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Mechanical design of the BIS module zero MDT chamber

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Abstract

The mechanical design of the BIS module 0 MDT chamber and an assembly scheme based on the BML chamber assembly method is described. Conceptual ideas on assembly tools and chamber transport and storage are also given.

1 Introduction

The purpose of this paper is to give a verbal description of the design of a standard MDT BIS chamber to help the understanding of the engineering drawings and to introduce some conceptual ideas on assembly, transport, and storage.

It mainly covers the mechanical aspects of the chamber. Gas distribution, on-chamber electronics, and other auxiliary equipment will follow the MDT standards. Also standard parts as material of the protection layer, mounting blocks, RASNIK system, etc. are not described in detail unless they differ from the standard solution for the other MDT chambers.

This note and the engineering drawings can be found via www under the address: http://atlasinfo.cern.ch/Atlas/project/TIE/detector/muon/prr/mdt/bis.

2 General description of the BIS chamber

A sketch of a standard BIS chamber is shown in Figure 1. The chamber consists of two multilayers (ML) composed of four layers of 30 mm diameter aluminium drift tubes each. Within a ML the tubes are close-packed with a wire pitch of 30.035 mm. The MLs are separated from each other by 7 mm. The arrangement of the tubes in the two MLs is mirror symmetric w.r.t. the mid-plane (x–y plane) of the chamber.

The chamber is supported via three kinematical mounting blocks which, differently than for the standard barrel MDT chambers, are connected to the top ML.

The outside of the two ML is covered by a layer of 30 mm thick insulating material and a 0.5 mm thick sheet of aluminium serving at the same time as thermal and shock protection.

The tubes (including the endplugs) are 1700 mm long; there are 30 tubes per layer for the module zero BIS chamber leading to a total length (z-direction) of the chamber of 916.035 mm.

The in-plane alignment system consists of a single ray RASNIK system and is mounted on the outside of the bottom ML. It is embedded in the thermal insulation and protected to the outside by the aluminium cover.

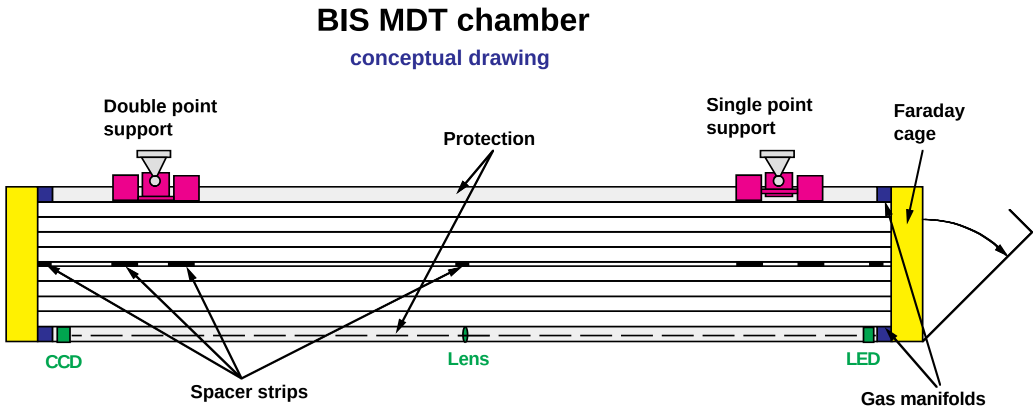

Figure 1: Sketch of a standard BIS chamber

3 Spacer structure and chamber support

The BIS chamber differs from the standard barrel MDT chambers mainly in two aspects: the spacer between the two MLs and the support.

3.1 Spacer structure - cross strips

Given the small distance of only 8 mm (nominal) between the two MLs there is not enough space for a standard MDT spacer structure. The solution adopted for the BIS chamber is to connect the two MLs by seven 6 mm thick aluminium strips. Thus, with the standard 0.5 mm thick glue gap the distance between the two MLs will become 7 mm. The width of the strips is either 25 mm or 50 mm depending on their position. The strips fulfil three purposes: they keep the distance between the two MLs, transfer the forces between the MLs, and improve the heat transfer between the two MLs. The number and positions of the strips have been chosen such that local deformations are minimized and heat transfer is maximized while keeping the total amount of material added small.

The strips are made of commercially available material.The flatness/straightness of the strips must be better than ±0.5 mm in order not to exceed the thickness of the glue gap. The strips are 880 mm long, leaving 10 mm space on either side for the passage of cables.

3.2 Support

The particular position of the BIS chamber in the detector does not allow for a support in the mid-plane of the chamber. The solution chosen instead is to support the chamber from the top. Three kinematic mounting blocks are fixed to the upper ML: two blocks on one side and a single support block on the other side. The mounting blocks are designed to have the standard degrees of freedom as in the other chambers. One of the blocks of the double support is fixed, the other one is free to move in the z-direction (along the rails). The single block on the other side is free to move along the z- and the x-direction (in the local chamber coordinate system). In addition all blocks have bearings which allow for ±0.5 degree angular movements w.r.t. the rail axis.

In the x-direction the mounting blocks are located at a distance of 200 mm from the tube ends. This distance has been chosen as a compromise taking into account the feasibility to locate the rails and the wish to move the support points as close to the tube ends as possible in order to minimize the chamber deformation under gravity[1]. As shown in finite element calculations small variations in this position result only in minor differences in the chamber deformations. In the z direction the blocks of the double support are located in the Bessel points and the single support block is located on the middle line of the chamber w.r.t. its centre of gravity.

The mounting blocks are connected via a set of two hollow aluminium profiles to the tubes. The profiles extend over the full chamber length (z direction) and thus distribute the loads. They also add stiffness to the chamber against deformations in the y-direction.

The blocks of the double support are standard commercially available parts. They are connected to the beams via two U-shaped aluminium profiles. The single support block is connected to the two support beams via a stainless steel rod of 12 mm diameter which allows for the lateral movement of the mounting block (degree of freedom in the x-direction). The bearing of this block is identical to the one of the double support blocks, however, its housing requires some modification. The modified block is expected to be provided by the supplier.

In order to minimize chamber deformations it has been attempted to place the rails as close as possible to the top ML of the chamber. This determines the y-position of the blocks.

3.3 Electrical insulation

The electrical insulation of the chamber is achieved by glueing 5 mm thick strips of resin impregnated glass fibre between the support beams and the tubes. This reduces at the same time the heat transmission through the support beams into the chamber, see below.

In order to be independent of the different thermal expansion coefficients of the glass fibre strips and aluminium the insulating layer is made of 80 mm long pads. The pads will be glued to the support beams with a distance of 10 mm between them such that they always span over three tubes.

4 Auxiliary equipment

The design of the auxiliary equipment of the BIS chamber follows as closely as possible the standard barrel chamber design. Standard parts will be used where possible. Given that there is no spacer some of the parts and their locations are different from the standard solutions for the barrel chambers.

4.1 Gas distribution

The gas manifolds are located on the outside of the multilayers. They are made of standard 30×30 mm^2 hollow aluminium profiles and form the outer boundaries of the chamber protection at the tube ends. At the same time they serve as support for cable connectors where appropriate. The gas distribution will eventually follow the general MDT scheme. Module 0 of the BIS chamber is designed to use a parallel gas flow scheme where each time four tubes sitting

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[1] If the chamber weight would be distributed homogeneously over the chamber width the support points should be placed at the Bessel points. Given the considerable additional weight of the endplugs, Faraday cages, gas distribution system, and electronics the optimal support points are closer to the tube ends and the 200 mm distance is a reasonable position.

on top of each other within a ML are connected by a single jumper (minifold) to the same outlet or inlet of the gas manifold[2]. The number of gas connection to the manifold is thus equal to the number of tubes per layer.

4.2 Faraday cage

A single Faraday cage (FC) on each side covers both multilayers. It consists of a ground plate, two corrugated side pieces, and a cover which can be opened.

4.2.1 Ground plate

The ground plate (GP) serves three purposes: it

1. provides the proper electrical ground connection between tubes, endplugs, and hedgehog boards;
2. closes the Faraday cage towards the endplugs;
3. provides mechanical stiffness to the chamber against deformations in the y direction.

The GP is made of 1 mm thick aluminium. It is glued to the gas manifolds on the top and bottom and screwed to the endplugs. Holes are provided at the proper locations such that it can be placed over the endplugs. No particular precision is required on the holes. The ground and mechanical contact is provided by a set of screws (or conducting glue)[3].

On the top, bottom, and the two sides the plate has extension ‘ears’ folded by 90 degrees. These ears serve as connection pieces for the other parts of the FC.

4.2.2 Side plates

The side covers are shaped to follow the tube arrangement such that neighbouring chambers can be placed with a nominal[4] tube-to-tube distance of 20 mm. The width of the piece is 58 mm. The pieces are screwed or glued to the ‘ears’ of the grounding plate.

4.2.3 Cover

The FC is closed by a cover shaped in the form of an inverted L. The long leg of the L is connected to the lower extension of the GP by two hinges such that it can be opened. When closed the short leg of the L overlaps with the upper folded part of the GP. Two turn-locks keep it in place. Cutouts are provided at the locations of the cable connectors. The exact size and shapes of these cut-outs are not defined yet, awaiting the specifications for the connector types.

The opening is such that the inside of the FC can be accessed from the top side of the chamber.

4.3 Patch panel

Depending on the final choice of the readout scheme for the data and other signals some additional boxes may need to be placed on the chamber. Such boxes could be placed on the top

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[2] A distribution scheme where several tubes are connected in series is possible, however, requires a more complicated gas jumper pattern since an odd number of tubes has to be connected in series in order to be able to have the input and output manifolds on the opposite tube ends.

[3] The hole pattern of the GP shown in the engineering drawings is only an example. It is based on the requirements of the Pavia endplug design and will be adapted to the final hole pattern required.

[4] The actual distance is 20 mm - 30×0.035 mm = 18.95 mm.

of the chamber close to the support beams and would be connected (signal on one side; HV, RASNIK, and DCS signals on the other side) via the appropriate cables.

4.4 In-plane alignment system

The in-plane alignment system consists of a single RASNIK system (LED+mask, lens, and CCD) mounted on the bottom multilayer. It is embedded into a 60 mm wide channel in the protection cover. Standard RASNIK elements are used, however adapted to the limited space. Their characteristics are:

LED+mask: diameter: 25 mm

lens: diameter 25 mm; focal length: 400 mm.

CCD: size: $25\times25\ mm^2$

It has been confirmed (H.v.d. Graaf) that the corresponding RASNIK elements are available and can be fit to these dimensions. However, no detailed engineering drawings of the housing of the elements do exist yet.

The elements are mounted via standard precision mounting plates with dowel pins to the tubes.

The aluminium cover of the protection above the RASNIK elements is removable such that the RASNIK elements can be accessed for maintenance.

4.5 B-field and temperature sensors

The chamber will be equipped with standard temperature and B-field sensors at locations to be specified.

Temperature sensors will be glued directly to the tubes or to auxiliary support pieces. Standard mechanical parts will be used provided they fit into the available space.

B-field sensors can only be mounted on the outside of the multilayers. There is not enough room for the B-field measurement heads between the MLs. Standard mounting blocks will be used. The measurement heads will be embedded into the protective foam.

5 Protection and thermal insulation

The chamber is covered on both outer faces by a protective layer which serves at the same time as thermal insulation. The same materials as in the other MDT chambers are used: a thick layer of non-flammable, radiation resistant, light-weight foam is glued to the tubes and a 0.5 mm thick sheet of aluminium is glued to the outside of it[5]. The thickness of the insulating material is 30 mm in the BIS chamber compared to 15 mm in most of the other chambers.

6 Chamber assembly

The assembly of the BIS chamber differs from the standard barrel chamber assembly. It has not yet been studied in all details and is still at the conceptual level. The scheme proposed here

[5] The exact choice of the insulating material and the metallic cover plate has not been made yet. The BIS design will follow the MDT standard. An alternative to the 0.5 mm aluminium sheet would be a 0.1 mm stainless steel sheet.

follows to a large extent the scheme of the BML assembly. The same jigs and distance pieces will be used and are not described unless they differ.

The full assembly will be done on a granite table of dimensions $2.7 \times 2.2 \times 0.4$ m^3 with a flatness of ±6 µm in a climatized clean room following the general MDT specifications. The dimensions of the granite table are such that, if required, two parallel sets of jigs for parallel assembly of two chambers can be set up.

Other tools as glue dispenser, monitoring devices, etc. will be identical to the ones used in the BML assembly.

The steps of the assembly are described below and shown graphically in Figure 2 to Figure 6. Note that here, for convenience and in contrast to the general naming scheme, the tube layers are counted 1–8 from top to bottom.

Again it should be stressed that the scheme described is only a concept. Detailed engineering studies will start after the PRR.

6.1 Assembly on the jigs

The scheme is similar to the BML assembly. However, instead of the spacer an auxiliary stiffback is used to provide for the required rigidity of the chamber during its assembly.

6.1.1 Top multilayer and support beams

1. Place first layer of tubes on the jigs and glue them together;
2. glue the support beams and upper gas manifolds to the tubes;
3. connect a stiffback structure (see below) to the support beams at the Bessel points in z;
4. lift the assembly;
5. place the next layer of tubes on the jigs;
6. apply glue to the tubes on the jigs except at two locations about 700 mm from both ends where two strips of 35 µm thick folded Al foil is placed across the tubes;
7. place precision distance blocks at the four corners of the stiffback structure in order to define the distance of this layer to the previous layer;
8. lower the assembly onto the precision blocks, glue the previous tube layer to the new layer on the jigs;
9. place two bars on the top of the outer tube layer at the position of the thin Al strips in order to remove any possible deformation of this layer in the y-direction;
10. for the 3rd tube layer: repeat steps 4–9;
11. for the 4th tube layer: repeat steps 4–8;
12. lift the assembly.

This completes the upper multilayer of the chamber.

6.1.2 Bottom multilayer

The bottom multilayer will be added by continuing the stacking procedure described above, after having glued the cross-strips to the 5th layer of tubes. In order to define the height of the 5th tube layer a special set of four precise blocks will be placed on the table. Then the distance blocks

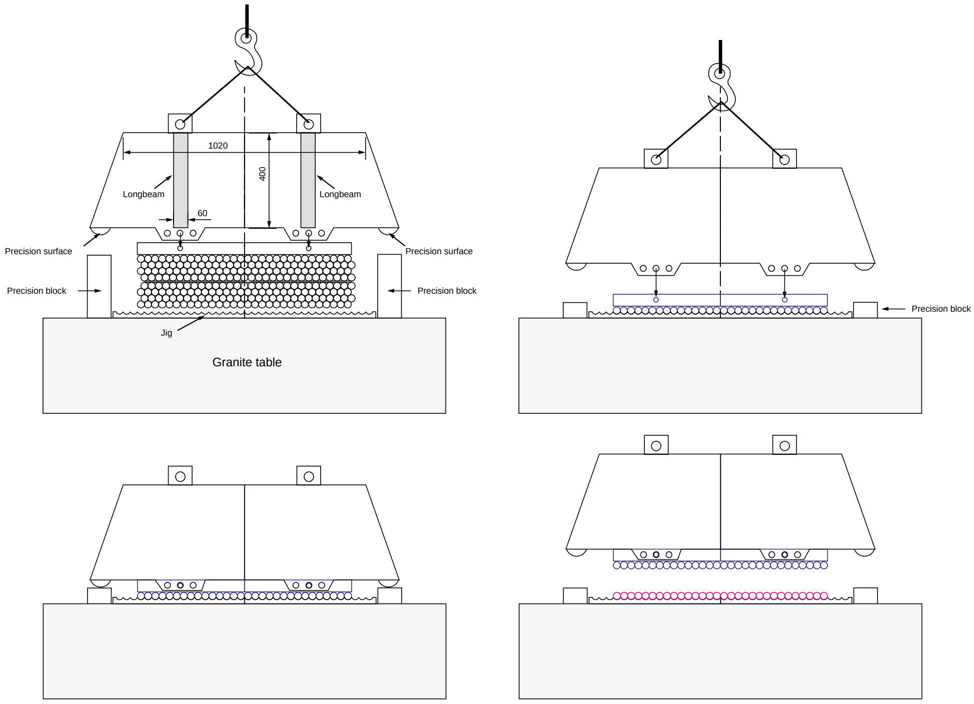

Figure 2: Schematic view of the chamber assembly showing the full chamber and the stiffback and the first glueing steps, see text

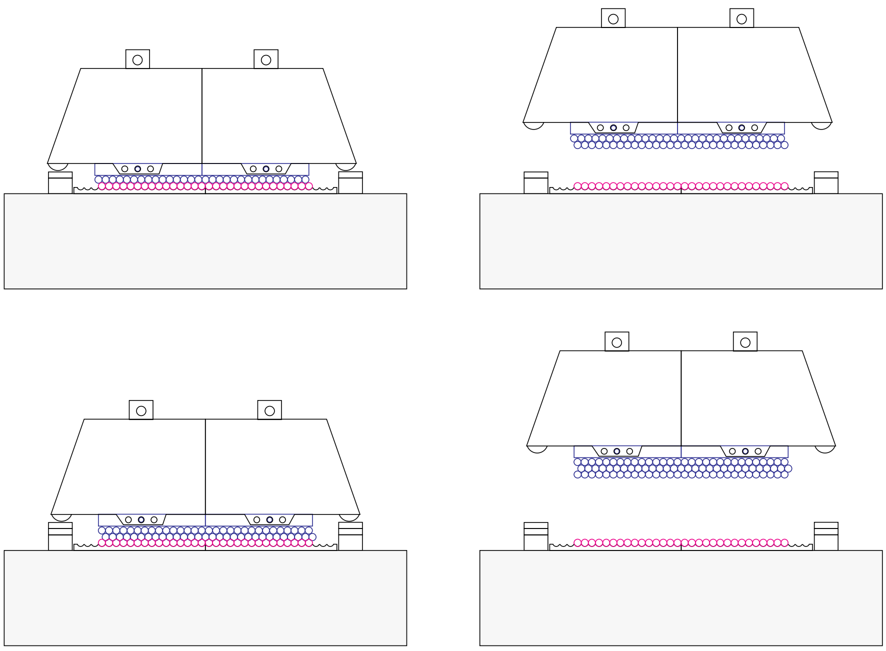

Figure 3: Schematic view of the chamber assembly. Shown are the up to the placement of the fourth ML.

which were used for the stacking of the first four layers will be re-used for the stacking of the remaining layers.

13. Place the 5th layer of tubes on the jigs, glue them together and glue the cross strips to them (no particular precision required);
14. repeat steps 7 and 8;
15. for the 6th tube layer: repeat steps 4–8;
16. for the 7th tube layer: repeat steps 4–8;
17. for the 8th tube layer: repeat steps 4–8;
18. lift the chamber and place a temporary support piece with the gas manifolds over the two outer jigs;
19. lower the chamber and glue the gas manifolds to the bottom ML.

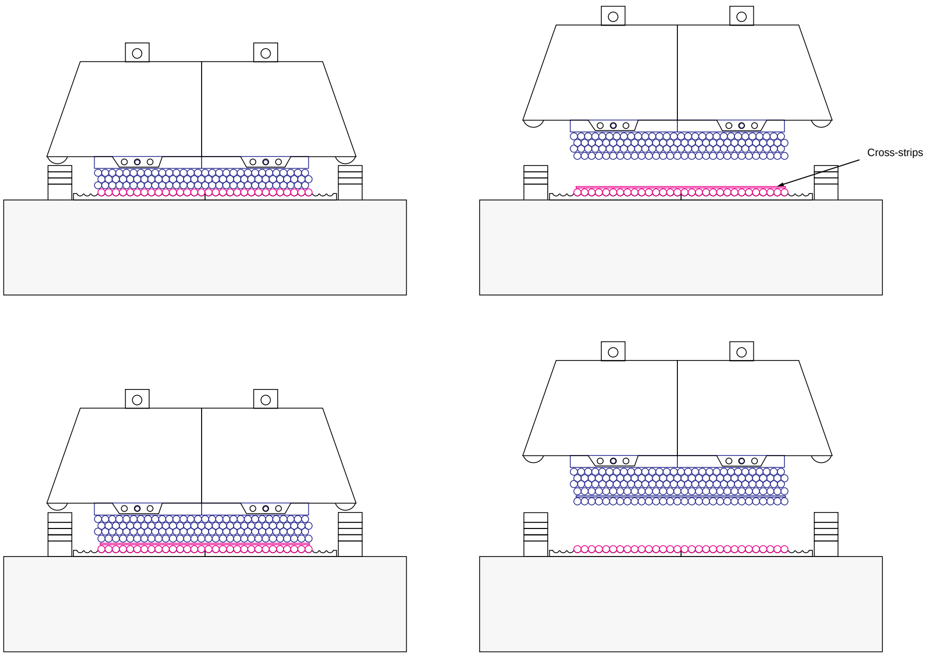

Figure 4: Schematic view of the chamber assembly. Shown are the glueing of the 5th and 6th layers.

6.1.3 Faraday cage ground plate

Before the chamber is removed from the jigs, the ground plates of the Faraday cages are added to the structure providing additional stiffness.

20. fix the FC ground plates to the two chamber ends;
21. remove the chamber from the granite table using the transport frame (see below).

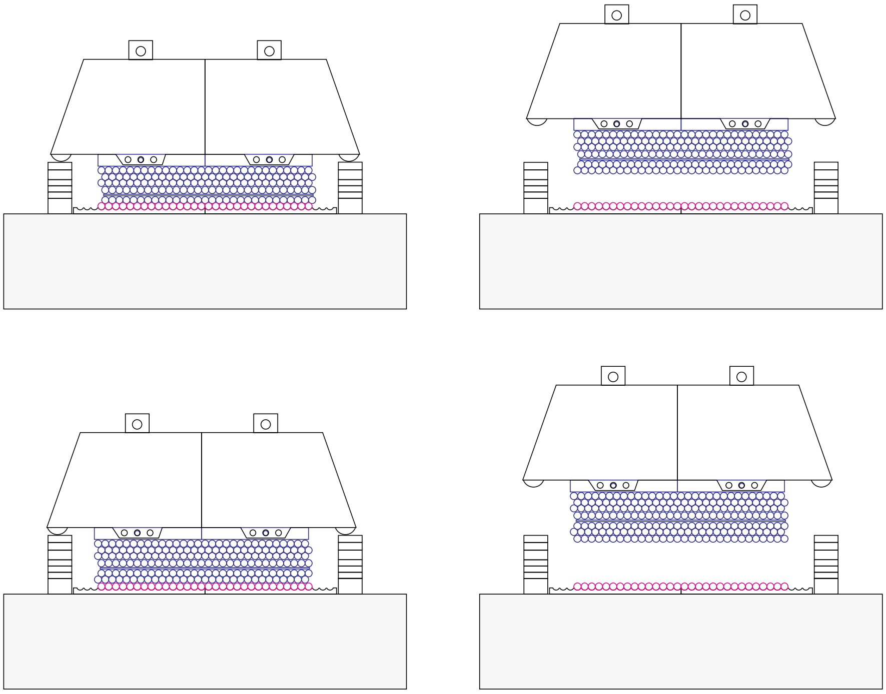

Figure 5: Schematic view of the chamber assembly; continued.

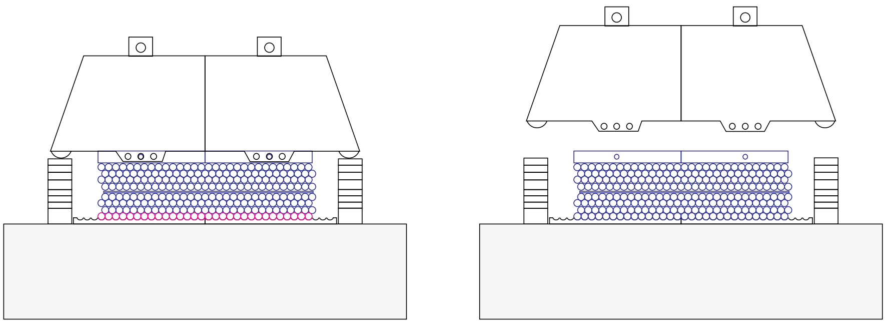

Figure 6: Schematic view of the chamber assembly. The last layer is glued.

6.2 Completion of the assembly

The remaining steps of the assembly sequence are no longer influencing the mechanical precision of the chamber. They can be done outside of the clean room. They consist of:

22. completing the FC;
23. mounting of the gas connectors;
24. adding the B- and T-sensors;
25. mounting the RASNIK system
26. adding the electronics boards;
27. cabling;
28. mounting of the protective layers;
29. adding the mounting blocks;
30. attach (possible) electronics/control boxes on the upper ML.

6.3 Assembly tools

6.3.1 Stiffback

A sketch of the stiffback is given in Figure 7. It consists of two identical cross-plates connected to each other by two longbeams and is made of aluminium. The cross-plates have on both sides precision surfaces which are placed on the precision distance blocks on the granite table.

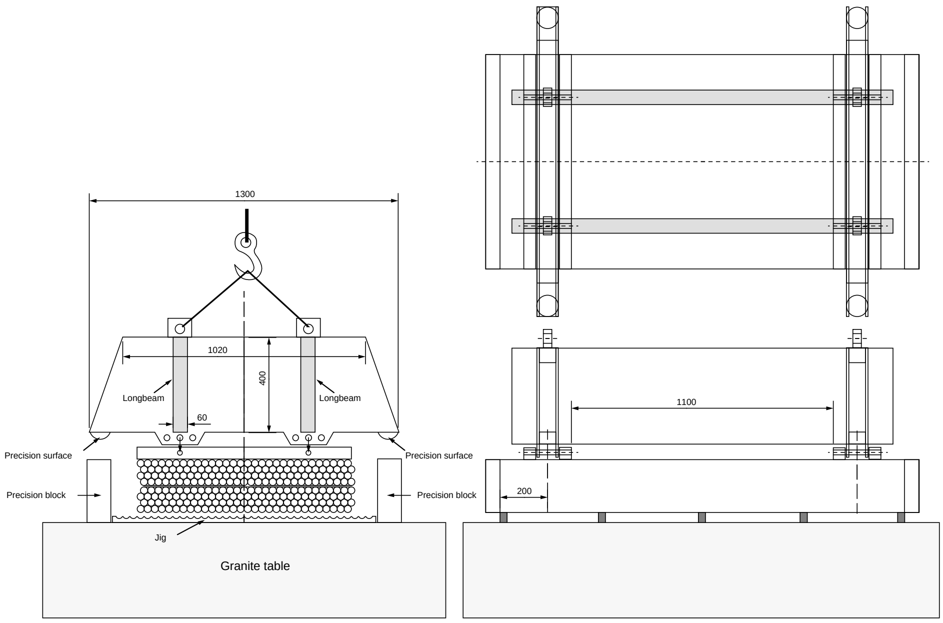

Figure 7: Sketch of the stiffback

The stiffback cross-plates can be connected to temporary connection pieces fixed to the U-shaped pieces between the support beams of the BIS chambers which later house the kinematic mounting blocks[6]. For this purpose two extensions per cross-plate with a set of three oversized holes each (corresponding to the pick-up points for the three different BIS chamber lengths) are foreseen.

When the first layer of tubes and the support beams are glued on the jigs the stiffback will be placed on the four precision blocks defining the nominal height of the connection points w.r.t. the first tube layer. The exact absolute position of the connection points is not very critical within the tolerances of the oversized holes in the cross-plates. The stiffback is then fixed to the connection points on the chamber and will stay connected until the chamber is completed.

6.3.2 Distance blocks

The distance blocks are precision machined blocks as used for the assembly of the other barrel chambers. They define the height steps from layer to layer. Eight different heights are required. In total four standard pieces and an additional block which defines the height of the 5th layer are required for each of the four legs.

7 Quality assurance

The QA procedures during and after the assembly of the chamber will follow the MDT specifications as documented in the general QA document for the M0 production and are not detailed here.

7.1 During assembly

The most critical elements to be monitored during the assembly are the proper placement of the tubes on the jigs and the definition of the height of the tube layers. The same tools and procedures as for the BML assembly will be applied.

In addition a RASNIK system on each of the two cross-plates of the stiffback will measure any deformations of the already glued elements in the x-y plane.

7.2 Acceptance tests

It is planned to test the BIS chambers for gas leakage and HV integrity using the standard methods and tools. In addition it is planned to measure the full functionality of the chamber using cosmic ray particles on a test stand with a scintillator hodoscope serving as trigger.

8 Storage and transport

The total weight of the BIS chamber is about 80 kg. For local transport (in the lab) a chariot will be used which can pick up the chamber from the top. It attaches to the support beams of the chamber by inserting pins into their openings at the ends, see the conceptual sketch of Figure 8.

The pick-up frame is mounted on a rotating axis such that the chamber can be oriented vertically for passage through narrow doors. The rotating support axis is designed such that it can be moved vertically and that the chamber can be lowered onto the ground and lifted upwards. Either a hydraulic or mechanical mechanism will be used.

[6] Although these pieces are only required for the mounting blocks on one side of the chamber the same U-shaped pieces will also be place on the other side; they are used only in the assembly.

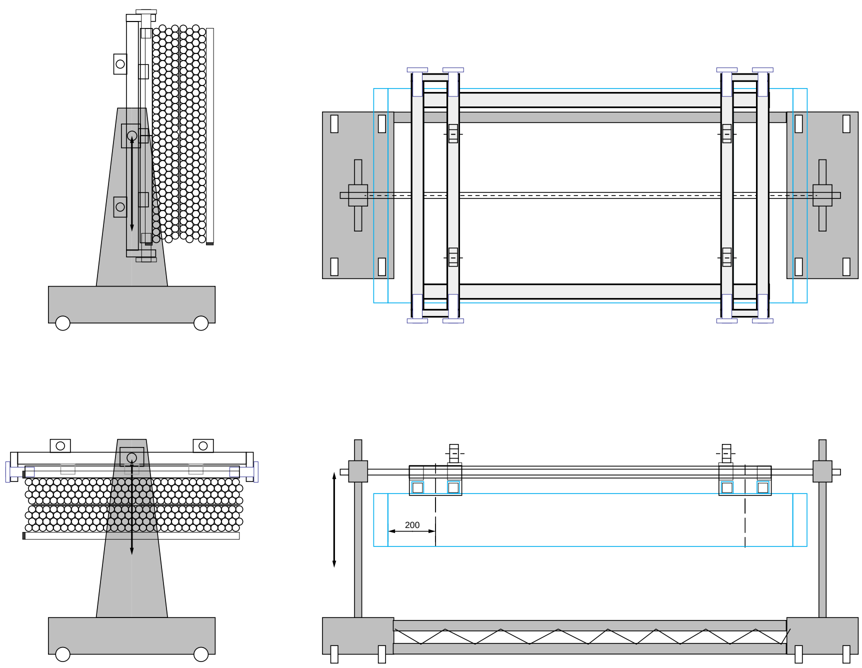

Figure 8: Sketch of the transport frame

A similar pick-up frame could also be used for long-distance transport; the frame being connected to the transport box.

The chambers will be stored vertically standing on the floor with the tubes parallel to the floor. For this purpose 10 mm thick rubber pads are glued to the ends of the gas manifolds on one side of the chamber and the chamber is sitting on these pads, see Figure 9. Each of the pads and gas manifolds has to take a load of about 20 kg. The same pads will also prevent chambers from running into each other during their installation on the rails.

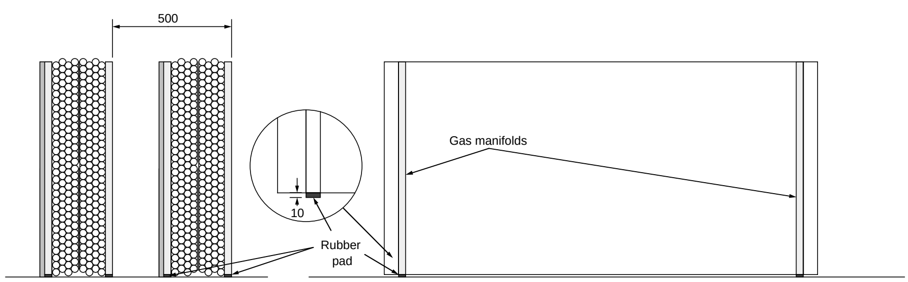

Figure 9: Sketch illustrating the storage of the BIS chambers