AGIPD Mechanics

Annette Delfs, FS-DS

XDAC Meeting 08.05.2015

Overview

- Cooling Block (electro-formed)
- Vacuum chamber
- Status quadrant design
- Outsourced engineering work
- Unprocessed engineering work
- Summary

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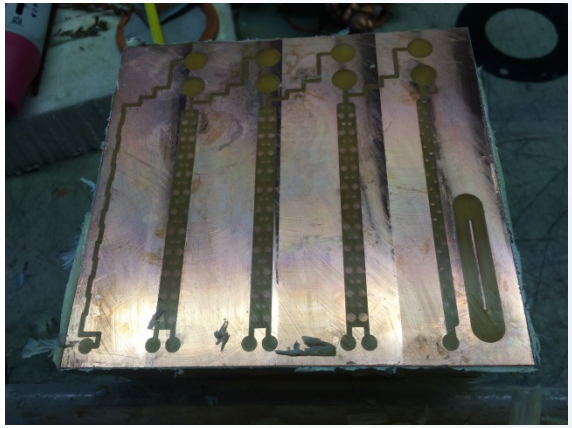
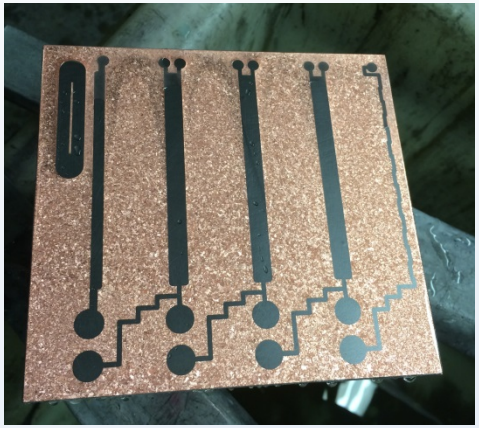
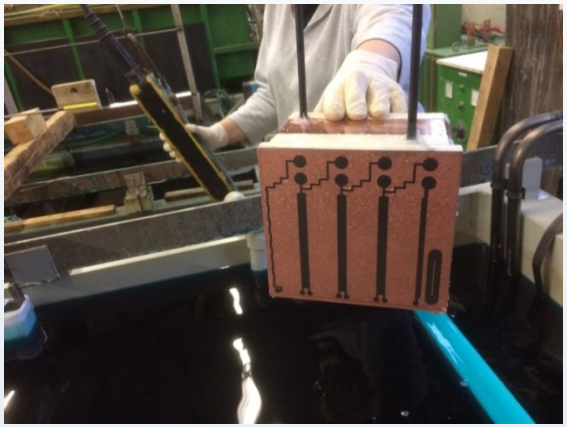
Cooling Block (electro-formed)



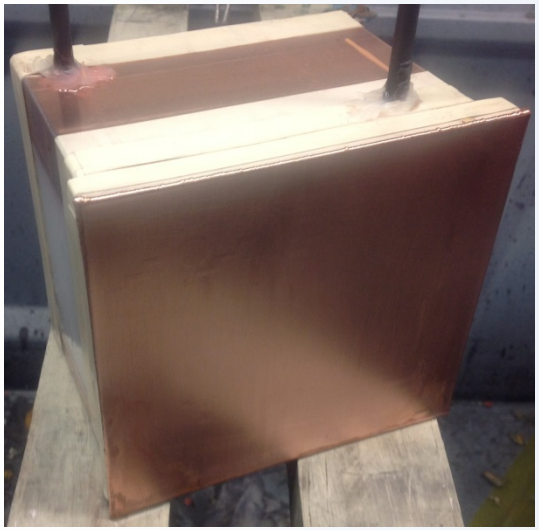
cavities filled with wax



cleaned with mordant

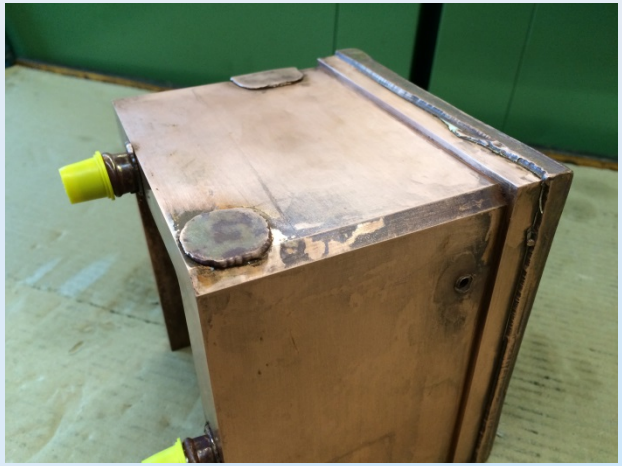


before galvanic bath



after 1 day in galvanic bath (20-25 µm/h)

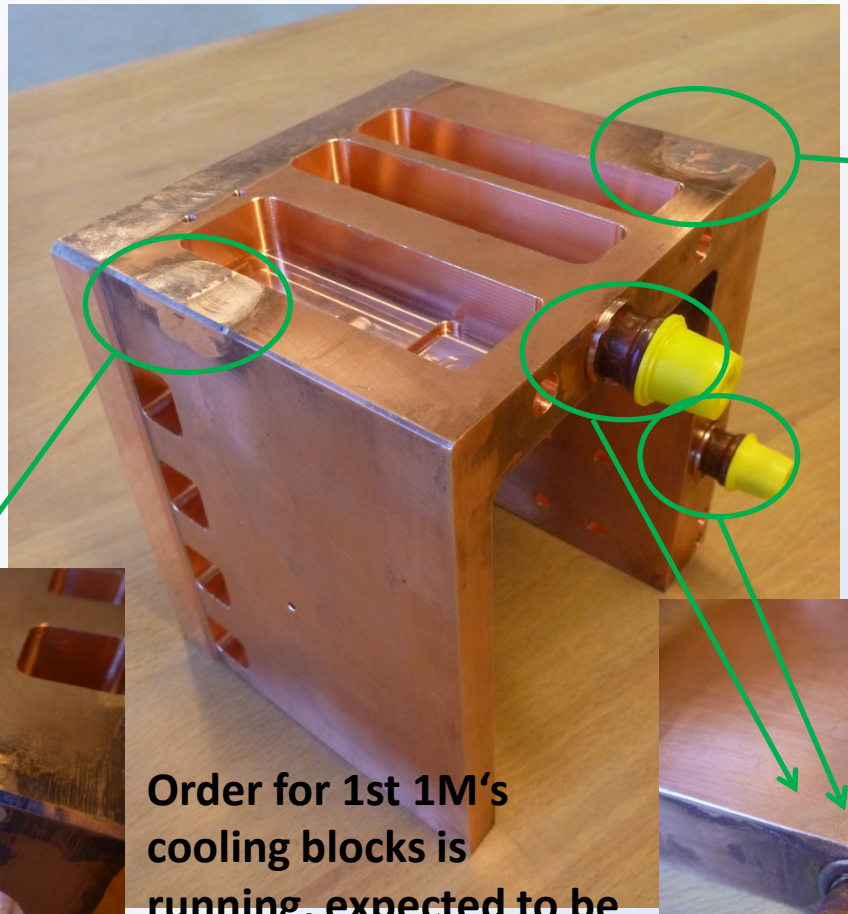
Closure of deep bores

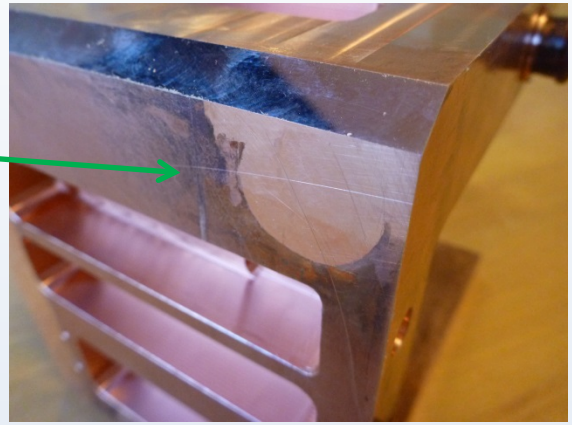


Cooling Block after electro-forming

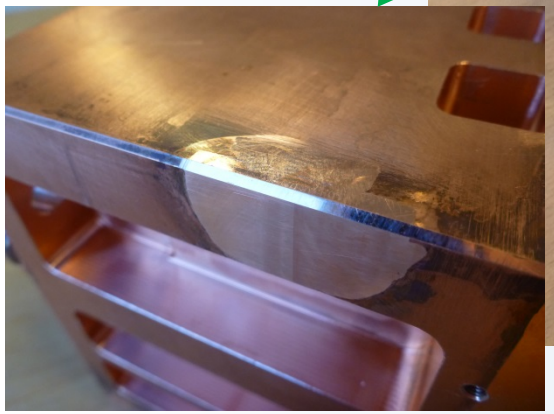
Cooling Block (electro-formed)

Cooling block after final machining





Closure deep bore



Closure deep bores

Order for 1st 1M‘s cooling blocks is running, expected to be ready in June.
Order for the 2nd 1M just started.

Connection of tube sockets for cooling tubes

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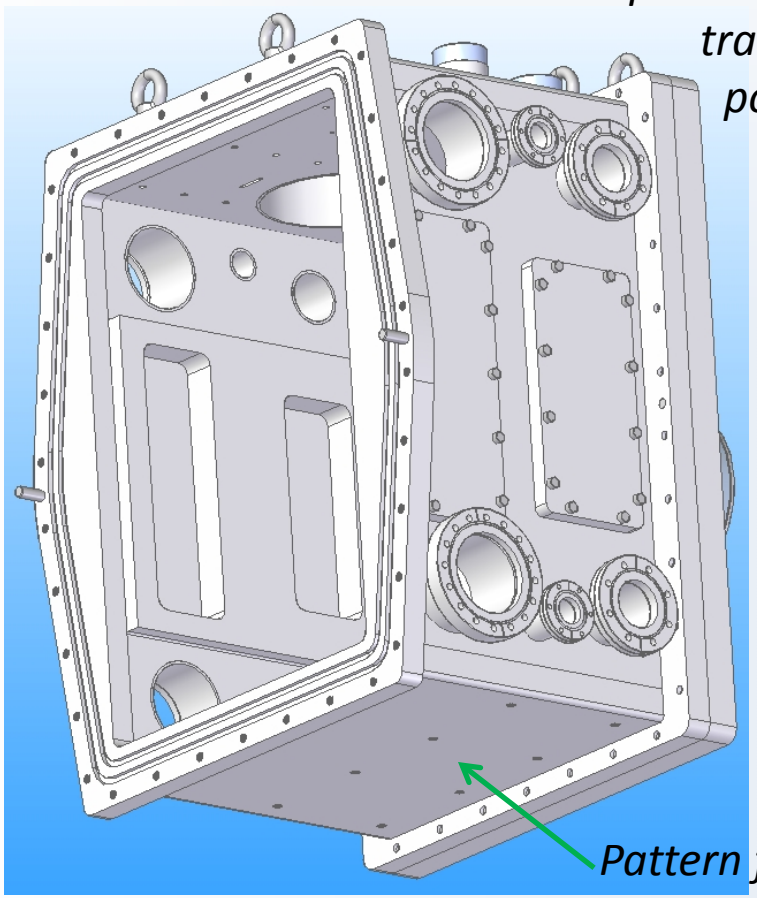
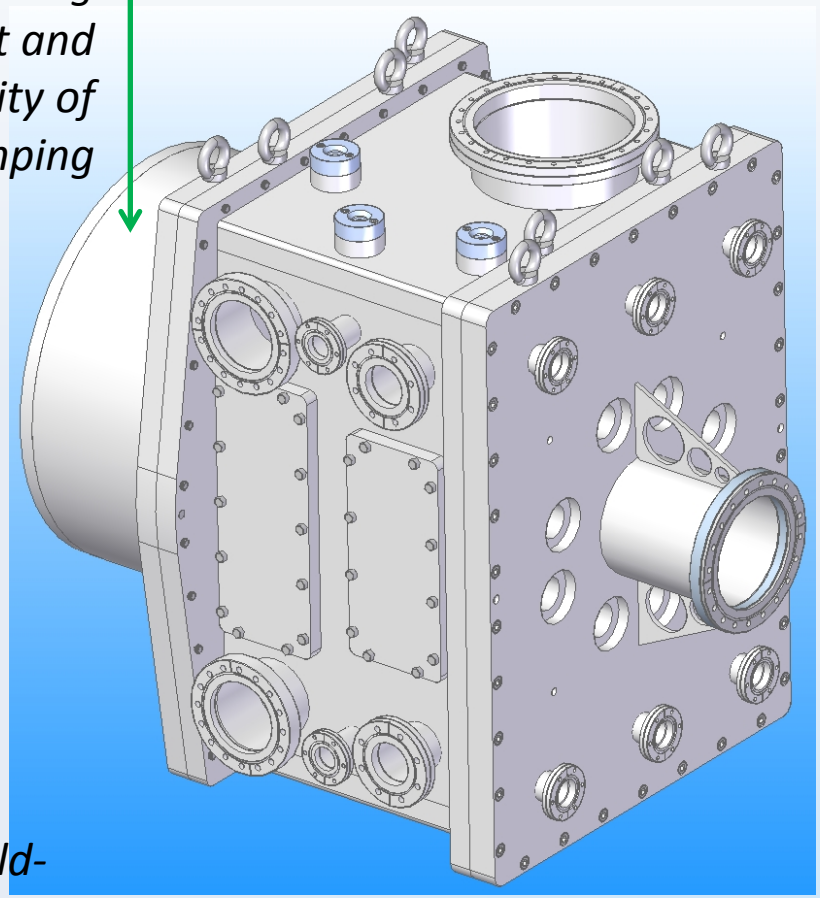
Vacuum chamber

- Engineering work ordered 07.01.15 (Hositrad)
- Confirmation of order received 23.01.15, delivery time 5 to 6 weeks
- Preliminary FEA results on 31st of March (3 weeks after scheduled delivery).
- Final FEA received April 14th, discussed April 27th.
- Answers to list of questions by XFEL on May 1st, send to XFEL on May 4th.
- Preparing of production drawings almost finished.
- Inquiries for production to be sent as soon as the final design was approved by XFEL.

Vacuum chamber





Blind flange for protection during transport and possibility of pumping

Pattern for hold-down bolts

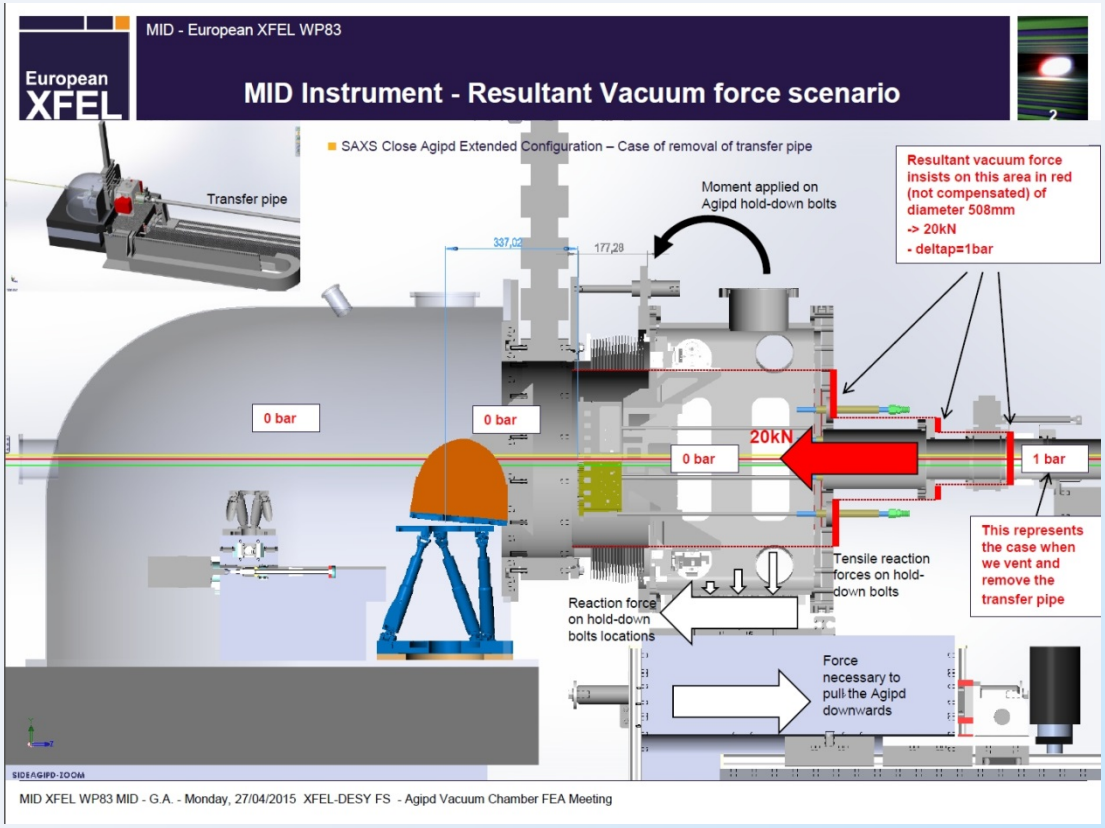
Upstream side

Downstream side

Vacuum chamber

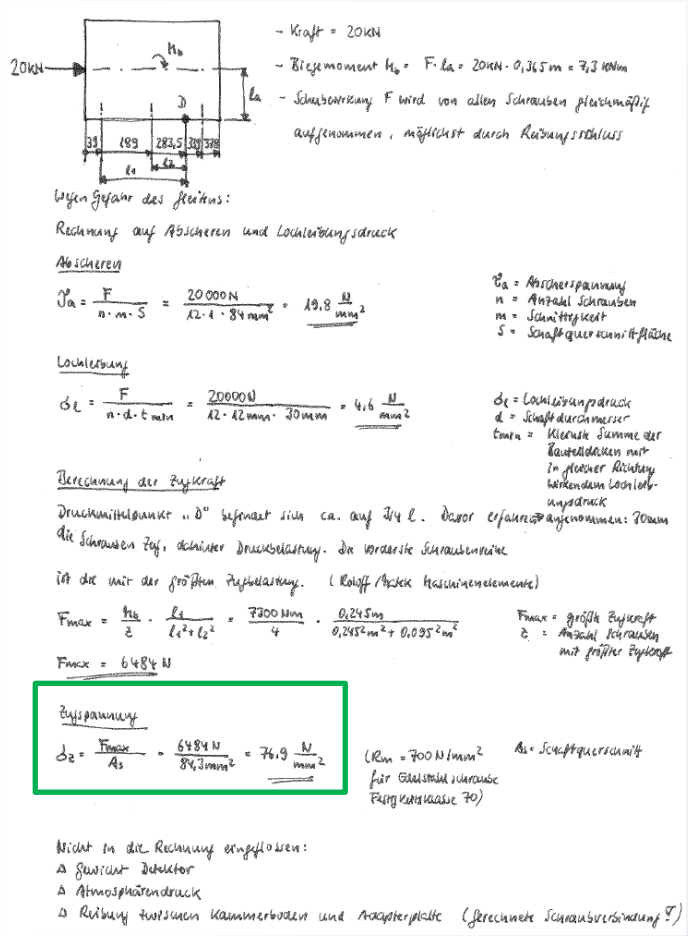
Main issue / concerns:

- 12x M12 screws tight enough to withstand tensile forces?
- Deflections acceptable?
- Stress in base plate acceptable?



Vacuum chamber

12x M12 screws tight enough to withstand tensile forces?



- Kraft = 20kN
- Biegemoment M_b = F · l_a = 20kN · 0,365 m = 7,3 kNm
- Schraubenkraft F wird von allen Schrauben gleichmäßig aufgenommen, möglichst durch Reibungsschluss

20kN

M_b

l_a

33 | 189 | 283,5 | 33 | 378

l_1 l_2

Mögliche Gefahr des Versagens:

Rechnung auf Abscheren und Lochleibungsdruck

Abscheren

$$\tau_a = \frac{F}{n \cdot m \cdot S} = \frac{20000\,N}{12 \cdot 1 \cdot 84\,mm^2} = 19{,}8\,\frac{N}{mm^2}$$

τ_a = Abscherspannung
n = Anzahl Schrauben
m = Schnittigkeit
S = Schaft-querschnittfläche

Lochleibung

$$\sigma_L = \frac{F}{n \cdot d \cdot t_{min}} = \frac{20000\,N}{12 \cdot 12\,mm \cdot 30\,mm} = 4{,}6\,\frac{N}{mm^2}$$

σ_L = Lochleibungsdruck
d = Schaft-durchmesser
t_{min} = Kleinste Summe der Blechdicken mit in gleicher Richtung wirkendem Lochleibungsdruck

Berechnung der Zugkraft

Druckmittelpunkt „D" befindet sich ca. auf 3/4 l_1. Dafür erfahrungsgemäß angenommen: 70mm

Die Schrauben Pos. nächster Druckbelastung, die vorderste Schraubenreihe ist die mit der größten Zugbelastung. (Roloff/Matek Maschinenelemente)

$$F_{max} = \frac{M_b}{z} \cdot \frac{l_2}{l_1^2 + l_2^2} = \frac{7300\,Nm}{4} \cdot \frac{0{,}245\,m}{0{,}2452\,m^2 + 0{,}035^2\,m^2}$$

F_{max} = größte Zugkraft
z = Anzahl Schrauben mit größter Zugkraft

F_{max} = 6484 N

Zugspannung

$$\sigma_z = \frac{F_{max}}{A_S} = \frac{6484\,N}{84{,}3\,mm^2} = 76{,}9\,\frac{N}{mm^2}$$

(R_m = 700 N/mm² für Edelstahl rostfrei Festigkeitsklasse 70)

A_S = Schaftquerschnitt

Nicht in die Rechnung eingeflossen:
- Gewicht Detektor
- Atmosphärendruck
- Reibung zwischen Kammerboden und Adapterplatte (Berechnete Schraubensicherung ?)

Calculation by hand (A. Delfs)

→ Screws tight enough even with weight of detector and friction between chamber and plate not taken into account.

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The customers do not agree with the tensile load of 0N on the hold-down screws for the "worst case" load, because the resultant axial force applies a torque (see black bended arrow in the sketch). The customers ask to clarify this.

Analyst Response (5):

This comment is correct. The effective Tensile *Operating Load* acting on the bolts is not zero because of a Bending Moment resulting from the 20 [kN] vacuum force acting at a moment arm of approximately 365 [mm]. There are no tensile operating bolt loads due to *gravity* or *atmospheric pressure*. Atmospheric pressure loads in vertical direction are balanced and gravity loads are directly transferred through the baseplate to the sub-structure. (this load path does not go through the bolts.). A re-run of the analysis without gravity loads applied and **with twelve individual Hold-down Bolt Boundary Condition definitions** resulted in the following Reaction Forces and corresponding Bolt Stresses due to Operating Loads:

Bolt #	Fx [N] Shear Reaction Force	Fz [N] Shear Reaction Force	Fxz [N] Combined Shear Reaction Force $=((Fx)^2 + (Fz)^2)^{0.5}$	Fy [N] Tensile reaction Force	Bolt Shear Stress [MPa] = Fxz / A_{shear}	Bolt Shear Stress / Allowable Shear Stress [%]	Bolt Tensile Stress [MPa] = ABS(Fy / $A_{Tensile}$)	Bolt Tensile Stress / Allowable Tensile Stress [%]
1	3,527	-689	3,593	8,539	42.7	44.3%	101.4	42.1%
2	1,018	1,457	1,777	2,824	21.1	21.9%	33.5	13.9%
3	-1,007	1,442	1,759	2,789	20.9	21.7%	33.1	13.7%
4	-3,543	-730	3,618	8,494	43.0	44.6%	100.9	41.9%
5	1,764	-4,607	4,933	2,131	58.6	60.8%	25.3	10.5%
6	702	-2,642	2,734	-2,129	32.5	33.7%	25.3	10.5%
7	-701	-2,644	2,735	-2,128	32.5	33.7%	25.3	10.5%
8	-1,764	-4,585	4,912	2,160	58.3	60.5%	25.6	10.6%
9	-585	-3,034	3,090	-8,007	36.7	38.1%	95.1	39.5%
10	-111	-620	630	-3,351	7.5	7.8%	39.8	16.5%
11	108	-612	621	-3,352	7.4	7.7%	39.8	16.5%
12	591	-3,005	3,062	7,970	36.4	37.7%	94.7	39.3%

Bolt Tensile Stress Area $A_{Tensile}$:	84.2	[mm^2]
Bolt Shear Stress Area A_{Shear} :	84.2	[mm^2]
Bolt Material minimum Ultimate Tensile Strength UTS_{30mm}:	482	[MPa]
Allowable Operating Bolt Tensile Stress: Sa_Tensile = 0.50*UTS_{30mm} :	241	[MPa]
Allowable Operating Bolt Shear Stress: Sa_Shear = 0.20*UTS_{30mm} :	96.4	[MPa]

Note-1: Above Bolt Loads are due to 100% of the applied 20 [kN] Vacuum Force

Note-2: All calculated Hold-down Bolt Stresses are acceptable.

FEA (consultant of Hositrad/Atlas)

Vacuum chamber

Deflections acceptable?

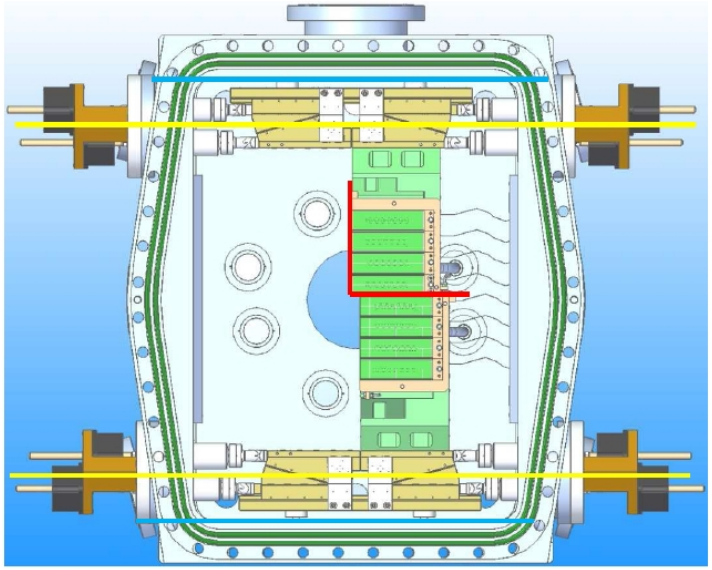

fig. 5a

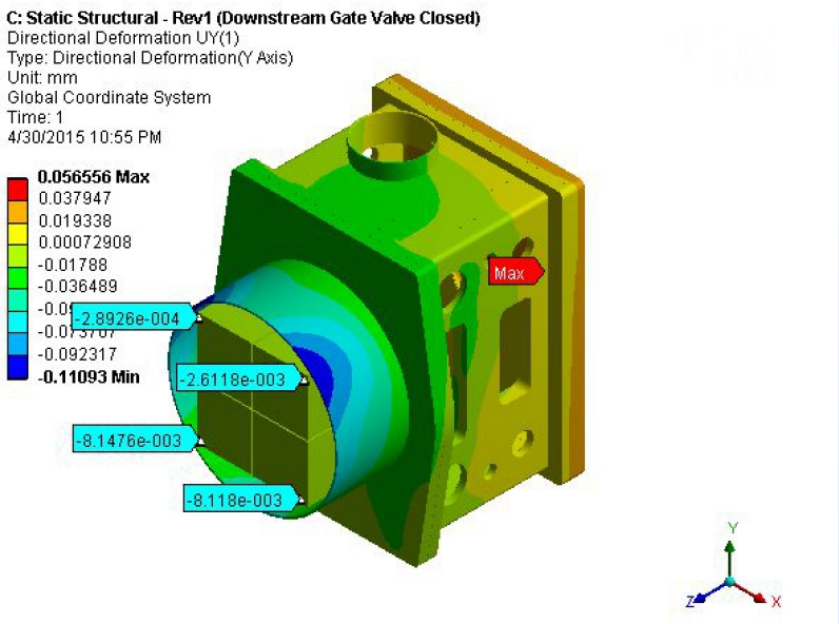

Figure 3.2.2-2: Calculated Directional (UY) Deflection in vertical direction and perpendicular to the beamline ('downstream gate valve closed' load case).

The maximum calculated UY differential deflection at the quadrants is (140 / 330)*(8.148E-03 – 0.289E-03) = 3.33E-03 [mm] over a length of 140 [mm]. The maximum allowable deflection per /2/ is 100E-03 [mm]. The edge-to-edge UY distance between Quadrant outer corners is 330 [mm], for modeling purposes only.

d) Precision

See *figures 5a and 5b*.

- It must be granted that the quadrants are positioned in parallel (see red lines in *figure 5a*). The quadrants are mounted on the adapters adjustable in a certain range. Adjusted quadrants may not change angle or position after pumping (change of parallelism less than 0,1 mm on a length of 14 cm). The vacuum chamber has to be designed such that this is granted.
- To achieve required parallelism between quadrants it's necessary to mount

Vacuum chamber

Stress in baseplate acceptable?

Max. stress = 129 Mpa
Equiv. Stress = 25% of max. stress

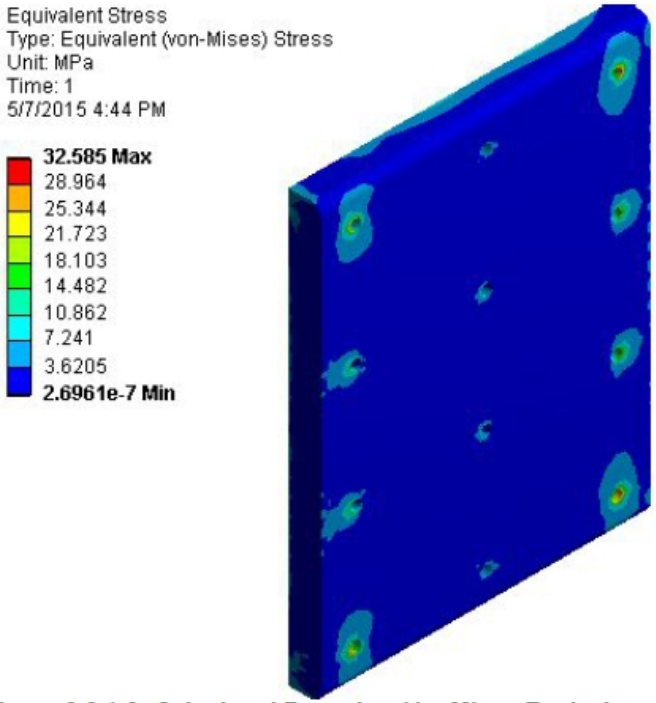

Figure 3.2.1-3: Calculated Baseplate VonMises Equivalent Stress due to Operating Conditions (full)

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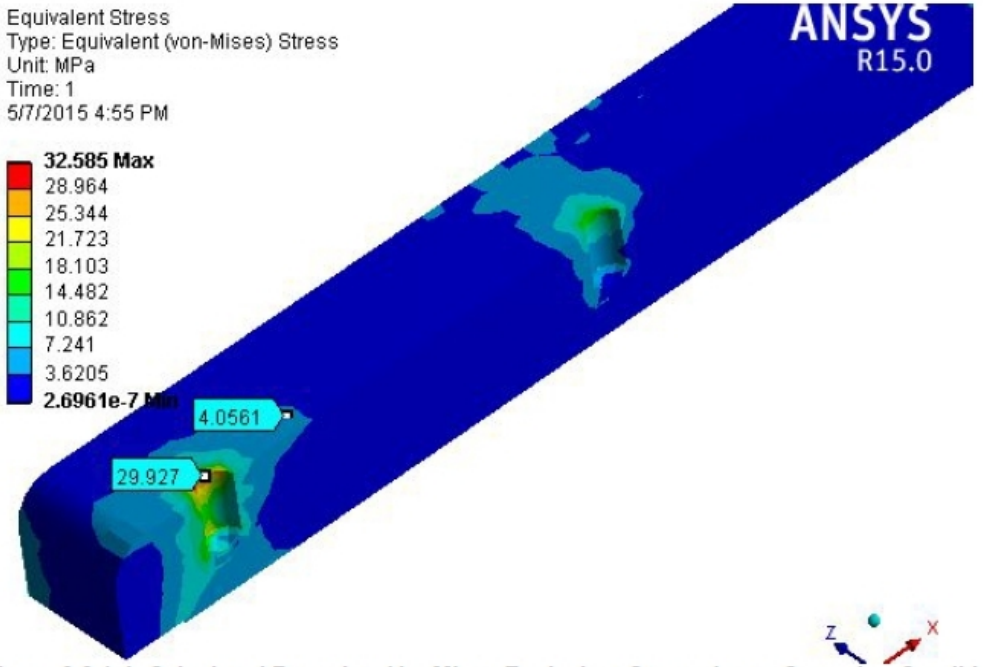

Figure 3.2.1-4: Calculated Baseplate VonMises Equivalent Stress due to Operating Conditions (slice)

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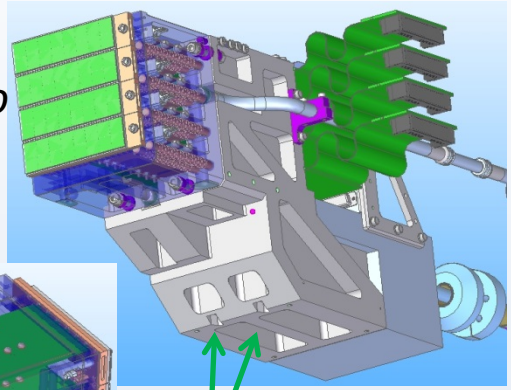
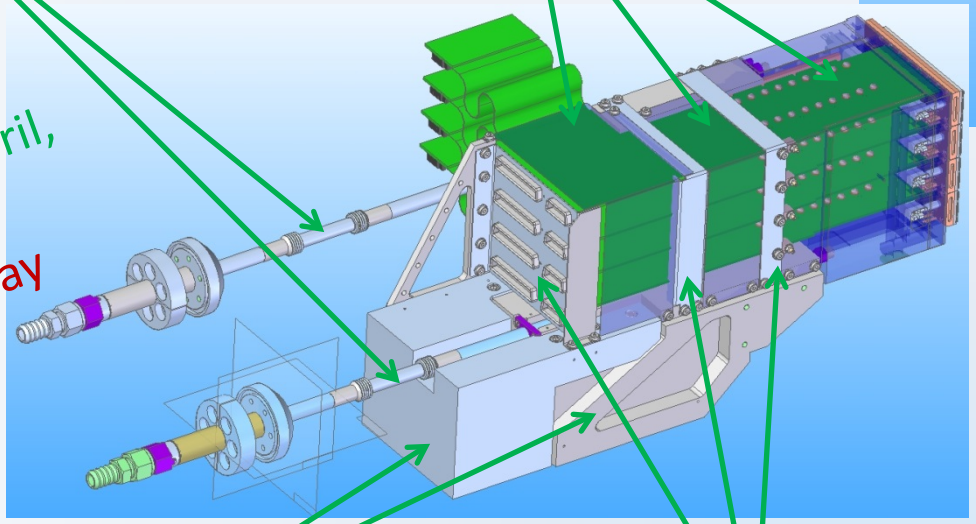
Status quadrant design

Finished re-design of cooling tubes, bellows pieces already ordered.

Finished design of stray shields, very challenging because nearly no space available





Design finished end of April, production drawings scheduled for end of May

Bores/pockets for correct positioning of quad on motion stage added.

Waiting for the design of the quadrant mounting device to be finished before producing adapter and counter weight.

Various smaller geometry changes in order to make the parts easier (cheaper) to manufacture.

Finished re-design of holders and realized adjustment for vacuum boards

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Outsourced engineering work

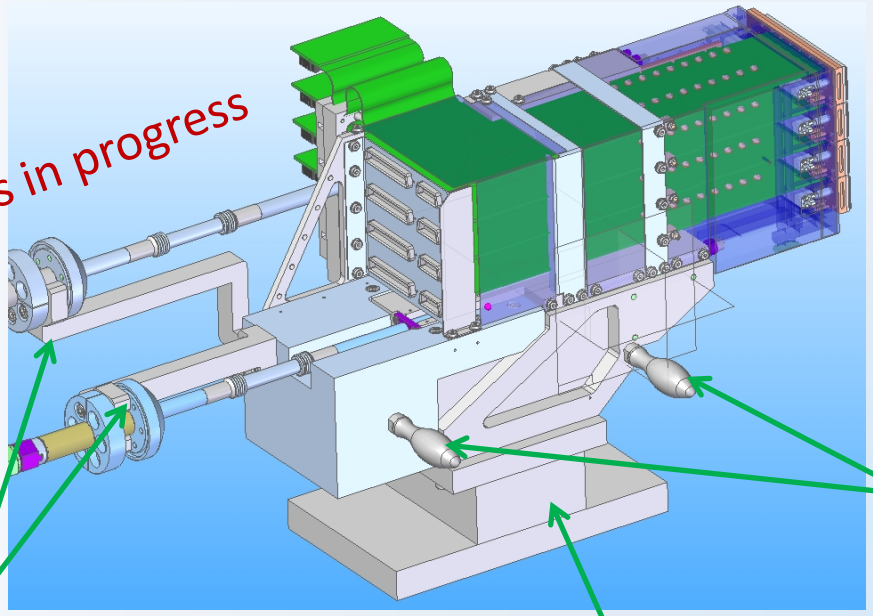
In order to keep on schedule engineering work was outsourced to the DESY engineering design department:

- Mounting devices and platforms for quadrants
- Plug lock for connectors vacuum board
- Rectangular flange holding the vacuum interface board
- External housing for data boards, incl. cooling

Outsourced engineering work

Outsourced engineering work (DESY engineering design dep.):

Mounting „platform“ for assembly of the quadrants, including support for the cooling tubes



design finished

production drawings in progress

Handholds
(2 on each side)

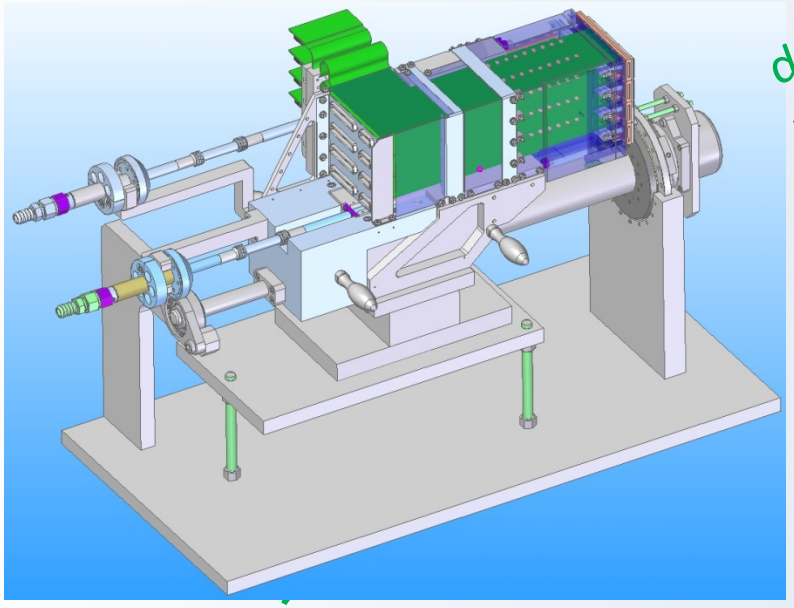
Support for cooling tubes

Mounting device
(replacement for motion stage)

Outsourced engineering work

Outsourced engineering work (DESY engineering design dep.):

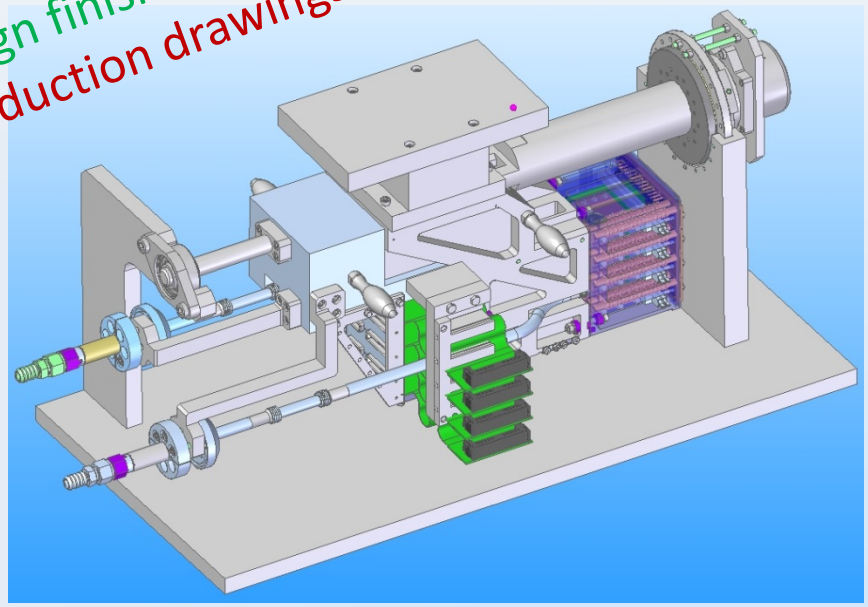
„Turn-Table“ to prepare a quadrant for „top“ mounting position



Quadrant in „bottom“ position

design finished

production drawings in progress

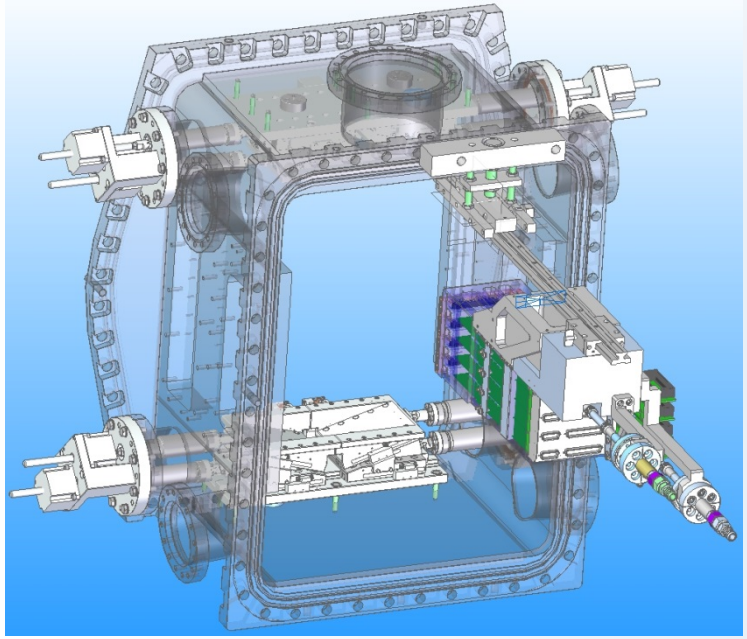


Quadrant, turned by 180° to „top“-position

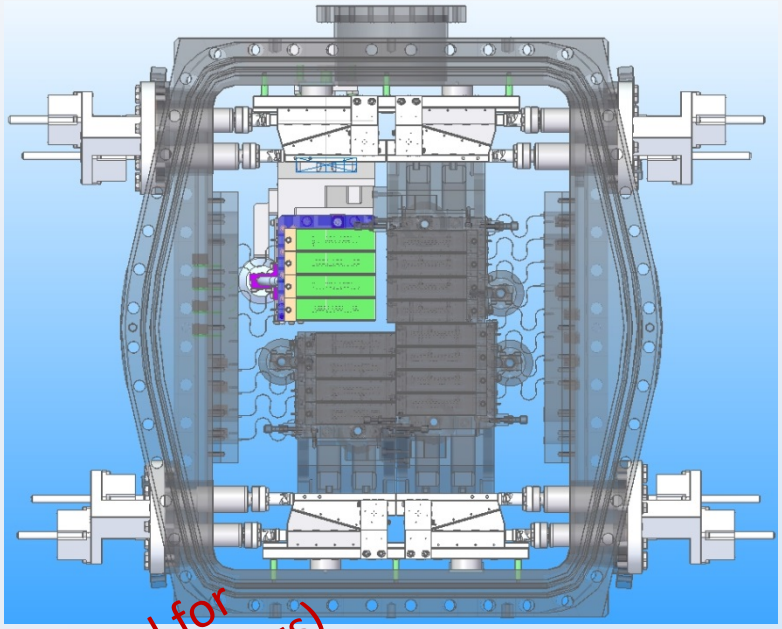
Outsourced engineering work

Outsourced engineering work (DESY engineering design dep.):

Mounting device to bring the quadrants into the chamber



Mounting device, under construction (still shown with old vacuum chamber). Mounting from downstream side of vacuum chamber.



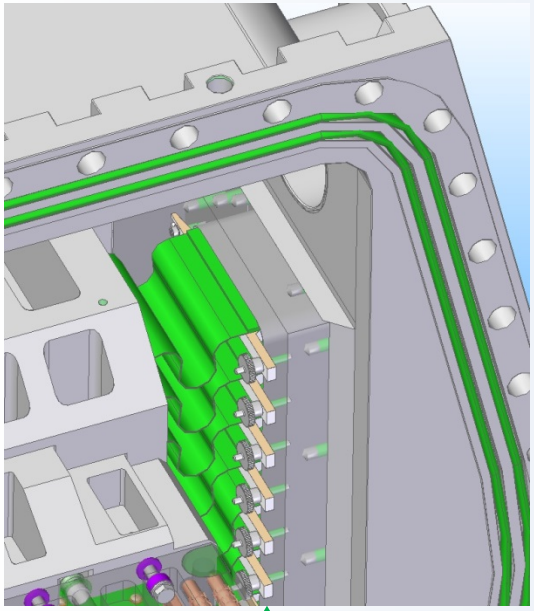
Not much space for mounting the last quadrant / to exchange a quadrant

Finish of design scheduled for end of May (incl. prod. drawings)

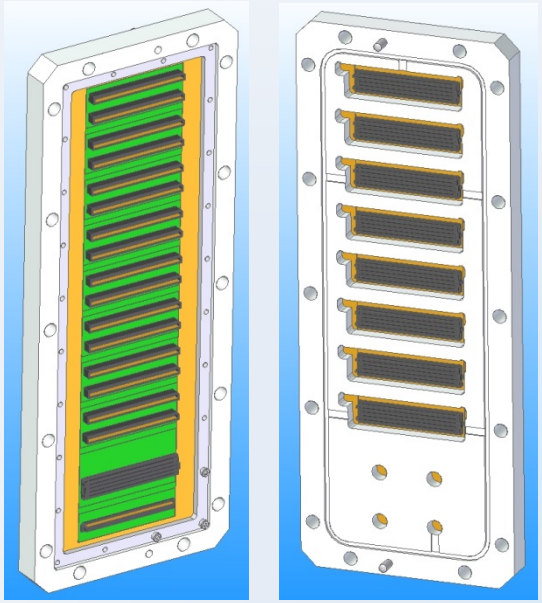
Outsourced engineering work

Outsourced engineering work (DESY engineering design dep.):

Design plug lock for connectors, review vacuum interface board, vacuum test of flange

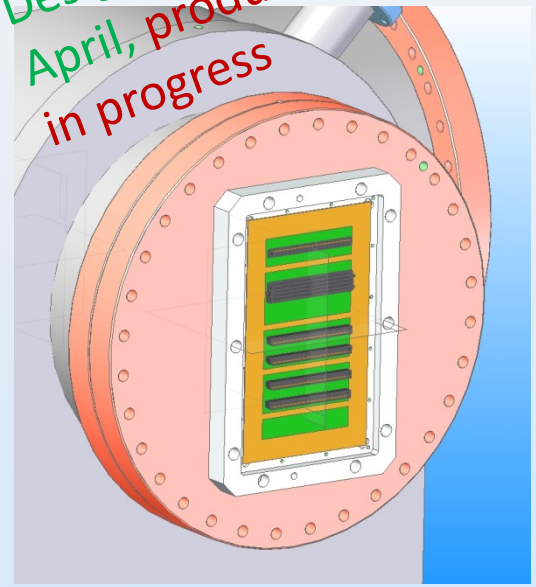


Plug locks for connectors of vacuum board designed



Assembly of rectangular flange (vacuum interface board) was reviewed and modifed

Design finished end of April, production drawings in progress

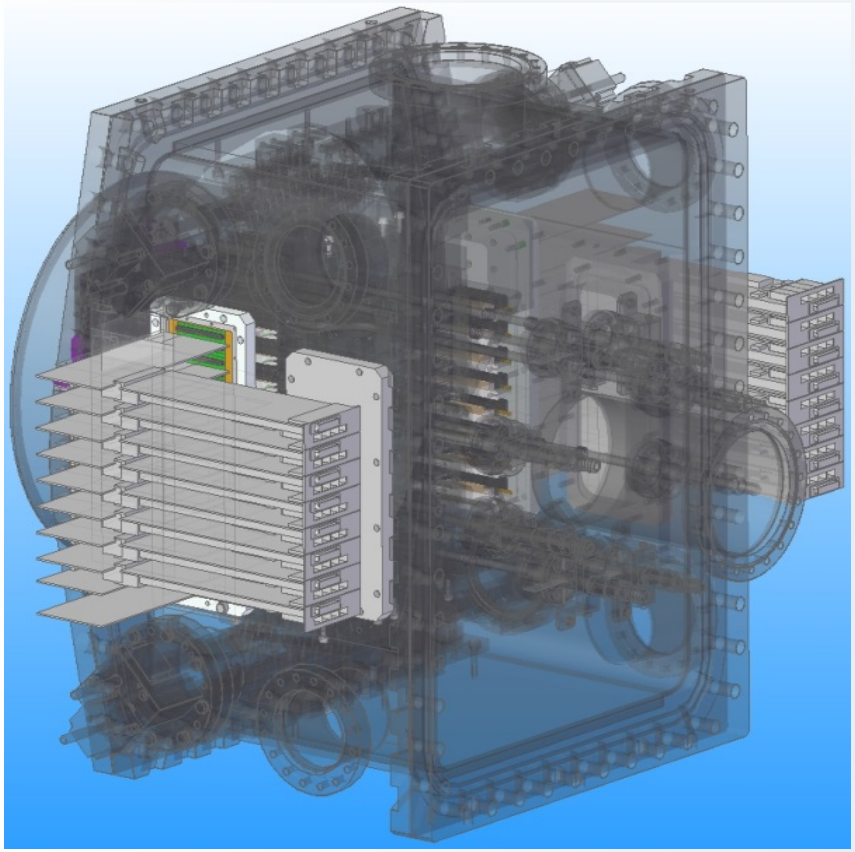


Test with smaller interface board in preparation.

Outsourced engineering work

Outsourced engineering work (DESY engineering design dep.):

External housing for data boards, incl. cooling



- *support for all boards*
- *housing of boards within small space*
- *cooling in order not to heat up air in hutch*

Finish of design scheduled for end of May

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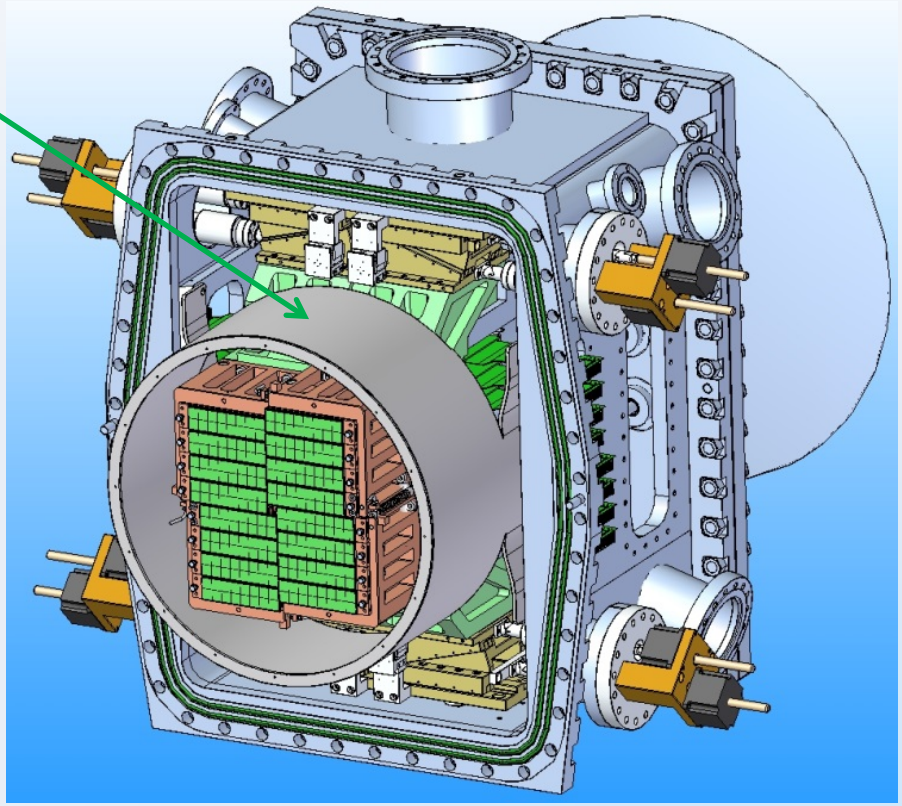
Unprocessed engineering work

Pending engineering work presently unprocessed :

Detector Hood

(requirements of this part
still have to be declared by XFEL)

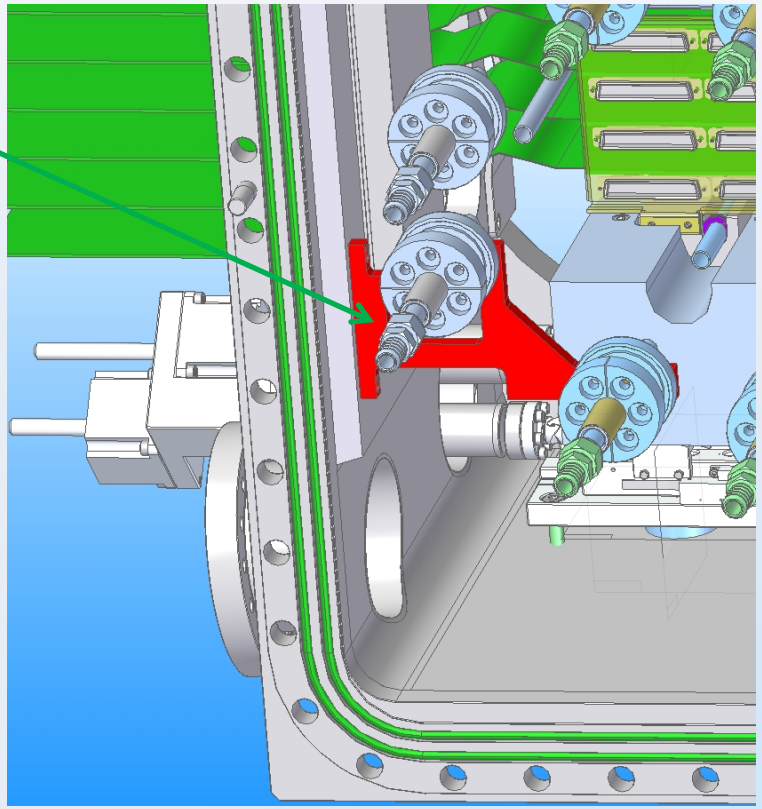


Unprocessed engineering work

Pending engineering work presently unprocessed:

Support for cooling tubes

inside vacuum chamber



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Summary

- *Cooling Block (electro-formed):* prototype in-house, parts for first 1M in production, scheduled to be ready in June; order for 2nd 1M just started beginning of May
- *Vacuum chamber:* Design finished, FEA to be approved by MID and SPB, after approval check of production drawings and 3D-model by FS-DS and then order of production
- *Status of quadrant:* Design finished, production drawings scheduled for end of May, order of production in preparation
- *Outsourced engineering work:* All pending major tasks outsourced to personnel of DESY engineering department
- *Unprocessed engineering work:* presently two minor tasks

End of talk

Thanks for your attention!

Questions?