

Miniball Flexible Frame

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WARNING (8th July 2022): this documentation includes information on the mounting of the old cryostats in the frame. This has changed in 2022 with the new cryostats. The rest of the documentation should still be correct. The pink bracket in figure 8 is still the same, but the rest has changed.

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1 Overview

As Miniball was intended to be used for a wide variety of experiments, a flexible frame was designed.

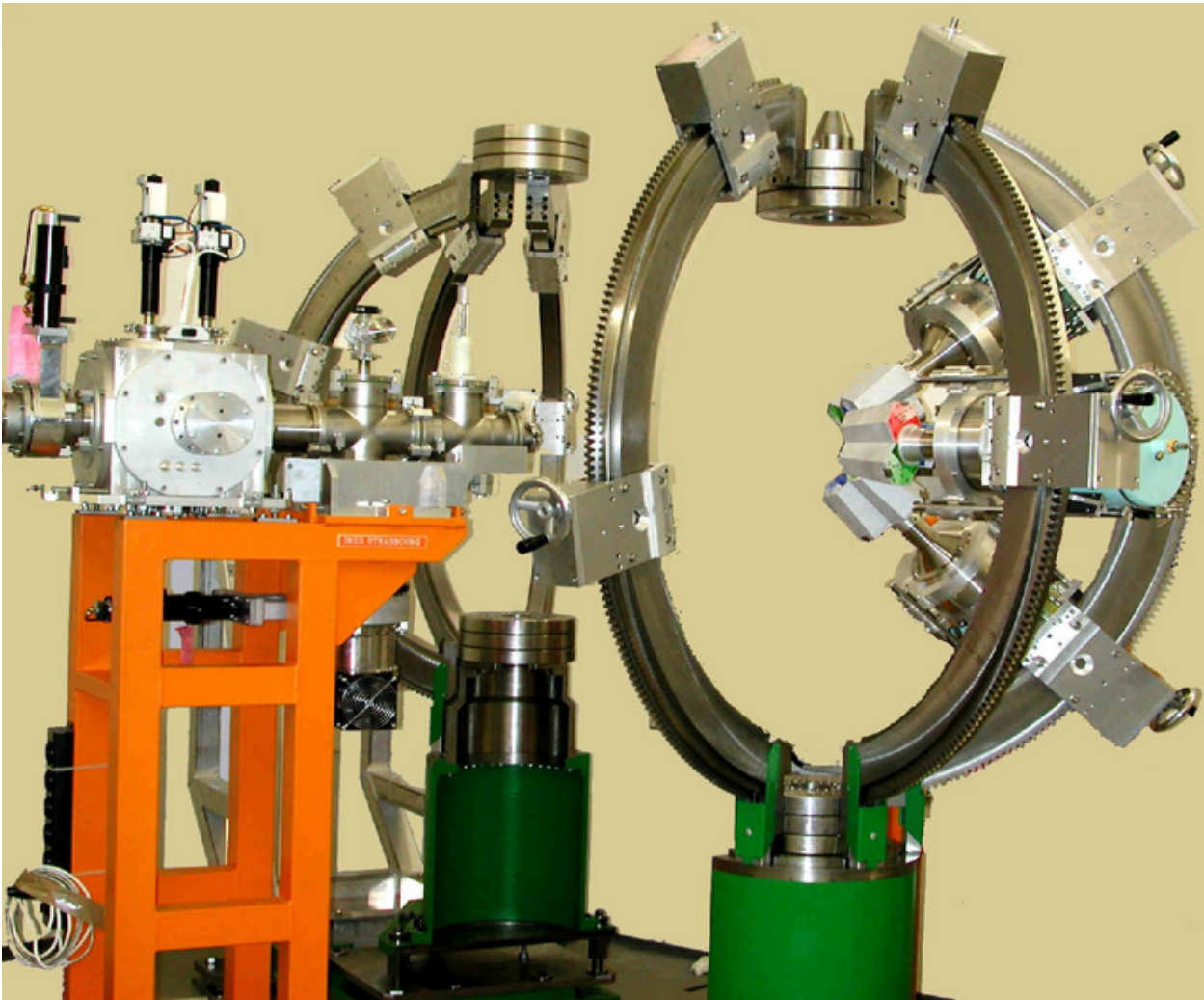


Figure 1: The Miniball flexible frame. The two halves are moved back to allow access to the target chamber (not shown). The orange upstream support has part of the beam line and a Leuven beam diagnostics box. The downstream part is not shown.

The frame consists of two halves (with the green base) which can move in and out, perpendicular to the beam direction, independently. There are three arcs on each side, each of which has two riders on. Detector mountings are bolted to the riders. The riders can move up and down along the arc, and the arcs can rotate about the vertical axis. See figure 1.

At the top and bottom, the arcs join to rings. The rings on one side are higher than the other, so the two rings go over each other when the frame is closed. Then, two centering cones are inserted: one at the top and one at the bottom. A slightly conical pin is inserted in the lower of each pair of rings and the corresponding opposite part through the hole. The two are then bolted together.

The orange support shown in figure 1 supports the target chamber, beam line and turbo pumps. There are two parts (only the upstream part is shown in the photo), which are not symmetric, as the downstream part slopes at the end.

Upstream, the beam line has two DN100 cross pieces. The first has a turbo pump (below) and a vacuum gauge (above). The second piece was for the start detector, but is no longer used. In the photo, there is also a Leuven diagnostic box, which was previously used at CERN, but will not be used for HIE-ISOLDE. There, it will be necessary to connect the DN100 flange of the Miniball beam line to the KF50 one of HIE-ISOLDE with a tube in place of this diagnostic box..

Downstream, there are also two DN100 cross pieces. The first was for the stop detector, but is no longer used. The second is for a turbo pump (below) and a vacuum gauge (above).

2 Modifications

2.1 Modifications to the height

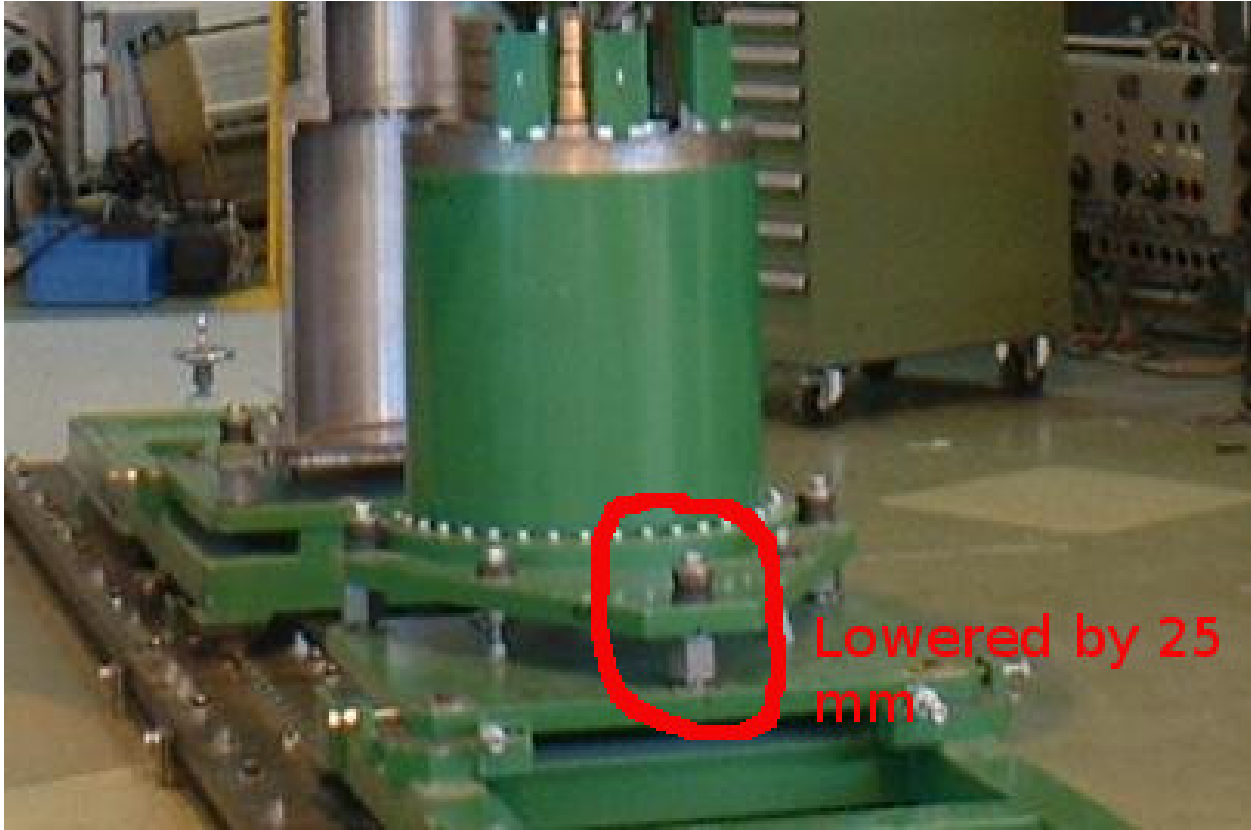


Figure 2: The modified height. The part supporting the weight has been changed and washers have been placed above, so the frame is lowered from 1750 mm (French standard) to 1725 mm (ISOLDE standard).

The original frame was built for a 1750 mm high beam-line, but the ISOLDE beam line is only 1725 mm. So a piece was modified to lower the frame by 25 mm (see figure 2). Note that there is also the possibility of mounting it so it is only 1260 mm high, but we have never used this.

The orange beam-line supports have bolts, which provide enough adjustment to lower by the necessary amount, so no modification was required.

2.2 Modifications to the winding mechanism

For some reason that nobody knows, the winding mechanism is not the same as on the CAD diagram. The screw is shorter and the eye pieces which hold the screw in place are different. Specifically, they have two screws, rather than the four shown on the CAD diagram.

2.3 Bridging the trench for HIE-ISOLDE

At HIE-ISOLDE, Miniball is mounted over a trench, which is uneven and should not take the weight of the instrument. To avoid this, five bridging pieces are placed over the trench and the lower part of the rail and the air-gap between the two rails removed. This gives the same height (see fig 3).

3 Frame adjustment

The frame is mounted on supports which slide on rails. The height can be adjusted by up to 10 mm using the very large bolts at the base.

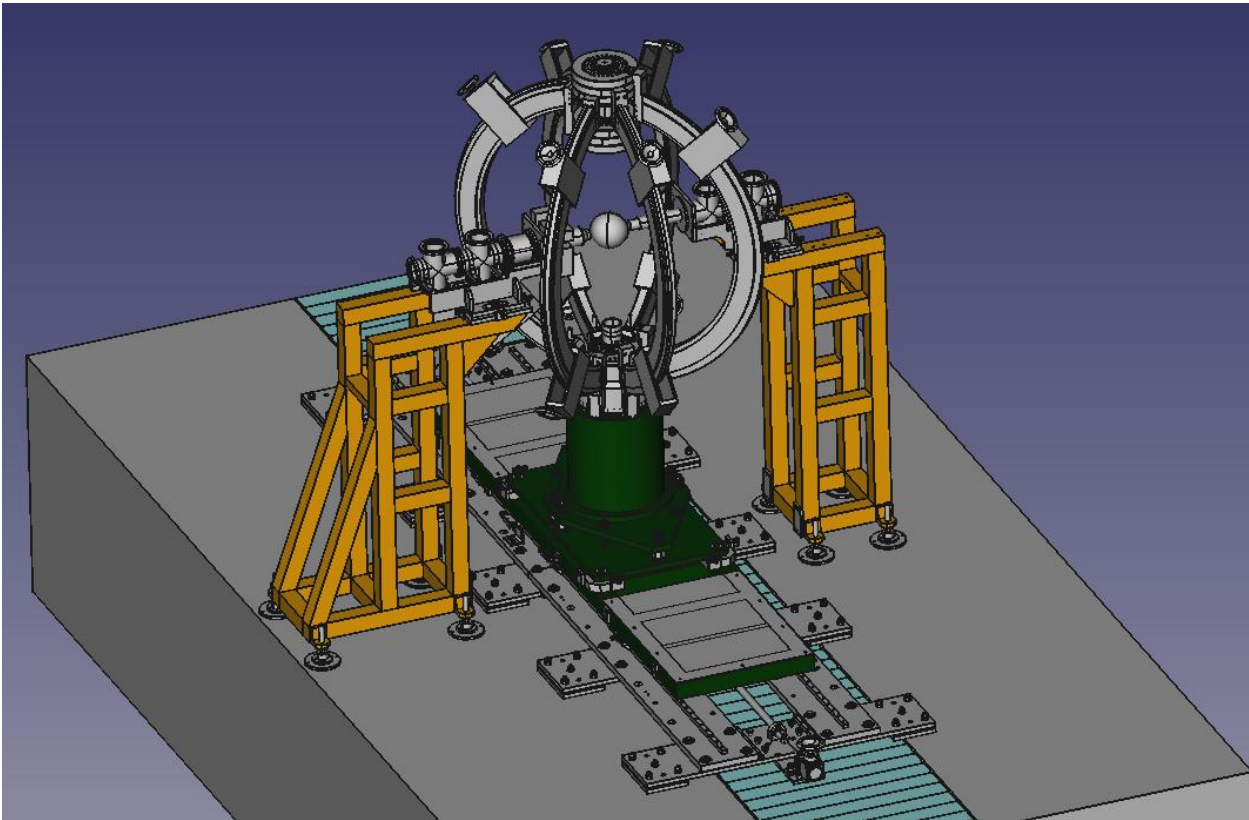


Figure 3: The Miniball flexible frame with bridging over the cable trench for HIE-ISOLDE. The beam goes from right to left.

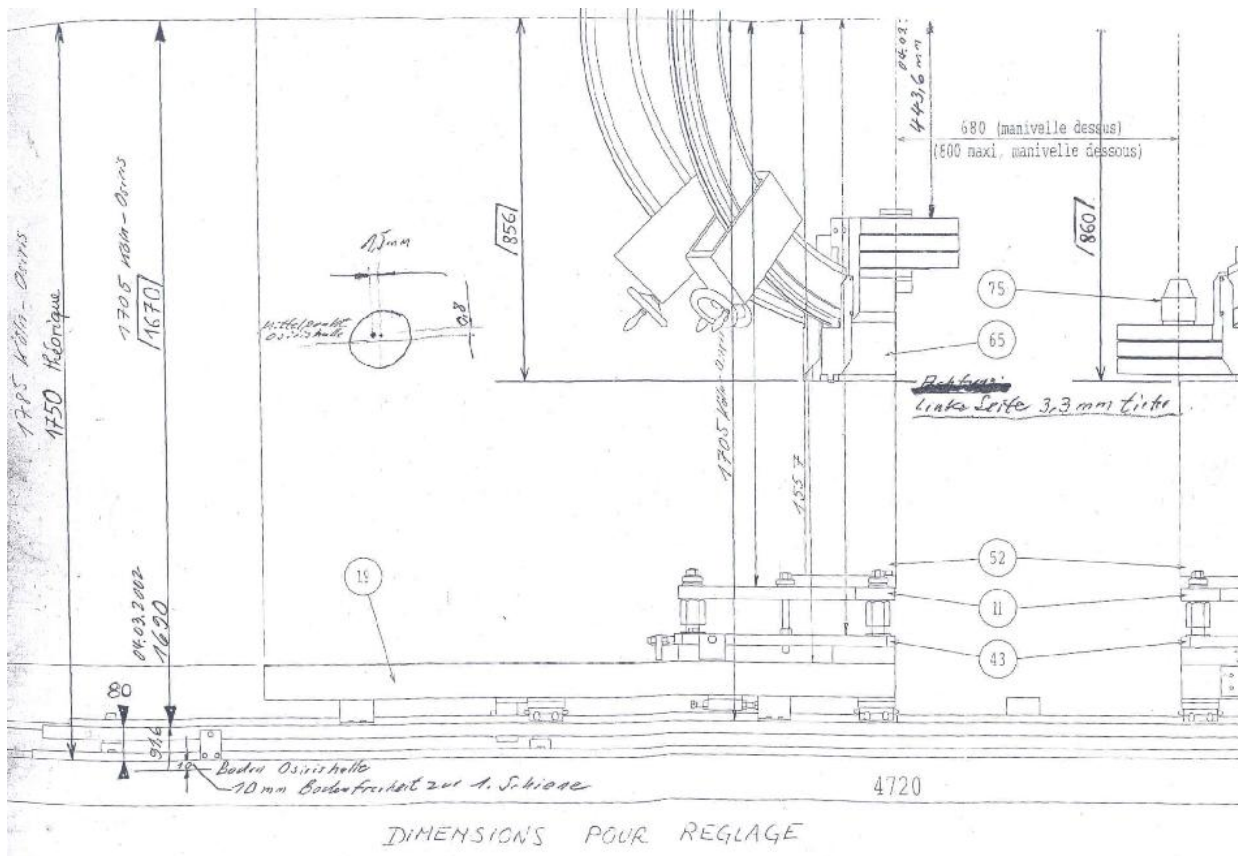


Figure 4: The adjustment of the frame

There is a centering pin marked 75 on the diagram on one side and a hole on the other side. When they are lined up, it is possible to slide a centering cone through the hole in the upper part so that it engages the pin

on the lower part. Note that the lower pin is missing in the photograph figure 1.

This same construction is repeated at the top (not shown on figure 4, but visible on the photograph figure 1).

Long screws with handles are used to move the two halves backwards and forwards.

4 Target-chamber bridge

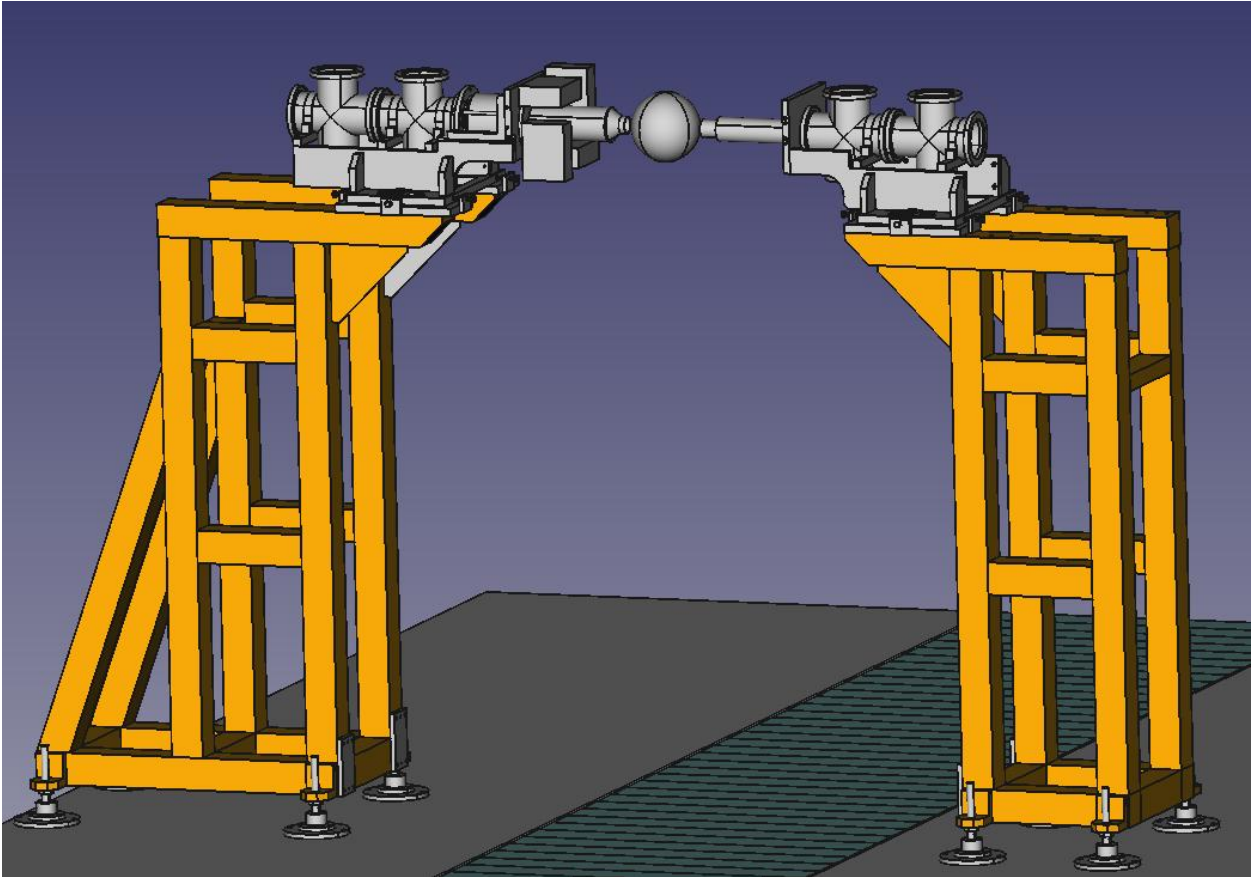


Figure 5: The target-chamber bridge, showing the orange support frame and the bridge with the target chamber. The beam goes from right to left.

Figure 5 shows the target chamber, the parts of the beam line connected to it and the orange support structure. In the original design the DN100 cross pieces of beam line nearest the target chamber were intended for the start/stop detectors. The other two are for the turbomolecular pumps and vacuum gauges. Note, however, that the start/stop detectors could not cope with the instantaneous rates and were never used.

Figure 6 shows the bolts, which have to be adjusted to align the beamline.

figure 7 shows how the bracket, which is part of the chamber (at the downstream end) sits on a rail. The upstream end has guiding pins and is connected first. As there is a bellow at the downstream end, there is some flexibility. Once the upstream end is fixed, the bracket is bolted to the rail. During this procedure, the side plates of the target chamber must be attached. Once the bracket is fixed, they can be removed.

5 Detector mounting

5.1 Mounting of detector support on frame

The detector support assembly is mounted onto the rider by four bolts (10 mm diameter, 25 mm length, M6 square cup) which go through the holes in the bracket and are screwed into the rider. They use the four inner positions and there is no thread on the bracket at this point. See figure 8, where the bracket is shown in pink.

Additionally, this bracket has four screws for bolts (10 mm diameter, 20 mm length, M6 square cup) which are used to align. They are screwed into the four outer positions of the bracket (there is a thread in the

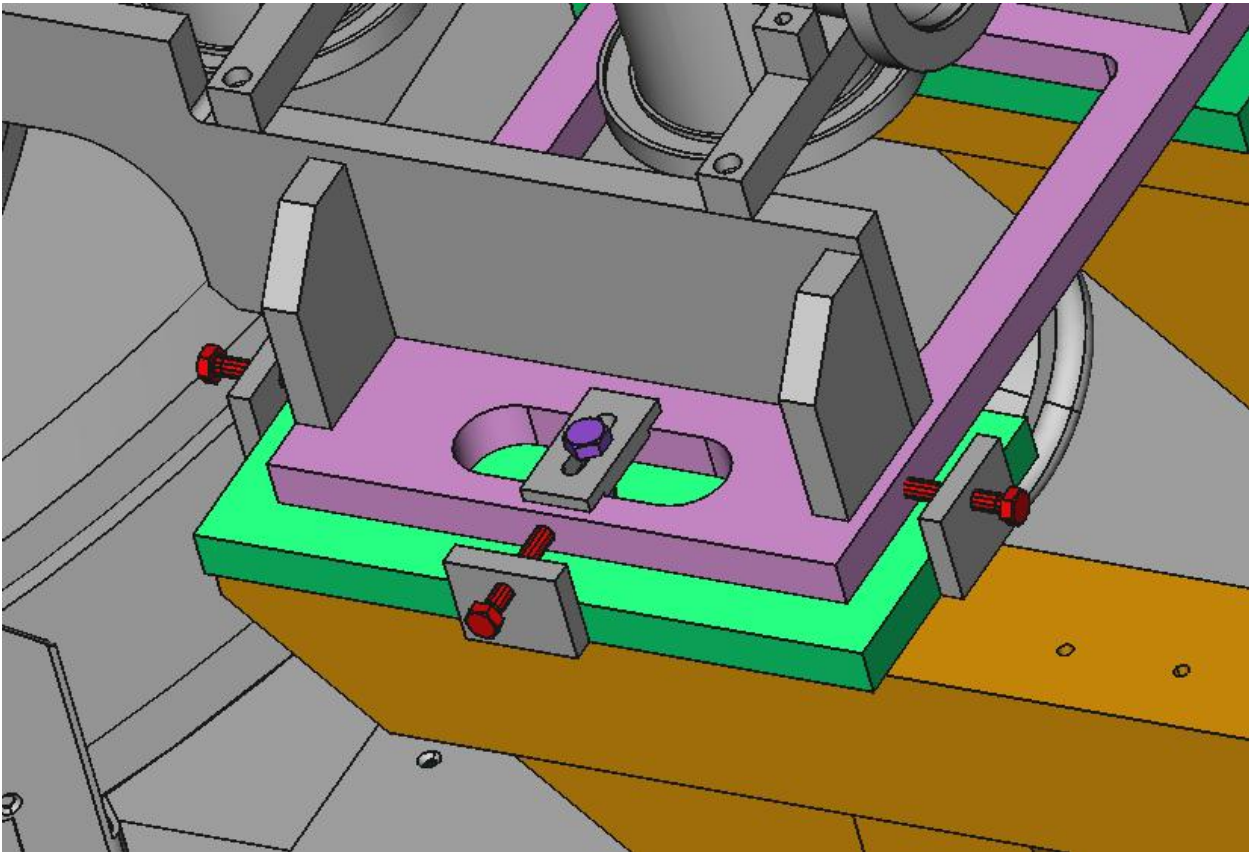


Figure 6: The bolts for aligning the beamline. The pink part slides over the green part. The purple bolt is for locking and the red ones for adjusting.

bracket there) and they do not go into the rider, but press against it. By having the fixing bolts loose, and tightening the alignment bolts, it is possible to align the detector.

Two rods are attached to the bracket, each with four bolts (5 mm diameter, 25 mm length, M5 square cup).

5.2 Mounting of detector in support

In order to mount the detector, one of its handles must be detached on the side closest to the arm on which the support is mounted. The other is used to hold the detector.

The detector ring is bolted onto the detector with four bolts (10 mm diameter, 15 mm length, M8 square cut and a specially short 7 mm head, so they fit properly). This inner ring has three pieces of teflon attached to it. One around the outer edge, and one on each side where it will make contact with the front and back rings. You have to remove one of these in order to get the bolts in, which fix the ring to the detector. The ring fixed to the detector is shown in blue on figure 10. Note, that the back plate of the ring (green in figure 10 has to be put in place, before the blue part is fixed to the detector, but it is not screwed down at this stage. It can move about the preamplifier housing, but cannot come off.

The detector ring, with the detector attached, is inserted into the front ring (pink on figure 10 - note that the pink ring is part of the detector support mounted on the frame). Since the head of the detector is wider than the hole, the neck of the detector is brought sideways through the slot in the ring. Once the detector ring is inserted into the front ring, a back ring is put in and screwed onto the front ring. In this way, the detector ring (blue) is sandwiched between the front ring (pink) and the back ring (green).

The front ring and the brass braking rings are mounted onto the rods. They can slide up and down, but both have screws to lock them into position. We always mount a brass ring on each rod for detectors which are pointing downwards, but only one for those pointing upwards. The brass rings are much better brakes than the ones built into the detector holder assembly and were added by Cologne as an afterthought.

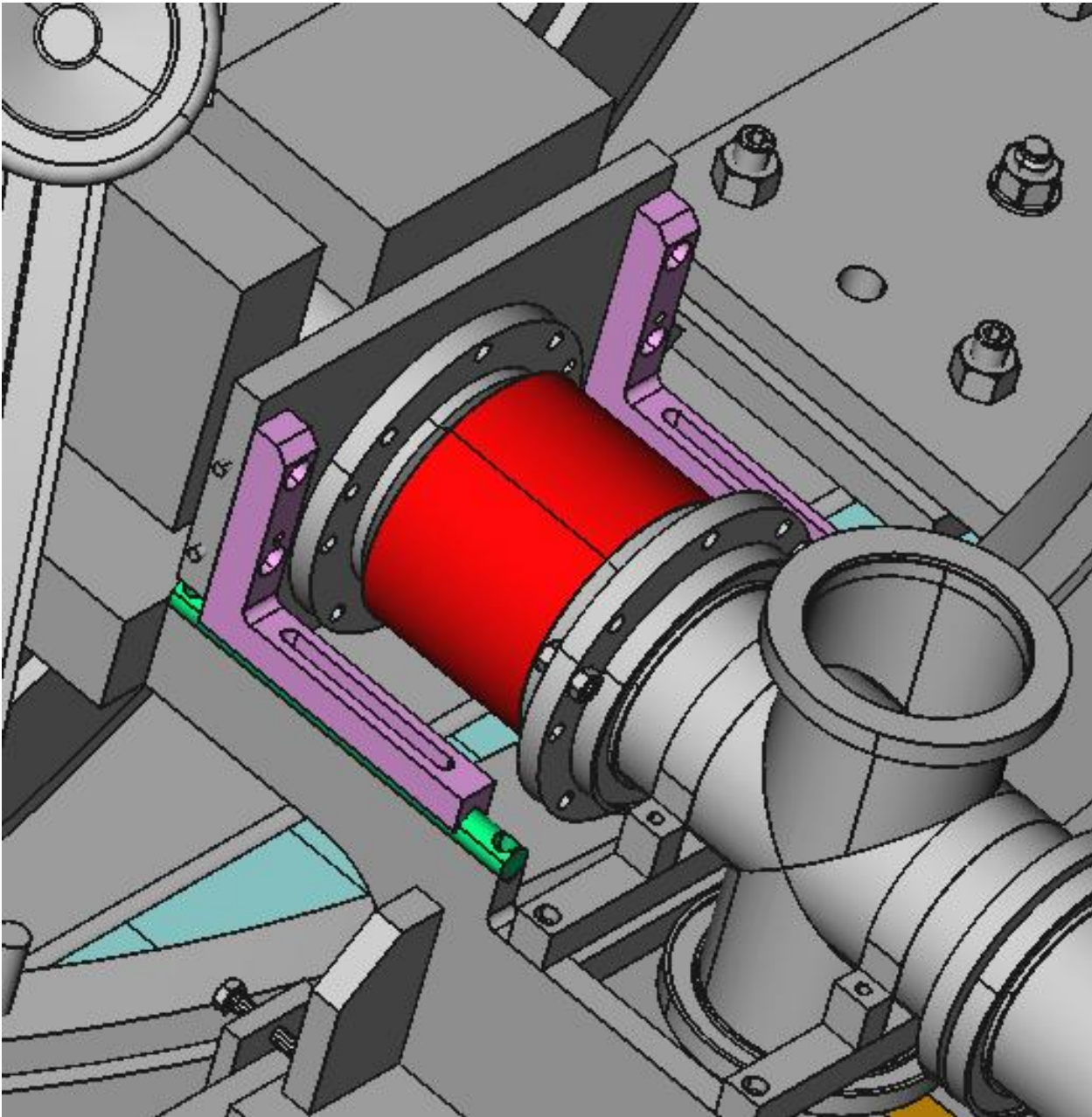


Figure 7: The pink bracket is attached to the downstream end of the target chamber. It sits on the green rail. The red piece is a bellows. Before removing the side plates of the target chamber, the pink part **must** be bolted to the green part.

6 The new detector ring mountings

The original system had the detector rings mounted on two rods, allowing them to slide in and out. A braking system made it possible to lock them in a given position. This proved to be rather hard to manipulate, so they were modified. The new system has a screw thread which can be wound with a handle, to move the detectors in and out precisely.

7 Aligning the detector rings

First dismount the target chamber and the beam dump and keep GV2 open by unplugging the D-sub connectors at the back of the TPG262 gauges and connecting pins 3 and 4 together with a jumper (the one for the beam dump only has these two pins, so you can't go wrong. The other one has these two for the beam line and pins 7 and 8 for the PPAC.) Then you can operate the valve with the buttons on the control system even though both sides are above the normal threshold¹.

¹See elog:12230 and figure 17 for more details.

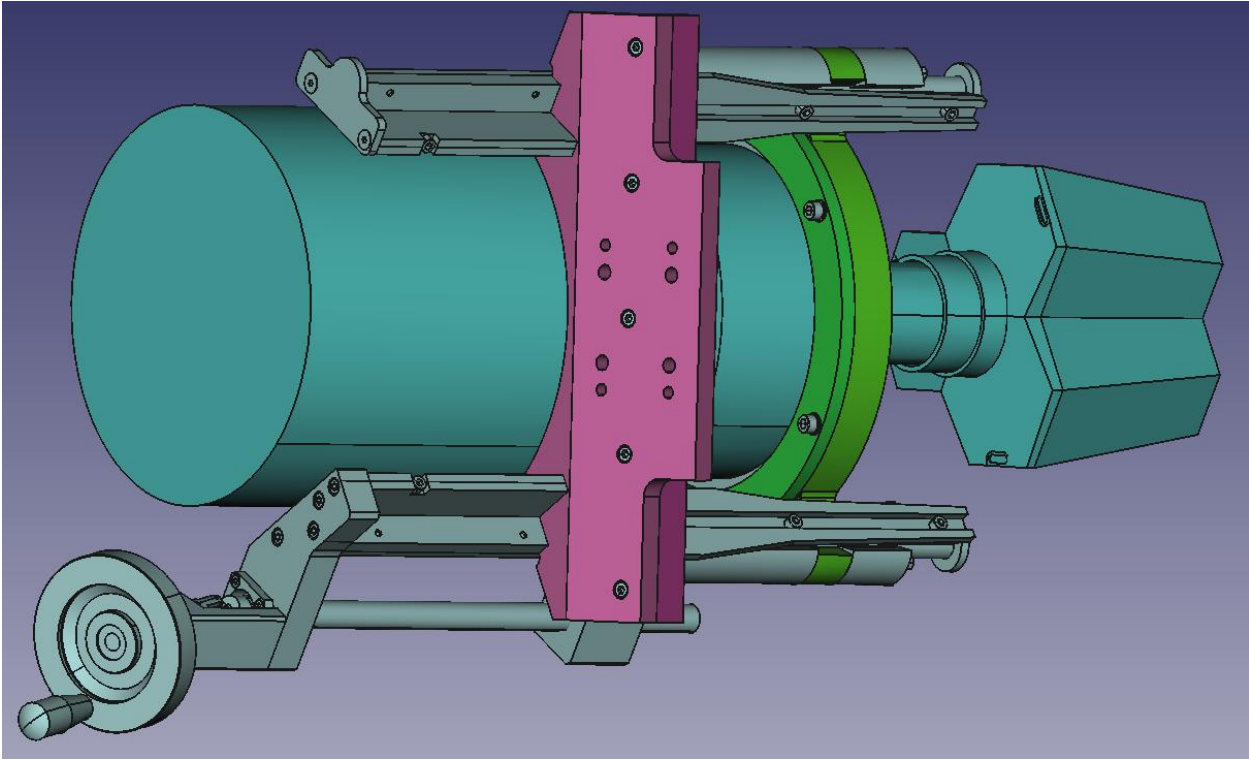


Figure 8: The detector with its mounting. The pink bracket is mounted onto the rider. The bracket has 8 holes: the outer four are threaded and are for alignment, while the inner four are not threaded and used to fix the bracket to the rider. The detector is mounted in the green ring. **WARNING: this is obsolete - the pink bracket is the same but the rest has changed.**

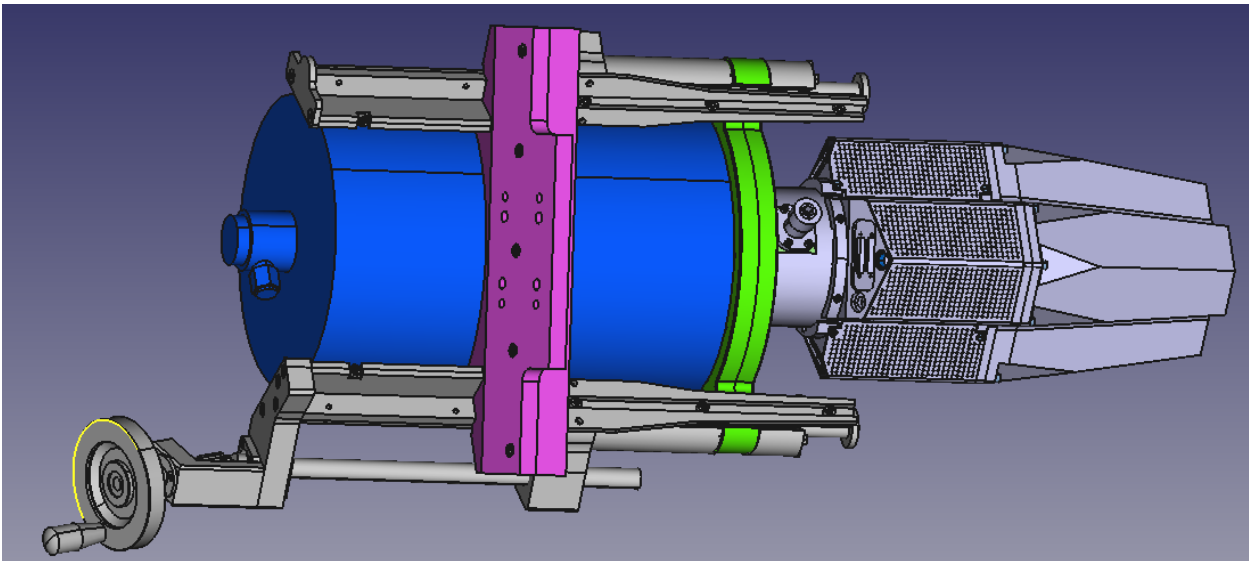


Figure 9: The new cryostat with its mounting. The pink bracket is mounted onto the rider, as before. The bracket has 8 holes: the outer four are threaded and are for alignment, while the inner four are not threaded and used to fix the bracket to the rider. This is unchanged, but a piece has been added to make it stiffer (also in pink). The green ring is now part of the detector.

To align the detector rings, first set up the theodolite and hang a plumb line, so that there is a clear reference point for the target position.

Then mount the special insert, which has the same diameter as a detector and a small hole in the middle. It is mounted in the same way as a detector into the holding rings. It is then possible to insert a rod with a sharp tip through the hole.

Adjust the rod and the bolts until the pointed tip of the rod is exactly at the target position and then tighten it so it can't move any more. To do this, remember there are four longer bolts (25 mm) in the middle four

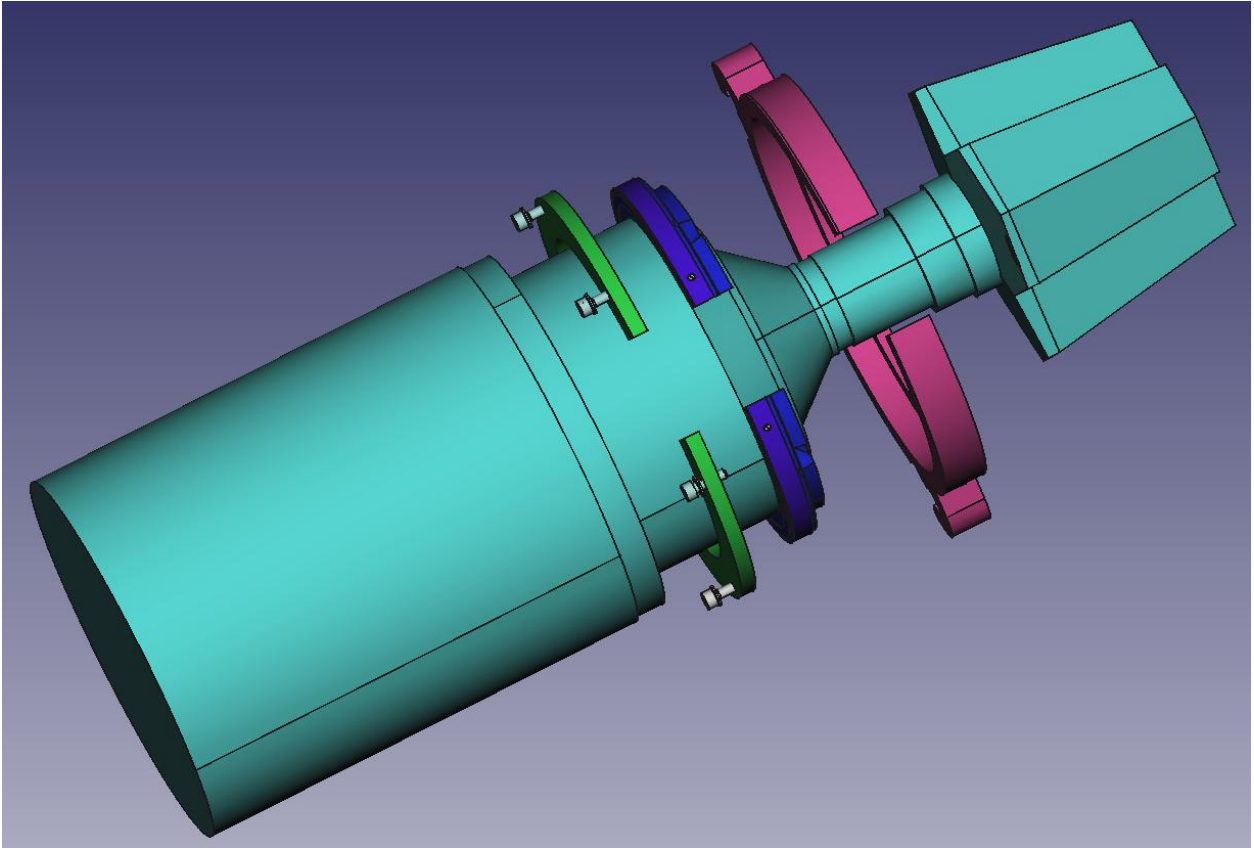


Figure 10: The blue ring is fixed to the detector after the green ring has been placed behind it, but not fixed. The pink ring is part of the holding structure. The blue part is inserted in the pink part and the green part is then screwed onto the pink part, so the blue part is held sandwiched between them. As its surfaces have teflon rings, which are smooth, the blue part and the detector can rotate about the detector's axis. The neck of the detector fits through the slot in the pink ring. **WARNING: this is obsolete.**

holes to bolt the assembly to the rider and four shorter ones (20 mm) in the four corners which are used to adjust.

8 Measuring the angles

Three angles describe the orientation of the Miniball clusters. The polar angles θ and ϕ give the orientation of the central axis of the cluster with respect to the beam direction, while the rotation angle α gives the orientation of the capsules about the axis of the cluster.

8.1 Theta

θ is the angle of the detector in the horizontal plane with respect to the beam direction, such that $\theta = 0^\circ$ corresponds to the beam direction and $0^\circ \leq \theta < 180^\circ$.

There is no easy way to read off the value of θ for the detector, but there is a scale on the frame to give the **angle of the arm**, θ_{arm} . Note, however, that for reasons best known to IRES (Strasbourg), they made the scale such that the beam direction is 90° . The error reading the scale is typically about $\pm 0.2^\circ$.

The magnitude of the offset between the detector and the arm varies a bit depending on the alignment bolts. It is between about 18° and 25° . It is nominally given as 17° , but I think this is only the case if the bolts are screwed right down and then the detector axis isn't lined up with the target position.

So there are two corrections which need to be made going from the value on the scale θ_{arm} to the angle of the detector, θ :

- Add 90° to correct the beam direction to 0° .
- Add or subtract the offset between the detector and the arm, as appropriate. Typically a mean value of 21.5° (i.e. half way between 18° and 25°) has been used.

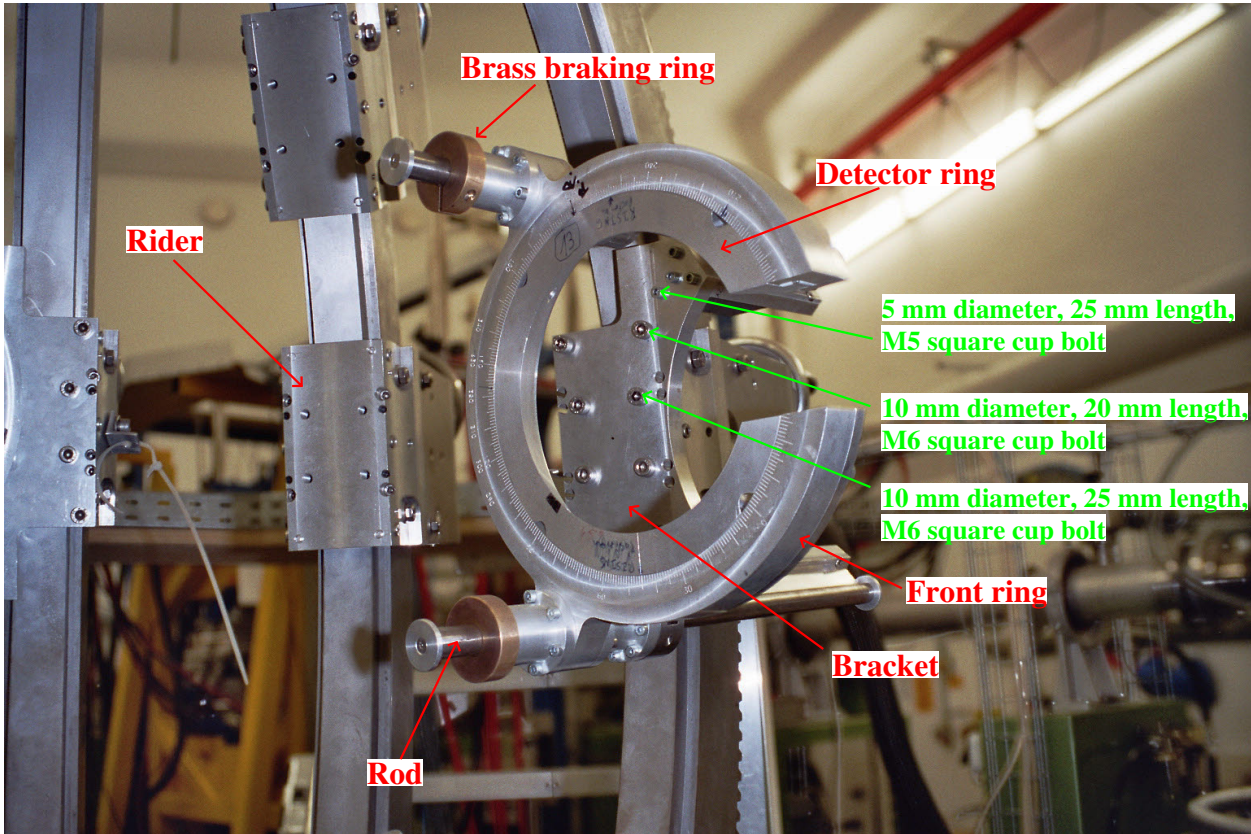


Figure 11: The detector mounting assembly. This is the old version with the braking rings and without the screw to wind the detector in and out. The detector ring and bracket are, however, the same.

- Add or subtract multiples of 180° to bring θ into the required range of 0 to 180° .

8.1.1 Example (September 2003)

Read value for YELLOW cluster $\theta_{arm} = 24.7^\circ$ (on scale)

Transformation to value needed for config-file: $\theta = 90^\circ + 24.7^\circ + 21.5^\circ = 136.2^\circ$

Explanation: - YELLOW cluster is in backward beam direction, so 90° have to be added to get the absolute value of theta and a further 21.5° for the offset between the detector and the arm.

8.2 Phi

ϕ is the angle around the beam axis in a vertical plane, with $0^\circ \leq \phi < 360^\circ$, such that zero degrees is vertically upwards and 180° is vertically downwards. Values below 180° are to the right with respect to the beam and those above 180° are to the left.

The values are given by the scale on the arcs, but have to be transformed, because for some reason, the IRES group has made 0° horizontal and has no distinction between left and right. The error on the scale is about $\pm 0.2^\circ$.

Furthermore, the old frame only had a scale on one side, so it was not possible to read the value for the ϕ of the detector, if the detector was on the side where the scale was, as it made it impossible to see the scale. Instead, we measure at the bottom edge of the holding plate, which is 6.75° less than the detector position. If we do this, we have to add the 6.75° to ϕ . Note that for the new frame, this isn't necessary, because it has a scale on each side.

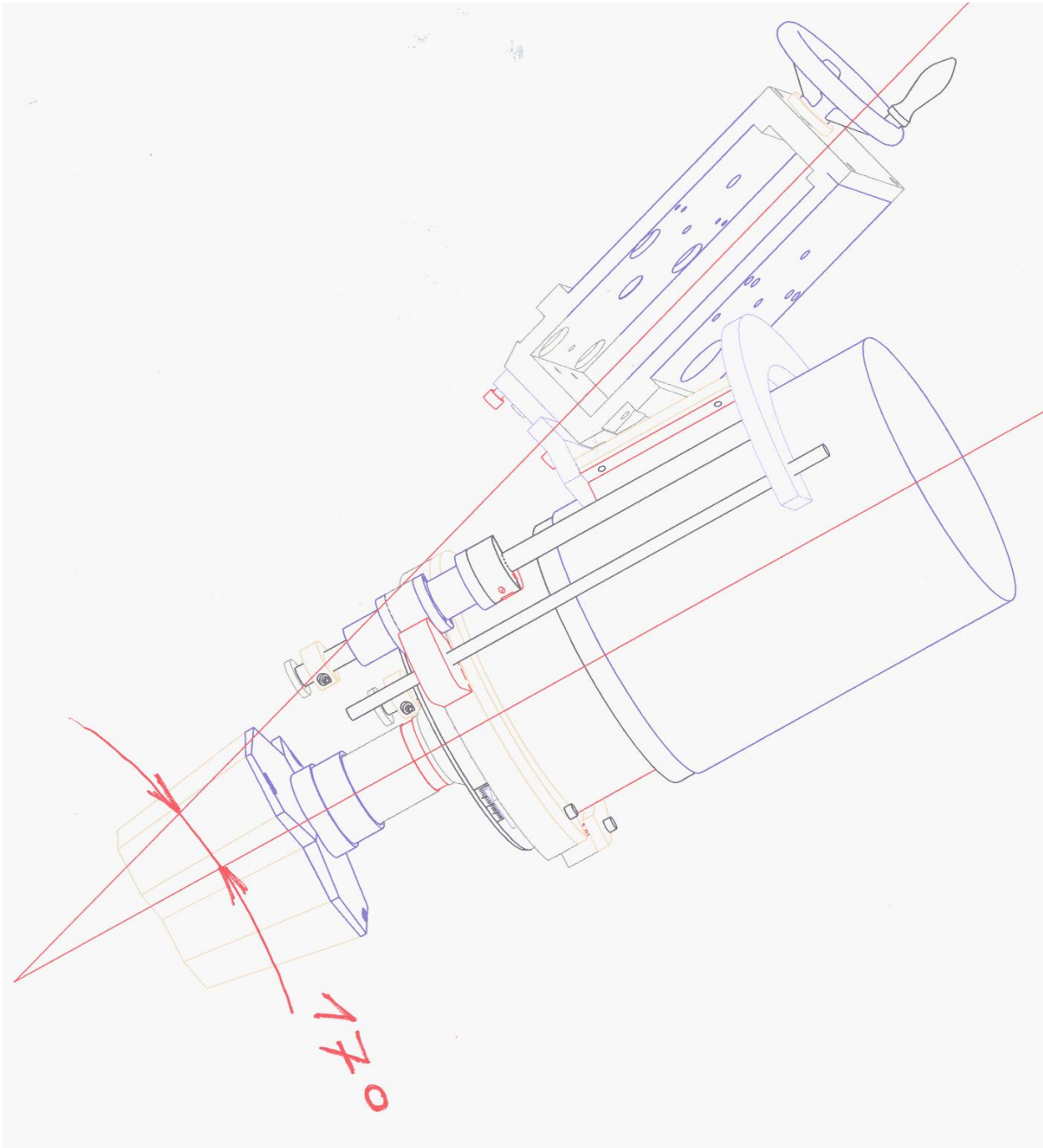


Figure 12: Technical diagram of assembly with detector

ϕ range	description
$\phi = 0^\circ$	vertically upwards
$0^\circ < \phi < 90^\circ$	top right
$\phi = 90^\circ$	horizontal to the right
$90^\circ < \phi < 180^\circ$	bottom right
$\phi = 180^\circ$	vertically downwards
$180^\circ < \phi < 270^\circ$	bottom left
$\phi = 270^\circ$	horizontal to the left
$270^\circ < \phi < 360^\circ$	top left

Using this table and the value from the scale, it is possible to figure out what multiple of 90° to add or subtract in order to get the correct angle.

8.2.1 Example (september 2003)

The yellow cluster was mounted in the top left quadrant, so we need a value of ϕ between 270° and 360° .

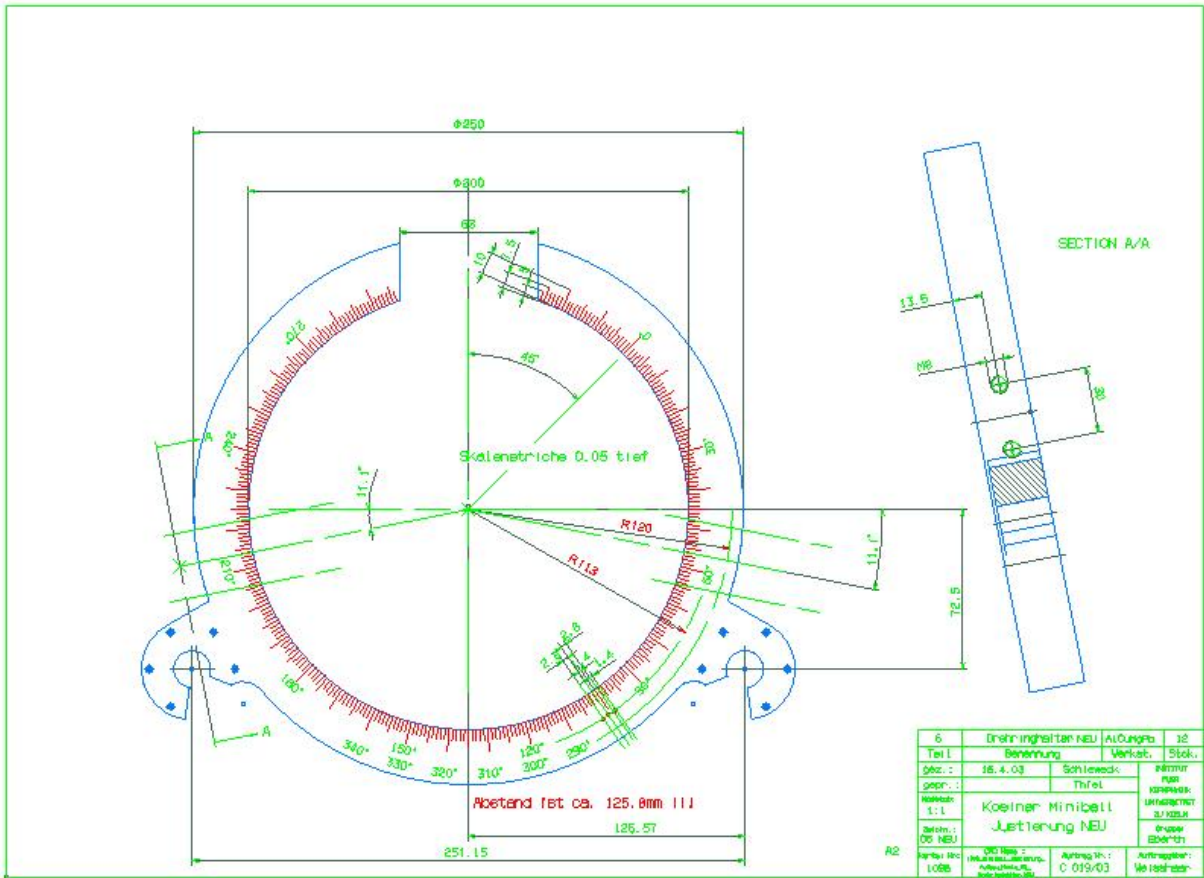
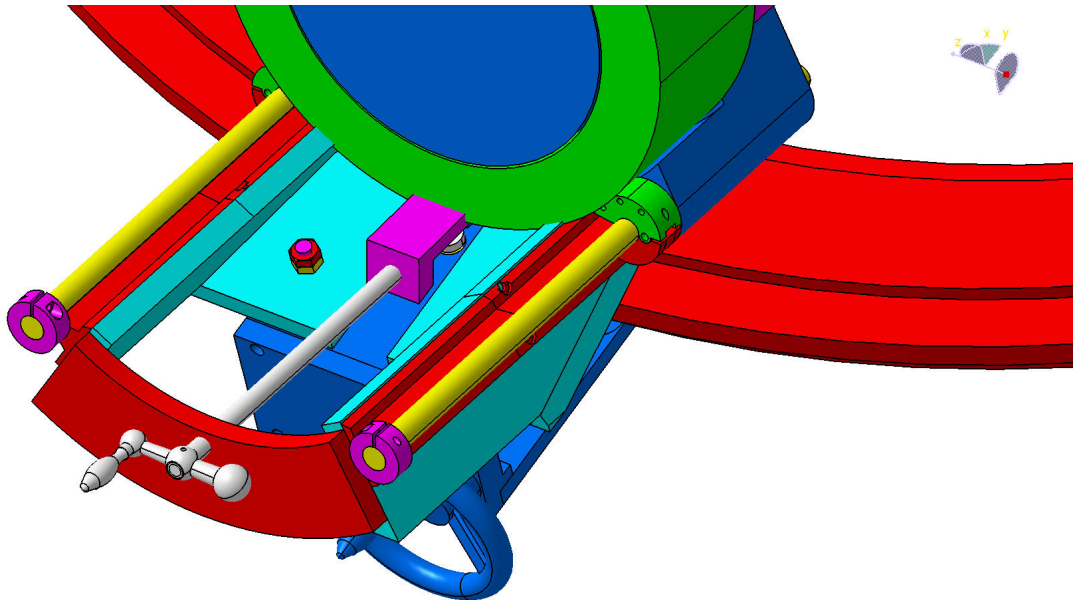


Figure 13: Technical diagram of ring mounting ring



zxy

Figure 14: The new detector mounting, with a threaded screw and a handle to wind the detector in and out.

Read value for the bottom edge of the holding plate for the YELLOW cluster: $\phi_{plate} = 27.8^\circ$ (on scale)

Transformation to value needed for config-file: $\phi = 270^\circ + 27.8^\circ + 6.75^\circ = 304.6^\circ$

Explanation: - YELLOW was located in the quadrant "top left", so a value of $+270^\circ$ has to be added to



Figure 15: Alignment: the tip of the brass “plumb” bob was aligned to the target position. The tip of the metal spike mounted in a detector ring was then aligned to this.

read value - the ϕ value was read at the lower side of the holding plate, and the ϕ range of this holding plate is 13.5° , and the ϕ value of the cluster is in the middle, so $13.5^\circ / 2 = 6.75^\circ$ has to be added.

8.3 Alpha

α is the angle of rotation of the cryostat about its own axis with:

$$\begin{aligned} \alpha &= 0^\circ && \text{(segment A3 pointing upwards)} \\ &240^\circ && \text{(segment B3 pointing upwards)} \\ &120^\circ && \text{(segment C3 pointing upwards)} \end{aligned}$$

There is a scale on the detector ring which is fixed to the frame and a marker on the inner ring which is fixed to the detector. However, the scale is only a relative one, so it needs to be calibrated. To do this, we set the detector *horizontally* ($\phi = 90^\circ$ or 270°) in a well-defined orientation (i.e. 0° , 120° or 240°) using the spirit level and read off the value of the marker.

The following formula converts the read α_{rel} angle of the markers to absolute α values:

$$\alpha = \alpha_{rel} - [\text{marker_value} - \text{marker_value_at_calibration}],$$

Note, however, that the detector is intended to be considered from behind, but the scale is at the front. This means that if we start, for example, with C3 pointing upwards at a scale mark of 211° , which corresponds to $\alpha = 120^\circ$ and we rotate 120° clockwise, as viewed from the front of the detector, the scale on the detector holder increases to 311° , but we rotate so that A3 is now pointing upwards, so α is now 0° . In other words, an increasing scale value corresponds to a *decreasing* value of α . So we must always subtract.

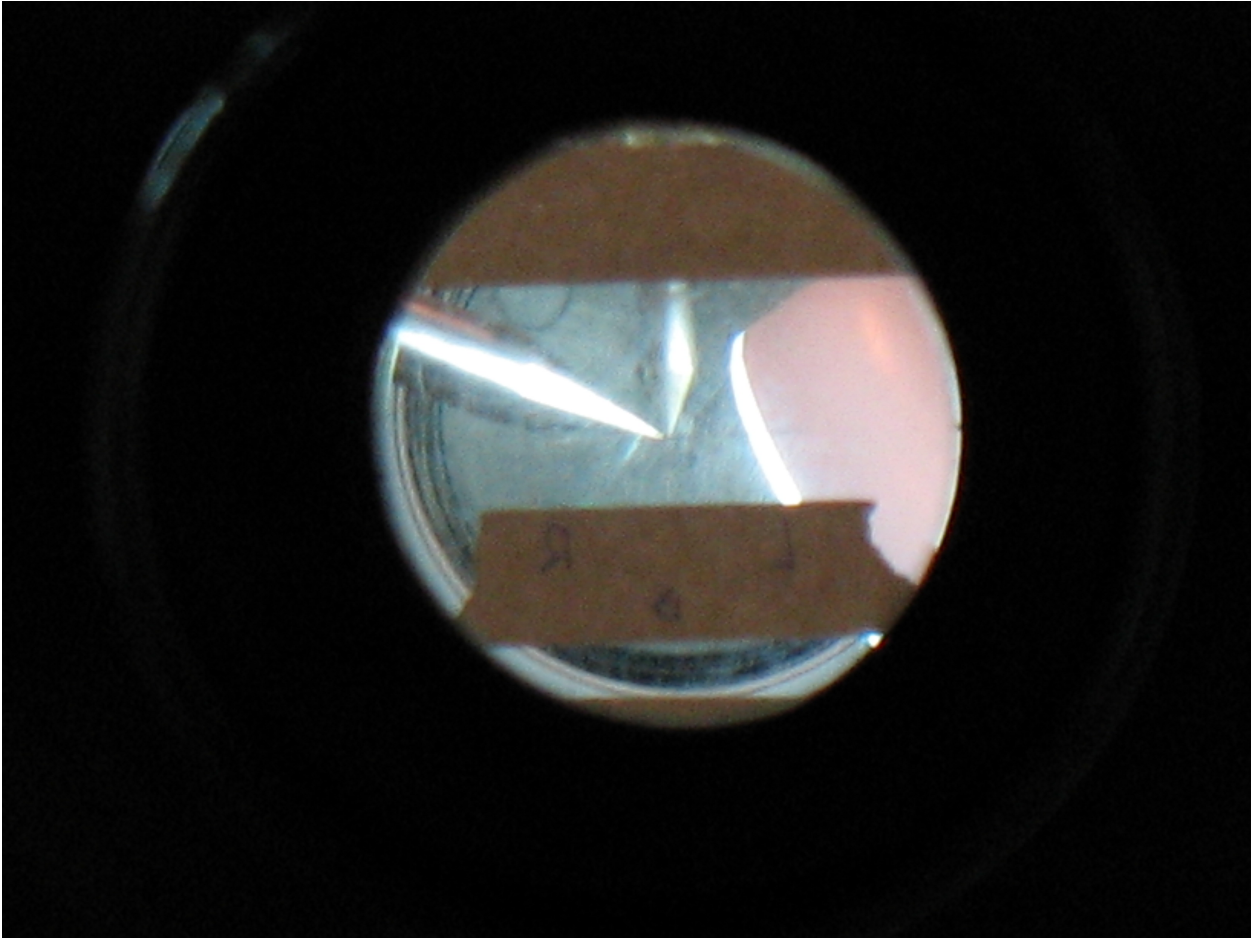


Figure 16: Alignment: View through the beam line (with the beam dump removed and GV2 open).

8.3.1 Example (september 2003)

Dirk Weißhaar mounted the YELLOW cluster with $\phi = 0^\circ$ and set C3 pointing upwards using the spirit level. He recorded in the logbook (elog:211) that in this position, the scale marking was 211° .

During the experiment, the scale marking for the YELLOW cluster was at 275° .

Transformation to value needed for config-file: $120^\circ - 275^\circ + 211^\circ = 56.0^\circ$

Explanation: looking from the front of the detector, we have rotated clockwise from 211° to 275° (i.e. a clockwise rotation of $+64^\circ$) compared to Dirk's calibration. In doing so, we are rotating from C3 upwards towards A3 upwards, so α is rotating from 120° towards 0° , which means that we have to *subtract* 64° from the calibration point of 120° , giving us 56° .

Important:

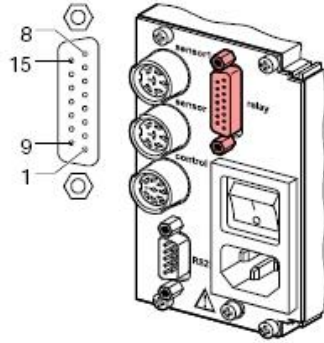
i) there is a blue marker and an engraved notch on the scale which are exactly opposite to each other ($+180$ deg.). So it has to be taken care at which marker the value is read.

ii) if the α value given by the above formula is $< 0^\circ$, then one can just add $+360^\circ$ to get a value $0^\circ \leq \alpha < 360^\circ$.

8.4 Complete example - September 2003

Read values from the MINIBALL hardware frame: (see elog:1435)

Pin assignment of the female 15-pole D-Sub appliance connector:



Pin	Signal
4	Switching function 1 SP1
3	
2	
7	Switching function 2 SP2
6	
5	
11	Switching function 3 SP3
10	
9	
14	Switching function 4 SP4
13	
12	
15	Supply for relays with higher switching power Fuse-protected at 300 mA with PTC element, self-resetting after power off or pulling the <i>relay</i> connector. Meets the requirements of a grounded protective extra low voltage (SELV-E according to EN 61010).
1	+24 VDC, 200 mA
8	GND

Figure 17: Information from manual of TPG262 gauge (page 22), showing the meaning of the relay pins. If the vacuum is good, the gauge connects pins 3 and 4 for set point 1 or 6 and 7 for set point 2. This connects to the interlock, which will only open the GV2 valve, if pins 3 and 4 are connected. So, to fake good vacuum, we disconnect the gauge completely and jumper the pins 3 and 4 on the cable-side of the connector. The interlock then thinks the vacuum is good and lets us open the GV2 valve.

Cluster	Number	θ_{arm}	ϕ_{plate}	α_{blue}	$\alpha_{opposite}$	POS
YELLOW	12	24.7	27.8	275.0	-	BLU
GREEN	22	24.7	41.2	-	235.1	BLD
BLUE	18	60.7	27.4	-	171.5	FLU
ORANGE	17	60.7	42.4	74.0	-	FLD
WHITE	14	58.8	26.2	124.0	-	FRU
BROWN	16	58.8	43.3	195.7	-	FRD
RED	13	22.3	27.9	-	293.9	BRU
VIOLET	23	22.3	41.7	356.7	-	BRD

θ_{arm} is the angle of the arm as read from the scale at the base of the frame.

ϕ_{plate} is the angle of the lower edge of the detector mounting plate as read from the scale on the arc.

α_{blue} is the angle of the blue marker on the detector ring measured on the scale of the detector holder.

$\alpha_{opposite}$ is the angle of the marker opposite the blue marker on the detector ring measured on the scale of the detector holder.

POS means position in MB frame with respect to the beam direction:

- B: backwards F: forwards
- L: left R: right
- U: up D: down

Transformed values for offline analysis:

Cluster	Theta	Phi	Alpha
YELLOW	136.2 (=90+24.7+21.5)	304.6 (=270+27.8+13.5/2)	56.0 (=120-(275-211))
GREEN	136.2 (=90+24.7+21.5)	235.6 (=180+90-(41.2-13.5/2))	305.9 (=240-((235.1-180)-121))
BLUE	39.2 (=60.7-21.5)	304.2 (=270+27.4+13.5/2)	99.0 (=120-(171.5-150.5))
ORANGE	39.2 (=60.7-21.5)	234.4 (=180+90-(42.4-13.5/2))	286.5 (=240-(74-120.5))
WHITE	37.3 (=58.8-21.5)	57.1 (=90-(26.2+13.5/2))	146.0 (=120-(124-150))
BROWN	37.3 (=58.8-21.5)	126.6 (=90+(43.3-13.5/2))	73.3 (=120-(195.7-149))
RED	133.8 (=90+22.3+21.5)	55.4 (=90-(27.9+13.5/2))	65.1 (=0-(293.9-359))
VIOLET	133.8 (=90+22.3+21.5)	125.0 (=90+(41.7-13.5/2))	183.3 (=120-(356.7-60)+360)