

CMS Phase II Beam Pipe

Temporary support at 3.5 m_ Bake-out position

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Introduction

Attached to HCAL with 4 screws M8 per side

Welded joints to reinforce

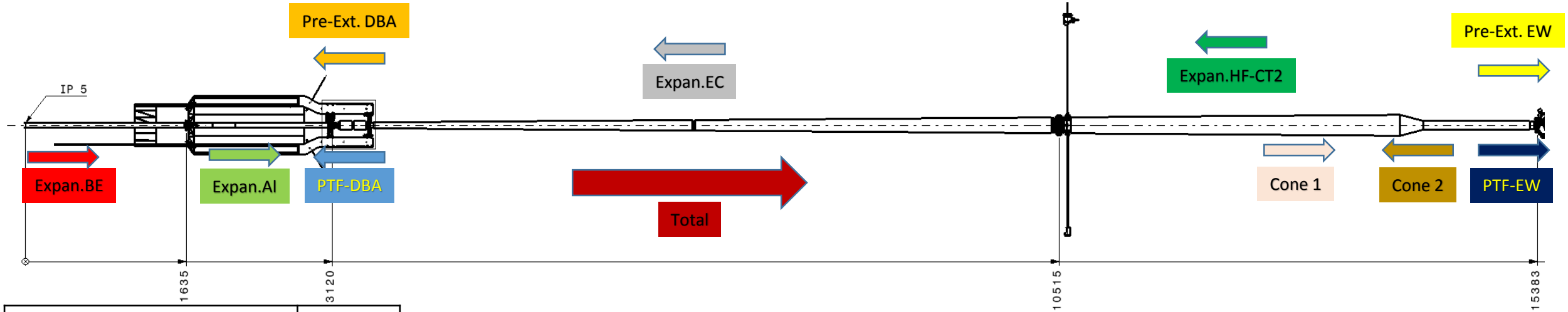
New Collar

Aluminium EN-AW 6060 profiles

Adjustment plates

- Temporary support used during Bake-out to lock the displacement in Z at 3.5 m;
- Same structure was used during LS1;
- Higher axial forces are expected during Run 3;
- Rebuilding the support with reinforcements on the welded joints to withstand the new forces;
- Assembly on Smarteam ST1248611_01 .

Axial forces at 3.5 m



Axial force at 3.5 m-Bake-out <u>Run3</u>	Value
Thermal expansion central BE	+55 N
Thermal expansion central AL	+56.7 N
Thermal expansion End-Cap	-69.54 N
Thermal expansion HF-CT2	-47.8 N
Pressure Thrust Force DBA	-254 N
Pressure Thrust Force EW bellow	+1107.4 N
Pre-extension DBA	-47.5 N
Pre-extension EW	+45.6 N
Cone 1	+2780.2 N
Cone 2	-2532 N
<u>Total</u>	<u>1094.1 N</u>

Detailed calculation
report on EDMS:
CMS-I-EN-0003

- For Run 3, during bake-out, an axial force of around 1.1 KN is expected at the fix point at 3.5 m;
- This value was around 300 N during Run 2.

Numerical Model

- *Support material: Aluminium alloy*
- *HCAL : Brass*
- *Bolts: Stainless Steel A2-70*

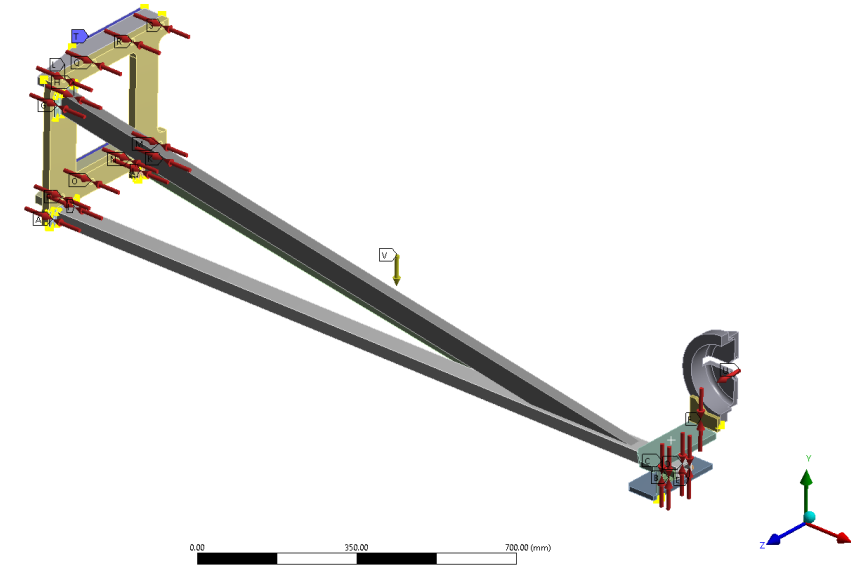
	Density [Kg/m3]	Young's modulus [GPa]	Yield strength [MPa]	Shear Strength [MPa]
Aluminium EN-AW 6060 T6	2700	71	190	207
Stainless Steel Bolts (A2-70)	7750	193	450	350
Brass	8640	103	125	200

Contacts:

- Aluminium to Aluminium frictional contact with 1.05 friction coefficient between the different components;
- Line to surface bonded (pure penalty) contact at the welded seams.

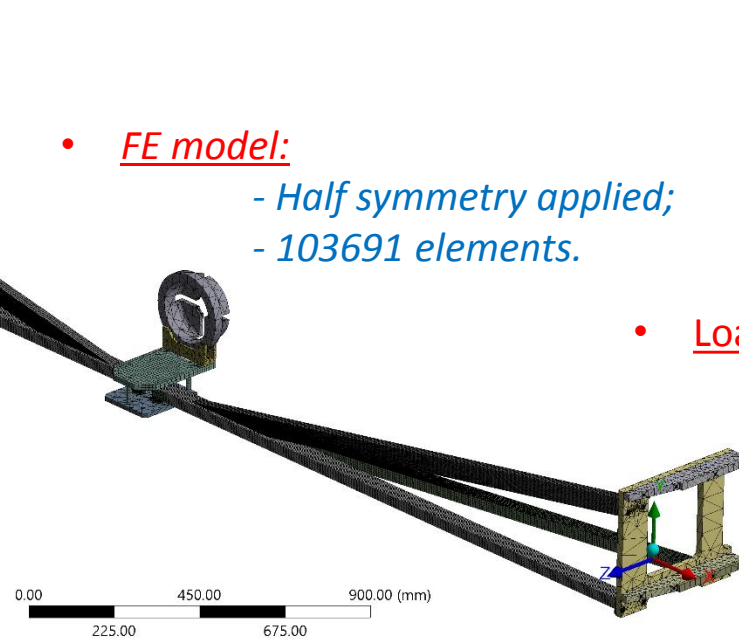
Rotation allowed
Static Structural
Time: 2 s
19/02/2020 14:03

- 1 Bolt Pretension 1: Lock
- 2 Bolt Pretension 2: Lock
- 3 Bolt Pretension 3: Lock
- 4 Bolt Pretension 4: Lock
- 5 Bolt Pretension 5: Lock
- 6 Bolt Pretension 6: Lock
- 7 Bolt Pretension 7: Lock
- 8 Bolt Pretension 8: Lock
- 9 Bolt Pretension 9: Lock
- 10 Bolt Pretension 10: Lock
- 11 Bolt Pretension 11: Lock
- 12 Bolt Pretension 12: Lock
- 13 Bolt Pretension 13: Lock
- 14 Bolt Pretension 14: Lock
- 15 Bolt Pretension 15: Lock
- 16 Bolt Pretension 16: Lock
- 17 Bolt Pretension 17: Lock
- 18 Bolt Pretension 18: Lock
- 19 Bolt Pretension 19: Lock
- 20 Fixed Support
- 21 Remote Force: 547. N
- 22 Standard Earth Gravity: 9806.6 mm/s²



FE model:

- Half symmetry applied;
- 103691 elements.

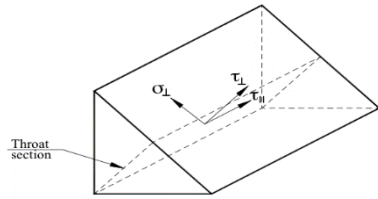


Loads & Boundary conditions:

- Own weight of the support;
- Bolts Pretension [70% of the yield strength];
- Fixed support at the HCAL plate;
- Axial force on the collar 1.1 KN.

Weld assessment

- The stress in the most loaded welds is assessed following the EN 1999-1-1: Eurocode 9;
- A uniform distribution of the stress is assumed on the throat section of the weld, leading to the normal stresses and shear stresses shown as follows:



$$\sigma_{Eqv} = \sqrt{\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{//}^2)} \leq \frac{f_w}{\gamma_{Mw}}$$

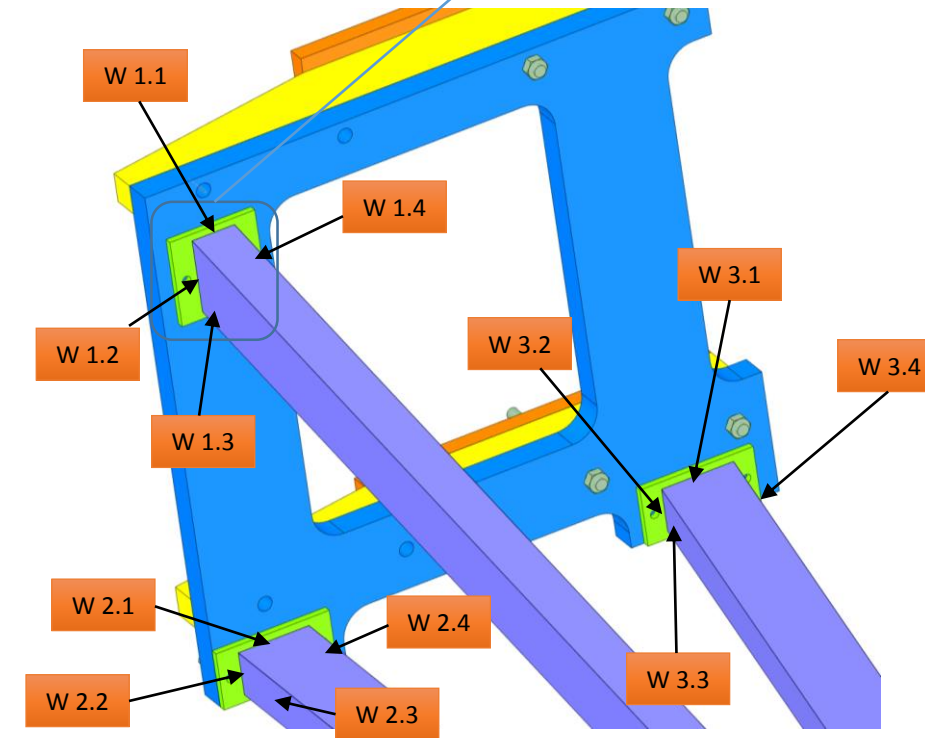
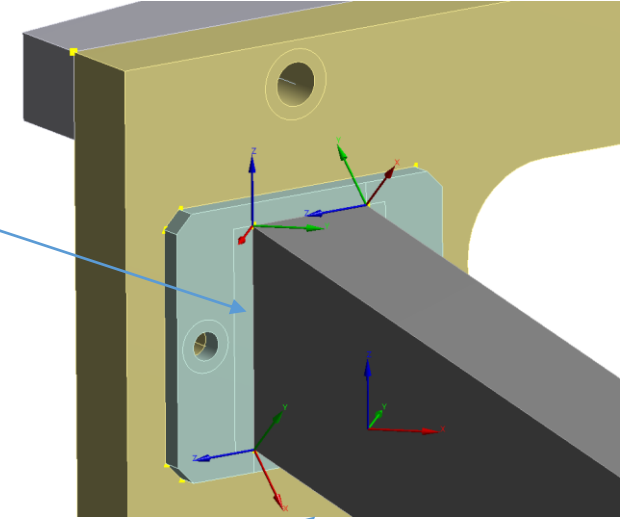
- f_w – Is the characteristic strength of weld metal, adopted value equals **160 MPa** for **EN AW-6060**, and **5356 as filler metal**;
- γ_{Mw} – Is the partial safety factor for welded joints, adopted value equal **1.25**.

Weld Number	Throat area A [mm ²]	F σ_{\perp} (Y) [N]	F τ_{\perp} (X) [N]	F $\tau_{//}$ (Z) [N]	σ_{\perp} [Mpa]	τ_{\perp} [Mpa]	$\tau_{//}$ [Mpa]	Weld stress [Mpa]
1.1	105	21.4	17.3	72.0	0.16	0.20	0.69	1.86
1.2	175	95.9	58.0	359.1	0.33	0.55	2.05	5.46
1.3	105	126.8	119.4	239.9	1.14	1.21	2.28	6.87
1.4	175	889.9	591.8	362.3	3.38	5.09	2.07	12.82
2.1	175	63.0	30.3	414.5	0.17	0.36	2.37	6.19
2.2	105	81.2	37.9	222.0	0.36	0.77	2.11	5.69
2.3	175	154.4	95.4	357.9	0.55	0.88	2.05	5.66
2.4	105	144.6	37.4	215.9	0.36	1.38	2.06	5.80
3.1	175	15.3	9.1	439.3	0.05	0.09	2.51	6.52
3.2	105	1318.7	765.2	226.6	7.29	12.56	2.16	27.29
3.3	175	13.5	33.7	337.6	0.19	0.08	1.93	5.04
3.4	105	1715.7	538.3	194.4	5.13	16.34	1.85	28.31

Retrieved from Ansys

- The failure criterion is **128 MPa**;
- Minimum safety factor of 4.5 on the welds.

Coordinate system associated to each welded seam.



Stresses and Deformation

I: Rotation allowed
 Directional Deformation
 Type: Directional Deformation(Z Axis)
 Unit: mm
 Global Coordinate System
 Time: 2
 18/02/2020 16:34

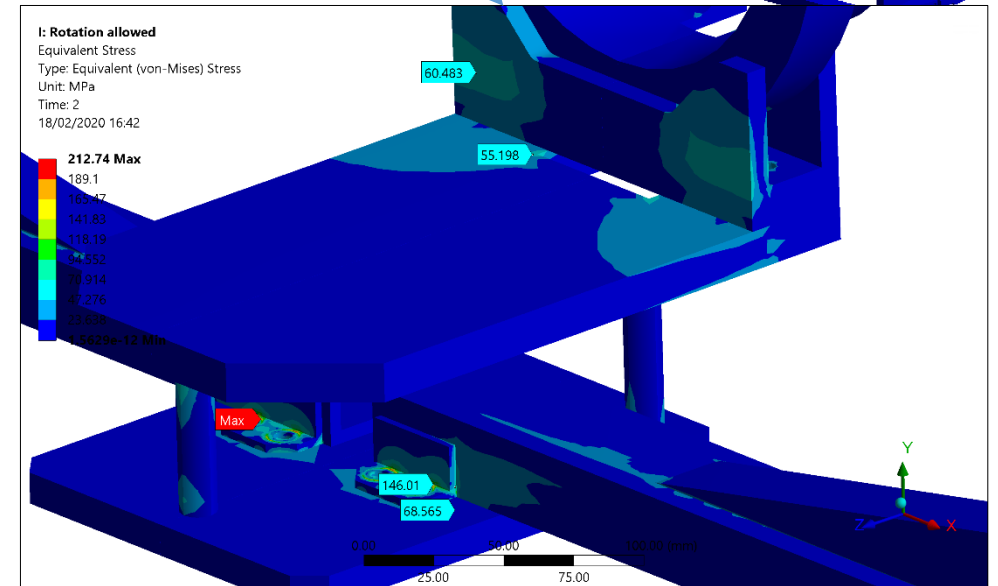
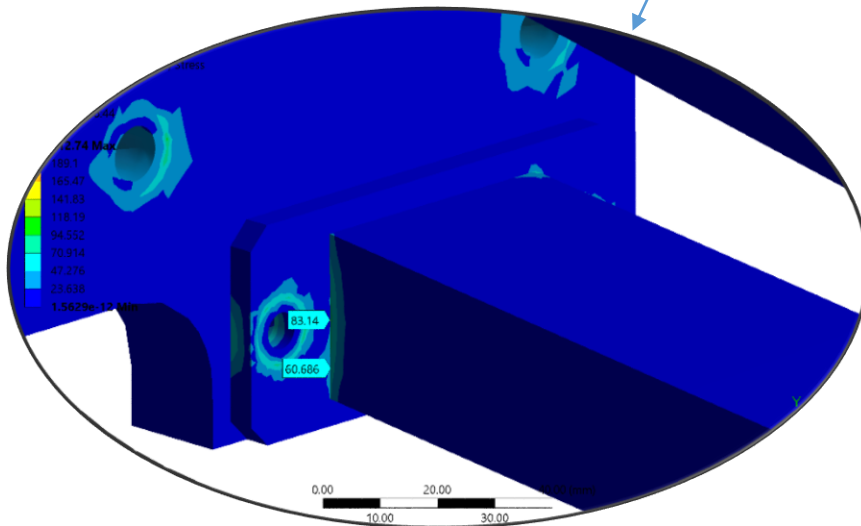
8.3968 Max
 7.4629
 6.5291
 5.5922
 4.9734
 4.9176
 3.721
 0.95456
 2.7937
 1.8599
 0.92605
 -0.0077896 Min

The deformation at the Beam pipe level is around 5.5 mm, while it goes to 8 mm locally on the top of the collar.

The maximum stress is 212 MPa, under the bolt caps (compressive stress due to bolts pretension, and to the fixed nodes in the bolt beam element model). The stress level is acceptable elsewhere on the support.

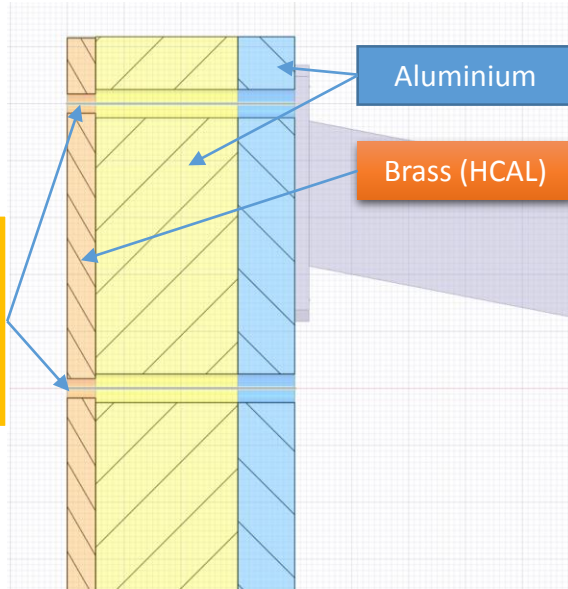
Equivalent Von-Mises Stress

Deformation in Z



Stress on the bolts

M8 threaded holes, 10 mm thread engagement minimum



Bolt size	M8
Effective length of engagement [Le]	10 mm
Brass shear strength [τ]	200 MPa
Tensile stress area of the bolt [At]	36.6 mm ²
Pitch diameter [do]	6.8 mm

- To make sure that the thread will not strip in the soft material (brass), the shear strength [**F**] of the thread is evaluated;
- The Shear strength [**F**] is equal to the shear area [**As**] times the shear strength [τ] of the brass;
- $As = 0.5 \pi d_o L_e = 106.8 \text{ mm}^2$.
- $F = \tau As = 21.3 \text{ kN}$.
- Therefore, the maximum tensile stress that can be taken by the thread is : $\sigma = F/At = 581 \text{ MPa}$.
- The pretension applied on the bolts is $315 \text{ MPa} < 581 \text{ MPa}$

I: Rotation allowed
Maximum Combined Stress
Type: Maximum Combined Stress
Unit: MPa
Time: 2
18/02/2020 17:06

377.92 Max
335.93
293.93
251.94
209.95
167.96
125.97
83.981
41.991
-7.2852e-11 Min

All bolts M6

0.00 25.00 50.00 75.00 100.00 (mm)

The proof strength of the bolts is 450 MPa, and the maximum stress is 377 MPa.

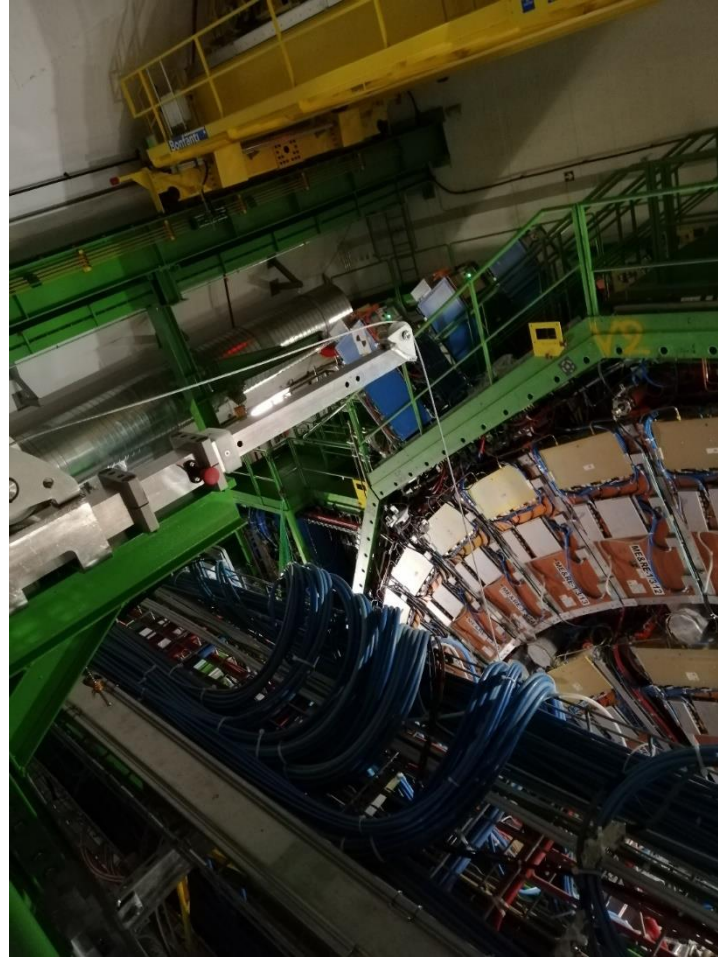
I: Rotation allowed
Maximum Combined Stress
Type: Maximum Combined Stress
Unit: MPa
Time: 2
18/02/2020 17:05

377.92 Max
335.93
293.93
251.94
209.95
167.96
125.97
83.981
41.991
-7.2852e-11 Min

0.00 50.00 100.00 150.00 200.00 (mm)

Maximum Combined stress on the bolts

The 6.8 m support is installed on top of YB+/-2.



- The drawings of the support at 16 m are under approval on CDD, LHCVH5__0175 to LHCVH5__0200.
- Assembly drawing of the support: LHCVH5__0191, and for the shielding: LHCVH5__0192.
- Calculation report on EDMS: CMS-I-EG-0007
- Working in collaboration with the engineering department on a unified version of the technical specifications, for the VAX support and the BP support at 16 m.