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Construction of module boxes for the outer tracker in LHCb

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Abstract

We describe the construction of the first full size module box as it will be used for the straw tube modules of the LHCb outer tracking system. Final handling tools foreseen for the mass production are used. Measurements on the gas-tightness, rigidity and straightness of the modules are presented and compared to the specification for their application in the outer tracker.

1 Introduction

In the LHCb outer tracking system detector modules of up to 5 m length and 34 cm width will be used. They house 256 straw tubes arranged in a double layer. A detector module is made of two panels equipped with 128 straws each, glued on top of each other. Sandwich panels made of carbon fibre skins and a Rohacel core are used. Their technical specification are described in [1]. The modules are closed by means of carbon fibre strips. The arrangement of the straw tubes in the module boxes is shown in figure 1.

To achieve the envisaged spatial resolution of 200μm the position of the straw tubes has to be known with a precision of 100μm (rms) perpendicular to the beam axis and 500μm (rms) parallel to the beam axis. The positioning of the straw tubes within one layer is guaranteed by a high precision template used to glue the straws to the panels. The template is described in [2]. The positioning of the two straw tube layers with respect to each other is given by precision dowel pins in the aluminium inserts of the sandwich panels. To achieve the precision parallel to the beam axis the intrinsic straightness of a module box must not exceed 500μm. This specifications is achieved by means of a dedicated tool developed for handling of the single panels during construction and gluing the module boxes. A detailed technical description of this tool is given in [3].

Another important requirements concerns the gas tightness of the module. Each detector module contains two independent gas volumes [4]. The gluing must guarantee, that their is no leaking between these two volumes. Also the module box itself has to be gas tight. This is quantitatively discussed in [5].

The deflection of the modules caused by changes in temperature and humidity has already been measured on a 3m prototype [6].

This note describes the gluing of a test box very similar to those boxes used for the construction of detector modules, using the final handling tool designed to glue gas tight module boxes of the required straightness.

2 Construction of the test box

In this note the construction of a 5m long test box consisting of two sandwich panels, carbon fibre side walls and spacers is described. A sketch of the module box is shown in figure 2. To ensure gas tightness, panels and side walls are covered by a laminate of 25 μm Kapton and 12.5 μm aluminium as it is also foreseen for the final detector modules. The presence of two separated gas volumes is mimicked by means of spacers.

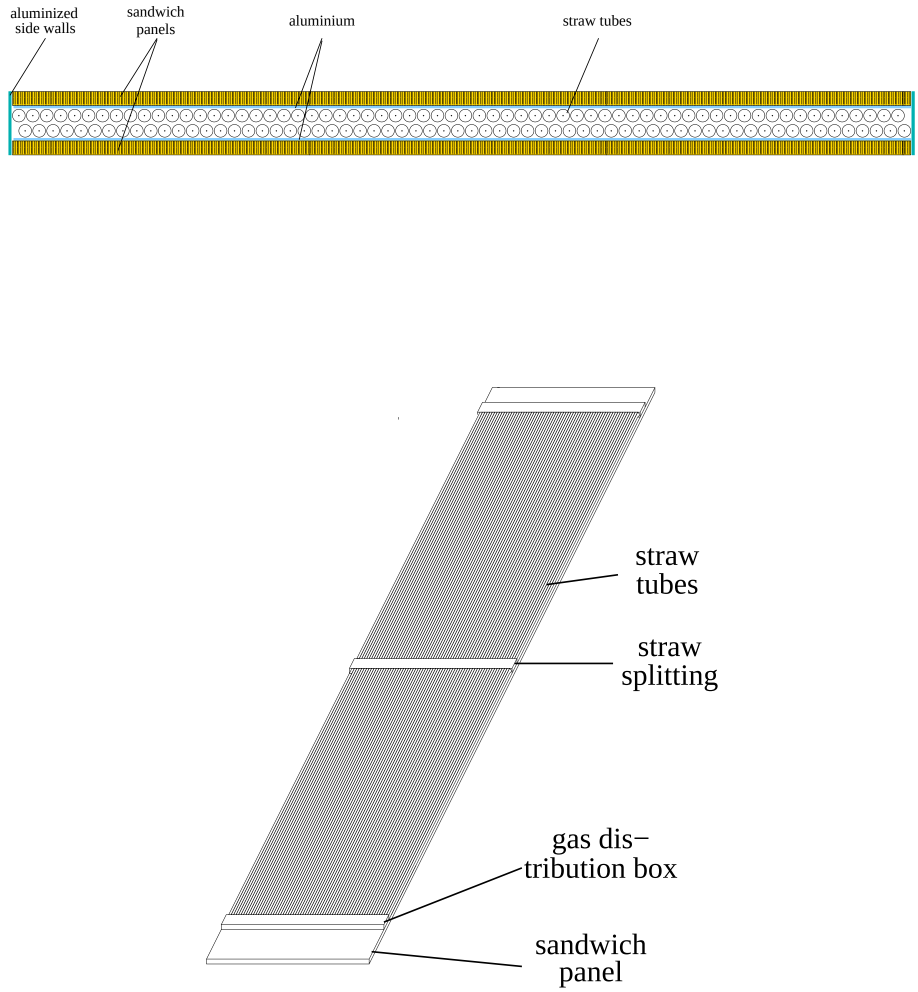

Figure 1: *Assembly of the straw tube modules: Cross section through the module (top) and view of a half module including one straw tube layer. The second half is mirrored, giving a double layer of straw tubes for one module.*

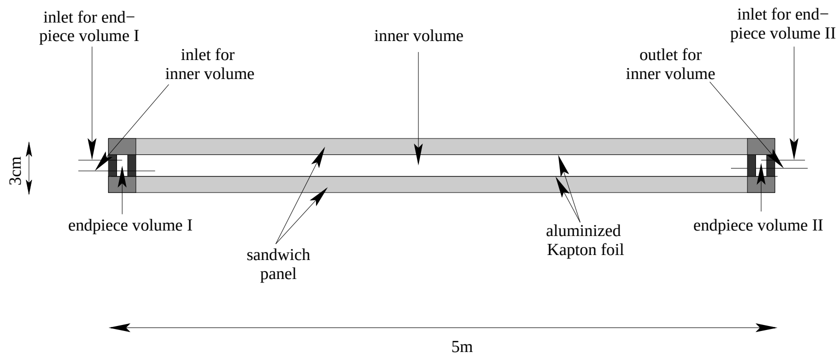

Figure 2: *Sketch of the test box. Note the different scales horizontally and vertically.*

2.1 Positioning of the panel on the handling tool

The panel is placed on a table with a flatness better than 100μm[1]. The handling tool is positioned with respect to the panel. Next, the panel is fixed to the tool as shown in figure 3. The panel is held by the tool by applying an under-pressure to the cylinders. The handling tool is dimensioned to to copy the straightness of the table (template) to the panel up to a precision of 100μm. It maintains this straightness during all production steps requiring it, i.e. gluing the panel on the straws in the template and gluing the box from to module half.
The straightness of the panel on the tool has been measured by means of a theodolite. The result is shown in figure 4. The deviation of the panel height from a straight line is less than 80 μm (rms), the maximum deviation about 150μm. This should be compared to the design goal of maximal 100 μm deviation (rms) from a straight line.

2.2 Choice of adhesive for module box gluing

It was foreseen to do all gluing joints in the module box using the adhesive Araldite AY103 in conjunction with the hardener HY991. This choice is based on the excellent out-gassing properties of that adhesive and because it cures at room temperature. But during the preparation of the module box gluing it turned out, that this glue tends to creep away from the joint before curing. Therefore we studied the possibility to increase viscosity by adding micro glass balloons to the glue [7]. As no degradation of the glueing properties of the adhesive were observed, the gluing of the test box is performed

[1]In the final production of the detector modules the template serves for that purpose.

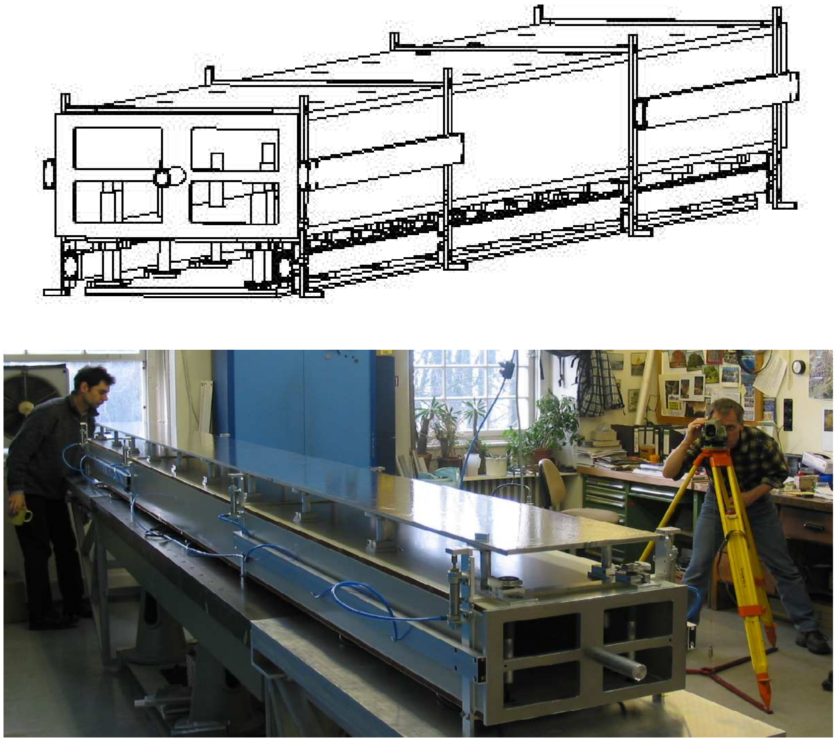

Figure 3: *Top: Sketch of panel handling tool with sandwich panel underneath. Bottom: Panel fixed on panel handling tool, during measurement of panel straightness with a theodolite.*

with Araldite AY103+HY991 with an admixture of the micro glass balloons with equal volume fraction.

2.3 Glueing procedure

The sandwich panels are joined and glued to each other when they are still connected to the panel handling tool to transfer the straightness of the panel on the tool to the box. This is shown figures 5 and 6. Like this the straightness of the panel on the tool is transferred to the box. The distance of the panels is defined by the height of the tool feet. The positioning of the panels with respect to each other is defined by means of precision dowel pins.
To glue the side-walls to the box they were fixed by scotch. Then a bar is pushed to the strips by pressured air. The gluing of the side-walls can be

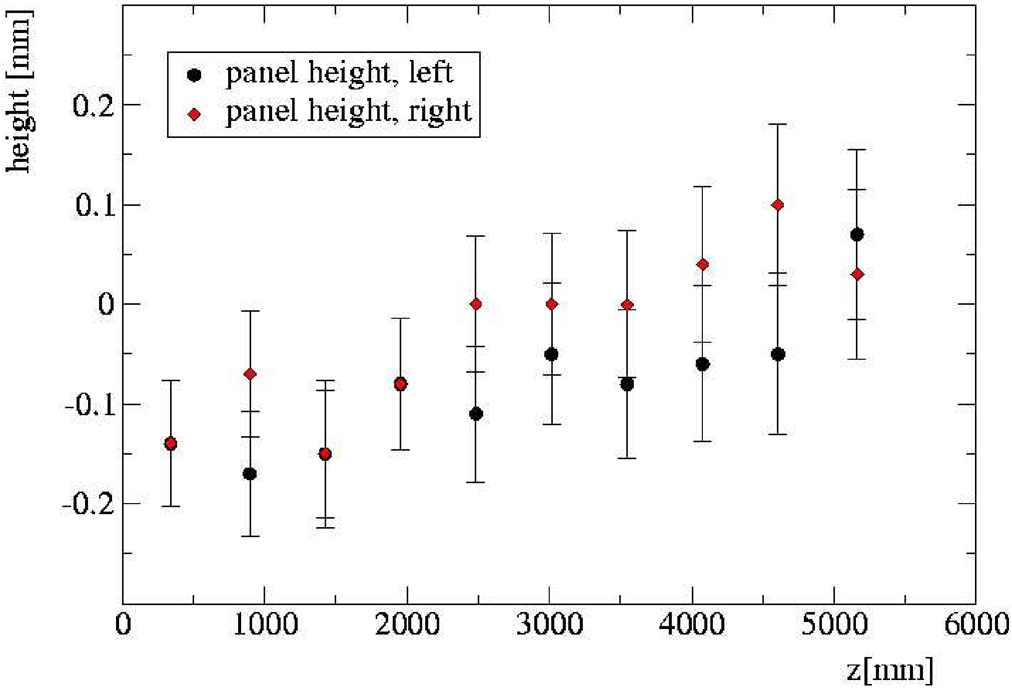

Figure 4: *Measurement of the panel straightness when kept by the handling tool. Note the different scales horizontally and vertically.*

done at the same time as the gluing of the panels to each other.

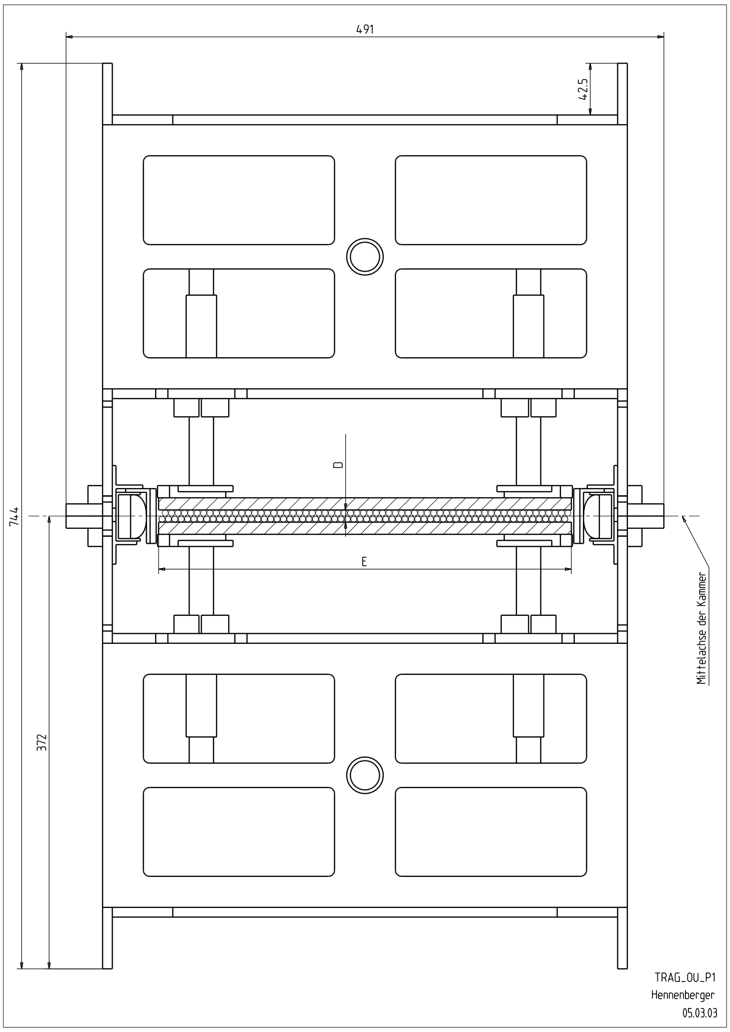

Figure 5: *Sketch of the arrangement of panels and panel handling tool to glue the panels equipped with straw tubes to each other.*

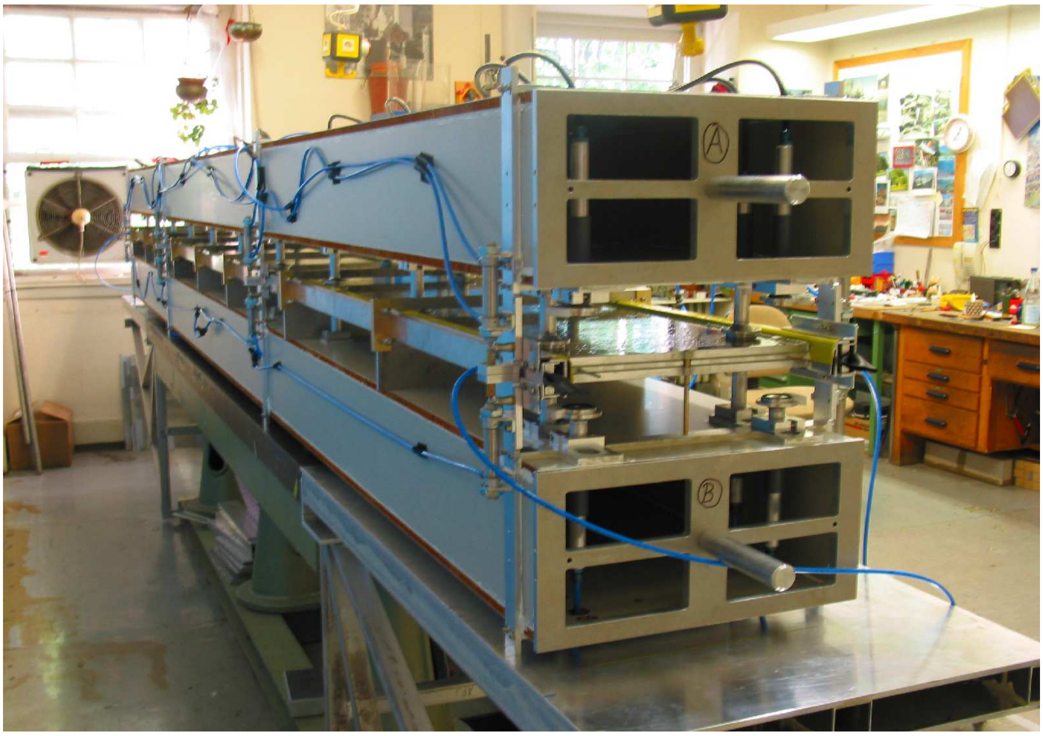

Figure 6: *Gluing of the test box.*

	overpressure $[mbar]$	**decay rate** $\left[\frac{mbar}{min}\right]$	**permeability** $\left[\frac{m}{bar \cdot s}\right]$
inner volume	3.3	0.06	$1.4 \cdot 10^{-6}$
endpiece I	5.6	0.1	$1.5 \cdot 10^{-6}$
endpiece II	7.4	0.16	$1.9 \cdot 10^{-6}$

Table 1: *Results on gas tightness tests.*

3 Results of measurements on the test box

To verify that the test box constructed by means of the panel handling tool fulfils the specification measurements on gas-tightness, rigidity and straightness were performed.

3.1 Gas-tightness

The gas-tightness of all three volumes of the test box (see figure 2) are tested independently for gas tightness by applying an overpressure and measuring its decay time. The results are given in table 1. From these measurements permeabilities of the volumes are calculated, as described in reference [5][2]. The measured permeabilities exceed the specification of $P < 2 \cdot 10^{-5} \frac{m}{bar \cdot s}$ defined in [5] by an order of magnitude. The measurements also show that not only the entire test box is gas-tight, but also that no significant leaking between the different volumes of the test box exist.

3.2 Rigidity

The rigidity of the test box is tested by a measurement of its sag, when the box is mounted horizontally with and without an additional load in the centre of the module. The results are given in table 2.

3.3 Straightness

The straightness of the test box has been measured as the deviation of the distance between the panel surface and a laser beam from a straight line. The result of the measurement is shown in figure 7. Despite a characteristic shape of the module box is observed the measured deviation from a straight

[2]The permeability allows to compare the gas tightness of volumes of different geometry.

add. weight $[g]$	**sag** $[mm]$
0	61.5
150	64.5
210	66.5
300	69
420	73
500	77.5

Table 2: *Results on gas tightness tests.*

line of about 300μm (rms) is within the specification of an rms less than 500μm. The maximum deviation from a straight line is 1mm.

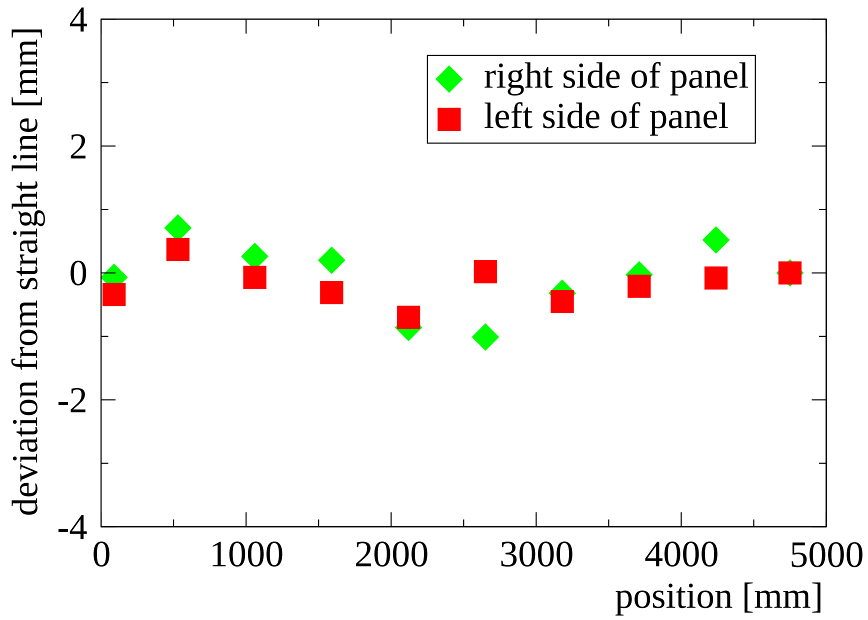

Figure 7: *Result for the straightness of the test box built with the panel handling tool. Note the difference in the horizontal and vertical scale. Beside the observed shape the straightness of the test box is within the specification given in section 1.*

4 Conclusion

In this report we describe the construction of module boxes for the LHCb outer tracking system. A dedicated tool has been developed to guarantee the straightness of the sandwich panels. Using this tool we reach a deflection of the panels of less than 100 μm during all production steps requiring high precision. A test box of 5m length has been built by means of that tool and tested for gas-tightness, rigidity and straightness. The measurements show that the box fulfils all specifications for the application in the outer tracking system.

References

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