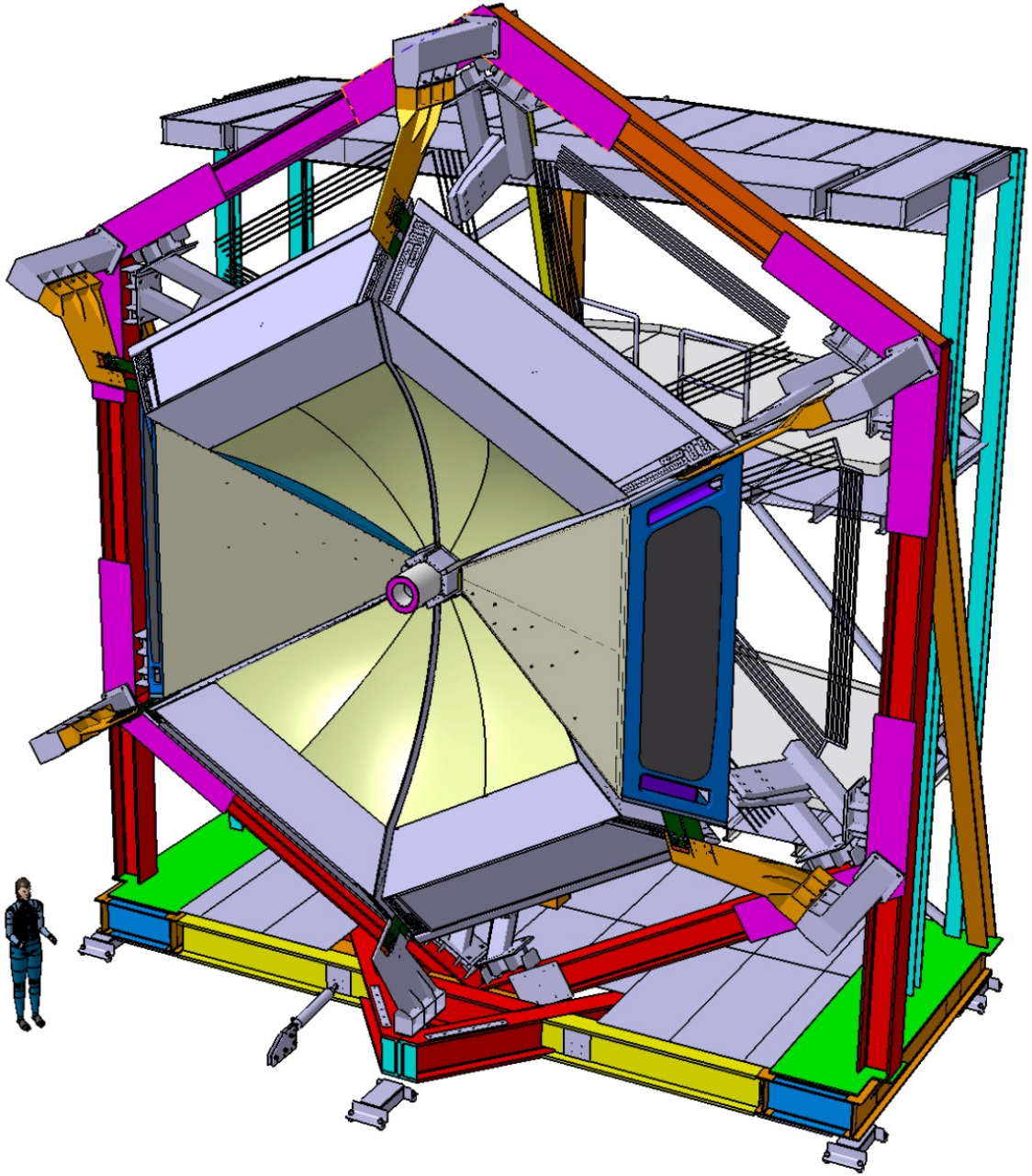
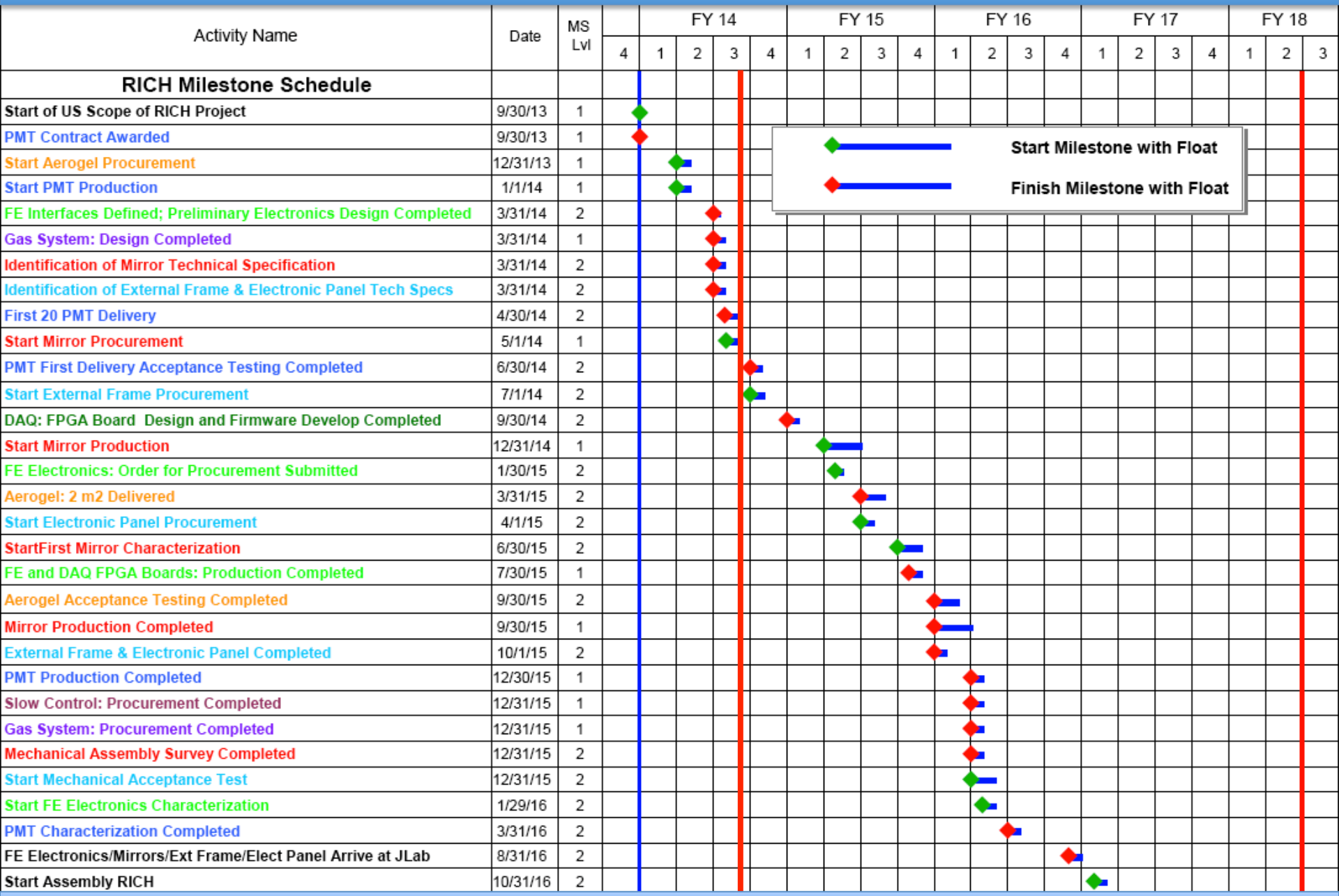


CLAS12-RICH Status-Report

March 5th 2014

RICH Project Milestones

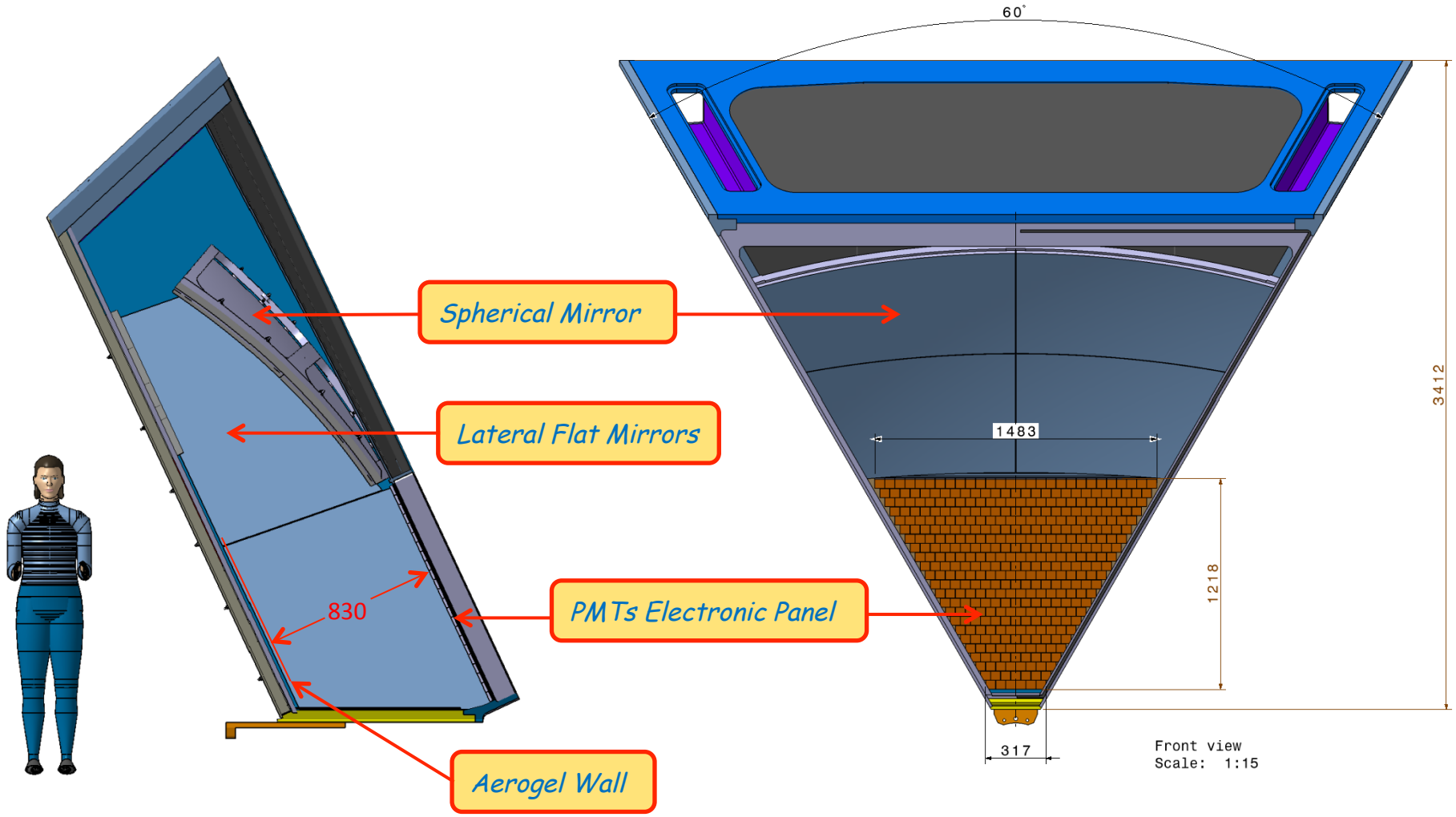
Activity Name	Date	MS Lvl
RICH Milestone Schedule		
Start of US Scope of RICH Project	9/30/13	1
PMT Contract Awarded	9/30/13	1
Start Aerogel Procurement	12/31/13	1
Start PMT Production	1/1/14	1
FE Interfaces Defined; Preliminary Electronics Design Completed	3/31/14	2
Gas System: Design Completed	3/31/14	1
Identification of Mirror Technical Specification	3/31/14	2
Identification of External Frame & Electronic Panel Tech Specs	3/31/14	2
First 20 PMT Delivery	4/30/14	2
Start Mirror Procurement	5/1/14	1
PMT First Delivery Acceptance Testing Completed	6/30/14	2
Start External Frame Procurement	7/1/14	2
DAQ: FPGA Board Design and Firmware Develop Completed	9/30/14	2
Start Mirror Production	12/31/14	1
FE Electronics: Order for Procurement Submitted	1/30/15	2
Aerogel: 2 m2 Delivered	3/31/15	2
Start Electronic Panel Procurement	4/1/15	2
StartFirst Mirror Characterization	6/30/15	2
FE and DAQ FPGA Boards: Production Completed	7/30/15	1
Aerogel Acceptance Testing Completed	9/30/15	2
Mirror Production Completed	9/30/15	1
External Frame & Electronic Panel Completed	10/1/15	2
PMT Production Completed	12/30/15	1
Slow Control: Procurement Completed	12/31/15	1
Gas System: Procurement Completed	12/31/15	1
Mechanical Assembly Survey Completed	12/31/15	2
Start Mechanical Acceptance Test	12/31/15	2
Start FE Electronics Characterization	1/29/16	2
PMT Characterization Completed	3/31/16	2
FE Electronics/Mirrors/Ext Frame/Elect Panel Arrive at JLab	8/31/16	2
Start Assembly RICH	10/31/16	2



RICH External Frame

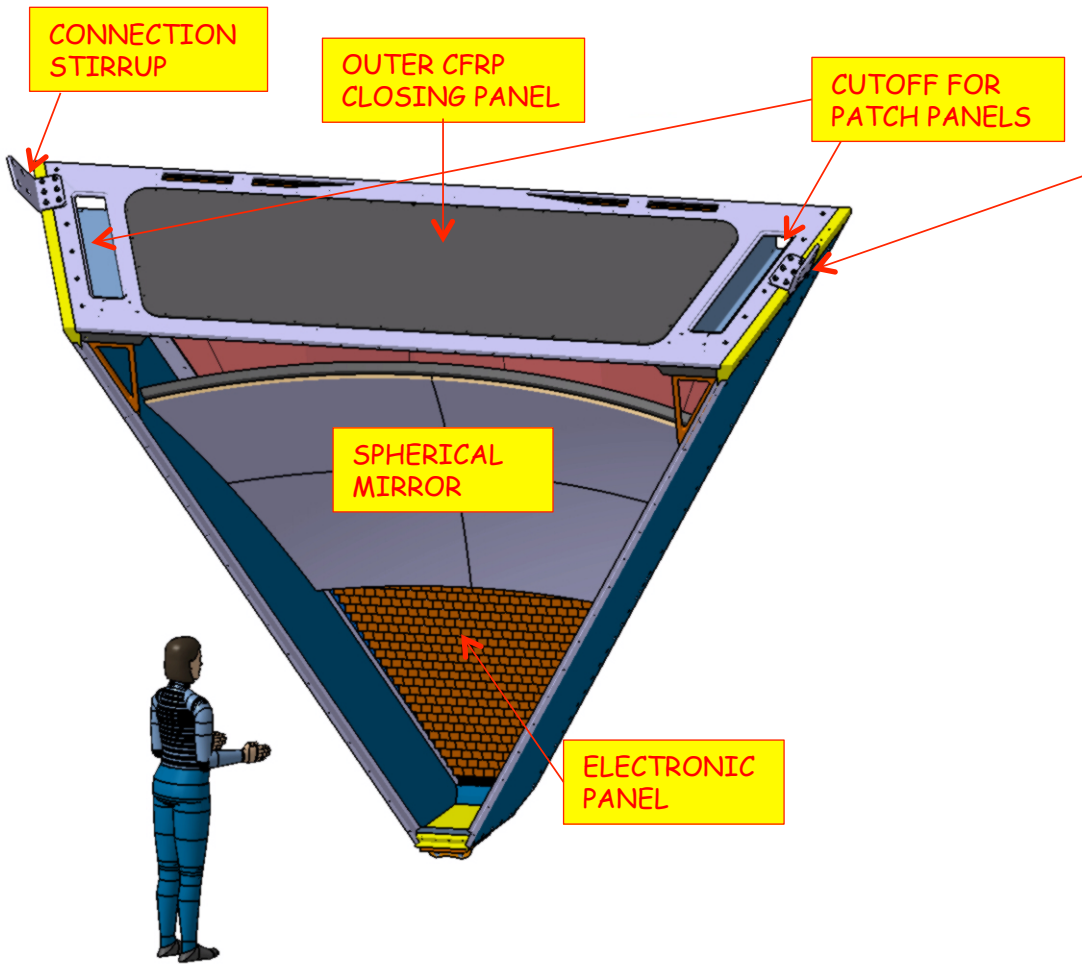
RICH Mechanics Review: 20 June 2014

RICH module designed to be as much as possible close to the existing LTCC sector layout

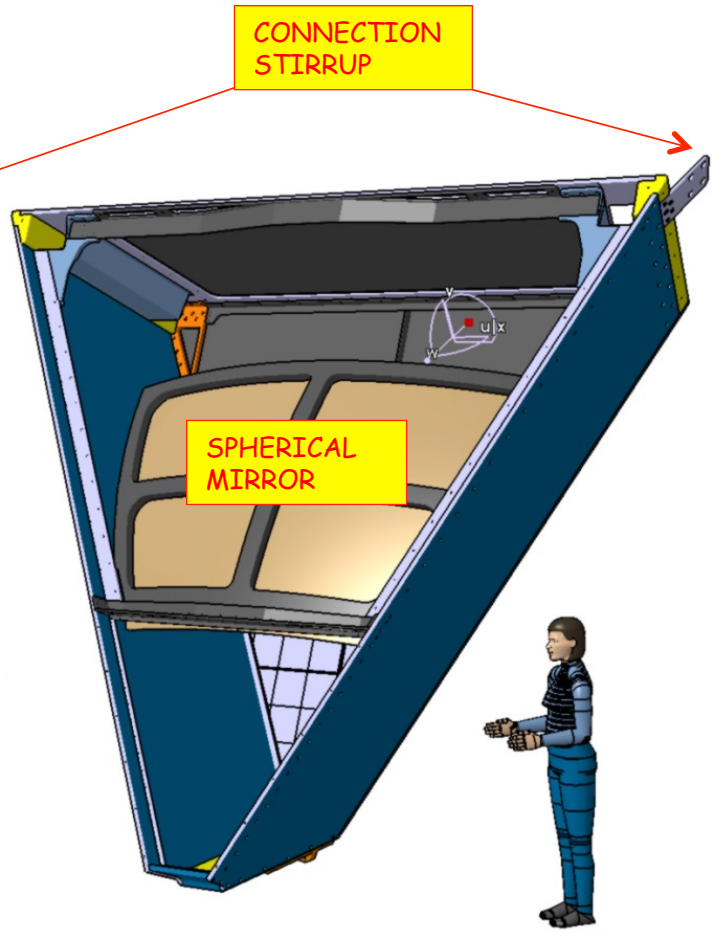


RICH Module General Assembly

RICH MODULE BACKWARD VIEW *(OPENED)*



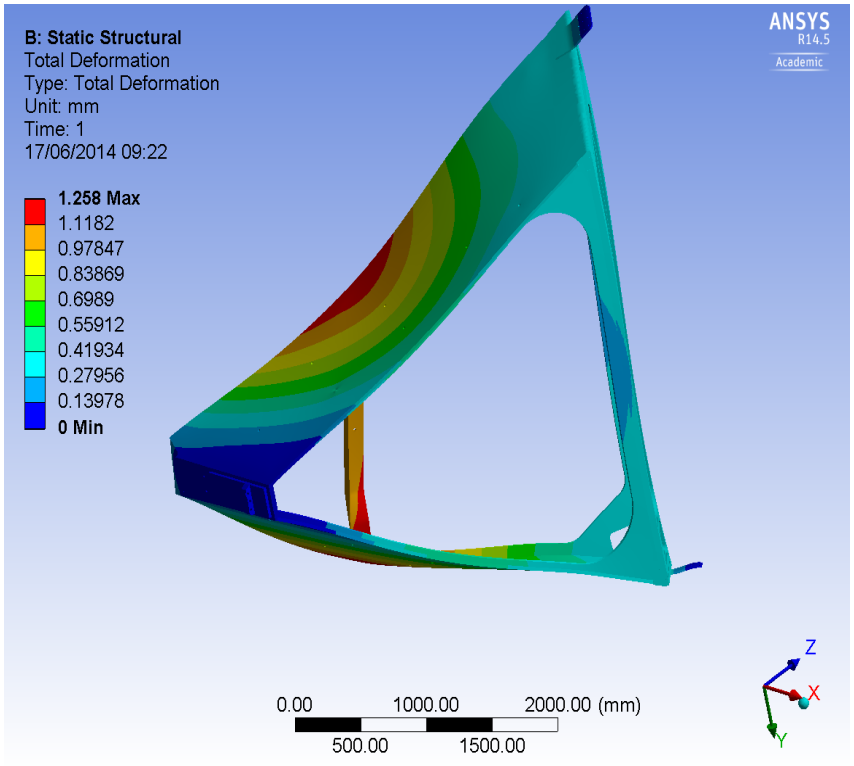
RICH MODULE FORWARD VIEW *(OPENED)*



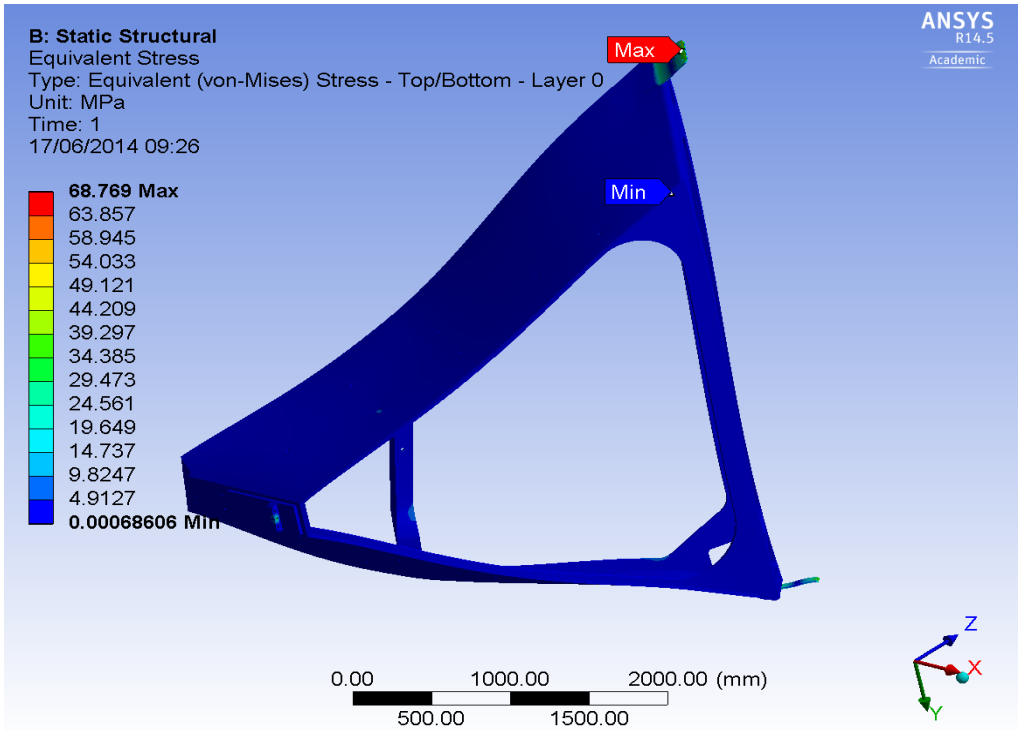
D. Orecchini

FEA Model Stress Analysis

Deformations

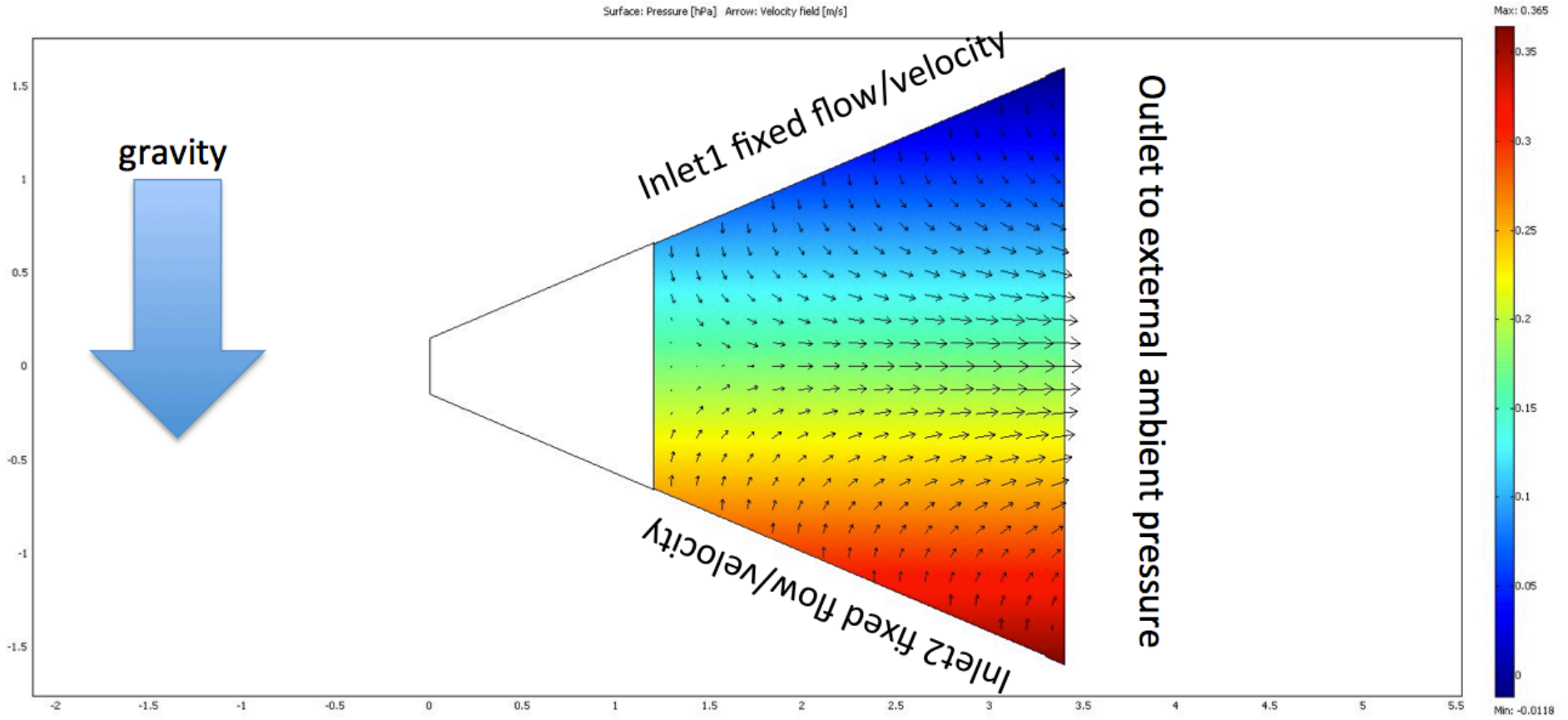


Constraint Weight Stress



S. Tomassini

Gas System Design Parameters

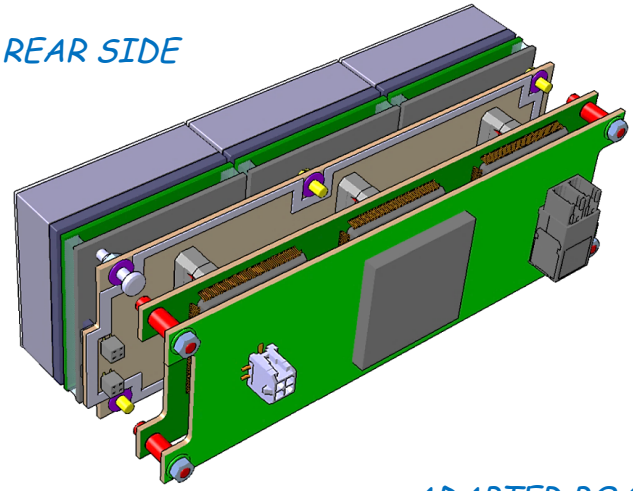


R. Perrino

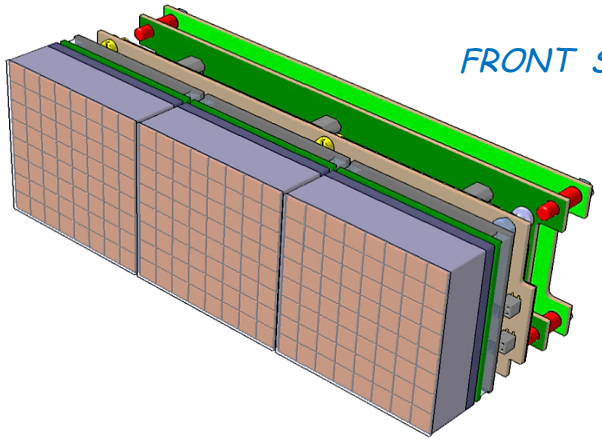
Read-Out Electronics

Procurement of the Front-End boards Initiated

REAR SIDE



FRONT SIDE

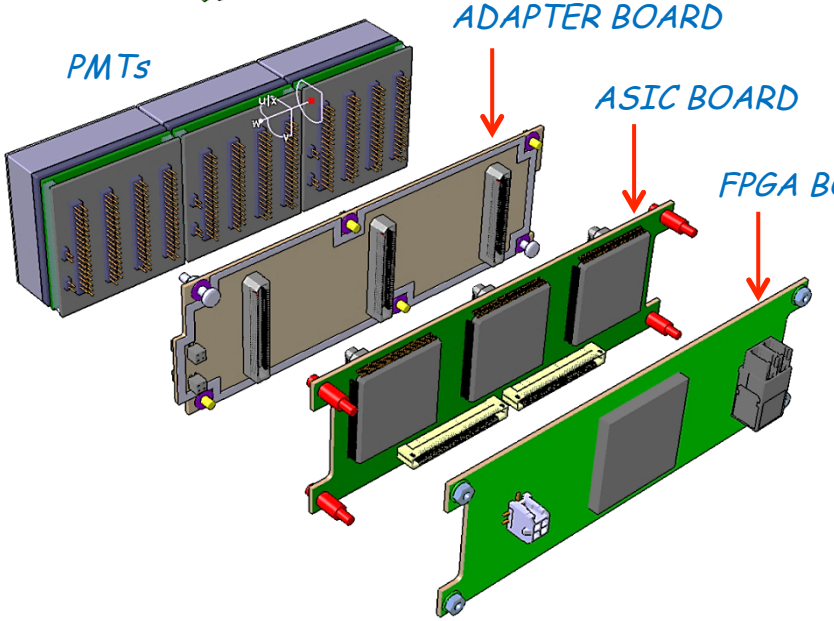


PMTs

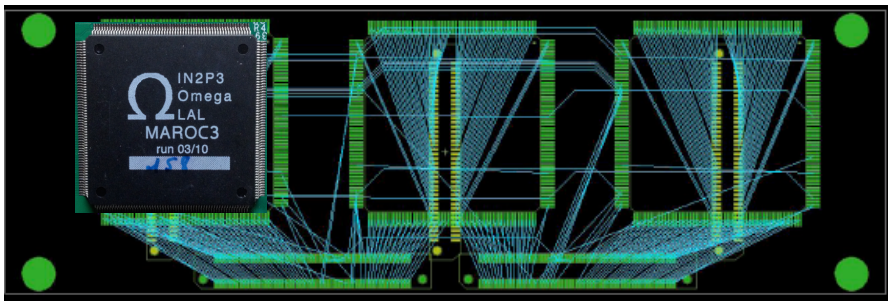
ADAPTER BOARD

ASIC BOARD

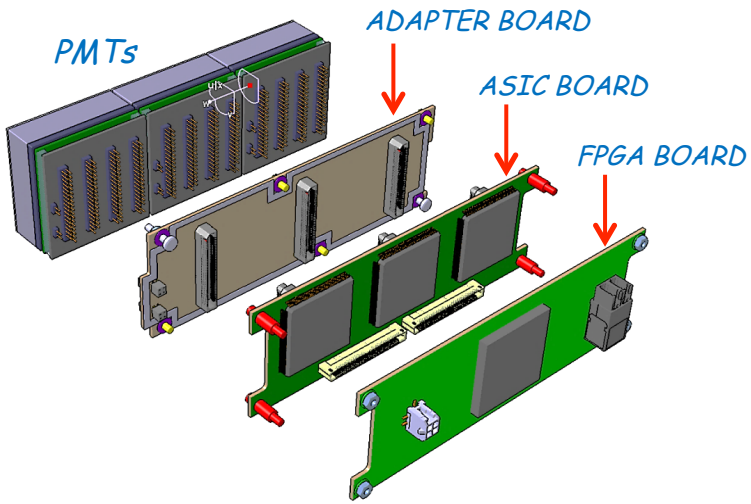
FPGA BOARD



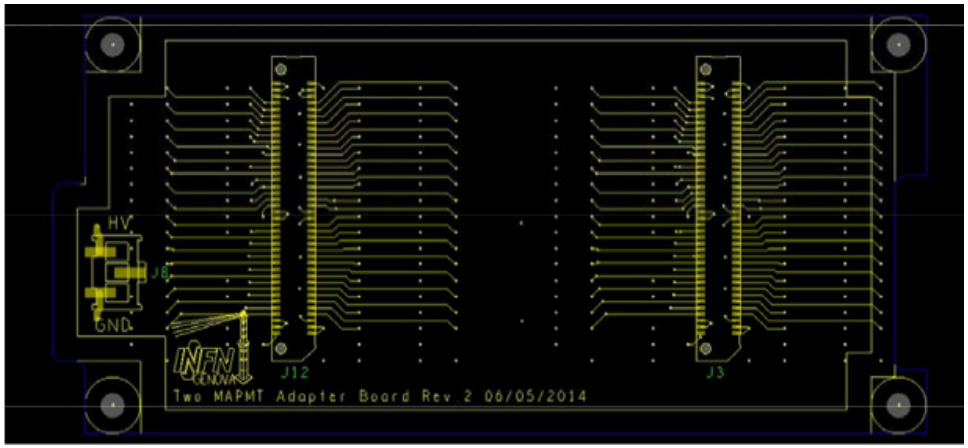
Preliminary ASIC BOARD routing (INFN)



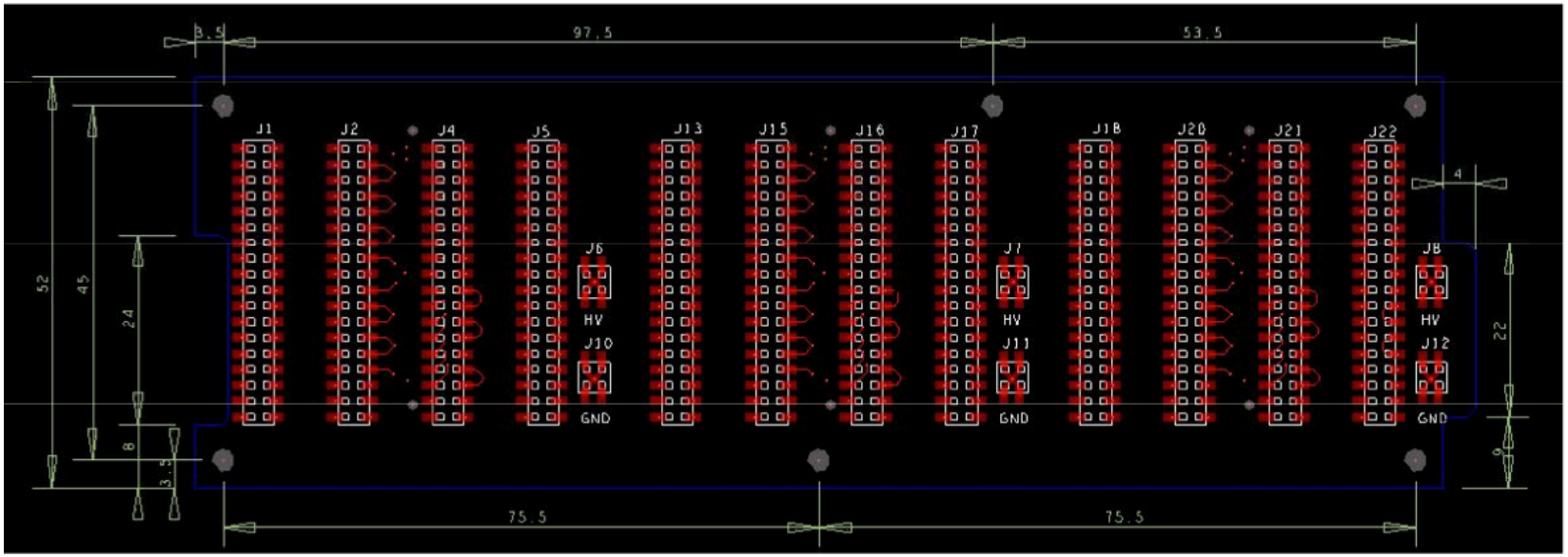
Adapter Boards



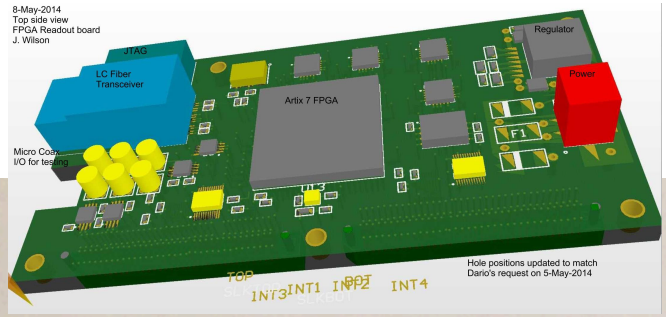
2 x PMTs



3 x PMTs



FPGA Boards



Sample Boards to check components conflicts and cabling issues

ASIC board
2 MaPMT

ASIC board
2 MaPMT

ASIC board
3 MaPMT

FPGA board #1
*Modified
Fiber Transceiver

FPGA board #2

FPGA board #3
*Modified
Fiber Transceiver

Two sample FPGA boards shown with modified orientation of the fiber transceiver.
LC Fiber cable omitted on FPGA board #3 (see photo) above.
No issues with DC input connector, but no cabling is shown at this point.

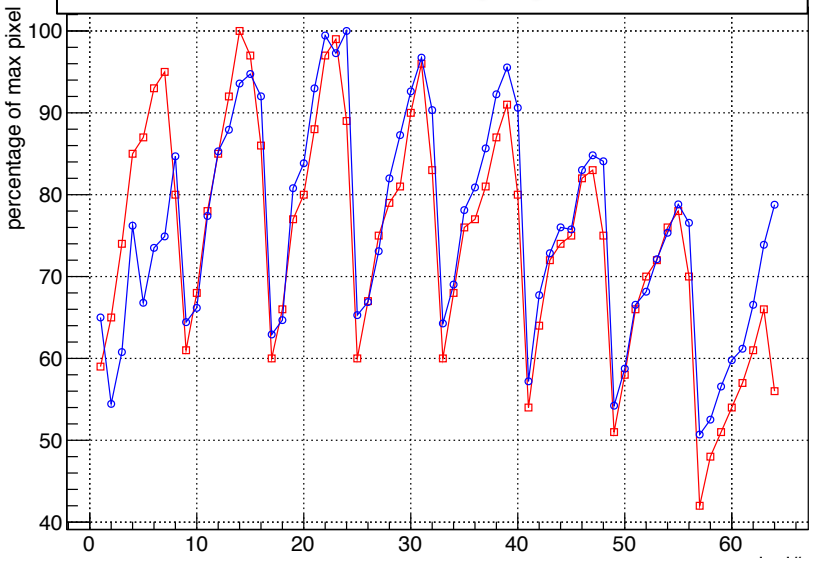
MA-PMTs Acceptance Tests

90 Hamamatsu MAPMT out of 400 delivered and tested at Jlab

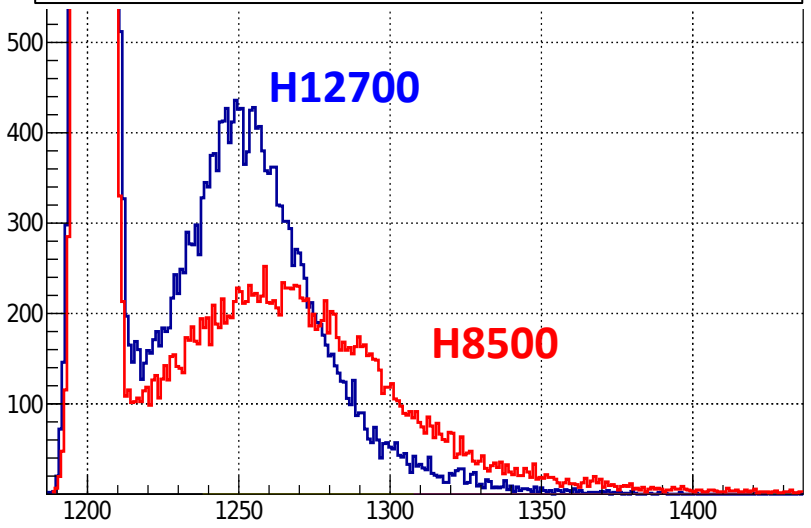
- 80 H8500 (2 rejected)
- 10 H12700 with enhanced single photoelectron spectrum

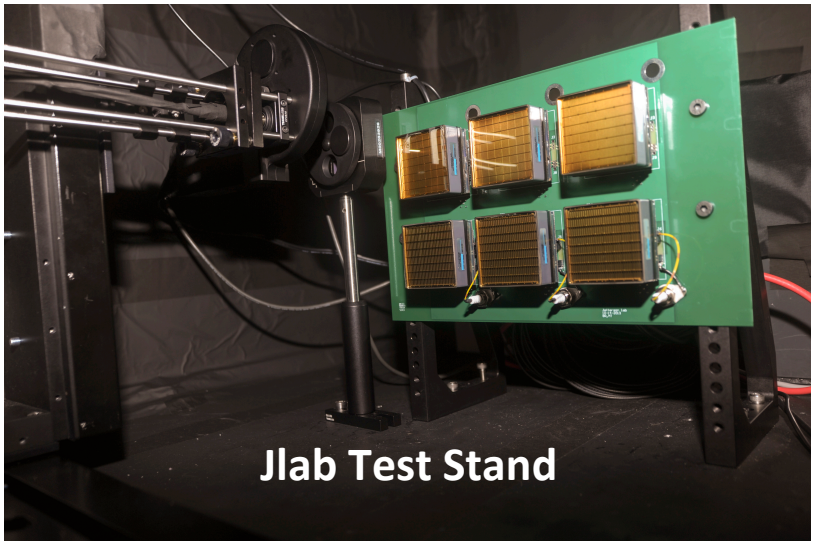
V. Kubarovsky

PMT Gain Comparison:
Hamamatsu ⟷ Jlab



Single Photoelectron Spectrum





Aerogel

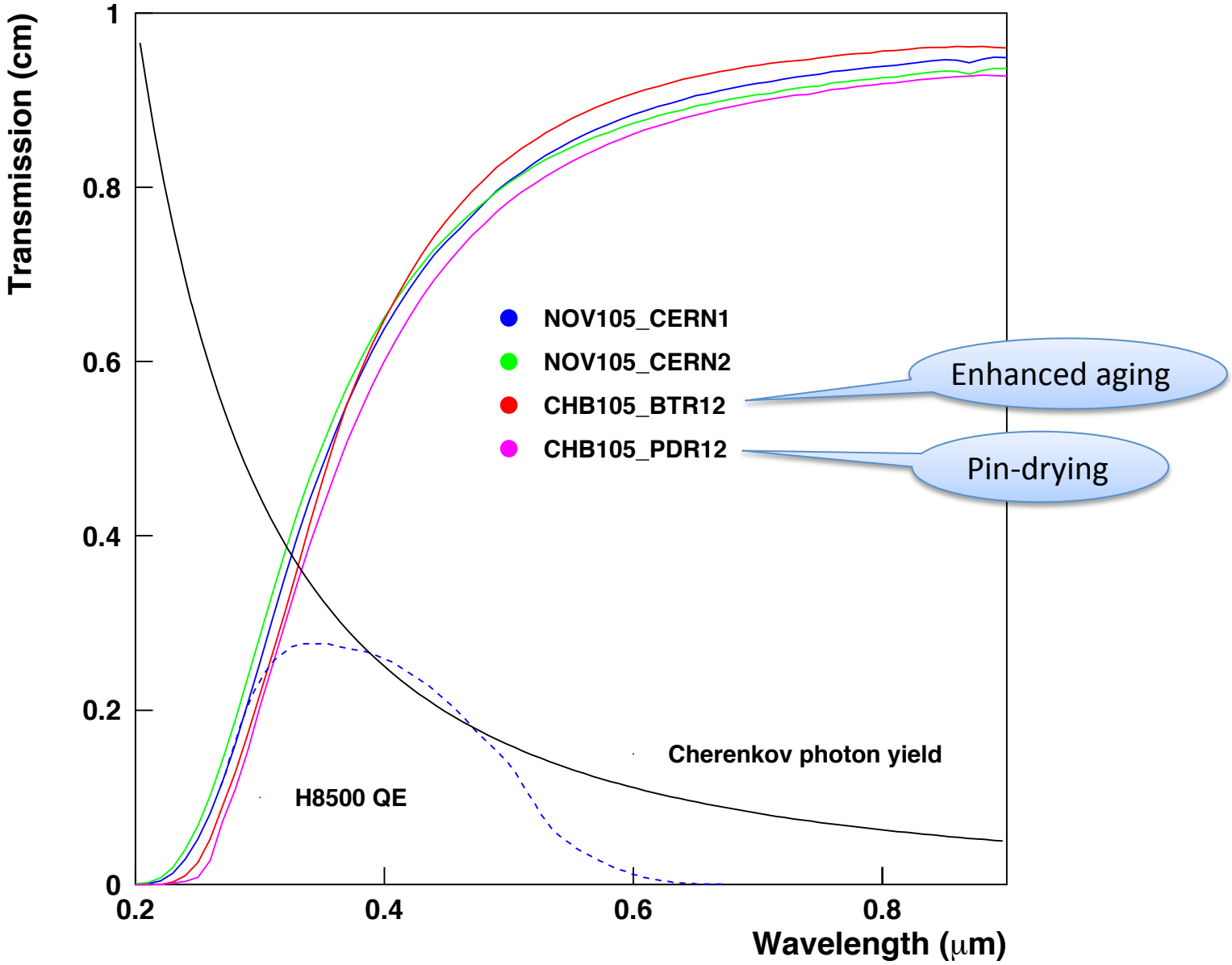
The Manufacture Engineering Phase by the Russian vendors at Novosibirsk to improve and stabilize large tiles production yield has been completed:

- large tiles yield acceptable for mass production has been achieved
- new tiles with optical improved surface delivered for test
- visit of the manufactures from Novosibirsk in Ferrara: March 17-23, 2014
- Chiba University (Belle II) aerogel acquired for comparison tests

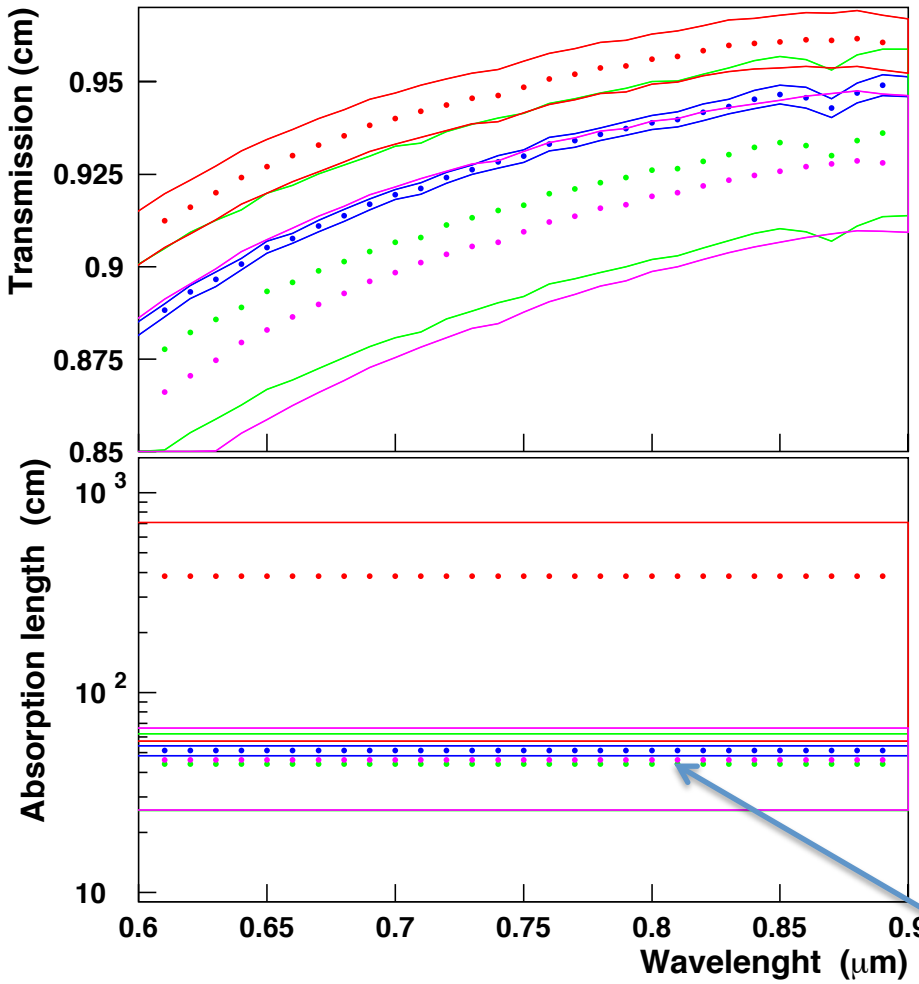
Aerogel Radiator

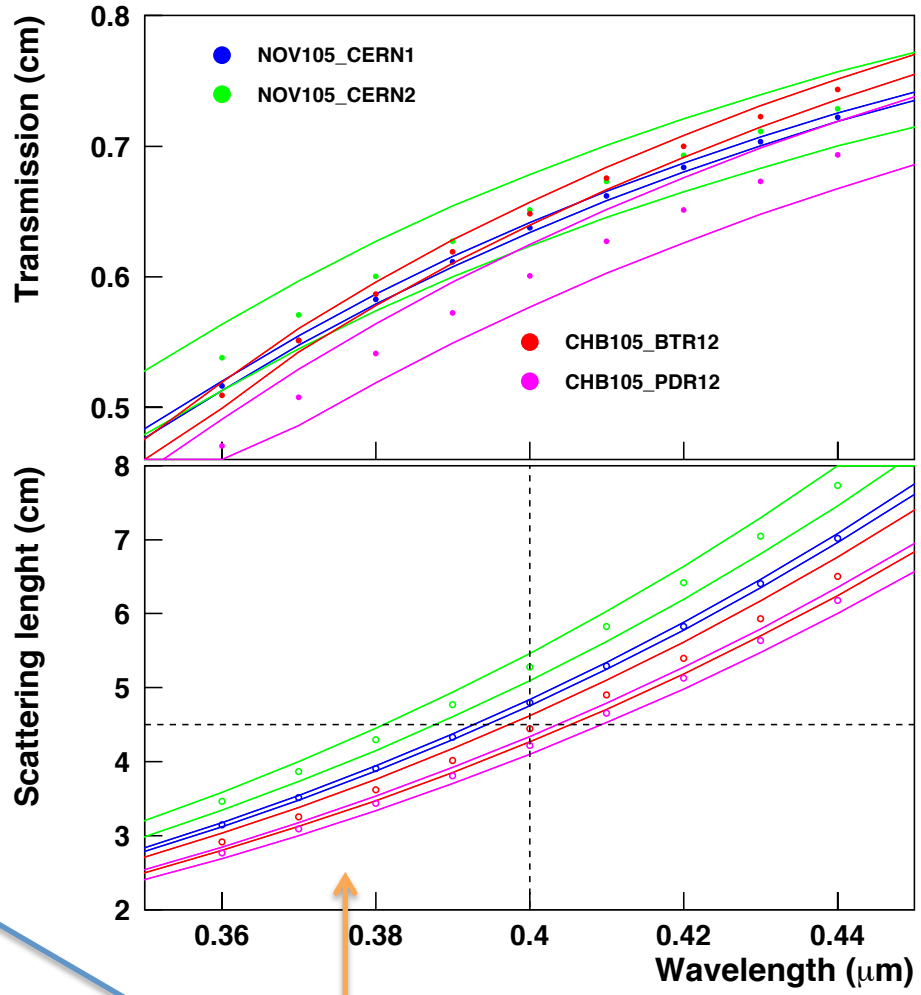
Rafractive index: 1.05
Area: 20x20 cm^2
Thickness: 3 cm
Scattering Length: greater than 50 mm

Transmittance



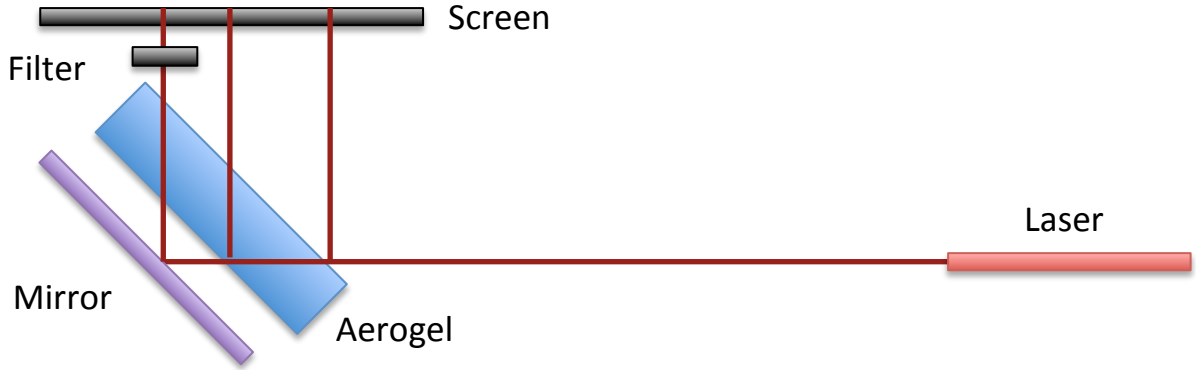
Hunt Analysis

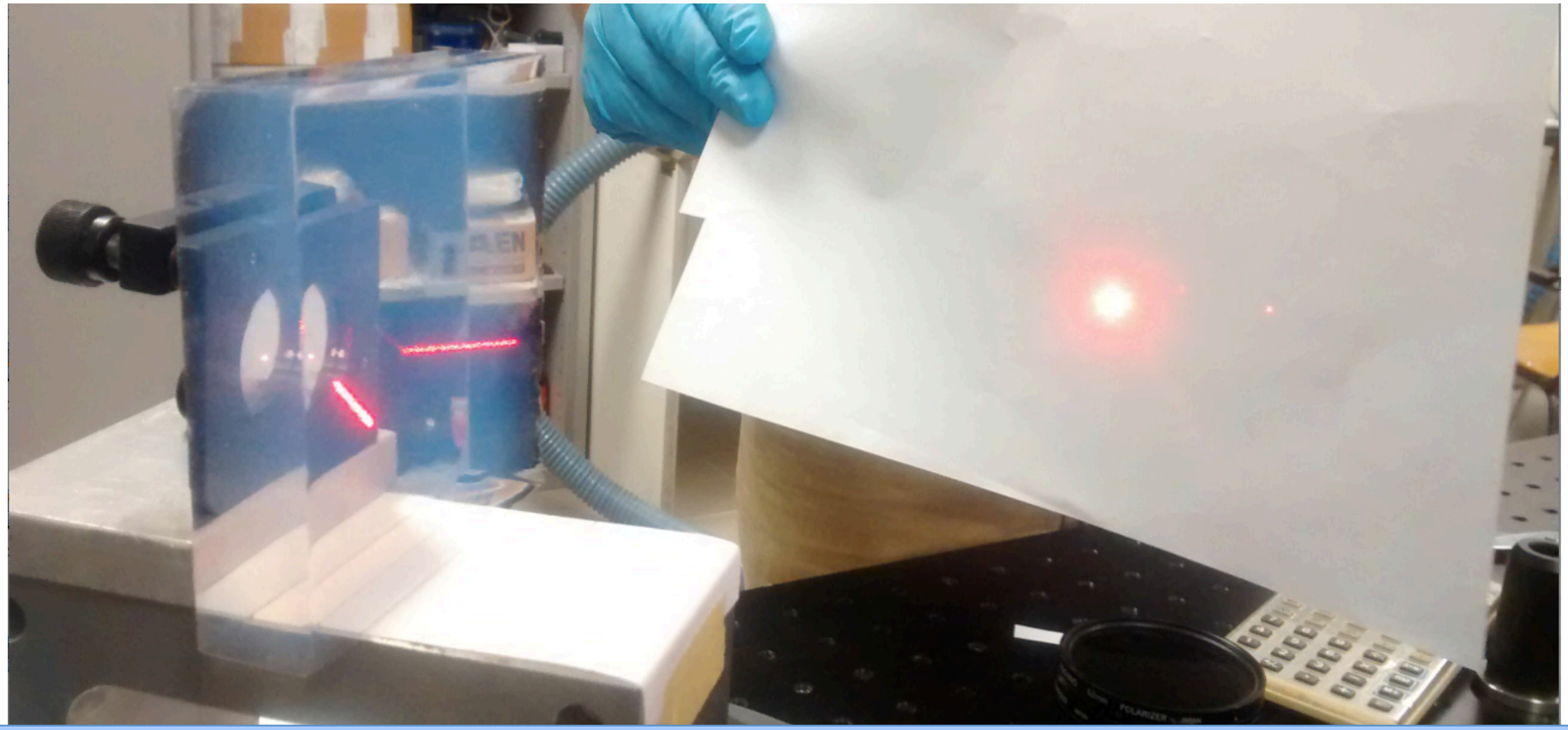




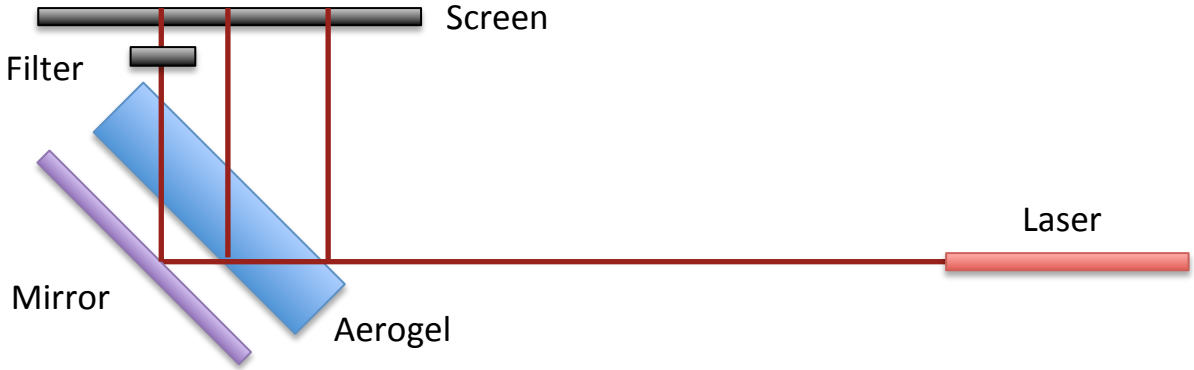
$$T_H(\lambda) = A \cdot e^{-\frac{Ct}{\lambda^2}} = e^{-\frac{t}{\Lambda_A}} \cdot e^{-\frac{t}{\Lambda_s}}$$

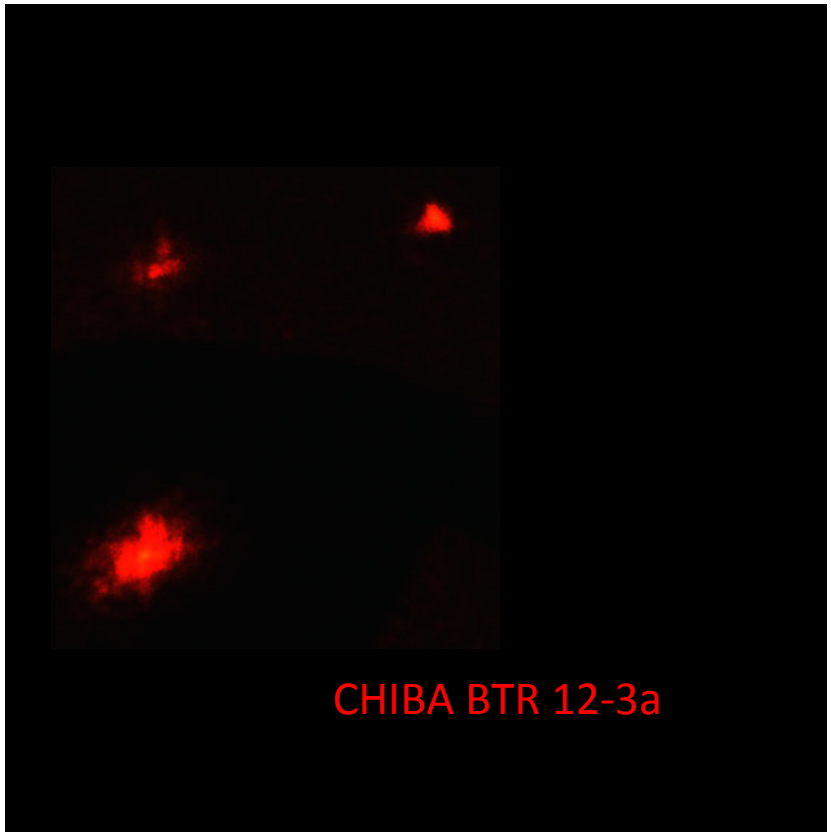
Aerogel Surface Quality

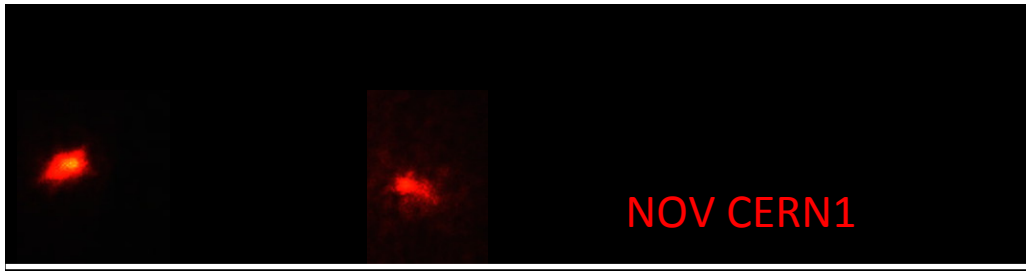




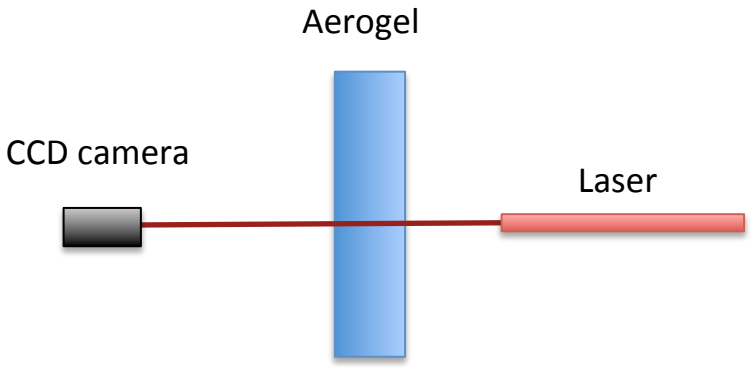
Aerogel Surface Quality



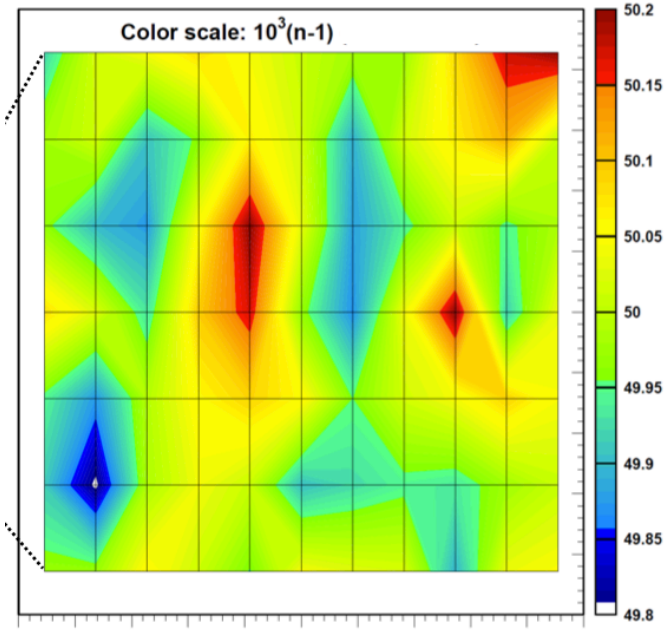




Aerogel Uniformity



New automatized system
Studying sensitivity on edge effects, tile bending



$$\delta n \sim 4 \cdot 10^{-4}$$

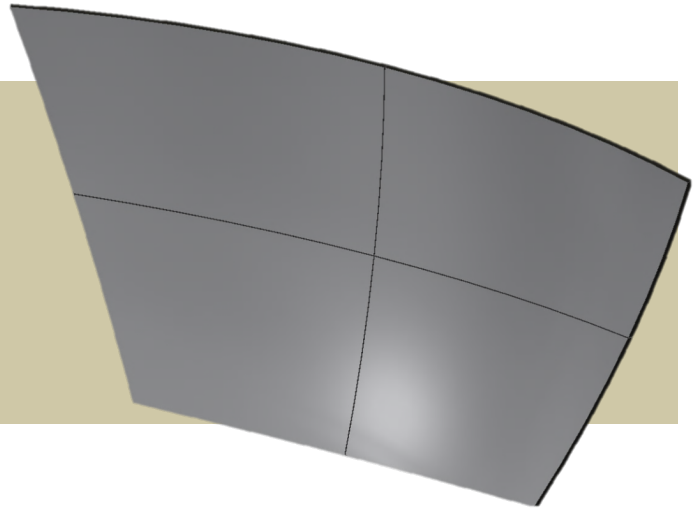
Mirrors

Milestone: Identification of Mirror Technical Specification (3/31/14) **achieved (2/28/14)**

Manufacture Engineering Phase ongoing with companies in Italy and USA
In contact with CERN laboratory for mirror characterization

CFRP SPHERICAL Mirror

Radius tolerance <= 1%
Surface accuracy: 5 µm RMS
Surface Quality: 3 nm RMS
D0 < 5 mm
Reflectivity > 90%



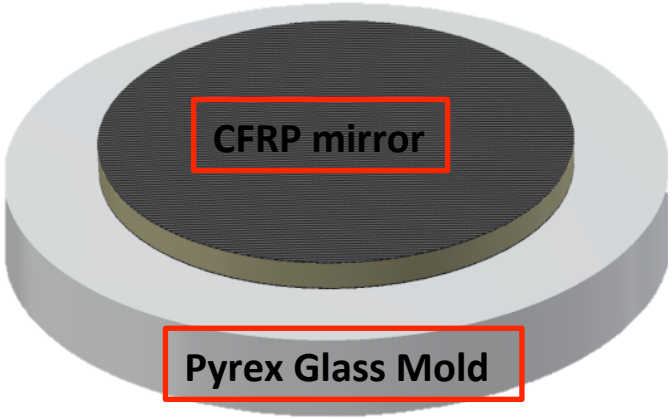
CFRP Spherical Mirror: Mandrel Demo

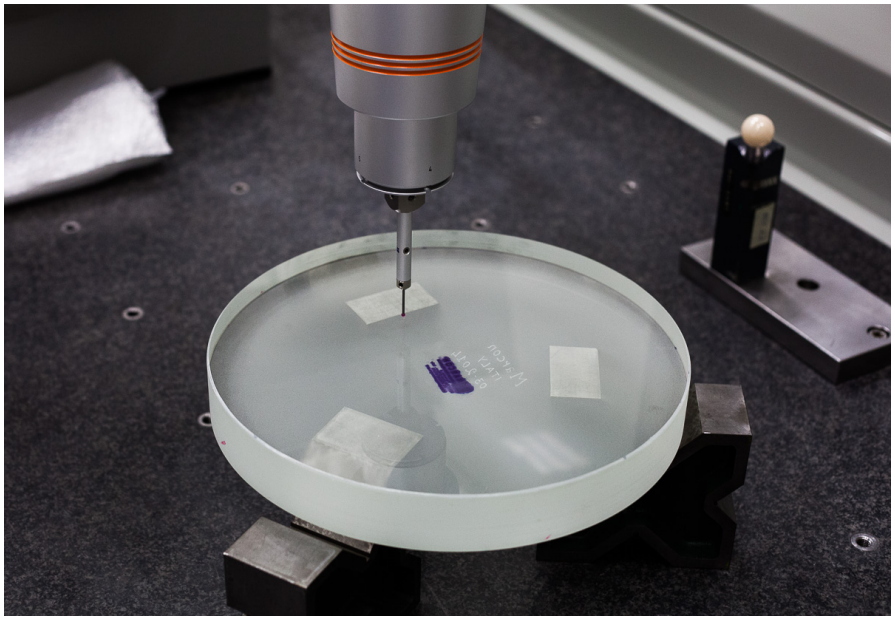
Mandrel demo in preparation at Marcon (Italy) :

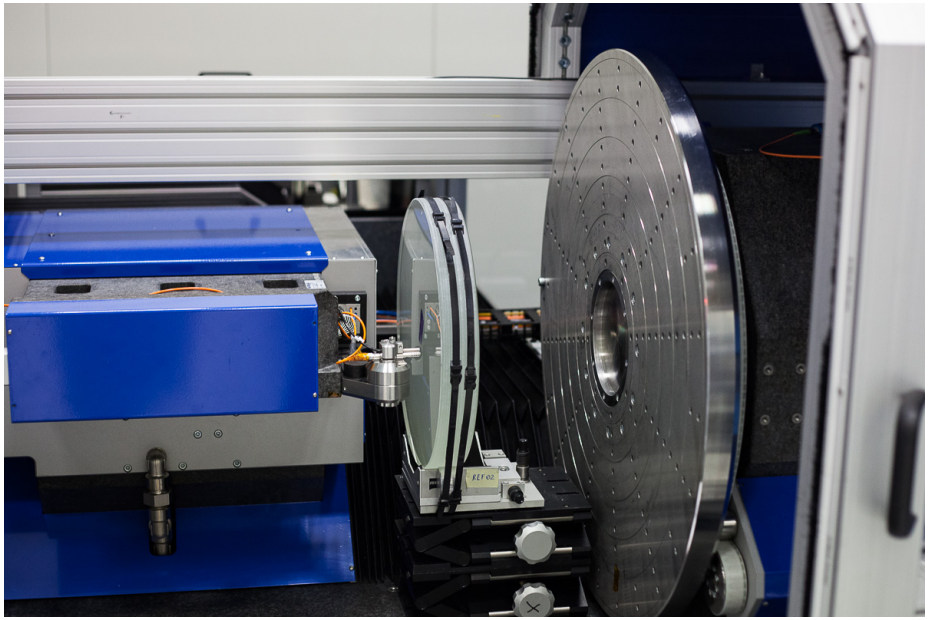
- supremax (borosilicate glass) material
- spherical shape, 4 m radius, 35 cm diameter

⇨ Delivered at the end of March

Mechanics is fulfilling specs







Mandrel Demo: Shape Accuracy

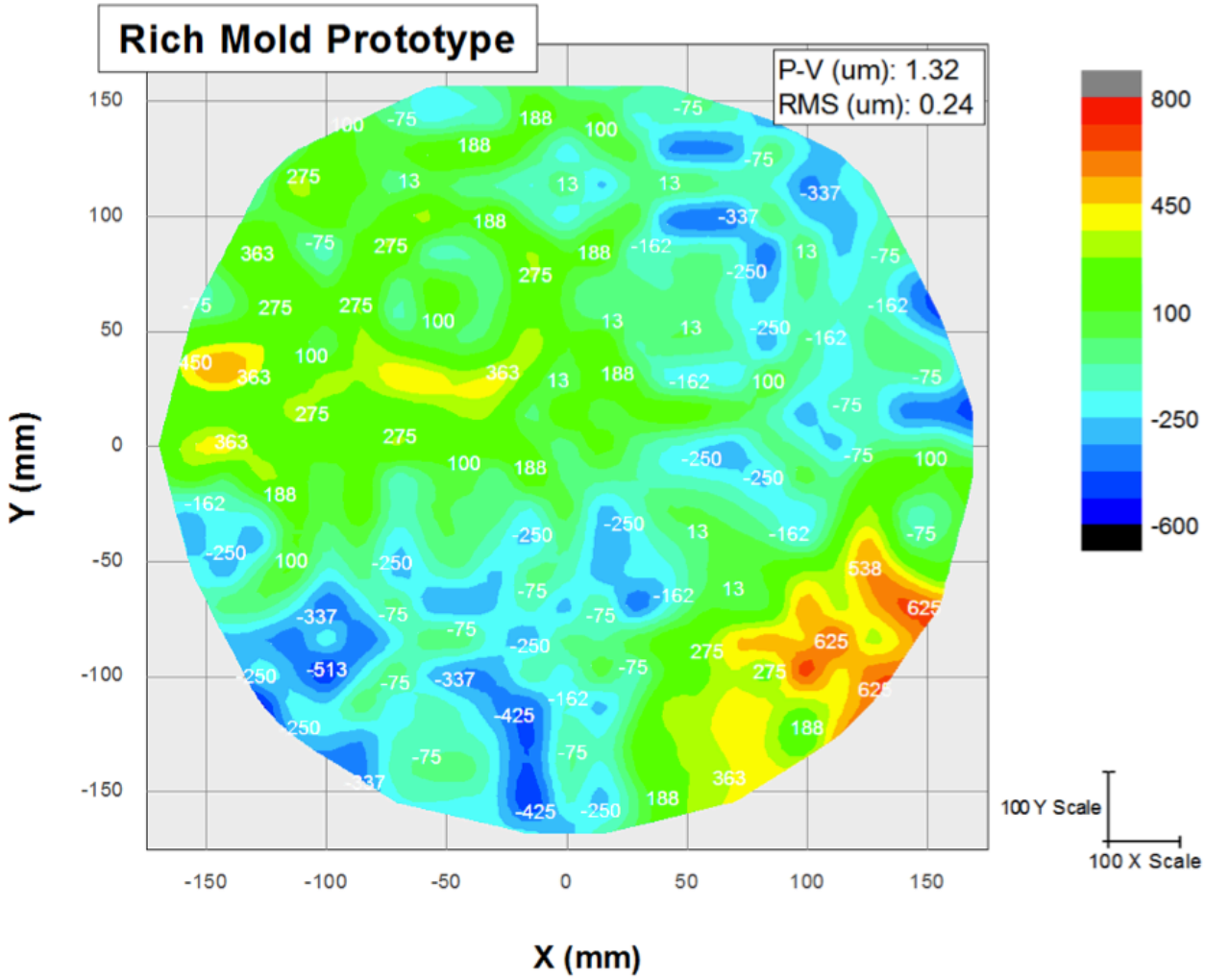
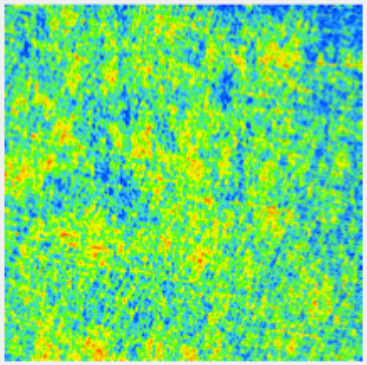
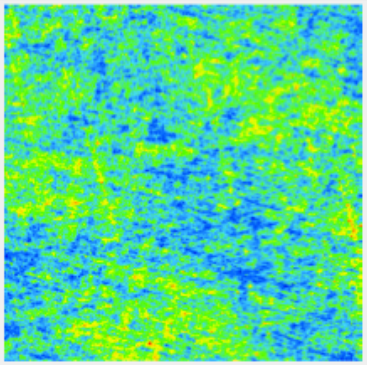
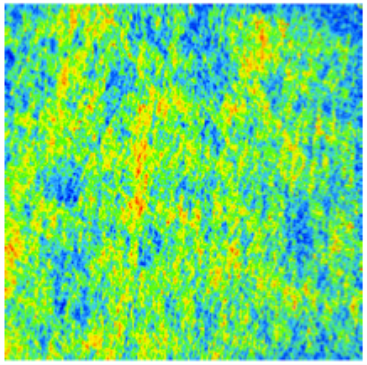
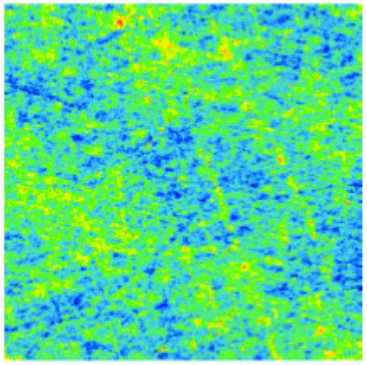
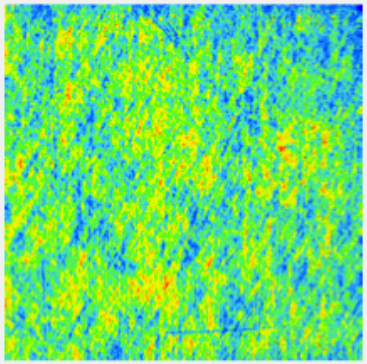
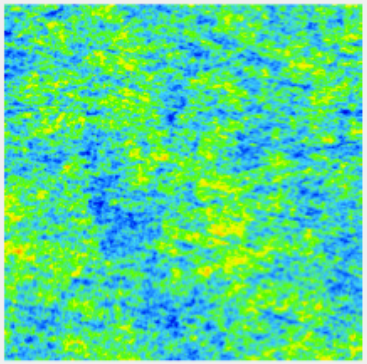


Figure 1 – Residual plot from CMM measurements

Mandrel Demo: Roughness

10X		50X	
Height Parameters **Sq** 0.524 nm **Sp** 1.88 nm **Sv** 1.30 nm **Sz** 3.18 nm **Sa** 0.422 nm			Height Parameters **Sq** 0.896 nm **Sp** 5.56 nm **Sv** 2.32 nm **Sz** 7.88 nm **Sa** 0.713 nm
Height Parameters **Sq** 0.547 nm **Sp** 2.87 nm **Sv** 1.32 nm **Sz** 4.19 nm **Sa** 0.439 nm			Height Parameters **Sq** 0.927 nm **Sp** 9.53 nm **Sv** 2.83 nm **Sz** 12.4 nm **Sa** 0.719 nm
Height Parameters **Sq** 0.502 nm **Sp** 2.11 nm **Sv** 1.24 nm **Sz** 3.35 nm **Sa** 0.403 nm			Height Parameters **Sq** 0.863 nm **Sp** 4.35 nm **Sv** 2.63 nm **Sz** 6.98 nm **Sa** 0.689 nm

Mandrel Demo: Characterization

Table 5 – Integrated bandwidth roughness from WLI

Interval	Integrated Roughness
1 mm ÷ 20 μm	0.73 nm
20 μm ÷ 1 μm	0.48 nm
1 mm ÷ 1 μm	0.87 nm

Conclusions

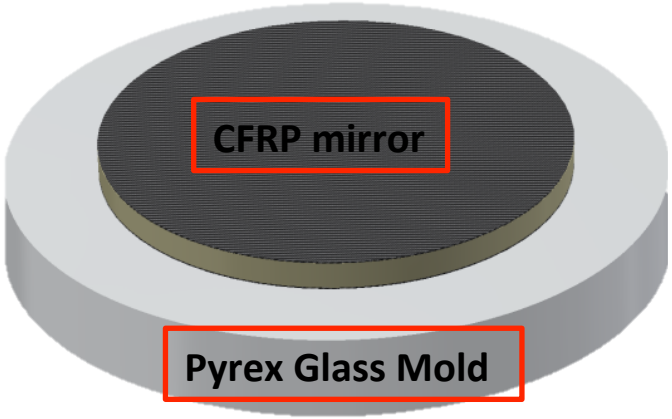
The glass prototype mold has been measured to assess shape errors and roughness.

- The deviation of the radius of curvature is below 1% from the nominal value.
- Roughness is below 1 nm in all requested spatial ranges.
- Measured shape accuracy is 1.32 μm P-V and 0.24 μm RMS.

CFRP Spherical Mirror

Two mirrors demo in preparation at CMA (USA) :

- CFRP skin and rohacell core
- spherical shape, 30 cm diameter
- 1st demo: 3.5 m radius, LHCb finish, from a CMA mandrel

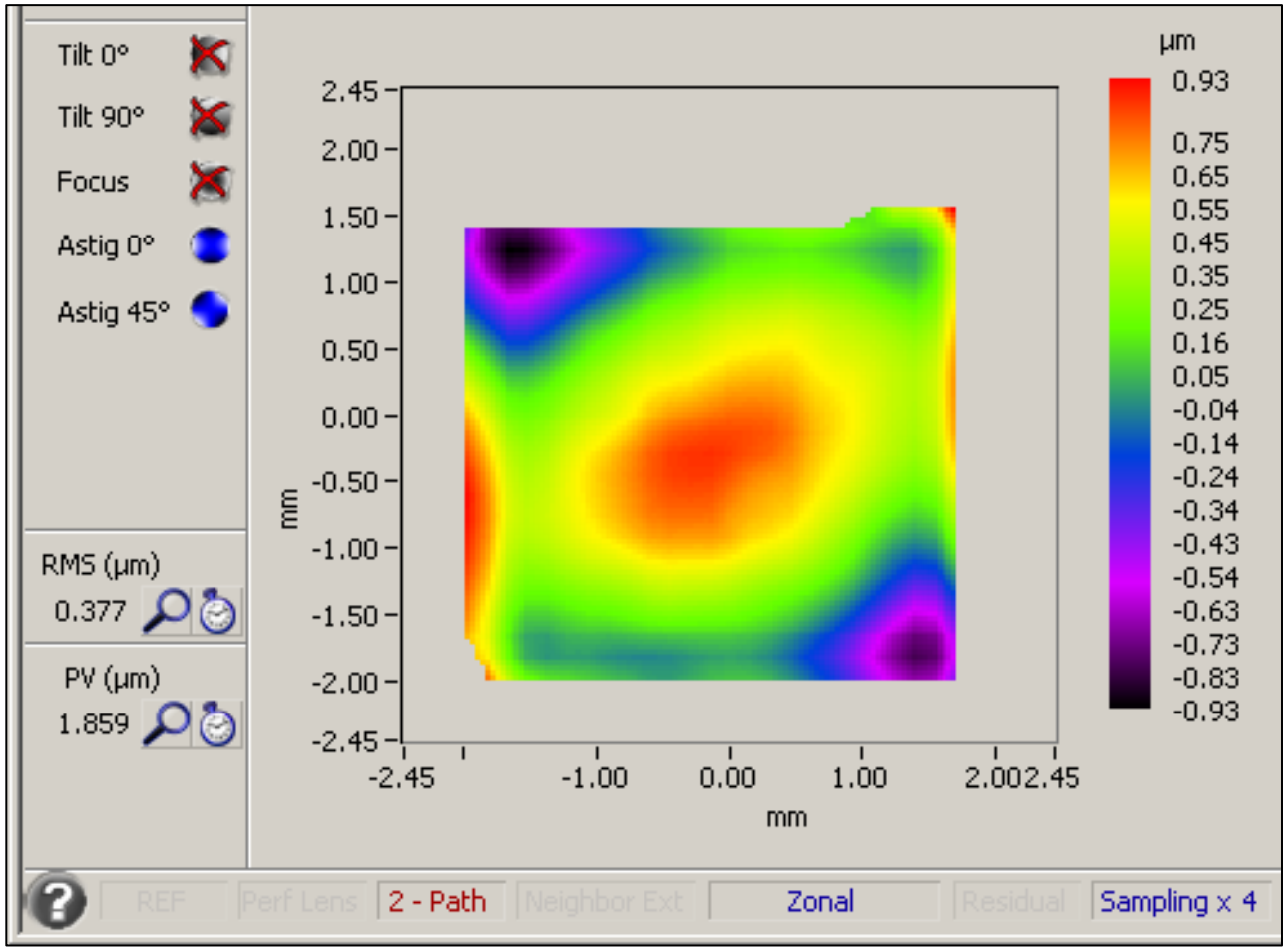


⇨ 2 samples (coated and not) delivered at the end of May
Mechanics does fulfill specifications
Reflective coating does not

- 2nd demo: 4 m radius, CLAS12 finish, from the Marcon mandrel

Wavefront Data

Shack-Hartmann wavefront sensor
Surface map of the CFRP mirror shows errors of 1.86μm p-v surface, below the 2.5 μm p-v surface requirement.

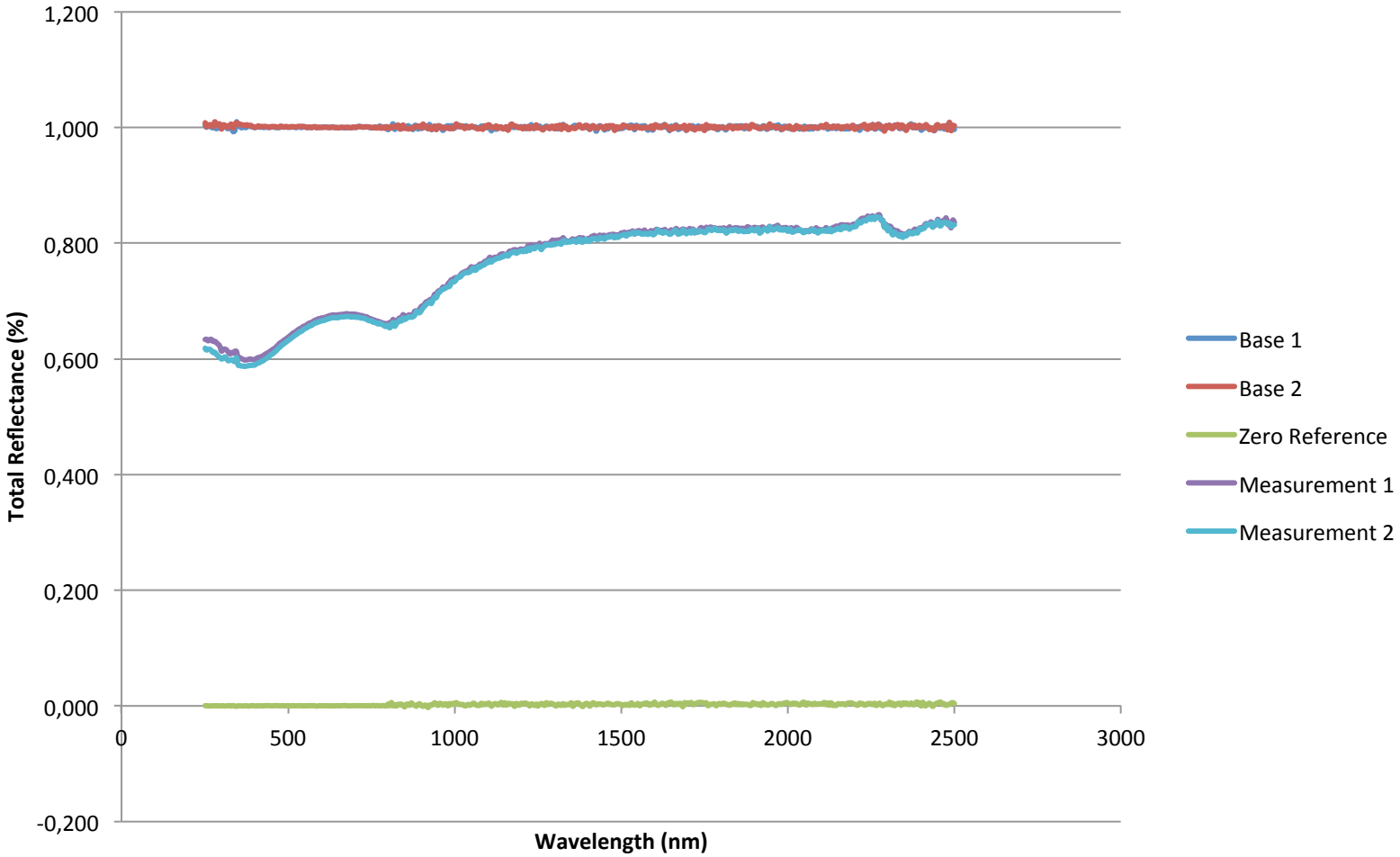


Surface Map of the full aperture of the CFRP mirror. Only tip, tilt and focus removed.

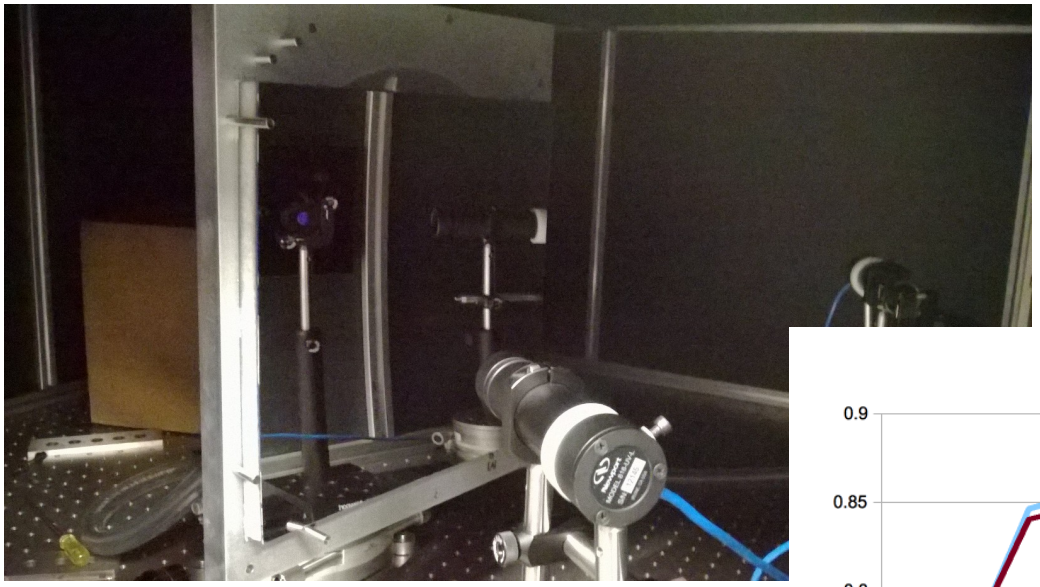
Error is 1.86 μm p-v on the surface.

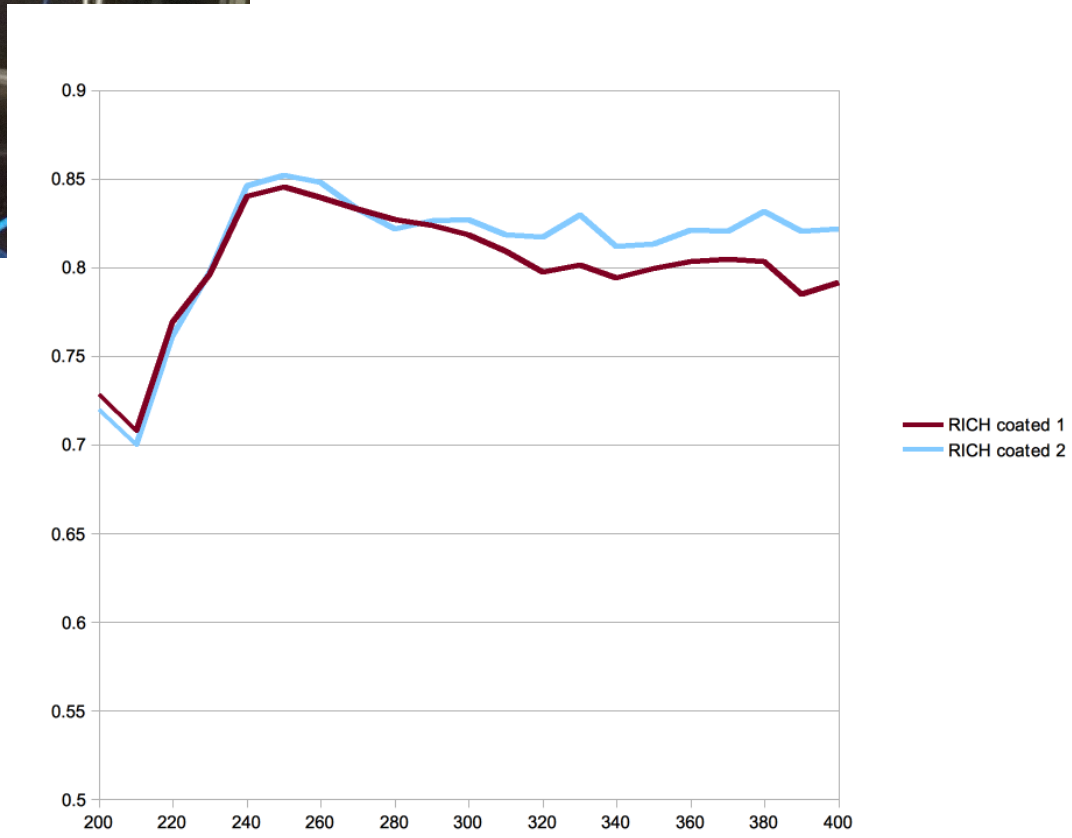
Reflectivity Data

The second measurement indicates just above 60% reflectivity at 450nm



JLab Reflectivity Test





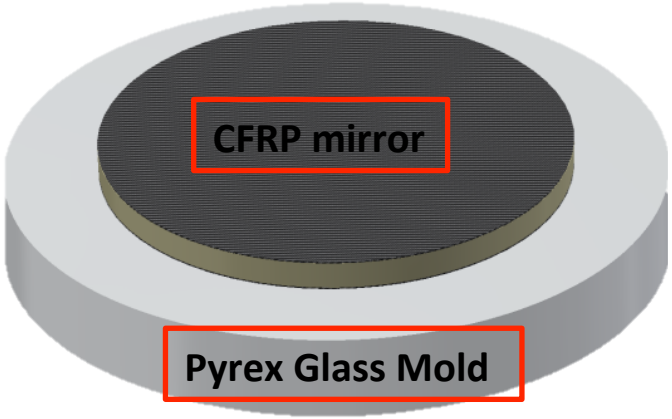
CFRP Spherical Mirror

Two mirrors demo in preparation at CMA (USA) :

- CFRP skin and rohacell core
- spherical shape, 30 cm diameter
- 1st demo: 3.5 m radius, LHCb finish, from a CMA mandrel

mechanics fulfilling specs. but coating process not reliable

- 2nd demo: 4 m radius, CLAS12 finish, from the Marcon mandrel



CMA can do the wanted CFRP substrate but not the coating

For coating we have contacted

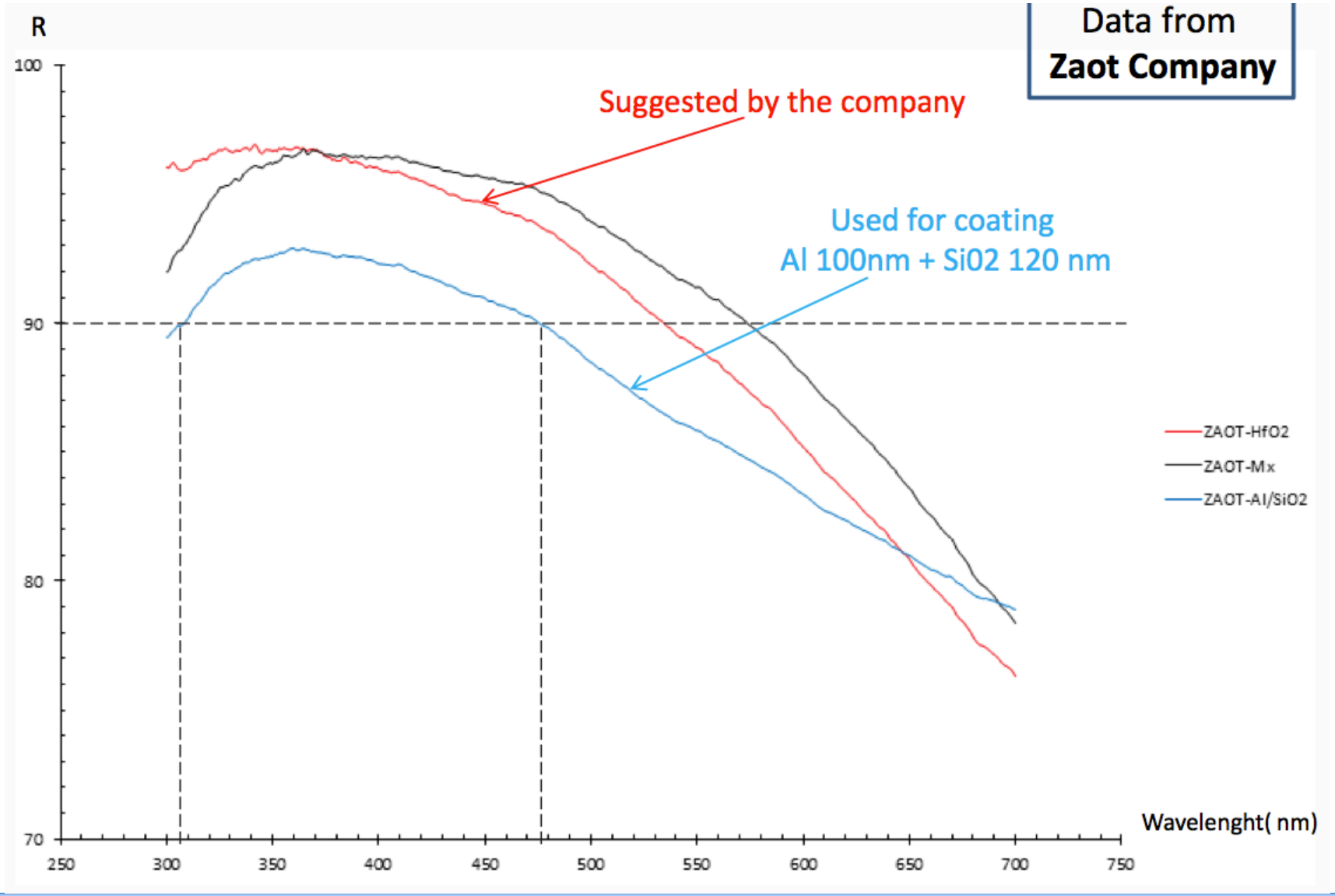
* SESO-Thales (France)
  made the coating for LHCb, max allowed mirror diameter 1.8 m

* Zaot (Italy)
  coating the planar mirrors for Media-Lario, max allowed mirror diameter 1.8 m,
  in principle able to reach 92-95% reflectivity in the 300-600 nm wavelength range

* HTCC company

Glass Skin Mirror

Suitable coating with room for improvement



Mirrors

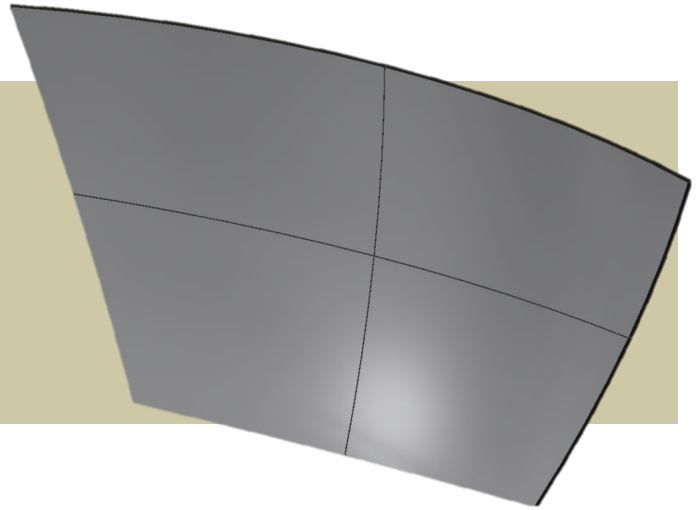
Milestone: Identification of Mirror Technical Specification (3/31/14)

Manufacture Engineering Phase ongoing with companies in Italy and USA

In contact with CERN laboratory for mirror characterization

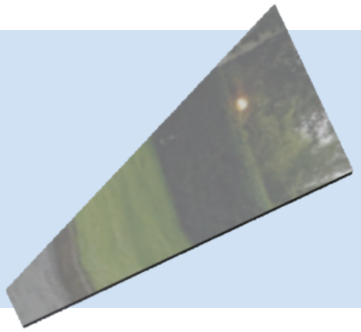
CFRP SPHERICAL Mirror

Radius tolerance <= 1%
Surface accuracy: 5 µm RMS
Surface Quality: 3 nm RMS
D0 < 5 mm
Reflectivity > 90%



Planar Glass Mirror

Planarity tolerance <= 0.1 mm
Surface accuracy: 5 µm RMS
Surface Quality: 3 nm RMS
Reflectivity > 90%

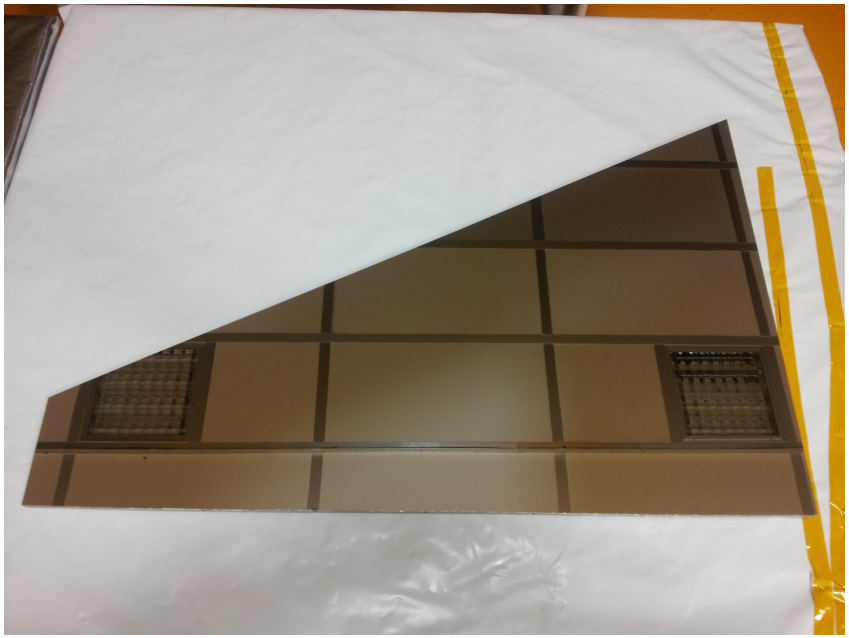


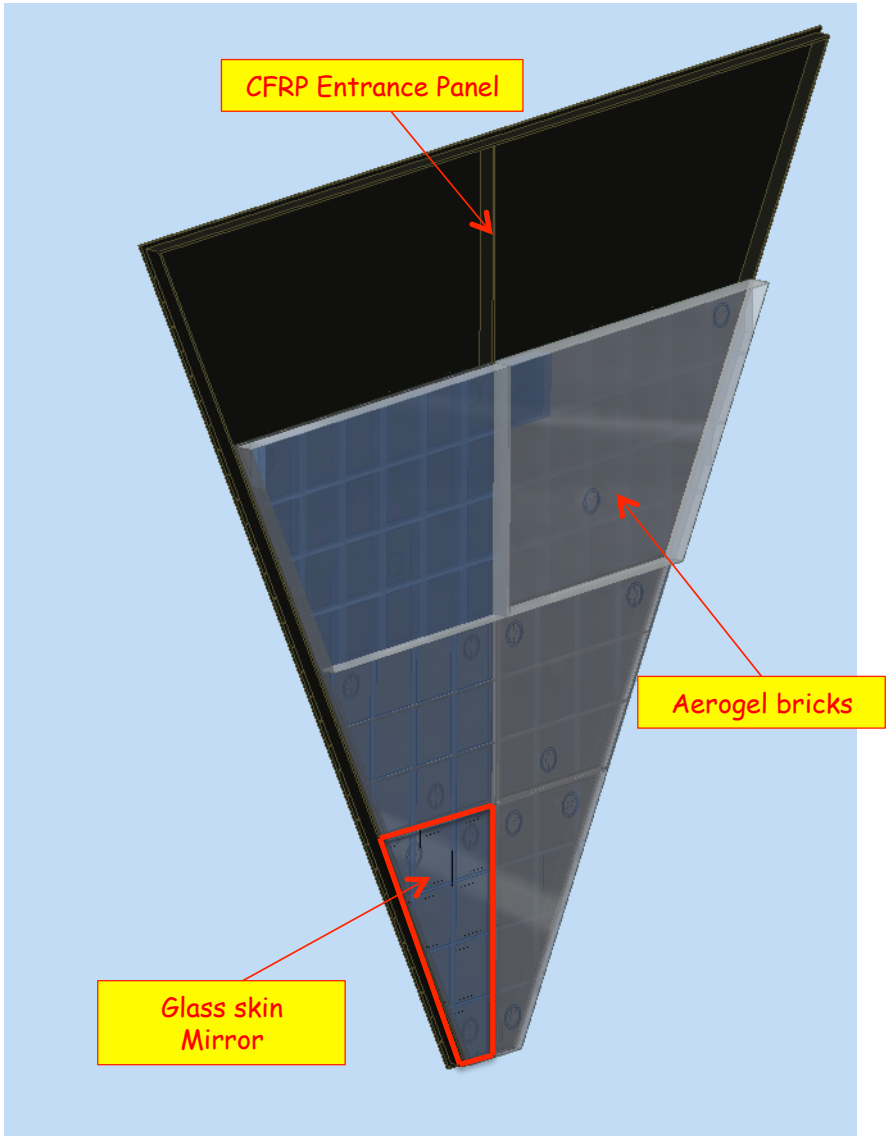
Glass Skin Mirror

Two demos under preparation at Media-Lario (Italy) :

- soda-line mm glass skin and Al honeycomb core
- reinforced frame for aerogel holder
- 1st demo: 1.6 mm (standard) glass skin thicknesses

Surface quality: 40 μm p-v, 8-9 μm rms
- not perfect Al mold (20 μm p-v)
- not optimized vacuum process
- gravity (to be studied by FEM simulation)





RICH Project Latest's

- ✔ Ongoing: Mechanic Review Process
- ✔ Ongoing: Procurement of Readout Electronic
- ✔ Ongoing: Mirror and Aerogel manufacture engineering
- ✔ Ongoing: H8500 and H12700 characterization

- ✔ Before summer: start aerogel production
- ✔ Fall: complete mirror manufacture engineering
- ✔ Fall: prototype of readout electronic ready for tests