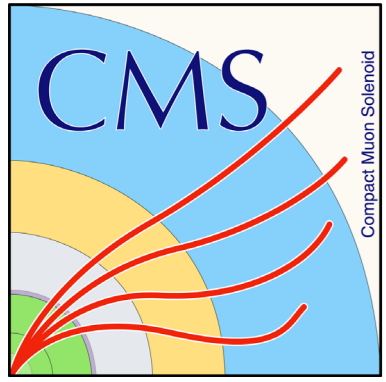


The construction of TBPX Layer1 and Layer4 - mechanical structures prototypes for CMS phase 2

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1) CMS phase 2 Inner Tracker – TBPX:

The most recent layout is: https://cms-tklayout.web.cern.ch/cms-tklayout/layouts-work/recent-layouts/OT806_IT742/layoutpixel.html

- Four layers.
- Pixel Modules arranged in rows.
- Nine modules each row.
- No overlap along the rows.
- Z max (all rows) = +/- 200,7 mm.
- In each rod a sensor centered in Z=0.
- Three types of sensors:
 - 3D Sensors for Layer 1
 - 2 chips x sensors for Layer 2
 - 4 chips x sensors for Layer 3 & 4

Layer	Radius [mm]	n. row = n. module (r-phi)	n. module (x layer)
1	30	12	108
2	61,5	24	216
3	104,5	20	180
4	146,5	28	252

2) TBPX design:

- Four quarters.
- In each quarter four layers.
- The External Cylinder supports all layers and allows the connection with the TFPX Service Cylinder.
- Different z length of layers in Z+ e Z- parts :
 - Layer4 Z+ (short) - 4 modules.
 - Layer4 Z- (long) - 5 modules.
 - (the same for all staggered layers).
- 14 cooling loops each quarter

3) Layer design:

- External Ladder
- Internal Ladder
- Layer4 and Layer3 Front-Flanges.
- High conductivity CF sheet
- CF foam rods
- Cooling pipe
- Internal ladders Layer1 Z+
- Mechanical flange
- Cooling loops
- Ladders
- Pillars
- Layer4 Z+

4) Layer assembly procedure:

- Pillars on Internal ladders gluing**
 - Internal Ladders on the spindle.
 - Reference: two pins and spindle surfaces.
 - Grease inside cooling grooves of Internal Ladders.
 - Gluing of internal pillars to Internal Ladders.
- Flange on Internal Ladders and cooling pipes positioning**
 - Front-Flange on the spindle.
 - Reference: front spindle face plus two pins on it.
 - Gluing of Front-Flange to Internal Ladders.
 - Cooling tubes in position.
 - Special jig to insert them through the flange windows.
- External Ladders gluing**
 - Grease inside cooling grooves of External Ladders.
 - Glue on the Internal Ladders.
 - at the external edges of CF foam rods.
 - External Ladders in position on top of Internal Ladders.
 - Reference: two pins and spindle surfaces.
 - Final gluing of External Ladders.
 - Glue at the connections between ladders, flange and pillars.
- Extraction and Internal Pillars gluing**
 - Mounting of Layer Holder and extraction of the layer.
 - Gluing of Internal Pillars with dedicated tool.

5) Assembly tools:

Accurate metrology made on them before use.

Reference pins	Nominal	Measured	Δx	Δy		
1,000	-91.000	101.070	-91.016	101.065	-0.016	-0.005
2,000	79.940	110.030	79.953	110.025	0.013	-0.005

- Spindle Layer1
- Spindle Layer4
- Several 3d printed accessories add to them to hold in position the various elements.

6) Layer1 - prototype:

- Three internal Ladders.
- Three external Ladders.
- Two cooling loops.
- The Front-flange.
- Three Pillars.
- Ladders assembled using the final procedure and materials.
- M1.5 bushing to mount the modules.
- Cooling tubes bended by a machine in a Swiss company.
- Special small inserts and cooling fittings laser welded to tubes.
- Currently the Layer1 prototype is connected to Marta CO2 system inside the climate chamber of the Pisa clean rooms for thermal tests.
- The first test was made applying the power at the tube of one cooling loop:
 - TCO2 input = -31.2C
 - TCO2 output = -33.1C
 - CO2 flux = 1.0 g/s
 - Injected thermal power = 85 W
 - Vapor quality at the outlet = 25%
 - Differential Pressure = 0.55 bar

7) Layer4 - prototype:

- Seven internal Ladders.
- Seven external Ladders.
- Five cooling loops.
- Front-flange and Pillars made in carbon peek.
- Moresco grease doped with 70% diamond inside the cooling tube grooves of the ladders (manually distributed).
- Special tool to glue the internal pillars after the extraction needed.
- We estimated 23 gr. of glue and grease in a total weight of 213.75 gr.
- Layer Holder prototype to extract the Layer and the handling of it after the assembling.

8) Layer4 measurements:

- The Layer4 prototype was fully measured with a laser 3D scan at CERN.
- Two pin holes in the flange and a machined surface (that will be connect to External Cylinder) on it define the reference system.
- The measurements was made in free and constrained state conditions.
- In the constrained state the Front-flange was connected to an aluminum plane, like the final condition to the External Cylinder.
- Relevant differences was observed between the free and the constrained state conditions.
- In the constrained status the positions of the ladders close to the flange are very good, the position of the ladders at the edges are less precise.
- The bending deflection of the ladders under the own weight is not negligible.
- Some ladder positions are out of the spec, reasons are under investigation.