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Fermilab Engineering Specification

LCLS-II PROTOTYPE CAVITY MAGNETIC SHIELD SPECIFICATION

ED0001196, Rev. -

Rev.	Date	Description	Originated By	Checked By	Approved By
-	4 MAR 2014	Initial Release	*C. Grimm*	*C. Crawford*	*N. Solyak*

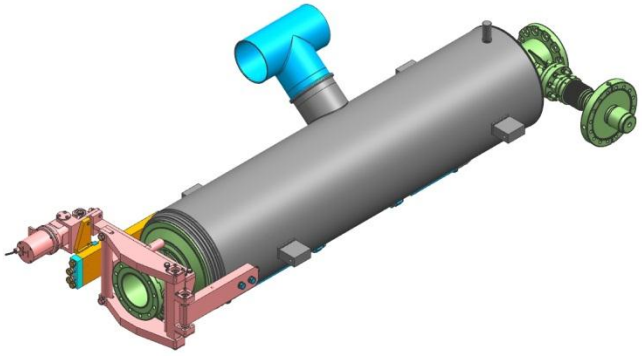
1.3GHz Magnetic Shielding Specification – LCSL-II

Chuck Grimm, 4-March-2014

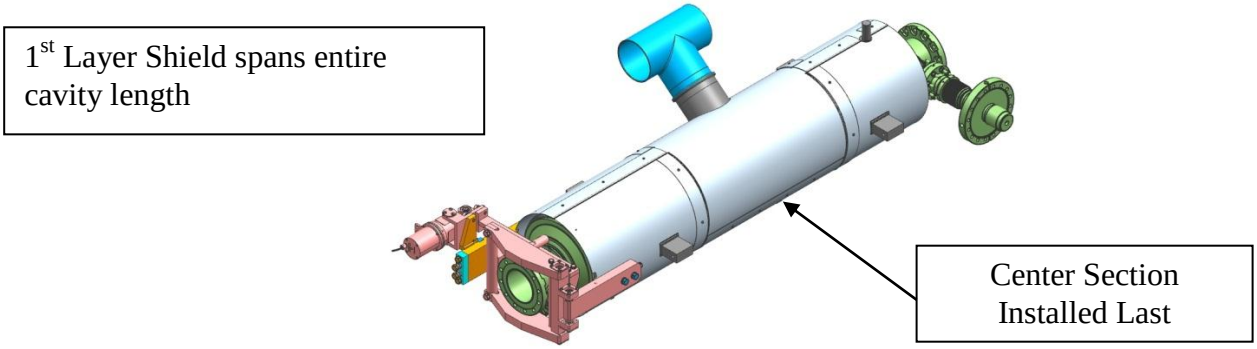
Project Location: Initial use at MP9 at FNAL. Final installation at SLAC.
Project Name: LCLS-II 1.3GHz Prototype Cryomodule

Scope of work:

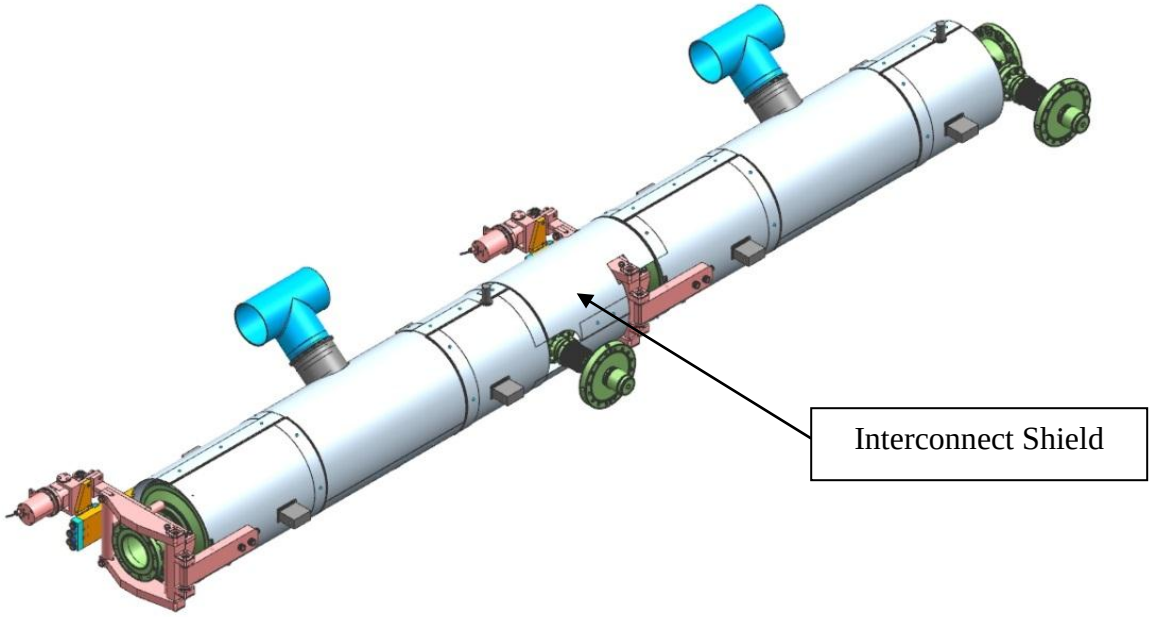
Fermilab has developed a double-layer magnetic shield design for the 1.3GHz LCLS-II Prototype Cryomodule. The first layer is assembled close around the helium vessel with approx. 3mm radial clearance, and the second layer is spaced 20mm out radially from the first layer using spacers. Both layers will be physically connected from cavity-to-cavity using interconnect shields, these will be screwed on around the tuner end of one cavity and designed with a floating joint at the coupler end of the opposite cavity. This will allow for movement in the interconnect region due to thermal contraction/expansion during cavity cool down/warm up (~1.8K/300K). The cavity string will consist of eight, 9-cell superconducting, Radio Frequency (RF) cavities.



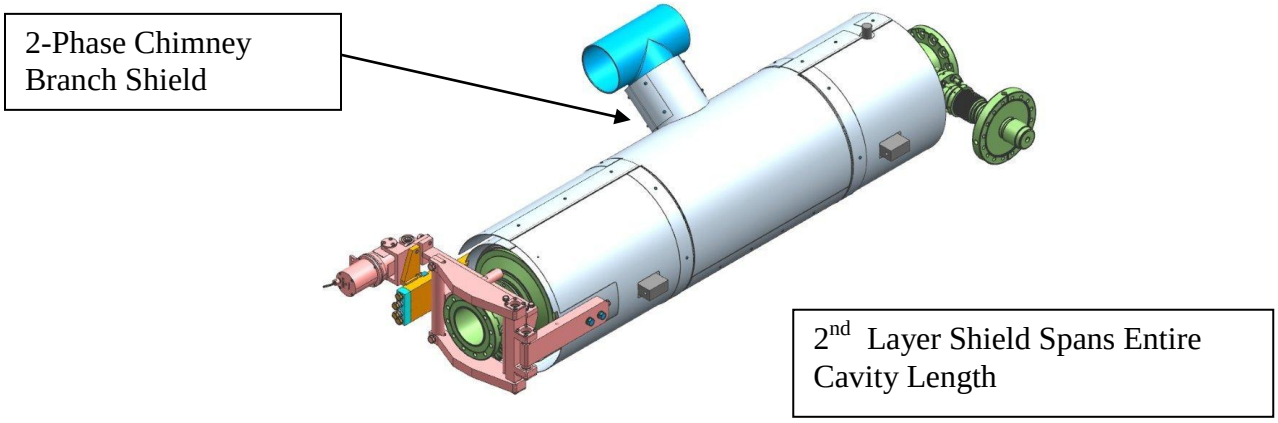
Cavity Prior to Magnetic Shield Installation



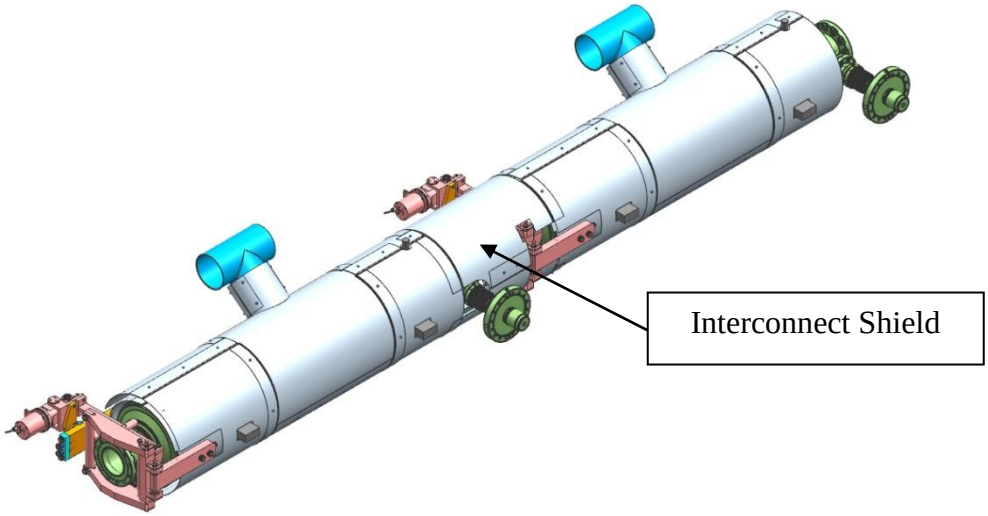
Cavity Complete with 1st Layer Magnetic Shielding



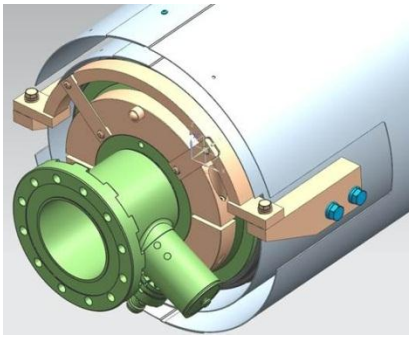
2-Cavity String with Complete 1st Layer Shielding



Cavity Complete with 2nd Layer Magnetic Shielding



2-Cavity String with Complete 2 Layers of Shielding



Close-Up of Shields with Bellows Restraint

The cavity and shielding is at the core of the cryomodule. This shell acts as the primary layers of magnetic shielding for the internal cavities.

Design Data Provided by Fermilab:

A STEP file of the shield design will be provided by Fermilab. This STEP file will contain the shield components, the cavities to be shielded, and the neighboring parts that the shield must be designed around. Drawings of the shield components, provided by Fermilab, have been detailed to avoid interferences and to provide reasonable magnetic shielding. A JT file (3-D model for viewing) and viewing software (JT2GO from UGS) will also be provided by Fermilab to assist in the quotation and design.

Shield Fasteners:

Fermilab requires that the shield components be fastened together using PEM fasteners but does not specify the style or required torque. The installation details of the fasteners, such as torque, are to be specified by the vendor and must be accepted in writing by Fermilab before the fabrication begins. Fermilab will specify the location of the fasteners per the manufacturing drawings.

Shield Spacers (2nd Layer):

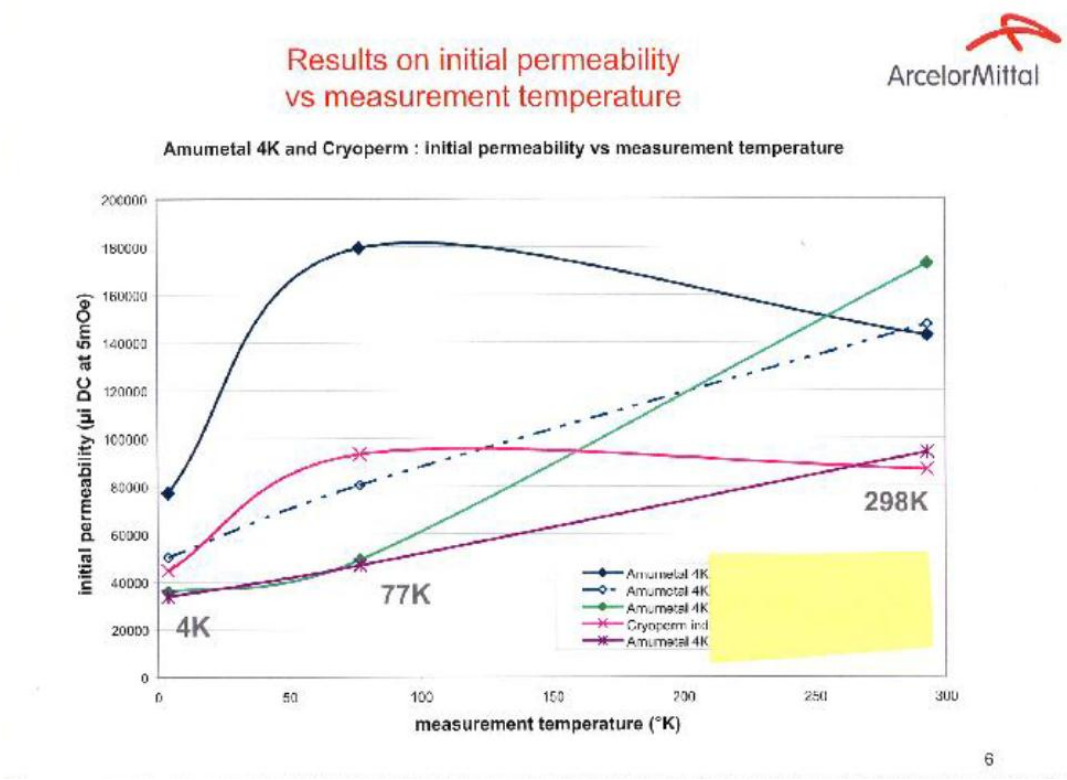
Fermilab requires that the shield components be spaced radially 20mm between the first layer and second layer shields. The spacers will fastened together using PEM fasteners but does not specify the style or required torque. The location and details of the spacers and fasteners, are to be specified by the vendor and must be accepted in writing by Fermilab before the fabrication begins. Vendor will specify the location of the spacers and fasteners as to avoid vessel penetrations and shield overlaps.

Vendor Review of Design:

The vendor will review the Fermilab shield design for manufacturability and will provide a cost for the Fermilab designed shield based on Engineering, Materials, Fabrication, Annealing, Packaging, Shipping, Assembly, etc. The initial quotation must include the fastener plan and associated cost as mentioned in *Shield Fasteners*. In addition to the initial quotation, the vendor may suggest alternate design features and processes to help optimize the shielding performance and/or to reduce cost. The initial review must contain a description of how the shields will be fastened together and attached to the cavity string.

Fabrication Details:

- *Shield Material*: Magnetic shields must be fabricated from Cryoperm10, Amumetal 4K, or an equivalent material that is specially prepared to have high permeability over a wide range of temperature; materials must be approved by FNAL. Suitable performance is illustrated in Figure 1. The relative magnetic permeability of the completed shields, after installation in the cryomodule, must exceed 10,000 over the temperature range 1.6K <T <300K. Note that this value for relative permeability is the minimum requirement after all mechanical and handling procedures have been completed and is based on the assumption that the permeability will be degraded significantly by mechanical stress and shock.



Curves for Cryoperm10 and for Amumetal 4K, Both are Acceptable for Magnetic Shield Use

- ***Magnetic Fields*:** The magnetic field inside the magnetic shield under normal operating conditions as well as during cryomodule cooldown must not exceed 5 milliGauss (0.5 microTesla). The shields will consist of two concentric layers of 1mm thick high magnetic permeability material separated by a radial gap of approximately 20 millimeters. Any spacers used between the shielding layers must be made from material with relative magnetic permeability less than 1.05. It must be ensured that there are no magnetic "shorts" present that would allow flux to pass easily from the outer shield layer to the inner layer. It is anticipated that the ambient flux outside the magnetic shield will be less than 500 milliGauss (50 microTesla).
- ***Labeling:*** Each piece of shielding will be properly identified with minimal 1/8 inch high lettering, embossed or engraved onto each shield in a location that is viewable after the shield is assembled. Each shield will be bagged in plastic and labeled with a tag identifying the part number and revision level.
- ***Fastener Material:*** The fasteners to join the shield components together must be made from 316L stainless steel or similar low magnetic permeability steel.
- ***Forming****:* The material will be formed via normal sheet metal operations. Laser cutting of the flat stock and rolling to final size is permitted. The fabrication techniques, from design to the final configuration, are identical to that of Amumetal®, the 80% Nickel alloy used for room temperature applications. The only difference between these two metals is the special annealing cycle used for Cryoperm®.

- ***Heat Treatment (Annealing):*** After forming, the shields must be annealed and processed accordingly to optimize the magnetic field properties at 4.2K. This process cannot be specified by Fermilab since, in most cases, this is a proprietary process.
- ***Grinding & Snipping****:* Before annealing, grinding and snipping are permissible to create a better fit with mating parts. No metal work is permitted once the annealing process has been completed.
- ***Handling:*** Before and after annealing, white cotton gloves must be worn to prevent cosmetic defects from dirty hands and skin oils. After processing of the shields, care must be taken in handling and shipping to not damage the developed magnetic characteristics of this material. Therefore, the shields are to be cautiously handled, packaged in bubble wrap and Styrofoam, and shipped in crates that will prevent impact to the shields and also minimize vibrations. Prior to awarding the contract, the vendor must explain their process and describe the method and container used for shipping.

Fermilab Review of fabrication Proposal:

The proposal will be reviewed by Fermilab engineers and any possible modifications will be discussed with the vendor. Fermilab may choose to visit the vendor to gain a better understanding of the fabrication process, to further refine the fabrication process, and to assess the capability of the vendor and the reliability of the proposed delivery schedule.