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Mechanical properties of the module boxes used for the LHCb outer tracking system

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Abstract

The rigidity of module boxes for the outer tracking system under mechanical load and for changing ambient temperature and humidity is measured.

1 The outer tracker modules

The outer tracker system of the LHCb experiment consists of a large number of straw tube detectors. 256 straw tubes are housed in one module with two staggered layers. The length of a module is 5 m, its width 34 cm. The height of the module is defined by the gas distribution boxes at the module ends. Figure 1 is a sketch of the module assembly: They are made of two sandwich panels, a layer of straw tubes glued to each panel. Strips of 400 μm carbon fibre tissue build the side walls. The inner side of the module is covered by a laminate made of Kapton (25 μm) and aluminium (12 μm). The sandwich panels consist of 80 μm carbon fibre skins and a core material of 10 mm height. As core material Rohacel and a Nomex-Honeycomb structure are taken into consideration. The sandwich panels and the side walls are produced at the Institute for Nuclear Physics in Krakow.

In this report we describe a detailed test of the mechanical properties, i.e. its behaviour under mechanical stress and in the presence of changing temperature and humidity. A box made of Rohacel panels, with a length or 3.2 m, a width of 34 cm and a height of 3.6 cm is tested[1]. Its height is defined by aluminium bars. The inner sides are covered by a 15 μm Aluminium foil and a 25 mum Kapton foil. Figure 2 shows the box.

2 Behaviour under mechanical stress

First the rigidity of the box under mechanical stress is tested. Overpressure is applied and the gas tightness of the box is measured. The overpressure is increased successively to 3 mbar, 5 mbar and 8 mbar. Each time the gas tightness is measured by observing the pressure drop over time. At a minimum measurement time of 15 minutes no measurable pressure drop has been observed. In the LHCb environment it will be ensured that the maximum overpressure applied to the detector modules does not exceed 2 mbar.

As second step the bending of the box loaded by weights has been measured. Supportedat only the end it sags by 5-6 mm. The resulting sag for additional loads are given in table 1. They are in agreement with calculations given in [1].

[1] To be more strict the length of one panel is 3.2 m, while the second panel is shorter by 15 cm

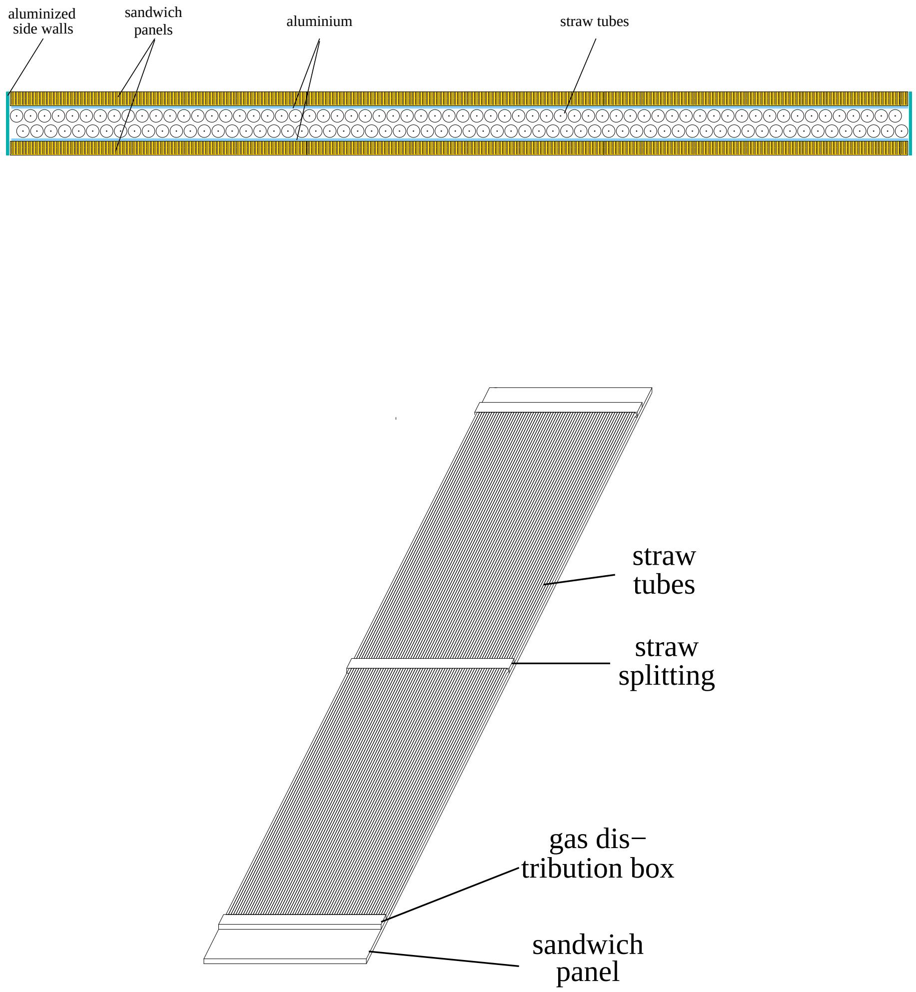

Figure 1: Assembly of the straw tube modules: Cross section through the module (top) and view of a half module including one straw tube layer. The second half is mirrored, giving a double layer of straw tubes for one module.

Figure 2: View of the box under test.

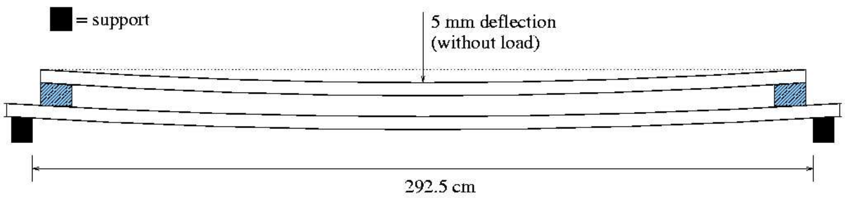

Figure 3: Set-up for the measurement of the sag. The measurement is done for the long panel up and down each.

long panel down		long panel up	
load [g]	sag [mm]	load [g]	sag [mm]
0	6	0	5
150	6.99	150	5.86
300	8	300	7.05
510	9.4	510	8.6

Table 1: Results from the sag measurements.

3 Deflections under changing temperature and humidity

To investigate the behaviour of the box under changes of ambient parameters it is placed in a tent. The tent is flushed by air. The humidity and temperature of the air is controlled in ranges of 5–60 % relative humidity and 20°C–40°C. Additionally the box can be flushed by dry air. The set-up for that measurement is shown in figure 4. The deflection of the box when changing from dry air to humid air is shown in figure 5. The measurements given are measured at position 5 (according to figure 4). The deflections at the other positions are negligible. Figure 6 summarizes the results for different temperatures. Again the only sizable effects are measured at position 5. Taking into account the large range of humidity and temperature during the measurements it is safe to assume that the maximum deflection of the module boxes in the experiment is below 2 mm. Even though this is not considered to be a problem it shows that it is necessary to support the modules in the direction along the beam line, to reach the desired precision in the measurement of the particle trajectory.

4 Tests of robustness limits

Finally the box was tested for its robustness. Two tests have been carried out: First, the box was loaded according to section 2 with an load of up to 3 kg. No damages have been observed. Also, the box remained gas tight. Then, the module has been handled intentionally very careless (e.g. by shaking the module) to simulate the handling of the module boxes during detector mounting and assembly[2]. Again, at the end of this test no damages or gas leaks have been observed.

[2] In fact it will be guaranteed that the final modules are handled much more carefully

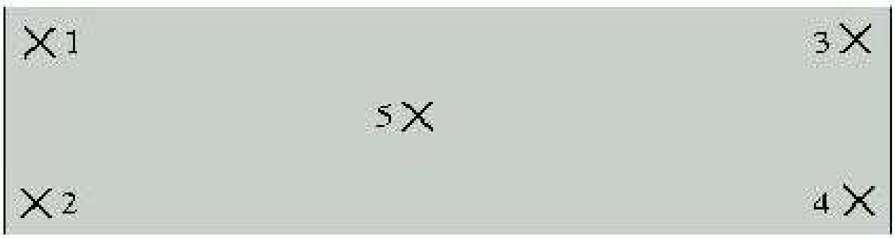

Figure 4: Set-up for the control of humidity and temperature (top). Positions for the deflection measurement (bottom).

The various tests performed give us confidence, that the current design of the module boxes for the LHCb outer tracking system fulfill the requirements on mechanical robustness.

References

[1] H. Schuijlenburg, talk given at the outer tracker meeting in Heidelberg, 28/29th February 2002

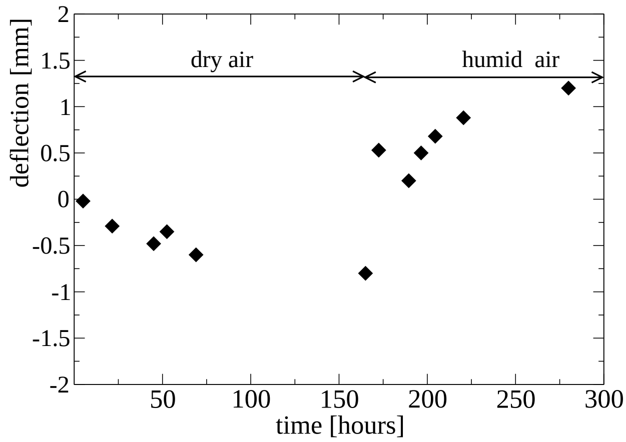

Figure 5: Deflection measured at point 5 under changing humidity. Before the measurement is started, the box is flushed with dry air (≈5% rel. humidity). At the beginning of the measurement the tent is also flushed with dry air. After 165 hours the tent is flushed with air at a humidity of ≈60% rel. humidity.

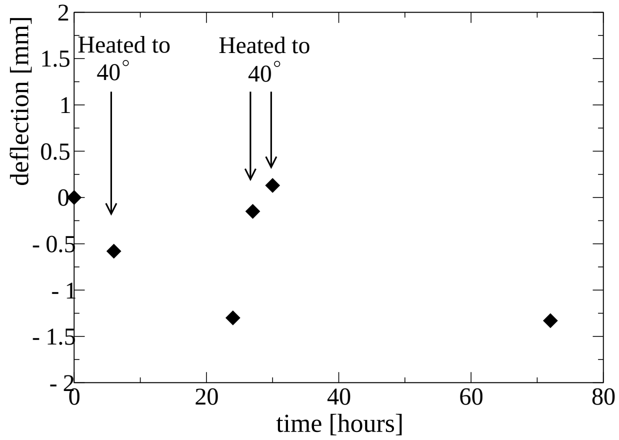

Figure 6: Deflection measured at point 5 at changing tempearature. At the start of the measurements the box is kept at room temperature. At the times indicated the ambient air is heated to 40°C.