CERN Summer Student

REPORT

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AEGIS EXPERIMENT

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August, 2015

Content

Steps towards the design of a cryogenic manipulator for an ultra-thin membrane in a 1T magnetic field

1. Explanation of the project

The main purpose of my working project in CERN was design, analysis and research on all conditions under which one *cryogenic* mechanism would produce extremely low temperatures needed for cooling down a silicon target for the production of positronium in a so-called "bread box" (a vacuum enclosure with laser and positron access ports, with a bread-box-like hinged covering).

This project belongs to the AEgIS experiment which aims to carry out the first direct measurement of a gravitational effect on an antimatter system. To reach this goal, silicon has to be bombarded by positrons in order to create positronium which is used to form antihydrogen atoms, on which the experiment is going to be done.

After receiving my first brief explanation and draft version of the system's design, I instantly started to further develop my ideas related to its functionality. Starting from the top of the system's construction, I did a research on how does liquid nitrogen and a vacuum flask match between each other. Of course, that wouldn't have worked out if I first haven't done a research regarding the cryogenic engineering itself.

Cryogenic engineering is the study of production and behavior of materials at a very low temperature. It usually starts at below *-150C (123K) to -180C (93,15K).*

The system is supposed to be cooling down the silicon target by using *Liquid Nitrogen,* as one of the most commonly used liquefied gases for this matter. LN2 must be kept between a range of -210C (63K) to -196C (77,2K). If it goes below 63K, nitrogen freezes and becomes a solid. If it goes above 77,2K it boils and returns to gas. What can also be used is Liquid Helium, but its high price makes it less desirable for its purpose.

When it comes to handling of the Liquid Nitrogen, it should not be placed in a continuously closed flask. A mobile plastic lid is undoubtedly advised as a cover, which will assure a constant pressure relief. As other materials are also possible for the lid's composition, the low price of plastics makes its usage more economically excused.

What is also very important when it comes to LN2's storage, is that flasks are not supposed to be filled with more than 80% of their capacity, since expansion of gases might cause excessive pressure buildup.

The flask is made of stainless steel, surrounded by vacuum to assure that the exterior temperature will not affect its interior.

The material that is supposed to conduct this low temperature produced within the flask into the vacuum of the enclosure that houses the silicon target is *copper*. Copper has very high thermal and electrical conductivity. Another material convenient for this purpose is the stainless steel, but copper has a better coefficient of thermal expansions which makes it more appropriate for this matter. Another advantages of copper are its antibacterial properties, flexibility and recyclability.

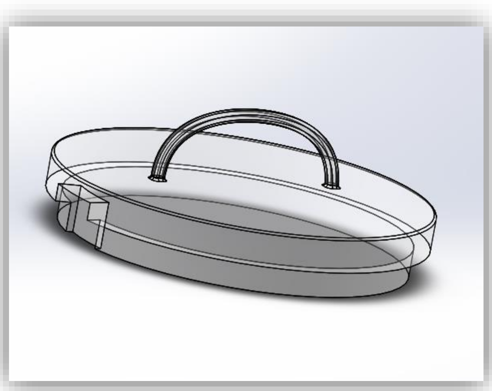
Copper is basically connected to the stainless steel flask by brazing, which is a quite easy process to do, and ensures vacuum tightness between the LN2 contained and the vacuum enclosure.

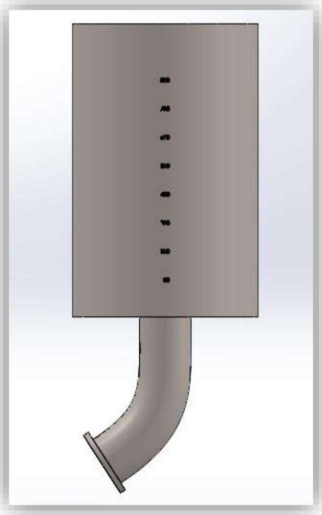
The copper conducts the low temperature through a rod, directly entering the bread box. A copper braid is anchored to the end of the rod, reaching the silicon and ensures that its environment obtains extremely low temperatures.

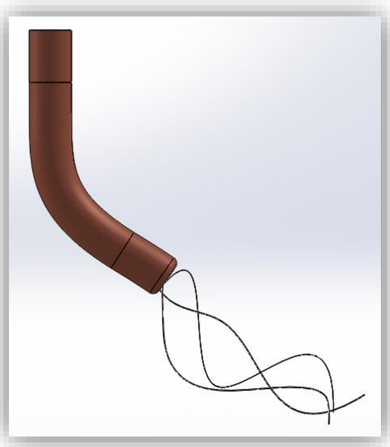
2. SolidWorks Designing

The design of this cryogenic system for cooling down a silicon target in a vacuum enclosure was made by using the SolidWorks software. The design consists out of three basic mechanical parts:

- *Plastic lid (1);*
- *Vacuum flask (2);*
- *Copper rod with screw holes for attaching a copper braid (3).*



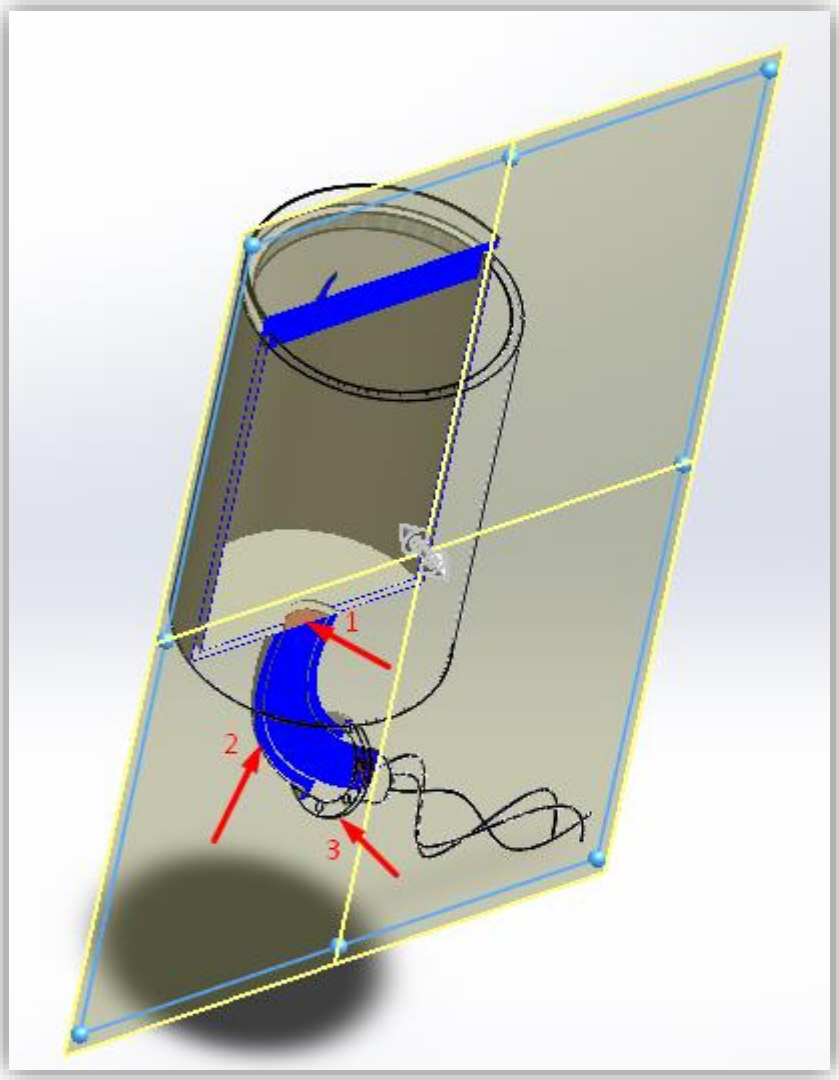




(1) **(2)** **(3)**

After first examination of the design, additional changes that were requested to be made were:

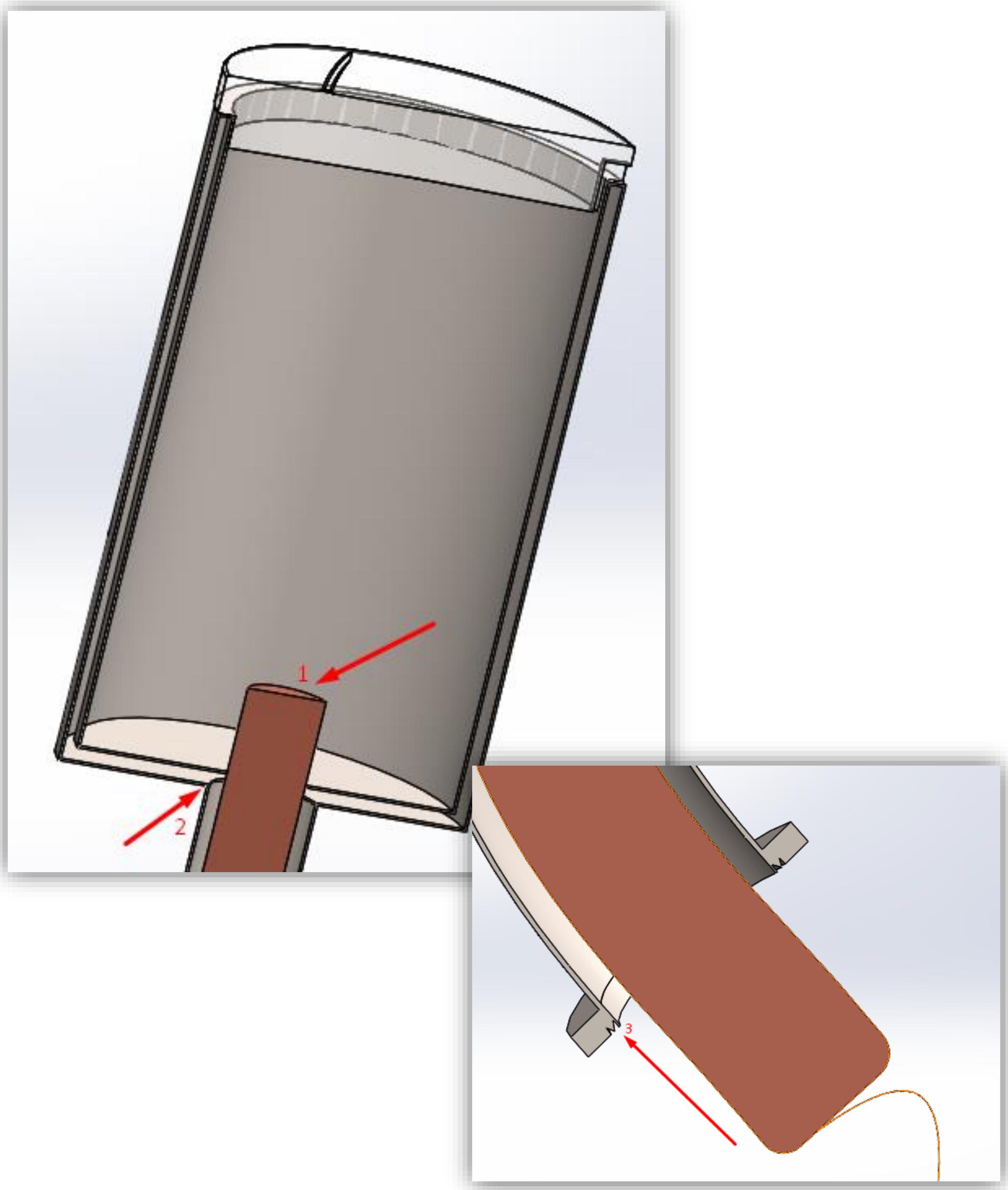
- *Increasing the length of the copper rod so that it goes through the vacuum flask (1);*
- *Forming a bigger gap between the copper rod and its vacuum flask so that copper can be easily screwed inside (2);*
- *Building up a DN40 flange so that the vacuum surrounding the copper rod can be easily attached to one of the bread box's entrances (3).*



Section view of the cryogenic manipulator

After second examination of the design, additional changes that were requested to be made were:

- *Increasing the length of the copper rod so that it goes through the vacuum flask <u>even more</u> (in order to allow a clean brazing connection to be made and to ensure good contact with the LN2) (1);*
- *Separate both vacuum walls from each other near the upper entrance of the copper to the flask (2);*
- *Modification of the flange (3).*



3. Final appearance