March 23, 2003
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U.Uwer

Panel Support, Handling and Glueing Tool

The following note describes the panel support and handling tool. The adjustment of the panels on the tool and handling of the tool is presented. The note allows the reader to deduce requirements on tables or support structures to hold the panel support-tool during the different production steps.

Important:

To ensure the proper gluing of the panels to modules the tool demands reference surfaces on the straw template. The document defines the parameters which have to be agreed on (D, B, G, R, E, L) before the final template production can start:

	Quantity	Value	Reference
D	inner height of module	10.90 mm	H.Schuijlenburg
A	height of reference surface $= \frac{1}{2}D$	5.45 mm	S.Hennenberger
B	distance between template surface and center of straws	0.95 mm	H.Schuijlenburg
G	glue thickness	50 – 110 μm	H.Schuijlenburg
R	outer straw radius	5.2 mm	H.Schuijlenburg
C	template spacer height $= R + B + G$	4.30	H.Schuijlenburg
E	distance defined by end-pieces + 3G	10.90 mm	
L	distance defined by feed-through and end-pieces + 4G	10.95 mm	

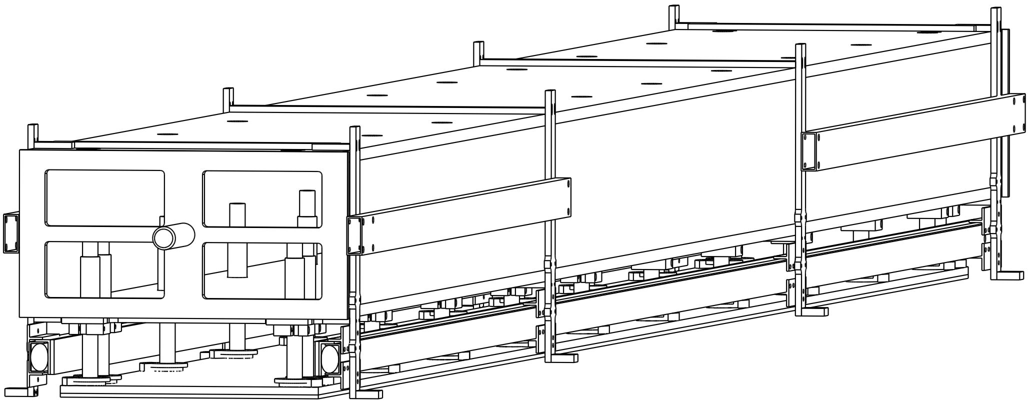


Figure 1:

Panel support tool

An Outer Tracker straw tube module will be built from 2 panels equipped with straws. The panels are held by a support tool which fixes their positions in all dimensions. The precision in the direction of the "x coordinate" is given by dowel pin holes at both ends of the panel. The same holds for the positioning in y. The precision in the z coordinate is provided by the tool.
The support tool allows the handling of the panels during wiring, the "storage" of wired panels, and the gluing of the panels to a box.
If used properly the tool guarantees deviations of the flat panel surfaces with respect to the flatness of the template surface of less than 0.1 mm.
As shown in Figure 1 the tool consists of a 5 (2.5) m long support bar built from a alu-honeycomb composite. Along its length the bar has 4 (2) feet on each side. The feet are used as reference for positioning. The above quoted flatness of less than 0.1 mm is only guaranteed if the feet stand on a flat (deviations <0.1mm) surface.
During the production process the flatness of the panel is only required during three production steps:

- positioning of the panel on the support-tool
- gluing the panel on the straws in the template
- gluing the box

All other production steps allow slight deviations from the flatness and thus they also demand less precise surfaces (tables) to pose the support-tool.

Initial positioning of the panels on the tool

The template is assumed to provide a flat surface necessary to glue the straws to the panel. It is therefore also used to position the panel on the support tool.
As shown in Fig 2 the panel is put with its flat surface on top of the template. The support-tool is put on top. The support-tool feet stand on a defined surface of the template. This surface defines the center-line of the later module box. The height A as indicated in Fig. 2 defines half of the distance D between the inner surfaces of the finished module box (for specification of D see also Fig. 5).
The parameter B as specified in Fig. 2 describes the distance between the upper surface of the template and the center of the straws.
Movable vacuum feet are lowered to the outer panel side. The position of the vacuum feet are locked and the panel is frozen in its current shape, i.e. the flatness of the template surface is copied to the flat side of the panel.

The flatness of a panel, taken from a flat surface and fixed to the support-tool was measured after the support-tool was moved and turned: The flatness of the table was kept by the panel with a precision better than 80 μm (RMS) or ± 150 μm (max. deviation). For details the reader is referred to the addendum

Gluing of the straws

To glue the panel to the straws aligned in the template the support tool is again put on to the template. This time a distance keeping spacer as indicated in Fig. 3 is put between the feet of the support-tool and the defining template surface. The height C of this spacer accounts for the outer straw radius, the distance B of Fig. 2 and the glue thickness.

Support-tool as wiring table

Turned upside-down and put on a table or support structure as shown in Fig. 4 the support tool holds the panel during further production steps.
Since no stringent flatness of the panel is required during wiring. There are thus no strict demands on the supporting tables.

Joining the panels to a module

Using the support-tools, the 2 panels of a module are brought together as shown in Fig. 5. The distance D of the two "inner flat surfaces" are fully defined by the support tool as explained above.
During the gluing of the side strips a bar moved by pressured air is used to push the strips against the panels.
To guarantee the straightness of the modules it is mandatory that the support-tools stand on a rigid and flat structure while the the glue is curing.

Definition of parameters and over-constraints

Table 1 defines the parameters necessary to be fixed before the straw templates can be produced. The parameters influence the reference surfaces on the template.

	Quantity	Value	Reference
D	inner height of module	10.90 mm	H.Schuijlenburg
A	height of reference surface $= \frac{1}{2}D$	5.45 mm	S.Hennenberger
B	distance template surface and center of straws	0.95 mm	H.Schuijlenburg
G	glue thickness straw-panel	50μm	H.Schuijlenburg
R	outer straw radius	5.2/2 mm	H.Schuijlenburg
C	template spacer height $= R + B + G$	4.30 mm	H.Schuijlenburg

Table 1:

<u>Remark on the calculation of parameters of Table1:</u>

- D(inner height of module): see Sect. "Straw and Endpiece Geometry" Fig. 9
- B = 1 mm − (2.65 mm − 2.60 mm) = 0.95 mm (see template drawing)
- G (glue thickness): between 50 and 110 μm
- R (outer straw radius): use max. value = 5.2/2 = 2.6 mm (min. 5.16/2 mm)
- C: $= R + B + G = 5.2/2 + 0.95 + 0.75 = 4.30$ mm

Over-constraints:
While the sides of the box are closed by carbon fiber walls which are glued from the outside against the panel sides, the module ends are closed by end-pieces and the feed-through boards which are located in between both panels. To ensure gas-tightness the thickness of the two end-pieces, the thickness of the feed-through boards, and the distance between the panels as defined by the tool should agree with each other. This will over-constrain the distance of the two panels as shown in Fig.6 and might lead to problems during gluing.

Table 2 summarizes the actual values of the 3 parameters – D (distance defined by support tool), E (distance defined by lego end-pieces) and L (distance defined by alu block and feed-through boards) – which (over-) define the distance of the 2 panels as shown in Fig. 6. The parameters E and L are defined as:

- $E = 10.90mm$:
  the same as D, last glueing step (joining of endpieces) has 110 μm
- $L = 10.95mm$:
  from panel to soldering pad surface of feed-through board (2.4$\pm$0.1 mm) + glueing (0.075 mm) + spacer (5.9 mm) + 2 glueings (each 50 μm).

$$L = 2 \times (2.400 + 0.075)\ \mathrm{mm} + 5.9\ \mathrm{mm} + 2 \times 0.05\ \mathrm{mm} = 10.95\ \mathrm{mm}$$

Quantity		Value	Reference
D	distance defined by the tool	10.90 mm	see Table 1
G	glue thickness	50 - 110 μm	see Table 1
E	distance defined by end-pieces + 3G	10.90 mm	see above.
L	distance defined by feed-through and end-pieces + 4G	10.95 mm	see above.

Table 2:

Remark:
The parameters D, E, L should account for the gluing layers: a 50μm slit to hold the glue should be foreseen between any 2 surfaces to be glued.

Heidelberg solution for the support tables

The clean room in the PI Heidelberg has only a total width of about 4 m. Equipping this room with conventional tables for the production of at least 2 modules in parallel was felt difficult. A cheap solution with a very high flexibility is sketched in Fig 7. The width of the shown supports is about 1.5 m allowing in maximum 3 support-tools to be put on the structure. The expected costs are about 7000 Euro in total.
The current scheduling allows the parallel production of always 2 modules.

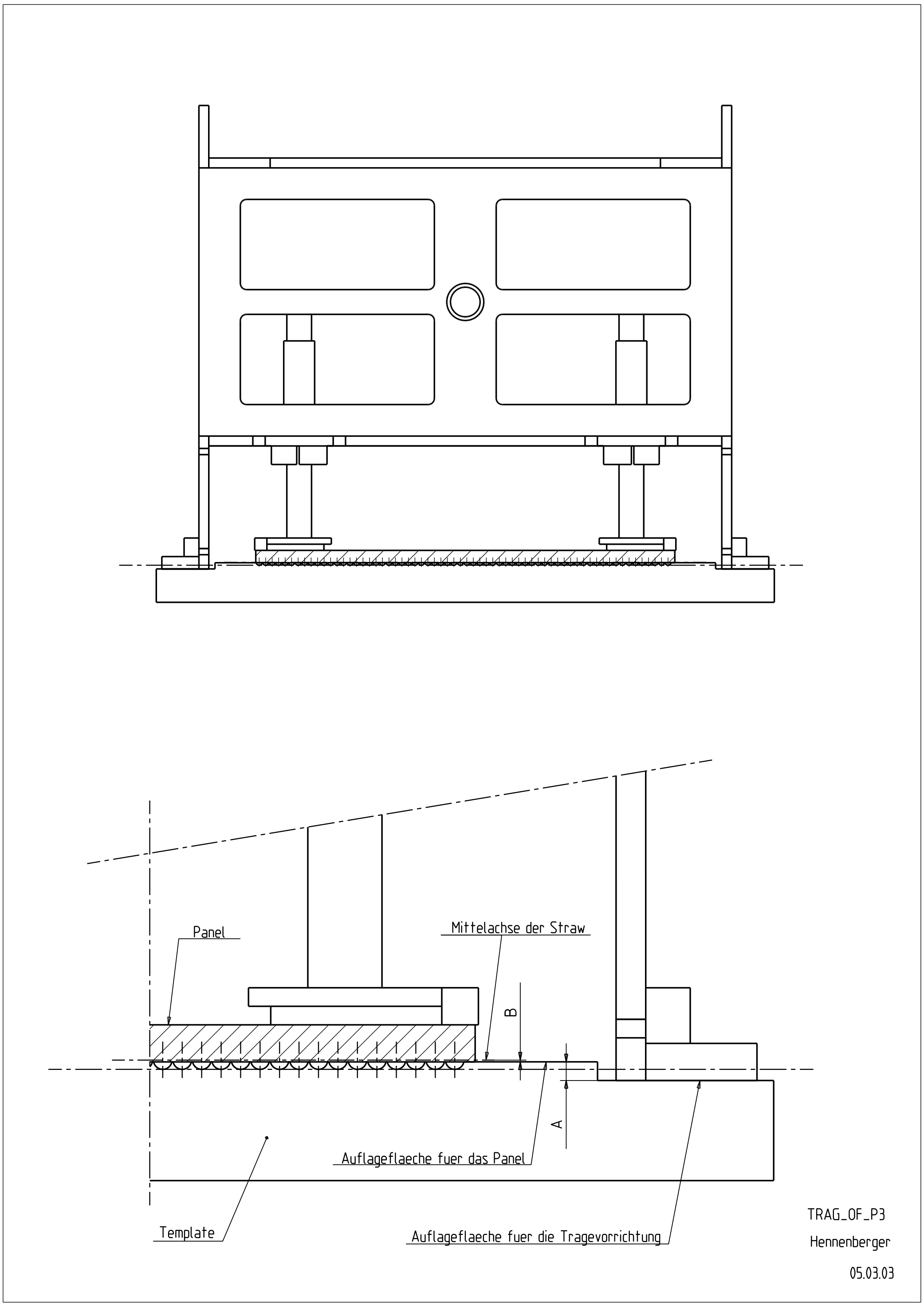

Panel
Mittelachse der Straw
B
A
Auflageflaeche fuer das Panel
Template
Auflageflaeche fuer die Tragevorrichtung
TRAG_OF_P3
Hennenberger
05.03.03

Figure 2:

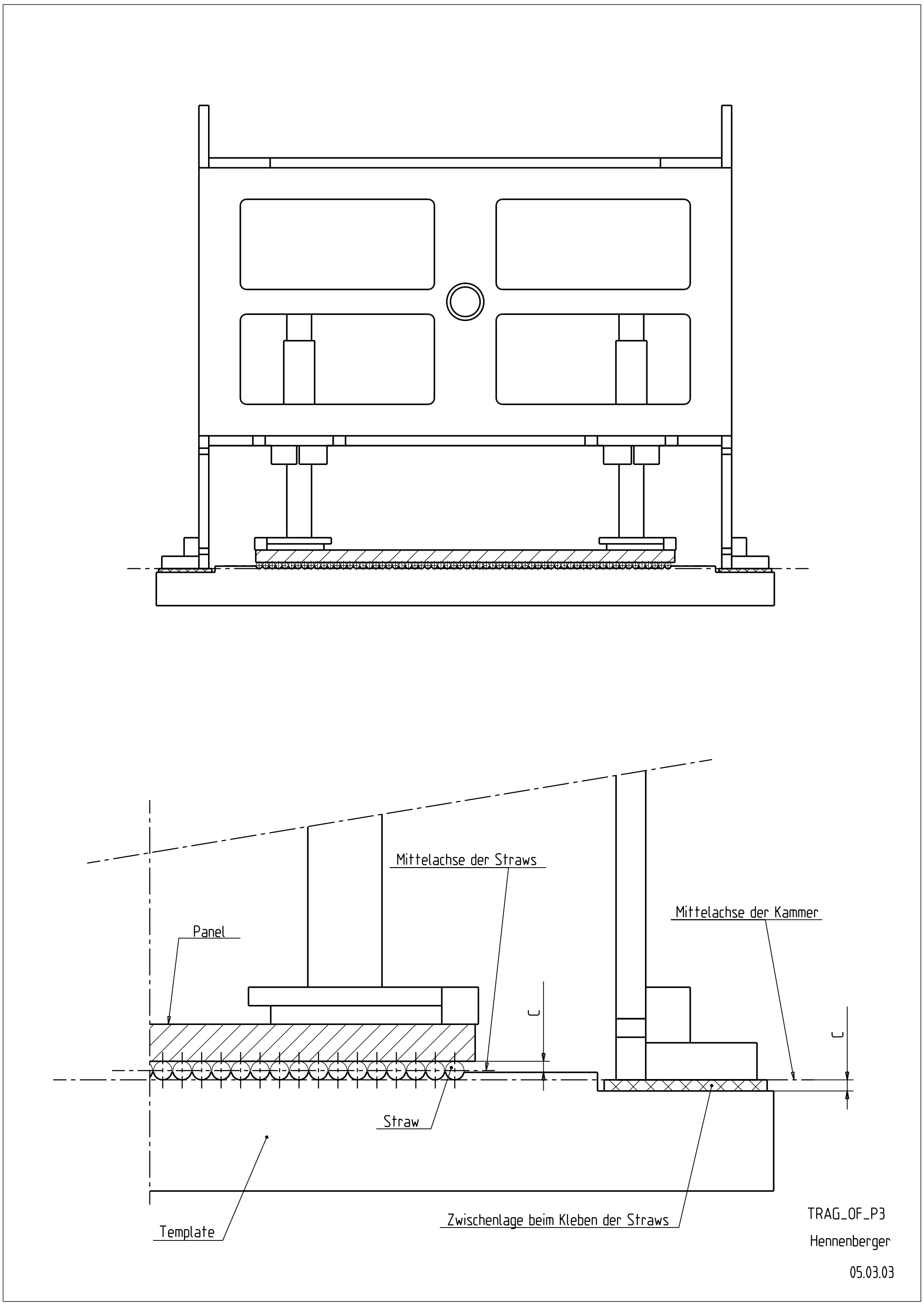

Mittelachse der Straws
Mittelachse der Kammer
Panel
C
C
Straw
Template
Zwischenlage beim Kleben der Straws
TRAG_OF_P3
Hennenberger
05.03.03

Figure 3:

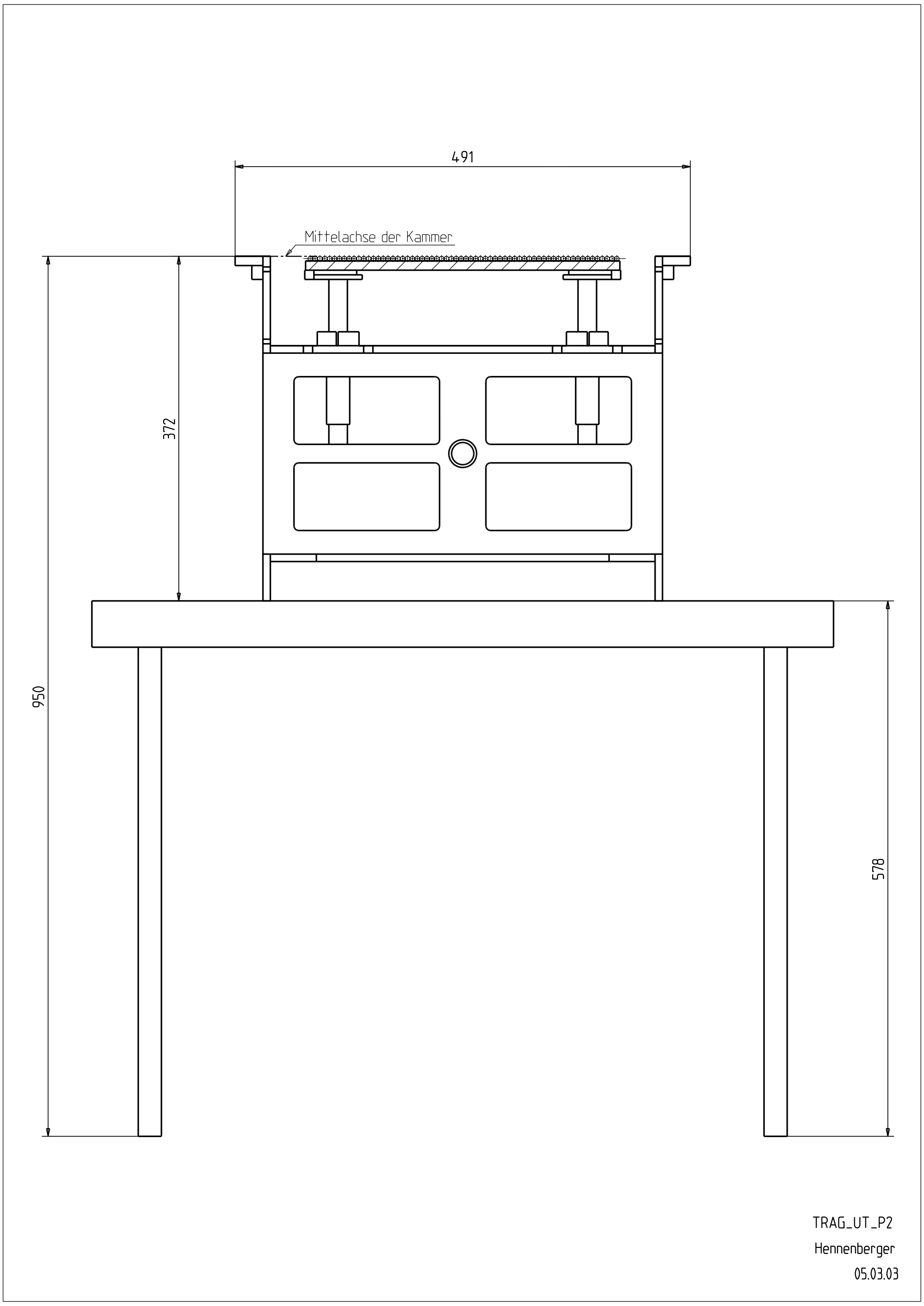

491
Mittelachse der Kammer
372
950
578
TRAG_UT_P2
Hennenberger
05.03.03

Figure 4:

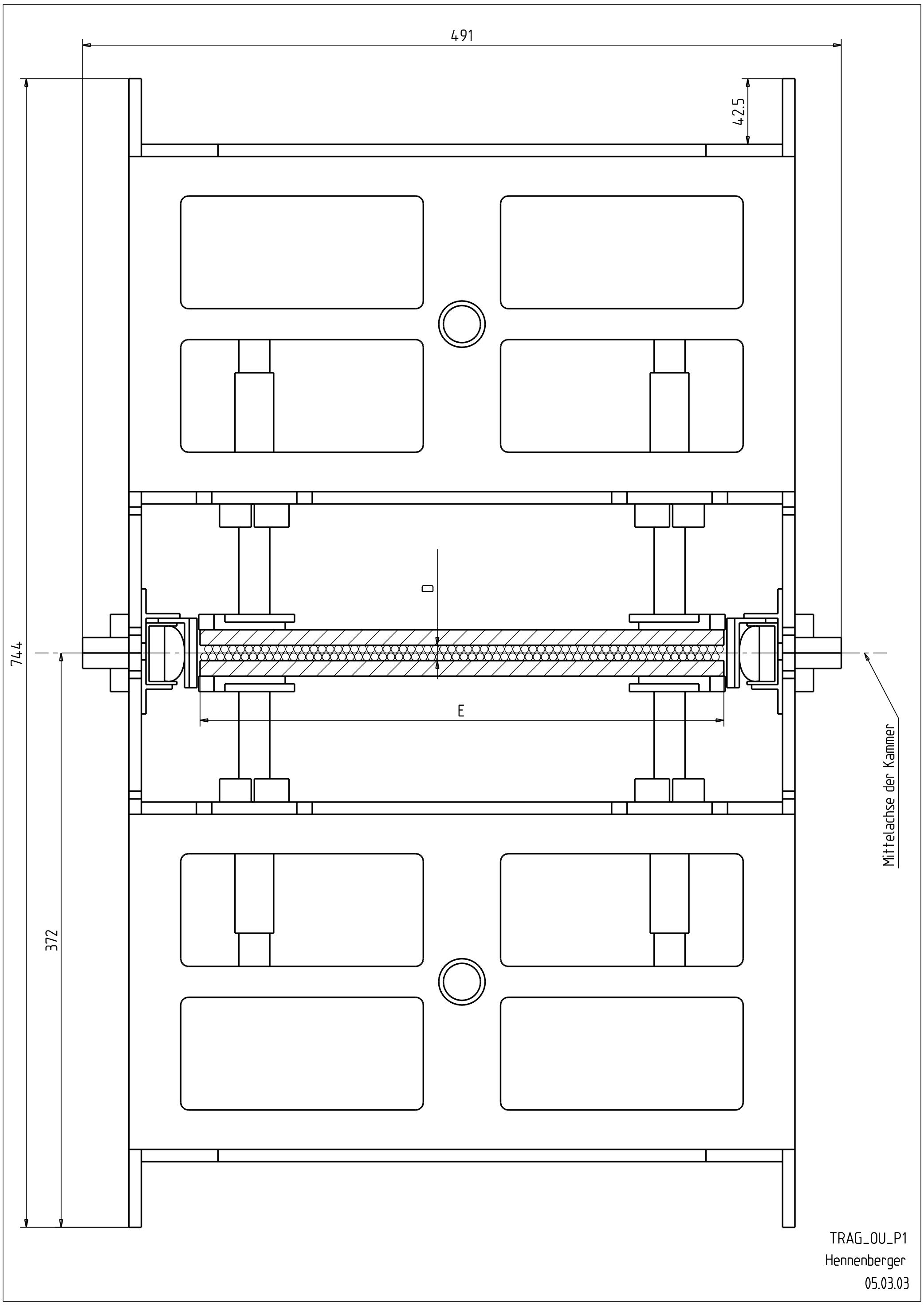

491
42.5
744
372
D
E
Mittelachse der Kammer
TRAG_OU_P1
Hennenberger
05.03.03

Figure 5:

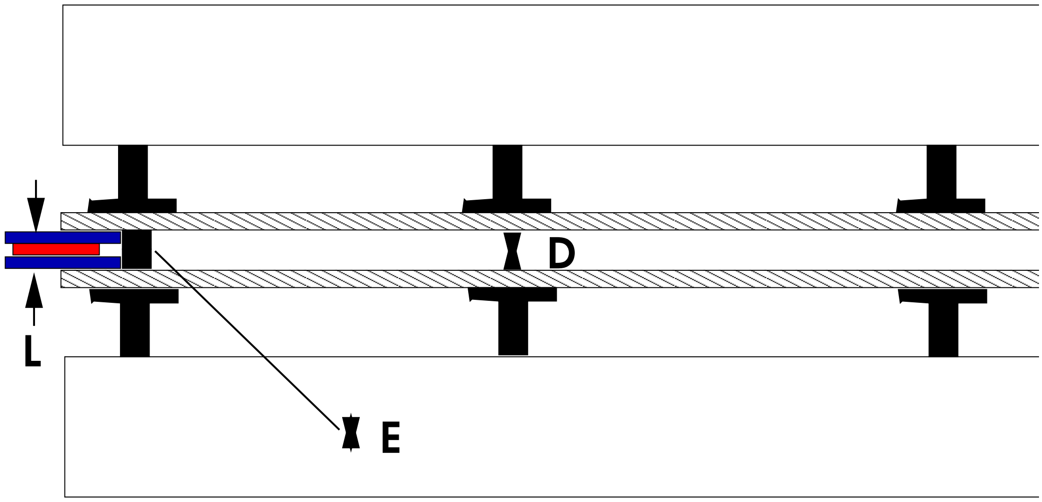


Figure 6:

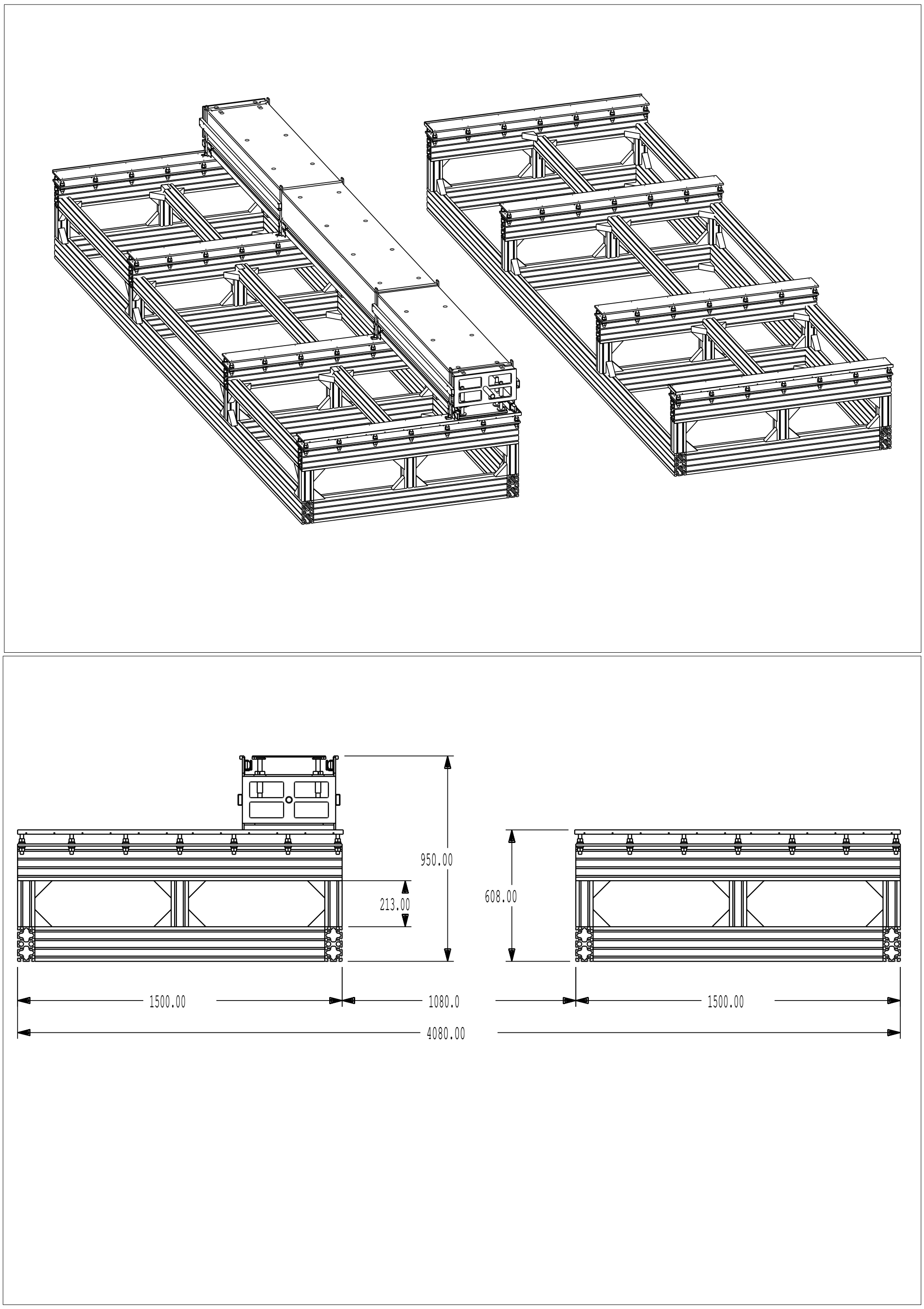


Figure 7:

Addendum: Measurement of the panel flatness

A support-tool as shown in Figure 1 was built and its functionality was tested:

A 5 m long Rohacell panel was put on a precise table with a surface flatness better than 100 μm. The support-tool was above the panel as indicated in Figure 2. The vacuum feet wer lowered and the panel was fixed to the support-tool. The tool was rotated and the "flat" surface of the panel, which after rotation is on the top (see also Figure 4), was measured.
Figure 8 shows the deviation of the measured points with respect to a straigth line. The measurements have been done along the full length of the panel, and separately a for the left and the right side.
The RMS of the deviations is less than 80μm. The maximum deviation is about 150μm.

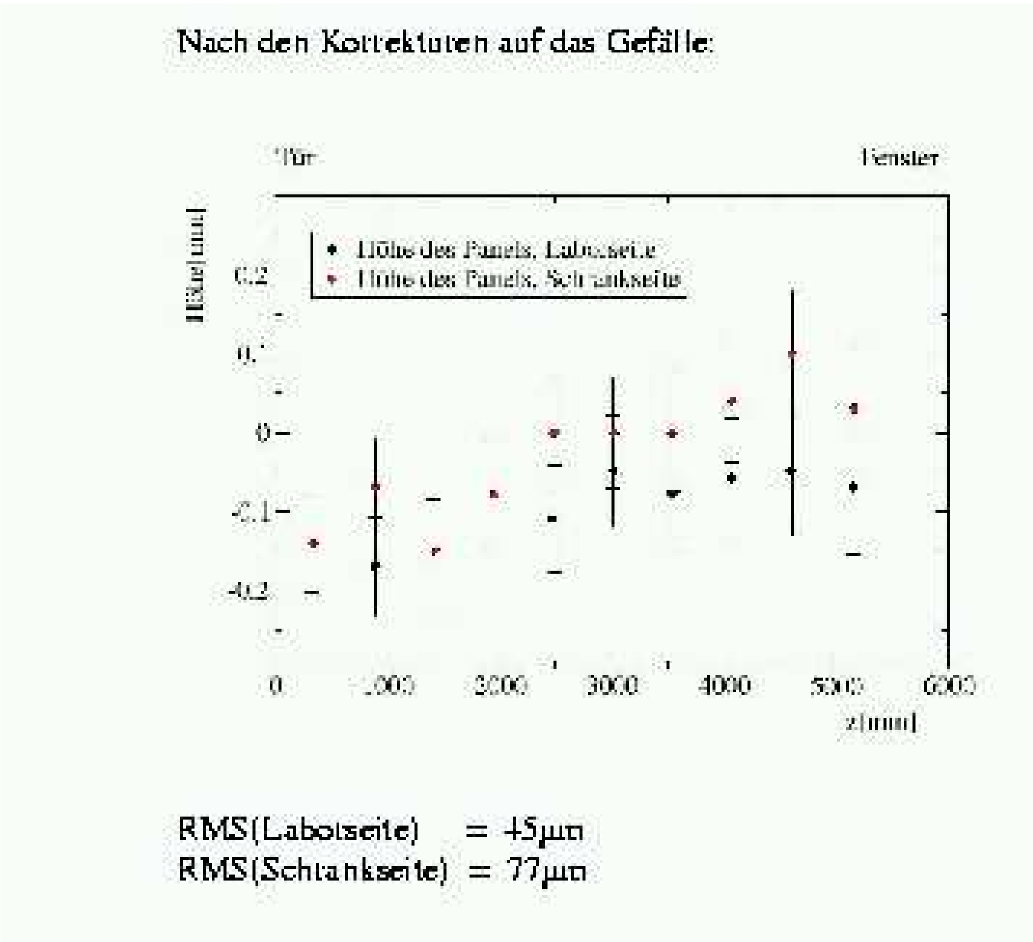
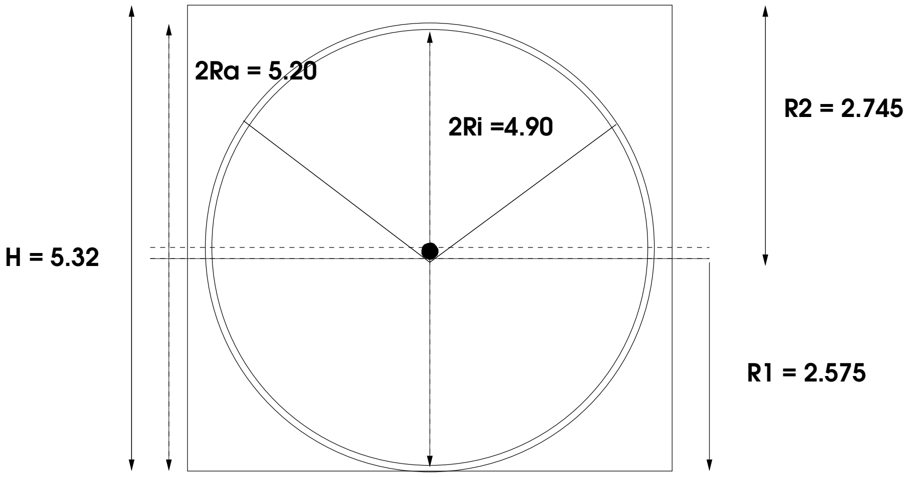


Figure 8:

Addendum: Straw and Enpiece Geometry



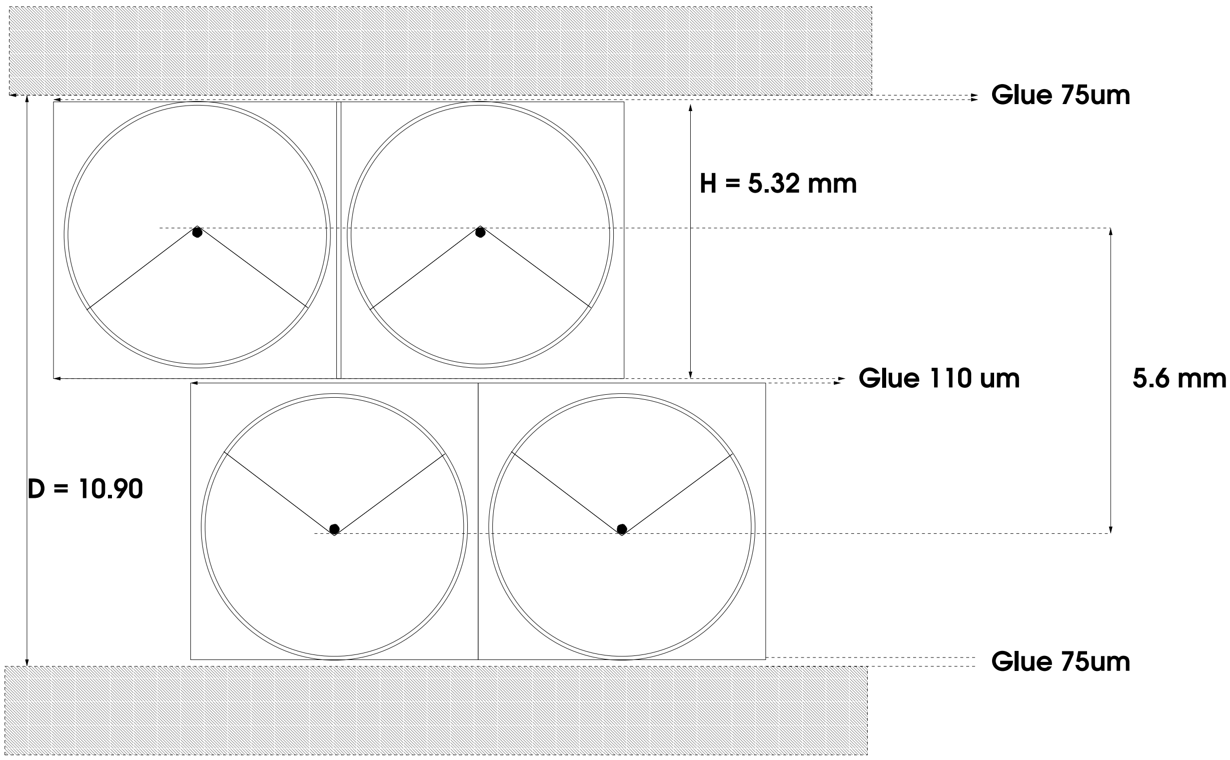


Figure 9: