorber the overload, due to the thermal expansion, avoiding induce big forces on the M10 bolt.



Installation sequence from top to bottom. Signal cables of the PD module: routed along the Stainless steel cables toward the top side of the membrane.

2.3.- Fixation system of the PD modules on the membrane: Version 2.

Cables fixed directly to the M10 bolt of the top and bottom corner of the membrane. Maximum number of PD modules by column are 8: $(12 \times 8 / 2 \text{ cables}) = 48 \text{ kg} + 3 \text{ kg}$ of the cable and its fixation elements $\rightarrow 51 \text{ kg}$ supported by the inox. cable due to the weight + 20 kg pre-tensioned cable force + signal cables weight (6 kg) = **77 kg support each 5 mm inox. cable.**



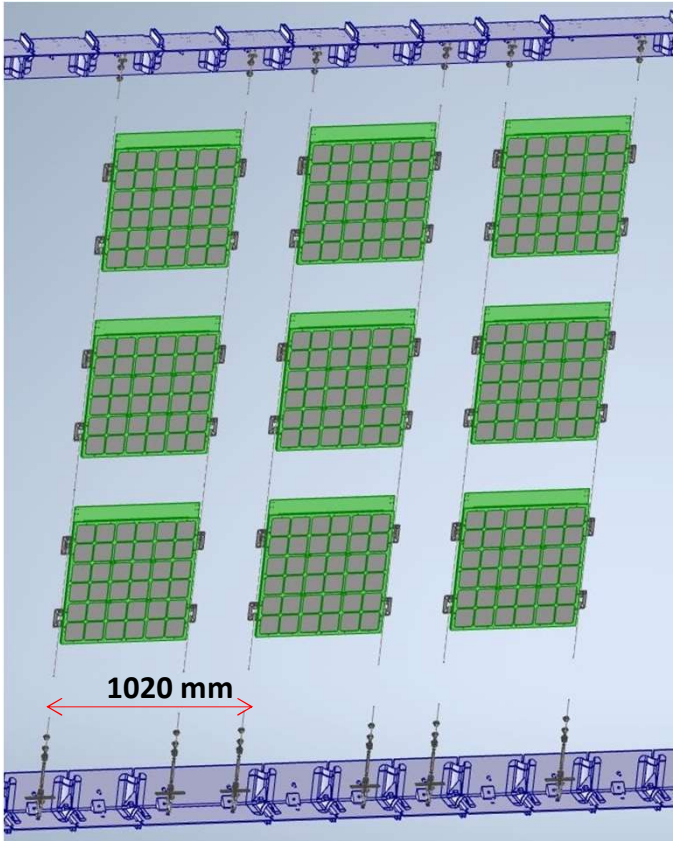
Top fixation of the cables



Straining Screw, Jaw to Jaw (adjustment range 75 mm)

Custom deformable piece to absorber the overload, due to the thermal expansion, avoiding induce big forces on the M10 bolt.

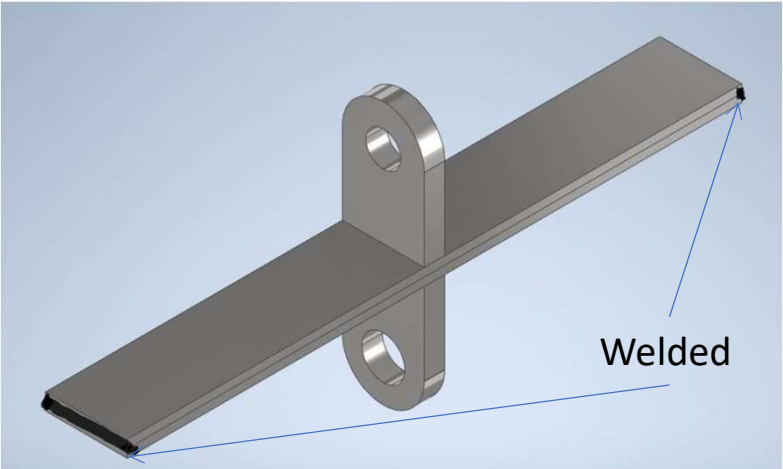
Bottom fixation of the cables



Installation sequence from top to bottom. Signal cables of the PD module: routed along the Stainless steel cables toward the top side of the membrane.

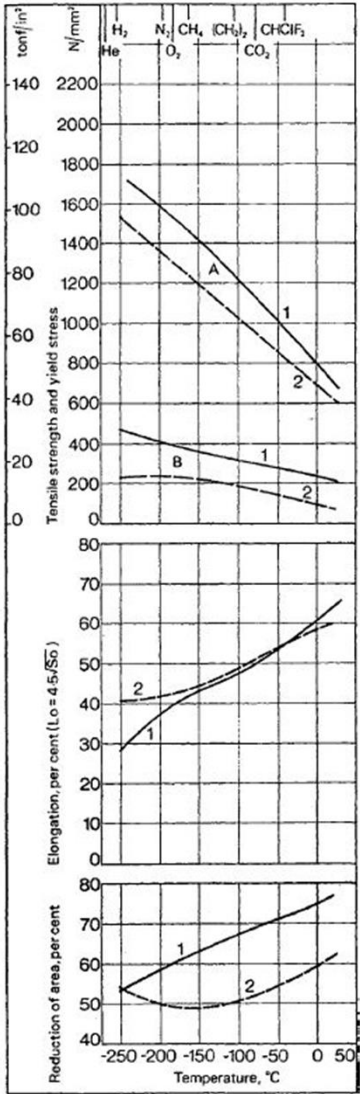
2.4.- Fixation system of the PD modules on the membrane: Custom deformable piece (Version 1 & 2).

Custom deformable piece to absorber the overload, due to the thermal expansion, avoiding induce big forces on the M10 bolt. When this piece exceeds its elastic limit, before breaking, it begins to deform plastically. At cryogenic temperature the AISI 304/304L/316 stainless steel, increase its tensile strength significantly (and its yield strength).



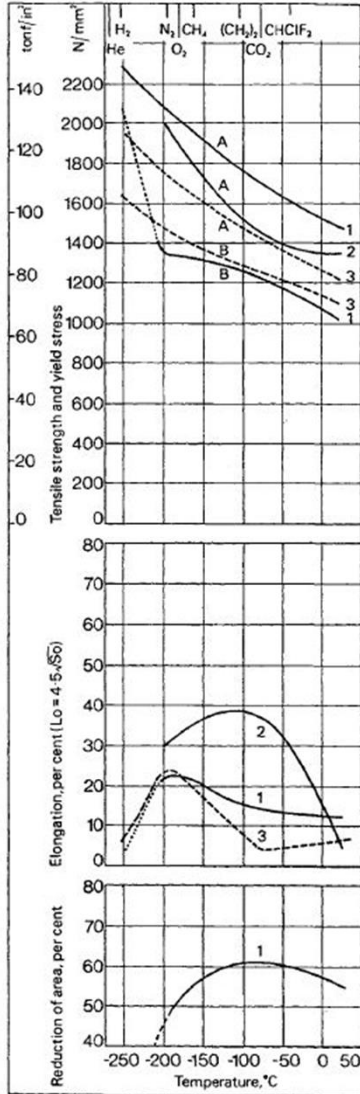
Custom deformable piece produced on AISI 304L stainless steel, to avoid internal stress of the material after welding.

Figure 1 Tensile properties of annealed stainless steels.



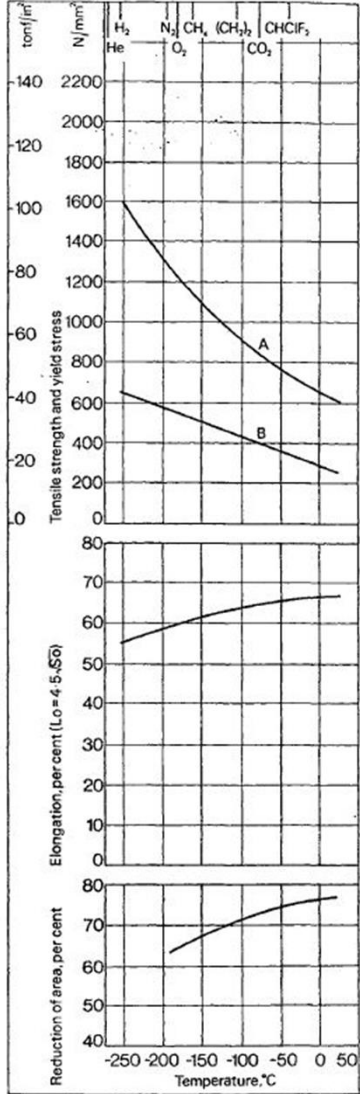
A tensile strength 1. Type 304
B yield stress 2. Type 304L

Figure 2 Tensile properties of cold-worked stainless steels.



A tensile strength 1. Type 304—cold drawn to 1450 N/mm² (148 kgf/mm²)
B yield stress 2. Type 304—cold rolled 60 per cent
3. Type 304L—full hard

Figure 3 Tensile properties of annealed Type 316 stainless steel.



A tensile strength B yield stress

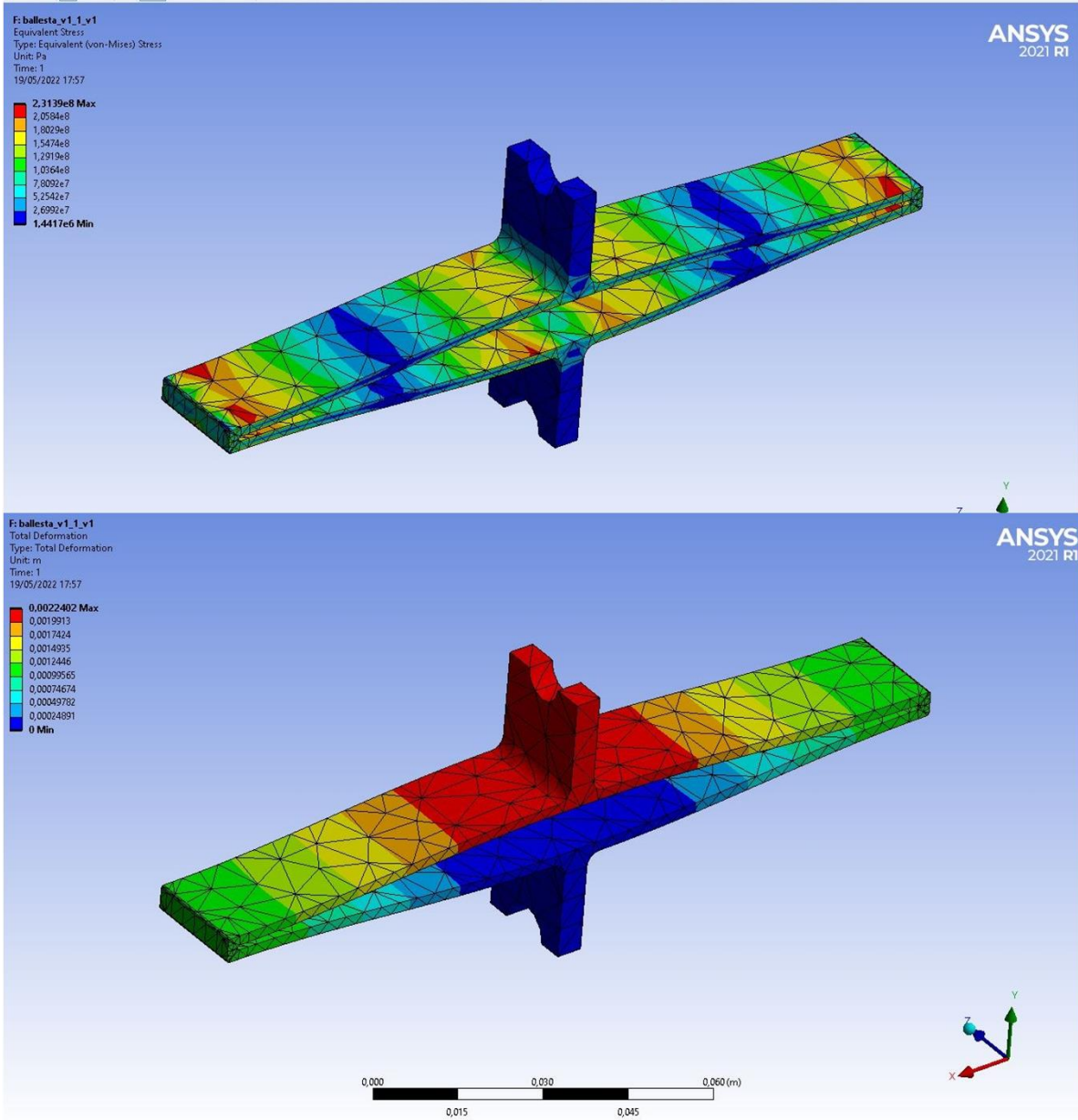
2.4.- Fixation system of the PD modules on the membrane:
Custom deformable piece.

Pieces of 150 mm length x 20 mm width x 2 mm thickness:
200 N force. (2.2 mm deformation)

Custom deformable piece could be designed to support a maximum force limit at cryogenic temperature. And once it reaches this, the piece begins to deform plastically.

Theoretically: maximum deformation induced on the membrane by the thermal expansion at cryogenic temperature between top and bottom side of the membrane (14 m and Δt 200 K) is about 46 mm.

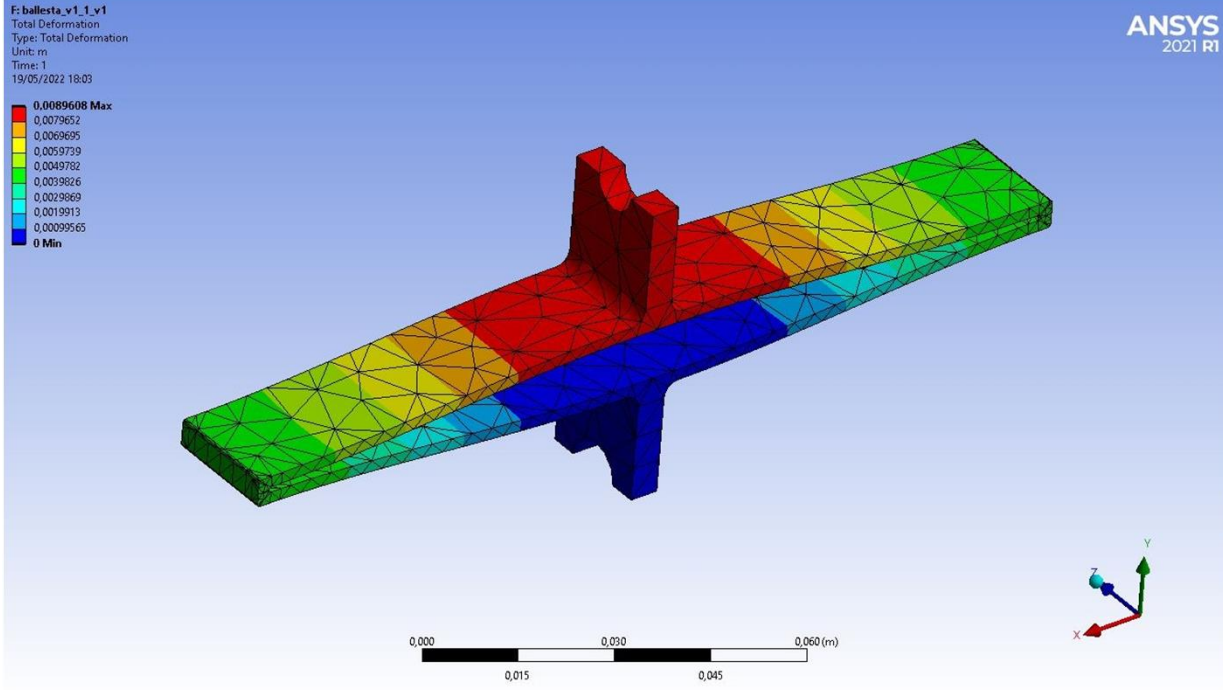
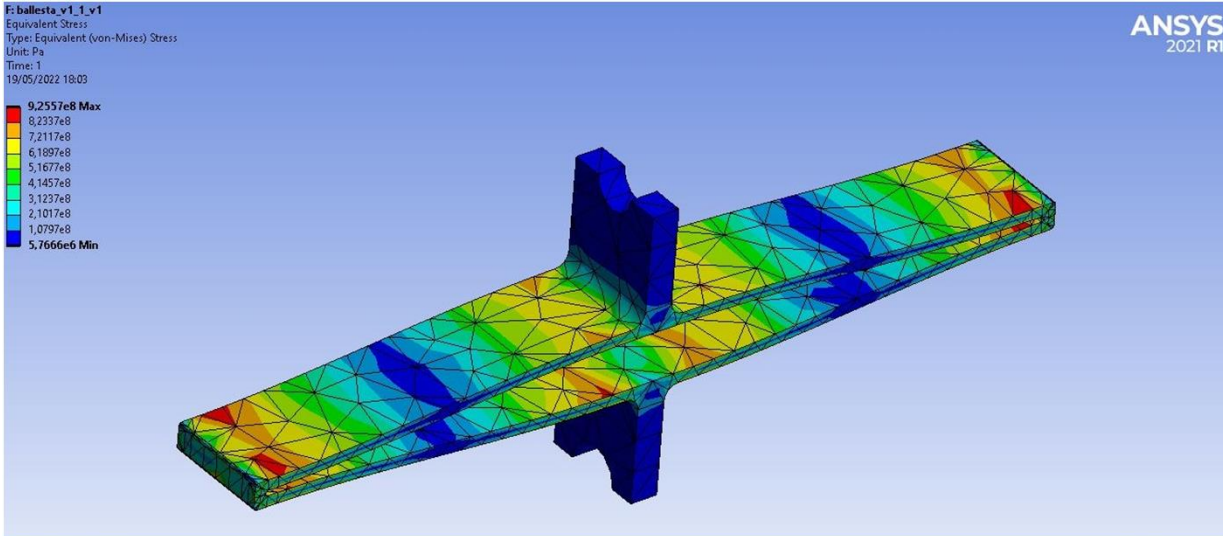
But, *I suppose*, that the cold down will be performed slowly and, at the same time, the membrane and fixation system of the PD modules, minimizing the gradient (only a few millimeters).



2.4.- Fixation system of the PD modules on the membrane:
Custom deformable piece.

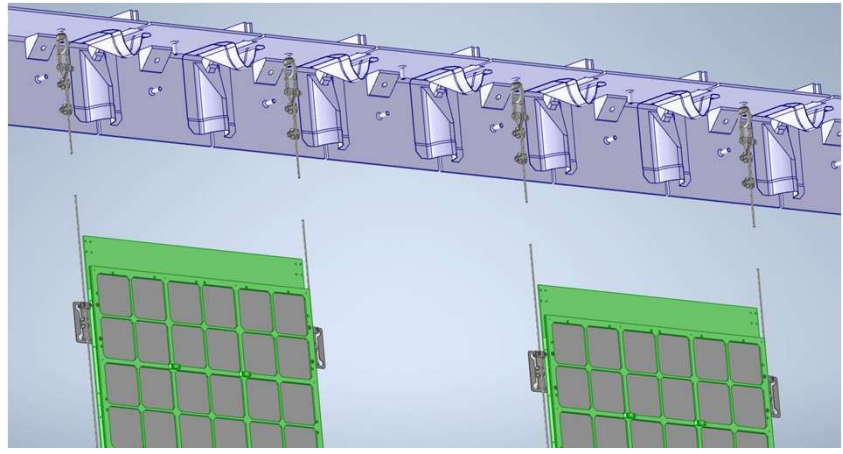
Pieces of 150 mm length x 20 mm width x 2 mm thickness:
800 N force.

Close the end of elastic behaviour (9 mm deformation).

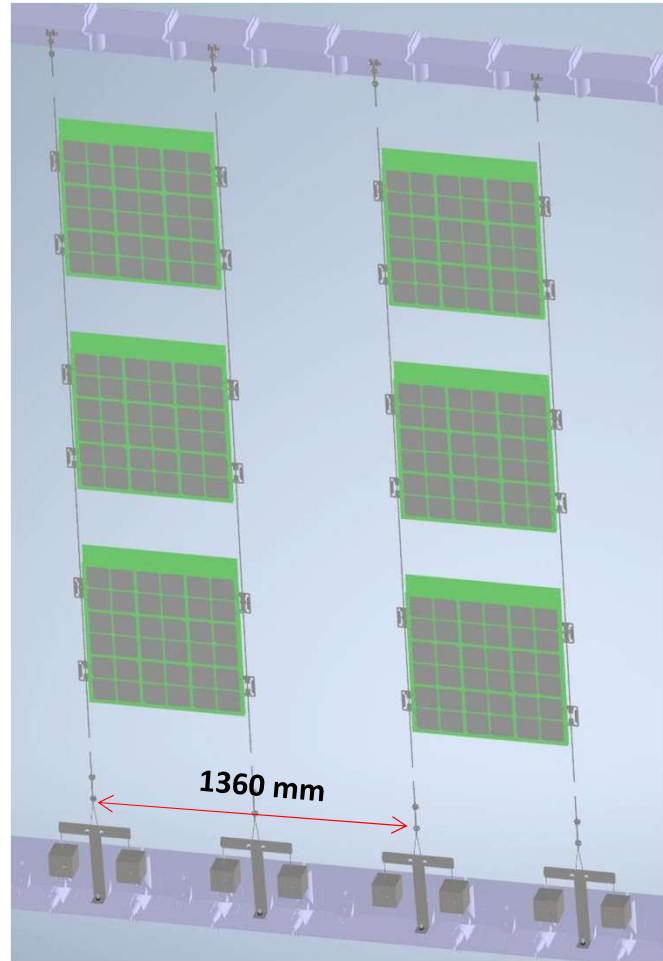
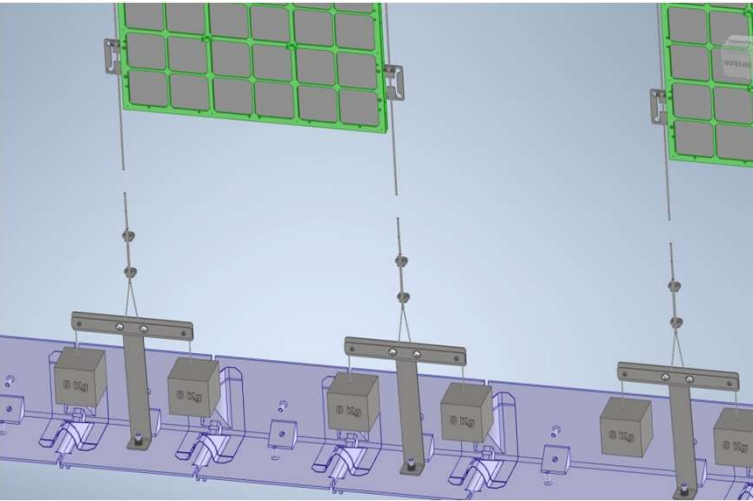


2.5.- Fixation system of the PD modules on the membrane: *Version 3*.

Cables fixed directly to the M10 bolt of the top and bottom corner of the membrane.



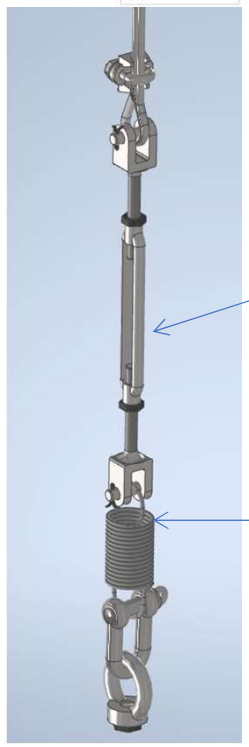
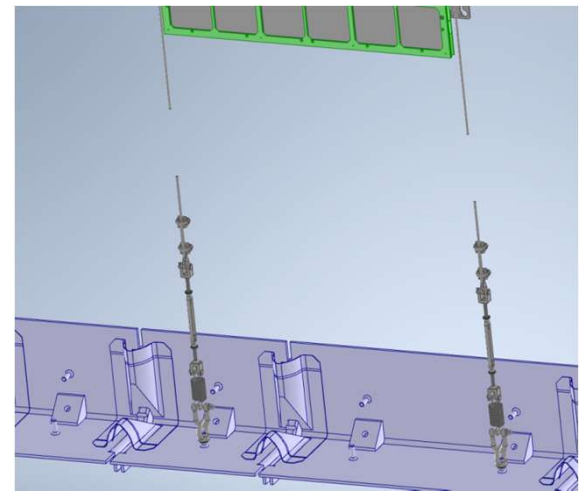
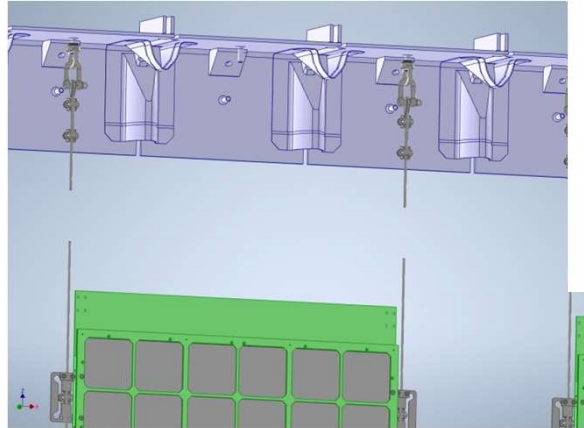
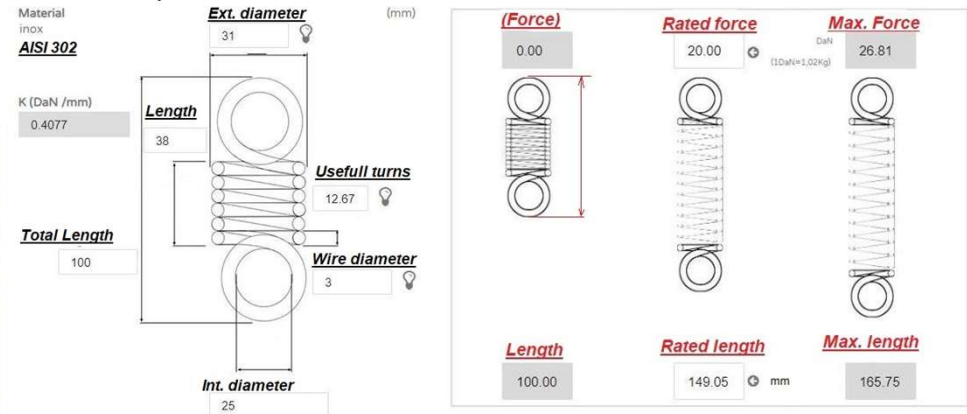
The 5 mm cable is spliced to another Two 3 mm cables, which support a 8+8 kg weight. This ensures a constant tension of the 5 mm cable, avoiding over-stress in the M10 bolt due to the thermal expansion gradient.



Installation sequence from top to bottom. Signal cables of the PD module: routed along the Stainless steel cables toward the top side of the membrane.

2.6.- Fixation system of the PD modules on the membrane: Version 4.

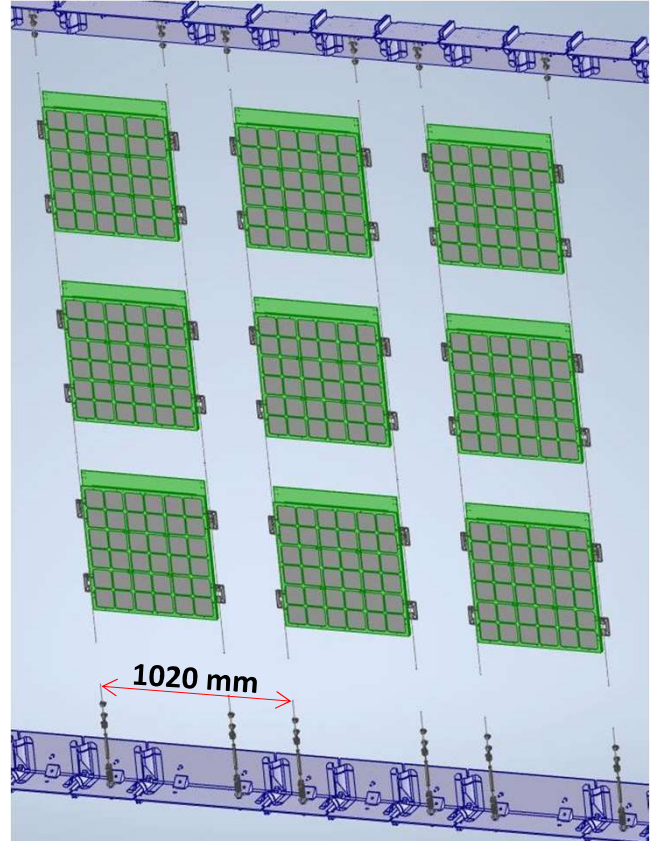
Cables fixed directly to the M10 bolt of the top and bottom corner of the membrane. Standard AISI 302 spring.



Pre-tensioned cables (15-20 kg)

Straining Screw, Jaw to Jaw (adjustment range 75 mm)

Spring to absorber the overload due to the thermal expansion, avoiding induce big forces on the M10 bolt.



Installation sequence from top to bottom. Signal cables of the PD module: routed along the Stainless steel cables toward the top side of the membrane.

3.- Budget of the different configurations.

Version 1 it is not quantified, since I don't know, how the possible intermediate piece should be.

		A option Regular distribution of 20 columns (160 PD modules by membrane)	B option Non-regular distribution of 59 columns (190 PD modules by membrane)
Version 2	Budget of the cables lines+ 'custom spring'	21213	62580
	Budget of the PD modules fixation	14301	16982
	Total (€)	35514	79562
Version 3	Budget of the cables lines + constant tension	24734	72965
	Budget of the PD modules fixation	14301	16982
	Total (€)	39034	89947
Version 4	Budget of the cables lines + spring	20573	60692
	Budget of the PD modules fixation	14301	16982
	Total (€)	34874	77674

4.- Open questions.

- design/position of the CRP cables trays (3Ds) including the top part up to the feedthroughs.
- location of the membrane PD modules feedthroughs.
- if we can't use the M10 screws to fix our inox. cables directly. How to fix the auxiliary profile?
- maximum force and momentum that can be applied to the M10 bolt of the membrane corners.
- expected gradient of temperature between top and bottom of cryostat during filling