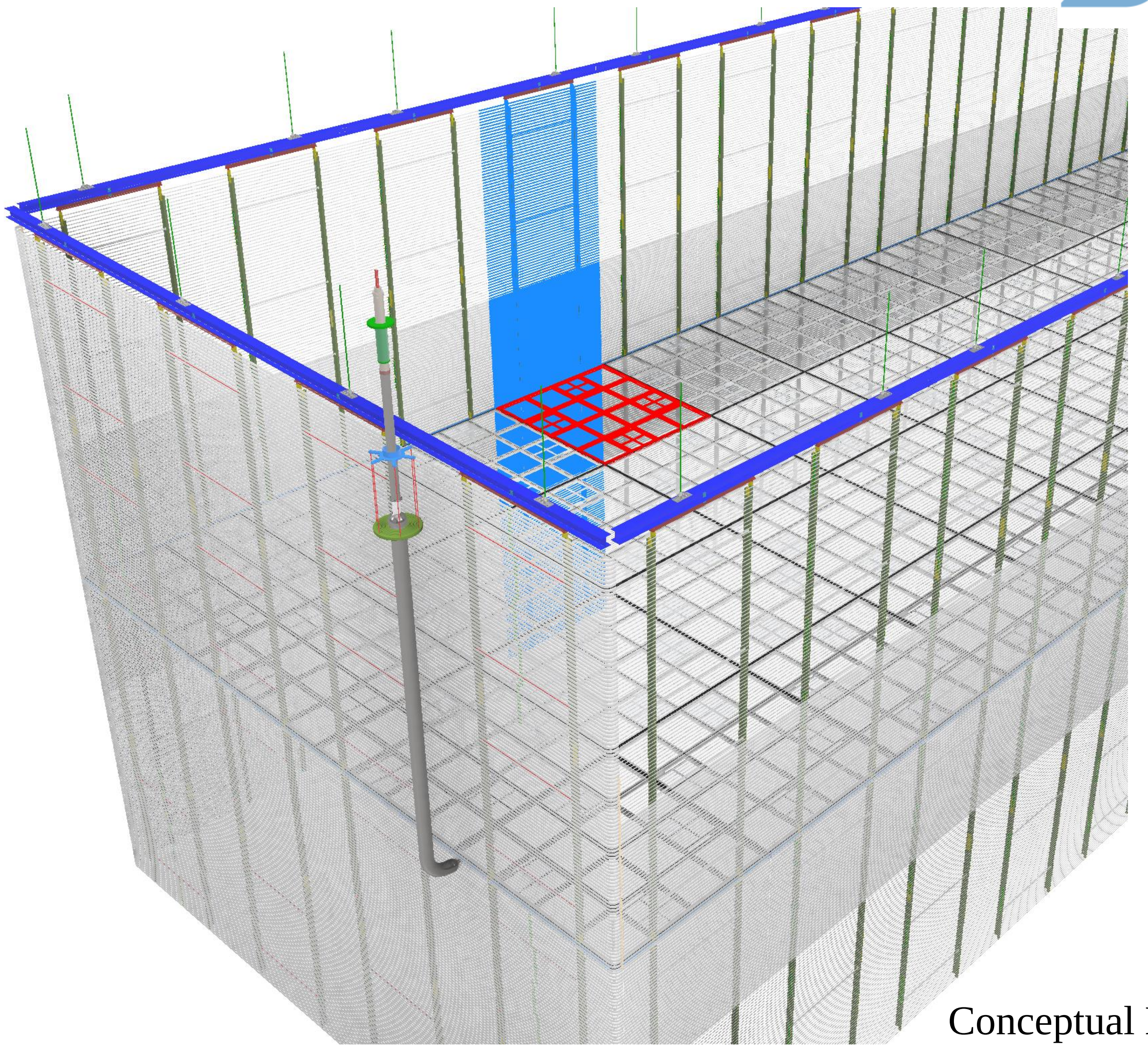
Vertical Drift Cathode

- **Requirements and Interactions with other consortia**
- **Cathode Frame and Suspension**
- **Cathode Mesh**
- **Arapuca Integration**
- **Installation plan**



Conceptual Design Review
Fabien Cavalier, June 14th 2021

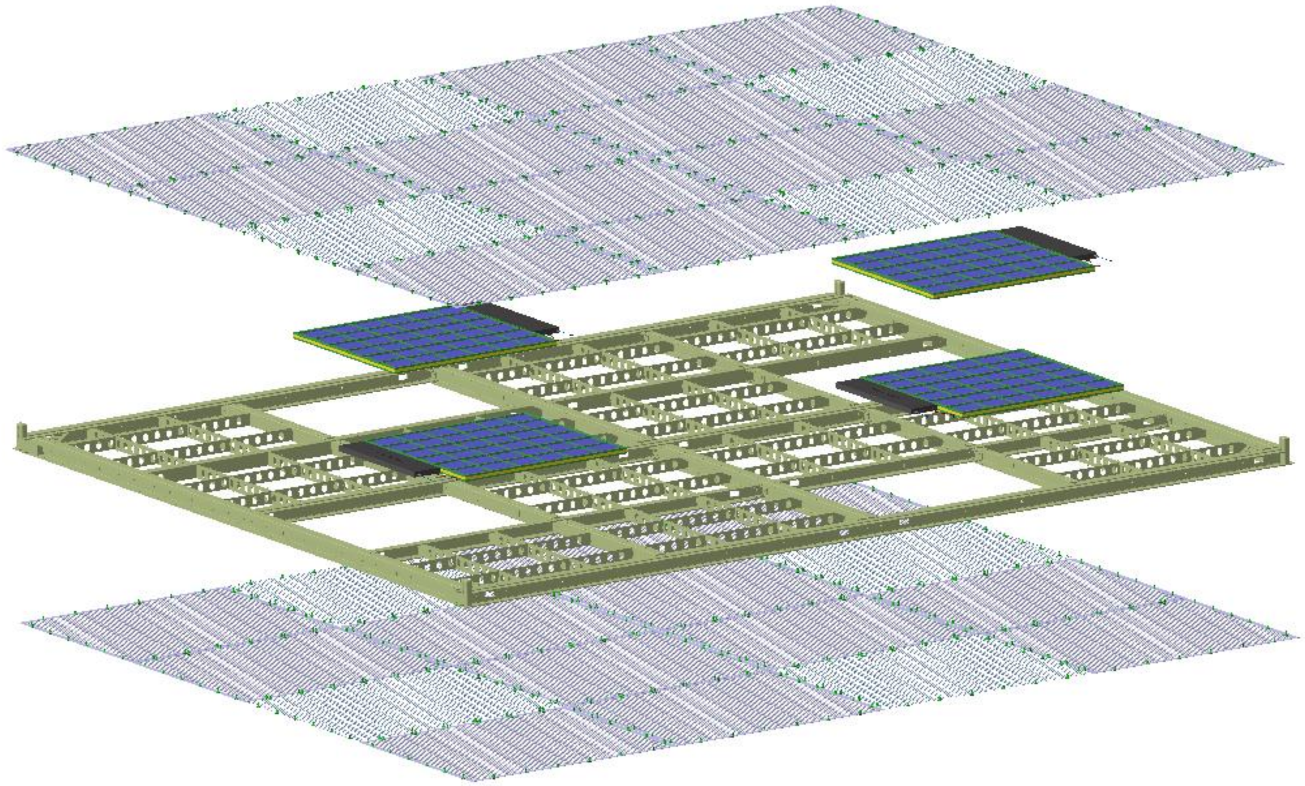
The Requirements

- Nominal Drift Field: **450 V/cm** => Cathode at -**300 kV**
- Drift Field **uniformity < ±1%** [in 99.8% volume]
- **Local** electric field **< 30 kV/cm**

- **Cathode Resistivity** : **> 1 GΩ/sq**. (lower limit 1 MΩ/sq., upper limit 10 TΩ/sq.)

- **Dimension : 3000 mm x 3375 mm x 50 (max) mm** (footprint of **CRP**)
- **Weight < 100 kg in air** (including **Photon Detector** to minimize deformation of **CRP**)
- **Bending < 20 mm in Lar**

- Mesh **transparency > 85%** over **Photon Detector** and **> 60%** elsewhere for LAr flow
- Mesh **pitch < 30 mm** for field uniformity

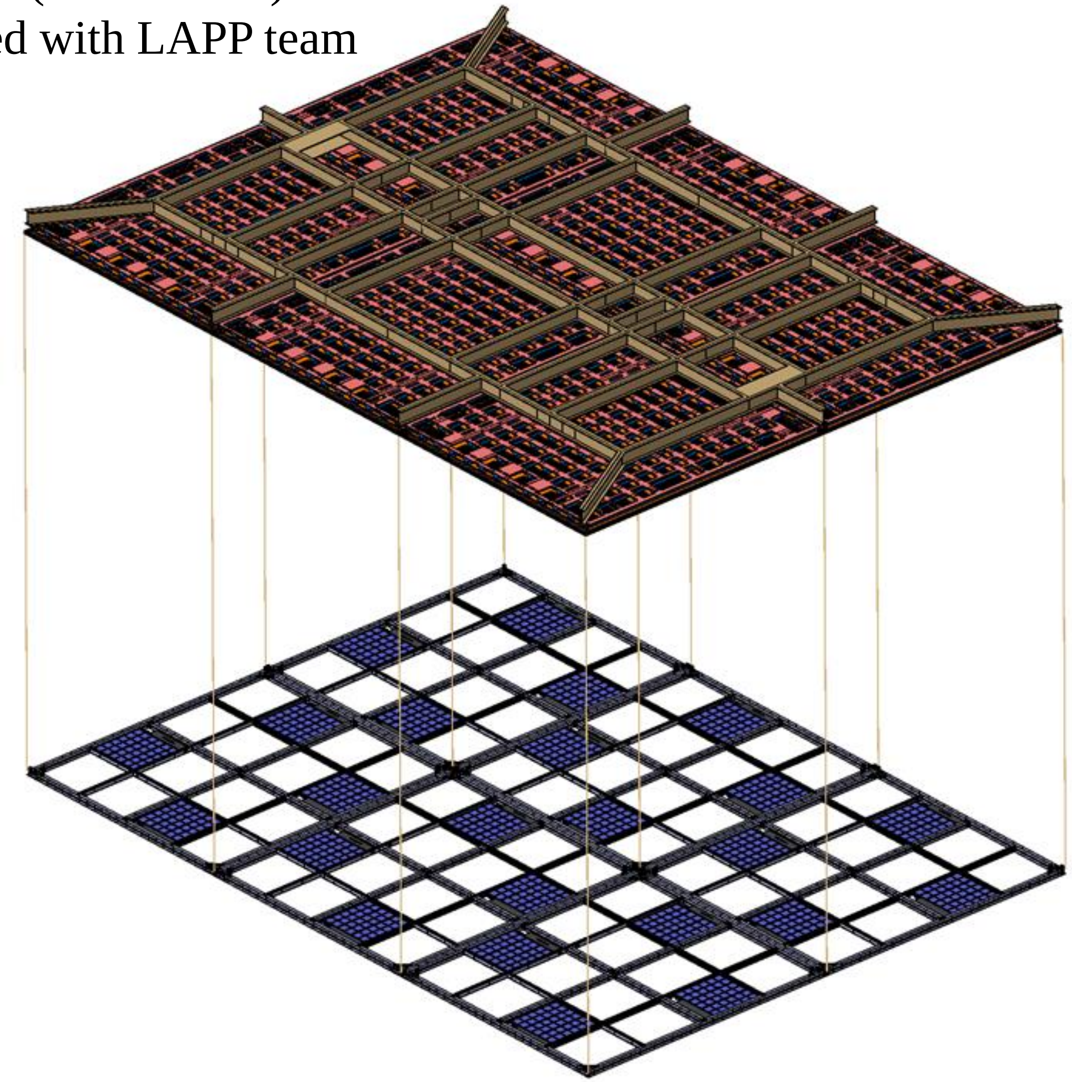


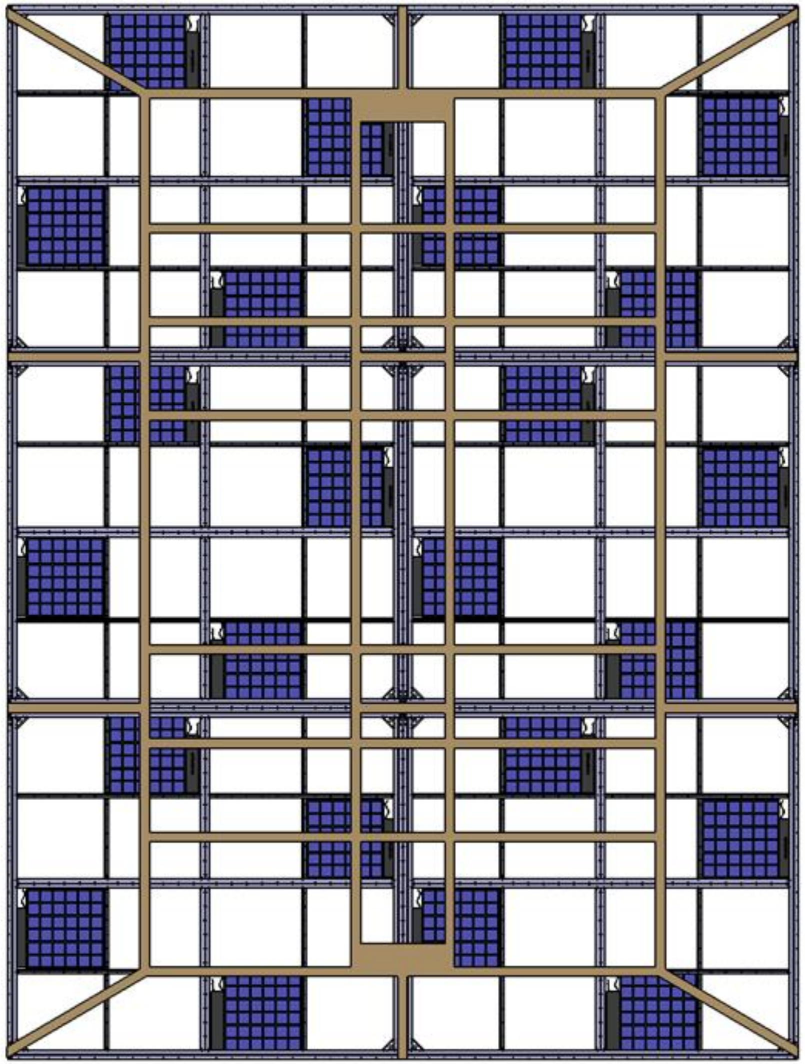
The Cathode and the CRP

- 6 cathodes to be attached to the SuperCRP
- All wires to be vertical

=>

- 12 ropes made in Dyneema (details after)
- Position of the wires agreed with LAPP team



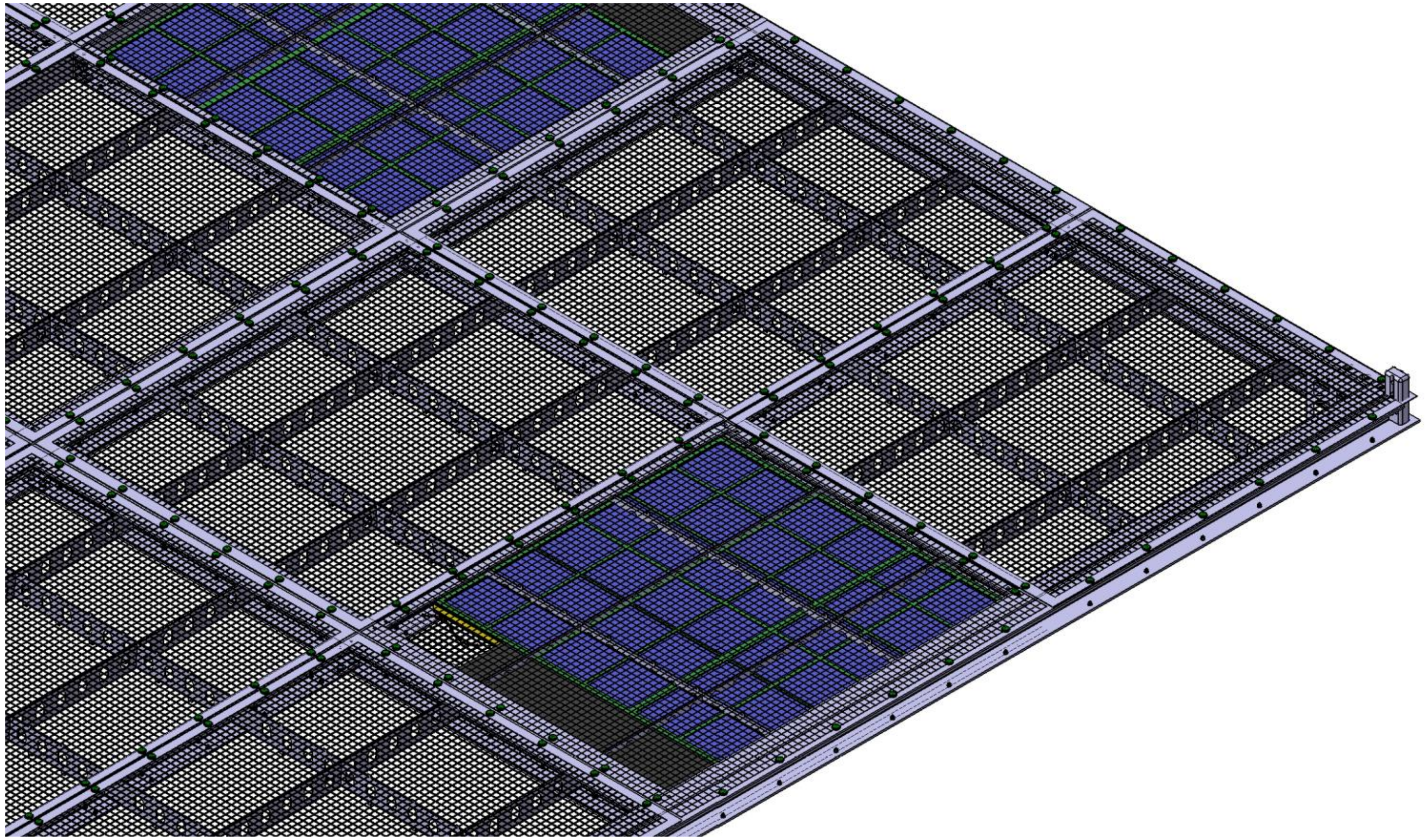


The supporting frame

- Polyester **glass fiber**
- 50 mm height
- **U/I profile**
- Reinforcement with crossribs above the mesh to insure mesh planarity
- Total weight (without Arapuca and mesh) : **62.5 kg in air, 8.3 kg in LAr**

⇒ Available **Payload : 37,5 kg**

- Arapuca : about ~7x4=28 kg in air
- ~10 kg available for the “electrical” part of the cathode



- Expected performances over the whole cathode:
  - Distortion below 32 mm in Air
  - Distortion below 15 mm in LAr

The supporting frame

- **Prototype Design Completed** (P.Rosier)

- **Production** of **2 frames:**
  - Pb (bad composition of the fiber glass) with first batch => one month of delay
  - One frame to be delivered **this summer** at CERN
  - The second will stay at Orsay for tests (creep, deformation …)

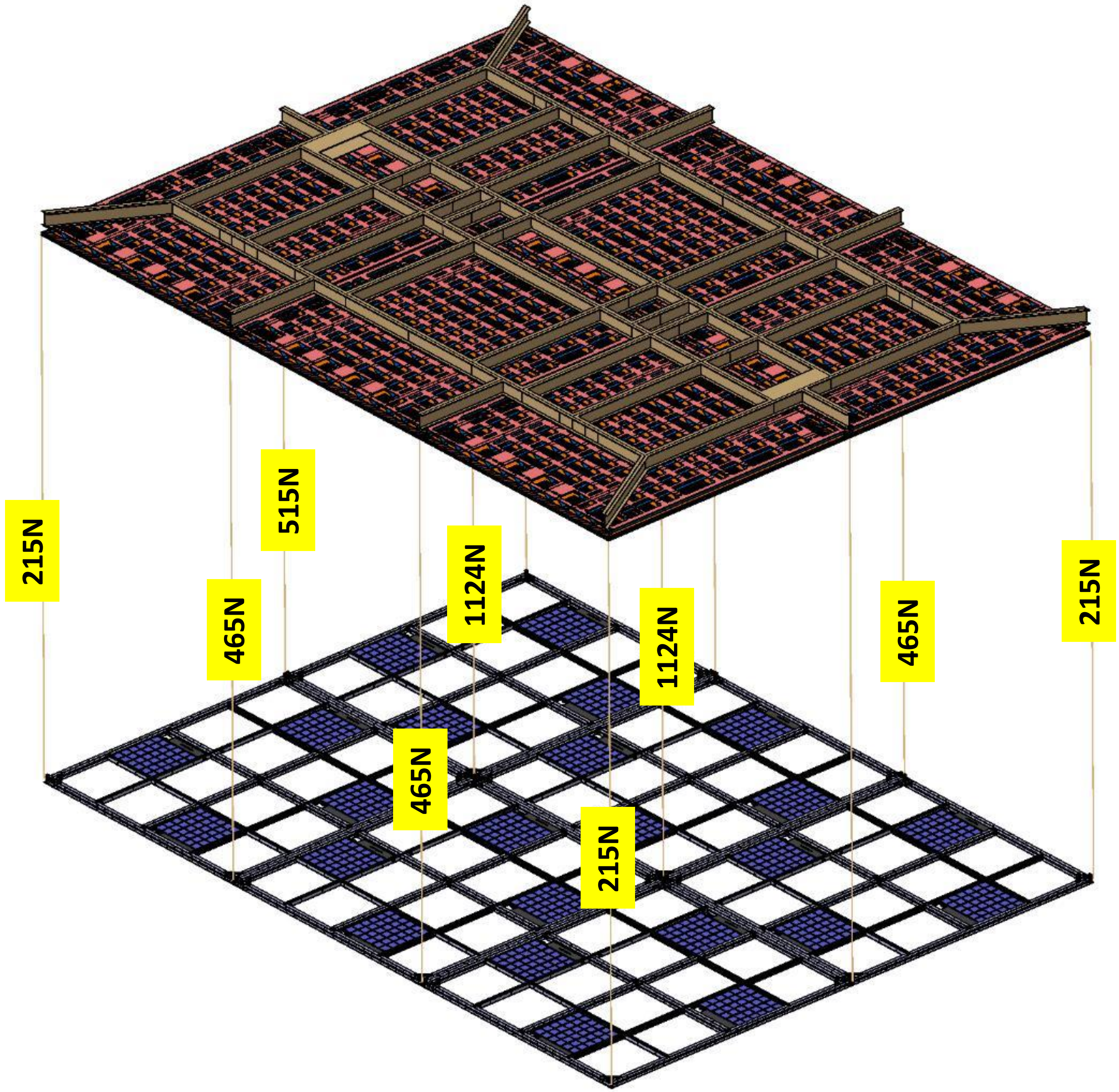
- **Impact** of **transport** to be taken into account

⇒ New design to be performed for ½ frames with easy reconnection at SURF

⇒ No major difficulties foreseen for final design

The suspension system

- Total load in Air ~ 600 kg
- Total load in LAr < 250 kg depending on mesh and Arapuca material
- Tension wire from 200 N to 1100 N



Wires made with Dyneema:

- High resistance with small diameter (3 mm is our choice)
- Low creep:
  - Creep at 300MPa = 0.00007%/day
  - 10 years = 87600 hours = 0.25% = 15 mm
  - In our case, we are at 142 Mpa max in air and 100 Mpa in LAr

=> Some measurements foreseen in NP02

M-Rig Max Standing Rigging

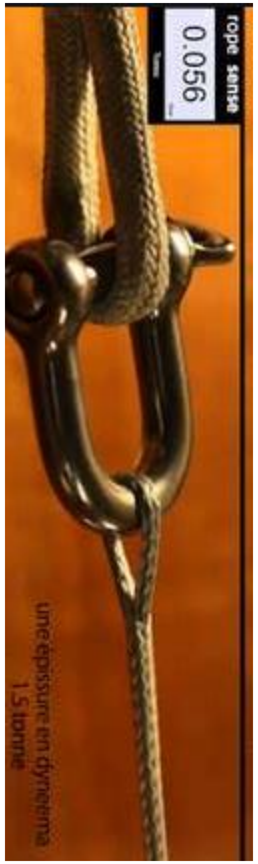
M-Rig Max

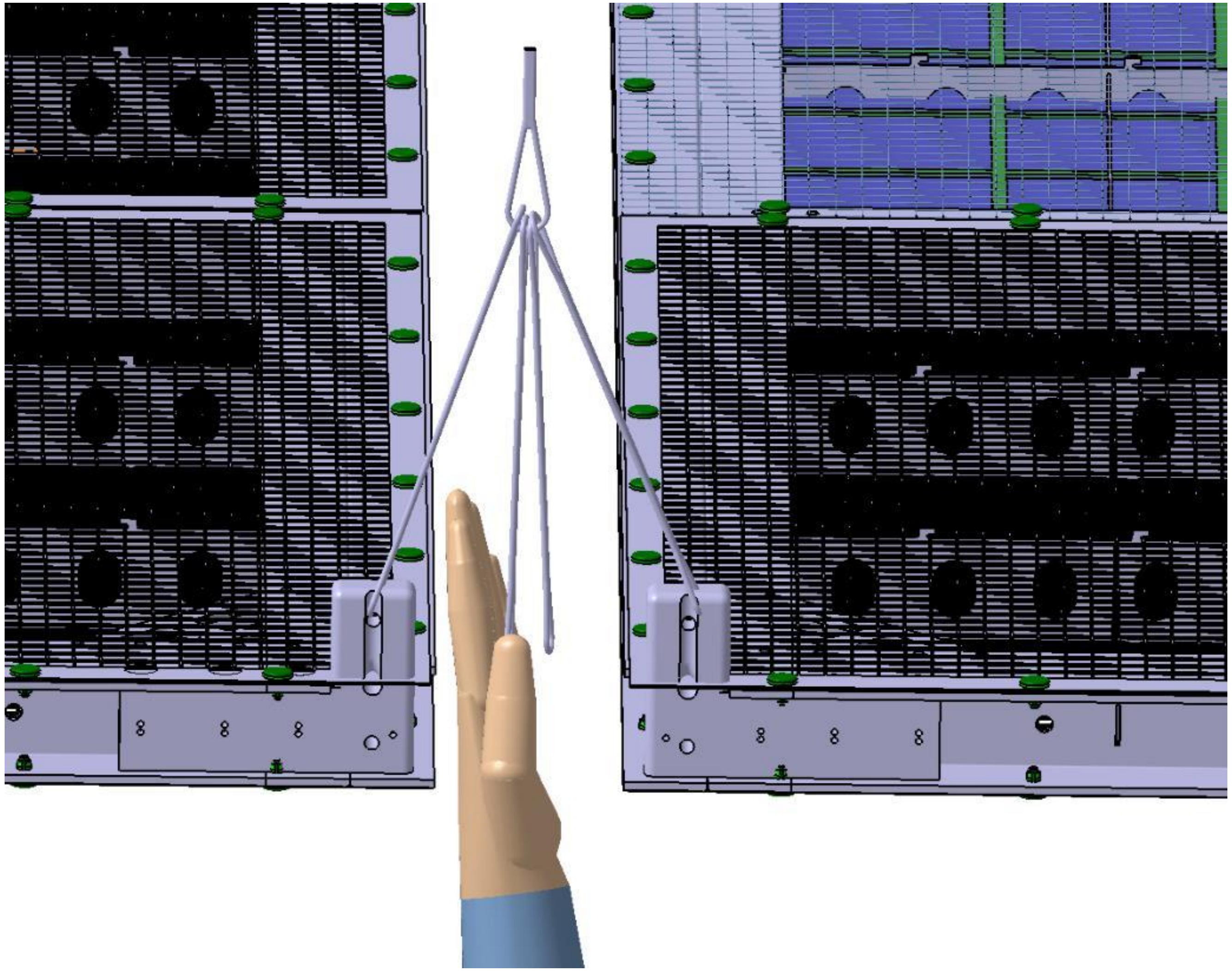
Part Nos: TV** JTV*****

-DM20 for Zero Creep
-Construction optimised for strength
-Colour coated with Polyurethane for improved abrasion resistance
-Heat set and super pre-stretched for zero constructional stretch
-Super Lightweight
-Higher strength than wire of the same diameter
-Good resistance to UV and Chemicals
-Easily Terminated with locking D12 Splice

Diameter mm	Mass g/m	Average strength kg	Min strength (spliced) kg	Stretch mm/mm/1000kg
2.5	4.5	902	839	0.04709
3	6.8	1353	1259	0.03141
4	11.1	2224	2069	0.01911
5	15.6	2874	2672	0.01479

- One wire will support one, two or four cathode corners according to its position
- A single long wire and 1/2/4 short wires at the end
- Connection device between wires to be designed



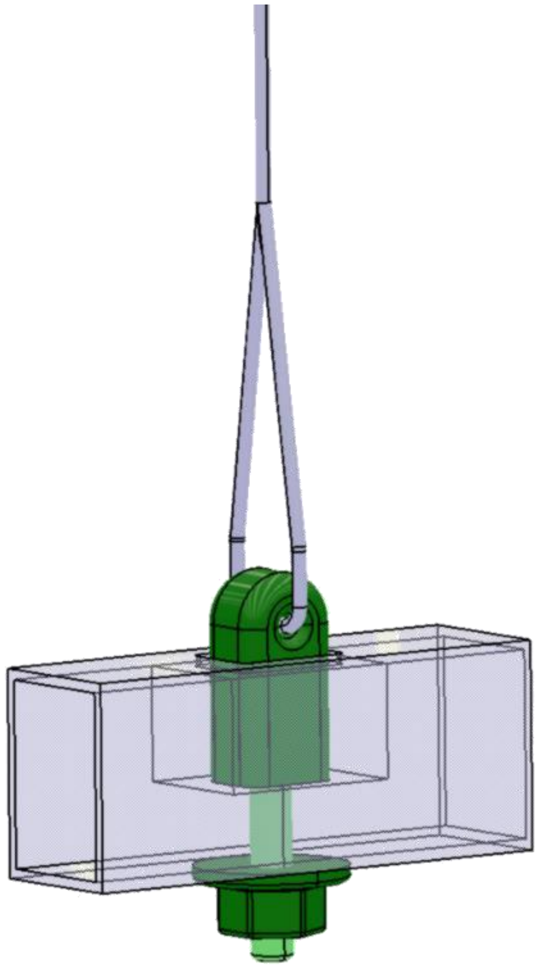


The Length Adjusting Device

- System located in a cathode frame corner, integrated inside the H beam and accessible from below.

- Rope tension from 215 N to 1125 N
- Rope elongation due to load from 2 mm to 9 mm
- Rope thermal expansion 14 mm (negative CTE)

- Different initial lengths for the ropes to take it into account (16 to 23 mm)
- Final adjustment with the length adjusting device +/- 10 mm



The Cathode Mesh

- More than **100 J stored** in the cathode

- In case of discharge:
  - if fully metallic, the energy is released in **few nanoseconds** => **severe damage** is possible
  - initial solution with **Stainless Steel mesh connected by resistive material** (release time increased to few seconds) but big risk of arching in LAr which will short-circuit the resistive part => back to previous situation

⇒ Move to **fully resistive mesh** to slow down the discharge

⇒ Current Design
  - Metallic mesh over Arapuca to easily insure transparency above 85%
  - FR4 laminated with Kapton and machined to create a mesh with transparency above 60% elsewhere
  - Cost: ~200 k€ of material, ~200 k€ for machining

  - Mechanical behavior after machining to be checked for resistive mesh: the providers were doubtful to get a satisfactory result starting from a too thin panel which will be machined to reach a 60% transparency because the amount of resin is not sufficient to insure a correct mechanical behavior (some fibers are not surrounded by enough resin to insure cohesion) => Manageable increase of weight ?

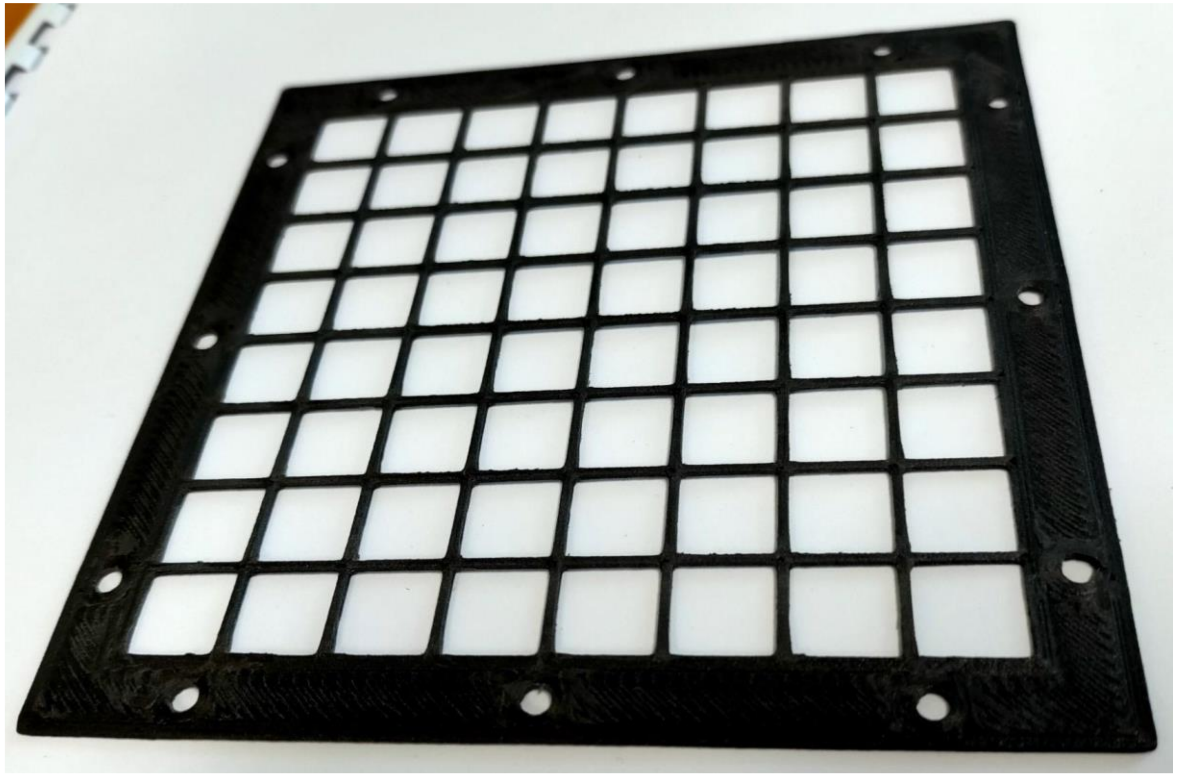
  With 5 mm thickness and 80% transparency, the 2 meshes **weight 38 kg (76kg for 60%)**

Backup solutions under investigation with CERN:

- Resistive FR4 (Vetronit), machined for transparency: same pb of mechanical behavior ?

- Kapton foil alone with eventually additional crossribs for planarity:
  - Preliminary tests after punching 200 holes (80% transparency) on a standard Kapton A3-size foil seems promising: object still difficult to tear, limited bending when put on a frame

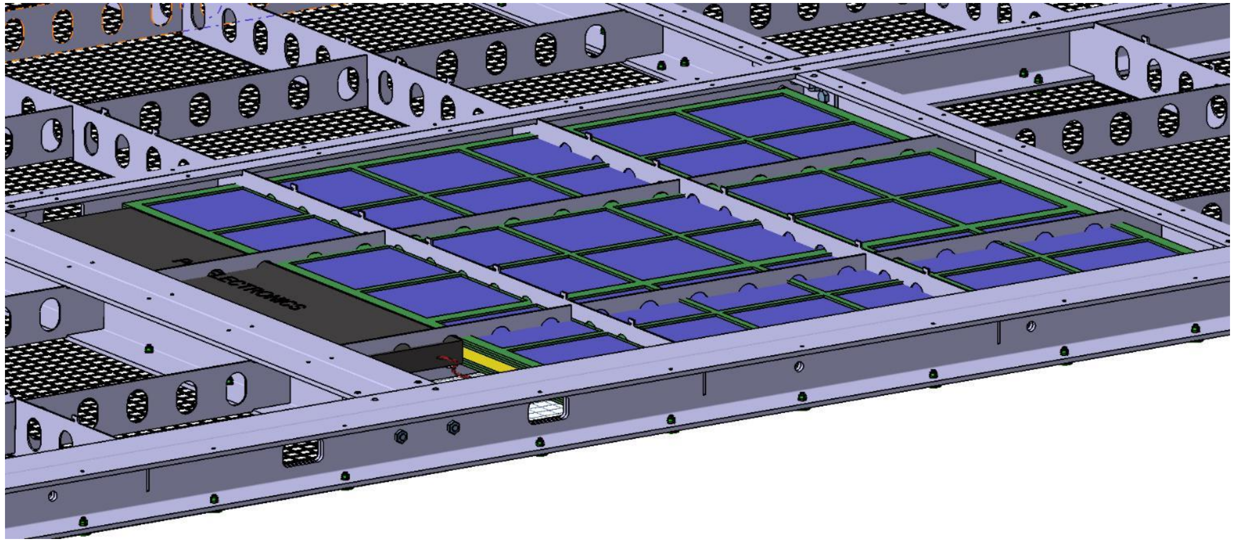
- Peek loaded with Carbon fibers using a 3D printer:
  - 1 mm thickness mesh produced
  - Resistivity above 100 GΩ, difficulty to measure it
  - Similar costs



Arapuca Integration

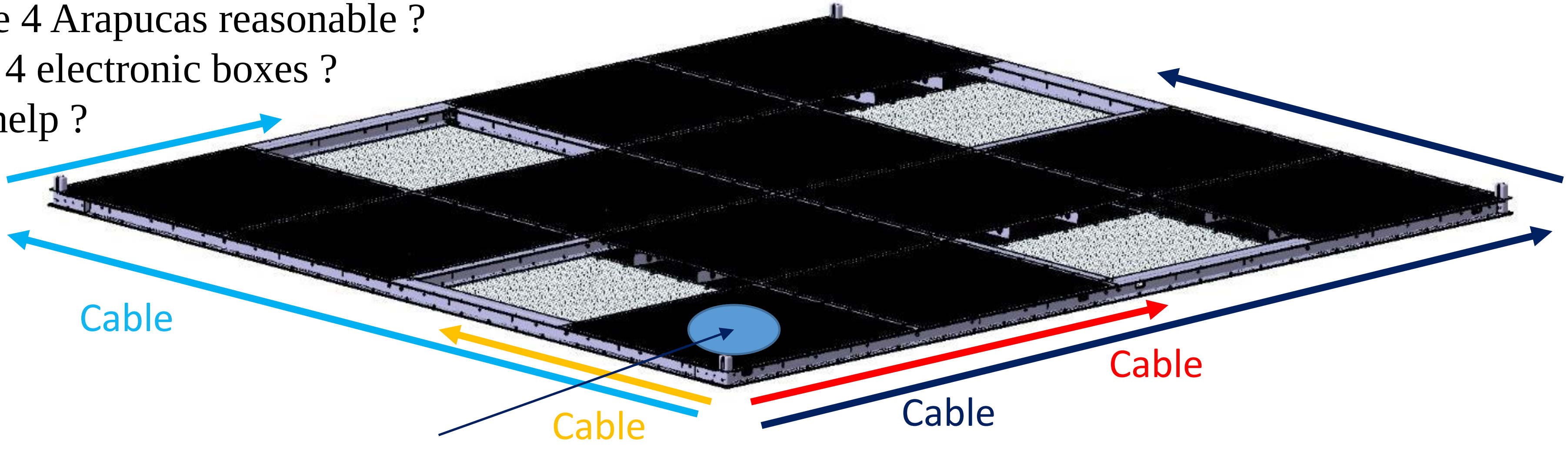
- Weight limit agreed with Arapuca team

- Routing of cables in the edge of the cathode frame
- Holes already implemented to go through the frame
- Possibility to easily plug external cables (fibers, umbilical …) to the electronic box from below to be investigated



- Impact on Arapuca interconnections to be clarified due to shortcuts introduced by copper wires

⇒ Is only one electronic box for the 4 Arapucas reasonable ?
⇒ Should we go in the direction of 4 electronic boxes ?
⇒ Removing metallic meshes can help ?



Integration Plan

At the lab:

- Reception of the frames produced in the industry
- Installation of Arapuca electronics and cable routing in the frame
- Mounting of all mesh elements (except the four above Arapuca tiles)

At SURF:

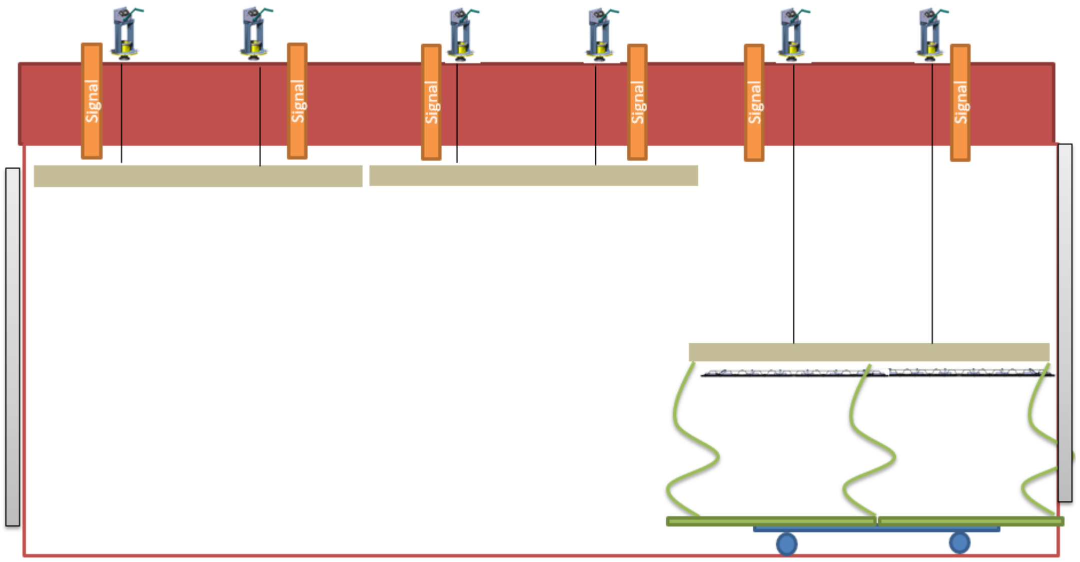
- Connection of the 2 ½ frames
- Installation of the 4 Arapuca tiles, connection to its electronics
- Mounting of the 4 missing meshs

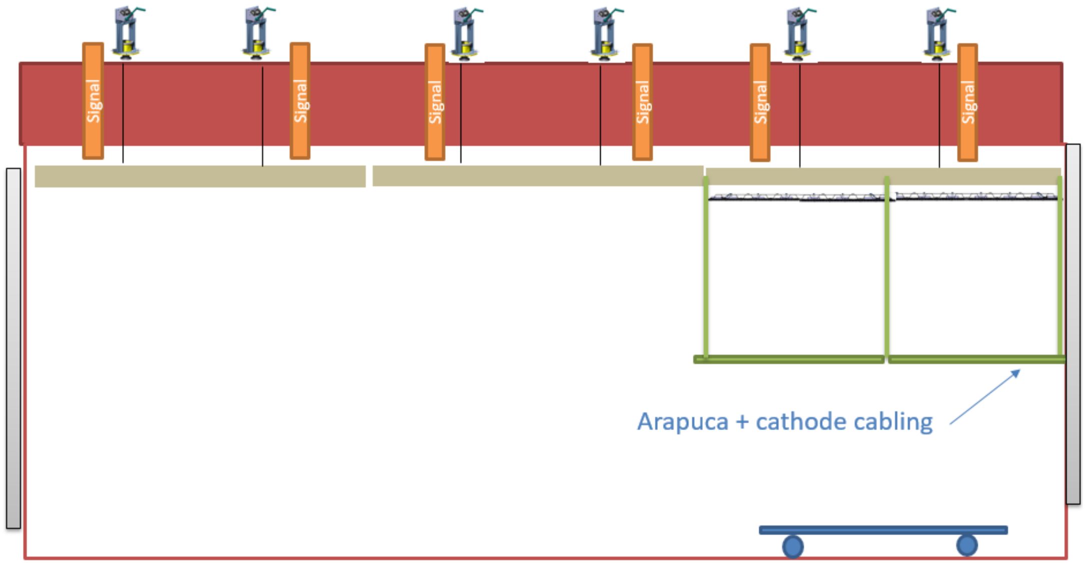
=> Full cathode ready to be installed

Our preferred scheme

- Sequence proposed in agreement with CRP installation (LAPP team)

- Wires installed on SuperCRP
- SuperCRP lowered using its winches around 6m to attach the 6 cathodes at human height
- SuperCRP raised at nominal position with the 6 cathodes attached to it
- Connection to HV
- Connection of Arapuca electronics
- Final tuning of the cathodes alignment





Pros:

- No cathode or set of 6 cathodes to be lifted by external means at 6 m
- Minimal activity on the cathode at 6m height

Cons:

- Cabling of CRP more tricky

Open questions:

- How the Arapuca will be connected up to flanges ?
- Is there any connector to plug or everything is already connected to electronic box (or elsewhere) ?

Conclusion

To be done