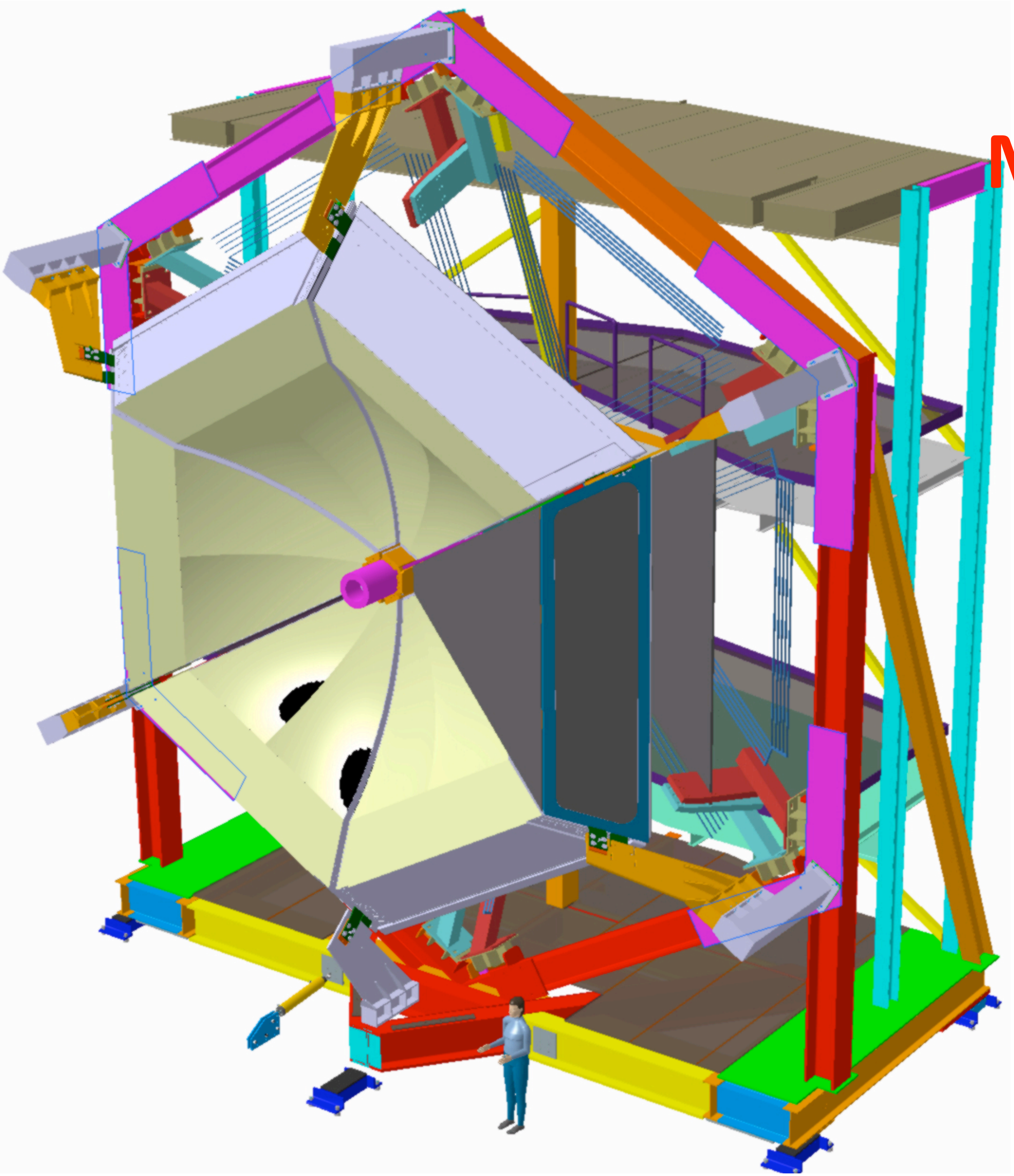


CLAS12-RICH Mechanical Design Status-Report

Technical Review

June 25-26th 2013

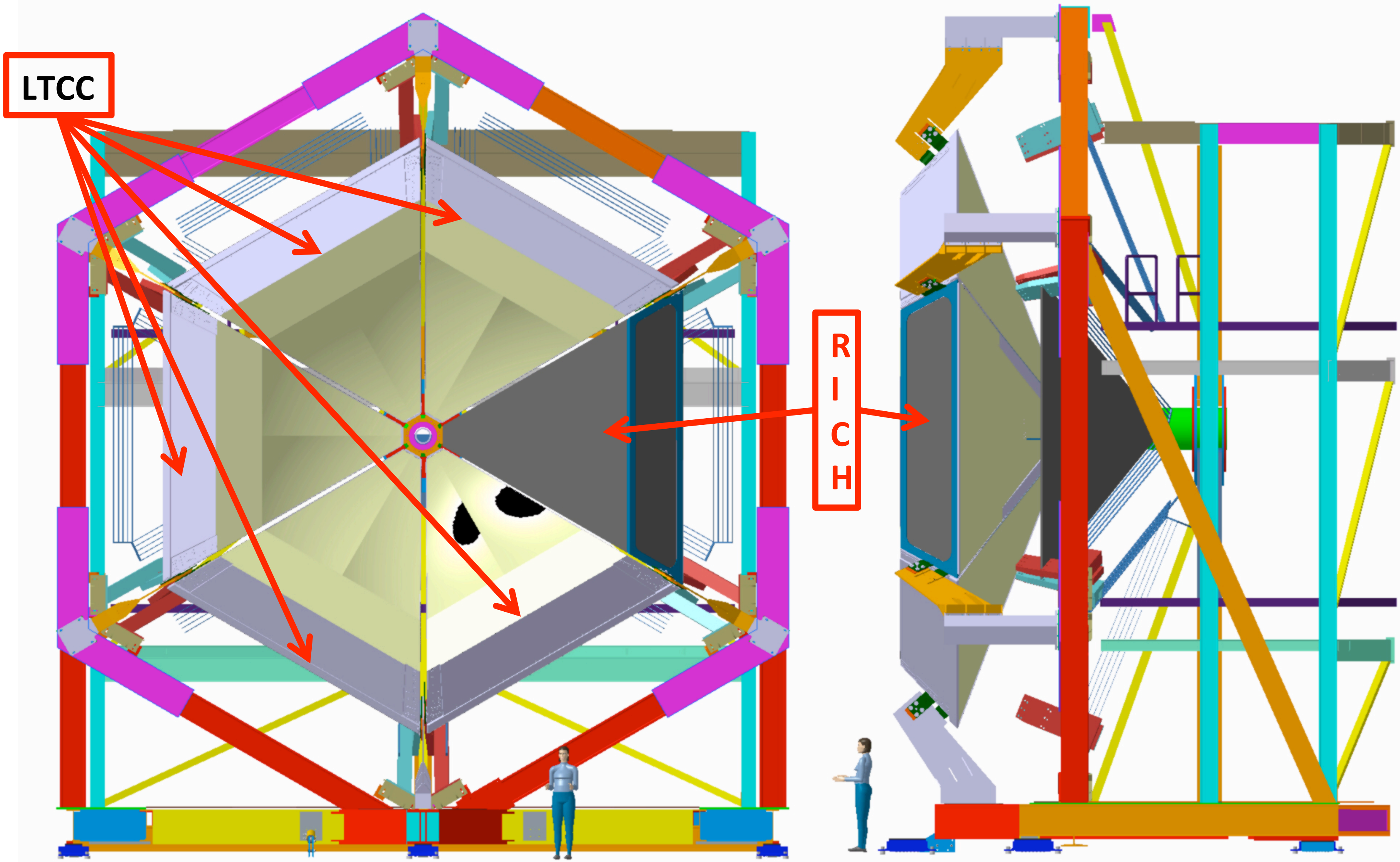
D. Orecchini, S. Tomassini

Outline

- Mechanical Integration in CLAS12
- CFRP Mirror Substrate Optimization
- CFRP mirror substrate Industrial feasibility
- Reflective film coating issue
- Alternative solutions to CFRP mirror substrate
- Conclusions

Mechanical Integration

RICH: Mechanical Integration In CLAS-12

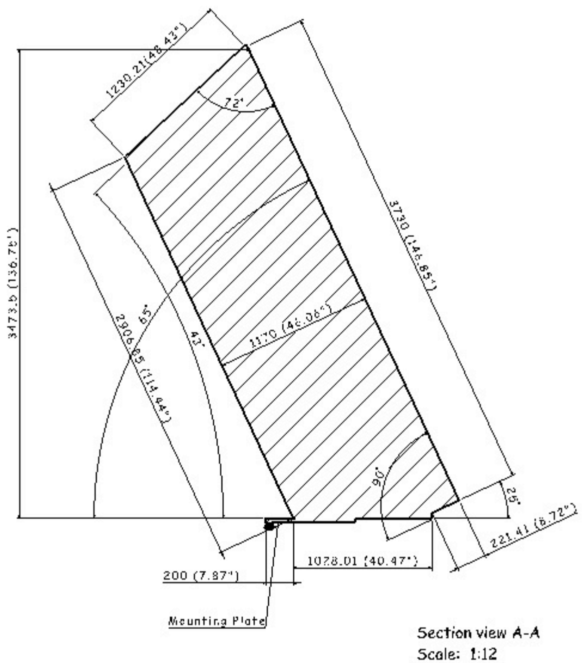


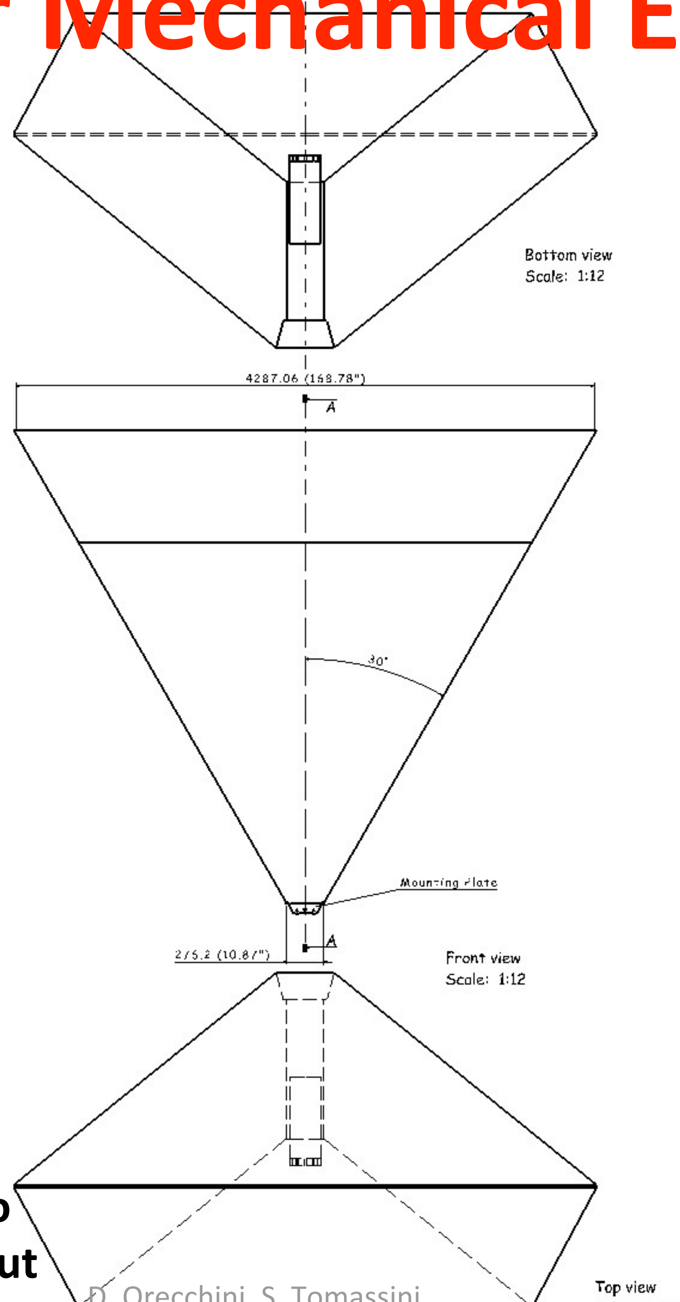
Frontal view

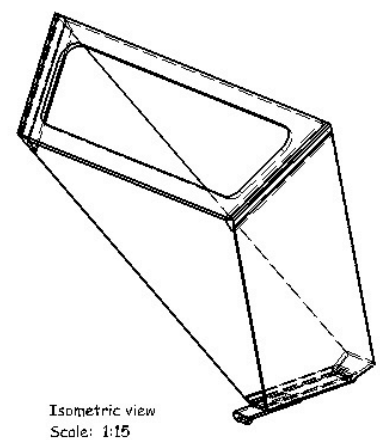
Side view

RICH: Outer Mechanical Envelope

The RICH outer envelope is almost the same as the LTCC envelope







The RICH envelope is fully compatible with the LTCC constraints. Can be constrained to the forward carriage frame without any modification of the frame itself

RICH Module: preliminary Weight Evaluation.

RICH MODULE: STRUCTURAL COMPONENTS WEIGHTS EVALUATION	
OUTER FRAME	216 Kg
LATERAL PLATES	174+174=348 Kg
OUTER FRAME CONNECTION PROFILES	50+50K=100 Kg
INNER SUPPORT PLATE_1	33 Kg
INNER SUPPORT PLATE_2	11 Kg
FORWARD LONG STIFFENER PROFILES	102+102= 204 Kg
AEROGEL PANEL CONNECTION PROFILES	10+10= 20 Kg
TOTAL WEIGHT	932 > **1000Kg**
ALUMINUM ALLOY: 2710 Kg/m^3	
AISI 317 (Amagnetic Stainless Alloy): 7860Kg/m^3	

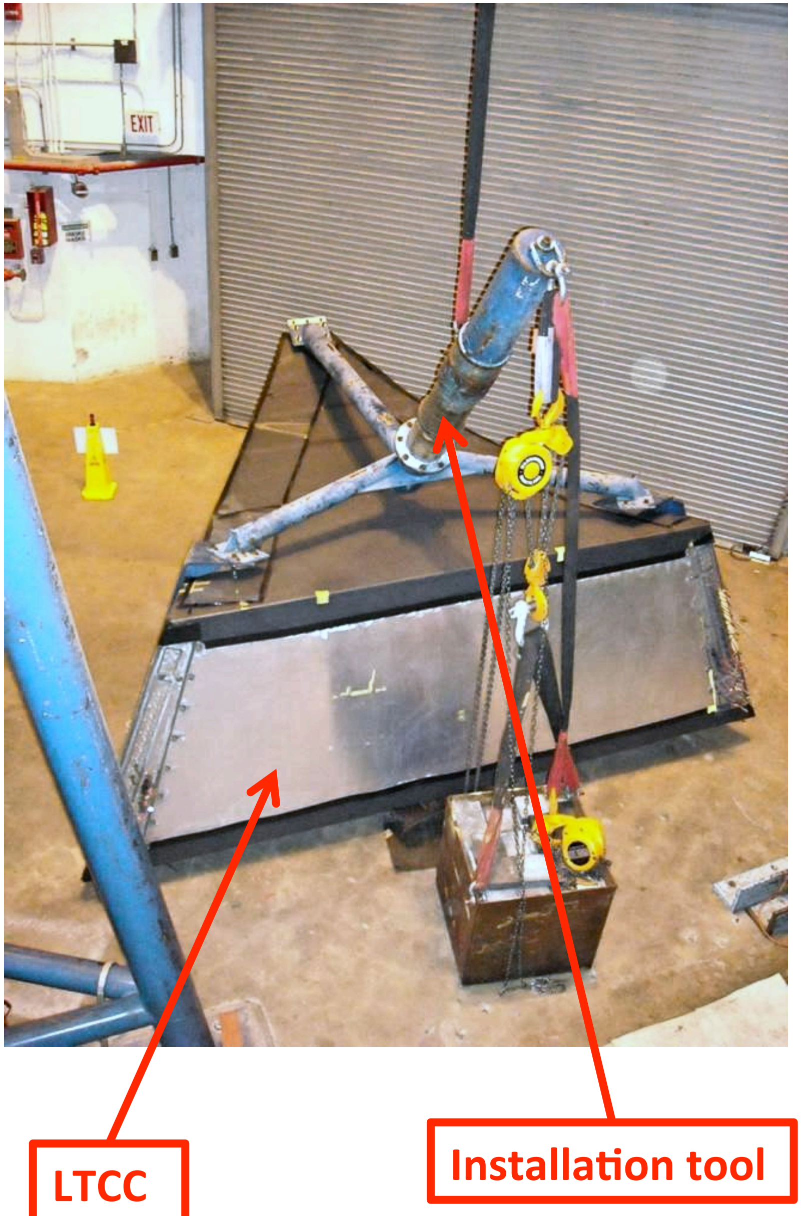
RICH MODULE: PMTs SYSTEM WEIGHTS EVALUATION	
PMTs 8500 Hamamatzu (125g / Each)	(408PMTs) - 51 Kg
FE-ELECTRONIC CARDS	40 Kg
HV - LV CABLES	50 Kg
SUPPORT PANEL	30 Kg
SUPPORT FRAME	30 Kg
TOTAL WEIGHT	**201 Kg**
VETRONITE FR4: 1950 Kg/m^3 (1,95g/m^3)	
DUROSTONE EPM203: 1850 Kg/m^3 (1,85g/m^3)	
ALUMINUM ALLOY: 2710 Kg/m^3	

RICH weight ≅ LTCC weight

RICH MODULE: COMPOSITE COMPONENTS WEIGHTS EVALUATION	
OUTER CLOSING PANEL	13 Kg
FORWARD CLOSING PANEL	35 Kg
BACKWARD PLANAR MIRROR	18 Kg
SPHERICAL MIRROR	15 Kg
AEROGEL TILES (82 Tiles 200x200mm)	36 Kg
TOTAL WEIGHT	**117 Kg**
ROHACELL 51 IG: 52 Kg / m^3	
CARBON FIBERS (Typical Values): 1750 Kg / m^3	

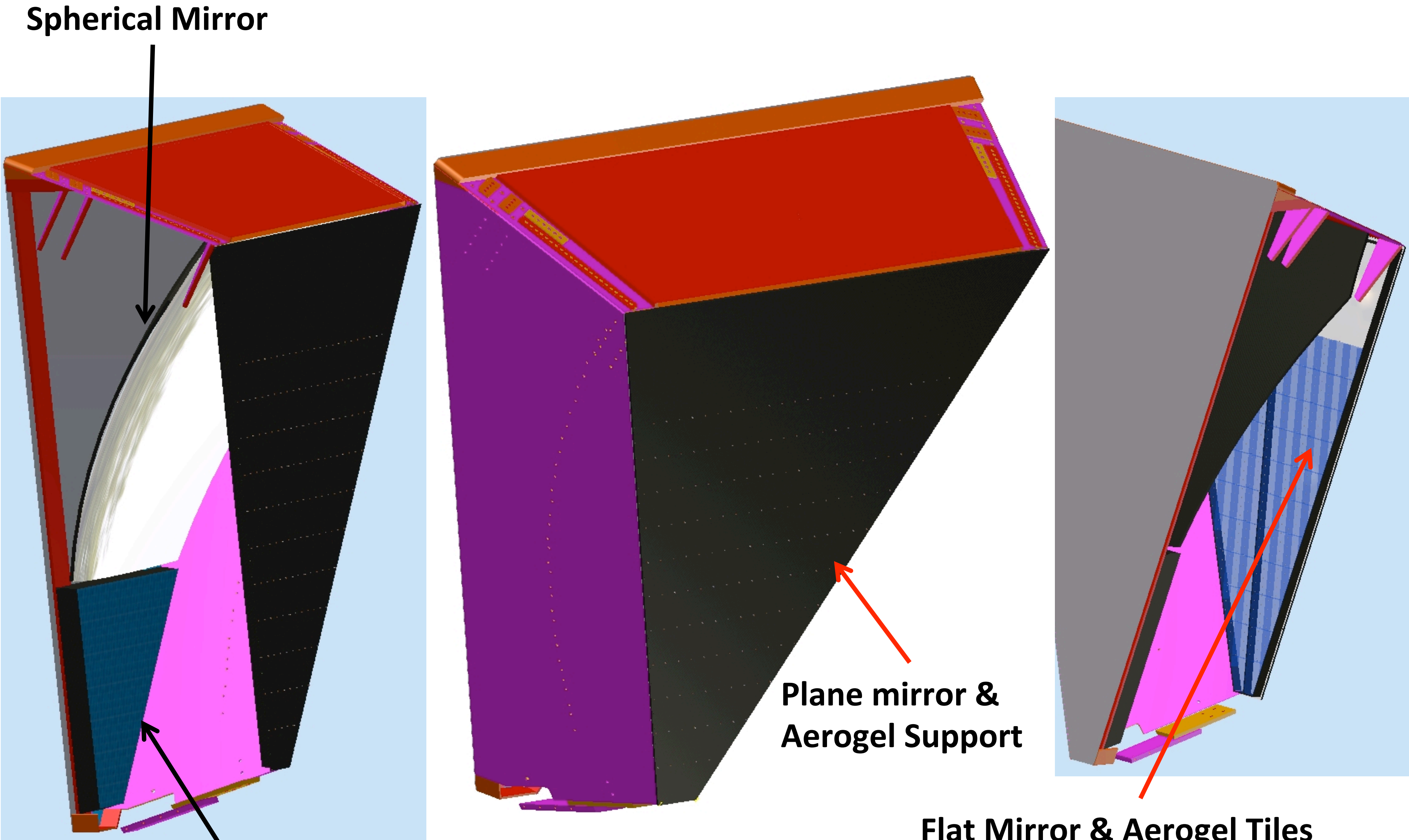
RICH MODULE: COMPONENTS WEIGHTS EVALUATION		
STRUCTURAL COMPONENTS WEIGHTS EVALUATION	1000Kg	
PMTs SYSTEM WEIGHTS EVALUATION	200 Kg	
COMPOSITE COMPONENTS WEIGHTS EVALUATION	120 Kg	
TOTAL	1320 Kg > **1400 Kg**	**3087 lbs**

RICH: Mechanical Installation In CLAS-12

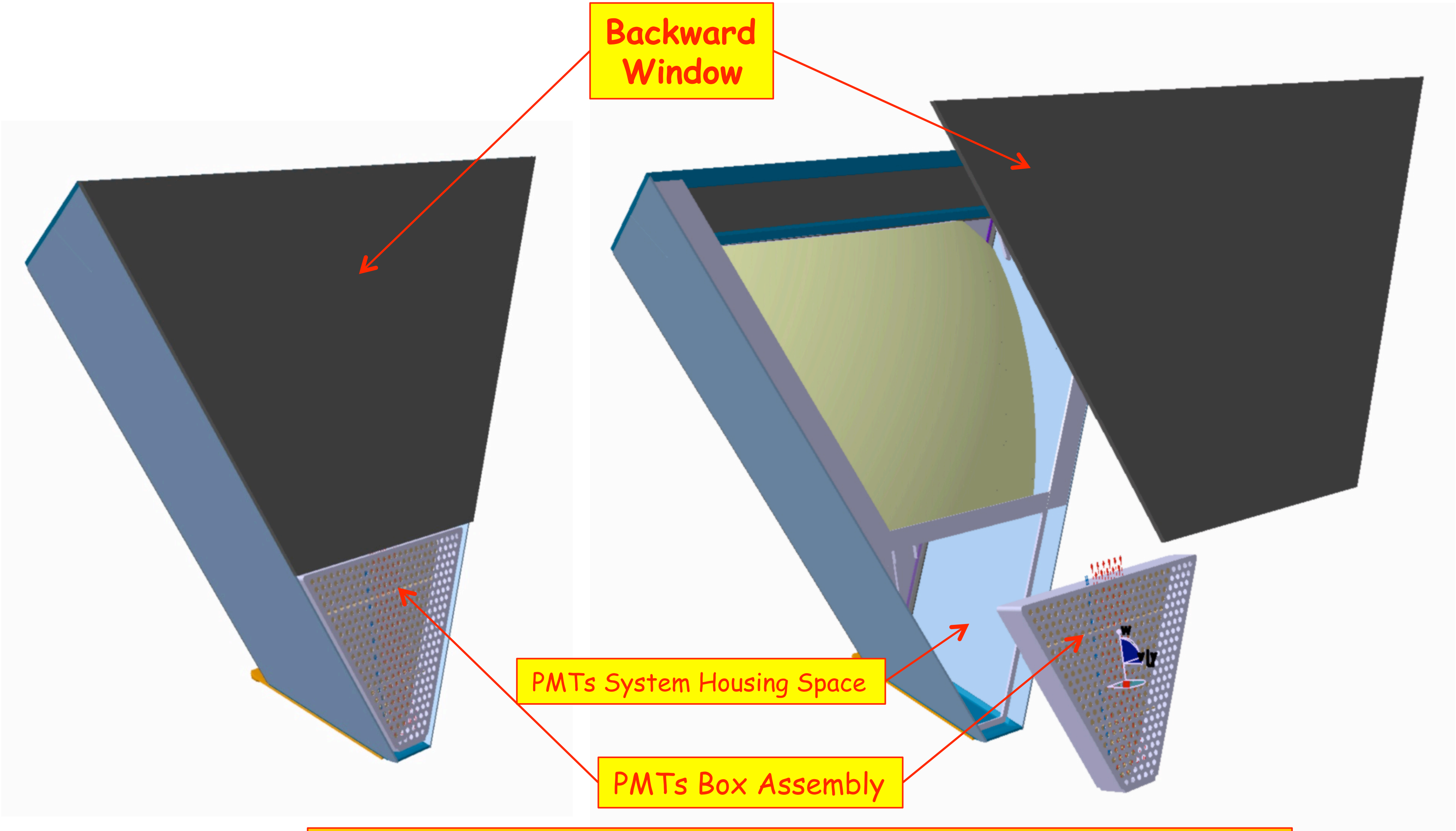


The LTCC installation tool and procedures can be reused for the RICH installation in the forward carriage frame <u>because of geometry and weight compatibility</u>. More detailed crosscheck are ongoing.

RICH: Inside Pictorial Views

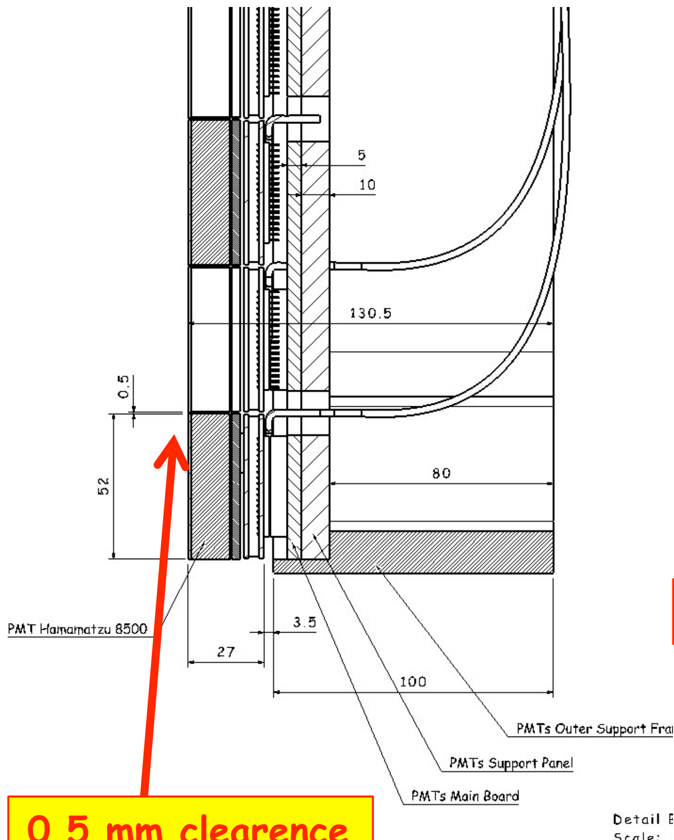


RICH: PMT Assembly preliminary layout.

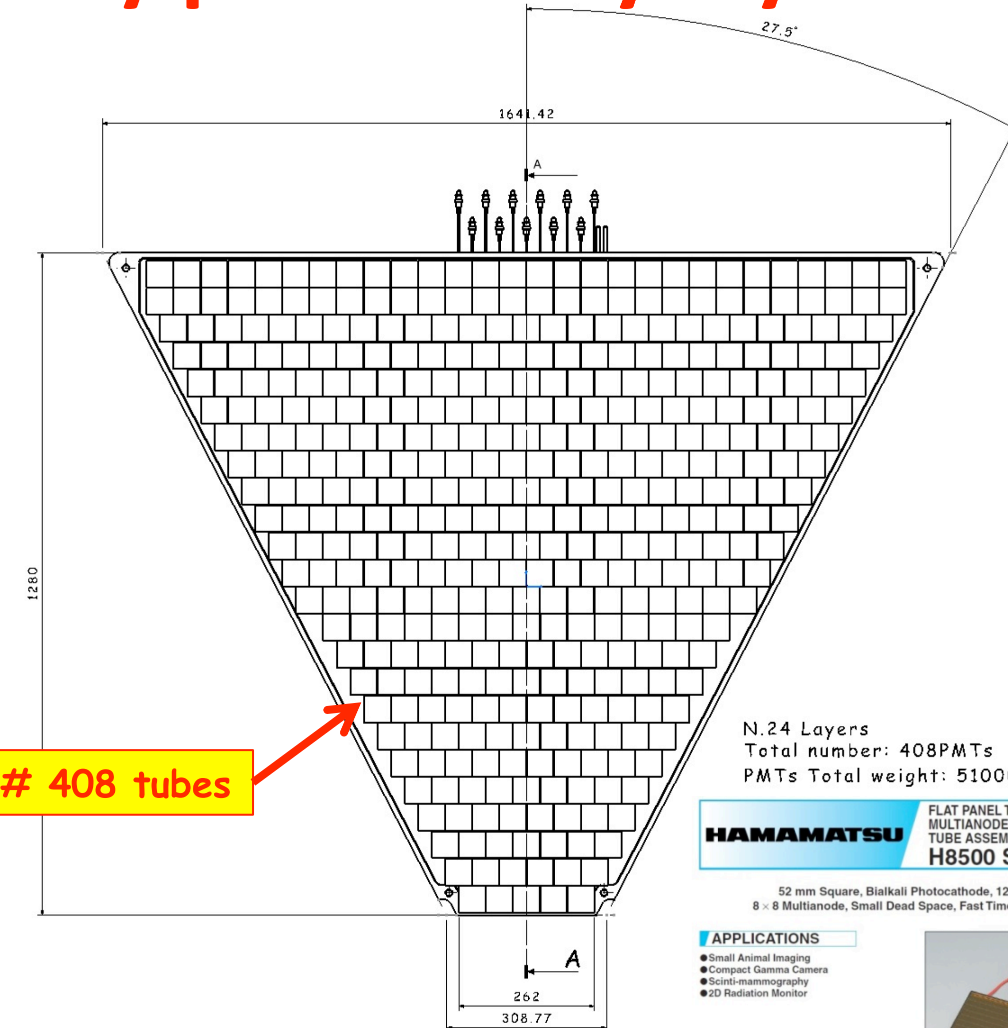


ADVANTAGES:
- More flexibily – the PMTs system is outside the rich module.
- More efficient heat dissipation.

RICH : PMT Array preliminary layout.



0.5 mm clearence



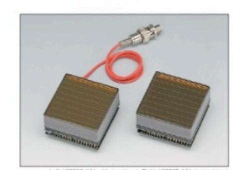
408 tubes

N.24 Layers
Total number: 408PMTs
PMTs Total weight: 51000g=510N

HAMAMATSU FLAT PANEL TYPE MULTIANODE PHOTOMULTIPLIER TUBE ASSEMBLY
H8500 SERIES

52 mm Square, Bialkali Photocathode, 12-stage, 8 × 8 Multianode, Small Dead Space, Fast Time Response

APPLICATIONS
- Small Animal Imaging
- Compact Gamma Camera
- Scinti-mammography
- 2D Radiation Monitor



Left: H8500C (HV cable input type), Right: H8500D (HV pin input type)

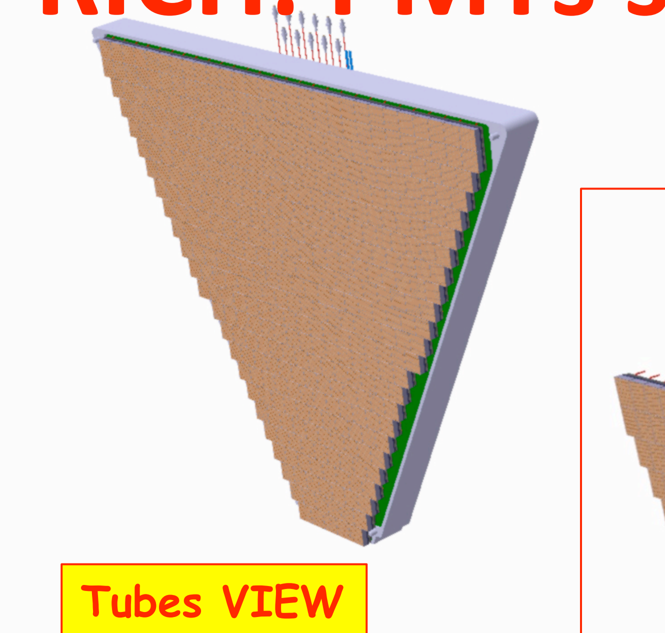
SPECIFICATIONS

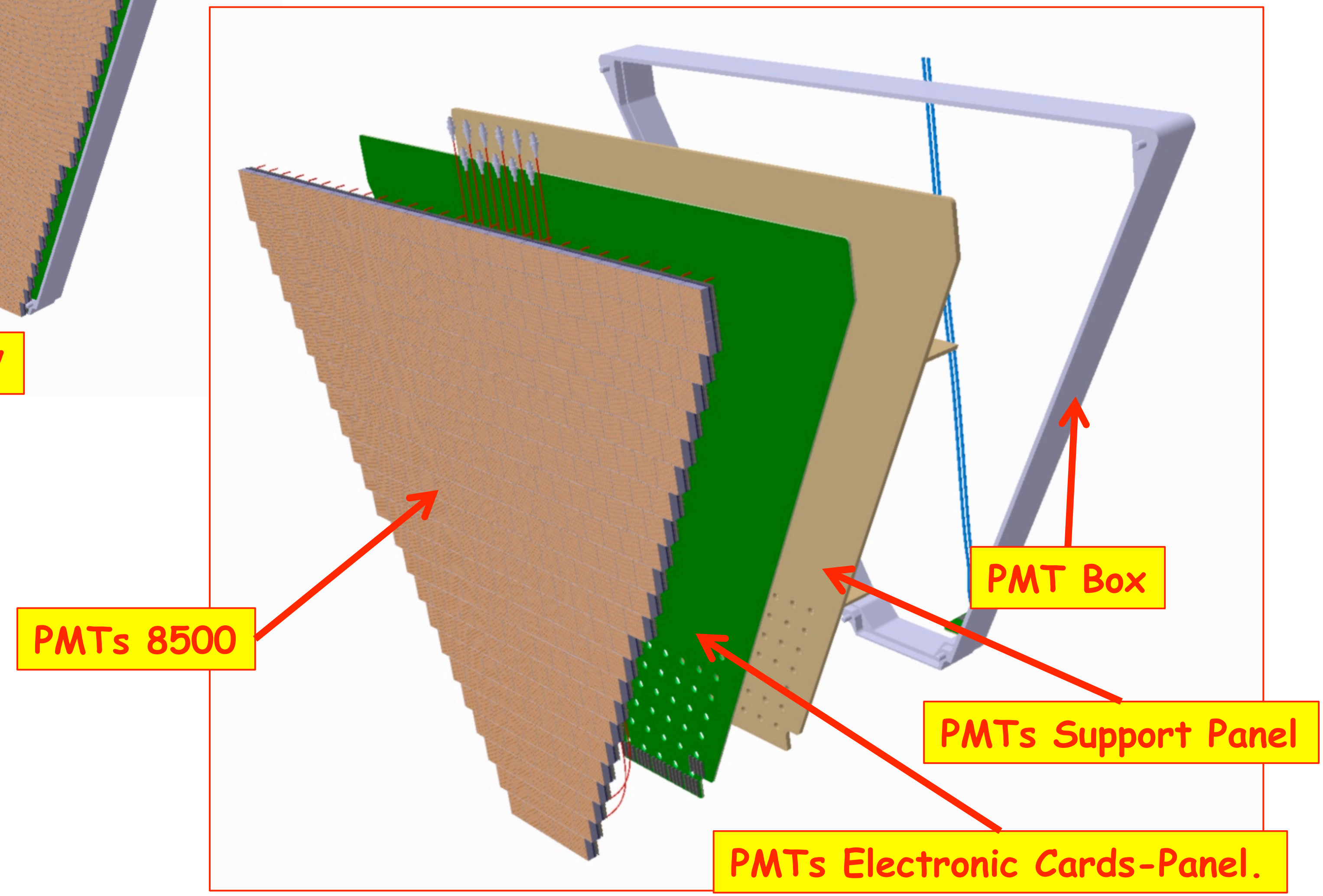
GENERAL

Parameter		H8500C	H8500D	H8500C-03	H8500D-03	Unit
Spectral Response		300 to 650		185 to 650		nm
Peak Wavelength		400				nm
Photocathode Material		Bialkali				—
Window	Material	Borosilicate glass		UV glass		—
	Thickness	1.5				mm
Dynode	Structure	Metal channel dynode				—
	Number of Stages	12				—
Number of Anode Pixels		64 (8 × 8 matrix)				—
Pixel Size / Pitch at Center		5.8 × 5.8 / 6.08				mm
Effective Area		49 × 49				mm
Dimensional Outline (W × H × D)		52 × 52 × 27.4				mm
Packing Density (Effective Area / External Size)		89				%
Weight		125	105	125	105	g
Operating Ambient Temperature		0 to +50				°C
Storage Temperature		-15 to +50				°C

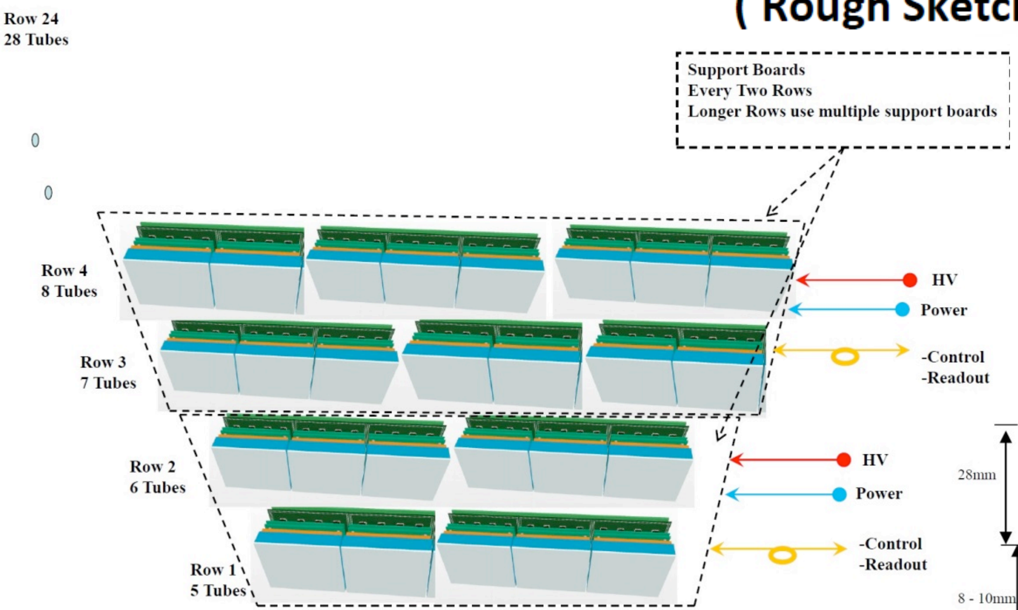
PMT Weight: 125g

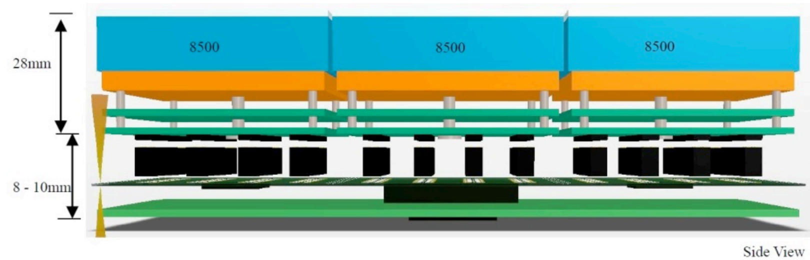
RICH: PMTs system preliminary layout





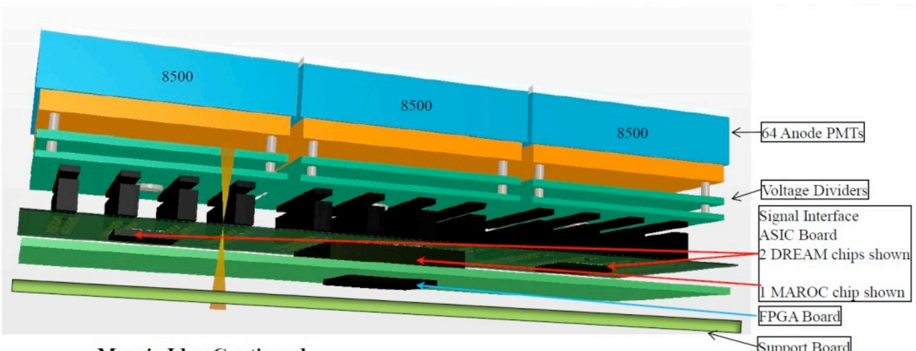
RICH Detector – 'Mosaic' Assembly
(Rough Sketch)





Mosaic Idea

- Design two 'Motherboards'
  1. Two 8500 tubes
  2. Three 8500 tubes (shown)
- Forty (40) of each Motherboard type
- One FPGA for each Motherboard supports I/O for ASIC chips
- Reduction of cabling
- Another board would support several "Mosaic" assemblies
  - Provides mechanical support
  - Low voltage distribution
  - HV bias for several "Mosaic" sections

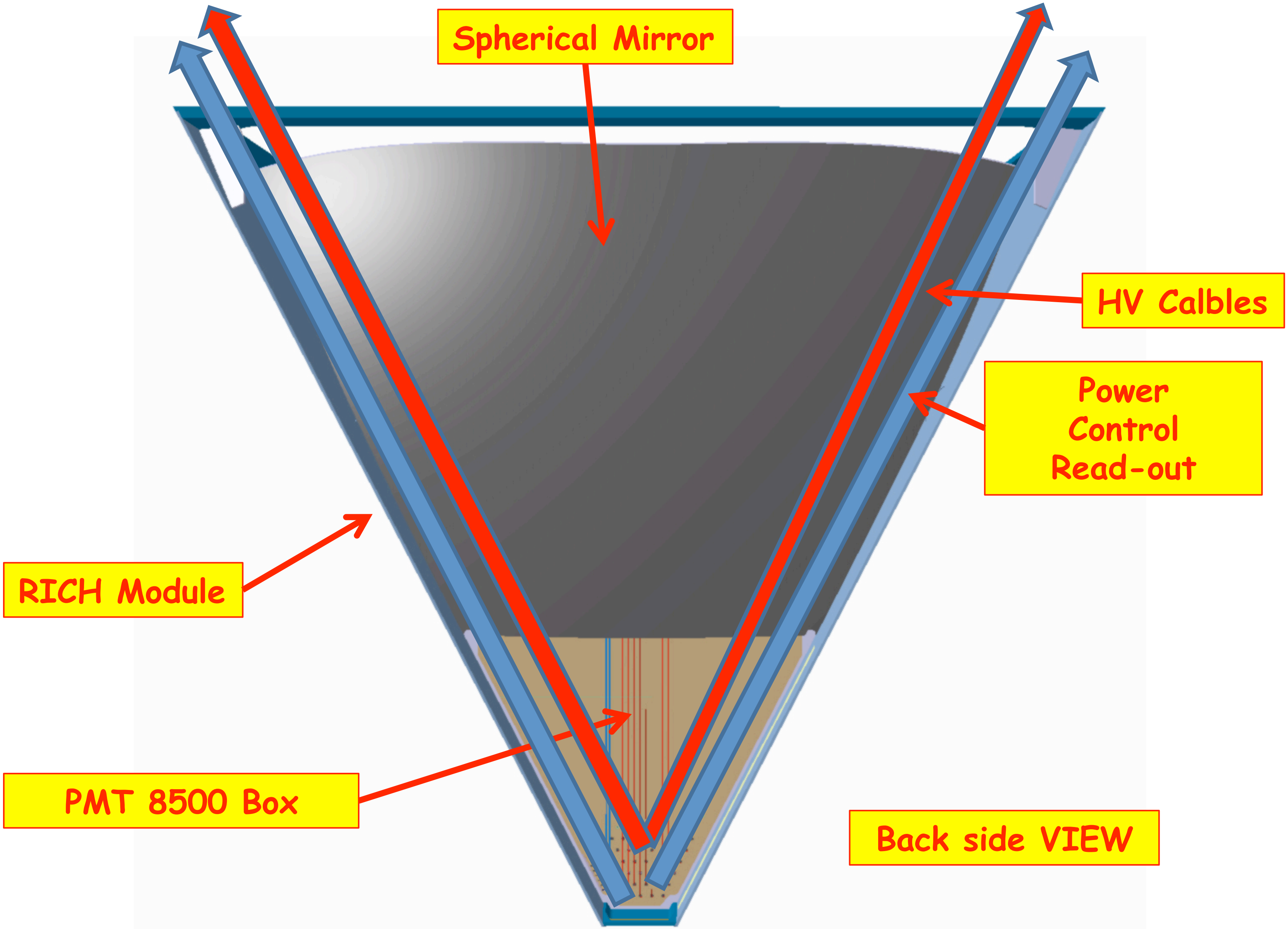


Mosaic Idea Continued

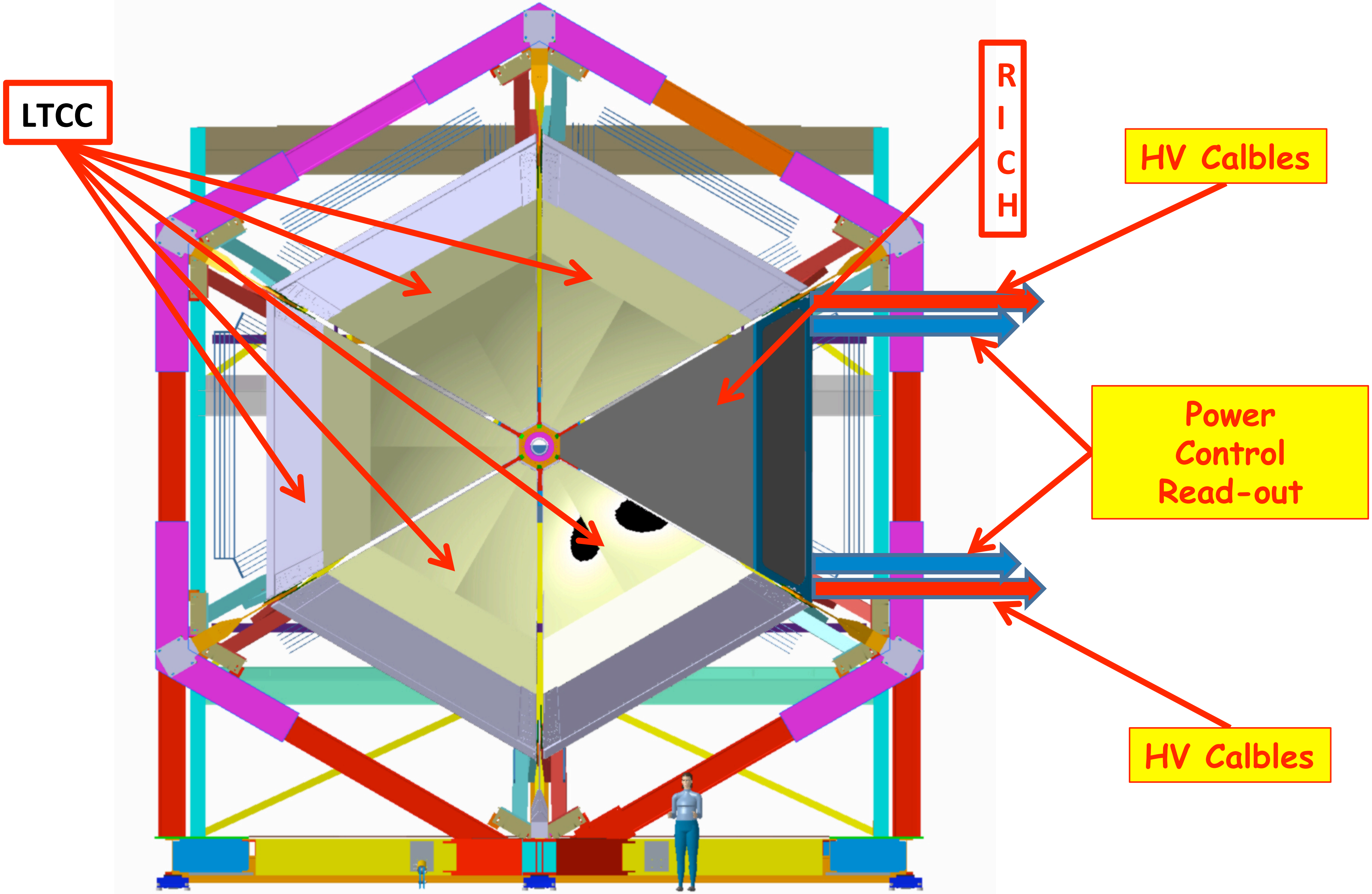
- Two ASICs shown for detail only
  - DREAM
  - MAROC3
- Reduction of cabling
- Support board services several "Mosaic" assemblies
  - Provides mechanical support

C. Cuevas courtesy

RICH: Utility lines and signal readout cabling



RICH ASSEMBLING CABLING



Mirror Optimization

LTCC mass budget for reference

Mail from Valery

Hi All,

Mauri wrote me about the LTCC material budget to compare with what we will have in RICH. Here it is:

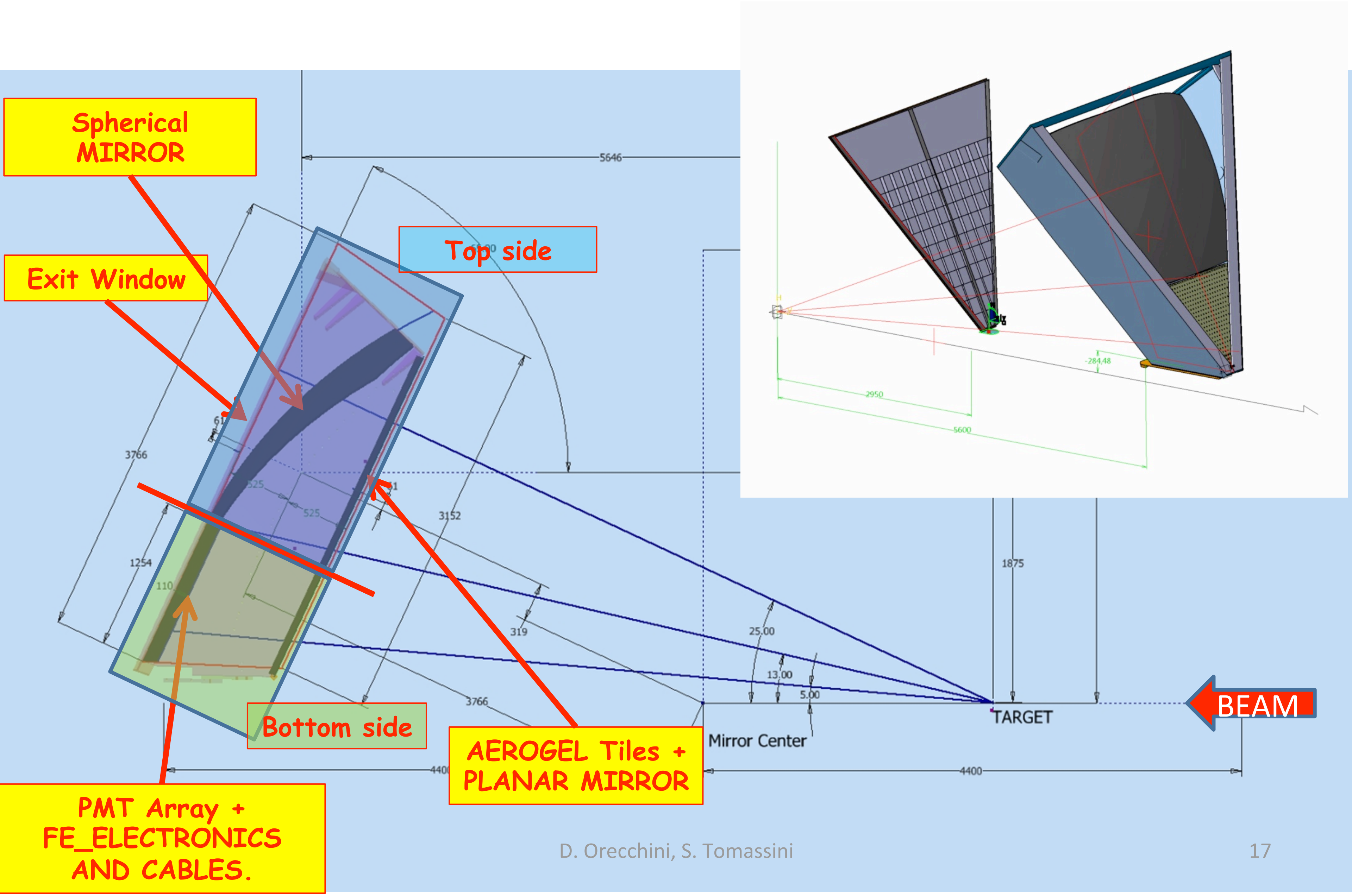
Regarding the LTCC thickness (in n. radiation lengths):

- ~1m C_4F_{10} is 2.7X0%
- Mirrors ~0.25X0%
- Windows: ~0.25X0%

So overall is 3.2X0%

Best, Maurizio

RICH scheme for Radiation Length Evaluation



RICH: Radiation Length Evaluation

In case of CFRP mirror Substrate and reflective coating applied on it

IN THE RICH TOP SIDE:

1. The flat mirror has an areal density of about 3.28 kg/m^2 equivalent to **0.76%X0**
2. the spherical mirror has an areal density of about 2.6 kg/m^2 equivalent to **0.60%X0**
3. The exit window in CFRP like LTCC is equivalent to **0.25%X0**

Total %X0= 0.6+0.76+ 0.25= **1.61%X0**

IN THE RICH BOTTOM SIDE:

1. The flat mirror has an areal density of about 3.28 kg/m^2 equivalent to **0.76%X0**
2. PMTs has an areal density of about 42 kg/m^2 equivalent to **15%X0**
3. Motherboard assumed equivalent to 1 cm of CFRP equivalent to **0.76%X0**

Total %X0= 0.76 + 15 + 0.76 = **16.52%X0**

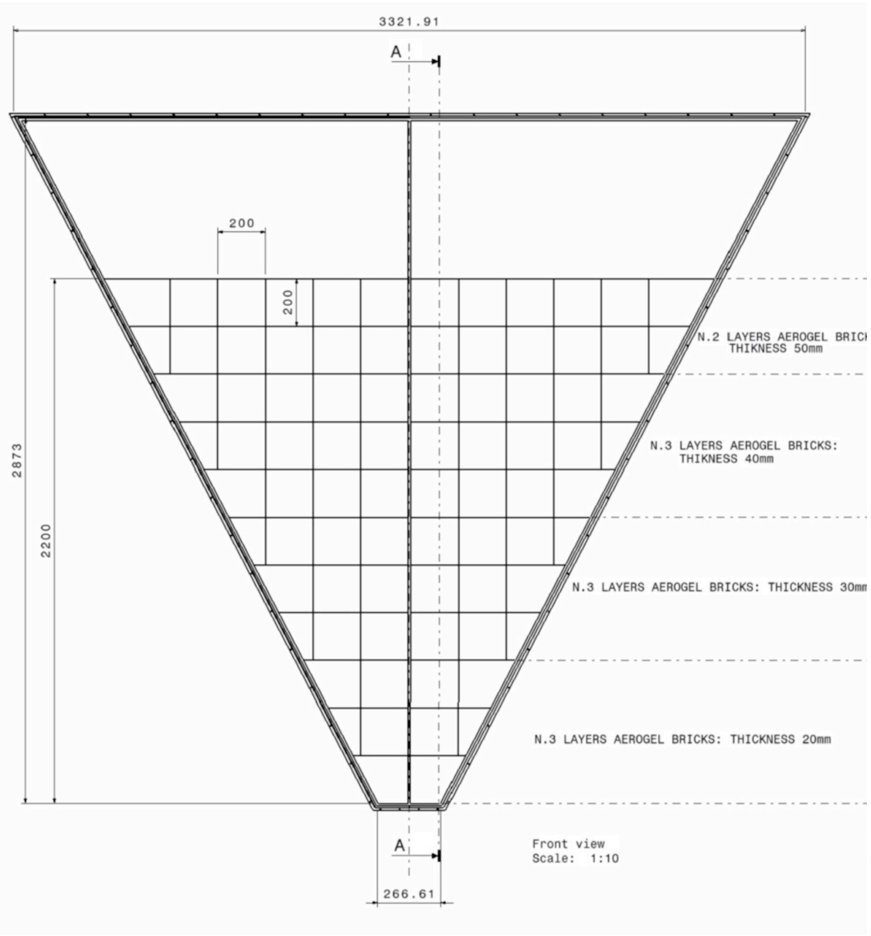
Lightweight mirrors are necessary.

FEM analysis were carried out for the spherical and flat mirror substrate taking into account CFRP material in order to minimize the mass and maximize the mechanical stiffness.

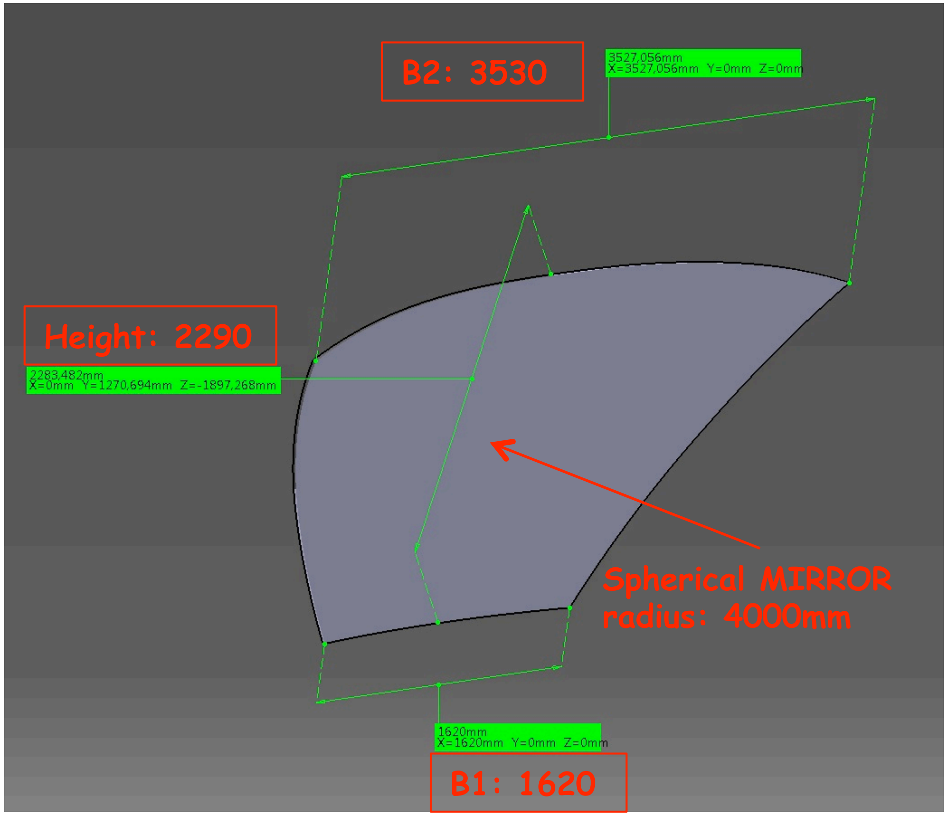
The mirror substrate **thickness** should not exceed 20 mm in case of sandwich CFRP materials

Mirror Geometry

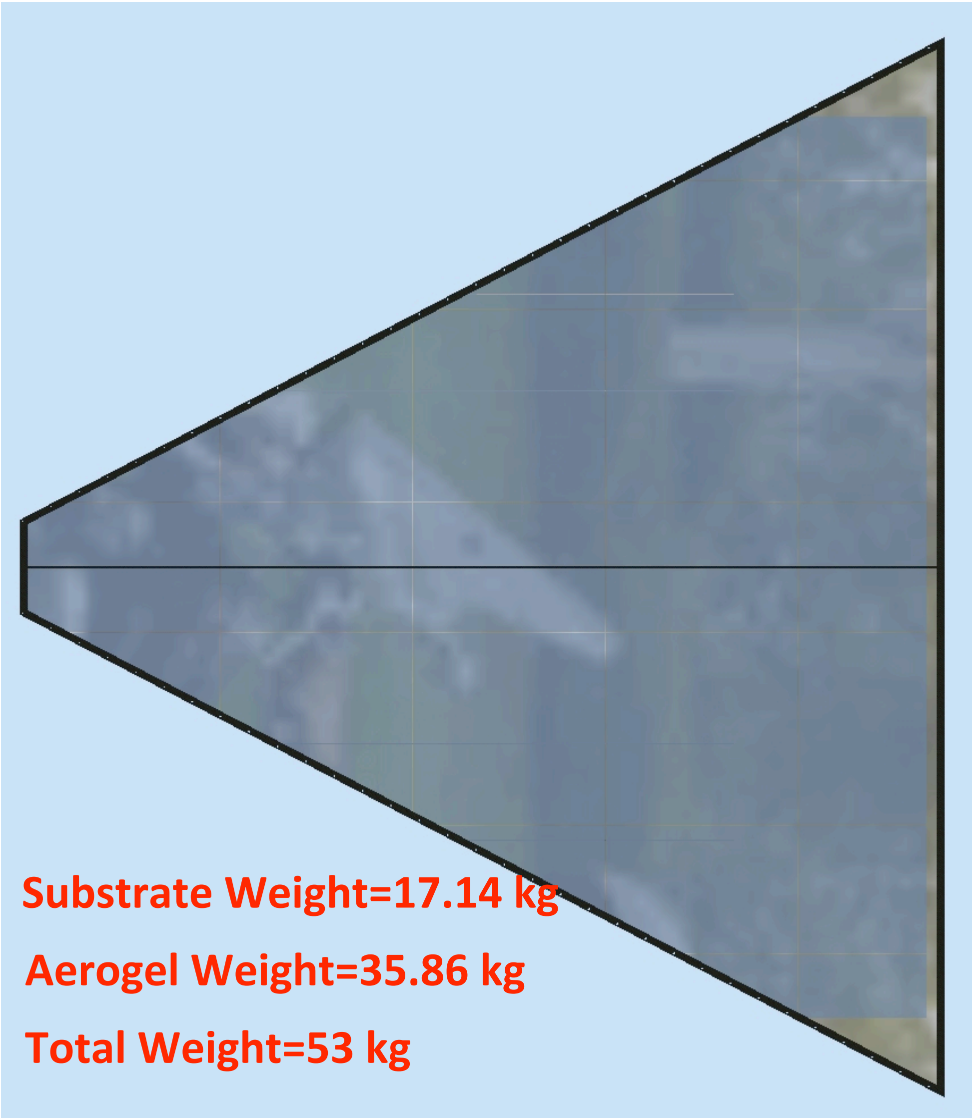
FLAT MIRROR

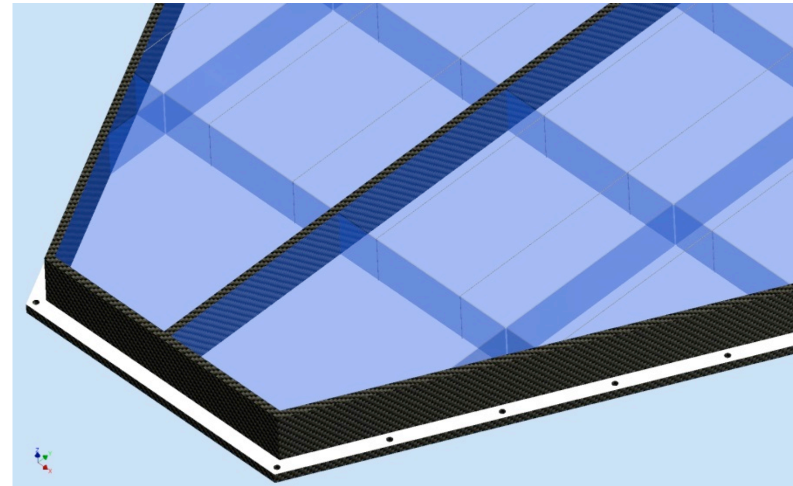


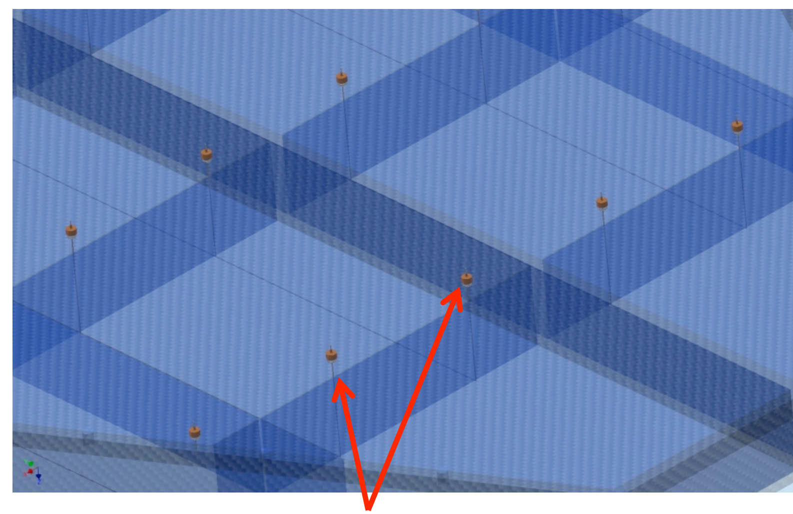
Spherical MIRROR



Flat Mirror Substrate & Aerogel support







Each tile is supported by two nylon wires

Flat Mirror Substrate lay-up

SAN_Foam_81kgm3

Density **8.1e-008 kg mm^-3**

Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
	60	0.3	50	23.077

Epoxy_Carbon_UD_395GPa_Prepreg

Density **1.54e-006 kg mm^-3** → 57% less wrt Aluminum

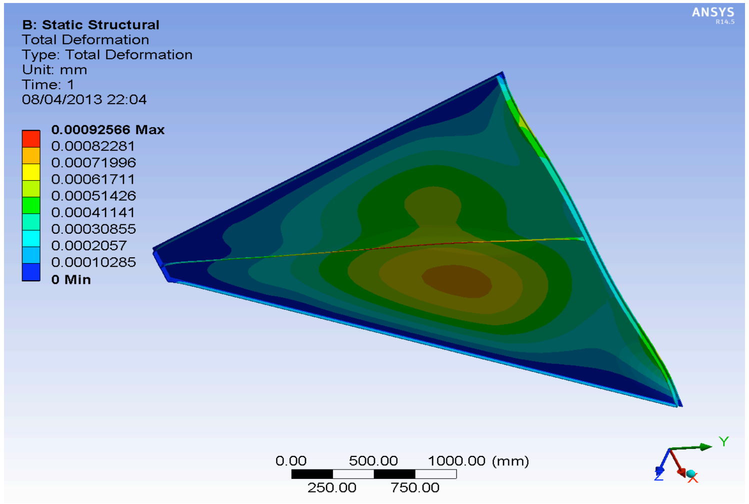
Temperature C	Young's Modulus X direction MPa	Young's Modulus Y direction MPa	Young's Modulus Z direction MPa	Poisson's Ratio XY	Poisson's Ratio YZ	Poisson's Ratio XZ	Shear Modulus XY MPa	Shear Modulus YZ MPa	Shear Modulus XZ MPa
	2.09e+005	9450	9450	0.27	0.4	0.27	5500	3900	5500

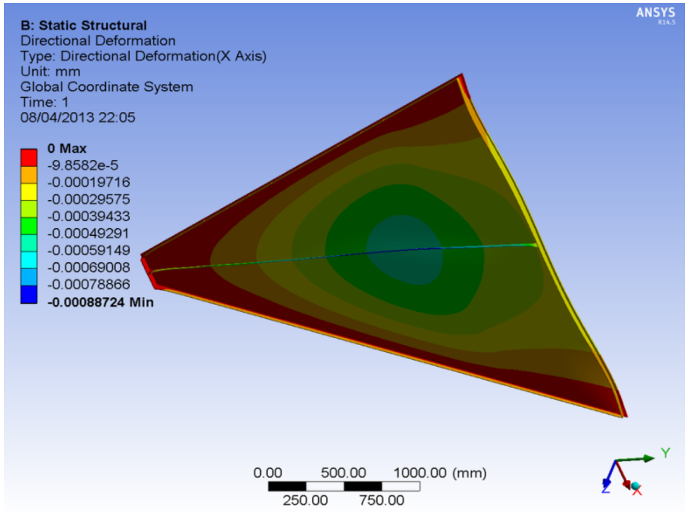
Composite Lamination

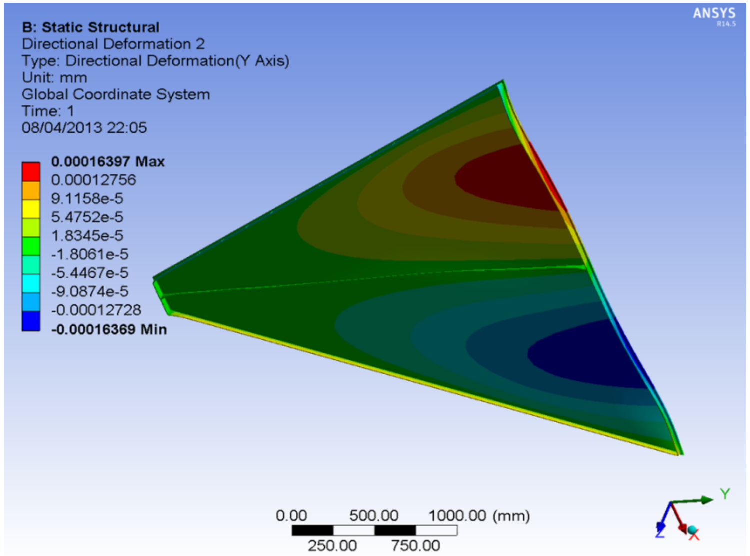
Layer	Material	Thickness (mm)	Angle (rad)
(+Z)			
9	Epoxy_Carbon_UD_395GPa_Prepreg	0.2	0
8	Epoxy_Carbon_UD_395GPa_Prepreg	0.2	-45
7	Epoxy_Carbon_UD_395GPa_Prepreg	0.2	45
6	Epoxy_Carbon_UD_395GPa_Prepreg	0.2	90
5	SAN_Foam_81kgm3	8	0
4	Epoxy_Carbon_UD_395GPa_Prepreg	0.2	90
3	Epoxy_Carbon_UD_395GPa_Prepreg	0.2	45
2	Epoxy_Carbon_UD_395GPa_Prepreg	0.2	-45
1	Epoxy_Carbon_UD_395GPa_Prepreg	0.2	0
(-Z)			

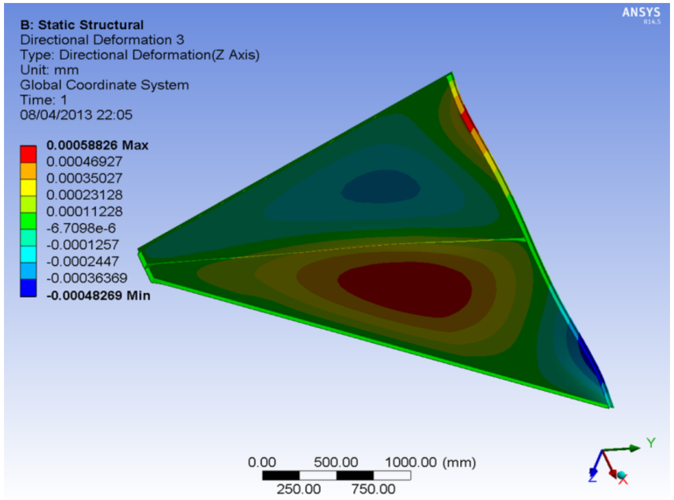
Total Thickness 9.6 mm

Displacement (total , x, y, z [mm]) **(run position)**

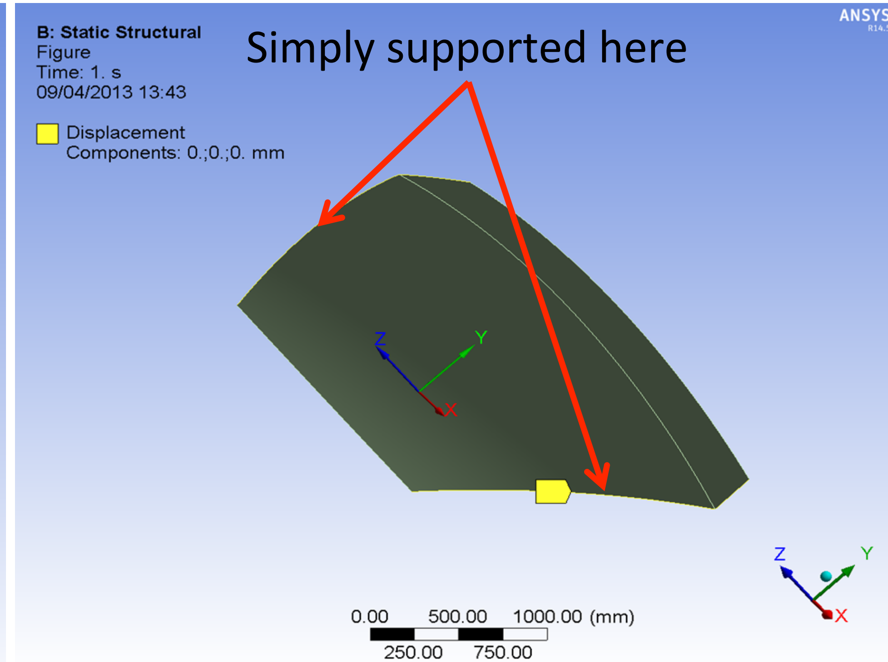


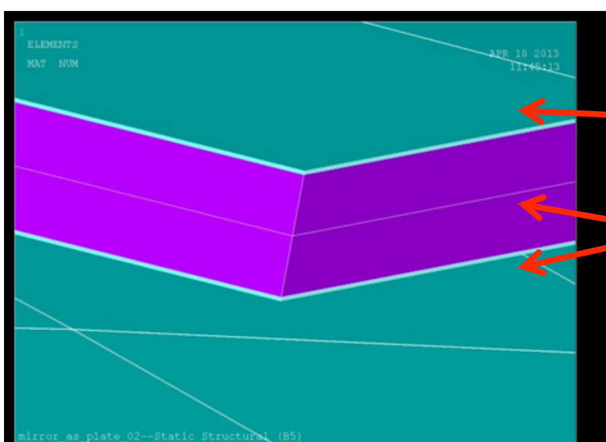






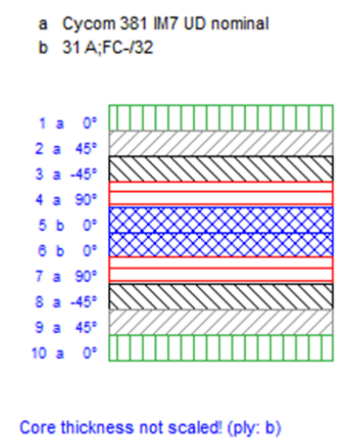
Spherical Mirror: **running position**



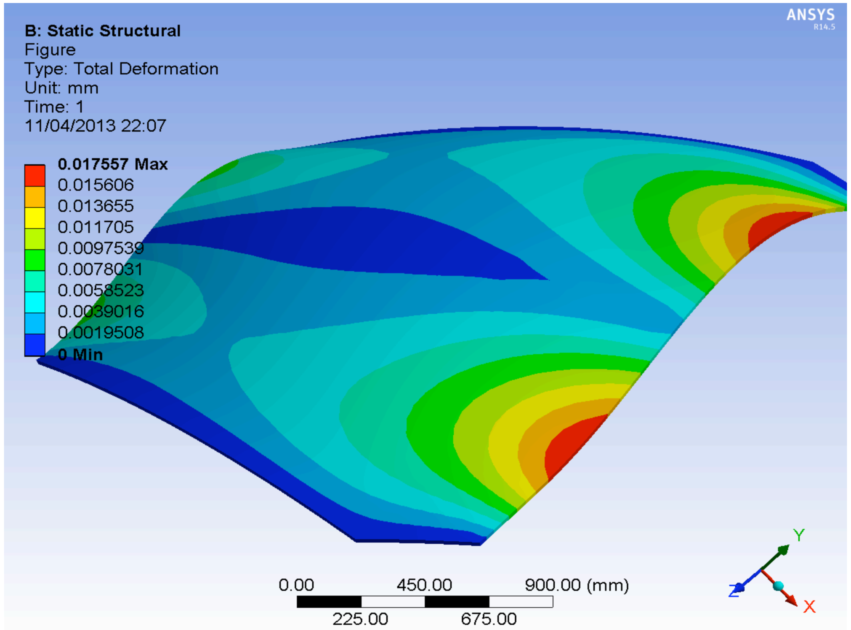


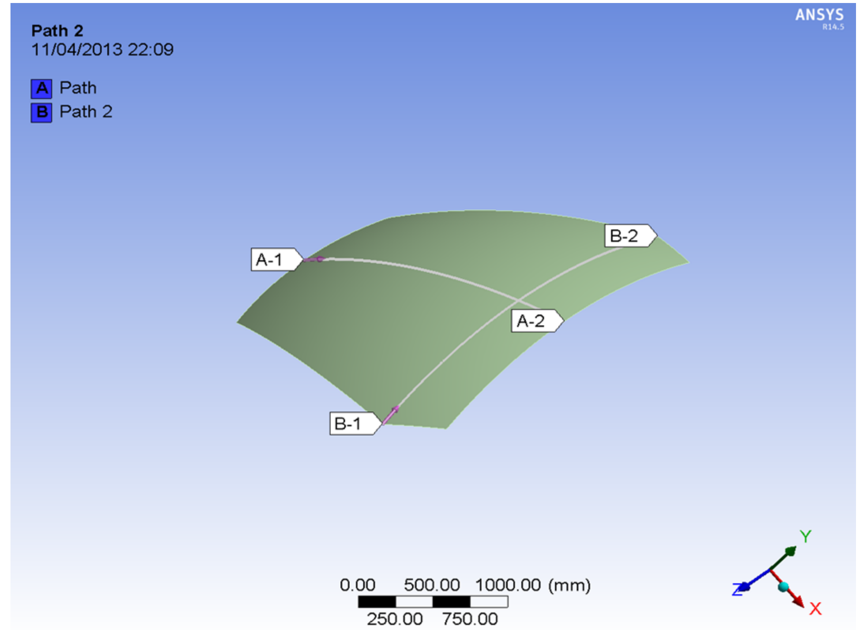
CFRP Skin

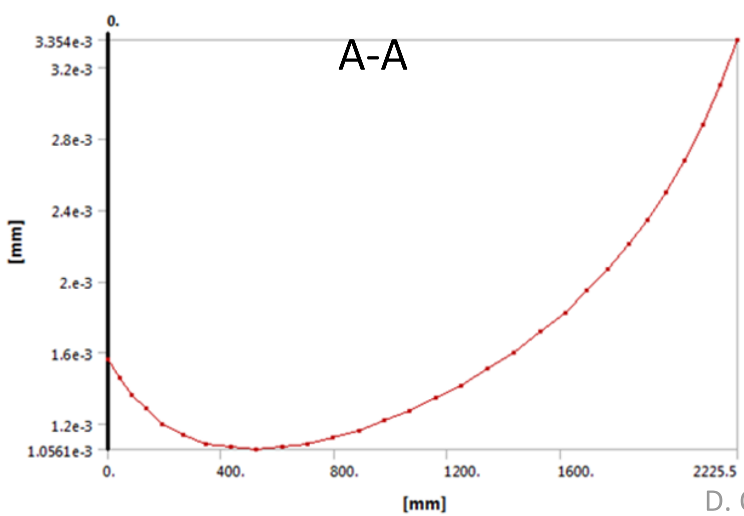
Foam

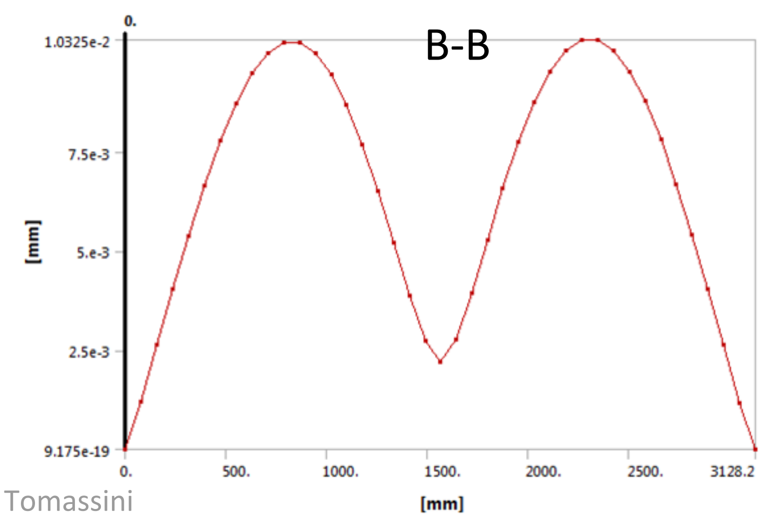


Displacement (total , path A, B [mm]) **(run position)**









CFRP Substrate Mirror: Industrial feasibility

We are in contact with many industries with the right expertise to manufacture CFRP substrate for Spherical and planar mirrors.

- **Riba Composites (Italy)**
- **Thales-Alenia (Italy-France)**
- **CMA (Usa –Tucson)**

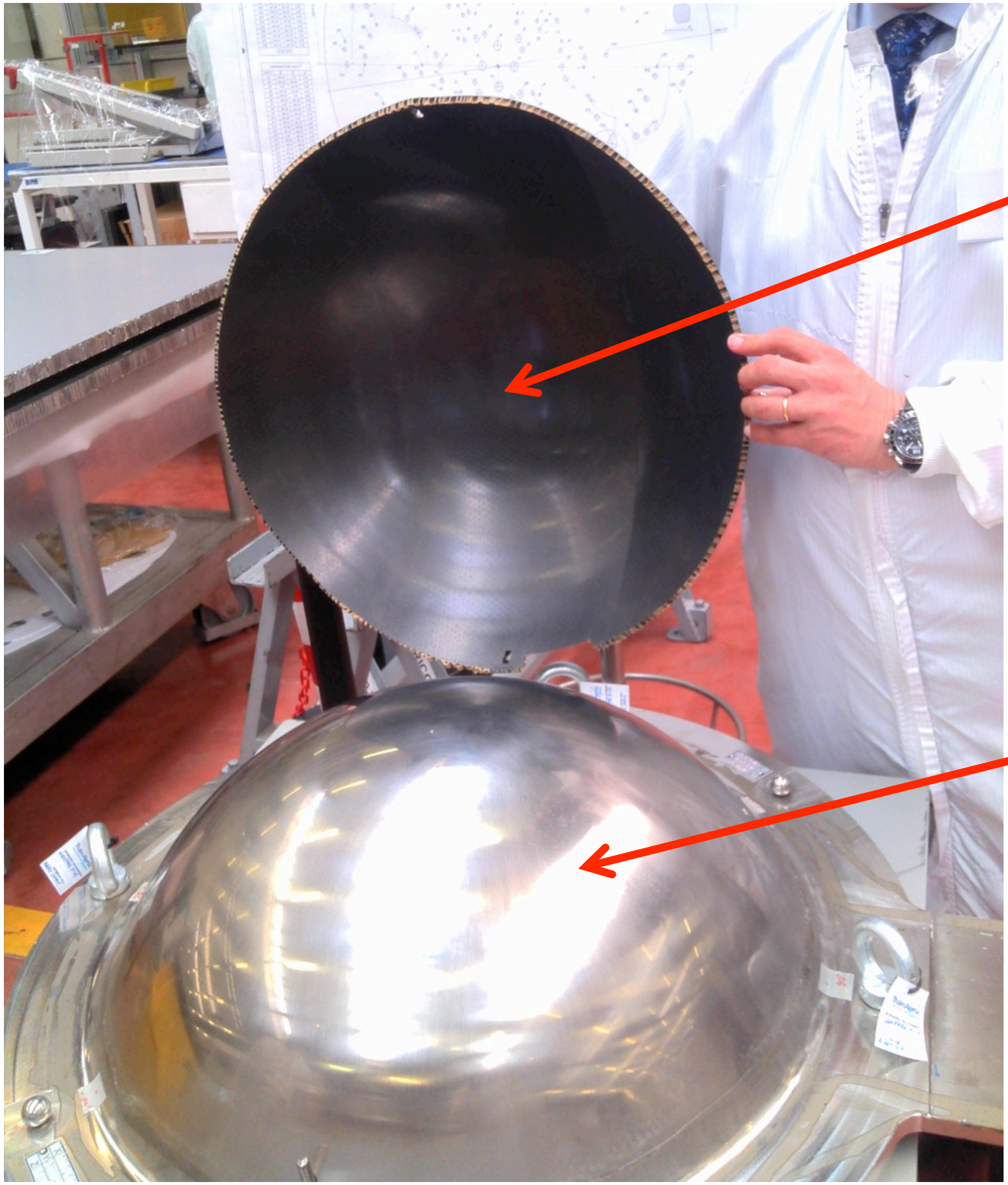
CMA produced the LHCb CFRP mirror for the RICH 1

Thales-Alenia has the know-how in the manufacturing of CFRP satellite antennas

Riba Composites produced parts of CFRP AMS

The LHCb specs have been assumed: $\Delta R/R < 1\%\ and\ surface\ roughness < 100\ nm$

CFRP Substrate Mirrors: Industrial feasibility



-Sphere radius = 600 mm

-INVAR mold

Thales-Alenia courtesy

Reflective Film Requirement and Feasibility

-Al substrate 80 nm
-SiO2 substrate 160 nm
-Mirror surface roughness = 100 nm

Many Companies all around the world can do Al and SiO2 film deposition BUT the maximum surface that can be managed is about 0.5 m^2 (Up to now!)

- **Thales-SeSo (France)**
- **CREO (Italy)**
- **C-S-M (Italy)**

Thales-SeSo produced the LHCb CFRP mirror coating for the RICH 1, the maximum area that can sputter is about 0.5 m^2 (800x600 mm)

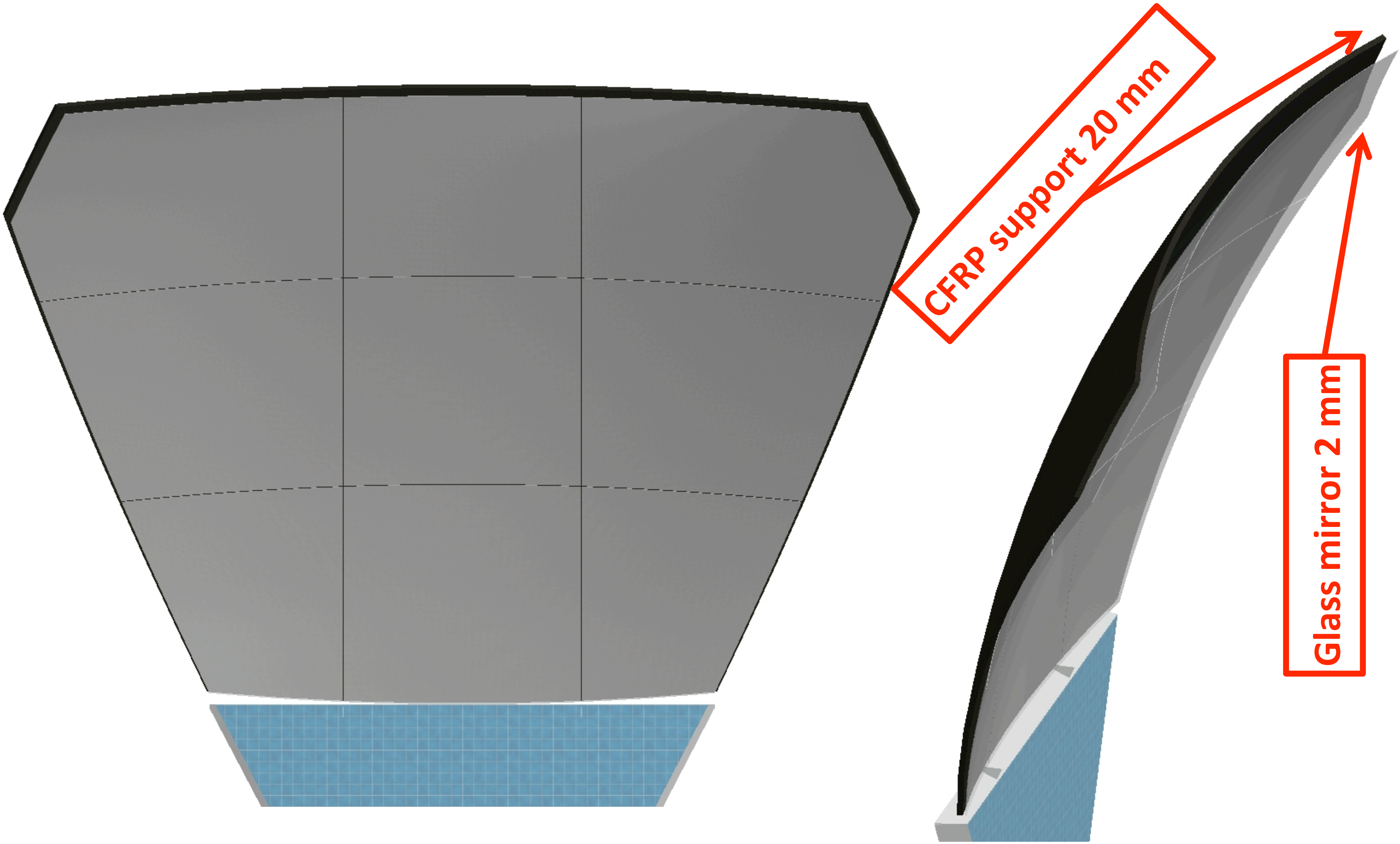
CREO has smaller sputter plant

C-S-M can sputter a maximum area of about 0.5 m^2

Aluminized pre-cured mosaic tiles technique can be adopted. Something similar is currently done for satellite antennas coating.

Alternative way to the CFRP technology

Preliminary Assembly spherical mirror



Glass Substrate Mirror: Industrial feasibility

The glass mirrors are less expensive than the CFRP mirrors but on the other hand increase the radiation length.

We are in contact with an industry with expertise to manufacture GLASS substrate mirrors.

- **Media Lario (Italy)**

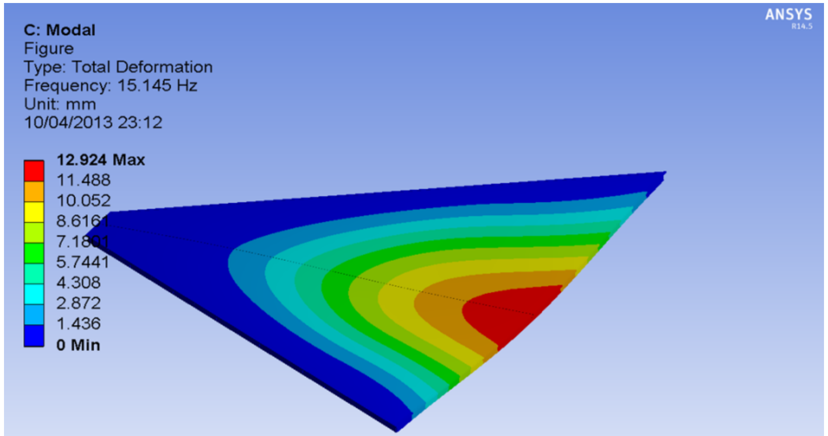
R&D is necessary for a mirror with a curvature radius of about 4000 mm

CONCLUSIONS

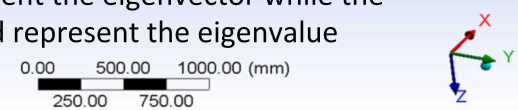
- RICH mechanic is fully compatible with the LTCC and CLAS forward carriage frame
- Installation tools and procedures for the LTCC can be reused for the RICH because of geometry and mass compatibility
- Tubes and electronic housing in a single box that can be dismounted, maintained and assembled outside seems feasible and a preliminary layout was shown. Thermal power of about 400 W to dissipate must be studied carefully but is not a concern.
- CFRP materials substrate are necessary in order to fulfill the goal of light weight, high stiffness and accurate mirror geometry. Mechanical deformations in the running position are very small for both spherical and flat mirrors
- The flat and spherical mirrors can be manufactured by two firms as single part
- Reflective film deposition for large surface is an issue but aluminized pre-cured mosaic tiles technique can be developed. Something similar is currently done for large satellite antennas coating. Thales-Alenia will do a prototype
- Glass or Aluminum mirror can be taken into account as alternative solution. This technology is less expensive but introduce more complexity because of support needs and increased radiation length.

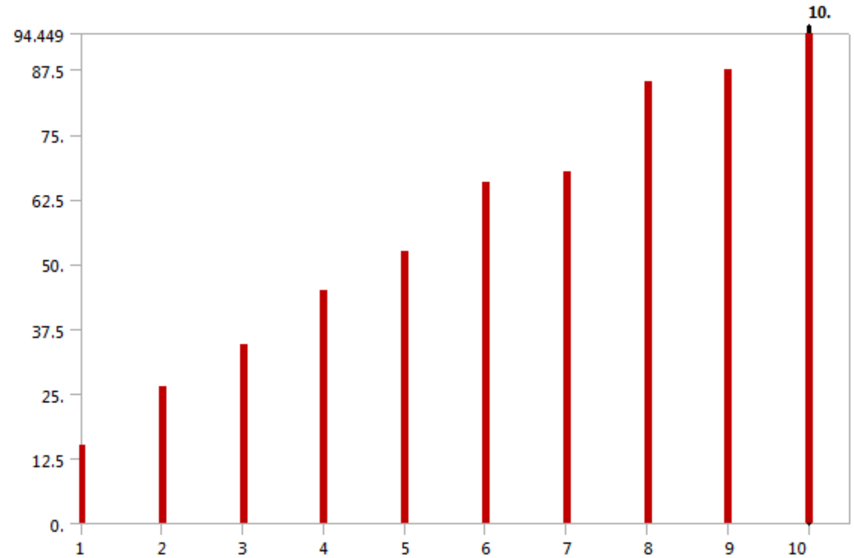
Thank you for your attention

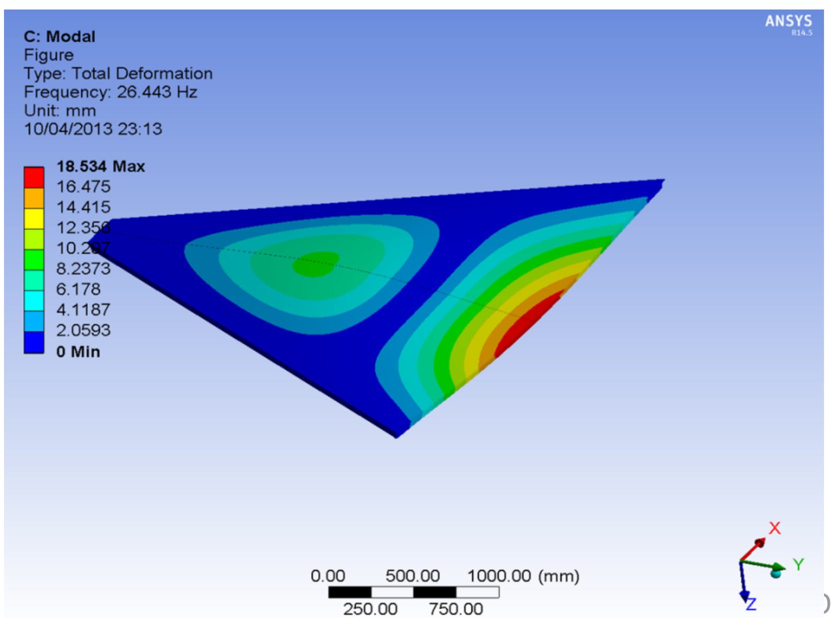
Modal Analysis (run position)



Pay attention: displacements magnitude in modal analysis are not real it represent the eigenvector while the frequency is real and represent the eigenvalue

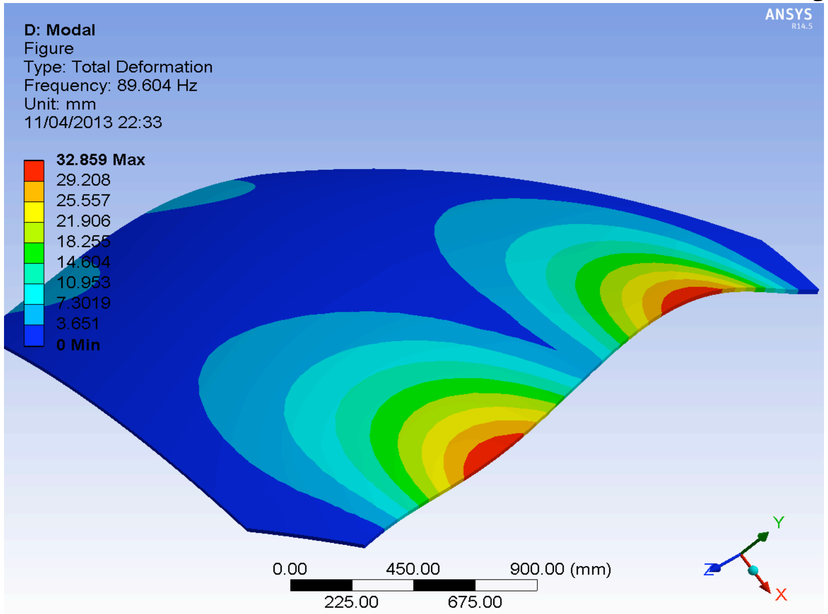


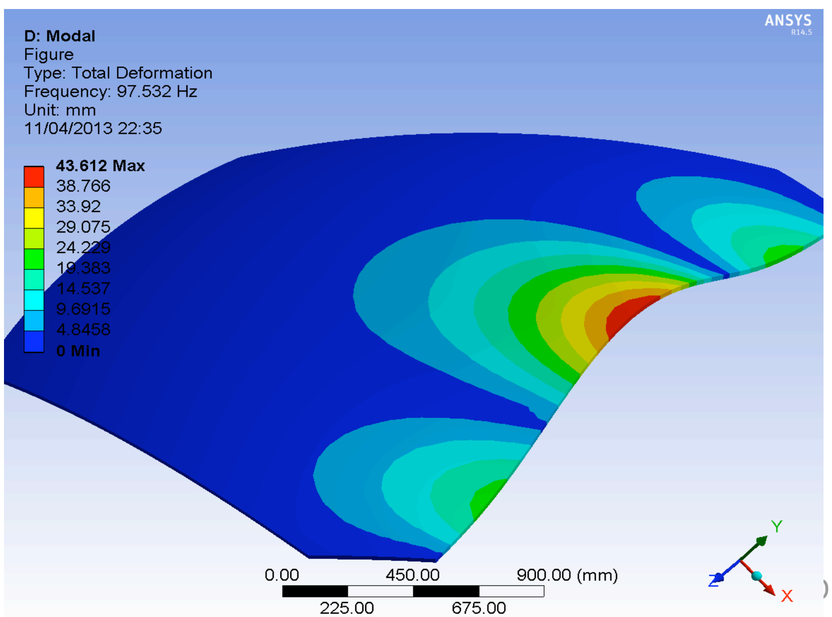


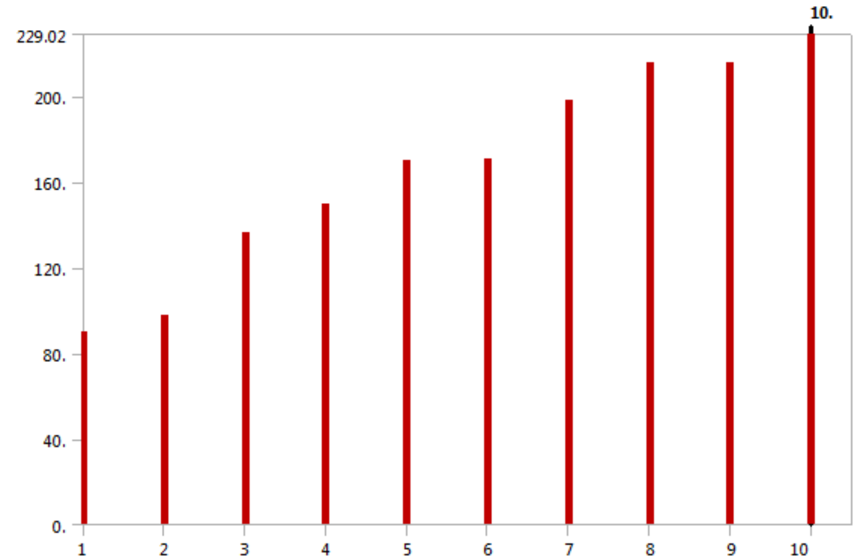


Mode	Frequency [Hz]
1.	15.145
2.	26.443
3.	34.464
4.	44.786
5.	52.536
6.	65.629
7.	67.908
8.	85.207
9.	87.36
10.	94.449

Modal Analysis (run position)







Mode	Frequency [Hz]
1.	**89.604**
2.	97.532
3.	136.34
4.	149.35
5.	170.27
6.	170.7
7.	198.45
8.	215.61
9.	215.87
10.	229.02