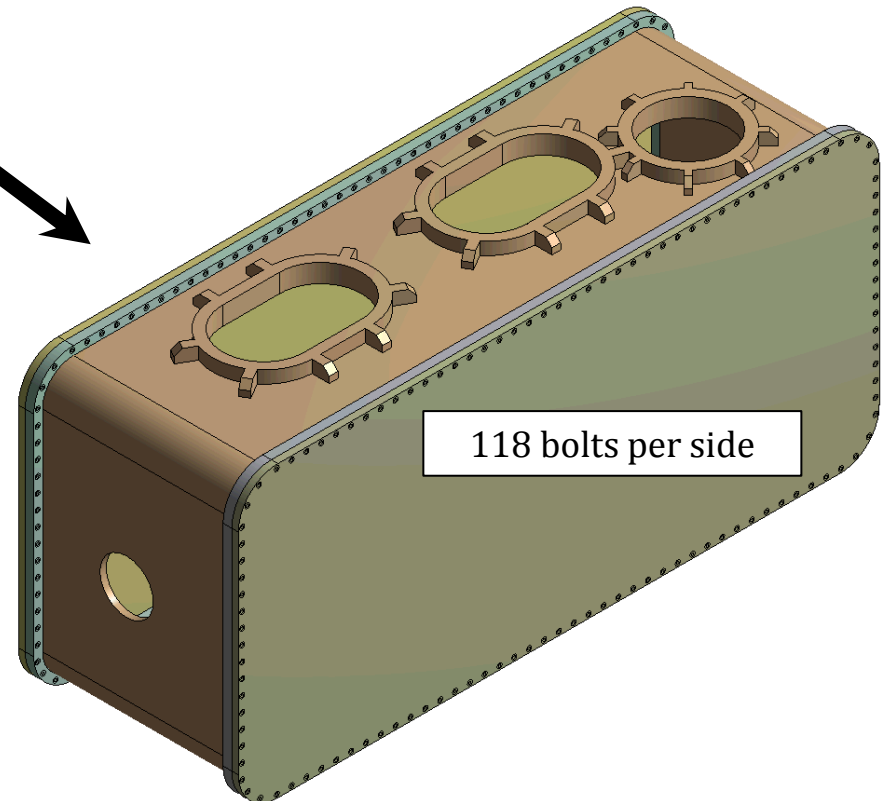# FE calculations for the vacuum vessel with bolts

November 24th 2014

Norbert Kuder, EN/MME

# Geometry

design 25x25mm

+ reinforcement on the top

118 bolts per side
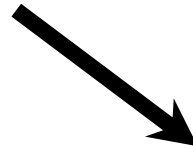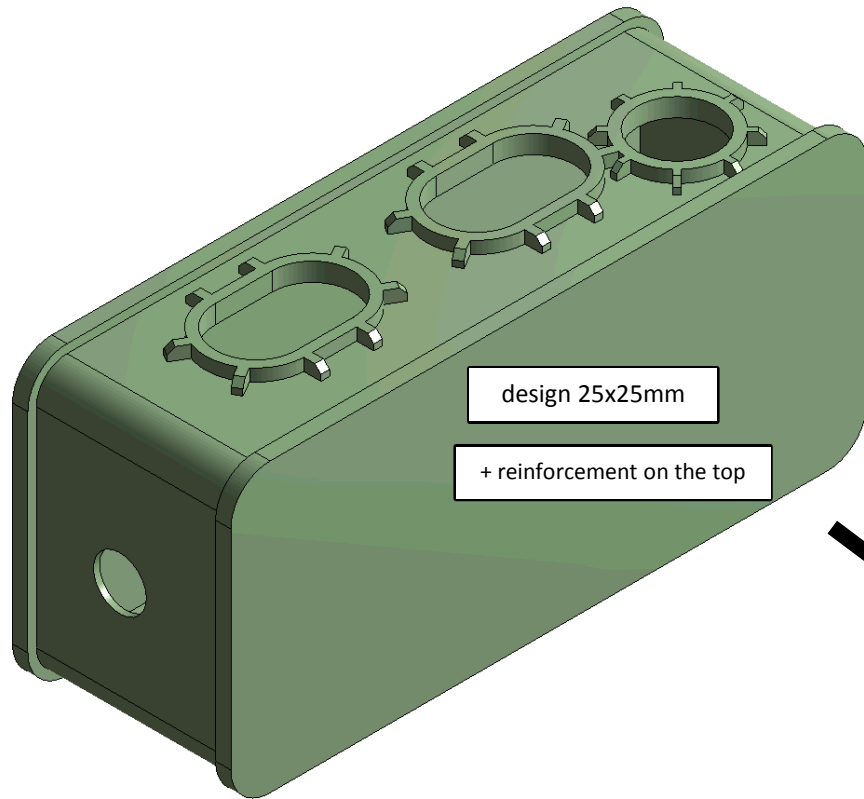
Material

| Physical properties at temperature 20°C [1]					
Material: Stainless Steel 316LN					
Poisson's ratio	Elastic modulus	Density	$R_{p0.2}$	$R_{p1.0}$	Max allowable stress $R_{p0.2}/1.5$
-	(GPa)	(kg/m³)	(MPa)	(MPa)	(MPa)
0.3	195	7950	280	320	186

[1] EN 10088-2, *Stainless steels. Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes.* September 2005.

Bolt stiffness

D = 20

d = 10

M10

L = 62
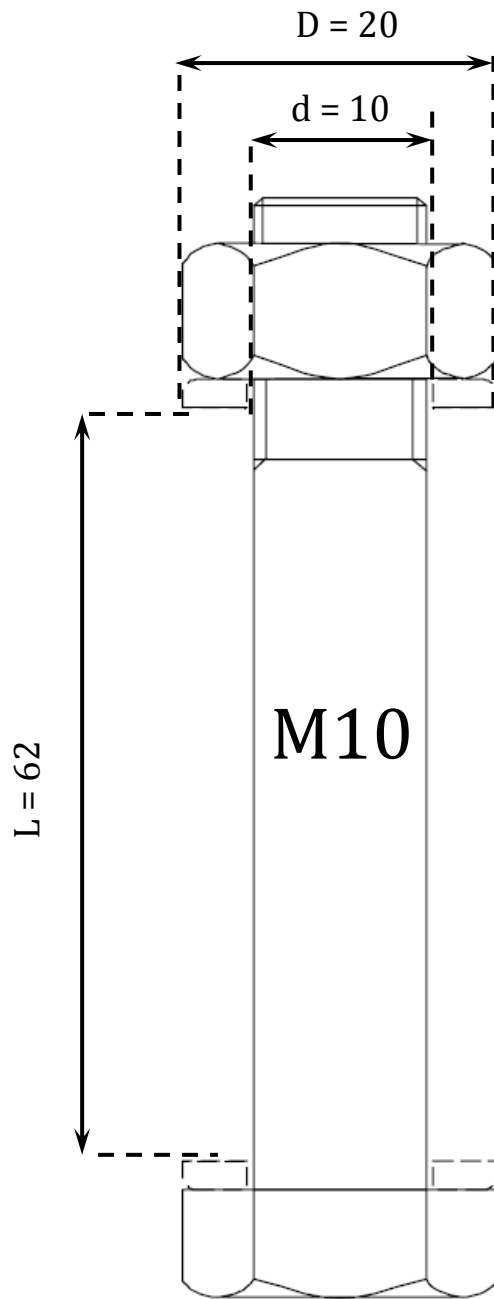
$$K = \frac{\pi d^2 E}{4L} \approx 250 \text{ kN/mm}$$

Bolt modeling
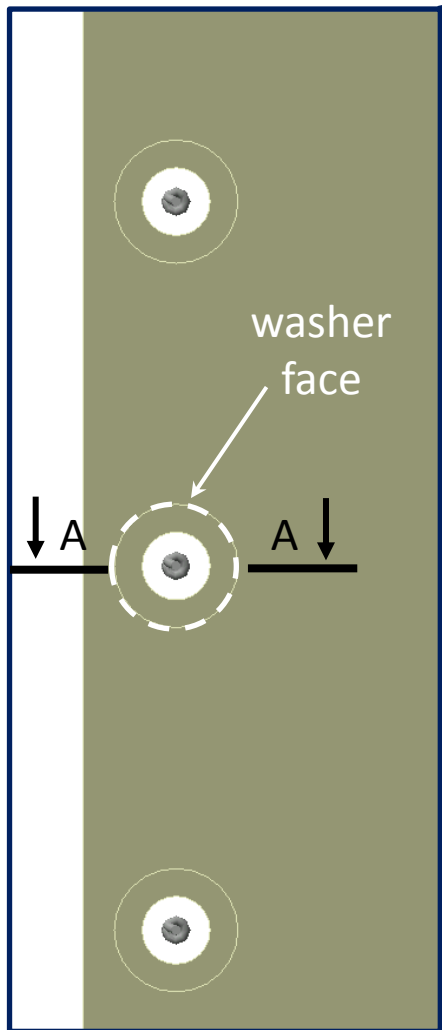
washer face

A — A

118 springs per side
pretensioned with 35 kN each

Definition	
Type	Longitudinal
Spring Behavior	Both
☐ Longitudinal Stiffness	2.5e+005 N/mm
☐ Longitudinal Damping	0. N·s/mm
Preload	Load
☐ Load	35000 N
Suppressed	No
Spring Length	62. mm
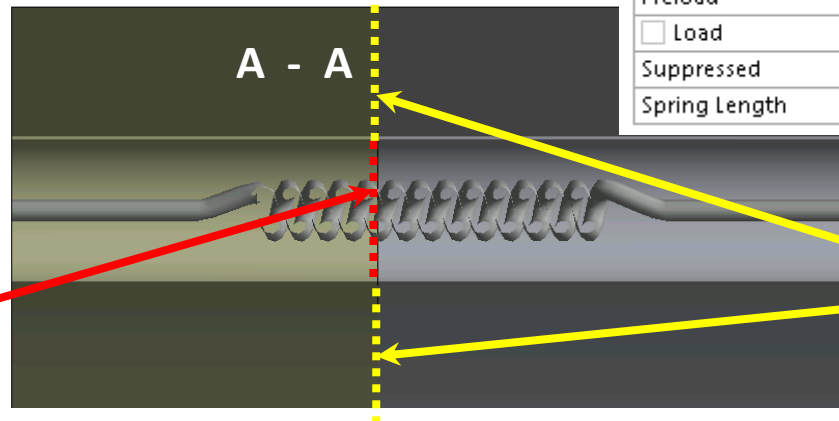
A - A

frictional contact
μ = 0.5
face-face

fixed joint
edge-edge

BCs & Loads
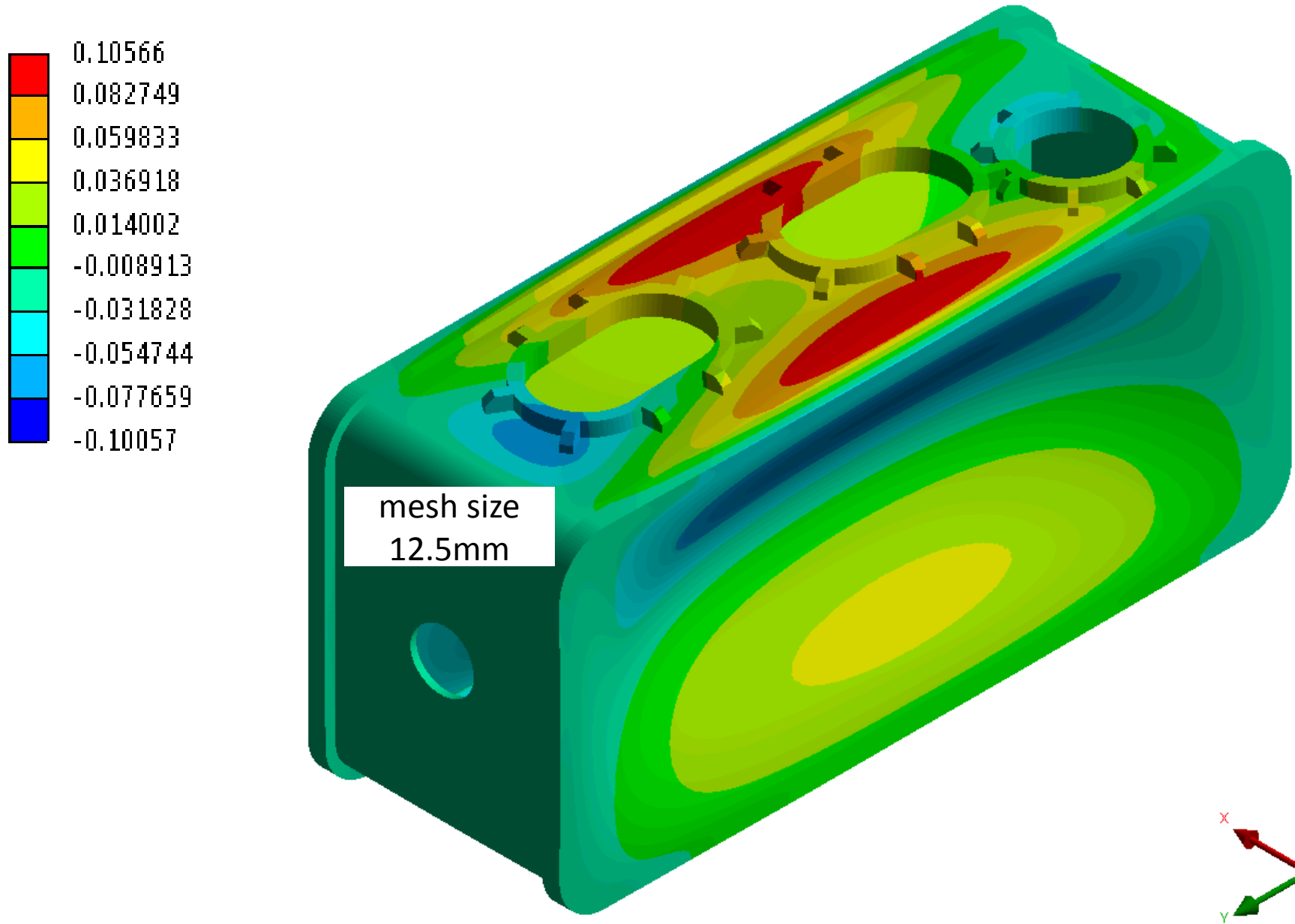
A — Pressure: 0.1 MPa
B — Vacuum1: 8245. N
C — Vacuum2: 16143 N
D — Vacuum3: 16143 N
E — Weight1: 1500. N
F — Weight2: 1500. N
G — Fixed Support
H — Standard Earth Gravity: 9806.6 mm/s^2

3 supporting cylinders

Z-directional deformation (bolts)

0.034224	
0.012764	
-0.0086967	
-0.030157	
-0.051617	
-0.073078	
-0.094538	
-0.116	
-0.13746	
-0.15892	

mesh size
20mm

Z-directional deformation (w/o bolts)

0.10566
0.082749
0.059833
0.036918
0.014002
-0.008913
-0.031828
-0.054744
-0.077659
-0.10057

mesh size
12.5mm

Total deformation (bolts)

Type: Total Deformation
Unit: mm

▮	0.146
▮	0.1
▮	0.087658
▮	0.075316
▮	0.062973
▮	0.050631
▮	0.038289
▮	0.025947
▮	0.013605
▮	0.0012625
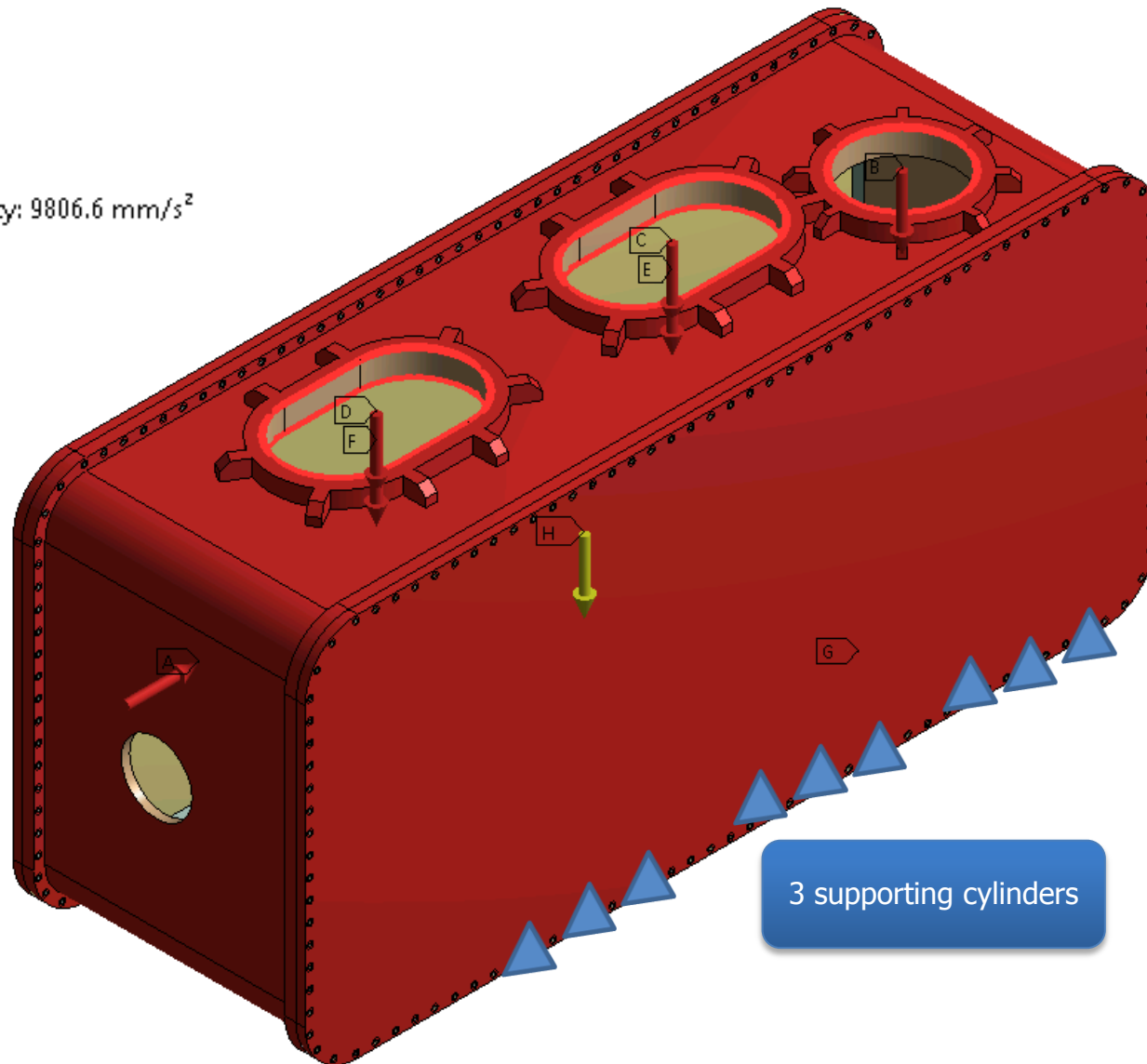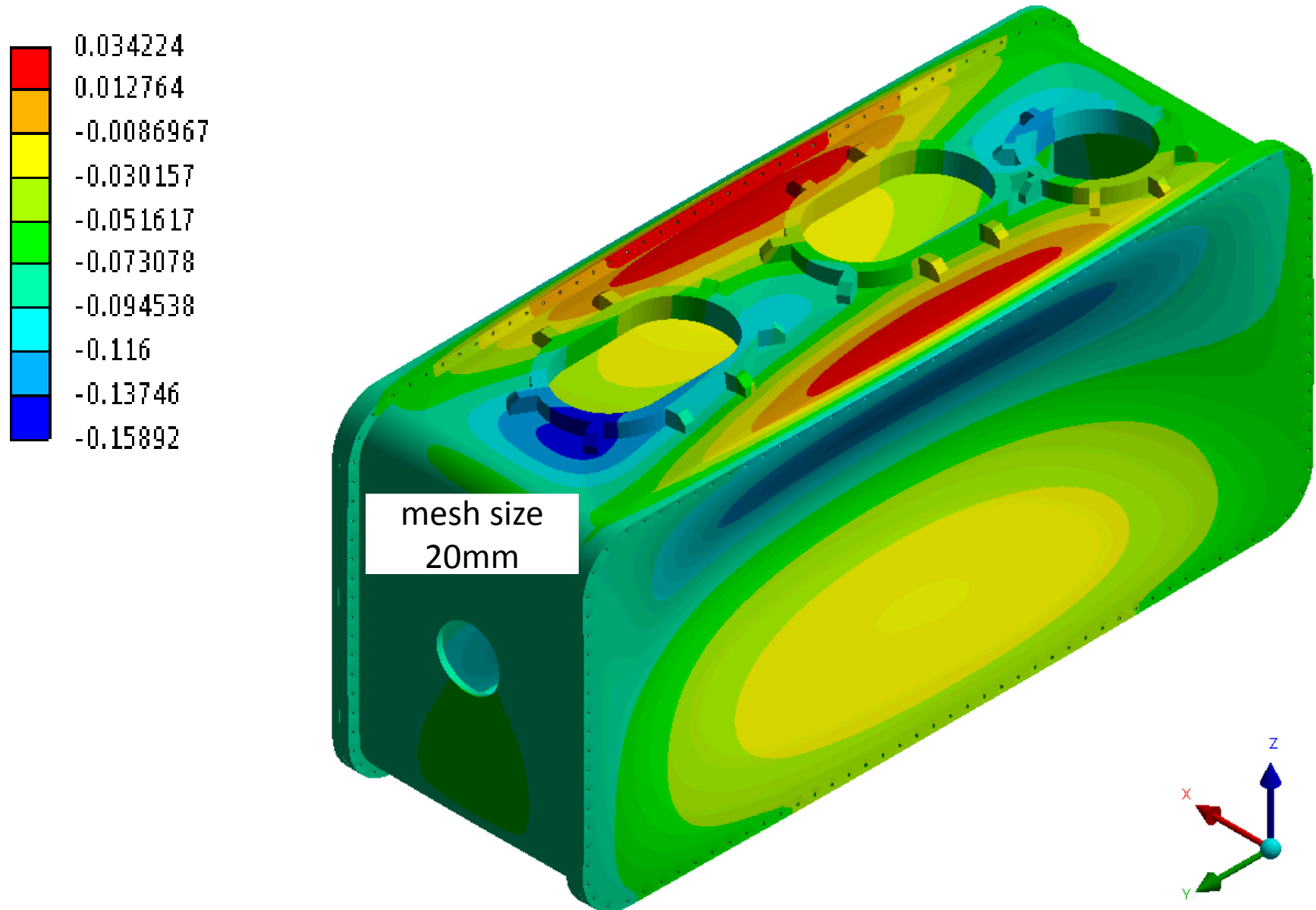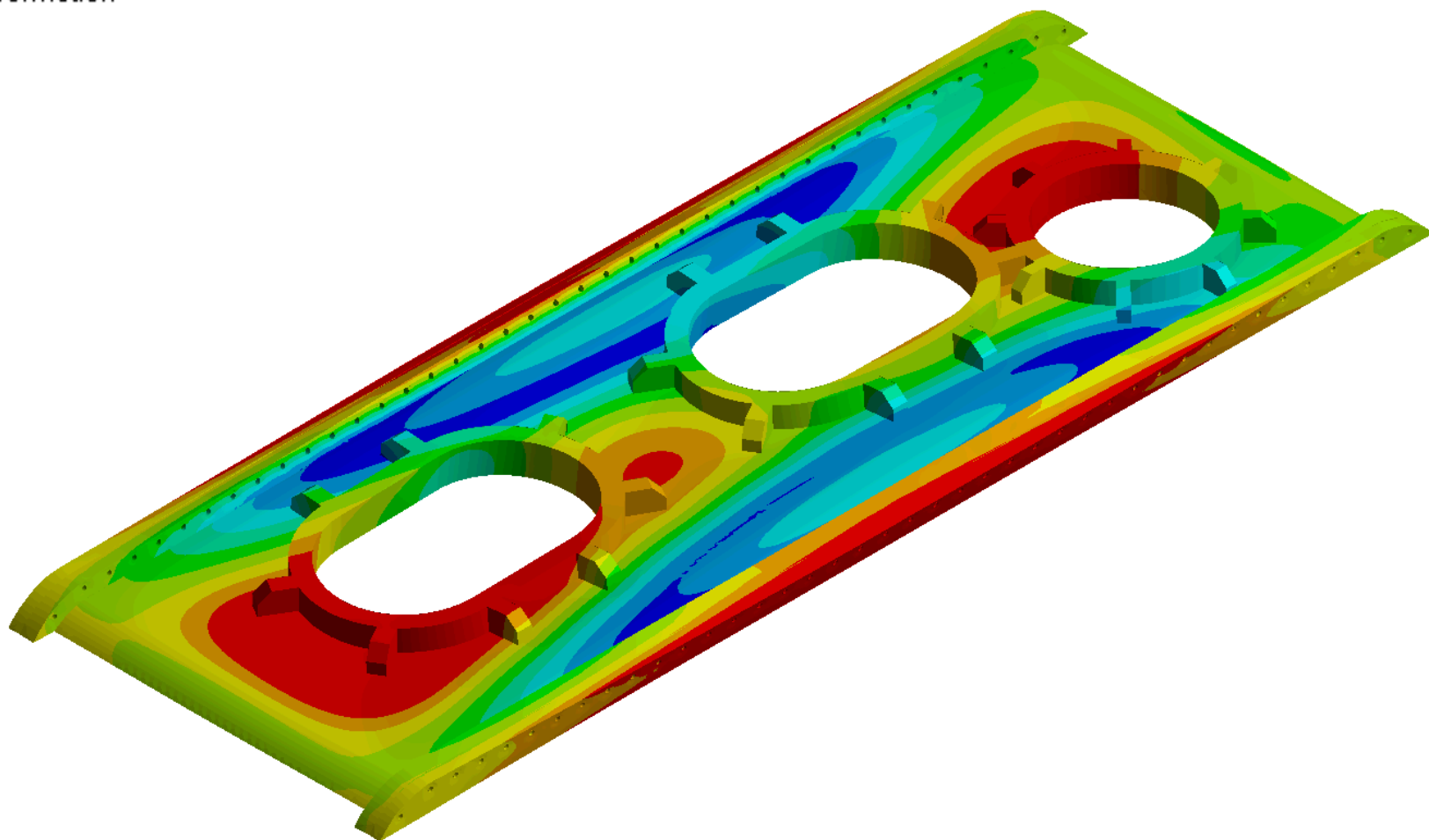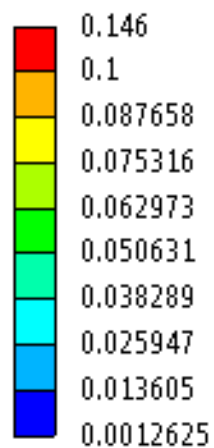
Total deformation (w/o bolts)

Type: Total Deformation
Unit: mm

🟥	0.10562
🟧	0.1
🟨	0.087618
🟨	0.075237
🟩	0.062855
🟩	0.050474
🟩	0.038092
🟦	0.02571
🟦	0.013329
🟦	0.00094722
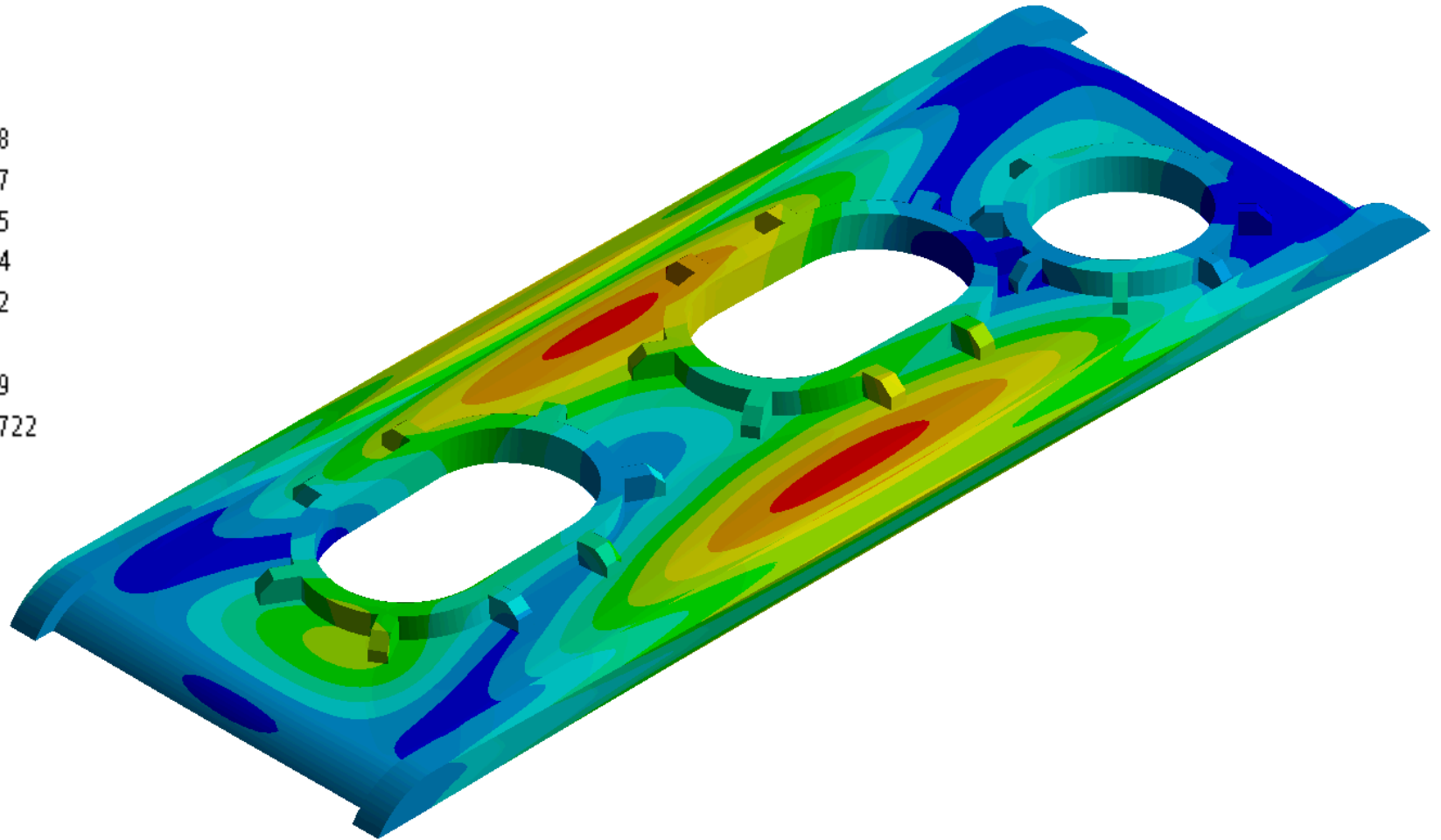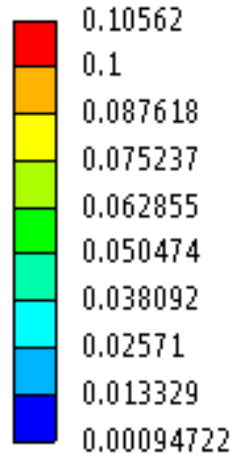
Conclusions

1. Calculations for the vacuum vessel with bolts showed that the deformation of the top plate is greater than for the vacuum vessel without bolts.

2. The lateral caps do not stiffen the structure and therefore increase the deformation of the main plate.

3. Fixed joints and the frictional contact can highly affect the results. Modeling of solid bolts?

4. Mesh size of the main plate for the compared models is different. Mesh quality for the model with holes is not so good.

5. Calculations for the bolted model are time-consuming (over 10hrs/simulation) and for the further design development problematic.