Design of a mount for a new generation X-ray detector board
Final Report

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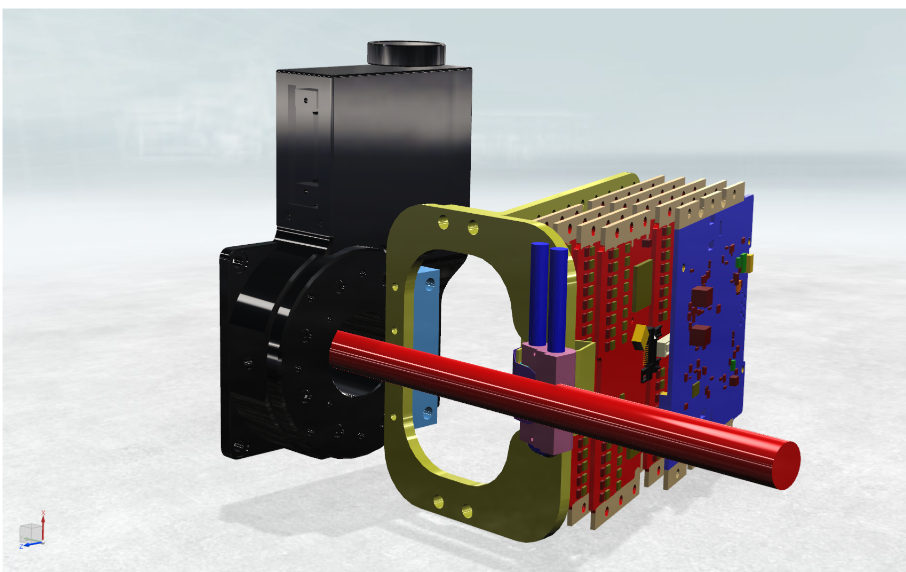

Figure 1: 3D model of the final concept

1 Design specifications and simulation conditions

1.1 Design Specifications

- **Mass** the mass of the ensemble (mount, sensor, electronics) is limited to **1 kg**
- **Protection** it is mandatory to protect the **electronic boards** from the X-Ray beam
- **Centering** the sensor has to be placed on the axis of rotation of an existent rotational stage
- **Dimensions** the ensemble has to be smaller than **400x400x120 mm**
- **Cables** to avoid the most signal noise possible the length of the cables has to be **minimal**
- **Symmetrical** since there are two similar installation the same mount must be **mountable on both** of them

1.2 Simulation Conditions

- **Water Flow:** the water flow available is $\mathbf{\dot{v} = 5\ l/min}$
- **Water Temperature:** the water temperature has been estimated to **T=25°C**
- **Pipe Size:** the pipe in the installation has a diameter of $\mathbf{d_{max} = 0.5\ Inch}$ - $\mathbf{d_{max} = 12.7\ mm}$
- **Environment:** the mount will take place in a closed box, **without free air flow**
- **Controlled Atmosphere:** in order to prevent/limit scattering of the X-Ray beam the box will be fulfilled with **Helium** at a temperature of roughly **25°C**
- **X-Ray Beam Size:** the beam will have a diameter of $\mathbf{d_b = 15\ mm}$
- **Cooling Pipe diameter:** the cooling pipe will have a diameter of $\mathbf{d_p = 6\ mm}$
- **Heating Power:** the heating power is approximated to a heat flux: $\mathbf{\dot{q} = 1\ W/mm^2}$

2 3D design

In this section the 3D design will be explicated and detailed. The labels of the different parts used are the same of the actual 3D files. Each color represents a different material:

Table 1: Colour materials

Colour	**Material**
Yellow	Aluminium
Light Pink	Copper
Blue	Cooling Pipe
Red	X-Ray beam

2.1 Overview

In the Figure 2 it is possible to see the final design of the support assembled with the rotational and translational stages:

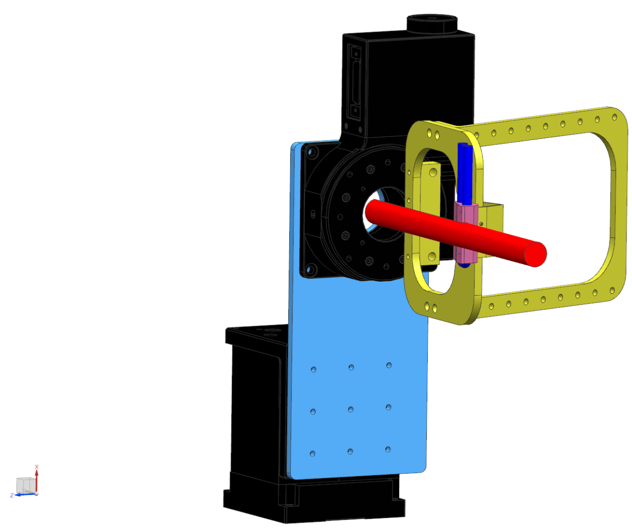

Figure 2: Final Design

In the Figure 3 it is possible to see the parts that have been actually designed and simulated:

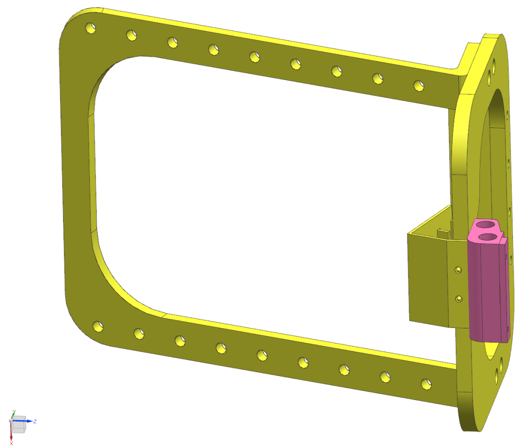

Figure 3: Actually designed and simulated parts

2.2 Detailed descriptions

2.2.1 Active_device_support

In the Figure 4 the support where the silicon wafer and the copper sensor will be glued is represented:

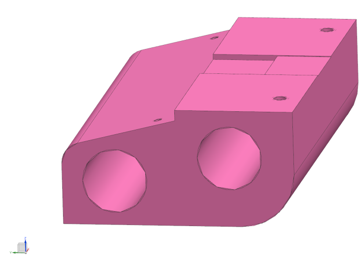

Figure 4: Active device support

On the diagonal plane, where the cables are supposed to be placed two holes make a fixation of the cables possible with a thin bar. According to the colours Table 1 the material of this part is copper (Cu). The mass is **44.75 g**.

2.2.2 Active_device_shield

In the Figure 5 the shield is represented:

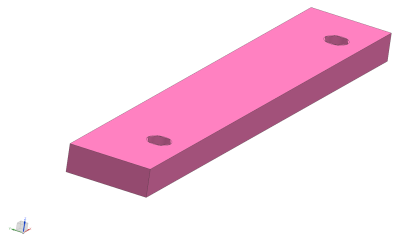

Figure 5: Active device shield

According to the colours Table 1 the material of this part is copper (Cu). The mass is **3.55 g**.

2.2.3 Main_plate

In the Figure 6 the main plate where the **Active_device_support** is screwed is represented:

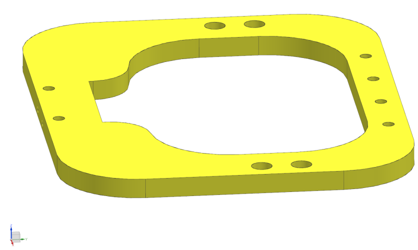

Figure 6: Main plate

According to the colours Table 1 the material of this part is aluminium (Al). The mass is **72.22 g**.

2.2.4 Electronics_support

In the Figure 7 the main plate where the electronic boards are screwed is represented:

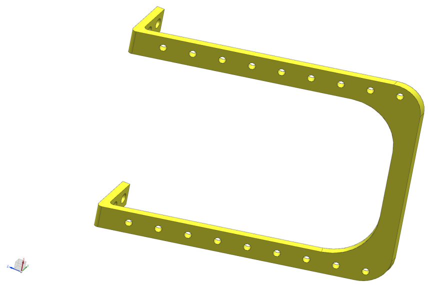

Figure 7: Electronics support

According to the colours Table 1 the material of this part is aluminium (Al). The mass is **58.07 g**.

2.2.5 Flange

In the Figure 8 the flange which is the connection between the **Rotational stage** and the **Main_plate** is represented:

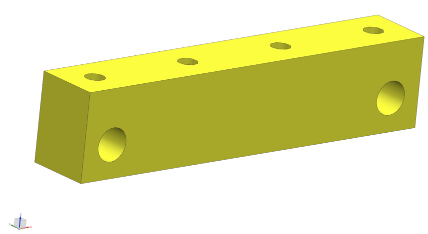

Figure 8: Flange

According to the colours Table 1 the material of this part is aluminium (Al). The mass is **20.67 g**.

2.2.6 Cables_support

In the Figure 9 the cables support on which the cables can be glued to maintain them in position is represented:

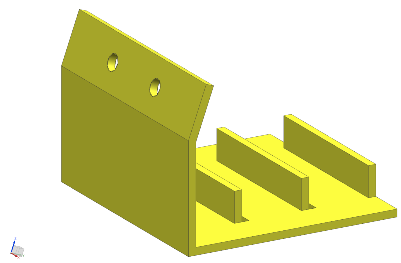

Figure 9: Cables Support

According to the colours Table 1 the material of this part is aluminium (Al). The mass is **12.77 g**.

The total mass of the support at this stage is **212.04 g** it is necessary to pay attention to the fact that screws/gluing were not calculated.

2.3 Considerations

In this actual configuration the support with the electronics produces a couple on the rotational stage. Since the final mass of the electronic boards is not yet defined, to counter balance this moment it is suggested to use one Flange and to screw to the flange a metal bar of appropriate mass. In the Figure 10 it is possible to see what it will look like, the grey solid is representing the counter weight, the material is not determined but it can be everything.

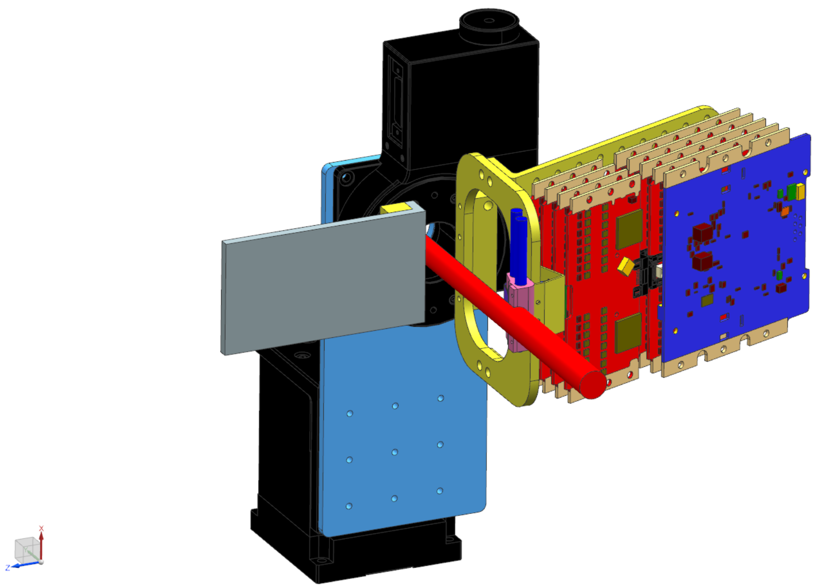

Figure 10: The final support with the counter weight integrated

3 FEA discretization and SIM model

3.1 FEA discretization

3.1.1 Pipe

In order to simulate the water cooling a pipe with the diameter of **6 mm** has been designed, this diameter combined with the maximal water flow determines a **Reynolds Number of 16000**: a turbulent flow is needed because it generates a better heat exchange. In the Figure 11 the FEA model of the pipe is represented:

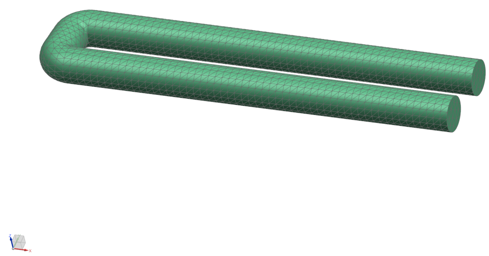

Figure 11: pipe

3.1.2 Assembly_support

In the Figure 12 the FEA model of the assembly support is represented:

Figure 12: Assembly support

3.2 SIM model and conditions

In the Figure 13 the necessary SIM objects like contact and gluing between surfaces are represented:

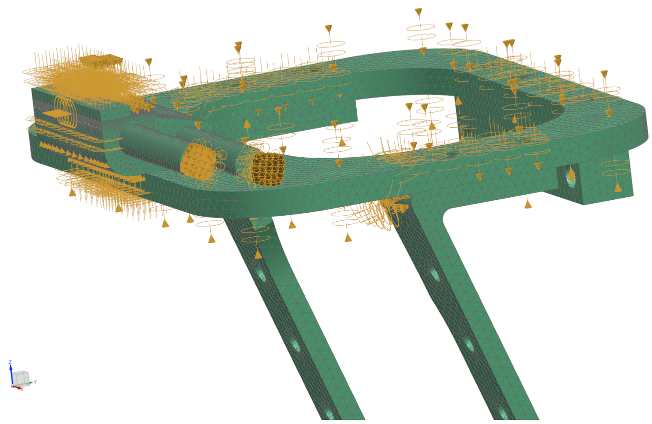

Figure 13: SIM objects

In the Figure 14 the necessary SIM initial conditions (in blue) are represented, in this case a starting temperature of the whole assembly has been decided to be 25℃:

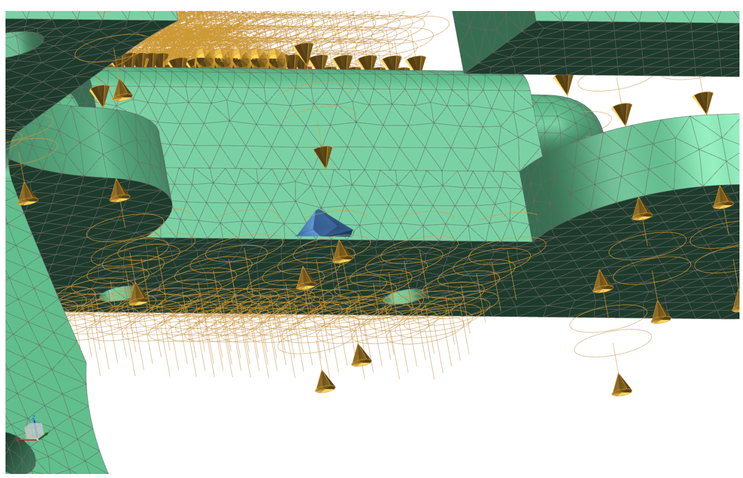

Figure 14: SIM initial conditions

And last but not least in the Figure 15 the beam power simulated by a heat flow has been added:

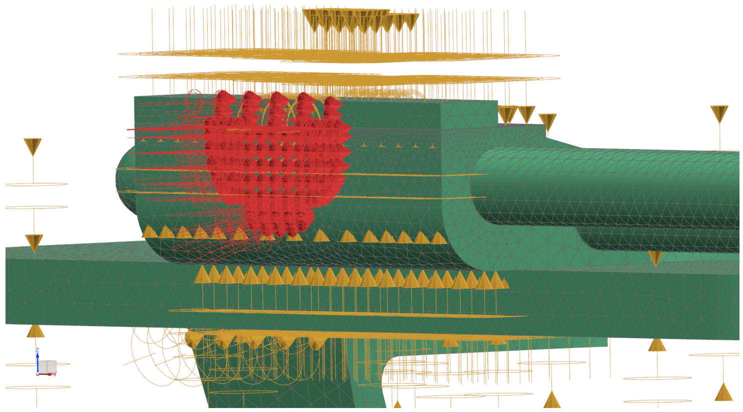

Figure 15: SIM beam target area

4 Simulations results

The simulation has been performed in order to reach the steady state of the system. The system is supposed to reach the steady state approximatively after 1700 seconds (system equilibrium constant) of continuous heat flow.

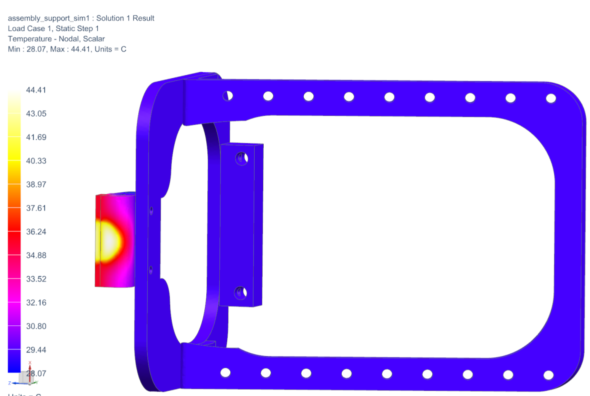

Figure 16: SIM solution general results

The maximal expected temperature is **44.4 °C**

4.1 The sensor

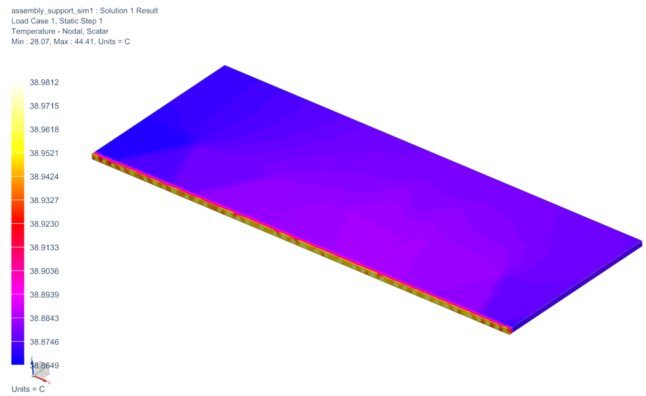

Figure 17: SIM solution sensor results

The maximal expected temperature is **38.98 ℃**, it is important to know that the difference between the hottest and the coldest point of the sensor is **0.1 ℃**, it is possible to assume that the sensor will reach an homogeneous temperature.

4.2 The active device support

In the following Figure 18 the results on the *the active device support* alone are represented, how it is possible to see the main heat remains on the copper support and does not spreads in an important way in the aluminium plates.

Figure 18: SIM solution complete active device support results

In the Figure 19 the support has been cut in the middle with a plane, it is now possible to see the heat transfer right in the middle of the sensor and consequently in the middle of the X-Ray beam

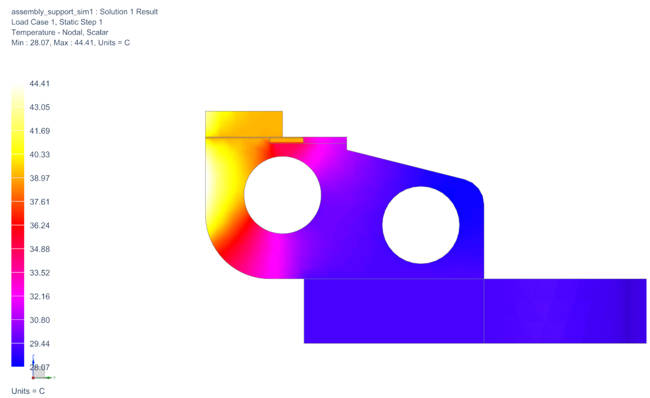

Figure 19: SIM solution complete active device support results

5 Software

For the design part the software used is : SIEMENS NX 10

For the simulation part the software used is : SIEMENS NX 10 Advanced Simulations

The solver used is : NX THERMAL/COUPLED

6 Contacts

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