

## RE $\pm 4/1$ Assembly

CMS is a general purpose experiment measuring proton-proton and heavy-ion collisions at the Large Hadron Collider (LHC) at CERN. The Resistive Plate Chamber (RPC) system is part of the CMS and contributes to the trigger, reconstruction and identification of muons. This is an RE  $\pm 4/1$  assembly manual with the final assembly shown on the right and below in figure 1.

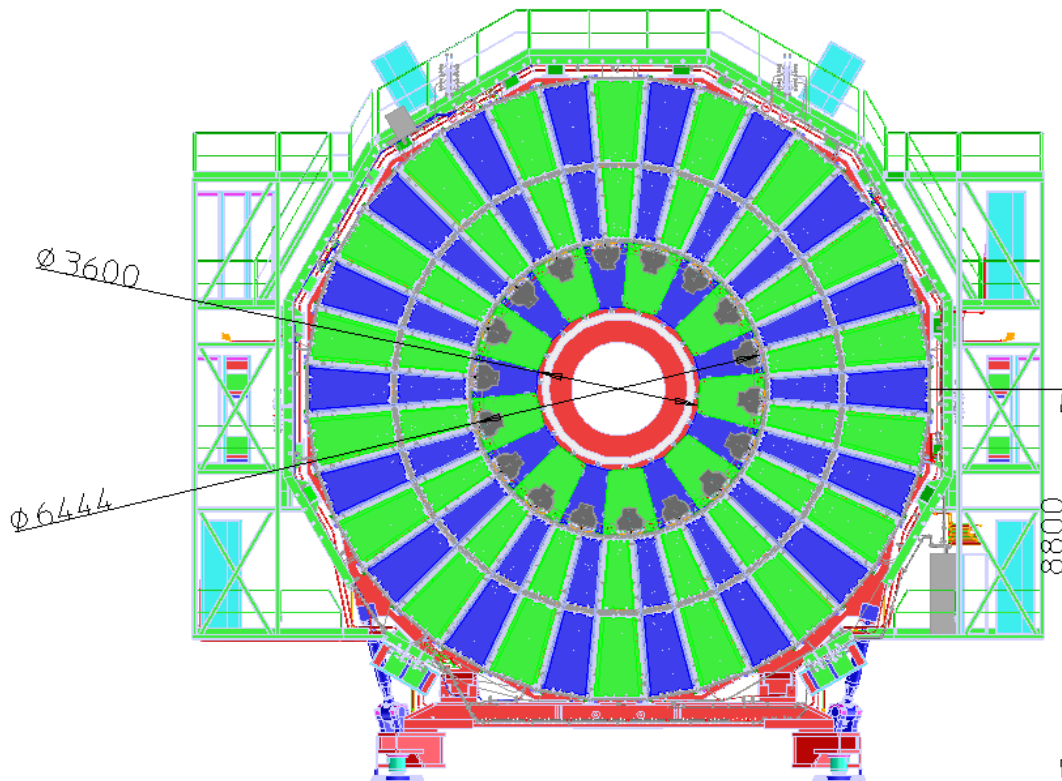
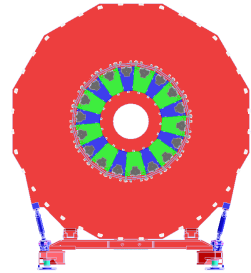


Figure 1: Model of the endcap that contains the RE  $\pm 4/1$  detectors

- The CMS is located at 100 meters underground
- Use a Cherry Picker at the different specified heights above and a crane to raise the detectors
- 2-4 people needed for this assembly (2 people is maximum on the cherry picker, other two should stay on ground for extra assistance)

### Devices:

- Cherry Picker
- Crane

### Hand-Held Tools:

- Set of Allen Keys (M6, M8, M12, M14, M16)
- Four Wrenches of each (M6, M8)

**Main Brackets (outer)**

The main bracket holds the ‘On yoke’ detectors from the outer points. They have the angled piece that allows the connection of the ‘Off yoke’ bracket as well. Each ‘on yoke’ detector connects with two main brackets. Assemble the brackets off-site.

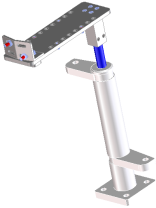


Table 1: Screws, nuts, and washers used for the main bracket.

	Nuts/Screws/Washers	Size	No. Per Bracket
<b>Main Bracket</b>	Screw DIN7984	M8x25	4
	Hexagonal Nut DIN934	M8	2
	Washer DIN126	M8	8
	Washer DIN127	A8.5	2
	Screw DIN7984	M10x30	2
	Washer DIN125	A10.5	2
	Screw DIN933	M5x14	4
	Washer DIN125	A5.4	4
	Screw ISO2009	M6x30	4

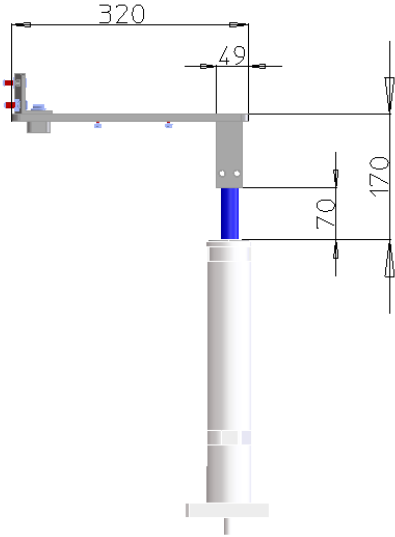


Figure 2: Dimensions of the main bracket

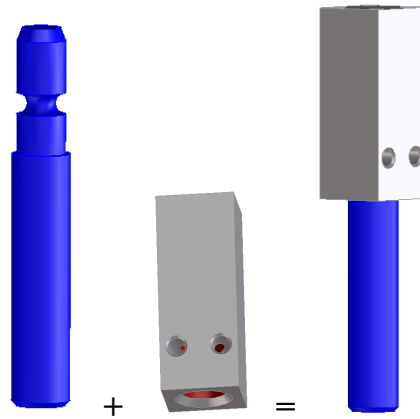


Figure 3: Square holder connection

The white post in figure 2 above is already mounted on the yoke and will be connected to the rest of the bracket through the threaded rod. The threaded rod is connected to the square holder with two M8 screws and nuts. This connection is designed in a way that allows the post to rotate clockwise and anticlockwise but constrains vertical movement which in turn allows the detector to rotate around that point.

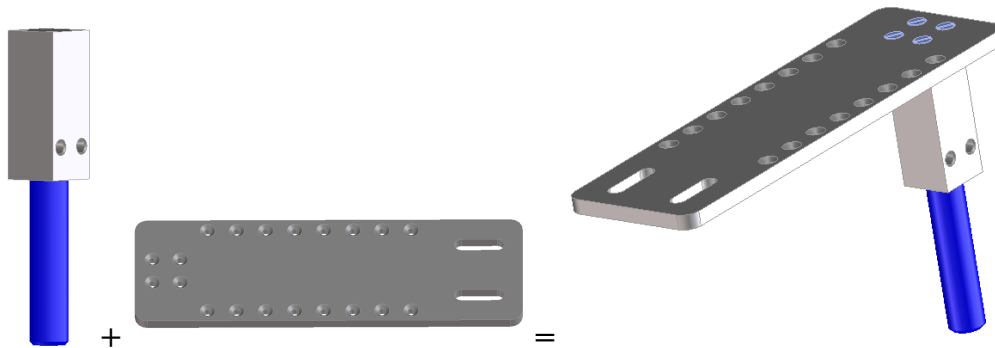


Figure 4: Main body connection

Then the main body is connected to the bracket base via four ISO 2009 Screws as seen in figure 4 above.

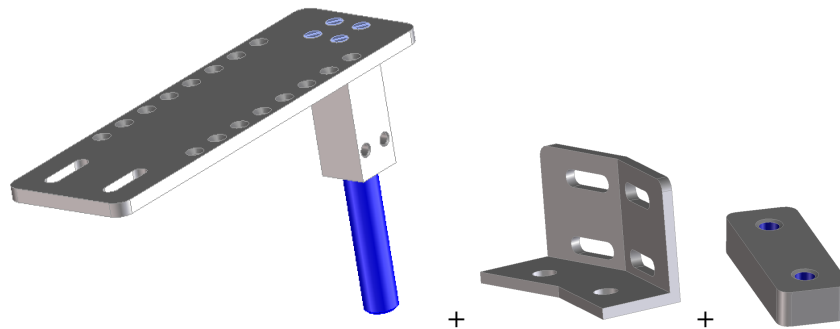


Figure 5: Angled L bracket and holder connection

The angled L bracket is connected above the main body and the holder below via two DIN 7984 M10 screws. The elliptical holes on the main body allow the RPCs to be adjusted inwards and outwards from the center. Moreover, the angled L brackets allow the RPCs attached to them to tilt within 20mm movement range. The final assembly of the main bracket is shown in figure 6 below.

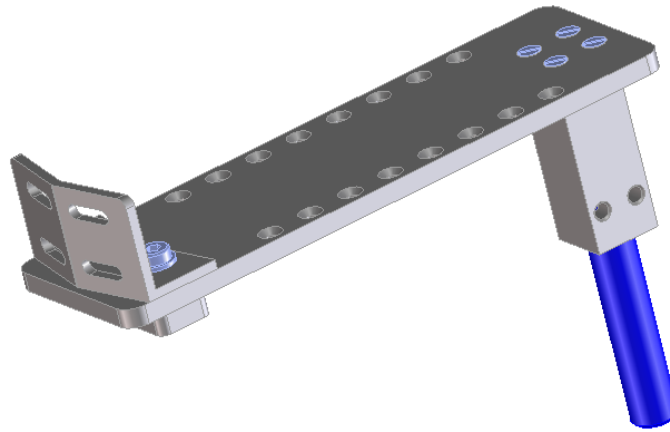


Figure 6: Main bracket (outer) assembly.

## Inner Brackets

The inner brackets are designed in two ways, one with a short post and one with a long post. The short post holds the ‘off yoke’ detectors and the long the post holds the ‘on yoke’ detectors, these brackets are shown on the right. These brackets should be assembled offsite.

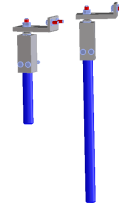
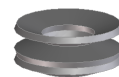


Table 2: Screws, nuts, and washers used for the inner brackets.

	Nuts/Screws/Washers	Size	No. Per Bracket
<b>Short Rod Bracket</b>	Screw DIN7984	M8x50	2
	Nut DIN934	M8	2
	Screw DIN7984	M8x25	2
	Washer DIN126	M8	8
	Washer DIN127	A8.5	2
	Screw ISO4766	M10x10	1
	Screw ISO4766	M10x50	1
	Nut DIN934	M10	1
	Washer DIN125	A10.5	3
	Spherical Bellivele Washer *	M8	3
<b>Long Rod Bracket</b>	Screw DIN7984	M8x50	2
	Nut DIN934	M8	2
	Screw DIN7984	M8x25	2
	Washer DIN126	M8	8
	Washer DIN127	A8.5	2
	Screw ISO4766	M10x10	1
	Screw ISO4766	M10x50	1
	Nut DIN934	M10	1
	Washer DIN125	A10.5	3

\* The Spherical Bellivele Washer (M8)- The purpose of a Belleville washer is to absorb heavy loads and vibrations by acting as a spring. In the bracket above, it is used to help tilt the angle of the brackets (see images on the right).



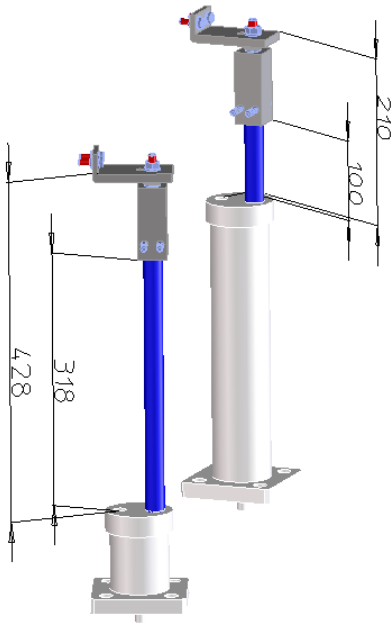


Figure 7: Dimensions of the inner brackets (long rod on the left and short rod on the right)

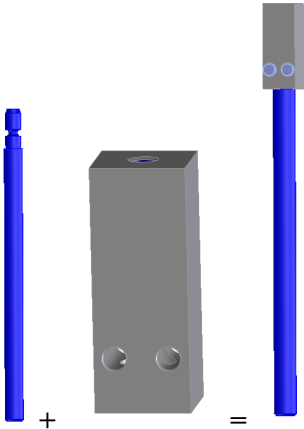


Figure 8: A sample of assembly is applied on the long rod connection with the square holder.

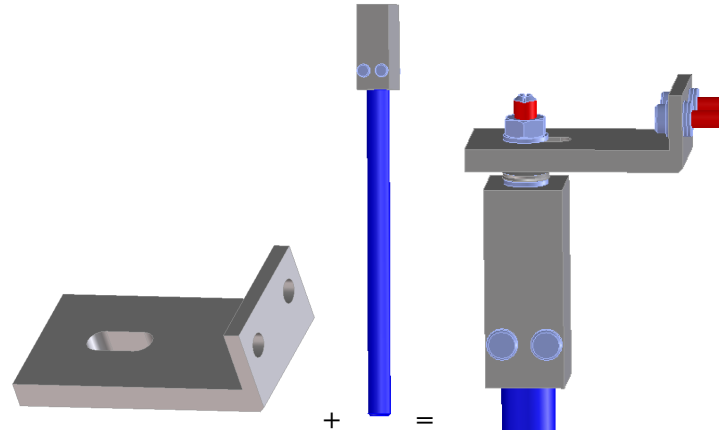


Figure 9: Connection of the L bracket

The L bracket above is connected to the rest of the assembly through the elliptical hole. This elliptical hole allows motion of the detector inwards and outwards towards the center (Note: always connect the Lbracket that has the elliptical hole with assembly that has the long threaded rod).

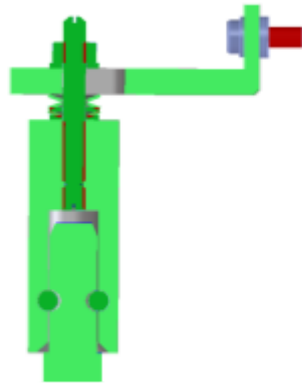


Figure 10: clipping that shows the threaded rod connection

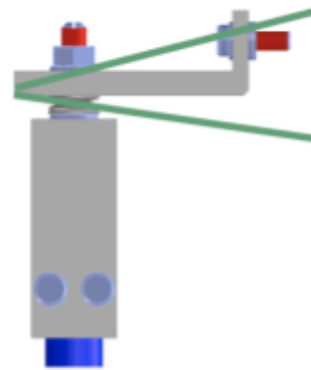


Figure 11: Effect of the belleville washers on the bracket

The connection between the L bracket and the square holder has two main features: the threaded rod and the belleville washers. The threaded rod in figure 10 has a plug piece that is glued into the hole, then the rest on the threaded rod is inserted and glued as well. This is necessary to make sure the connection is fixed. On the other hand, figure 11 shows how the belleville washer design affects the bending movement of the bracket.

The assembly of the long and short rod inner brackets are similar, the difference lies in the shape of the L bracket. For the short rod, the bracket will not have an elliptical hole. This is because the 'on yoke' detector placement should be specific and doesn't need adjustments. However, the 'off yoke' detectors need that flexibility in placement shown in figure 9. The final assembly of the short rod bracket is shown below in figure 12.



Figure 12: L bracket for the short rod inner bracket

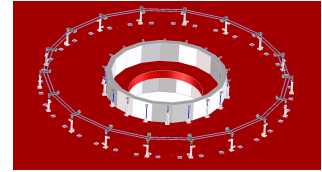


Figure 12: Final assembly of the short rod bracket.



## Assembly of the Brackets on the Yoke

Note that the white posts are already attached to the yoke through their square base. To connect the brackets, screw the rods to the white posts. On the inner circle, alternate between short and long rods. Short rods correspond with long white posts, and long rods correspond to short white posts.



The outer brackets are also screwed on the white posts. All outer brackets are connected together by two flat bars that have elliptical holes on the end to control how close the RPCs are. This is shown in figure 13 below. These flat bars are used to help adjust the location of cables and pipes so that they don't touch other detectors.

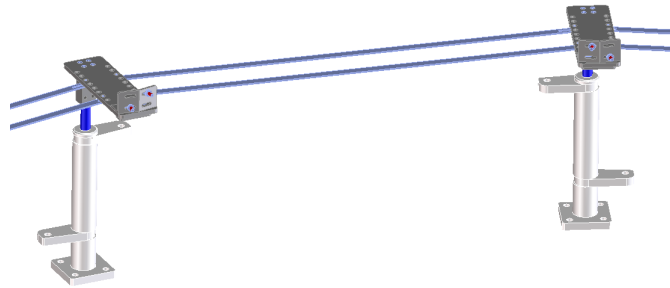


Figure 13: Flat bars connecting the outer brackets

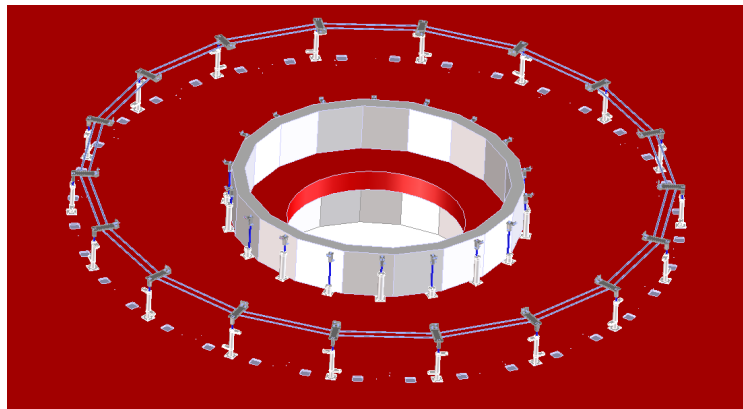


Figure 14: All brackets attached to the yoke

**RE4/1 Detector Brackets Assembly**

Shown on the right is an example of the ‘on yoke’ detector. Attach the brackets on the detector off site so that it is ready to be attached to the yoke.

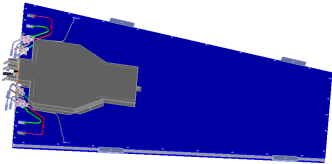
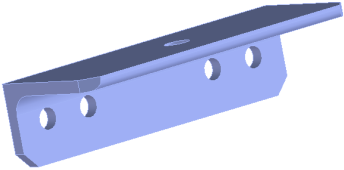


Table 2: Screws, nuts, and washers used for the inner brackets.

Nuts/Screws/Washers	Size	No. Per Detector
Hexagonal Nut DIN912	M8	5
Washer DIN912	M8	
Screw DIN912	M8	

Table 3: Brackets to attach on the detector

Brackets	No. per Detector
	4

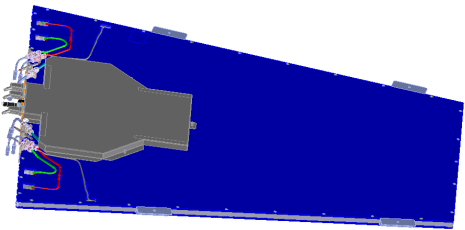


Figure 15: On-yoke detector with brackets attached

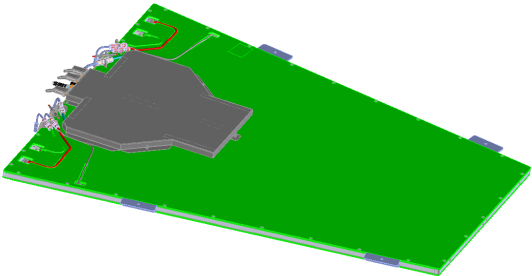


Figure 16: Off-yoke detector with brackets attached

### RE4/1 Detectors Assembly

Detectors should be initially attached in one of the following orders:

- Starting from the bottom and moving up left and right
- Starting from one of the sides (left or right) and moving downwards
- Starting from the top and moving on only one side

This is to avoid the effect of gravity on the movement of the detectors this will help attach every detector.

Notice that there are other detectors and chambers assembled below where the eRPC detectors should be placed.

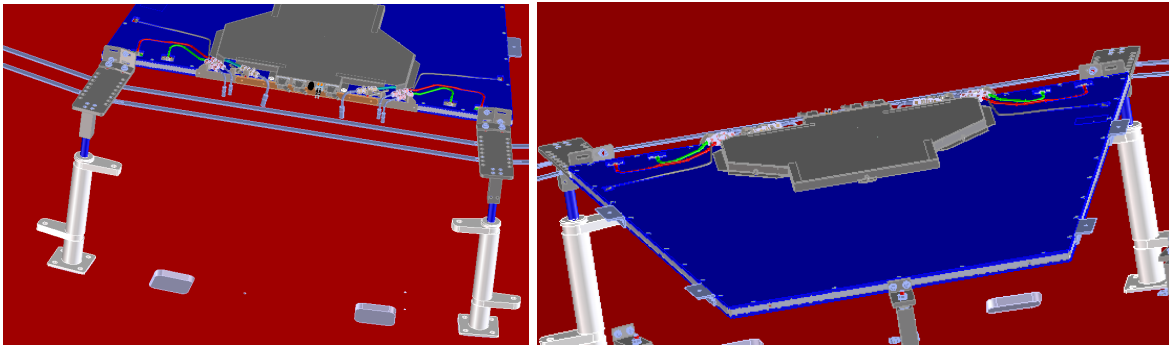


Figure 17: Two angles of how the 'on yoke' detector is attached to the brackets (outer and inner)

Using a crane to raise the detector (crane should only hold the detector from two points), one 'on yoke' detector is placed and attached on two outer brackets and one inner (short rod bracket). Once one detector is attached, the same process is repeated for another alongside 'on yoke' detector so they are placed as seen below in figure 18. Notice that for the inner brackets, it is preferable to attach on the outer hole on the L bracket, but if necessary connecting to the inner hole is also possible.

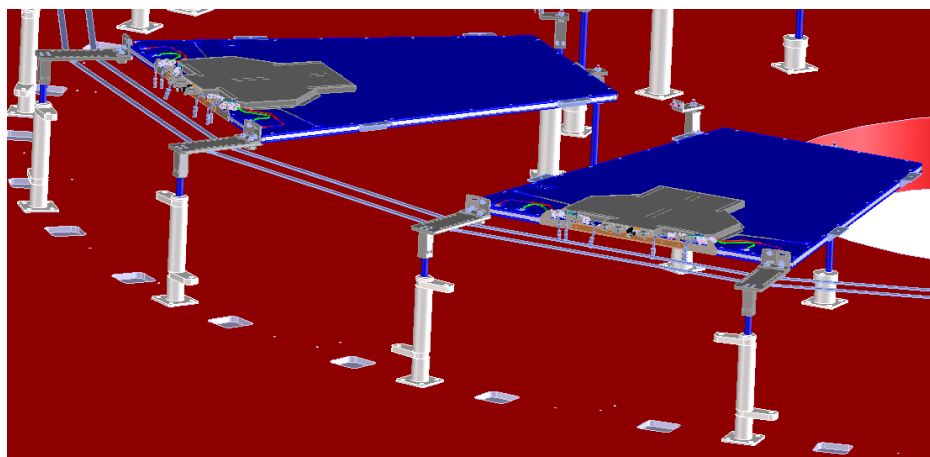


Figure 18: Two 'on yoke' detectors attached to the brackets

After that one 'off yoke' detector is attached on top of the two 'on yoke' detectors and are connected together by the brackets that were pre-attached to the detectors as seen in figure 19.

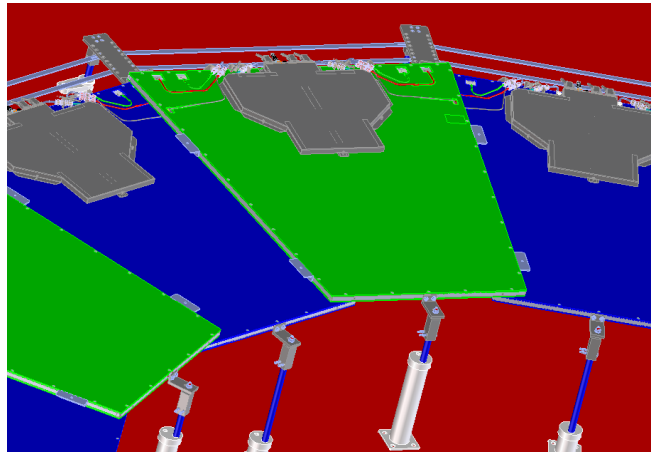


Figure 19: 'Off yoke' detectors attached

Alternate between 'on yoke' and 'off yoke' detectors in the same method above. Adjust the angles of the detectors as needed. Finally place the final detector after needed adjustments as seen below.

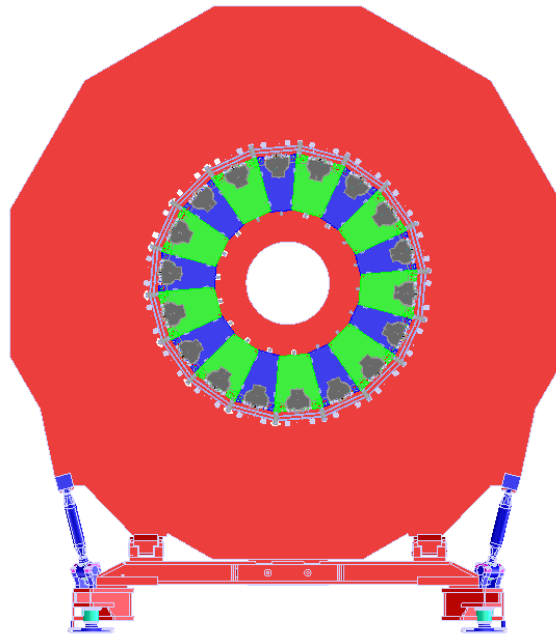


Figure 20: Final assembly results