ACCDIV TECHNICAL NOTE

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UA9 ROMAN POT MECHANICAL STUDY AND TEST

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Introduction

The CERN group "EN-STI" has designed the assembly for the insertion of TIMEPIX detector in the SPS accelerator line. The case for the detector with a thin walled window, and the vacuum chamber carrying the device needed some mechanical refinement that has been done by the Mechanical Engineering Group of the Accelerator Division of the LNF. The updated design has been validated by analyses and test. The FEM mechanical studies are reported as well as the pressure test results for the detector case.

1. Thin window case

The case for the detector has a thin window in the middle, as in figure 1. A wall as thin as possible is required for the detector success. At operation conditions, the vacuum is outside the case.

A simulation under internal pressure of 100 kPa has been performed with ANSYS 2019R2 at several window thickness values. The stainless steel AISI 316 LN has been chosen because of its good mechanical strength (0.2% yield strength no less than 280 10^6 Pa). Nevertheless, given the closeness of the equivalent stress result of the model to the yield, a test was advisable.

In the table 1 the values of deformation and equivalent stress are reported.

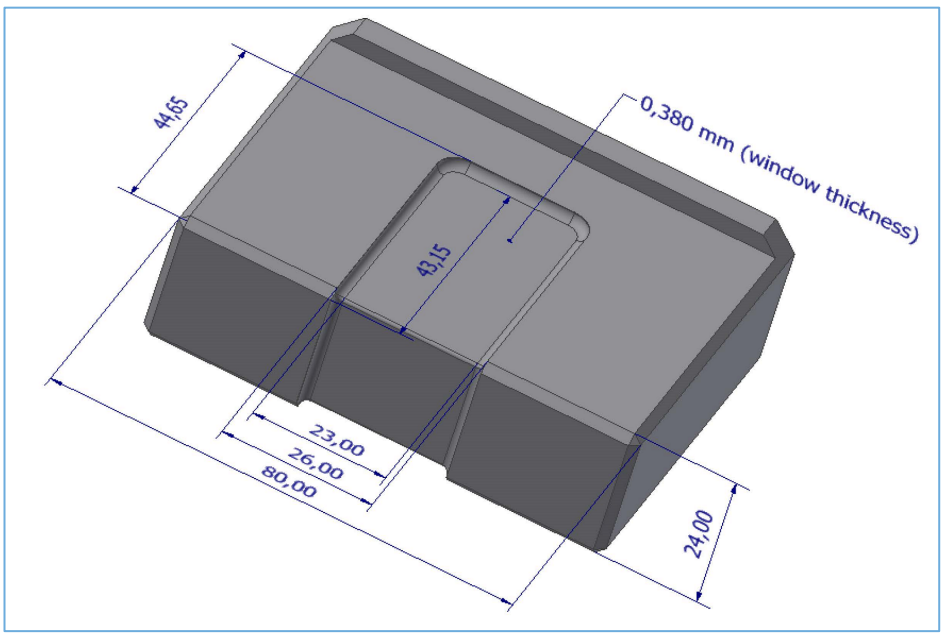

Figure 1: Detector case with thin window in the middle.

Table 1: Deformation and stress of the window under external vacuum load at different thickness.

Thickness (mm)	Stress (MPa)	Deformation (mm)
0.3	288	0.19
0.35	211	0.12
0.38	**179**	**0.09**
0.4	162	0.08

The 0.38 mm thickness has been chosen as a reasonable compromise. In the figure 2 and 3 are the results in graphical form for the 0.38 mm window only. The simulation has been performed on half window for symmetry reason.

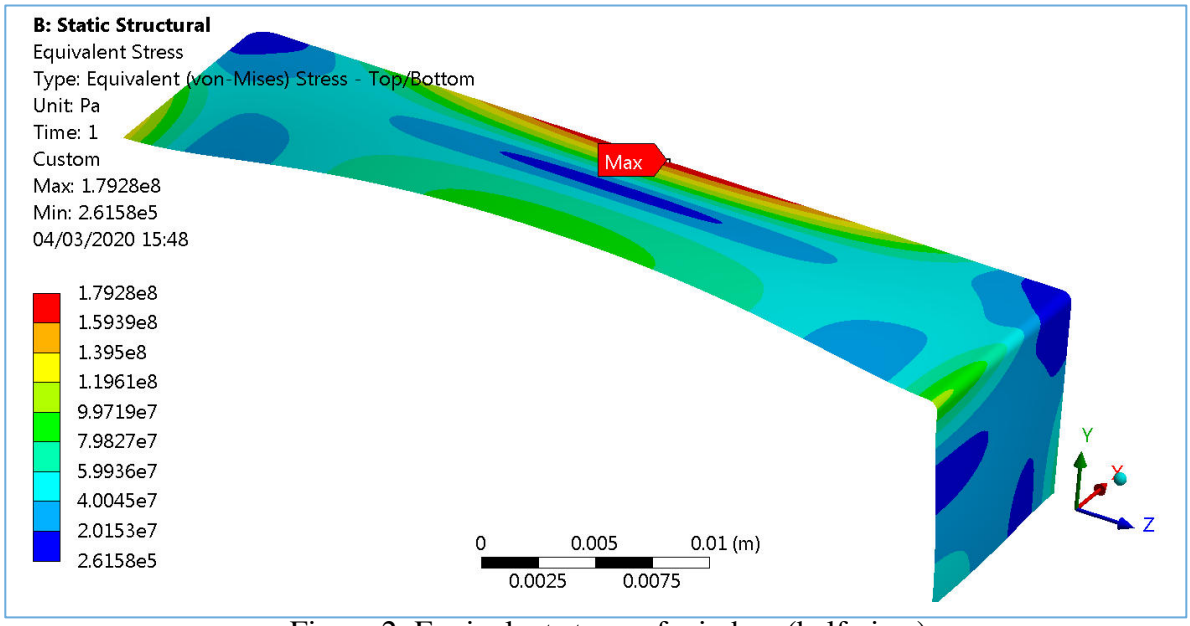

Figure 2: Equivalent stress of window (half view).

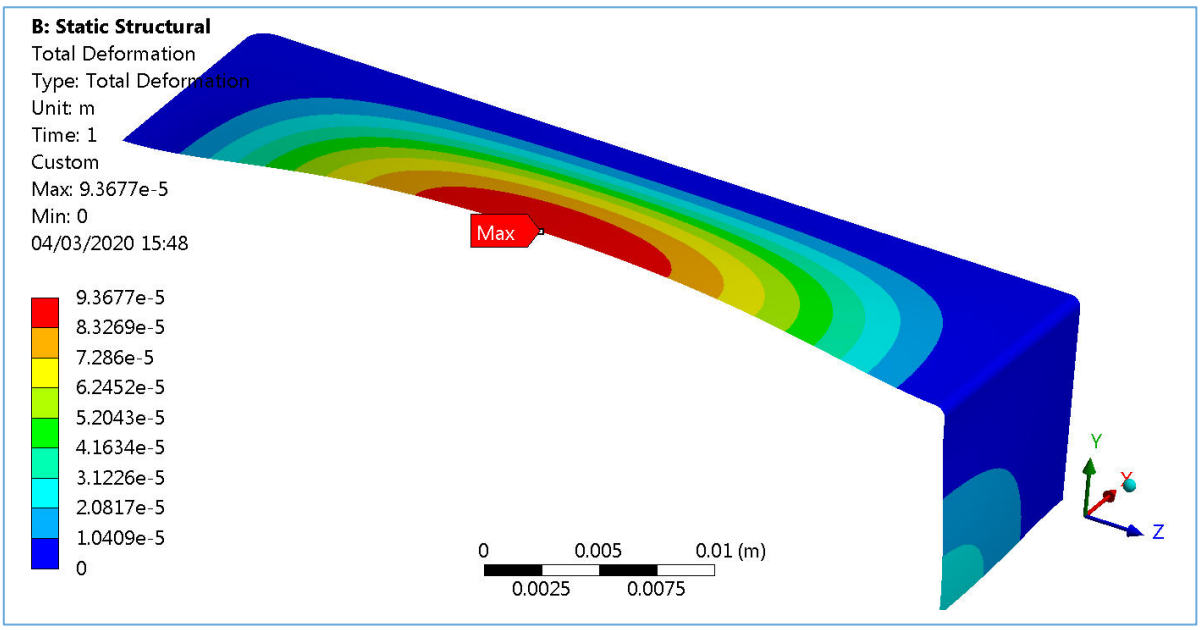

Figure 3: Deformation of window (half view).

A prototype has been produced and has undergone a test with a Nitrogen gas internal pressure. The setup includes three dial gauge with an accuracy of 0.01 mm (see figure 5) pointing at the upper and lower part and front of the thin window.

Several cycles of pressure load and unload have been done. A safety factor of 3 has been chosen, corresponding to a load of 300 kPa. The test has been satisfactory, in good agreement with the FEM results. A small residual deformation (plasticity) has been detected only cycling over 250 kPa, demonstrating that the material stayed in the elastic field at least until twice the operational pressure (see table 2, points 14, 17 and 19 and figure 4).

Table 2: Internal pressure test results (0.38 mm thickness).

	int. pressure (kPa)	upper window displ.(mm)	lower window displ.(mm)	front window displ.(mm)
1	0	0.000	0.000	0.000
2	50	0.050	0.050	0.000
3 (*)	**100**	**0.100**	**0.120**	**0.000**
4	0	0.000	0.000	0.000
5	110	0.100	0.120	0.010
6	150	0.150	0.175	0.015
7	0	0.000	0.000	0.000
8	200	0.200	0.235	0.020
9	0	0.000	0.000	0.000
10	200	0.210	0.235	0.020
11	250	0.265	0.305	0.030
12 (**)		0.220	0.250	0.025
13	250	0.270	0.300	0.030
14	0	0.015	0.010	0.000
15	250	0.275	0.290	0.030
16	300	0.325	0.350	0.035
17	0	0.030	0.025	0.005
18	300	0.330	0.360	0.035
19	0	0.030	0.015	0.000
20	300	0.335	0.350	0.030

(*) the point 3 is at nominal pressure value.

(**) the point 12 has been taken after 15 min in static pressure without connection to the Nitrogen bottle. The deformation reduction is due to a small leak in the test setup.

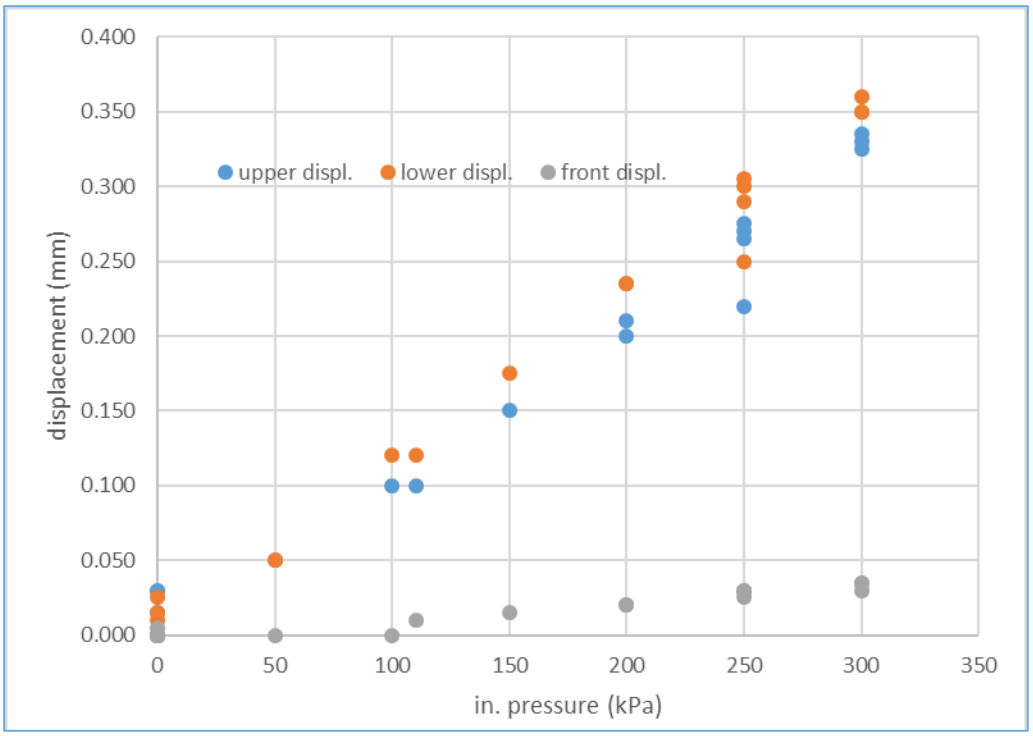

Figure 4: test data chart (ref. table 2).

Figure 5: Experimental setup.

2. Vacuum chamber

The vacuum chamber for the insertion of the detector is shown in the figure 6.

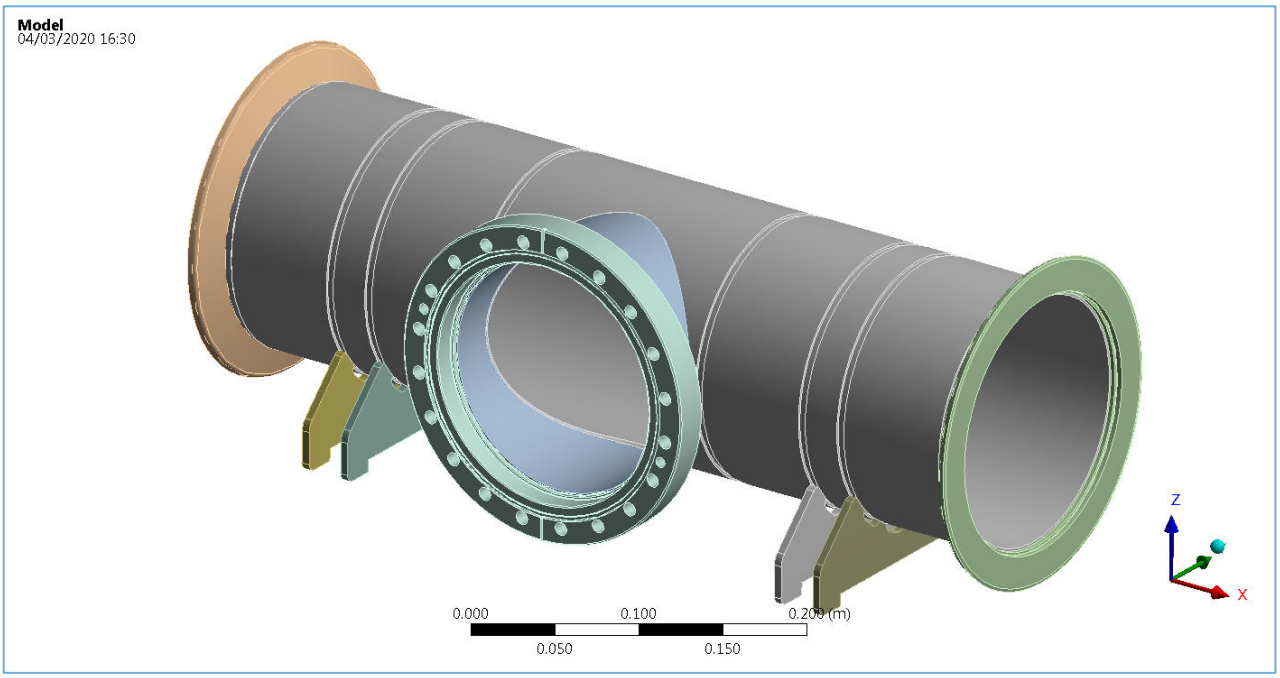

Figure 6: Insertion vacuum chamber.

The central flange is designed to accommodate the TIMEPIX detector setup, while the two lateral are for the insertion in the main vacuum pipe. The thickness of the pipe is 4.5 mm, while six grooves (1.5 mm depth) are used to precisely accommodate the lower and the upper brackets (these latter not in figure) that are used to support the chamber and all the experimental setup. The FEM analysis results are summarized in the pictures 7 and 8. The only load is the external pressure (100kPa).

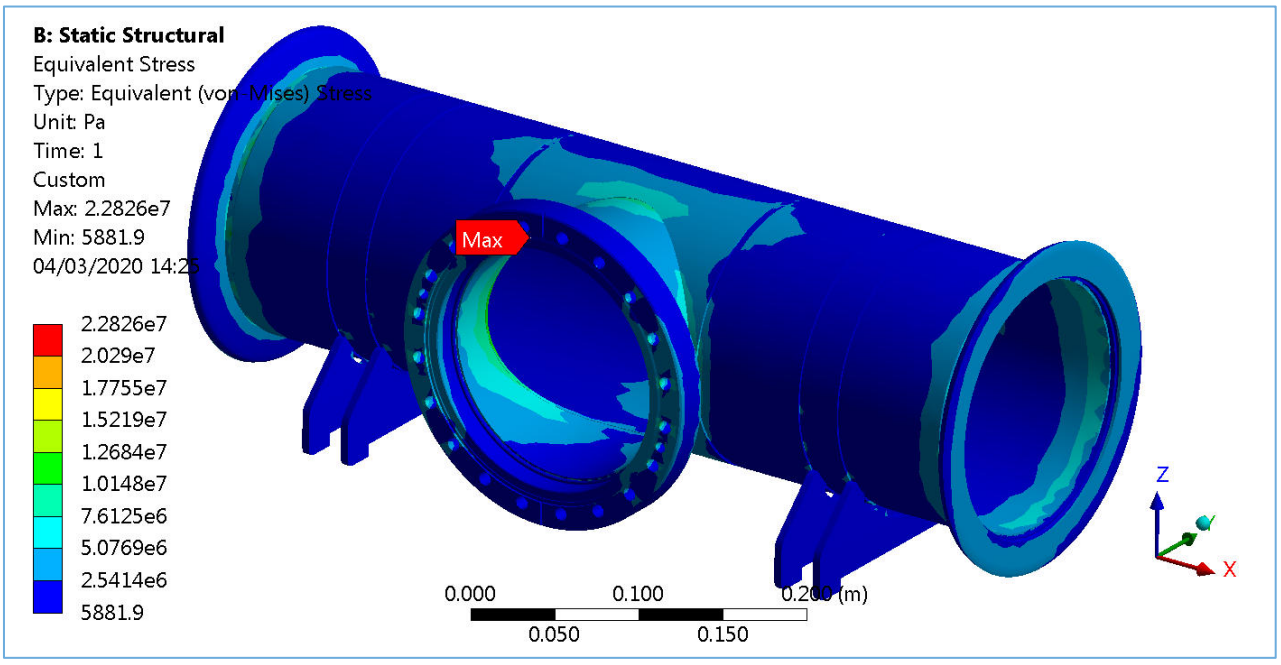

Figure 7: Vacuum chamber deformation.

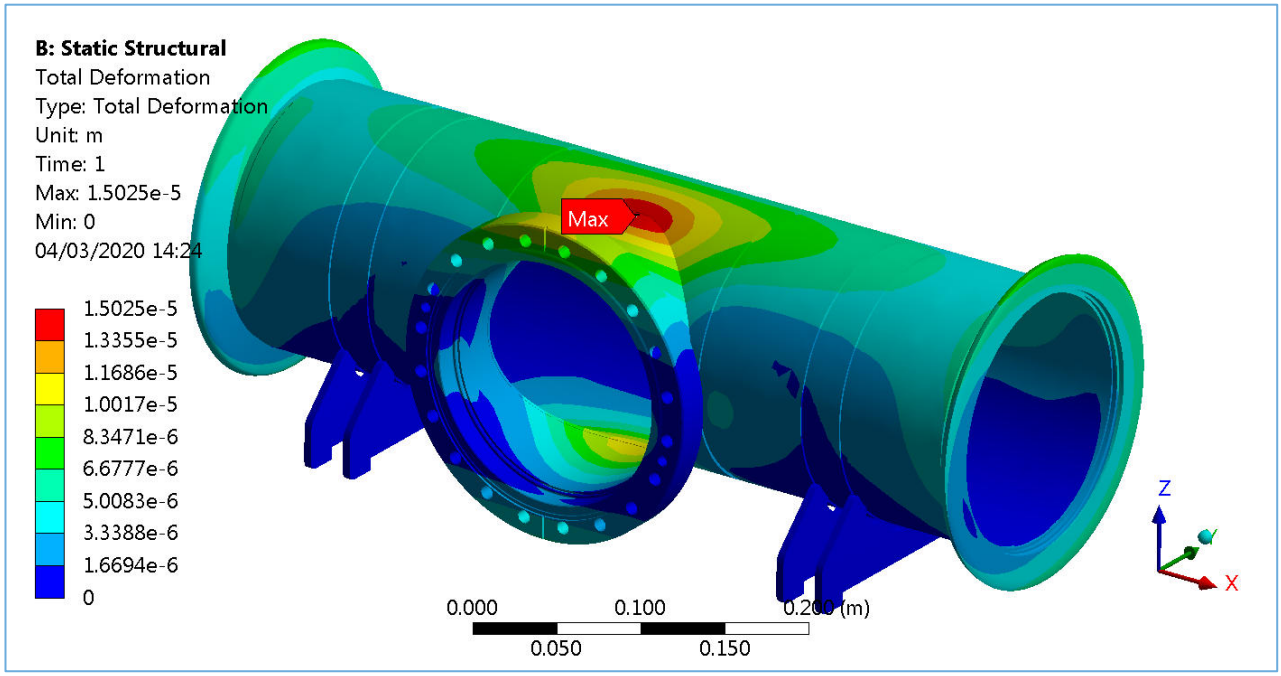

Figure 8: Vacuum chamber equivalent stress.

3. Conclusions

The simulation for the critical item (the detector case) yields quite a high stress, even if within the limit, while the deformation is not an issue. On other hand, the successful test at a pressure three times the operational one confirms the design choice. The deformation in the test and the FEM analysis result are in good agreement. A further simulation with internal vacuum (in case of non-operational conditions) has yield results of the same magnitude.

About the vacuum chamber design, the simulation results do not show any special issues. In particular, the grooves do not seem to weaken the resistance of the chamber, so no further actions seem advisable.