PS Module Assembly Scheme

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Abstract

In this report a design study for an assembly system for Pixel Strip (PS) Modules is presented. The modules will be part of the CMS Tracker for HL-LHC. The purpose of this study is to figure out what are the individual steps in the assembly procedure, to realize a possible semi-automatic system for assembly and to understand the machine requirements in order to find a valid manufacturing supplier.

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1. HL-CMS Tracker description

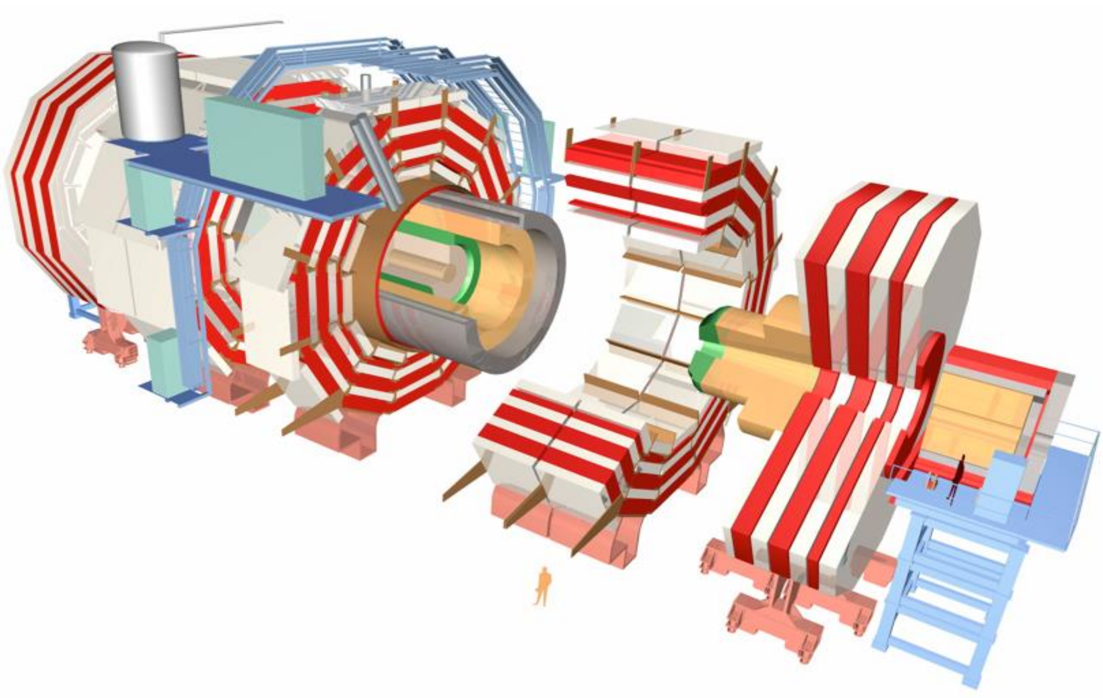


Fig. 1: The actual CMS Detector

In 2024 the CMS Tracker will be upgraded in order to improve its characteristics. The most important features will be:

- Higher granularity - more than 200 collisions per bunch crossing are expected and therefore modules will have shorter strips in order to keep a low occupancythat . It means that there will be much more data per event, so the need to be selective is really important.
- Improve of tracking performance - the strip pitch will be lower in order to increase resolution for high momentum particles and there will be a reduction of the amount of material, to improve the resolution for low momentum particles.
- Higher radiation tolerance - it has to tolerate 3000 fb^{-1} so sensors will be made of radiation hard materials. That has to been cooled to -20°C.
- Using Tracker information in the level 1 trigger - with higher luminosity the event data rate will increase. Although the level-1 trigger transfer data will be increase to 750Hz, to not increase theresholds (which would reduce physics performance), there is the need to include tracker information in the level-1 trigger decision (Fig.3, Fig.4).

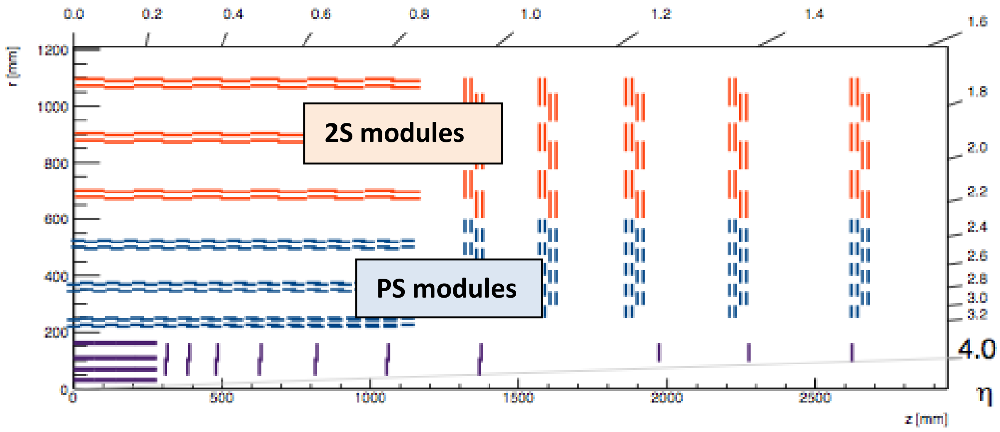


Fig. 2: Tracker layout

The tracker will be composed by two different kind of modules: Strip-Strip (2S) and Pixel-Strip (PS) Modules (Fig. 2). As their names say, the first one are made by two strip sensors, and they will be placed in the outer part of the tracker; and the second ones by one pixel sensor and one strip sensor, and they'll be in the inner part.

The main features of these modules is that they are able to distinguish high momentum particles from the low momentum ones (comparing signals from the two sensors) and so they can select which signals are consistents and which ones're not. The need of this behaviour is that with high luminosity the amount of tracks will be too huge, and the signal transmission rate isn't able to collect all the datas it would have otherwise

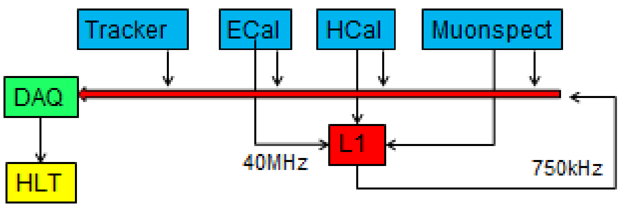


Fig. 3: Actual Tracker working scheme

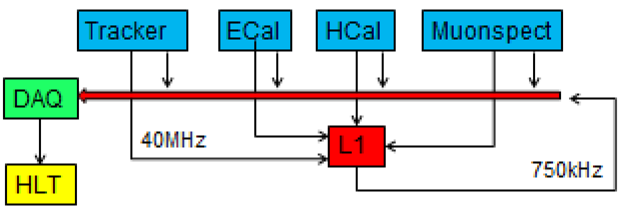


Fig. 4: Future Tracker working scheme

2. PS Module description

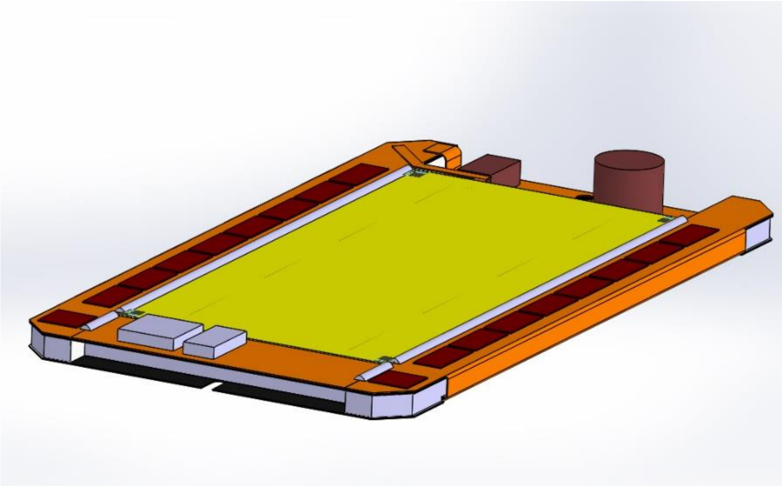


Fig. 5: PS Module

The main feature of the PS Module (Fig.5) is its capability to perform an on-module momentum measurement. It is able to do this thanks to the presence of the two sensors. Indeed it is able to understand which signals are linked to the passage of a high momentum particle through it. When a particle is surrounded by a magnetic field, it bends its trajectory more and more the less its momentum is. Bending of particles in magnetic field results in a sizeable shift already at short distances. So each particle cross the two sensors, and if it's a high momentum particle it will cross the sensors as shown in Fig.6 (the yellow marked trajectory). Otherwise, if the particle is a low momentum one, it will bend more its trajectory and so it will cross the sensor in two points that are not one over the other (Fig.6-right). Therefore, it generates two different signals, an ASIC present on the module compares these signals, and it can understand which kind of particle has generated them. In this way a cut on the momentum is used to generate trigger signals for high momentum tracks and it can trigger at 40MHz without losing important events.

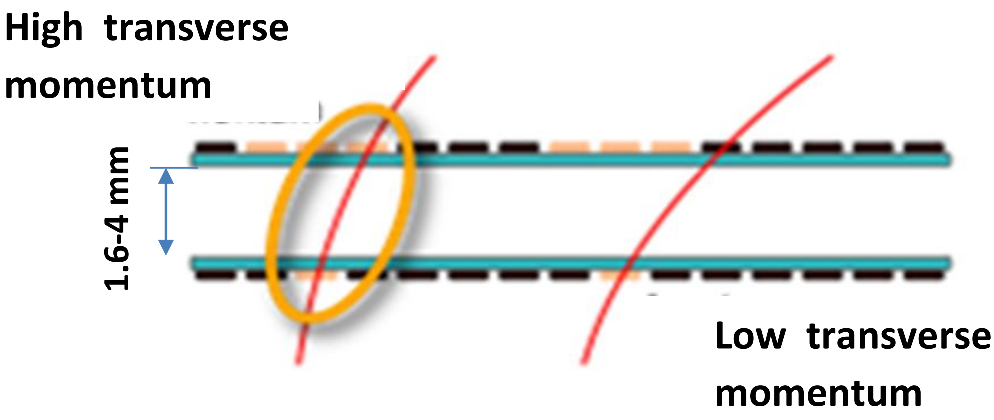


Fig. 6: PS Module section

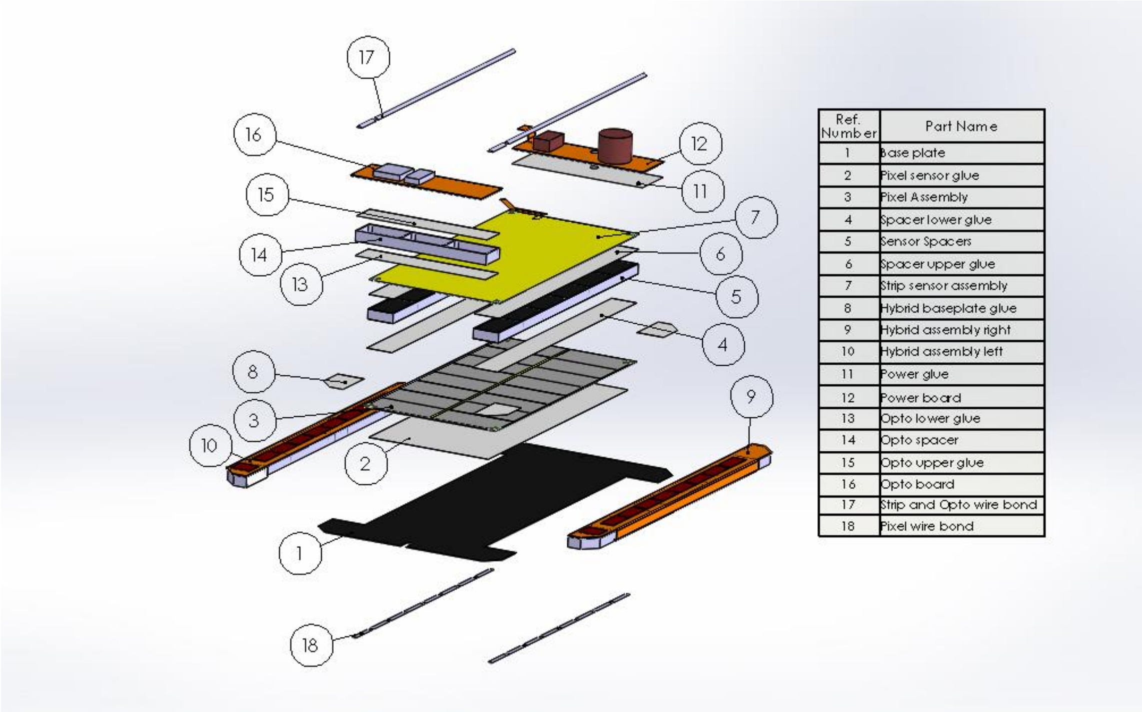


Fig. 7: PS Module exploded view

The main parts the module is composed are (Fig. 7):

- the carbon fiber base plate (1), which supports the module;
- the pixel sensor (3) with ASICs on the top, in order to amplify signals from the sensor and compare them with the strip signals in order to achieve the particle selection mentioned above;
- the strip sensor (7) that is spaced to the pixel sensor by two spacers;
- two hybrid (9, 10) that are connected to the pixel and strip sensor by bond wires (17, 18). They have ASICs on the top to amplify strip signals and other to codify signals to be sent to the opto board;
- the opto board (16) has the duty of transmitting data via optical fibers;
- the power board (12) for DC-DC conversion.

All this components are joined by glue, in order to avoid heavy mass fasteners (like screws, nuts and other similar).

3. Mounting system design

In order to figure out the most delicate steps of assembly, understand possible design problems and to understand the possibility to commit production to factories, a possible scheme for semi-automated assembly has been designed.

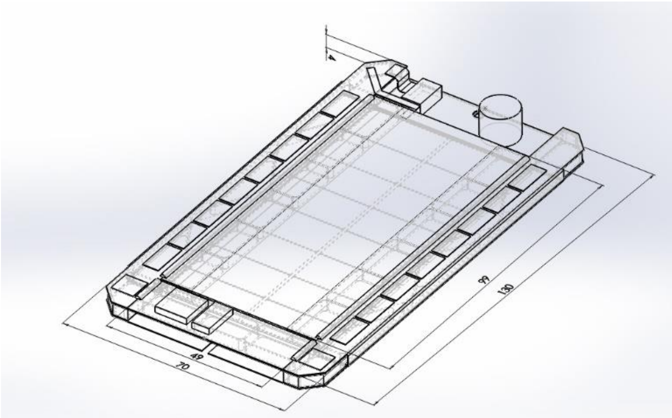


Fig. 8: PS Module

3.1. PS Module assembly description

The most important tasks for assembly are:

- high precision in positioning between the strip and pixel sensors and the carbon fiber base plate: two points that should have to stay one over the other one cannot be misaligned more than 15 μm. Moreover, the two sensors should be also parallel one to each other. This because their misalignment cannot be corrected offline (in order to use less material on the module) and it's necessary to perform the on-module momentum measurement (see Fig.6). Therefore, this precision has to be guaranteed by the production system.
- other parts have to be quite precise in positioning (less than 100 μm);
- the whole process has to be repeatable because the future tracker will consist of around seven thousand PS Modules.

All the parts are completely already processed and some of those are pre-assembled (like the hybrid modules).

In order to reach the requirements we decided to differentiate the process in three different phases:

- in the first one there will be all the operations requiring high precision. A CNC machine will make all of that. During this operation the pixel and the strip sensor will be mounted;
- in the second one there will be all the operation requiring less precision. An operator will make these steps. In this way the assembly will be faster (because it will happen in parallel) and probably less expensive;

- in the last part all the bond wire connections will be made. This step requires dedicated machines.

3.2. Prototypal Mounting Design

Shown below there is a possible PS Module assembly scheme. Some equipment needed for this has been designed just for this purpose, others are commercial equipments.

The frame for all the machine-made operation is the assembly plate (Fig. 9). It’s an aluminum plate with two glass pegs for references (the using of the glass material will be explained better further) and a vacuum system to fix the module during assembly operations by applying a uniform pressure that avoid to bend or tilt it.

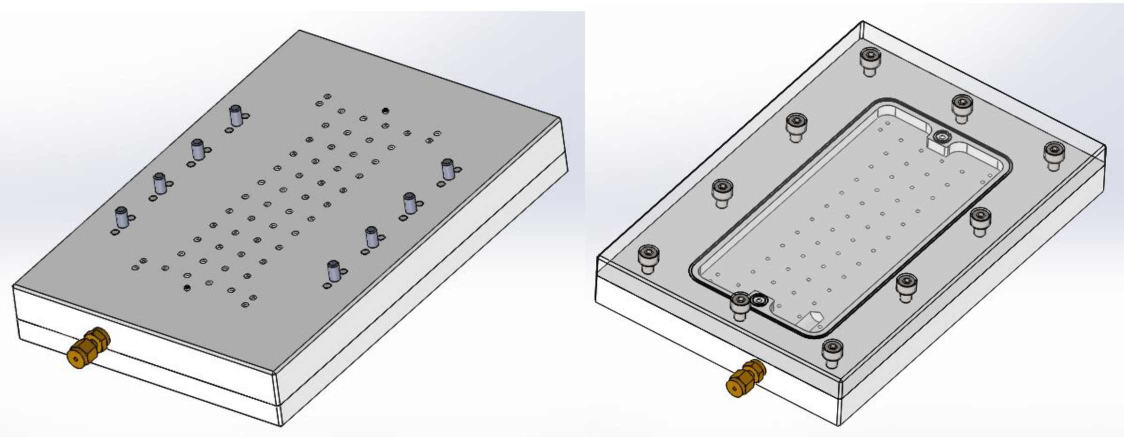


Fig. 9: The assembly plate

There are also other reference pegs (on the sides) but they need in the further operations.

The first step is to place the carbon fiber base plate to the assembly plate (Fig. 10). The two glass pegs slot in the holes of the carbon fiber. Now turning on the suction pump (not shown in the pictures), the carbon fiber is fixed to the assembly plate.

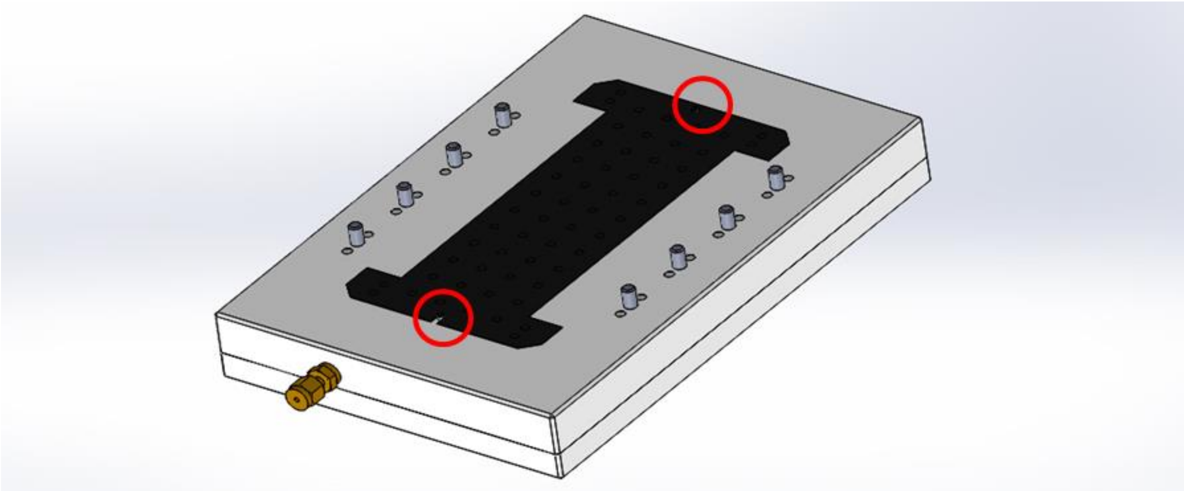


Fig. 10: The assembly plate with the carbon fiber base plate

After that the pixel sensor (with ASICs) has to be glued. The idea is to have a dispenser for glue automatic on the robotic arm of the machine. This arm has to have also a visioning system and a gripping end-effector (a suction kind). Indeed the pixel assembly has markers on its top and the glass pins have a cross engraved on their top for an easy reading (Fig. 11). So after their scanning the robotic arm can pick and place the sensor in the right position. Indeed, thanks to the visioning system, the robotic arm can check marks and making sure of the precision required has been achieved.

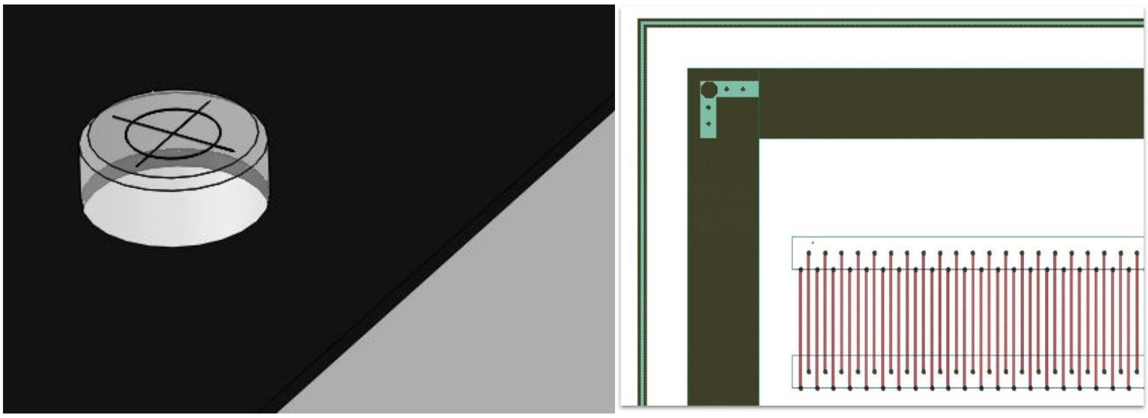


Fig. 11: Glass pin and sensor reference marker

The problem at this time is how to hold the pixel sensor during glue curing. This process can last more than one hour and the use of robotic arm for this purpose is a waste of money (machine time is the most expensive part). We cannot use also ordinary clamps, because there is no security about the amount of pressure and the possibility of pixel sensor shifting during curing. Indeed using ordinary clamps there is the possibility they apply shear forces. Because curing lasts a lot of time also little shear forces are dangerous because they can shift components too much. For these reasons, we decided to use four inflatable clamps (Pic.12).

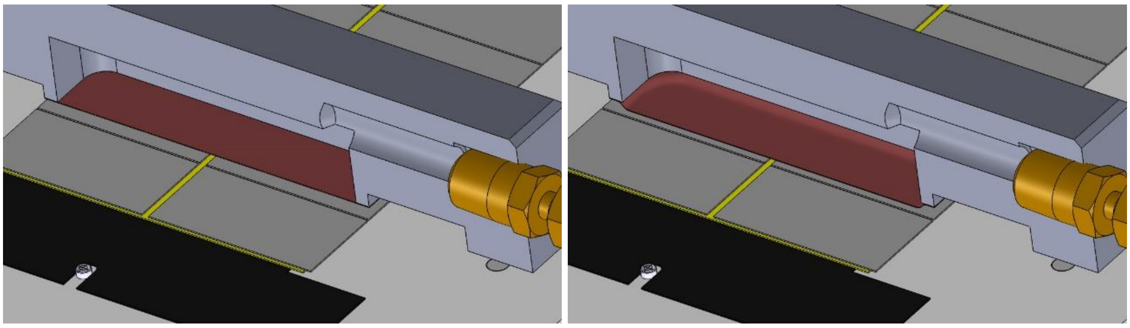


Fig. 12: Inflatable clamps for pixel assembly

These clamps are fixed on the assembly plate by magnets (their size has to be set after we know how much pressure the clamp has to apply) and they are easy to put in position thanks to references pins. They have a rubber membrane on the bottom and a fastener to join pressure pipes. When they are inflated, the membrane expands until it has contact with the pixel sensor. In this way we can be sure that the pressure made by the clamp is homogenous, and it can be regulated by inflating pressure, and that will not be shear forces. This operation is made by hand. So while the robot holds the pixel sensor in position, the operator mounts two of the clamps (the external ones) and inflates them. Only at this point, the robotic arm release the sensor letting the operator to mount the other ones. The suction gripper to use for this has to be sized to do this work.

After mounting all the clamps the assembly plate can be removed from the machine for curing of the glue. In the meanwhile the machine can start another production step with another set of tooling.

The next step is positioning of the strip sensor. To assure that the two spacers are glued very parallel to the sensor (this should be done for mechanical reasons, otherwise the strip sensor can crack when we apply pressure during glue curing), they are glued in a dedicated step before. The strip sensor lays on the ground and the two spacers are glued on it.

After this, the way to place the strip sensor over the pixel sensor is similar to the previous step. The clamps we use are similar to the previous ones (Fig. 13); the only differences are they apply pressure just over the spacers (in order to do not crack the sensor that have any support in the middle) and they have the reference holes in different places.

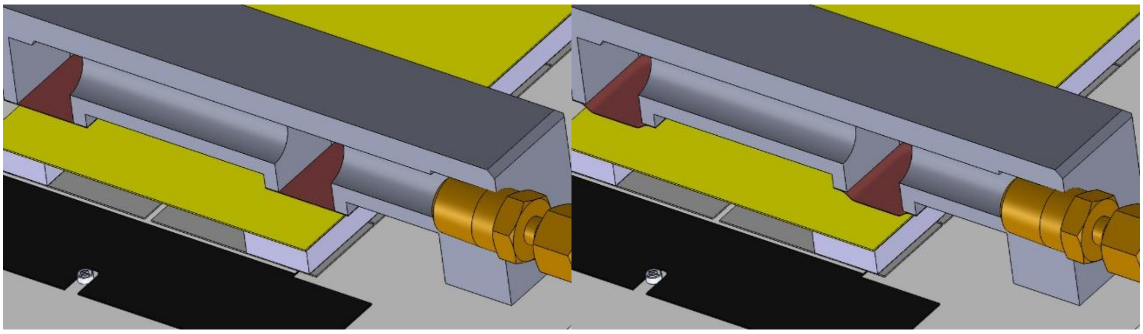


Fig. 13: Inflatable clamps for strip assembly

Now the high precision steps are complete and there is no more need to use the assembly plate. So the module is shifted to another aluminum baseplate (Fig. 14). This is simpler than the previous one. It has some fixed toggle clamps (Fig. 15) and only references pins. The smaller pins are for positioning of the module on the frame, while the bigger ones are for gluing template.

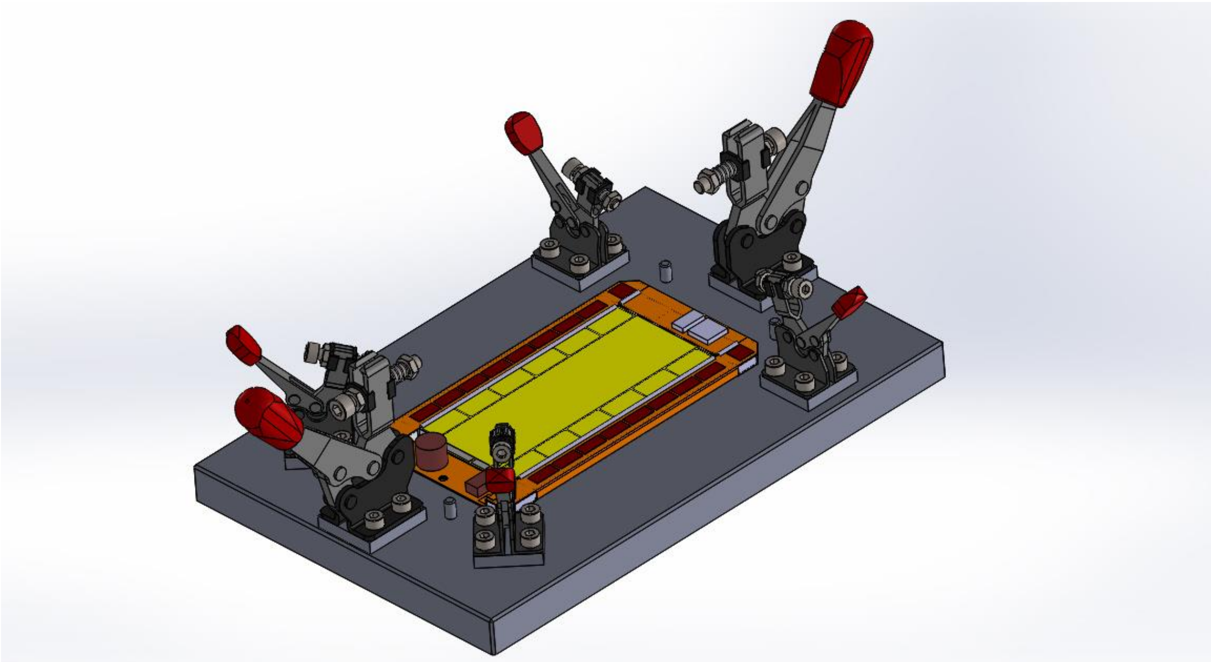


Fig. 14: The clamping assembly plate

The particularities of the clamps are that they are very easy to use and there's the possibility of setting pressure. Indeed they have a screw on the top, which can shift inside its slot, and a spring, which pull the screw on the bottom. So its sensitivity for errors is very low. And if they are mounted over inclined steps they have the possibility to apply also shear forces. At this time this is useful features because in the next steps positioning is made doing edges reach mechanic stops. So to be sure that during curing any shift happens, it's better if there's some shear force that push over that.

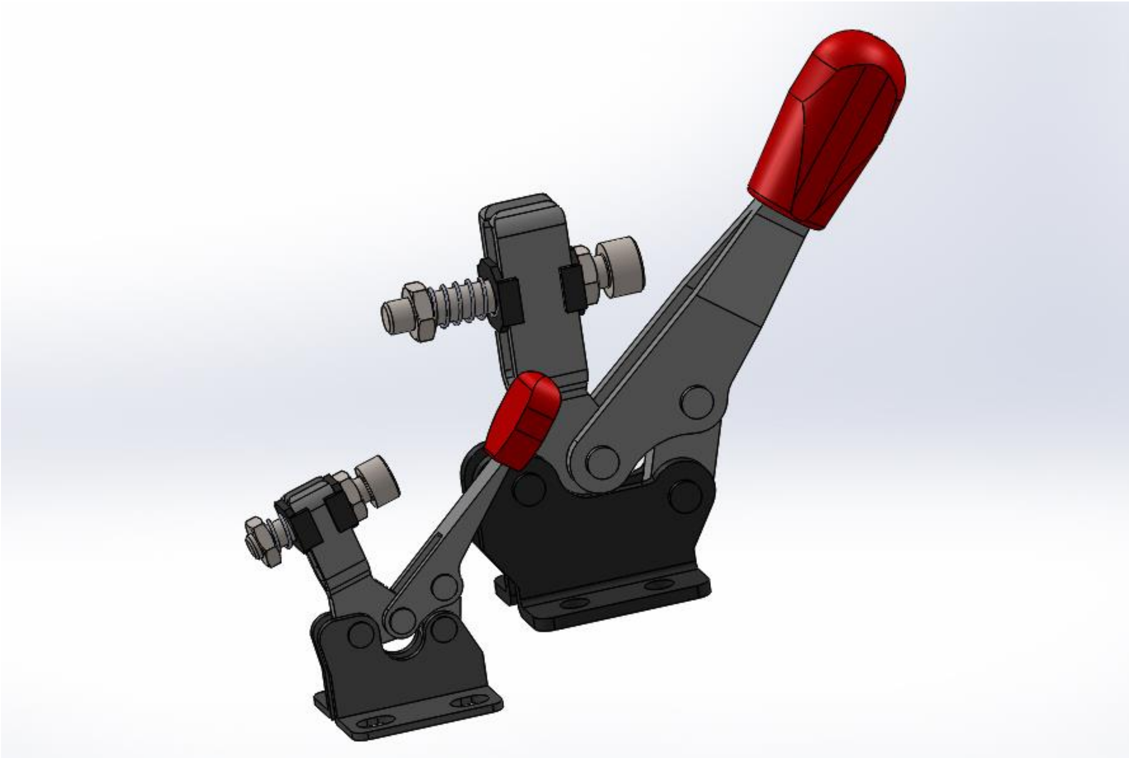


Fig. 15: Toggle clamps

The first step is to glue the two hybrid modules (Fig. 16). It's done putting a template (the red one) fitting into the pegs. This template is hold in position by two beams that wedge them in the template (the green one).

So the operator has to put in position the template, to lock it with the beam, to apply glue, to place hybrids and to close the four little toggle clamps. After glue has cured he has to make the reverse process. We choose this solution because it's better don't have the possibility to hit these components when the template is removed. In this way they slide away (after removing the locking beam).

In order to not damage the hybrids, the clamps don't push directly over them, but there are covers that are shaped to push them in not delicate points. The shape of them has to be defined after the pieces have their final configuration.

After, the operator has to make the same process with the power board and the opto board (Fig. 17). These templates are simply thrown away from their pins after used them (there is any locking bar).

These operations can be done also in the same sub phase because they are independent one to each other. In this way they can cure together.

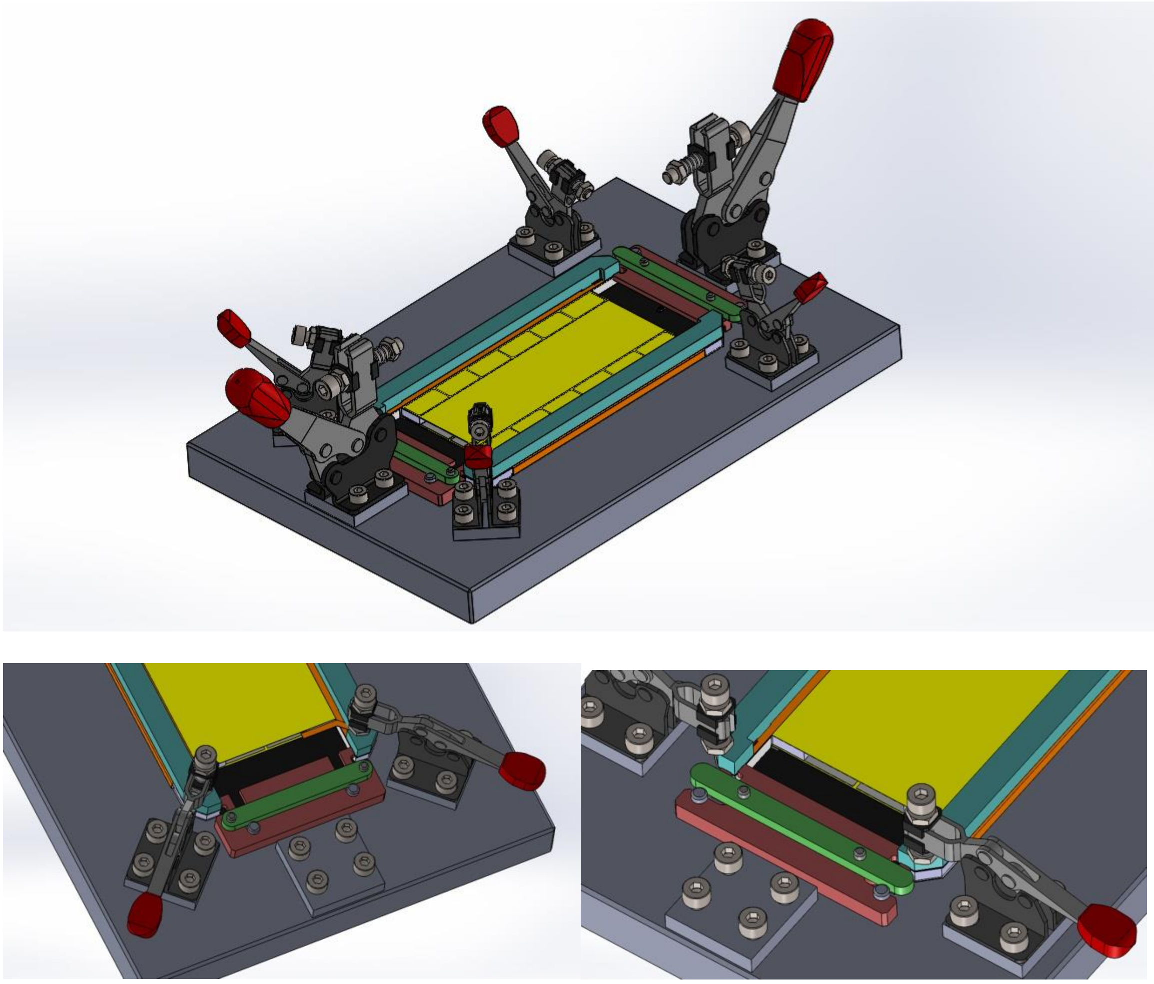


Fig. 16: Hybrid mounting

The Last operation is creating electrical connection between all the parts, and it's done by a dedicated machine. There are any particular advertising in that. There is only the need to pose the module upside down when wire bond connections are done to the pixel sensor. A possibility is to create a Teflon step that fit on the strip sensor, and all the module lays over it during this operation.

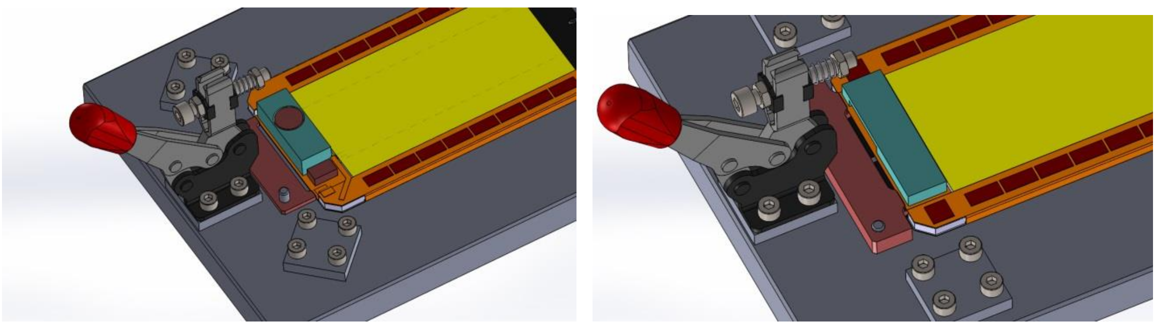
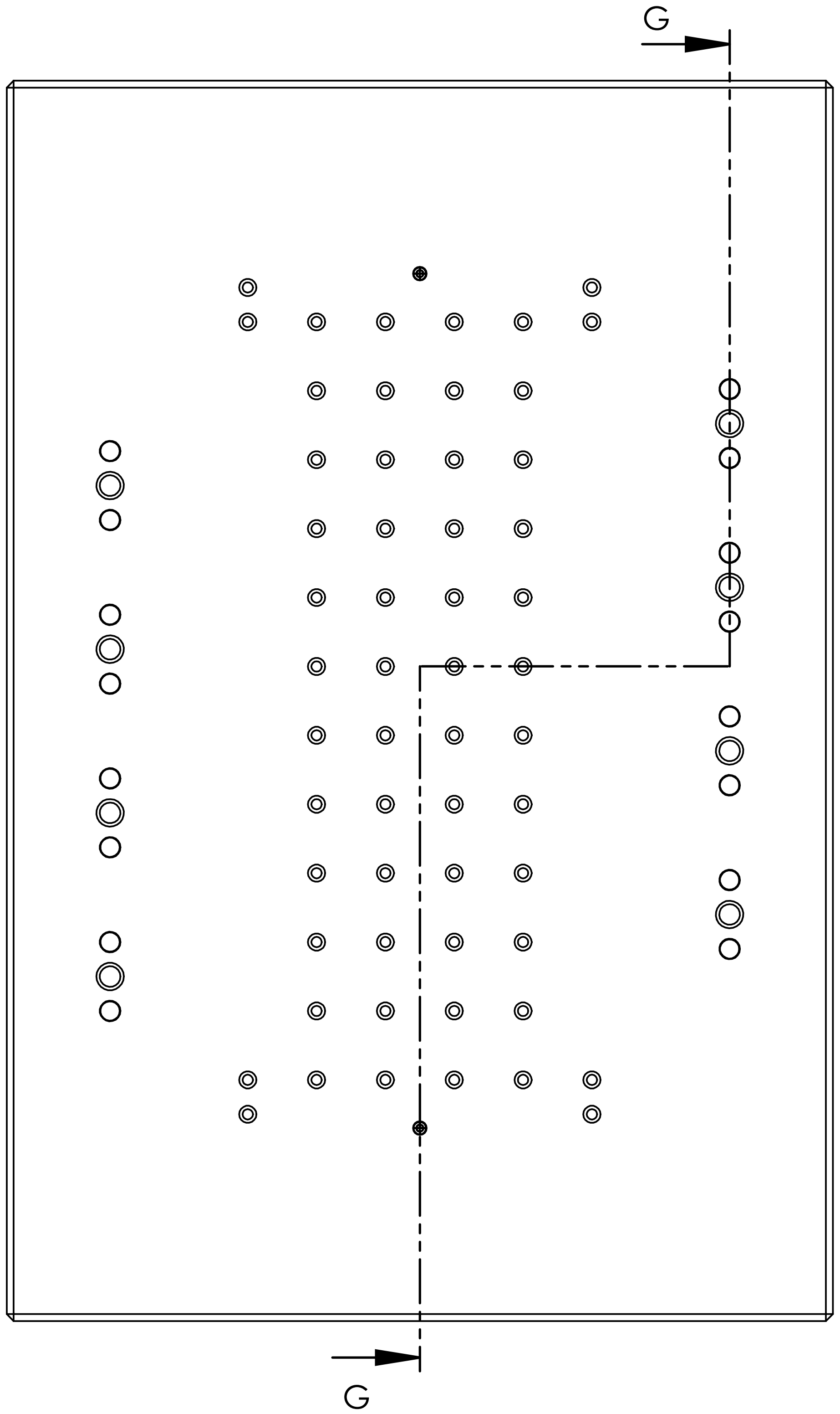


Fig. 17: Power and opto boards mounting

4. Preliminary technical drawings

Shown below there are the technical drawings about home-made equipment.

These components, as said before, are not definitive. They are only an outline for a further complete design. Also followings are not complete for production and installation.



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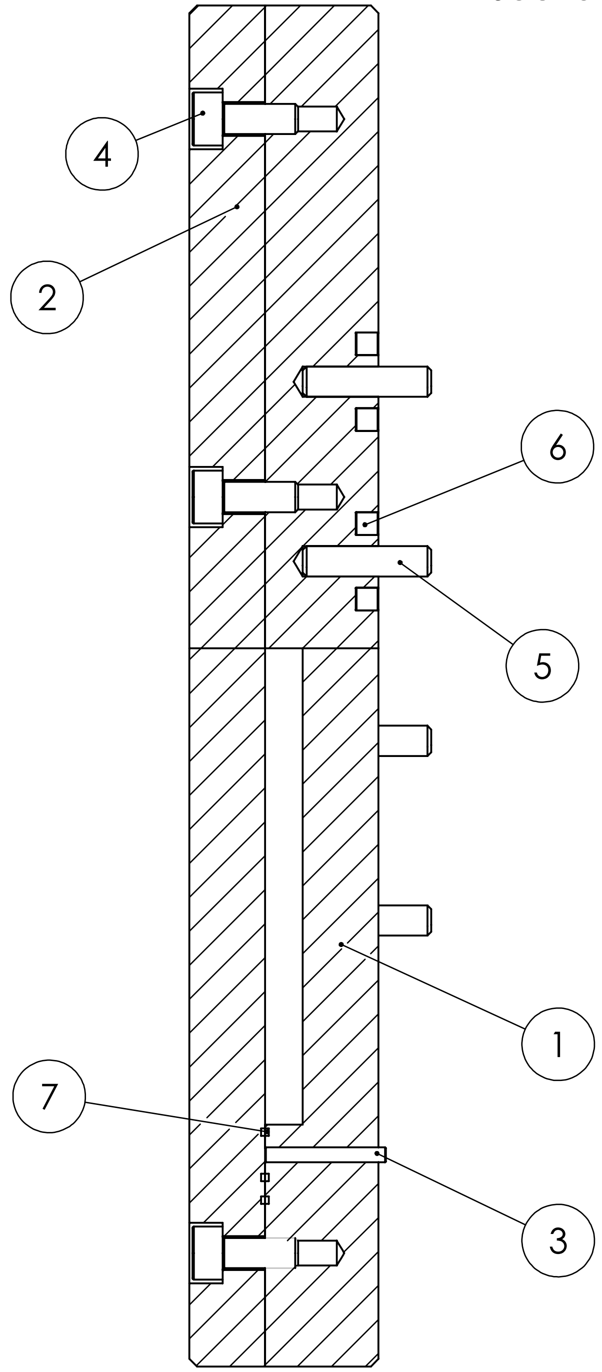

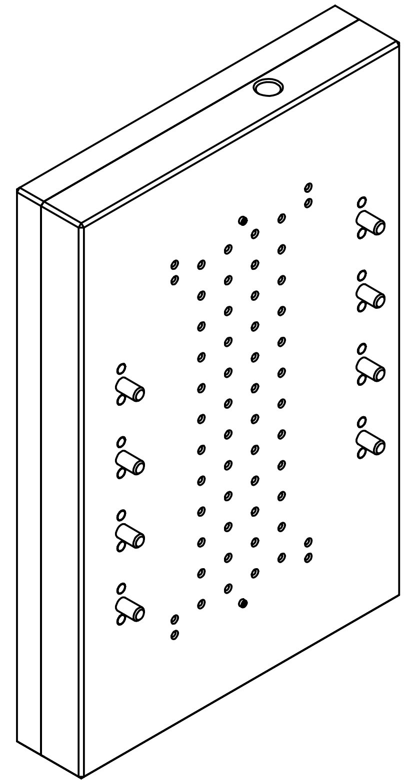

Ref.	Name	Quantity
1	Assembly Plate Upper	1
2	Assembly Plate Lower	1
3	Glass peg	2
4	ISO 4762 M4 x 10 --- 10N	10
5	Dowel Pin 4x16 ISO 2338 m6	8
6	Magnet	16
7	Seal	3

Projekt / PROJECT	Arbeitspaket / WORKPACKAGE	Gruppe / GROUP	Ers.für / REPLACES	Ers.durch / REPLACED BY
HL-LHC	PS Module Assembly system	CMS		

Gewicht / WEIGHT

Halbzeug / SEMIFINISHED PRODUCT

DESY

Werkstoff / MATERIAL

Format/SIZE: A3

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Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE: ISO 8015

Oberflächenkenngrößen / SURFACE TEXTURE: ISO 1302, 4287, 4288

Toleranzklasse / TOLERANCE CLASS: mH

Maßstab / SCALE: 1:1

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Frei. REL.		
Gen. APR.		

Titel / TITLE: Automatic Assembly plate

Dokument-Nr. / DOCUMENT NO.: 1

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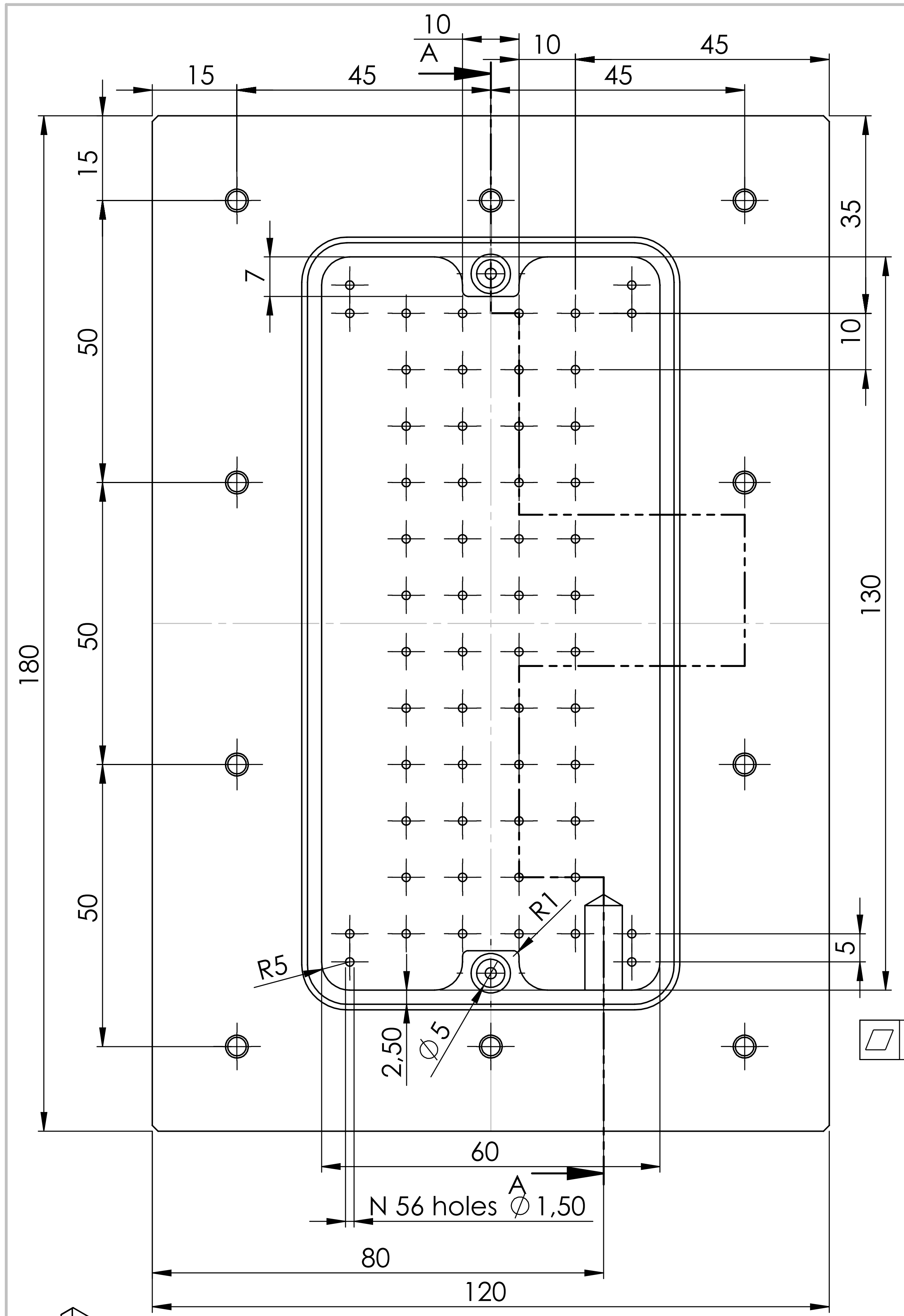

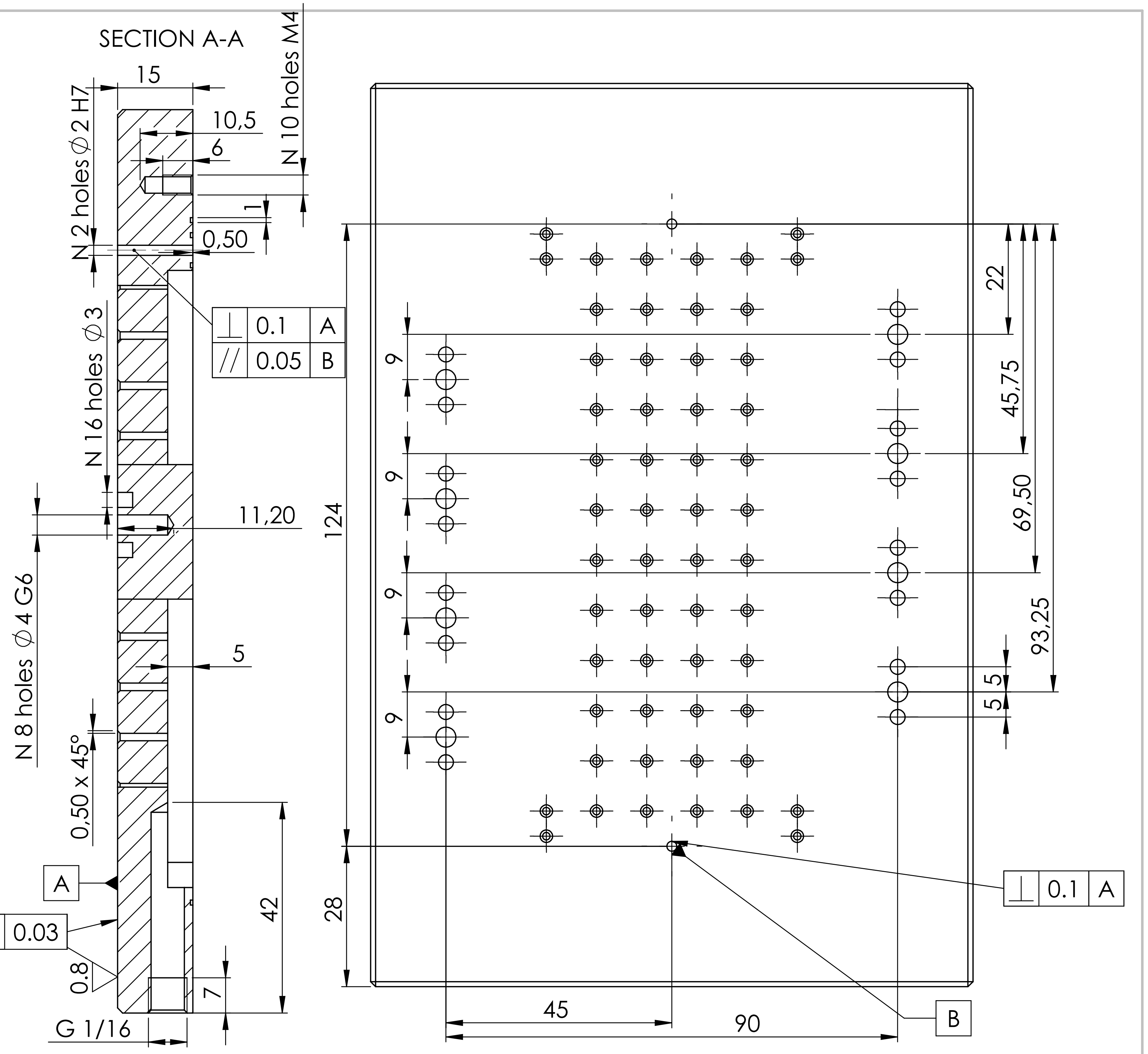

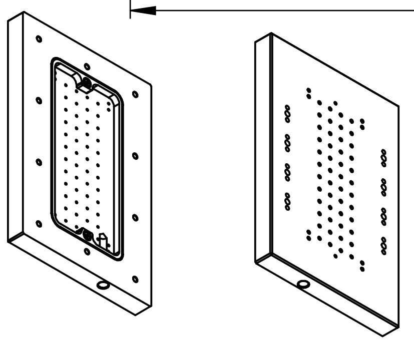

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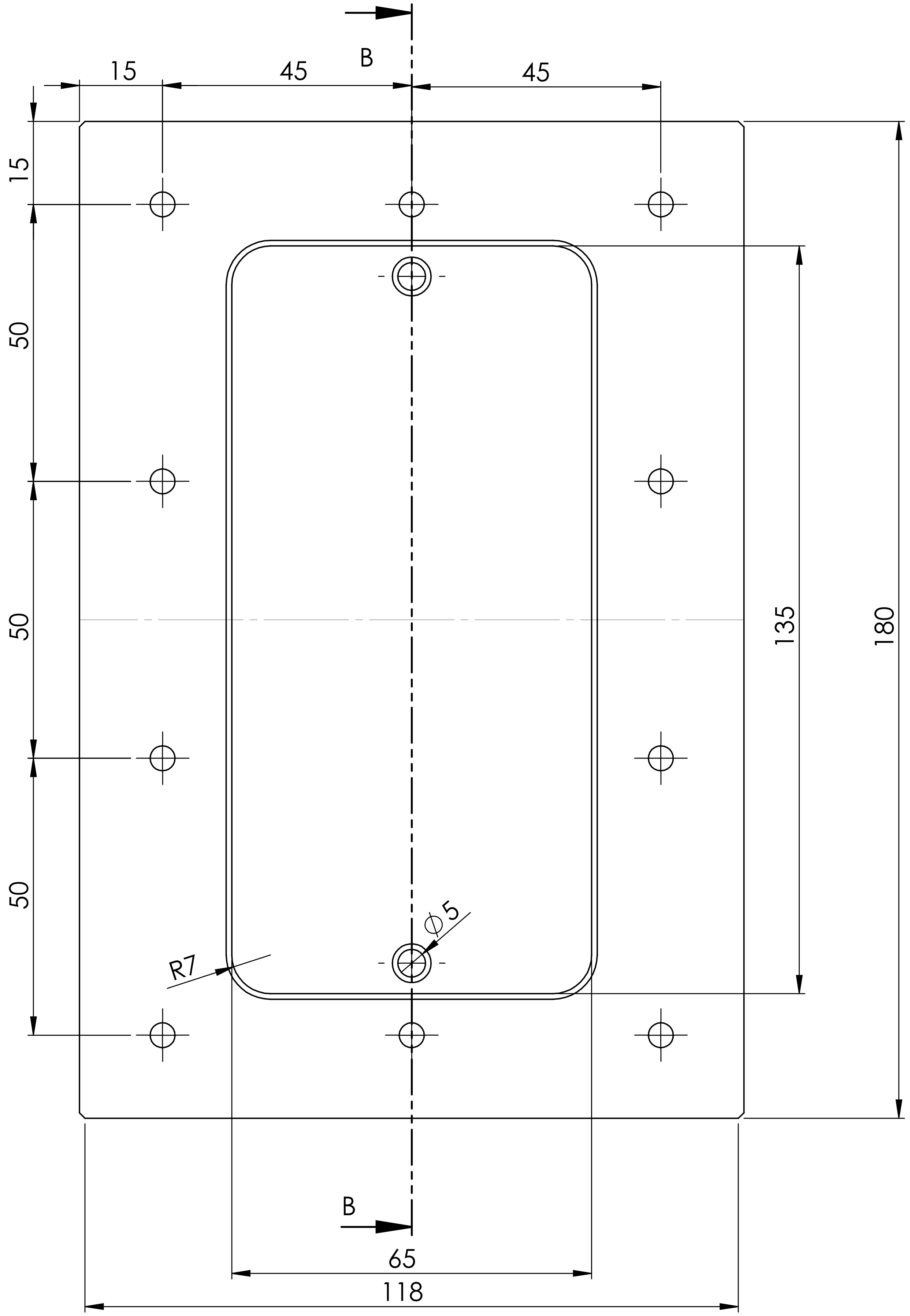

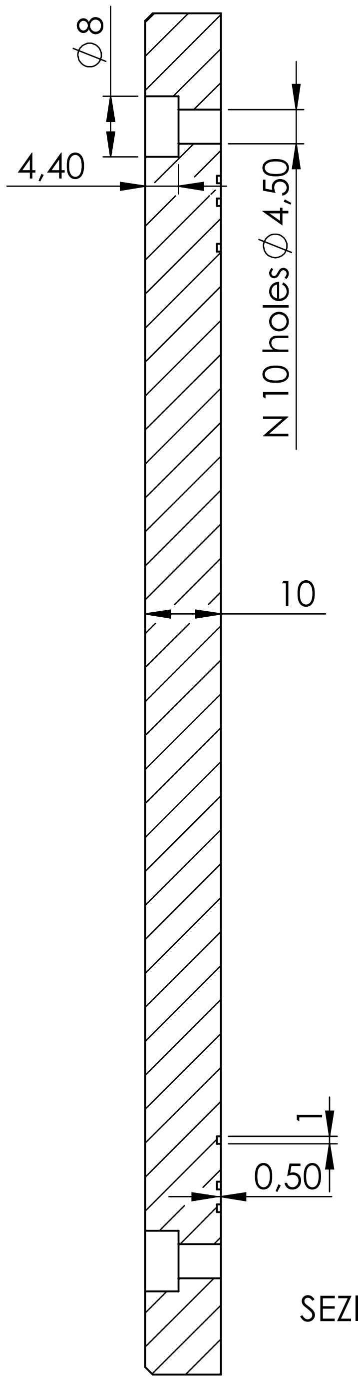

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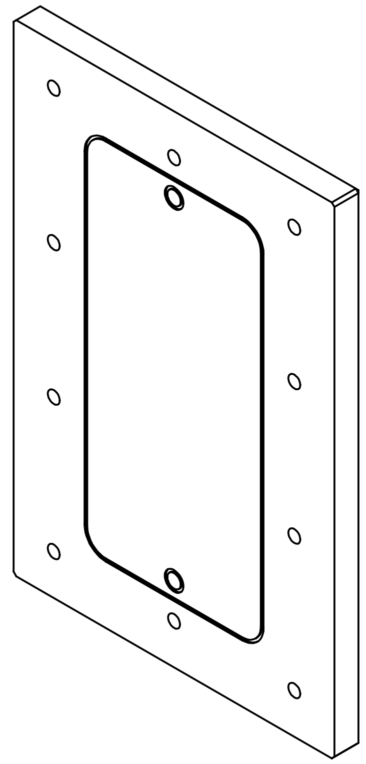

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Gruppe / GROUP	CMS
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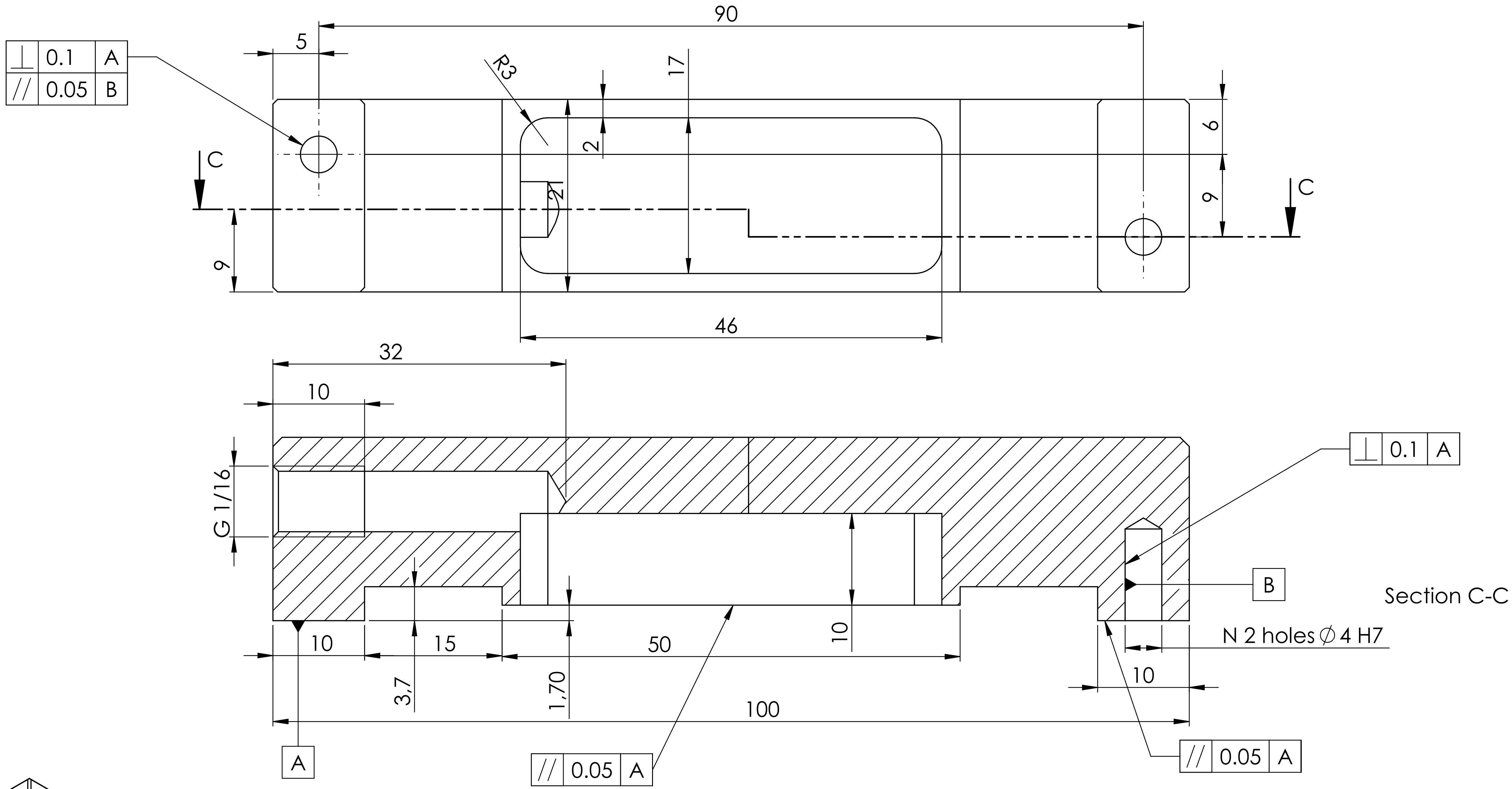

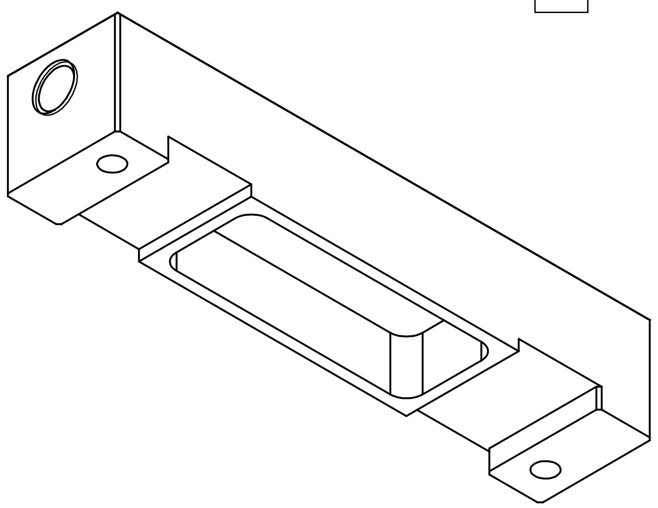

A rubber sheet has to be glued on the pocket

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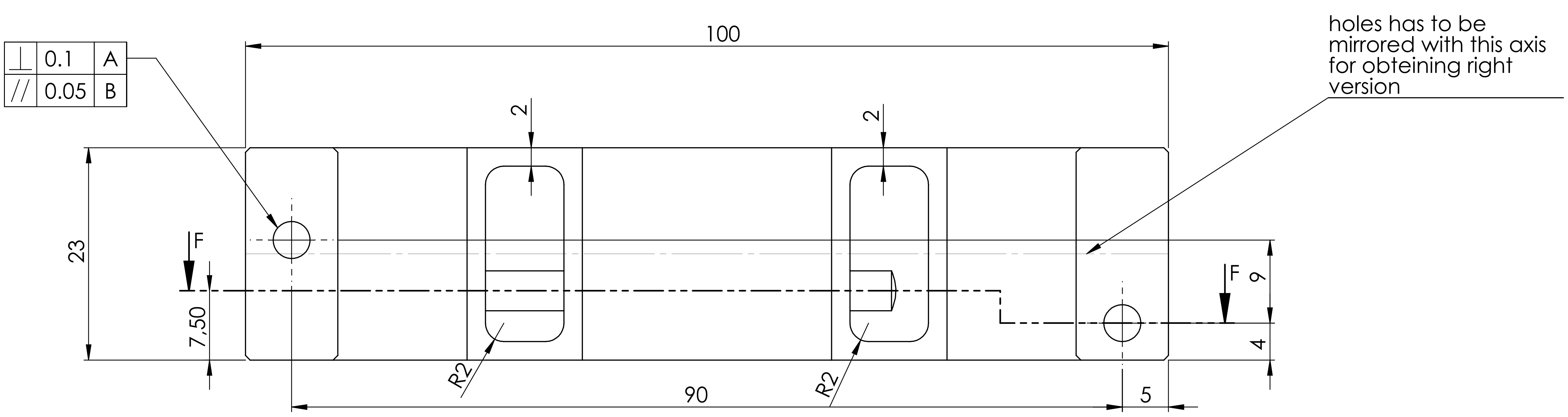

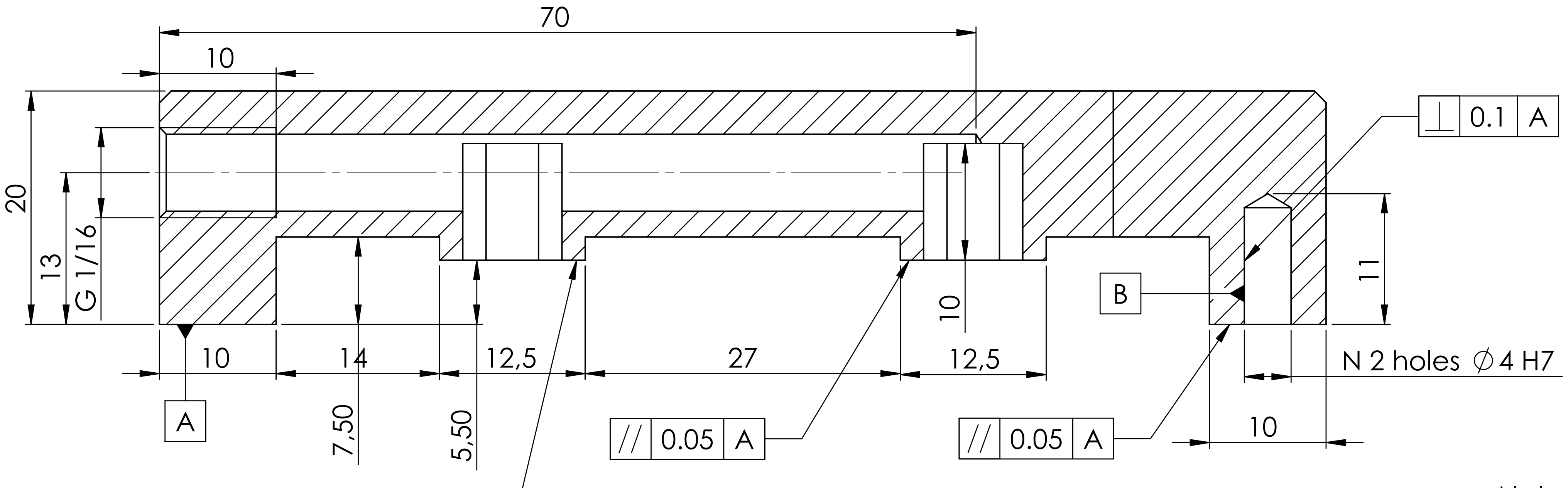

Section F-F

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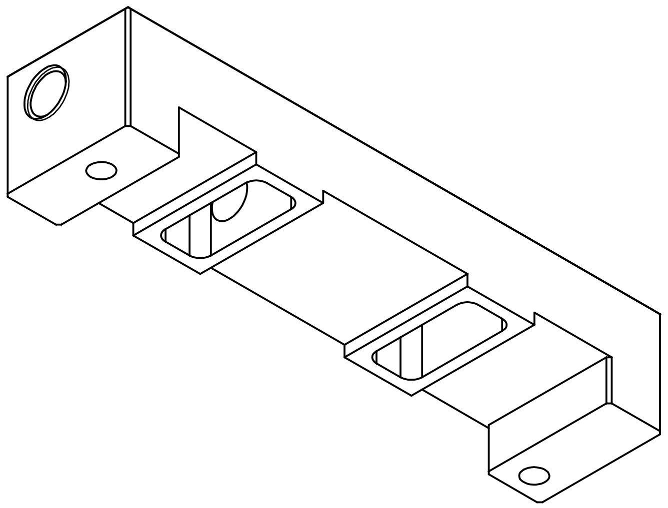
The right version has holes mirrored with longitudinal axes



Rubber sheets have to be glued on pockets

Projekt / PROJECT: HL-LHC	Arbeitspaket / WORKPACKAGE: PS Module Assembly system	Gruppe / GROUP: CMS	Ers.für / REPLACES	Ers.durch / REPLACED BY
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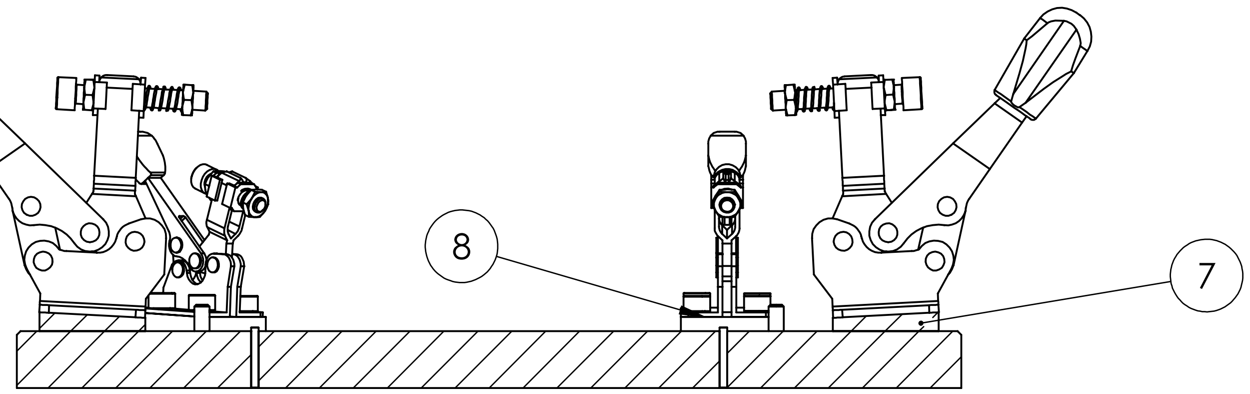
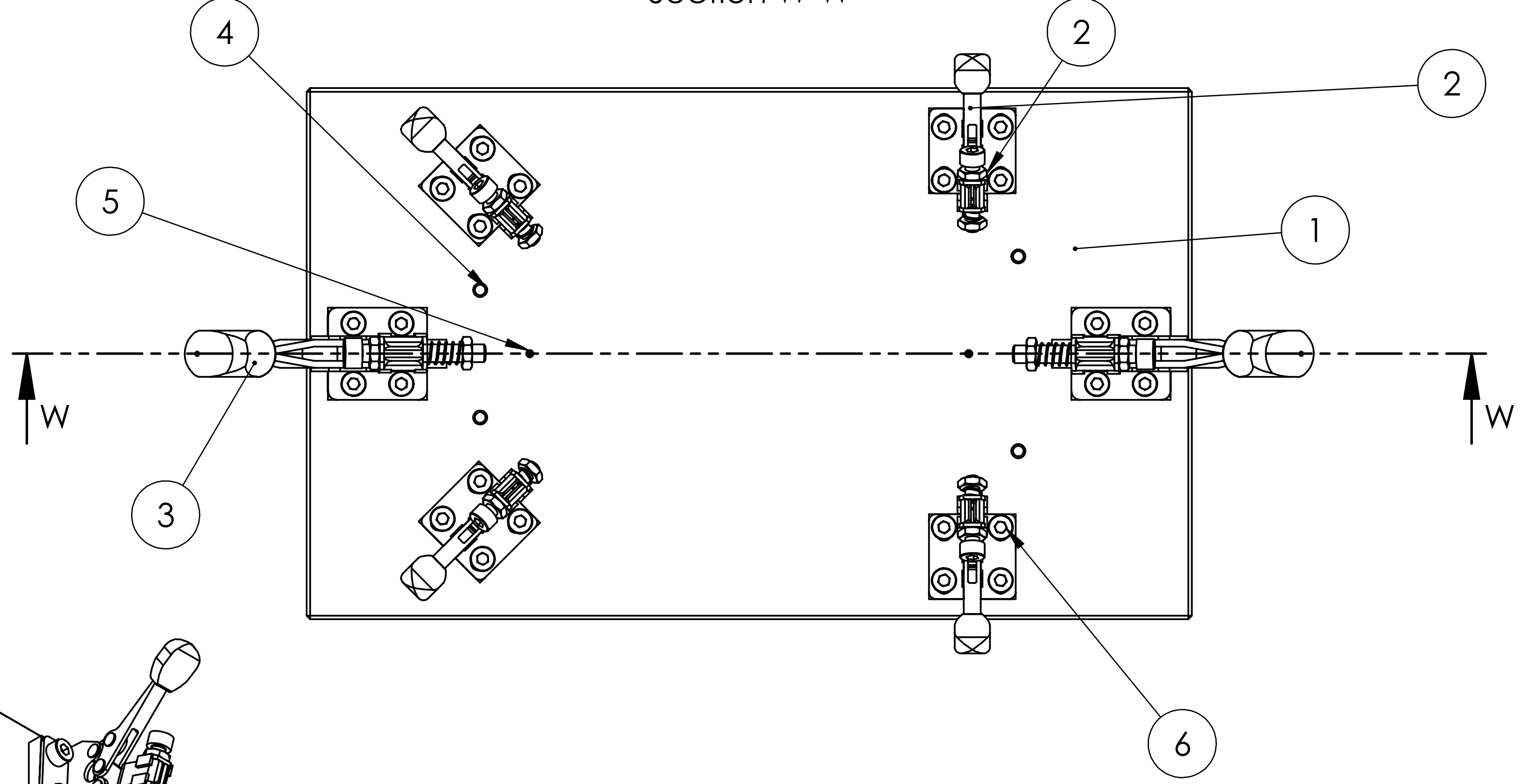
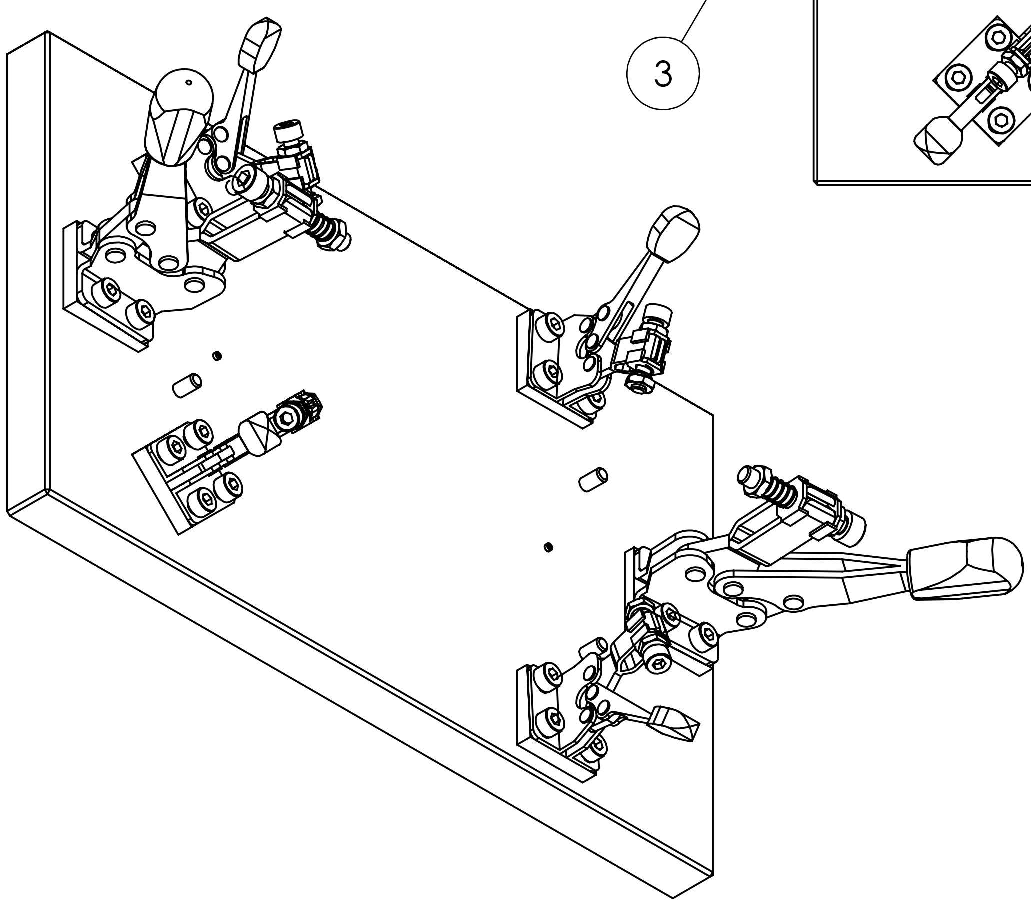


Section W-W





Ref	Name	Quantty
1	Operator Plate	1
2	GN 820-455-M	4
3	GN 820-455-M big	2
4	Dowel Pin 4x16 ISO 2338 m6	4
5	Glass peg	2
6	ISO 4762 M4 x 16 --- 16N	24
7	Clamps step big	2
8	Clamp step little	4
9	Holder steps	1

Projekt / PROJECT: HL-LHC	Arbeitspaket / WORKPACKAGE: PS Module Assembly system	Gruppe / GROUP: CMS	Ers.für / REPLACES	Ers.durch / REPLACED BY
Gewicht / WEIGHT	Halbzeug / SEMIFINISHED PRODUCT	DESY	Werkstoff / MATERIAL	Format/SIZE: A3

Allg. Toleranzen / GENERAL TOLERANCES	ISO 2768 ISO 13920	
Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE	ISO 8015	Toleranzklasse / TOLERANCE CLASS: mH
Oberflächenkenngrößen / SURFACE TEXTURE	ISO 1302 4287, 4288	

Maßstab / SCALE: 1:2

Teil-ID / PART-ID

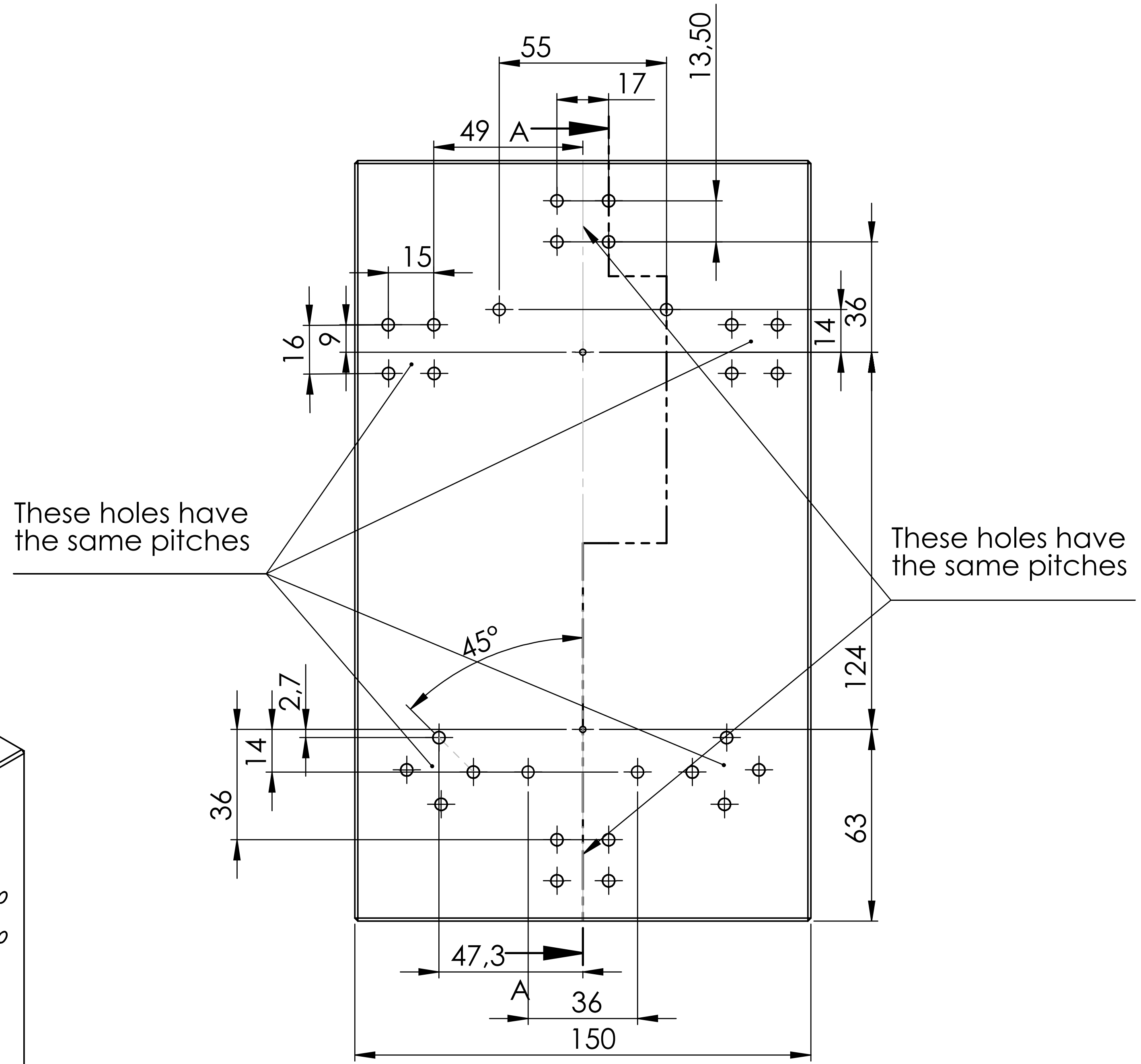
	Datum/DATE	Name / NAME
Gez. CRE.	09/09/14	Daniele Pasciuto
Gepr. REV.		
Frei. REL.		
Gen. APR.		

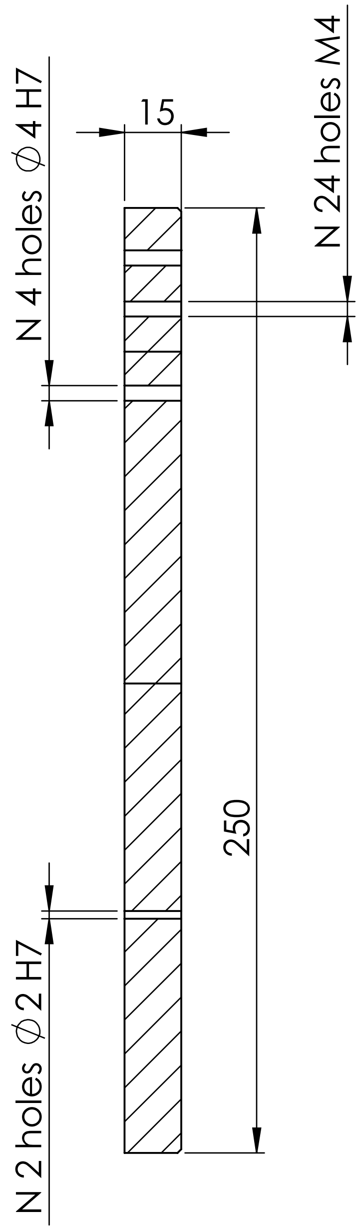
Titel / TITLE: Operator Assembly Plate

Dokument-Nr. / DOCUMENT NO. 6

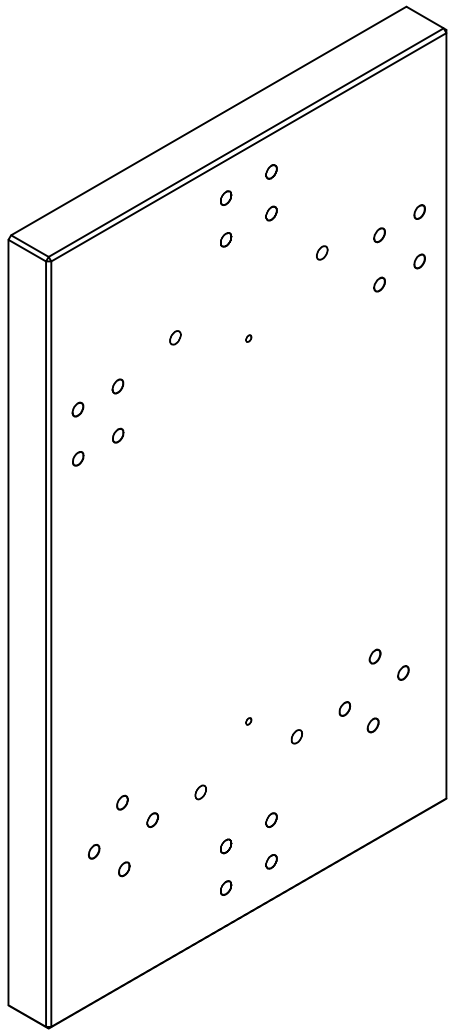
Blatt SHEET 1 von OF 1

Zchng.-ID DRAW.-ID | Rev. REV. | Ver. VER. | Status STATUS





Section A-A



Not marked chanfers are 1x45°

Projekt / PROJECT HL-LHC	Arbeitspaket / WORKPACKAGE PS Module Assembly system	Gruppe / GROUP CMS	Ers.für / REPLACES	Ers.durch / REPLACED BY
Gewicht / WEIGHT	Halbzeug / SEMIFINISHED PRODUCT	DESY	Werkstoff / MATERIAL Aluminum	Format/SIZE A3

Allg. Toleranzen / GENERAL TOLERANCES ISO 2768 ISO 13920

Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE ISO 8015

Oberflächenkenngrößen / SURFACE TEXTURE ISO 1302 4287, 4288

Toleranzklasse / TOLERANCE CLASS mH

Maßstab / SCALE 1:2

Teil-ID PART-ID

	Datum/DATE	Name / NAME
Gez. CRE.	09/09/14	Daniele Pasciuto
Gepr. REV.		
Frei. REL.		
Gen. APR.		

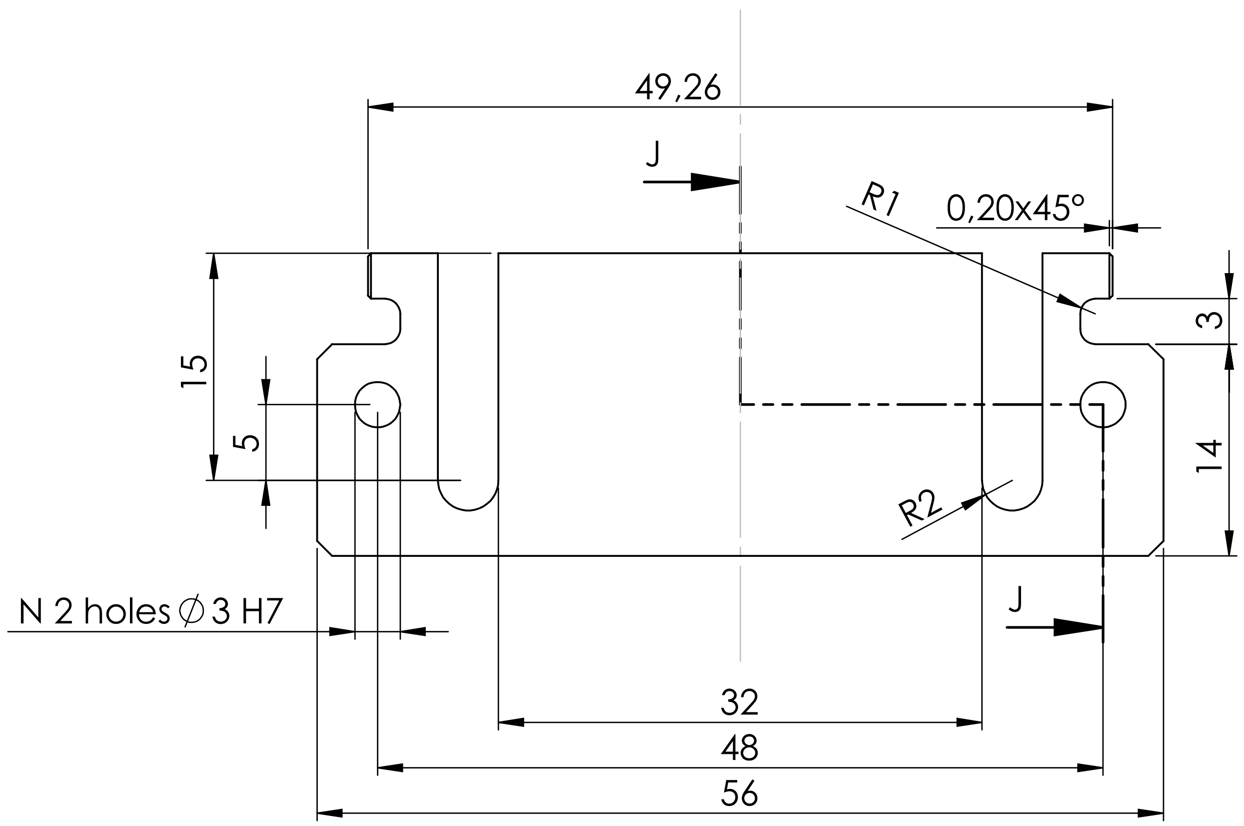
Titel / TITLE

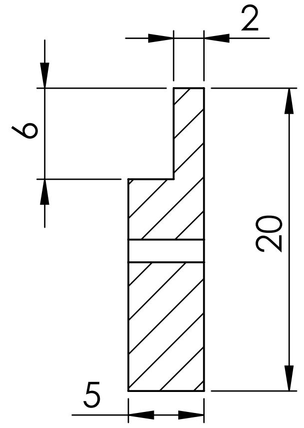
Operator Plate

Dokument-Nr. / DOCUMENT NO.
7

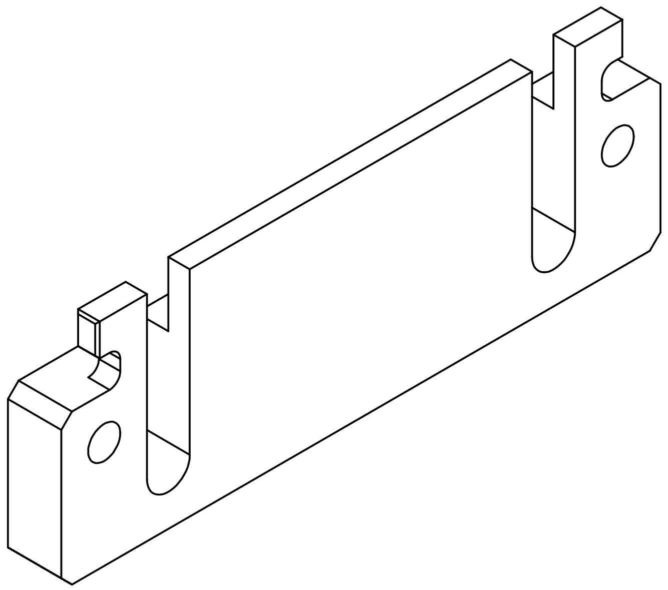
Blatt SHEET 1 von OF 1

Zchng.-ID DRAW.-ID | Rev. REV. | Ver. VER. | Status STATUS





Section J-J



It needs 2 Dowel Pin 3x10 ISO 2338 filling the holes
Not marked chanfers are 1x45°

Projekt / PROJECT: HL-LHC	Arbeitspaket / WORKPACKAGE: PS Module Assembly system	Gruppe / GROUP: CMS	Ers.für / REPLACES	Ers.durch / REPLACED BY
Gewicht / WEIGHT	Halbzeug / SEMIFINISHED PRODUCT	DESY	Werkstoff / MATERIAL: Aluminum	Format/SIZE: A3

Allg. Toleranzen / GENERAL TOLERANCES	ISO 2768 ISO 13920	
Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE	ISO 8015	Toleranzklasse / TOLERANCE CLASS: mH
Oberflächenkenngrößen / SURFACE TEXTURE	ISO 1302 4287, 4288	

Maßstab / SCALE: 2:1

Teil-ID / PART-ID

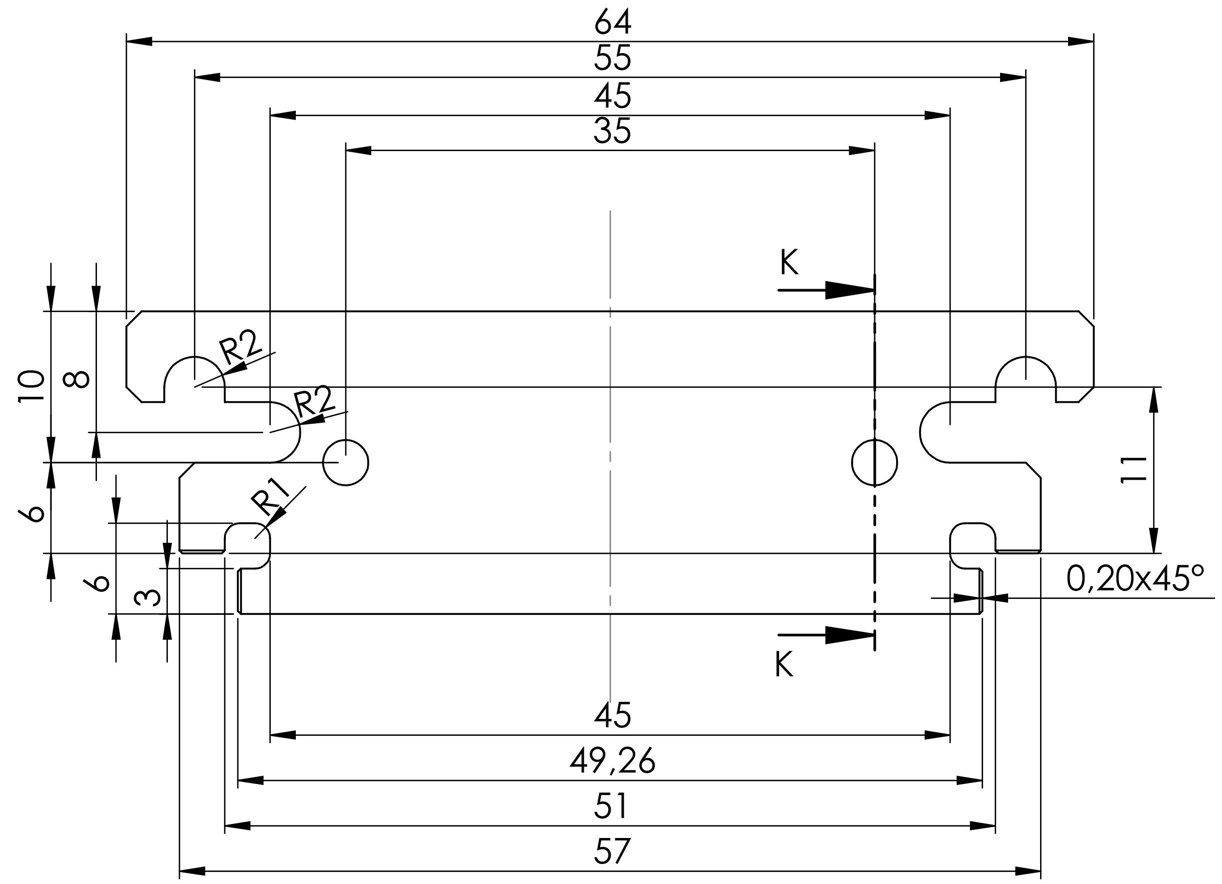
	Datum/DATE	Name / NAME
Gez. CRE.	09/09/14	Daniele Pasciuto
Gepr. REV.		
Frei. REL.		
Gen. APR.		

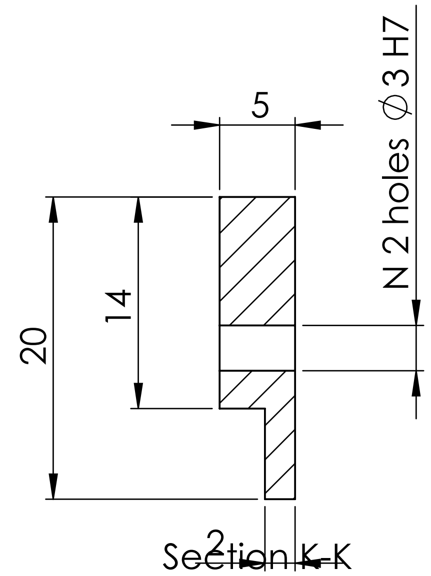
Titel / TITLE: Hybrid template down

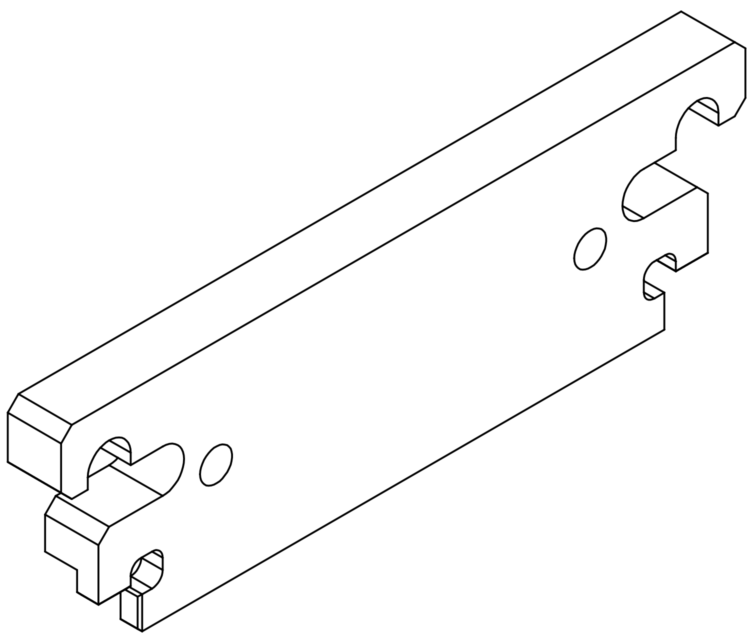
Dokument-Nr. / DOCUMENT NO.: 8

Blatt SHEET 1 von OF 1

Zchng.-ID DRAW.-ID | Rev. REV. | Ver. VER. | Status STATUS





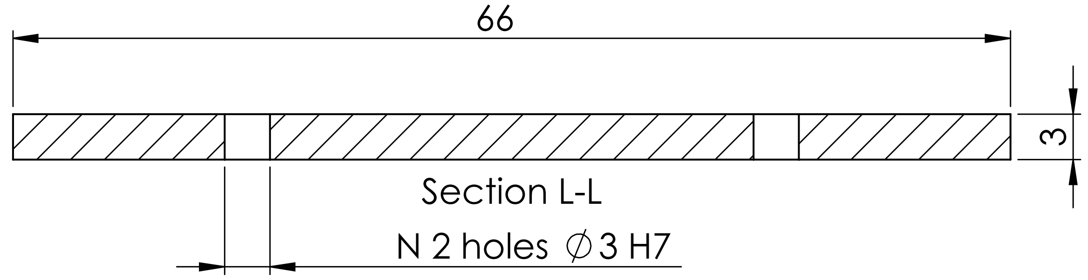


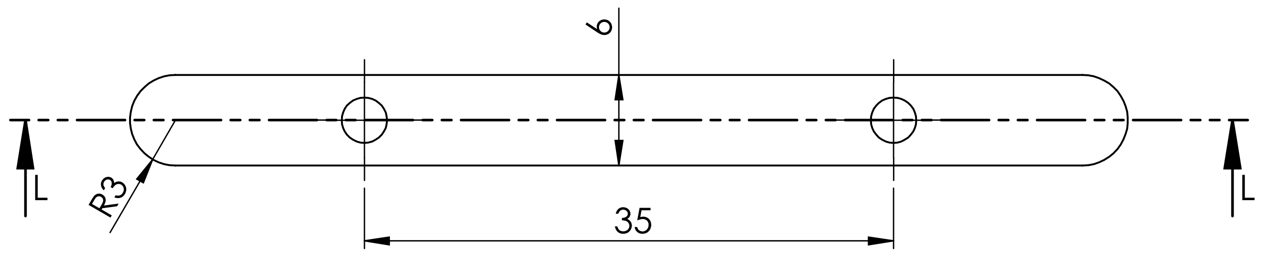
It needs 2 Dowel Pin 3x10 ISO 2338 filling the holes

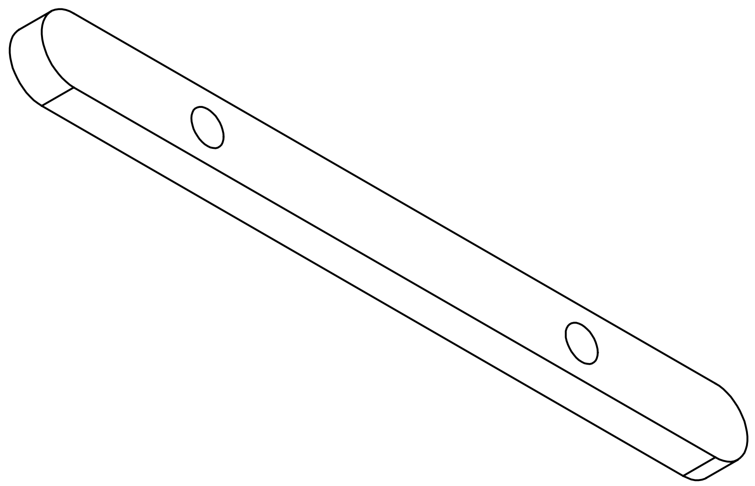
Not marked chanfers are 1x45°

Projekt / PROJECT	Arbeitspaket / WORKPACKAGE	Gruppe / GROUP	Ers.für / REPLACES	Ers.durch / REPLACED BY
HL-LHC	PS Module Assembly system	CMS		
Gewicht / WEIGHT	Halbzeug / SEMIFINISHED PRODUCT	DESY	Werkstoff / MATERIAL: Aluminum	Format/SIZE: A3

Allg. Toleranzen / GENERAL TOLERANCES	ISO 2768 ISO 13920		Maßstab / SCALE: 2:1	Titel / TITLE
Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE	ISO 8015	Toleranzklasse / TOLERANCE CLASS	Teil-ID PART-ID	Hybrid template up
Oberflächenkenngrößen / SURFACE TEXTURE	ISO 1302 4287, 4288	mH	Datum/DATE · Name / NAME	
			Gez. CRE. 09/09/14 · Daniele Pasciuto	
			Gepr. REV.	Dokument-Nr. / DOCUMENT NO. 9 · Blatt SHEET 1 · von OF 1
			Frei. REL.	
			Gen. APR.	Zchng.-ID DRAW.-ID · Rev. REV. · Ver. VER. · Status STATUS







Projekt / PROJECT HL-LHC	Arbeitspaket / WORKPACKAGE PS Module Assembly system	Gruppe / GROUP CMS	Ers.für / REPLACES	Ers.durch / REPLACED BY
Gewicht / WEIGHT	Halbzeug / SEMIFINISHED PRODUCT	DESY	Werkstoff / MATERIAL Aluminum	Format/SIZE A3

Allg. Toleranzen / GENERAL TOLERANCES ISO 2768 ISO 13920		Maßstab / SCALE 2:1		Titel / TITLE Hybrid template holder up
Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE ISO 8015	Toleranzklasse / TOLERANCE CLASS	Teil-ID PART-ID		
Oberflächenkenngrößen / SURFACE TEXTURE ISO 1302 4287, 4288	mH		Datum/DATE	Name / NAME
		Gez. CRE.	09/09/14	Daniele Pasciuto
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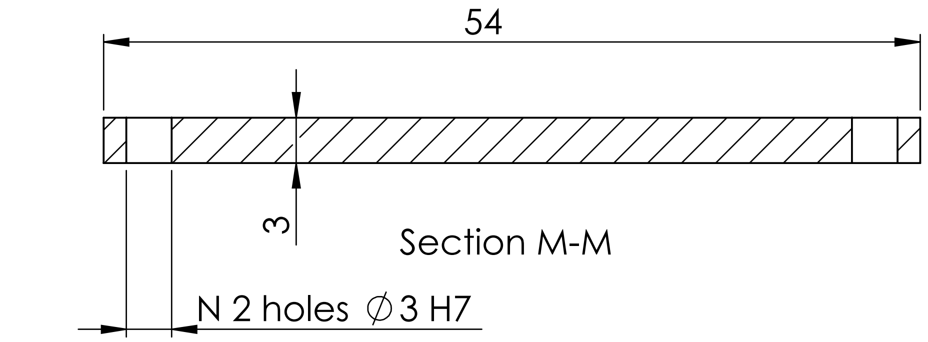
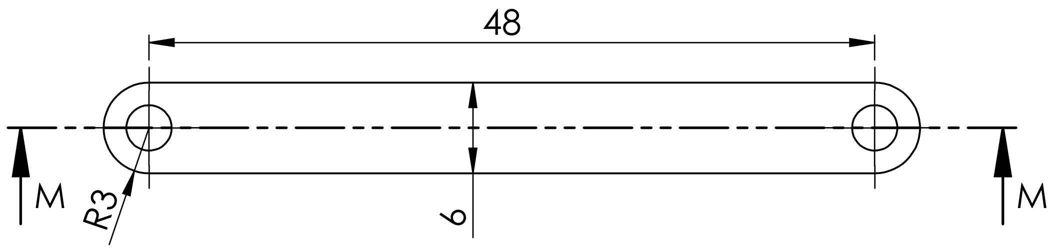
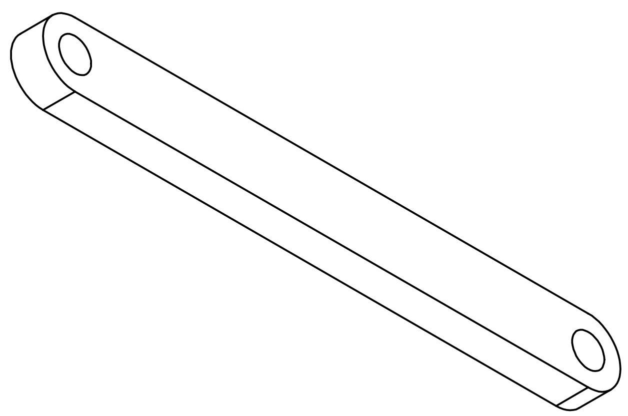
		Gen. APR.		

Dokument-Nr. / DOCUMENT NO. 10				Blatt SHEET 1 von OF 1
Zchng.-ID DRAW.-ID	Rev. REV.	Ver. VER.	Status STATUS	







Projekt / PROJECT HL-LHC	Arbeitspaket / WORKPACKAGE PS Module Assembly system	Gruppe / GROUP CMS	Ers.für / REPLACES	Ers.durch / REPLACED BY
Gewicht / WEIGHT	Halbzeug / SEMIFINISHED PRODUCT	DESY	Werkstoff / MATERIAL Aluminum	Format/SIZE A3

Allg. Toleranzen / GENERAL TOLERANCES ISO 2768 ISO 13920		Maßstab / SCALE 2:1		Titel / TITLE Hybrit template holder down
Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE ISO 8015	Toleranzklasse / TOLERANCE CLASS mH	Teil-ID PART-ID		
Oberflächenkenngrößen / SURFACE TEXTURE ISO 1302 4287, 4288			Datum/DATE	Name / NAME
		Gez. CRE.	09/09/14	Daniele Pasciuto
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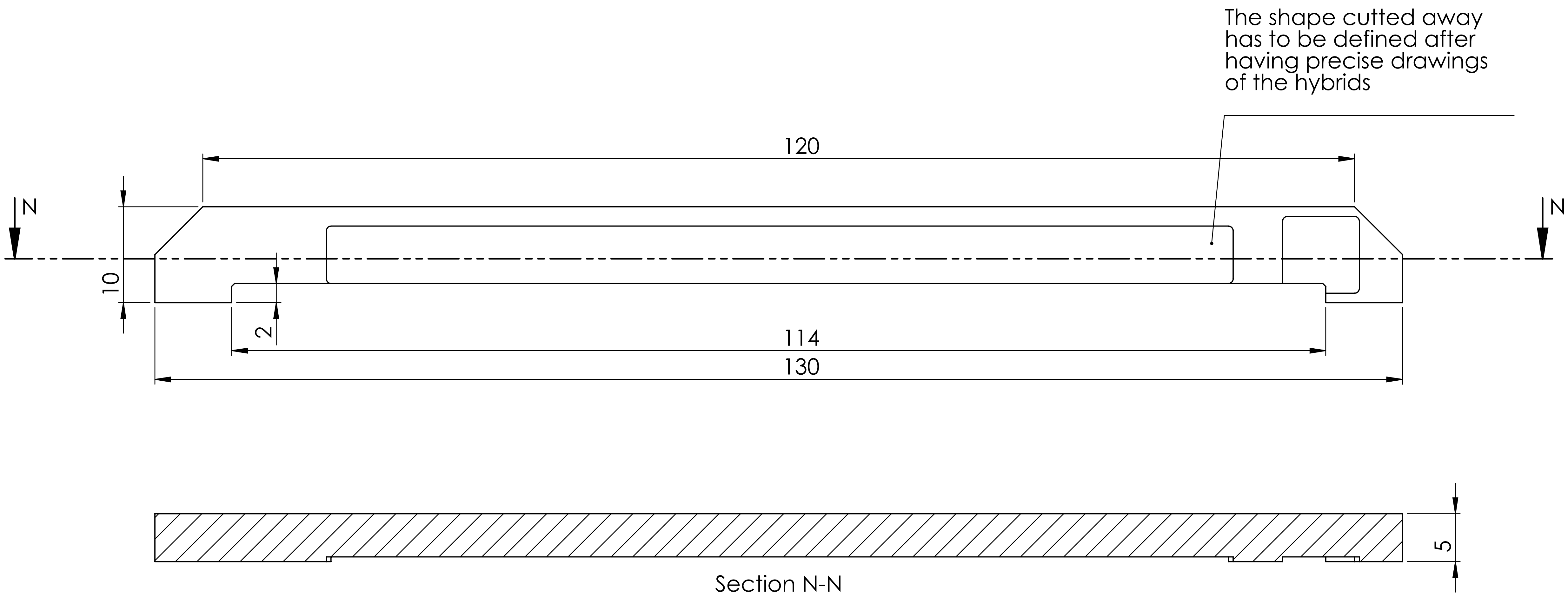
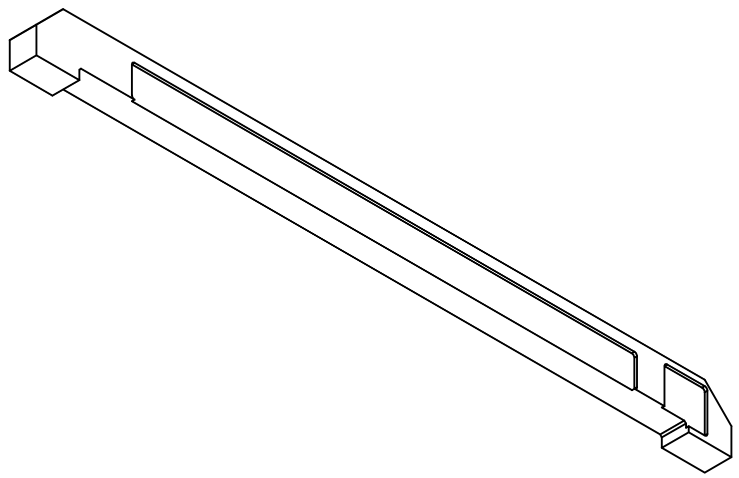
		Frei. REL.		
		Gen. APR.		

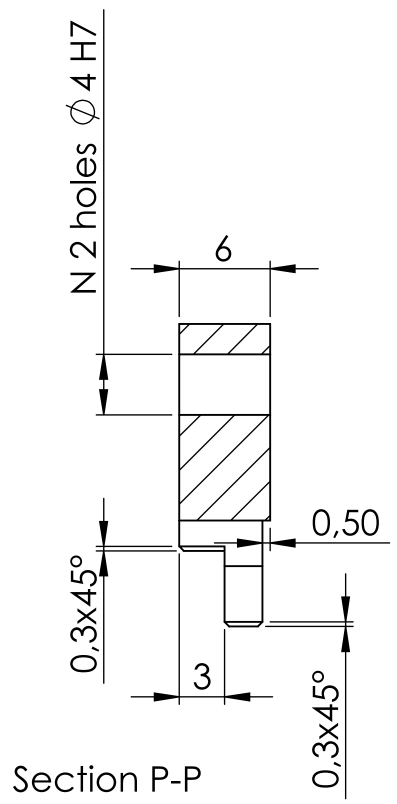
Dokument-Nr. / DOCUMENT NO. 11				Blatt SHEET 1 von OF 1
Zchng.-ID DRAW.-ID	Rev. REV.	Ver. VER.	Status STATUS	



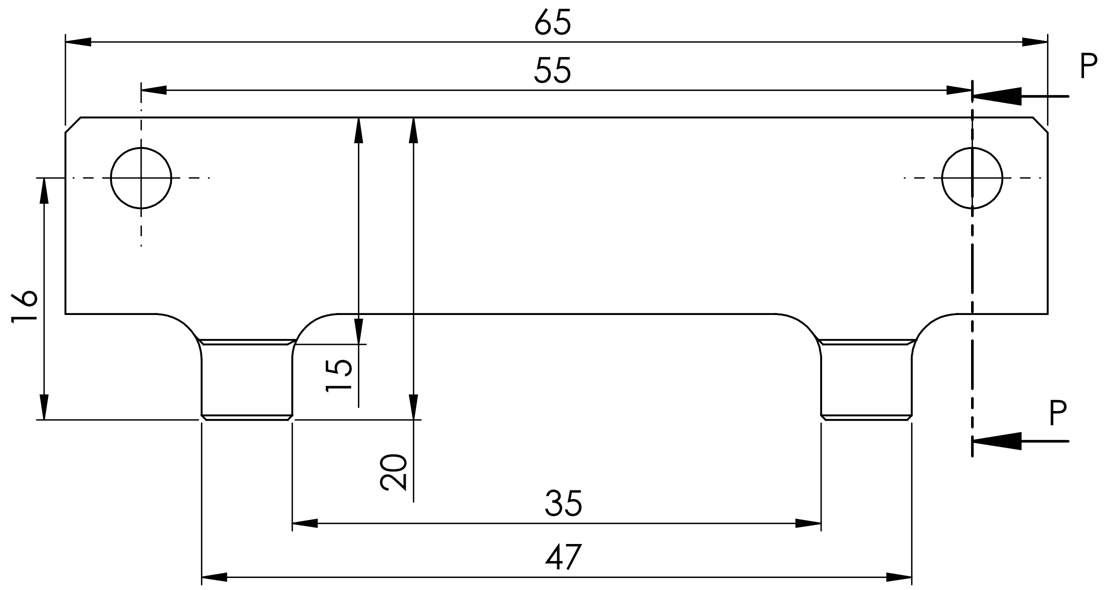


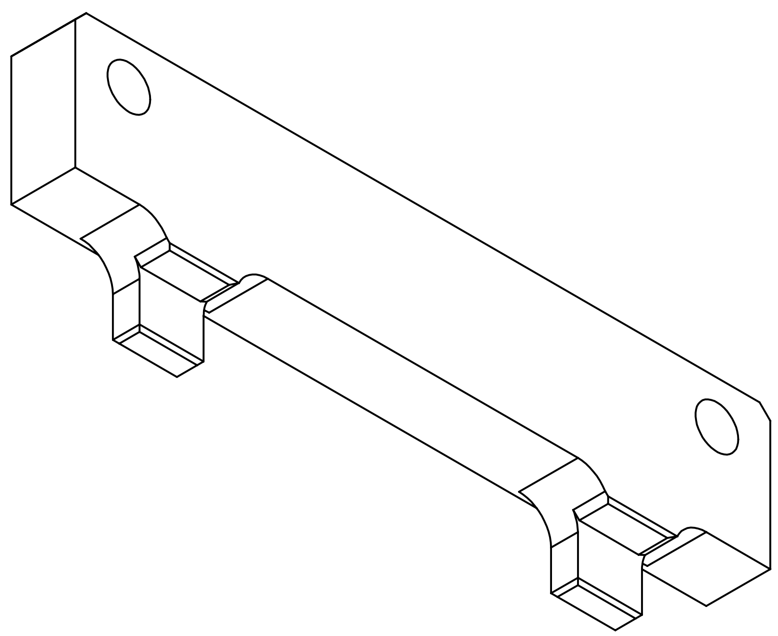
The right part is obtained mirroring the left part

Projekt / PROJECT HL-LHC	Arbeitspaket / WORKPACKAGE PS Module Assembly system	Gruppe / GROUP CMS	Ers.für / REPLACES	Ers.durch / REPLACED BY
Gewicht / WEIGHT	Halbzeug / SEMIFINISHED PRODUCT	DESY	Werkstoff / MATERIAL Aluminum	Format/SIZE A3
Allg. Toleranzen / GENERAL TOLERANCES ISO 2768 ISO 13920 Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE ISO 8015 Oberflächenkenngrößen / SURFACE TEXTURE ISO 1302 4287, 4288	Toleranzklasse / TOLERANCE CLASS mH	Maßstab / SCALE 2:1 Teil-ID PART-ID	Titel / TITLE Hybrid holder left (and right)	
		Datum/DATE	Name / NAME	
	Gez. CRE.	09/09/14	Daniele Pasciuto	
	Gepr. REV.			Dokument-Nr. / DOCUMENT NO. 12
	Frei. REL.			Blatt SHEET 1 von OF 1
	Gen. APR.			Zchng.-ID DRAW.-ID / Rev. REV. / Ver. VER. / Status STATUS



Section P-P

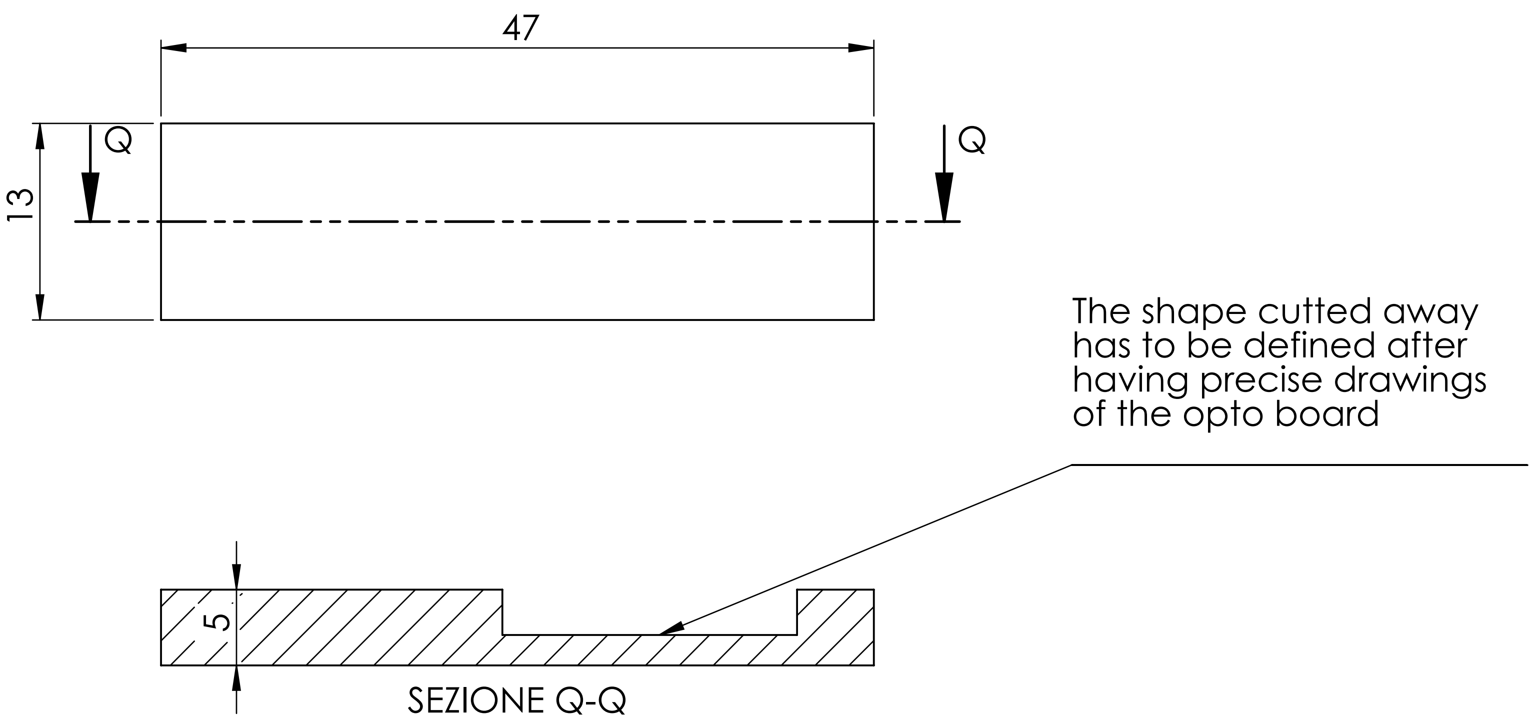


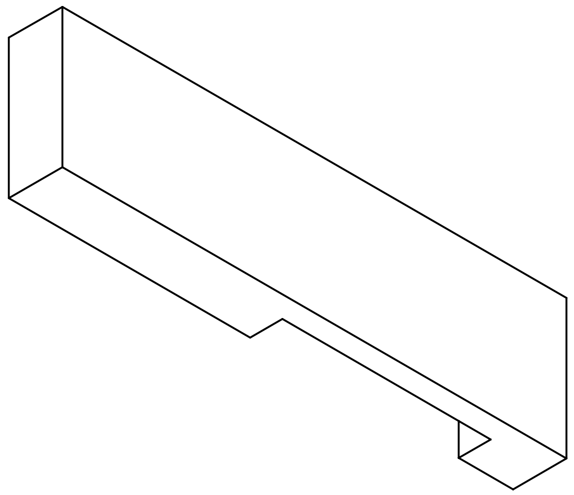


Not marked chanfers are 1x45°

Projekt / PROJECT	HL-LHC
Arbeitspaket / WORKPACKAGE	PS Module Assembly system
Gruppe / GROUP	CMS
Ers.für / REPLACES	
Ers.durch / REPLACED BY	
Gewicht / WEIGHT	
Halbzeug / SEMIFINISHED PRODUCT	
Werkstoff / MATERIAL	Aluminum
Format/SIZE	A3
Allg. Toleranzen / GENERAL TOLERANCES	ISO 2768 ISO 13920
Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE	ISO 8015
Oberflächenkenngrößen / SURFACE TEXTURE	ISO 1302 4287, 4288
Toleranzklasse / TOLERANCE CLASS	mH
Maßstab / SCALE	2:1
Teil-ID PART-ID	
Titel / TITLE	Opto board template
Dokument-Nr. / DOCUMENT NO.	13
Blatt SHEET	1
von OF	1
Zchng.-ID DRAW. -ID	
Rev. REV.	
Ver. VER.	
Status STATUS	

	Datum/DATE	Name / NAME
Gez. CRE.	09/09/14	Daniele Pasciuto
Gepr. REV.		
Frei. REL.		
Gen. APR.		





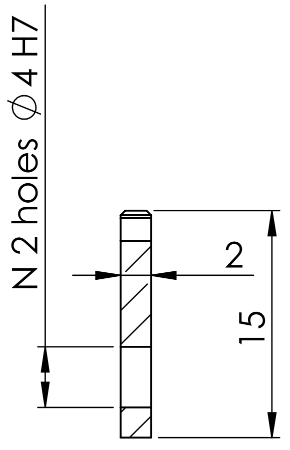
Projekt / PROJECT	Arbeitspaket / WORKPACKAGE	Gruppe / GROUP	Ers.für / REPLACES	Ers.durch / REPLACED BY
HL-LHC	PS Module Assembly system	CMS		

Gewicht / WEIGHT	Halbzeug / SEMIFINISHED PRODUCT	Werkstoff / MATERIAL	Format/SIZE
		Aluminum	A3

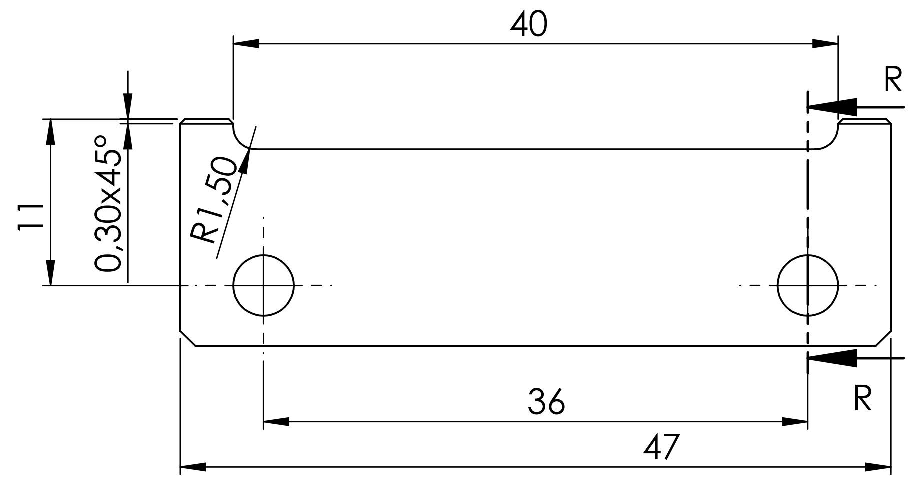
Allg. Toleranzen / GENERAL TOLERANCES: ISO 2768, ISO 13920
Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE: ISO 8015
Oberflächenkenngrößen / SURFACE TEXTURE: ISO 1302, 4287, 4288
Toleranzklasse / TOLERANCE CLASS: mH
Maßstab / SCALE: 2:1
Teil-ID / PART-ID:
Titel / TITLE: Opto boart holder

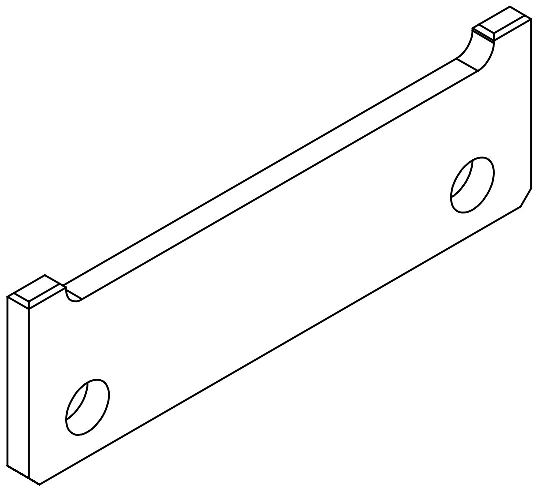
	Datum/DATE	Name / NAME
Gez. CRE.	09/09/14	Daniele Pasciuto
Gepr. REV.		
Frei. REL.		
Gen. APR.		

Dokument-Nr. / DOCUMENT NO.: 14
Blatt SHEET 1 von OF 1
Zchng.-ID DRAW.-ID | Rev. REV. | Ver. VER. | Status STATUS



Section R-R





Projekt / PROJECT HL-LHC	Arbeitspaket / WORKPACKAGE PS Module Assembly system	Gruppe / GROUP CMS	Ers.für / REPLACES	Ers.durch / REPLACED BY
Gewicht / WEIGHT	Halbzeug / SEMIFINISHED PRODUCT	DESY	Werkstoff / MATERIAL Aluminum	Format/SIZE A3
Allg. Toleranzen / GENERAL TOLERANCES ISO 2768 ISO 13920 Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE ISO 8015 Oberflächenkenngrößen / SURFACE TEXTURE ISO 1302 4287, 4288	Toleranzklasse / TOLERANCE CLASS mH	Maßstab / SCALE 2:1 Teil-ID PART-ID	Titel / TITLE Power board template	
		Datum/DATE	Name / NAME	
	Gez. CRE.	09/09/14	Daniele Pasciuto	
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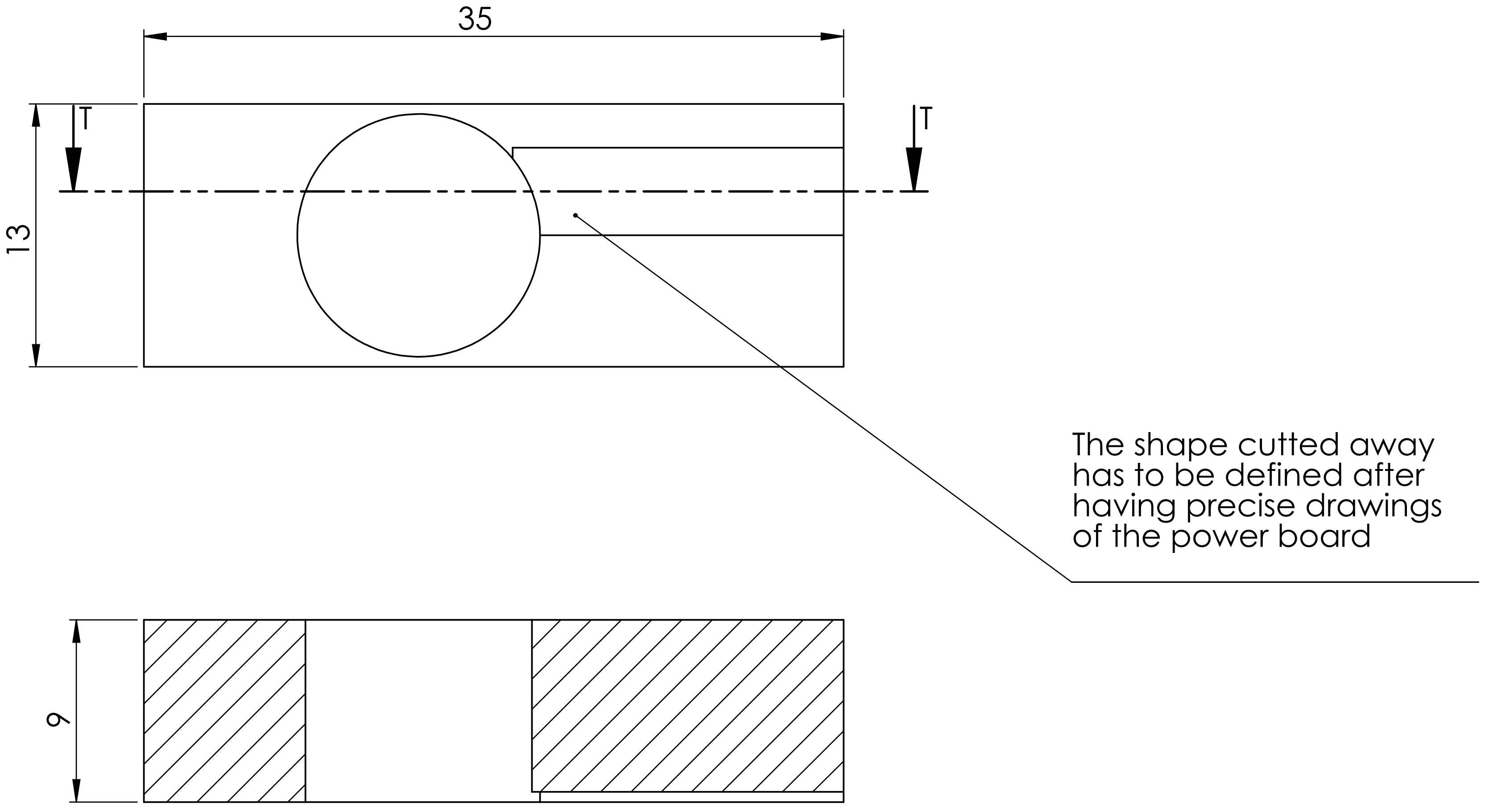
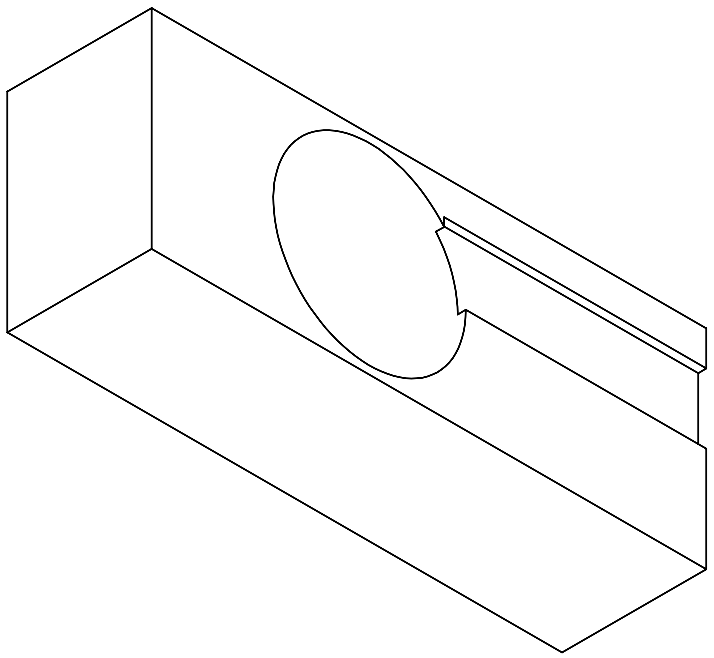
			Zchng.-ID DRAW.-ID	Rev. REV. / Ver. VER. / Status STATUS



SEZIONE T-T



Projekt / PROJECT	Arbeitspaket / WORKPACKAGE	Gruppe / GROUP	Ers.für / REPLACES	Ers.durch / REPLACED BY
HL-LHC	PS Module Assembly system	CMS		

Gewicht / WEIGHT	Halbzeug / SEMIFINISHED PRODUCT	Werkstoff / MATERIAL	Format/SIZE
		Aluminum	A3

Allg. Toleranzen / GENERAL TOLERANCES — ISO 2768, ISO 13920
Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE — ISO 8015
Oberflächenkenngrößen / SURFACE TEXTURE — ISO 1302, 4287, 4288
Toleranzklasse / TOLERANCE CLASS: mH
Maßstab / SCALE: 3:1
Teil-ID / PART-ID

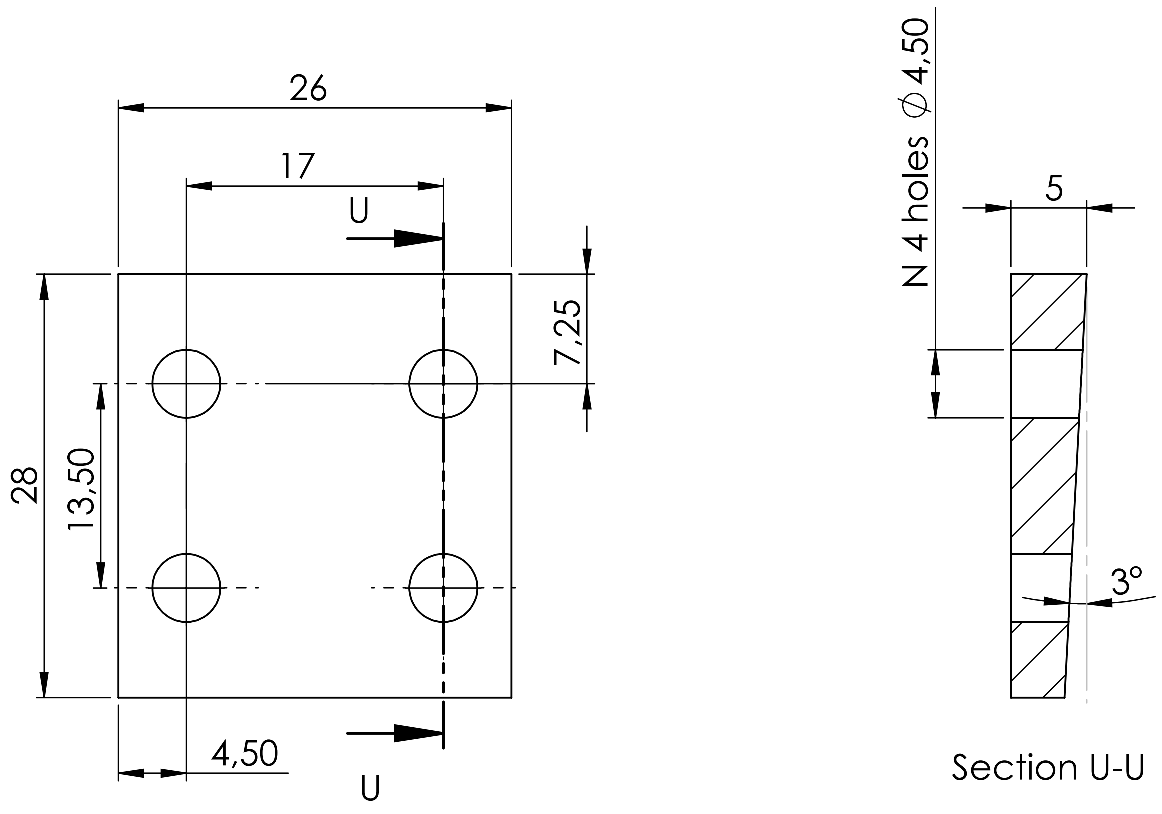
	Datum/DATE	Name / NAME
Gez. CRE.	09/09/14	Daniele Pasciuto
Gepr. REV.		
Frei. REL.		
Gen. APR.		

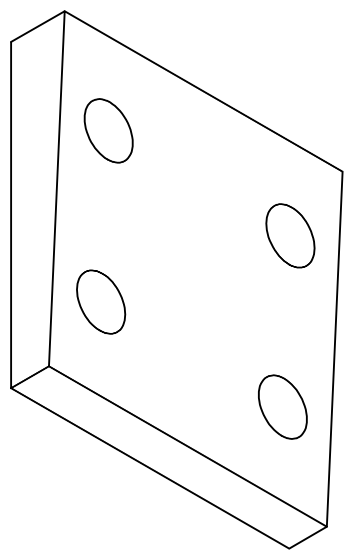
Titel / TITLE: Power board holder

Dokument-Nr. / DOCUMENT NO.: 16

Blatt SHEET 1 von OF 1

Zchng.-ID DRAW.-ID | Rev. REV. | Ver. VER. | Status STATUS





Projekt / PROJECT HL-LHC	Arbeitspaket / WORKPACKAGE PS Module Assembly system	Gruppe / GROUP CMS	Ers.für / REPLACES	Ers.durch / REPLACED BY	
Gewicht / WEIGHT	Halbzeug / SEMIFINISHED PRODUCT	DESY	Werkstoff / MATERIAL Aluminum		Format/SIZE A3
Allg. Toleranzen / GENERAL TOLERANCES ISO 2768 ISO 13920 Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE ISO 8015 Oberflächenkenngrößen / SURFACE TEXTURE ISO 1302 4287, 4288	Toleranzklasse / TOLERANCE CLASS mH	Maßstab / SCALE 2:1 Teil-ID PART-ID	Titel / TITLE Clamp step big		
		Datum/DATE / Name / NAME			
		Gez. CRE. 09/09/14 Daniele Pasciuto			
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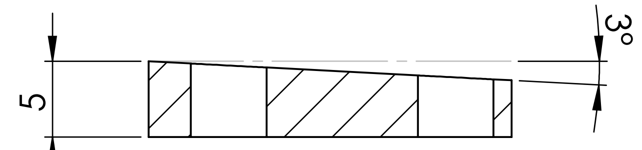
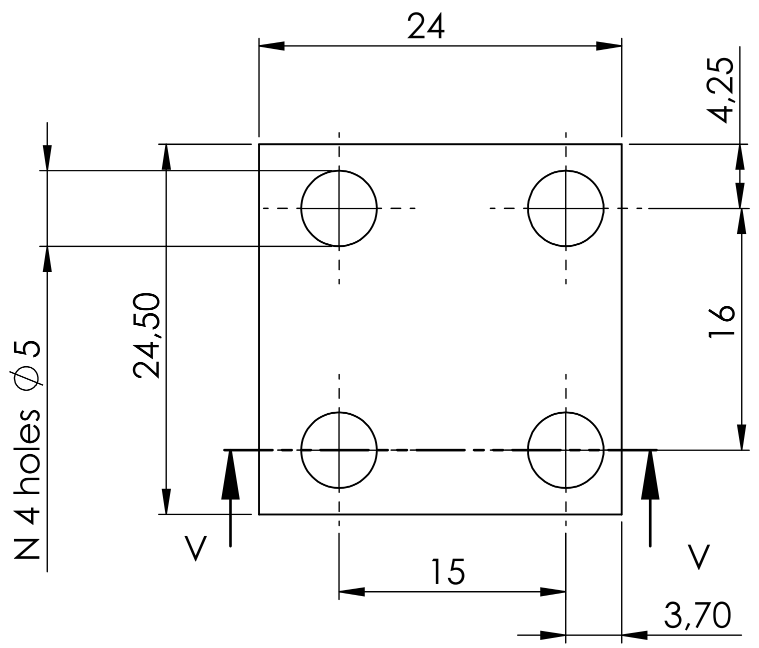
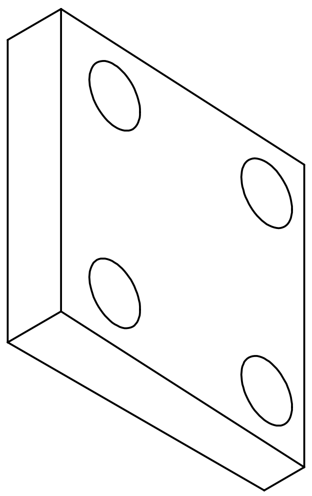
			Zchng.-ID DRAW.-ID	Rev. REV. / Ver. VER. / Status STATUS	



Section V-V





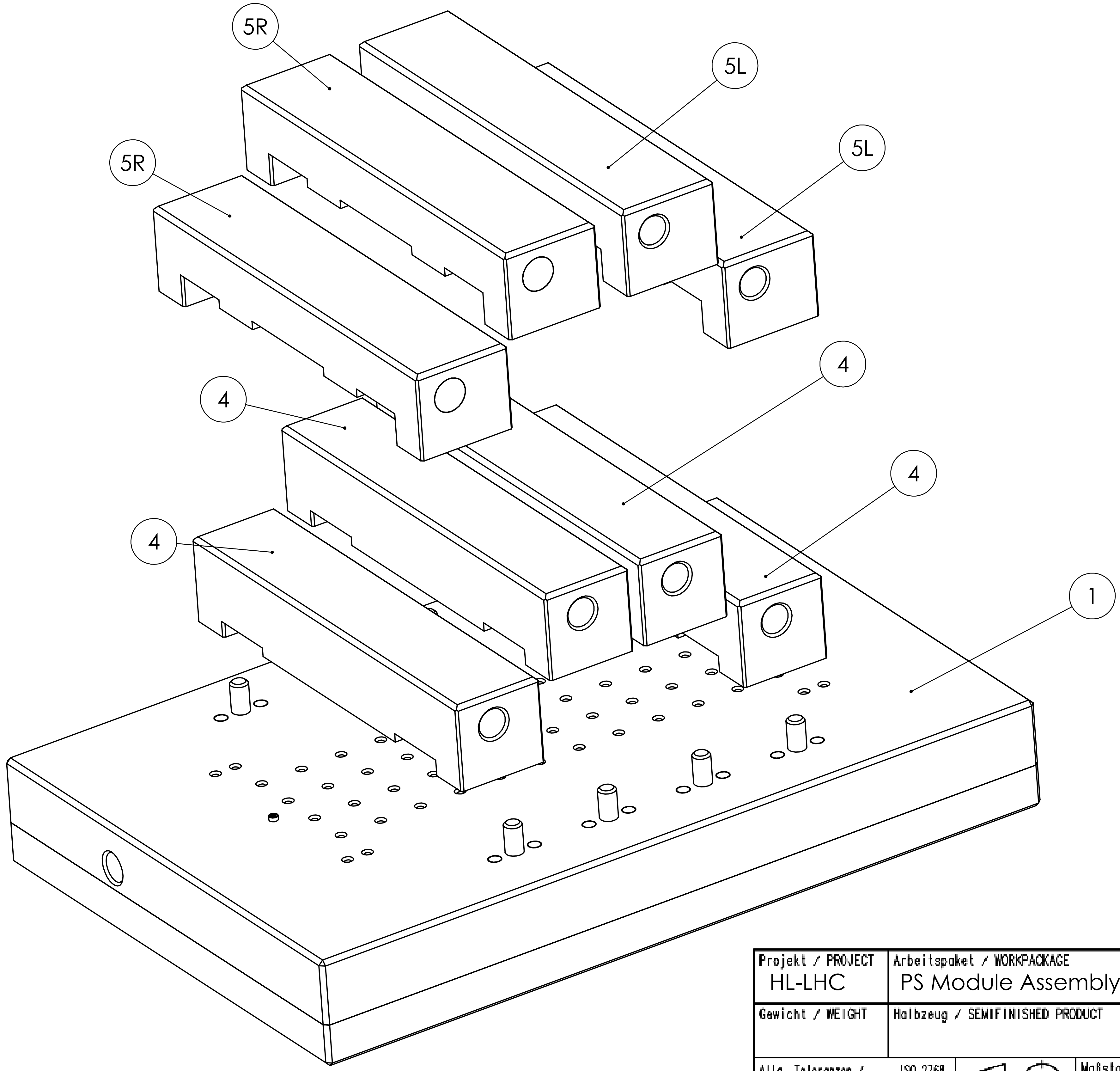
Projekt / PROJECT
HL-LHC
Arbeitspaket / WORKPACKAGE
PS Module Assembly system
Gruppe / GROUP
CMS
Ers.für / REPLACES
Ers.durch / REPLACED BY

Gewicht / WEIGHT
Halbzeug / SEMIFINISHED PRODUCT
DESY
Werkstoff / MATERIAL
Aluminum
Format/SIZE
A3

Allg. Toleranzen / GENERAL TOLERANCES ISO 2768 ISO 13920
Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE ISO 8015
Toleranzklasse / TOLERANCE CLASS
mH
Oberflächenkenngrößen / SURFACE TEXTURE ISO 1302 4287, 4288
Maßstab / SCALE
2:1
Teil-ID PART-ID
Titel / TITLE
Clamp step little

	Datum/DATE	Name / NAME
Gez. CRE.	09/09/14	Daniele Pasciuto
Gepr. REV.		
Frei. REL.		
Gen. APR.		

Dokument-Nr. / DOCUMENT NO.
18
Blatt SHEET 1
von OF 1
Zchng.-ID DRAW.-ID
Rev. REV.
Ver. VER.
Status STATUS



Projekt / PROJECT HL-LHC	Arbeitspaket / WORKPACKAGE PS Module Assembly system	Gruppe / GROUP CMS	Ers.für / REPLACES	Ers.durch / REPLACED BY
Gewicht / WEIGHT	Halbzeug / SEMIFINISHED PRODUCT	DESY	Werkstoff / MATERIAL	Format/SIZE A3

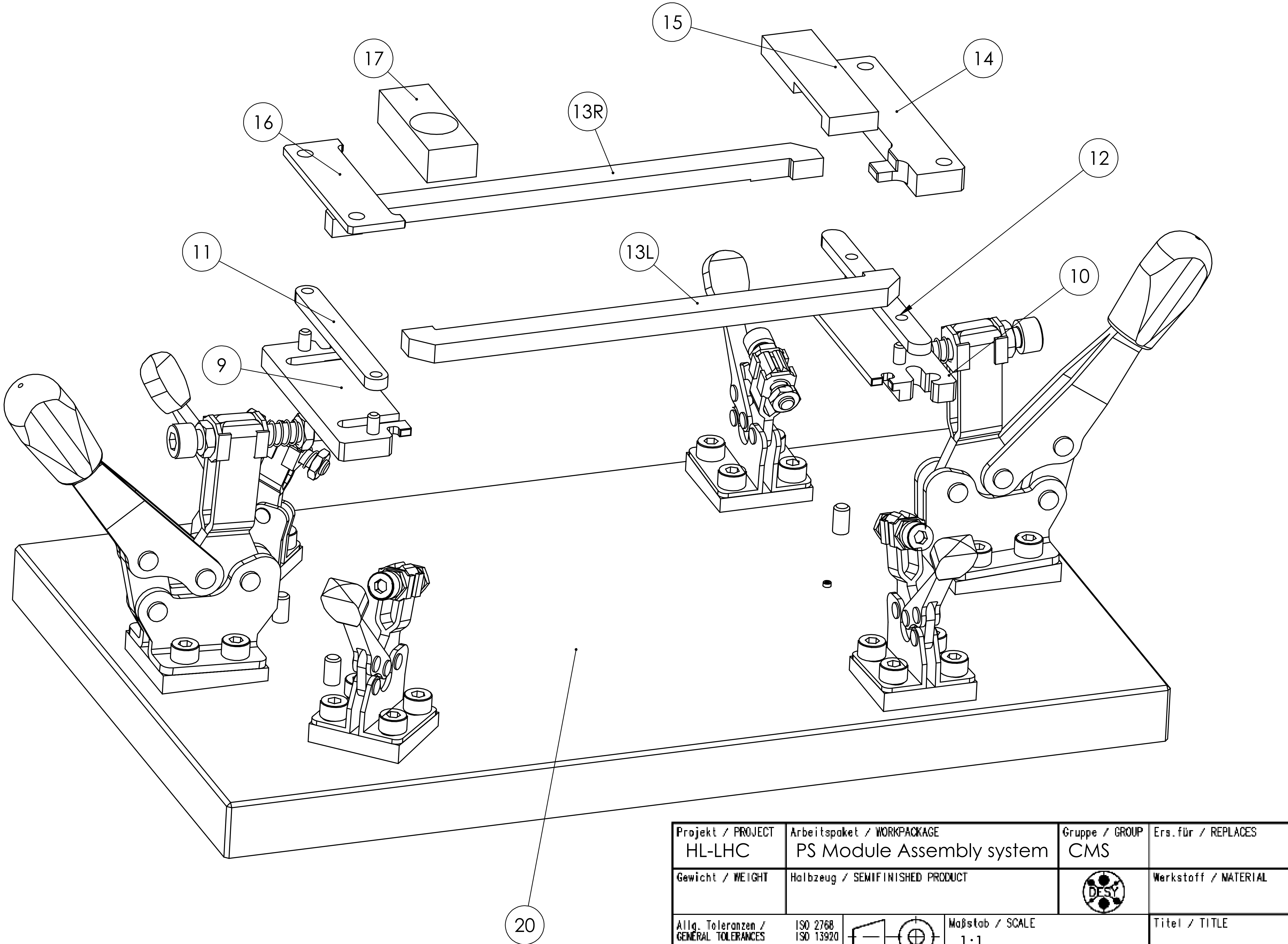
Allg. Toleranzen / GENERAL TOLERANCES	ISO 2768 ISO 13920		Maßstab / SCALE 1:1	Titel / TITLE Exploded view high precision operations
Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE	ISO 8015	Toleranzklasse / TOLERANCE CLASS mH	Teil-ID PART-ID	
Oberflächenkenngrößen / SURFACE TEXTURE	ISO 1302 4287, 4288			

	Datum/DATE	Name / NAME
Gez. CRE.	09/09/14	Daniele Pasciuto
Gepr. REV.		
Frei. REL.		
Gen. APR.		

Dokument-Nr. / DOCUMENT NO.
19

Blatt SHEET 1 von OF 1

Zchng.-ID DRAW.-ID | Rev. REV. | Ver. VER. | Status STATUS



Projekt / PROJECT: HL-LHC

Arbeitspaket / WORKPACKAGE: PS Module Assembly system

Gruppe / GROUP: CMS

Ers.für / REPLACES

Ers.durch / REPLACED BY

Gewicht / WEIGHT

Halbzeug / SEMIFINISHED PRODUCT

Werkstoff / MATERIAL

Format/SIZE: A3

Allg. Toleranzen / GENERAL TOLERANCES: ISO 2768, ISO 13920

Tolerierungsgrundsatz / FUNDAMENTAL TOLERANCING PRINCIPLE: ISO 8015

Oberflächenkenngrößen / SURFACE TEXTURE: ISO 1302, 4287, 4288

Toleranzklasse / TOLERANCE CLASS: mH

Maßstab / SCALE: 1:1

Teil-ID / PART-ID

	Datum/DATE	Name / NAME
Gez. CRE.	09/09/14	Daniele Pasciuto
Gepr. REV.		
Frei. REL.		
Gen. APR.		

Titel / TITLE: Exploded view low precision operations

Dokument-Nr. / DOCUMENT NO.: 20

Blatt SHEET 1 von OF 1

Zchng.-ID DRAW.-ID | Rev. REV. | Ver. VER. | Status STATUS