



Summer Student Report

Update on the Apparatus for Surface Physics and Interfaces at CERN's Ion Implantation Chamber (ASCII)

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Abstract

This report is a summary of the different tasks and updates done on the ASCII setup during the Summer Student Programme 2025 by student Felix Jeschek. This includes the installation of the ASCII Faraday cage, design and development of a Differential Vacuum Chamber (DVC) and its supporting structure including CAD modeling and molflow vacuum simulations. An Outlook for upcoming tasks can be found at the end of this report.

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Introduction

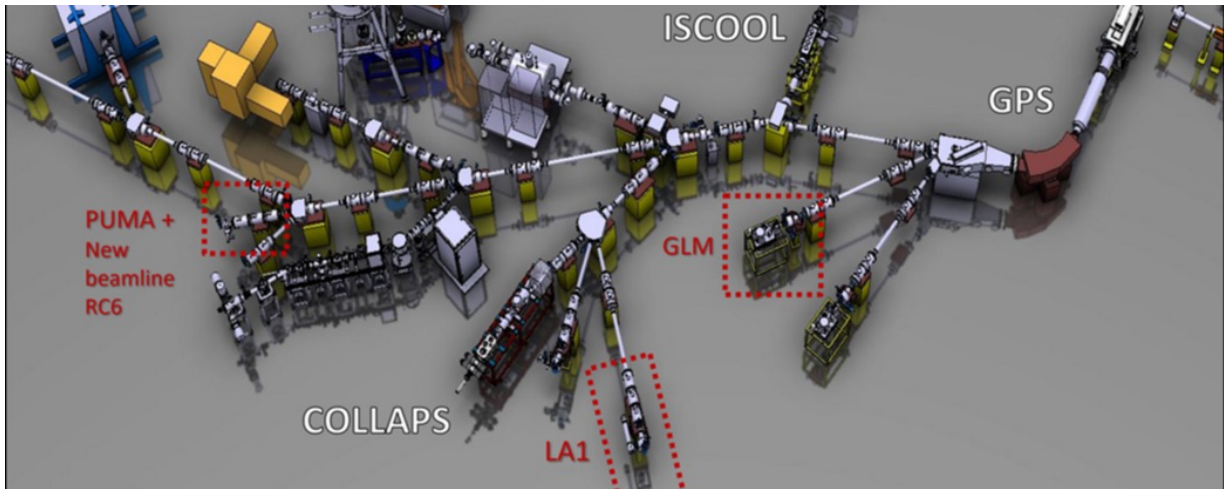


Figure 1: Location of the GLM area inside the ISOLDE hall

Inside the facilities of the Isotope Separator On Line Device (ISOLDE)¹ the Apparatus for Surface Physics and Interfaces at CERN's Ion Implantation Chamber (ASCII)^{2,3,4} is currently under construction to enable ultra low energy ion implantation of radioactive isotopes onto and into 2D materials as well as multiferritics in the near future at the General-purpose separator Low Mass beam line (GLM) (Also see letters of intent: [3](#), [4](#)). Delivered in March 2023, several people under supervision of Juliana Schell have continuously improved and refined the ASCII setup. Important to name in arbitrary order: PhD students Nicole Pereira de Lima and Arnaldo Alves Miranda Filho as well as the summer students Hannes Guerlich and Carl Jarschke. Their work and reports can be found in the cernbox shared ASCII folder. This introduction on ASCII is heavily based on those reports. This document reports on the progress on the ASCII setup during the CERN Summer Student Programme 2025. This includes:

- **Corrections and installment of ASCII's Faraday cage** ensuring continuous electrical safety during handling
- **Design and simulation of a differential vacuum chamber (DVC)** between GLM beam line and ASCII to ensure stable ultra high vacuum (UHV) throughout experiments.
- **CAD drawings of ASCII and the GLM area** including ASCII, the new ion implantation chamber and miscellaneous electrical equipment.

ASCII Chamber

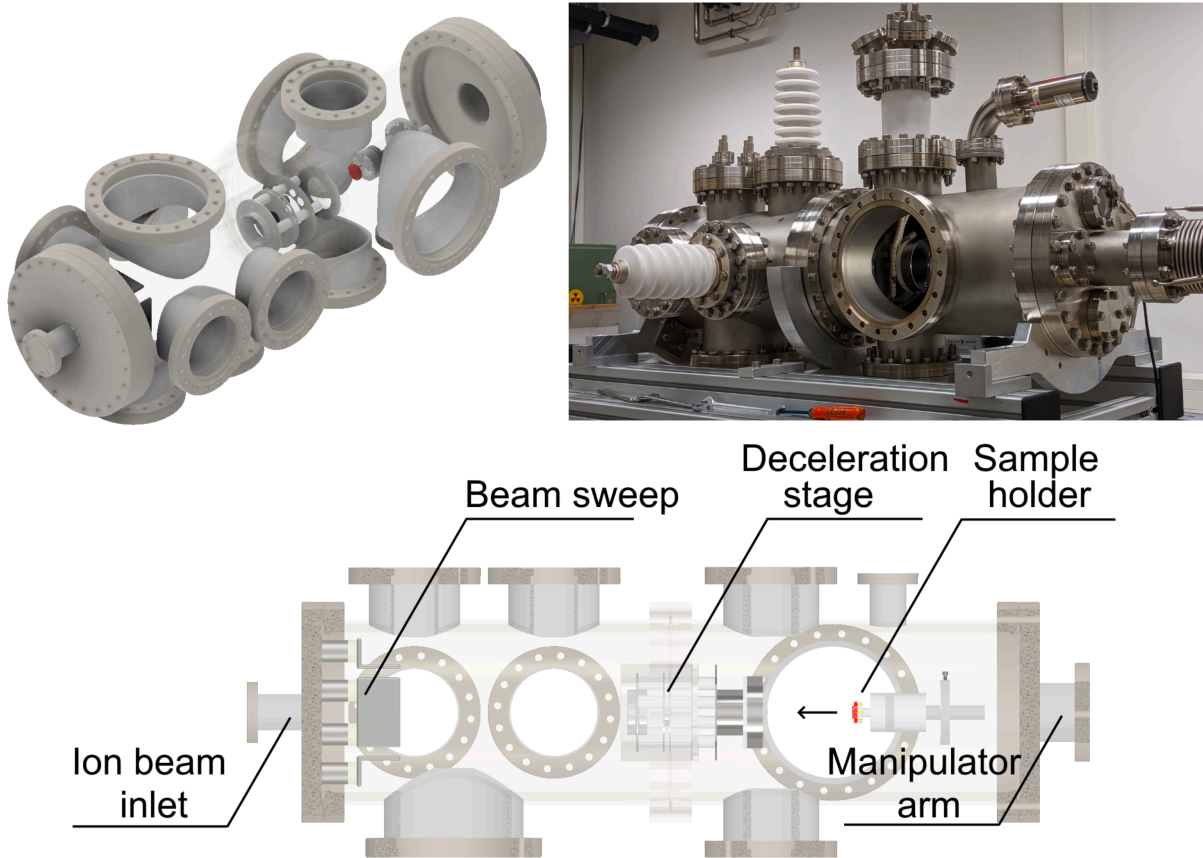


Figure 2: ASCII's internal deceleration setup

ASCII's purpose is the ultra-low energy implantation (≥ 20 eV) of ions in and onto surfaces and interfaces to study their not yet researched properties. Using several vacuum pumps and being bakeable at 150°C an ultra-high vacuum (UHV) ($< 10^{-9}$ mbar) during operation is ensured. A combination of beam sweep, deceleration stage and sample holder are providing a precise control over the implantation area and depth at the sample. Their specifications are listed here:

- **Beam sweep:** Positioned directly after the beam inlet, the beam sweep is made out of four electrodes arranged in a square around the beam. By applying a preprogrammed alternating voltage the beam can be swept in a pattern over small angles ($\leq 1.5^{\circ}$). Earlier studies have shown that Fermats spiral patterns lead to a homogeneous implantation.⁵
- **Deceleration stage:** In the middle of the chamber the deceleration stage lowers the energy of incoming ions from $\leq 60\text{keV}$ to ≥ 20 eV by using an sequence of high voltage electrodes. The final ion energy is precisely tunable by adjusting the bias voltage of the last electrode.
- **Sample holder:** The sample holder is positioned at the end of the chamber and can hold one sample at a time. It is equipped with a bayonett locking system for efficient sample exchange and a heating element to reduce implantation-induced defects in the sample while enhancing the diffusion of ions into the sample.

Personal contributions to ASCII

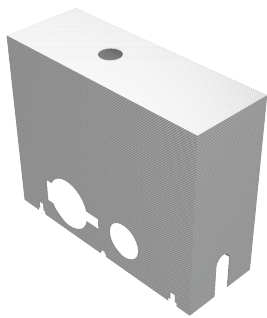
1 ASCII's Faraday cage

As the deceleration stage and the beam sweep of the ASCII chamber use high voltages, it was decided to shield the protruding connectors to ensure the continuous electrical safety of anyone operating the setup. ASCII's Faraday cage (AFC) was already designed in 2024 by summer student Carl Jarschke. Additional work and changes on parts were implemented by Arnaldo Alves Miranda Filho. Corrections and assembly was done during this years summer student programme.

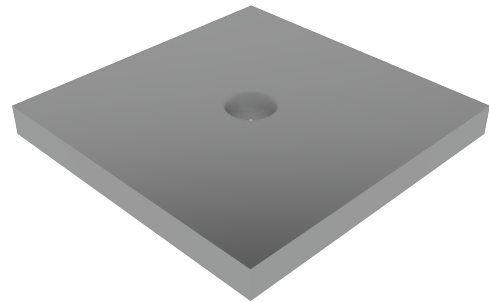
The cage is made out of a solid aluminium skeleton with four perforated aluminium plates (PAPs) which will be screwed to its sides and one on its top (see figure ??). Additionally, two cylindric insulator caps are screwed to two side walls shielding the connectors of Faraday cup and deceleration state.

Due to mistakes in the cutting of the PAP and the additional height added by the AFC's mount several corrections had to be added which are shown in figure 4. This included enlarging the cutout for the knob of the loading flange and a 5mm down shift of the side PAPs. For the complete technical drawing, see [A](#).

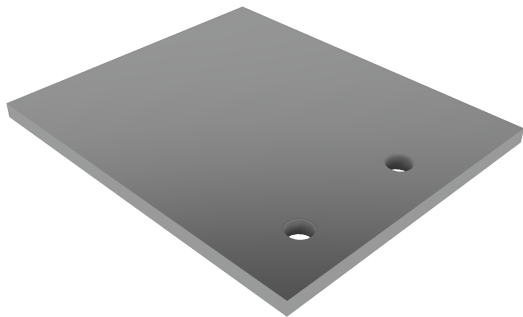
- previous design didnt fit properly due to supporting plates and door flange
- corrections and mounting of cage
- drawings



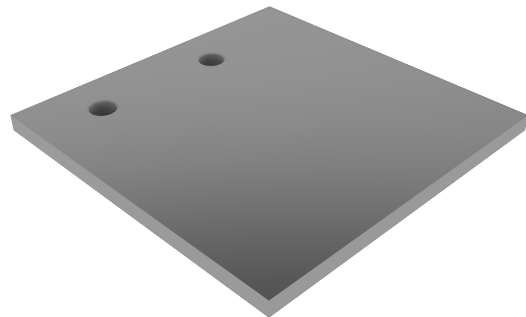
(a) ASCII's FC main body



(b) ASCII's FC skeleton foot plate



(c) ASCII's FC support initial plate



(d) ASCII's FC support end plate

Figure 3

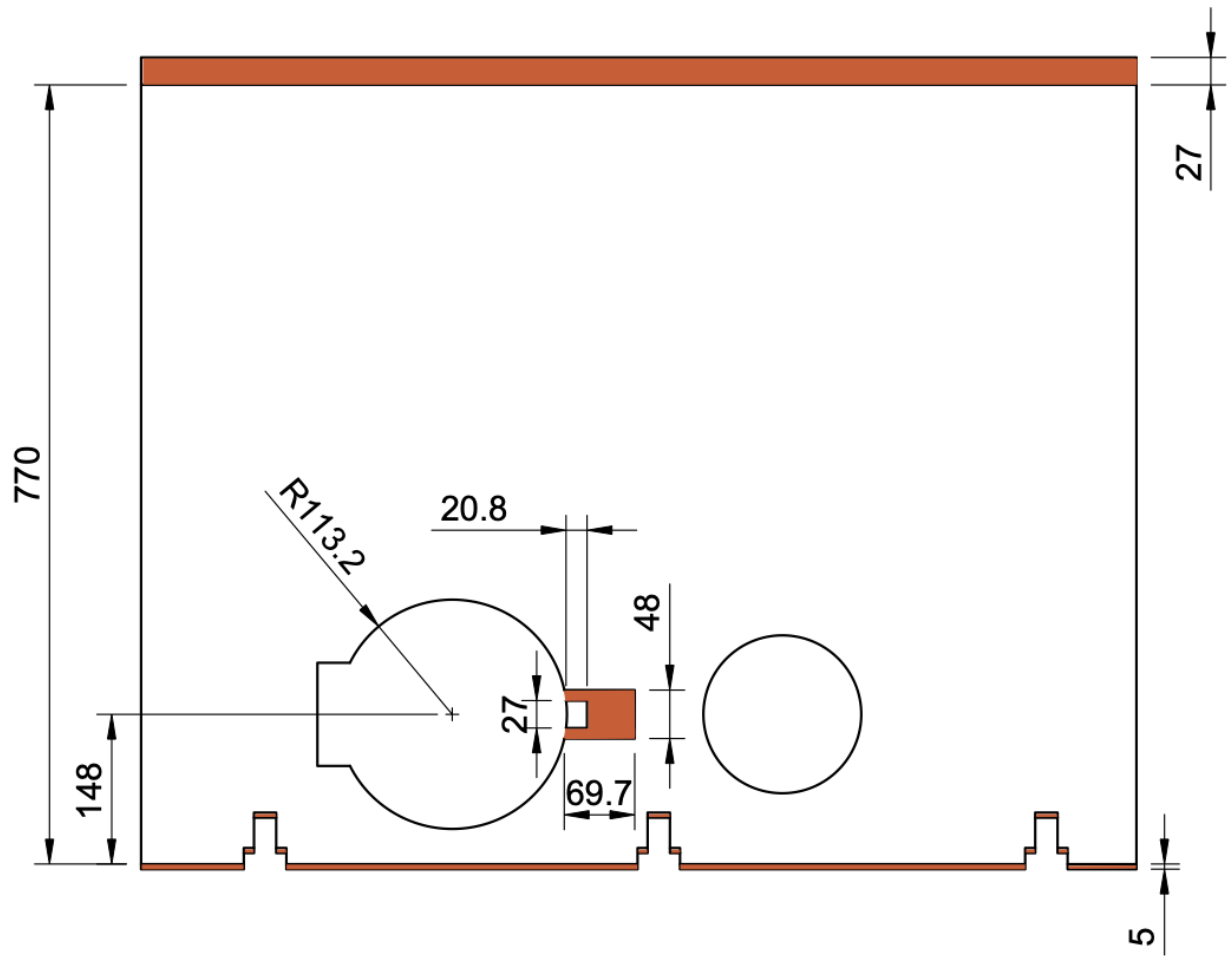


Figure 4: Corrections made to the ASCII Faraday cage design. Subtractive changes are shown in red

The corrections are exemplary shown in figure 4. The current design of the ASCII Faraday cage can be found in the appendix. Below a first mounting using tape is shown

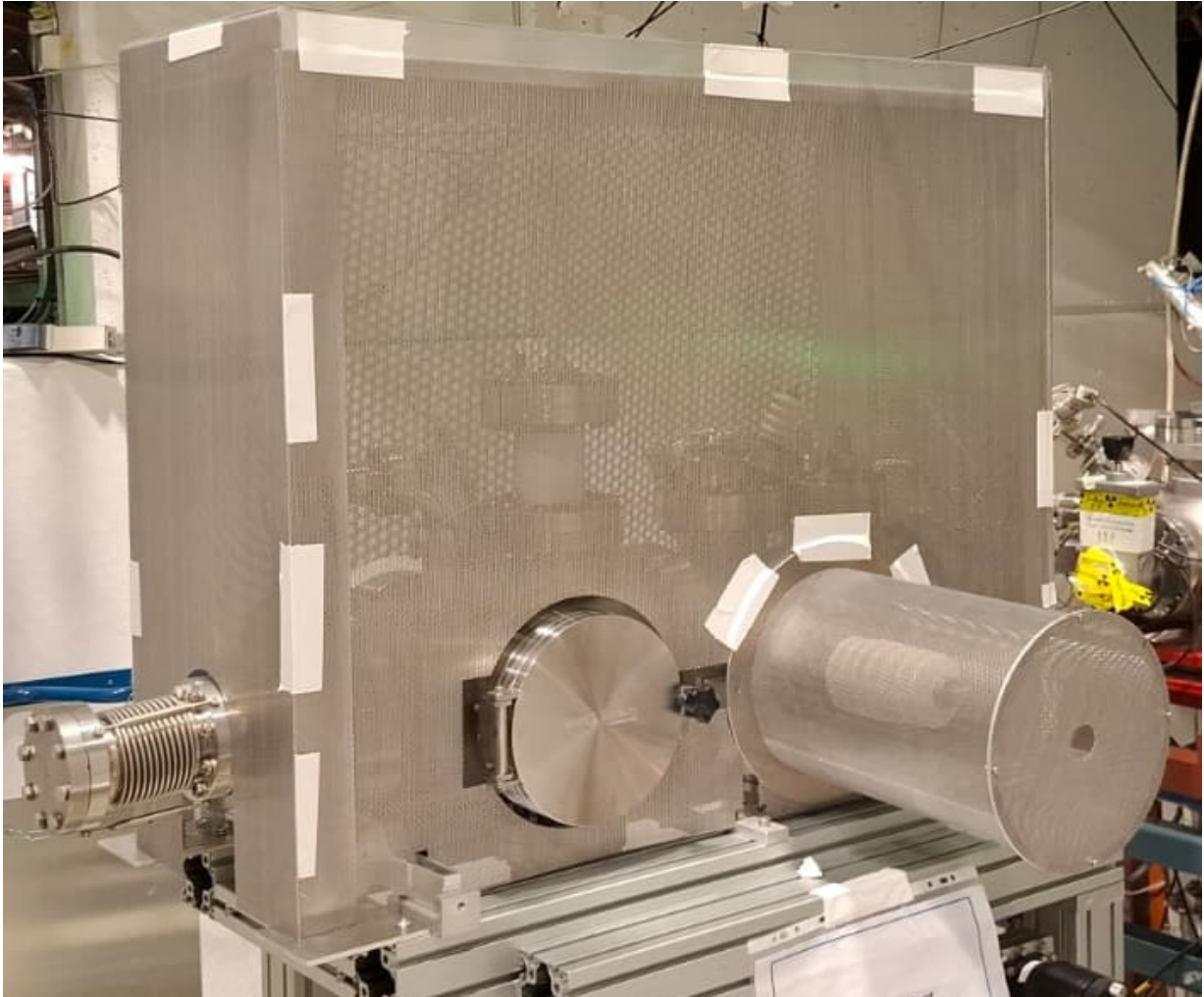


Figure 5: Mounted ASCII Faraday cage (door side)

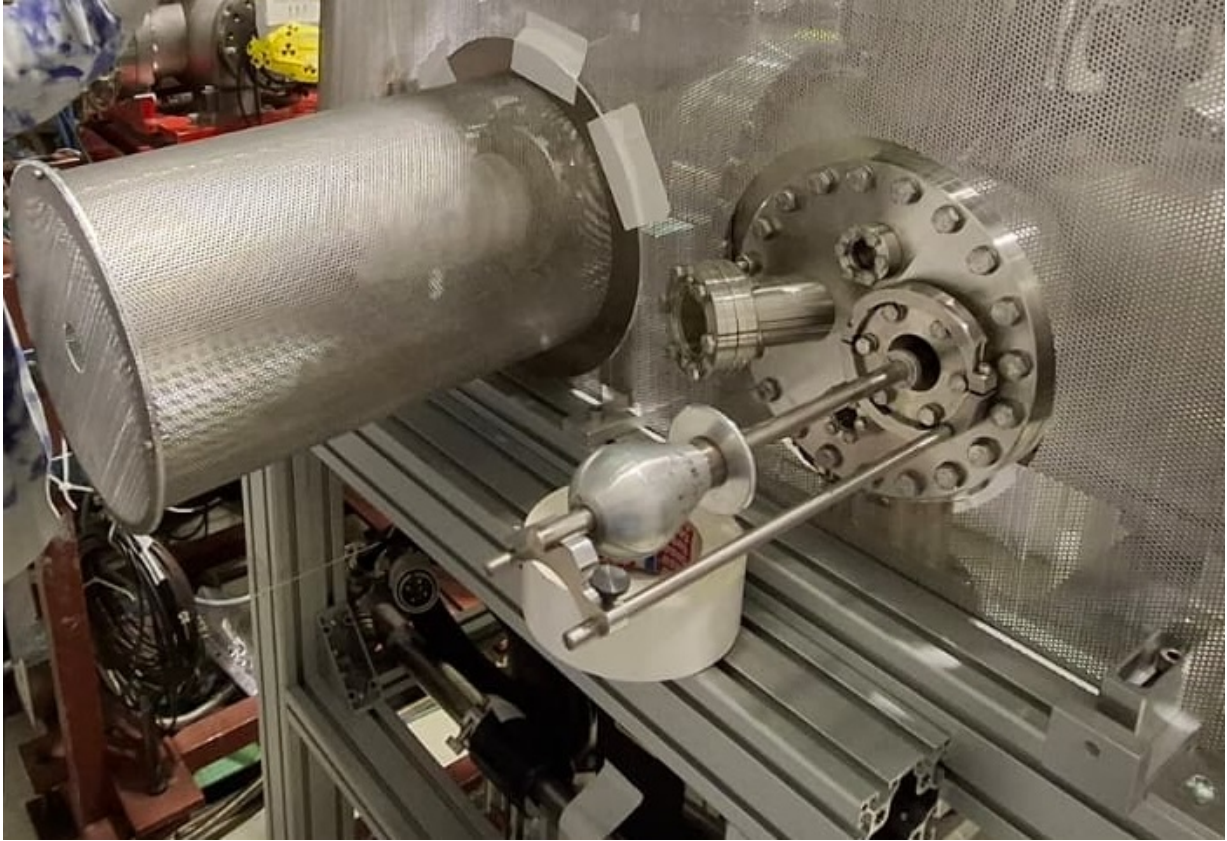


Figure 6: Mounted ASCII Faraday cage (other side)

2 Differential Vacuum Chamber

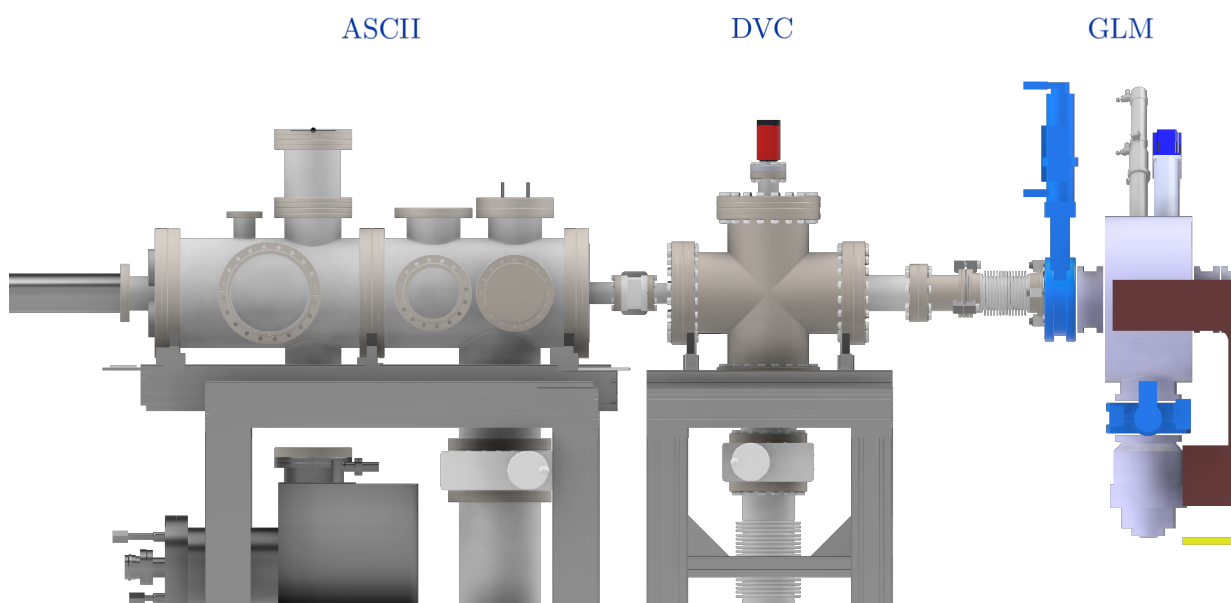


Figure 7: Placement of DVC between ASCII and GLM beam line

The Differential Vacuum Chamber (DVC) will reduce the vacuum gradient between GLM beam line (10^{-6} mbar) and ASCII ($\leq 10^{-9}$ mbar) to ensure a stable and constant UHV throughout the ASCII setup. This will be achieved by using two gasket plates with custom-made holes between each GLM-DVC and DVC-ASCII (see figure 8). This leads to the vacuum being partially confined in both DVC and ASCII.

To verify the design, vacuum simulations were conducted using molflow⁶ as discussed in the following section.

Additionally a DVC supporting aluminium structure was designed on the basis of ASCII's supporting structure to allow for a stable, horizontal and vertical adjustable setup.

At last a table of all components ordered for the DVC (last update: 28.08.2025) is shown.

2.1 Gasket Plates

The Gasket plates dimensions are based on standard DN CF flange gaskets. The first is a DN 63 CF gasket plate placed between GLM beam line and DVC. The second is a DN 40 CF gasket plate placed between DVC and ASCII. Both have holes with a 10 mm diameter. For all dimensions see technical drawings in appendix.

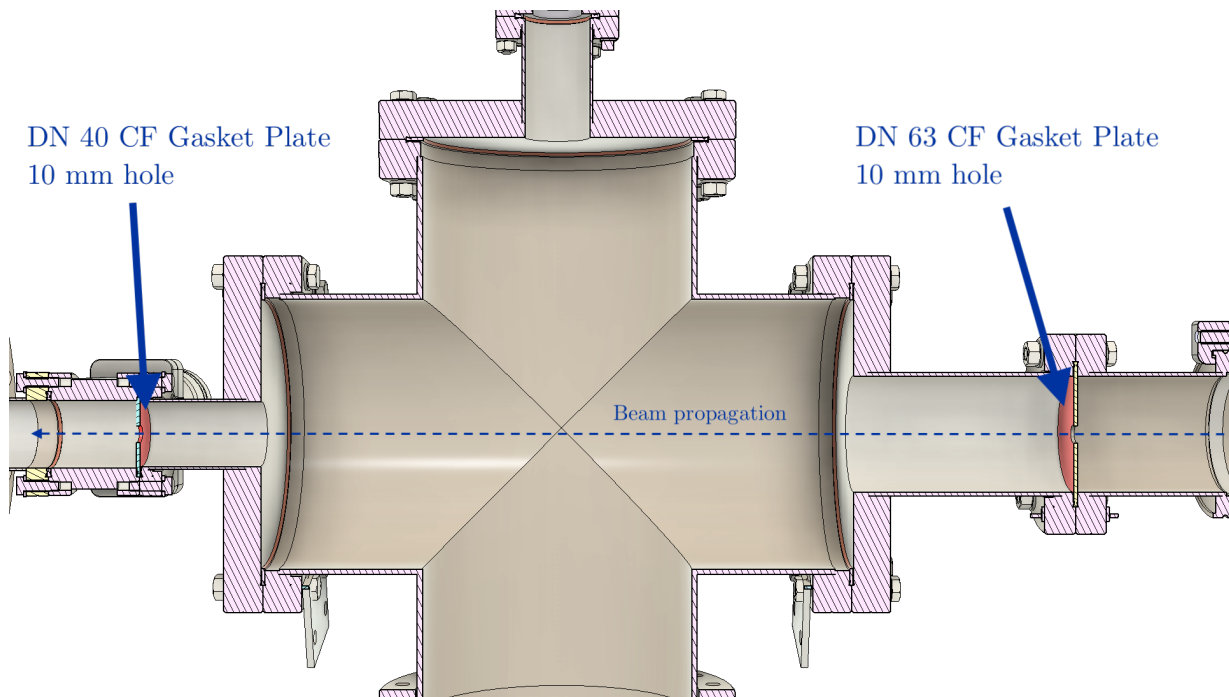


Figure 8: Cross section of DVC showing placement of custom copper gaskets with 10 mm holes to confine the vacuum in DVC and ASCII

In earlier discussions it was thought of implementing an Einzellens in case of significantly elongating the total beam path length. Since the DVC will replace the old ion implantation chamber there will be no significant change in the total beam path length. Therefore, it was decided to not include an Einzel lens in the DVC.

2.2 Connections

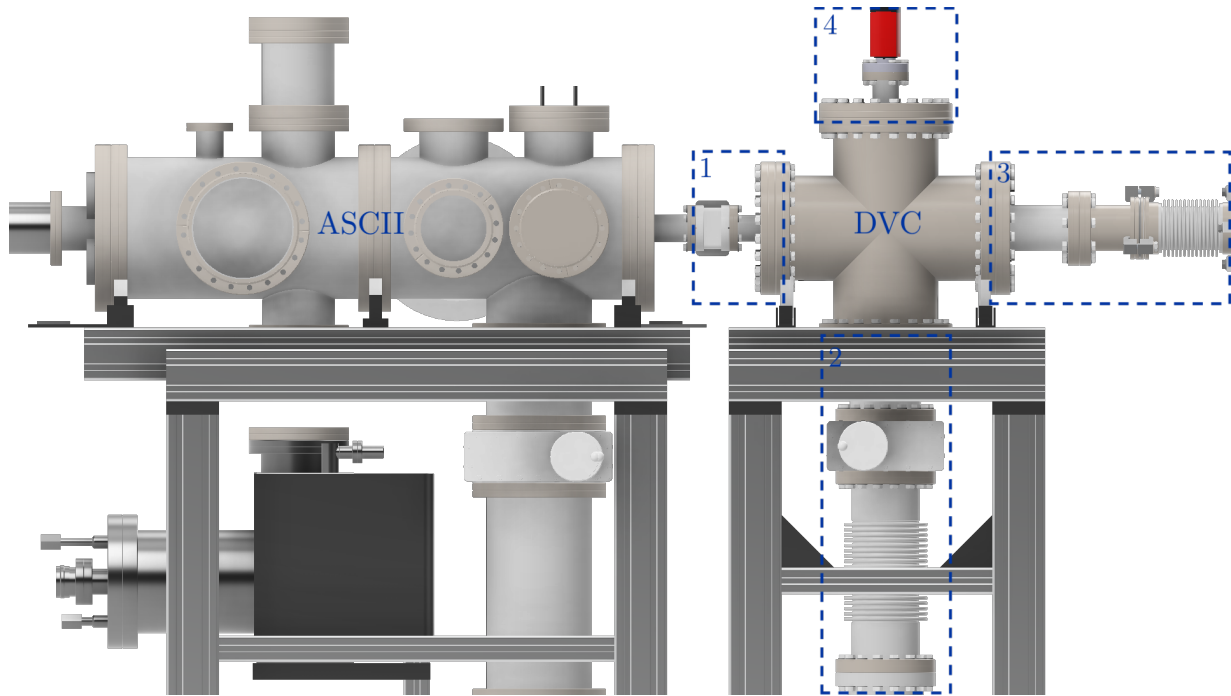


Figure 9: Connections attached to the DVC: 1. ASCII, 2. Vacuum Pump, 3. GLM, 4. Vacuum Sensor

As the DVC is mainly composed of a cross, four connections have to be made, namely (numbered from 1-4 in figure 9) to ASCII, a vacuum pump, GLM and to a vacuum sensor. The main components were all ordered at <https://www.shop.buschgroup.com> and are listed in directional order (screws and clamps are listed in the appendix):

1. ASCII to DVC

- Copper gasket, OFHC copper, DN 40 CF
- UHV gate valve, DN 40 CF, metric, manual, SS/Cu/FKM
- Custom copper gasket plate DN 40 CF with 10mm hole
- Straight reducing piece, stainless steel 304L, DN 160-40 CF
- Copper gasket, OFHC copper, DN 160 CF

2. DVC to vacuum pump

- Copper gasket, OFHC copper, DN 160 CF
- Straight reducing piece, stainless steel 304L, DN 160-100 CF
- Copper gasket, OFHC copper, DN 100 CF
- UHV gate valve, DN 100 CF, metric, manual, SS/Cu/FKM
- Copper gasket, OFHC copper, DN 100 CF
- Bellow tube, stainless steel: Flange 304L, bellows 316L, DN 100 CF (custom length 305mm)

- Copper gasket, OFHC copper, DN 100 CF
- Splinter shield for turbopumps, DN 100 CF-F
- HiCube Classic 300

3. DVC to GLM

- Copper gasket, OFHC copper, DN 160 CF
- Straight reducing piece, stainless steel 304L, DN 160-63 CF
- Custom copper gasket plate DN 63 CF with 10mm hole
- Adapter, stainless steel 304/1.4301, CF flange 304L, DN 63 CF/ DN 63 ISO-K
- Centering ring with outer ring, aluminum, FKM, DN 63 ISO-K
- Bellow tube, stainless steel: flange 304; bellows 316L, DN 63 ISO-K
- Centering ring with multifunction coating, DN 63 ISO-K/-F

4. DVC to vacuum sensor

- Copper gasket, OFHC copper, DN 160 CF
- Straight reducing piece, stainless steel 304L, DN 160-40 CF
- Copper gasket, OFHC copper, DN 40 CF
- PKR 360, low current, DN 40 CF-F

2.3 Molflow⁶ simulations

Simulating a vacuum gives valuable first insights about constraints and necessary changes to the setup before engaging in the often expensive and time consuming installation. To check that the DVC would ensure a stable vacuum inside ASCII, molflow simulations were conducted including GLM beam line, DVC and ASCII. For these simulations one needs information about the pumping speed of primary gases concerned in the experiment as well as the dimension of the inside of the camber complex and the outgassing rate of the used material.

First a 3D model of the inner walls of the GLM-DVC-ASCII connection had to be designed. This was done by using the existing models of GLM beam line and ASCII chamber and by designing the DVC. The final model can be found [here](#).

After consulting several papers on the hydrogen outgassing of baked stainless steel $3 \cdot 10^{-12}$ was chosen as upper value for all internal surfaces of the chambers.

Additionally, before combining all three chambers in one simulation, a pressure of 10^{-6} mbar had to be created inside the GLM beam line. This was achieved by iterating outgassing at the back end of the beam line and the pumping rate of the vacuum pump at its front end. The final values are $2.5 \cdot 10^{-6} \frac{\text{mbar} \cdot \text{l}}{\text{s} \cdot \text{cm}^2}$ for the outgassing back end and 250 and $300 \frac{\text{l}}{\text{s}}$ for the front end vacuum pump regarding the pumping rates of H_2 and N_2 . Regarding DVC and ASCII, their pump configurations were chosen according to the used vacuum pumps which are the following:

1. GLM pump

Pumping speed:

- N_2 : $300 \frac{\text{l}}{\text{s}}$
- H_2 : $250 \frac{\text{l}}{\text{s}}$

2. HiCube 300 Classic⁷

Pumping speed:

- N_2 : $260 \frac{l}{s}$
- H_2 : $220 \frac{l}{s}$

3. TwisTorr 704 FS Turbo Pump⁸

Pumping speed:

- N_2 : $660 \frac{l}{s}$
- H_2 : $480 \frac{l}{s}$

4. VacIon Plus 150 Combination Pump⁹

Pumping speed:

- N_2 : $610 \frac{l}{s}$
- H_2 : $1380 \frac{l}{s}$

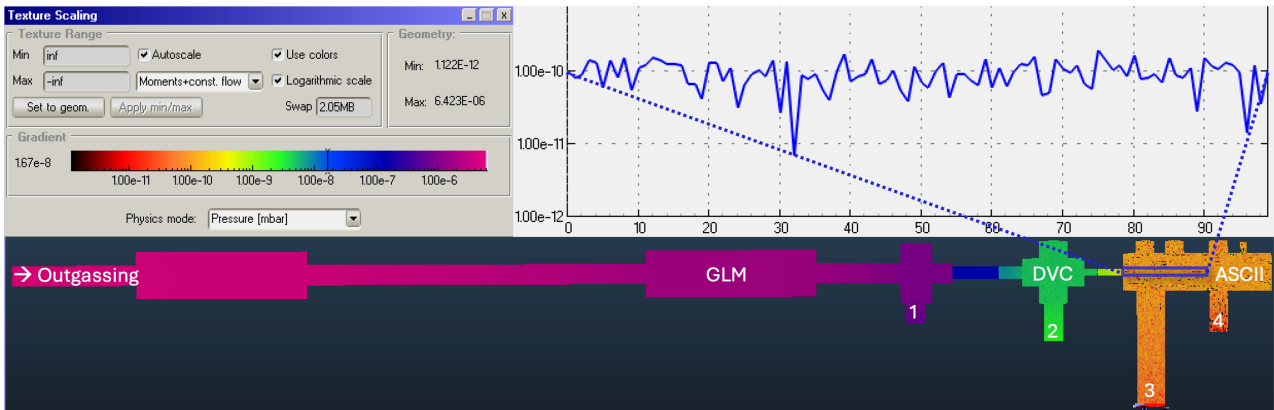


Figure 10: Molflow simulation of ASCII setup for N_2 . Outgassing rate: $300 \frac{mbar \cdot l}{s \cdot cm^2}$. For pump rates of pumps 1-4 see above. Final pressure in ASCII chamber: $1 \cdot 10^{-10}$ mbar



Figure 11: Molflow simulation of ASCII setup for H_2 . Outgassing rate: $250 \frac{mbar \cdot l}{s \cdot cm^2}$. For pump rates of pumps 1-4 see above. Final pressure in ASCII chamber: $2 \cdot 10^{-10}$ mbar

As can be seen in figures 10 and 11 simulations for each Nitrogen and Hydrogen achieve a final pressure in ASCII of $1 \cdot 10^{-10}$ mbar and $2 \cdot 10^{-10}$ mbar respectively. The chosen setup therefore seems feasible to achieve the desired $\leq 10^{-9}$ mbar in ASCII even when accounting for additional outgassing factors of the actual setup.

2.4 DVC Supporting Structure

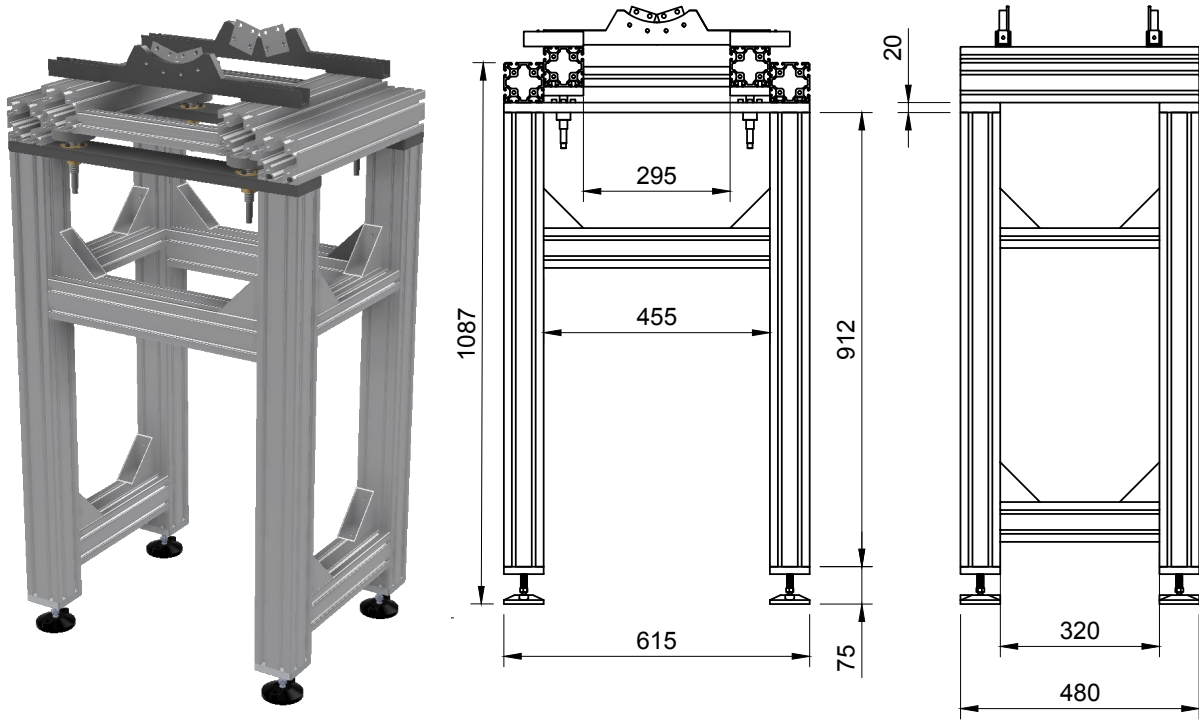


Figure 12: DVC supporting structure

The supporting structure of the DVC holds the weight of the DVC while enabling vertical and horizontal adjustment to ensure the alignment with the beam line. The design is a copy of the supporting structure of ASCII with adaptations regarding weight, and overall dimensions including similar features, i.e. a vertical and horizontal adjustable table. Most of the structure is made out of standard aluminium profiles purchased from [myaluprofil](#). Besides that several parts had to be designed and manufactured by the workshop or bought from different distributors.

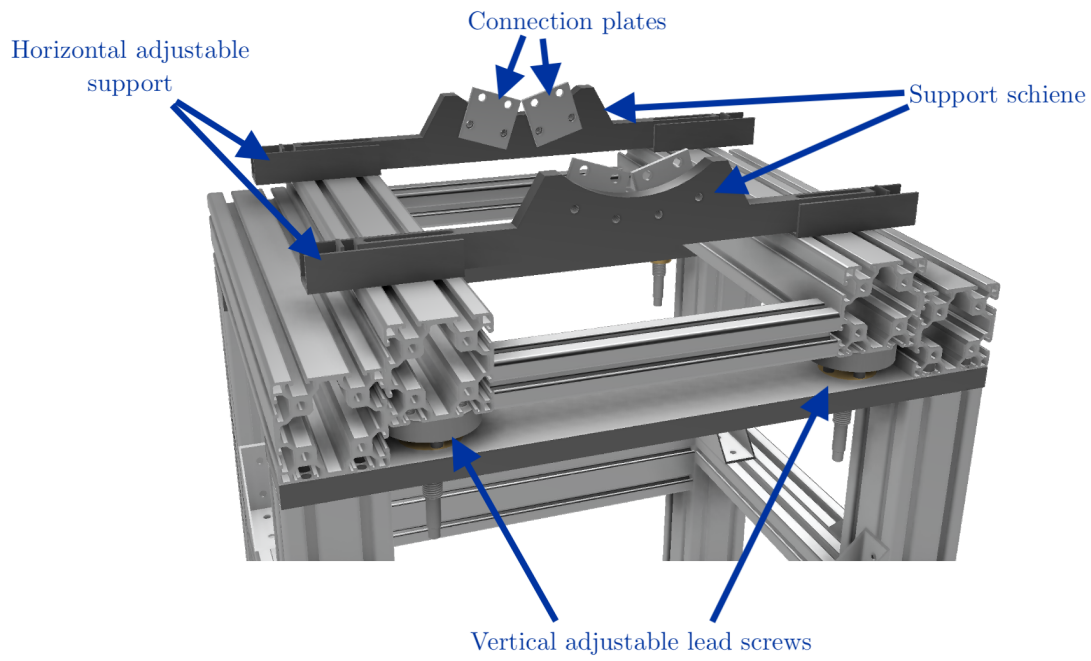


Figure 13: Close-up upper part of DVC supporting structure



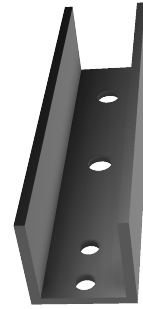
(a) Supporting Slab



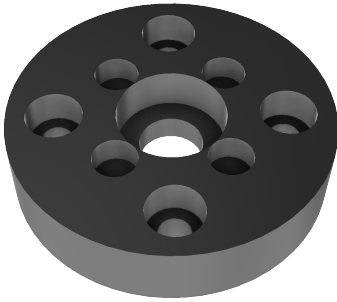
(b) Support Schiene



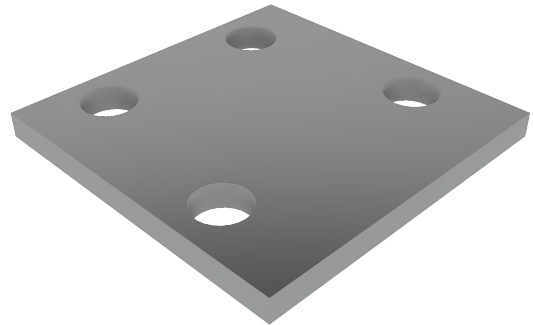
(c) Supporting Angle



(d) Supporting Channel



(e) bearing encapsule



(f) Connection Plate

Figure 14: Custom designed parts for the DVC supporting structure

Lead Screw Setup

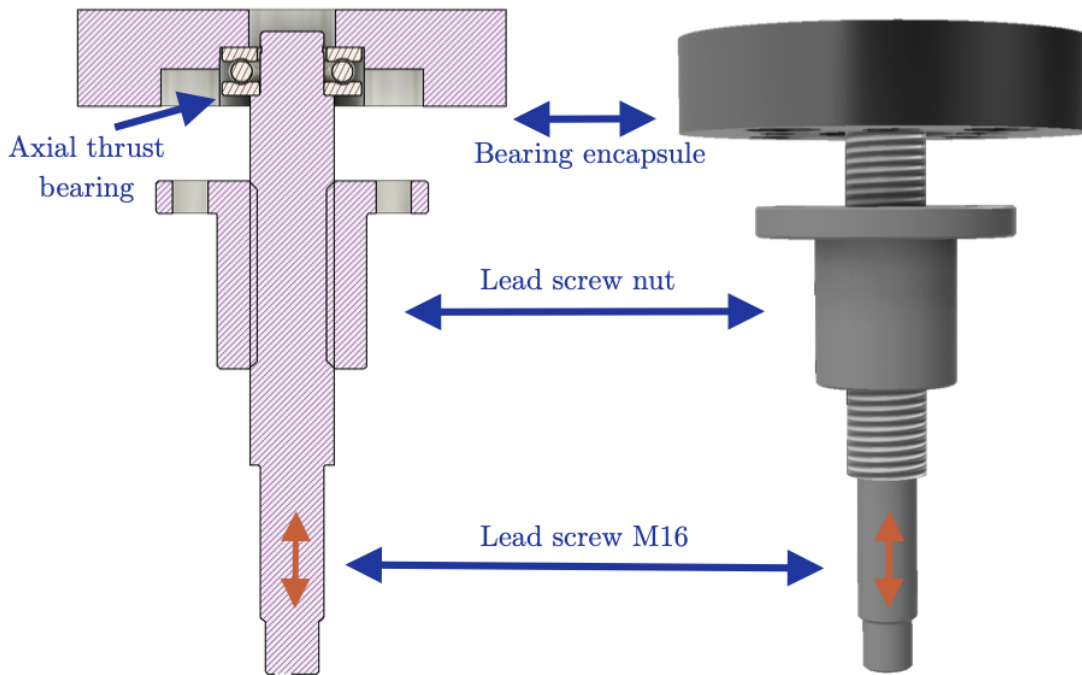


Figure 15: Lead screw setup

A lead screw setup (see figure 15) is used for the vertical adjustment of the DVCSS. By turning the lead screw the rotary motion is converted to linear motion by a lead screw nut that is fixed to the supporting slab. The upper end of the lead screw is connected to the table of the DVC via an axial thrust bearing, enclosed in a custom bearing encapsule. The bearing encapsules are screwed to the upper aluminium profiles. The three ordered components are listed here:

- Lead screw, MTKW16-120-S10, [misumi](#)



Figure 16: Lead screw

- Lead screw nut, MTRFR16, [misumi](#)



Figure 17: Lead screw nut

- Single direction thrust ball bearing, 51101, [SKF](#)

2.5 Horizontal Movement & Supporting Schiene

The horizontal movement of the DVC is achieved via a custom designed system consisting of a lead screw setup moving supporting schiene on which the DVC is mounted. The horizontal lead screw setup is made out of a channel and an angle piece, both steel, bought from the CERN shop. Both are modified with holes to be mounted to the aluminium profile beneath. A M6 screw is threaded through the angle so that its rotary movement is transferred into linear motion pushing the supporting schiene. The supporting channel and supporting schiene were already delivered by the workshop but need holes and threads to be drilled into them (see technical drawings in [A](#)). The supporting schiene is mounted to the channel via two feet, one on each side.

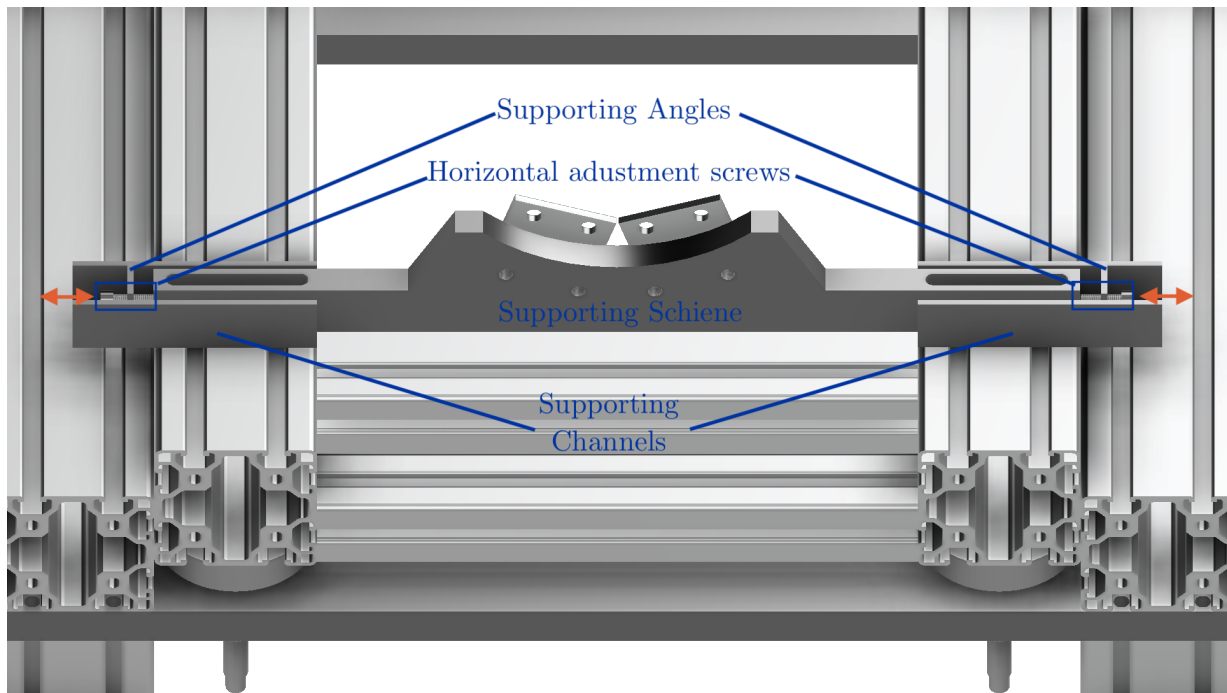


Figure 18: Overview horizontal lead screw setup

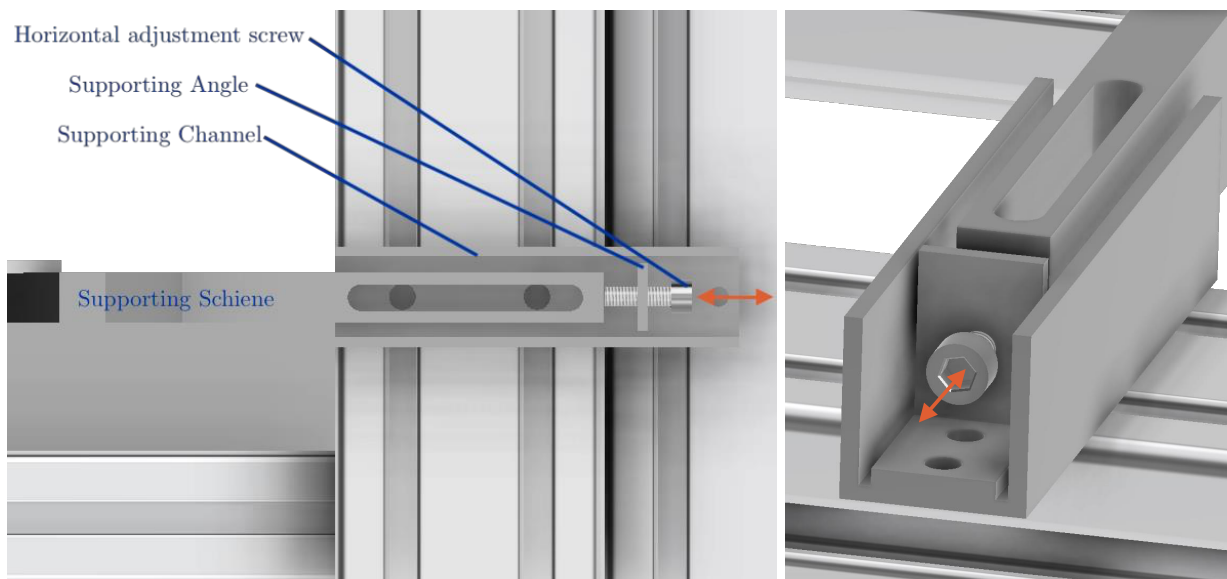


Figure 19: Topview horizontal lead screw setup



(a) Channel and angle piece of horizontal lead screw setup



(b) Feet of supporting structure

To tightly mount the DVC to its supporting structure, four connector plates (two per supporting schiene) are used to fix DVC to the supporting schiene. M6 threads are cut into the supporting schiene. Technical drawings can be found in [A](#).

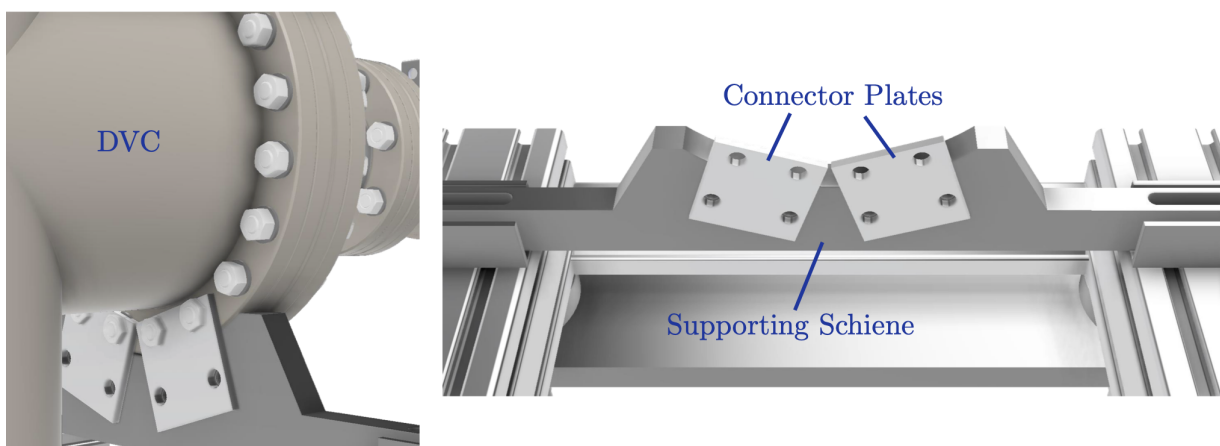


Figure 21: Connector plates and supporting schiene to fix DVC to supporting structure

3 Modeling of the GLM area

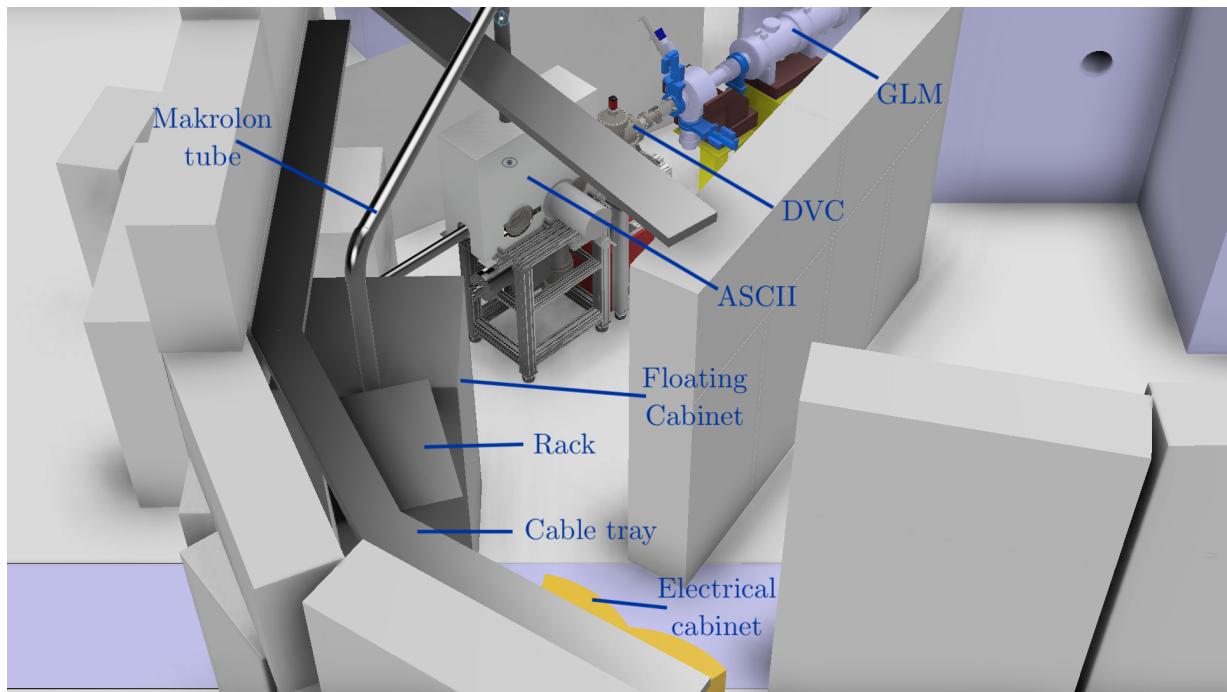


Figure 22: GLM area with ASCII setup and electrical equipment

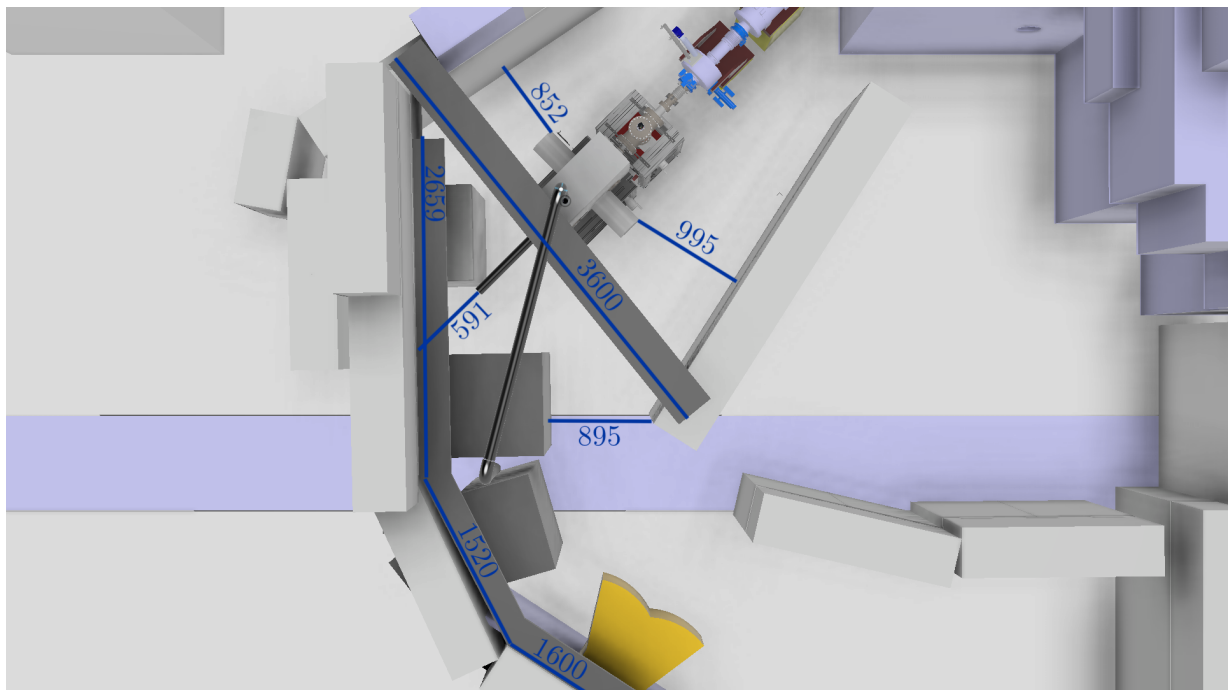


Figure 23: Top view of GLM area with ASCII setup and electrical equipment, measurements included

It was decided to create an updated 3D model of the GLM area including the ASCII setup to facilitate planning and communication regarding future and ongoing construction works inside

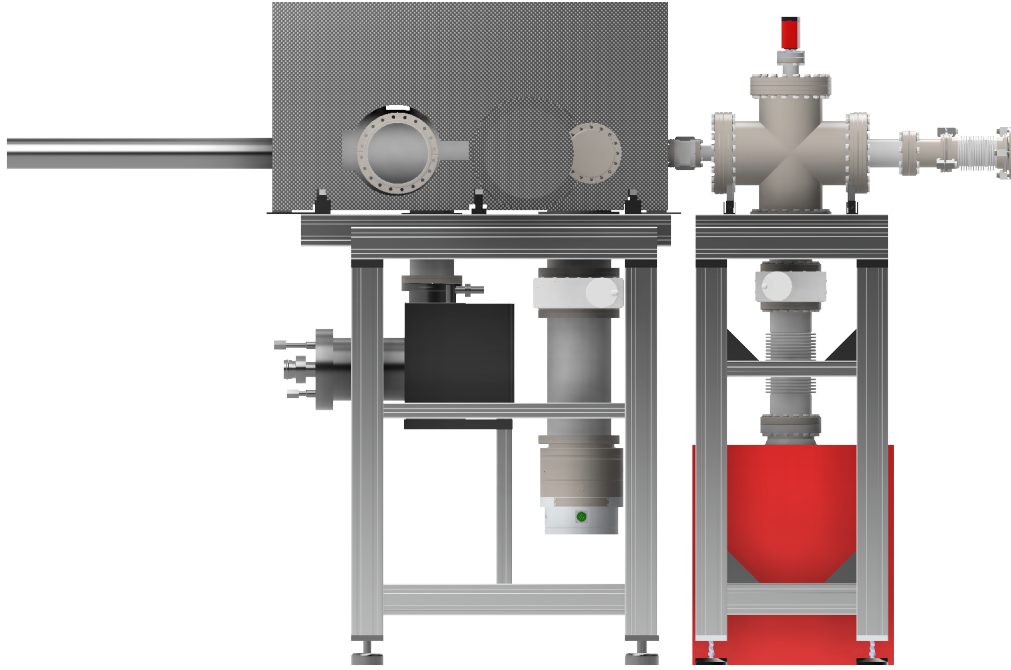


Figure 24: Complete ASCII + DVC setup

and above the GLM area.

The base model of the ISOLDE hall including an old version of the GLM area was generously provided by Vincent Barozier.

A preliminary model of the ASCII chamber, as well as an old version of ASCII's faraday cage were found in the shared cernbox ASCII folder.

During this summer student programme the following parts were newly designed (updated):

- ASCII's faraday cage (updated), see section [1](#)
- Caps and connections of ASCII
- Supporting structure of ASCII
- DVC, see section [2](#)
- Miscellaneous equipment

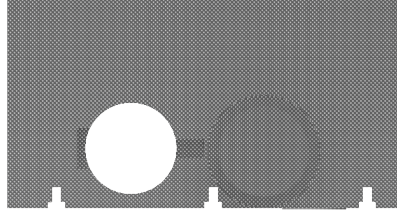


Figure 25: ASCII's Faraday cage

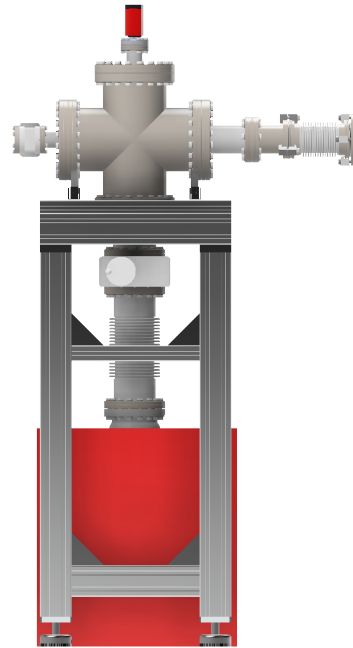


Figure 26: DVC setup

3.1 Caps and Connections of ASCII

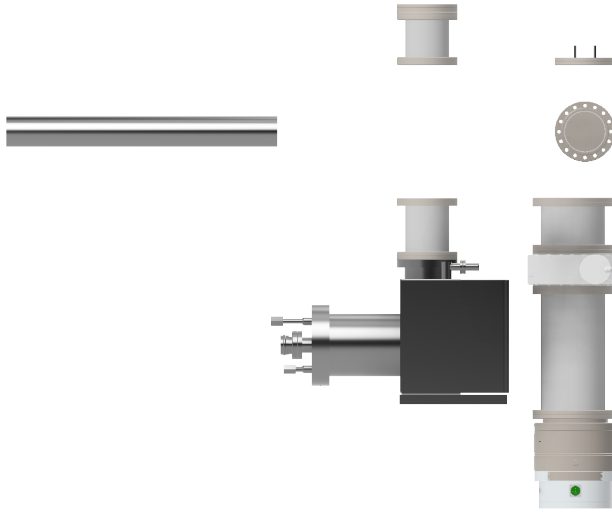


Figure 27: Additional caps and connections of ASCII

To the rough model of the ASCII, parts that could be found as step-file online were added including pumps and some caps. The insulator caps and door could not be found and have to be included manually if needed.

3.2 Supporting structure of ASCII



Figure 28: ASCII's supporting structure

The supporting structure of ASCII was roughly measured and modeled to retain its overall dimensions and shape. The actual setup might vary slightly as the measurements were taken within an error of ± 1 mm.

3.3 Miscellaneous equipment

Additionally, various other components and equipment were included in the model to the ASCII setup. This includes the rack, the faraday cage of the floating cabinet, the electrical cabinet, the cable trays and the makrolon tube. The models are very rough and only confine the overall dimensions of the components. The electrical cabinet's model includes the safety requirements stated by safety inspector James Devine namely that it has to be always accessible and its door has to be openable at least 110 degrees. The makrolon tube seems to be too long in regards to the position of the ASCII chamber. This has to be checked and if needed adapted.

4 Additional Tasks & Information

4.1 High Voltage Cables

To connect the high voltage power supplies to the ASCII chamber's connectors, the safety department asked us to search for halogen cables. Over the course of this summer, the search for halogen free cables meeting the voltage requirements of 60 kV was fruitless. XP Power itself and Hivolt could not provide us with the required cables. After another exchange with the safety department, it was decided that we should use halogen containing cables. These were ordered at XP Power. This is the email of the safety officer permitting the purchase:

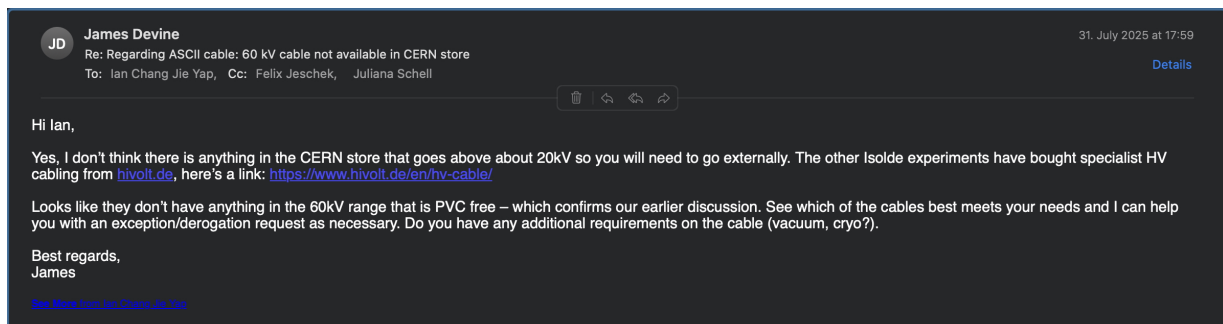


Figure 29: Email from safety officer permitting purchase of halogen cables

After requesting cables from HiVolt they denied their affiliation with XP Power:

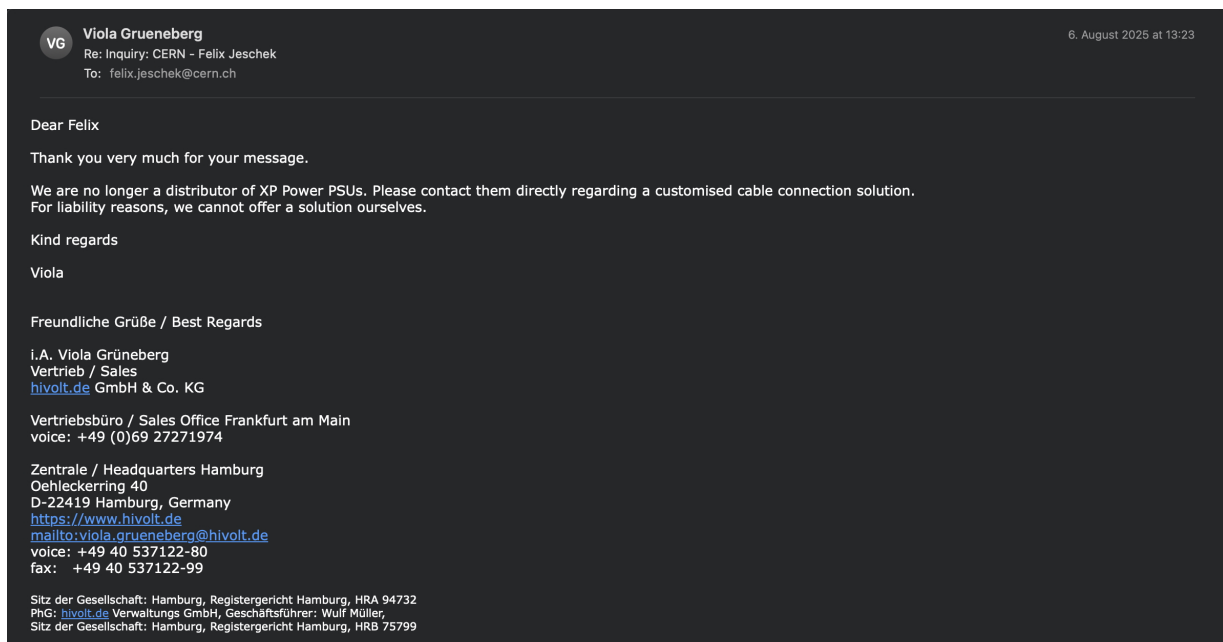


Figure 30: Email from HiVolt regarding cable availability

Finally cables were ordered at XP Power.

4.2 Electrical cabinet

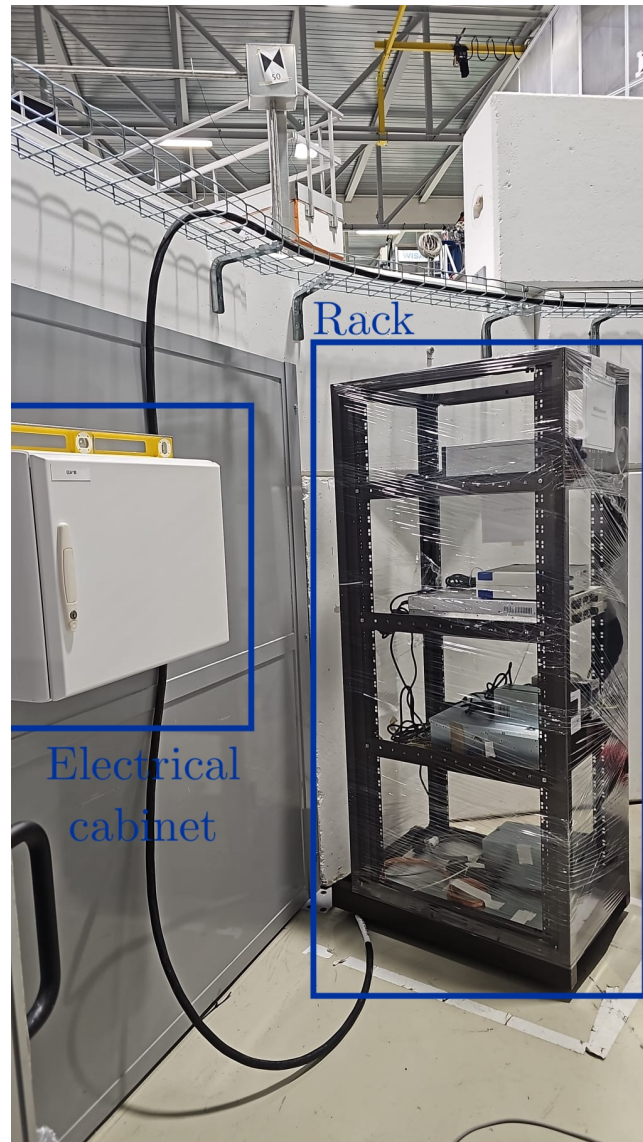


Figure 31: Electrical cabinet for ASCII

The electrical cabinet for ASCII was installed during the summer. Its located left of the rack. Its safety requirements are to be *always* accessible and openable by an angle of at least 110 degrees. Therefore it should be at all times avoided to place or store things in front or close to the electrical cabinet.

4.3 New ion implantation chamber

Designed by summer student Juan Franciso, the new ion implantation chamber was also placed inside the modeled GLM area.

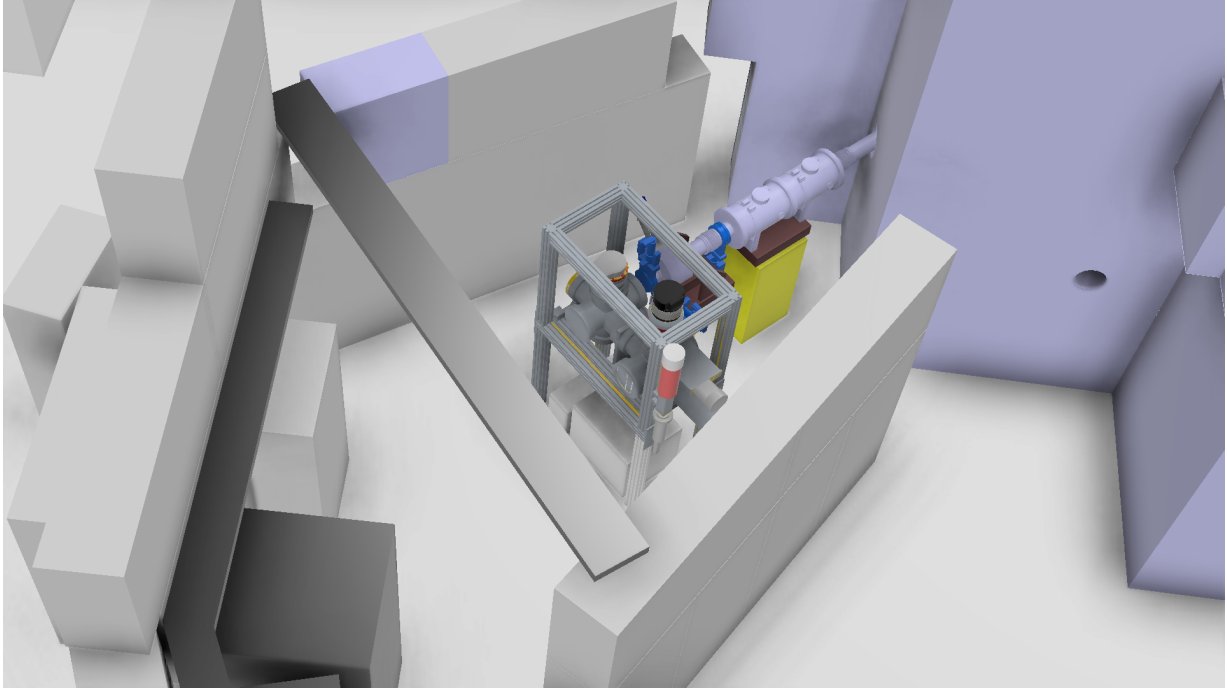


Figure 32: New ion implantation chamber

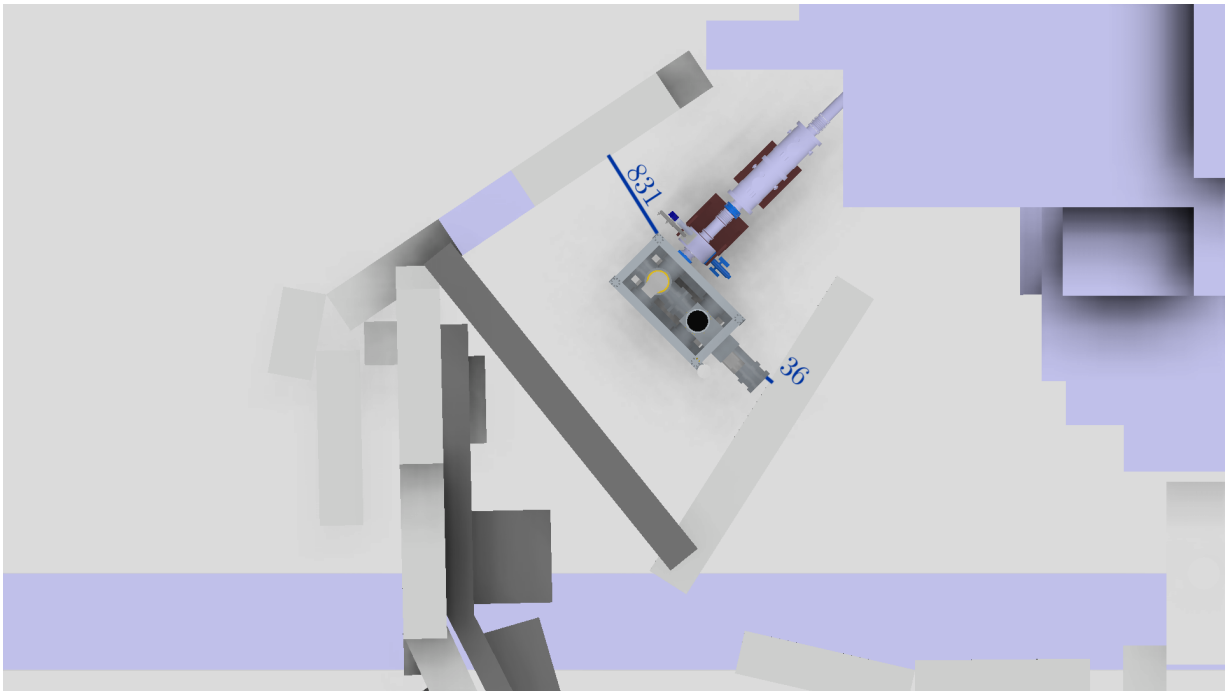


Figure 33: New ion implantation chamber top view, measurements for nearest wall distances included

5 Outlook

Although there has been significant progress on the ASCII setup during this summer student programme, several tasks still have to be done to complete the setup. These include:

- Finishing ordering parts for the DVC's supporting structure
- Assembly of DVC's supporting structure
- Assembly of DVC setup
- Connecting DVC to ASCII
- Cabling
- Write and verify safety protocols
- Testing vacuum
- Stable beam test

At some point a complete documentation of the ASCII would be quite beneficial not only intern but especially for future users conducting experiments.

Acknowledgments

I want to express a heartfelt thank you to everyone who supported me during my time at CERN. Special thanks to Juliana Schell for her guidance and support throughout the project, as well as Ian, Vincent and Peter for the advice on the DVC. I also want to mention Martin introducing me into CAD and helping me with my first steps. At last a big thank you to Harold, Uday, Anton, Julia, Carl, Dario, Juan and Lars for sharing the summer student programme experience with me.

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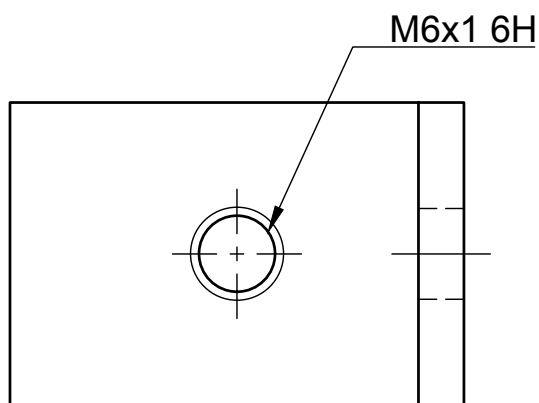
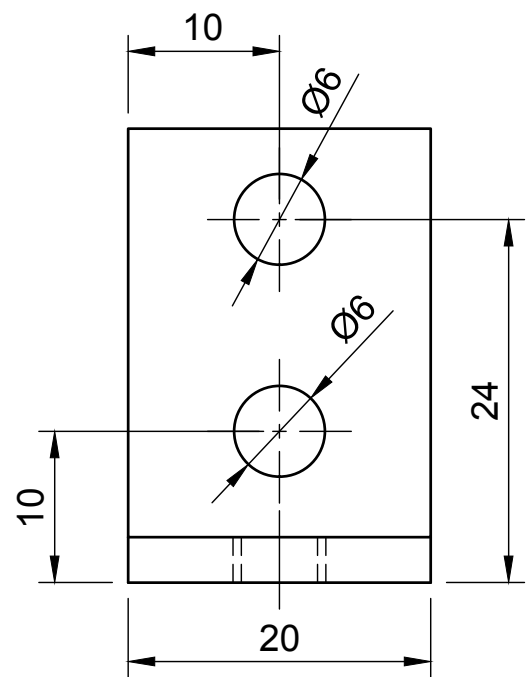
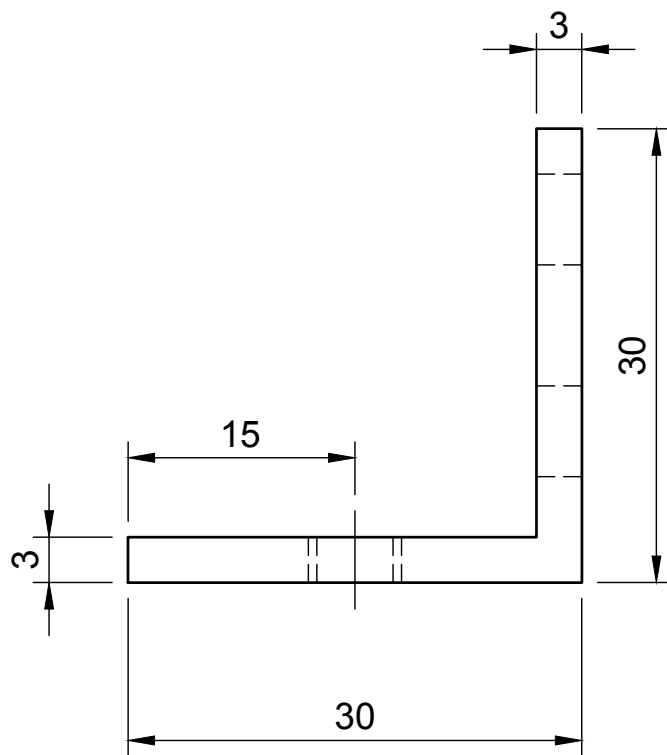
References

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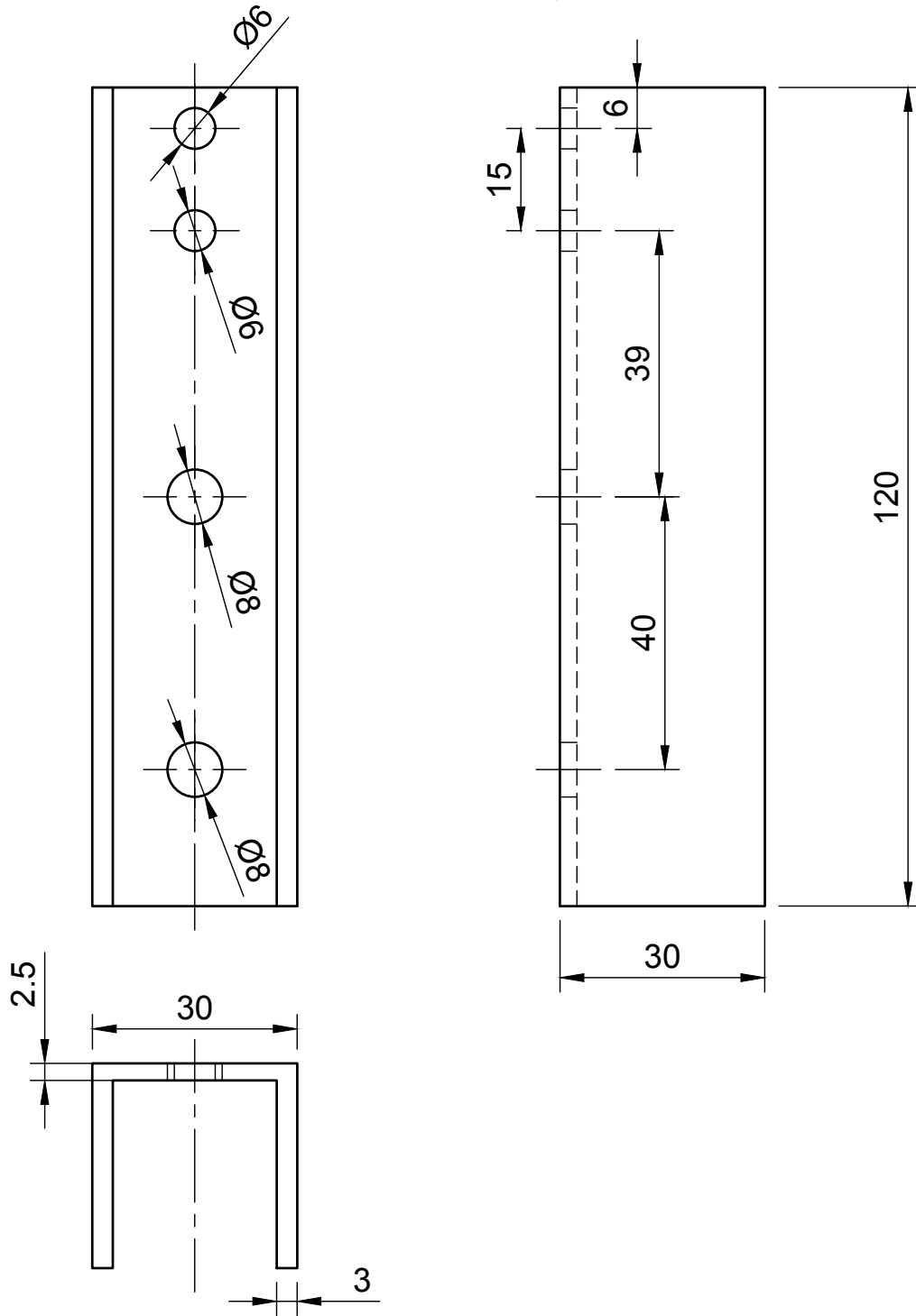
A Ordered & designed parts for DVC and ASCII by Felix Jeschek

Name	Serial number / ID	N	Specifications	Distributor	Used for/in
Aluminium profile 80x80 light groove 8 I-type	H1088080L	4	912 mm with threads	myaluprofil	DVC – supp – base
Aluminium profile 80x80 light groove 8 I-type	H1088080L	2	320 mm	myaluprofil	DVC – supp – base
Aluminium profile 80x80 light groove 8 I-type	H1088080L	2	455 mm	myaluprofil	DVC – supp – base
Aluminium profile 80x80 light groove 8 I-type	H1088080L	4	480 mm	myaluprofil	DVC – supp – base
Aluminium profile 40x80 light groove 8 I-type	H1088040L	2	320 mm	myaluprofil	DVC – supp – base
Angle 40x80 ZN Slot 8 I-Type	H208W80	12		myaluprofil	DVC – supp – base
Aluminium profile 40x40 light groove 8 I-type	H1084040L	2	295 mm	myaluprofil	DVC – supp – base
Slot nut with bar slot 8 M8 I type	H208NSMS8	50		myaluprofil	DVC – supp – base
Adjustable foot 80mm M12x100	80-M12X100	4		aluxprofile	DVC – supp – feet
Hexagon socket head cap screw ISO 4762 M8x40	ISO 4762-M8X40	16		aluxprofile	DVC – supp – feet
Transport and base plate 8080 M12	8080-M8	4		aluxprofile	DVC – supp – feet
Lead Screw Nut	Lead Screw Nuts	4	L: 120mm S: 10mm	misumi	DVC – supp – vert
Lead Screws For Support Units DIN 103	MTWK16-120-S10	4		misumi	DVC – supp – vert
Single direction thrust ball bearing	51101	4		SKF	DVC – supp – vert
Channel steel	44.47.34.032.3	4	length 120 mm	CERN Store	DVC – supp – hori
Angle steel	44.47.02.030.8	4	length 20 mm	CERN Store	DVC – supp – hori
10m HV cable, one side open for PS/FJ60R02.0-22	OPC8U-033A005	2		XP Power	ASCII – power supply
5m HV cable, one side open for PS/FJ60R02.0-22	OPC8U-017A004	1		XP Power	ASCII – power supply

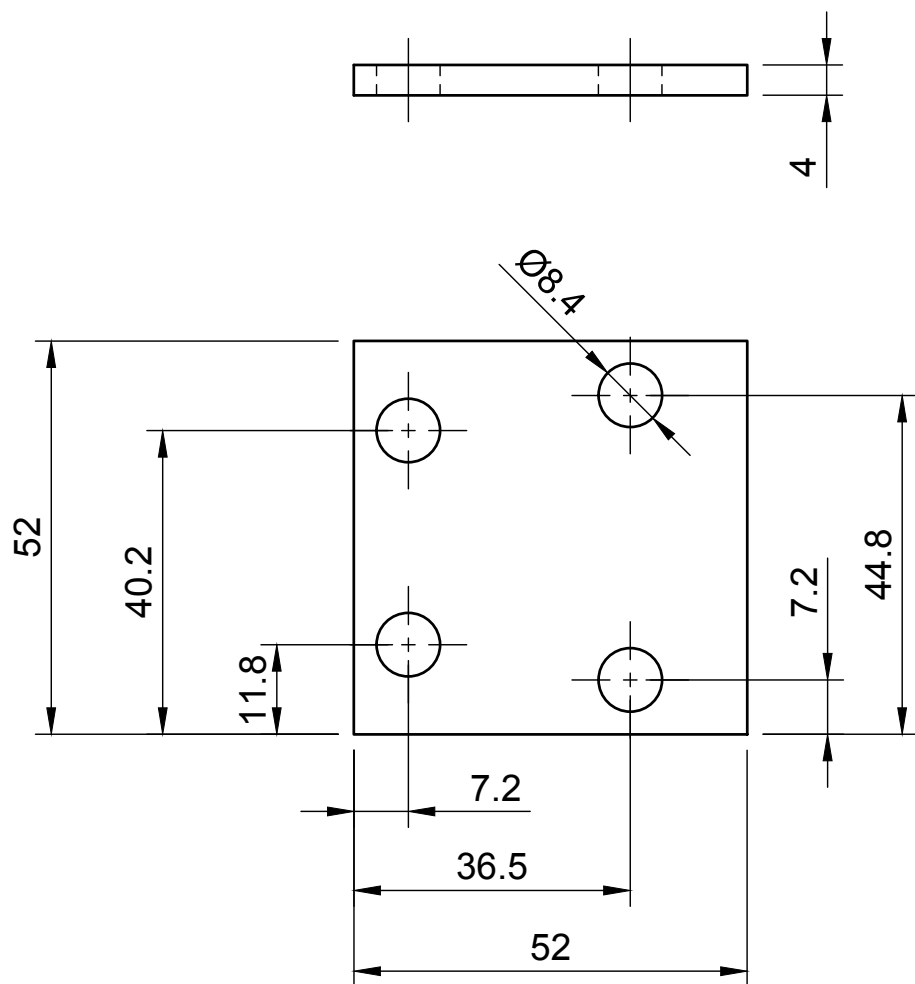
For further ordering please refer to Carl Jarschkes work.



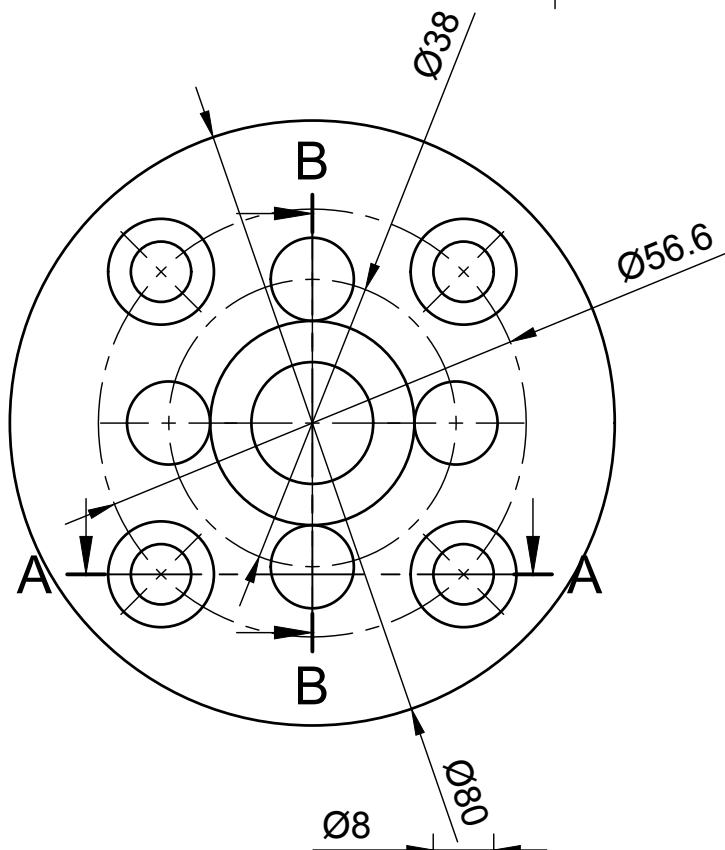
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		Document type				Document status
		Title supporting angle				DWG No.
			Rev.	Date of issue	Sheet 1/1	



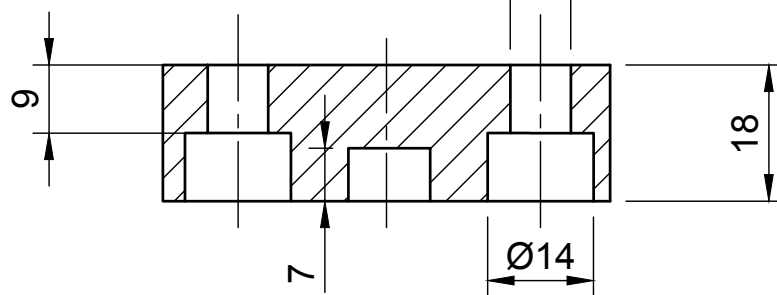
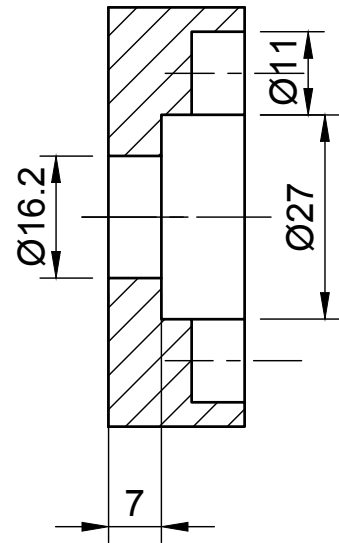
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			Rev.	Date of issue			Sheet 1/1	



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		Document type	Document status		
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			Rev.	Date of issue	Sheet 1/1

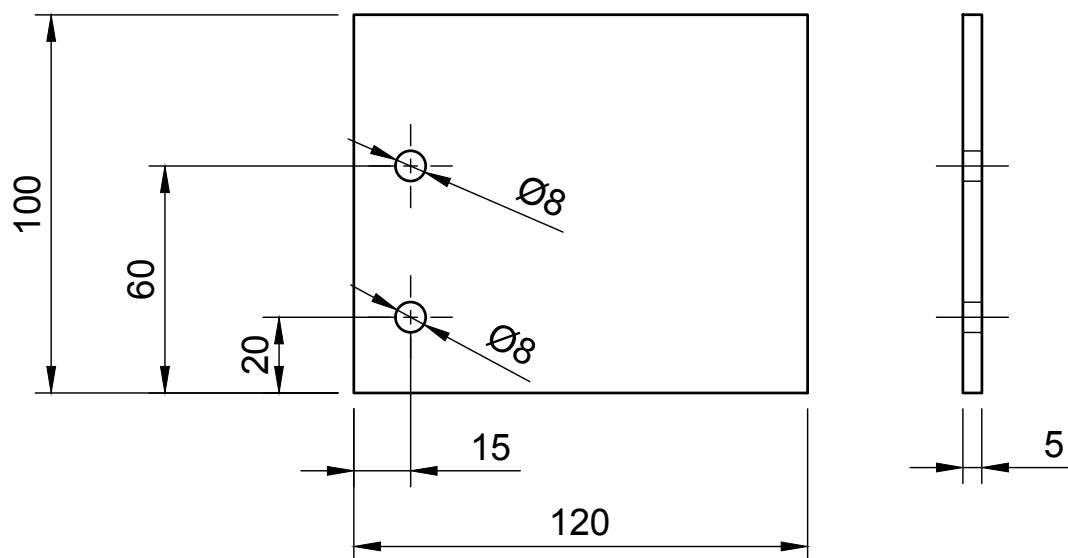


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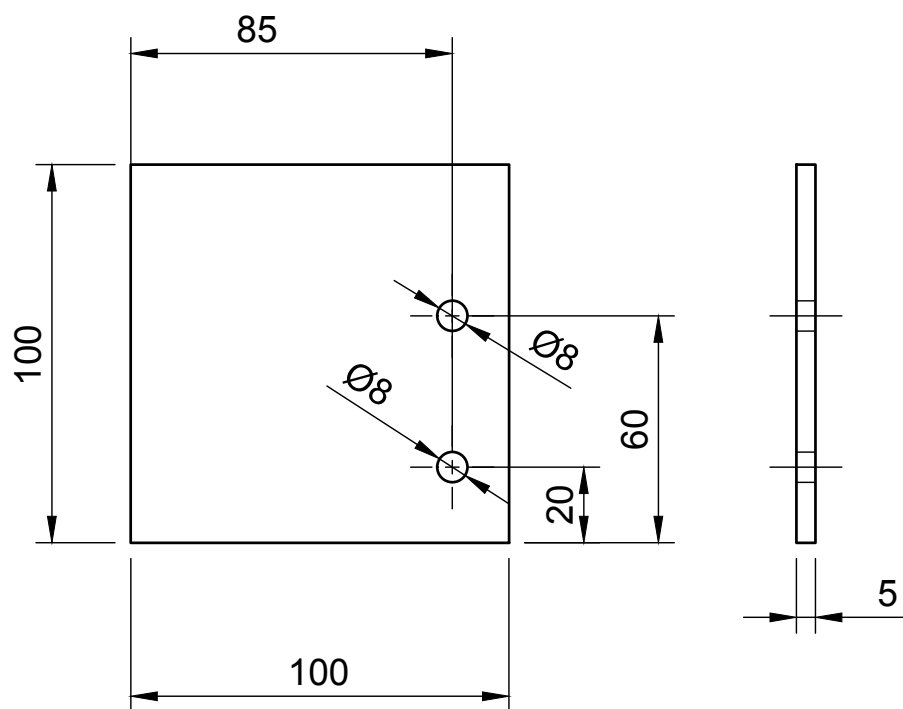


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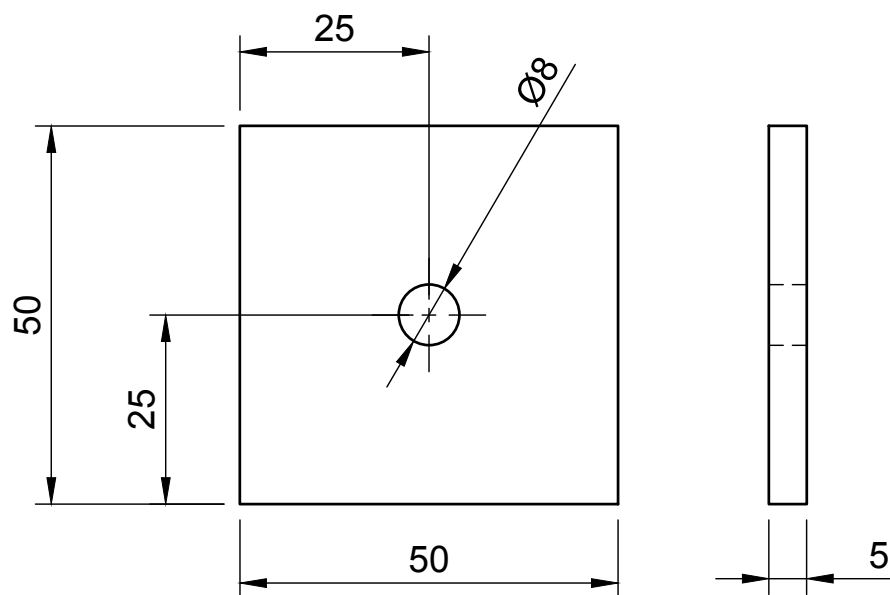
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		Rev.	Date of issue	Sheet 1/1



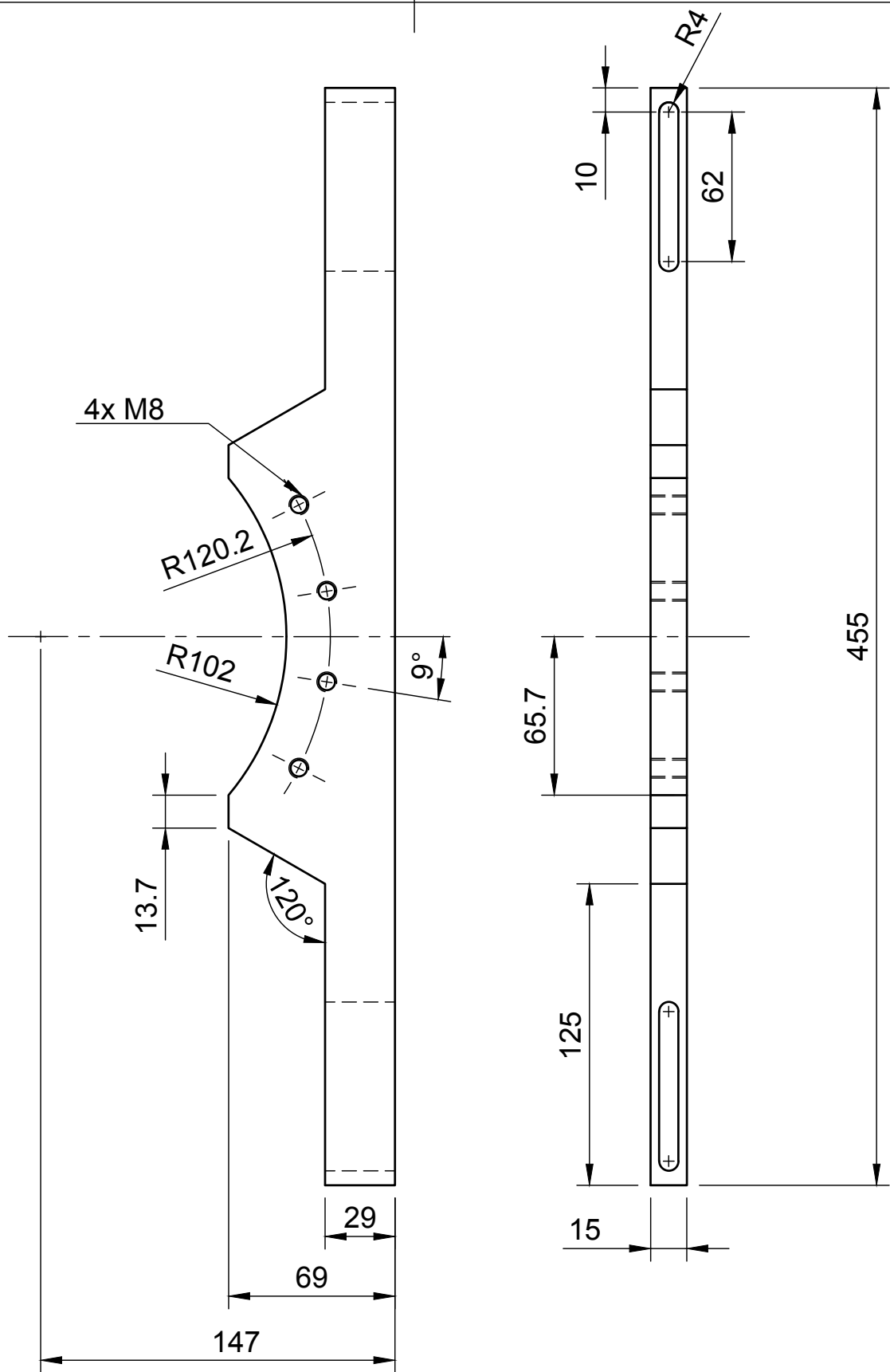
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			Rev.	Date of issue	Sheet 1/1



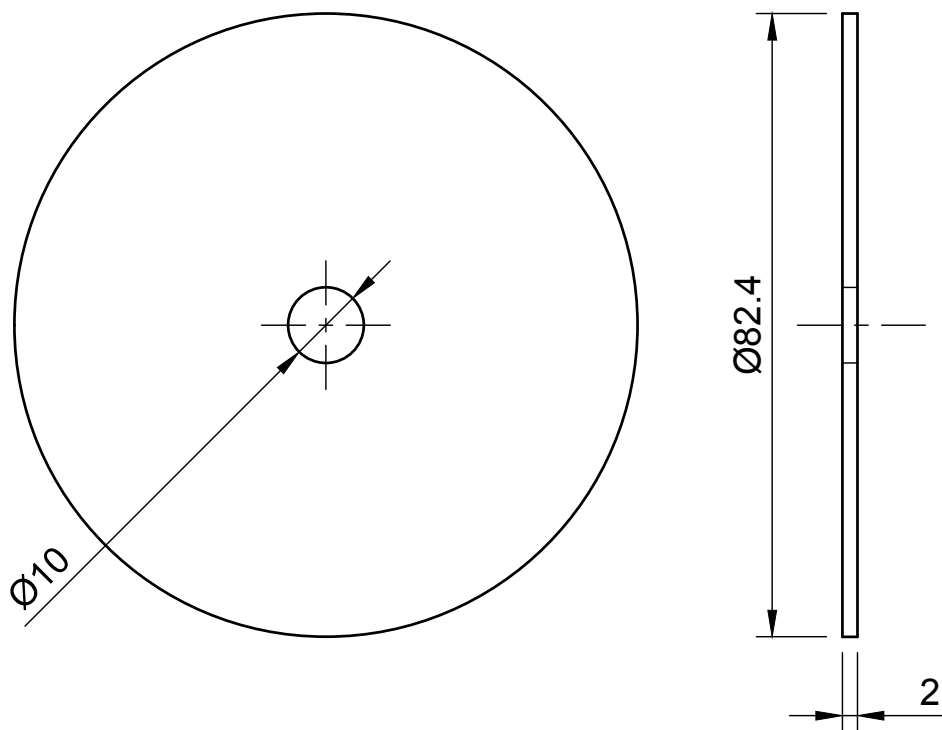
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			Rev.	Date of issue	Sheet 1/1



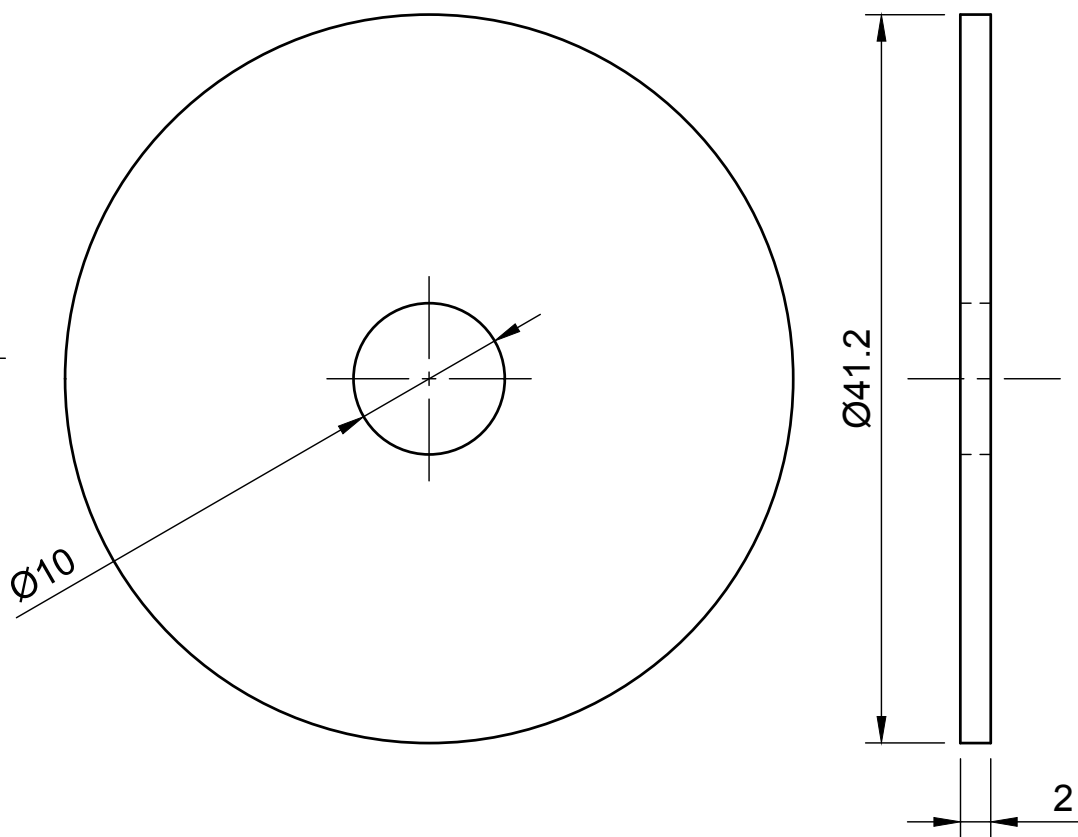
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					Rev.	Date of issue		Sheet 1/1



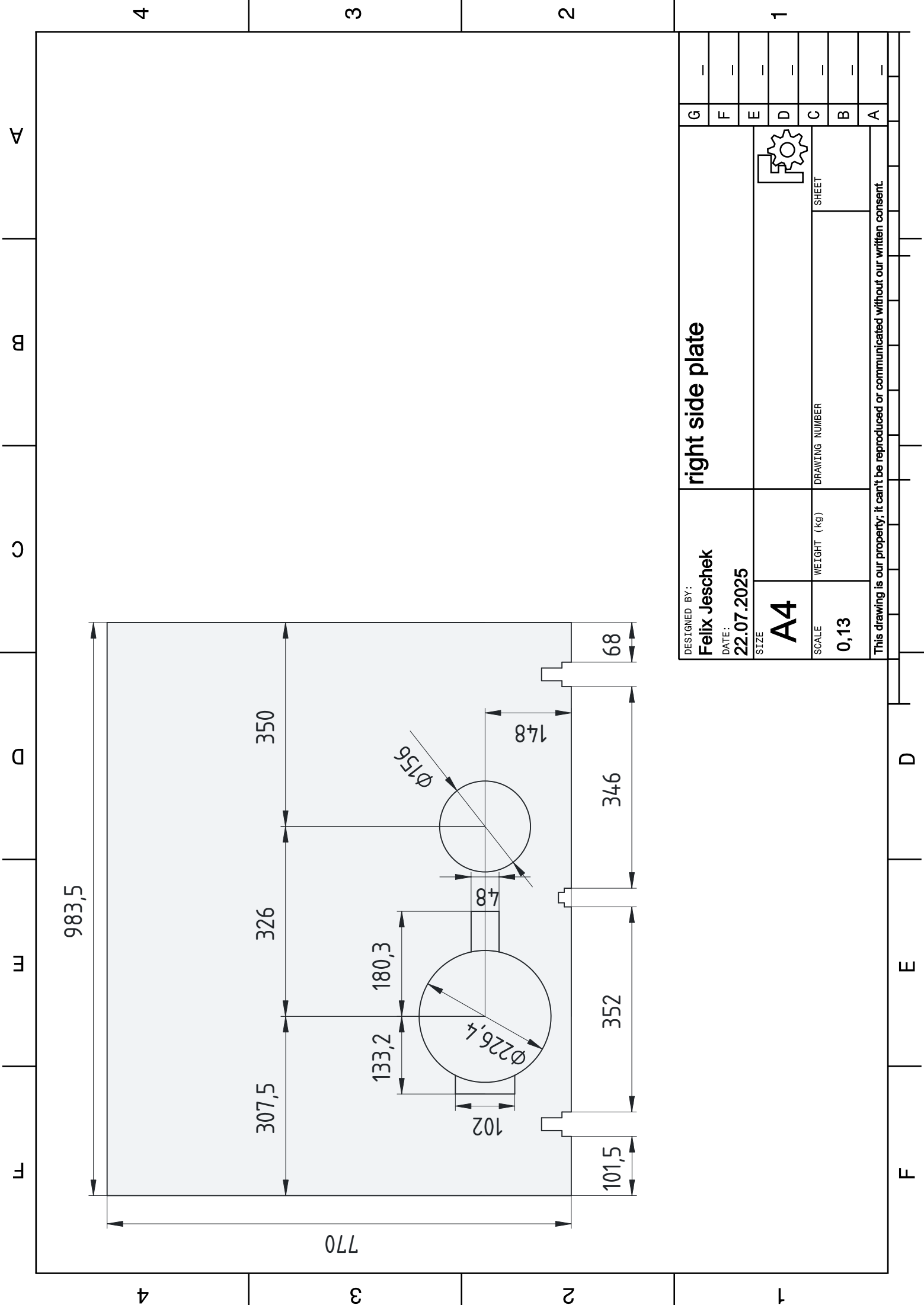
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		Rev.	Date of issue	Sheet 1/1

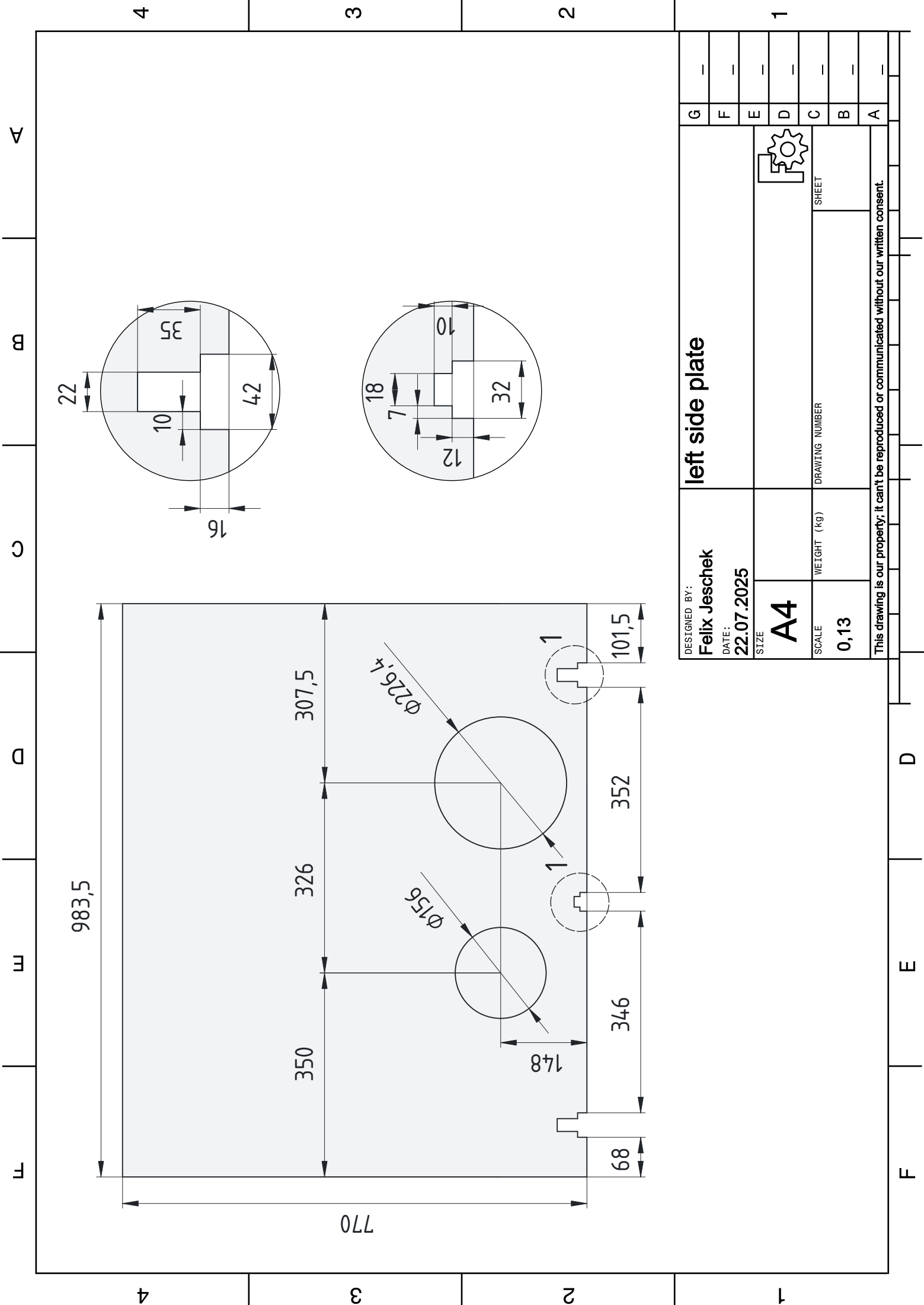


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		Document type	Document status		
		Title Gasketplate_63	DWG No.		
			Rev.	Date of issue	Sheet 1/1

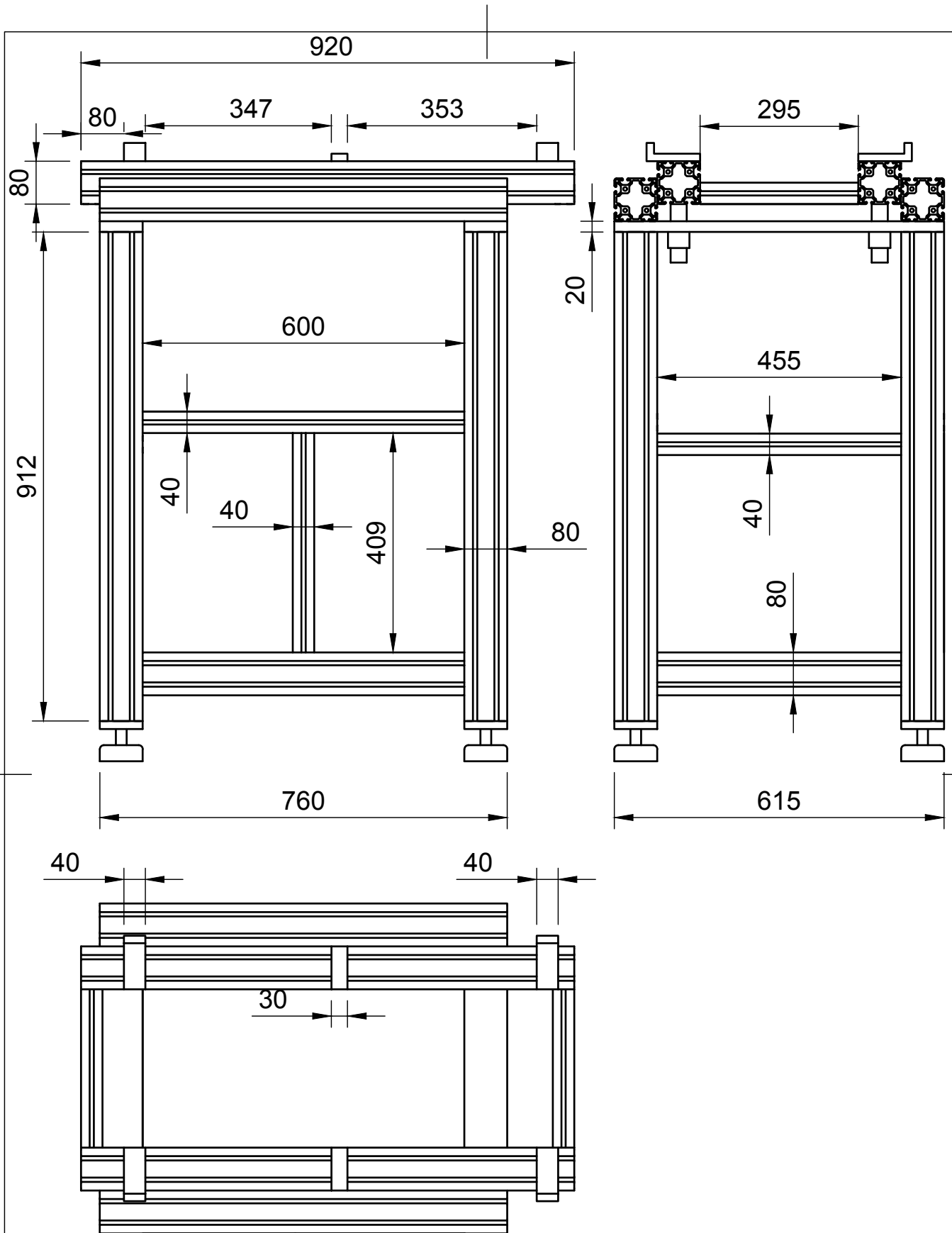


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		Title Gasketplate_40	DWG No.		
			Rev.	Date of issue	Sheet 1/1





DESIGNED BY: Felix Jeschek		left side plate		</
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		Document type	Document status		
		Title ASCII's supporting structure	DWG No.		
			Rev.	Date of issue	Sheet 1/1