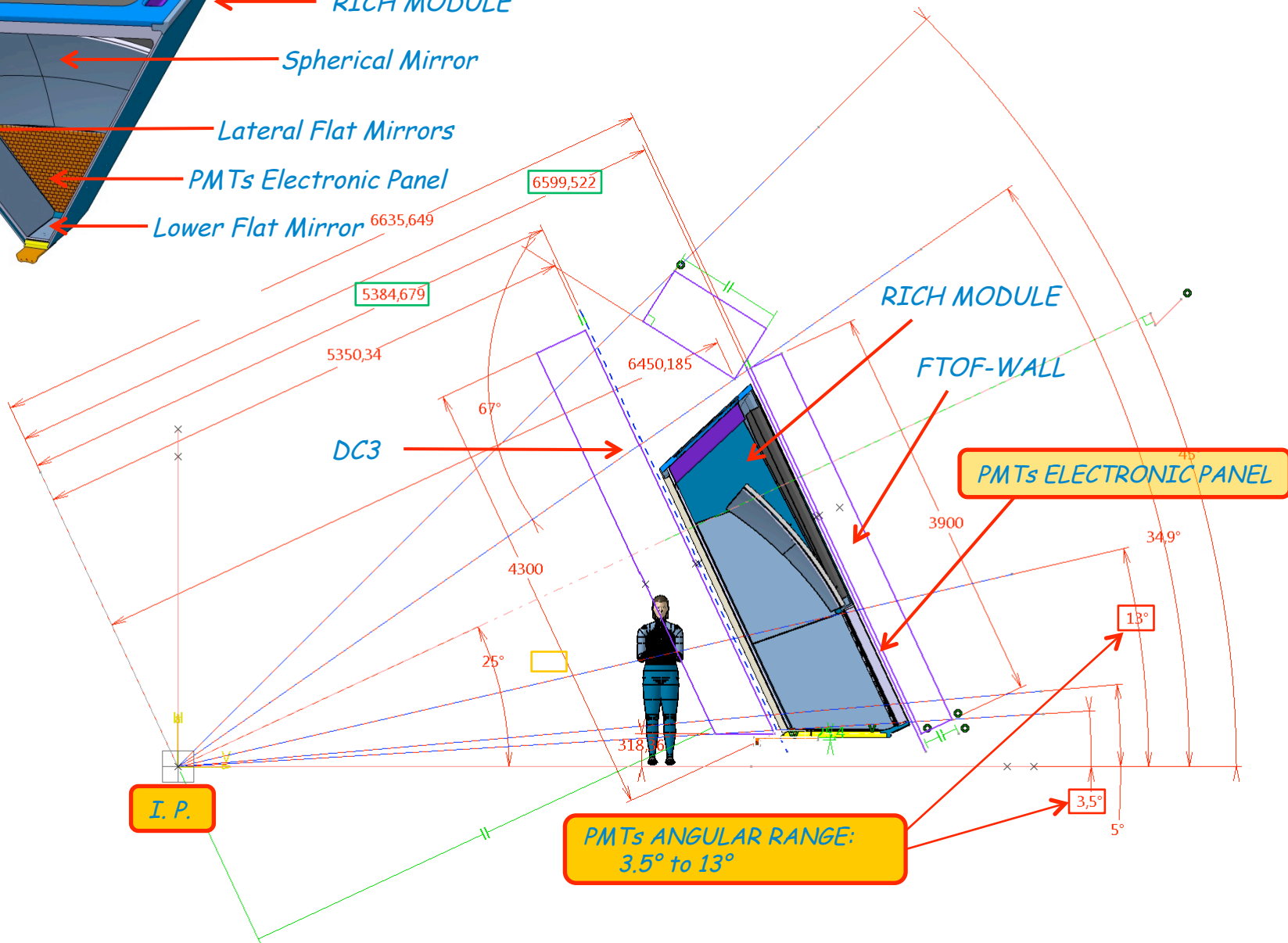
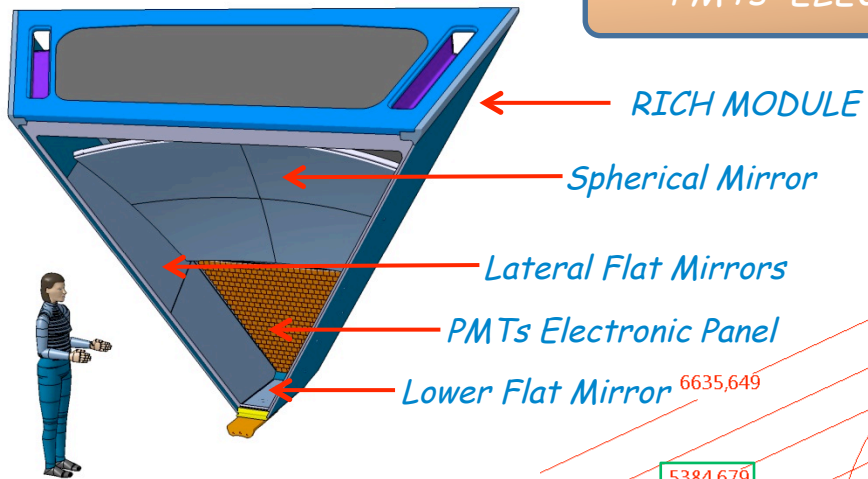


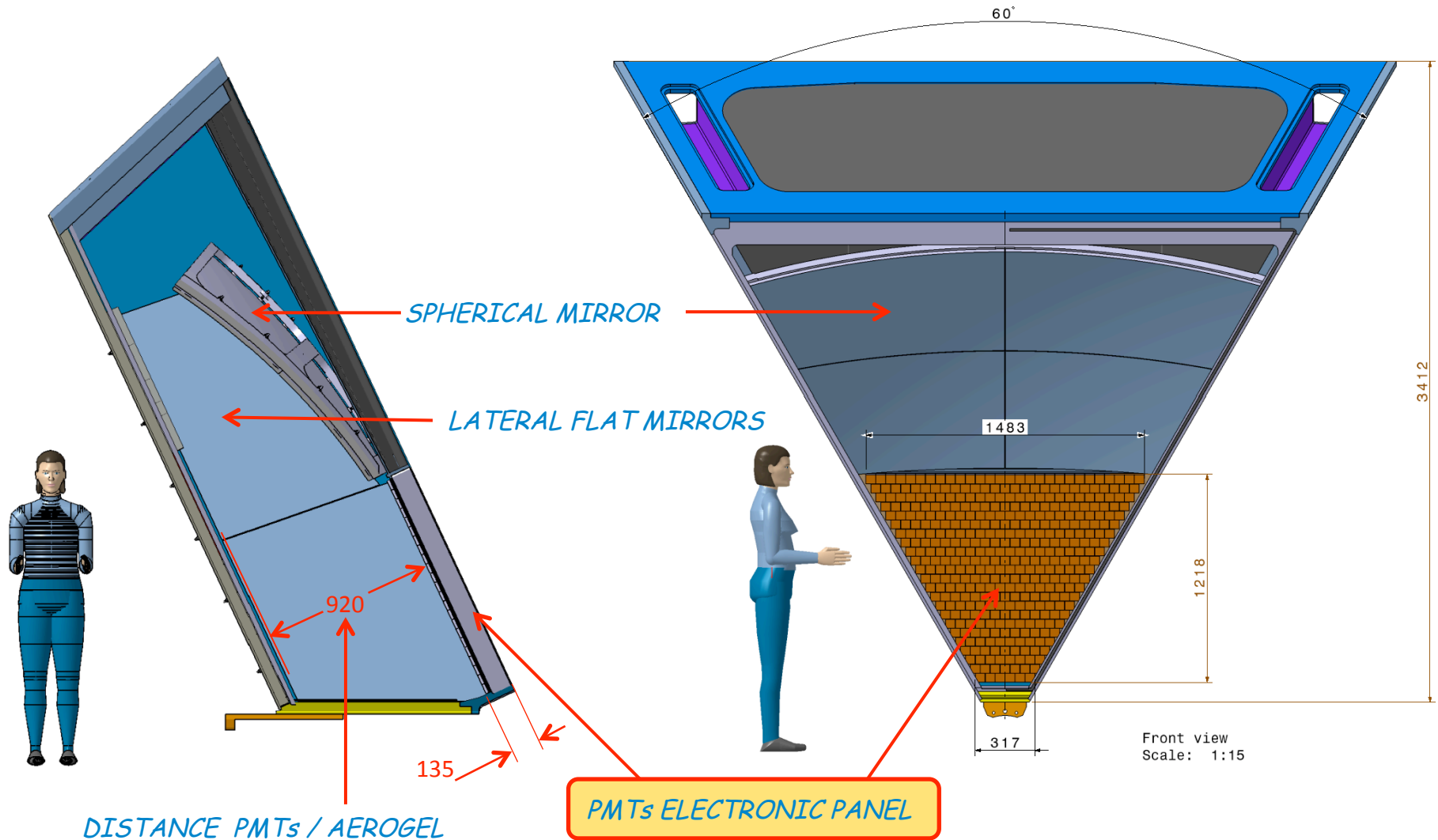
A detailed 3D CAD model of a PMT electronic panel mechanical design. The model shows a complex structure with various colored components: a large yellow conical structure, a grey rectangular panel, and a base with red, yellow, and blue elements. A person is shown at the bottom for scale. The model is supported by a network of red, yellow, and blue beams. A central purple cylindrical component is visible on the left side. The overall structure is mounted on a green base with blue supports.

*PMTs ELECTRONIC PANEL: MECHANICAL DESIGN  
DARIO ORECCHINI INFN-FRASCATI*

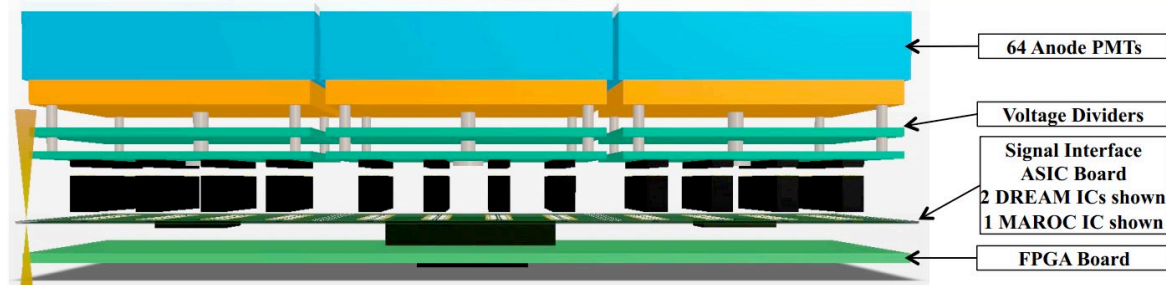
# PMTs ELECTRONIC PANEL IN RICH MODULE LAYOUT



PMTs ELECTRONIC PANEL IN RICH MODULE LAYOUT



## PMT Assembly



### Mosaic Idea: group PMTs to reduce digital electronics resources

- Design two motherboards
  - x3 PMT Motherboard
  - x2 PMT Motherboard
- One FPGA for each Motherboard supports I/O for ASIC chips
- Reduction of cabling
  - Low voltage distribution
    - One Low Voltage power cable for each PMT assembly
  - High voltage distribution
    - One HV channel controls either 2 or 3 H8500 PMT



### FROM BASIC IDEA OF REALIZE TWO TYPOLOGY OF PMTs TILES:

1 TYPE : 2 PMTs TILE

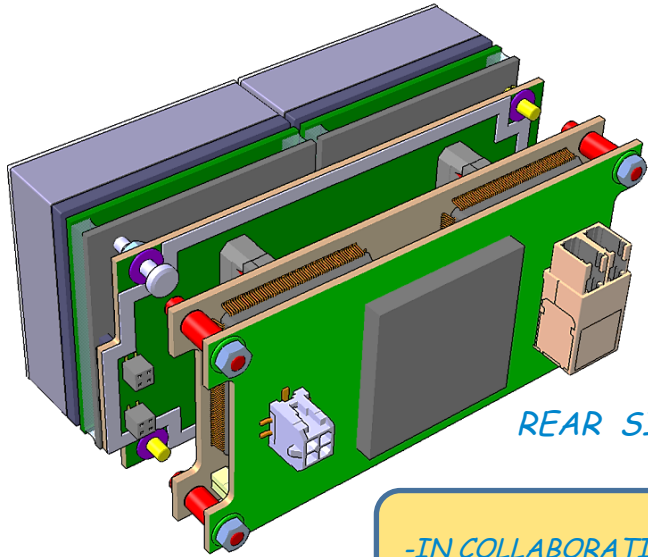
1 TYPE: 3 PMTs TILE

### SUBSTANTIAL BENEFITS:

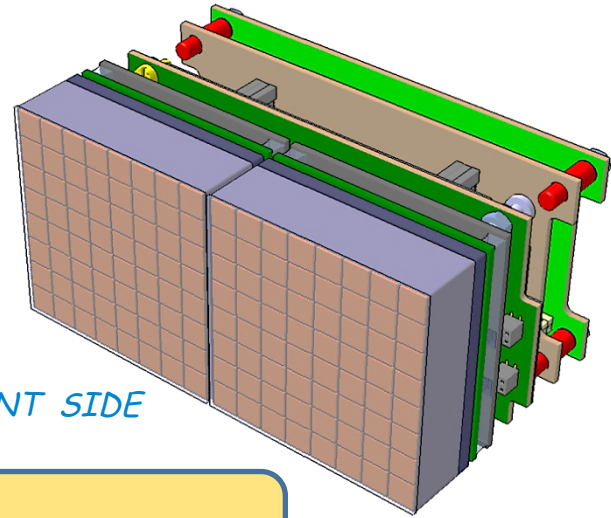
- RAZIONALIZATION OF THE ELECTRONIC BOARDS DESIGN AND OF THE NUMBERS OF CABLES;
- COMBINING THE TWO TILES TYPES TO SIMPLIFY THE COVERAGE OF TRAPEZOIDAL SHAPE OF PMTs SURFACE.

*(Idea from Chris Cuevas.)*

PMTs ELECTRONIC PANEL - 2 PMTs TILE DESIGN

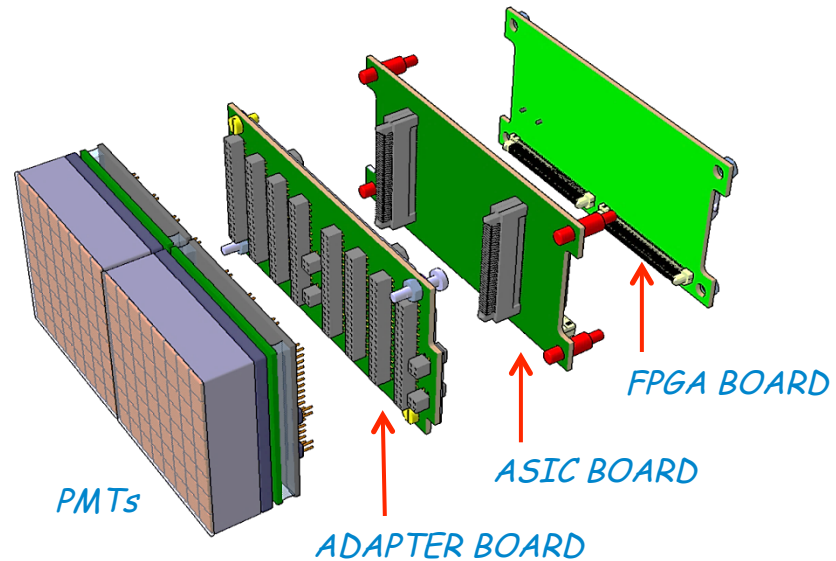
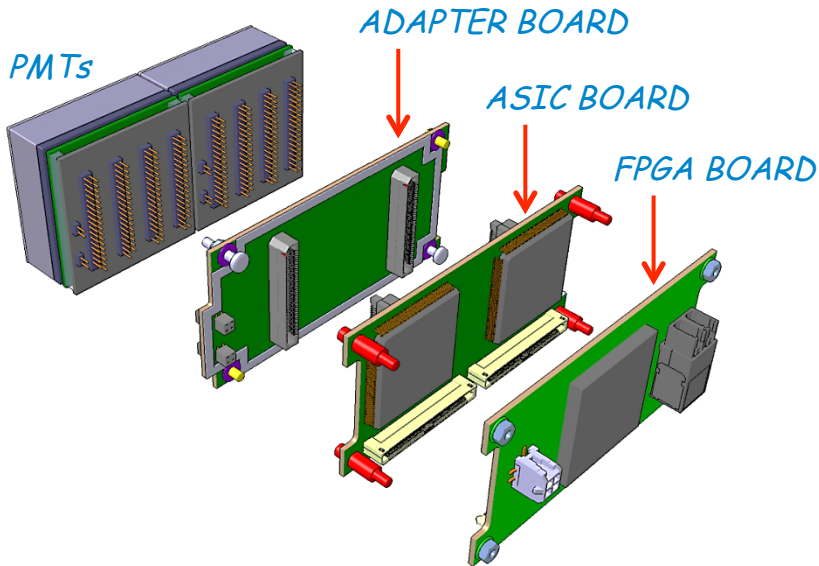


REAR SIDE

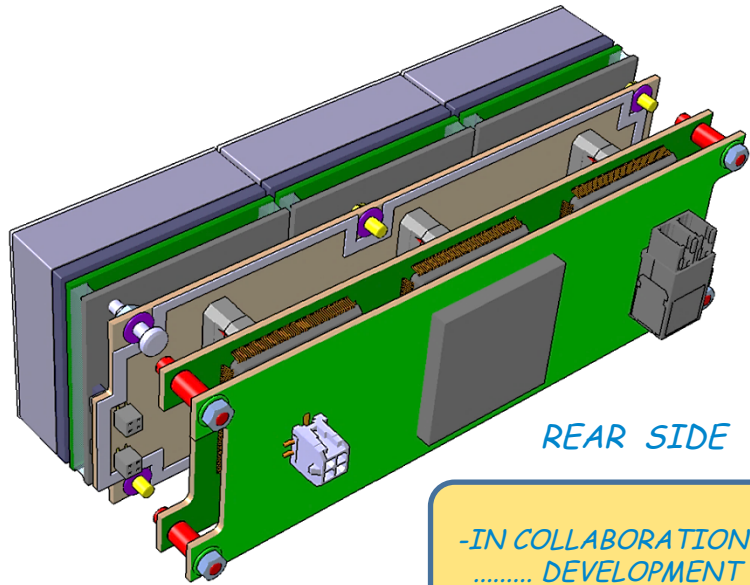


FRONT SIDE

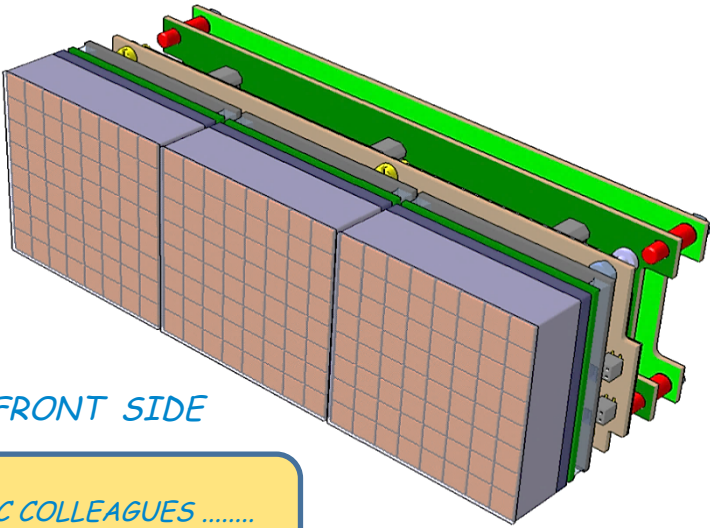
-IN COLLABORATION WITH ELECTRONIC COLLEAGUES .....  
..... DEVELOPMENT OF THE MECHANICAL OPTIMIZATION.



# PMTs ELECTRONIC PANEL - 3 PMTs TILE DESIGN

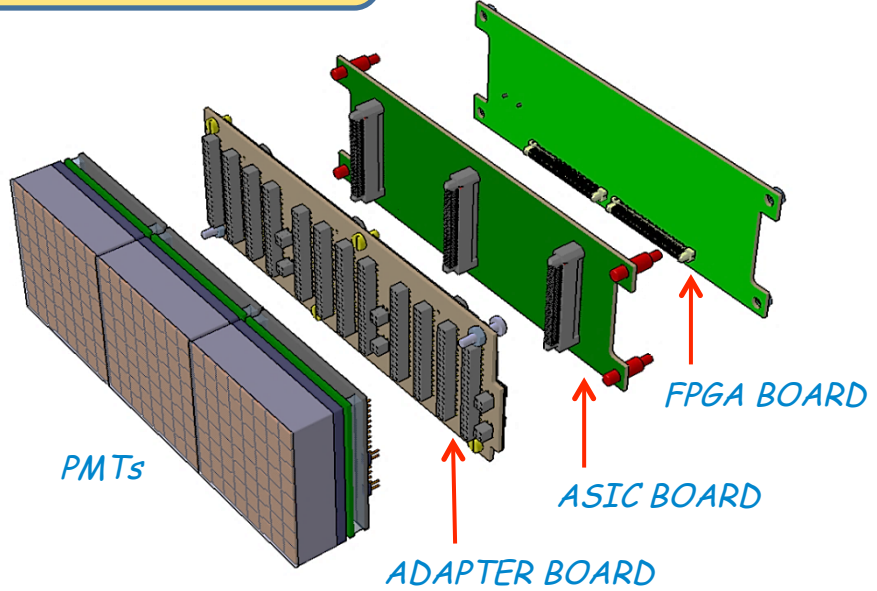
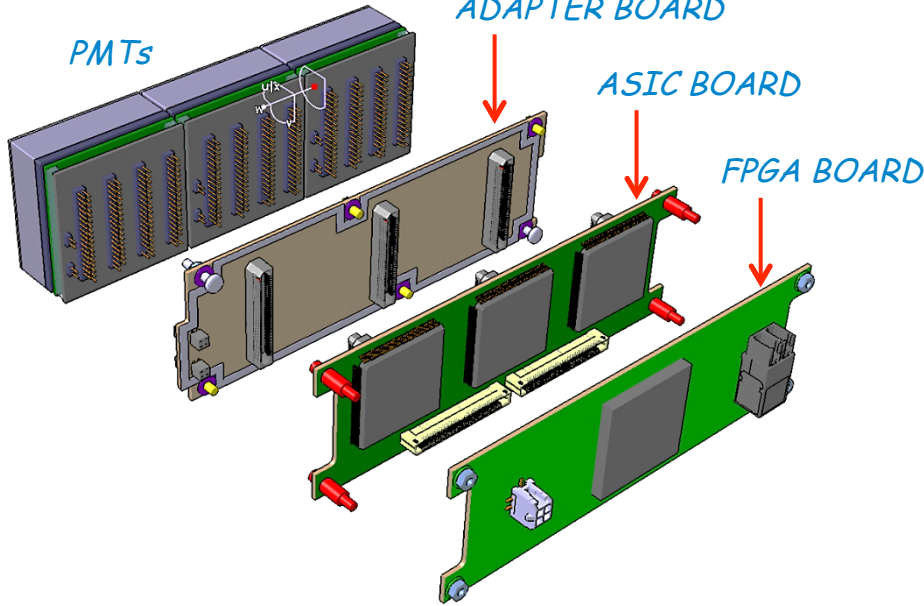


REAR SIDE



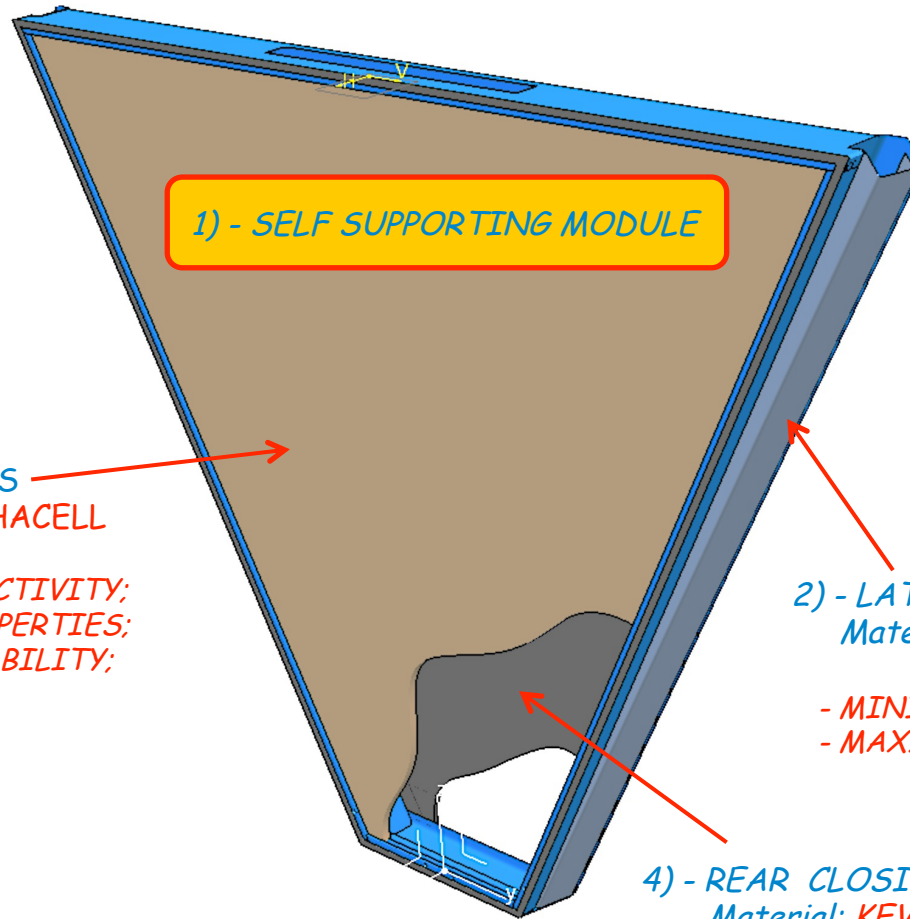
FRONT SIDE

-IN COLLABORATION WITH ELECTRONIC COLLEAGUES .....  
..... DEVELOPMENT OF THE MECHANICAL OPTIMIZATION.



# PMTs ELECTRONIC PANEL - BOARDS ASSEMBLY PROCEDURE DETAILS

PMTs ELECTRONIC PANEL:  
OVERALL OF THE SUPPORT FRAME MECHANICAL COMPONENTS.



1) - SELF SUPPORTING MODULE

3) - PMTs SUPPORT PLATES

Material: EPM 203 / ROHACELL

- VERY LOW HEAT CONDUCTIVITY;
- GOOD MECHANICAL PROPERTIES;
- GOOD MECHANICAL STABILITY;
- GOOD MACHINING;

2) - LATERAL SUPPORT FRAME

Material: ALUMINUM SHAPED SHEETS

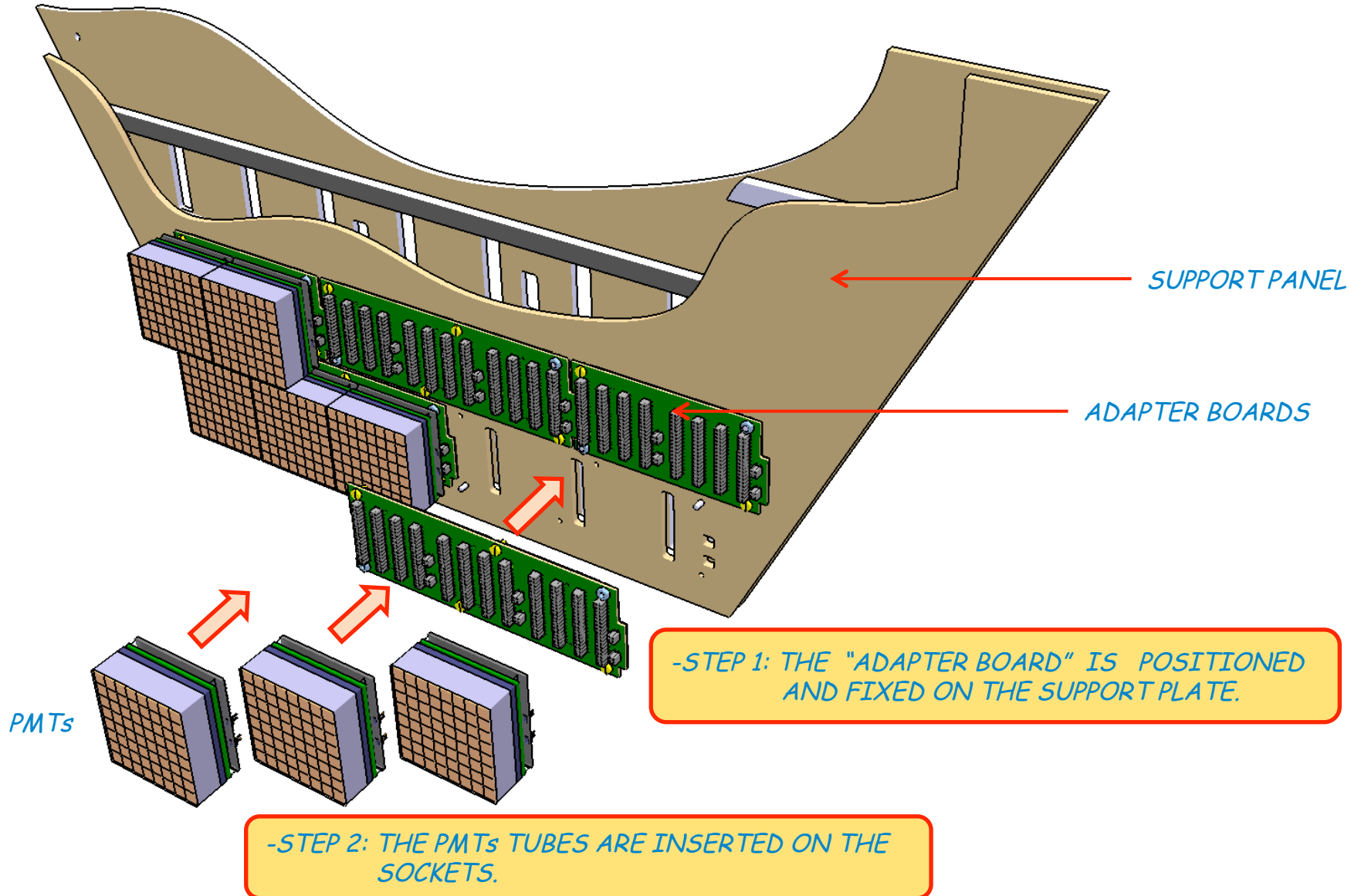
- MINIMIZATION OF THICKNESS;
- MAXIMIZATION OF STIFFNESS.

4) - REAR CLOSING PANEL

Material: KEVLAR

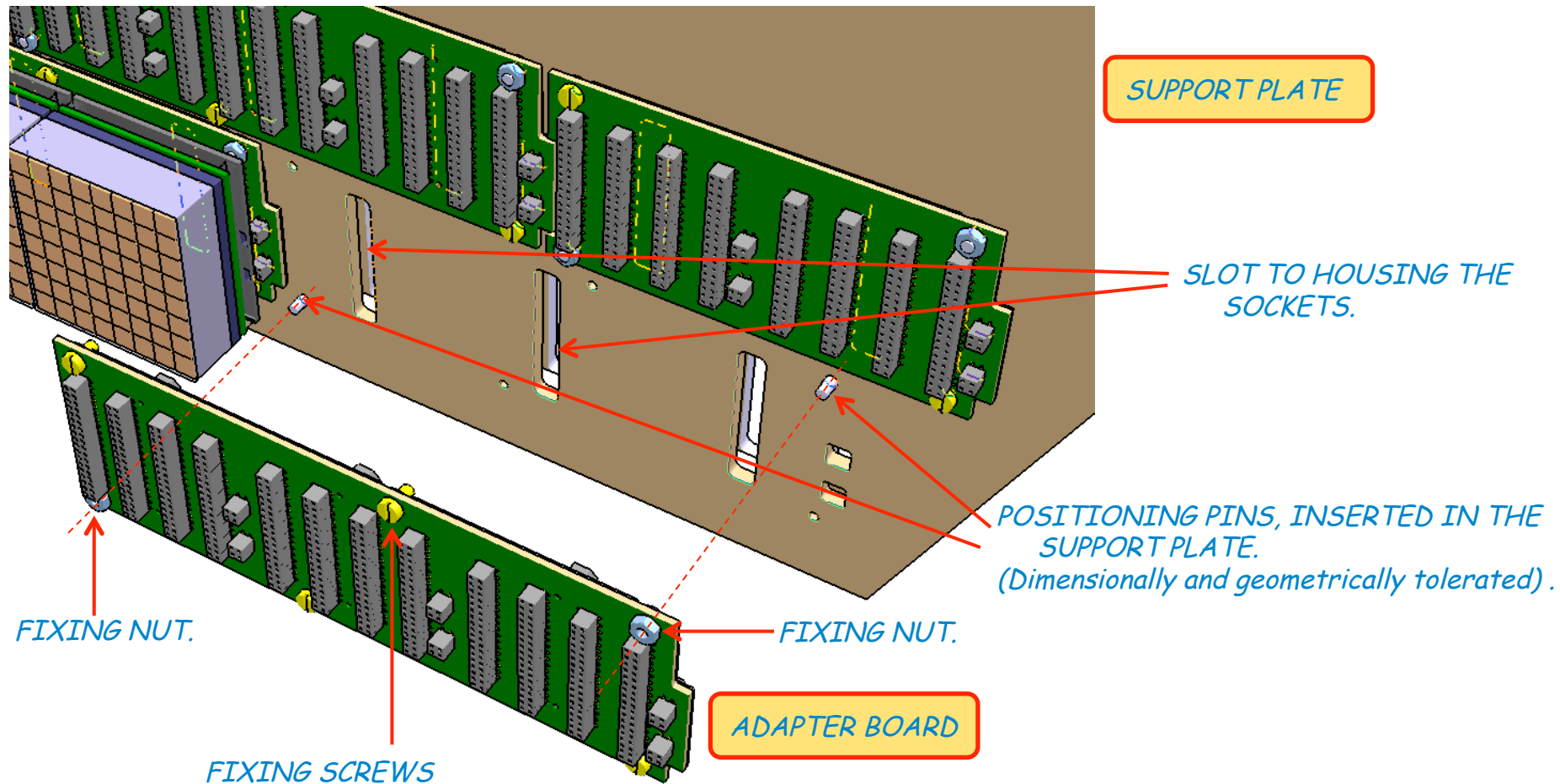
- VERY LOW HEAT CONDUCTIVITY;
- VERY LOW ELECTRIC CONDUCTIVITY.

# PMTs ELECTRONIC PANEL - BOARDS ASSEMBLY PROCEDURE DETAILS





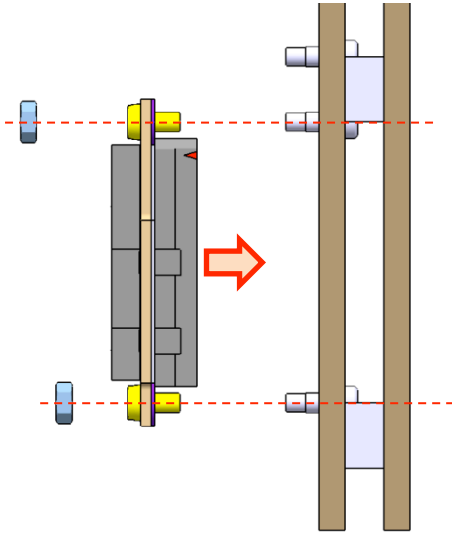
## PMTs ELECTRONIC PANEL - BOARDS ASSEMBLY PROCEDURE DETAILS



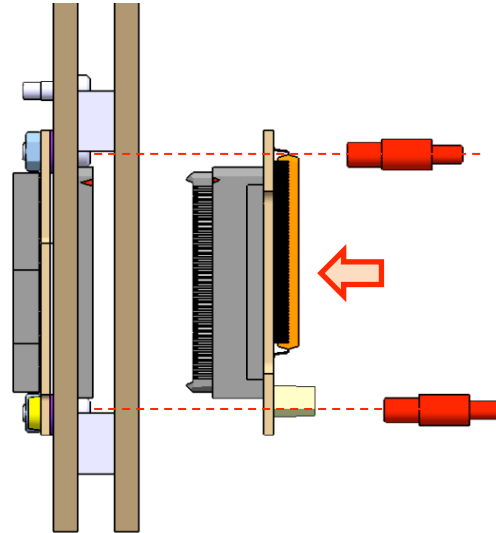
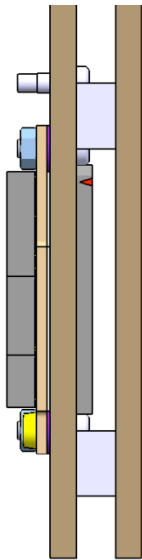
### THE ROLE OF THE ADAPTER BOARD IS CRUCIAL .....

- IT ALLOWS THE POSITIONING AND THE FIXING OF THE TILES ON THE SUPPORT PLATE;
- IT MUST ENSURE THE ACCURACY OF THE MUTUAL POSITION BETWEEN THE PMTs;
- IT MUST ENSURE THE "LIGHT TIGHT" BETWEEN THE "ADAPTER BOARD" AND THE SUPPORT PLATE.

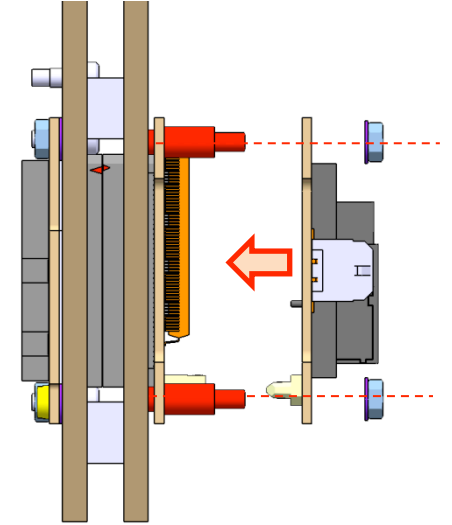
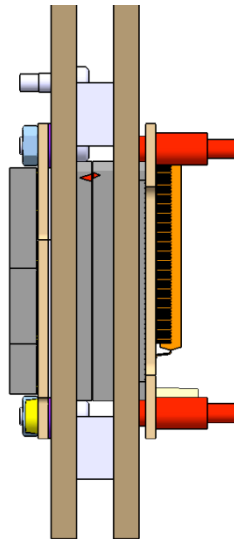
# PMTs ELECTRONIC PANEL - BOARDS ASSEMBLY PROCEDURE DETAILS



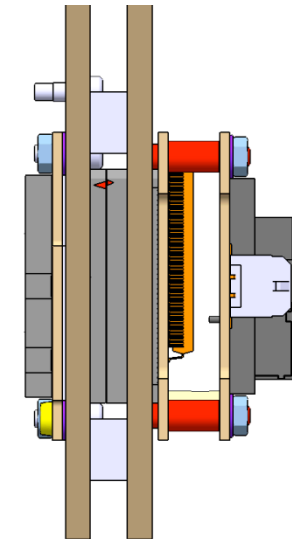
1) - THE ADAPTER BOARD IS POSITIONED AND FIXED ON THE SUPPORT PLATE .



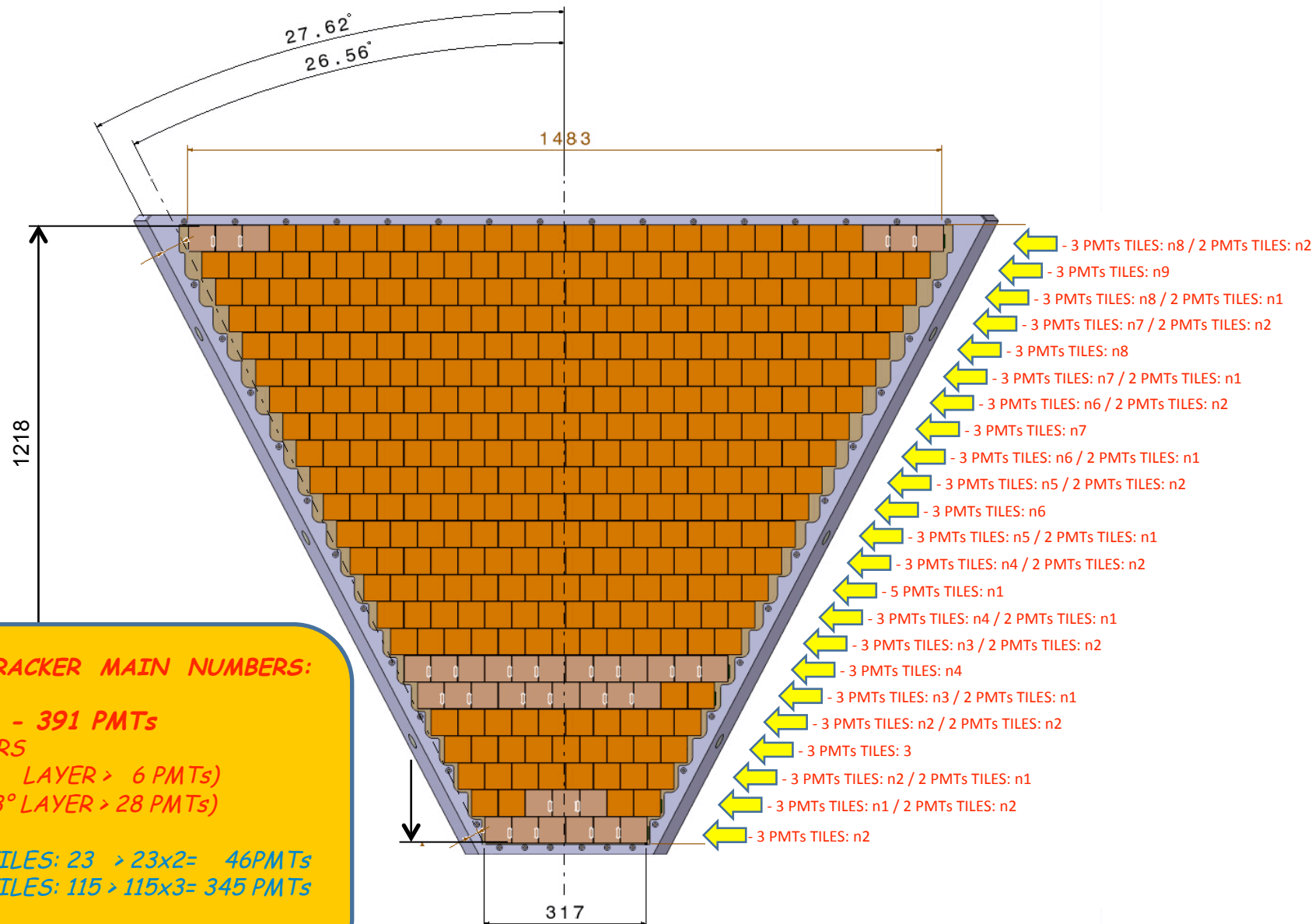
2) - THE ASIC BOARD IS POSITIONED AND FIXED ON THE SUPPORT PLATE .



3) - THE FPGA BOARD IS POSITIONED AND FIXED ON THE SUPPORT PLATE .



# PMTs ELECTRONIC PANEL - OVERALL ARRANGEMENT



**PMTs TRACKER MAIN NUMBERS:**

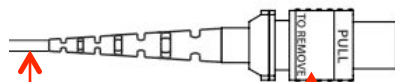
- 391 PMTs
- 23 LAYERS
- (1° LAYER > 6 PMTs)
- (23° LAYER > 28 PMTs)
- 2 PMTs TILES: 23 > 23x2= 46PMTs
- 3 PMTs TILES: 115 > 115x3= 345 PMTs
- (-3 PMTs TILES HAVE BEEN PREFERRED)

Front view  
Scale: 1:5

# PMTs ELECTRONIC PANEL: CABLES & AIR PIPES IDENTIFICATION

## -FIBER OPTIC CABLES (2 Cables each TILE)

MTP-LC Fiber Optic Cable - 12 Strand, 50/125µm 10Gb Multimode OM3, Plenum

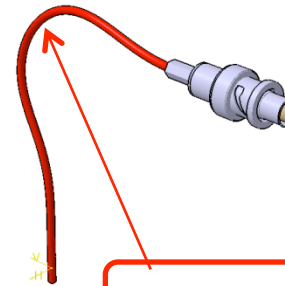


Fiber Connector

CLICK TO ZOOM

OUTER DIAMETER: 2mm

## -PMTs HW VOLTAGE CABLES (1 Cable each TILE)



OUTER DIAMETER: 2,5 mm

## -PMTs LOW VOLTAGE CABLES (1 Cable each TILE)



Customer Specification

PART NO. 58124

OUTER DIAMETER: 1,32mm

Construction

				Diameters (in)	
1) Component 1		4 X 1 COND			
a) Conductor		20 (7/0121) AWG BC		0.065	
b) Insulation		0.008" Wall, Nom. PVC, Plenum Rated		0.052	
(1) Color Code		Alpha Wire Color Code D2			
Cond	Color	Cond	Color	Cond	Color
1	BLACK	3	RED		
2	WHITE	4	GREEN		
2) Cable Assembly		4 Components Cabled			
a) Twists:		6.0 Twists/foot (min)			
3) Shield:		Alum/Mylar Tape, 25% Overlap, Min.			
a) Foil Facing		Foil Facing Out			
b) Drain Wire		22 (7/30) AWG TC			
4) Jacket		0.015" Wall, Nom. PVC, Plenum Rated		0.160 (0.168 Max.)	
a) Color(s)		SLATE			
b) Print		ALPHA WIRE- P/N 58124 4C 20 AWG SHIELDED 75C CMP(UL) C(UL) OR 75C (UL) CL2P CE ROHS * = Factory Code [Note: Product may have c(UL) or CSA markings depending upon plant of manufacture.]			

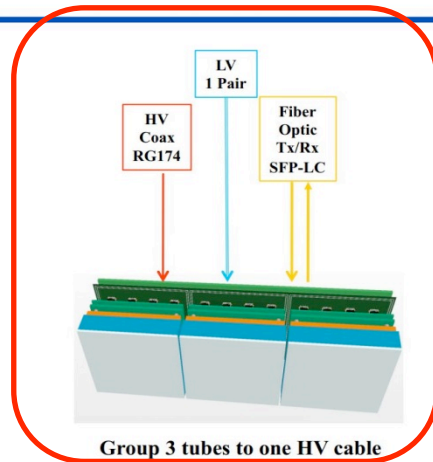
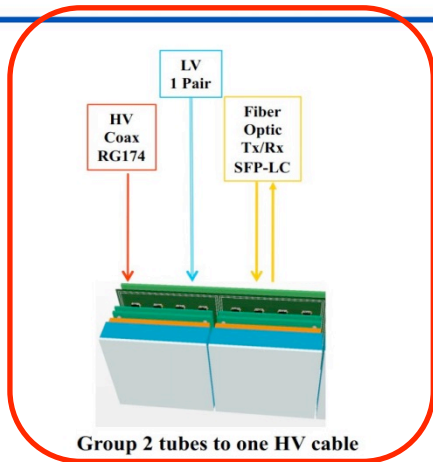
## - AIR PIPES (2 Pipes each PMTs Layer)



OUTER DIAMETER: 4 mm

# PMTs ELECTRONIC PANEL: CABLES QUANTIFYING

## Cable Interfaces to "Tile" Boards



Same cable interface for each Tile Type



$4\text{mm dia} > 16\text{mm}^2 \text{ each} > 16 \times 2 \times 23 \text{ layers} = 736\text{mm}^2$

-  $115 + 23 = 138$  HV COAX CABLES

$3\text{mm dia} > 9\text{mm}^2 \text{ each} > 9 \times 138 = 1242\text{mm}^2$

-  $115 + 23 = 138$  LV CABLES

$1,32\text{mm dia} > 1,75\text{mm}^2 \text{ each} > 1,75 \times 138 = 242\text{mm}^2$

-  $115 + 23 = 138 \times 2 = 276$  FIBER OPTIC CABLES

$2\text{mm dia} > 4\text{mm}^2 \text{ each} > 4 \times 276 = 1104\text{mm}^2$

For conservative reasons, the areas of the cables have been considered as square shape.

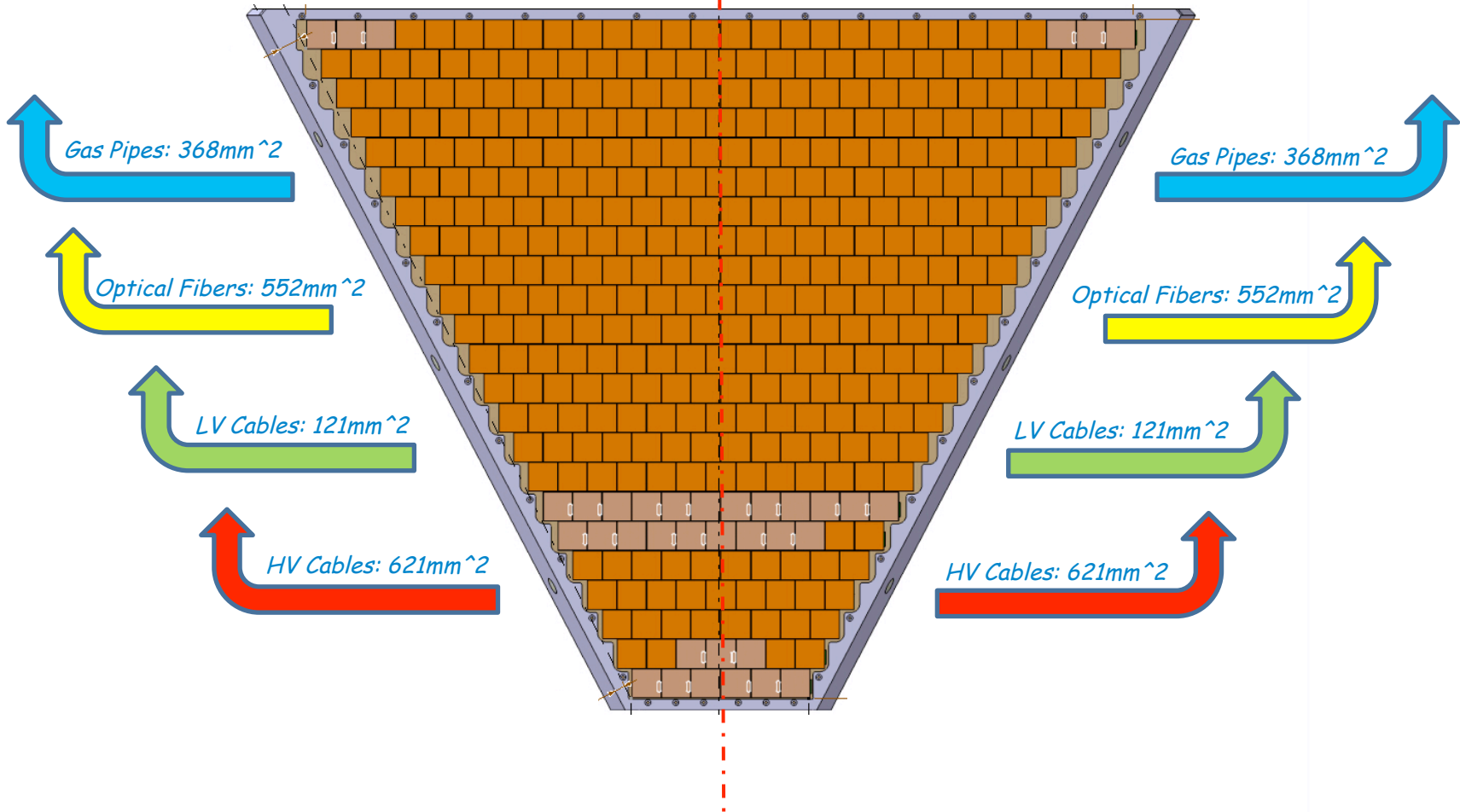
**TOTAL REQUIRED CROSS SECTION: 3324mm<sup>2</sup>**

# PMTs TRACKER - CABLES & GAS PIPES REQUIRED CROSS SECTION FOR EACH SIDE

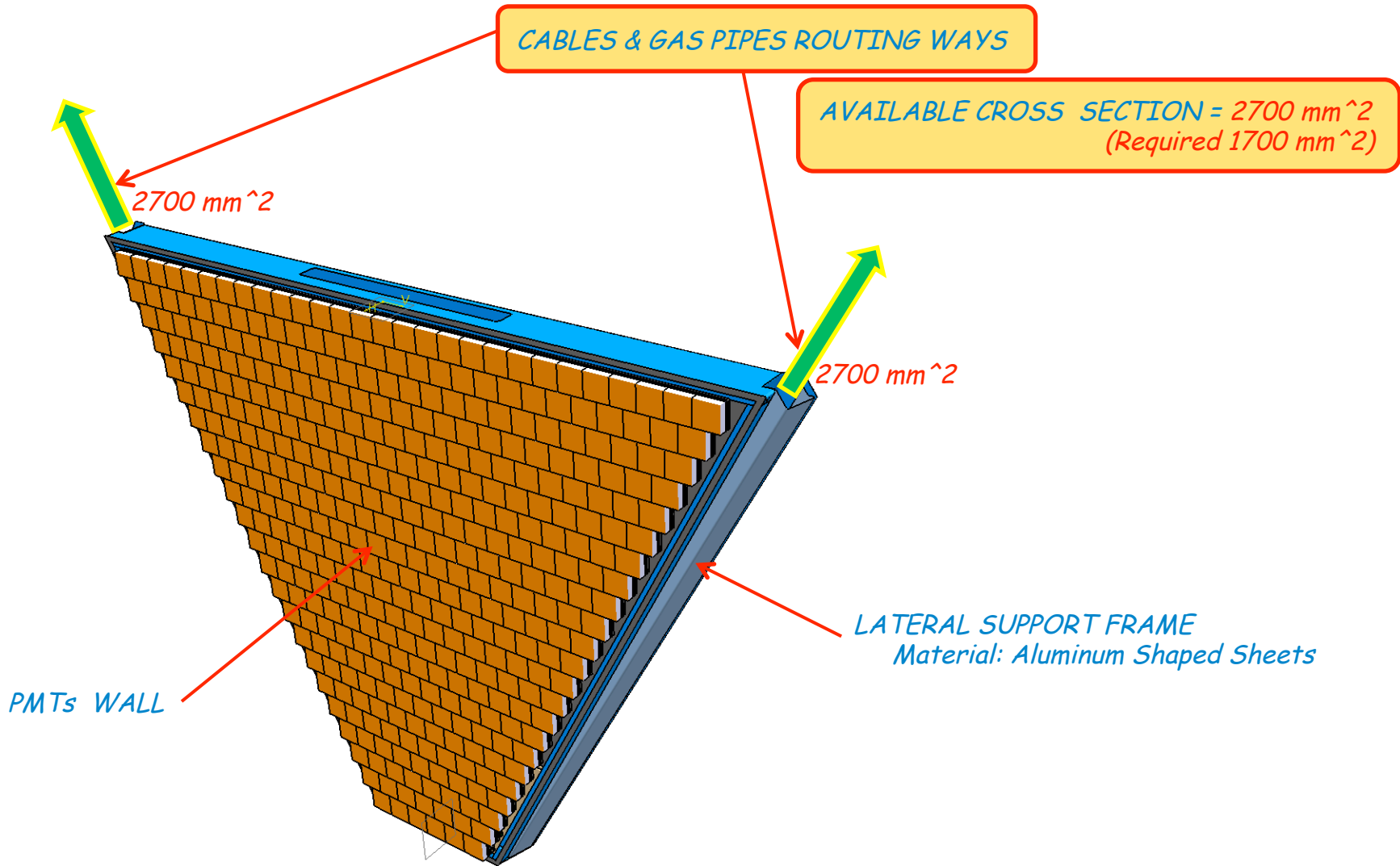
TOTAL REQUIRED CROSS SECTION:  $3324/2 = 1662\text{mm}^2$

-TOTAL REQUIRED CROSS SECTION:  $1700\text{mm}^2$

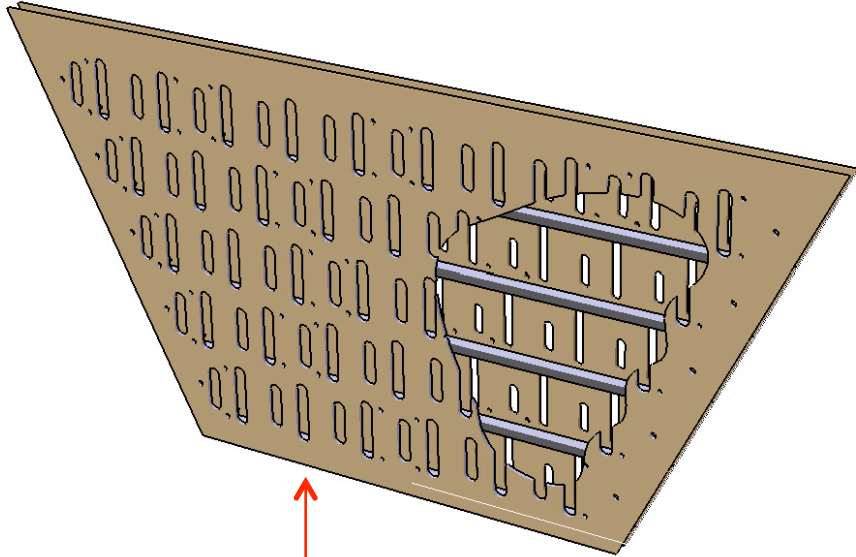
-TOTAL REQUIRED CROSS SECTION:  $1700\text{mm}^2$



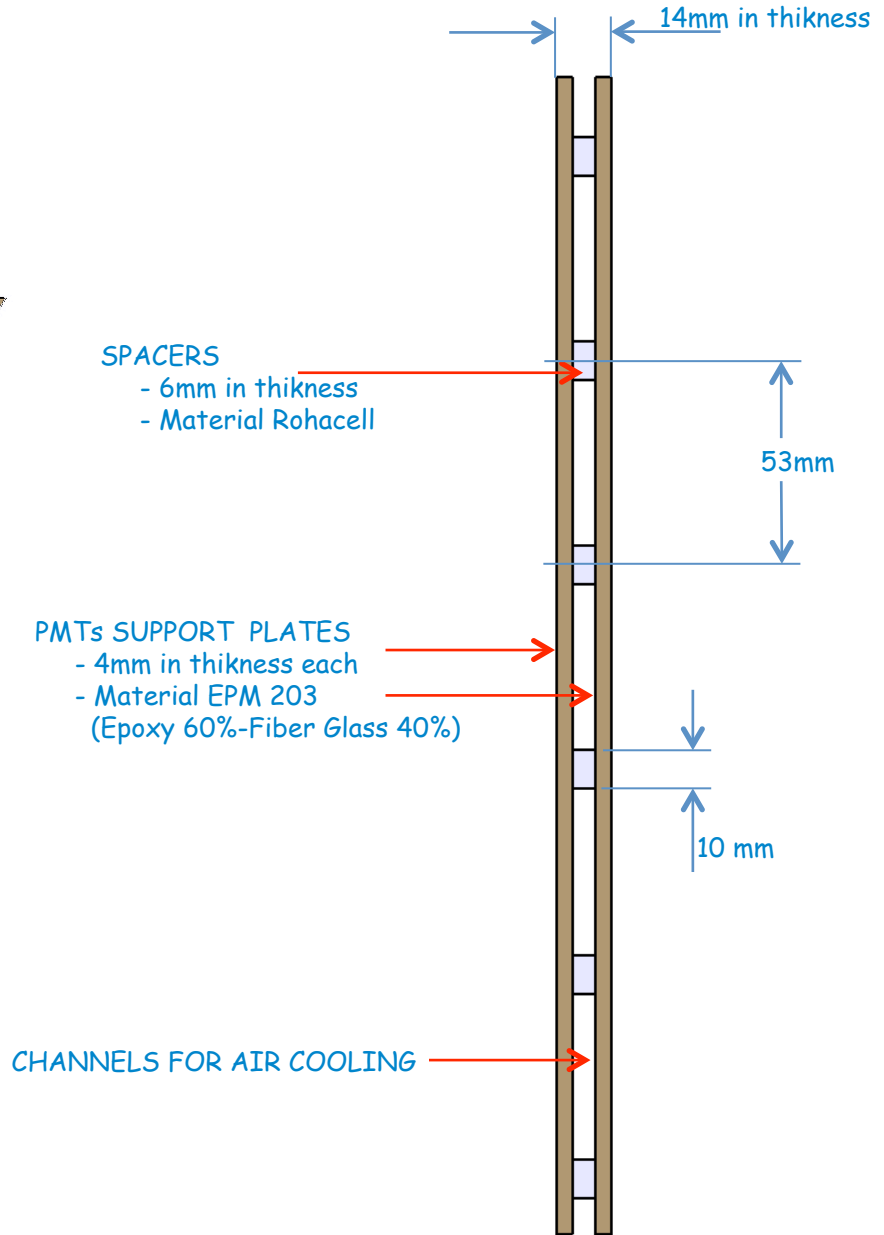
# PMTs TRACKER - CABLES & GAS PIPES ROUTING WAYS



# PMTs ELECTRONIC PANEL - SUPPORT PLATES



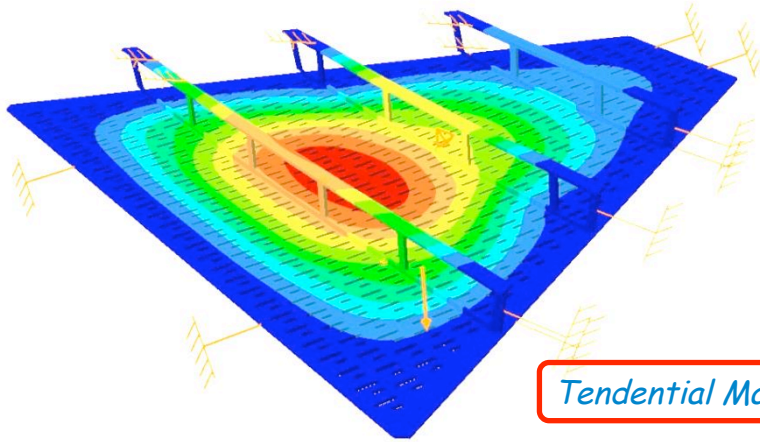
**PMTs SANDWICH SUPPORT PLATES**  
- Material EPM 203 / Rohacell



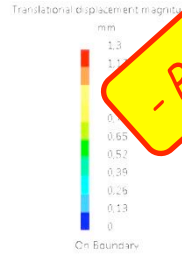


# PMTs ELECTRONIC PANEL - SUPPORT PLATES

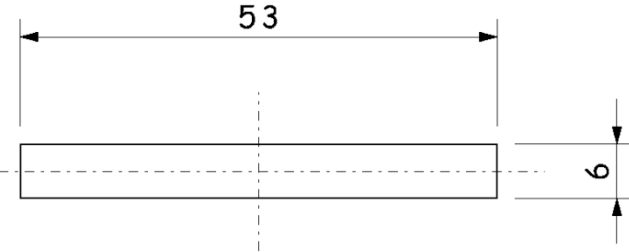
- SINGLE SUPPORT PLATE WITH STIFFNESS RIBS



Tendential Max Sagitta: 1,3mm

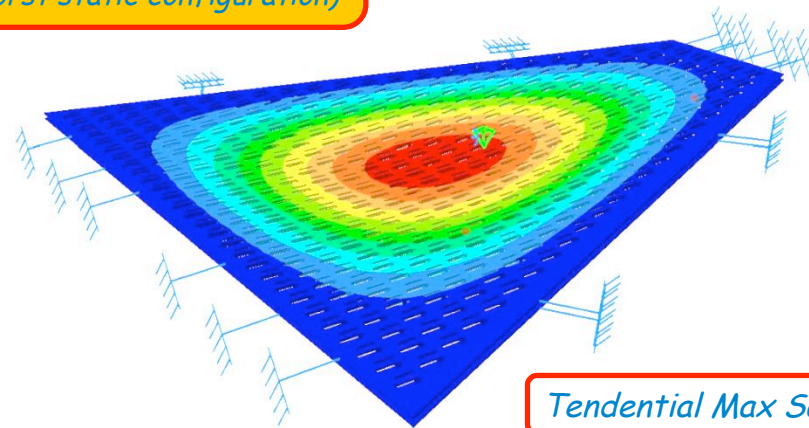


- PRELIMINARY -

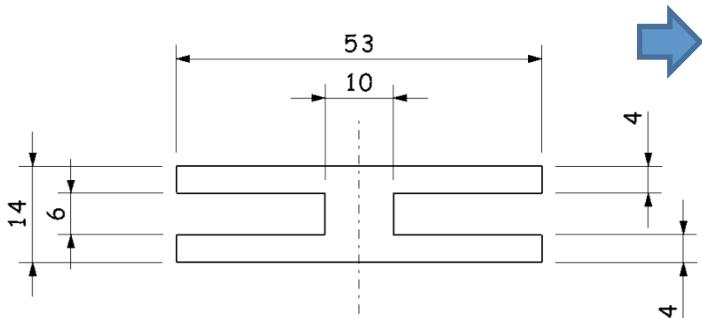
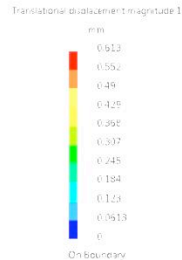


**SIGNIFICANT IMPROVEMENT IN STIFFNESS**  
Total load evaluated: 60 Kg  
(FEM model positioned in the worst static configuration)

- SANDWICH SUPPORT PLATES



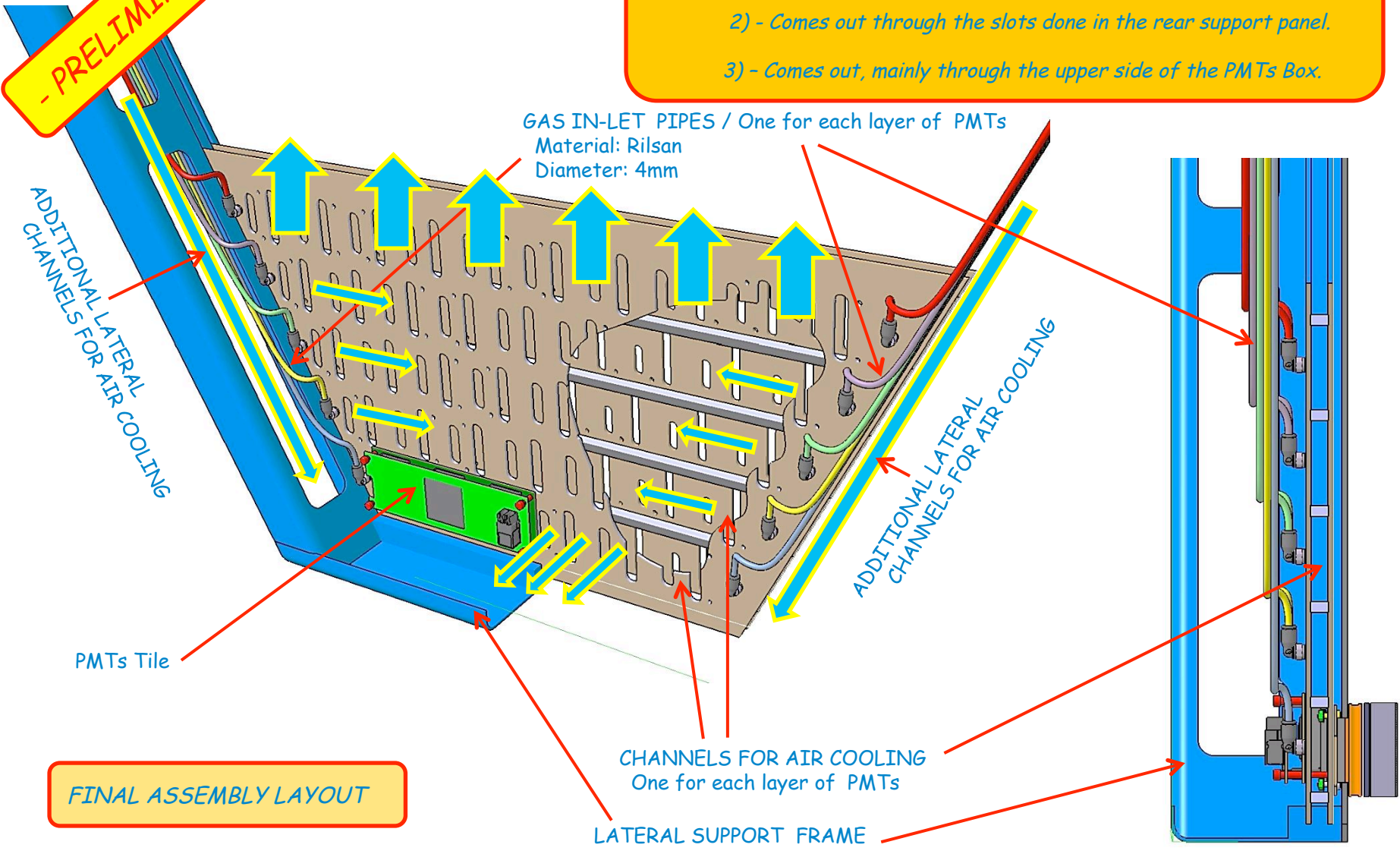
Tendential Max Sagitta: 0,65mm



# PMTs ELECTRONIC PANEL - COOLING SYSTEM HYPOTESIS

**- PRELIMINARY -**

- THE COOLING AIR:
  - 1) - Enters in each layer through the gas in-let pipes
  - 2) - Comes out through the slots done in the rear support panel.
  - 3) - Comes out, mainly through the upper side of the PMTs Box.



**FINAL ASSEMBLY LAYOUT**

## PMTs ELECTRONIC PANEL - NEXT STEPS

1) - COMPLETION OF THE COMMON MECHANICAL AND ELECTRONIC DESIGN ....

2) - SOFTWARE SIMULATION OF THE AIR COOLING SYSTEM .....

3) - REALIZATION OF A PROTOTYPE.



4) - DEVELOPMENT OF THE CONSTRUCTIVE DESIGN.....

5) - TENDER WITH COMPANYS AND REALIZATION.....

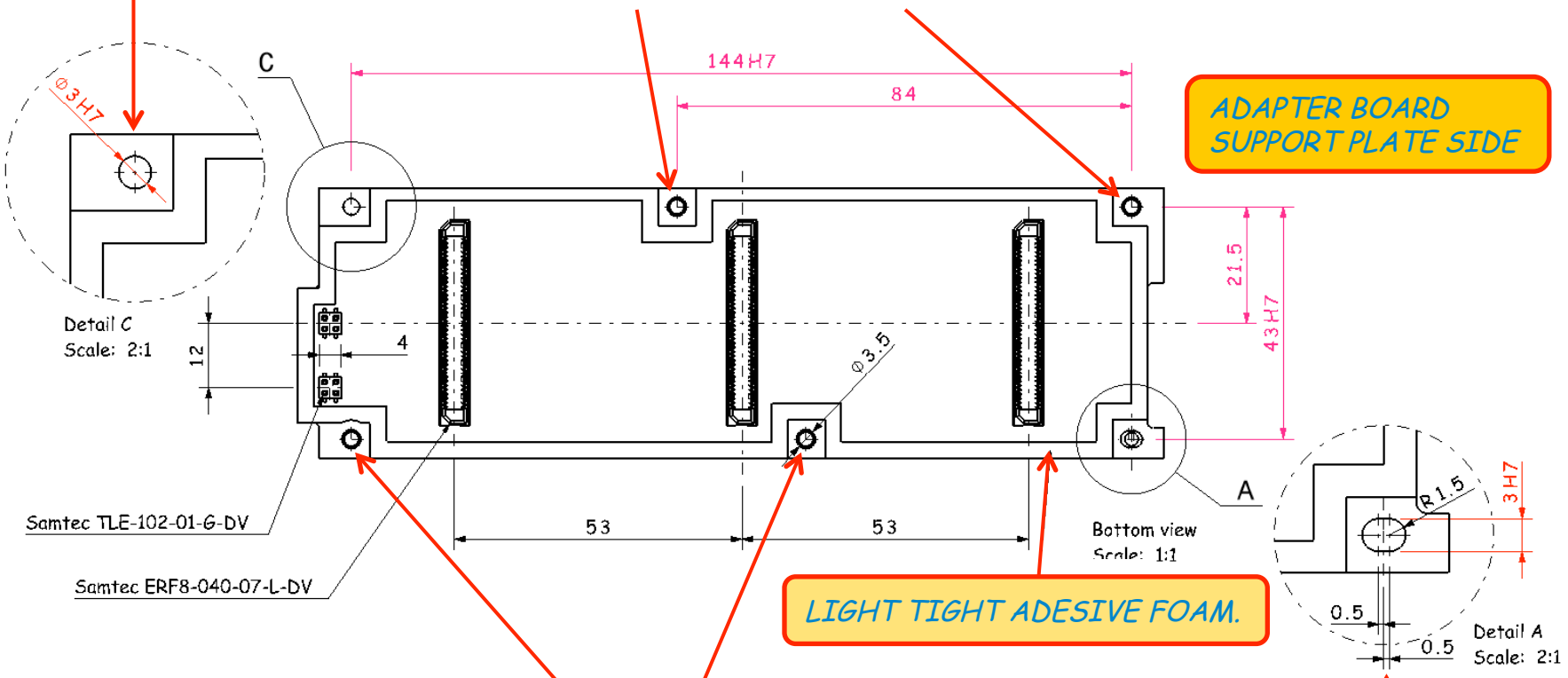
# SPARE SLIDES

# PMTs ELECTRONIC PANEL - ADAPTER BOARD DETAILS

HOLE FOR POSITIONING PIN  
(DIMENSIONALLY AND GEOMETRICALLY TOLERATED).

HOLE FOR FASTENING SCREWS.

ADAPTER BOARD  
SUPPORT PLATE SIDE

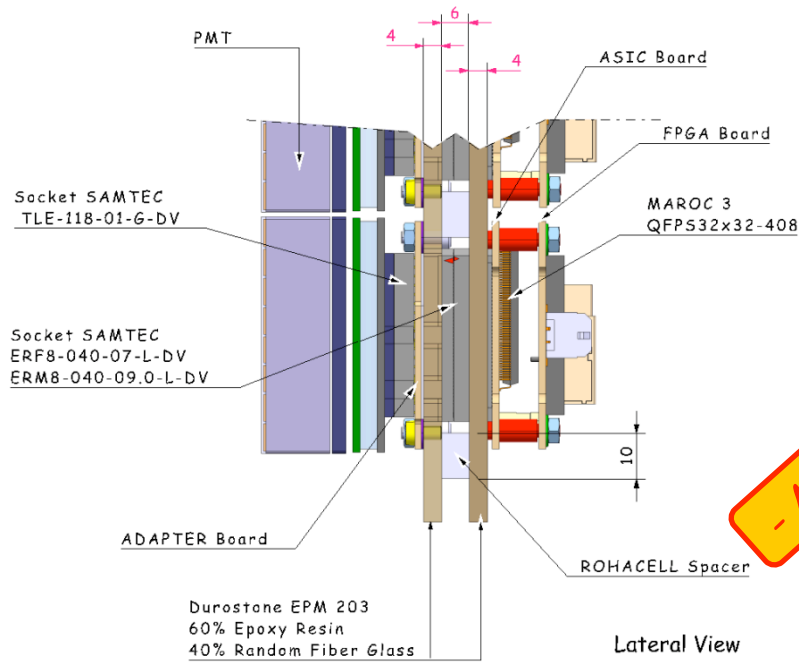


LIGHT TIGHT ADESIVE FOAM.

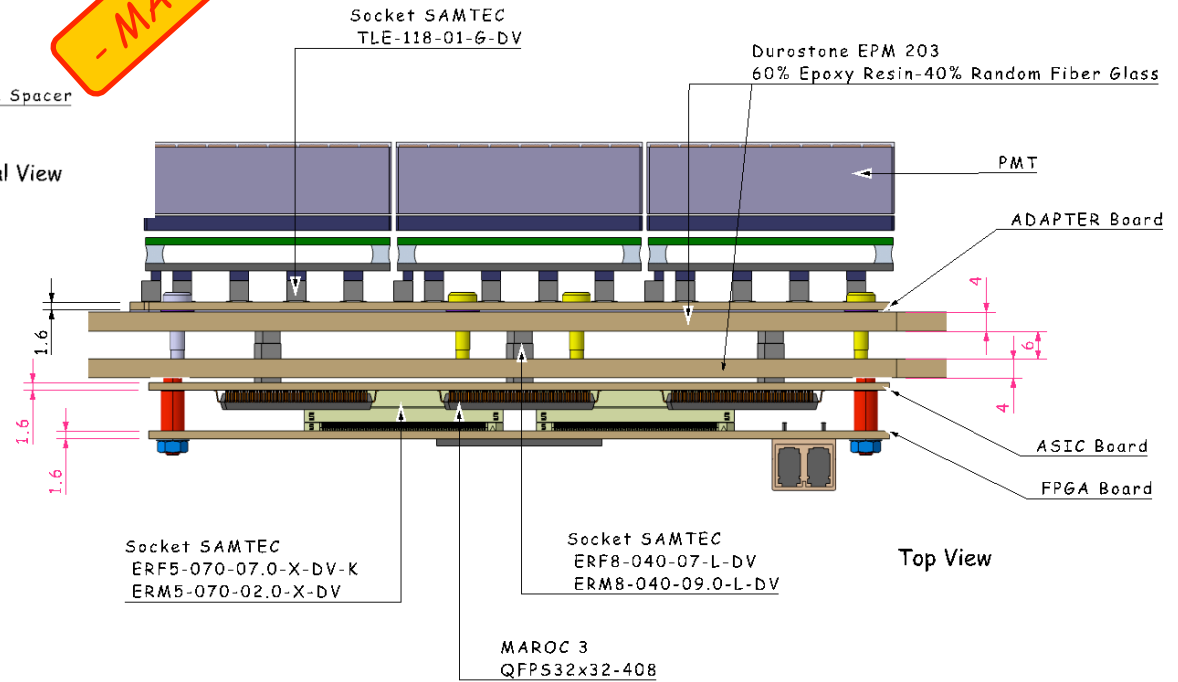
HOLE FOR FASTENING SCREWS.

SLOT FOR POSITIONING PIN.  
(DIMENSIONALLY AND GEOMETRICALLY TOLERATED).

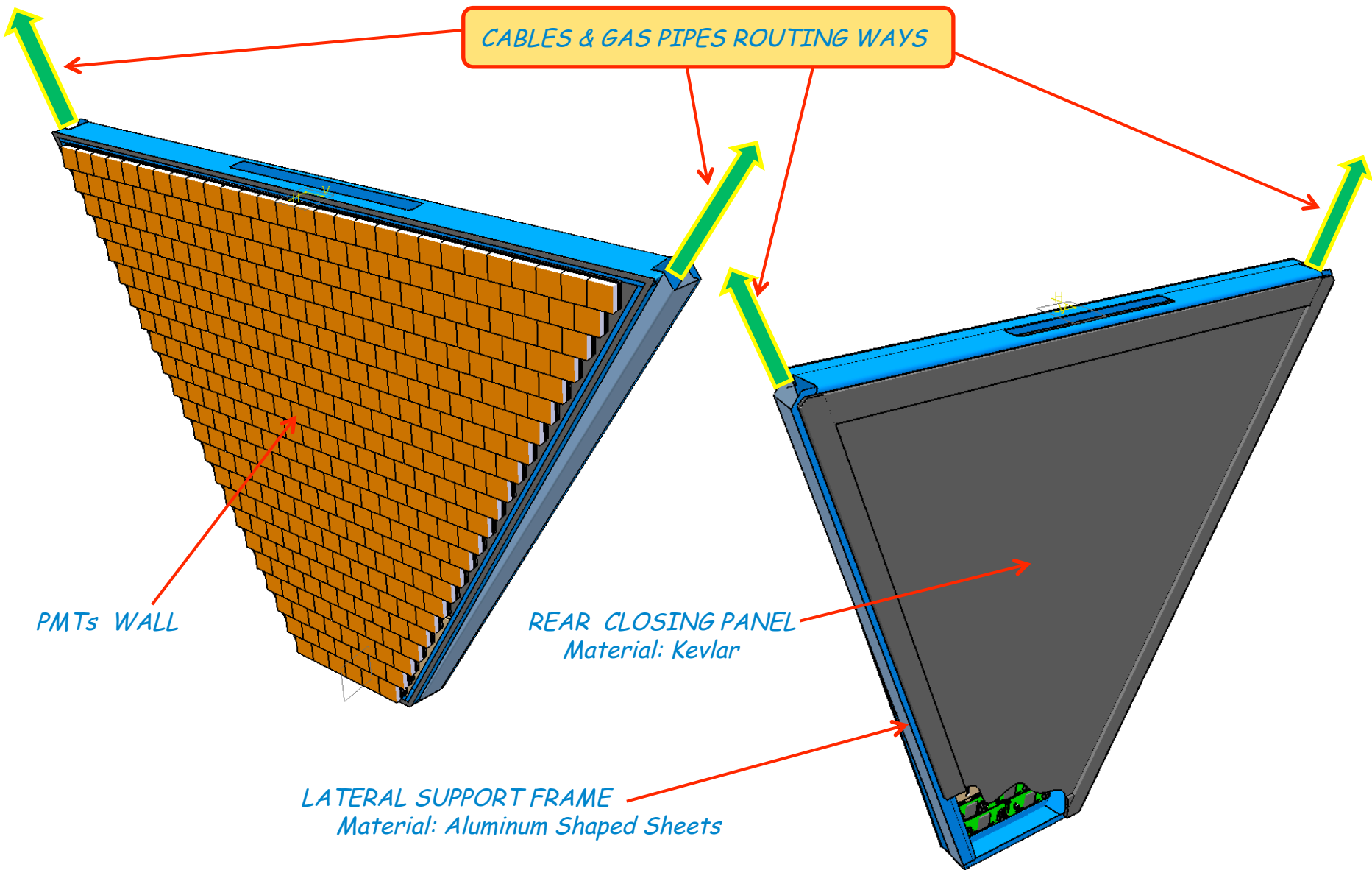
# PMTs ELECTRONIC PANEL - PMTs TILES OVERALL ASSEMBLY



**- MATERIAL BUDGET ??-**

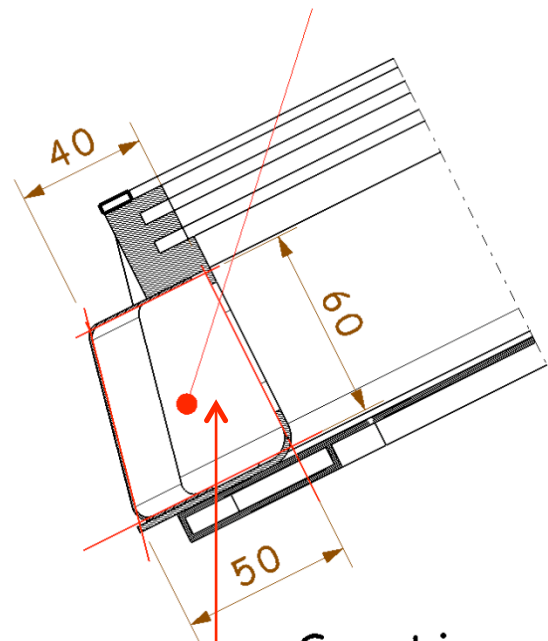


PMTs TRACKER - CABLES & GAS PIPES ROUTING WAYS



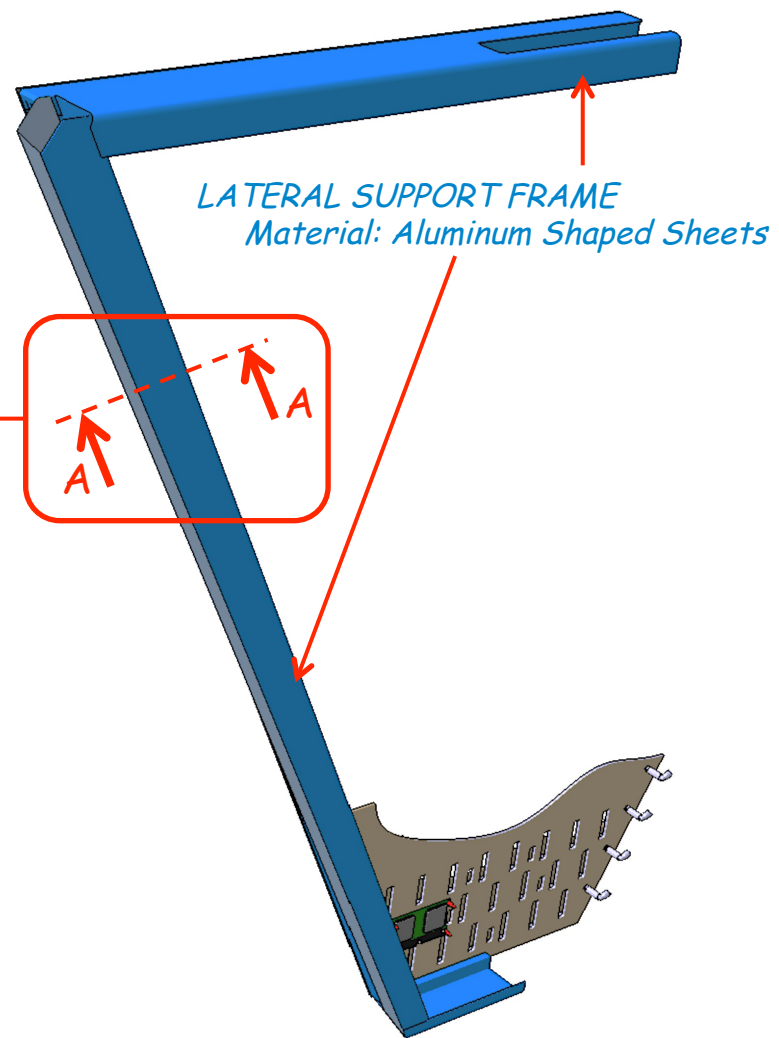
PMTs TRACKER - CABLES & GAS PIPES: VERIFYING OF REQUIRED CROSS SECTION

$$(50+40) \times 60 = 5400 / 2 = 2700 \text{ mm}^2$$

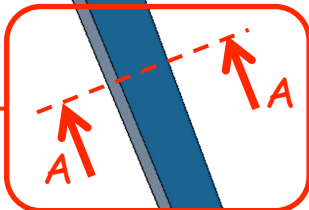


Section view A-A

-LATERAL AVAILABLE CROSS SECTION = 2700 mm<sup>2</sup>  
(Required 1700 mm<sup>2</sup>)



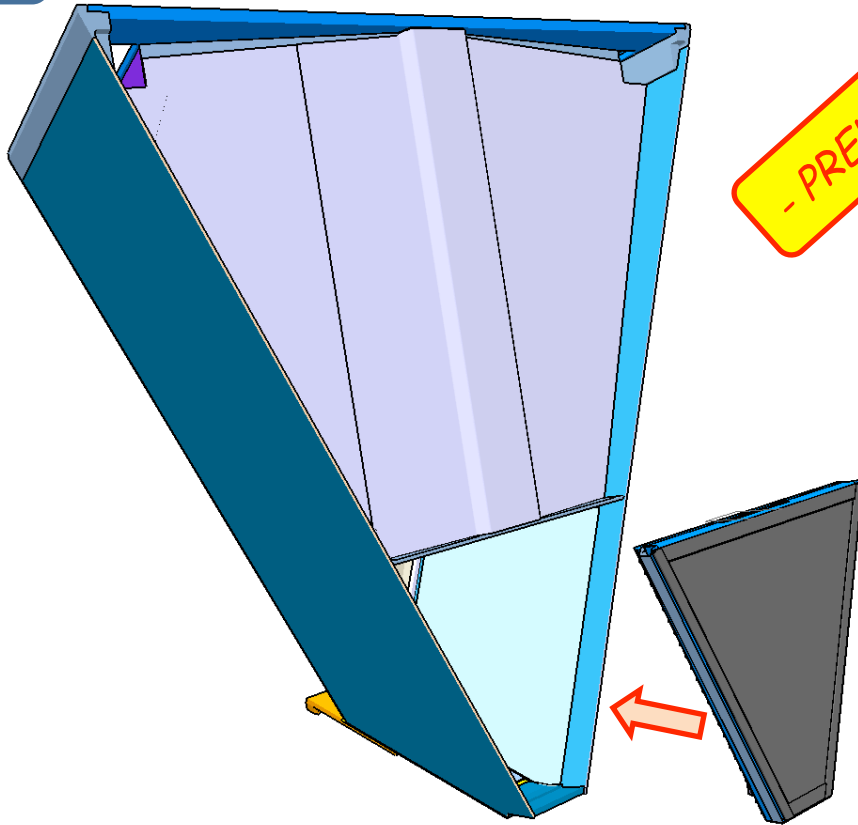
LATERAL SUPPORT FRAME  
Material: Aluminum Shaped Sheets





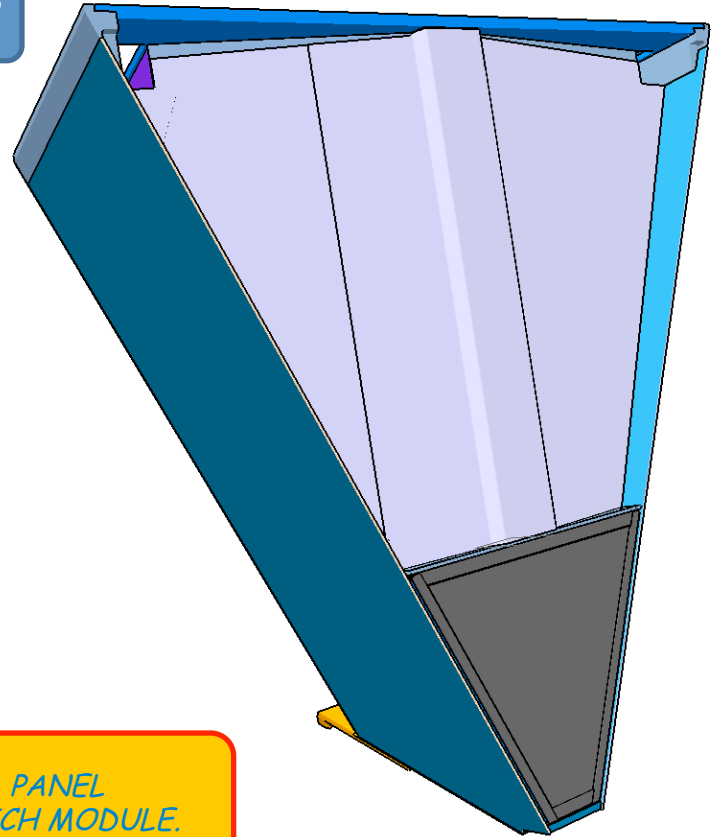
PMTs ELECTRONIC PANEL - LAST STEP: ASSEMBLY IN THE RICH MODULE

1°

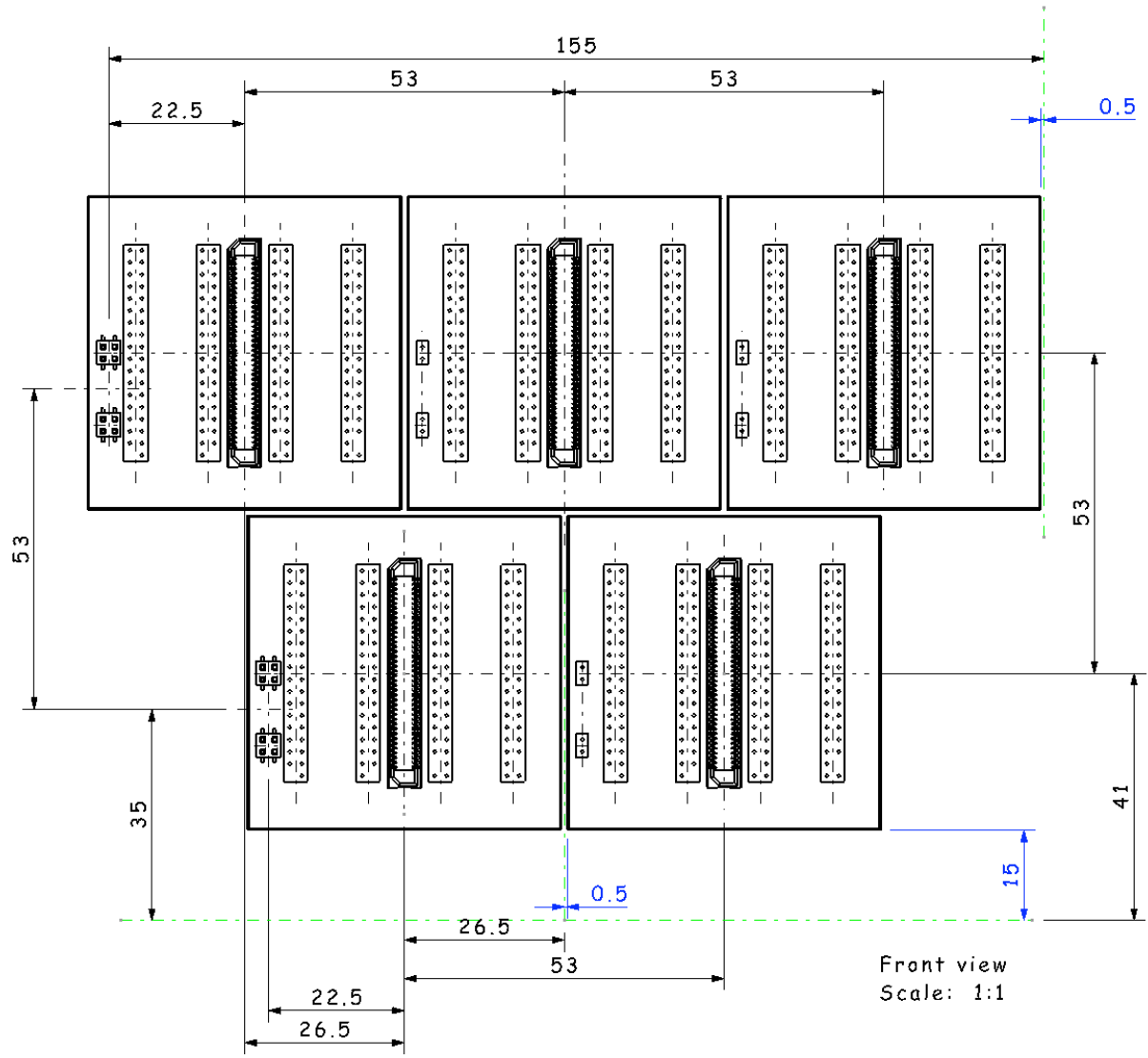


- PRELIMINARY -

2°



- A SELF SUPPORTING PMTs ELECTRONIC PANEL IS HOUSED AND FIXED IN THE RICH MODULE.



Front view  
 Scale: 1:1

PRELIMINARY

*PMTs ELECTRONIC PANEL WEIGHTS:*

2 PMTs TILE: 1)- TRANSITION BOARD > 0,030  
2)- ASIC BOARD > 0,035  
3)- FPGA BOARD > 0,030  
4)- PMTs H8500D 0,105x2 => 0,215

---

Total weight: 0,31 Kg

- 3 PMTs TILE: 1)- TRANSITION BOARD > 0,040  
2)- ASIC BOARD > 0,045  
3)- FPGA BOARD > 0,040  
4)- PMTs H8500D 0,105x3 => 0,315

---

Total weight: 0,44 Kg

- 2 PMTs TILES: 23 >  $23 \times 0,31 = 7,13$  > 8 Kg

- 3 PMTs TILES: 115 >  $115 \times 0,44 = 50,6$  > 51 Kg

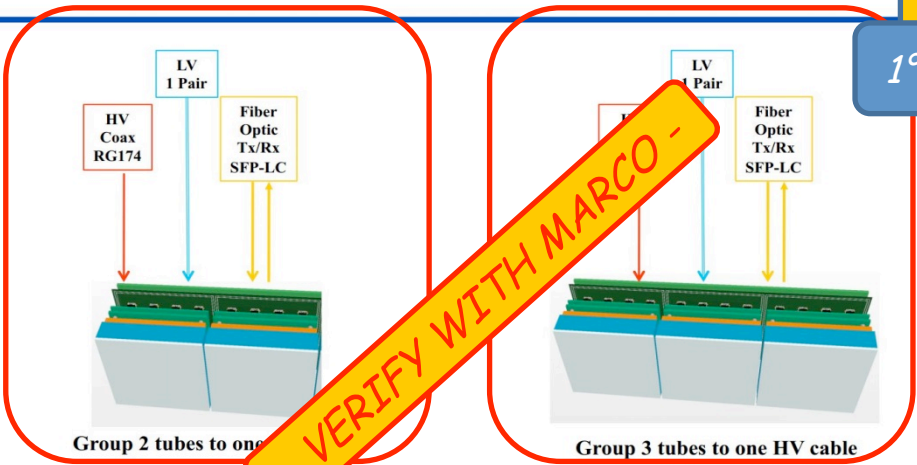
---

Total weight: 60Kg

*(-The cables weight have not been still considered.)*

# PMTs ELECTRONIC PANEL: CABLES QUANTIFYING

## Cable Interfaces to "Tile" Boards



**1°** - CHRIS CUEVAS HYPOTHESIS:  
ONE HV CABLE FOR EACH PMT

**2°** - ALTERNATIVE HYPOTHESIS:  
ONE HV CABLE FOR EACH PMT

- IN TOTAL:  
> 391 PMTs = **391 HV COAX**  
> 115 + 23 = 138 LV  
> 115 + 23 = 138 FIBER OPTIC

Same cable interface for each Tile Type



**-FOR N.23 2PMTs TILE:**

- > 23 HV COAX
- > 23 LV
- > 23 FIBER OPTIC

**-FOR N.115 3PMTs TILE:**

- > 115 HV COAX
- > 115 LV
- > 115 FIBER OPTIC

**- IN TOTAL:**

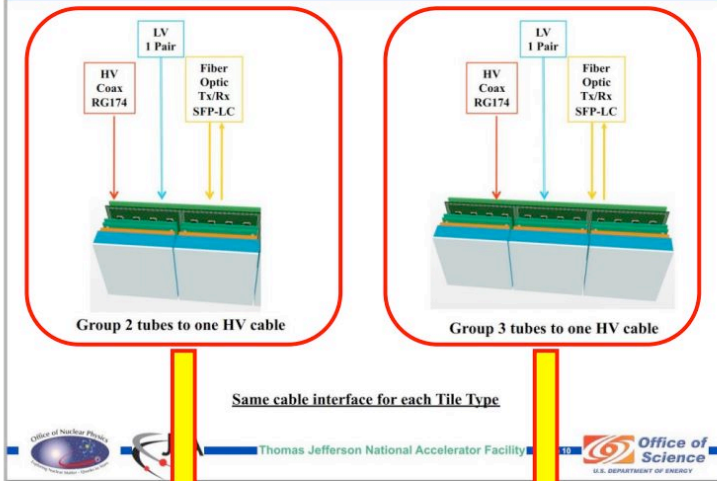
- > 115 + 23 = **138 HV COAX**
- > 115 + 23 = 138 LV
- > 115 + 23 = 138 FIBER OPTIC

**138 Versus 391 HV COAX**

CHRIS CUEVAS HYPOTHESIS

1°

Cable Interfaces to "Tile" Boards



**- VERIFY WITH MARCO -**

4mm dia > 16mm<sup>2</sup> each > 16x2x23 layers = 740mm<sup>2</sup>

-FOR N.23 2PMTs TILE :  
 > 23 HV COAX  
 > 23 LV  
 > 23 FIBER OPTIC

-FOR N.115 3PMTs TILE:  
 > 115 HV COAX  
 > 115 LV  
 > 115 FIBER OPTIC

- IN TOTAL:  
 > 115 + 23= 138 HV COAX  
 > 115 + 23= 138 LV  
 > 115 + 23= 138 FIBER OPTIC

3mm dia > 9mm<sup>2</sup> each > 9x138 = 1250mm<sup>2</sup>

1,32mm dia > 1,75mm<sup>2</sup> each > 1,75x138 = 245mm<sup>2</sup>

Single tract 2mm dia > 4mm<sup>2</sup> each > 4x138 = 560mm<sup>2</sup>  
 12 wire tracts

For conservative reasons , the areas of the cables have been considered as square shape.